SPECIFICATIONS

FASTENER TIGHTENING SPECIFICATIONS

Fastener Tightening Specifications

Application	Specification	
	Metric	English
A/C Compressor to Block Bolt	20 N.m	15 lb ft
Balance Shaft Adjustable Chain Guide Bolt	10 N.m	89 lb in
Balance Shaft Bearing Carrier to Block Bolt	10 N.m	89 lb in
Balance Shaft Fixed Chain Guide Bolt	10 N.m	89 lb in
Balance Shaft Sprocket Bolt	50 N.m	37 lb ft
Block Heater Bolt	10 N.m	89 lb in
Cam Cover to Cylinder Head Bolt	10 N.m	89 lb in
Cam Cover to Ground Cable Bolt	10 N.m	89 lb in
Cam Cover to Ground Cable Stud	10 N.m	89 lb in
Camshaft Bearing Cap Bolt	10 N.m	89 lb in
Camshaft Sprocket Bolt		
• First Pass	85 N.m	63 lb ft
• Final Pass	30 degrees	
Camshaft Timing Chain Tensioner	75 N.m	55 lb ft
Chain Guide Access Hole Plug	90 N.m	59 lb ft
Connecting Rod Bolts		
• First Pass	25 N.m	18 lb ft
• Final Pass	100 degrees	
Crankshaft Bearing Lower Crankcase to Block Bolts		
• First Pass	20 N.m	15 lb ft
• Final Pass	70 degrees	
Crankshaft Position Sensor Bolt	10 N.m	89 lb in
Crankshaft Pulley Bolt		
• First Pass	100 N.m	74 lb ft
• Final Pass	125 degrees	
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
Dipstick Guide to Intake Manifold Bolt	10 N.m	89 lb in
Drive Belt Tensioner Bolt	45 N.m	33 lb ft
EGR Cover Bolt	25 N.m	18 lb ft
Elek. ICM Cover Bolt	10 N.m	89 lb in
Engine Coolant Temperature Sensor	22 N.m	16 lb ft
Engine Lift Bracket Front Bolt	25 N.m	18 lb ft
Engine Lift Bracket Rear Bolt	25 N.m	18 lb ft
Engine Mount Intermediate Bracket Bolts	100 N.m	74 lb ft
Engine Mount to Intermediate Bracket Bolts	50 N.m	37 lb ft
Engine Mount to Mid-Rail Nuts	100 N.m	74 lb ft
Exhaust Manifold to Cylinder Head Nut	14 N.m	124 lb in
Exhaust Manifold to Cylinder Head Stud	10 N.m	89 lb in
Exhaust Manifold Pipe Flange Stud	16 N.m	12 lb ft
Exhaust Take down Pipe Nuts	30 N.m	22 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	
Frame Bolts		
• First Pass	100 N.m	74 lb ft
• Second Pass	180 degrees	
Front Cover to Block Bolt	25 N.m	18 lb ft
Front Lift Bracket Bolt	25 N.m	18 lb ft
Fuel Line Bracket Bolt	10 N.m	89 lb in
Fuel Pipe Bracket Bolt	10 N.m	89 lb in
Fuel Rail Bracket Stud	10 N.m	89 lb in
Generator Connector Nut	20 N.m	15 lb ft
Generator to Block Bolt	23 N.m	17 lb ft
Heat Shield to Exhaust Manifold Bolt	23 N.m	17 lb ft
Ignition Coil Bolt	10 N.m	89 lb in
Intake Camshaft Rear Cap Bolt	25 N.m	18 lb ft
Intake Manifold to Cylinder Head Bolt	10 N.m	89 lb in
Intake Manifold to Cylinder Head Nut	10 N.m	89 lb in
Intake Manifold to Cylinder Head Stud	6 N.m	53 lb in
Knock Sensor Bolt	25 N.m	18 lb ft

Lower Crankcase to Block Peripheral Bolts	25 N.m	18 lb ft
Oil Filter Housing Cover	25 N.m	18 lb ft
Oil Gallery Plug	35 N.m	26 lb ft
Oil Gallery Plug - Rear	60 N.m	44 lb ft
Oil Level Indicator Tube Bolt	10 N.m	89 lb in
Oil Pan Drain Plug	25 N.m	18 lb ft
Oil Pan to Block Bolts	25 N.m	18 lb ft
Oil Pressure Switch	22 N.m	16 lb ft
Oil Pump Gerotor 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
Power Steering Pump Block out Plate Bolts	25 N.m	18 lb ft
Rear Lift Bracket Bolt	25 N.m	18 lb ft
Spark Plug	20 N.m	15 lb ft
Starter Motor to Block Bolt	53 N.m	39 lb ft
Starter Terminal Nut	17 N.m	13 lb ft
Thermostat Housing to Block Bolts	10 N.m	89 lb in
Throttle Body Bolt	10 N.m	89 lb in
Throttle Body Nut	10 N.m	89 lb in
Throttle Body Stud	6 N.m	53 lb in
Timing Chain Adjustable Guide Bolt	10 N.m	89 lb in
Timing Chain Fixed Guide Bolt	10 N.m	89 lb in
Timing Chain Oil Nozzle Bolt	10 N.m	89 lb in
Timing Chain Upper Guide Bolt	10 N.m	89 lb in
Torque Converter Bolts	62 N.m	46 lb ft
Transmission to Engine Bolts	75 N.m	55 lb ft
Vent Tube to Cylinder Head	15 N.m	11 lb ft
Water Pipe Support Bracket Bolt	10 N.m	89 lb in
Water Pump Access Cover Bolt	7 N.m	62 lb in
Water Pump/Balance Shaft Chain Tensioner Bolt	10 N.m	89 lb in
Water Pump Bolts	25 N.m	18 lb ft
Water Pump Drain Plug	20 N.m	15 lb ft
Water Pump Sprocket Bolt	10 N.m	89 lb in

ENGINE MECHANICAL SPECIFICATIONS

Engine Mechanical Specifications

Application	Specification	
	Metric	English
General Data		
• Engine Type	Inline 4 Cylinder	

• Displacement	2.2 L	134 CID
• RPO	L61	
• Liter (VIN)	F	
• Bore	85.992-86.008 mm	3.3855-3.3861 in
• Stroke	94.6 mm	3.727 in
• Compression Ratio	10:01	
Balance Shaft		
• Bearing Clearance	0.030-0.063 mm	0.0012-0.0025 in
• Bearing Diameter - Inside - Carrier	20.050-20.063 mm	0.7894-0.7899 in
• Bearing Diameter - Outside - Carrier	41.975-41.995 mm	1.6526-1.6534 in
• Bearing Journal Diameter	20.000-20.020 mm	0.7874-0.7882 in
• Bushing Clearance	0.033-0.102 mm	0.0013-0.0040 in
• Bushing Diameter - Inside	36.776-36.825 mm	1.4479-1.4498 in
• Bushing Journal Diameter	36.723-36.743 mm	1.4458-1.4466 in
• End Play	0.100-0.300 mm	0.0020-0.0118 in
Block		
• Balance Shaft Bearing Bore Diameter - Carrier	42.000-42.016 mm	1.6535-1.6542 in
• Balance Shaft Bushing Bore Diameter	40.763-40.776 mm	1.6048-1.6054 in
• Crankshaft Main Bearing Bore Diameter	64.068-64.082 mm	2.5224-2.5229 in
• Cylinder Bore Diameter	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		
	0.040-0.144 mm	0.0016-0.0057

• Camshaft End Play		in
• Camshaft Journal Diameter	26.935-26.960 mm	1.0604-1.0614 in
• Camshaft Thrust Surface	21.000-21.052 mm	0.8268-0.8252 in
Connecting Rod		
• Connecting Rod Bearing Clearance	0.029-0.069 mm	0.0011-0.0027 in
• Connecting Rod Bore Diameter - Bearing End	52.118-52.134 mm	2.0519-2.05252 in
• Connecting Rod Bore Diameter - Pin End	20.007-20.021 mm	0.7877-0.7882 in
• Connecting Rod Side Clearance	0.070-0.370 mm	0.0028-0.0146 in
• Connecting Rod Straightness - Bend - Maximum	0.021 mm	0.0083 in
• Connecting Rod Straightness - Twist - Maximum	0.04 mm	0.0157 in
Crankshaft		
• Connecting Rod Journal Diameter	49.000-49.014 mm	1.9291-1.9297 in
• Crankshaft End Play	0.050-0.380 mm	0.0012-0.0150 in
• Crankshaft Main Bearing Clearance	0.031-0.067 mm	0.0012-0.0026 in
• Crankshaft Main Journal Diameter	55.994-56.008 mm	2.2045-2.2050 in
Cylinder Head		
• Surface Flatness - Block Deck - 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
Lubrication System		
• Oil Pressure - Minimum - @1000 RPM	344.75-551.60 kPa	50-80 psi
• Oil Capacity	4.8L	5.0 quarts
Piston Rings		
• Piston Ring End Gap - First Compression Ring	0.20-0.40 mm	0.008-0.016 in

• Piston Ring End Gap - Second Compression Ring	0.35-0.55 mm	0.014-0.022 in
• Piston Ring End Gap - Oil Control Ring - Rails	0.25-0.76 mm	0.010-0.030 in
• Piston Ring to Groove Clearance - First Compression Ring	0.04-0.08 mm	0.0015-0.0031 in
• Piston Ring to Groove Clearance - Second Compression Ring	0.030-0.069 mm	0.0012-0.0027 in
• Piston Ring to Groove Clearance - Oil Control Ring	0.090-0.106 mm	0.0035-0.0042 in
• Piston Ring Thickness - First Compression Ring	1.170-1.190 mm	0.0461-0.0469 in
• Piston Ring Thickness - Second Compression Ring	1.471-1.490 mm	0.0579-0.0587 in
• Piston Ring Thickness - Oil Control Ring - Rail - Maximum	0.43 mm	0.0169 in
• Piston Ring Thickness - Oil Control Ring - Spacer	1.574-1.651 mm	0.0620-0.0650 in
Pistons and Pins		
• 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 Grove Width - Top	1.23-1.25 mm	0.0484-0.0492 in
• Piston - Piston Ring Grove Width - Second	1.52-1.54 mm	0.0598-0.0606 in
• Piston - Piston Ring Grove Width - Oil Control	2.52-2.54 mm	0.0992-0.1000 in
• Piston - Piston To Bore Clearance	0.010-0.041 mm	0.0004-0.0016 in
• Pin - Piston Pin Clearance to Connecting Rod Bore	0.007-0.026 mm	0.0003-0.0010 in
• Pin - Piston Pin Clearance to Piston Pin Bore	0.002-0.012 mm	0.0001-0.0005 in
• Pin - Piston Pin Diameter	19.995-20.000 mm	0.7872-0.7874 in
• Pin - Piston Pin End Play	0.19-1.16 mm	0.0075-0.0461 in
Valve System		
• Valves - Valve Face Runout - Maximum	0.04 mm	0.0016 in
• Valves - Valve Seat Runout - Maximum	0.05 mm	0.0020 in
• Valves - Valve Stem Diameter - Intake	5.955-5.970 mm	0.2344-0.2355 in
		0.2337-0.2343

• Valves - Valve Stem Diameter - Exhaust	5.935-5.950 mm	in
• Valves - Valve Stem to Guide Clearance - Intake	0.030-0.057 mm	0.0012-0.0022 in
• Valves - Valve Stem to Guide Clearance - Exhaust	0.050-0.077 mm	0.0020-0.0026 in
• Valve Lifters - Valve Lifter Diameter - Stationary Lash Adjuster	11.986-12.000 mm	0.0005-0.0020 in
• Valve Lifters - Valve Lifter-to-Bore Clearance - Stationary Lash Adjuster	0.013-0.051 mm	3.2210-3.2299 in
• Valve Springs - Valve Spring Load - Closed - @22.5 mm	245.0-271.0 N. - Eng Spec.	
• Valve Springs - Valve Spring Load - Open - @32.5 mm	525.0-575.0 N. - Eng Spec.	

SEALERS, ADHESIVES, AND LUBRICANTS

Sealers, Adhesives, and Lubricants

Application	Type of Material	Part Number
# 6 Intake Rear Camshaft Cap	Sealant	Permatex(R) Anaerobic Gasket Maker 51813
Cam Lobes	Lubricant	Engine Oil Supplement
Crank Sensor O-ring	Engine Oil	5 W 30 or equivalent
Cylinder Head Plugs	Threadlocker	21485277
Dipstick Tube O-rings	Lubricant	Engine Oil Supplement
Engine Block Threaded Plugs	Sealant	21485278
Engine Block To Bed Plate	Sealant	21019581
Engine Oil	Engine Oil	5 W 30 or equivalent
Engine Oil Level Indicator Tube O-ring	Lubricant	Engine Oil Supplement
Fuel Injector O-rings	Engine Oil	5 W 30 or equivalent
Fuel Injector Tip Insulators	Engine Oil	5 W 30 or equivalent
Intake and Exhaust Valve Stems	Lubricant	Engine Oil Supplement
Oil Filter Cap (Threads and O-ring Lead-in Chamfers)	Engine Oil	5 W 30 or equivalent
Oil Pan to Bedplate Joint	Sealant	21019581
Oil Pump (Pump Elements)	Engine Oil	5 W 30 or equivalent
Oxygen Sensor Threads	Antiseize	12397953
Stationary Hydraulic Lash Adjusters	Lubricant	Engine Oil Supplement
Timing Chain Guide Bolt Access Hole Plug	Threadlocker	21485277
Valve Rocker Arm / Valve Tip	Lubricant	Engine Oil Supplement
Water Feed Tube O-rings	Lubricant	Antifreeze
Water Pump Drain Plug	Sealant	21485278

THREAD REPAIR SPECIFICATIONS

Engine Block - Front View

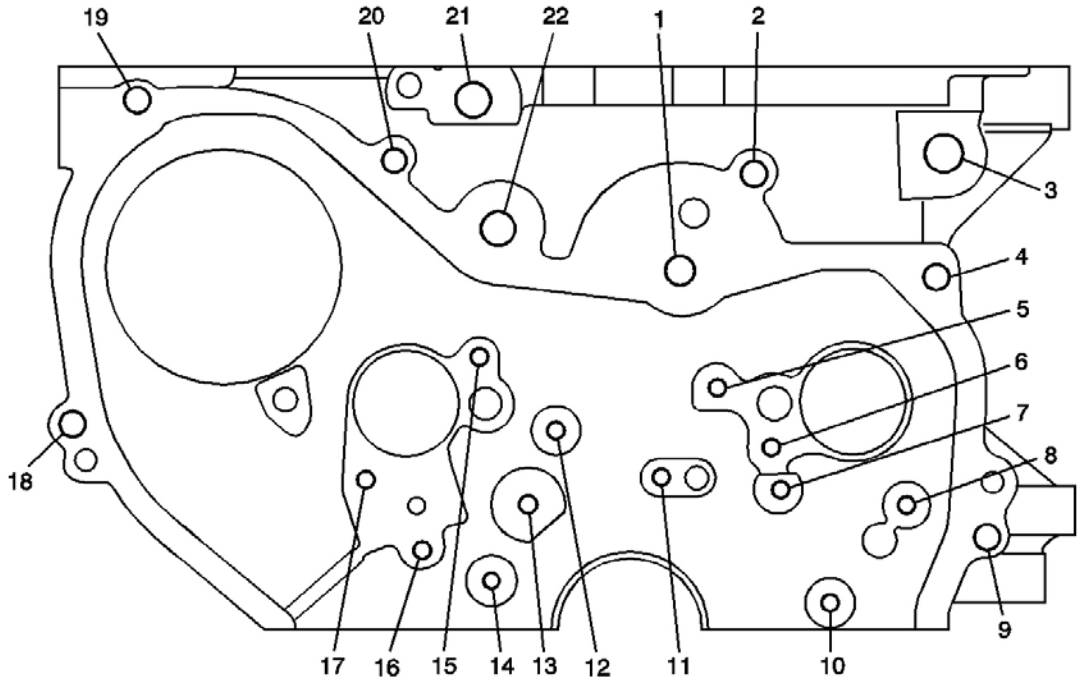


Fig. 1: Engine Block Front View
Courtesy of GENERAL MOTORS CORP.

Engine Block - Front View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
J 42385-							MM	(IN)	MM	(IN)
1	M10 x 1.5	215	211	212	213	214	24.5	0.96	19.5	0.77
2	M8 x 1.25	210	206	207	208	209	23.5	0.93	18.5	0.73
3	M12 x 1.75	855	856	857	858	859	33.5	1.32	26.5	1.04
4	M8 x 1.25	210	206	207	208	209	23.5	0.93	18.5	0.73
5	M6 x 1	205	201	202	203	204	20	0.787	16	0.63
6	M6 x 1	205	201	202	203	204	20	0.787	16	0.63
7	M6 x 1	205	201	202	203	204	20	0.787	16	0.63
8	M6 x 1	205	201	202	203	204	20	0.787	16	0.63

9	M8 x 1.25	210	206	207	208	209	25.5	1.00	THRU	
10	M6 x 1	205	201	202	203	204	20	0.787	16	0.63
11	M6 x 1	205	201	202	203	204	20	0.787	16	0.63
12	M6 x 1	205	201	202	203	204	20	0.787	16	0.63
13	M6 x 1	205	201	202	203	204	20	0.787	16	0.63
14	M6 x 1	205	201	202	203	204	20	0.787	16	0.63
15	M6 x 1	205	201	202	203	204	20	0.787	16	0.63
16	M6 x 1	205	201	202	203	204	20	0.787	16	0.63
17	M6 x 1	205	201	202	203	204	20	0.787	16	0.63
18	M8 x 1.25	210	206	207	208	209	23.5	0.93	18.5	0.73
19	M8 x 1.25	210	206	207	208	209	55	2.17	THRU	
20	M8 x 1.25	210	206	207	208	209	23.5	0.93	18.5	0.73
21	M12 x 1.75	855	856	857	858	859	33.5	1.32	26.5	1.04
22	M12 x 1.75	855	856	857	858	859	33.5	1.32	26.5	1.04

Engine Block - Back View

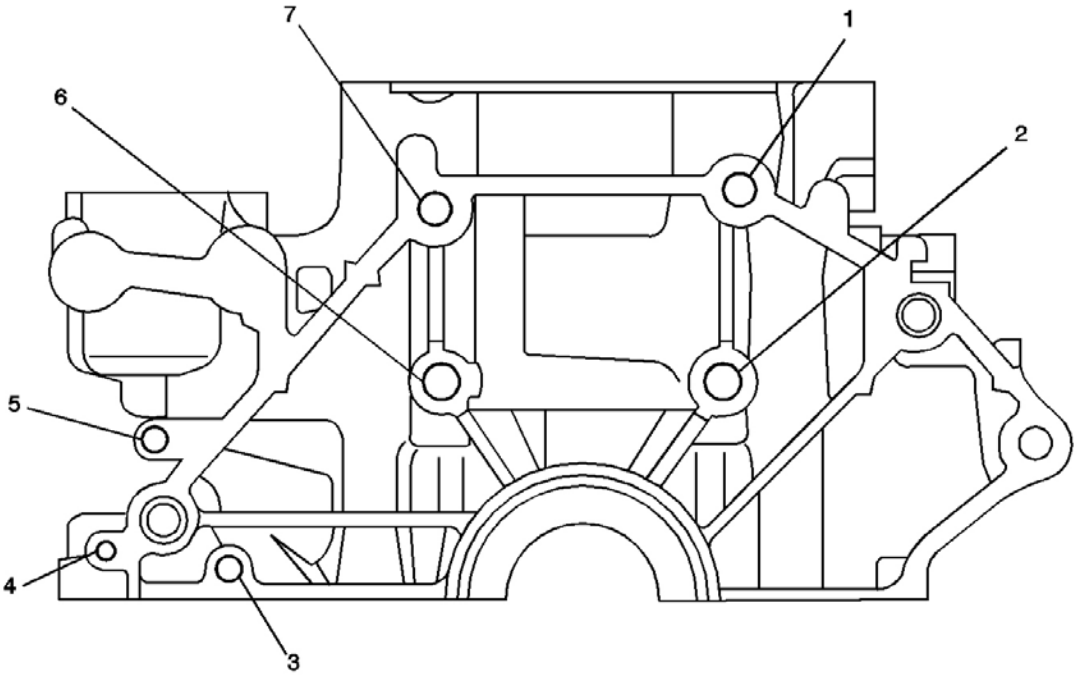


Fig. 2: Engine Block Back View
Courtesy of GENERAL MOTORS CORP.

Engine Block - Back View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
J 42385-							MM	(IN)	MM	(IN)
1	M12 x 1.75	855	856	857	858	859	39	1.535	33.5	1.32
2	M16 x 1.5	860	861	862	863	864	21	0.827	15	0.59
3	M10 x 1.5	215	211	212	213	214	29	1.161	THRU	
4	M8 x 1.25	210	206	207	208	209	18	0.709	THRU	
5	M8 x 1.25	854 No Flange	206	207	208	209	18	0.709	THRU	
6	M16 x 1.5	860	861	862	863	864	21	0.827	15	0.59
7	M12 x 1.75	855	856	857	858	859	39	1.535	33.5	1.32

Engine Block - Left Side View

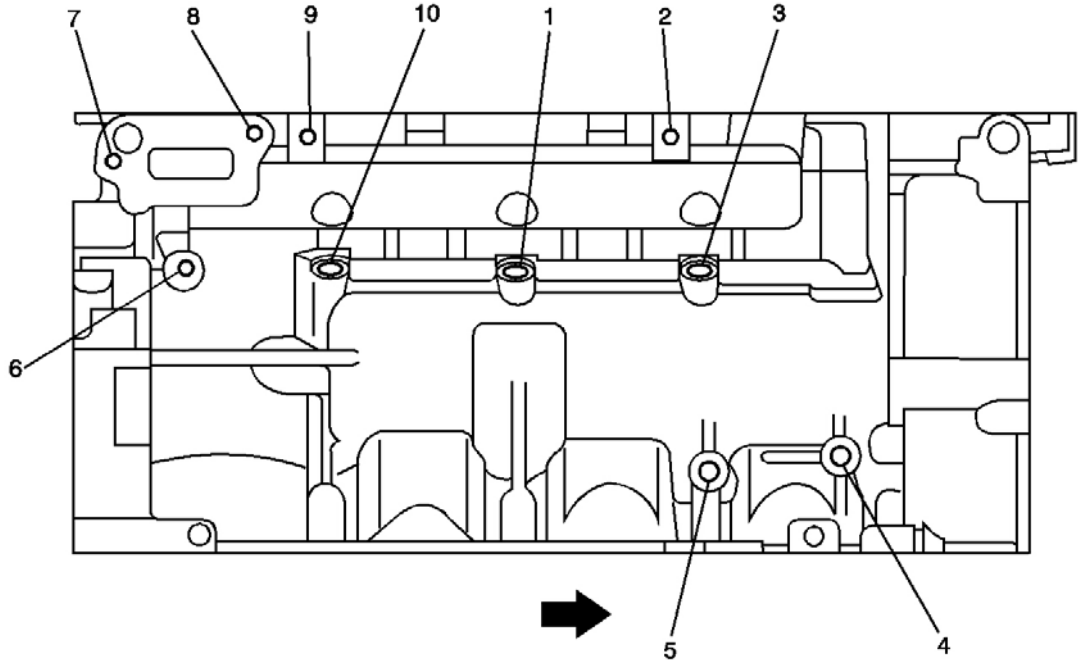


Fig. 3: Engine Block Left Side View
Courtesy of GENERAL MOTORS CORP.

Engine Block - Left Side View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
J 42385-							MM	(IN)	MM	(IN)
1	M12 x 1.75	865	856	857	858	859	19.50	0.768	12.5	0.49
2	M6 x 1.0	205	201	202	203	204	-	-	-	-
3	M12 x 1.75	865	856	857	858	859	19.50	0.768	12.5	0.49
4	M10 x 1.5	215	211	212	213	214	23.50	0.925	18.5	0.73
5	M10 x 1.5	215	211	212	213	214	23.50	0.925	18.5	0.73
6	M6 x 1.0	205	201	202	203	204	20.50	0.807	16.0	0.63
7	M6 x 1.0	205	201	202	203	204	20.50	0.807	16.0	0.63
8	M6 x 1.0	205	201	202	203	204	20.50	0.807	16.0	0.63
9	M6 x 1.0	205	201	202	203	204	-	-	-	-
10	M12 x 1.75	865	856	857	858	859	19.50	0.768	12.5	0.49

Engine Block - Bottom View

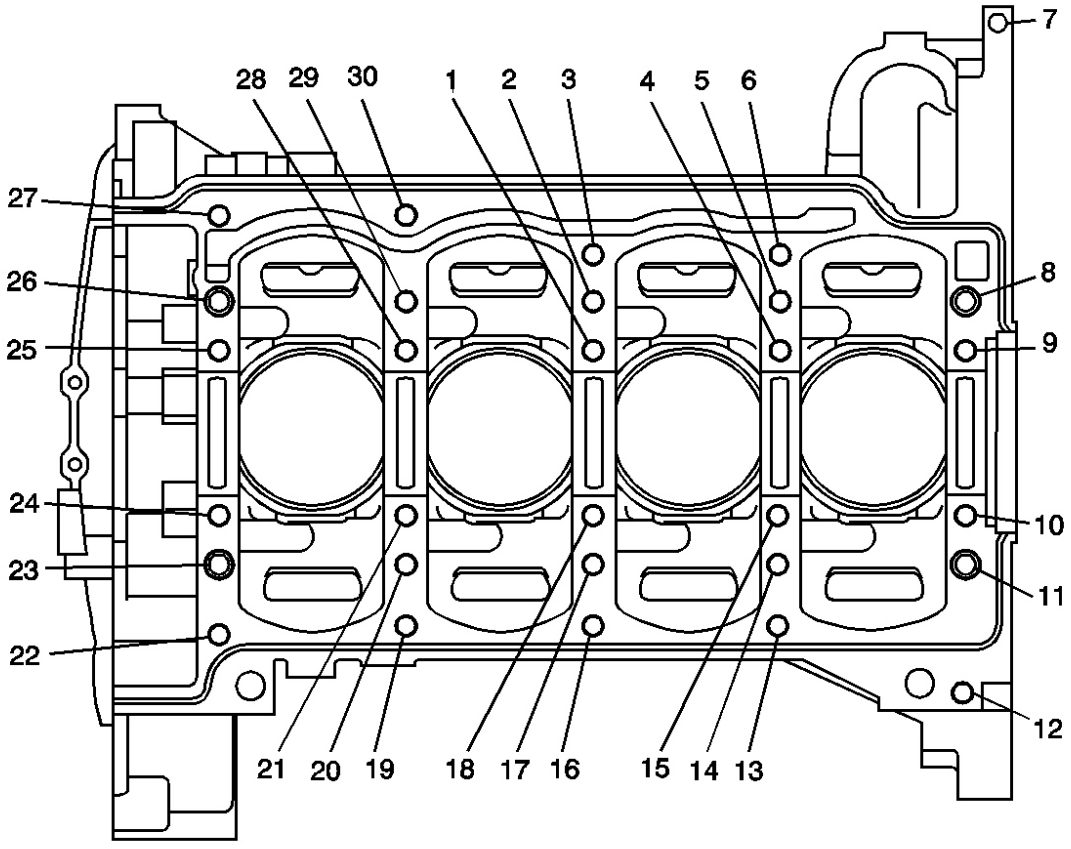


Fig. 4: Engine Block Bottom View
Courtesy of GENERAL MOTORS CORP.

Engine Block - Bottom View

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

	1.5									
6	M8 x 1.25	210	206	207	208	209	28	1.102	22	0.87
7	M8 x 1.25	210	206	207	208	209	28	1.102	22	0.87
8	M10 x 1.5	514	511	N/A	512	513	60	2.362	53.5	2.11
9	M10 x 1.5	514	511	N/A	512	513	60	2.362	53.5	2.11
10	M10 x 1.5	514	511	N/A	512	513	60	2.362	53.5	2.11
11	M10 x 1.5	514	511	N/A	512	513	60	2.362	53.5	2.11
12	M8 x 1.25	210	206	207	208	209	28	1.102	22	0.87
13	M8 x 1.25	210	206	207	208	209	28	1.102	22	0.87
14	M10 x 1.5	514	511	N/A	512	513	60	2.362	53.5	2.11
15	M10 x 1.5	514	511	N/A	512	513	60	2.362	53.5	2.11
16	M8 x 1.25	210	206	207	208	209	28	1.102	22	0.87
17	M10 x 1.5	514	511	N/A	512	513	60	2.362	53.5	2.11
18	M10 x 1.5	514	511	N/A	512	513	60	2.362	53.5	2.11
19	M8 x 1.25	210	206	207	208	209	28	1.102	22	0.87
20	M10 x 1.5	514	511	N/A	512	513	60	2.362	53.5	2.11
21	M10 x 1.5	514	511	N/A	512	513	60	2.362	53.5	2.11
22	M8 x 1.25	210	206	207	208	209	28	1.102	22	0.87
23	M10 x 1.5	514	511	N/A	512	513	60	2.362	53.5	2.11
24	M10 x 1.5	514	511	N/A	512	513	60	2.362	53.5	2.11
25	M10 x 1.5	514	511	N/A	512	513	60	2.362	53.5	2.11
26	M10 x 1.5	514	511	N/A	512	513	60	2.362	53.5	2.11
	M8 x									

27	1.25	210	206	207	208	209	28	1.102	22	0.87
28	M10 x 1.5	514	511	N/A	512	513	60	2.362	53.5	2.11
29	M10 x 1.5	514	511	N/A	512	513	60	2.362	53.5	2.11
30	M8 x 1.25	210	206	207	208	209	28	1.102	22	0.87

Engine Block - Right Side View

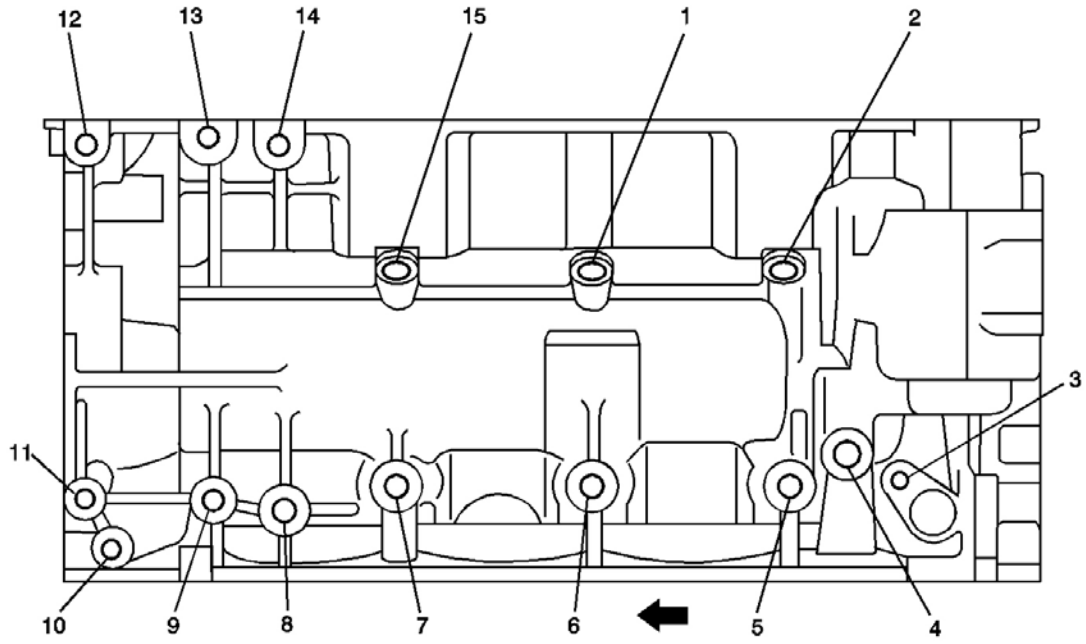


Fig. 5: Engine Block Right Side View
Courtesy of GENERAL MOTORS CORP.

Engine Block - Right Side View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
J 42385-							MM	(IN)	MM	(IN)
1	M12 x 1.75	865	856	857	858	859	19.50	0.778	12.5	0.49
2	M12 x 1.75	865	856	857	858	859	19.50	0.778	12.5	0.49
3	M6 x 1.0	205	201	202	203	204	20.50	0.807	16.5	.065
4	M12 x 1.75	865	856	857	858	859	15.50	0.610	12.5	0.49

5	M8 x 1.25	210	206	207	208	209	23.50	0.925	18.0	0.71
6	M8 x 1.25	210	206	207	208	209	23.50	0.925	18.0	0.71
7	M8 x 1.25	210	206	207	208	209	23.50	0.925	18.0	0.71
8	M12 x 1.75	855	856	857	858	859	33.50	1.319	26.5	1.04
9	M8 x 1.25	210	206	207	208	209	30.50	1.201	22.5	0.89
10	M8 x 1.25	210	206	207	208	209	30.50	1.201	22.5	0.89
11	M8 x 1.25	210	206	207	208	209	30.50	1.201	22.5	0.89
12	M8 x 1.25	210	206	207	208	209	30.50	1.201	22.5	0.89
13	M8 x 1.25	210	206	207	208	209	30.50	1.201	22.5	0.89
14	M12 x 1.75	855	856	857	858	859	33.50	1.319	26.5	1.04
15	M12 x 1.75	865	856	857	858	859	19.50	0.778	12.5	0.49

Engine Block - Top View

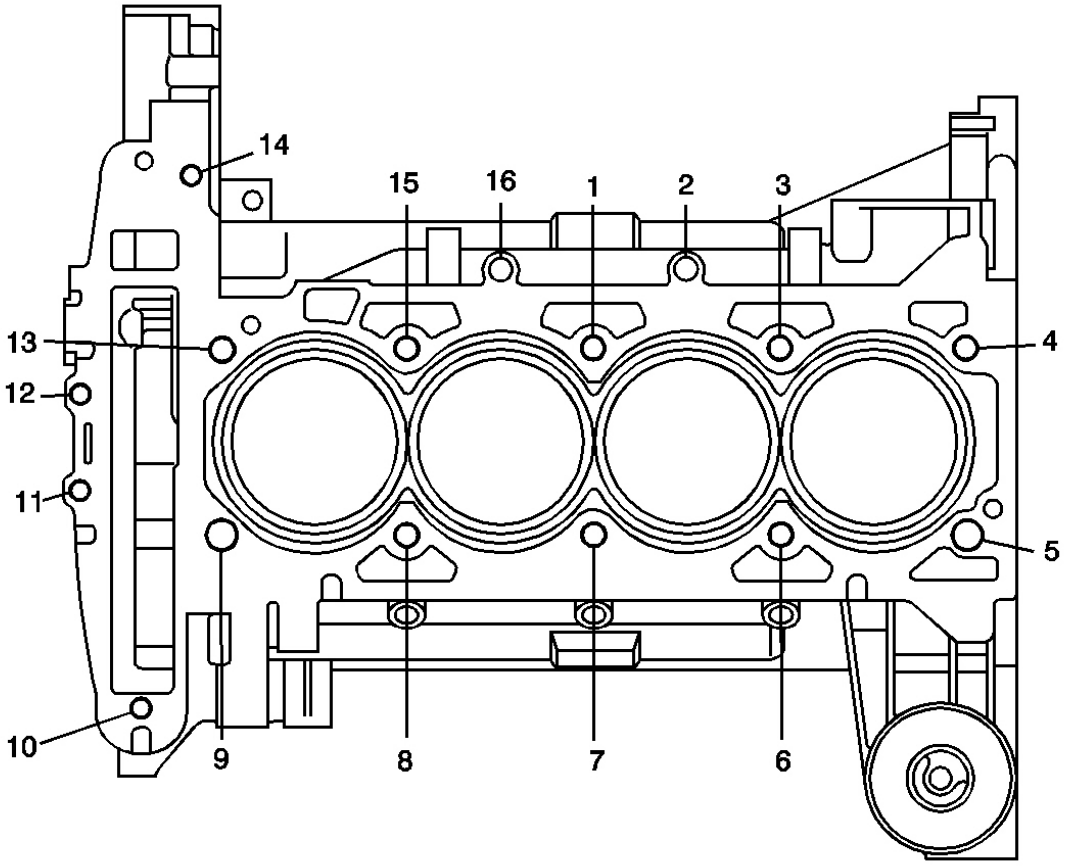


Fig. 6: Engine Block Top View
Courtesy of GENERAL MOTORS CORP.

Engine Block - Top View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
J 42385-							MM	(IN)	MM	(IN)
1	M11 x 1.5	507	504	N/A	505	506	113.30	4.461	107.3	4.22
2	M12 x 1.75	865	856	857	858	859	13.50	0.531	12.5	0.49
3	M11 x 1.5	507	504	N/A	505	506	113.30	4.461	107.3	4.22
4	M11 x 1.5	507	504	N/A	505	506	113.30	4.461	107.3	4.22
5	M11 x 1.5	507	504	N/A	505	506	113.30	4.461	107.3	4.22

6	M11 x 1.5	507	504	N/A	505	506	113.30	4.461	107.3	4.22
7	M11 x 1.5	507	504	N/A	505	506	113.30	4.461	107.3	4.22
8	M11 x 1.5	507	504	N/A	505	506	113.30	4.461	107.3	4.22
9	M11 x 1.5	507	504	N/A	505	506	113.30	4.461	107.3	4.22
10	M8 x 1.25	210	206	207	208	209	23.50	0.925	18.5	0.73
11	M8 x 1.25	210	206	207	208	209	23.50	0.925	18.5	0.73
12	M8 x 1.25	210	206	207	208	209	23.50	0.925	18.5	0.73
13	M11 x 1.5	507	504	N/A	505	506	113.30	4.461	107.3	4.22
14	M8 x 1.25	210	206	207	208	209	23.50	0.925	18.5	0.73
15	M11 x 1.5	507	504	N/A	505	506	113.30	4.461	107.3	4.22
16	M12 x 1.75	865	856	857	858	859	13.50	0.531	12.5	0.49

Lower Crankcase - Front View

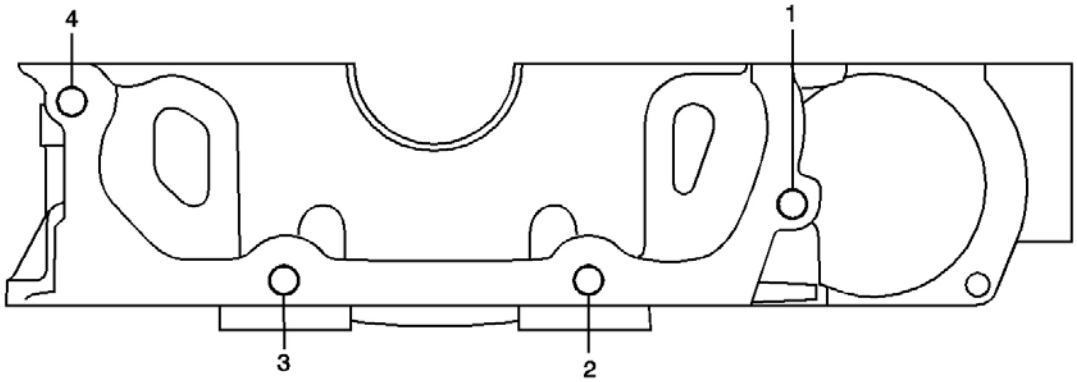


Fig. 7: Lower Crankcase Front View
Courtesy of GENERAL MOTORS CORP.

Lower Crankcase - Front View

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

J 42385-							MM	(IN)	MM	(IN)
1	M8 x 1.25	210	206	207	208	209	23.50	0.925	18.5	0.73
2	M8 x 1.25	210	206	207	208	209	30.50	1.201	25.5	1.00
3	M8 x 1.25	210	206	207	208	209	30.50	1.201	25.5	1.00
4	M8 x 1.25	210	206	207	208	209	23.50	0.925	18.5	0.73

Lower Crankcase - Back View

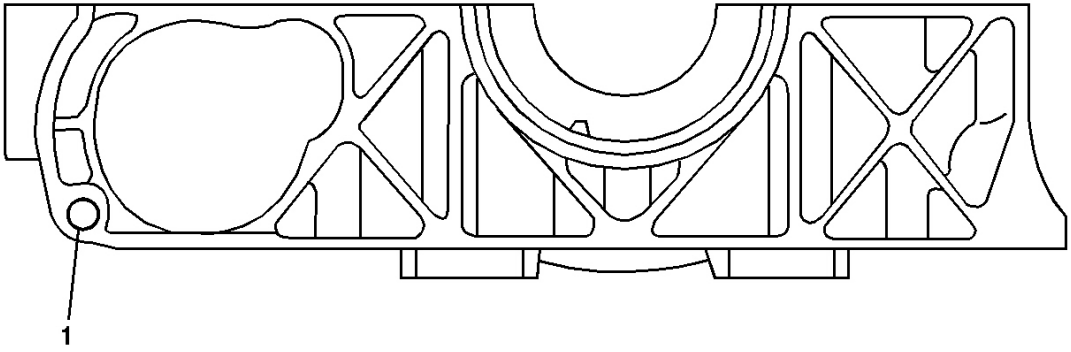


Fig. 8: Lower Crankcase Back View
Courtesy of GENERAL MOTORS CORP.

Lower Crankcase - Back View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
J 42385-							MM	(IN)	MM	(IN)
1	M10 x 1.5	215	211	212	213	214	29.50	1.161	THRU	

Lower Crankcase - Bottom View

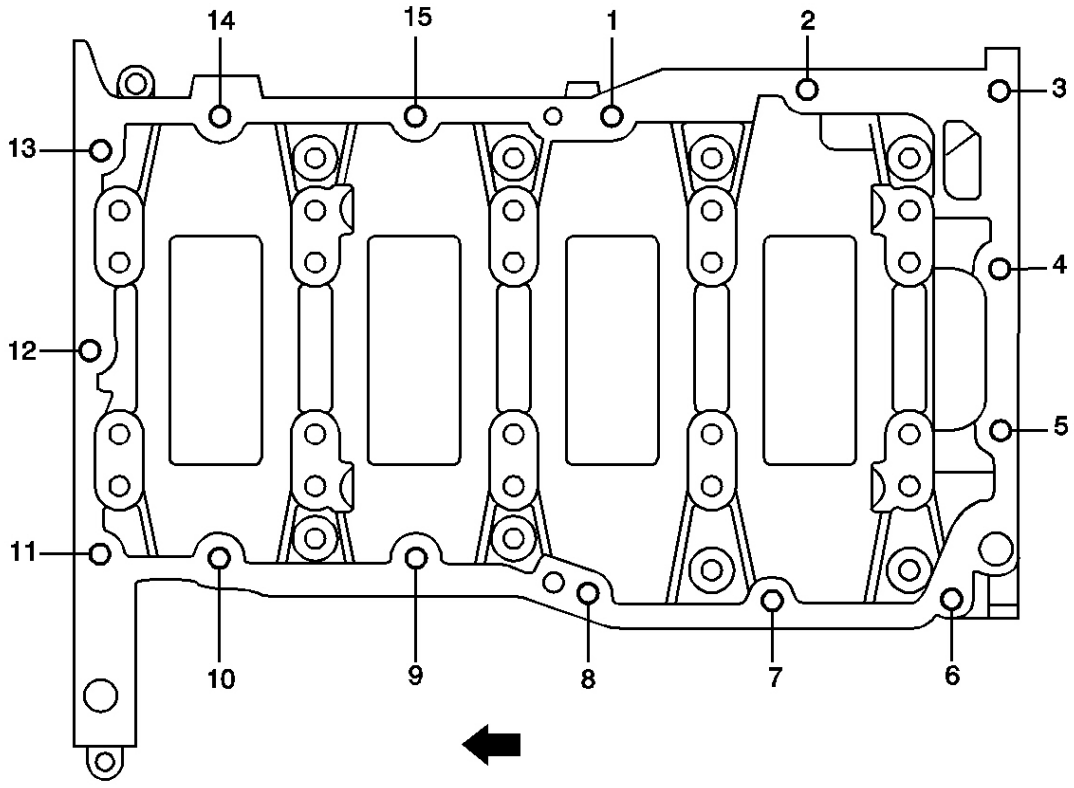


Fig. 9: Lower Crankcase Bottom View
Courtesy of GENERAL MOTORS CORP.

Lower Crankcase - Bottom View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
J 42385-							MM	(IN)	MM	(IN)
1	M8 x 1.25	210	206	207	208	209	23.50	0.925	18.5	0.73
2	M8 x 1.25	210	206	207	208	209	23.50	0.925	18.5	0.73
3	M8 x 1.25	210	206	207	208	209	23.50	0.925	18.5	0.73
4	M8 x 1.25	210	206	207	208	209	23.50	0.925	18.5	0.73
5	M8 x 1.25	210	206	207	208	209	23.50	0.925	18.5	0.73
6	M8 x 1.25	210	206	207	208	209	23.50	0.925	18.5	0.73
	M8 x									

7	1.25	210	206	207	208	209	23.50	0.925	18.5	0.73
8	M8 x 1.25	210	206	207	208	209	23.50	0.925	18.5	0.73
9	M8 x 1.25	210	206	207	208	209	23.50	0.925	18.5	0.73
10	M8 x 1.25	210	206	207	208	209	23.50	0.925	18.5	0.73
11	M8 x 1.25	210	206	207	208	209	23.50	0.925	18.5	0.73
12	M8 x 1.25	210	206	207	208	209	23.50	0.925	18.5	0.73
13	M8 x 1.25	210	206	207	208	209	23.50	0.925	18.5	0.73
14	M8 x 1.25	210	206	207	208	209	23.50	0.925	18.5	0.73
15	M8 x 1.25	210	206	207	208	209	23.50	0.925	18.5	0.73

Lower Crankcase - Left View

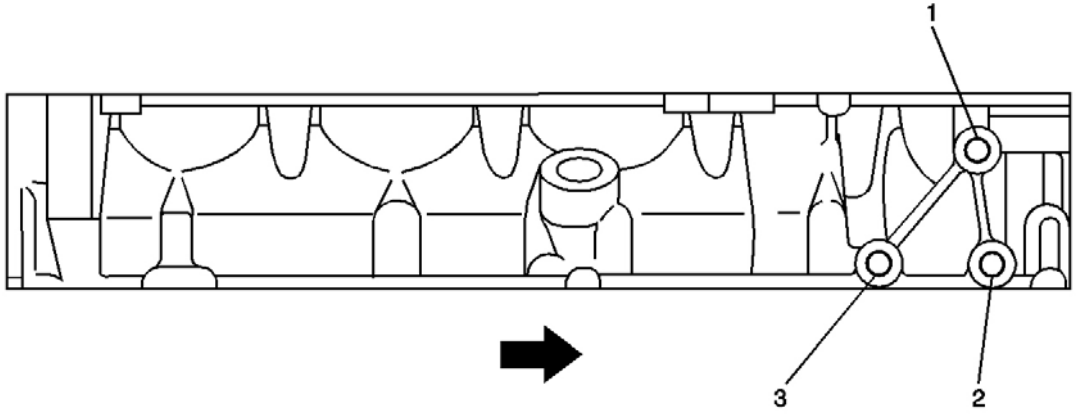


Fig. 10: Lower Crankcase Left View
Courtesy of GENERAL MOTORS CORP.

Lower Crankcase - Left View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
J 42385-							MM	(IN)	MM	(IN)
1	M10 x 1.5	215	211	212	213	214	28.50	1.122	22.5	0.89
	M10 x									

2	1.5	215	211	212	213	214	28.50	1.122	22.5	0.89
3	M10 x 1.5	215	211	212	213	214	28.50	1.122	22.5	0.89

Lower Crankcase - Right View

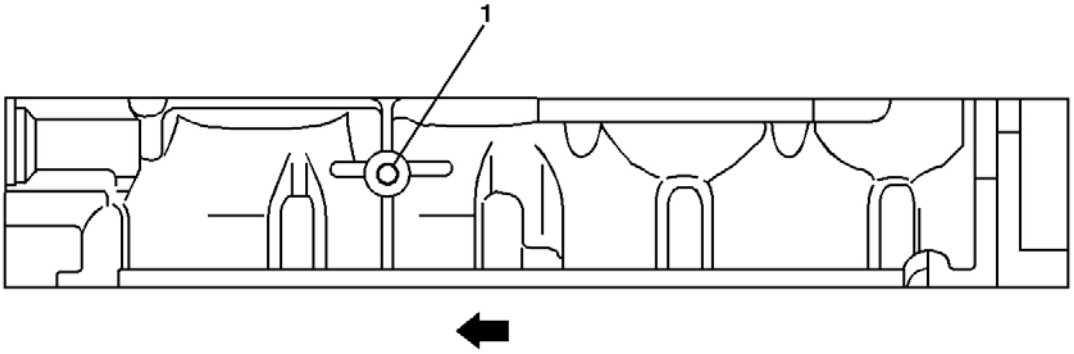


Fig. 11: Lower Crankcase Right View
Courtesy of GENERAL MOTORS CORP.

Lower Crankcase - Right View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
J 42385-							MM	(IN)	MM	(IN)
1	M8 x 1.25	210	211	212	213	214	30.50	1.201	22.5	0.886

Cylinder Head - Top View

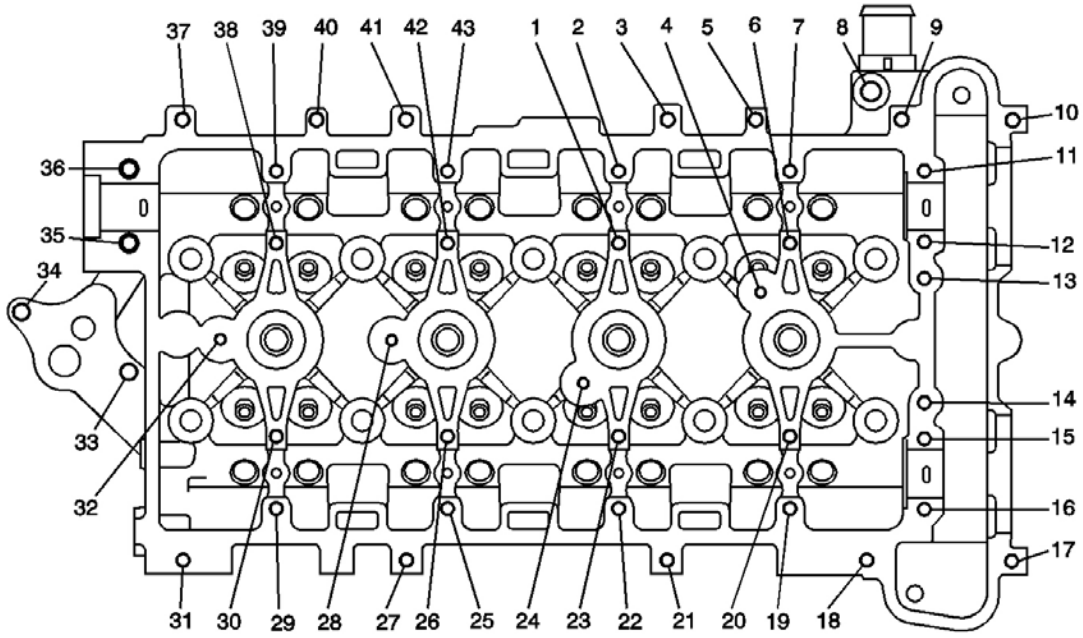


Fig. 12: Cylinder Head Top View
Courtesy of GENERAL MOTORS CORP.

Cylinder Head - Top View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
J 42385-							MM	(IN)	MM	(IN)
1	M6 x 1.0	205	852	N/A	203	204	24	0.945	20	0.787
2	M6 x 1.0	205	852	N/A	203	204	24	0.945	20	0.787
3	M6 x 1.0	205	201	202	203	204	20	0.787	16	0.630
4	M6 x 1.0	205	201	202	203	204	20	0.787	16	0.630
5	M6 x 1.0	205	201	202	203	204	20	0.787	16	0.630
6	M6 x 1.0	205	852	N/A	203	204	24	0.945	20	0.787
7	M6 x 1.0	205	852	N/A	203	204	24	0.945	20	0.787
8	M8 x 1.25	854 No Flange	206	207	208	209	THRU		THRU	
9	M6 x 1.0	205	201	202	203	204	20	0.787	16	0.630
10	M6 x 1.0	205	201	202	203	204	20	0.787	16	0.630
11	M6 x 1.0	205	852	N/A	203	204	24	0.945	20	0.787
12	M6 x 1.0	205	852	N/A	203	204	24	0.945	20	0.787
13	M6 x 1.0	205	201	202	203	204	16	0.630	THRU	
14	M6 x 1.0	205	201	202	203	204	16	0.630	THRU	

15	M6 x 1.0	205	852	N/A	203	204	24	0.945	20	0.787
16	M6 x 1.0	205	852	N/A	203	204	24	0.945	20	0.787
17	M6 x 1.0	205	201	202	203	204	20	0.787	16	0.630
18	M6 x 1.0	205	201	202	203	204	20	0.787	16	0.630
19	M6 x 1.0	205	852	N/A	203	204	24	0.945	20	0.787
20	M6 x 1.0	205	852	N/A	203	204	24	0.945	20	0.787
21	M6 x 1.0	205	201	202	203	204	20	0.787	16	0.630
22	M6 x 1.0	205	852	N/A	203	204	24	0.945	20	0.787
23	M6 x 1.0	205	852	N/A	203	204	24	0.945	20	0.787
24	M6 x 1.0	205	201	202	203	204	20	0.787	16	0.630
25	M6 x 1.0	205	852	N/A	203	204	24	0.945	20	0.787
26	M6 x 1.0	205	852	N/A	203	204	24	0.945	20	0.787
27	M6 x 1.0	205	201	202	203	204	20	0.787	16	0.630
28	M6 x 1.0	205	201	202	203	204	20	0.787	16	0.630
29	M6 x 1.0	205	852	N/A	203	204	24	0.945	20	0.787
30	M6 x 1.0	205	852	N/A	203	204	24	0.945	20	0.787
31	M6 x 1.0	205	201	202	203	204	20	0.787	16	0.630
32	M6 x 1.0	205	201	202	203	204	20	0.787	16	0.630
33	M8 x 1.25	210	206	207	208	209	25	0.984	20	0.787
34	M8 x 1.25	210	206	207	208	209	25	0.984	20	0.787
35	M8 x 1.25	854 No Flange	853	N/A	208	209	25	0.984	20	0.787
36	M8 x 1.25	854 No Flange	853	N/A	208	209	25	0.984	20	0.787
37	M6 x 1.0	210	206	207	208	209	20	0.787	16	0.630
38	M6 x 1.0	205	852	N/A	203	204	24	0.945	20	0.787
39	M6 x 1.0	205	852	N/A	203	204	24	0.945	20	0.787
40	M6 x 1.0	210	206	207	208	209	20	0.787	16	0.630
41	M6 x 1.0	210	206	207	208	209	20	0.787	16	0.630
42	M6 x 1.0	205	852	N/A	203	204	24	0.945	20	0.787
43	M6 x 1.0	205	852	N/A	203	204	24	0.945	20	0.787

Cylinder Head - Intake Manifold Deck View

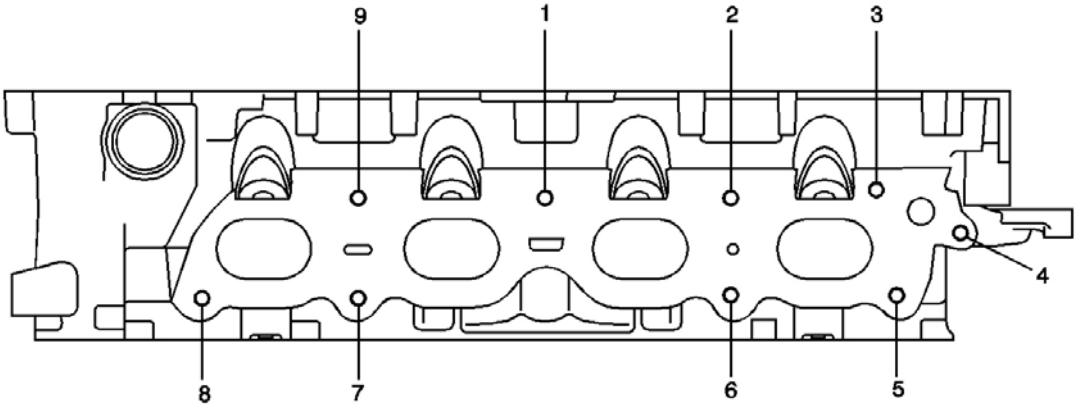


Fig. 13: Cylinder Head Intake Manifold Deck View
Courtesy of GENERAL MOTORS CORP.

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-							MM	(IN)	MM	(IN)
1	M6 x 1.0	205	201	202	203	204	20	0.787	16	0.630
2	M6 x 1.0	205	201	202	203	204	20	0.787	16	0.630
3	M6 x 1.0	205	201	202	203	204	20	0.787	16	0.630
4	M6 x 1.0	205	201	202	203	204	20	0.787	16	0.630
5	M6 x 1.0	205	201	202	203	204	20	0.787	16	0.630
6	M6 x 1.0	205	201	202	203	204	20	0.787	16	0.630
7	M6 x 1.0	205	201	202	203	204	20	0.787	16	0.630
8	M6 x 1.0	205	201	202	203	204	20	0.787	16	0.630
9	M6 x 1.0	205	201	202	203	204	20	0.787	16	0.630

Cylinder Head - Exhaust Manifold Deck View

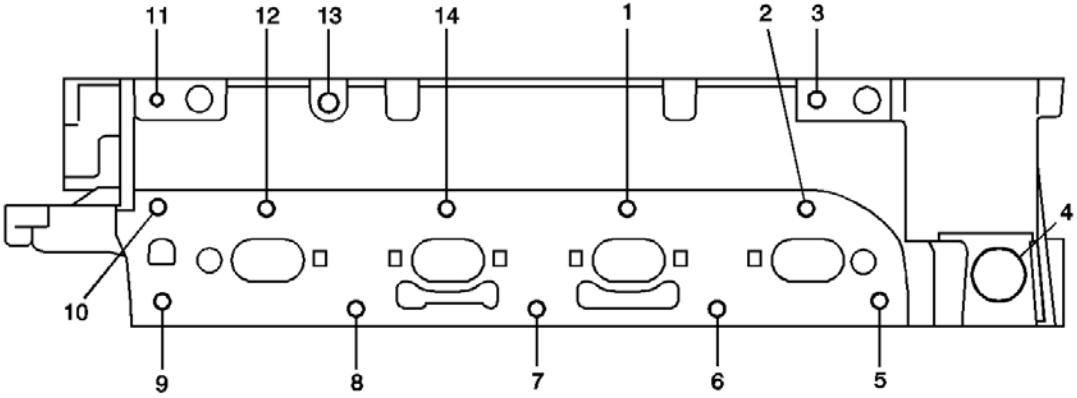


Fig. 14: Cylinder Head Exhaust Manifold Deck View
Courtesy of GENERAL MOTORS CORP.

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-							MM	(IN)	MM	(IN)
1	M8 x 1.25	210	206	207	208	209	25	0.984	20	0.78
2	M8 x 1.25	210	206	207	208	209	25	0.984	20	0.78
3	M8 x 1.25	210	206	207	208	209	25	0.984	20	0.78
4	M27 x 2.0	N/A	N/A	N/A	N/A	N/A	THRU		12	0.78
5	M8 x 1.25	210	206	207	208	209	25	0.984	20	0.78
6	M8 x 1.25	210	206	207	208	209	25	0.984	20	0.78
7	M8 x 1.25	210	206	207	208	209	25	0.984	20	0.78
8	M8 x 1.25	210	206	207	208	209	25	0.984	20	0.78
9	M8 x 1.25	210	206	207	208	209	25	0.984	20	0.78
10	M8 x 1.25	210	206	207	208	209	25	0.984	20	0.78
11	M6 x 1.0	205	201	202	203	204	20	0.78	16	0.630
12	M8 x 1.25	210	206	207	208	209	25	0.984	20	0.78

13	M8 x 1.25	210	206	207	208	209	25	0.984	20	0.78
14	M8 x 1.25	210	206	207	208	209	25	0.984	20	0.78

Cylinder Head - Front View

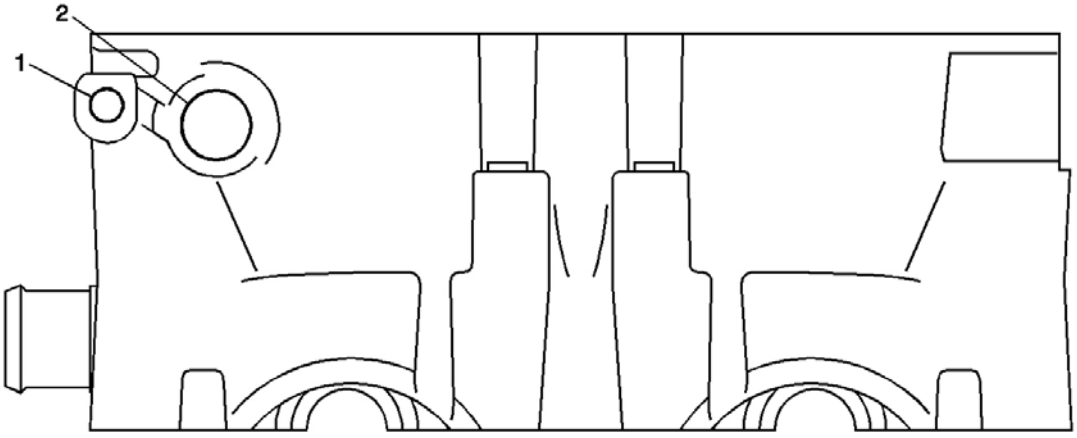


Fig. 15: Cylinder Head Front View
Courtesy of GENERAL MOTORS CORP.

Cylinder Head - Front View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
J 42385-							MM	(IN)	MM	(IN)
1	M8 x 1.25	210	206	207	208	209	25	0.984	20	0.787
2	M6 x 1.0	205	201	202	203	204	20	0.787	16	0.630

Cylinder Head - Back View

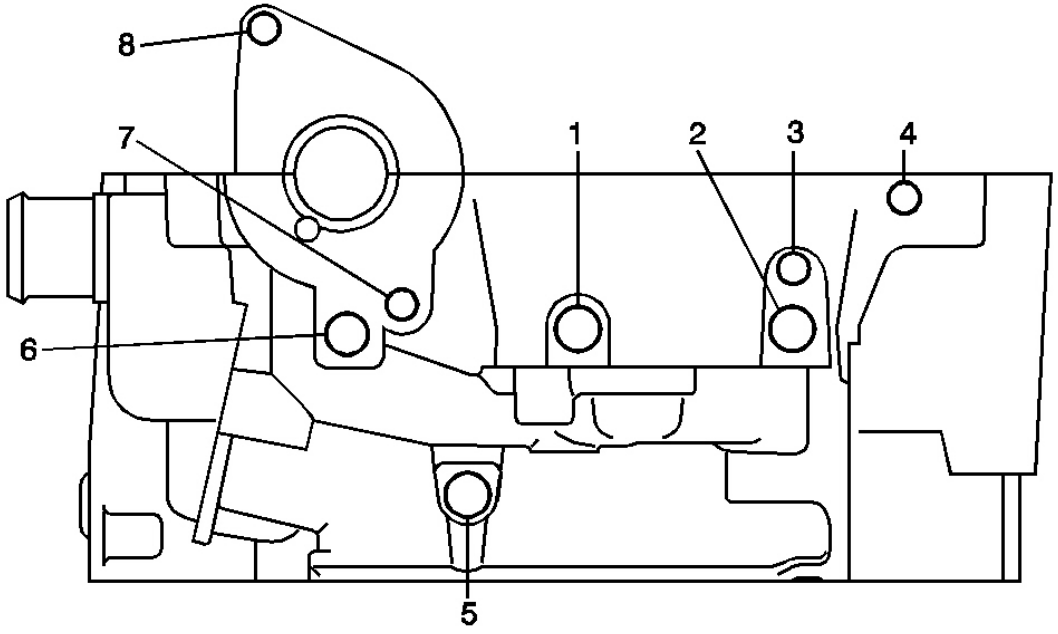


Fig. 16: Cylinder Head Back View
Courtesy of GENERAL MOTORS CORP.

Cylinder Head - Back View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
J 42385-							MM	(IN)	MM	(IN)
1	M12 x 1.75	865	856	857	858	859	17	0.670	14	0.551
2	M12 x 1.75	865	856	857	858	859	17	0.670	14	0.551
3	M8 x 1.25	210	206	207	208	209	25	0.984	20	0.787
4	M8 x 1.25	210	206	207	208	209	25	0.984	20	0.787
5	M12 x 1.75	865	856	857	858	859	17	0.670	14	0.551
6	M12 x 1.75	865	856	857	858	859	17	0.670	14	0.551
7	M8 x 1.25	210	206	207	208	209	25	0.984	THRU	
8	M8 x 1.25	854 No	206	207	208	209	25	0.984	THRU	

		Flange							

Note: 1, 2, 5, 6 holes are oil passages.

Cylinder Head - Bottom View

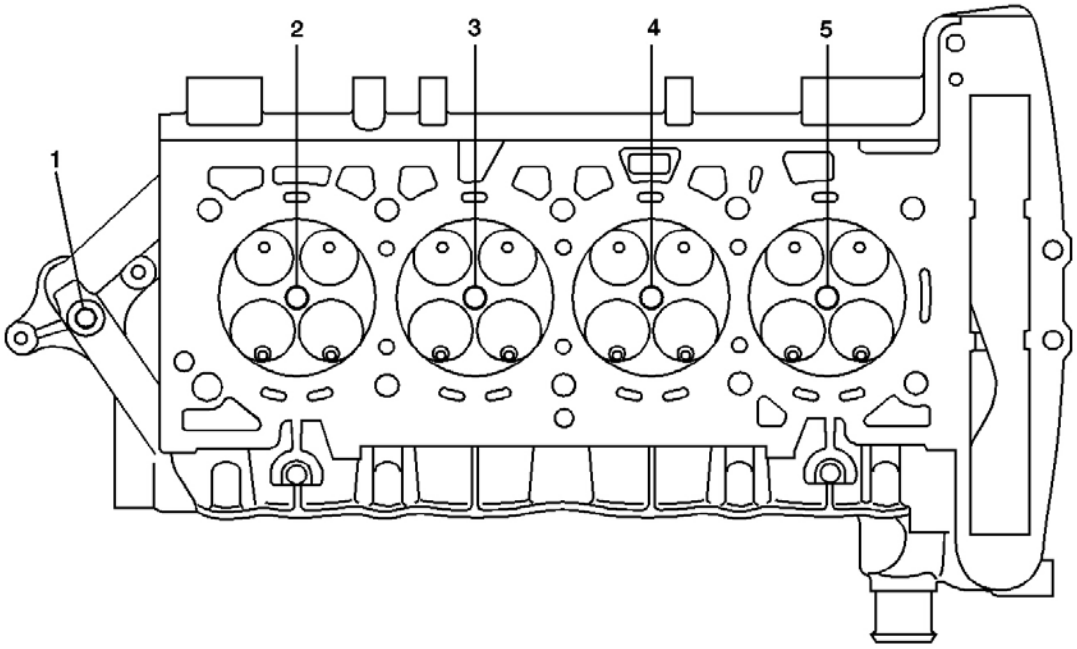


Fig. 17: Cylinder Head Bottom View
Courtesy of GENERAL MOTORS CORP.

Cylinder Head - Bottom View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
J 42385-							MM	(IN)	MM	(IN)
1	M12 x 1.75	865	856	857	858	859	17	0.670	14	0.551
2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

COMPONENT LOCATOR

DISASSEMBLED VIEWS

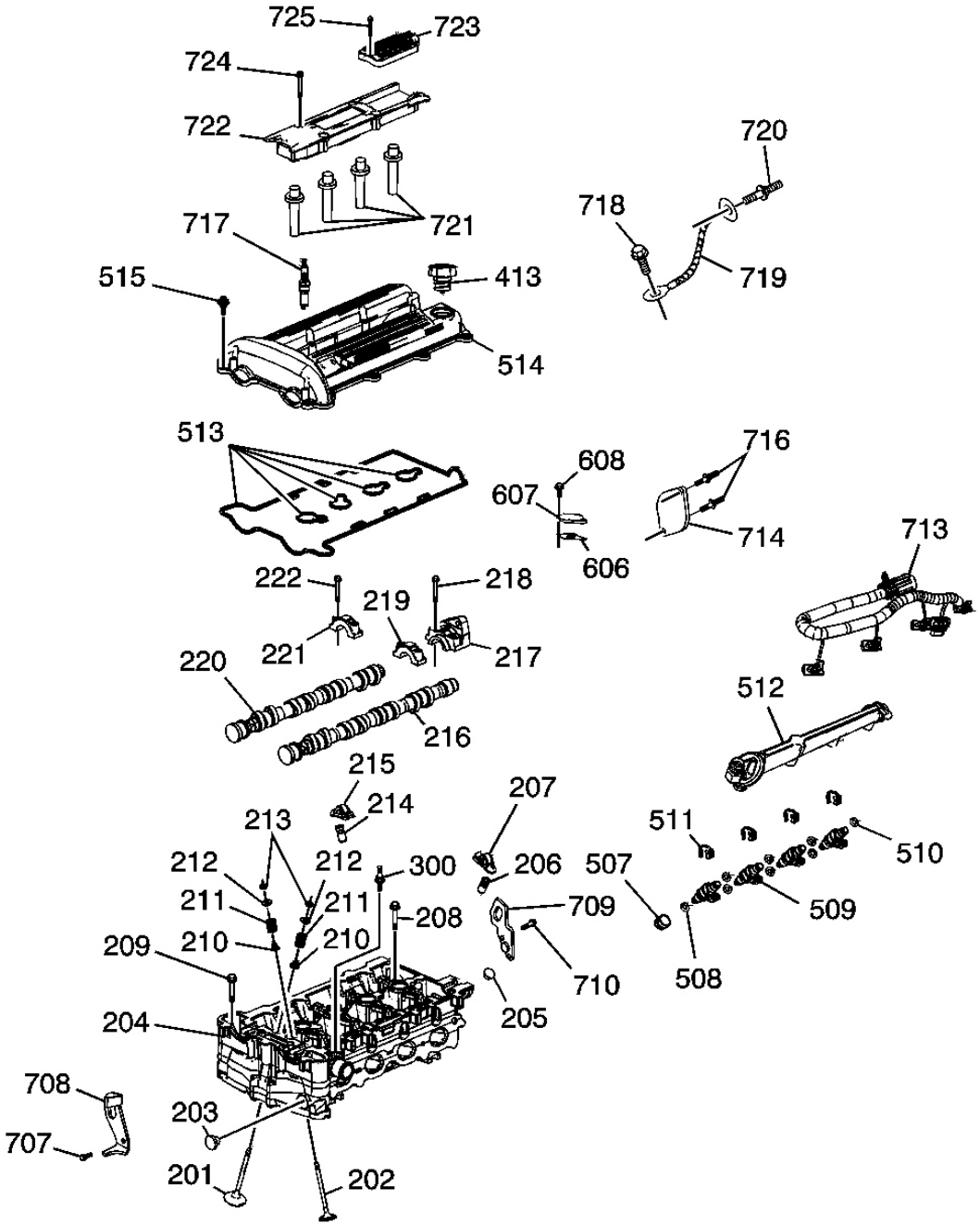


Fig. 18: Disassembled View Of Cylinder Head and Components
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 18

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
210	Valve Stem Seal
211	Valve Spring
211	Valve Spring
212	Valve Spring Retainer
212	Valve Spring Retainer
213	Valve Keys
214	Hydraulic Lash Adjuster
215	Roller Finger Follower
216	Intake Camshaft
217	Camshaft Rear Cap
218	Camshaft Rear Cap Bolt
219	Camshaft Cap
220	Exhaust Camshaft
221	Camshaft Cap
222	Camshaft Cap Bolt
300	Coolant Air Bleed Fitting
413	Engine Oil Fill Cap
507	Fuel Injector Rotator Cup
508	Fuel Injector O-ring
509	Fuel Injector
510	Fuel Injector O-ring
511	Fuel Injector Clip
512	Fuel Rail
513	Camshaft Cover Gasket
514	Camshaft Cover
515	Camshaft Cover Bolt
606	EGR Port Cover Gasket
607	EGR Port Cover
608	EGR Port Cover Bolt
707	Front Lift Bracket Bolt
708	Front Lift Bracket

709	Rear Lift Bracket
710	Rear Lift Bracket Bolt
713	Fuel Injector Wiring Harness
714	Power Steering Pump
716	Power Steering Pump Bolt Stud
717	Spark Plug
718	Ground Strap Bolt
719	Ground Strap
720	Ground Strap Bolt Stud
721	Spark Plug Boots
722	Ignition Module
723	Ignition Coil
724	Ignition Module Bolt
725	Ignition Coil Screw

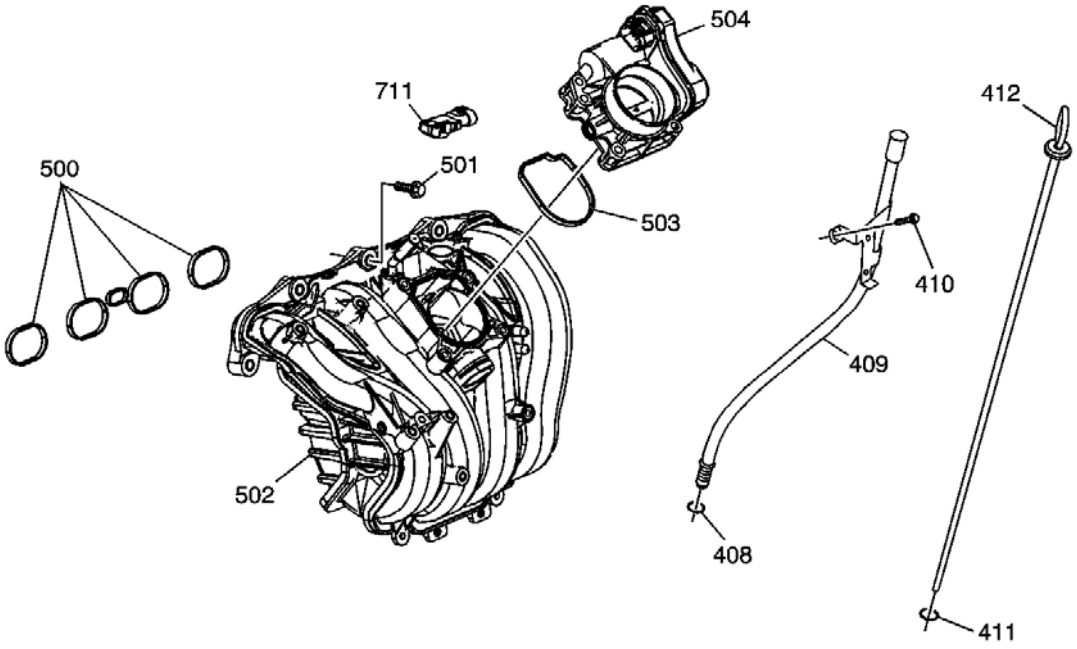


Fig. 19: Disassembled View Of Intake Manifold and Components
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 19

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 Gasket
504	Throttle Body
711	Map Sensor

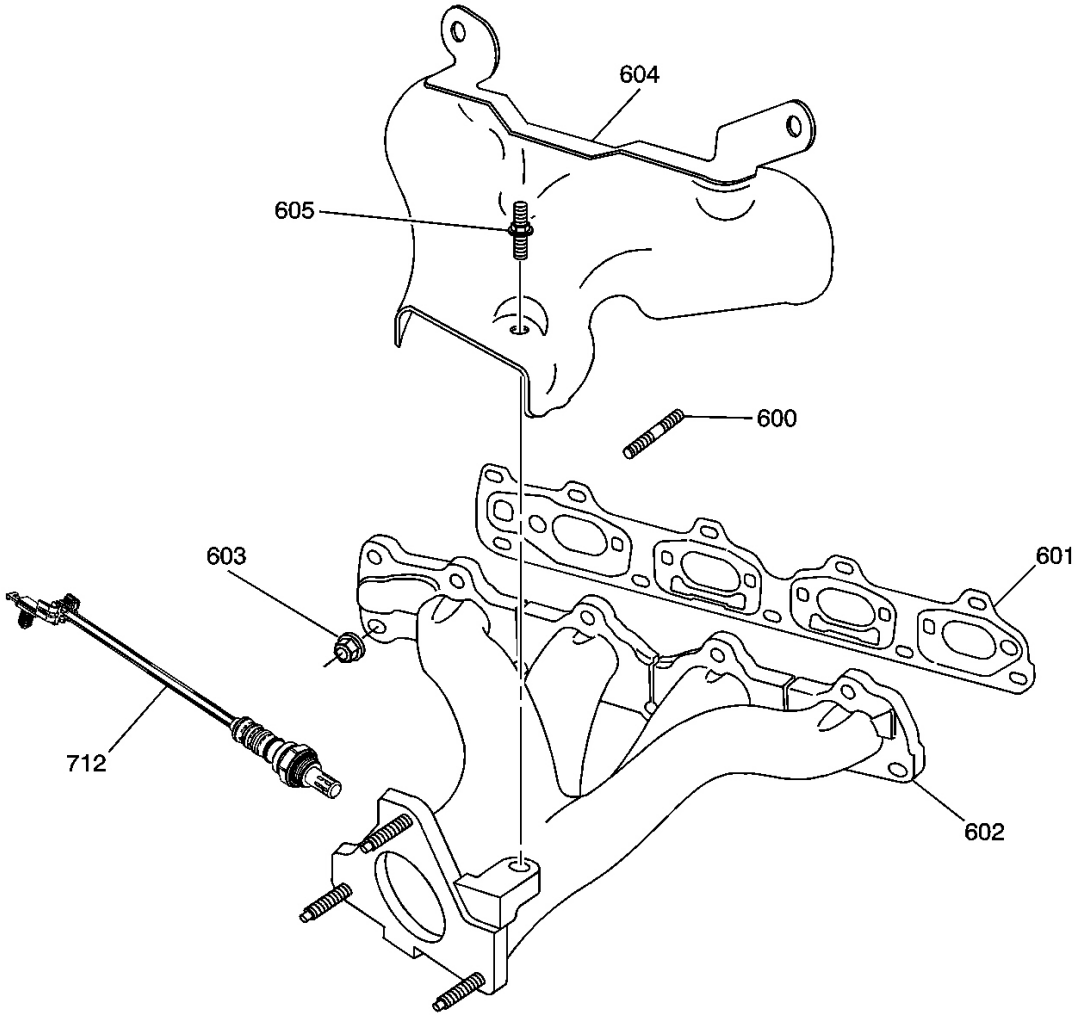


Fig. 20: Disassembled View Of Exhaust Manifold and Components
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 20

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

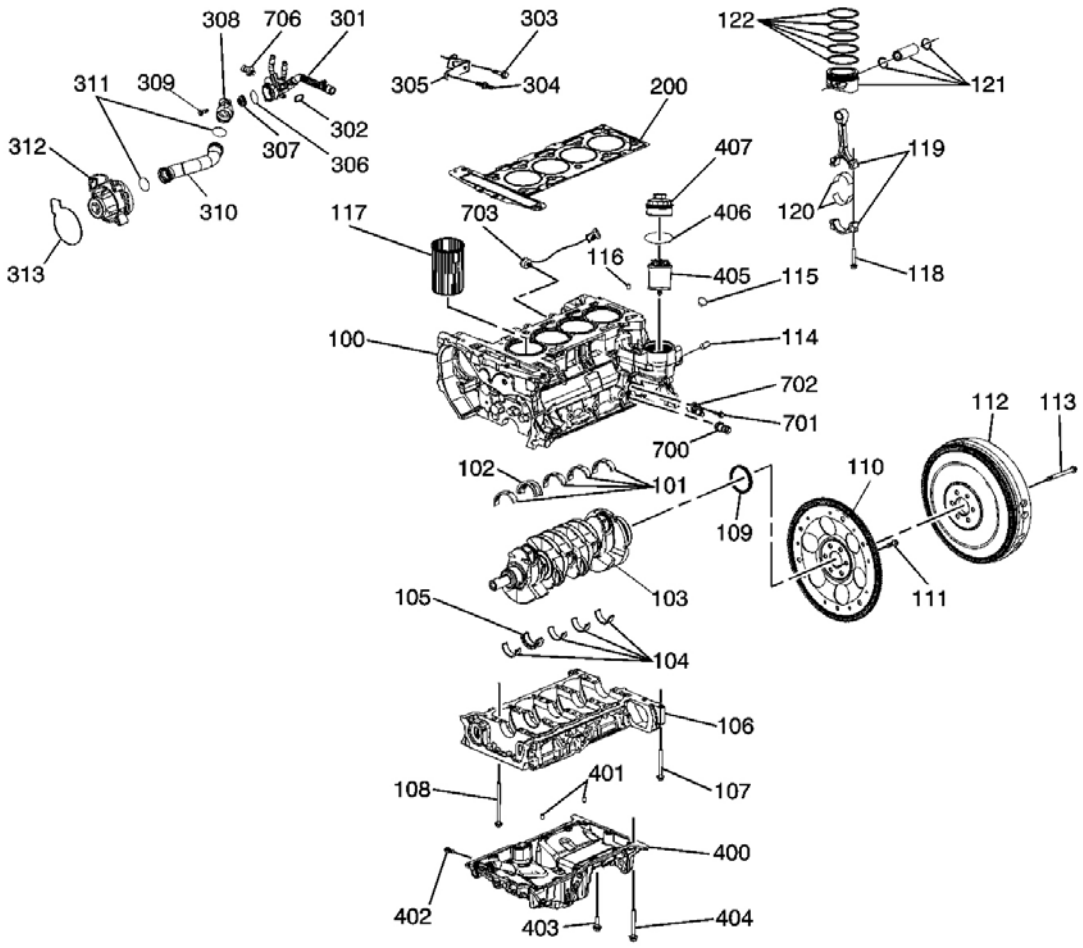


Fig. 21: Disassembled View Of Engine Block and Components
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 21

Callout	Component Name
100	Engine Block

101	Crankshaft Bearing - Upper
102	Crankshaft Thrust Bearing - Upper
103	Crankshaft
104	Crankshaft Bearing - Lower
105	Crankshaft Thrust Bearing - Lower
106	Lower Crankcase
107	Lower Crankcase Perimeter Bolt
108	Lower Crankcase Main Bearing Bolt
109	Crankshaft Rear Seal
110	Flywheel - Automatic Transmission
111	Automatic Transaxle Flywheel to Crankshaft Bolt
112	Manual Transaxle Flywheel
113	Manual Transaxle Flywheel Bolt
114	Engine Block to Transaxle Alignment Pin
115	Engine Block Gallery Plug
116	Cylinder Head Alignment Pin
117	Cylinder Bore Sleeve
118	Connecting Rod Cap Bolt
119	Connecting Rod
120	Connecting Rod Bearing
121	Piston Assembly
122	Piston Ring Assembly
200	Cylinder Head Gasket
301	Thermostat Housing
302	Thermostat Housing to Block Gasket
303	Water Pipe Support Bracket Bolt
304	Water Pipe Support Bracket Bolt Stud
305	Water Pipe Support Bracket
306	Thermostat Gasket
307	Thermostat
308	Thermostat Housing Cap
309	Thermostat Housing Cap Bolt
310	Water Transfer Pipe
311	Water Transfer Pipe O-ring Seals
312	Water Pump
313	Water Pump to Engine Block Seal
400	Engine Oil Pan
401	Engine Oil Pan Alignment Pins
402	Engine Oil Pan Drain Plug
403	Engine Oil Pan Bolt
404	Engine Oil Pan Long Bolt

405	Oil Filter
406	Oil Filter Cap O-ring
407	Oil Filter Cap
700	Oil Pressure Switch
701	Crankshaft Position Sensor Bolt
702	Crankshaft Position Sensor
703	Knock Sensor
706	Coolant Temperature Sensor

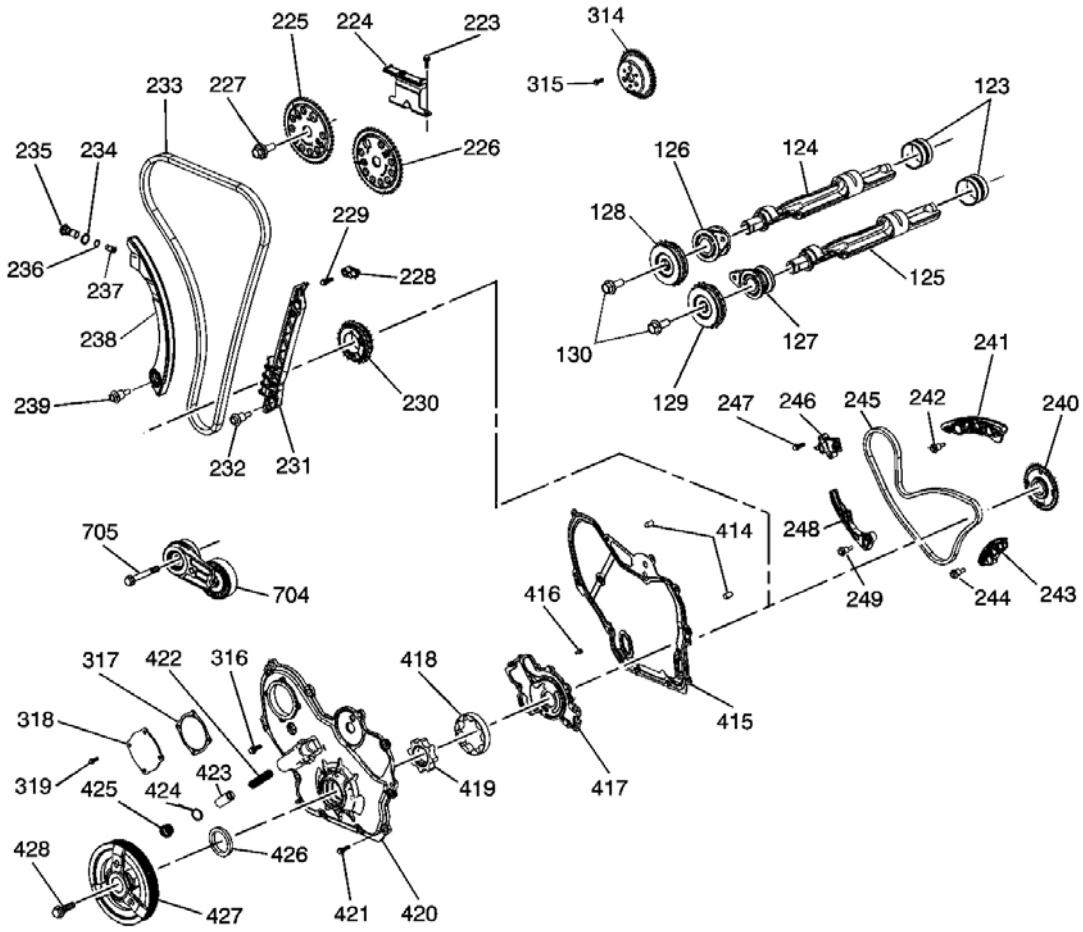


Fig. 22: Disassembled View Of Timing Chain and Components
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 22

Callout	Component Name
123	Balance Shaft Rear Bearing
124	Exhaust Balance Shaft

125	Intake Balance Shaft
126	Exhaust Balance Shaft Bearing Carrier
127	Intake Balance Shaft Bearing Carrier
128	Exhaust Balance Shaft Drive Sprocket
129	Intake Balance Shaft Drive Sprocket
130	Balance Shaft Drive Sprocket Bolts
223	Upper Timing Chain Guide Bolt
224	Upper Timing Chain Guide
225	Exhaust Camshaft Sprocket
226	Intake Camshaft Sprocket
227	Camshaft Sprocket to Camshaft 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
419	Oil Pump Inner Gerotor
420	Engine Front Cover
421	Engine Front Cover Bolt
422	Oil Pressure Relief Valve Spring
423	Oil Pressure Relief Valve Plunger
424	Oil Pressure Relief Valve O-ring Seal
425	Oil Pressure Relief Valve Plug
426	Crankshaft Front Seal
427	Crankshaft Dampener
428	Crankshaft Dampener Bolt
704	Belt Tensioner
705	Belt Tensioner Bolt

ENGINE IDENTIFICATION

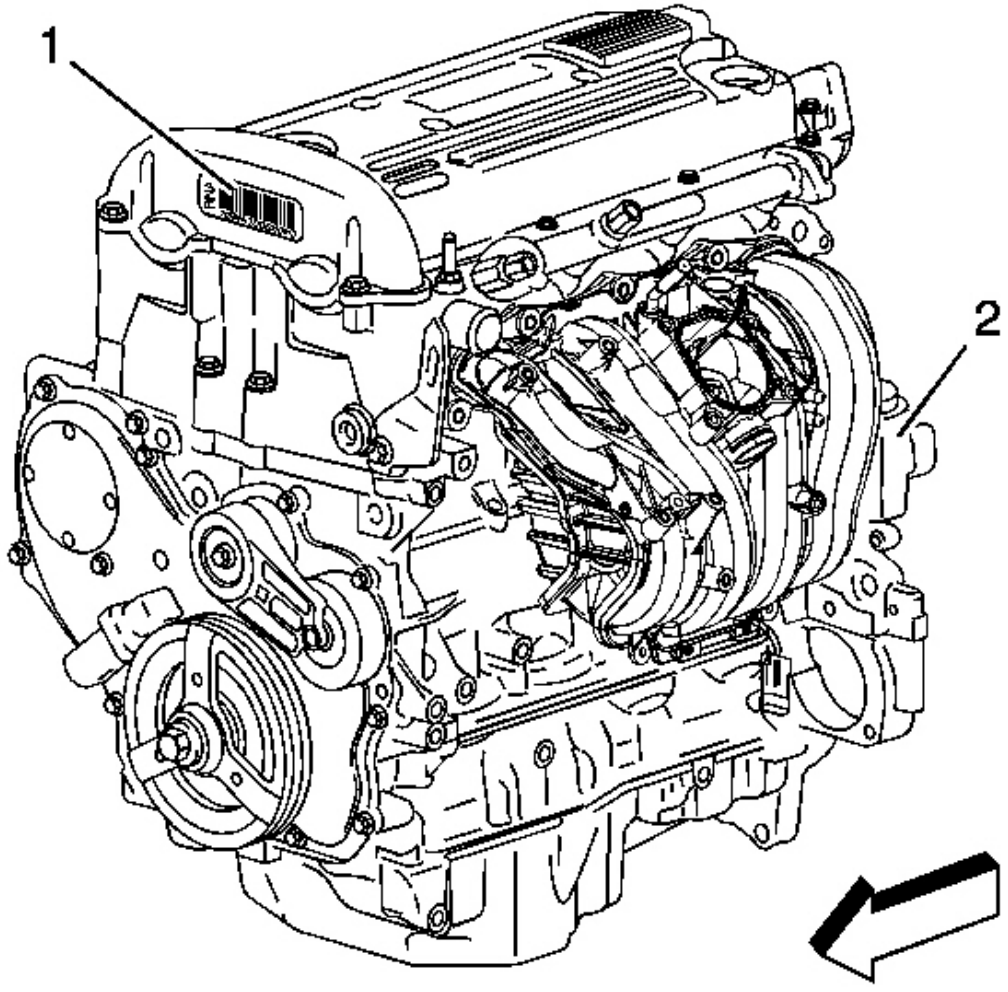


Fig. 23: View Of Engine Identification Numbers
Courtesy of GENERAL MOTORS CORP.

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

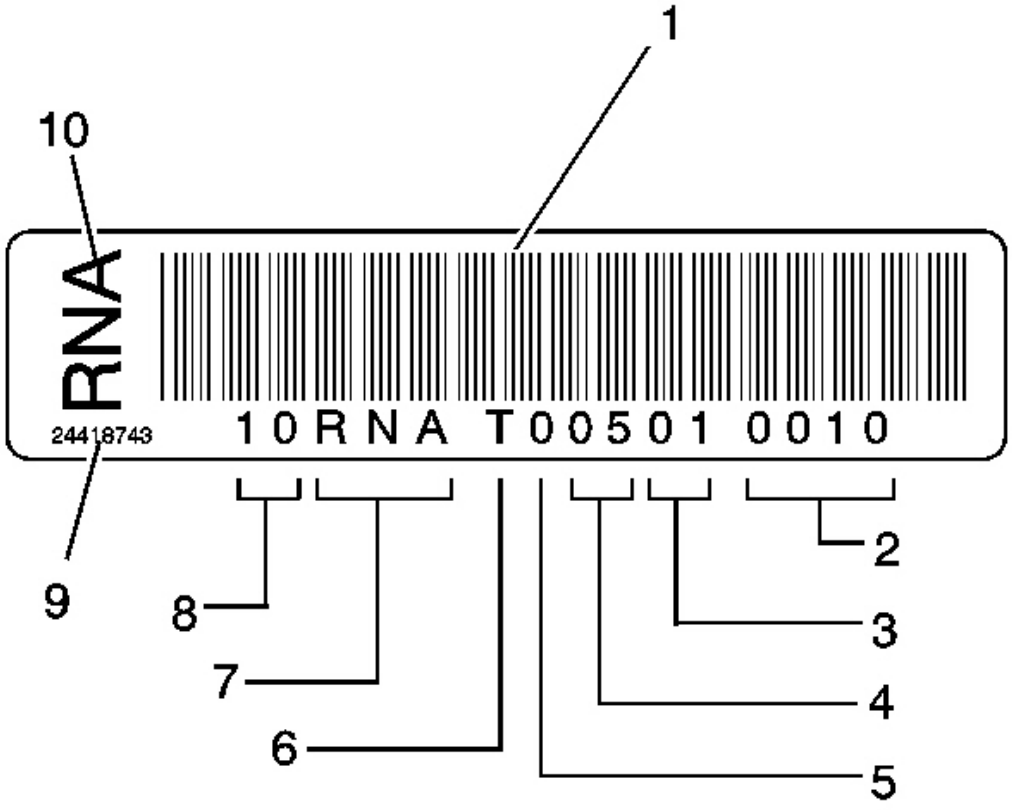


Fig. 24: View Of Broadcast Code Label
Courtesy of GENERAL MOTORS CORP.

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

The partial VIN identifies the specific vehicle by sequence number.

DIAGNOSTIC INFORMATION AND PROCEDURES

DIAGNOSTIC STARTING POINT - ENGINE MECHANICAL

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

SYMPTOMS - ENGINE MECHANICAL

Strategy Based Diagnostics

1. Perform the **Diagnostic System Check - Engine Controls** in Engine Controls 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** or **Engine Component Description** and **Lubrication Description** in Engine Unit Repair.

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 Compression Test**
- **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**
- **Oil Consumption Diagnosis**
- **Oil Pressure Diagnosis and Testing**
- **Oil Leak Diagnosis**

BASE ENGINE MISFIRE WITHOUT INTERNAL ENGINE NOISES

Base Engine Misfire without Internal Engine Noises

Cause	Correction
Abnormalities, severe cracking, bumps, or missing areas in the accessory drive belt Abnormalities in the accessory drive system and/or components may cause engine RPM variations and lead to a misfire DTC. A misfire code may be present without an actual misfire condition.	Replace the drive belt.
Worn, damaged, or mis-aligned accessory drive components or excessive pulley runout may lead to a misfire DTC. A misfire code may be present without an actual misfire condition.	Inspect the components, and repair or replace as required.
A loose or improperly installed engine flywheel or crankshaft balancer A misfire code may be present without an actual misfire condition.	Repair or replace the flywheel and/or balancer as required.
Restricted exhaust system A severe restriction in the exhaust flow can cause significant loss of engine performance and may set a DTC. Possible causes of restrictions include collapsed or dented pipes or plugged mufflers and/or catalytic converters.	Repair or replace as required.
Improperly installed or damaged vacuum hoses	Repair or replace as required.
Improper sealing between the intake manifold and cylinder heads or throttle body.	Replace the intake manifold, gaskets, cylinder heads, and/or throttle body as required.
Improperly installed or damaged MAP sensor 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.
Worn camshaft lobes	Replace the camshaft and valve lifters.
Excessive oil pressure A lubrication system with excessive oil pressure may lead to excessive valve lifter pump up and loss of compression.	• Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing** . • Repair or replace the oil pump as required.
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages Coolant consumption may or may not cause the engine to overheat.	• Inspect for spark plugs saturated by coolant. • Inspect the cylinder heads, engine block, and/or head gaskets. • Repair or replace as required.
Worn piston rings Oil consumption may or may not cause the engine to misfire.	• Inspect the spark plugs for oil deposits. • Inspect the cylinders for a loss of compression. Refer to **Engine Compression Test** . • Perform cylinder leak down and compression testing to identify the cause. • Repair or replace as required.
A damaged crankshaft reluctor wheel A damaged crankshaft reluctor wheel can result in different symptoms depending on the severity and location of the damage. • Systems with electronic communications, DIS or coil per cylinder, and severe reluctor ring damage may exhibit periodic loss of crankshaft position, stop delivering a signal, and then re-sync the crankshaft position. • Systems with electronic communication, DIS or coil per cylinder, and slight reluctor ring damage may exhibit no loss of crankshaft position and no misfire may occur. However, a P0300 DTC may be set. • Systems with mechanical communications, high voltage	Replace the sensor and/or crankshaft as required.

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.	

BASE ENGINE MISFIRE WITH ABNORMAL INTERNAL LOWER ENGINE NOISES

Base Engine Misfire with Abnormal Internal Lower Engine Noises

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

BASE ENGINE MISFIRE WITH ABNORMAL VALVE TRAIN NOISE

Base Engine Misfire with Abnormal Valve Train Noise

Cause	Correction
Worn or loose rocker arms The rocker arm bearing end caps and/or needle bearings should intact within the rocker arm assembly.	Replace the valve rocker arms as required.
Stuck valves Carbon buildup on the valve stem can cause the valve to not close properly.	Repair or replace as required.

Excessively worn or mis-aligned timing chain	Replace the timing chain and sprockets as required.
Worn camshaft lobes	Replace the camshaft and valve lifters.
Sticking lifters	Replace as required.

BASE ENGINE MISFIRE WITH COOLANT CONSUMPTION

Base Engine Misfire with Coolant Consumption

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

BASE ENGINE MISFIRE WITH EXCESSIVE OIL CONSUMPTION

Base Engine Misfire with Excessive Oil Consumption

Cause	Correction
Worn valves, valve guides and/or valve stem oil seals	• Inspect the spark plugs for oil deposits. • Repair or replace as required.
Worn piston rings Oil consumption may or may not cause the engine to misfire.	• Inspect the spark plugs for oil deposits. • Inspect the cylinders for a loss of compression. Refer to **Engine Compression Test** . • Perform cylinder leak down and compression testing to determine the cause. • Repair or replace as required.

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

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

Cause	Correction
Incorrect oil filter without anti-drainback feature	Install the correct oil filter.
Incorrect oil viscosity	1. Drain the oil. 2. Install the correct viscosity oil.
High valve lifter leak down rate	Replace the lifters as required.
Worn crankshaft thrust bearing	• Inspect the thrust bearing and crankshaft.

	• Repair or replace as required.
Damaged or faulty oil filter by-pass valve	• Inspect the oil filter by-pass valve for proper operation. • Repair or replace as required.

UPPER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Upper Engine Noise, Regardless of Engine Speed

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

	• The valve guides

LOWER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

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	• Inspect the accessory drive system. • Repair or replace as required.
Loose or damaged crankshaft balancer	• Inspect the crankshaft balancer. • Repair or replace as required.
Detonation or spark knock	Verify the correct operation of the ignition system. Refer to **Detonation/Spark Knock** in Engine Controls - 2.2L.
Loose torque converter bolts	• Inspect the torque converter bolts and flywheel. • Repair or replace as required.
Loose or damaged flywheel	Repair or replace the flywheel.
Damaged oil pan, contacting the oil pump screen An oil pan that has been damaged, may improperly position the oil pump screen, preventing proper oil flow to the oil pump.	• Inspect the oil pan. • Inspect the oil pump screen. • Repair or replace as required.
Oil pump screen loose, damaged or restricted	• Inspect the oil pump screen. • Repair or replace as required.
Excessive piston-to-cylinder bore clearance	• Inspect the piston and cylinder bore. • Repair as required.
Excessive piston pin-to-bore clearance	• Inspect the piston, piston pin, and the connecting rod. • Repair or replace as required.
Excessive connecting rod bearing clearance	Inspect the following components, and repair as required: • The connecting rod bearings • The connecting rods • The crankshaft

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

ENGINE NOISE UNDER LOAD

Engine Noise Under Load

Cause	Correction
Low oil pressure	• Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing** . • Repair or replace as required.
Detonation or spark knock	Verify the correct operation of the ignition. Refer to **Detonation/Spark Knock** in Engine Controls - 2.2L.
Loose torque converter bolts	• Inspect the torque converter bolts and flywheel. • Repair as required.
Cracked flywheel, automatic transmission	• Inspect the flywheel bolts and flywheel. • Repair as required.
Excessive connecting rod bearing clearance	Inspect the following components, and repair as required: • The connecting rod bearings • The connecting rods • The crankshaft
Excessive crankshaft bearing clearance	Inspect the following components, and repair as required: • The crankshaft bearings • The crankshaft journals • The cylinder block crankshaft bearing bore

ENGINE WILL NOT CRANK - CRANKSHAFT WILL NOT ROTATE

Engine Will Not Crank - Crankshaft Will Not Rotate

Cause	Correction
Seized accessory drive system component	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. Refer to Unit Repair Manual - Manual Transmission.
Broken timing chain and/or gears	• Inspect timing chain and gears. • Repair as required.
Seized balance shaft	• Inspect balance shaft. • Repair as required.
Material in cylinder • Broken valve • Piston material • Foreign material • Cracked cylinder wall	• Inspect cylinder for damaged components and/or foreign materials. • Inspect for fallen cylinder wall. • Repair or replace as required.
Seized crankshaft or connecting rod bearings	• Inspect crankshaft and connecting rod bearings. • Inspect for fallen cylinder wall. • Repair as required.
Bent or broken connecting rod	• Inspect connecting rods. • Repair as required.
Broken crankshaft	• Inspect crankshaft. • Repair as required.

COOLANT IN COMBUSTION CHAMBER

Coolant in Combustion Chamber

Cause	Correction
DEFINITION: Excessive white smoke and/or coolant type odor coming from the exhaust pipe may	

indicate coolant in the combustion chamber. Low coolant levels, an inoperative cooling fan, or a faulty thermostat may lead to an "overtemperature" condition which may cause engine component damage.

1. A slower than normal cranking speed may indicate coolant entering the combustion chamber. Refer to **Engine Will Not Crank - Crankshaft Will Not Rotate** .
2. Remove the spark plugs and inspect for spark plugs saturated by coolant or coolant in the cylinder 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 sleeve	Replace the components as required.
Cylinder head or block porosity	Replace the components as required.

COOLANT IN ENGINE OIL

Coolant in Engine Oil

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

Cracked cylinder head	Replace the cylinder head and gasket.
Cracked cylinder sleeve	Replace the components as required.
Cylinder head or block porosity	Replace the components as required.

ENGINE COMPRESSION TEST

Perform the following steps to conduct a compression test.

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

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

- **Normal**

  Compression builds up quickly and evenly to specified compression on each cylinder.

- **Piston Rings**

  Compression is low on the first stroke, tends to build up on following strokes, but does not reach normal. Compression improves considerably with the addition of oil.

- **Valves**

  Compression is low on the first stroke, does not tend to build up on the following strokes, and does not improve much with the addition of oil. Use approximately 3 squirts from a plunger-type oiler.

CYLINDER LEAKAGE TEST

Tools Required

J 35667-A Cylinder Head Leakdown Tester or equivalent

Cylinder Leakage Test

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

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

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

1. Disconnect the battery ground negative cable.
2. Remove the spark plugs. Refer to **Spark Plug Replacement** in Engine Controls - 2.2L.
3. Rotate the crankshaft to place the piston in the cylinder being tested at Top Dead Center (TDC) of the compression stroke.
4. Install the J 35667-A or equivalent.

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

5. Apply shop air pressure to the J 35667-A and adjust according to the manufacturers instructions.
6. Record the cylinder leakage value. Cylinder leakage that exceeds 25 percent in 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 more 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 check for the correct oil level.

- Improper oil viscosity

  Use recommended SAE viscosity for the prevailing temperatures.

- Continuous high speed driving and/or severe usage
- Crankcase ventilation system restrictions or malfunctioning components
- Valve guides and/or valve stem oil seals worn, or the seal omitted

  Ream guides and install oversize service valves and/or new valve stem oil seals.

- Piston rings broken, improperly installed, worn, or not seated properly

  Allow adequate time for rings to seat. Replace broken or worn rings as necessary.

- Piston improperly installed or mis-fitted

OIL PRESSURE DIAGNOSIS AND TESTING

Tools Required

J 44953 Oil Pressure Gage Adapter. See **Special Tools and Equipment** .

Oil Pressure Diagnosis

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

oil level.

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

- Run the engine, and verify low, or no oil pressure on the vehicle gage or light. Listen for a noisy valve train or a knocking noise.
- Inspect for the following:
  - Oil diluted by moisture or unburned fuel mixtures
  - Improper oil viscosity for the expected temperature
  - Incorrect or malfunctioning oil pressure sender
  - Incorrect or malfunctioning oil pressure gage
  - Plugged oil filter
  - Malfunctioning oil bypass valve
- Remove the oil pressure sender or another engine block oil gallery plug.
- Install **J 44953** and an oil pressure gage and measure the engine oil pressure. See **Special Tools and Equipment** .
- Compare the readings to specifications. Refer to **Engine Mechanical Specifications** .
- If the engine oil pressure is below specifications, inspect the engine for one or more of the following:
  - Oil pump worn or dirty

    Refer to **Oil Pump Disassemble** .

  - Oil pump-to-engine front cover bolts loose

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

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

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

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

    Refer to **Engine Block Assemble** .

  - Broken lash adjusters

OIL LEAK DIAGNOSIS

Oil Leak Diagnosis

Step	Action	Yes	No
DEFINITION: You can repair most fluid leaks by first, visually locating the leak, repairing or replacing the component, or by resealing the gasket surface. Once the leak is identified, determine the cause of the leak. Repair the cause of the leak as well as the leak itself.			
1	1. Operate the vehicle until it reaches normal operating temperature. Refer to **Engine Mechanical Specifications** . 2. Park the vehicle on a level surface, over a large sheet of paper or other clean surface. 3. Wait 15 minutes. 4. Check for drippings. Are drippings present?	Go to **Step 2**	System OK
2	Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 3**
3	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 4**
4	1. Completely clean the entire engine and surrounding components. 2. Operate the vehicle for several miles at normal operating temperature and at varying speeds. 3. Park the vehicle on a level surface, over a large sheet of paper or other clean surface. 4. Wait 15 minutes. 5. Identify the type of fluid, and the approximate location of the leak. Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 5**
5	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 6**

6	1. Completely clean the entire engine and surrounding components. 2. Apply an aerosol-type powder, for example, baby powder or foot powder, to the suspected area. 3. Operate the vehicle for several miles at normal operating temperature and at varying speeds. 4. Identify the type of fluid, and the approximate location of the leak, from the discolorations in the powder surface. Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 7**
7	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 8**
8	Use **J 28428-E** , Dye and Light Kit in order to identify the type of fluid, and the approximate location of the leak. See **Special Tools and Equipment** . Refer to the manufacturer's instructions when using the tool. Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 9**
9	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	System OK
10	1. Inspect the engine for mechanical damage. Special interest should be shown to the following areas: • Higher than recommended fluid levels • Higher than recommended fluid pressures • Plugged or malfunctioning fluid filters or pressure bypass valves • Plugged or malfunctioning engine ventilation system • Improperly tightened or damaged fasteners • Cracked or porous components • Improper sealants or gaskets where required • Improper sealant or gasket installation • Damaged or worn gaskets or seals		

	• Damaged or worn sealing surfaces 2. Inspect the engine for customer modifications. Is there mechanical damage, or customer modifications to the engine?	Go to **Step 11**	System OK
11	Repair or replace all damaged or modified components.	Go to **Step 1**	-

CRANKCASE VENTILATION SYSTEM INSPECTION/DIAGNOSIS

1. Disconnect the PCV hose.
2. Start the engine.
3. Check for vacuum at the hose. If there is no vacuum, check for a plugged hose or manifold port. Check for a hose that collapses when blocked (vacuum applied). Replace the plugged or the deteriorated hoses.
4. Allow the engine to idle at normal operating temperature.
5. Remove the engine oil dipstick and install a vacuum gage on the dipstick tube.
6. Block off the PCV system fresh air intake passage.
7. Run the engine at 1500 RPM for 30 seconds, then read vacuum gage while engine is running at 1500 RPM.
   - If vacuum is present, this indicates that the crankcase ventilation system is functioning properly.
   - If no vacuum is indicated, the engine may not be sealed and is drawing in outside air. Check the valve covers, the oil pan gasket or other sealing areas for leaks.
   - If the vacuum gage registers a pressure, or if a vacuum gage is pushed out of dipstick tube, check for a plugged PCV port, a plugged hose or an excessive engine blow-by.

DRIVE BELT CHIRPING DIAGNOSIS

Diagnostic Aids

The symptom may be intermittent due to moisture on the drive belt or the pulleys. It may be necessary to spray a small amount of water on the drive belt 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.

A loose or improper installation of a body component, a suspension component, or other items of the vehicle may cause the chirping noise.

Test Description

The numbers below refer to the step number 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 belt 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 belt 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 misalign pulley using a straight edge in the pulley grooves across 2 or 3 pulleys. If a misalign pulley is found refer to that accessory drive component for the proper installation procedure for that pulley.

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

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

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

Drive Belt Chirping Diagnosis

Step	Action	Yes	No
NOTE: **Refer to Belt Dressing Notice in Cautions and Notices.** DEFINITION: The following items are indications of chirping: • A high pitched noise that is heard once per revolution of the drive belt or a pulley. • It usually occurs on cold damp mornings.			
1	Did you review the Symptoms - Engine Mechanical operation and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	Verify that there is a chirping noise. Does the engine make the chirping noise?	Go to **Step 3**	Go to Diagnostic Aids
3	1. Remove the drive belt. Refer to **Drive Belt Replacement** . 2. Operate the engine for no longer than 30 to 40 seconds. Does the chirping noise still exist?	Go to **Engine Noise on Start-Up, but Only Lasting a Few Seconds** , **Upper Engine Noise, Regardless of Engine Speed** , **Lower Engine Noise, Regardless of Engine Speed** , or **Engine Noise Under Load**	Go to **Step 4**
	Inspect for severe pilling exceeding 1/3 of the belt groove		

4	depth. Does 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 15**	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 15**	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 15**	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	Tighten any loose fasteners. Refer to **Fastener Tightening Specifications** . Did you complete the repair?	Go to **Step 15**	Go to **Step 12**
12	Inspect for a bent pulley. Did you find the condition?	Go to **Step 13**	Go to **Step 14**
13	Replace the bent pulley. Did you complete the repair?	Go to **Step 15**	Go to **Step 14**
14	Replace the drive belt. Refer to **Drive Belt Replacement** . Did you complete the repair?	Go to **Step 15**	Go to Diagnostic Aids
15	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 3**

DRIVE BELT SQUEAL DIAGNOSIS

Diagnostic Aids

A loose or improper installation of a body component, a suspension component, or other items of the vehicle may cause the squeal noise.

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.

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 belt and operating the engine for a brief period will verify the squeal noise is the drive belt or an accessory drive component. 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 belt removed.

4: This test is to verify that an accessory drive component does not have a seized bearing. With the belt remove test the bearings in the accessory drive components for turning smoothly. Also test the accessory drive components with the engine operating by varying the load on the components to verify that the components operate properly.

5: 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.

6: 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.

7: 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 misalign pulley using a straight edge in the pulley grooves across two or three pulleys. If a misalign pulley is found refer to that accessory drive component for the proper installation procedure for that pulley.

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

Drive Belt Squeal Diagnosis

Step	Action	Yes	No
NOTE: **Refer to Belt Dressing Notice in Cautions and Notices.** DEFINITION: The following items are indications of drive belt squeal: • A loud screeching noise that is caused by a slipping drive belt. • 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.			
1	Did you review the Symptoms - Engine Mechanical operation and		Go to **Symptoms -**

	perform the necessary inspections?	Go to **Step 2**	**Engine Mechanical**
2	Verify that there is a squeal noise. Does the engine make the squeal noise?	Go to **Step 3**	Go to Diagnostic Aids
3	1. Remove the drive belt. Refer to **Drive Belt Replacement** . 2. Operate the engine for no longer than 30 to 40 seconds. Does the noise still exist?	Go to **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** , or **Engine Noise Under Load**	Go to **Step 4**
4	Inspect for an accessory drive component seized bearing or a faulty accessory drive component. Did you find and correct the condition?	Go to **Step 9**	Go to **Step 5**
5	Test the drive belt tensioner for proper operation. Refer to **Drive Belt Tensioner Diagnosis** Did you find and correct the condition?	Go to **Step 9**	Go to **Step 6**
6	Inspect for the correct drive belt length. Refer to **Drive Belt Replacement** . Did you find and correct the condition?	Go to **Step 9**	Go to **Step 7**
7	Inspect for misalignment of a pulley. Did you find and correct the condition?	Go to **Step 9**	Go to **Step 8**
8	Inspect for the correct pulley size. Did you find and correct the condition?	Go to **Step 9**	Go to Diagnostic Aids
9	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 3**

DRIVE BELT WHINE DIAGNOSIS

Diagnostic Aids

The drive belt will not cause the whine noise.

If the whine noise is intermittent, verify the accessory drive components by varying their loads making sure they are operated to their maximum capacity. Such items but not limited to may be an A/C system overcharged, the power steering system restricted or the wrong fluid, or the generator failing.

Test Description

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

3: This test is to verify that the noise is being caused by the drive belt or the accessory drive components. 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 belt removed.

4: The inspection should include checking the drive belt tensioner and the drive belt idler pulley bearings. The drive belt may have to be installed and the accessory drive components operated separately by varying their loads. Refer to the suspected accessory drive component for the proper inspection and replacement procedure.

Drive Belt Whine Diagnosis

Step	Action	Yes	No
NOTE: **Refer to Belt Dressing Notice in Cautions and Notices.** DEFINITION: A high pitched continuous noise that may be caused by an accessory drive component failed bearing.			
1	Did you review the Symptoms - Engine Mechanical operation and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	Verify that there is a whine noise. Does the engine make the whine noise?	Go to **Step 3**	Go to Diagnostic Aids
3	1. Remove the drive belt. Refer to **Drive Belt Replacement** . 2. Operate the engine for no longer than 30 to 40 seconds. Does the whine noise still exist?	Go to **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** , or **Engine Noise Under Load**	Go to **Step 4**
4	Inspect for a failed accessory drive component bearing. Did you find and repair the condition?	Go to **Step 5**	Go to Diagnostic Aids
5	Operate the system in order to verify the repair. Did you correct the condition?	System OK	-

DRIVE BELT RUMBLING DIAGNOSIS

Diagnostic Aids

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

The drive belt may have a 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 belt is 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 the drive belt is causing the rumbling noise. Rumbling noise may be confused with an internal engine noise due to the similarity in the description. Remove only one drive belt at a time if the vehicle has multiple drive belts. When removing the drive 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 belt removed.

4: Inspecting the drive belt is to ensure that it is not causing a the noise. Small cracks across the ribs of the drive belt will not cause the noise. Belt separation is identified by the plays 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.

Drive Belt Rumbling Diagnosis

Step	Action	Yes	No

NOTE:
Refer to Belt Dressing Notice in Cautions and Notices.
 	
DEFINITION:
 	
• A low pitch tapping, knocking, or thumping noise heard at or just above idle.
• Heard once per revolution of the drive belt or a pulley.
• Rumbling may be caused from:
  ○ Pilling, the accumulation of rubber dust that forms small balls or strings in the drive belt pulley groove
  ○ The separation of the drive belt			

	○ A damaged drive belt		
1	Did you review the Symptoms - Engine Mechanical operation and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	Verify that there is a rumbling noise. Does the engine make the rumbling noise?	Go to **Step 3**	Go to Diagnostic Aids
3	1. Remove the drive belt. Refer to **Drive Belt Replacement** . 2. Operate the engine for no longer than 30 to 40 seconds. Does the rumbling noise still exist?	Go to **Engine Noise on Start-Up, but Only Lasting a Few Seconds** , **Upper Engine Noise, Regardless of Engine Speed** , **Lower Engine Noise, Regardless of Engine Speed** , or **Engine Noise Under Load**	Go to **Step 4**
4	Inspect the drive belt for damage, separation, or sections of missing ribs. 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 belt. Refer to **Drive Belt Replacement** . Did you complete the repair?	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**	-
8	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Diagnostic Aids

DRIVE BELT VIBRATION DIAGNOSIS

Diagnostic Aids

The accessory drive components can have an affect on engine vibration. Such as 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.

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 such as the exhaust system, or the drivetrain.

3: This test is to verify that the drive belt or accessory drive components may be causing the vibration. 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 belt removed.

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

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

8: This step should only be performed if the fan is driven by the drive belt. Inspect the engine cooling fan for bent, twisted, loose, or cracked blades. Inspect the fan clutch for smoothness, ease of turning. Inspect for a bent fan shaft or bent mounting flange.

9: 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 smoothness and excessive play. Compare the water pump with a known good water pump.

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

Drive Belt Vibration Diagnosis

Step	Action	Yes	No
	NOTE: **Refer to Belt Dressing Notice in Cautions and Notices.** DEFINITION: The following items are indications of drive belt vibration: • The vibration is engine-speed related. • The vibration may be sensitive to accessory load.		
1	Did you review the Symptoms - Engine Mechanical operation and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	Verify that the vibration is engine related. Does the engine make the vibration?	Go to **Step 3**	Go to Diagnostic Aids
	1. Remove the drive belt. Refer to **Drive Belt**		

3	**Replacement** . 2. Operate the engine for no longer than 30 to 40 seconds. Does the engine still make the vibration?	Go to **Diagnostic Starting Point - Vibration Diagnosis and Correction** in Vibration Diagnosis and Correction	Go to **Step 4**
4	Inspect the drive belt for wear, damage, debris build-up and missing drive belt ribs. Did you find any of these conditions?	Go to **Step 5**	Go to **Step 6**
5	Install a new drive belt. Refer to **Drive Belt Replacement** . Did you complete the replacement?	Go to **Step 11**	-
6	Inspect for improper, loose or missing fasteners. Did you find any of these conditions?	Go to **Step 7**	Go to **Step 8**
7	1. Tighten any loose fasteners. 2. Replace improper or missing fasteners. Refer to **Fastener Tightening Specifications** . Did you complete the repair?	Go to **Step 11**	-
8	Inspect for damaged fan blades or bent fan clutch shaft, if the fan is belt driven. Did you find and correct the condition?	Go to **Step 11**	Go to **Step 9**
9	Inspect for a bent water pump shaft, if the water pump is belt driven. Refer to **Water Pump Replacement (L61)Water Pump Replacement (L66)** in Engine Cooling. Did you find and correct the condition?	Go to **Step 11**	Go to **Step 10**
10	Inspect for bent or cracked brackets. Did you find and correct the condition?	Go to **Step 11**	Go to Diagnostic Aids
11	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 3**

DRIVE BELT FALLS OFF DIAGNOSIS

Diagnostic Aids

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

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

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

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 misalign pulley using a straight edge in the pulley grooves across two or three pulleys. If a misalign 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.

Drive Belt Falls Off Diagnosis

Step	Action	Yes	No
NOTE: **Refer to Belt Dressing Notice in Cautions and Notices.** DEFINITION: The drive belt falls off the pulleys or may not ride correctly on the pulleys.			
1	Did you review the Symptoms - Engine Mechanical operation and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	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	1. Tighten any loose fasteners. 2. Replace improper or missing fasteners. Refer to **Fastener Tightening Specifications** . Does the drive belt continue to fall off?	Go to **Step 9**	System OK

9	Test the drive belt tensioner for operating correctly. Refer to **Drive Belt Tensioner Diagnosis** . Does the drive belt tensioner operate correctly?	Go to **Step 11**	Go to **Step 10**
10	Replace the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement** . 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**

DRIVE BELT EXCESSIVE WEAR DIAGNOSIS

Diagnostic Aids

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: 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.

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

4: 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.

Drive Belt Excessive Wear Diagnosis

Step	Action	Yes	No
NOTE: **Refer to Belt Dressing Notice in Cautions and Notices.** DEFINITION: Wear at the outside ribs of the drive belt due to an incorrectly installed drive belt.			
	Did you review the Symptoms - Engine Mechanical	Go to	Go to **Symptoms -**

1	operation and perform the necessary inspections?	**Step 2**	**Engine Mechanical**
2	Inspect the drive belt for the proper installation. Refer to **Drive Belt Replacement** . Did you find this condition?	Go to **Step 5**	Go to **Step 3**
3	Inspect for the proper drive belt. Did you find this condition?	Go to **Step 5**	Go to **Step 4**
4	Inspect for the drive belt rubbing against a bracket, hose, or wiring harness. Did you find and repair the condition?	Go to **Step 6**	Go to Diagnostic Aids
5	Replace the drive belt. Refer to **Drive Belt Replacement** . Did you complete the replacement?	Go to **Step 6**	-
6	Operate the system in order to verify the repair. Did you correct the condition?	System OK	-

DRIVE BELT TENSIONER DIAGNOSIS

Drive Belt Tensioner Diagnosis

Step	Action	Yes	No
1	Remove the drive belt. 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

DRIVE BELT REPLACEMENT

Tools Required

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

Removal Procedure

CAUTION: The tensioner assembly's internal parts are not serviceable. To avoid injury, do not disassemble the tensioner.

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
2. Raise the vehicle on the hoist. Refer to **Lifting and Jacking the Vehicle** in General Information.
3. Remove the right wheel and the splash shield.
4. Install the **J 44811** onto the tensioner. See **Special Tools and Equipment** .
5. Remove the accessory drive belt.

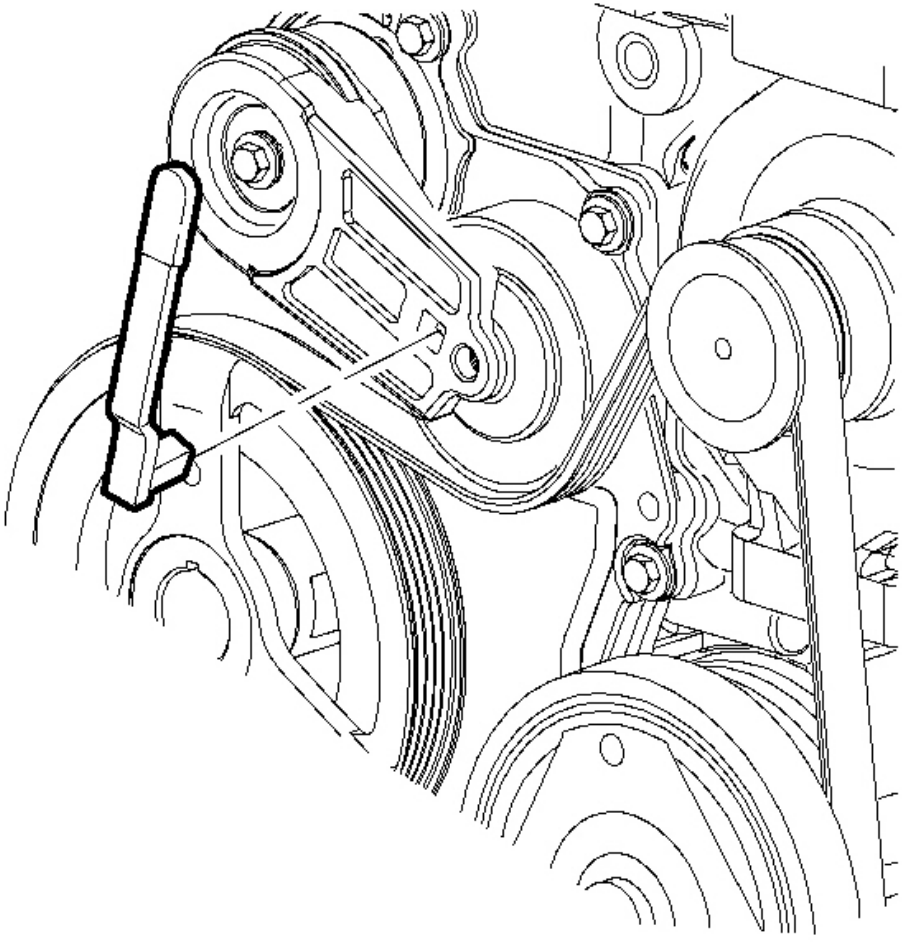


Fig. 25: View Of Drive Belt Tensioner Tool
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: To remove the tensioner bolt an access hole has been provided through the inner and outer engine rail.

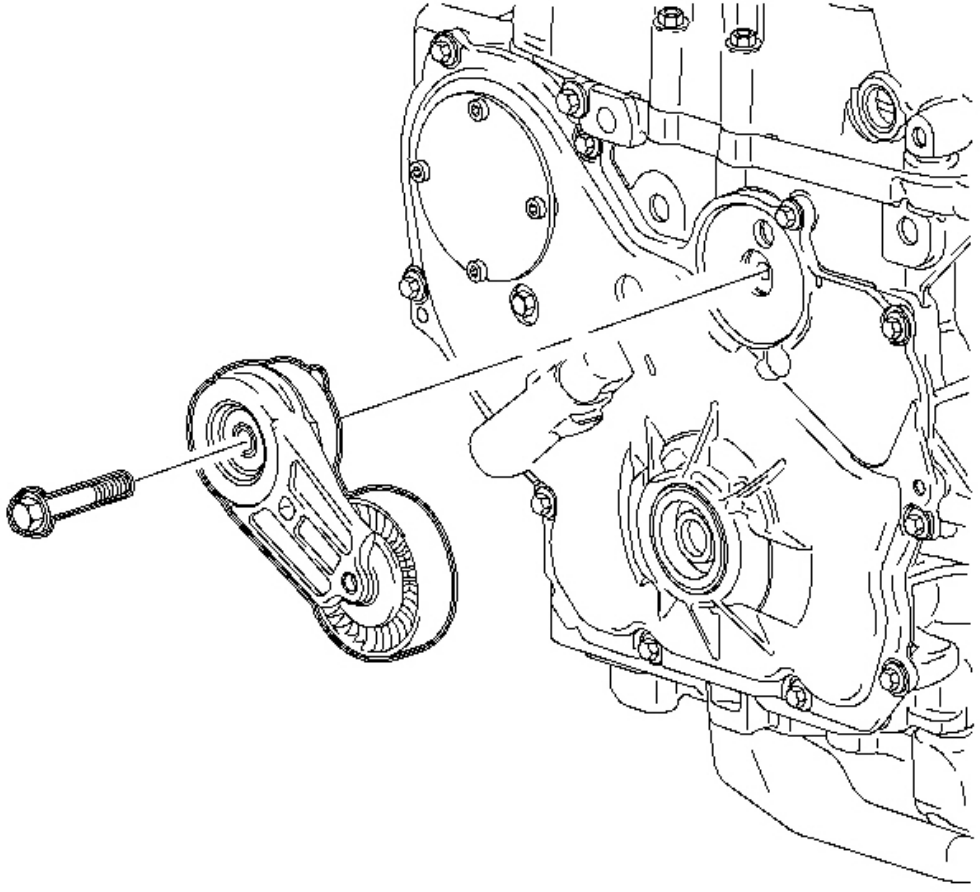


Fig. 26: Removing/Installing Tensioner Assembly & Bolt
Courtesy of GENERAL MOTORS CORP.

6. Remove the tensioner assembly.
7. Remove the tensioner bolt.

Installation Procedure

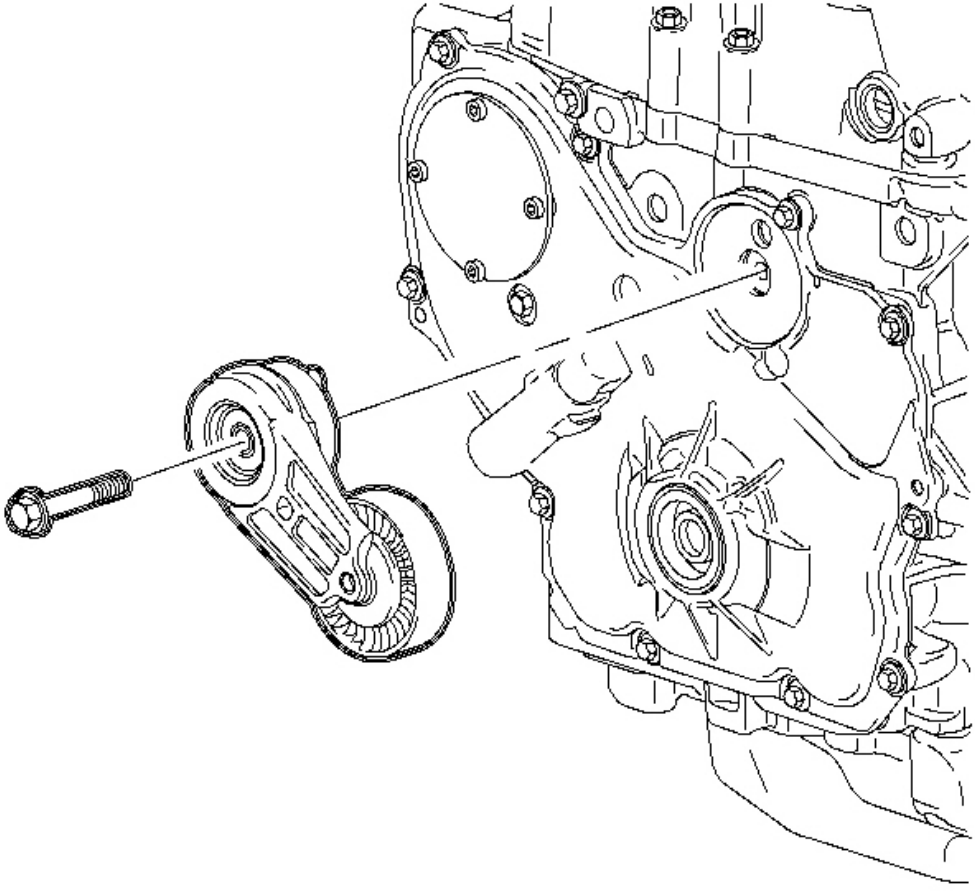


Fig. 27: Removing/Installing Tensioner Assembly & Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

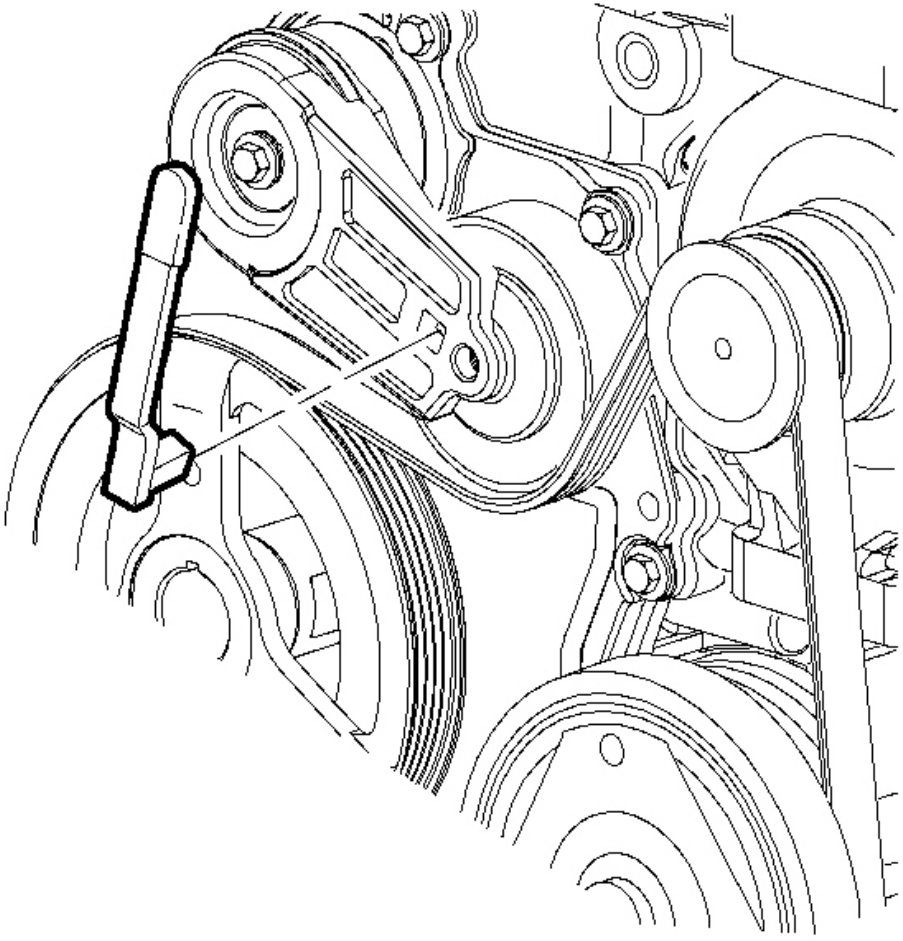


Fig. 28: View Of Drive Belt Tensioner Tool
Courtesy of GENERAL MOTORS CORP.

1. Install the tensioner assembly and bolt (if removed).

   Tighten: Tighten the drive belt tensioner bolt 45 N.m (33 lb ft).

2. Route the belt around the alternator and the A/C compressor.
3. Install the **J 44811** onto the tensioner and unload spring tension from the tensioner while positioning the belt. See **Special Tools and Equipment** .
4. Release the tensioner and remove the tool.
5. Install the right engine inner splash shield.

6. Install the right wheel and hand tighten the wheel nuts.
7. Lower the vehicle.

   Tighten: Tighten the wheel nuts 125 N.m (92 lb ft).

8. Connect the negative battery cable

   Tighten: Tighten the battery terminal bolt 17 N.m (23 lb ft).

DRIVE BELT TENSIONER REPLACEMENT

Tools Required

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

Removal Procedure

CAUTION: The tensioner assembly's internal parts are not serviceable. To avoid injury, do not disassemble the tensioner.

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

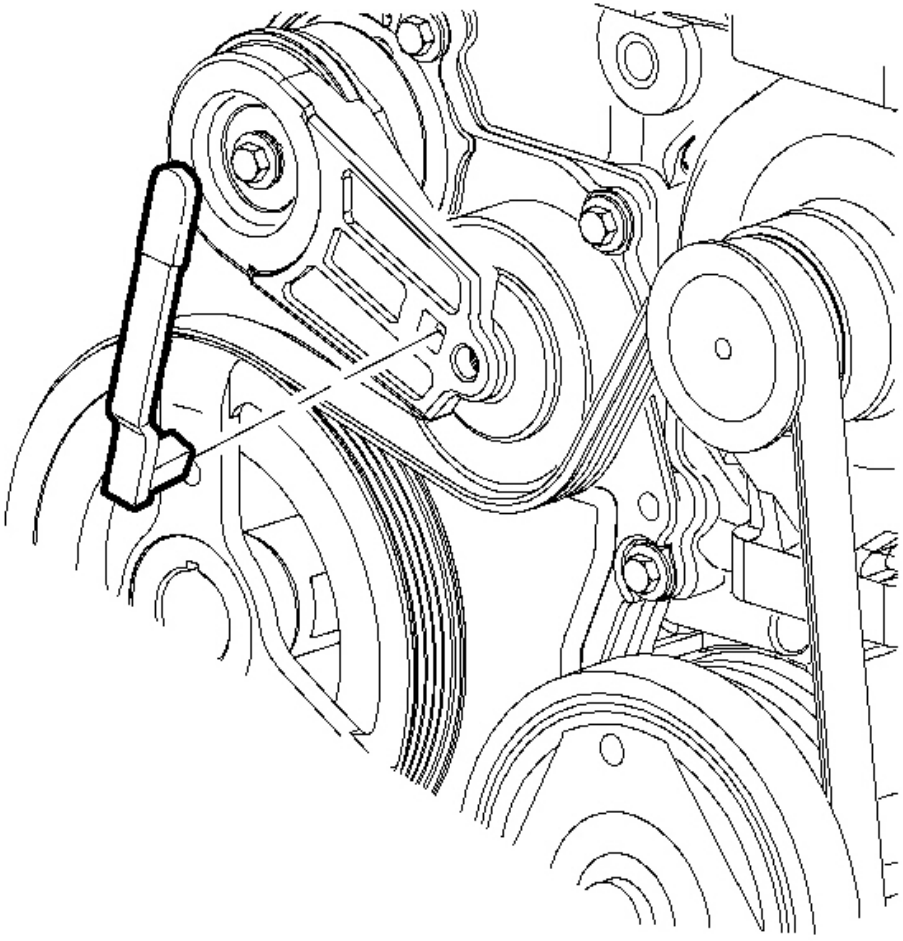


Fig. 29: View Of Drive Belt Tensioner Tool
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the negative battery cable.
2. Raise the vehicle on the hoist. Refer to **Lifting and Jacking the Vehicle** in General Information.
3. Remove the right wheel and the splash shield.
4. Install the **J 44811** onto the tensioner. See **Special Tools and Equipment** .
5. Remove the accessory drive belt.

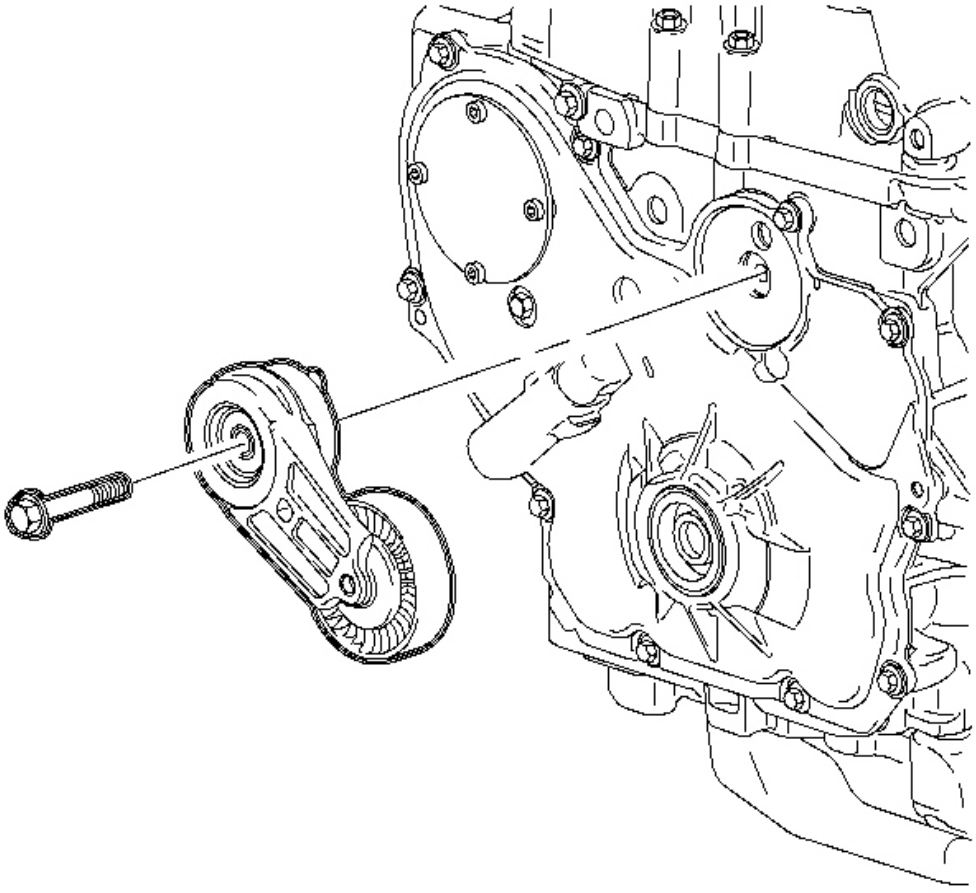


Fig. 30: Removing/Installing Tensioner Assembly & Bolt
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: To remove the tensioner bolt an access hole has been provided through the inner and outer engine rail.

6. Remove the tensioner assembly.
7. Remove the tensioner bolt.

Installation Procedure

NOTE: Refer to Fastener Notice in Cautions and Notices.

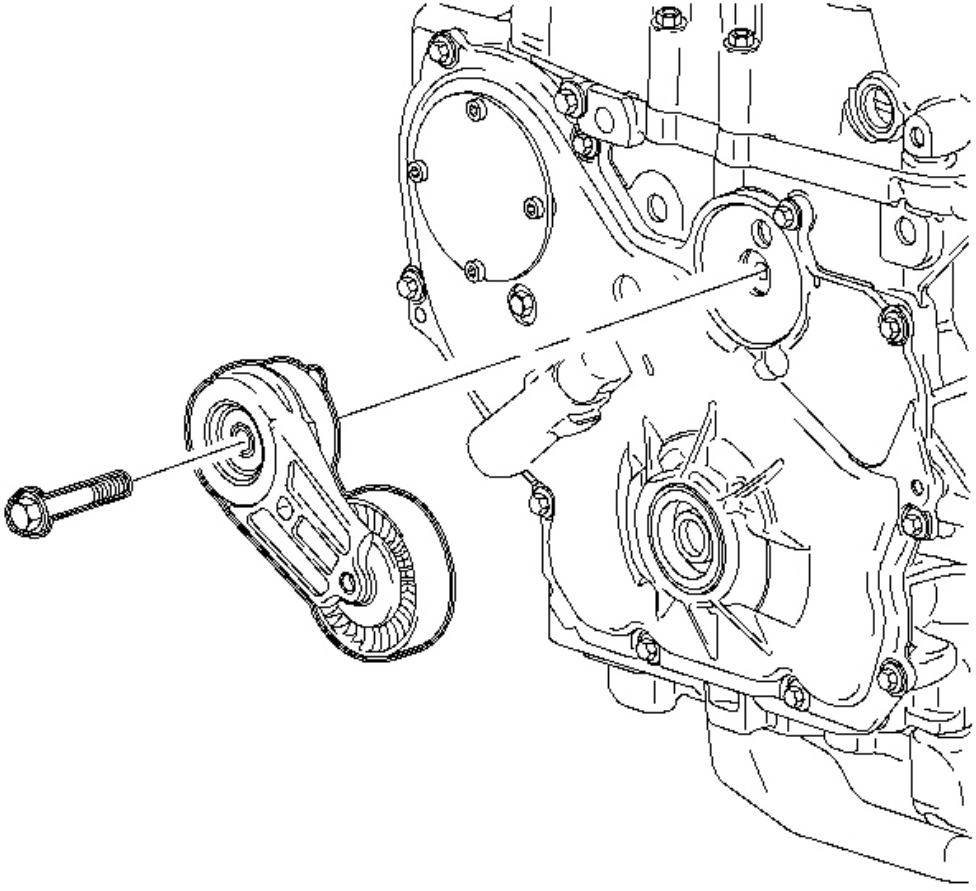


Fig. 31: Removing/Installing Tensioner Assembly & Bolt
Courtesy of GENERAL MOTORS CORP.

1. Install the tensioner assembly and bolt, if removed.

   Tighten: Tighten the drive belt tensioner bolt 45 N.m (33 lb ft).

2. Route the belt around the alternator and the A/C compressor.

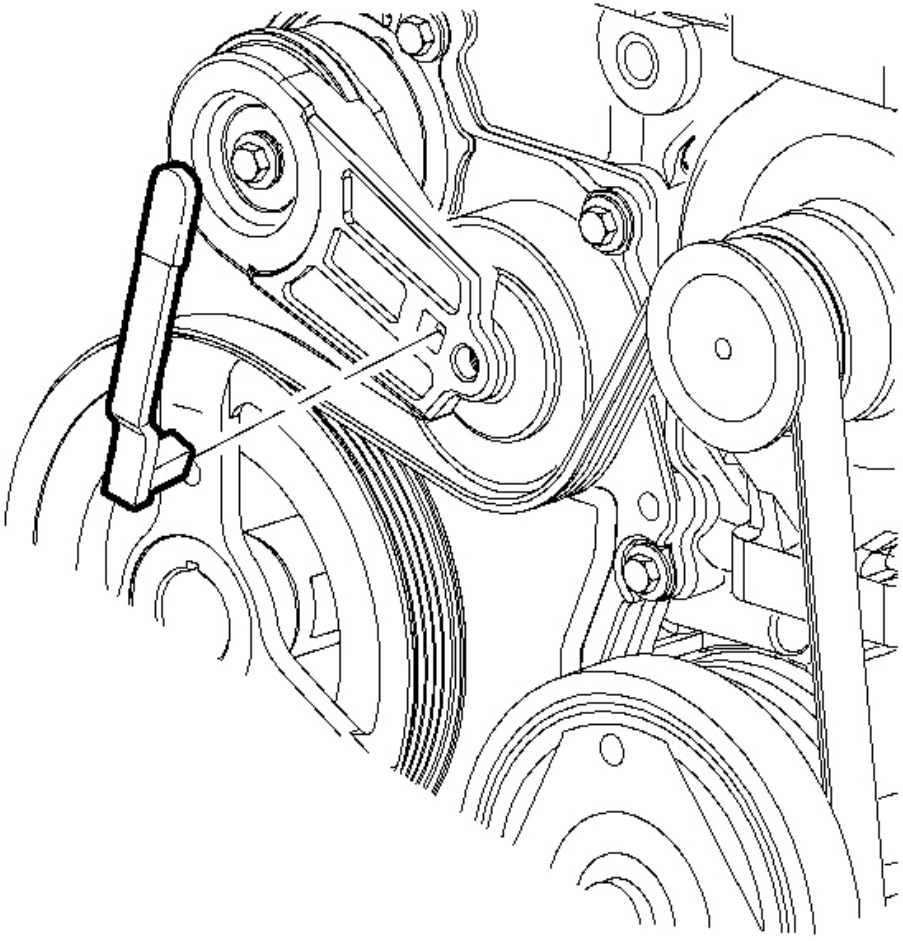


Fig. 32: View Of Drive Belt Tensioner Tool
Courtesy of GENERAL MOTORS CORP.

3. Install the **J 44811** onto the tensioner and unload spring tension from the tensioner while positioning the belt. See **Special Tools and Equipment** .
4. Release the tensioner and remove the tool.
5. Install the right engine inner splash shield.
6. Install the right wheel and hand tighten the wheel nuts.
7. Lower the vehicle.

Tighten: Tighten the wheel nuts 125 N.m (92 lb ft).

8. Connect the negative battery cable

   Tighten: Tighten the battery terminal bolt 17 N.m (23 lb ft).

ENGINE OIL PRESSURE SENSOR AND/OR SWITCH REPLACEMENT

Special Tools

J 35749 Oil Pressure Socket

Removal Procedure

1. Turn ignition OFF.
2. Disconnect engine oil pressure (EOP) switch harness connector.

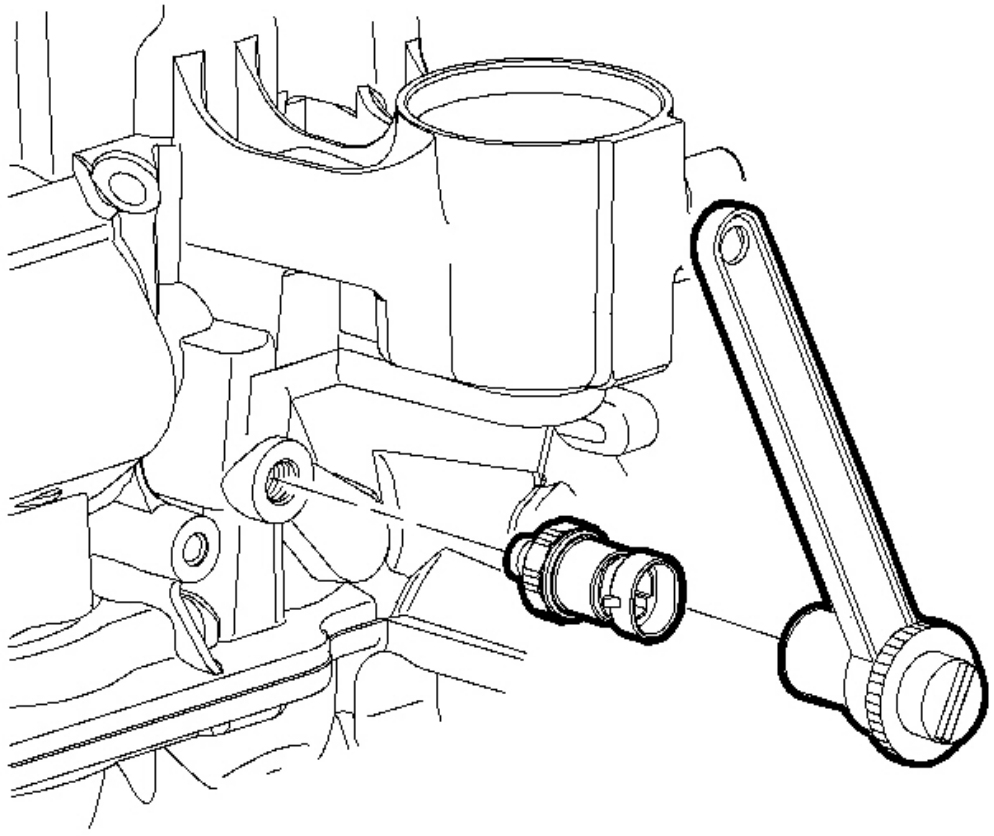


Fig. 33: View Of Engine Oil Pressure & Switch
Courtesy of GENERAL MOTORS CORP.

3. Remove the EOP switch using the J 35749 .

Installation Procedure

1. Apply RTV sealant (or equivalent) to the EOP switch threads.

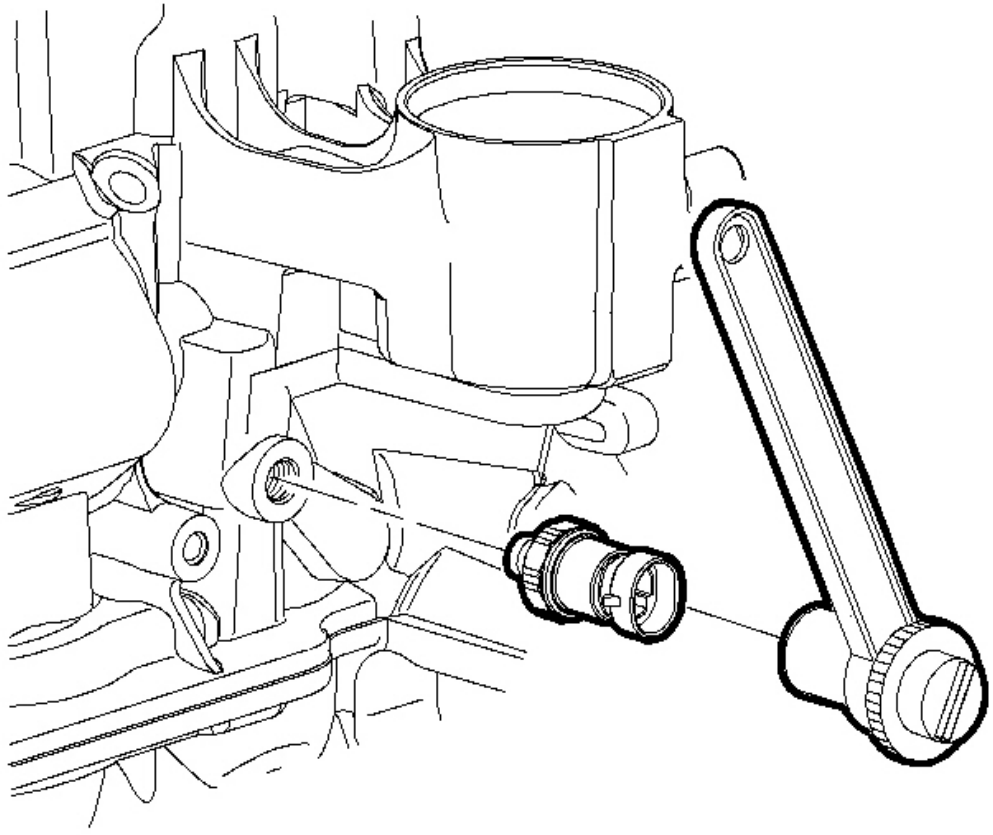


Fig. 34: View Of Engine Oil Pressure & Switch
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the EOP switch.

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

3. Connect the EOP switch harness connector. Push in the connector until a click is heard, then pull back to confirm a positive engagement.
4. Check the oil level and fill if low.

5. Start the engine and check for leaks.

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. Observe the engine mount while raising the engine. Raising the engine removes the weight from the engine mount and creates slight tension on the rubber.
3. Replace the engine mount if the engine mount exhibits any of the following conditions:
   - The hard rubber is covered with heat check cracks.
   - The rubber is separated from the metal plate of the engine mount.
   - The rubber is split through the center of the engine mount.
   - The engine mount itself is leaking fluid.
4. For engine mount replacement. Refer to **Engine Mount Replacement** .

POWERTRAIN MOUNT BALANCE PROCEDURE - TOTAL MOUNT

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

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

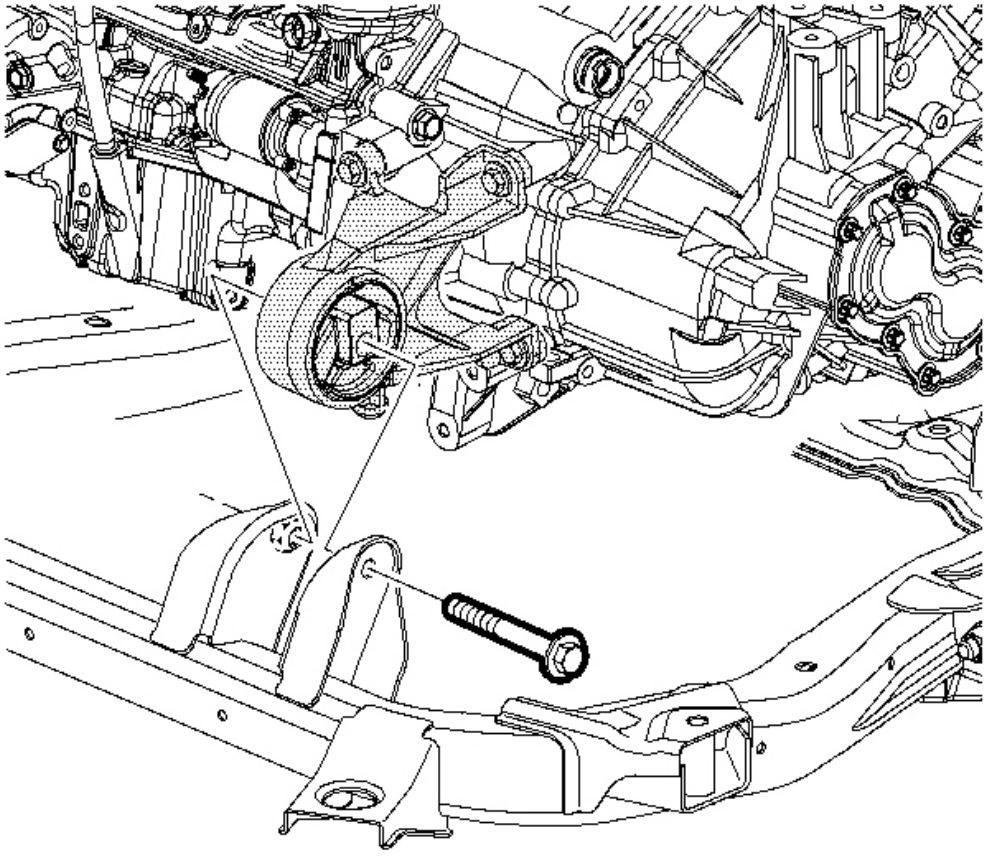


Fig. 35: Loosening Front Mount Through Bolt
Courtesy of GENERAL MOTORS CORP.

2. Loosen the front mount through bolt. Do not remove.

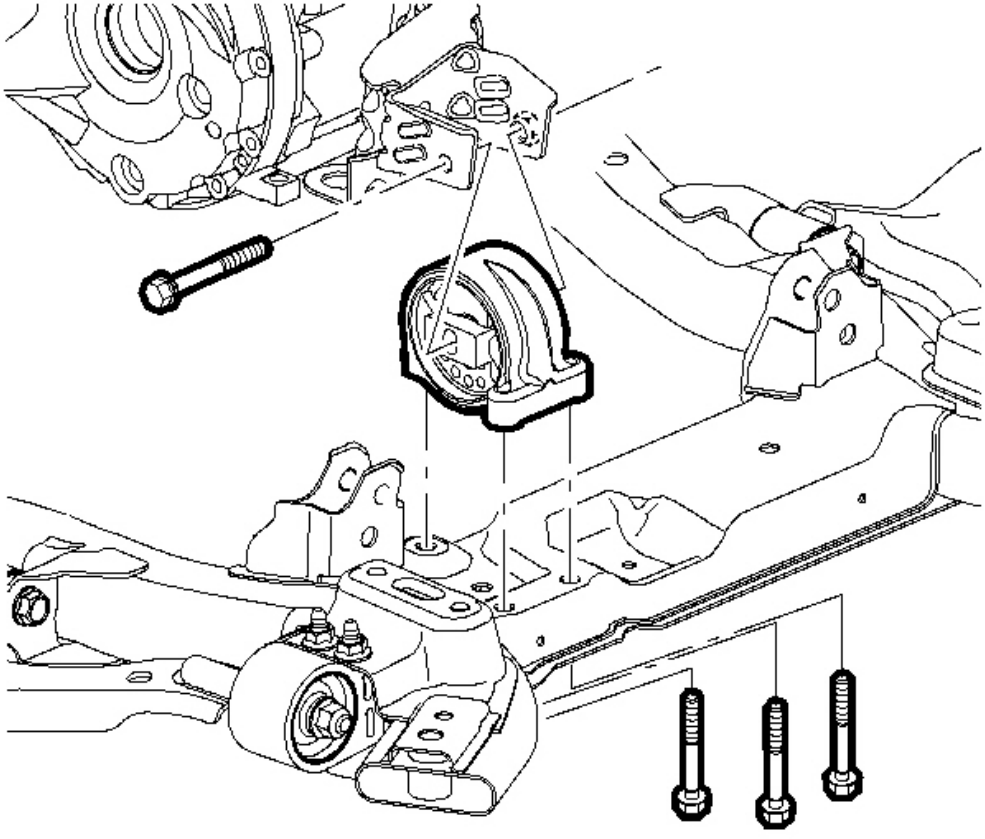


Fig. 36: Locating Engine Mount
Courtesy of GENERAL MOTORS CORP.

3. Loosen the rear mount through bolt. Do not remove.
4. Position two floor jacks with wood blocks under the engine and transmission to support the powertrain assembly.

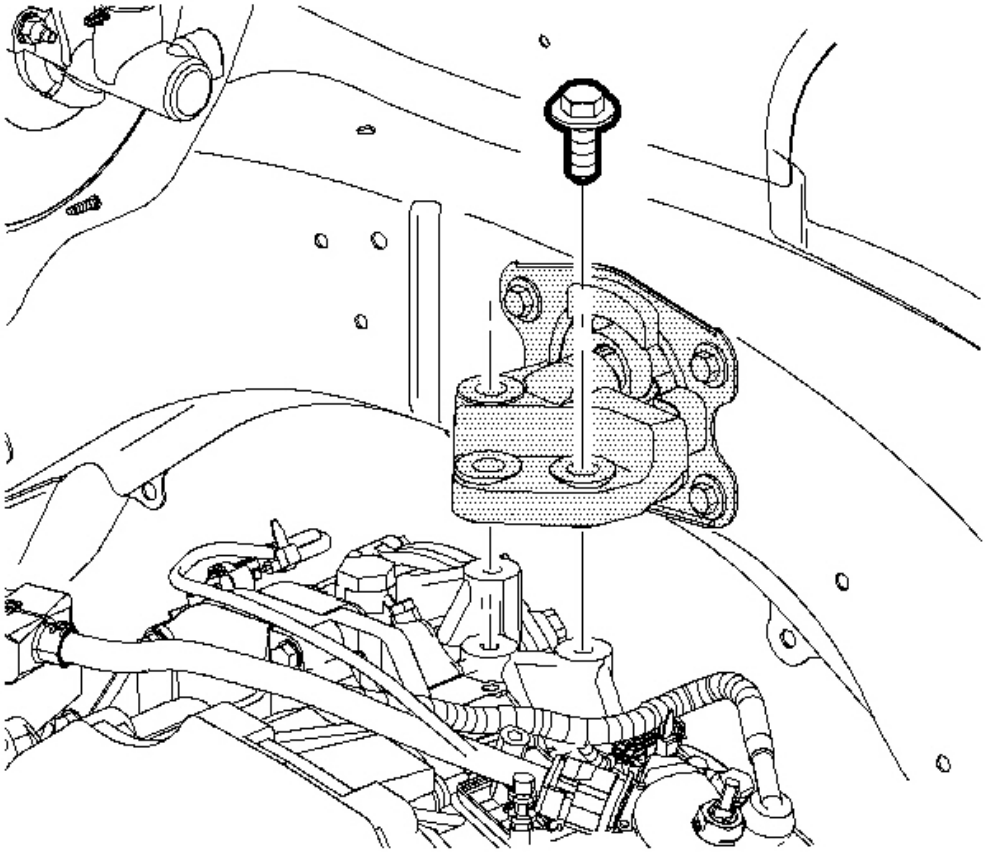


Fig. 37: Loosening Engine Compartment
Courtesy of GENERAL MOTORS CORP.

5. From the engine compartment, loosen, do not remove the LH mount bolts.

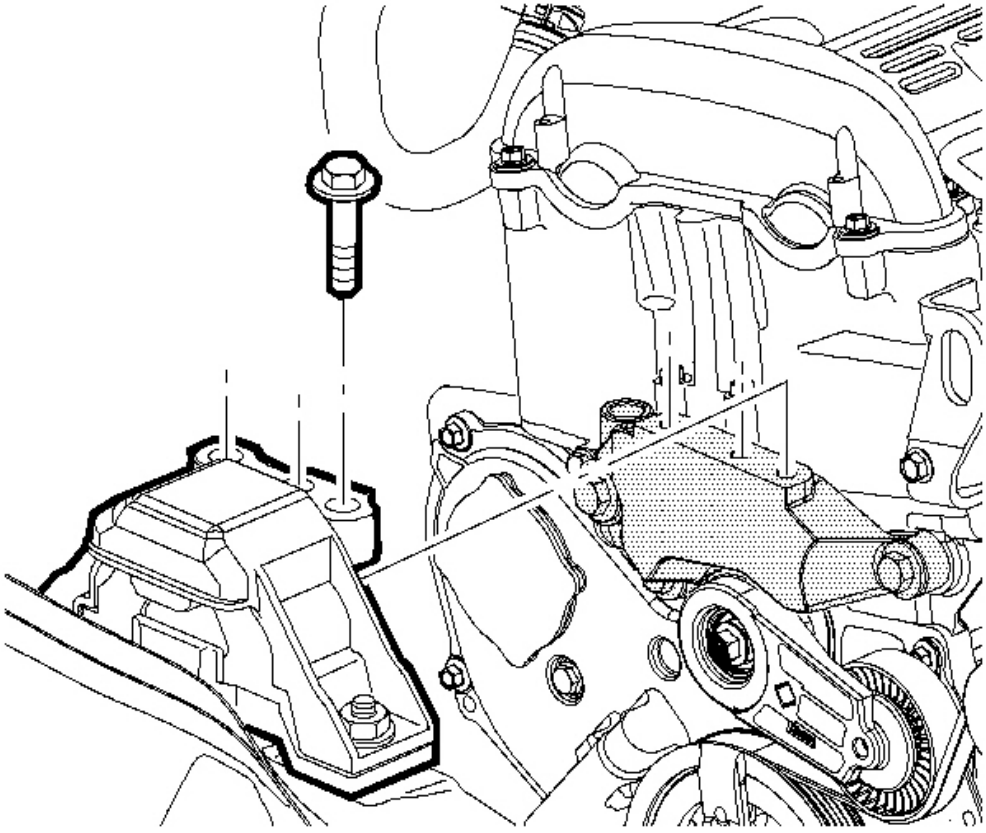


Fig. 38: Tightening RH Mount With The Center Bolt
Courtesy of GENERAL MOTORS CORP.

6. Loosen, do not remove the RH mount bolts.
7. Reposition the floor jacks to allow a 1/8 in gap between the mount and mount bracket

NOTE: Refer to Fastener Notice in Cautions and Notices.

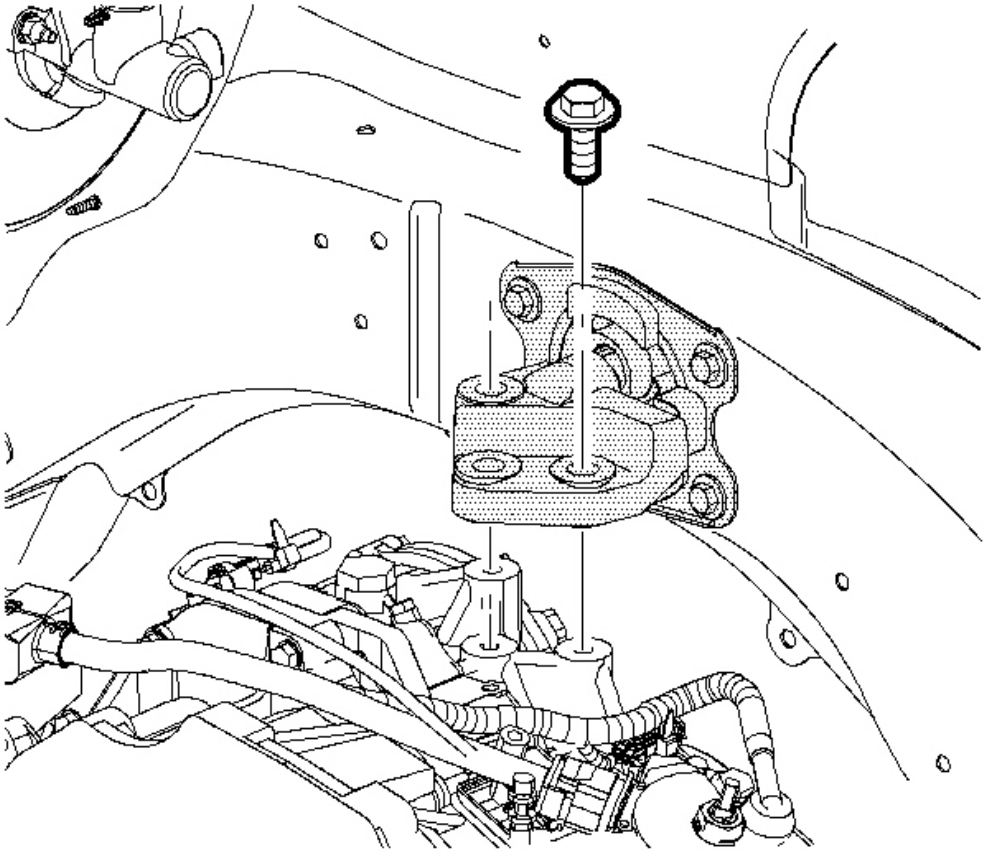


Fig. 39: LH Mount And Bolts
Courtesy of GENERAL MOTORS CORP.

8. Tighten the LH mount starting with the center bolt.

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

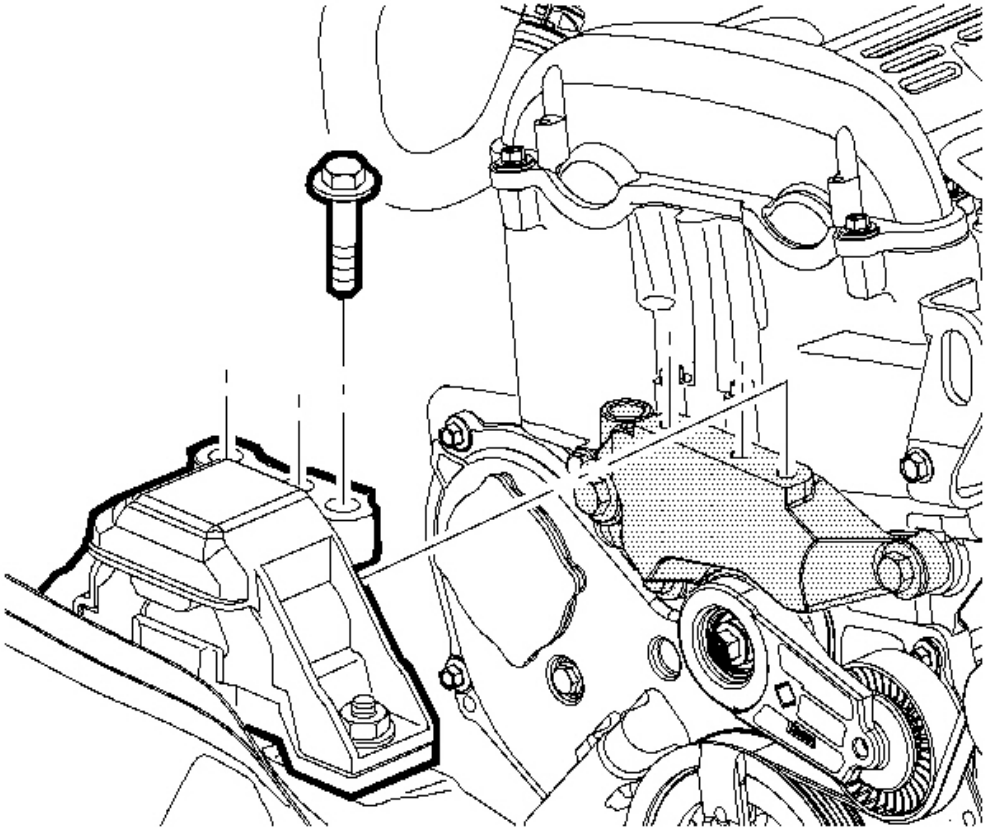


Fig. 40: RH Mount With Bolts
Courtesy of GENERAL MOTORS CORP.

9. Tighten the RH mount starting with the center bolt.

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

10. Remove the floor jacks.
11. Shake the powertrain Vigorously from front to rear and allow the powertrain to settle.

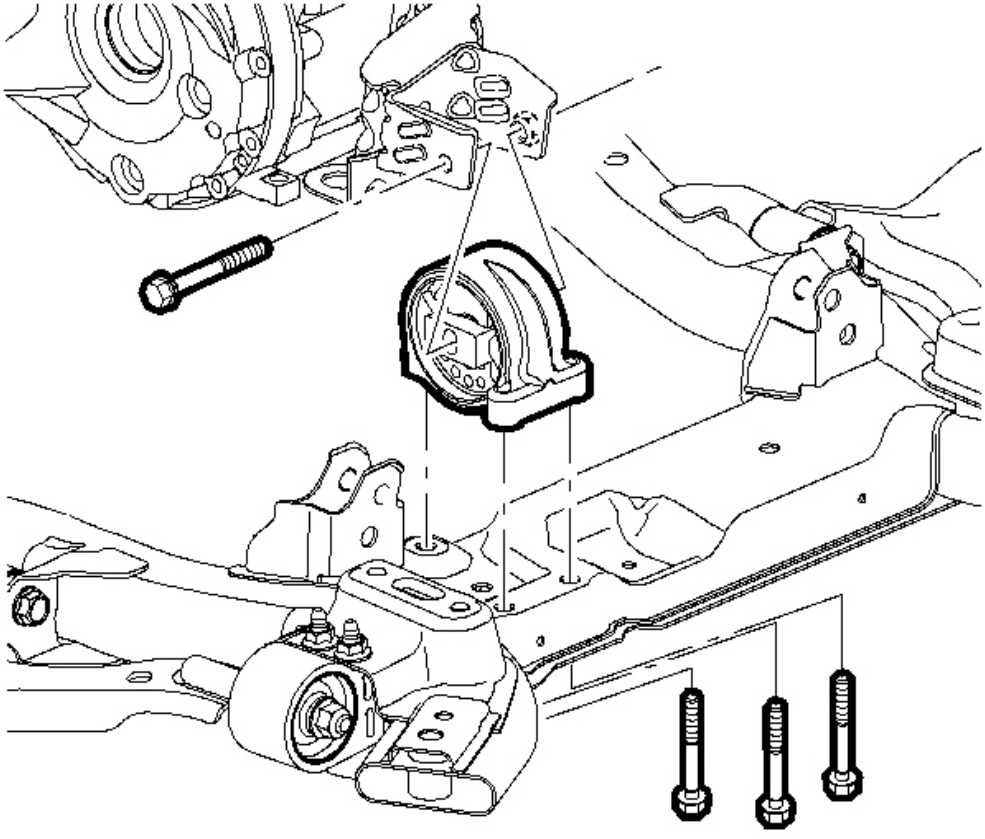


Fig. 41: Locating Rear Engine Mount
Courtesy of GENERAL MOTORS CORP.

12. Tighten the rear mount through bolt.

    Tighten: Tighten the bolts to 110 N.m (81 lb ft).

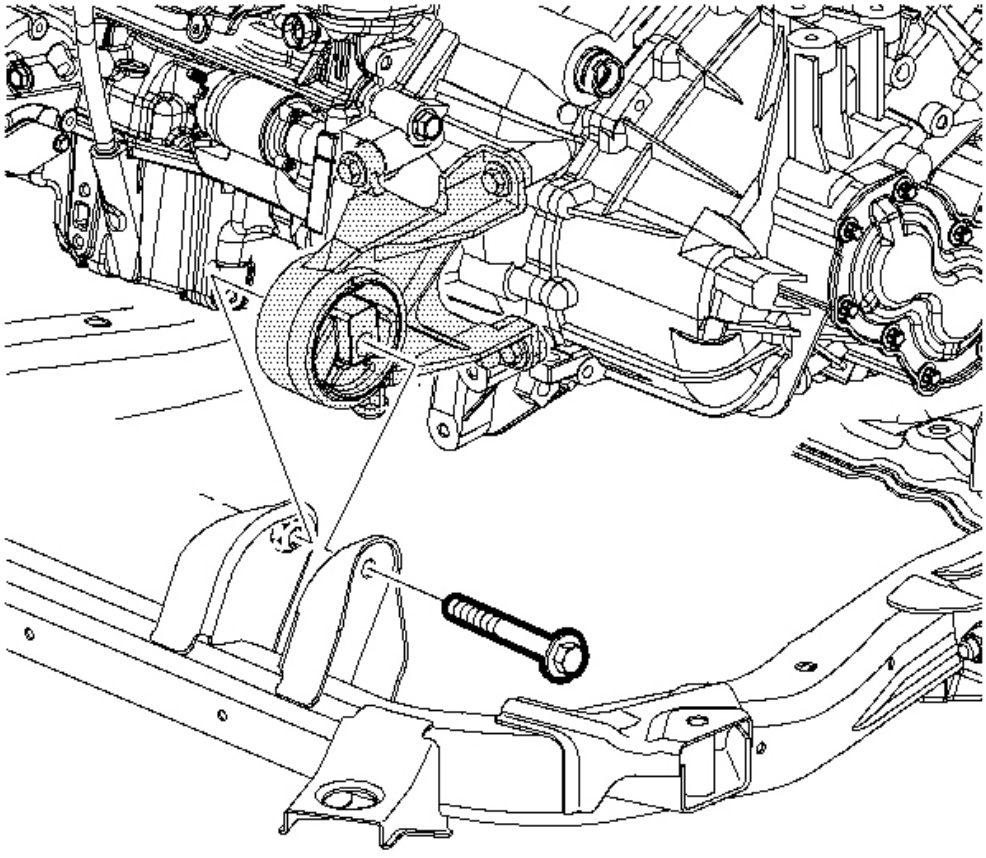


Fig. 42: Front Mount Through Bolt
Courtesy of GENERAL MOTORS CORP.

13. Tighten the front mount through bolt.

    Tighten: Tighten the bolts to 110 N.m (81 lb ft).

14. Lower the vehicle.

POWERTRAIN MOUNT BALANCE PROCEDURE - LOWER MOUNT

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

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

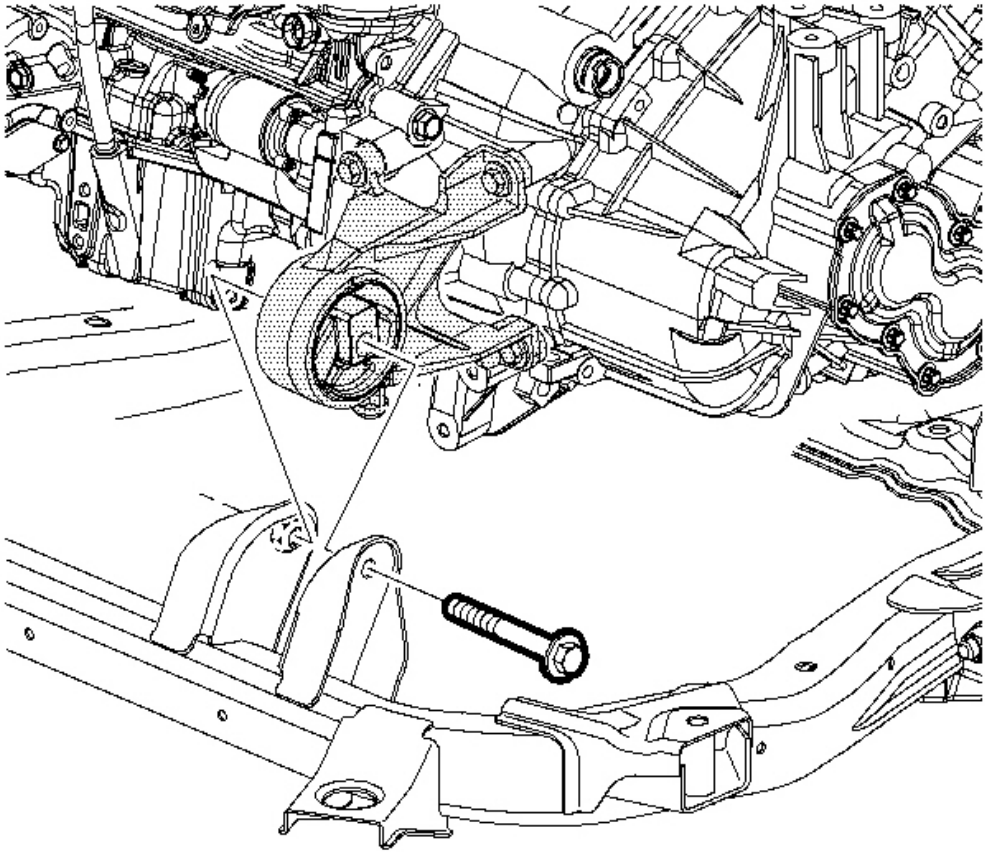


Fig. 43: Front Mount Through Bolt
Courtesy of GENERAL MOTORS CORP.

2. Loosen the front mount through bolt. Do not remove.

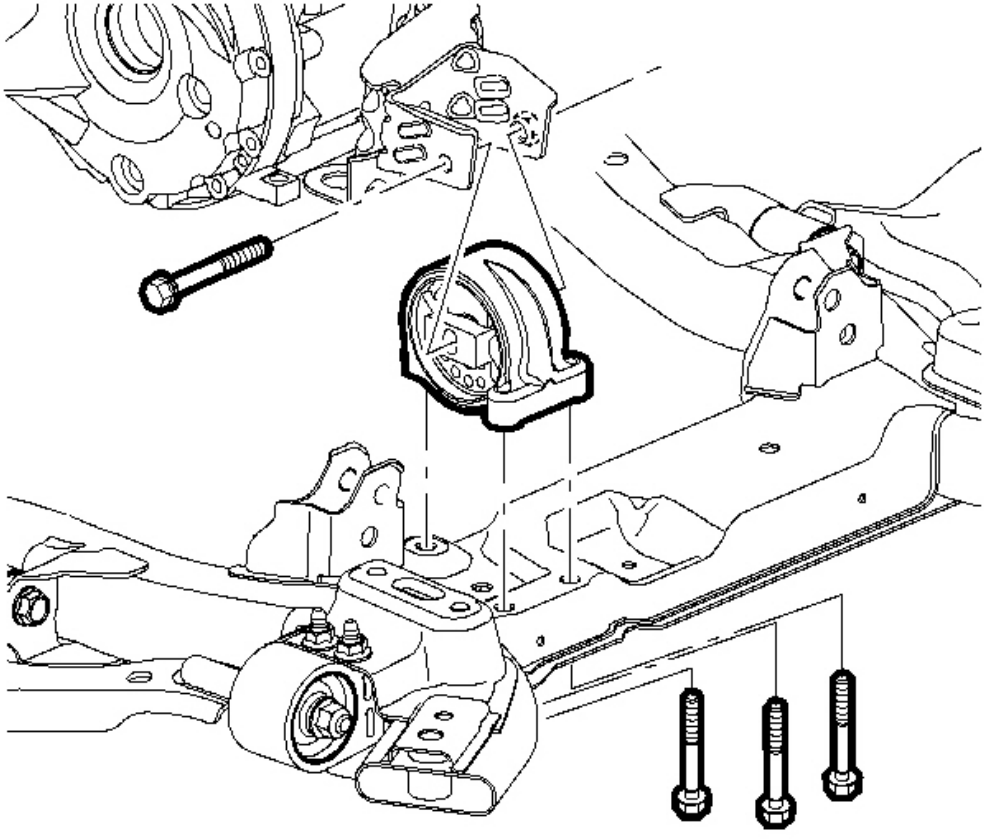


Fig. 44: Locating Rear Engine Mount
Courtesy of GENERAL MOTORS CORP.

3. Loosen the rear mount through bolt. Do not remove.
4. Shake the powertrain vigorously from front to rear and allow the powertrain to settle.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Tighten the rear motor mount through bolt.

Tighten: Tighten the bolt to 110 N.m (81 lb ft).

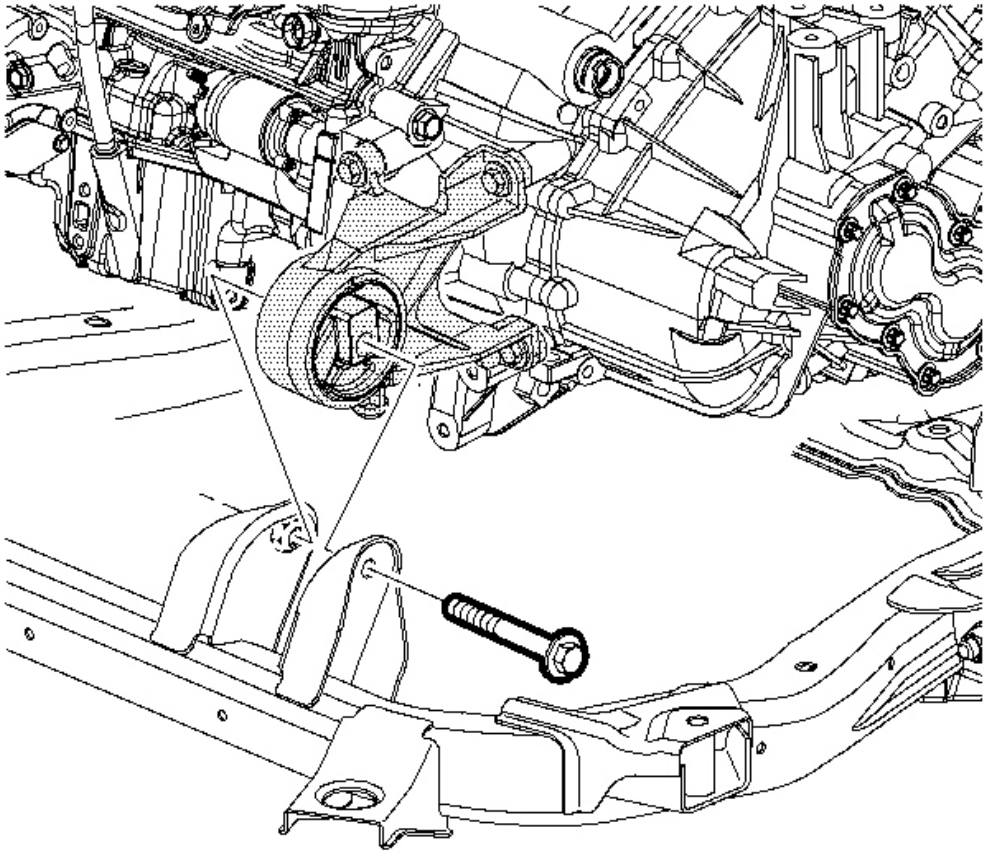


Fig. 45: Front Mount Through Bolt
Courtesy of GENERAL MOTORS CORP.

6. Tighten the front motor mount through bolt.

   Tighten: Tighten the bolt to 110 N.m (81 lb ft).

7. Lower the vehicle.

ENGINE MOUNT BRACKET REPLACEMENT

Removal Procedure

1. Remove the RH mount. Refer to **Engine Mount Replacement** .

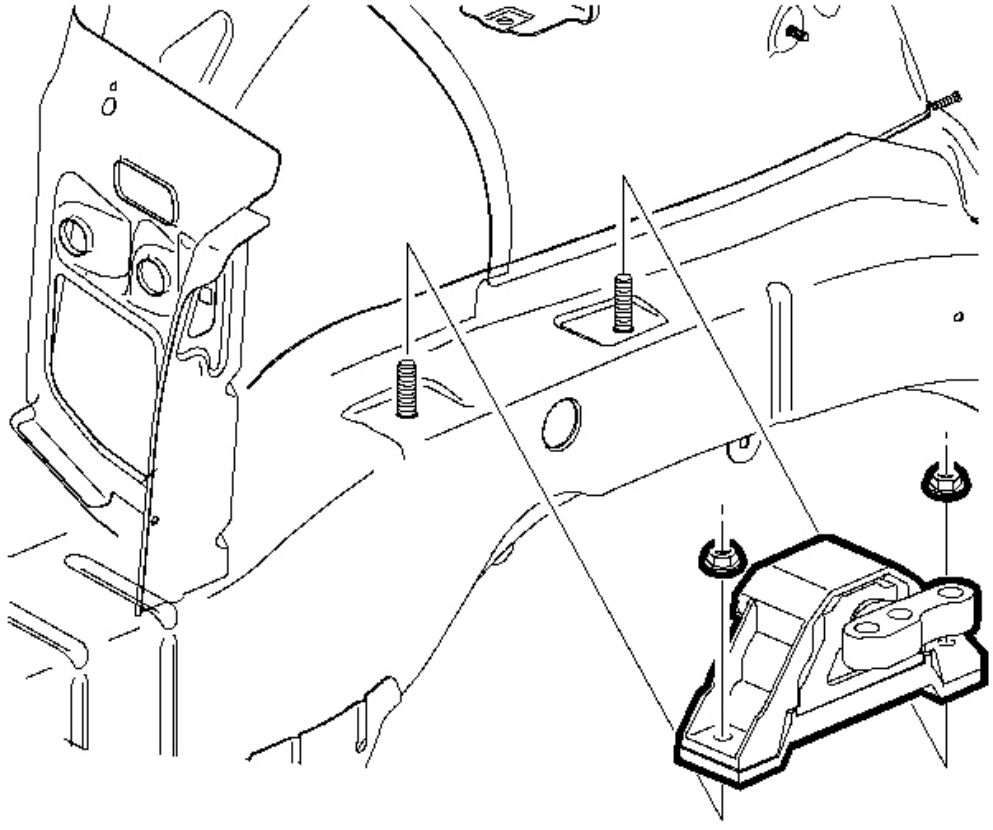


Fig. 46: View Of RH Engine Mount
Courtesy of GENERAL MOTORS CORP.

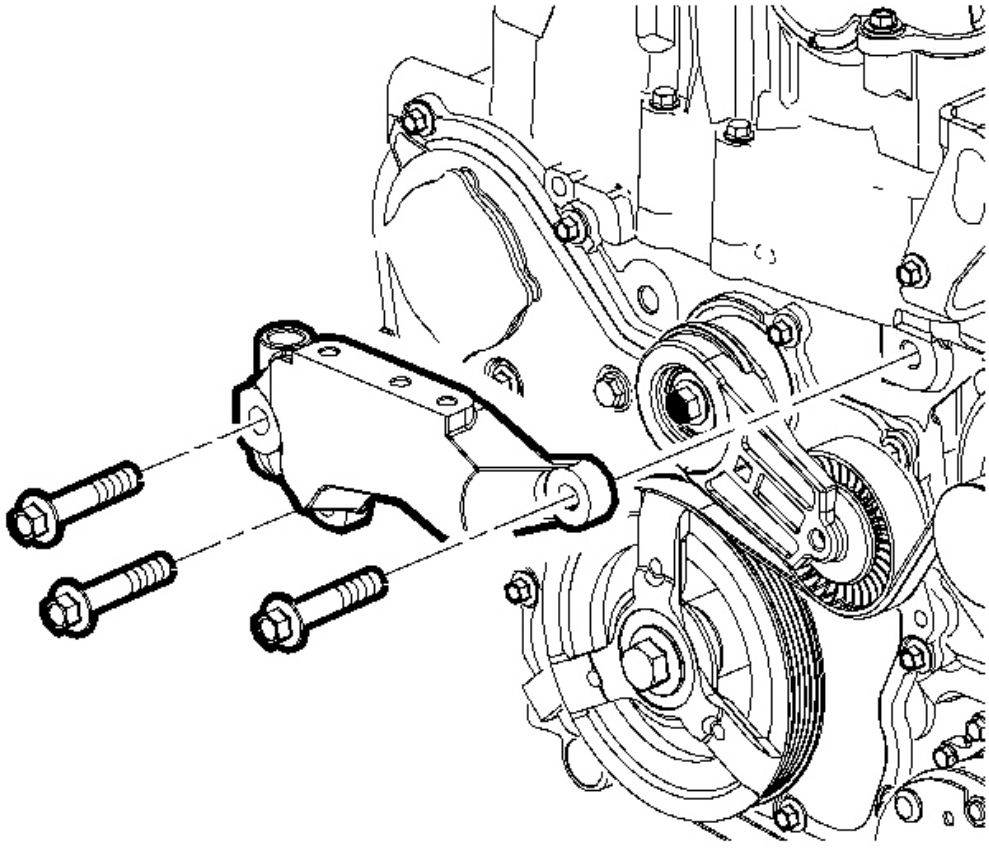


Fig. 47: Removing/Installing Right Hand Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

2. Remove the mount bracket to engine bolts.
3. Remove the mount bracket from the engine.

Installation Procedure

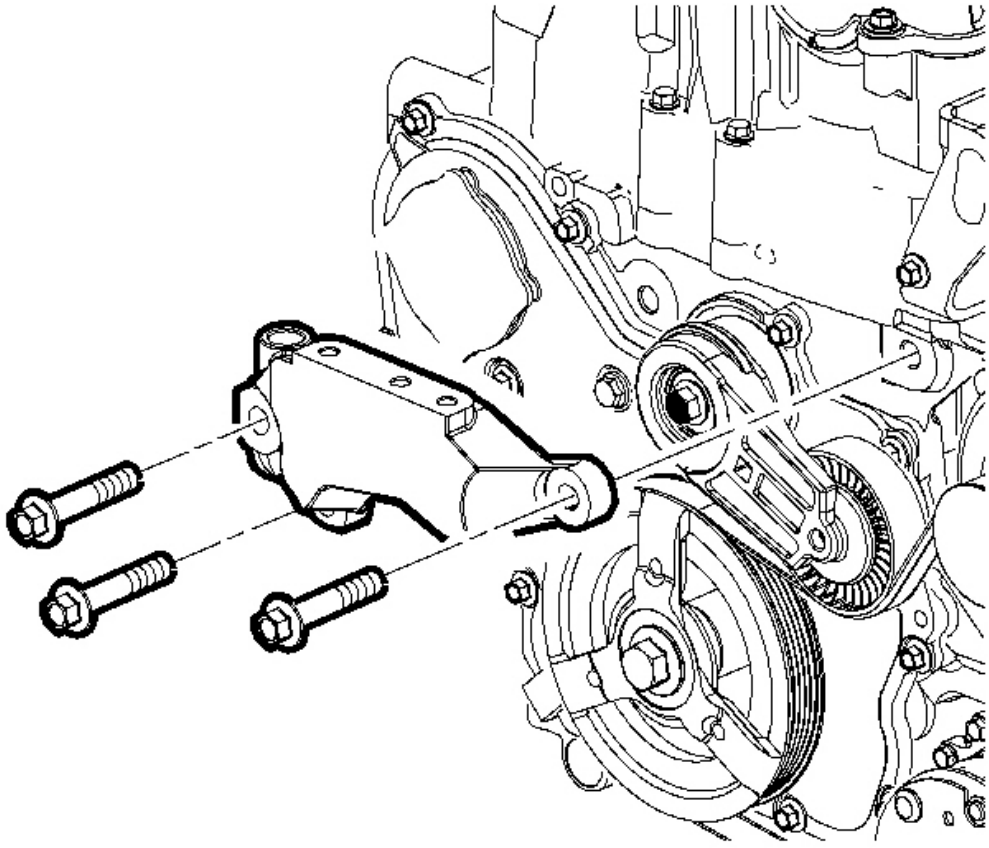


Fig. 48: Removing/Installing Right Hand Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

1. Place the mount bracket to the engine.

NOTE: **Refer to Fastener Notice in Cautions and Notices.**

2. Install the mount bracket to engine bolts.

Tighten: Tighten the bolts to 110 N.m (81 lb ft).

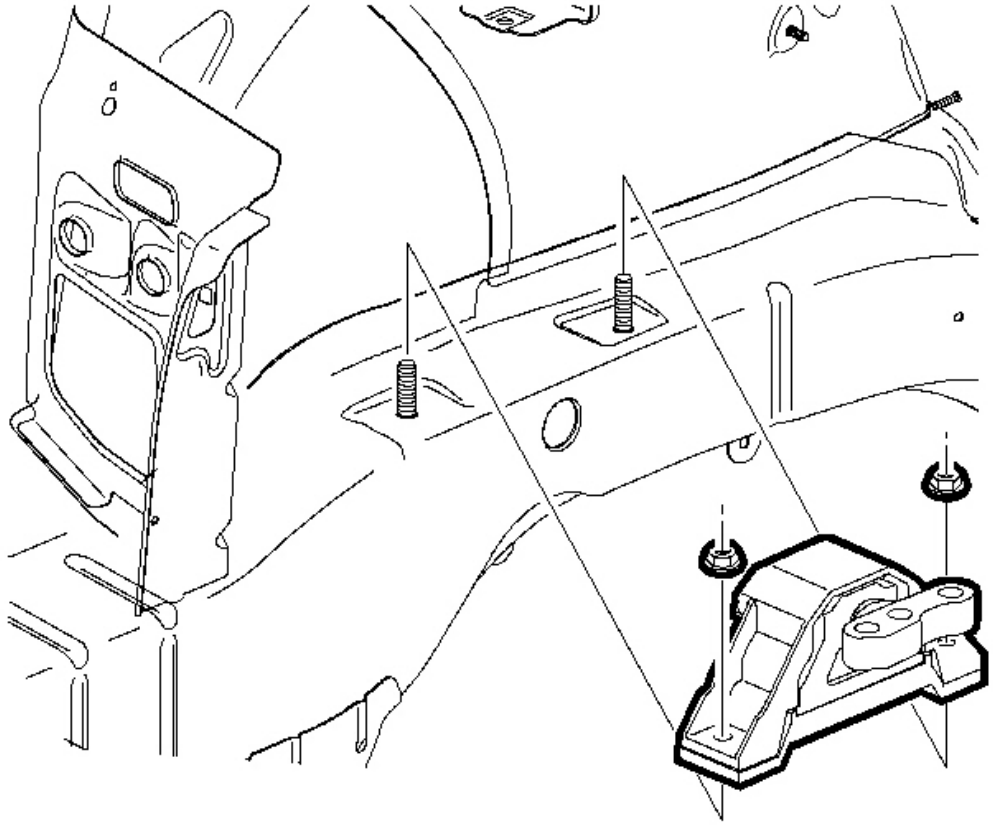


Fig. 49: View Of RH Engine Mount
Courtesy of GENERAL MOTORS CORP.

3. Install the RH mount. Refer to **Engine Mount Replacement** .

IMPORTANT: Powertrain mounts must be tightened in sequence.

4. Balance the powertrain mounts. Refer to **Powertrain Mount Balance Procedure - Total Mount** .

ENGINE MOUNT REPLACEMENT

Removal Procedure

1. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** in Engine Controls.
2. Place a floor jack with a wood block under the engine oil pan in order to support the powertrain.

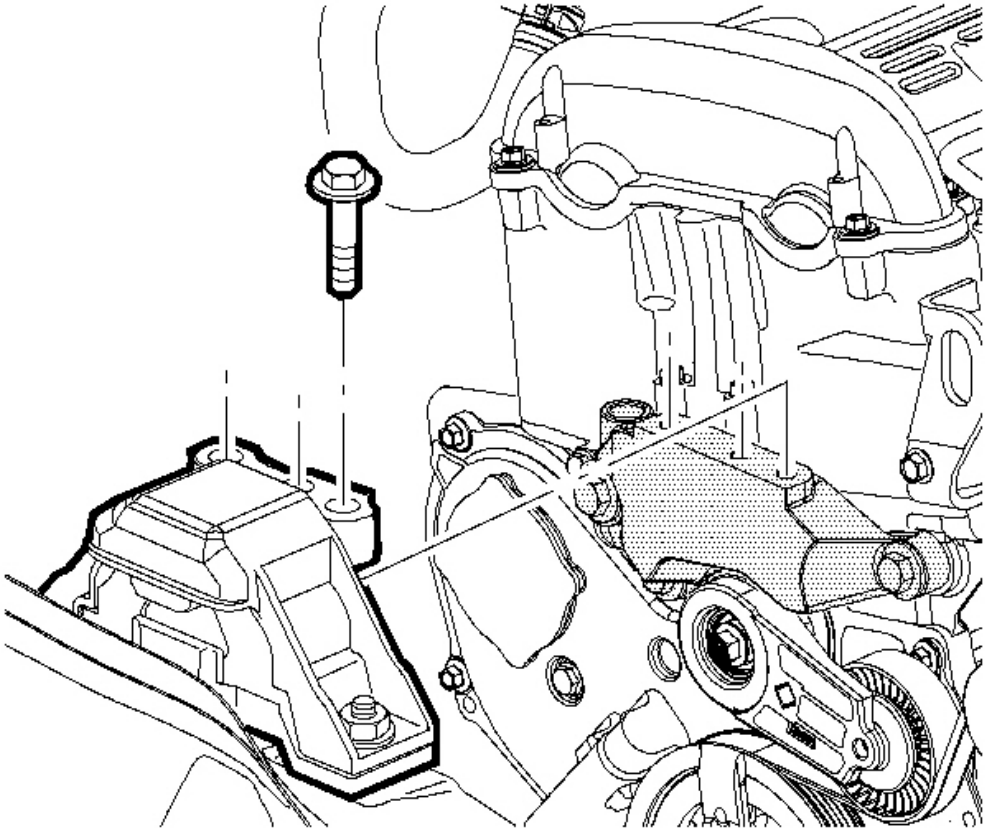


Fig. 50: Tightening RH Mount With The Center Bolt
Courtesy of GENERAL MOTORS CORP.

3. Remove the mount to mount bracket bolts.

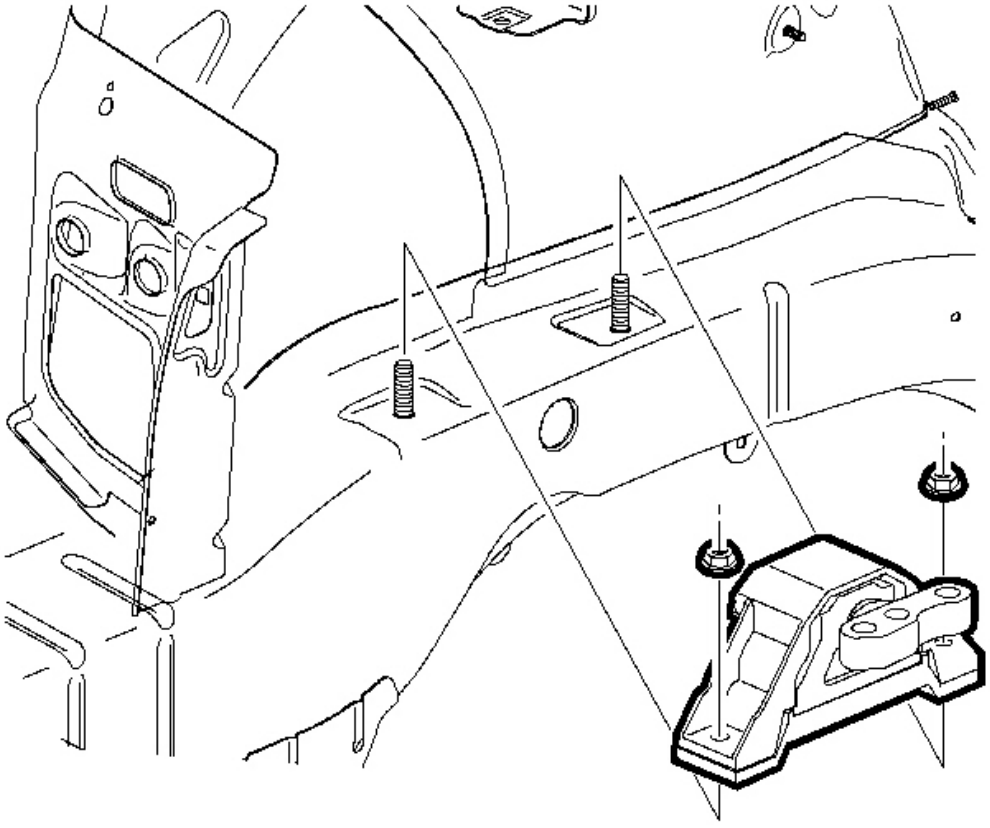


Fig. 51: View Of RH Engine Mount
Courtesy of GENERAL MOTORS CORP.

4. Remove the mount to frame rail nuts.
5. Remove the RH mount.

Installation Procedure

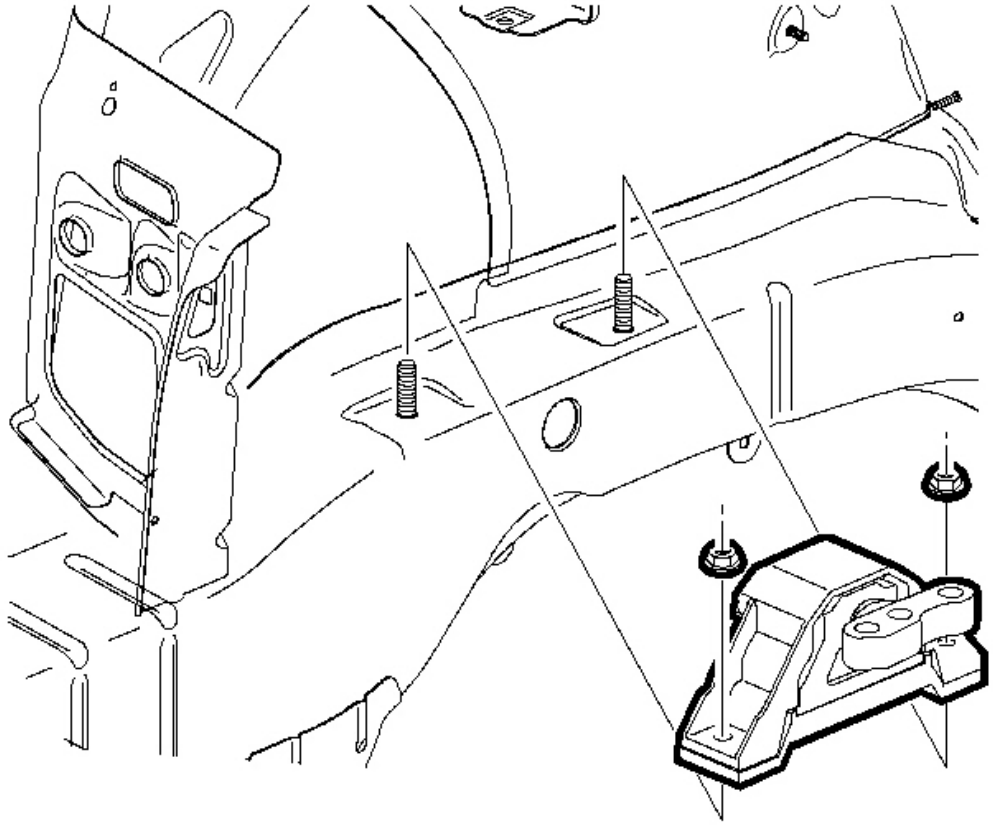


Fig. 52: View Of RH Engine Mount
Courtesy of GENERAL MOTORS CORP.

1. Install the RH mount to the frame rail studs.

NOTE: **Refer to Fastener Notice in Cautions and Notices.**

2. Install the RH mount to frame rail nuts.

Tighten: Tighten the nuts to 110 N.m (81 lb ft).

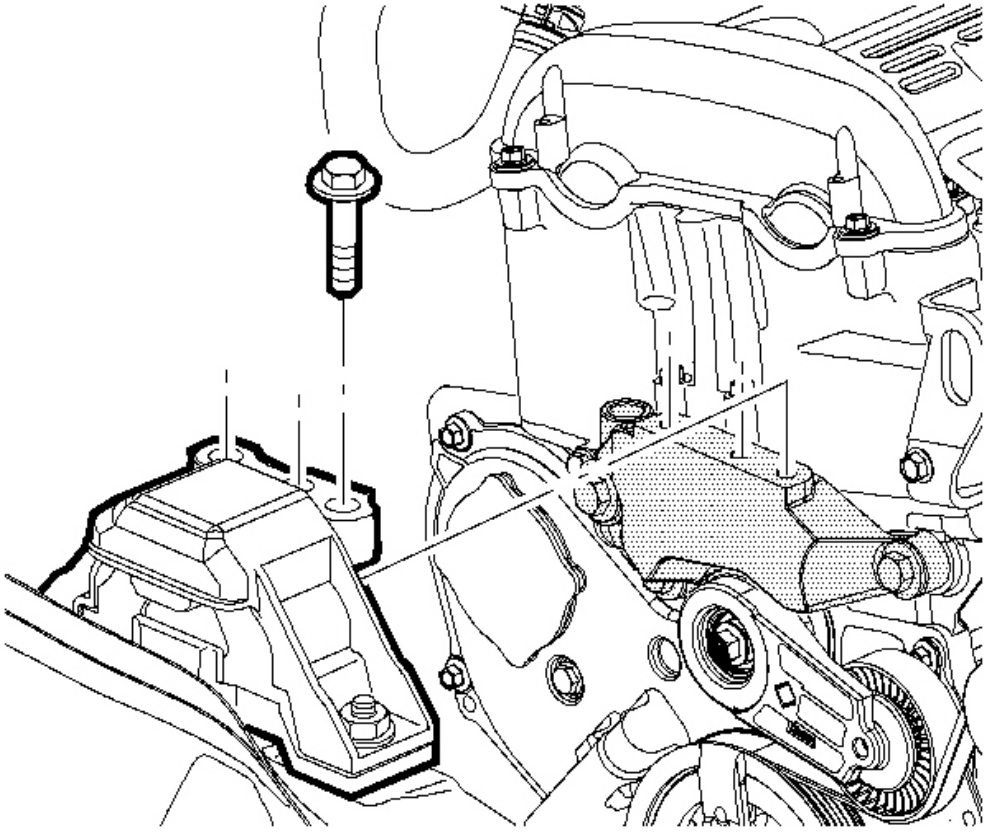


Fig. 53: Tightening RH Mount With The Center Bolt
Courtesy of GENERAL MOTORS CORP.

3. Hand start the RH mount to bracket bolts.

IMPORTANT: Powertrain mounts must be tightened in sequence.

4. Balance the powertrain mounts. Refer to **Powertrain Mount Balance Procedure - Total Mount** .
5. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** in Engine Controls.

ENGINE SUPPORT FIXTURE

Tools Required

- **SA9105E** Engine Support Fixture (3-Bar). See **Special Tools and Equipment** .
- **J 43405** Engine Support Fixture Adapter. See **Special Tools and Equipment** .

Installation Procedure

1. Install the **SA9105E** (2) to the vehicle. See **Special Tools and Equipment** .
2. Install the J 45122 (1) to the engine support fixture legs.

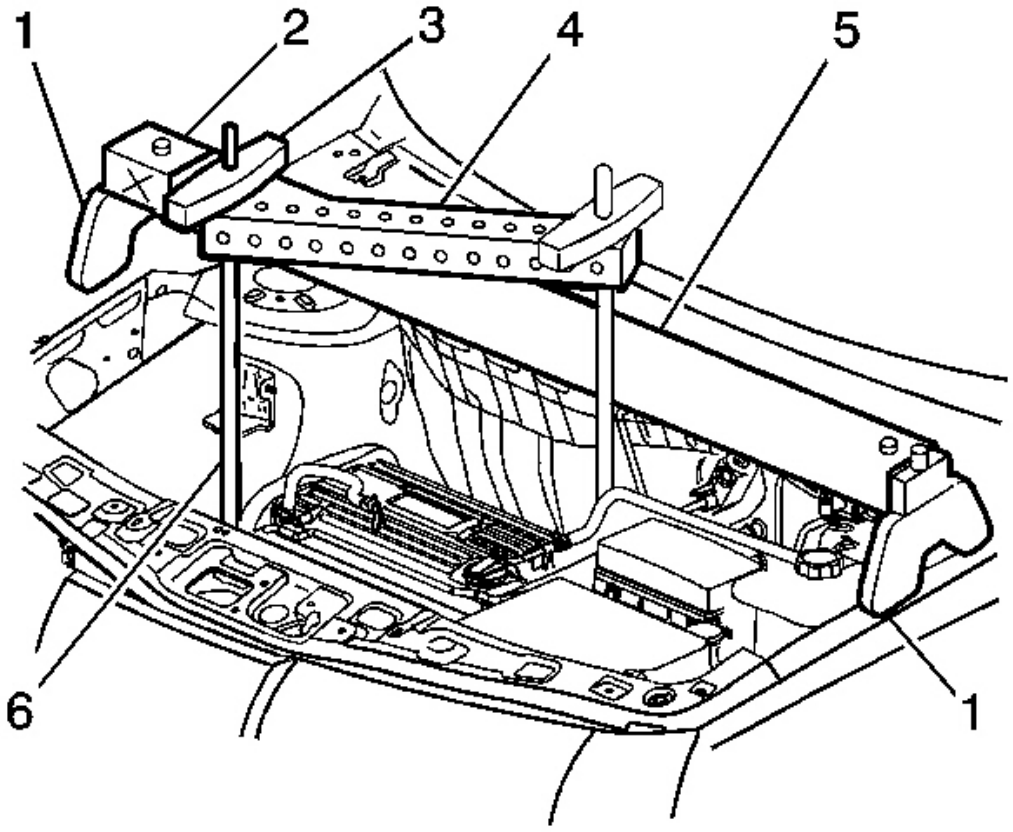


Fig. 54: View Of Engine Support Fixture
Courtesy of GENERAL MOTORS CORP.

3. Install the **SA9105E** (4) to the engine support fixture long bar. See **Special Tools and Equipment** .
4. Install the **J 43405** (5) to engine support crossbar. See **Special Tools and Equipment** .
5. Install the **J 43405** (6) to the engine support fixture hooks. See **Special Tools and Equipment** .

OIL LEVEL INDICATOR AND TUBE REPLACEMENT

Removal Procedure

1. Remove the oil level indicator tube bolt from the intake manifold.

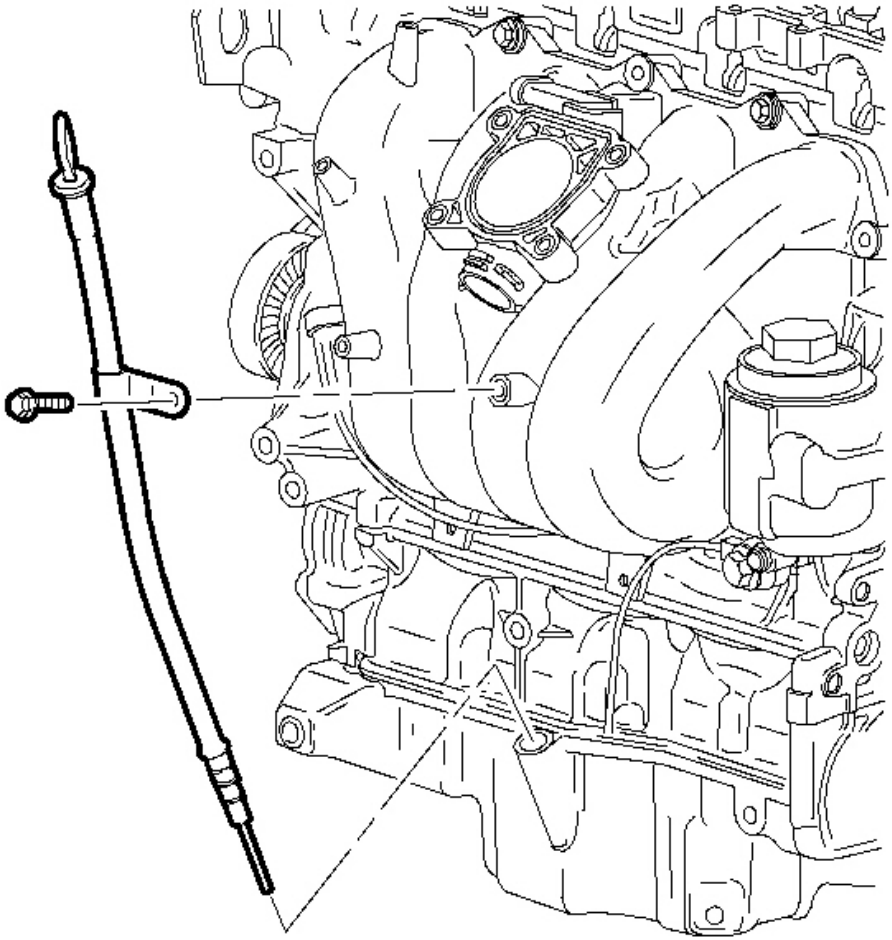


Fig. 55: View Of Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil level tube assembly.
3. Replace the oil level tube O-ring seal if damaged.

Installation Procedure

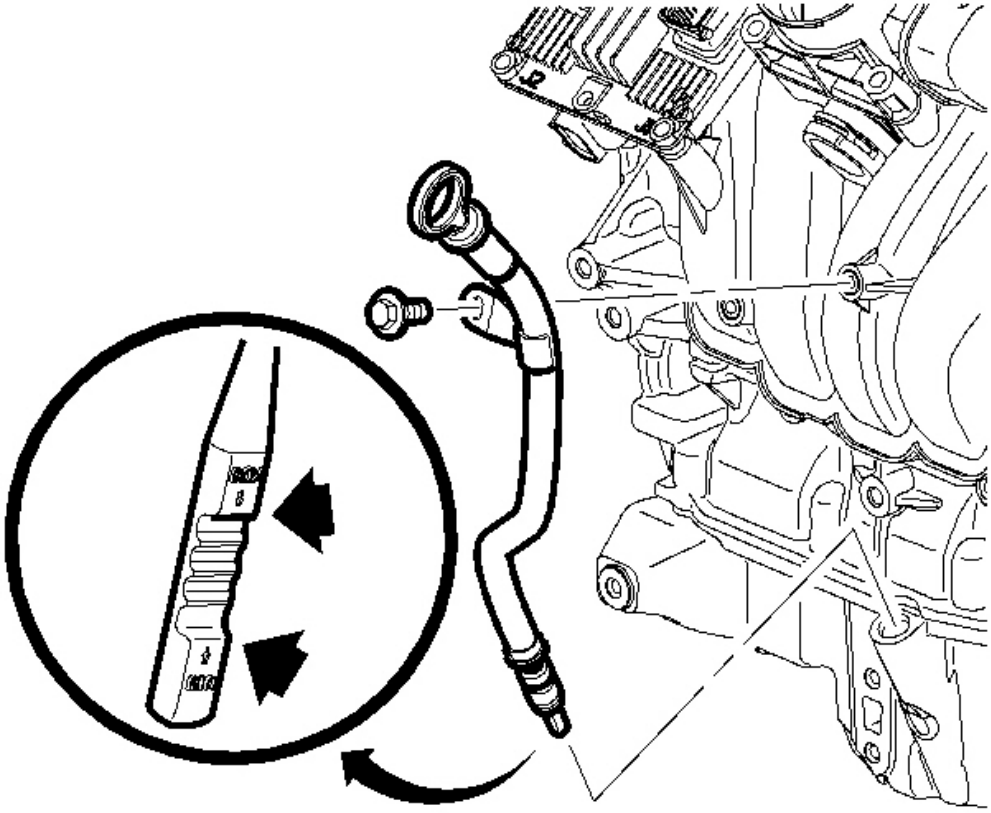


Fig. 56: Installing Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

1. Install the oil level indicator tube into the block.

NOTE: **Refer to Fastener Notice in Cautions and Notices.**

2. Install the oil level indicator tube bolt to the intake manifold.

Tighten: Tighten the oil indicator tube assembly bolt - L61 to 10 N.m (89 lb in).

INTAKE MANIFOLD REPLACEMENT

Removal Procedure

1. Disconnect the intake air temperature (IAT) sensor connector.

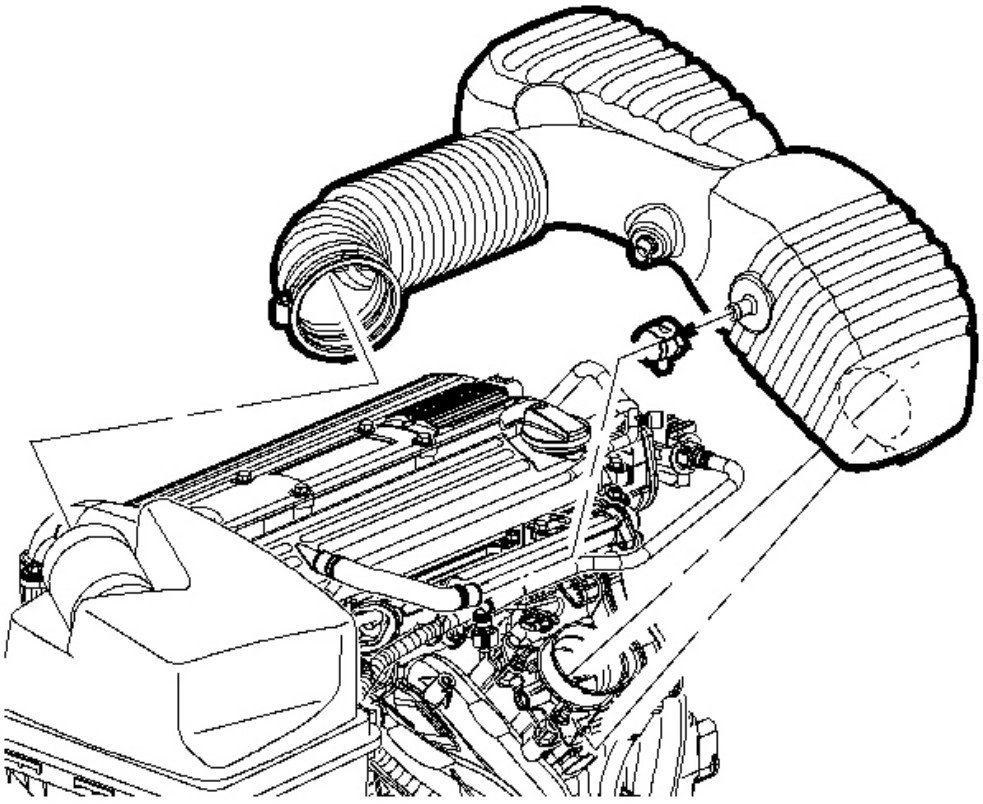


Fig. 57: Locating Air Intake Assembly
Courtesy of GENERAL MOTORS CORP.

2. Loosen the clamp at the air cleaner assembly.
3. Remove the push pin attachment from the outlet resonator/duct assembly to support bracket.
4. Loosen the clamp at the throttle body assembly.
5. Disconnect the PCV fresh air vent hose at the outlet duct assembly.
6. Remove the outlet resonator/duct assembly.

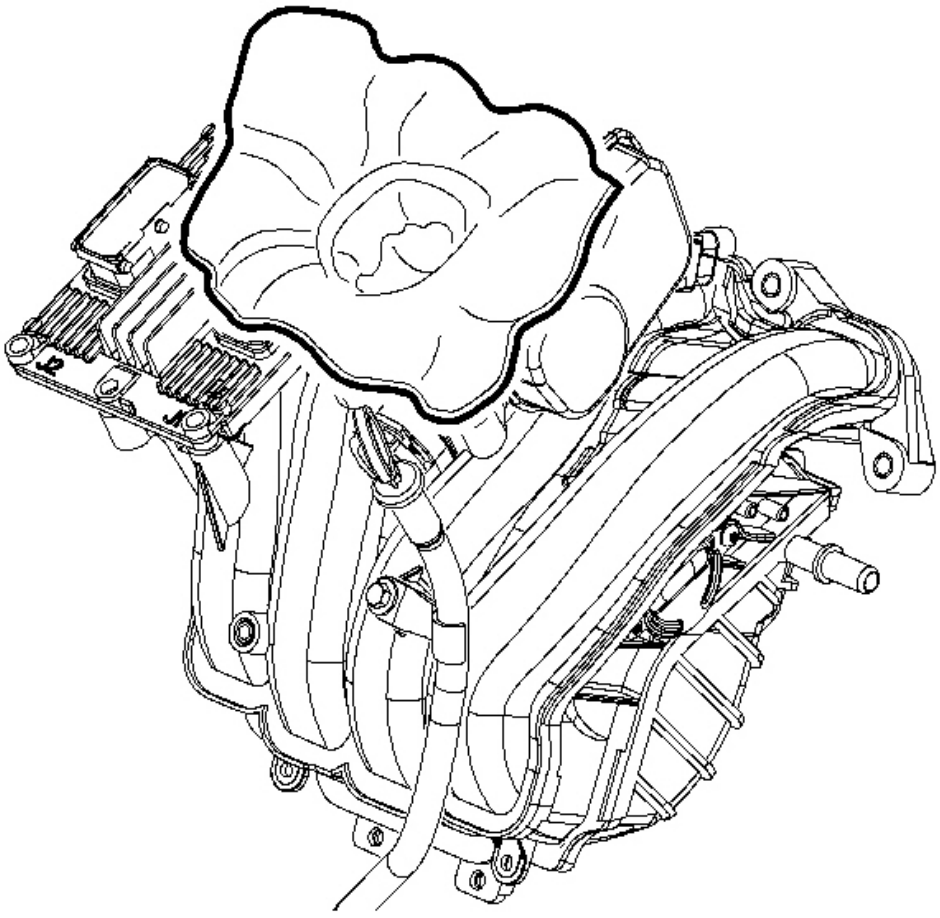


Fig. 58: Cover Throttle Body Opening With A Shop Towel
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The mating surfaces between the throttle body to manifold and manifold to cylinder head should be free from dirt and foreign material before servicing.

7. Cover the throttle body opening with a shop towel and use the shop air to remove any dirt at the base of the throttle body to intake and intake manifold to cylinder head.

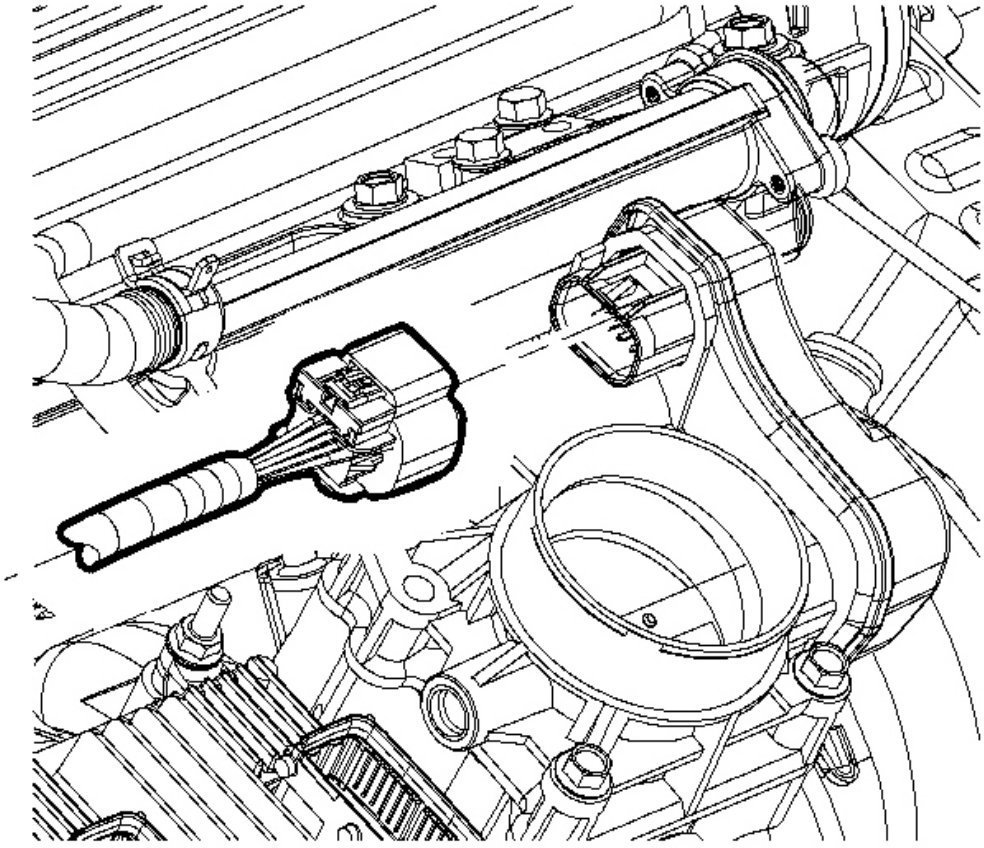


Fig. 59: Disconnecting/Connecting Throttle Body Electrical Connector
Courtesy of GENERAL MOTORS CORP.

8. Disconnect the harness connector at the throttle body.

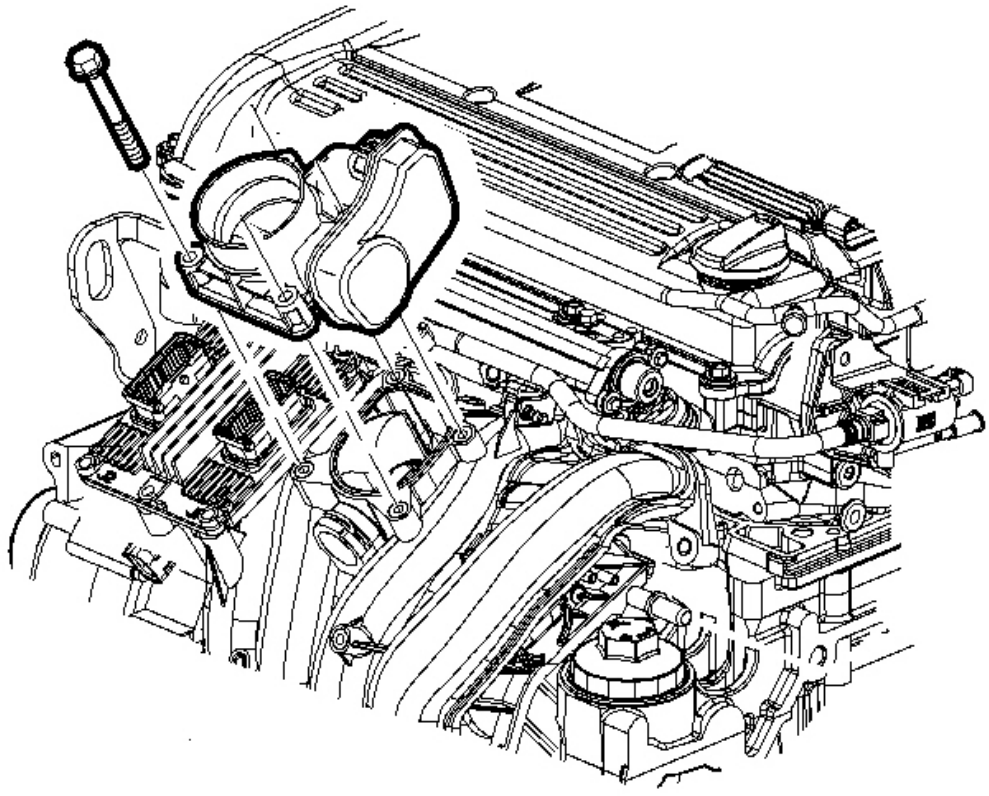


Fig. 60: Removing/Installing Throttle Body Gasket
Courtesy of GENERAL MOTORS CORP.

9. Remove the throttle body bolts.
10. Remove the throttle body.
11. Remove the throttle body gasket.

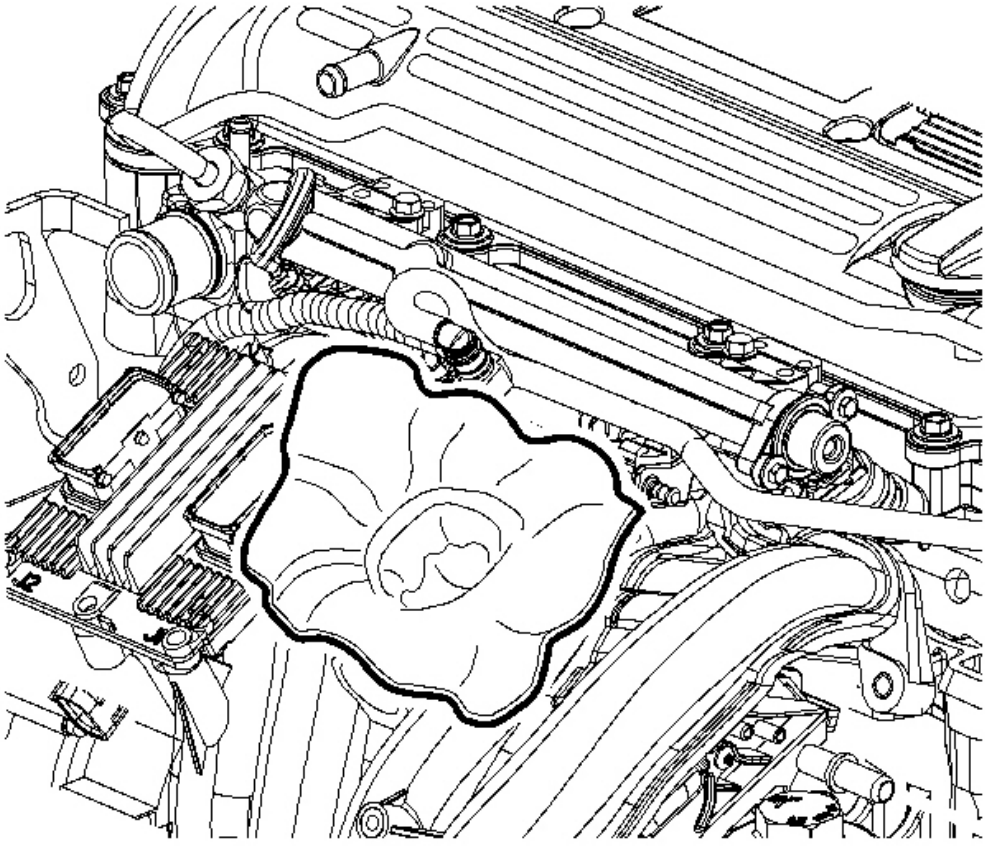


Fig. 61: Removing Shop Towel From The Throttle Body Opening
Courtesy of GENERAL MOTORS CORP.

NOTE: Cover the intake manifold opening with a shop towel whenever the throttle body is removed to prevent foreign material entry.

12. Block the intake manifold opening with a clean shop towel to prevent dirt from entering.

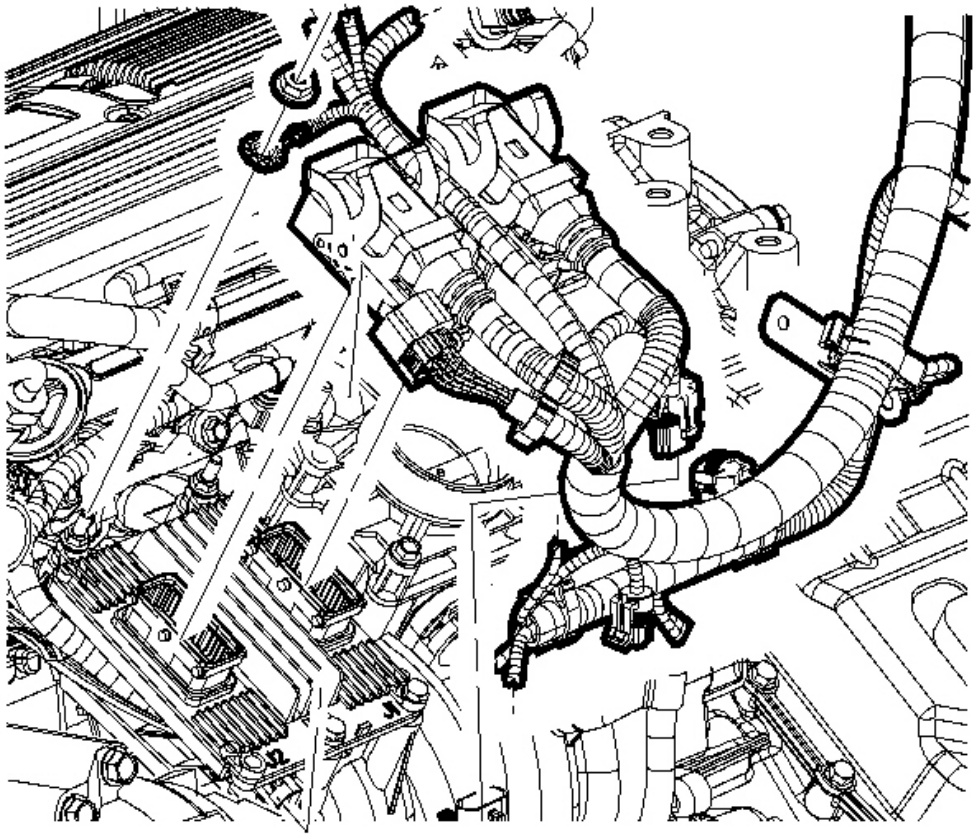


Fig. 62: Removing/Installing ECM Assembly & Bolts
Courtesy of GENERAL MOTORS CORP.

13. Remove the engine control module (ECM) bolts and set the ECM aside.
14. Disconnect the electrical connectors (injector harness) attach to the side of the manifold and position the harness away from the manifold and set aside.
15. Disconnect the manifold absolute pressure (MAP) sensor.
16. Disconnect the purge hose.
17. Disconnect the electrical attachment bolt at bottom of the manifold.
18. Raise the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
19. Disconnect the electrical harness clips at the bottom of the manifold.

20. Lower the vehicle.

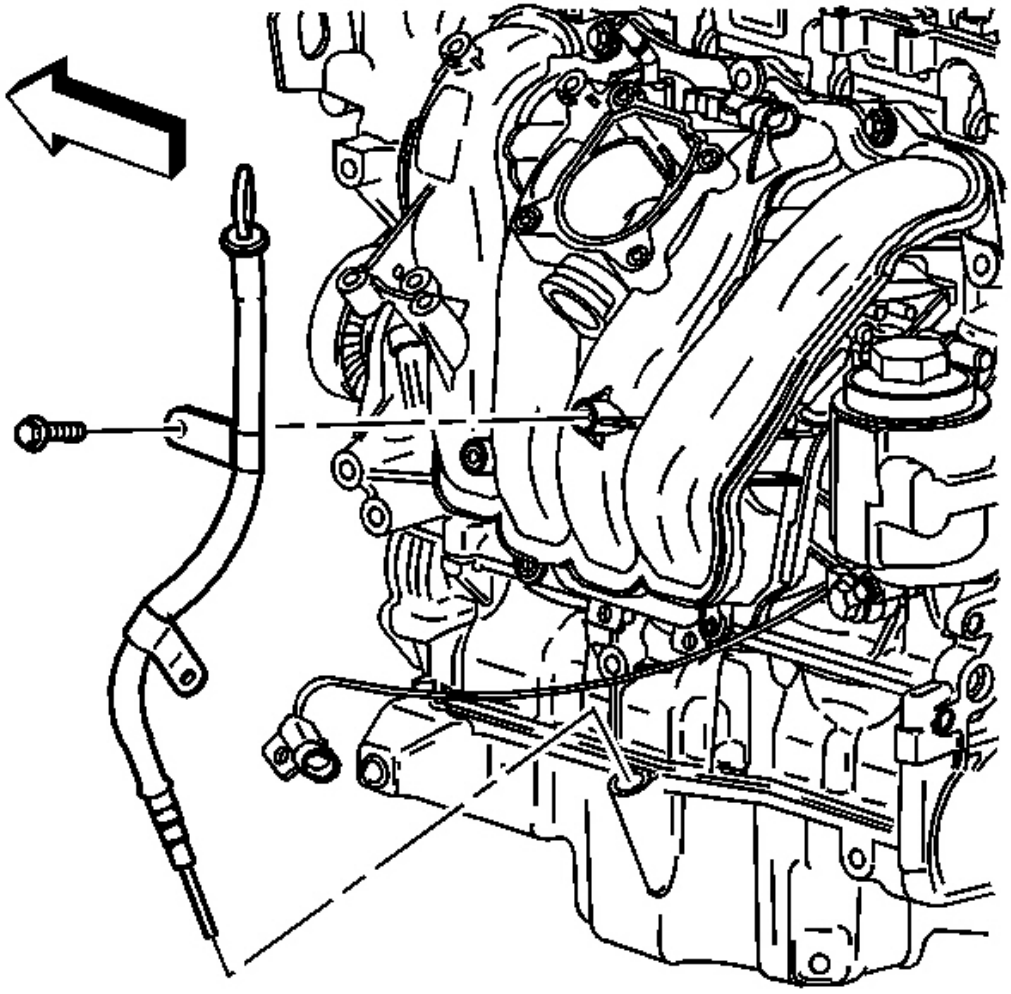


Fig. 63: Removing/Installing Oil Level Indicator Tube Assembly & Bolt
Courtesy of GENERAL MOTORS CORP.

21. Remove the oil level tube bolt and rotate tube away from the manifold.
22. Remove the intake manifold bolts and nuts.
23. Pull the manifold away from the cylinder head.

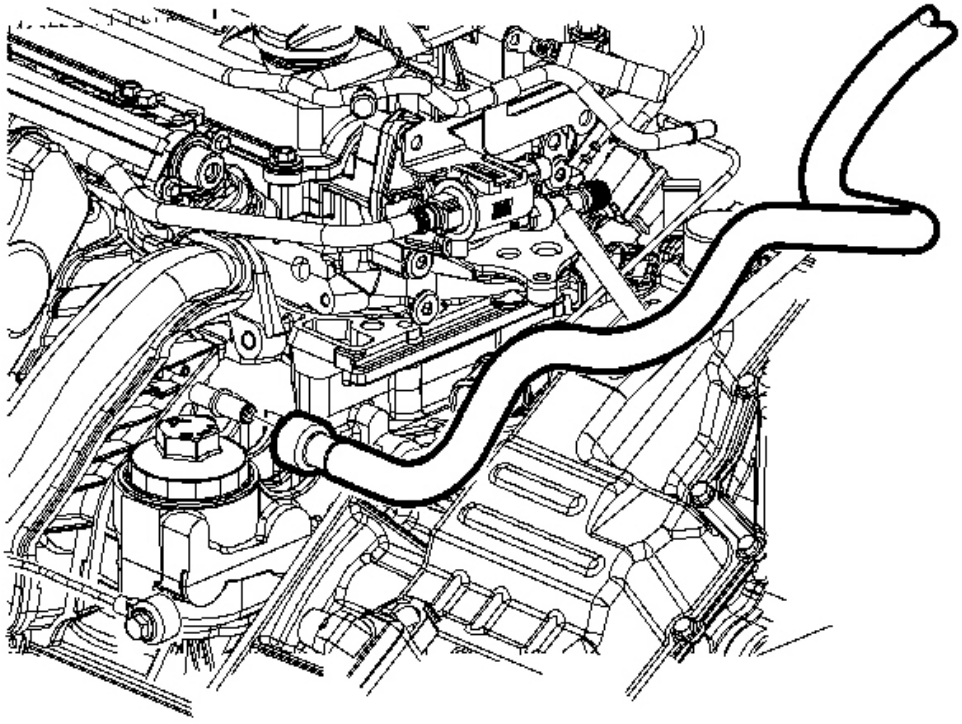


Fig. 64: Disconnecting/Connecting Brake Booster Hose
Courtesy of GENERAL MOTORS CORP.

24. Disconnect the brake booster hose at the manifold by releasing the white tab.
25. Remove the intake manifold assembly.

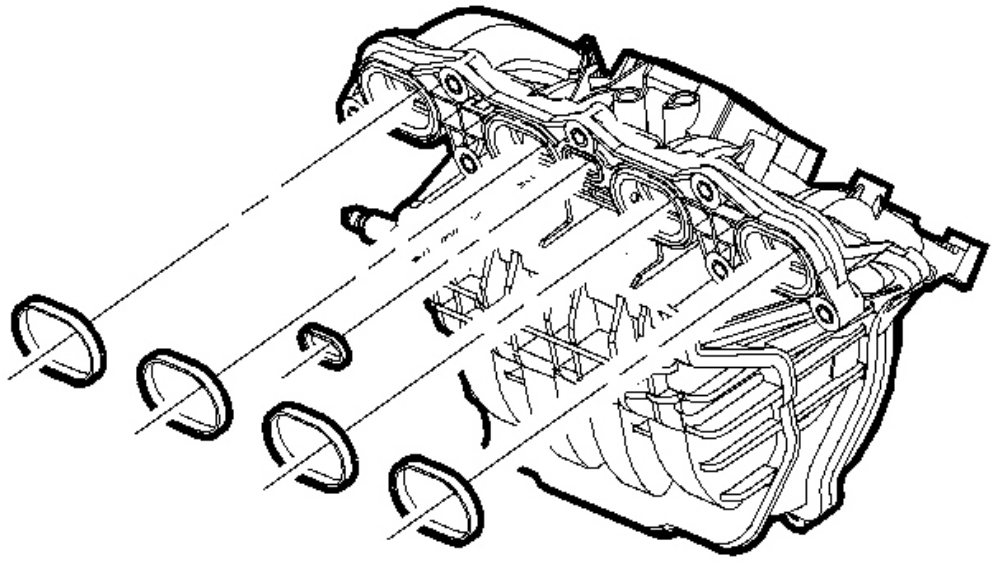


Fig. 65: Removing/Installing Intake Manifold Gasket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The intake manifold gasket is not reusable.

26. Remove the intake manifold gasket and discard.

NOTE: Cover the cylinder head ports with a shop towel to prevent foreign material from entering the cylinder head.

27. Block the intake manifold to cylinder head openings with a clean shop towel to prevent dirt from entering.

Installation Procedure

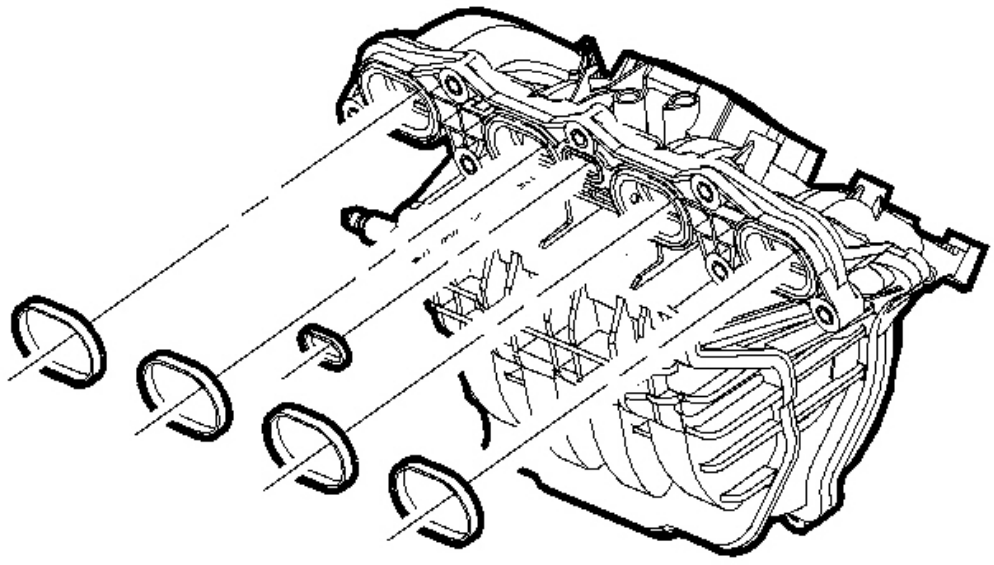


Fig. 66: Removing/Installing Intake Manifold Gasket
Courtesy of GENERAL MOTORS CORP.

1. Remove the shop towel from the throttle body opening.
2. Install the intake manifold gasket to manifold.

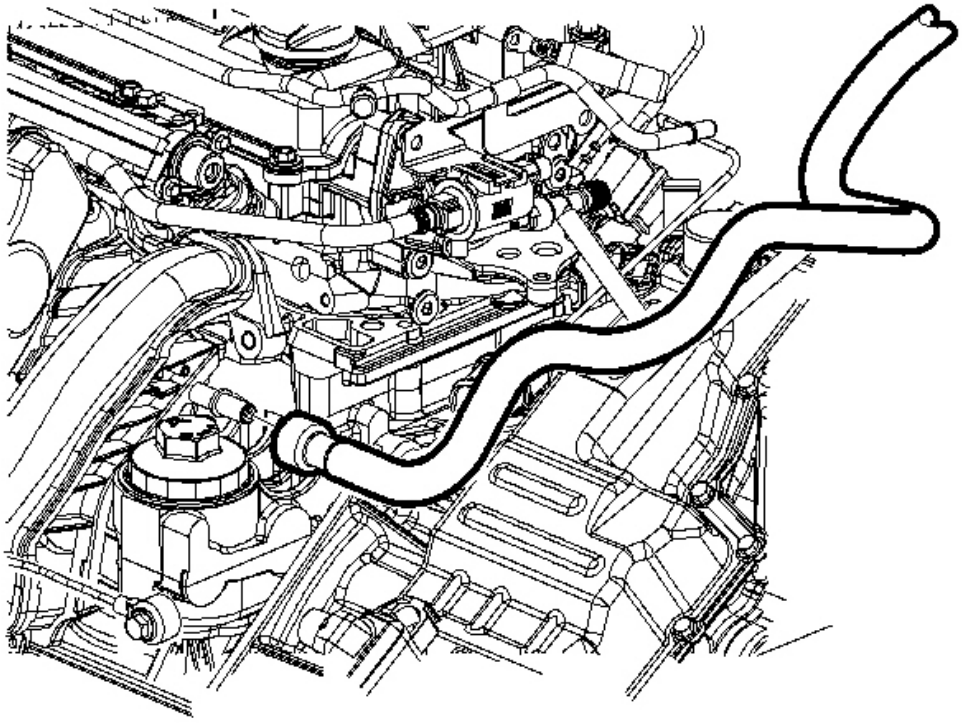


Fig. 67: Disconnecting/Connecting Brake Booster Hose
Courtesy of GENERAL MOTORS CORP.

3. Connect the brake booster hose to intake manifold.
4. Install the intake manifold to cylinder head.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Install the intake manifold bolts and nuts.

Tighten

- Tighten the intake manifold-to-cylinder head bolts L61 to 10 N.m (89 lb in).
- Tighten the intake manifold-to-cylinder head nuts L61 to 10 N.m (89 lb in).

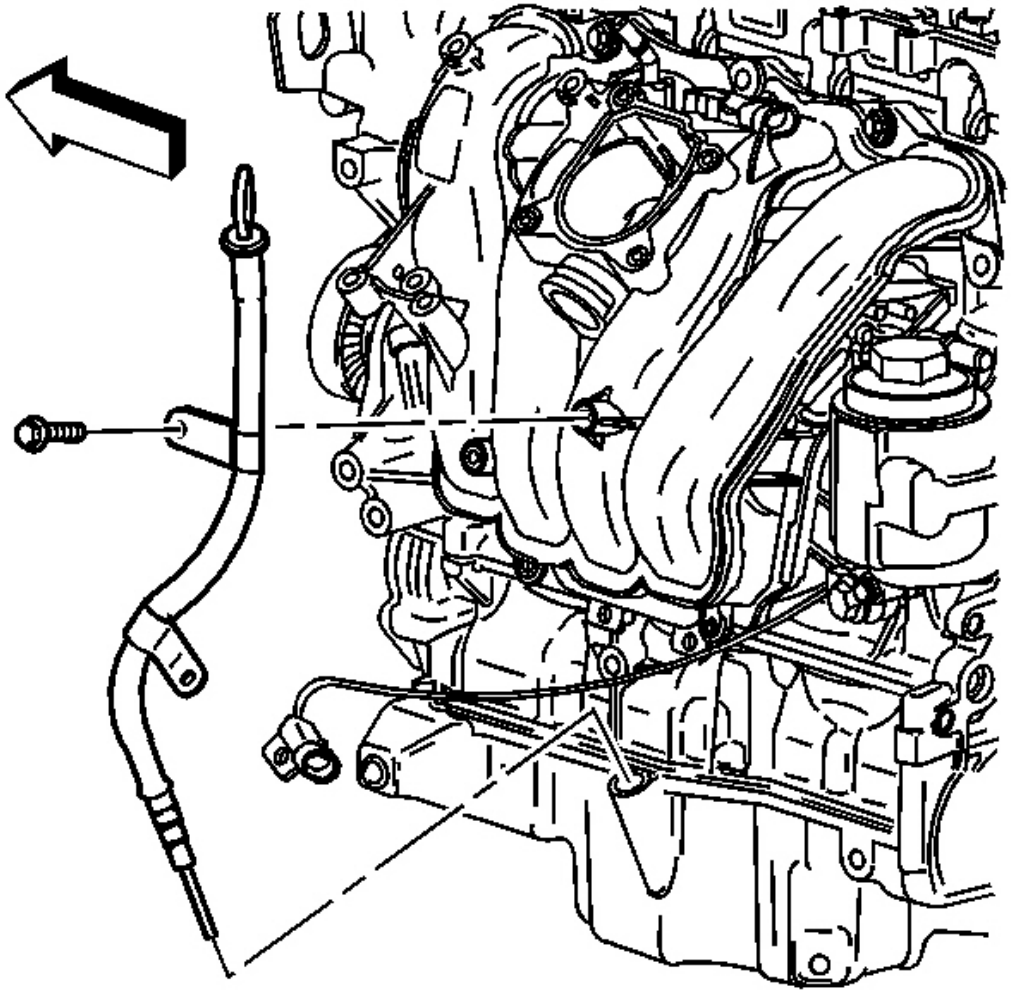


Fig. 68: Removing/Installing Oil Level Indicator Tube Assembly & Bolt
Courtesy of GENERAL MOTORS CORP.

6. Install the oil level indicator tube assembly and bolt.

   Tighten: Tighten the oil level indicator tube-to-intake manifold bolt L61 to 10 N.m (89 lb in).

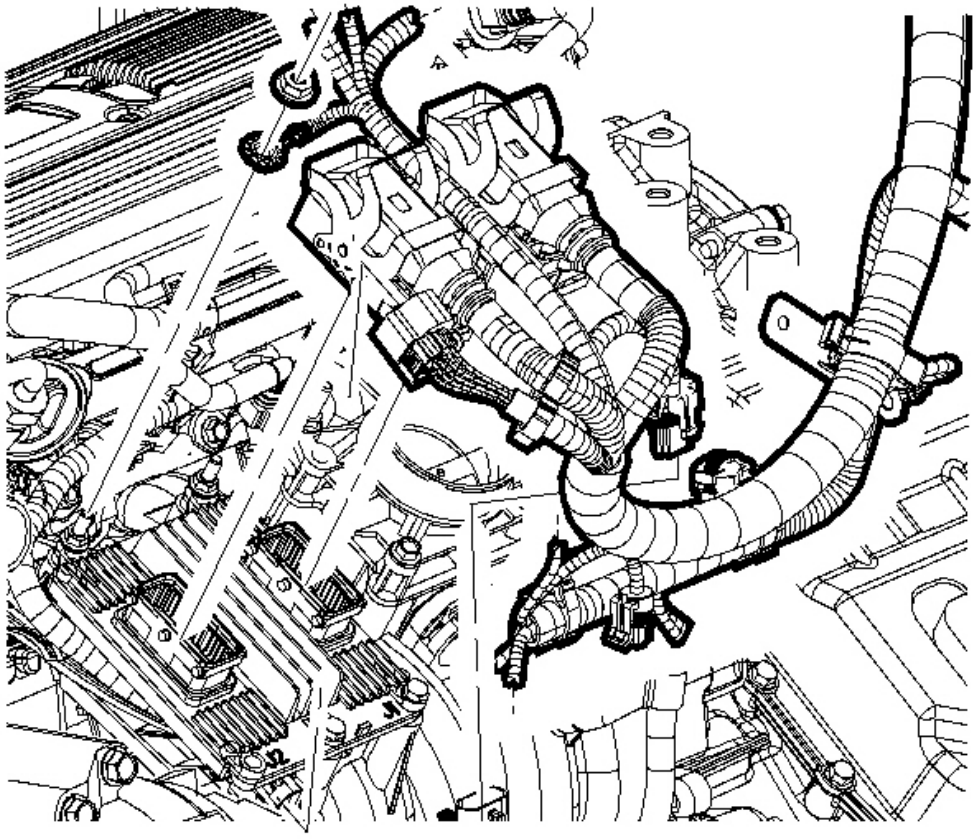


Fig. 69: Removing/Installing ECM Assembly & Bolts
Courtesy of GENERAL MOTORS CORP.

7. Install the ECM assembly and bolts.
8. Attach the electrical harness to the bottom of the intake manifold.
9. Connect the electrical connector at the ECM, injector harness and MAP sensor.

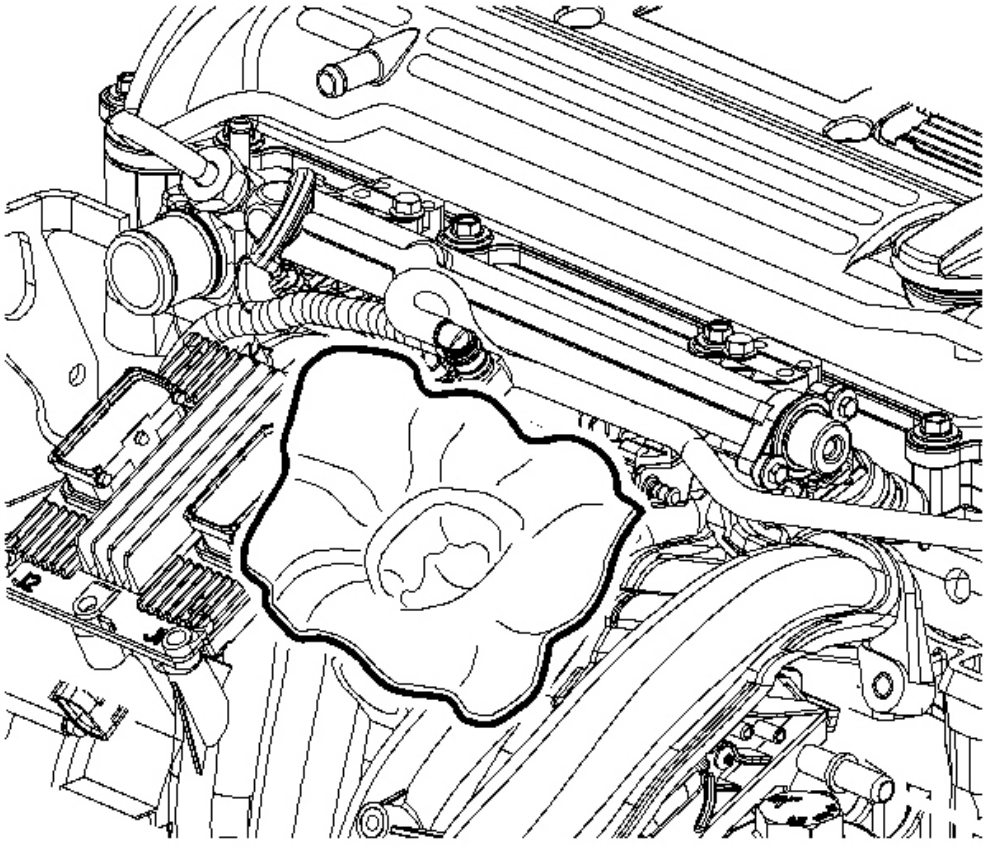


Fig. 70: Removing Shop Towel From The Throttle Body Opening
Courtesy of GENERAL MOTORS CORP.

10. Connect the purge hose.
11. Remove the shop towel from the throttle body opening.

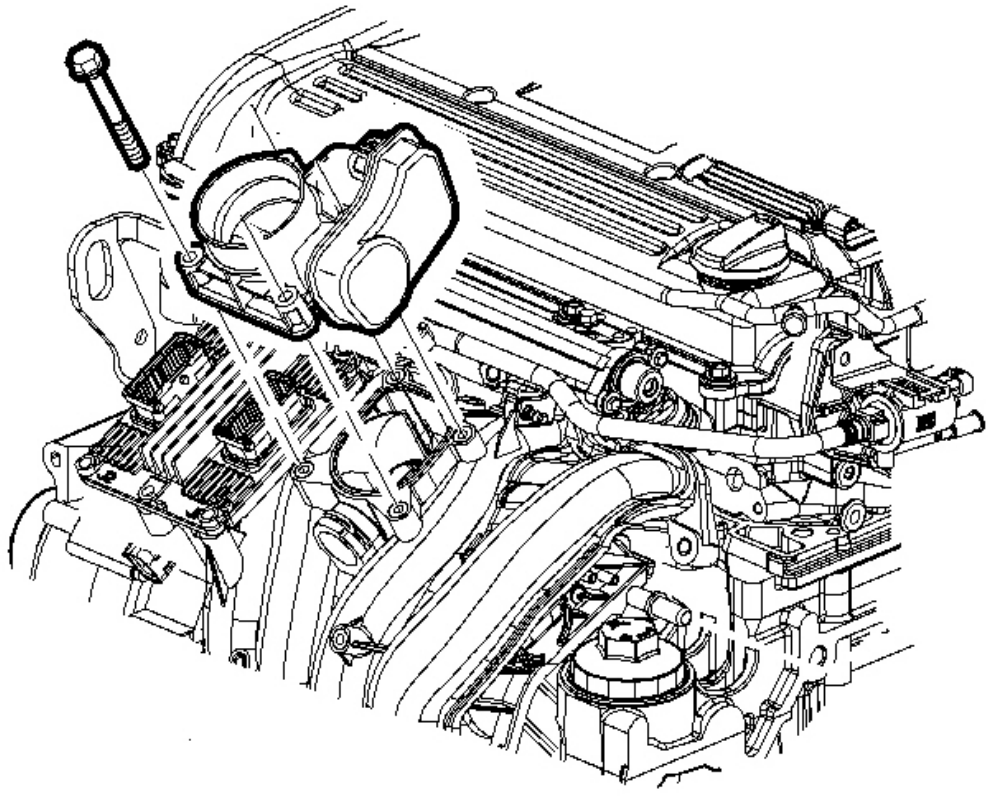


Fig. 71: Removing/Installing Throttle Body Gasket
Courtesy of GENERAL MOTORS CORP.

12. Install the new throttle body gasket.
13. Install the throttle body assembly and bolts.

Tighten: Tighten the throttle body-to-intake manifold bolts L61 to 10 N.m (89 lb in).

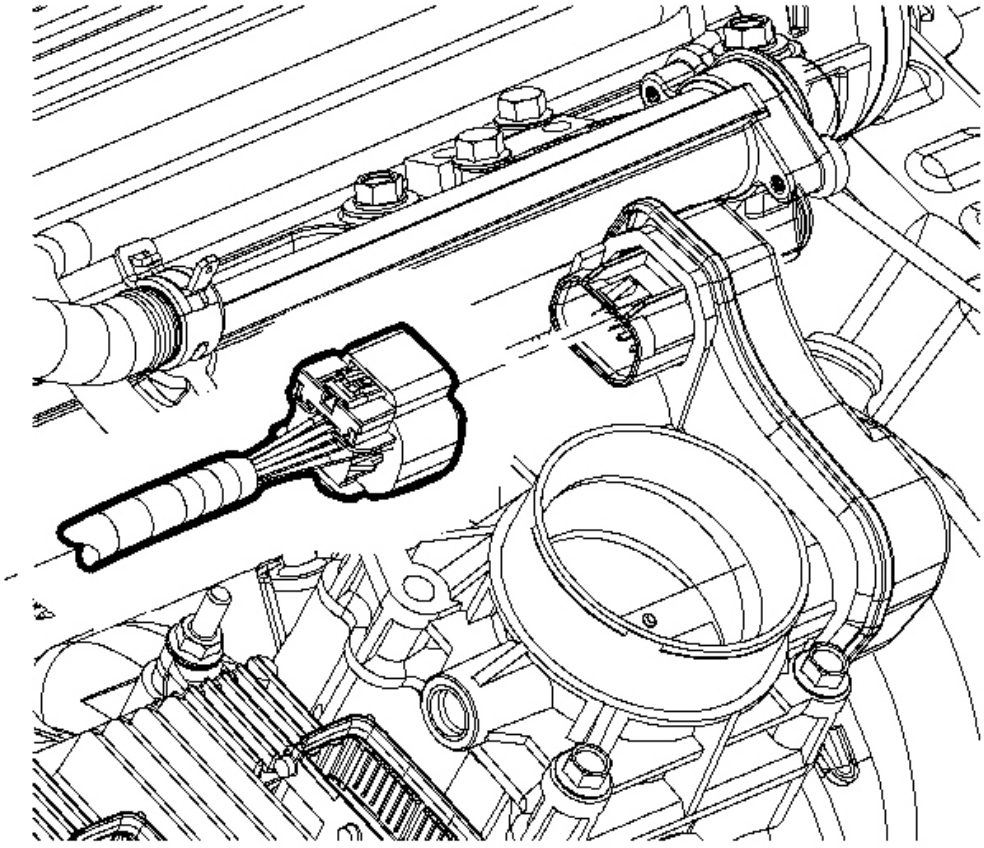


Fig. 72: Disconnecting/Connecting Throttle Body Electrical Connector
Courtesy of GENERAL MOTORS CORP.

14. Connect the throttle body electrical connector.

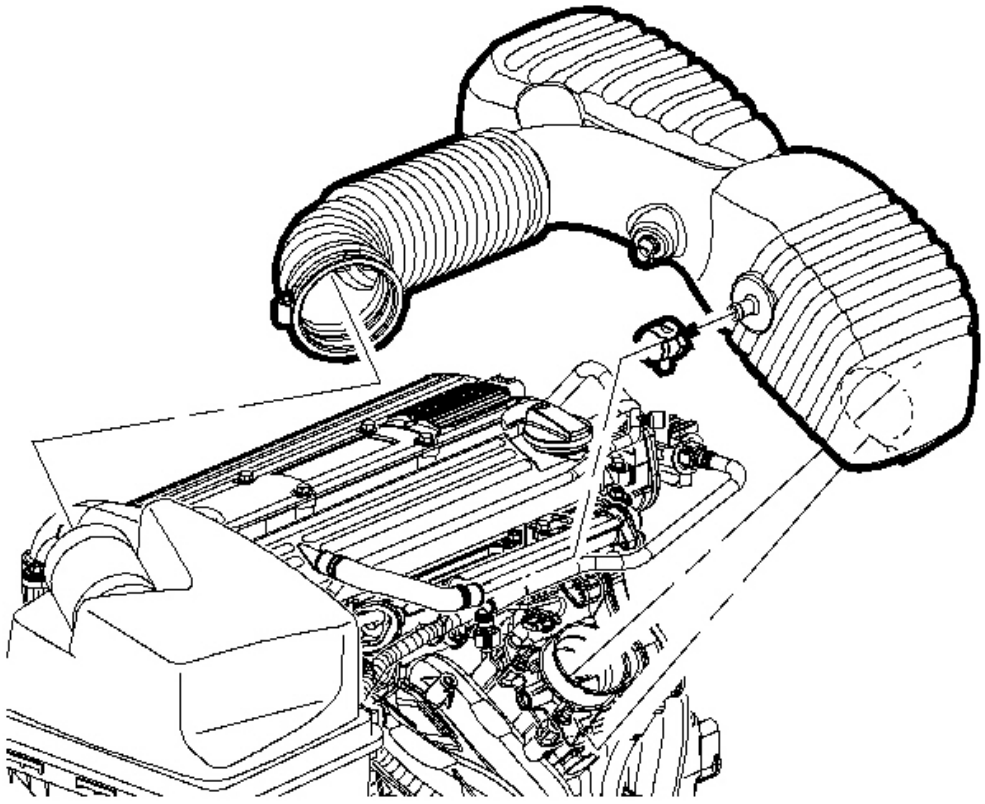


Fig. 73: Locating Air Intake Assembly
Courtesy of GENERAL MOTORS CORP.

15. Position the outlet resonator/duct assembly into position.
16. Connect the PCV fresh air vent hose assembly.
17. Tighten the clamp at the throttle body assembly.
18. Position the outlet resonator/duct assembly up with support bracket and install the push-pin.
19. Tighten the clamp at the air cleaner assembly.
20. Connect the intake air temperature (IAT) sensor connector.

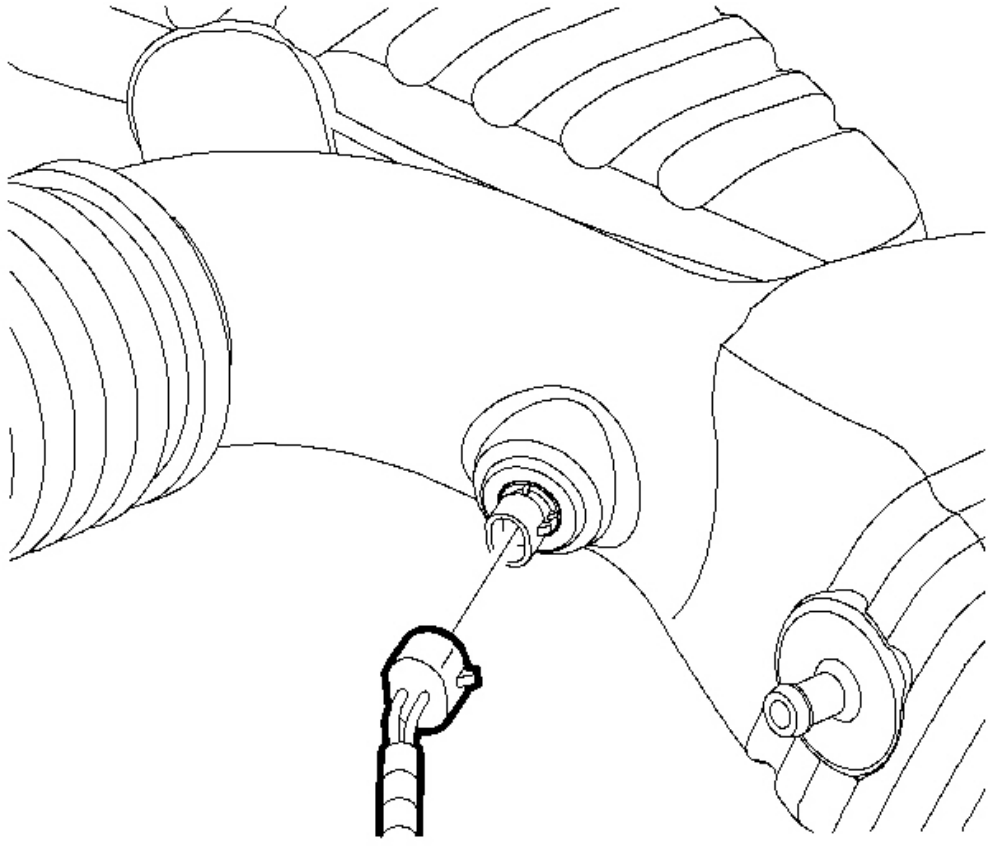


Fig. 74: Connecting Intake Air Temperature (IAT) Sensor Connector
Courtesy of GENERAL MOTORS CORP.

CRANKSHAFT BALANCER REPLACEMENT

Tools Required

- J 38122-A Crankshaft Pulley Holder
- **J 44811** Accessory Belt Tensioner Unloader. See **Special Tools and Equipment** .

Removal Procedure

CAUTION: Ensure that the vehicle is properly supported and squarely

positioned. To help avoid personal injury when a vehicle is on a hoist, provide additional support for the vehicle on the opposite end from which the components are being removed.

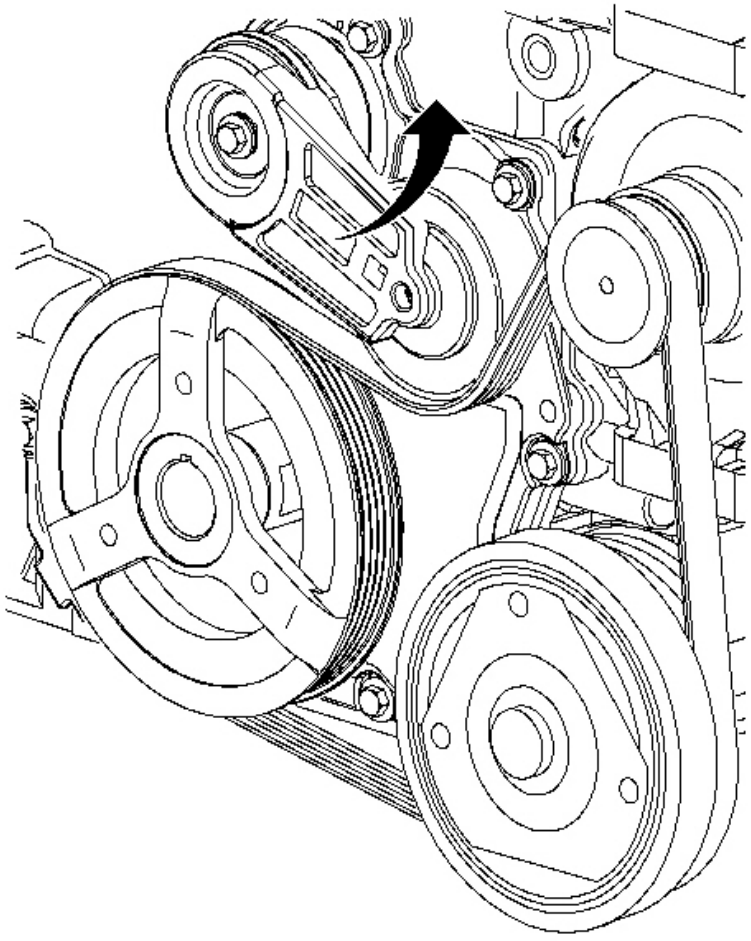


Fig. 75: Installing Accessory Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
2. Raise the vehicle on a hoist.
3. Remove the right wheel and splash shield.
4. Install the **J 44811** . See **Special Tools and Equipment** .

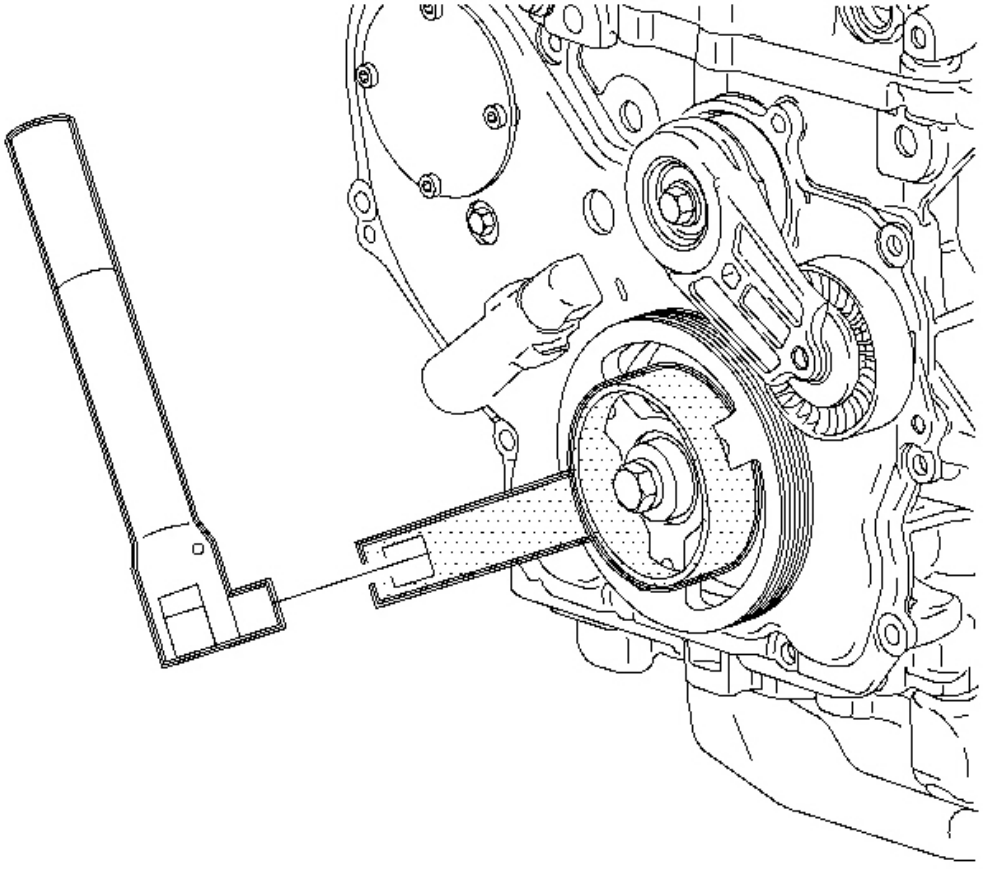


Fig. 76: Installing Crankshaft Pulley Holder
Courtesy of GENERAL MOTORS CORP.

5. Remove the accessory drive belt.
6. Install the J 38122-A .

NOTE: The crankshaft damper pulley bolt head and the washer assembly prevents oil leakage at the center of the pulley. Do not damage the sealing surfaces. If the pulley can not be removed by pulling with your hand, use a three-jaw puller.

NOTE: To avoid damage to the front cover assembly, do not pry against the

cover.

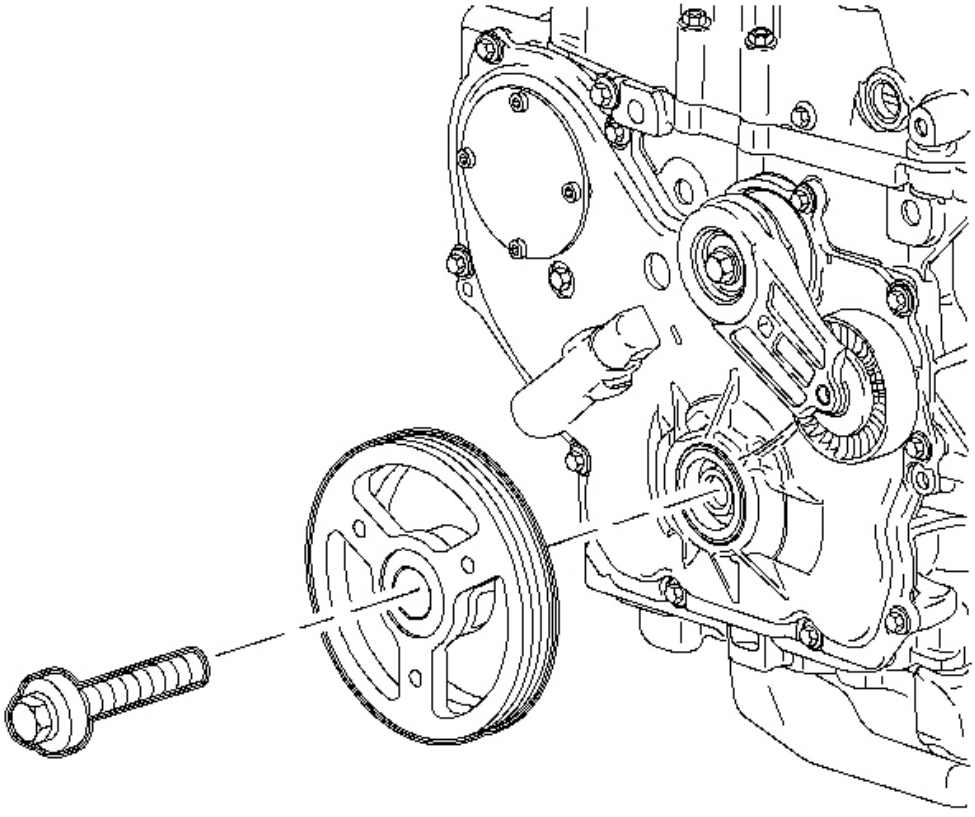


Fig. 77: Removing/Installing Crankshaft Balancer Pulley Bolt
Courtesy of GENERAL MOTORS CORP.

7. Remove the crankshaft balancer pulley bolt and pulley. Discard the pulley bolt.

Installation Procedure

1. Lubricate the front seal and sealing surface of the pulley with clean motor oil.
2. Install the balancer pulley onto the crankshaft indexing keyway. Use care to properly align the flats on the balancer pulley with the flats on the oil pump drive in the front cover assembly.

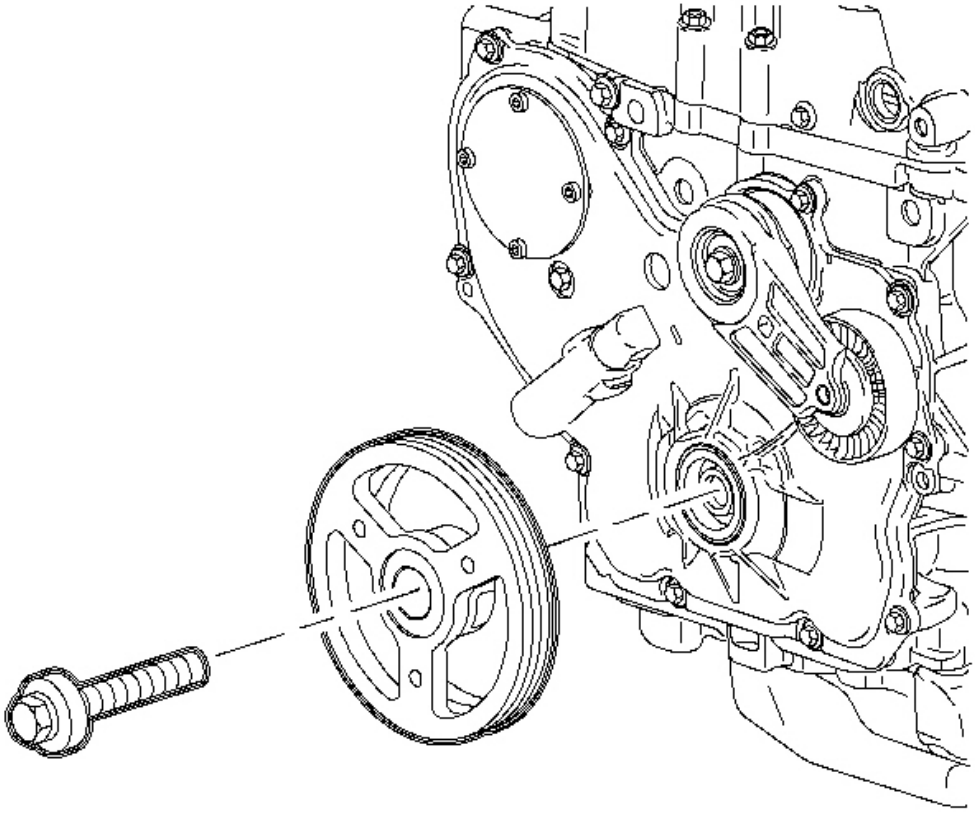


Fig. 78: Removing/Installing Crankshaft Balancer Pulley Bolt
Courtesy of GENERAL MOTORS CORP.

3. Install the crankshaft damper pulley.
4. Install a new crankshaft balancer pulley bolt with washer assembly.

NOTE: Refer to Fastener Notice in Cautions and Notices.

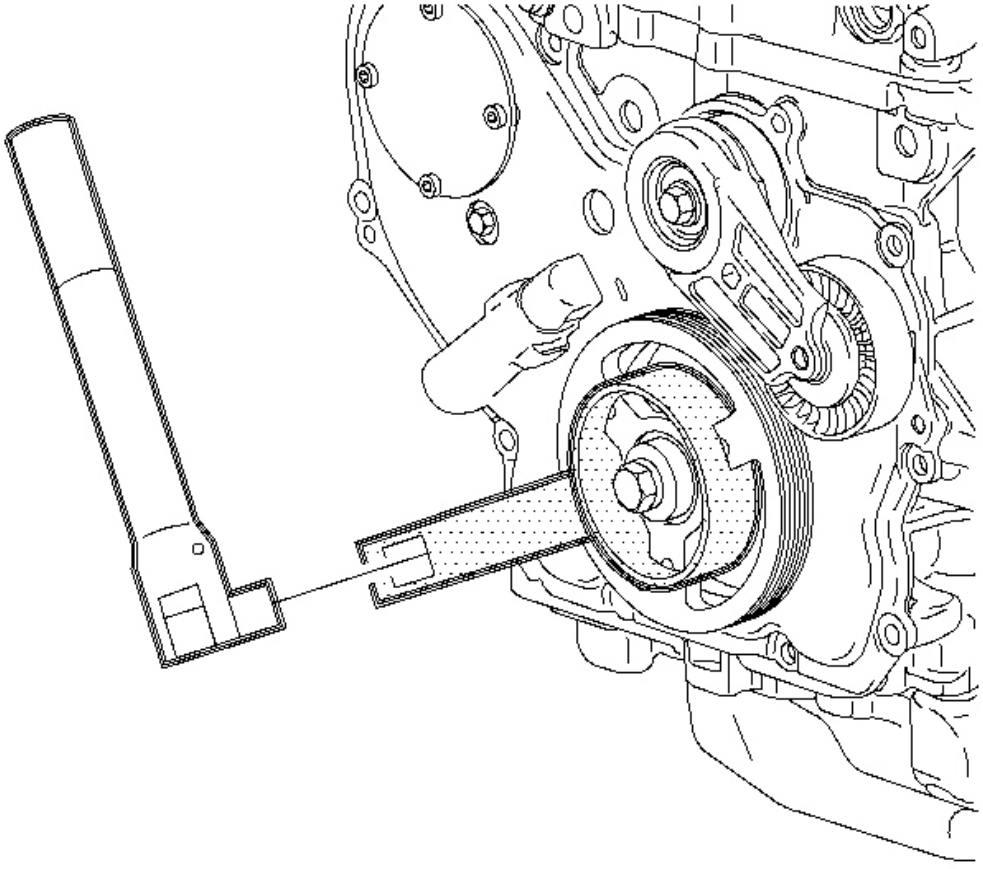


Fig. 79: Installing Crankshaft Pulley Holder
Courtesy of GENERAL MOTORS CORP.

5. Install the J 38122-A .

   Tighten: Tighten the crankshaft pulley bolt to 100 N.m (74 lb ft) +75 degrees.

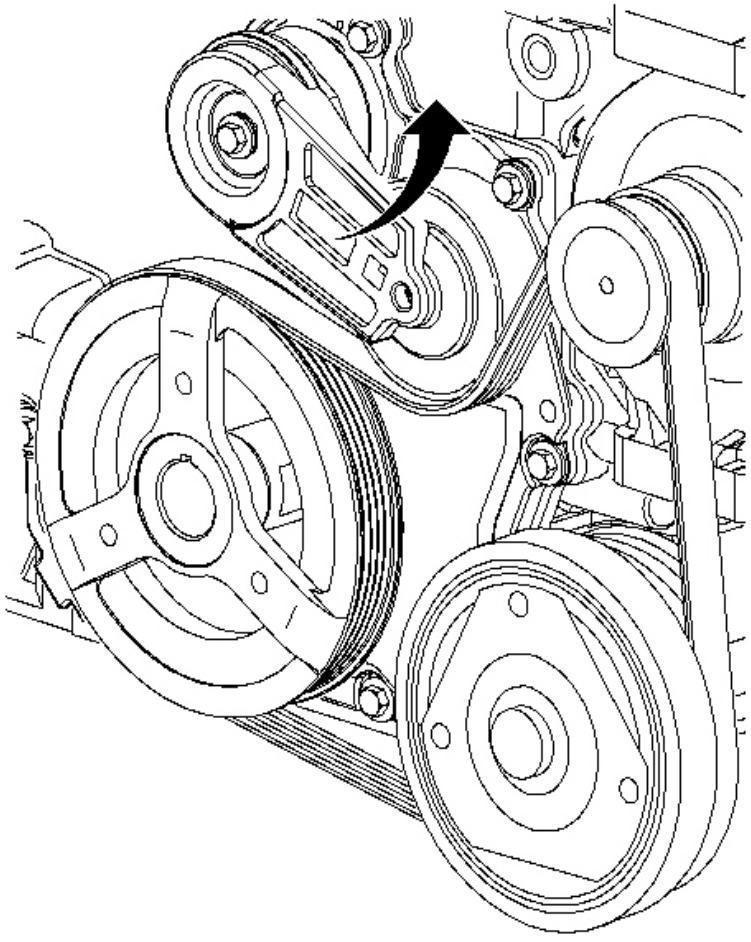


Fig. 80: Installing Accessory Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

6. Route the belt around the alternator and A/C compressor.

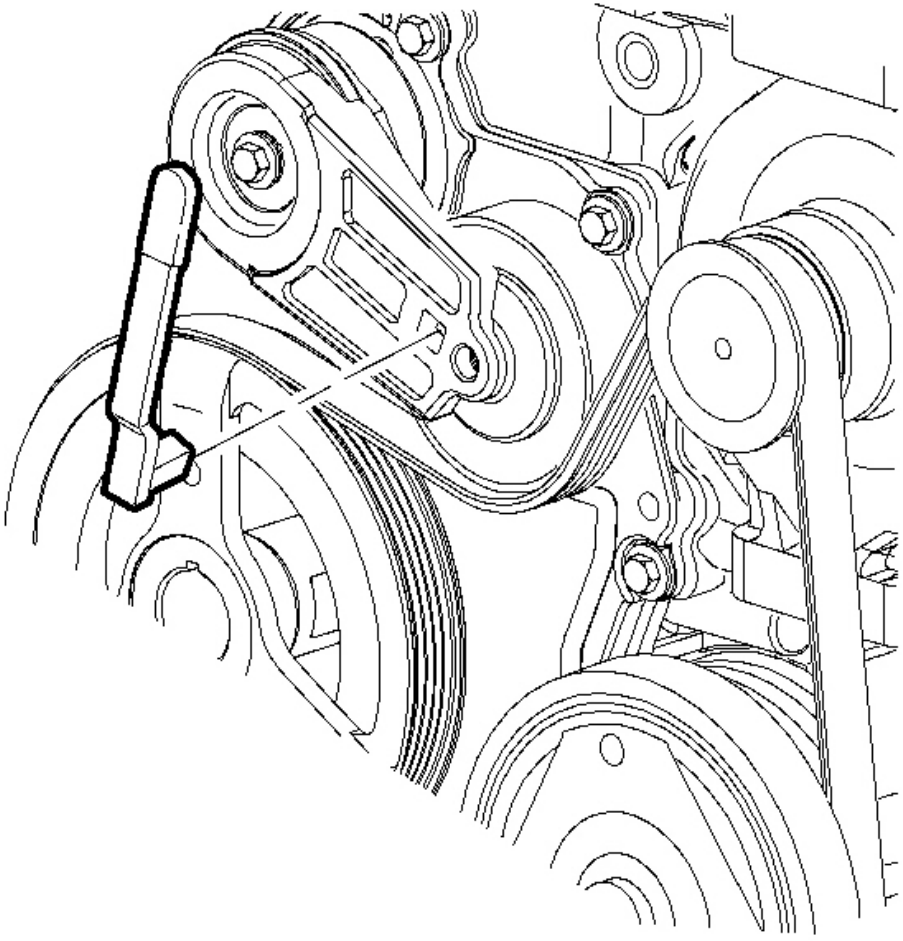


Fig. 81: View Of Drive Belt Tensioner Tool
Courtesy of GENERAL MOTORS CORP.

7. Install the **J 44811** onto the tensioner and unload the spring tension from the tensioner while positioning the belt. See **Special Tools and Equipment** .
8. Release the tensioner and remove the tool.
9. Install the right engine inner splash shield.
10. Install the right wheel and hand tighten the nuts.
11. Lower the vehicle.

Tighten: Tighten the wheel nuts to 125 N.m (92 lb ft).

CRANKSHAFT FRONT OIL SEAL REPLACEMENT

Tools Required

J 35268-A Camshaft/Front Main Seal Installer

Crankshaft Front Oil Seal Replacement

1. Remove the crankshaft balancer pulley.

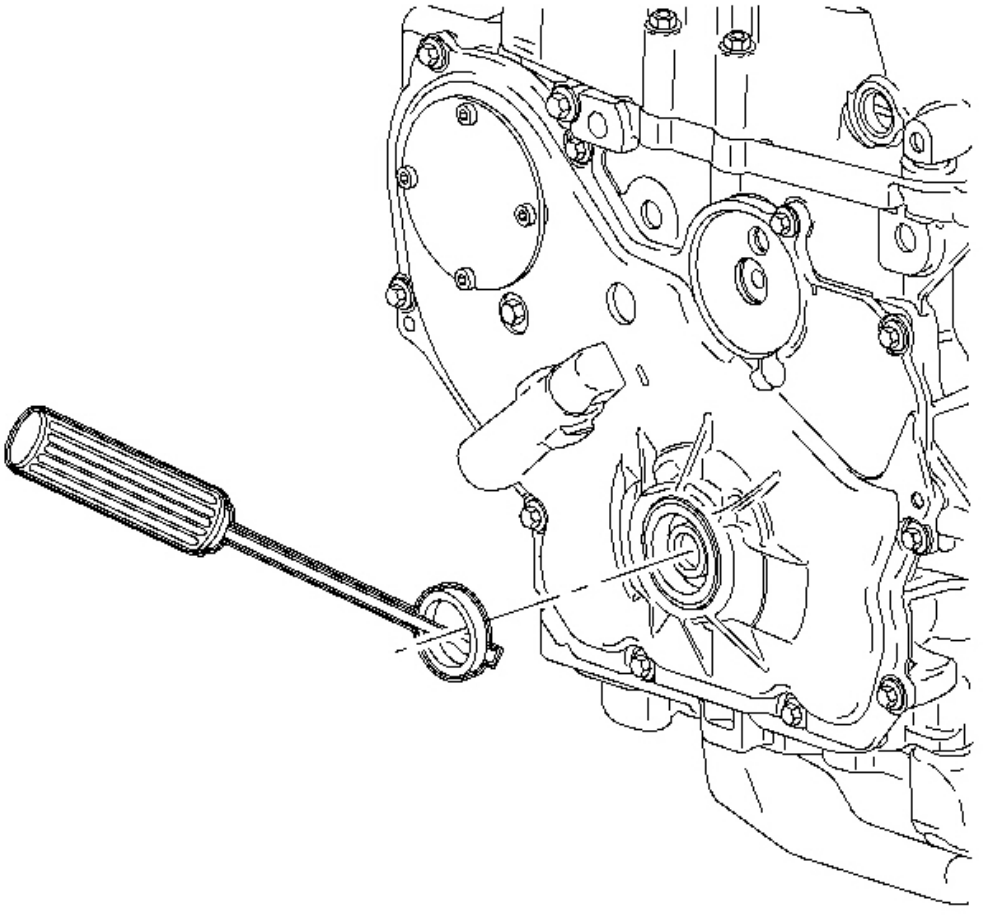


Fig. 82: Removing Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

2. Using a seal removal tool or screwdriver, remove the oil seal from the front cover.
    - Clean the seal bore and oil drain back passage way.
    - Ensure that the oil drain back passage is free of RTV or debris.

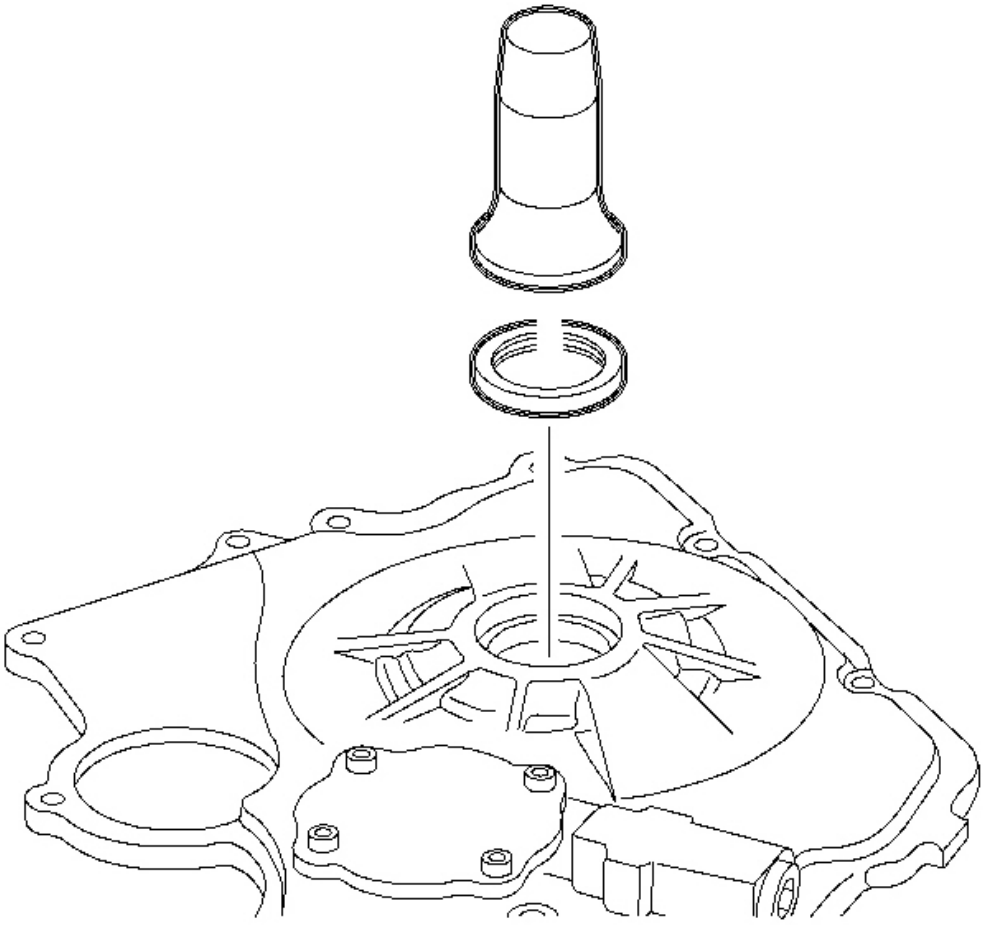


Fig. 83: Installing Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

3. Install a new oil seal using the J 35268-A

IMPORTANT: Always ensure that the oil pump cover is properly supported when installing.

- Ensure that the font main oil seal is fully and evenly sealed.
- Apply a thin film of oil to seal the lip.

4. Install the crankshaft balancer pulley. Refer to **Crankshaft Balancer Replacement** .

OIL PUMP REPLACEMENT

Tools Required

- J 38122-A Crankshaft Pulley Holder
- **J 44811** Accessory Belt Tensioner Unloader. See **Special Tools and Equipment** .
- **SA9105E** Engine Three-Bar Fixture. See **Special Tools and Equipment** .

Removal Procedure

CAUTION: Ensure that the vehicle is properly supported and squarely positioned. To help avoid personal injury when a vehicle is on a hoist, provide additional support for the vehicle on the opposite end from which the components are being removed.

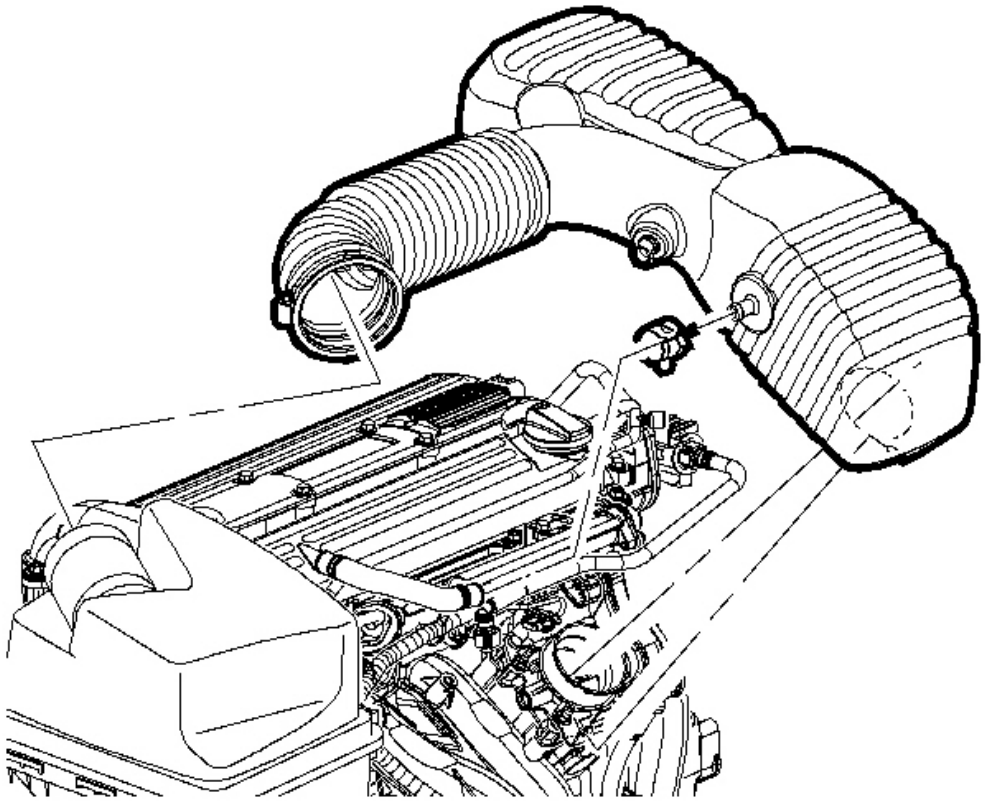


Fig. 84: Removing Outlet Resonator/Duct Assembly
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
2. Disconnect the intake air temperature (IAT) sensor connector.
3. Loosen the clamp at the air cleaner assembly.
4. Remove the push pin attachment from the outlet resonator/duct assembly to support bracket.
5. Loosen the clamp at the throttle body assembly.
6. Disconnect the PCV fresh vent hose at the cam cover.
7. Remove the outlet resonator/duct assembly.

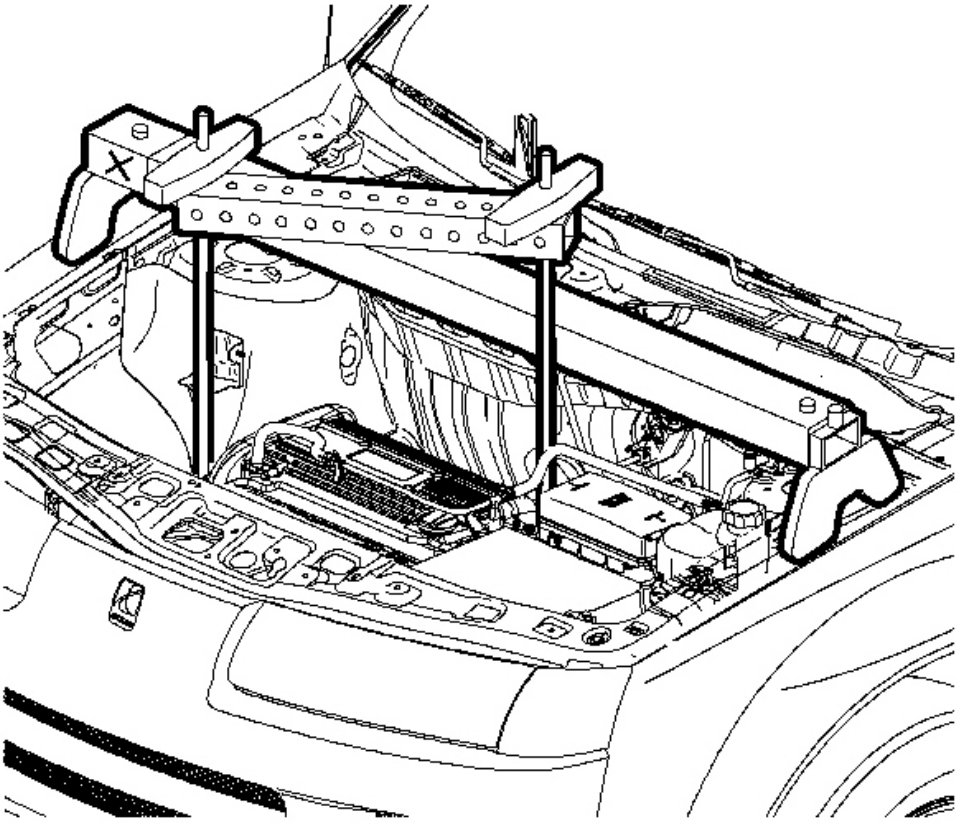


Fig. 85: Installing SA9105E Set Up For SUV Application
Courtesy of GENERAL MOTORS CORP.

8. Install the **SA9105E** setup for SUV application. See **Special Tools and Equipment** . Refer to **Engine Support Fixture** .

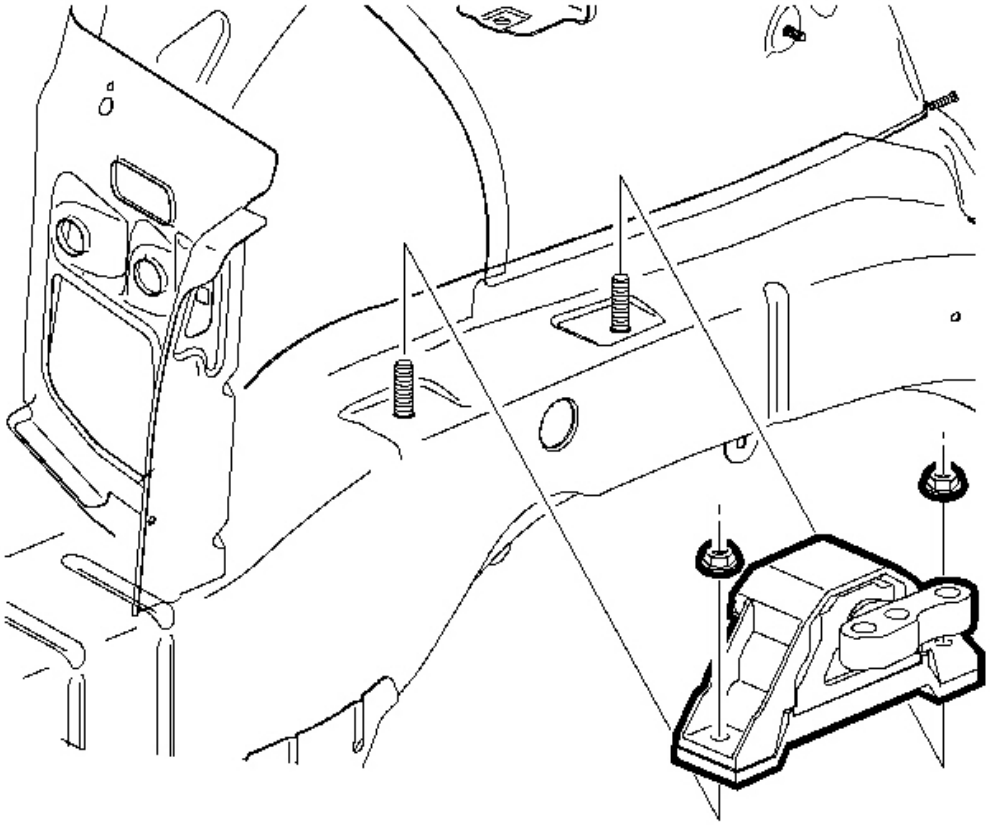


Fig. 86: View Of RH Engine Mount
Courtesy of GENERAL MOTORS CORP.

9. Remove the right hand mount. Refer to **Engine Mount Replacement** .
10. Remove the right hand engine mount bracket.
11. Jack the vehicle or raise on a hoist **Lifting and Jacking the Vehicle** in General Information.
12. Remove the right wheel and splash shield.

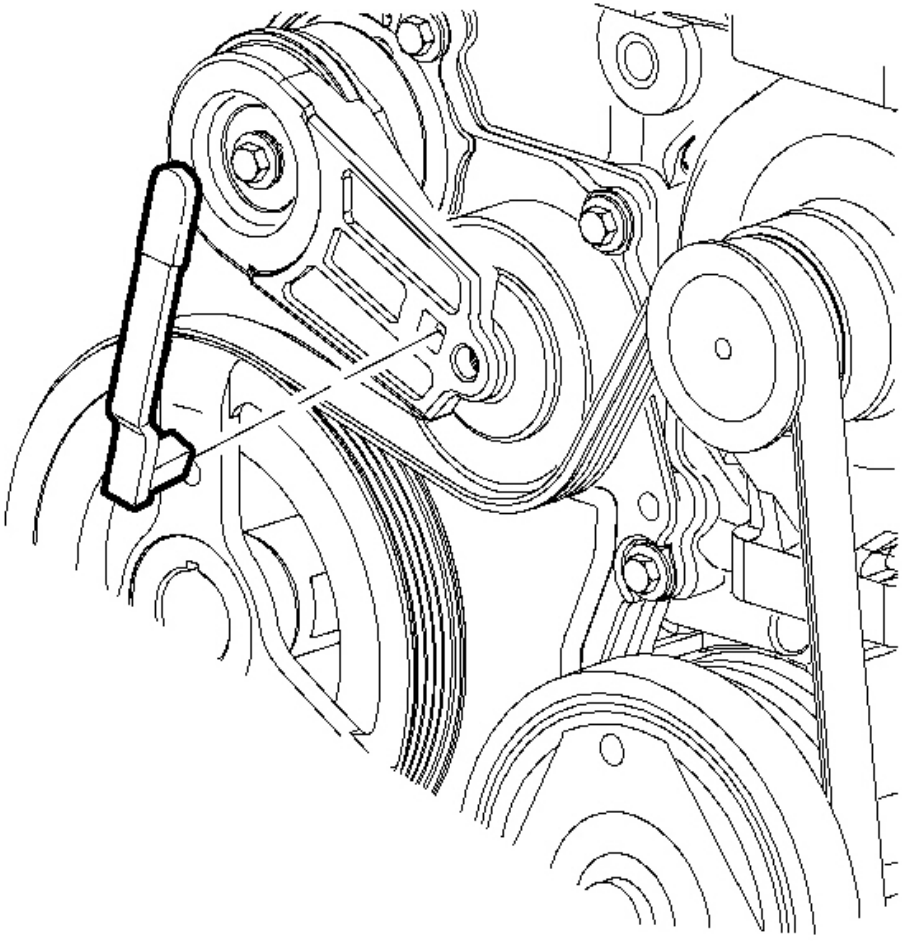


Fig. 87: View Of Drive Belt Tensioner Tool
Courtesy of GENERAL MOTORS CORP.

13. Install the **J 44811** . See **Special Tools and Equipment** .

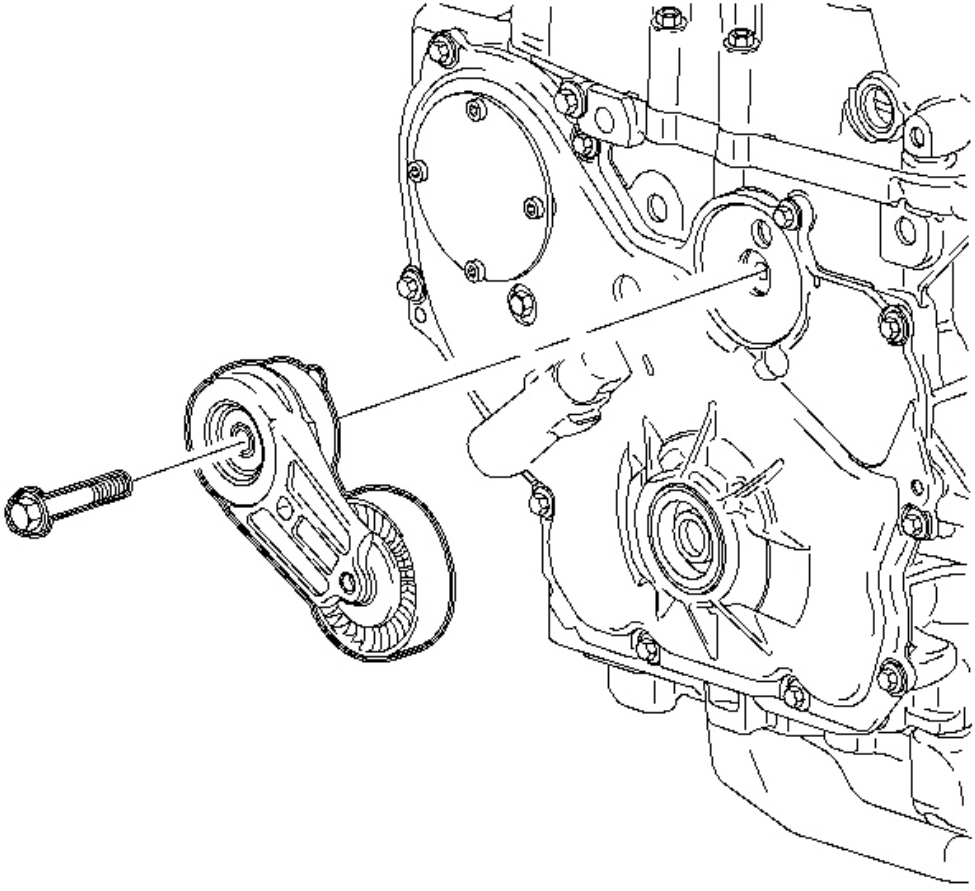


Fig. 88: Removing/Installing Tensioner Assembly & Bolt
Courtesy of GENERAL MOTORS CORP.

14. Remove the accessory drive belt.

IMPORTANT: To remove the tensioner bolt, an access hole has been provided through the inner and outer engine rail.

15. Remove the tensioner bolt.
16. Remove the tensioner assembly.

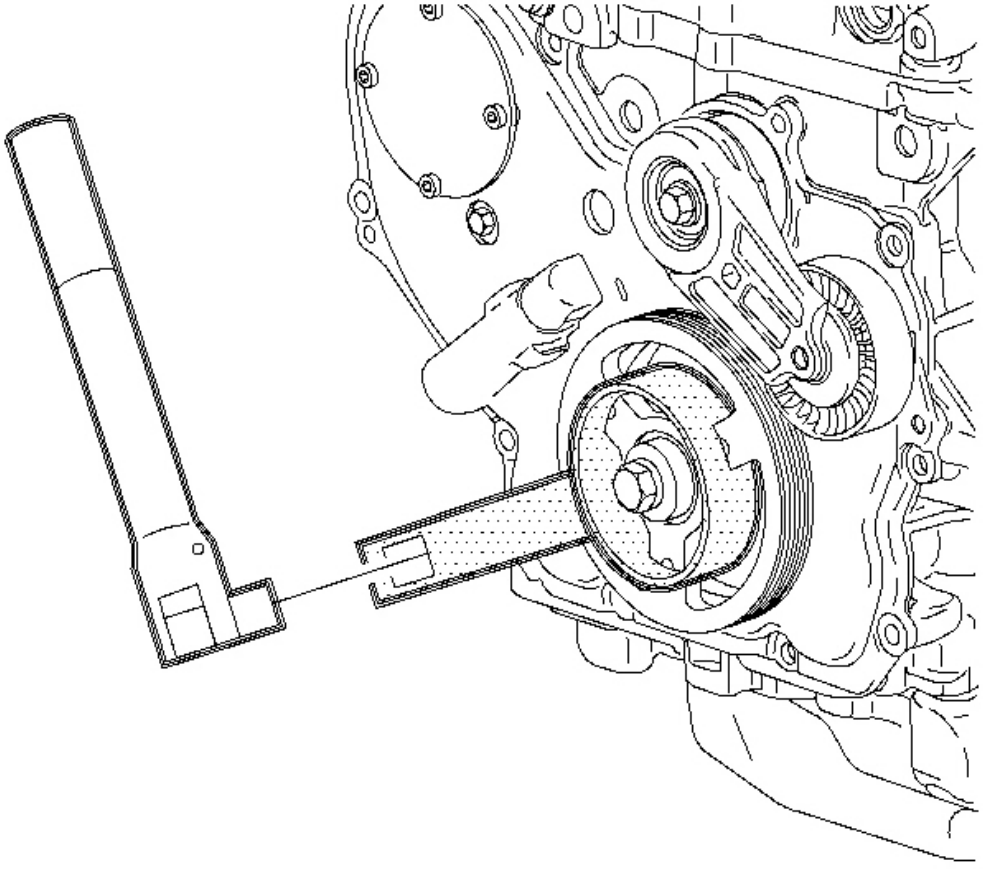


Fig. 89: Installing Crankshaft Pulley Holder
Courtesy of GENERAL MOTORS CORP.

17. Install the J 38122-A .

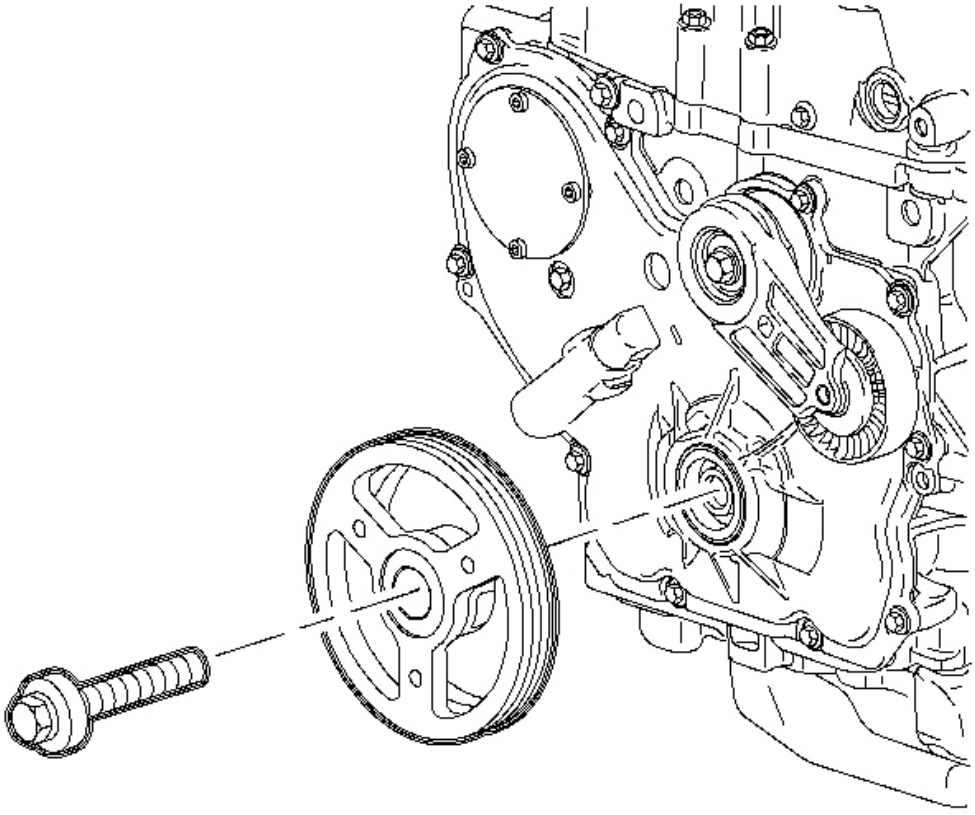


Fig. 90: Removing/Installing Crankshaft Balancer Pulley Bolt
Courtesy of GENERAL MOTORS CORP.

18. Remove the crankshaft balancer pulley bolt and pulley. Discard the pulley.

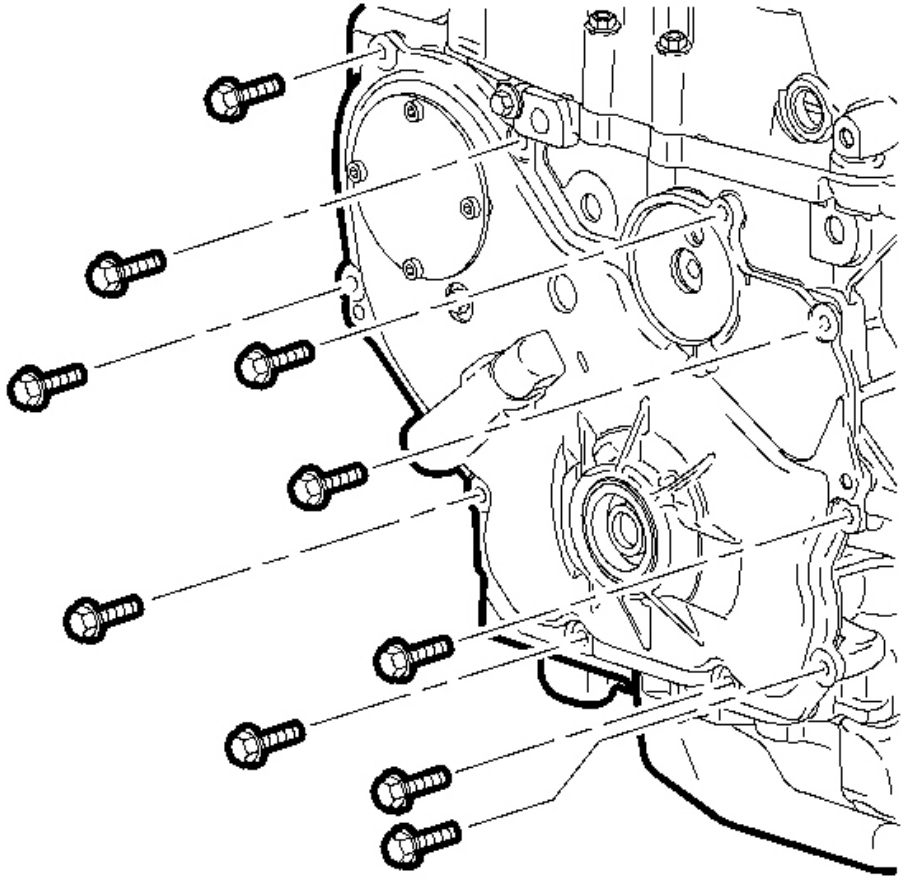


Fig. 91: Removing/Installing Front Cover Assembly
Courtesy of GENERAL MOTORS CORP.

NOTE: To avoid damage to the front cover assembly, do not pry against the cover.

IMPORTANT: The crankshaft balancer pulley bolt head and washer assembly prevents oil leakage at the center of the pulley. Do not damage the sealing surfaces. If the pulley cannot be removed by pulling with your hand, use a three-jaw puller.

19. Remove the front cover.

20. Remove the lower water pump assembly bolt.
21. Remove the front cover/oil pump assembly and gasket.

Installation Procedure

IMPORTANT: A new oil seal can be installed either in or out of the vehicle. Refer to Timing Chain, Sprockets, and/or Tensioner Replacement .

1. Install the front cover assembly.

NOTE: Refer to Fastener Notice in Cautions and Notices.

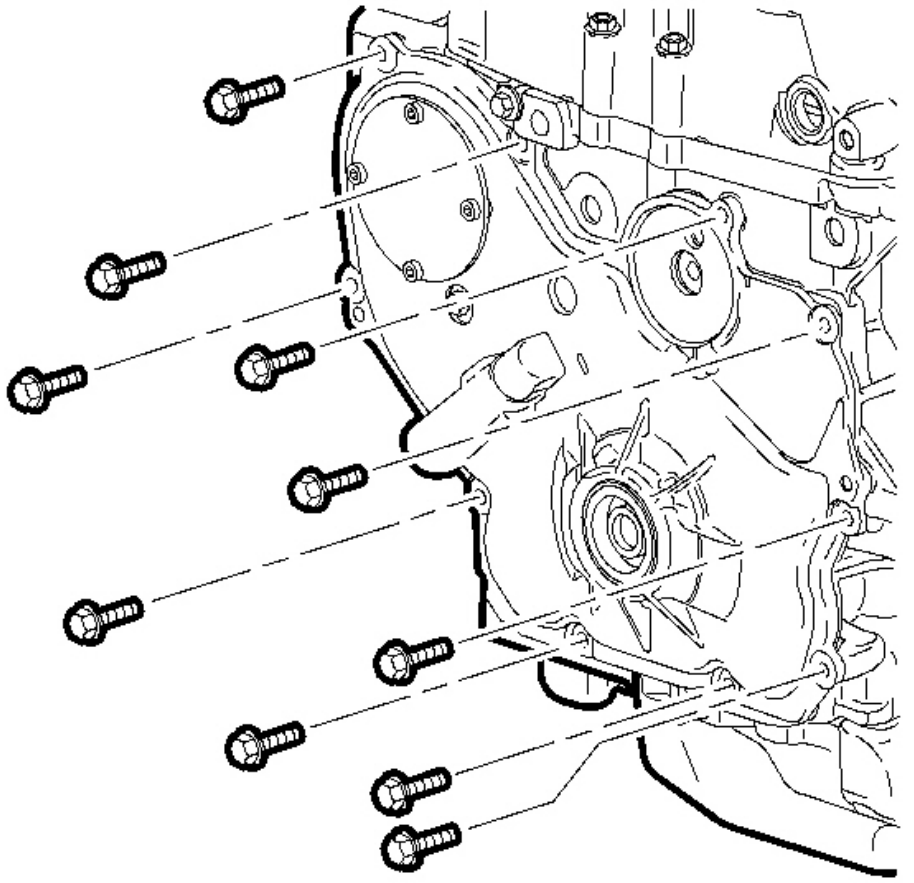


Fig. 92: Removing/Installing Front Cover Assembly
Courtesy of GENERAL MOTORS CORP.

2. Install the front cover assembly bolts and lower water pump bolt.

   Tighten:
   - Tighten the cover-to-block bolts - L61 to 25 N.m (18 lb ft).
   - Tighten the water pump bolts - L61 to 25 N.m (18 lb ft).

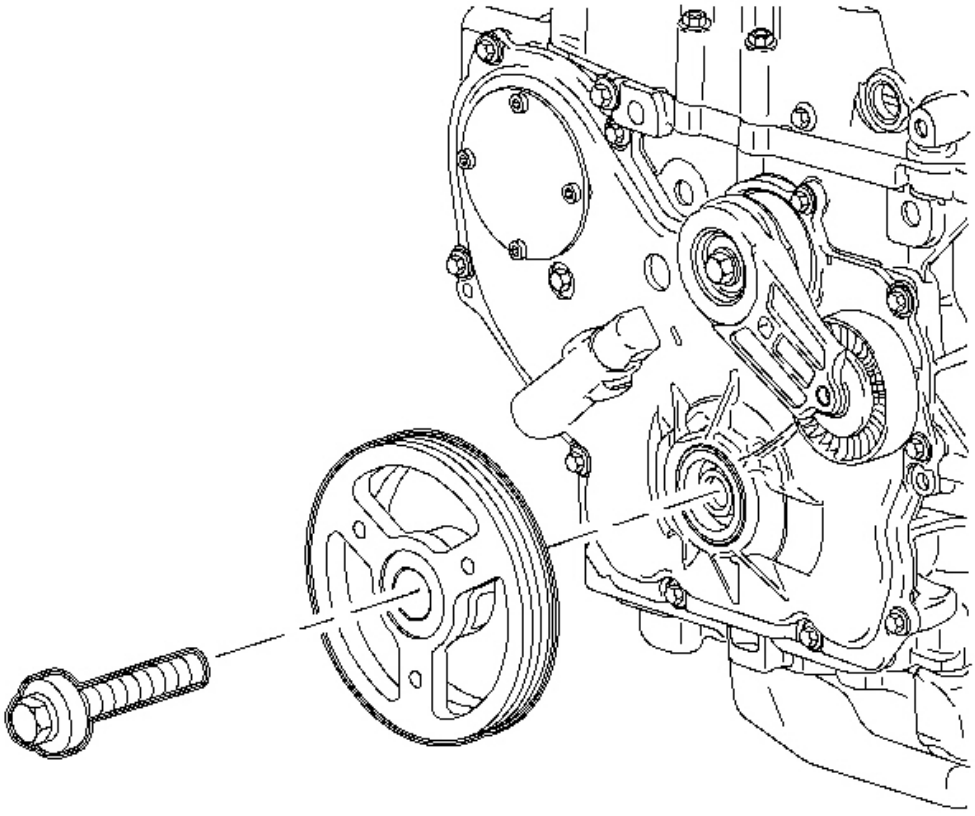


Fig. 93: Removing/Installing Crankshaft Balancer Pulley Bolt
Courtesy of GENERAL MOTORS CORP.

3. Lubricate the front seal and sealing surface of the pulley with clean motor oil.

4. Install the balancer pulley onto the crankshaft indexing keyway. Use care to properly align the flats on the balancer pulley with the flats on the oil pump drive in the front cover assembly.
5. Install the crankshaft damper pulley.
6. Install a new crankshaft balancer pulley bolt with washer assembly.

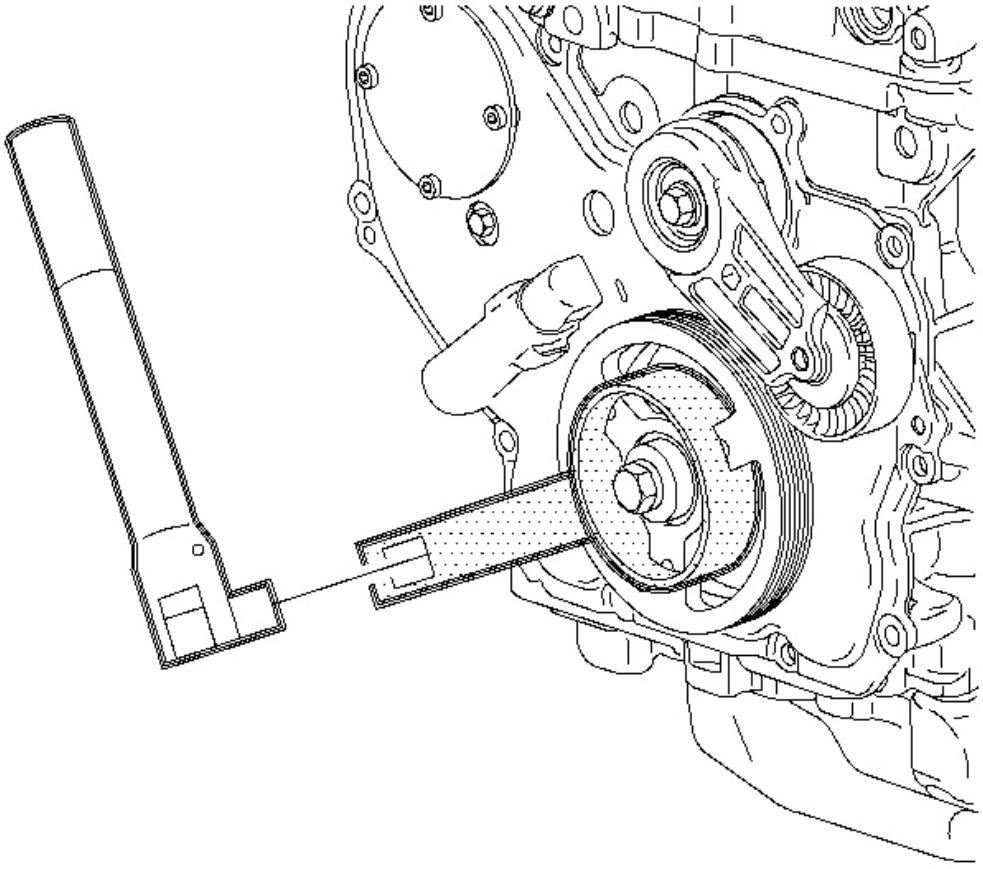


Fig. 94: Installing Crankshaft Pulley Holder
Courtesy of GENERAL MOTORS CORP.

7. Install the J 38122-A .

Tighten: Tighten the crankshaft pulley bolt - L61 to 100 N.m (74 lb ft) +75 degrees.

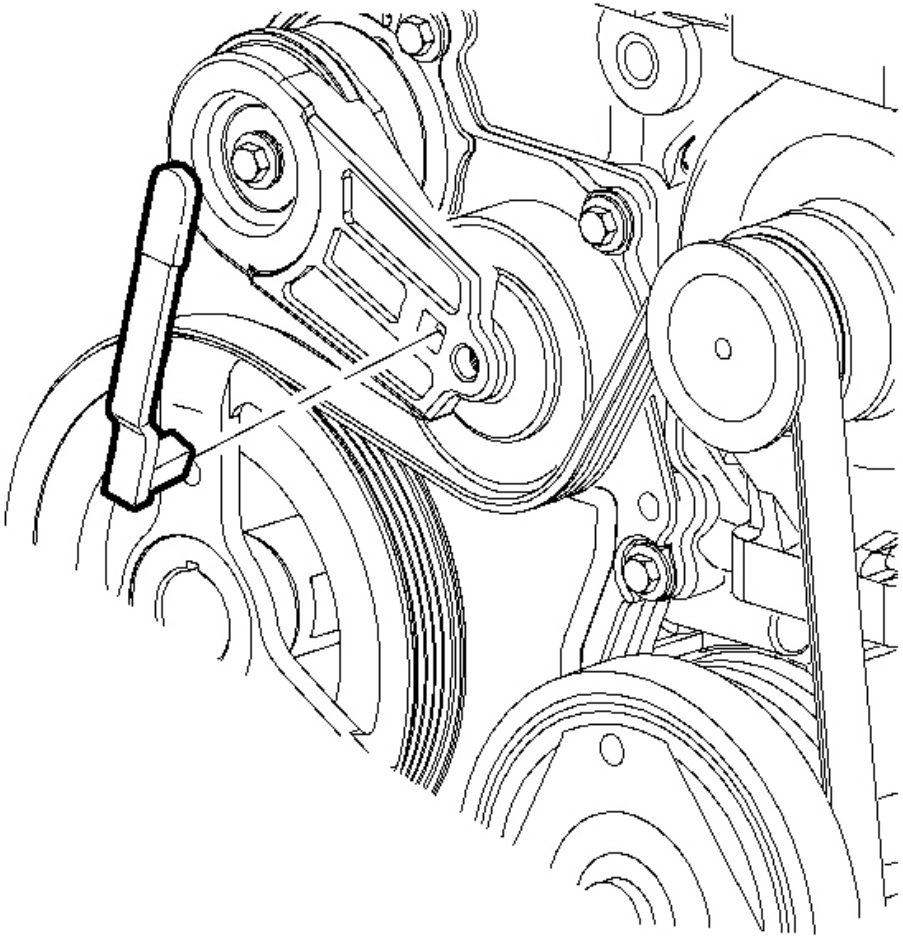


Fig. 95: View Of Drive Belt Tensioner Tool
Courtesy of GENERAL MOTORS CORP.

8. Install the drive belt tensioner assembly.

   Tighten: Tighten the drive belt tensioner bolt - L61 to 45 N.m (33 lb ft).

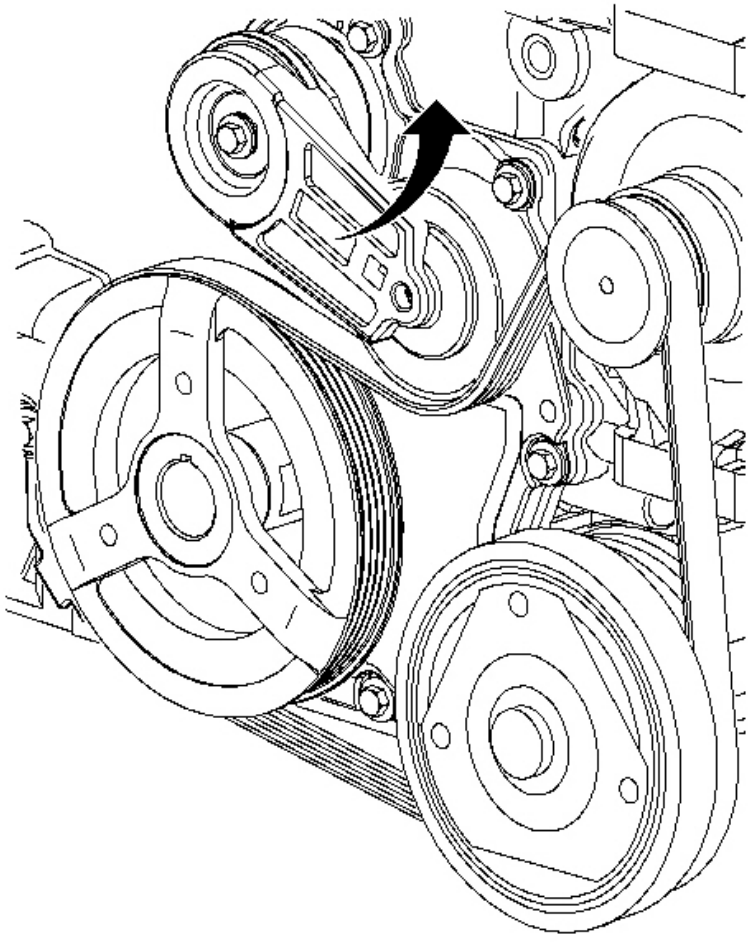


Fig. 96: Installing Accessory Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

9. Route the belt around the alternator and A/C compressor. Install the **J 44811** onto the tensioner and unload spring tension from the tensioner while positioning the belt. See **Special Tools and Equipment** .
10. Release the tensioner and remove the tool.
11. Install the right engine inner splash shield.
12. Install the right wheel and hand tighten the wheel nuts.
13. Lower the vehicle.
14. Tighten the wheel nuts.

Tighten: Tighten the wheel nuts to 125 N.m (92 lb ft).

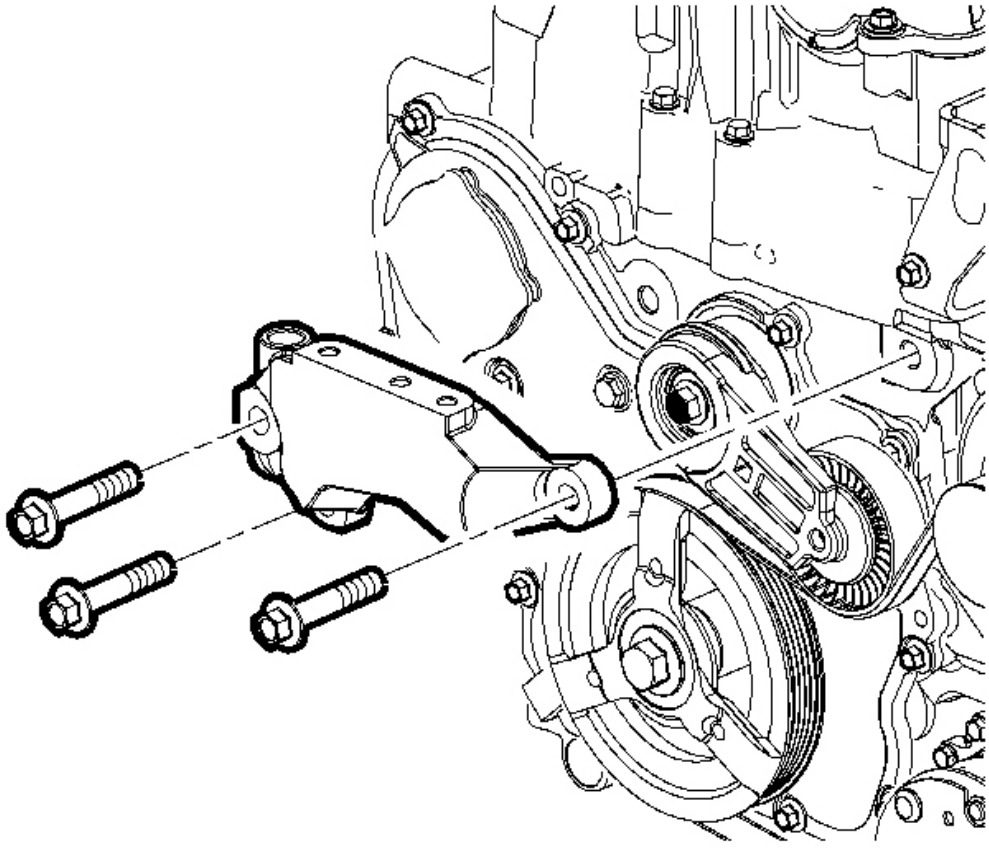


Fig. 97: Removing/Installing Right Hand Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

15. Install the right hand engine bracket and bolts to the engine. Refer to **Engine Mount Replacement** .

    Tighten: Tighten the engine mount bracket-to-engine bolts - L61 to 110 N.m (81 lb ft).

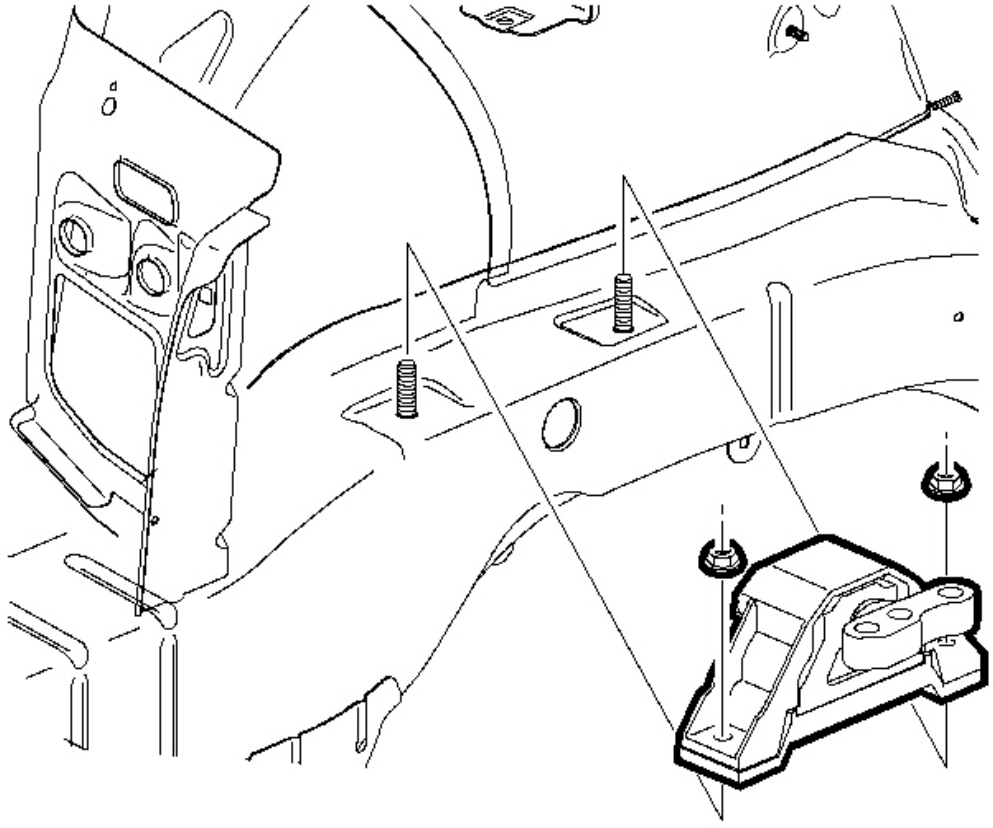


Fig. 98: View Of RH Engine Mount
Courtesy of GENERAL MOTORS CORP.

16. Install the shims on the right hand side rail studs.
17. Install the right hand engine shims onto the studs.
18. Install the right hand engine mount over the body side rail studs.
19. Install the right hand engine mount nuts.

    Tighten: Tighten the engine mount bracket-to-body nuts to 110 N.m (81 lb ft).

20. Install the right hand engine mount bolts to the engine mount bracket.

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

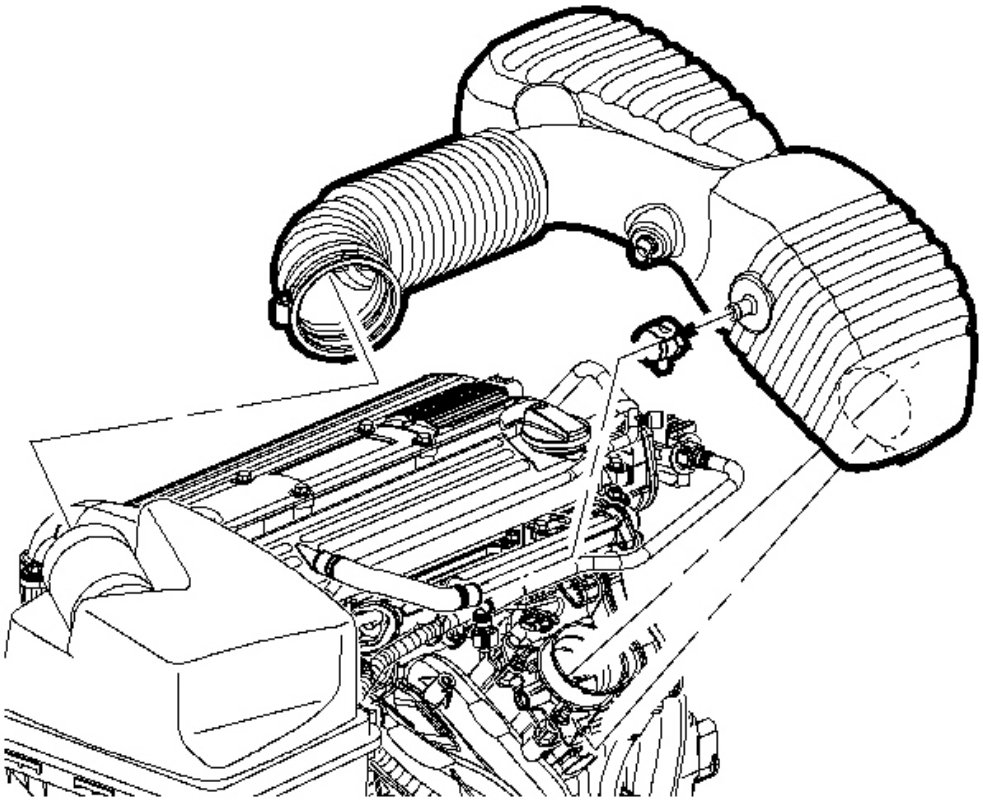


Fig. 99: Locating Air Intake Assembly
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: When starting the vehicle, check for excessive idle shake. Powertrain rebalance may be required.

21. Remove the **SA9105E** . See **Special Tools and Equipment** .
22. Position the outlet resonator/duct assembly into position.
23. Connect the PCV fresh air vent hose assembly.
24. Tighten the clamp at the throttle body assembly.

25. Position the outlet resonator/duct assembly up with the support bracket and install the push-pin.
26. Tighten the clamp at the air cleaner assembly.
27. Connect the intake air temperature (IAT) sensor connector.
28. Connect the negative battery cable.

    Tighten: Tighten the negative battery terminal bolt to 17 N.m (13 lb ft) + 75 degrees.

TIMING CHAIN, SPROCKETS, AND/OR TENSIONER REPLACEMENT

Tools Required

- **J 38122-A** Crankshaft Pulley Holder. See **Special Tools and Equipment** .
- **J 43405** Engine Support Fixture Adaptor. See **Special Tools and Equipment** .
- **J 44811** Accessory Belt Tensioner Unloader. See **Special Tools and Equipment** .
- **SA9105E** 3-Bar Engine Support Fixture. See **Special Tools and Equipment** .
- **SA9127E** Gage Bar Set. See **Special Tools and Equipment** .
- **J 39914** Serpentine Belt Tension Unloader. See **Special Tools and Equipment** .
- **J 45027** Tensioner Tool. See **Special Tools and Equipment** .

Removal Procedure

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
2. Disconnect the intake air temperature (IAT) sensor connector.
3. Loosen the clamp at the air cleaner assembly.

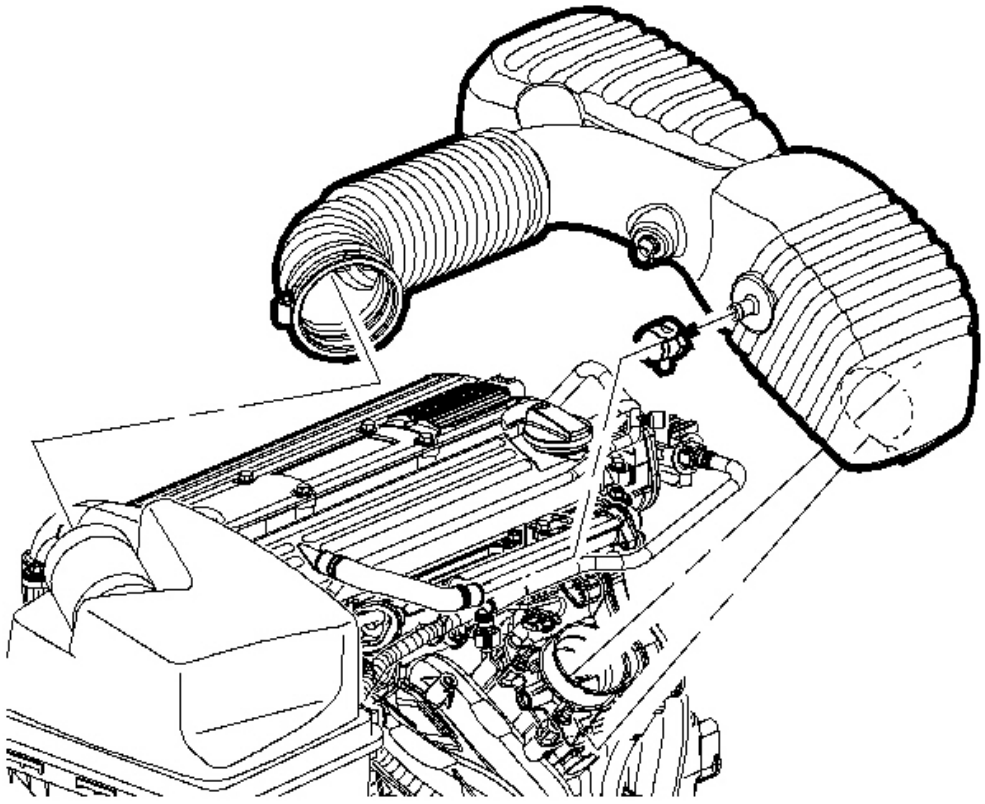


Fig. 100: Locating Air Intake Assembly
Courtesy of GENERAL MOTORS CORP.

4. Remove the push pin attachment from the outlet resonator/duct assembly to the support bracket.
5. Loosen the clamp at the throttle body assembly.
6. Disconnect the PCV fresh air vent hose at the cam cover.
7. Remove the outlet resonator/duct assembly.
8. Remove the air cleaner assembly hold-down bolt.
9. Remove the air cleaner assembly.

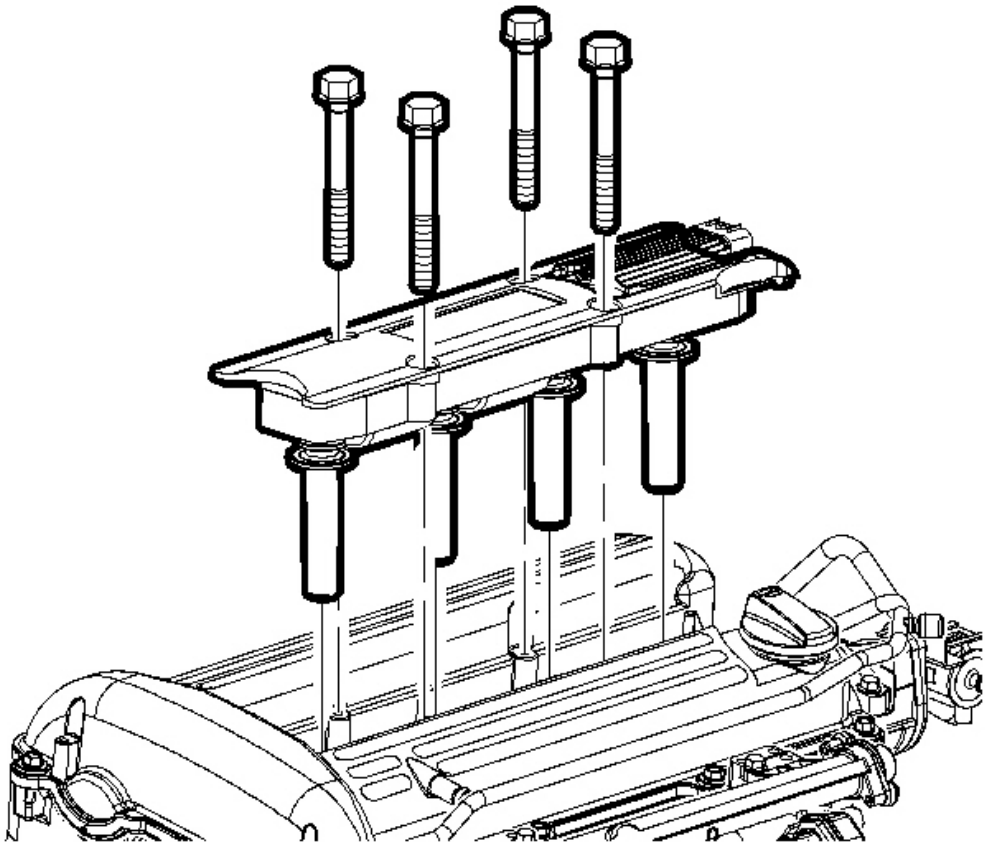


Fig. 101: Removing/Installing Ignition Module Assembly
Courtesy of GENERAL MOTORS CORP.

10. Remove the ignition module bolts.
11. Remove the ignition module assembly.

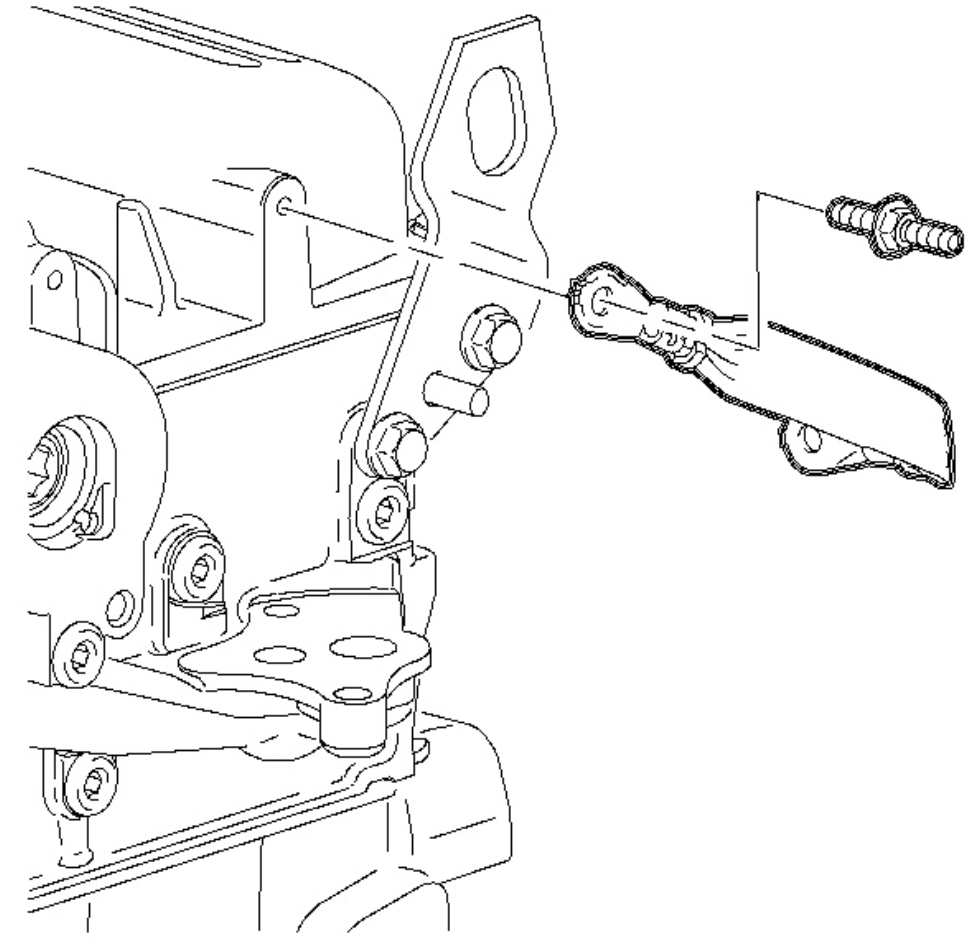


Fig. 102: Disconnecting/Connecting Ground Strap On The Camshaft Cover Assembly
Courtesy of GENERAL MOTORS CORP.

12. Disconnect the de-gas hose at the clamp at the cylinder head and unclip from the fuel rail. Position away from the cam cover assembly.
13. Disconnect the ground strap at the rear of the cam cover assembly.

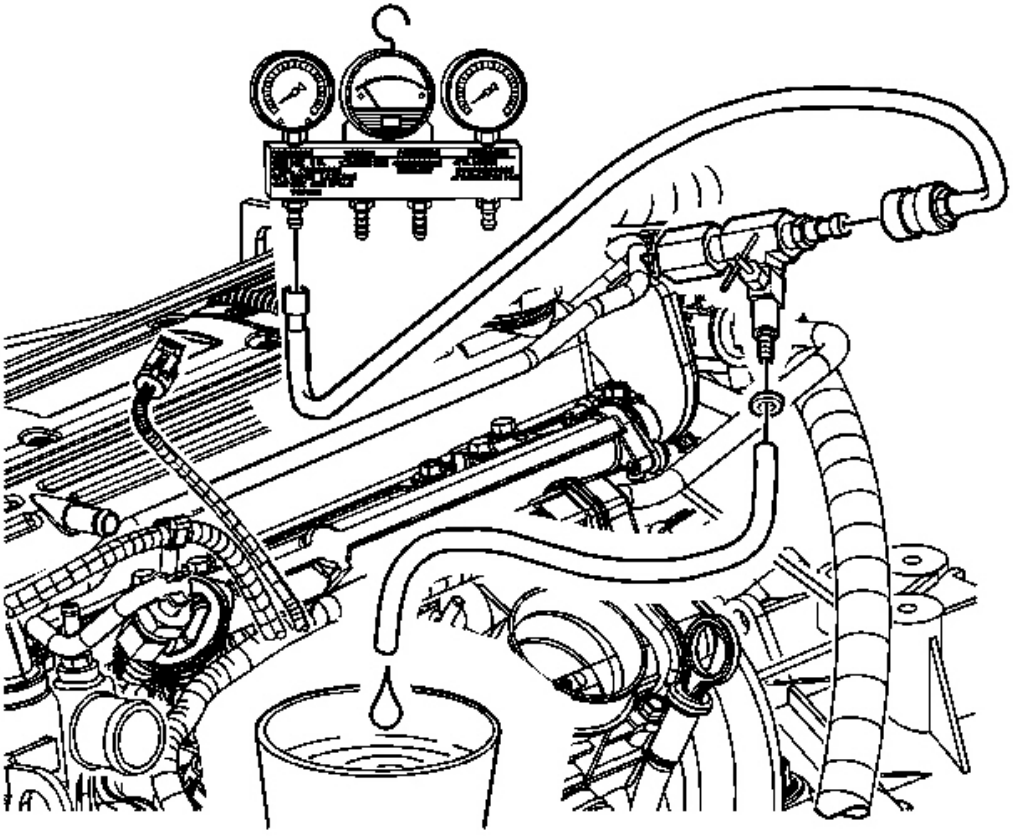


Fig. 103: Disconnecting Gage Bar Set SA9127E
Courtesy of GENERAL MOTORS CORP.

14. Relieve the fuel system pressure.
15. Disconnect the after the pressure has been relieved.

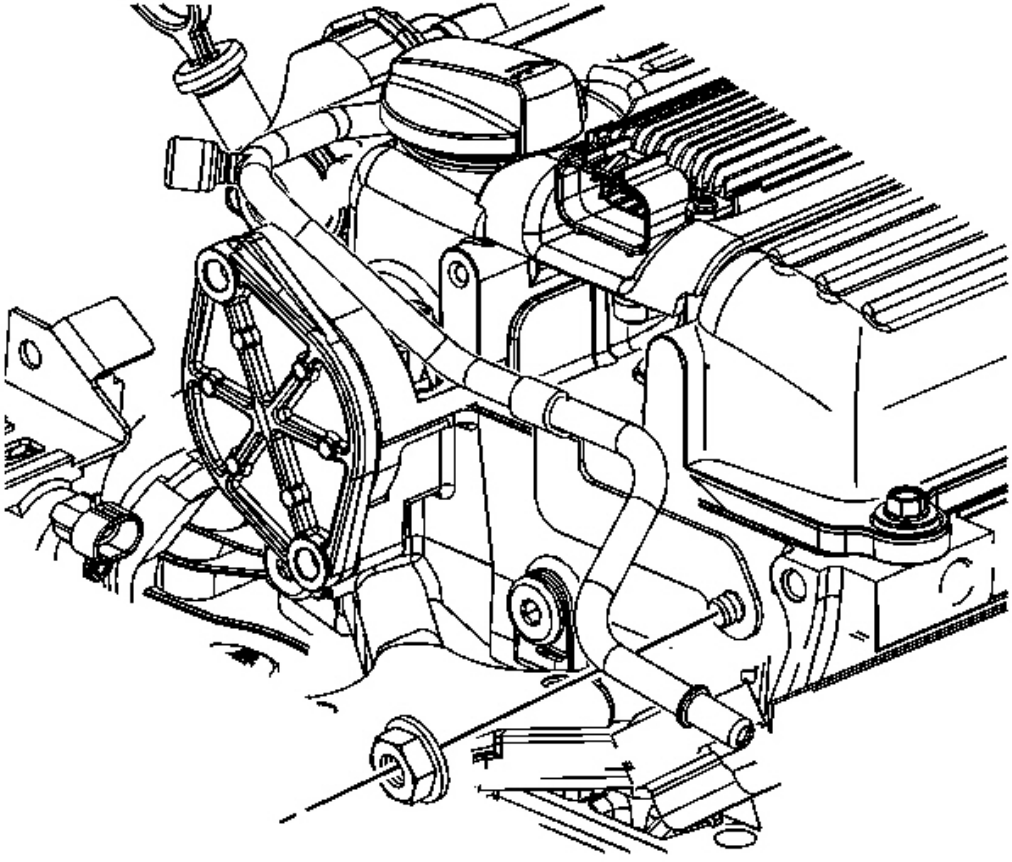


Fig. 104: Fuel Rail Bracket
Courtesy of GENERAL MOTORS CORP.

16. Disconnect the fuel rail bracket and bolt at the rear of the cam cover.

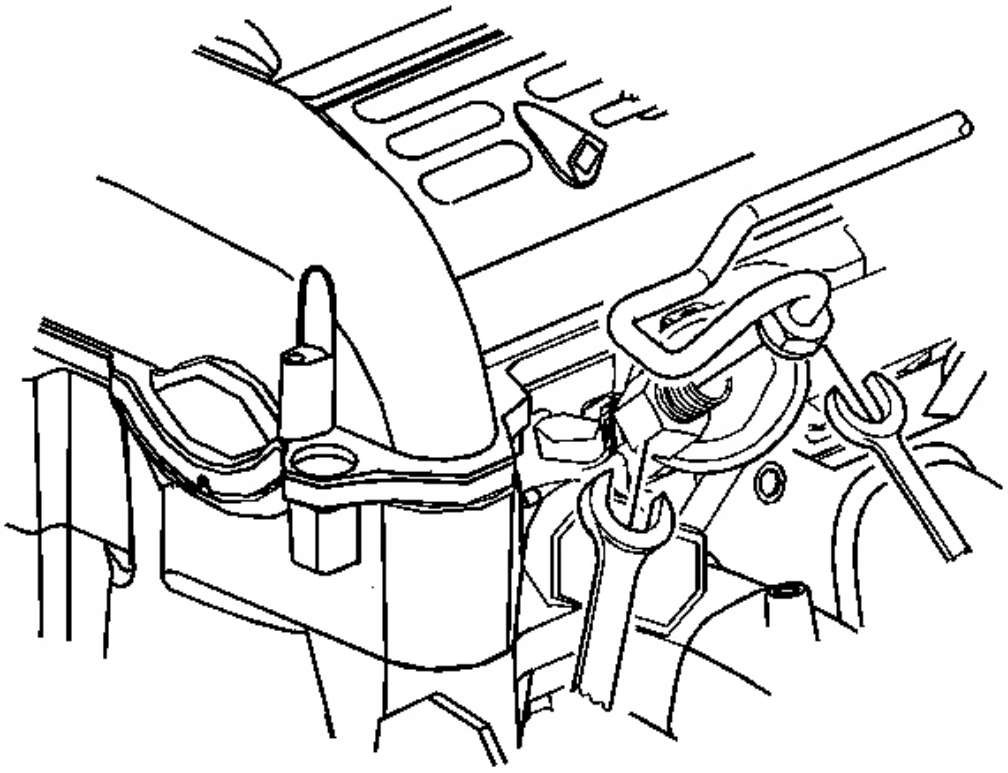


Fig. 105: Repositioning Fuel Line Assembly
Courtesy of GENERAL MOTORS CORP.

17. While supporting the fuel rail assembly with an open end wrench, loosen the transfer line fitting at the fuel rail.

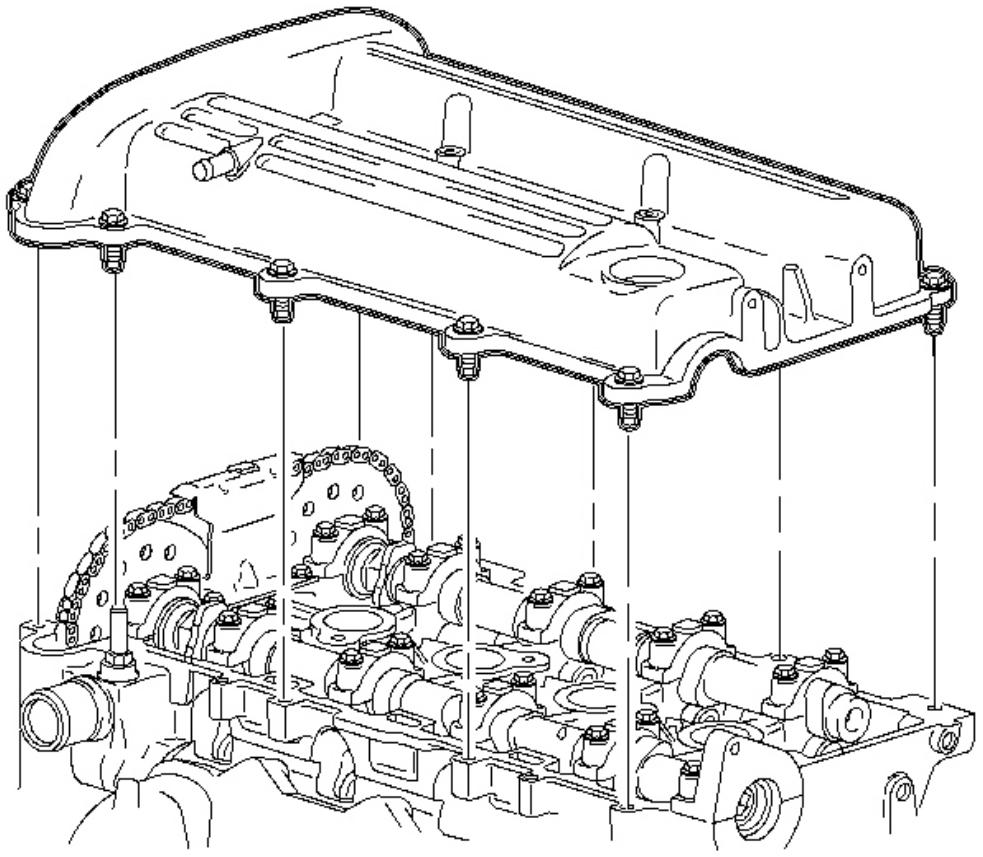


Fig. 106: Removing Cam Cover Assembly
Courtesy of GENERAL MOTORS CORP.

18. Position the fuel line away from the cam cover assembly.
19. Remove the cam cover assembly bolts.
20. Remove the cam cover assembly.

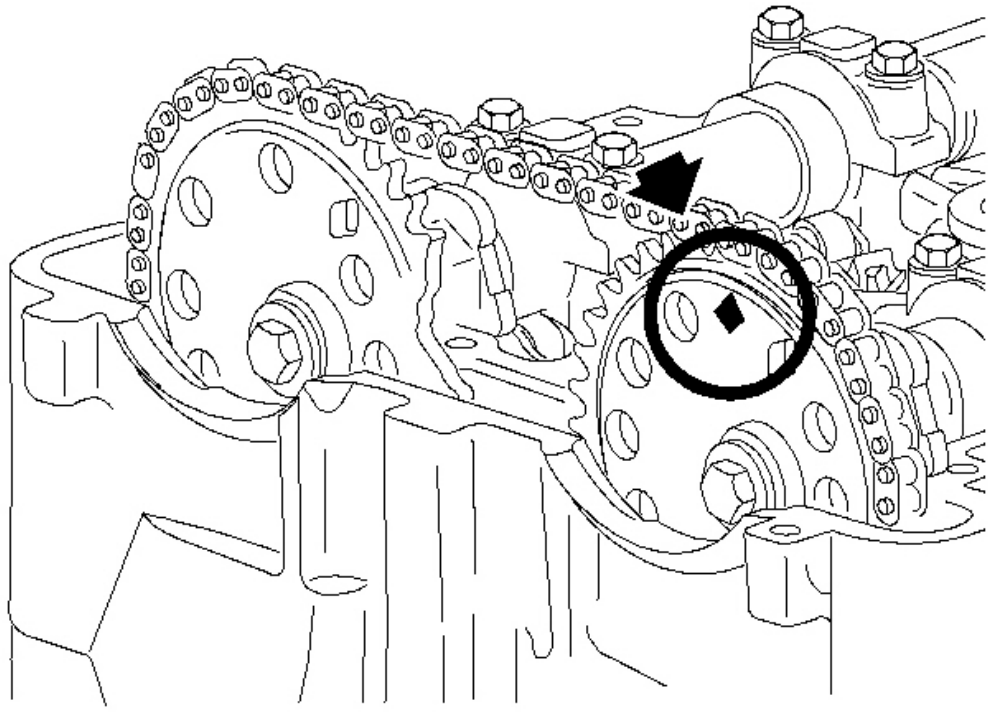


Fig. 107: Rotating Camshaft Using 24 mm Open-End Wrench
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: To rotate the camshaft, use a 24 mm open-end wrench on the camshaft flats. Camshaft should be rotated in a clockwise direction only, facing camshaft sprockets from the passenger side of the vehicle.

21. Locate the No. 1 piston to approximately 60 degrees before top dead center (diamond shaped hole on intake camshaft sprocket at 12 o'clock position). Remove the spark plugs. This will ease the rotation effort.

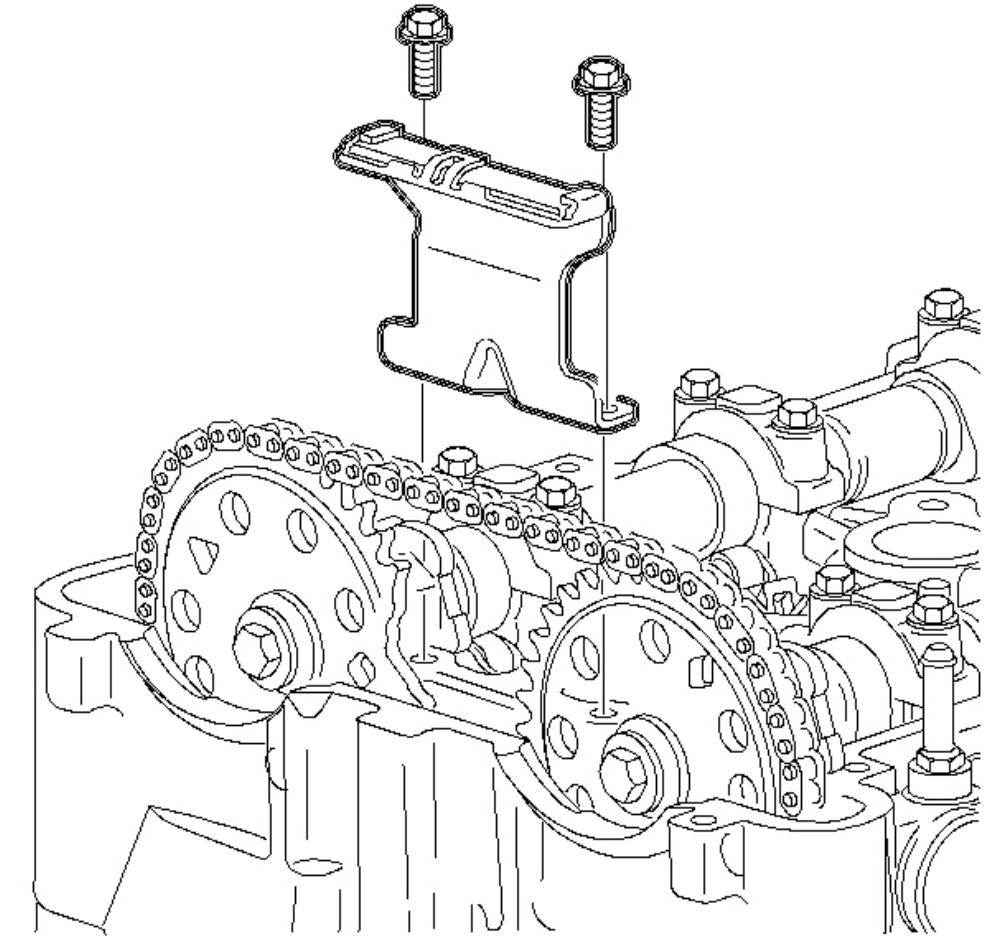


Fig. 108: Removing/Installing Upper Timing Chain Guide & Bolts
Courtesy of GENERAL MOTORS CORP.

22. Remove the upper timing chain guide.

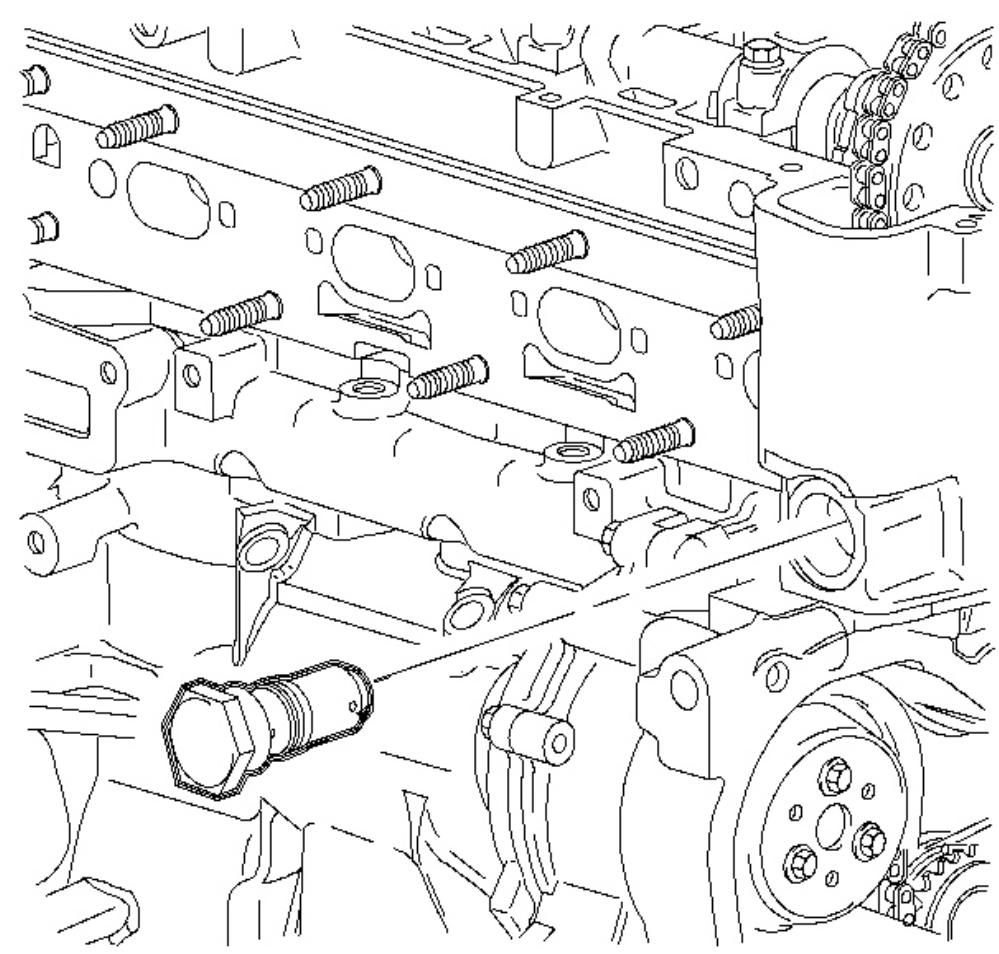


Fig. 109: Removing/Installing Timing Chain Tensioner Assembly
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The timing chain tensioner must be removed to unload the chain tension before the timing chain is removed. If it is removed, the timing chain may bind and be difficult to remove.

23. Remove the timing chain tensioner.

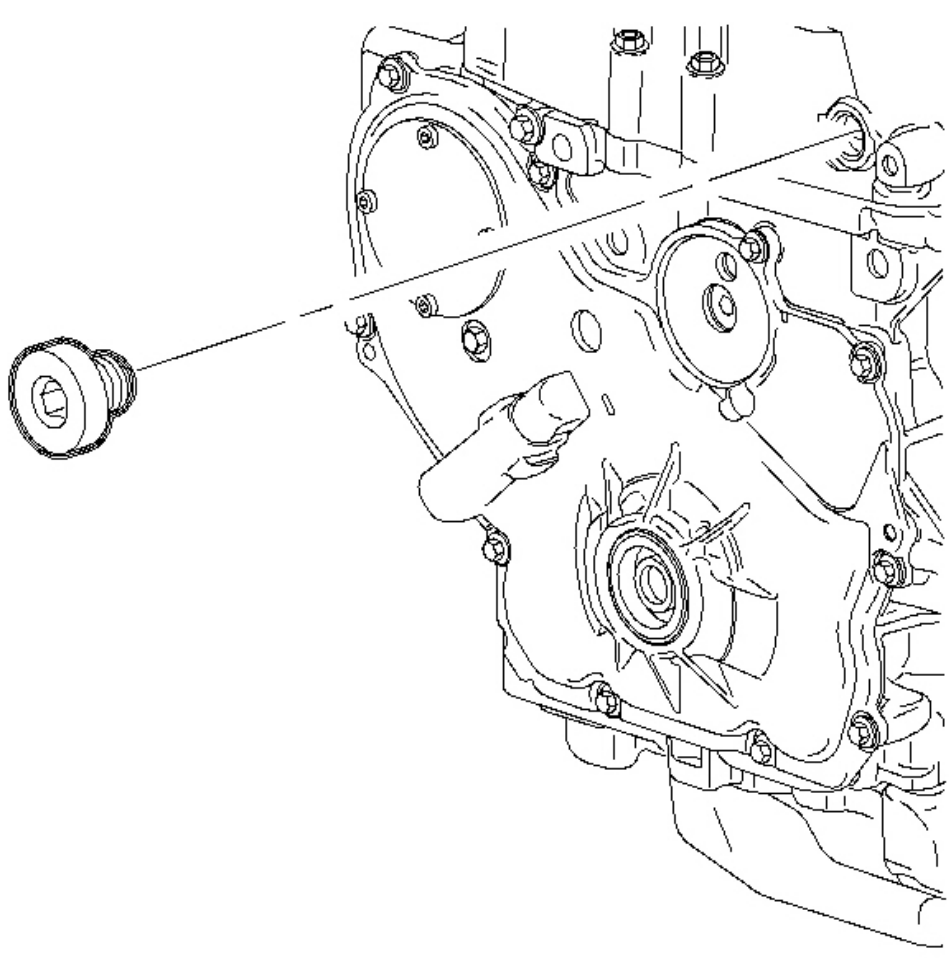


Fig. 110: Removing Fixed Timing Chain Guide Access Plug
Courtesy of GENERAL MOTORS CORP.

24. Remove the fixed timing chain guide access plug.
25. Using a magnetic socket, remove the upper fixed guide bolt.

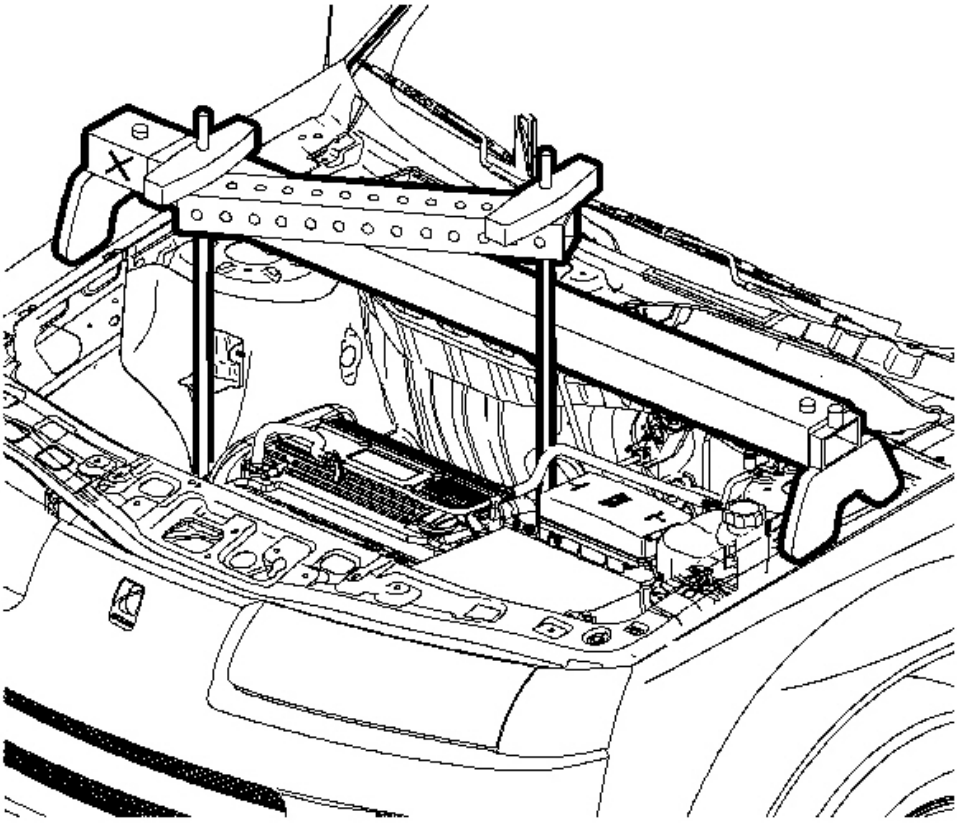


Fig. 111: Installing SA9105E Set Up For SUV Application
Courtesy of GENERAL MOTORS CORP.

26. Install the set up for SUV application.

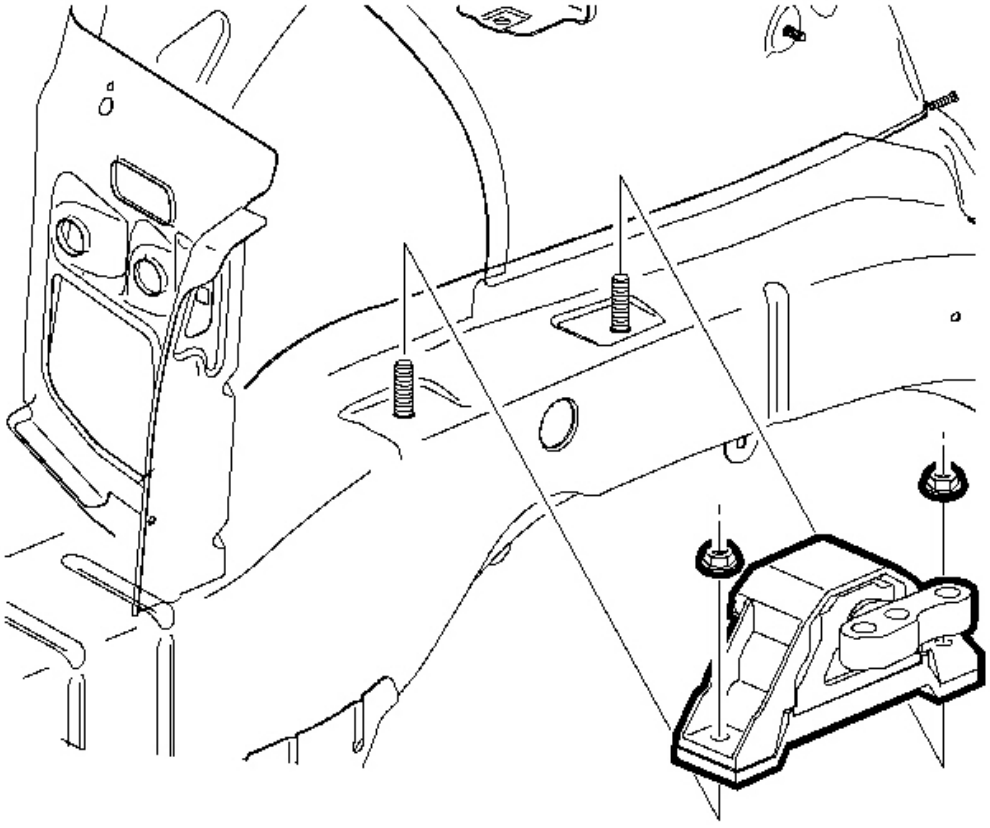


Fig. 112: View Of RH Engine Mount
Courtesy of GENERAL MOTORS CORP.

27. Remove the right-hand engine mount-to-bracket bolts.
28. Remove the right-hand mount assembly nuts.
29. Remove the right-hand engine mount assembly.

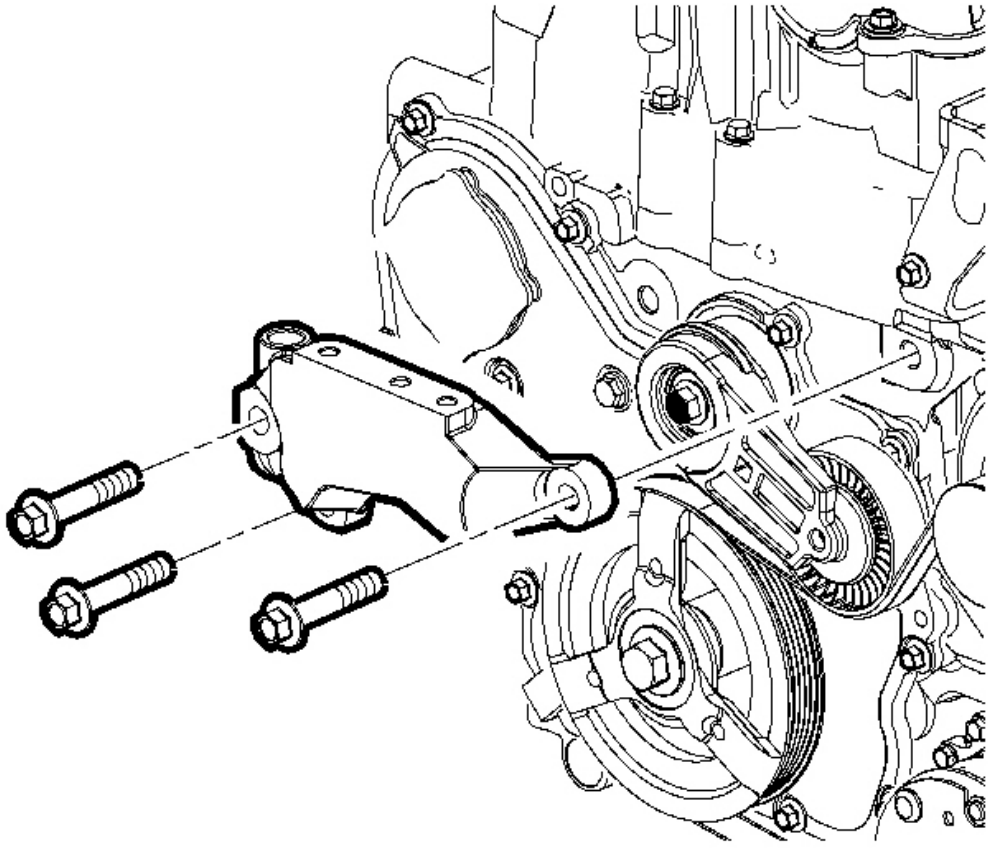


Fig. 113: Removing/Installing Right Hand Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

30. Remove the right-hand mount bracket.
31. Remove the right-hand engine mount bracket.
32. Raise the vehicle on a hoist.
33. Remove the right wheel and splash shield.

IMPORTANT: Do not rest the engine assembly on the oil pan plug outside of the oil pan near the crankshaft or an oil leak may result.

34. Install the block of wood (1x2x4) between the oil pan and the cradle.

35. Install the **J 44811** . See **Special Tools and Equipment** .
36. Remove the accessory drive belt.
37. Remove the tensioner bolt. To remove the bolt, an access hole has been provided through the inner and outer engine rail.

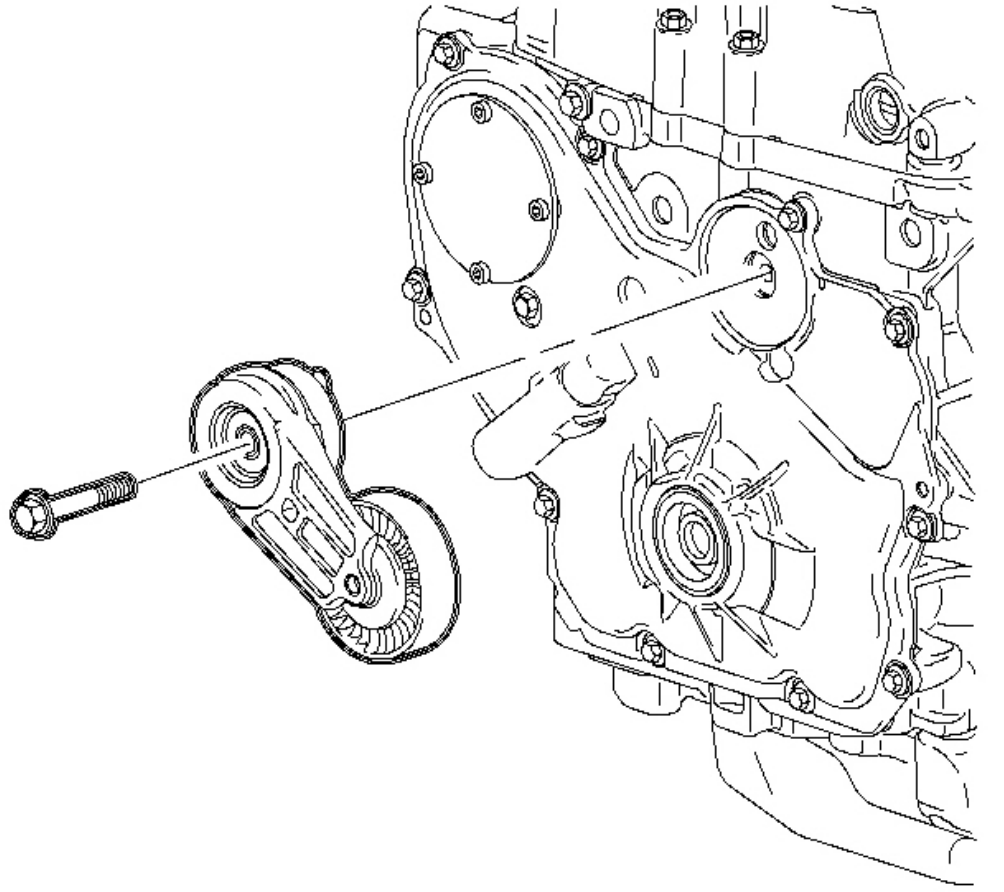


Fig. 114: Removing/Installing Tensioner Assembly & Bolt
Courtesy of GENERAL MOTORS CORP.

38. Remove the tensioner assembly.

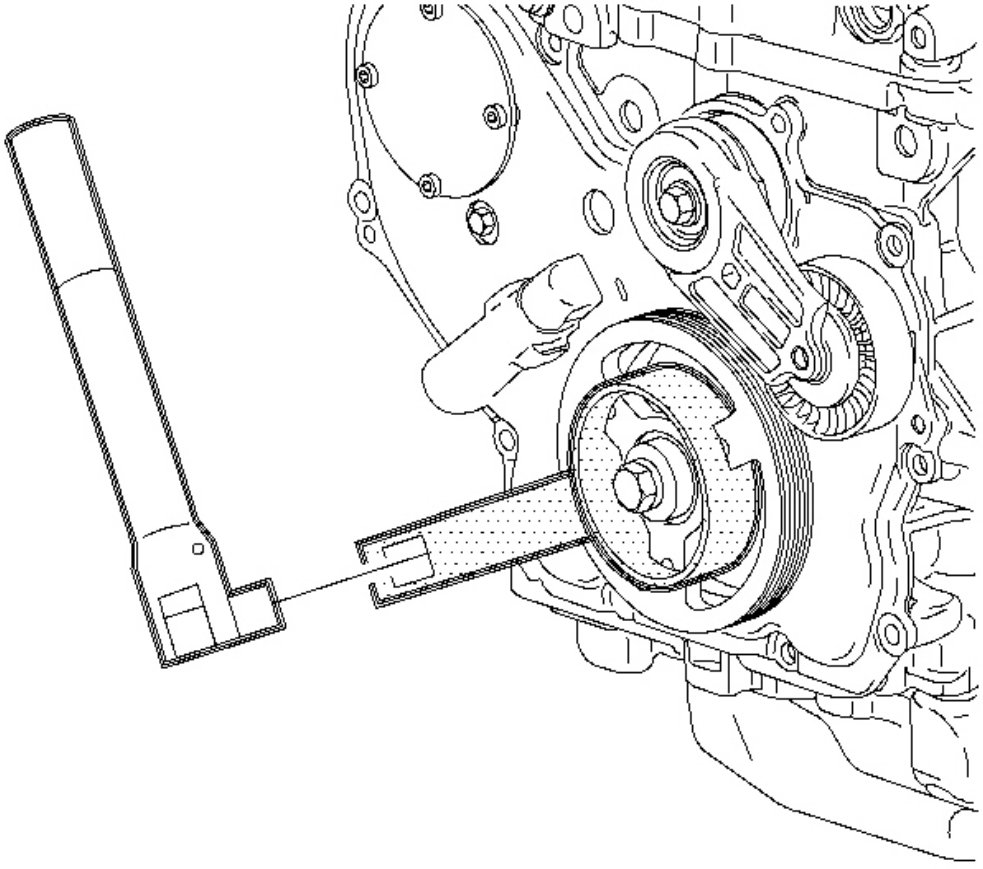


Fig. 115: Installing Crankshaft Pulley Holder
Courtesy of GENERAL MOTORS CORP.

39. Install the **J 38122-A** . See **Special Tools and Equipment** .

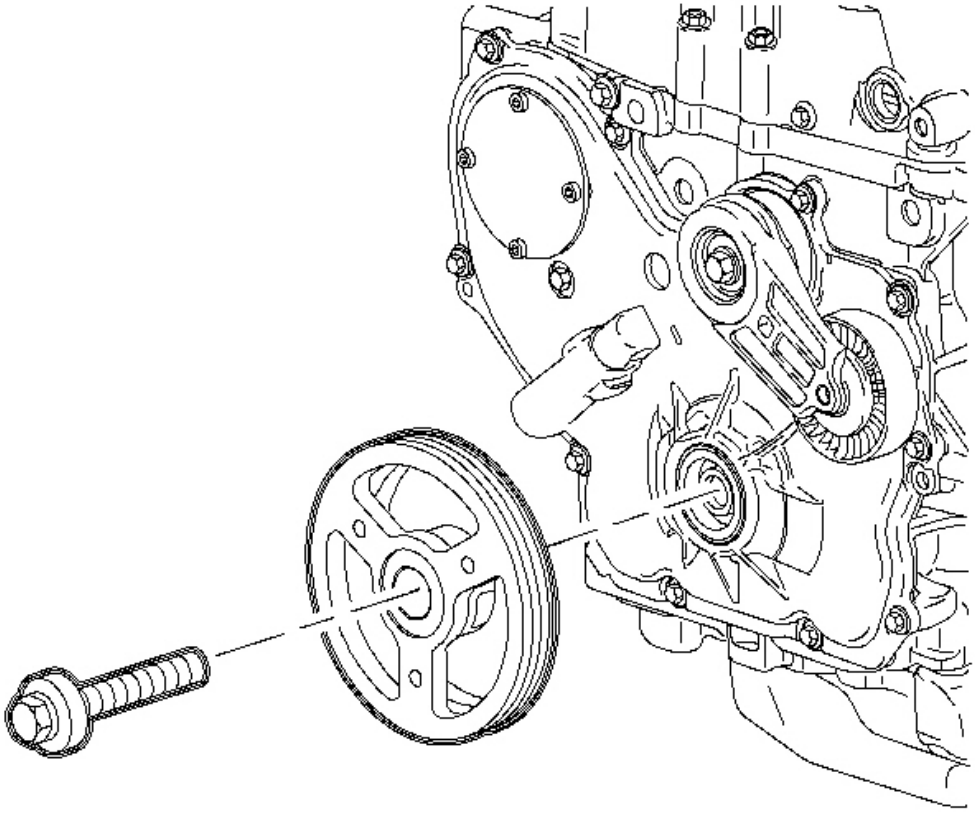


Fig. 116: Removing/Installing Crankshaft Balancer Pulley Bolt
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The crankshaft balancer pulley bolt head and washer assembly prevents oil leakage at the center of the pulley. Do not damage the sealing surfaces. If the pulley cannot be removed by pulling with the hand, use a three-jaw puller.

40. Remove the crankshaft balancer pulley bolt and pulley.

    Discard the pulley bolt.

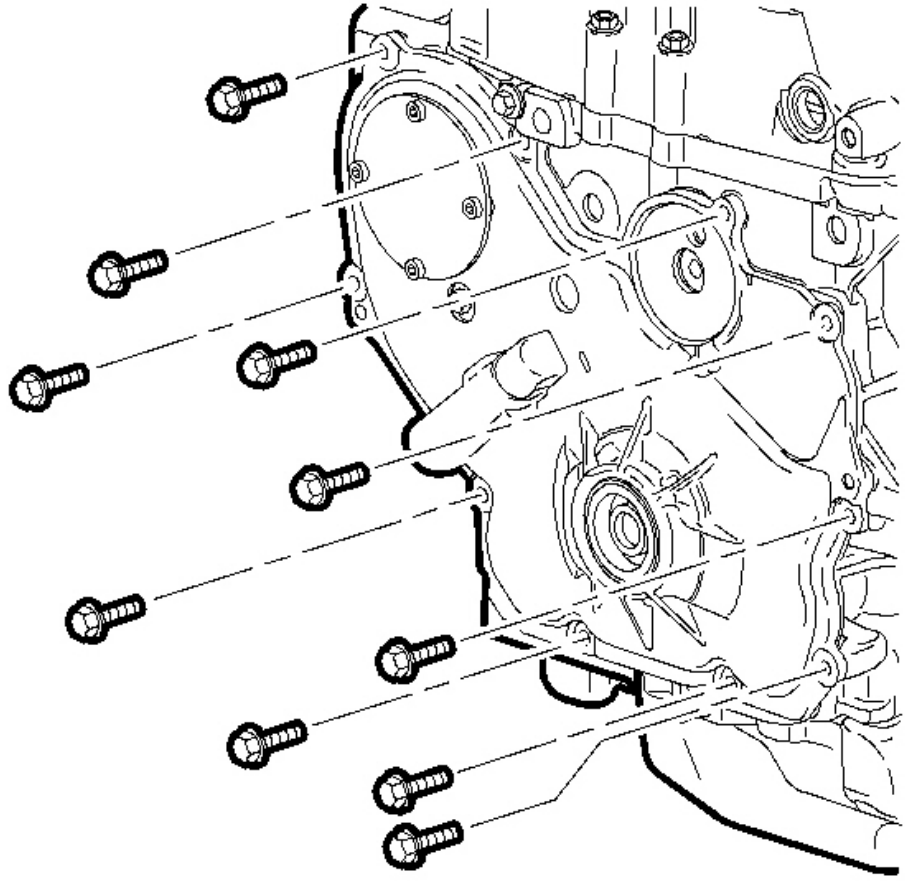


Fig. 117: Removing/Installing Front Cover Assembly
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: To avoid damage to the front cover assembly, do not pry against the cover.

41. Remove the front cover assembly bolts.
42. Remove the lower water pump assembly bolt.
43. Remove the front cover assembly and gasket.

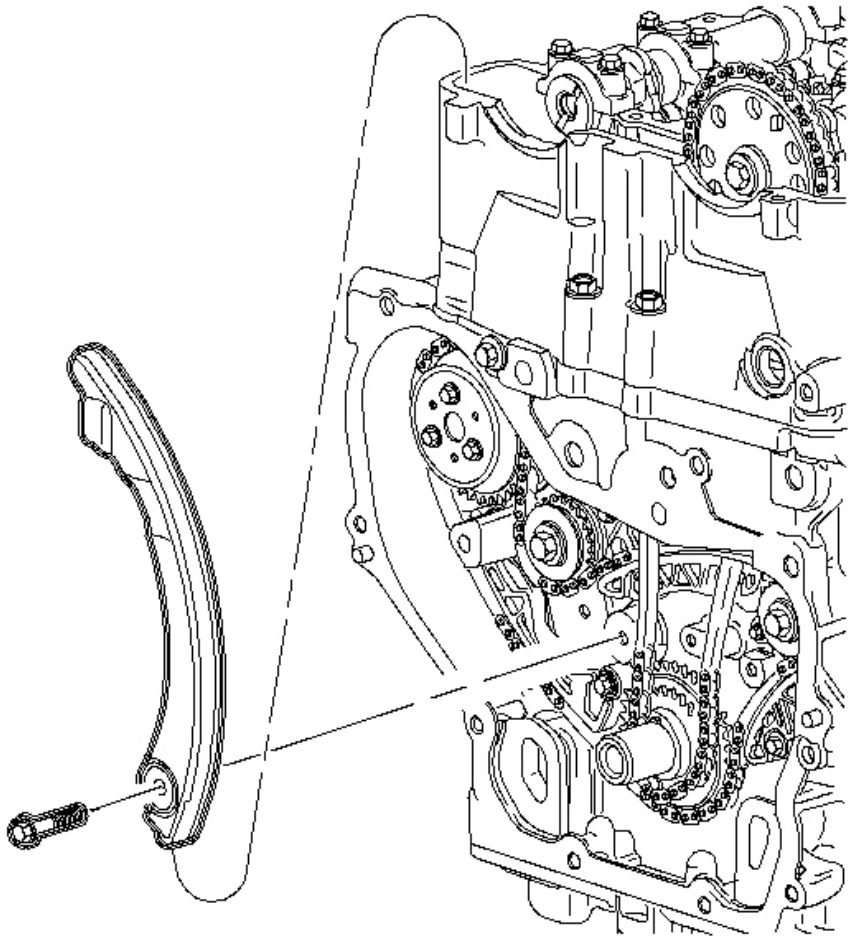


Fig. 118: Timing Chain Adjustable Guide And Bolt
Courtesy of GENERAL MOTORS CORP.

44. Remove the adjustable guide bolt.

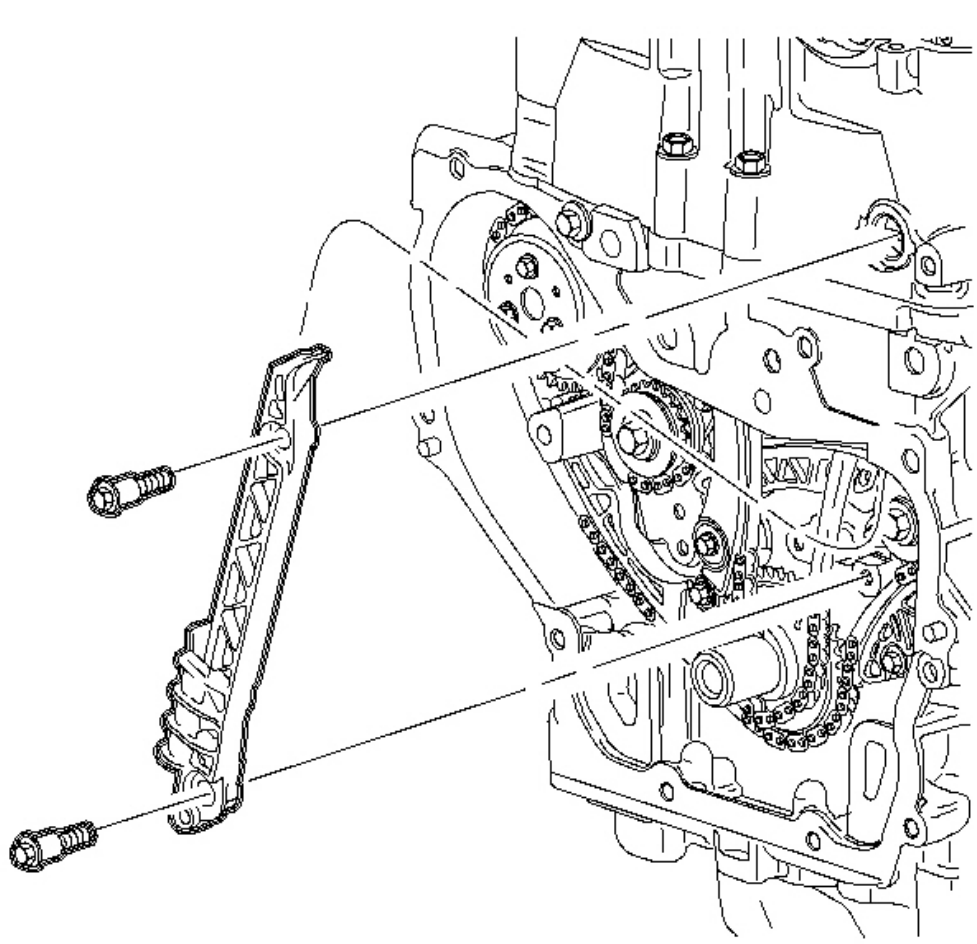


Fig. 119: Fixed Timing Chain Guide & Bolts
Courtesy of GENERAL MOTORS CORP.

45. Remove the lower fixed guide bolt.
46. Remove the fixed guide.

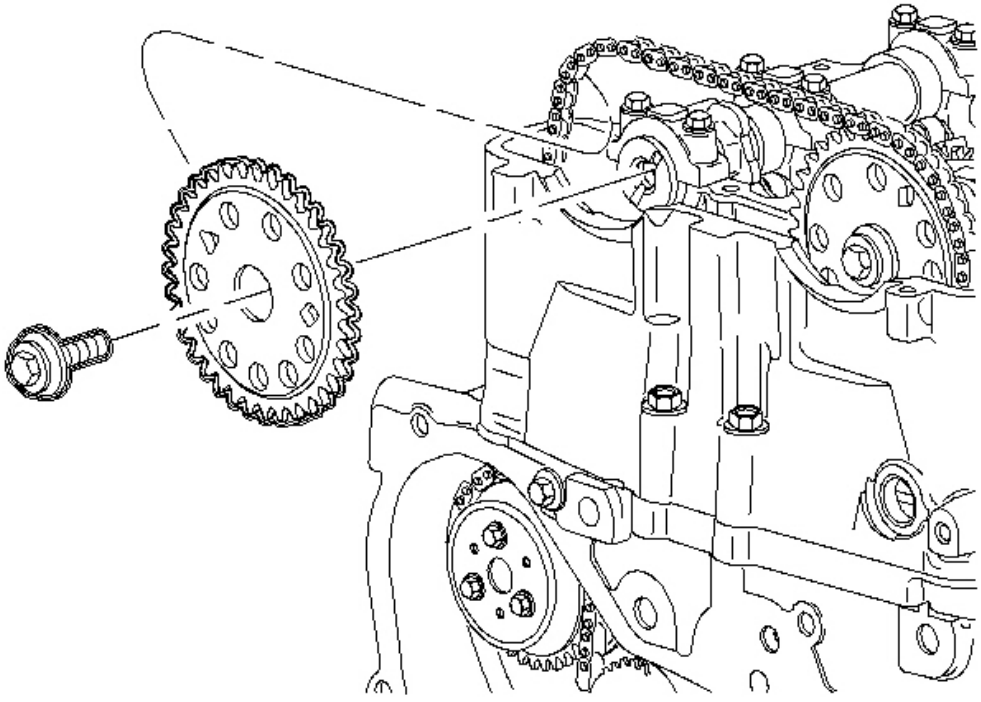


Fig. 120: Removing/Installing Camshaft Sprocket Bolt
Courtesy of GENERAL MOTORS CORP.

47. Use a 24 mm wrench to hold the camshaft assembly while removing the exhaust sprocket bolt. Discard the bolt.
48. Remove the exhaust sprocket.

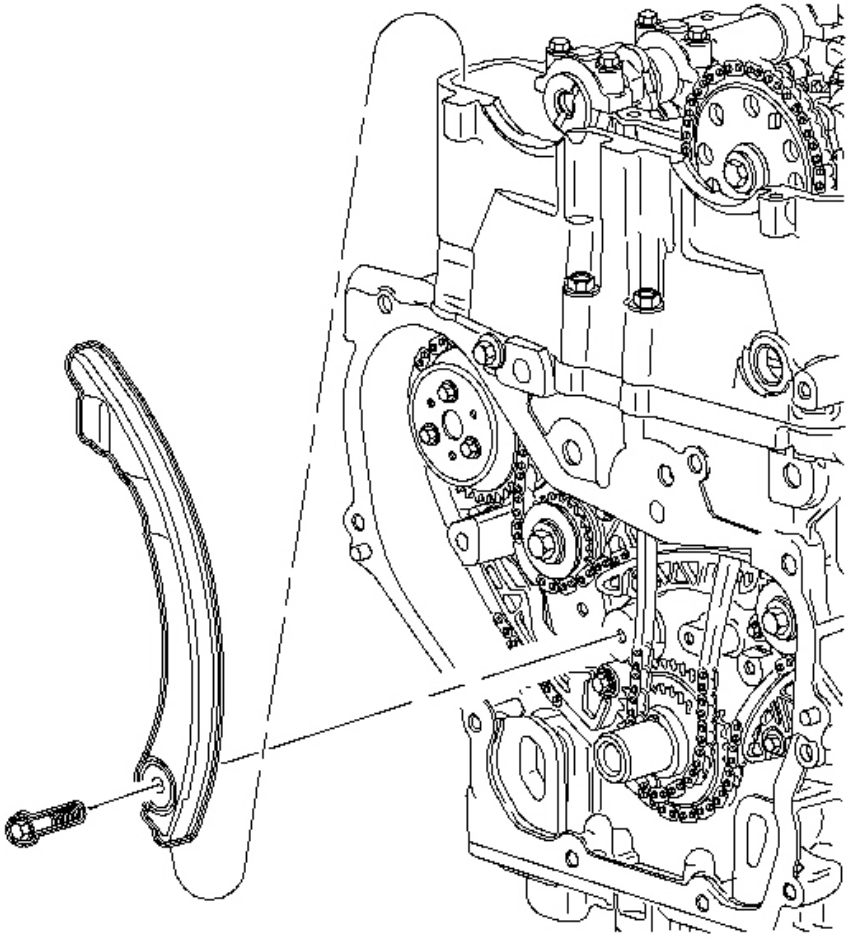


Fig. 121: Timing Chain Adjustable Guide And Bolt
Courtesy of GENERAL MOTORS CORP.

49. Remove the adjustable guide through the top of the cylinder head.

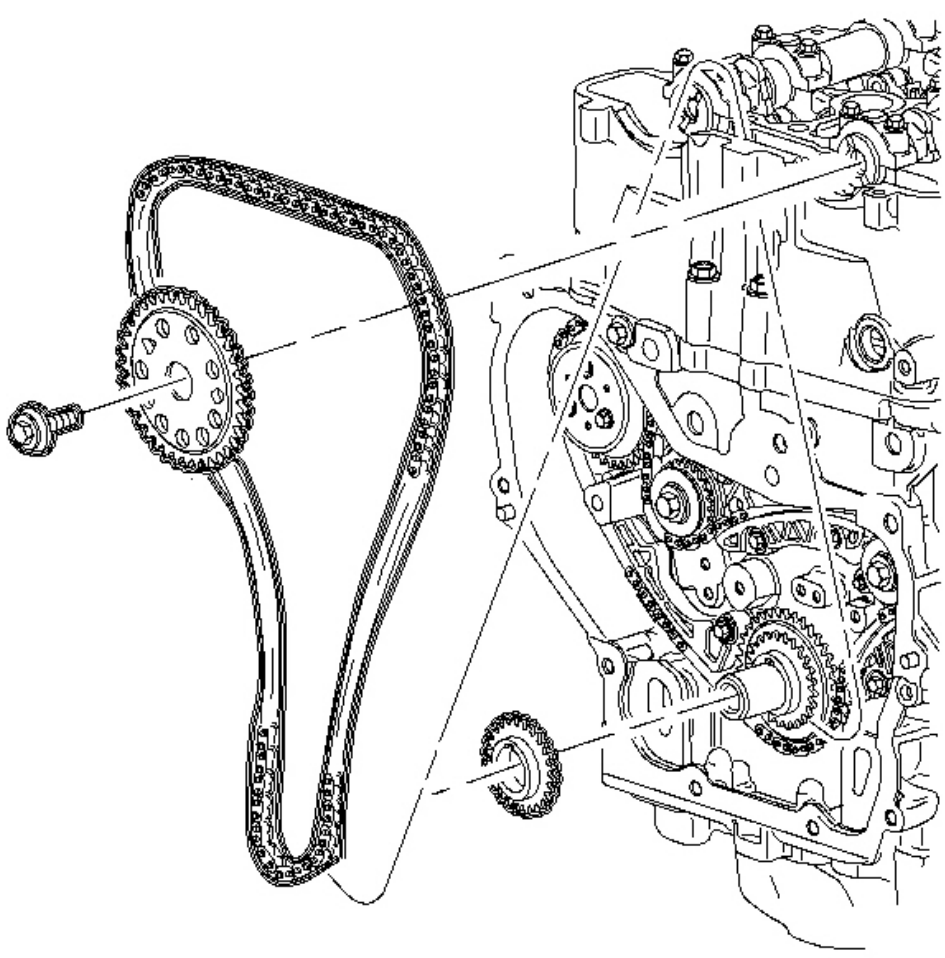


Fig. 122: Holding Camshaft Assembly Using 24 mm Wrench
Courtesy of GENERAL MOTORS CORP.

50. Use a 24 mm wrench to hold the camshaft assembly while removing the intake sprocket bolt. Discard the bolt.
51. Remove the intake sprocket.
52. Remove the timing chain assembly through the top of the cylinder head.
53. Remove the timing chain drive sprocket from the crankshaft.

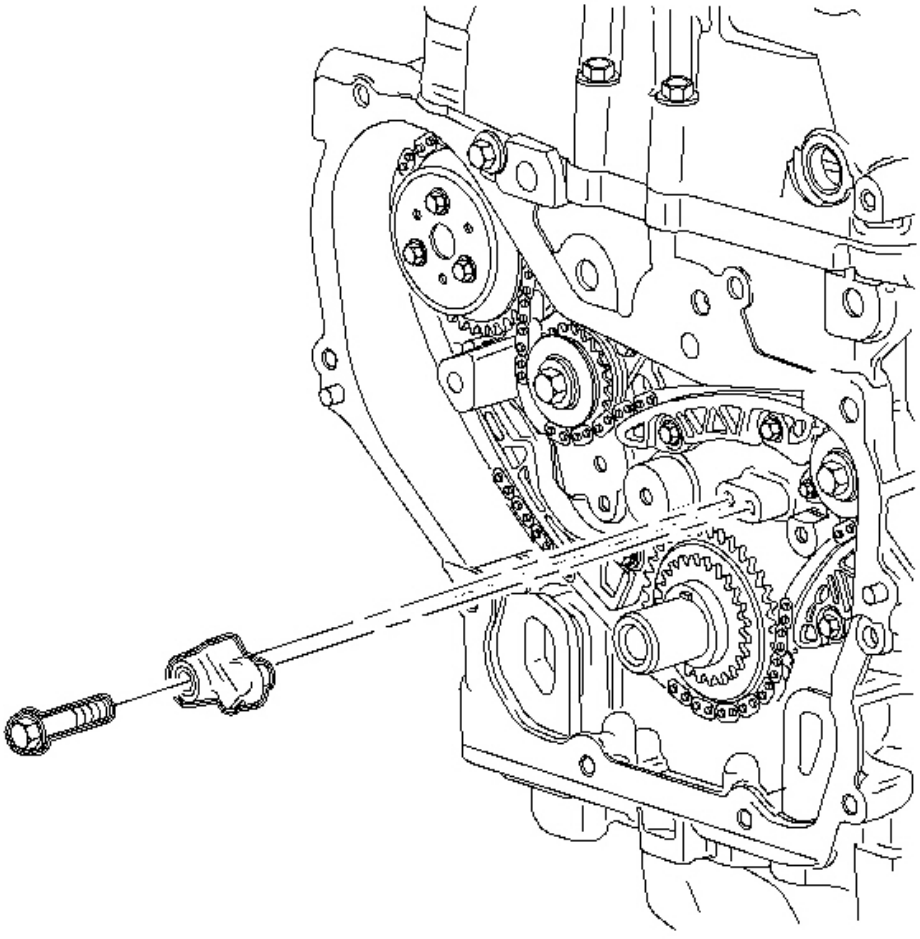


Fig. 123: Removing/Installing Timing Chain Oiling Nozzle & Bolt
Courtesy of GENERAL MOTORS CORP.

54. Remove the timing chain oiler nozzle and bolt.
55. Clean the oil nozzle orifice on the block to remove any debris.

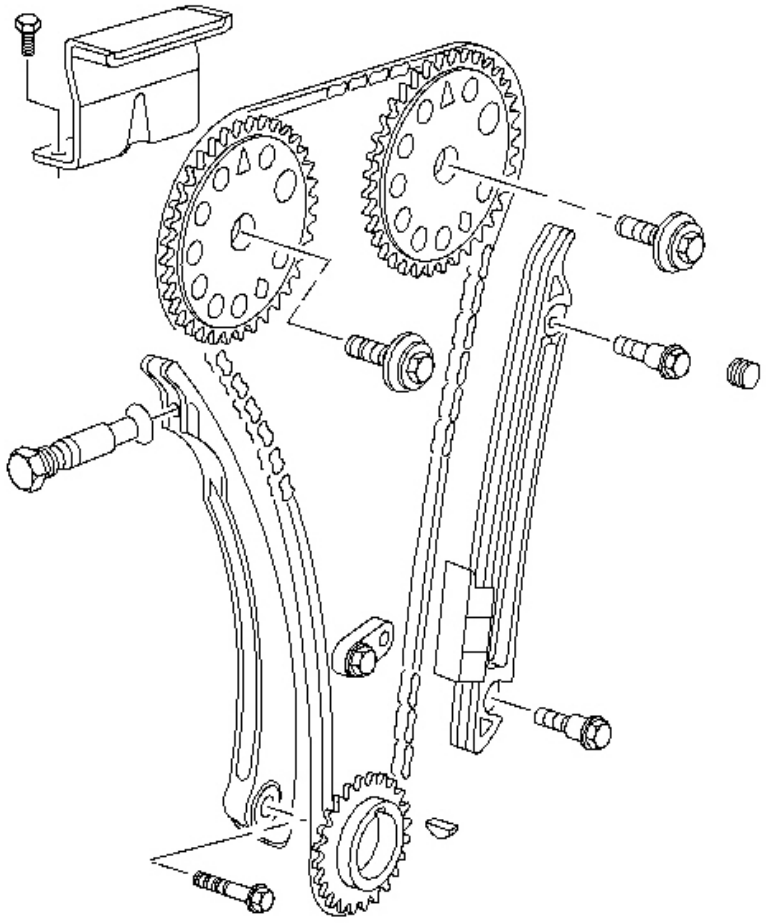


Fig. 124: Inspecting Timing Chain Guides
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Replace the timing chain guides if the wear exceeds 1.12 mm (0.045 in).

56. Inspect the timing chain guide for wear.
57. Inspect the timing chain and the sprockets for signs of excessive wear, chipping, or seizure to links on the chain.

Installation Procedure

NOTE: Refer to Fastener Notice in Cautions and Notices.

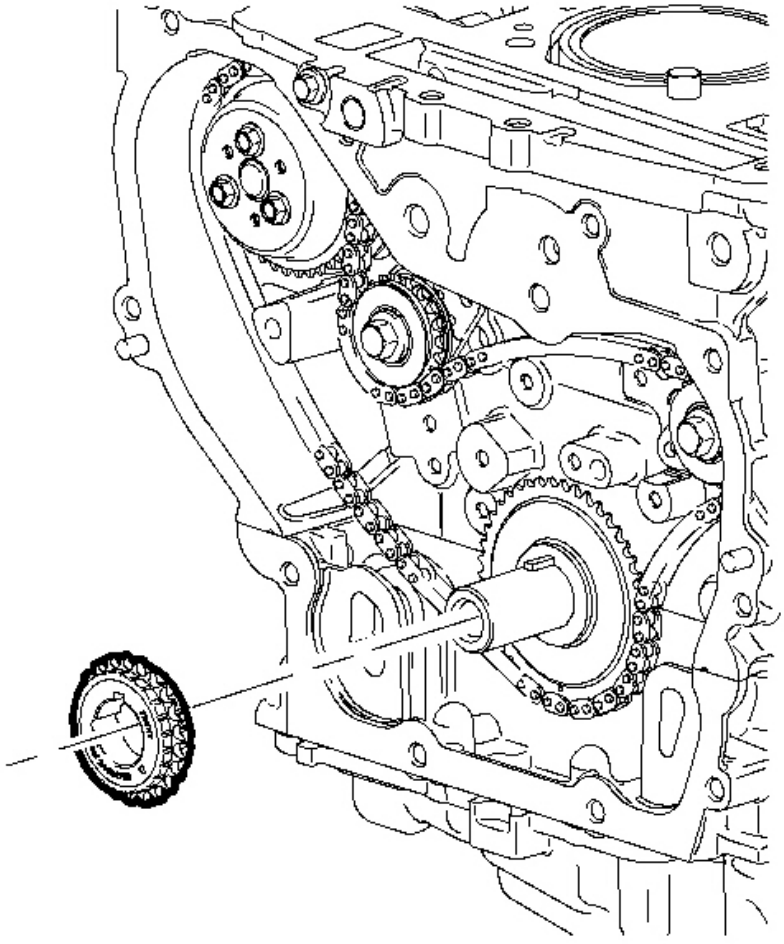


Fig. 125: Installing Timing Chain Drive Sprocket
Courtesy of GENERAL MOTORS CORP.

1. Install the timing chain oiler nozzle and the bolt, then tighten.

   Tighten: Tighten the timing chain oil nozzle bolt to 10 N.m (89 lb in).

2. Install the timing chain drive sprocket to the crankshaft.

   NOTE: Set crankshaft to 60 degrees before top-dead center or after TDC to prevent valve to piston contact.

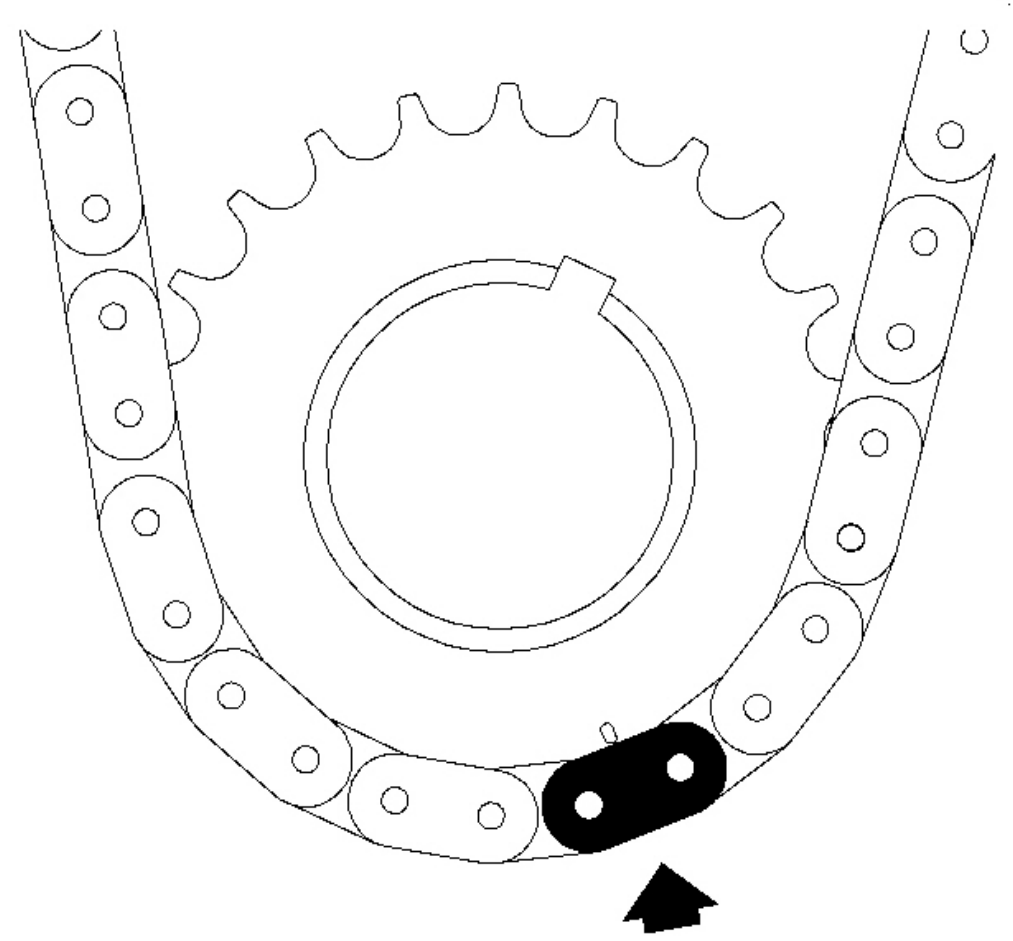


Fig. 126: Setting Mark On The Timing Chain Drive Sprocket At 5 O'clock Position
Courtesy of GENERAL MOTORS CORP.

3. Using the dampener, rotate the crank so that the mark on the timing chain drive sprocket is at 5 o'clock position.
4. Set the crankshaft to 60 degrees before the top dead center.

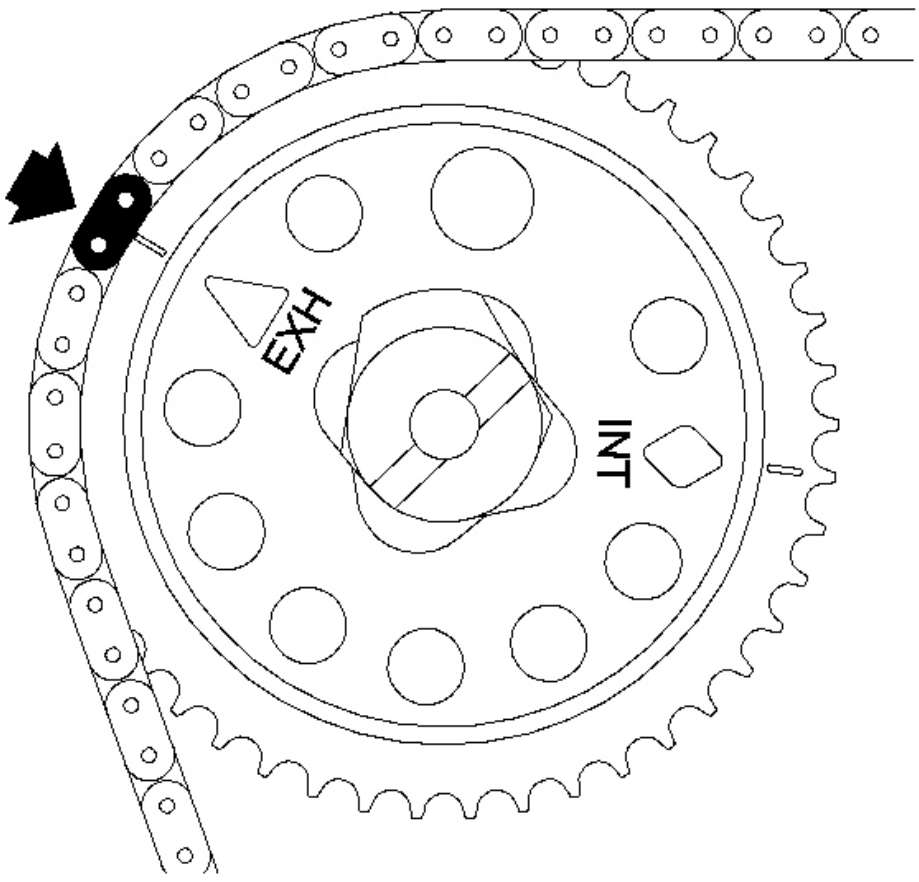


Fig. 127: Positioning Exhaust Camshaft
Courtesy of GENERAL MOTORS CORP.

5. Position the exhaust camshaft with the offset slot to 2 o'clock position.

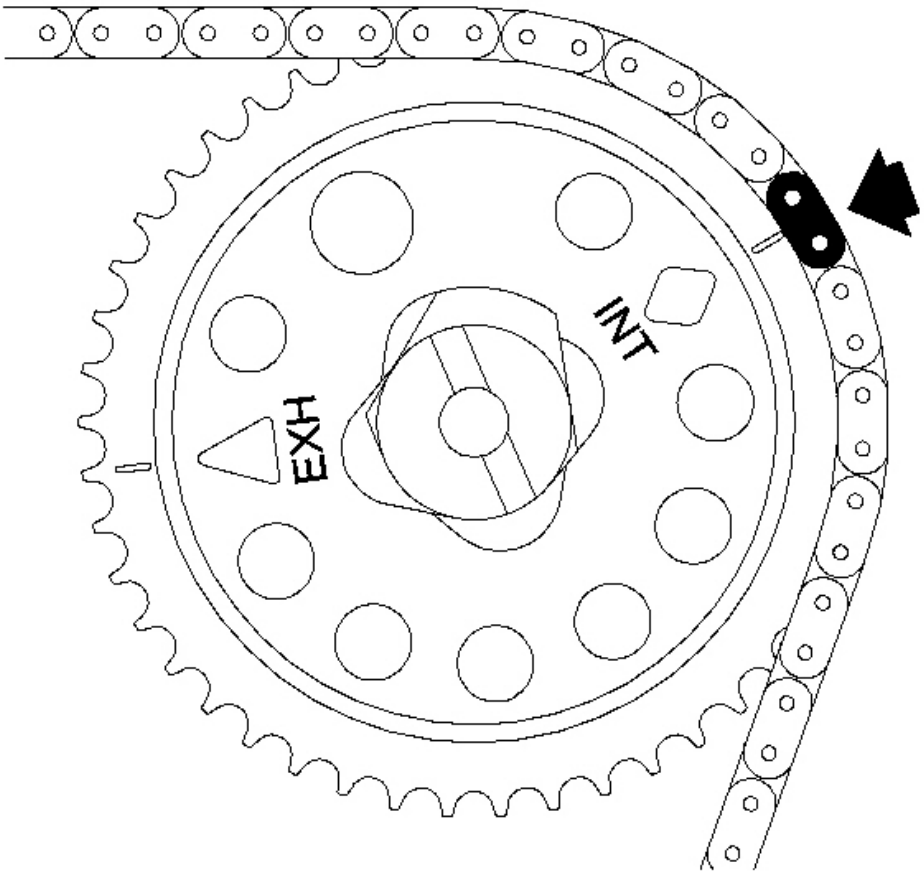


Fig. 128: Positioning Intake Camshaft
Courtesy of GENERAL MOTORS CORP.

6. Position intake camshaft with offset slot to 11 o'clock position.
7. Assemble the chain to the intake camshaft sprocket aligning the upper link to the INT diamond timing mark on the camshaft sprocket.

IMPORTANT: When lowering the timing chain into the cylinder head, rotate the assembly 90 degrees to allow the chain to fall between the cylinder block bosses, then rotate the assembly back so that the camshaft sprocket is facing forward.

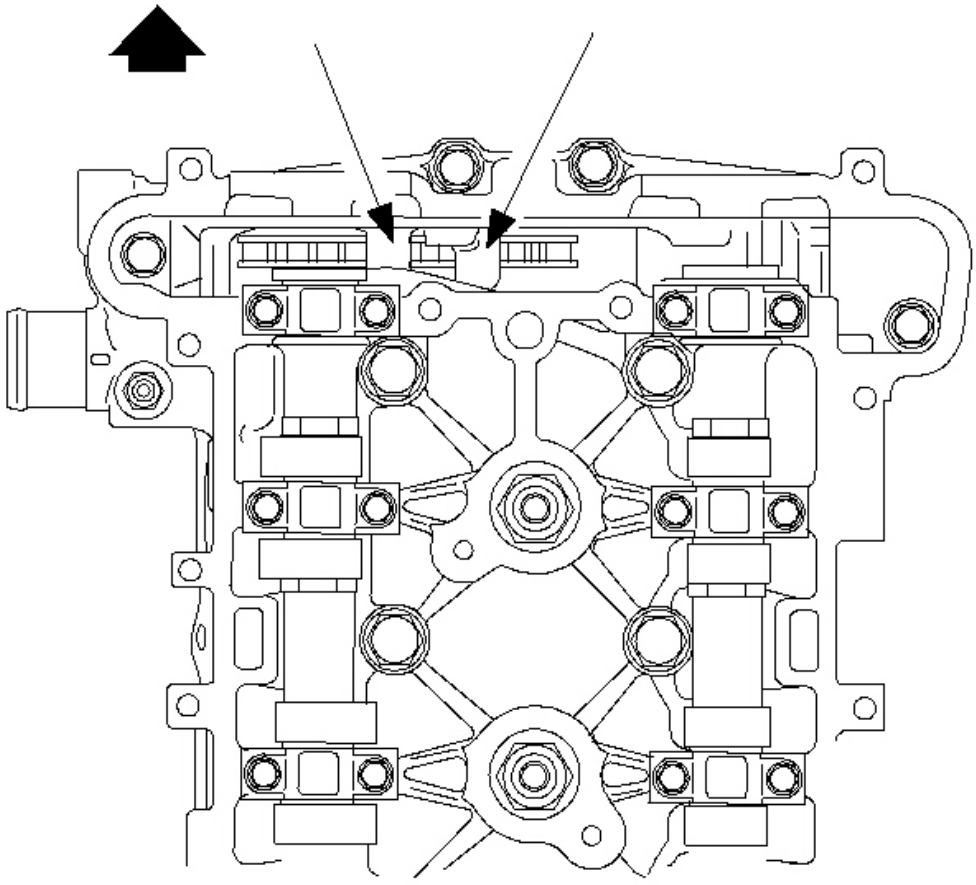


Fig. 129: Rotating Assembly 90 Degrees To Allow The Chain To Fall Between The Cylinder Block Bosses
Courtesy of GENERAL MOTORS CORP.

8. Lower the assembly through chain housing opening on top of the cylinder head. Use care to make sure that the chain goes around both sides of the cylinder block bosses.

IMPORTANT: The crankshaft sprocket timing mark will be at approximately the 5 o'clock position.

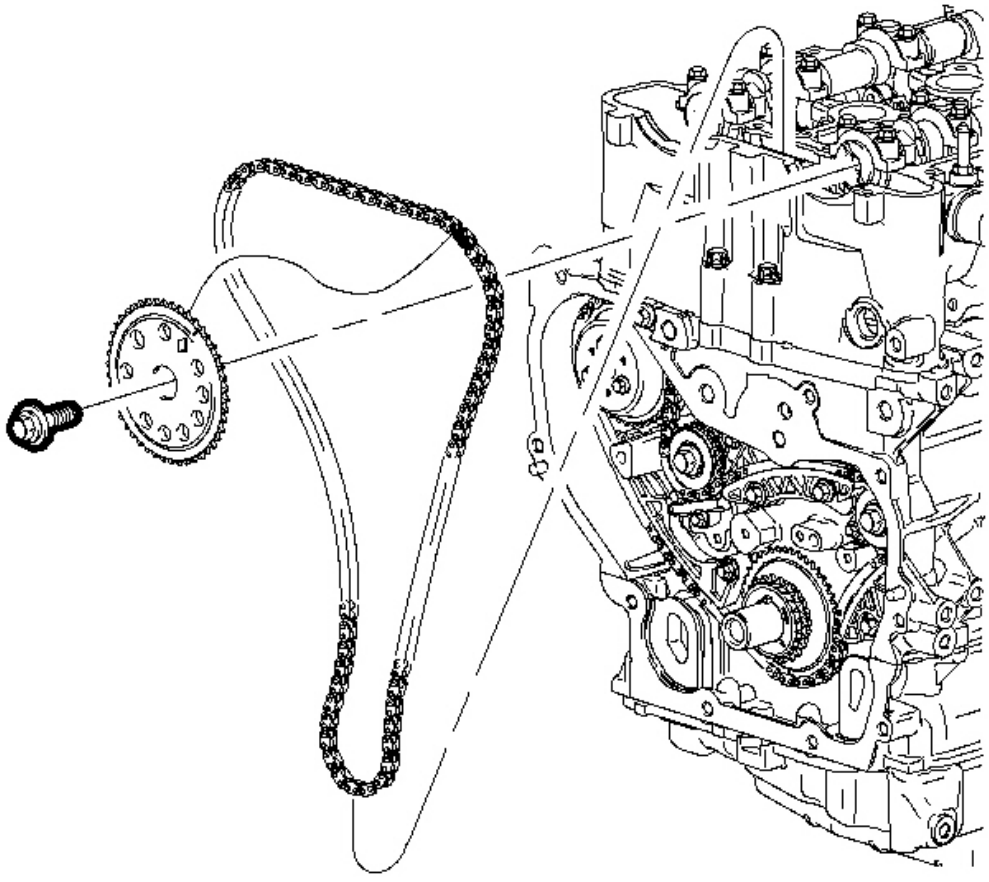


Fig. 130: Routing The Timing Chain Around The Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

9. Route the chain around the crankshaft sprocket and align the silver link to the timing mark.

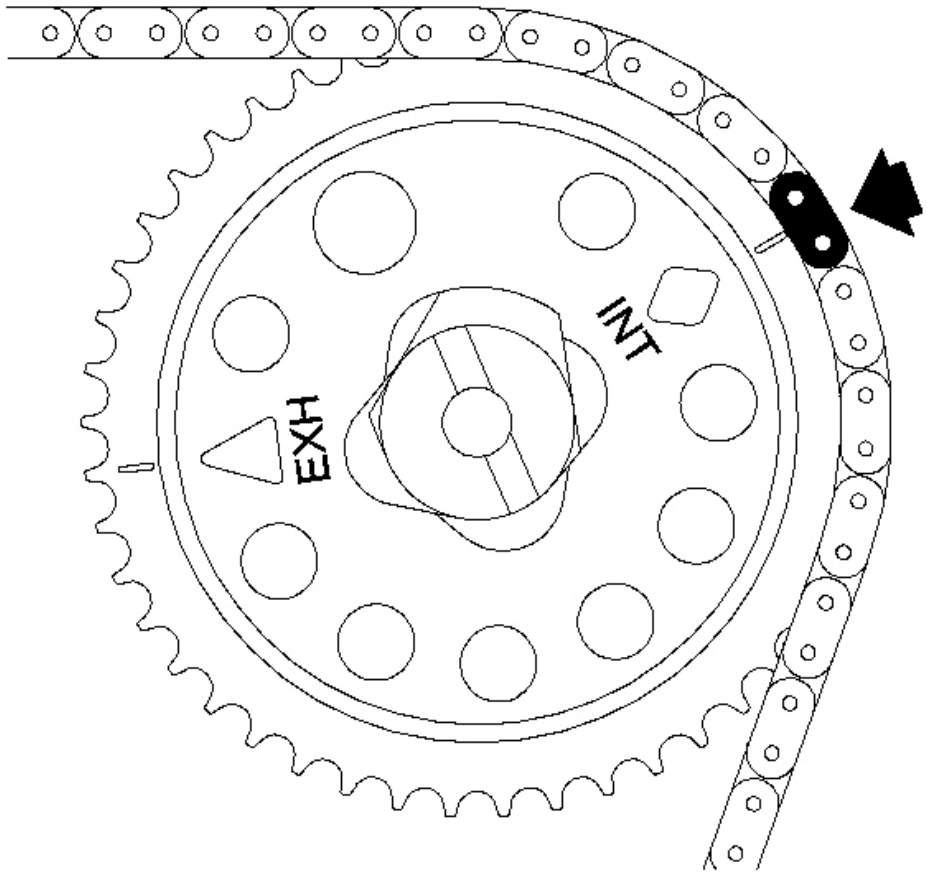


Fig. 131: Positioning Intake Camshaft
Courtesy of GENERAL MOTORS CORP.

NOTE: The camshaft sprocket bolts are not reusable, it is a torque-to-yield (TTY) bolt, and must be discarded to prevent premature failure.

10. Install the intake camshaft sprocket with the chain in proper position to the camshaft. Rotate the intake camshaft using a 24 mm wrench on the flats on the camshaft until the camshaft aligns with the sprocket.
11. Install the new intake camshaft sprocket bolt and finger tighten.

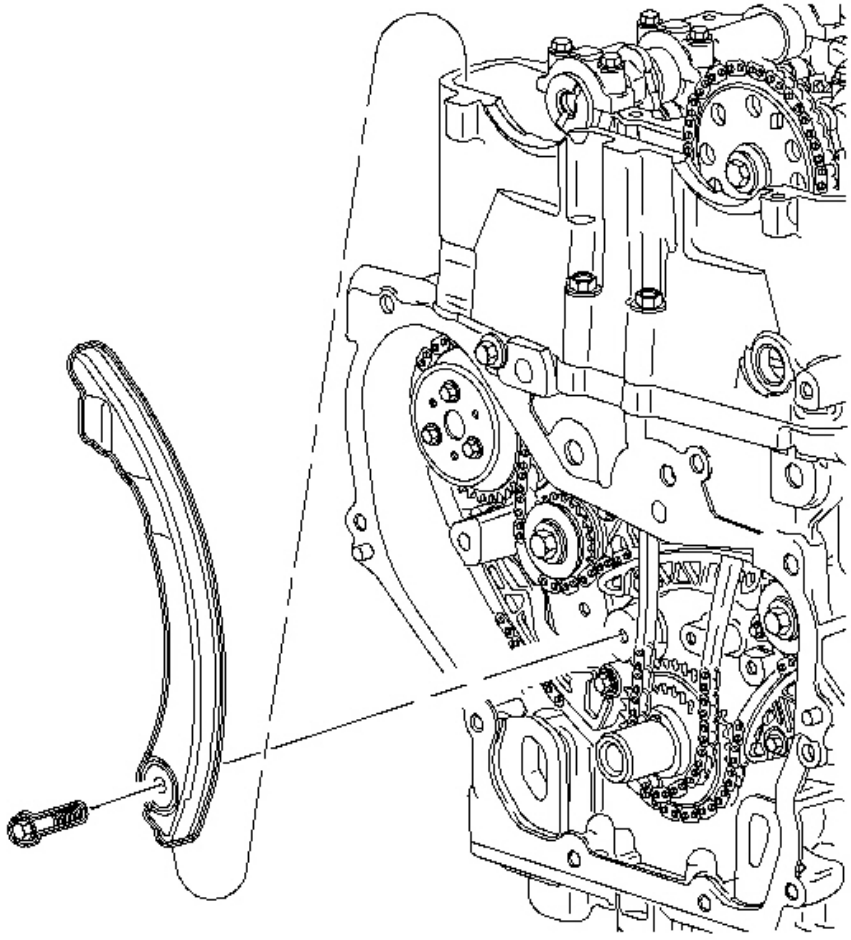


Fig. 132: Timing Chain Adjustable Guide And Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE: Excess slack in the chain must be kept to the chain tensioner side (movable guide) of the cylinder block when installing the timing chain or the camshaft sprockets will not be correctly timed to the crankshaft sprocket.

IMPORTANT: Make sure the crankshaft marks and the camshaft marks aligns with the colored links.

12. Install the adjustable timing chain guide through the opening at the top of the cylinder head and install the

chain guide bolt.

Tighten: Tighten the timing chain guide (adjustable) bolt to 10 N.m (89 lb in).

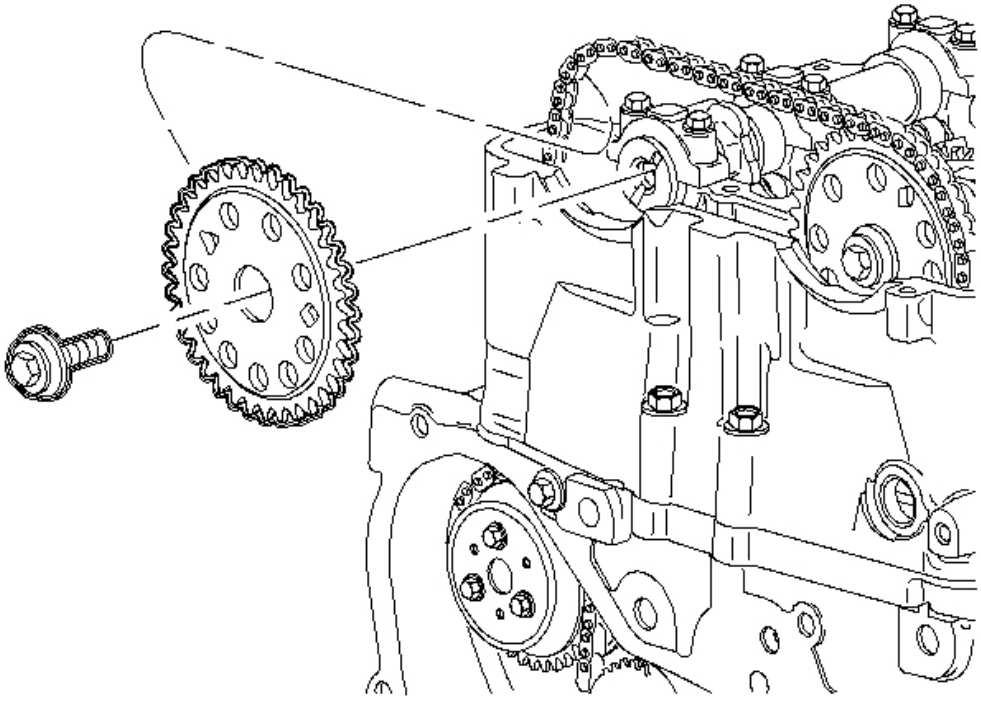


Fig. 133: Removing/Installing Camshaft Sprocket Bolt
Courtesy of GENERAL MOTORS CORP.

13. Install the exhaust camshaft sprocket loosely on the exhaust camshaft with the timing mark on the sprocket aligned with the silver link.
14. Install new camshaft sprocket bolt loosely.

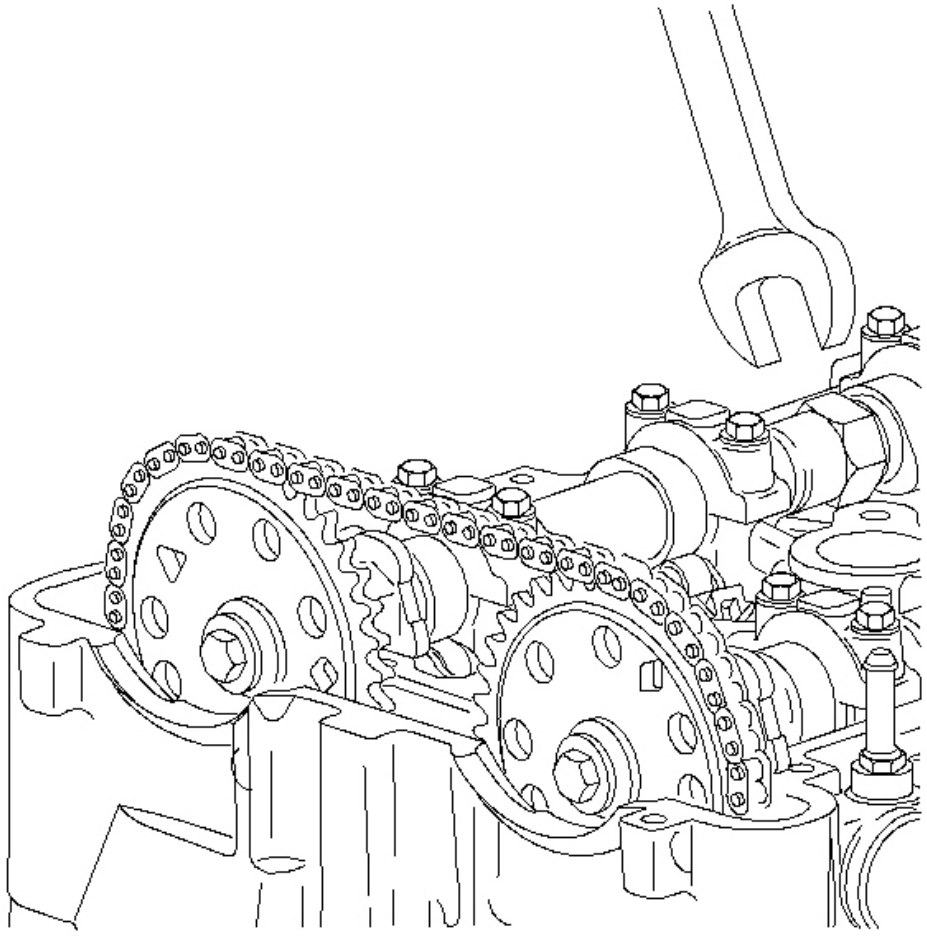


Fig. 134: Using 24 mm Wrench To Support The Camshaft
Courtesy of GENERAL MOTORS CORP.

15. Align the camshaft sprocket with the chain in proper position to the camshaft. Rotate the exhaust clockwise using a 24 mm wrench on the flats on the camshaft until the camshaft aligns with the sprocket.

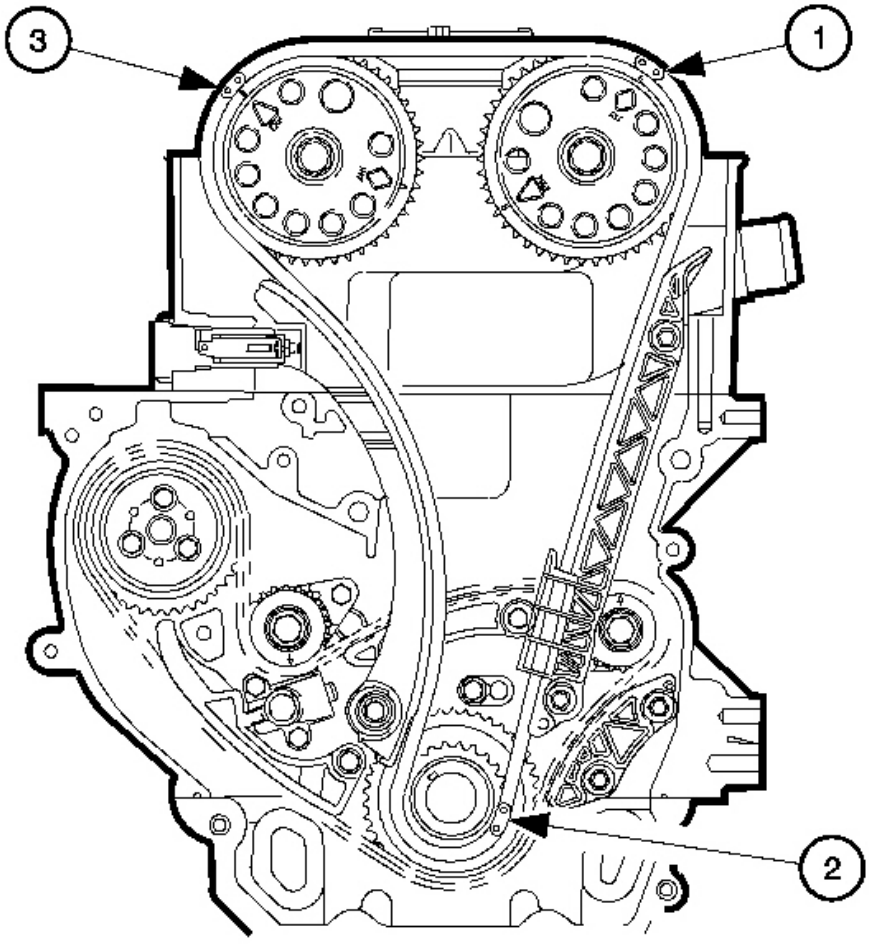


Fig. 135: Verifying All Colored Timing Chain Links Are Aligned With Crankshaft & Camshaft Marks
Courtesy of GENERAL MOTORS CORP.

16. Verify that all the colored links are aligned with the appropriate intake (1), crankshaft sprocket (2), and (3) exhaust marks.
17. Verify the crankshaft sprocket timing mark is at 5 o'clock.
18. If marks are not correct, you must repeat the timing procedure.

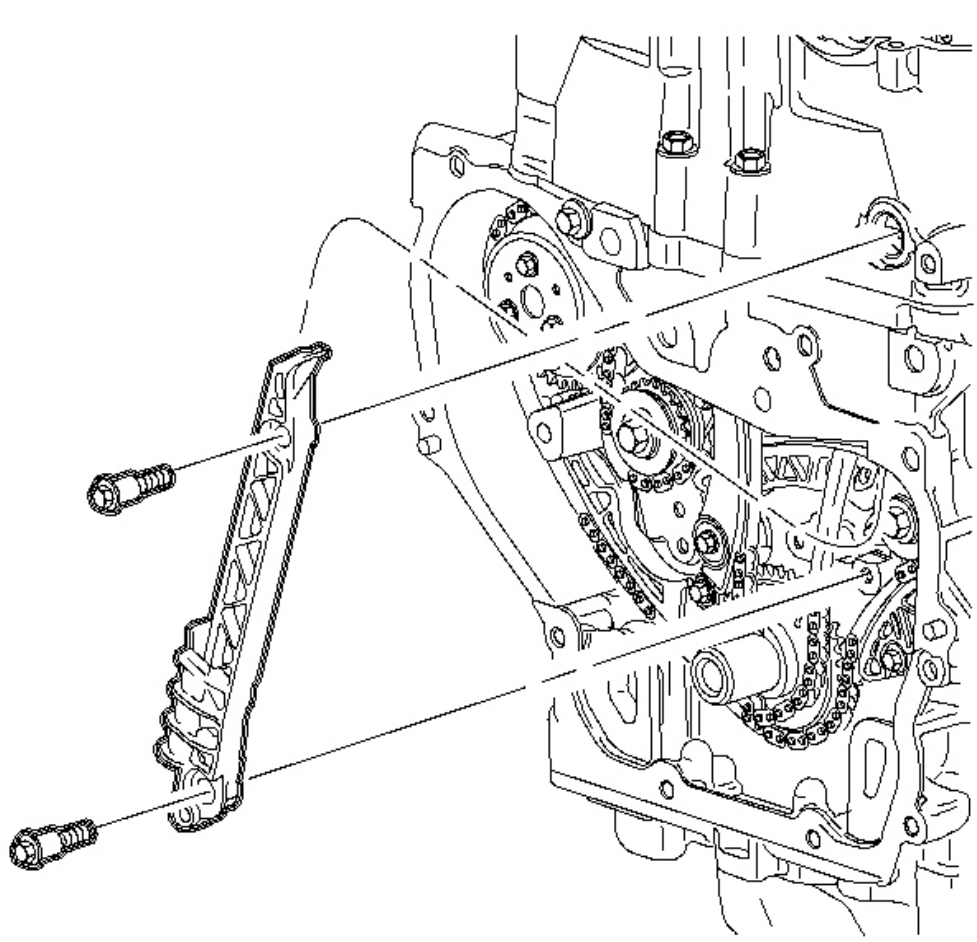


Fig. 136: Fixed Timing Chain Guide & Bolts
Courtesy of GENERAL MOTORS CORP.

19. Install the fixed timing chain guide and bolts.

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

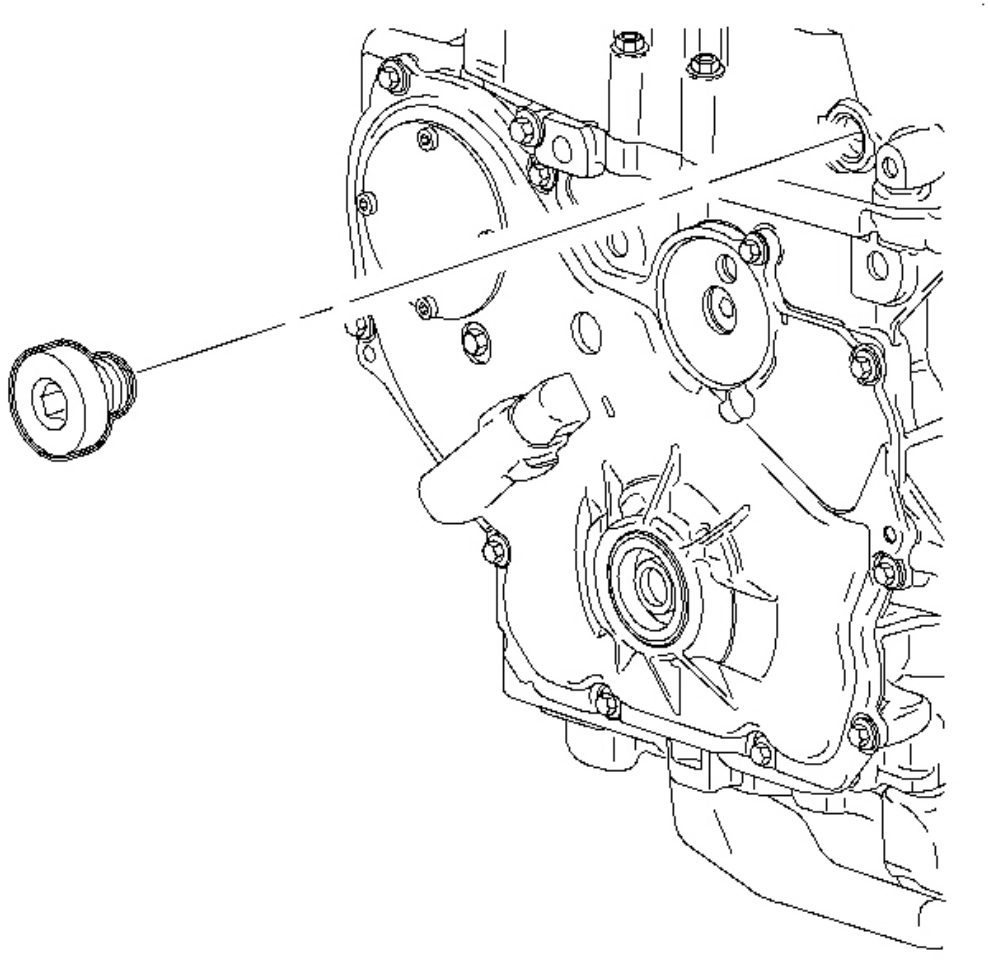


Fig. 137: Fixed Timing Chain Guide Access Plug
Courtesy of GENERAL MOTORS CORP.

20. Apply the thread sealant Permatex(R) Thread Pipe Sealant or equivalent compound to the thread. Install fixed guide bolt access hole plug.

    Tighten: Tighten the timing chain bolt access hole plug to 40 N.m (30 lb ft).

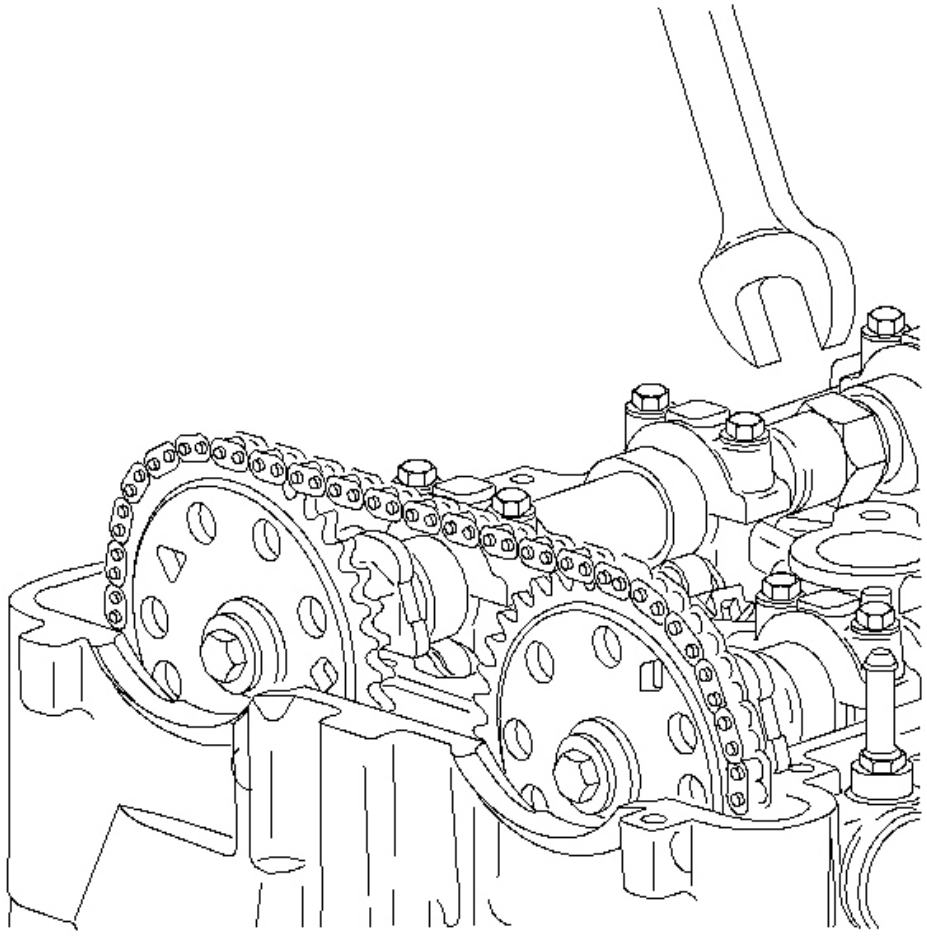


Fig. 138: Using 24 mm Wrench To Support The Camshaft
Courtesy of GENERAL MOTORS CORP.

NOTE: Use a 24 mm wrench to support the camshaft while applying torque to camshaft sprocket bolt. Do not torque camshaft bolts against timing chain, as it may damage the timing chain.

21. Tighten intake and exhaust camshaft sprocket bolts while holding camshaft with 24 mm wrench.

    Tighten: Tighten the camshaft sprocket bolts to 85 N.m (63 lb ft) + 30 degrees

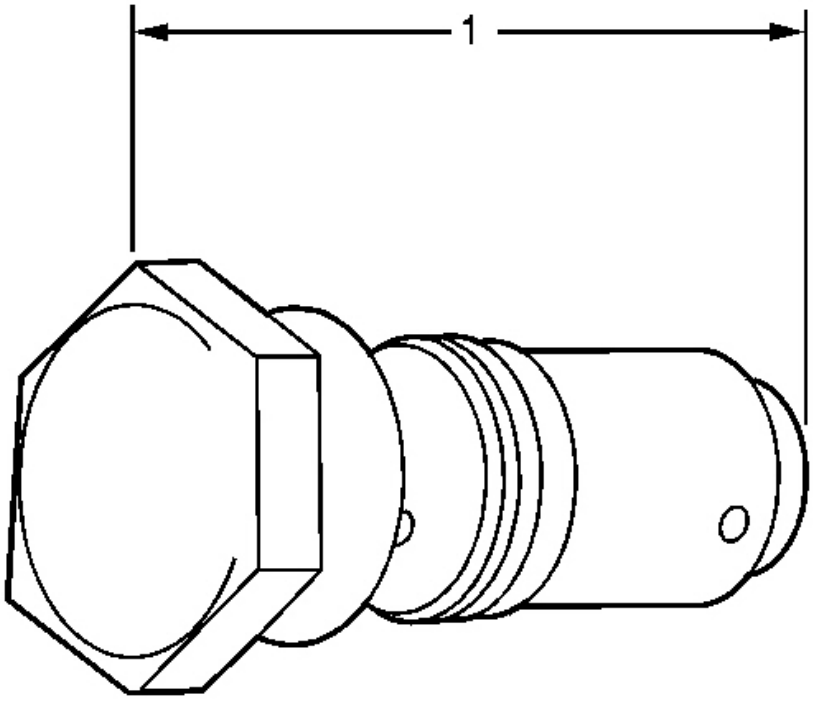


Fig. 139: Inspecting Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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) (1) from end to end. A tensioner in the active state will measure 85 mm (3.53 in) from end to end.

22. Inspect the timing chain tensioner. If the timing chain tensioner, O-ring seal, or washer is damaged, replace the timing chain tensioner.

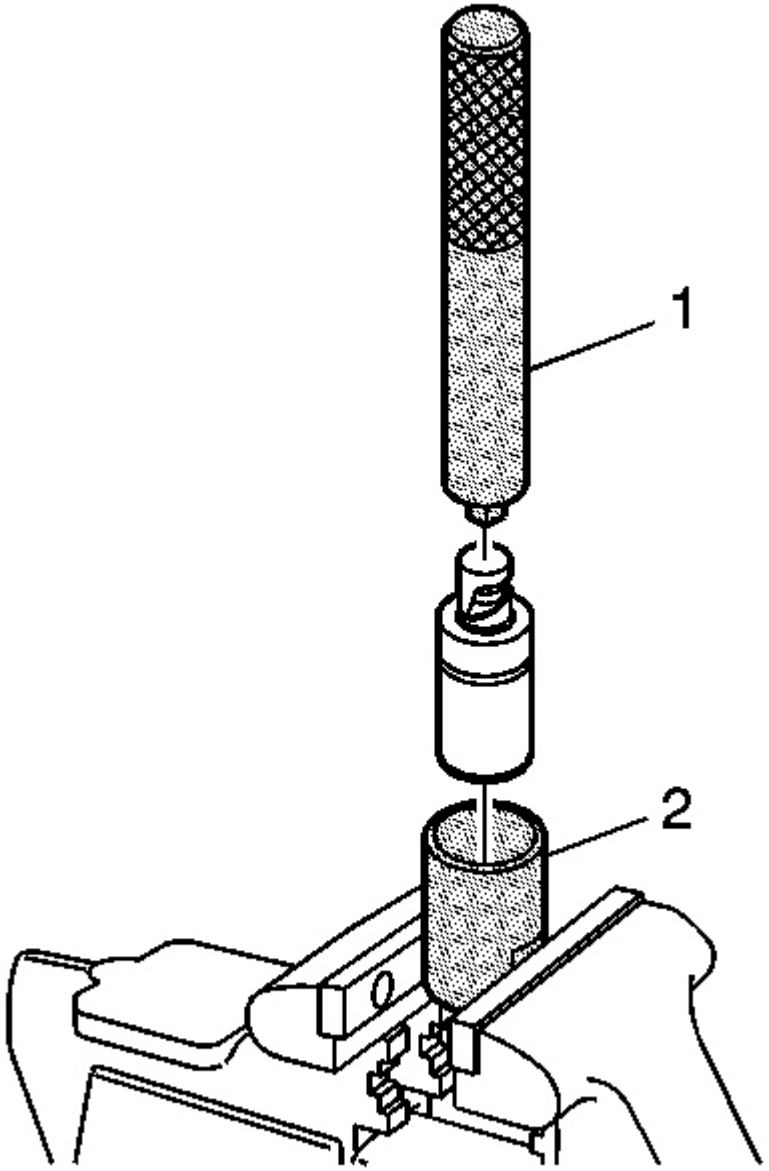


Fig. 140: View Of Tensioner Tool
Courtesy of GENERAL MOTORS CORP.

23. Measure the timing chain tensioner assembly from end-to-end.
24. 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 J45027-2 (2) into a vise.
3. Install the notch end of the piston assembly into the J45027-2 (2).

25. Using J45027-1 (1), turn the ratchet cylinder into the piston.

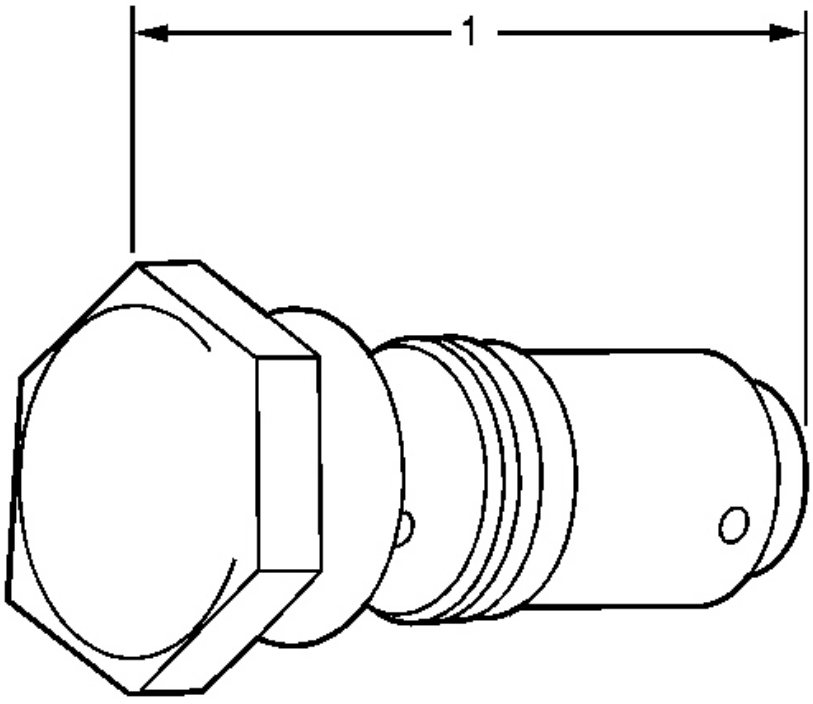


Fig. 141: Inspecting Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

26. Inspect the bore of the tensioner body for dirt, debris and damage. If any damage appears, replace the tensioner. Clean dirt of debris out with a lint free cloth.
27. 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.

28. At this point, the tensioner should measure approximately 72 mm (2.83 in) (1) from end-to-end. If the tensioner does not read 72 mm (2.83 in) (1) from end to end repeat step 24

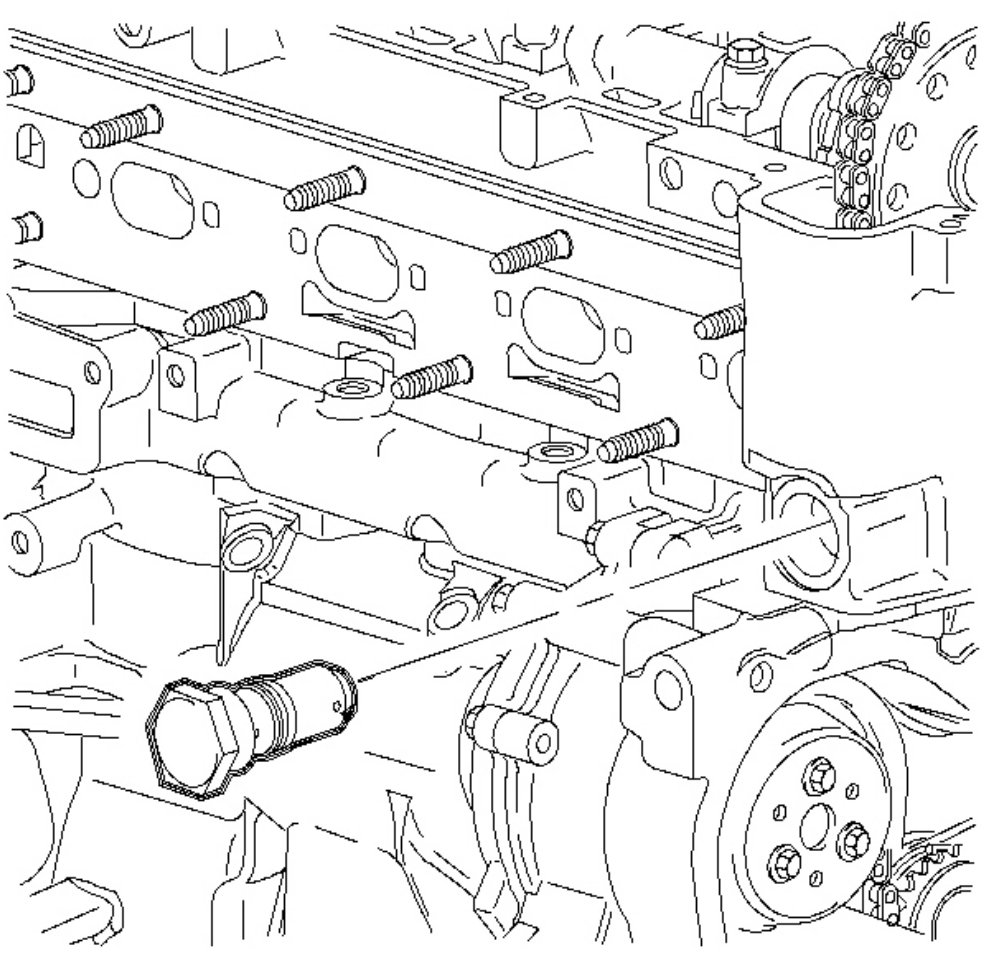


Fig. 142: Removing/Installing Timing Chain Tensioner Assembly
Courtesy of GENERAL MOTORS CORP.

29. Ensure all dirt and debris is removed from the timing chain tensioner threaded hole in the cylinder head.
30. Install the new timing chain tensioner assembly bolt and tighten.

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

31. 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.

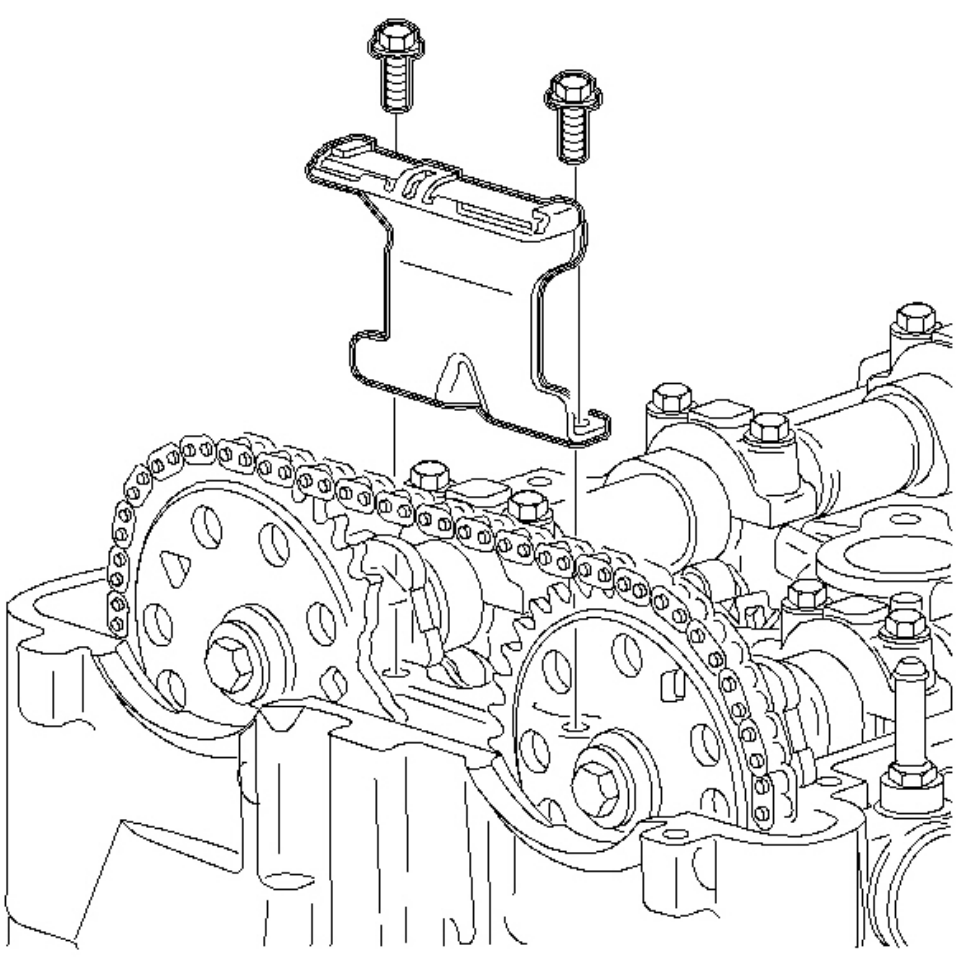


Fig. 143: Removing/Installing Upper Timing Chain Guide & Bolts
Courtesy of GENERAL MOTORS CORP.

32. Install the upper timing chain guide and bolts.

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

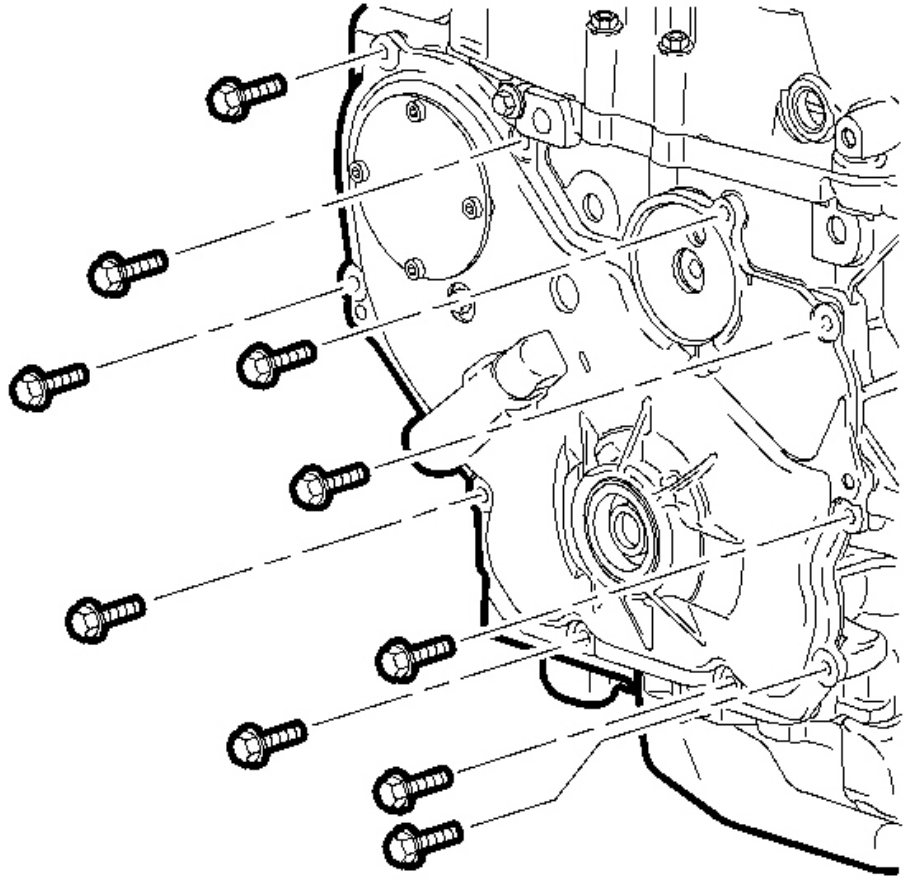


Fig. 144: Removing/Installing Front Cover Assembly
Courtesy of GENERAL MOTORS CORP.

33. Raise the vehicle if necessary.
34. Install the new front cover gasket.
35. Install the front cover assembly.
36. Install the front cover assembly bolts.

    Tighten: Tighten the front cover-to-block bolts to 25 N.m (18 lb ft).

37. Install the front cover water pump bolt.

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

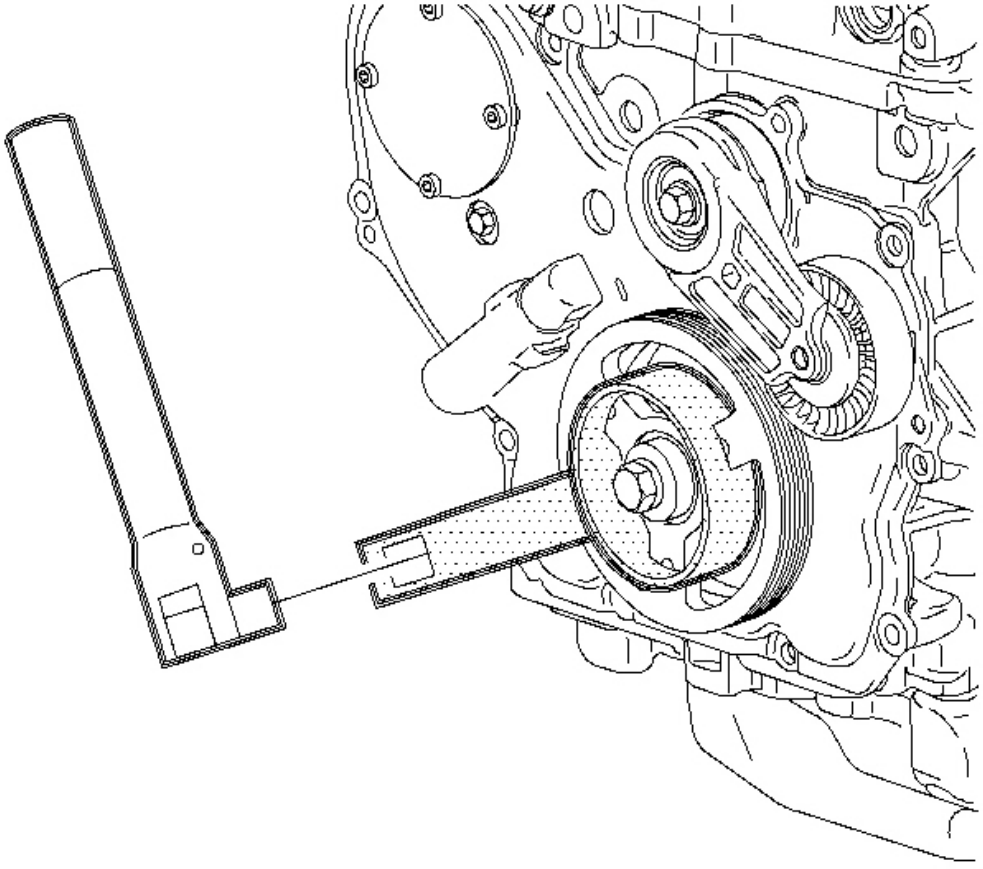


Fig. 145: Installing Crankshaft Pulley Holder
Courtesy of GENERAL MOTORS CORP.

38. Lubricate the front seal and the sealing surface of the pulley with the clean motor oil.
39. Install the balancer pulley onto the crankshaft indexing keyway. Use care to properly align the flats on the balancer pulley with the flats on the oil pump drive in the front cover assembly.
40. Install the crankshaft damper pulley.

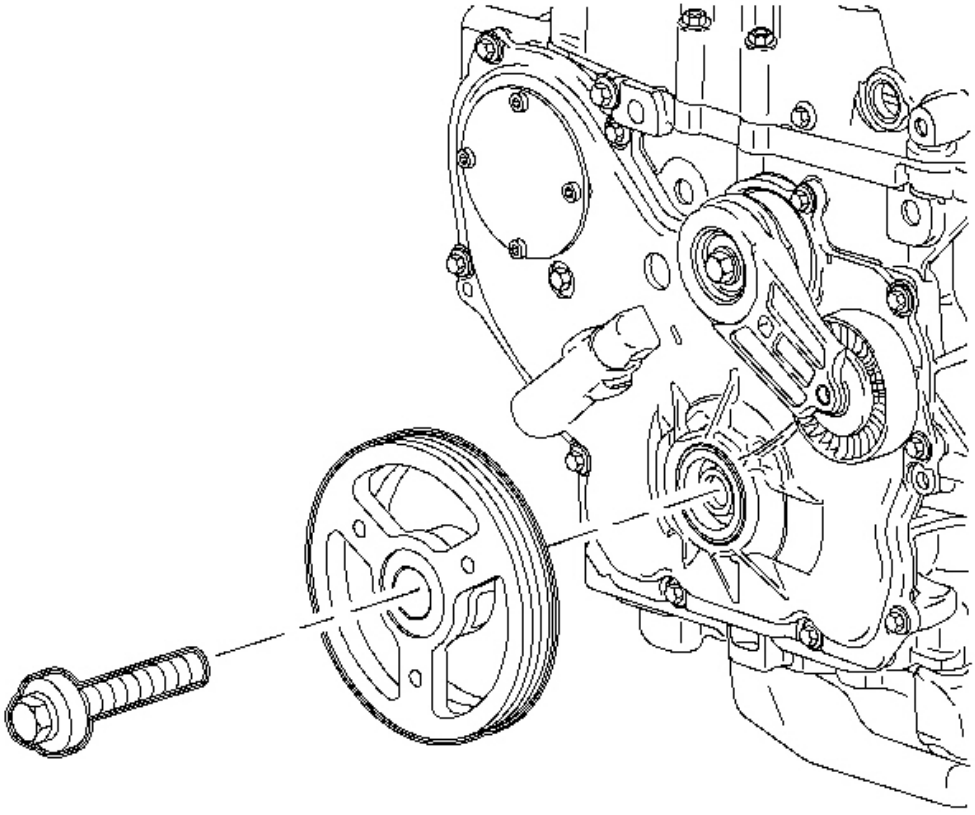


Fig. 146: Removing/Installing Crankshaft Balancer Pulley Bolt
Courtesy of GENERAL MOTORS CORP.

41. Install the new crankshaft balancer pulley bolt with the washer assembly.

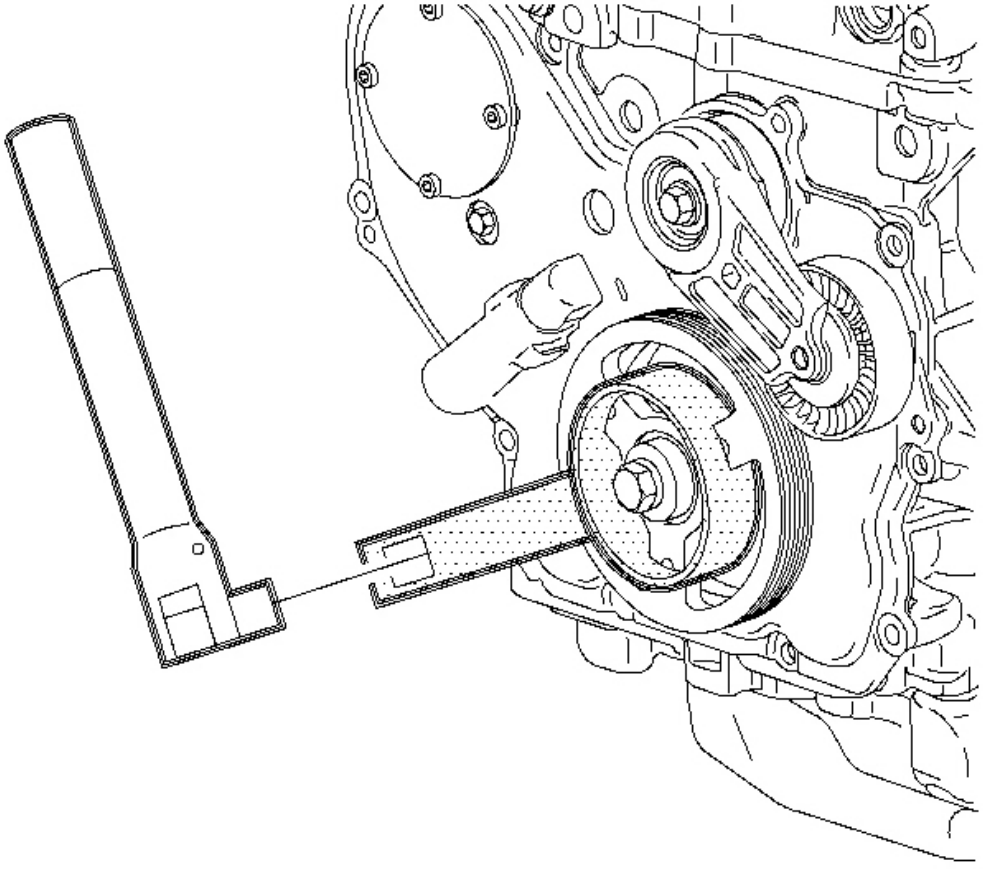


Fig. 147: Installing Crankshaft Pulley Holder
Courtesy of GENERAL MOTORS CORP.

42. Install the **J 38122-A** . See **Special Tools and Equipment** .

Tighten: Tighten the crankshaft pulley bolt to 100 N.m (74 lb ft) + 75 degrees

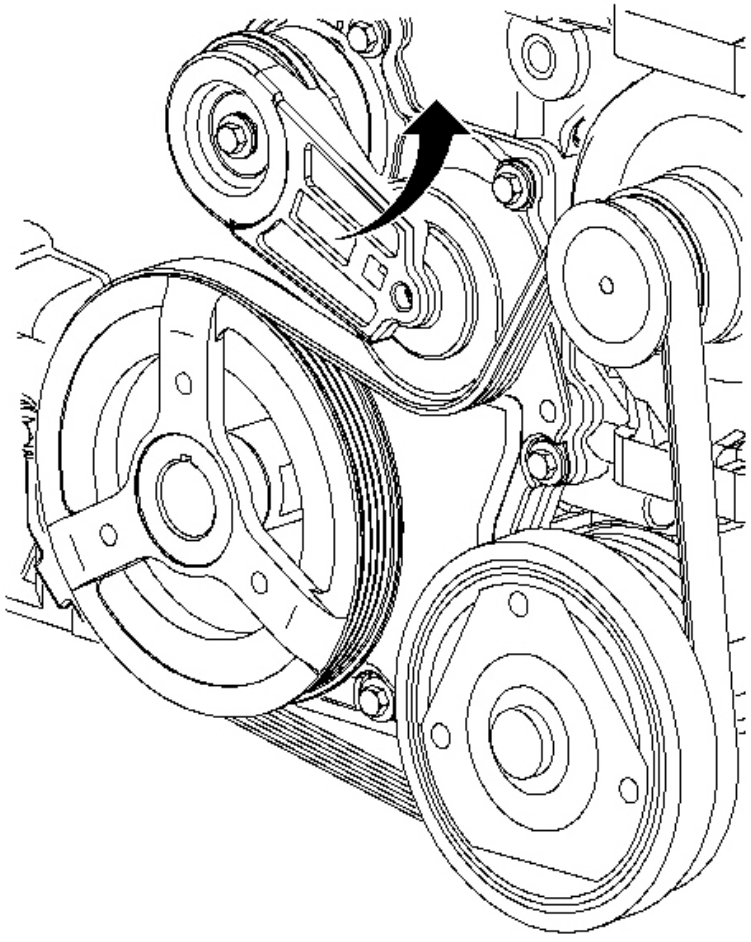


Fig. 148: Installing Accessory Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

43. Install the accessory drive belt tensioner.

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

44. Route belt around the alternator and the A/C compressor.
45. Install the **J 39914** onto the tensioner and unload spring tension from the tensioner while positioning the belt. See **Special Tools and Equipment** .
46. Release the tensioner and remove the tool.

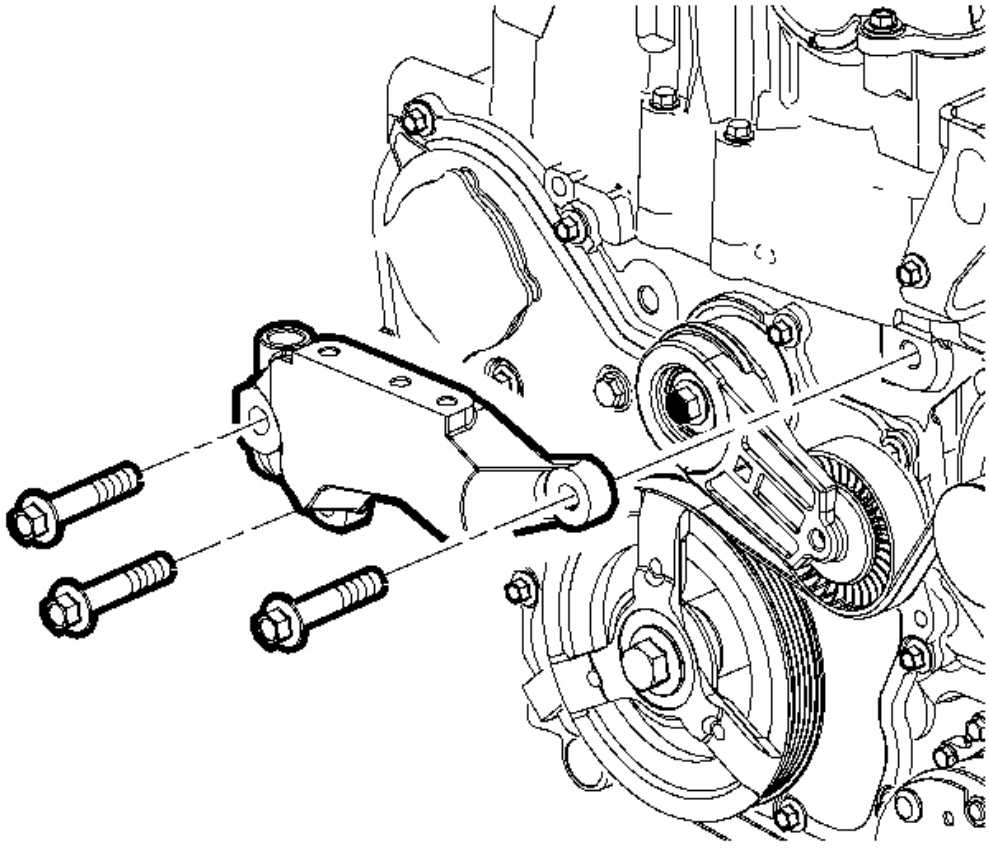


Fig. 149: Removing/Installing Right Hand Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

47. Install the right hand engine bracket and bolts.

    Tighten: Tighten the engine mount bracket-to-engine bolts to 110 N.m (81 lb ft).

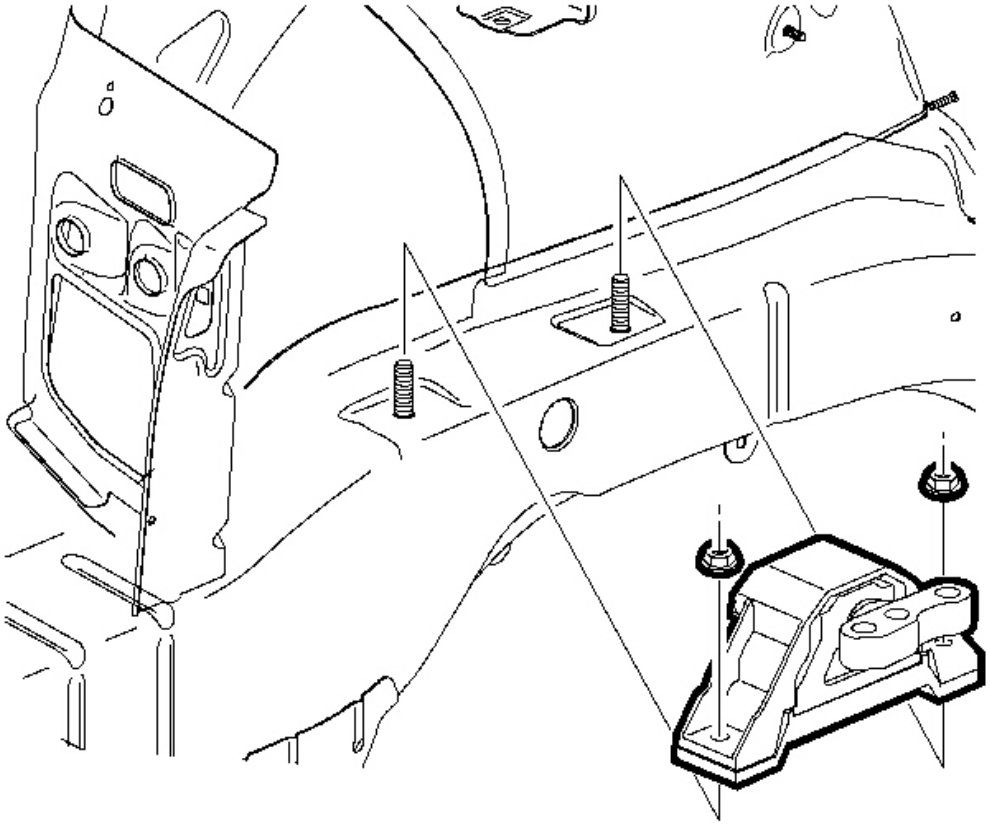


Fig. 150: View Of RH Engine Mount
Courtesy of GENERAL MOTORS CORP.

48. Install the right hand engine mount shims.
49. Install the right hand engine mount onto the body side rail studs.
50. Install the right hand engine mount-to-body nuts.

    Tighten: Tighten the engine mount-to-body nuts to 110 N.m (81 lb ft).

51. Install the right-hand engine mount-to-engine mount bracket bolts.

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

52. Remove the **SA9105E** . See **Special Tools and Equipment** .
53. Install the right engine inner splash shield.
54. Install the right wheel and hand-tighten the wheel nuts.
55. Tighten the wheel nuts.

    Tighten: Tighten the wheel nuts to 125 N.m (92 lb ft).

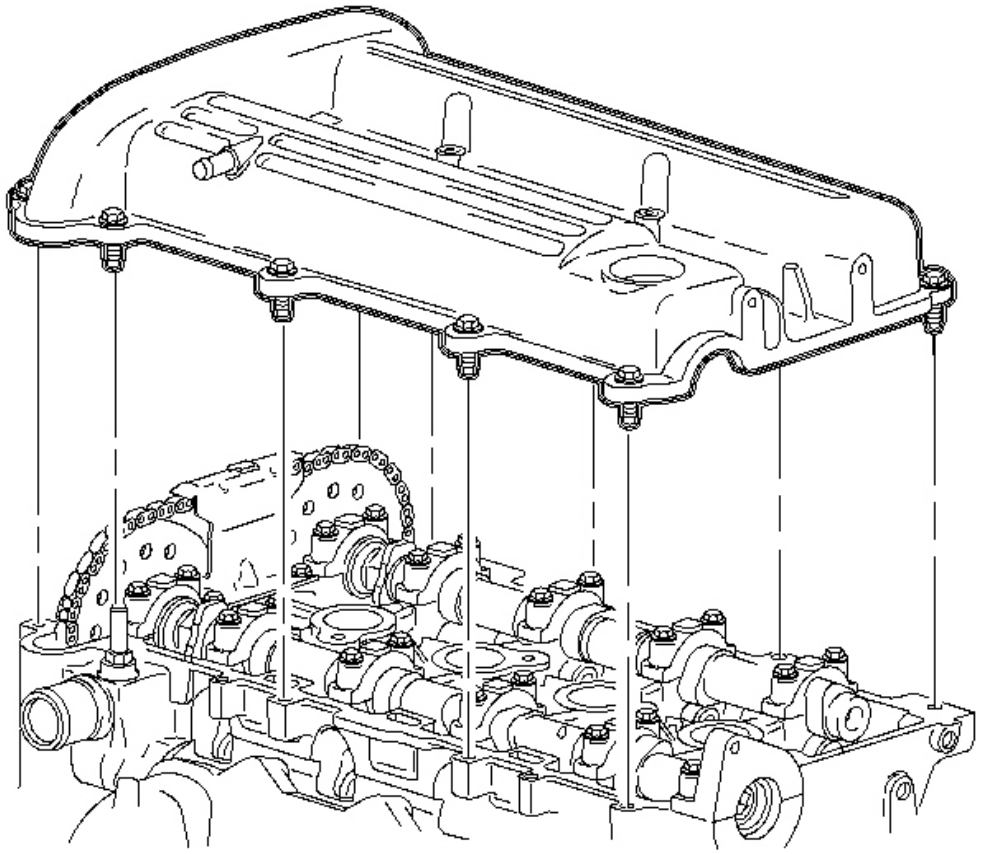


Fig. 151: Removing Cam Cover Assembly
Courtesy of GENERAL MOTORS CORP.

56. Visually inspect the camshaft cover gasket for signs of leakage. The camshaft cover gasket is reusable if not damaged.

57. Assemble the camshaft cover and gasket using care to make sure that gasket is located in retaining groove on camshaft cover.
58. Install the cover on cylinder head and hand-tighten the bolts.

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

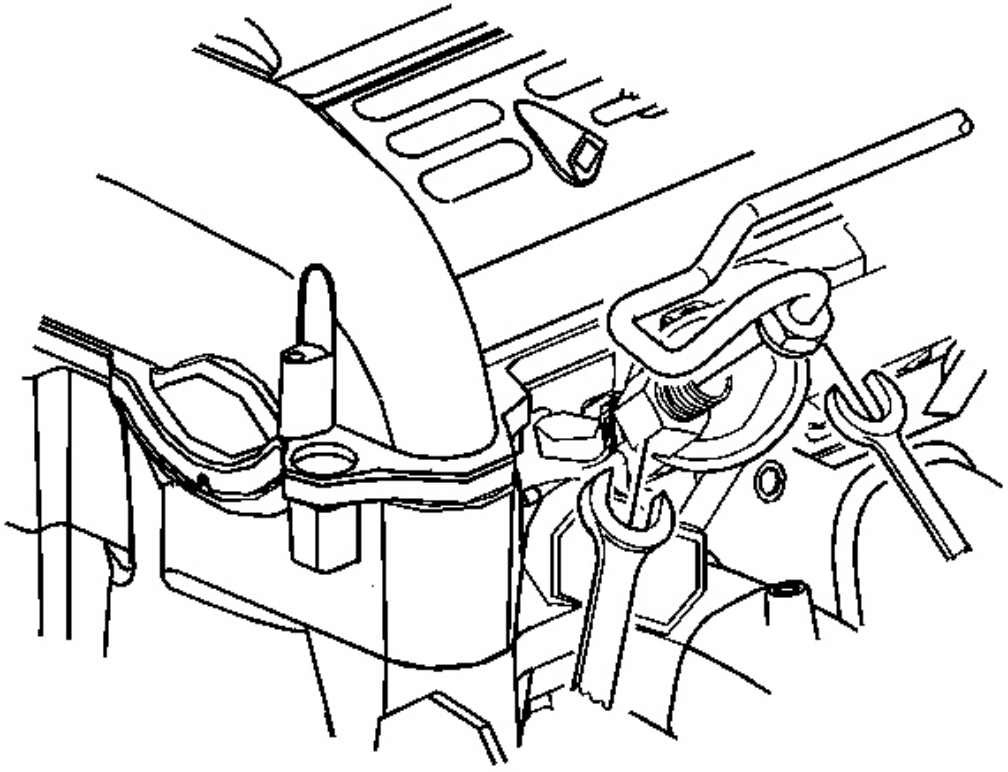


Fig. 152: Repositioning Fuel Line Assembly
Courtesy of GENERAL MOTORS CORP.

59. Reposition fuel line assembly.

    NOTE: An open-end wrench must be used to support the fuel line to rail connection during loosening/tightening to avoid damaging the fuel rail assembly.

60. Install the transfer line fitting at fuel to fuel rail.

Tighten: Tighten the transfer line fitting-to-fuel rail to 10 N.m (89 lb in).

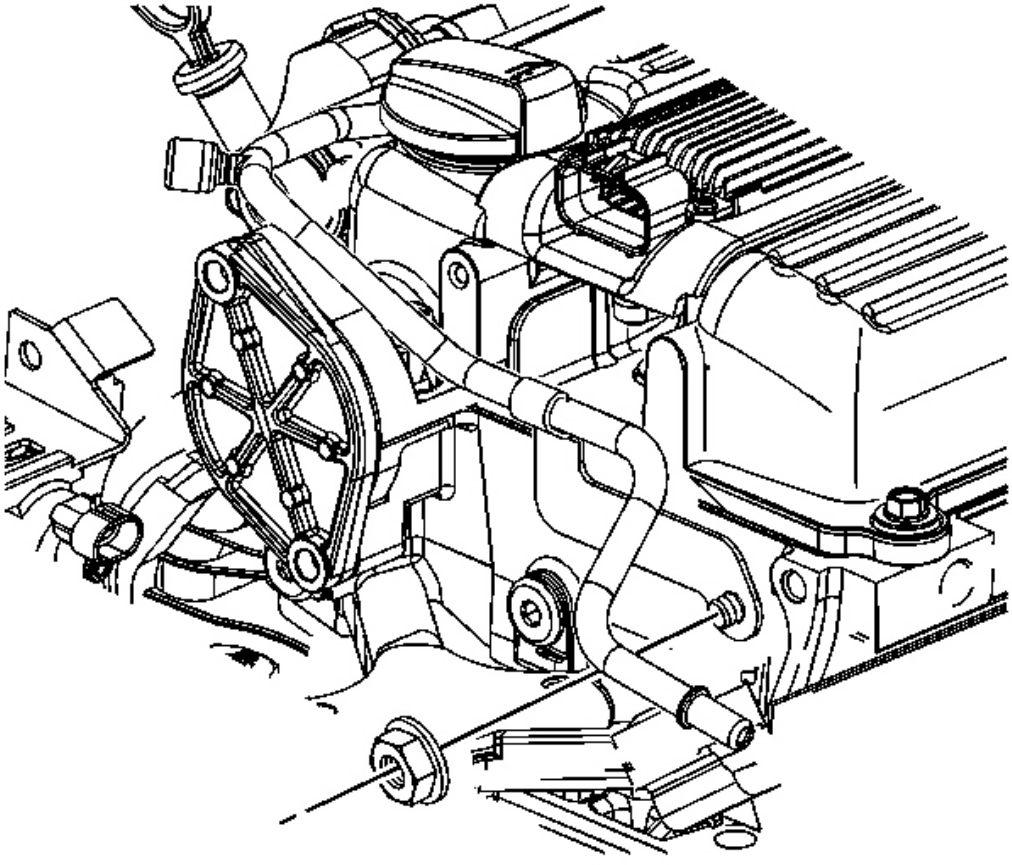


Fig. 153: Fuel Rail Bracket
Courtesy of GENERAL MOTORS CORP.

61. Connect the fuel rail bracket and bolt to the cylinder head.

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

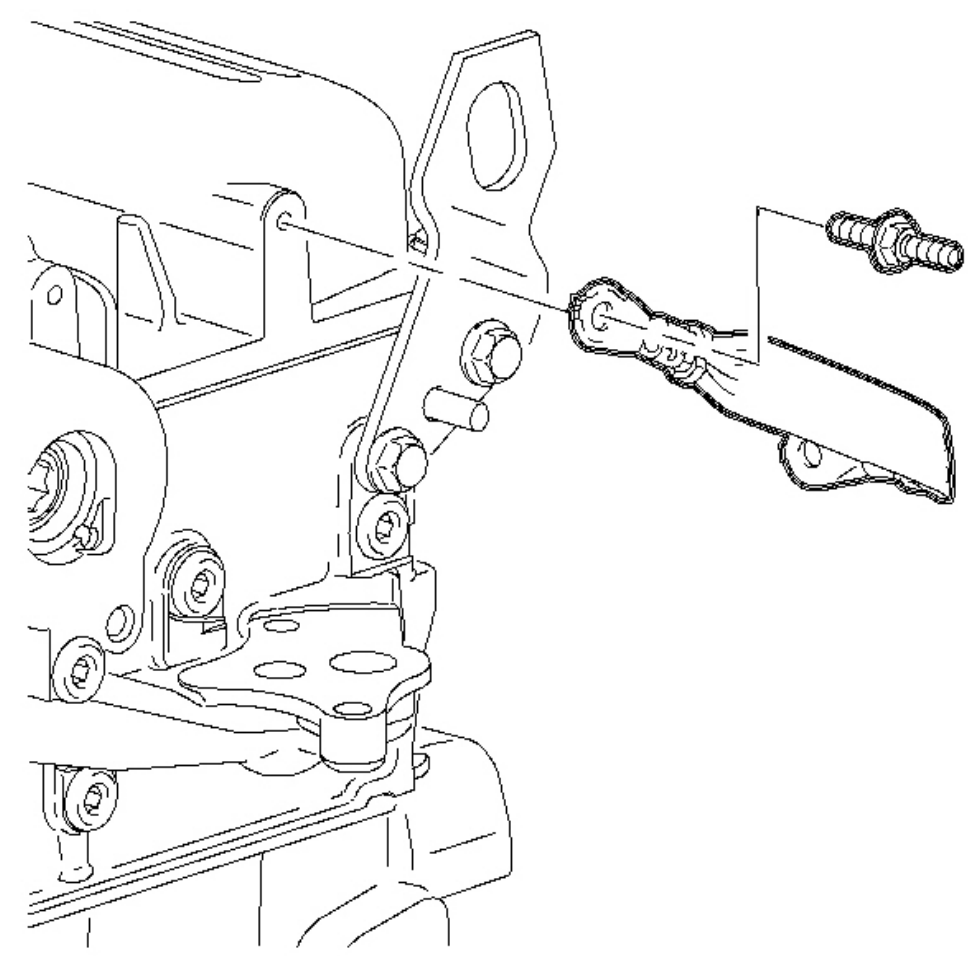


Fig. 154: Disconnecting/Connecting Ground Strap On The Camshaft Cover Assembly
Courtesy of GENERAL MOTORS CORP.

62. Connect the ground strap to the camshaft cover assembly.

    Tighten: Tighten the camshaft cover ground strap bolts to 10 N.m (89 lb in).

63. Connect the degas hose and attach to the fuel rail.
64. Connect the coolant pipe bracket bolts to the cylinder head.

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

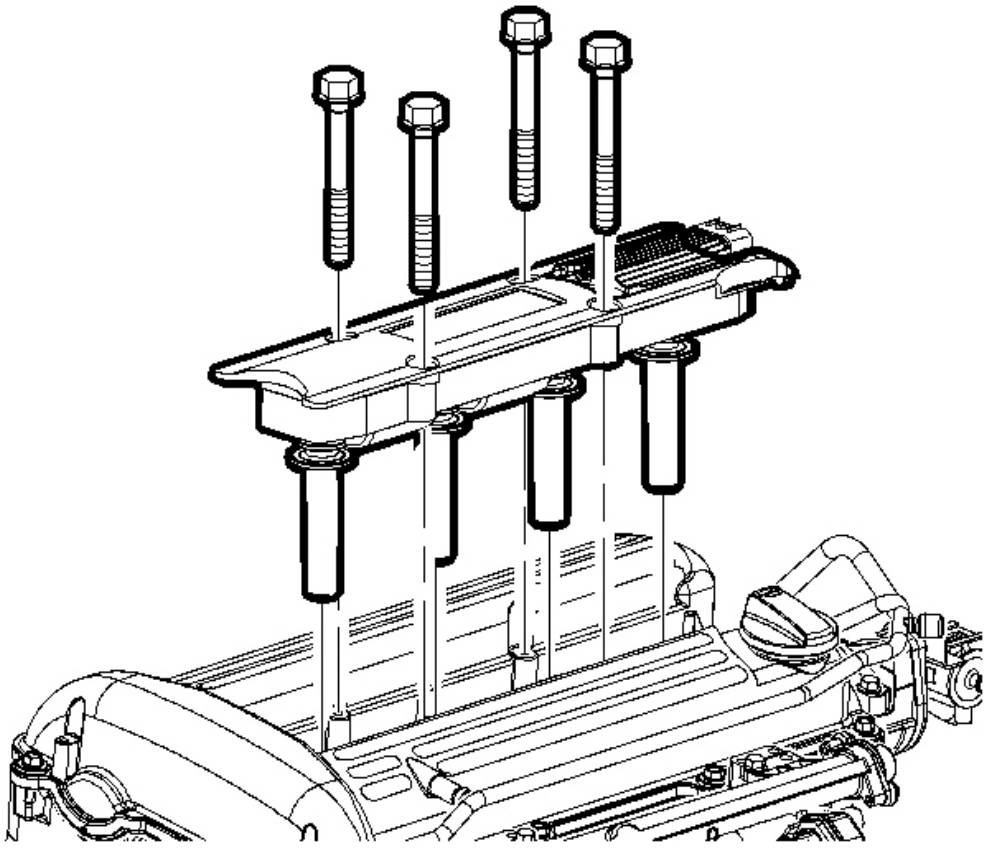


Fig. 155: Removing/Installing Ignition Module Assembly
Courtesy of GENERAL MOTORS CORP.

65. Install the spark plugs (if removed).

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

66. Install the ignition module assembly to the cam cover and hand-tighten the retaining bolts.

    Tighten: Tighten the ignition module-to-camshaft cover bolts to 8 N.m (71 lb in).

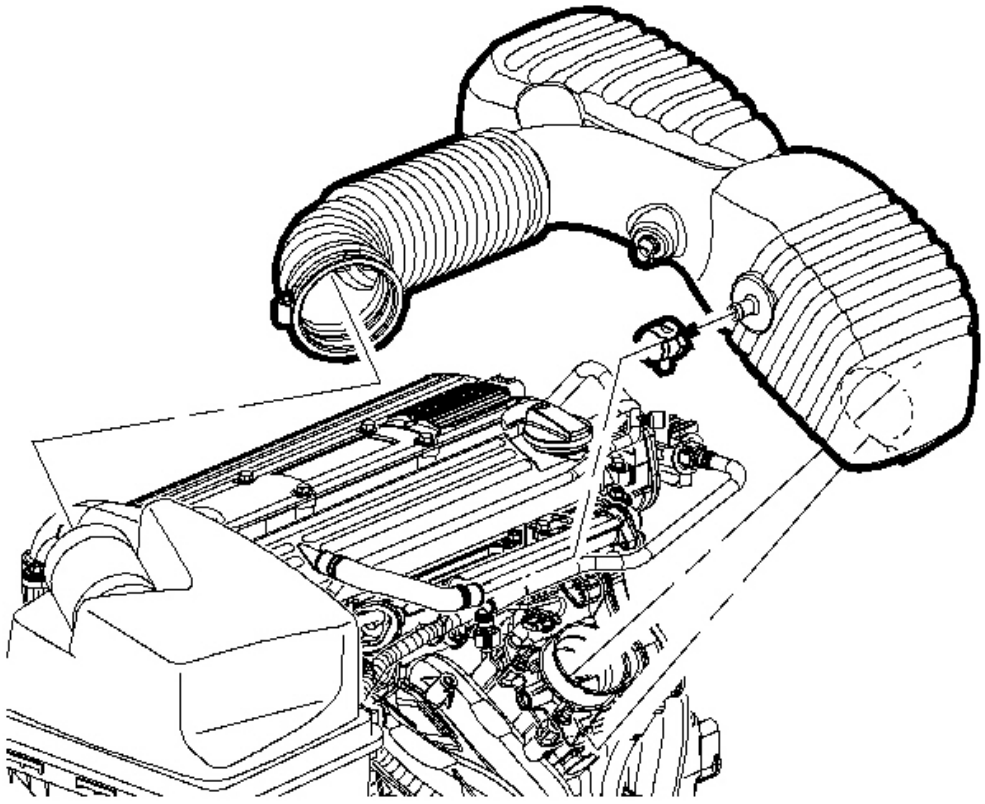


Fig. 156: Locating Air Intake Assembly
Courtesy of GENERAL MOTORS CORP.

67. Install the air cleaner assembly and bolt.

    Tighten: Tighten the air cleaner-to-support bracket bolt to 10 N.m (89 lb in).

68. Install the outlet resonator/duct assembly into position.
69. Connect the PCV fresh air vent hose assembly.
70. Tighten the clamp at the throttle body assembly.
71. Position the outlet resonator/duct assembly up with support bracket and install push-pin.
72. Tighten the clamp at the air cleaner assembly.

73. Connect the intake air temperature (IAT) sensor connector.
74. Connect the negative battery cable.

Tighten: Tighten the battery terminal bolt to 17 N.m (13 lb ft).

CAMSHAFT COVER REPLACEMENT

Tools Required

SA9127E Gage Bar Set. See **Special Tools and Equipment** .

Removal Procedure

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

1. Disconnect the negative battery cable.
2. Disconnect the intake air temperature (IAT) sensor connector.
3. Loosen the clamp at the air cleaner assembly.

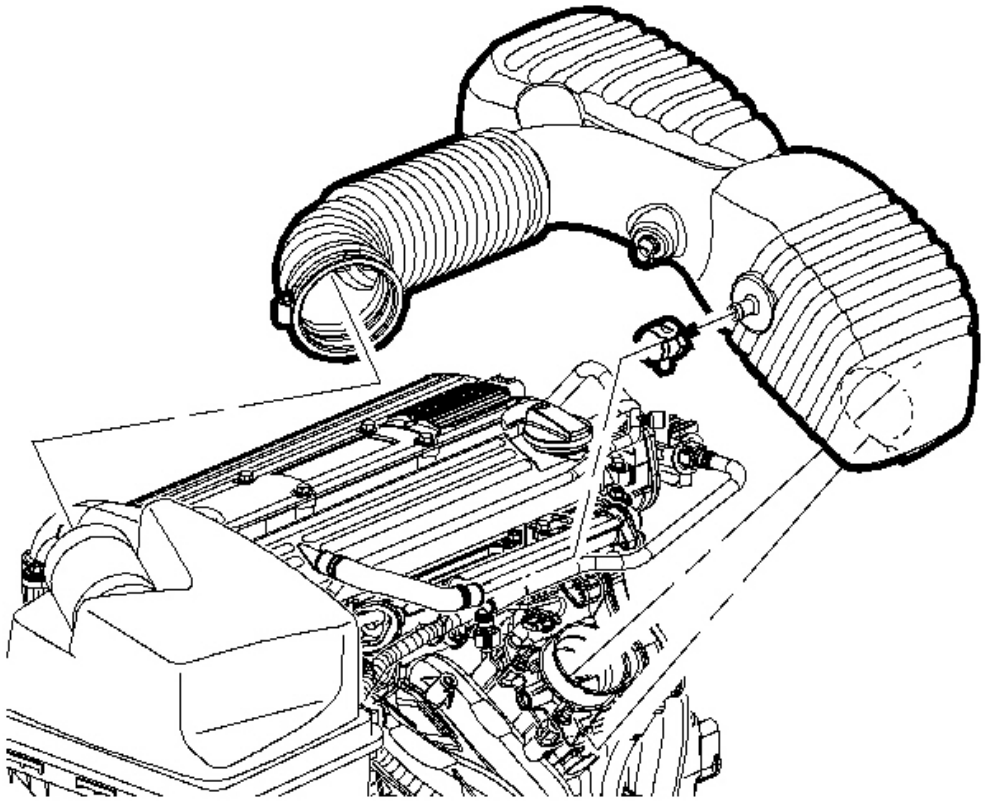


Fig. 157: Locating Air Intake Assembly
Courtesy of GENERAL MOTORS CORP.

4. Remove the push-pin attachment from the outlet resonator/duct assembly-to-support bracket.
5. Loosen the clamp at the throttle body assembly.
6. Disconnect the PCV fresh air vent hose at the cam cover.
7. Remove the outlet resonator/duct assembly.

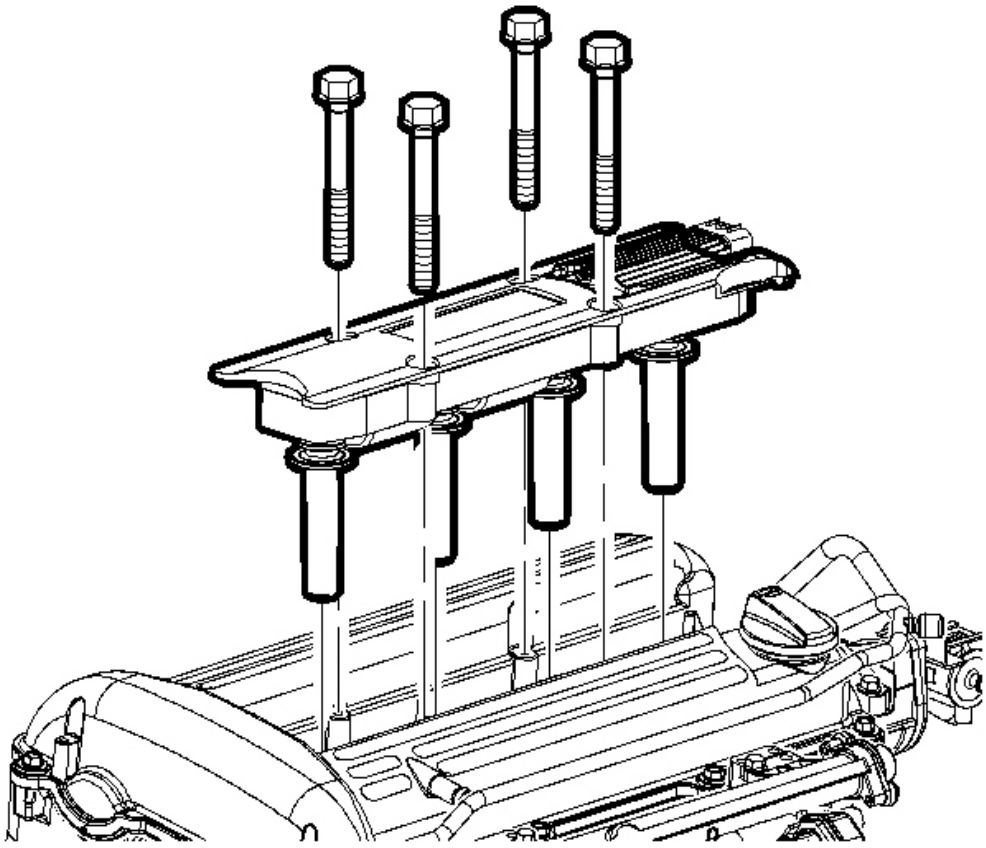


Fig. 158: Removing/Installing Ignition Module Assembly
Courtesy of GENERAL MOTORS CORP.

8. Remove the ignition module bolts.
9. Remove the ignition module assembly.
10. Disconnect the coolant degas hose from the fuel rail.
11. Disconnect the degas hose clamp at the cylinder head and position it away from the cam cover assembly.

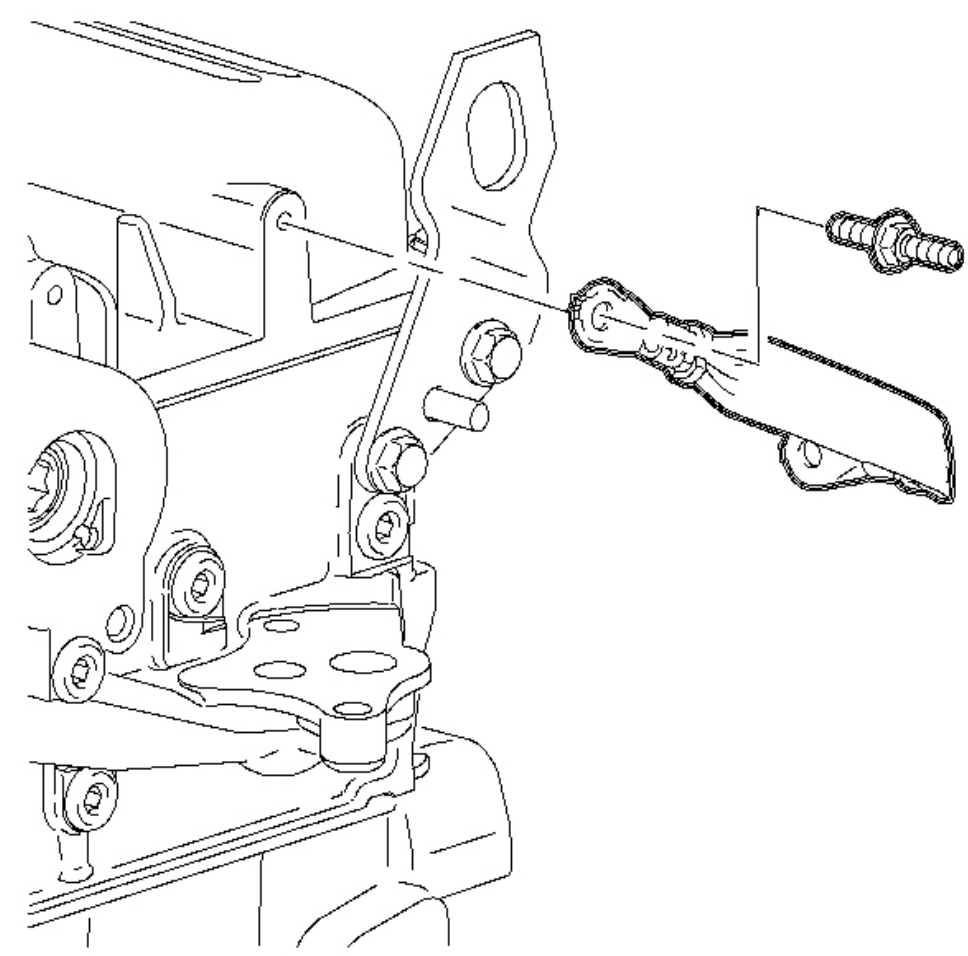


Fig. 159: Disconnecting/Connecting Ground Strap On The Camshaft Cover Assembly
Courtesy of GENERAL MOTORS CORP.

12. Disconnect the ground strap at the rear of the cam cover assembly.
13. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief Procedure** .
14. Disconnect the **SA9127E** after the pressure has been relieved. See **Special Tools and Equipment** .

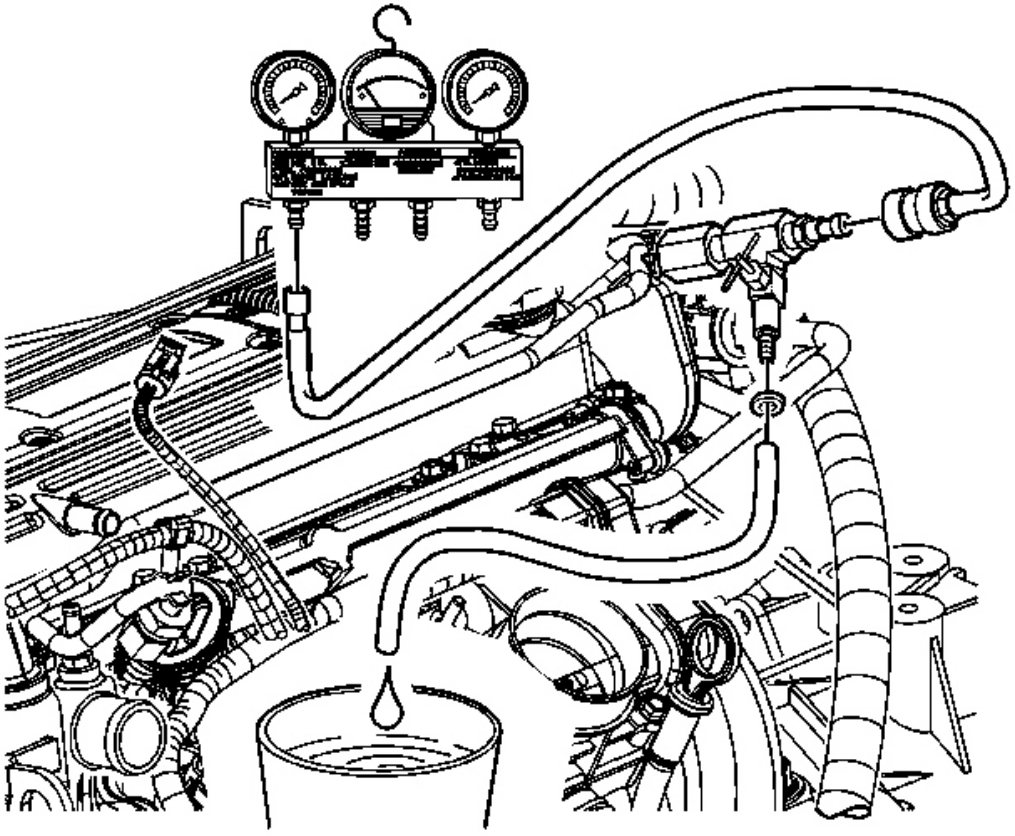


Fig. 160: Disconnecting Gage Bar Set SA9127E
Courtesy of GENERAL MOTORS CORP.

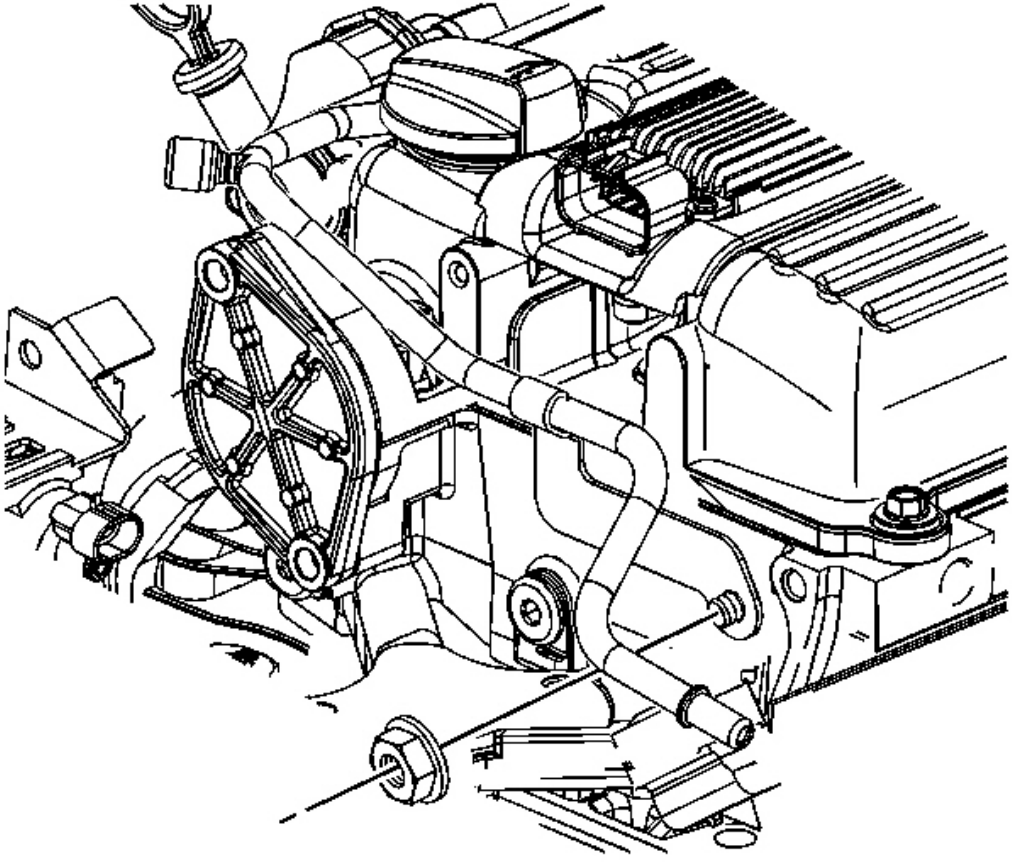


Fig. 161: Fuel Rail Bracket
Courtesy of GENERAL MOTORS CORP.

15. Disconnect the fuel rail bracket and bolt at the rear of the cam cover.

CAUTION: Whenever fuel line fittings are loosened or disconnected, wrap a shop cloth around the fitting to collect fuel. Place the cloth in an approved container.

NOTE: An open-end wrench must be used to support the fuel line to rail connection during loosening/tightening to avoid damaging the fuel rail assembly.

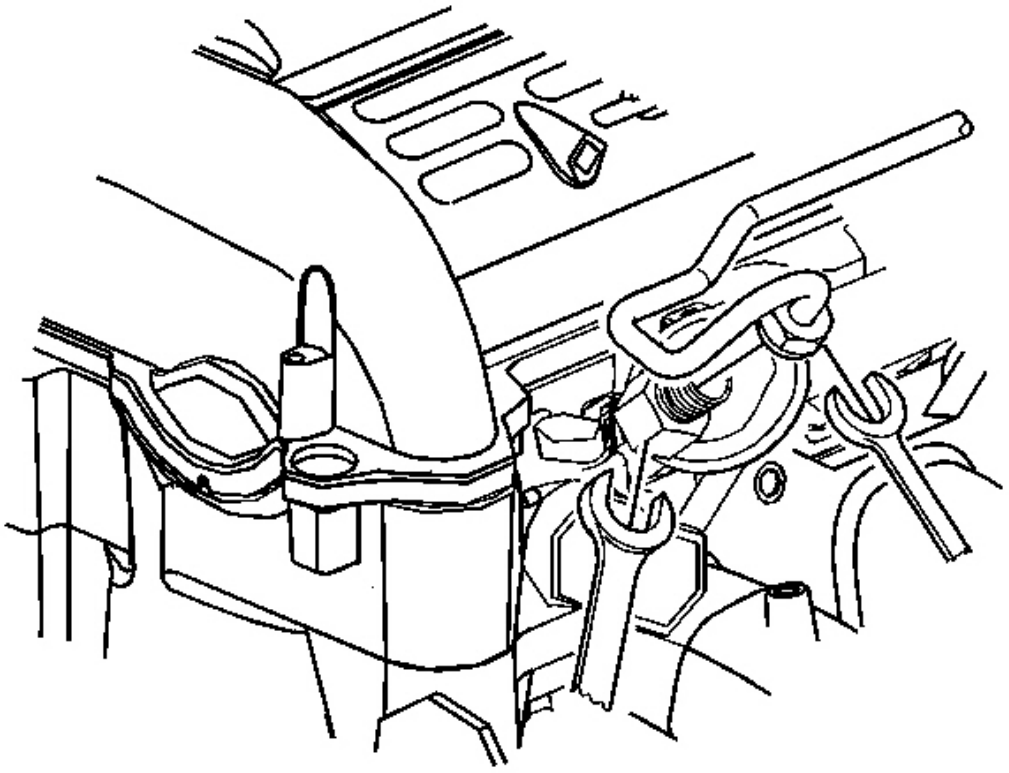


Fig. 162: Repositioning Fuel Line Assembly
Courtesy of GENERAL MOTORS CORP.

16. While supporting the fuel rail assembly with an open end wrench, loosen the transfer line fitting at the fuel rail.
17. Position the fuel line away from the cam cover assembly.

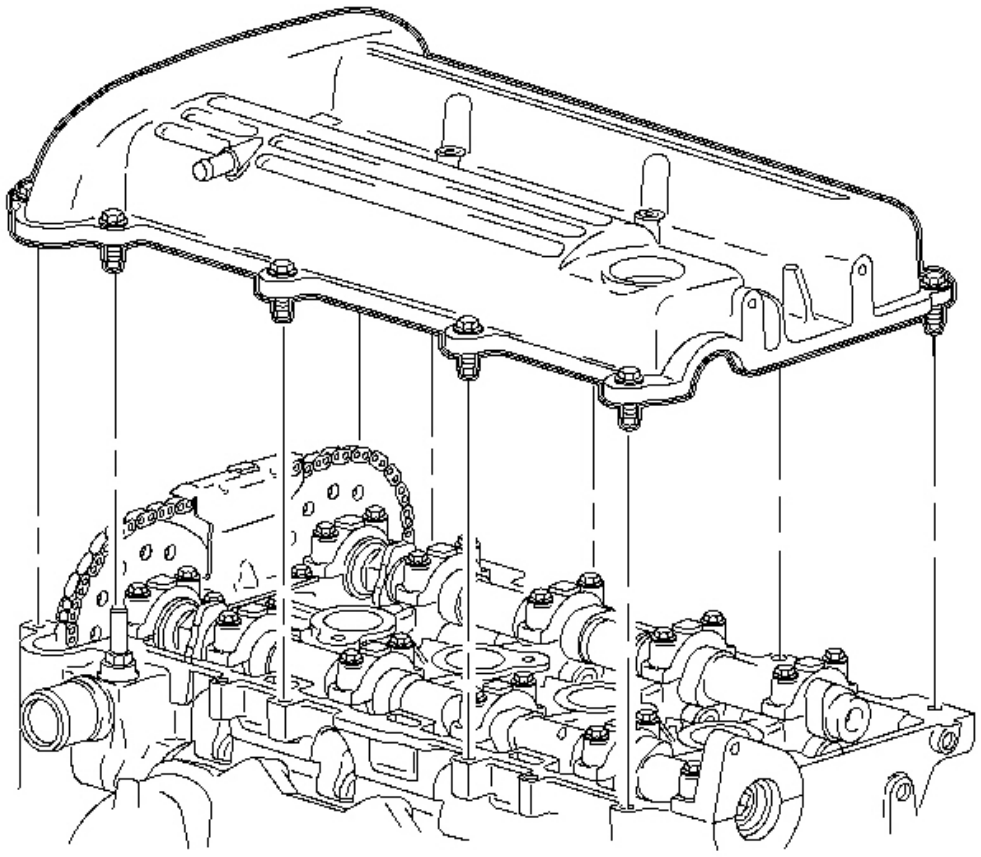


Fig. 163: Removing Cam Cover Assembly
Courtesy of GENERAL MOTORS CORP.

18. Remove the cam cover assembly bolts.
19. Remove the cam cover assembly.

Installation Procedure

1. Visually inspect the camshaft cover gasket for signs of leakage. The camshaft cover gasket is reusable if not damaged.
2. Assemble the camshaft cover and gasket. Use care to make sure the gasket is located in the retaining groove on the camshaft cover.

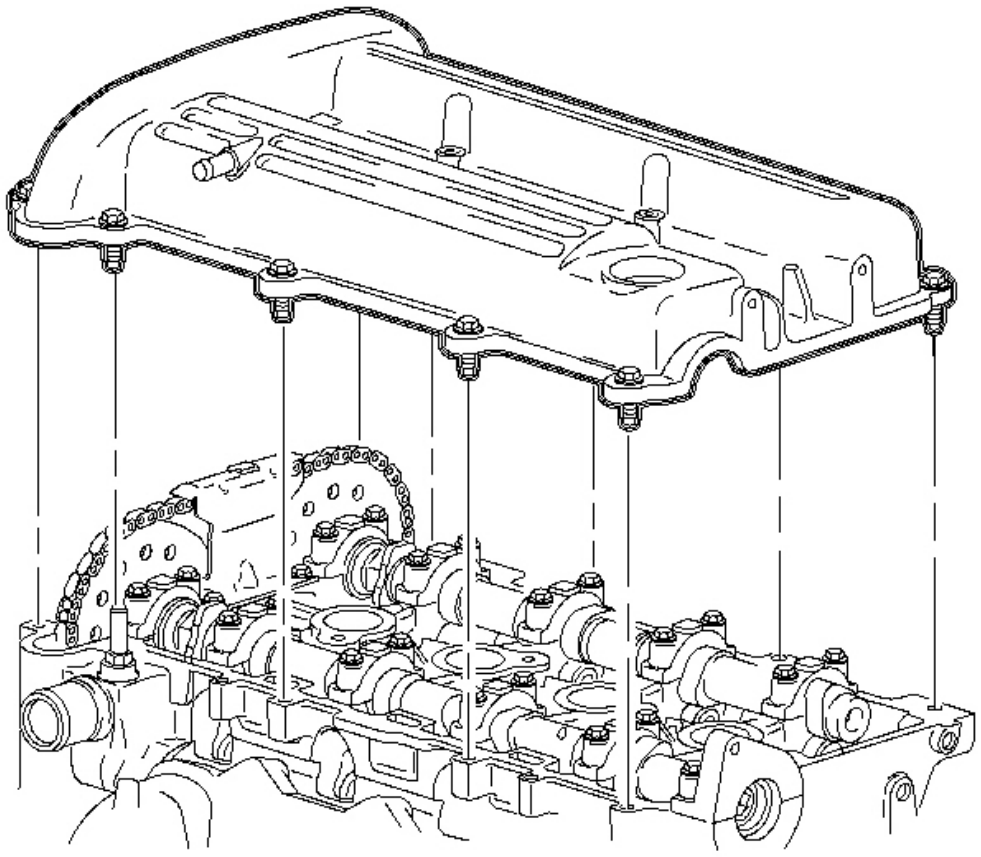


Fig. 164: Removing Cam Cover Assembly
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the cover on the cylinder head and hand-tighten the bolts.

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

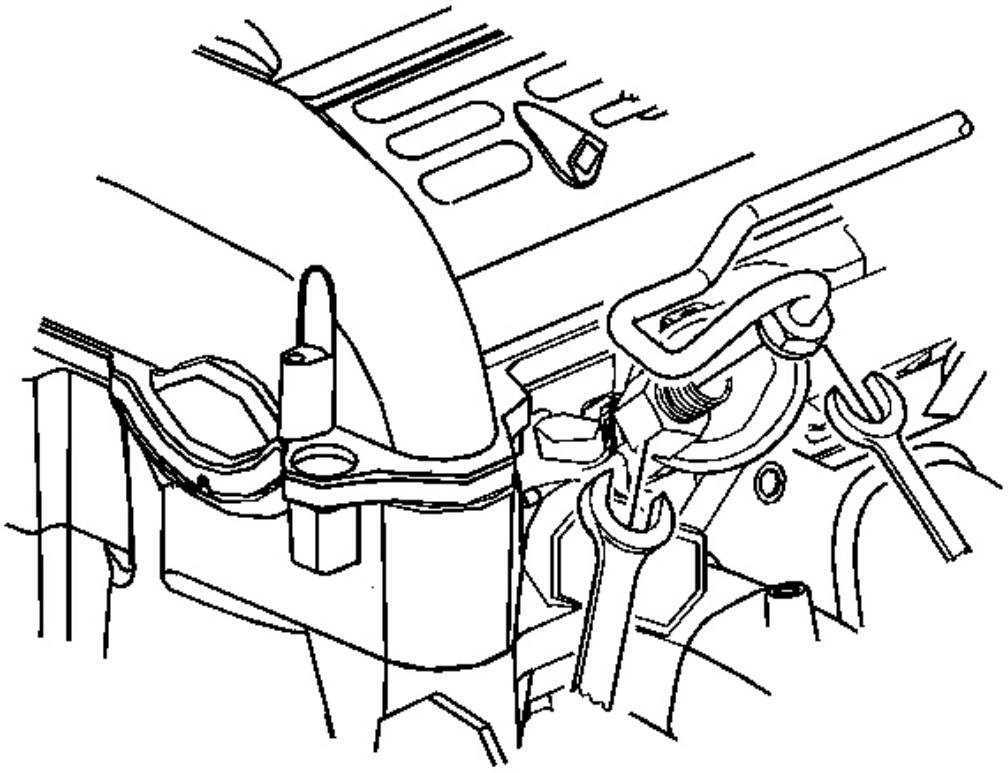


Fig. 165: Repositioning Fuel Line Assembly
Courtesy of GENERAL MOTORS CORP.

4. Reposition the fuel line assembly.

NOTE: **An open-end wrench must be used to support the fuel line to rail connection during loosening/tightening to avoid damaging the fuel rail assembly.**

5. Install the transfer line fitting to the fuel rail.

Tighten: Tighten the transfer fitting-to-fuel rail to 10 N.m (89 lb in).

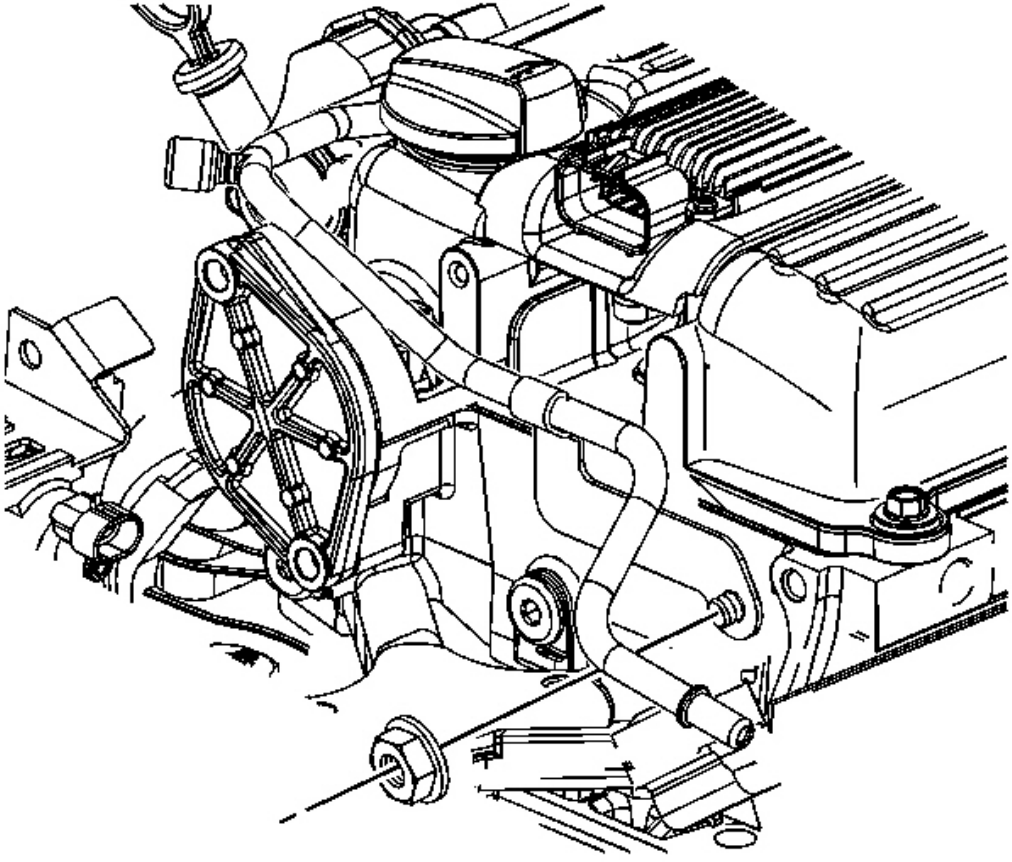


Fig. 166: Fuel Rail Bracket
Courtesy of GENERAL MOTORS CORP.

6. Connect the fuel rail bracket and bolt to the cylinder head.

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

7. Connect the ground strap to camshaft cover assembly.

   Tighten: Tighten the camshaft cover ground strap bolts to 10 N.m (89 lb in).

8. Connect the degas hose and clamp to the cylinder head.
9. Connect the degas hose bracket and bolt to the cylinder head.

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

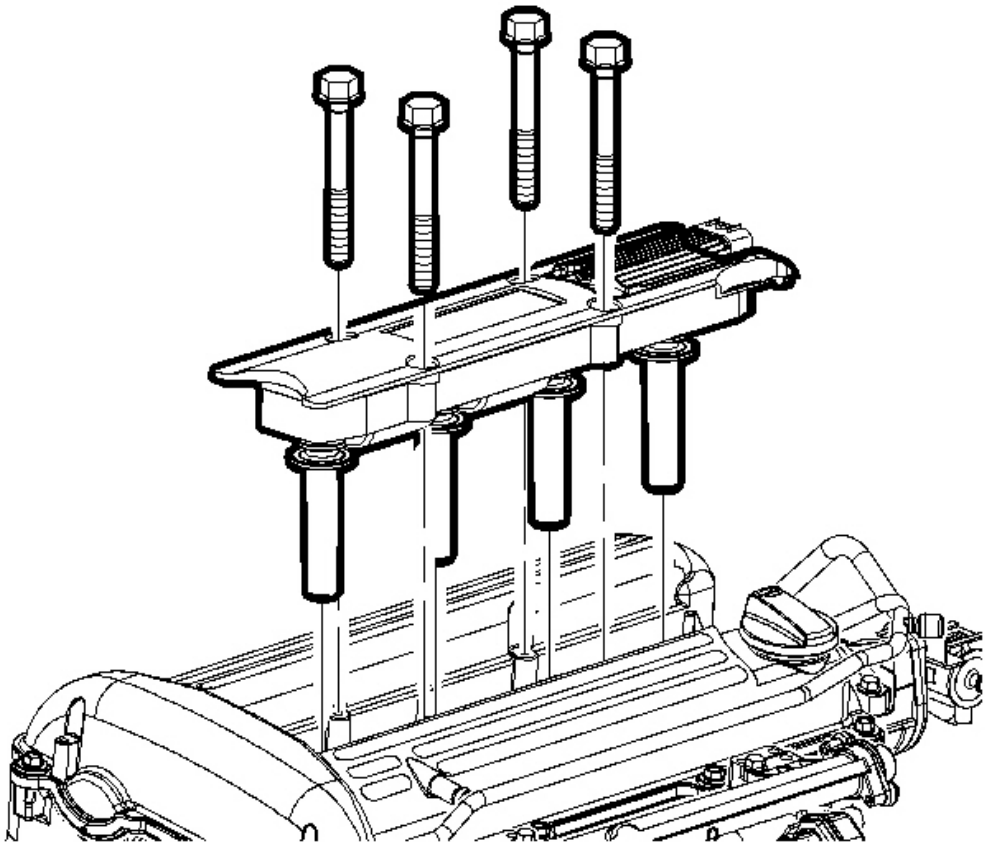


Fig. 167: Removing/Installing Ignition Module Assembly
Courtesy of GENERAL MOTORS CORP.

10. Install the ignition module assembly to cam cover and hand tighten the retaining bolts.

    Tighten: Tighten the ignition module-to-camshaft cover bolts to 8 N.m (71 lb in).

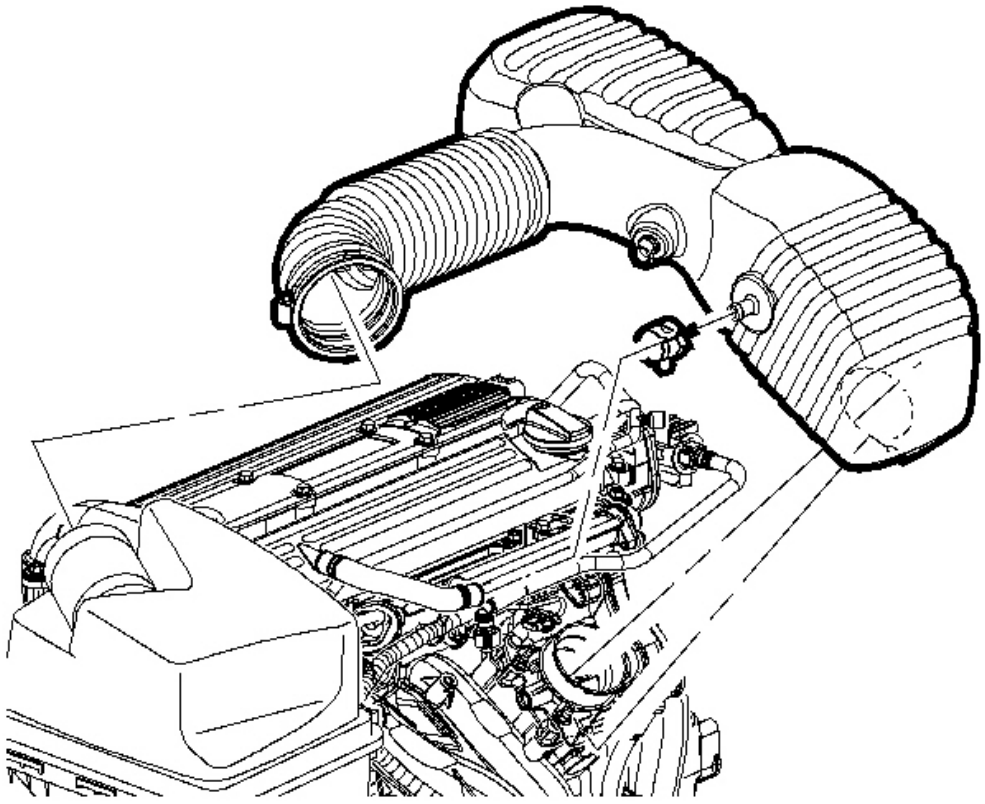


Fig. 168: Locating Air Intake Assembly
Courtesy of GENERAL MOTORS CORP.

11. Install the outlet resonator/duct assembly into position.
12. Connect the PCV fresh air vent hose assembly.
13. Tighten the clamp at the throttle body assembly.
14. Position the outlet resonator/duct assembly up with support bracket and install the push-pin.
15. Tighten the clamp at the air cleaner assembly.
16. Connect the intake air temperature (IAT) connector.
17. Install the air cleaner outlet duct assembly. Refer to **Air Cleaner Outlet Resonator Replacement** .
18. Connect the negative battery cable.

INTAKE CAMSHAFT AND LIFTER REPLACEMENT

Tools Required

- **J 43655** Camshaft Support Holding. See **Special Tools and Equipment** .
- **SA9127E-7** Gage Bar Set. See **Special Tools and Equipment** .

Removal Procedure

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

1. Disconnect the negative battery cable.
2. Disconnect the intake air temperature (IAT) sensor connector.

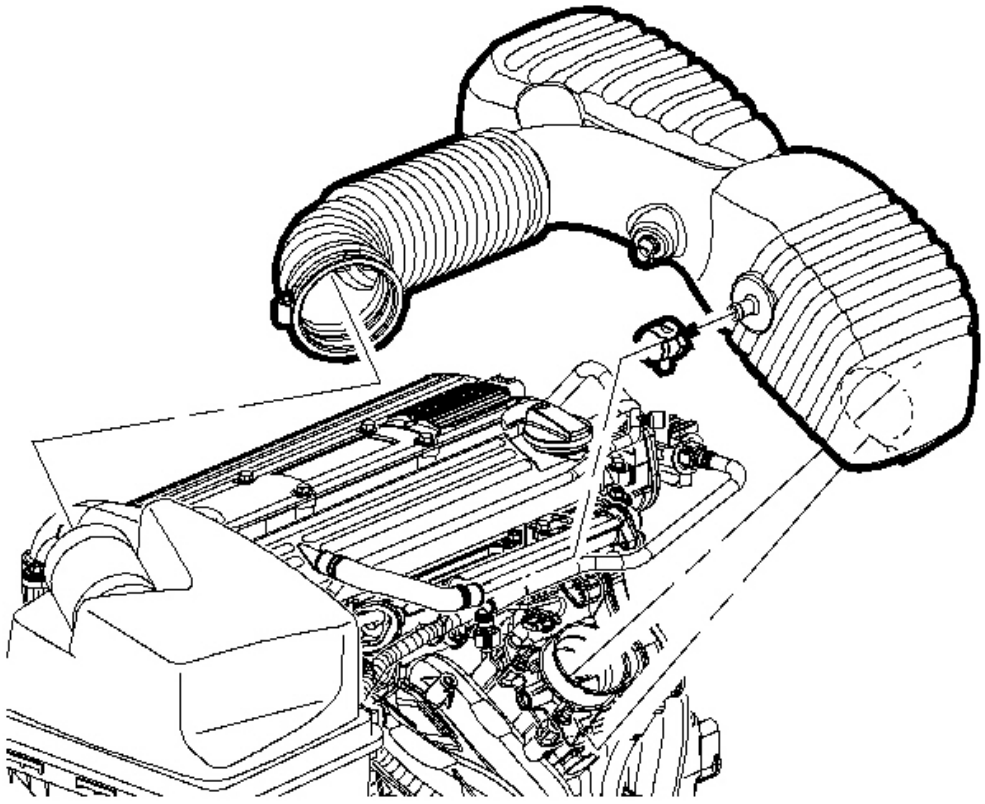


Fig. 169: Locating Air Intake Assembly
Courtesy of GENERAL MOTORS CORP.

3. Loosen the clamp at the air cleaner assembly.
4. Remove the push pin attachment from the outlet resonator/duct assembly to support bracket.
5. Loosen the clamp at the throttle body assembly.
6. Disconnect the PCV fresh air vent hose at the cam cover.
7. Remove the outlet resonator/duct assembly.

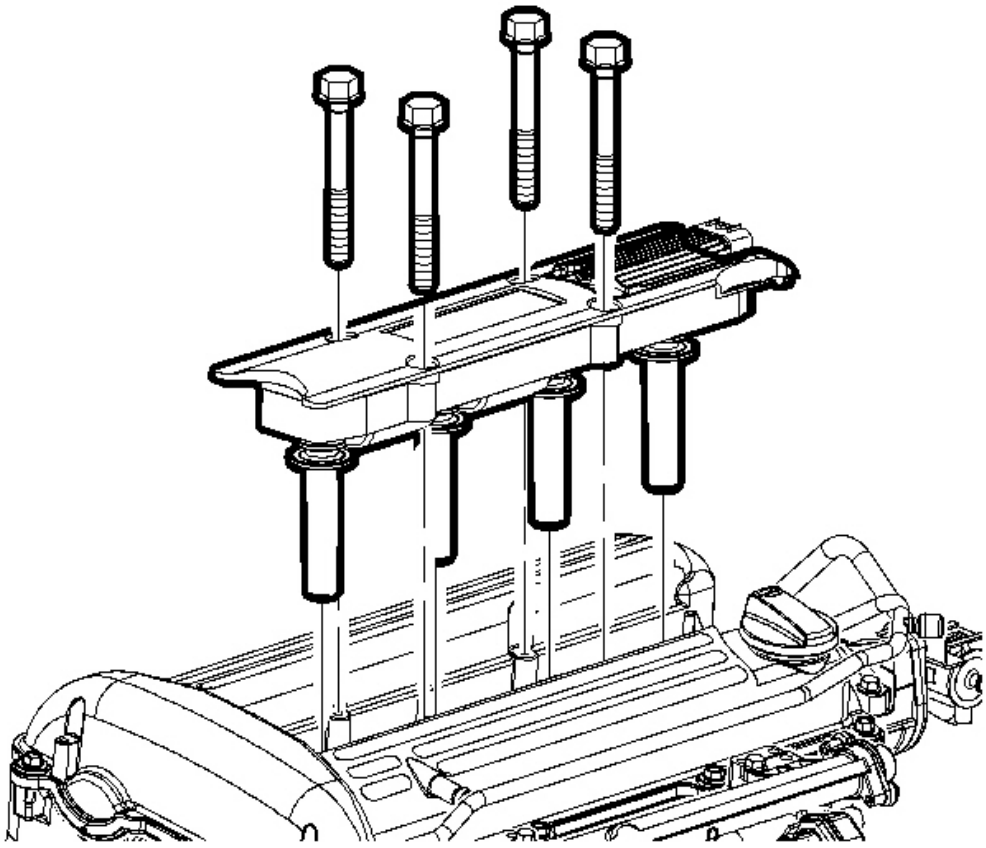


Fig. 170: Removing/Installing Ignition Module Assembly
Courtesy of GENERAL MOTORS CORP.

8. Disconnect the electrical connector at the ignition module.
9. Remove the ignition module assembly with bolts.
10. Disconnect the coolant de-gas hose clip on the fuel rail.

CAUTION: Whenever fuel line fittings are loosened or disconnected, wrap a shop cloth around the fitting to collect fuel. Place the cloth in an approved container.

NOTE: An open-end wrench must be used to support the fuel line to rail

connection during loosening/tightening to avoid damaging the fuel rail assembly.

11. Disconnect the ground strap at the rear of the cam cover assembly.
12. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief Procedure** in Engine Controls - 2.2L (L61).
13. Disconnect the gage bar set **SA9127E-7** after the pressure has been relieved. See **Special Tools and Equipment** .

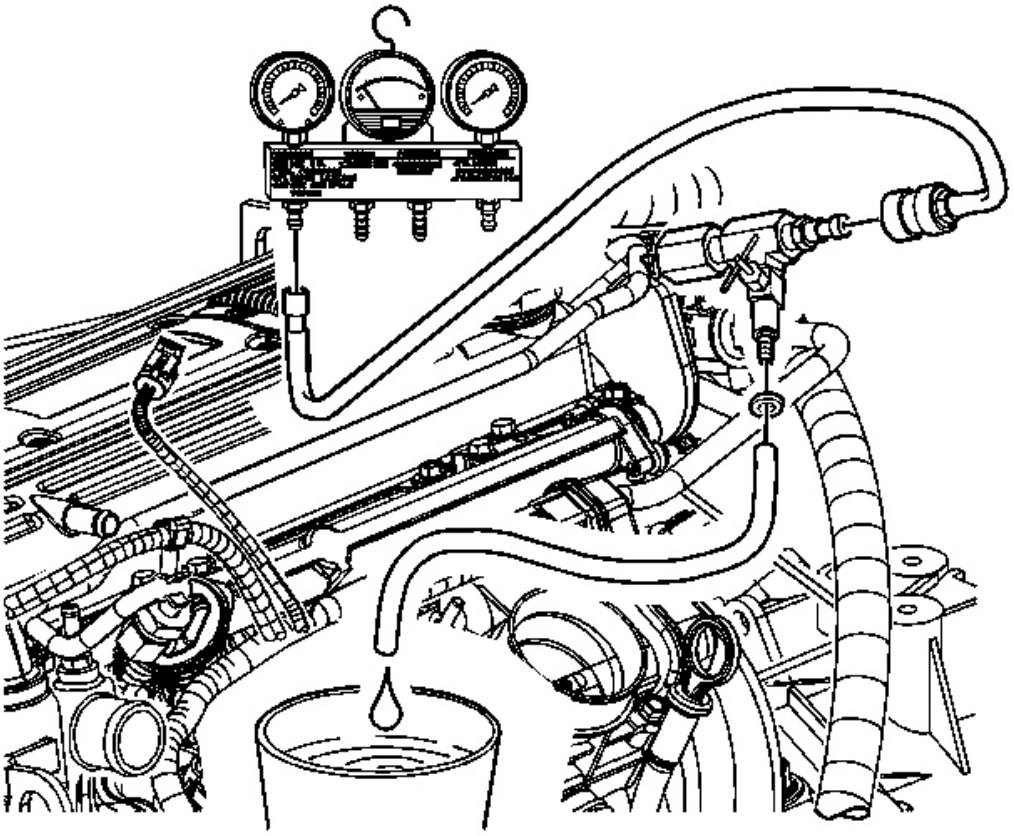


Fig. 171: Disconnecting Gage Bar Set SA9127E
Courtesy of GENERAL MOTORS CORP.

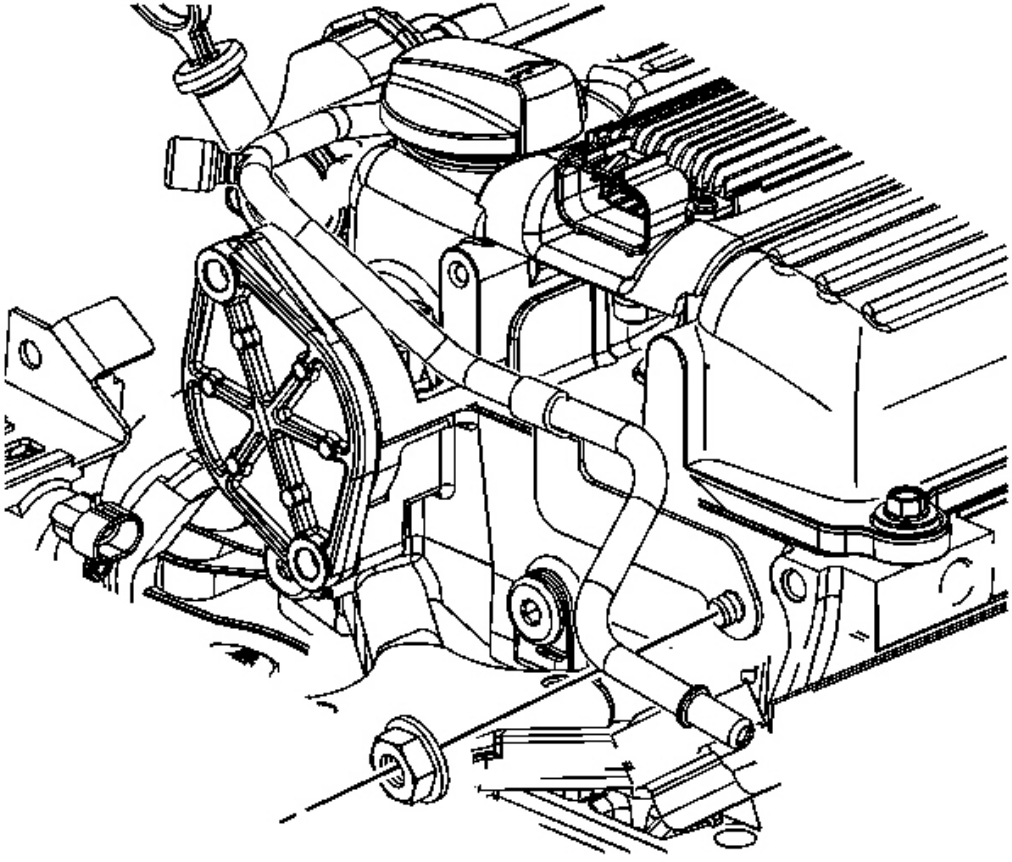


Fig. 172: Fuel Rail Bracket
Courtesy of GENERAL MOTORS CORP.

14. Disconnect the fuel ail bracket and bolt at the rear of the cam.
15. While supporting the fuel rail assembly with an open-end wrench, loosen the transfer line fitting at fuel.

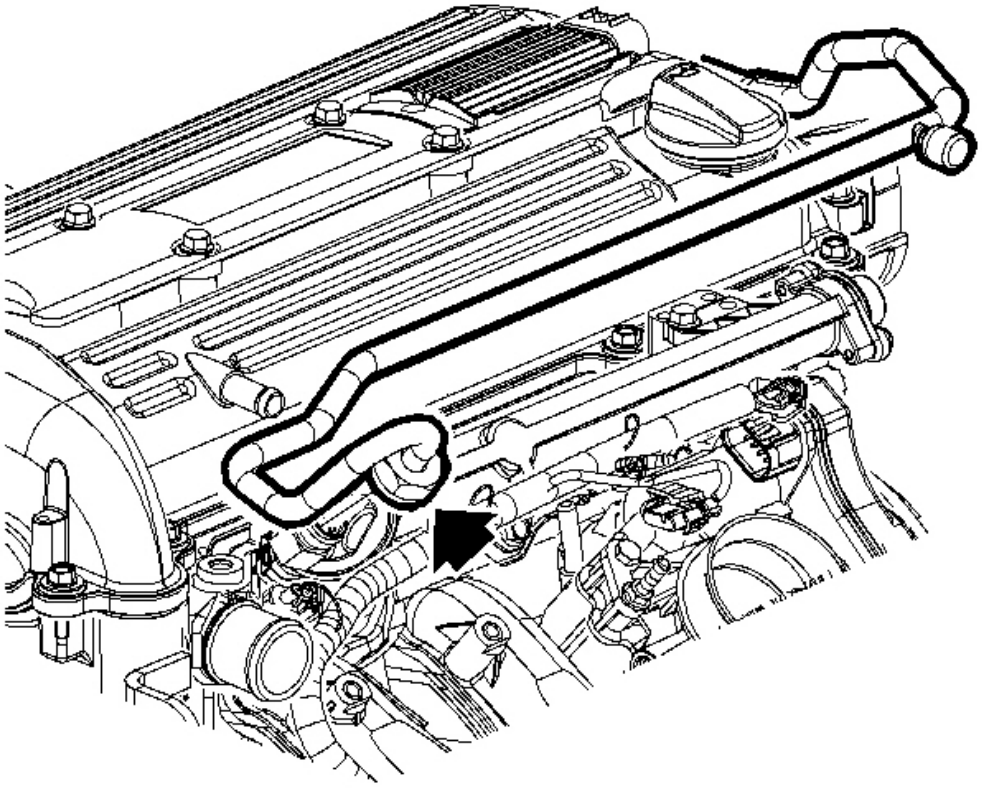


Fig. 173: Positioning Fuel Line
Courtesy of GENERAL MOTORS CORP.

16. Position the fuel line away from the cam cover assembly.
17. Remove then cam cover assembly bolts.
18. Remove the cam cover assembly.

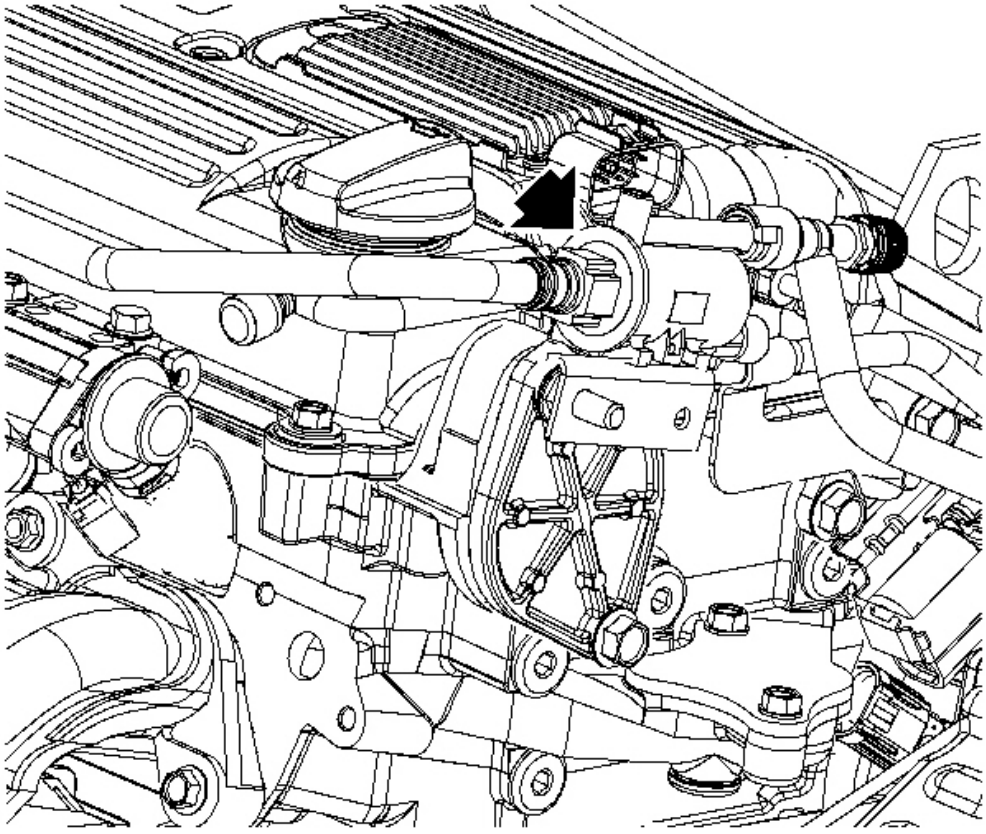


Fig. 174: Locating Purge Solenoid
Courtesy of GENERAL MOTORS CORP.

19. Remove the purge solenoid from the power steering plate.
20. Remove the power steering block off plate if the intake camshaft is being removed.

NOTE: To avoid valve piston contact, No. 1 cylinder piston must be positioned at approximately 60 degrees before-top dead center (BTDC). Pistons are properly positioned when the diamond shaped hole on the intake camshaft sprocket is located at 12 o'clock.

IMPORTANT: To rotate camshafts, use a 24 mm open end wrench on camshaft flats.

Camshafts should be rotated in a clockwise direction only, facing camshaft sprockets from passenger side of the vehicle.

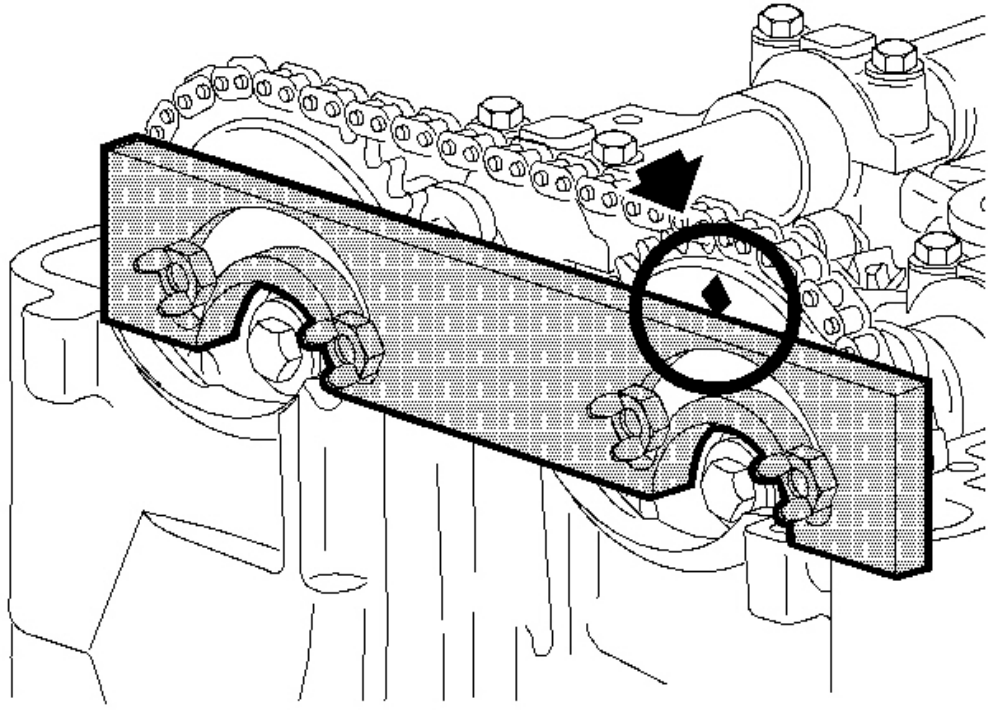


Fig. 175: Locating Diamond Shaped Hole On The Intake Camshaft Sprocket At The 12 O'clock Position
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: When removing guide bolts, do not drop the bolt down into the front cover area

21. Locate the number 1 piston to approximately 60 degrees before top dead center, diamond shaped hole on the intake camshaft sprocket at the 12 o'clock position. Remove the spark plugs. This will ease rotation

effort.

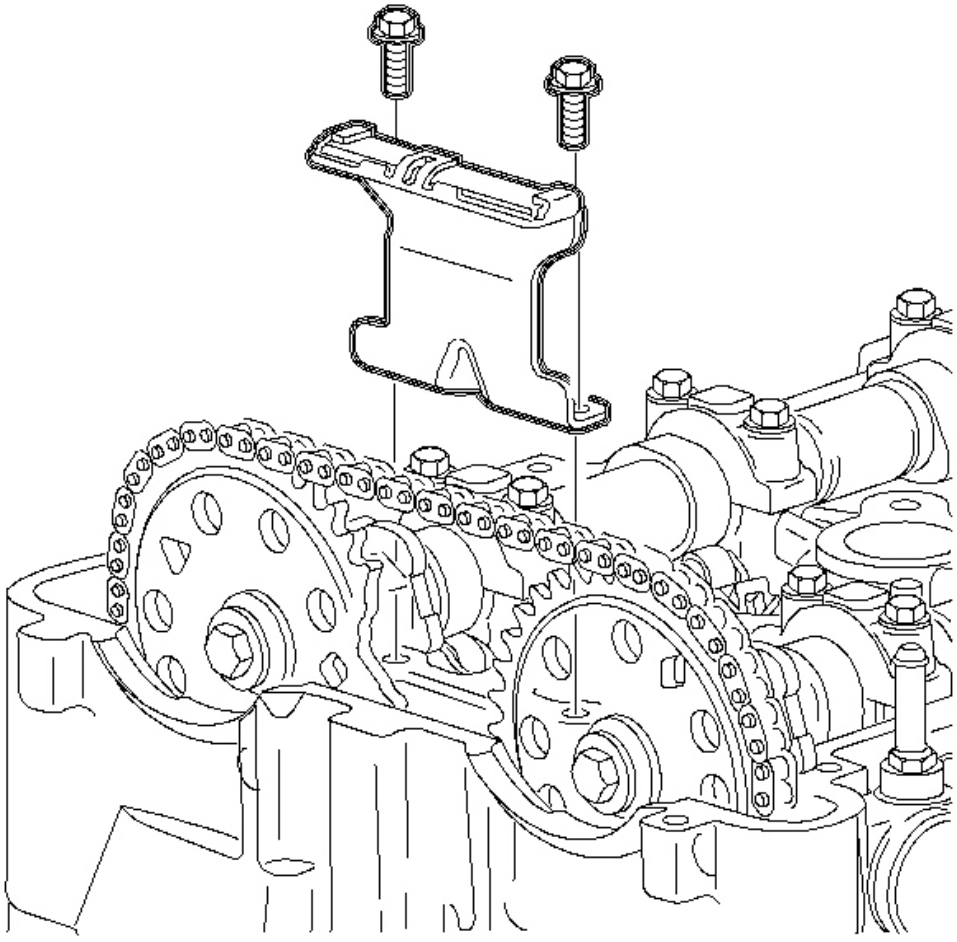


Fig. 176: Removing/Installing Upper Timing Chain Guide & Bolts
Courtesy of GENERAL MOTORS CORP.

22. Remove the upper timing chain guide.

NOTE: During camshaft removal procedure, the pistons are locked in position by the J 43655. DO NOT rotate the engine crankshaft or tool damage and timing reset will be required. Camshafts an be rotated ONLY AFTER the #1 piston is at 60 degrees before top dead center (BTDC) and sprocket had been disengaged from camshaft.

23. Remove the front camshaft caps.

IMPORTANT: Lubricate the sprocket pins with clean motor oil. This will allow the sprockets to easily slide on the sprocket pins.

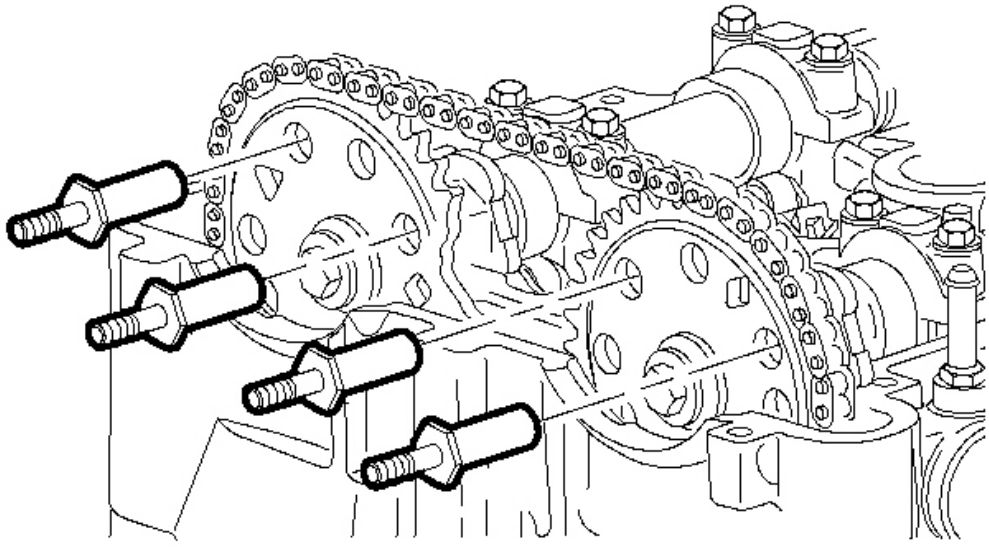


Fig. 177: Installing J43655 Through The Sprocket Holes
Courtesy of GENERAL MOTORS CORP.

24. Install the **J 43655** through the sprocket holes from the timing side of the sprocket towards the rear of the engine. See **Special Tools and Equipment** .
25. With guide pin installed in the sprocket, align the guide pins into the slots on the support plate.

NOTE: **Refer to Fastener Notice in Cautions and Notices.**

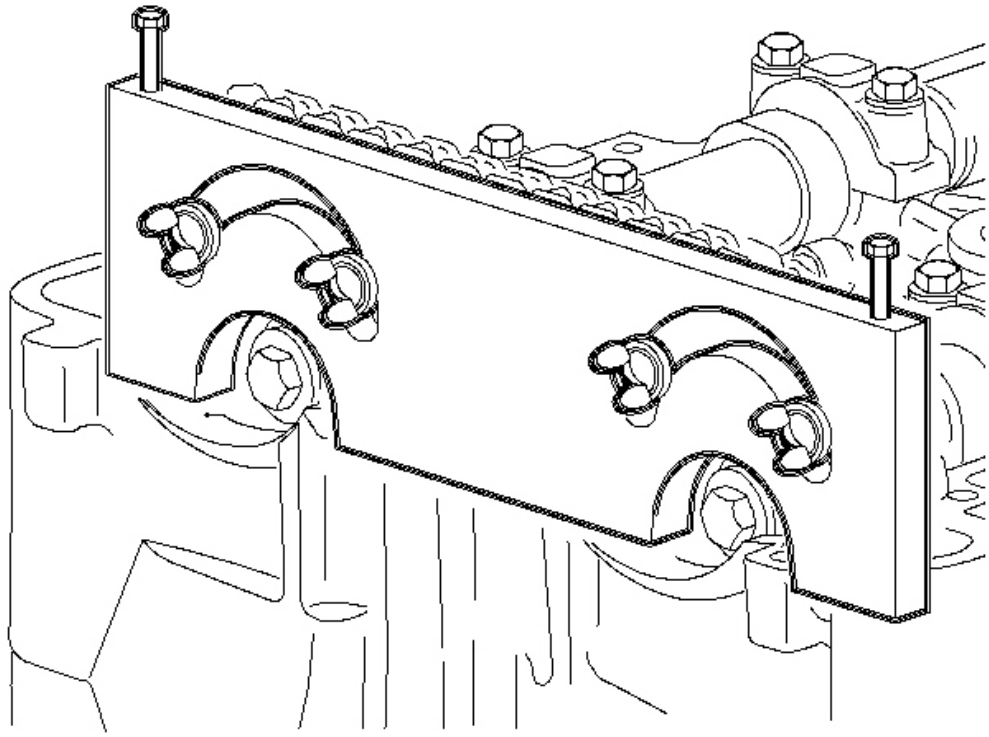


Fig. 178: Tightening Support Bracket To Cylinder Head
Courtesy of GENERAL MOTORS CORP.

26. Tighten the support bracket to cylinder head.

    Tighten: Tighten the support plate to cylinder head to 10 N.m (89 lb in).

27. Install the wing nuts and tighten.

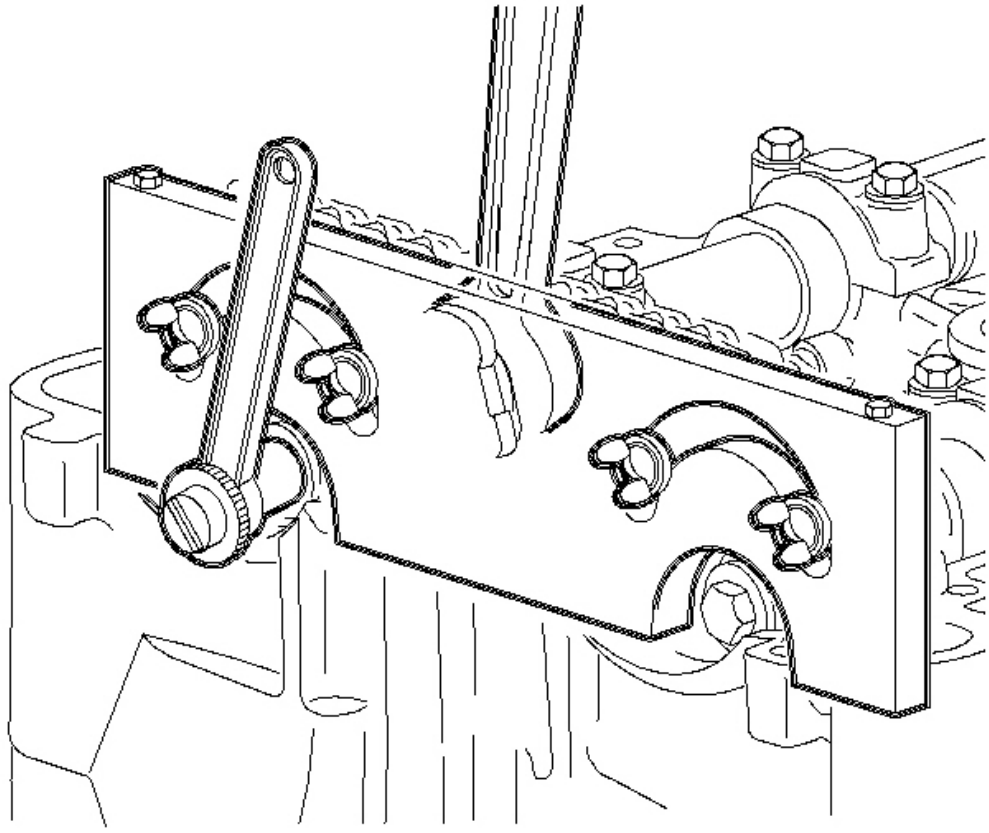


Fig. 179: Holding Camshaft In Place Using A 24 mm Open End Wrench
Courtesy of GENERAL MOTORS CORP.

28. Hold each camshaft in place using a 24 mm open end wrench and carefully remove the camshaft sprocket timing retaining bolts and washers. Discard the torque-to-yield bolts.

IMPORTANT:

- **When sliding the timing chain and sprocket onto the guide pins, be sure the timing chain is positioned properly on the adjustable and fixed guide or guide damage will occur. Care should be taken when removing the sprockets from the camshafts.**
- **Camshafts are spring loaded and may rotate. Care should be taken until all spring tension is removed from the camshaft.**

29. Slide the camshaft sprockets away from the camshafts.
30. To release the spring tension on the camshaft, after the camshaft is disengaged from the sprocket, rotate the camshaft using a 24 mm wrench to a neutral position.

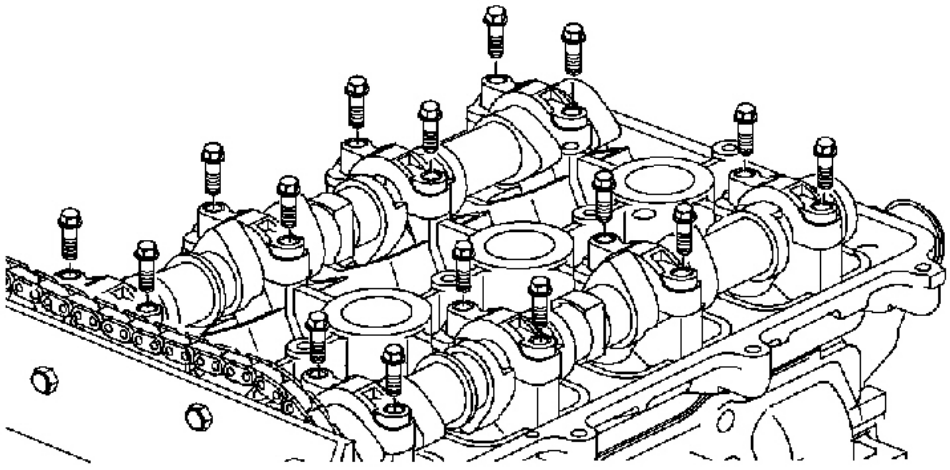


Fig. 180: Removing/Installing Camshaft Bearing Cap Bolts
Courtesy of GENERAL MOTORS CORP.

31. Uniformly loosen and remove the remaining camshaft bearing cap bolts.

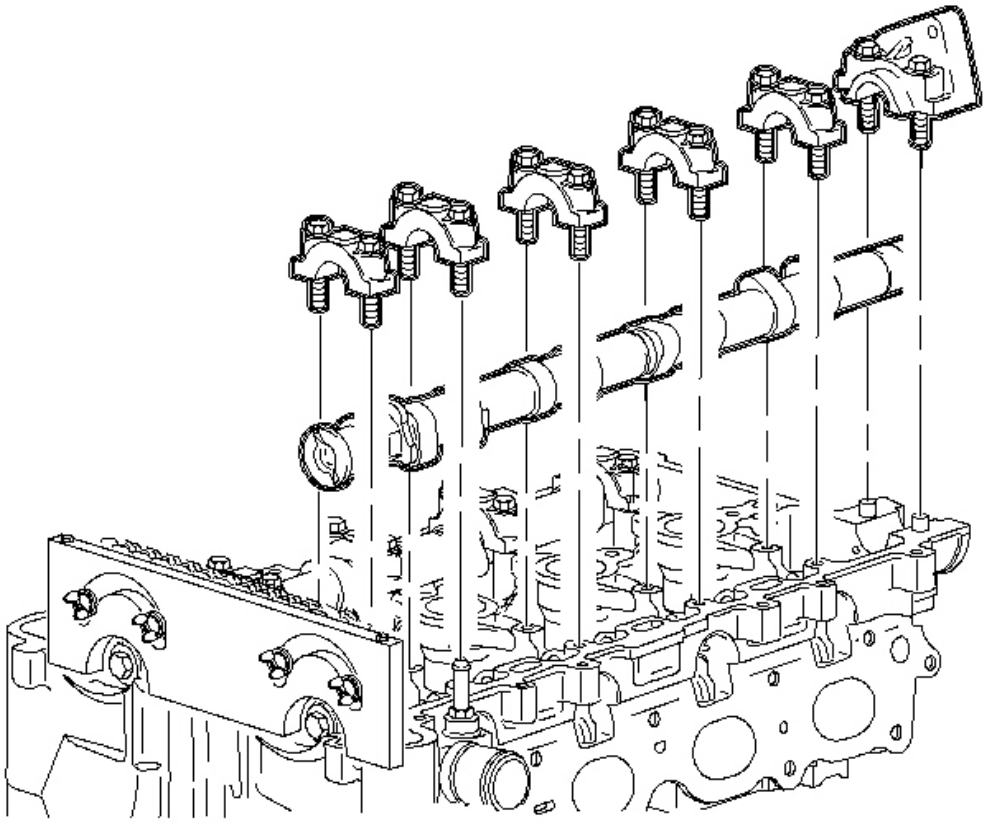


Fig. 181: Pulling Camshafts Straight Up To Avoid Damaging The Cylinder Head Thrust Surfaces
Courtesy of GENERAL MOTORS CORP.

32. Carefully pull the camshafts straight up to avoid damaging the cylinder head thrust surfaces.

Installation Procedure

NOTE: After cylinder block, head, or lifter replacement, it will be necessary to allow the engine to idle for 3-5 minutes. If the lifters are noisy, warm the engine up at less than 200 RPM. After the coolant temperature has reached approximately 85°C (185°F), cycle the engine RPM from idle to 300 RPM for approximately 10 minutes or drive the vehicle 8 kilometers (5 miles) to purge the air. If the air cannot be purged, the faulty lifters will

have to be replaced.

NOTE: **Lifters that are pumped up may cause PCM misfire codes to set. Continue to operate the engine until the lifters bleed down. Using the scan tool, clear the codes and malfunction history.**

NOTE: **If a valve seal is removed after it has been installed, it must be discarded. The valve stem lock groove will cut the seal's lip during removal. Use extreme care when installing valve retainers and do not damage the valve stems.**

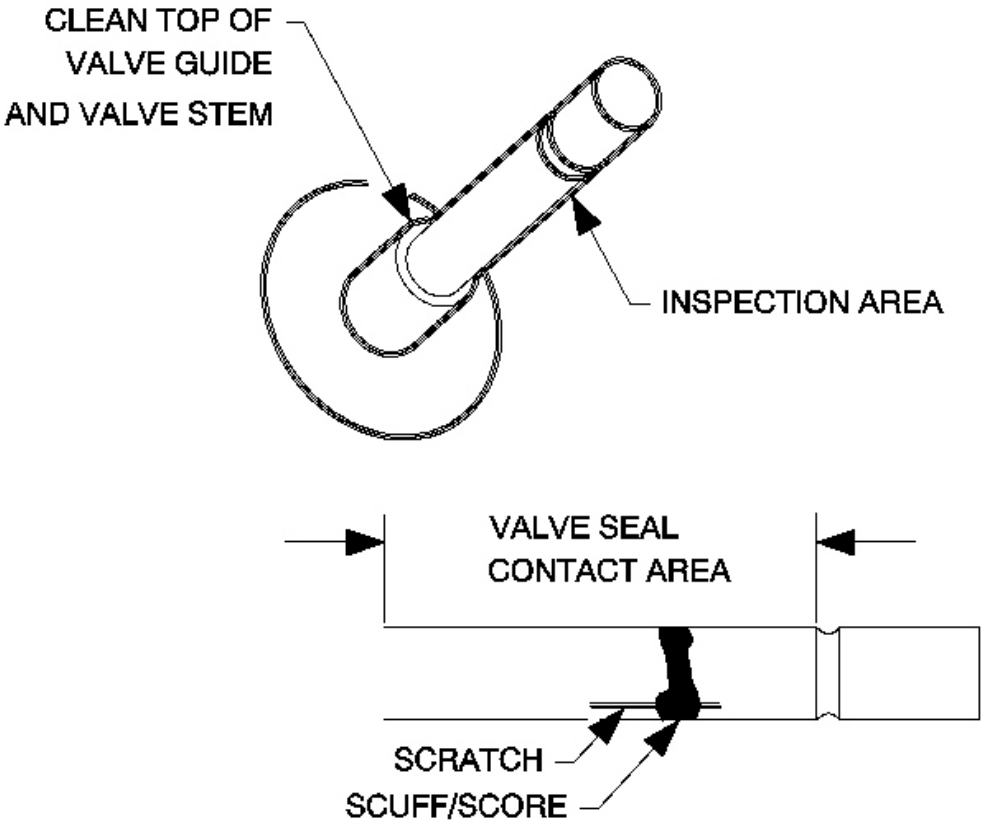


Fig. 182: Inspecting Valve Seal Contact Area

Courtesy of GENERAL MOTORS CORP.

1. Allow the engine to idle.

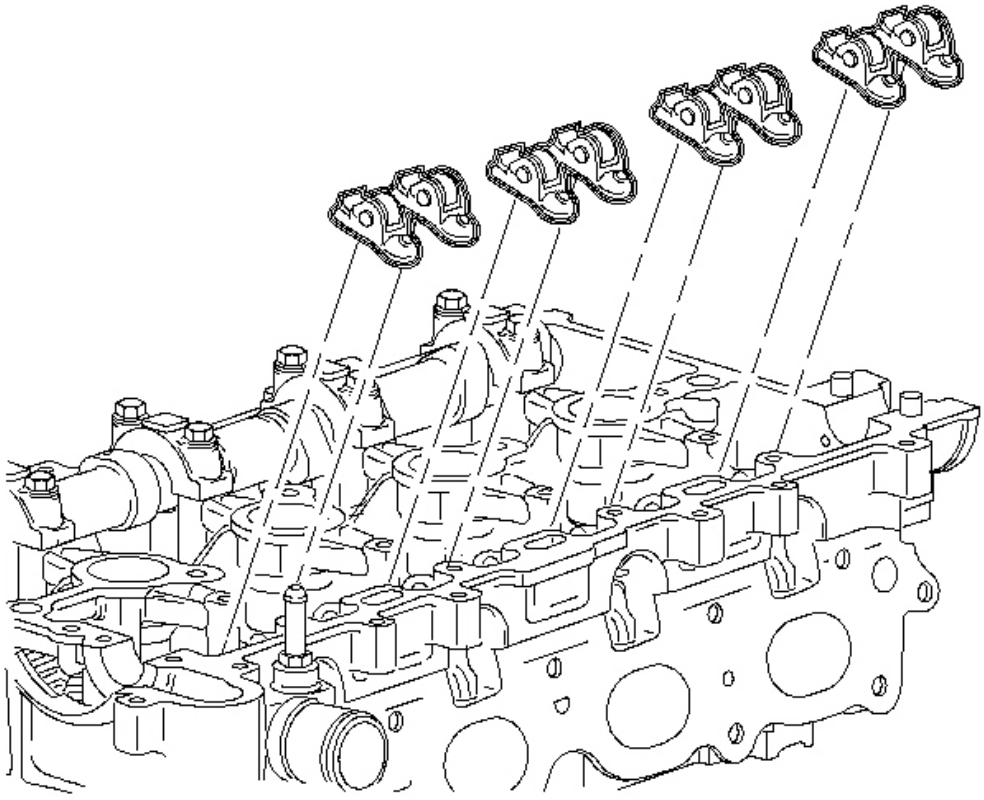


Fig. 183: Installing Rocker Arms
Courtesy of GENERAL MOTORS CORP.

2. Ensure install rocker arms are in their proper location, followers.
3. Lubricate the camshaft bearing journals with clean engine oil and install both camshafts.
4. When installing the camshafts, align to position camshaft slot in line with the notch on the sprockets.

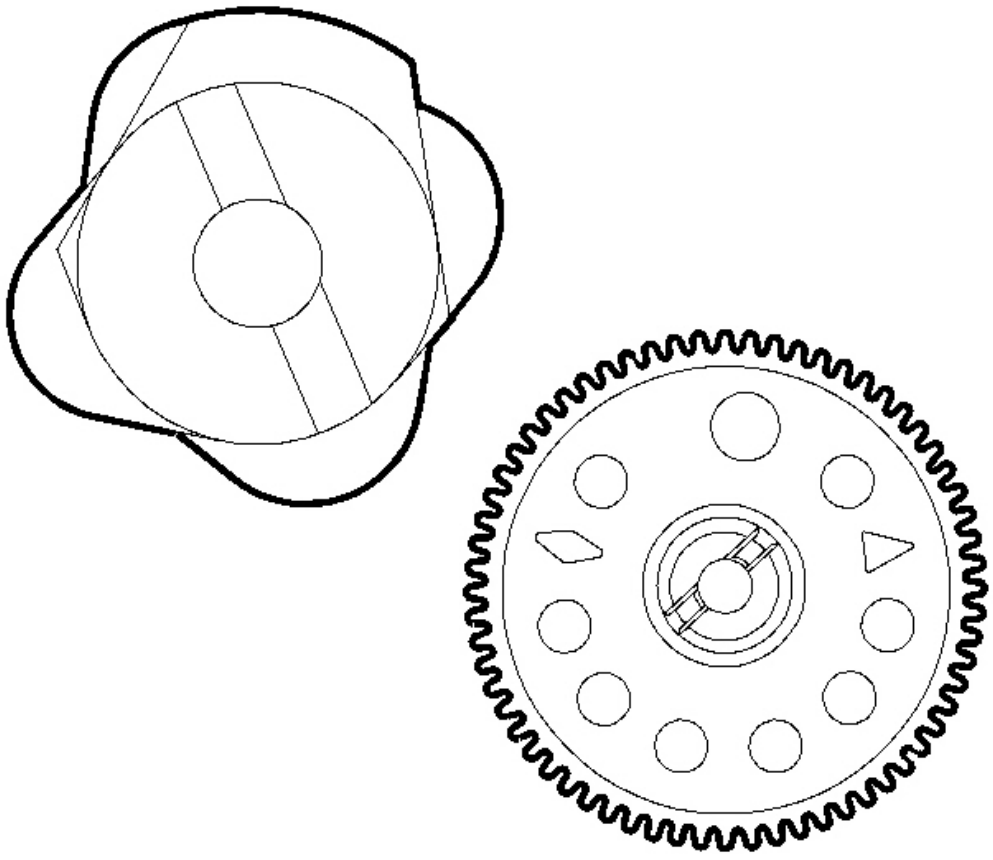


Fig. 184: Aligning Camshaft Slot In Line With The Notch On The Sprockets
Courtesy of GENERAL MOTORS CORP.

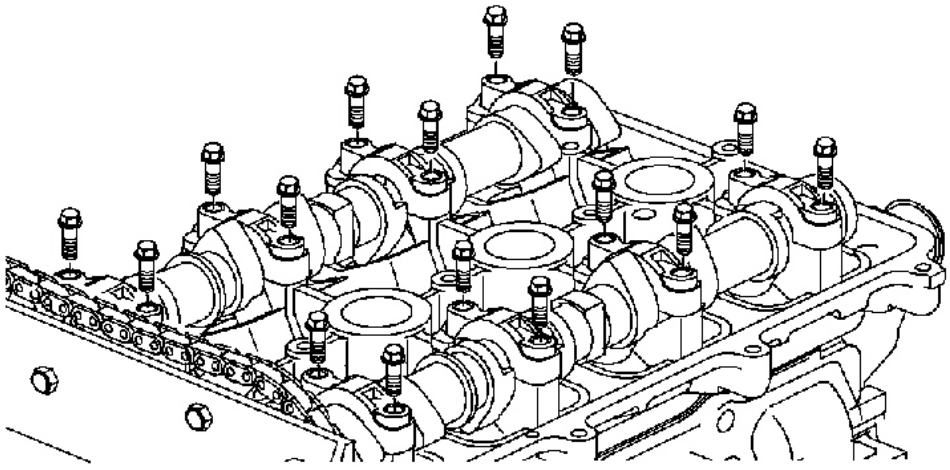


Fig. 185: Removing/Installing Camshaft Bearing Cap Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Install all bearing caps except the front caps and rear intake camshaft cap, if serviced. Tighten down the bearing caps uniformly.

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

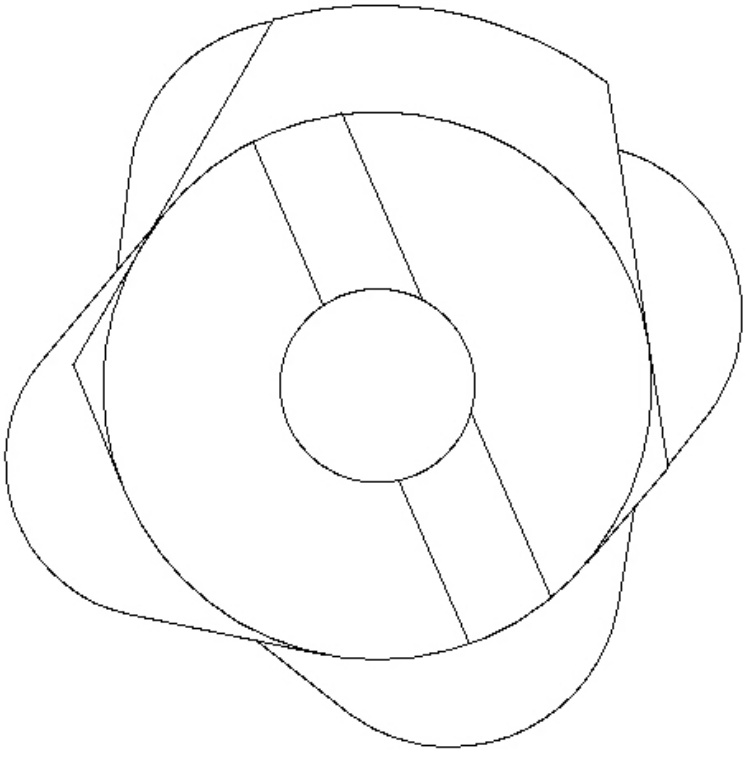


Fig. 186: Camshaft Alignment Slots
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Ensure that the alignment slots are correctly aligned with the notches in the camshaft sprockets before final tightening is applied.**
- **Verify the timing chain is properly positioned on the fixed guide or guide damage will occur.**
- **Verify the camshafts are properly timed as outlined in this section prior to starting the engine.**

6. Verify camshaft timing.

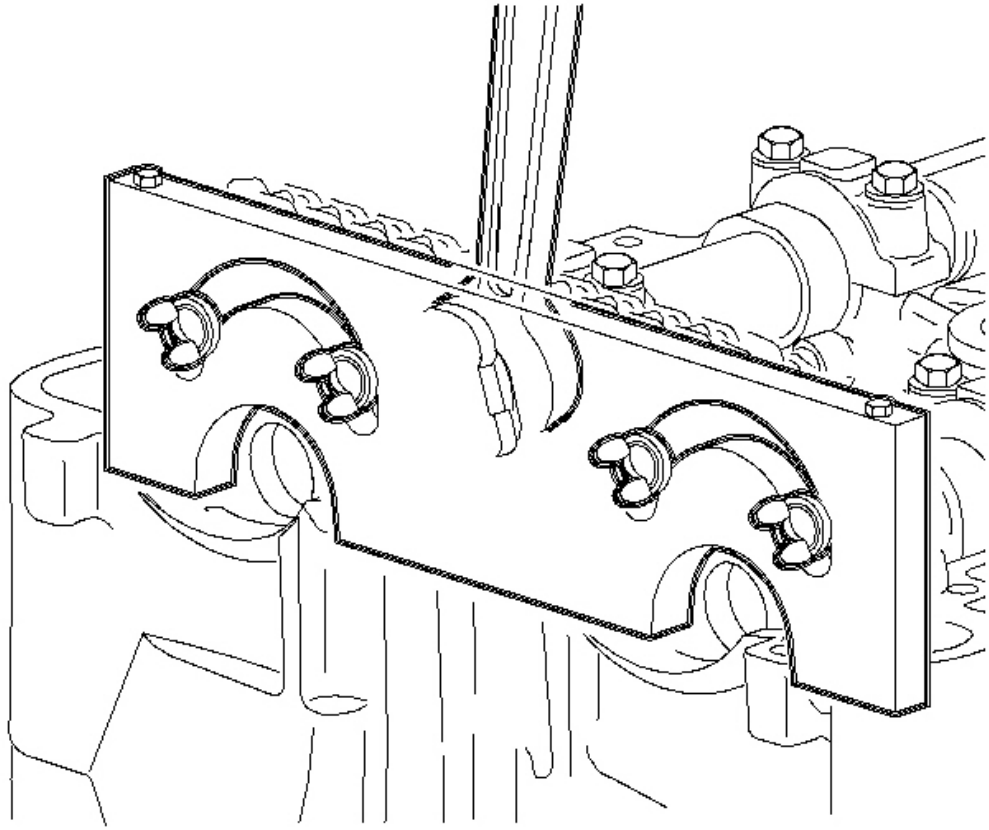


Fig. 187: Rotating Camshafts With 24 mm Open End Wrench To Align The Camshaft & Sprockets
Courtesy of GENERAL MOTORS CORP.

7. Slide the camshaft sprockets and timing chain on the guide pins toward the camshafts. Rotate the camshafts with a 24 mm open end wrench to properly align the camshaft and sprockets.
8. Install new camshaft sprocket bolt and tighten. This will pull the camshaft sprockets into the cams. Hold the camshaft with the 24 mm open end wrench during tightening.

   Tighten: Tighten the camshaft sprocket bolts to 85 N.m (63 lb ft) +30 degrees.

9. Remove the **J 43655** . See **Special Tools and Equipment** .
10. Install the front camshaft caps.

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

IMPORTANT: Apply Permatex(R) Threadlocker Blue P/N 21485277 to the upper timing chain guide bolts.

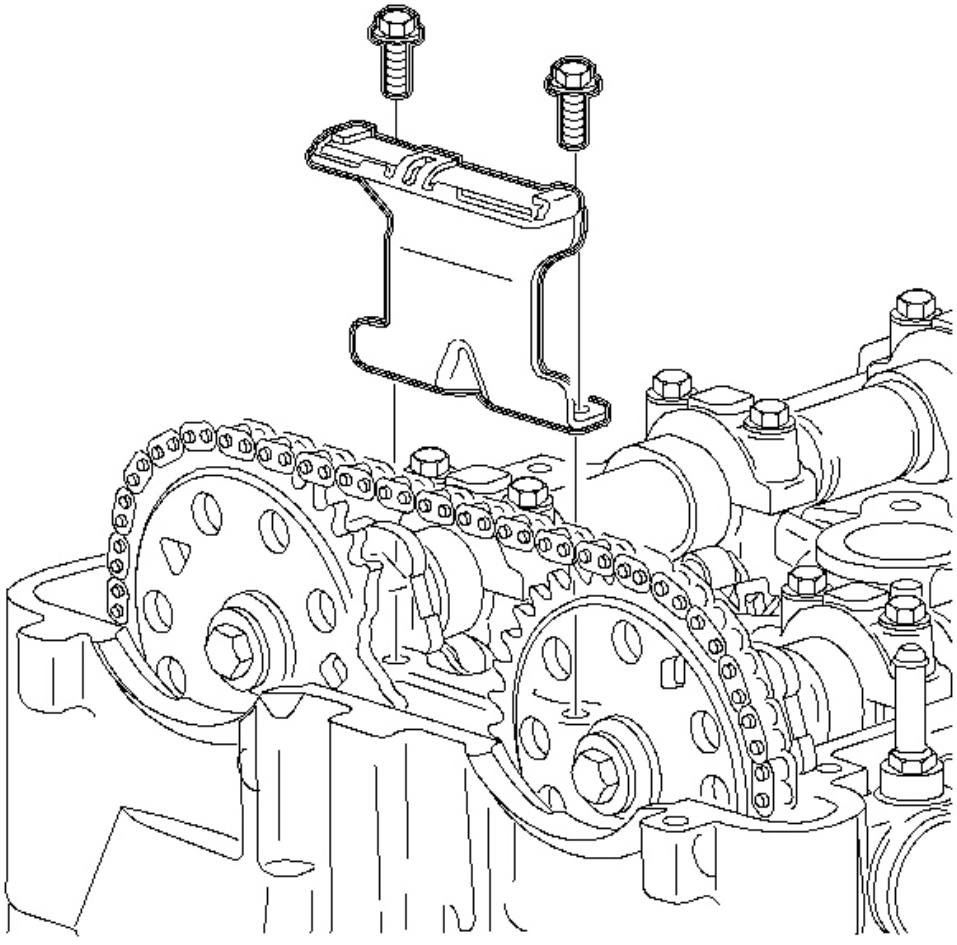


Fig. 188: Removing/Installing Upper Timing Chain Guide & Bolts
Courtesy of GENERAL MOTORS CORP.

11. Install the upper timing chain guide and bolts.

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

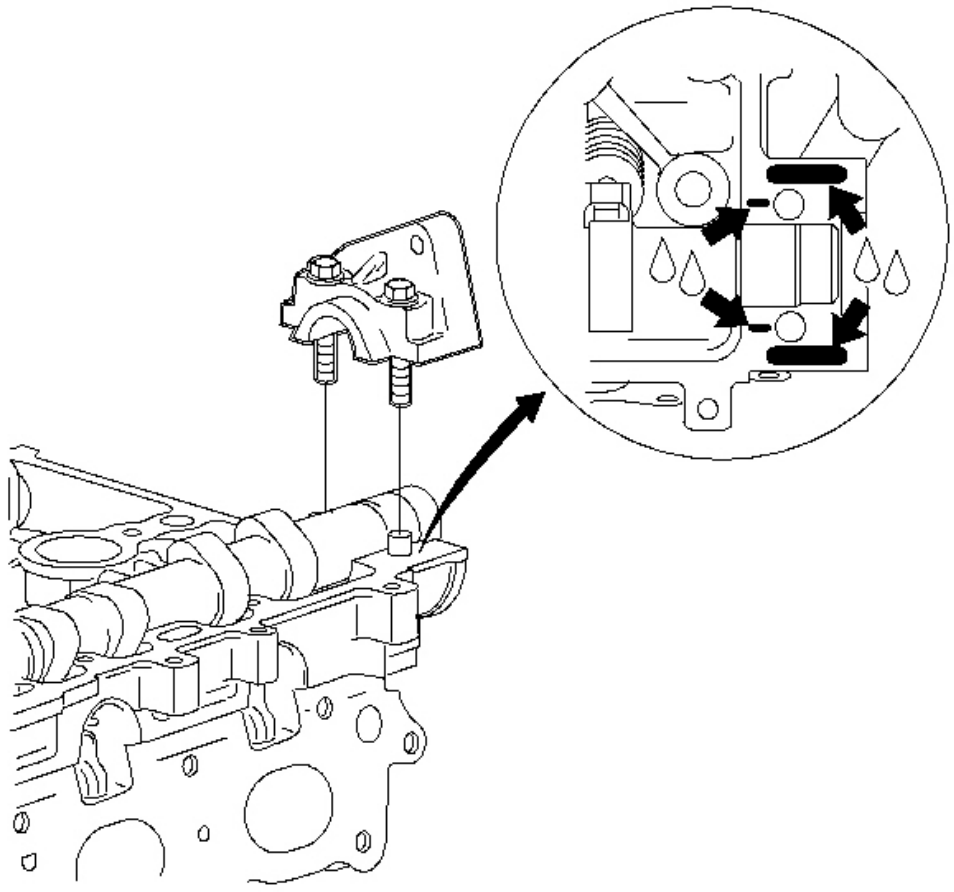


Fig. 189: Installing Rear Intake Camshaft Bearing Cap
Courtesy of GENERAL MOTORS CORP.

12. Install the rear intake camshaft bearing cap.

IMPORTANT: Apply Permatex(R) Anerobic Flange sealant to the cylinder head near the rear intake cap as shown.

13. Install the rear intake camshaft bearing cap.

Tighten: Tighten the intake camshaft rear cap to 25 N.m (18 lb ft).

14. Install the power steering block-off plate.

Tighten: Tighten the power steering block-off plate to 25 N.m (18 lb ft).

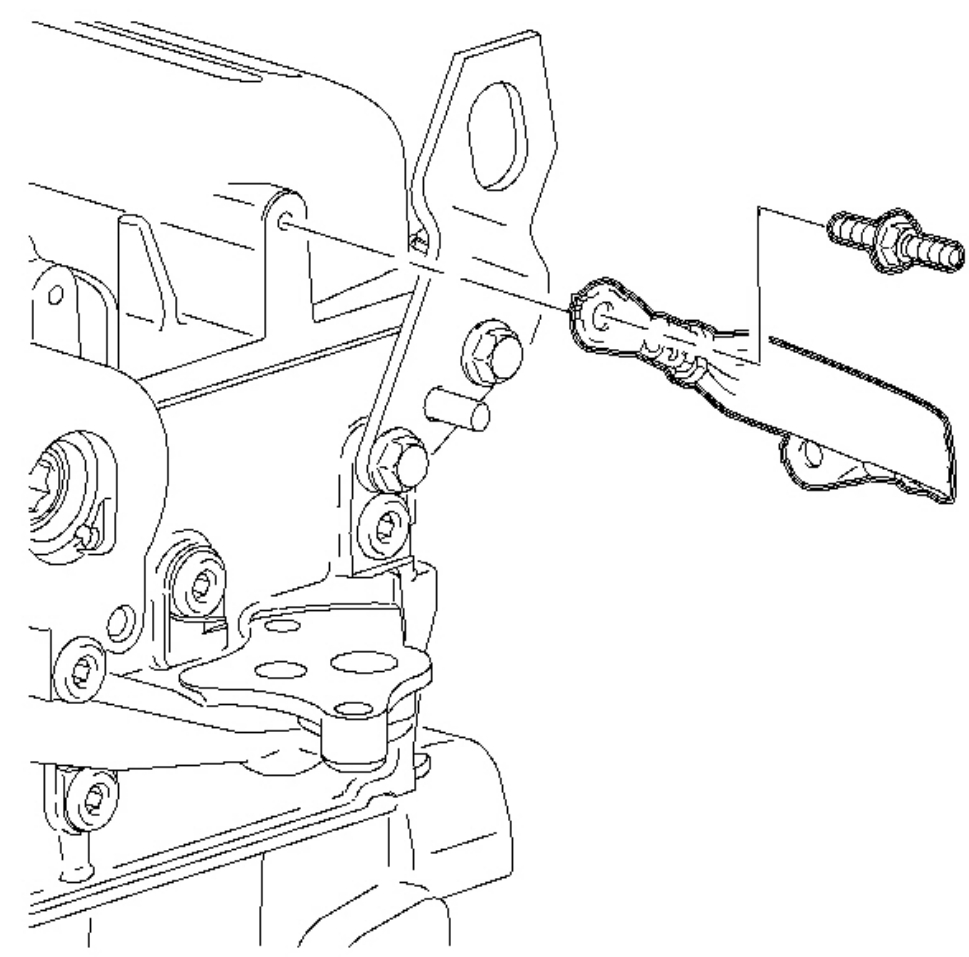


Fig. 190: Disconnecting/Connecting Ground Strap On The Camshaft Cover Assembly
Courtesy of GENERAL MOTORS CORP.

15. Visually inspect the camshaft cover gasket for signs of leakage. The camshaft cover gasket is reusable if not damaged.
16. Assemble the camshaft cover and gasket. Use care to make sure the gasket is located in the retaining groove on the camshaft cover.
17. Install the cover on the cylinder head and hand-tighten the bolts.

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

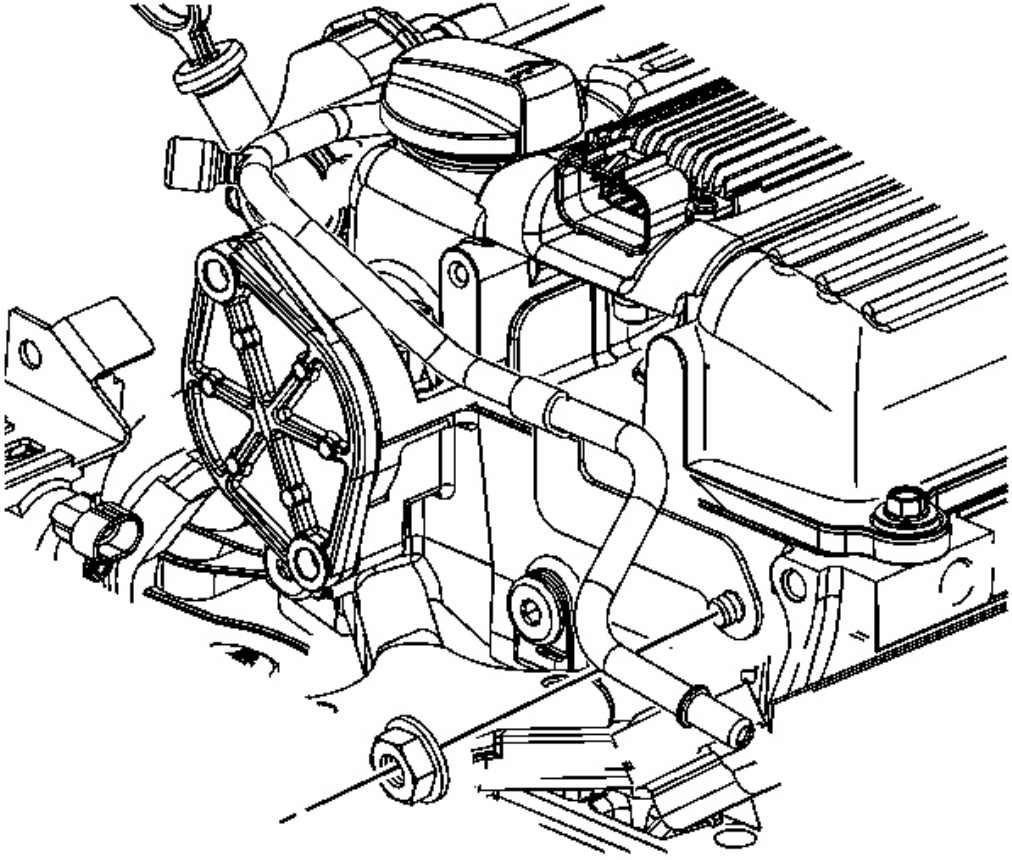


Fig. 191: Fuel Rail Bracket
Courtesy of GENERAL MOTORS CORP.

18. Reposition the fuel line assembly.

NOTE: An open-end wrench must be used to support the fuel line to rail connection during loosening/tightening to avoid damaging the fuel rail assembly.

19. Install the transfer line fitting at the fuel-to-fuel rail.

Tighten: Tighten the transfer line fitting-to-fuel rail to 10 N.m (89 lb in).

20. Connect the fuel rail bracket and bolt to the cylinder head.

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

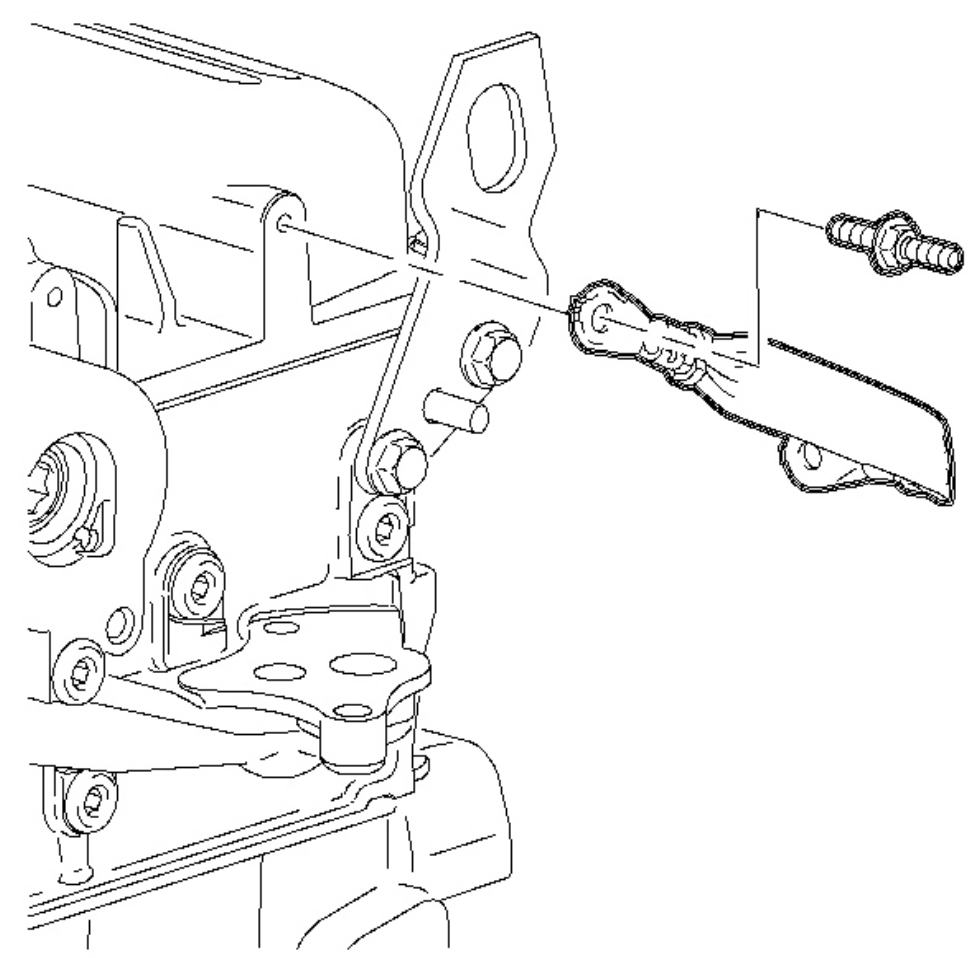


Fig. 192: Disconnecting/Connecting Ground Strap On The Camshaft Cover Assembly
Courtesy of GENERAL MOTORS CORP.

21. Connect the ground strap to the camshaft cover assembly.

    Tighten: Tighten the camshaft cover ground strap bolts to 10 N.m (89 lb in).

22. Connect the degas hose and clamp to the cylinder head.
23. Connect the degas hose bracket and bolt to the cylinder head.

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

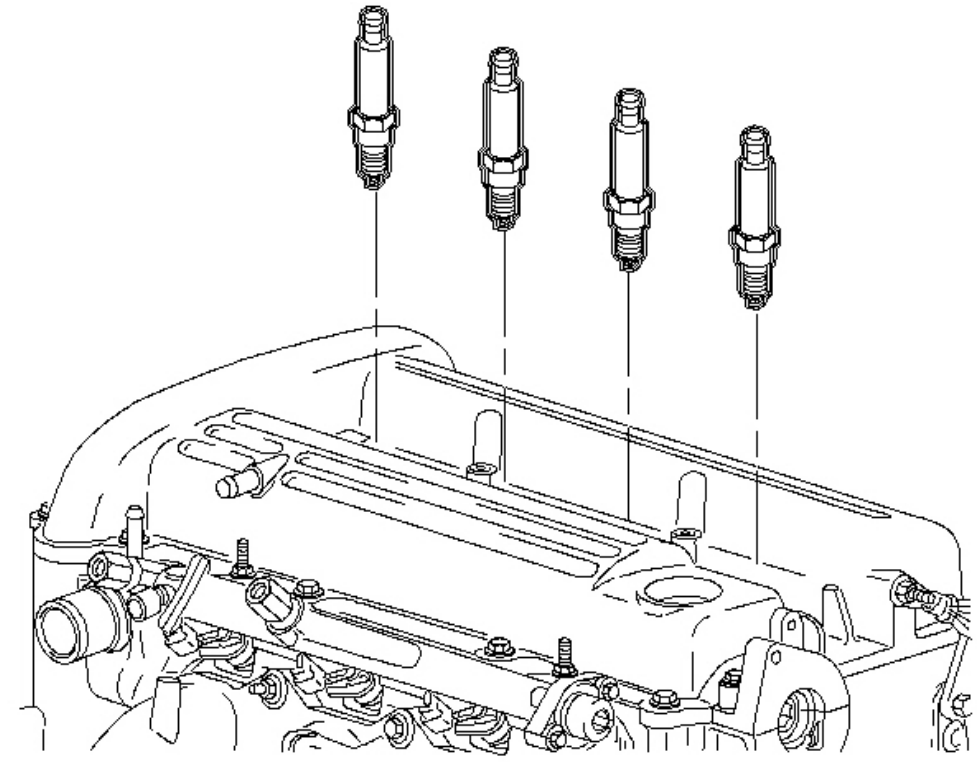


Fig. 193: Installing Spark Plugs
Courtesy of GENERAL MOTORS CORP.

24. Install the spark plugs.

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

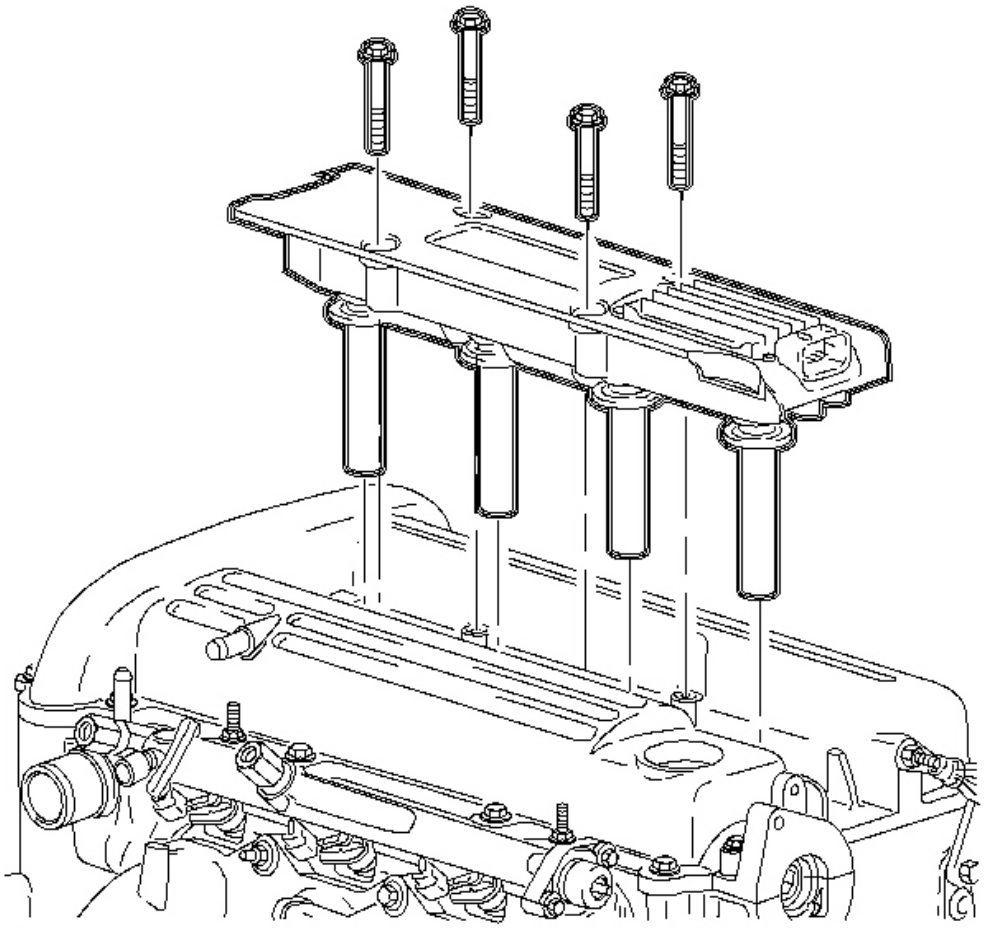


Fig. 194: Installing Ignition Module Assembly
Courtesy of GENERAL MOTORS CORP.

25. Install the ignition module assembly to cam cover and hand tighten the retaining bolts.

    Tighten: Tighten the ignition module-to-camshaft cover bolts to 8 N.m (71 lb in).

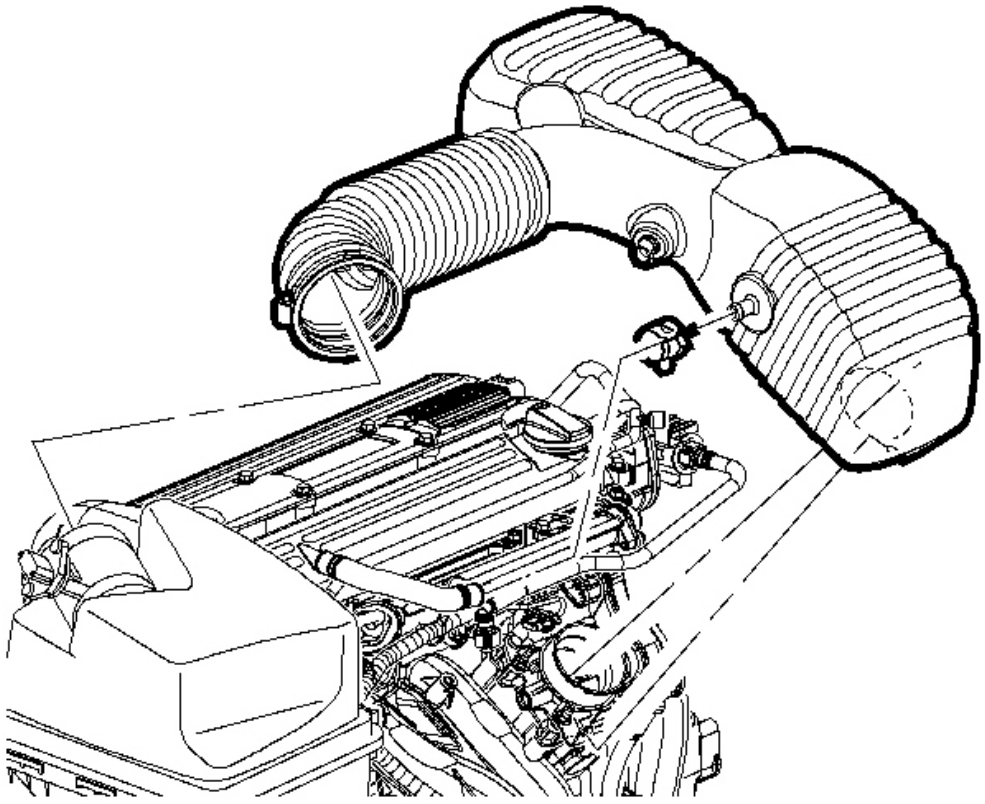


Fig. 195: Positioning Outlet Resonator/Duct Assembly
Courtesy of GENERAL MOTORS CORP.

26. Position the outlet resonator/duct assembly into position.
27. Connect the PVC fresh air vent hose assembly.
28. Tighten the clamp at the throttle body assembly.
29. Position the outlet resonator/duct assembly up with the support bracket and install the push-pin.
30. Tighten the clamp at the air cleaner assembly.
31. Connect the intake air temperature (IAT) sensor connector.
32. Connect the negative battery cable.

Tighten: Tighten the battery terminal bolt to 17 N.m (13 lb ft).

EXHAUST CAMSHAFT AND LIFTER REPLACEMENT

Tools Required

- **J 43655** Camshaft Support Holding. See **Special Tools and Equipment** .
- **SA9127E** Gage Bar Set. See **Special Tools and Equipment** .

Removal Procedure

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

1. Disconnect the negative battery cable.
2. Disconnect the intake air temperature (IAT) sensor connector.
3. Loosen the clamp at the air cleaner assembly.
4. Remove the push pin attachment from the outlet resonator/duct assembly to support bracket.

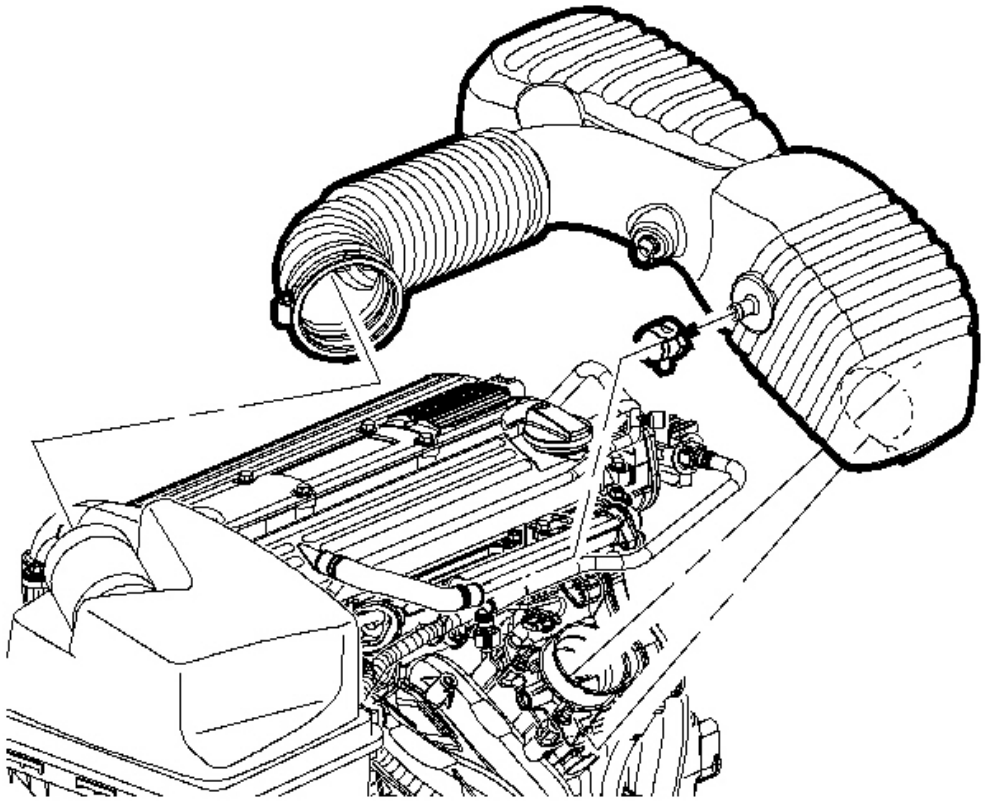


Fig. 196: Removing Outlet Resonator/Duct Assembly
Courtesy of GENERAL MOTORS CORP.

5. Loosen the clamp at the throttle body assembly.
6. Disconnect the PCV fresh air vent hose at the cam cover.
7. Remove the outlet resonator/duct assembly.

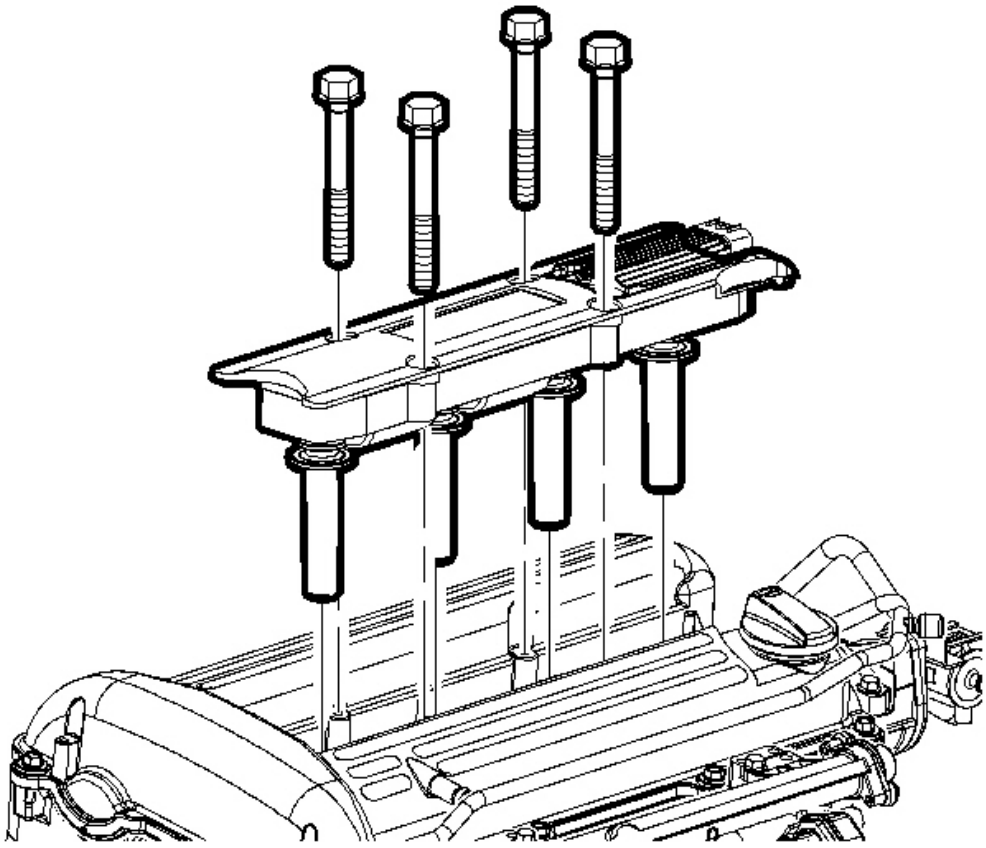


Fig. 197: Removing/Installing Ignition Module Assembly
Courtesy of GENERAL MOTORS CORP.

8. Disconnect the electrical connector at the ignition module.
9. Remove the ignition module assembly with bolts.
10. Disconnect the coolant de-gas hose clip on the fuel rail.

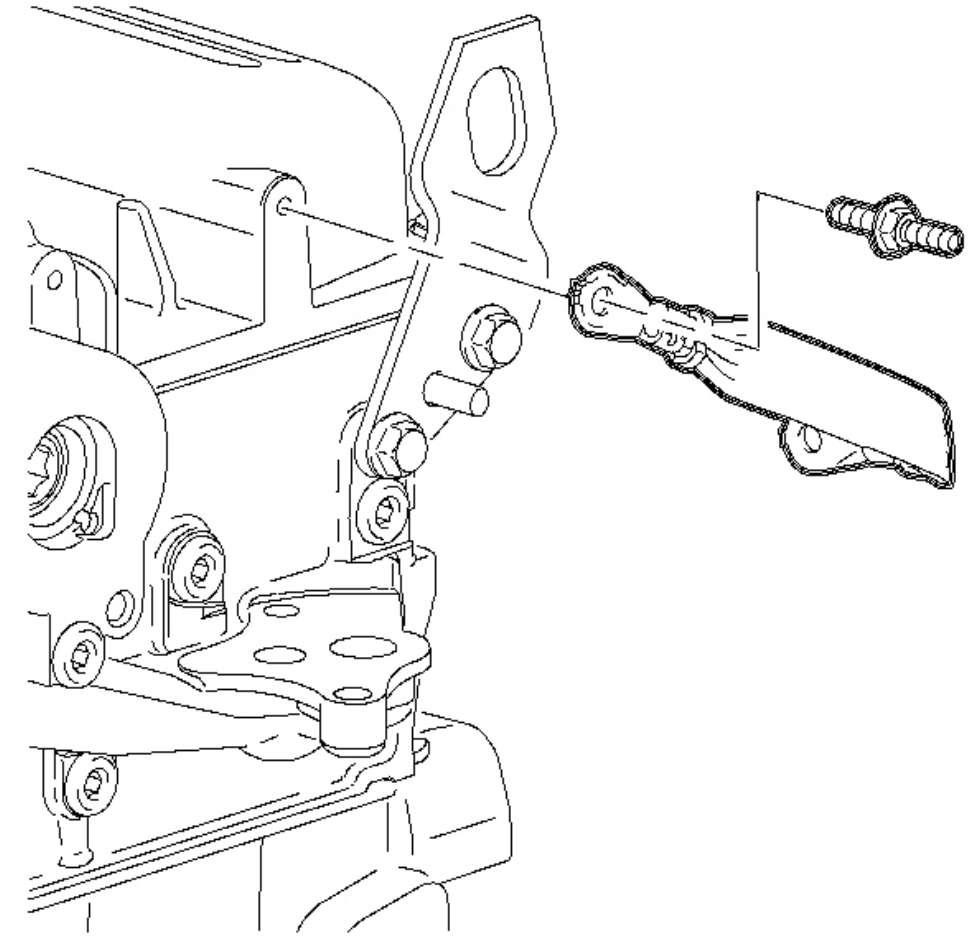


Fig. 198: Disconnecting/Connecting Ground Strap On The Camshaft Cover Assembly
Courtesy of GENERAL MOTORS CORP.

11. Disconnect the ground strap at the rear of the cam cover assembly.

CAUTION: Whenever fuel line fittings are loosened or disconnected, wrap a shop cloth around the fitting to collect fuel. Place the cloth in an approved container.

NOTE: An open-end wrench must be used to support the fuel line to rail connection during loosening/tightening to avoid damaging the fuel rail assembly.

12. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief Procedure** in Engine Controls - 2.2L (L61).
13. Disconnect the gage bar set SA9127E after the pressure has been relieved.

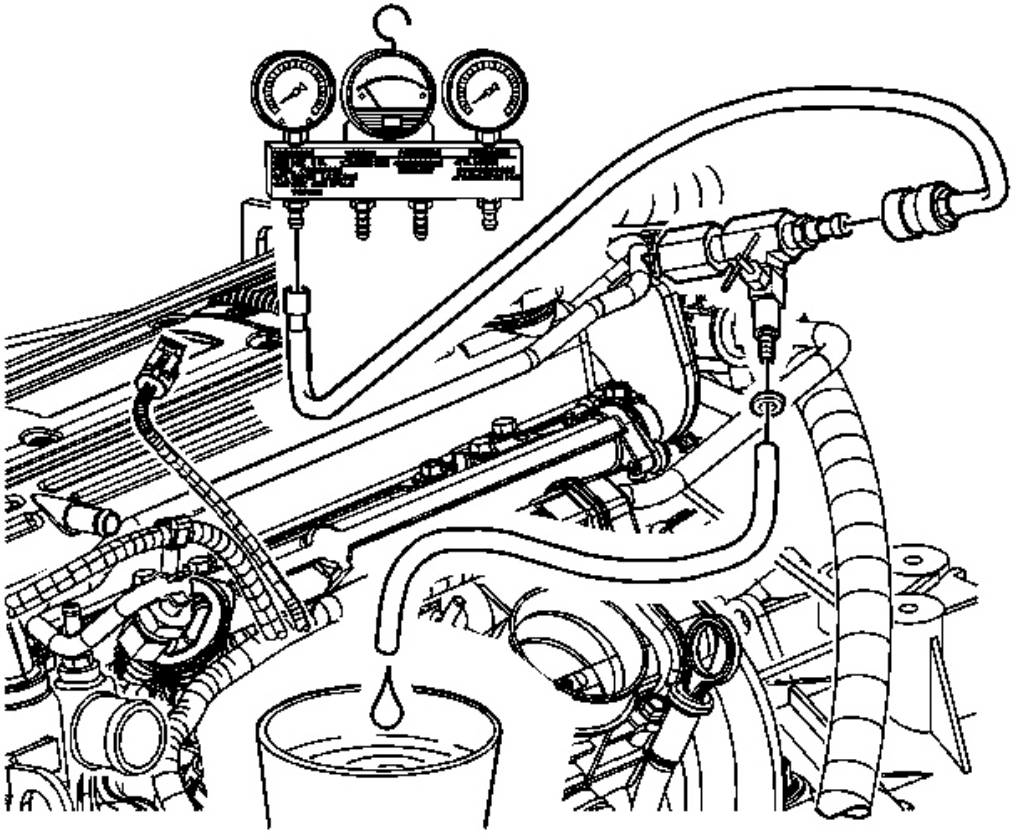


Fig. 199: Disconnecting Gage Bar Set SA9127E
Courtesy of GENERAL MOTORS CORP.

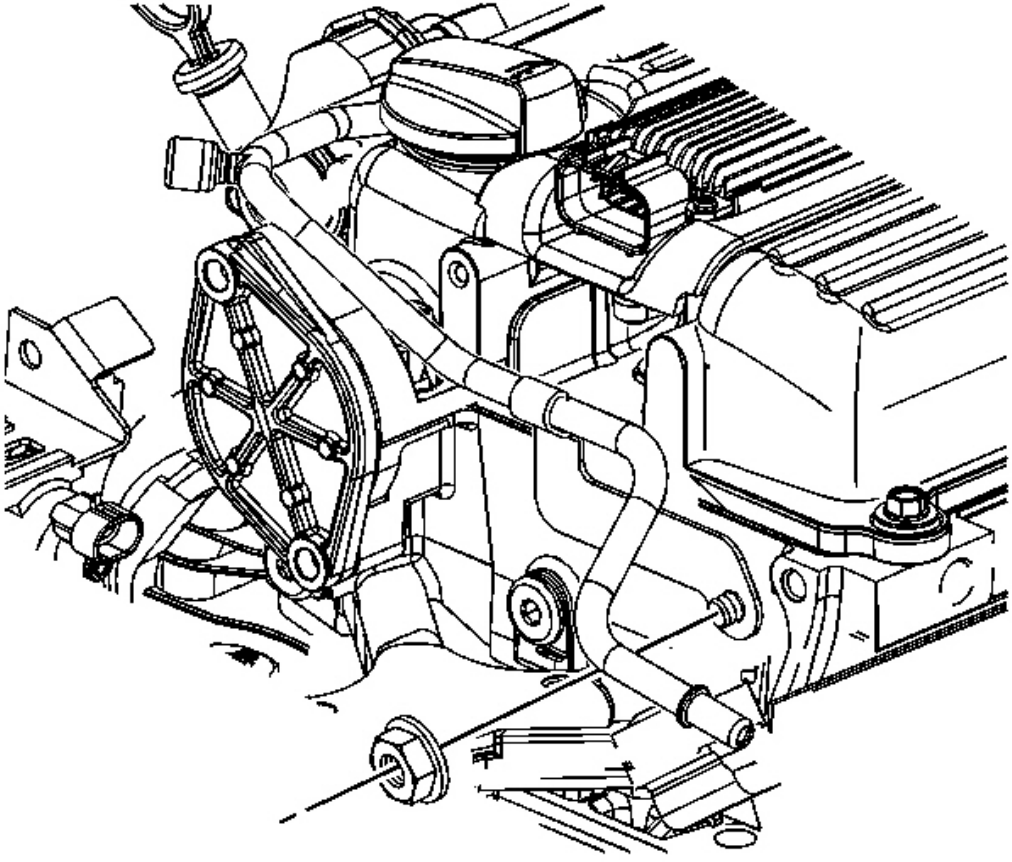


Fig. 200: Fuel Rail Bracket
Courtesy of GENERAL MOTORS CORP.

14. Disconnect the fuel rail bracket and bolt at the rear of the cam.
15. While supporting the fuel rail assembly with an open-end wrench, loosen the transfer line fitting at fuel.

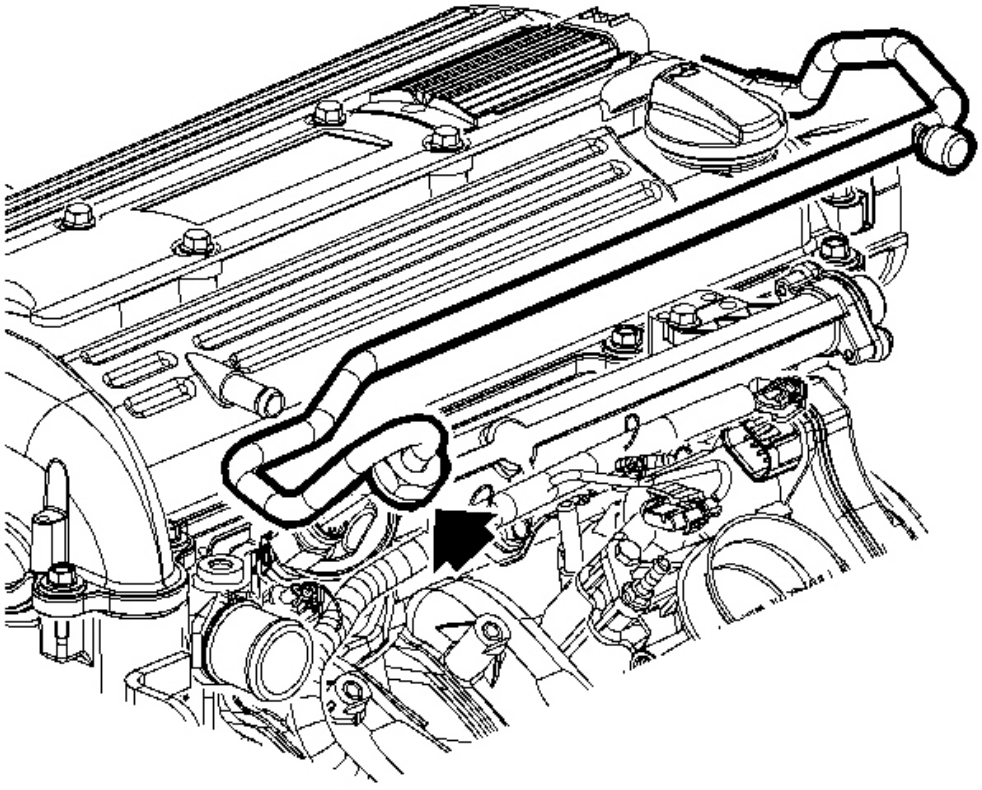


Fig. 201: Positioning Fuel Line
Courtesy of GENERAL MOTORS CORP.

16. Position the fuel line away from the cam cover assembly.

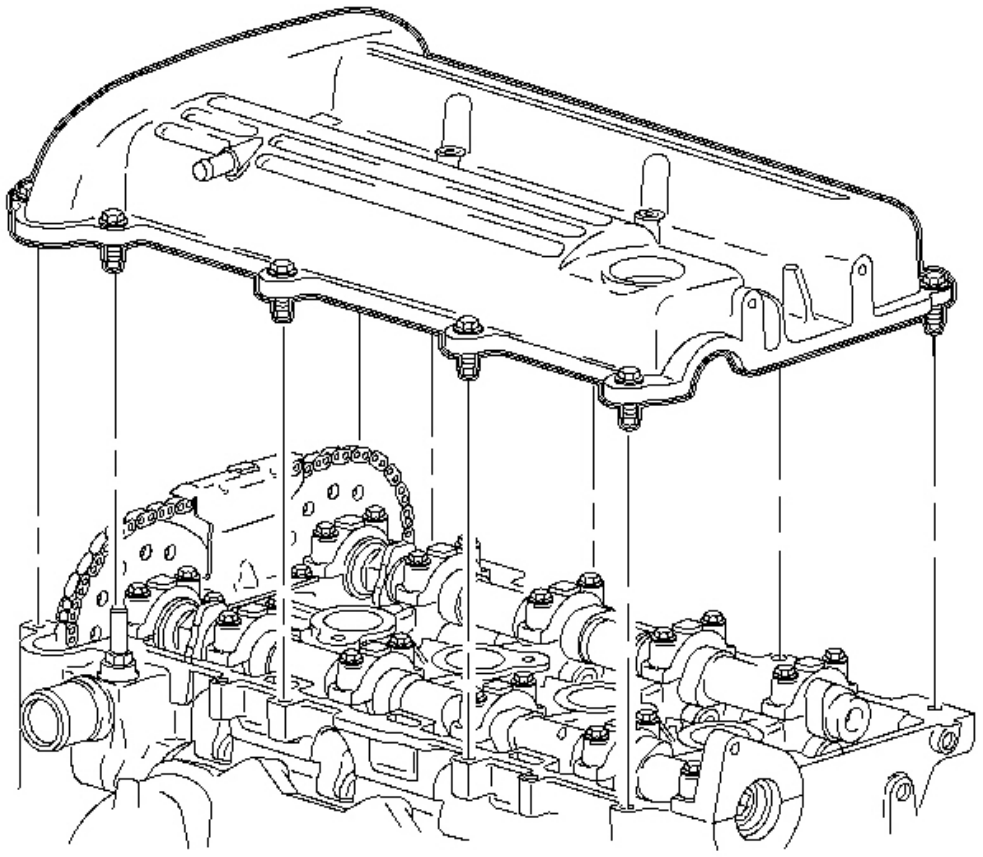


Fig. 202: Removing Cam Cover Assembly
Courtesy of GENERAL MOTORS CORP.

17. Remove then cam cover assembly bolts.
18. Remove the cam cover assembly.

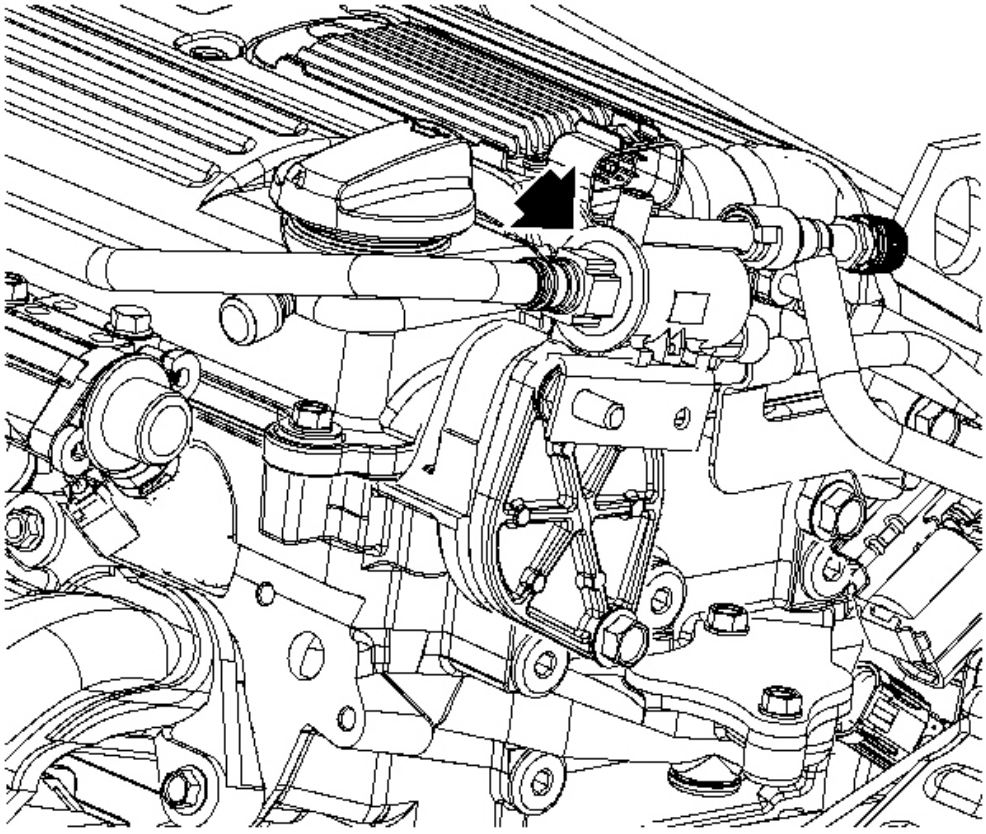


Fig. 203: Locating Purge Solenoid
Courtesy of GENERAL MOTORS CORP.

19. Remove the purge solenoid from the power steering plate.
20. Remove the power steering block off plate if the intake camshaft is being removed.

NOTE: To avoid valve piston contact, No. 1 cylinder piston must be positioned at approximately 60 degrees before-top dead center (BTDC). Pistons are properly positioned when the diamond shaped hole on the intake camshaft sprocket is located at 12 o'clock.

IMPORTANT: To rotate camshafts, use a 24 mm open end wrench on camshaft flats.

Camshafts should be rotated in a clockwise direction only, facing camshaft sprockets from passenger side of the vehicle.

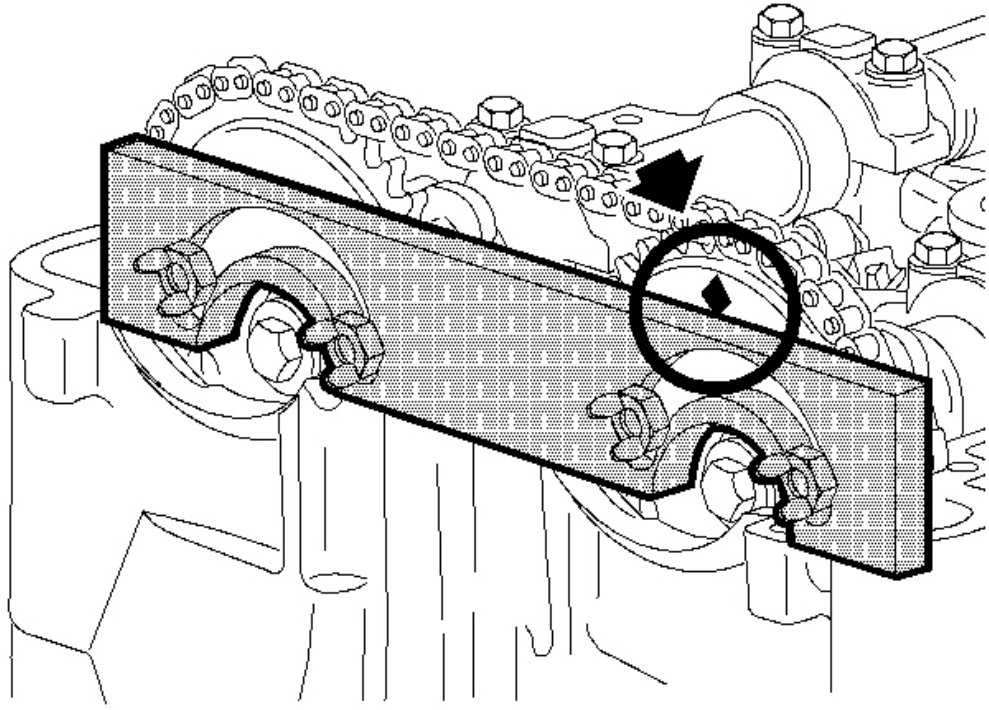


Fig. 204: Locating Diamond Shaped Hole On The Intake Camshaft Sprocket At The 12 O'clock Position
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: When removing guide bolts, do not drop the bolt down into the front cover area

21. Locate the number 1 piston to approximately 60 degrees before top dead center, diamond shaped hole on the intake camshaft sprocket at the 12 o'clock position. Remove the spark plugs. This will ease rotation

effort.

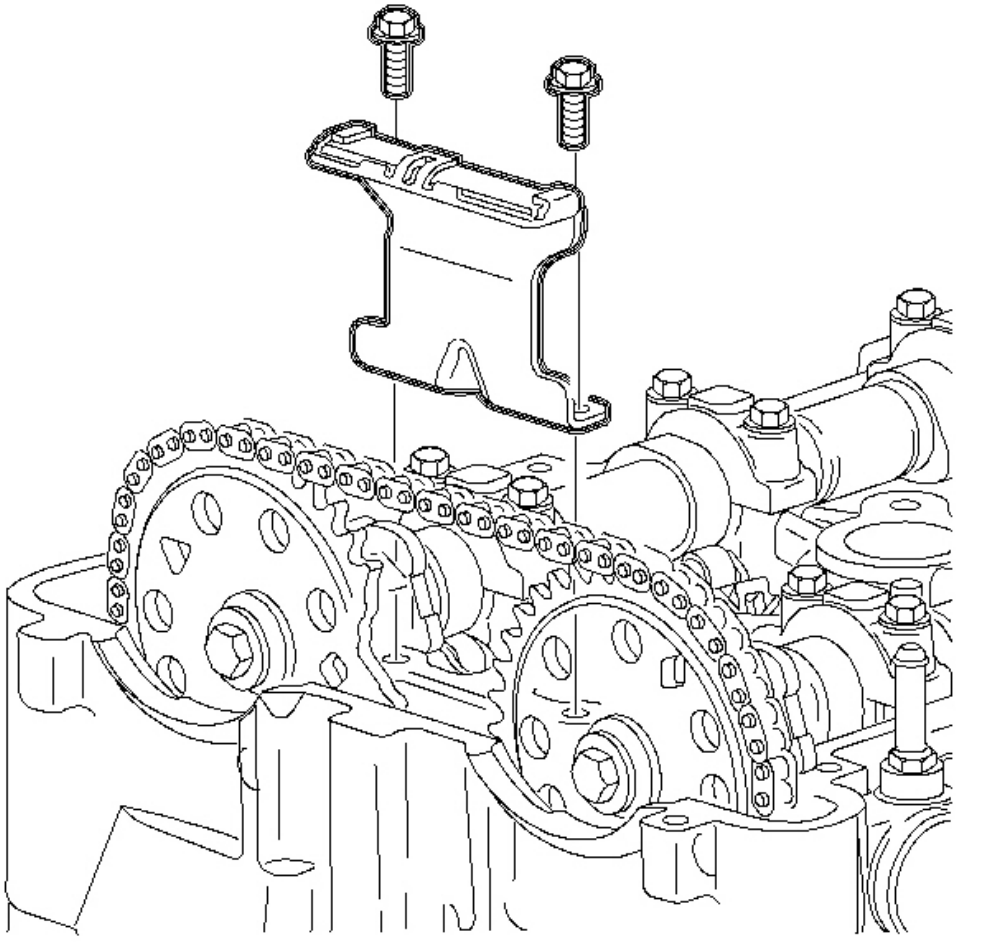


Fig. 205: Removing/Installing Upper Timing Chain Guide & Bolts
Courtesy of GENERAL MOTORS CORP.

22. Remove the upper timing chain guide.

NOTE: During camshaft removal procedure, the pistons are locked in position by the J 43655 tool. DO NOT rotate the engine crankshaft or tool damage and timing reset will be required. Camshafts an be rotated ONLY AFTER the #1 piston is at 60 degrees before top dead center (BTDC) and sprocket had been disengaged from camshaft.

23. Remove the front camshaft caps.

IMPORTANT: Lubricate the sprocket pins with clean motor oil. This will allow the sprockets to easily slide on the sprocket pins.

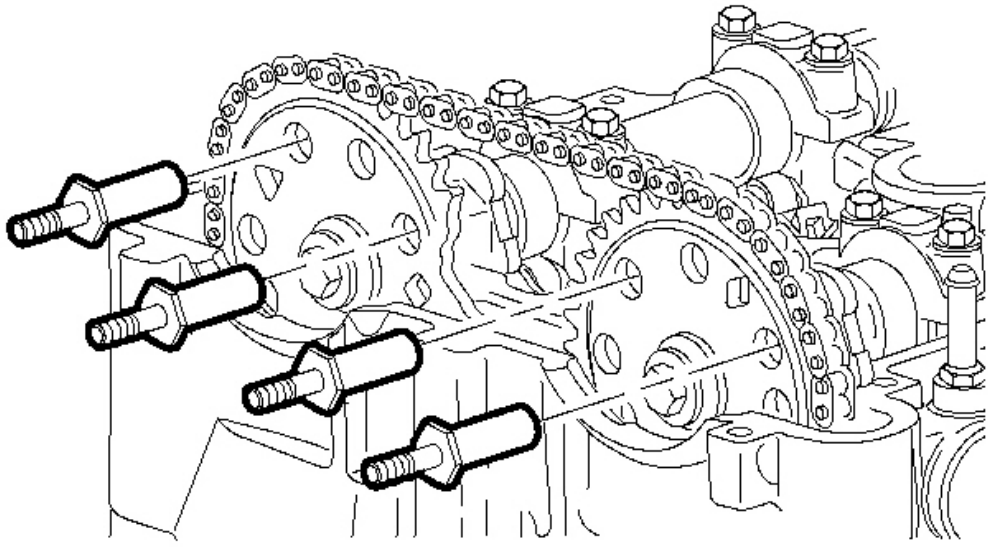


Fig. 206: Installing J43655 Through The Sprocket Holes
Courtesy of GENERAL MOTORS CORP.

24. Install the **J 43655** through the sprocket holes from the timing side of the sprocket towards the rear of the engine. See **Special Tools and Equipment** .
25. With guide pin installed in the sprocket, align the guide pins into the slots on the support plate.

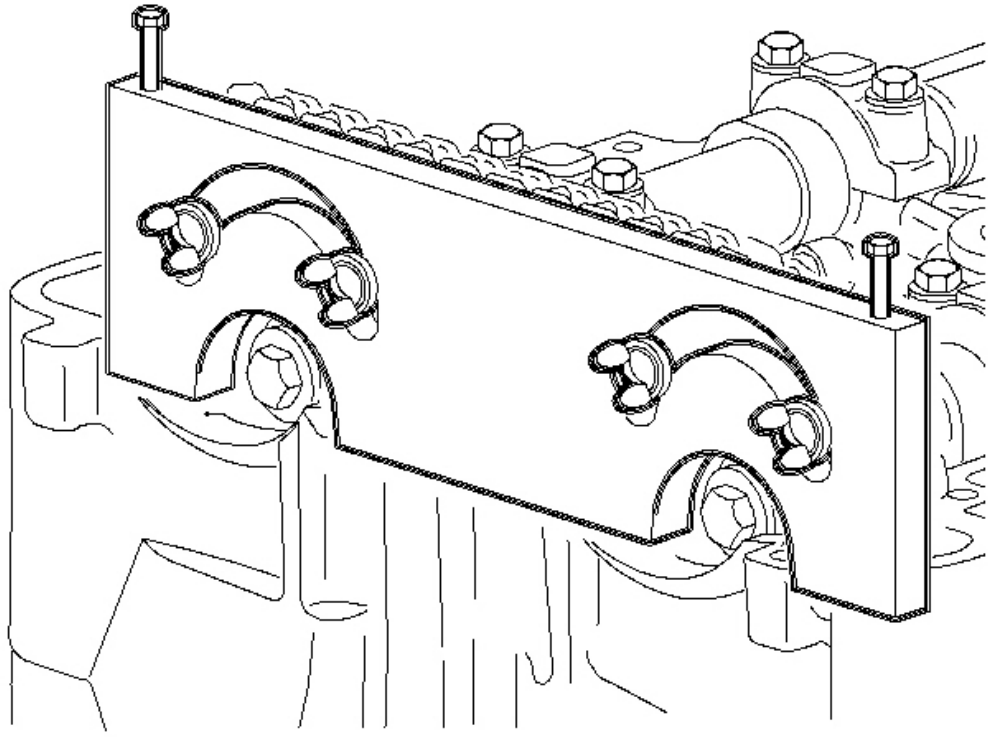


Fig. 207: Tightening Support Bracket To Cylinder Head
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

26. Tighten the support bracket to cylinder head.

    Tighten: Tighten the support plate to cylinder head to 10 N.m (89 lb in).

27. Install the wing nuts and tighten.

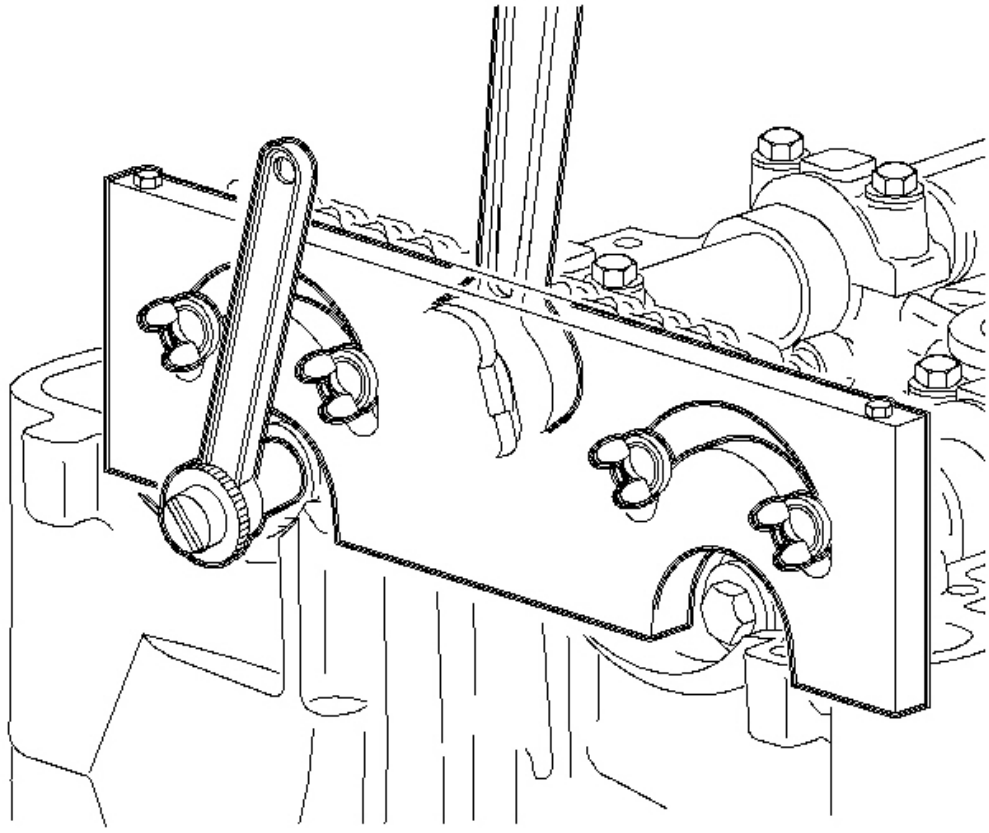


Fig. 208: Holding Camshaft In Place Using A 24 mm Open End Wrench
Courtesy of GENERAL MOTORS CORP.

28. Hold each camshaft in place using a 24 mm open end wrench and carefully remove the camshaft sprocket timing retaining bolts and washers. Discard the torque-to-yield (TTY) bolts.

IMPORTANT:

- **When sliding the timing chain and sprocket onto the guide pins, be sure the timing chain is positioned properly on the adjustable and fixed guide or guide damage will occur. Care should be taken when removing the sprockets from the camshafts.**
- **Camshafts are spring loaded and may rotate. Care should be taken until all spring tension is removed from the camshaft.**

29. Slide the camshaft sprockets away from the camshafts.
30. To release the spring tension on the camshaft, after the camshaft is disengaged from the sprocket, rotate the camshaft using a 24 mm wrench to a neutral position.

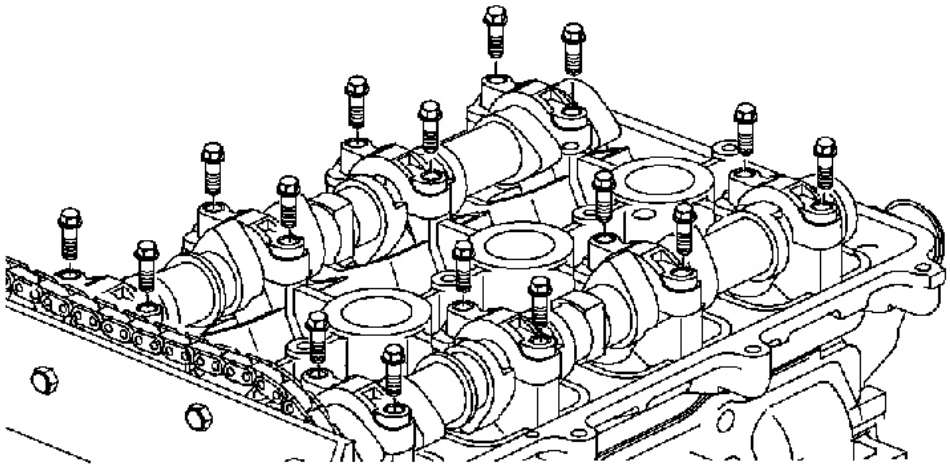


Fig. 209: Removing/Installing Camshaft Bearing Cap Bolts
Courtesy of GENERAL MOTORS CORP.

31. Uniformly loosen and remove the remaining camshaft bearing cap bolts.

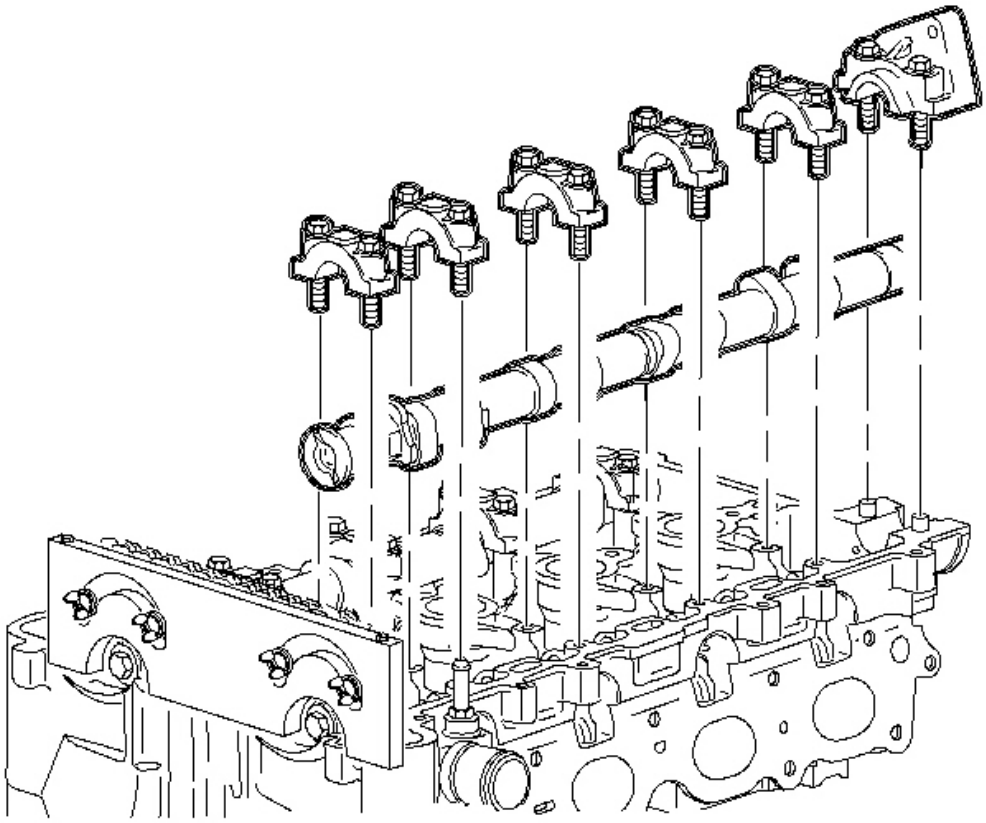


Fig. 210: Pulling Camshafts Straight Up To Avoid Damaging The Cylinder Head Thrust Surfaces
Courtesy of GENERAL MOTORS CORP.

32. Carefully pull the camshafts straight up to avoid damaging the cylinder head thrust surfaces.

Installation Procedure

NOTE: After cylinder block, head, or lifter replacement, it will be necessary to allow the engine to idle for 3-5 minutes. If the lifters are noisy, warm the engine up at less than 200 RPM. After the coolant temperature has reached approximately 85°C (185°F), cycle the engine RPM from idle to 300 RPM for approximately 10 minutes or drive the vehicle 8 kilometers (5 miles) to purge the air. If the air cannot be purged, the faulty lifters will

have to be replaced.

NOTE: Lifters that are pumped up may cause PCM misfire codes to set. Continue to operate the engine until the lifters bleed down. Using the scan tool, clear the codes and malfunction history.

NOTE: If a valve seal is removed after it has been installed, it must be discarded. The valve stem lock groove will cut the seal's lip during removal. Use extreme care when installing valve retainers and do not damage the valve stems.

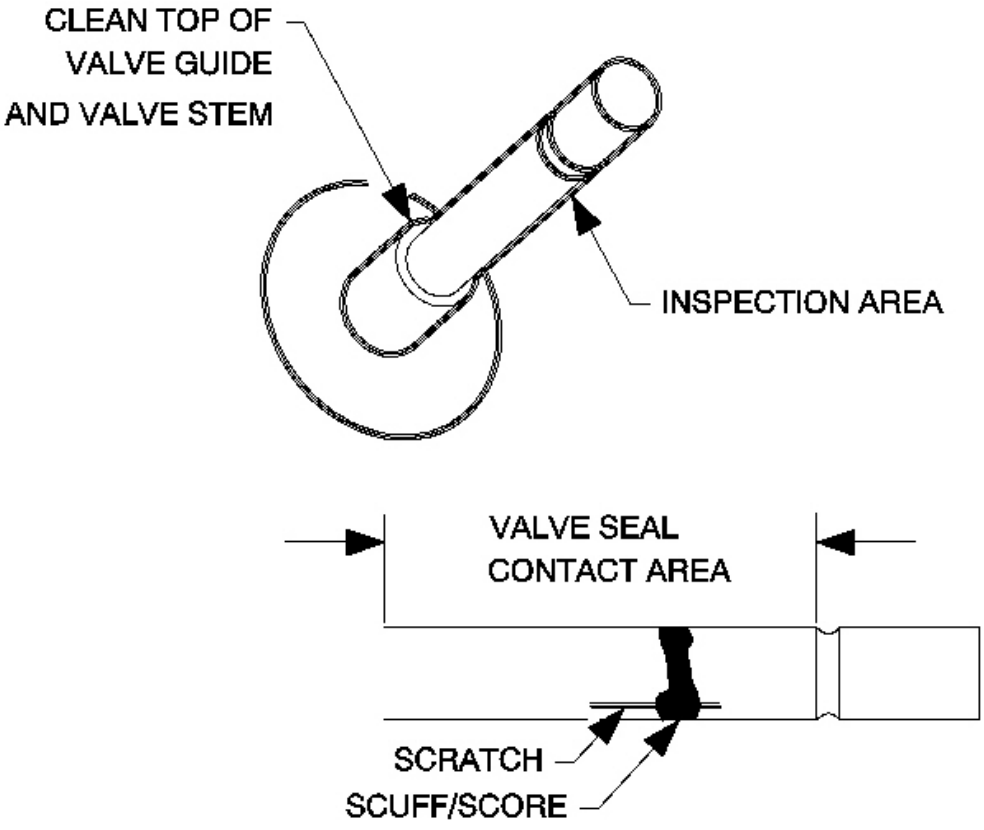


Fig. 211: Inspecting Valve Seal Contact Area

Courtesy of GENERAL MOTORS CORP.

1. Allow the engine to idle.

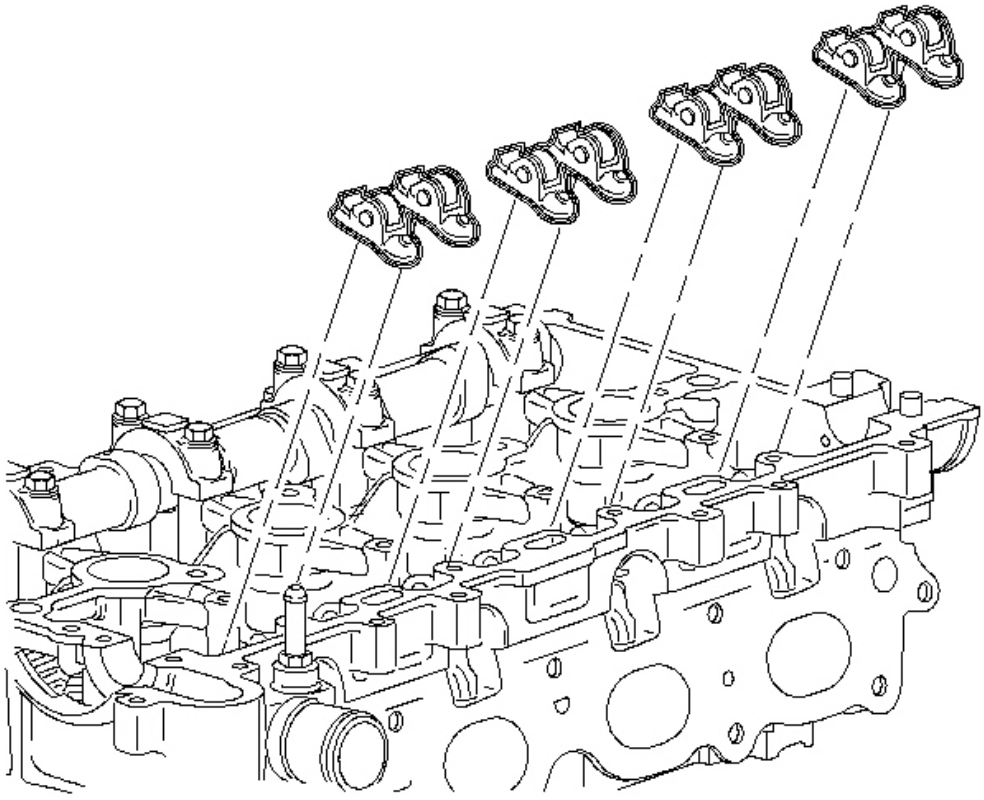


Fig. 212: Installing Rocker Arms
Courtesy of GENERAL MOTORS CORP.

2. Ensure install rocker arms are in their proper location, followers.

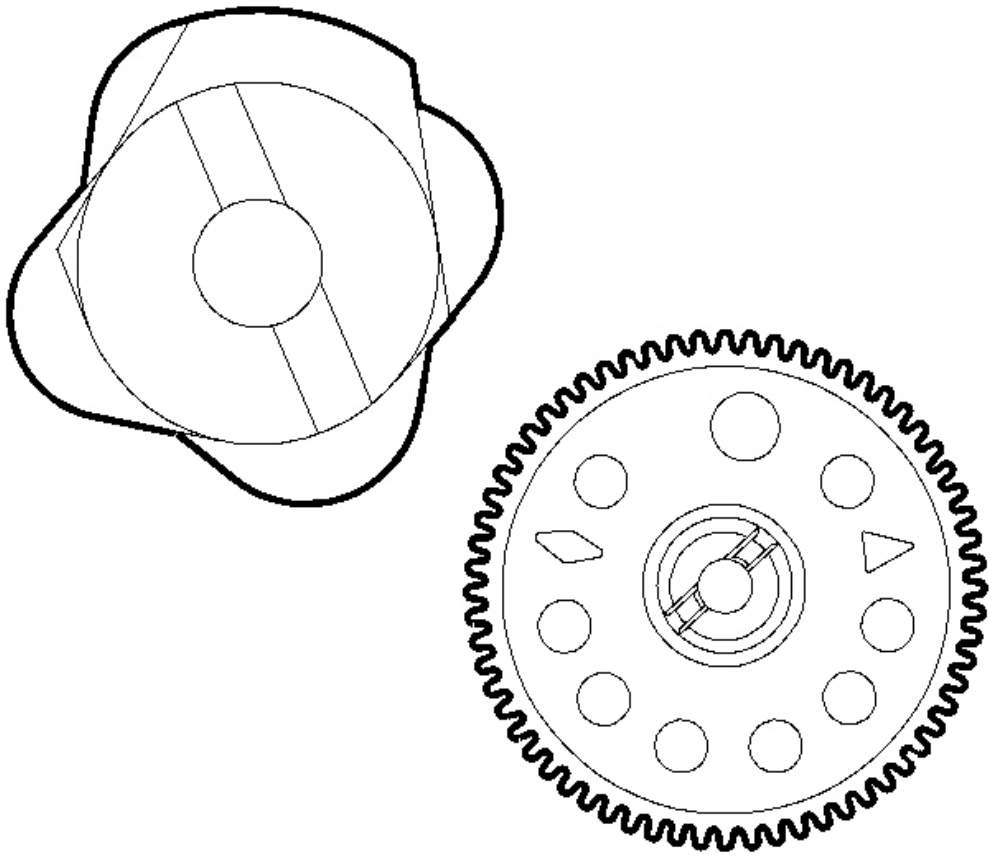


Fig. 213: Aligning Camshaft Slot In Line With The Notch On The Sprockets
Courtesy of GENERAL MOTORS CORP.

3. Lubricate the camshaft bearing journals with clean engine oil and install both camshafts.
4. When installing the camshafts, align to position camshaft slot in line with the notch on the sprockets.

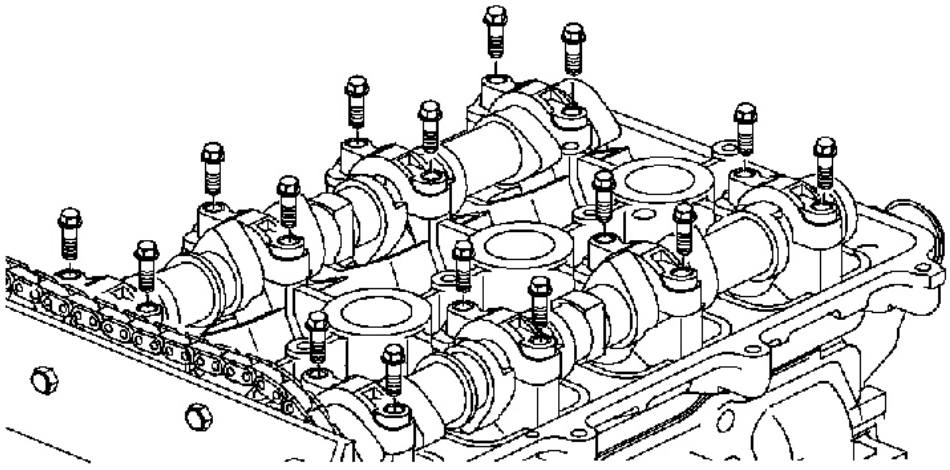


Fig. 214: Removing/Installing Camshaft Bearing Cap Bolts
Courtesy of GENERAL MOTORS CORP.

5. Install all bearing caps except the front caps and rear intake camshaft cap, if serviced. Tighten down the bearing caps uniformly.

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

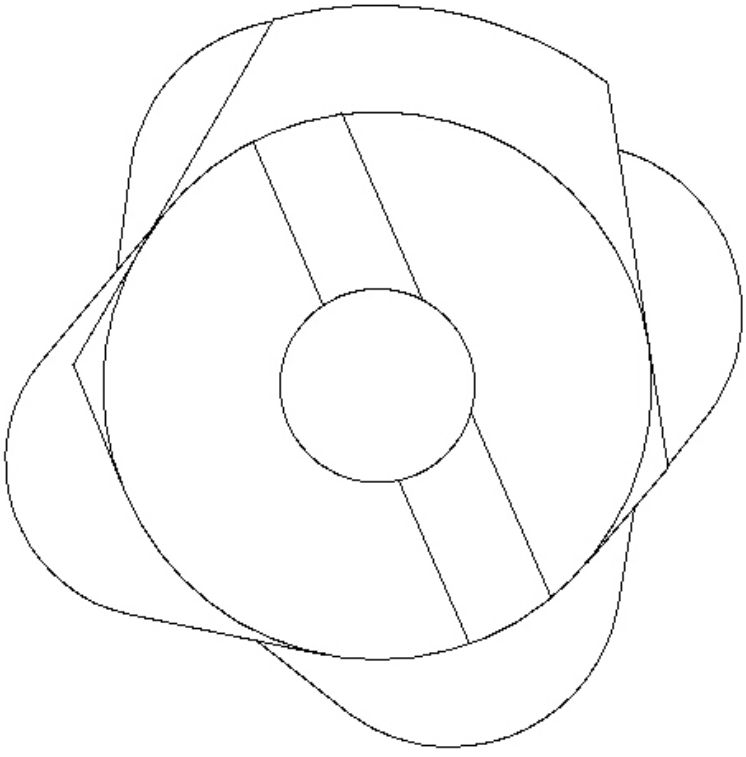


Fig. 215: Camshaft Alignment Slots
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Ensure that the alignment slots are correctly aligned with the notches in the camshaft sprockets before final tightening is applied.**
- **Verify the timing chain is properly positioned on the fixed guide or guide damage will occur.**
- **Verify the camshafts are properly timed as outlined in this section prior to starting the engine.**

6. Verify camshaft timing.

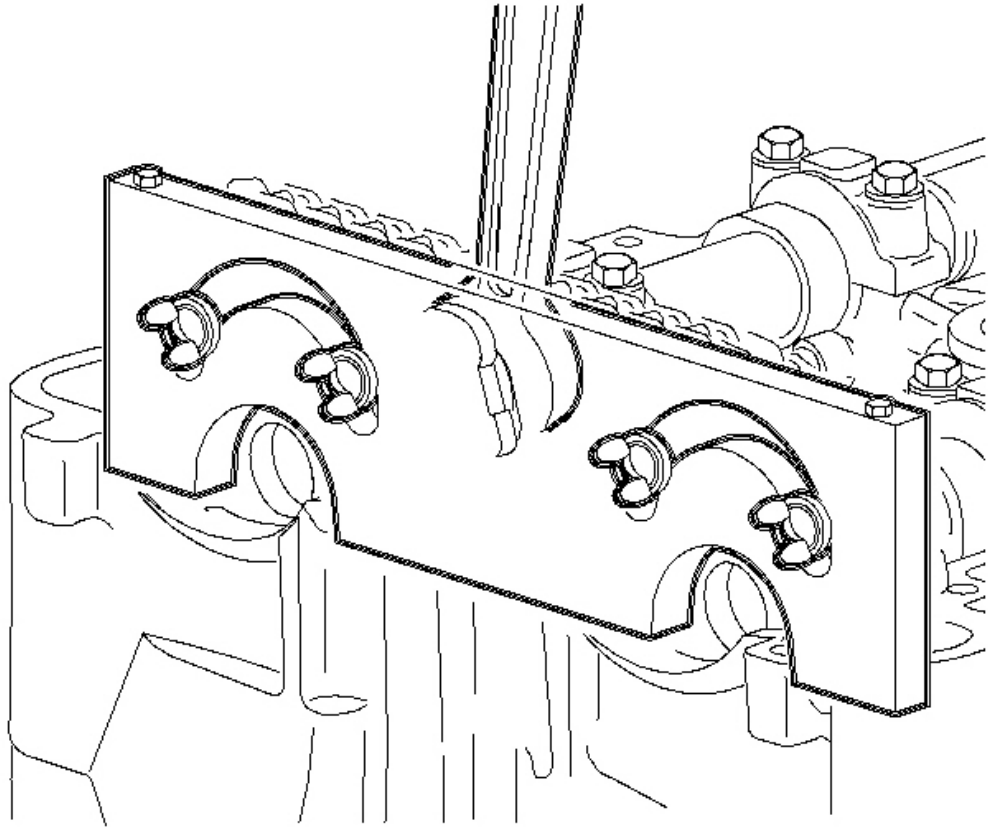


Fig. 216: Rotating Camshafts With 24 mm Open End Wrench To Align The Camshaft & Sprockets
Courtesy of GENERAL MOTORS CORP.

7. Slide the camshaft sprockets and timing chain on the guide pins toward the camshafts. Rotate the camshafts with a 24 mm open end wrench to properly align the camshaft and sprockets.
8. Install new camshaft sprocket bolt and tighten. This will pull the camshaft sprockets into the cams. Hold the camshaft with the 24 mm open end wrench during tightening.

   Tighten: Tighten the camshaft sprocket bolts to 85 N.m (63 lb ft) +30 degrees.

9. Remove the **J 43655** . See **Special Tools and Equipment** .
10. Install the front camshaft caps.

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

IMPORTANT: Apply Permatex(R) Threadlocker Blue P/N 21485277 to the upper timing chain guide bolts.

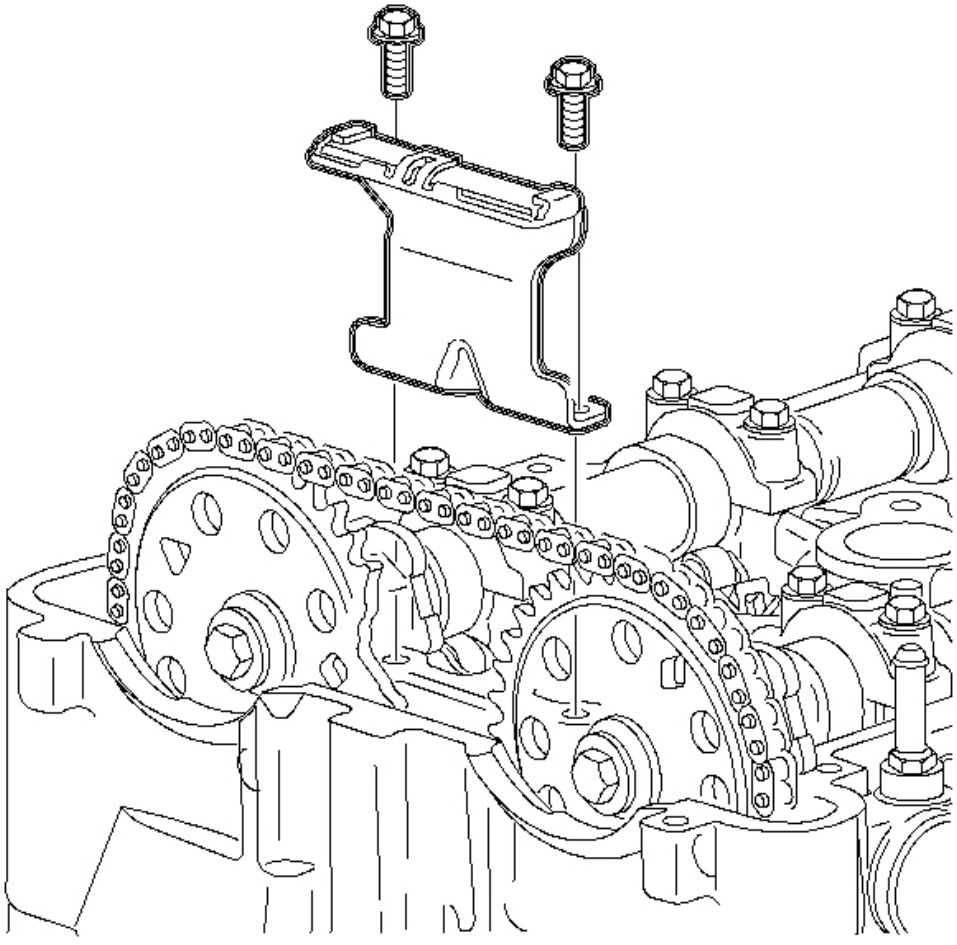


Fig. 217: Removing/Installing Upper Timing Chain Guide & Bolts
Courtesy of GENERAL MOTORS CORP.

11. Install the upper timing chain guide and bolts.

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

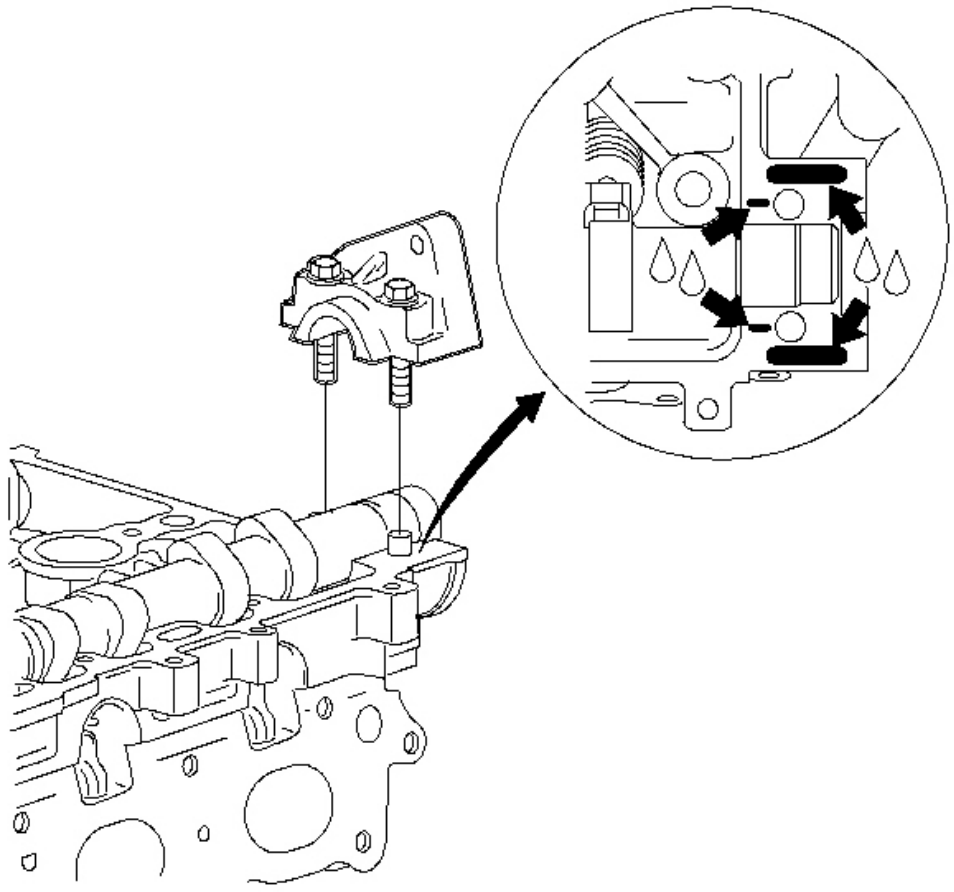


Fig. 218: Installing Rear Intake Camshaft Bearing Cap
Courtesy of GENERAL MOTORS CORP.

12. Install the rear intake camshaft bearing cap.

IMPORTANT: Apply Permatex(R) Anerobic Flange sealant to the cylinder head near the rear intake cap as shown.

13. Install the rear intake camshaft bearing cap.

Tighten: Tighten the intake camshaft rear cap to 25 N.m (18 lb ft).

14. Install the power steering block-off plate.

Tighten: Tighten the power steering block-off plate to 25 N.m (18 lb ft).

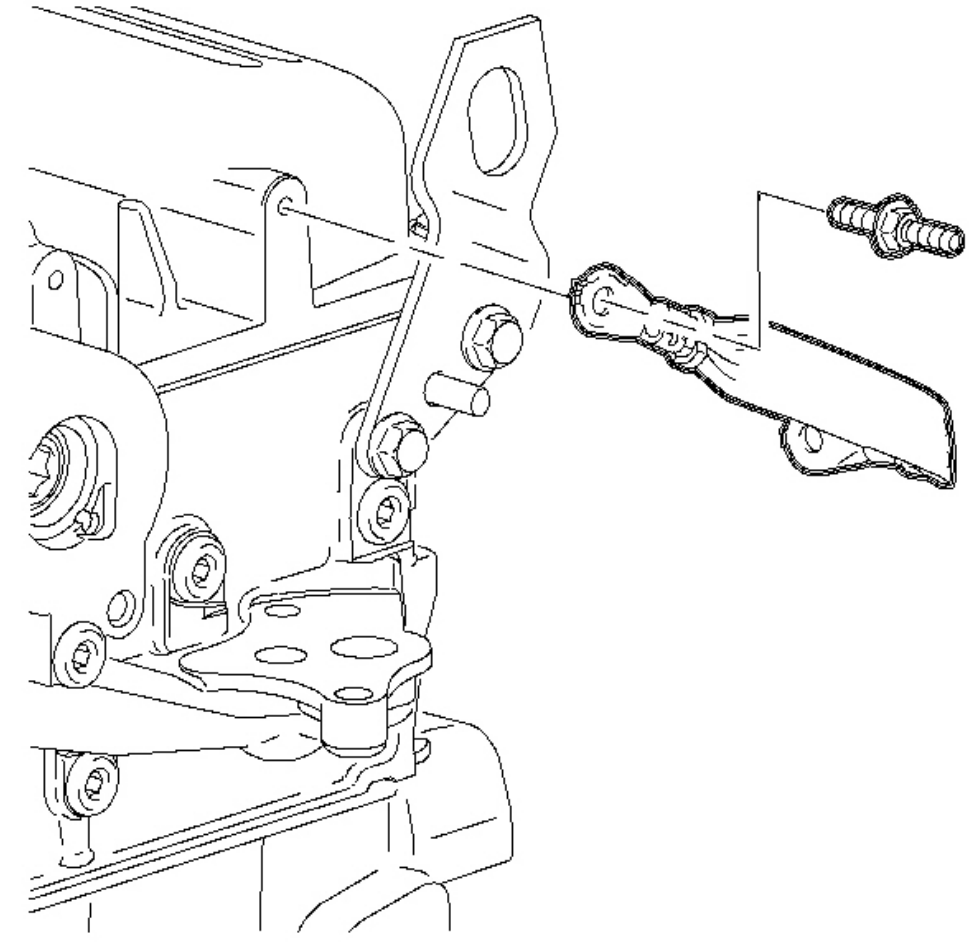


Fig. 219: Disconnecting/Connecting Ground Strap On The Camshaft Cover Assembly
Courtesy of GENERAL MOTORS CORP.

15. Visually inspect the camshaft cover gasket for signs of leakage. The camshaft cover gasket is reusable if not damaged.
16. Assemble the camshaft cover and gasket. Use care to make sure the gasket is located in the retaining groove on the camshaft cover.
17. Install the cover on the cylinder head and hand-tighten the bolts.

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

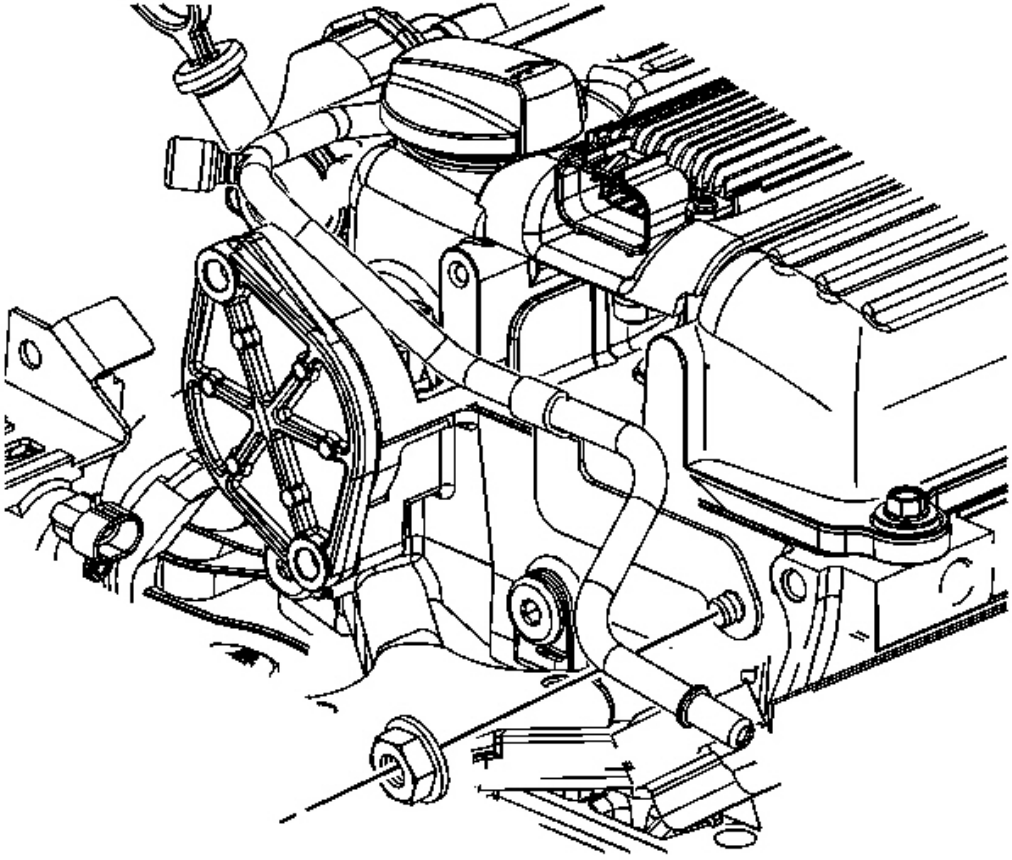


Fig. 220: Fuel Rail Bracket
Courtesy of GENERAL MOTORS CORP.

18. Re-position the fuel line assembly.

NOTE: An open-end wrench must be used to support the fuel line to rail connection during loosening/tightening to avoid damaging the fuel rail assembly.

19. Install the transfer line fitting at the fuel-to-fuel rail.

Tighten: Tighten the transfer line fitting-to-fuel rail to 10 N.m (89 lb in).

20. Connect the fuel rail bracket and bolt to the cylinder head.

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

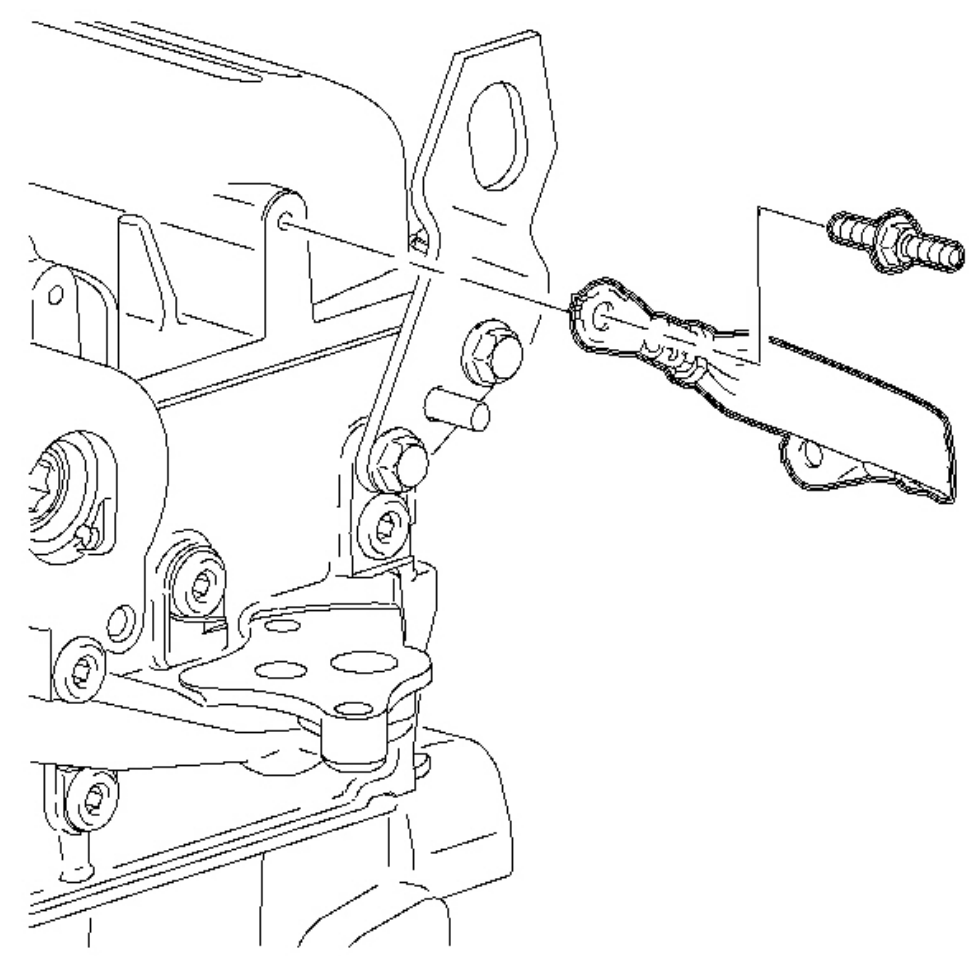


Fig. 221: Disconnecting/Connecting Ground Strap On The Camshaft Cover Assembly
Courtesy of GENERAL MOTORS CORP.

21. connect the ground strap to the camshaft cover assembly.

    Tighten: Tighten the camshaft cover ground strap bolts to 10 N.m (89 lb in).

22. Connect the degas hose and clamp to the cylinder head.
23. Connect the degas hose bracket and bolt to the cylinder head.

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

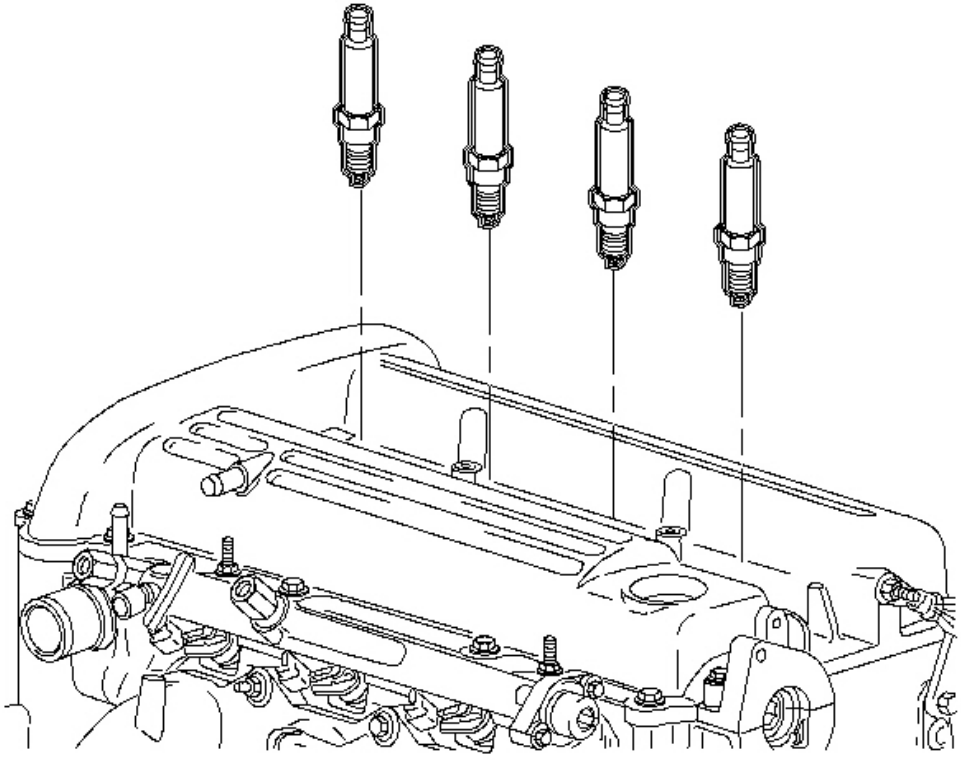


Fig. 222: Installing Spark Plugs
Courtesy of GENERAL MOTORS CORP.

24. Install the spark plugs.

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

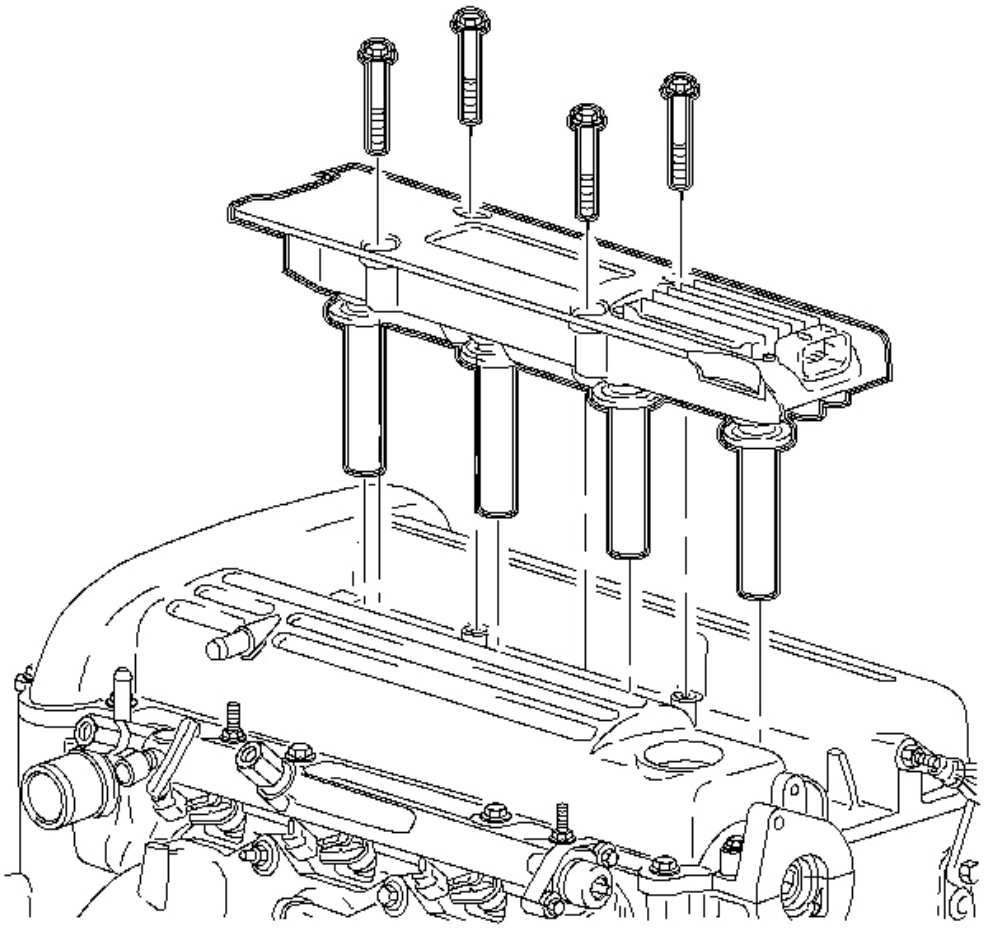


Fig. 223: Installing Ignition Module Assembly
Courtesy of GENERAL MOTORS CORP.

25. Install the ignition module assembly to cam cover and hand tighten the retaining bolts.

    Tighten: Tighten the ignition module-to-camshaft cover bolts to 8 N.m (71 lb in).

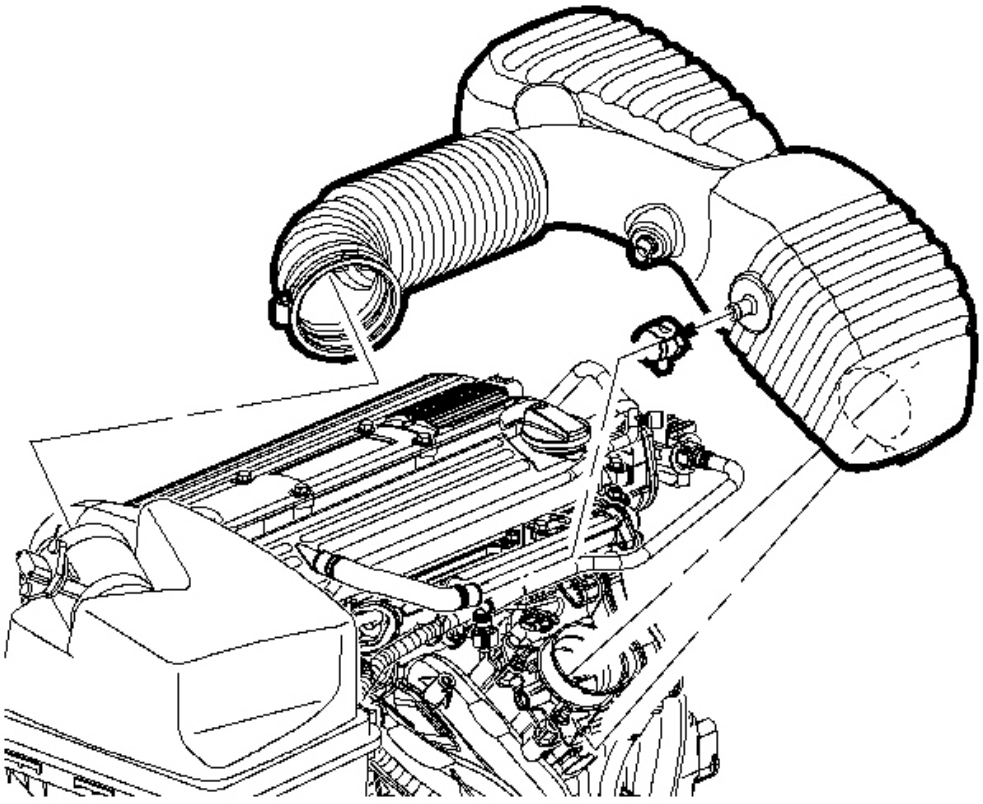


Fig. 224: Positioning Outlet Resonator/Duct Assembly
Courtesy of GENERAL MOTORS CORP.

26. Position the outlet resonator/duct assembly into position.
27. Connect the PVC fresh air vent hose assembly.
28. Tighten the clamp at the throttle body assembly.
29. Position the outlet resonator/duct assembly up with the support bracket and install the push-pin.
30. Tighten the clamp at the air cleaner assembly.
31. Connect the intake air temperature (IAT) sensor connector.
32. Connect the negative battery cable.

Tighten: Tighten the battery terminal bolt to 17 N.m (13 lb ft).

CYLINDER HEAD REPLACEMENT

Tools Required

- **J 38122-A** Crankshaft Pulley Holder. See **Special Tools and Equipment** .
- **J 43405** Engine Support Fixture Adapter. See **Special Tools and Equipment** .
- **J 44811** Accessory Belt Tensioner Unloader. See **Special Tools and Equipment** .
- J 45122 Engine Support Adapter
- **SA9105E** Engine Three Bar Fixture. See **Special Tools and Equipment** .
- **SA9127E** Gage Bar Set. See **Special Tools and Equipment** .
- **J 45027** Tensioner Tool. See **Special Tools and Equipment** .

Removal Procedure

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
2. Disconnect the intake air temperature (IAT) sensor connector.
3. Loosen the clamp at the air cleaner assembly.
4. Remove push pin attachment from outlet resonator/duct assembly to support bracket.

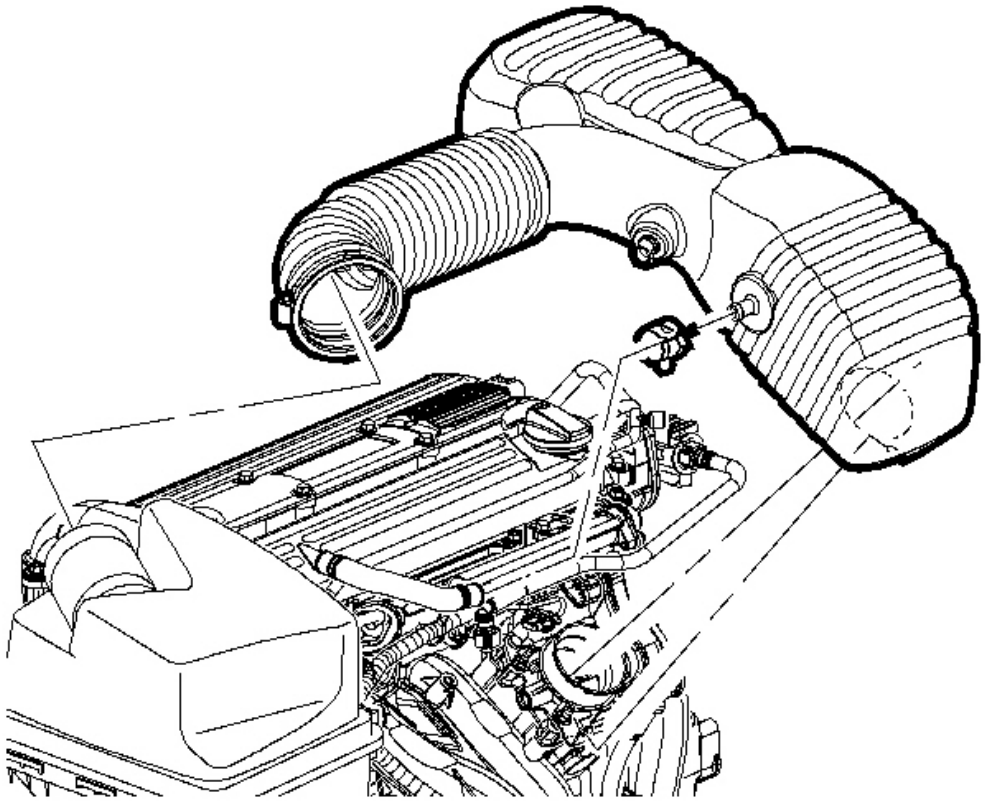


Fig. 225: Locating Air Intake Assembly
Courtesy of GENERAL MOTORS CORP.

5. Loosen the clamp at the throttle body assembly.
6. Disconnect the PCV fresh air vent hose at the cam cover.
7. Remove outlet resonator/duct assembly.
8. Remove the air cleaner assembly hold-down bolt.
9. Remove the air cleaner assembly.

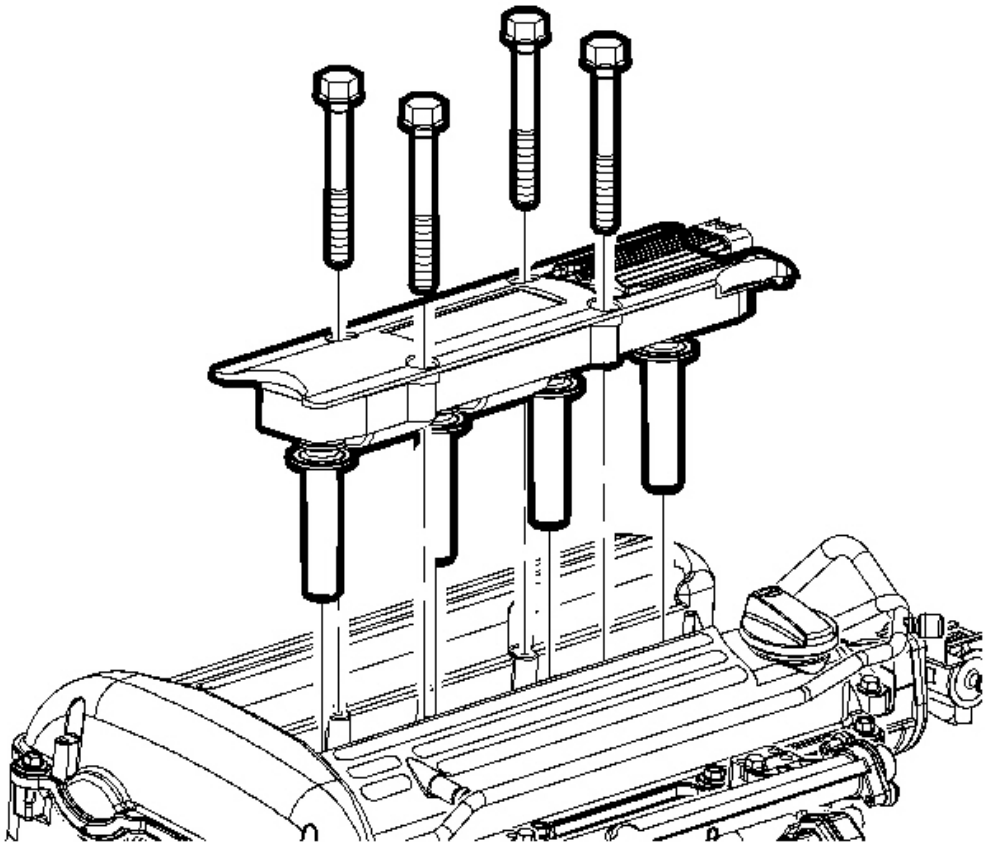


Fig. 226: Removing/Installing Ignition Module Assembly
Courtesy of GENERAL MOTORS CORP.

10. Remove the ignition module bolts.
11. Remove the ignition module assembly.

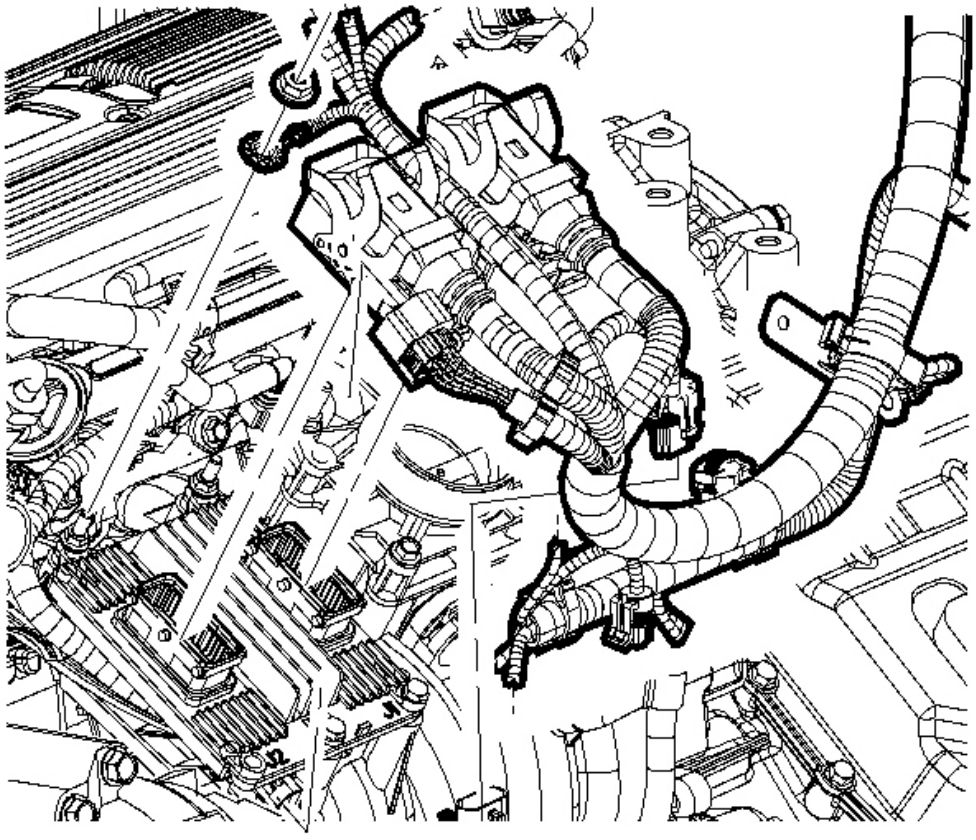


Fig. 227: Removing/Installing ECM Assembly & Bolts
Courtesy of GENERAL MOTORS CORP.

12. Disconnect ECM electrical connector and ground at ECM.
13. Remove oil level indicator bolt to manifold.
14. Disconnect the electrical connector at the throttle body.
15. Disconnect the electrical connector at the fuel injector harness and the attachment at bottom of the intake manifold.
16. Disconnect the electrical connector at purge solenoid and MAP sensor.
17. Disconnect the vacuum hose at the brake booster.

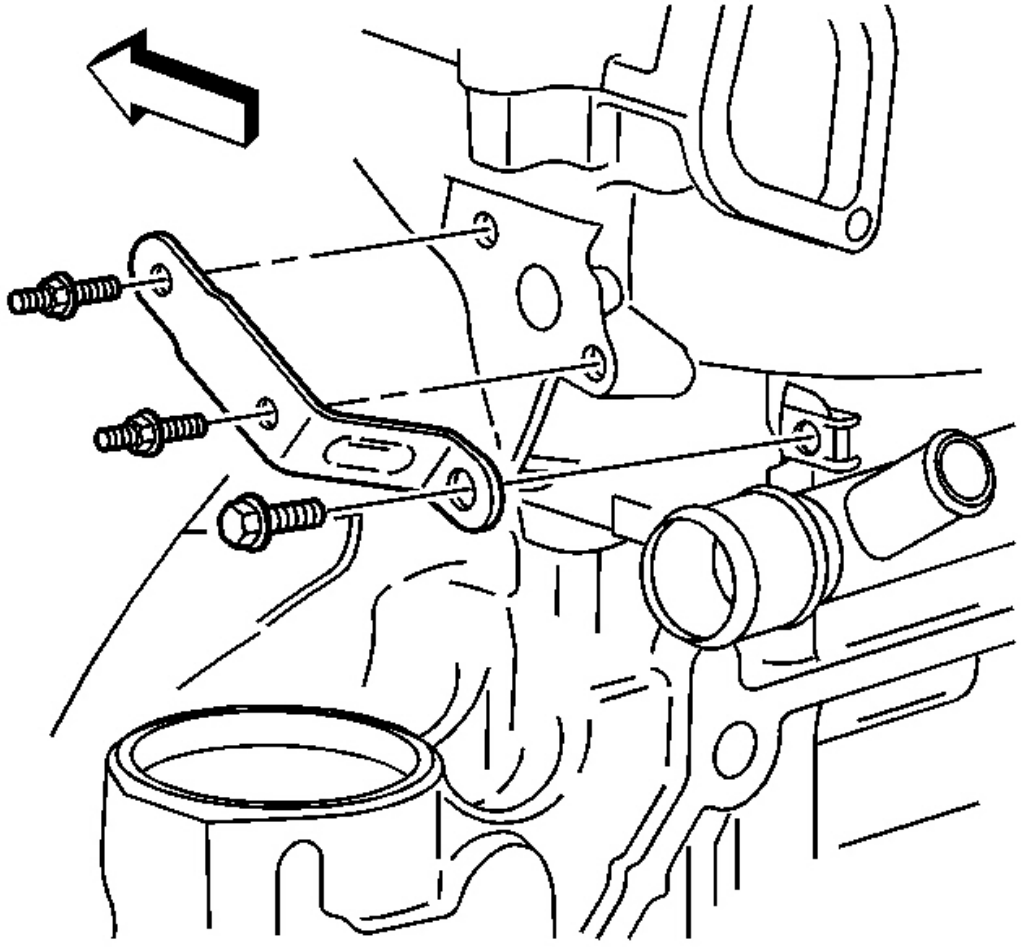


Fig. 228: View Of Water Pipe Support Bracket
Courtesy of GENERAL MOTORS CORP.

18. Disconnect the coolant pipe bracket bolts to front of cylinder head.

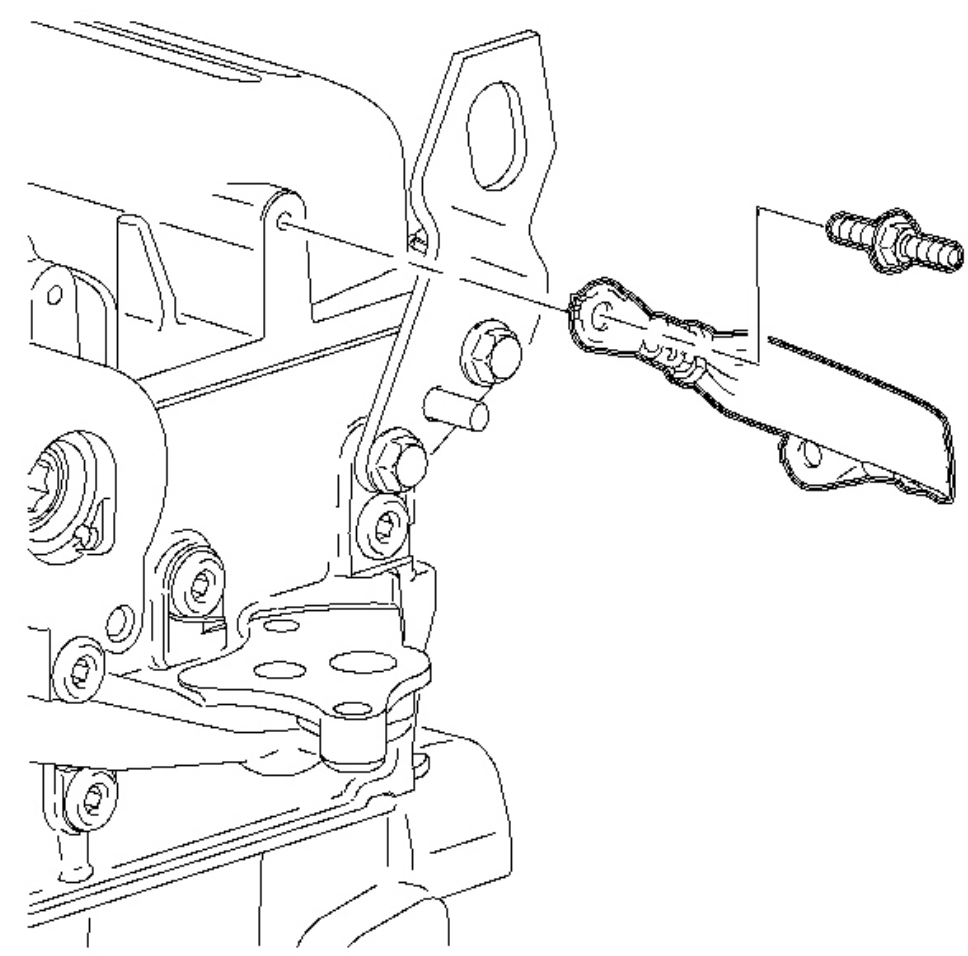


Fig. 229: Disconnecting/Connecting Ground Strap On The Camshaft Cover Assembly
Courtesy of GENERAL MOTORS CORP.

19. Disconnect the degas hose at clamp at the cylinder head and unclip from the fuel rail. Position away from the cam cover assembly.
20. Disconnect ground strap at rear of the cam cover assembly.

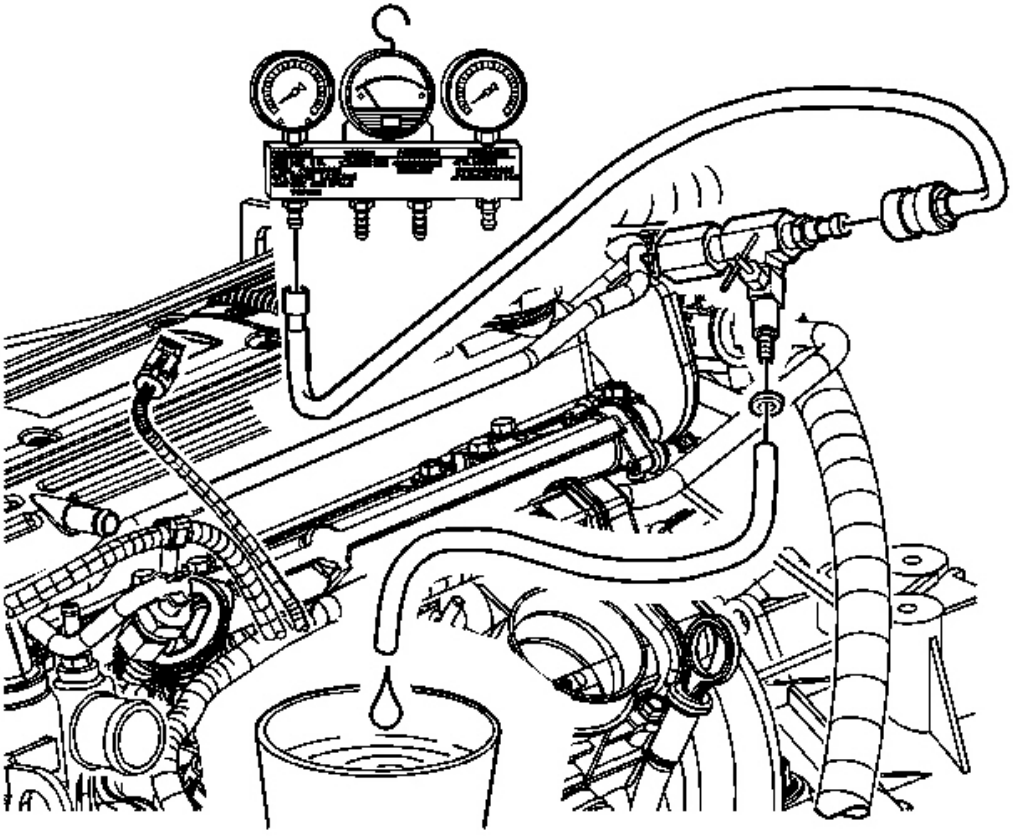


Fig. 230: Disconnecting Gage Bar Set SA9127E
Courtesy of GENERAL MOTORS CORP.

21. Relieve fuel system pressure. Refer to **Fuel Pressure Relief Procedure** in Engine Controls - 2.2L (L61).
22. Disconnect the **SA9127E** after pressure has been relieved. See **Special Tools and Equipment** .

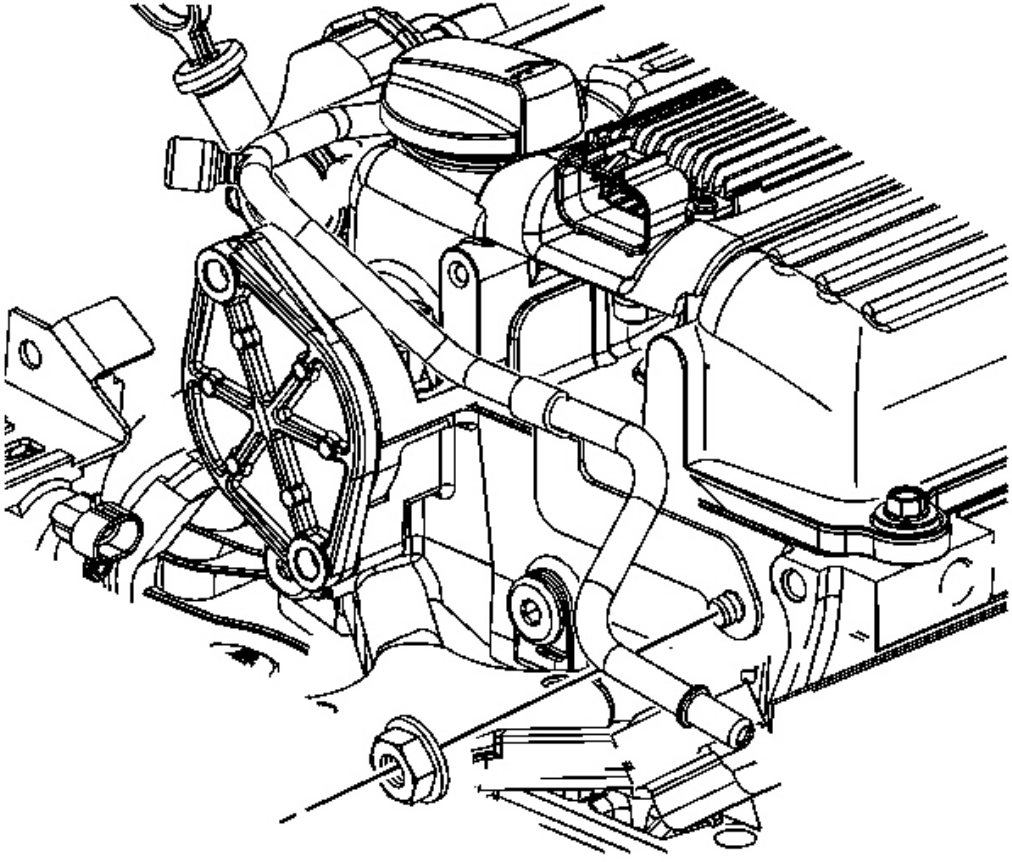


Fig. 231: Fuel Rail Bracket
Courtesy of GENERAL MOTORS CORP.

23. Disconnect the fuel rail bracket and bolt at the rear cam cover.

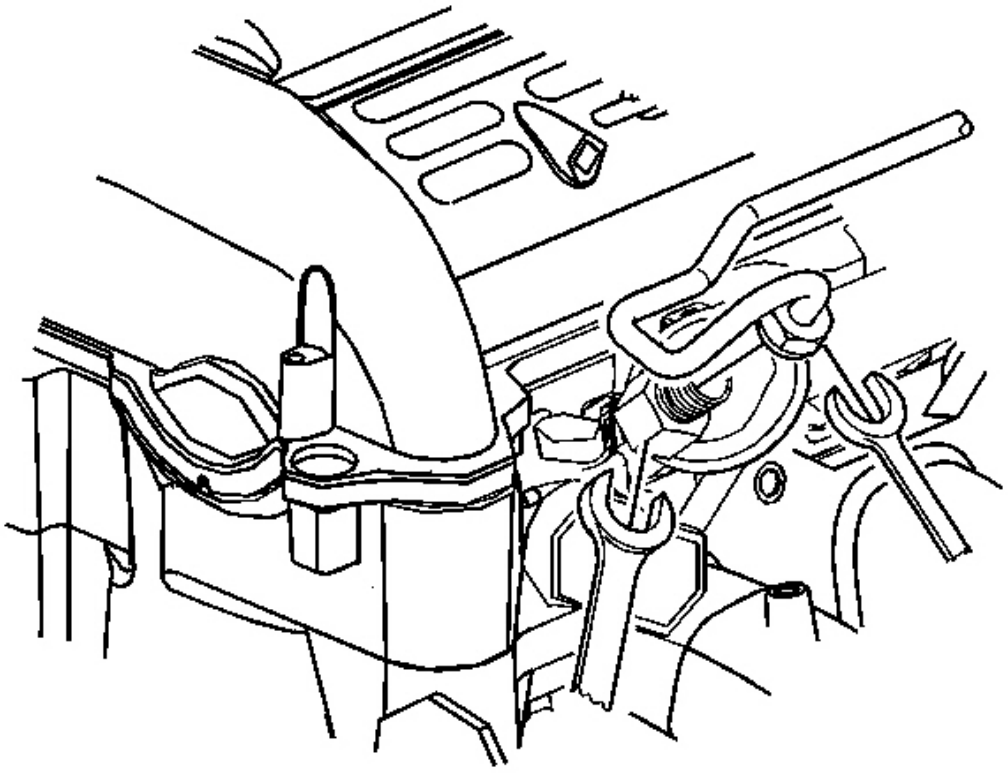


Fig. 232: Repositioning Fuel Line Assembly
Courtesy of GENERAL MOTORS CORP.

CAUTION: Whenever fuel line fittings are loosened or disconnected, wrap a shop cloth around the fitting to collect fuel. Place the cloth in an approved container.

NOTE: An open-end wrench must be used to support the fuel line to rail connection during loosening/tightening to avoid damaging the fuel rail assembly.

24. While supporting the fuel rail assembly with an open-end wrench, loosen the transfer line fitting at the fuel rail.

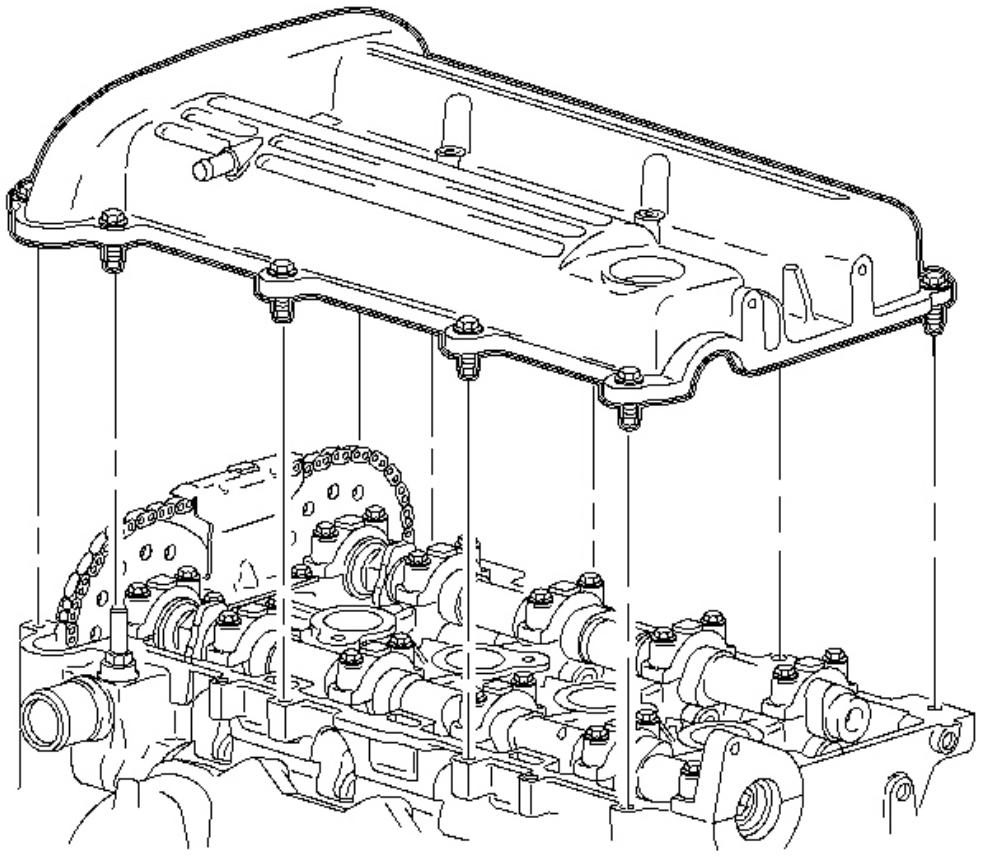


Fig. 233: Removing Cam Cover Assembly
Courtesy of GENERAL MOTORS CORP.

25. Position the fuel line away from the cam cover assembly.
26. Remove the cam cover assembly bolts.
27. Remove the cam cover assembly.

NOTE: To avoid valve piston contact, No. 1 cylinder piston must be positioned at approximately 60 degrees before-top dead center (BTDC). Pistons are properly positioned when the diamond shaped hole on the intake camshaft sprocket is located at 12 o'clock.

IMPORTANT: To rotate camshafts, use a 24 mm open-end wrench on camshaft flats. Camshafts should be rotated in a clockwise direction only, facing camshaft sprockets from passenger side of vehicle.

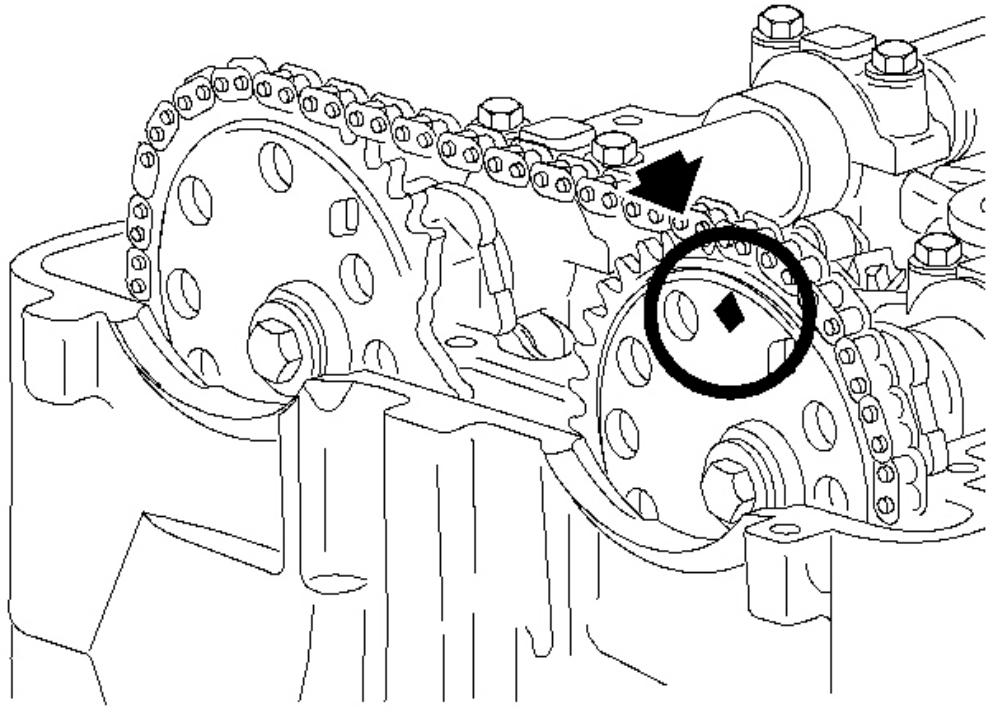


Fig. 234: Rotating Camshaft Using 24 mm Open-End Wrench
Courtesy of GENERAL MOTORS CORP.

28. Locate the No.1 piston to approximately 60 degrees before top dead center (diamond shaped hole on intake camshaft sprocket at 12 o'clock position). Remove spark plugs. This will ease rotation effort.

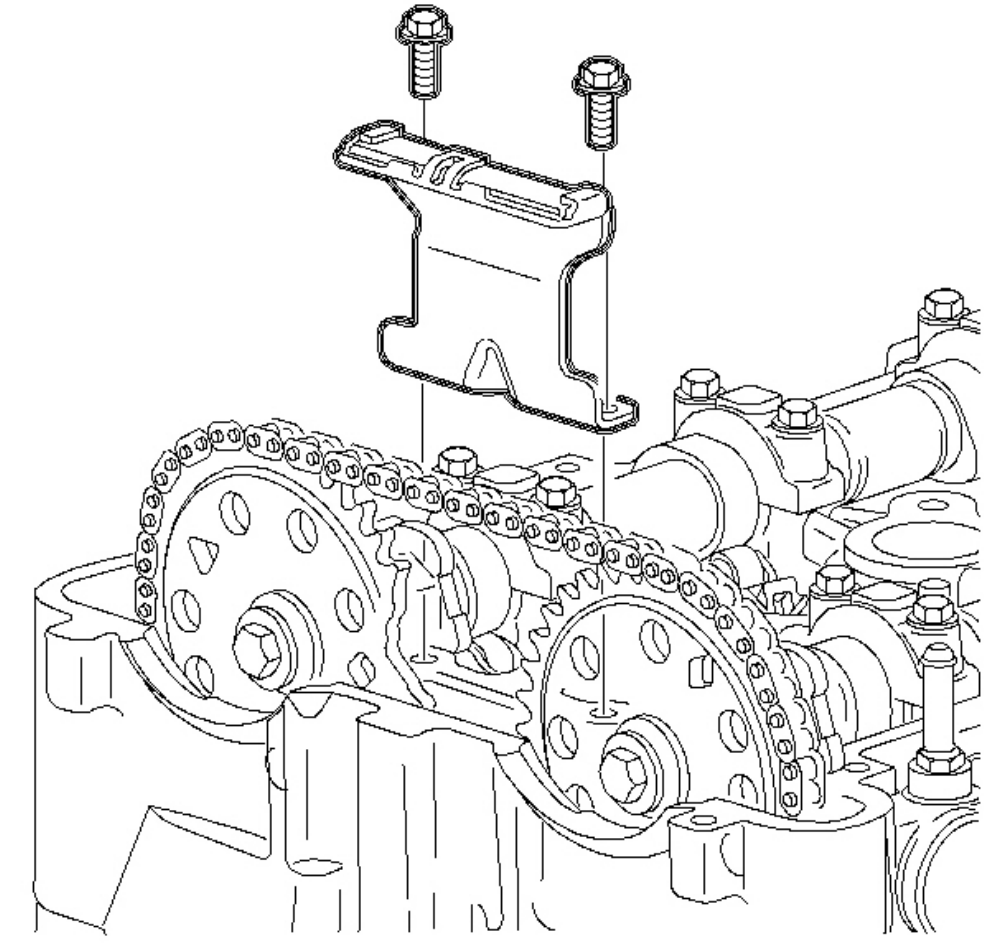


Fig. 235: Removing/Installing Upper Timing Chain Guide & Bolts
Courtesy of GENERAL MOTORS CORP.

29. Remove upper timing chain guide.

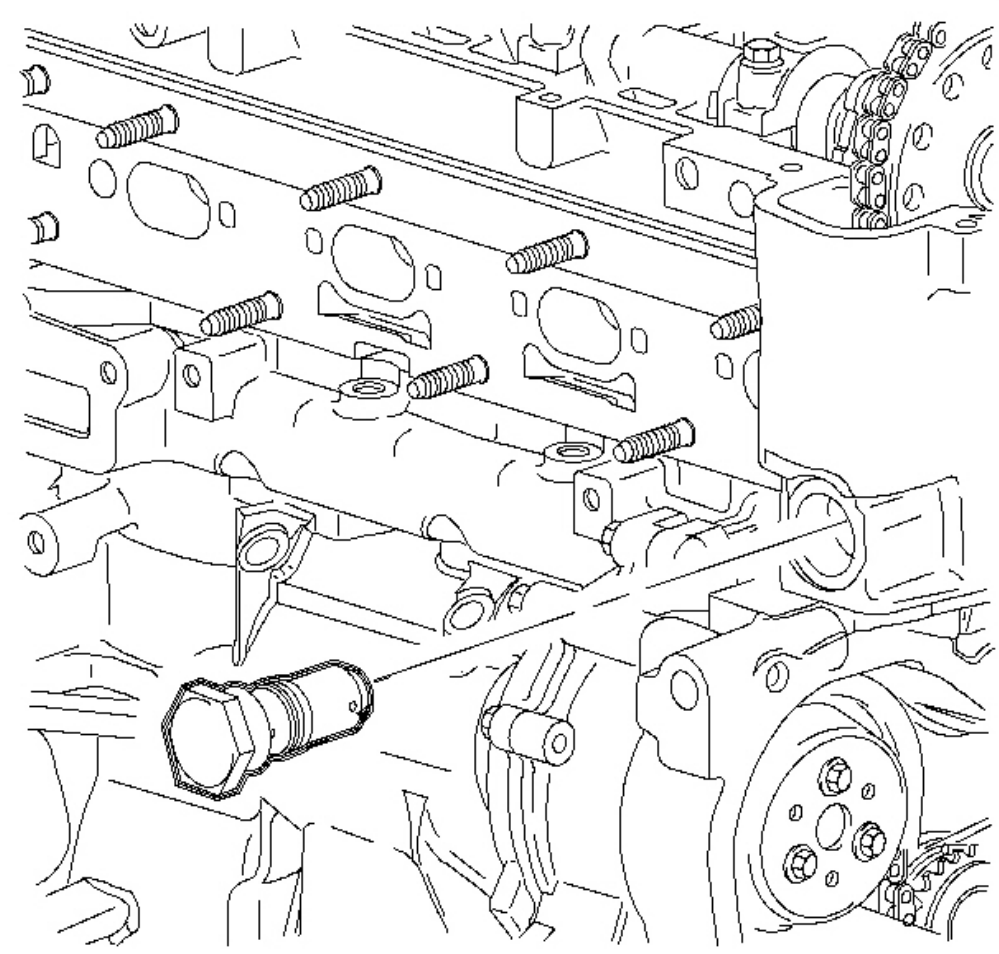


Fig. 236: Removing/Installing Timing Chain Tensioner Assembly
Courtesy of GENERAL MOTORS CORP.

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

30. Remove the timing chain tensioner.

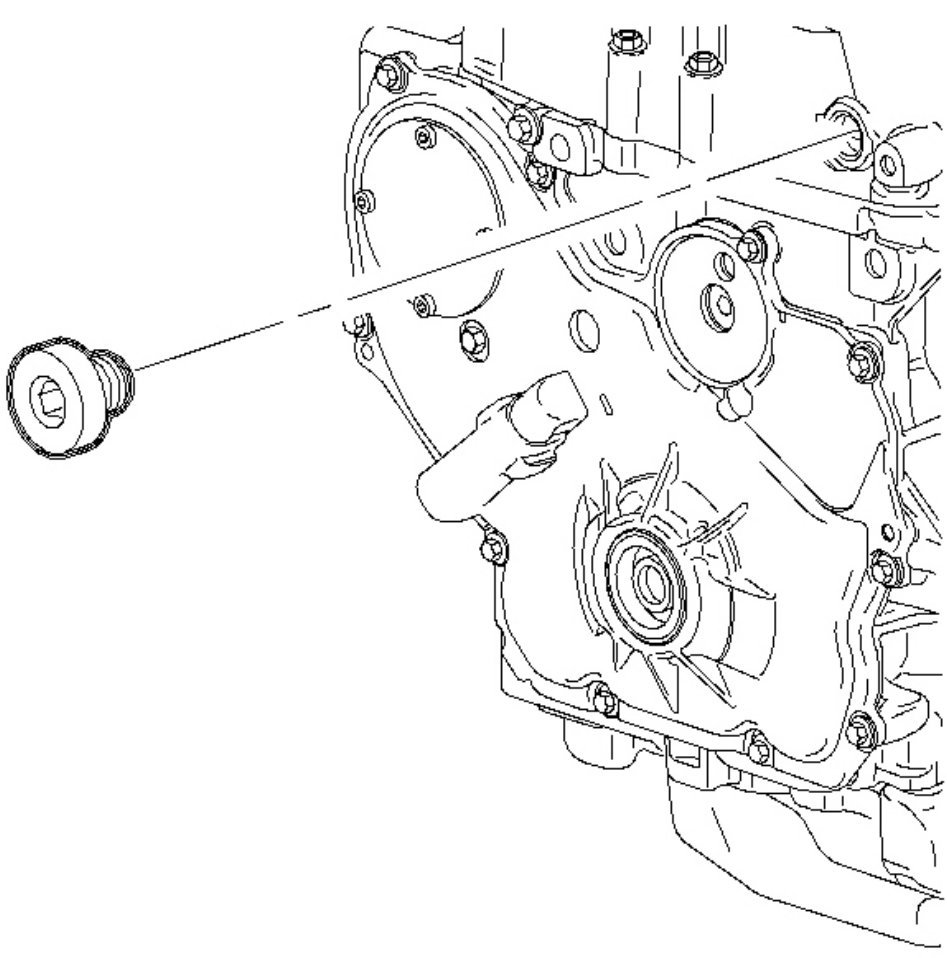


Fig. 237: Removing Fixed Timing Chain Guide Access Plug
Courtesy of GENERAL MOTORS CORP.

31. Remove the fixed timing chain guide access plug.
32. Using a magnetic socket, remove the upper fixed guide bolt.

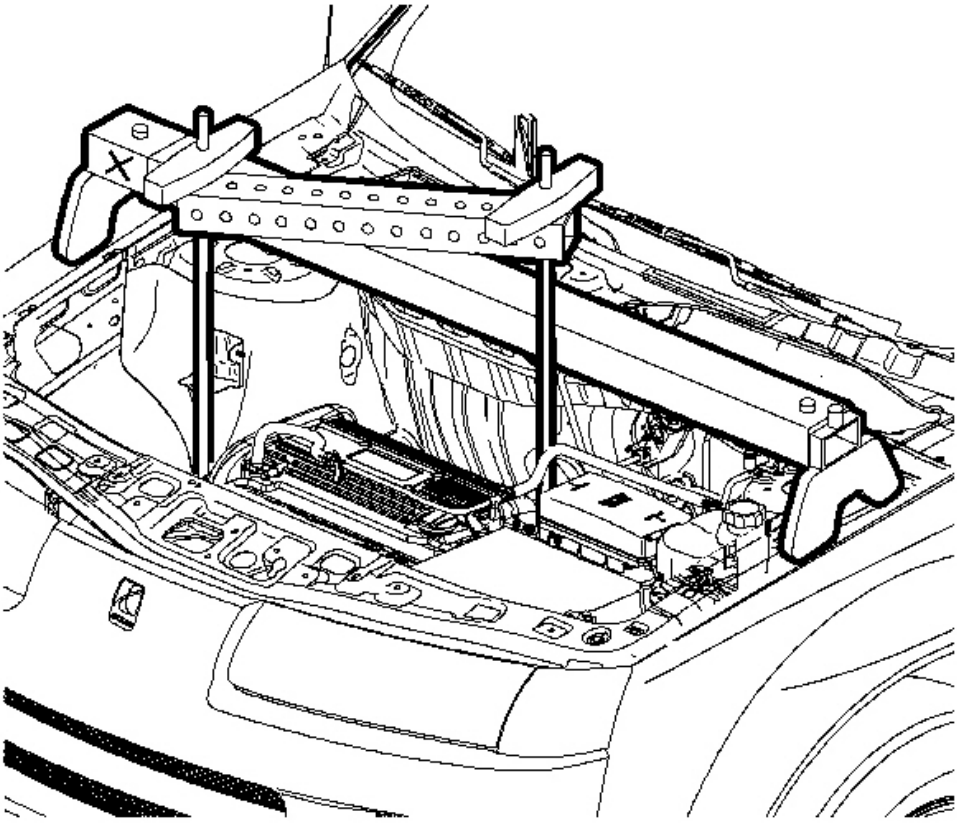


Fig. 238: Installing SA9105E Set Up For SUV Application
Courtesy of GENERAL MOTORS CORP.

33. Install**SA9105E** set up for SUV application. Also, use J 45122 with long hooks from **J 43405** . Refer to **Engine Support Fixture** .

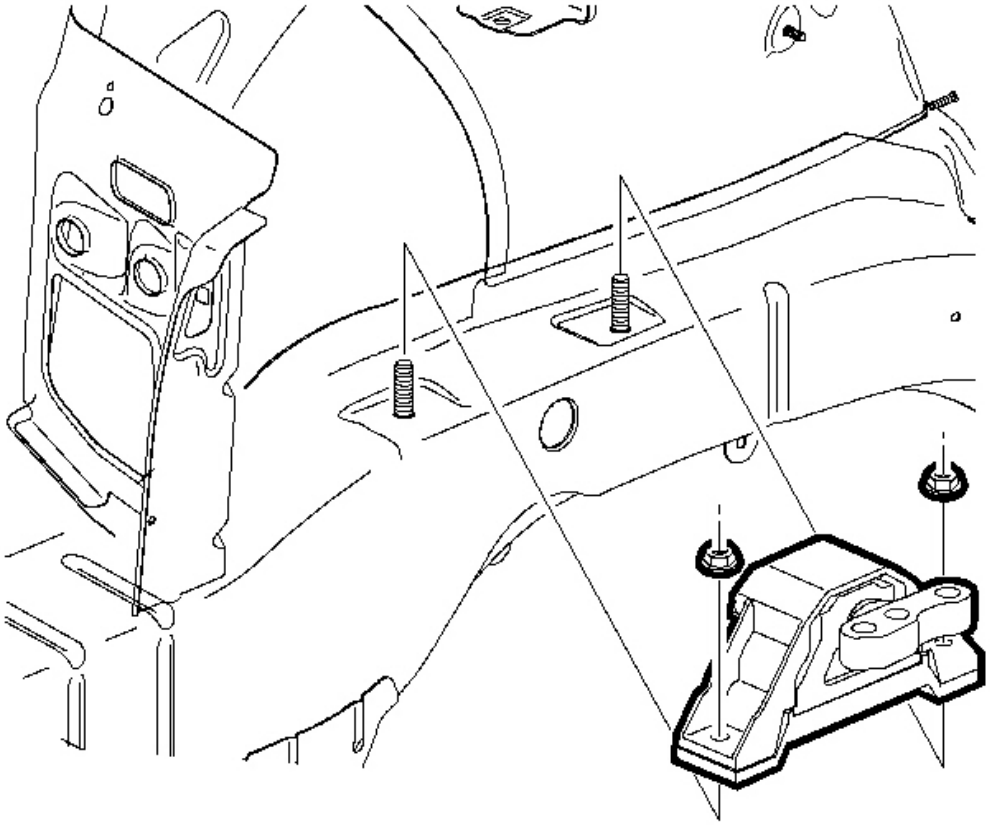


Fig. 239: View Of RH Engine Mount
Courtesy of GENERAL MOTORS CORP.

34. Remove the right-hand engine mount-to-bracket bolts.
35. Remove the right-hand mount assembly nuts.
36. Remove the right-hand engine mount assembly.

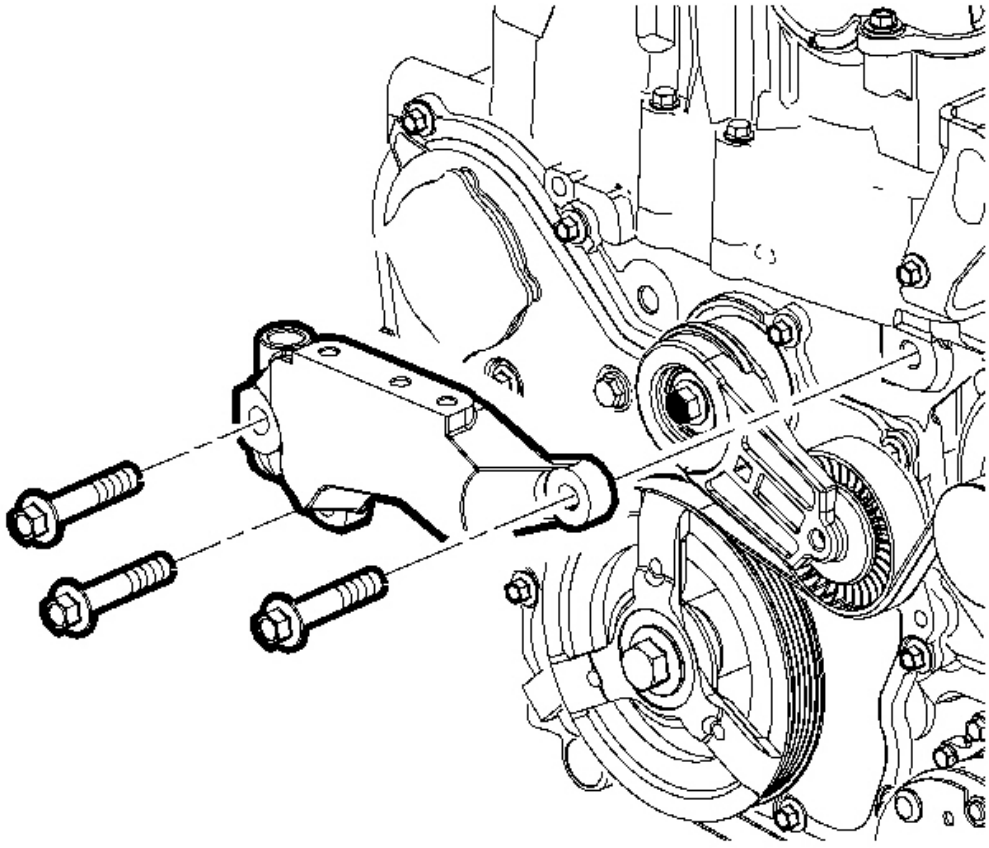


Fig. 240: Removing/Installing Right Hand Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

37. Remove the right-hand mount bracket.
38. Remove the right-hand engine mount bracket.
39. Raise the vehicle on hoist.
40. Remove the right wheel and splash shield.
41. Remove **J 44811** . See **Special Tools and Equipment** .
42. Remove the accessory drive belt.
43. Remove the tensioner bolt. To remove bolt, an access hole has been provided through the inner and outer engine rail.

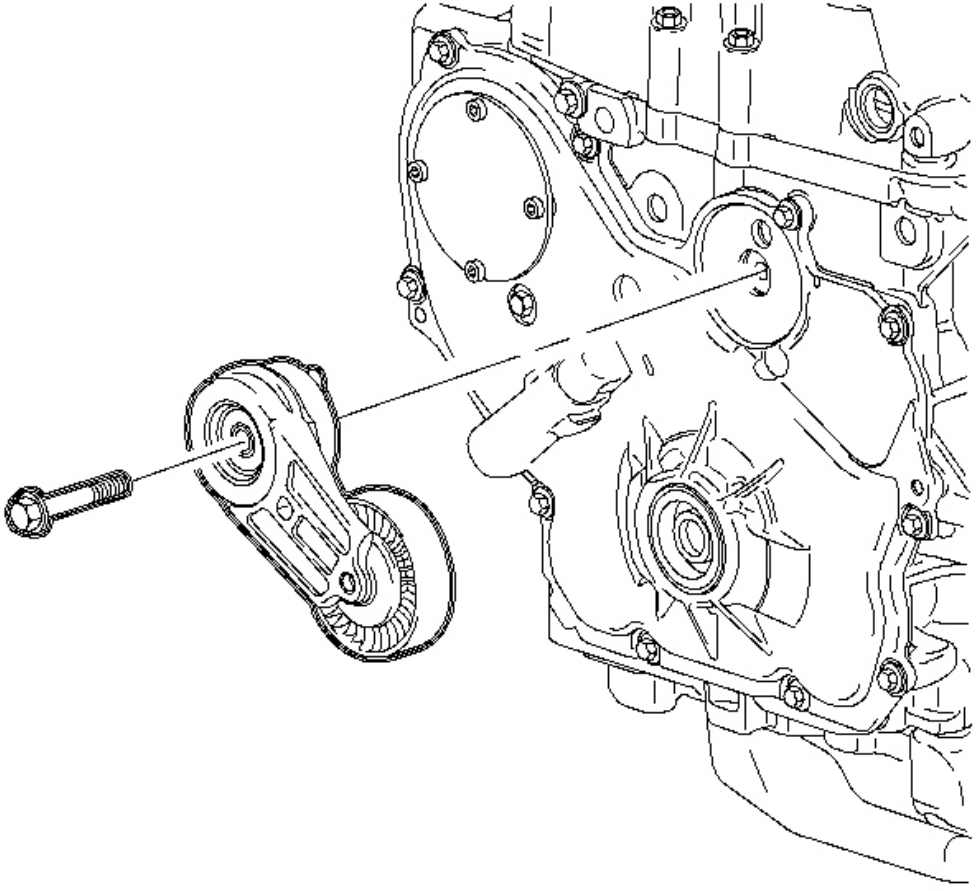


Fig. 241: Removing/Installing Tensioner Assembly & Bolt
Courtesy of GENERAL MOTORS CORP.

44. Remove the tensioner assembly.

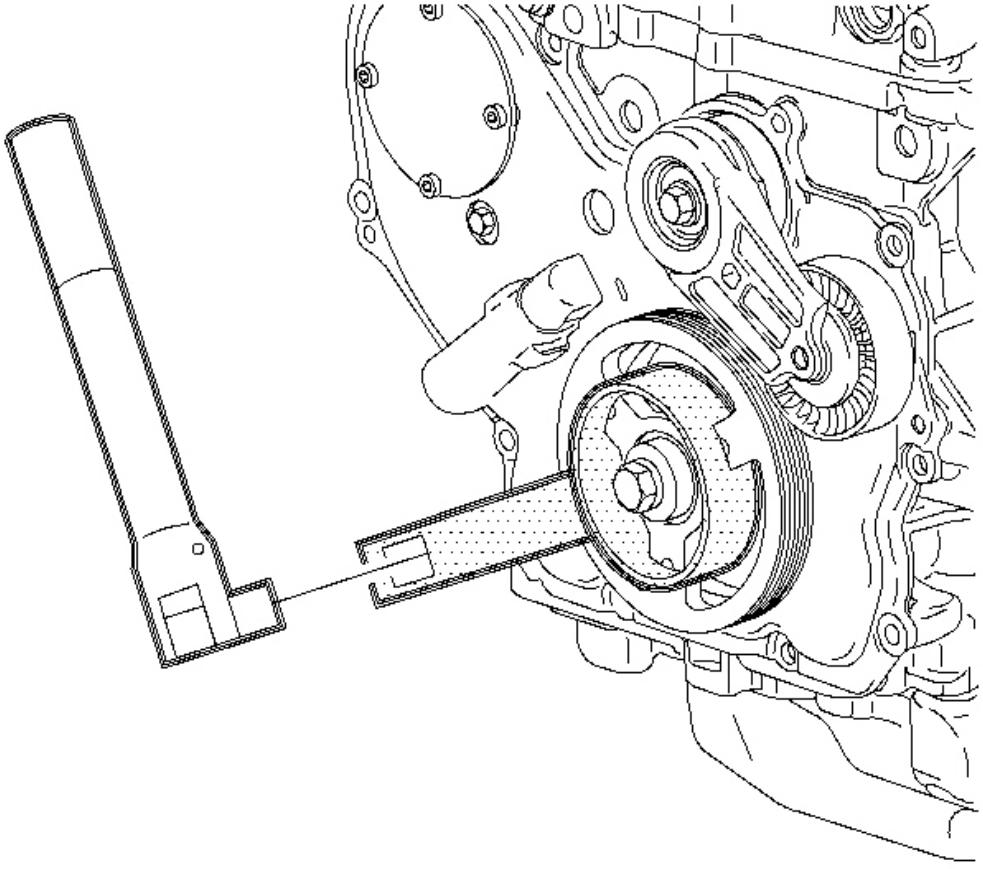


Fig. 242: Installing Crankshaft Pulley Holder
Courtesy of GENERAL MOTORS CORP.

45. Install **J 38122-A** . See **Special Tools and Equipment** .

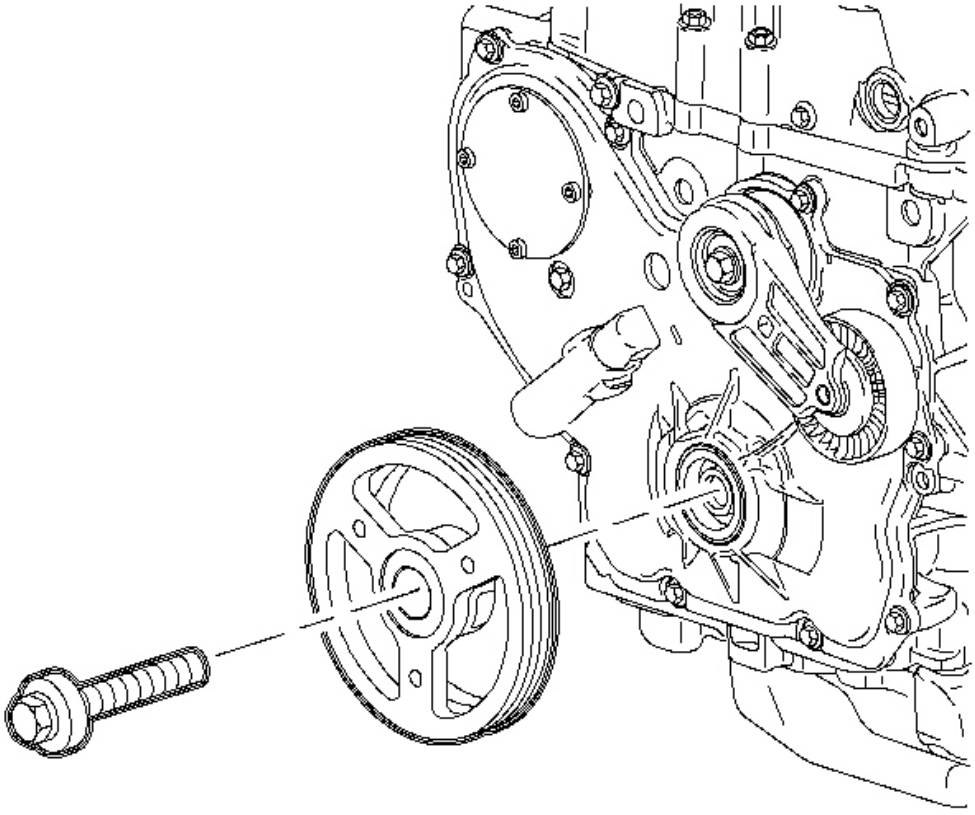


Fig. 243: Removing/Installing Crankshaft Balancer Pulley Bolt
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The crankshaft balancer pulley bolt head and washer assembly prevents oil leakage at center of pulley. Do not damage sealing surfaces. If pulley cannot be removed by pulling with hand, use a threw-jay puller.

46. Remove the crankshaft balancer pulley bolt and pulley. Discard the pulley bolt.

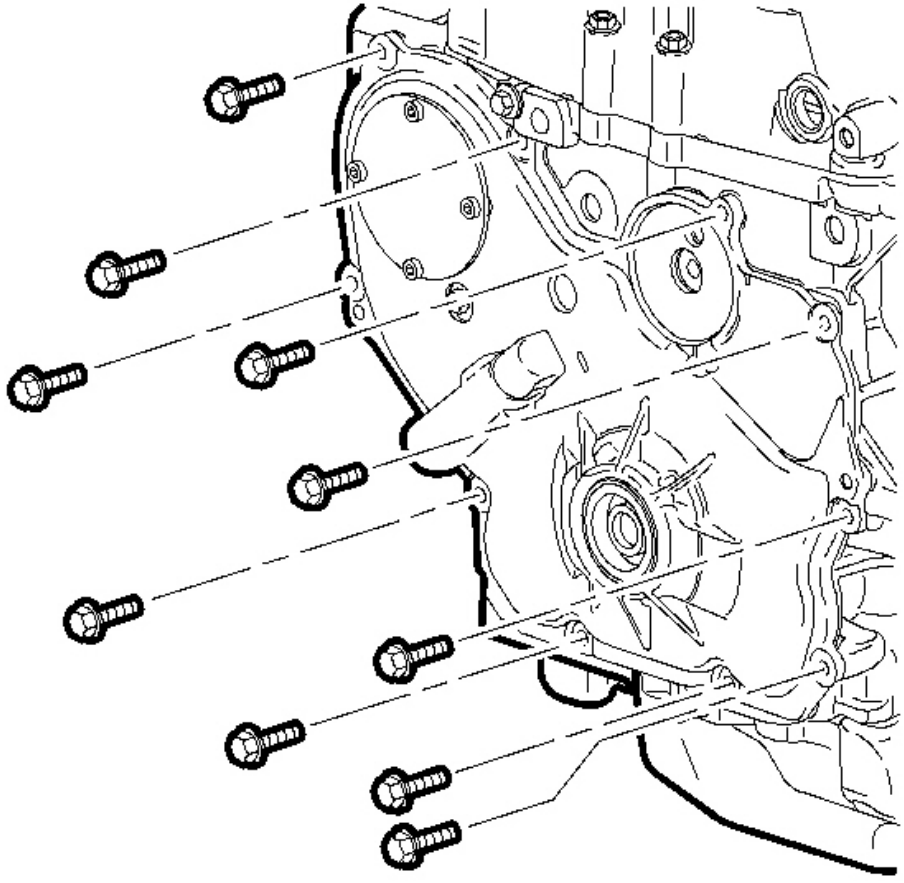


Fig. 244: Removing/Installing Front Cover Assembly
Courtesy of GENERAL MOTORS CORP.

NOTE: To avoid damage to the front cover assembly, do not pry against the cover.

47. Remove the front cover assembly bolts.
48. Remove the lower water pump assembly bolt.
49. Remove the front cover assembly and gasket.

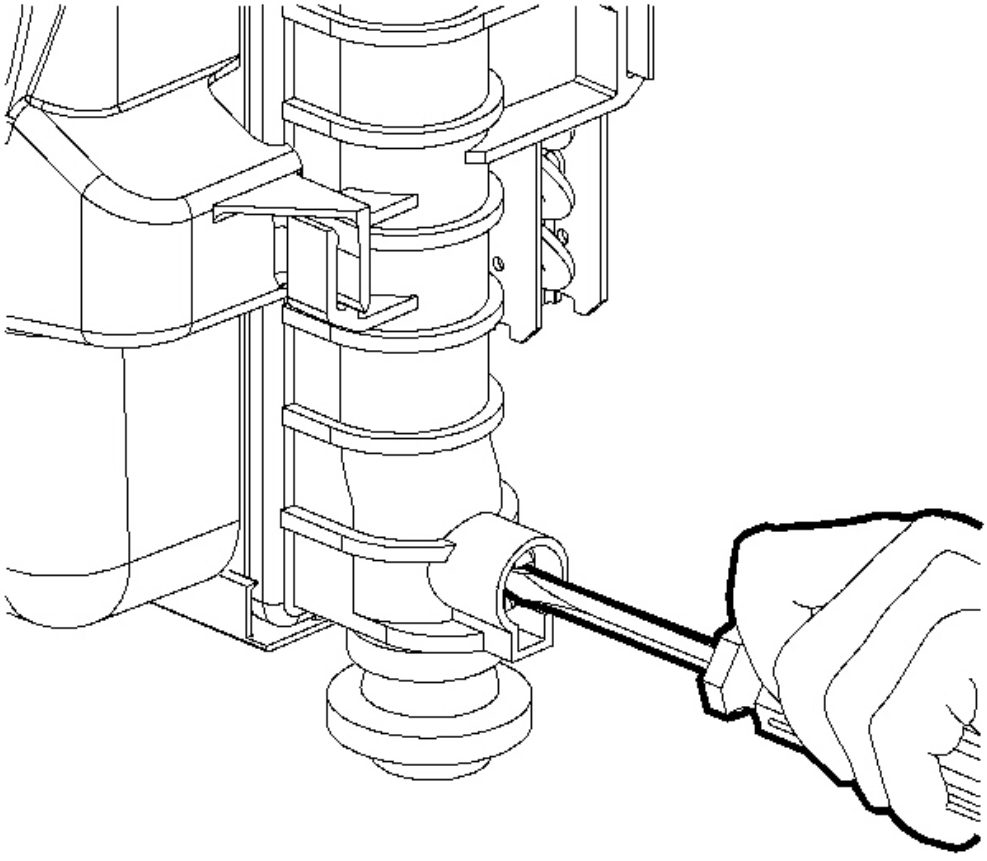


Fig. 245: Draining Coolant System
Courtesy of GENERAL MOTORS CORP.

50. Drain the coolant system. Refer to **Draining and Filling Cooling System** in Engine Cooling.

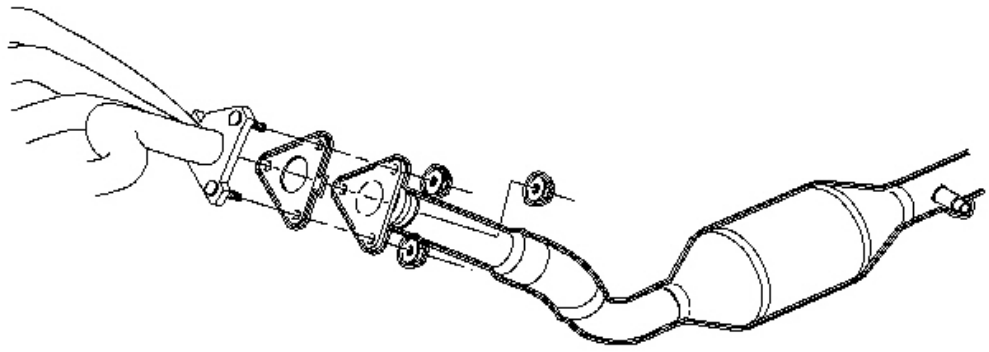


Fig. 246: Removing Exhaust Manifold Pipe
Courtesy of GENERAL MOTORS CORP.

51. Remove the exhaust manifold pipe to the manifold nuts.
52. Disconnect the electrical connectors at the front and rear oxygen sensors.
53. Remove down pipe to intermediate pipe nuts.
54. Remove down pipe assembly.
55. Lower the vehicle.

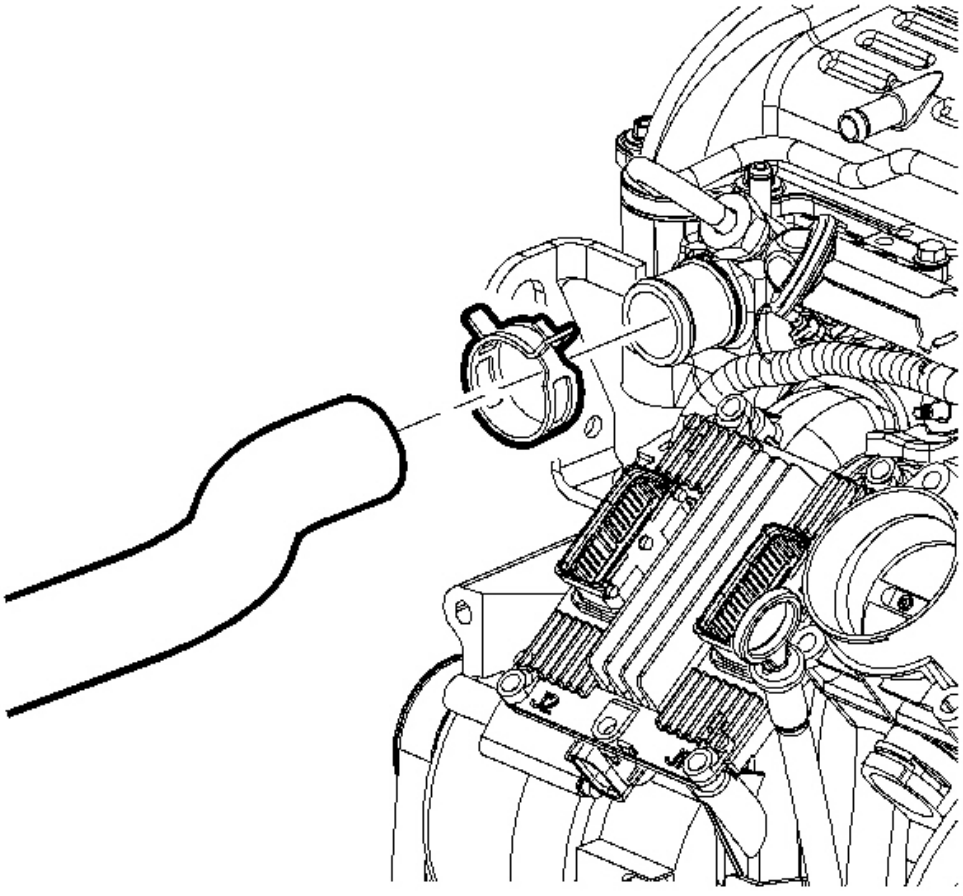


Fig. 247: Removing Upper Radiator Hose From Cylinder Head
Courtesy of GENERAL MOTORS CORP.

56. Remove the upper radiator hose from cylinder head.

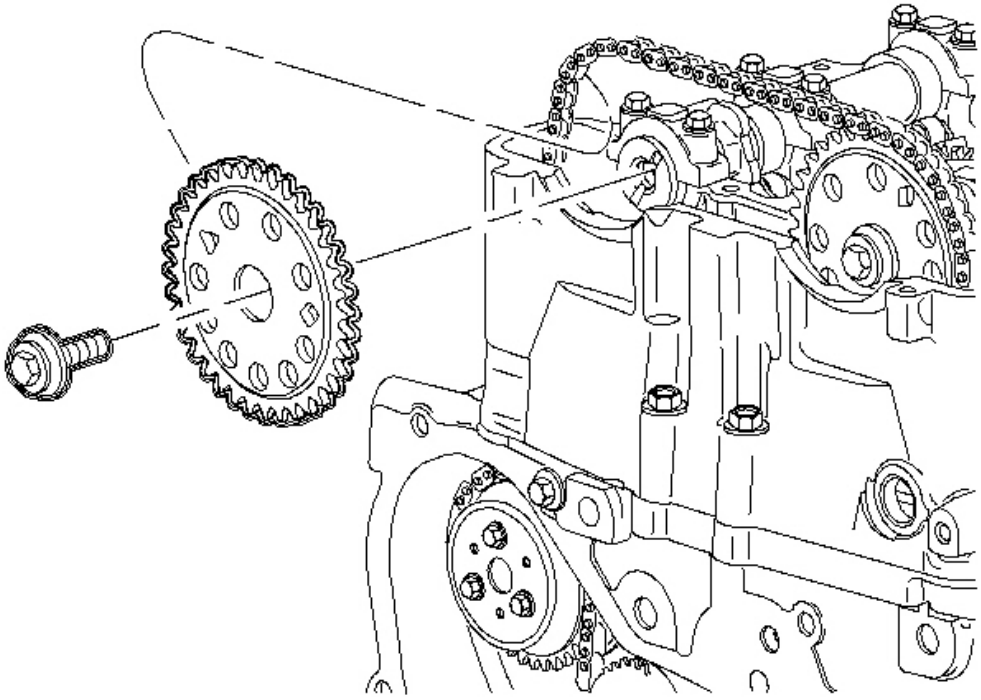


Fig. 248: Removing/Installing Camshaft Sprocket Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE: The camshaft sprocket bolts are not reusable, it is a torque-to-yield (TTY) bolt, and must be discarded to prevent premature failure.

57. Use a 24 mm wrench to hold the camshaft assembly while removing the exhaust sprocket bolt. Discard the bolt.
58. Remove the exhaust sprocket.

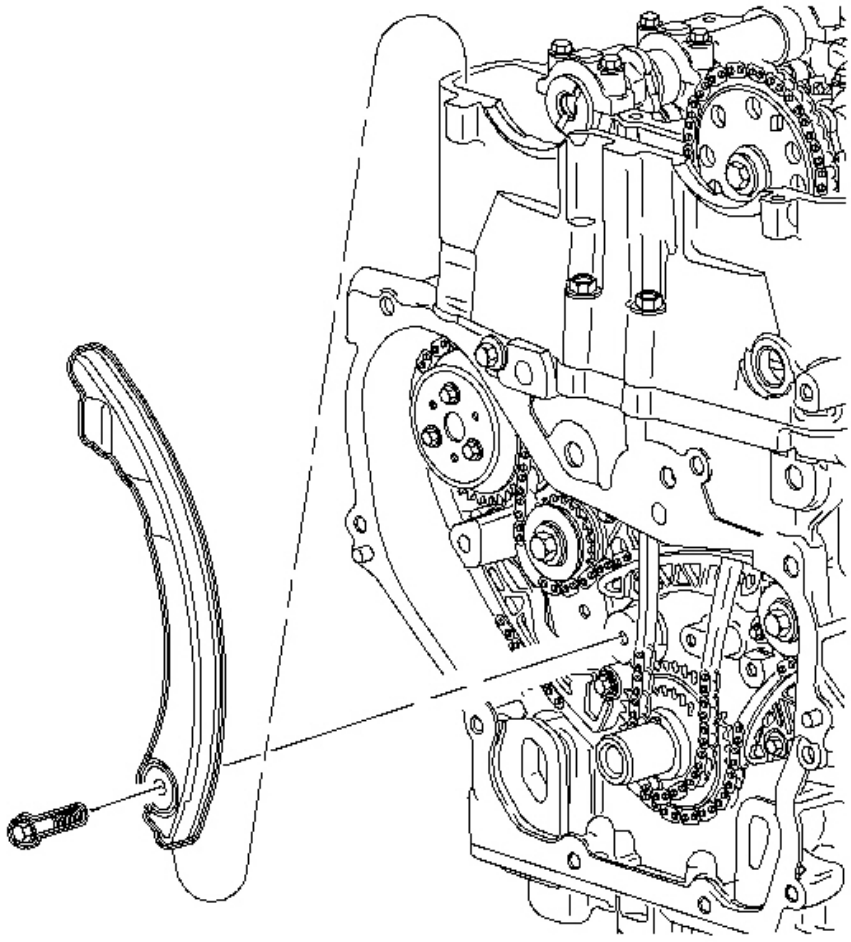


Fig. 249: Timing Chain Adjustable Guide And Bolt
Courtesy of GENERAL MOTORS CORP.

59. Remove the adjustable guide through the top of the cylinder head.

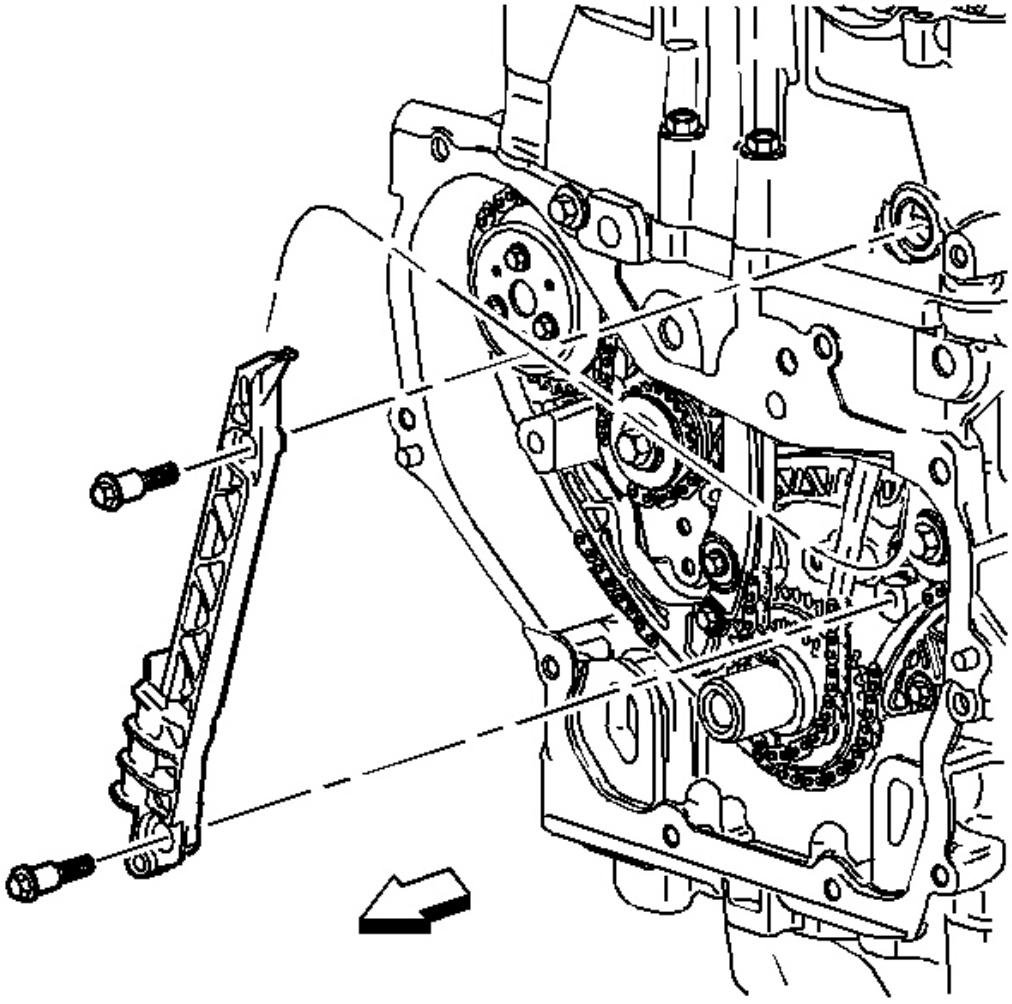


Fig. 250: View Of Fixed Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

60. Remove the fixed timing chain guide.

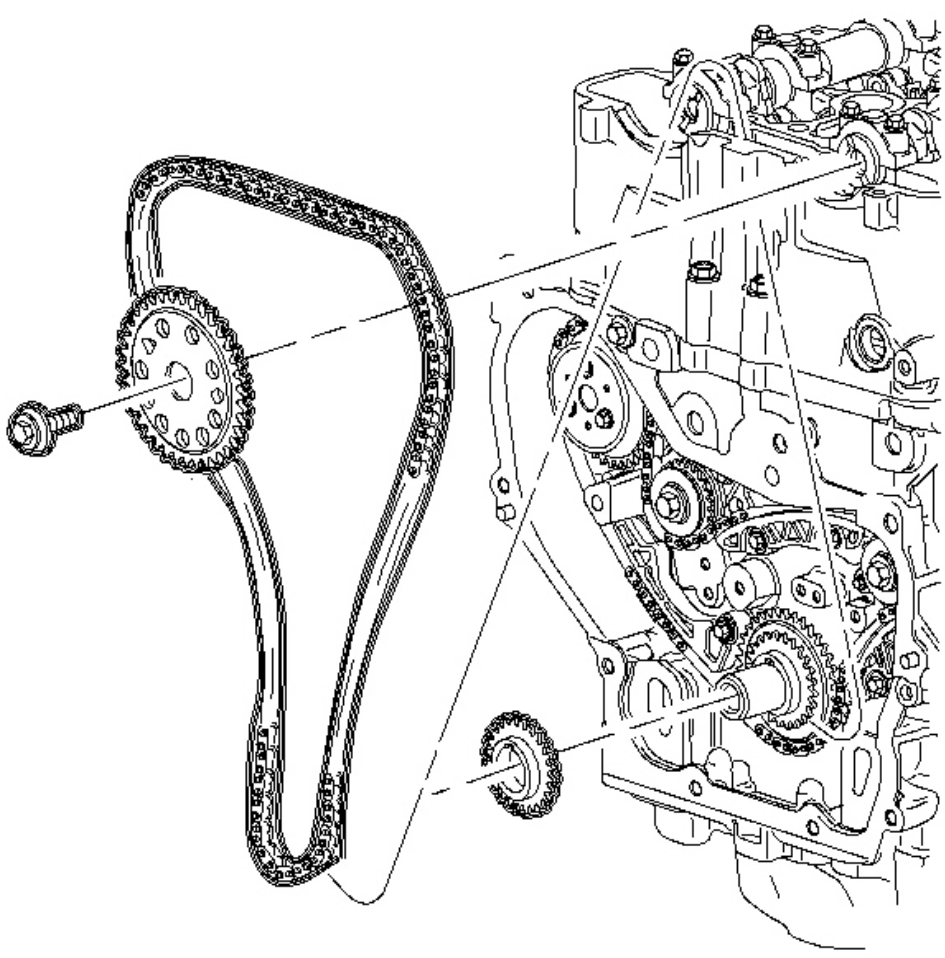


Fig. 251: Holding Camshaft Assembly Using 24 mm Wrench
Courtesy of GENERAL MOTORS CORP.

61. Use a 24 mm wrench to hold the camshaft assembly while removing the intake sprocket bolt. Discard the bolt.
62. Remove the intake sprocket.
63. Remove the timing chain assembly through top of cylinder head.
64. Remove the timing chain drive sprocket from the crankshaft.

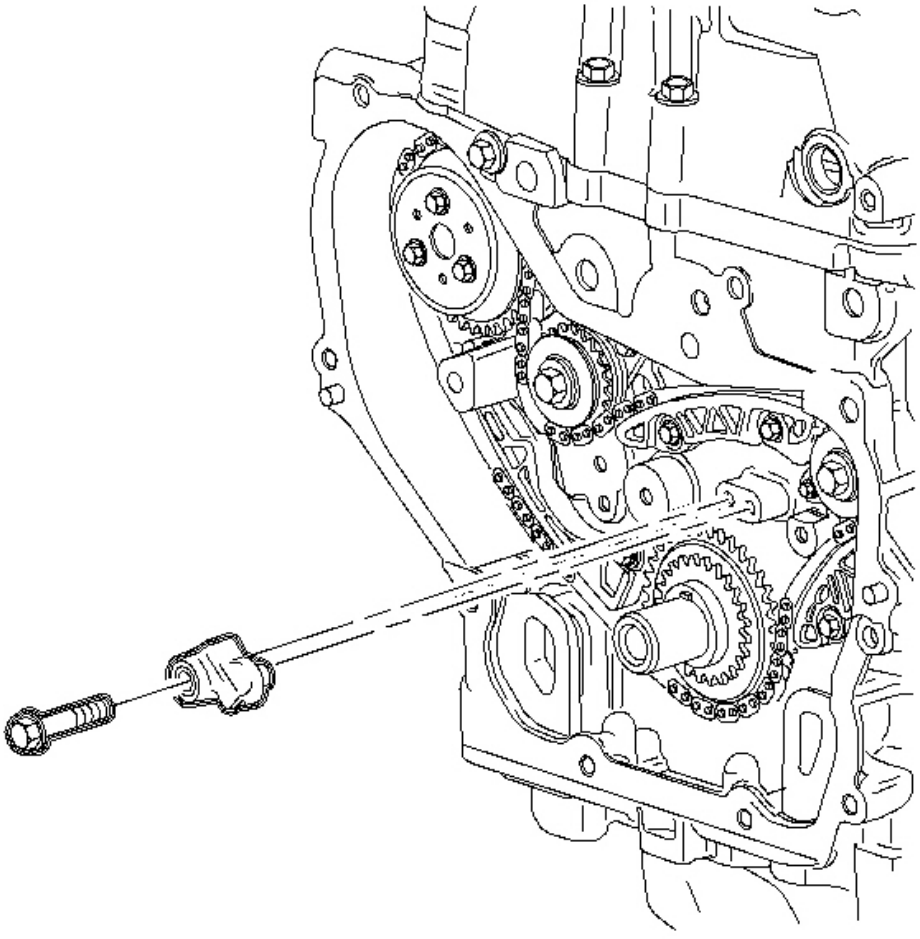


Fig. 252: Removing/Installing Timing Chain Oiling Nozzle & Bolt
Courtesy of GENERAL MOTORS CORP.

65. Remove the timing chain oiling nozzle and remove any debris from hole in block.

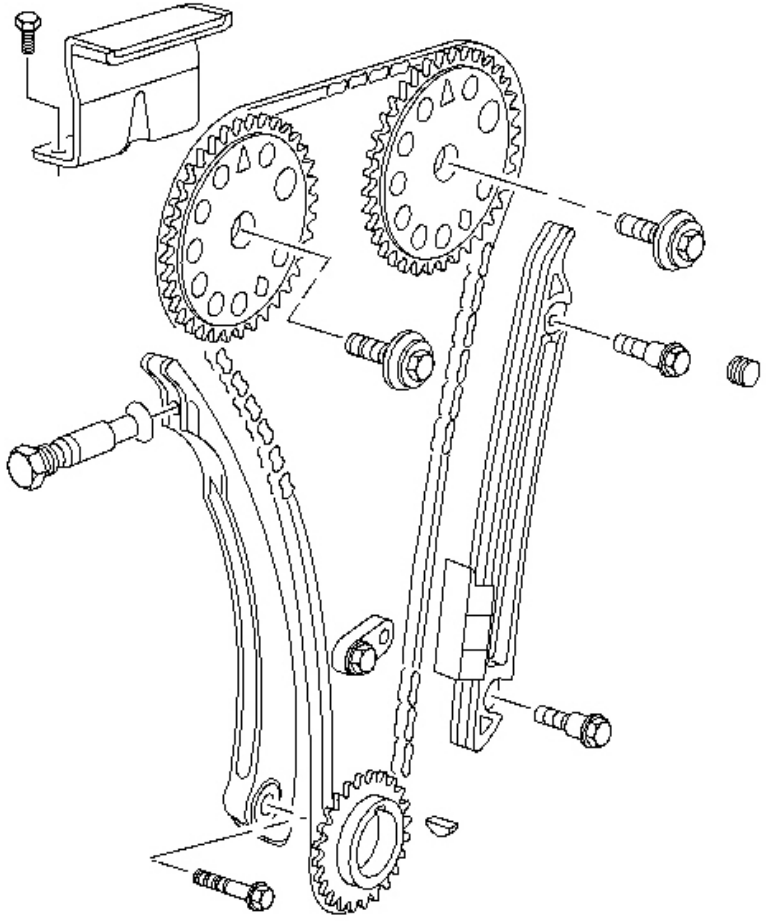


Fig. 253: Inspecting Timing Chain Guides
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Replace timing chain guides if wear exceeds 1.12 mm (0.045 in).

66. Inspect timing chain guide for wear.
67. Inspect the timing chain and sprockets for signs of excessive wear, chipping, or seizure to links on the chain.

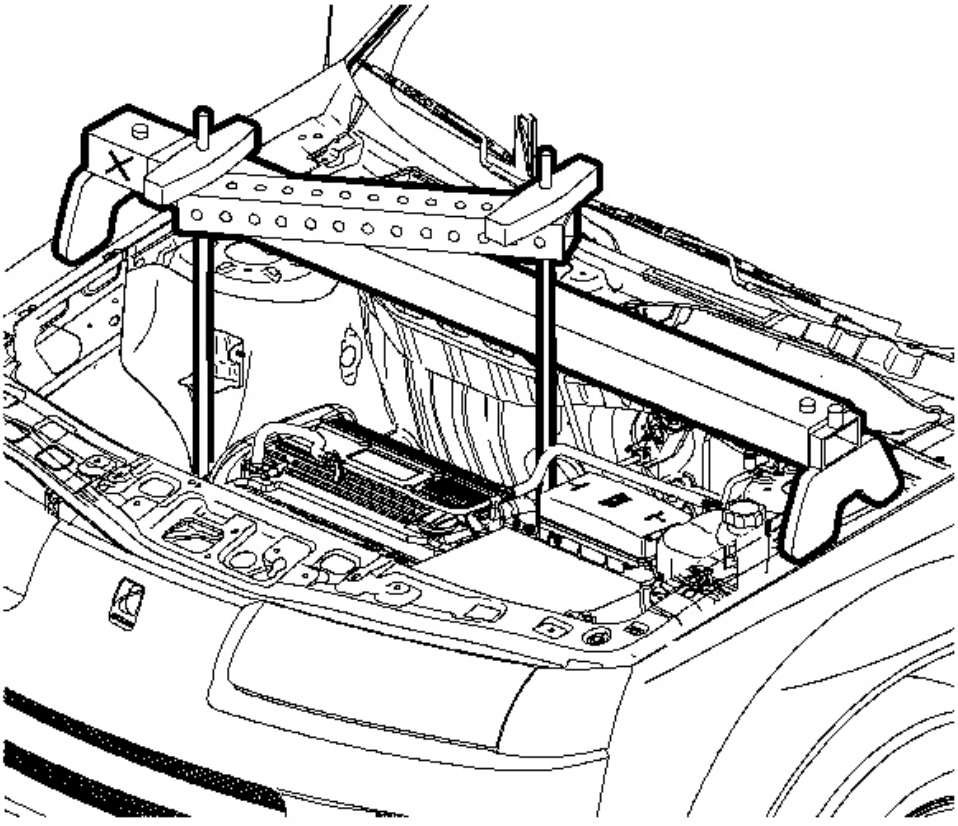


Fig. 254: Installing SA9105E Set Up For SUV Application
Courtesy of GENERAL MOTORS CORP.

CAUTION: Do not raise the vehicle without the right hand mount or the engine support fixture attached. Bodily harm or engine mount damage may occur.

68. Install floor jack with block of wood and support the engine at the center of the oil pan.
69. Remove engine three bar engine support fixture to allow cylinder head to be removed.

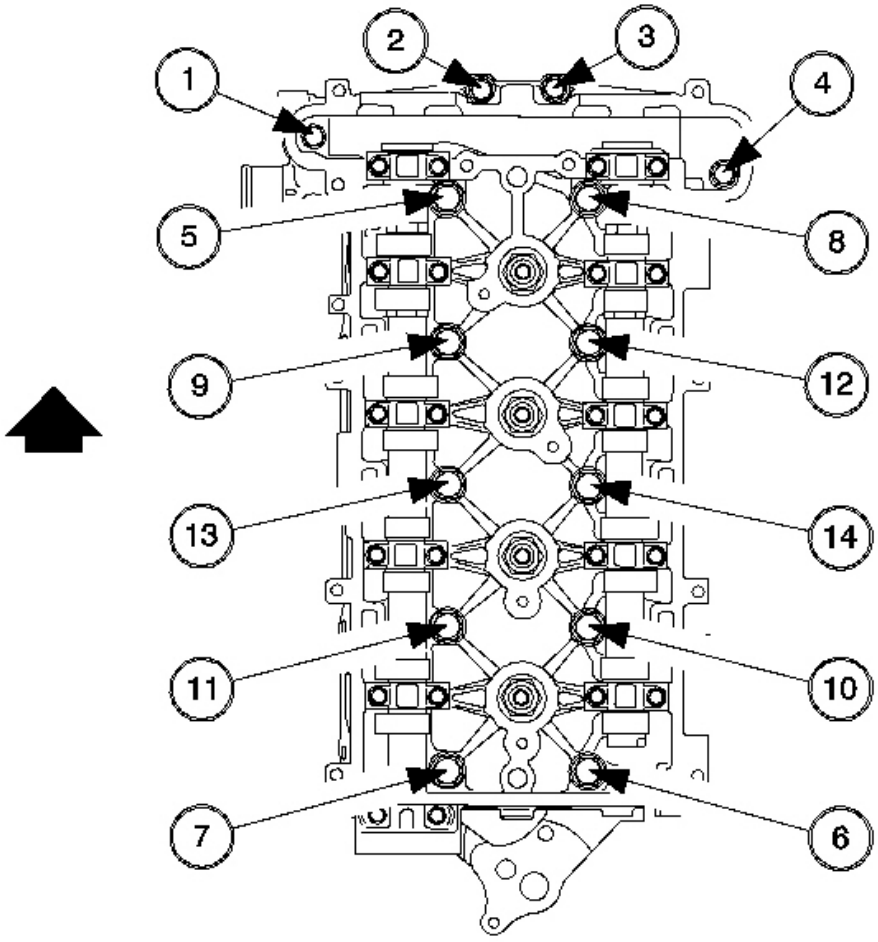


Fig. 255: Removing Cylinder Head Bolts Using Loosening Sequence
Courtesy of GENERAL MOTORS CORP.

70. Remove cylinder head bolts using loosening sequence.
71. With assistance, remove the cylinder head from block with the exhaust and intake manifold attached.

Installation Procedure

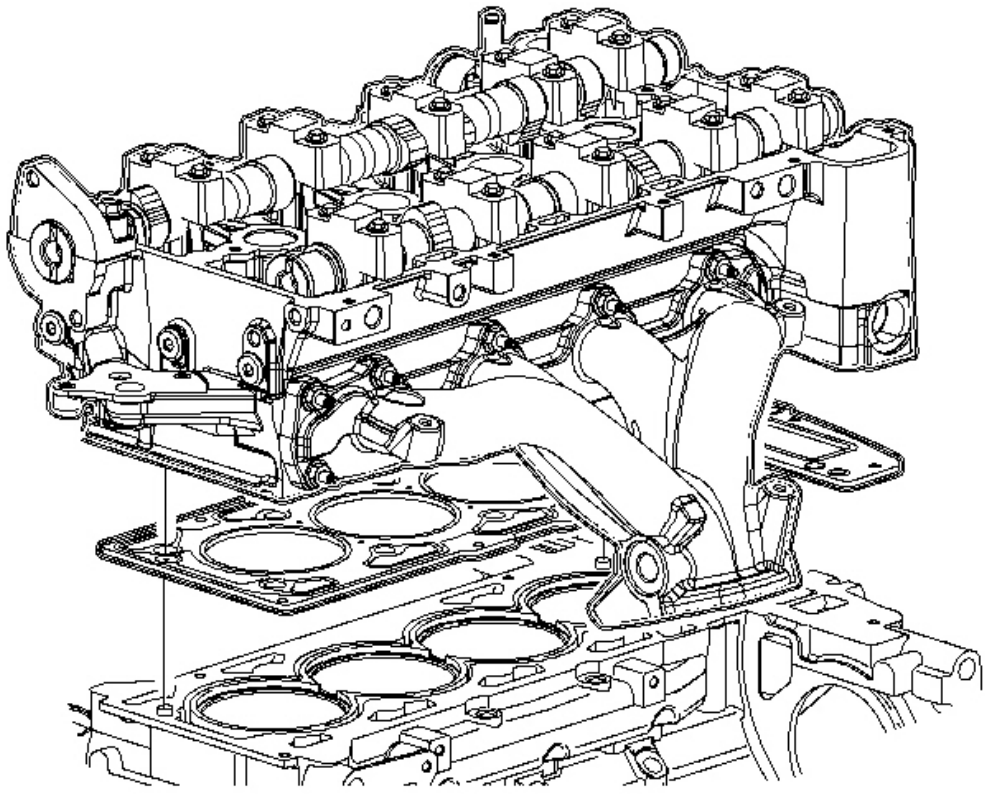


Fig. 256: Inspecting Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

NOTE: Set crankshaft to 60 degrees before top-dead center or after TDC to prevent valve to piston contact.

1. Transfer all components. (intake manifold, plugs, ect.)

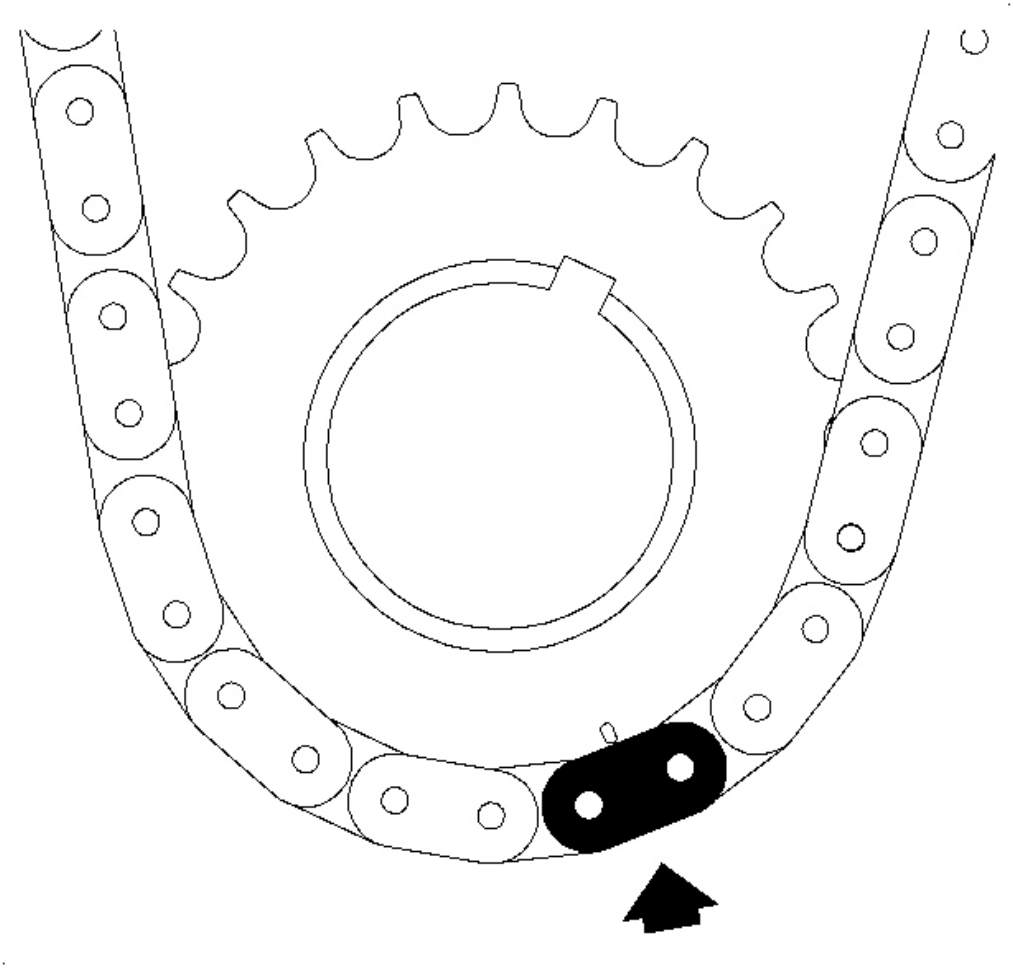


Fig. 257: Setting Mark On The Timing Chain Drive Sprocket At 5 O'clock Position
Courtesy of GENERAL MOTORS CORP.

2. Set crankshaft to 60 degrees before top dead center.

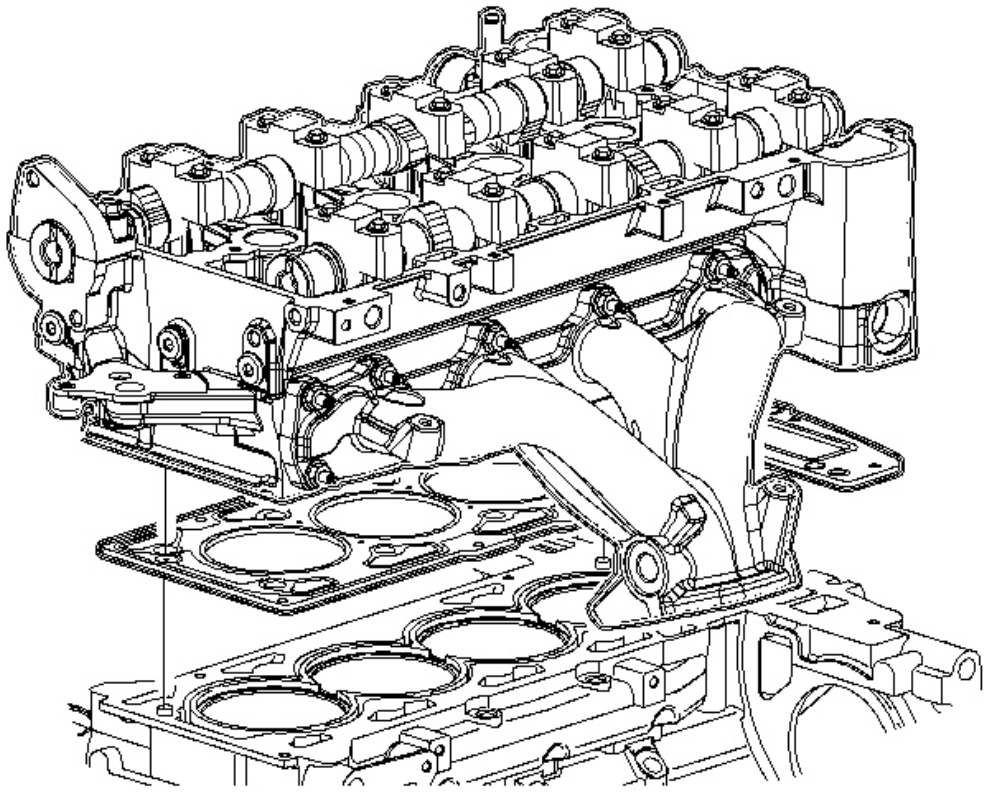


Fig. 258: Installing The Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

3. Install the cylinder head gasket placing OPEN facing up.

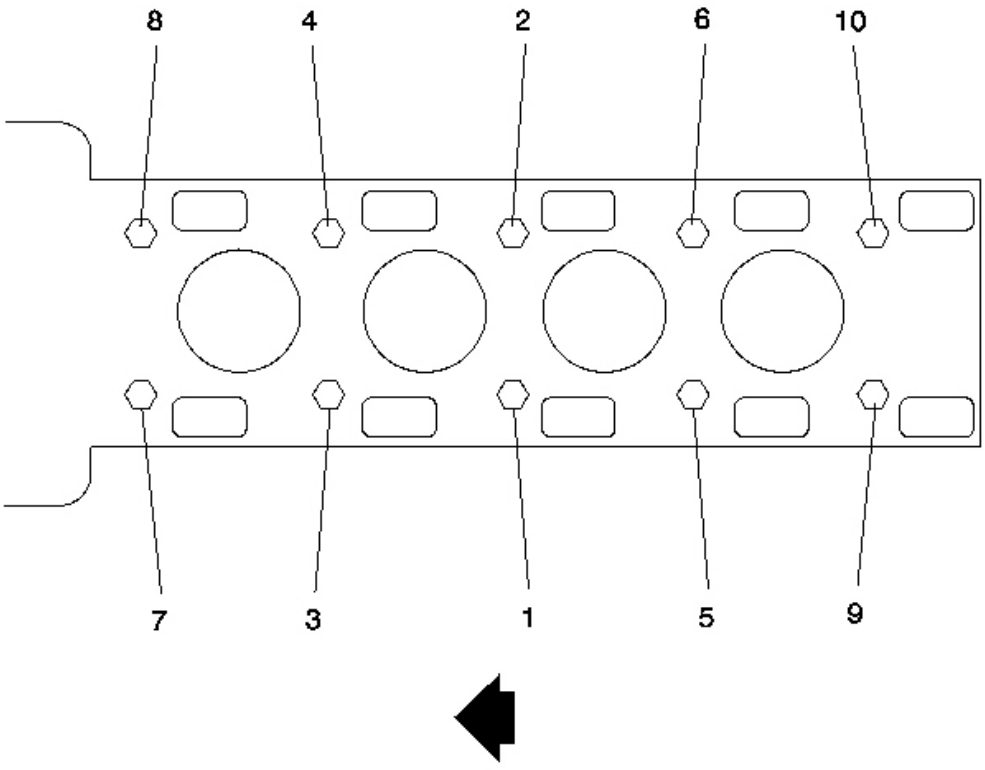


Fig. 259: Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Always use new cylinder head bolts.

4. With assistance, install cylinder head, aligning it onto cylinder head dowels.
5. Lightly apply clean engine oil to threads and to the bottom side of flange of head bolts. Allow oil to drain before installing.

NOTE: Refer to Fastener Notice in Cautions and Notices.

6. Install and torque cylinder head bolts in sequence.

Tighten: Tighten the cylinder head bolts to 30 N.m (22 lb ft) + 155 degrees.

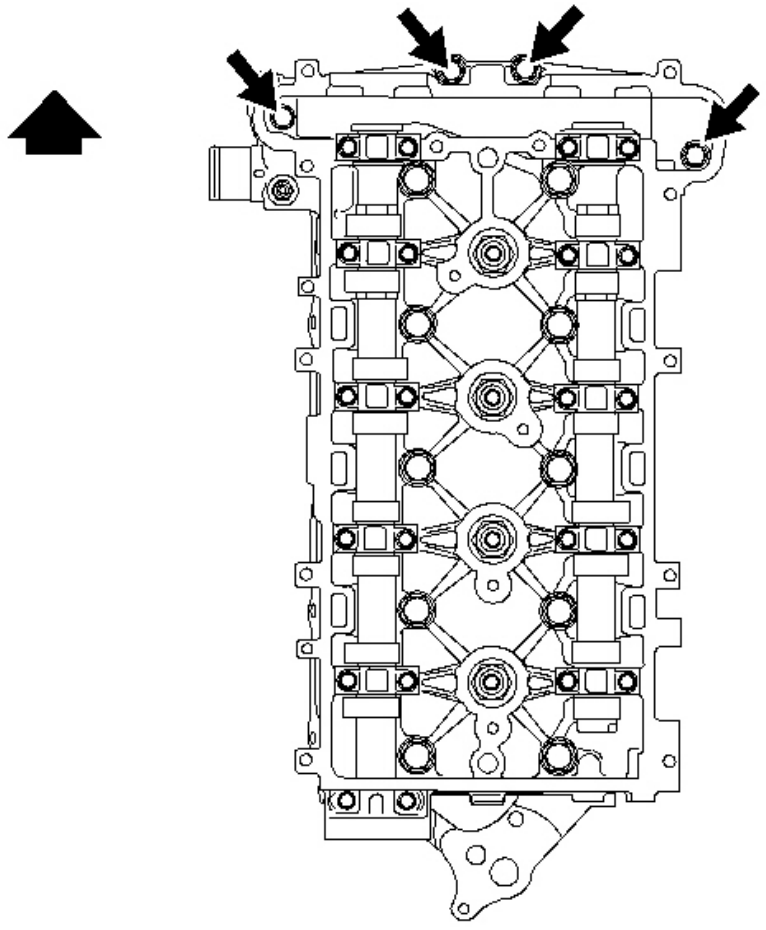


Fig. 260: View Of Front Cylinder Head Crankcase Bolts
Courtesy of GENERAL MOTORS CORP.

7. Coat the front cylinder head crankcase bolts with Permatex(R) Threadlocker(R) Blue P/N 21485278, or equivalent.

   Tighten: Tighten the cylinder head front chaincase bolts to 35 N.m (24 lb ft).

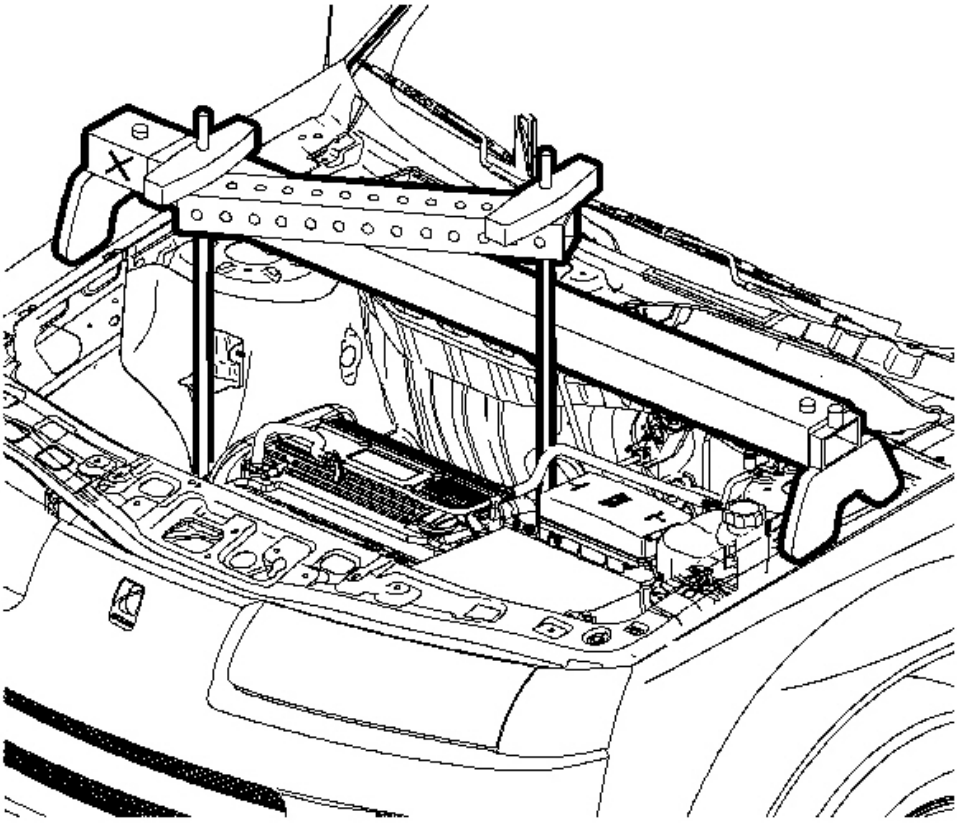


Fig. 261: Installing SA9105E Set Up For SUV Application
Courtesy of GENERAL MOTORS CORP.

8. Install the **SA9105E** that was removed earlier. See **Special Tools and Equipment** .

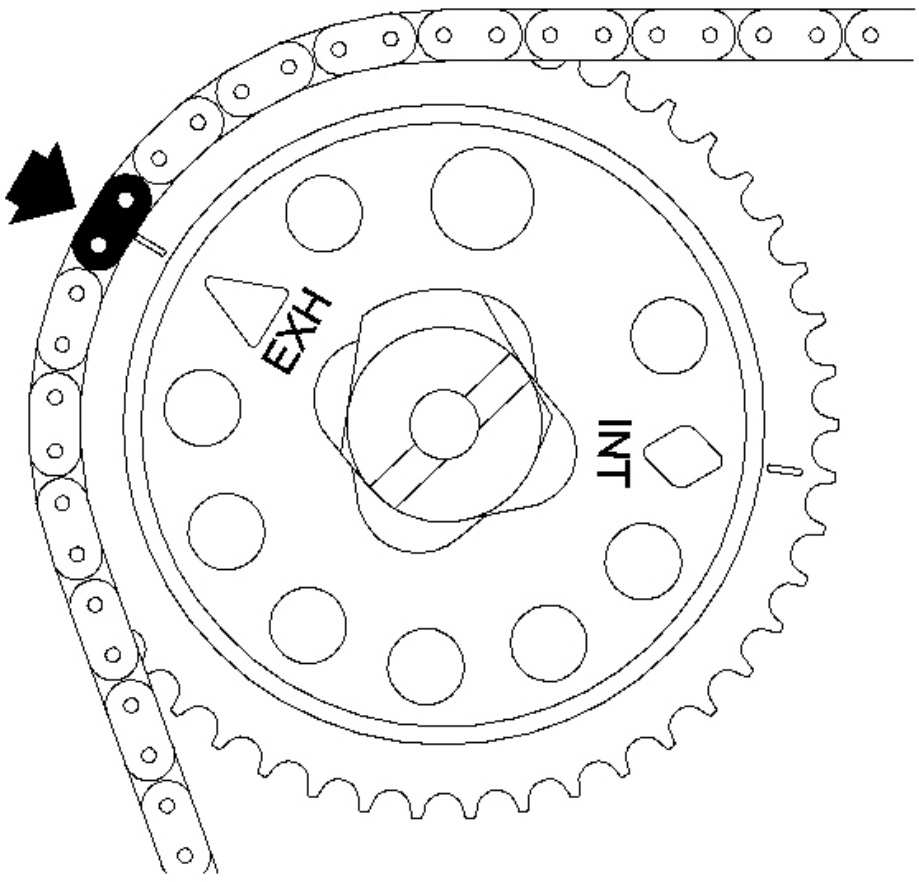


Fig. 262: Positioning Exhaust Camshaft
Courtesy of GENERAL MOTORS CORP.

9. Position the exhaust camshaft with offset slot to the 10 o'clock position.

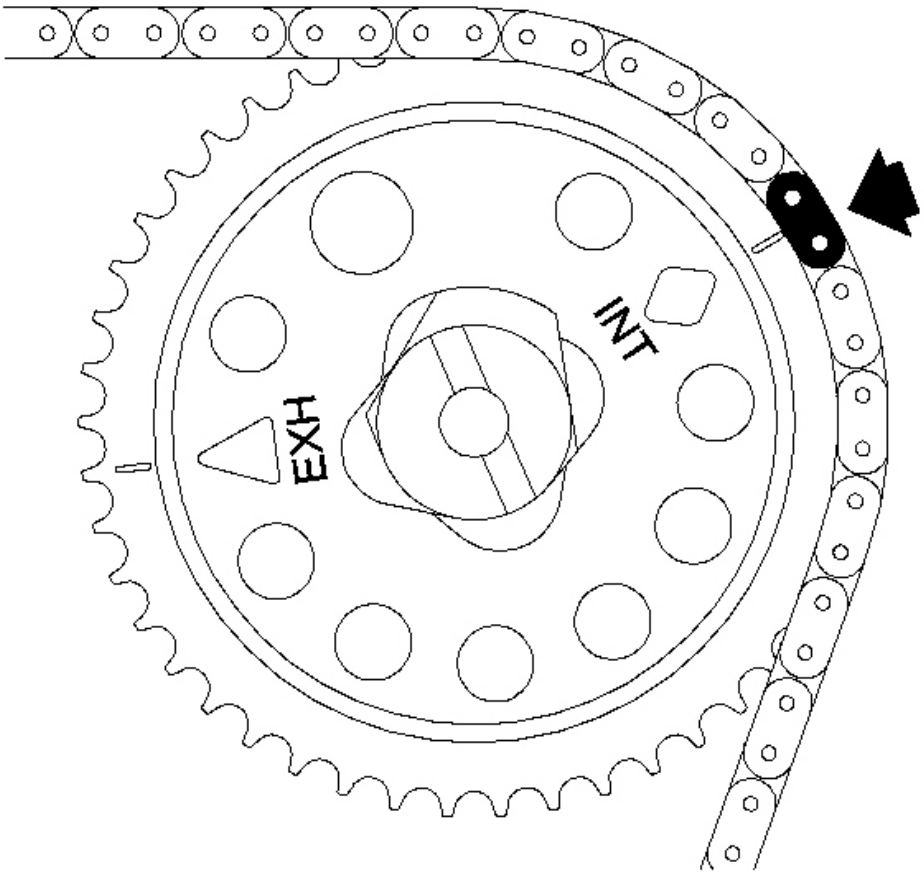


Fig. 263: Positioning Intake Camshaft
Courtesy of GENERAL MOTORS CORP.

10. Position the intake camshaft with offset slot to the 2 o'clock position.

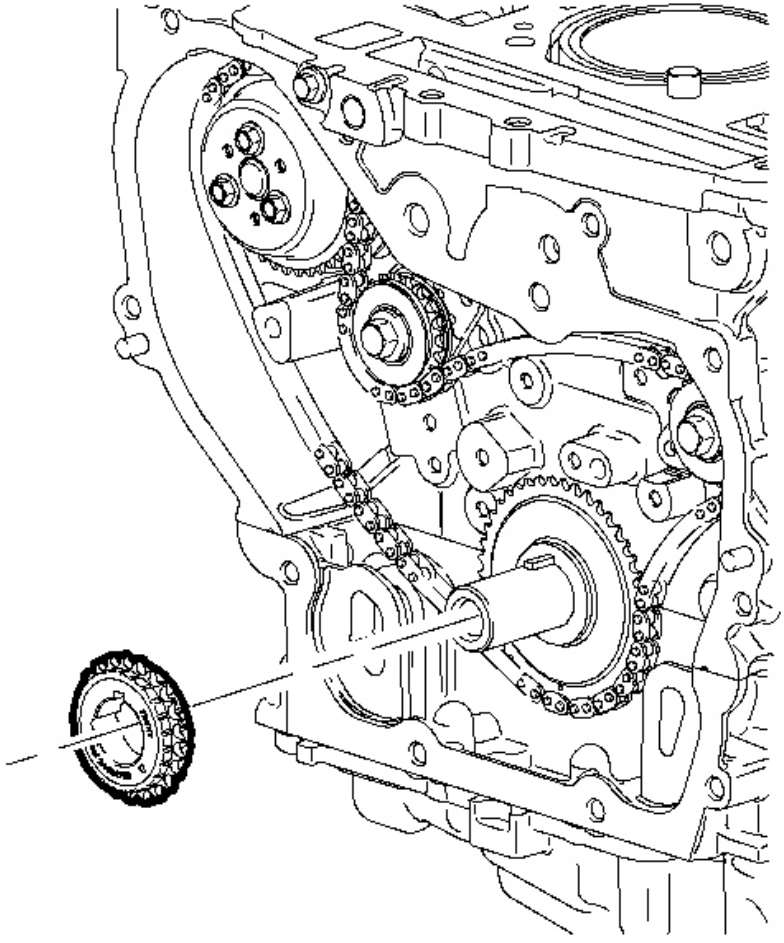


Fig. 264: Installing Timing Chain Drive Sprocket
Courtesy of GENERAL MOTORS CORP.

11. Install timing chain drive sprocket to the crankshaft.
12. Using dampener, rotate the crank so that the mark on the timing chain drive sprocket is at the 5 o'clock position.

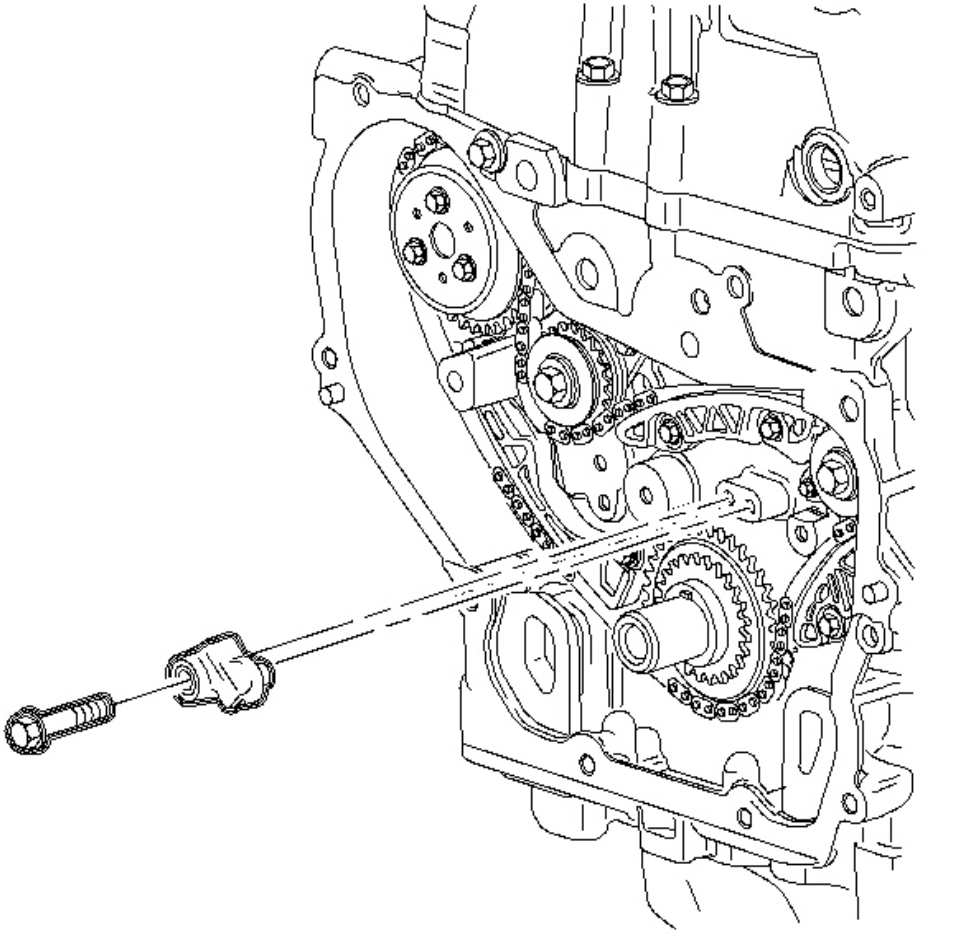


Fig. 265: Removing/Installing Timing Chain Oiling Nozzle & Bolt
Courtesy of GENERAL MOTORS CORP.

13. Install timing chain oiling nozzle and bolt.

    Tighten: Tighten the timing chain oil nozzle bolt to 10 N.m (89 lb ft).

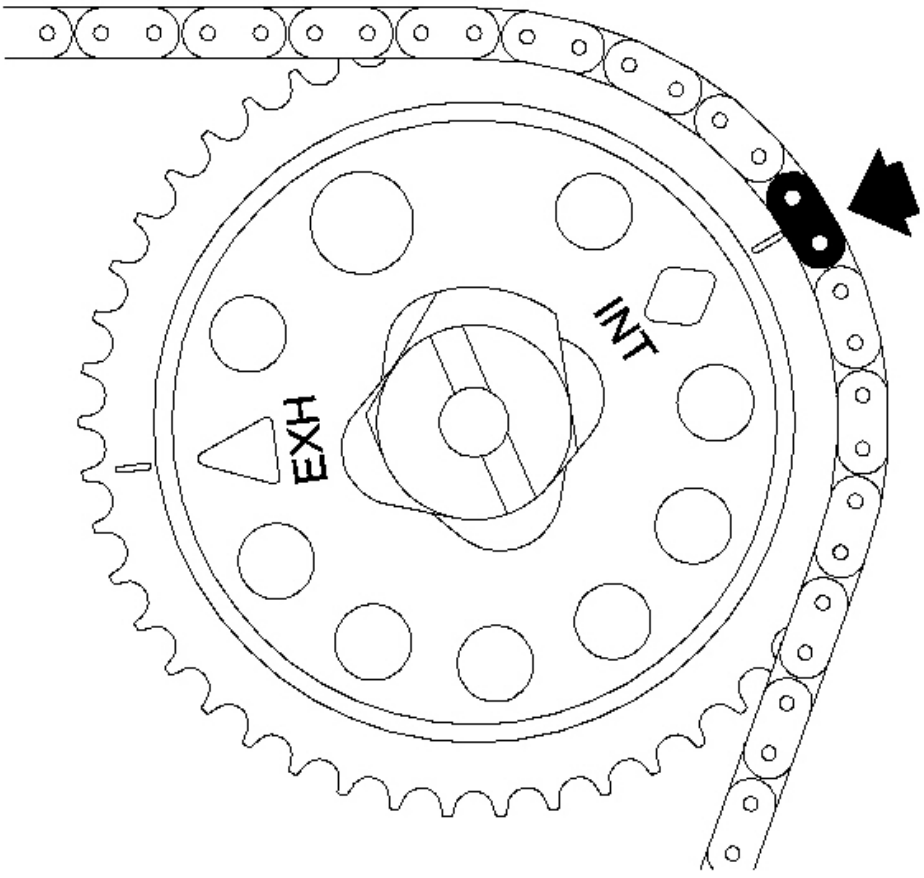


Fig. 266: Positioning Intake Camshaft
Courtesy of GENERAL MOTORS CORP.

14. Assemble the chain to the intake camshaft sprocket aligning the copper link to INT diamond timing mark on camshaft sprocket.

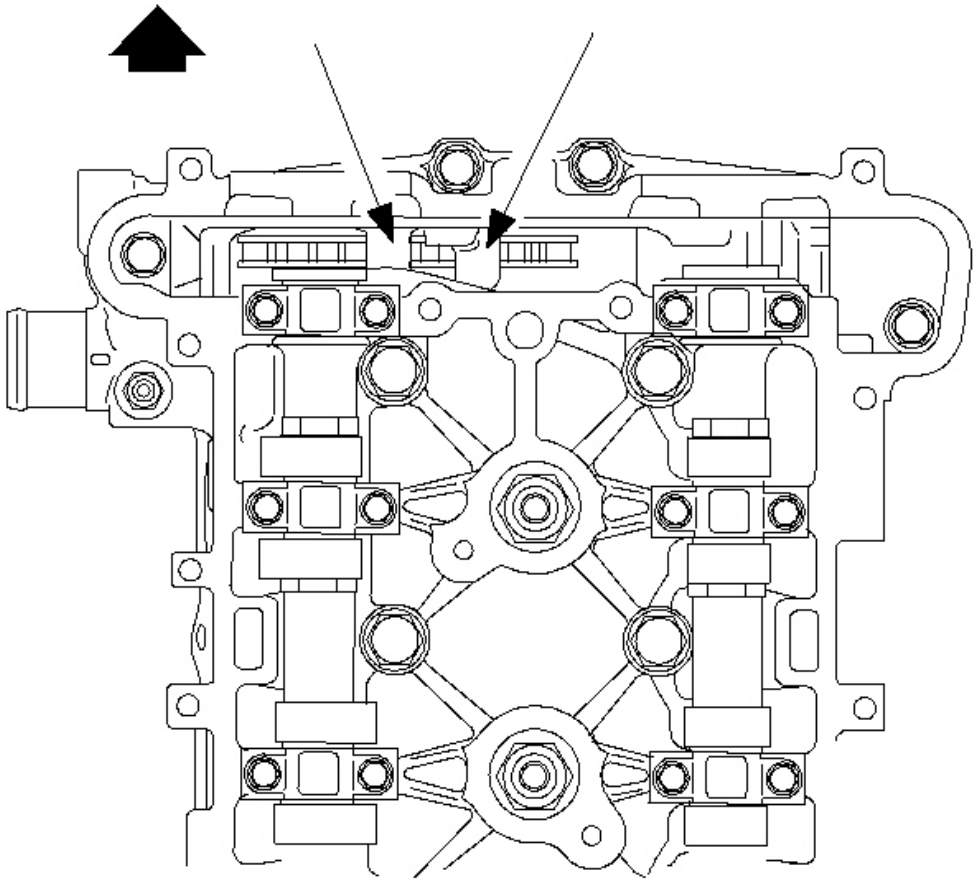


Fig. 267: Rotating Assembly 90 Degrees To Allow The Chain To Fall Between The Cylinder Block Bosses
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: When lowering the timing chain into the cylinder head, rotate the assembly 90 degrees to allow the chain to fall between the cylinder block bosses, then rotate assembly back to that the camshaft sprocket is facing forward.

15. Lower assembly through chain housing opening on top of the cylinder head. Use care to make sure that the chain goes around both sides of the cylinder block bosses.

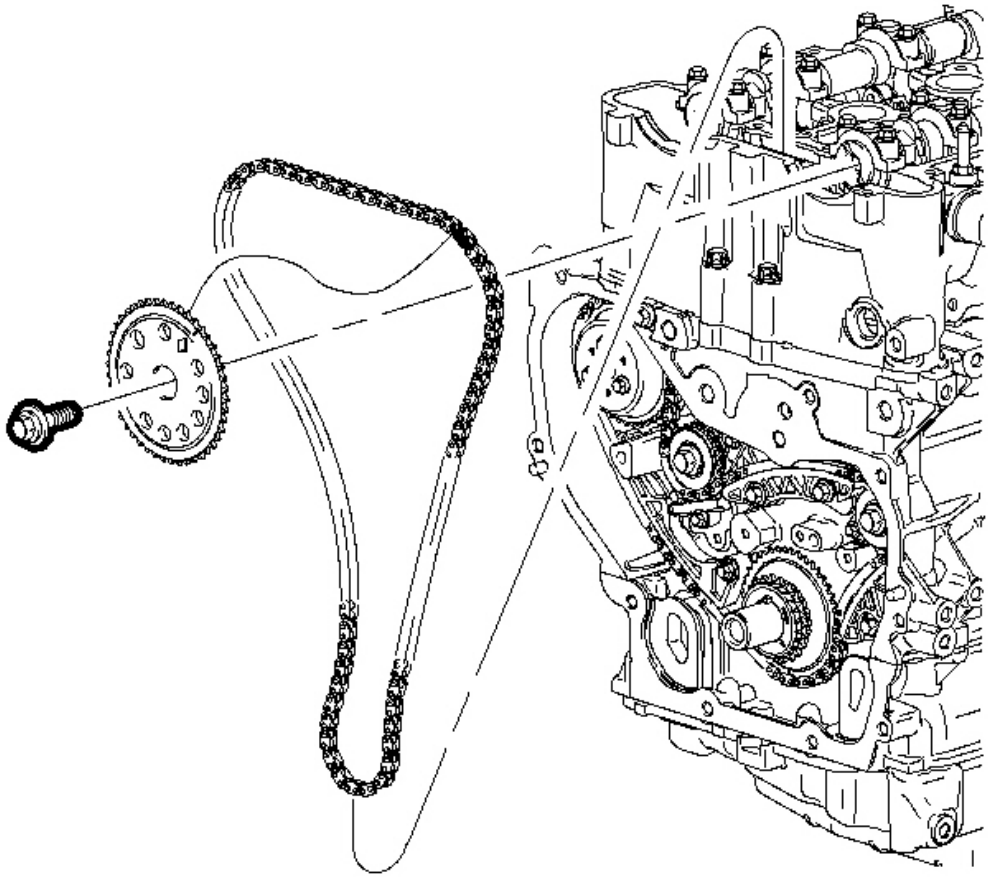


Fig. 268: Routing The Timing Chain Around The Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The crankshaft sprocket timing mark will be at approximately the 5 o'clock position.

16. Route chain around crankshaft sprocket and align silver link to timing mark.

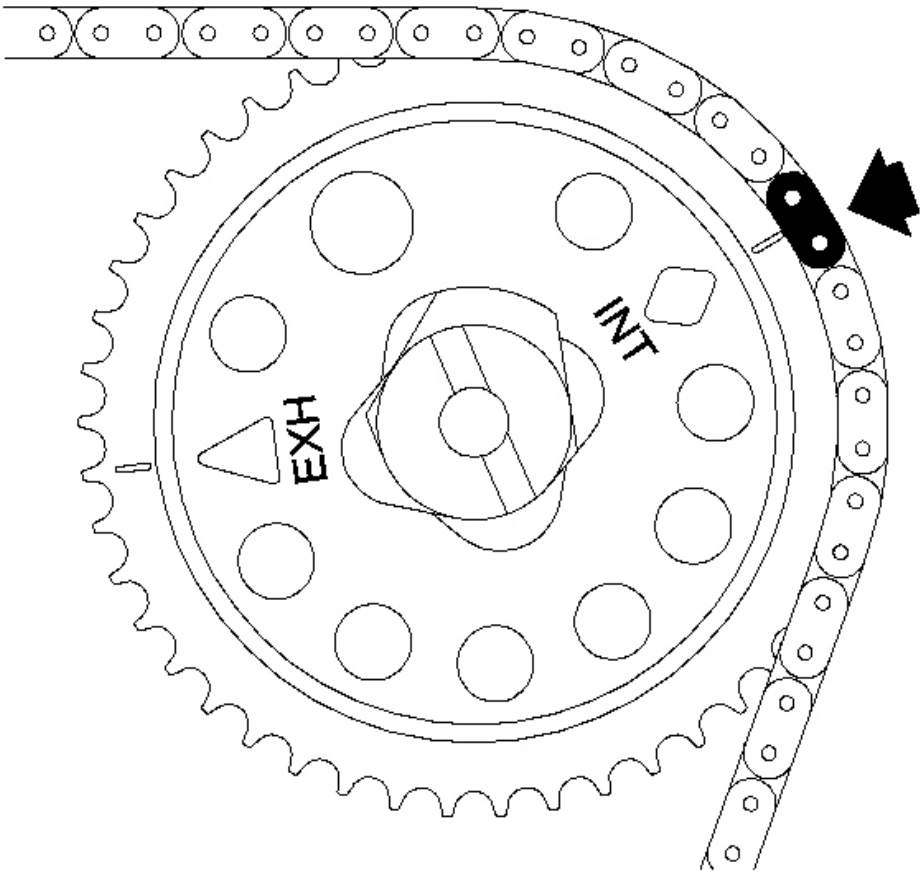


Fig. 269: Positioning Intake Camshaft
Courtesy of GENERAL MOTORS CORP.

NOTE: The camshaft sprocket bolts are not reusable, it is a torque-to-yield (TTY) bolt, and must be discarded to prevent premature failure.

17. Install the intake camshaft sprocket with the chain in the proper position to the camshaft. Rotate the intake camshaft using a 24 mm wrench on flats on camshaft until camshaft aligns with sprocket.

IMPORTANT: With the timing chain aligned to crankshaft sprocket mark, the crankshaft can be rotated slightly to eliminate slack from the fixed side of the timing chain. Be sure that the marks are properly aligned.

18. Install new intake camshaft sprocket bolt and finger tighten.

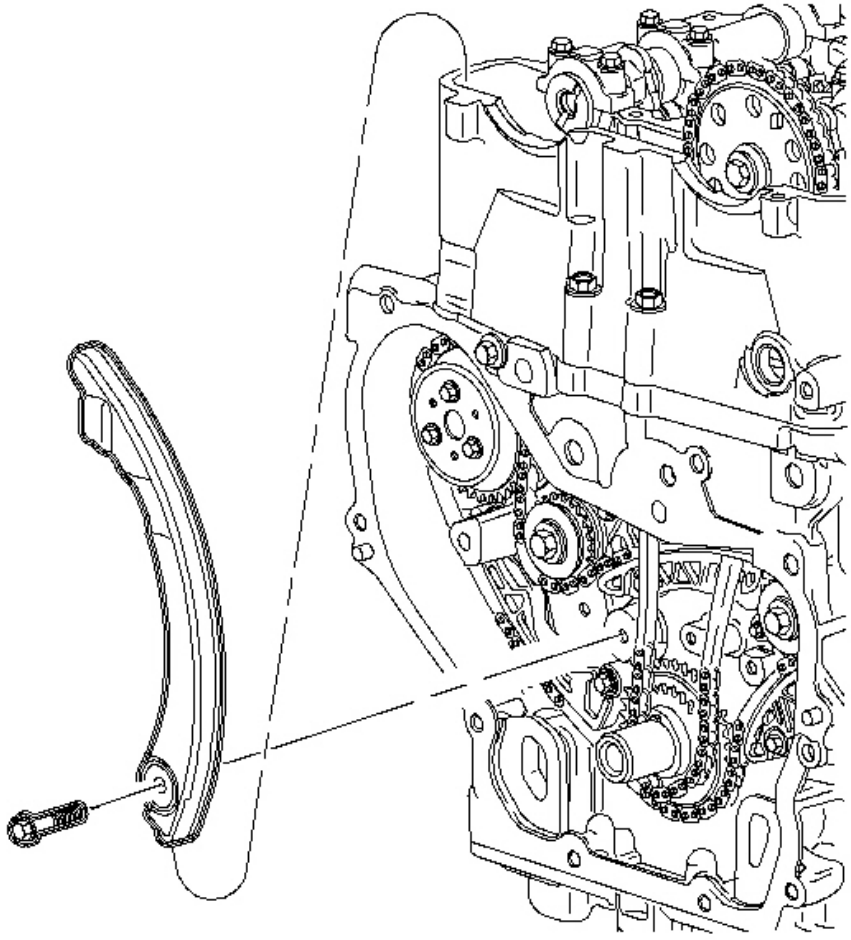


Fig. 270: Timing Chain Adjustable Guide And Bolt
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Make sure the crankshaft marks and the camshaft marks aligns with the colored links.

19. Install adjustable timing chain guide through the opening at the top of the cylinder head and install chain guide bolt.

Tighten: Tighten the timing chain guide adjustable bolt to 10 N.m (89 lb in).

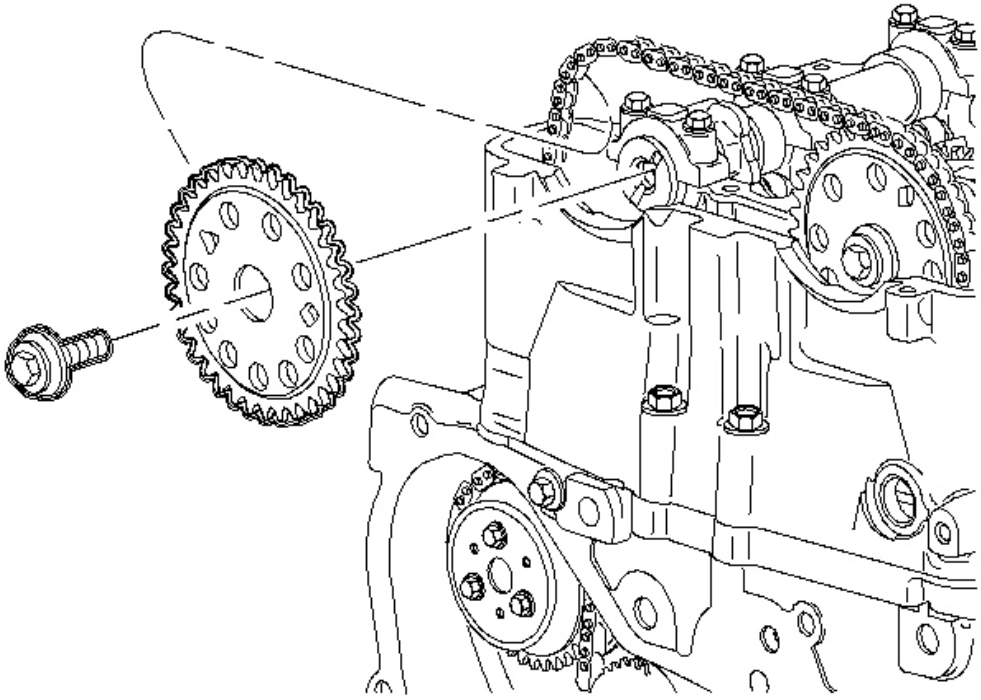


Fig. 271: Removing/Installing Camshaft Sprocket Bolt
Courtesy of GENERAL MOTORS CORP.

20. Install exhaust camshaft sprocket loosely on exhaust camshaft with timing mark on sprocket aligned with silver link.
21. Install new camshaft sprocket bolt loosely.

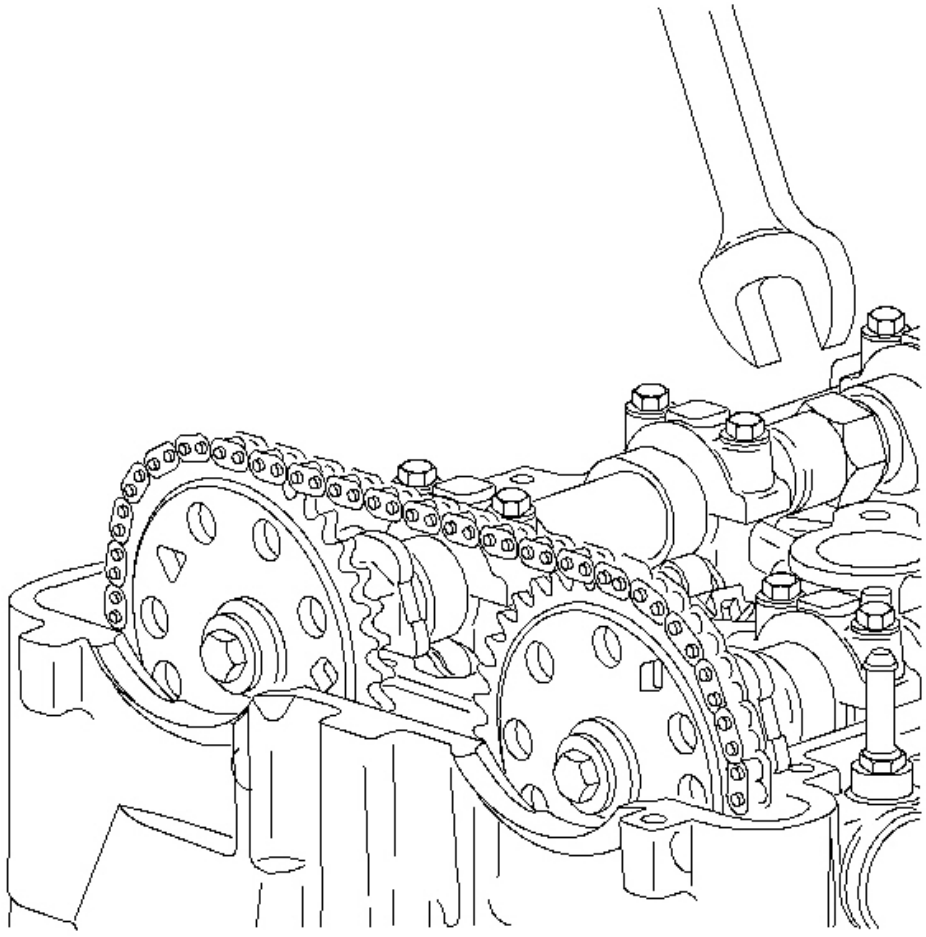


Fig. 272: Using 24 mm Wrench To Support The Camshaft
Courtesy of GENERAL MOTORS CORP.

22. Align the exhaust camshaft sprocket with the chain in proper position to the camshaft. Rotate exhaust clockwise using a 24 mm wrench on flats on camshaft until the camshaft aligns with sprocket.

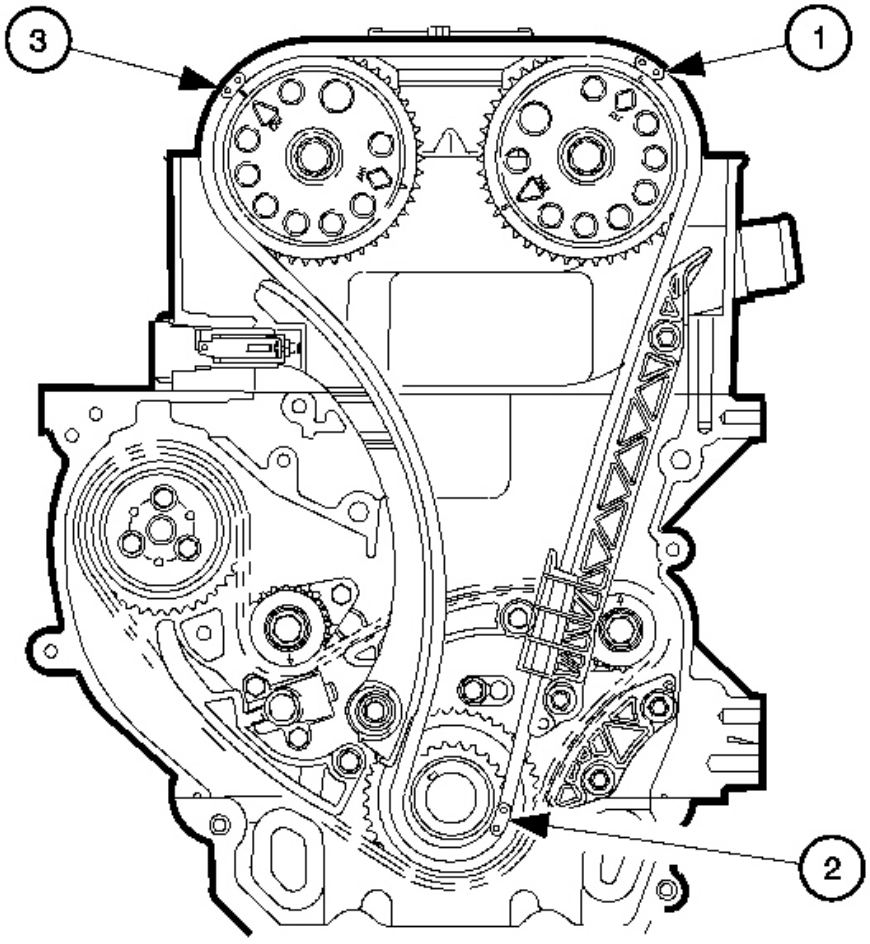


Fig. 273: Verifying Crankshaft Sprocket & Exhaust Marks
Courtesy of GENERAL MOTORS CORP.

23. Verify that all colored links are aligned with the appropriate intake (1), crankshaft sprocket (2), and exhaust marks.
24. Verify crankshaft sprocket timing mark is at the 5 o'clock position.
25. If marks are not correct you must repeat the timing procedure.

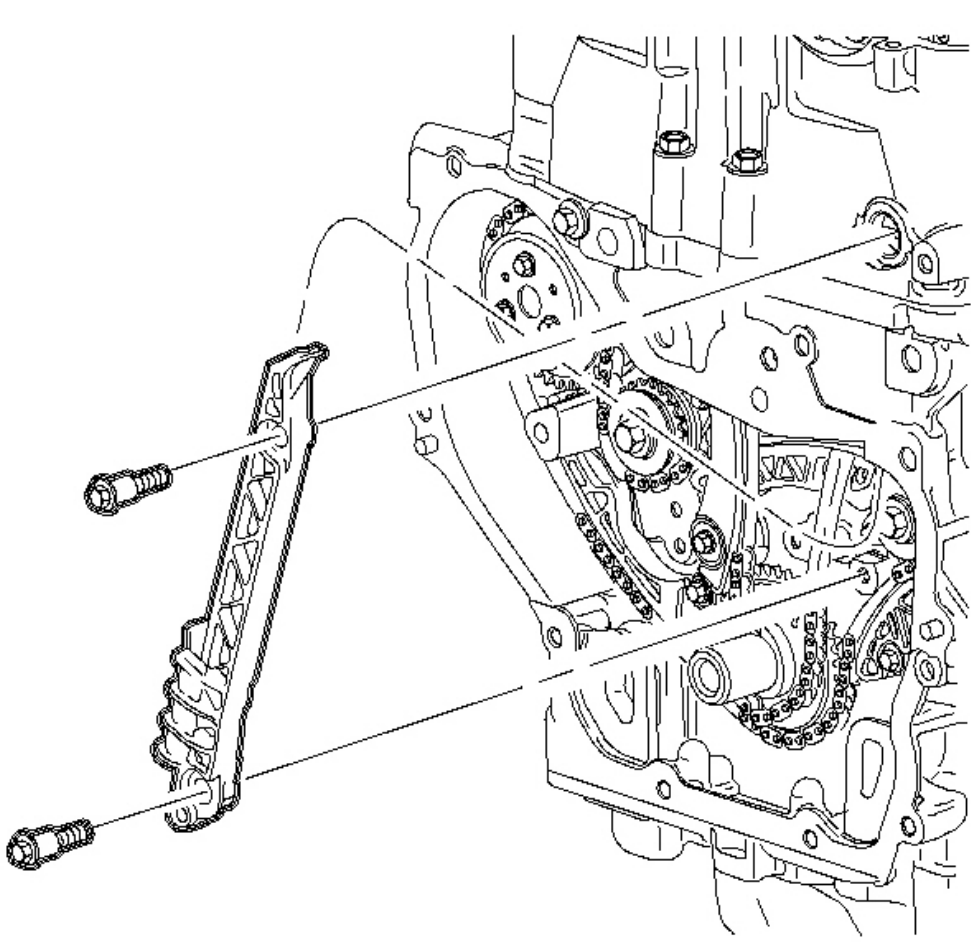


Fig. 274: Fixed Timing Chain Guide & Bolts
Courtesy of GENERAL MOTORS CORP.

26. Install the fixed timing chain guide and bolts.

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

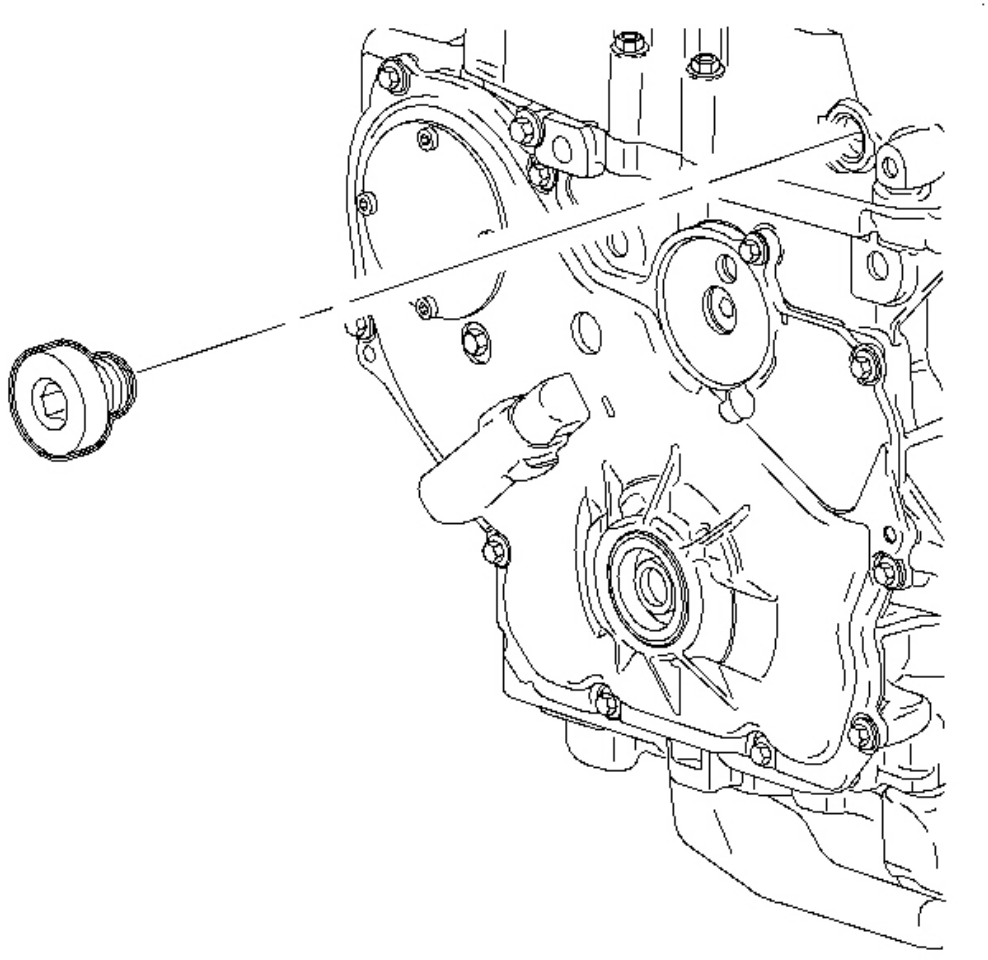


Fig. 275: Removing Fixed Timing Chain Guide Access Plug
Courtesy of GENERAL MOTORS CORP.

27. Apply thread sealant Permatex(R) Thread Pipe Sealant (or equivalent) compound to the thread. Install the fixed guide bolt access hole plug.

    Tighten: Tighten the timing chain guide bolt access hole plug to 40 N.m (30 lb ft).

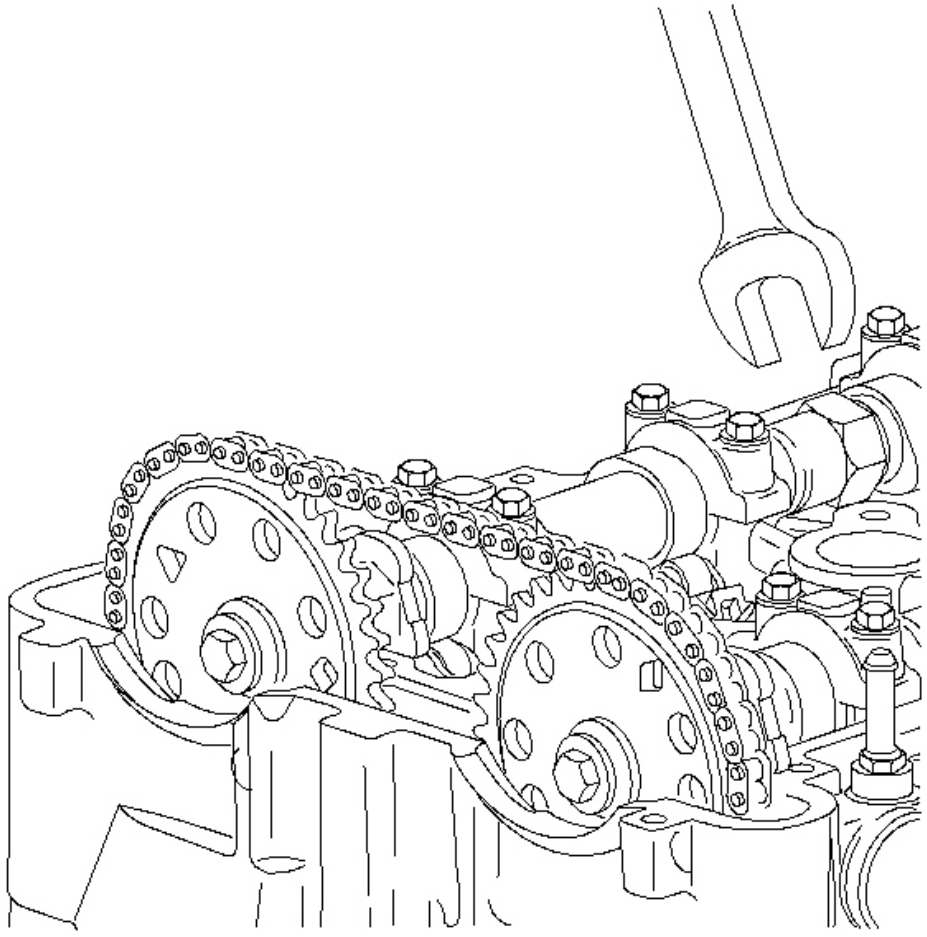


Fig. 276: Using 24 mm Wrench To Support The Camshaft
Courtesy of GENERAL MOTORS CORP.

NOTE: Use a 24 mm wrench to support the camshaft while applying torque to camshaft sprocket bolt. Do not torque camshaft bolts against timing chain, as it may damage the timing chain.

28. Tighten the intake and exhaust camshaft sprocket bolts while holding the camshaft with 24 mm wrench.

    Tighten: Tighten the camshaft sprocket bolts to 85 N.m (63 lb ft) +30 degrees.

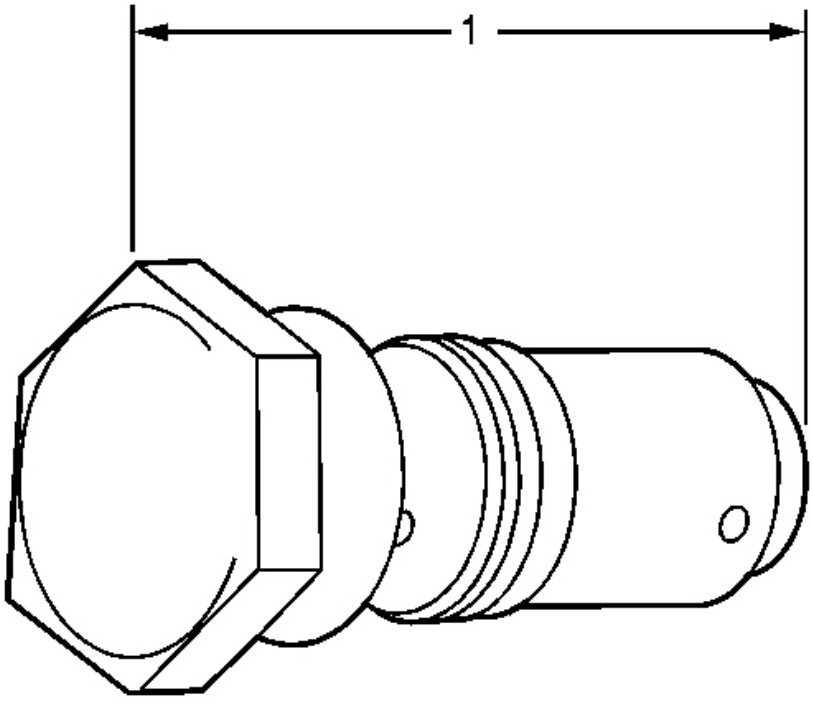


Fig. 277: Inspecting Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

29. Inspect the timing chain tensioner. If the timing chain tensioner, O-ring or washer is damaged replace the timing chain tensioner.

IMPORTANT: 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) (1) from end to end. A tensioner in the active state will measure 85 mm (3.35 in) (1) from end to end.

30. Measure the timing chain tensioner assembly from end to end.

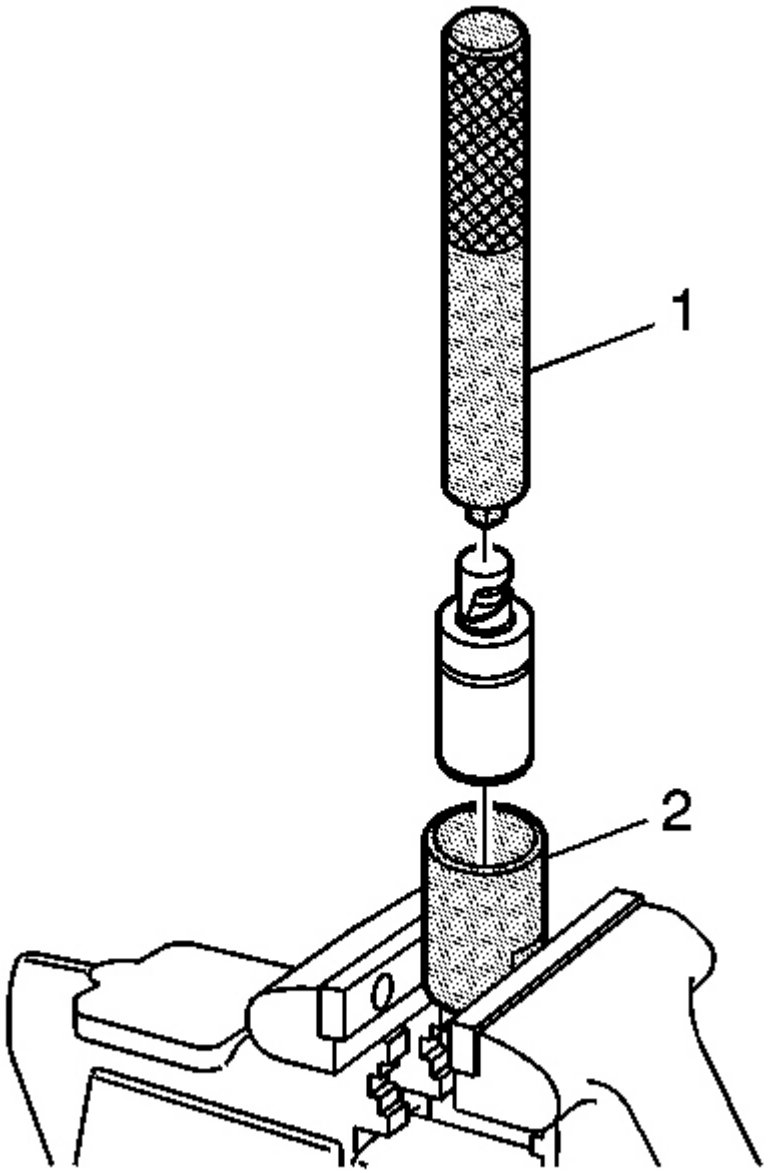


Fig. 278: View Of Tensioner Tool
Courtesy of GENERAL MOTORS CORP.

31. 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 **J 45027** (2) into a vise. See **Special Tools and Equipment** .

3. Install notch end of piston assembly into **J 45027** (2). See **Special Tools and Equipment** .
4. Using **J 45027** (1), turn the ratchet cylinder into the piston. See **Special Tools and Equipment** .

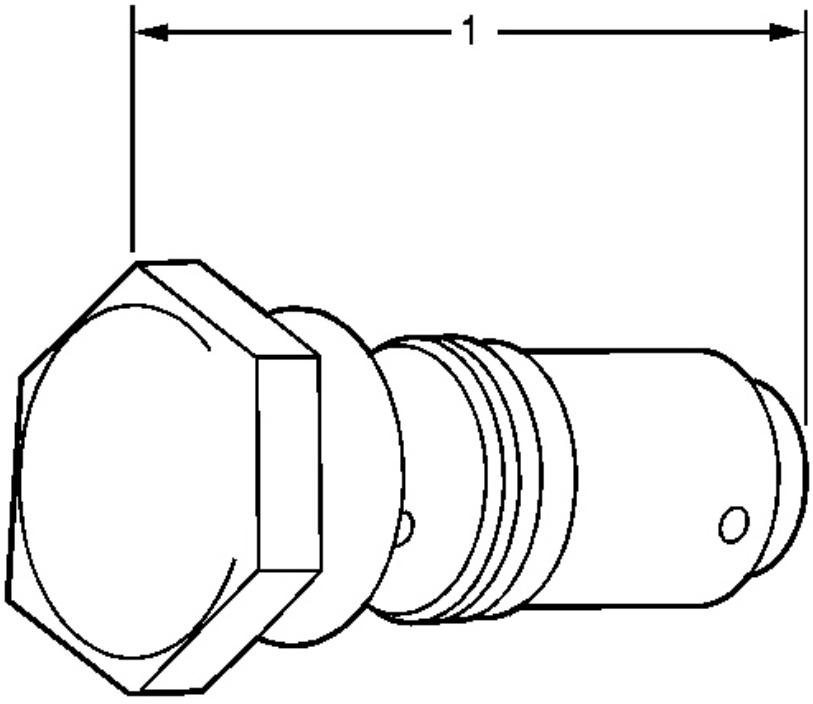


Fig. 279: Inspecting Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

32. 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 lint free cloth.
33. 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.

34. At this point the tensioner should measure approximately 72 mm (2.83 in) (1) from end to end. If the tensioner does not read 72 mm (2.83 in) (1) from end to end repeat step 30.

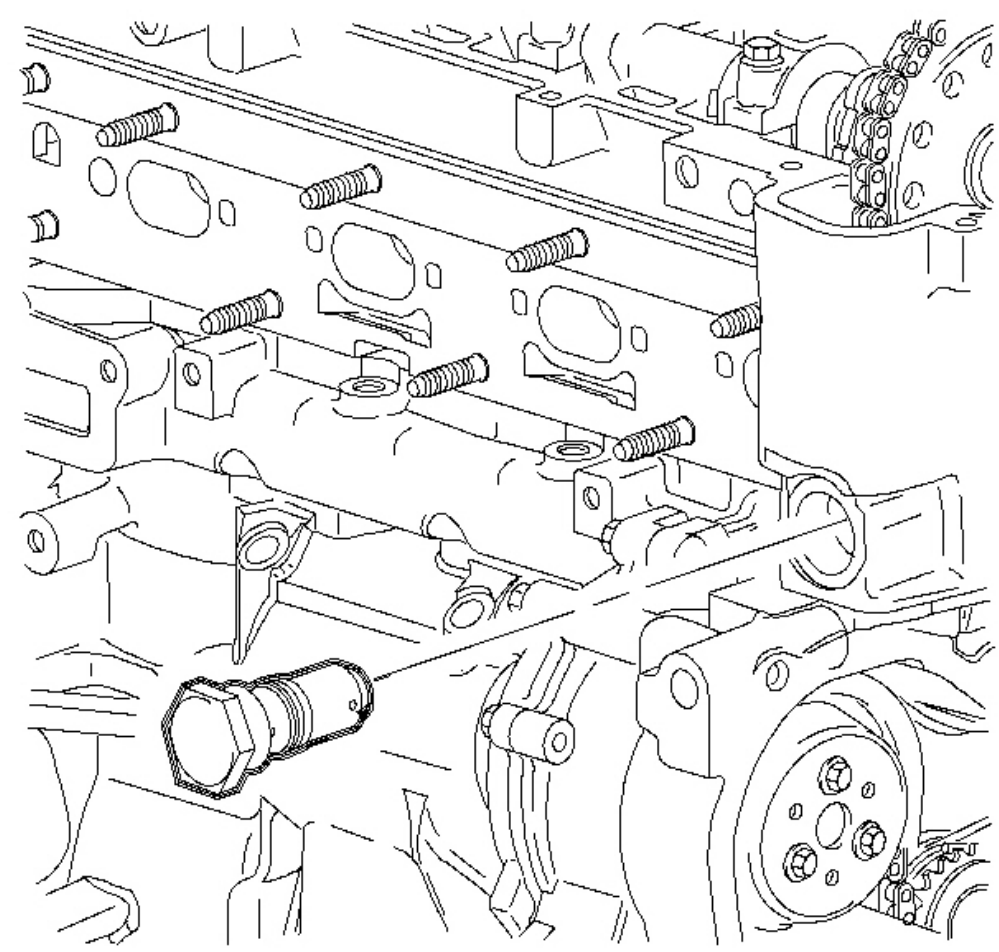


Fig. 280: Removing/Installing Timing Chain Tensioner Assembly
Courtesy of GENERAL MOTORS CORP.

35. Ensure all dirt and debris is removed from the timing chain tensioner threaded hold in the cylinder head.
36. Install new timing chain tensioner assembly and tighten.

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

37. 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.

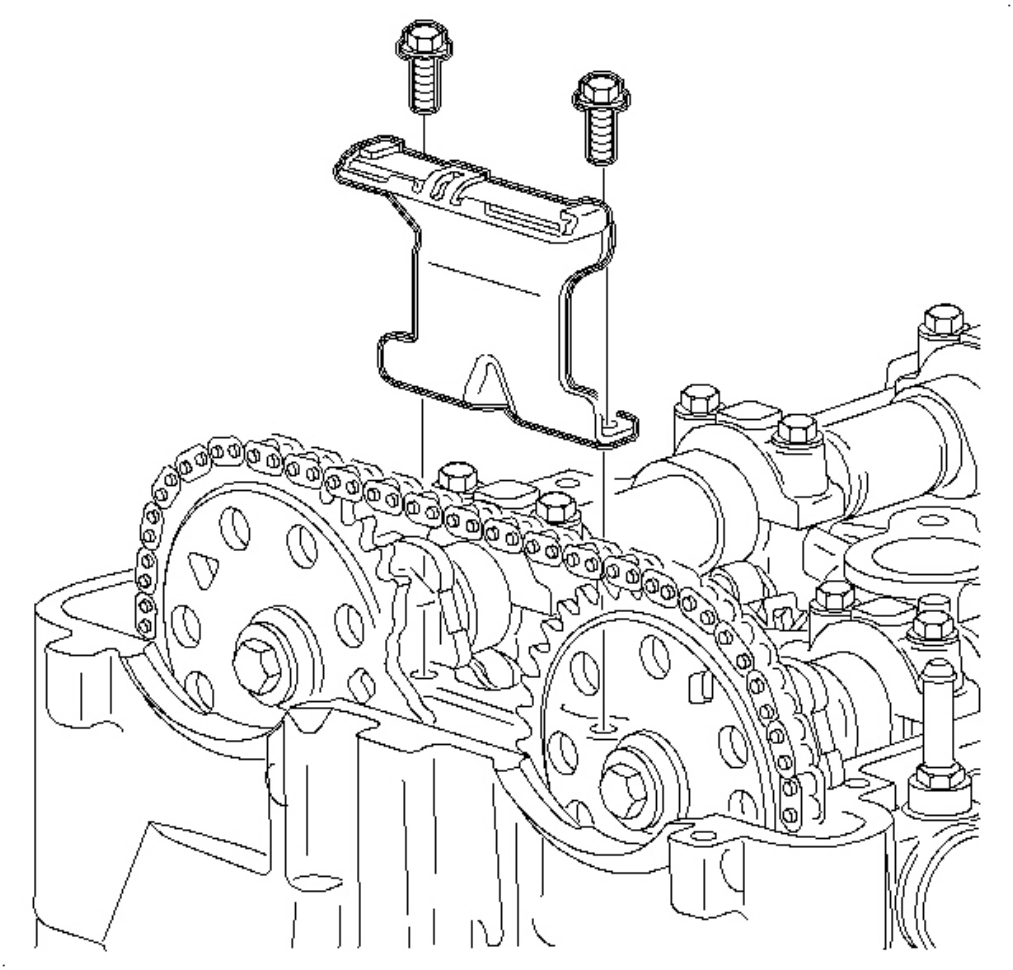


Fig. 281: Removing/Installing Upper Timing Chain Guide & Bolts
Courtesy of GENERAL MOTORS CORP.

38. Install upper timing chain guide and bolts.

    Tighten: Tighten the timing chain guide upper bolts to 10 N.m (89 lb ft).

39. Raise the vehicle if necessary.
40. Install new front cover gasket.
41. Install the front cover assembly.

42. Install the front cover assembly bolts.

    Tighten: Tighten the front cover-to-block bolts to 25 N.m (18 lb ft).

43. Install the front cover water pump bolts.

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

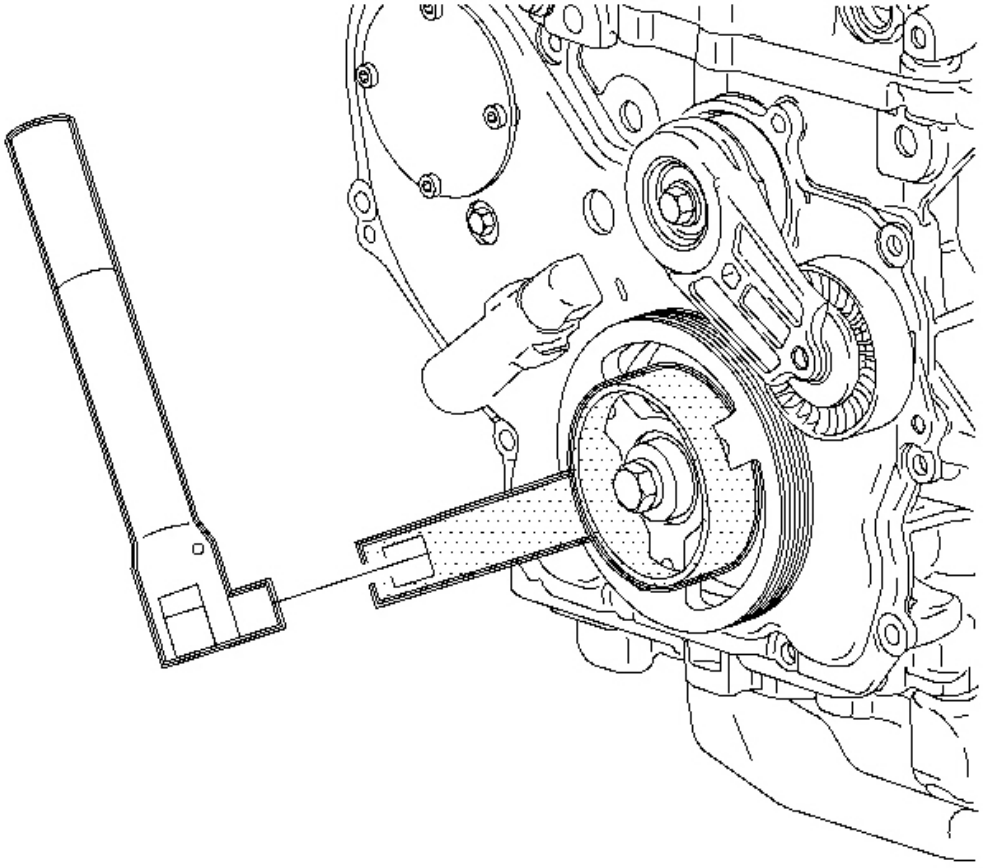


Fig. 282: Installing Crankshaft Pulley Holder
Courtesy of GENERAL MOTORS CORP.

44. Lubricate the front seal and sealing surface of the pulley with clean motor oil.

45. Install balancer pulley onto crankshaft indexing keyway. Use care to properly align flats on balancer pulley with flats on oil pump drive in front cover assembly.
46. Install the crankshaft damper pulley.

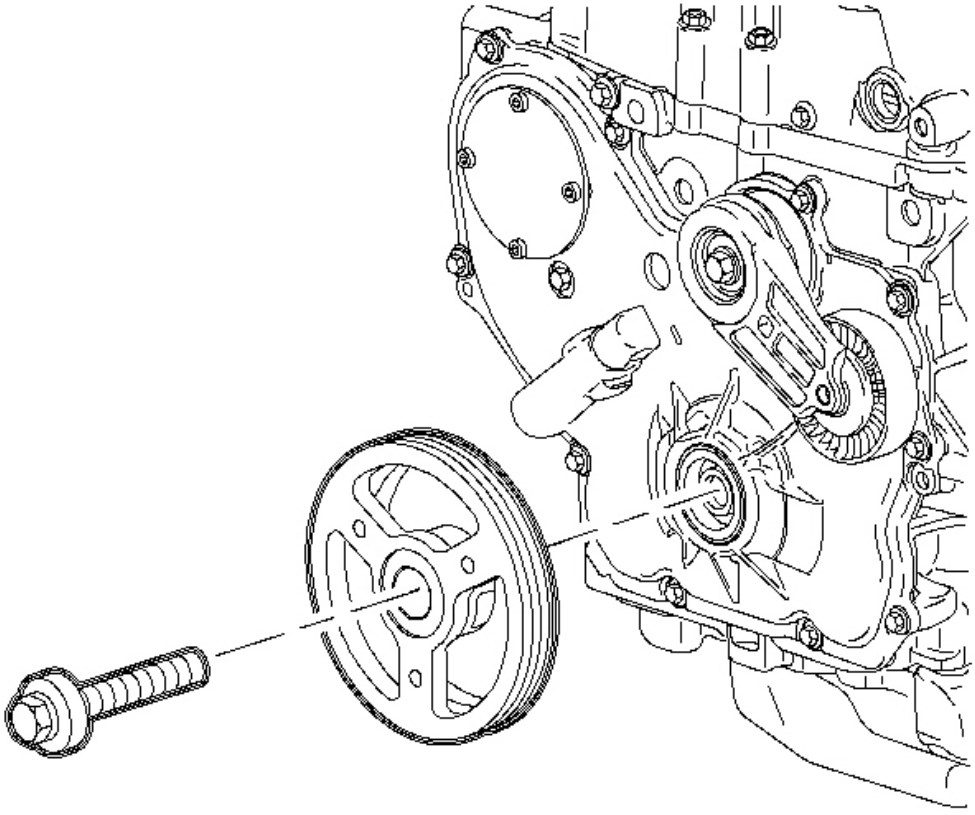


Fig. 283: Removing/Installing Crankshaft Balancer Pulley Bolt
Courtesy of GENERAL MOTORS CORP.

47. Install new crankshaft balancer pulley bolt with washer assembly.

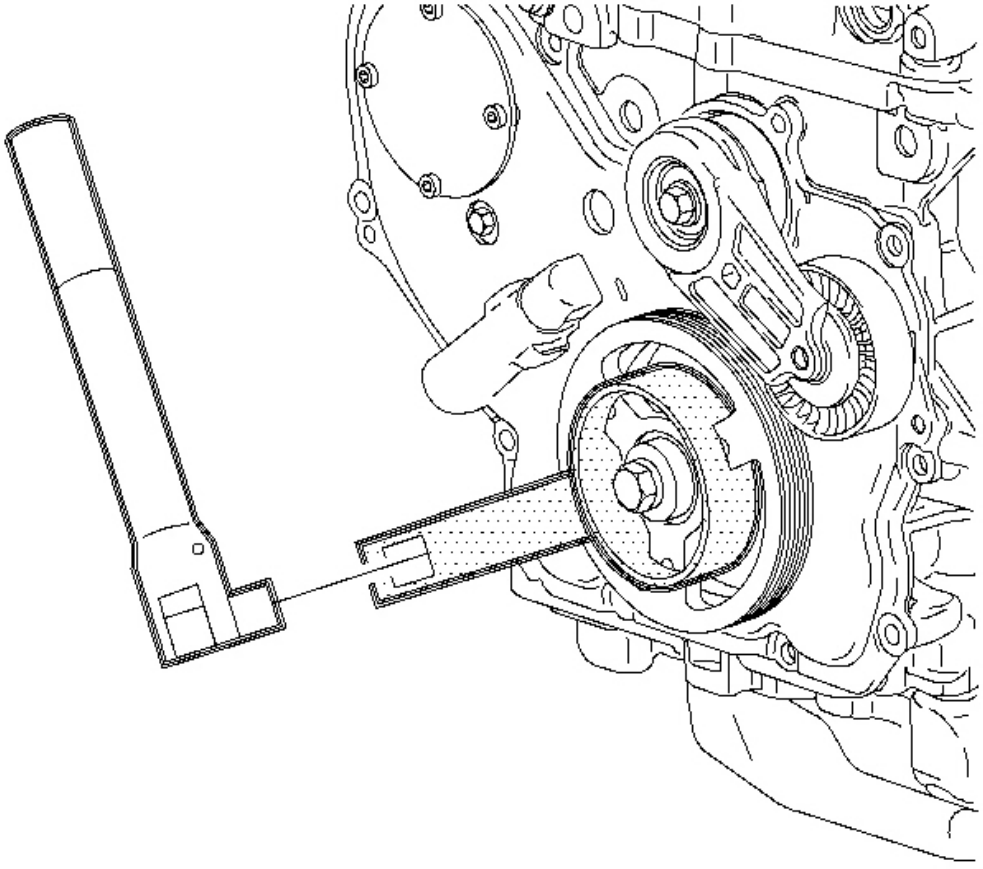


Fig. 284: Installing Crankshaft Pulley Holder
Courtesy of GENERAL MOTORS CORP.

48. Install crankshaft pulley holder **J 38122-A** . See **Special Tools and Equipment** .

Tighten: Tighten the crankshaft pulley bolt to 100 N.m (74 lb ft) +75.

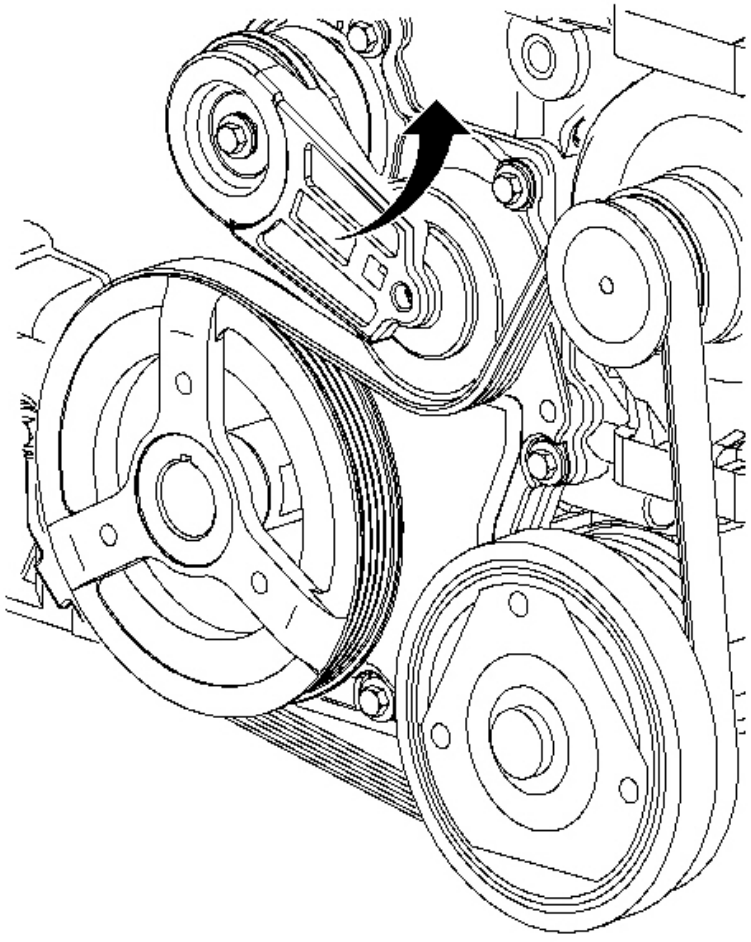


Fig. 285: Installing Accessory Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

49. Install accessory drive belt tensioner.

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

50. Route belt around the alternator and the A/C compressor.
51. Install **J 39914** onto tensioner and upload spring tension from tensioner while positioning belt. See **Special Tools and Equipment** .
52. Release tensioner and remove the tool
53. Position manifold down pipe with gasket onto flange studs.

54. Install exhaust manifold pipe to exhaust manifold nuts.

    Tighten: Tighten the exhaust manifold nuts to 30 N.m (22 lb ft).

55. Attach electrical harness at bottom intake manifold.
56. Position oil level indicator into oil pan assembly.
57. Install oil level indicator tube bolt.

    Tighten:: Tighten the oil level indicator-to-manifold bolt to 10 N.m (89 lb in).

58. Remove the oil drain plug and drain oil.

    Tighten: Tighten the oil drain plug to 25 N.m (18 lb ft).

59. Lower the vehicle.
60. Remove the oil filter and install a new oil filter.
61. Fill the engine with oil.

    Tighten: Tighten the oil filter cap to 25 N.m (18 lb ft)

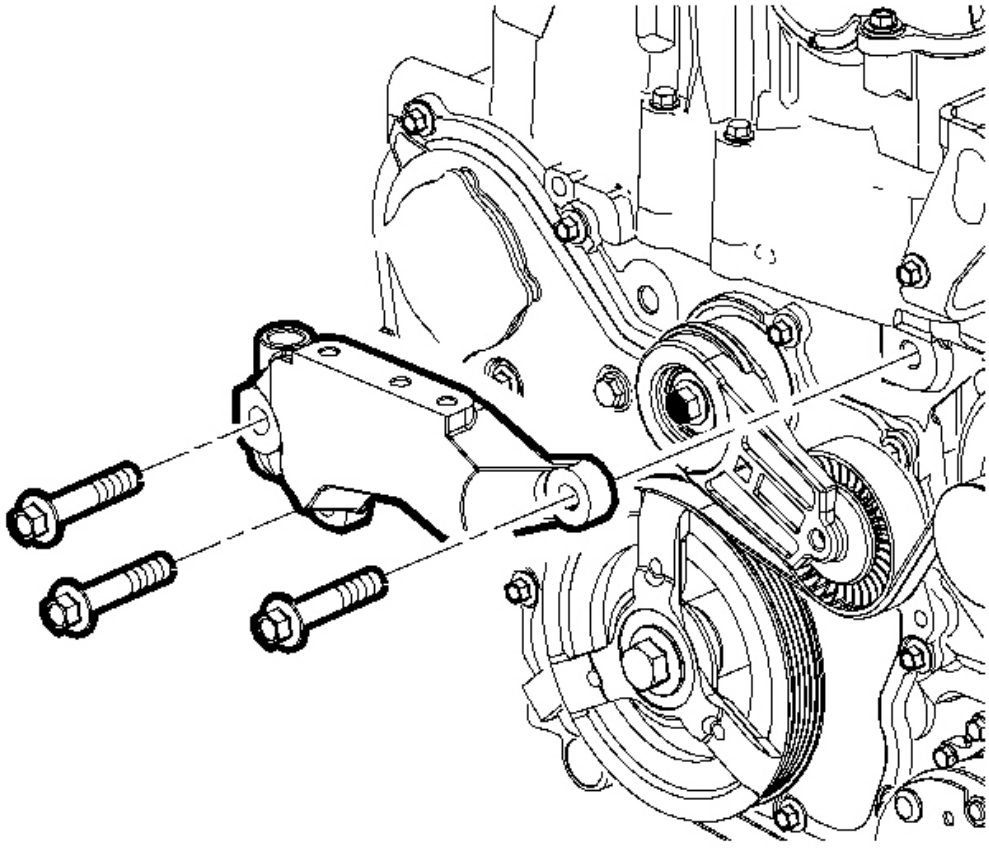


Fig. 286: Removing/Installing Right Hand Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

62. Install right-hand engine bracket and bolts.

    Tighten: Tighten the engine mount bracket-to-engine bolts to 90 N.m (66 lb ft).

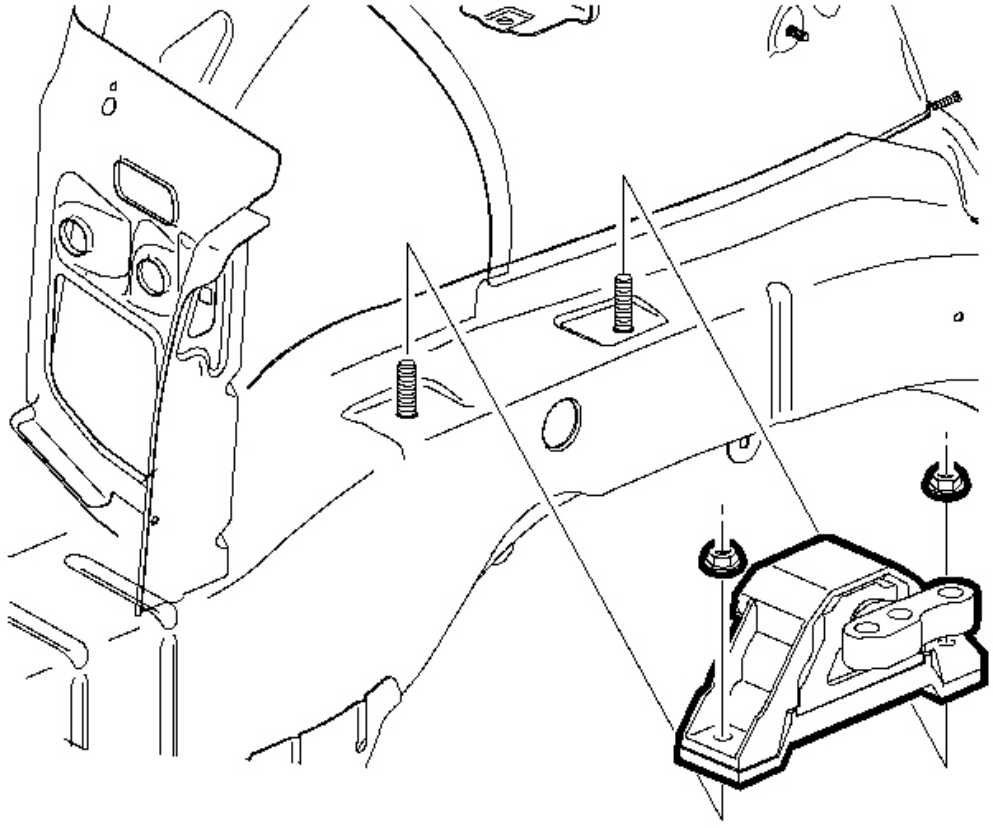


Fig. 287: View Of RH Engine Mount
Courtesy of GENERAL MOTORS CORP.

63. Install shims on right hand engine mount studs.
64. Install right-hand engine mount onto body side rail studs.
65. Install right-hand engine mount to body nuts.

    Tighten: Tighten the engine mount-to-body nuts to 110 N.m (81 lb ft).

66. Install right-hand engine mount to engine mount bracket bolts.

    Tighten: Tighten engine mount-to-engine mount bracket bolts to 55 N.m (41 lb ft).

67. Install the right engine inner splash shield.
68. Install the right wheel and hand-tighten wheel nuts.
69. Tighten wheel nuts.

    Tighten: Tighten wheel nuts to 125 N.m (92 lb ft).

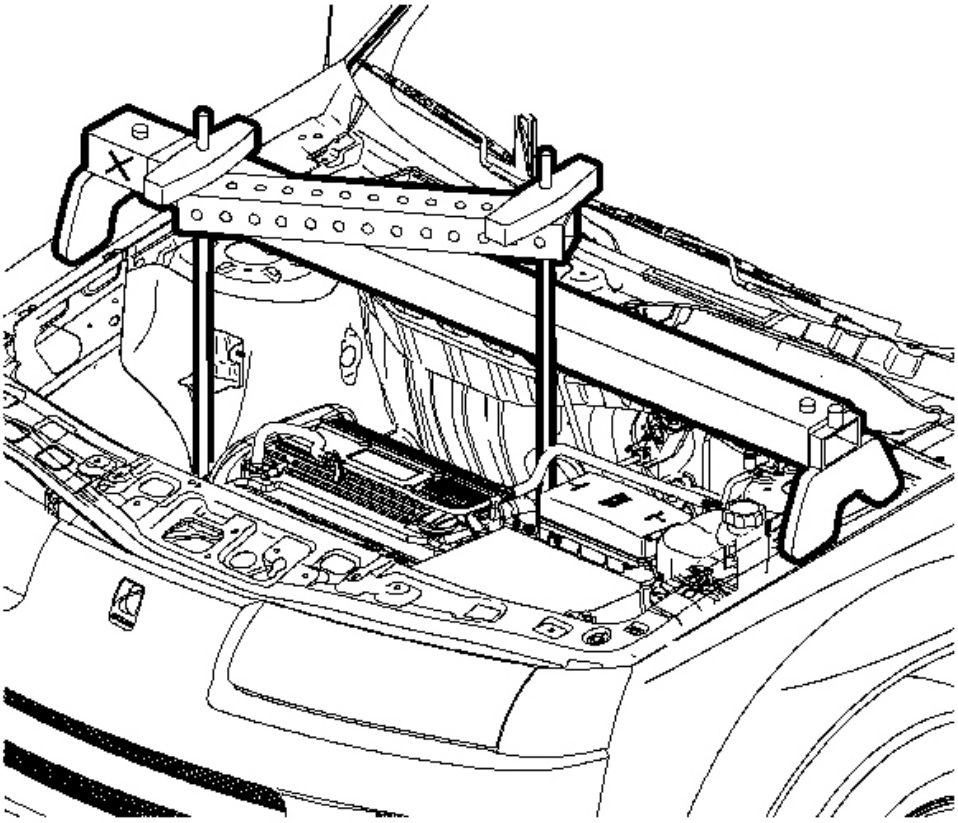


Fig. 288: Installing SA9105E Set Up For SUV Application
Courtesy of GENERAL MOTORS CORP.

70. Remove three bar engine support fixture.

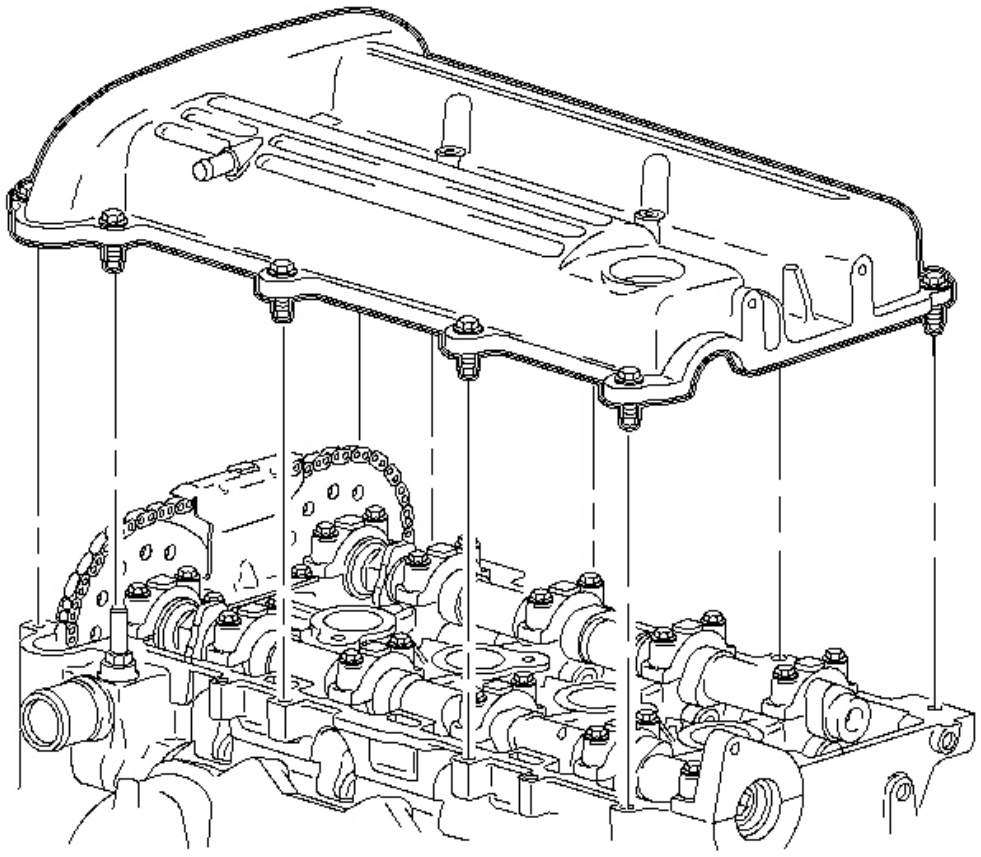


Fig. 289: Removing Cam Cover Assembly
Courtesy of GENERAL MOTORS CORP.

71. Visually inspect the camshaft cover gasket for signs of leakage. Camshaft cover gasket is reusable if not damaged.
72. Assemble the camshaft cover and gasket using care to make sure that the gasket is located in the retaining groove on the camshaft cover.
73. Install cover on the cylinder head and tighten the bolts.

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

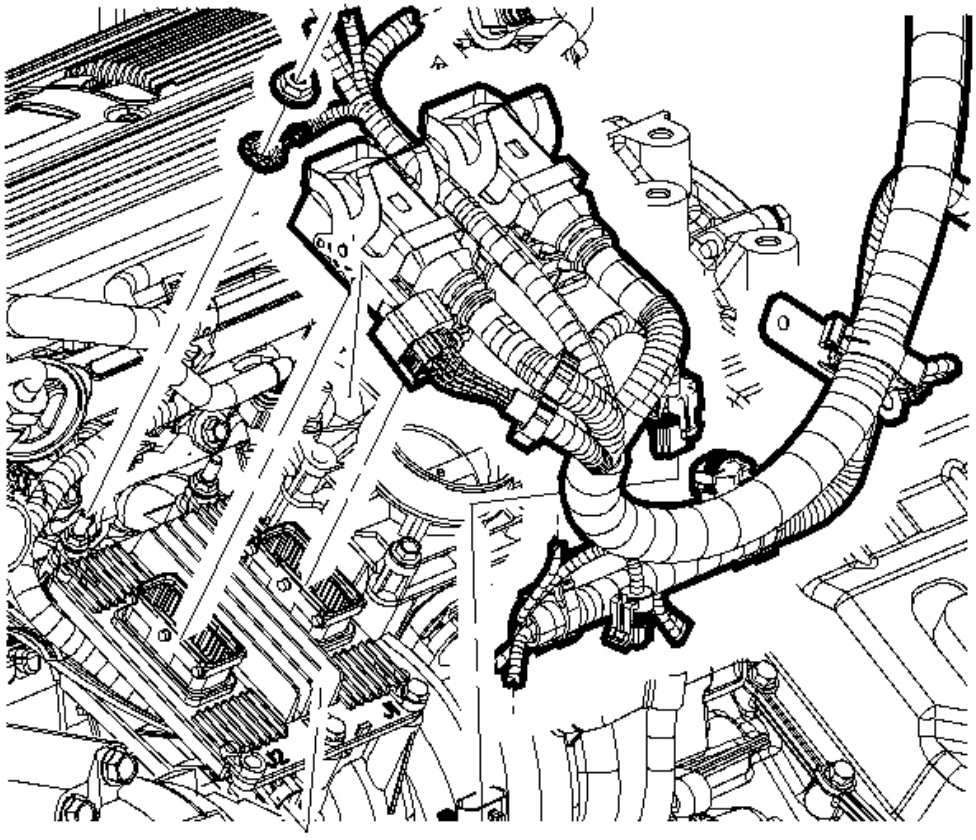


Fig. 290: Removing/Installing ECM Assembly & Bolts
Courtesy of GENERAL MOTORS CORP.

74. Position engine harness and install fasteners at cam cover.
75. Connect the throttle body connector.
76. Attach ECM ground and ECM connector.
77. Connect the fuel injector harness.
78. Connect the upper radiator hose.
79. Connect the brake booster hose at booster
80. Connect EVAP purge hose and connector.
81. Connect the oxygen sensors at the exhaust manifold.

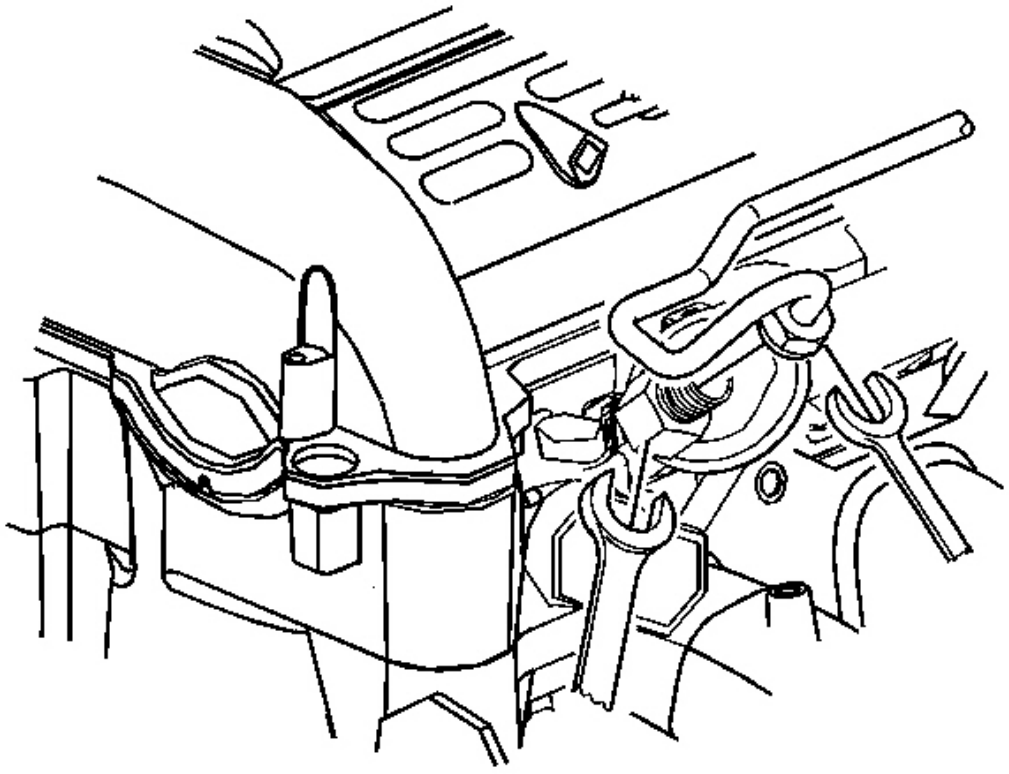


Fig. 291: Repositioning Fuel Line Assembly
Courtesy of GENERAL MOTORS CORP.

82. Reposition the fuel line assembly.

NOTE: An open-end wrench must be used to support the fuel line to rail connection during loosening/tightening to avoid damaging the fuel rail assembly.

83. Install transfer line at fuel-to-fuel rail.

Tighten: Tighten the transfer line fitting-to-fuel rail to 10 N.m (89 lb in).

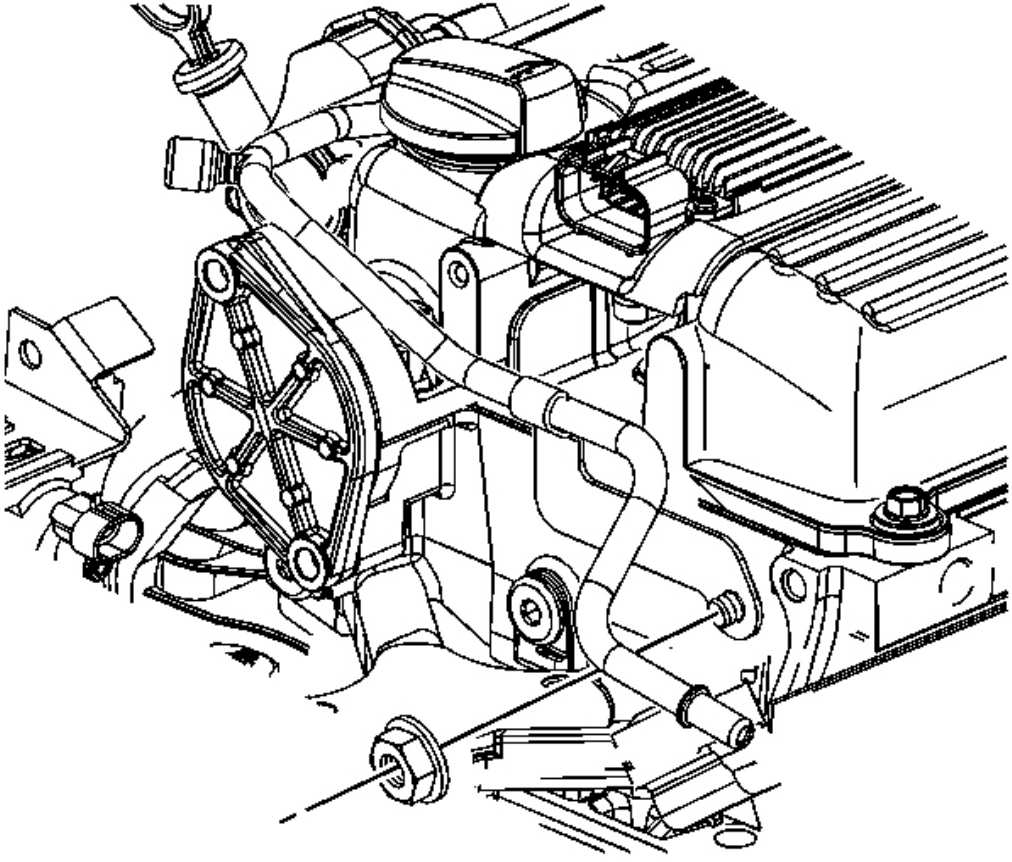


Fig. 292: Fuel Rail Bracket
Courtesy of GENERAL MOTORS CORP.

84. Connect the fuel rail bracket and bolt to the cylinder head.

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

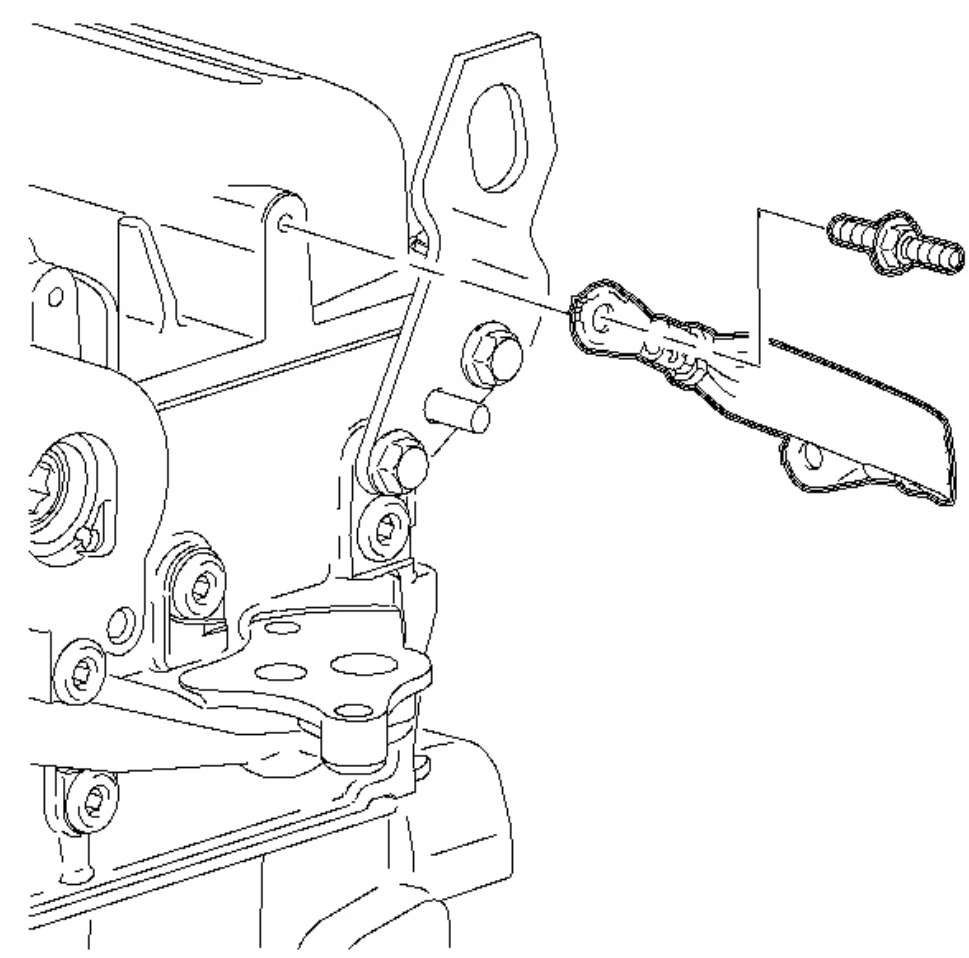


Fig. 293: Disconnecting/Connecting Ground Strap On The Camshaft Cover Assembly
Courtesy of GENERAL MOTORS CORP.

85. Connect the ground strap to the camshaft cover assembly.

    Tighten: Tighten the camshaft cover ground strap bolts to 10 N.m (89 lb in).

86. Connect the degas hose and attach to the fuel fail.
87. Connect the coolant pipe bracket bolts to the cylinder head.

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

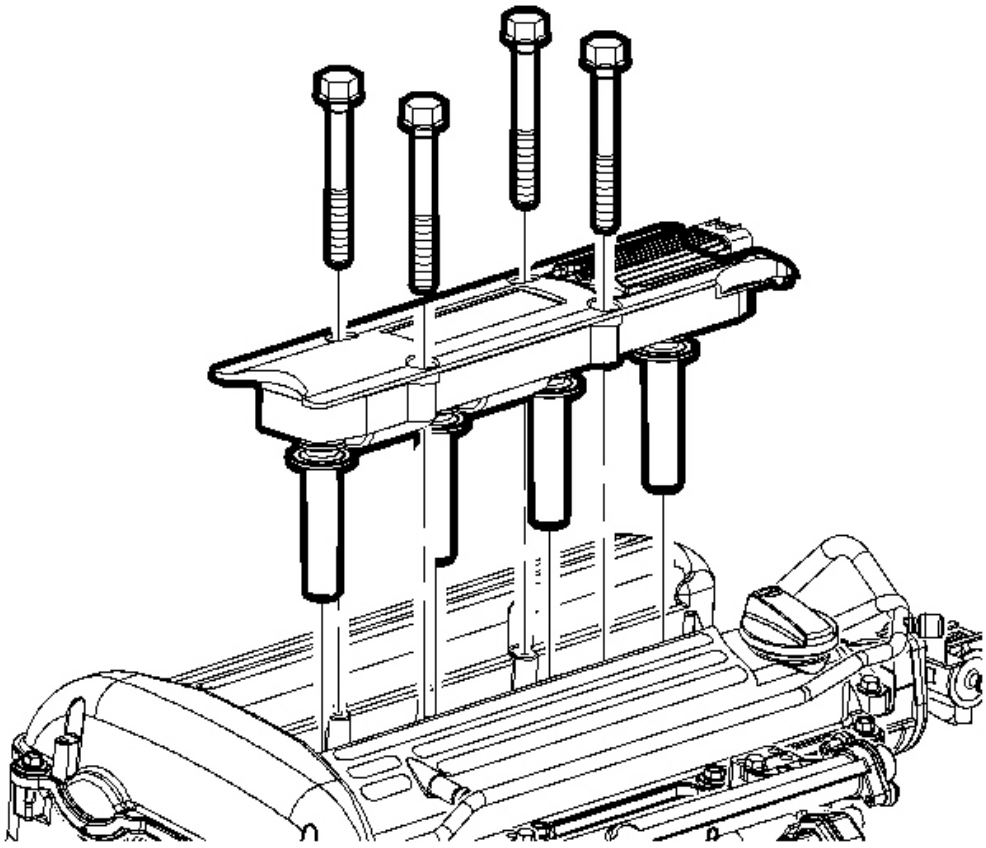


Fig. 294: Removing/Installing Ignition Module Assembly
Courtesy of GENERAL MOTORS CORP.

88. Install spark plugs, if removed.

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

89. Install the ignition module assembly to cam cover and hand tighten retaining bolts.

    Tighten: Tighten the Ignition module-to-camshaft cover bolts to 8 N.m (71 lb in).

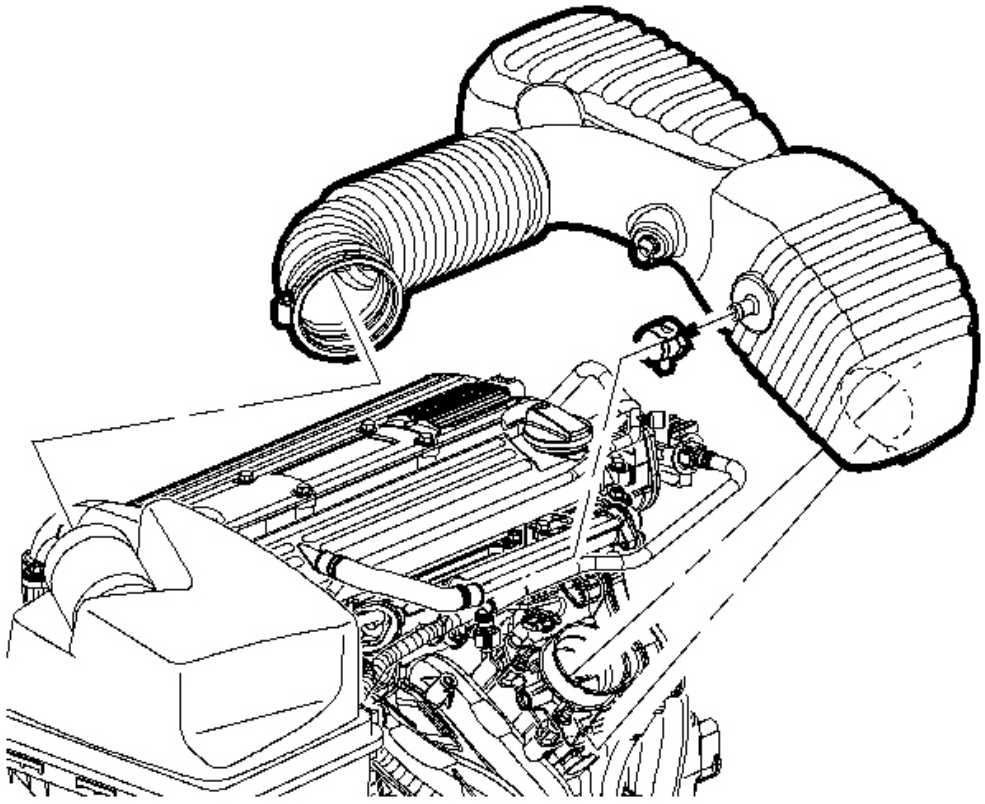


Fig. 295: Locating Air Intake Assembly
Courtesy of GENERAL MOTORS CORP.

90. Install air cleaner assembly and bolt.

    Tighten: Tighten air cleaner-to-support bracket bolt to 10 N.m (89 lb in).

91. Install outlet resonator/duct assembly into position.
92. Connect PCV fresh air vent hose assembly.
93. Tighten clamp at throttle body assembly.
94. Position outlet resonator/duct assembly up with support bracket and install push-pin.
95. Tighten the clamp at the air cleaner assembly.

96. Connect intake air temperature (IAT) sensor connector.
97. Install coolant. Refer to **Draining and Filling Cooling System** in Engine Cooling.
98. Connect negative battery cable.

    Tighten: Tighten the battery terminal bolt to 17 N.m (13 lb ft).

99. Start the vehicle and inspect for leaks.

OIL PAN REPLACEMENT

Tools Required

SA9105E Engine Support Fixture (3-Bar). See **Special Tools and Equipment** .

Removal Procedure

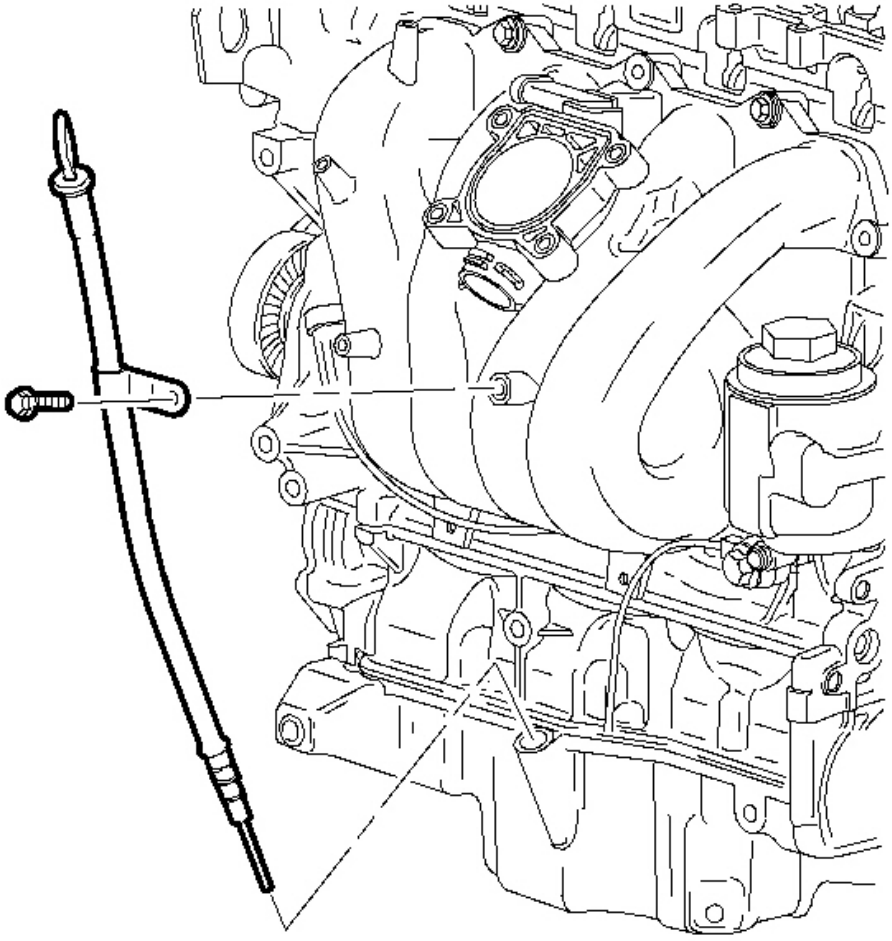


Fig. 296: View Of Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil level indicator tube bolt to manifold.
2. Remove the oil level indicator assembly.
3. Remove the oil level tube.
4. The O-ring seal should be replaced if damaged.

IMPORTANT: The support bar must be installed to provide enough access to remove and properly tighten the oil pan bolts.

5. Install the **SA9105E** set up for SUV application. See **Special Tools and Equipment** . Refer to **Engine**

Support Fixture .

6. Remove the right hand engine mount bolts to bracket and body.
7. Remove the right hand engine mount.

IMPORTANT: Clear the access as needed to the oil pan bolts for proper tightening and torque.

8. Raise the engine approximately 3 inches using the support tool.

CAUTION: Ensure that the vehicle is properly supported and squarely positioned. To help avoid personal injury when a vehicle is on a hoist, provide additional support for the vehicle on the opposite end from which the components are being removed.

9. Raise the vehicle.

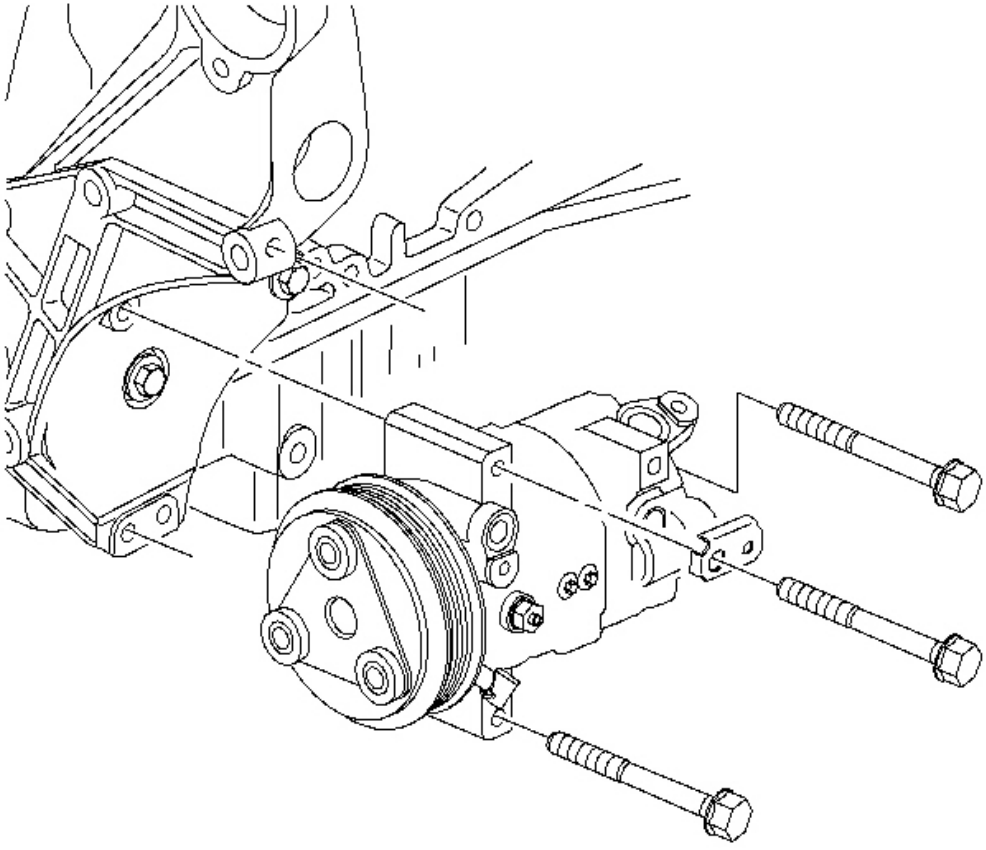


Fig. 297: Removing/Installing Lower A/C Compressor Bolt
Courtesy of GENERAL MOTORS CORP.

10. Remove only the lower A/C compressor bolt to oil pan.

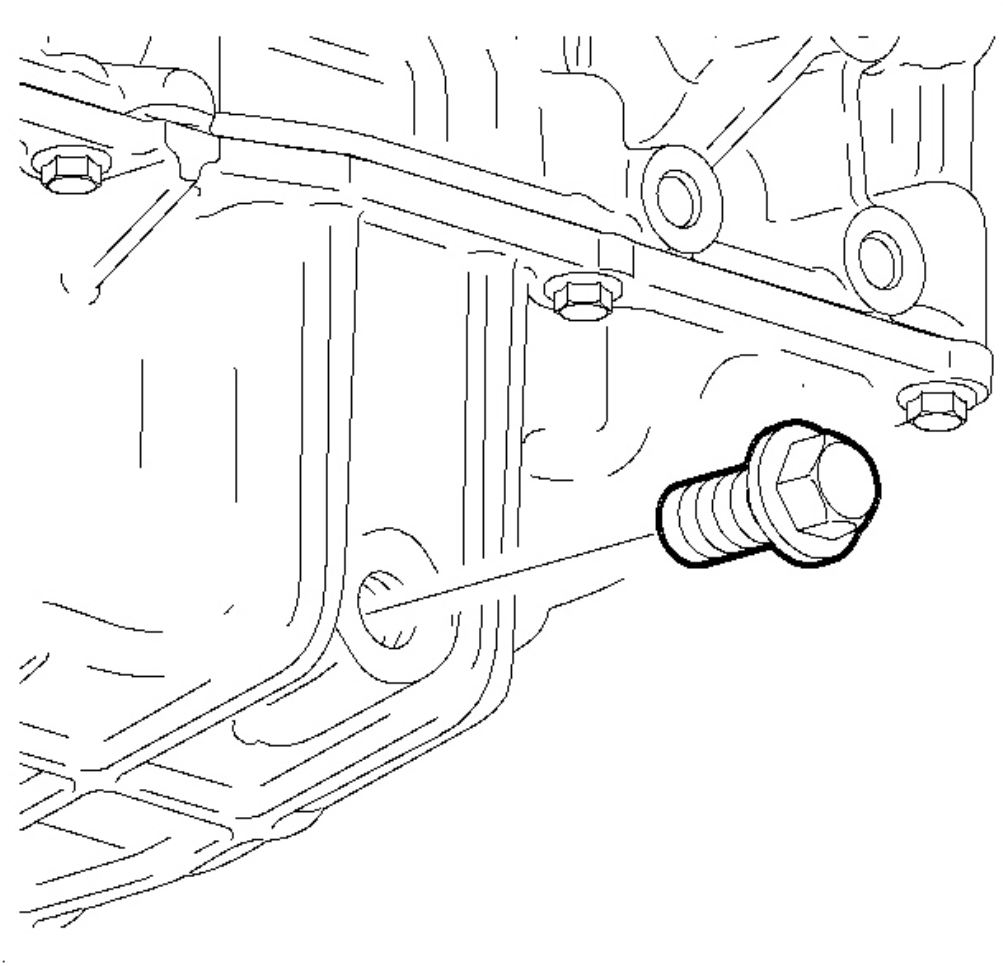


Fig. 298: Removing/Installing Oil Pan Drain Plug
Courtesy of GENERAL MOTORS CORP.

11. Remove the oil pan drain plug and drain the engine oil.

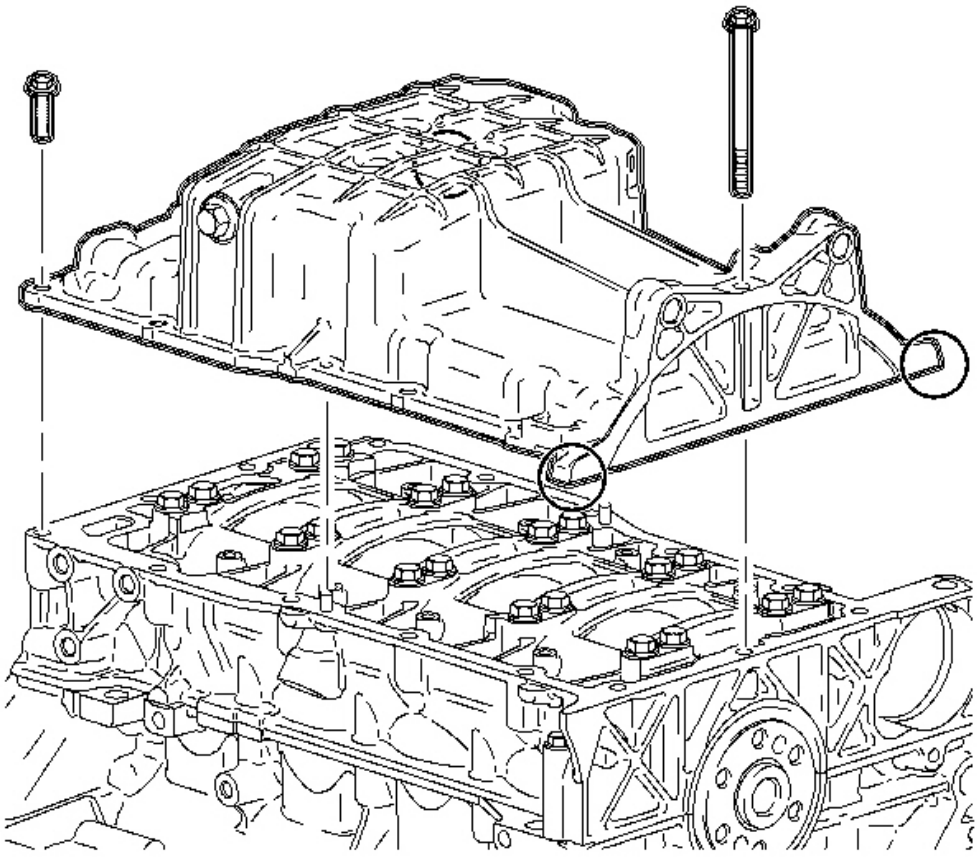


Fig. 299: Removing Engine Oil Pan Bolts
Courtesy of GENERAL MOTORS CORP.

12. Remove the engine oil pan bolts.
13. Remove the oil pan using pry points to separate the pan from the engine block.
14. Clean all oil pan, block mating surfaces, and oil pan bolts.

Installation Procedure

NOTE: Ensure that there is not excessive RTV material around the oil pick-up gallery flange area. Engine damage may occur if excessive material is drawn into the oil pump assembly.

IMPORTANT: Ensure that the mating surfaces are clean and free of debris. Allow adequate time to allow for the oil pump to drain. This will prevent oil from dripping on the mating flange during installation.

1. Clean oil from the mating surface before the oil pan is installed to assure a proper seal. Oil may drain from the oil pump assembly.
2. Apply a 2 mm bead of Permatex(R) The Right Stuff to the oil pan.

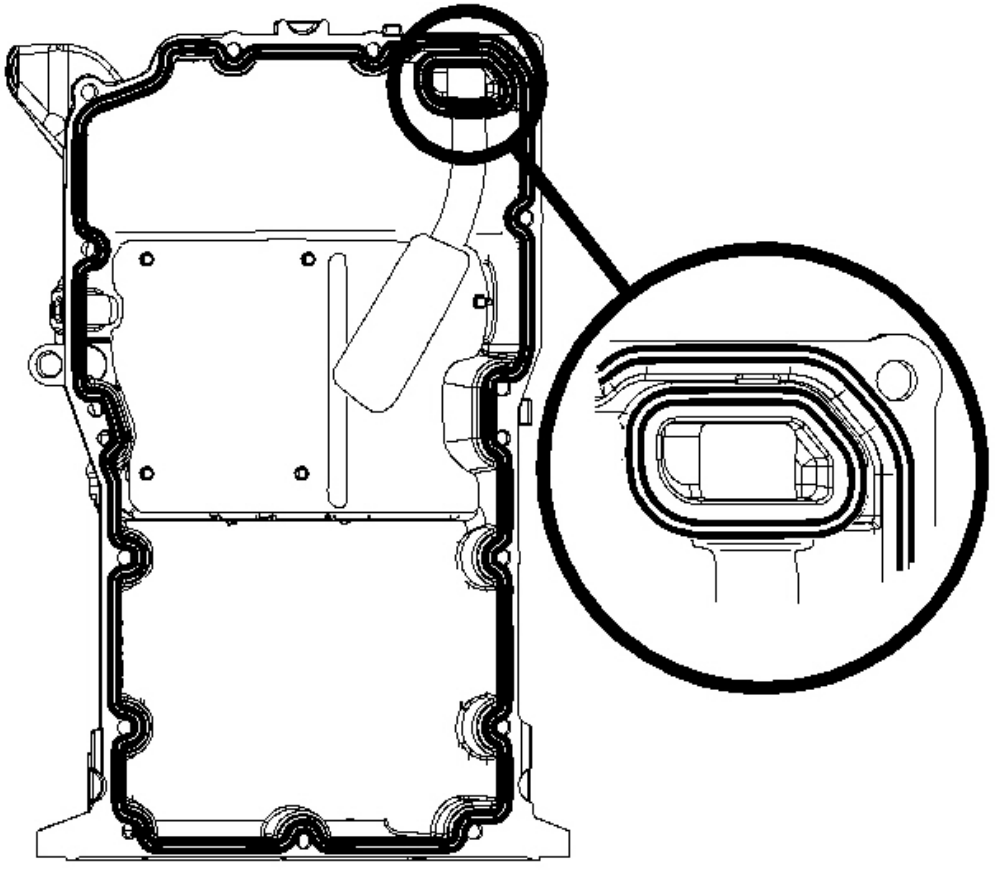


Fig. 300: Applying 2 mm bead of Permatex(R) To The Oil Pan
Courtesy of GENERAL MOTORS CORP.

3. Ensure the engine block to oil pan mating surfaces are clean and dry.

4. Place the oil pan into position and hand tighten the pan bolts.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Tighten the oil pan using the appropriate sequence.

Tighten: Tighten the oil pan bolts - L61 to 15 N.m (11 lb ft).

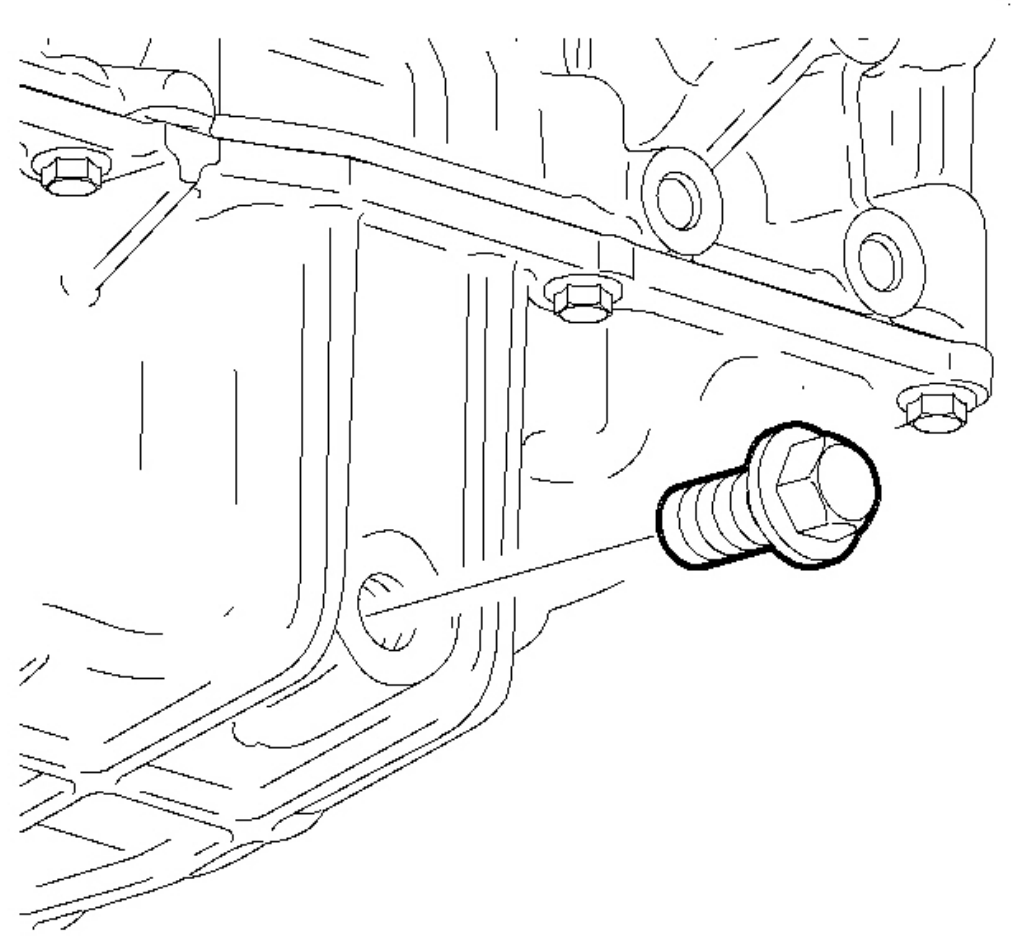


Fig. 301: Removing/Installing Oil Pan Drain Plug
Courtesy of GENERAL MOTORS CORP.

6. Install the oil pan drain plug.

Tighten: Tighten the oil pan drain plug - L61 to 25 N.m (18 lb ft).

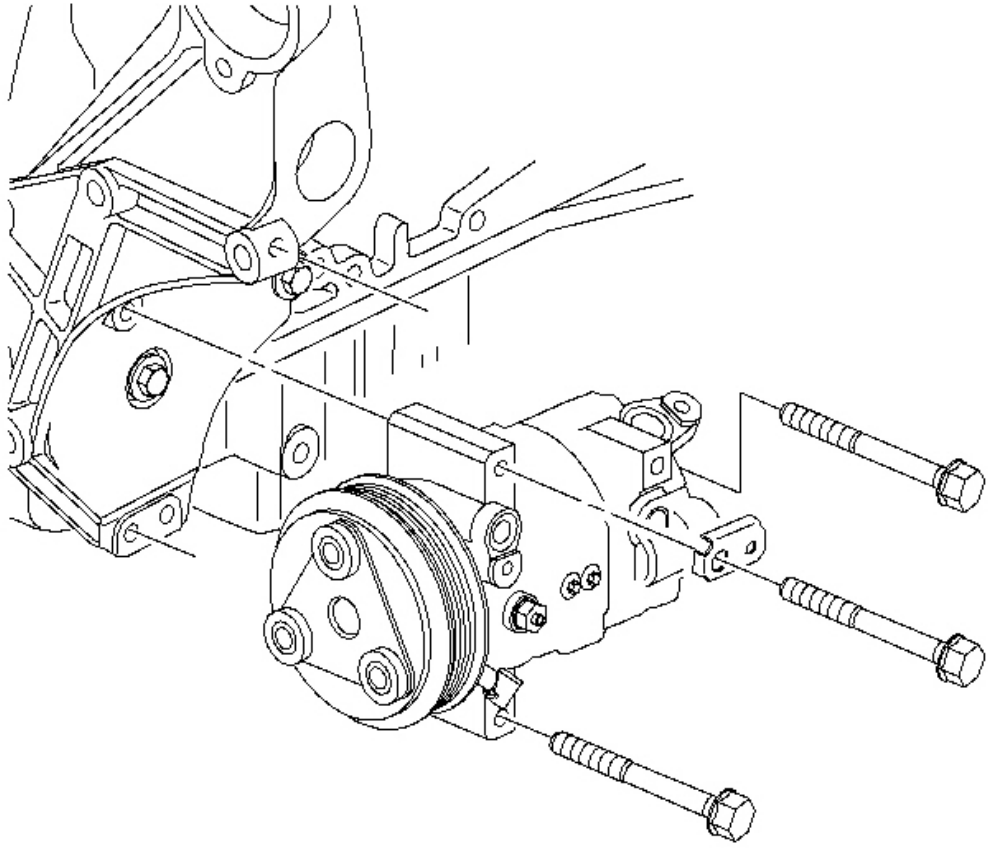


Fig. 302: Removing/Installing Lower A/C Compressor Bolt
Courtesy of GENERAL MOTORS CORP.

7. Install the lower A/C bolt.

   Tighten: Tighten the A/C compressor bolt - L61 to 20 N.m (15 lb ft).

8. Lower the vehicle.
9. Install the right hand engine mount.

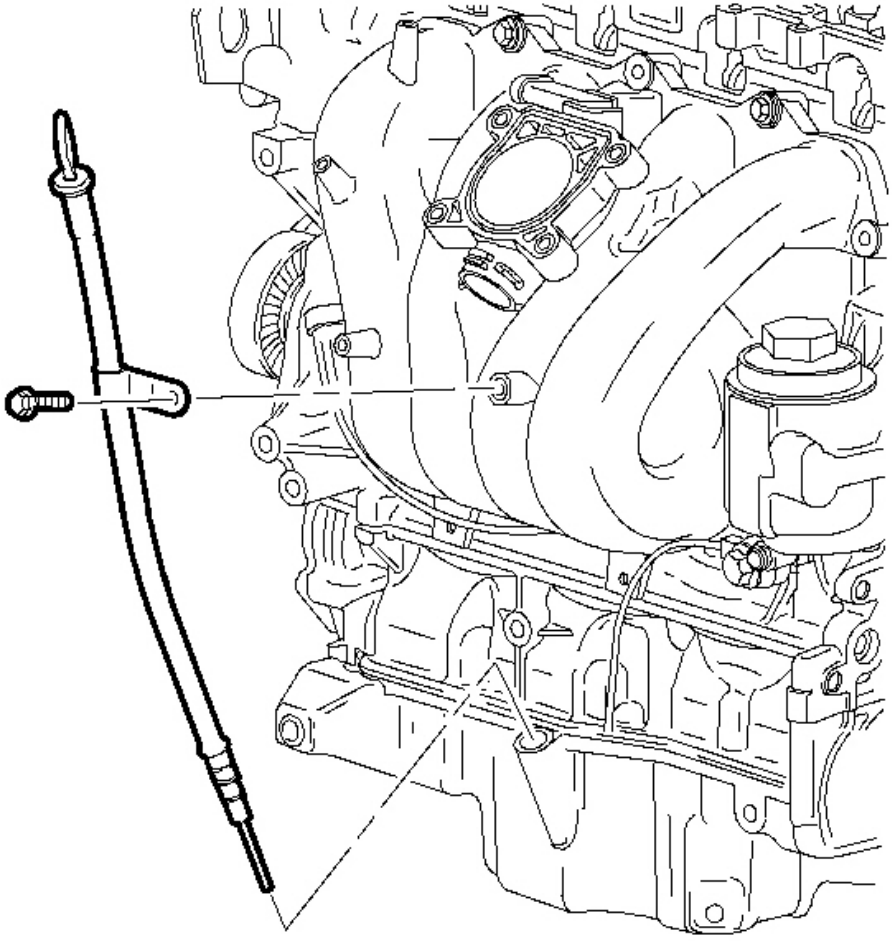


Fig. 303: View Of Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

10. Install the oil level indicator tube into the block.
11. Install the oil level indicator tube bolt.

Tighten: Tighten the oil level indicator tube bolt - L61 to 10 N.m (89 lb in).

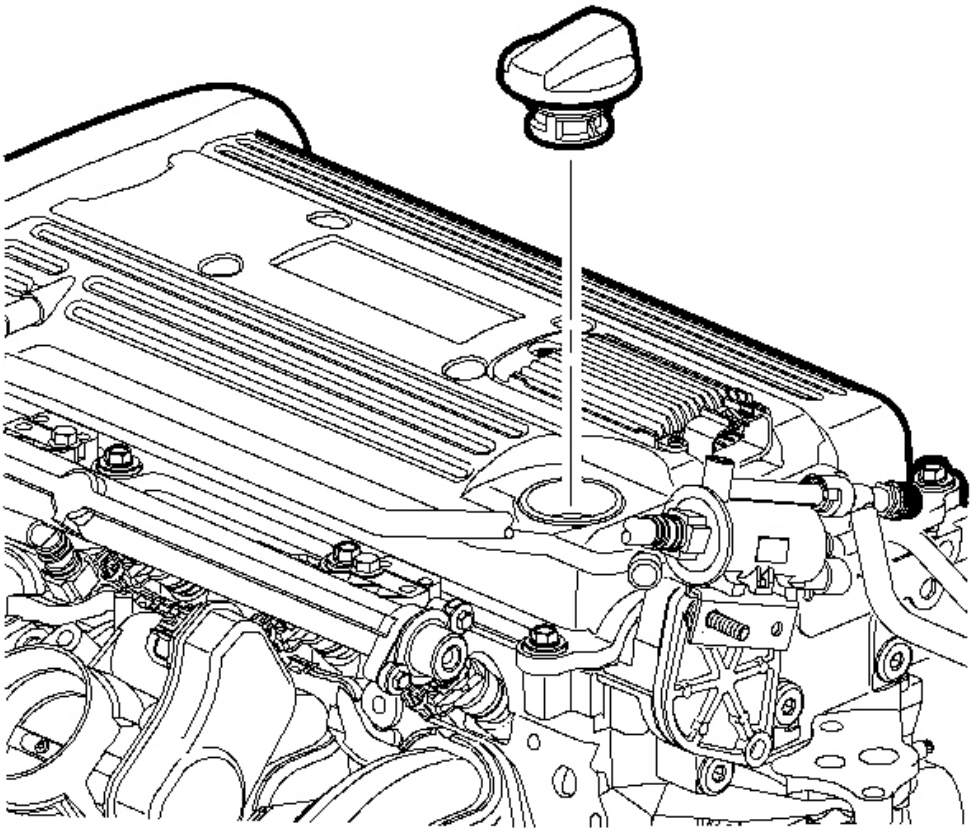


Fig. 304: Removing/Installing Oil Fill Cap
Courtesy of GENERAL MOTORS CORP.

12. Remove the oil fill cap.
13. Fill the engine with 4.73 L (5 qt) of new 5W-30 engine oil.
14. Install the oil fill cap.

IMPORTANT: The oil level should be checked on a level surface.

15. Start the engine and inspect for leaks.
16. Check the engine oil level after the engine is OFF for 5 minutes. This will allow the engine oil to drain down into the oil pan from the cylinder head.

17. Verify the oil level and inspect for leaks.

CRANKSHAFT REAR OIL SEAL REPLACEMENT

Tools Required

- **J 42067** Rear Crankshaft Seal Installer. See **Special Tools and Equipment** .
- **J 43653** Flywheel Holding Tool. See **Special Tools and Equipment** .

Removal Procedure

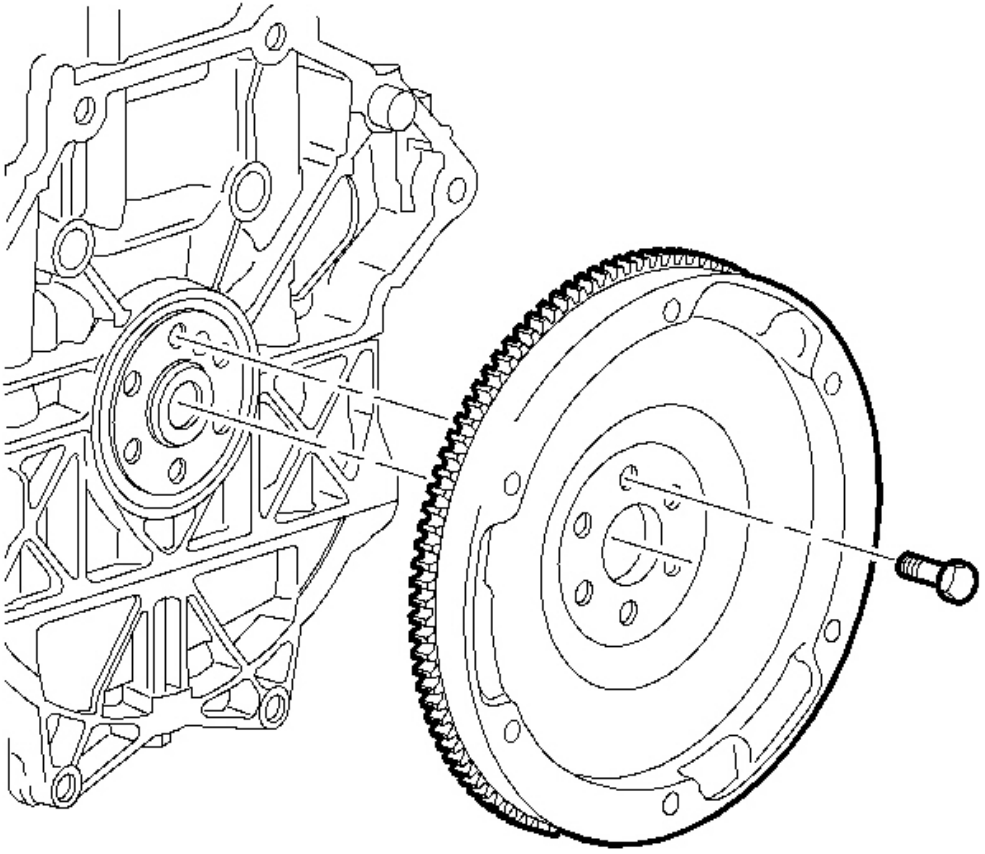


Fig. 305: Removing/Installing Flywheel/Flexplate
Courtesy of GENERAL MOTORS CORP.

1. Remove the transaxle assembly. Refer to **Transmission Replacement** in Automatic Transmission - VT25E, or**Transmission Replacement** in Manual Transmission - Getrag 5 Speed.
2. If servicing the rear main seal on a manual transaxle vehicle, refer to **Clutch Assembly Replacement** in Clutch.
3. Install the **J 43653** . See **Special Tools and Equipment** .

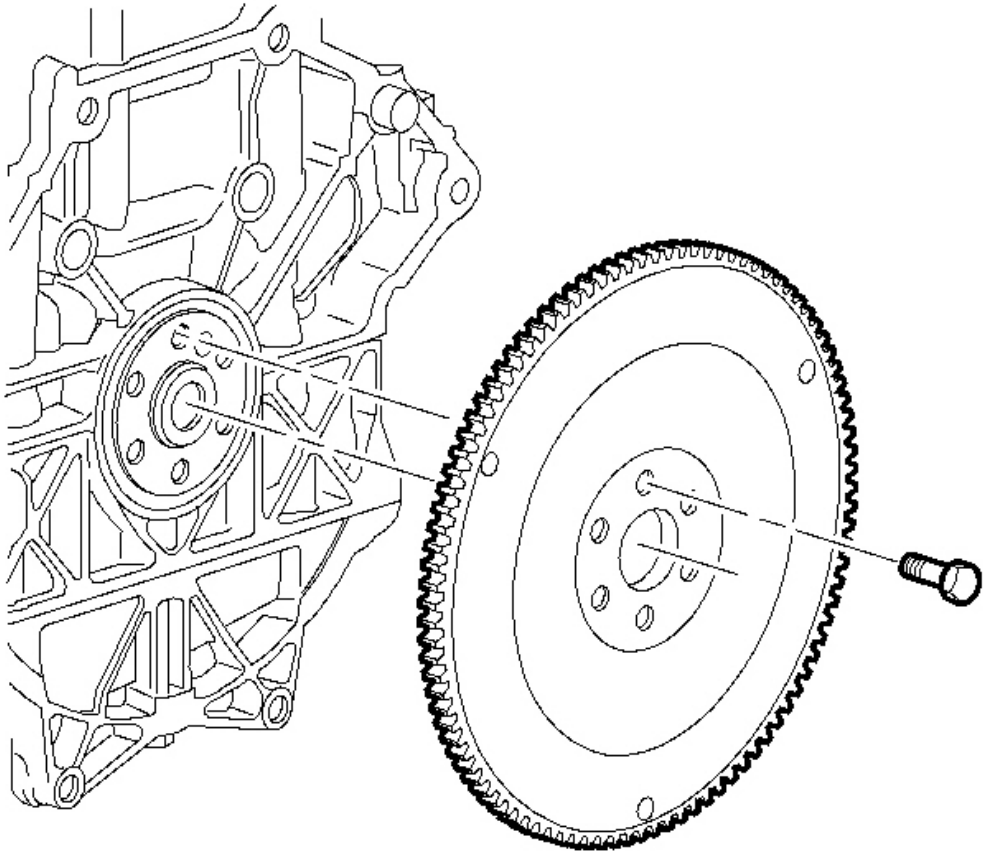


Fig. 306: Removing/Installing Flexplate/Flywheel Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the flexplate/flywheel bolts and discard.
5. Remove the flexplate/flywheel assembly.
6. Clean the thread adhesive from the flywheel bolts. Use a nylon bristle to clean the bolt holes from the

crankshaft.

7. Remove the **J 43653** . See **Special Tools and Equipment** .

IMPORTANT: Do not damage the block or sealing surface when removing the rear main seal.

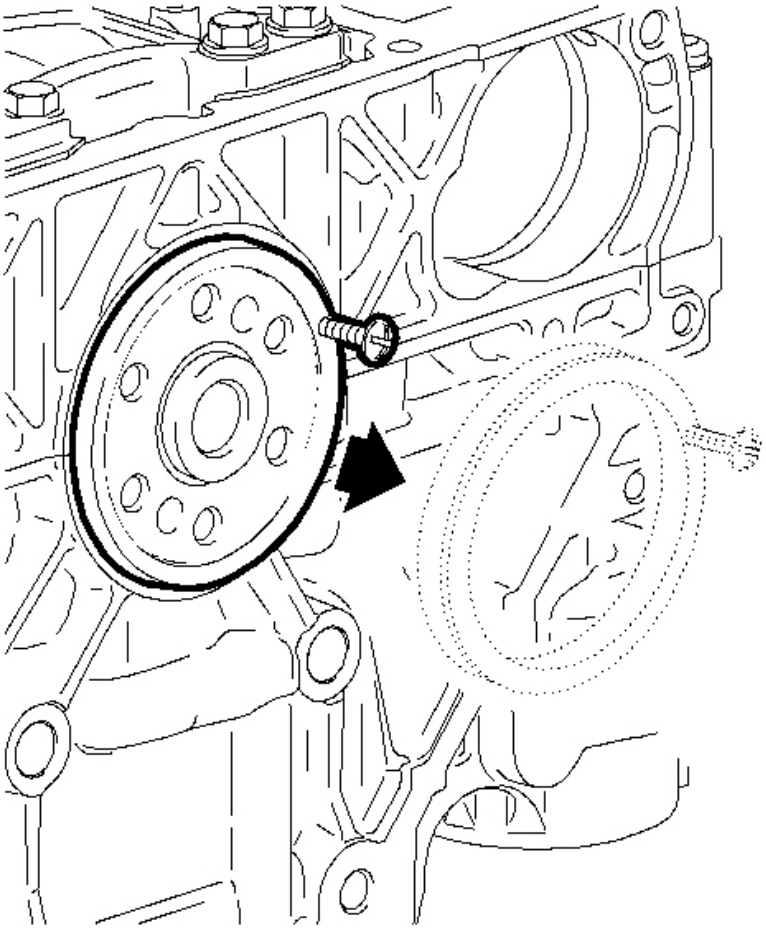


Fig. 307: Removing Rear Main Seal
Courtesy of GENERAL MOTORS CORP.

8. Remove the rear main seal by using a seal removal tool, or by inserting a self tapping screw and slide hammer into the seal.

Installation Procedure

1. Make sure the rear main seal bore is free from debris. If a sealer is present, it must be removed to assure proper installation of the rear main seal.
2. Lubricate the outer diameter of the rear main seal with clean engine oil.
3. Using the **J 42067** , press the new seal into the housing until fully seated. See **Special Tools and Equipment** . The installer will control the depth of the seal installation.

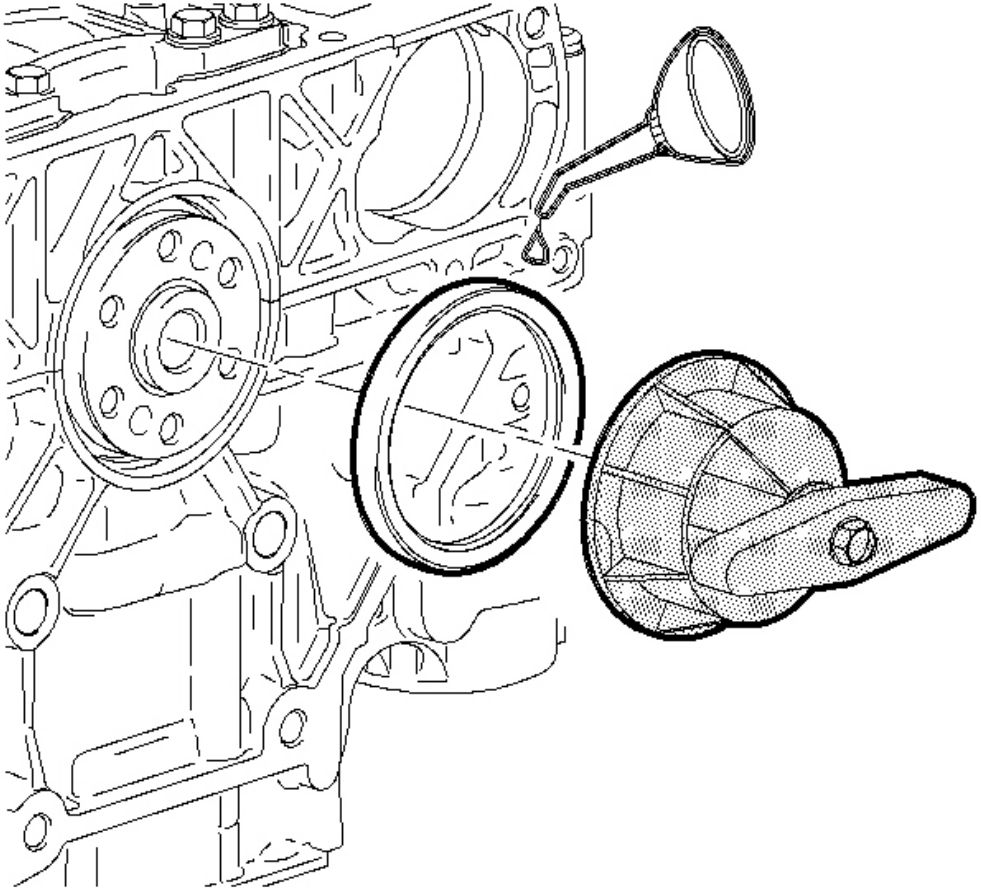


Fig. 308: Pressing New Rear Main Seal Into Housing
Courtesy of GENERAL MOTORS CORP.

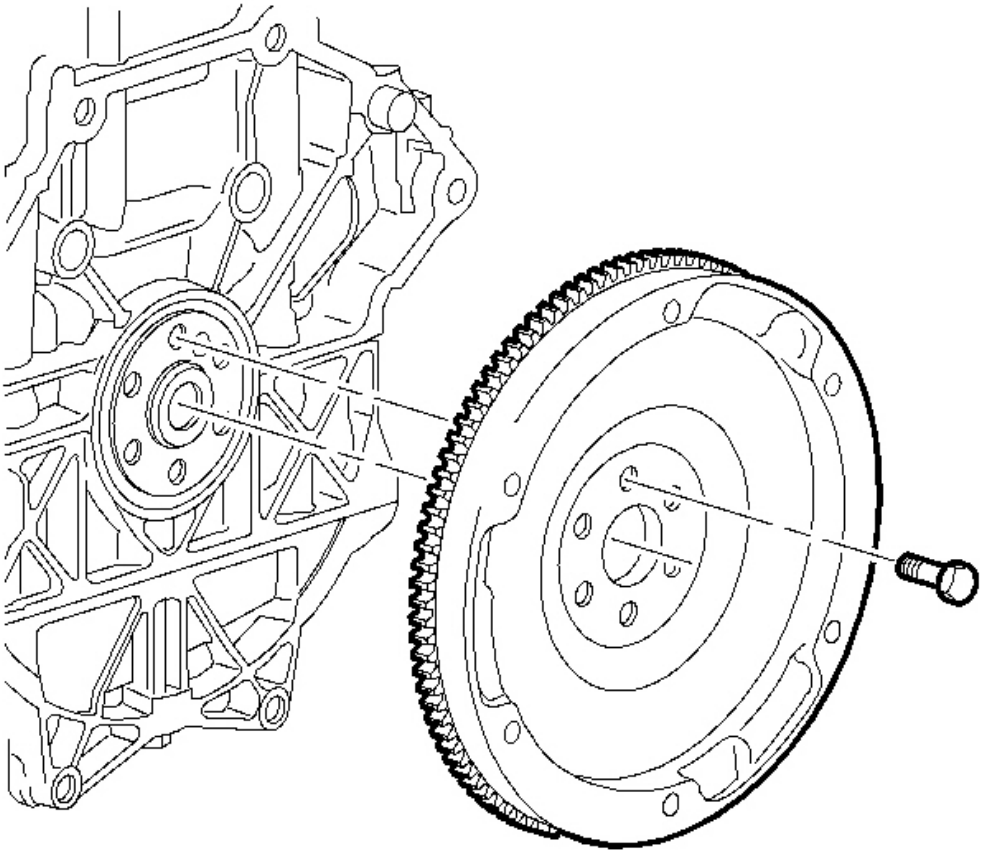


Fig. 309: Removing/Installing Flywheel/Flexplate
Courtesy of GENERAL MOTORS CORP.

4. Install the flywheel/flexplate.

NOTE: **Refer to Fastener Notice in Cautions and Notices.**

5. Install new flywheel bolts.
6. Install the **J 43653** . See **Special Tools and Equipment** .
7. Tighten the flywheel bolts.

Tighten: Tighten the flywheel bolts L61 to 53 N.m (39 lb ft) +25 degrees.

8. Remove the **J 43653** . See **Special Tools and Equipment** .
9. If the vehicle is equipped with a manual transaxle. Install the clutch assembly. Refer to **Clutch Assembly Replacement** in Clutch.
10. Install the transaxle assembly. Refer to **Transmission Replacement** in Automatic Transmission - VT25E, or**Transmission Replacement** in Manual Transmission - Getrag 5 Speed.

ENGINE FLYWHEEL REPLACEMENT

Tools Required

J 38122-A Harmonic Balancer Holder

Engine Flywheel Replacement

1. Remove the flywheel attaching bolt. Use the J 38122-A to prevent crankshaft rotation.

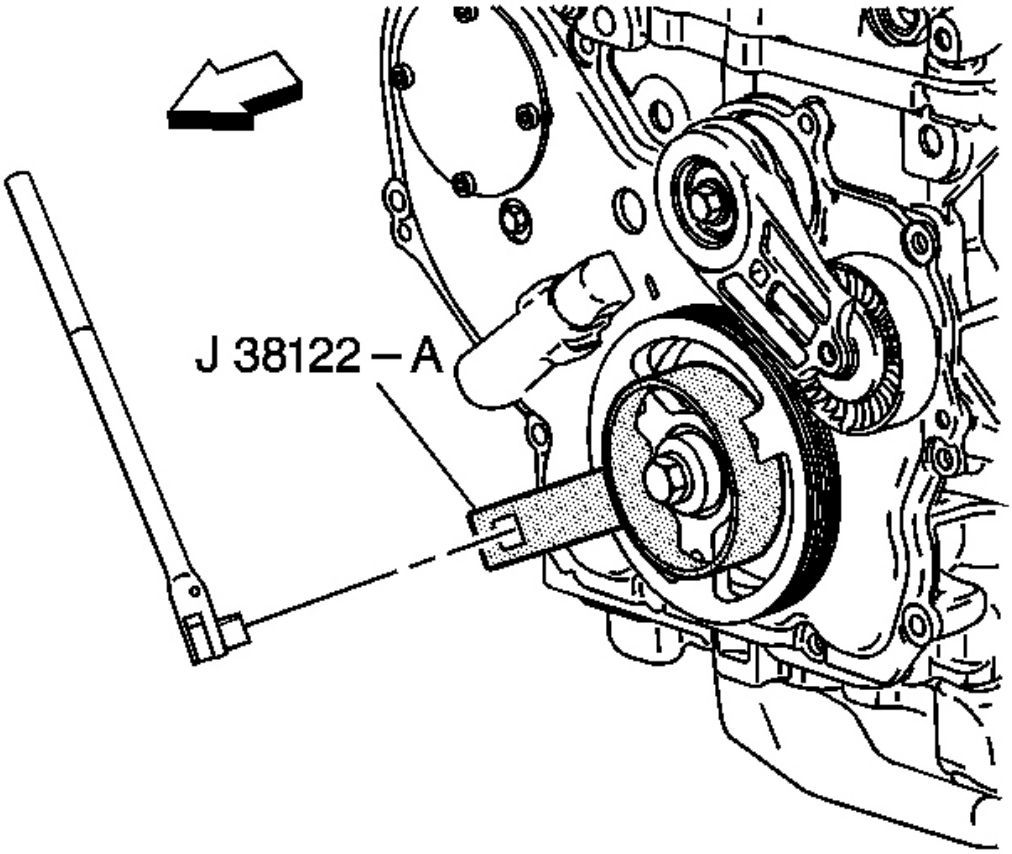


Fig. 310: View Of Harmonic Balancer Holder J38122-A
Courtesy of GENERAL MOTORS CORP.

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.

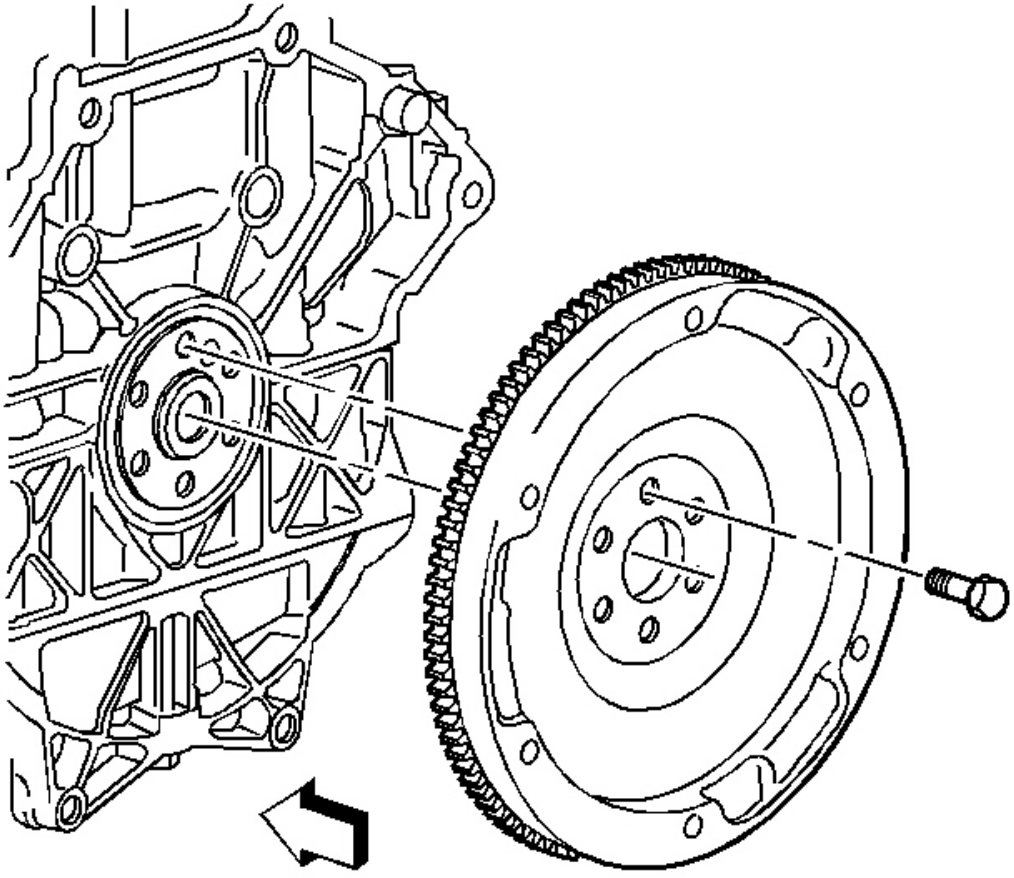


Fig. 311: Identifying Flywheel Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

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

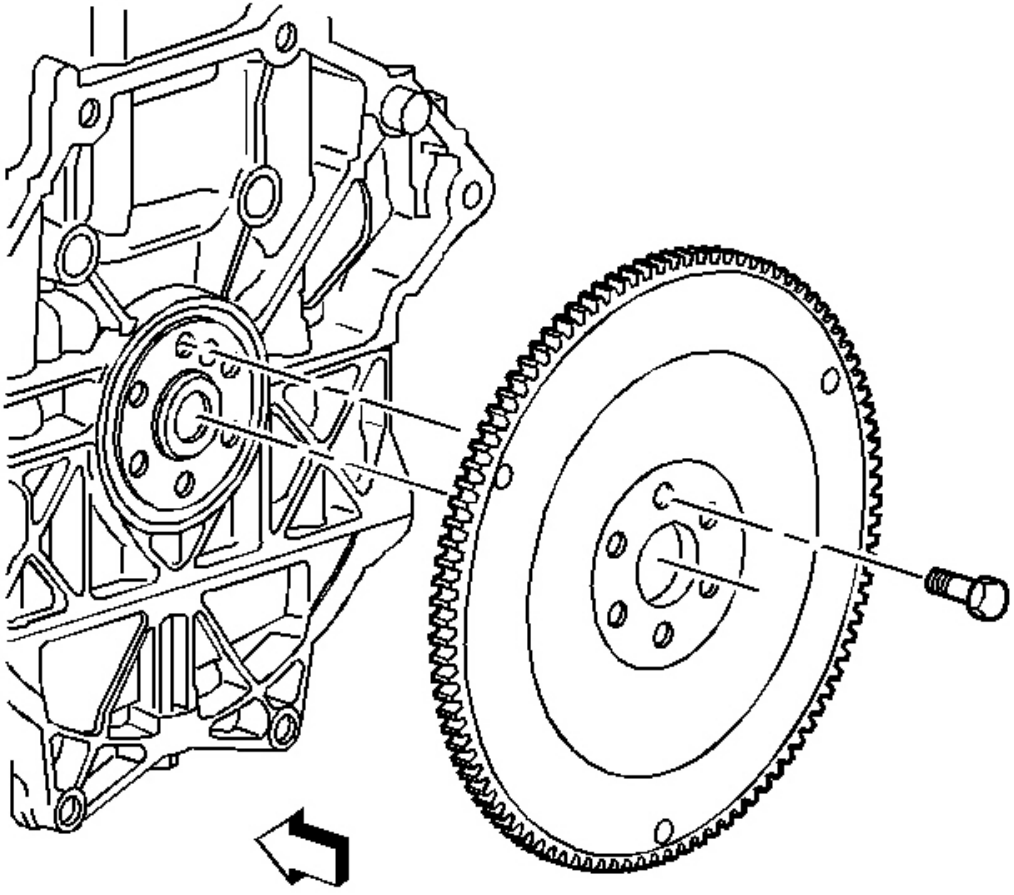


Fig. 312: View Of Flywheel
Courtesy of GENERAL MOTORS CORP.

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.

ENGINE REPLACEMENT

Tools Required

- **J 36346** Fascia Retainer Remover. See **Special Tools and Equipment** .
- **J 39914** Serpentine Belt Tension Unloader. See **Special Tools and Equipment** .

- **J 43828** Ball Joint Separator
- **J 44811** Accessory Belt Tensioner Unloader. See **Special Tools and Equipment** .
- **J 45341** Rear Wheel Drive Shaft Removal Tool
- **SA91100C** Tie Rod Separator
- **SA9127E** Gage Bar Set. See **Special Tools and Equipment** .
- **SA9805E** Fuel Line Separator. See **Special Tools and Equipment** .

Removal Procedure

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
2. Disconnect the air intake temperature (IAT) sensor connector.
3. Loosen the clamp air cleaner assembly.

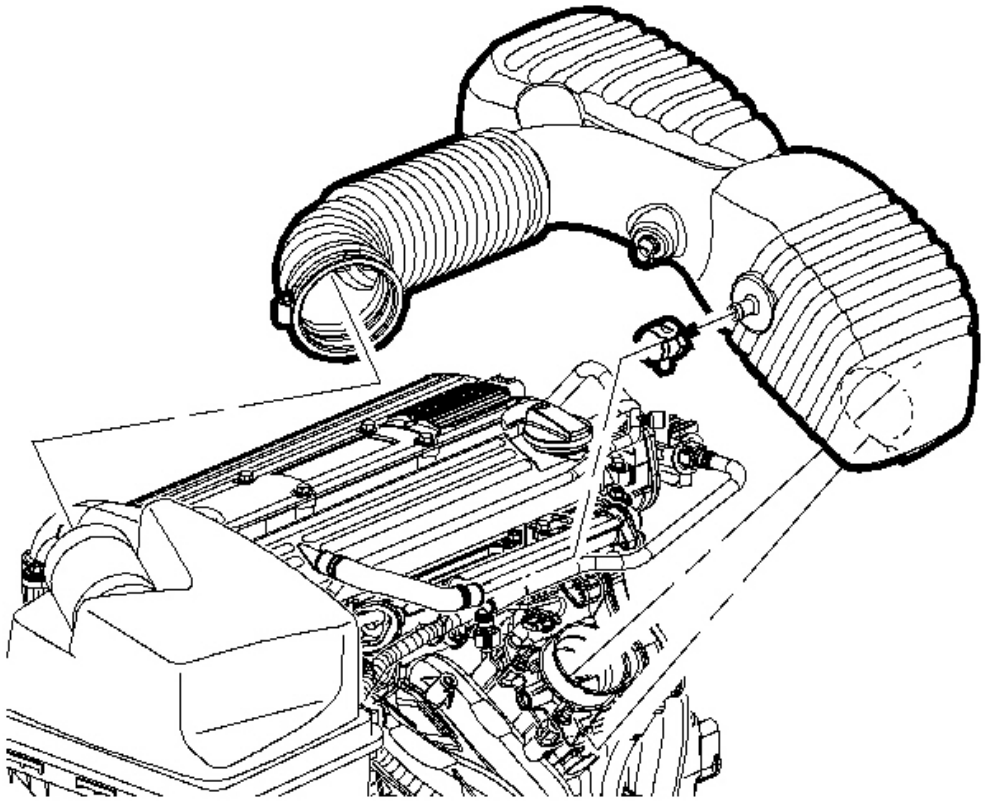


Fig. 313: Locating Air Intake Assembly
Courtesy of GENERAL MOTORS CORP.

4. Remove the pushpin attachment from the outlet resonator/duct assembly to the support bracket.
5. Loosen the clamp at the throttle body assembly.
6. Disconnect the positive crankcase ventilation (PCV) fresh air vent hose at the cam cover.
7. Remove the outlet resonator/duct assembly.

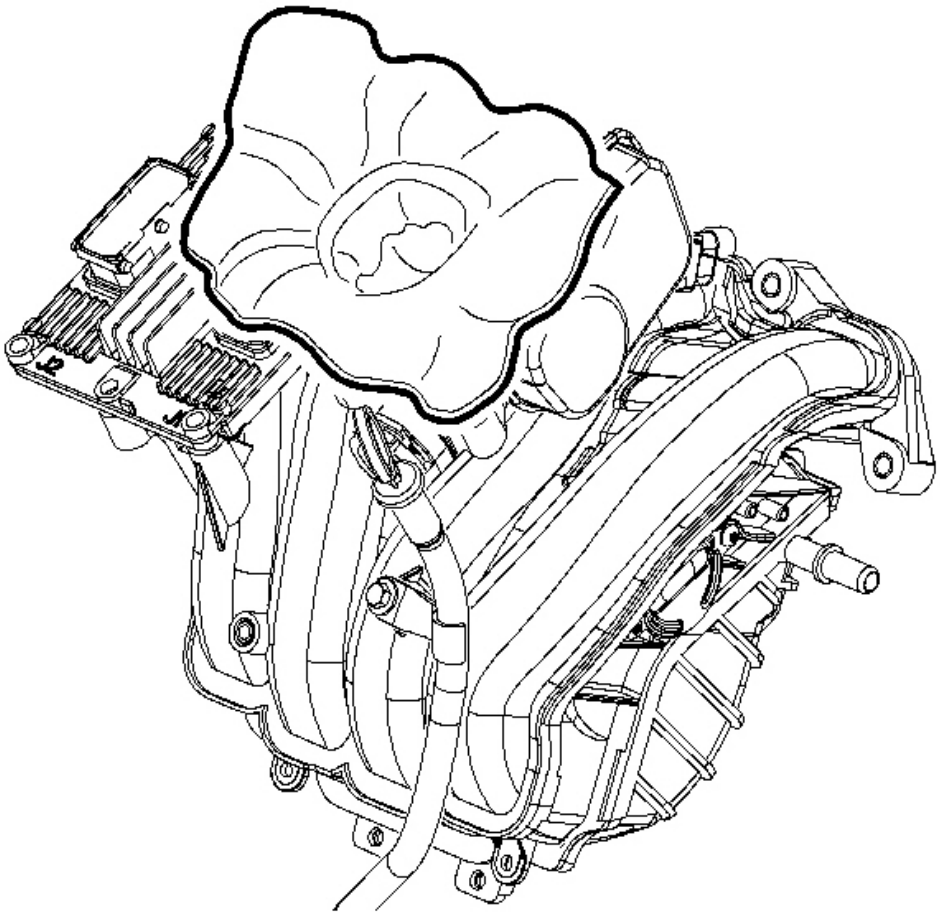


Fig. 314: Covering Throttle Body Opening With A Shop Towel
Courtesy of GENERAL MOTORS CORP.

8. Cover the throttle body opening with a shop towel. Use shop air to remove any dirt around the throttle body and intake manifold to cylinder head.

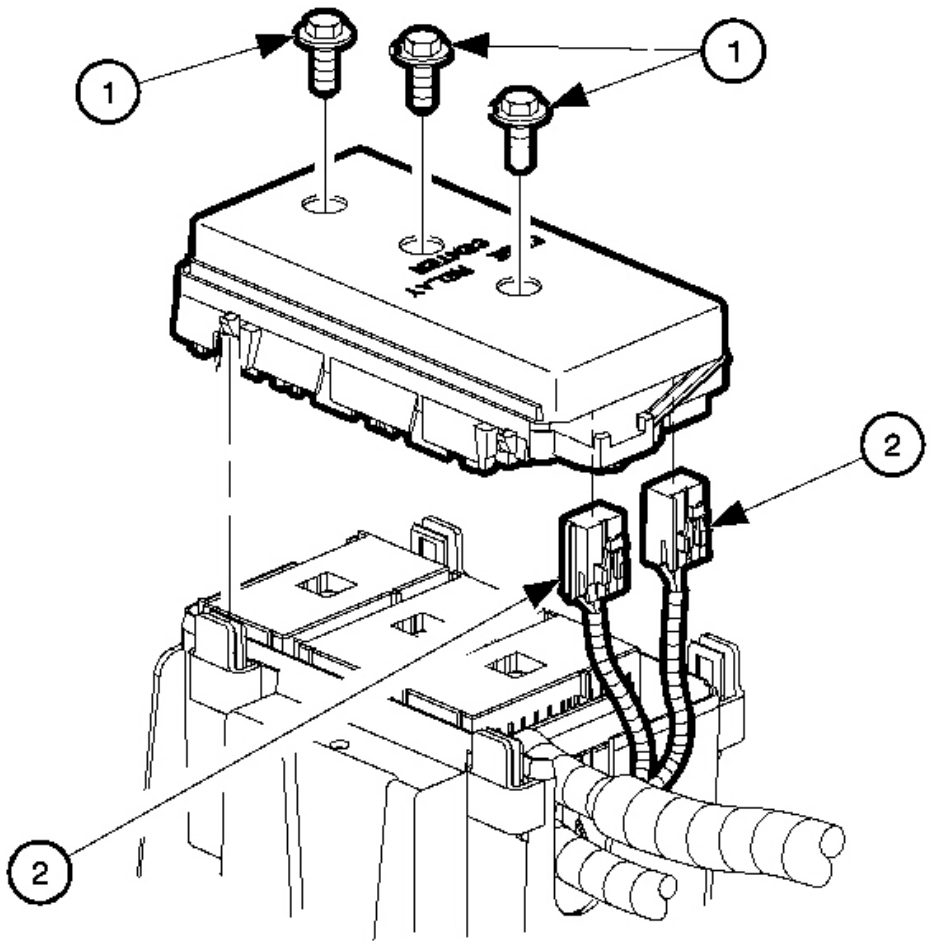


Fig. 315: Locating Underhood Fuse Block (UHFB) Fuse Cover
Courtesy of GENERAL MOTORS CORP.

9. Remove the underhood fuse block (UHFB) fuse cover by separating the clips on each side.
10. Remove the UHFB fuse cover.
11. Remove the inner UHFB fuse cover.
12. Loosen the three connectors through bolts (1) at the top of the UHFB.
13. Remove the battery and the electronic power steering feed wire connection nut and remove the wire from the UHFB stud.
14. Release the tabs on each side of the UHFB with a screwdriver.
15. Raise the UHFB from the connectors. Disconnect the electrical connectors on each side of UHFB.

16. Remove the UHFB from the vehicle.
17. Remove the battery cable and the harness attachment clips the on side of battery tray/UHFB bracket assembly.
18. Remove the main connectors from the UHFB housing.
19. Lay the battery positive cable wire over the engine. The battery cables will be removed with powertrain assembly.
20. Remove the electrical harness clips to battery tray.
21. Remove the UHFB and the battery tray bolts.
22. Remove the UHFB and the battery tray.

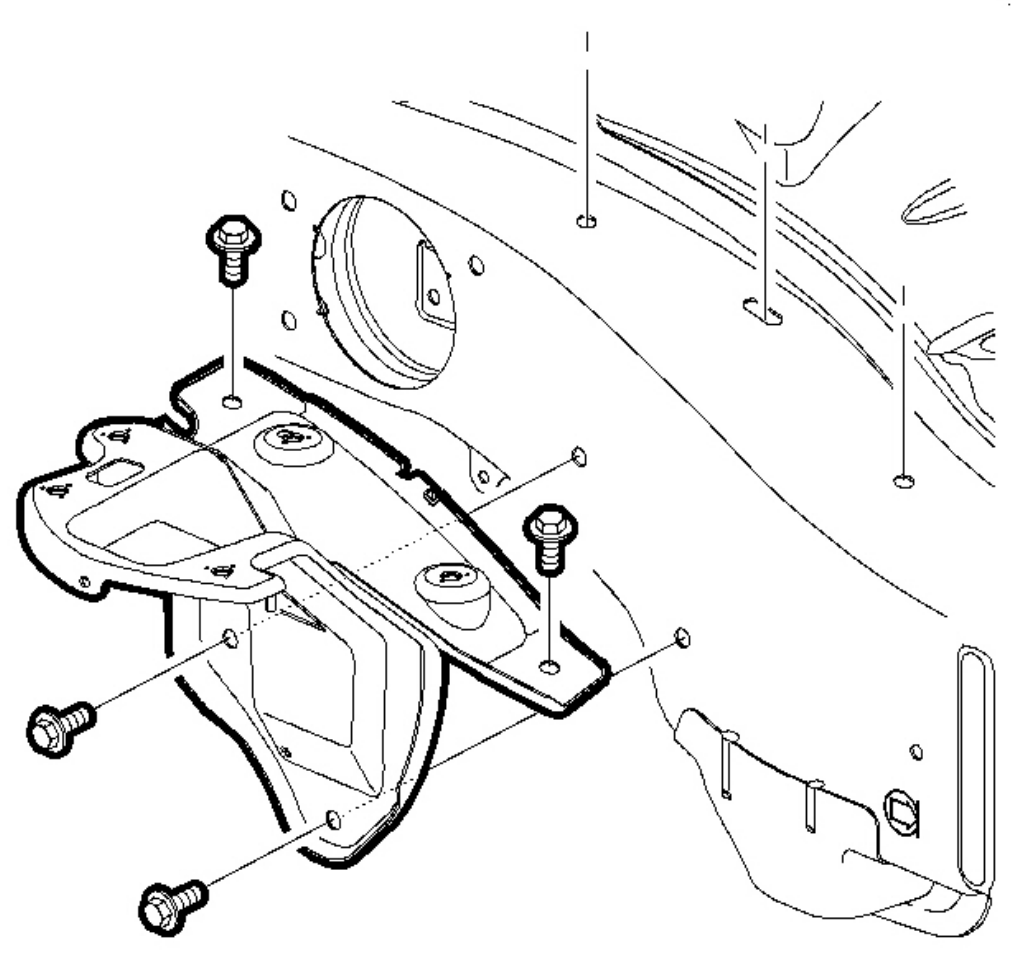


Fig. 316: Installing Headlamp Assemblies & Torque Bolts

Courtesy of GENERAL MOTORS CORP.

23. Disconnect the electrical connectors at the transaxle control module (TCM), if equipped.
24. Remove the engine-to-body ground bolt.
25. Disconnect the connector for the rear O2 sensor.
26. Remove the vacuum hose with the check valve from the booster and lay across the engine.
27. Disconnect the 8-way electrical connector.
28. Remove the main engine harness gray connector and lay over the engine assembly. This will allow the engine harness to be removed the with powertrain.

NOTE: Do not remove the shifter cable from the bracket before removing the cable from the transaxle range switch. Damage to the manual shift linkage may occur.

29. If equipped with the automatic range transaxle, disconnect the shifter cable plastic retainer by using a screwdriver. Slightly pry between the shifter cable plastic retainer and the transaxle range switch.

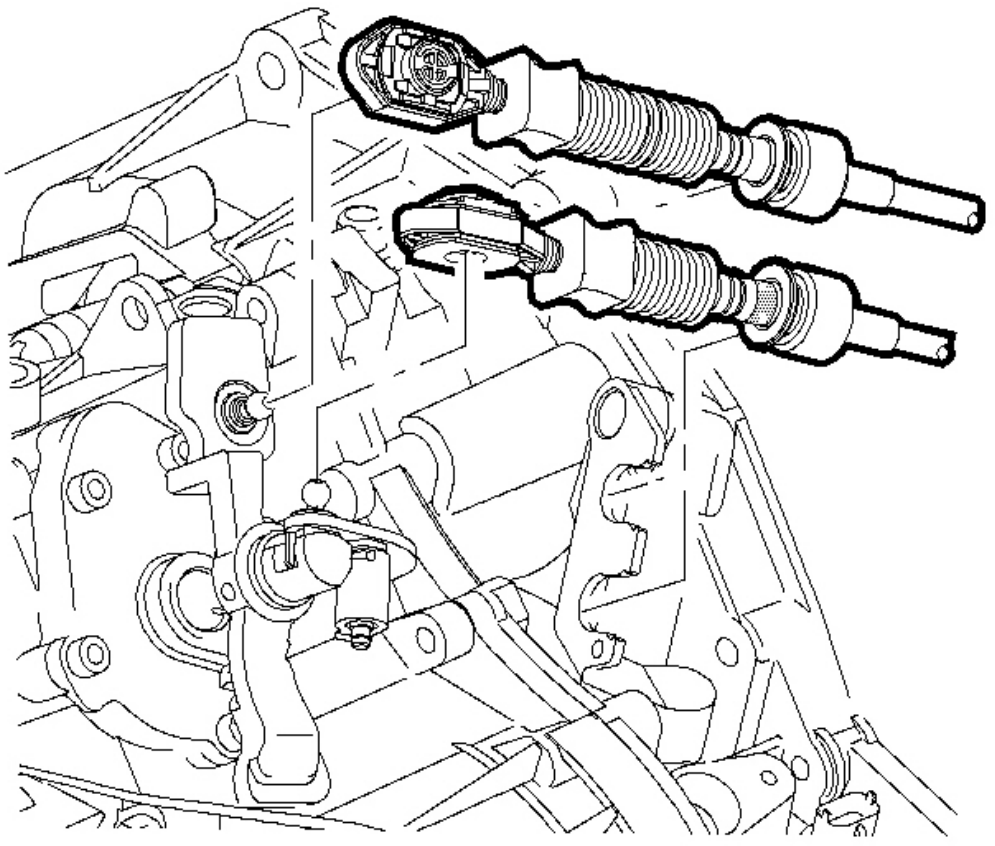


Fig. 317: Locating Shift Level Cables
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not use too much force when disconnecting the shift cables or damage may result.

30. Disconnect the shift lever cables from the shift control housing by prying with even pressure using a **J 36346** or equivalent manual transmission only. See **Special Tools and Equipment** .
31. Disconnect the shift lever cables from the shift lever cable bracket manual transmission only.

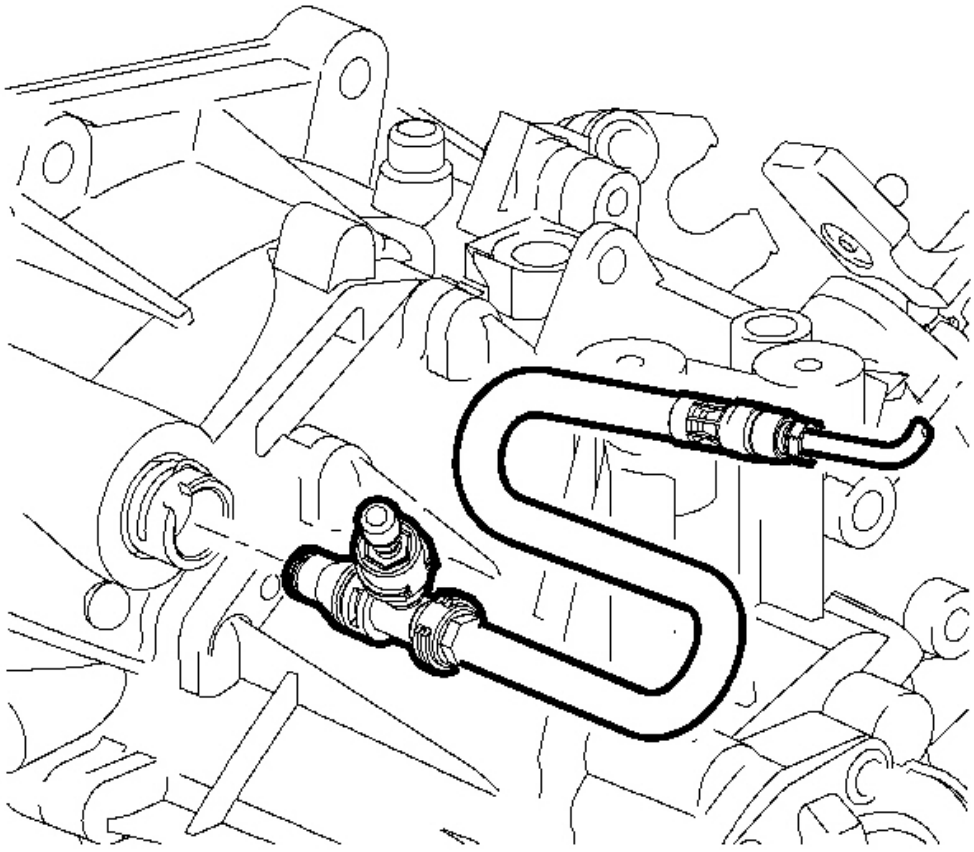


Fig. 318: Disconnecting/Connecting Clutch Hydraulic Line
Courtesy of GENERAL MOTORS CORP.

32. Disconnect the pressure line from the clutch actuator cylinder by removing the C-clip then pulling the line away from the clutch actuator cylinder manual transmission only.

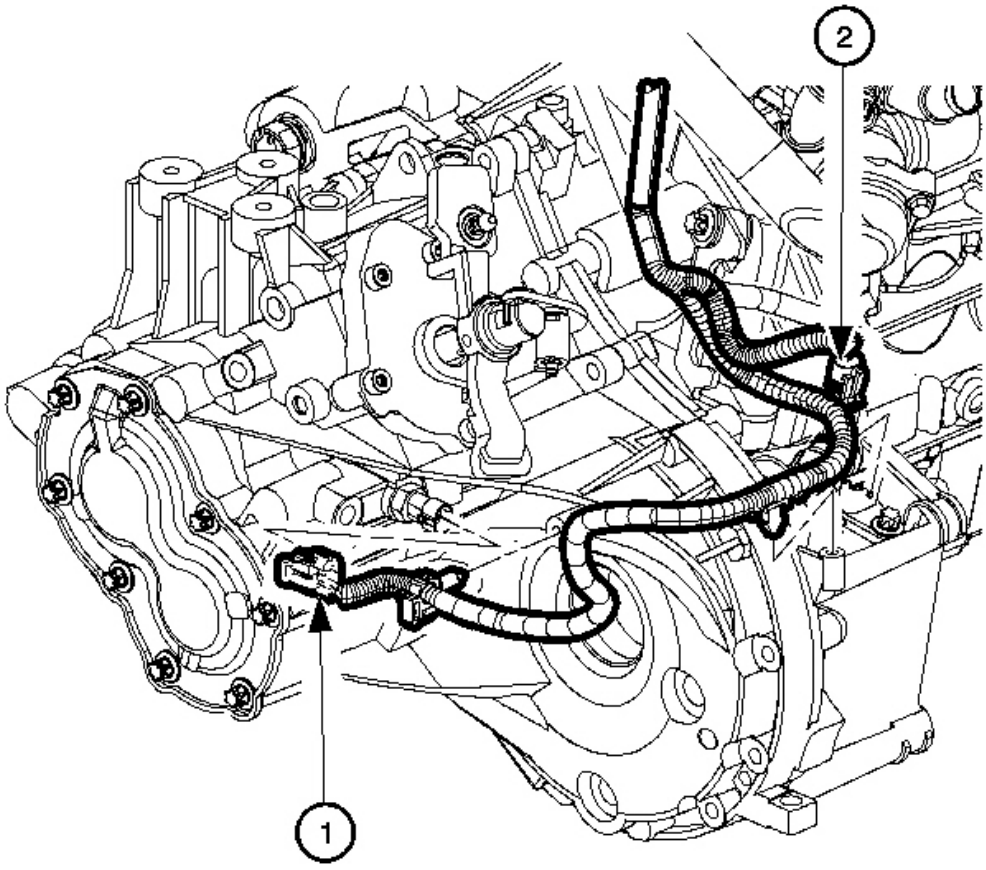


Fig. 319: Disconnecting Back-Up Lamp Switch & Front Wheel Speed Sensor (WSS)
Courtesy of GENERAL MOTORS CORP.

33. Disconnect the back-up lamp switch (1) and the front wheel speed sensor (WSS) (2) manual transmission only.

IMPORTANT: Place a shop towel on the generator to prevent coolant from entering the generator assembly.

34. Drain the coolant. Refer to **Draining and Filling Cooling System** in Engine Cooling.
35. Disconnect the upper radiator hose at the engine cylinder head.

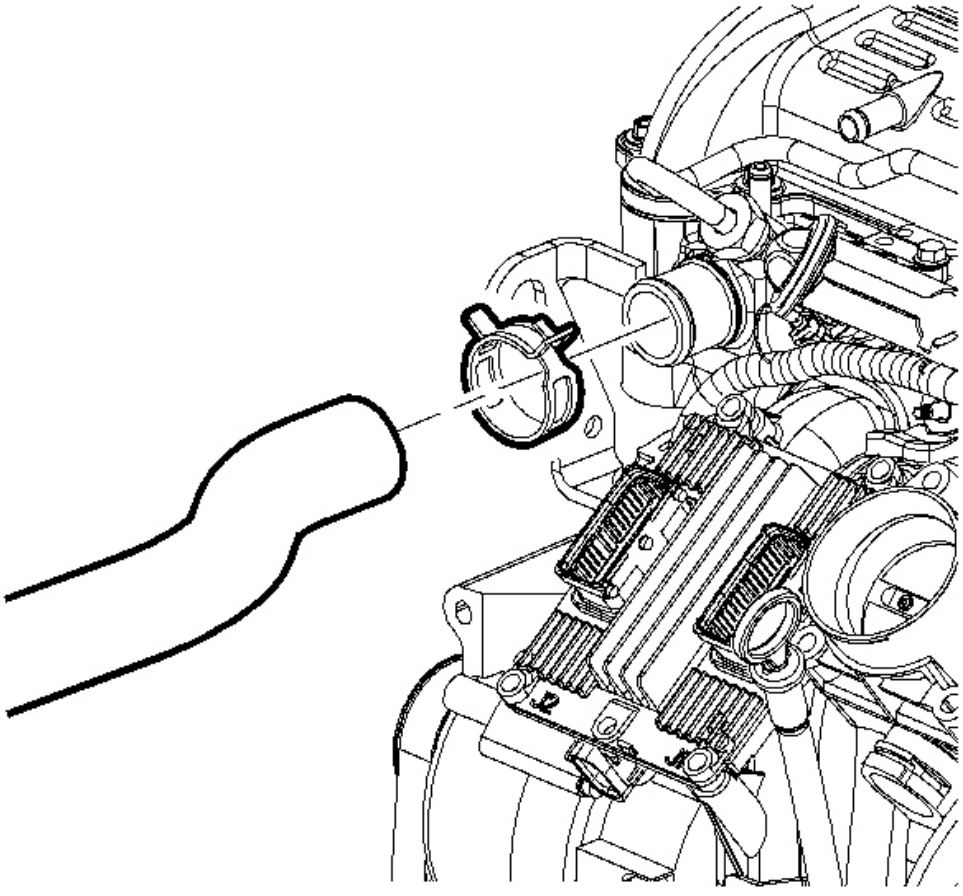


Fig. 320: Removing Upper Radiator Hose From Cylinder Head
Courtesy of GENERAL MOTORS CORP.

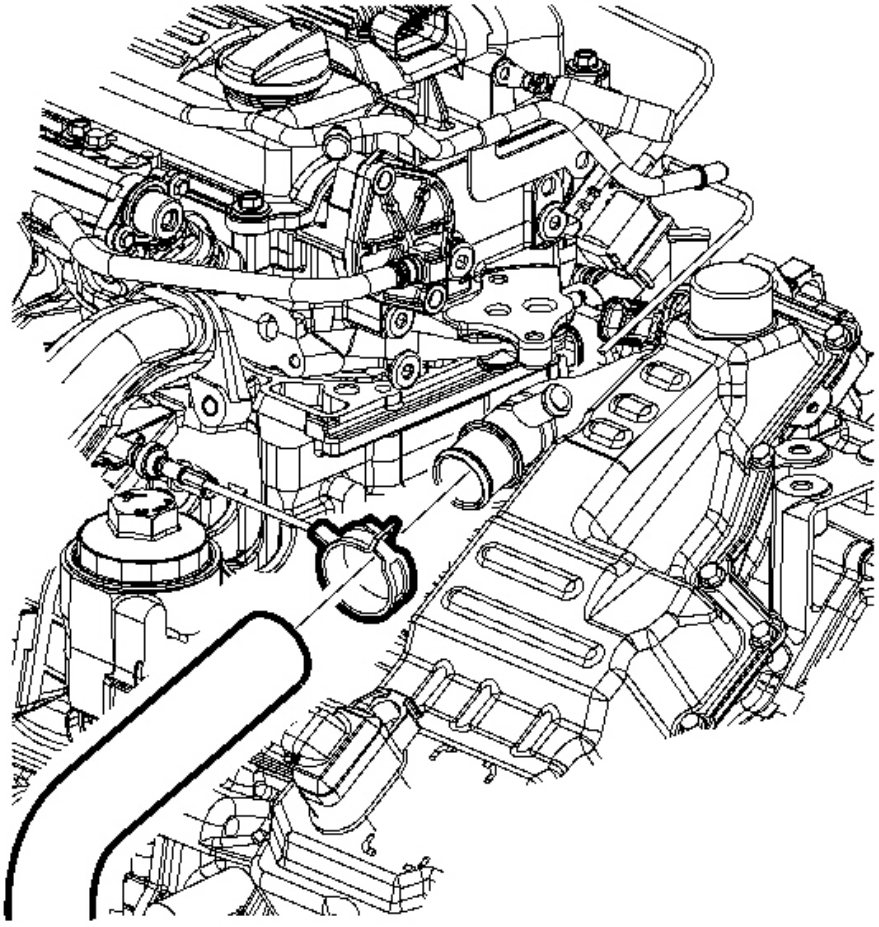


Fig. 321: Disconnecting/Connecting Lower Radiator Hose
Courtesy of GENERAL MOTORS CORP.

36. Disconnect the lower radiator hose at the coolant pipe.

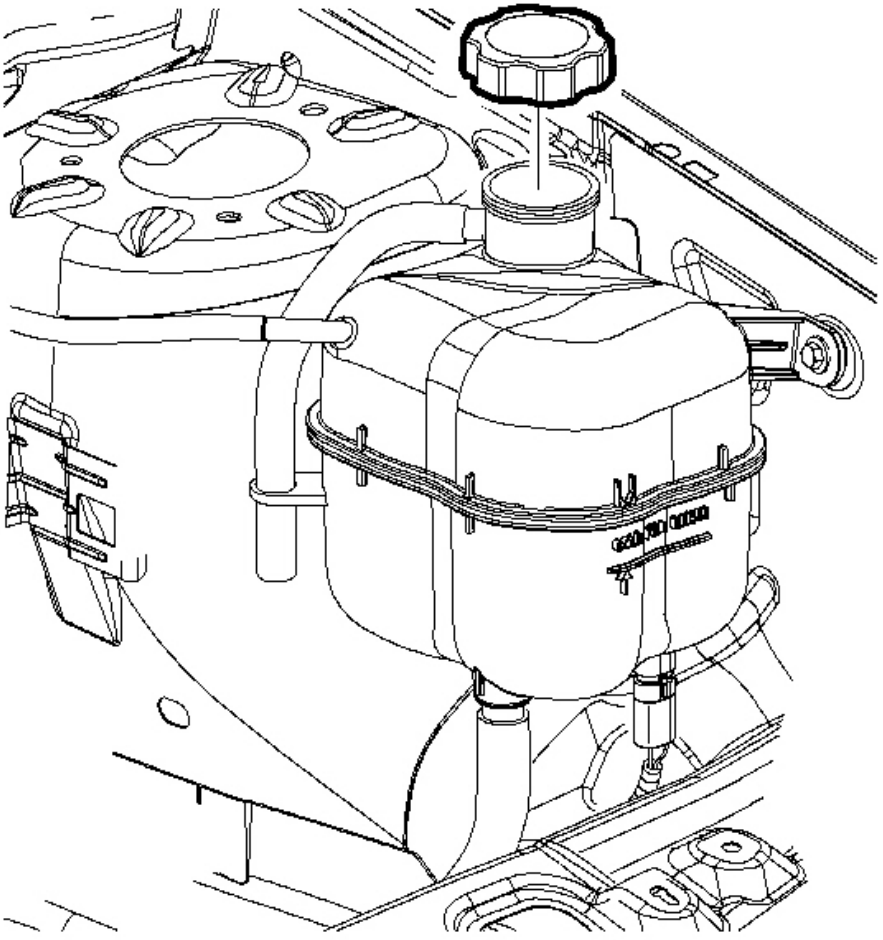


Fig. 322: Disconnecting Degas Hose
Courtesy of GENERAL MOTORS CORP.

37. Disconnect the degas hose at surge tank.
38. Disconnect the surge hose at the bottom of the surge tank.
39. Disconnect the heater hoses from the heater core at the front of the dash.

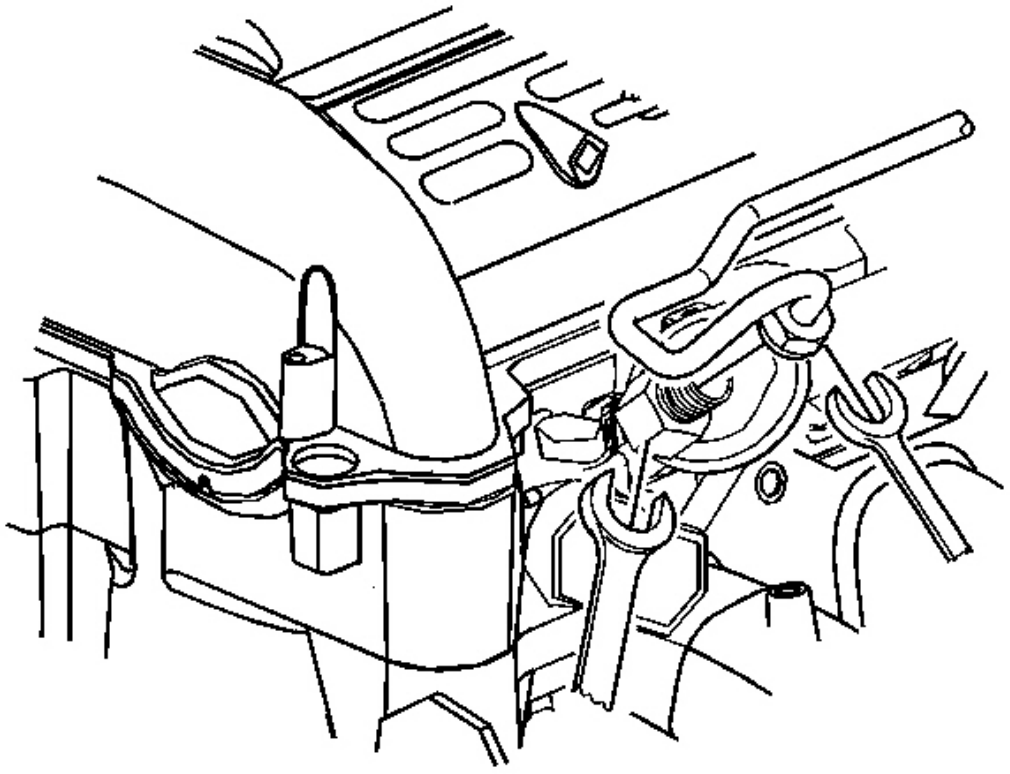


Fig. 323: Repositioning Fuel Line Assembly
Courtesy of GENERAL MOTORS CORP.

40. Relieve the fuel system pressure using the **Fuel Pressure Relief Procedure** in Engine Controls - 2.2L (L61).
41. Disconnect the **SA9127E** after the pressure has been relieved. See **Special Tools and Equipment** .
42. Remove the safety clip and disconnect the fuel line transfer line at the quick connect from the fuel line using the **SA9805E** . See **Special Tools and Equipment** .
43. Disconnect the purge hoses at the rear of the purge solenoid.
44. Remove the headlamp assemblies.

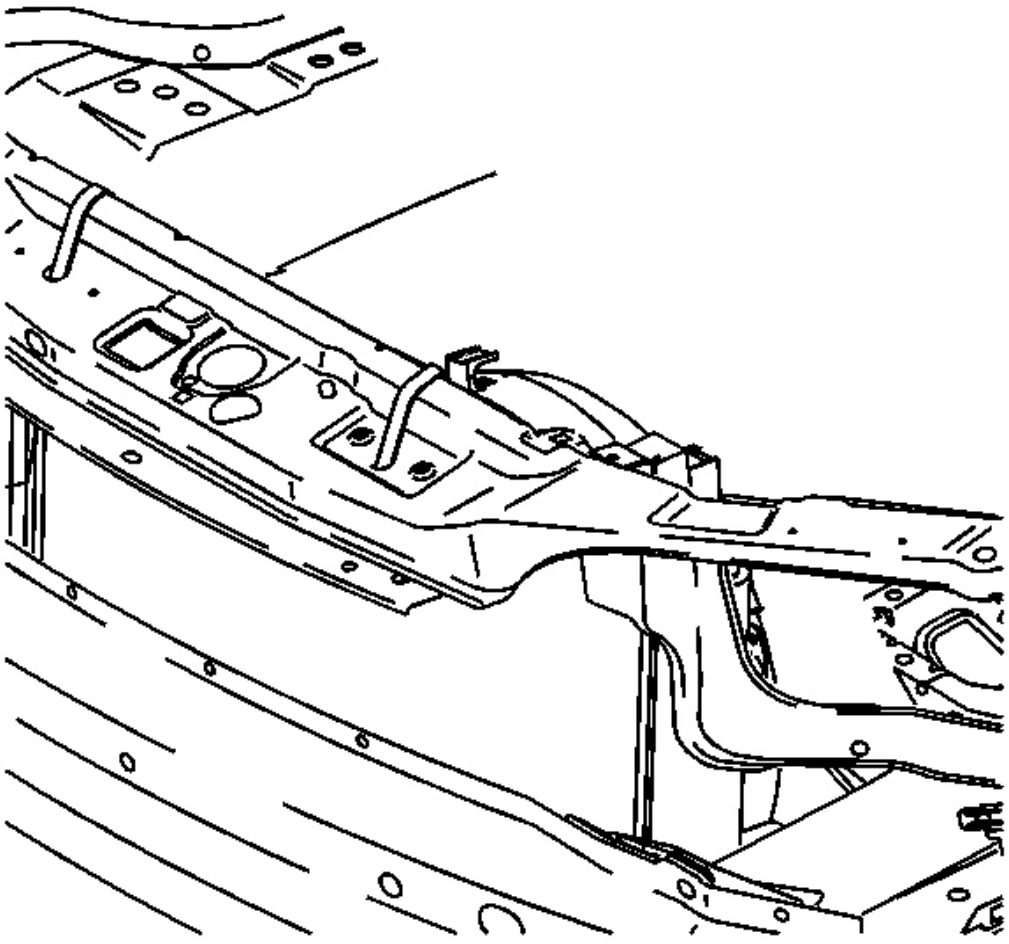


Fig. 324: Securing Radiator/Condenser Fan Assembly
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The radiator/condenser/fan assembly will stay in the vehicle during engine removal.

45. Using long tie straps, secure the radiator/condenser fan assembly to the radiator support assembly.

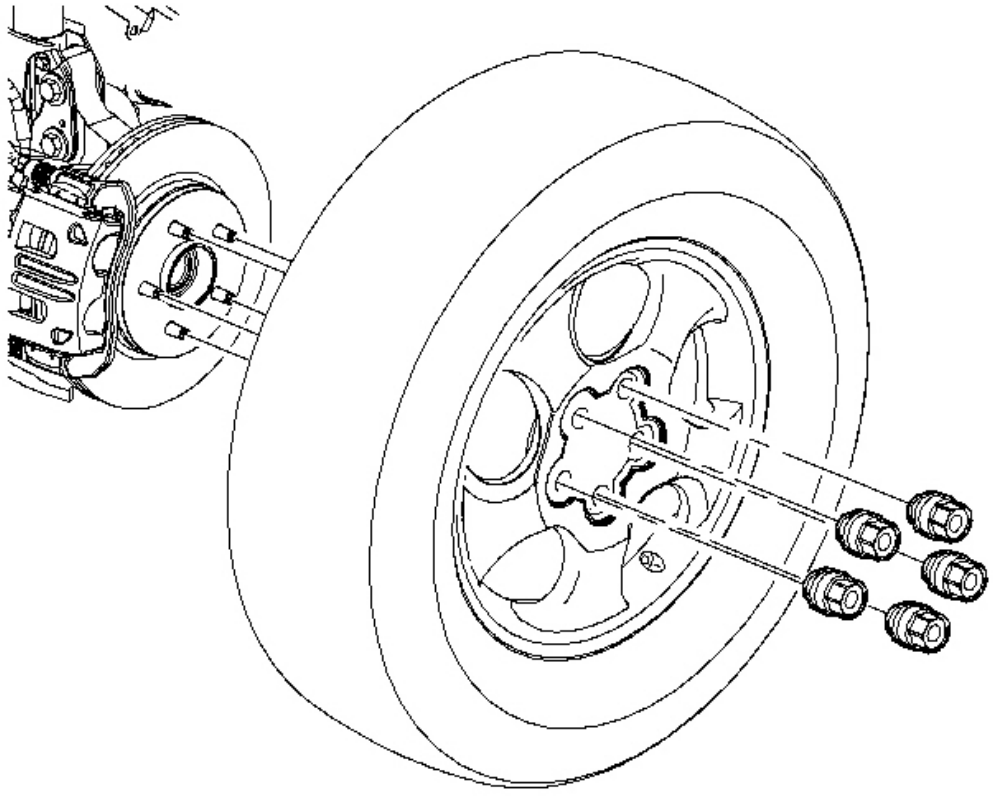


Fig. 325: Front Left-Hand (LH) Wheel
Courtesy of GENERAL MOTORS CORP.

CAUTION: Ensure that the vehicle is properly supported and squarely positioned. To help avoid personal injury when a vehicle is on a hoist, provide additional support for the vehicle on the opposite end from which the components are being removed.

46. Raise the vehicle.
47. Remove the front left-hand (LH) wheel.
48. Remove the front LH wheel inner splash shield.

IMPORTANT: A piece of hardwood should be used between the transaxle case and cradle assembly. This wood will support the transaxle when the LH mount bolts are removed.

49. Install a piece of hardwood 1 x 2 x 4 between the transaxle case and the engine cradle assembly.
50. Remove the front right-hand (RH) wheel.
51. Remove the wheel inner splash shield.

NOTE: Do not install wood under the oil pan plug boss. Damage to the oil pan may occur.

IMPORTANT: A piece of hardwood should be used between the oil pan assembly and the engine cradle. This wood will support the engine when the RH mount bolts are removed.

52. Install a piece of hardwood 1 x 2 x 4 between the engine oil pan and engine cradle assembly near the crankshaft.

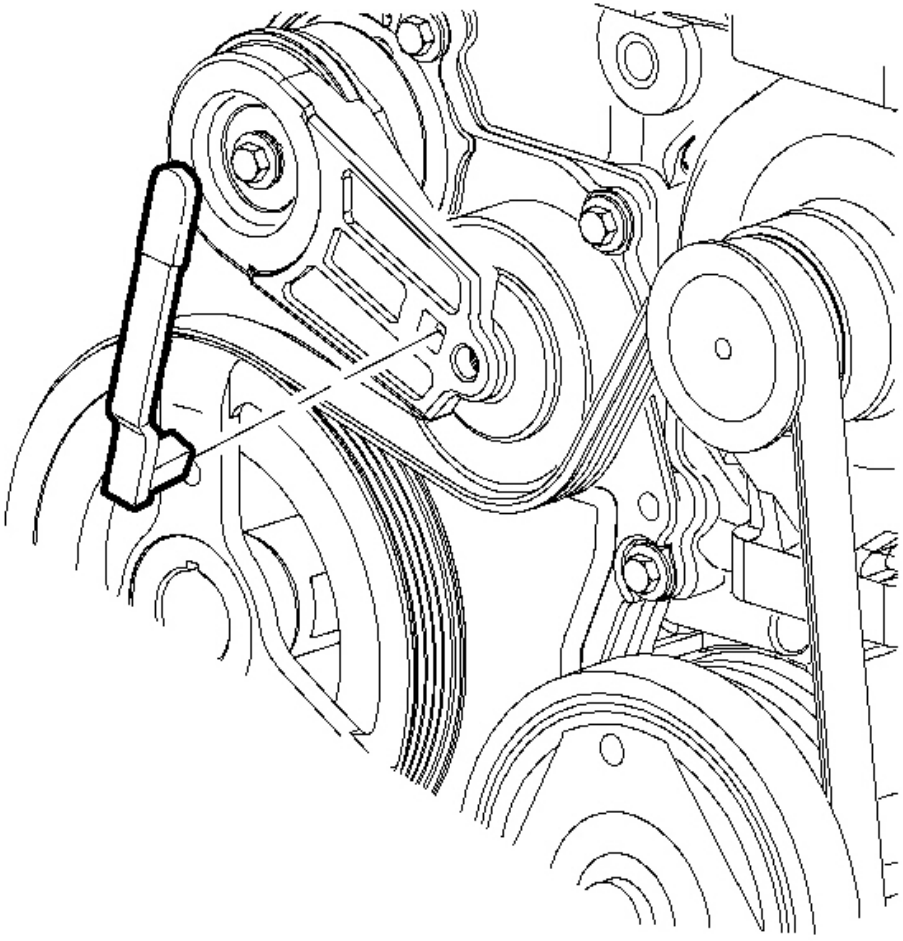


Fig. 326: View Of Drive Belt Tensioner Tool
Courtesy of GENERAL MOTORS CORP.

53. Install the accessory **J 44811** tool onto the tensioner. See **Special Tools and Equipment** .
54. Remove the accessory drive belt.
55. Disconnect the electrical connector at the A/C compressor.
56. Disconnect the electrical connector at the A/C pressure transducer on-line.
57. Remove the A/C compressor bolts.
58. Support the compressor and the line assembly to the body with support straps.
59. Remove the pushpins that retain the air deflector assembly to the cradle.

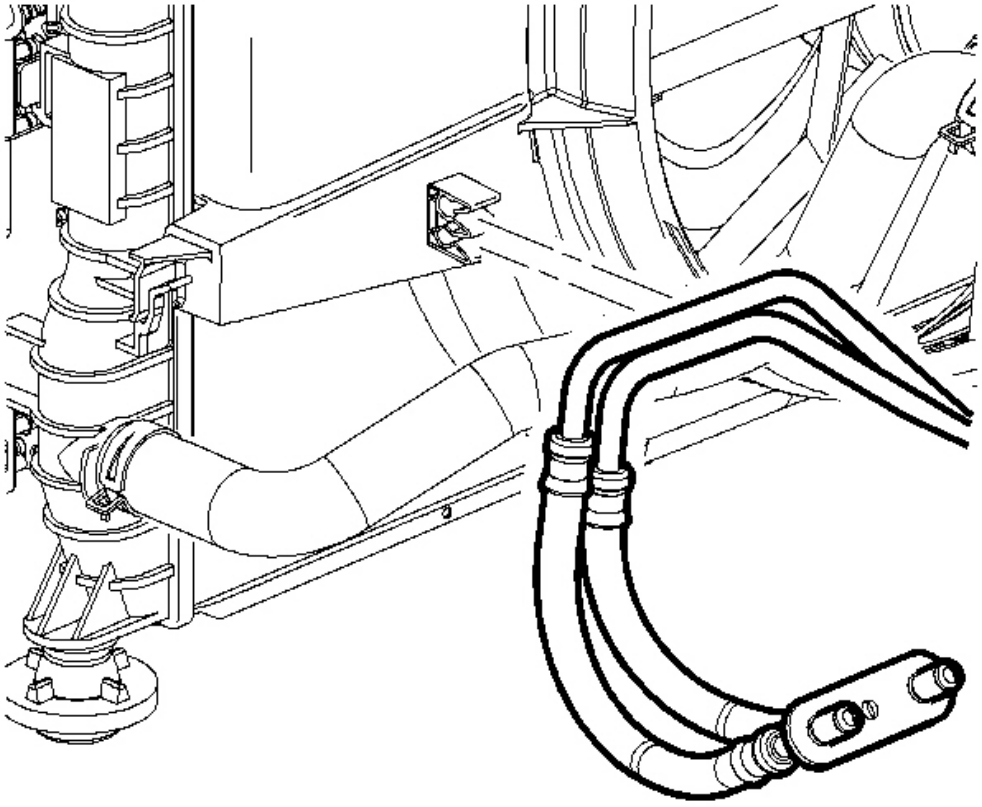


Fig. 327: Connecting Transaxle Lines
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: When the transaxle lines are disconnected, new seals must be installed into the transaxle to prevent the potential for leak.

IMPORTANT: Fluid will leak when the lines are disconnected. Place a drip pan to collect the transaxle oil.

60. Drain the transaxle fluid.
61. If equipped with automatic, disconnect the transaxle lines from the transaxle.
62. Disconnect the rear O2 sensor.

63. Remove the exhaust pipe-to-manifold flange bolts.
64. Remove the exhaust pipe to intermediate pipe nuts.
65. Remove the converter pipe assembly and the support intermediate pipe assembly.
66. Remove the propshaft bolts to the power take-off unit (PTU) - AWD Only.
67. Remove the propshaft bolts at the rear axle assembly - AWD Only.
68. Remove the propshaft support bracket-to-body bolts - AWD Only.
69. Remove the propshaft assembly - AWD Only.

NOTE: Do not remove the shifter cable from the bracket before removing the cable from the transaxle range switch. Damage to the manual shift linkage may occur.

70. If equipped with automatic, remove the shifter cable from the bracket assembly.

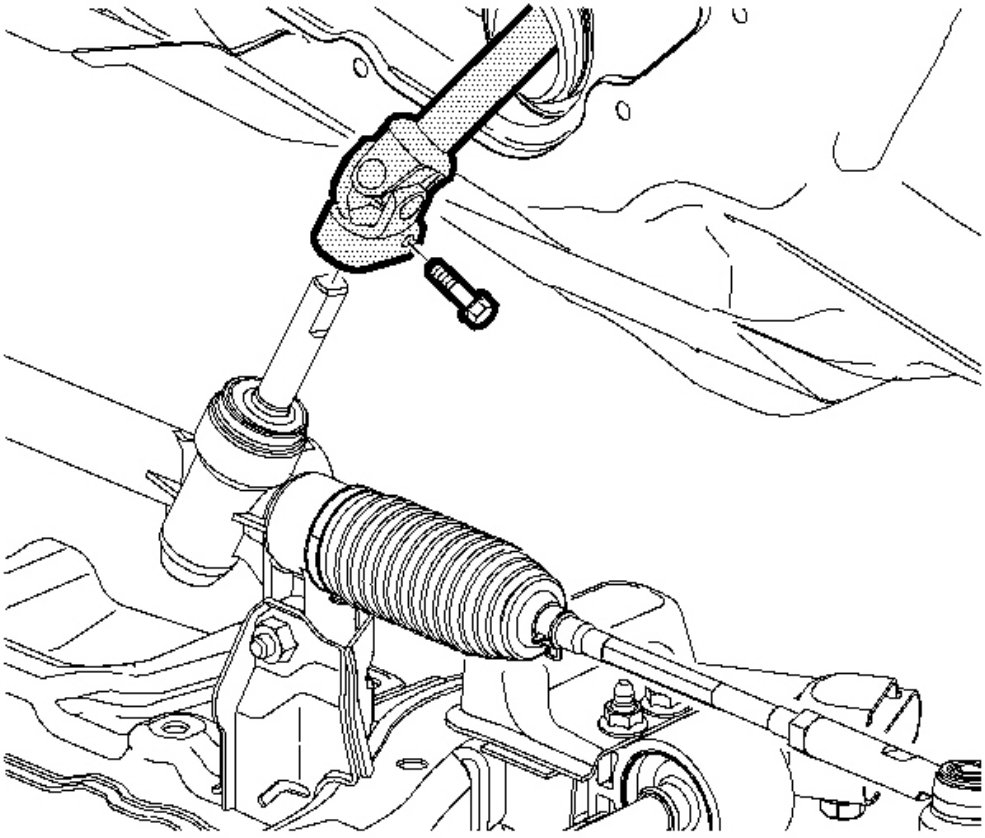


Fig. 328: Removing/Installing Steering Shaft To The Intermediate Shaft
Courtesy of GENERAL MOTORS CORP.

71. Remove the steering gear to the intermediate shaft bolt.

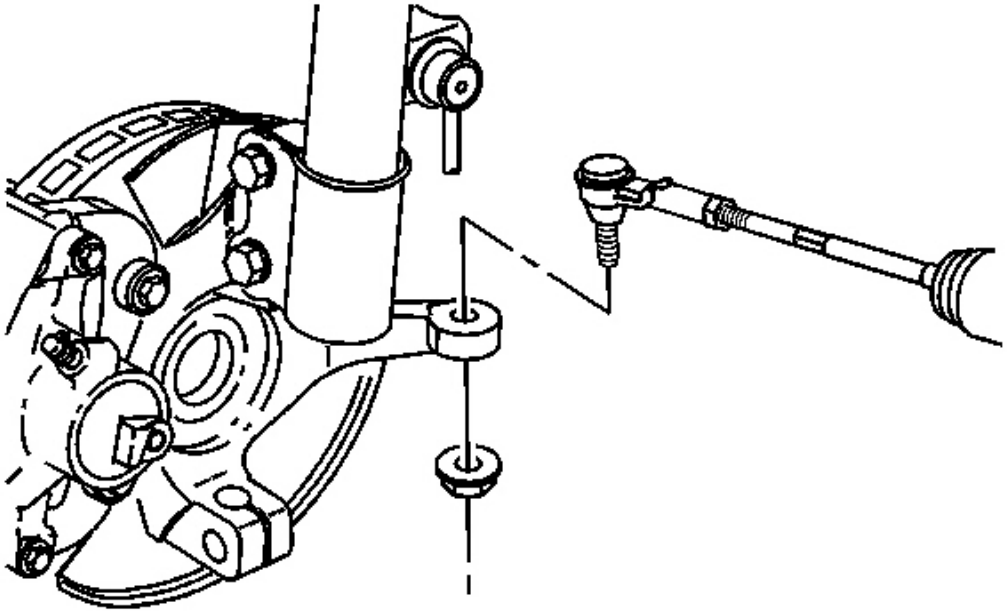


Fig. 329: Tie Rod To Knuckle View
Courtesy of GENERAL MOTORS CORP.

72. Remove the tie rod to knuckle nuts.
73. Separate the tie rod assemblies from the knuckle assemblies using the **SA91100C** .
74. Remove the lower control arm cotter pins and the nuts to knuckle assembly.
75. Separate the **J 43828** .

IMPORTANT: The stabilizer links will stay in the vehicle connected to the strut assembly on the engine removal.

76. Remove the lower stabilizer link nuts to the stabilizer bar.
77. Remove the LH axle shaft assembly from the transaxle.
78. Disconnect the RH shaft assembly from the intermediate drive shaft using the **J 45341** tool with the appropriate slide tool.
79. Lower the vehicle.
80. Remove the RH engine mount to the engine bracket bolts. The engine should rest on the wood blocks.

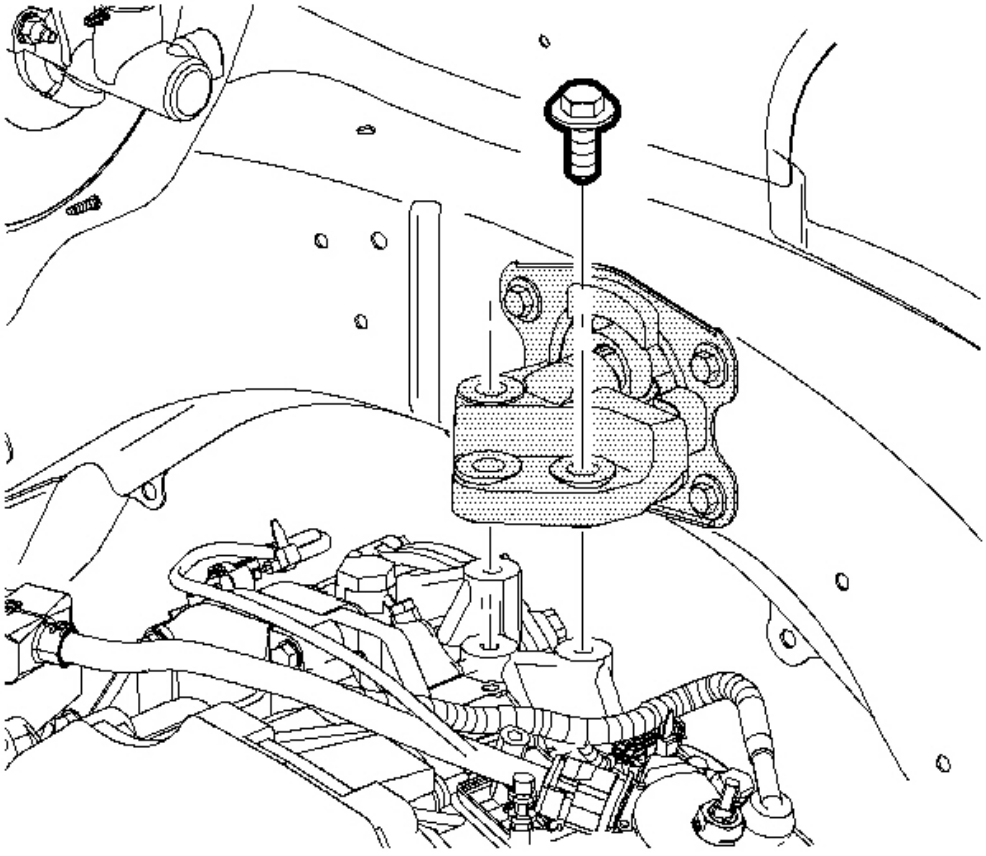


Fig. 330: LH Transaxle Mount
Courtesy of GENERAL MOTORS CORP.

81. Remove the LH transaxle mount to the transaxle bolts, the transaxle should rest on the wood blocks.
82. Raise the vehicle on the hoist.

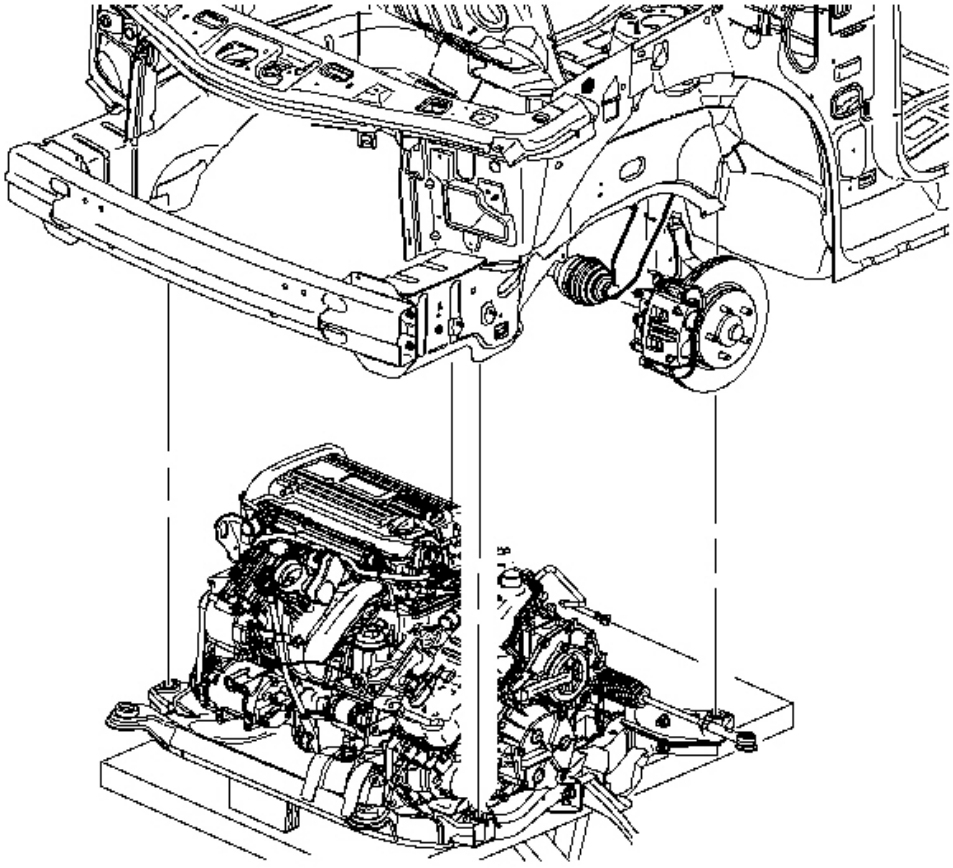


Fig. 331: Raising Powertrain Assembly Into Position
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: During the powertrain removal support the vehicle body by placing a jack at the rear of the vehicle.

83. Position the engine support table under the powertrain assembly.

IMPORTANT: Blocks of wood can be used between the front of cradle and the oil pan to table to level powertrain during the removal.

84. With the table positioned, fully raise the table to contact with powertrain assembly.

85. Remove the cradle to body bolts.

IMPORTANT: When lowering the engine/transaxle assembly, verify all brake lines, shifter cable and other components are free during the removal.

86. Lower the engine table and raise the body on the hoist until the engine/transaxle and the cradle assembly is free from the vehicle.

Installation Procedure

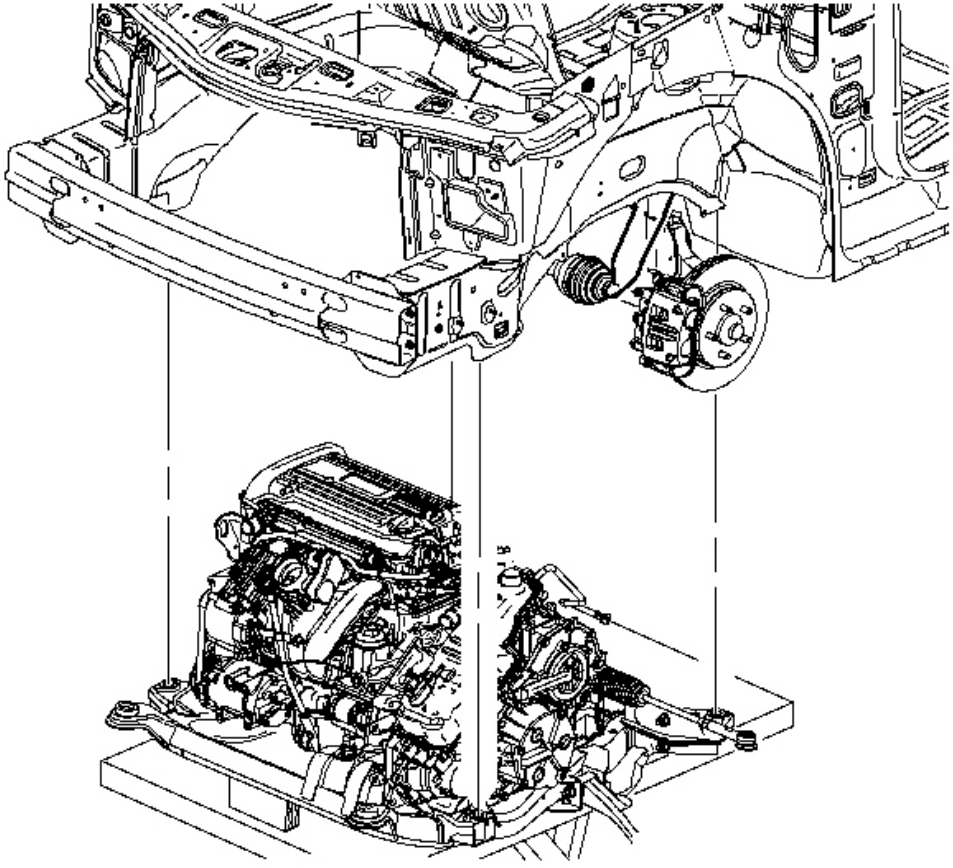


Fig. 332: Raising Powertrain Assembly Into Position
Courtesy of GENERAL MOTORS CORP.

1. With the powertrain supported on the jacking table, raise the powertrain into position.

NOTE: If the radiator assembly is not properly positioned to the cradle, damage could occur.

2. Raise the powertrain assembly into position. Align the lower radiator alignment pins with the cradle assembly. Be sure all the hoses and the electrical harnesses are correctly routed and free from the loading path of the powertrain assembly.
3. Raise the transaxle into the vehicle to align the input shaft to the center of clutch. Guide the transaxle into position, rotate back and forth to align the input shaft splines to the clutch disc manual transmission only.

NOTE: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT: The body to cradle bolts are a one time use fastener and should be discarded after removal.

4. Position the cradle guide pins into the location and install the new cradle-to-body bolts.

   Tighten: Tighten the frame-to-body bolts to 155 N.m (114 lb ft).

5. Lower the vehicle.
6. Install the RH engine mount-to-engine bracket bolts.

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

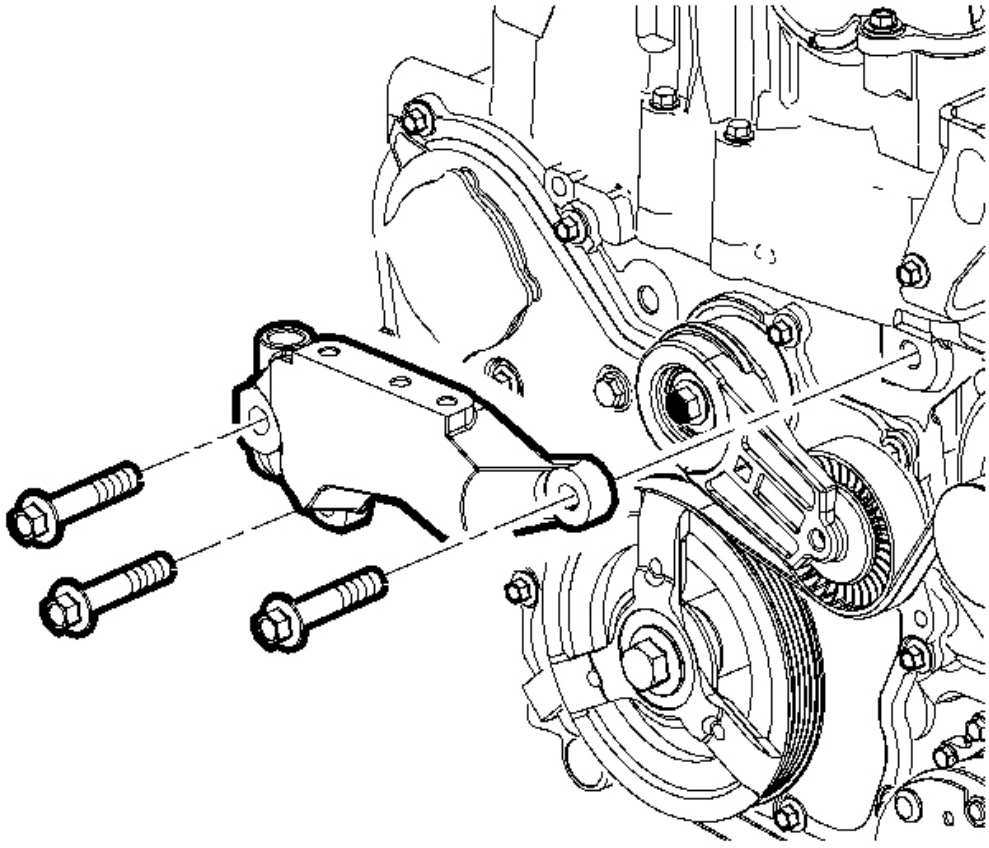


Fig. 333: Removing/Installing Right Hand Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

7. Install the RH engine mount assembly and the nuts.

   Tighten: Tighten the wheel nuts to 125 N.m (92 lb ft).

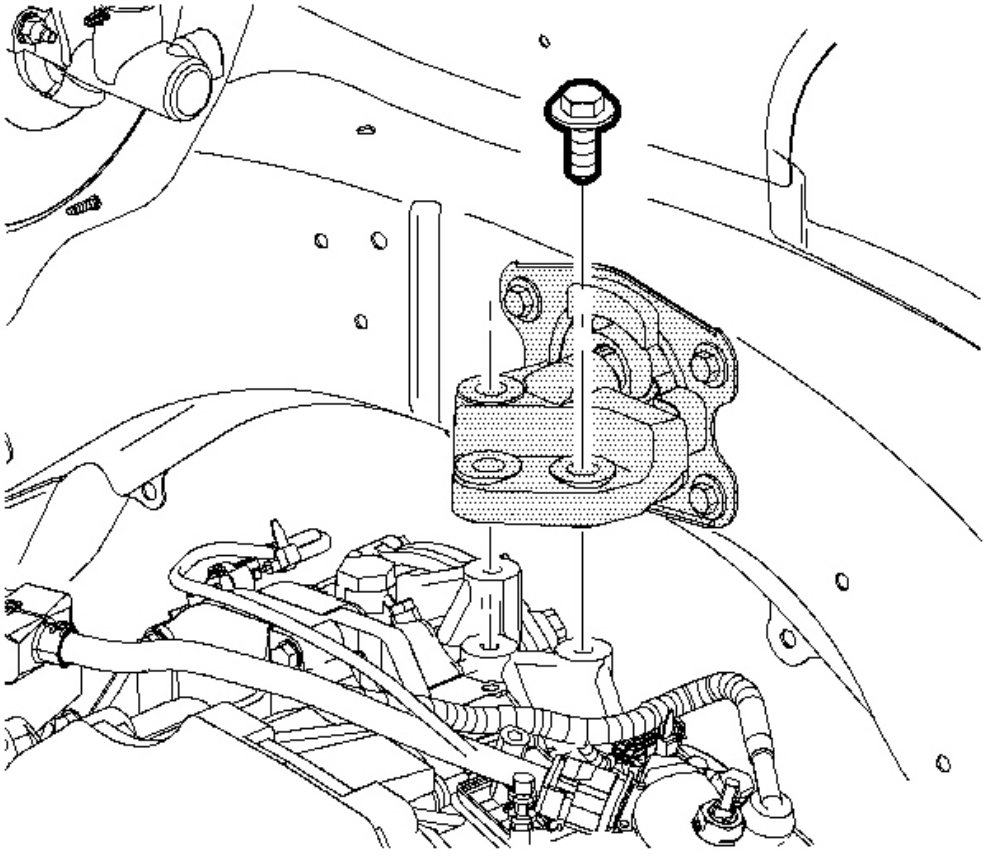


Fig. 334: LH Transaxle Mount
Courtesy of GENERAL MOTORS CORP.

8. Install the LH transaxle mount-to-transaxle bolts.

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

9. Raise the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
10. Remove the wood blocks between the cradle and the powertrain.

IMPORTANT: Do not damage the transaxle and the bearing races when the axles are seated.

11. Swing the axle shafts into position and fully seat the axles into the transaxle.
12. Position the strut assemblies onto the lower control arms.
13. Install the lower control arm nut.

    Tighten: Tighten the lower control arm-to-knuckle nut to 10 N.m (89 lb in) +150 degrees.

14. Verify the axles are fully seated.
15. Position the stabilizer link into position and install the nut.
16. Install the stabilizer nut.

    Tighten: Tighten the stabilizer link to strut to 65 N.m (48 lb ft).

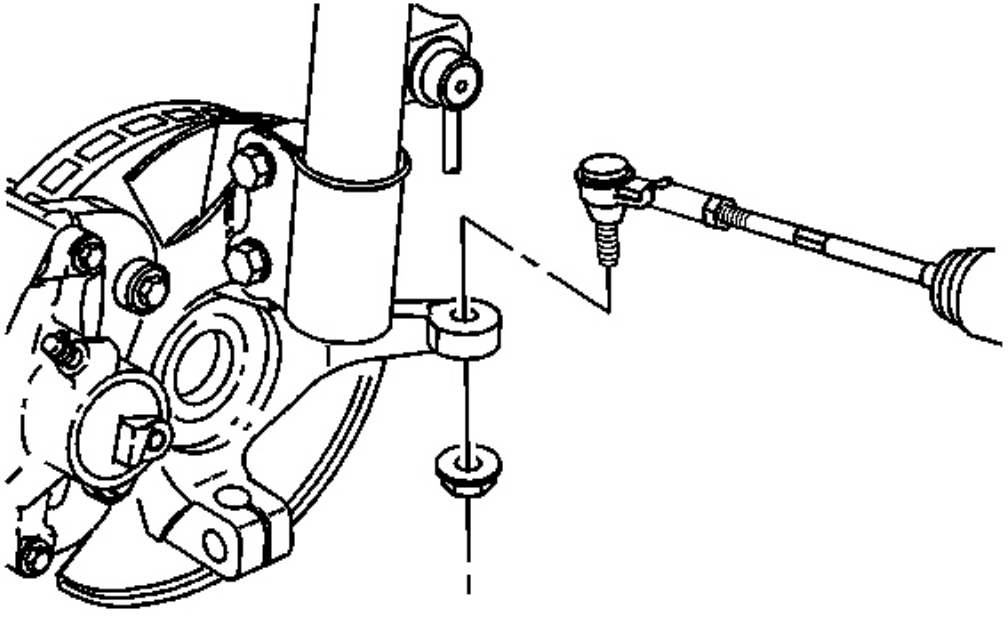


Fig. 335: Tie Rod To Knuckle View
Courtesy of GENERAL MOTORS CORP.

17. Install tie rod end into strut knuckle assembly.

    Tighten: Tighten the tie rod knuckle assembly to 50 N.m (37 lb ft).

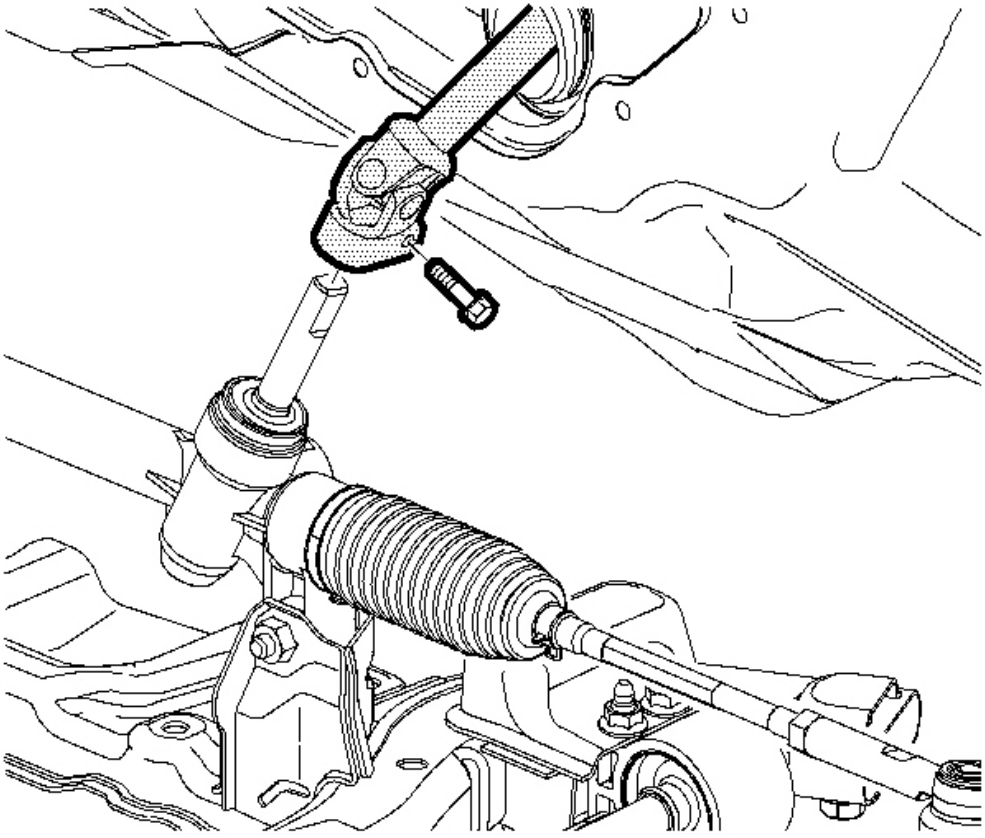


Fig. 336: Removing/Installing Steering Shaft To The Intermediate Shaft
Courtesy of GENERAL MOTORS CORP.

18. Install the steering shaft to the intermediate shaft.
19. Install the steering shaft-to-intermediate shaft bolt.

    Tighten: Tighten the steering shaft-to-rack bolt to 34 N.m (25 lb ft).

20. Install the propshaft into position. Hand-tighten the center bearing nuts - AWD Only.
21. Install the propshaft into position - AWD Only.
22. Install the propshaft-to-PTU bolts - AWD Only.

Tighten: Tighten the propshaft-to-PTU bolts to 25 N.m (19 lb ft).

23. Install the propshaft into the rear axle assembly - AWD Only.
24. Install the propshaft to rear module bolts - AWD Only.

    Tighten: Tighten the propshaft-to-rear module bolts to 50 N.m (37 lb ft).

25. Tighten the propshaft support bearing bolts - AWD Only.

    Tighten: Tighten the propshaft support bearing bolts to 25 N.m (19 lb ft).

26. Install the propshaft support strap - AWD Only.

    Tighten: Tighten the propshaft guard strap to 25 N.m (19 lb ft).

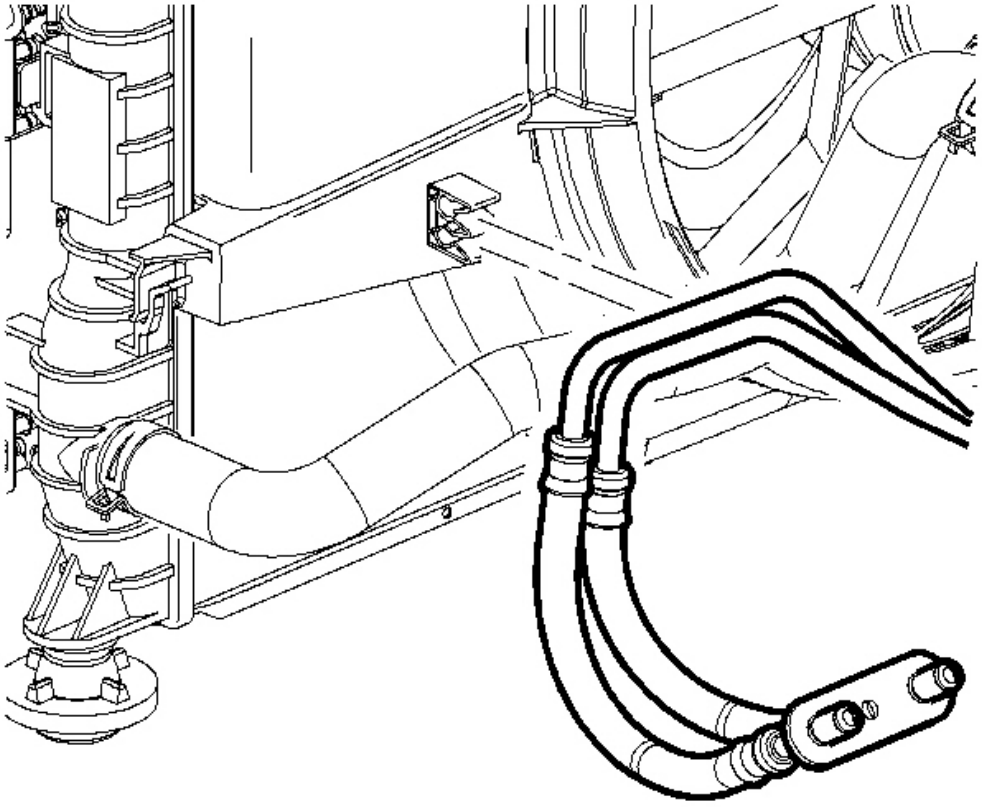


Fig. 337: Connecting Transaxle Lines
Courtesy of GENERAL MOTORS CORP.

27. Connect the transaxle lines-to-transaxle.

    Tighten

    - Tighten the transaxle cooler lines-to-transaxle stud 20 N.m (15 lb ft) - Automatic Only.
    - Tighten the transaxle cooler lines-to-transaxle nut 10 N.m (89 lb in) - Automatic Only.

28. Install the gasket and down pipe-to-intermediate pipe assembly.
29. Hand tighten the nuts.
30. Install the gasket and down pipe-to-exhaust manifold.

Tighten: Tighten the down pipe-to-intermediate pipe nuts to 50 N.m (37 lb ft).

31. Route the O2 harness into position at heat shield.

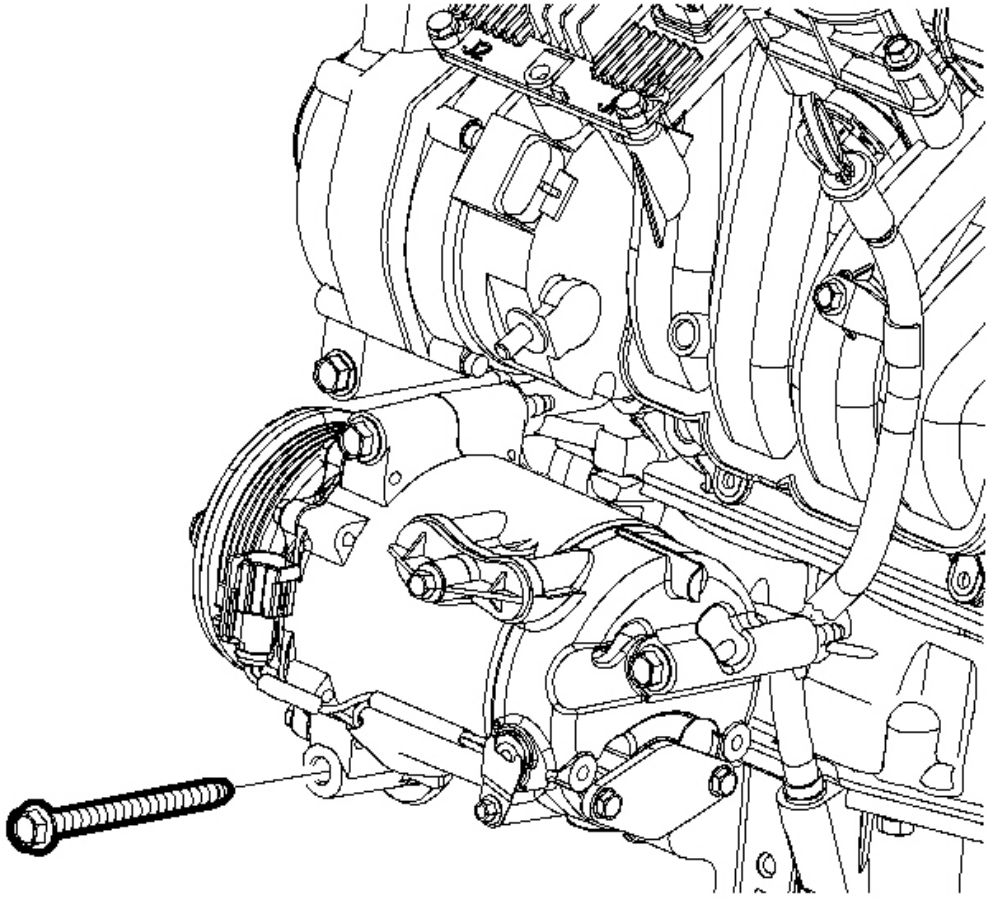


Fig. 338: Installing A/C Compressor
Courtesy of GENERAL MOTORS CORP.

32. Install the A/C compressor to the engine block.

    Tighten: Tighten the A/C compressor-to-block bolt to 25 N.m (18 lb ft).

33. Connect the A/C compressor harness-to-compressor.
34. Connect the A/C pressure transducer-to-sensor.

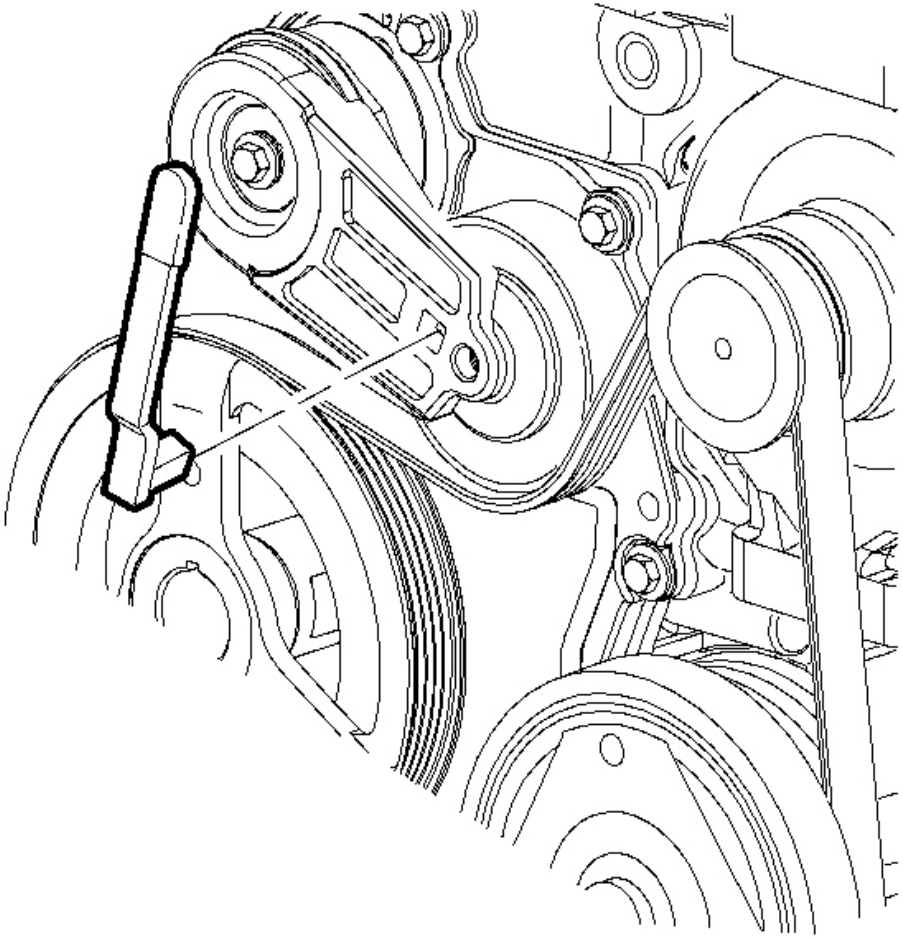


Fig. 339: View Of Drive Belt Tensioner Tool
Courtesy of GENERAL MOTORS CORP.

35. Install the route belt around alternator and the A/C compressor.
36. Install the **J 39914** onto the tensioner and unload the spring tension from the tensioner while positioning the belt. See **Special Tools and Equipment** .
37. Release the tensioner and remove the tool.
38. Attach the front air deflector to the cradle assembly.
39. Route and install the shifter cable onto the bracket.
40. Install the right engine inner splash shield.
41. Install the right wheel and hand tighten the wheel nuts.

42. Install the LH inner splash shield.
43. Install the left wheel and hand tighten the wheel nuts.

    Tighten: Tighten the wheel nuts to 125 N.m (92 lb ft).

44. Lower the vehicle.
45. Connect the shifter cable to the transaxle range switch. Adjustment is required. Refer to **Shift Cable Adjustment** in Automatic Transmission - VT25-E.

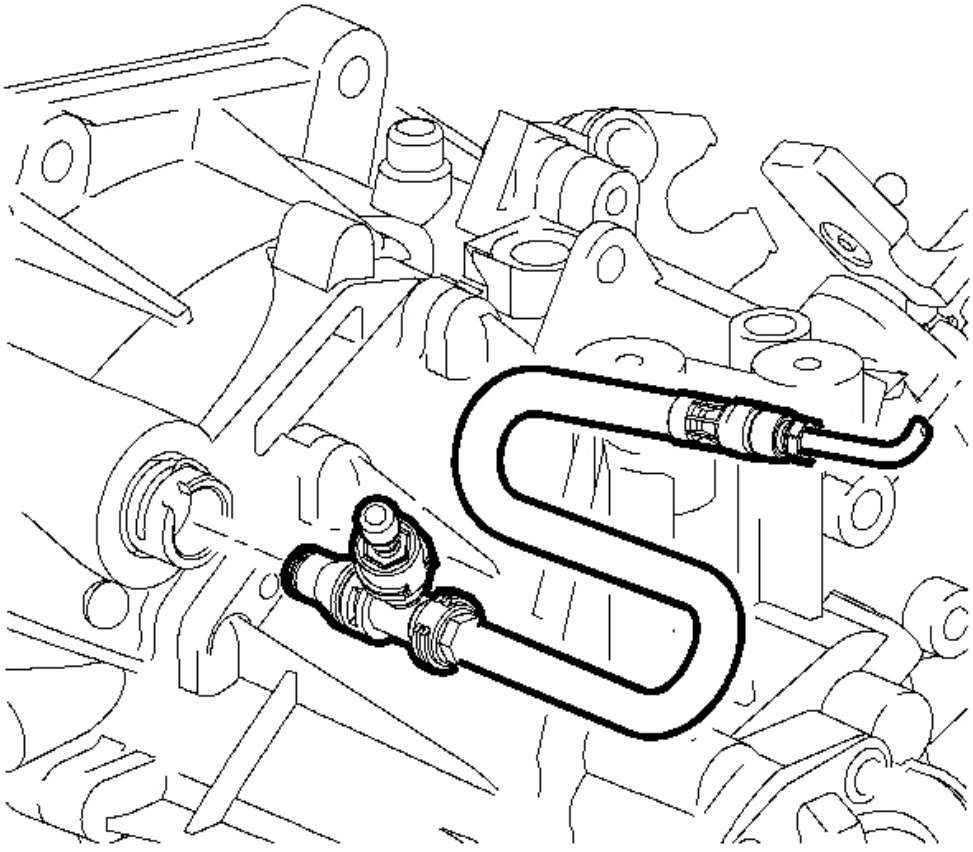


Fig. 340: Disconnecting/Connecting Clutch Hydraulic Line
Courtesy of GENERAL MOTORS CORP.

46. Connect the clutch hydraulic line to the actuator cylinder by inserting and pushing in the C-clip until it stops manual transmission only.
47. Connect the shift cables into the shift cable bracket manual transmission only.
48. Connect the shift cable ends to the transaxle manual transmission only.
49. Connect the heater hoses to the heater core at the front of the dash.
50. Connect the purge hose at the purge solenoid.
51. Connect the fuel transfer line to the quick connect to the fuel line.
52. Connect the surge hose at the bottom of the surge tank.
53. Connect the degas hose at the surge tank.

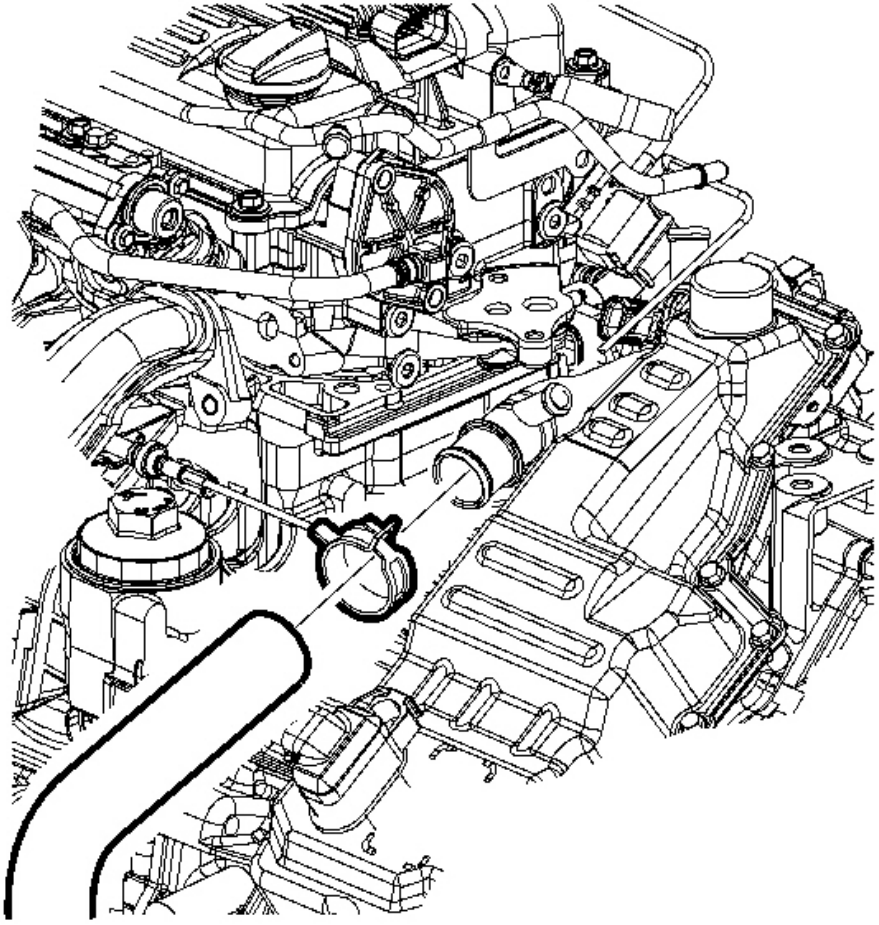


Fig. 341: Disconnecting/Connecting Lower Radiator Hose

Courtesy of GENERAL MOTORS CORP.

54. Connect the lower radiator hose at the coolant pipe.
55. Connect the upper radiator hose at the engine cylinder head.
56. Cut the radiator support straps and remove.

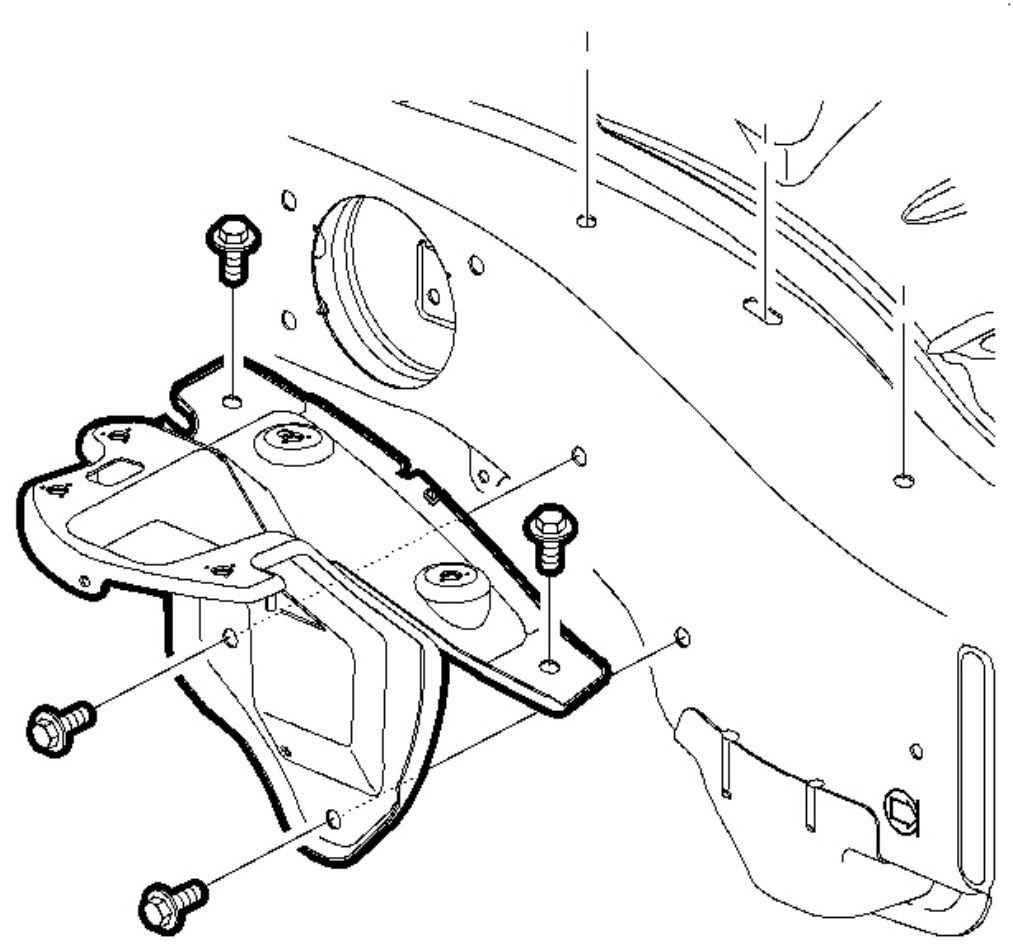


Fig. 342: Installing Headlamp Assemblies & Torque Bolts
Courtesy of GENERAL MOTORS CORP.

57. Install the headlamp assemblies and the torque bolts.
58. Route the engine ground under the A/C line.
59. Install the engine ground-to-body bolt.

Tighten: Tighten the engine ground-to-body bolt to 20 N.m (15 lb ft).

60. Install the UHFB and the battery tray.
61. Install the UHFB and the battery tray bolts.

    Tighten: Tighten the battery tray bolts to 16 N.m (11 lb ft).

62. Route the engine harness into position and install the main engine and the body harness connectors into the UHFB housing.

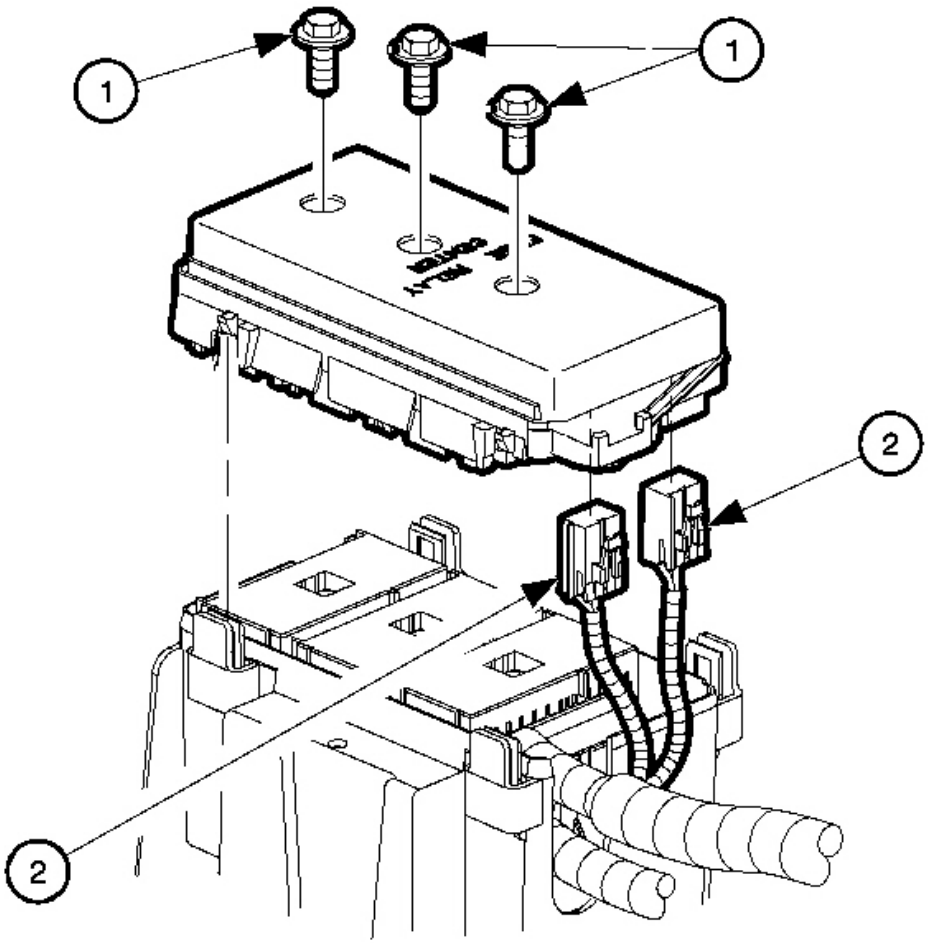


Fig. 343: Locating Underhood Fuse Block (UHFB) Fuse Cover
Courtesy of GENERAL MOTORS CORP.

63. Snap the connectors into position in the UHFB.
64. Connect both electrical connectors (2) underneath the UHFB.

IMPORTANT: Make sure the engine and body harnesses are properly positioned to avoid damage to the harness.

65. Install the UHFB while aligning the UHFB with the connectors.
66. Snap the UHFB into position.
67. Tighten the UHFB connector bolts (1).

    Tighten: Tighten the UHFB connector bolts to 4 N.m (35 lb in).

68. Install the battery and electronic power steering (EPS) feed wire to the UHFB stud and tighten the nut.

    Tighten: Tighten the battery positive-to-UHFB stud to 10 N.m (89 lb in).

69. Install the UHFB fuse cover into position.
70. Connect the electrical connectors to the TCM, if equipped.
71. Install the battery cable and the harness attachment clips on the side of the battery tray/UHFB bracket assembly.
72. Install the battery and the cover.
73. Install the brake vacuum hose into the booster.
74. Connect the rear O2 sensor connector.
75. Secure the rear O2 sensor to the body clips, near air cleaner assembly.
76. Remove the shop towel from the throttle body opening.

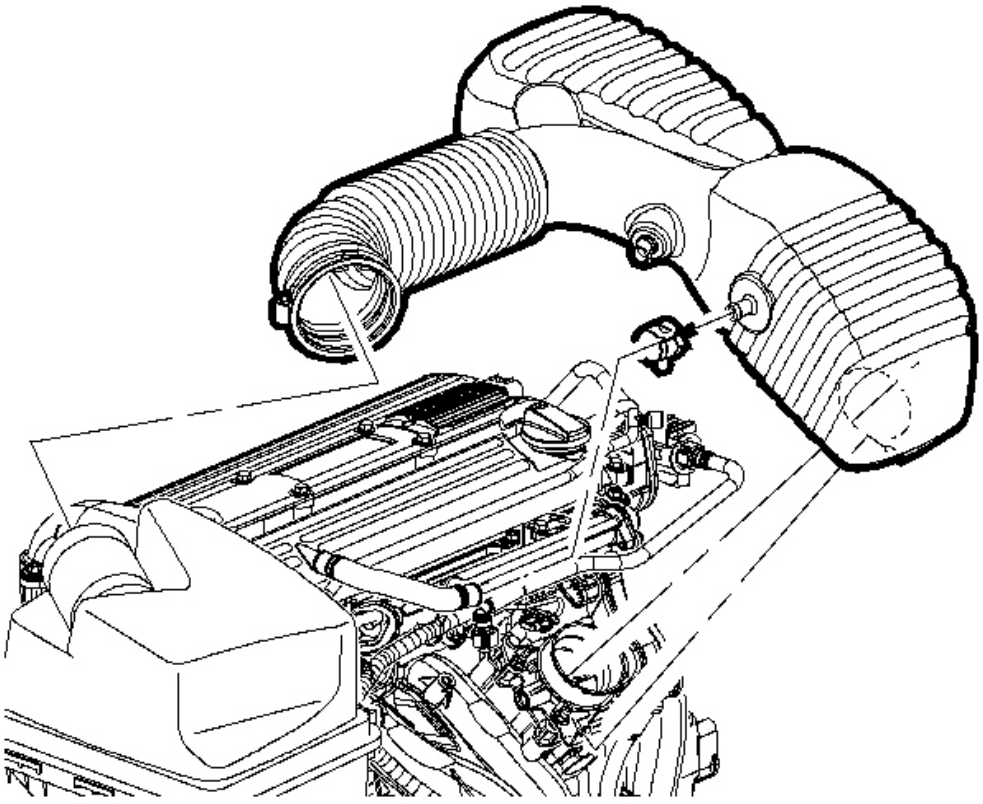


Fig. 344: Locating Air Intake Assembly
Courtesy of GENERAL MOTORS CORP.

77. Position the outlet resonator/duct assembly into position.
78. Connect the PCV fresh air vent hose assembly.
79. Tighten the clamp at the throttle body assembly.
80. Position the outlet resonator/duct assembly up with the support bracket and install the pushpin.
81. Tighten the clamp at air the cleaner assembly.
82. Connect the intake air temperature (IAT) sensor connector.
83. Connect the negative battery cable.

Tighten: Tighten the battery terminal bolt to 17 N.m (13 lb ft).

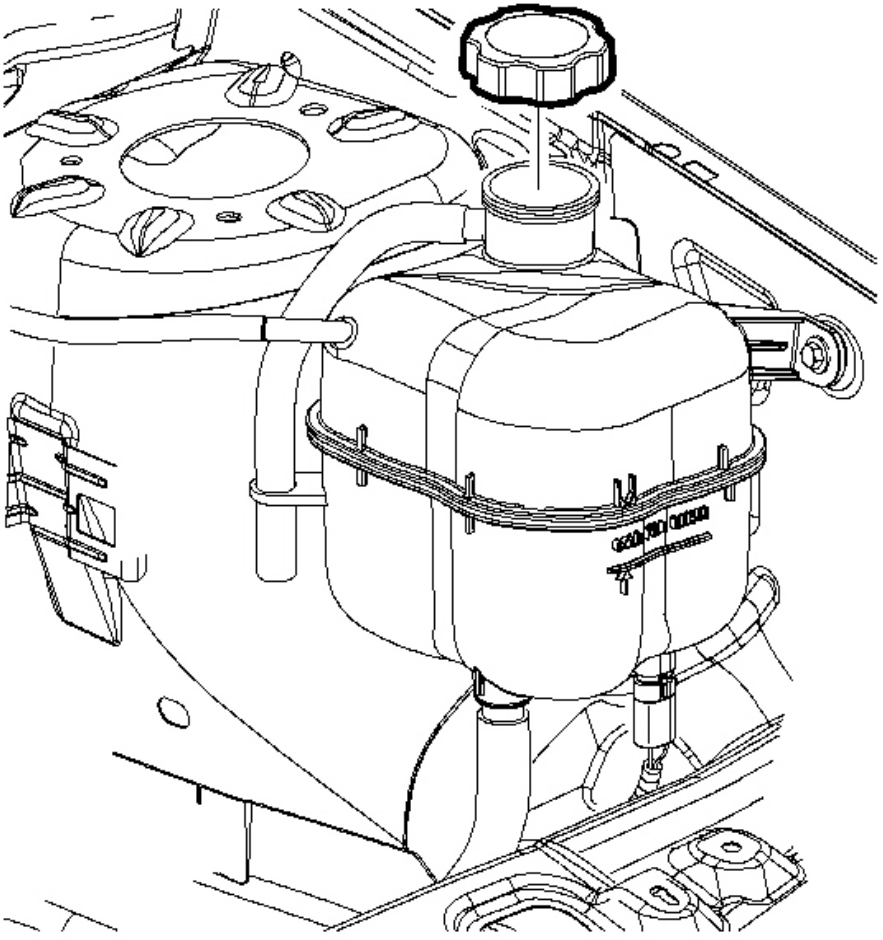


Fig. 345: Disconnecting Degas Hose
Courtesy of GENERAL MOTORS CORP.

NOTE: All entrapped air must be purged from the powertrain cooling system before the final coolant level can be determined. Proper coolant level is critical to avoid engine damage.

84. Fill the coolant system. Refer to **Draining and Filling Cooling System** in Engine Cooling.
85. Start the engine and fill the transaxle fluid. Refer to **Transmission Fluid Replacement** .
86. Check for leaks.
87. If excessive engine idle vibration is noticed, mount adjustment procedure can be performed. Refer to **Powertrain Mount Balance Procedure - Total Mount** .

88. Verify the wheel alignment is within specifications.

ENGINE OIL AND OIL FILTER REPLACEMENT

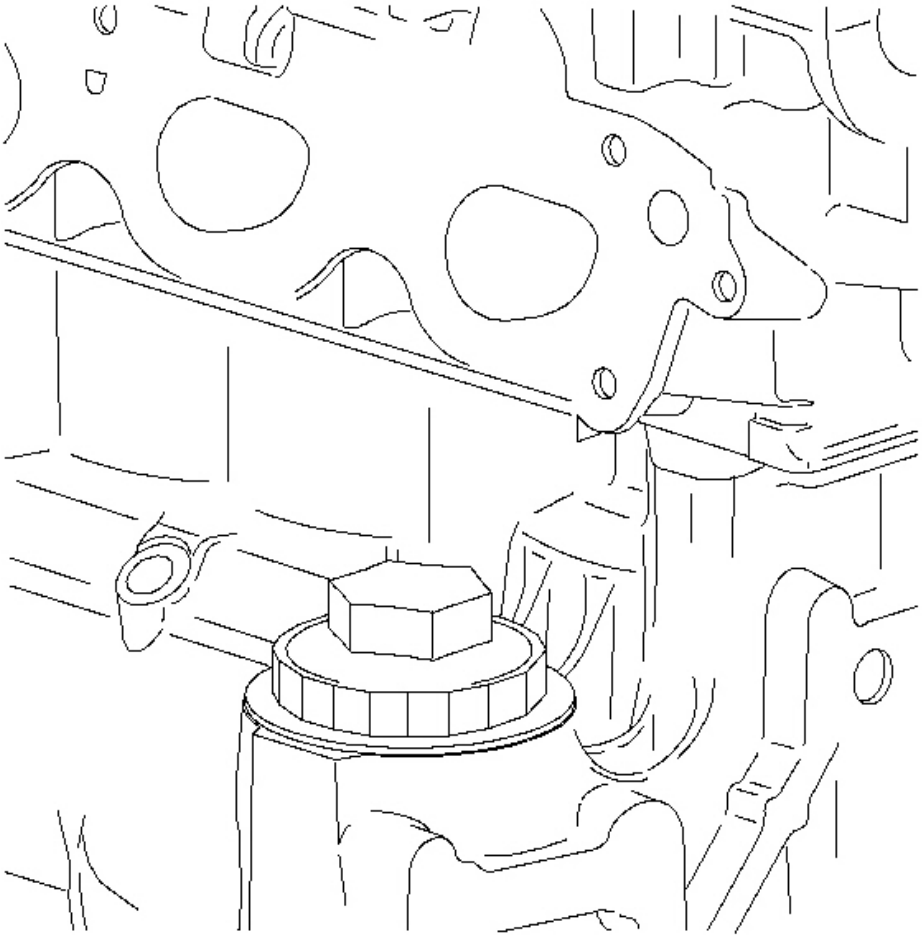


Fig. 346: View Of Engine & Oil Filter
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not use a universal type oil filter wrench to remove oil filter cap. Damage to the oil cap and the engine may result.

IMPORTANT: When performing an oil change, if the oil filter cap being serviced has a 10 mm yellow dot located on top of 32 mm hex P/N 24460712, use only oil

filter, P/N 24460713.

IMPORTANT: Either a 68 mm, 14 flute oil filter wrench or a 32 mm socket must be used to loosen the oil filter cap assembly.

1. Using a 14-flat 68 mm (2.68 in) oil filter wrench or a 32 mm (1.26 in) socket, fully unscrew the oil filter cap from the housing. Allow the oil to drain back from the filter housing assembly.

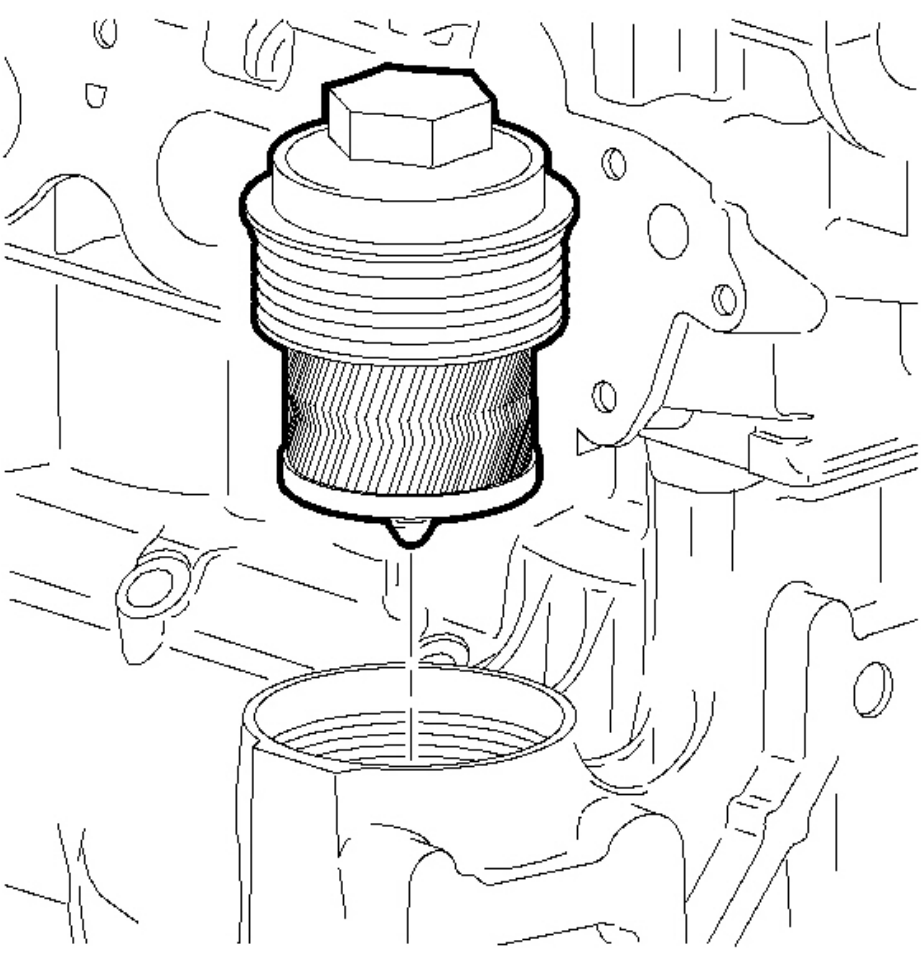


Fig. 347: Removing/Installing Oil Filter Cap
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil filter cap assembly with the filter.

3. Grasp the oil filter cap with the filter element attached and gently tap the filter off onto an approved recycling container.
4. Inspect the O-seal on the cap assembly. Replace if worn, cut or damaged.

CAUTION: Ensure that the vehicle is properly supported and squarely positioned. To help avoid personal injury when a vehicle is on a hoist, provide additional support for the vehicle on the opposite end from which the components are being removed.

5. Raise the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.

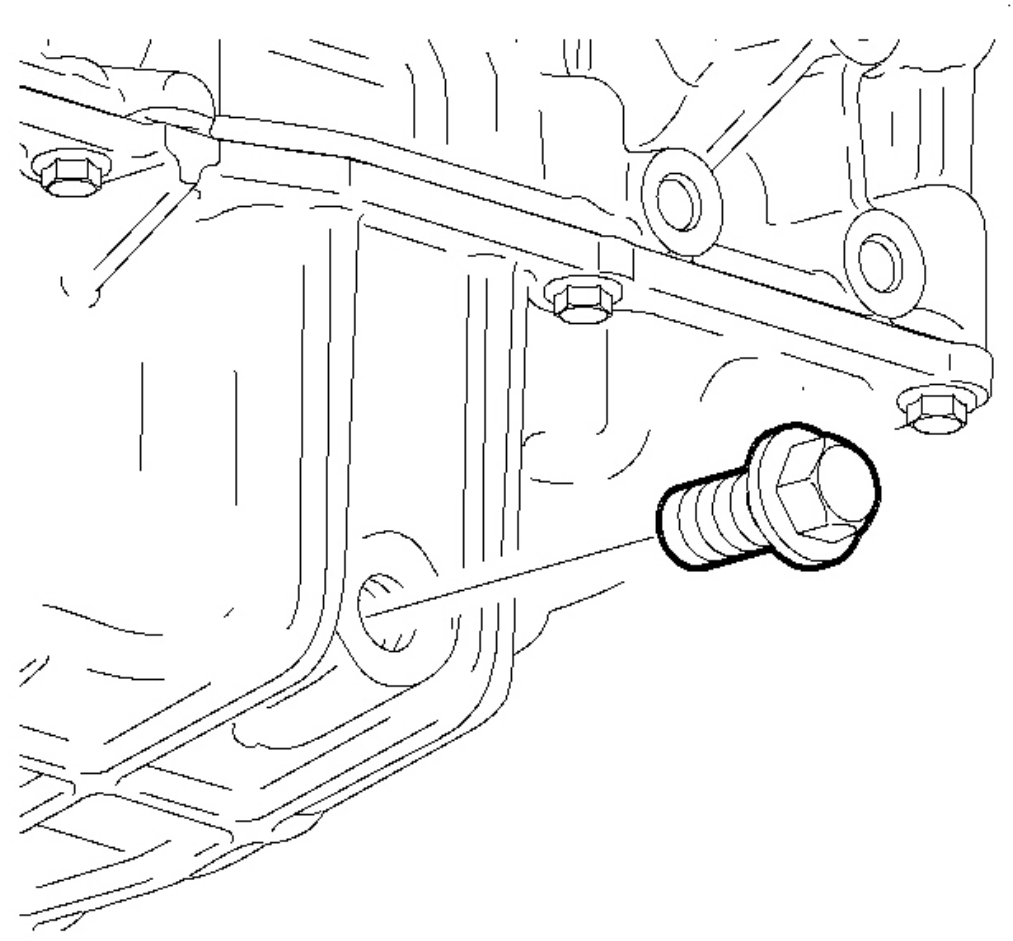


Fig. 348: Removing/Installing Oil Pan Drain Plug

Courtesy of GENERAL MOTORS CORP.

6. Remove the engine oil drain plug and drain the oil into an approved container.
7. Inspect the engine oil drain plug. Replace the drain plug if the sealing surface is worn or damaged.
8. Remove the engine oil drain plug and drain the oil into an approved container.

NOTE: Refer to Fastener Notice in Cautions and Notices.

9. Install the engine oil drain plug.

   Tighten: Tighten the oil pan drain plug - L61 to 25 N.m (18 lb ft).

10. Lower the vehicle.

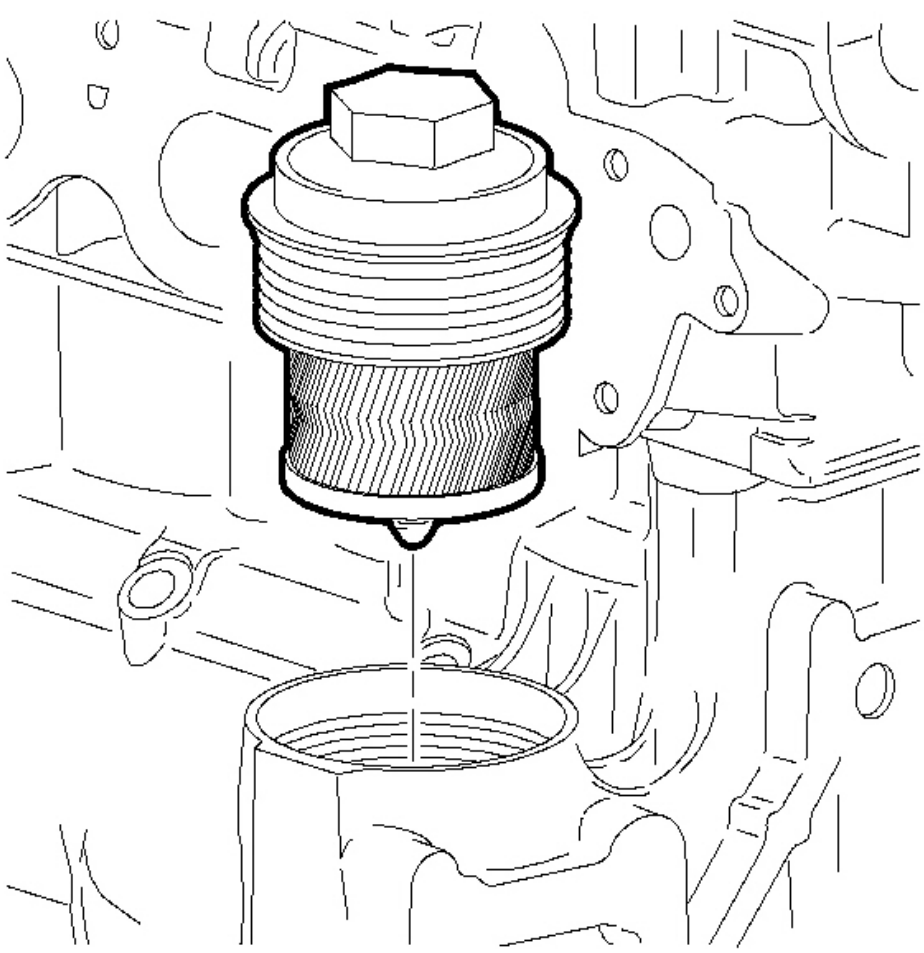


Fig. 349: Removing/Installing Oil Filter Cap
Courtesy of GENERAL MOTORS CORP.

NOTE: **The oil filter must snap into the oil filter cap. If a snap does not occur, verify the correct oil filter element is being installed or engine damage may occur.**

11. Snap a new oil filter element into the oil filter cap.
12. Install the oil filter cap with the element into the casting in the block and tighten.

Tighten: Tighten the oil filter cap to 25 N.m (18 lb ft).

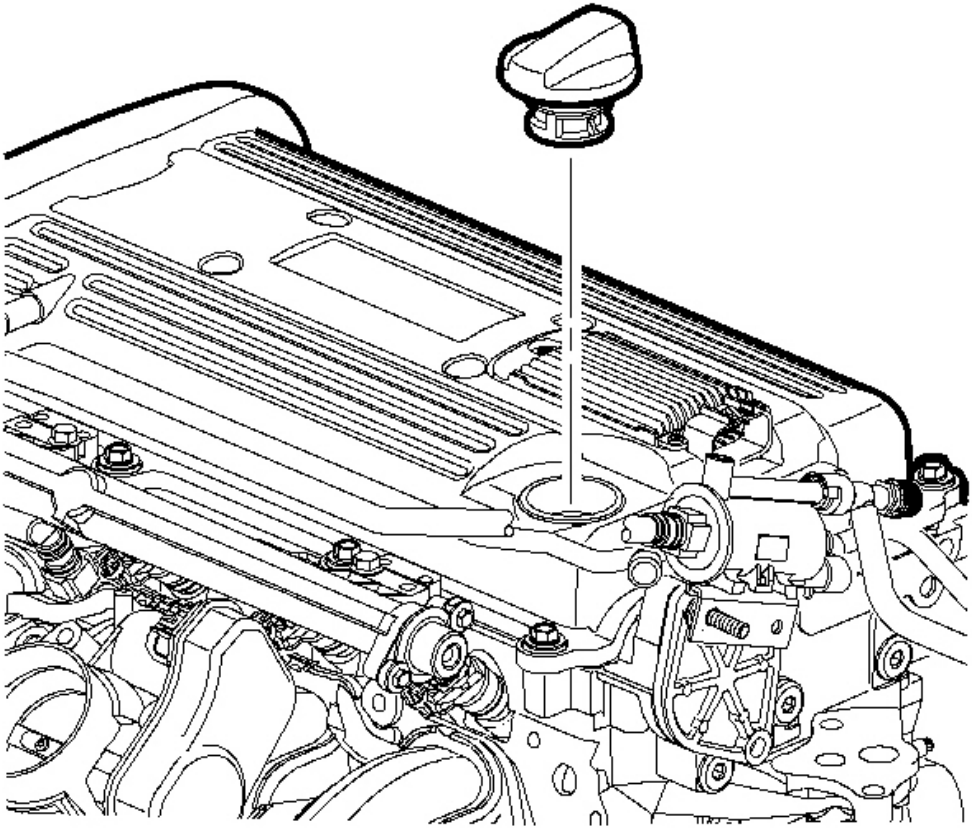


Fig. 350: Removing/Installing Oil Fill Cap
Courtesy of GENERAL MOTORS CORP.

13. Remove the engine oil fill cap.
14. Fill the engine with .73 L (5 qt) of new 5W-30 engine oil.
15. Install the engine oil filler cap.
16. Start the engine and inspect for leaks.

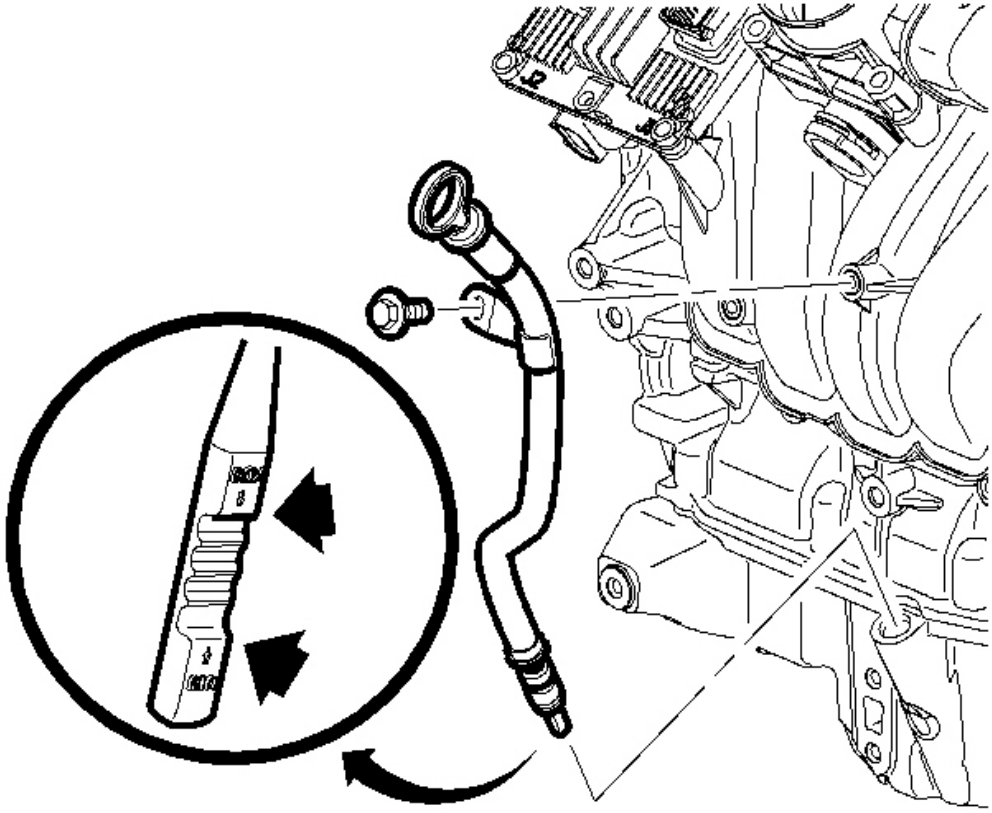


Fig. 351: Installing Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

17. Check the engine oil level after the engine is OFF for 5 minutes. This will allow the engine oil to drain down into the oil pan from the cylinder head.
18. Reset the CHANGE OIL SOON telltale lamp. Refer to **Engine Oil and Oil Filter Replacement** .

VALVE STEM OIL SEAL AND VALVE SPRING REPLACEMENT

Tools Required

- **J 43649** Valve Spring Compressor. See **Special Tools and Equipment** .
- **J 36017** Valve Guide Seal Remover. See **Special Tools and Equipment** .

Removal Procedure

1. Remove the camshaft. Refer to **Intake Camshaft and Lifter Replacement** or **Exhaust Camshaft and Lifter Replacement** .

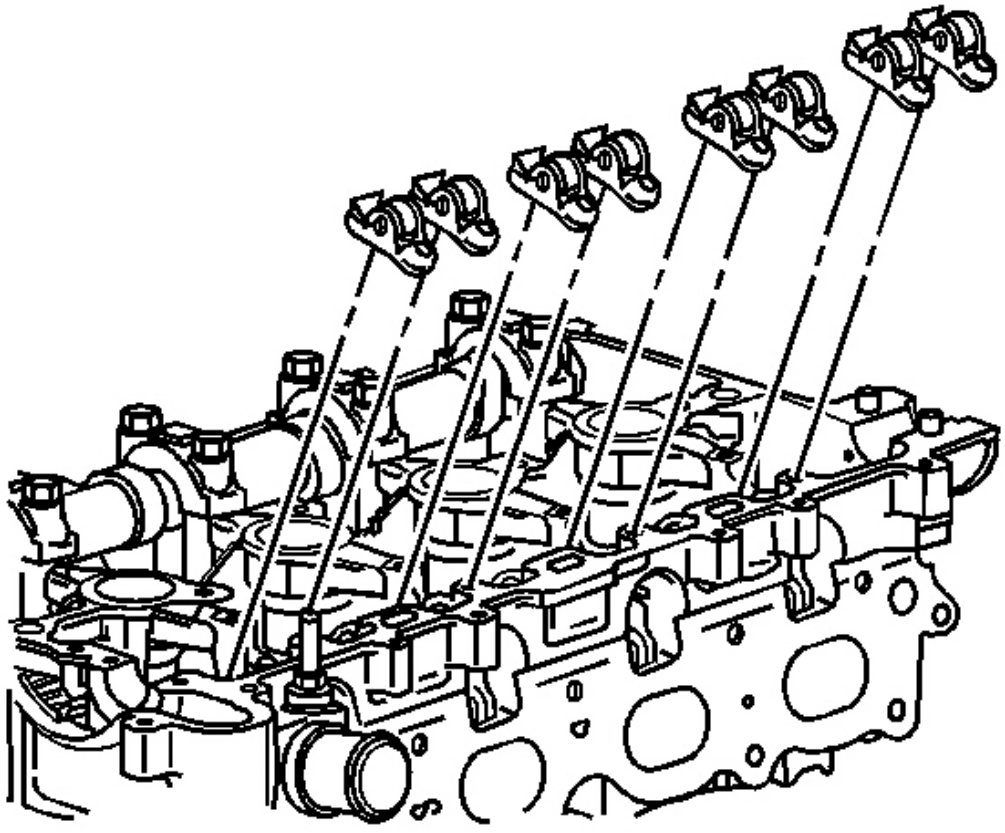


Fig. 352: Identifying Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

2. Remove the camshaft roller followers.

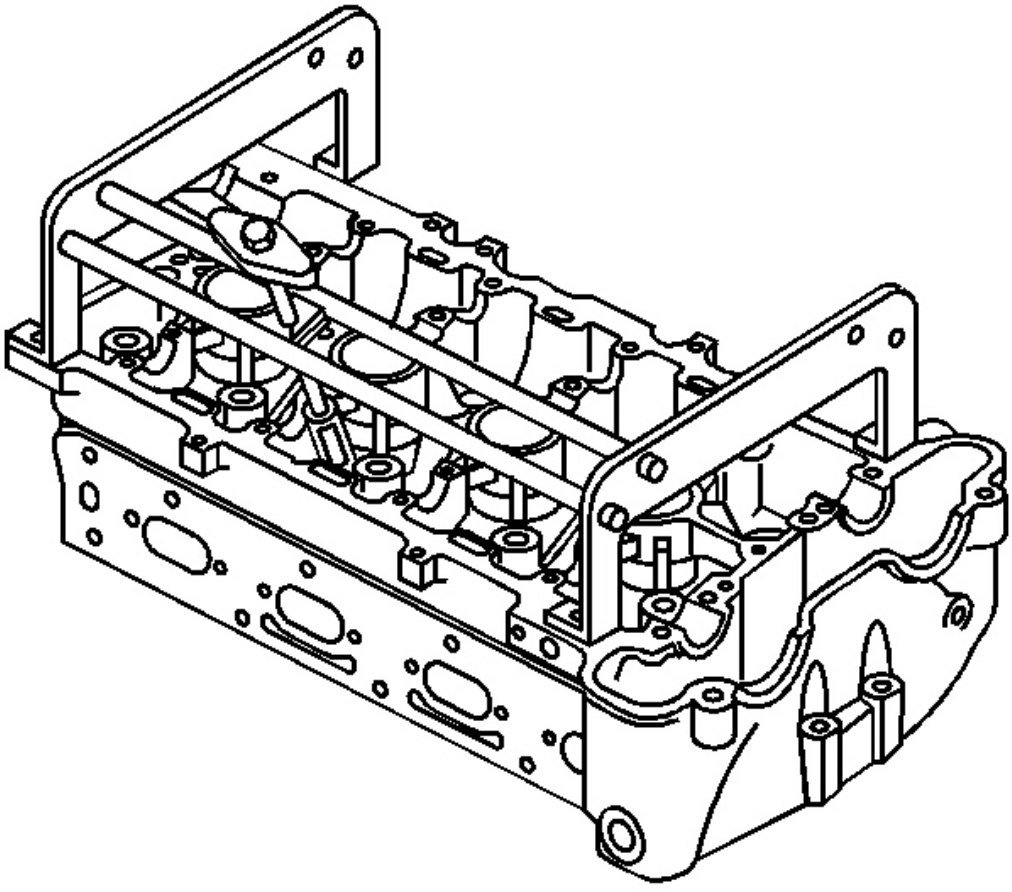


Fig. 353: View Of Valve Spring Compressor
Courtesy of GENERAL MOTORS CORP.

3. Install the **J 43649** to the cylinder head. See **Special Tools and Equipment** .
4. Remove the spark plugs. Refer to **Spark Plug Replacement** in Engine Controls - 2.2L (L61).

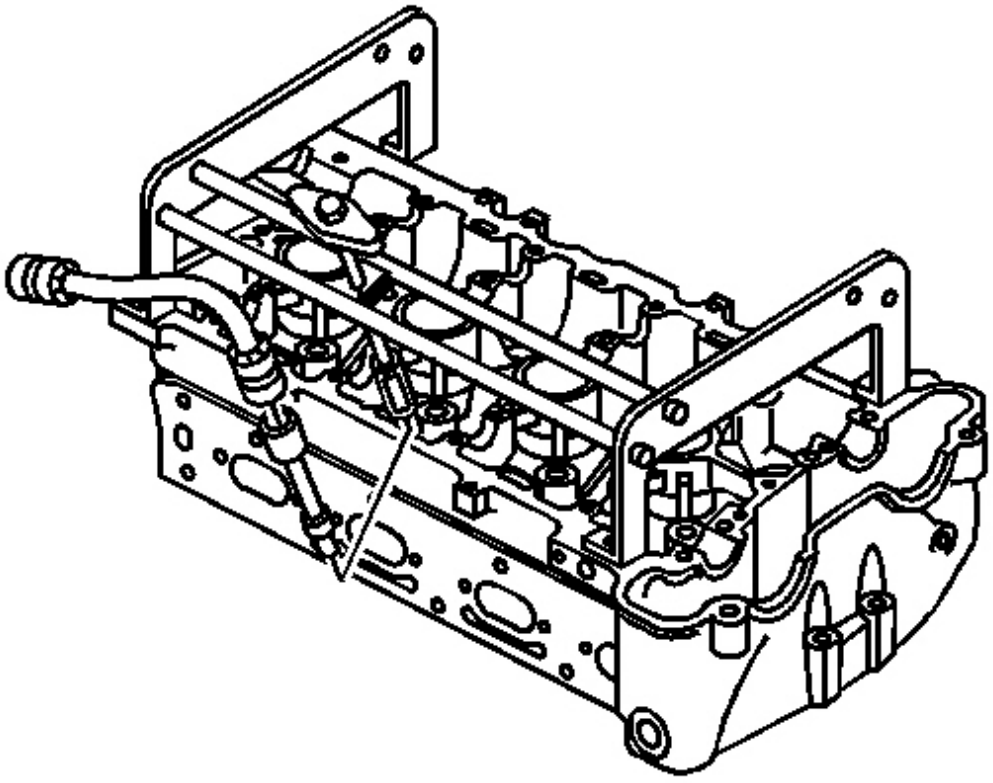


Fig. 354: Aligning Air Hose Adaptor
Courtesy of GENERAL MOTORS CORP.

5. Install an air hose adaptor into the spark plug hole.
6. Pressurize the cylinder to 690 kPa (100 psi).
7. Compress the valve spring.
8. Remove the valve spring keepers.
9. Remove the valve spring.

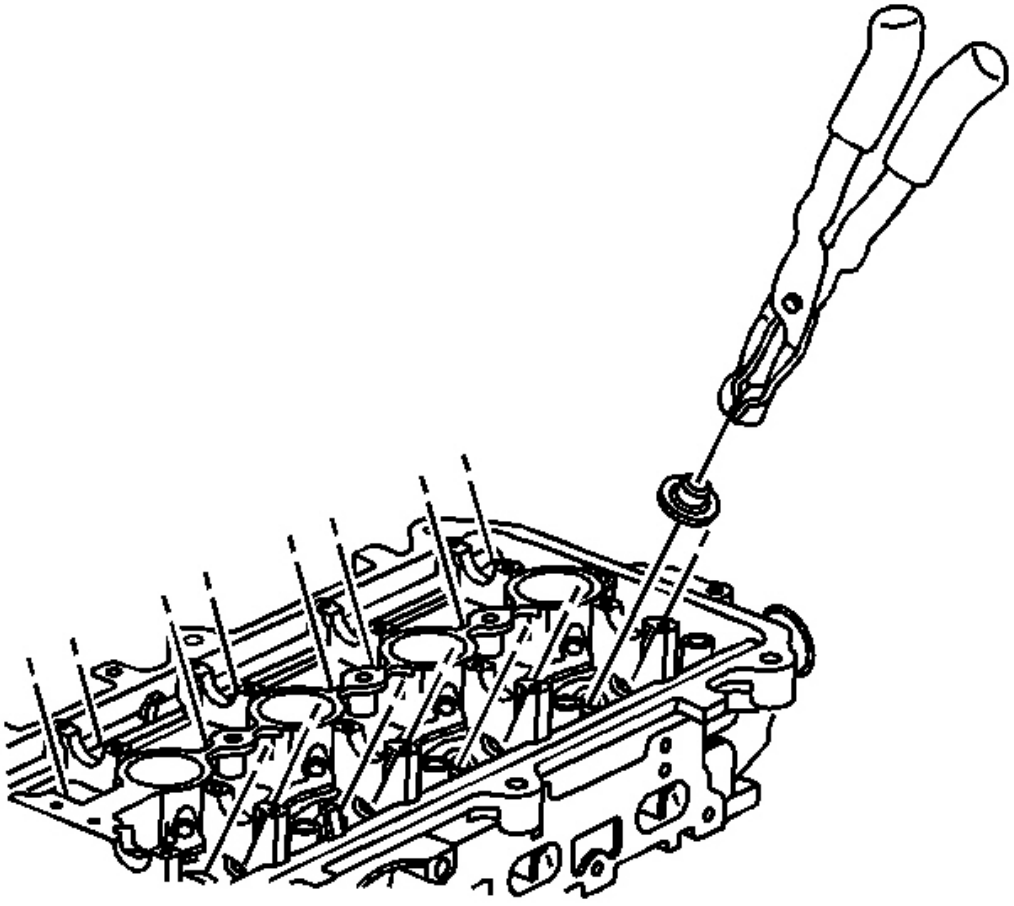


Fig. 355: Using J 36017 To Remove The Valve Seal
Courtesy of GENERAL MOTORS CORP.

10. Using the **J 36017** remove the valve seal. See **Special Tools and Equipment** .

Installation Procedure

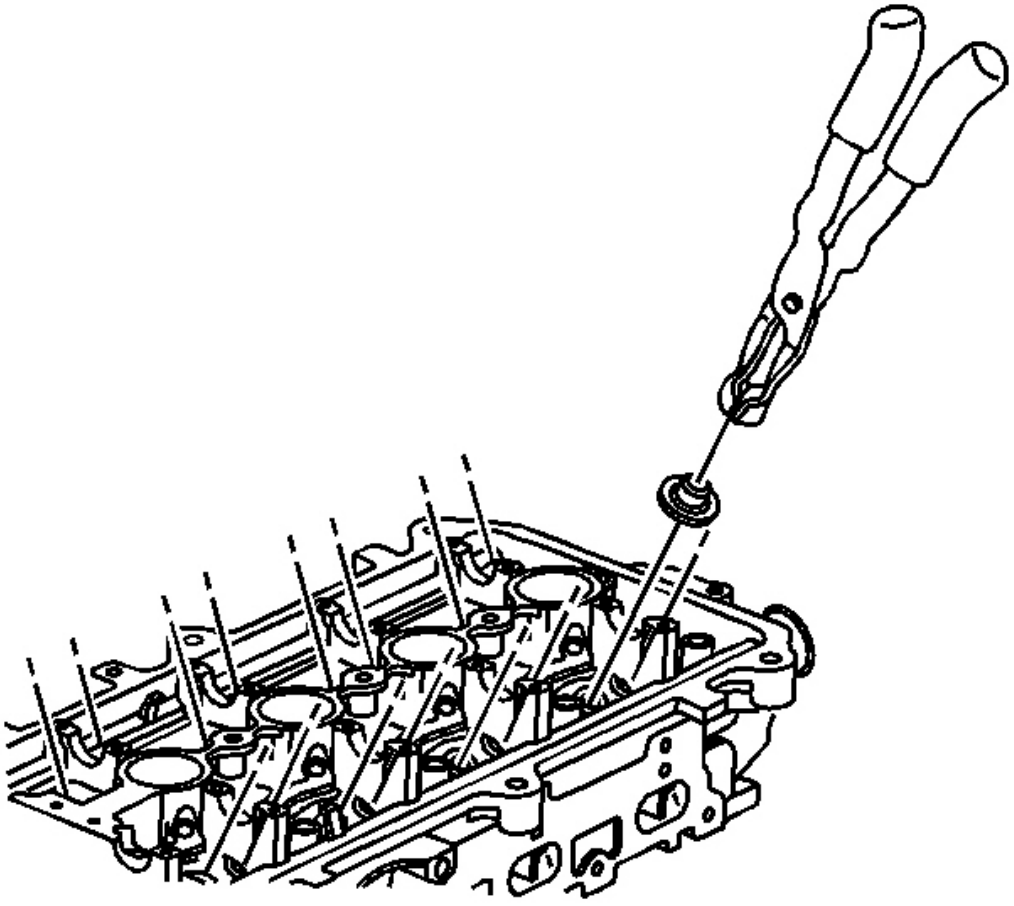


Fig. 356: Using J 36017 To Install The Valve Seal
Courtesy of GENERAL MOTORS CORP.

1. Using the **J 36017** install the valve seal. See **Special Tools and Equipment** .

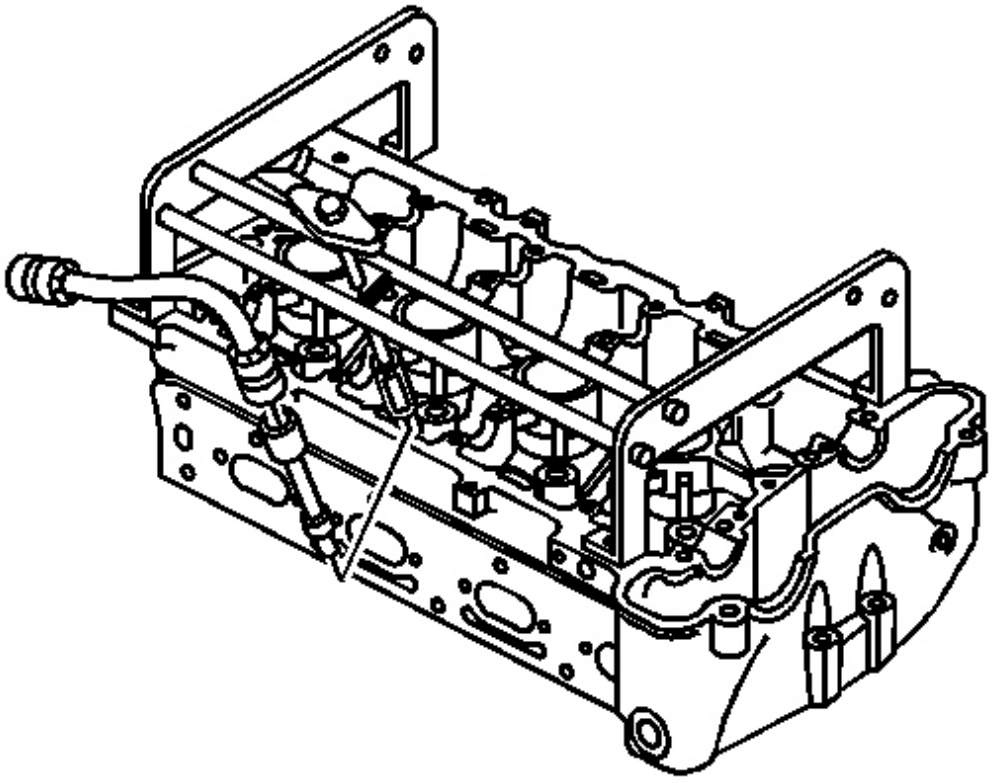


Fig. 357: Aligning Air Hose Adaptor
Courtesy of GENERAL MOTORS CORP.

2. Install the valve spring.
3. Compress the valve spring.
4. Install the valve spring keepers.
5. Remove the air hose adaptor into the spark plug hole.

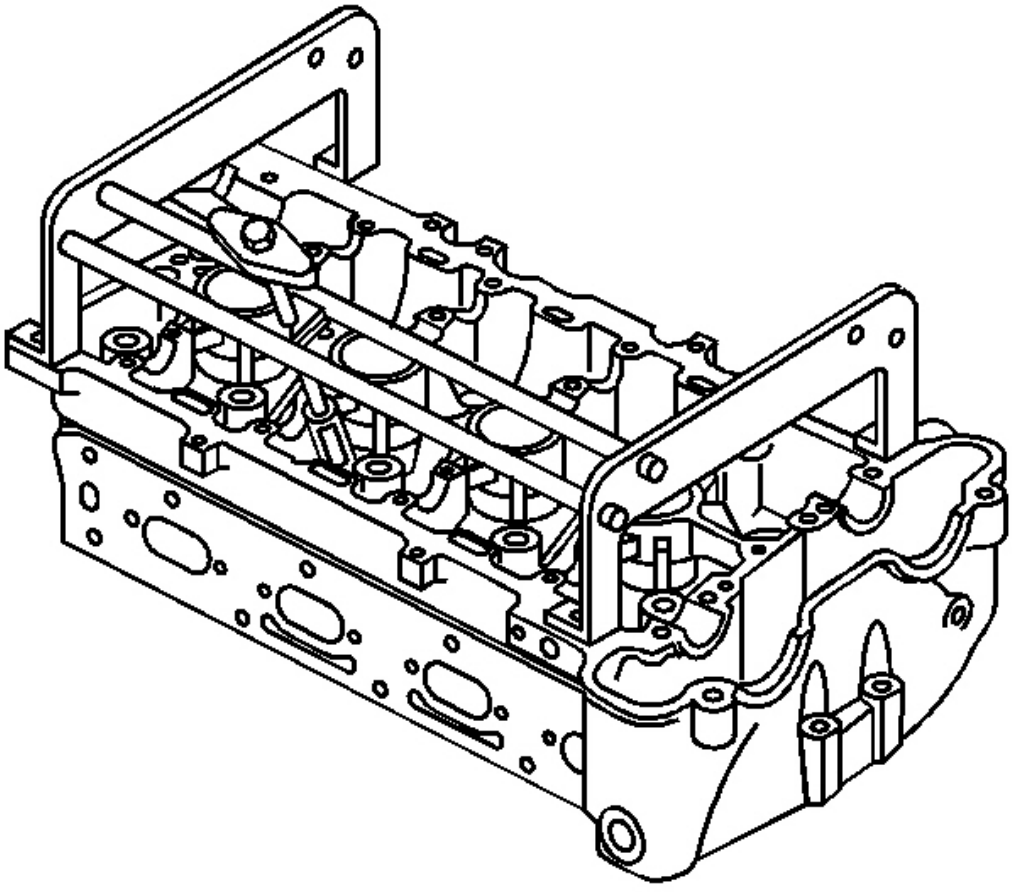


Fig. 358: View Of Valve Spring Compressor
Courtesy of GENERAL MOTORS CORP.

6. Remove the **J 43649** from the cylinder head. See **Special Tools and Equipment** .
7. Install the spark plugs. Refer to **Spark Plug Replacement** in Engine Controls - 2.2L (L61).

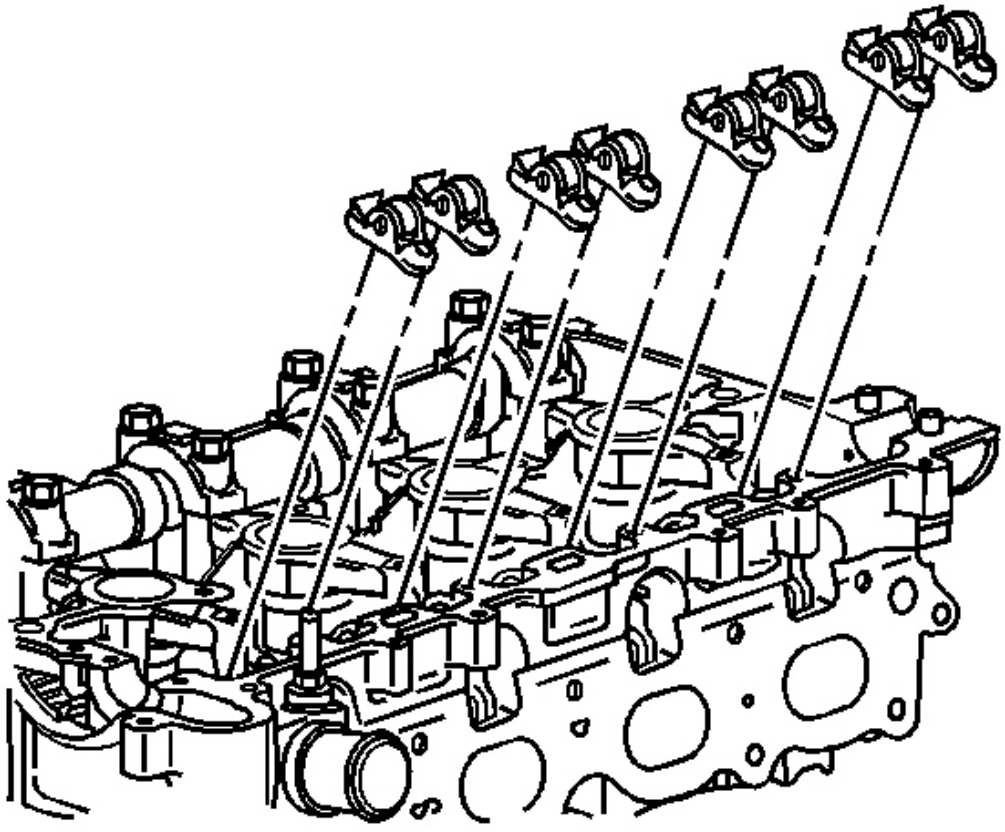


Fig. 359: Identifying Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

8. Install the camshaft roller followers.
9. Install the camshaft. Refer to **Intake Camshaft and Lifter Replacement** or **Exhaust Camshaft and Lifter Replacement** .

DRAINING FLUIDS AND OIL FILTER REMOVAL

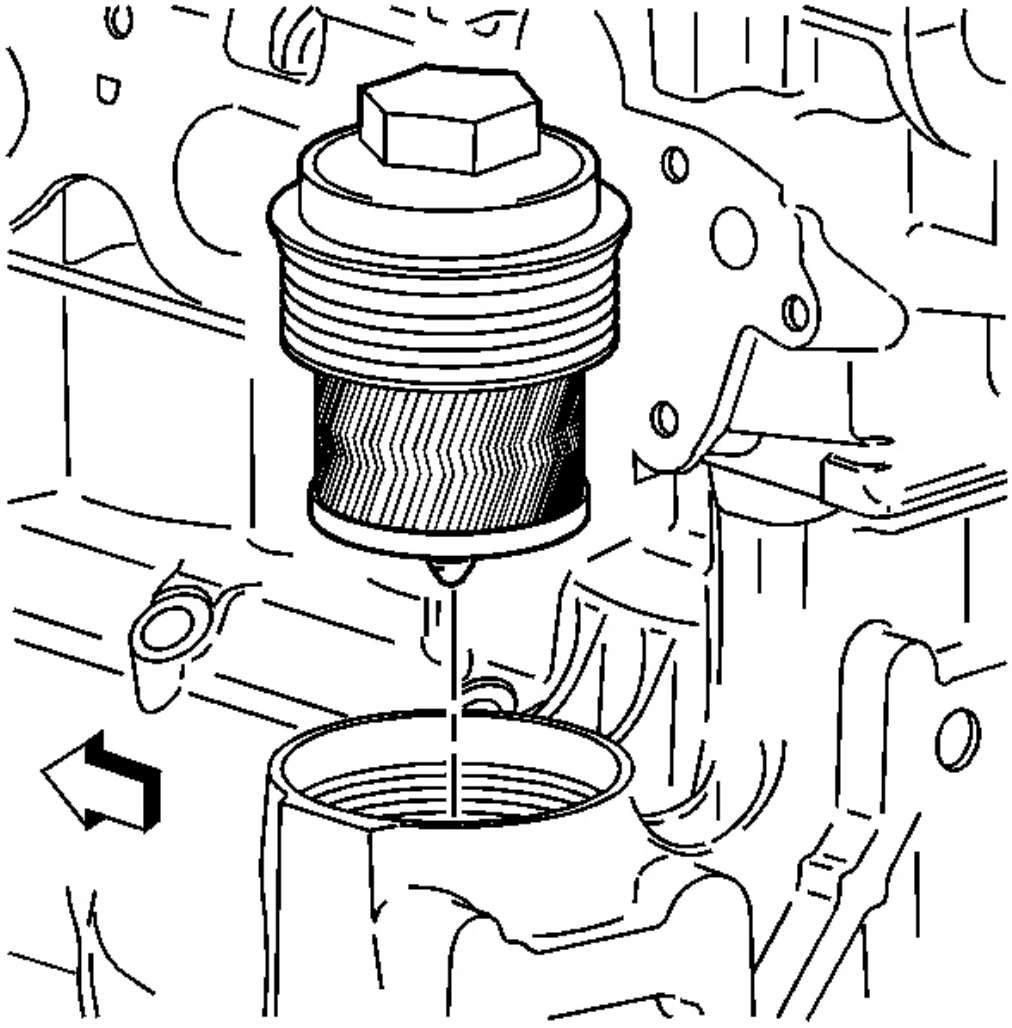


Fig. 360: Identifying Oil Filter
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil filter cap. Remove the oil pan drain plug and allow the oil to drain out.
2. Remove the oil filter from the cap and discard.
3. Clean the oil filter housing in the engine block.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the oil pan drain plug.

Tighten: Tighten the oil pan drain plug to 25 N.m (18 lb ft).

5. Remove the water pump drain plug from the water pump and allow the coolant to drain from the water pump.
6. Apply sealant P/N 21485278 to the water pump drain plug.
7. Install the water pump drain plug.

   Tighten: Tighten the water pump drain plug to 20 N.m (15 lb ft).

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

ENGINE FLYWHEEL REMOVAL

Tools Required

J 38122-A Harmonic Balancer Holder

1. Remove the flywheel attaching bolt. Use the J 38122-A to prevent crankshaft rotation.

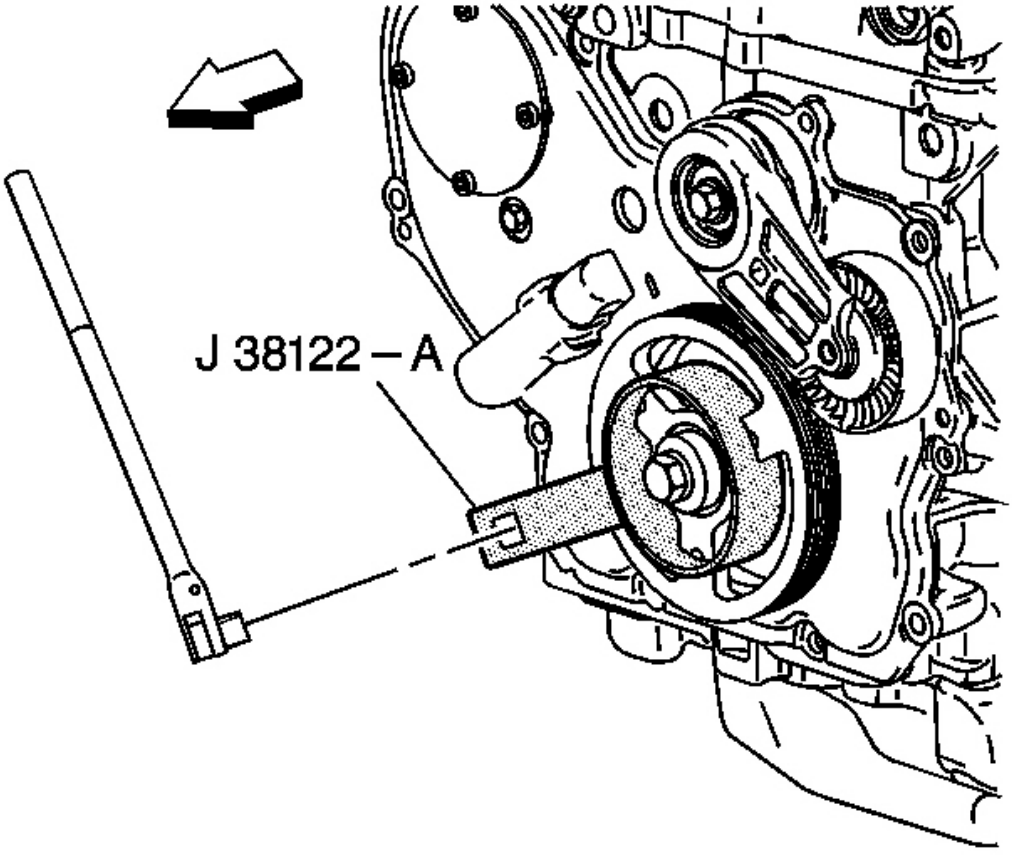


Fig. 361: View Of Harmonic Balancer Holder J38122-A
Courtesy of GENERAL MOTORS CORP.

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.

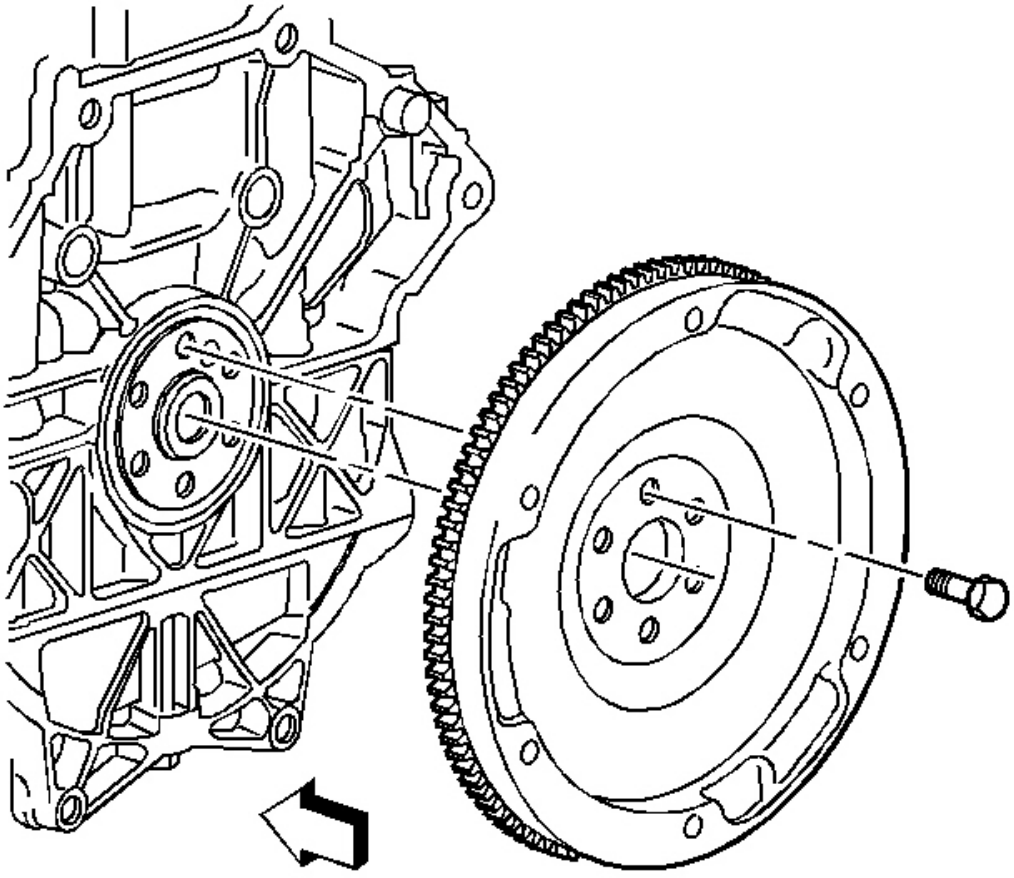


Fig. 362: Identifying Flywheel Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

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

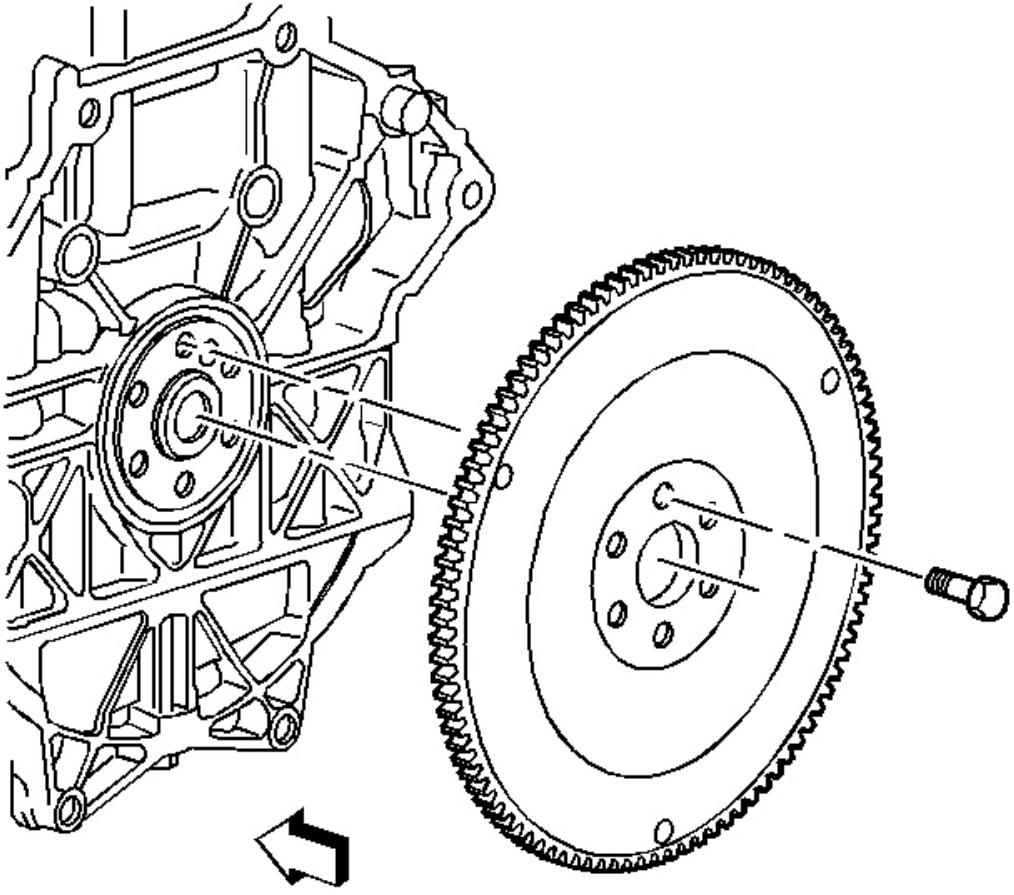


Fig. 363: View Of Flywheel
Courtesy of GENERAL MOTORS CORP.

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

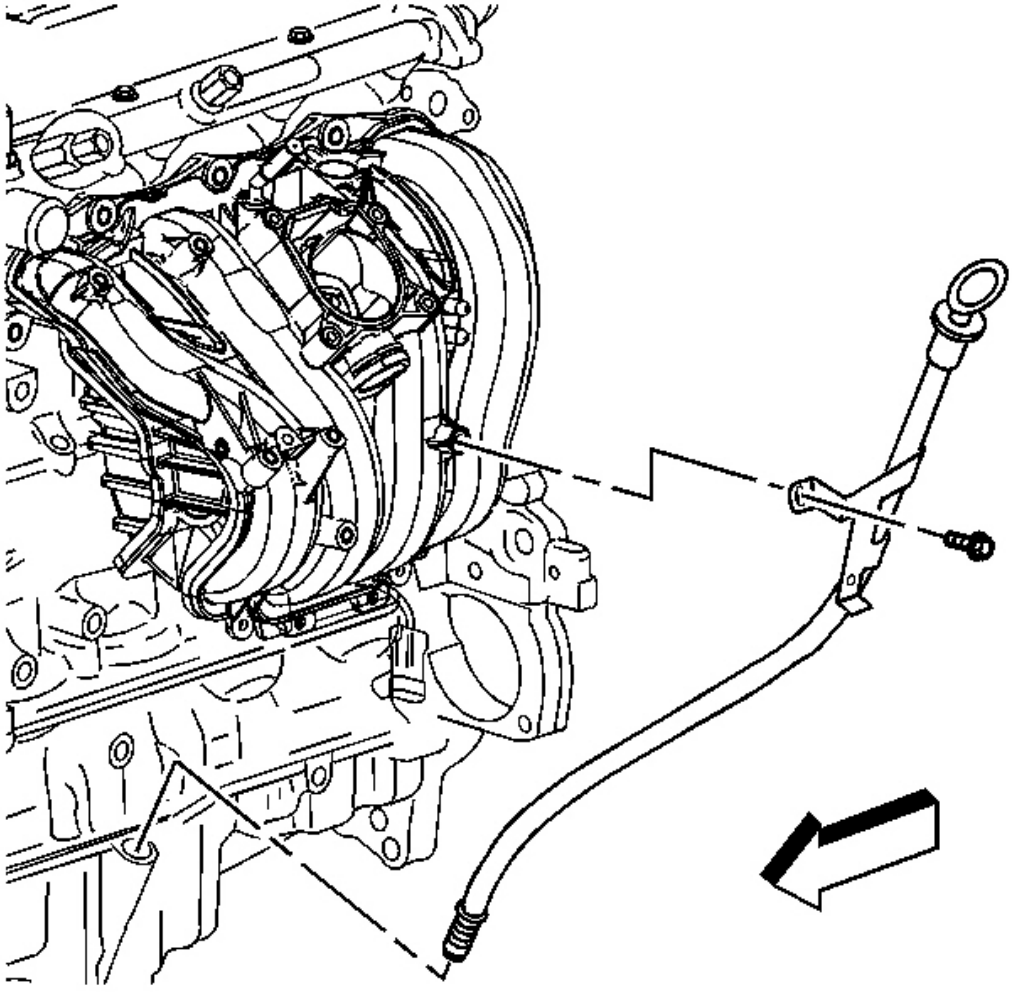


Fig. 364: View Of Oil Level Indicator
Courtesy of GENERAL MOTORS CORP.

1. Remove knock sensor connector from the oil level indicator tube.
2. Remove the oil level indicator tube bracket to the intake manifold bolt.
3. Remove the oil level indicator and the oil level indicator tube from the oil pan.

EXHAUST MANIFOLD REMOVAL

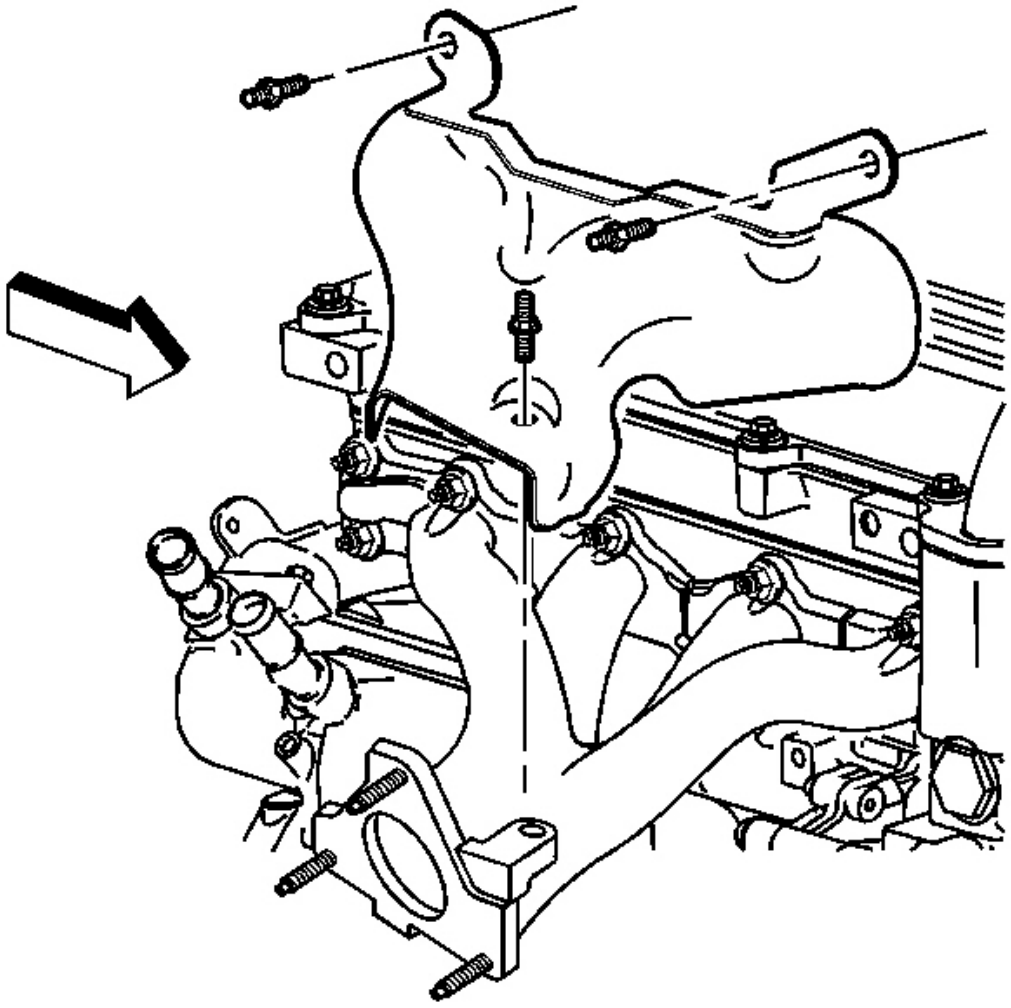


Fig. 365: View Of Exhaust Heat Shield
Courtesy of GENERAL MOTORS CORP.

1. Remove the exhaust manifold heat shield.

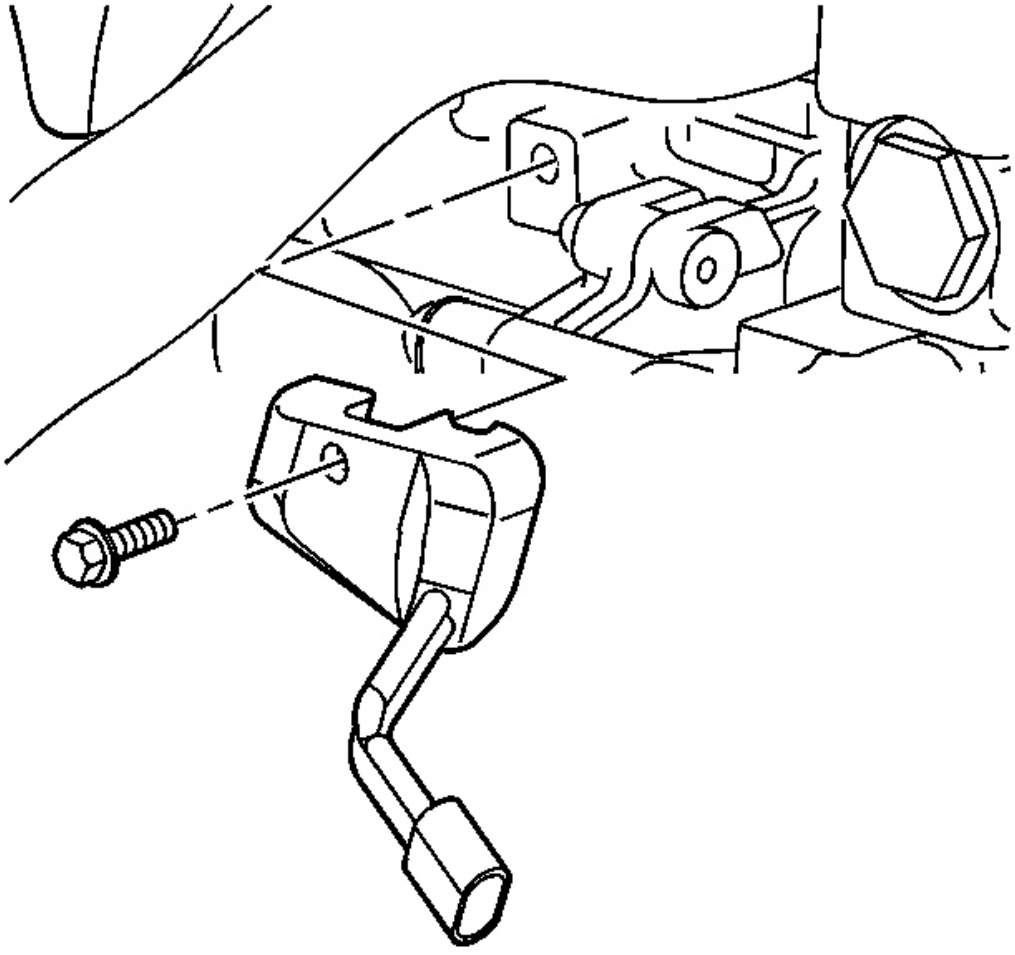


Fig. 366: View Of Block Heater
Courtesy of GENERAL MOTORS CORP.

2. Remove the block heater if equipped.

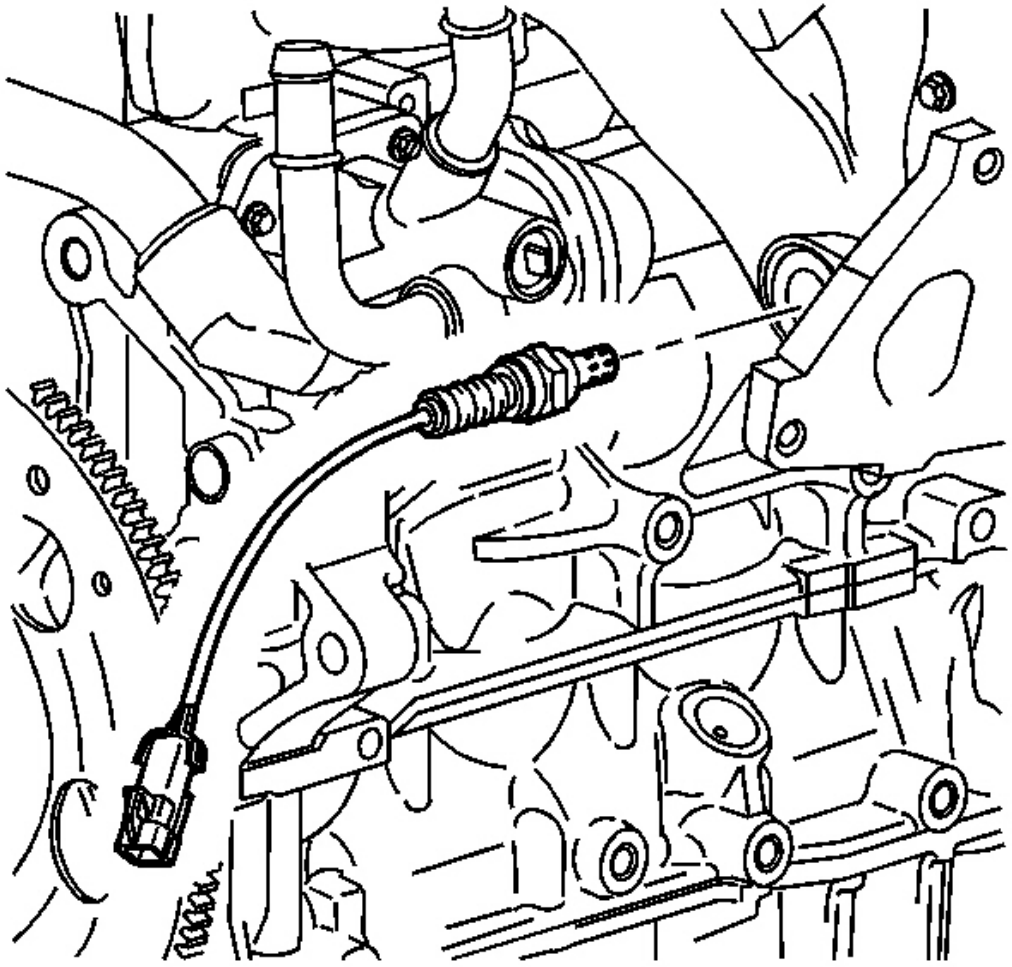


Fig. 367: Identifying Oxygen Sensor
Courtesy of GENERAL MOTORS CORP.

3. Remove the oxygen sensor.

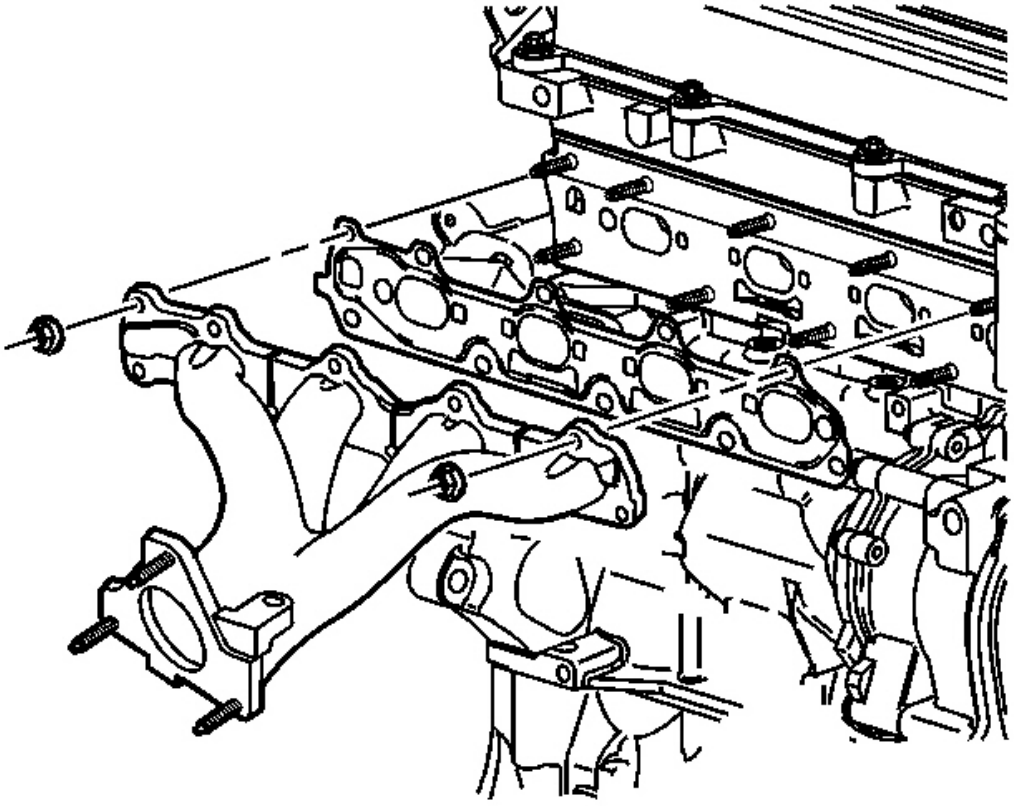


Fig. 368: View Of Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

4. Remove and discard the exhaust manifold to cylinder head retaining nuts.
5. Remove the exhaust manifold.
6. Clean all of the sealing surfaces.
7. If the exhaust manifold is being replaced, transfer the following parts:
    - The exhaust manifold heat shield
    - The oxygen sensor

INTAKE MANIFOLD REMOVAL

NOTE: Never attempt to remove the intake manifold from a hot engine, allow the engine to cool to ambient temperature. The intake manifold is made of a composite plastic and can be damaged if it is removed when the engine is hot.

1. Remove the EVAP emission canister valve tube (1).
2. Remove the EVAP emission canister valve (2).

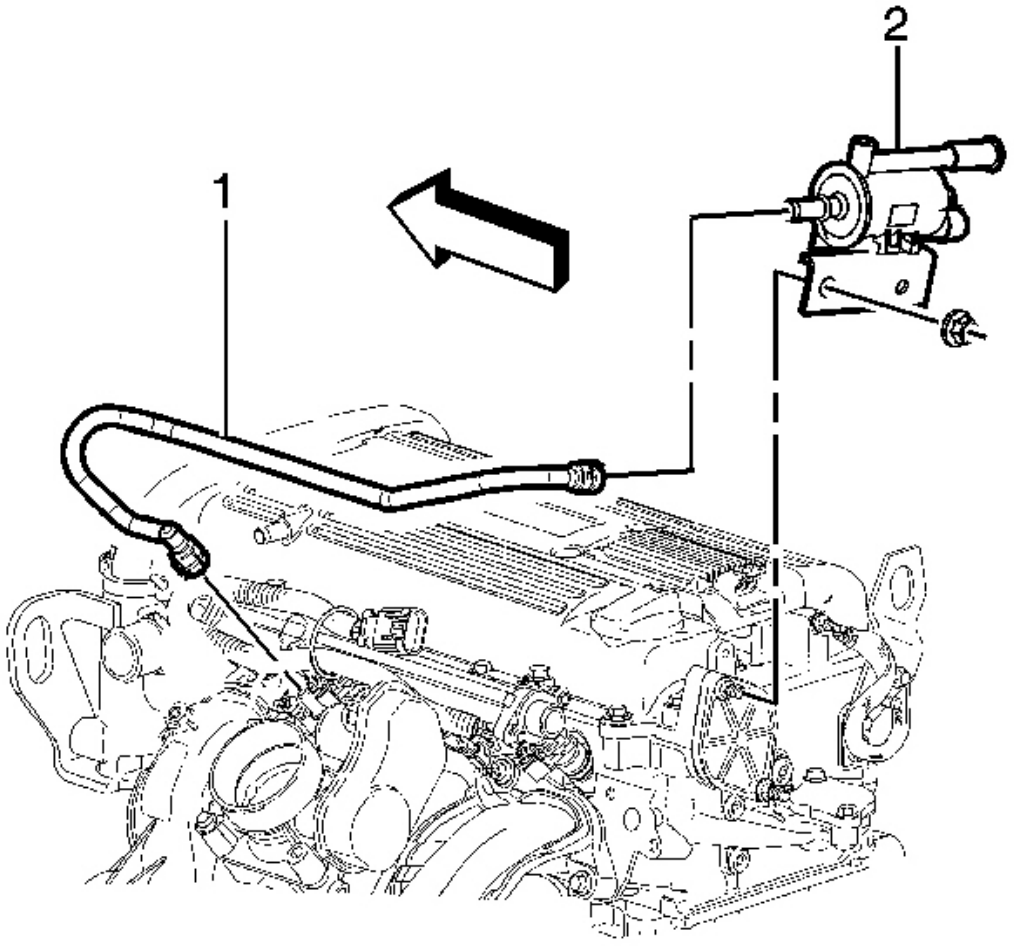


Fig. 369: View Of EVAP Emission Canister Valve
Courtesy of GENERAL MOTORS CORP.

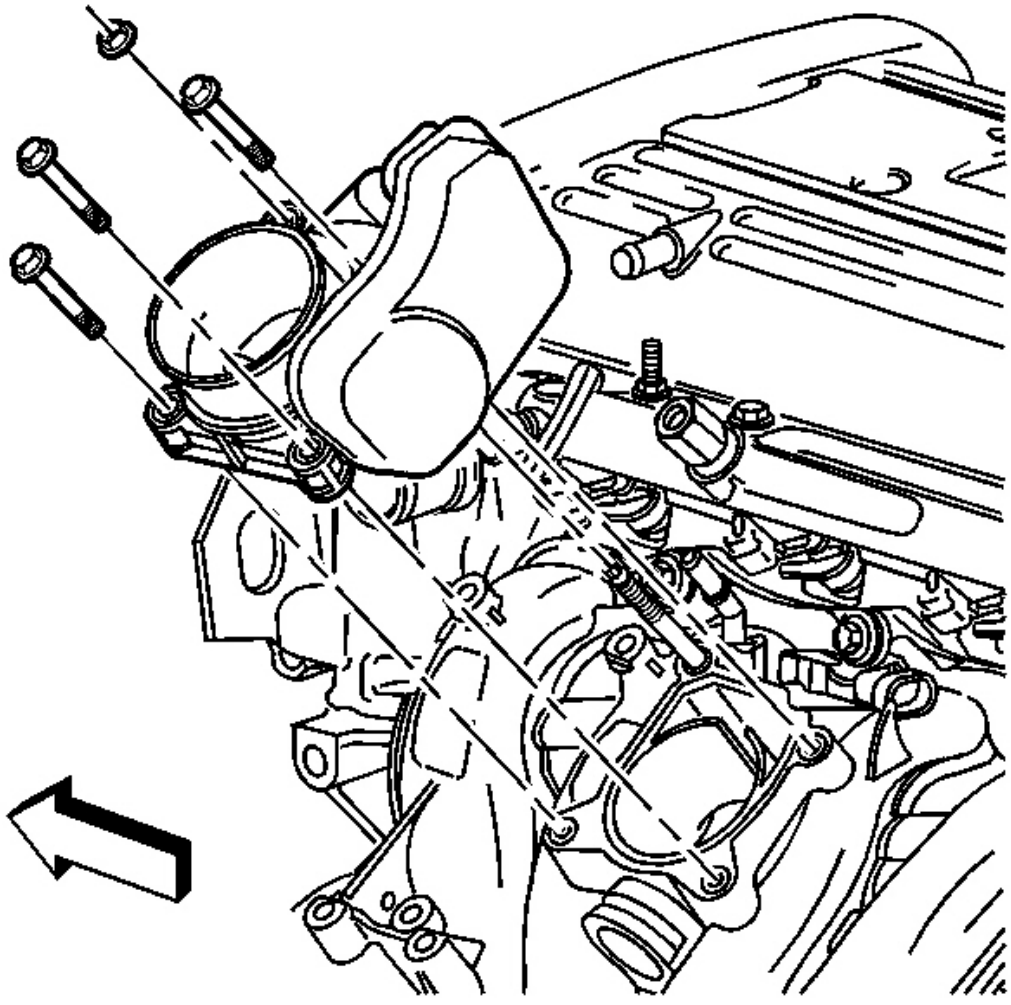


Fig. 370: View Of Throttle Body
Courtesy of GENERAL MOTORS CORP.

3. Remove the throttle body.

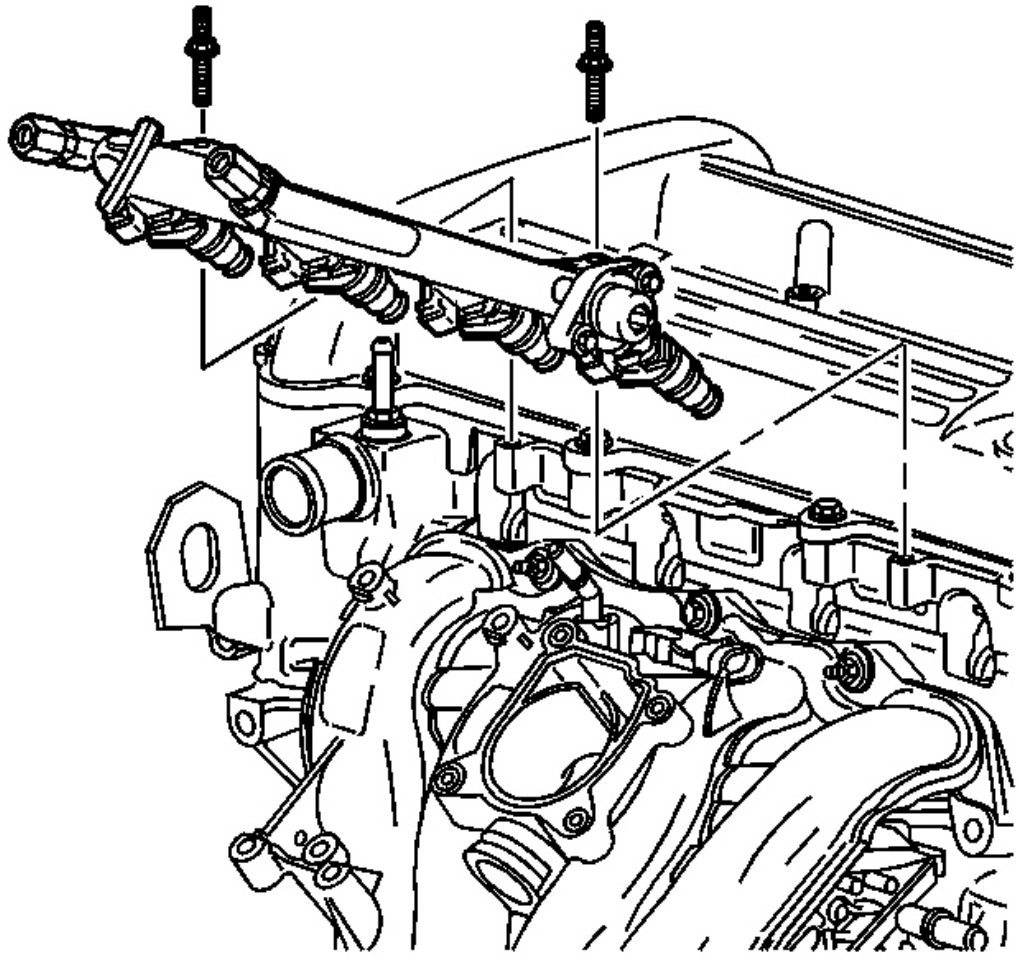


Fig. 371: Identifying Fuel Rail Assembly
Courtesy of GENERAL MOTORS CORP.

4. Remove fuel pipes and clip. Remove the fuel rail assembly.

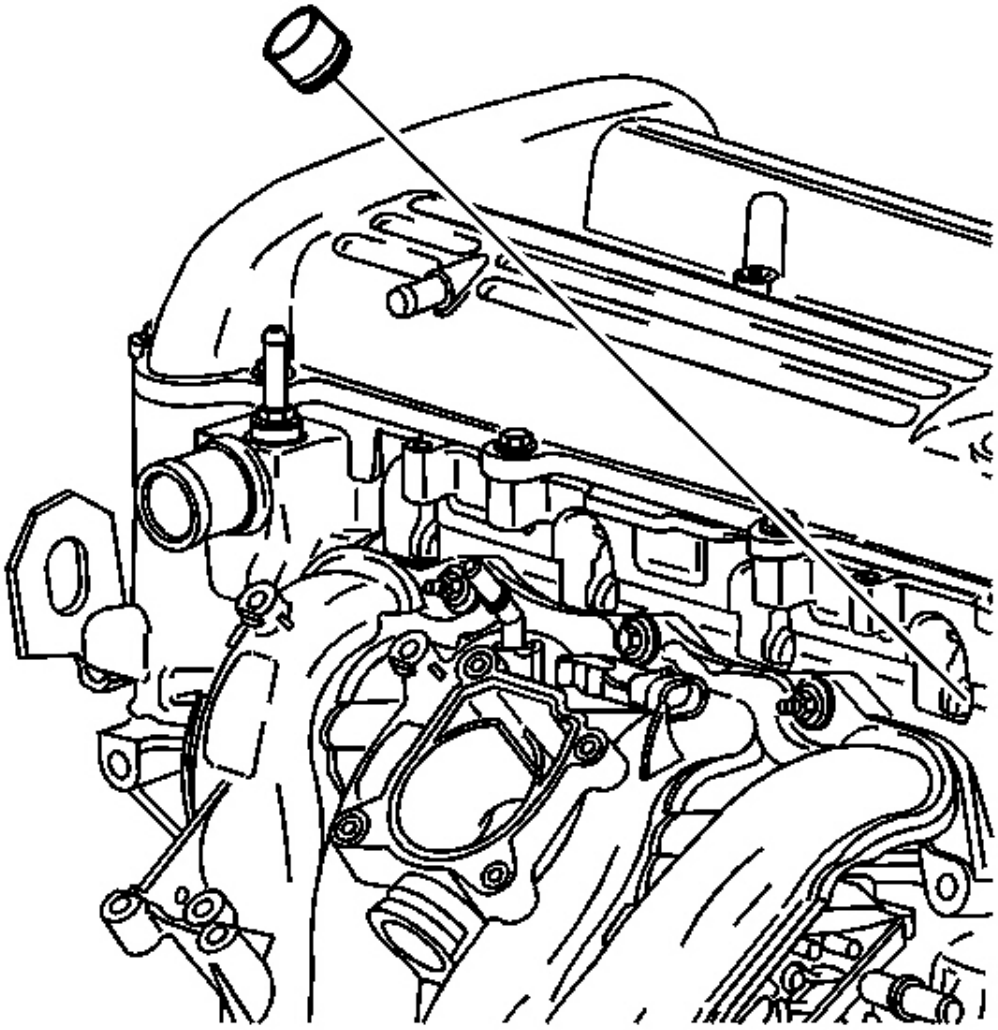


Fig. 372: View Of Fuel Injector Tip Insulators
Courtesy of GENERAL MOTORS CORP.

5. Remove the fuel injector tip insulators and discard.

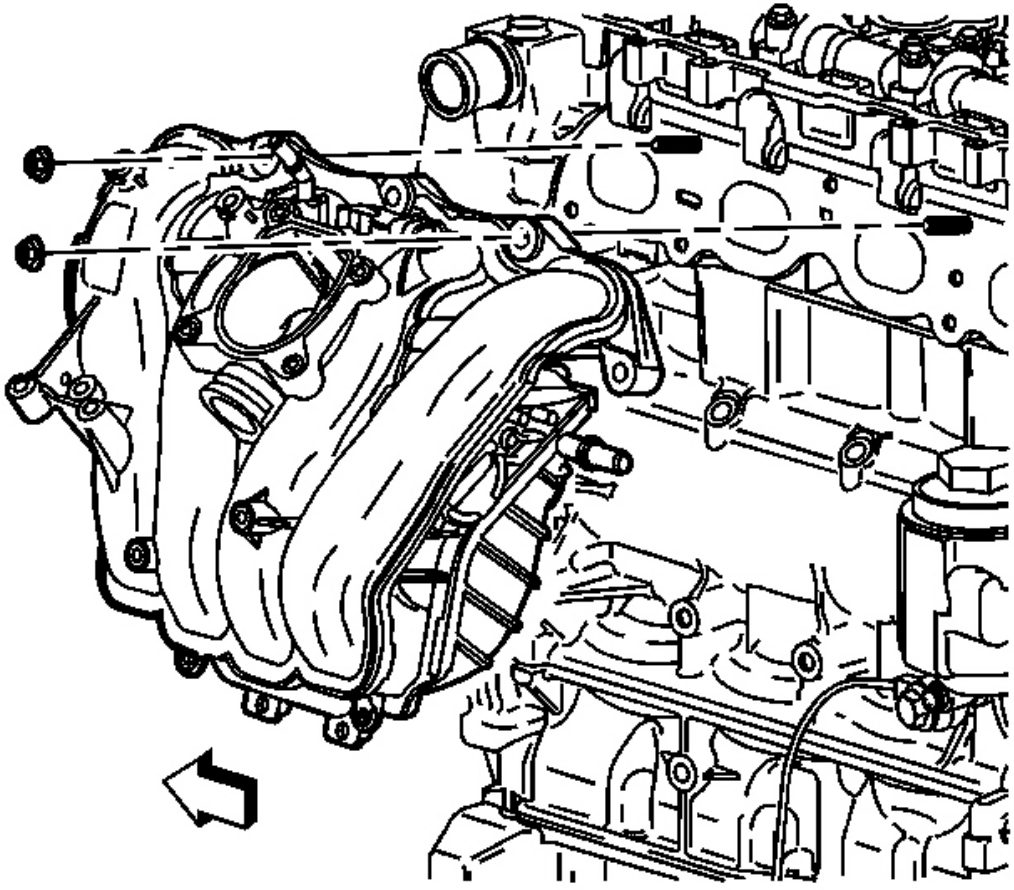


Fig. 373: Identifying Intake Manifold
Courtesy of GENERAL MOTORS CORP.

6. Remove the intake manifold retaining nuts and bolts.
7. Remove the intake manifold.
8. Remove the intake manifold gasket, if necessary. The gasket is reusable if it is not damaged.
9. If the intake manifold needs to be replaced, transfer the following parts:
    - The throttle body
    - The throttle body gasket

    The manifold-to-throttle body gasket is reusable if it is not damaged.

CRANKSHAFT DAMPER REMOVAL

Tools Required

J 38122-A Harmonic Balancer Holder

Crankshaft Damper Removal

1. Install the J 38122-A .

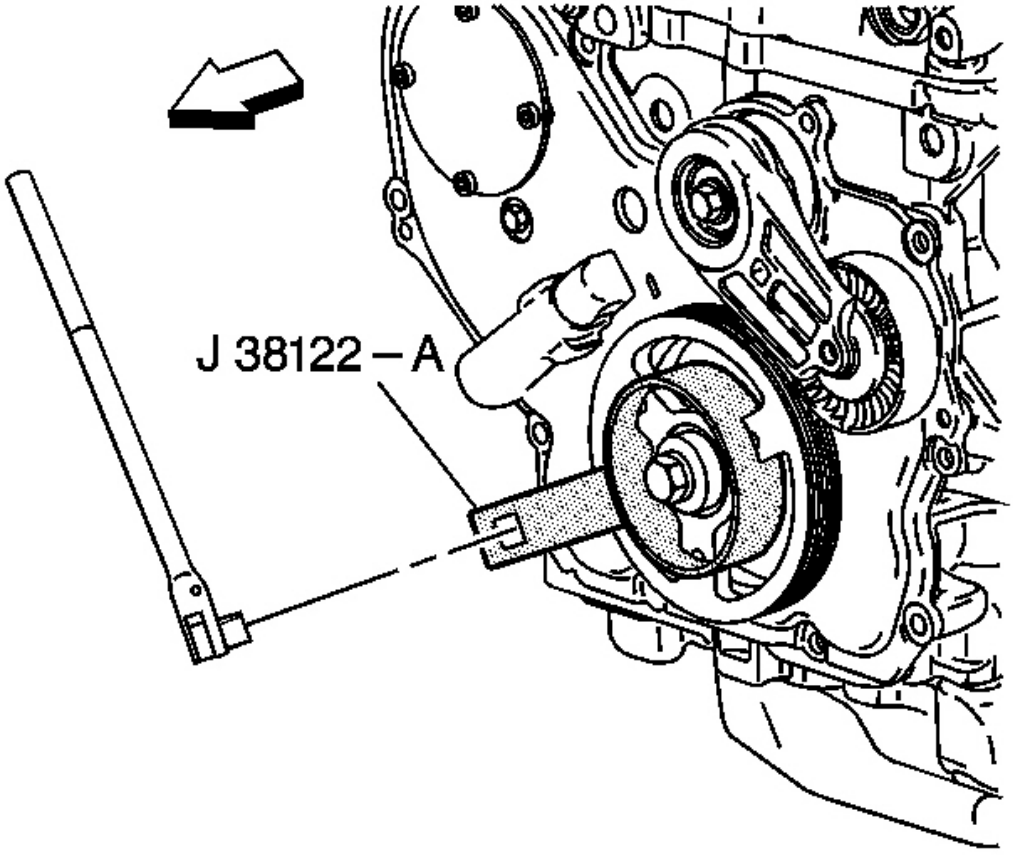


Fig. 374: View Of Harmonic Balancer Holder J38122-A
Courtesy of GENERAL MOTORS CORP.

2. Remove the damper retaining bolt and washer. Use the J 38122-A and a breaker bar in order to prevent the crankshaft from rotating when loosening the bolt.

   Discard the bolt.

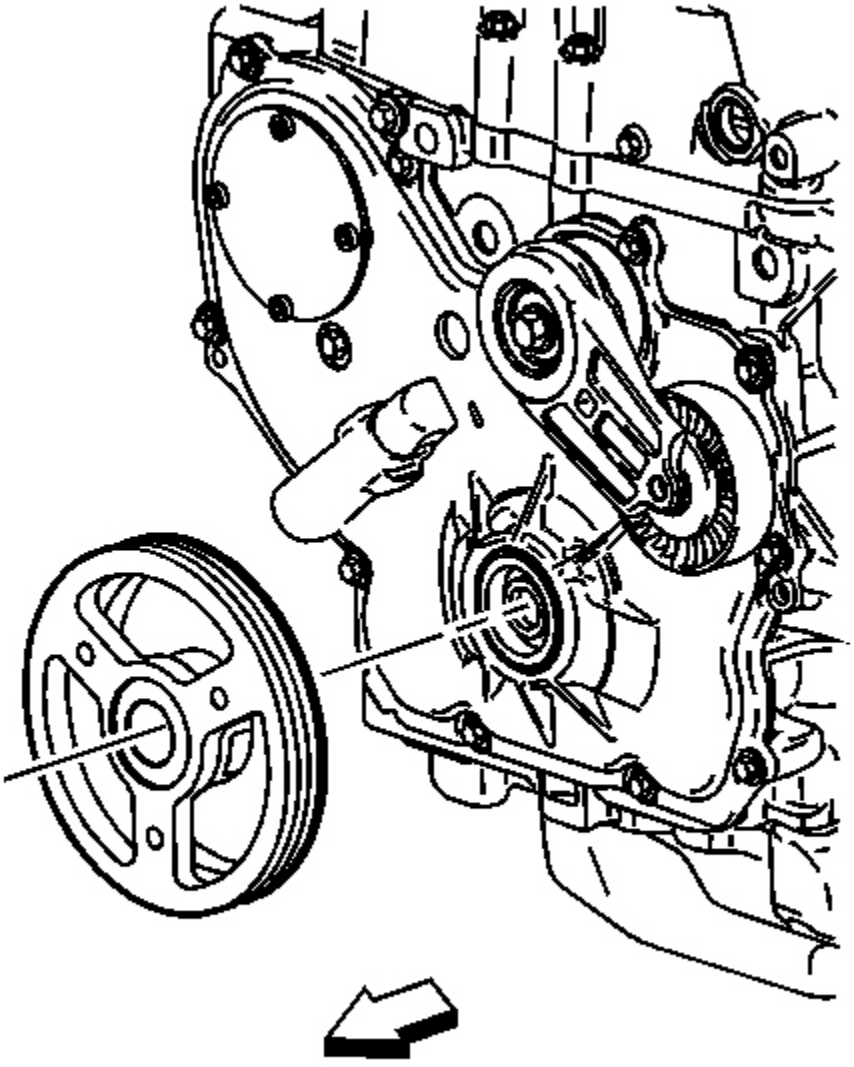


Fig. 375: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

3. Remove the damper assembly.

CAMSHAFT COVER REMOVAL

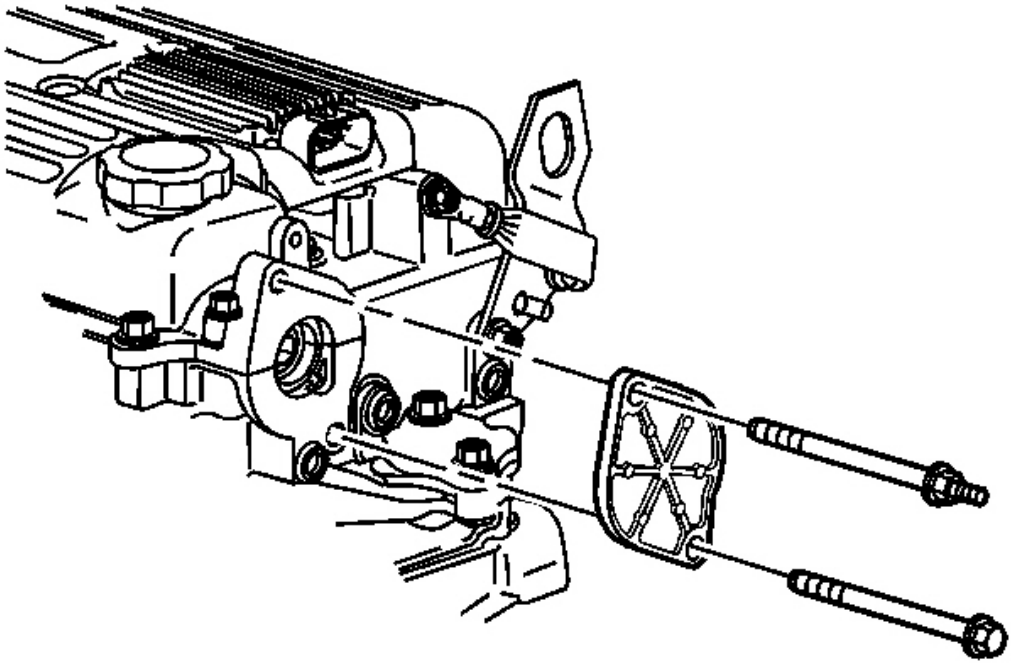


Fig. 376: View Of Power Steering Blockout Plate
Courtesy of GENERAL MOTORS CORP.

1. Remove the power steering blockout plate.

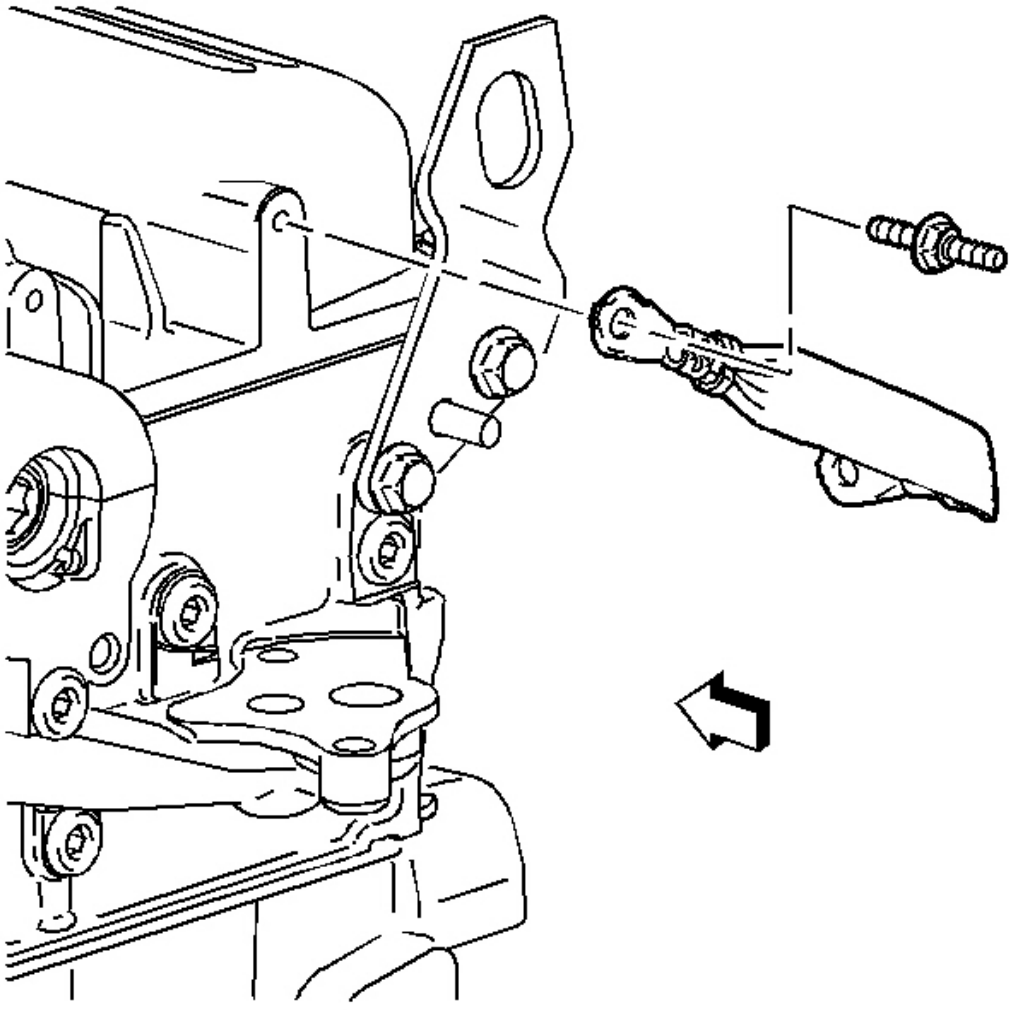


Fig. 377: View Of Camshaft Cover Ground Strap
Courtesy of GENERAL MOTORS CORP.

2. Remove the camshaft cover grounding strap.

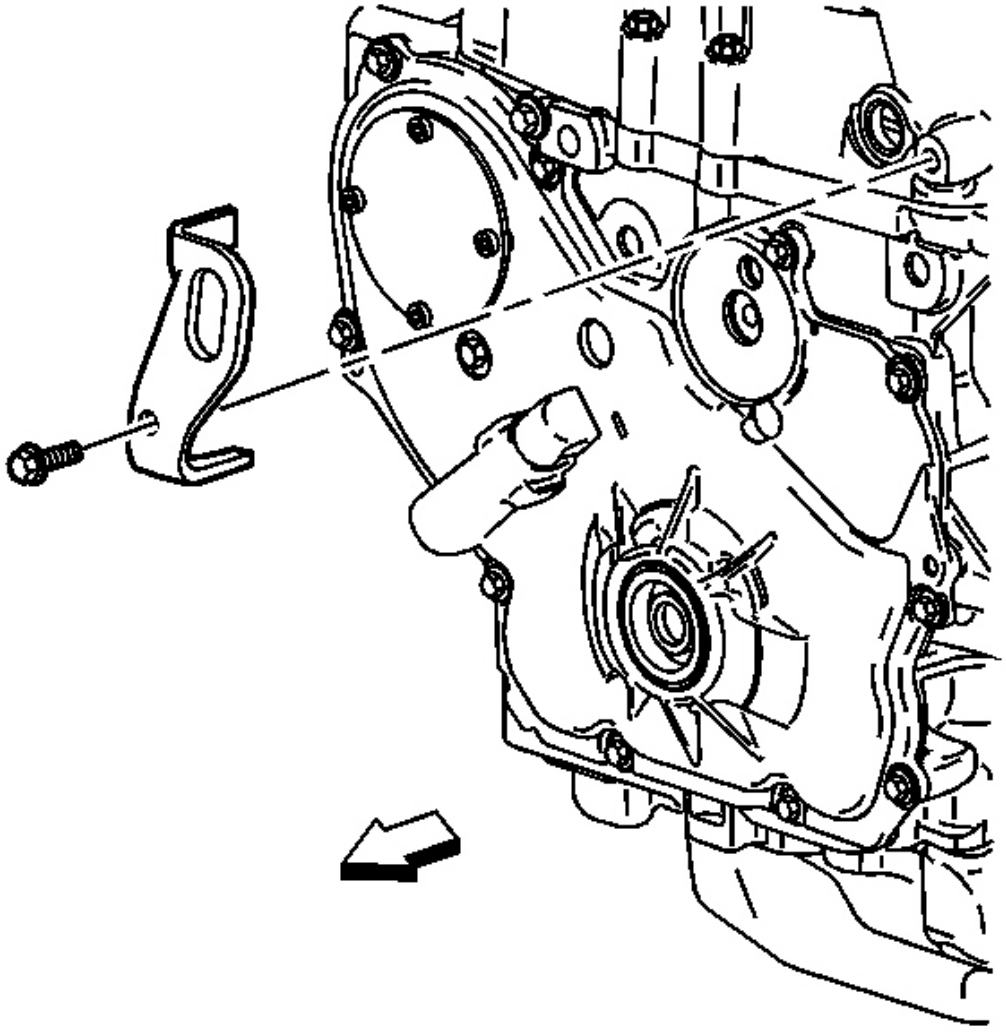


Fig. 378: View Of Front Lift Bracket
Courtesy of GENERAL MOTORS CORP.

3. Remove the front lift bracket.

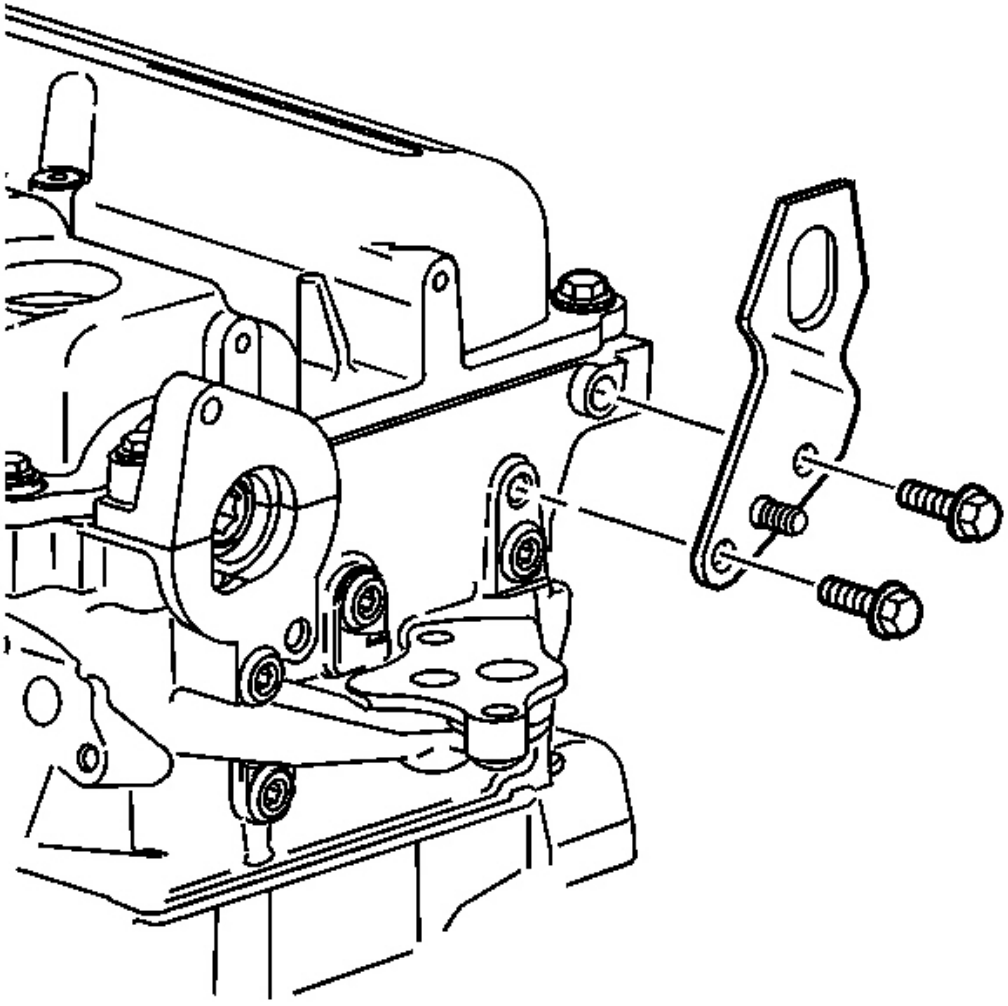


Fig. 379: View Of Rear Lift Bracket
Courtesy of GENERAL MOTORS CORP.

4. Remove the rear lift bracket.

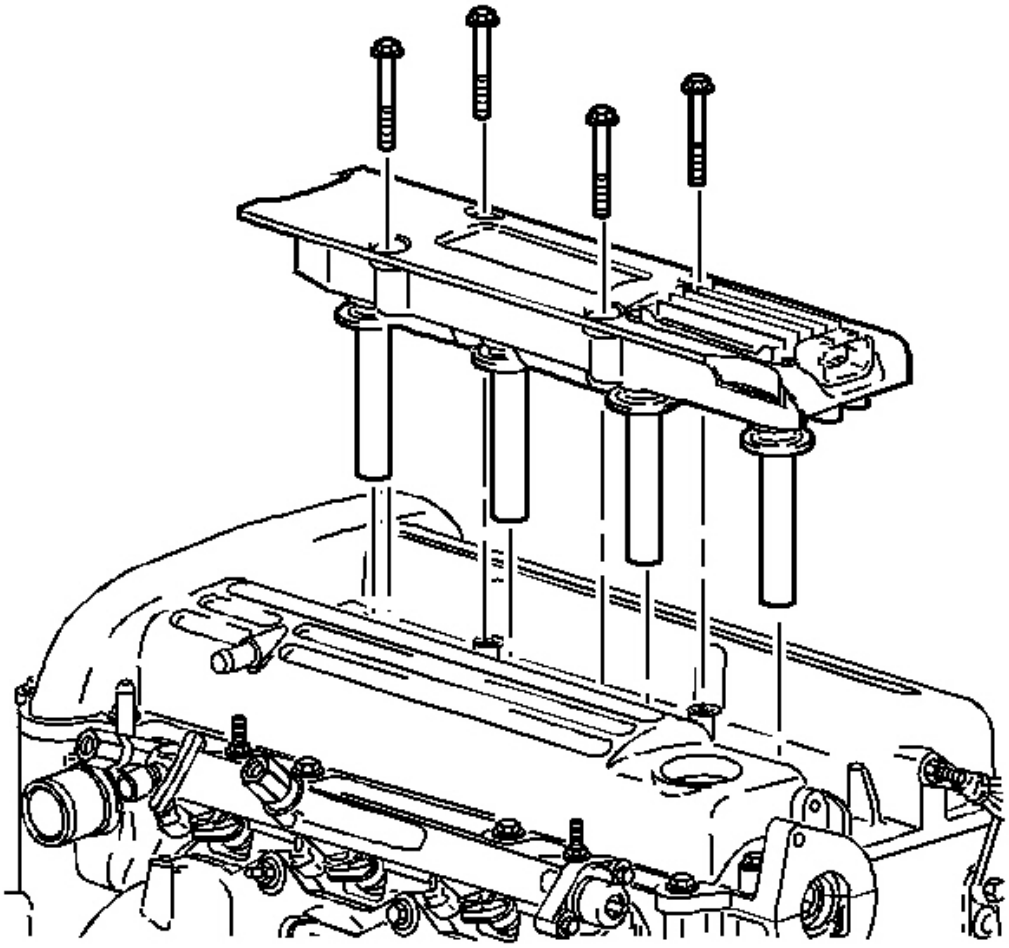


Fig. 380: View Of Ignition Coil & Module Assembly
Courtesy of GENERAL MOTORS CORP.

5. Remove the ignition module and coil assembly.

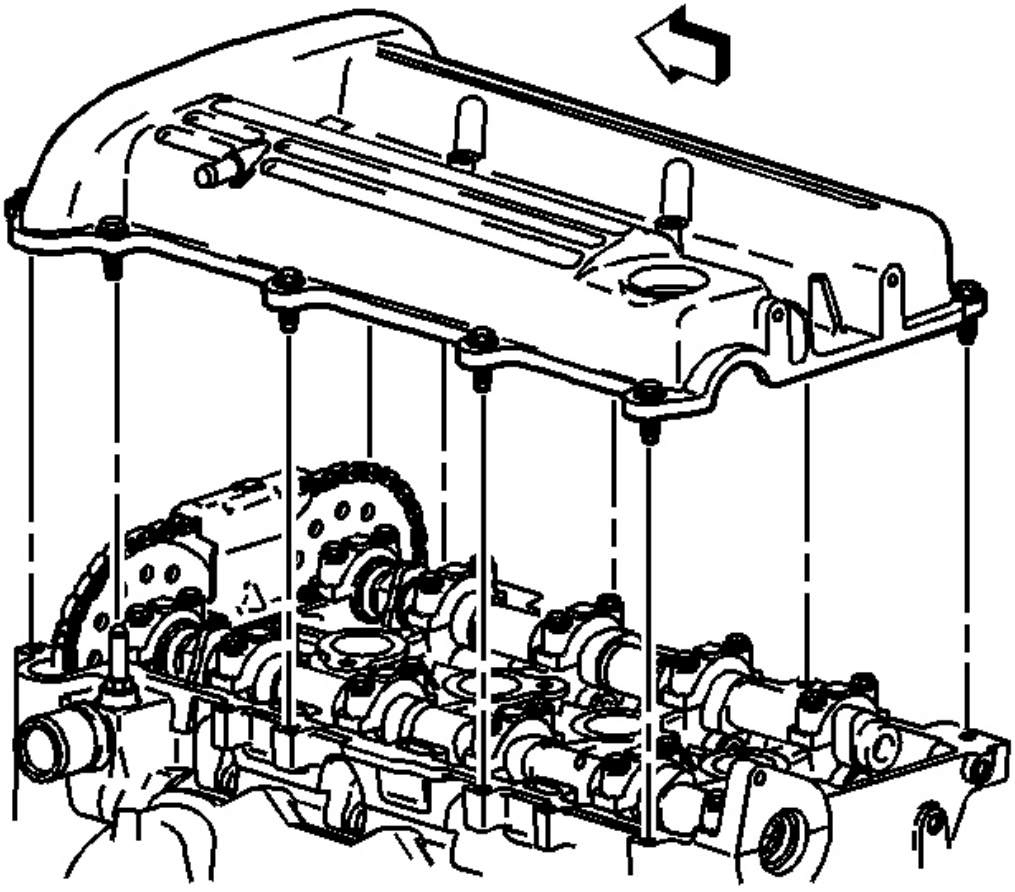


Fig. 381: View Of Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

6. Remove the camshaft cover assembly.

ENGINE FRONT COVER AND OIL PUMP REMOVAL

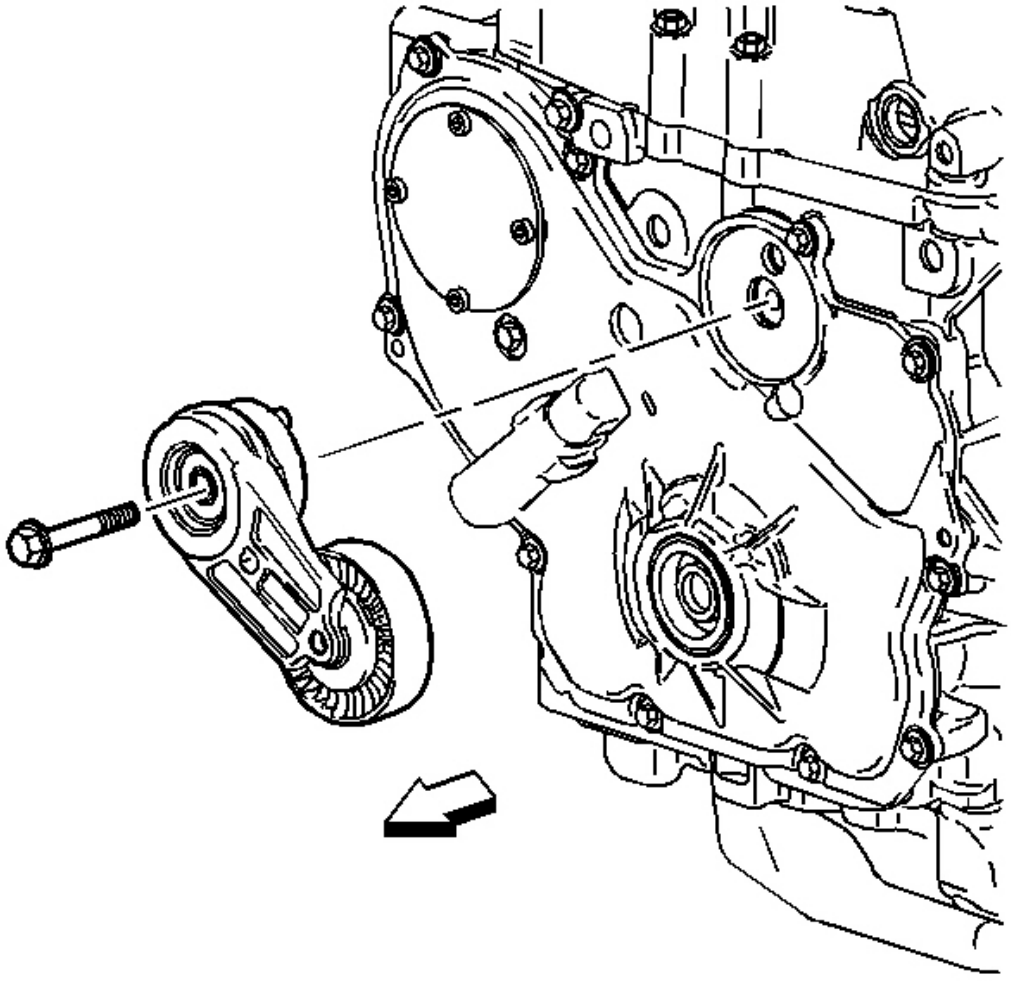


Fig. 382: View Of Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

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

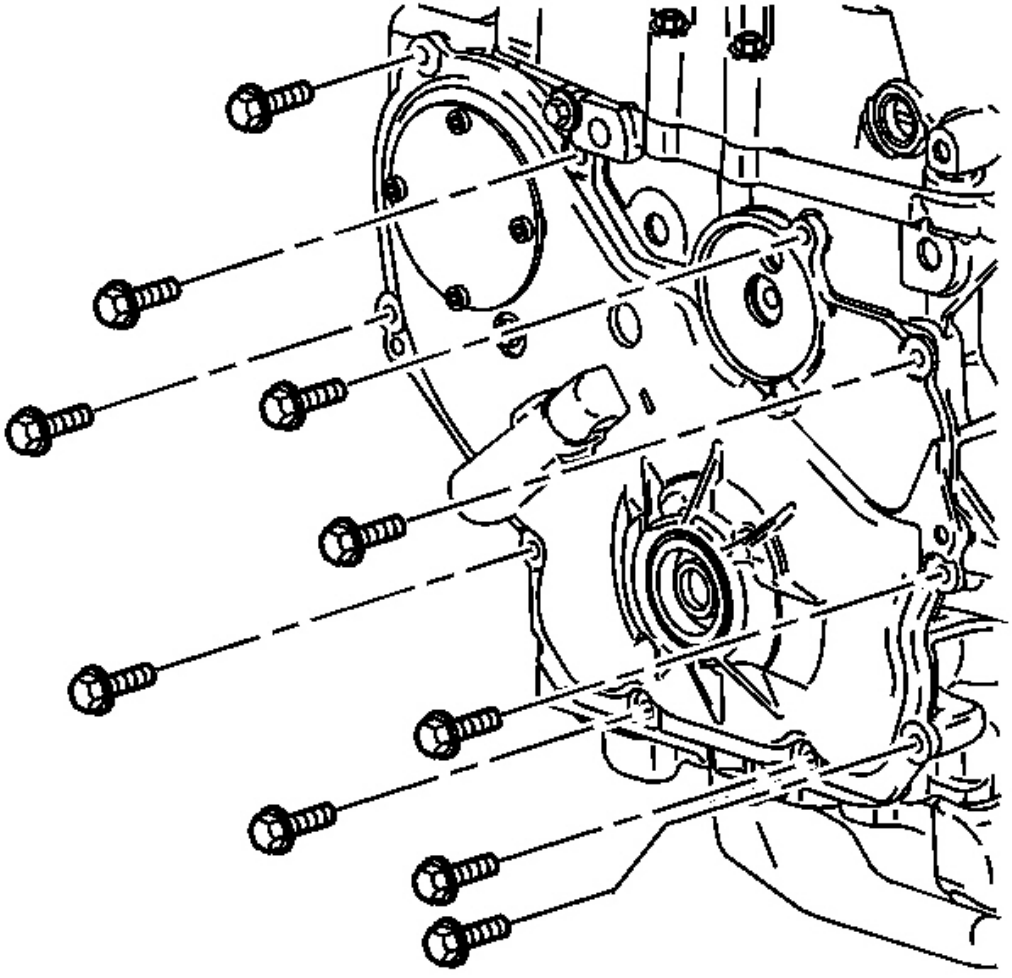


Fig. 383: View Of Engine Front Cover Bolts
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine front cover bolts.

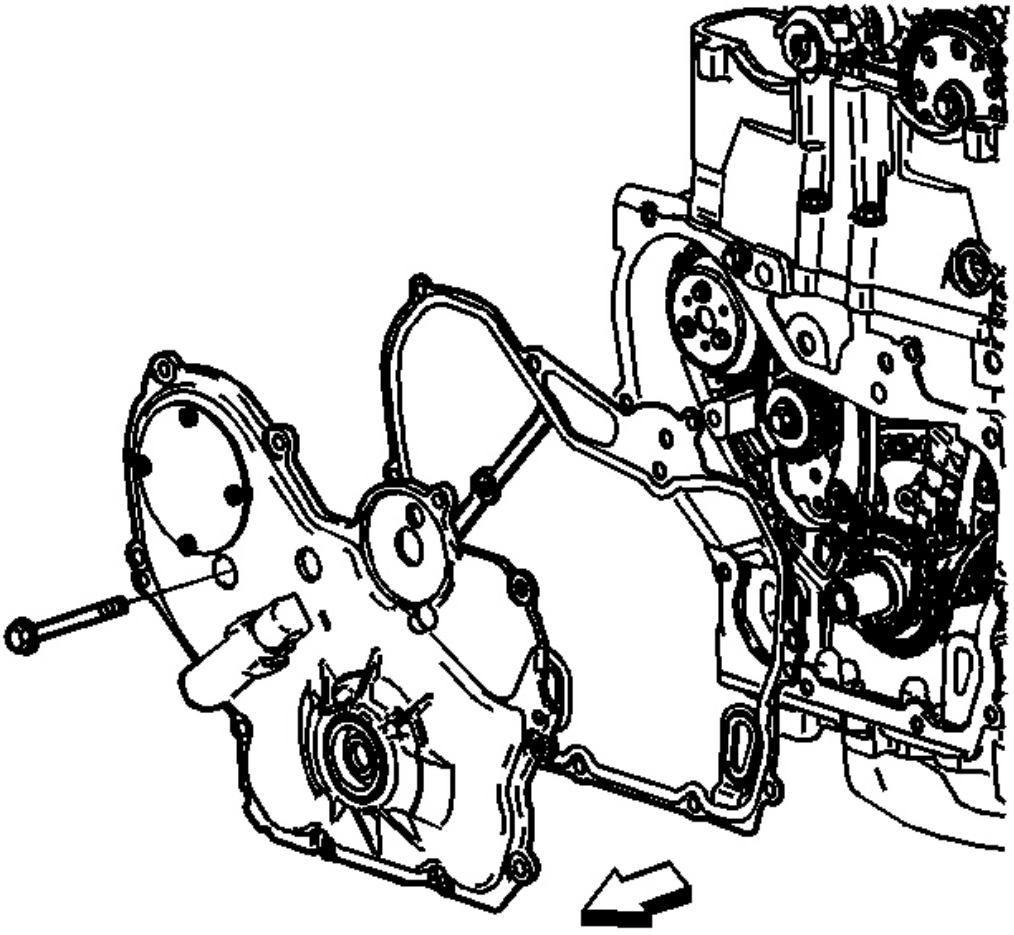


Fig. 384: View Of Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

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

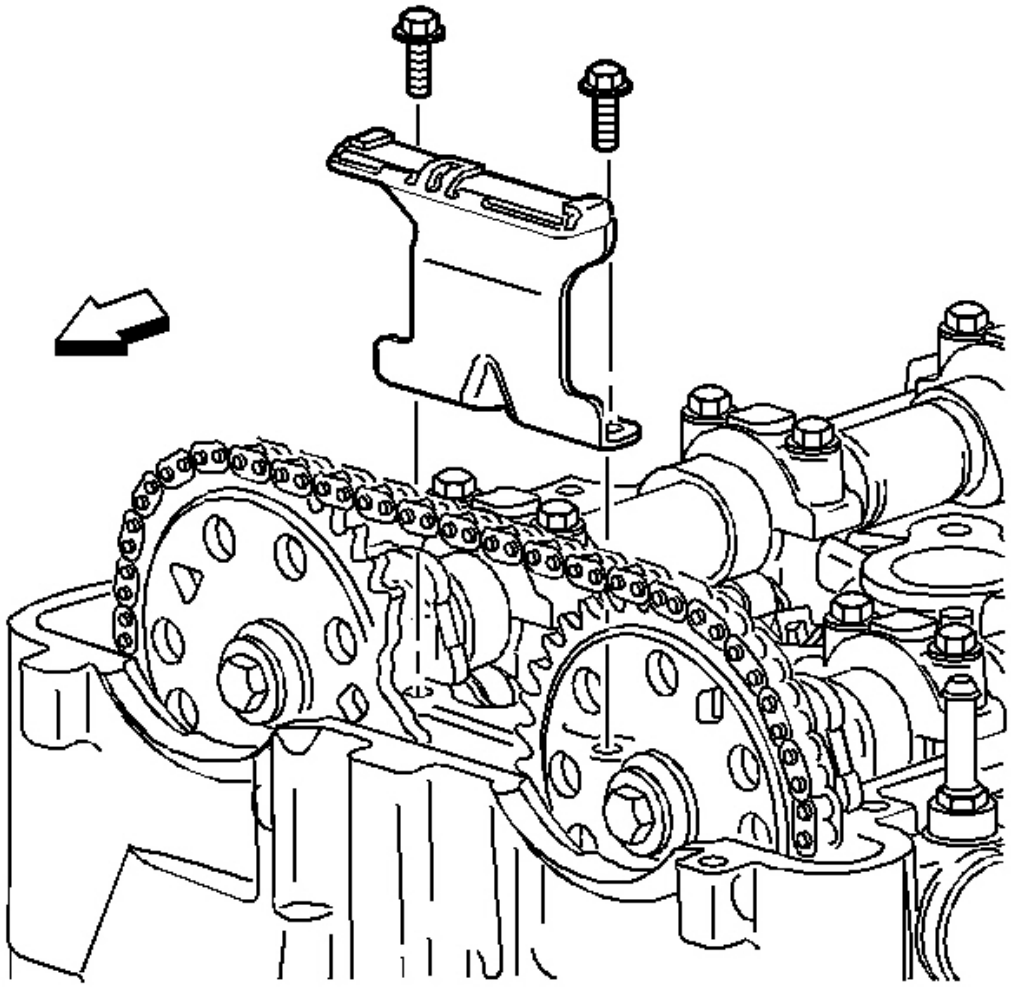


Fig. 385: View Of Upper Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

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

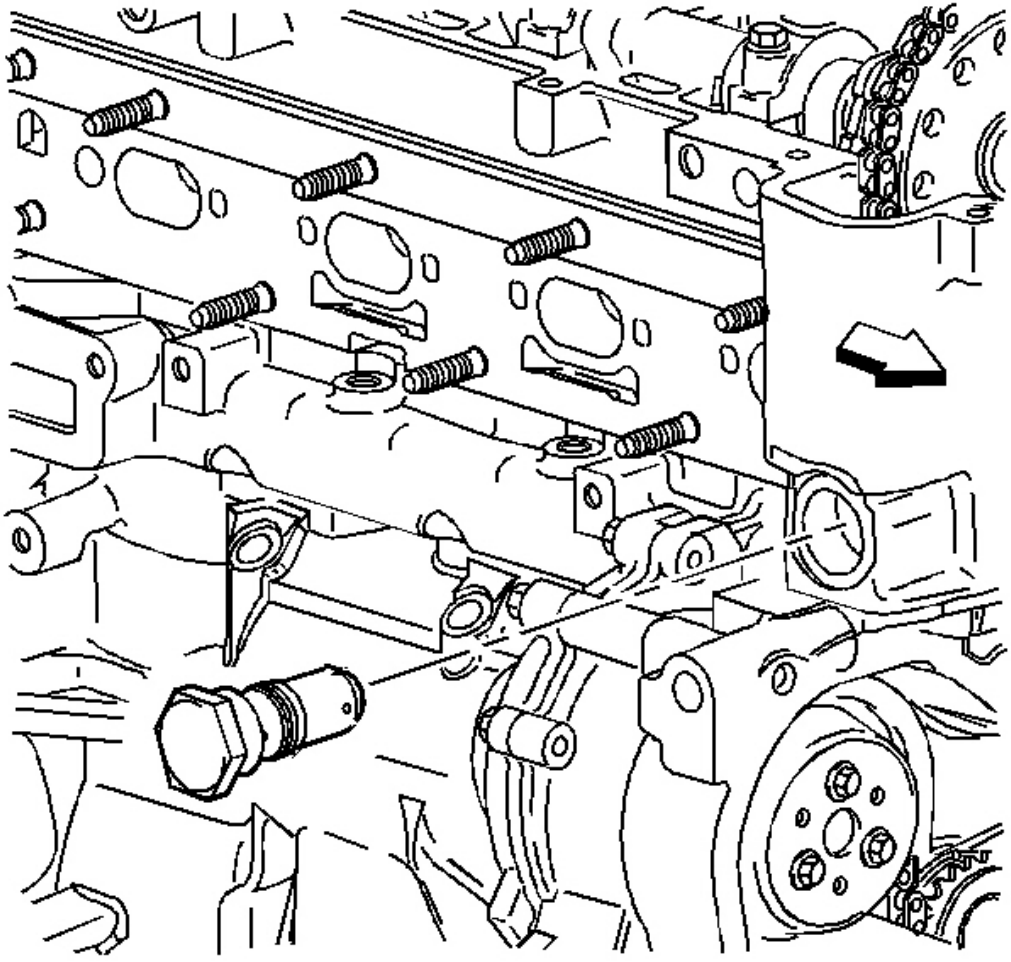


Fig. 386: View Of Timing Chain Tensioner Plunger
Courtesy of GENERAL MOTORS CORP.

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

3. Remove the timing chain tensioner plunger.

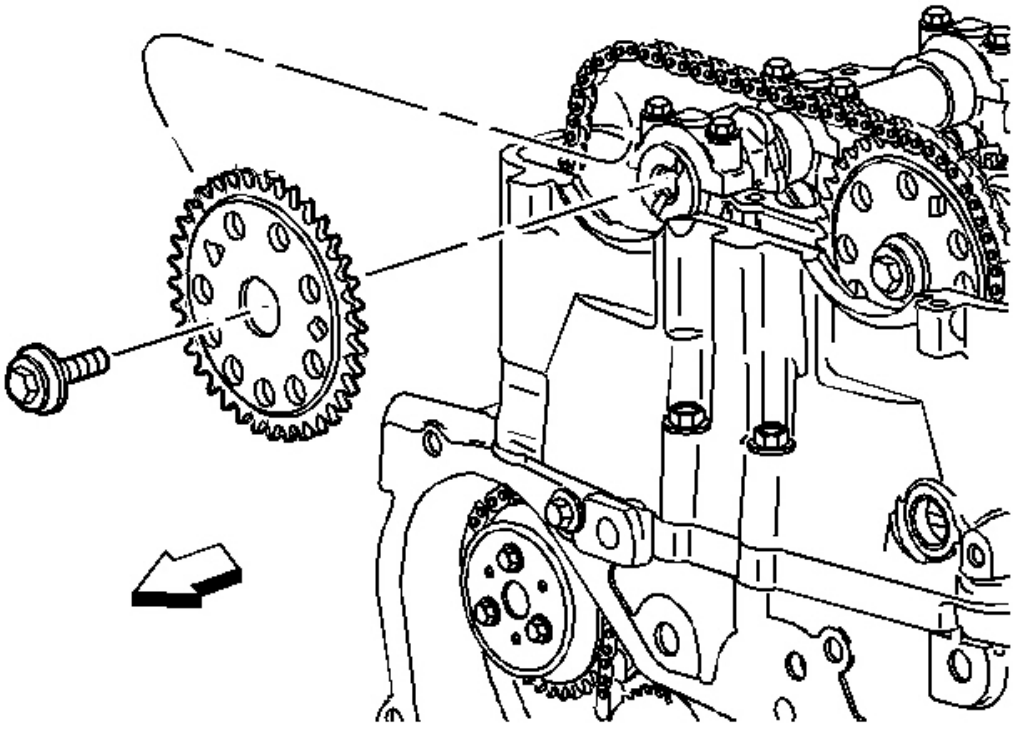


Fig. 387: View Of Exhaust Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

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

   Discard the bolt.

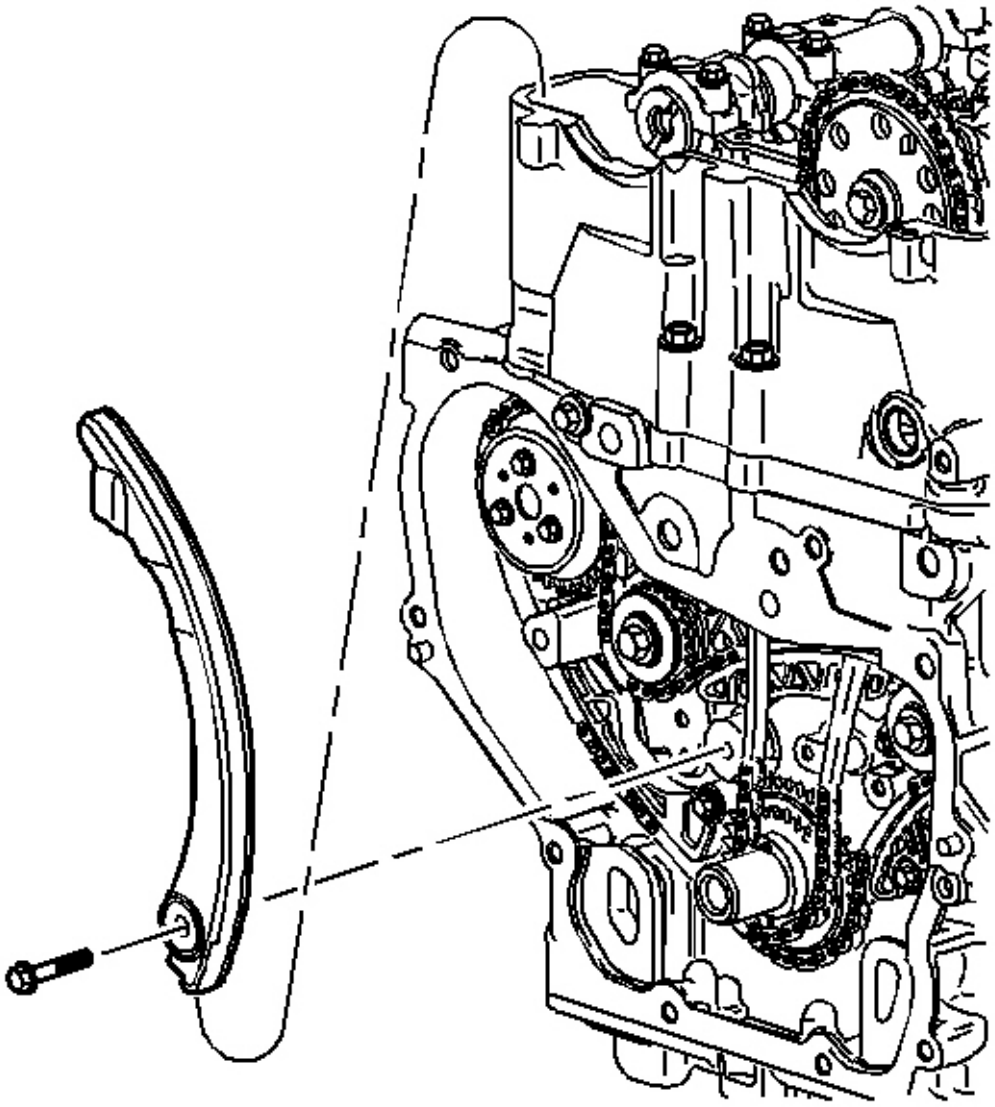


Fig. 388: View Of Timing Chain Tensioner Guide
Courtesy of GENERAL MOTORS CORP.

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

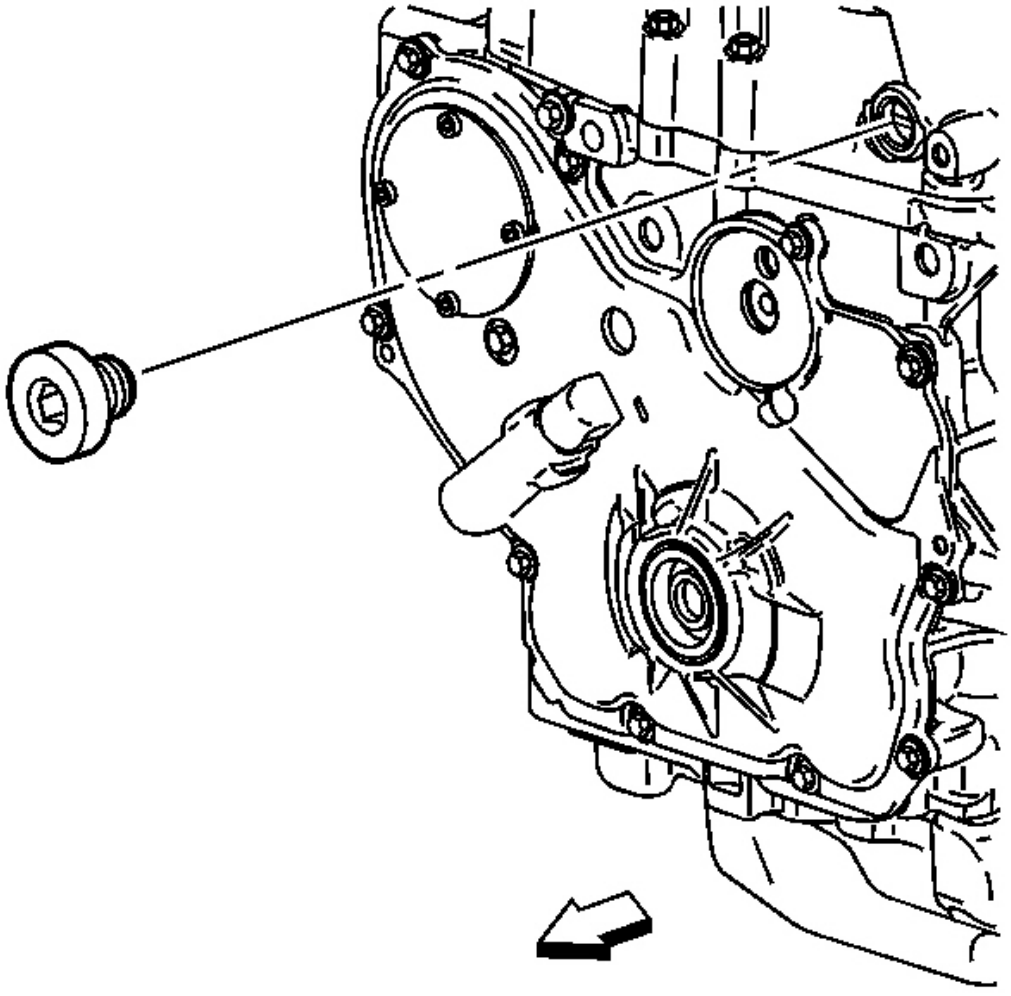


Fig. 389: View Of Fixed Timing Chain Guide Access Plug
Courtesy of GENERAL MOTORS CORP.

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

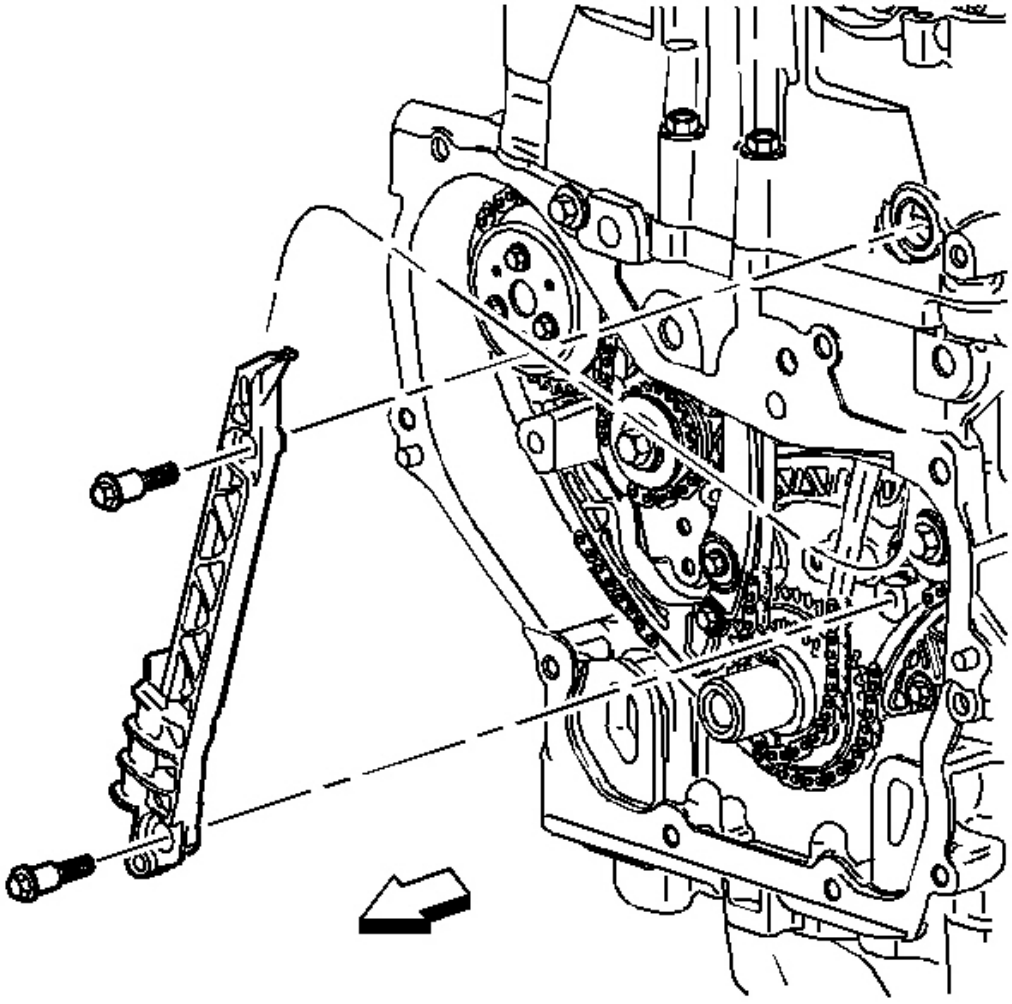


Fig. 390: View Of Fixed Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

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

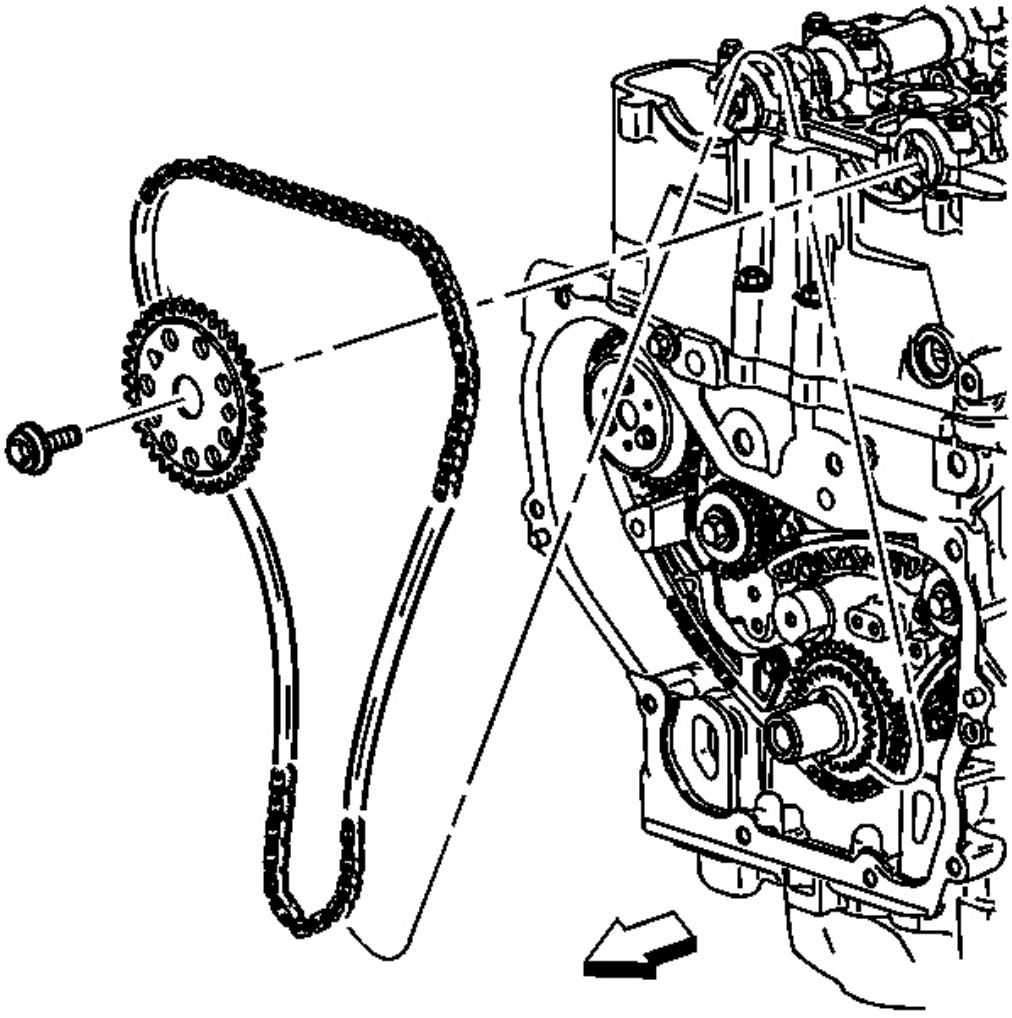


Fig. 391: Exploded View Of Intake Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

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

    Discard the bolt.

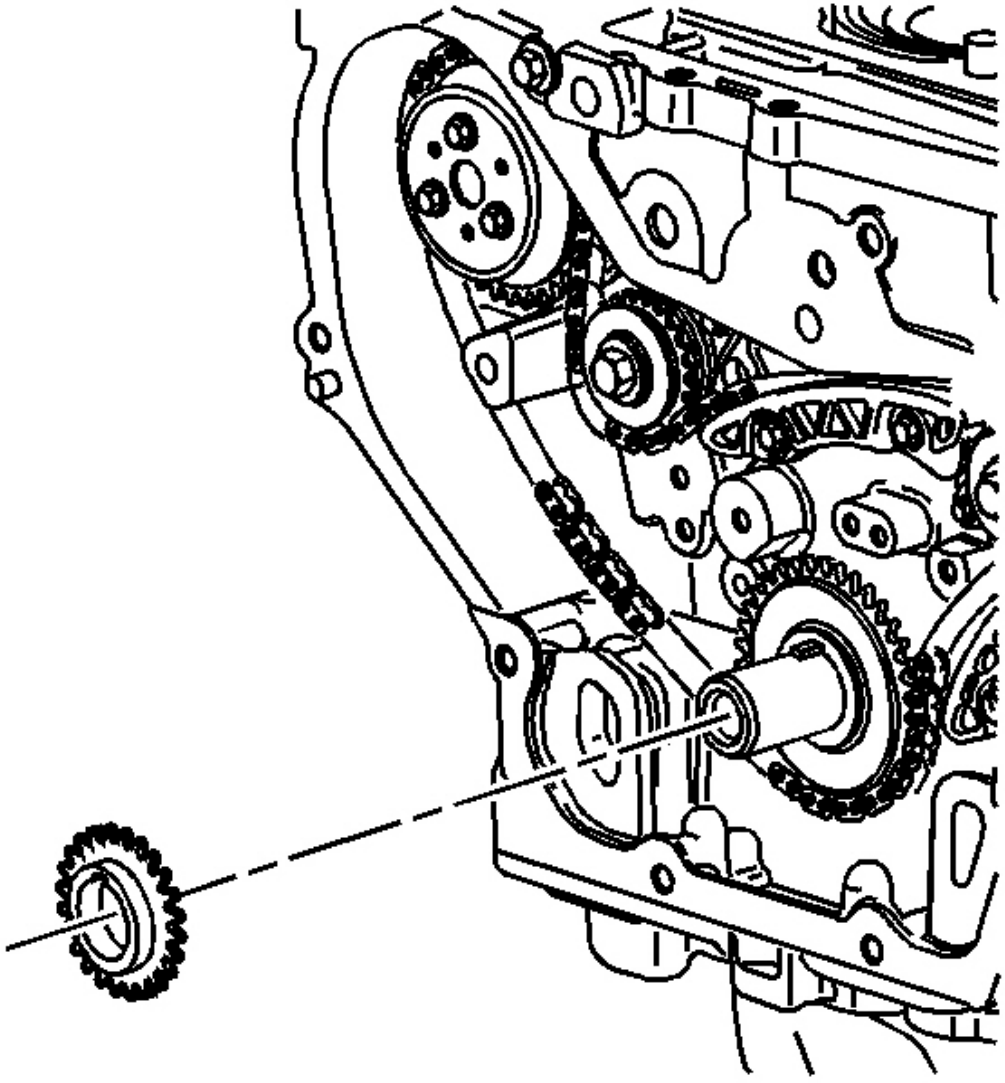


Fig. 392: View Of Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

13. Remove the crankshaft sprocket.

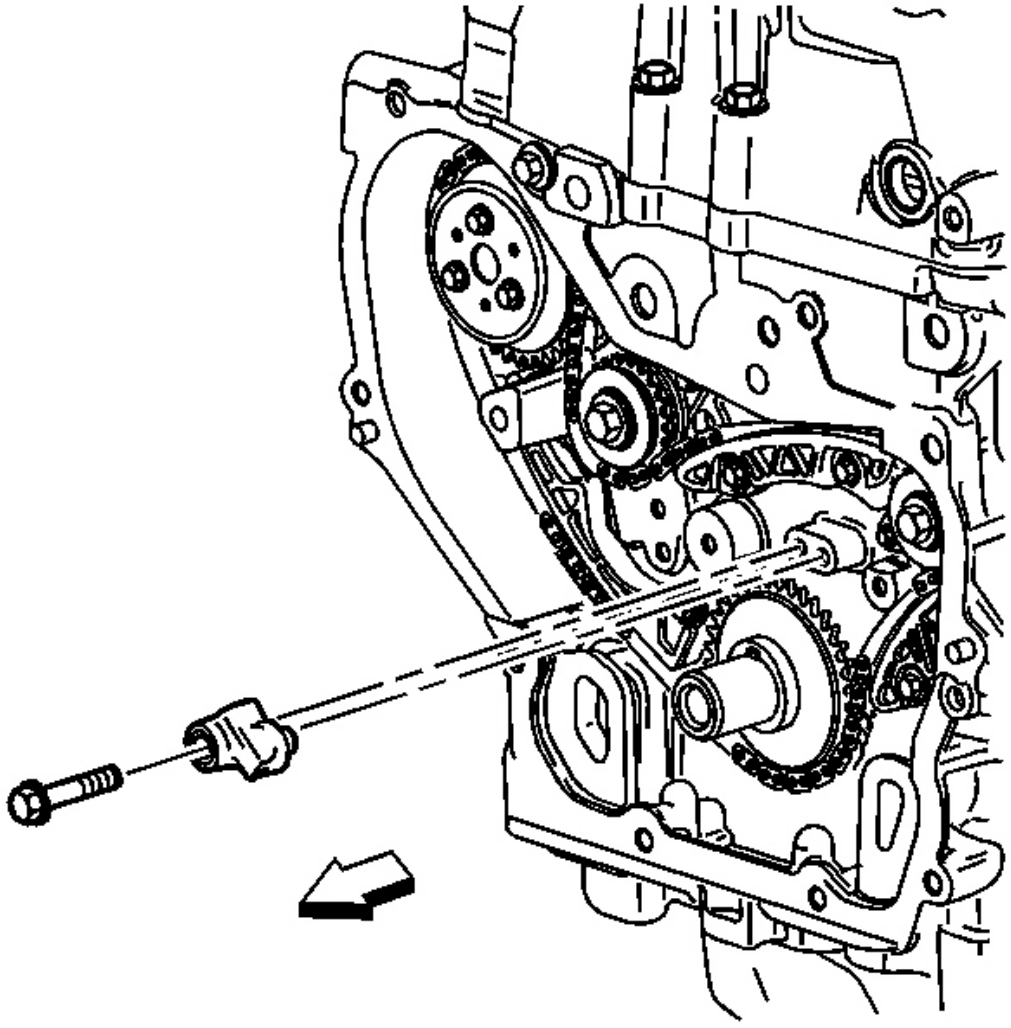


Fig. 393: View Of Oil Nozzle
Courtesy of GENERAL MOTORS CORP.

14. Remove the oil nozzle and bolt.

INTAKE CAMSHAFT, FOLLOWER, AND ADJUSTER REMOVAL

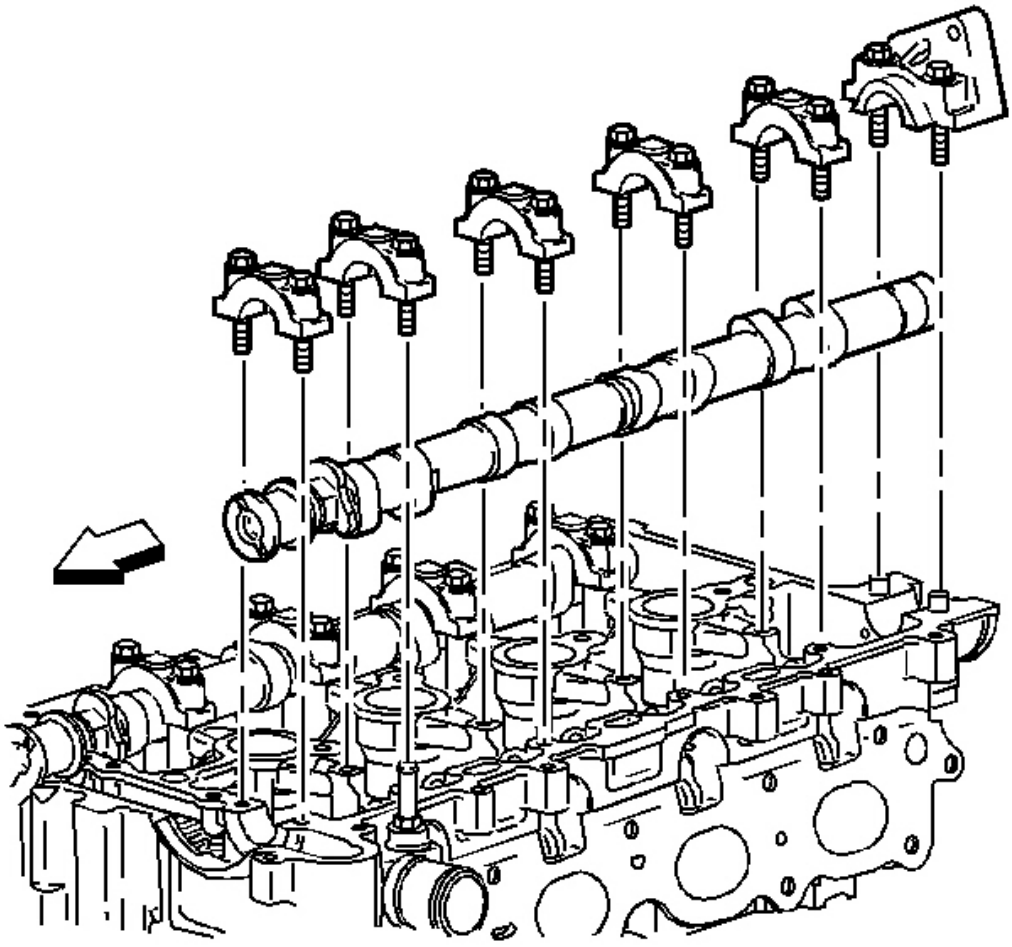


Fig. 394: View Of Intake Camshaft
Courtesy of GENERAL MOTORS CORP.

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

1. Mark bearing caps to ensure they are installed in the same position.
2. Remove the intake camshaft bearing cap bolts.
3. Remove the camshaft bearing caps.
4. Remove the intake camshaft.

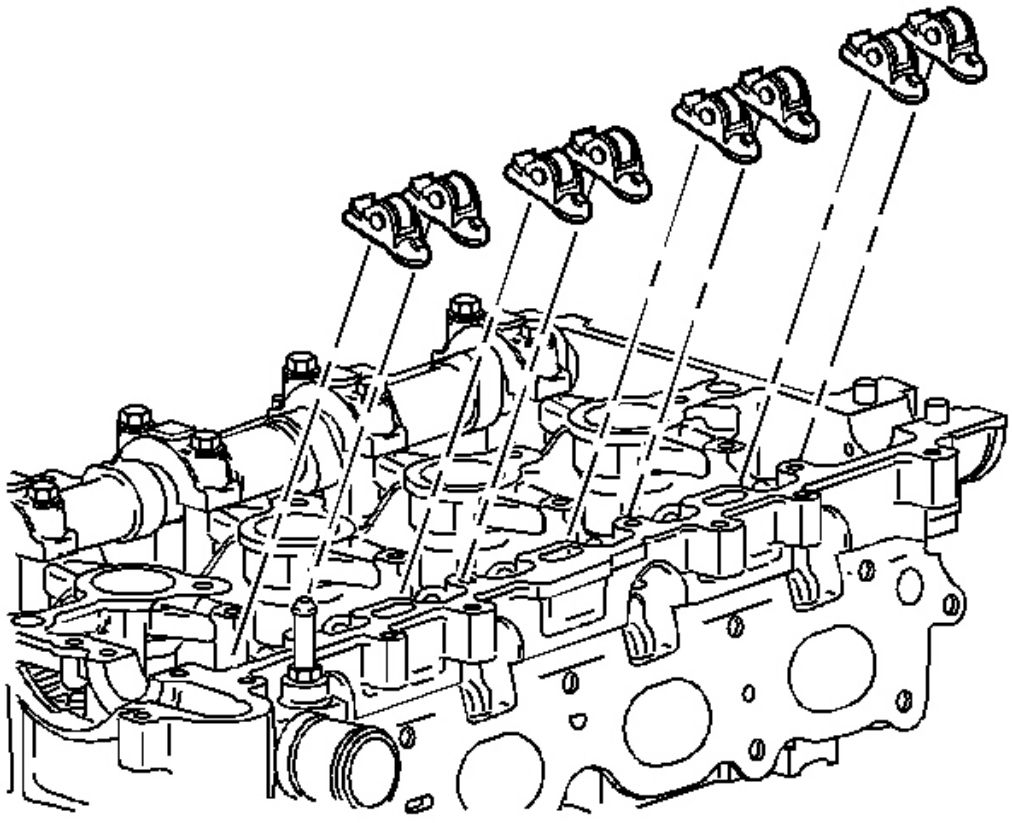


Fig. 395: View Of Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

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

5. Remove the intake camshaft roller finger followers.

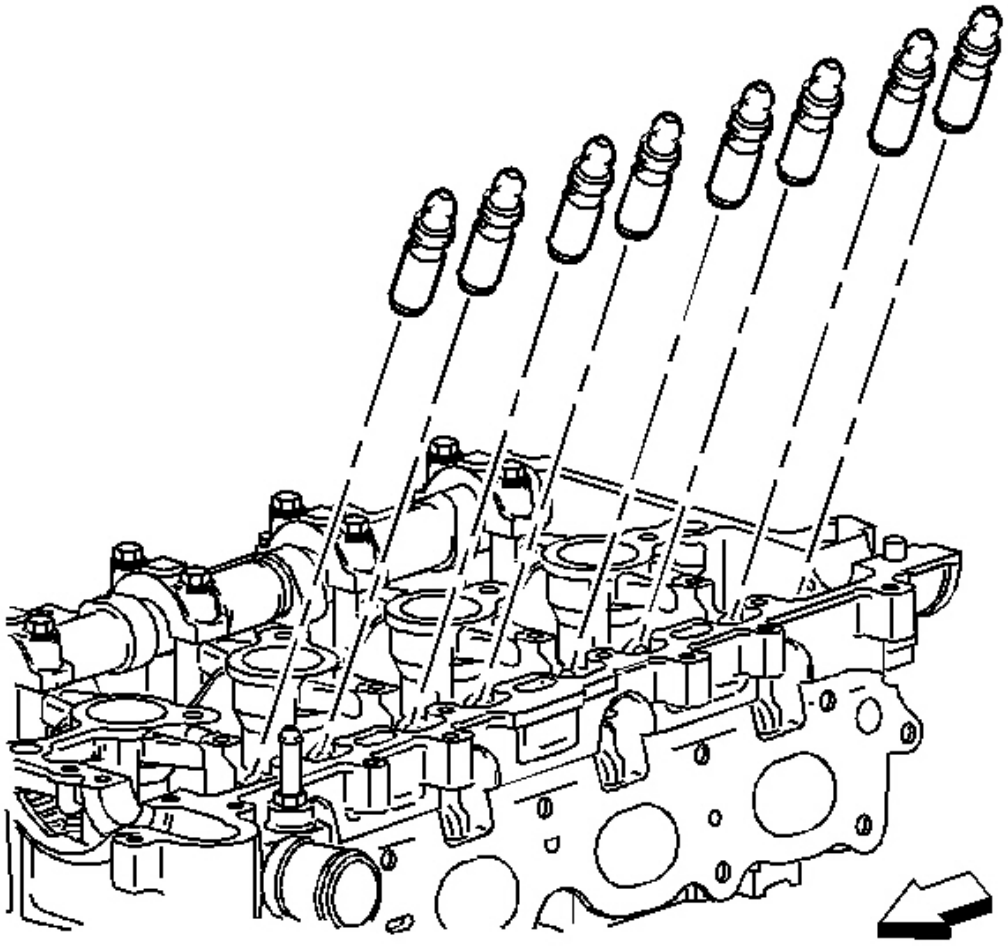


Fig. 396: View Of Hydraulic Element Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

6. Remove the hydraulic element adjusters.

EXHAUST CAMSHAFT, FOLLOWER, AND ADJUSTER REMOVAL

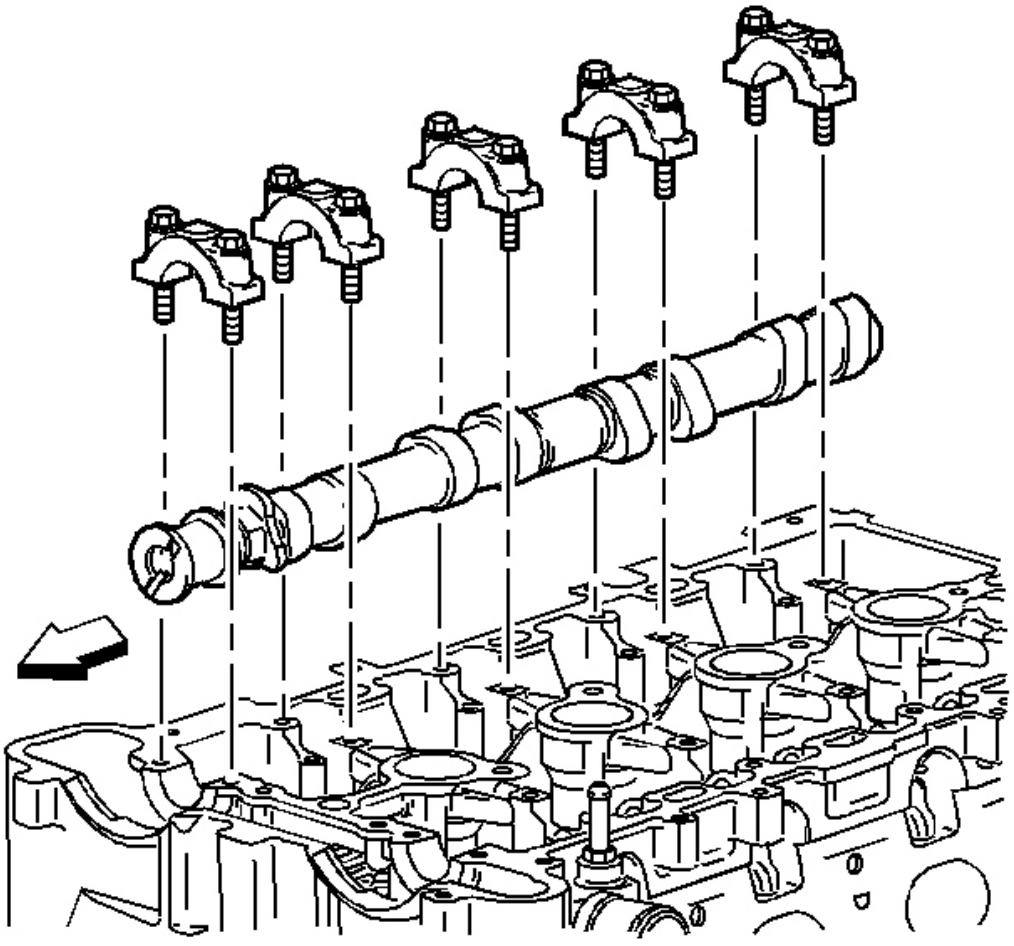


Fig. 397: View Of Exhaust Camshaft
Courtesy of GENERAL MOTORS CORP.

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

1. Mark bearing caps to ensure they are installed in the same position.
2. Remove the exhaust camshaft bearing cap bolts.
3. Remove the camshaft bearing caps ensuring they are marked and refitted in same position on assembly.
4. Remove the exhaust camshaft.

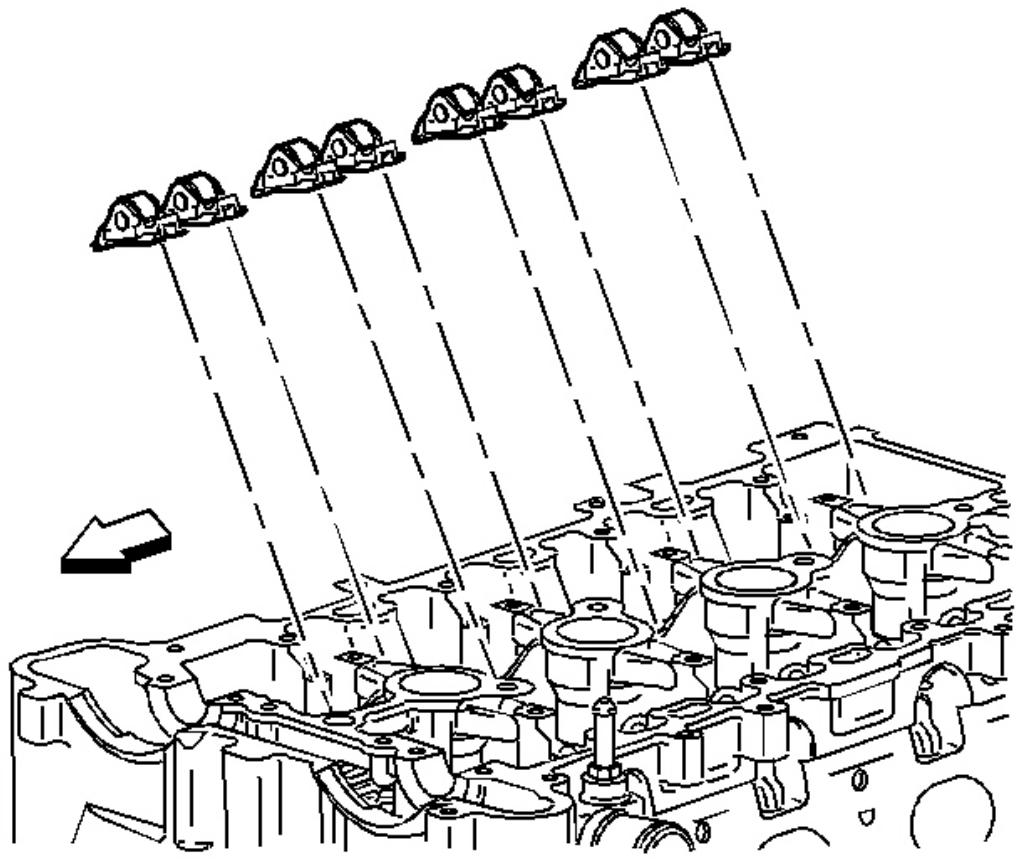


Fig. 398: View Of Exhaust Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

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

5. Remove the exhaust camshaft roller finger followers.

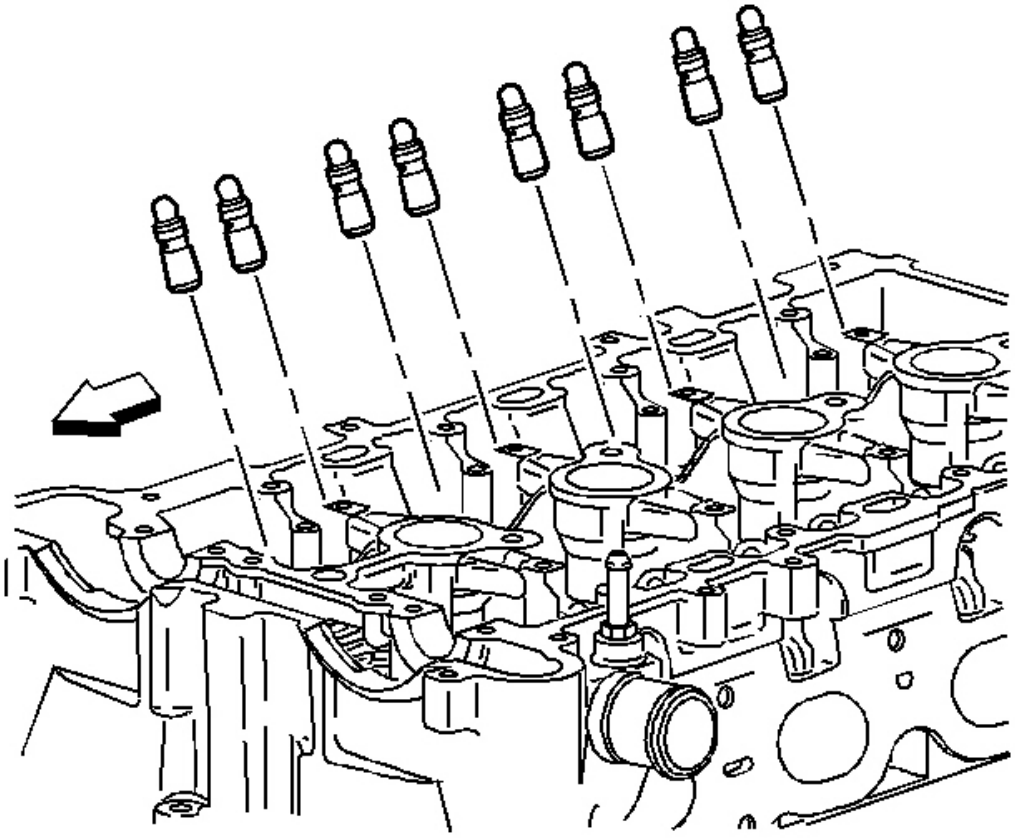


Fig. 399: View Of Hydraulic Element Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

6. Remove the hydraulic element adjusters.

BALANCE SHAFT DRIVE CHAIN AND TENSIONER REMOVAL

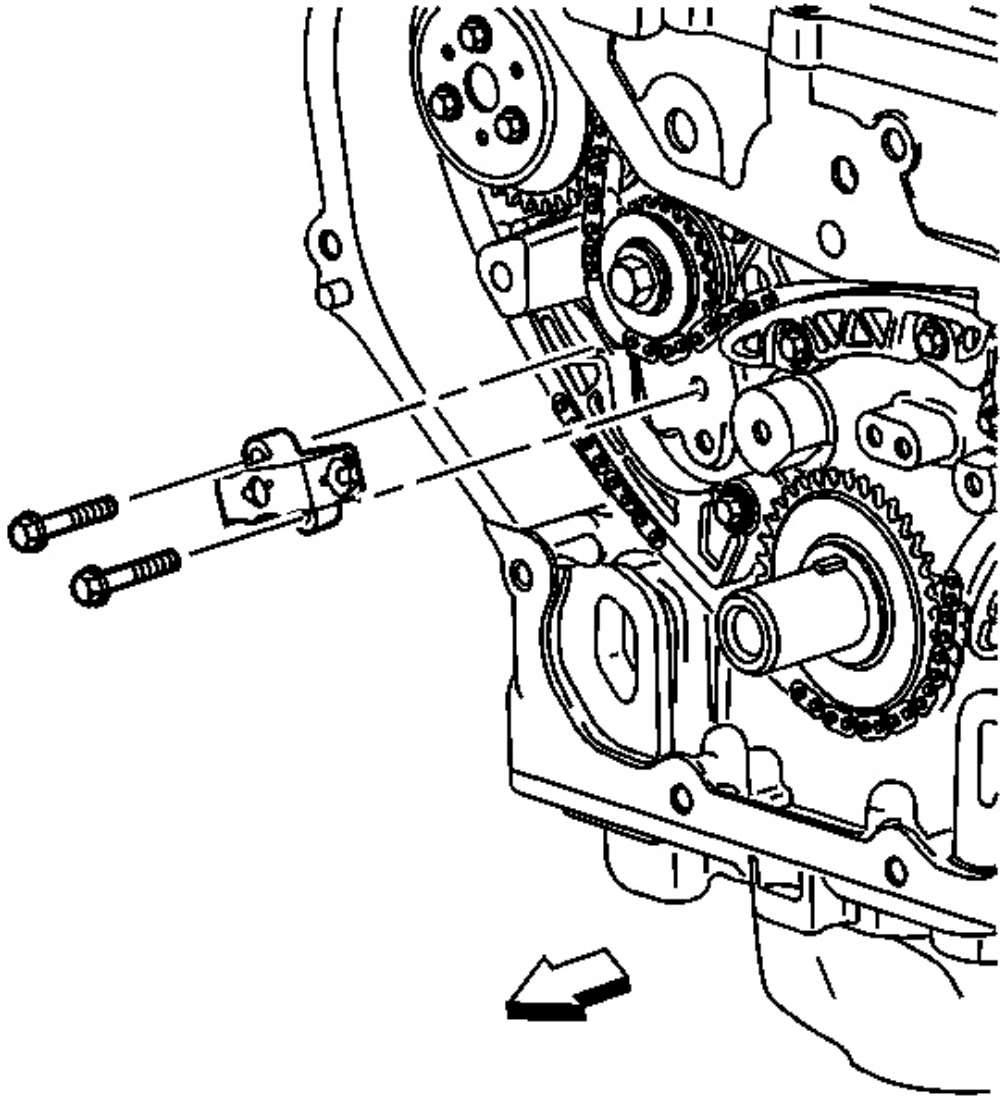


Fig. 400: Identifying Balance Shaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

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

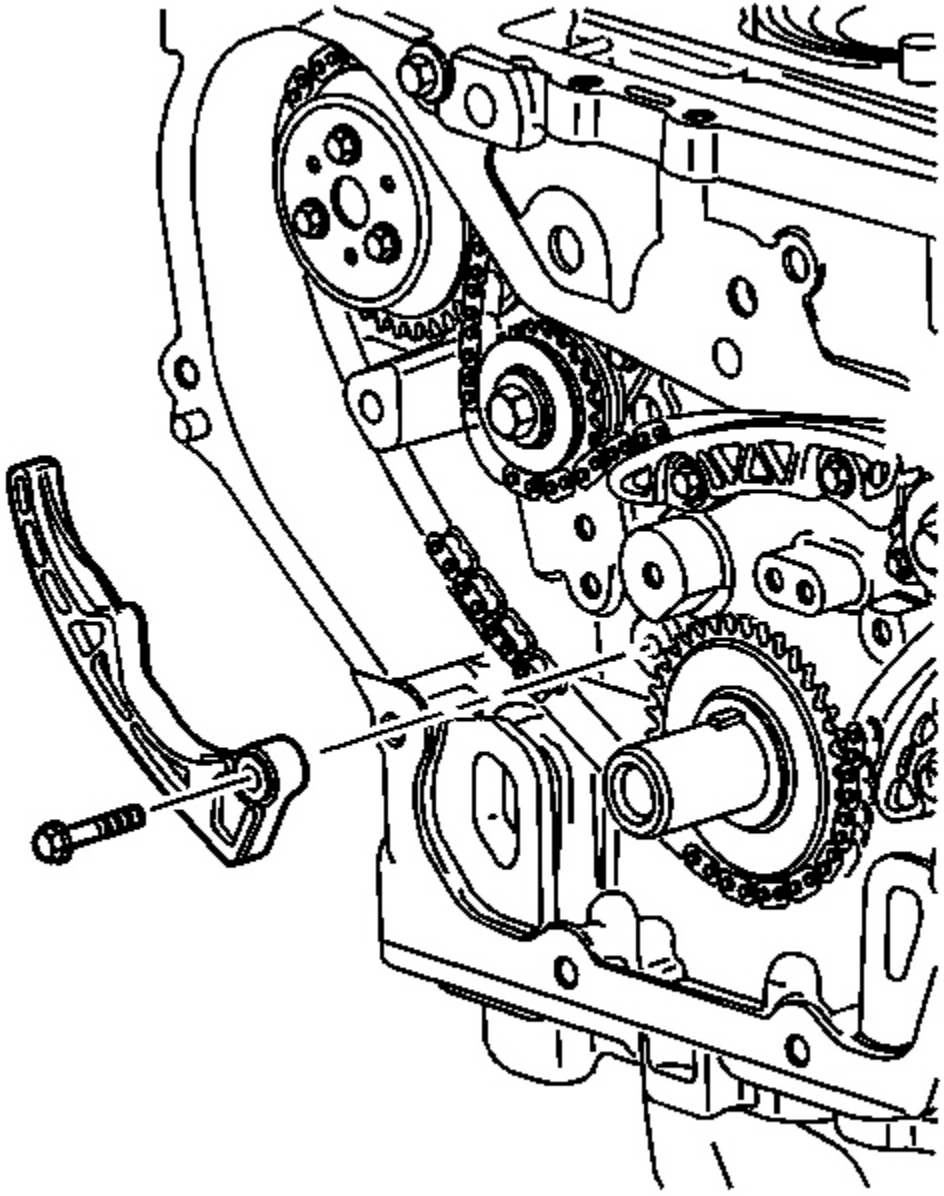


Fig. 401: View Of Adjustable Balance Shaft Chain Guide
Courtesy of GENERAL MOTORS CORP.

3. Remove the adjustable balance shaft chain guide bolt.
4. Remove the adjustable balance shaft chain guide.

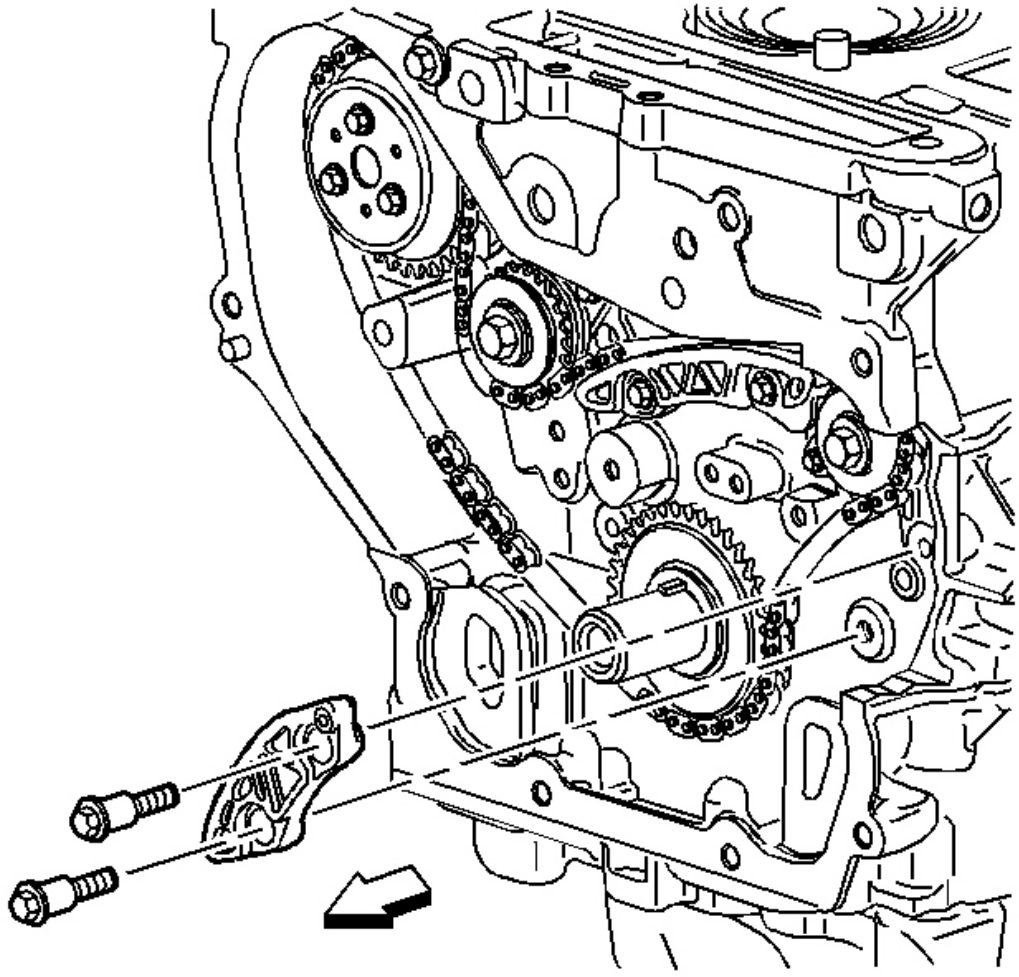


Fig. 402: View Of Small Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

5. Remove the small balance shaft drive chain guide bolts.
6. Remove the small balance shaft drive chain guide.

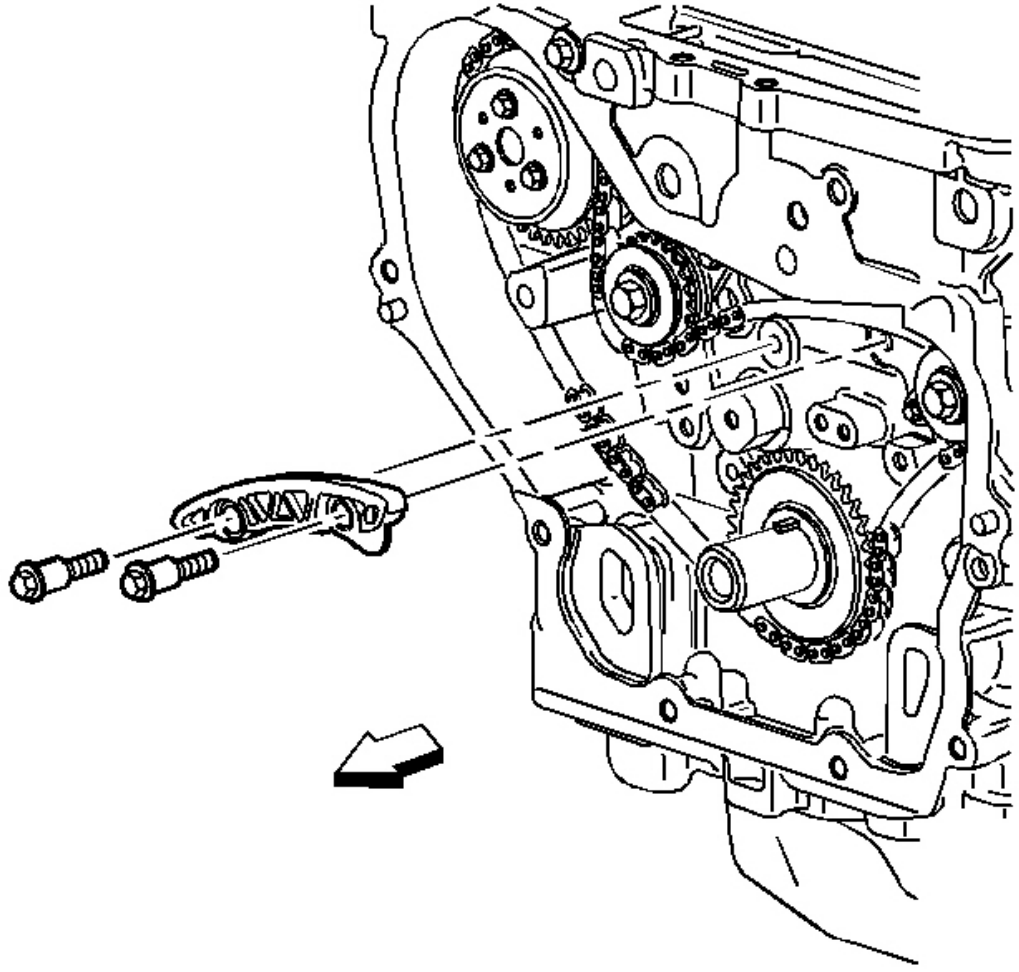


Fig. 403: View Of Upper Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

7. Remove the upper balance shaft drive chain guide bolts.
8. Remove the upper balance shaft drive chain guide.

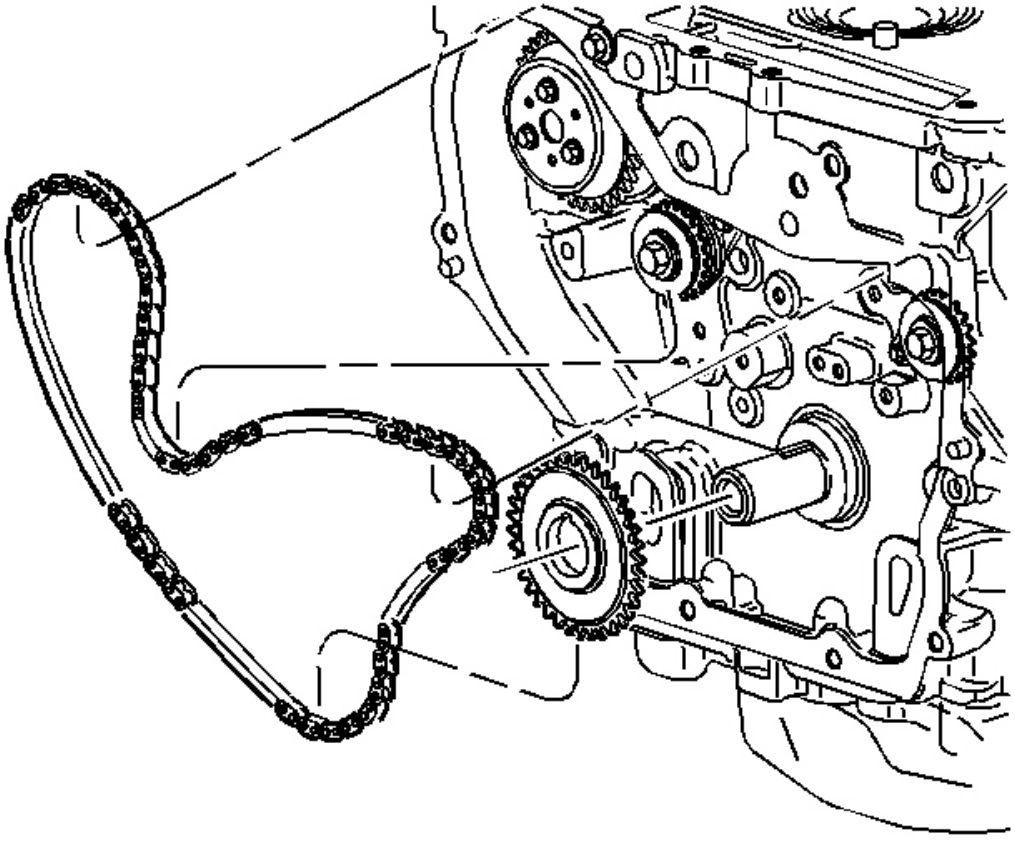


Fig. 404: Identifying Upper Balance Shaft Drive Chain
Courtesy of GENERAL MOTORS CORP.

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

9. Remove the balance shaft drive chain.
10. Remove the balance shaft drive sprocket.

BALANCE SHAFT REMOVAL

Tools Required

J 43650 Balancer Shaft Bearing Remover and Installer. See **Special Tools and Equipment** .

Balance Shaft Removal

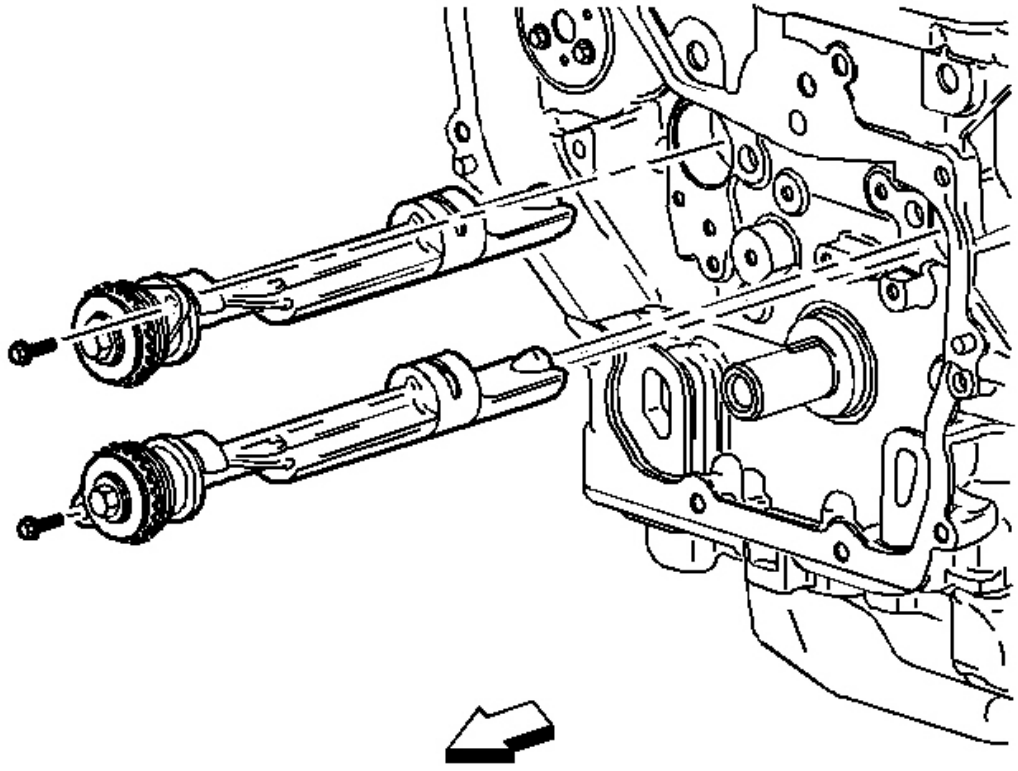


Fig. 405: View Of Balance Shaft
Courtesy of GENERAL MOTORS CORP.

1. Remove the balance shaft bearing carrier bolts.

IMPORTANT:

- **It is possible to install the intake side balance shaft into the exhaust side and vice versa. Please use care not to install the balance shafts into the wrong bores. Engine vibration will result.**
- **Do not remove the bolt holding the sprocket.**

2. Remove the balance shaft assemblies.

NOTE: **Proper centering of the tool is required on the balance shaft bushing. If the tool is not properly centered then damage to the bearing bore and block will occur.**

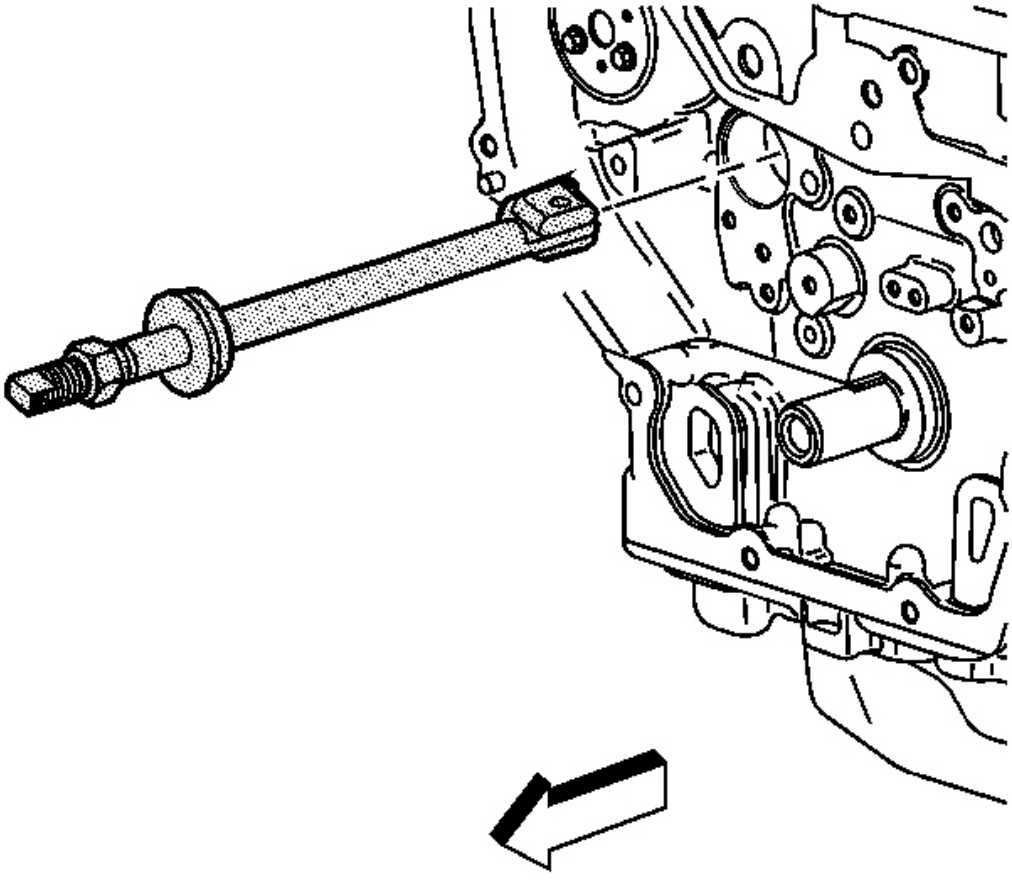


Fig. 406: View Of J43650 Installed Into The Balance Shaft Hole
Courtesy of GENERAL MOTORS CORP.

3. Install the **J 43650** into the balance shaft hole. See **Special Tools and Equipment** . Insert the tool with the foot parallel to the shaft.

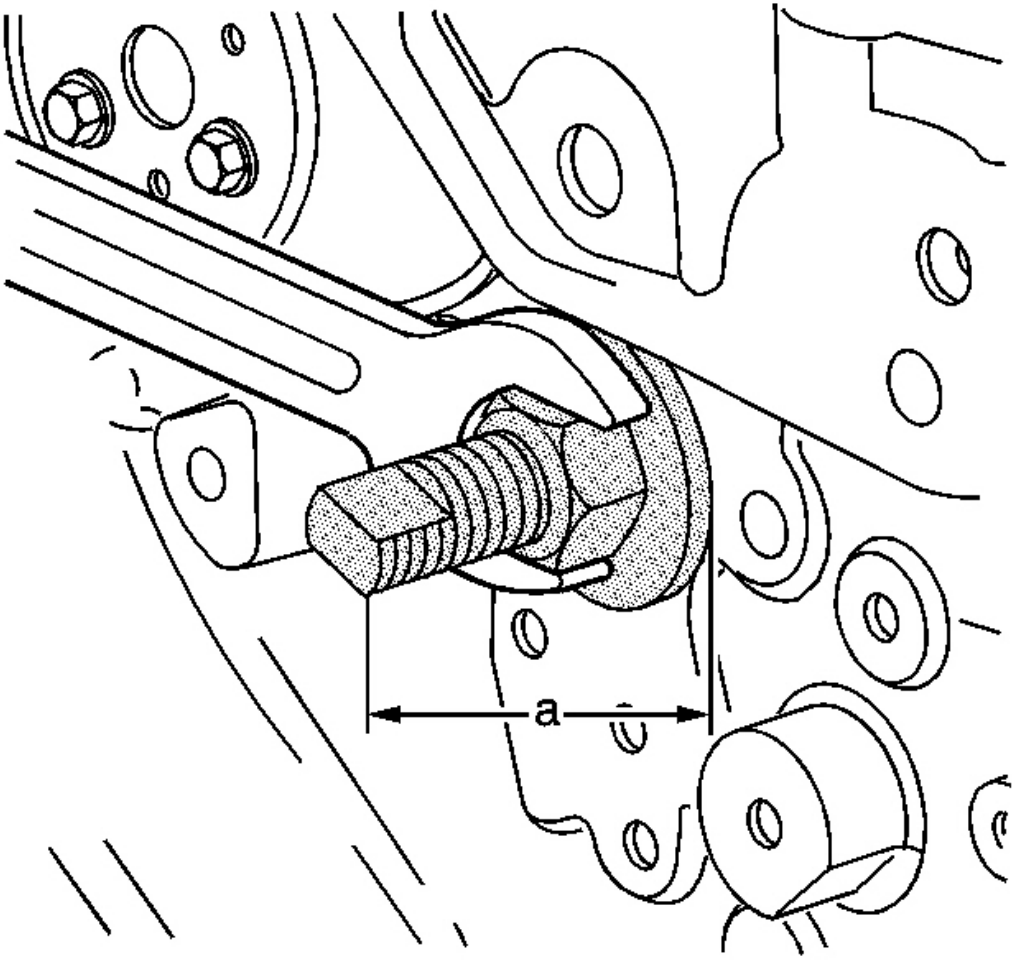


Fig. 407: J43650 Inserted In The Block
Courtesy of GENERAL MOTORS CORP.

4. When the **J 43650** is inserted in the block turn the **J 43650** so that the foot becomes perpendicular to the shaft.
5. Center the foot of the **J 43650** on the balance shaft bushing.
6. Once the **J 43650** is centered on the balance shaft bushing, then insert the centering guide into the front balance shaft bore and tighten the nut with an appropriate wrench. See **Special Tools and Equipment** .

   When the **J 43650** is properly installed, before removing the bushing, the end of the tool should be 116 mm (4.6 in) (a) from the block face.See **Special Tools and Equipment**

   If the **J 43650** is less than approximately 114 mm (4.5 in) (a), recheck the tool alignment.See **Special**

Tools and Equipment

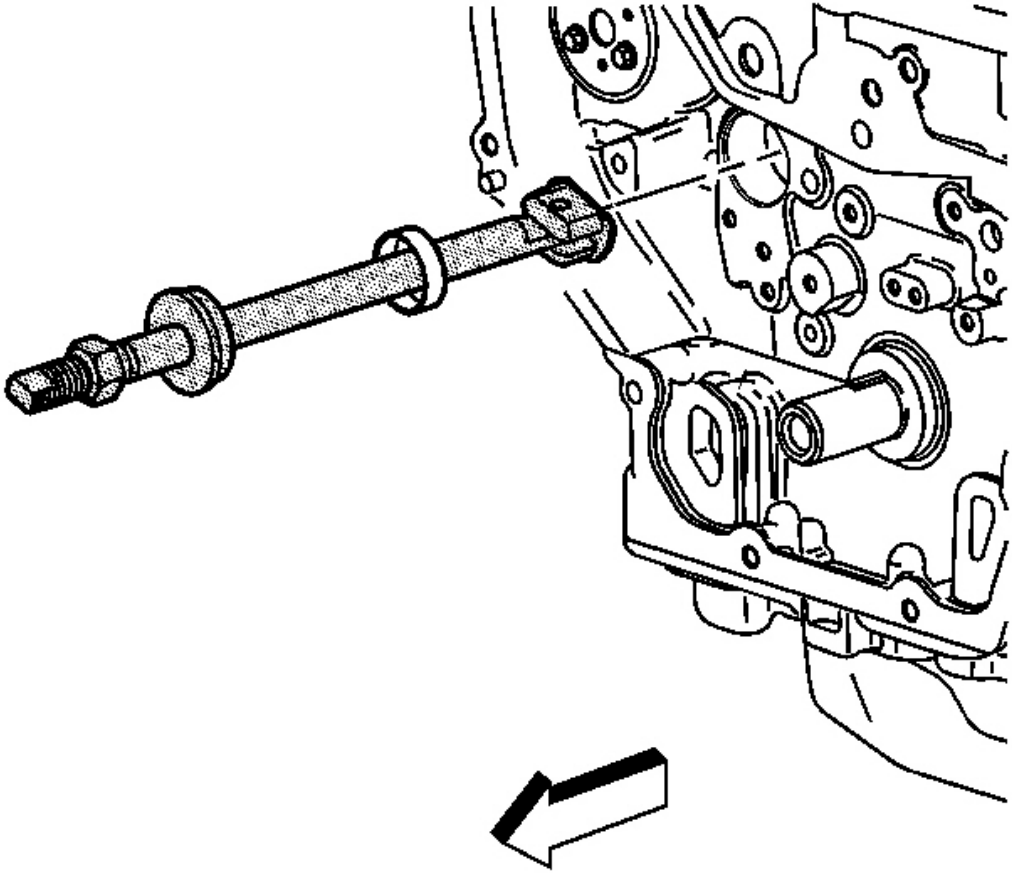


Fig. 408: View Of J43650
Courtesy of GENERAL MOTORS CORP.

7. Tighten the nut on the **J 43650** until the tension releases. When the tension releases, remove the **J 43650** and the balance shaft bushing.

WATER PUMP REMOVAL

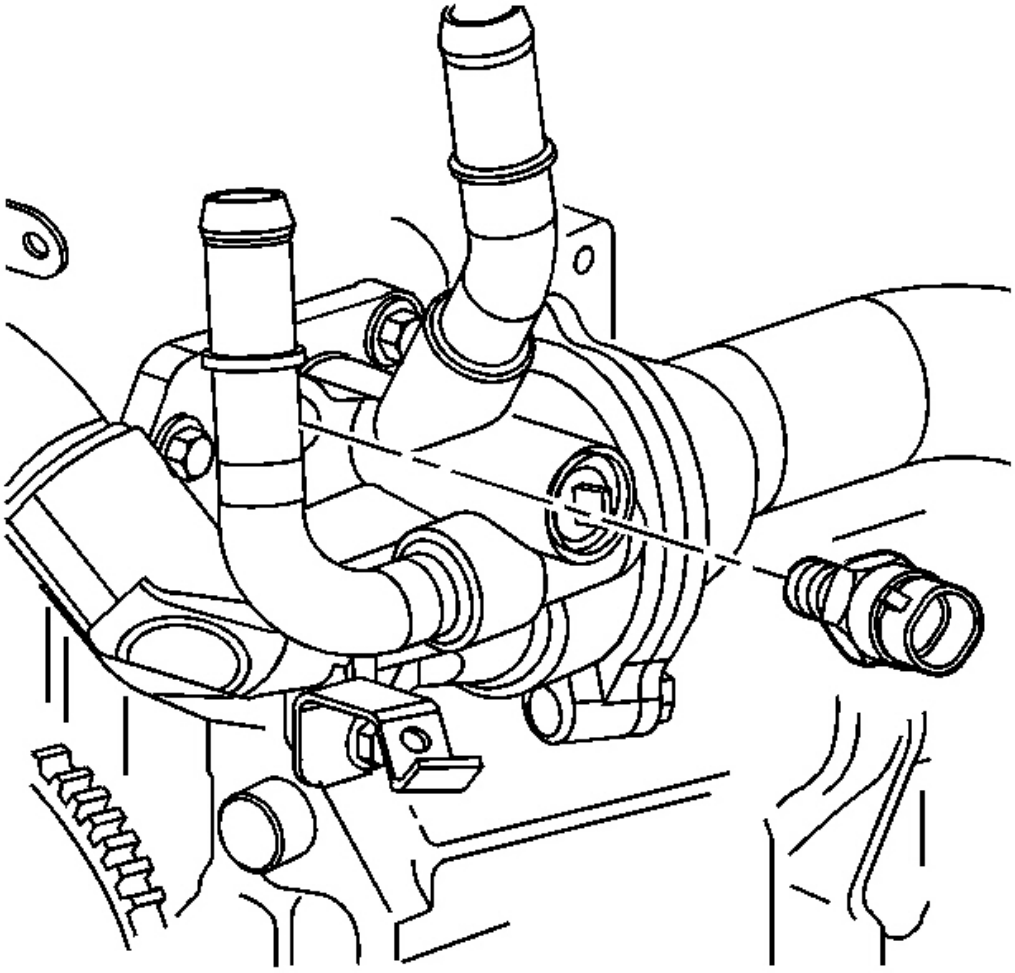


Fig. 409: View Of Engine Coolant Temperature Sensor
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine coolant temperature sensor.

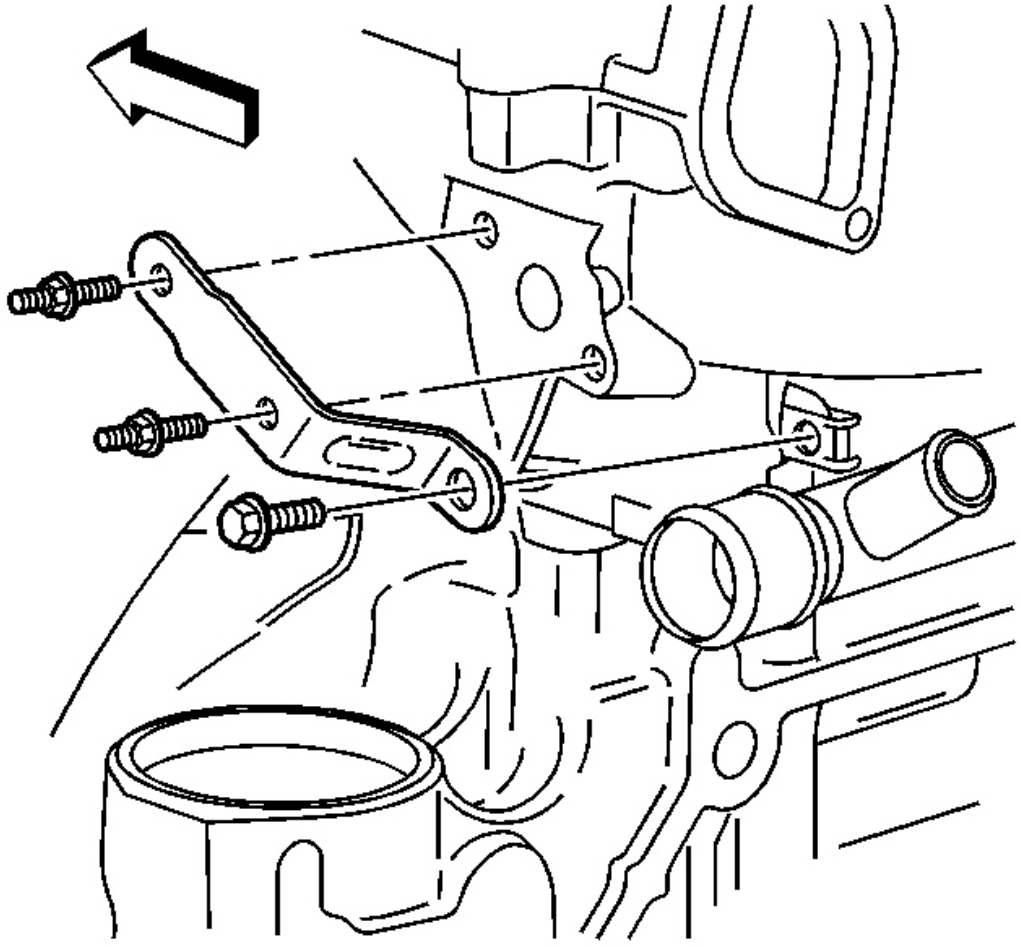


Fig. 410: View Of Water Pipe Support Bracket
Courtesy of GENERAL MOTORS CORP.

2. Remove the water pipe support bracket and bolts.

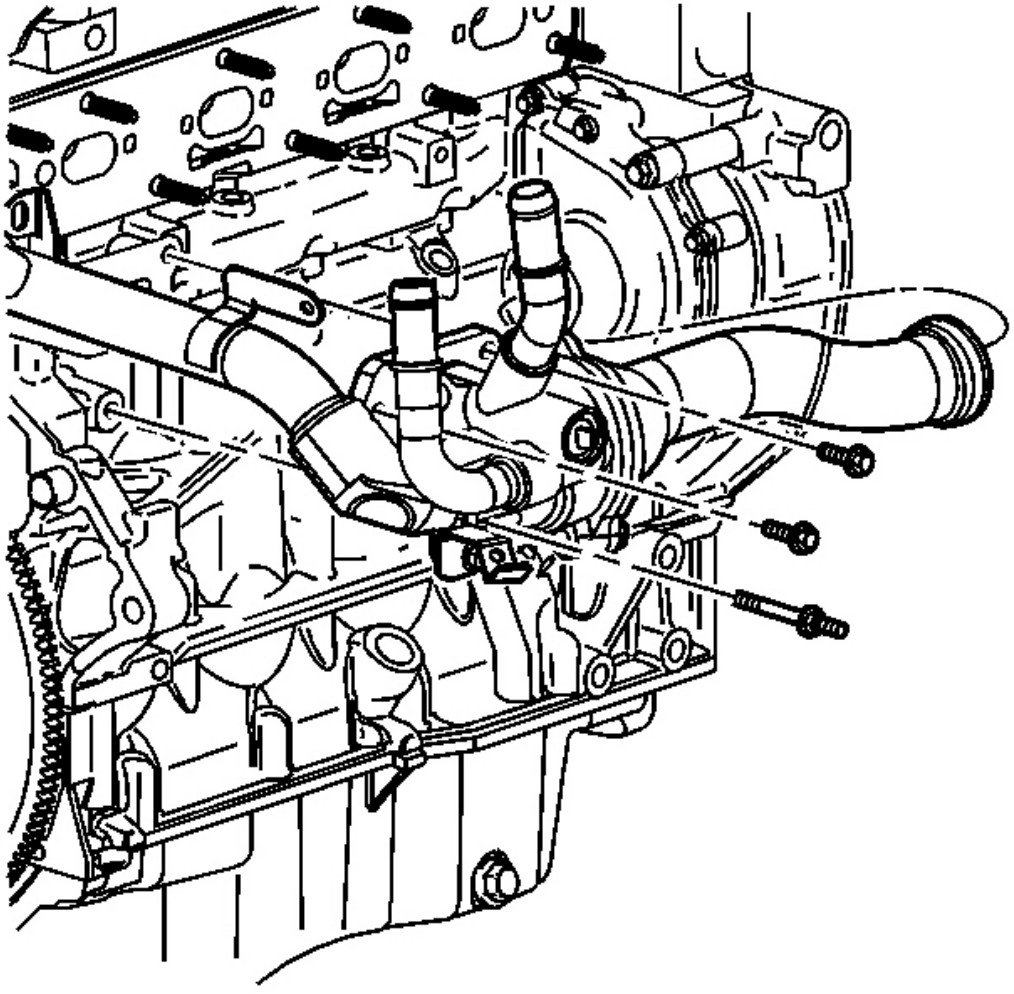


Fig. 411: View Of Thermostat & Water Feed Pipe
Courtesy of GENERAL MOTORS CORP.

3. 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.

4. Remove the thermostat housing and water feed pipe from the water pump cover.

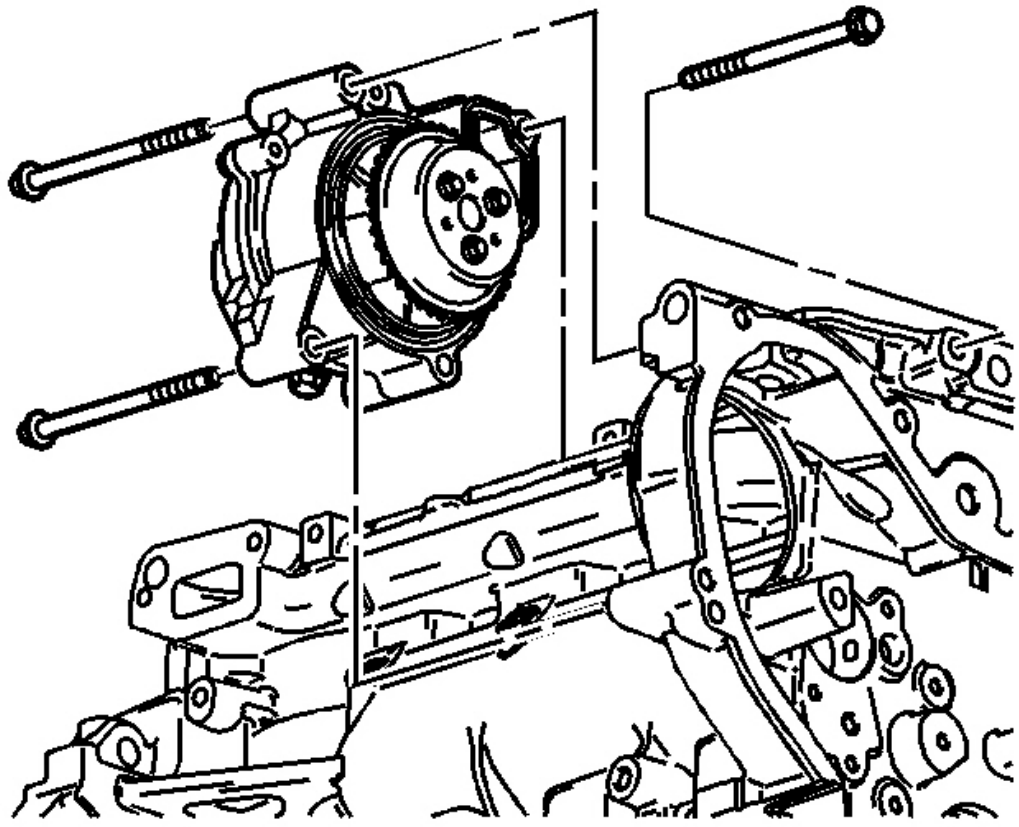


Fig. 412: View Of Water Pump Assembly
Courtesy of GENERAL MOTORS CORP.

5. Remove the water pump retaining bolts. Be sure to remove the bolt that goes through the front of the engine block.
6. Remove the water pump assembly.

CYLINDER HEAD REMOVAL

Tools Required

J 38188 Cylinder Head Broken Bolt Extractor Kit. See **Special Tools and Equipment** .

Cylinder Head Removal

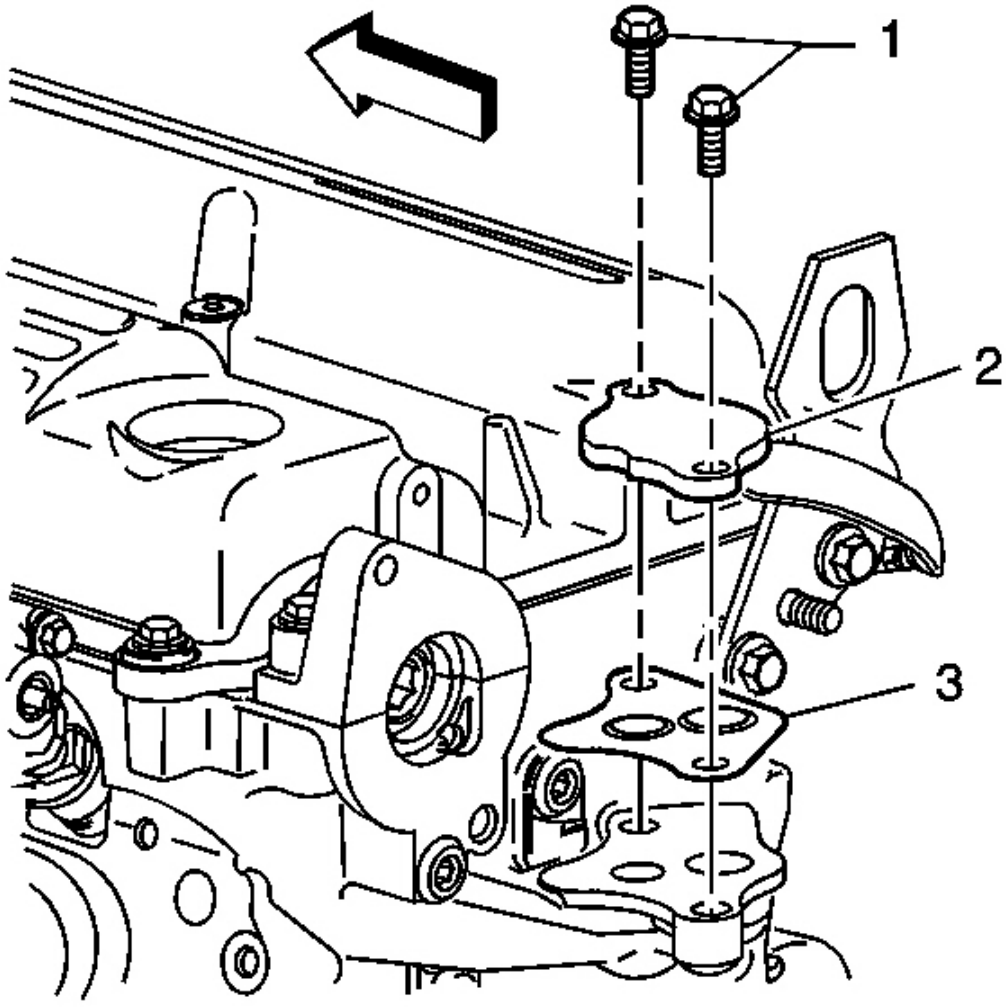


Fig. 413: View EGR Cover & Gasket
Courtesy of GENERAL MOTORS CORP.

1. Remove the EGR cover (2), the bolts (1), and the EGR cover gasket (3).

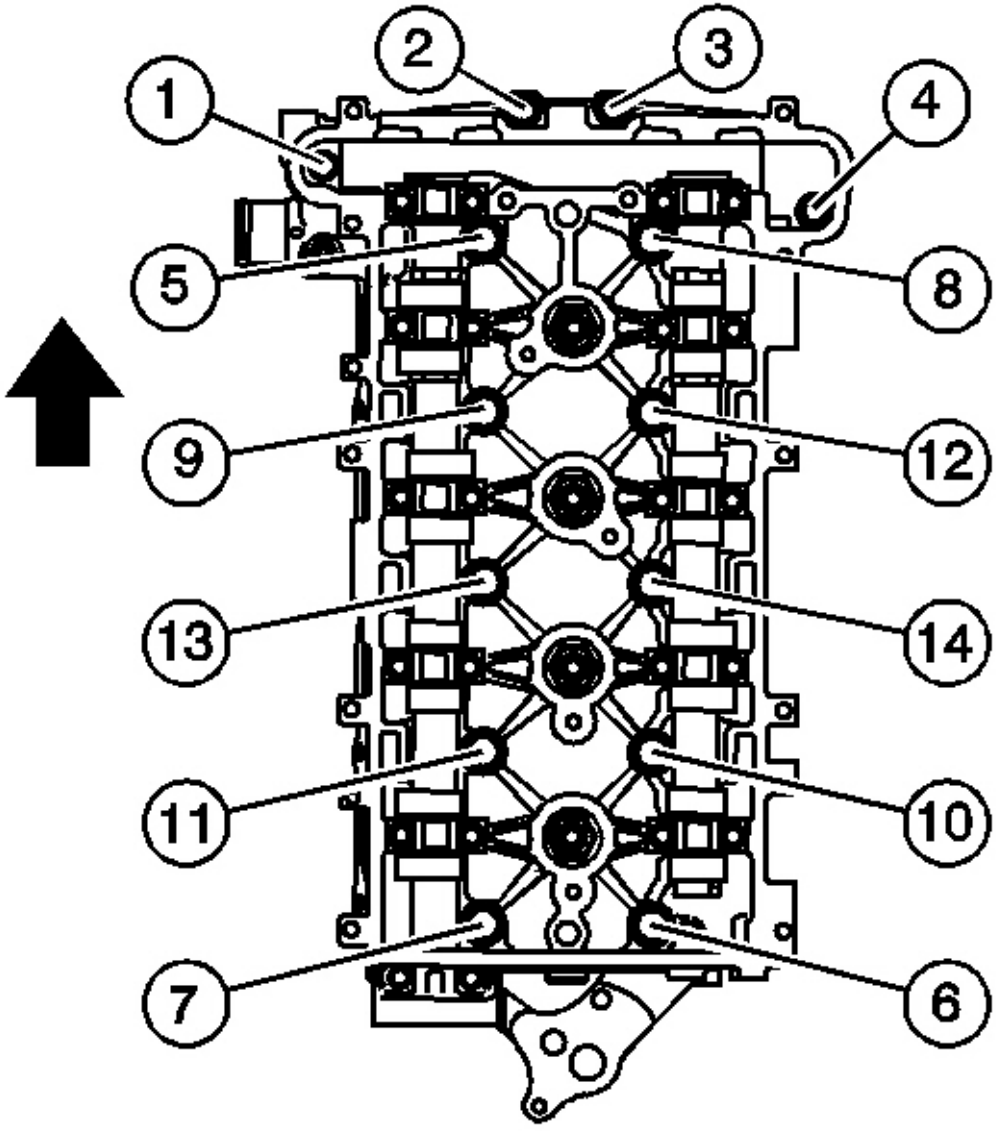


Fig. 414: Identifying Cylinder Head Bolts Loosening Sequence
Courtesy of GENERAL MOTORS CORP.

2. Remove the cylinder head to the block bolts in sequence.

   Discard the bolts.

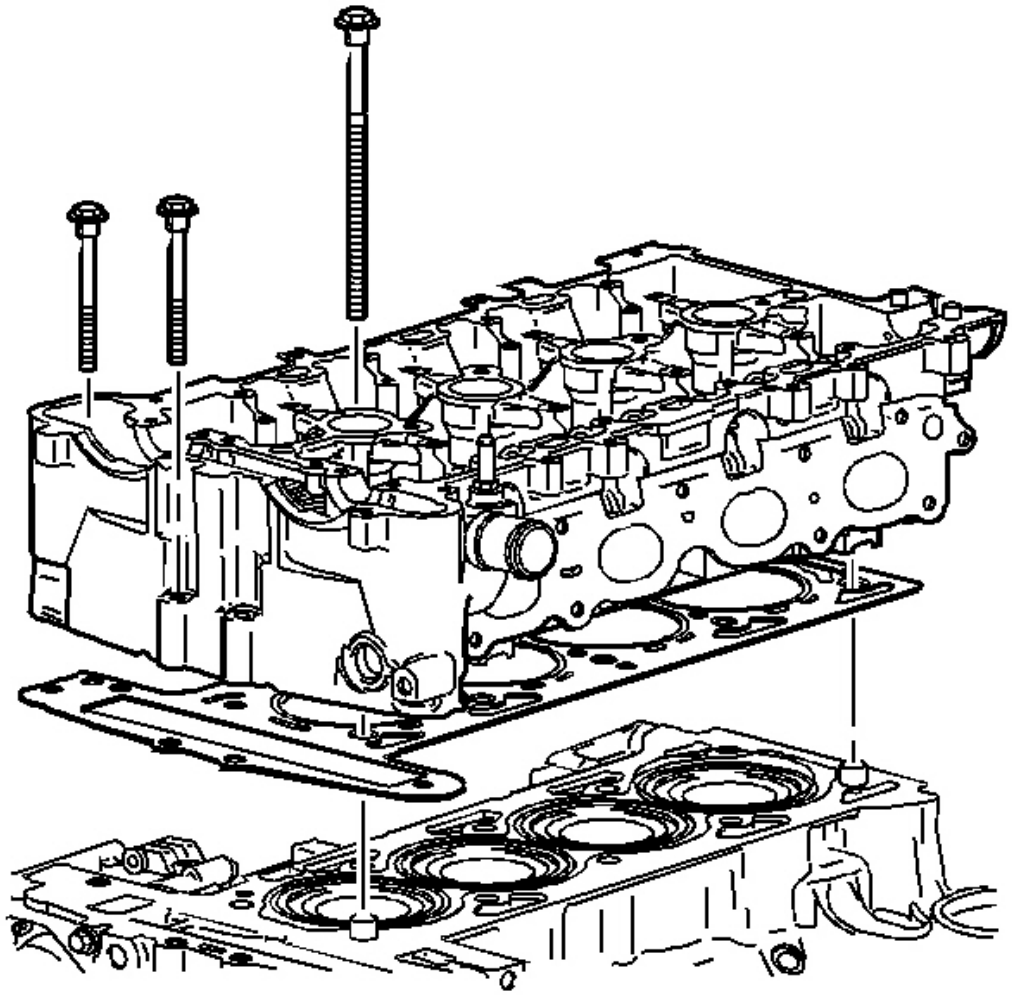


Fig. 415: Identifying Cylinder Head
Courtesy of GENERAL MOTORS CORP.

3. Remove the cylinder head.
4. Remove the cylinder head gasket.
5. Clean all of the gasket surfaces.
6. 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.

IMPORTANT: Do not use any other method or technique to clean these gasket

surfaces.

- Use a new razor blade for each cylinder head and cylinder block.

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

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

IMPORTANT: Do not use a tap to clean the cylinder head bolt holes.

7. Clean the old sealer/lube and dirt from the bolt holes.
8. Clean the bolt holes with a nylon bristle brush.

CAUTION: Wear safety glasses to avoid injury when using compressed air or any cleaning solvent. Bodily injury may occur if fumes are inhaled or if skin is exposed to chemicals.

9. 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.
10. Remove any broken long cylinder head bolts using the **J 38188** . See **Special Tools and Equipment** .

OIL PAN REMOVAL

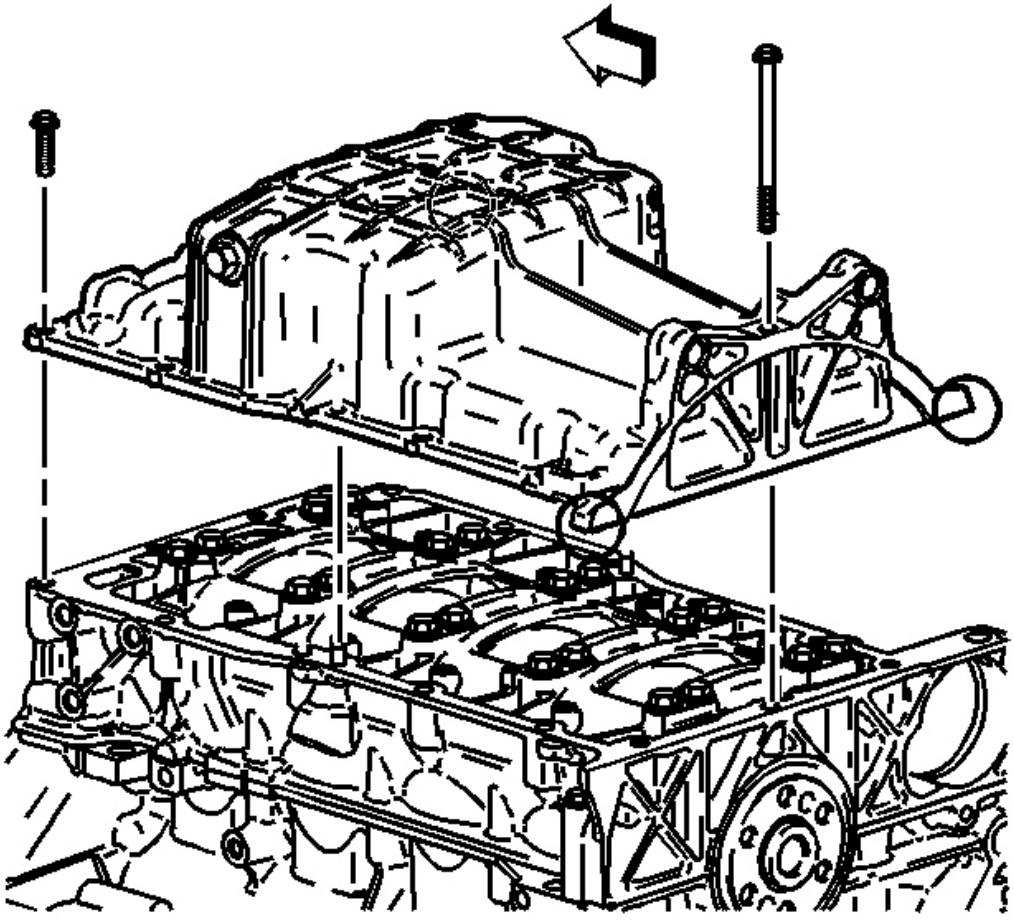


Fig. 416: View Of Oil Pan
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pan bolts.
2. Remove the oil pan at pry points.

PISTON, CONNECTING ROD, AND BEARING REMOVAL

Tools Required

- **J-43966-1** Connecting Rod Guides. See **Special Tools and Equipment** .
- **J 41742** Connecting Rod Guides. See **Special Tools and Equipment** .

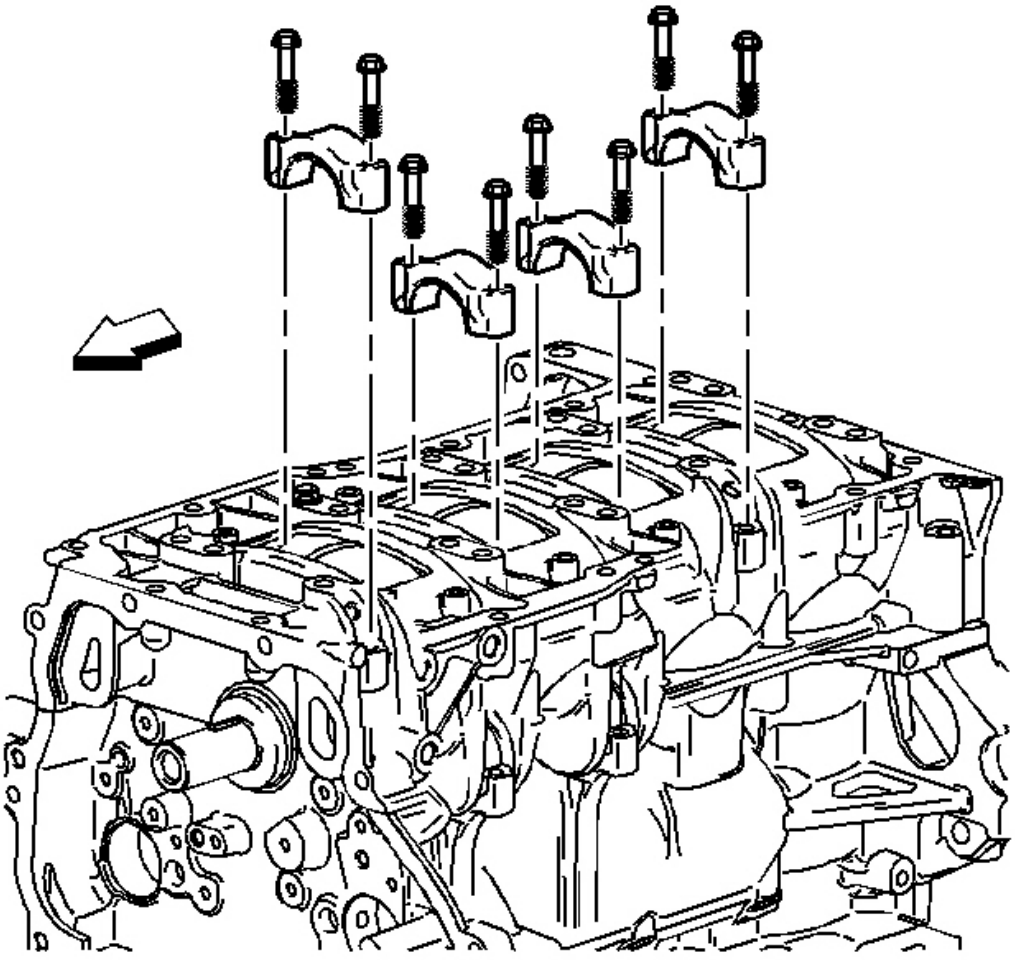


Fig. 417: View Of Connecting Rod Cap
Courtesy of GENERAL MOTORS CORP.

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.

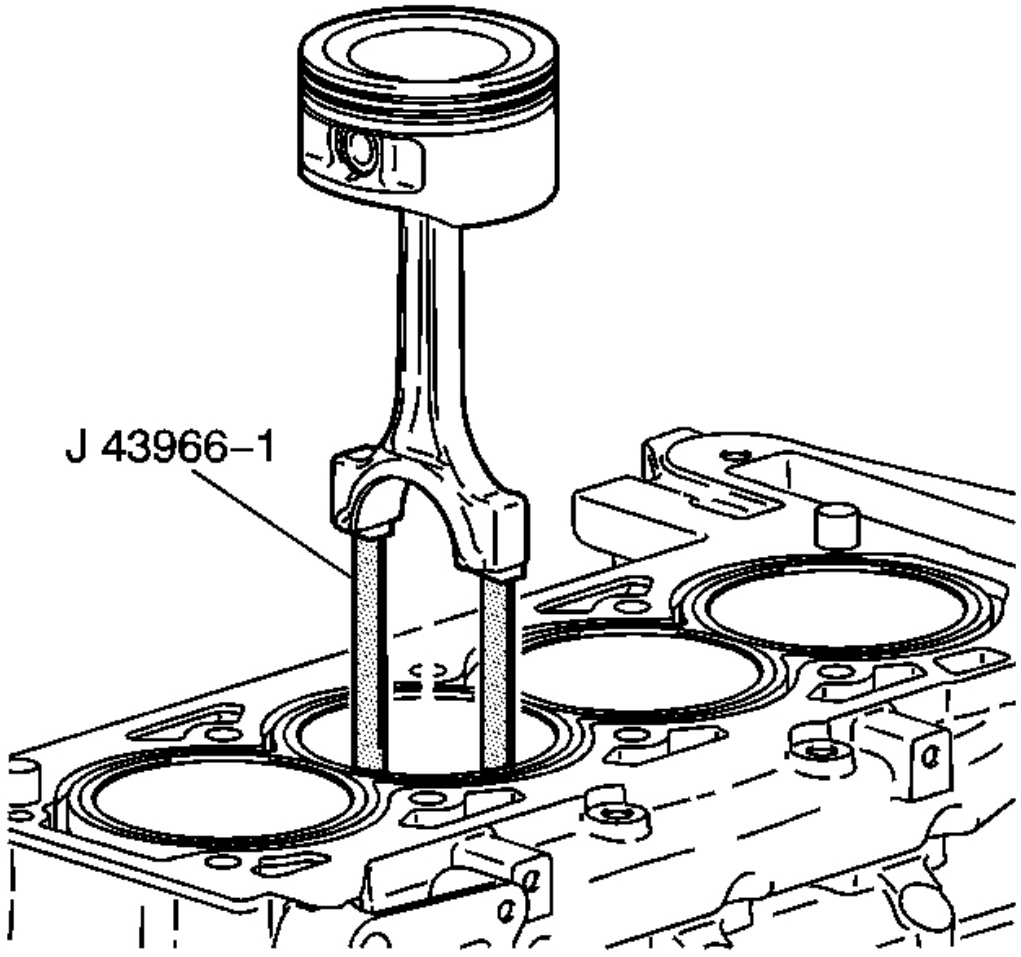


Fig. 418: View Of Connecting Rod Guides
Courtesy of GENERAL MOTORS CORP.

6. Install **J-43966-1** and **J 41742** on the connecting rod bolts before removing the piston and connecting rod assembly.
7. Remove the piston and connecting rod assembly.

LOWER CRANKCASE REMOVAL

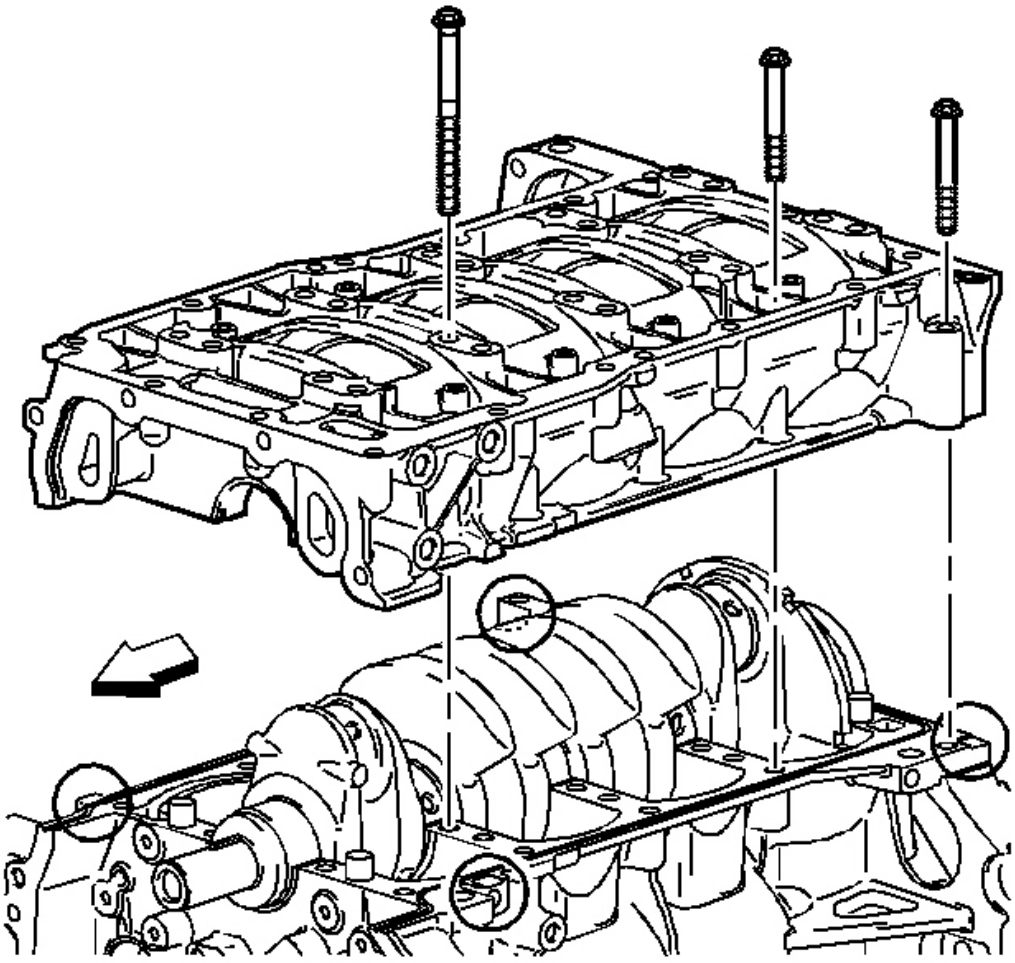


Fig. 419: View Of Upper And Lower Crankcase Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft position sensor. Inspect the position sensor for damage. Replace if necessary.
2. Remove the bedplate perimeter bolts.
3. Remove and discard the crankshaft bearing bolts.
4. Using the pry-points and an appropriate prying tool, gently separate the upper and lower crankcase.

CRANKSHAFT AND BEARINGS REMOVAL

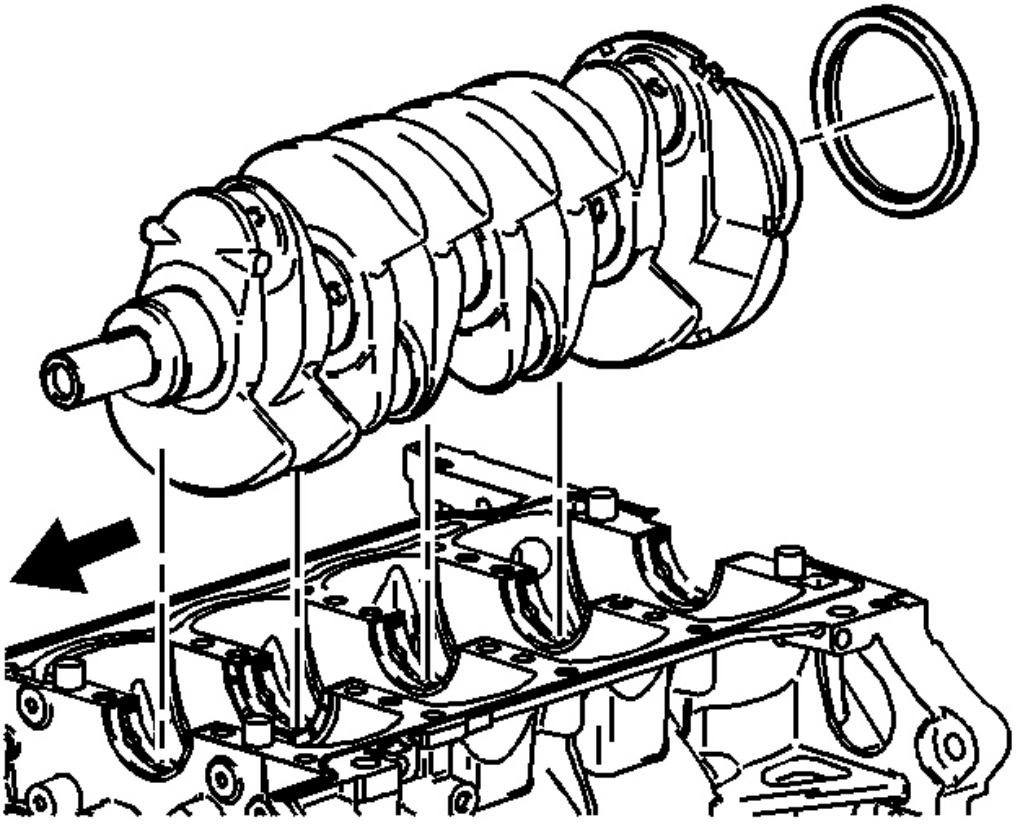


Fig. 420: View Of Crankshaft
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft from the block.
2. Remove the crankshaft rear oil seal from the block.

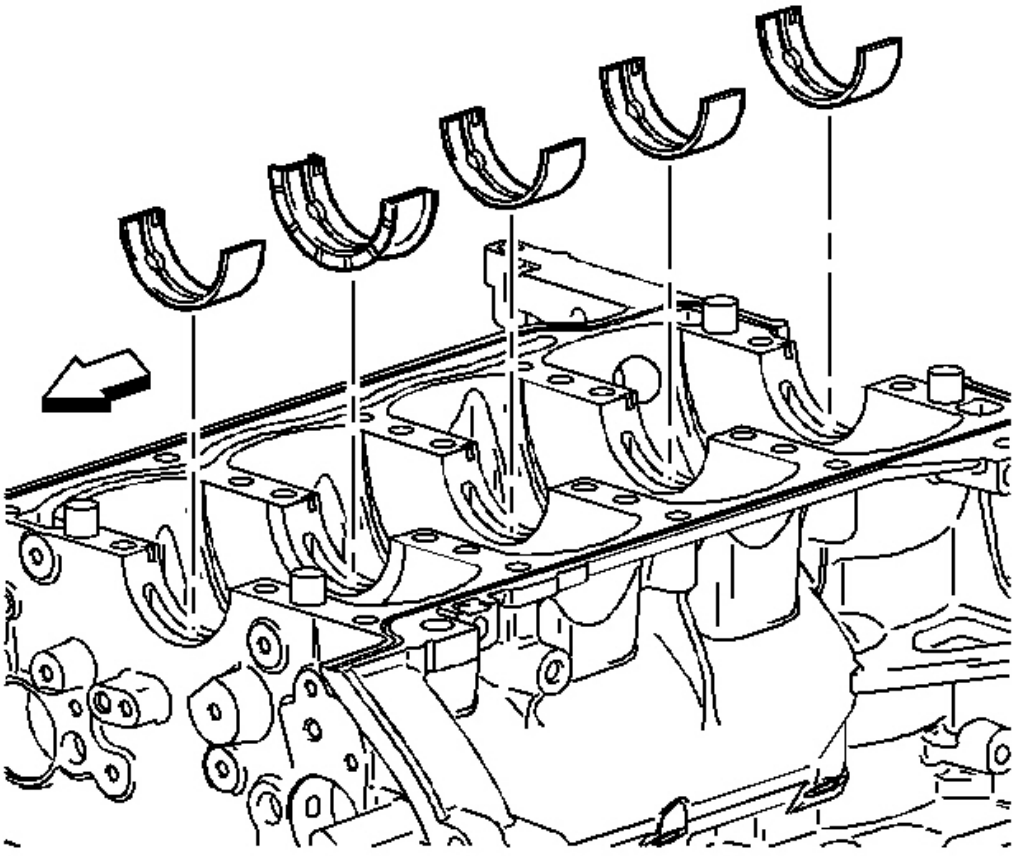


Fig. 421: View Of Crankshaft Bearing Inserts
Courtesy of GENERAL MOTORS CORP.

3. Remove the bearing inserts from the block.

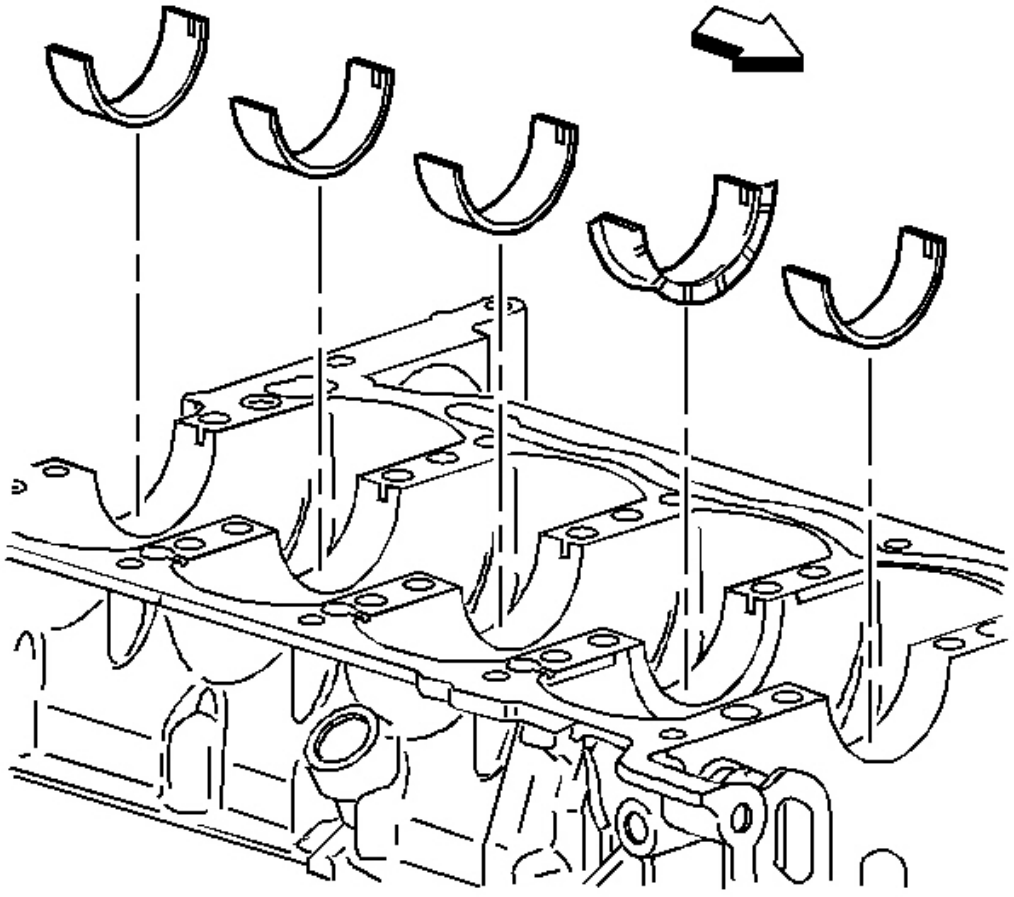


Fig. 422: Identifying Crankshaft Bearing Inserts
Courtesy of GENERAL MOTORS CORP.

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

- 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

1. Remove the water jacket drain plug.

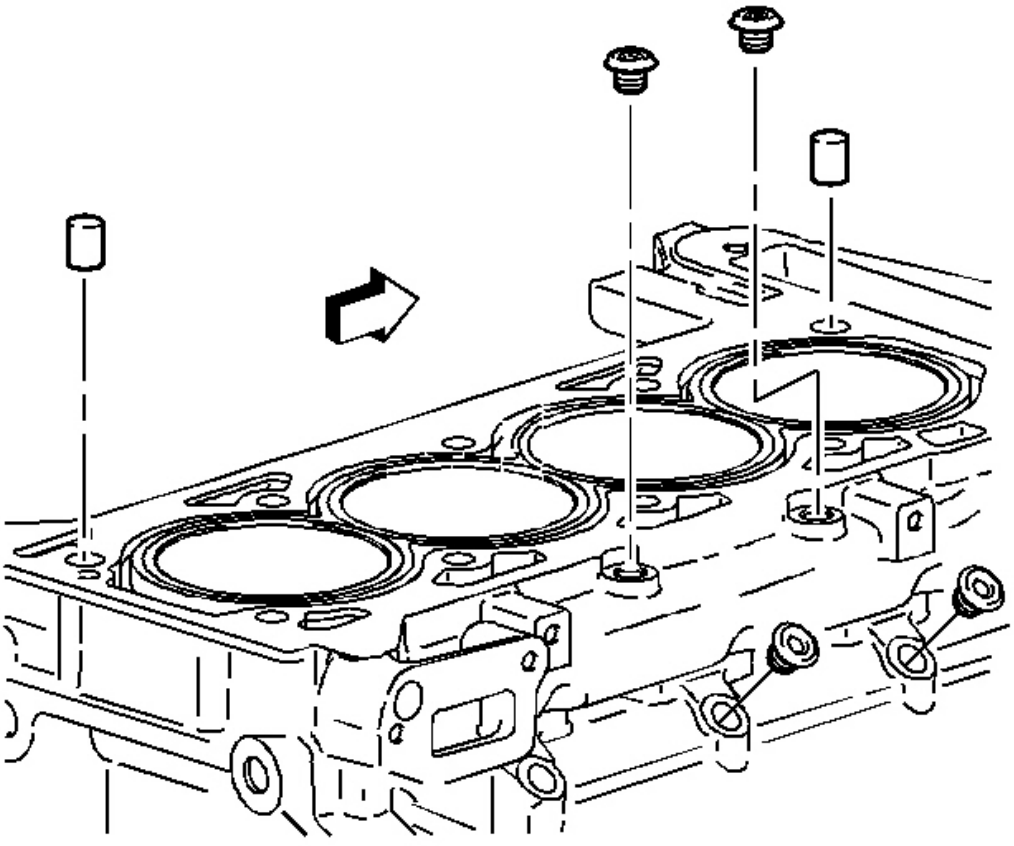


Fig. 423: View Of Oil Passage Plug, Oil Flow Check Valve & Water Jacket Drain Plug
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil flow check valve.
3. Remove the rear oil passage plug.
4. Remove the six oil passage plugs on the sides of the block.
5. Remove the two water passage plugs on the top of the block.
6. Remove the two front oil passage plugs.

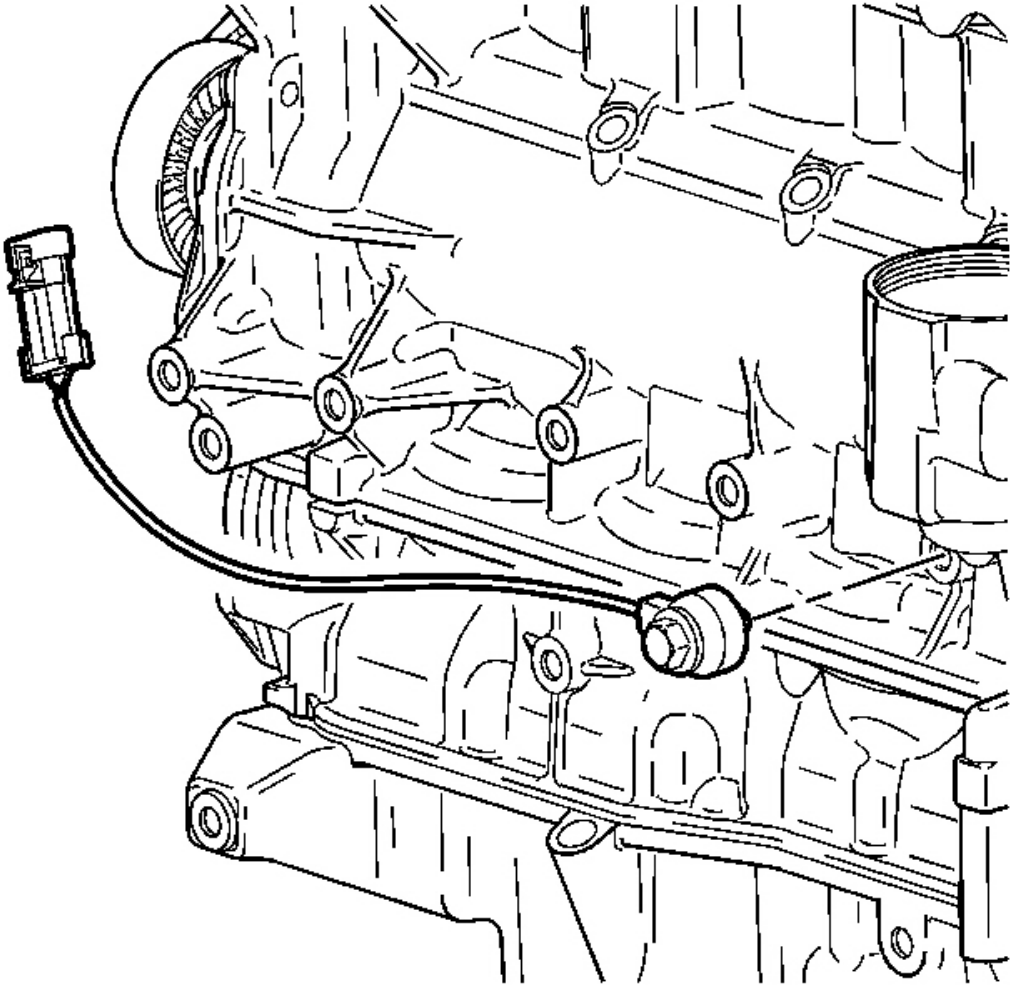


Fig. 424: View of Knock Sensor
Courtesy of GENERAL MOTORS CORP.

7. Remove the knock sensor and bolt.

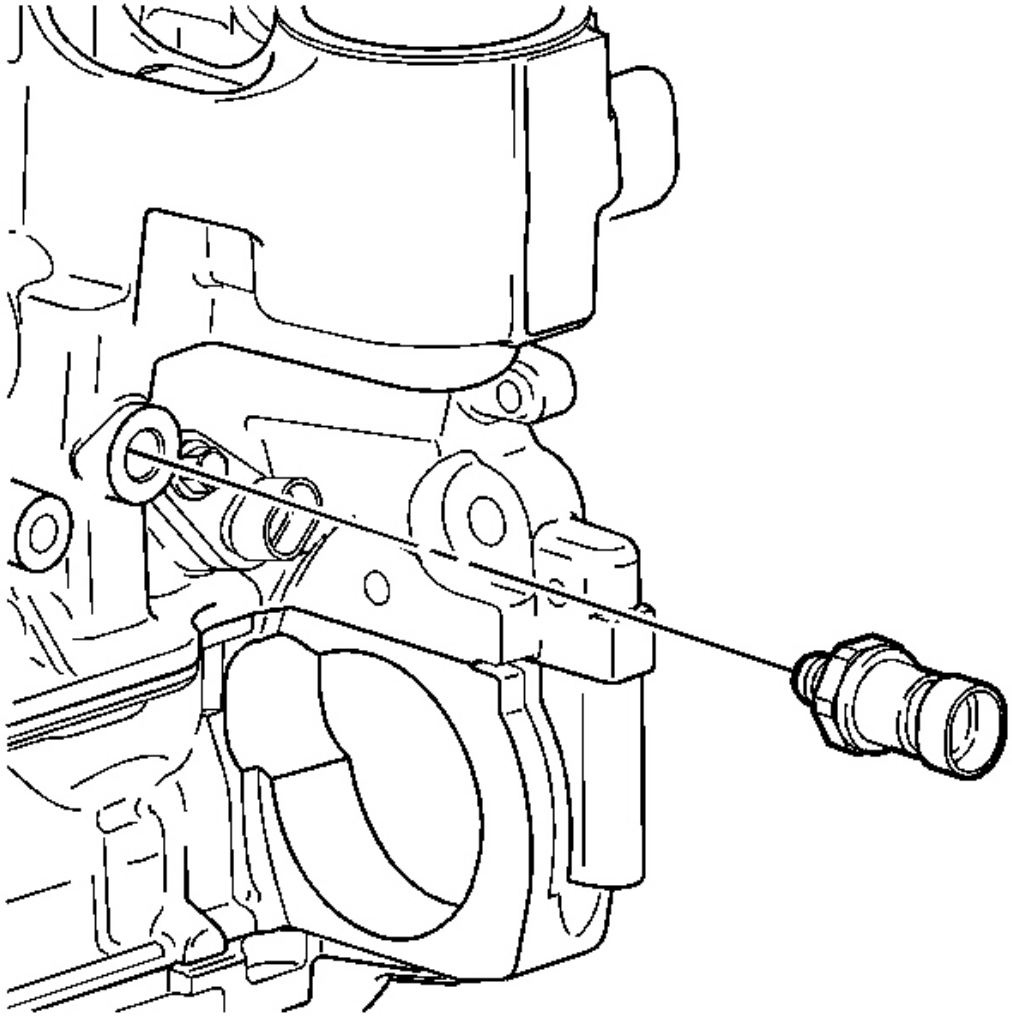


Fig. 425: View Of Engine Oil Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

8. Remove the oil pressure switch.

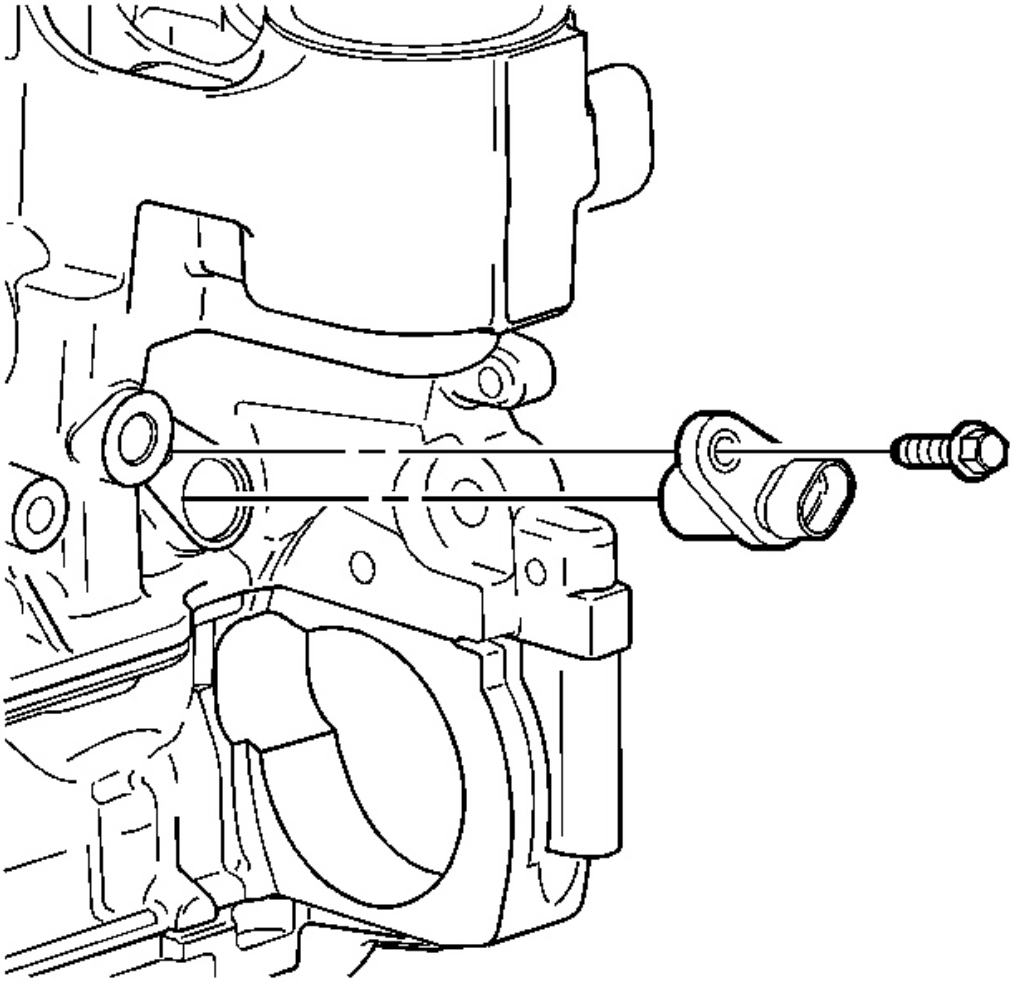


Fig. 426: View Of Crankshaft Position Sensor
Courtesy of GENERAL MOTORS CORP.

9. Remove the crankshaft position sensor and bolt.

ENGINE BLOCK CLEANING AND INSPECTION

Tools Required

- **J 7872** Magnetic Base Dial Indicator. See **Special Tools and Equipment** .
- **J 8087** Cylinder Bore Gage. See **Special Tools and Equipment** .

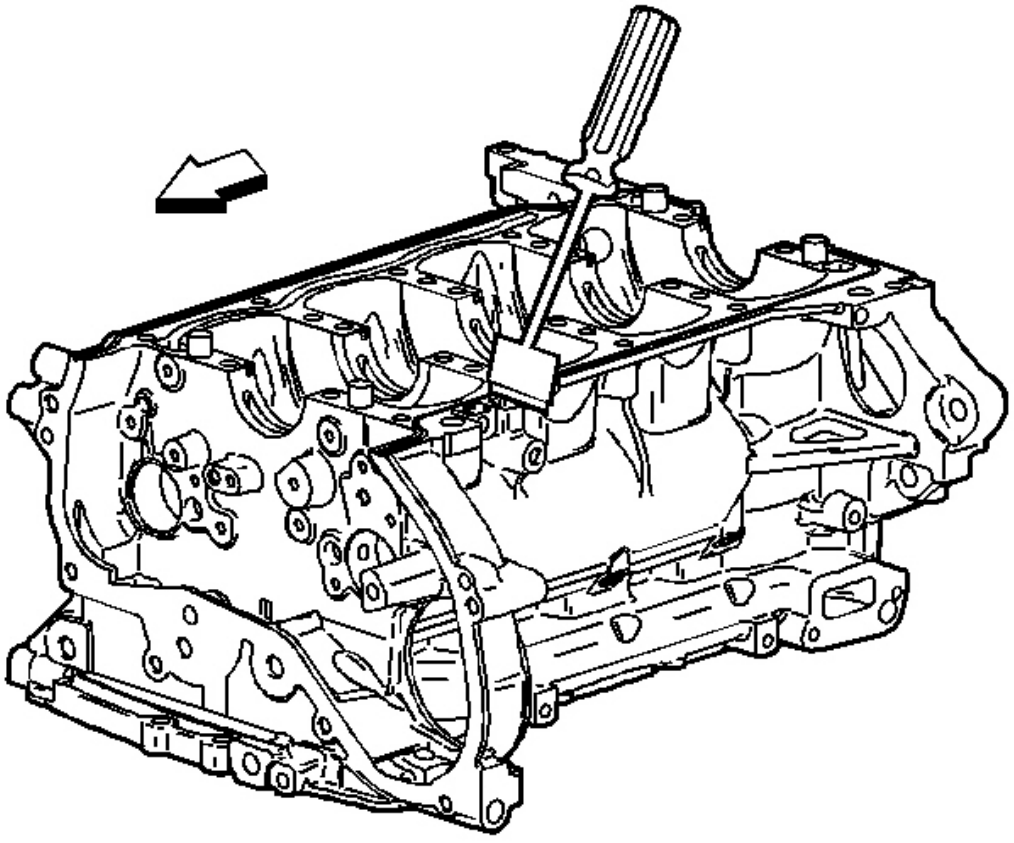


Fig. 427: Cleaning Sealing Material From The Gasket Mating Surfaces Of Engine Block
Courtesy of GENERAL MOTORS CORP.

1. Clean the sealing material from the gasket mating surfaces.
2. Clean the engine block and lower crankcase in a cleaning tank with solvent appropriate for aluminum.
3. Flush the engine block with clean water or steam.
4. Clean the oil passages.
5. Clean the blind holes.
6. Spray the cylinder bores and the machined surfaces with engine oil.
7. Inspect the threaded holes. Clean the threaded holes with a rifle brush. If necessary, drill out the holes and install thread inserts. Refer to **Thread Repair** .

IMPORTANT: Do not attempt to machine the lower crankcase to engine block surfaces.

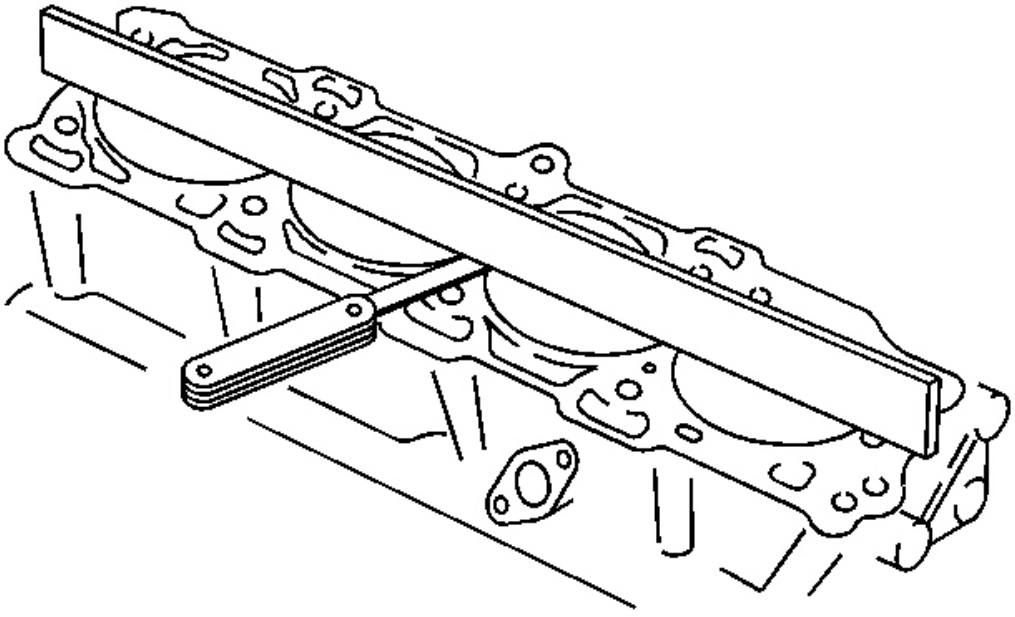


Fig. 428: Checking The Deck Surface For Flatness
Courtesy of GENERAL MOTORS CORP.

8. Use a straight edge and a feeler gage to check the deck surface for flatness. Carefully machine minor irregularities. Replace the block if more than 0.254 mm (0.010 in) must be removed.
9. Inspect the oil pan rail for nicks. Inspect the front cover attaching area for nicks. Use a flat mill file to remove any nicks.

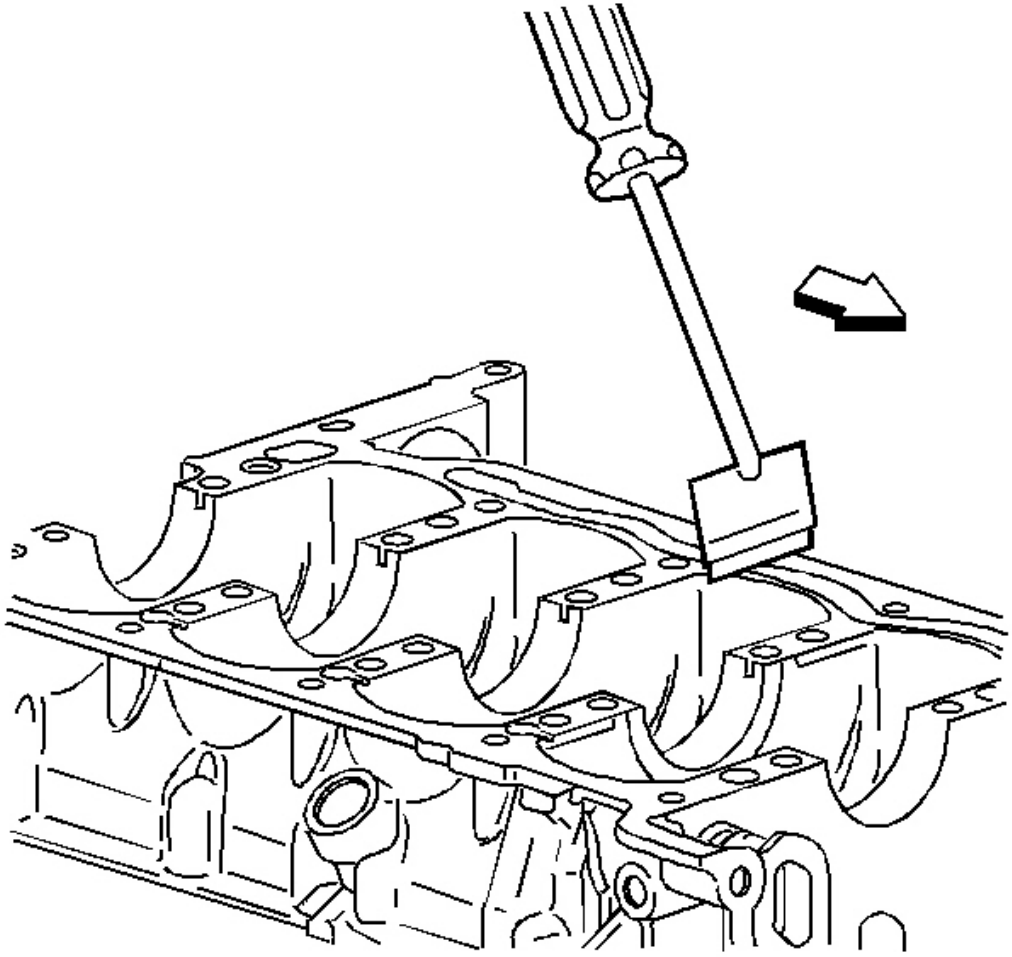


Fig. 429: Cleaning Sealing Material From Gasket Mating Surfaces On The Lower Crankcase Engine Block Side
Courtesy of GENERAL MOTORS CORP.

10. Clean the sealing material from the gasket mating surfaces on the lower crankcase engine block side.

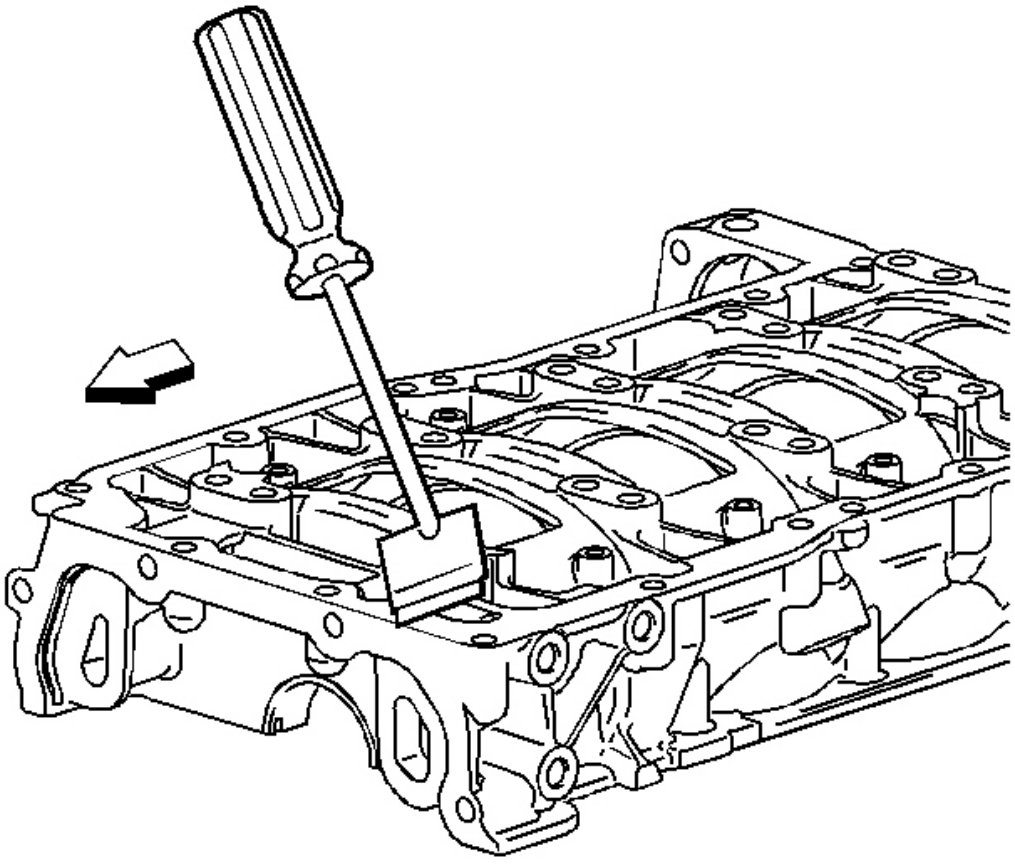


Fig. 430: Cleaning Sealing Material From The Gasket Mating Surfaces On The Lower Crankcase Oil Pan Side
Courtesy of GENERAL MOTORS CORP.

11. Clean the sealing material from the gasket mating surfaces on the lower crankcase oil pan side.
12. Inspect the mating surfaces of the transmission face.

NOTE: A broken flywheel may result if the transmission case mating surface is not flat.

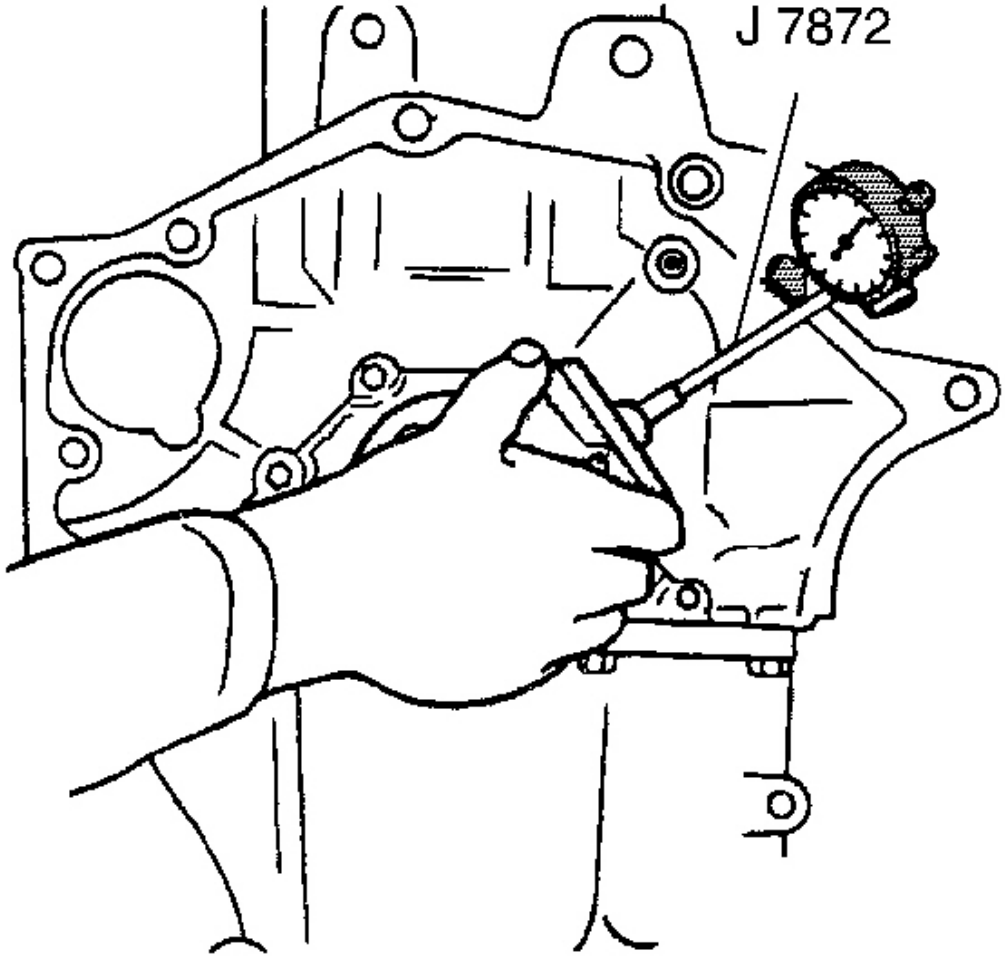


Fig. 431: Measuring The Engine Block Flange Runout At The Mounting Bolt Hole Bosses
Courtesy of GENERAL MOTORS CORP.

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. Measure the crankshaft flange runout using the **J 7872** . See **Special Tools and Equipment** .
    2. Hold the gage 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).

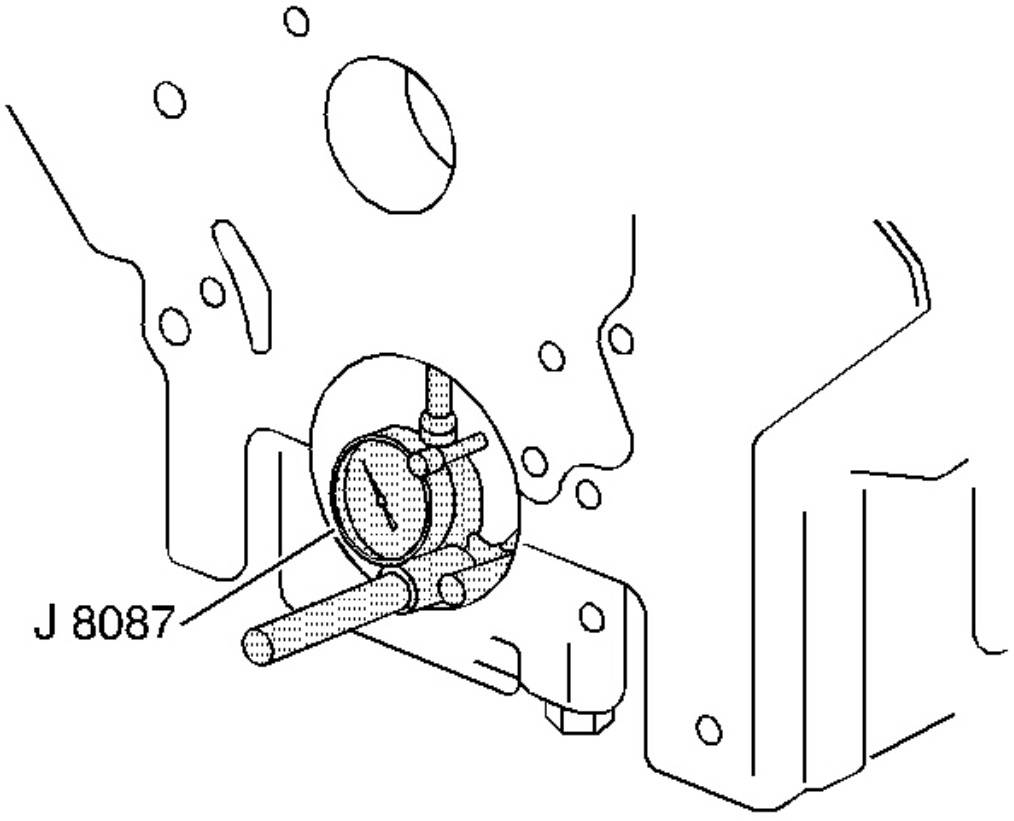


Fig. 432: Measuring Crankshaft Main Bearing Bore For Taper & Out-Of-Round
Courtesy of GENERAL MOTORS CORP.

14. Inspect the crankshaft main bearing bores. Use the **J 8087** to measure the bearing bore concentricity and alignment. See **Special Tools and Equipment** .
15. Replace the engine block and bed plate if the crankshaft bearing bores are out of specification.

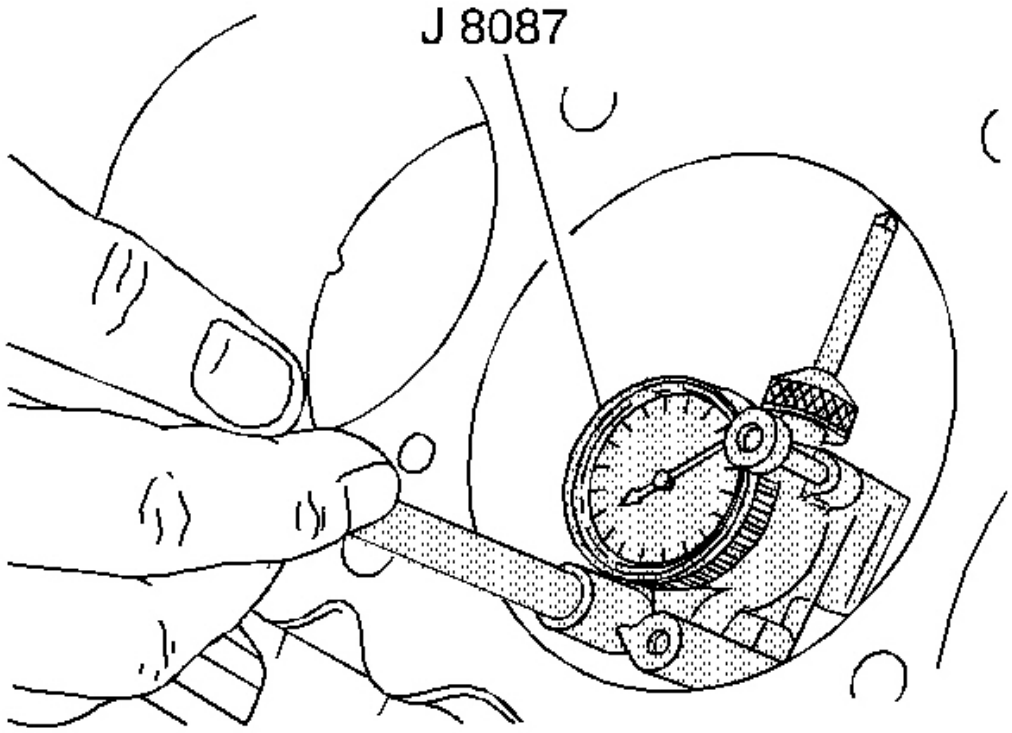


Fig. 433: Inspecting Cylinder Bores
Courtesy of GENERAL MOTORS CORP.

16. Inspect the cylinder bores using the **J 8087** . See **Special Tools and Equipment** . Inspect for the following items:
    - Wear
    - Taper
    - Runout
    - Ridging
17. Refer to **Engine Mechanical Specifications** .
18. If the cylinder bores are out of specification, replace the block.

CYLINDER HONING

Tools Required

J 8087 Cylinder Bore Gage. See **Special Tools and Equipment** .

Cylinder Honing

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.

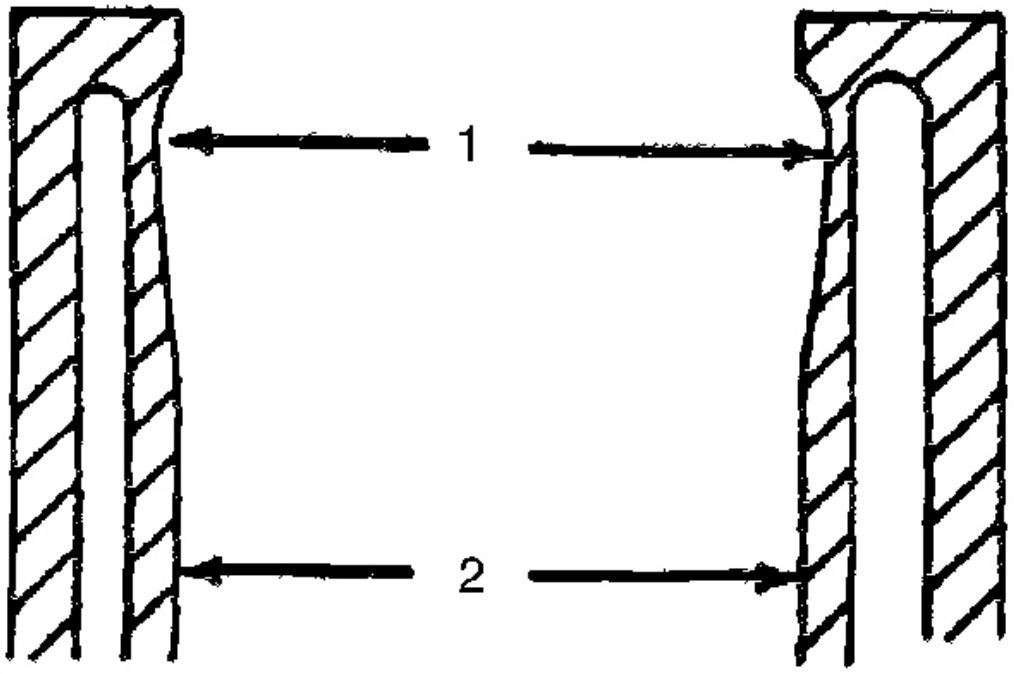


Fig. 434: Measuring Points For Cylinder Bore Out-Of-Round And Taper
Courtesy of GENERAL MOTORS CORP.

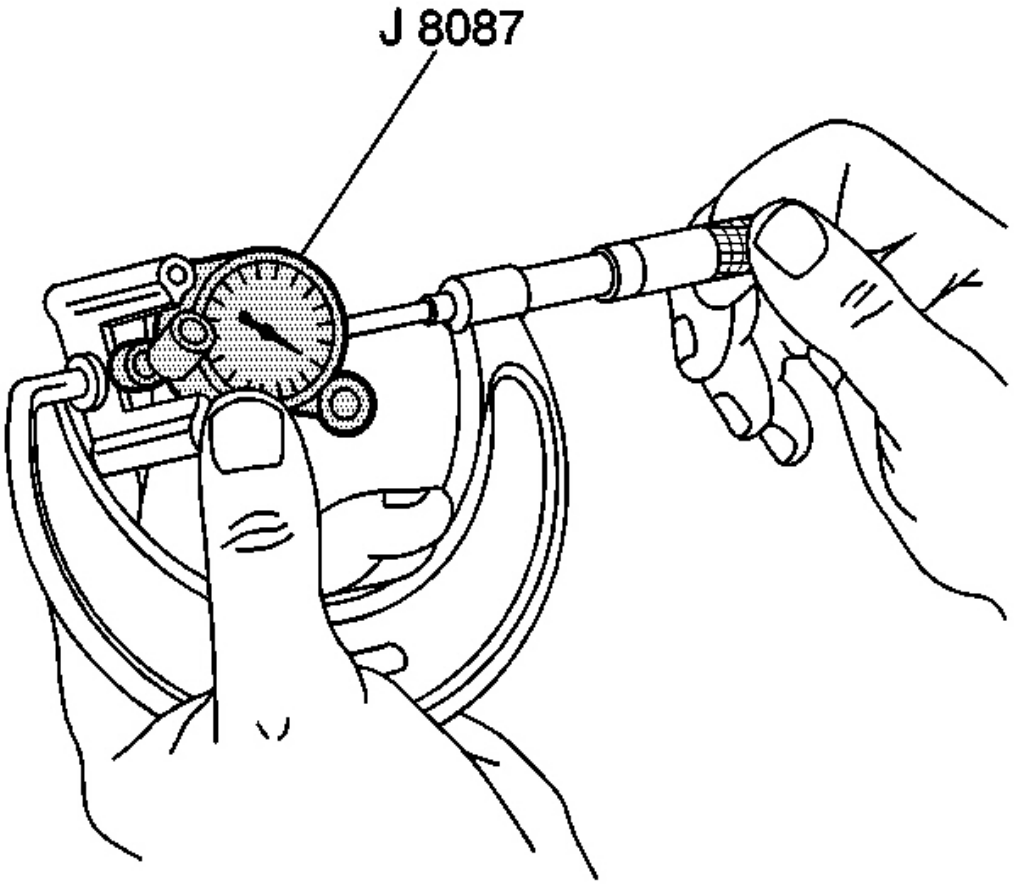


Fig. 435: Measuring J 8087 Dimension
Courtesy of GENERAL MOTORS CORP.

3. Measure the cylinder bores by setting the **J 8087** dial at zero in the cylinder at the point of the desired measurement. See **Special Tools and Equipment** . Lock the dial indicator at zero before removing the dial from the cylinder. Measure across the gage contact points with an outside micrometer, with the gage at the same zero setting as when the gage was removed from the cylinder.
4. Fine vertical scratches made by the ring ends do not, by themselves, cause excessive oil consumption. Do not hone the cylinder in order to remove these scratches.
5. If the bore is glazed but otherwise serviceable, lightly break the glaze with a hone. Replace the piston rings. Refer to **Piston, Connecting Rod, and Bearing Installation** .
    - The honing stones must be clean, sharp, and straight.
    - Move the hone slowly up and down to produce a 45 degree cross-hatch pattern.
    - Clean the bore thoroughly with soap and water.

- Dry the bore.
- Rub clean engine oil in the bore.
- Remeasure the bore.

6. If the cylinder bore is out of specification, replace the block.
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.

CRANKSHAFT BALANCER CLEANING AND INSPECTION

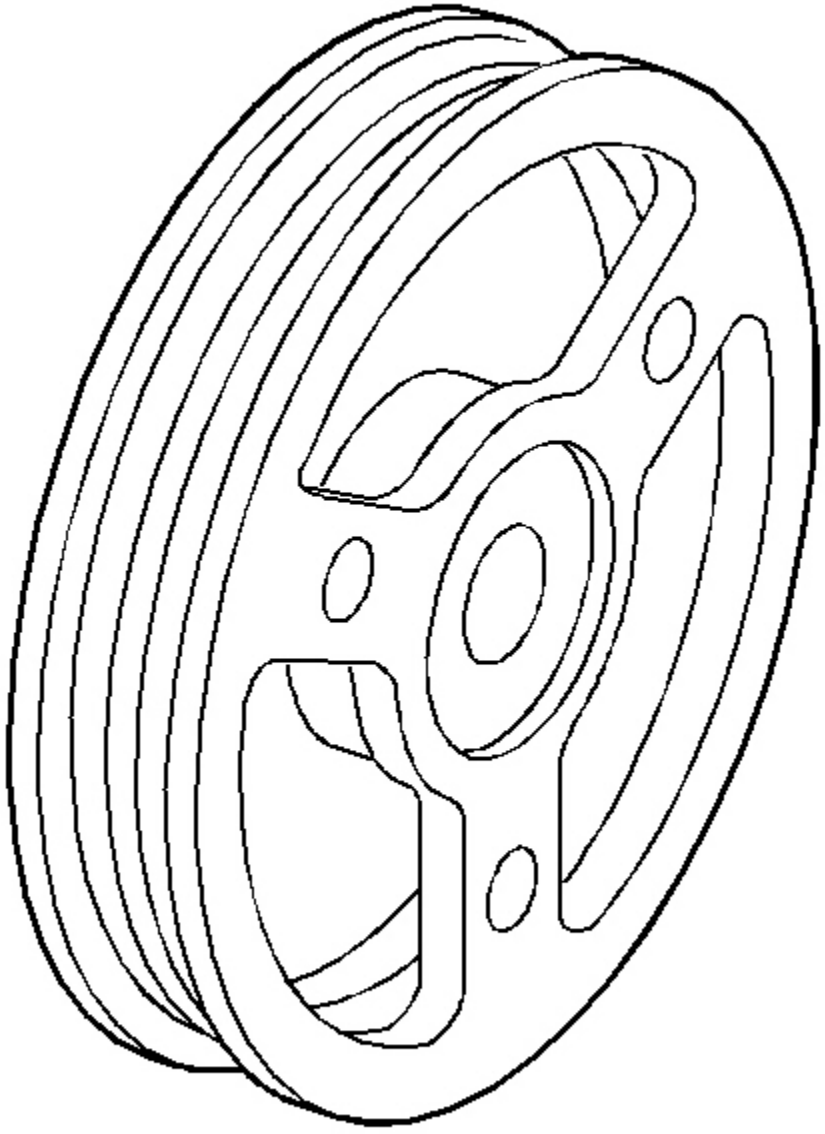


Fig. 436: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

1. Clean the crankshaft balancer.
2. Clean the belt grooves of all dirt or debris with a wire brush.

CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

3. Dry the crankshaft balancer with compressed air.
4. Inspect the crankshaft balancer for the following:
    - Worn, grooved, or damaged hub seal surface

      A crankshaft balancer hub seal surface with excessive scoring, grooves, rust or other damage must be replaced.

      IMPORTANT: In order for the belt to track properly, the belt grooves should be free of all dirt or debris.

    - Dirty or damaged belt grooves

      The balancer belt grooves should be free of any nicks, gouges, or other damage that may not allow the belt to track properly.

      Minor imperfections may be removed with a fine file.

    - Worn, chunking or deteriorated rubber between the hub and pulley

ENGINE FLYWHEEL CLEANING AND INSPECTION

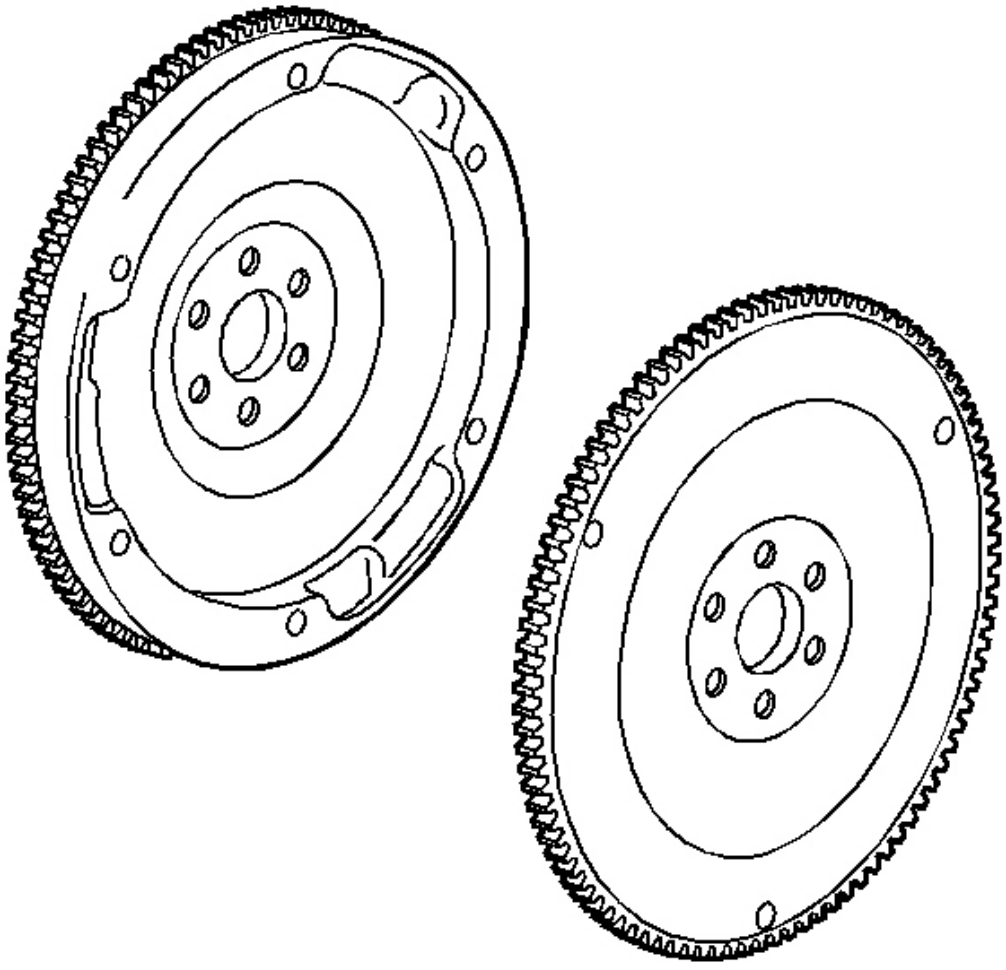


Fig. 437: View Of Engine Flywheel
Courtesy of GENERAL MOTORS CORP.

1. Clean the flywheel in solvent.

CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

2. Dry the flywheel with compressed air.

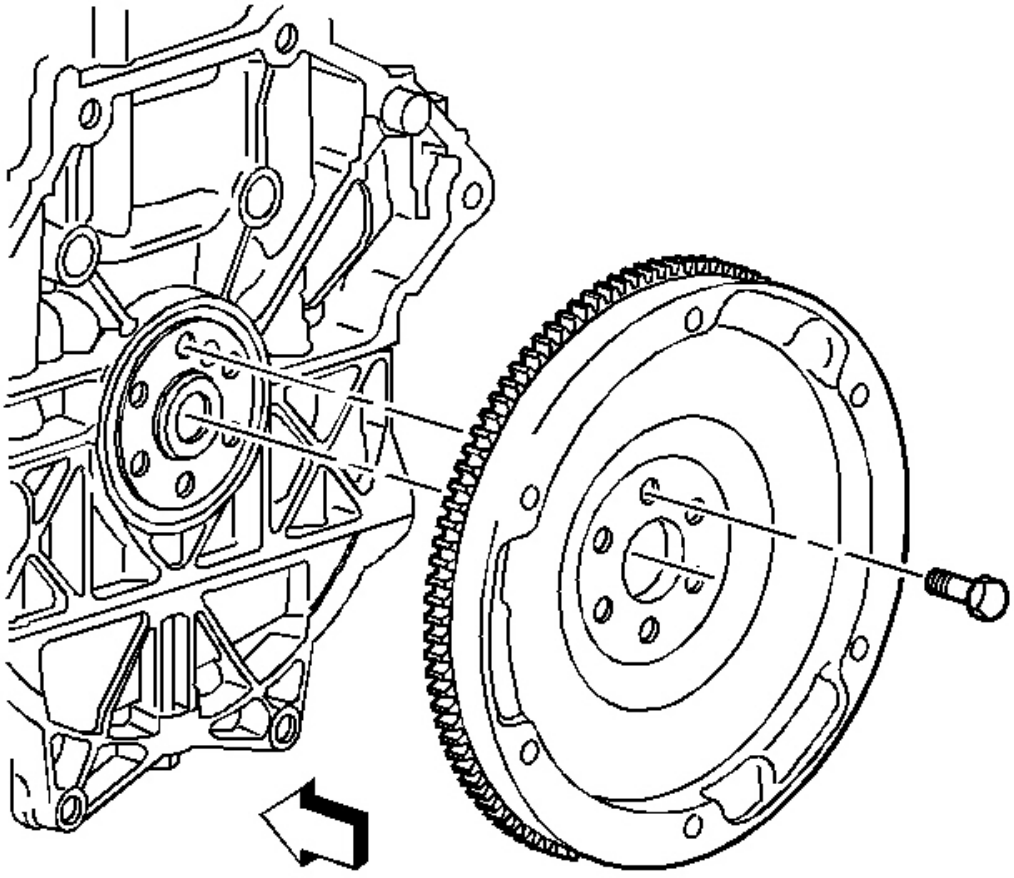


Fig. 438: Identifying Flywheel Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

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

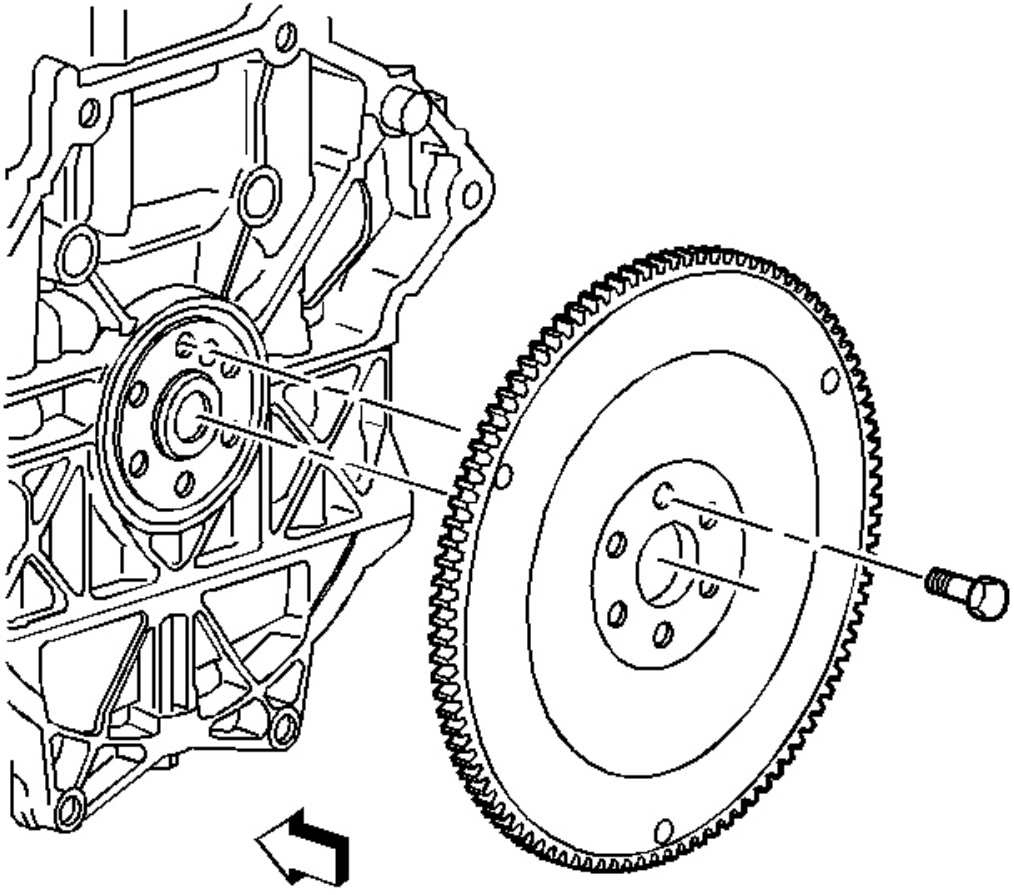


Fig. 439: View Of Flywheel
Courtesy of GENERAL MOTORS CORP.

4. Inspect the automatic transmission flywheel for the following:
    - Damaged ring gear teeth
    - Stress cracks around the flywheel-to-crankshaft bolt hole locations
    - Weight saving holes

CRANKSHAFT AND BEARINGS CLEANING AND INSPECTION

Tools Required

J 7872 Magnetic Base Dial Indicator Set. See **Special Tools and Equipment** .

Crankshaft and Bearings Cleaning and Inspection

1. Clean the crankshaft with solvent.

IMPORTANT: Use care when handling the crankshaft. Avoid damage to the bearing surfaces or the lobes of the crankshaft position reluctor ring. Damage to the teeth of the crankshaft position reluctor ring may effect OBD II system performance.

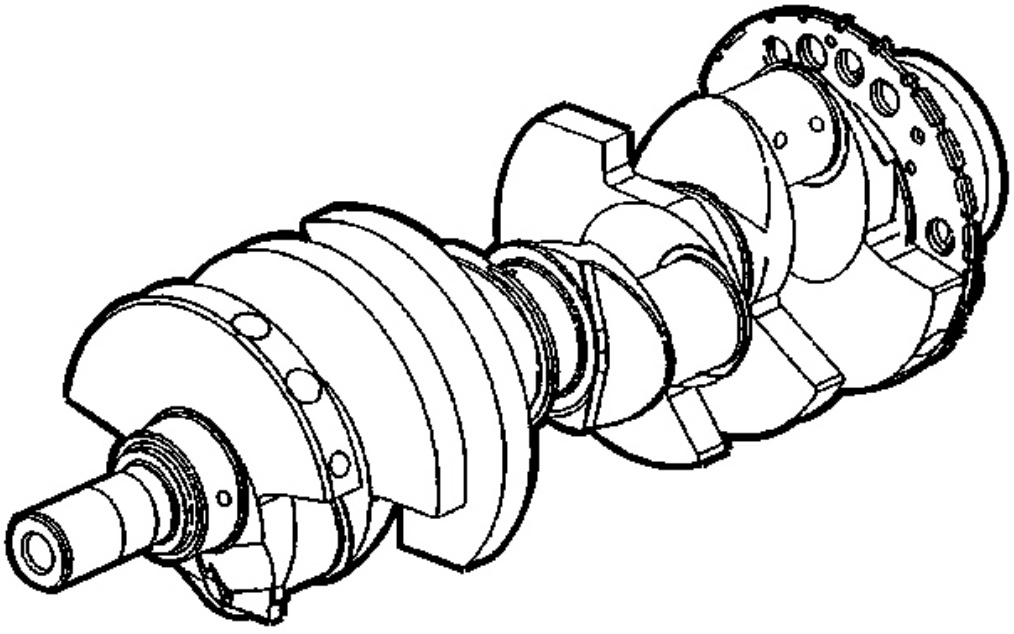


Fig. 440: View Of Crankshaft
Courtesy of GENERAL MOTORS CORP.

2. Thoroughly clean all oil passages and inspect for restrictions or burrs.

CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

3. Dry the crankshaft with compressed air.

IMPORTANT: Reluctor ring teeth should not have imperfections on the rising or falling edges.
Imperfections of the reluctor ring teeth may effect OBD II system performance.

4. Perform a visual inspection of the crankshaft for damage.

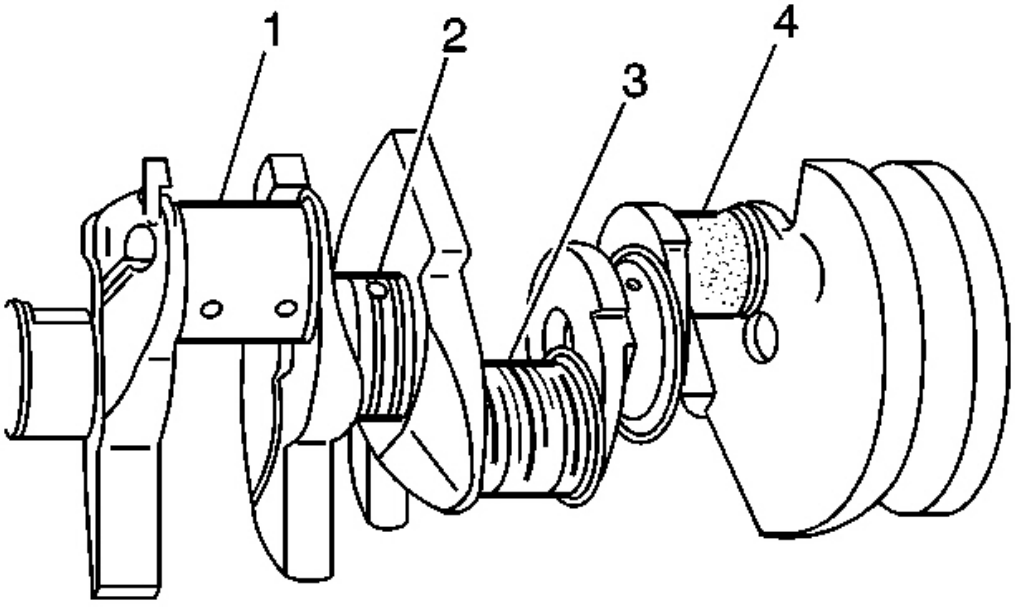


Fig. 441: Crankshaft Inspection Areas
Courtesy of GENERAL MOTORS CORP.

5. Inspect the crankshaft journals for wear (1).

   Journals should be smooth with no signs of scoring, wear, or damage.

6. Inspect the crankshaft journals for grooves or scoring (2).
7. Inspect the crankshaft journals for scratches or wear (3).
8. Inspect the crankshaft journals for pitting or imbedded bearing material (4).

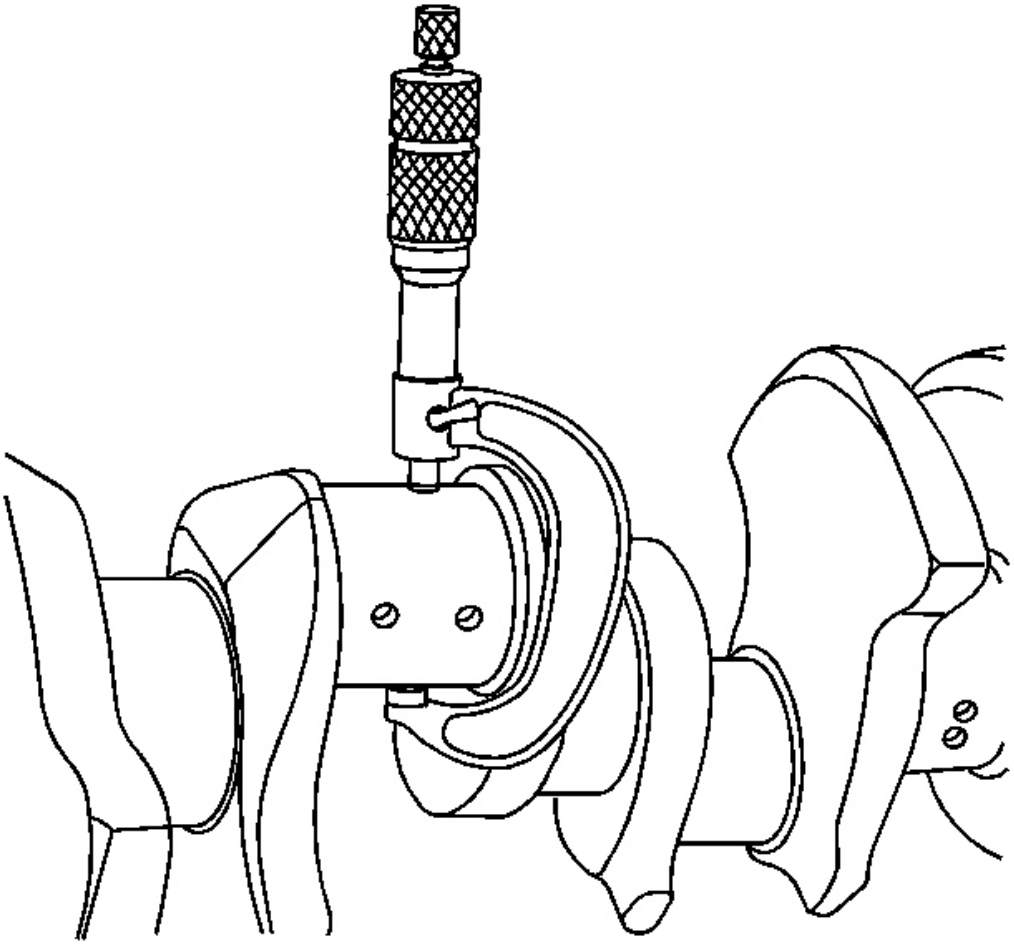


Fig. 442: Measuring Crankshaft Journals
Courtesy of GENERAL MOTORS CORP.

9. Measure the crankshaft journals for out-of-round.
10. Measure the crankshaft journals for taper.

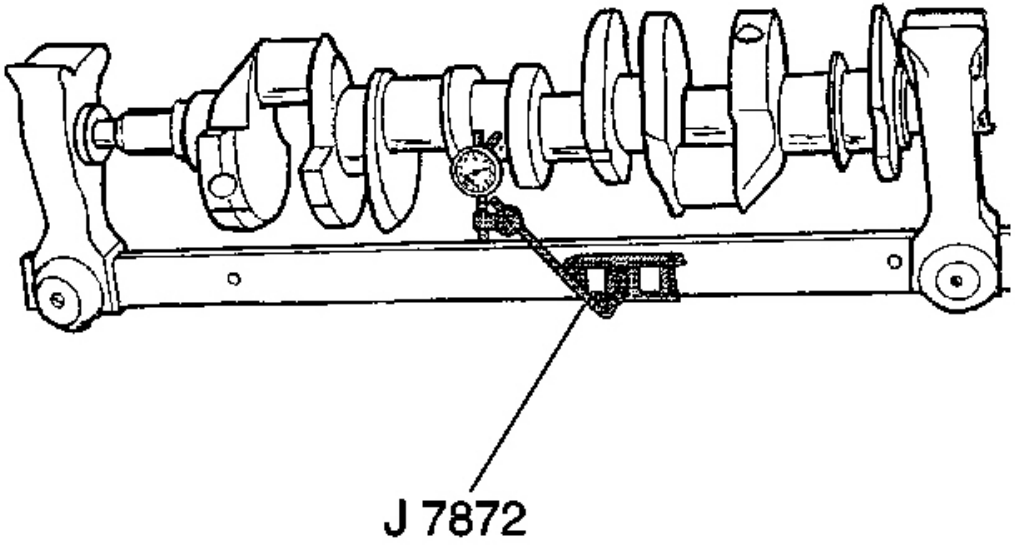


Fig. 443: Measuring Crankshaft Journal Runout
Courtesy of GENERAL MOTORS CORP.

11. Measure the crankshaft runout.

    Using wooden V blocks, support the crankshaft on the front and rear journals.

12. Use the **J 7872** in order to measure the crankshaft runout at the front and rear intermediate journals. See **Special Tools and Equipment** .
13. Use the **J 7872** in order to measure the runout of the crankshaft rear flange. See **Special Tools and Equipment** .
14. Replace the crankshaft if the measurements are not within specifications.

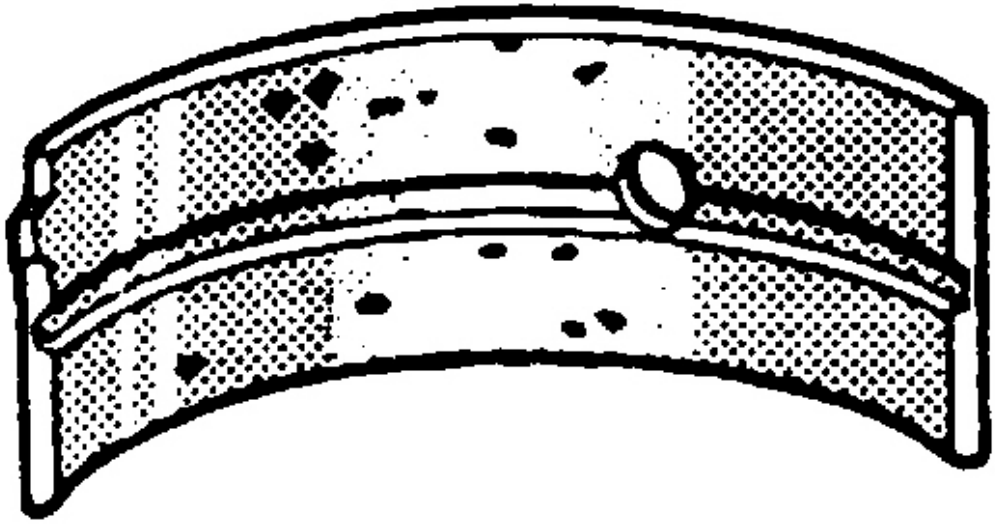


Fig. 444: Inspecting Bearings For Damage
Courtesy of GENERAL MOTORS CORP.

15. Inspect crankshaft bearings for craters or pockets. Flattened sections on the bearing halves also indicate fatigue.

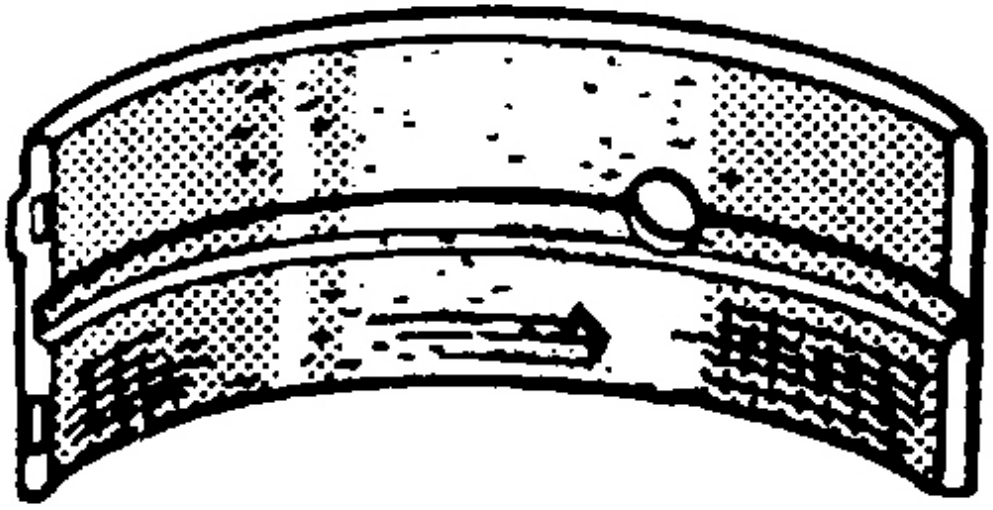


Fig. 445: Inspecting Connecting Rod Bearings For Excess Scoring Or Discoloration
Courtesy of GENERAL MOTORS CORP.

16. Inspect the crankshaft bearings for excessive scoring or discoloration.
17. Inspect the crankshaft bearings for dirt or debris imbedded into the bearing material.

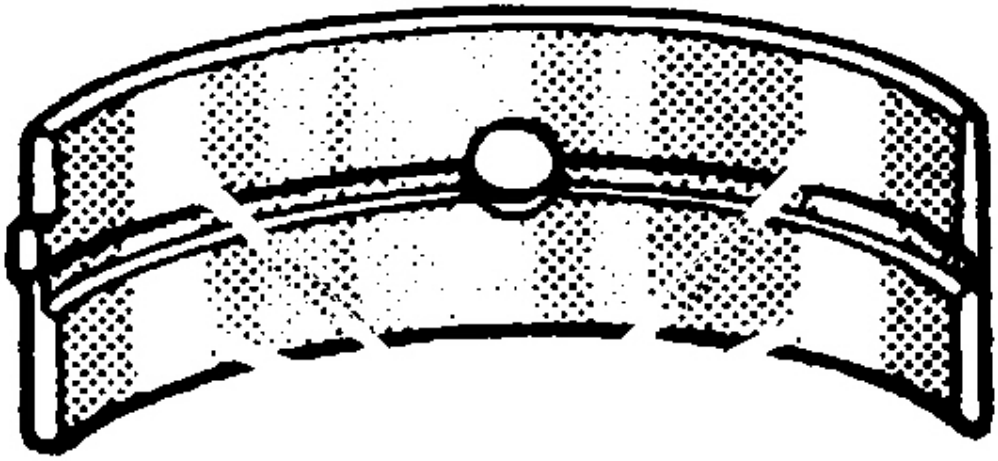


Fig. 446: Inspecting Bearings For Improper Seating
Courtesy of GENERAL MOTORS CORP.

18. Inspect the crankshaft bearings for improper seating indicated by bright, polished sections of the bearing.

    If the lower half of the bearing is worn or damaged, both upper and lower halves should be replaced.

    Generally, if the lower half is suitable for use, the upper half should also be suitable for use.

PISTON AND CONNECTING ROD DISASSEMBLE

Tools Required

J 43654 Piston Pin Clip Remover and Installer. See **Special Tools and Equipment** .

Piston and Connecting Rod Disassemble

CAUTION: Handle the piston carefully. Worn piston rings are sharp and may cause bodily injury.

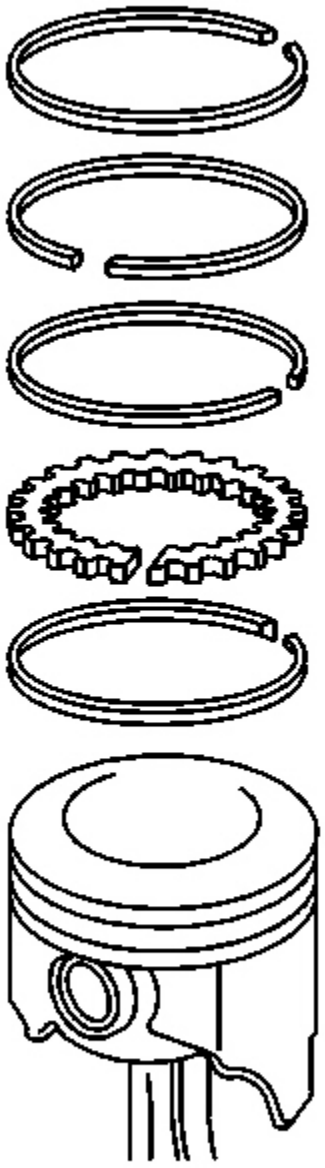


Fig. 447: Installing Piston Rings
Courtesy of GENERAL MOTORS CORP.

1. Disassemble the piston rings. Use a suitable tool in order to expand the rings. The piston rings must not be reused.

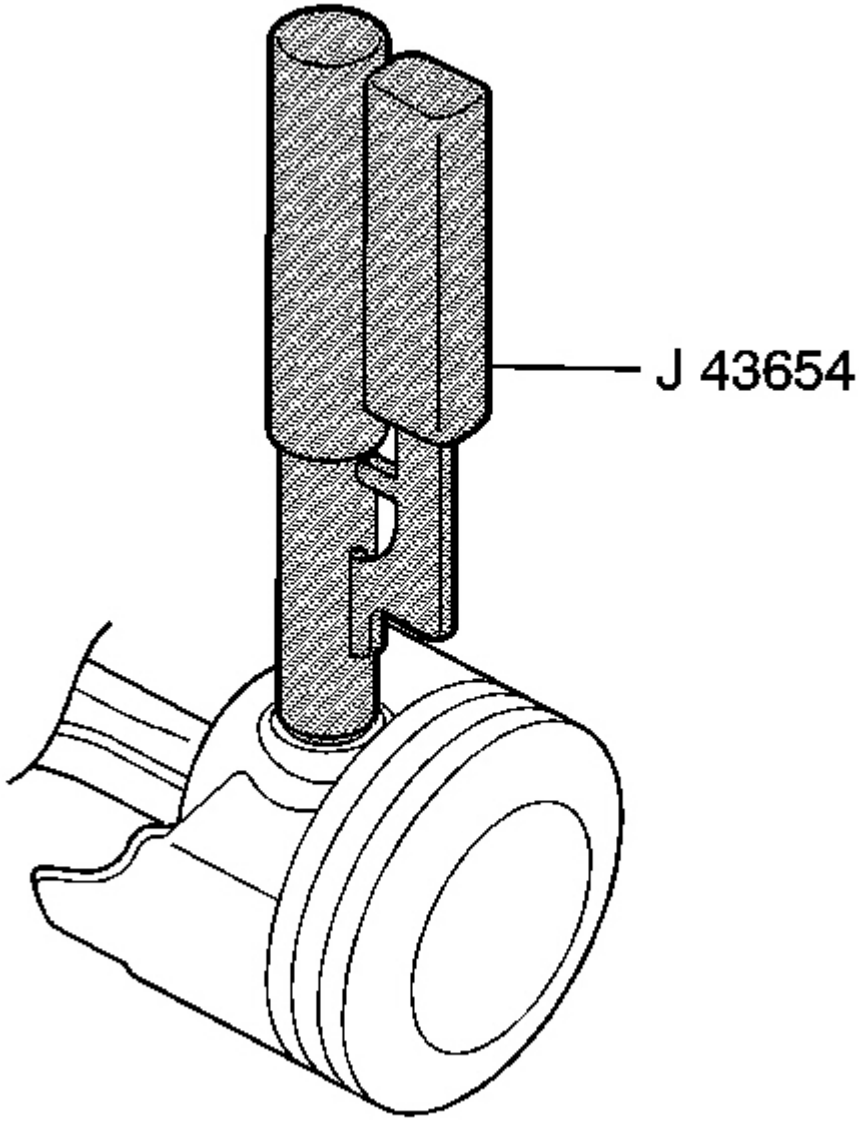


Fig. 448: View Of Piston Pin Clip Remover & Installer
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Two retainers hold the piston pins in place. No special tools are required to remove the retainers or the piston pins. Ensure that the piston pin is not damaged. Do not reuse the retaining clips.

2. Remove the piston pin retaining clips using the **J 43654** . See **Special Tools and Equipment** .

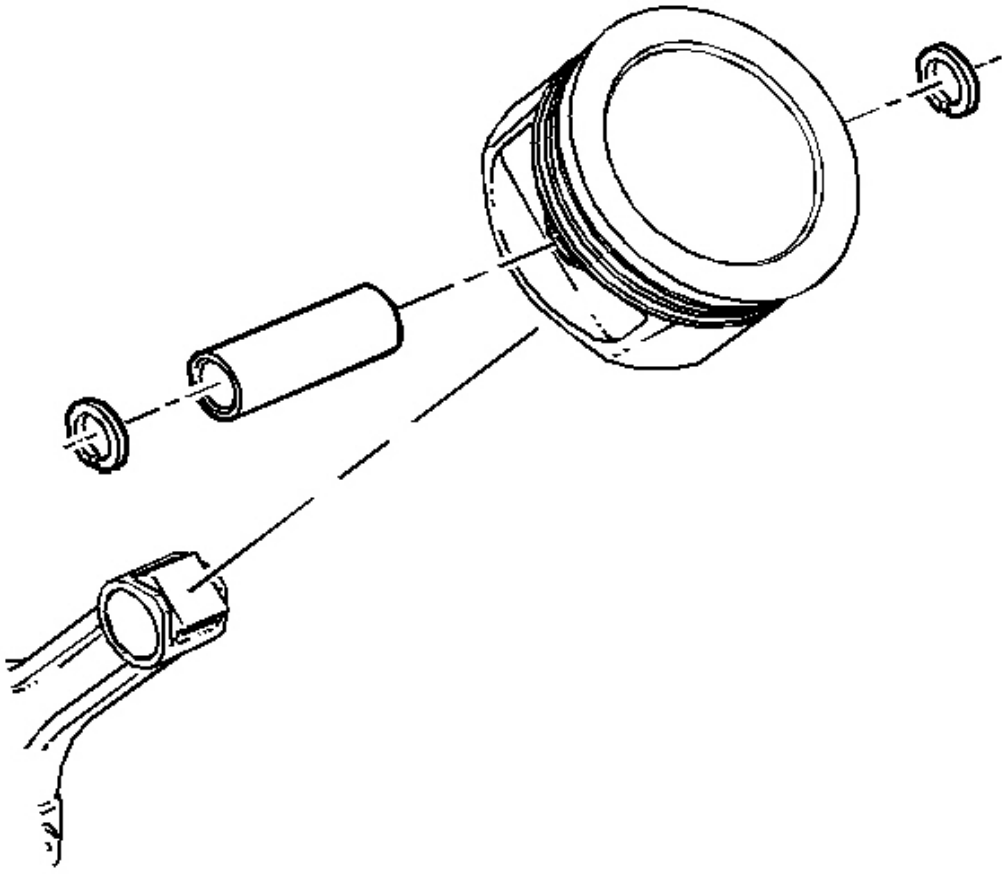


Fig. 449: Identifying Piston Pin & Components
Courtesy of GENERAL MOTORS CORP.

3. Remove the piston pin.

PISTON, CONNECTING ROD, AND BEARINGS CLEANING AND INSPECTION

Connecting Rod Measurement

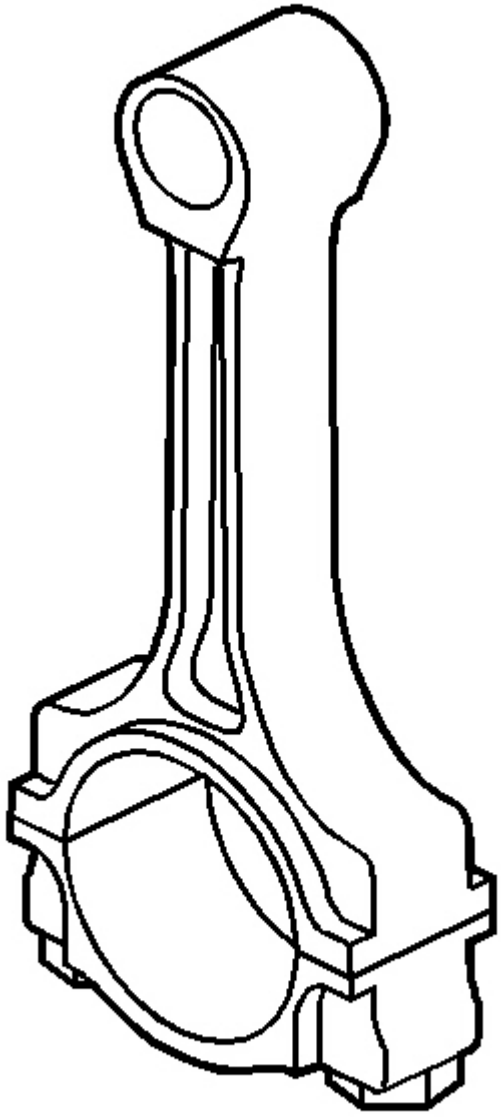


Fig. 450: View Of Connecting Rod
Courtesy of GENERAL MOTORS CORP.

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.
    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

1. Clean the piston skirts and the pins with a cleaning solvent. DO NOT wire brush any part of the piston.

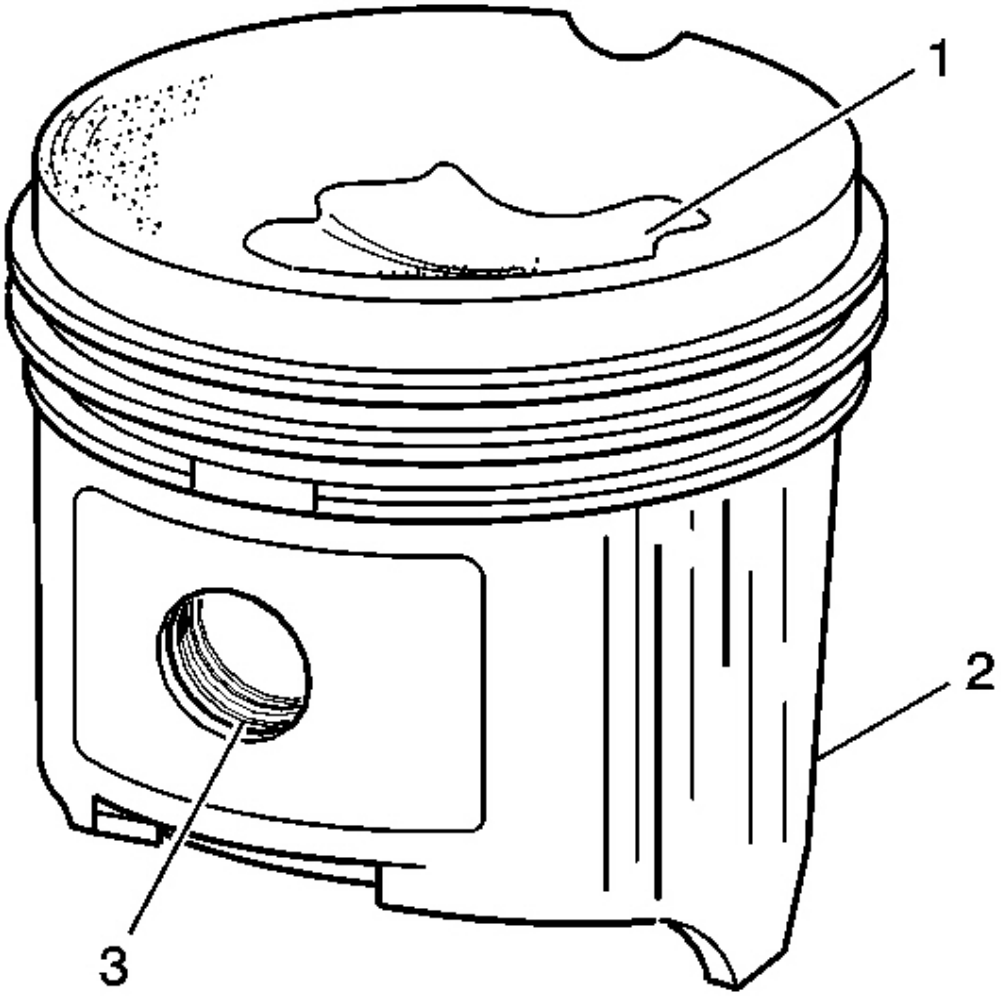


Fig. 451: Inspecting Piston For Damage
Courtesy of GENERAL MOTORS CORP.

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)
    - 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.

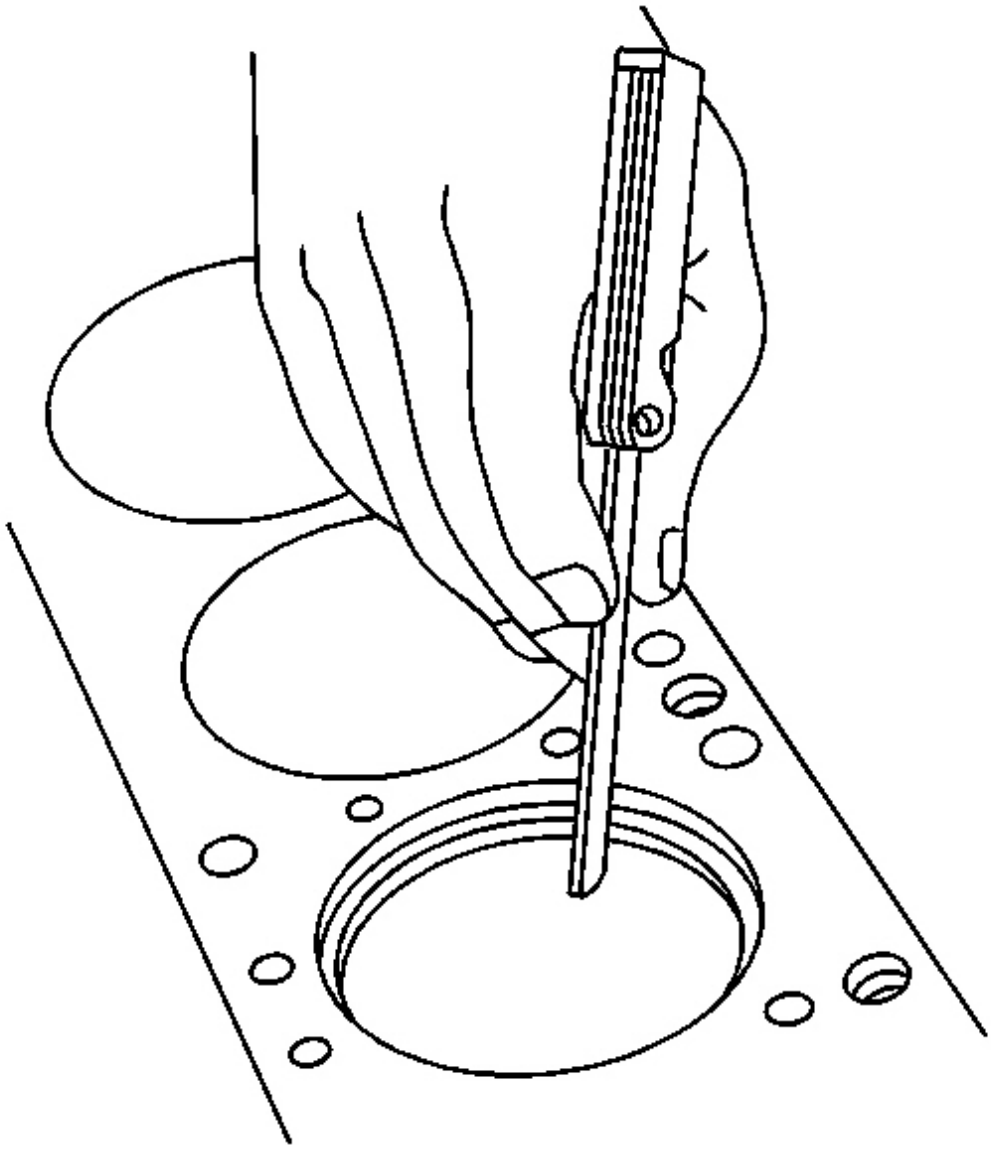


Fig. 452: Measuring Piston Compression Ring End Gap
Courtesy of GENERAL MOTORS CORP.

6. Measure the piston ring end gap using the following procedure:
    1. Place the piston ring in the area of the bore where the piston ring will travel (approximately 25 mm or 1 inch down from the deck surface). Be sure the ring is square with the cylinder bore by positioning the ring with the piston head.

2. Measure the end gap of the piston ring with feeler gages. Compare the measurements with those provided below:
    - The top compression ring end gap should be 0.20-0.40 mm (0.0060-0.015 in).
    - The second compression ring end gap should be 0.35-0.55 mm (0.0137-0.0216 in).
    - The oil ring end gap should be 0.25-0.76 mm (0.0098-0.029 in).
3. If the clearance exceeds the provided specifications, the piston rings must be replaced.
4. Repeat the procedure for all the piston rings.

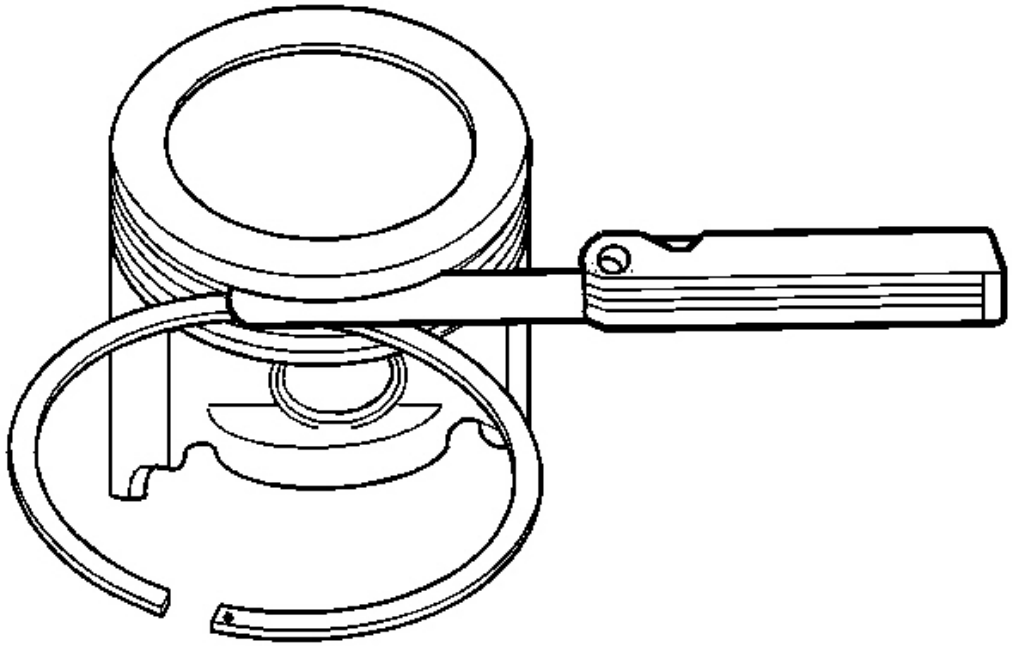


Fig. 453: Measuring Piston Ring Side Clearance With Feeler Gauge
Courtesy of GENERAL MOTORS CORP.

7. Measure the piston ring side clearance using the following procedure:
    1. Roll the piston ring entirely around the piston ring groove. If any binding is caused by a distorted piston ring, replace the ring.
    2. With the piston ring on the piston, use feeler gages to check clearance at multiple locations.
    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.

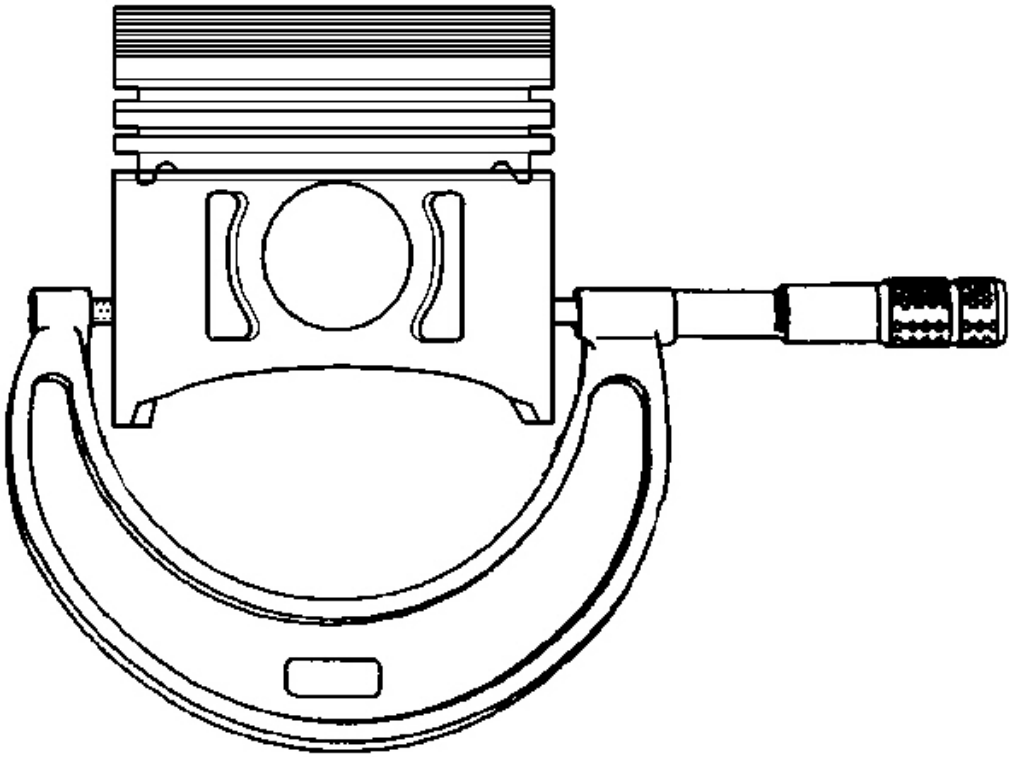


Fig. 454: Measuring Piston Diameter
Courtesy of GENERAL MOTORS CORP.

11. Measure piston width using the following procedure:
    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

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 inspection, they are within specifications.

1. Inspect the engine block cylinder bore. Refer to **Engine Block Cleaning and Inspection** .
2. Inspect the piston and the piston pin. Refer to **Piston, Connecting Rod, and Bearings Cleaning and Inspection** .
3. Use a bore gauge and measure the cylinder bore diameter. Measure at a point 64 mm (2.5 in) from the top of the cylinder bore.

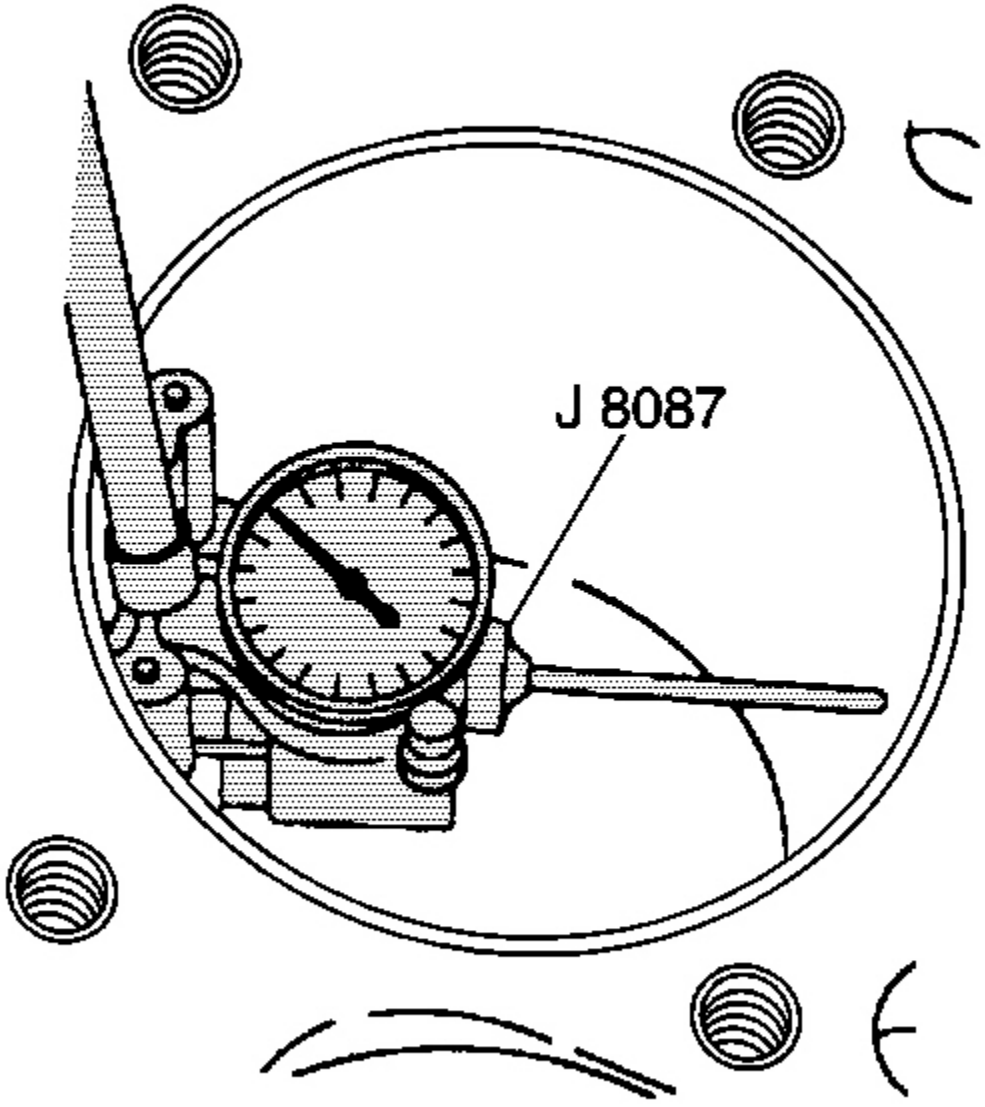


Fig. 455: Determining The Cylinder Bore Out-Of-Round Using J 8087
Courtesy of GENERAL MOTORS CORP.

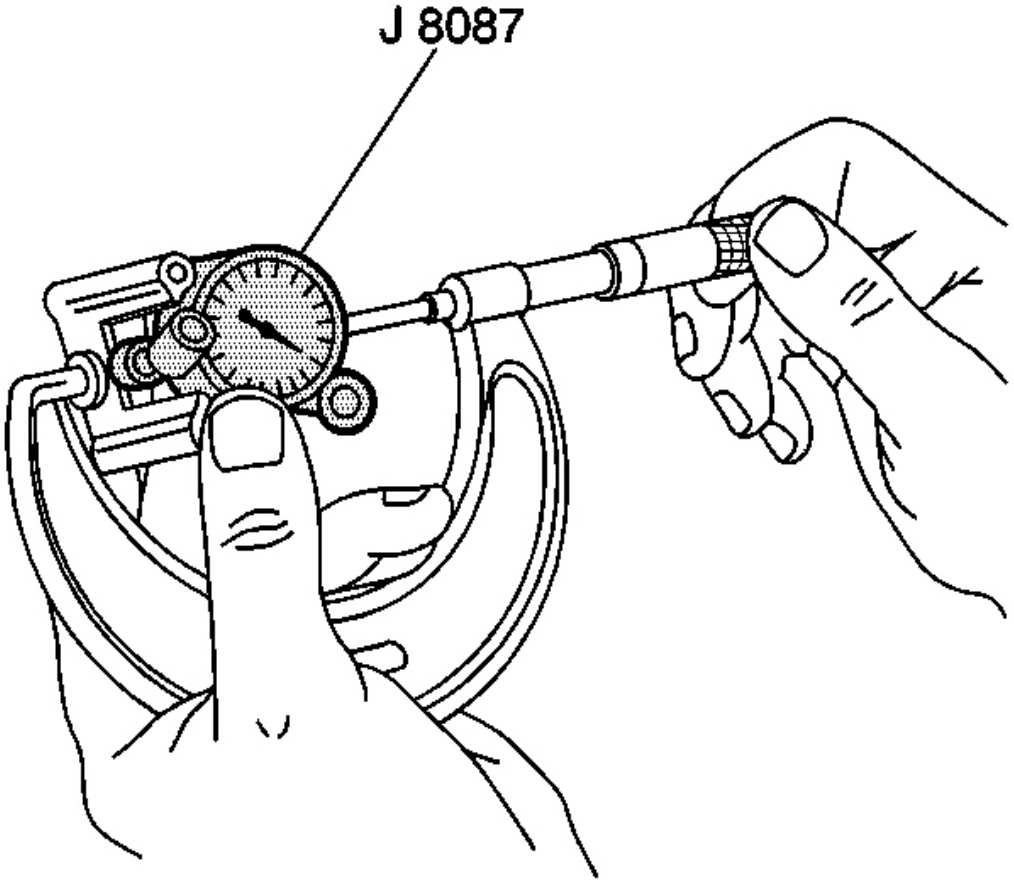


Fig. 456: Measuring J 8087 Dimension
Courtesy of GENERAL MOTORS CORP.

4. Measure the bore gauge with a micrometer and record the reading.

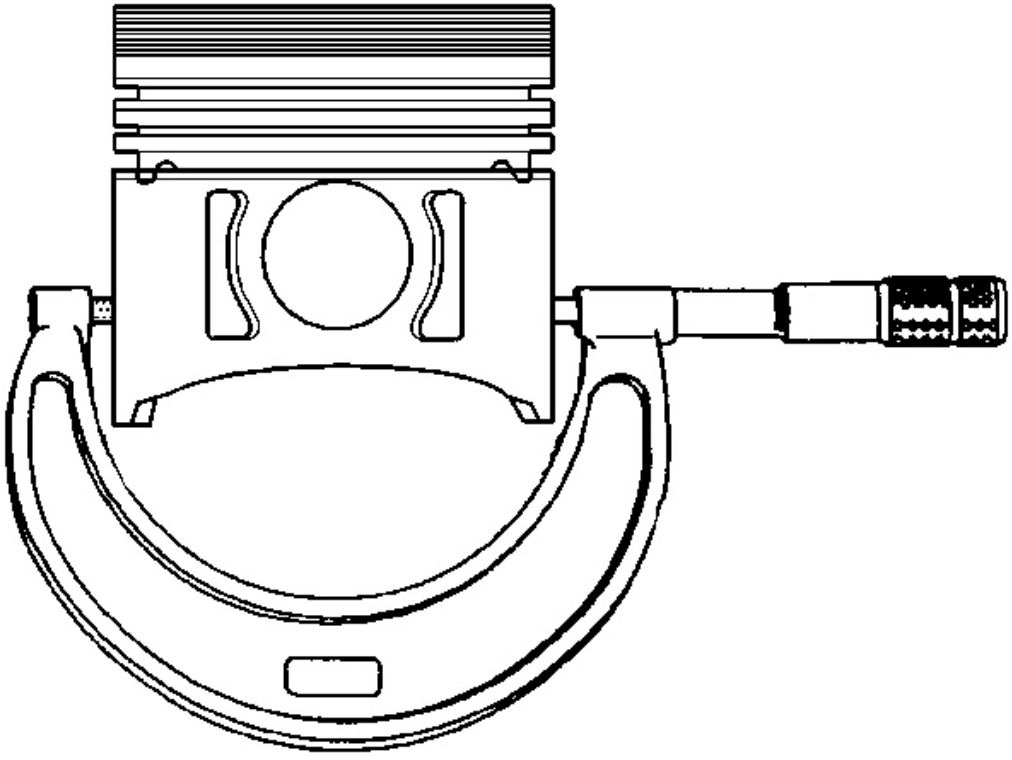


Fig. 457: Measuring Piston Diameter
Courtesy of GENERAL MOTORS CORP.

5. With a micrometer or caliper at a right angle to the piston, measure the piston 14 mm (0.570 in) from the bottom of the skirt.
6. Subtract the piston diameter from the cylinder bore diameter in order to determine piston-to-bore clearance.
7. For proper piston-to-bore clearance. Refer to **Engine Mechanical Specifications** .
8. If the proper clearance cannot be obtained, select another piston and measure for the clearances.
9. If the proper fit cannot be obtained, hone the cylinder bore or replace the cylinder block.
10. When the piston-to-cylinder bore clearance is within specifications, mark the top of the piston using a permanent marker for installation to the proper cylinder. Refer to **Separating Parts** .

PISTON AND CONNECTING ROD ASSEMBLE

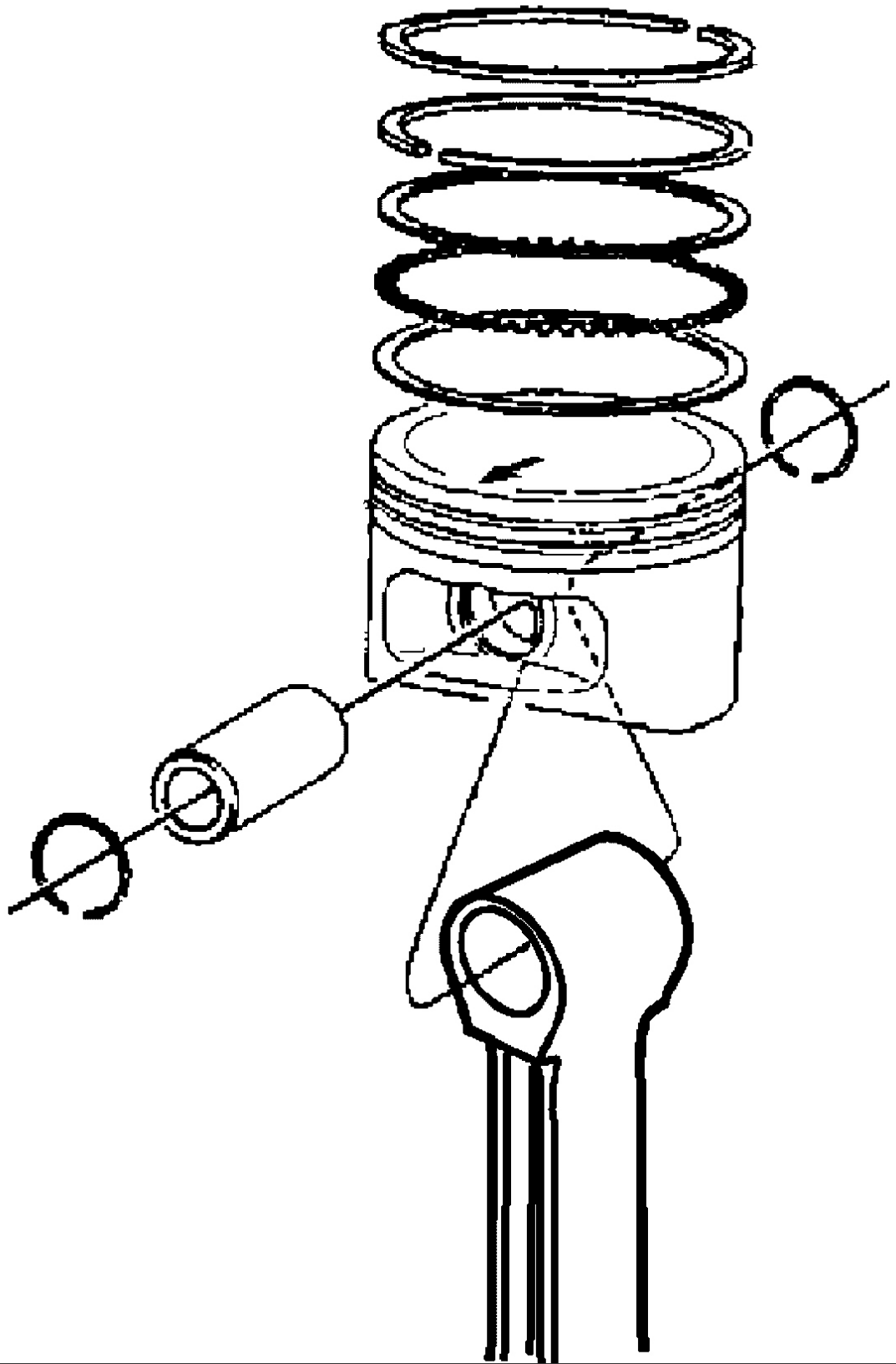


Fig. 458: View Of Piston & Connecting Rod
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Install the piston onto the connecting rod with the arrow oriented toward the front of the engine.

1. Assemble the connecting rod and the piston.

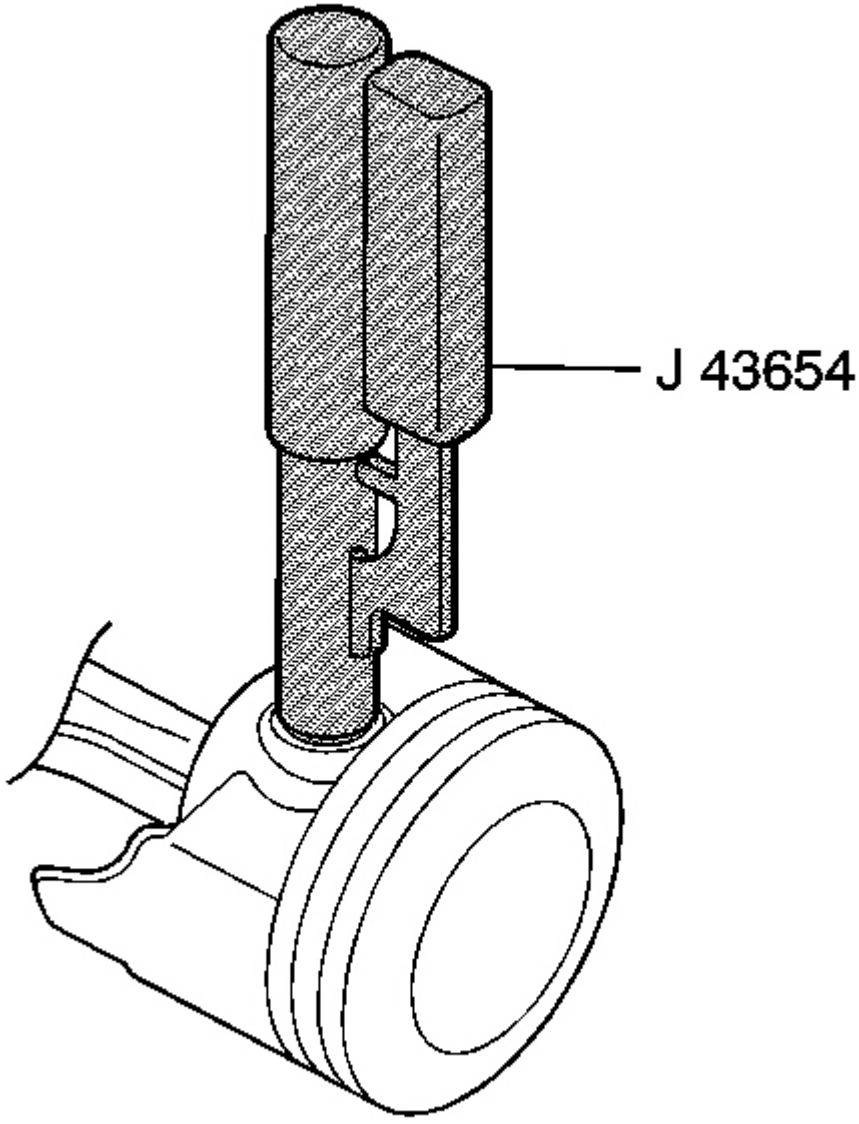


Fig. 459: View Of Piston Pin Clip Remover & Installer
Courtesy of GENERAL MOTORS CORP.

NOTE: Install the piston pin retainers correctly in the retaining groove during assembly in order to avoid engine damage.

2. Use the following procedure in order 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 the **J 43654** . See **Special Tools and Equipment** . Rotate the retainer until it is fully seated in the groove, use insertion tool.
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 the **J 43654** . See **Special Tools and Equipment** .
5. Ensure that the piston moves freely.

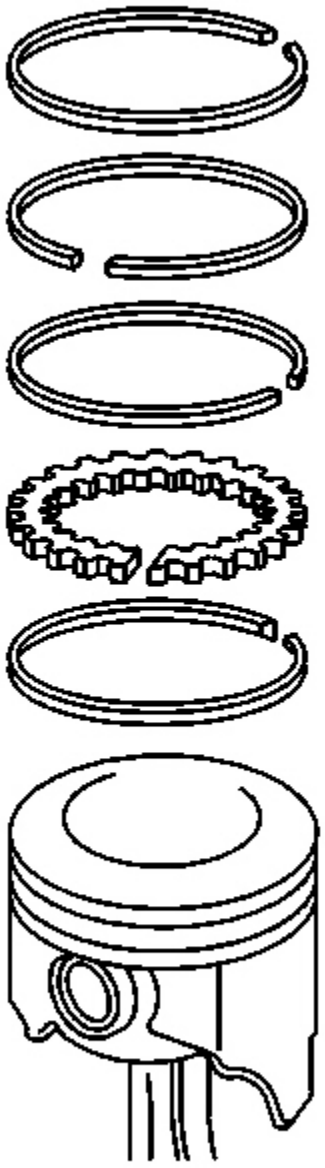


Fig. 460: Installing Piston Rings
Courtesy of GENERAL MOTORS CORP.

NOTE: **Use a piston ring expander to install the piston rings. The rings may be damaged if expanded more than necessary.**

3. Install the following components of the oil control ring assembly (bottom ring):
    1. The expander
    2. The lower oil control ring
    3. The upper control ring
4. Install the lower compression ring (second ring). Place the manufacturer's mark facing up.
5. Install the upper compression ring (top ring).

CAMSHAFT CLEANING AND INSPECTION

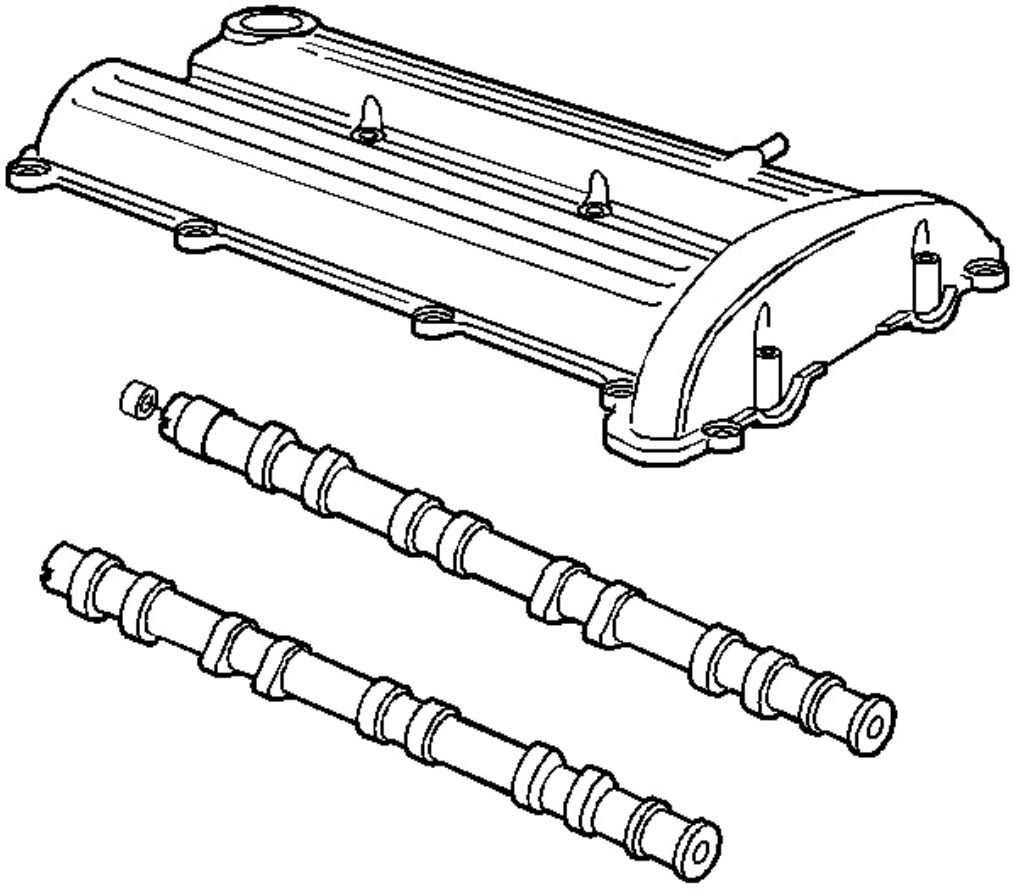


Fig. 461: View Of Camshafts
Courtesy of GENERAL MOTORS CORP.

- 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.

TIMING CHAIN AND SPROCKETS CLEANING AND INSPECTION

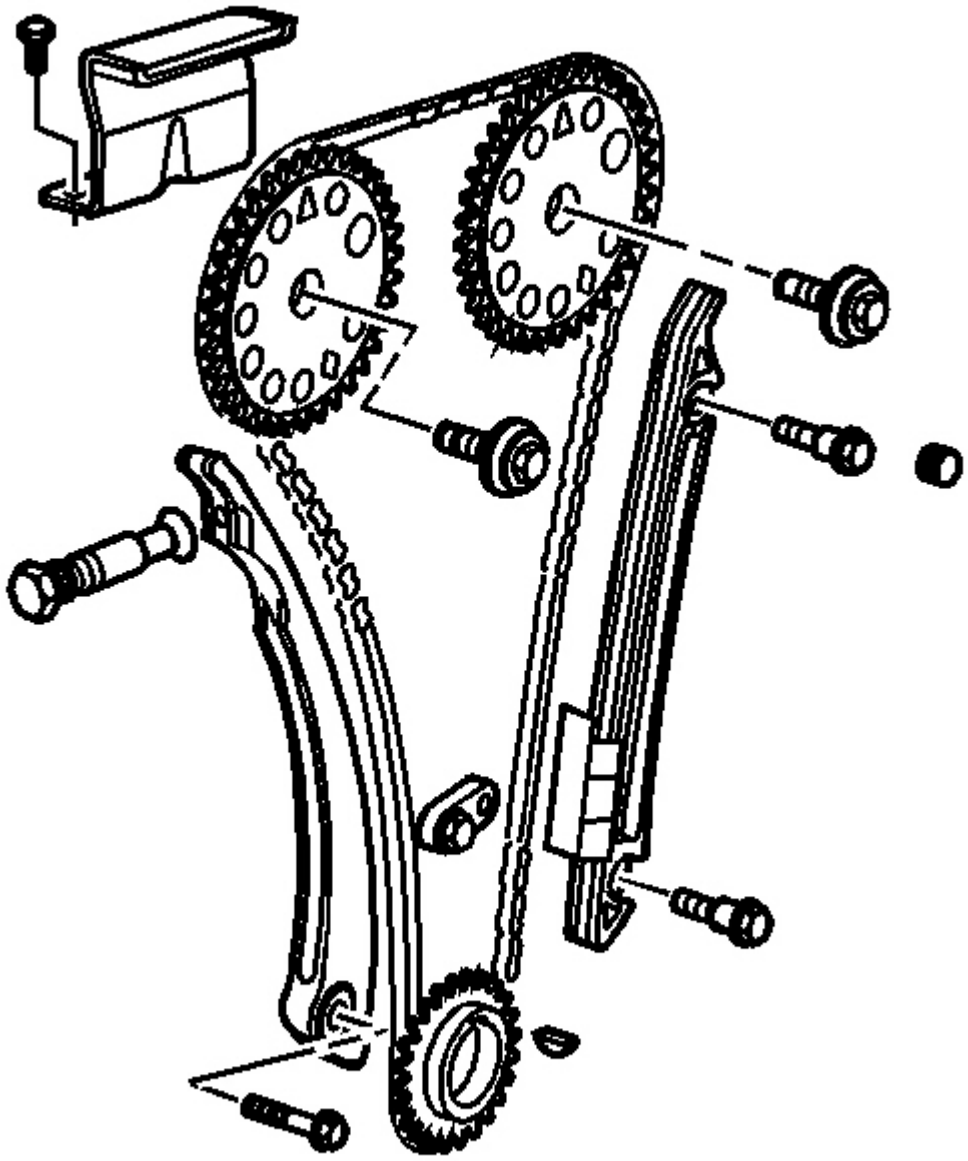


Fig. 462: View Of Timing Chain Guides
Courtesy of GENERAL MOTORS CORP.

1. Inspect the timing chain guides for cracking or wear.
2. Replace the timing chain guides if wear exceeds 1.12 mm (0.045 in) depth on the chain guide surface.
3. Inspect the timing chain tensioner shoe for wear.

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 sprockets for wear.
6. Inspect the camshaft sprocket faces for signs of movement.
7. Inspect the camshaft sprocket 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. Remove the old oil from the timing chain tensioner.
10. Inspect the timing chain tensioner for the scoring or free movement.
11. Inspect the timing chain washer and O-ring for damage. If damaged, replace the timing chain tensioner.

BALANCE SHAFT CLEANING AND INSPECTION

1. Clean the balance shafts in solvent.

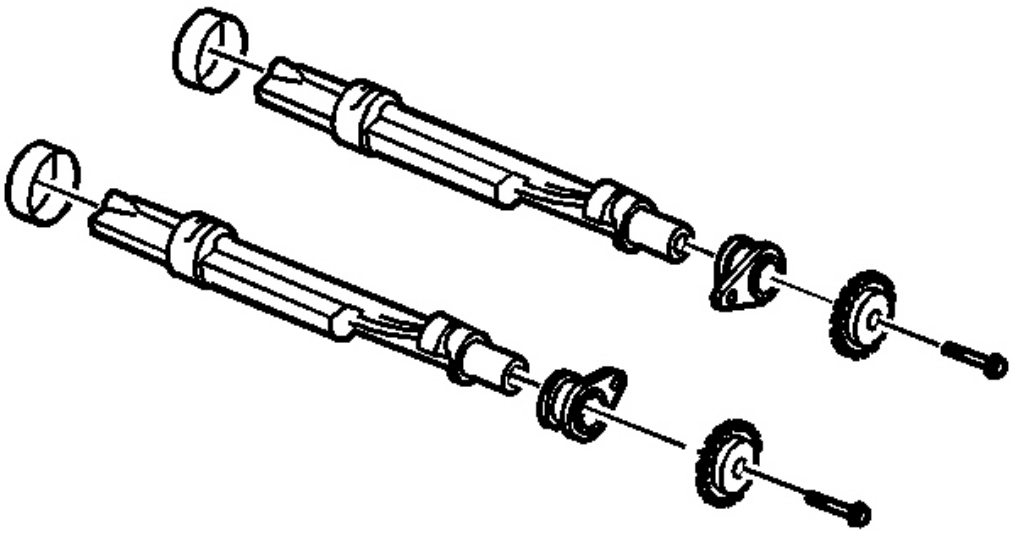


Fig. 463: View Of Balance Shafts
Courtesy of GENERAL MOTORS CORP.

2. Remove the balance shaft front bearing carriers from the balance shafts.
3. Inspect the bearing surfaces on the balance shafts for scoring or unusual wear.
4. Inspect the balance shaft drive sprockets for wear, damage, or missing teeth. When installing new balance

shaft drive sprockets tighten to 55 N.m (41 lb ft).

5. Measure the rear bearing journals on the balance shafts, the journals should be 36.723-36.743 mm (1.4458-1.4466 in) in diameter.
6. Measure the front bearing journals on the balance shafts, the front bearing journals should be 20.020-20.000 mm (0.7881-0.7874 in) in diameter.
7. When the balance shafts have been installed in the engine block, check for smooth rotation, sticking, binding, or roughness.

BALANCE SHAFT DRIVE CHAIN AND SPROCKETS CLEANING AND INSPECTION

1. Inspect the balance shaft drive chain guides for cracking or wear.

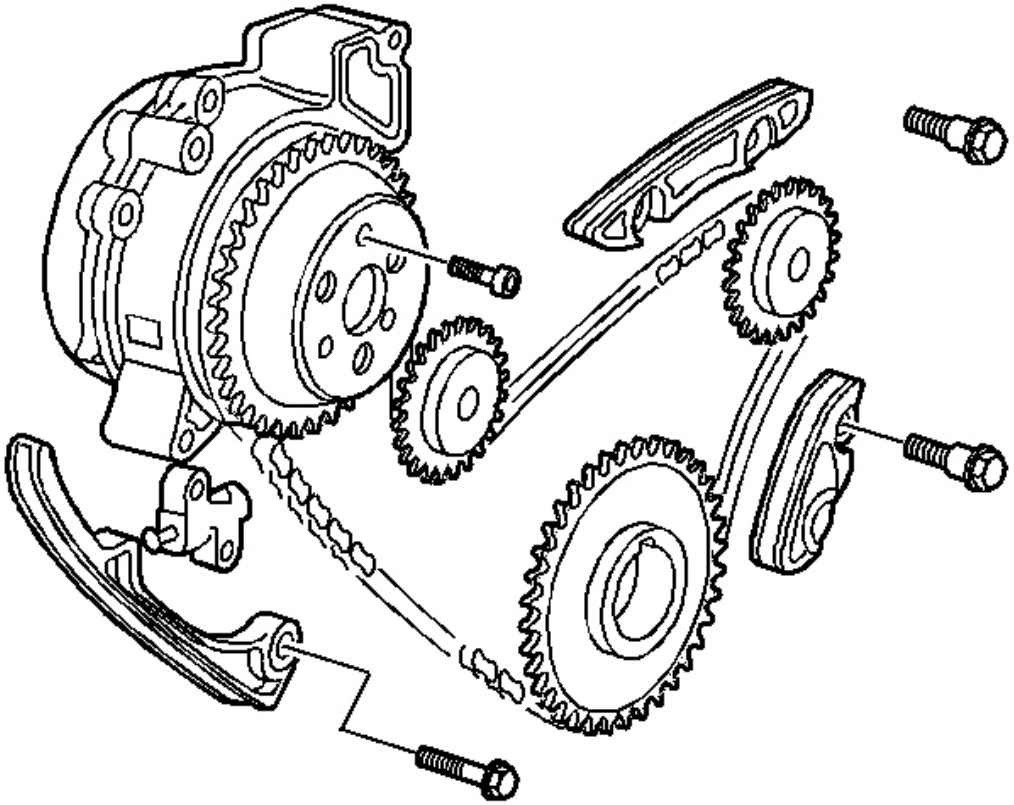


Fig. 464: View Of Balance Shaft Drive Chain
Courtesy of GENERAL MOTORS CORP.

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

Tools Required

- **J 8062** Valve Spring Compressor. See **Special Tools and Equipment** .
- **J 36017** Valve Guide Seal Remover. See **Special Tools and Equipment** .
- **J 43963** Valve Spring Compressor Adapter. See **Special Tools and Equipment** .

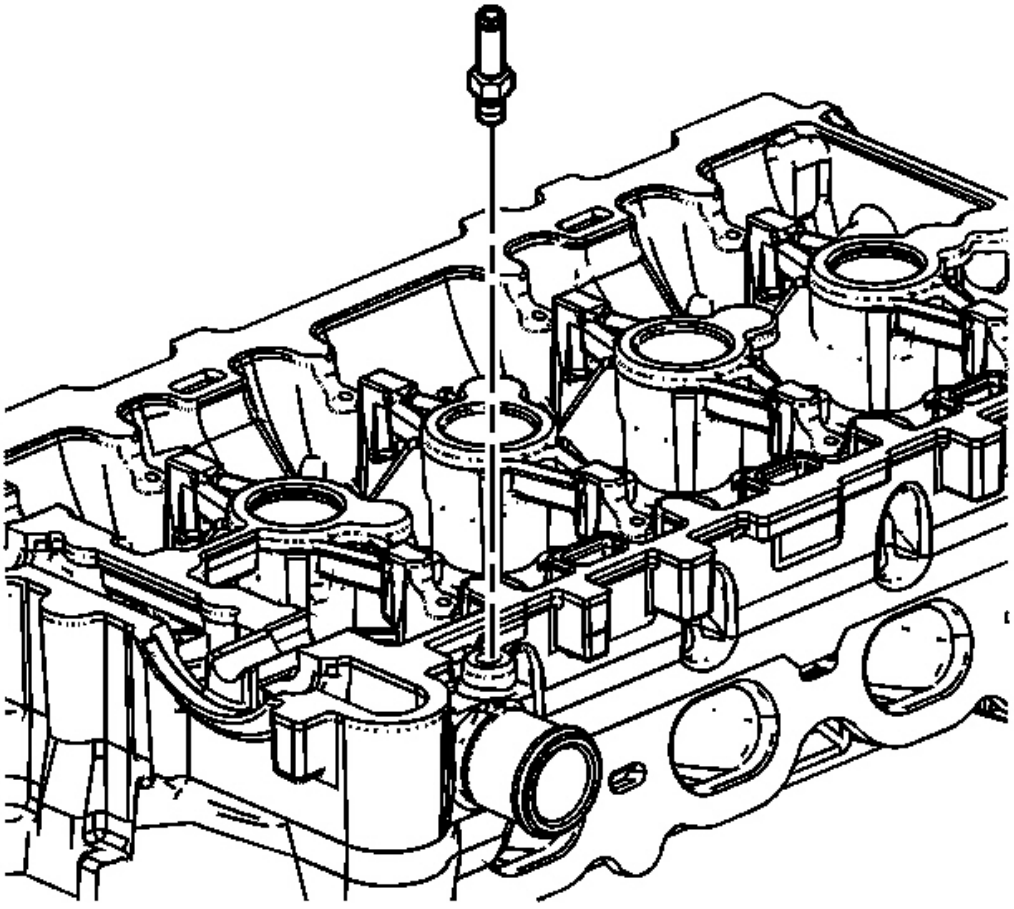


Fig. 465: Identifying Cylinder Head Air Bleed Tube
Courtesy of GENERAL MOTORS CORP.

1. Remove the coolant air bleed hose fitting.

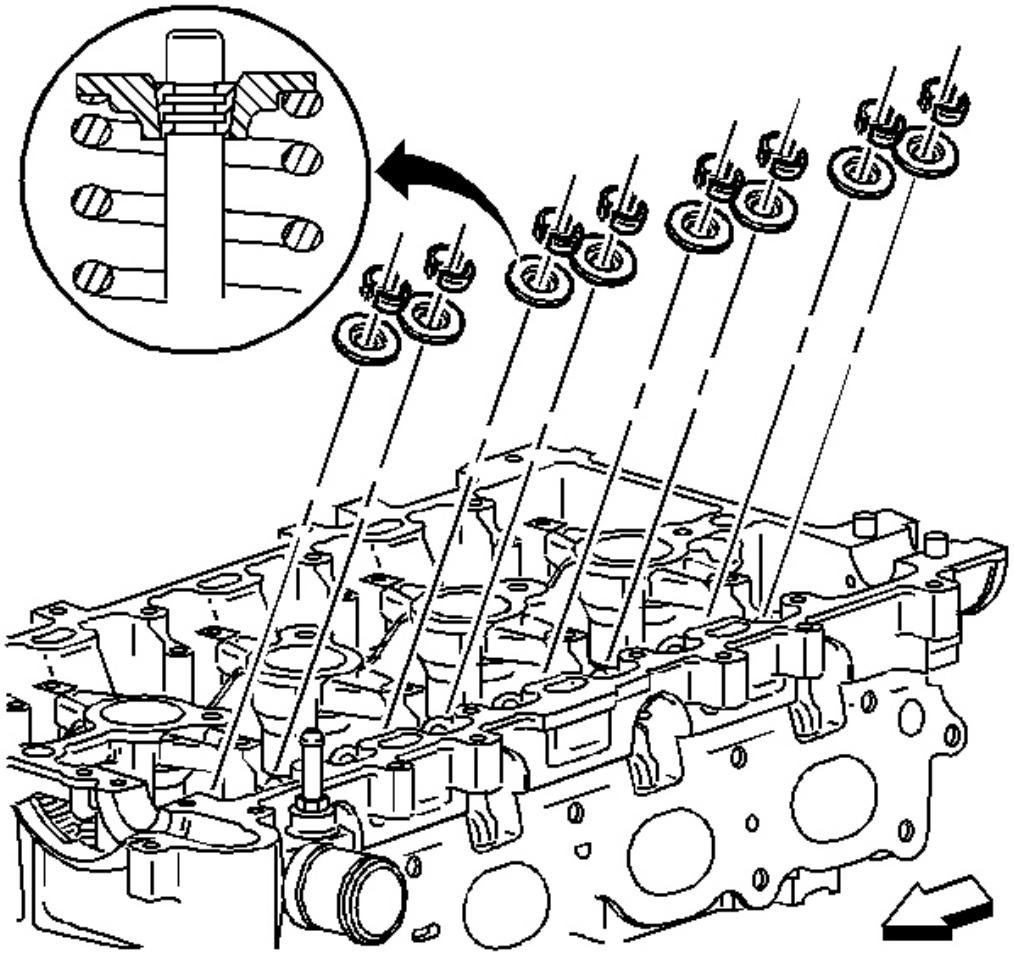


Fig. 466: Identifying Valve Spring Retainer
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure that the valve train components are kept together and identified in order for proper re-installation in their original position.

2. Using the **J 8062** and the. See **Special Tools and Equipment** .**J 43963** , compress the valve spring. See **Special Tools and Equipment** .
3. Remove the valve keys.
4. Slowly release the **J 8062** and the **J 43963** from the valve spring assembly.
5. Remove the retainer.

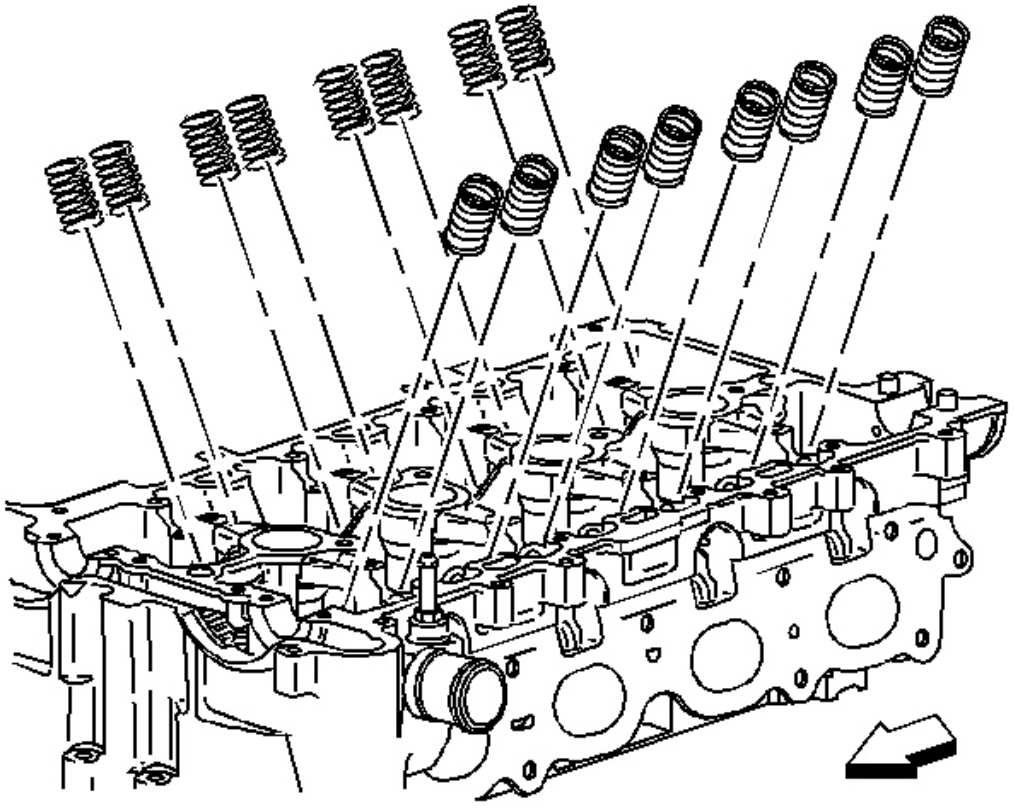


Fig. 467: View of Valve Springs
Courtesy of GENERAL MOTORS CORP.

6. Remove the spring.

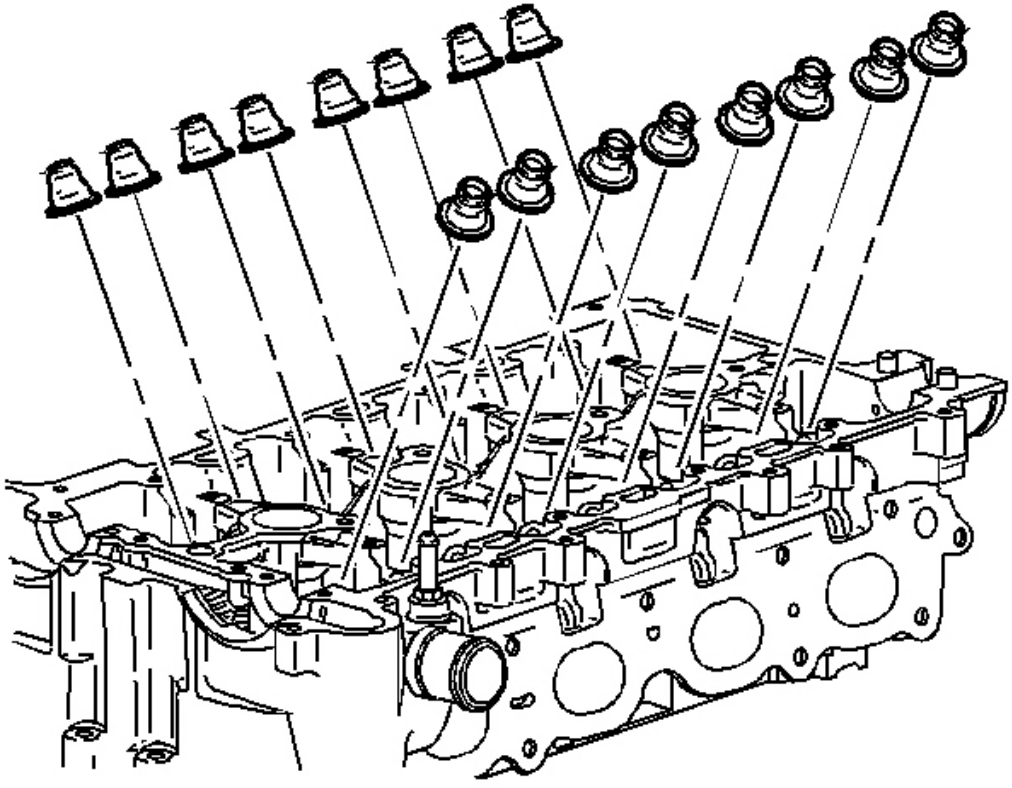


Fig. 468: View Of Valve Seal
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not damage the valve guide. Remove any burrs that have formed at the key groove by chamfering the valve stem with an oil stone or a file.

7. Remove the valve seal. Use the **J 36017** . See **Special Tools and Equipment** . Do not reuse.

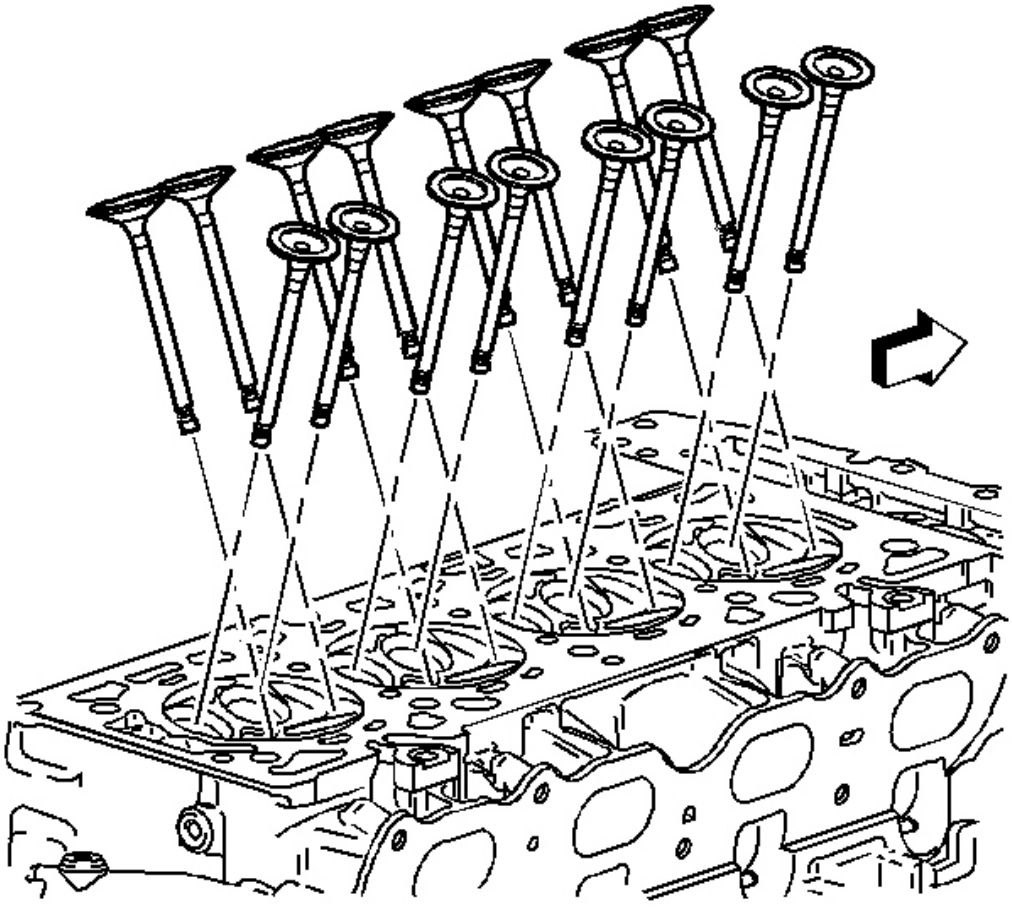


Fig. 469: Identifying Engine Valves
Courtesy of GENERAL MOTORS CORP.

8. Remove the valve.
9. Remove the remaining valves.

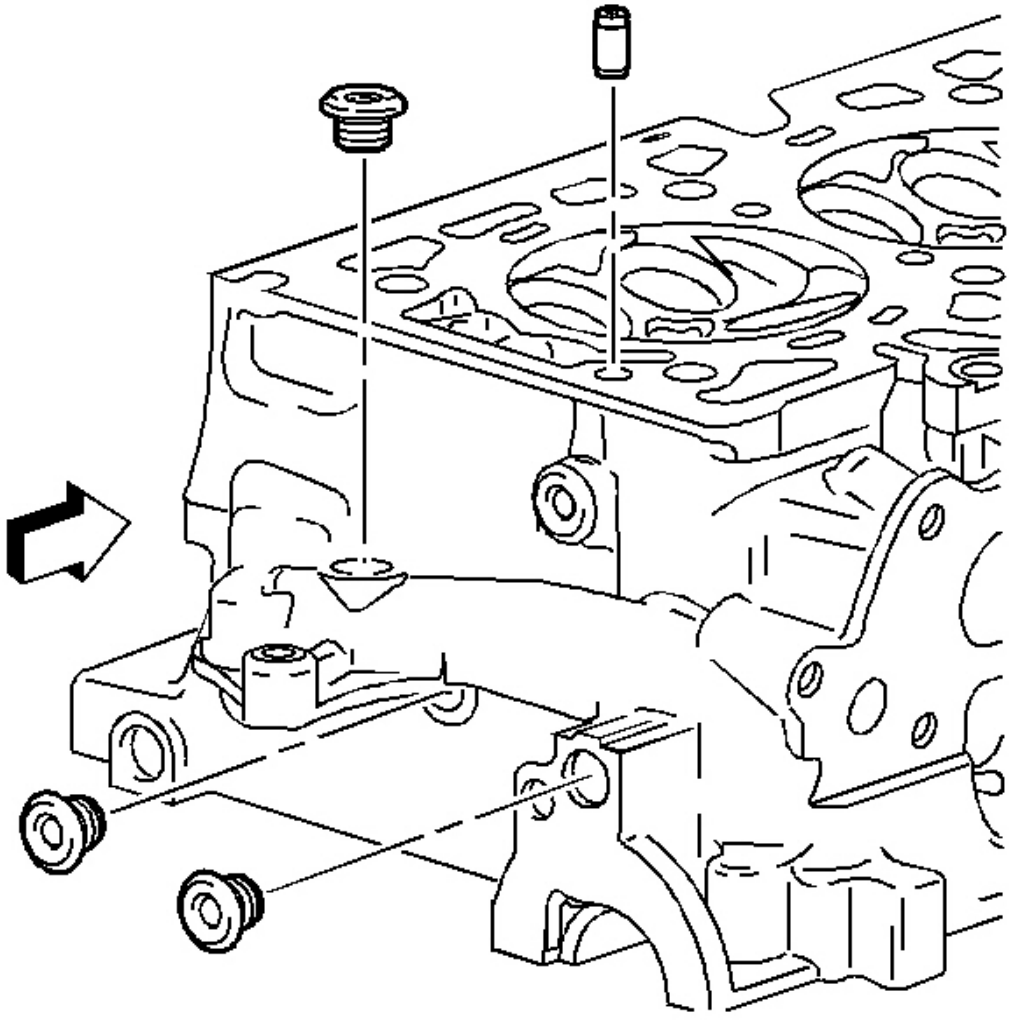


Fig. 470: View Of Cylinder Head Plugs
Courtesy of GENERAL MOTORS CORP.

10. Remove the cylinder head plugs.

CYLINDER HEAD CLEANING AND INSPECTION

Valve Cleaning and Inspection

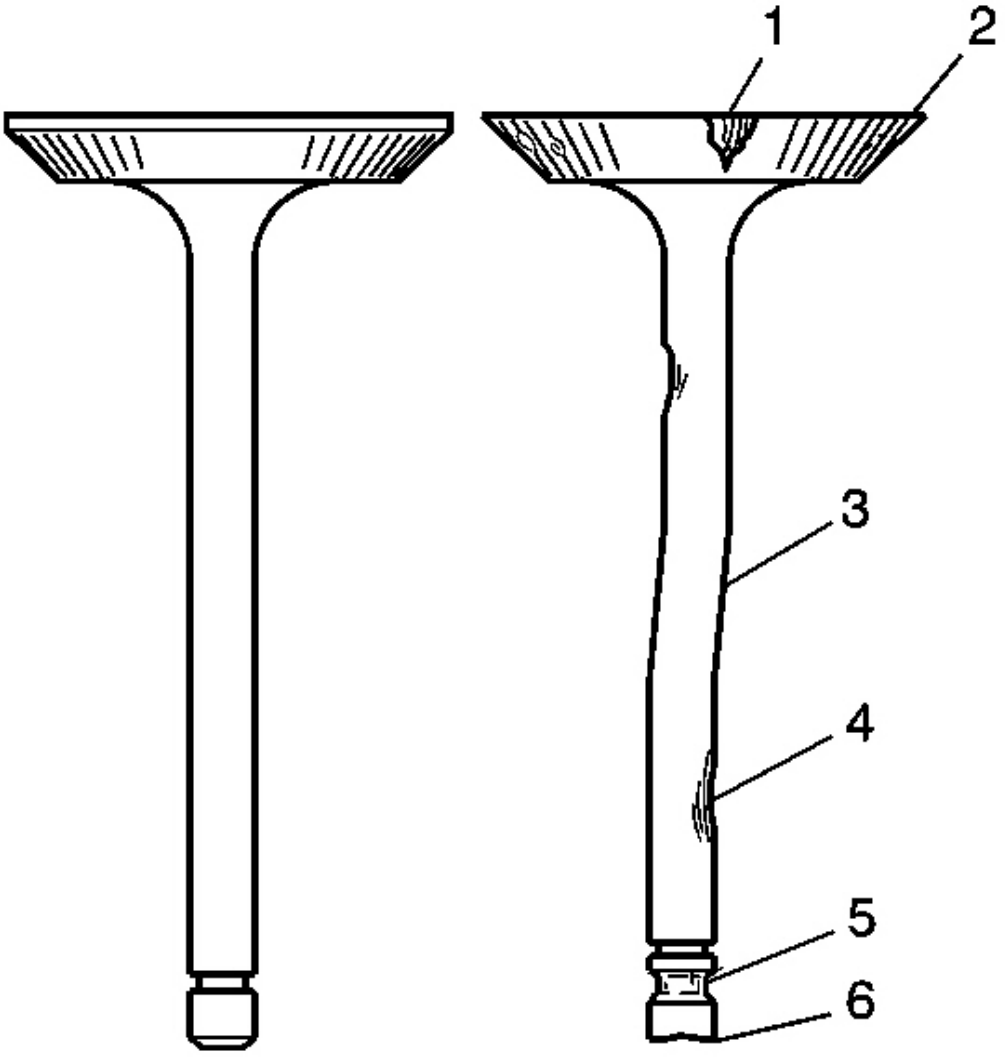


Fig. 471: Inspecting Valves For Damage
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not scratch the valve stem with the wire brush.

1. Clean the valves of carbon, oil and varnish. Carbon can be removed with a wire brush, varnish can be removed by soaking in Parts Immersion Solvent, or equivalent.
2. Clean the valve guides.
3. Inspect the valve stem for wear (4).

4. Inspect the valve keeper groove for chipping or wear (5). Replace the valve if chipped or worn.
5. Inspect the valve face for burning or cracking (1). If pieces are broken off, inspect the corresponding piston and cylinder head area for damage.
6. Inspect the valve stem for burrs and scratches. Burrs and minor scratches may be removed with an oil stone.
7. Inspect the valve stem for straightness and the valve head for bending or distortion (3) using V blocks. Bent or distorted valves must be replaced.
8. Clean the deposits from the valve face. Inspect the valve face for grooving.
9. Replace the valve if the face is grooved. Valve faces cannot be machined. If worn, or damaged, the valves must be replaced.
10. The valves may be lightly lapped to the valve seats.

Cylinder Head and Gasket Surface Cleaning and Inspection

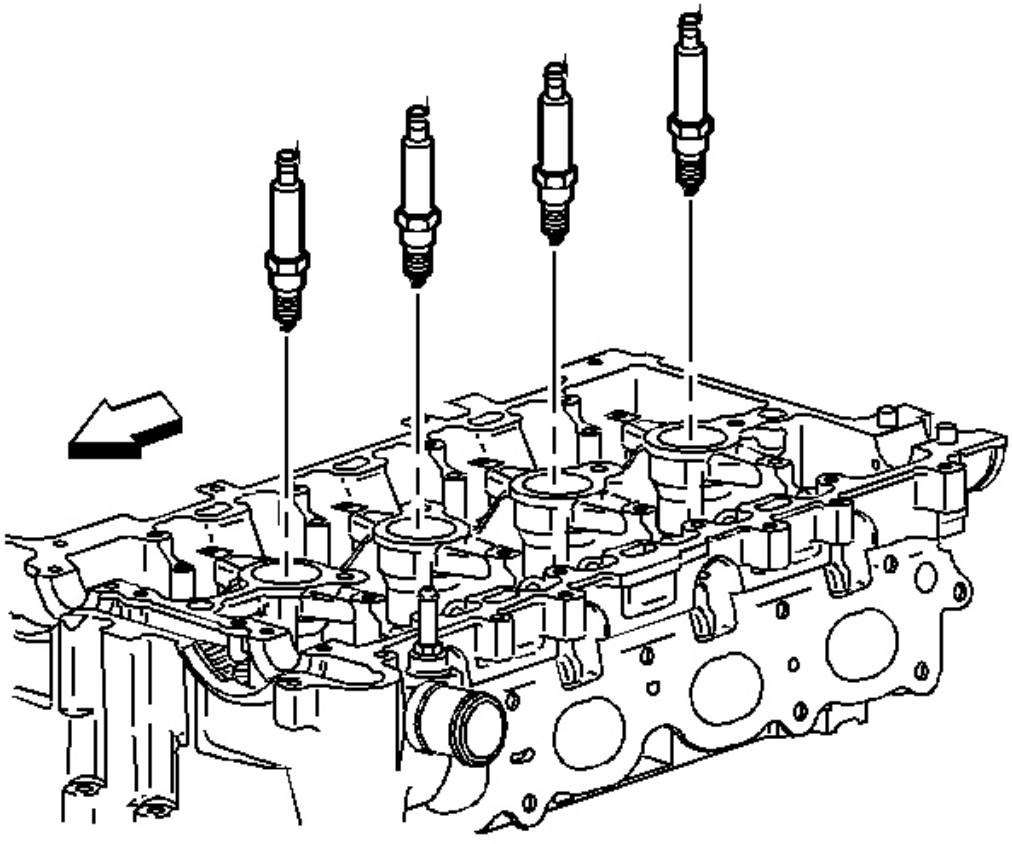


Fig. 472: View Of Spark Plugs

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:
    - Improper installation
    - Loose or warped cylinder head
    - Missing, off location or not fully seated dowel pins
    - Corrosion in the seal area around the coolant passages
    - Chips or debris in the cylinder head bolt holes
    - Bolt holes in the cylinder block not drilled or tapped deep enough
    - Other

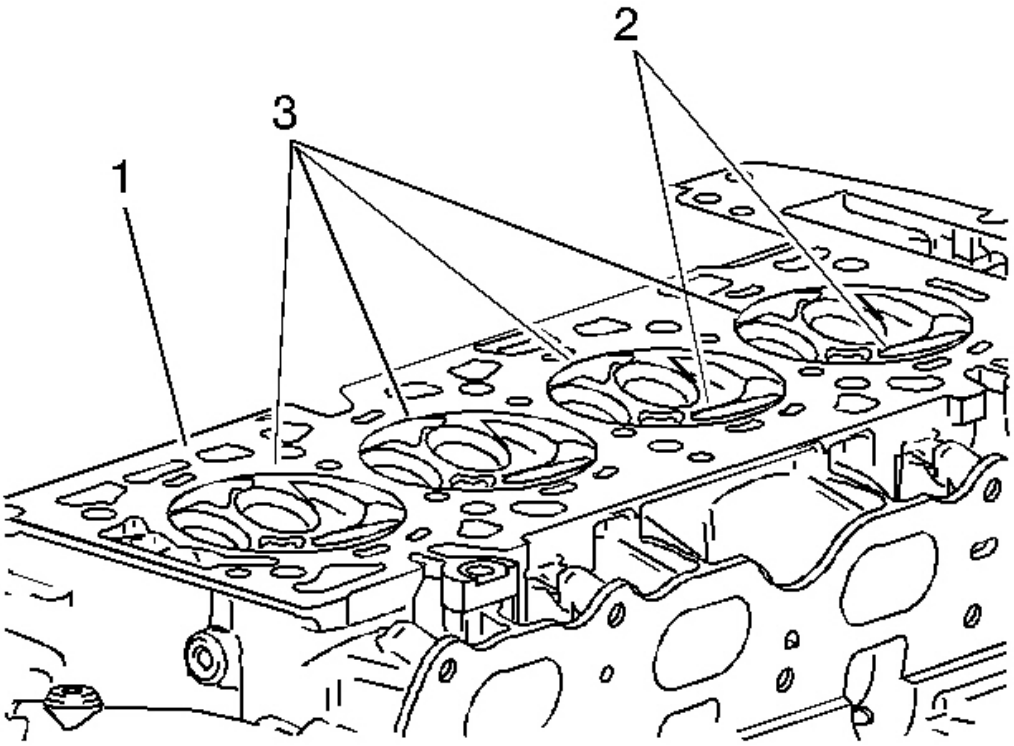


Fig. 473: View Of Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

3. Inspect the cylinder head gasket surface.

- Cylinder head may be reused if corrosion is found only outside a 4 mm (0.375 in) band around each combustion chamber (1).
- Replace the cylinder head if the area between the valve seats is cracked (2).
- Replace the cylinder head if corrosion has been found inside a 4 mm (0.375 in) band around each combustion chamber (3).

4. Clean the cylinder head bolts.

IMPORTANT: Do not use a wire brush on any gasket sealing surface.

5. Clean the cylinder head. Remove all varnish, soot and carbon to the bare metal.
6. Clean the valve guides.
7. Clean the threaded holes. Use a nylon bristle brush.
8. Clean the remains of the sealer from the plug holes.
9. Inspect the cylinder head bolts for damaged threads or stretching and damaged heads caused by improper use of tools.
10. Replace all suspect bolts.
11. Inspect the cylinder head for cracks. Check between the valve seats and in the exhaust ports.

IMPORTANT: Do not attempt to weld the cylinder head, replace it.

12. Inspect the cylinder head deck for corrosion, sand inclusions and blow holes.

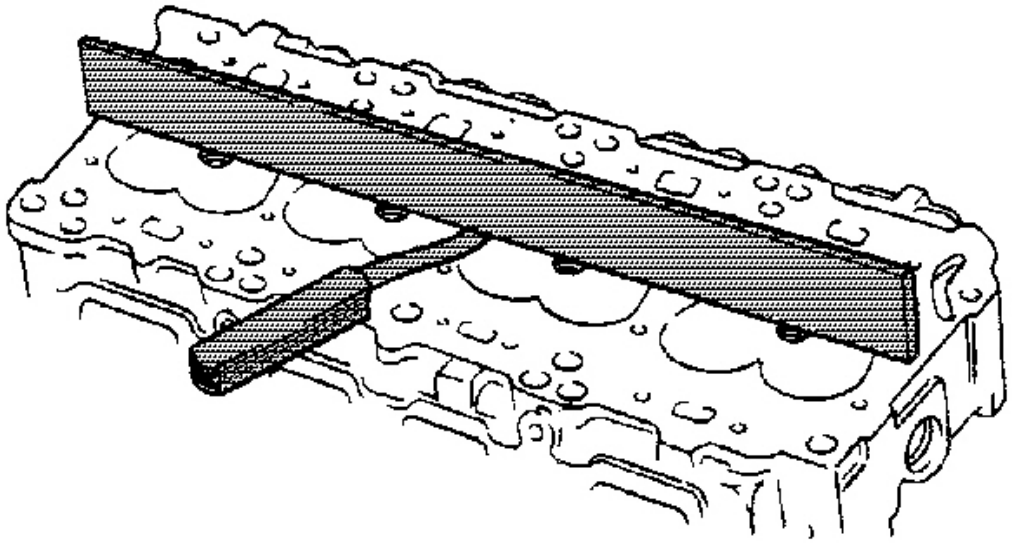


Fig. 474: Inspecting The Cylinder Head Deck Surface For Flatness
Courtesy of GENERAL MOTORS CORP.

13. Inspect the cylinder head deck surface for flatness. Refer to **Engine Mechanical Specifications** .
14. Inspect the cylinder head intake and exhaust manifold mating surface for flatness.
15. Inspect all the threaded holes for damage. Threads may be reconditioned with thread inserts.
16. Inspect the sealing surfaces.

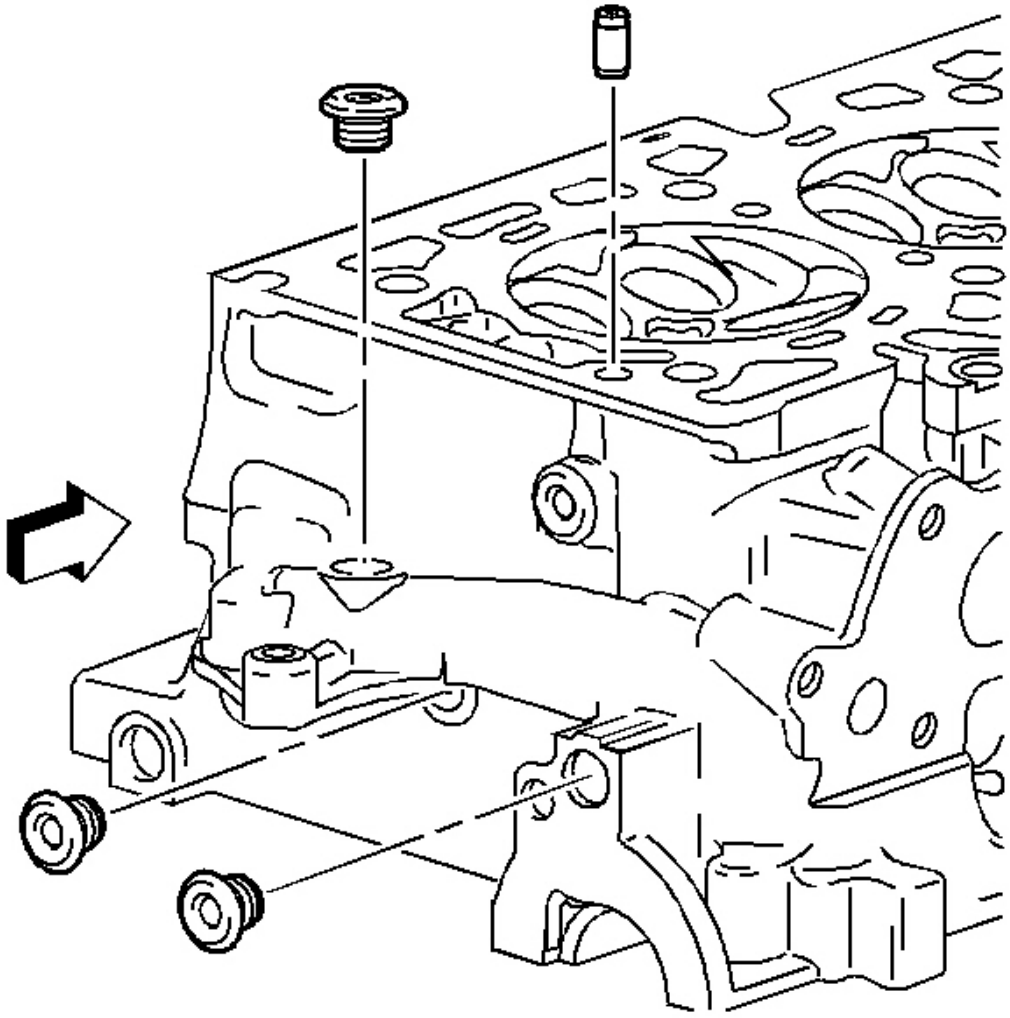


Fig. 475: View Of Cylinder Head Plugs
Courtesy of GENERAL MOTORS CORP.

17. Inspect the cylinder head plugs.

CYLINDER HEAD ASSEMBLE

Tools Required

- **J 8062** Valve Spring Compressor. See **Special Tools and Equipment** .
- J 9666 Valve Spring Tester

- **J 43963** Valve Spring Compressor Adapter. See **Special Tools and Equipment** .

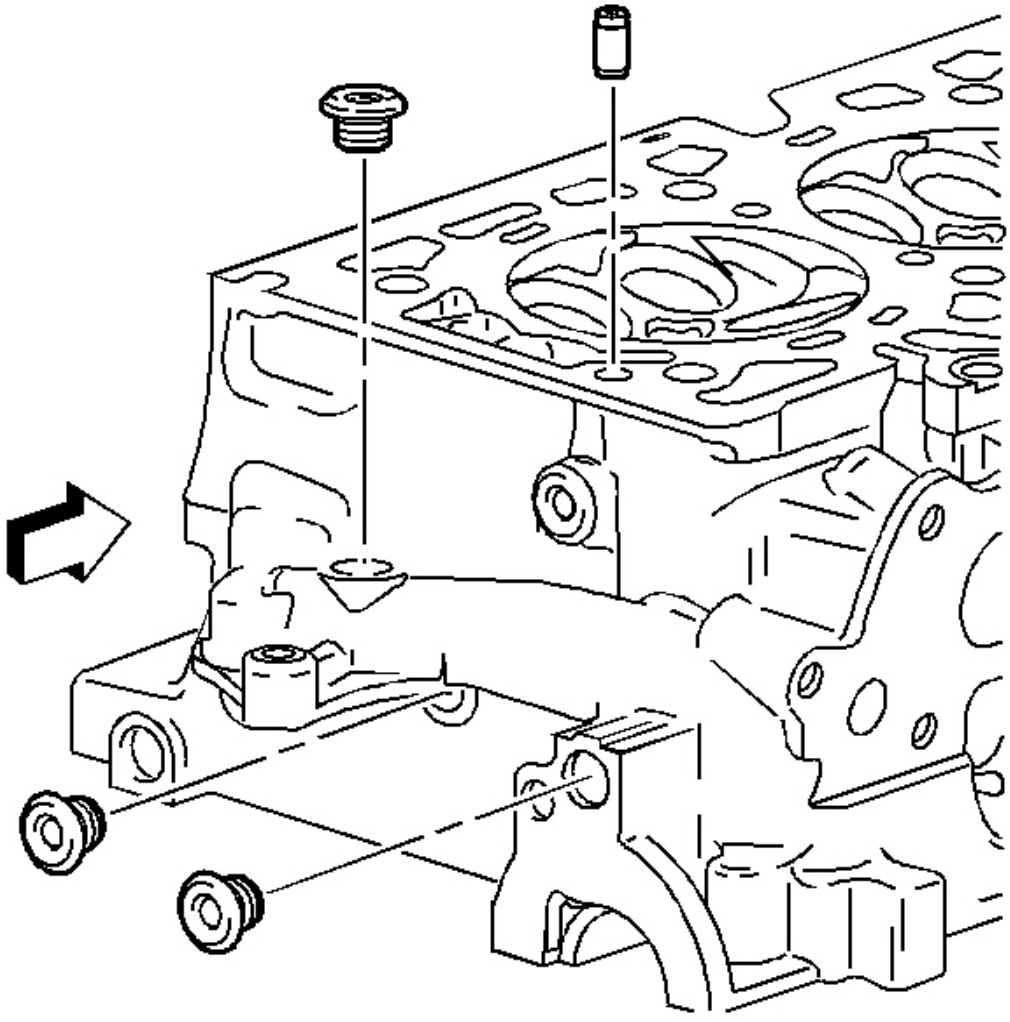


Fig. 476: View Of Cylinder Head Plugs
Courtesy of GENERAL MOTORS CORP.

NOTE: In order to avoid damage, install the spark plugs after the cylinder head has been installed on the engine.

1. Install NEW cylinder head plugs. Coat the plugs with threadlocker P/N 21485277, or equivalent.

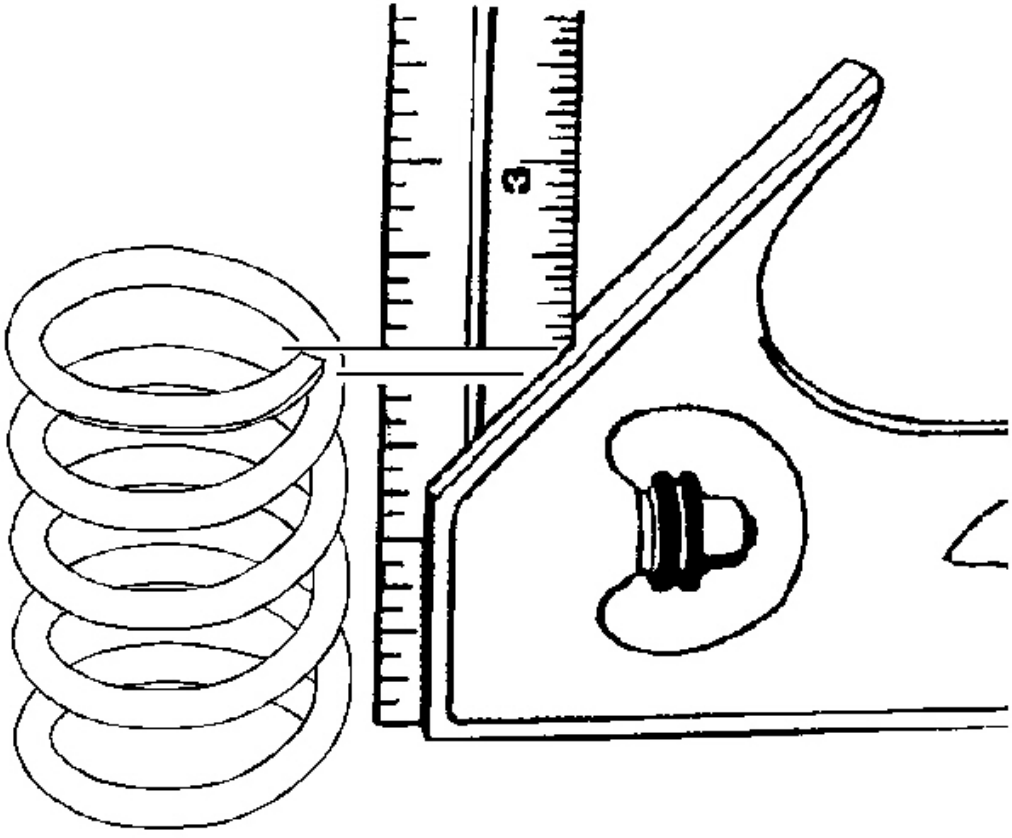


Fig. 477: Inspecting Valve Spring For Squareness
Courtesy of GENERAL MOTORS CORP.

2. Inspect the valve springs. Refer to **Engine Mechanical Specifications** for the tolerances.
3. Look for the following conditions when inspecting the valve springs:
    - Expanded height
    - Unparallel spring ends
    - Spring tension using **J 9666** . See **Special Tools and Equipment** .
    - Any distorted springs should be replaced
4. Assemble the valves.
5. Use the following steps to measure valve runout:
    1. Apply a dab of Prussian blue on the entire valve face. Seat the valve but do not rotate it. The Prussian blue traces transferred to the valve seat are an indication of concentricity of the valve seat.
    2. Clean all traces of Prussian blue.

3. Apply a dab of Prussian blue on the valve seat and repeat the check. The traces of Prussian blue transferred to the valve face indicates valve face concentricity.
4. Replace the valves, if required.

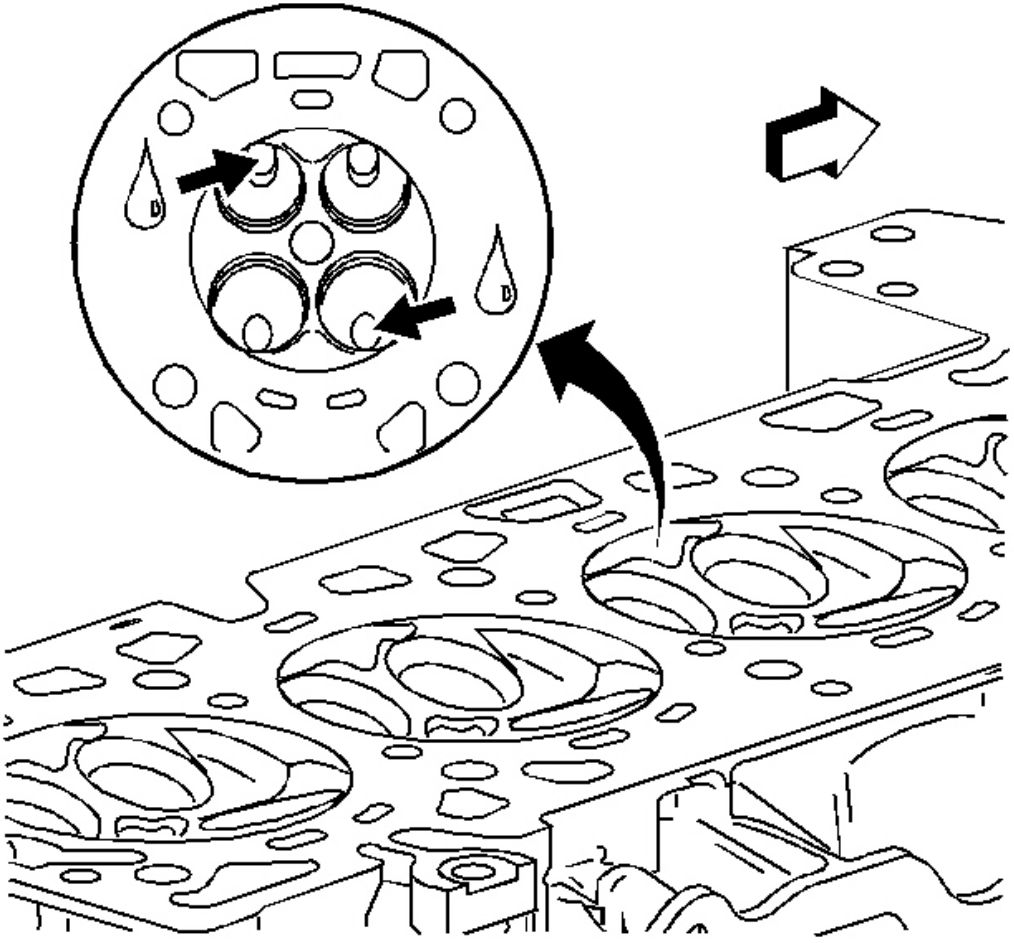


Fig. 478: Measuring Valve Runout
Courtesy of GENERAL MOTORS CORP.

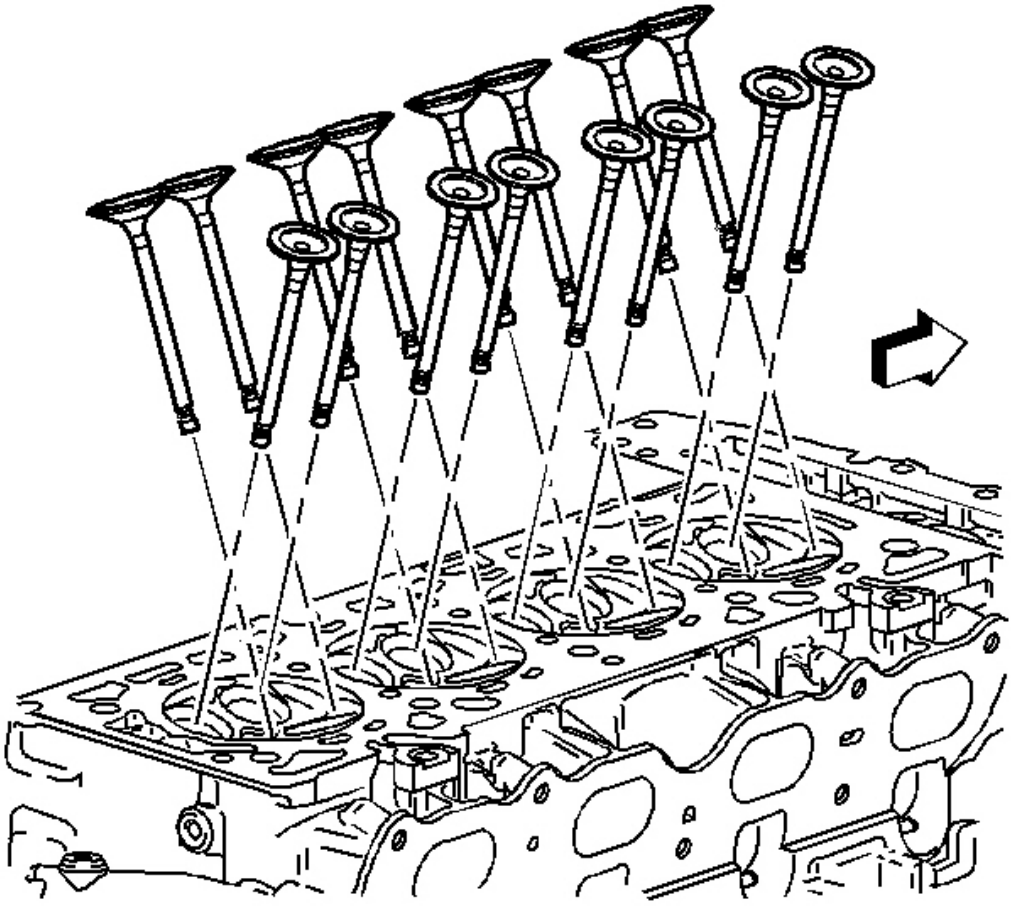


Fig. 479: Identifying Engine Valves
Courtesy of GENERAL MOTORS CORP.

6. Lubricate the valve stems with engine oil supplement.
7. Install the valves.

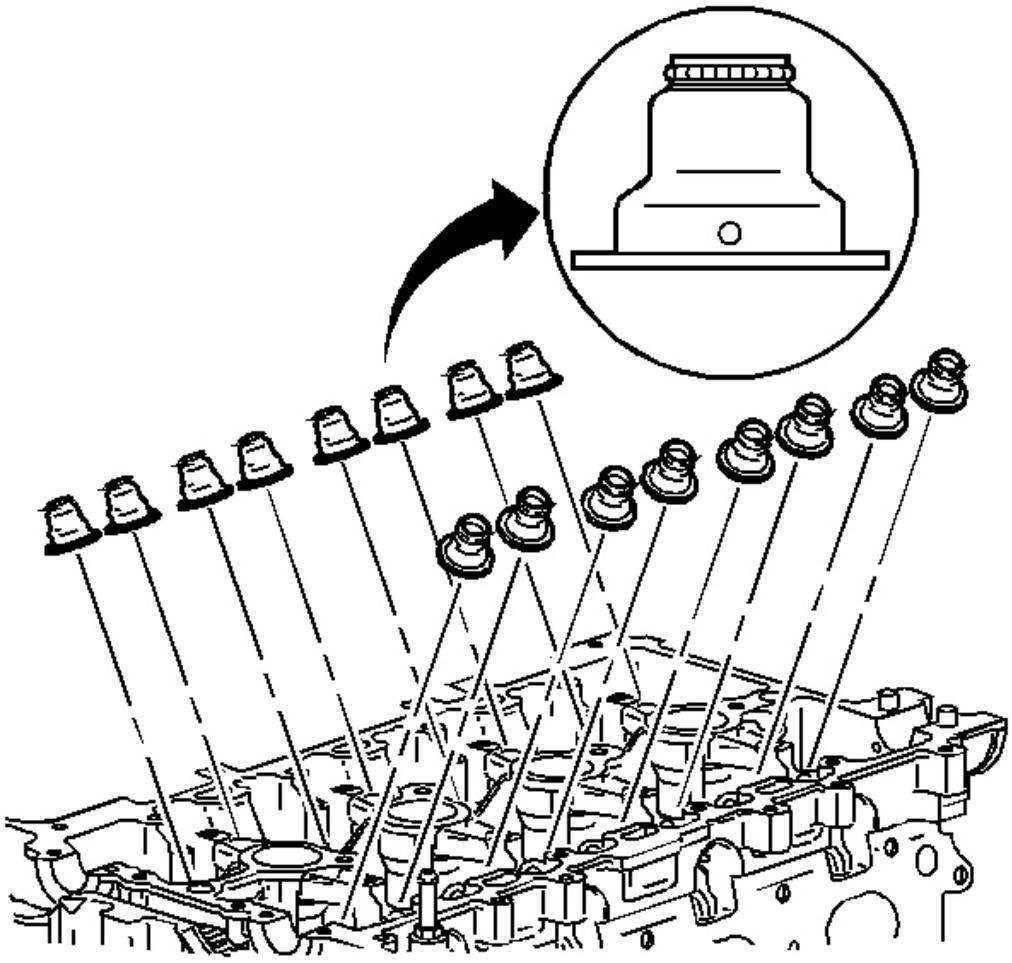


Fig. 480: View Of Valve Seals
Courtesy of GENERAL MOTORS CORP.

8. Install the new valve seals. Fully seat the seals on the valve guides.

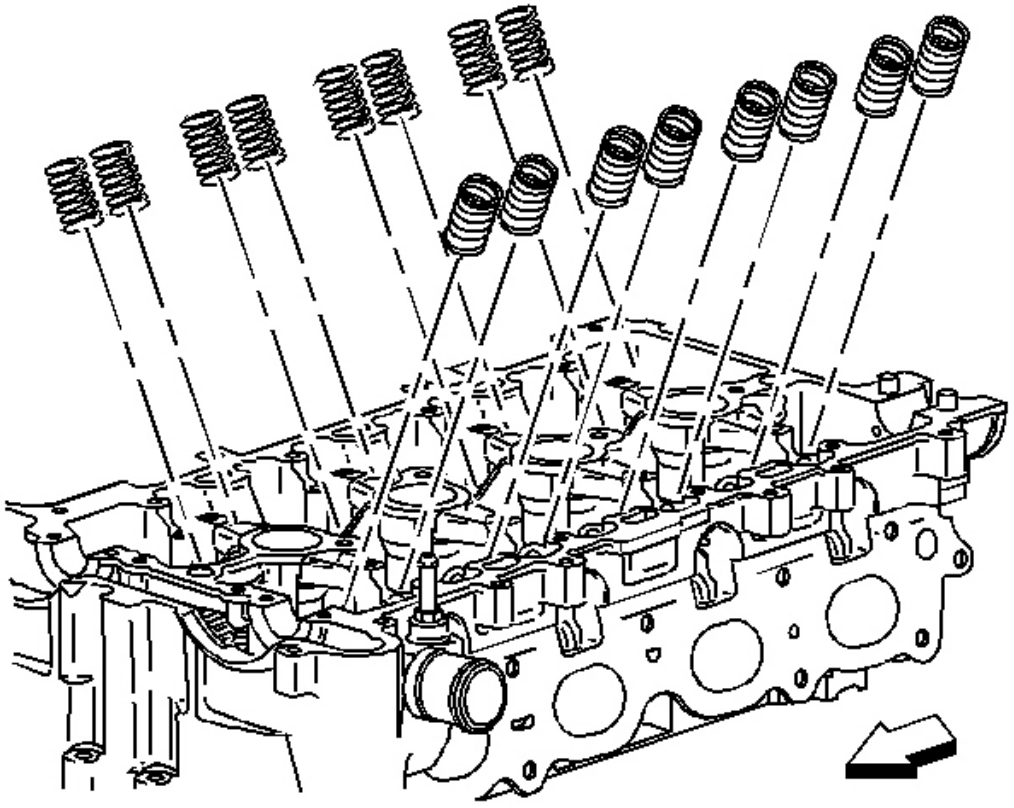


Fig. 481: View of Valve Springs
Courtesy of GENERAL MOTORS CORP.

9. Install the spring.

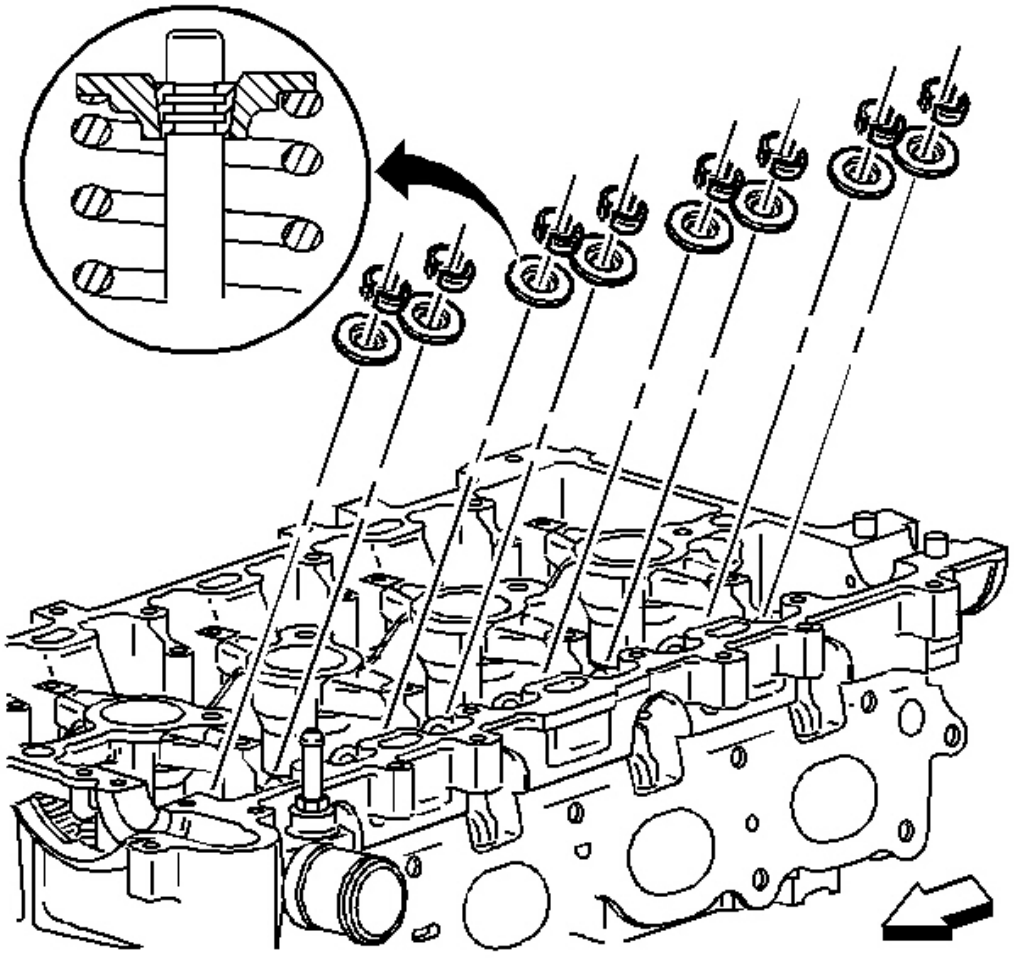


Fig. 482: Identifying Valve Spring Retainer
Courtesy of GENERAL MOTORS CORP.

10. Install the retainer.
11. Using the **J 8062** and the. See **Special Tools and Equipment** .**J 43963** , compress the valve spring. See **Special Tools and Equipment** .
12. Install the valve keys.
13. Slowly release the **J 8062** and the. See **Special Tools and Equipment** .**J 43963** from the valve/spring assembly. See **Special Tools and Equipment** .
14. Inspect for proper valve key seating.

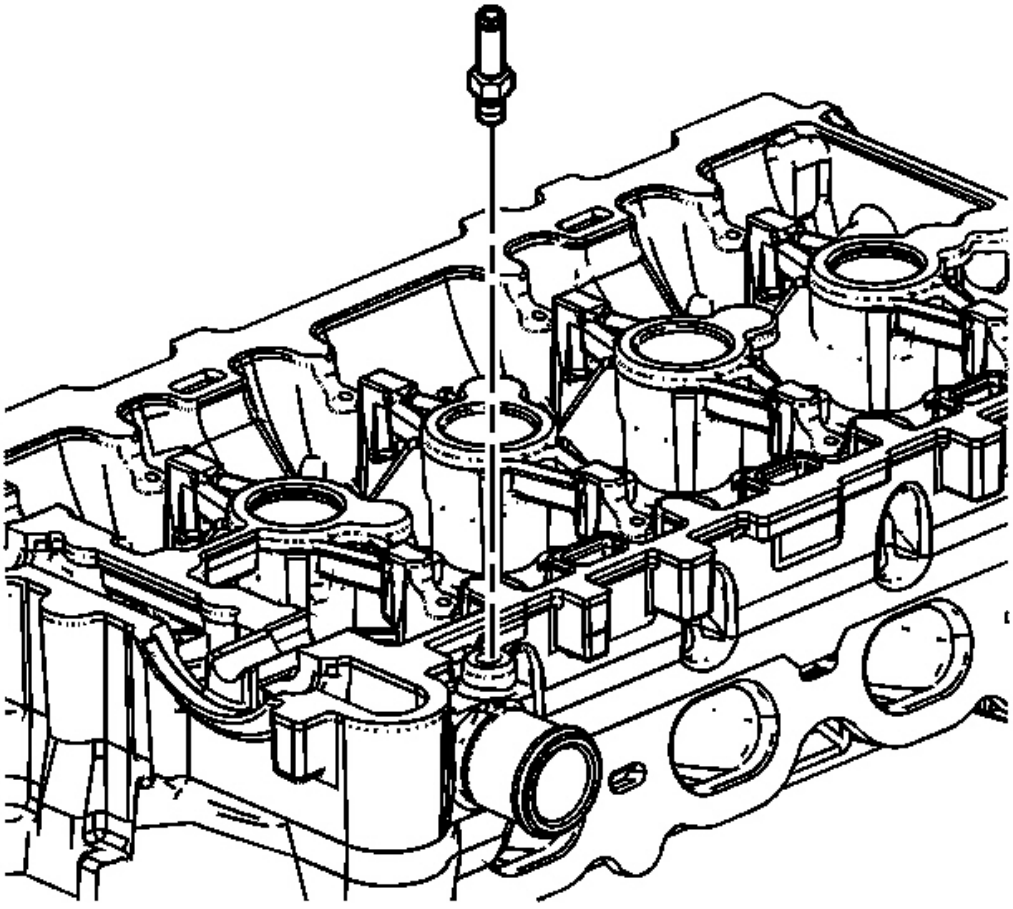


Fig. 483: Identifying Cylinder Head Air Bleed Tube
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

15. Install the cylinder head air bleed tube.

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

OIL PUMP DISASSEMBLE

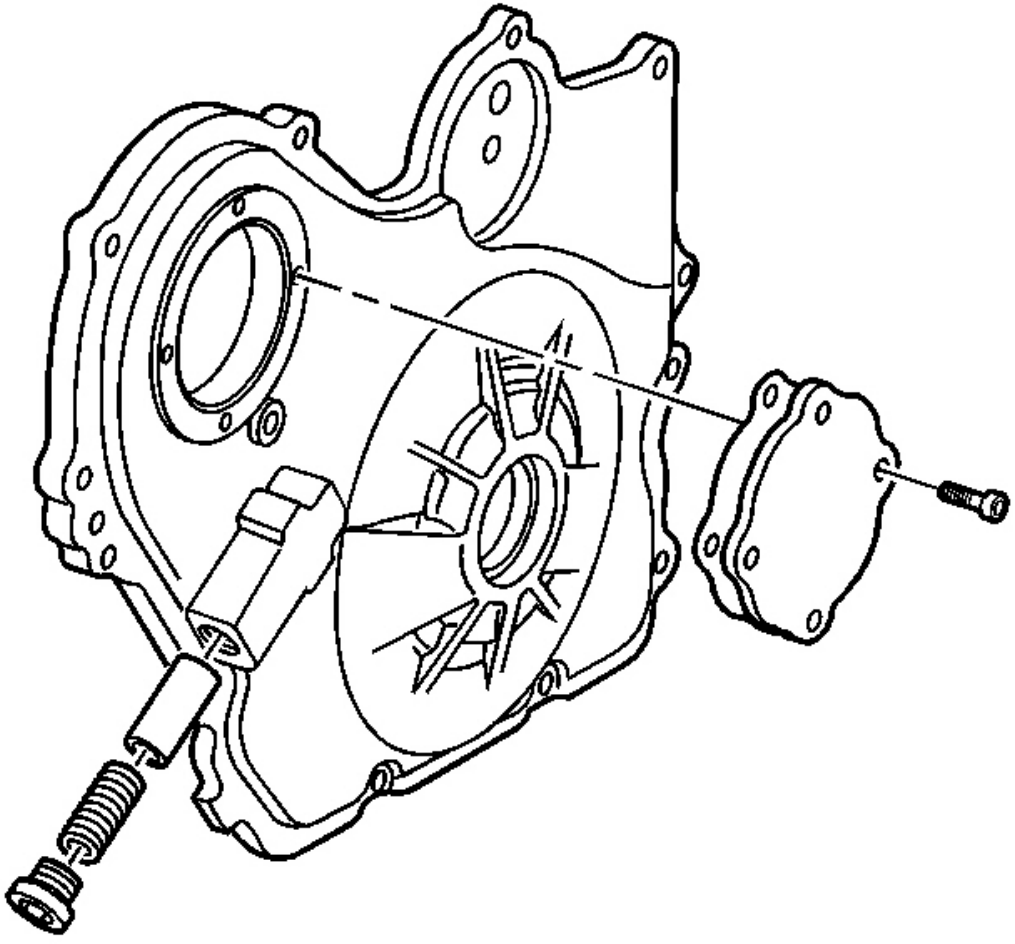


Fig. 484: View Of Pressure Relief Valve
Courtesy of GENERAL MOTORS CORP.

1. Disassemble the pressure relief valve.

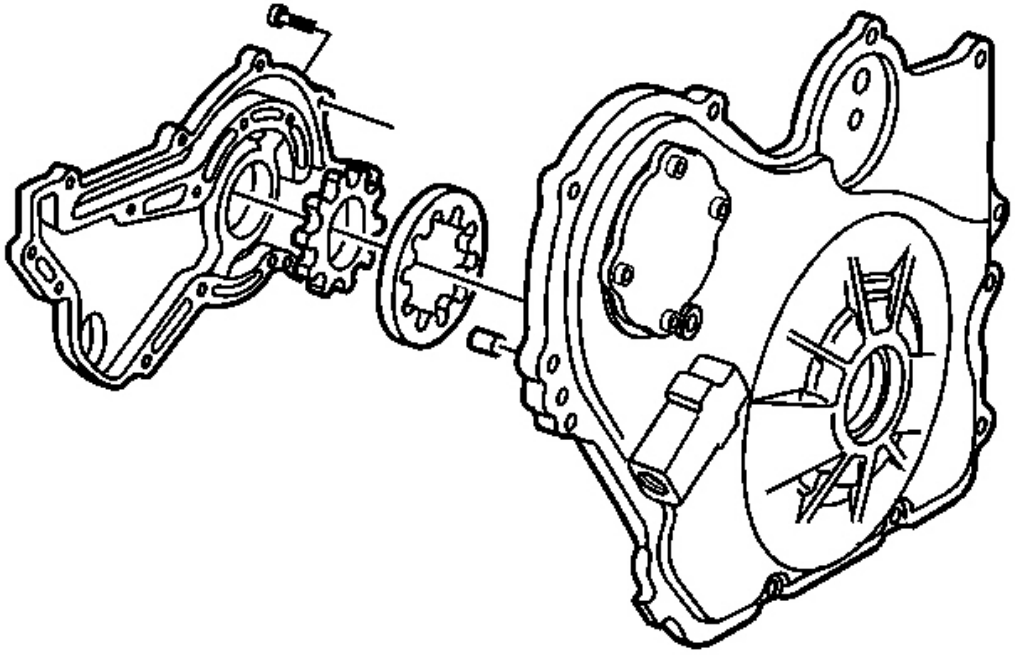


Fig. 485: Identifying Oil Pump Gerotor Cover
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil pump gerotor cover and bolts.
3. Clean all of the parts in cleaning solvent. Remove varnish, sludge and dirt.
4. Inspect the oil pump for wear and scoring. Insure that all components are within specifications. Refer to **Engine Mechanical Specifications** .

   Replace the front cover and oil pump assembly if it is out of specification or damaged.

OIL PUMP ASSEMBLE

1. Lubricate all oil pump parts with engine oil.
2. Install the inner gear into the outer gear.

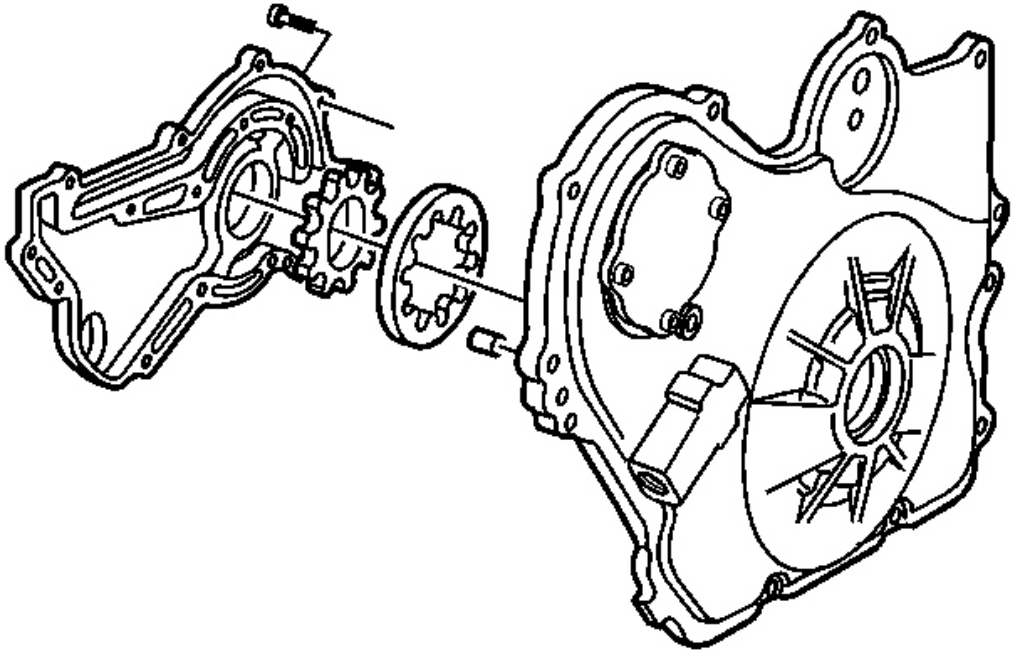


Fig. 486: Identifying Oil Pump Gerotor Cover
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If gears are improperly installed in the front cover, the gerotor cover will not bolt on.

3. Install the gears together into the front cover with the hub of the center gear facing the front cover.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the oil pump gerotor cover and bolts.

Tighten: Tighten the oil pump gerotor bolts to 6 N.m (53 lb in).

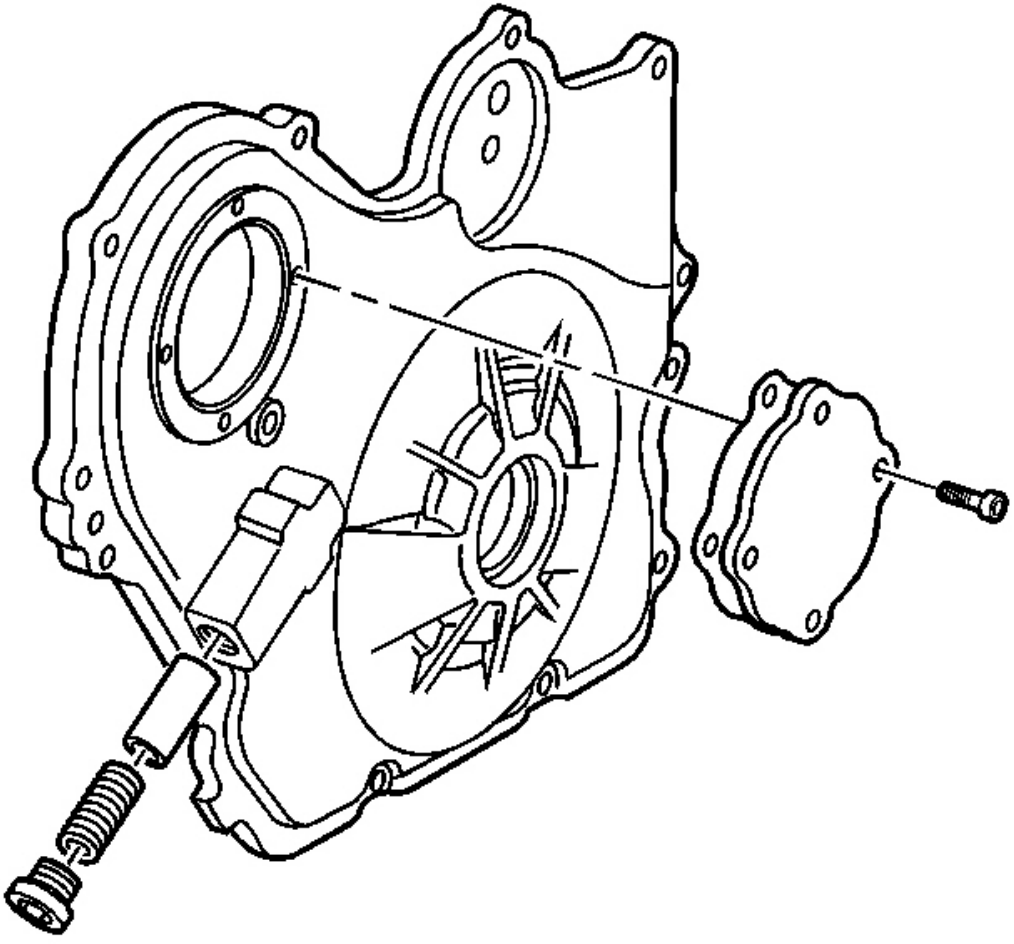


Fig. 487: View Of Pressure Relief Valve
Courtesy of GENERAL MOTORS CORP.

5. Install the pressure relief valve piston.
6. Install the pressure relief valve spring.

Tighten: Tighten the pressure relief valve plug to 40 N.m (30 lb ft).

INTAKE MANIFOLD CLEANING AND INSPECTION

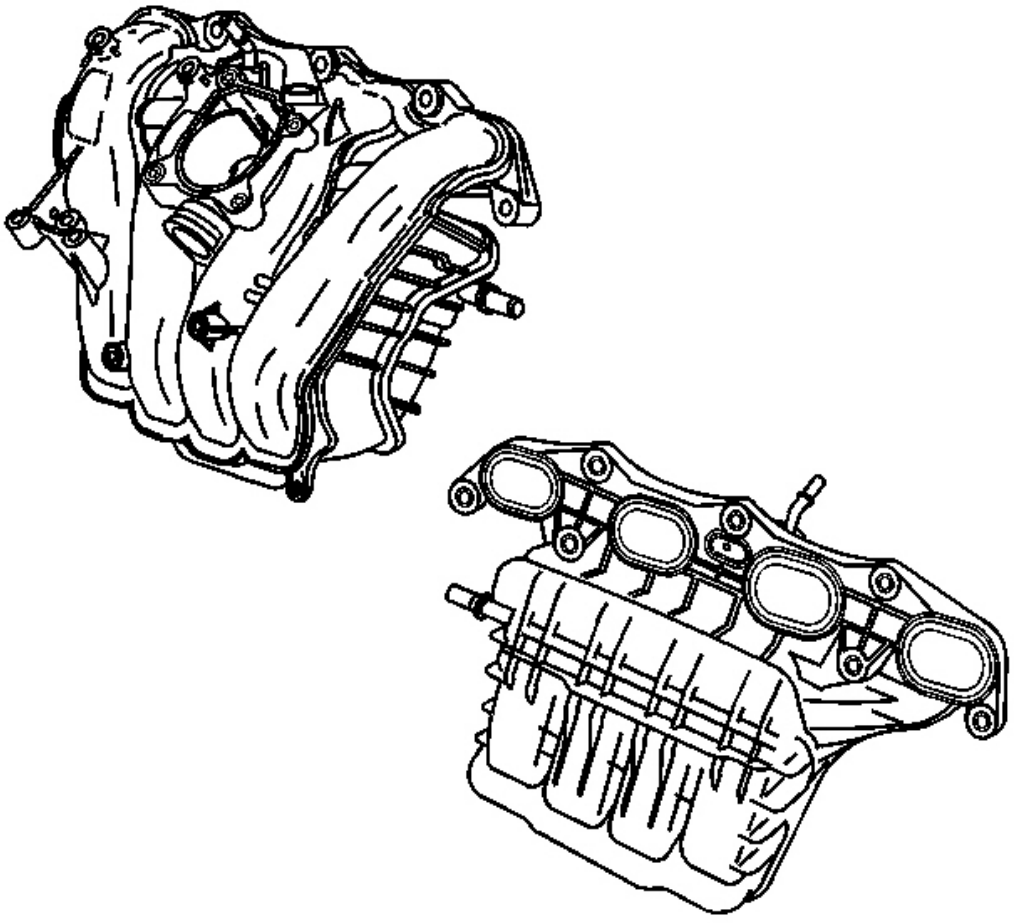


Fig. 488: View Of Intake Manifold
Courtesy of GENERAL MOTORS CORP.

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.

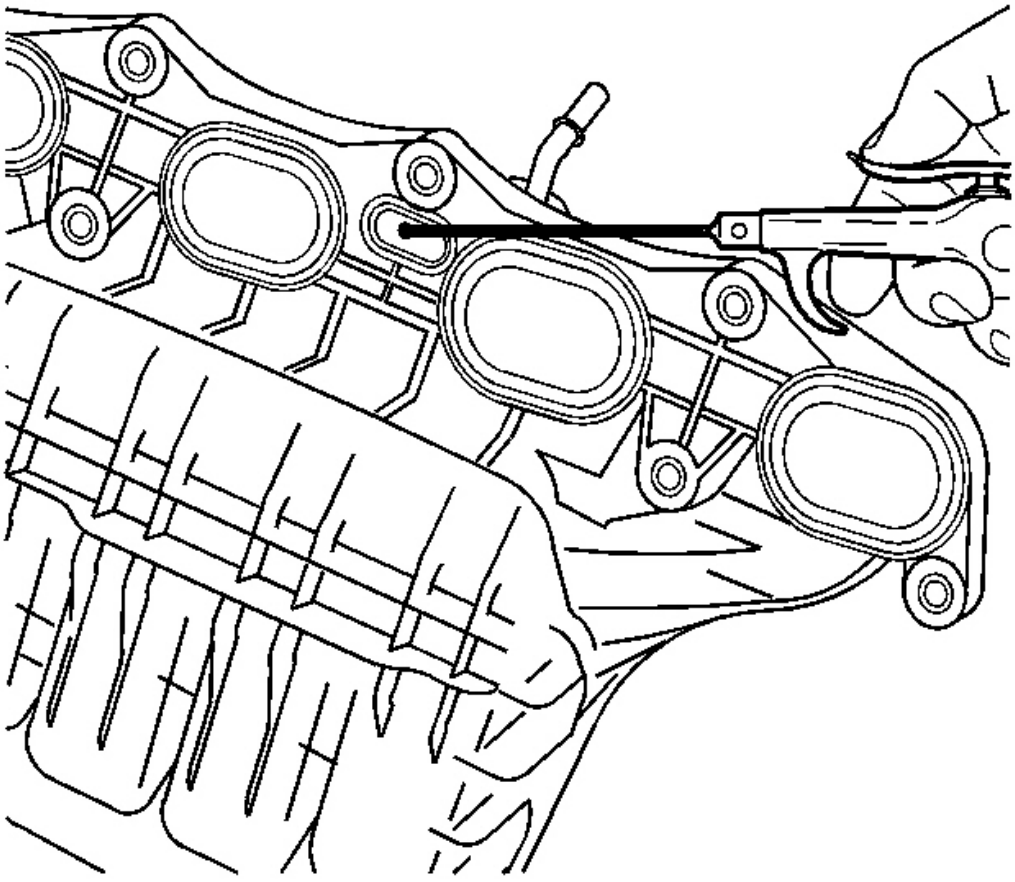


Fig. 489: Cleaning Crankcase Ventilation Passages With Compressed Air
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

5. Clean the crankcase ventilation passages with compressed air if necessary. Use a maximum of 172 kPa (25 psi) of air pressure.
6. Replace the intake manifold as necessary.

EXHAUST MANIFOLD CLEANING AND INSPECTION

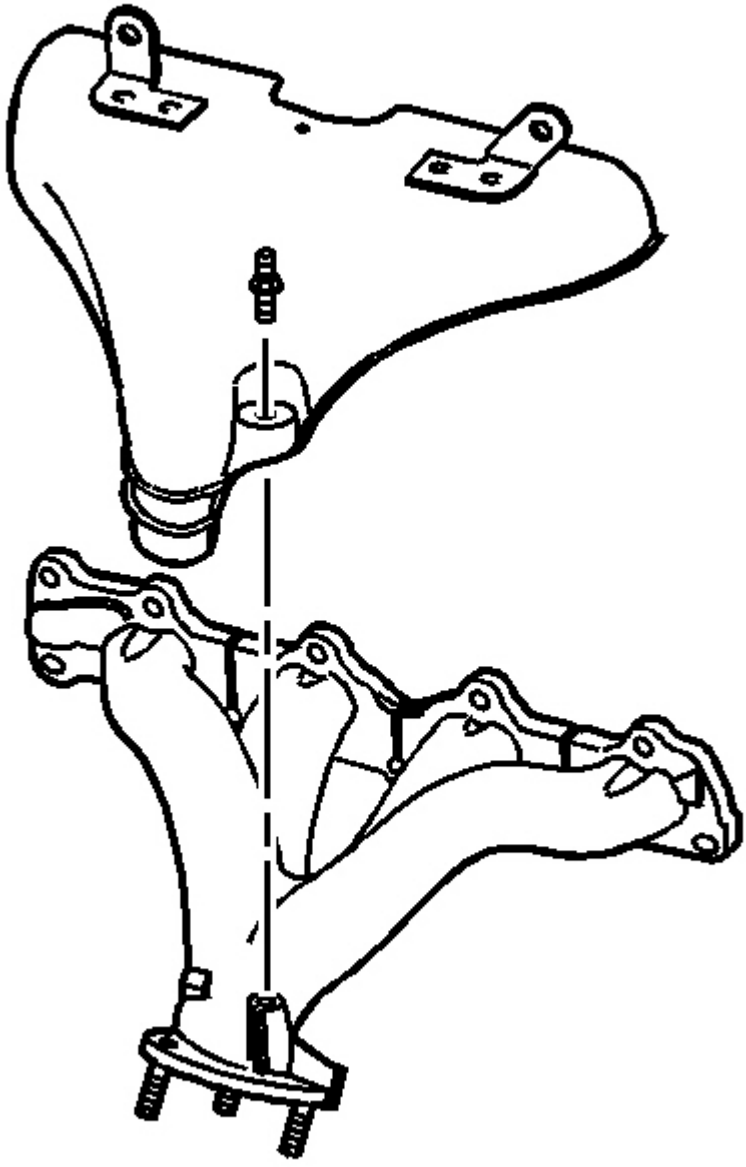


Fig. 490: View Of Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Do not reuse the exhaust manifold-to-cylinder head gaskets. Upon installation of the exhaust manifold, install a NEW gasket. An improperly installed gasket or leaking exhaust system may effect**

On-Board Diagnostics (OBD) II system performance.

- **Remove the oxygen sensor prior to cleaning the manifold, do not submerge the oxygen sensor in cleaning solvent.**

1. Remove the oxygen sensor from the manifold.
2. Clean the exhaust manifold in solvent.

CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

3. Dry the exhaust manifold with compressed air.
4. Inspect the heat shield for damage.

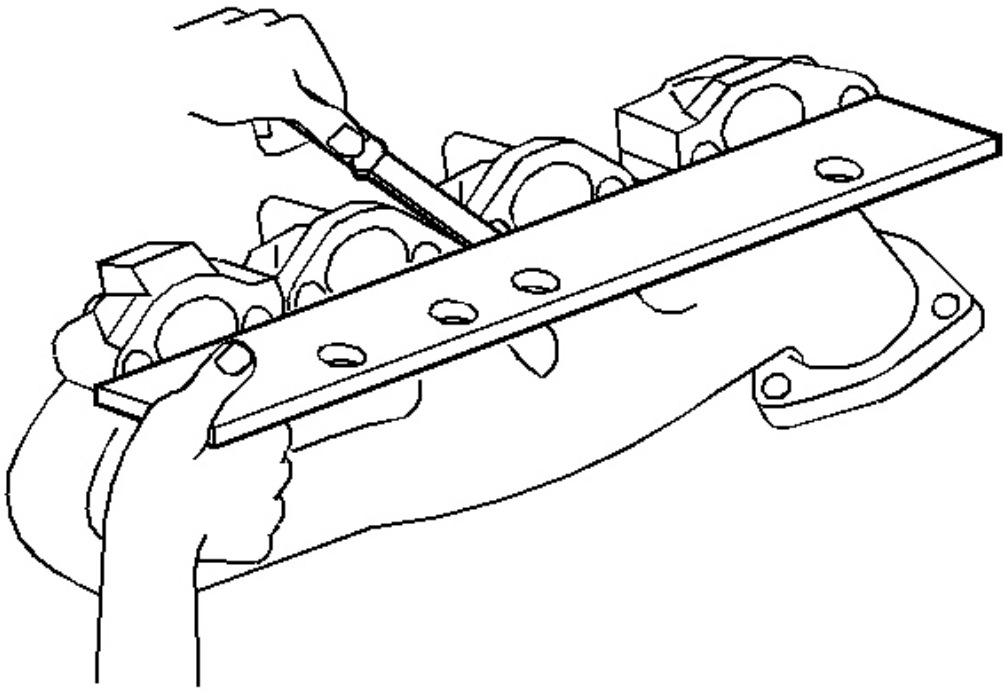


Fig. 491: Measuring Exhaust Manifold To Cylinder Head Surface For Warpage
Courtesy of GENERAL MOTORS CORP.

5. Use a straight edge and a feeler gage and measure the exhaust manifold mounting face for warpage.

An exhaust manifold face with warpage in excess of 0.25 mm (0.010 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

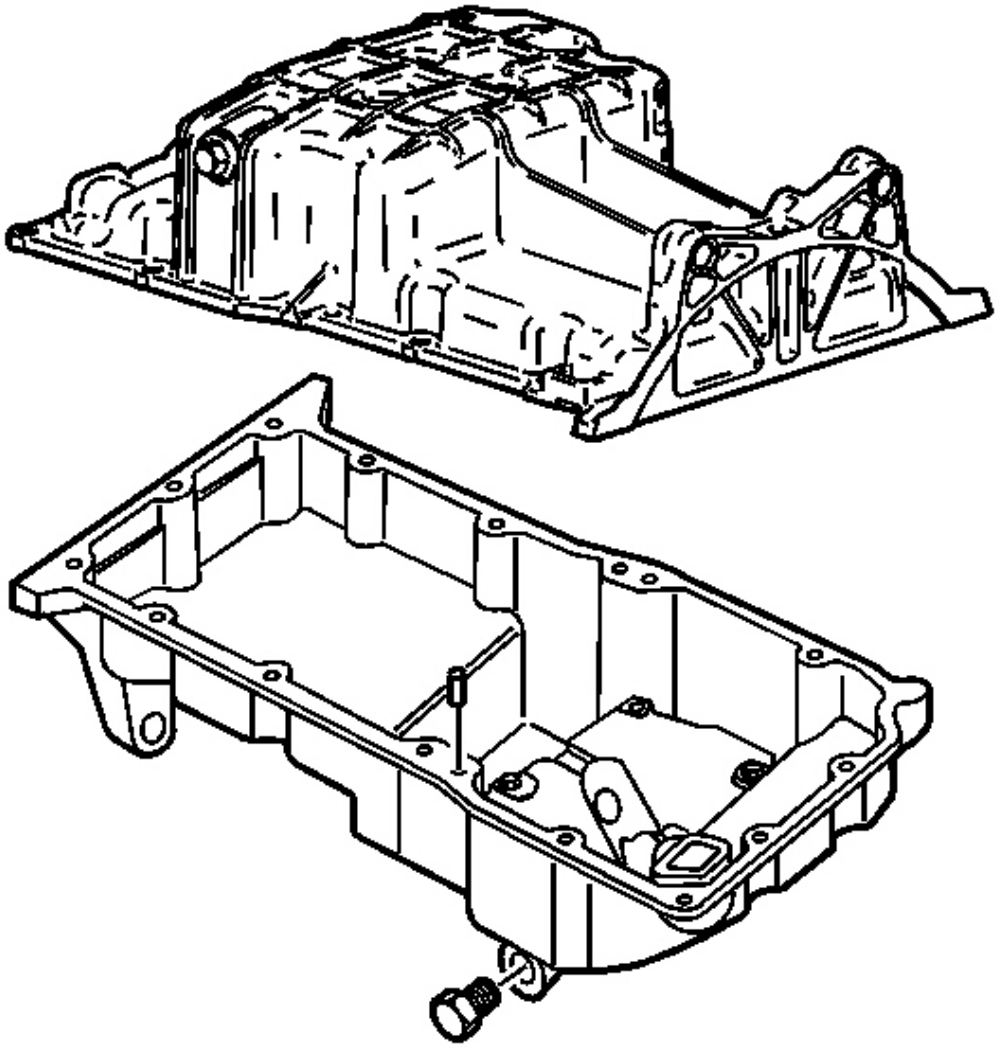


Fig. 492: View Of Oil Pan
Courtesy of GENERAL MOTORS CORP.

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.

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

Tools Required

J 42385-850 Thread Repair Kit. See **Special Tools and Equipment** .

General Thread Repair

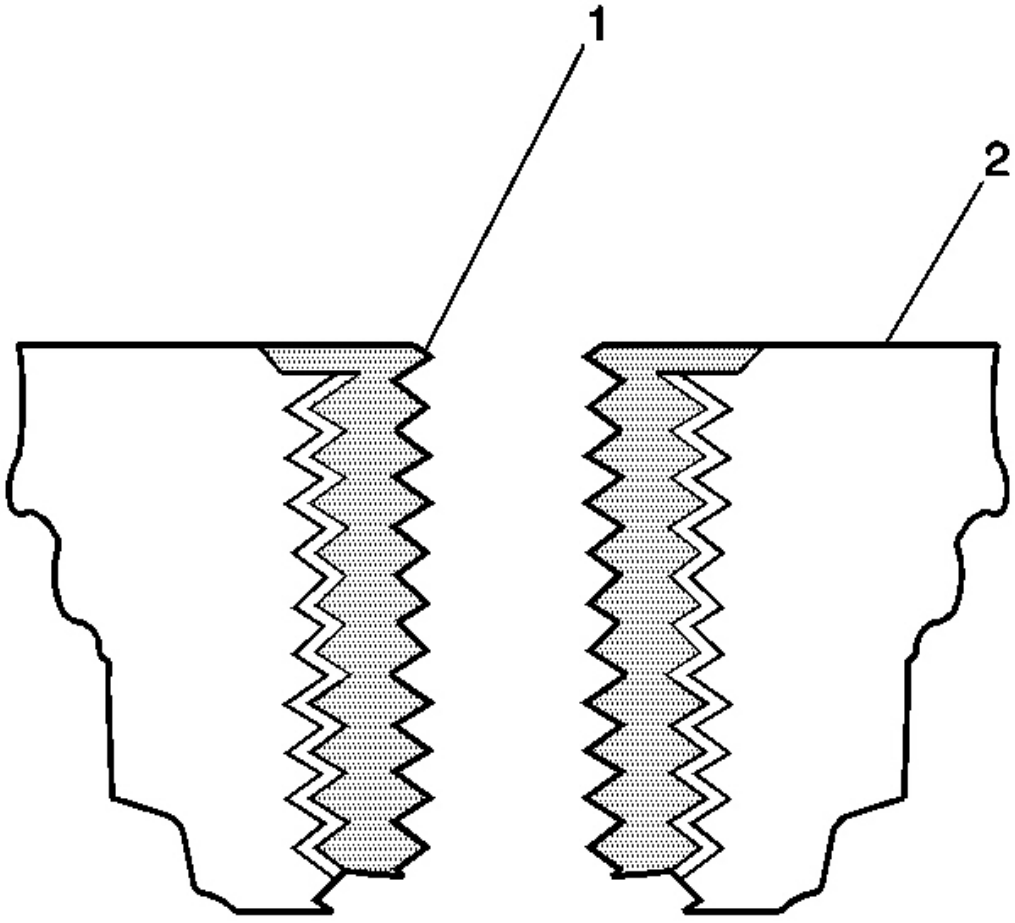


Fig. 493: View Of Bushing Type Insert & Base Material
Courtesy of GENERAL MOTORS CORP.

The thread repair process involves a solid, thin walled, self-locking, carbon steel, bushing type insert (1). During the bushing installation process, the driver tool expands the bottom external threads of the insert into the base material (2). This action mechanically locks the insert in place. Also, when installed to the proper depth, the flange of the insert will be seated against the counterbore of the repaired hole.

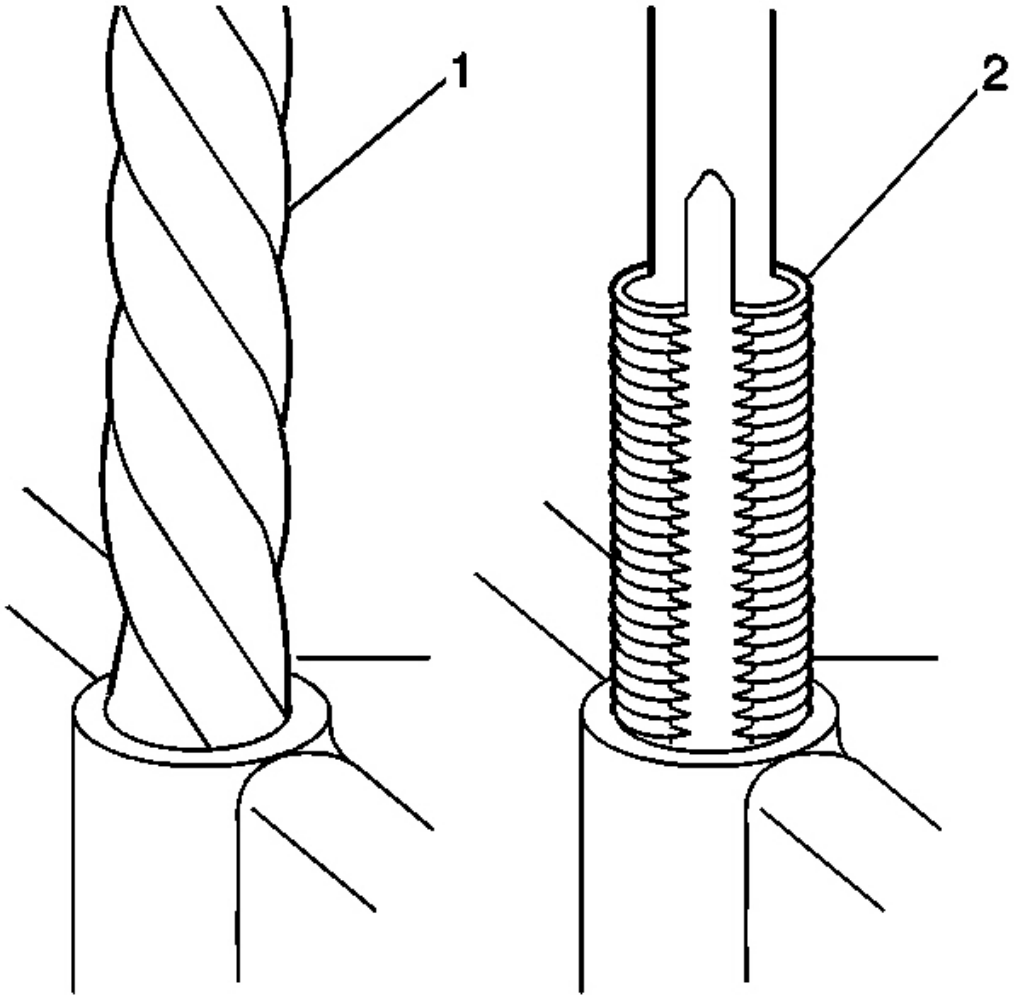


Fig. 494: Removing Damaged Threads
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

IMPORTANT: The use of a cutting type fluid P/N 1052864, WD 40(R), or equivalent, is recommended when performing the drilling, counterboring, and tapping procedures.
Driver oil MUST be used on the installer driver tool.
The tool kits are designed for use with either a suitable tap wrench or drill

motor.

1. Drill out the threads of the damaged hole (1).
    - M6 inserts require a minimum drill depth of 15 mm (0.59 in).
    - M8 inserts require a minimum drill depth of 20 mm (0.79 in).
    - M10 inserts require a minimum drill depth of 23.5 mm (0.93 in).
2. Using compressed air, clean out any chips.

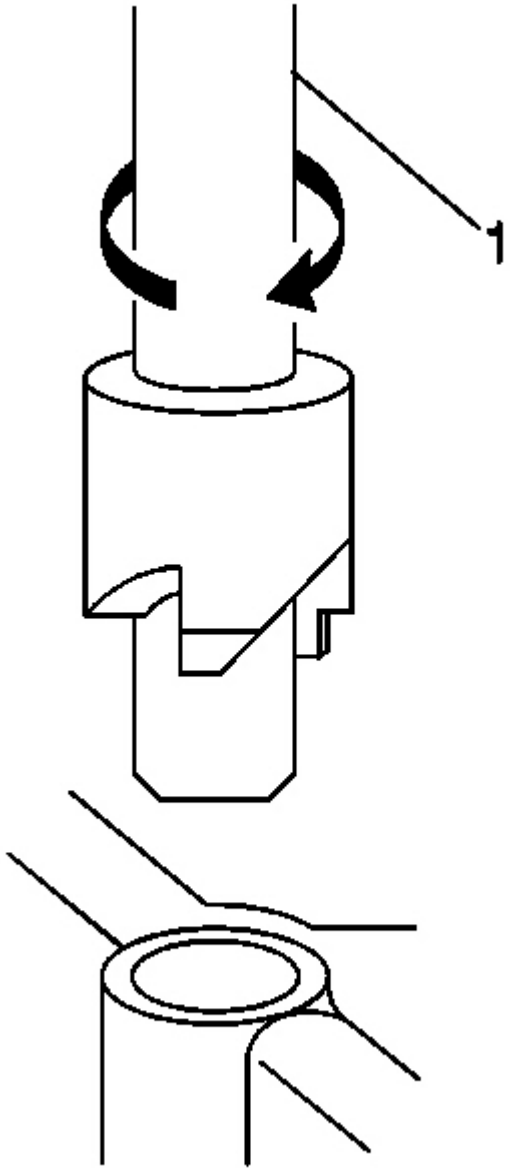


Fig. 495: View Of Counterbore Drill
Courtesy of GENERAL MOTORS CORP.

3. Counterbore the hole to the full depth permitted by the tool (1).
4. Using compressed air, clean out any chips.

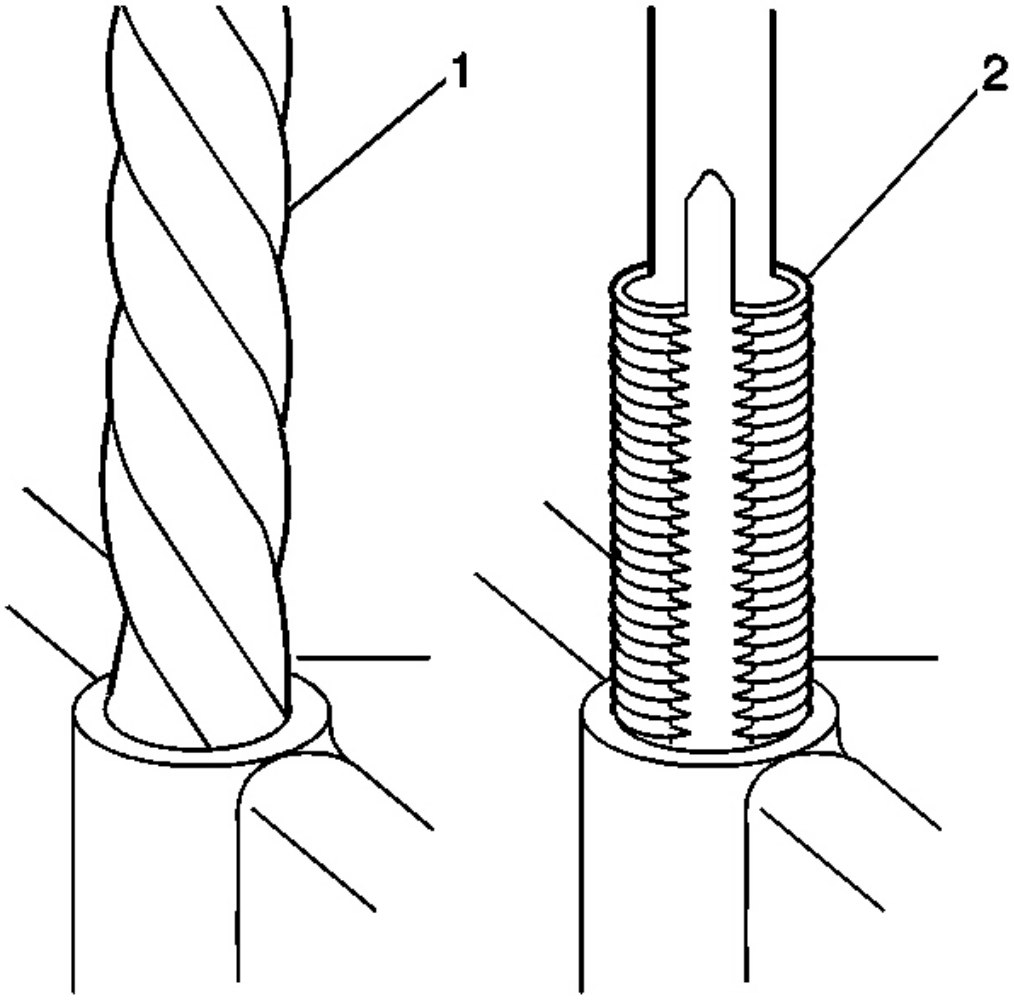


Fig. 496: Removing Damaged Threads
Courtesy of GENERAL MOTORS CORP.

5. Using a tap wrench (2), tap the threads of the drilled hole.
    - M6 inserts require a minimum tap depth of 15 mm (0.59 in).
    - M8 inserts require a minimum tap depth of 20 mm (0.79 in).
    - M10 inserts require a minimum tap depth of 23.5 mm (0.93 in).
6. Using compressed air, clean out any chips.
7. Spray cleaner GM P/N 12346139, GM P/N 12377981, or equivalent, into the hole.
8. Using compressed air, clean any cutting oil and chips out of the hole.

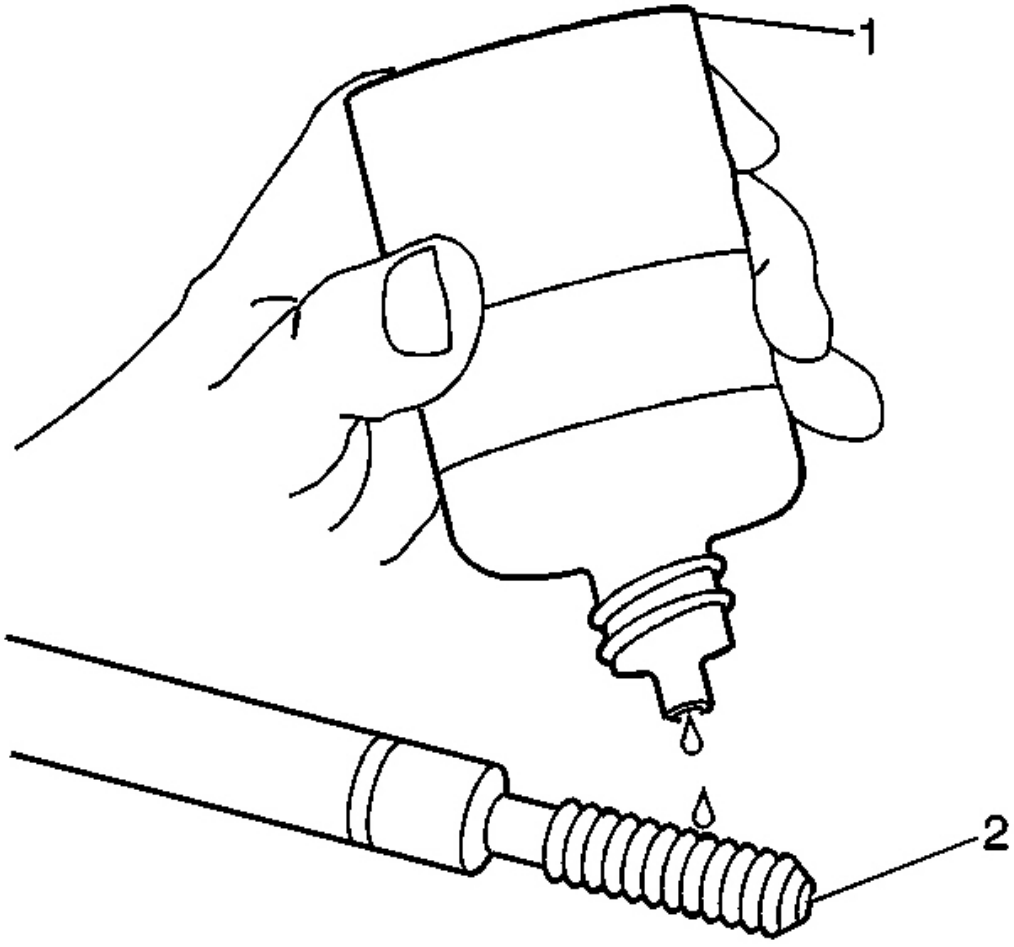


Fig. 497: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

9. Lubricate the threads of the installer tool (2) with the driver oil (1).

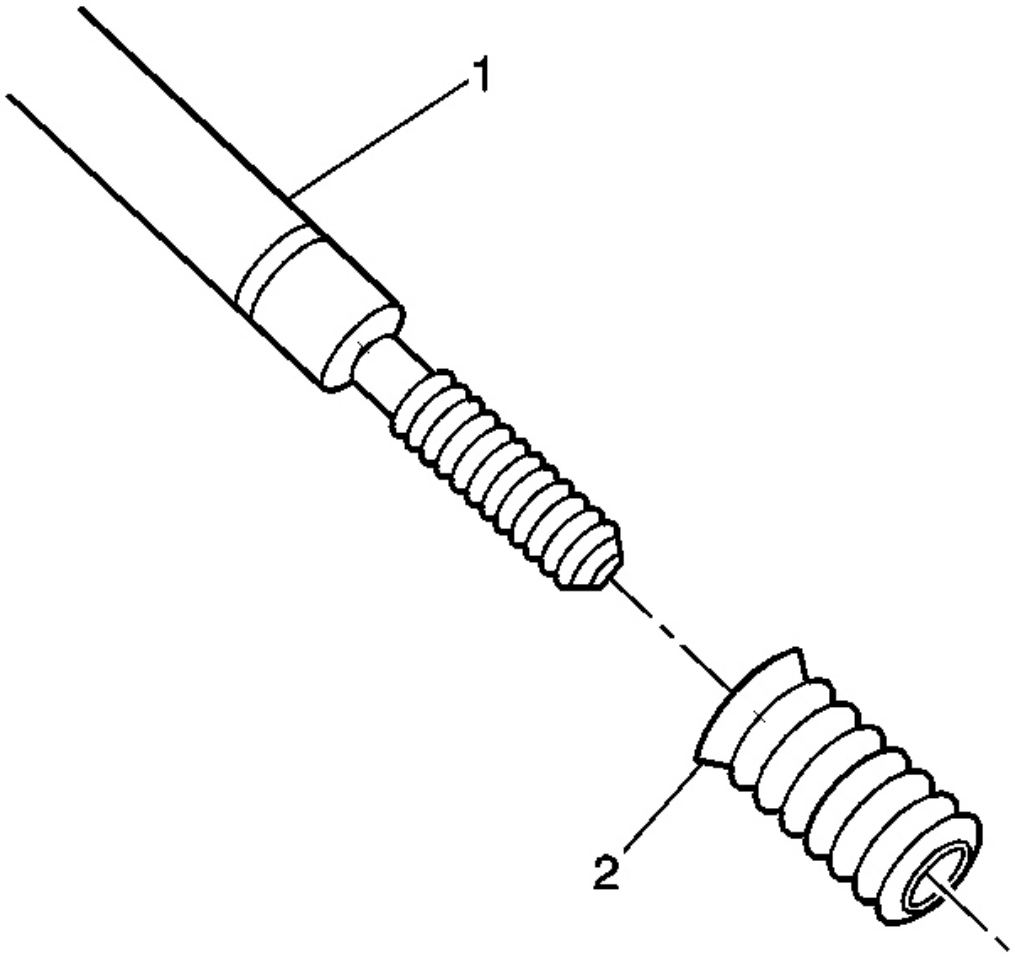


Fig. 498: Installing The Insert Onto The Driver Tool
Courtesy of GENERAL MOTORS CORP.

10. Install the insert (2) onto the driver tool (1).

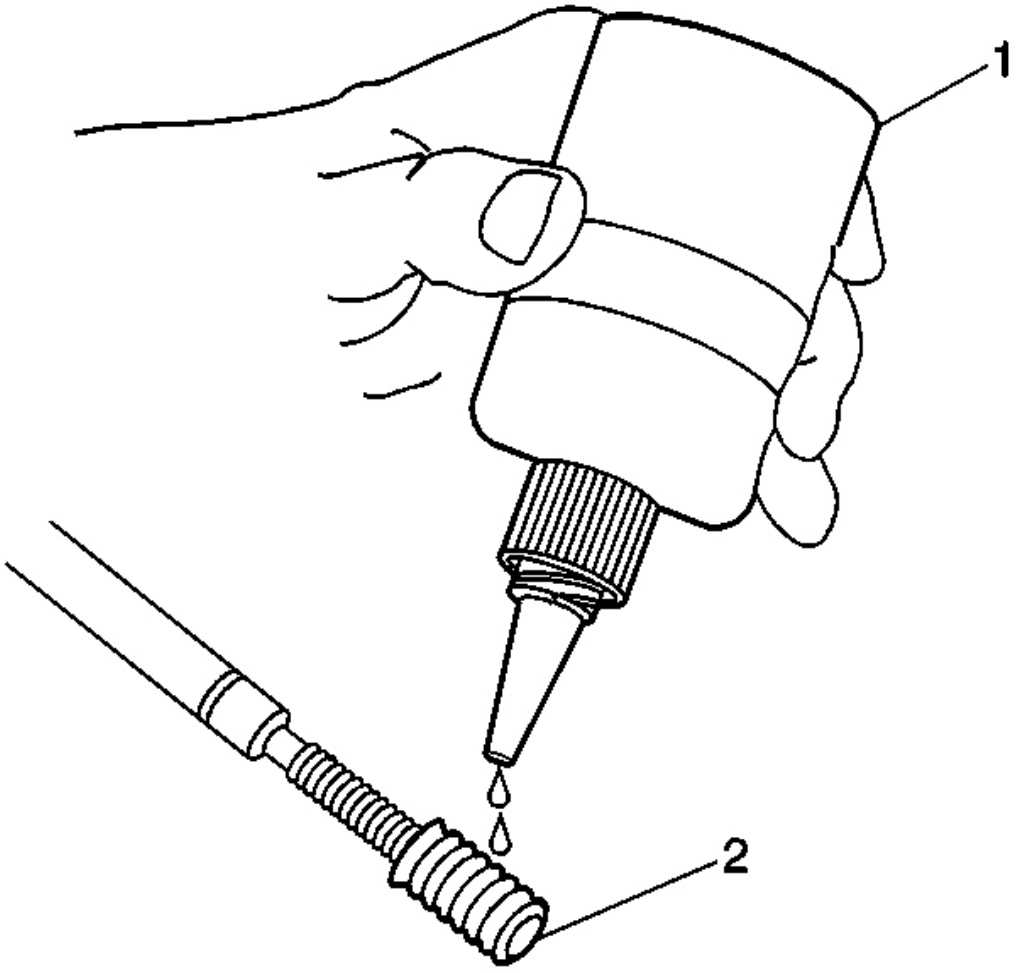


Fig. 499: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

11. Apply threadlock LOCTITE(tm) 277, J 42385-109 (1), or equivalent to the insert OD threads (2).

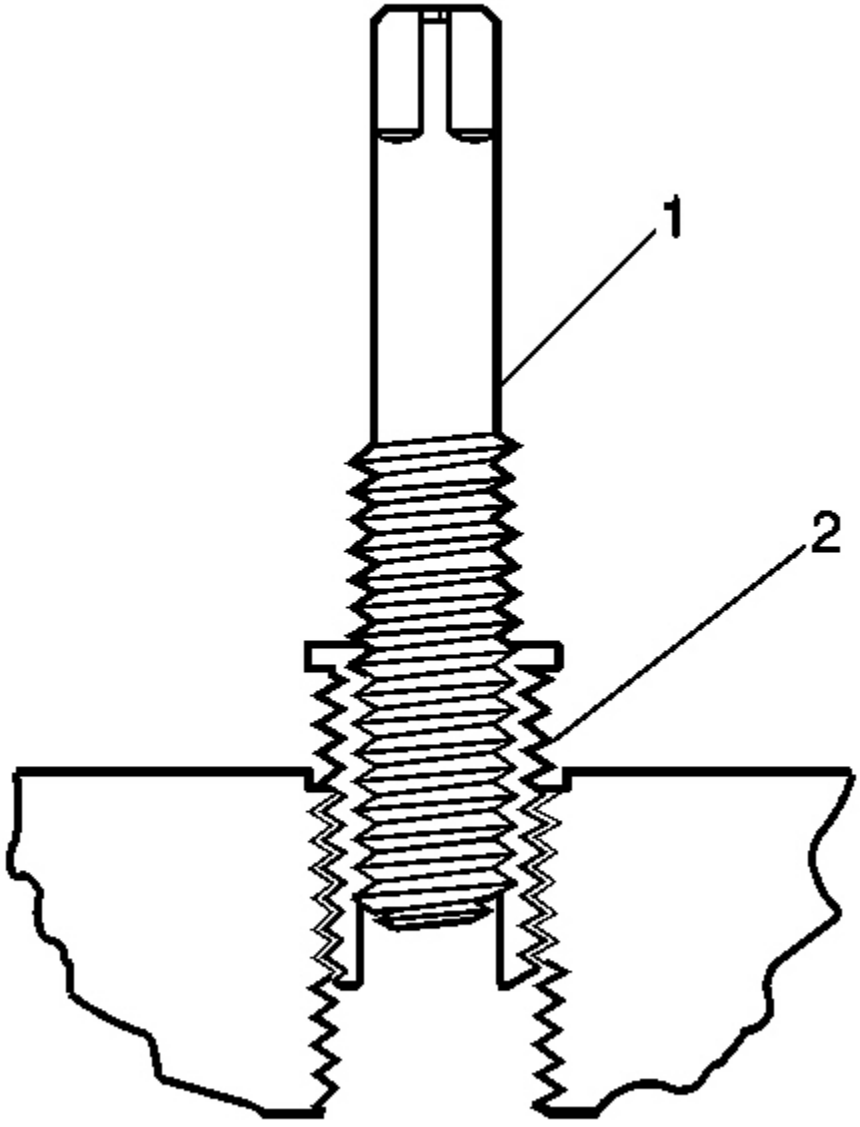


Fig. 500: Installing Insert Into Bolt Hole Using Installer Tool
Courtesy of GENERAL MOTORS CORP.

12. Install the insert (2) into the hole.

    Install the insert until the flange of the insert contacts the counterbored surface. Continue to rotate the installer tool (1) through the insert.

The installer tool will tighten up before screwing completely through the insert. This is acceptable. You are forming the bottom threads of the insert and mechanically locking the insert to the base material threads.

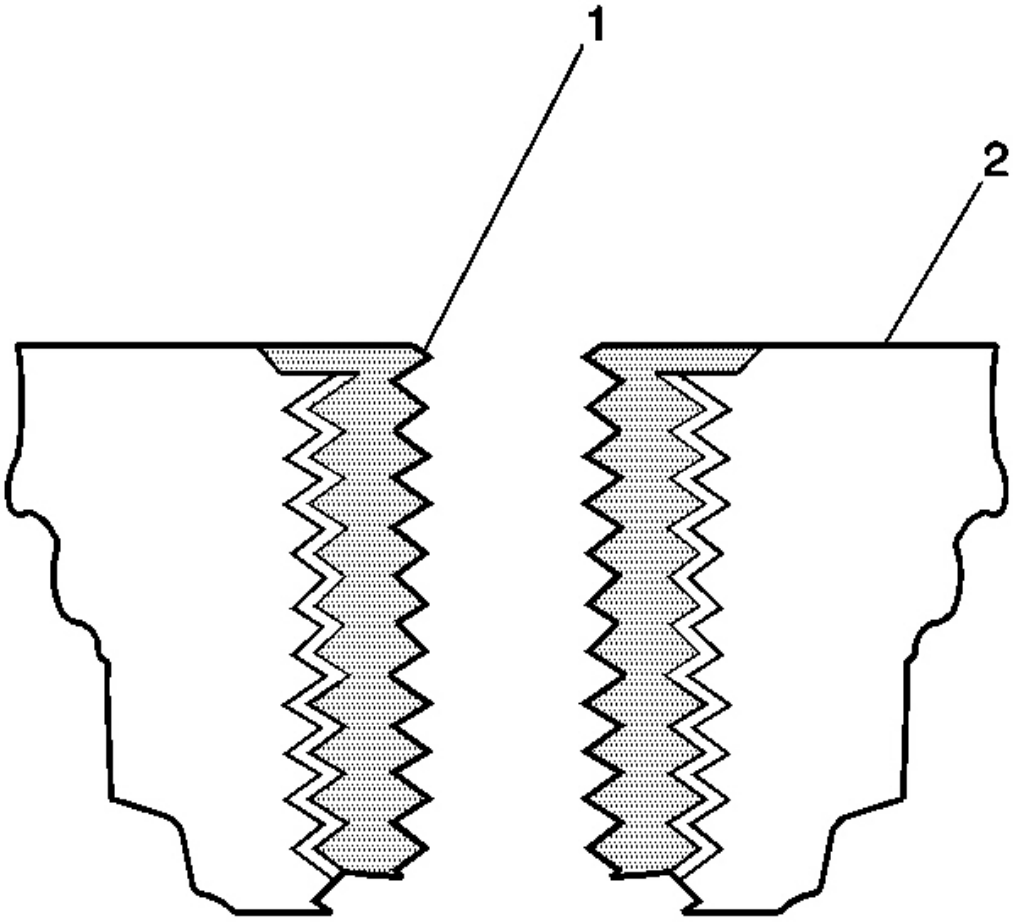


Fig. 501: View Of Bushing Type Insert & Base Material
Courtesy of GENERAL MOTORS CORP.

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

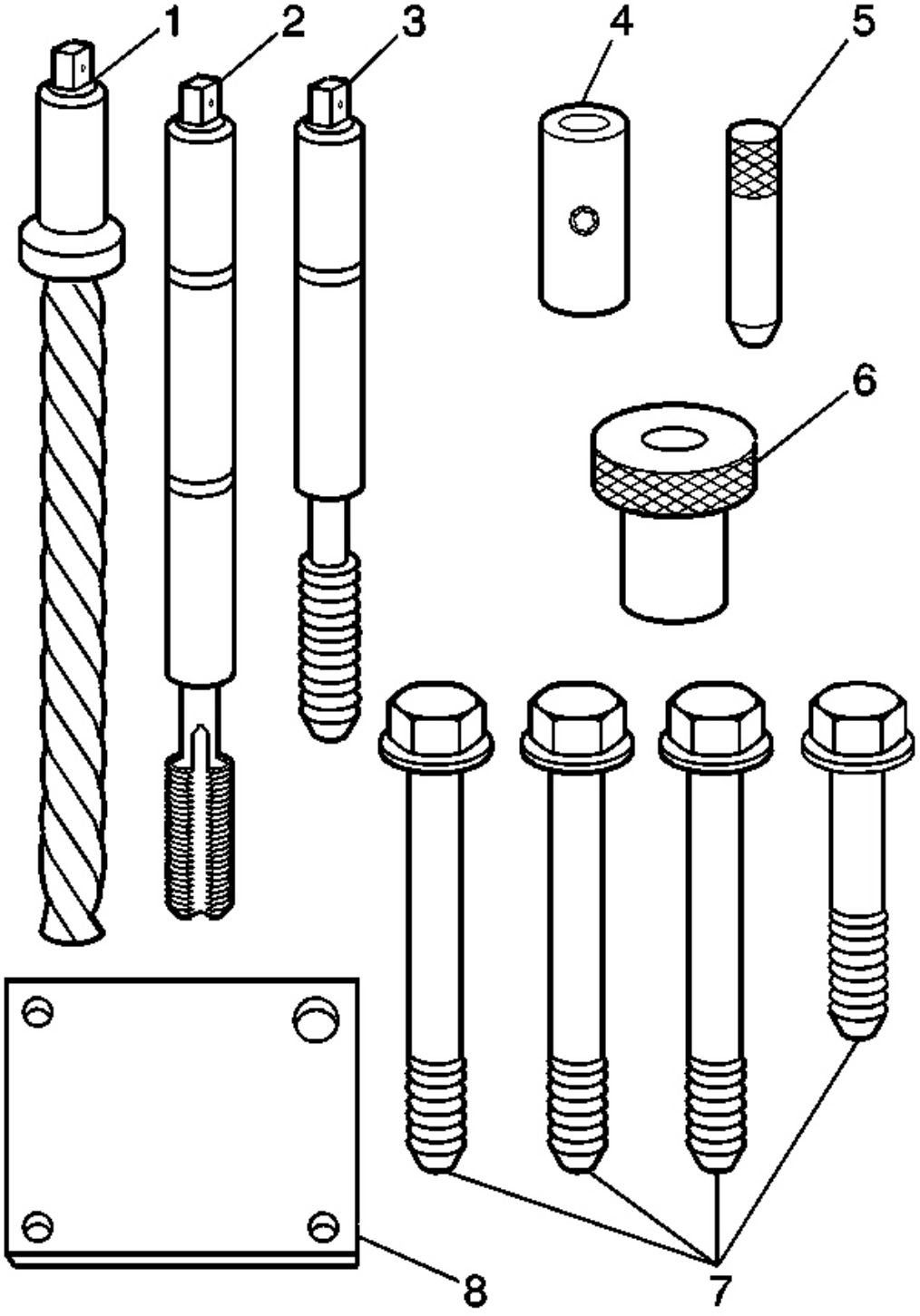

1
2
3
4
5
6
7
8

Fig. 502: View Of Cylinder Head Bolt Hole Thread Repair Kit
Courtesy of GENERAL MOTORS CORP.

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)

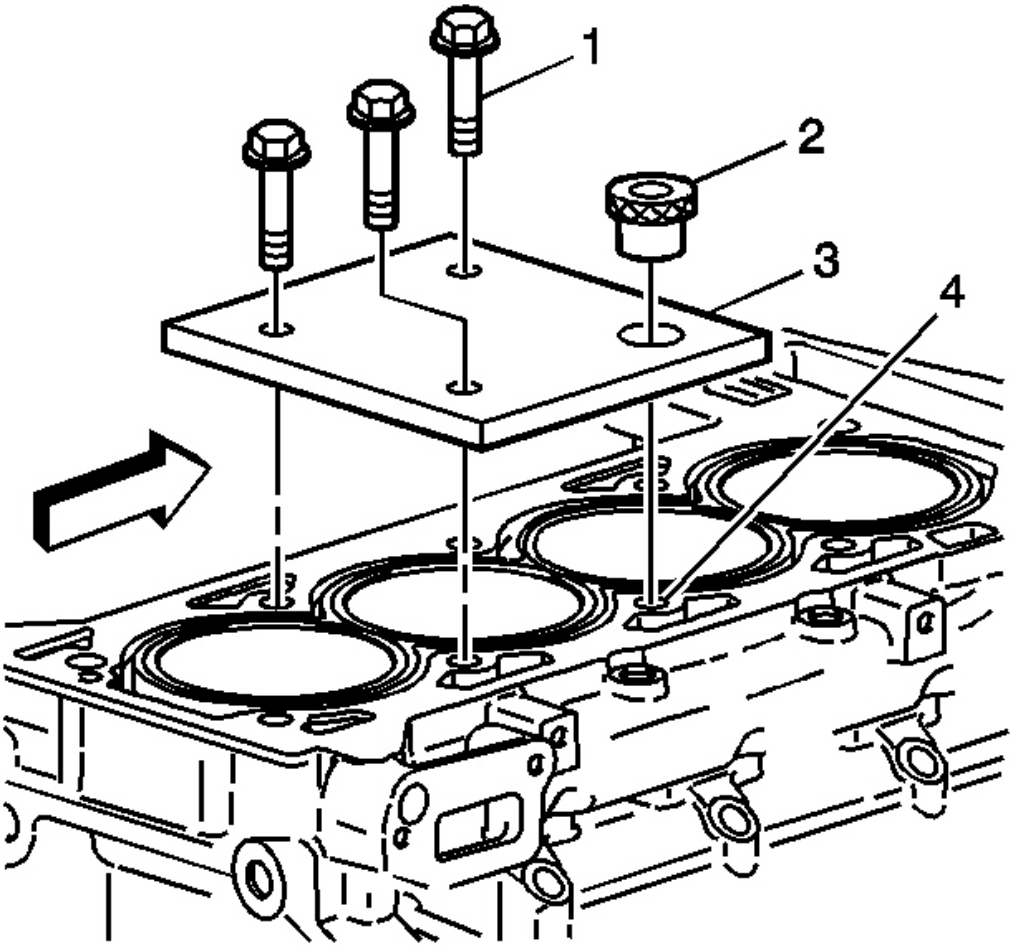


Fig. 503: View Of Fixture Plate
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

IMPORTANT: The use of a cutting type fluid P/N 1052864, WD 40(R), or equivalent, is recommended when performing the drilling and tapping procedures.
Driver oil MUST be used on the installer driver tool.
The tool kits are designed for use with either a suitable tap wrench or drill motor.

2. Install the fixture plate (3), bolts (1), and bushing (2) onto the engine block deck.

Position the fixture plate and bushing over the hole that is to be repaired (4).

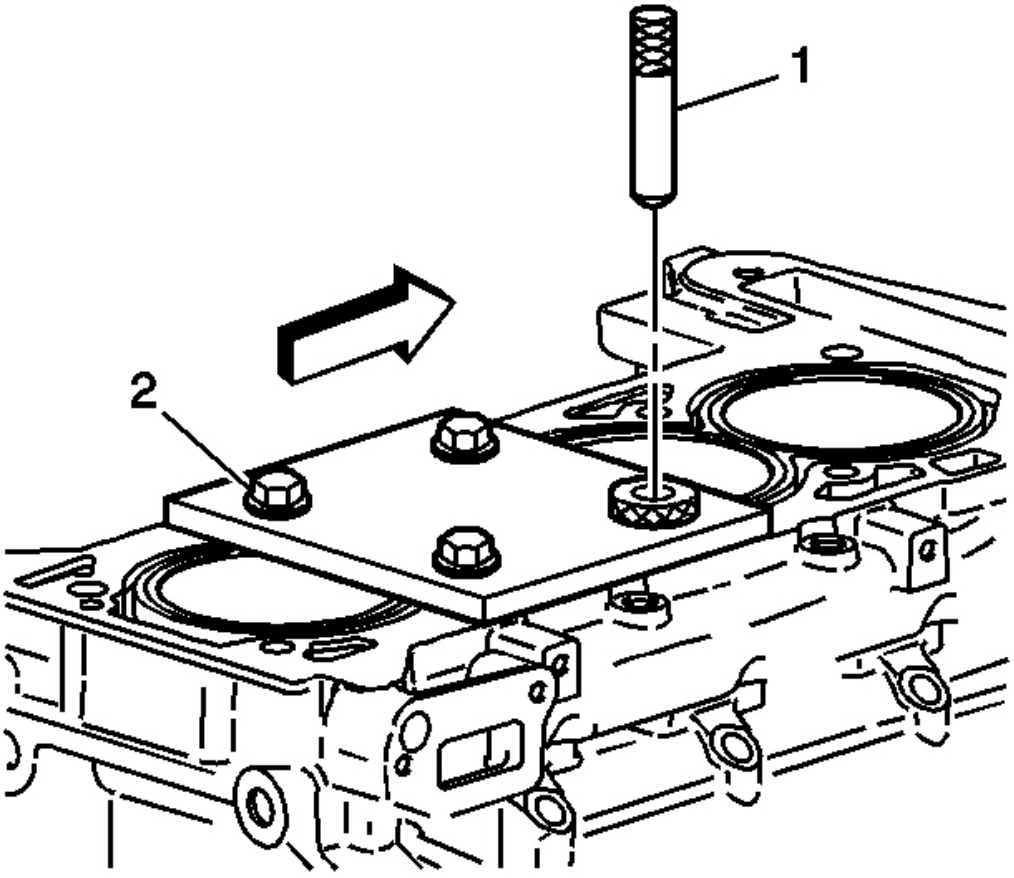


Fig. 504: Positioning Alignment Pin
Courtesy of GENERAL MOTORS CORP.

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.

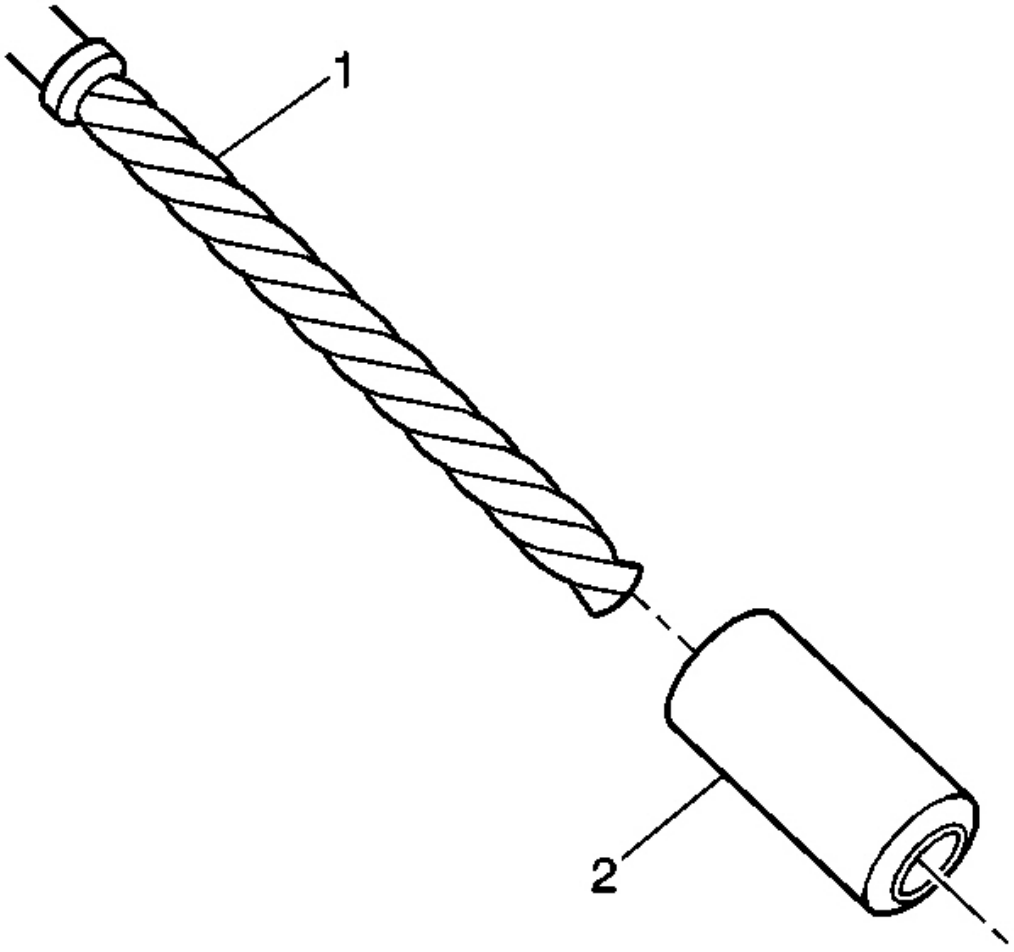


Fig. 505: Identifying Repair Kit Sleeve
Courtesy of GENERAL MOTORS CORP.

6. Install the sleeve (2) onto the drill (1), if required.

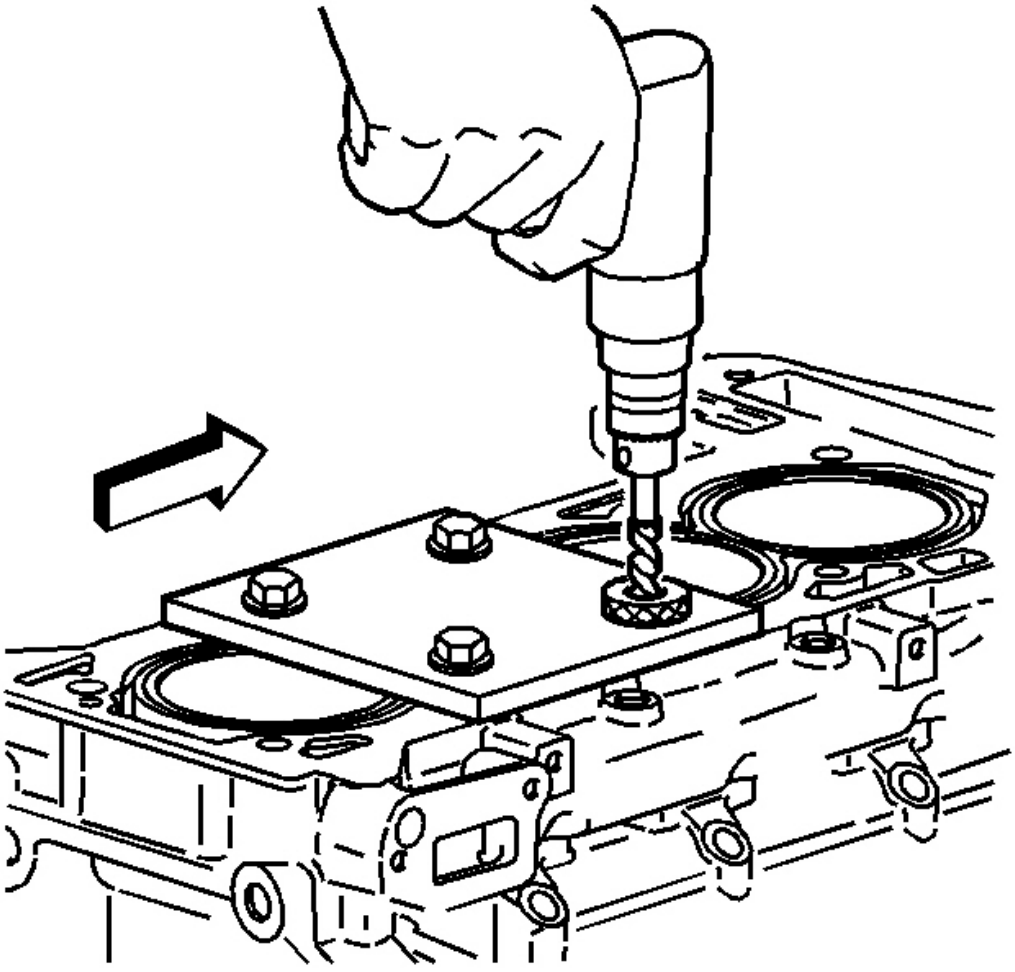


Fig. 506: Drilling Out The Threads Of The Damaged Hole
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: During the reaming process, it is necessary to repeatedly remove the drill and clean the chips from the hole.

7. Drill out the threads of the damaged hole.

   Drill the hole until the stop collar of the drill bit or the sleeve contacts the bushing.

8. Using compressed air, clean out any chips.

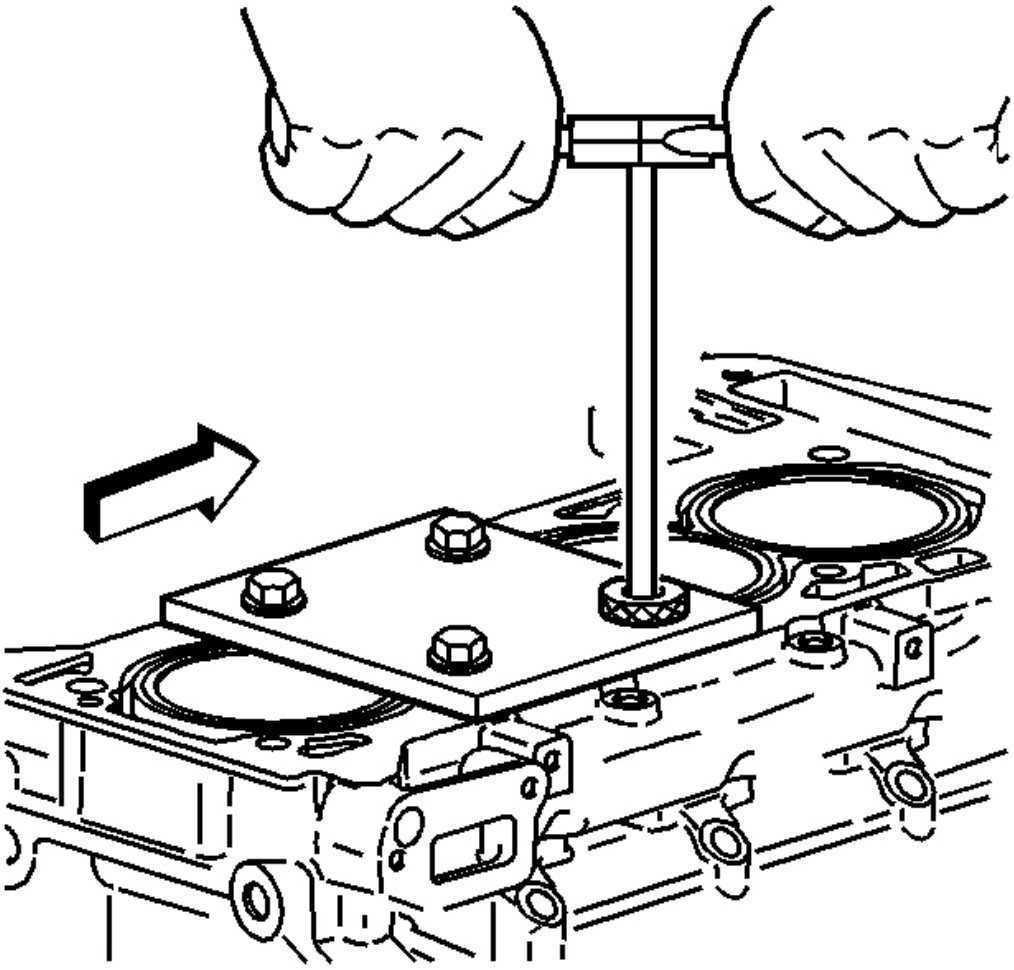


Fig. 507: Tapping Threads Of The Drilled Hole
Courtesy of GENERAL MOTORS CORP.

9. Using a tap wrench, tap the threads of the drilled hole.

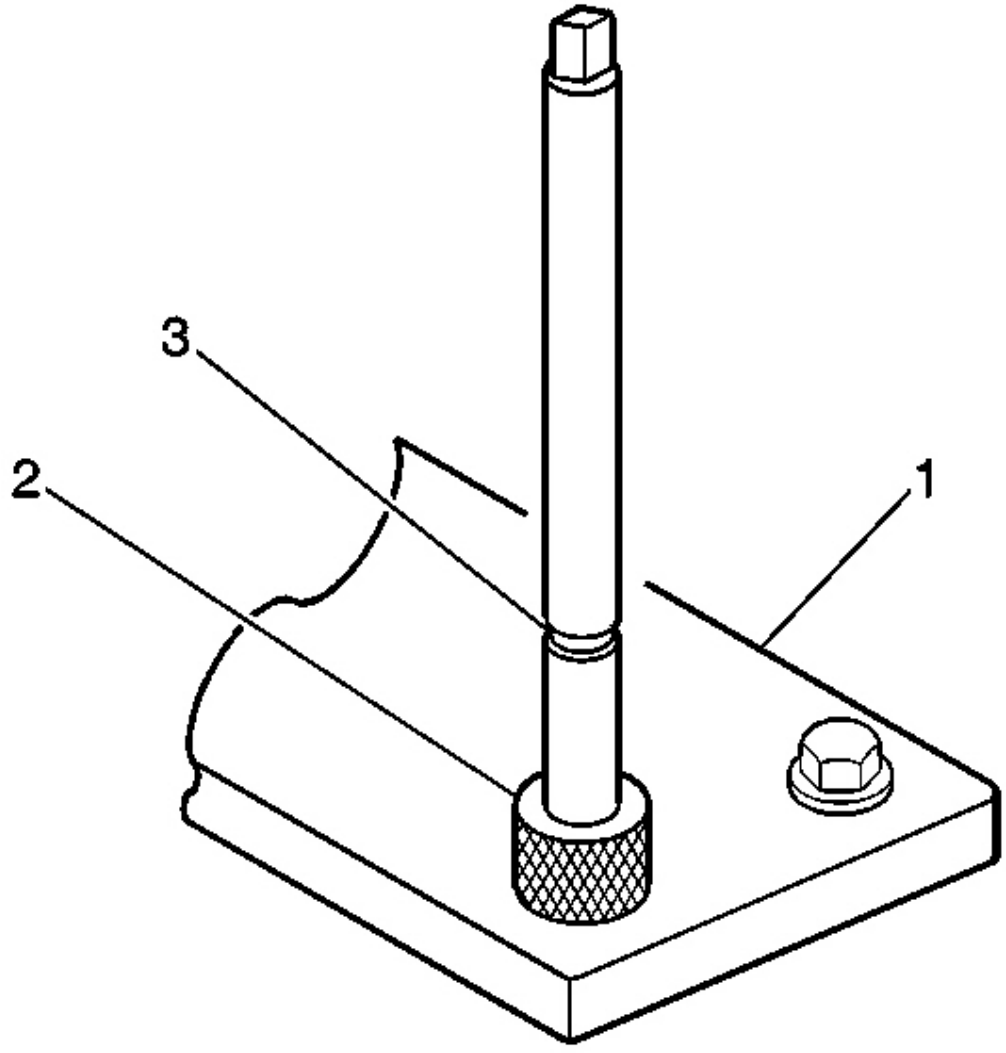


Fig. 508: View Of Driver, Bushing & Tool Marking
Courtesy of GENERAL MOTORS CORP.

10. Using a TAP wrench, tap the threads of the drilled hole.

    In order to tap the new threads to the proper depth, rotate the tap into the hole until the mark (3) on the tap align with the top of the drill bushing (2).

11. Remove the fixture plate (1), bushing (2), and bolts.
12. Using compressed air, clean out any chips.

13. Spray cleaner GM P/N 12346139, GM P/N 12377981, or equivalent, into the hole.
14. Using compressed air, clean any cutting oil and chips out of the hole.

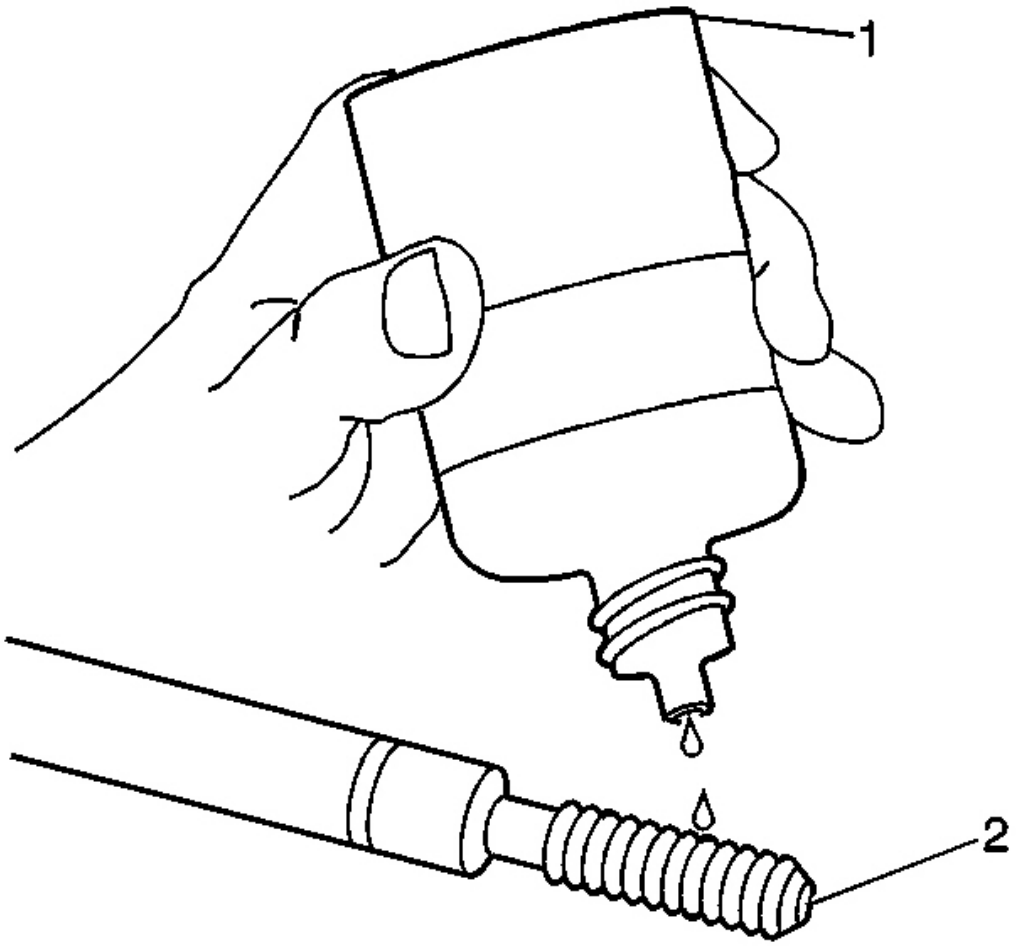


Fig. 509: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

15. Lubricate the threads of the installer tool (2) with the driver oil (1).

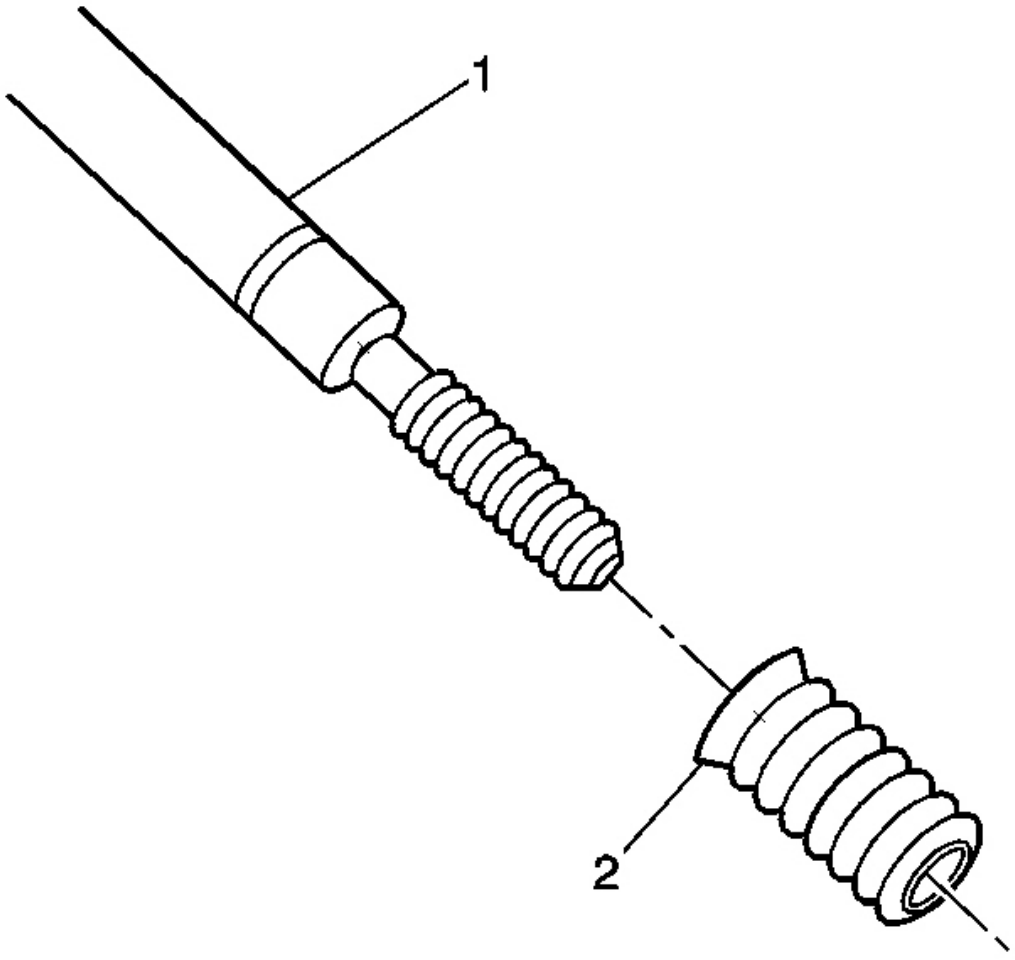


Fig. 510: Installing The Insert Onto The Driver Tool
Courtesy of GENERAL MOTORS CORP.

16. Install the insert (2) onto the driver tool (1).

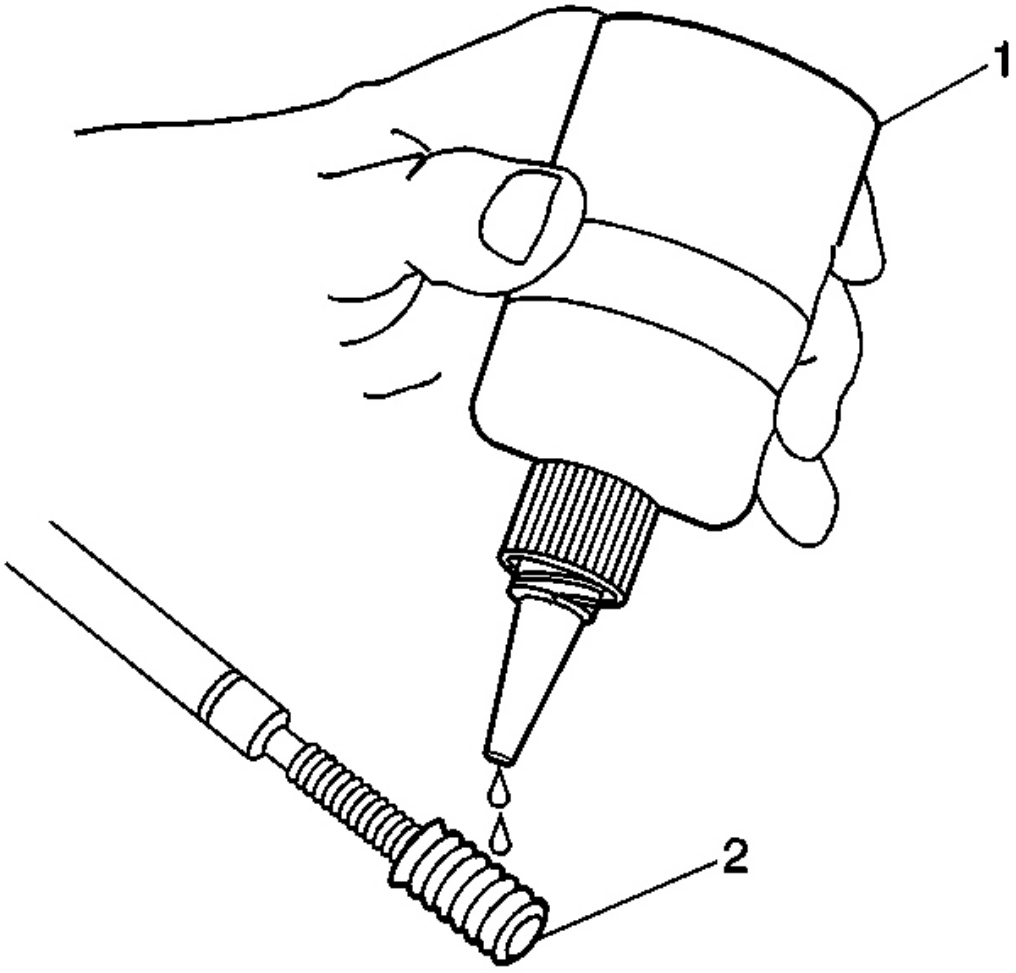


Fig. 511: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

17. Apply threadlock LOCTITE(tm) 277, J 42385-109 (1), or equivalent to the insert OD threads (2).

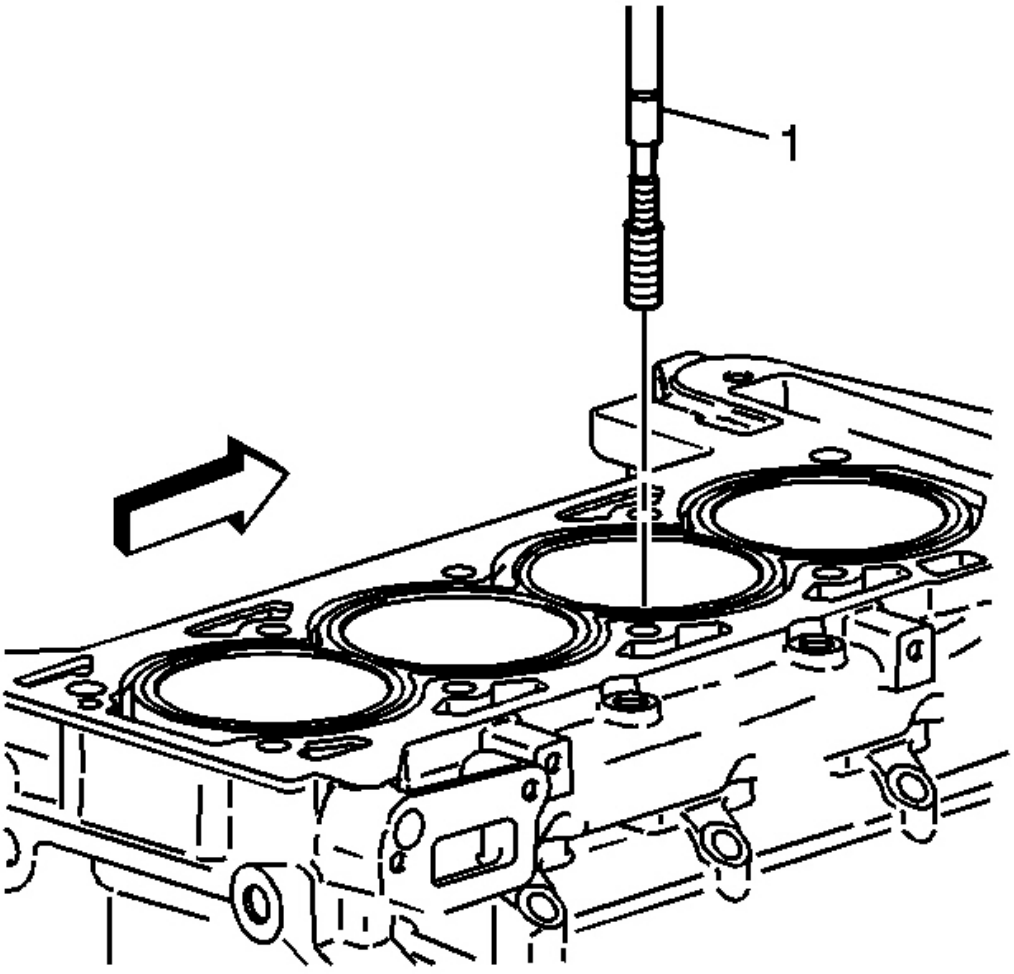


Fig. 512: View Of Insert Driver Tool
Courtesy of GENERAL MOTORS CORP.

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

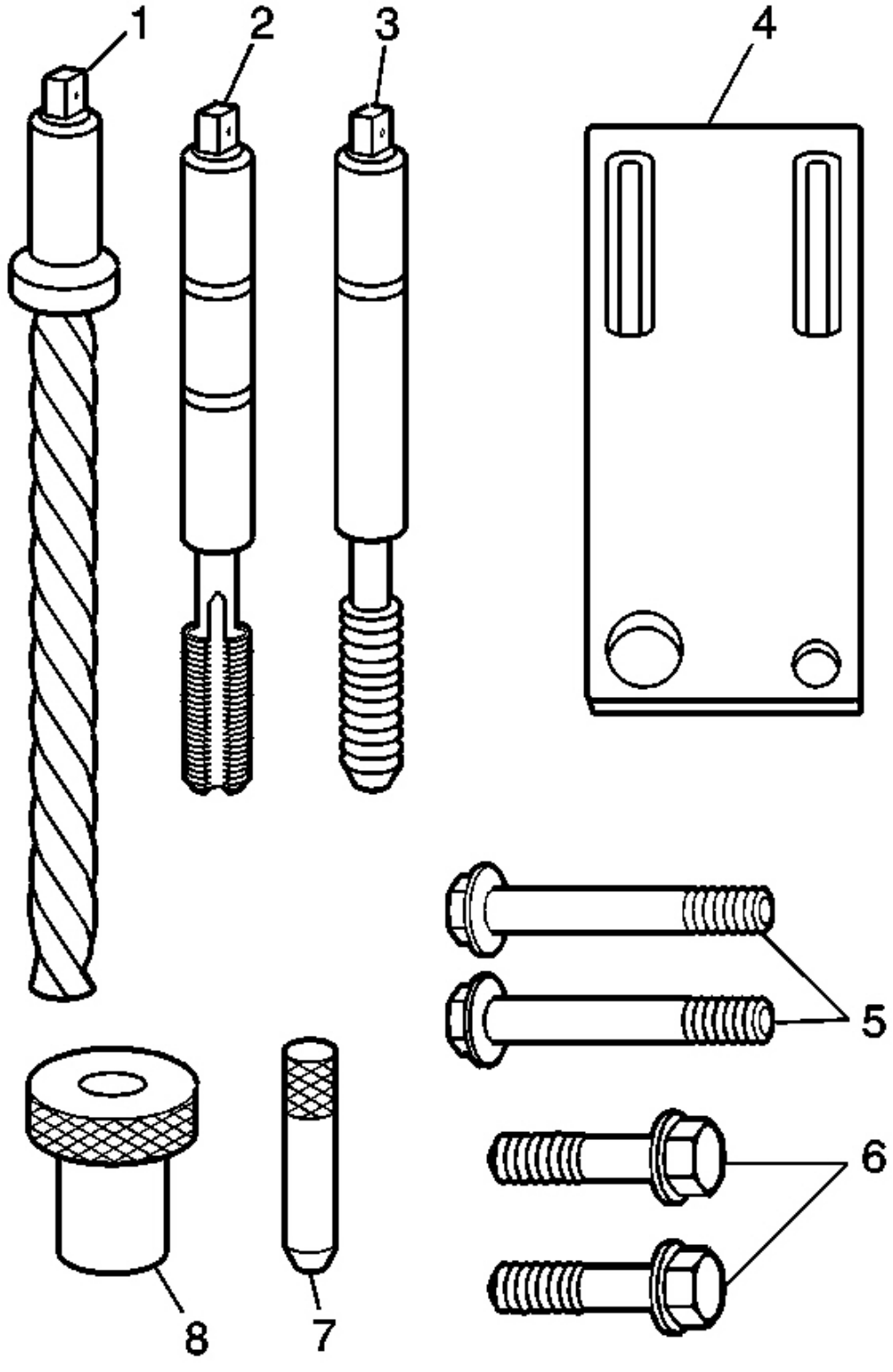

1
2
3
4
5
6
7
8

Fig. 513: Exploded View Of Main Cap Bolt Hole Thread Repair Kit
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)
    - Fixture Plate (4)
    - Long Bolts (5)
    - Short Bolts (6)
    - Alignment Pin (7)
    - Bushing (8)

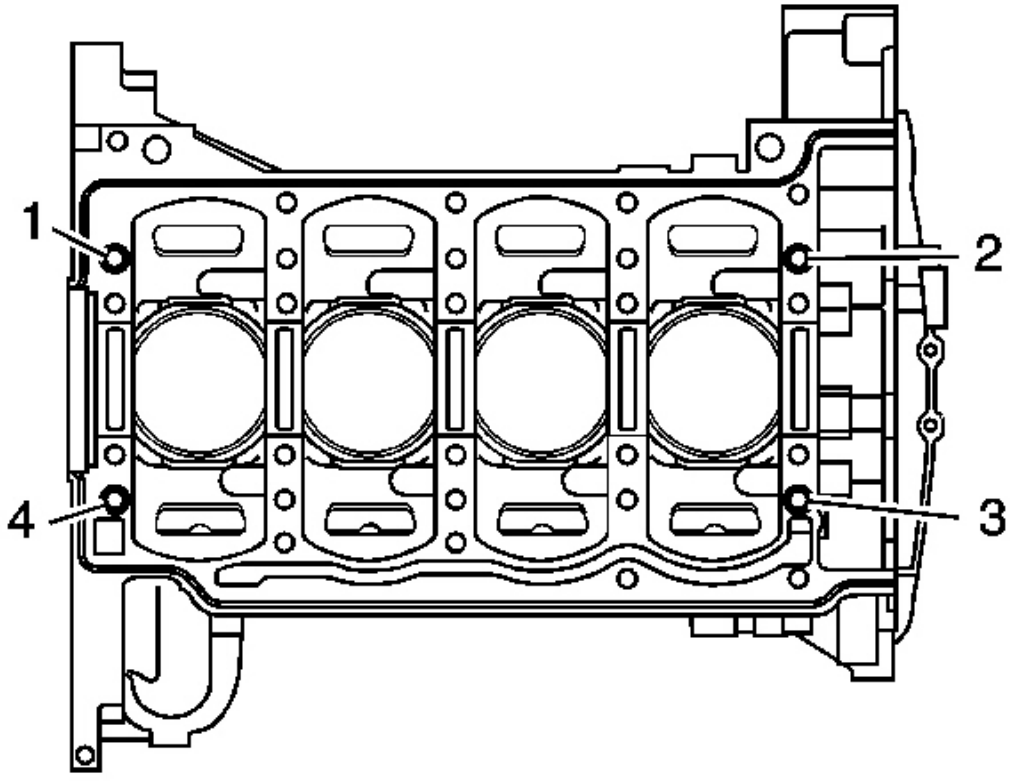


Fig. 514: Identifying Alignment Dowel Pins
Courtesy of GENERAL MOTORS CORP.

2. Remove the alignment doll pins on the holes (1-4), if necessary.

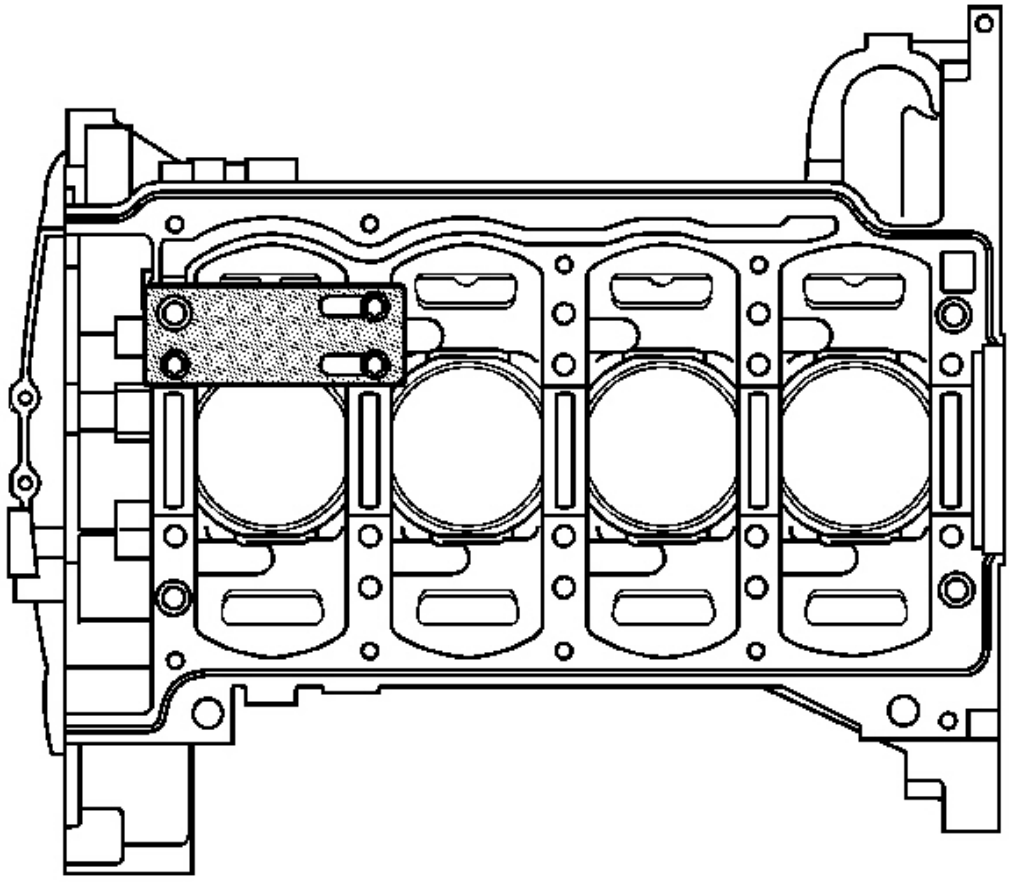


Fig. 515: View Of Fixture Plate
Courtesy of GENERAL MOTORS CORP.

3. Install the fixture plate, bolt, and bushing, onto the engine block.

   Position the fixture plate and bushing over the hole that is to be repaired.

4. Position the alignment pin in the desired hole and tighten the fixture retaining bolts.
5. Drill out the damaged hole.
6. Using compressed air, clean out any chips.

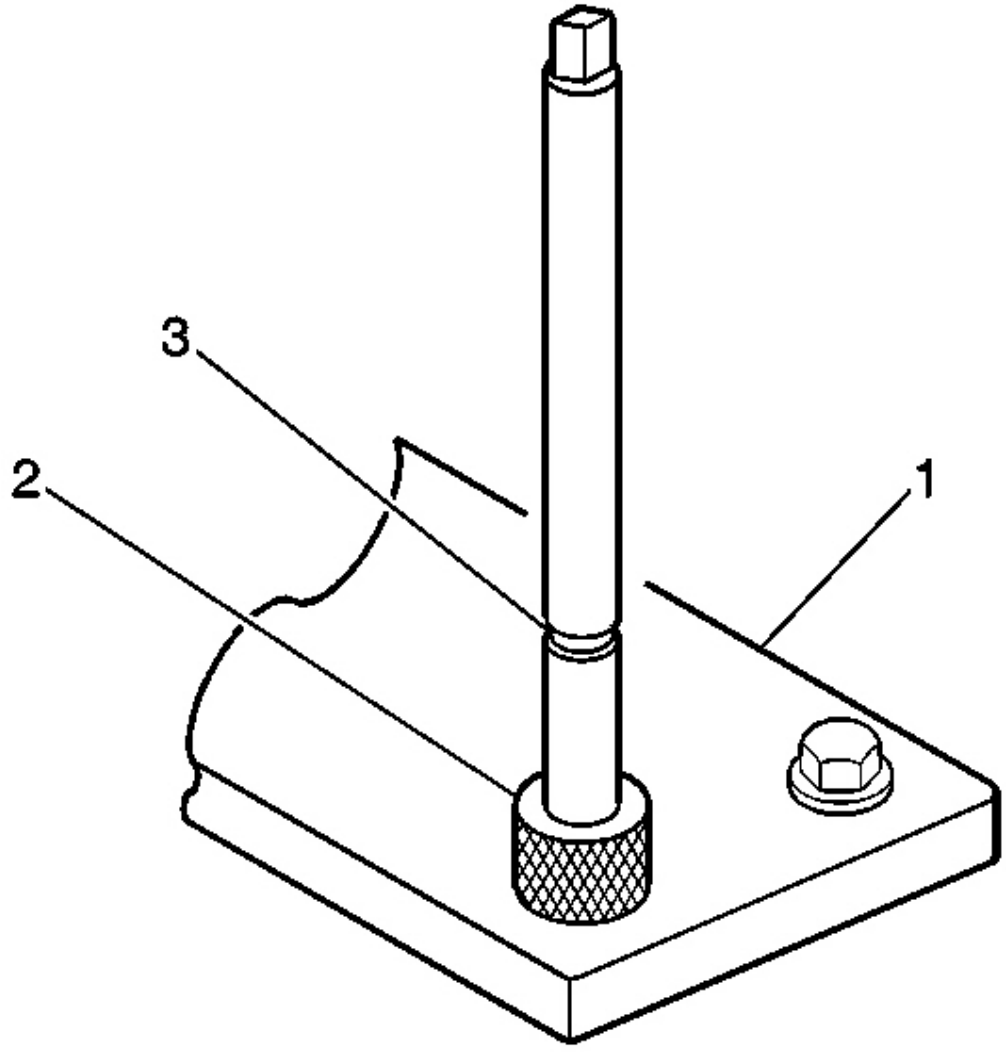


Fig. 516: View Of Driver, Bushing & Tool Marking
Courtesy of GENERAL MOTORS CORP.

7. Using a tap wrench, tap the threads of the drilled hole.

   In order to tap the new threads to the proper depth, rotate the tap into the hole until the mark (3) on the tap aligns with the top of the bushing (2).

8. Using compressed air, clean out any chips.
9. Spray cleaner GM P/N 12346139, or equivalent, into the hole.

10. Using compressed air, clean any cutting oil and chips out of the hole.

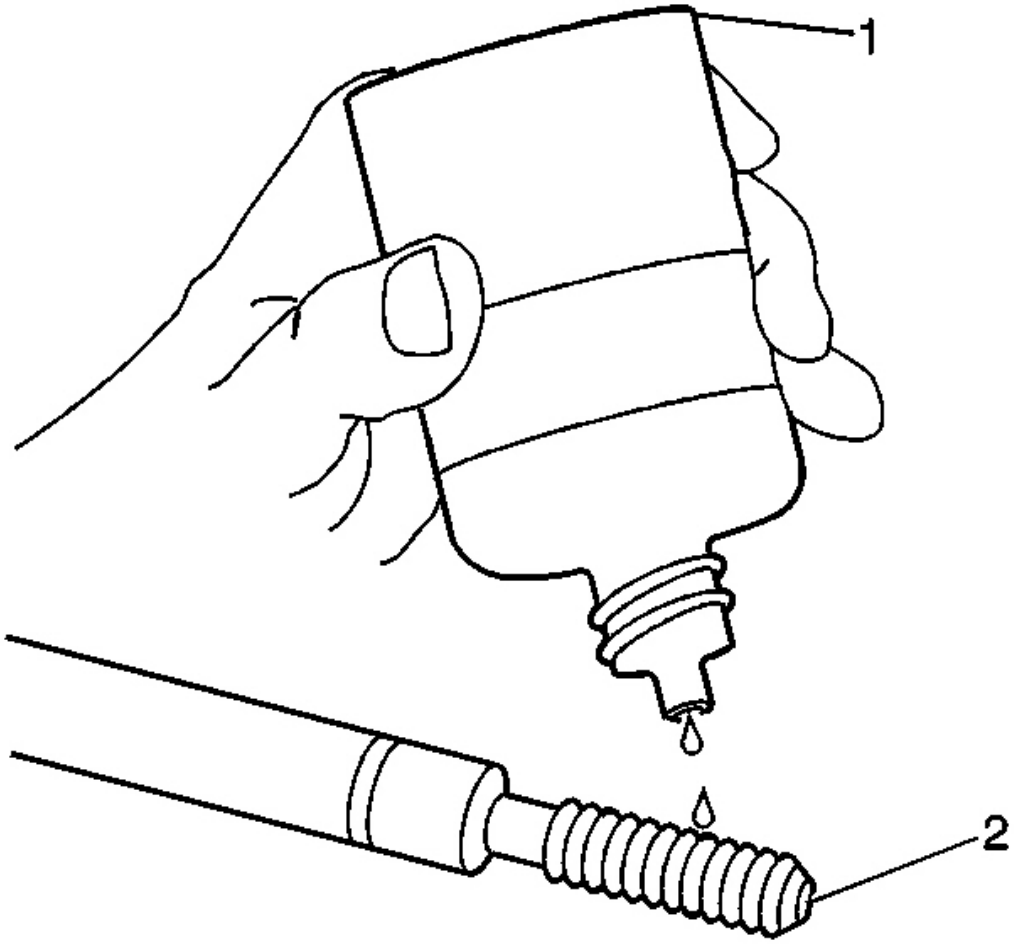


Fig. 517: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

11. Lubricate the threads of the installer tool (2) with the driver oil (1).

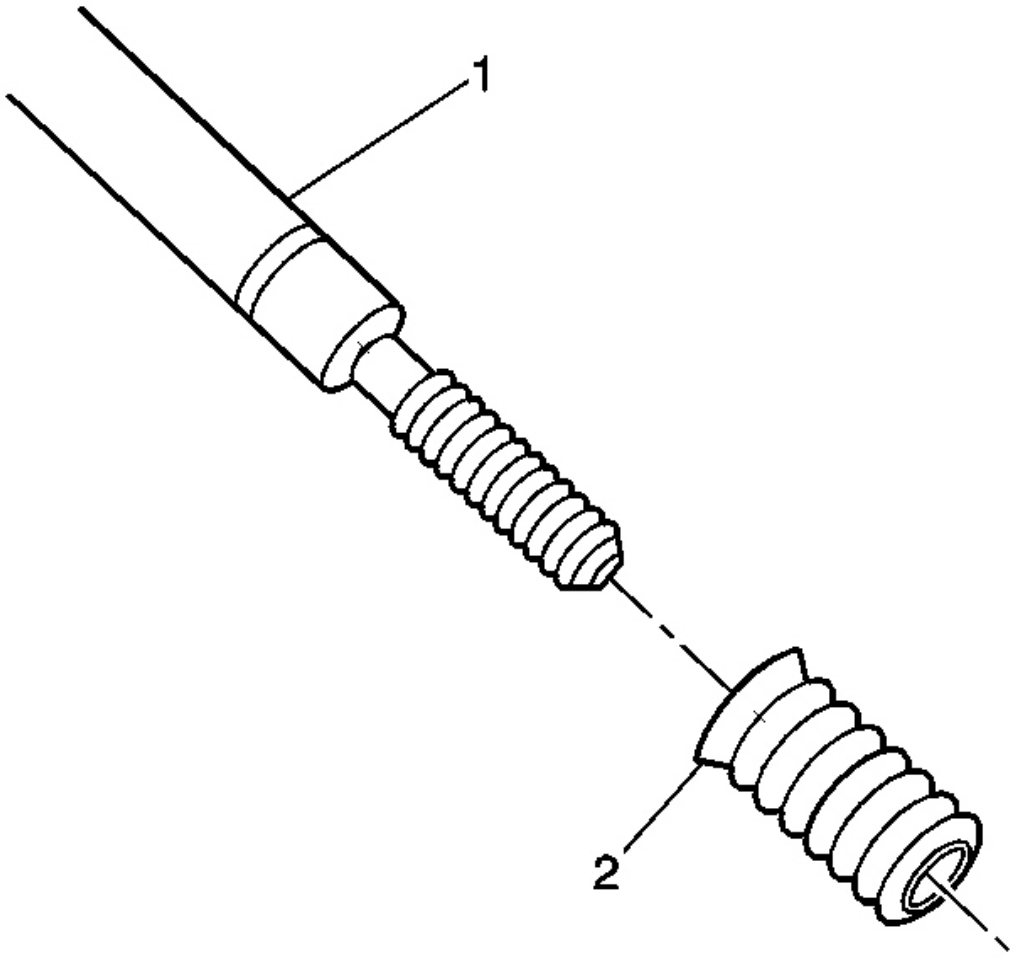


Fig. 518: Installing The Insert Onto The Driver Tool
Courtesy of GENERAL MOTORS CORP.

12. Install the insert (2) onto the driver tool (1).

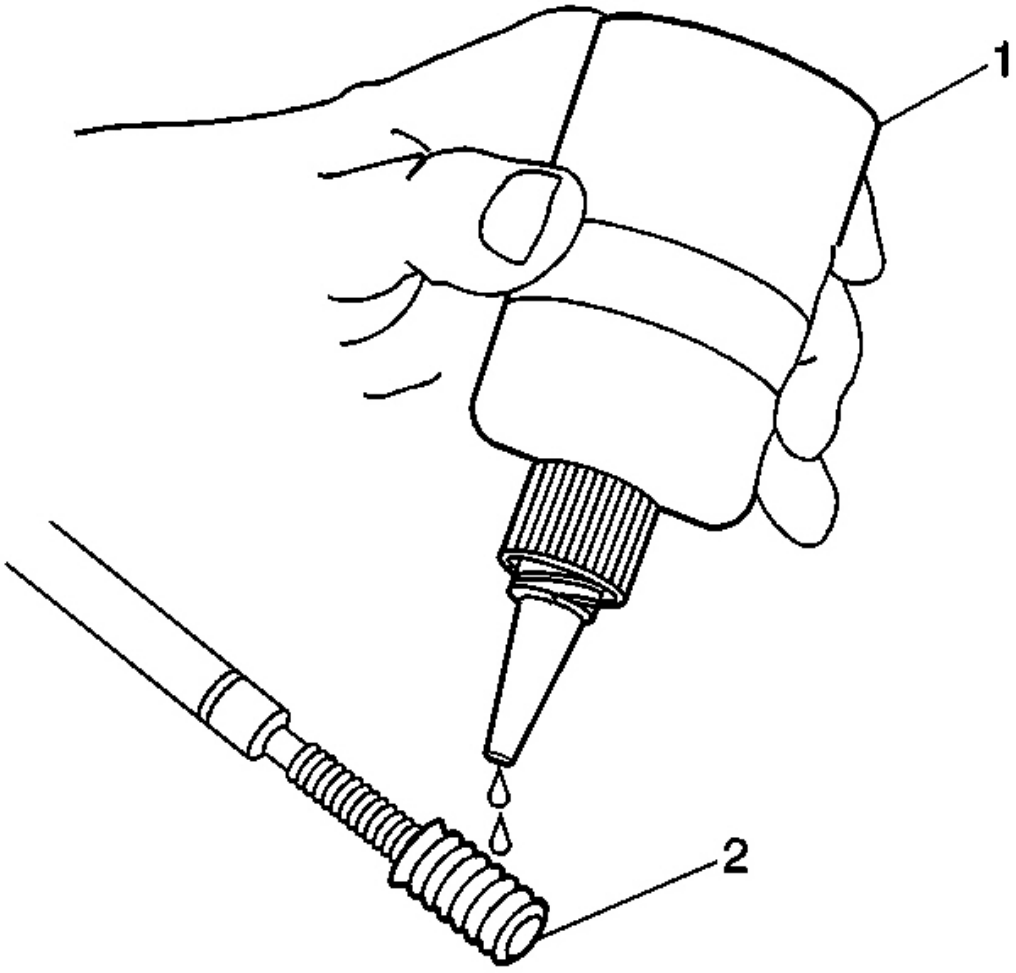


Fig. 519: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

13. Apply threadlock LOCTITE(tm) 277, J 42385-109 (1), or equivalent to the insert OD threads (2).

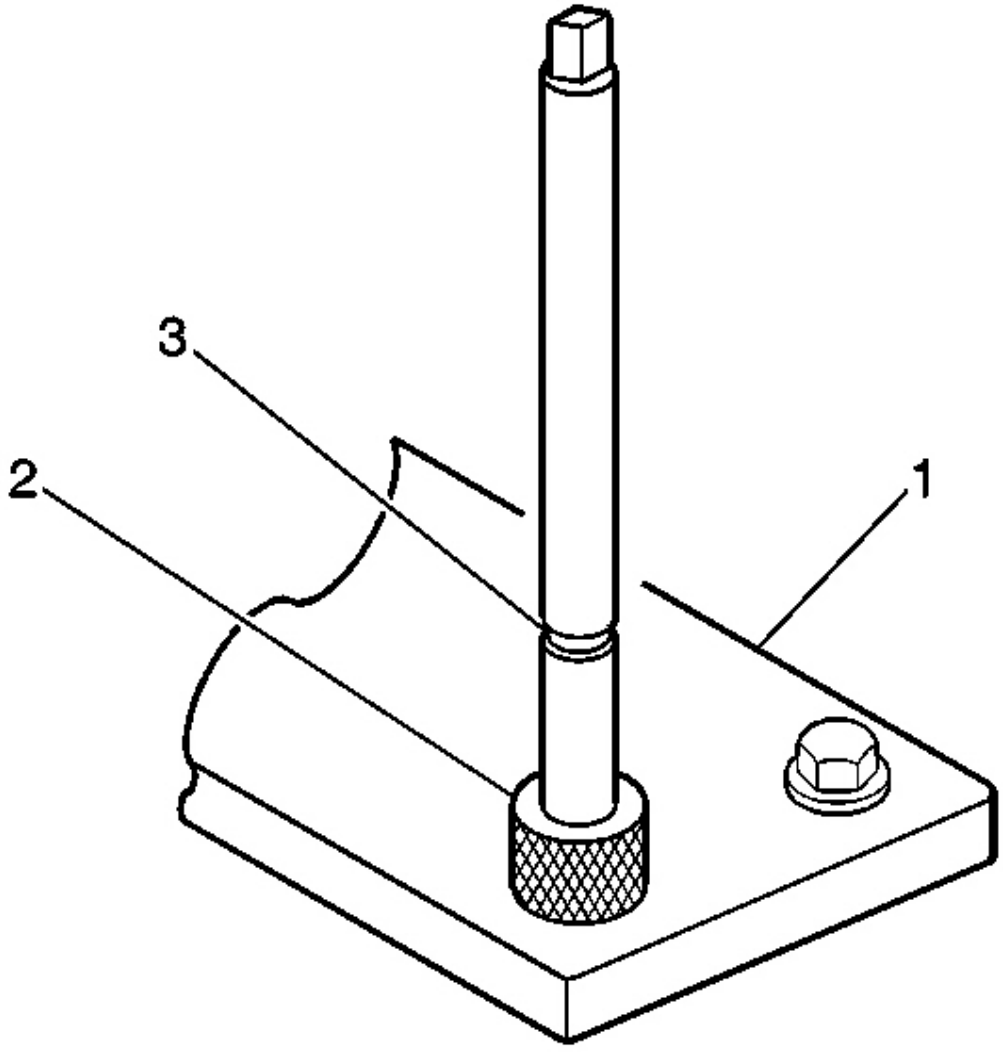


Fig. 520: View Of Driver, Bushing & Tool Marking
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The fixture plate and bushing remains installed onto the engine block during the insert installation procedure.

14. Install the insert and driver through the bushing (2), fixture plate (1) and into the hole.

    Rotate the driver tool until the mark on the tool (3) aligns with the top of the bushing (2).

The installer tool will tighten up before screwing completely through the insert. This is acceptable. You are forming the bottom threads of the insert and mechanically locking the insert to the base material threads.

15. Remove the driver, bushing (2), fixture plate (1), and bolts.

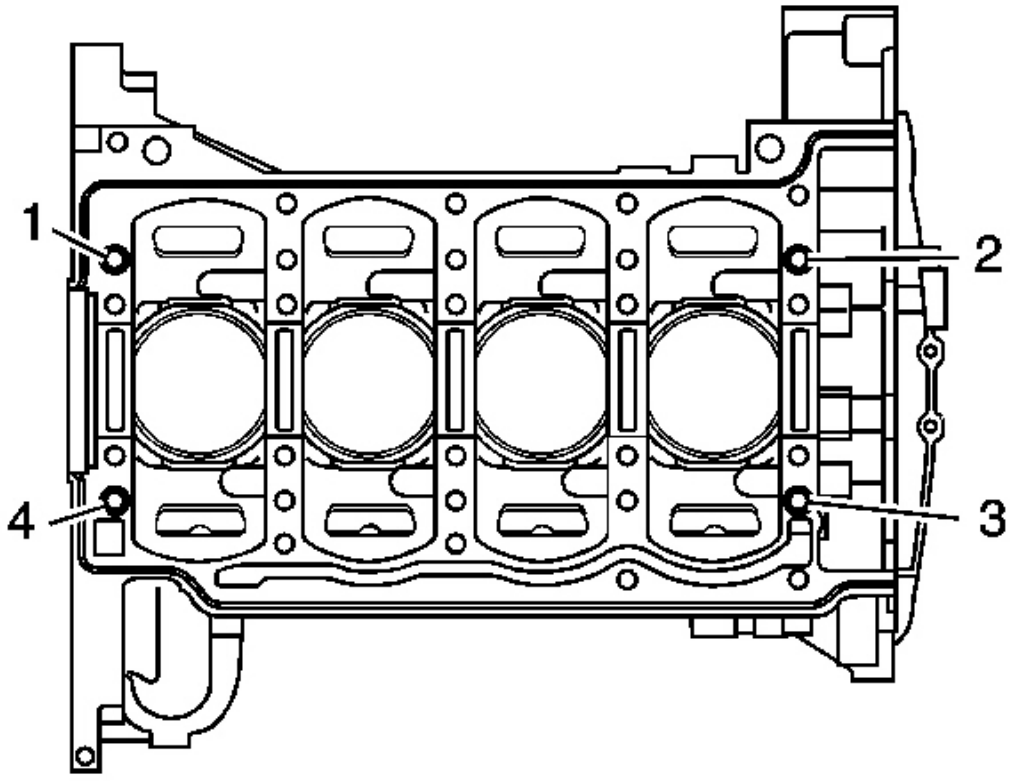


Fig. 521: Identifying Alignment Dowel Pins
Courtesy of GENERAL MOTORS CORP.

16. Install the alignment doll 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 PRELUBING

Tools Required

J 45299 Engine Preluber. See **Special Tools and Equipment** .

Engine Prelubing

1. Locate the oil pressure switch and remove.

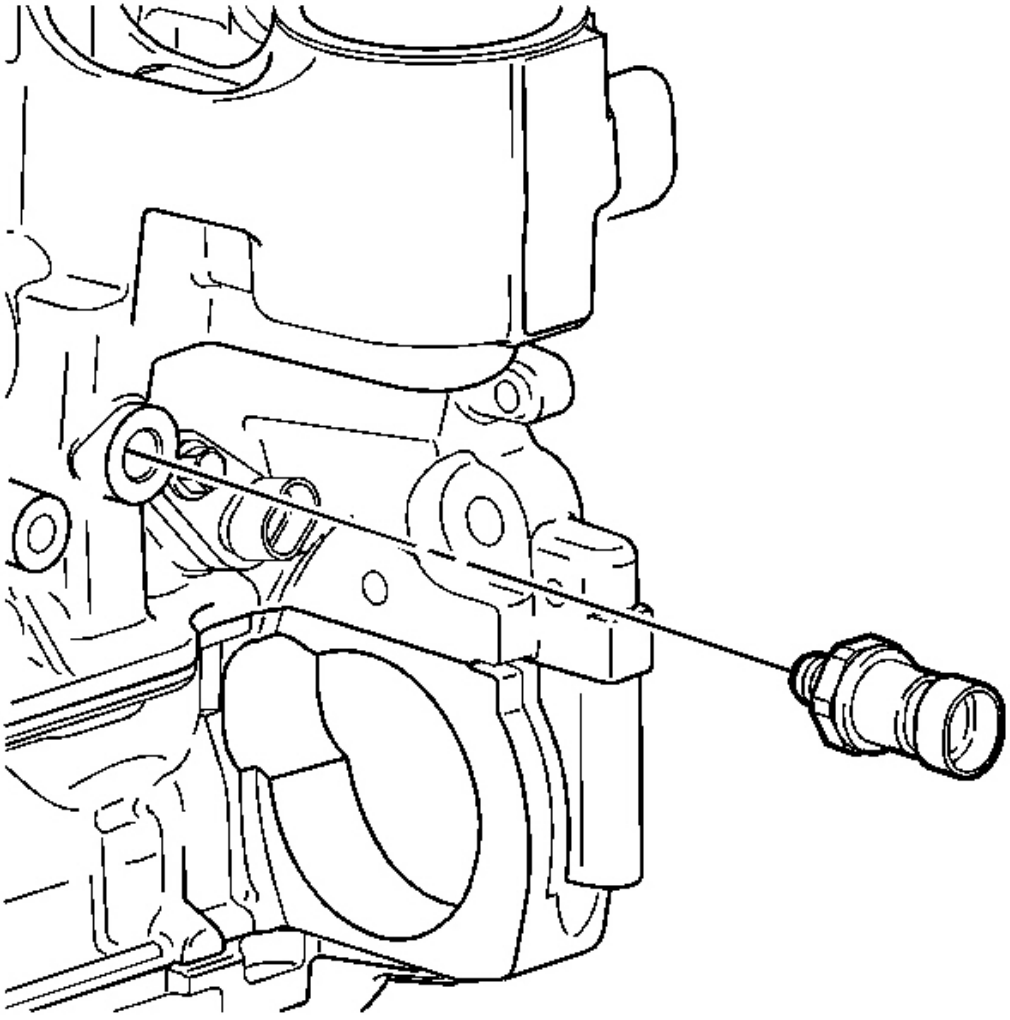


Fig. 522: View Of Engine Oil Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: A constant and continuous flow of clean engine oil is required in order to properly prime the engine. Be sure to use an approved engine oil as specified in the owners manual.

2. Install the M12 x 1.75 adapter P/N 509376.

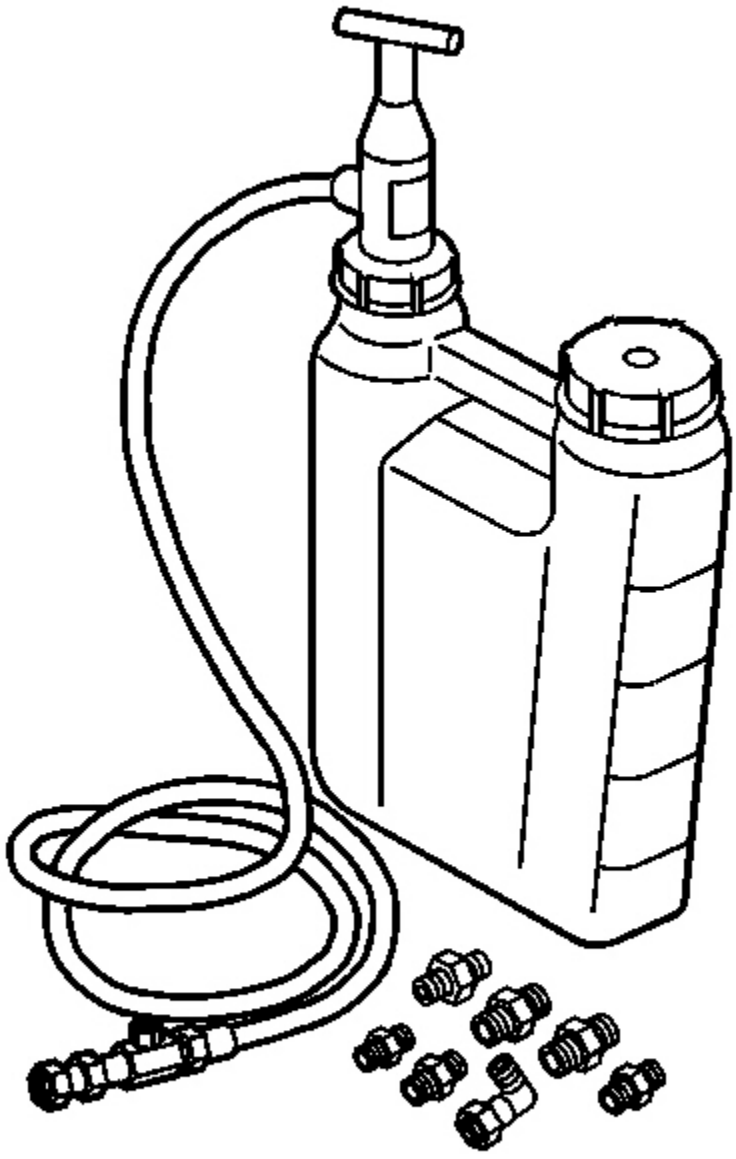


Fig. 523: Identifying J 45299
Courtesy of GENERAL MOTORS CORP.

3. Install the flexible hose to the adapter and open the valve.
4. Pump the handle on the **J 45299** in order to flow a minimum of 1-1. See **Special Tools and Equipment** .9 liters (1-2 quarts) of engine oil. Observe the flow of engine oil through the flexible hose

and into the engine assembly.

5. Close the valve and remove the flexible hose and adapter from the engine.

NOTE: Refer to Fastener Notice in Cautions and Notices.

6. Install the oil pressure switch to the engine.

   Tighten: Tighten the oil pressure switch to 22 N.m (16 lb ft).

7. Top-off the engine oil to the proper level.

ENGINE BLOCK ASSEMBLE

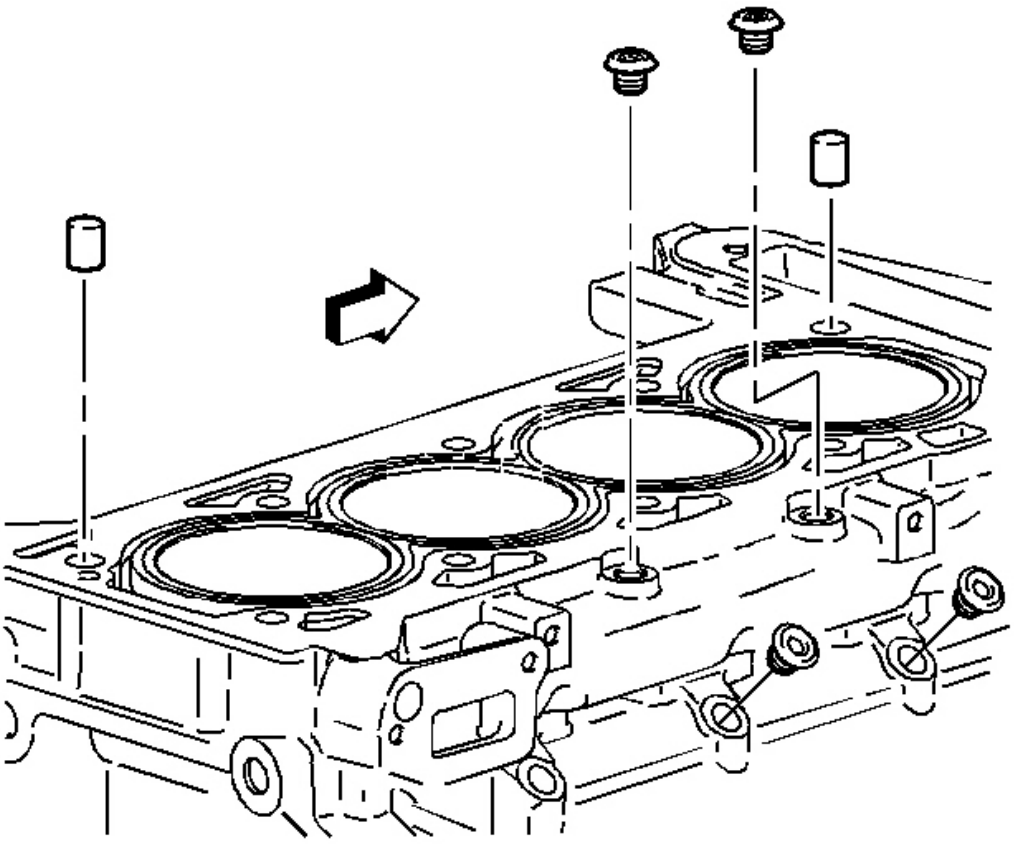


Fig. 524: View Of Oil Passage Plug
Courtesy of GENERAL MOTORS CORP.

1. Install the drain plug in the water pump.
2. Apply sealant P/N 21485278, to the plug before installation.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the coolant jacket plugs.

   Tighten: Tighten the coolant jacket plug to 35 N.m (26 lb ft).

4. Install the rear oil passage plugs.
5. Apply sealant P/N 21485278, to the plugs before installation.

   Tighten: Tighten the oil passage plug to 60 N.m (44 lb ft).

6. Install the other oil passage plugs.
7. Apply sealant P/N 21485278, to the plug before installation.

   Tighten: Tighten the oil passage plugs to 35 N.m (26 lb ft).

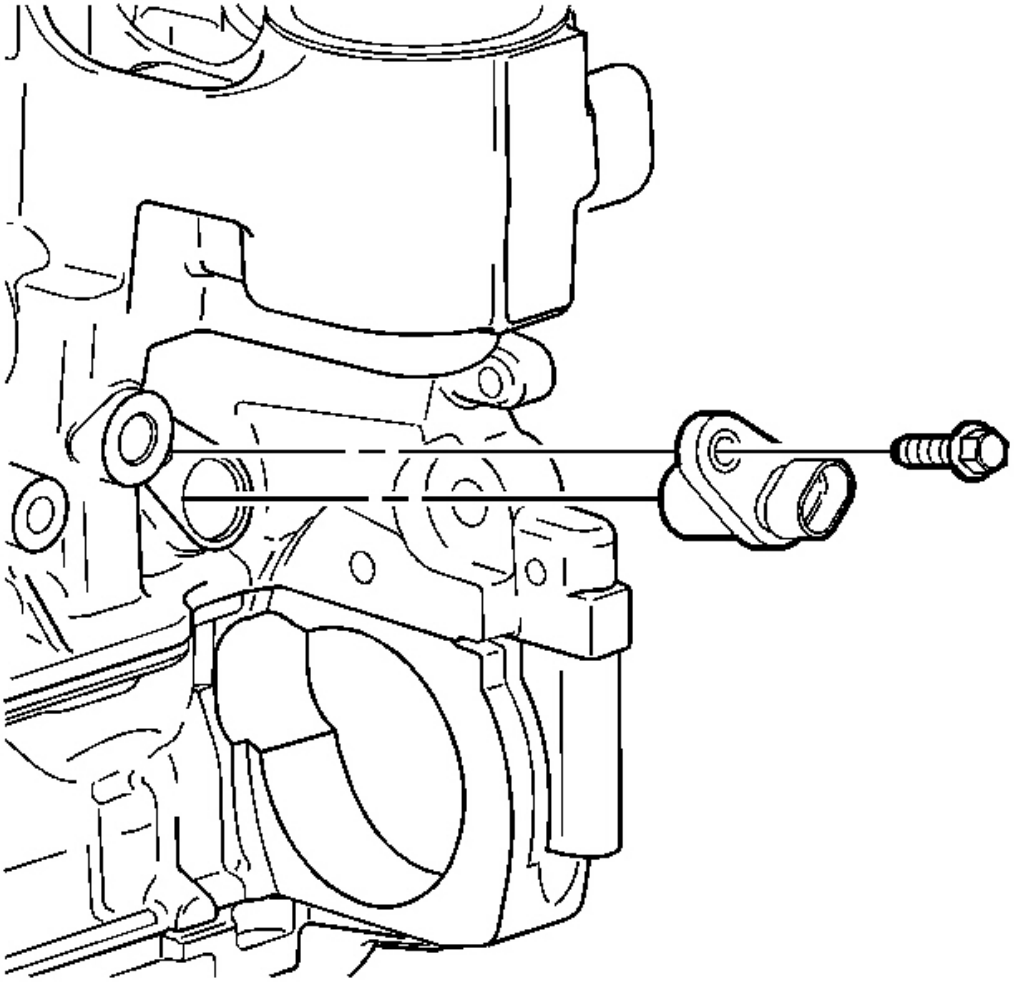


Fig. 525: View Of Crankshaft Position Sensor
Courtesy of GENERAL MOTORS CORP.

8. Lubricate the crankshaft position sensor O-ring with engine oil.
9. Install the crankshaft position sensor and bolt.

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

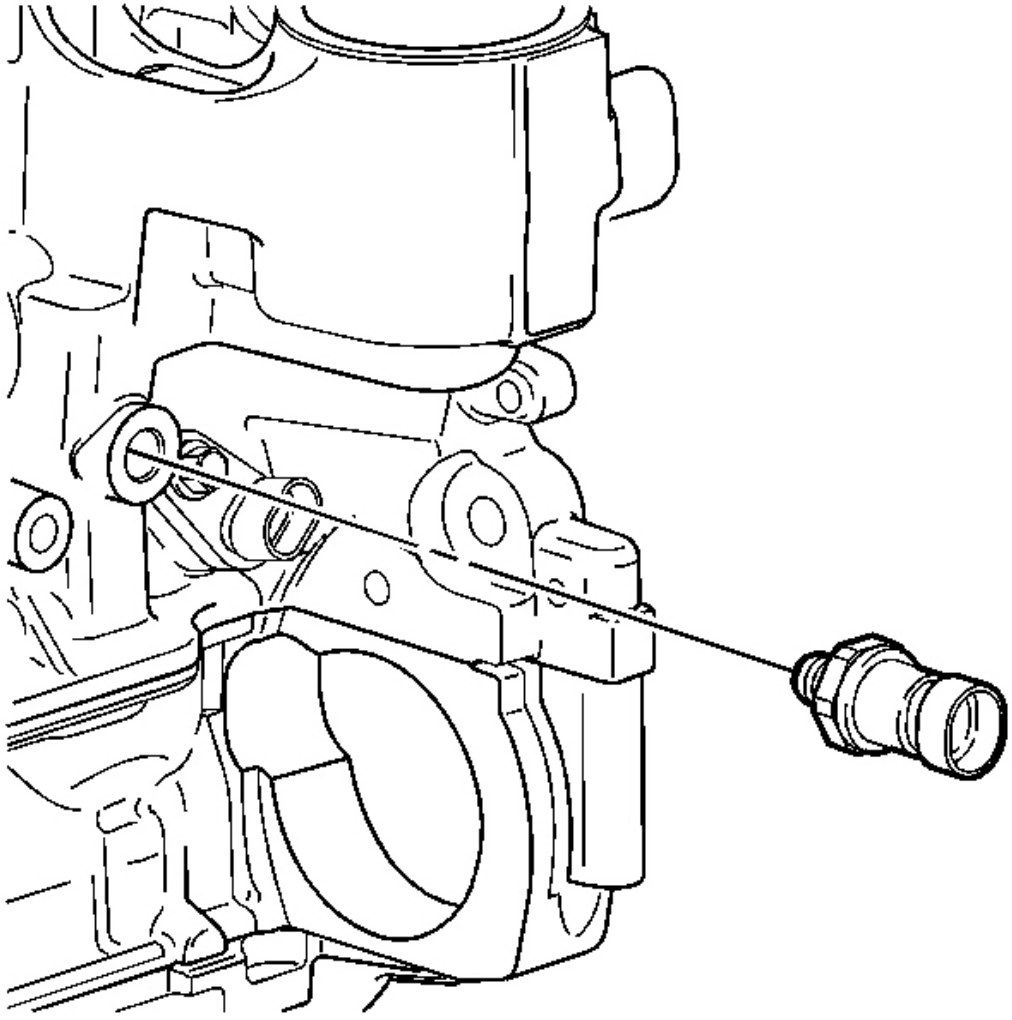


Fig. 526: View Of Engine Oil Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

10. Install the oil pressure switch.

    Tighten: Tighten the oil pressure switch to 10 N.m (89 lb in).

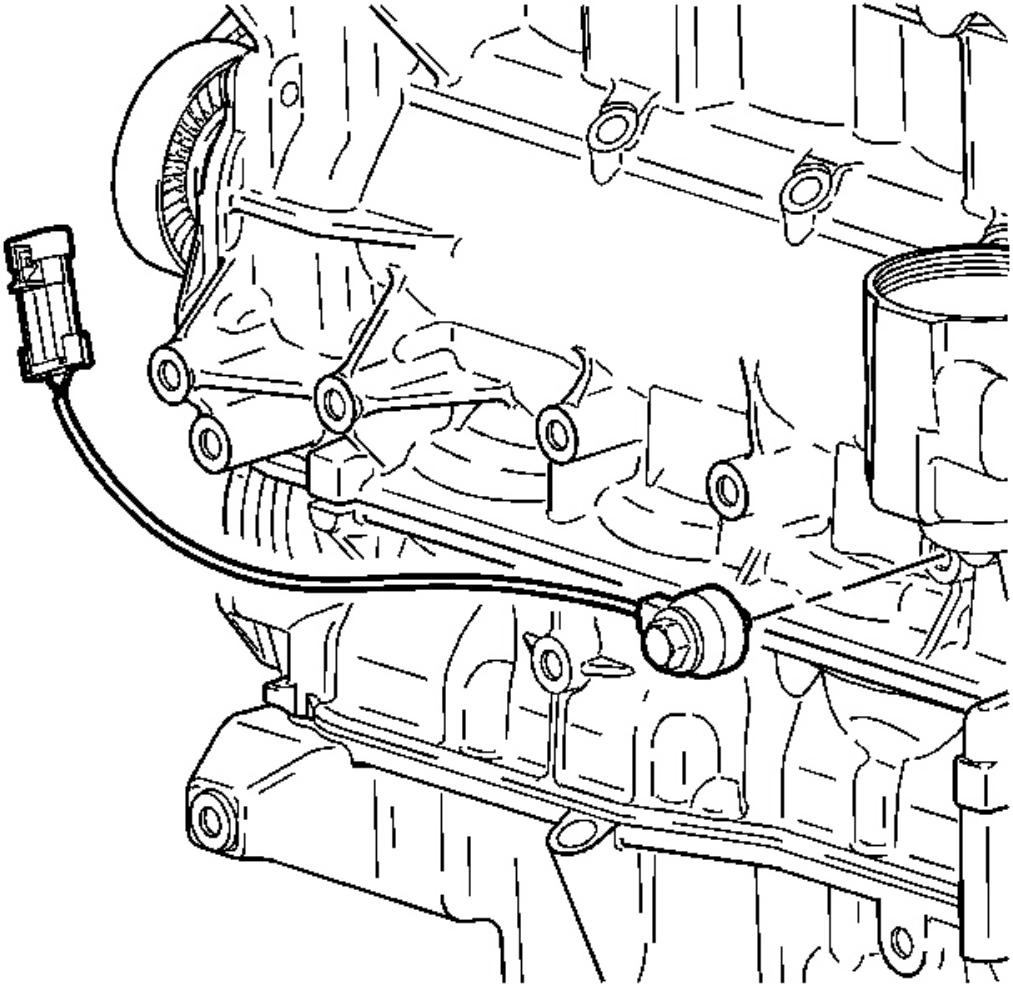


Fig. 527: View of Knock Sensor
Courtesy of GENERAL MOTORS CORP.

11. Install the knock sensor and bolt.

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

CRANKSHAFT AND BEARINGS INSTALLATION

Tools Required

- **J 8087** (SA9178NE-A) Cylinder Bore Checking Gage. See **Special Tools and Equipment** .

- **J 45059** Angle Meter. See **Special Tools and Equipment** .

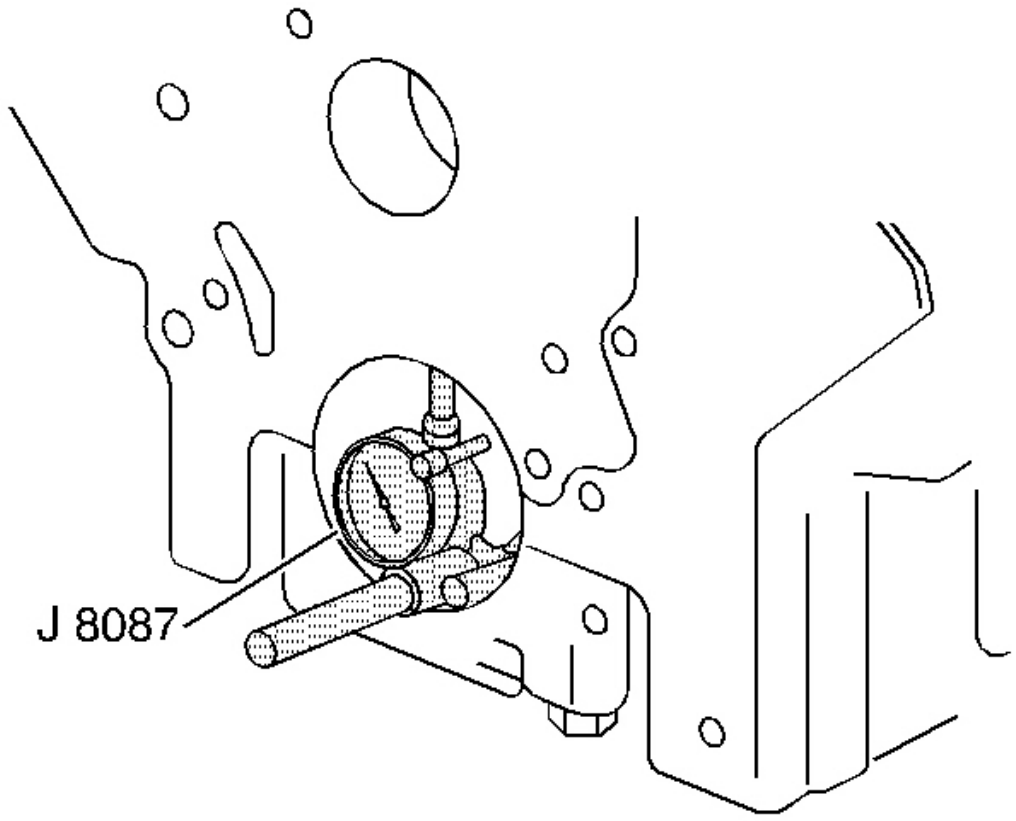


Fig. 528: Measuring Bearing Bore For Taper & Out-Of-Round
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If crankshaft bearing failure is due to other than normal wear, investigate the cause. Inspect the crankshaft or connecting rod bearing bores.

Inspect the connecting rod bearing bores or crankshaft main bearing bores using the following procedure:

- Tighten the bearing cap to specification.
- Measure the bearing bore for taper and out-of-round using the **J 8087** (SA9178NE-A). See **Special Tools and Equipment** .
- 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 two 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.

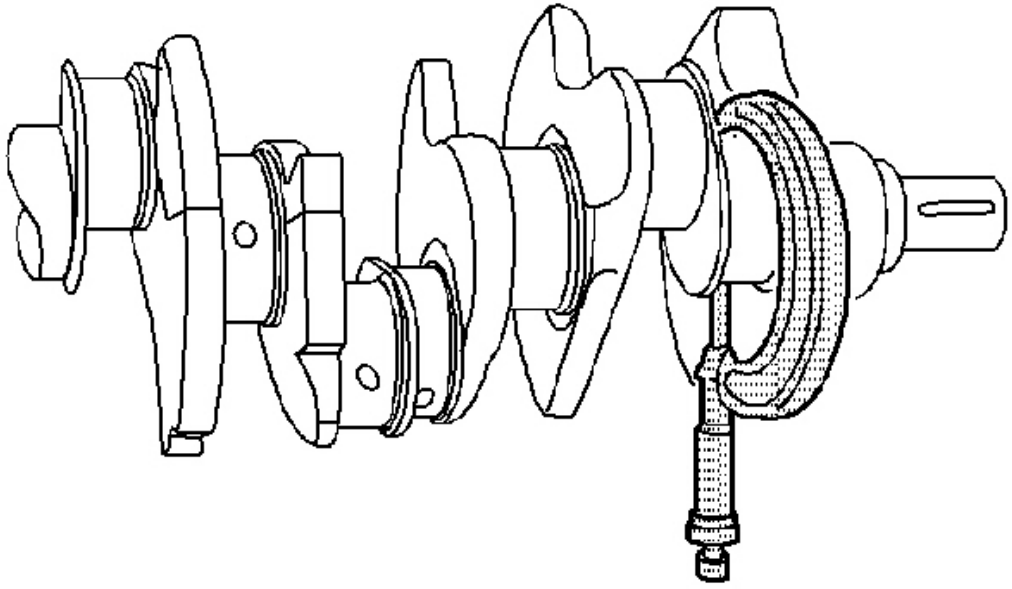


Fig. 529: Measuring Crankshaft Bearing Journal Taper & Runout
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not mix inserts of different nominal size in the same bearing bore.

2. To measure bearing clearance using Method A, use the following procedure:
    1. Measure the crankshaft bearing journal diameter with a micrometer in several places, 90 degrees apart. Average the measurements.
    2. Measure the crankshaft bearing journal taper and runout.
    3. Install the lower crankcase and tighten the bearing cap bolts to specification.
    4. Measure bearing I.D. in several places 90 degrees apart, average measurements.
    5. Subtract journal measurement from bearing I.D. measurement to determine clearance.
    6. Determine whether clearance is within specification.
    7. If out of spec 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.

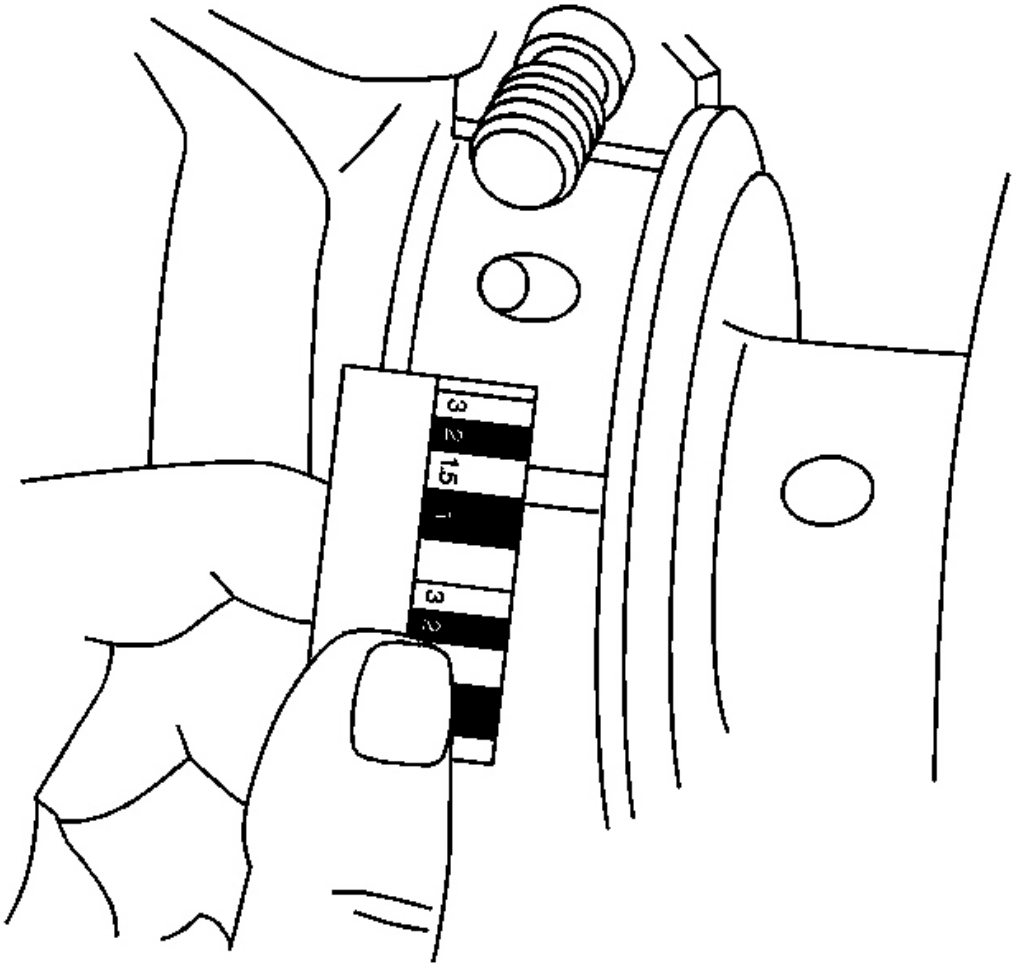


Fig. 530: Measuring Gaging Plastic On Crankshaft
Courtesy of GENERAL MOTORS CORP.

3. To measure bearing clearance using Method B, use the following procedure:
    1. Clean the used bearing inserts.
    2. Install the used bearing inserts.
    3. Place a piece of gaging plastic across the entire bearing width.
    4. Install the bearing caps.

NOTE: **In order to prevent the possibility of cylinder block or crankshaft bearing cap damage, the crankshaft bearing caps are tapped into the cylinder block cavity using a brass, lead, or a leather mallet before the attaching bolts are installed. Do not use attaching bolts to pull the crankshaft bearing caps into the seats. Failure to use this process may damage a cylinder block or a bearing cap.**

5. Install the bearing cap bolts to specification using **J 45059** . See **Special Tools and Equipment** . Refer to specification table.

IMPORTANT: 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 printed on the gaging plastic package.
8. Remove the gaging plastic.

LOWER CRANKCASE INSTALLATION

Tools Required

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

Lower Crankcase Installation

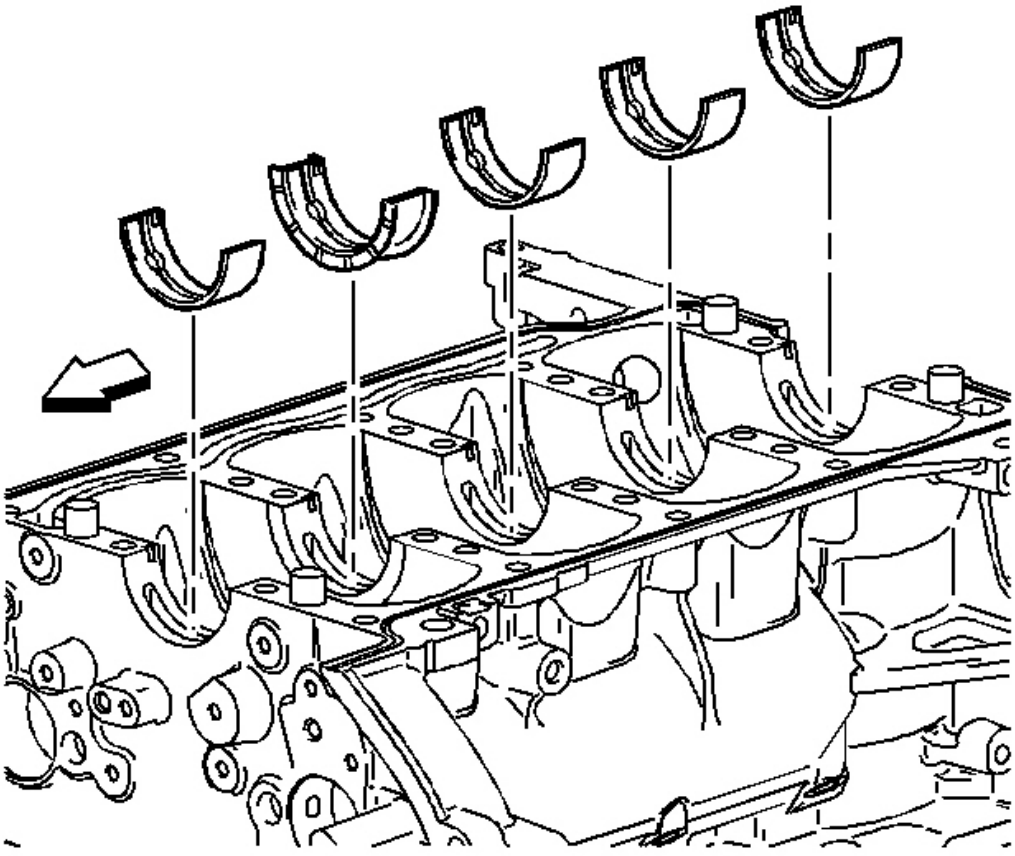


Fig. 531: View Of Crankshaft Bearing Inserts
Courtesy of GENERAL MOTORS CORP.

1. Install the crankshaft bearings and lubricate bearing surfaces with engine oil.

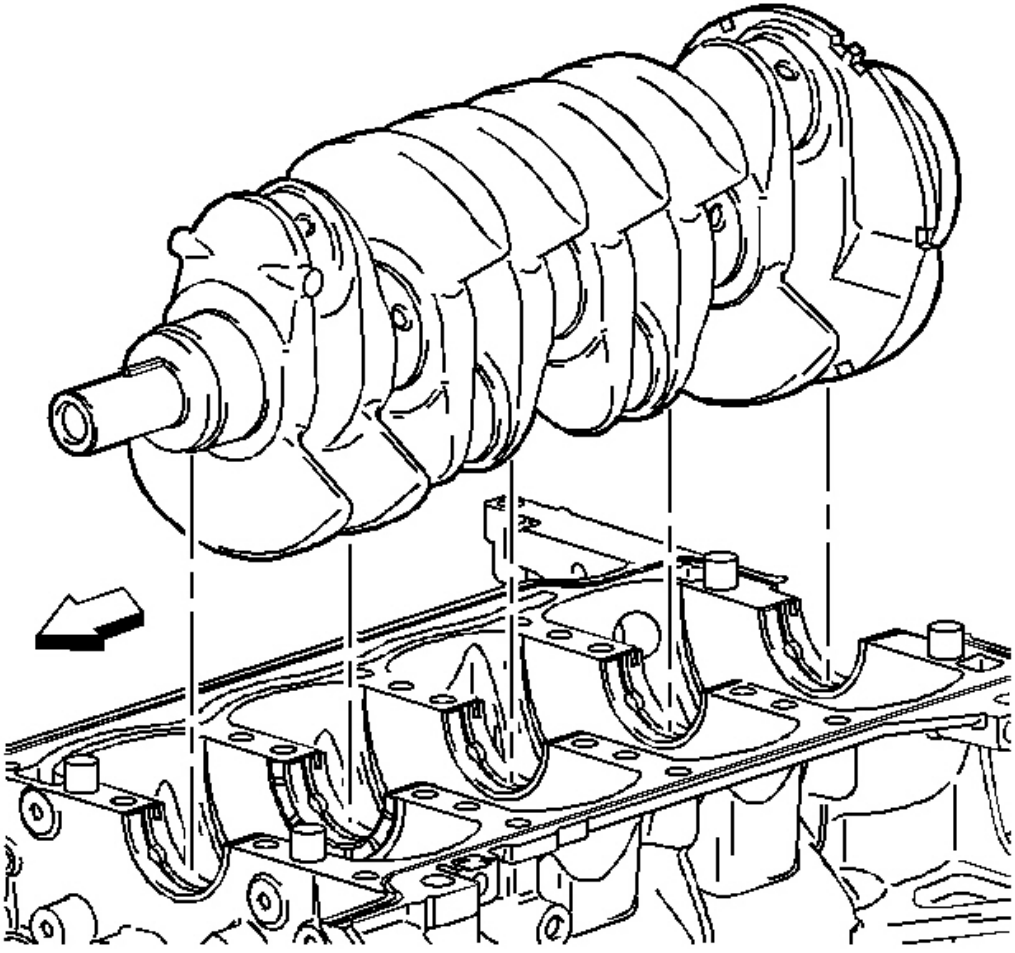


Fig. 532: View Of Crankshaft Journals
Courtesy of GENERAL MOTORS CORP.

2. Install the crankshaft on the journals.

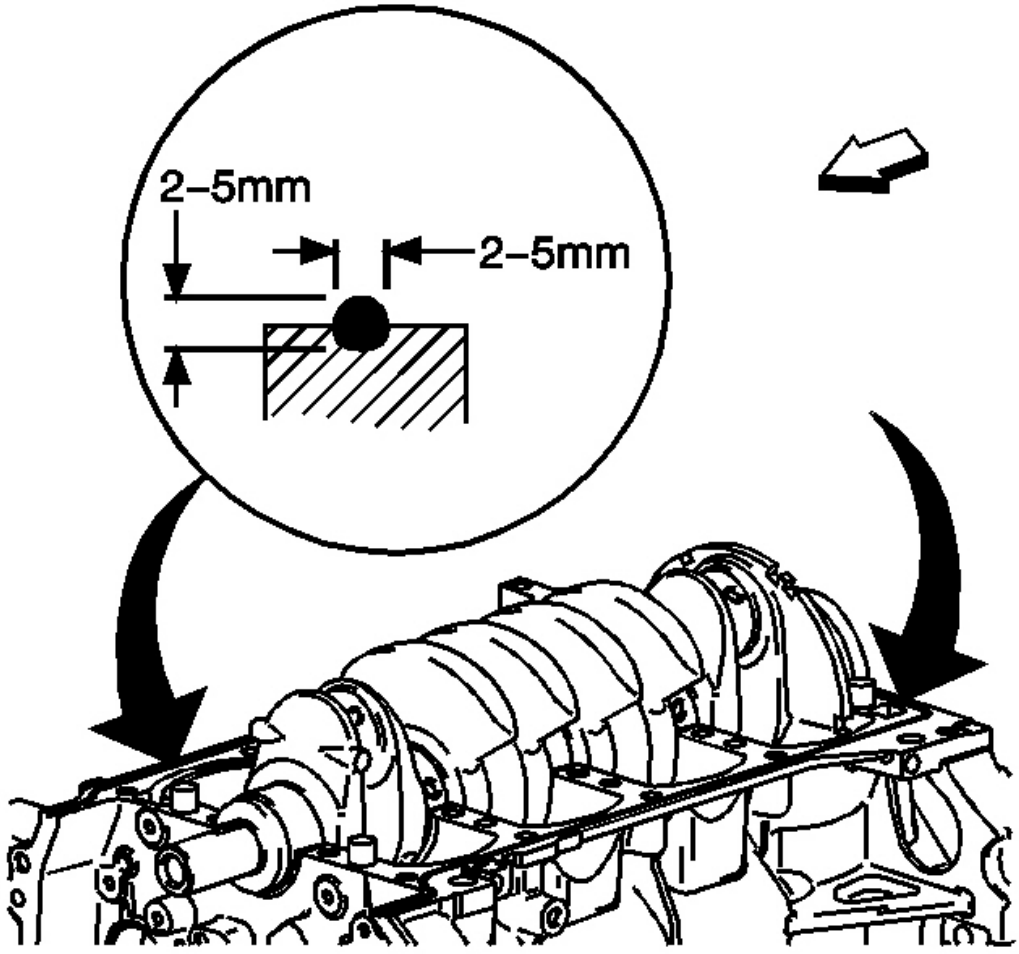


Fig. 533: Applying Sealer P/N 21019581
Courtesy of GENERAL MOTORS CORP.

3. Apply sealer P/N 21019581, to the surfaces of the engine block to bedplate mating surfaces.

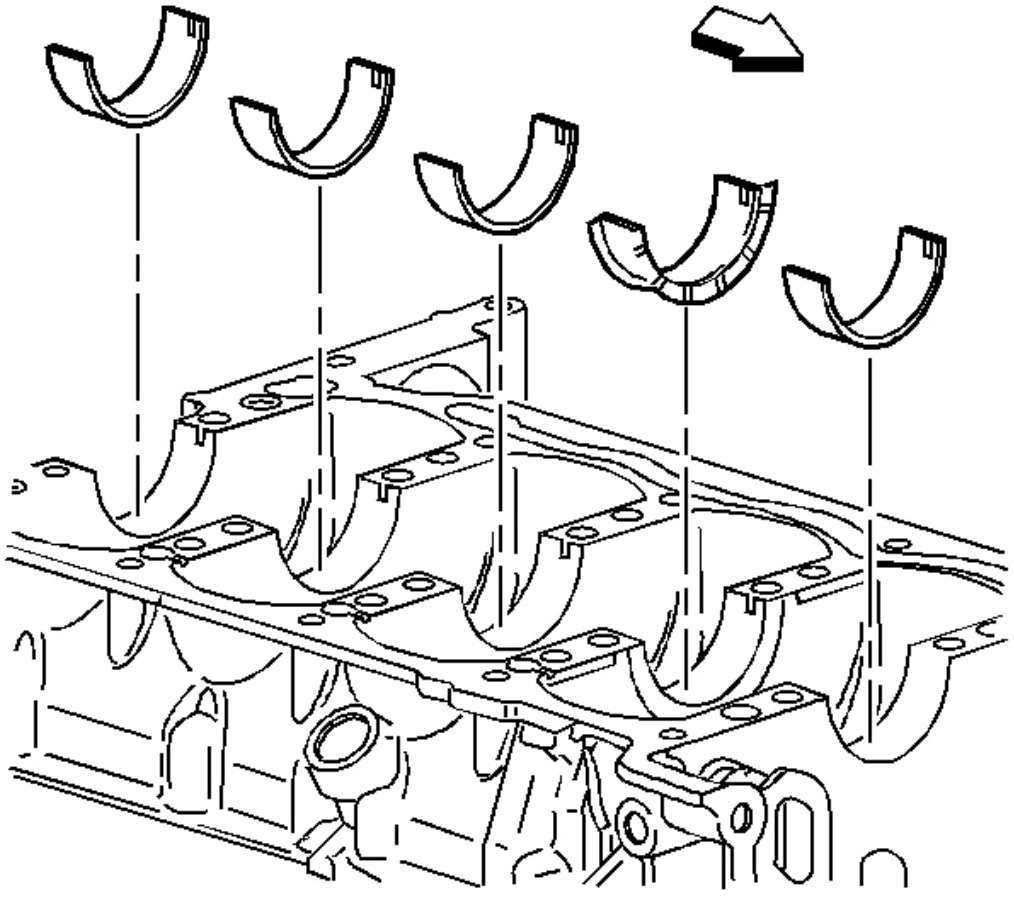


Fig. 534: Identifying Crankshaft Bearing Inserts
Courtesy of GENERAL MOTORS CORP.

4. Install the lower bearing halves, without grooves, into the lower crankcase. Apply oil to bearing surfaces.

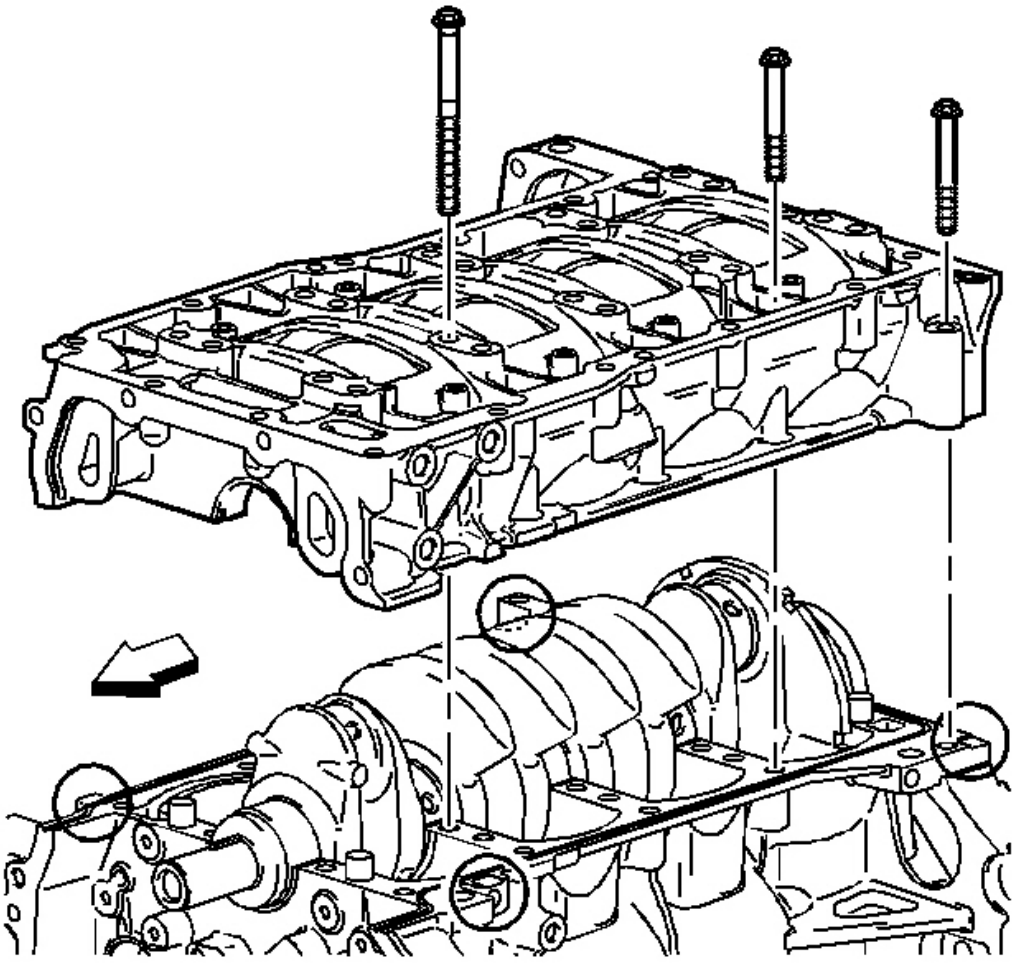


Fig. 535: View Of Upper And Lower Crankcase Bolts
Courtesy of GENERAL MOTORS CORP.

5. Install the lower crankcase. Tap gently into place with a suitable tool if necessary. Ensure it is aligned properly on the dowels.

NOTE: Refer to Fastener Notice in Cautions and Notices.

6. Install the crankshaft bearing bolts in sequence finger tight.
    1. Tighten the crankshaft bearing bolts in sequence.

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

2. Tighten the crankshaft bearing bolts in sequence.

   Tighten: Tighten the crankshaft bearing bolts 70 degrees using **J 45059** . See **Special Tools and Equipment** .

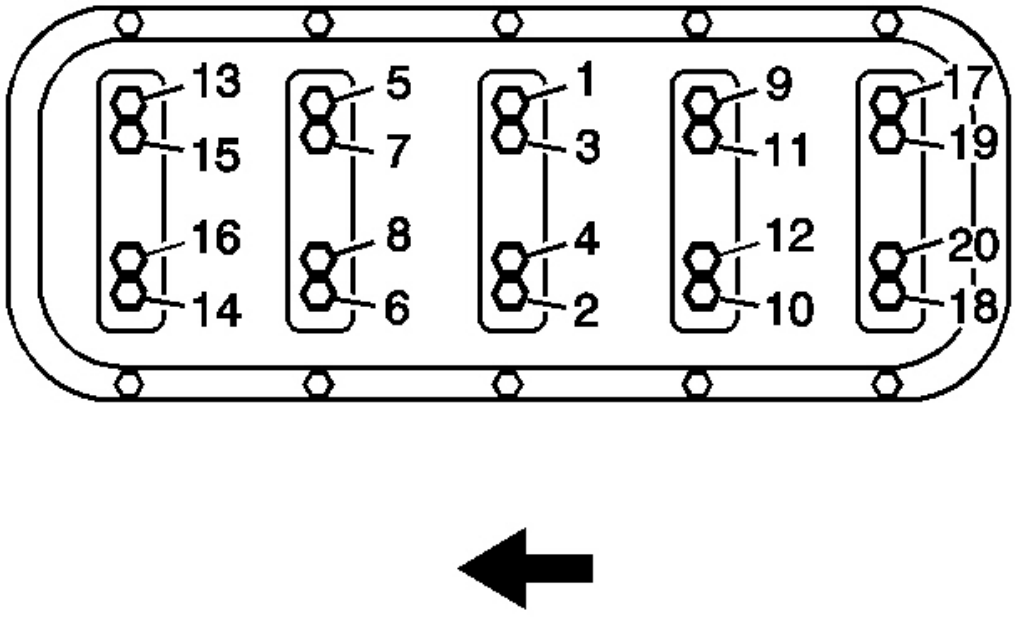


Fig. 536: View Of Crankshaft Bearing Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

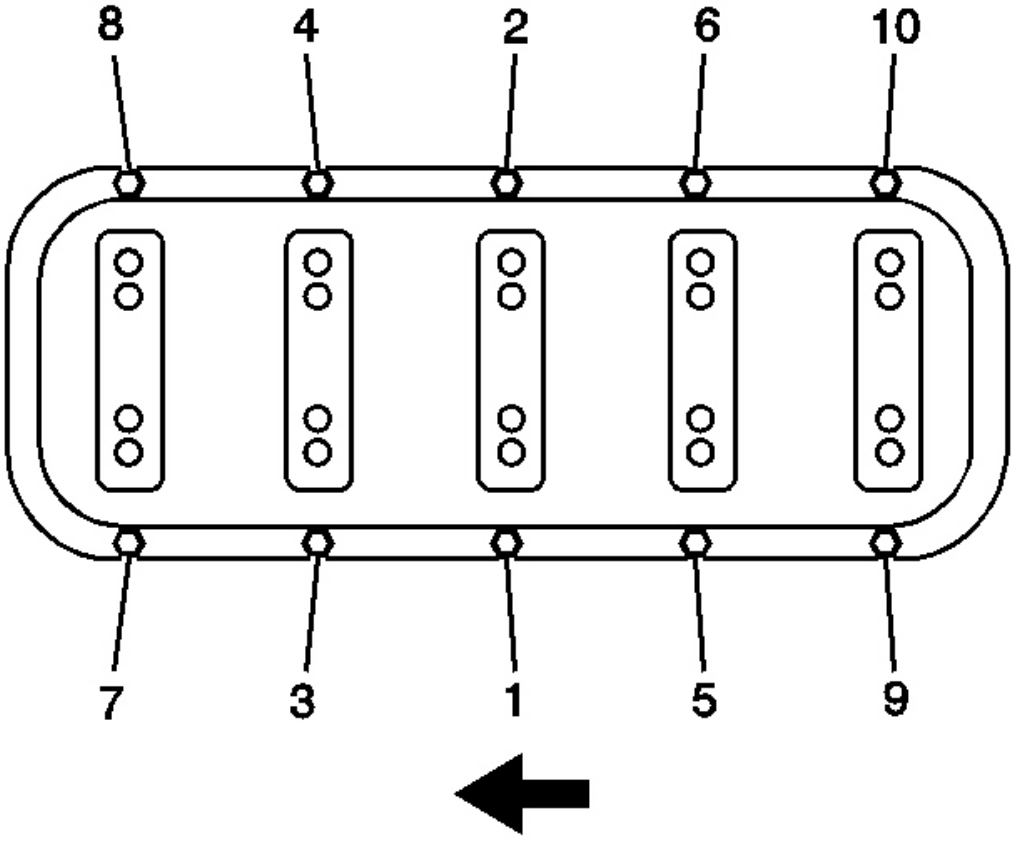


Fig. 537: View Of Lower Crankcase Perimeter Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

7. Tighten the lower crankcase perimeter bolts in sequence.

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

CRANKSHAFT REAR OIL SEAL INSTALLATION

Tools Required

J 42067 Rear Main Seal Installer. See **Special Tools and Equipment** .

Crankshaft Rear Oil Seal Installation

1. Remove excess sealer from seal recess.

2. Lubricate the outside diameter of the new crankshaft seal with clean engine oil.
3. Using the **J 42067** , press the new crankshaft seal into the housing. See **Special Tools and Equipment** . The **J 42067** also establishes the depth of the seal in the crankshaft seal bore. See **Special Tools and Equipment** .

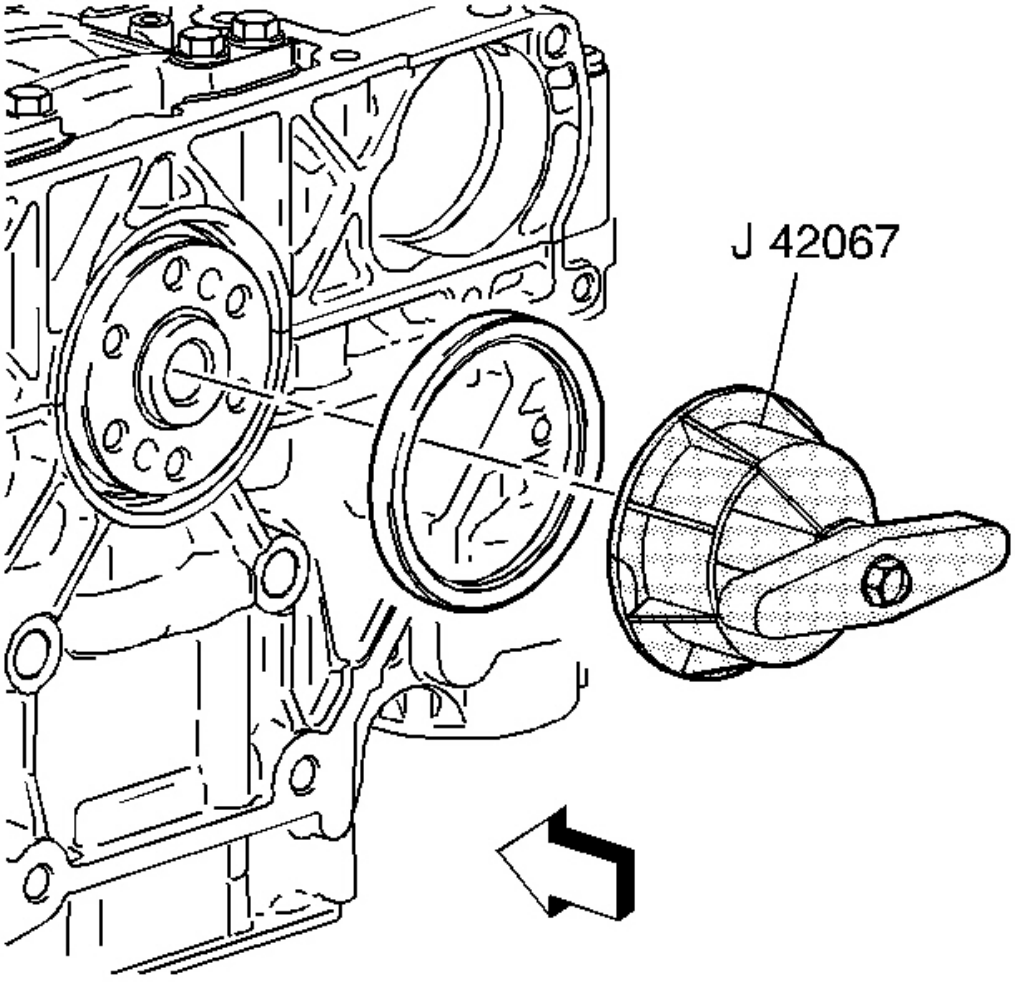


Fig. 538: View Of Crankshaft Rear Main Seal installer
Courtesy of GENERAL MOTORS CORP.

PISTON, CONNECTING ROD, AND BEARING INSTALLATION

Tools Required

- **J 8037** and **J 43953** Piston Ring Compressor. See **Special Tools and Equipment** .
- **J 45059** Angle Meter. See **Special Tools and Equipment** .
- **J-43966-1** and **J 41742** Connecting Rod Guides. See **Special Tools and Equipment** .

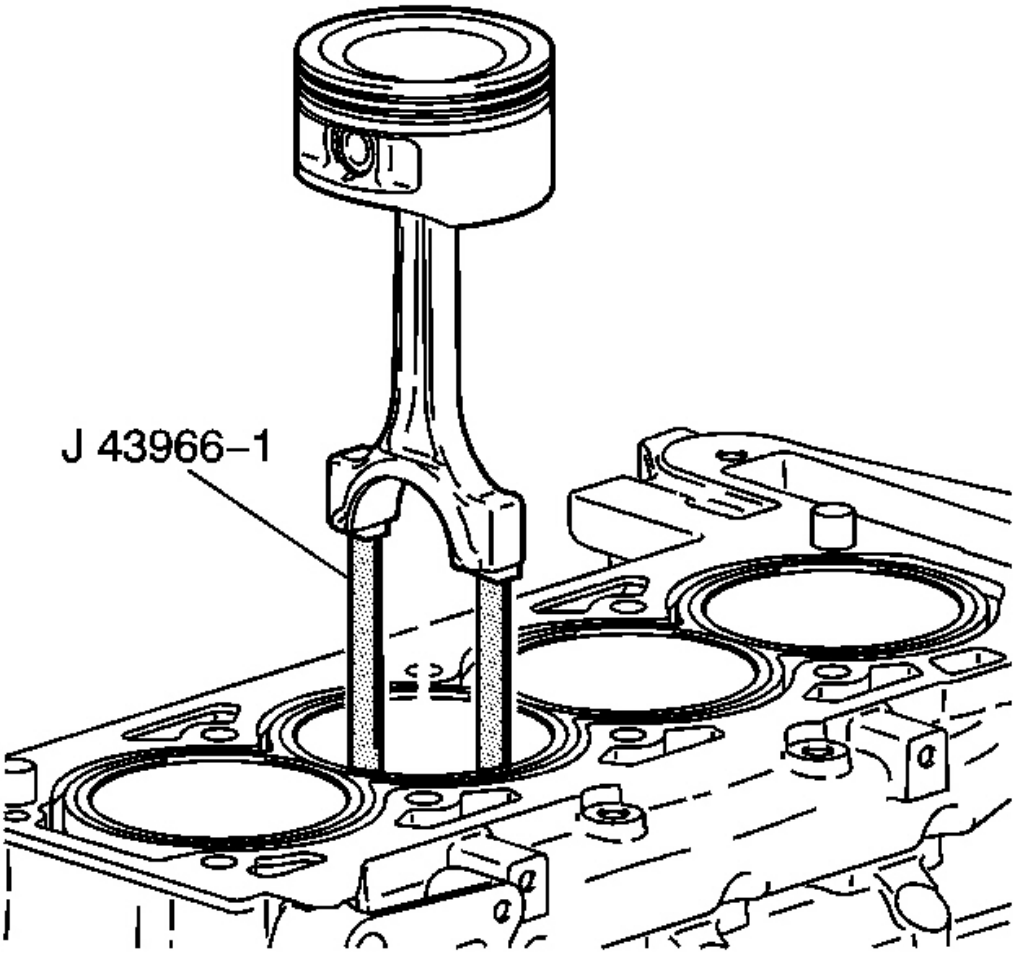


Fig. 539: View Of Connecting Rod Guides
Courtesy of GENERAL MOTORS CORP.

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** /**J 41742** into the connecting rod bolt holes. See **Special Tools and Equipment** . 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 8037** /**J 43953** over the piston. See **Special Tools and Equipment** . 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 8037** /**J 43953** against the engine block until all the rings have entered the cylinder bore. See **Special Tools and Equipment** .
    8. Remove the connecting rod guides from the connecting rod bolt holes.

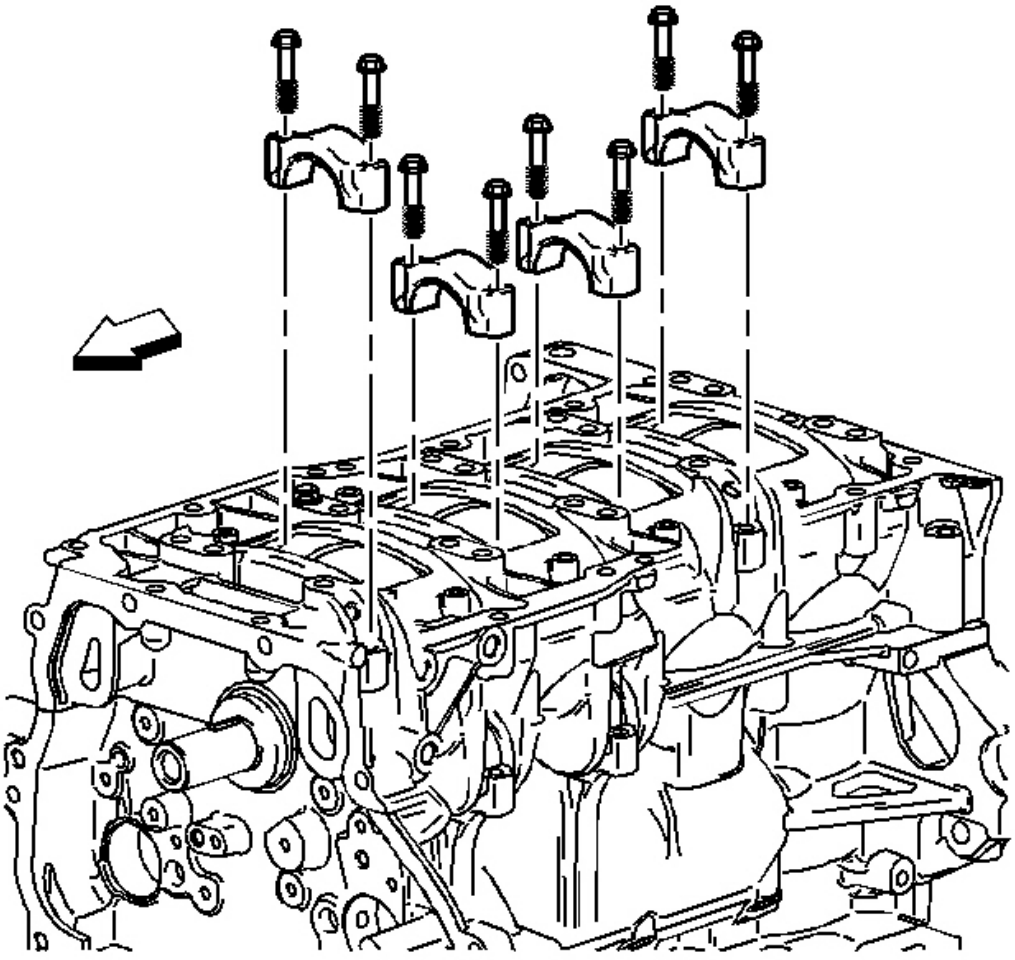


Fig. 540: View Of Connecting Rod Cap
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure that the connecting rod cap is properly oriented on the connecting rod.

4. Install the connecting rod cap.

   NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Install the connecting rod bolts. Always use new bolts.

   Tighten: Tighten the connecting rod bolt nuts to 25 N.m (18 lb ft), then rotate 100 degrees using **J**

45059 . See **Special Tools and Equipment** .

6. Install the remaining connecting rods and piston assemblies.

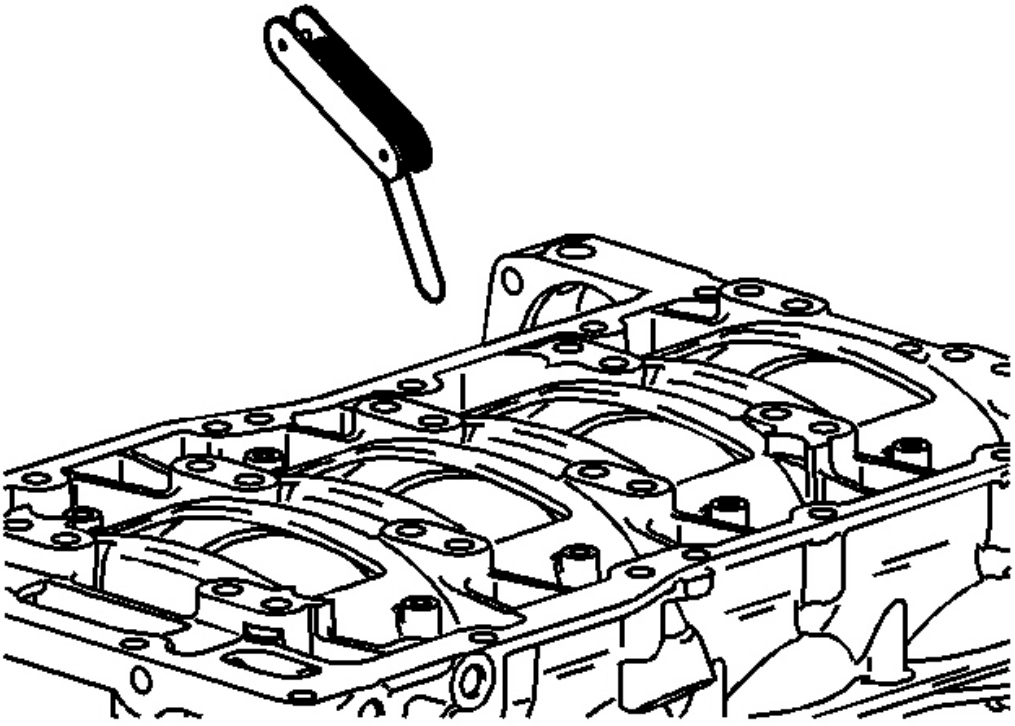


Fig. 541: Measuring Connecting Rod Side Clearance
Courtesy of GENERAL MOTORS CORP.

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

Tools Required

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

Cylinder Head Installation

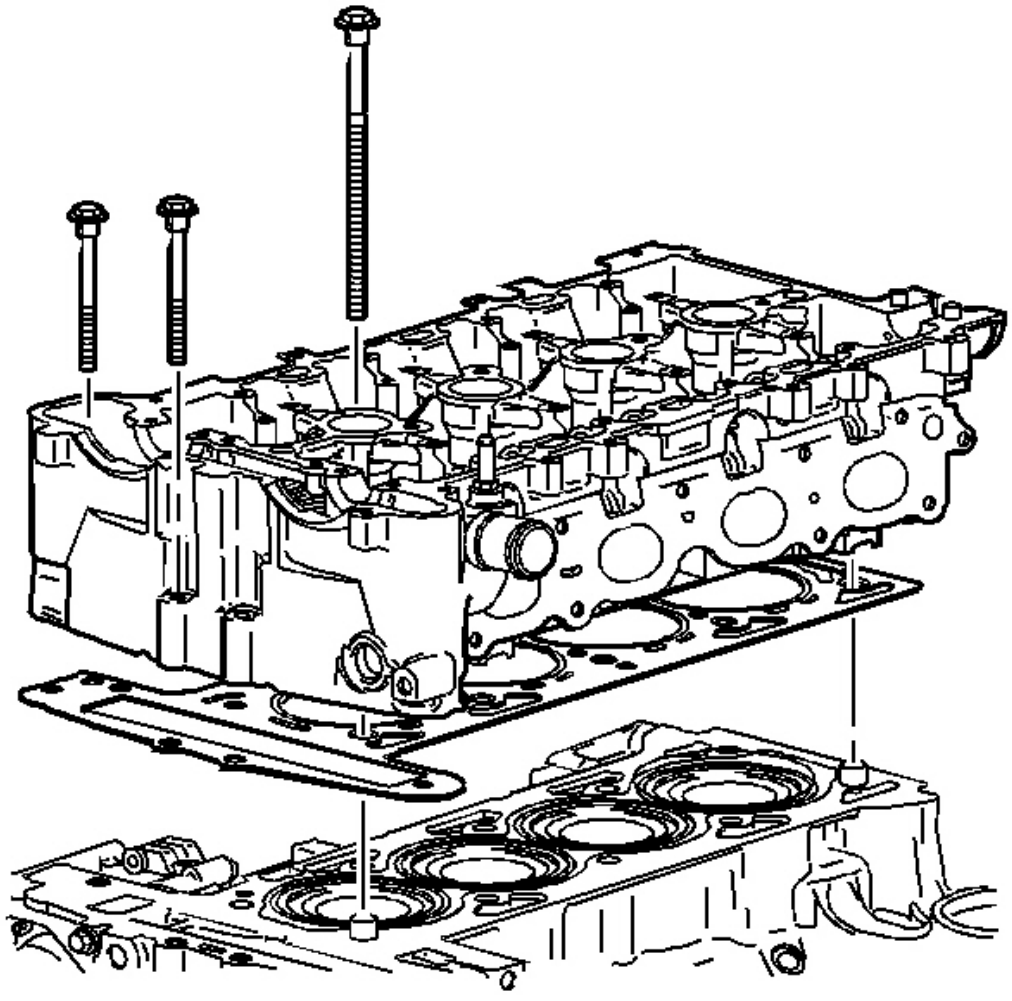


Fig. 542: View Of Cylinder Head
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not use any sealing material.

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

IMPORTANT: Always use new cylinder head bolts.

3. Lightly apply clean engine oil to the threads and the bottom side of the flange of the head bolt and allow

the oil to drain before installing.

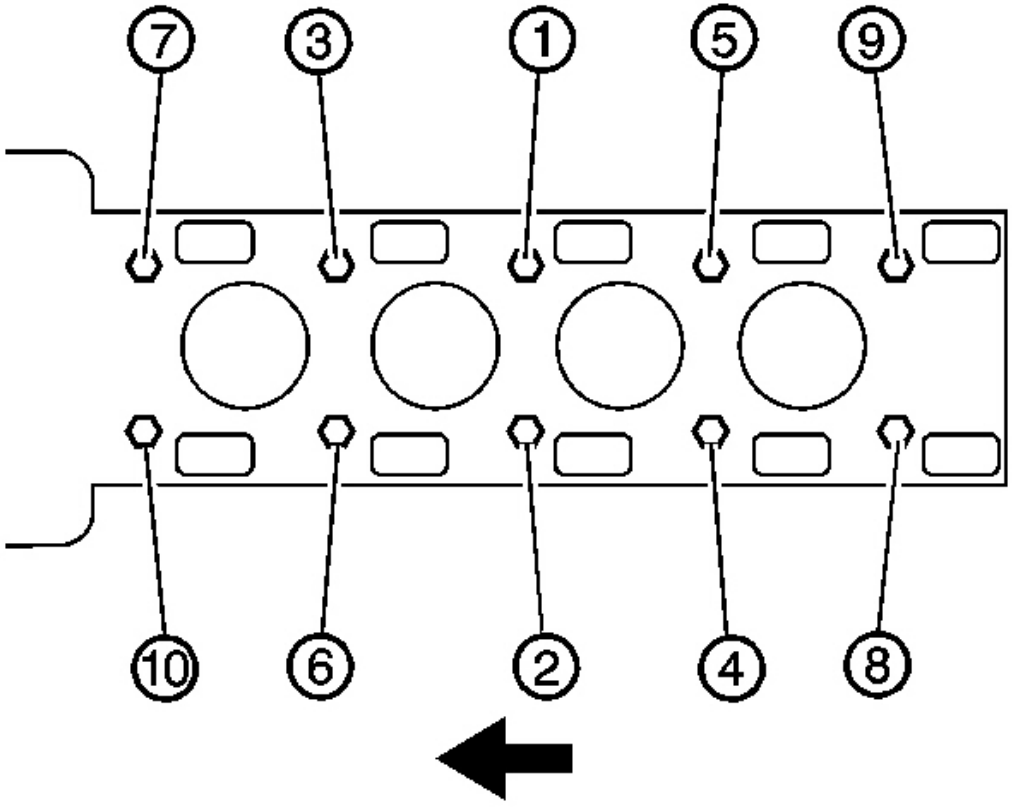


Fig. 543: Identifying Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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

Tighten:

- Tighten the bolts to 30 N.m (22 lb ft).
- Then turn all the bolts 155 degrees in sequence. Use the **J 45059** . See **Special Tools and Equipment** .

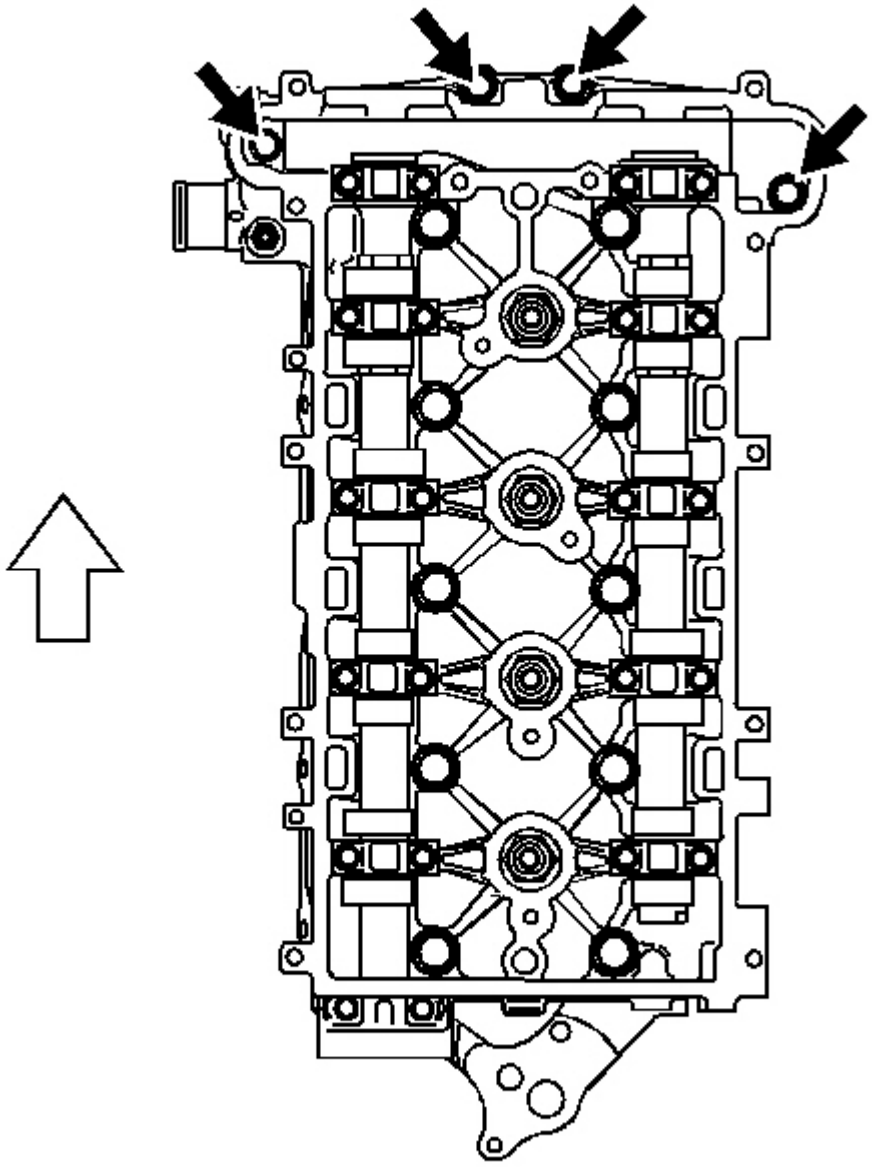


Fig. 544: Locating Front Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

5. Install the front cylinder head bolts.

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

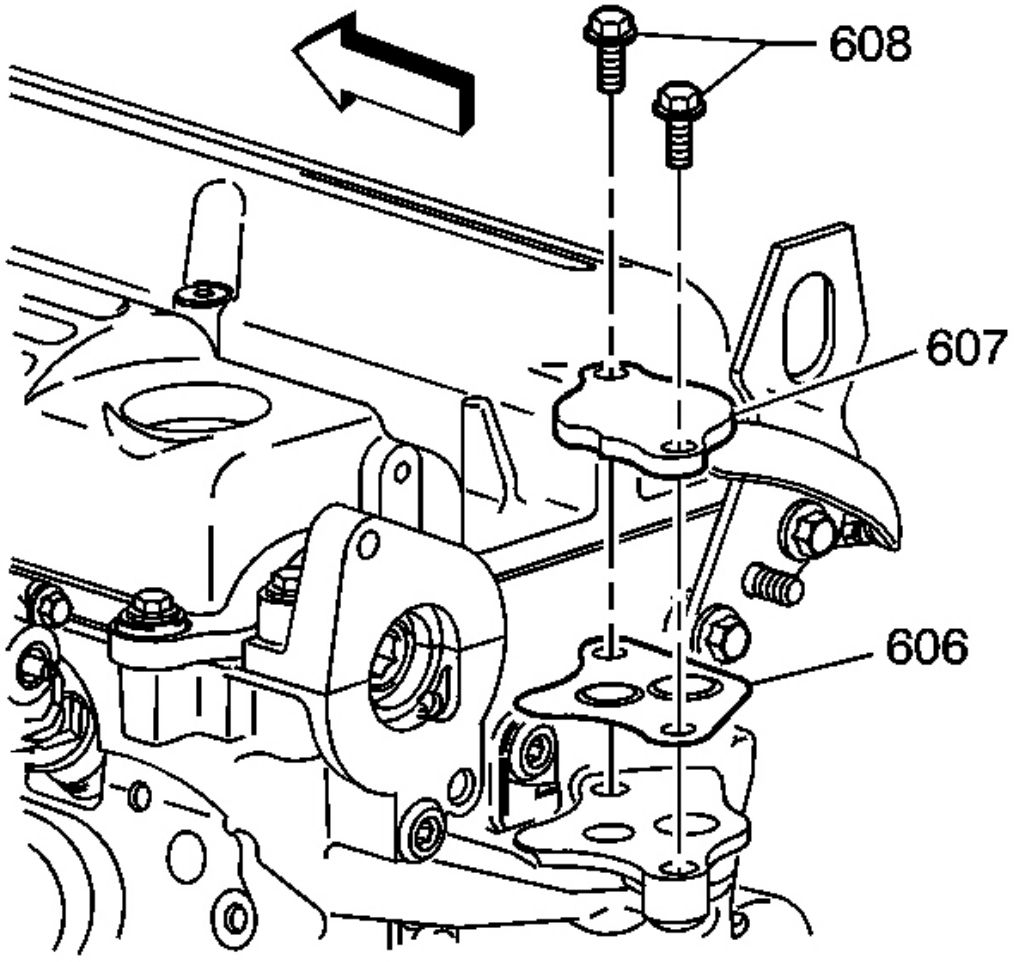


Fig. 545: View of EGR Cover
Courtesy of GENERAL MOTORS CORP.

6. Install the EGR cover (607), the bolts (608), and the EGR cover gasket (606).

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

INTAKE CAMSHAFT, FOLLOWER, AND ADJUSTER INSTALL

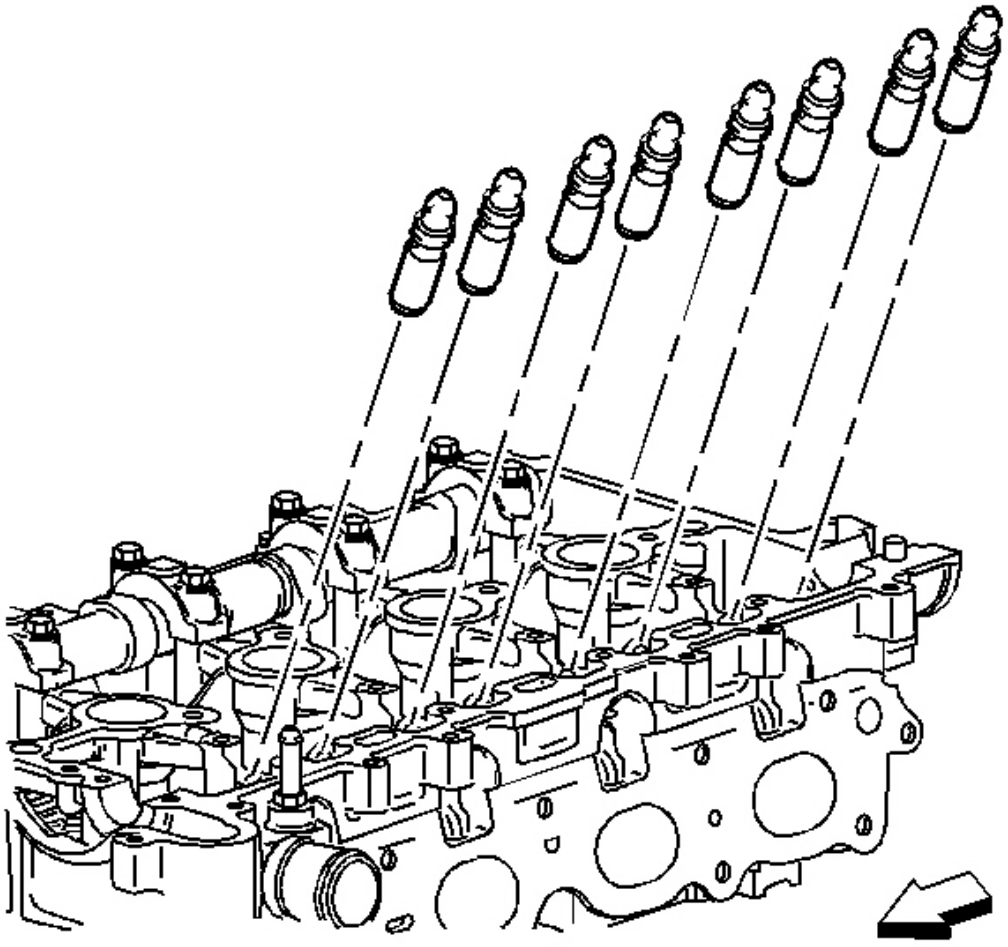


Fig. 546: View Of Hydraulic Element Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

1. Install the hydraulic element lash adjusters into their bores in the cylinder head.
2. Lubricate the hydraulic lash adjusters with engine oil supplement.

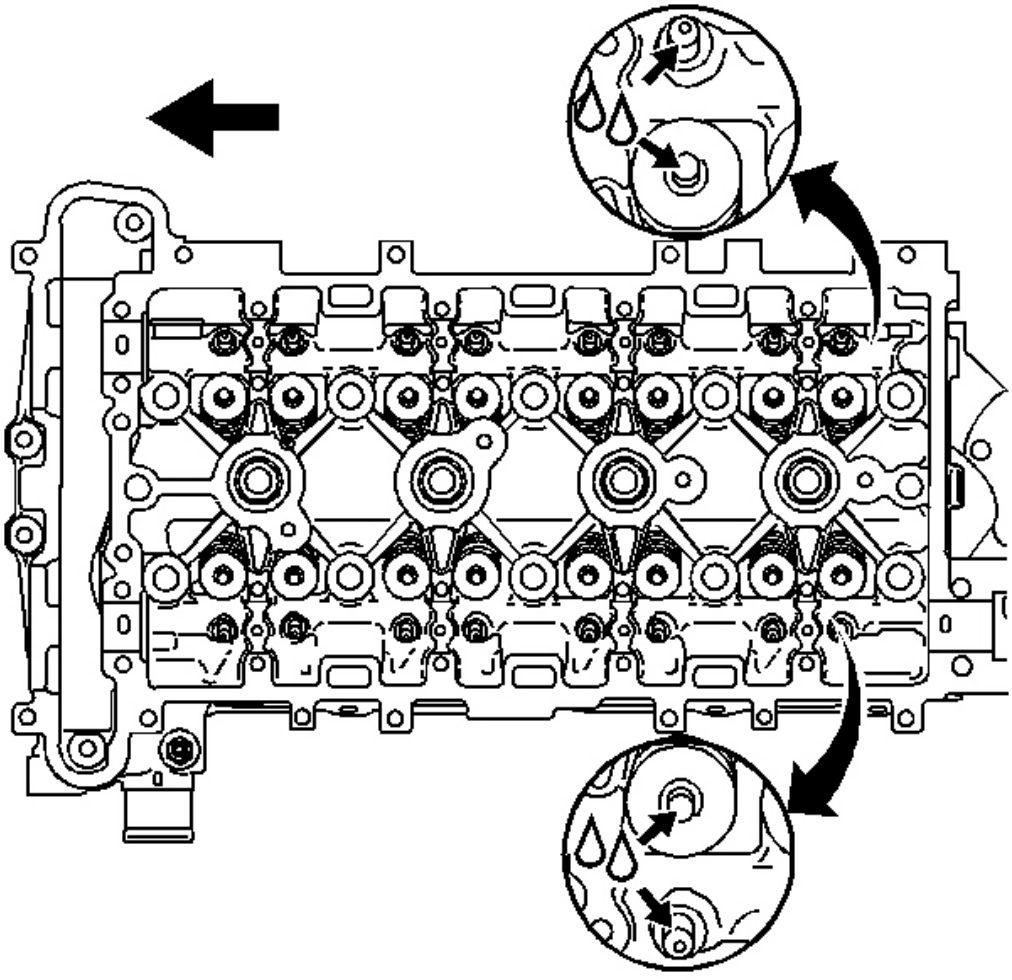


Fig. 547: Exploded View Of Valve Tips
Courtesy of GENERAL MOTORS CORP.

3. Lubricate the valve tips with engine oil supplement.

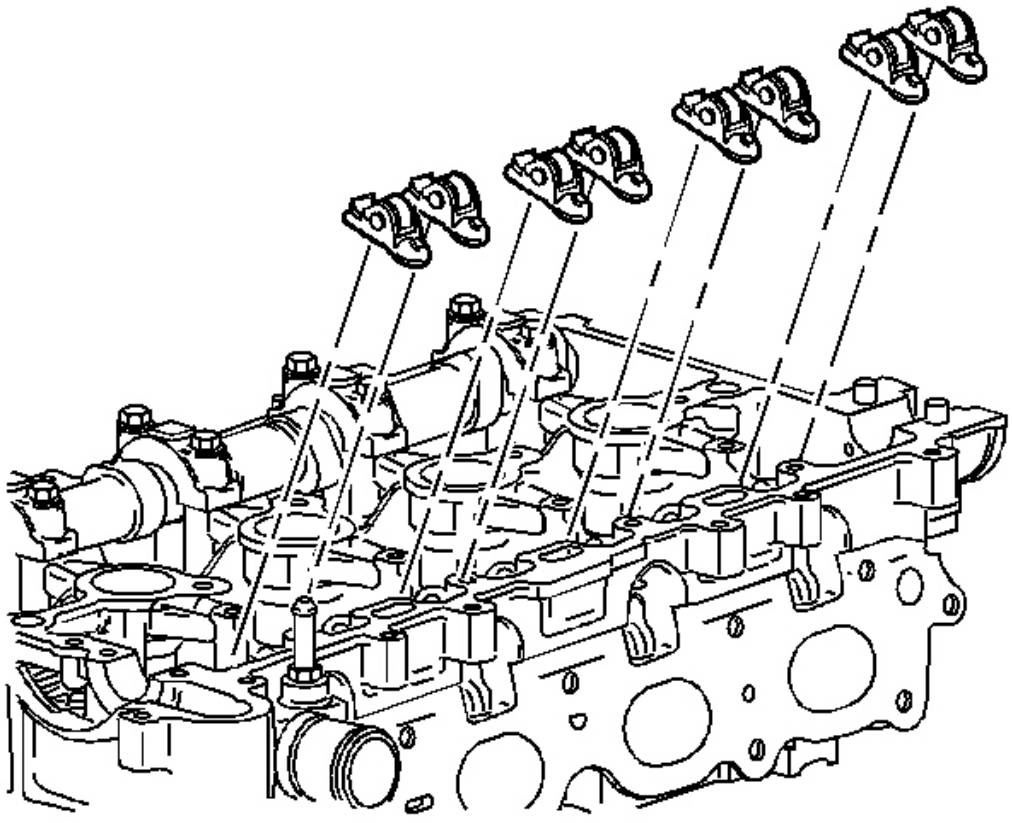


Fig. 548: View Of Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

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

4. Position the roller followers on the tip of the valve stem and on the lash adjuster. Lubricate the roller followers with engine oil supplement.

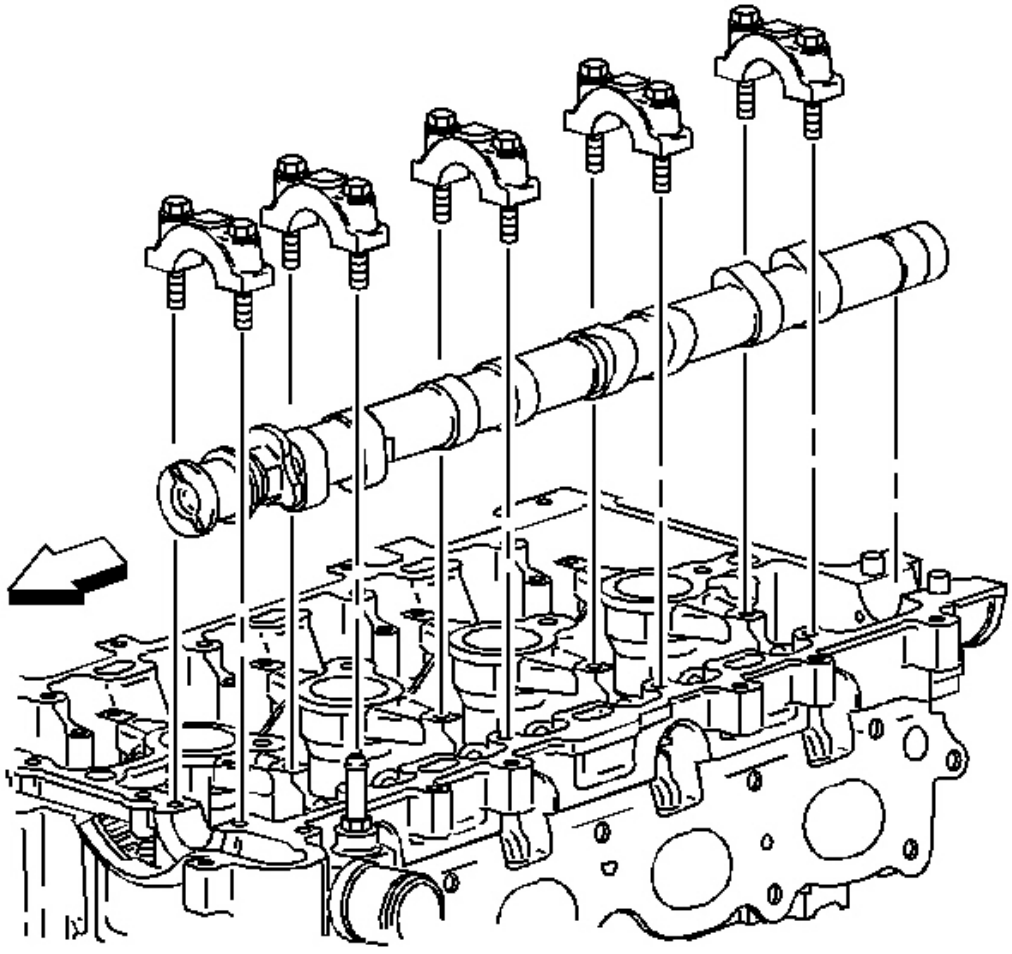


Fig. 549: View Of Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

5. Set the intake camshaft on top of the roller followers in the camshaft bearing journals and lobes. Lubricate with engine oil supplement.
6. Install the camshaft bearing caps and hand start the camshaft cap bolts.

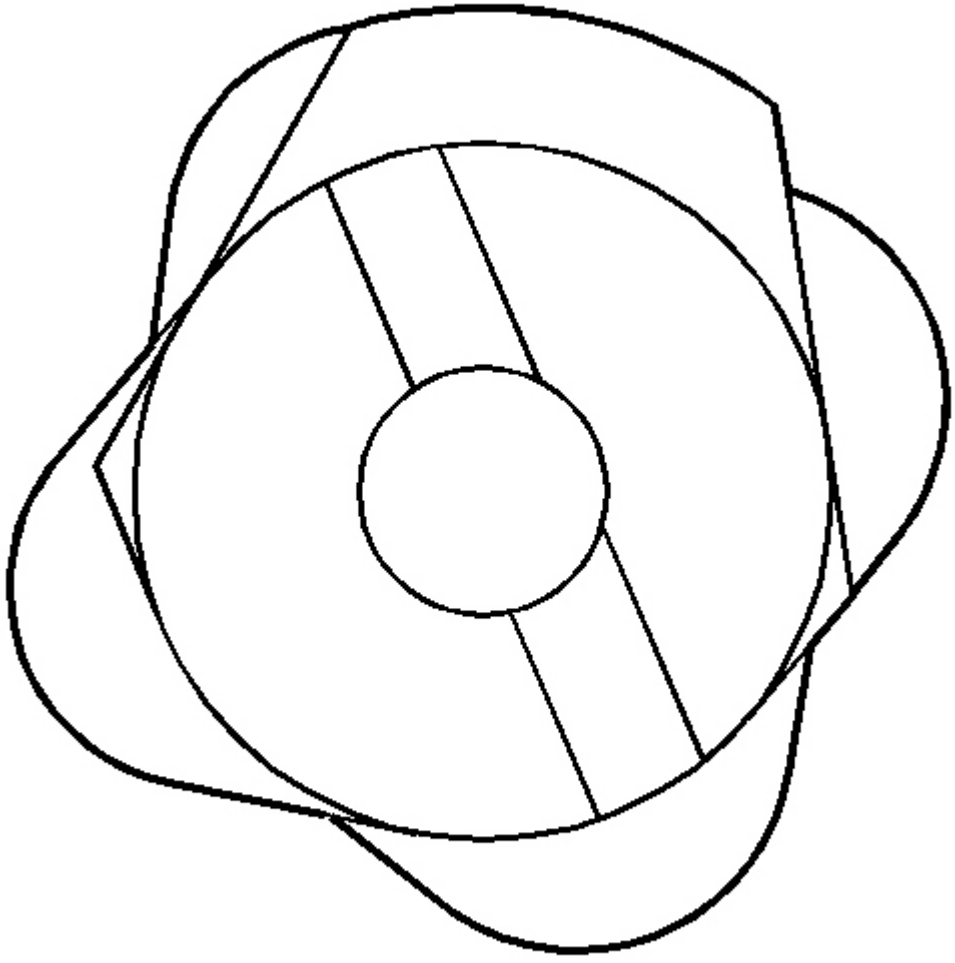


Fig. 550: View Of Camshaft Alignment Notches
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

7. The timing chain sprocket alignment notch should be oriented to the eleven o'clock position.
8. Tighten the camshaft bearing cap bolts in increments of three turns until they are seated.

Tighten: Tighten the camshaft bearing caps to 10 N.m (89 lb in).

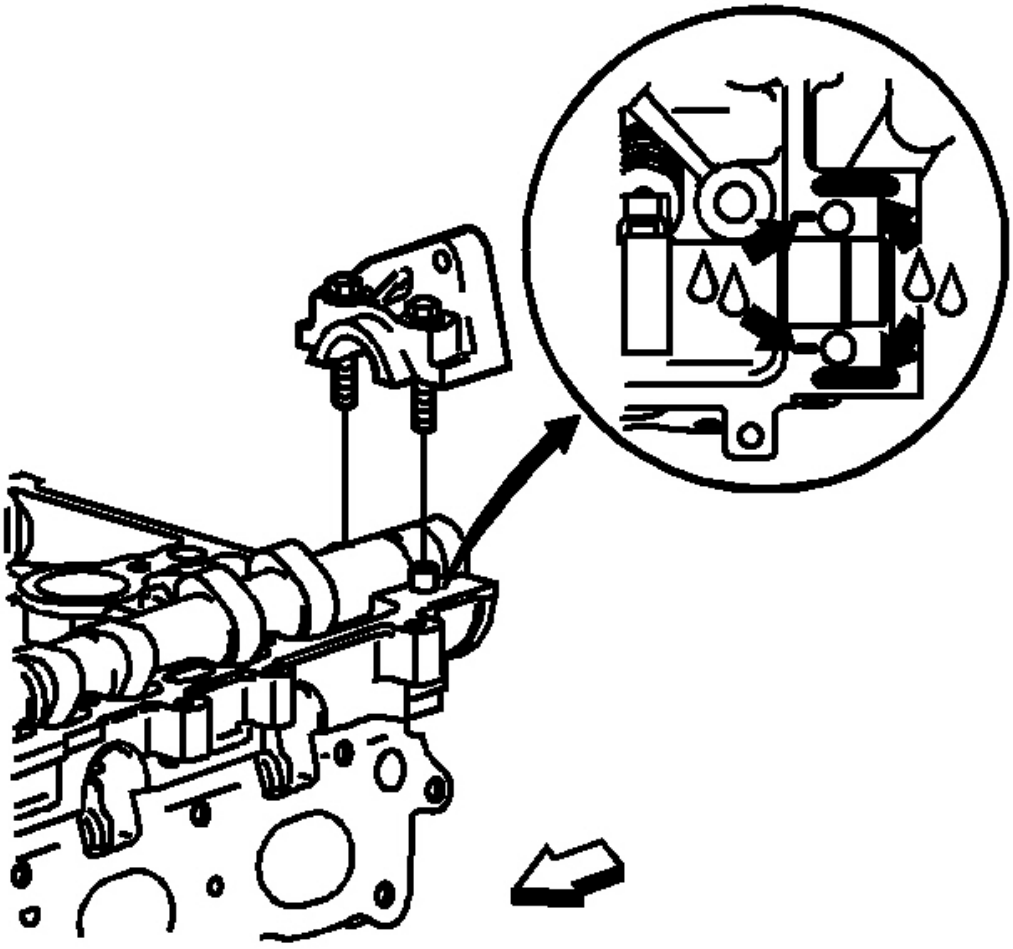


Fig. 551: Applying Camshaft Bearing Cap Sealer
Courtesy of GENERAL MOTORS CORP.

9. Apply Permatex(R) Anaerobic Gasket Maker 51813, 3.5 mm (0.138 in) bead, to rear intake camshaft bearing cap.
10. Install the rear intake camshaft bearing cap bolts.

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

EXHAUST CAMSHAFT, FOLLOWER, AND ADJUSTER INSTALL

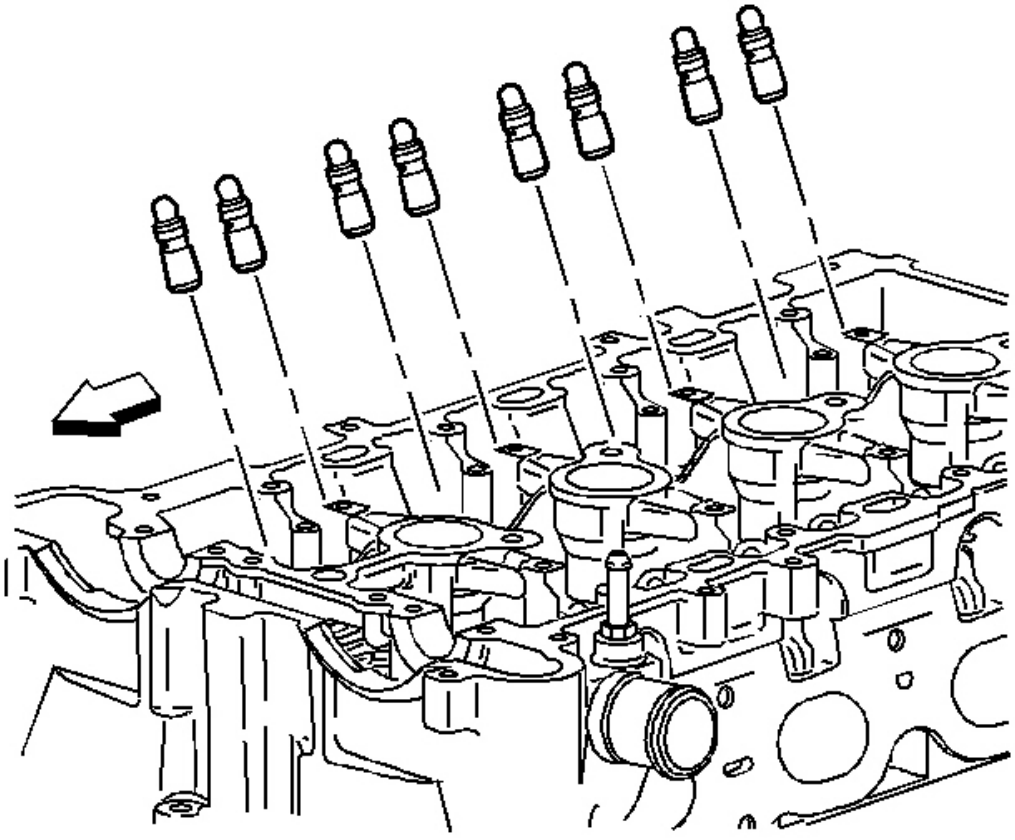


Fig. 552: View Of Hydraulic Element Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

1. Install the hydraulic element lash adjusters into their bores in the cylinder head.
2. Lubricate the hydraulic element lash adjusters with engine oil supplement.

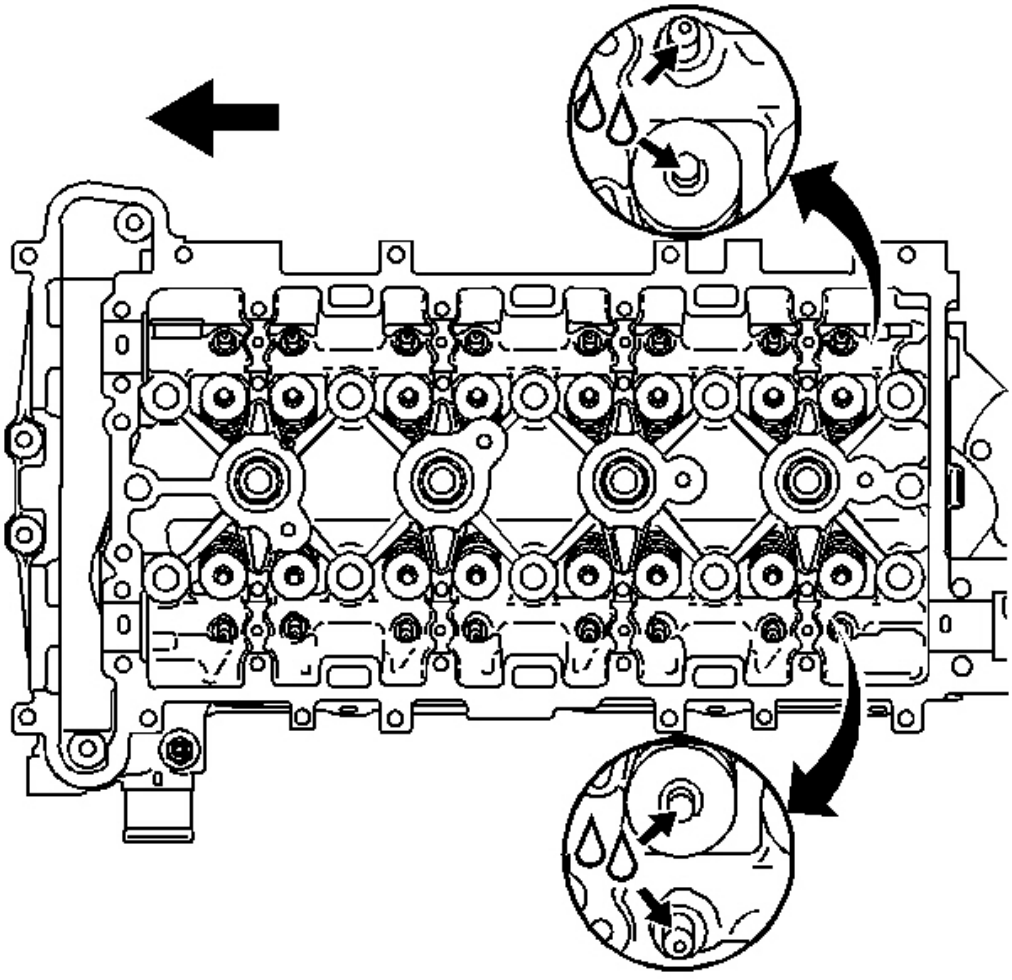


Fig. 553: Exploded View Of Valve Tips
Courtesy of GENERAL MOTORS CORP.

3. Lubricate the valve tips with engine oil supplement.

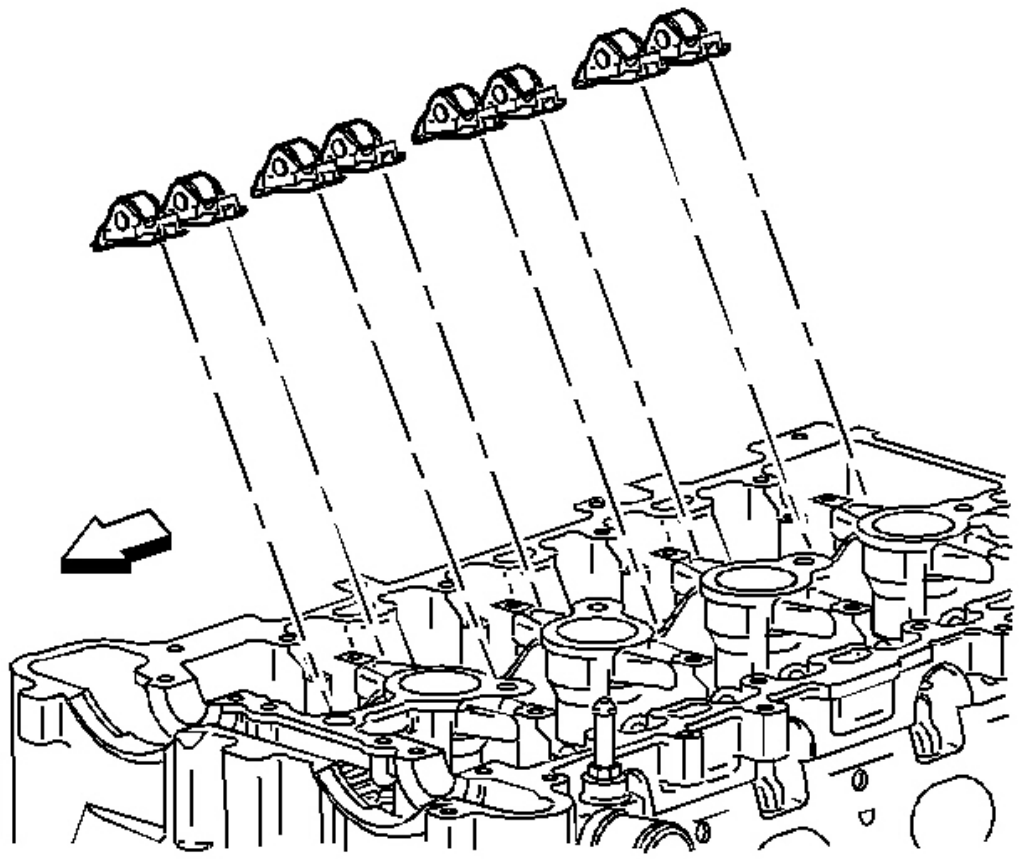


Fig. 554: View Of Exhaust Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

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

4. Position the roller followers on the tip of the valve stem and on the lash adjuster. Lubricate the roller followers with engine oil supplement.

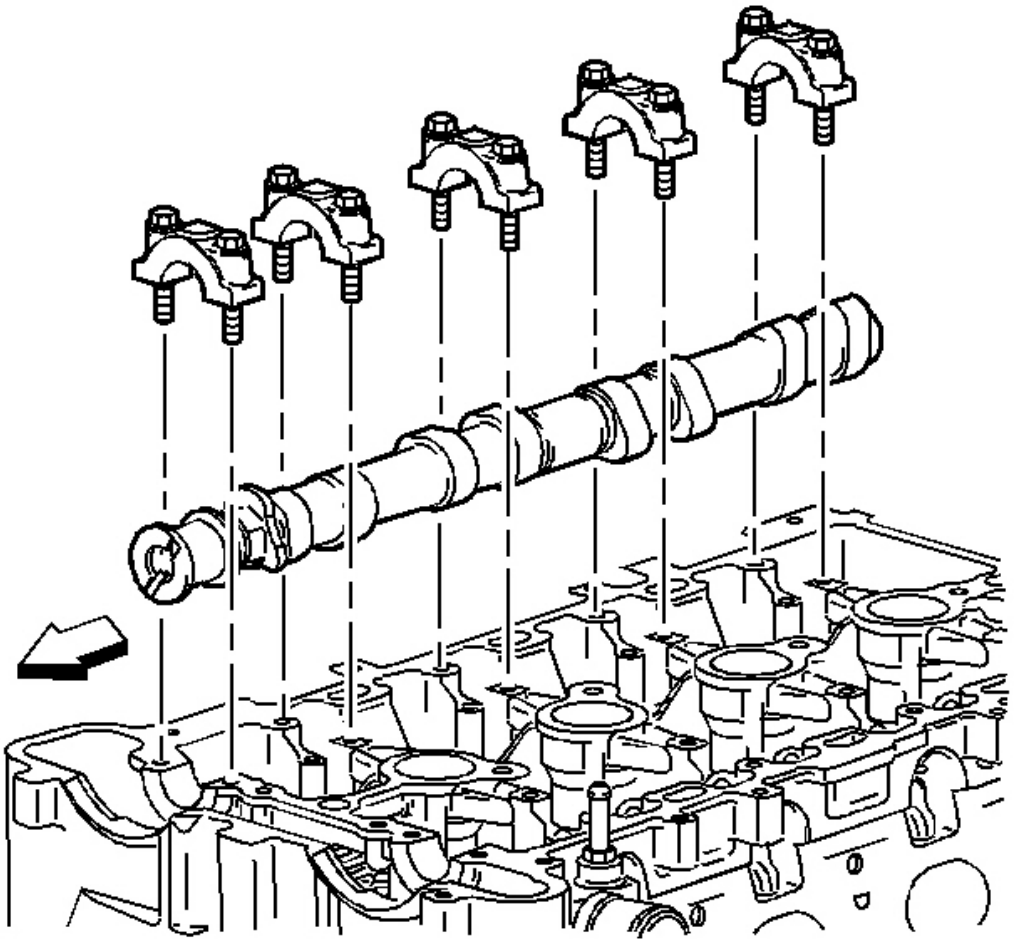


Fig. 555: View Of Exhaust Camshaft
Courtesy of GENERAL MOTORS CORP.

5. Set the exhaust camshaft on top of the roller followers in the camshaft bearing journals. Lubricate with engine oil supplement.
6. Install the camshaft bearing caps and hand start the camshaft cap bolts.

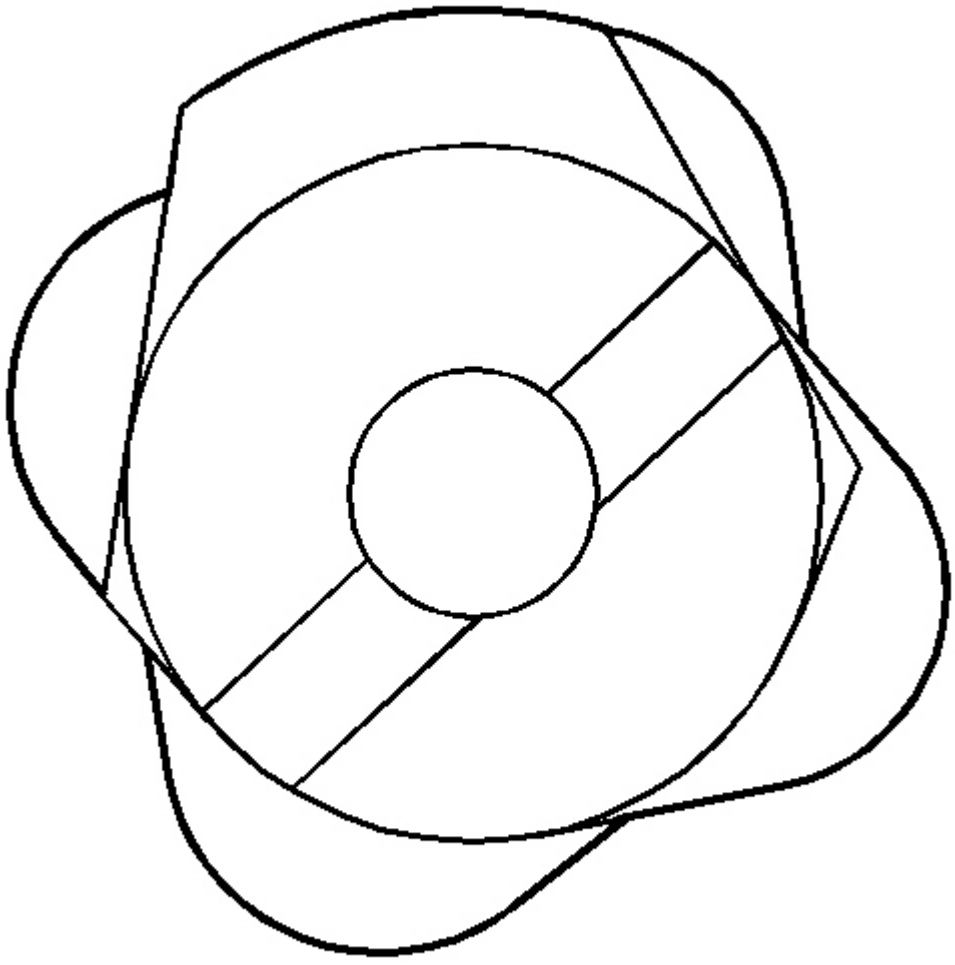


Fig. 556: Timing Chain Sprocket Alignment Notch Oriented To The Two O' Clock Position
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

7. The timing chain sprocket alignment notch should be oriented to the two o' clock position.
8. Tighten the camshaft bearing cap bolts in increments of three turns until they are seated, lubricate.

Tighten: Tighten the camshaft bearing caps to 10 N.m (89 lb in).

BALANCE SHAFT INSTALLATION

Tools Required

J 43650 Balance Shaft Bushing Remover/Installer. See **Special Tools and Equipment** .

Balance Shaft Installation

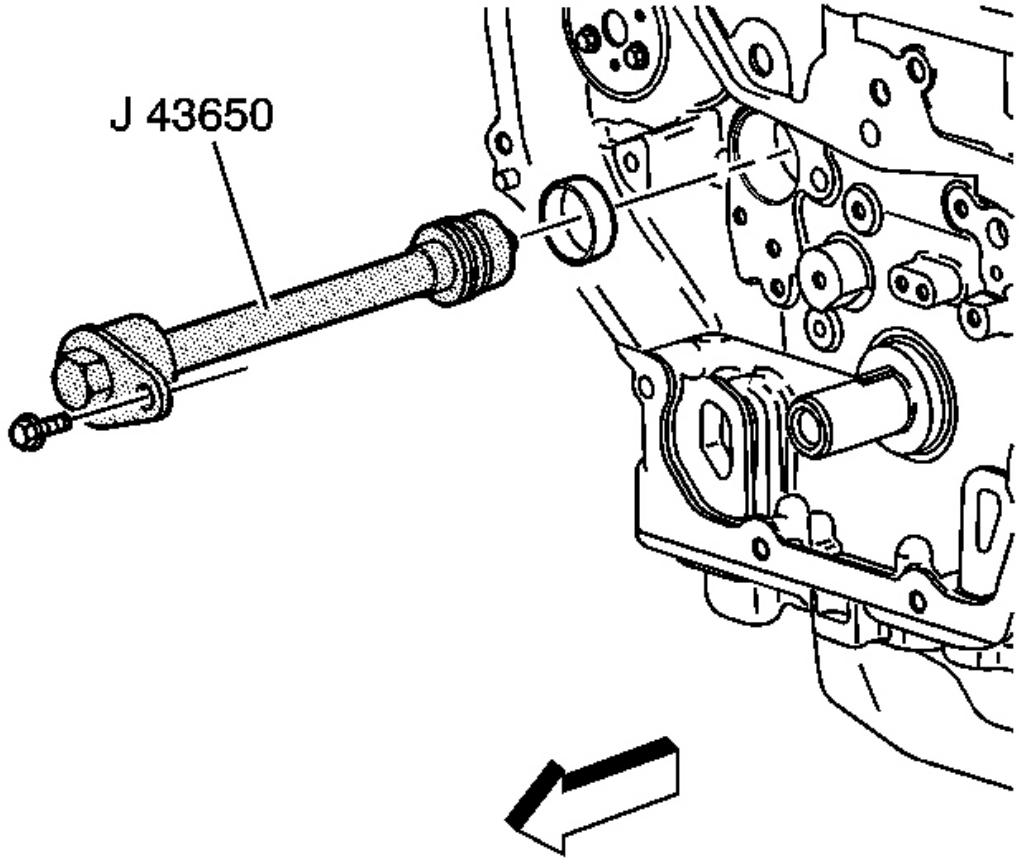


Fig. 557: Installing Balance Shaft Bushing
Courtesy of GENERAL MOTORS CORP.

1. Install the balance shaft bushing using the **J 43650** . See **Special Tools and Equipment** .

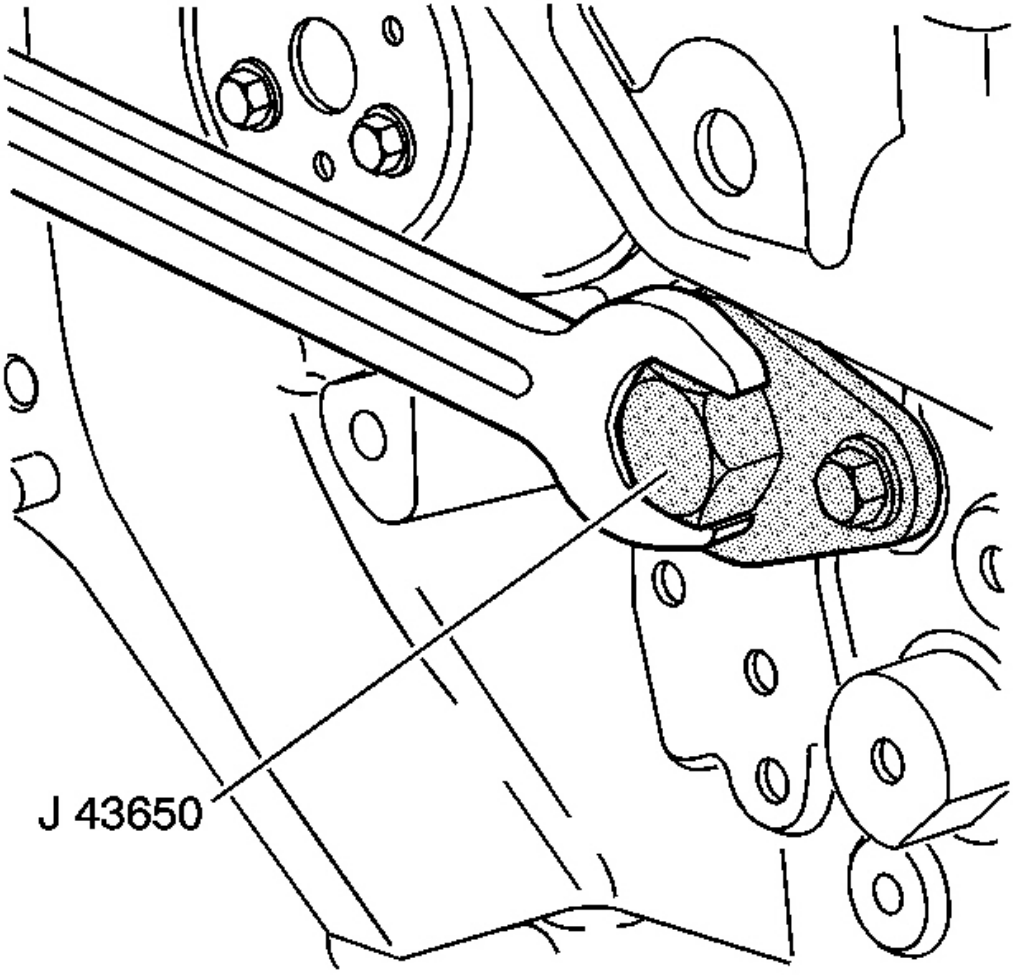


Fig. 558: Seating Balance Shaft Bushing Into Bore
Courtesy of GENERAL MOTORS CORP.

2. Seat the balance shaft bushing into the bore using the **J 43650** and a wrench. See **Special Tools and Equipment** .
3. When the **J 43650** is fully seated in the engine block remove it with a wrench. See **Special Tools and Equipment** .

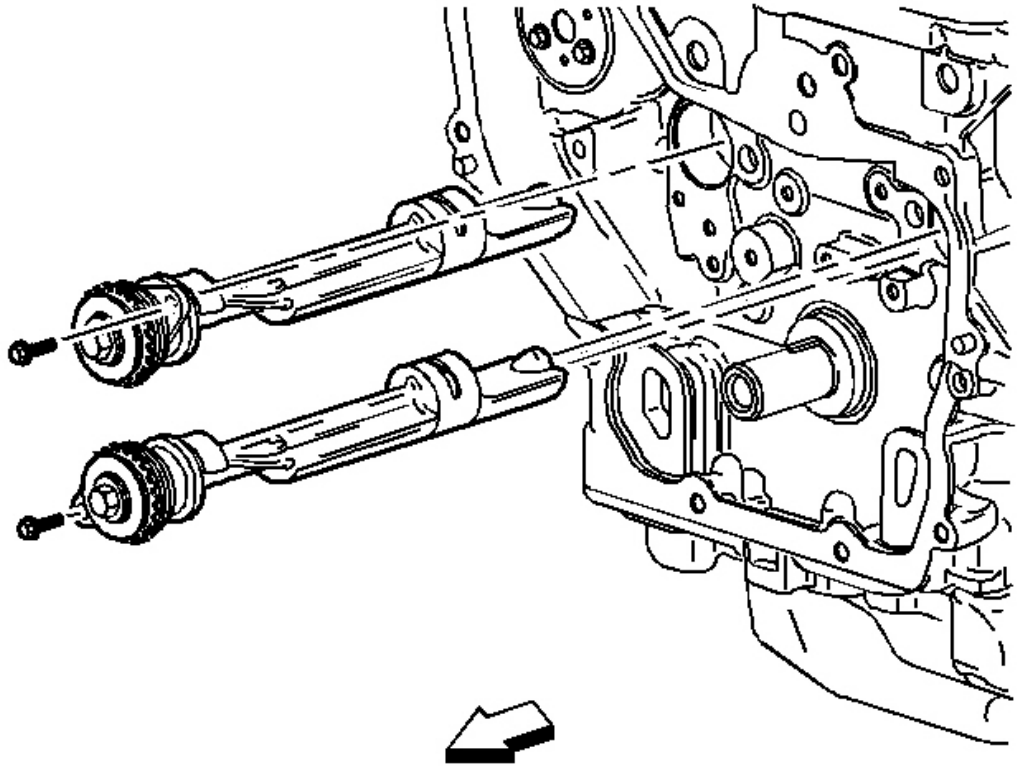


Fig. 559: View Of Balance Shaft
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If the balance shafts are not properly timed to the engine, the engine may vibrate or make noise.
Install the balance shaft assemblies to the engine using the following steps:

4. Place the number one piston at TDC.
5. Install the balance shaft drive chain sprocket on the crankshaft.
6. Lubricate the balance shaft lobes with engine oil.
7. Install the balance shafts into their bores.

NOTE: Refer to Fastener Notice in Cautions and Notices.

8. Install the balance shaft retaining bolts.

Tighten: Tighten the balance shaft retaining bolts 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.

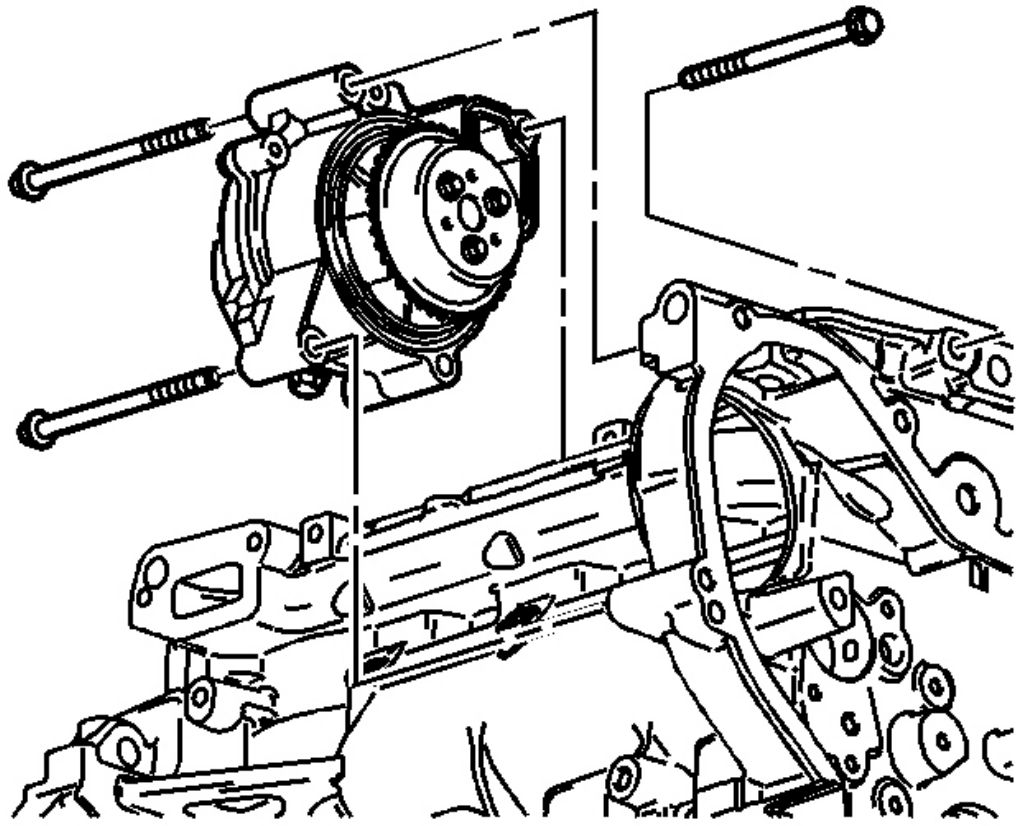


Fig. 560: View Of Water Pump Assembly
Courtesy of GENERAL MOTORS CORP.

1. Install the water pump assembly.
2. Install the water pump bolts. Finger tighten the bolts.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Tighten the water pump bolts.

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

4. Apply sealant P/N 21485278 to the water pump drain plug.
5. Install the water pump drain plug, if necessary.

   Tighten: Tighten the water pump drain plug to 20 N.m (15 lb ft).

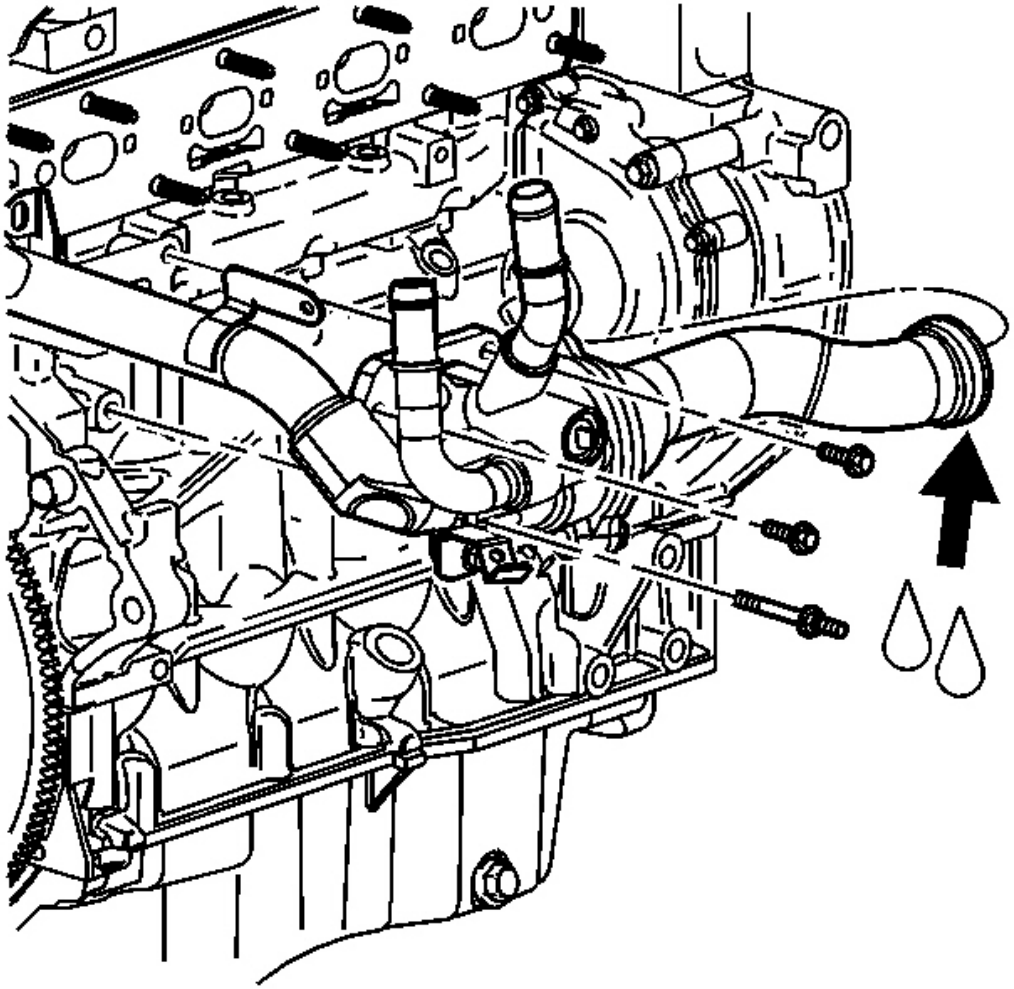


Fig. 561: View Of Water Feed Tube
Courtesy of GENERAL MOTORS CORP.

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.

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

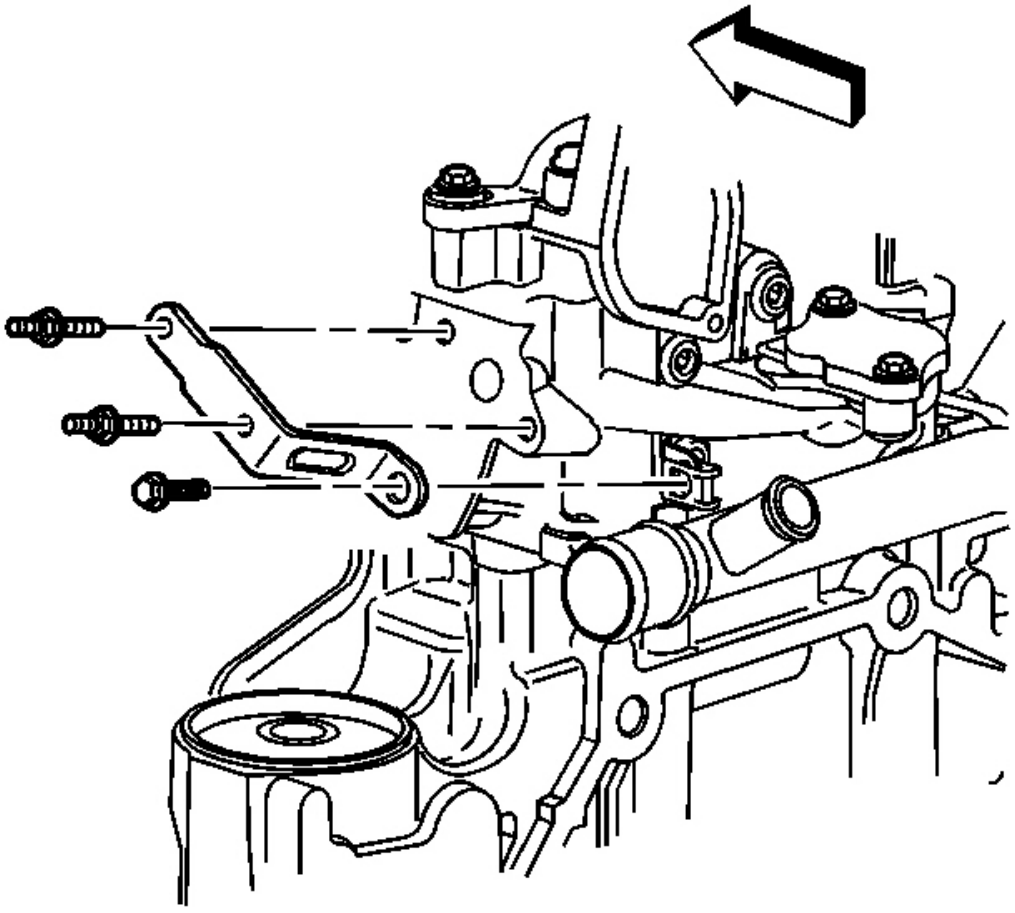


Fig. 562: View Of Water Pipe Support Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

10. Install the water pipe support bracket and bolts.

    Tighten: Tighten the water pipe support bracket bolts to 10 N.m (89 lb in).

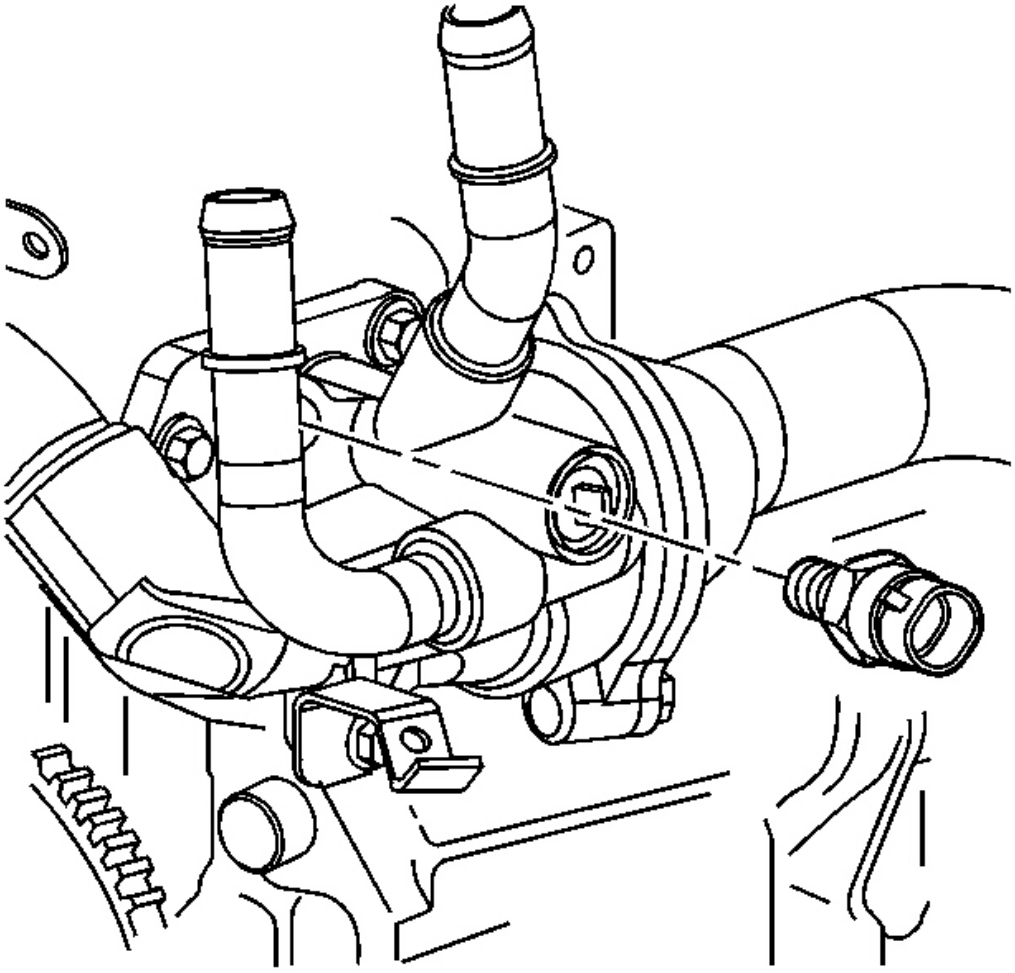


Fig. 563: View Of Engine Coolant Temperature Sensor
Courtesy of GENERAL MOTORS CORP.

11. Install the engine coolant temperature sensor by hand.
12. Tighten the engine coolant temperature sensor.

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

TIMING BALANCE SHAFTS TO ENGINE

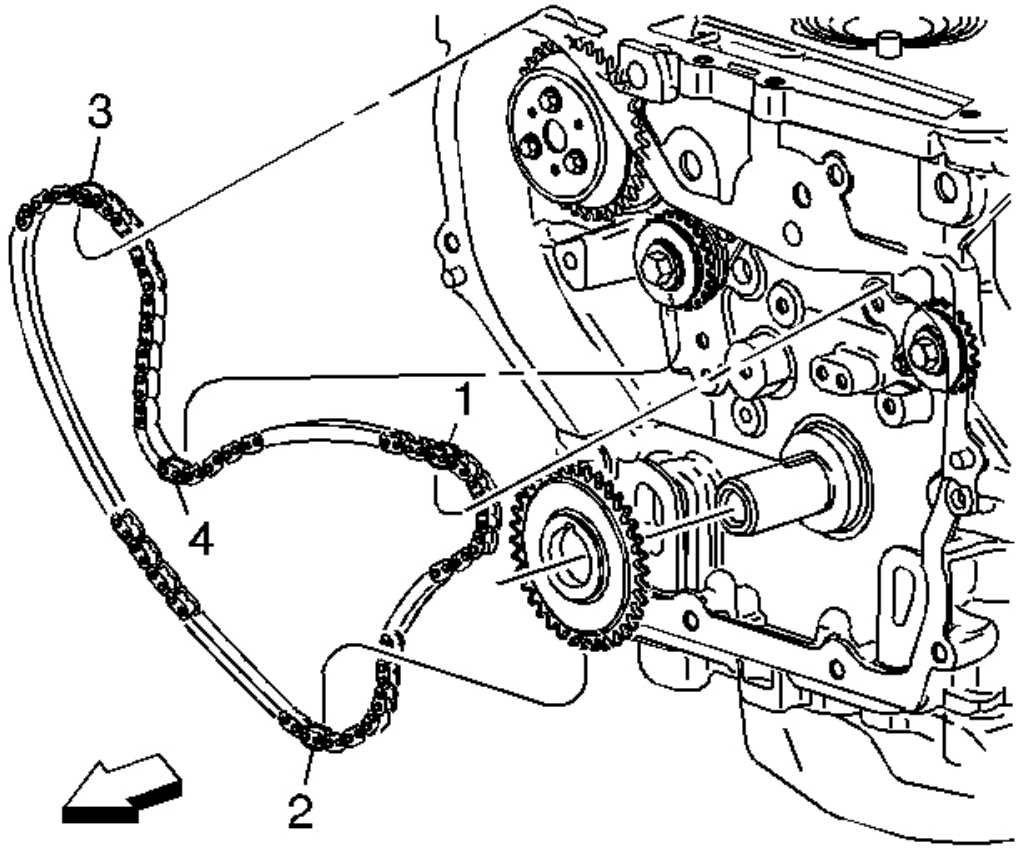


Fig. 564: Aligning Balance Shaft Drive Chain
Courtesy of GENERAL MOTORS CORP.

1. Install the balance shaft drive sprocket.

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

2. Install the balance shaft drive chain with the colored links lined up on with the marks on the balance shaft drive sprockets and the crankshaft sprocket. There are three colored links on the chain. Two links are of matching colors, and one link is of a unique color. Use the following procedure to line up the links with the sprockets:

   Orient the chain so that the colored links are visible.

3. Place the uniquely colored link (1) so that it lines up with the timing mark on the intake side balance shaft

sprocket.

4. Working clockwise around the chain, place the first matching colored link (2) in line with the timing mark on the crankshaft drive sprocket. (approximately 6 o'clock position on the crank sprocket)
5. Place the chain (3) on the water pump drive sprocket. The alignment is not critical.
6. Align the last matching colored link (4) with the timing mark on the exhaust side balance shaft drive sprocket.

BALANCE SHAFT DRIVE CHAIN AND TENSIONER INSTALL

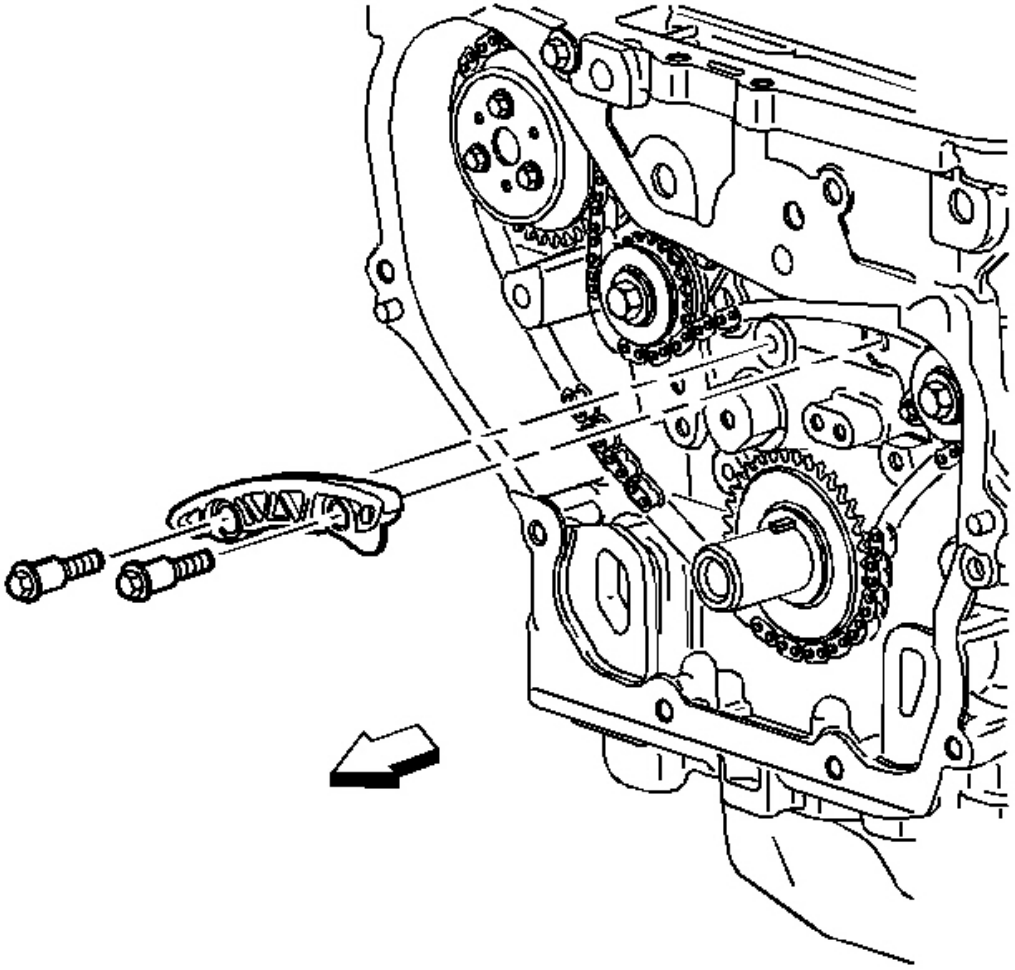


Fig. 565: View Of Upper Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Fastener Notice in Cautions and Notices.**

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

1. Install the upper balance shaft chain guide and bolts.

   Tighten: Tighten the upper balance shaft chain guide bolts to 10 N.m (89 lb in).

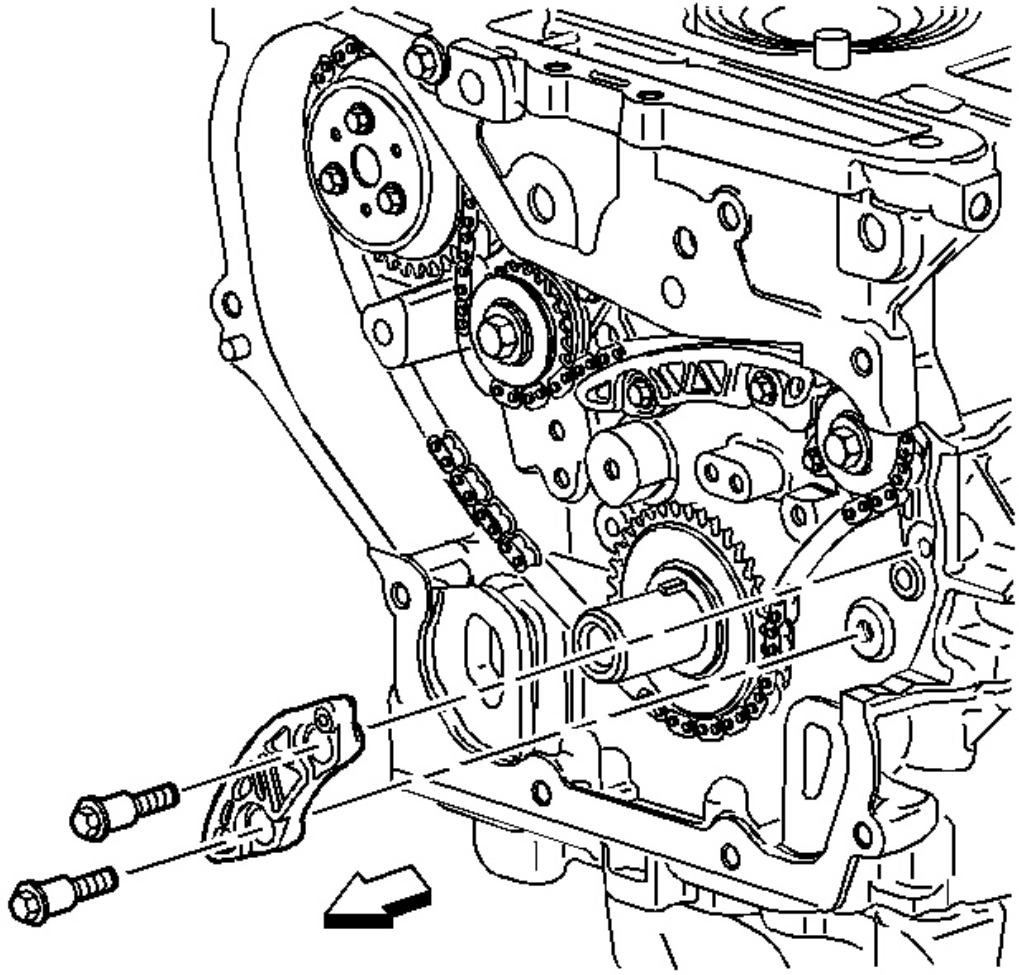


Fig. 566: View Of Small Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

2. Install the small balance shaft chain guide.
3. Install the balance shaft chain guide bolts.

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

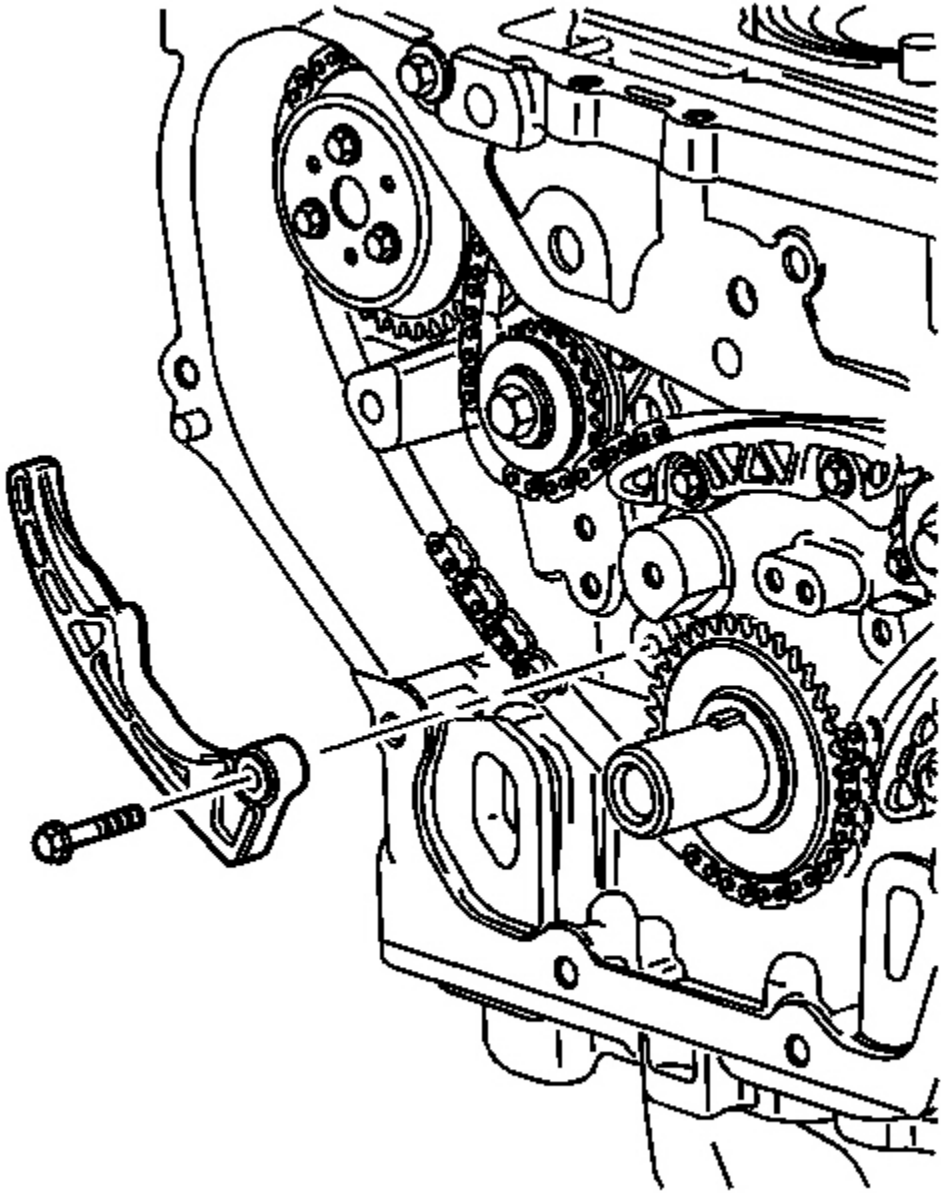


Fig. 567: View Of Adjustable Balance Shaft Chain Guide
Courtesy of GENERAL MOTORS CORP.

4. Install the adjustable balance shaft drive chain guide.
5. Install the adjustable balance shaft drive chain guide bolts.

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

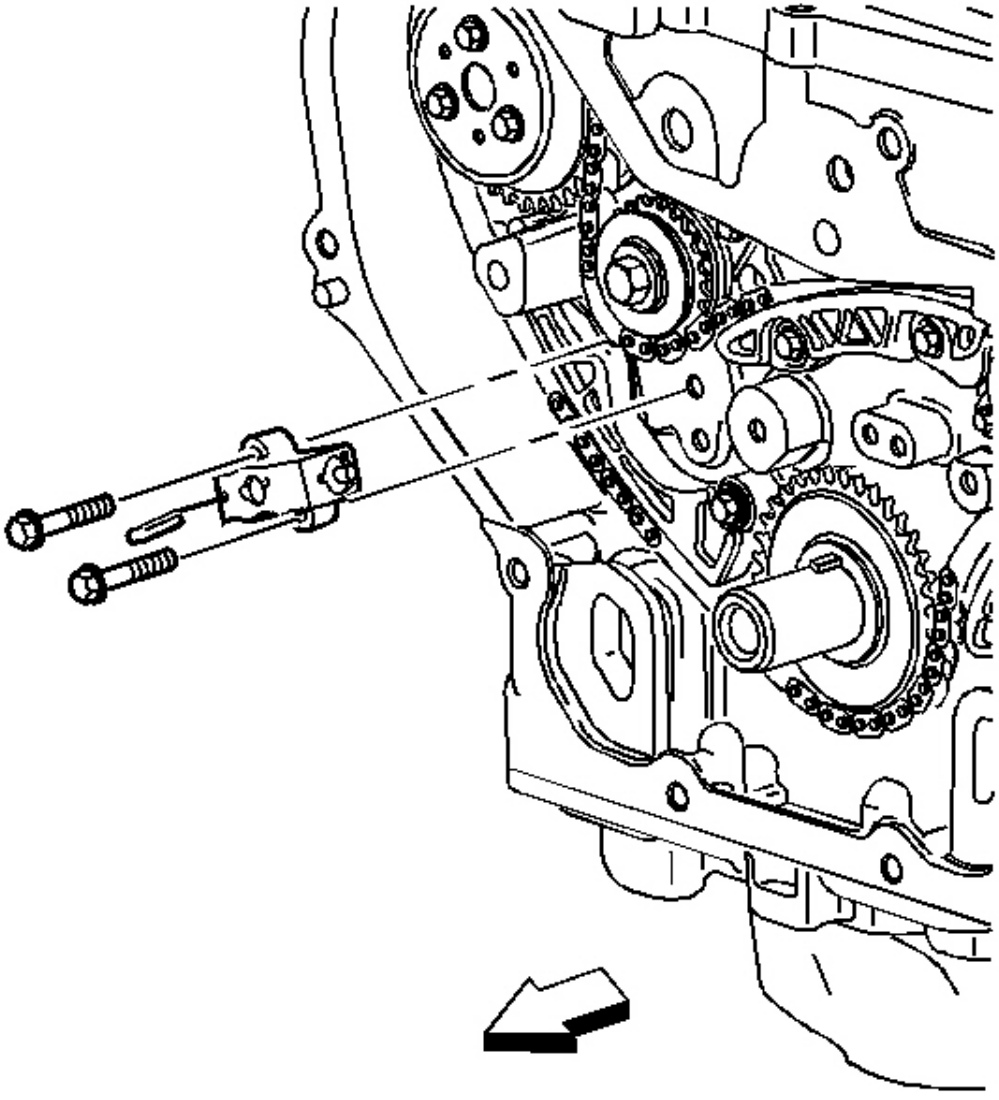


Fig. 568: Identifying Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

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.
8. Install the chain tensioner bolts.

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

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

TIMING CHAIN, SPROCKETS, TENSIONER INSTALLATION

Tools Required

- **J 45027** Tensioner Tool. See **Special Tools and Equipment** .
- **J 45059** Angle Meter. See **Special Tools and Equipment** .

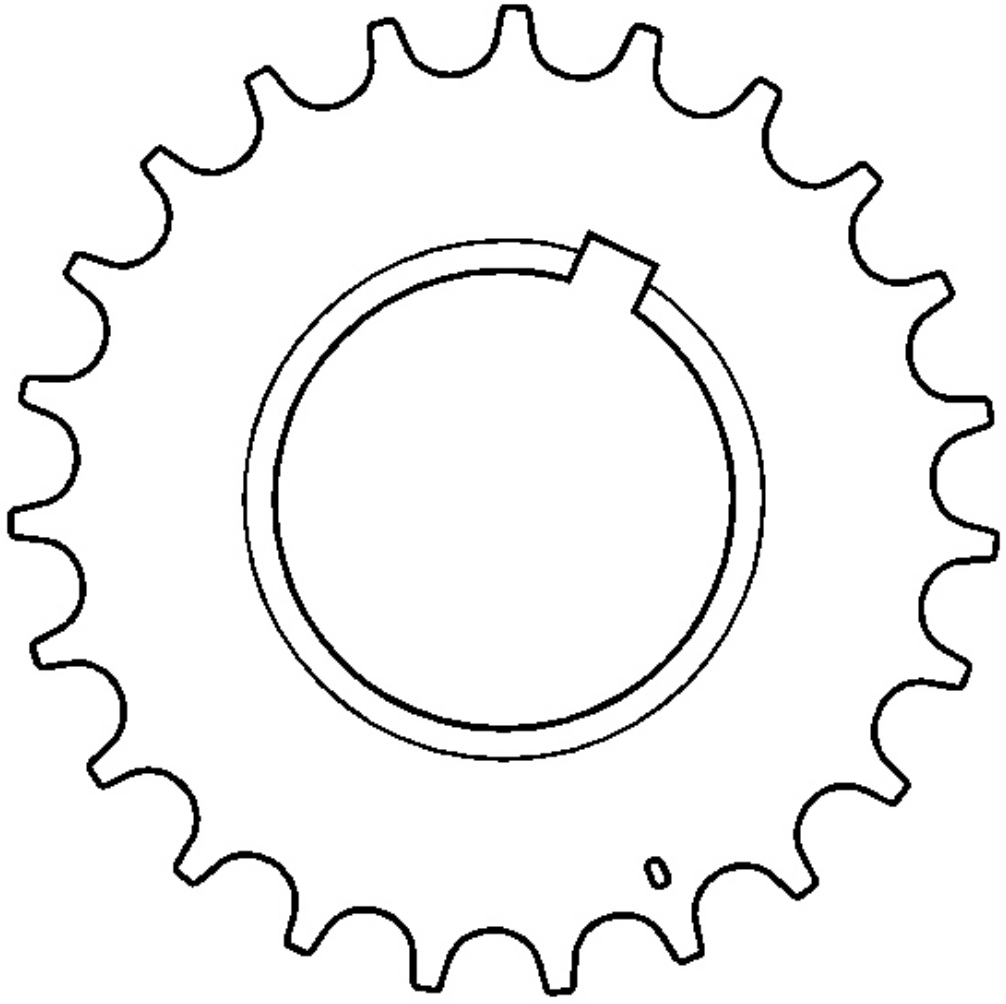


Fig. 569: View Of Crankshaft Sprocket Timing Mark In The 5 O'clock Position
Courtesy of GENERAL MOTORS CORP.

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

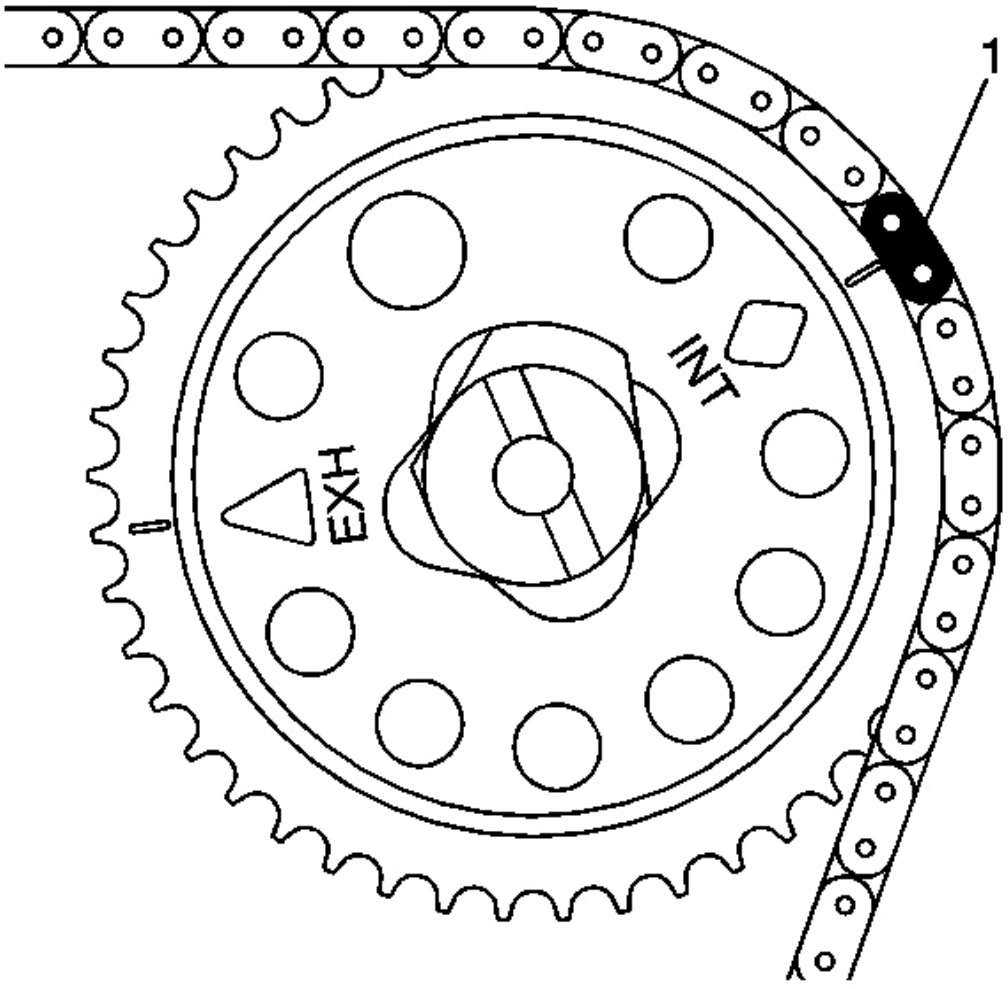


Fig. 570: Aligning Timing Chain Link & Intake Timing Mark
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **There are three colored links on the timing chain. Two links are of matching color and one link is of a unique color. Use the following procedure to line up the links with the sprockets. Orient the chain so that the colored links are visible.**
- **Always use new sprocket bolts.**

2. Assemble the intake camshaft sprocket to the timing chain with the timing mark lined up with the uniquely colored link (1). Hand tighten a new intake camshaft sprocket bolt.

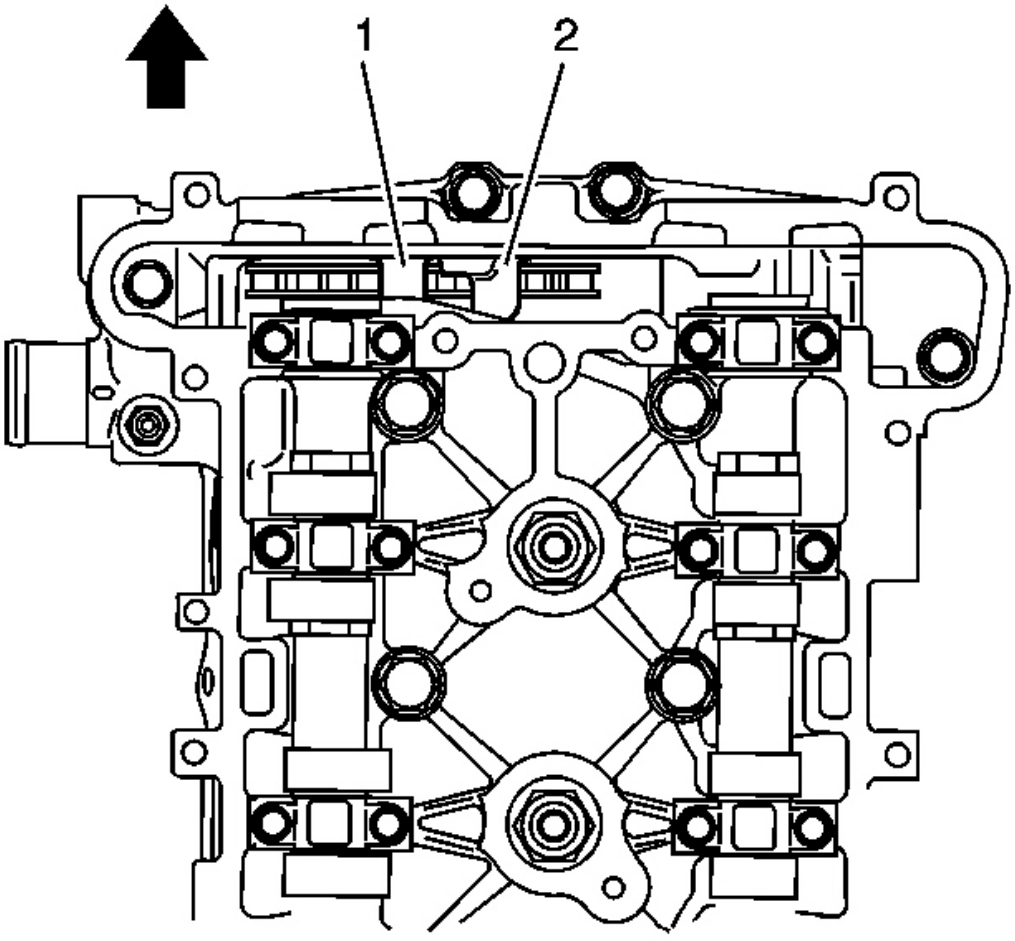


Fig. 571: View Of Cylinder Block Bosses
Courtesy of GENERAL MOTORS CORP.

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

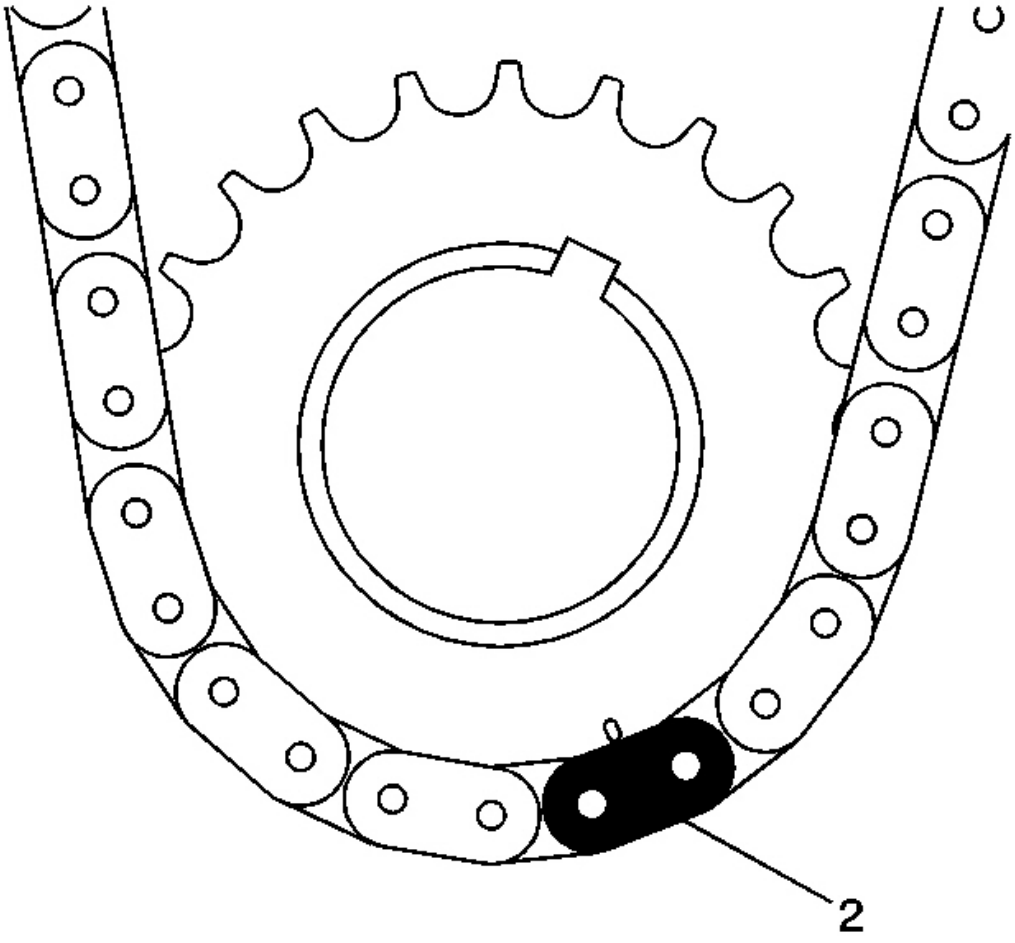


Fig. 572: Lineing Up The First Matching Colored Link With Timing Mark On The Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

4. Route the timing chain around the crankshaft sprocket and line up the first matching colored link (2) with the timing mark on the crankshaft sprocket, in approximately the 5 o'clock position.

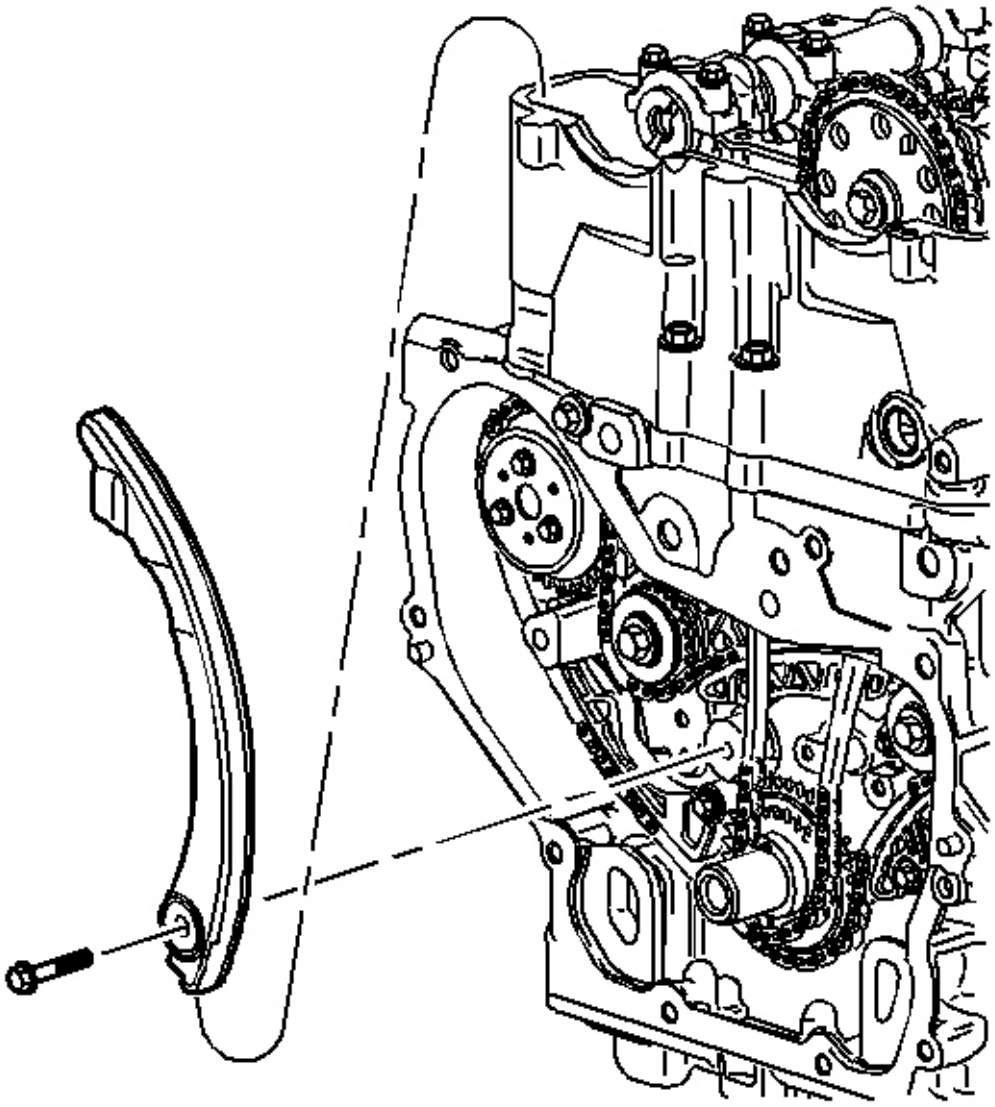


Fig. 573: View Of Timing Chain Tensioner Guide
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Install the adjustable timing chain guide through the opening in the cylinder head and install the adjustable timing chain bolt.

Tighten: Tighten the adjustable timing chain guide bolt to 10 N.m (89 lb in).

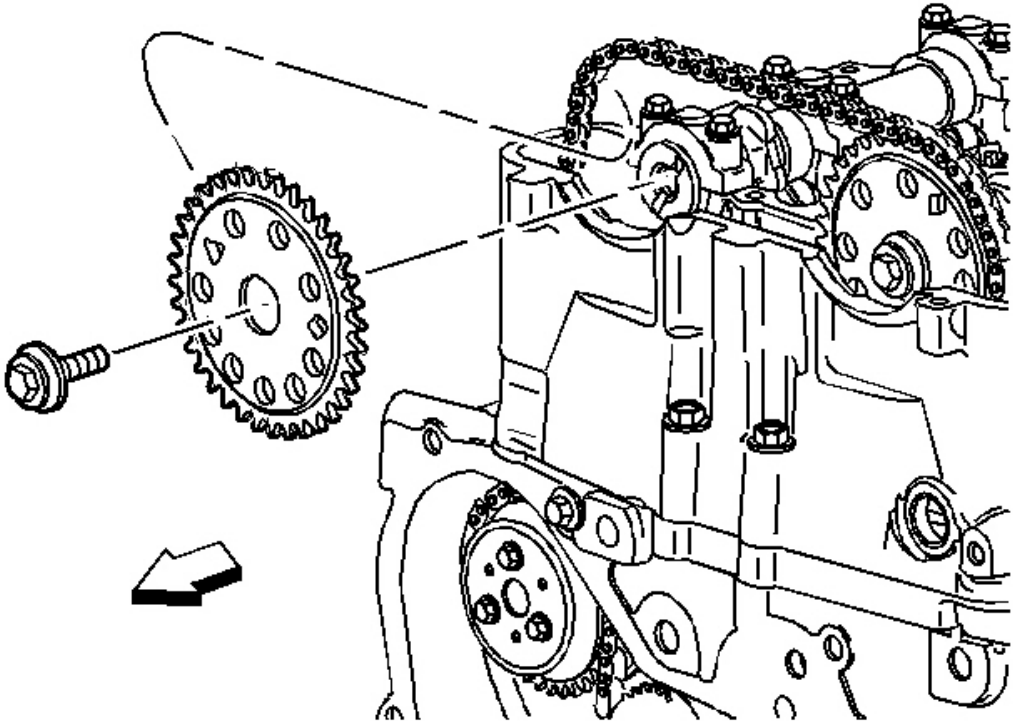


Fig. 574: View Of Exhaust Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Always install new sprocket bolts.

6. Install the exhaust camshaft sprocket and a new bolt loosely onto the exhaust camshaft.

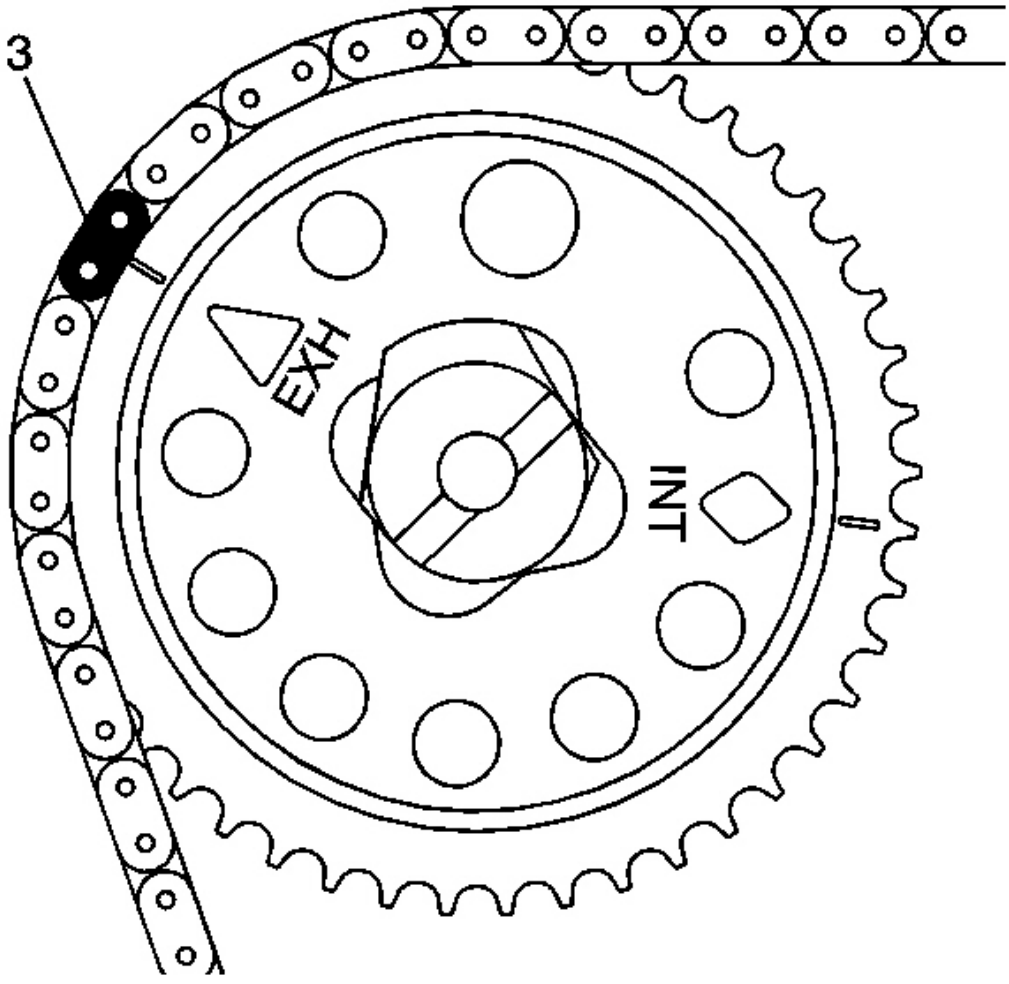


Fig. 575: Aligning Timing Chain Link & Exhaust Timing Mark
Courtesy of GENERAL MOTORS CORP.

7. Align the timing mark on the sprocket with the last matching colored link (3). Install the bolt finger tight.

IMPORTANT: Do not turn the camshaft more than 1/2 turn in either direction. To do so may cause valve to piston contact. This may damage a valve and/or a piston. If the camshaft is 180 degrees out of time, use the following procedure to re-align the cam.

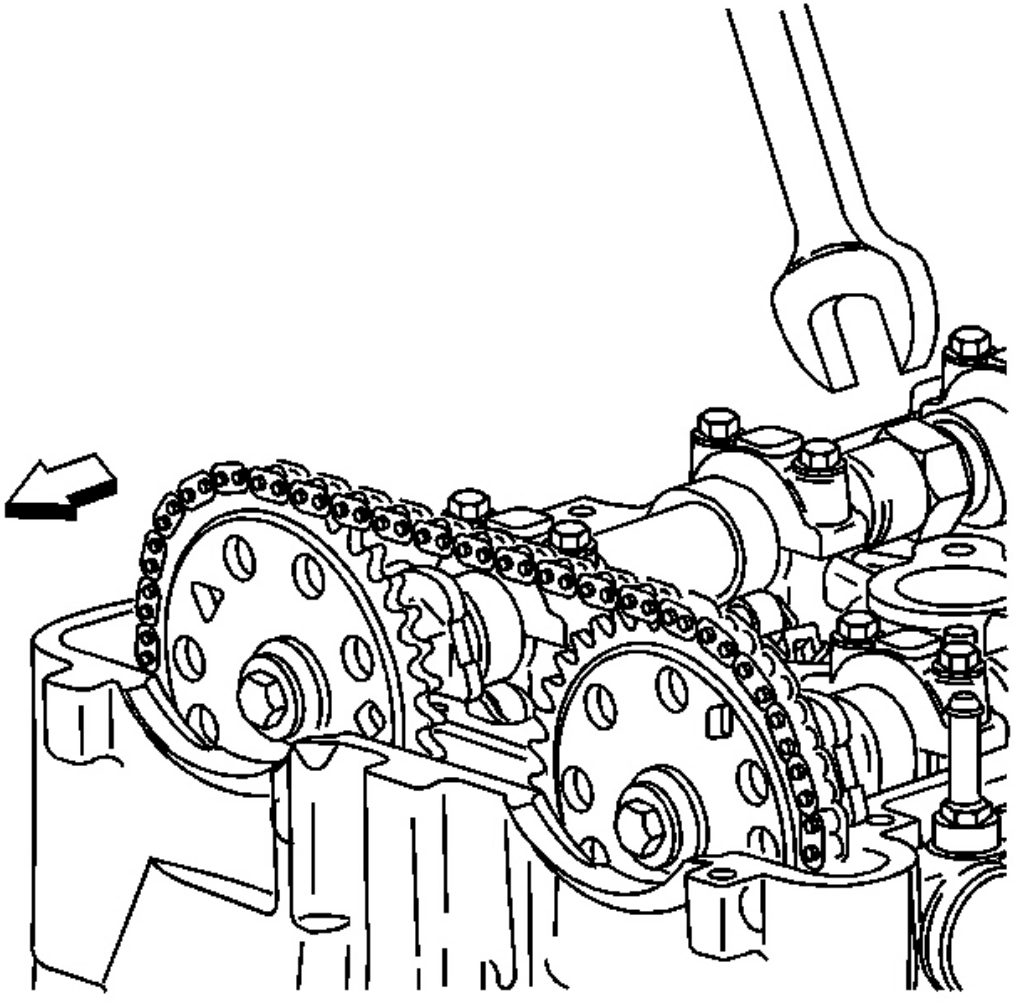


Fig. 576: Turning Camshaft Using 24 mm Wrench
Courtesy of GENERAL MOTORS CORP.

8. Using a 24 mm wrench, first turn the intake camshaft until the alignment feature on the back of the camshaft sprocket seats in the notch in the front of the intake camshaft.
    1. Turn the crankshaft 45 degrees in either direction.
    2. Turn the intake cam to the appropriate location.
    3. Turn the crankshaft back to top dead center.
9. When the sprocket seats on the cam, tighten the sprocket bolt hand tight.
10. Verify that all of the colored links and the appropriate timing marks are still aligned. If they are not, repeat the portion of the procedure necessary to align the timing marks.

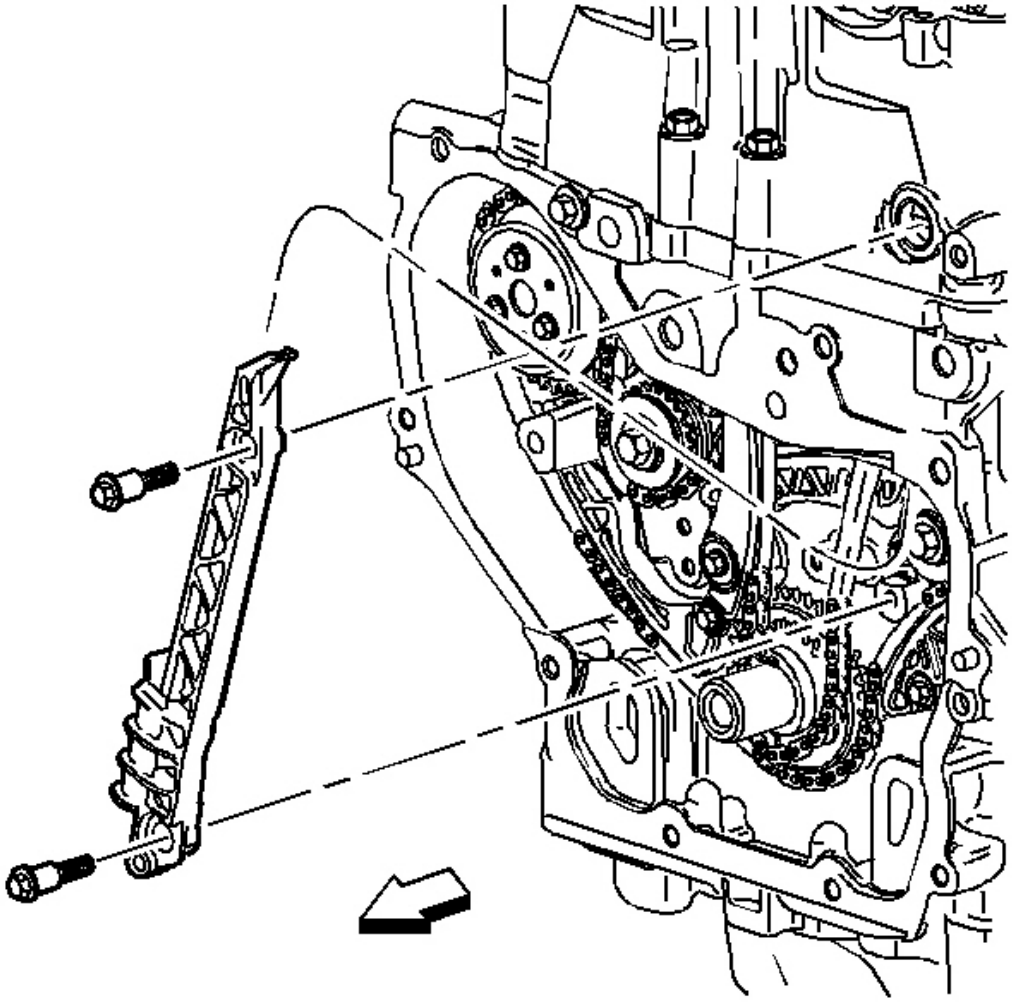


Fig. 577: View Of Fixed Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

11. Install the fixed timing chain guide.

    Tighten: Tighten the fixed timing chain guide bolts to 10 N.m (89 lb in).

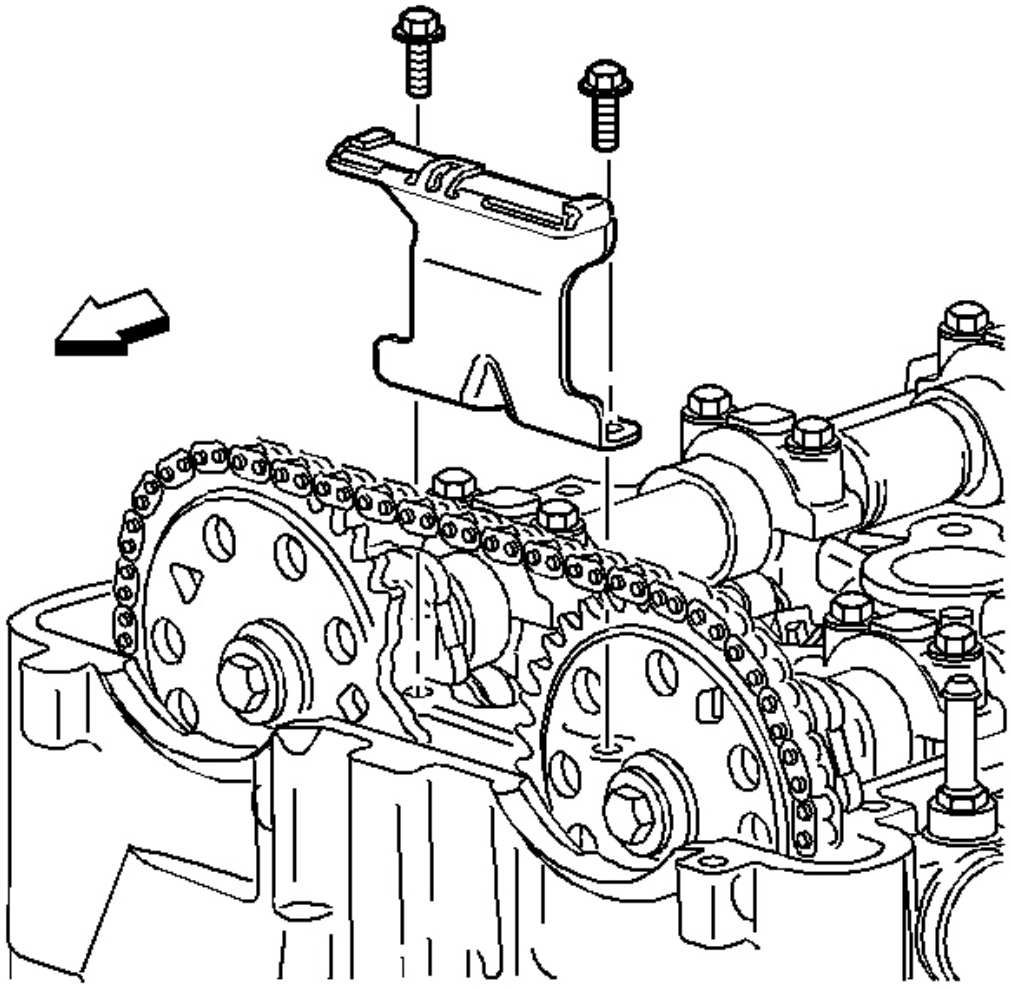


Fig. 578: View Of Upper Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

12. Install the upper timing chain guide.

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

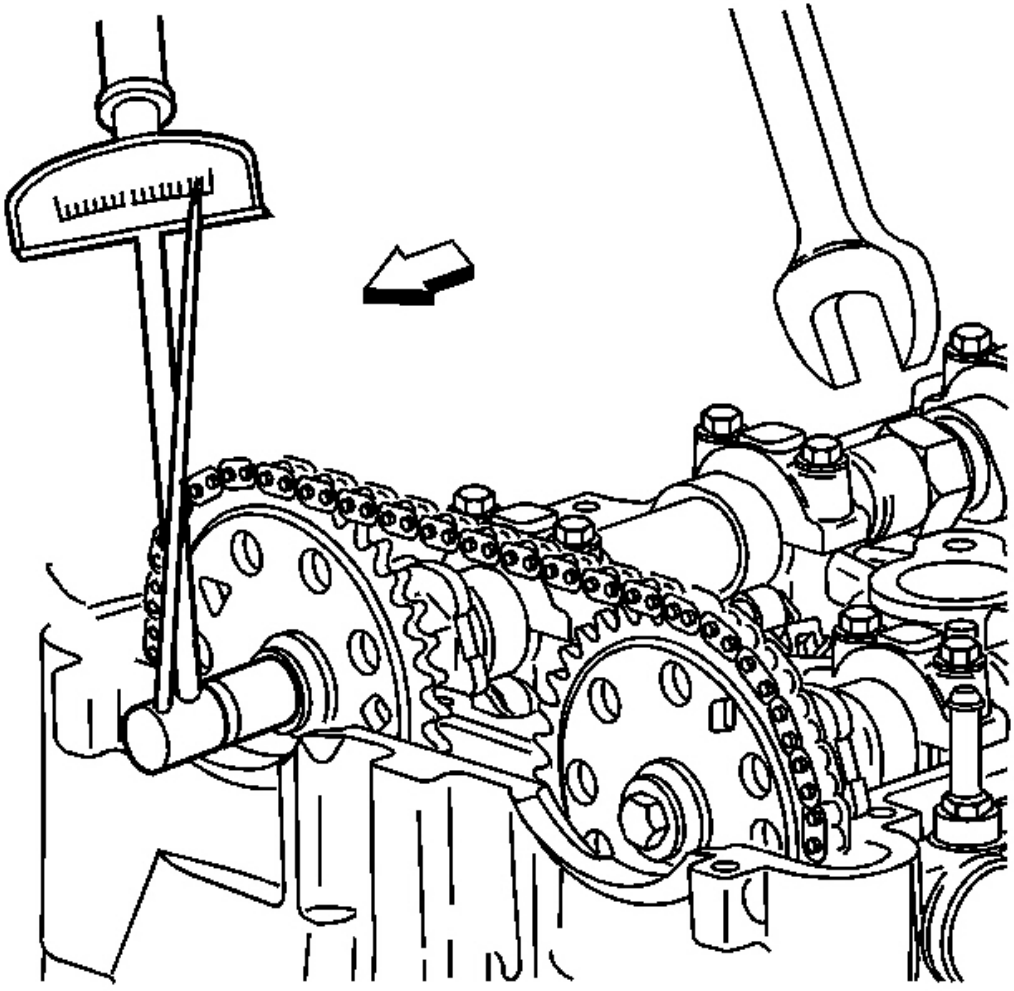


Fig. 579: Installing Camshaft Sprocket Bolts
Courtesy of GENERAL MOTORS CORP.

13. Using a 24 mm wrench, engage the hex on the intake camshaft and using a torque wrench, tighten the camshaft sprocket bolt.

    Tighten: Tighten the intake camshaft sprocket bolt to 85 N.m (63 lb ft), plus 30 degrees using **J 45059** . See **Special Tools and Equipment** .

14. Using a 24 mm wrench, engage the hex on the exhaust camshaft and using a torque wrench, tighten the camshaft sprocket bolt.

Tighten: Tighten the exhaust camshaft sprocket bolt to 85 N.m (63 lb ft), plus 30 degrees using **J 45059** . See **Special Tools and Equipment** .

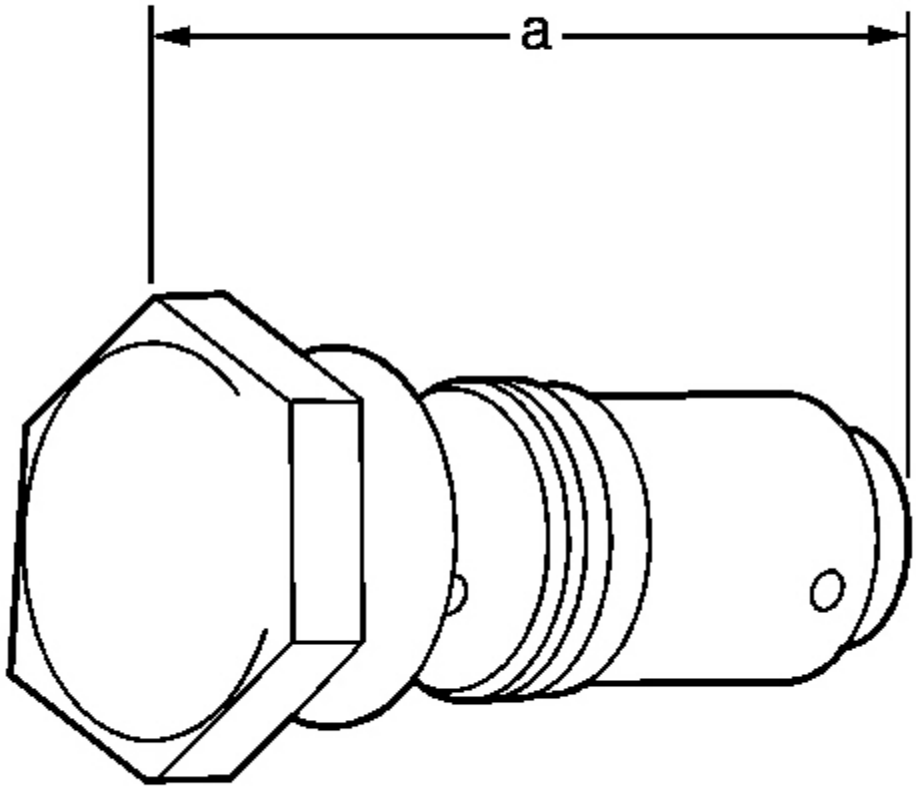


Fig. 580: Checking Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

15. Remove the old oil from the timing chain tensioner.
16. Inspect the timing chain tensioner for scoring or free movement.
17. Inspect the timing chain chain washer and O-ring for damage. If damaged, replace the timing chain tensioner.
18. Measure the timing chain tensioner assembly from end to end.

    A new tensioner should be supplied in the fully compressed non-active state. A tensioner in the compressed state will measure 72 mm (2.83 in) (a) from end to end. A tensioner in the active state will measure 85 mm (3.35 in) (a) from end to end.

19. 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.

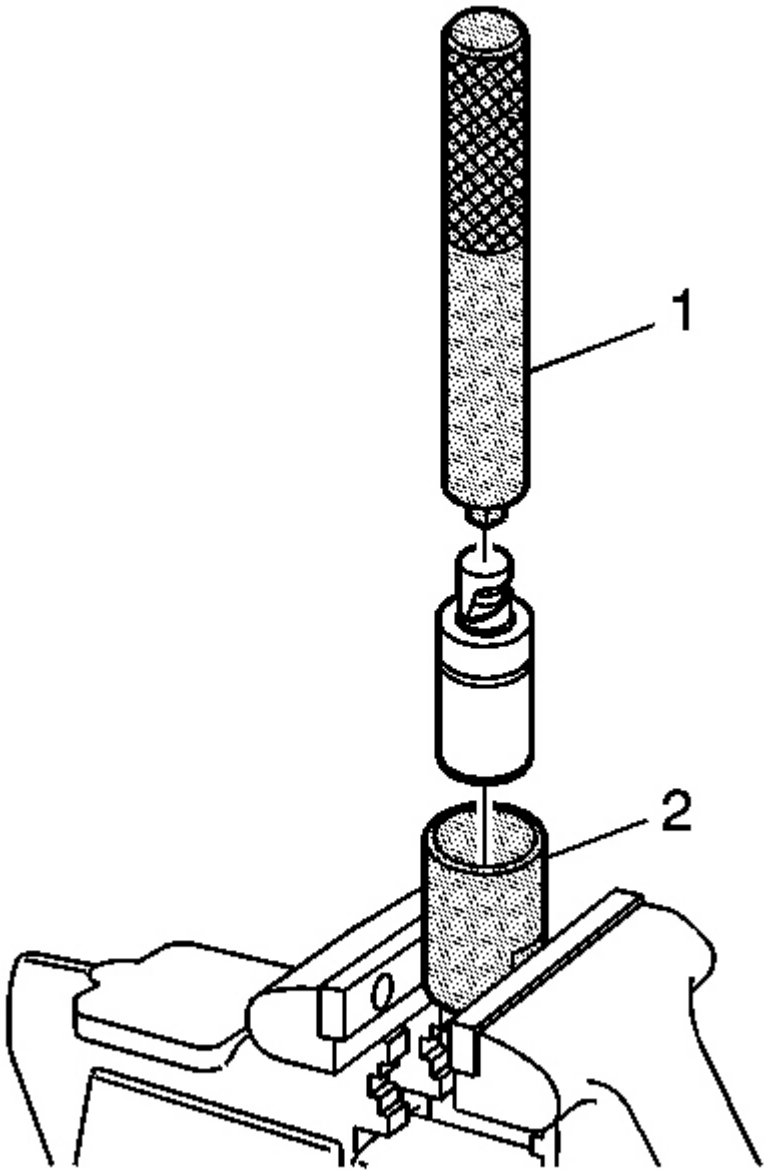


Fig. 581: Turn The Ratchet Cylinder Into The Piston Using J 45027-1
Courtesy of GENERAL MOTORS CORP.

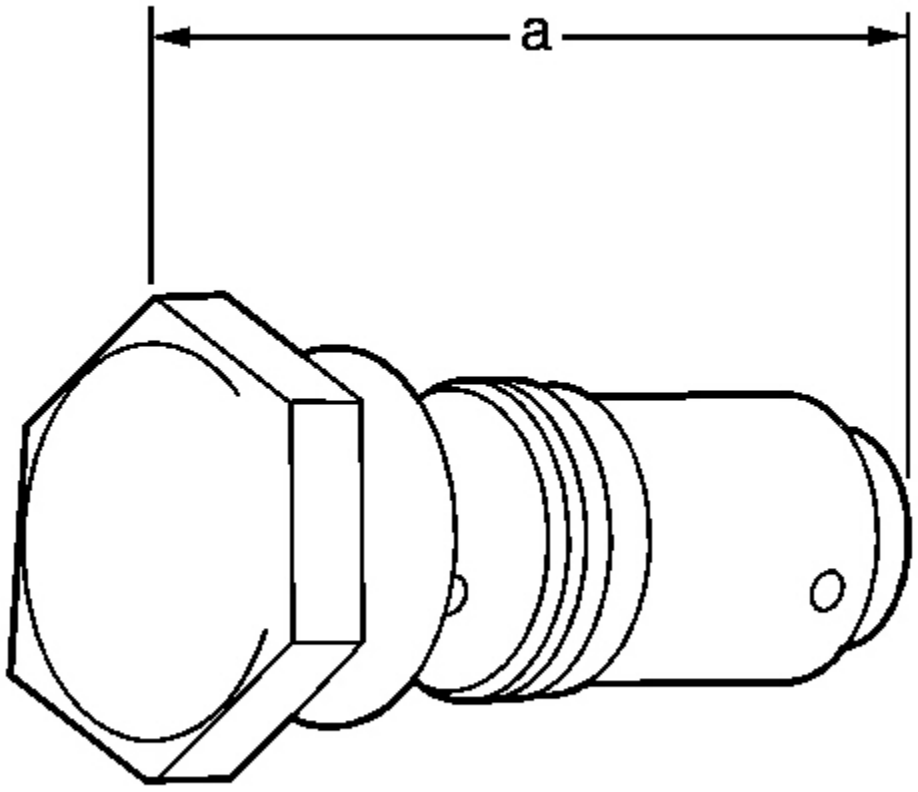


Fig. 582: Checking Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

20. 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.
21. 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.
22. 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 16.1 and 16.4.

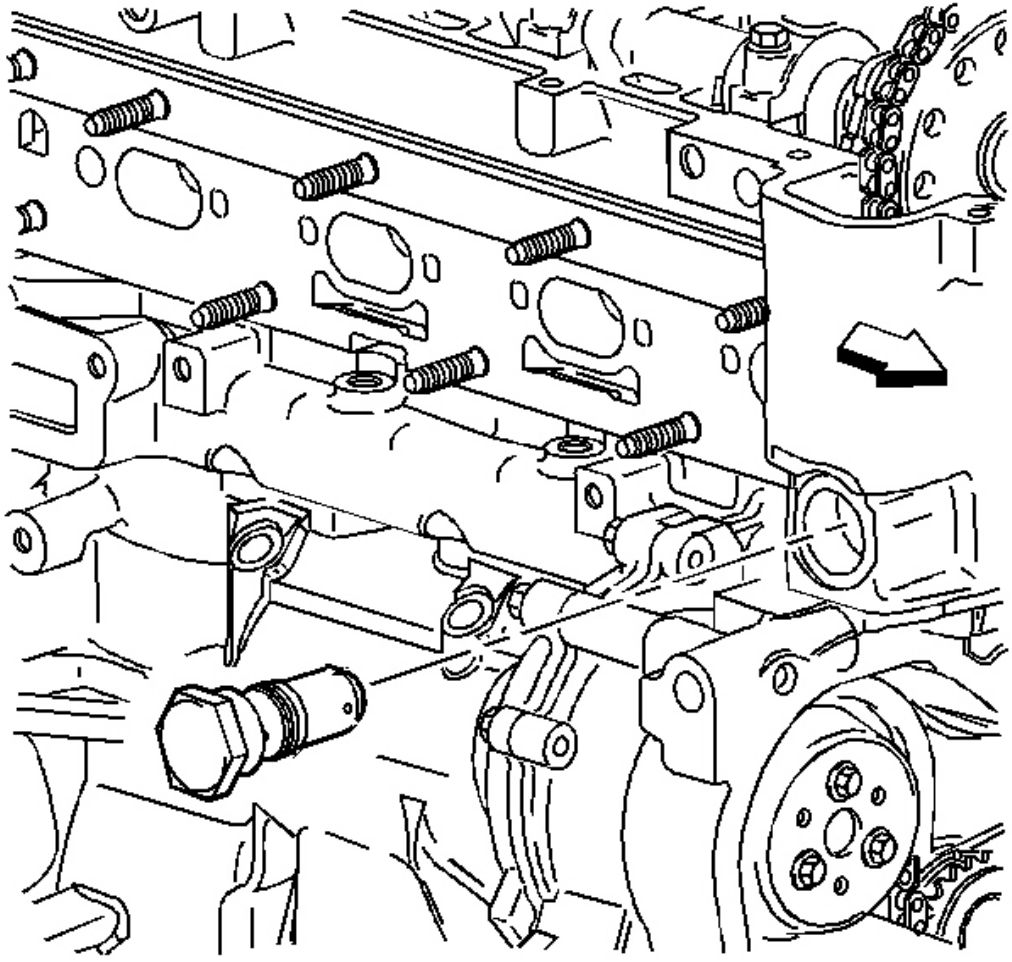


Fig. 583: View Of Timing Chain Tensioner Plunger
Courtesy of GENERAL MOTORS CORP.

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

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

25. 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.

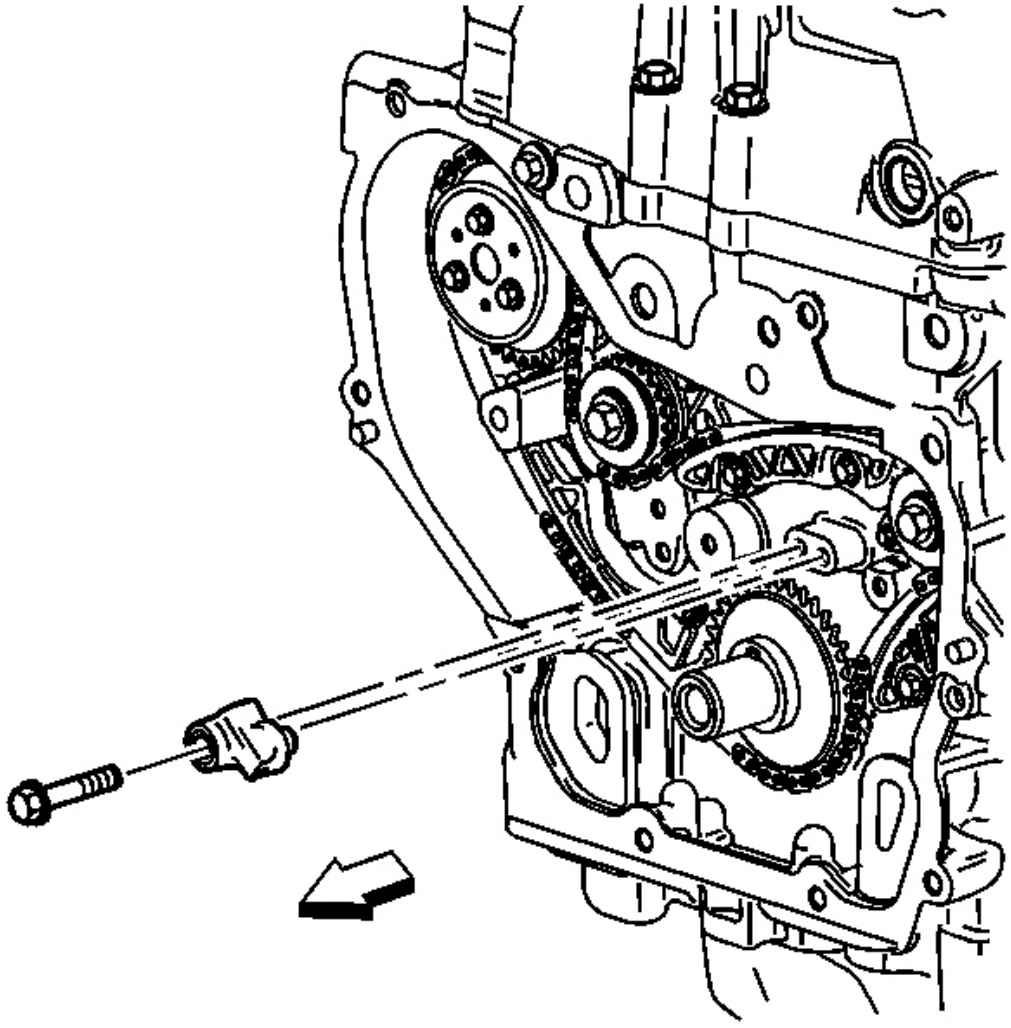


Fig. 584: View Of Oil Nozzle
Courtesy of GENERAL MOTORS CORP.

26. Inspect to ensure that all dirt and debris is removed from the timing chain oiling nozzle hole in the engine block.
27. Install the timing chain oiling nozzle.

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

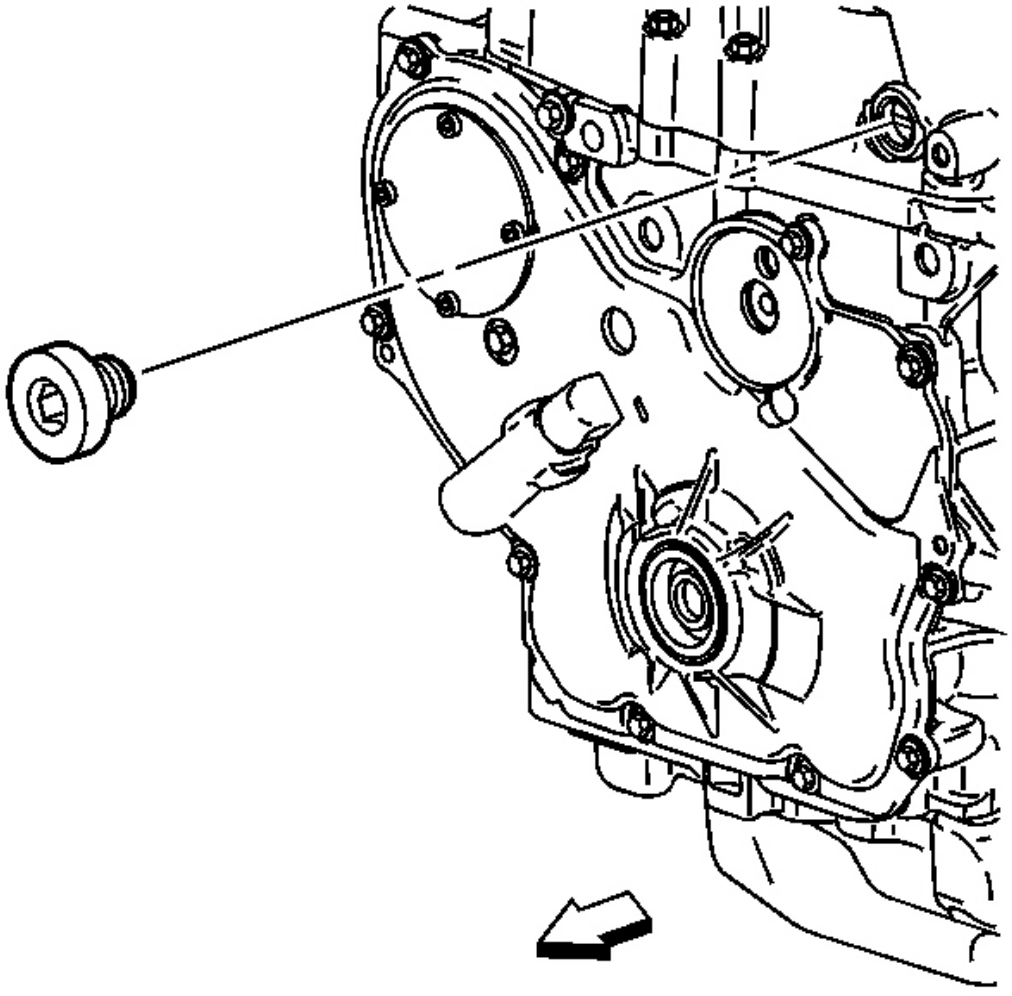


Fig. 585: View Of Fixed Timing Chain Guide Access Plug
Courtesy of GENERAL MOTORS CORP.

28. Apply sealant P/N 21485277 compound to the thread, and install the timing chain guide bolt access hole plug.

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

CRANKSHAFT FRONT OIL SEAL INSTALLATION

Tools Required

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

Crankshaft Front Oil Seal Installation

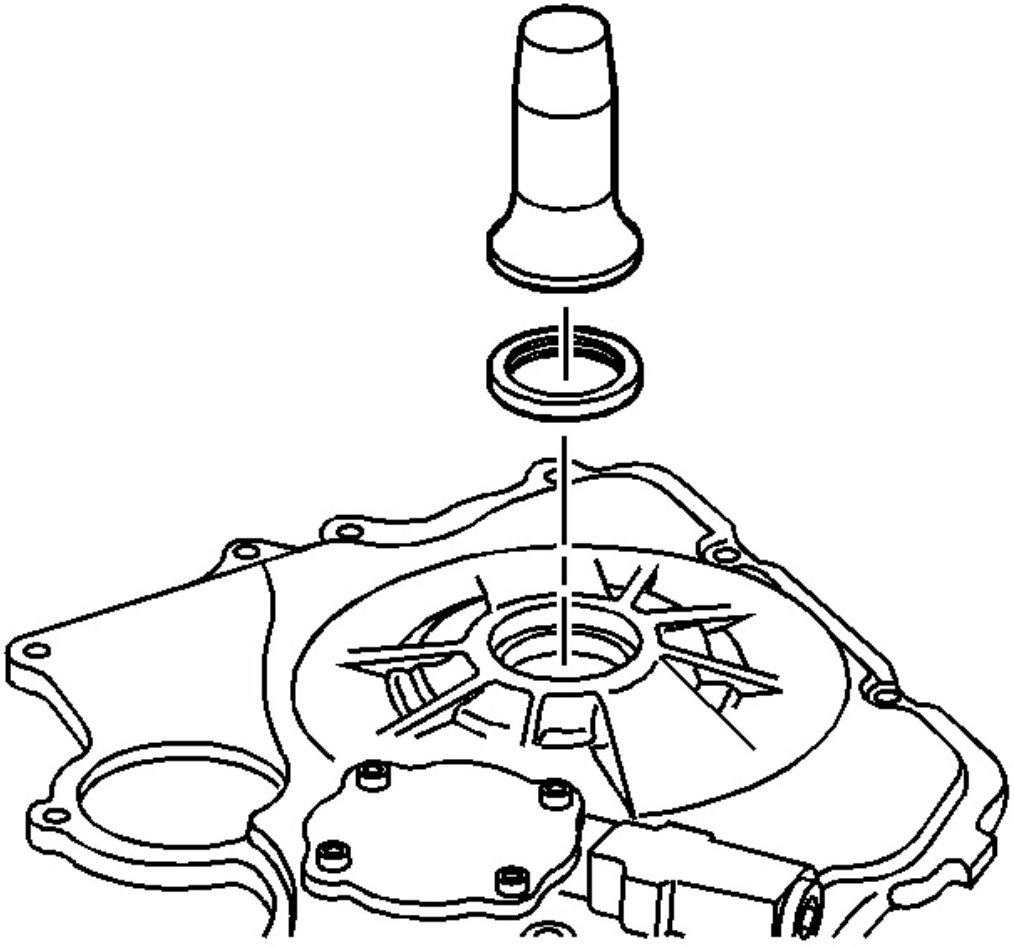


Fig. 586: View Of Crankshaft/Front Main Seal
Courtesy of GENERAL MOTORS CORP.

1. Install the seal into the front cover by driving it in from the timing chain side using **J 35268-A** . See **Special Tools and Equipment** .
2. Ensure that the engine front cover is properly supported when installing the seal.

ENGINE FRONT COVER AND OIL PUMP INSTALLATION

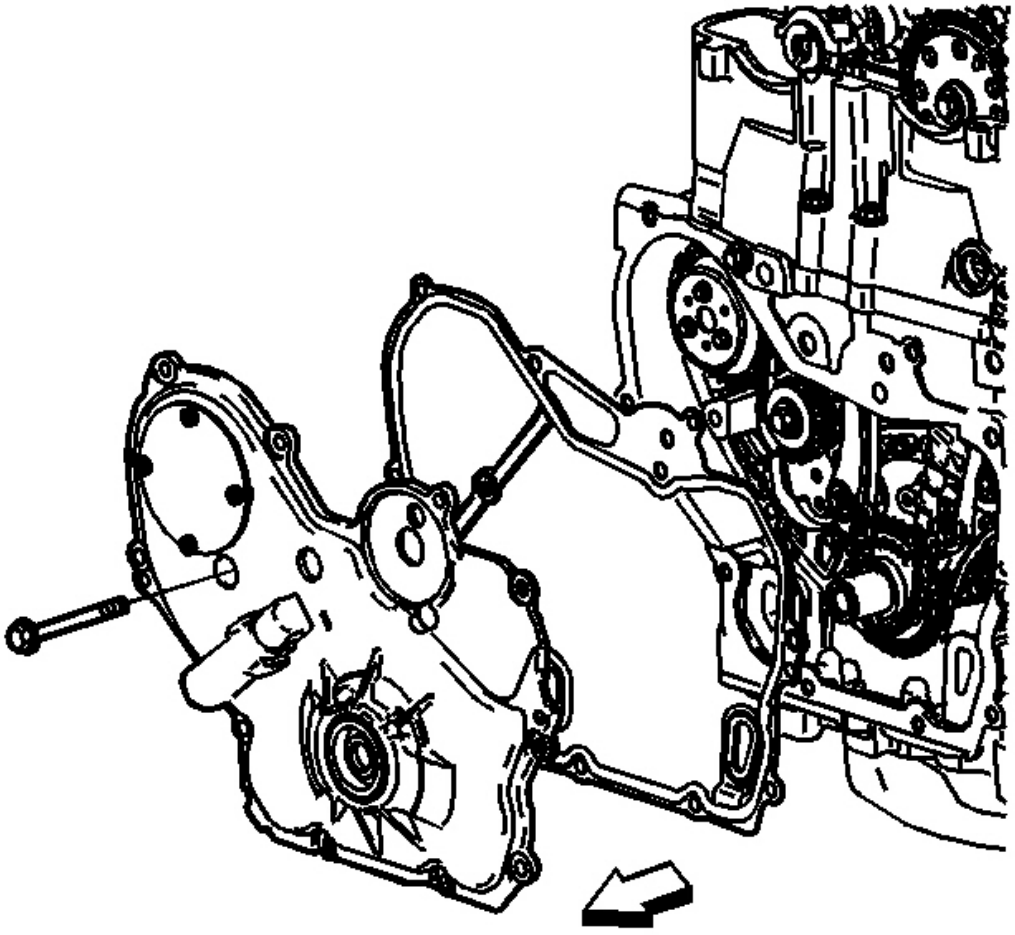


Fig. 587: View Of Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

1. Install the engine front cover with a new gasket.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the long water pump bolt.

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

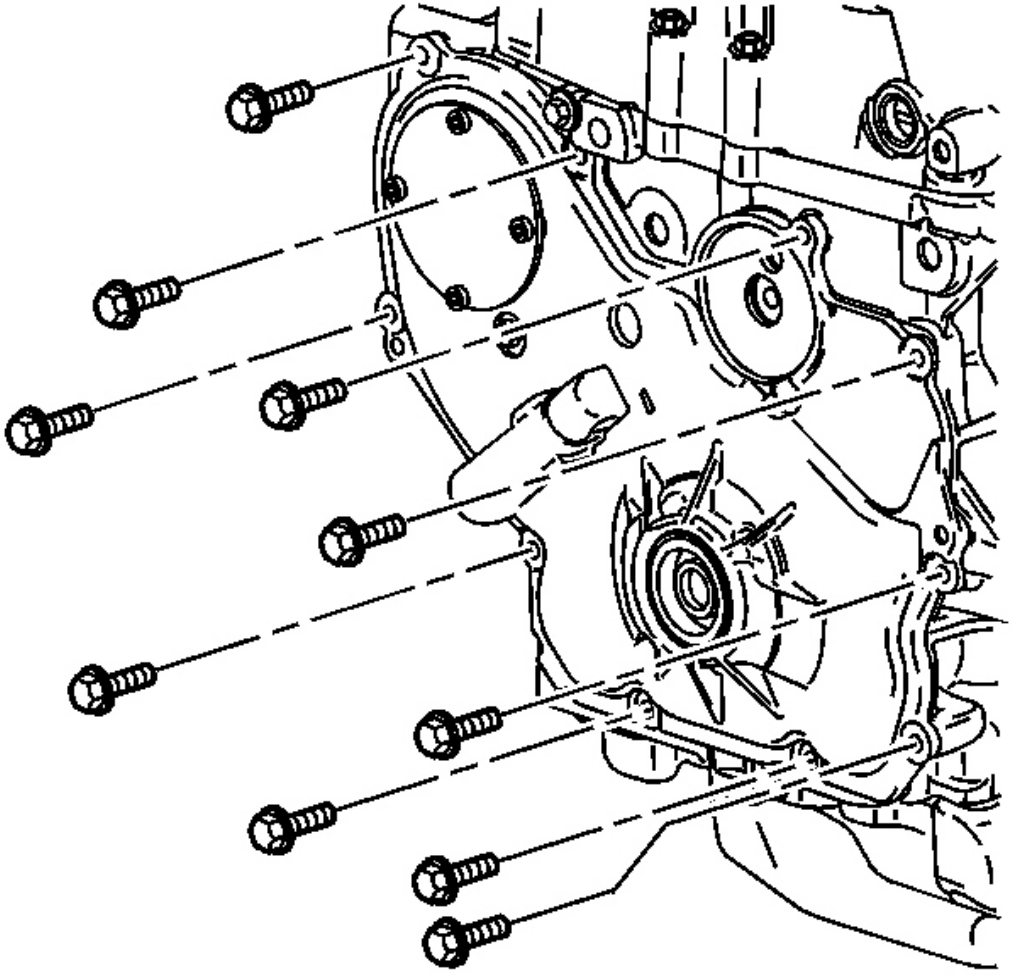


Fig. 588: View Of Engine Front Cover Bolts
Courtesy of GENERAL MOTORS CORP.

3. Install the engine front cover bolts.

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

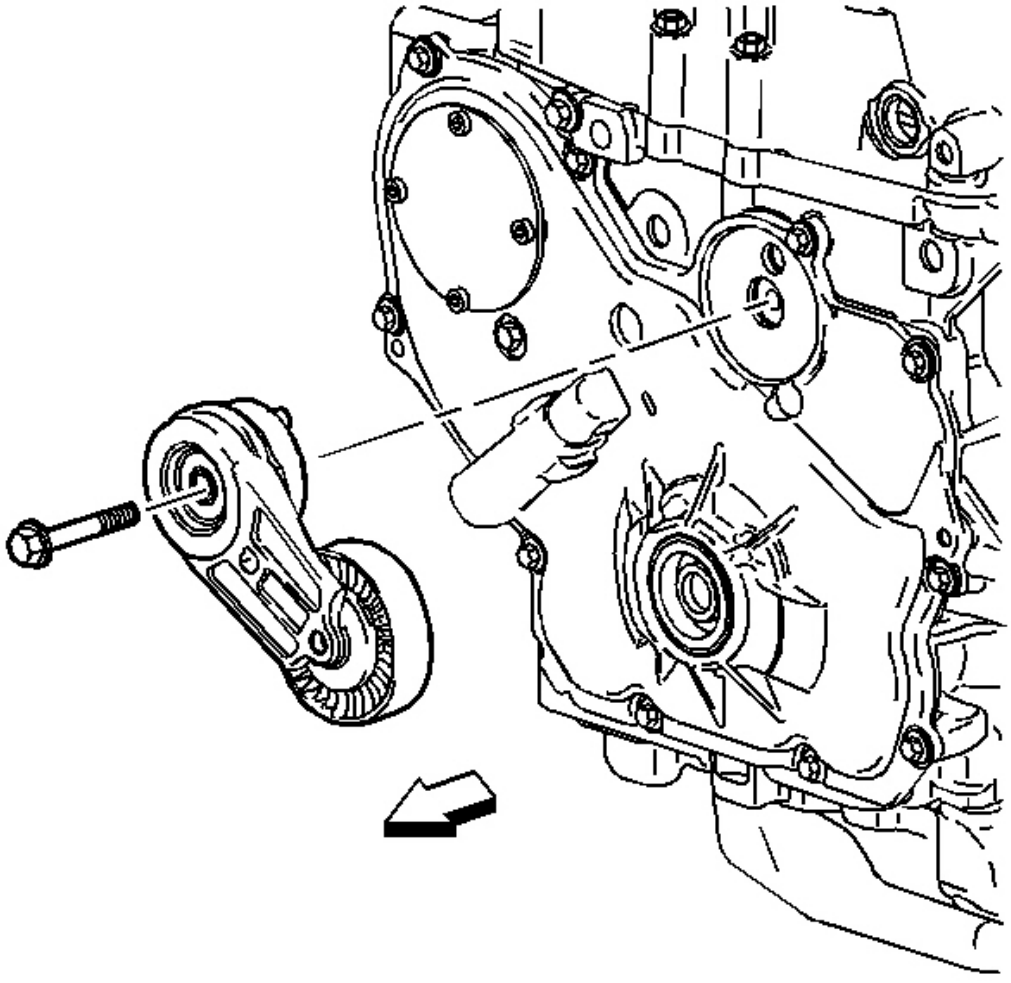


Fig. 589: View Of Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

4. Install the accessory drive belt tensioner.
5. Install the accessory drive belt tensioner bolt.

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

CAMSHAFT COVER INSTALLATION

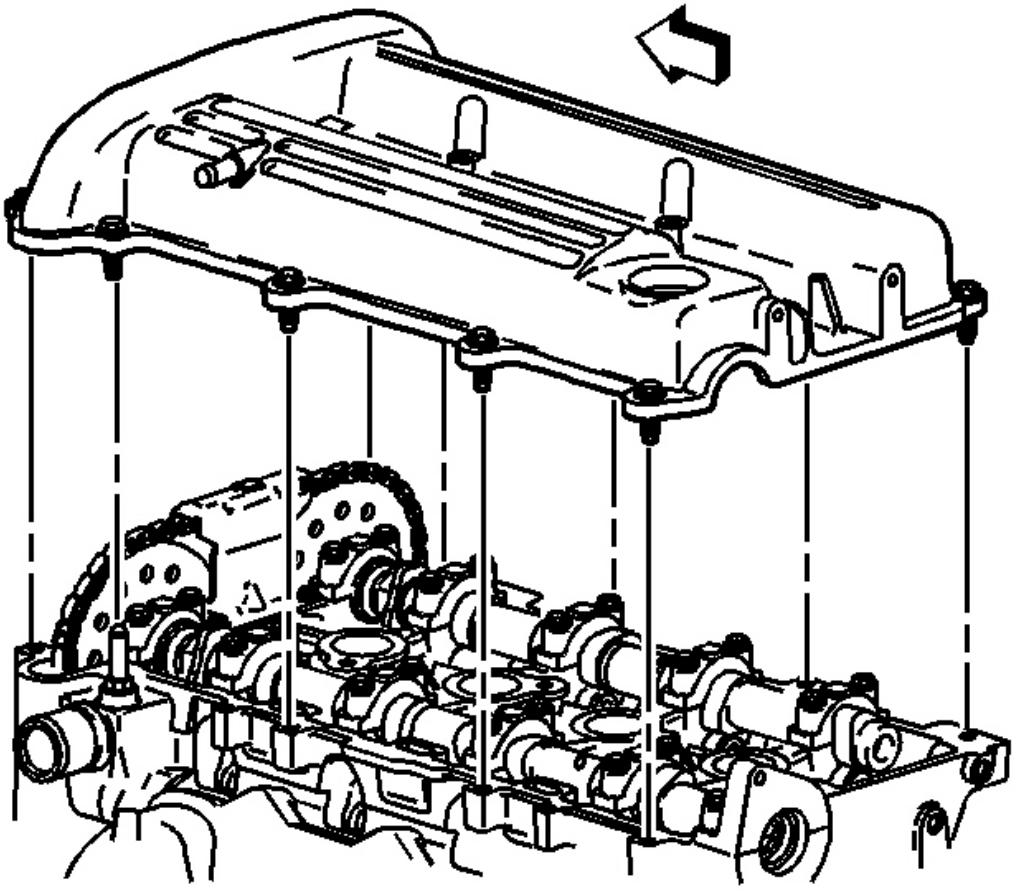


Fig. 590: View Of Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

1. Assemble the camshaft cover and gasket. Ensure that the gasket is located in the retaining groove in the camshaft cover.

   NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the cover on the cylinder head and hand start the bolts.

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

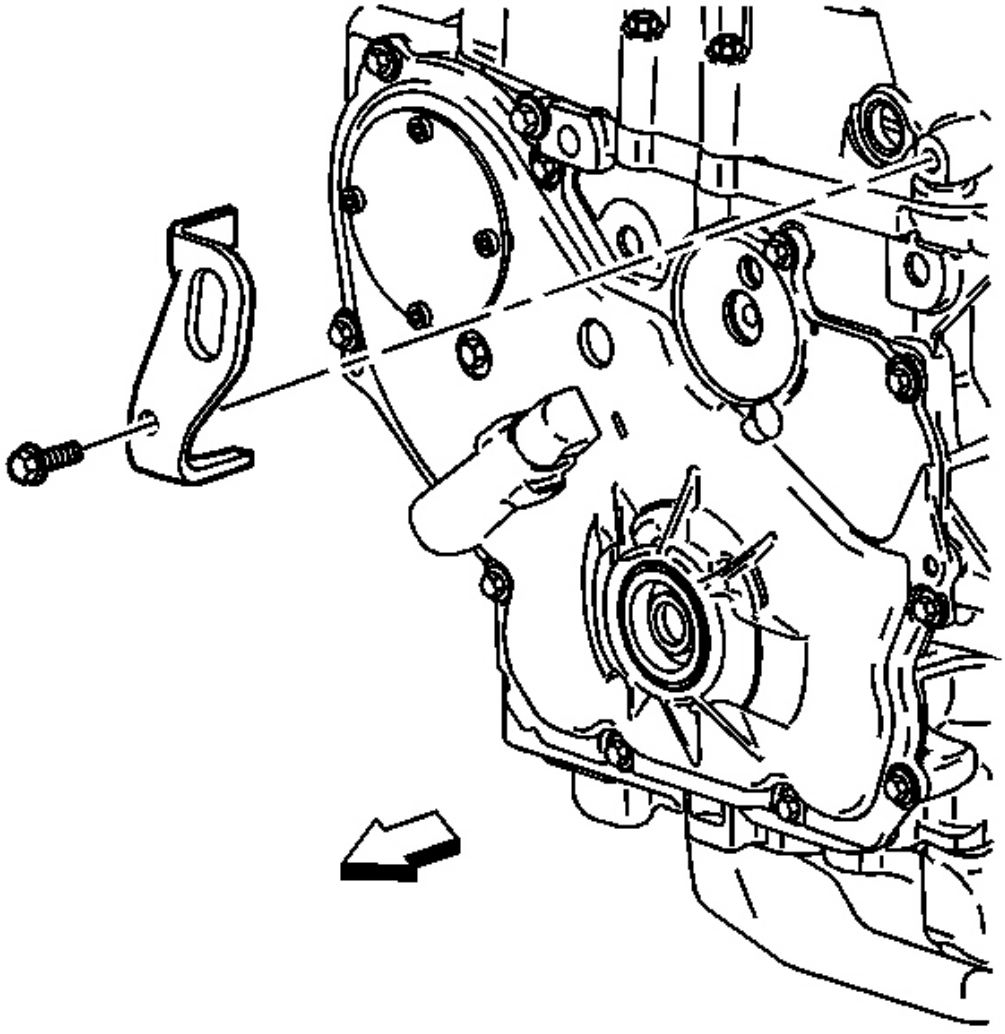


Fig. 591: View Of Front Lift Bracket
Courtesy of GENERAL MOTORS CORP.

3. Install the front lift bracket.

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

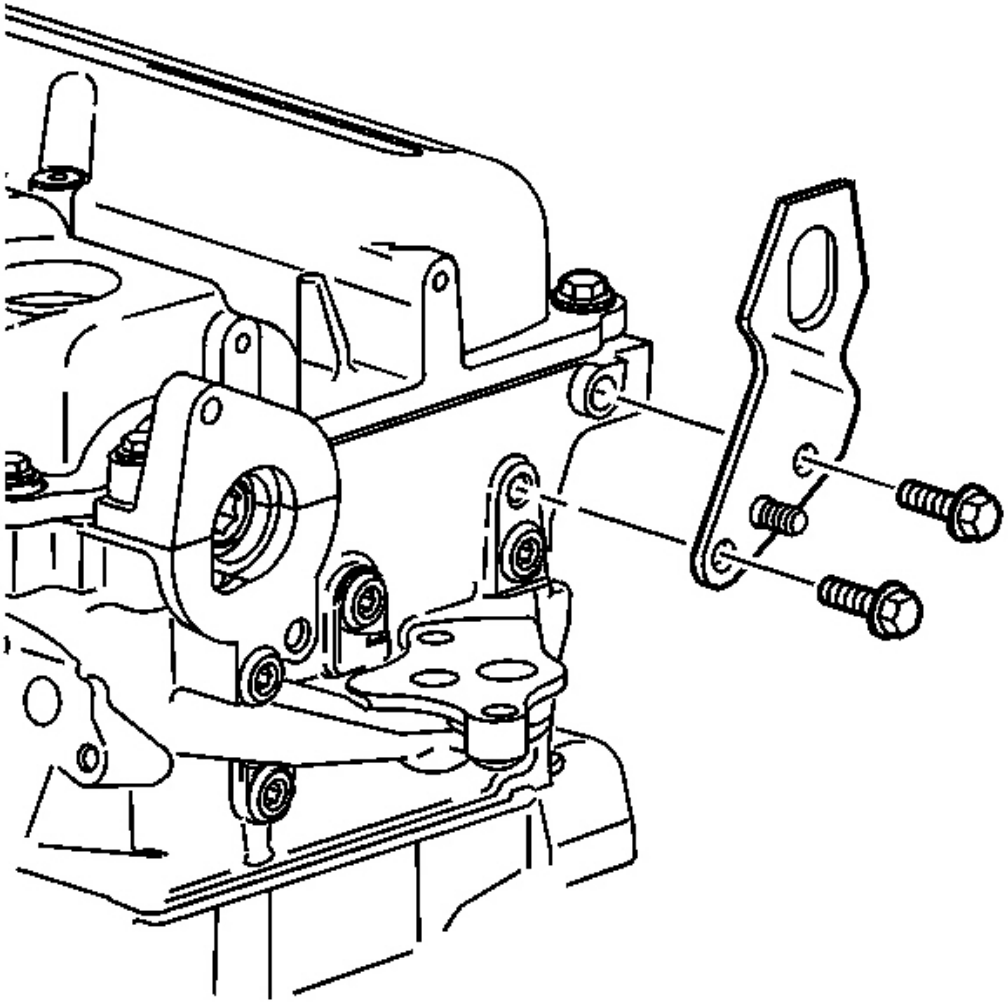


Fig. 592: View Of Rear Lift Bracket
Courtesy of GENERAL MOTORS CORP.

4. Install the rear lift bracket.

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

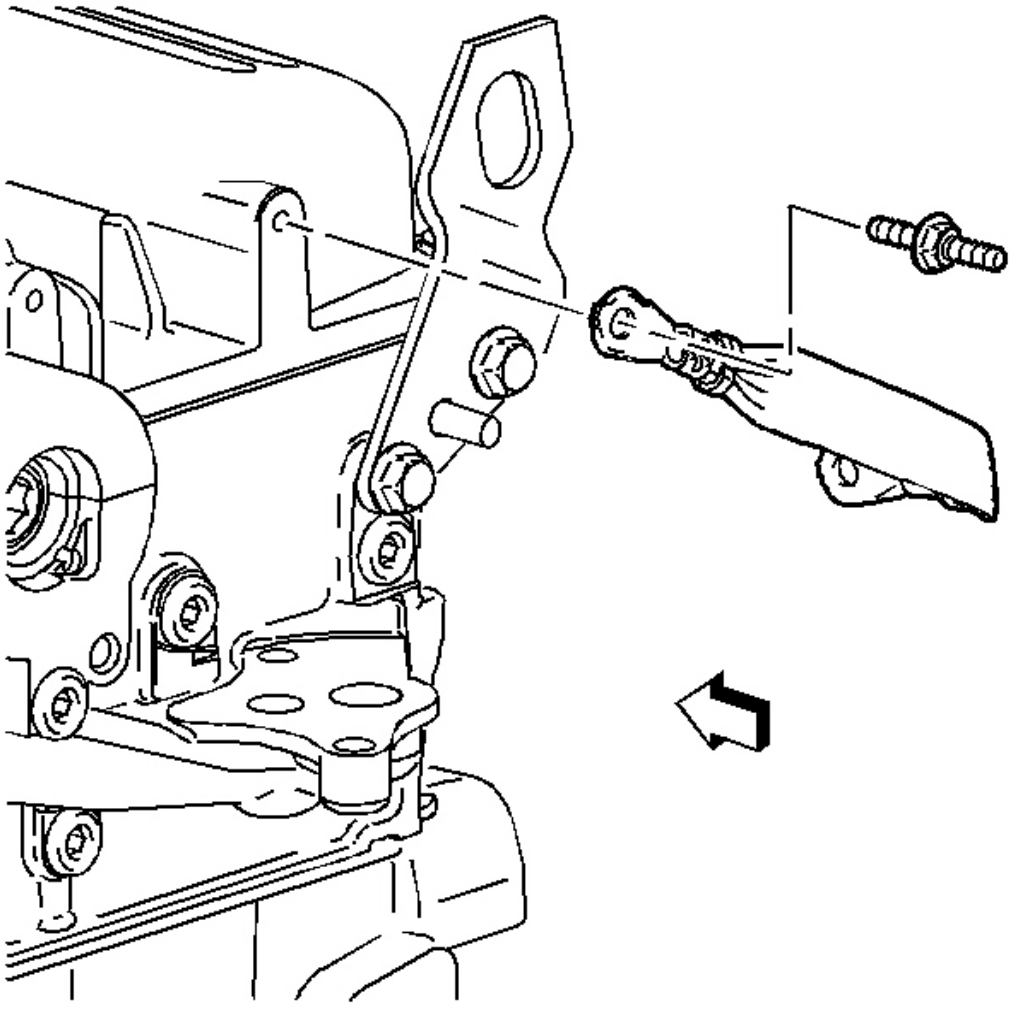


Fig. 593: View Of Ground Strap
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Install the ground strap.

   Tighten: Tighten the camshaft cover ground strap bolts to 10 N.m (89 lb in).

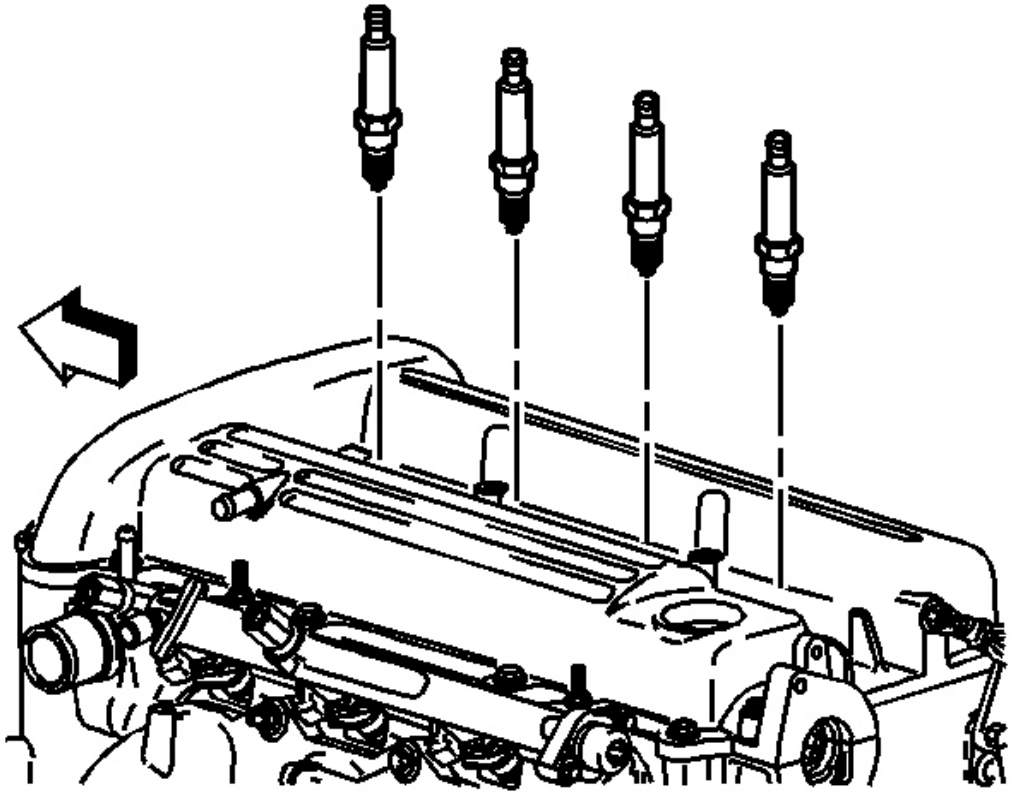


Fig. 594: View Of Spark Plugs
Courtesy of GENERAL MOTORS CORP.

6. Install the spark plugs.

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

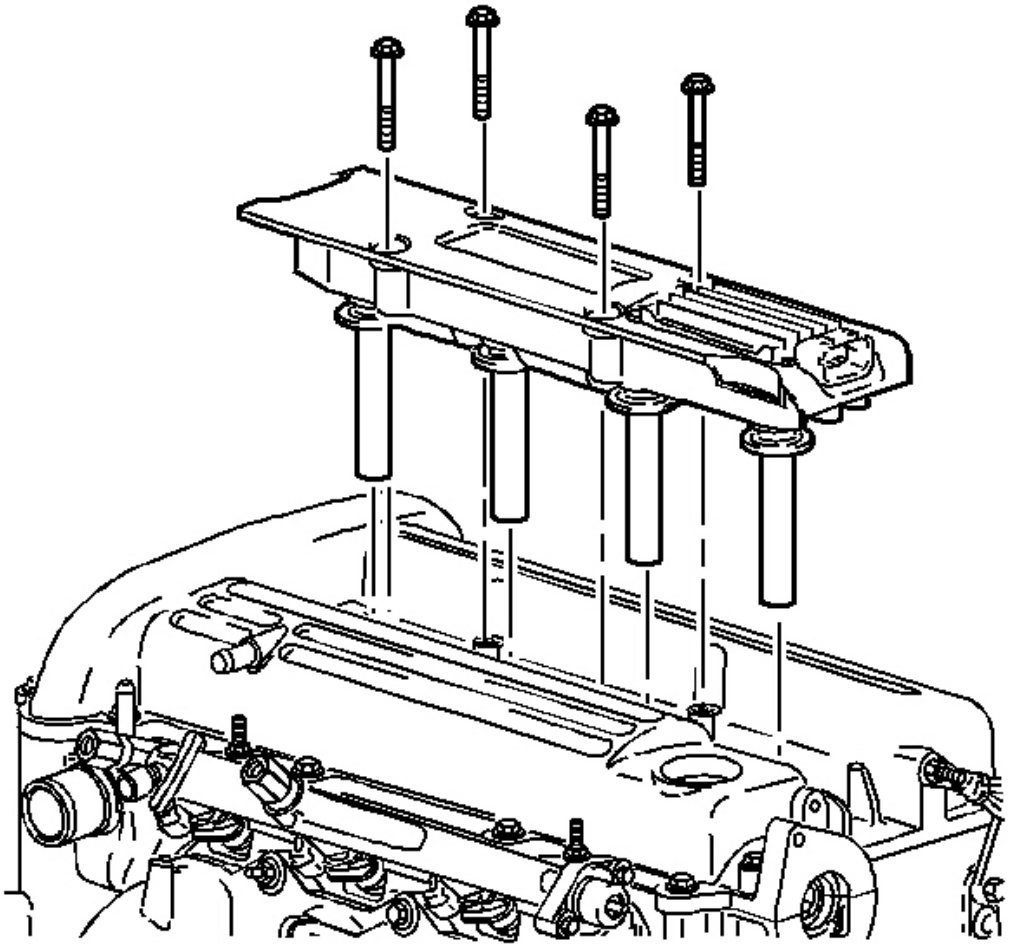


Fig. 595: View Of Ignition Coil & Module Assembly
Courtesy of GENERAL MOTORS CORP.

7. Install the ignition coil and module assembly to the cam cover.

   Tighten: Tighten the ignition coil and module assembly bolts to 10 N.m (89 lb in).

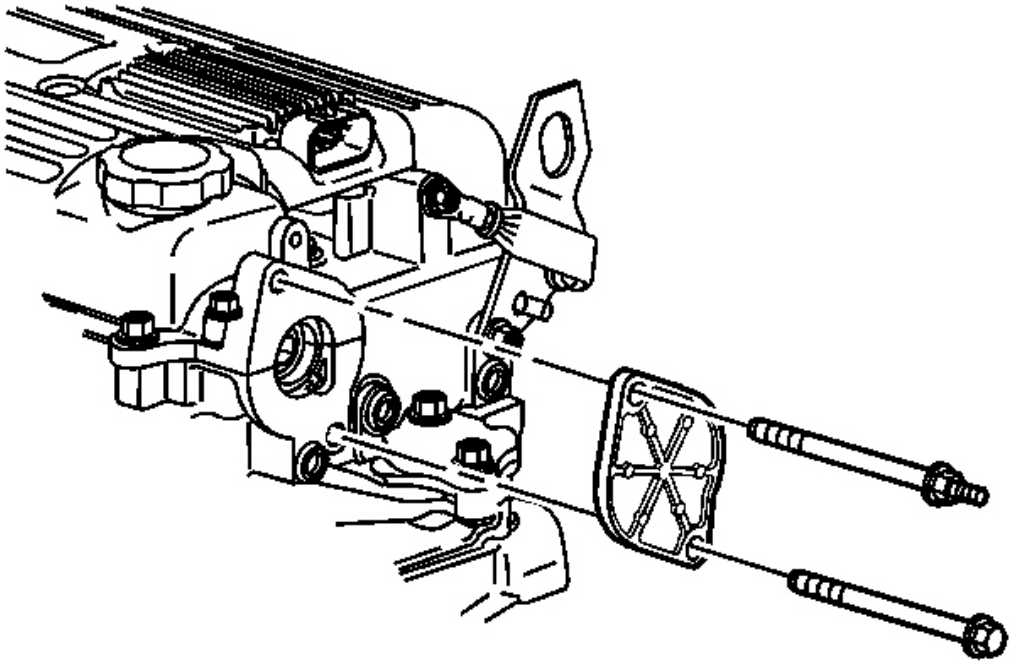


Fig. 596: View Of Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

8. Install the power steering blockout plate.

   Tighten: Tighten the power steering blockout plate bolts to 25 N.m (18 lb ft).

OIL PAN INSTALLATION

1. Make sure that the oil pan and mounting surface on the lower crankcase are free of all oil and debris.
2. Apply a 2 mm bead of RTV P/N 21019581, around the perimeter of the oil pan and the oil suction port opening. Do not over apply the RTV. More than a 2 mm bead is not required.

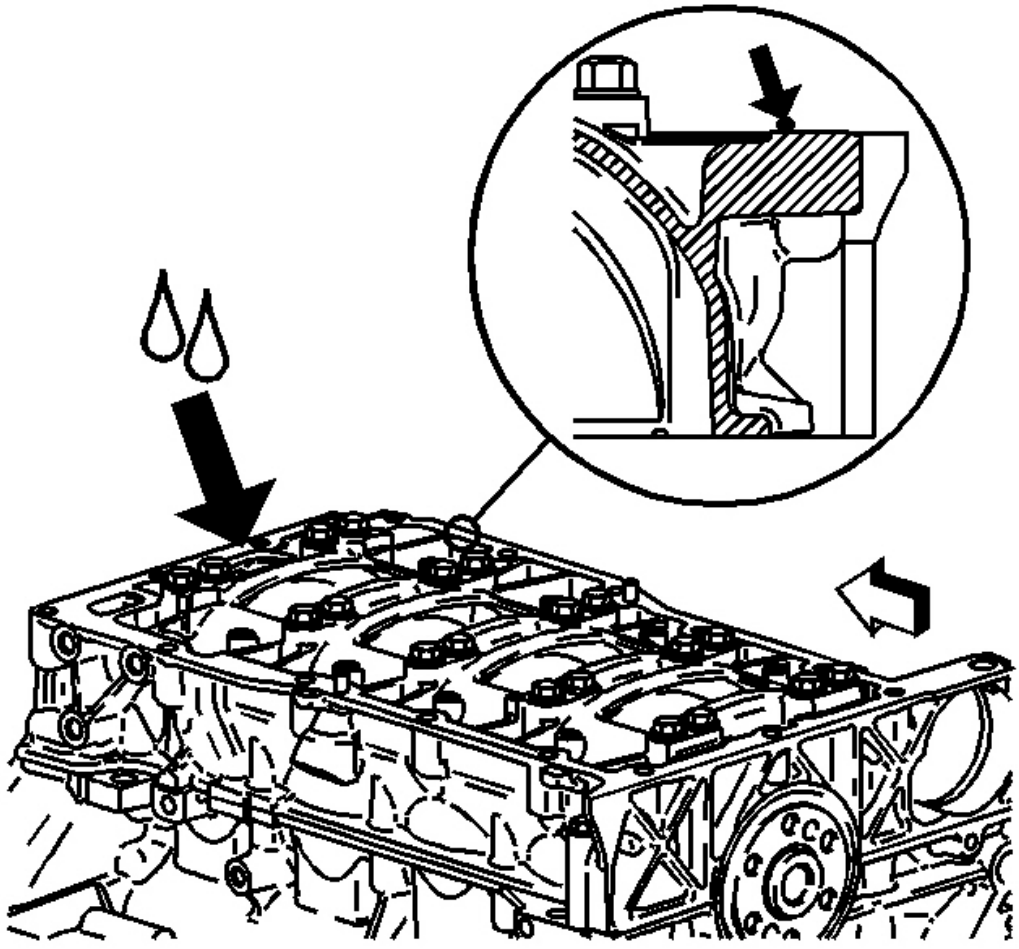


Fig. 597: Applying 2 mm Bead Of RTV P/N 21019581 Around The Perimeter Of The Oil Pan And The Oil Suction Port Opening
Courtesy of GENERAL MOTORS CORP.

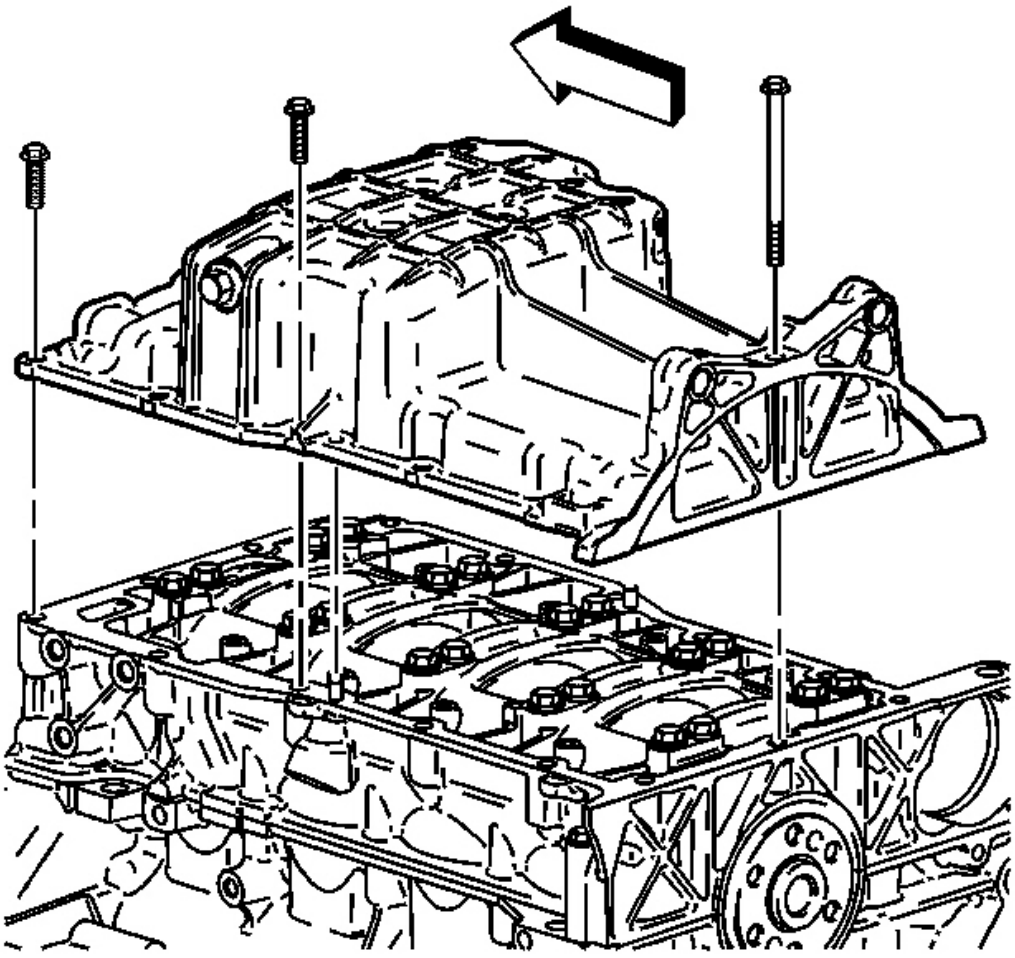


Fig. 598: View Of Oil Pan
Courtesy of GENERAL MOTORS CORP.

3. Install the oil pan.

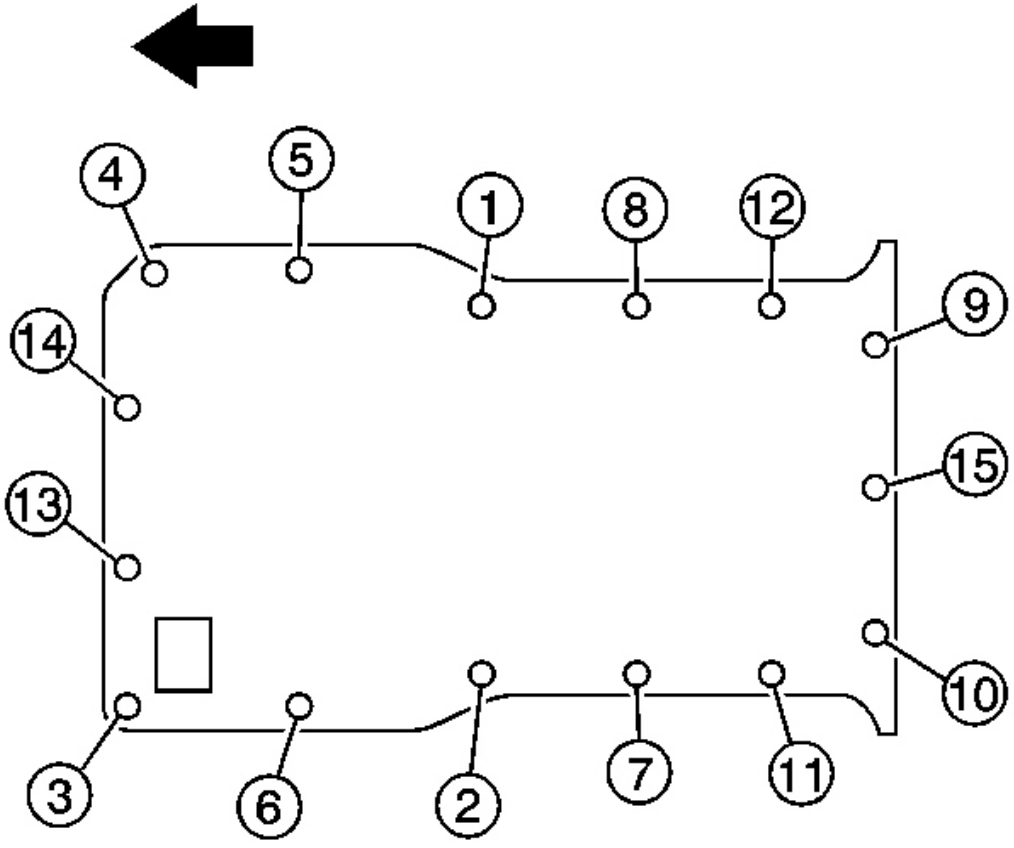


Fig. 599: Identifying Oil Pan Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices

4. Install the oil pan bolts hand tight.

   Tighten: Tighten the oil pan bolts to 25 N.m (18 lb ft) in sequence.

OIL FILTER ADAPTER INSTALLATION

Tools Required

J 44887 Oil Filter Wrench. See **Special Tools and Equipment** .

Oil Filter Adapter Installation

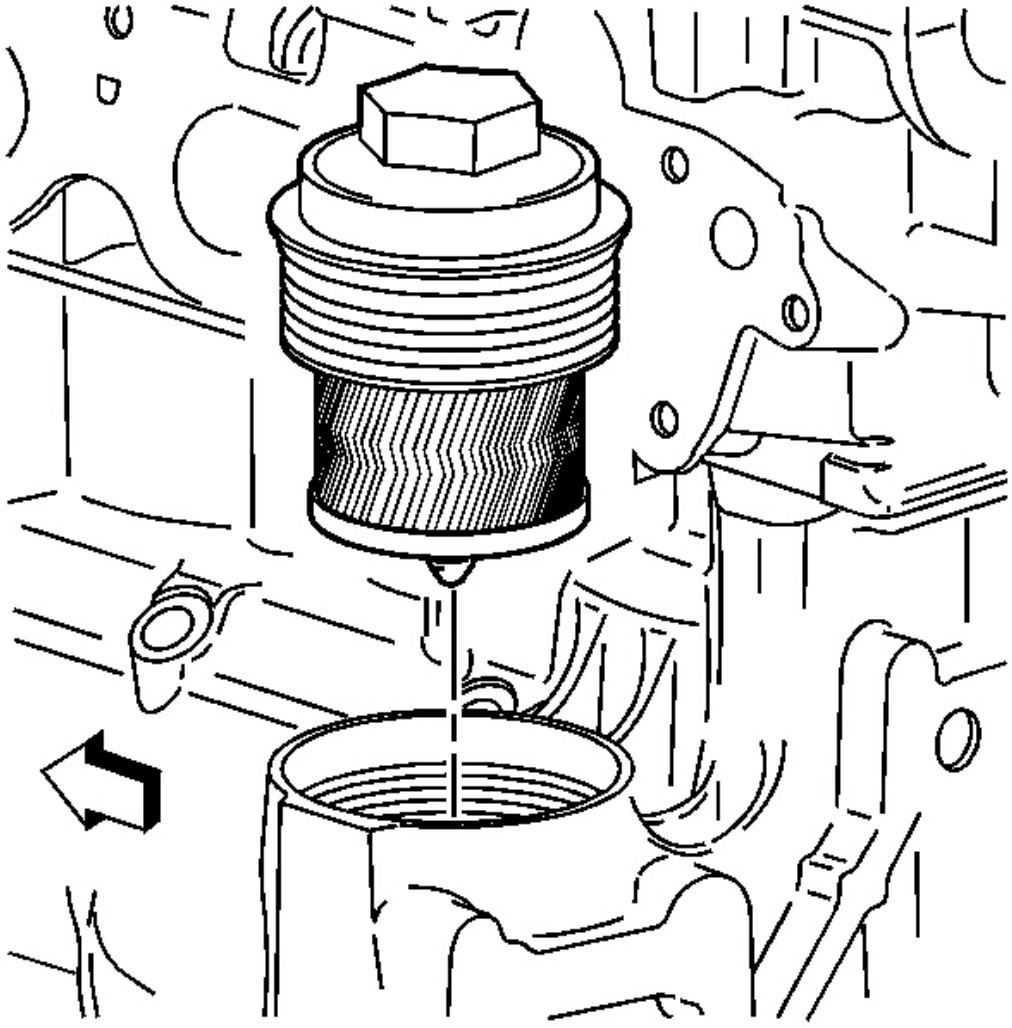


Fig. 600: Identifying Oil Filter
Courtesy of GENERAL MOTORS CORP.

1. Install a new oil filter on the oil filter cap.
2. Lubricate the O-ring on the oil filter cap with 5 W 30 engine oil.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Use **J 44887** to install the oil filter adapter. See **Special Tools and Equipment** .

Tighten: Tighten the oil filter adapter to 22 N.m (16 lb ft).

INTAKE MANIFOLD INSTALLATION

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the intake manifold studs in the manifold face.

   Tighten: Tighten the intake manifold studs to 6 N.m (60 lb in).

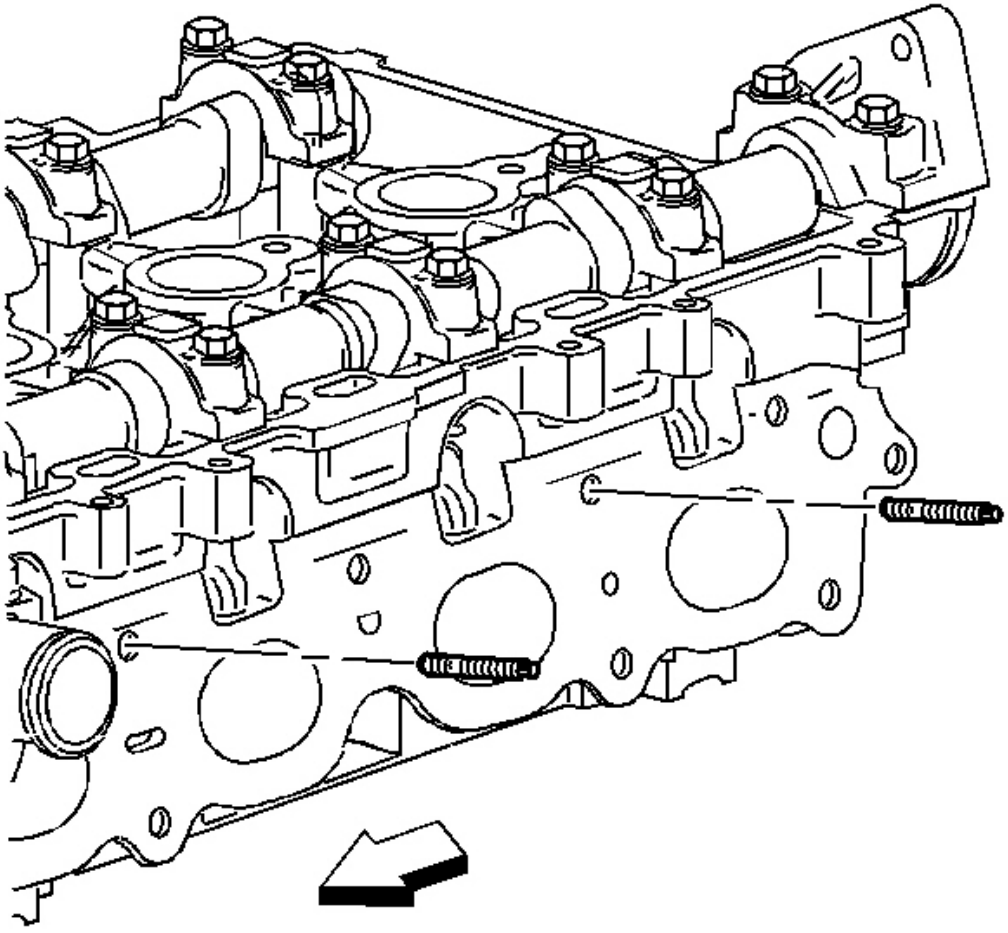


Fig. 601: View Of Intake Manifold Studs
Courtesy of GENERAL MOTORS CORP.

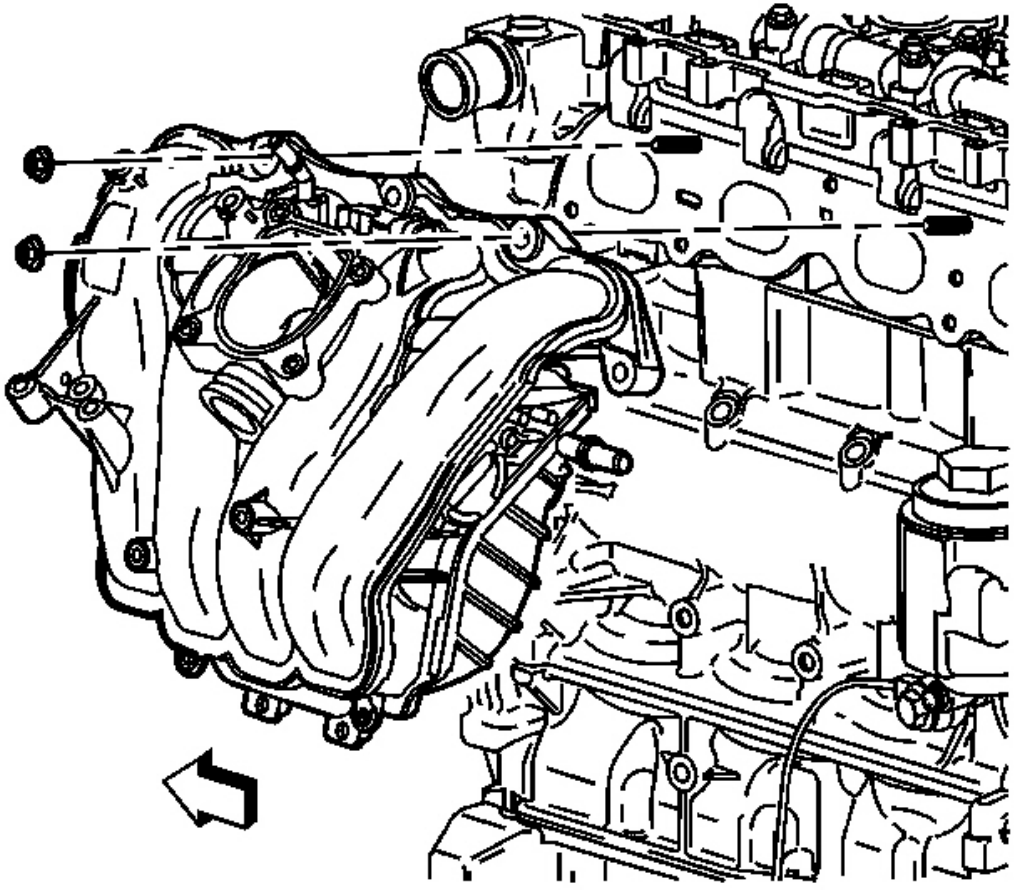


Fig. 602: Identifying Intake Manifold
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Gaskets must be clean. Swollen gaskets should be replaced.

2. Install a new intake manifold gasket on the intake manifold, if necessary.
3. Install the intake manifold.
4. Install the intake manifold bolts and nuts. Follow the tightening sequence.

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

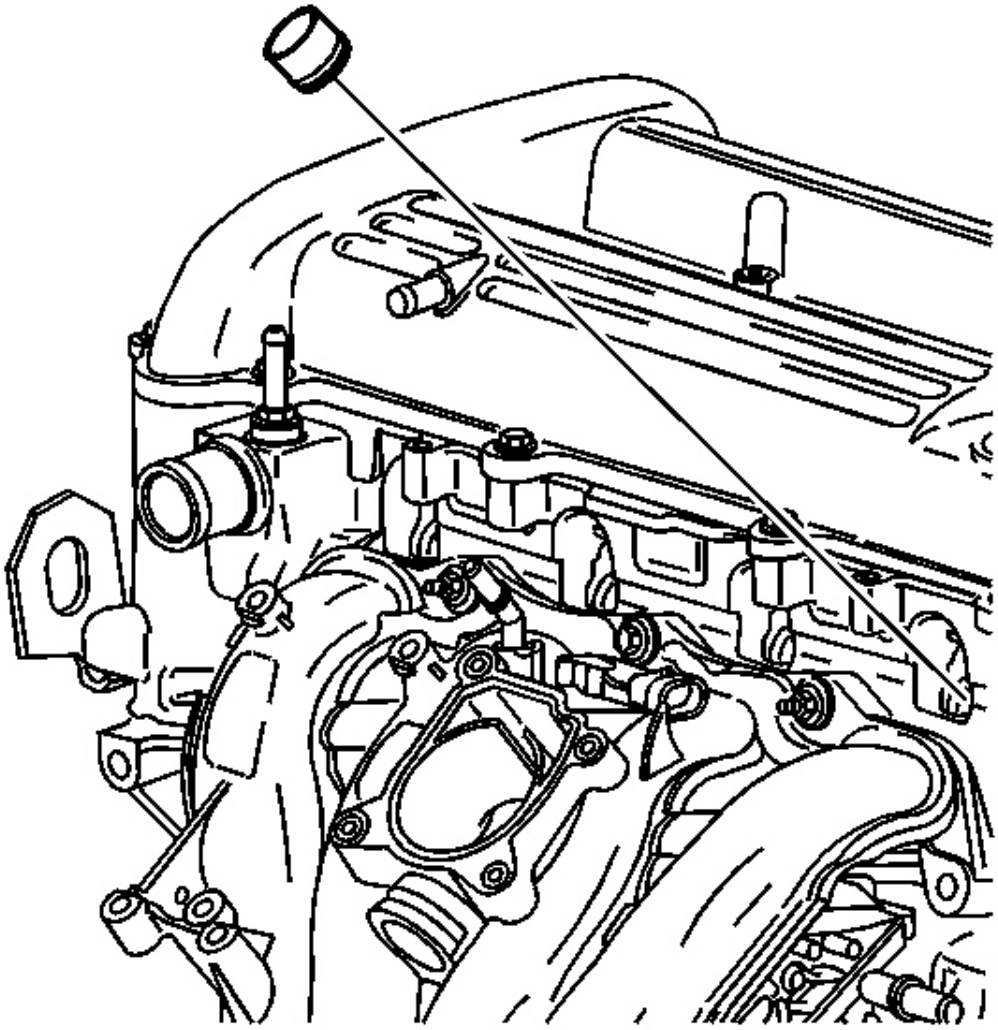


Fig. 603: View Of Fuel Injector Tip Insulators
Courtesy of GENERAL MOTORS CORP.

5. Lubricate NEW fuel injector tip insulators with engine oil.
6. Install the NEW fuel injector tip insulators.

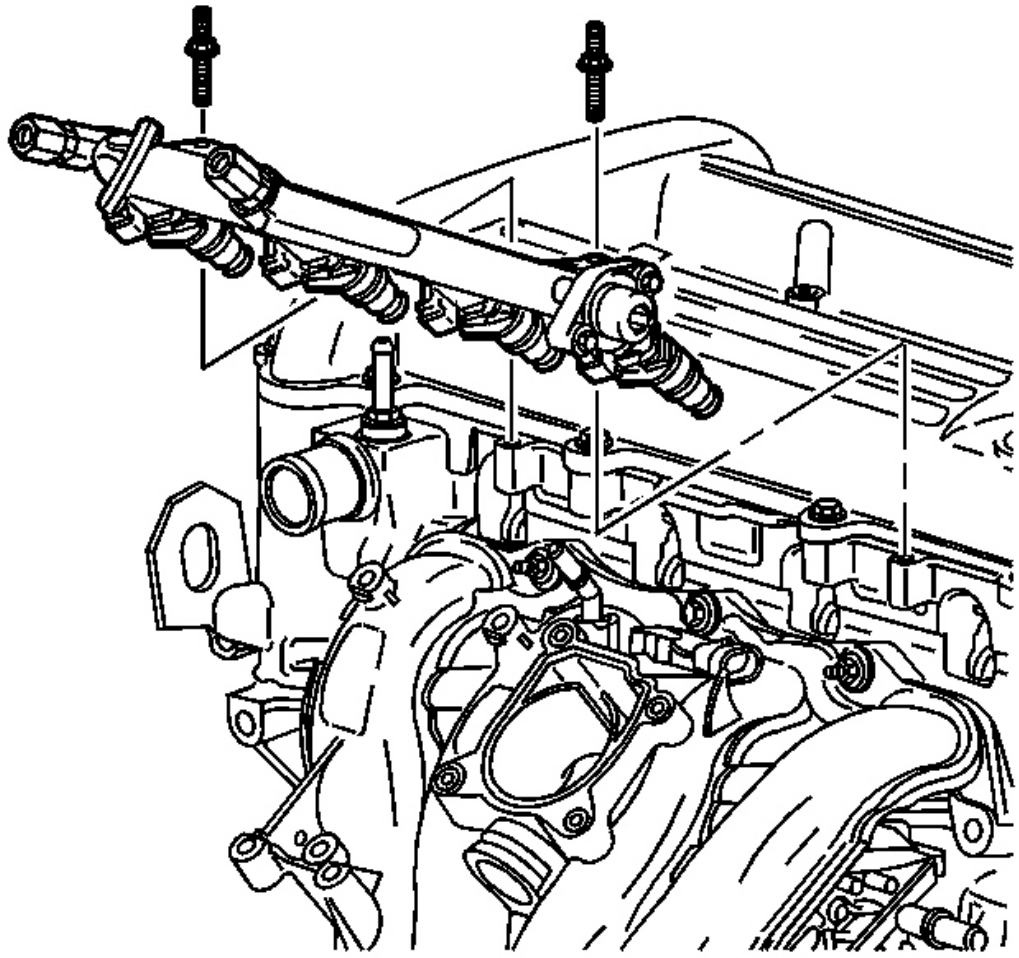


Fig. 604: Identifying Fuel Rail Assembly
Courtesy of GENERAL MOTORS CORP.

7. Install the fuel rail assembly.
8. Install the fuel rail stud.

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

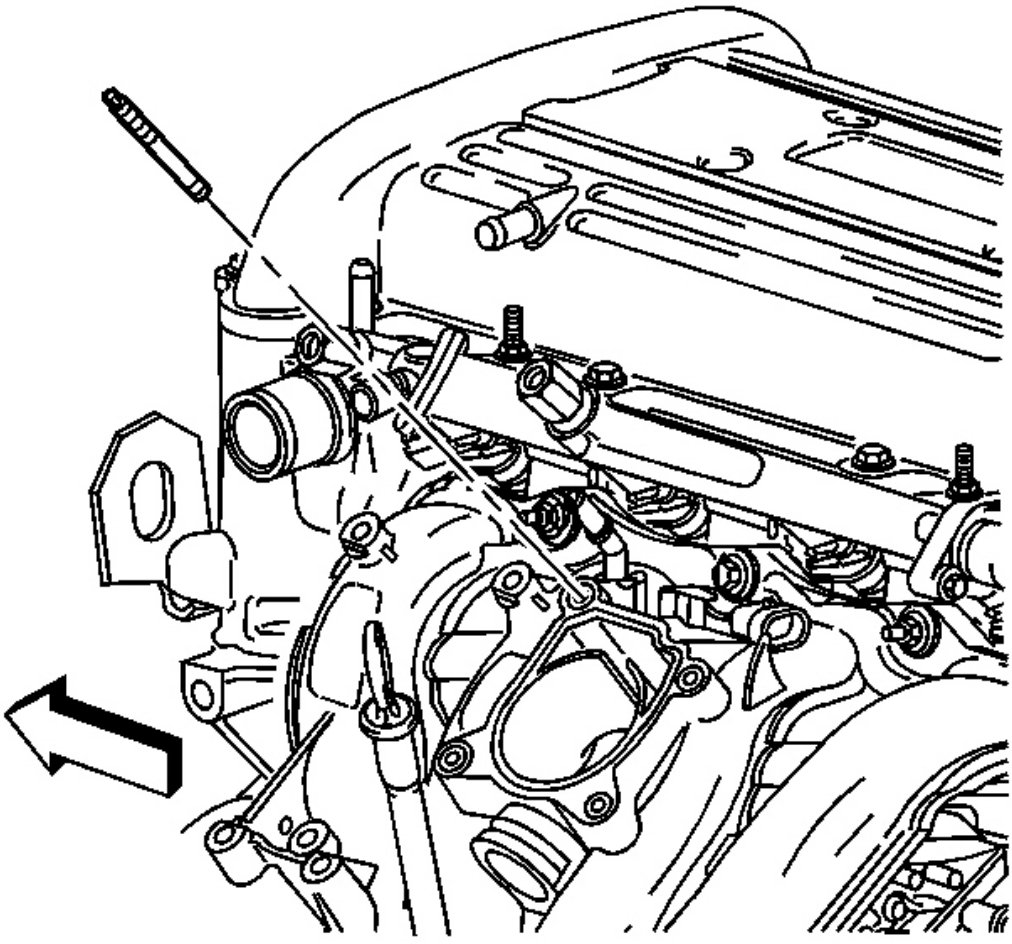


Fig. 605: Identifying Throttle Body Stud
Courtesy of GENERAL MOTORS CORP.

9. Install a NEW throttle body stud, if necessary.

   Tighten: Tighten the bolts and nuts to 6 N.m (60 lb in).

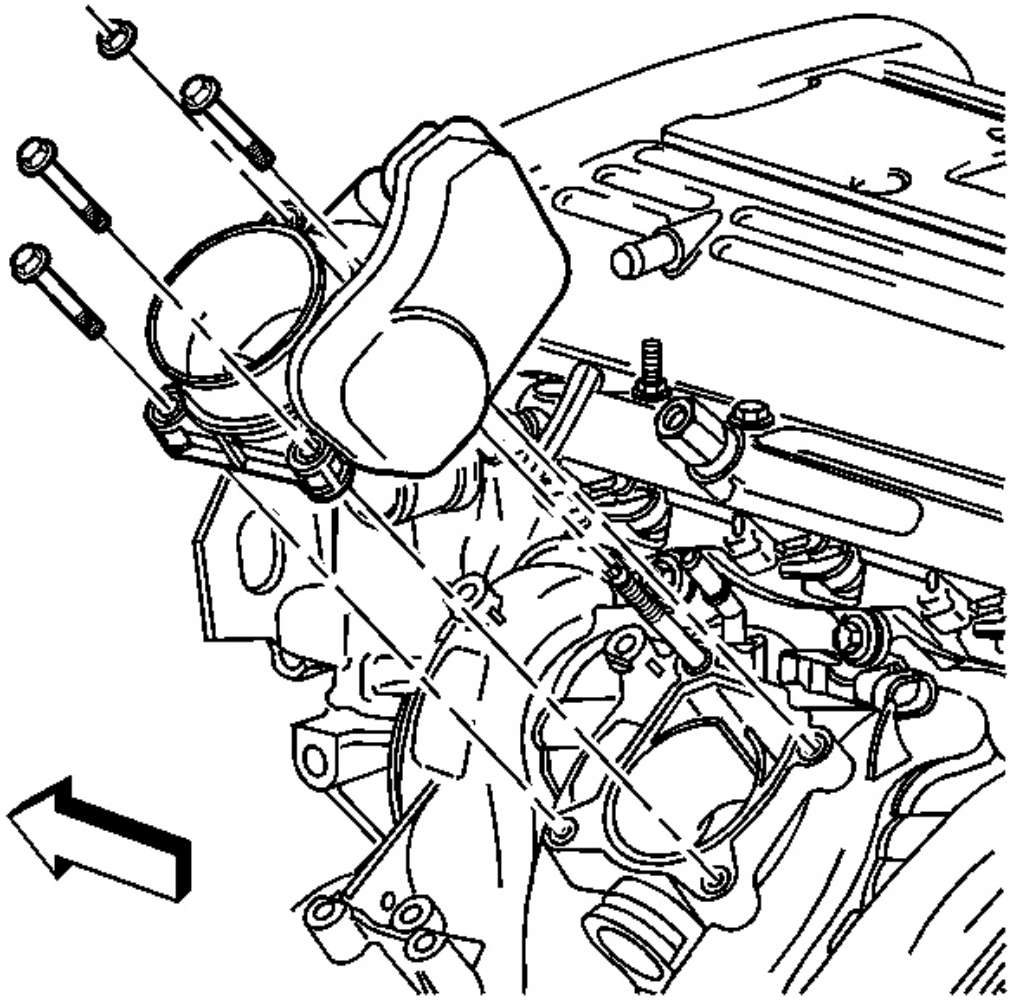


Fig. 606: View Of Throttle Body
Courtesy of GENERAL MOTORS CORP.

10. Install the throttle body.

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

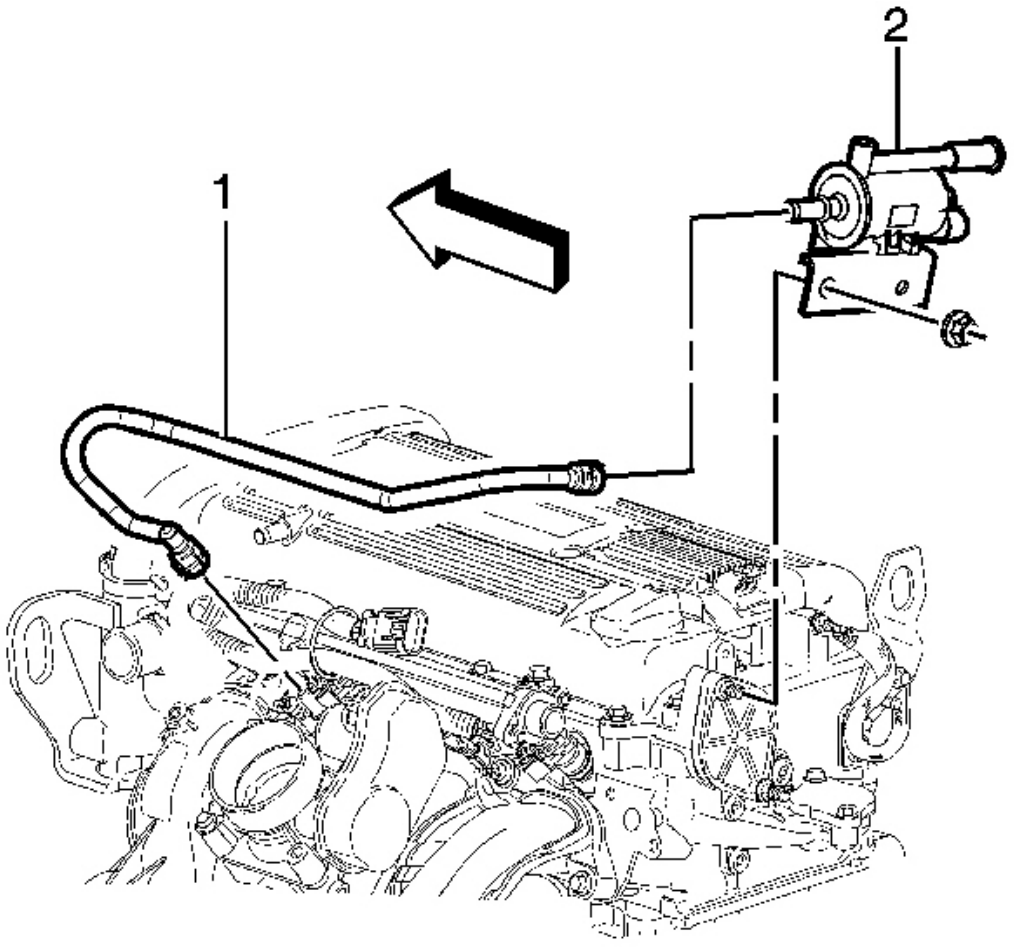


Fig. 607: View Of Intake Manifold
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure that the rear metal tab of the EVAP emission canister valve is resting on the power steering pump metal body.

11. Install the EVAP emission canister valve (2).

    Tighten: Tighten the EVAP emission canister valve to 22 N.m (16 lb ft).

12. Install the EVAP emission canister valve tube (1).

CRANKSHAFT DAMPER INSTALLATION

- **J 38122-A** Harmonic Balancer Holder. See **Special Tools and Equipment** .
- **J 45059** Angle Meter. See **Special Tools and Equipment** .

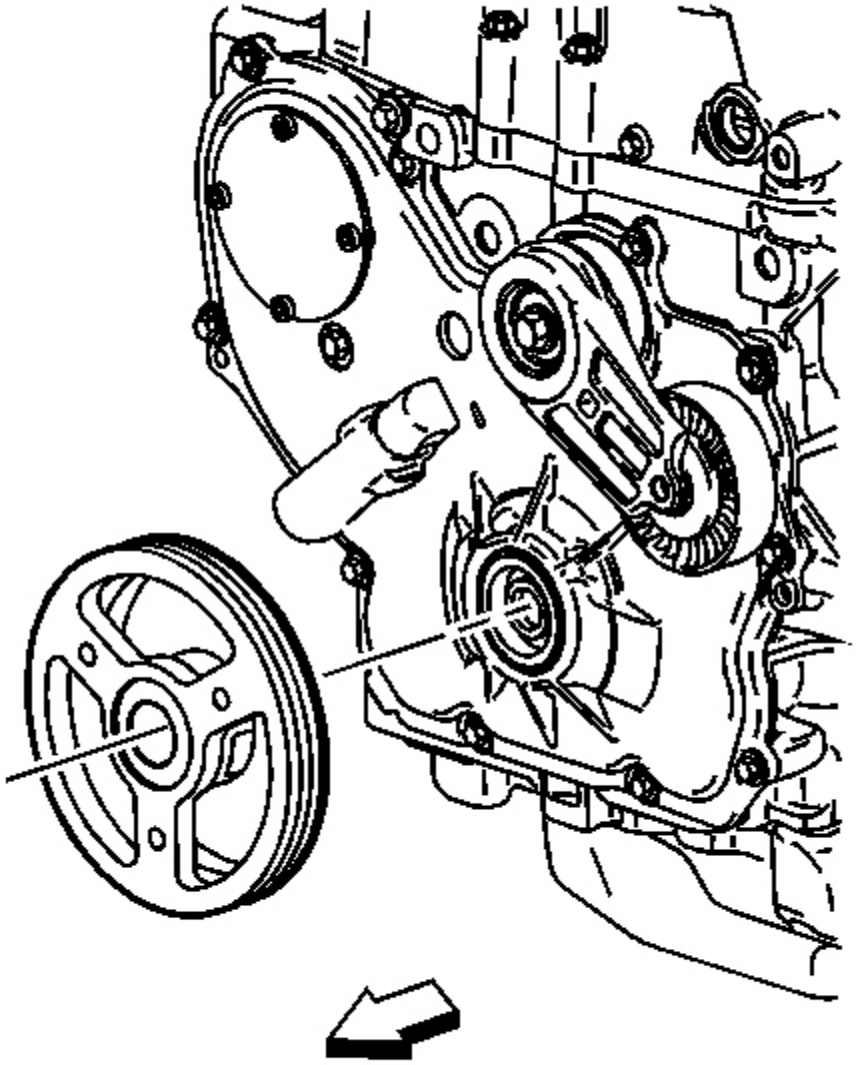


Fig. 608: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

NOTE: Ensure both components are aligned correctly or serious engine damage will occur.

1. Install the damper onto the crankshaft indexing keyway. Use care to properly align the keyway and flats on the damper with the oil pump drive.

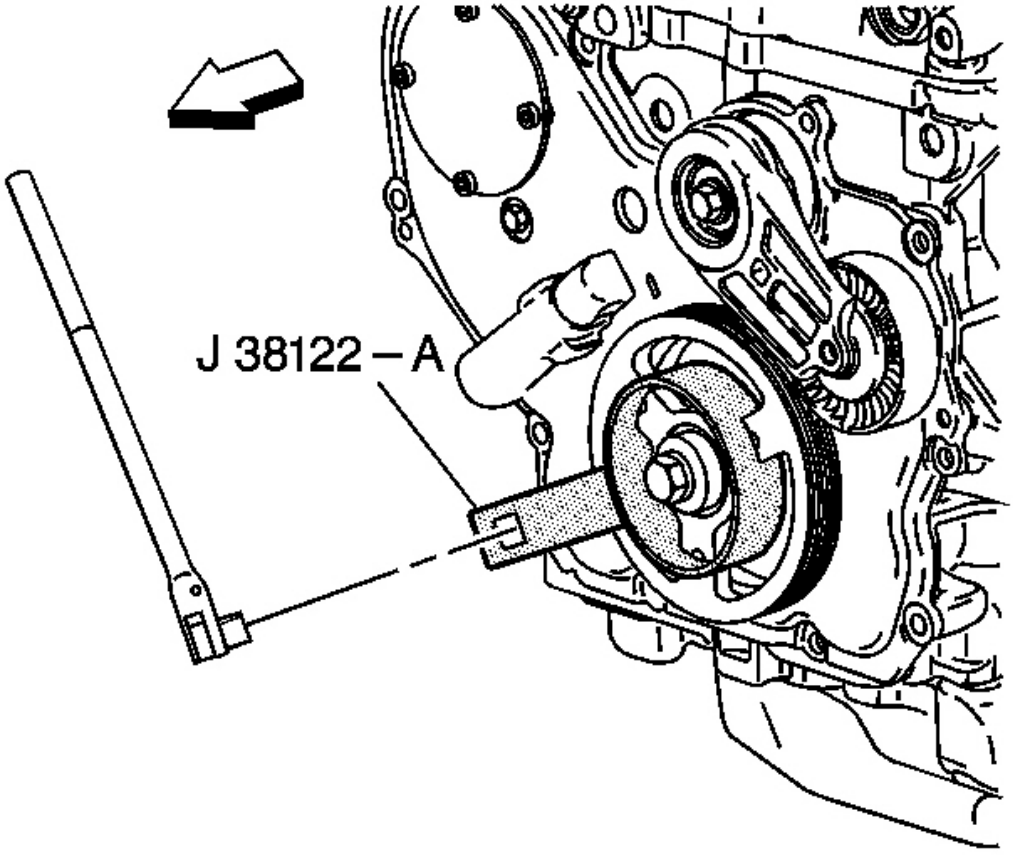


Fig. 609: View Of Harmonic Balancer Holder J38122-A
Courtesy of GENERAL MOTORS CORP.

2. Install the **J 38122-A** . See **Special Tools and Equipment** .

NOTE: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT: Always install a new crankshaft damper retaining bolt and washer.

3. Install a new retaining bolt and washer. Use the **J 38122-A** and a breaker bar in order to prevent the crankshaft from rotating when tightening the bolt. See **Special Tools and Equipment** .

Tighten: Tighten the bolt to 100 N.m (74 lb ft) plus 125 degrees using the **J 45059** . See **Special Tools and Equipment** .

EXHAUST MANIFOLD INSTALLATION

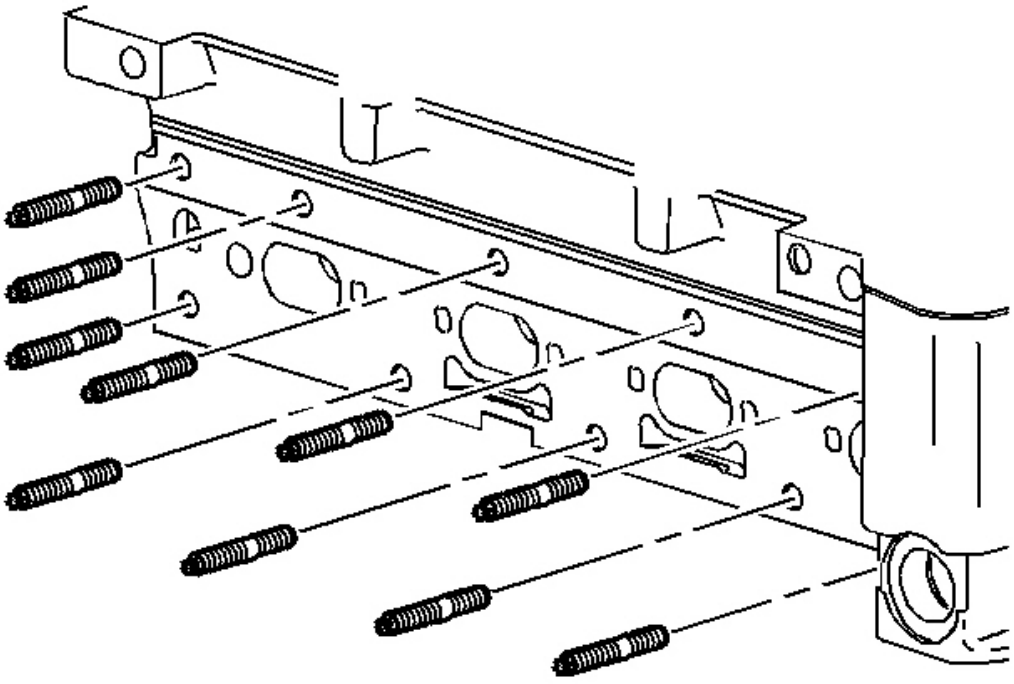


Fig. 610: View Of Exhaust Manifold Studs
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install new exhaust manifold studs.

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

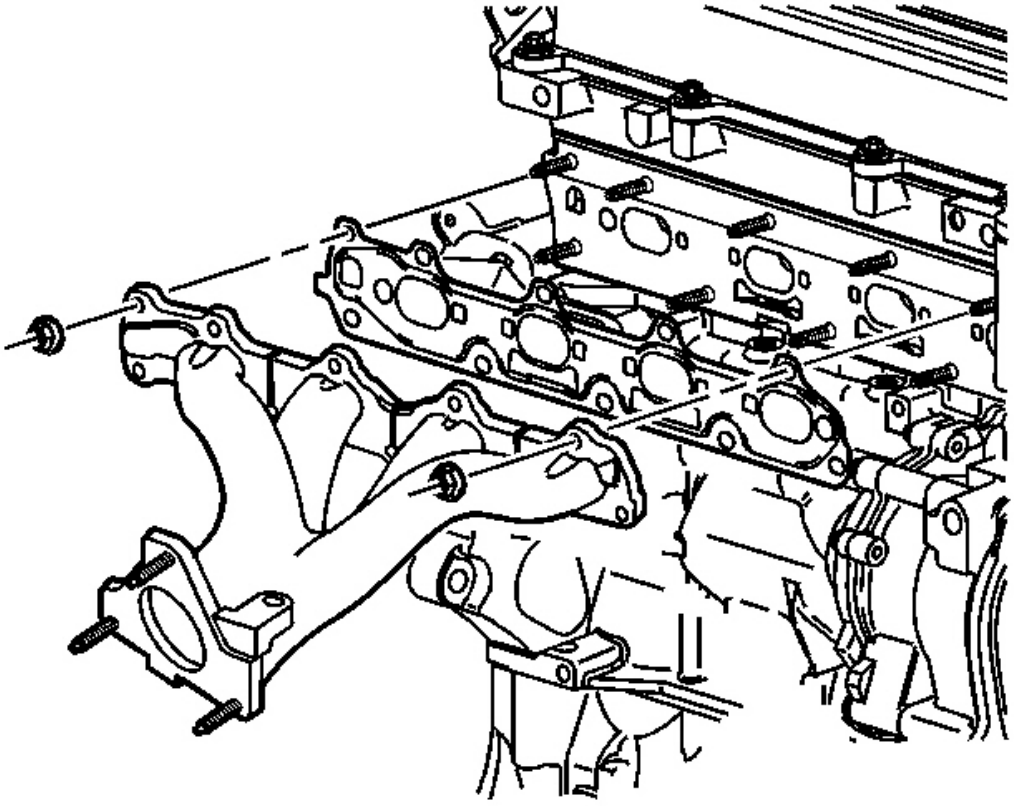


Fig. 611: View Of Exhaust Manifold Gasket
Courtesy of GENERAL MOTORS CORP.

2. Install the exhaust manifold gasket.
3. Install the exhaust manifold to the cylinder head.
4. Install NEW exhaust manifold to cylinder head retaining nuts finger tight.

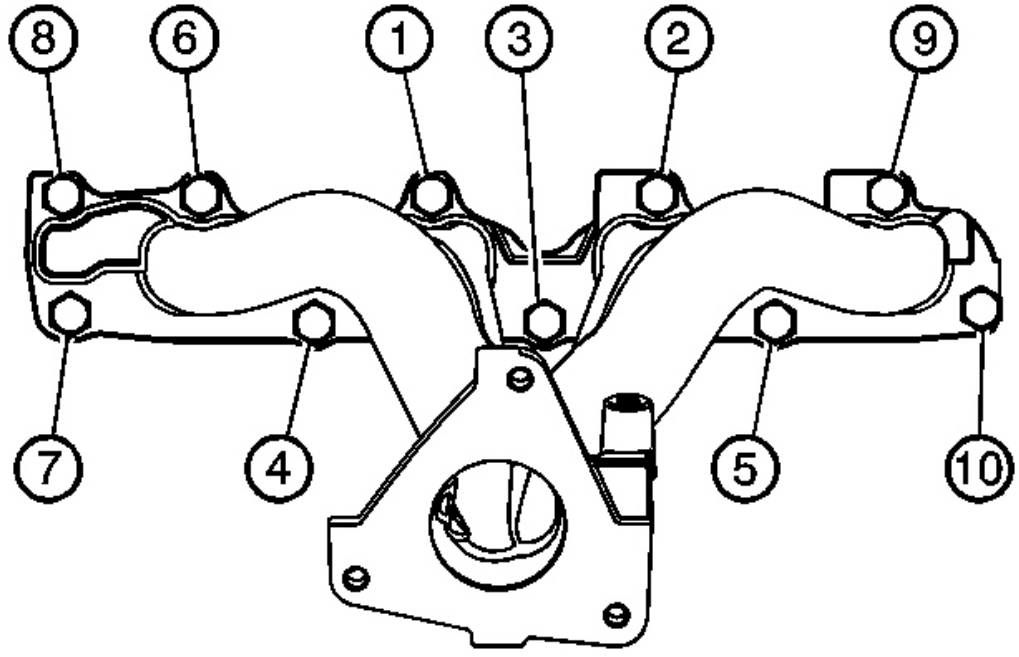


Fig. 612: Identifying Cylinder Head Retaining Nuts Fastening Sequence
Courtesy of GENERAL MOTORS CORP.

5. Tighten the NEW exhaust manifold to cylinder head retaining nuts in sequence.

   Tighten: Tighten the nuts to 14 N.m (124 lb in).

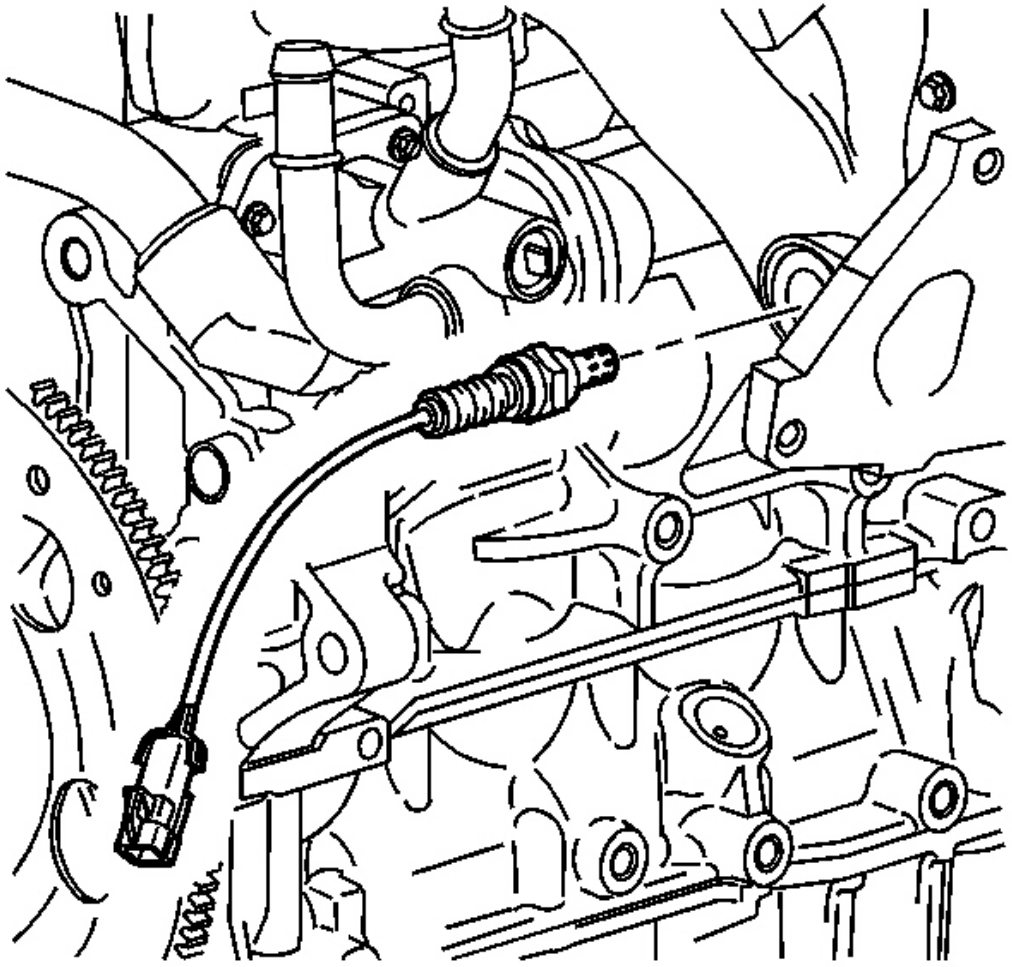


Fig. 613: Identifying Oxygen Sensor
Courtesy of GENERAL MOTORS CORP.

6. Coat the threads of the oxygen sensor with antiseize compound P/N 12397953.
7. Install the oxygen sensor.

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

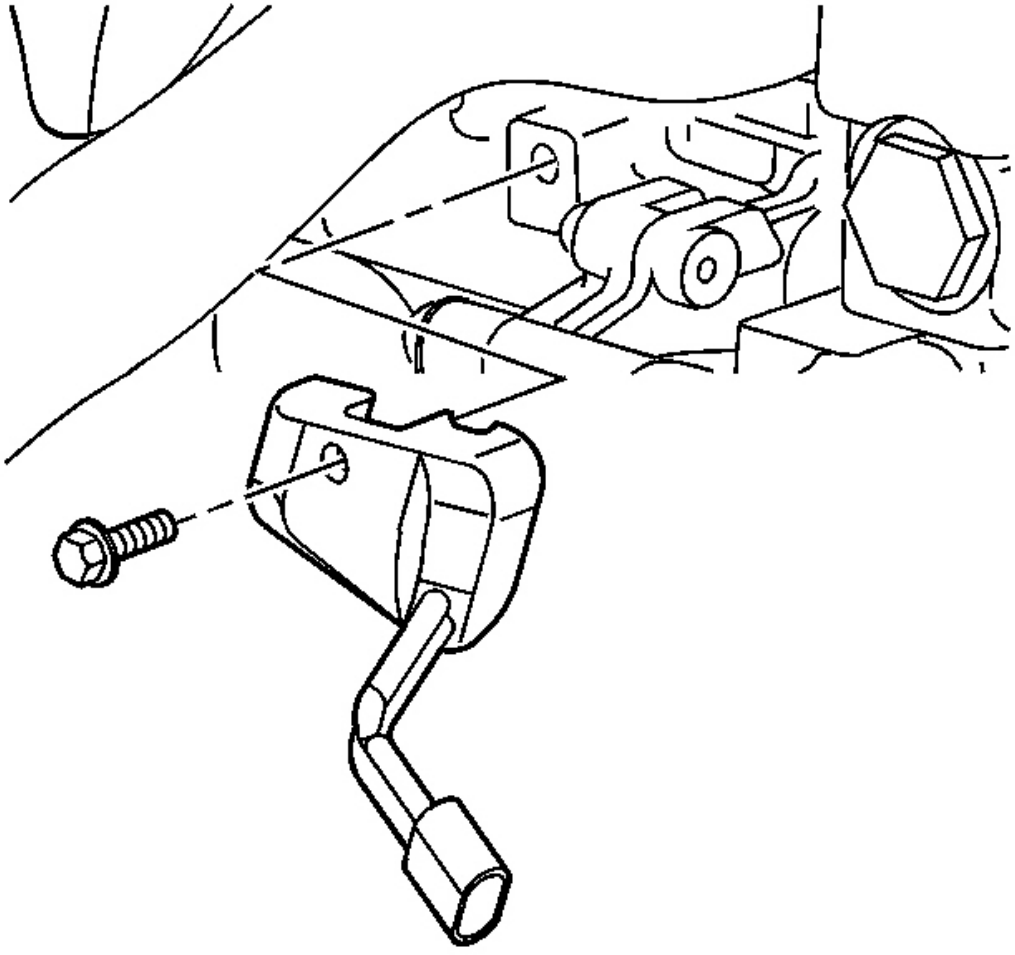


Fig. 614: View Of Block Heater
Courtesy of GENERAL MOTORS CORP.

8. Install the block heater and bolt, if equipped.

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

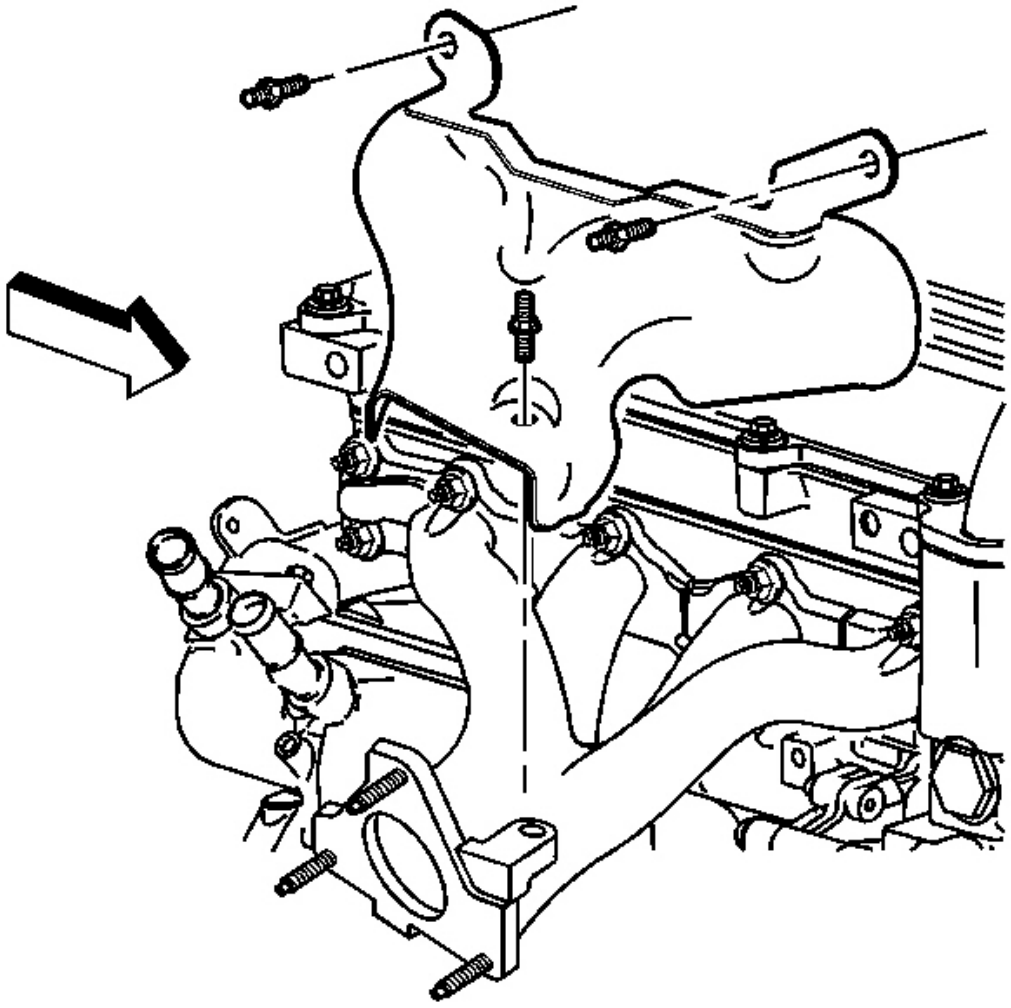


Fig. 615: View Of Exhaust Heat Shield
Courtesy of GENERAL MOTORS CORP.

9. Install the exhaust manifold heat shield.
10. Install the exhaust manifold heat shield bolts.

Tighten: Tighten the bolts to 23 N.m (17 lb ft).

OIL LEVEL INDICATOR AND TUBE INSTALLATION

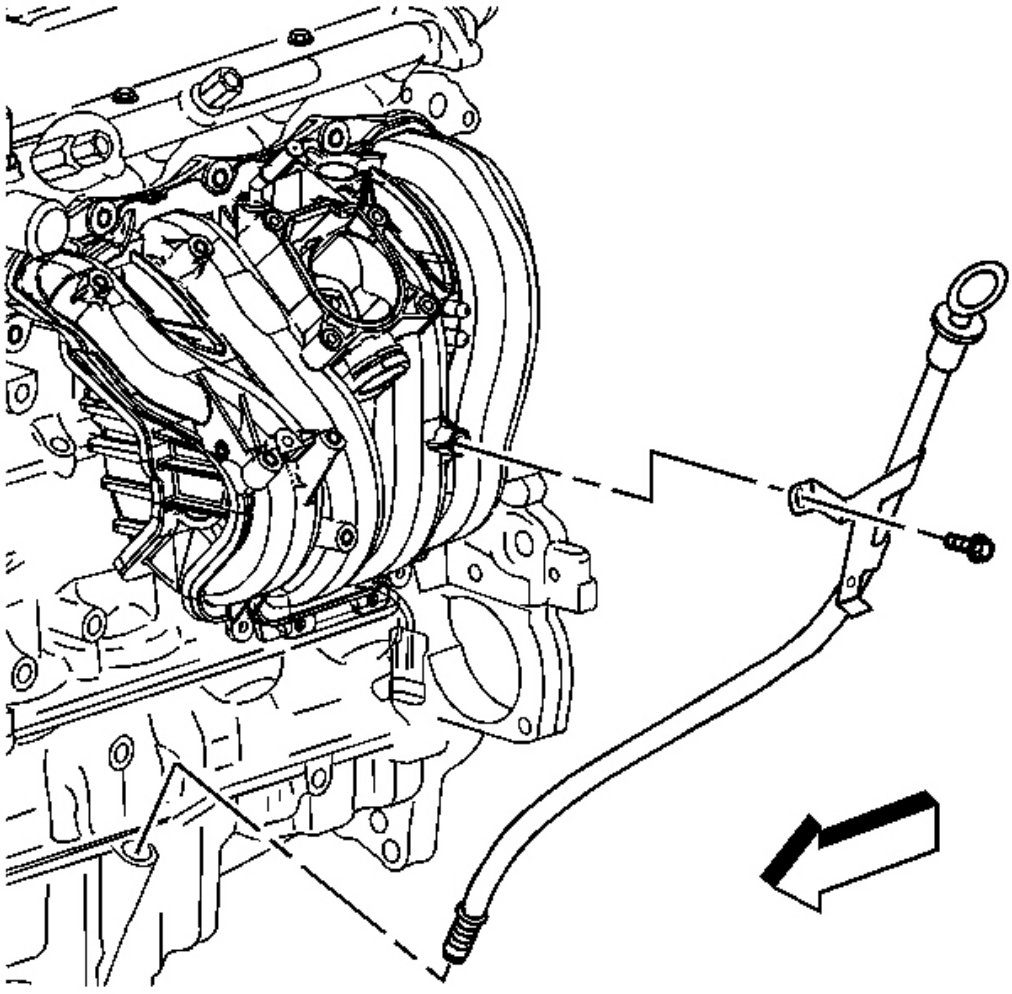


Fig. 616: View Of Oil Level Indicator
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the oil level indicator tube O-ring with engine oil supplement.
2. Install the oil level indicator and the oil level indicator tube into the oil pan.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the oil level indicator tube bracket to the intake manifold bolt.

Tighten: Tighten the bolt 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

Tools Required

- **J 38122-A** Harmonic Balancer Holder. See **Special Tools and Equipment** .
- **J 45059** Angle Meter. See **Special Tools and Equipment** .

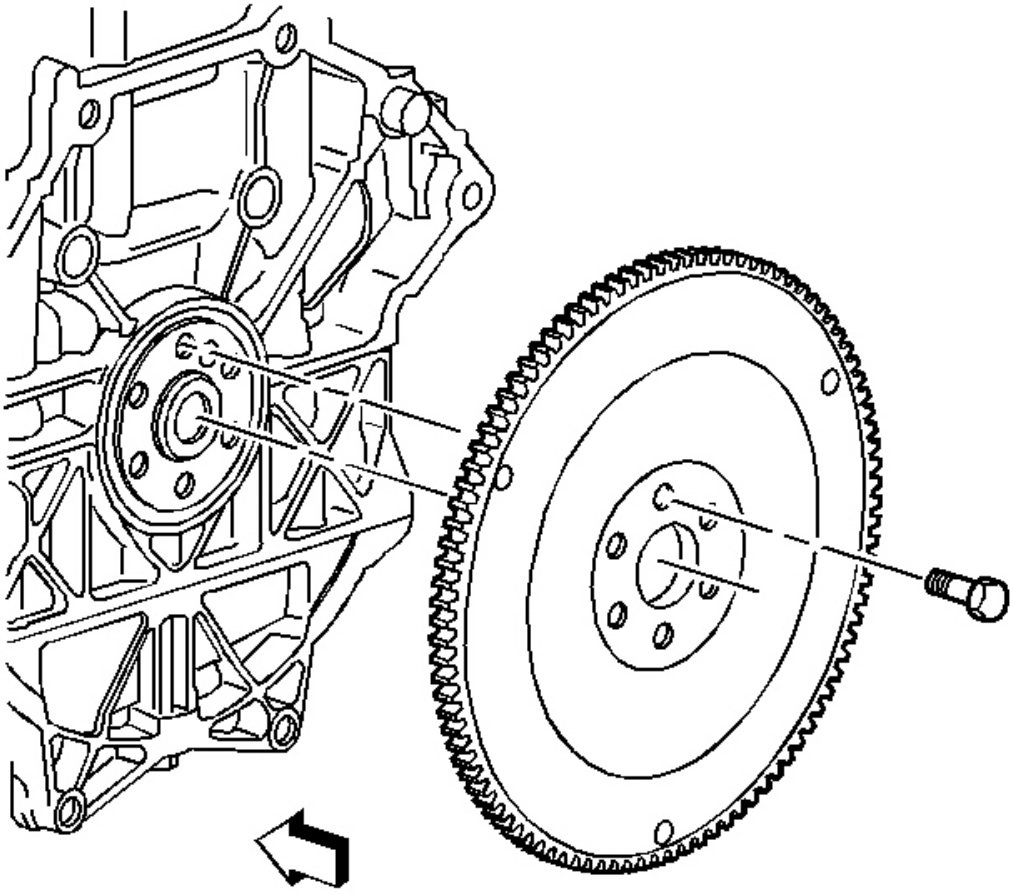


Fig. 617: View Of Flywheel
Courtesy of GENERAL MOTORS CORP.

1. Install the flywheel.

2. Install the NEW bolts.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Holding the crankshaft damper with the **J 38122-A** , tighten the bolts evenly. See **Special Tools and Equipment** .

   Tighten: Tighten the bolts to 53 N.m (39 lb ft), plus 25 degrees using the **J 45059** . See **Special Tools and Equipment** .

DESCRIPTION AND OPERATION

ENGINE COMPONENT DESCRIPTION

Engine Description

Cylinder Block

The cylinder block is lost foam cast aluminum with four cylinders arranged in-line. The cylinders have pressed in place iron liners. The block has five 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 eight counterweights. The number eight 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 two 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 two 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 bearing journals and camshaft bearing caps.

Valves

There are two intake and two exhaust valves per cylinder. Rotators are used on all of the intake valves. The rotators are located at the bottom of the valve spring to reduce valve train reciprocating mass. Positive valve stem seals are used on all valves.

Camshaft

Two camshafts are used, one for all intake valves, the other for all exhaust valves. The camshafts are cast iron. The intake camshaft had a pressed-in hex insert. The hex inset is used to drive the direct drive power steering pump.

Valve Lifters

The valve train uses a roller finger follower acted on by a hydraulic element adjuster. The roller finger follower reduces friction and noise.

Camshaft Cover

The camshaft cover is cast aluminum with steel crankcase ventilation baffling incorporated. The camshaft cover has mounting locations for the ignition system.

Camshaft Drive

A single row roller chain is used for camshaft drive. There is a tensioner and active guide used on the slack side of the chain to control chain motion and noise. The chain drive promotes long valve train life and low maintenance.

Intake and Exhaust Manifold

The intake manifold is made of composite plastic. The exhaust manifold is cast iron. The intake manifold incorporates a distribution and control system for PCV gases. The exhaust manifold is a dual plane design that promotes good low end torque and performance.

LUBRICATION DESCRIPTION

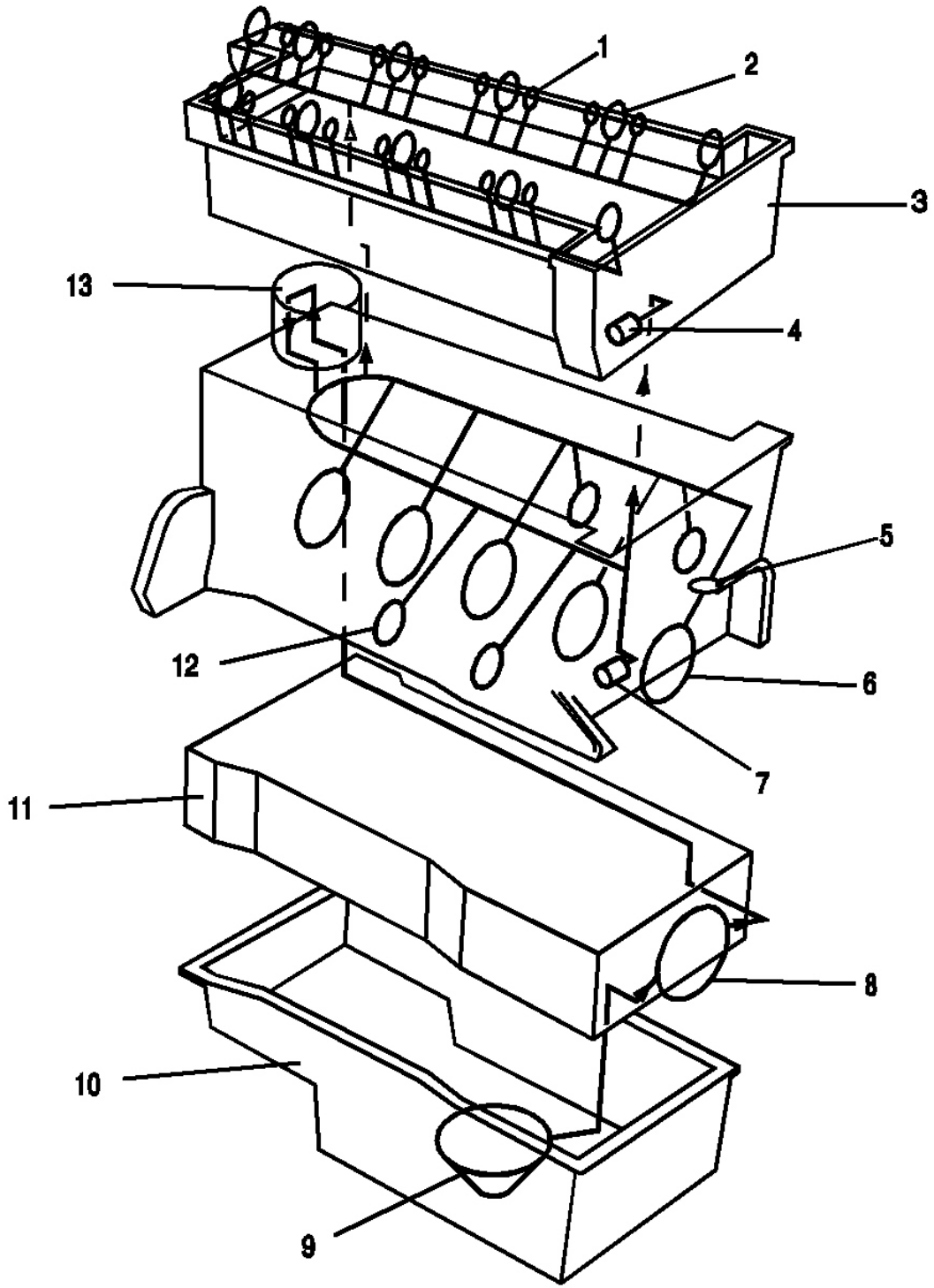


Fig. 618: Lubrication System
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 618

Callout	Component Name
1	Hydraulic Lifter
2	Cam Bearing
3	Cylinder Head
4	Timing Chain Tensioner
5	Cam Drive Chain Oil Nozzle
6	Crankshaft Bearing
7	Balance Shaft Chain Tensioner
8	Oil Pump
9	Oil Pick Up
10	Oil Pan
11	Bedplate
12	Balance Shaft Bearings
13	Oil Filter

Oil is applied under pressure to the crankshaft, connecting rods, balance shaft assembly, camshaft bearing surfaces, valve lifters and timing chain hydraulic tensioner. All other moving parts are lubricated by gravity flow or splash. Oil enters the gerotor type oil pump thorough a fixed inlet screen. The oil pump is driven by the crankshaft. The oil pump body is within the engine front cover. The pressurized oil from the pump passes through the oil filter. The oil filter is located on the right (front) side of the engine block. The oil filter is housed in a casting that is integrated with the engine block. The oil filter is a disposable cartridge type. A by-pass valve in the filter cap allows continuous oil flow in case the oil filter should become restricted. Oil then enters the gallery where it is distributed to the balance shafts, crankshaft, camshafts and camshaft timing chain oiler nozzle. The connecting rod bearings are oiled by constant oil flow passages through the crankshaft connecting the main journals to the rod journals. A groove around each upper main bearing furnishes oil to the drilled crankshaft passages. The pressurized oil passes through the cylinder head restrictor orifice into the cylinder head and then into each camshaft feed gallery. Cast passages feed each hydraulic element adjuster and drilled passages feed each camshaft bearing surface. An engine oil pressure switch or sensor is installed at the end. Oil returns to the oil pan through passages cast into the cylinder head. The timing chain lubrication drains directly into the oil pan.

CLEANLINESS AND CARE

An automobile engine is a combination of many machined, honed, polished, and lapped surfaces with tolerances that are measured in ten thousandths of an inch. When any internal engine parts are serviced, care and cleanliness are important. A liberal coating of engine oil should be applied to friction areas during assembly to protect and lubricate the surfaces during initial operation. Throughout this section, it should be understood that proper cleaning and protection of machined surfaces and friction areas are part of the repair procedure. This is considered standard shop practice even if not specifically stated.

When valve train components are removed for service, they should be retained in order. At the time of installation, they should be installed in the same locations and with the same mating surfaces as when removed.

SEPARATING PARTS

IMPORTANT:

- **Disassembly of the piston, press fit design piston pin, and connecting rod may create scoring or damage to the piston pin and piston pin bore. If the piston, pin, and connecting rod have been disassembled, replace the components as an assembly.**
- **Many internal engine components will develop specific wear patterns on their friction surfaces.**
- **When disassembling the engine, internal components MUST be separated, marked, or organized in a way to ensure installation to their original location and position.**

Separate, mark, or organize the following components:

- Piston and the piston pin
- Piston to the specific cylinder bore
- Piston rings to the piston
- Connecting rod to the crankshaft journal
- Connecting rod to the bearing cap

  A paint stick or etching/engraving type tool are recommended. Stamping the connecting rod or cap near the bearing bore may affect component geometry.

- Crankshaft main and connecting rod bearings
- Camshaft and valve lifters
- Valve lifters, lifter guides, pushrods and rocker arm assemblies
- Valve to the valve guide
- Valve spring and shim to the cylinder head location
- Engine block main bearing cap location and direction
- Oil pump drive and driven gears

REPLACING ENGINE GASKETS

Tools Required

J 28410 Gasket Remover

Gasket Reuse and Applying Sealants

- Do not reuse any gasket unless specified.
- Gaskets that can be reused will be identified in the service procedure.
- Do not apply sealant to any gasket or sealing surface unless called out in the service information.

Separating Components

- Use a rubber mallet to separate components.
- Bump the part sideways to loosen the components.
- Bumping should be done at bends or reinforced areas to prevent distortion of parts.

Cleaning Gasket Surfaces

- Remove all gasket and sealing material from the part using the **J 28410** or equivalent.
- Care must be used to avoid gouging or scraping the sealing surfaces.
- Do not use any other method or technique to remove sealant or gasket material from a part.
- Do not use abrasive pads, sand paper, or power tools to clean the gasket surfaces.
    - These methods of cleaning can cause damage to the component sealing surfaces.
    - Abrasive pads also produce a fine grit that the oil filter cannot remove from the oil.
    - This grit is abrasive and has been known to cause internal engine damage.

Assembling Components

- When assembling components, use only the sealant specified or equivalent in the service procedure.
- Sealing surfaces should be clean and free of debris or oil.
- Specific components such as crankshaft oil seals or valve stem oil seals may require lubrication during assembly.
- Components requiring lubrication will be identified in the service procedure.
- When applying sealant to a component, apply the amount specified in the service procedure.
- Do not allow the sealant to enter into any blind threaded holes, as it may prevent the bolt from clamping properly or cause component damage when tightened.
- Tighten bolts to specifications. Do not overtighten.

USE OF ROOM TEMPERATURE VULCANIZING (RTV) AND ANAEROBIC SEALER

Pipe Joint Compound

IMPORTANT: Three types of sealer are commonly used in engines. These are RTV sealer, anaerobic gasket eliminator sealer, and pipe joint compound. The correct sealer and amount must be used in the proper location to prevent oil leaks. DO NOT interchange the three 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 two 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 two rigid parts (such as the lower crankcase and the engine block) are assembled together.
- Do not use Room Temperature Vulcanizing (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** .

- 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.

IMPORTANT: 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.

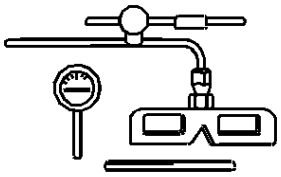
To properly service the engine assembly, the following items should be readily available:

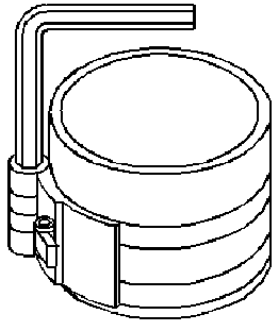
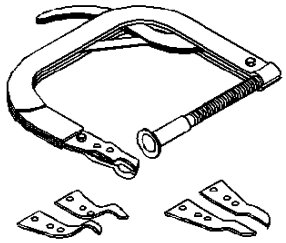
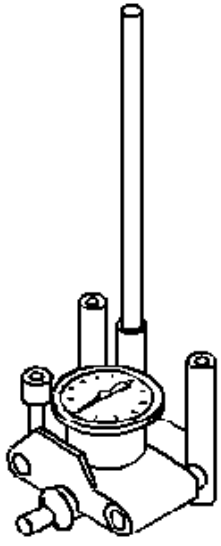
- Approved eye protection and safety gloves
- A clean, well lit, work area
- A suitable parts cleaning tank
- A compressed air supply
- Trays or storage containers to keep parts and fasteners organized
- An adequate set of hand tools
- Approved engine repair stand
- An approved engine lifting device that will adequately support the weight of the components

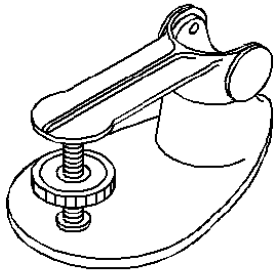
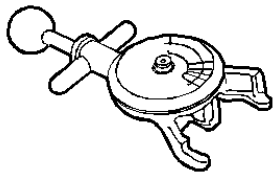
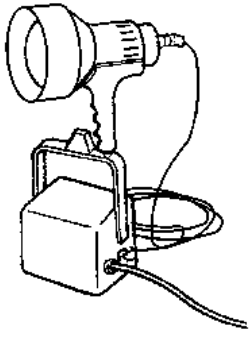
SPECIAL TOOLS AND EQUIPMENT

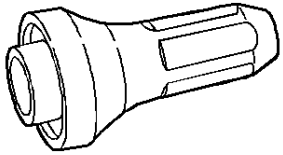
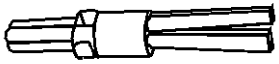
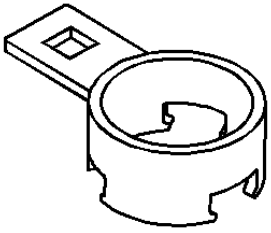
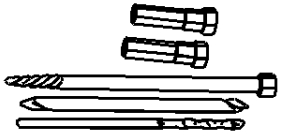
SPECIAL TOOLS

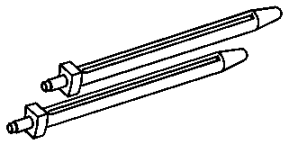
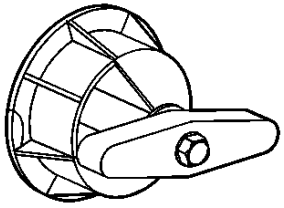
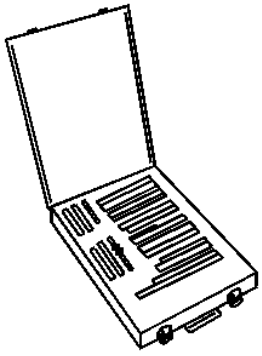
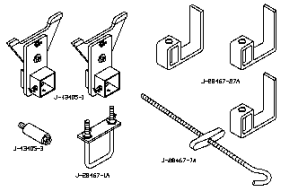
Special Tools

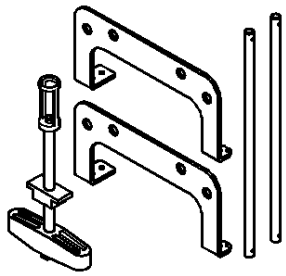
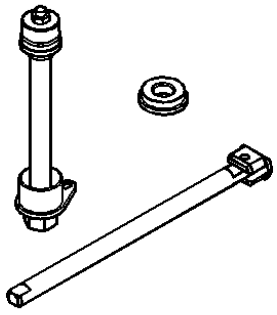
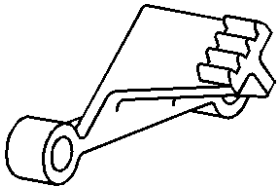
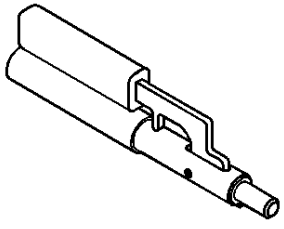
Illustration	Tool Number/Description
	J 7872 Magnetic Base Dial Indicator Set

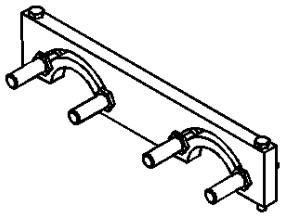
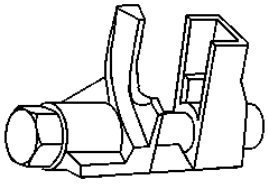
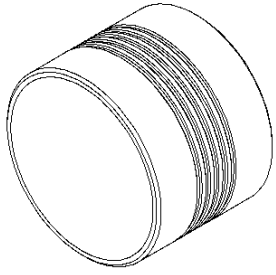
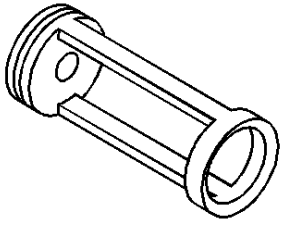
	J 8037 Piston Ring Compressor
	J 8062 Valve Spring Compressor
	J 8087 Cylinder Bore Gage

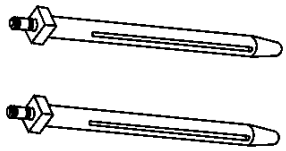
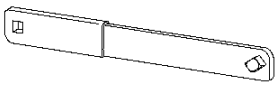
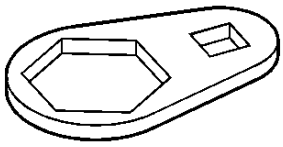
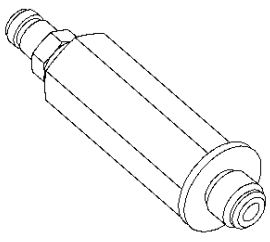
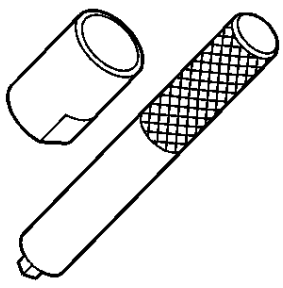
	J 9666 Valve Spring Tester
	J 23600-B Belt Tension Gage
	J 28410 Gasket Remover
	J 28428-E High Intensity Black Light Kit
	J 35268-A Front Crankshaft Seal Installer

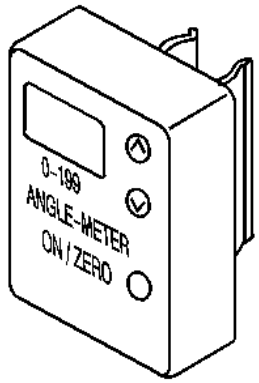
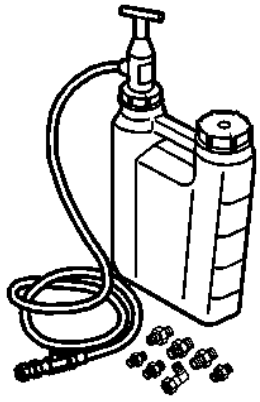
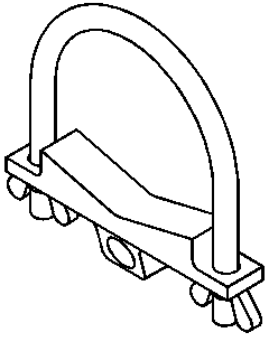
	
	J 36017 Valve Guide Seal Remover
	J 36346 Fascia Retainer Remover
	J 38122-A Harmonic Balancer Holder
	J 38188 Cylinder Head Broken Bolt Extractor Kit
	J 39914 Serpentine Belt Tensioner Unloader
	J 41742-SAT2

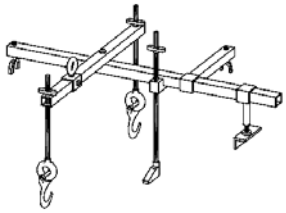
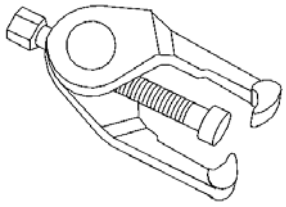
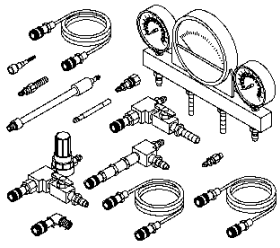
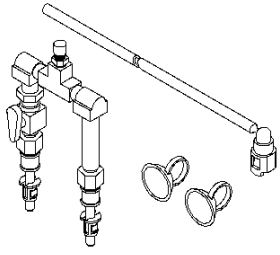
	Connecting Rod Guide Pin
	J 42067 Rear Main Seal Installer
	J 42385-850 Thread Repair Kit
	J 43405 Engine Support Fixture Adapter

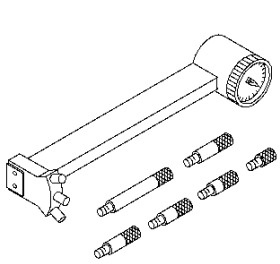
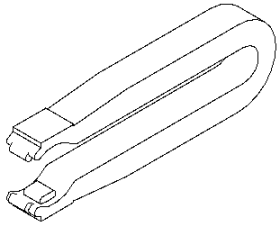
	J 43649 Valve Spring Compressor
	J 43650 Balance Shaft Bearing Remover/Installer
	J 43653 Flywheel Holding Tool
	J 43654 Piston Pin Clip Remover/Installer

	J 43655 Camshaft Sprocket Holding Tool
	J 43828 Ball Joint Separator
	J 43953 Piston Ring Compressor
	J 43963 Valve Spring Compressor
	J 43966-1 Connecting Rod Guides

	
	J 44811 Accessory Belt Tensioner Unloader
	J 44887 Oil Filter Wrench
	J 44953 Oil Pressure Fitting
	J 45027 Tensioner Tool

	J 45059 Angle Meter
	J 45299 Engine Pre-Luber
	J 45341 Rear Wheel Drive Shaft Removal Tool

	SA9105E Engine Support Fixture (3-Bar)
	SA91100C Tie Rod Separator
	SA9127E Gauge Bar Set
	SA9127E-7 Fuel Pressure Flow Adapter

	SA9178NE-A Dial Bore Gauge
	SA9805E Fuel Line Separator

SPECIFICATIONS

FASTENER TIGHTENING SPECIFICATIONS

Fastener Tightening Specifications

Application	Specification	
	Metric	English
A/C Compressor Bolts	22 N.m	16 lb ft
A/C Compressor Bracket Bolts	44 N.m	33 lb ft
Camshaft Cap Bolts	22 N.m	16 lb ft
Camshaft Cap Studs	12 N.m	106 lb in
Camshaft Position (CMP) Sensor Bolt	4 N.m	35 lb in
Camshaft Sprocket Bolts	90 N.m	67 lb ft
Catalytic Converter Bracket-to-Engine Block Bolt	22 N.m	16 lb ft
Catalytic Converter Heat Shield Bolts	12 N.m	106 lb in
Catalytic Converter-to-Cylinder Head Nuts	31 N.m	23 lb ft
Catalytic Converter-to-Exhaust Take down Pipe Studs	18 N.m	13 lb ft
Connecting Rod Cap Bolts - First Pass	20 N.m	14 lb ft
Connecting Rod Cap Bolts - Final Pass	90 degrees	
Coolant Crossover Housing Bolts/Nuts	22 N.m	16 lb ft
Crankshaft Balancer Bolt	245 N.m	181 lb ft
Crankshaft Main Bearing Cap Bottom M11 Bolts	74 N.m	54 lb ft
Crankshaft Main Bearing Cap Side M10 Bolts	49 N.m	36 lb ft
Crankshaft Oil Deflector Bolts	12 N.m	106 lb in
Crankshaft Position Sensor (CKP) Bolt/Nut	9.8 N.m	87 lb in
Cylinder Head Bolts - First Pass	39 N.m	29 lb ft
Cylinder Head Bolts - Second Pass	69 N.m	51 lb ft
Cylinder Head Bolts - Final Pass	98.1 N.m	72.3 lb ft
Cylinder Head-to-Catalytic Converter Studs	22 N.m	16 lb ft
Drive Belt Tensioner Bolt	22 N.m	16 lb ft
Drive Belt Tensioner Pulley Bolt	80 N.m	59 lb ft
Engine Block Coolant Drain Fitting - Right Side	39.2 N.m	28.9 lb ft
Engine Block Coolant Drain Plug - Left Side	78.5 N.m	57.9 lb ft
Engine Block Coolant Drain Plug - Right Side	9.8 N.m	87 lb in
Engine Block Coolant Heater	60 N.m	44 lb ft
Engine Coolant Temperature (ECT) Sensor	12 N.m	106 lb in
Engine Ground Cable Bolt	12 N.m	106 lb in

Engine Mount Adapter - Right Side M10 Bolts	50 N.m	37 lb ft
Engine Mount Bracket - Right Side Nuts	110 N.m	82 lb ft
Engine Mount Bracket Bolts - Right Side M12 Bolts	54 N.m	40 lb ft
Engine Mount Front Bracket Bolts	44 N.m	33 lb ft
Engine Mount Front Bracket M10 Bolts	50 N.m	37 lb ft
Engine Mount Rear M12 Bolts	110 N.m	82 lb ft
Engine Mount Rear Bracket M12 Bolts	110 N.m	82 lb ft
Engine Mount Rear Support M10 Bolts	50 N.m	37 lb ft
Engine Mount Side Bracket M6 Bolts	12 N.m	106 lb in
Engine Mount Side Bracket M10 Bolts	44 N.m	33 lb ft
Evaporative Emission Canister Purge (EVAP) Valve Bolt	9.8 N.m	87 lb in
Exhaust Gas Recirculation (EGR) Nuts	22 N.m	16 lb ft
Exhaust Gas Recirculation (EGR) Studs	10 N.m	88 lb in
Exhaust Gas Recirculation (EGR) Tube-to-Intake Manifold Bolts	12 N.m	106 lb in
Exhaust Take down Pipe-to-Catalytic Converter Nuts	54 N.m	40 lb ft
Flywheel Bolts	74 N.m	54 lb ft
Front Lift Bracket Bolts	22 N.m	16 lb ft
Fuel Hose-to-Fuel Pipe Nuts	12 N.m	106 lb in
Fuel Injection Manifold-to-Cylinder Head Bolts/Nuts	22 N.m	16 lb ft
Fuel Injector Manifold-to-Intake Manifold Studs	22 N.m	16 lb ft
Fuel Rail Bolts	10 N.m	89 lb in
Fuel Rail-to-Fuel Hose Nuts	12 N.m	106 lb in
Fuel Rail-to-Fuel Hose Studs	4.9 N.m	43 lb in
Generator Bolt - M8 Bolt	22 N.m	16 lb ft
Generator Bolt - M10 Bolt	44 N.m	33 lb ft
Generator Harness Clamp Bolt	12 N.m	106 lb in
Ignition Coil Bolts	12 N.m	106 lb in
Intake Air Temperature (IAT) Sensor	12 N.m	106 lb in
Intake Manifold Side Cover Bolt/Nut	12 N.m	106 lb in
Intake Manifold Side Cover Stud	3.4 N.m	30 lb in
Intake Manifold-to-Spacer Bolts/Nuts - First Pass	11 N.m	97 lb in
Intake Manifold-to-Spacer Bolts/Nuts - Final Pass	22 N.m	16 lb ft
Intake Manifold Top Cover Bolts/Nuts - First Pass	6 N.m	53 lb in
Intake Manifold Top Cover Bolts/Nuts - Final Pass	12 N.m	106 lb in
Intake Rocker Arm Oil Flow Control Module Bolts	22 N.m	16 lb ft
Intake Rocker Arm Oil Flow Control Solenoid Bolts	12 N.m	106 lb in
Intake Rocker Arm Oil Flow Control Switch	22 N.m	16 lb ft
Knock Sensor	31 N.m	23 lb ft
Manifold Absolute Pressure (MAP) Sensor Bolt	3.4 N.m	30 lb in
Oil Filter	12 N.m	106 lb in
Oil Filter Fitting	49 N.m	36 lb ft

Oxygen Sensor	44 N.m	33 lb ft
Oil Pan Bolts - First Pass	6 N.m	53 lb in
Oil Pan Bolts - Final Pass	12 N.m	106 lb in
Oil Pan Drain Plug Bolt	39 N.m	29 lb ft
Oil Pan-to-Transmission Bolt	64 N.m	47 lb ft
Oil Pressure Switch	18 N.m	13 lb ft
Oil Pump Assembly-to-Engine Block Bolts	12 N.m	106 lb in
Oil Pump Plug - Large	44 N.m	32.5 lb ft
Oil Pump Plug - Small	34.3 N.m	25.3 lb ft
Oil Pump Pressure Relief Valve Bolt	39 N.m	28 lb ft
Oil Pump Rear Cover Bolts	6 N.m	53 lb in
Oil Pump Screen Bolts	12 N.m	106 lb in
Positive Crankcase Ventilation (PCV) Valve Bolt	12 N.m	106 lb in
Rear Housing Bolts	12 N.m	106 lb in
Serpentine Drive Belt Auto Tensioner M6 Bolts	12 N.m	106 lb in
Serpentine Drive Belt Auto Tensioner M8 Bolts	22 N.m	16 lb ft
Serpentine Drive Belt Tensioner Pulley Bolt	80 N.m	59 lb ft
Spark Plugs	18 N.m	13 lb ft
Starter Motor Bolt	74 N.m	54 lb ft
Starter Motor Positive Cable Nut	9.8 N.m	86 lb in
Thermostat Housing Bolts	12 N.m	106 lb in
Throttle Body Bolts/Nuts	22 N.m	16 lb ft
Throttle Body Studs	7.8 N.m	69 lb in
Timing Belt Auto - Tensioner Bolts	12 N.m	106 lb in
Timing Belt Front Cover Bolts	12 N.m	106 lb in
Timing Belt Idler Pulley Bolt	44 N.m	33 lb ft
Timing Belt Rear Cover Bolts	22 N.m	16 lb ft
Timing Belt Tensioner Bolt	25 N.m	18 lb ft
Timing Belt Tensioner Pulley Bolt	25 N.m	18 lb ft
Timing Belt Tensioner Pulley Nut	80 N.m	59 lb ft
Torque Converter Cover Bolts	12 N.m	106 lb in
Transaxle-to-Engine Bolts	64 N.m	47 lb ft
Valve Rocker Arm Adjusting Screw Nuts	20 N.m	14 lb ft
Valve Rocker Arm Cover Bolts - First Pass	6 N.m	53 lb in
Valve Rocker Arm Cover Bolts - Final Pass	12 N.m	106 lb in
Valve Rocker Arm Shaft Bolts - First Pass	12 N.m	106 lb in
Valve Rocker Arm Shaft Bolts - Final Pass	24 N.m	17 lb ft
Water Pump Bolts	12 N.m	106 lb in
Wiring Harness Bracket Bolts	12 N.m	106 lb in

ENGINE MECHANICAL SPECIFICATIONS

Engine Mechanical Specifications

Application	Specification	
	Metric	English
General		
• Engine Type	Water Cooled, 4-Stroke, SOHC Gasoline Engine	
• Displacement	3471 cc	212 cu in
• RPO	L66	
• VIN	U	
• Cylinder Arrangement	60° V6 Transverse	
• Bore	89.0 mm	3.50 in
• Stroke	93.0 mm	3.66 in
• Compression Ratio	10.0:1	
• Engine Compression Test - Minimum	990 kPa	145 psi
• Engine Compression Test - Maximum Variation	200 kPa	29 psi
• Idle Speed	680-780 RPM	
• Firing Order	1-4-2-5-3-6	
• Spark Plug Gap - Production	1.0-1.1 mm	0.039-0.043 in
• Spark Plug Gap - Service	1.3 mm	0.051 in
• Ignition Timing	8-12 BTDC at 680-780 RPM	
Block		
• Crankshaft Main Bearing Bore Diameter	77.0-77.024 mm	3.031-3.032 in
• Cylinder Bore Diameter - Production	89.0-89.015 mm	3.5039-3.5045 in
• Cylinder Bore Diameter - Service	89.065 mm	3.5065 in
• Cylinder Bore Diameter - 0.25 mm (0.0098 in) Oversize Piston	89.25-89.265 mm	3.5138-3.5144 in
• Cylinder Bore Taper - Service	0.05 mm	0.002 in
• Cylinder Head Deck Surface Flatness - Production	0.07 mm	0.003 in
• Cylinder Head Deck Surface Flatness - Service	0.1 mm	0.004 in
• Cylinder Reboring Limit - Service	0.25 mm	0.01 in
• Rear Housing-to-Oil Seal Clearance	0.5-0.8 mm	0.019-0.031 in
Camshaft		
• Camshaft-to-Cap Clearance - Production	0.05-0.2 mm	0.002-0.008 in
• Camshaft-to-Cap Clearance - Service	0.2 mm	0.008 in
• End Play - Production	0.05-0.20 mm	0.002-0.008 in

• End Play - Service	0.2 mm	0.008 in
• Journal Diameter	42.935-42.950 mm	1.690-1.691 in
• Journal Out-of-Round - Maximum	0.03 mm	0.0012 in
• Camshaft-to-Journal Clearance - Production	0.05-0.089 mm	0.002-0.0035 in
• Camshaft-to-Journal Clearance - Service	0.15 mm	0.006 in
• Lobe Height - Intake Primary	35.041 mm	1.3796 in
• Lobe Height - Intake Mid	36.445 mm	1.4348 in
• Lobe Height - Intake Secondary	35.284 mm	1.3891 in
• Lobe Height - Exhaust	36.326 mm	1.4302 in
• Lobe Lift - Intake Primary	5.041 mm	0.1984 in
• Lobe Lift - Intake Mid	6.323 mm	0.2489 in
• Lobe Lift - Intake Secondary	5.284 mm	0.2080 in
• Lobe Lift - Exhaust	6.326 mm	0.2490 in
• Runout - Production	0.03 mm	0.001 in
• Runout - Service	0.04 mm	0.002 in
Cooling System		
• Thermostat Begins-to-Open Temperature	76-80°C	168-176°F
• Thermostat Full Open Temperature	90°C	194°F
• Water Pump Displacement - at 6,000 RPM Per Minute	176 liters	186 qts
Connecting Rod		
• Bearing Clearance - Production	0.02-0.044 mm	0.0008-0.0017 in
• Bearing Clearance - Service	0.05 mm	0.002 in
• Bore Diameter - Bearing End	58 mm	2.28 in
• Bore Diameter - Pin End	21.97-21.976 mm	0.865-0.8652 in
• Bore Out-of-Round - Bearing End	0.005 mm	0.0002 in
• Length	158.5 mm	6.24 in
• End Play - Production	0.15-0.35 mm	0.006-0.014 in
• End Play - Service	0.45 mm	0.018 in
• Connecting Rod Bolt - Difference in Diameter - Service	0.0-0.1 mm	0.0-0.004 in
Crankshaft		
• Connecting Rod Journal Diameter	54.976-55.0 mm	2.1644-2.1654 in
• Connecting Rod Journal Out-of-Round - Production	0.005 mm	0.0002 in
• Connecting Rod Journal Out-of-Round - Service	0.01 mm	0.0004 in

• Connecting Rod Journal Taper - Production	0.005 mm	0.0002 in
• Connecting Rod Journal Taper - Service	0.01 mm	0.0004 in
• Connecting Rod Journal Width	17.55-17.75 mm	0.691-0.699 in
• End Play - Production	0.1-0.35 mm	0.004-0.014 in
• End Play - Service	0.45 mm	0.018 in
• Main Bearing Clearance - Production	0.02-0.044 mm	0.0008-0.0017 in
• Main Bearing Clearance - Service	0.05 mm	0.002 in
• Main Journal Diameter	71.976-72.0 mm	2.8337-2.8346 in
• Main Journal Out-of-Round - Production	0.005 mm	0.0002 in
• Main Journal Out-of-Round - Service	0.01 mm	0.0004 in
• Main Journal Taper - Production	0.005 mm	0.0002 in
• Main Journal Taper - Service	0.01 mm	0.0004 in
• Runout - Production - Journals 1 and 4	0.02 mm	0.0008 in
• Runout - Production - Journals 2 and 3	0.025 mm	0.001 in
• Runout - Service	0.03 mm	0.0012 in
• Thrust Surface Distance	0.1-0.35 mm	0.004-0.014 in
• Thrust Surface Runout	0.45 mm	0.018 in
Cylinder Head		
• Combustion Chamber Volume	51.3 cu cm	3.13 cu in
• Cylinder Head Height/Thickness	120.95-121.05 mm	4.762-4.766 in
• Surface Flatness - Block Deck	0.05 mm	0.002 in
• Surface Flatness - Exhaust Manifold Deck	0.05 mm	0.002 in
• Surface Flatness - Intake Manifold Deck	0.05 mm	0.002 in
• Resurface Limit - Block Deck	0.2 mm	0.008 in
• Valve Guide Bore - Exhaust - Production	5.515-5.53 mm	0.2171-0.2178 in
• Valve Guide Bore - Exhaust - Service	5.55 mm	0.219 in
• Valve Guide Bore - Intake - Production	5.515-5.530 mm	0.2171-0.2177 in
• Valve Guide Bore - Intake - Service	5.55 mm	0.219 in
• Valve Guide Installed Height - Exhaust	20.63-21.63 mm	0.812-0.852 in
• Valve Guide Installed Height - Intake	21.2-22.2 mm	0.835-0.874 in
Lubrication System		
• Oil Type	5W-20	
	5.0 liters	5.2 qts

• Oil Capacity - with Engine Overhaul		
• Oil Capacity - with Filter	4.3 liters	4.5 qts
• Oil Capacity - without Filter	4.0 liters	4.2 qts
• Oil Pressure - at Idle and Engine at 80°C (176°F)	70 kPa	10 psi
• Oil Pressure - at 3,000 RPM and Engine at 80°C (176°F)	490 kPa	71 psi
Oil Pump		
• Displacement - at 6,000 RPM Per Minute	58.4 liters	61.7 qts
• Rotor Diameter - Outer	84 mm	3.307 in
• Rotor Pocket - Depth - Inner	12.72 mm	0.5 in
• Rotor Pocket - Depth - Outer	12.78 mm	0.503 in
• Inner Rotor-to-Outer Rotor Radial Clearance - New	0.04-0.16 mm	0.002-0.0063 in
• Inner Rotor-to-Outer Rotor Radial Clearance - Service Limit	0.2 mm	0.008 in
• Housing-to-Rotor Axial Clearance - New	0.02-0.07 mm	0.001-0.003 in
• Housing-to-Rotor Axial Clearance - Service Limit	0.12 mm	0.005 in
• Housing-to-Outer Rotor Radial Clearance - New	0.10-0.19 mm	0.004-0.007 in
• Housing-to-Outer Rotor Radial Clearance - Service Limit	0.2 mm	0.008 in
Piston Rings		
• End Gap - Top - Production	0.2-0.35 mm	0.008-0.014 in
• End Gap - Top - Service	0.6 mm	0.024 in
• End Gap - Second - Production	0.4-0.55 mm	0.0016-0.022 in
• End Gap - Second - Service	0.7 mm	0.028 in
• End Gap - Oil - Production	0.2-0.7 mm	0.008-0.028 in
• End Gap - Oil - Service	0.8 mm	0.031 in
• First Compression Ring - Production	0.02-0.35 mm	0.008-0.014 in
• First Compression Ring - Service	0.6 mm	0.024 in
• Second Compression Ring - Production	0.4-0.055 mm	0.0016-0.0022 in
• Second Compression Ring - Service	0.7 mm	0.028 in
• Oil Control Ring - Production	0.2-0.7 mm	0.008-0.028 in
• Oil Control Ring - Service	0.8 mm	0.031 in
• Piston Ring-to-Groove Clearance - Top - Production	0.055-0.08 mm	0.0022-0.0031 in
• Piston Ring-to-Groove Clearance - Top - Service	0.15 mm	0.006 in
• Piston Ring-to-Groove Clearance - Second - Production	0.03-0.055 mm	0.0012-0.0022 in

• Piston Ring-to-Groove Clearance - Second - Service	0.13 mm	0.005 in
• First Compression Ring - Production	0.055-0.08 mm	0.0022-0.0031 in
• First Compression Ring - Service	0.13 mm	0.005 in
• Second Compression Ring - Production	0.03-0.055 mm	0.0012-0.0022 in
• Second Compression Ring - Service	0.13 mm	0.005 in
• First Compression Ring Height	1.2 mm	0.05 in
• First Compression Width	3.1 mm	0.12 in
• Second Compression Height	1.2 mm	0.05 in
• Second Compression Width	3.4 mm	0.13 in
Pistons		
• Diameter - Production - Measure 16 mm (0.63 in) from Bottom of Skirt	88.975-88.985 mm	3.5029-3.5033 in
• Diameter - Service	88.965 mm	3.5026 in
• Diameter - 0.25 mm Oversize Piston	89.225-89.235 mm	3.5128-3.5132 in
• Out-of-Round - Measured by Clearance to Cylinder Bore	0.08 mm	3.15 in
• Pin Bore Diameter	21.96-22.03 mm	0.864-0.867 in
• Ring Groove Width - Top - Production	1.24-1.25 mm	0.0488-0.0492 in
• Ring Groove Width - Top - Service	1.27 mm	0.05 in
• Ring Groove Width - Second - Production	1.22-1.23 mm	0.048-0.0484 in
• Ring Groove Width - Second - Service	1.25 mm	0.049 in
• Ring Groove Width - Oil - Production	2.805-2.825 mm	0.1104-0.1112 in
• Ring Groove Width - Oil - Service	2.85 mm	0.112 in
• Piston to Bore Clearance - Production	0.015-0.04 mm	0.0006-0.0016 in
• Piston to Bore Clearance - Service	0.08 mm	0.003 in
Piston Pin		
• Clearance to Connecting Rod Bore - Production	0.005-0.014 mm	0.0002-0.0006 in
• Clearance to Connecting Rod Bore - Service	0.019 mm	0.0007 in
• Clearance to Piston Pin Bore - Production	-0.005 to +0.001 mm	-0.0002 to +0.00004 in
• Clearance to Piston Pin Bore - Service	0.004 mm	0.0002 in
• Diameter - Production	21.962-21.965 mm	0.8646-0.8648 in
• Diameter - Service	21.954 mm	0.8643 in
• Length	53.77-54.23 mm	2.116-2.135 in

Starter		
• Rated Output	1.6 kw	2.15 hp
Timing Belt Tensioner		
• Tensioner Rod Extended	48.8-58.7 mm	1.92-2.31 in
• Tensioner Spring Load - Rod Extended	151 N at 58.7 mm	34 lb at 2.31 in
• Tensioner Spring Load - Rod Partially Extended	185 N at 54.4 mm	41.5 lb at 2.14 in
• Tensioner Spring Load - Rod Retracted	228 N at 48.8 mm	51 lb at 1.92 in
Valves and Valve Seats		
• Clearance - Cold - Exhaust	0.28-0.32 mm	0.011-0.013 in
• Clearance - Cold - Intake	0.20-0.24 mm	0.008-0.009 in
• Face Angle - Exhaust	40-60 degrees	
• Face Angle - Intake	45-60-70 degrees	
• Face Runout - Maximum	0.04 mm	0.0016 in
• Face Width	2.121 mm	0.083 in
• Head Diameter - Exhaust	29.9-30.1 mm	1.177-1.185 in
• Head Diameter - Intake	34.9-35.1 mm	1.374-1.382 in
• Key Groove Diameter	4.595-4.60 mm	0.180-0.181 in
• Length - Exhaust	113.9-114.5 mm	4.484-4.508 in
• Length - Intake	115.7-116.3 mm	4.555-4.579 in
• Seat Angle - Exhaust	30-45-60 degrees	
• Seat Angle - Intake	30-45-67 degrees	
• Seat Width - Exhaust - Production	1.25-1.55 mm	0.049-0.061 in
• Seat Width - Exhaust - Service	2.0 mm	0.079 in
• Seat Width - Intake - Production	1.25-1.55 mm	0.049-0.061 mm
• Seat Width - Intake - Service	2.0 mm	0.079 in
• Stem Diameter - Exhaust - Production	5.45-5.46 mm	0.2146-0.215 in
• Stem Diameter - Exhaust - Service	5.42 mm	0.2134 in
• Stem Diameter - Intake - Production	5.485-5.495 mm	0.2159-0.2163 in
• Stem Diameter - Intake - Service	5.455 mm	0.2148 in
• Stem Installed Height - Exhaust - Production	46.68-47.48 mm	1.838-1.869 in
• Stem Installed Height - Exhaust - Service	47.73 mm	1.879 in
• Stem Installed Height - Intake - Production	46.75-47.55 mm	1.841-1.872 in
• Stem Installed Height - Intake - Service	47.8 mm	1.882 in

• Stem-to-Guide Clearance - Exhaust - Production	0.055-0.08 mm	0.0022-0.0031 in
• Stem-to-Guide Clearance - Exhaust - Service	0.11 mm	0.004 in
• Stem-to-Guide Clearance - Intake - Production	0.02-0.045 mm	0.0008-0.0018 in
• Stem-to-Guide Clearance - Intake - Service	0.08 mm	0.003 in
Valve Guides		
• Valve Guide Installed Height - Intake	21.20-22.2 mm	0.835-0.874 in
• Valve Guide Installed Height - Exhaust	20.63-21.63 mm	0.812-0.852 in
Valve Lash Adjuster		
• Free Length	47.41 mm	1.87 in
• Spring Load	49 N at 45.5 mm	11 lb at 1.79 in
Rocker Arms and Shafts		
• Bore Diameter	20.02-20.05 mm	0.788-0.789 in
• Arm-to-Shaft Clearance - Exhaust - Production	0.026-0.077 mm	0.001-0.003 in
• Arm-to-Shaft Clearance - Exhaust - Service	0.077 mm	0.003 in
• Arm-to-Shaft Clearance - Intake - Production	0.026-0.067 mm	0.001-0.0026 in
• Arm-to-Shaft Clearance - Intake - Service	0.067 mm	0.0026 in
• Ratio	1.5:1	
• Shaft Diameter	20.0 mm	0.7874 in
• Intake Rocker Arm Test - Regulator Pressure Setting	440-540 kPa	64-78 psi
Valve Springs		
• Coil Thickness - Exhaust	3.5 mm	0.137 in
• Coil Thickness - Intake	3.6 mm	0.141 in
• Diameter - Inside	16.2 mm	0.637 in
• Diameter - Outside - Exhaust	23.2 mm	0.913 in
• Diameter - Outside - Intake	23.4 mm	0.921 in
• Free Length - Exhaust	51.06 mm	2.01 in
• Free Length - Intake	51.54 mm	2.029 in
• Installed Height	43.4 mm	1.708 in

CRANKSHAFT BEARINGS SELECTION SPECIFICATIONS

Crankshaft Bearings Selection Specifications

*Crankshaft Main Journal	**Engine Block Main Journal Bore			
	A or I	B or II	C or III	D or IIII
1 or I	Red/Pink	Pink	Pink/Yellow	Yellow

2 or II	Pink	Pink/Yellow	Yellow	Yellow/Green
3 or III	Pink/Yellow	Yellow	Yellow/Green	Green
4 or IIII	Yellow	Yellow/Green	Green	Green/Brown
5 or IIIII	Yellow/Green	Green	Green/Brown	Brown
6 or IIIIII	Green	Green/Brown	Brown	Brown/Black

IMPORTANT:

The color code is on the edge of the bearing. When using bearing halves of different colors, it does not matter which color is used in the top or bottom position.

*As the numbers increase, the crankshaft journal diameter decreases and the bearing thickness increases.**As the letters or numbers increase, the main journal bore diameter increases and the bearing thickness increases.

CONNECTING ROD BEARINGS SELECTION SPECIFICATIONS

Connecting Rod Bearings Selection Specifications

*Crankshaft Connecting Rod Journal	**Connecting Rod Journal Bore			
	1 or I	**2 or II**	**3 or III**	**4 or IIII**
A or I	Pink	Pink/Yellow	Yellow	Yellow/Green
B or II	Pink/Yellow	Yellow	Yellow/Green	Green
C or III	Yellow	Yellow/Green	Green	Green/Brown
D or IIII	Yellow/Green	Green	Green/Brown	Brown
E or IIIII	Green	Green/Brown	Brown	Brown/Black
F or IIIIII	Green/Brown	Brown	Brown/Black	Black

IMPORTANT:

The color code is on the edge of the bearing. When using bearing halves of different colors, it does not matter which color is used in the top or bottom position.

*As the letters or numbers increase, the crankshaft journal diameter decreases and the bearing thickness increases.**As the numbers increase, the connecting rod bore diameter increases and the bearing thickness increases.

SEALERS, ADHESIVES, AND LUBRICANTS

Sealers, Adhesives, and Lubricants

Application	Type of Material	GM Part Number	
		United States	**Canada**
Bearing Cap Bolts	Engine Oil	5W-20 or equivalent	
Bearing Cap Side Bolts	Engine Oil	5W-20 or equivalent	
Camshaft Oil Seal	Engine Oil	5W-20 or equivalent	
Camshaft Sprocket Bolts	Engine Oil	5W-20 or equivalent	
Connecting Rod Bearings	Engine Oil	5W-20 or equivalent	

Crankshaft Front Oil Seal	Grease	-	
Crankshaft Rear Oil Seal	Grease	-	
Cylinder Bores	Engine Oil	5W-20 or equivalent	
Engine Oil	Oil	5W-20 or equivalent	
Front Motor Mount - Lower Bolt Threads	Adhesive/Sealant	21485277	10953489
Main Bearings	Engine Oil	5W-20 or equivalent	
Oil Filter Rubber Seal	Engine Oil	5W-20 or equivalent	
Oil Pan-to-Engine Block	Liquid Gasket Sealant	12346240	10953493
Oil Pressure Switch Threads	Liquid Gasket	12346240	10953493
Oil Pump Housing Bolt Threads	Liquid Gasket	12346240	10953493
Oil Pump O-Ring	Engine Oil	5W-20 or equivalent	
Oil Pump-to-Engine Block Surface	Liquid Gasket	12346240	10953493
Oil Screen O-Ring	Engine Oil	5W-20 or equivalent	
Piston Pin-to-Connecting Rod	Engine Oil	5W-20 or equivalent	
Rear Housing-to-Engine Block Surface	Liquid Gasket	12346240	10953493
Spark Plug Threads	Anti-Seize Compound	21485279	-
Thrust Washer Surfaces	Engine Oil	5W-20 or equivalent	
Timing Belt Idler Pulley Bolt Threads	Liquid Gasket	12346240	10953493
Valve Face Contact Pattern	Gear Pattern Checking Grease	1052351	10953497

COMPONENT LOCATOR

DISASSEMBLED VIEWS

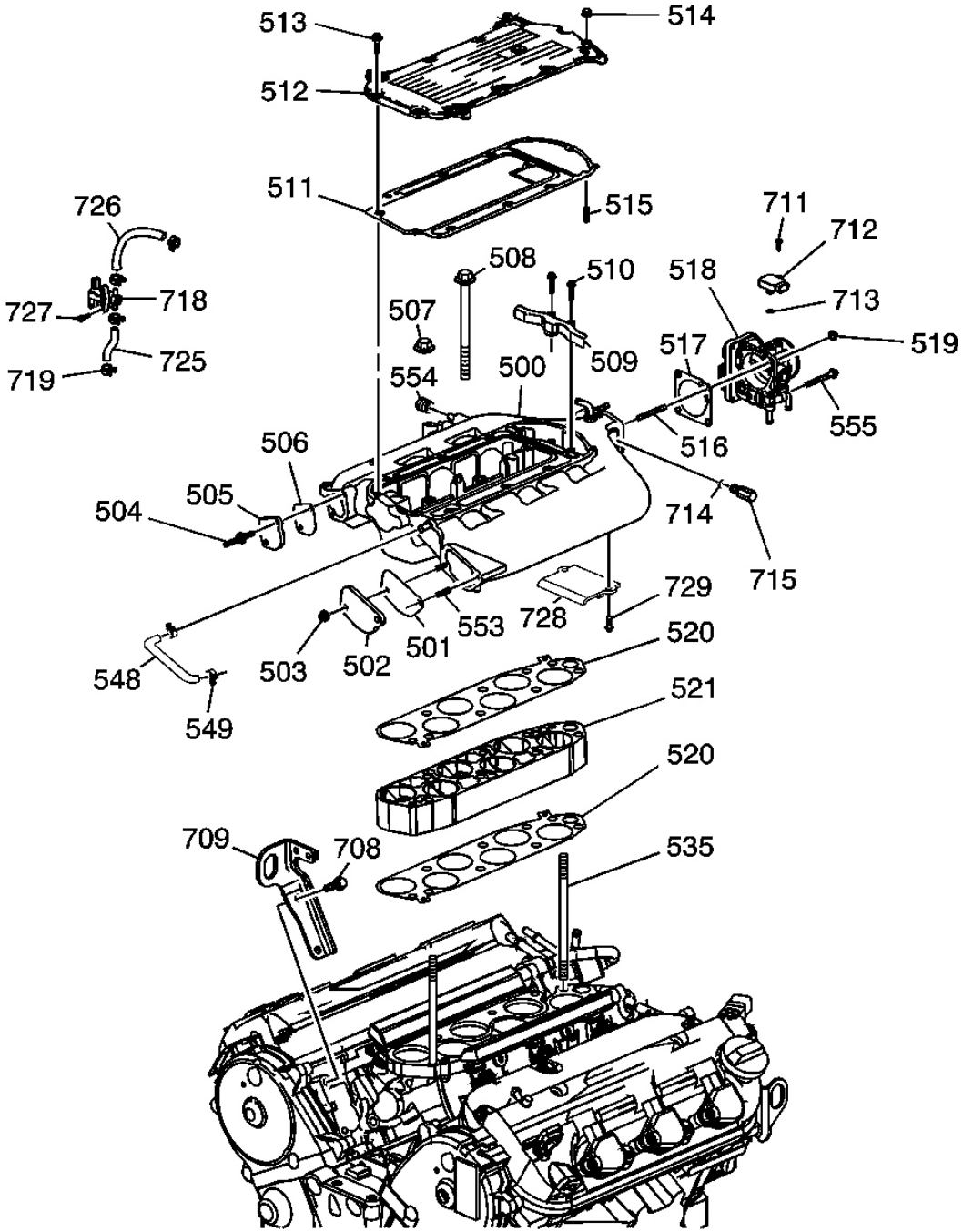


Fig. 1: Intake Manifold
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 1

Callout	Component Name
500	Intake Manifold
501	Gasket
502	Cover - Side
503	Nut
504	Bolt/Stud
505	Cover - Side
506	Gasket
507	Nut
508	Bolt
509	Exhaust Gas Recirculation (EGR) Tube
510	Bolt
511	Gasket
512	Cover - Top
513	Bolt
514	Nut
515	Stud
516	Stud
517	Gasket
518	Throttle Body
519	Nut
520	Gasket
520	Gasket
521	Spacer
535	Stud
548	Positive Crankcase Ventilation (PCV) Hose
549	Clamp
553	Stud
554	Cap
555	Bolt
708	Bolt
709	Front Lift Bracket
711	Bolt
712	Manifold Absolute Pressure (MAP) Sensor
713	O-Ring
714	O-Ring
715	Intake Air Temperature (IAT) Sensor
718	Evaporative Emission (EVAP) Valve
719	Clamp
725	Hose
726	Hose

727	Bolt
728	Dampener
729	Bolt

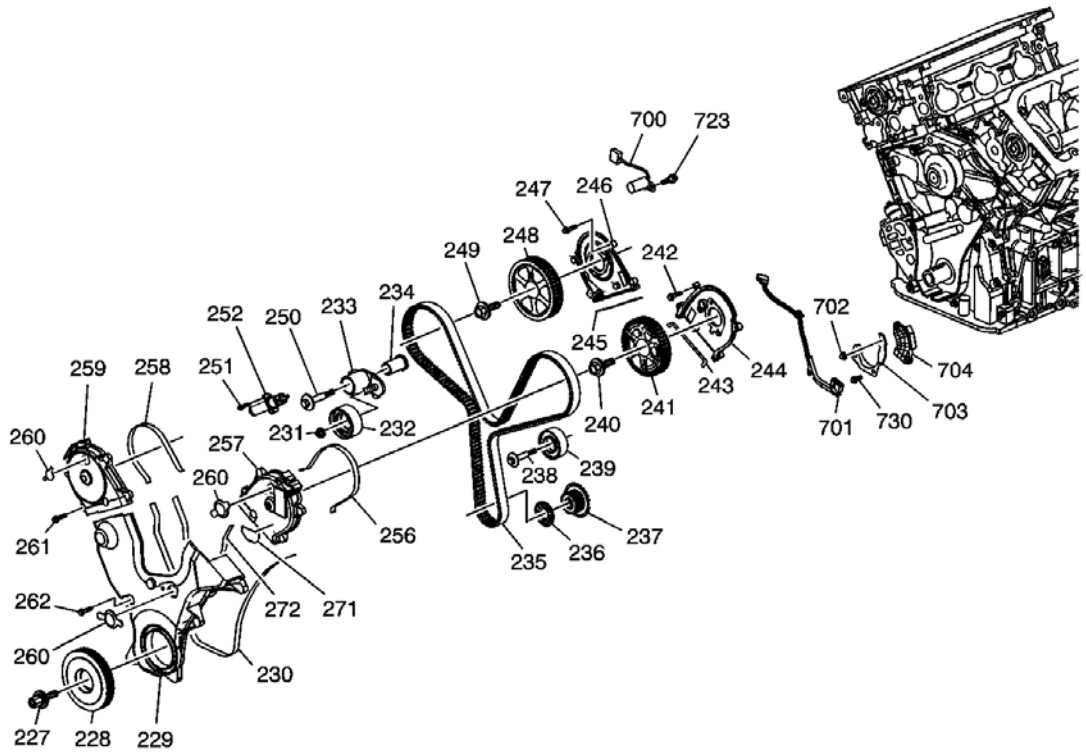


Fig. 2: Camshaft Timing Components
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 2

Callout	Component Name
227	Balancer Bolt with Washer
228	Crankshaft Balancer
229	Cover - Lower Front
230	Seal
231	Nut
232	Tensioner Pulley
233	Tensioner Bracket
234	Tensioner Bushing
235	Timing Belt
236	Guide
237	Sprocket

238	Bolt
239	Idler Pulley
240	Bolt
241	Sprocket
242	Bolt
243	Seal
244	Cover - Upper Rear
245	Seal
246	Cover - Upper Rear
247	Bolt
248	Sprocket
249	Bolt
250	Bolt
251	Bolt
252	Tensioner
256	Seal
257	Cover - Upper Front
258	Seal
259	Cover - Upper Front
260	Grommet
260	Grommet
260	Grommet
261	Bolt
262	Bolt
271	Label
272	Seal
700	Camshaft Position (CMP) Sensor
701	Harness
702	Nut
703	Guide
704	Crankshaft Position (CKP) Sensor
723	Bolt
730	Bolt

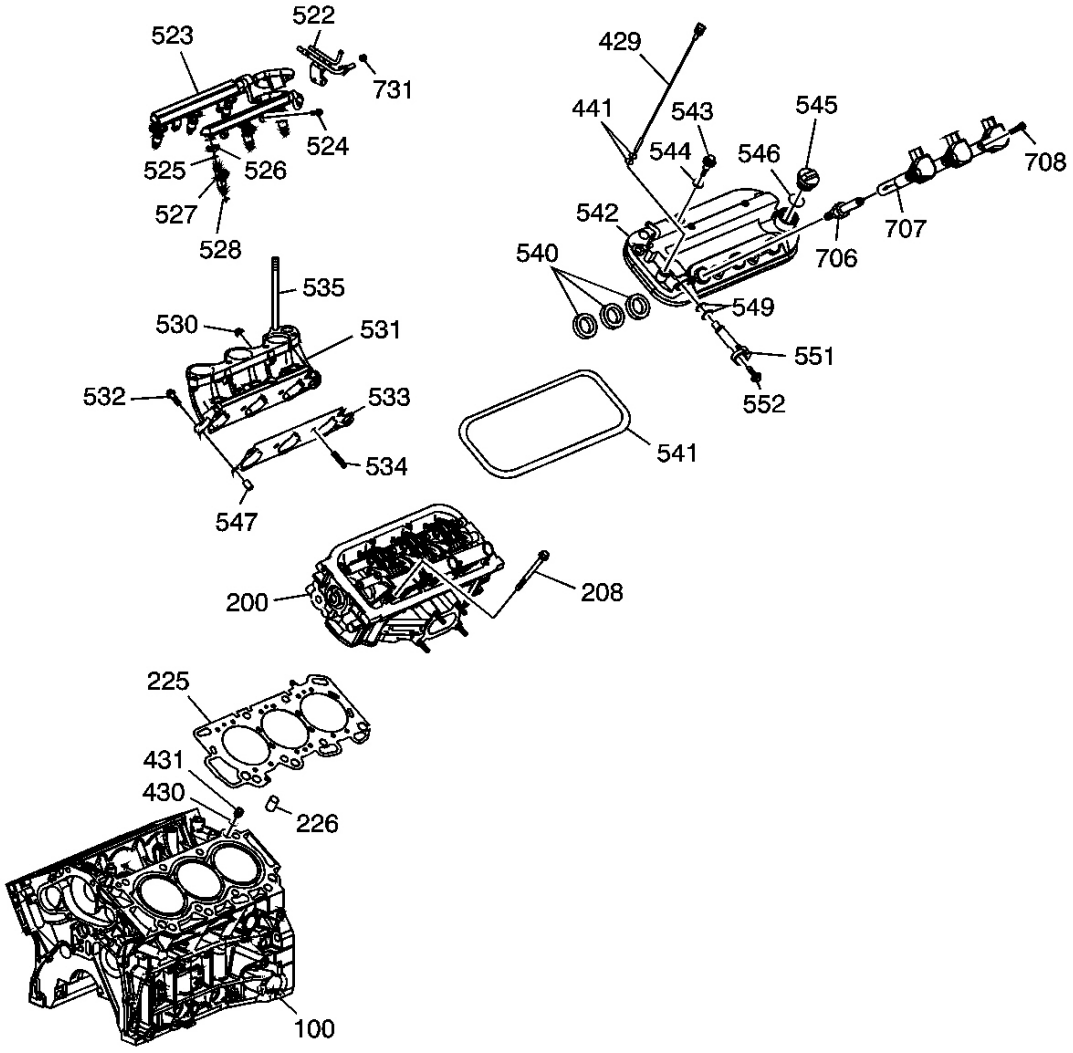


Fig. 3: Cylinder Head/Upper Engine
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 3

Callout	Component Name
100	Engine Block
200	Cylinder Head
208	Bolt
225	Gasket
226	Pin
429	Oil Level Indicator
430	O-Ring

431	Restrictor
441	O-Ring
522	Fuel Feed Pipe
523	Fuel Rail with Injectors and Hoses
524	Bolt
525	O-Ring
526	Clip
527	Fuel Injector
528	O-Ring
530	Nut
531	Manifold
532	Bolt
533	Gasket
534	Stud
535	Stud
540	Seal
541	Gasket
542	Cover
543	Bolt
544	Grommet
545	Oil Fill Cap
546	O-Ring
547	Pin
549	O-Ring
551	Positive Crankcase Ventilation (PCV) Valve
552	Bolt
706	Spark Plug
707	Ignition Coil
708	Bolt
731	Nut

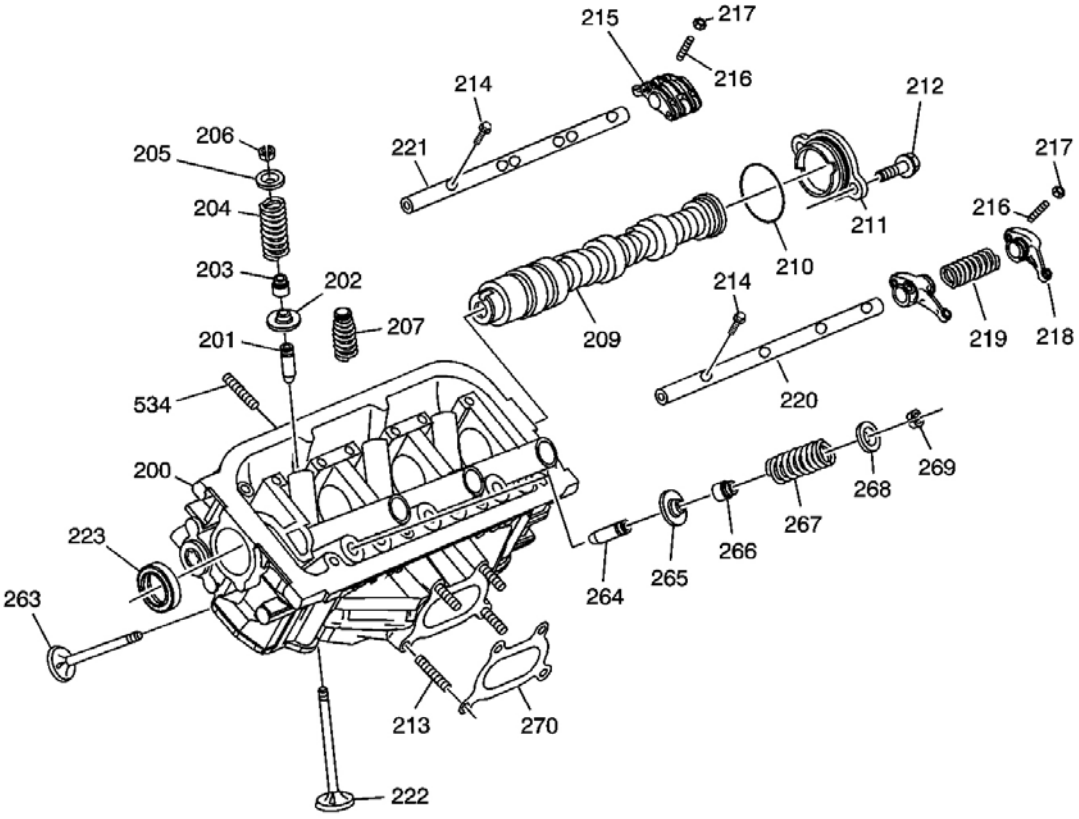


Fig. 4: Cylinder Head Assembly
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 4

Callout	Component Name
200	Cylinder Head
201	Guide - Intake
202	Seat - Intake
203	Seal - Intake
204	Spring - Intake
205	Cap - Intake
206	Keys - Intake
207	Valve Lash Adjuster
209	Camshaft
210	O-Ring
211	Cap
212	Bolt
213	Stud

214	Bolt
214	Bolt
215	Rocker Arm Assembly - Intake
216	Bolt
216	Bolt
217	Nut
217	Nut
218	Rocker Arm - Exhaust
219	Spring
220	Shaft - Exhaust
221	Shaft - Intake
222	Valve - Intake
223	Seal
263	Valve - Exhaust
264	Guide - Exhaust
265	Seat - Exhaust
266	Seal - Exhaust
267	Spring - Exhaust
268	Cap - Exhaust
269	Keys - Exhaust
270	Gasket
534	Stud

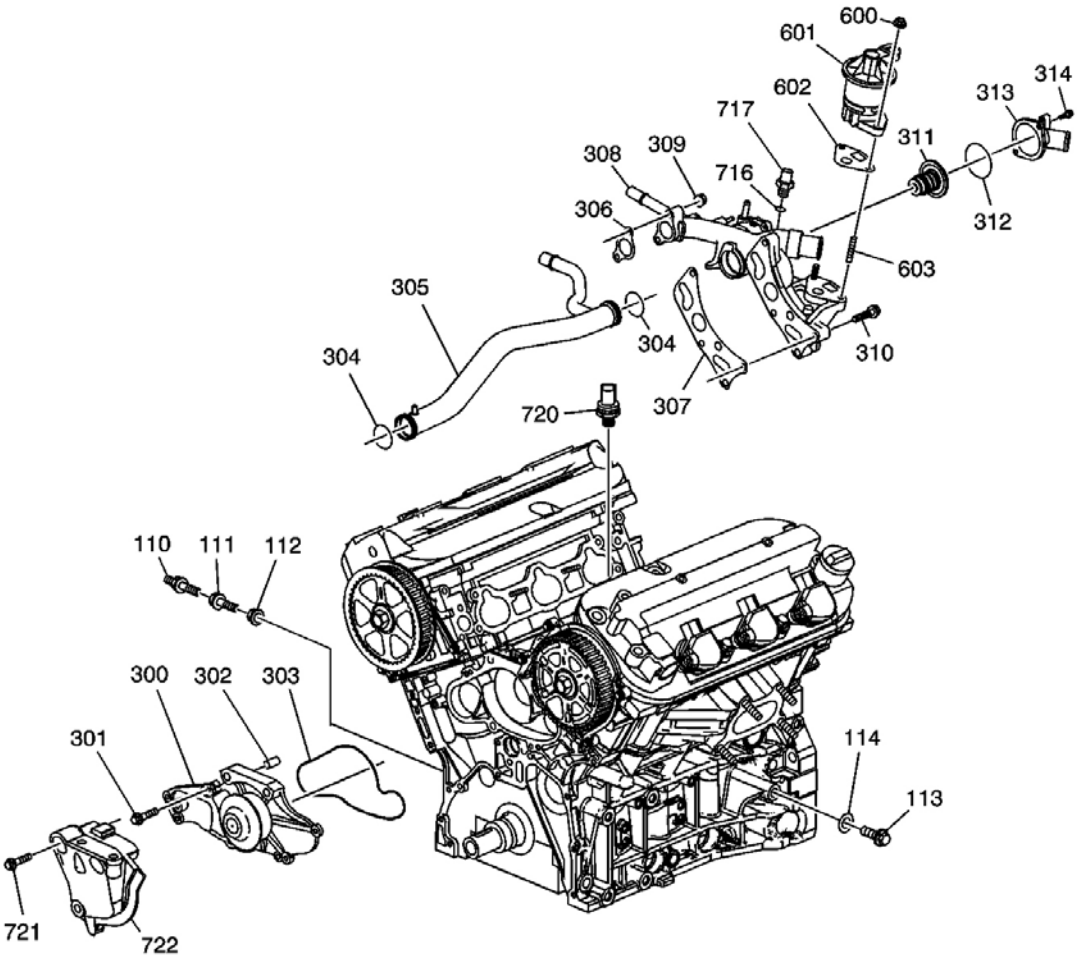


Fig. 5: Cooling System/EGR
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 5

Callout	Component Name
110	Coolant Drain Plug
111	Coolant Drain Fitting
112	Washer
113	Coolant Drain Plug
114	Washer
300	Water Pump
301	Bolt
302	Pin
303	O-Ring
304	O-Ring

304	O-Ring
305	Coolant Crossover Pipe
306	Gasket
307	Gasket
308	Housing
309	Nut
310	Bolt
311	Thermostat
312	O-Ring
313	Housing
314	Bolt
600	Nut
601	Exhaust Gas Recirculation (EGR) Valve
602	Gasket
603	Stud
716	O-Ring
717	Coolant Temperature Sensor (CTS)
720	Knock Sensor
721	Bolt
722	Mount - Front

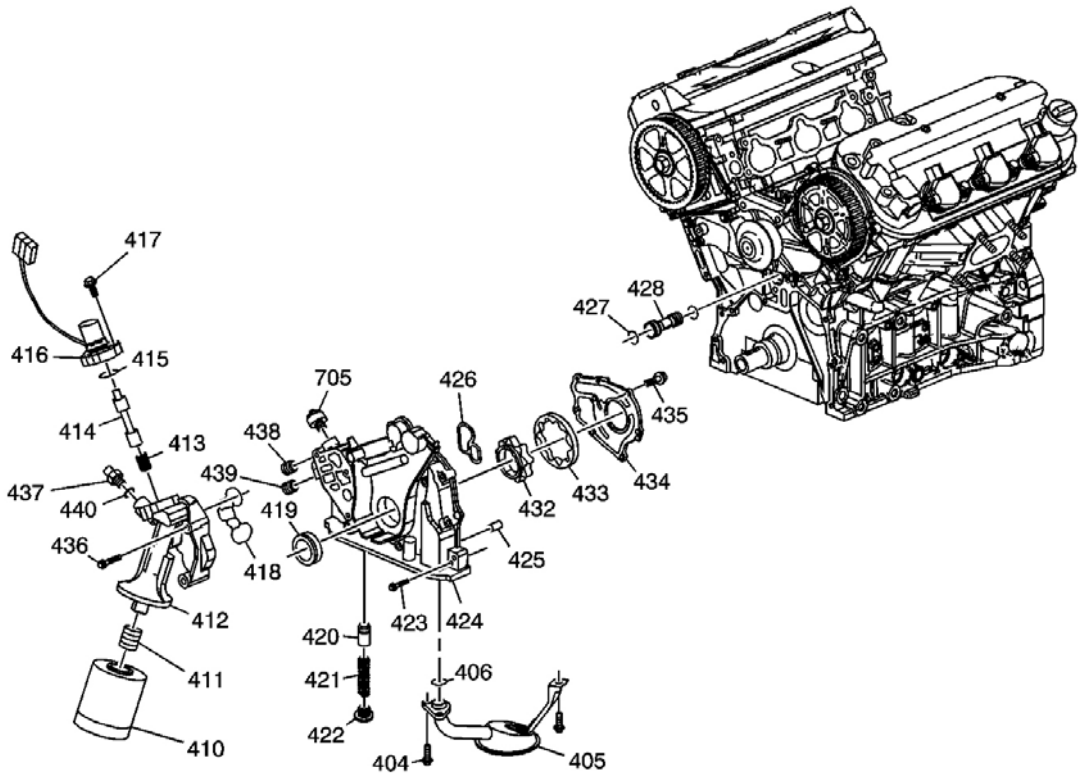


Fig. 6: Oiling System
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 6

Callout	Component Name
404	Bolt
405	Screen
406	O-Ring
410	Oil Filter
411	Fitting
412	Oil Flow Control Module
413	Spring
414	Valve
415	O-Ring
416	Solenoid
417	Bolt
418	O-Ring - With Screen
419	Seal
420	Valve
421	Spring

422	Bolt
423	Bolt
424	Oil Pump
425	Pin
426	O-Ring
427	O-Ring
428	Oil Transfer Pipe
432	Rotor - Inner
433	Rotor - Outer
434	Cover
435	Bolt
436	Bolt
437	Oil Flow Control Switch
438	Plug
439	Plug
440	O-Ring
705	Oil Pressure Switch

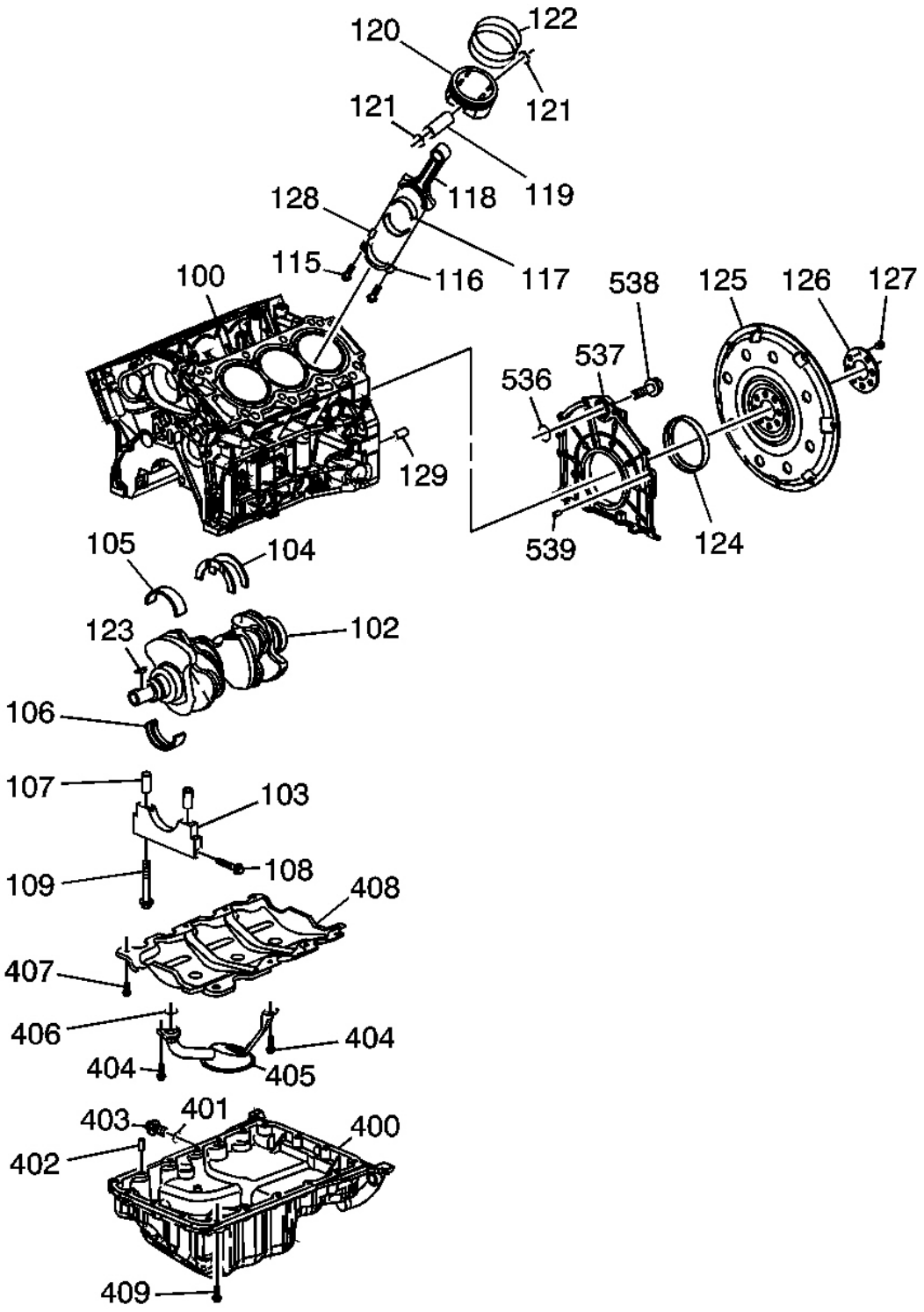


Fig. 7: Lower Engine Assembly

Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 7

Callout	Component Name
100	Engine Block
102	Crankshaft
103	Cap
104	Bearing - Thrust
105	Bearing - Main Upper
106	Bearing - Main Lower
107	Pin
108	Bolt
109	Bolt
115	Bolt
116	Connecting Rod Cap
117	Bearing - Connecting Rod
118	Connecting Rod
119	Pin
120	Piston
121	Clip
121	Clip
122	Piston Rings
123	Key
124	Seal
125	Flywheel
126	Washer
127	Bolt
128	Pin
129	Pin
400	Oil Pan
401	O-Ring
402	Pin
403	Drain Plug
404	Bolt
404	Bolt
405	Screen
406	O-Ring
407	Bolt
408	Deflector
409	Bolt
536	O-Ring

537	Housing
538	Bolt
539	Pin

ENGINE IDENTIFICATION

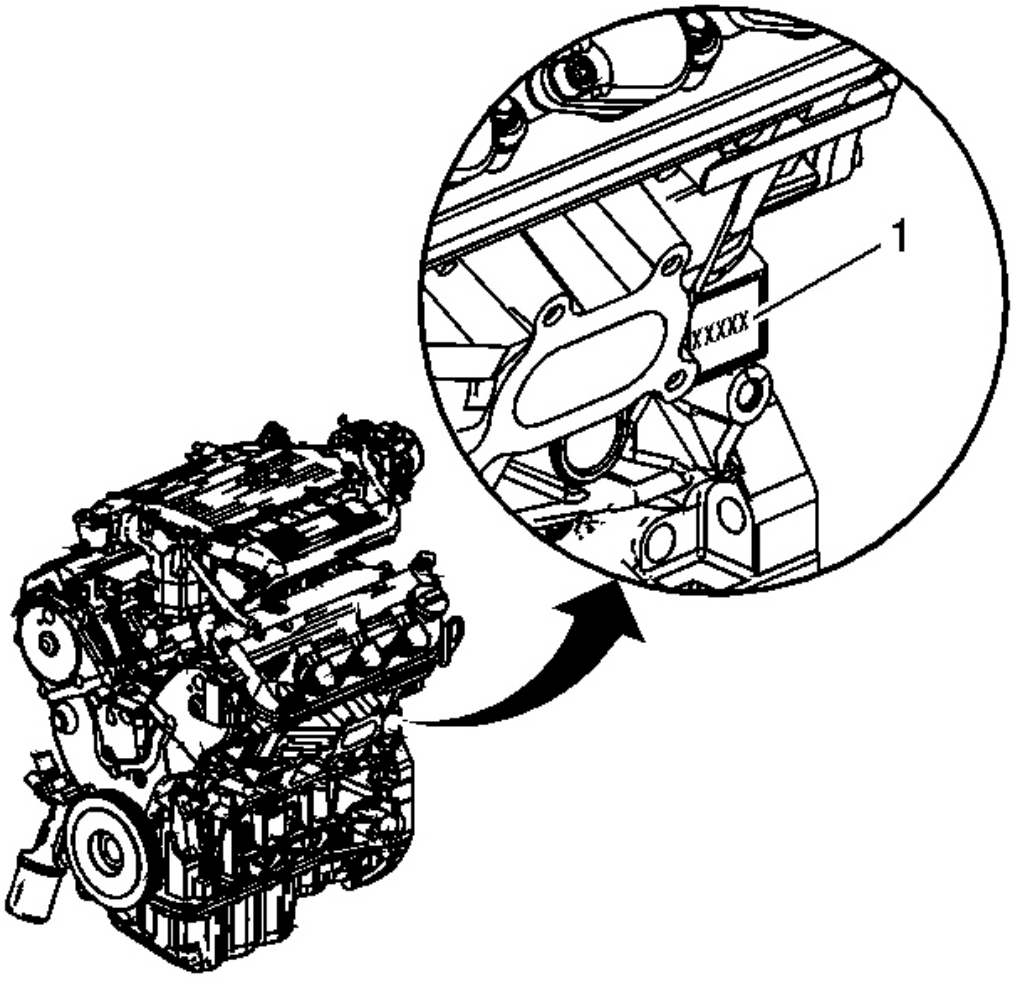


Fig. 8: View Of Engine Identification
Courtesy of GENERAL MOTORS CORP.

The engine identification (ID) number (1) is located on the left-side rear of the engine block.

- Digits 1-5 identify the engine type.

- Digits 6-12 identify the engine serial number.

SCHEMATIC AND ROUTING DIAGRAMS

CAMSHAFT TIMING BELT ALIGNMENT DIAGRAM

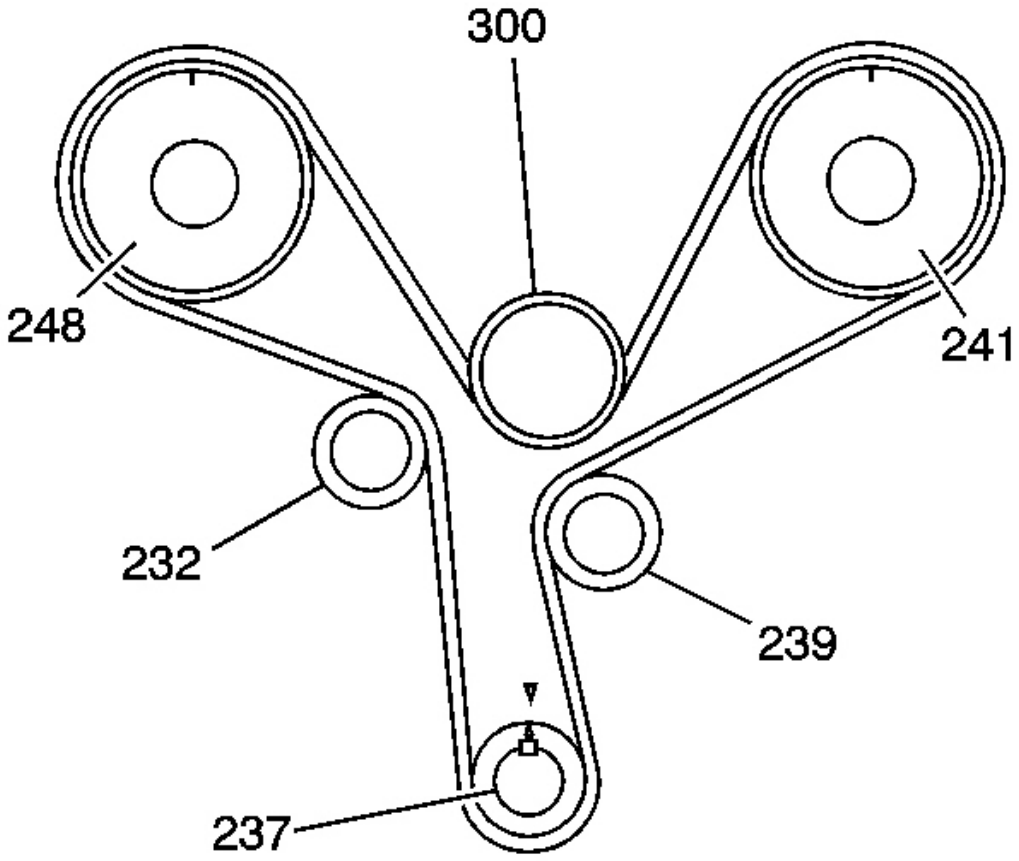


Fig. 9: Identifying Camshaft Timing Belt
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Install the drive belt in a clockwise direction, beginning with the tensioner pulley (232).

- Tensioner pulley (232)
- Crankshaft sprocket (237)
- Idler pulley (239)

- Camshaft sprocket - left (241)
- Camshaft sprocket - right (248)
- Water pump (300)

DIAGNOSTIC INFORMATION AND PROCEDURES

DIAGNOSTIC STARTING POINT - ENGINE MECHANICAL

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

SYMPTOMS - ENGINE MECHANICAL

Strategy Based Diagnostics

1. Perform the **Diagnostic System Check - Engine Controls** in Engine Controls - 3.5L (L66) 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** or **Engine Component Description** or **Lubrication Description** and **Intake Rocker Arm Control System Operation** .

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

Visual/Physical Inspection

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

Intermittent

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

properly.

Symptom List

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

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

BASE ENGINE MISFIRE WITHOUT INTERNAL ENGINE NOISES

Base Engine Misfire without Internal Engine Noises

Cause	Correction
Abnormalities, severe cracking, bumps, or missing areas in the accessory drive belt Abnormalities in the accessory drive system and/or components may cause engine RPM variations and lead to a misfire DTC. A misfire code may be present without an actual misfire condition.	Replace the drive belt. Refer to **Drive Belt Replacement** - Accessory.
Worn, damaged, or mis-aligned accessory drive components or excessive pulley runout - May lead to a misfire DTC. A misfire code may be present without an actual misfire condition.	Inspect the components, and repair or replace as required.
Loose or improperly installed engine flywheel or crankshaft balancer A misfire code may be present without an actual misfire condition.	Repair or replace the flywheel and/or balancer as required. Refer to **Engine Flywheel Replacement** or **Crankshaft Balancer Replacement** .

Restricted exhaust system A severe restriction in the exhaust flow can cause significant loss of engine performance and may set a DTC. Possible causes of restrictions include collapsed or dented pipes or plugged mufflers and/or catalytic converters.	Repair or replace as required.
Improperly installed or damaged vacuum hoses	Repair or replace as required.
Improper operation of the intake rocker arm control system	1. Inspect the intake rocker arm control system for proper operation. 2. Repair as required.
Improper sealing between the intake manifold, fuel injection manifolds, cylinder heads and throttle body	Replace components as required.
Improperly installed or damaged MAP sensor and/or seal The O-ring seal of the MAP sensor should not be torn or damaged.	Repair or replace the MAP sensor as required.
Improperly installed or damaged EVAP purge solenoid and/or hoses	Repair or replace the EVAP purge solenoid as required.
Worn or incorrectly adjusted rocker arms	Adjust or replace 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 camshaft timing components	Replace the components as required.
Worn camshaft lobes	Replace the camshaft as required.
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages - Refer to Diagnostic Starting Point - Engine Cooling in Engine Cooling. Coolant consumption may or may not cause the engine to overheat.	1. Inspect for spark plugs saturated by coolant. Refer to **Spark Plug Inspection** in Engine Controls - 3.5L (L66). 2. Inspect the cylinder heads, engine block, and/or head gaskets. 3. Repair or replace as required.
Worn piston rings Oil consumption may or may not cause the engine to misfire.	1. Inspect the spark plugs for oil deposits. Refer to **Spark Plug Inspection** in Engine Controls - 3.5L (L66). 2. Inspect the cylinders for a loss of compression. Refer to **Engine Compression Test** . 3. Perform cylinder leak down and compression testing to identify the cause. 4. Repair or replace as required.
Damaged crankshaft sprocket reluctor teeth Damaged crankshaft sprocket reluctor teeth can result in	Replace or repair as required.

different symptoms depending on the severity and location of the damage. • Systems with SEVERE damage may exhibit periodic loss of crankshaft position, stop delivering a signal, and then re-sync the crankshaft position. • Systems with SLIGHT damage may exhibit no loss of crankshaft position and no misfire may occur. However, a P0300 DTC may be set.	

BASE ENGINE MISFIRE WITH ABNORMAL INTERNAL LOWER ENGINE NOISES

Base Engine Misfire with Abnormal Internal Lower Engine Noises

Cause	Correction
Abnormalities, severe cracking, bumps or missing areas in the accessory drive belt Abnormalities in the accessory drive system and/or components may cause engine RPM variations, noises similar to a faulty lower engine and also lead to a misfire condition. A misfire code may be present without an actual misfire condition.	Replace the drive belt. Refer to **Drive Belt Replacement** - Accessory.
Worn, damaged, or mis-aligned accessory drive components or excessive pulley runout A misfire code may be present without an actual misfire condition.	Inspect the components and 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 engine flywheel and/or crankshaft balancer as required. Refer to **Engine Flywheel Replacement** or **Crankshaft Balancer Replacement** .
Worn or broken piston rings Oil consumption may or may not cause the engine to misfire.	1. Inspect the spark plugs for oil deposits. Refer to **Spark Plug Inspection** in Engine Controls - 3.5L (L66). 2. Inspect the cylinders for a loss of compression. Refer to **Engine Compression Test** . 3. Perform cylinder leak down and compression testing to determine the cause. 4. Repair or replace as required.
Worn crankshaft thrust bearings Severely worn thrust surfaces on the crankshaft and/or thrust bearing may permit fore and aft movement of the crankshaft and create a DTC without an actual misfire condition.	Replace the crankshaft and bearings as required.

BASE ENGINE MISFIRE WITH ABNORMAL VALVE TRAIN NOISE

Base Engine Misfire with Abnormal Valve Train Noise

Cause	Correction
Worn or incorrectly adjusted valve rocker arms The valve rocker arm and rocker arm rollers should be intact and in the proper working condition.	Adjust or replace the 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 components	Replace components as required.
Worn camshaft lobes	Replace the camshafts as required.

BASE ENGINE MISFIRE WITH COOLANT CONSUMPTION

Base Engine Misfire with Coolant Consumption

Cause	Correction
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages - Refer to **Diagnostic Starting Point - Engine Cooling** in Engine Cooling. Coolant consumption may or may not cause the engine to overheat.	1. Inspect for spark plugs saturated by coolant. Refer to **Spark Plug Inspection** in Engine Controls - 3.5L (L66). 2. Perform a cylinder leak down test. 3. Inspect the cylinder heads and engine block for damage to the coolant passages and/or a faulty head gasket. 4. Repair or replace as required.

BASE ENGINE MISFIRE WITH EXCESSIVE OIL CONSUMPTION

Base Engine Misfire with Excessive Oil Consumption

Cause	Correction
Worn valves, valve guides and/or valve stem oil seals	1. Inspect the spark plugs for oil deposits. Refer to **Spark Plug Inspection** in Engine Controls - 3.5L (L66). 2. Repair or replace as required.
Improper operation of the positive crankcase ventilation (PCV) system	Repair or replace as required.
Damaged or worn piston and/or rings Oil consumption may or may not cause the engine to misfire.	1. Inspect the spark plugs for oil deposits. Refer to **Spark Plug Inspection** in Engine Controls - 3.5L (L66). 2. Inspect the cylinders for a loss of compression. Refer to **Engine Compression Test** . 3. Perform cylinder leak down and compression testing to

	determine the cause. 4. Repair or replace as required.

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

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

Cause	Correction
Incorrect oil filter	Install the correct oil filter.
Incorrect viscosity oil	Drain the engine oil and replace with the correct viscosity oil.
Worn crankshaft thrust bearings	1. Inspect the thrust bearings 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. 2. Repair or replace as required.

UPPER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Upper Engine Noise, Regardless of Engine Speed

Cause	Correction
Low oil pressure	1. Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing** . 2. Repair or replace as required.
Worn camshafts and/or valve rocker arms or improperly adjusted rocker arms	Adjust rocker arms or replace components as required.
Improper lubrication to the valve rocker arms	1. Inspect the following components, and repair or replace as required: • The valve rocker arm and shaft • The oil filter • The oil filter bypass valve • The oil pump and pump screen • The cylinder head oil galleries • The engine block oil galleries and restrictors 2. Inspect the intake rocker arm control system for proper operation.
Broken valve spring	Replace the valve spring.
Stretched or broken timing components	Replace the timing components.
Worn timing belt or tensioner	Replace the timing belt tensioner as required.
Worn timing belt	Replace the timing belt as required.
Worn camshaft lobes	1. Inspect the camshaft lobes. 2. Replace the camshafts as required.

Worn valve guides or valve stems	Inspect the following components, and repair as required: • The valves • The valve guides
Stuck valves Carbon on the valve stem or valve seat may cause the valve to stay open.	Inspect the following components, and repair as required: • The valves • The valve guides

LOWER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Lower Engine Noise, Regardless of Engine Speed

Cause	Correction
Low oil pressure	1. Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing** . 2. Repair or replace damaged components as required.
Worn accessory drive components Abnormalities, such as severe cracking, bumps or missing areas in the accessory drive belt and/or misalignment of system components.	1. Inspect the accessory drive system. 2. Repair or replace as required.
Loose or damaged crankshaft balancer	1. Inspect the crankshaft balancer. 2. Repair or replace as required.
Detonation or spark knock	Verify the correct operation of the ignition system. Refer to **Detonation/Spark Knock** in Engine Controls - 3.5L (L66).
Loose torque converter bolts	1. Inspect the torque converter bolts and engine flywheel. 2. Repair or replace as required.
Loose or damaged engine flywheel	Repair or replace the engine 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.
Cut or damaged oil pump screen O-ring	Replace components 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-pin bore clearance	1. Inspect the piston, piston pin and the connecting rod. 2. Repair or replace as required.
Excessive connecting rod bearing clearance	Inspect the following components and repair as required: • The connecting rod bearings • The connecting rods • The crankshaft • The crankshaft journals
Excessive crankshaft bearing clearance	Inspect the following components and repair as required: • The crankshaft bearings • The crankshaft journals
Incorrect piston, piston pin and connecting rod installation Pistons must be installed with the arrow on the top of the piston facing the front of the engine.	1. Verify the pistons, piston pins and connecting rods are installed correctly. 2. Repair as required.

ENGINE NOISE UNDER LOAD

Engine Noise Under Load

Cause	Correction
Low oil pressure	1. Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing** . 2. Repair or replace as required.
Detonation or spark knock	Verify the correct operation of the ignition system. Refer to **Detonation/Spark Knock** in Engine Controls - 3.5L (L66).
Loose torque converter bolts	1. Inspect the torque converter bolts and engine flywheel. 2. Repair as required.
Cracked engine flywheel	1. Inspect the engine flywheel and bolts. 2. Repair as required.
Excessive connecting rod bearing clearance	Inspect the following components and repair as required: • The connecting rod bearings • The connecting rods • The crankshaft
Excessive crankshaft bearing clearance	Inspect the following components and repair as required: • The crankshaft bearings

	• The crankshaft journals • The cylinder block crankshaft bearing bore

ENGINE WILL NOT CRANK - CRANKSHAFT WILL NOT ROTATE

Engine Will Not Crank - Crankshaft Will Not Rotate

Cause	Correction
Seized accessory drive system component	1. Remove the accessory drive belt. 2. Rotate the crankshaft by hand at the crankshaft balancer or the engine flywheel location. 3. Repair or replace components as required.
Seized starter motor	Replace as required.
Hydraulically locked cylinder • Coolant/Antifreeze in cylinder • Oil in cylinder • Fuel in cylinder	1. Remove the spark plugs and check for fluid in the cylinder bore. 2. Inspect for a sticking fuel injector. 3. Inspect for a failed cylinder head or gasket. 4. Inspect for a cracked engine block. 5. Repair or replace as required.
Seized automatic transmission torque converter	1. Remove the torque converter bolts. 2. Rotate the crankshaft by hand at the crankshaft balancer or the engine flywheel location. 3. Repair or replace as required.
Material in cylinder • Broken valve • Piston material • Foreign material	1. Inspect the cylinder for damaged components and/or foreign materials. 2. Repair or replace as required.
Seized crankshaft or connecting rod bearings	1. Inspect the crankshaft and the connecting rod bearings. 2. Repair as required.
Bent or broken connecting rod	1. Inspect the connecting rods. 2. Repair as required.
Broken crankshaft	1. Inspect the crankshaft. 2. Repair as required.
Seized or broken camshaft	1. Inspect the camshafts. 2. Inspect the cylinder head camshaft journals for damage. 3. Repair as required.
Broken or mis-aligned camshaft timing components	An improperly installed timing belt may lead to valve-to-piston contact.

Seized or broken valve train components	1. Inspect the rocker arms. 2. Inspect the lash adjusters. 3. Inspect the valves. 4. Inspect the valve springs. 5. Repair as required.

COOLANT IN COMBUSTION CHAMBER

Coolant in Combustion Chamber

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

COOLANT IN ENGINE OIL

Coolant in Engine Oil

Cause	Correction
DEFINITION: Foamy or discolored oil or an engine oil "overfill" condition may indicate coolant entering the engine crankcase. Low coolant levels, an inoperative cooling fan, or a faulty thermostat may lead to an overtemperature condition which may cause engine component damage. Contaminated engine	

oil and oil filter should be changed.

1. Inspect the oil for excessive foaming or an overfill condition. Oil diluted by coolant may not properly lubricate the crankshaft bearings and may lead to component damage. Refer to **Lower Engine Noise, Regardless of Engine Speed** .
2. Inspect by performing a cylinder leak-down test. During this test, excessive air bubbles within the cooling system may indicate a faulty gasket or damaged component.
3. Inspect by performing a cylinder compression test. Two cylinders side-by-side on the engine block with low compression may indicate a failed cylinder head gasket. Refer to **Engine Compression Test** .

Faulty external engine oil cooler, if applicable	Replace components as required.
Faulty cylinder head gasket	Replace the head gasket and components as required. Refer to **Cylinder Head Cleaning and Inspection** and **Cylinder Head (Left) Replacement** and **Cylinder Head (Right) Replacement** .
Warped cylinder head	Machine the cylinder head to proper flatness and replace the cylinder head gasket. Refer to **Cylinder Head Cleaning and Inspection** .
Cracked cylinder head	Replace the cylinder head and gasket.
Cracked cylinder liner or engine block	Replace components as required.
Cylinder head or block porosity	Replace components as required.

ENGINE COMPRESSION TEST

Tools Required

SA9127E Gage Bar Set

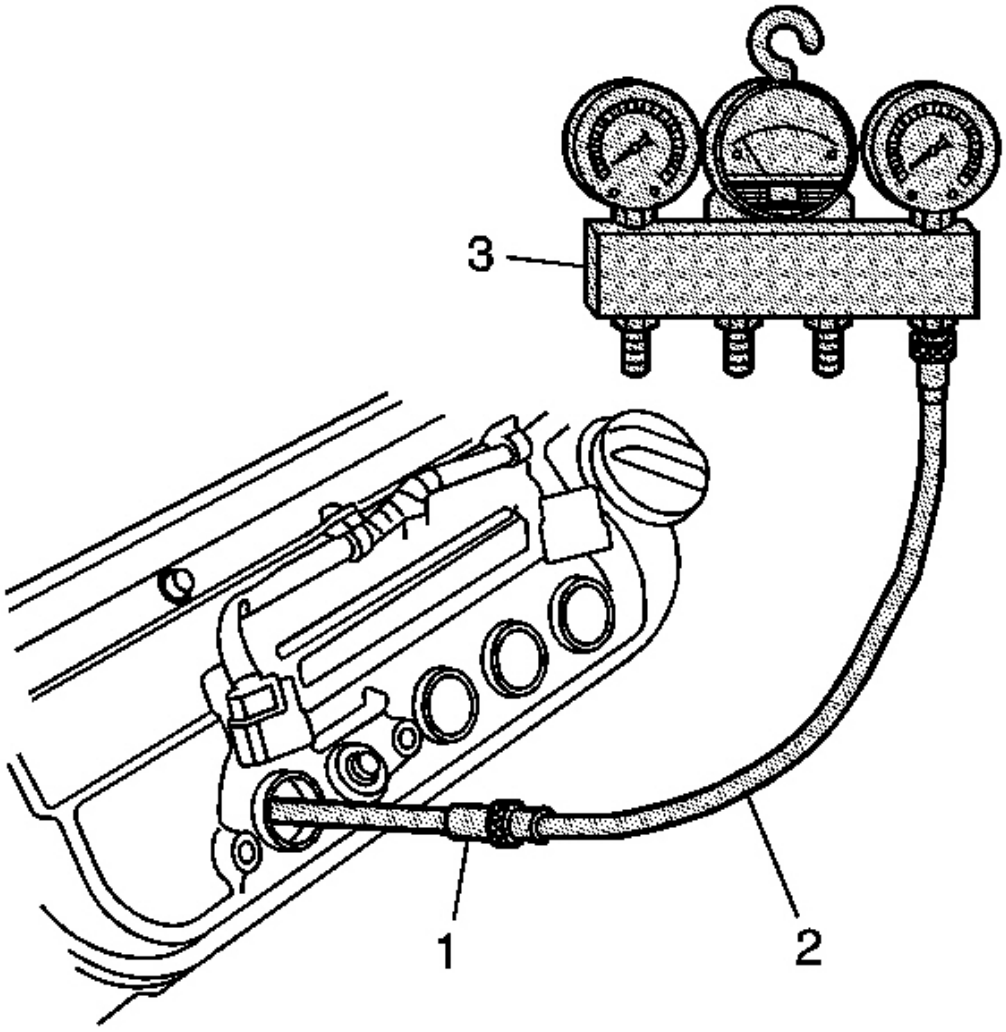


Fig. 10: View Of Engine Compression
Courtesy of GENERAL MOTORS CORP.

1. Warm up the engine to a normal operating temperature of 98°C (208° F).
2. Turn the ignition switch OFF.
3. Remove the ignition coils. Refer to **Valve Rocker Arm Cover Removal - Left** and **Valve Rocker Arm Cover Removal - Right** .
4. Remove the spark plugs.
5. Attach the adapter (1), hose (2) and compression gage (3) to a spark plug hole.
6. Connect a tachometer.

7. Connect the scan tool.
8. Turn the ignition switch to the ON position.
9. Using the scan tool, command the injectors all off.
10. Depress the accelerator pedal to open the throttle fully.
11. Crank the engine with the starter motor and measure the compression.
12. Perform the measurement on each cylinder and compare the readings.

    Specification:

    - Compression pressure: minimum 990 kPa (145 psi) at 200 RPM
    - Maximum compression variation: 200 kPa (28 psi)

13. If the compression is not within specifications, inspect for the following conditions and measure the compression again.
    - Improperly adjusted valves
    - Improperly positioned timing belt and sprockets
    - Damaged or worn valves or seats
    - Damaged cylinder head gasket
    - Damaged or worn piston rings
    - Damaged or worn piston and cylinder bore
14. Using the scan tool, perform the PCM Reset Procedure to return the fuel injectors to normal operation.

OIL CONSUMPTION DIAGNOSIS

Oil Consumption Diagnosis

Checks	Causes
DEFINITION: Excessive oil consumption, not due to leaks, is the use of 0.9 L (1 qt) or more of engine oil within 3 200 kilometers (2,000 miles). The causes of excessive oil consumption may include the following conditions:	
Preliminary	• External oil leaks Refer to **Oil Leak Diagnosis** . • Incorrect oil level or improper reading of the oil level indicator With the vehicle on a level surface, run the engine for a few minutes, allow adequate drain down time of 2-3 minutes and check for the correct engine oil level. • Improper oil viscosity Refer to the vehicle owners manual and use the recommended SAE grade and viscosity for the prevailing temperatures.

	• Continuous high speed driving and/or severe usage • Crankcase ventilation system restrictions or malfunctioning components • Improper operation of the positive crankcase ventilation (PCV) system • Worn valve guides and/or valve stems • Worn or improperly installed valve stem oil seals • Piston rings broken, worn, not seated properly Allow adequate time for the rings to seat. Replace worn piston rings as necessary. • Piston and rings improperly installed or miss-fitted to the cylinder bore

OIL PRESSURE DIAGNOSIS AND TESTING

- **EN 46333** Oil Pressure Testing Adapter. See **Special Tools and Equipment** .
- **SA9127E** Gage Bar Set

1. Check and fill the engine oil to the proper level prior to performing the testing procedure.
2. Connect a tachometer or a scan tool.

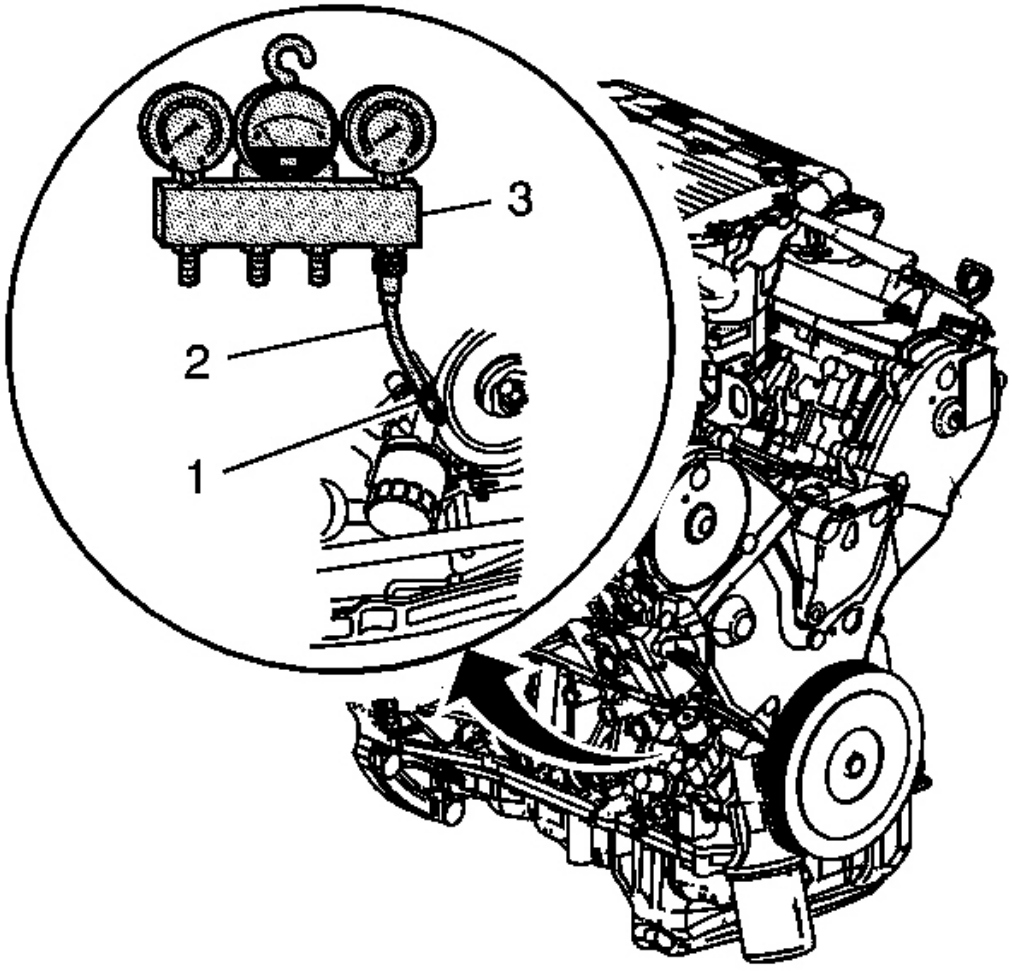


Fig. 11: View Of Engine Oil Pressure Switch
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine oil pressure switch and install the **EN 46333** (1), flexible hose (2) and the. See **Special Tools and Equipment** .**SA9127E** (3).

IMPORTANT: Shut the engine off immediately if the gage measures no oil pressure. Repair the condition before continuing. If the oil pressure is not within specifications, inspect the oil pump. Refer to Oil Pump Cleaning and Inspection .

4. Start the engine and allow it to reach normal operating temperature. Measure the engine oil pressure.

Specification:

- Engine oil temperature: 80°C (176°F)
- Engine oil pressure - at idle speed: 70 kPa (10 psi) minimum
- Engine oil pressure - at 3,000 RPM: 490 kPa (71 psi)

5. Low or no oil pressure may be caused by one or more of the following conditions:
   - Low engine oil level
   - Dirty or improper viscosity oil
   - Faulty oil pump
   - Worn or sticking oil pump pressure relief valve
   - Loose or damaged oil pump screen or cut O-ring seal
   - Excessive main or connecting rod bearing clearance
6. Higher than recommended oil pressure may be caused by one or more of the following conditions:
   - Worn or sticking oil pump pressure relief valve
   - Plugged oil filter
   - Improper viscosity oil

OIL LEAK DIAGNOSIS

Oil Leak Diagnosis

Step	Action	Yes	No
IMPORTANT: **You can repair most fluid leaks by, first, visually locating the leak, repairing or replacing the component, or by resealing the gasket surface. Once the leak is identified, determine the cause of the leak. Repair the cause of the leak as well as the leak itself.**			
1	1. Operate the vehicle until it reaches normal operating temperature. 2. Park the vehicle on a level surface, over a large sheet of paper or other clean surface. 3. Wait 15 minutes. 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 9**	Go to **Step 3**
3	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Inspect for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components		

	Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 9**	Go to **Step 4**
4	1. Completely clean the entire engine and surrounding components. 2. Operate the vehicle for several kilometers - miles at normal operating temperature and at varying speeds. 3. Park the vehicle on a level surface, over a large sheet of paper or other clean surface. 4. Wait 15 minutes. 5. Identify the type of fluid, and the approximate location of the leak. Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 9**	Go to **Step 5**
5	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Inspect for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 9**	Go to **Step 6**
6	1. Completely clean the entire engine and surrounding components. 2. Apply an aerosol-type powder, baby powder, foot powder, etc., to the suspected area. 3. Operate the vehicle for several kilometers - miles at normal operating temperature and at varying speeds. 4. Identify the type of fluid and the approximate location of the leak from the discolorations in the powder surface. Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 9**	Go to **Step 7**
7	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Inspect for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 9**	Go to **Step 8**
	1. Inspect the engine for mechanical damage. Special attention should be shown to the following areas: • Higher than recommended fluid levels • Higher than recommended fluid pressures		

8	• 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 9**	System OK
9	Repair or replace all damaged or modified components. Does the engine still leak oil?	Go to **Step 1**	System OK

INTAKE ROCKER ARM DIAGNOSIS AND TESTING

Tools Required

- **EN 46339** Intake Rocker Arm Testing Adapter. See **Special Tools and Equipment** .
- **EN 46340** Intake Rocker Arm Testing Air Stopper. See **Special Tools and Equipment** .
- **EN 46348** Intake Rocker Arm Testing Air Pressure Regulator and Hose. See **Special Tools and Equipment** .
- **EN 46352** Intake Rocker Arm Testing Air Adapter. See **Special Tools and Equipment** .

1. Start the engine and let it run for 5 minutes.
2. Turn the ignition to the OFF position.
3. Remove the intake air duct.
4. Remove the brake booster vacuum hose from the intake manifold.
5. Remove the ignition coils. Refer to **Valve Rocker Arm Cover Removal - Left** and **Valve Rocker Arm Cover Removal - Right** .
6. Remove the intake manifold. Refer to **Intake Manifold Removal** .
7. Remove the valve rocker arm covers. Refer to **Valve Rocker Arm Cover Removal - Left** and **Valve Rocker Arm Cover Removal - Right** .

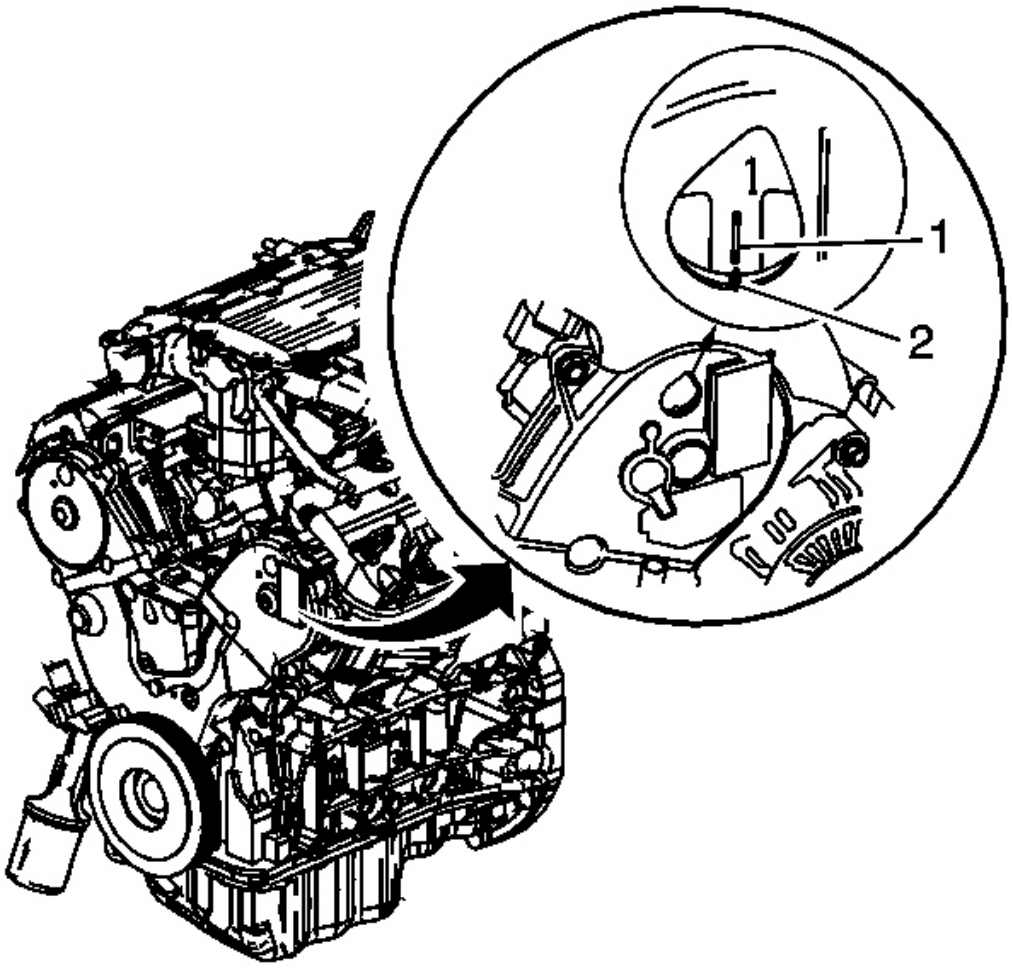


Fig. 12: Aligning The Upper Cover With The Number 1 Cylinder
Courtesy of GENERAL MOTORS CORP.

8. Rotate the engine and set number 1 piston at top dead center (TDC). In this position, the mark on the camshaft sprocket (1) will align with the pointer on the cover (2).

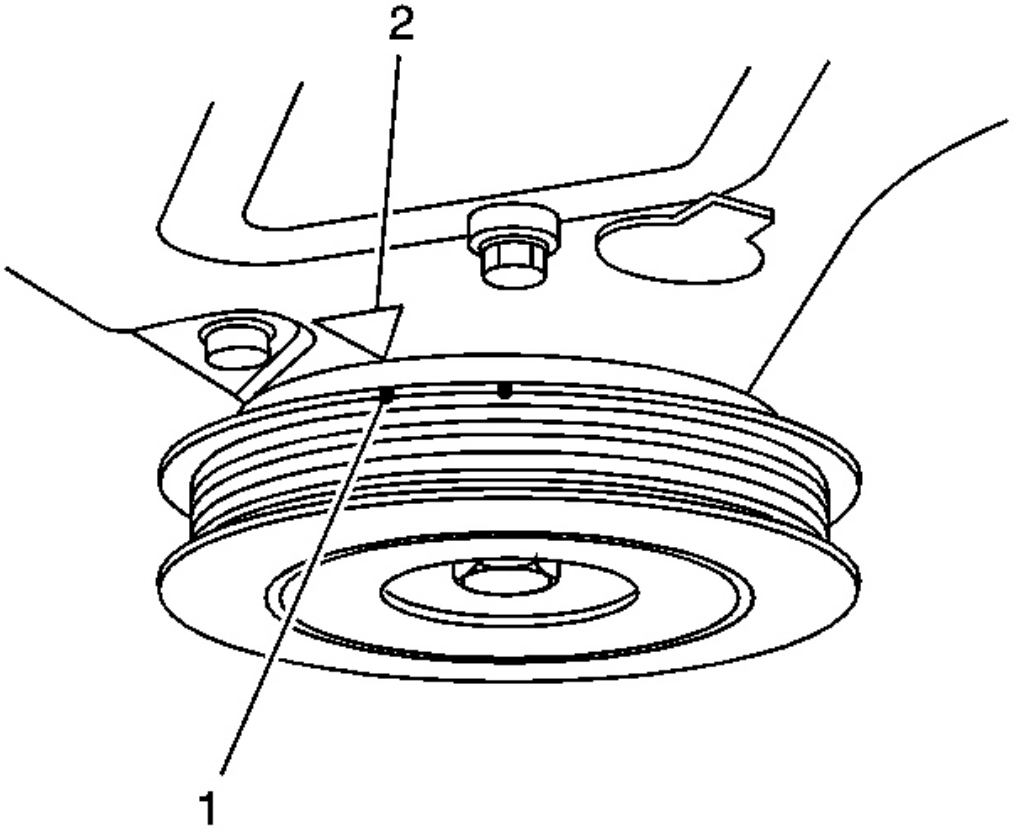


Fig. 13: Aligning Mark On The Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

9. With the engine rotated and positioned with number 1 piston at TDC, the alignment mark on the crankshaft balancer (1) will also be aligned with the pointer (2) on the front cover.

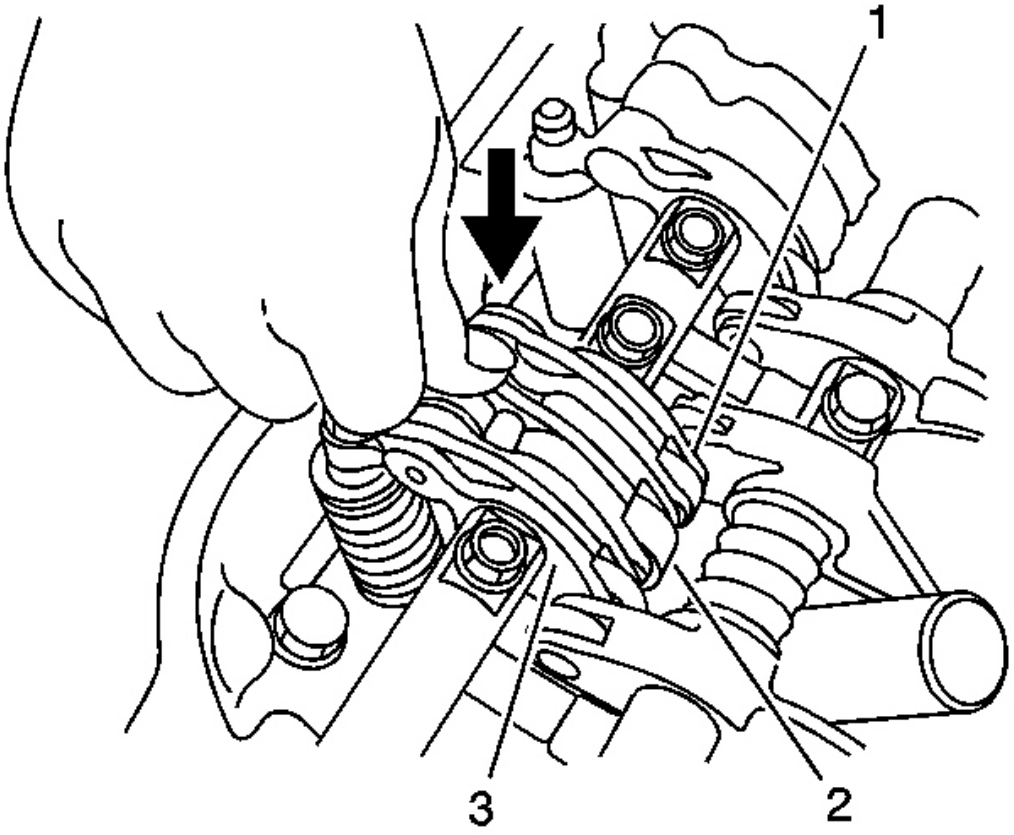


Fig. 14: View Of Mid Rocker Arm
Courtesy of GENERAL MOTORS CORP.

10. Push on the intake mid rocker arm (2) for the number 1 cylinder. The mid rocker arm should move independently of the primary (1) and secondary (3) rocker arms.
    - If the intake mid rocker arm does not move, remove the mid, primary, and secondary intake rocker arms as an assembly. Check that the pistons in the mid and primary rocker arms move smoothly. Refer to **Valve Rocker Arm and Shaft Removal** and **Valve Rocker Arm and Shaft Cleaning and Inspection** .
    - If any of the rocker arm requires replacement, replace the primary, mid, and secondary rocker arms as an assembly and test again.
11. Repeat Steps 9 and 10 on each of the remaining intake mid rocker arms with the piston of the cylinder to be tested at TDC.

IMPORTANT: In order to properly test the rocker arms, the shop air supply must be higher than 690 kPa (100 psi).

12. Inspect the valves for proper valve adjustment. Refer to **Valve Lash Adjustment** .
13. Cover the timing belt with a shop towel to protect the belt.

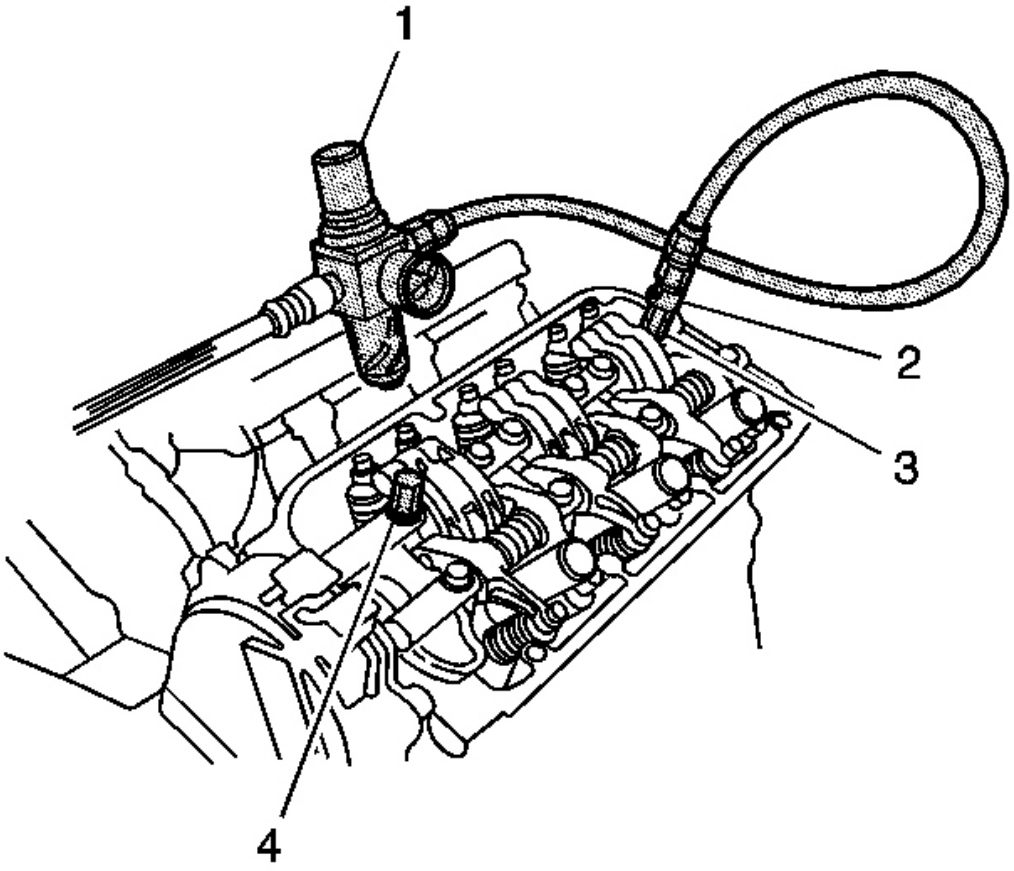


Fig. 15: Identifying Intake Rocker Arm Shaft Mounting Bolts
Courtesy of GENERAL MOTORS CORP.

14. Remove the 2 end intake rocker arm shaft mounting bolts and install the **EN 46339** (3),. See **Special Tools and Equipment** .**EN 46340** (4),. See **Special Tools and Equipment** .**EN 46348** (1) and the. See **Special Tools and Equipment** .**EN 46352** (2). See **Special Tools and Equipment** .
15. Connect the shop air supply.
16. Loosen the valve on the regulator and adjust the air pressure to 440-540 kPa (64-78 psi).

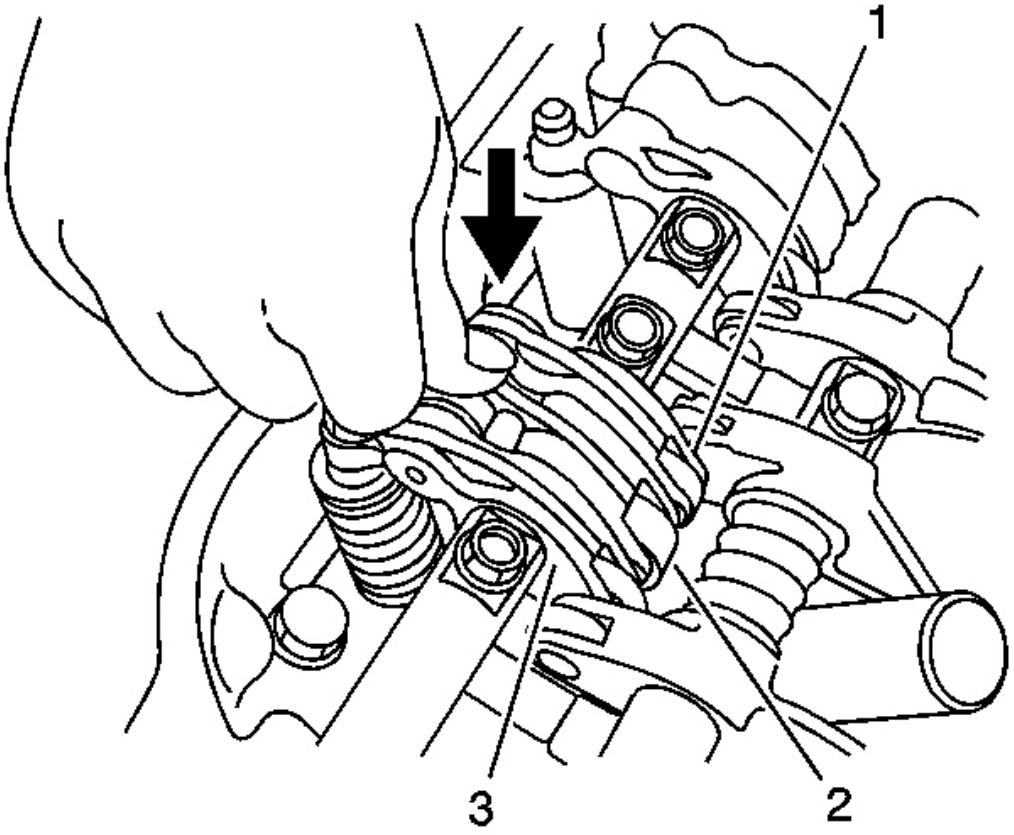


Fig. 16: View Of Mid Rocker Arm
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If the synchronizing pistons do not move after applying shop air pressure, move the primary and secondary rocker arms up and down manually.

17. Ensure the primary rocker arm (2) and intake secondary rocker arm (1) are mechanically connected by the piston and that the mid rocker arm does not move independently when pushed manually. If any intake mid rocker arms move independently of the primary and secondary rocker arms, replace the rocker arms as an assembly.
18. Inspect the valve lash adjusters. Replace lash adjusters that do not move smoothly. Refer to **Valve Lash Adjuster Cleaning and Inspection** .
19. Upon completion, inspect and ensure the Service Engine Soon lamp is not illuminated.

DRIVE BELT CHIRPING DIAGNOSIS

Diagnostic Aids

The symptom may be intermittent due to moisture on the drive belt or the pulleys. It may be necessary to spray a small amount of water on the drive belt 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.

A loose or improper installation of a body component, a suspension component, or other items of the vehicle may cause the chirping noise.

Test Description

The numbers below refer to the step number 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 belt 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 belt 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 mis-align pulley using a straight edge in the pulley grooves across 2 or 3 pulleys. If a mis-align pulley is found refer to that accessory drive component for the proper installation procedure for that pulley.

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

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

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

Drive Belt Chirping Diagnosis

Step	Action	Yes	No
	NOTE: **Refer to Belt Dressing Notice in Cautions and Notices.** DEFINITION: The following items are indications of chirping: • A high pitched noise that is heard once per revolution of the drive belt or a pulley. • It usually occurs on cold damp mornings.		
	Did you review the Symptoms -		Go to

1	Engine Mechanical operation and perform the necessary inspections?	Go to **Step 2**	**Symptoms - Engine Mechanical**
2	Verify that there is a chirping noise. Does the engine make the chirping noise?	Go to **Step 3**	Go to Diagnostic Aids
3	1. Remove the drive belt. Refer to **Drive Belt Replacement** . 2. Operate the engine for no longer than 30 to 40 seconds. Does the chirping noise still exist?	Go to **Engine Noise on Start-Up, but Only Lasting a Few Seconds** , **Upper Engine Noise, Regardless of Engine Speed** , **Lower Engine Noise, Regardless of Engine Speed** , or **Engine Noise Under Load**	Go to **Step 4**
4	Inspect for severe pilling exceeding 1/3 of the belt groove depth. Does 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 15**	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 15**	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 15**	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	Tighten any loose fasteners. Refer to **Fastener Tightening Specifications** . Did you complete the repair?	Go to **Step 15**	Go to **Step 12**
12	Inspect for a bent pulley. Did you find the condition?	Go to **Step 13**	Go to **Step 14**

13	Replace the bent pulley. Did you complete the repair?	Go to **Step 15**	Go to **Step 14**
14	Replace the drive belt. Refer to **Drive Belt Replacement** . Did you complete the repair?	Go to **Step 15**	Go to Diagnostic Aids
15	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 3**

DRIVE BELT SQUEAL DIAGNOSIS

Diagnostic Aids

A loose or improper installation of a body component, a suspension component, or other items of the vehicle may cause the squeal noise.

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.

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 belt and operating the engine for a brief period will verify the squeal noise is the drive belt or an accessory drive component. 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 belt removed.

4: This test is to verify that an accessory drive component does not have a seized bearing. With the belt remove test the bearings in the accessory drive components for turning smoothly. Also test the accessory drive components with the engine operating by varying the load on the components to verify that the components operate properly.

5: 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.

6: 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.

7: 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 mis-align pulley using a straight edge in the pulley grooves across two or three pulleys. If a mis-align pulley is found refer to that accessory drive component for the proper installation procedure for that pulley.

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

Drive Belt Squeal Diagnosis

Step	Action	Yes	No
NOTE: **Refer to Belt Dressing Notice in Cautions and Notices.** DEFINITION: The following items are indications of drive belt squeal: • A loud screeching noise that is caused by a slipping drive belt. • 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.			
1	Did you review the Symptoms - Engine Mechanical operation and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	Verify that there is a squeal noise. Does the engine make the squeal noise?	Go to **Step 3**	Go to Diagnostic Aids
3	1. Remove the drive belt. Refer to **Drive Belt Replacement** . 2. Operate the engine for no longer than 30 to 40 seconds. Does the noise still exist?	Go to **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** , or **Engine Noise Under Load**	Go to **Step 4**
4	Inspect for an accessory drive component seized bearing or a faulty accessory drive component. Did you find and correct the condition?	Go to **Step 9**	Go to **Step 5**
5	Test the drive belt tensioner for proper operation. Refer to **Drive Belt Tensioner Diagnosis** Did you find and correct the condition?	Go to **Step 9**	Go to **Step 6**
6	Inspect for the correct drive belt length. Refer to **Drive Belt Replacement** . Did you find and correct the condition?	Go to **Step 9**	Go to **Step 7**

7	Inspect for misalignment of a pulley. Did you find and correct the condition?	Go to **Step 9**	Go to **Step 8**
8	Inspect for the correct pulley size. Did you find and correct the condition?	Go to **Step 9**	Go to Diagnostic Aids
9	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 3**

DRIVE BELT WHINE DIAGNOSIS

Diagnostic Aids

The drive belt will not cause the whine noise.

If the whine noise is intermittent, verify the accessory drive components by varying their loads making sure they are operated to their maximum capacity. Such items but not limited to may be an A/C system overcharged, the power steering system restricted or the wrong fluid, or the generator failing.

Test Description

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

3: This test is to verify that the noise is being caused by the drive belt or the accessory drive components. 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 belt removed.

4: The inspection should include checking the drive belt tensioner and the drive belt idler pulley bearings. The drive belt may have to be installed and the accessory drive components operated separately by varying their loads. Refer to the suspected accessory drive component for the proper inspection and replacement procedure.

Drive Belt Whine Diagnosis

Step	Action	Yes	No
NOTE: **Refer to Belt Dressing Notice in Cautions and Notices.** DEFINITION: A high pitched continuous noise that may be caused by an accessory drive component failed bearing.			
1	Did you review the Symptoms - Engine Mechanical operation and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
	Verify that there is a whine noise.		

2	Does the engine make the whine noise?	Go to **Step 3**	Go to Diagnostic Aids
3	1. Remove the drive belt. Refer to **Drive Belt Replacement** . 2. Operate the engine for no longer than 30 to 40 seconds. Does the whine noise still exist?	Go to **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** , or **Engine Noise Under Load**	Go to **Step 4**
4	Inspect for a failed accessory drive component bearing. Did you find and repair the condition?	Go to **Step 5**	Go to Diagnostic Aids
5	Operate the system in order to verify the repair. Did you correct the condition?	System OK	-

DRIVE BELT RUMBLING DIAGNOSIS

Diagnostic Aids

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

The drive belt may have a 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 belt is 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 the drive belt is causing the rumbling noise. Rumbling noise may be confused with an internal engine noise due to the similarity in the description. Remove only one drive belt at a time if the vehicle has multiple drive belts. When removing the drive 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 belt removed.

4: Inspecting the drive belt is to ensure that it is not causing a 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.

Drive Belt Rumbling Diagnosis

Step	Action	Yes	No

NOTE:
Refer to Belt Dressing Notice in Cautions and Notices.
 	
DEFINITION:
• A low pitch tapping, knocking, or thumping noise heard at or just above idle.
• Heard once per revolution of the drive belt or a pulley.
• Rumbling may be caused from:
  ○ Pilling, the accumulation of rubber dust that forms small balls or strings in the drive belt pulley groove
  ○ The separation of the drive belt
  ○ A damaged drive belt			

1	Did you review the Symptoms - Engine Mechanical operation and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	Verify that there is a rumbling noise. Does the engine make the rumbling noise?	Go to **Step 3**	Go to Diagnostic Aids
3	1. Remove the drive belt. Refer to **Drive Belt Replacement** . 2. Operate the engine for no longer than 30 to 40 seconds. Does the rumbling noise still exist?	Go to **Engine Noise on Start-Up, but Only Lasting a Few Seconds** , **Upper Engine Noise, Regardless of Engine Speed** , **Lower Engine Noise, Regardless of Engine Speed** , or **Engine Noise Under Load**	Go to **Step 4**
4	Inspect the drive belt for damage, separation, or sections of missing ribs. 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 belt. Refer to **Drive Belt Replacement** . Did you complete the repair?	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**	-
8	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Diagnostic Aids

DRIVE BELT VIBRATION DIAGNOSIS

Diagnostic Aids

The accessory drive components can have an affect on engine vibration. Such as 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.

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 such as the exhaust system, or the drivetrain.

3: This test is to verify that the drive belt or accessory drive components may be causing the vibration. 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 belt removed.

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

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

8: This step should only be performed if the fan is driven by the drive belt. Inspect the engine cooling fan for bent, twisted, loose, or cracked blades. Inspect the fan clutch for smoothness, ease of turning. Inspect for a bent fan shaft or bent mounting flange.

9: 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 smoothness and excessive play. Compare the water pump with a known good water pump.

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

Drive Belt Vibration Diagnosis

Step	Action	Yes	No
	NOTE: **Refer to Belt Dressing Notice in Cautions and Notices.** DEFINITION: The following items are indications of drive belt vibration: • The vibration is engine-speed related. • The vibration may be sensitive to accessory load.		
1	Did you review the Symptoms - Engine Mechanical operation and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	Verify that the vibration is engine related. Does the engine make the vibration?	Go to **Step 3**	Go to Diagnostic Aids
3	1. Remove the drive belt. Refer to **Drive Belt Replacement** . 2. Operate the engine for no longer than 30 to 40 seconds. Does the engine still make the vibration?	Go to **Diagnostic Starting Point - Vibration Diagnosis and Correction** in Vibration Diagnosis and Correction	Go to **Step 4**
4	Inspect the drive belt for wear, damage, debris build-up and missing drive belt ribs. Did you find any of these conditions?	Go to **Step 5**	Go to **Step 6**
5	Install a new drive belt. Refer to **Drive Belt Replacement** . Did you complete the replacement?	Go to **Step 11**	-
6	Inspect for improper, loose or missing fasteners. Did you find any of these conditions?	Go to **Step 7**	Go to **Step 8**
7	1. Tighten any loose fasteners. 2. Replace improper or missing fasteners. Refer to **Fastener Tightening Specifications** . Did you complete the repair?	Go to **Step 11**	-
8	Inspect for damaged fan blades or bent fan clutch shaft, if the fan is belt driven. Did you find and correct the condition?	Go to **Step 11**	Go to **Step 9**
9	Inspect for a bent water pump shaft, if the water pump is belt driven. Refer to **Water Pump Replacement (L61)Water Pump Replacement**		

	(L66) in Engine Cooling. Did you find and correct the condition?	Go to **Step 11**	Go to **Step 10**
10	Inspect for bent or cracked brackets. Did you find and correct the condition?	Go to **Step 11**	Go to Diagnostic Aids
11	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 3**

DRIVE BELT FALLS OFF DIAGNOSIS

Diagnostic Aids

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

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

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

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 mis-align pulley using a straight edge in the pulley grooves across two or three pulleys. If a misalign 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.

Drive Belt Falls Off Diagnosis

Step	Action	Yes	No
NOTE: **Refer to Belt Dressing Notice in Cautions and Notices.** DEFINITION: The drive belt falls off the pulleys or may not ride correctly on the pulleys.			

1	Did you review the Symptoms - Engine Mechanical operation and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	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	1. Tighten any loose fasteners. 2. Replace improper or missing fasteners. Refer to **Fastener Tightening Specifications** . Does the drive belt continue to fall off?	Go to **Step 9**	System OK
9	Test the drive belt tensioner for operating correctly. Refer to **Drive Belt Tensioner Diagnosis** . Does the drive belt tensioner operate correctly?	Go to **Step 11**	Go to **Step 10**
10	Replace the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement** . 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**

DRIVE BELT EXCESSIVE WEAR DIAGNOSIS

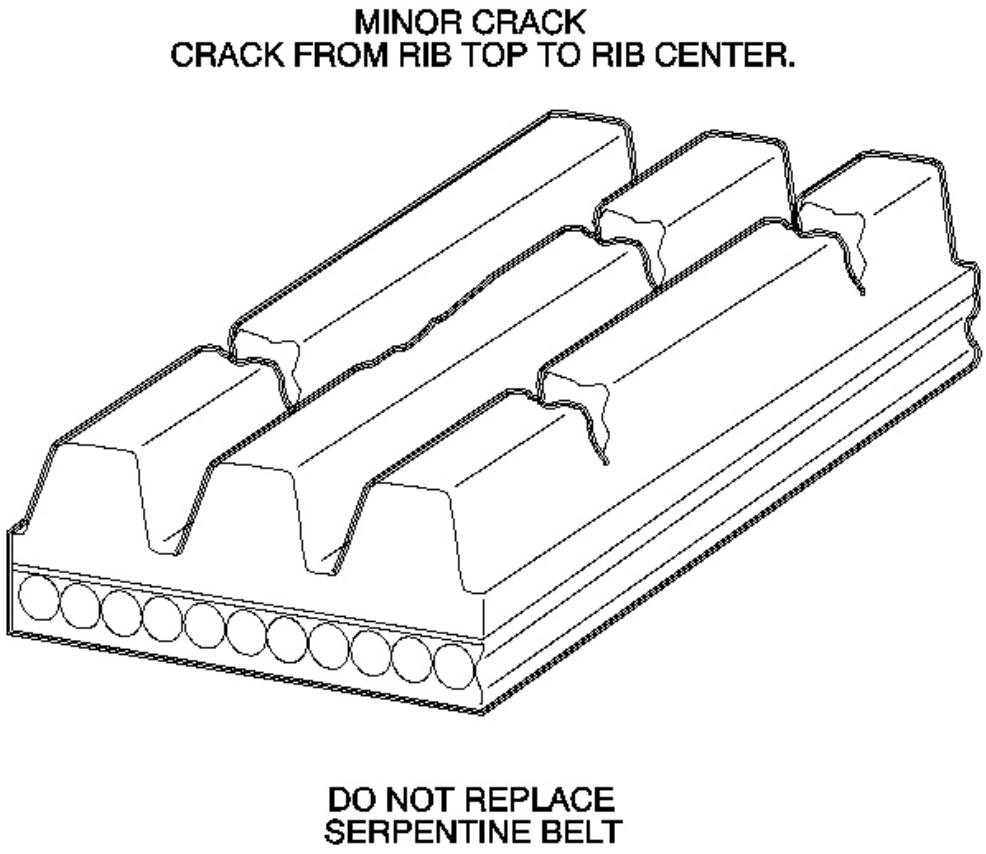
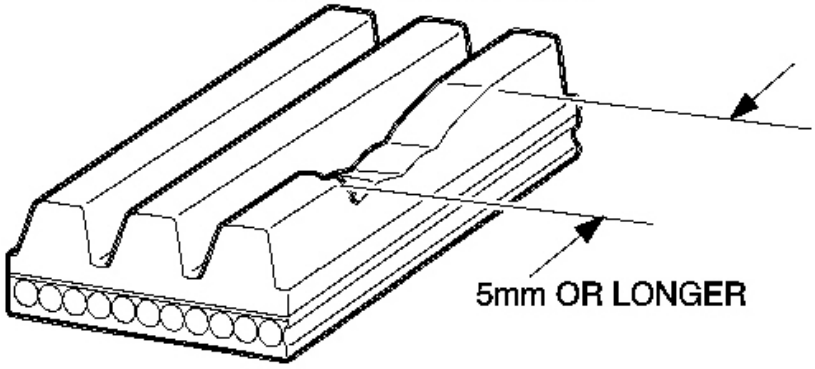


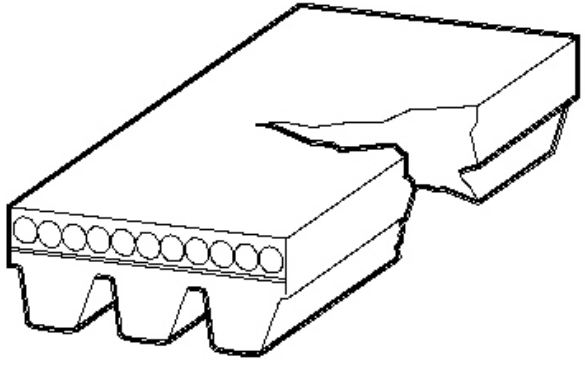
Fig. 17: View Of Drive Belt
Courtesy of GENERAL MOTORS CORP.

Minor cracks in the belt rib are normal. They are the result of reverse bending around a backside pulley. Do not replace belts for minor cracks.

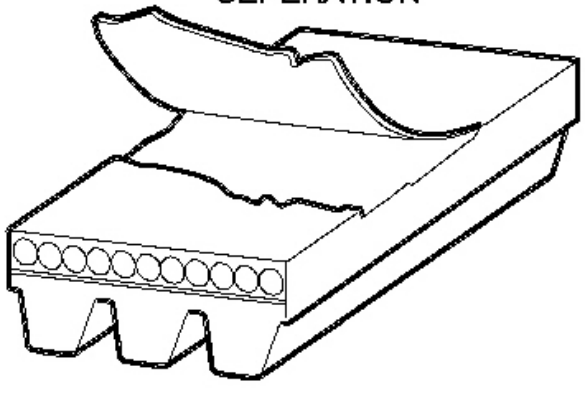
CHUNKING
LACK OF RIB RUBBER



CORD BREAK



SEPERATION



REPLACE BELT FOR ANY OF
THE ABOVE CONDITIONS

Fig. 18: View Of Damaged Belts
Courtesy of GENERAL MOTORS CORP.

Belts that have chunking longer than 5 mm (13/16 in) in one or more places should be replaced.

Belts should also be replaced if cord breakage or fabric separation is observed.

DRIVE BELT TENSIONER DIAGNOSIS

Drive Belt Tensioner Diagnosis

Step	Action	Yes	No
1	Remove the drive belt. 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

DRIVE BELT REPLACEMENT

Removal Procedure

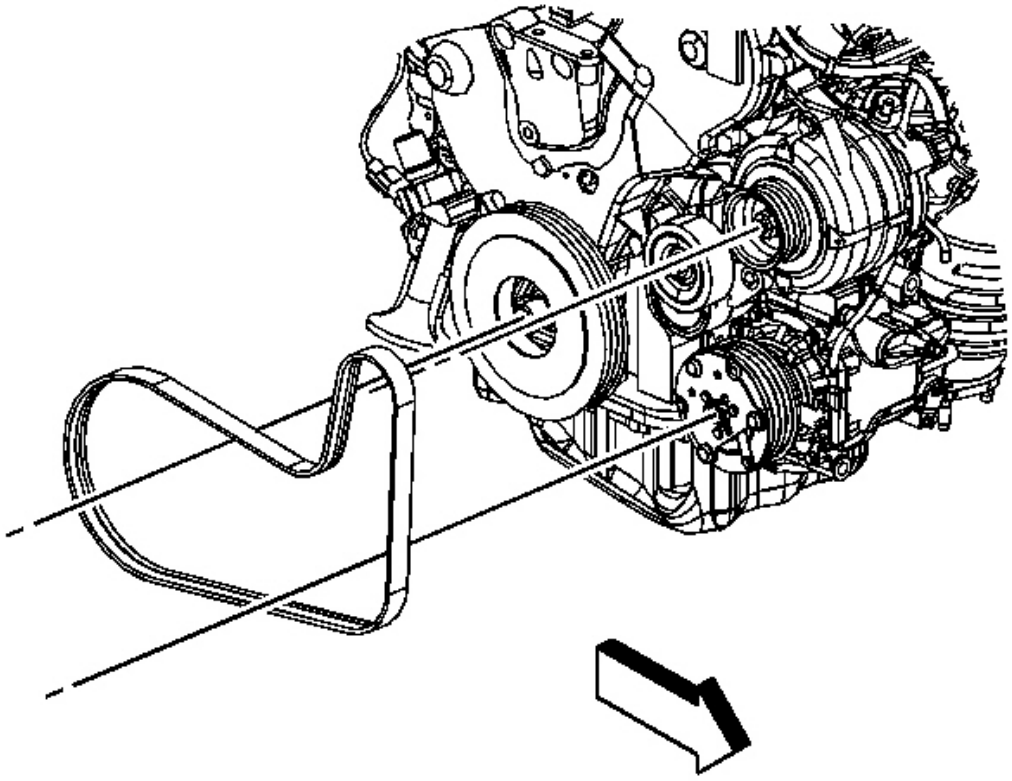


Fig. 19: Identifying Drive Belt
Courtesy of GENERAL MOTORS CORP.

1. Remove the air cleaner assembly. Refer to**Air Cleaner Assembly Replacement** in Engine Controls - 3.5L (L66).
2. Loosen the drive belt tensioner by rotating the tensioner pulley clockwise while sliding the drive belt off the tensioner.
3. Remove the drive belt.
4. Clean and inspect the serpentine drive belt surfaces.

Installation Procedure

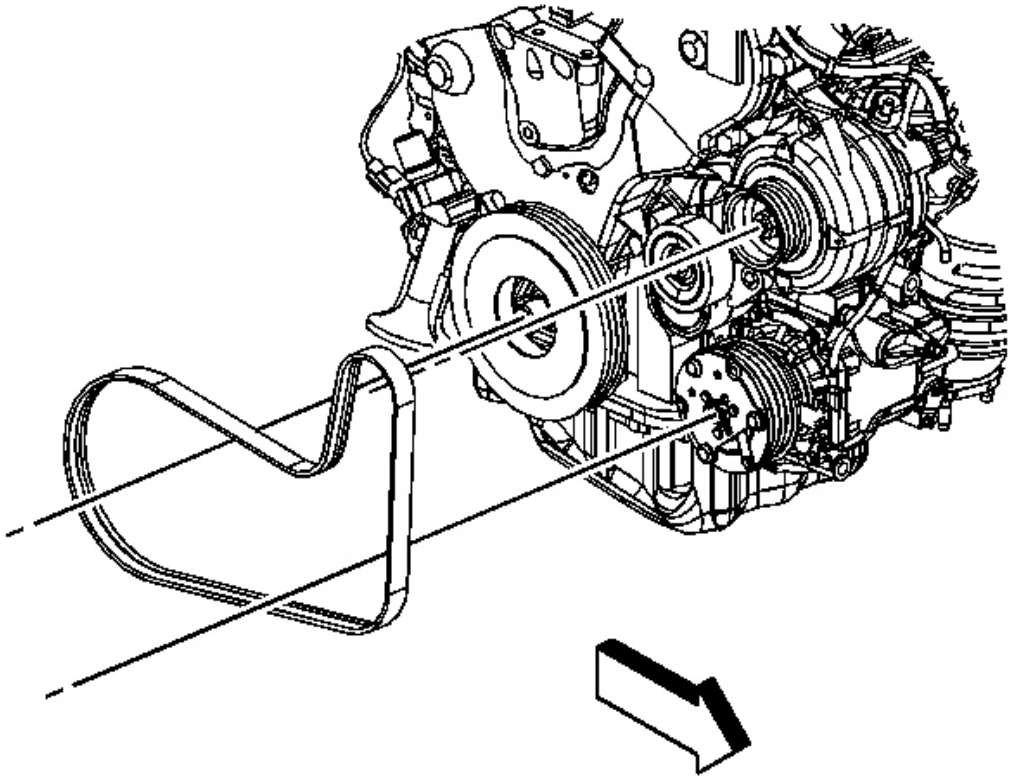


Fig. 20: Identifying Drive Belt
Courtesy of GENERAL MOTORS CORP.

1. Route the belt around all pulleys, except the tensioner.

IMPORTANT: Ensure that the drive belt is aligned into the proper grooves on the drive pulley.

2. Rotate the tensioner pulley clockwise and install the drive belt.
3. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** in Engine Controls - 3.5L (L66).

DRIVE BELT TENSIONER REPLACEMENT

Removal Procedure

1. Remove the drive belt. Refer to **Drive Belt Replacement** .

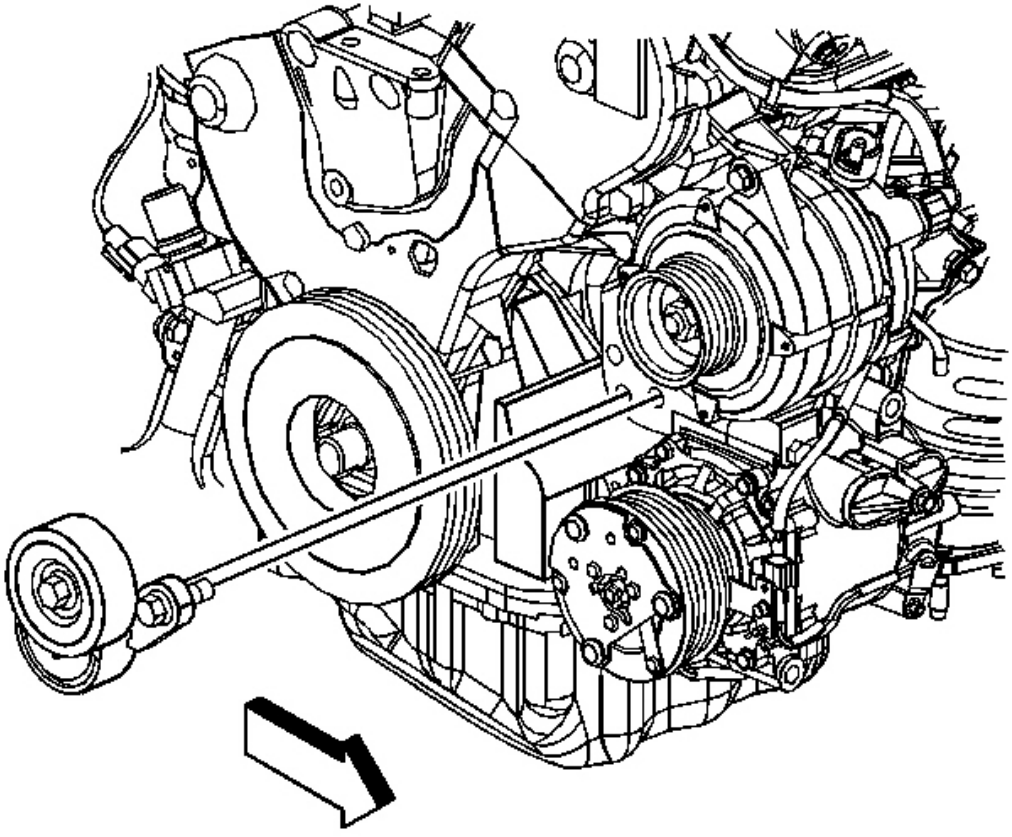


Fig. 21: View Of Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

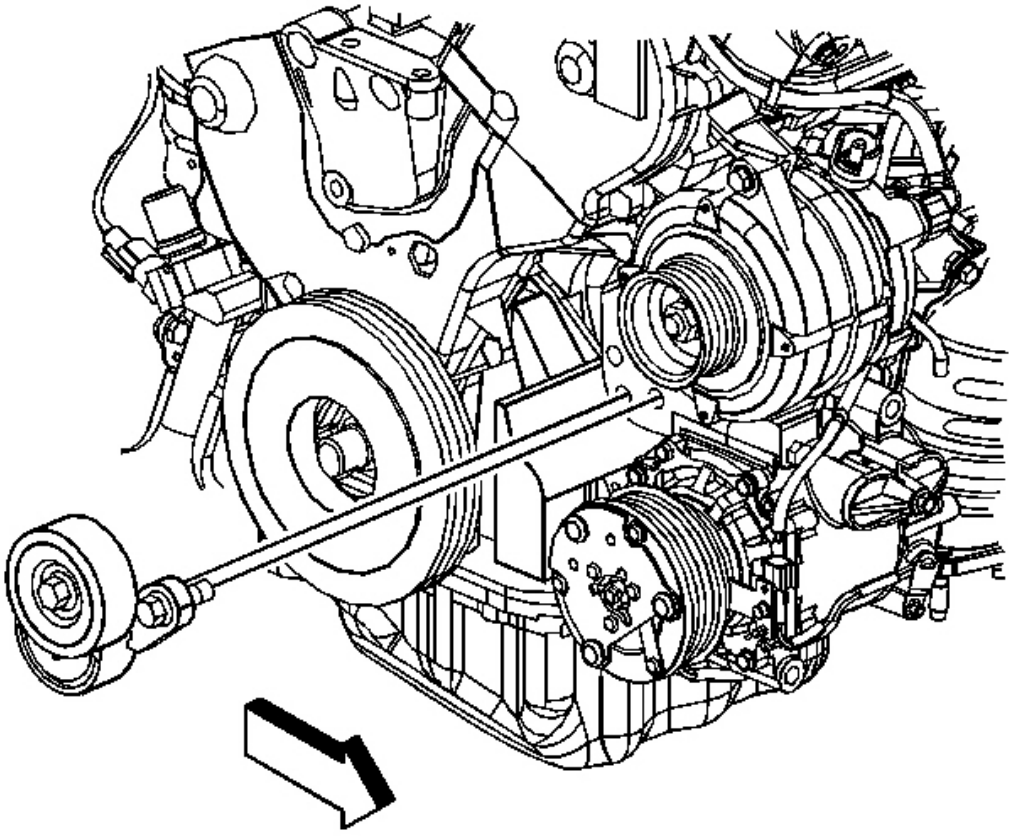


Fig. 22: View Of Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Install the drive belt tensioner.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the drive belt tensioner bolts.

   Tighten: Tighten the drive belt tensioner bolts to 22 N.m (16 lb ft).

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

ENGINE SUPPORT FIXTURE

Tools Required

SA9105E Engine Support Fixture (3-Bar)

Installation Procedure

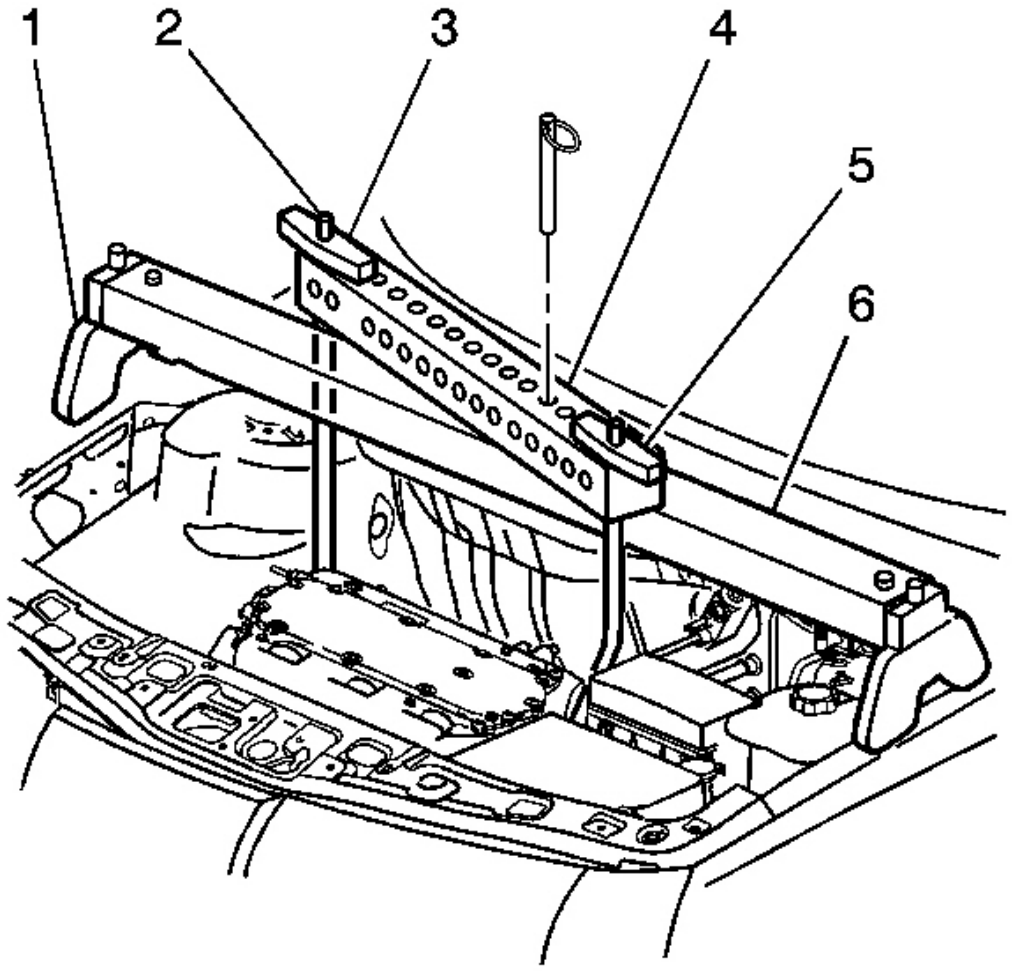


Fig. 23: View Of Engine Support Fixture
Courtesy of GENERAL MOTORS CORP.

1. Install the engine support fixture long bar (6) to the vehicle.
2. Install the engine support fixture long bar legs (1).
3. Install the crossbar (4) to the engine support fixture long bar.
4. Install the lift hook (2) to the rear of the engine support fixture crossbar, and install the lift hook wing nut (3).

5. Install the lift hook (5) to the front of the engine support fixture crossbar, and install the lift hook wing nut (3).
6. Install the engine support fixture long bar to crossbar holding pin.

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. Observe the engine mount while raising the engine. Raising the engine removes the weight from the engine mount and creates slight tension on the rubber.
3. Replace the engine mount if the engine mount exhibits any of the following conditions:
   - The hard rubber is covered with heat check cracks.
   - The rubber is separated from the metal plate of the engine mount.
   - The rubber is split through the center of the engine mount.
   - The engine mount itself is leaking fluid.
4. For engine mount replacement. Refer to the following procedures:
   - **Engine Mount Replacement - Right**
   - **Engine Mount Bracket Replacement - Right**
   - **Automatic Transmission Mount Replacement - Rear** in Automatic Transmission
   - **Transmission Mount Bracket Replacement - Front** in Automatic Transmission

ENGINE MOUNT REPLACEMENT - RIGHT

Removal Procedure

1. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** in Engine Controls - 3.5L (L66).
2. Support the engine. Refer to **Engine Support Fixture** .
3. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.

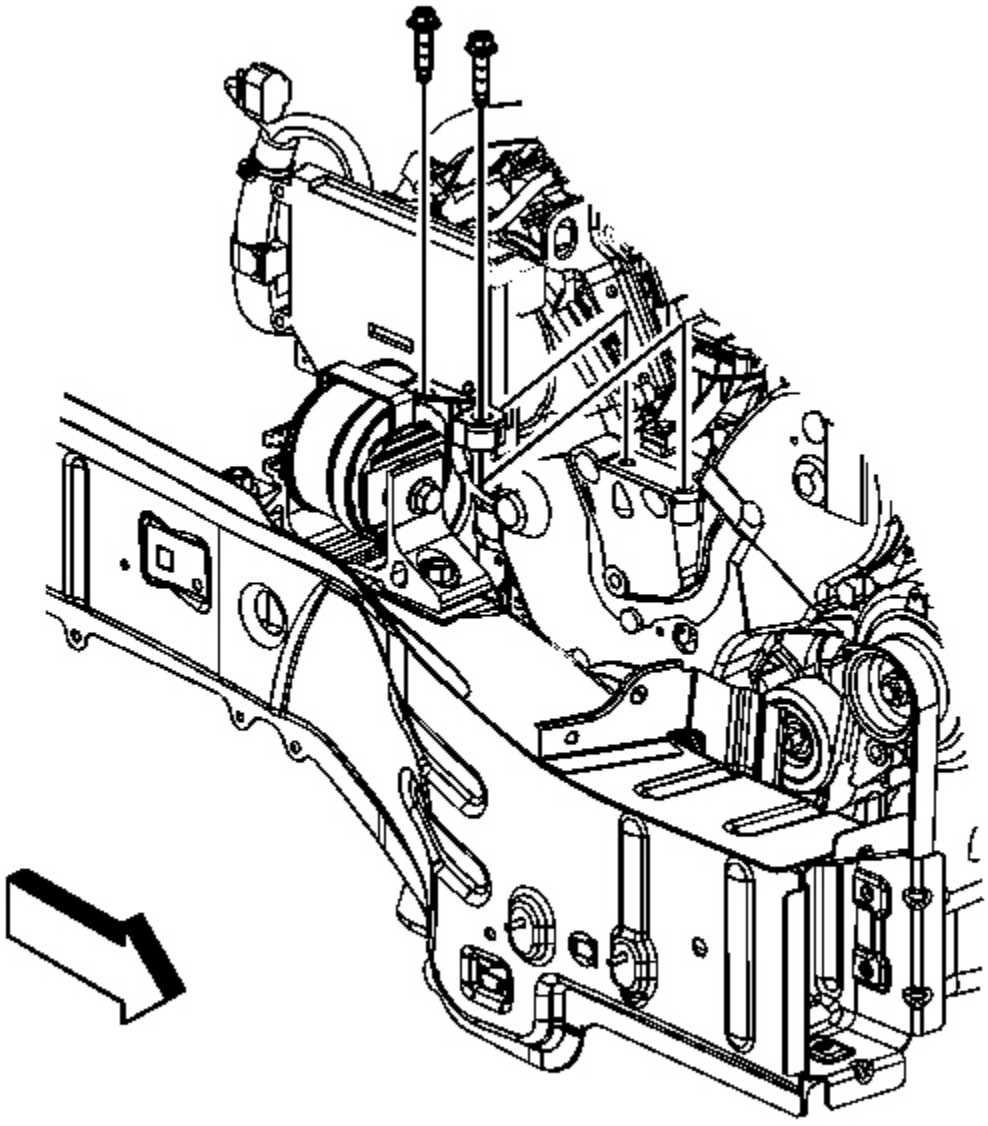


Fig. 24: View Of Engine Mount
Courtesy of GENERAL MOTORS CORP.

4. Remove the engine mount to bracket bolts.

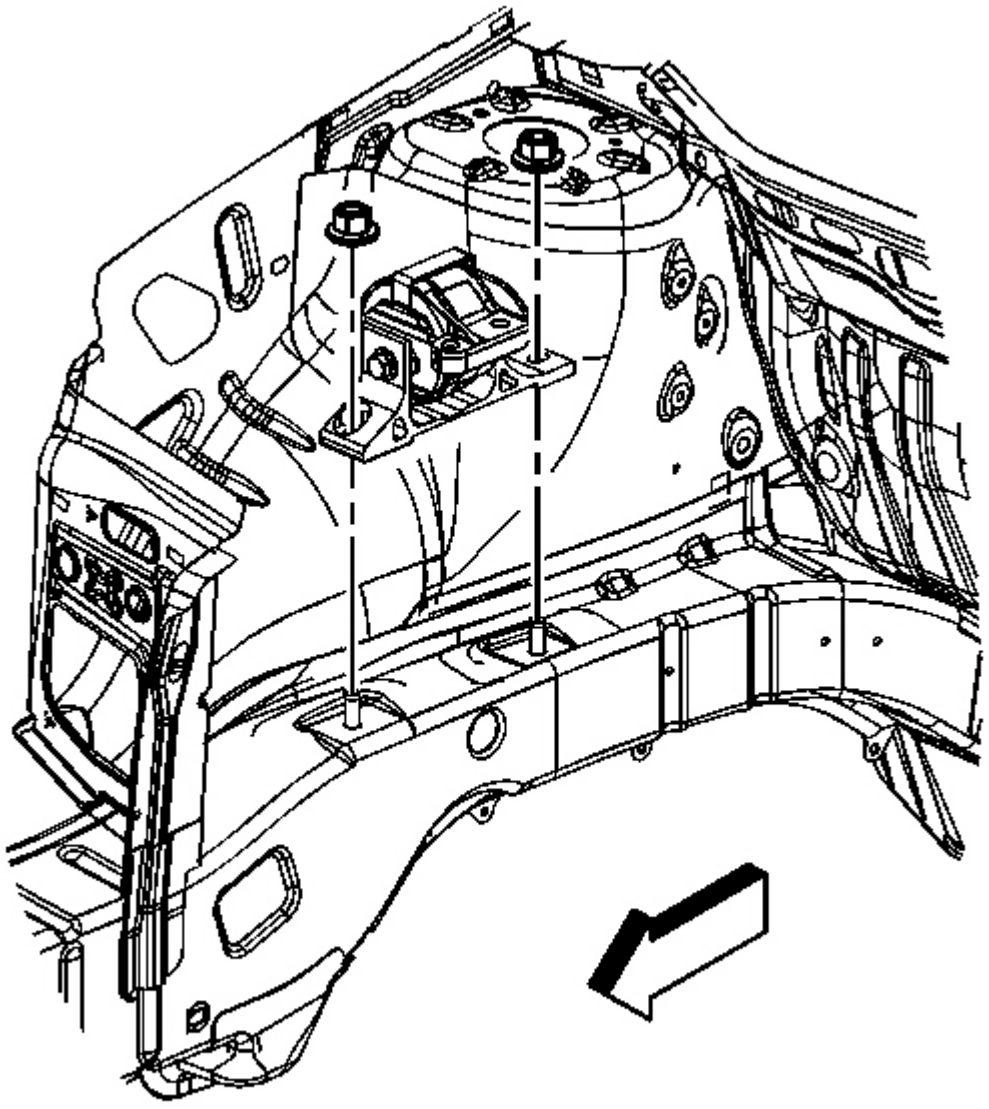


Fig. 25: Identifying Engine Mount
Courtesy of GENERAL MOTORS CORP.

5. Remove the engine mount to frame rail nuts.
6. Remove the engine mount from the vehicle.

Installation Procedure

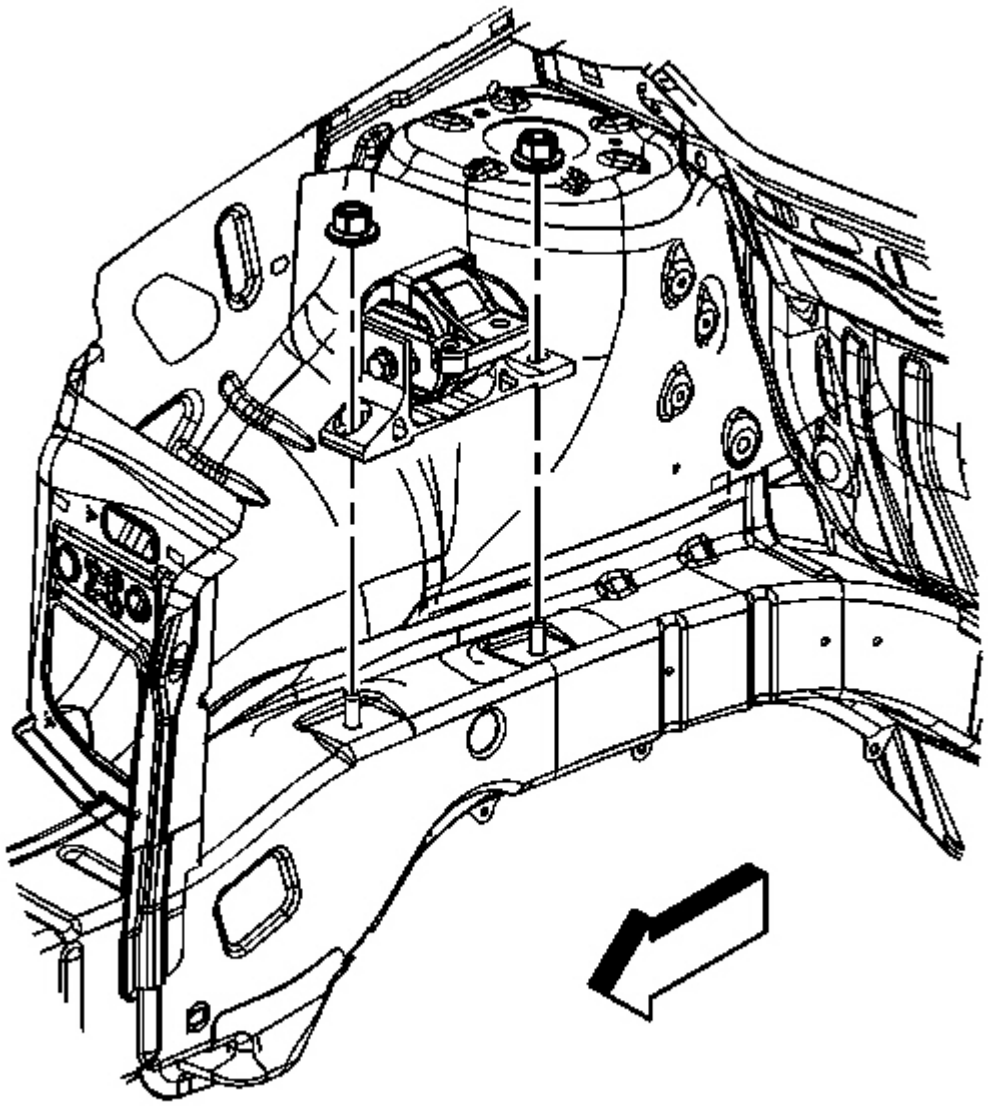


Fig. 26: Identifying Engine Mount
Courtesy of GENERAL MOTORS CORP.

1. Position the engine mount onto the frame rail studs.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the engine mount to frame rail stud nuts.

Tighten: Tighten the nuts to 110 N.m (81 lb ft).

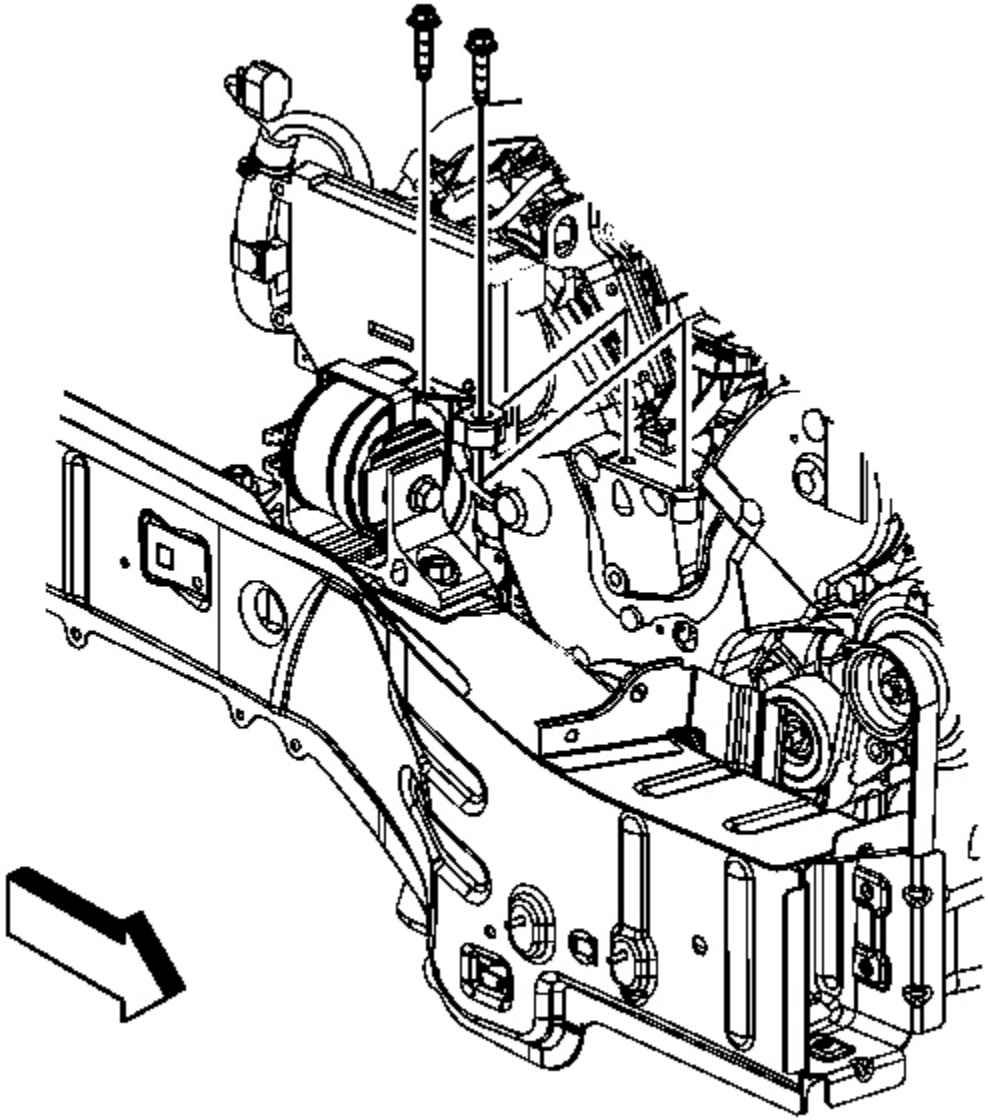


Fig. 27: View Of Engine Mount
Courtesy of GENERAL MOTORS CORP.

3. Install the engine mount to engine mount bracket bolts. Take care when aligning the engine mount to engine mount bracket bolt holes, while hand tightening all the bolts.

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

   Tighten: Tighten the bolts to 110 N.m (81 lb ft).

5. Lower the vehicle.
6. Remove the engine support. Refer to **Engine Support Fixture** .
7. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** in Engine Controls - 3.5L (L66).

ENGINE MOUNT BRACKET REPLACEMENT - RIGHT

Removal Procedure

1. Remove the right engine mount. Refer to **Engine Mount Replacement - Right** .

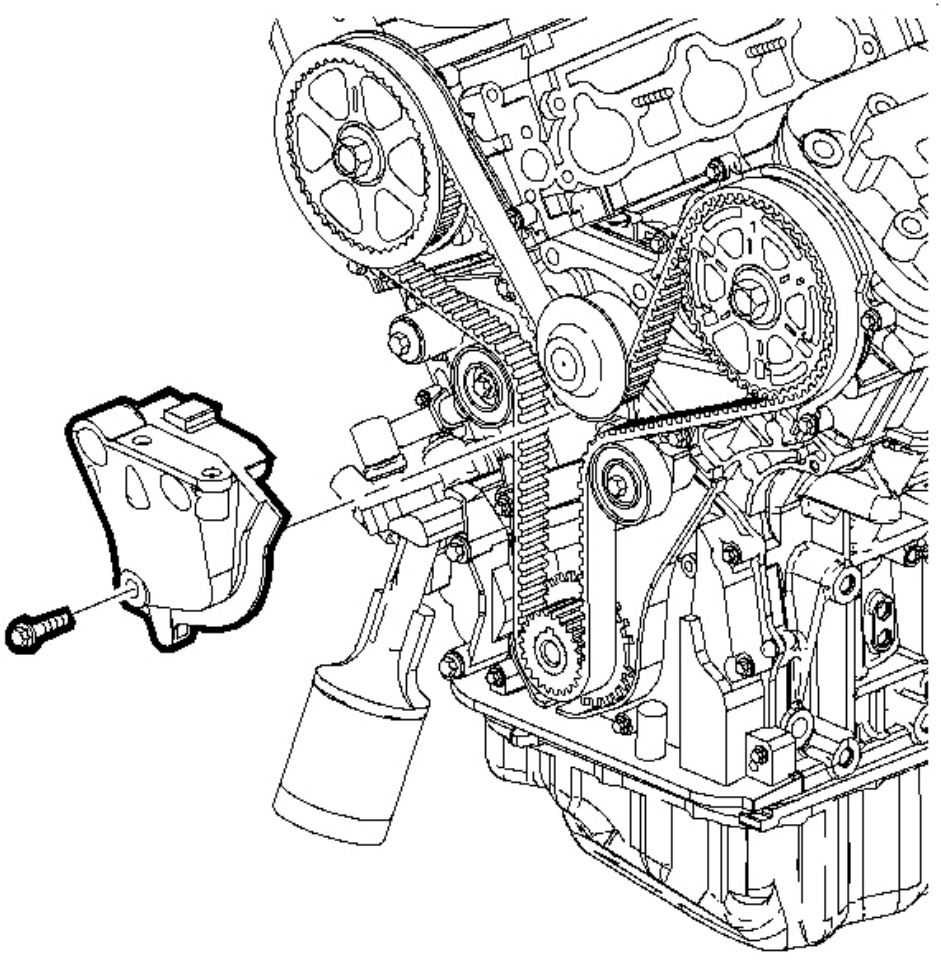


Fig. 28: View Of Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

2. Remove the engine mount bracket to engine bolts.
3. Remove the engine mount bracket from the engine.

Installation Procedure

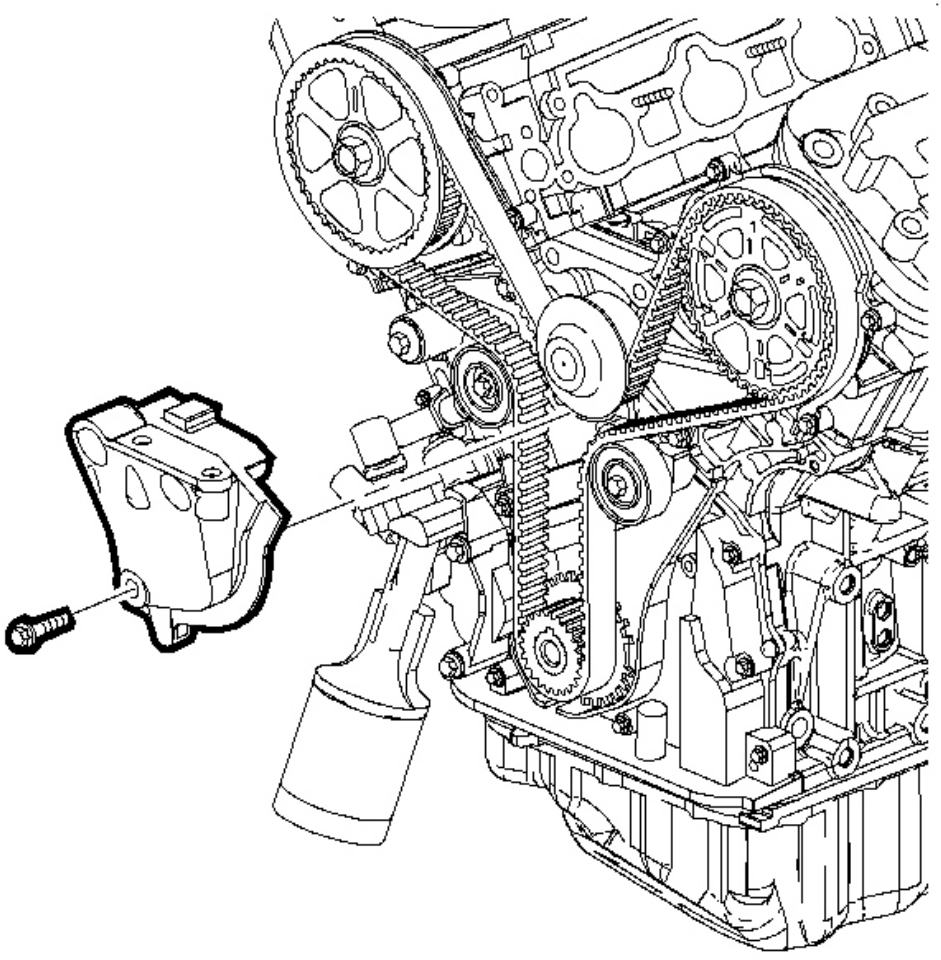


Fig. 29: View Of Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

1. Position the engine mount bracket to the engine.

NOTE: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT: Three bolts retain the mount bracket to the engine. Apply sealant to the lower bolt only.

2. Apply sealant Saturn P/N 21485277 (GM P/N 12345382) or equivalent, to the engine mount bracket lower bolt only and install the engine mount bracket to engine bolts.

Tighten: Tighten the bolts to 44 N.m (33 lb ft).

3. Install the right engine mount. Refer to **Engine Mount Replacement - Right** .

OIL LEVEL INDICATOR - REPLACE

Removal Procedure

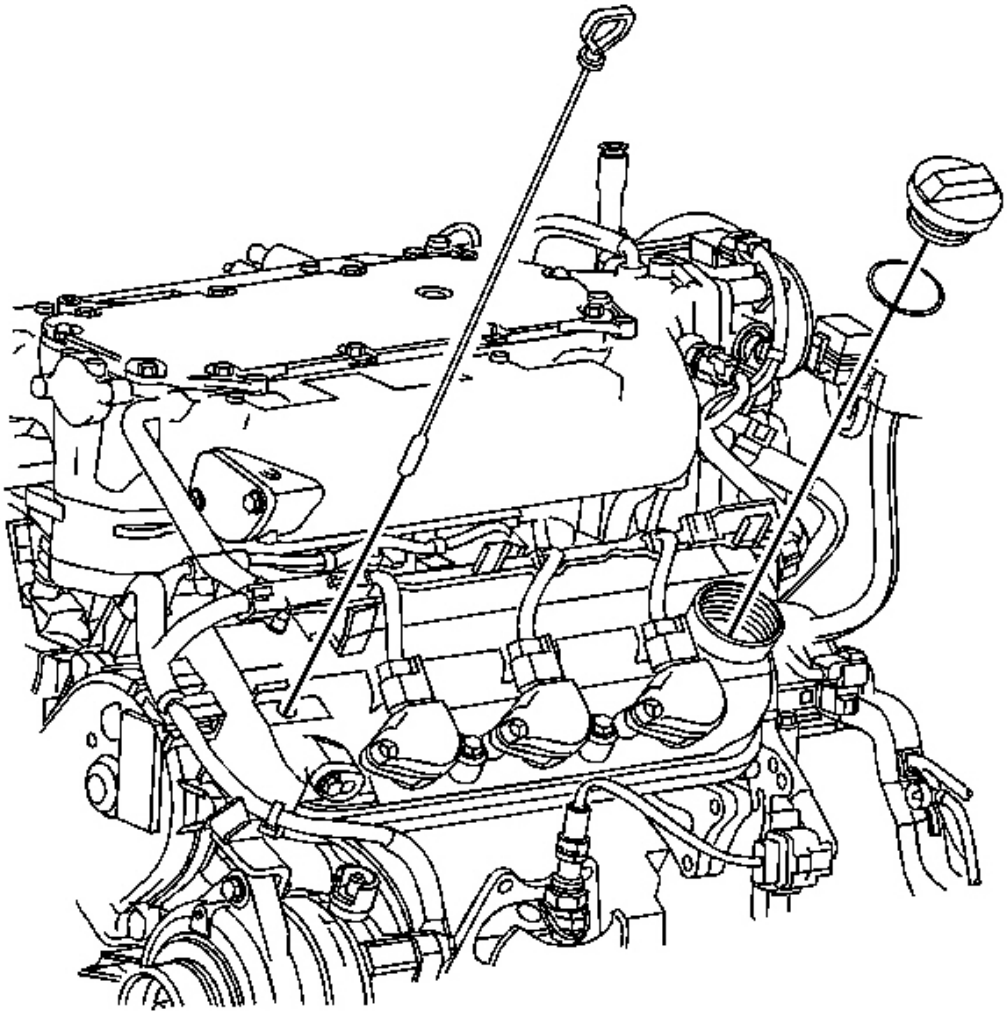


Fig. 30: View Of Oil Level Indicator
Courtesy of GENERAL MOTORS CORP.

Remove the oil level indicator.

Installation Procedure

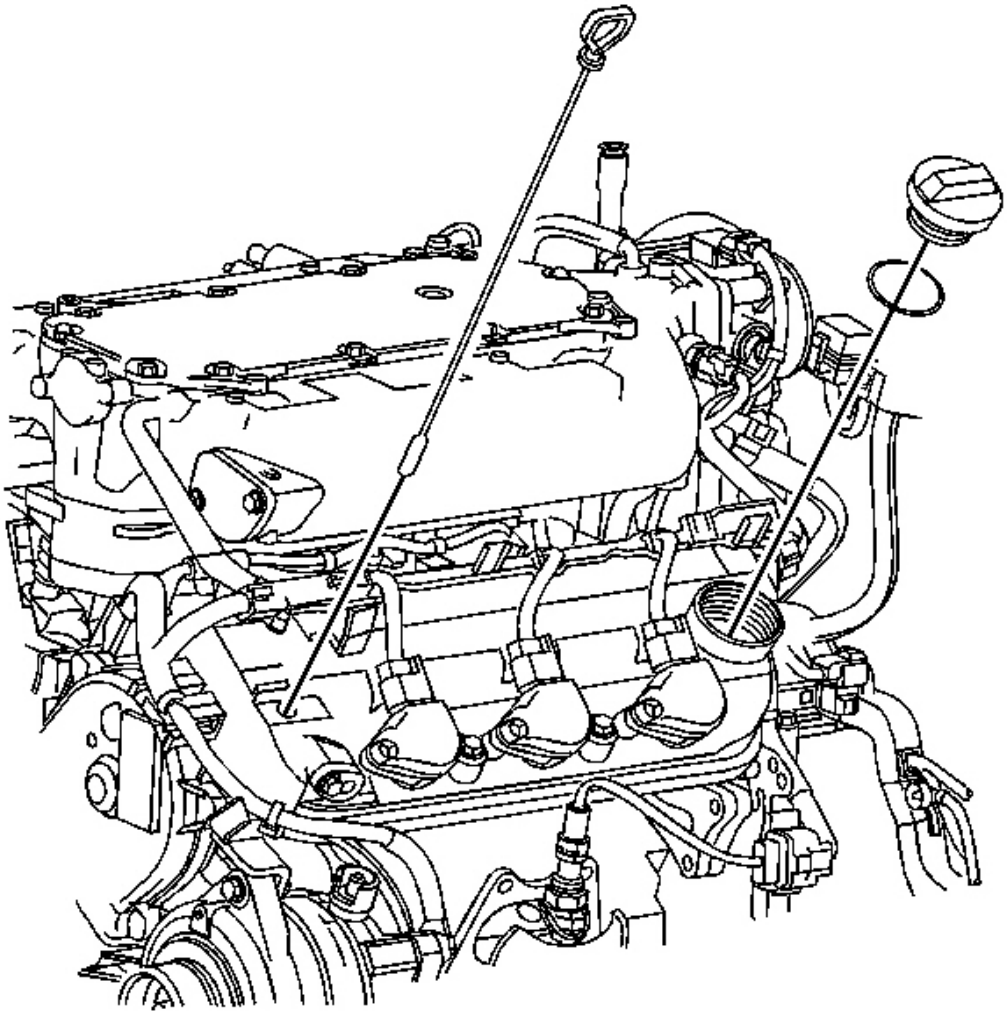


Fig. 31: View Of Oil Level Indicator
Courtesy of GENERAL MOTORS CORP.

Install the oil level indicator.

OIL FLOW CONTROL MODULE REPLACEMENT

Removal Procedure

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
2. Remove the oil filter. Refer to**Engine Oil and Oil Filter Replacement** .

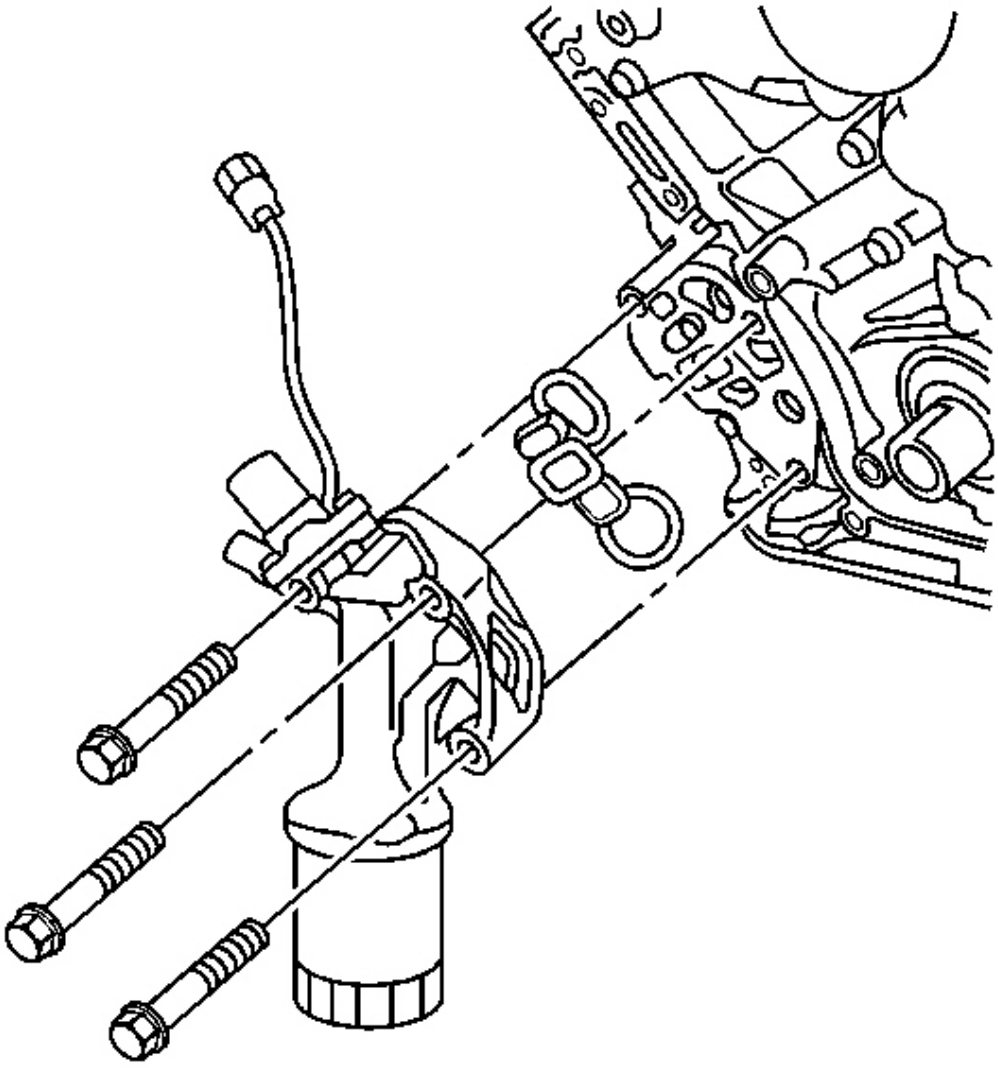


Fig. 32: View Of Oil Flow Control Module
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil flow control module.
4. Clean and inspect the oil flow control module sealing area.

Installation Procedure

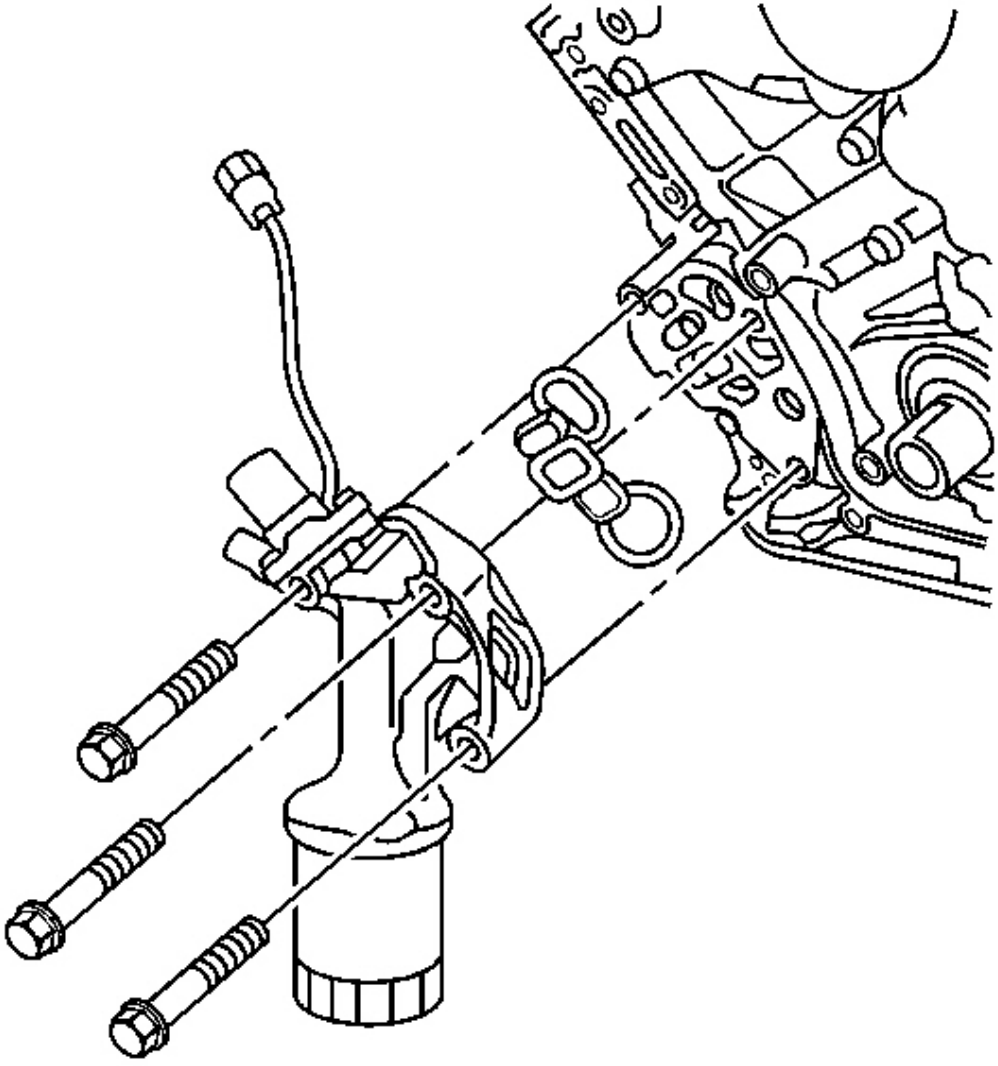


Fig. 33: View Of Oil Flow Control Module
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW oil flow control module screen.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the oil flow control module and bolts.

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

3. Install a new oil filter. Refer to**Engine Oil and Oil Filter Replacement** .

INTAKE MANIFOLD REPLACEMENT

Removal Procedure

1. Remove the outlet resonator/duct assembly. Refer to**Air Cleaner Resonator Outlet Duct Replacement** in Engine Controls - 3.5L (L66).
2. Remove the throttle body. Refer to **Throttle Body Assembly Replacement** in Engine Controls - 3.5L (L66).
3. Disconnect the PCV hoses from the intake manifold.
4. Disconnect the brake booster hose from the intake manifold.

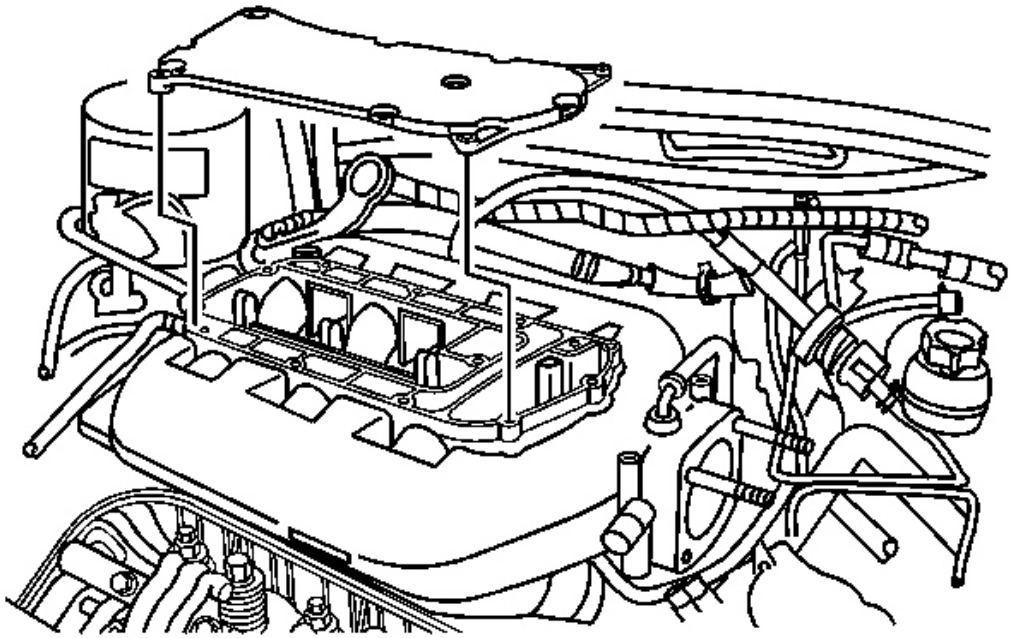


Fig. 34: View Of Intake Manifold
Courtesy of GENERAL MOTORS CORP.

5. Remove the intake manifold top cover nuts and bolts.

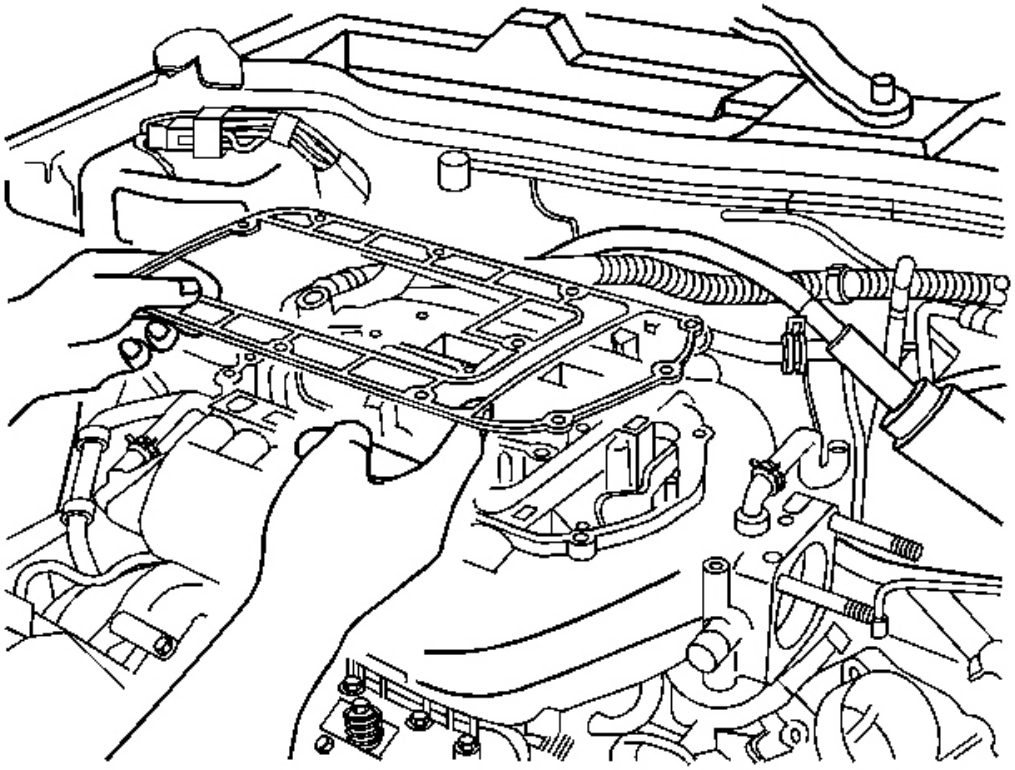


Fig. 35: Identifying Intake Manifold Top Cover Gasket
Courtesy of GENERAL MOTORS CORP.

6. Remove and discard the intake manifold top cover gasket.

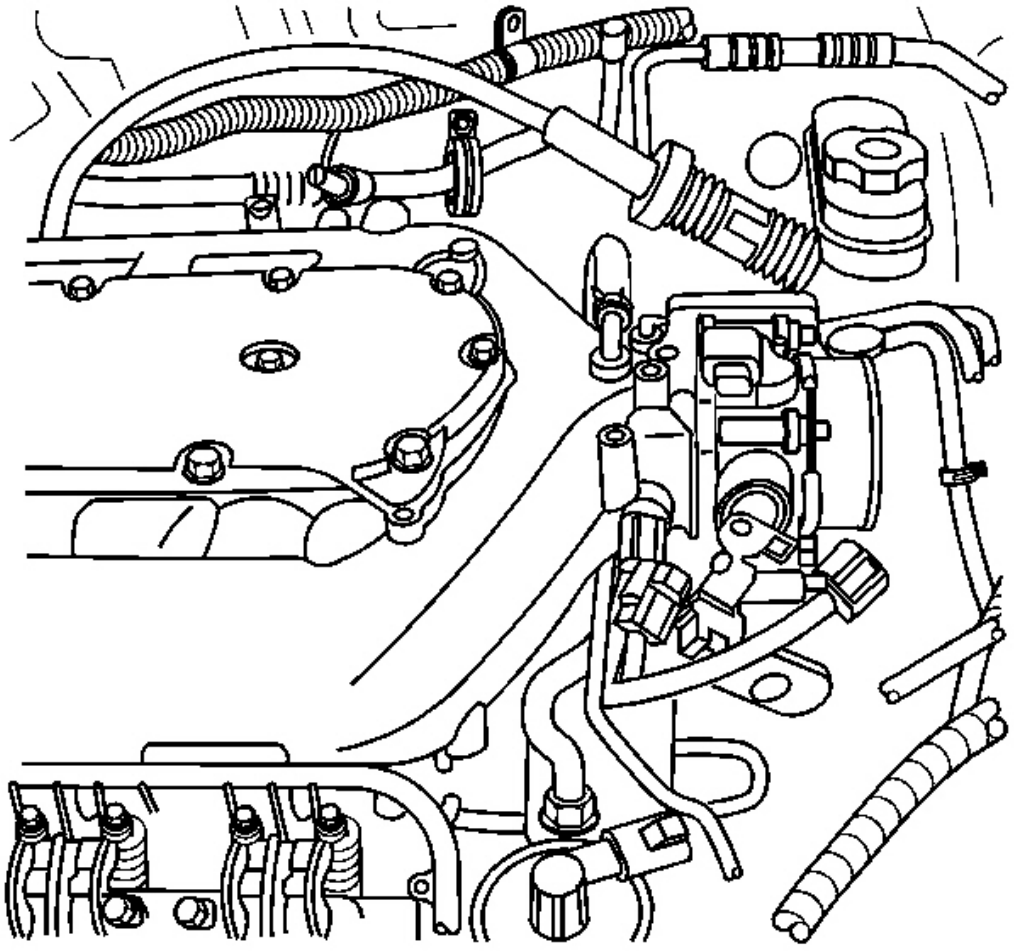


Fig. 36: View Of IAT2 Sensor
Courtesy of GENERAL MOTORS CORP.

7. Remove the IAT2 sensor.
8. Disconnect the PCV hose.
9. Remove the air outlet duct bracket.
10. Remove the intake manifold nuts and bolts.

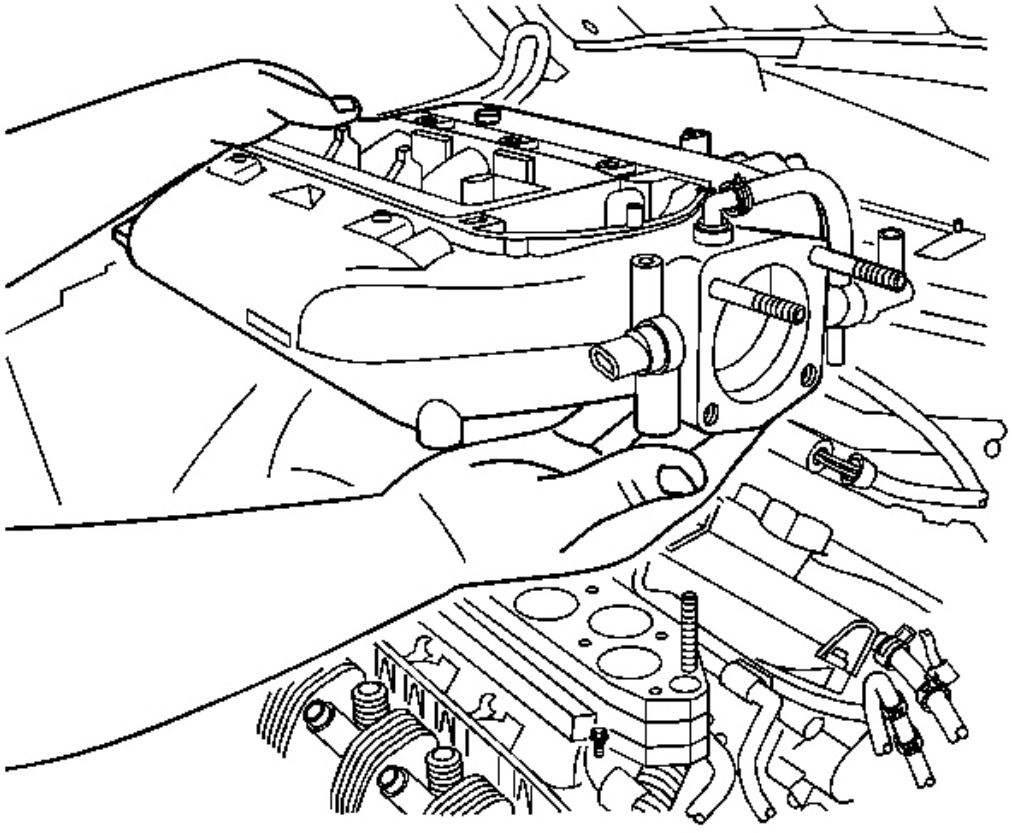


Fig. 37: View Of Intake Manifold Gasket
Courtesy of GENERAL MOTORS CORP.

11. Remove the intake manifold.
12. Remove and discard the intake manifold gasket.

Installation Procedure

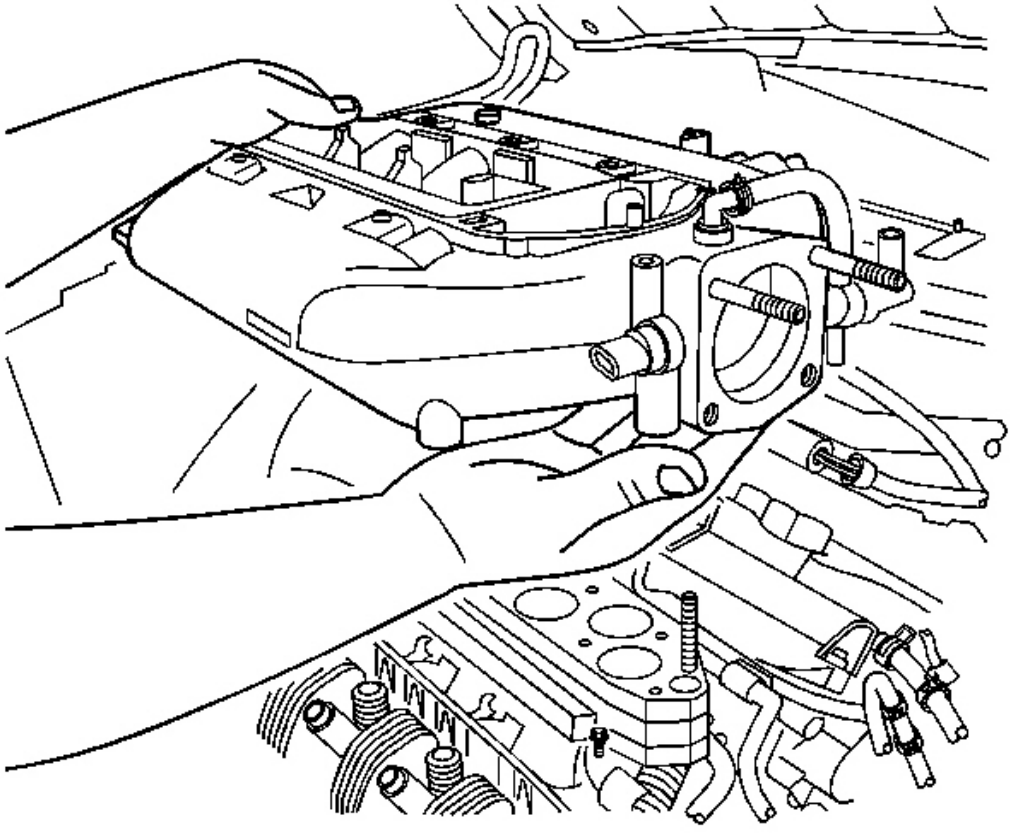


Fig. 38: View Of Intake Manifold Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install the intake manifold with gasket.

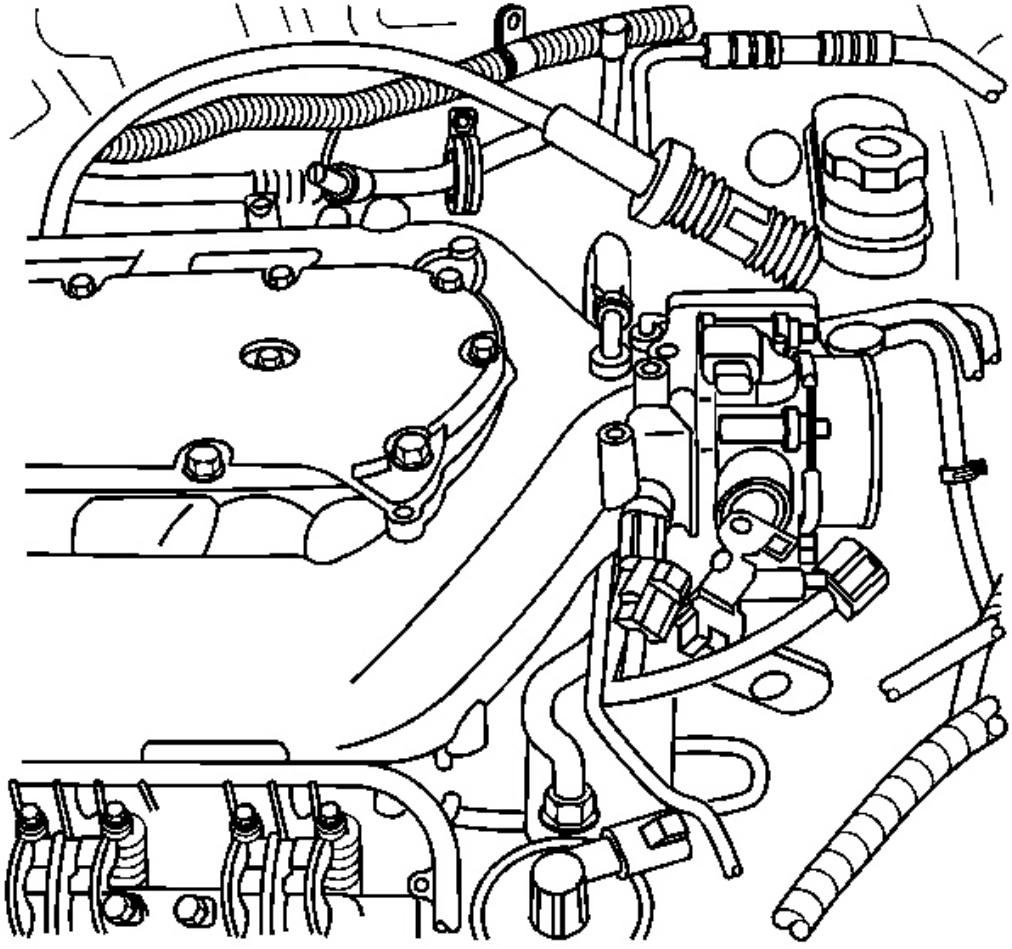


Fig. 39: View Of IAT2 Sensor
Courtesy of GENERAL MOTORS CORP.

2. Install the intake manifold nuts and bolts in sequence.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Tighten the intake manifold nuts and bolts.

Tighten:

- Tighten the intake manifold nuts and bolts to first pass to 11 N.m (97 lb in).
- Tighten the intake manifold nuts and bolts final pass to 22 N.m (16 lb ft).

4. Install the outlet duct bracket and nuts.

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

5. Install the IAT2 sensor.

   Tighten: Tighten the IAT2 sensor to 18 N.m (13 lb ft).

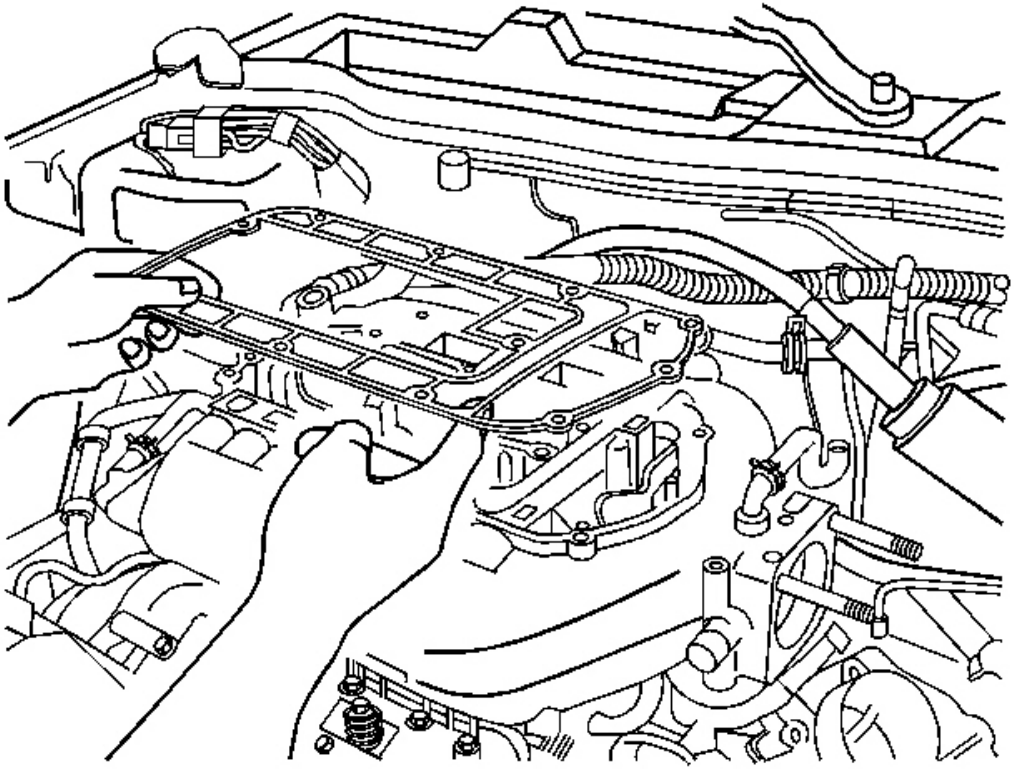


Fig. 40: Identifying Intake Manifold Top Cover Gasket
Courtesy of GENERAL MOTORS CORP.

6. Install the intake manifold top cover gasket.

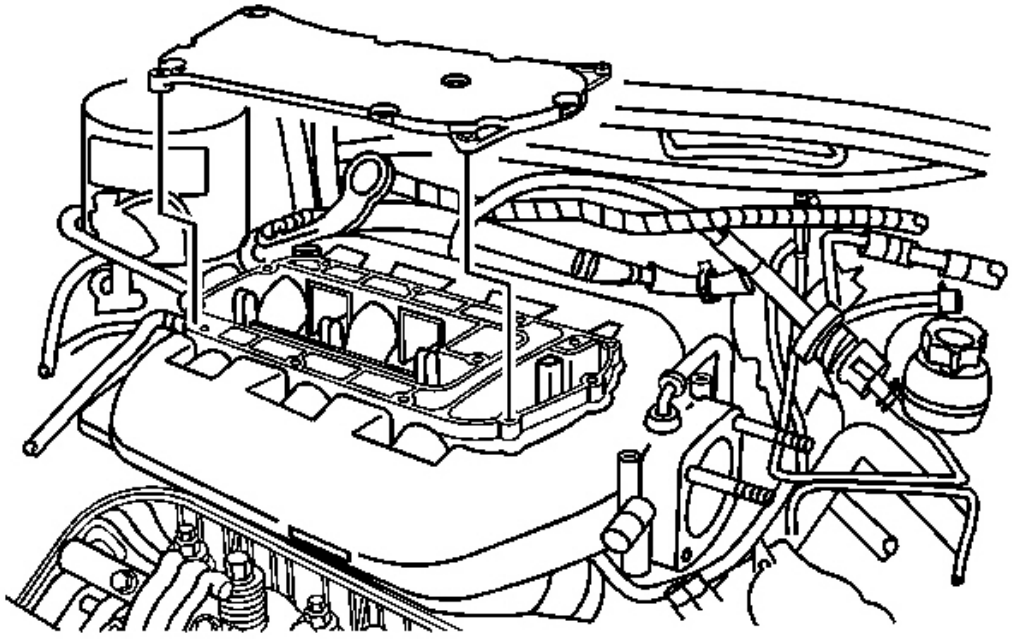


Fig. 41: View Of Intake Manifold
Courtesy of GENERAL MOTORS CORP.

7. Install the intake manifold top cover, nuts, and bolts.
8. Tighten the nuts, and bolts in sequence.

   Tighten:

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

9. Install the throttle body. Refer to **Throttle Body Assembly Replacement** in Engine Controls - 3.5L (L66).
10. Connect the PCV hoses to the intake manifold.
11. Connect the brake booster hose from the intake manifold.
12. Install the outlet resonator/duct assembly. Refer to **Air Cleaner Resonator Outlet Duct Replacement** in Engine Controls - 3.5L (L66).

INTAKE MANIFOLD SPACER REPLACEMENT

Removal Procedure

1. Remove the intake manifold. Refer to **Intake Manifold Replacement** .

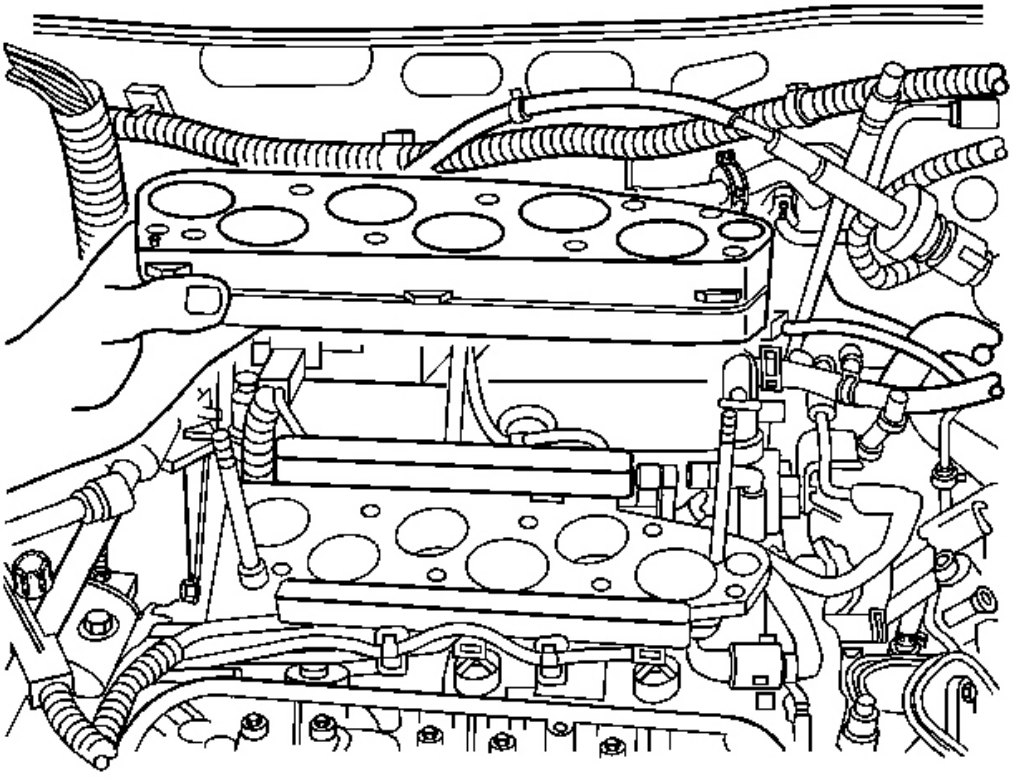


Fig. 42: View Of Intake Manifold Spacer
Courtesy of GENERAL MOTORS CORP.

2. Remove the intake manifold spacer top gasket. Discard the gasket.
3. Remove the intake manifold spacer and spacer bottom gasket. Discard the gasket.

Installation Procedure

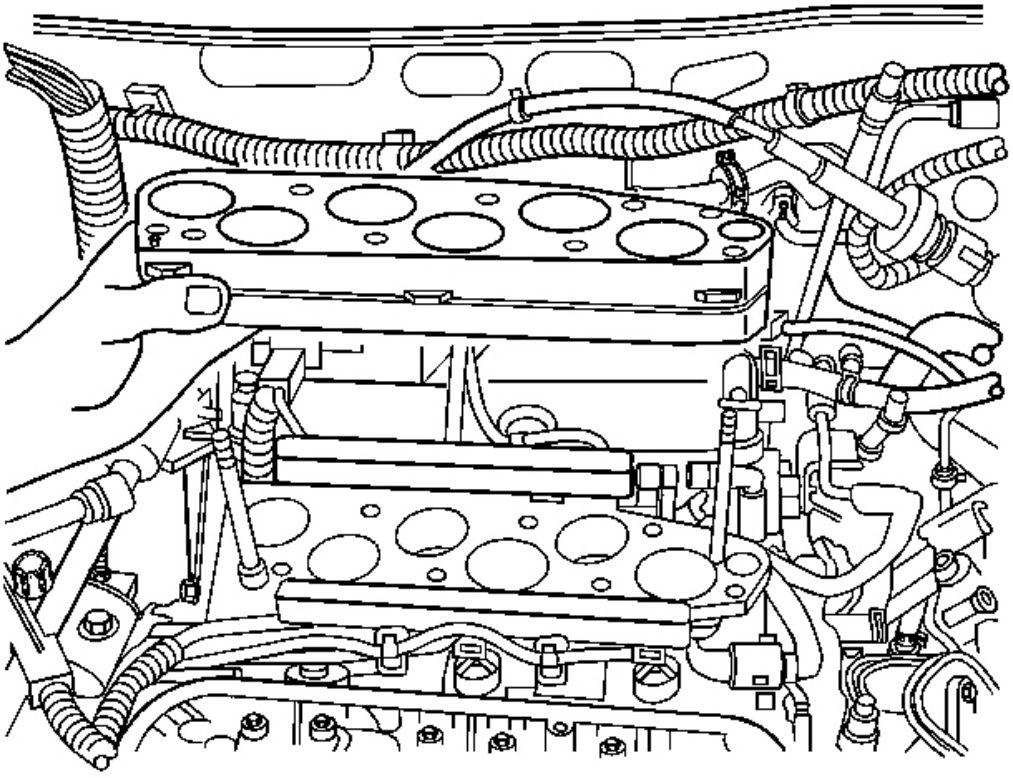


Fig. 43: View Of Intake Manifold Spacer
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW intake manifold spacer bottom gasket.
2. Install the intake manifold spacer.
3. Install a NEW intake manifold spacer top gasket.
4. Install the intake manifold. Refer to **Intake Manifold Replacement** .

INTAKE MANIFOLD REPLACEMENT - LOWER LEFT

Removal Procedure

1. Remove the left fuel rail. Refer to **Fuel Rail Assembly Replacement** in Engine Controls - 3.5L (L66).

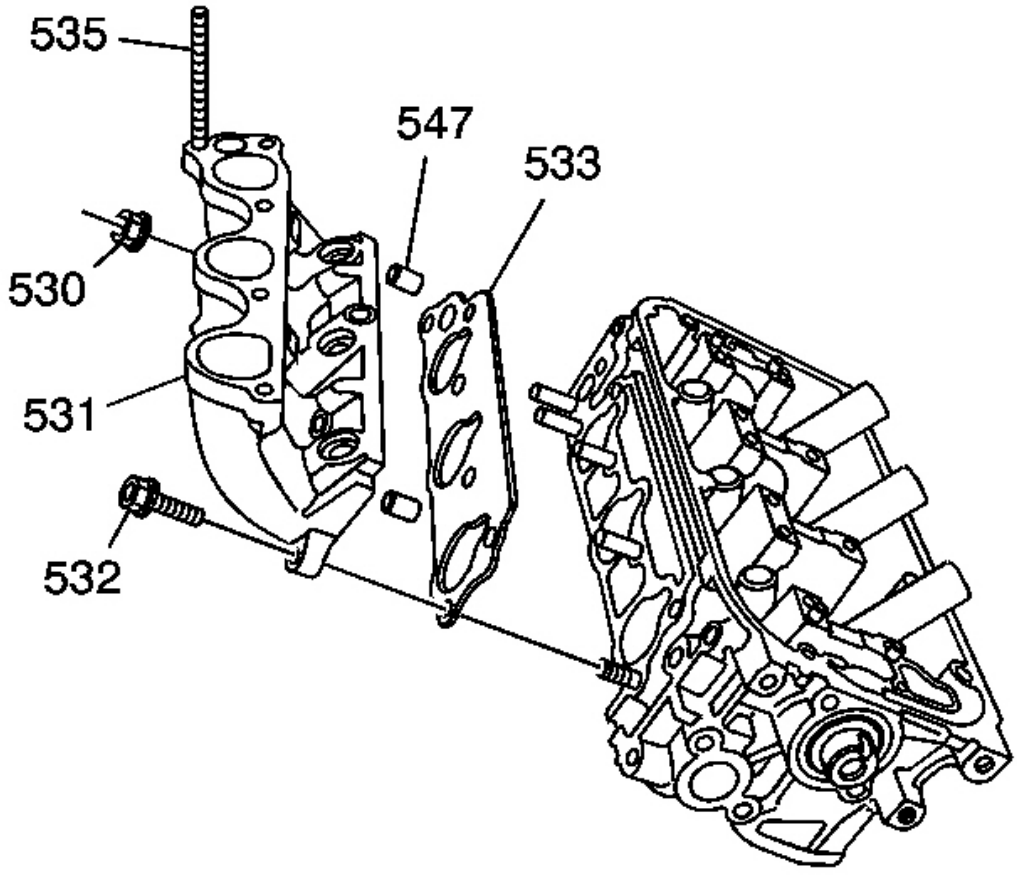


Fig. 44: Identifying Lower Intake Manifold
Courtesy of GENERAL MOTORS CORP.

2. Remove the lower intake manifold nuts (530) and bolts (532).
3. Remove the lower intake manifold and gasket. Discard the gasket.

Installation Procedure

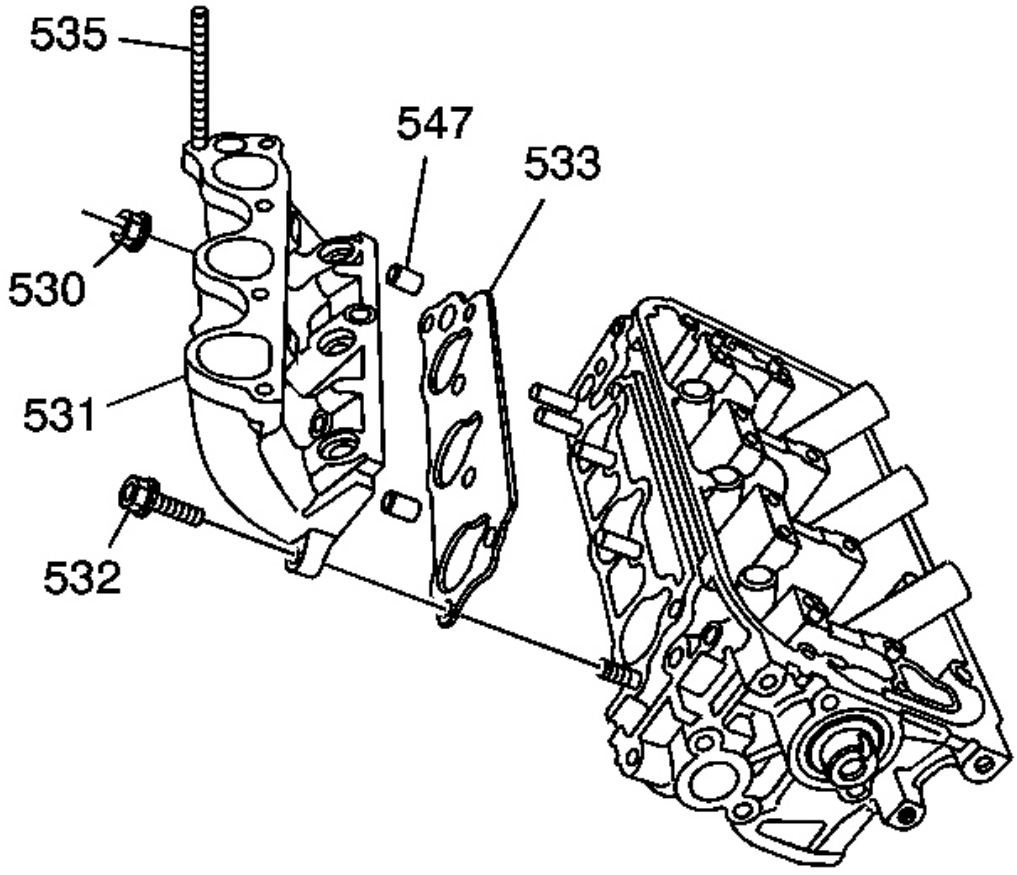


Fig. 45: Identifying Lower Intake Manifold
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW lower intake manifold gasket.
2. Install the lower intake manifold.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the nuts (530) and bolts (532).

   Tighten: Tighten the nuts and bolts to 22 N.m (16 lb ft).

4. Install the left fuel rail. Refer to **Fuel Rail Assembly Replacement** .

INTAKE MANIFOLD REPLACEMENT - LOWER RIGHT

Removal Procedure

1. Remove the right fuel rail. Refer to **Fuel Rail Assembly Replacement** in Engine Controls - 3.5L (L66).

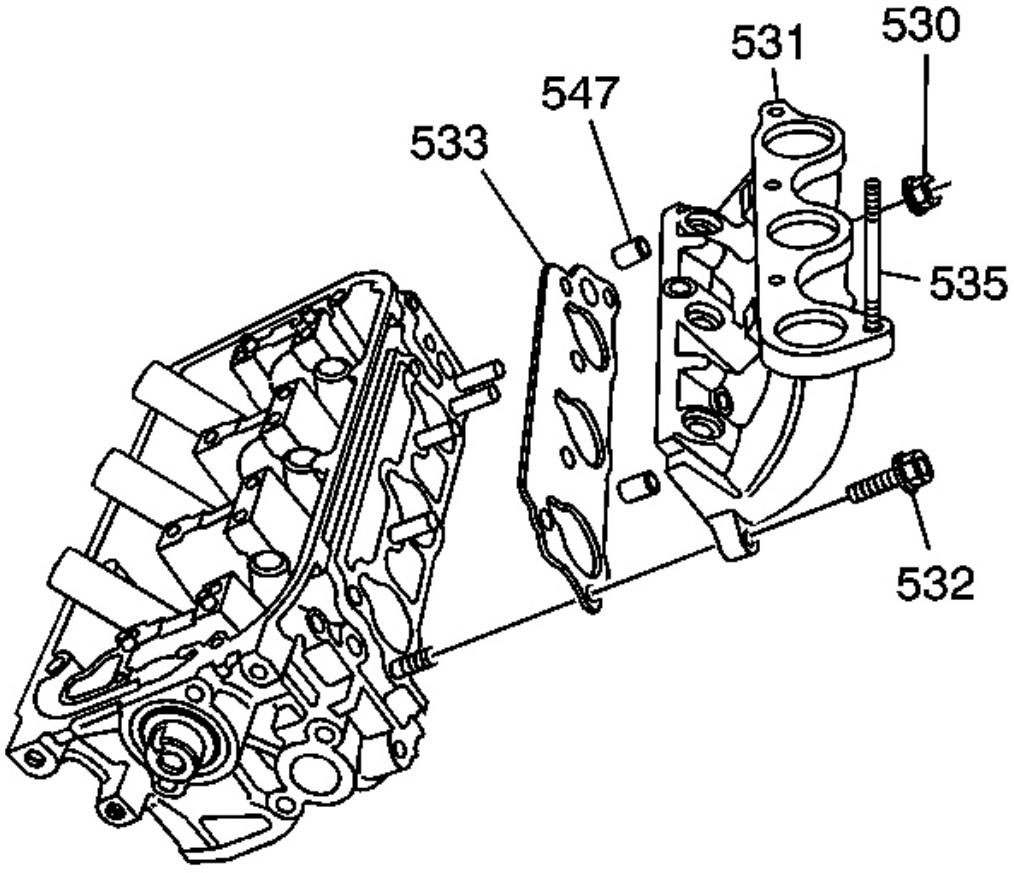


Fig. 46: View Of Lower Intake Manifold
Courtesy of GENERAL MOTORS CORP.

2. Remove the lower intake manifold nuts (530) and bolts (532).
3. Remove the lower intake manifold and gasket. Discard the gasket.

Installation Procedure

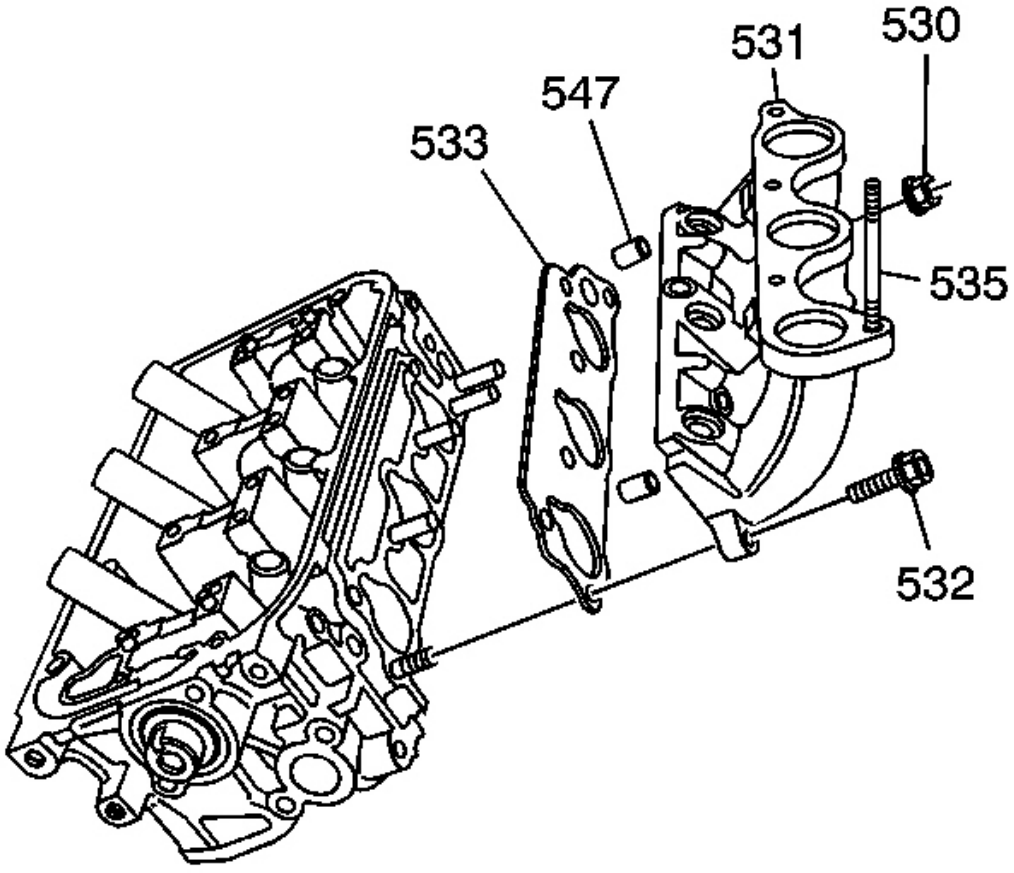


Fig. 47: View Of Lower Intake Manifold
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW lower intake manifold gasket.
2. Install the lower intake manifold.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the nuts (530) and bolts (532).

   Tighten: Tighten the nuts and bolts to 22 N.m (16 lb ft).

4. Install the right fuel rail. Refer to **Fuel Rail Assembly Replacement** .

VALVE ROCKER ARM COVER REPLACEMENT - LEFT

Removal Procedure

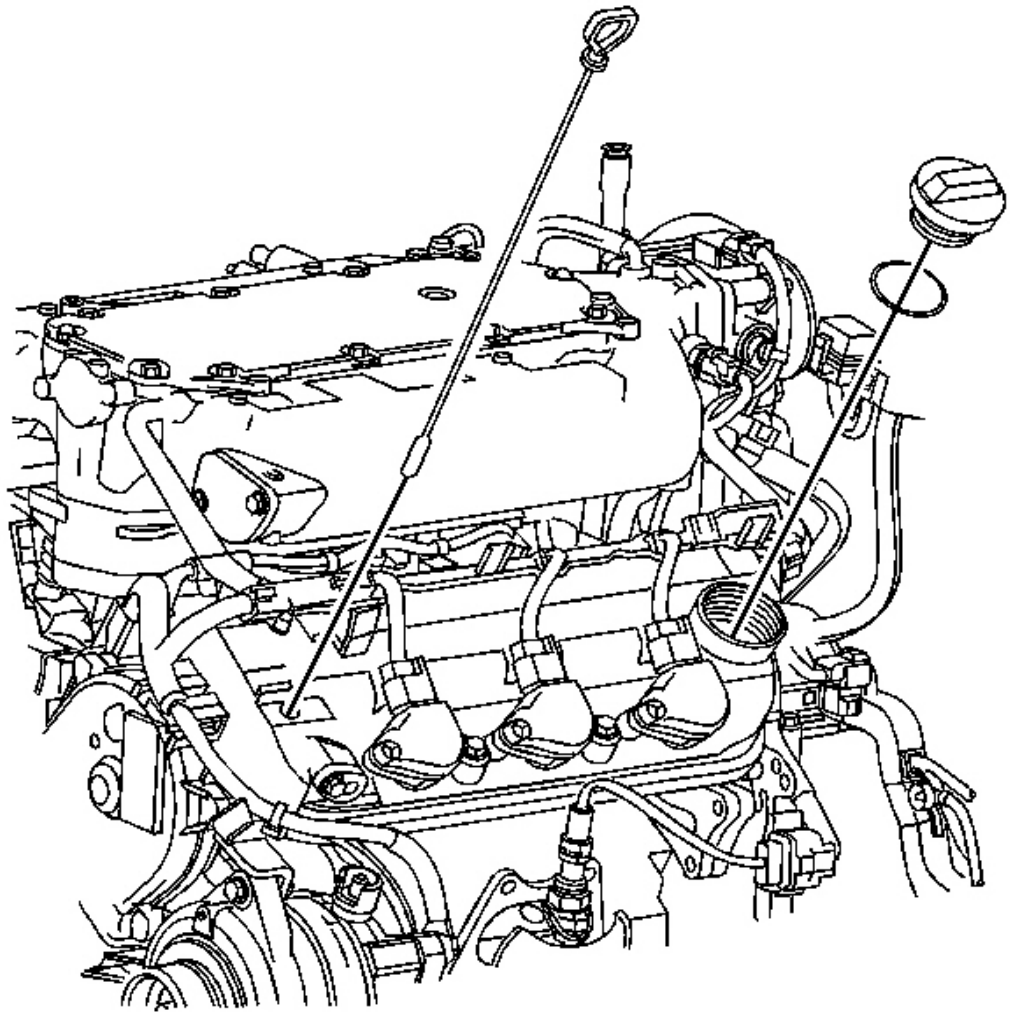


Fig. 48: View Of Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil level indicator.
2. Remove the oil fill cap.
3. Remove the PCV valve and bolt. Refer to **Positive Crankcase Ventilation Valve Replacement** in Engine Controls - 3.5L (L66).
4. Disconnect the ignition wring harness from the ignition coils and retaining bracket.
5. Remove the wiring harness bracket bolt from the cylinder head.

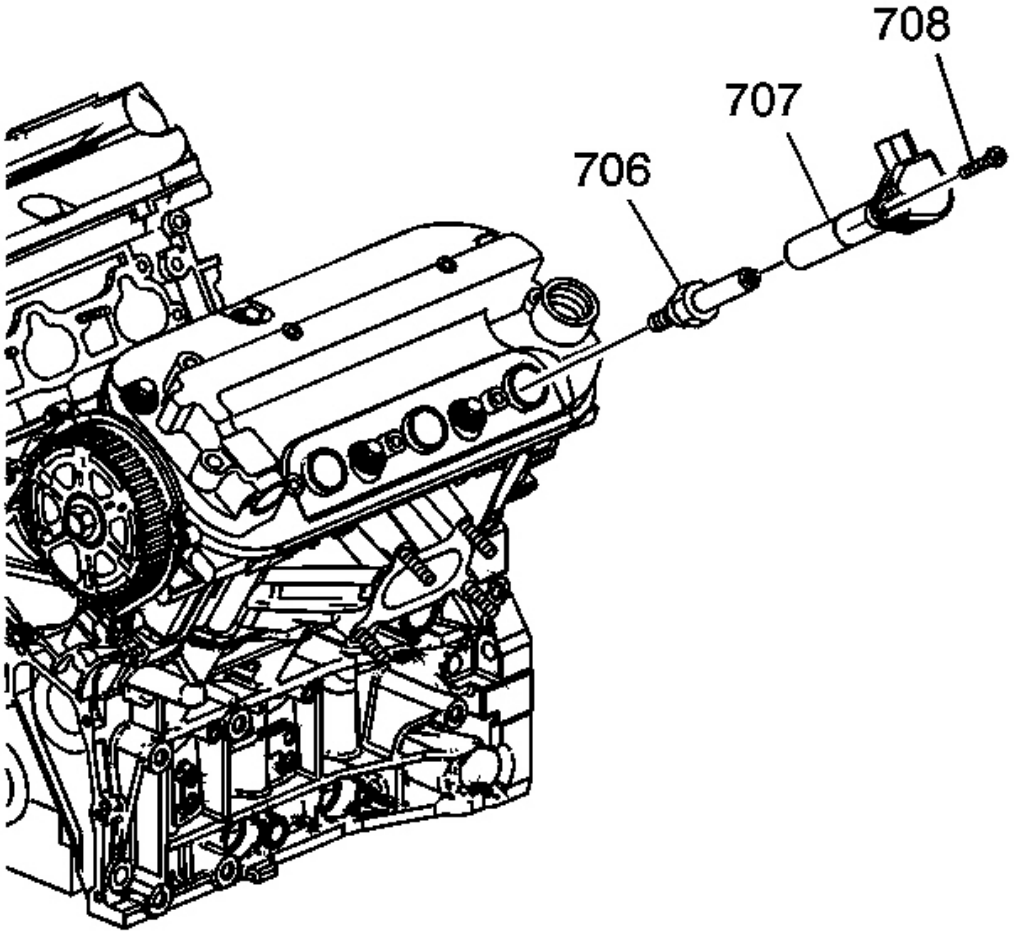


Fig. 49: View Of Bolts & Ignition Coils
Courtesy of GENERAL MOTORS CORP.

6. Remove the bolts (708), and ignition coils (707).

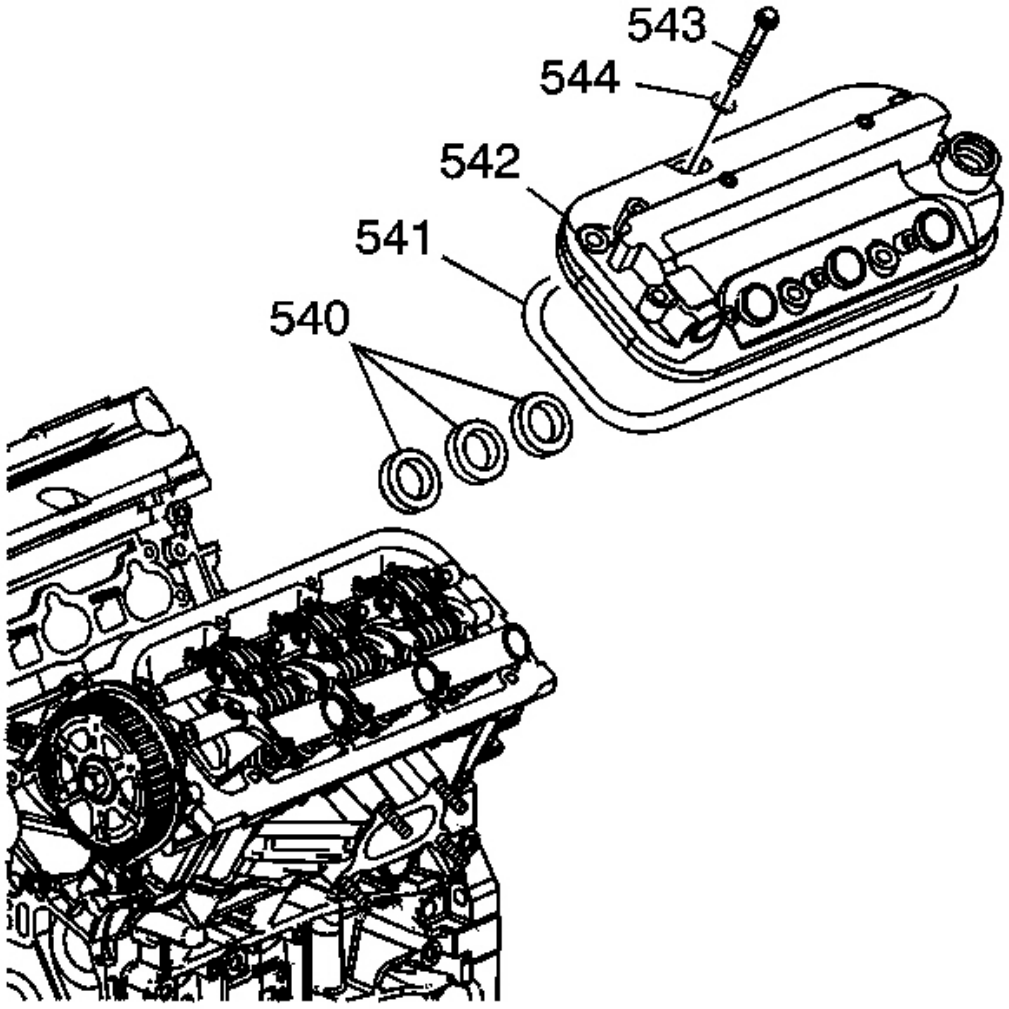


Fig. 50: View Of Seals, Gasket, Cover, Grommets & Bolts
Courtesy of GENERAL MOTORS CORP.

7. Remove the bolts (543), grommets (544), valve cover (542) and gasket (541).
8. Remove the seals (540), if required.

Installation Procedure

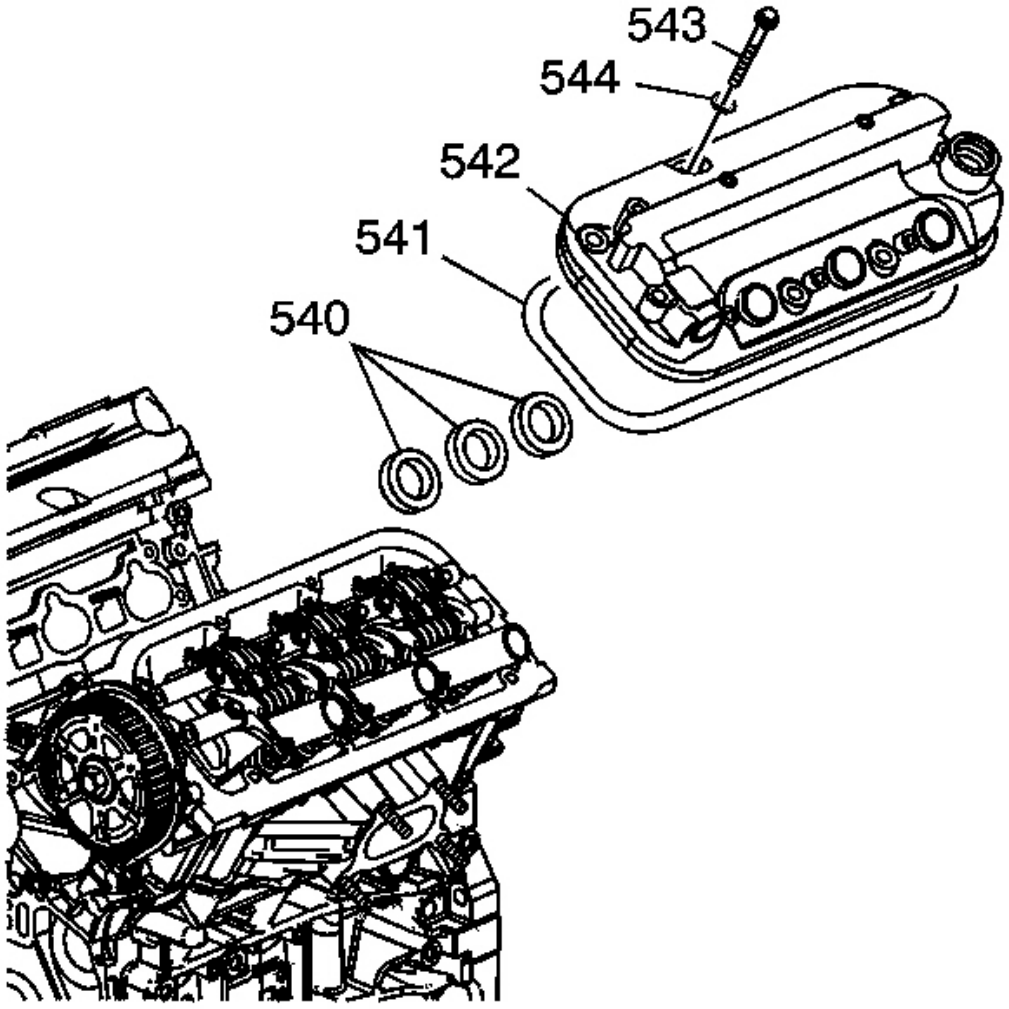


Fig. 51: View Of Seals, Gasket, Cover, Grommets & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install NEW seals (540), NEW gasket (541), cover (542), NEW grommets (544) and bolts (543).

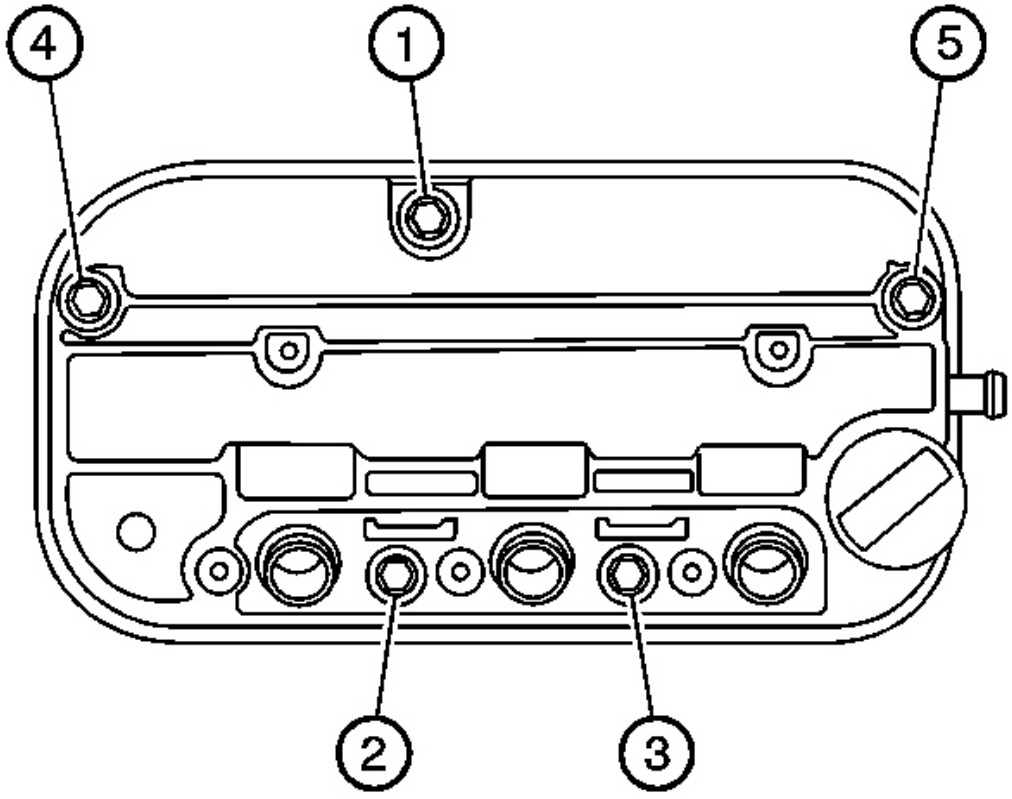


Fig. 52: Identifying Bolts In Sequence
Courtesy of GENERAL MOTORS CORP.

2. Tighten the bolts in sequence.

Tighten:

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

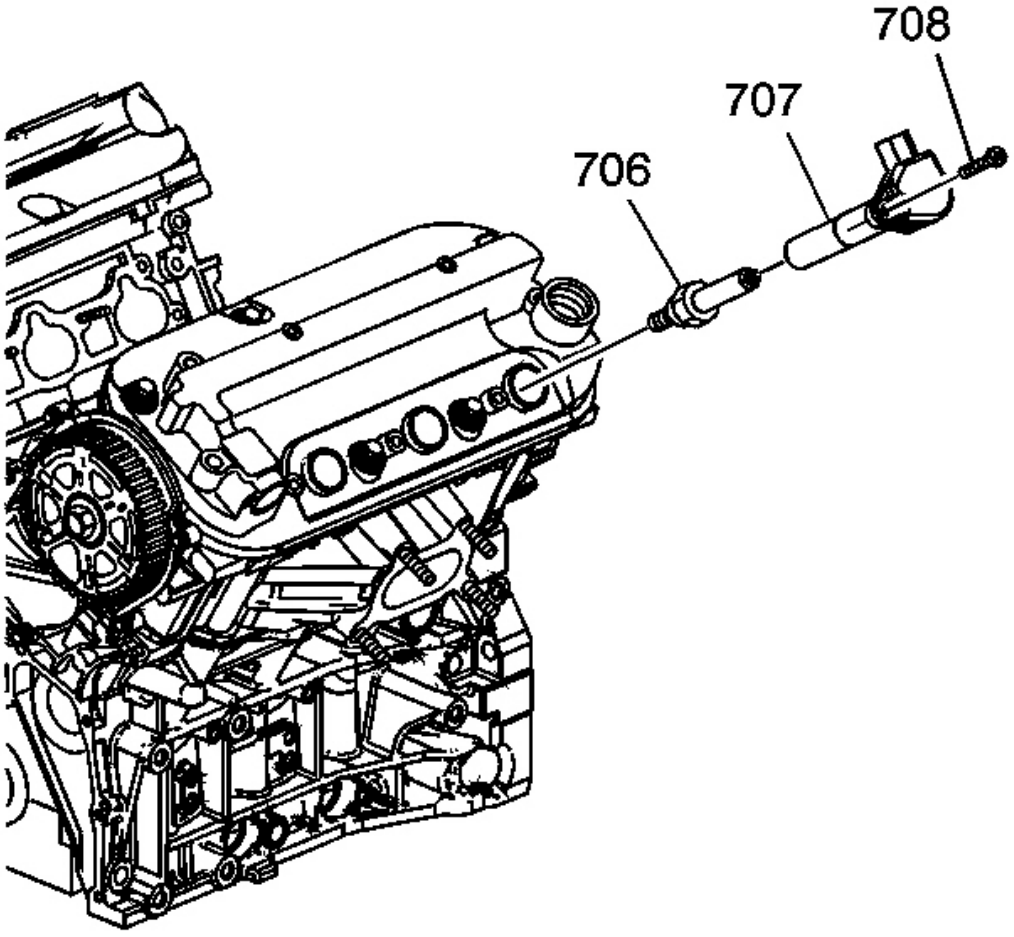


Fig. 53: View Of Bolts & Ignition Coils
Courtesy of GENERAL MOTORS CORP.

3. Install the ignition coils (707) and bolts (708).

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

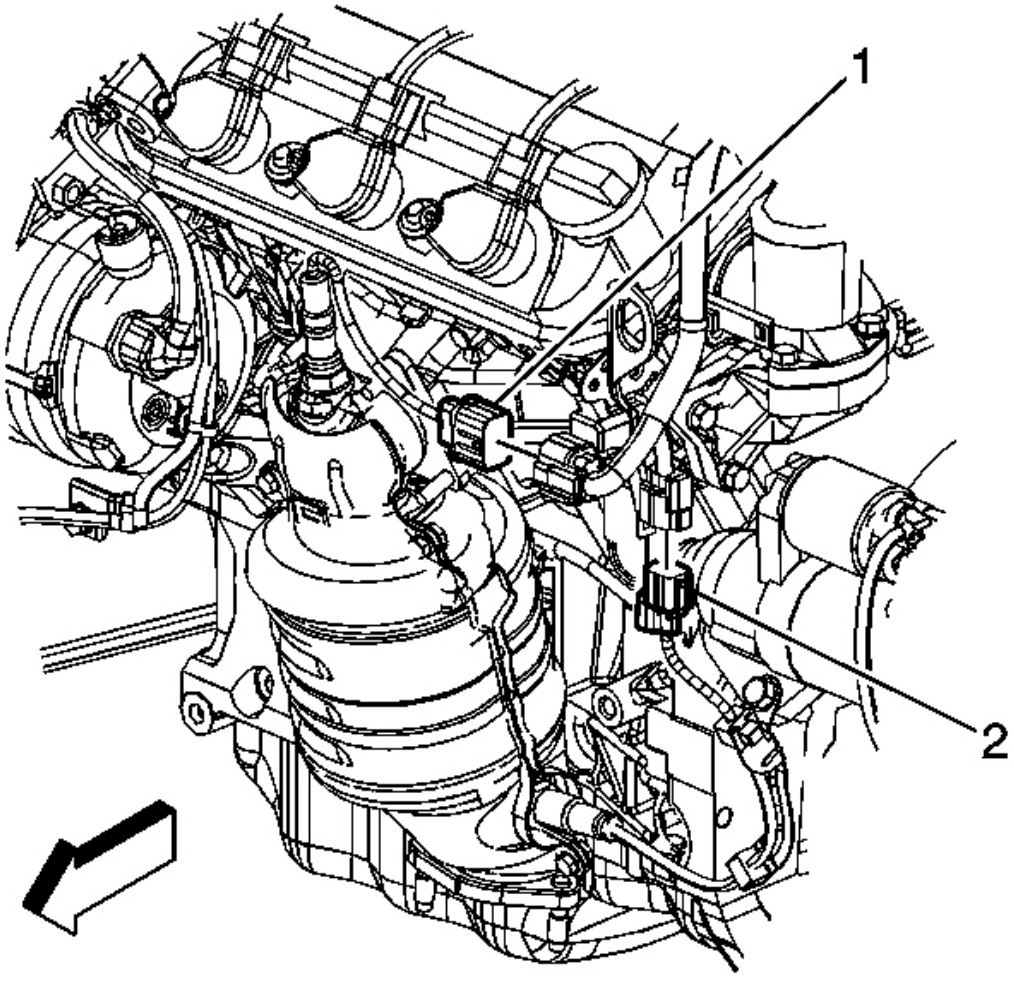


Fig. 54: View Of Wiring Harness Bracket Bolt
Courtesy of GENERAL MOTORS CORP.

4. Install the wiring harness bracket bolt to the cylinder head.

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

5. Connect the ignition wiring harness to the retaining bracket and ignition coils.

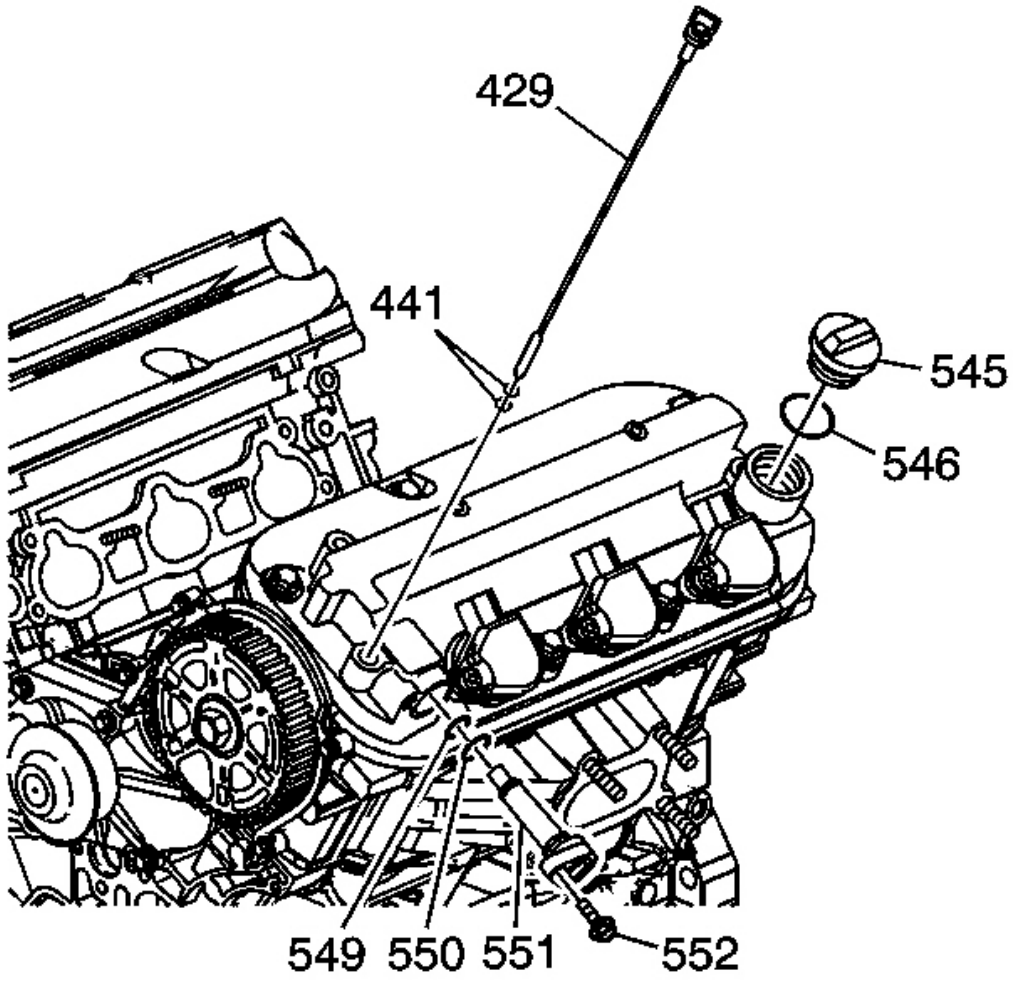


Fig. 55: Identifying Oil Level Indicator, O-rings, Positive Crankcase Ventilation, Valve, Bolts & Cap
Courtesy of GENERAL MOTORS CORP.

6. Install the oil level indicator (429) and NEW O-rings (441).
7. Install the NEW O-rings (549 and 550), positive crankcase ventilation (PCV) valve (551) and bolt (552).

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

8. Install the NEW O-ring (546) and cap (545).

VALVE ROCKER ARM COVER REPLACEMENT - RIGHT

Removal Procedure

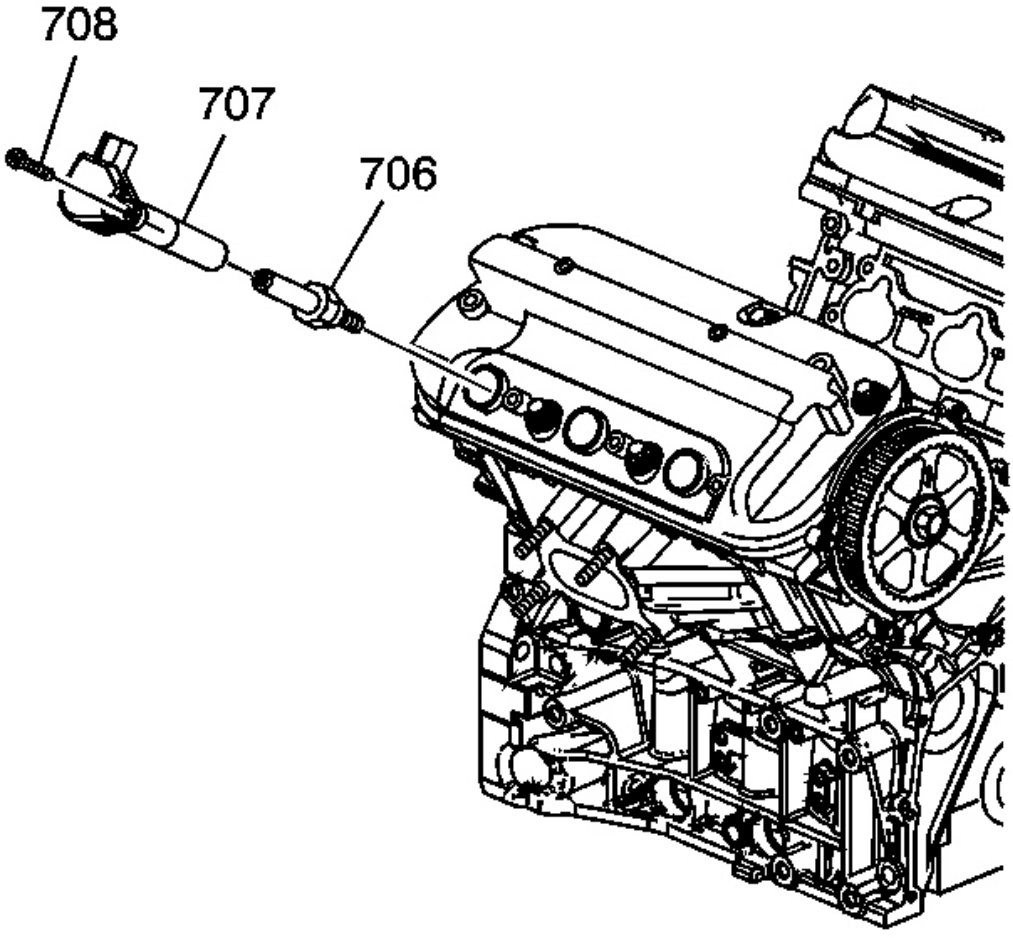


Fig. 56: Identifying Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the vacuum brake booster hose.
2. Disconnect the MAP sensor connector.
3. Disconnect the IAT sensor connector.
4. Disconnect the ECT sensor connector.
5. Disconnect the EVAP purge hose from the purge valve.
6. Remove the intake manifold. Refer to **Intake Manifold Removal** .
7. Disconnect the fuel injector connectors.

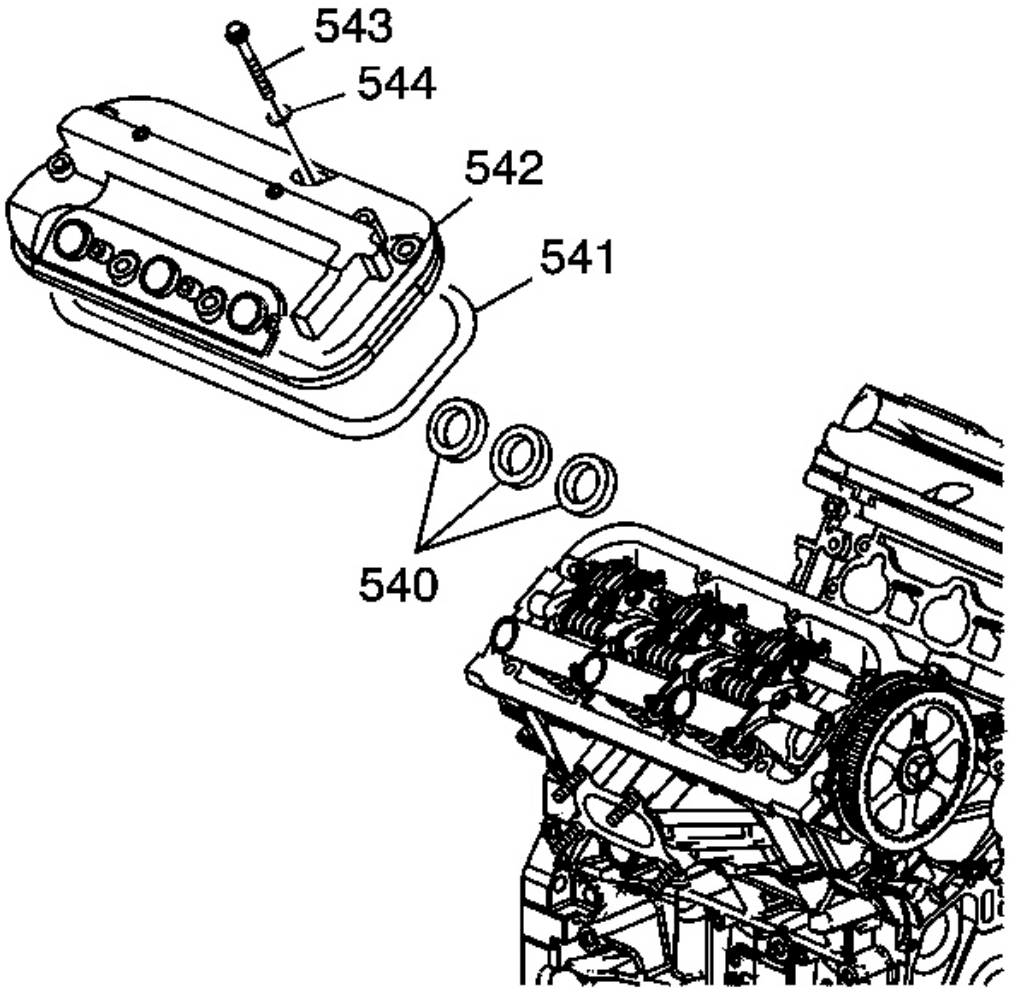


Fig. 57: Identifying Wiring Harness Bracket Bolt
Courtesy of GENERAL MOTORS CORP.

8. Remove the wiring harness bracket bolt from the valve rocker arm cover.
9. Remove the ignition coils. Refer to **Ignition Coil(s) Replacement - Bank 1** .
10. Remove the bolts (543), grommets (544), valve cover (542) and gasket (541).
11. Remove the seals (540), if required.

Installation Procedure

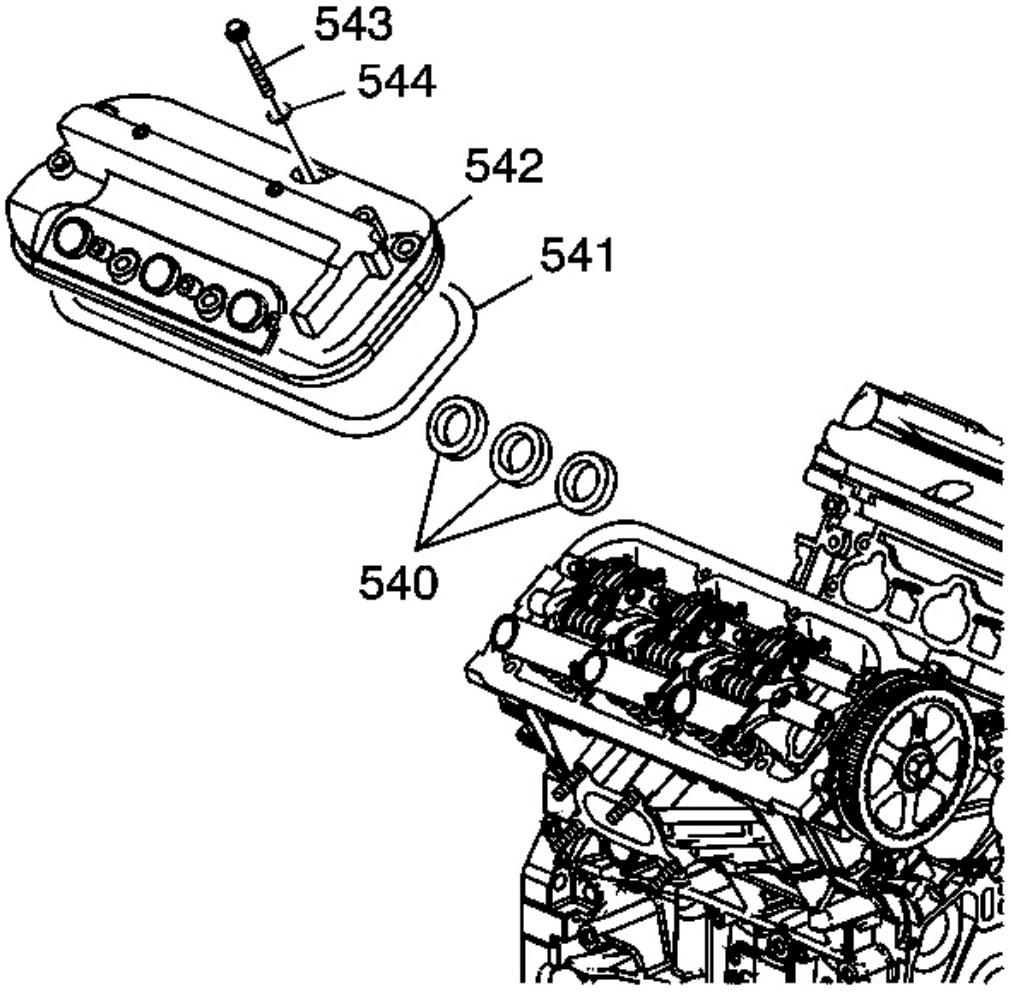


Fig. 58: Identifying Wiring Harness Bracket Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install NEW seals (540), NEW gasket (541), cover (542), NEW grommets (544) and bolts (543).

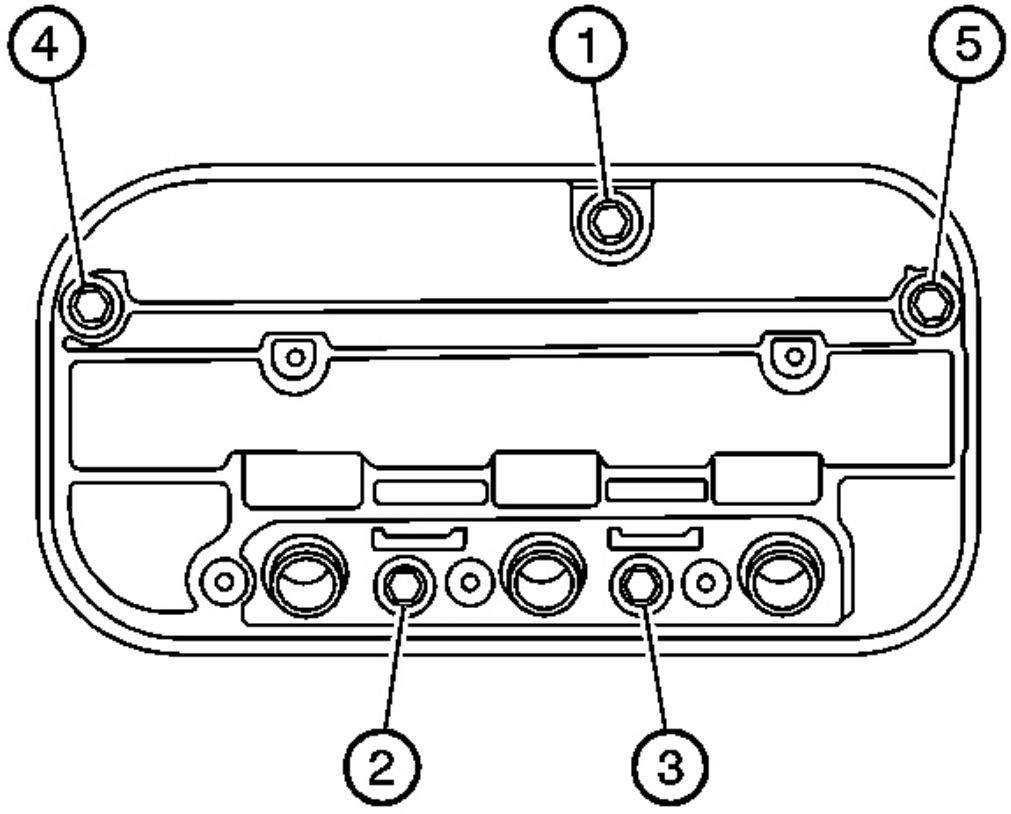


Fig. 59: View Of Bolts In Sequence
Courtesy of GENERAL MOTORS CORP.

2. Tighten the bolts in sequence.

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

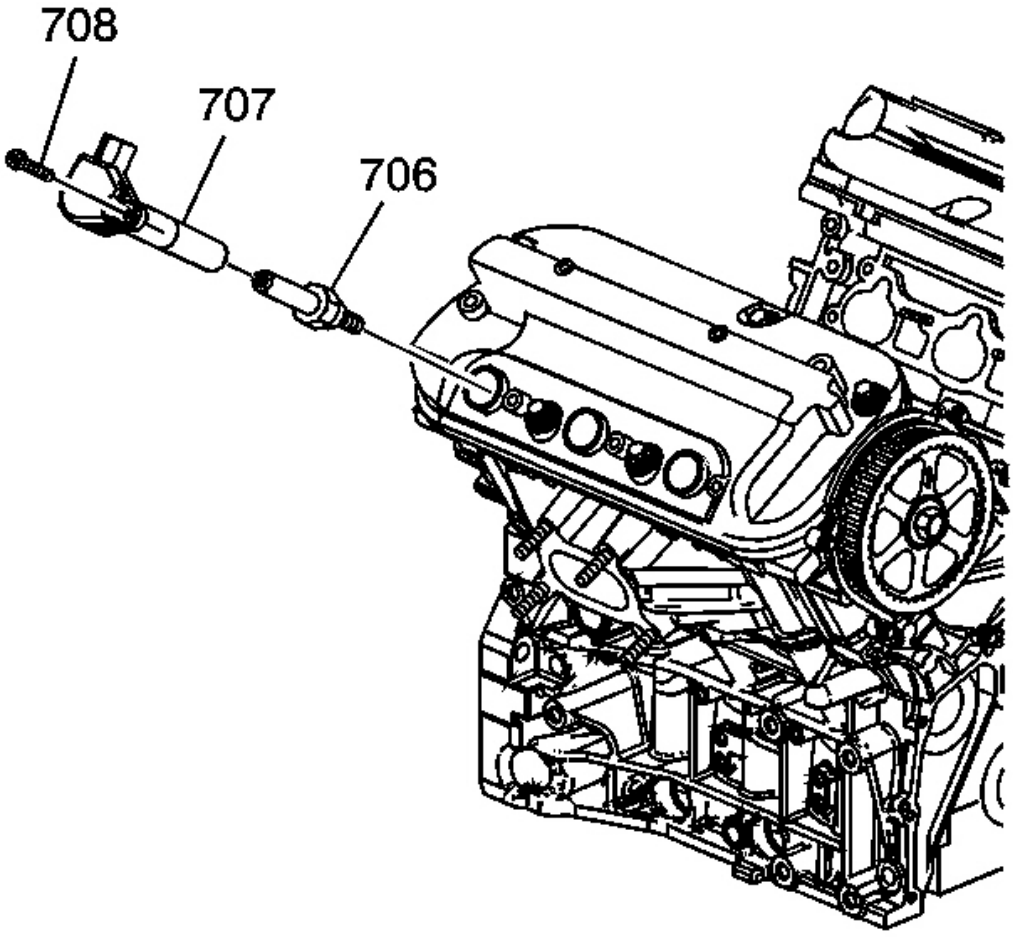


Fig. 60: Identifying Spark Plugs, Ignition Coils & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Install the ignition coils (707) and bolts (708).

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

4. Install the wiring harness bracket bolt to the valve rocker arm cover.

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

5. Connect the fuel injector connectors.
6. Install the intake manifold. Refer to **Intake Manifold Removal** .

7. Connect the EVAP purge hose.
8. Connect the IAT sensor connector.
9. Connect the MAP sensor connector.
10. Connect the vacuum brake booster hose.
11. Connect the ECT sensor connector.

VALVE ROCKER ARM AND SHAFT REPLACEMENT

Removal Procedure

IMPORTANT: Identify parts as they are removed so they can be installed in their original locations if used again. When removing or installing the rocker arm shaft assembly, do not remove the rocker arm shaft mounting bolts. The bolts will retain the springs and rocker arms onto the shaft.

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

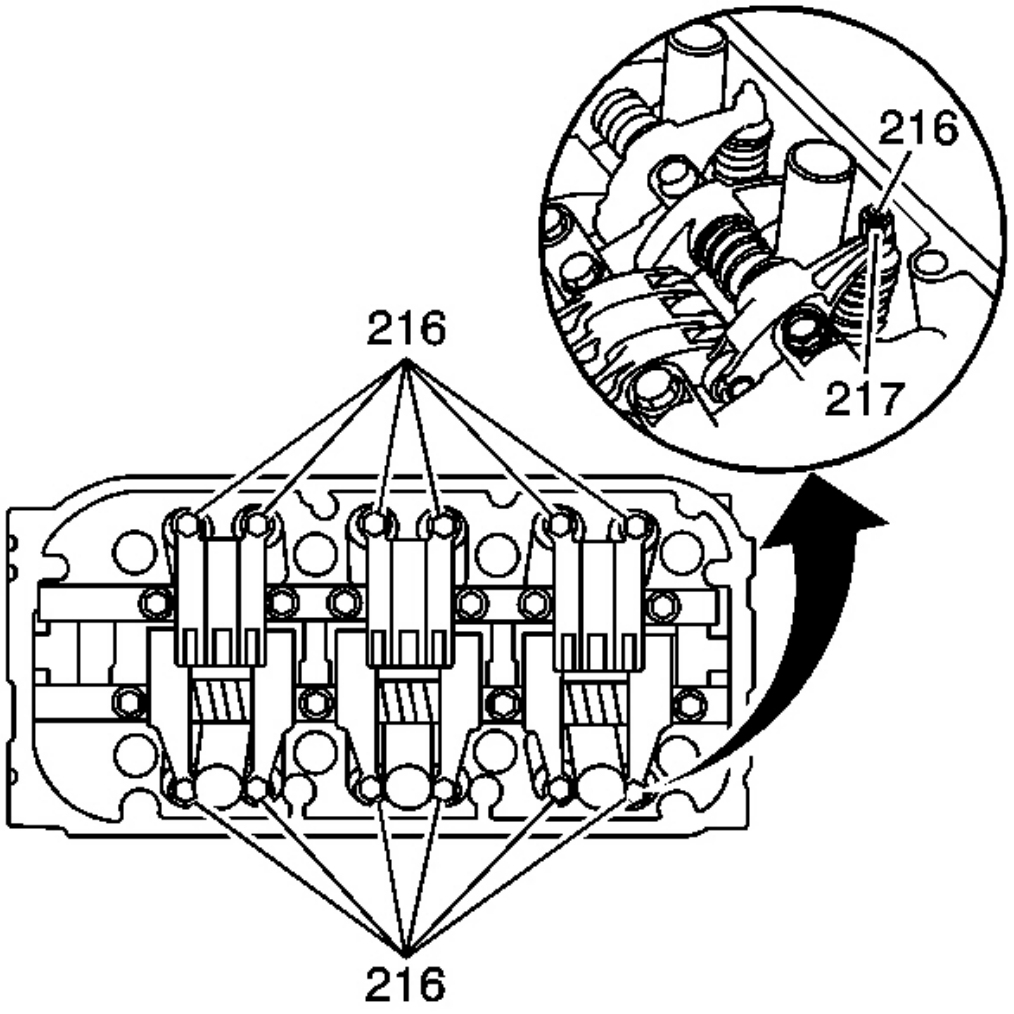


Fig. 61: View Of Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

2. Loosen the adjusting nuts (217) and bolts (216).

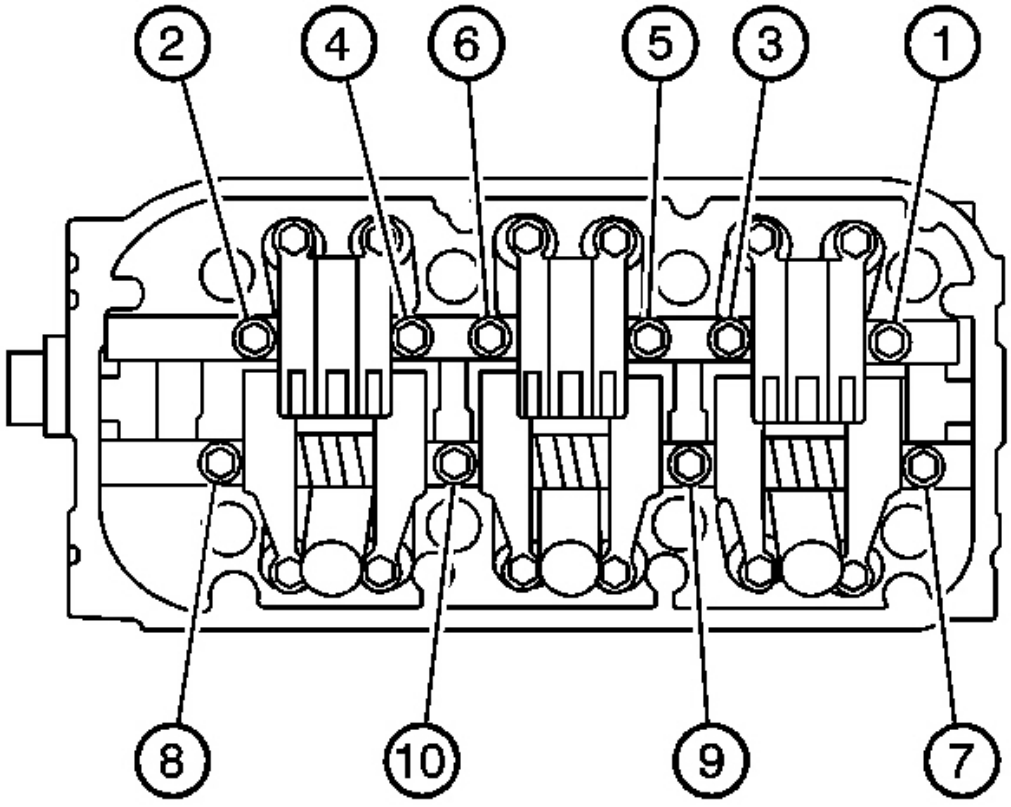


Fig. 62: Identifying Rocker Shaft Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

3. Loosen the left side rocker shaft retaining bolts in sequence. Loosen the valve rocker shaft mounting bolts 2 turns at a time in sequence, to prevent damaging the valves or rocker arms.

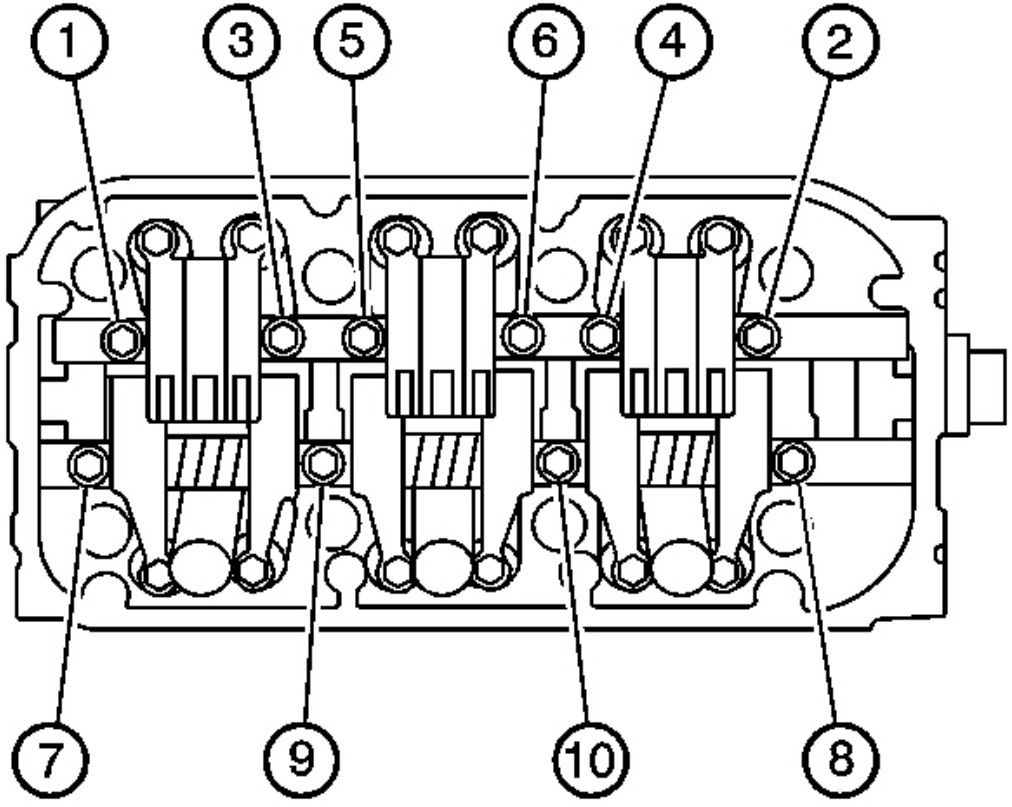


Fig. 63: View Of Right Side Rocker Shaft Retaining Bolts In Sequence
Courtesy of GENERAL MOTORS CORP.

4. Loosen the right side rocker shaft retaining bolts in sequence. Loosen the valve rocker shaft mounting bolts 2 turns at a time in sequence, to prevent damaging the valves or rocker arms.

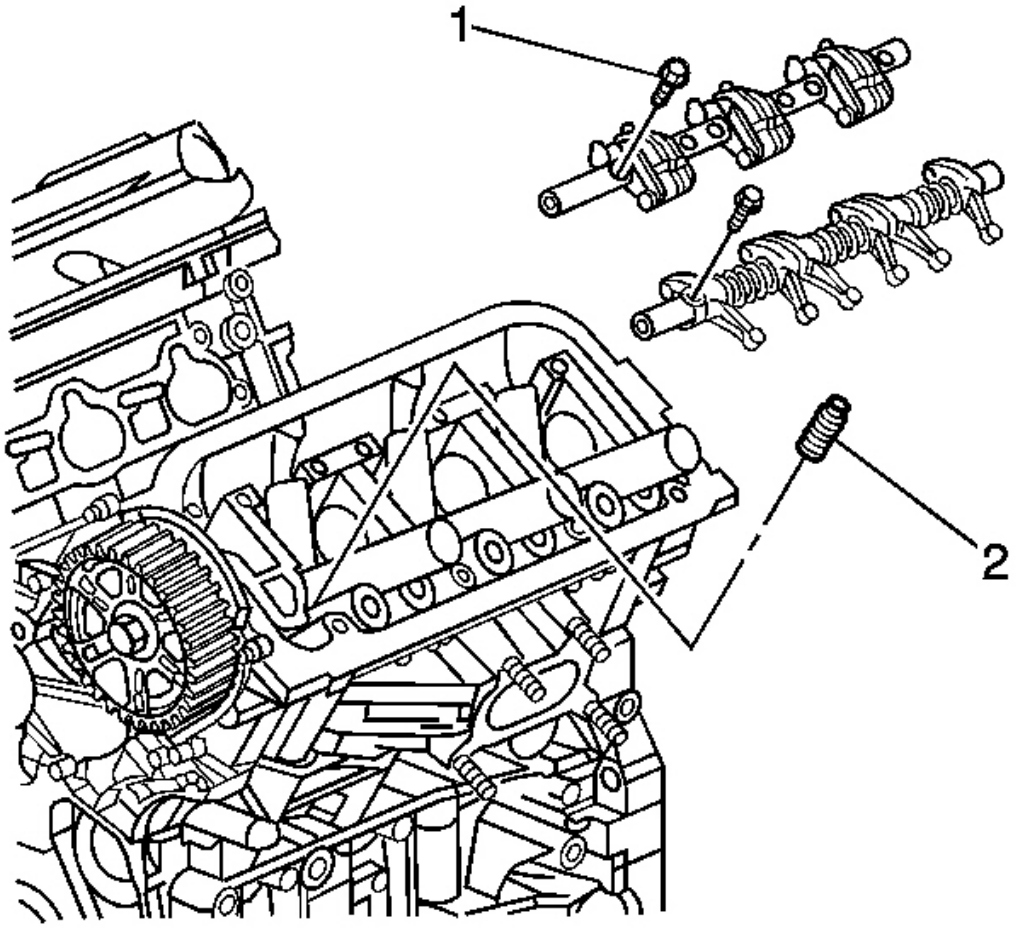


Fig. 64: View Of Bolts, Valve Rocker Arm & Shaft Assemblies
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Identify parts as they are removed so they can be installed in their original locations if used again. When removing or installing the rocker arm shaft assembly, do not remove the rocker arm shaft mounting bolts. The bolts will retain the springs and rocker arms on the shaft.

5. Remove the bolts (1) and valve rocker arm and shaft assemblies.
6. Remove the lash adjusters (2).

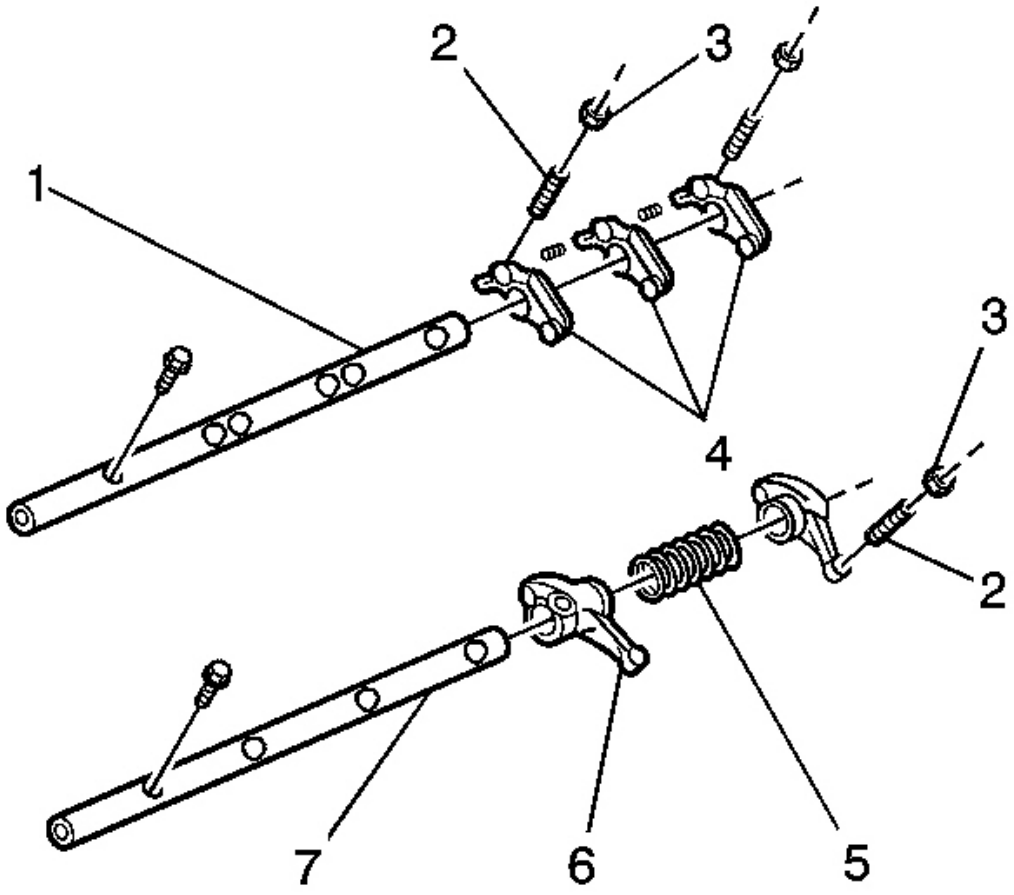


Fig. 65: Exploded View Of Intake Valve Rocker Arms
Courtesy of GENERAL MOTORS CORP.

7. Remove the intake valve rocker arms as an assembly (4) from the shaft (1). Refer to **Separating Parts** .
8. Remove the exhaust valve rocker arms (6) and springs (5) from the shaft (7).
9. Remove the nuts (3) and bolts (2).

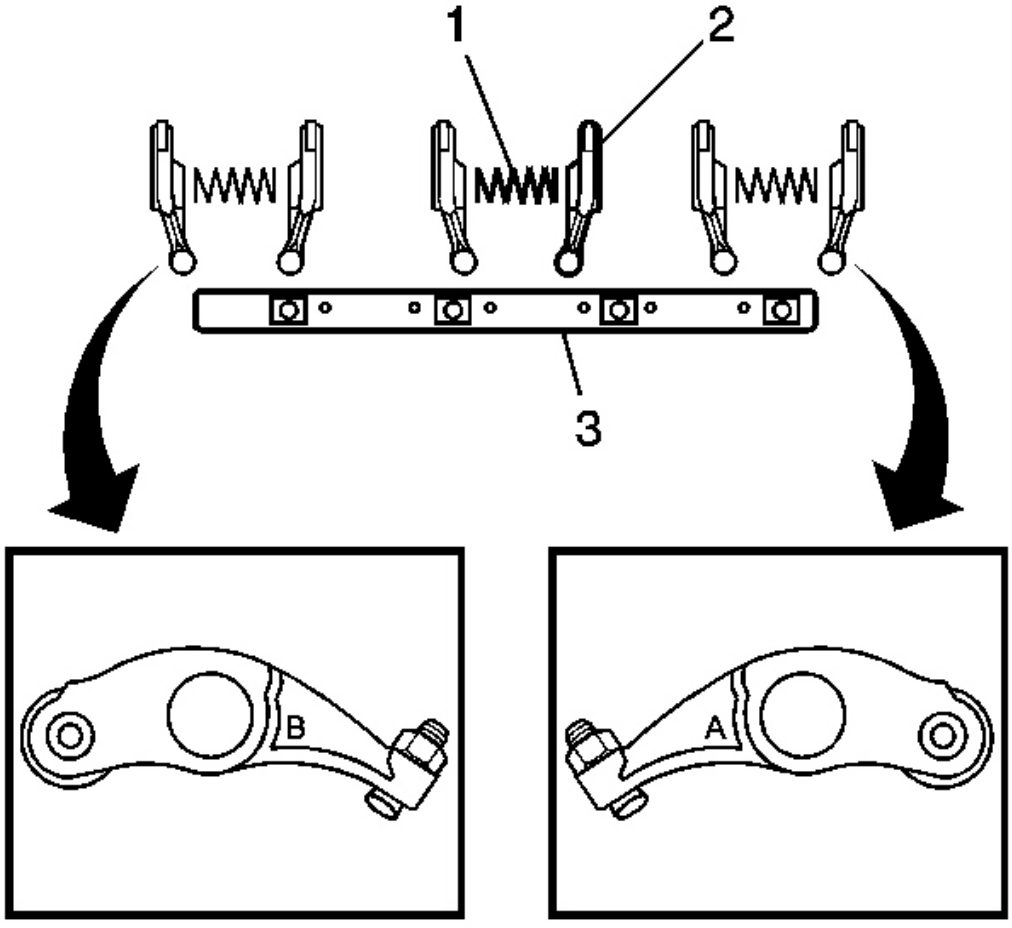


Fig. 66: View Of Exhaust Valve Rocker Arms
Courtesy of GENERAL MOTORS CORP.

10. Note the installed location of the exhaust valve rocker arms (2).

Installation Procedure

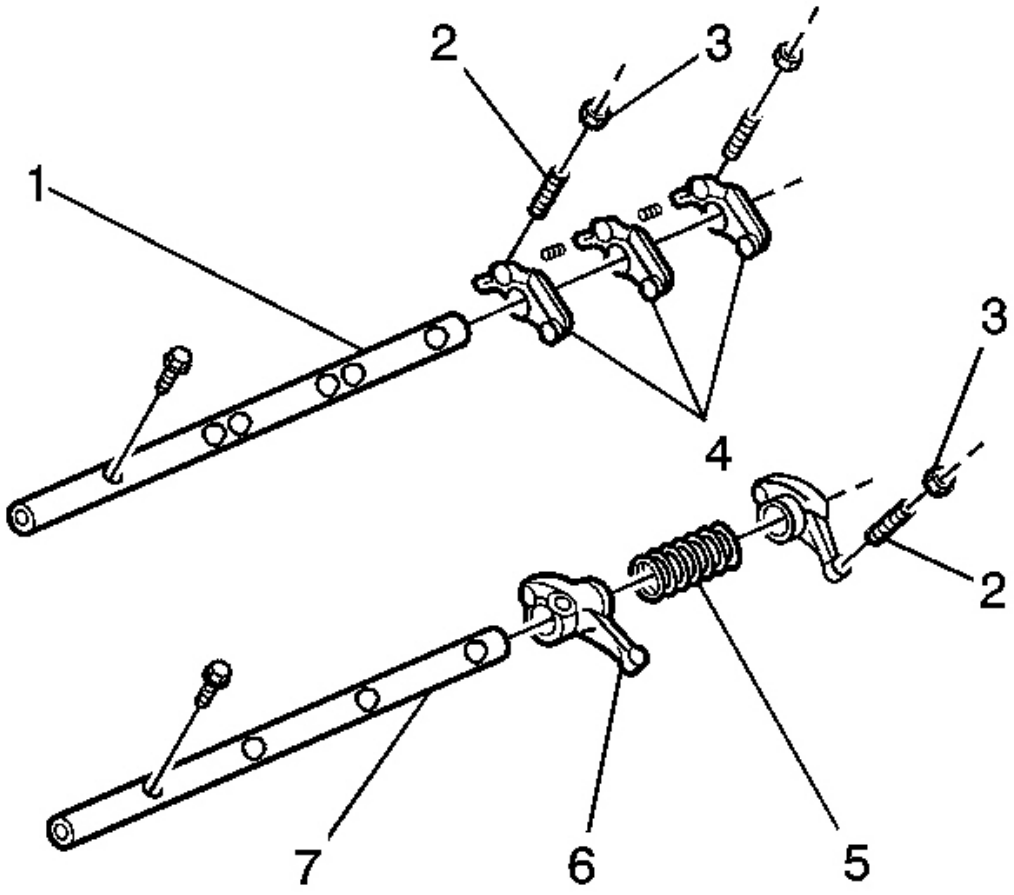


Fig. 67: Exploded View Of Intake Valve Rocker Arms
Courtesy of GENERAL MOTORS CORP.

1. Install the bolts (2) and nuts (3). Do not tighten the nuts at this time.
2. Install the intake valve rocker arm assemblies (4) onto the shaft (1).
3. Install the bolts to the shaft (1).
4. Install the exhaust valve rocker arms (6) and springs (5) onto the shaft (7).

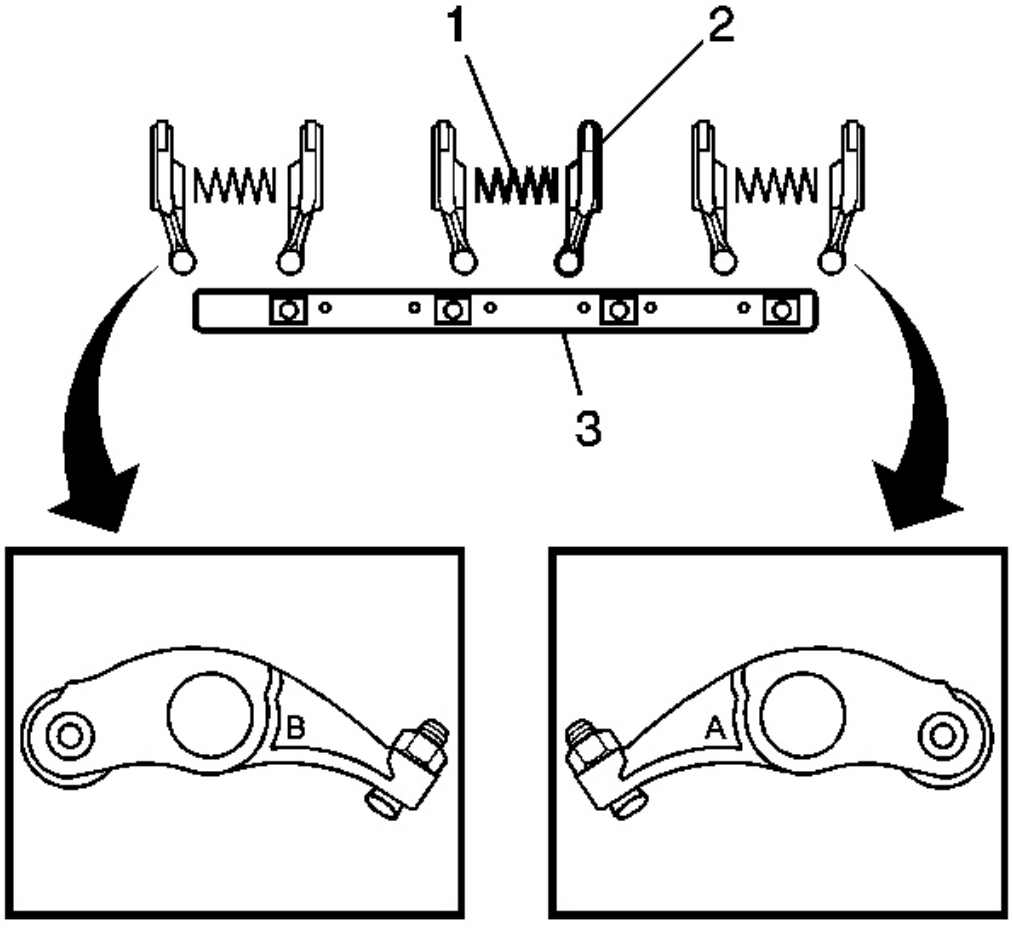


Fig. 68: View Of Exhaust Valve Rocker Arms
Courtesy of GENERAL MOTORS CORP.

5. Note the installed position of the exhaust valve rocker arms (2).
6. Install the bolts to the shaft (3).

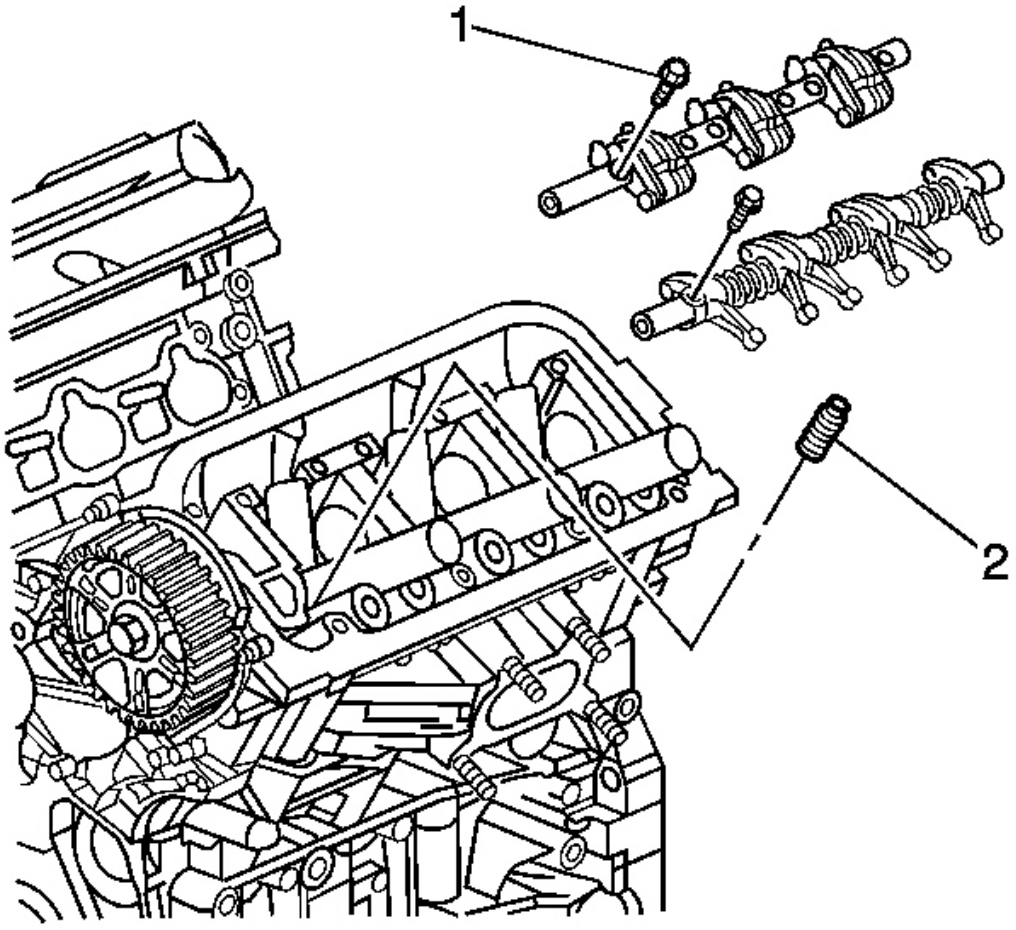


Fig. 69: View Of Bolts, Valve Rocker Arm & Shaft Assemblies
Courtesy of GENERAL MOTORS CORP.

7. Install the lash adjusters (2).

NOTE: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT: The intake rocker arm shaft front locating pin serves as an oil passage for VTEC system operation. During assembly, use care to locate the shaft onto the pin. Replace pins that are bent or damaged.

8. Install the rocker arm and shaft assemblies and bolts (1).

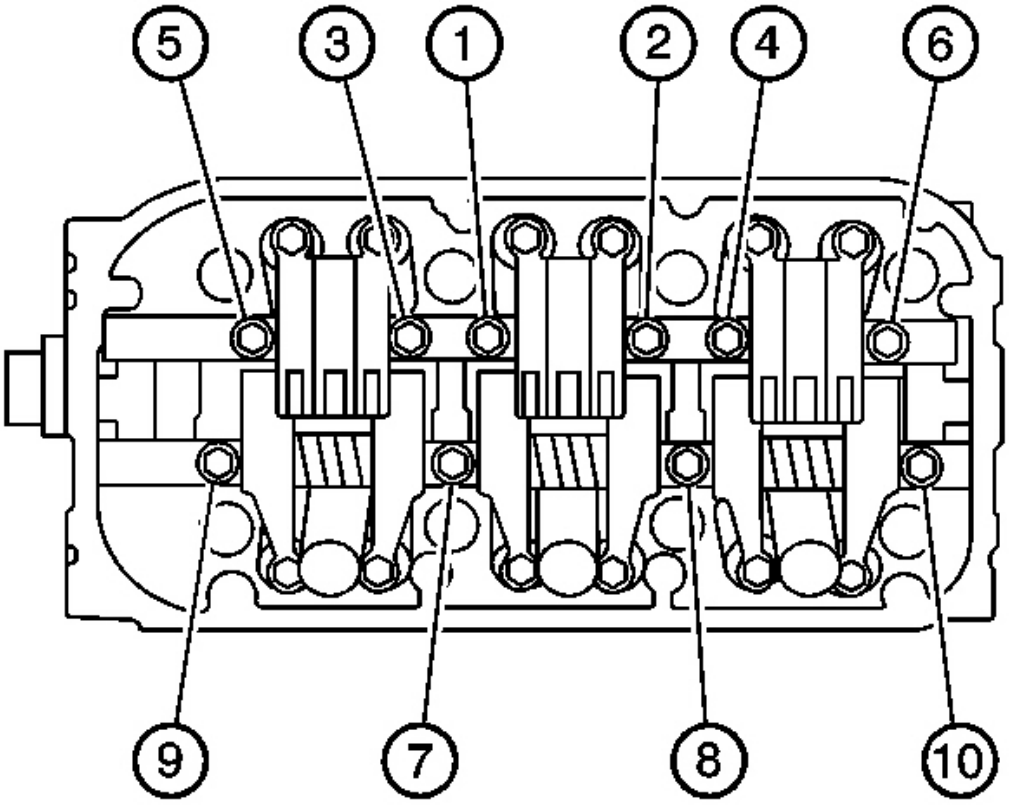


Fig. 70: View Of Left Side Rocker Shaft Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

9. Tighten the left side rocker shaft retaining bolts in sequence. Tighten the bolts 2 turns at a time in sequence, to ensure that the rocker arms do not bind on the valves.

   Tighten:

   1. Tighten the bolts in sequence a first pass to 12 N.m (106 lb in).
   2. Tighten the bolts in sequence a final pass to 24 N.m (17 lb ft).

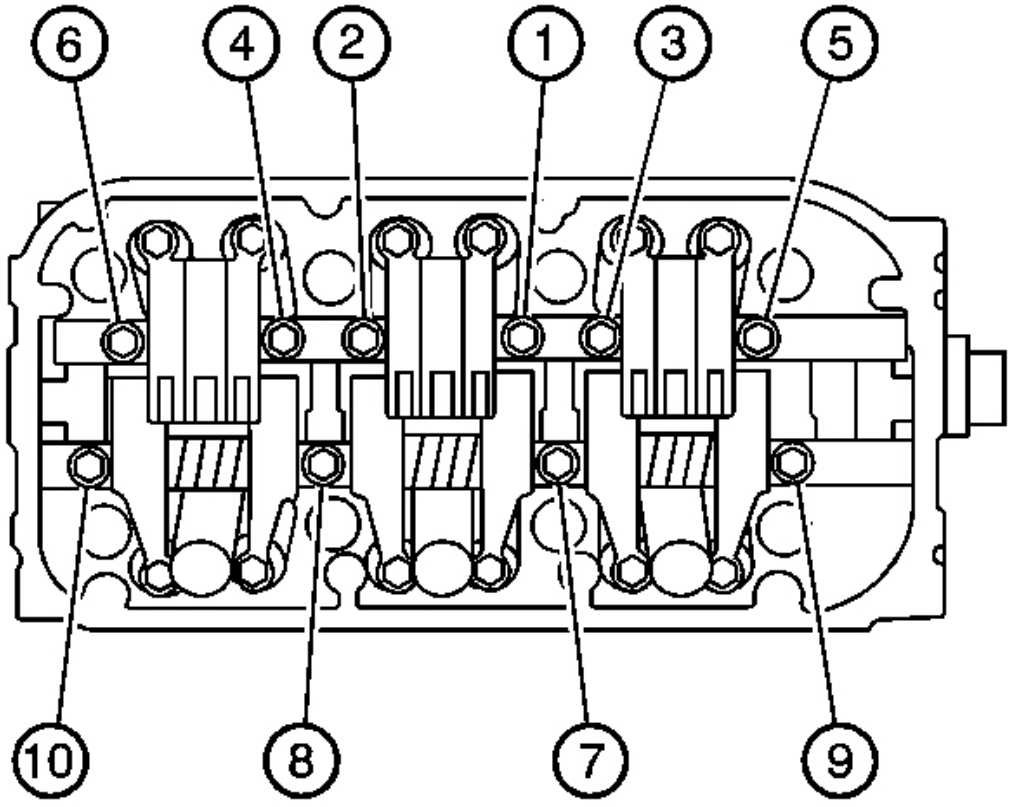


Fig. 71: Identifying Right Side Rocker Shaft Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

10. Tighten the right side rocker shaft retaining bolts in sequence. Tighten the bolts 2 turns at a time in sequence, to ensure that the rocker arms do not bind on the valves.
11. Install the valve rocker arm cover. Refer to**Valve Rocker Arm Cover Replacement - Left** and **Valve Rocker Arm Cover Replacement - Right** .

VALVE STEM OIL SEAL AND VALVE SPRING REPLACEMENT

Tools Required

- J 43059 Valve Retainer Remover/Installer
- **SA9102E-A** Valve Stem Seal Installer. See **Special Tools and Equipment** .
- **SA9127E** Spark Plug Port Adapter
- **EN 46335** Valve Spring Compressor. See **Special Tools and Equipment** .

- **EN 46336** Valve Guide Seal Installer. See **Special Tools and Equipment** .

Removal Procedure

1. Remove the valve rocker arms. Refer to **Valve Rocker Arm and Shaft Replacement** .
2. Remove the spark plug. Refer to **Spark Plug Replacement** in Engine Controls - 3.5L (L66).
3. Install the **SA9127E** and apply air pressure to the cylinder in order to keep the valve from dropping into the cylinder.
4. Using an appropriately sized deep socket and a plastic hammer, lightly tap on the valve spring retainer to loosen the valve keepers.

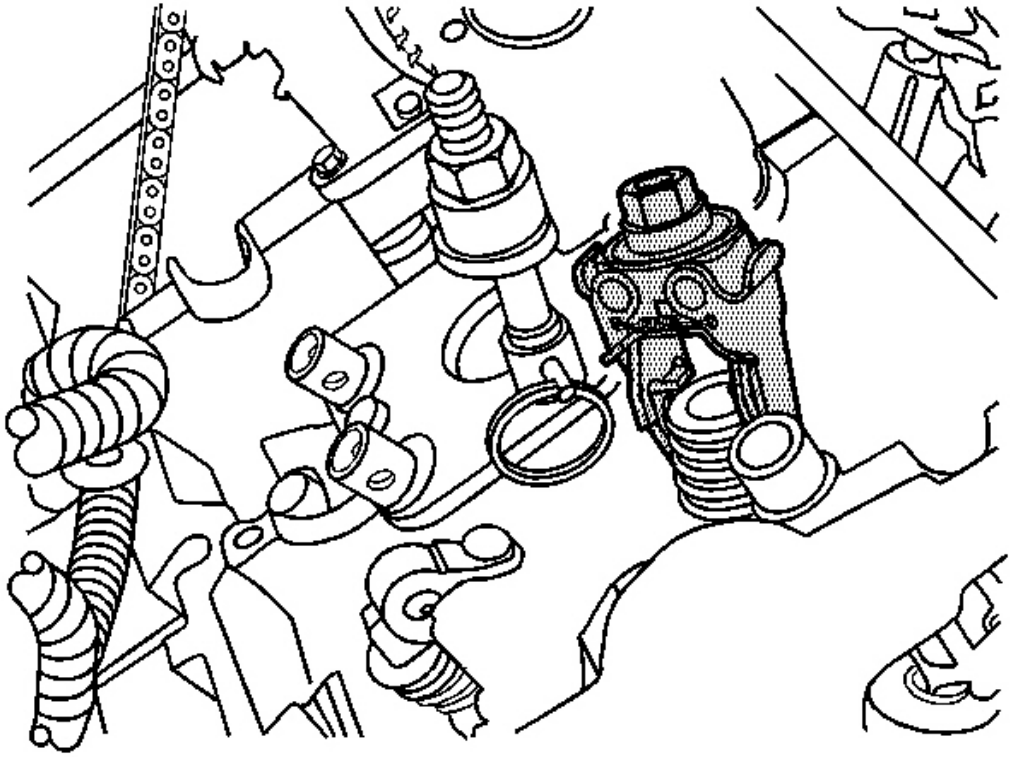


Fig. 72: View Of Valve Steam Seal
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Compressed Valve Spring Caution in Cautions and Notices.

5. Compress the valve spring with the **EN 46335** . See **Special Tools and Equipment** .

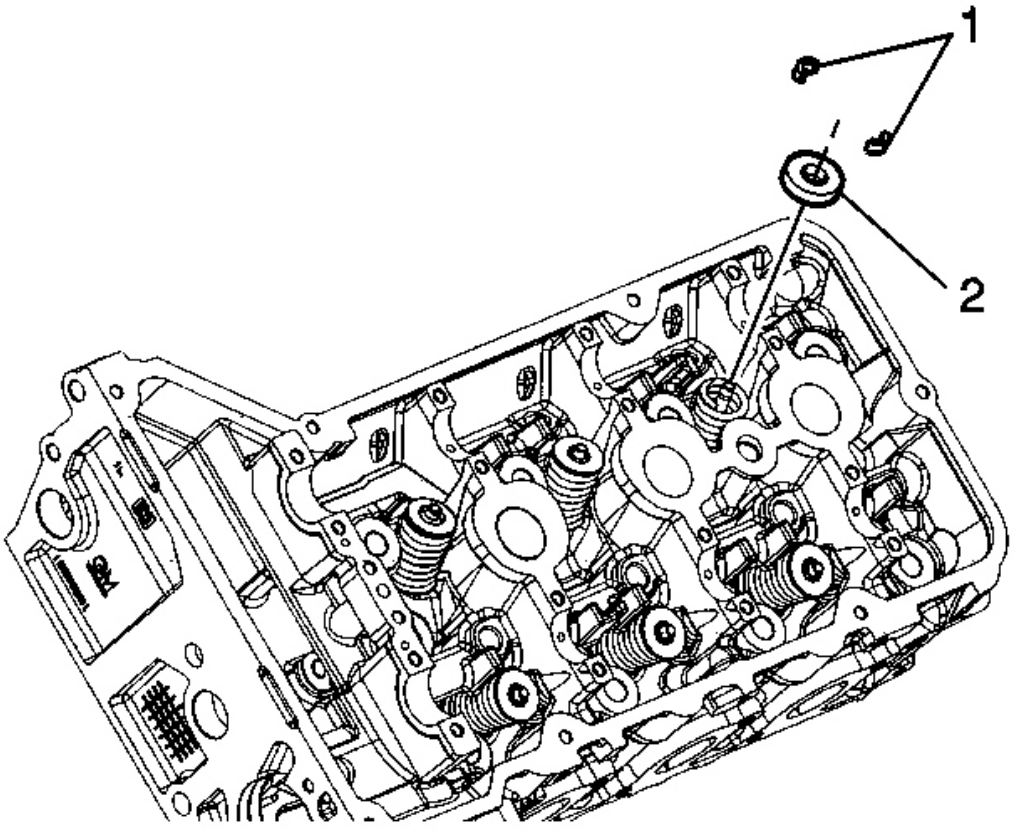


Fig. 73: View Of Valve Spring Retainer
Courtesy of GENERAL MOTORS CORP.

6. Use the magnetic end of the J 43059 in order to remove the valve keepers (1).
7. Remove the **EN 46335** . See **Special Tools and Equipment** .
8. Remove the valve spring retainer (2).

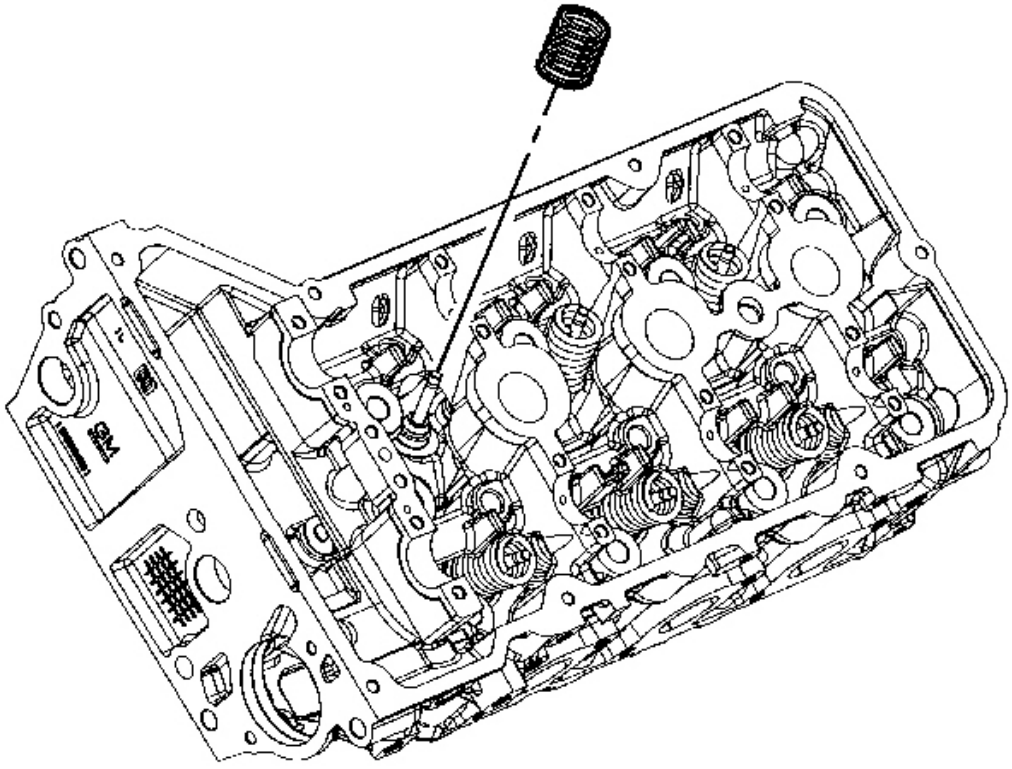


Fig. 74: View Of Valve Spring
Courtesy of GENERAL MOTORS CORP.

9. Remove the valve spring.

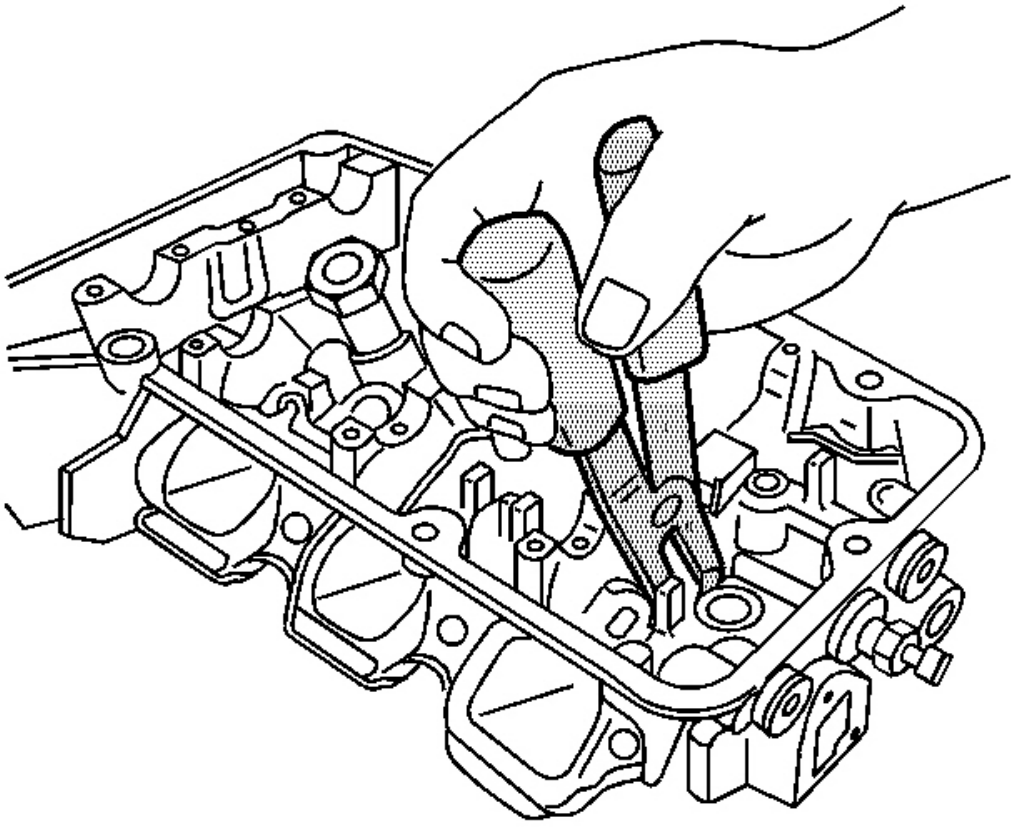


Fig. 75: View Of Valve Seal
Courtesy of GENERAL MOTORS CORP.

10. Remove the valve seal using the **SA9102E-A** . See **Special Tools and Equipment** .

Installation Procedure

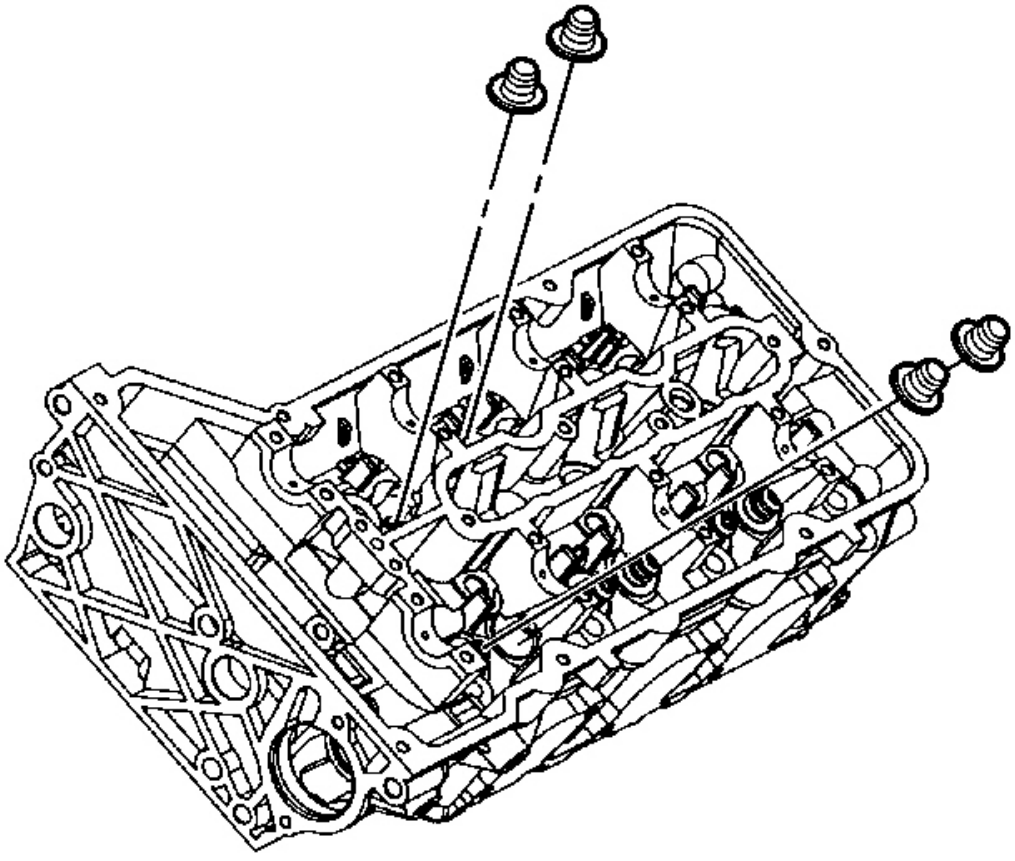


Fig. 76: View Of Valve Stem, Valve Seal & Guide With Engine Oil
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the valve stem, valve seal and guide with engine oil.

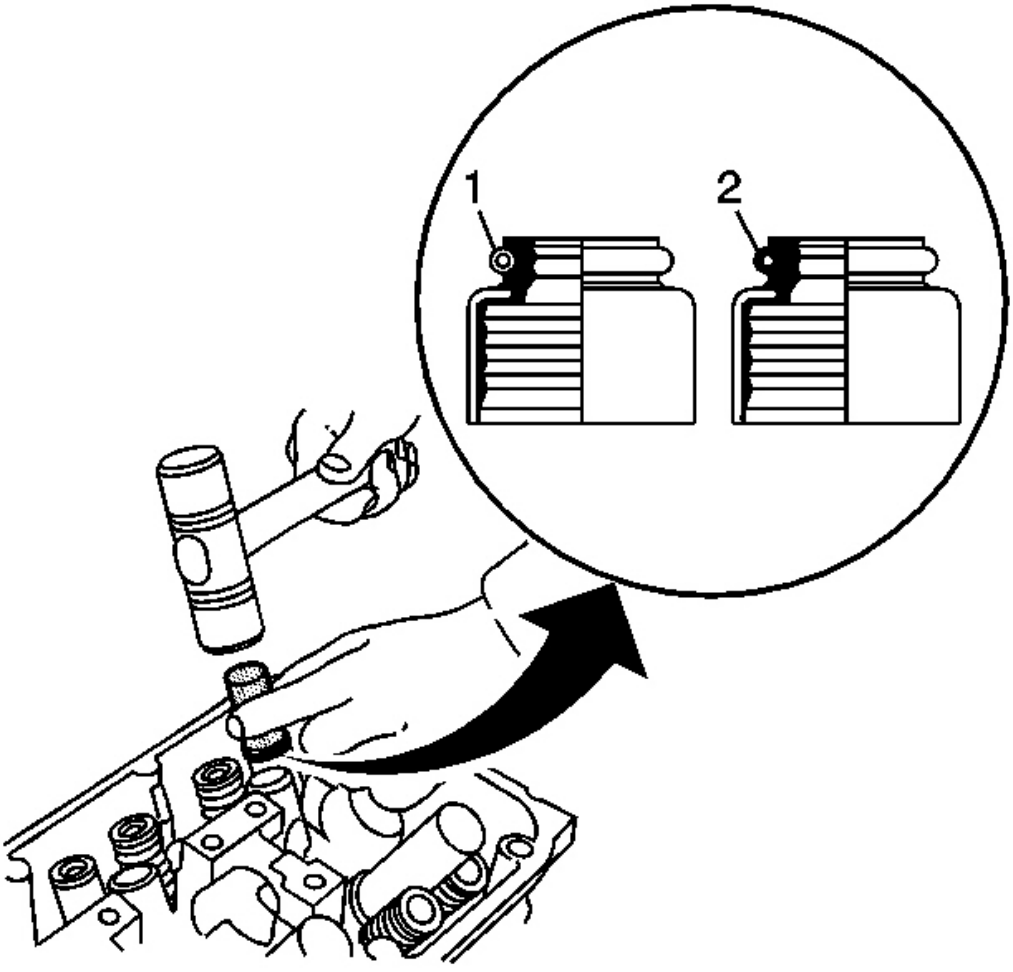


Fig. 77: View Of Valve Stem Oil Seals Onto The Guides
Courtesy of GENERAL MOTORS CORP.

2. Use the **EN 46336** to install the valve stem oil seals onto the guides. See **Special Tools and Equipment** . Intake valve seals have a white spring (1). Exhaust valve seals have a black spring (2).

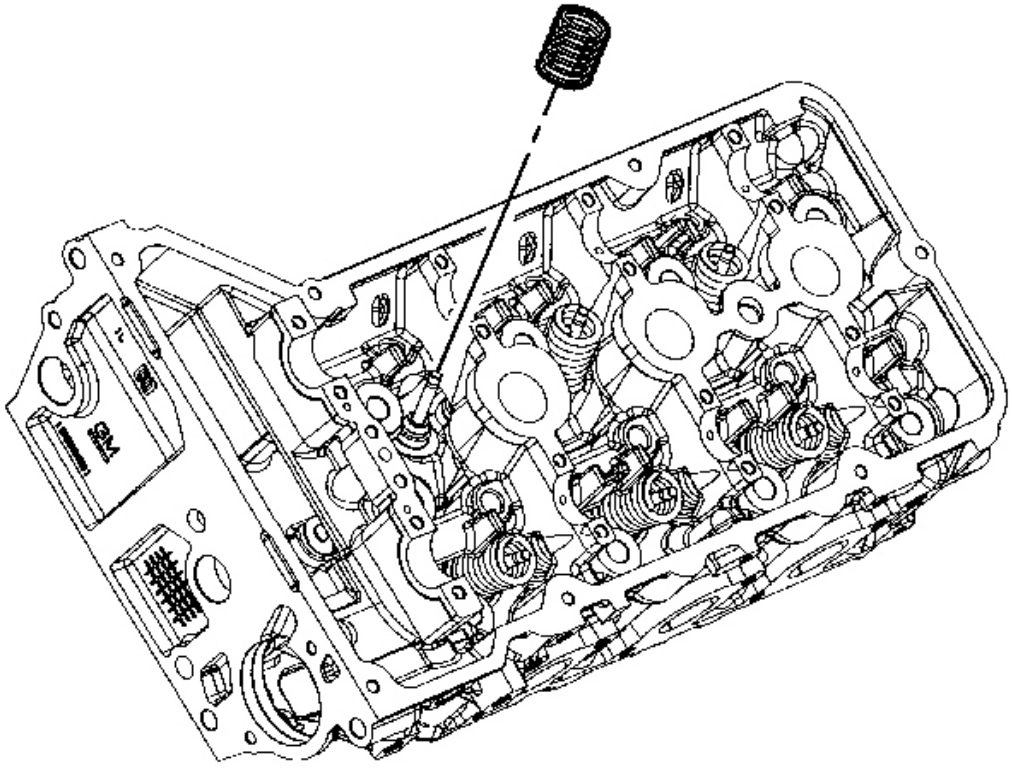


Fig. 78: View Of Valve Spring
Courtesy of GENERAL MOTORS CORP.

3. Position the valve spring on the spring seat.

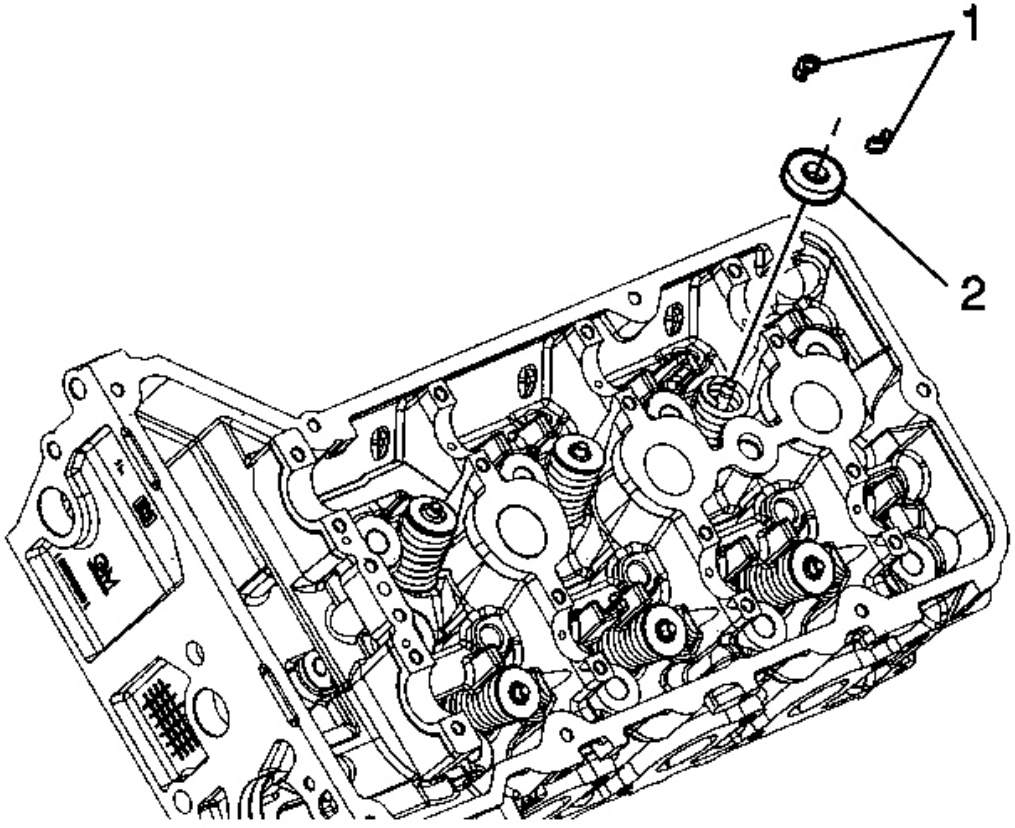


Fig. 79: View Of Valve Spring Retainer
Courtesy of GENERAL MOTORS CORP.

4. Place the valve spring retainer (2) onto the valve spring.

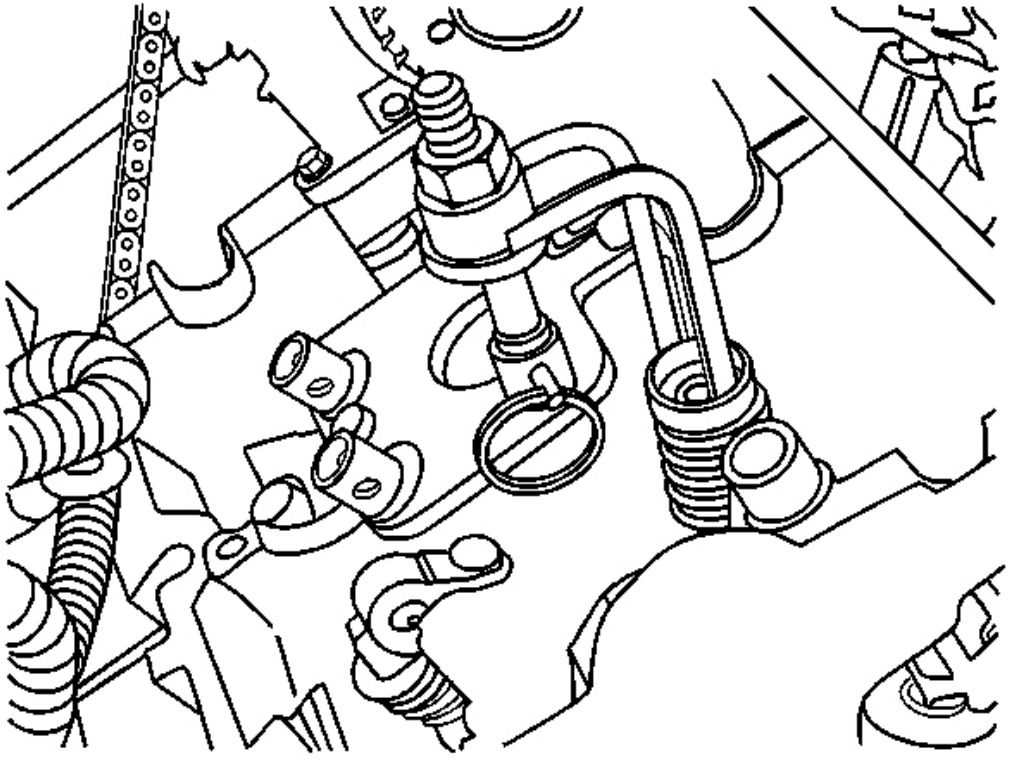


Fig. 80: Identifying Valve Spring
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Compressed Valve Spring Caution in Cautions and Notices.

5. Compress the valve spring using the **EN 46335** . See **Special Tools and Equipment** .

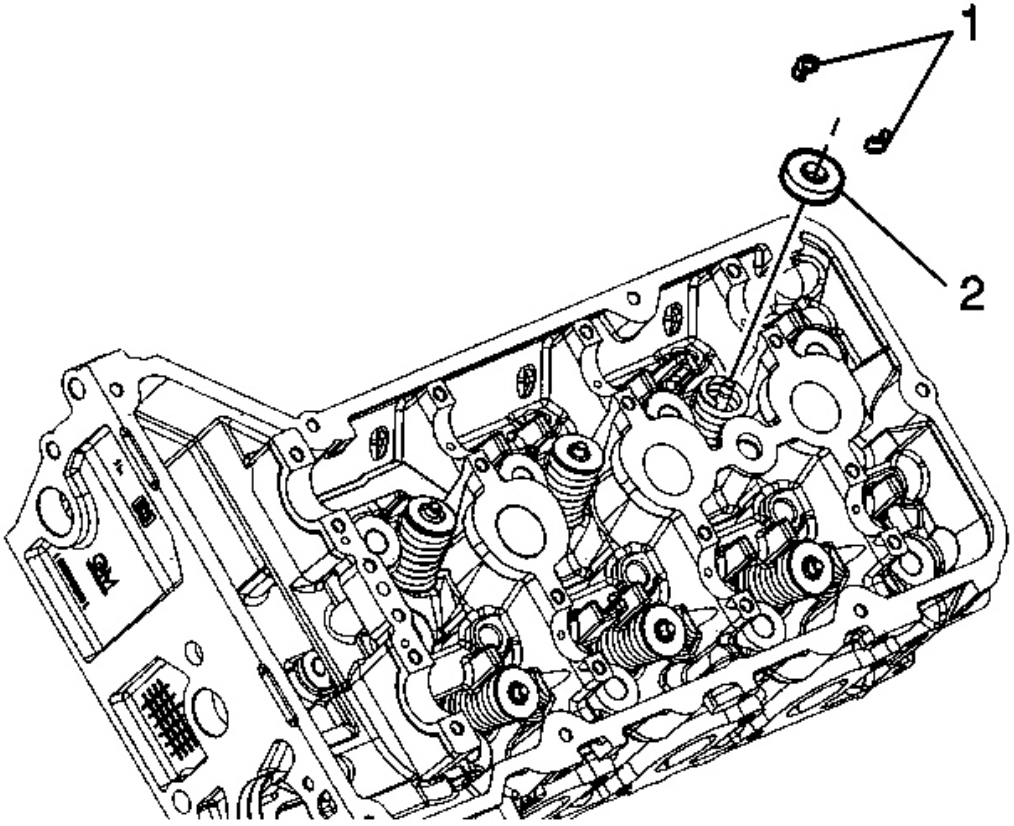


Fig. 81: View Of Valve Spring Retainer
Courtesy of GENERAL MOTORS CORP.

6. With the spring compressed, install the valve keepers into the J 43059 .
7. Place the keepers (1) into position by pushing the tool downward.
8. Release the tension on the spring compressor and remove the **EN 46335** . See **Special Tools and Equipment** .
9. Verify that the valve keepers are installed by placing a rag over the valve tip and tapping with a dead-blow hammer. The valve keepers and the spring should remain in place.
10. Relieve the air pressure from the cylinder and remove the **SA9127E** .
11. Install the spark plug. Refer to **Spark Plug Replacement** in Engine Controls - 3.5L (L66).
12. Install the valve rocker arms. Refer to **Valve Rocker Arm and Shaft Replacement** .

VALVE ROCKER ARM AND VALVE LASH ADJUSTER REPLACEMENT

Removal Procedure

IMPORTANT: Adjust the values only when the cylinder head temperature is less than 38°C (100°F).

1. Remove the intake manifold. Refer to **Intake Manifold Removal** .
2. Remove the valve rocker arm covers. Refer to **Valve Rocker Arm Cover Replacement - Left** or **Valve Rocker Arm Cover Replacement - Right** .
3. Adjust the values. Refer to **Valve Lash Adjustment** .

Installation Procedure

1. Install the valve rocker arm covers. Refer to **Valve Rocker Arm Cover Replacement - Left** or **Valve Rocker Arm Cover Replacement - Right** .
2. Install the intake manifold. Refer to **Intake Manifold Removal** .

CRANKSHAFT BALANCER REPLACEMENT

Tools Required

EN 46337 Camshaft Sprocket/Crankshaft Balancer Holder. See **Special Tools and Equipment** .

Removal Procedure

1. Remove the drive belt. Refer to**Drive Belt Replacement** .
2. Remove the right front wheel. Refer to**Tire and Wheel Removal and Installation** in Tires and Wheels.

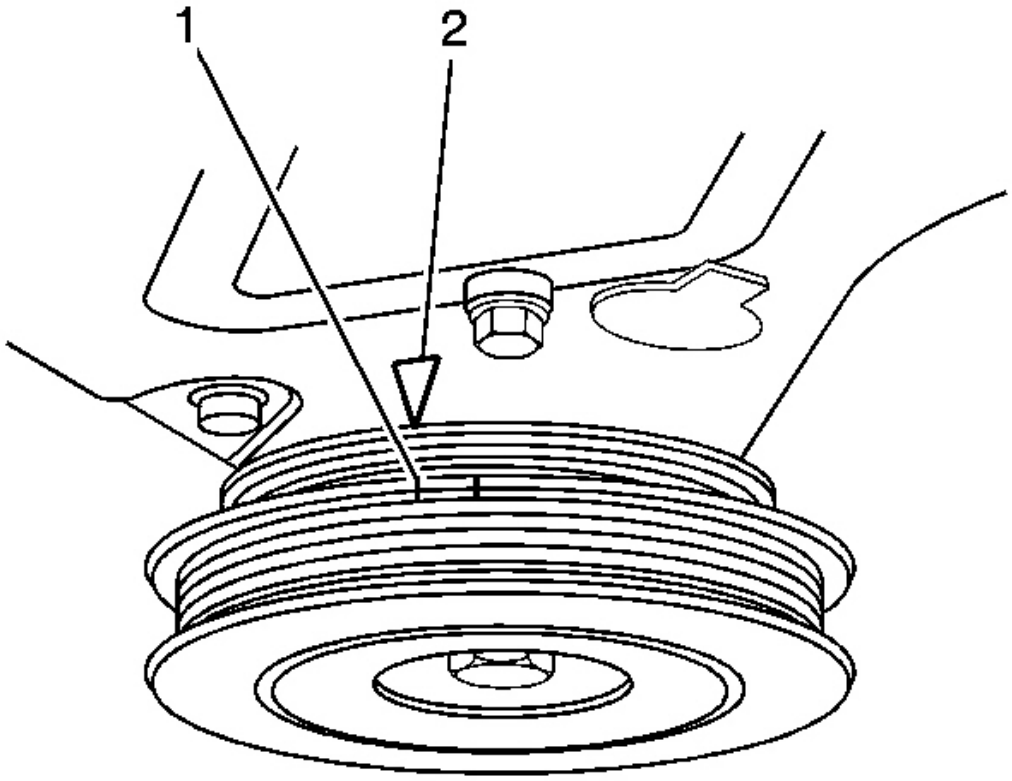


Fig. 82: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If the timing belt is to be removed, the crankshaft balancer must be rotated to position number 1 piston at top dead center (TDC) of compression stroke to avoid valve-to-piston contact.

3. Turn the crankshaft so its white mark (1) lines up with the pointer (2).

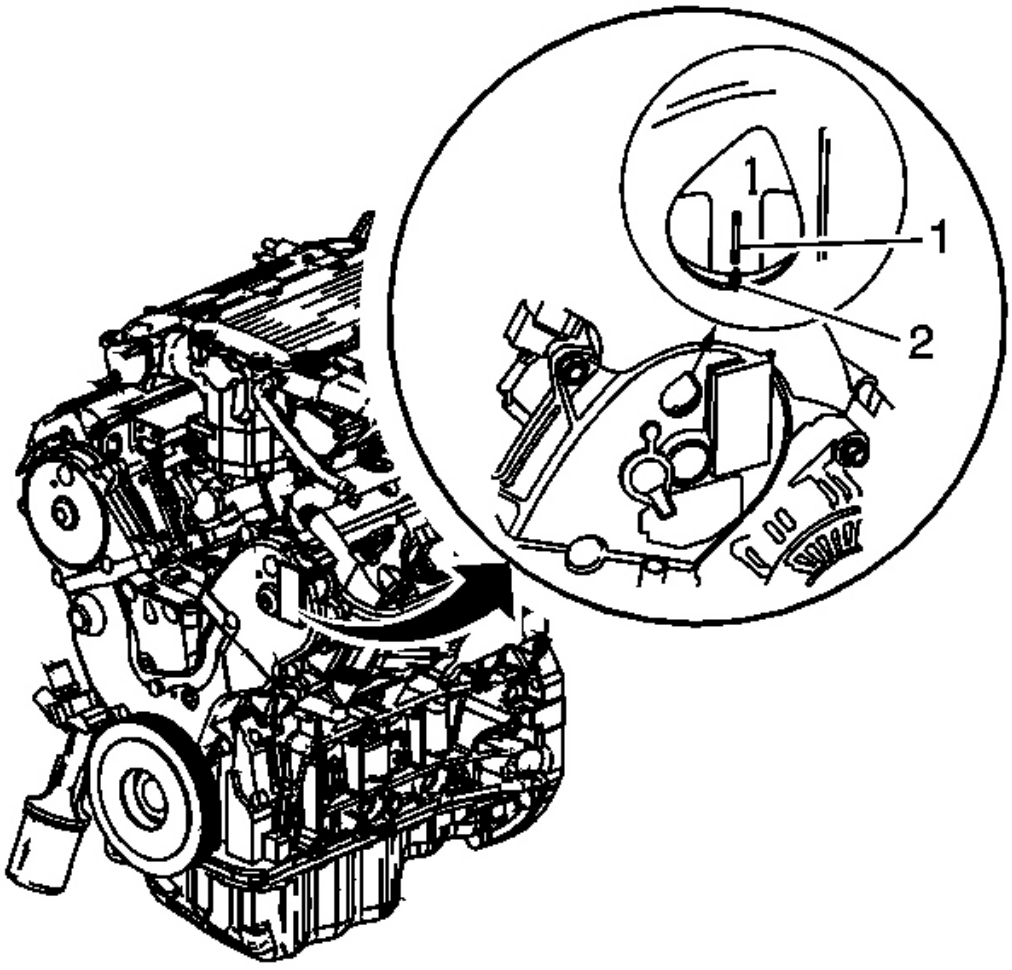


Fig. 83: Aligning The Upper Cover With The Number 1 Cylinder
Courtesy of GENERAL MOTORS CORP.

4. Inspect for cylinder number 1 piston at TDC. The pointer on the upper cover (2) will be aligned with the number 1 cylinder TDC mark (1) on the camshaft pulley.

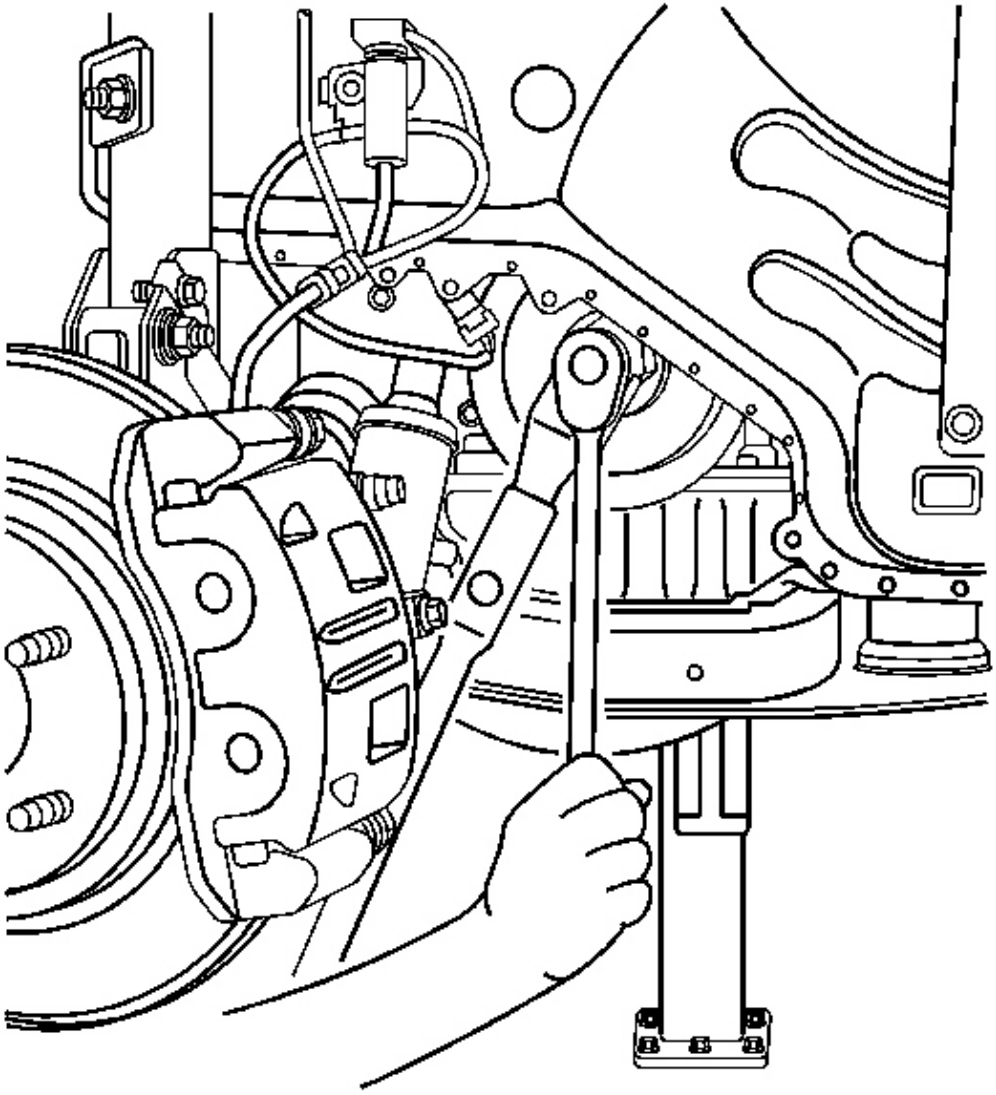


Fig. 84: View Of Right Front Wheel
Courtesy of GENERAL MOTORS CORP.

5. Use the **EN 46337** and a breaker bar in order to retain the balancer. See **Special Tools and Equipment** .

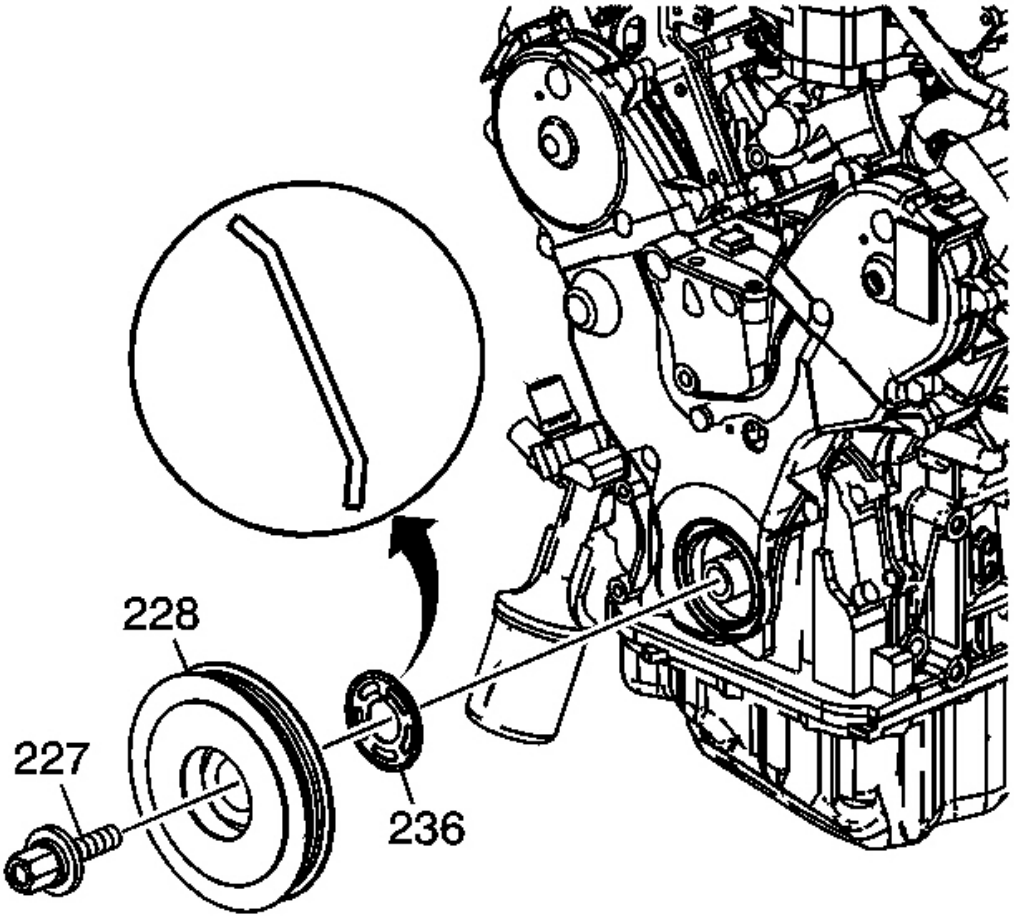


Fig. 85: View Of Bolt, Balancer & Guide
Courtesy of GENERAL MOTORS CORP.

6. Remove the bolt (227), balancer (228) and guide (236).

Installation Procedure

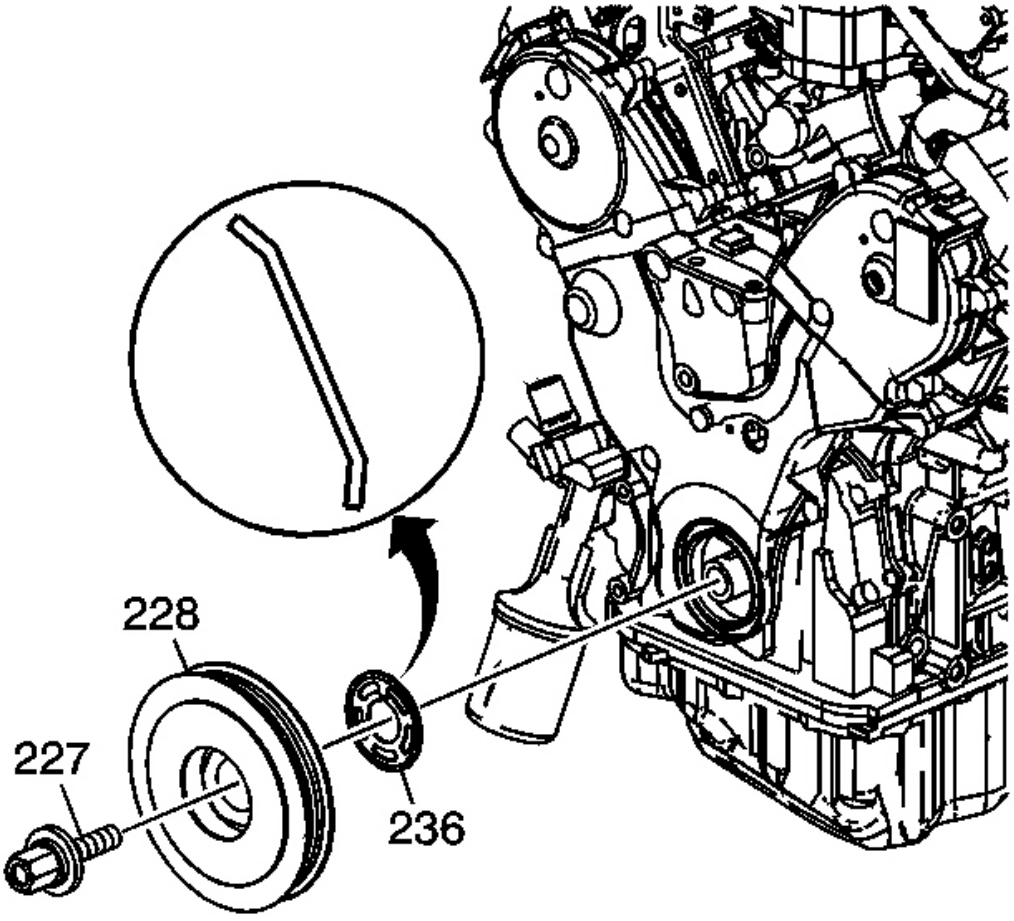


Fig. 86: View Of Bolt, Balancer & Guide
Courtesy of GENERAL MOTORS CORP.

1. Clean all oil from the balancer (228), guide (236), bolt (227) and crankshaft.
2. Lubricate the threads of the bolt (227) with clean engine oil.
3. Install the guide (236), balancer (228) and bolt (227). Install the guide with the concave surface facing the balancer.

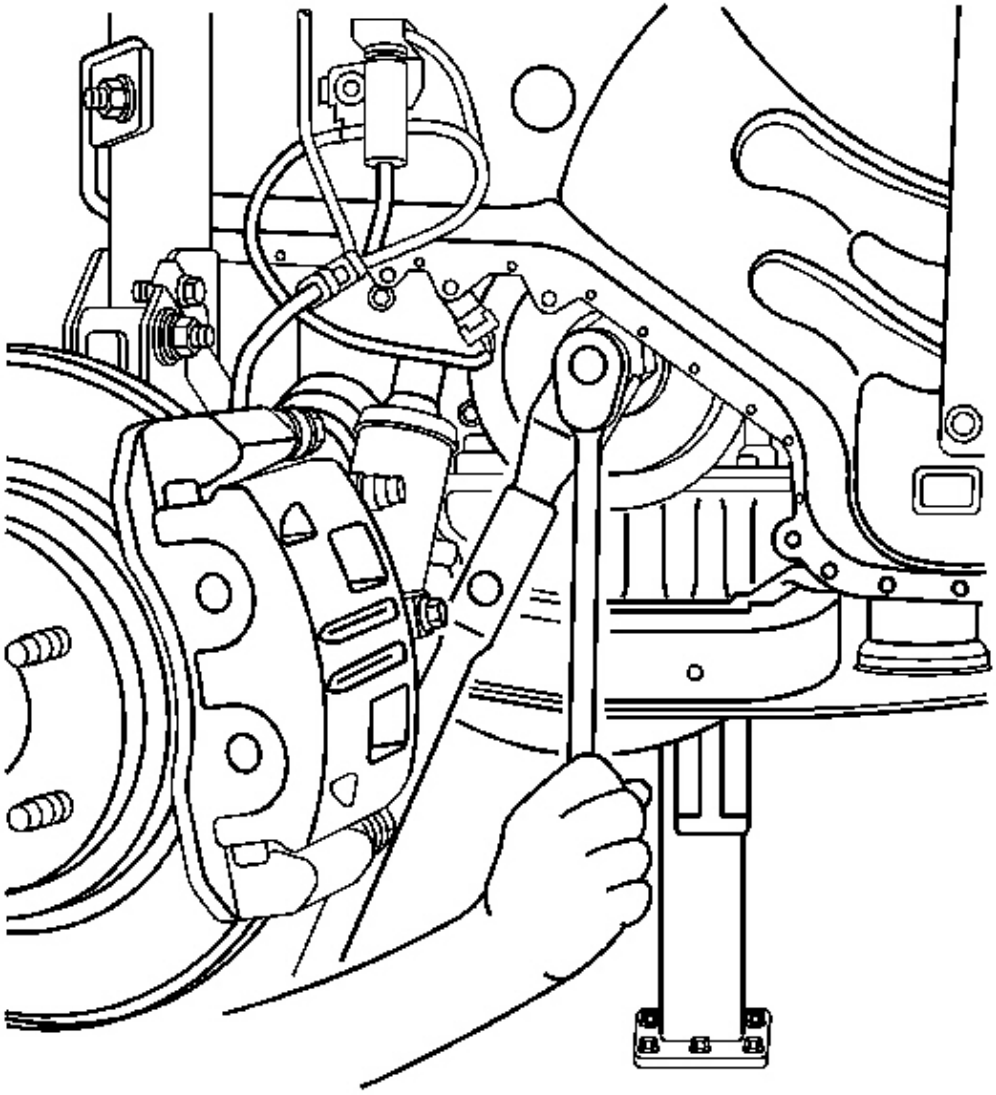


Fig. 87: View Of Right Front Wheel
Courtesy of GENERAL MOTORS CORP.

4. Use the **EN 46337** and a breaker bar in order to retain the crankshaft balancer. See **Special Tools and Equipment** .

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Tighten the balancer bolt.

   Tighten: Tighten the bolt to 245 N.m (181 lb ft).

6. Install the right front wheel. Refer to**Tire and Wheel Removal and Installation** in Tires and Wheels.
7. Install the drive belt. Refer to**Drive Belt Replacement** .

OIL PAN REPLACEMENT

Removal Procedure

1. Drain the oil. Refer to **Engine Oil and Oil Filter Replacement** .
2. Remove the crossunder exhaust pipe. Refer to **Exhaust Manifold Pipe Replacement (L66)** or **Exhaust Manifold Pipe Replacement (L61)** in Engine Exhaust.
3. Remove the oil pan.
4. Clean sealer material from the block and oil pan assembly.

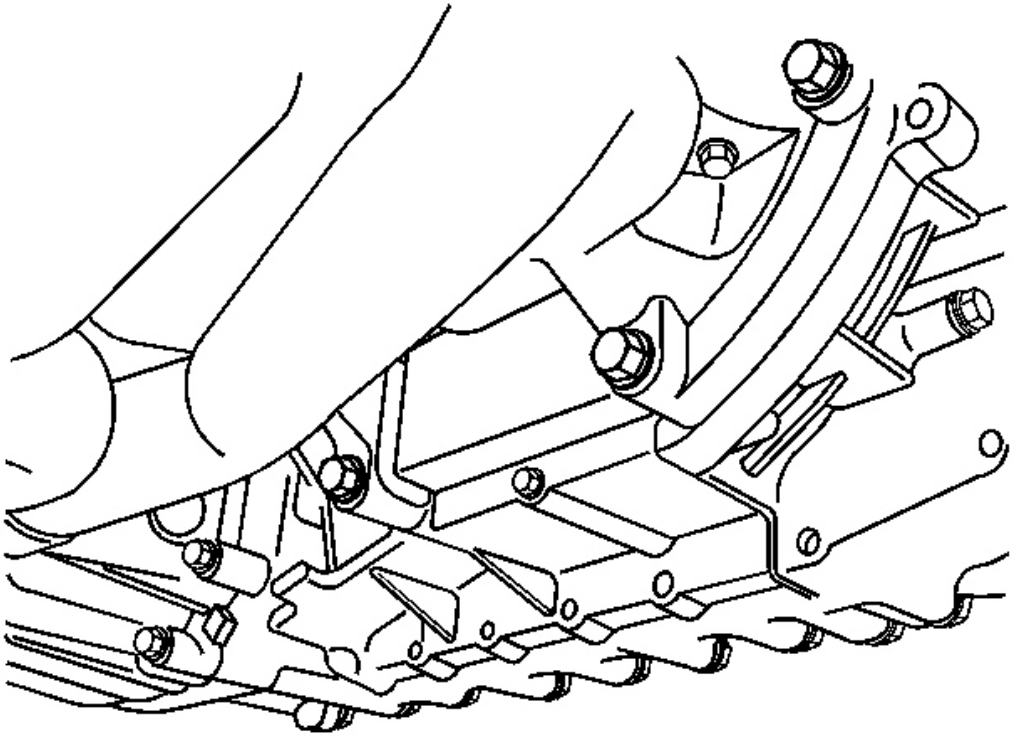


Fig. 88: View Of Oil Pan

Courtesy of GENERAL MOTORS CORP.

5. Remove the engine rear cover.
6. Remove the crossunder exhaust pipe brace.
7. Remove the oil pan bolts, and oil pan.
8. Clean sealer material from the block and oil pan assembly.

Installation Procedure

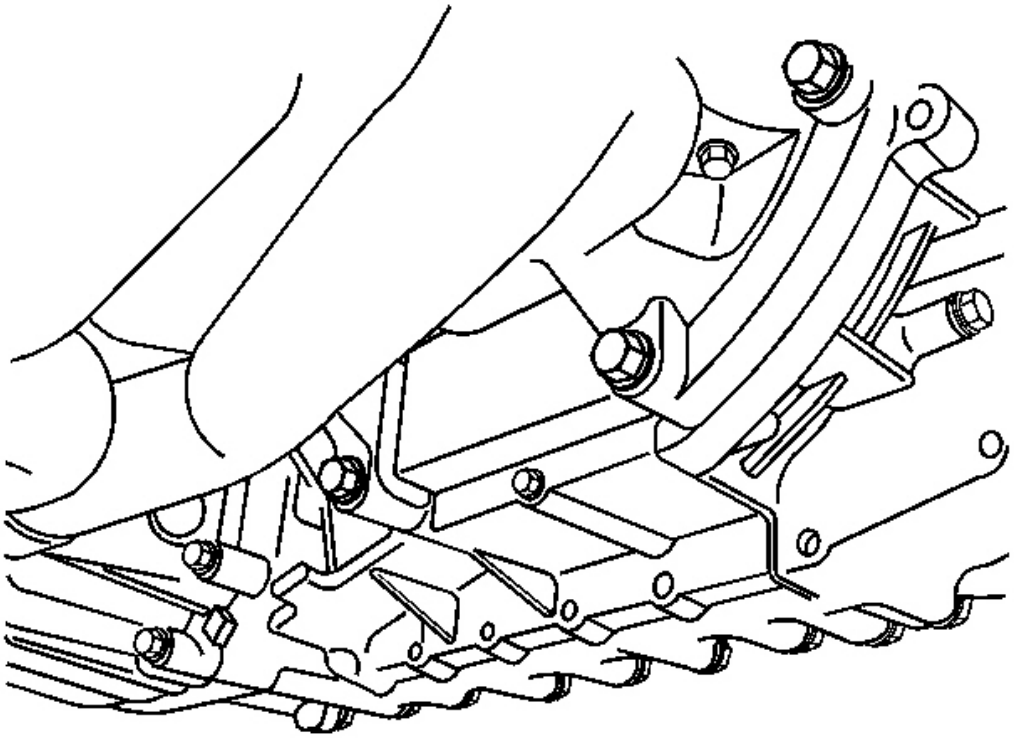


Fig. 89: View Of Oil Pan
Courtesy of GENERAL MOTORS CORP.

1. Clean the oil pan and engine block sealing surfaces.
2. Apply sealant GM P/N 12346240 (Canadian P/N 10953493) or equivalent evenly to the oil pan mating surface of the engine block.
3. Install the oil pan to the engine.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the oil pan bolts.

   Tighten

   - Tighten the bolts, a first pass to 6 N.m (53 lb in).
   - Tighten the bolts, a second pass to 12 N.m (106 lb in).
5. Install the rear engine cover.
6. Install the crossunder exhaust pipe brace.
7. Install the crossunder exhaust pipe. Refer to **Exhaust Manifold Pipe Replacement (L66)** or **Exhaust Manifold Pipe Replacement (L61)** in Engine Exhaust.
8. Refill the engine with oil and adjust the oil level.
9. Start the vehicle and inspect for oil leaks.

ENGINE OIL PRESSURE SENSOR AND/OR SWITCH REPLACEMENT

Removal Procedure

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

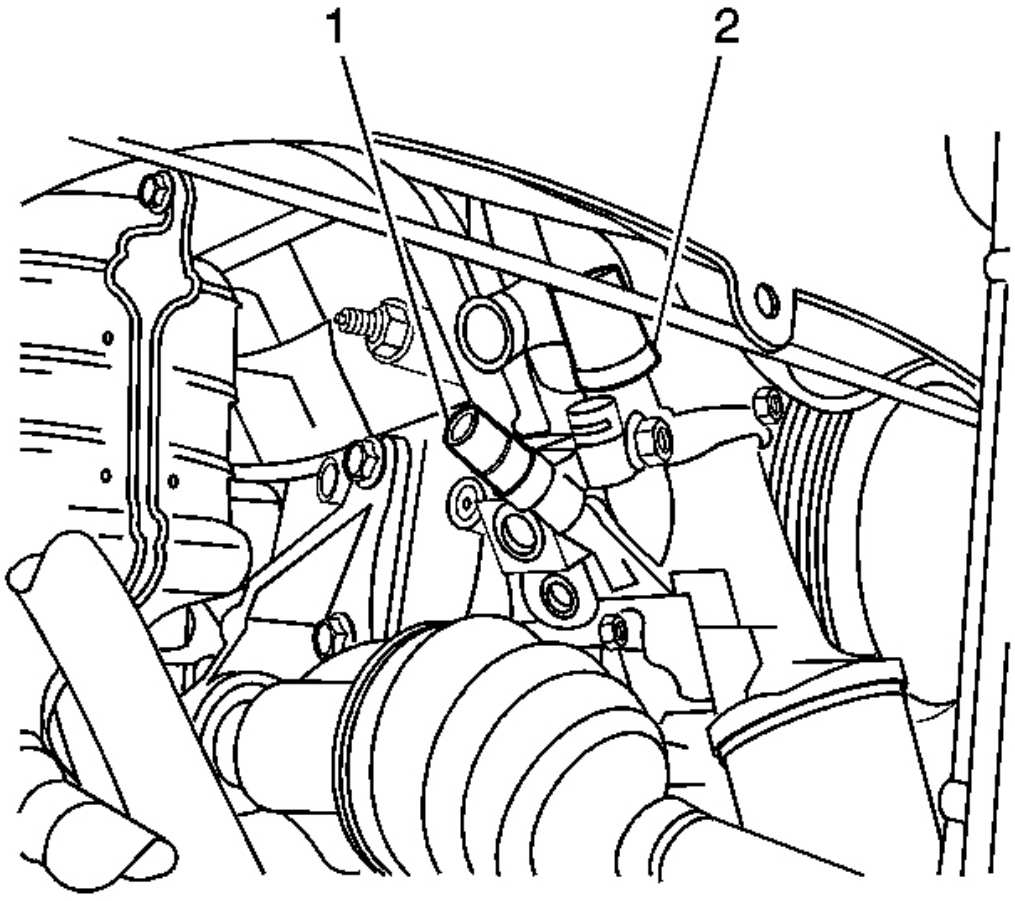


Fig. 90: View Of Oil Pressure Sensor Connector
Courtesy of GENERAL MOTORS CORP.

2. Disconnect the oil pressure sensor connector.
3. Remove the oil pressure sensor (1).

Installation Procedure

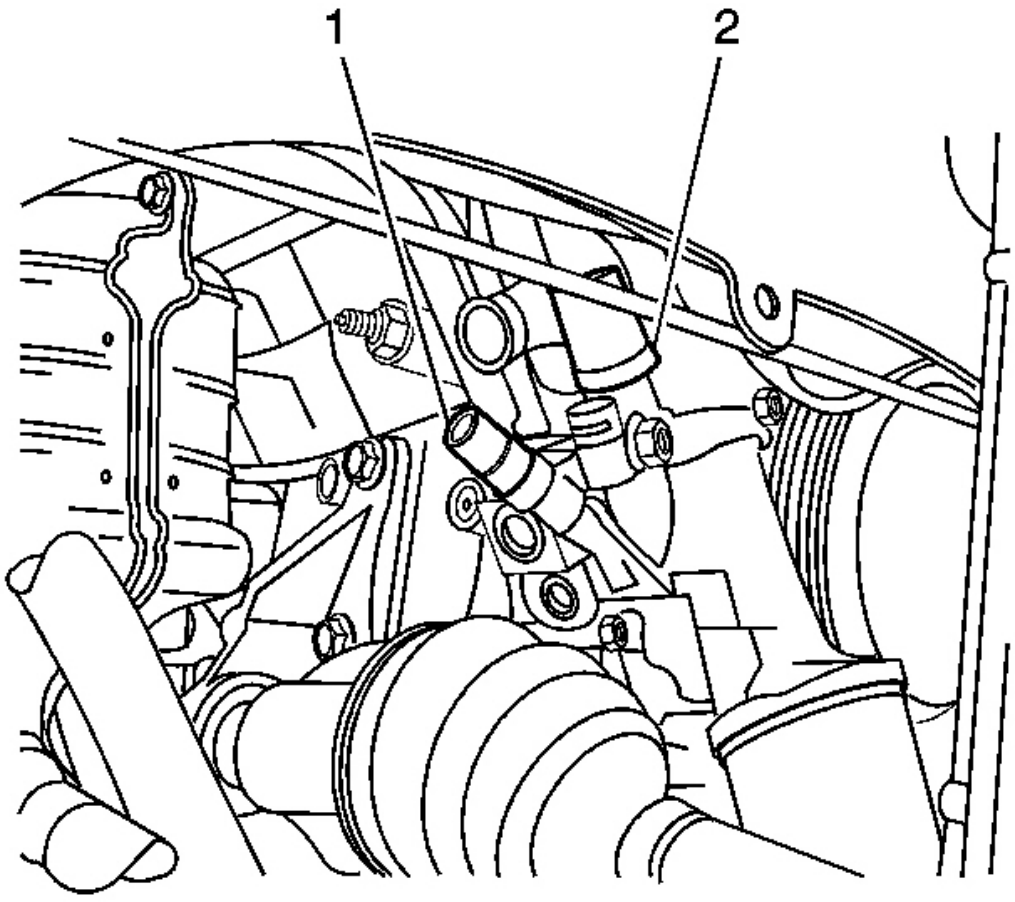


Fig. 91: View Of Oil Pressure Sensor Connector
Courtesy of GENERAL MOTORS CORP.

1. Apply sealant GM P/N 12346240 (Canadian P/N 10953493).

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the oil pressure sensor (1).

   Tighten: Tighten the sensor to 18 N.m (13 lb ft).

3. Connect the oil pressure sensor connector.
4. Lower the vehicle.

OIL PUMP REPLACEMENT

Tools Required

- J 35268-A Camshaft/Front Main Seal Installer
- J 42065 Crank Hub Holding Tool
- J 42098 Crank Hub TORX Socket

Removal Procedure

1. Remove the timing belt. Refer to **Timing Belt Replacement** .
2. Remove the timing belt idler pulley. Refer to **Timing Belt Idler Pulley Replacement** .
3. Remove the oil flow control module. Refer to **Oil Flow Control Module Replacement** .

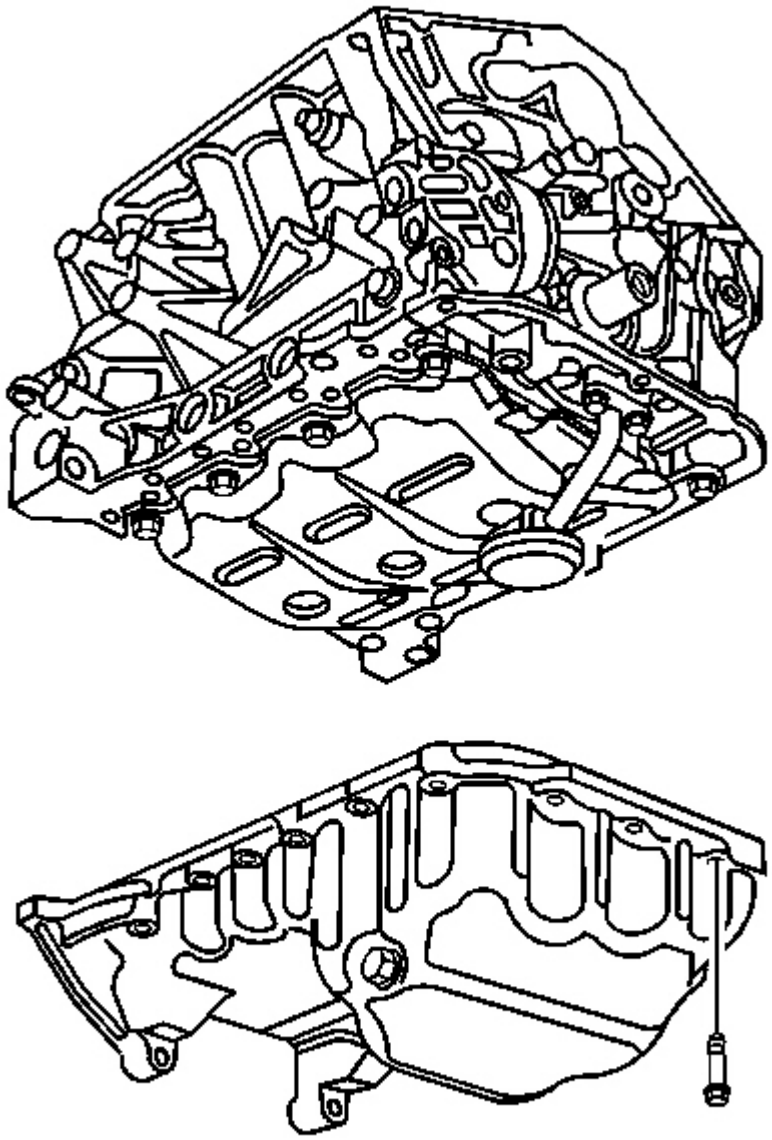


Fig. 92: View Of Oil Pump Pickup Tube
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil pan. Refer to **Oil Pan Replacement** .
5. Remove the oil pump pickup tube.

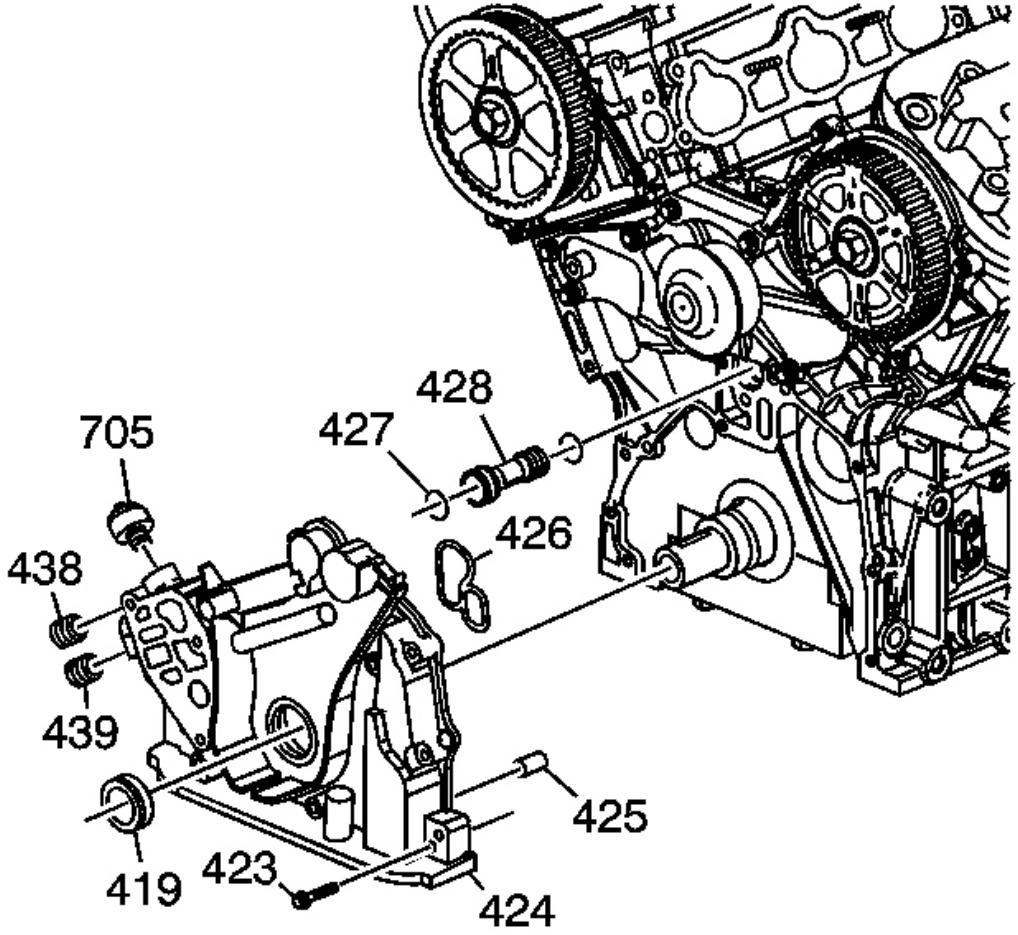


Fig. 93: Exploded View Of Oil Pump Assembly
Courtesy of GENERAL MOTORS CORP.

6. Remove the oil pump bolts (423).
7. Remove the oil pump (424).
8. Clean the oil pump sealing surfaces if pump is to be reinstalled.

Installation Procedure

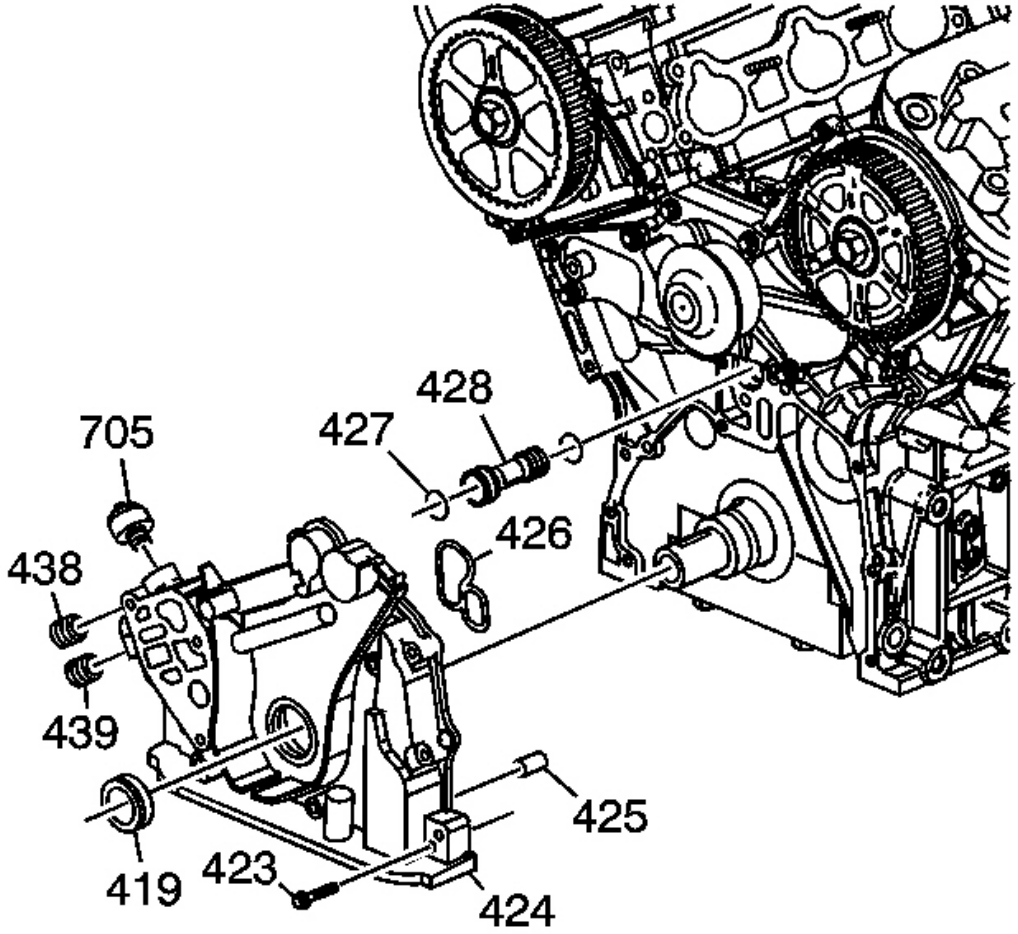


Fig. 94: Exploded View Of Oil Pump Assembly
Courtesy of GENERAL MOTORS CORP.

1. Install NEW O-rings (427) onto the oil transfer pipe (428).
2. Install the pipe (428) into the block.
3. Apply sealant GM P/N 12346240 or equivalent, evenly to the block mating surface of the oil pump housing and to the inner threads of the bolt holes.
4. Install the pins (426).
5. Install a NEW O-ring (426).

NOTE: Refer to Fastener Notice in Cautions and Notices.

6. Install the oil pump assembly and bolts.

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

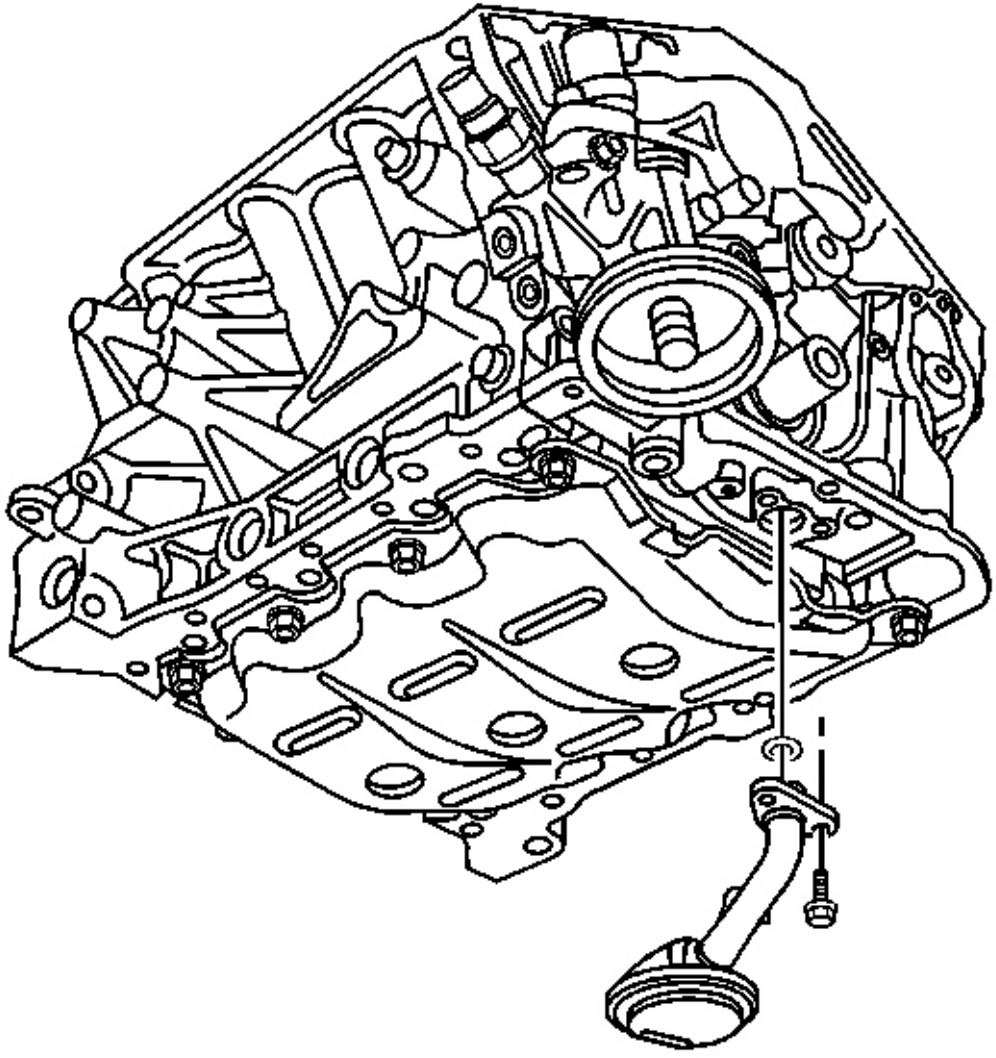


Fig. 95: View Of Oil Pipe Bolts
Courtesy of GENERAL MOTORS CORP.

7. Install a NEW O-ring.
8. Install the oil pump pickup tube.
9. Install the oil pump pickup tube bolts.

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

10. Install the oil pan. Refer to **Oil Pan Replacement** .
11. Install the oil flow control module. Refer to **Oil Flow Control Module Replacement** .
12. Install the timing belt idler pulley. Refer to **Timing Belt Idler Pulley Replacement** .
13. Install the timing belt. Refer to **Timing Belt Replacement** .

OIL PUMP PIPE AND SCREEN ASSEMBLY REPLACEMENT

Removal Procedure

1. Raise and support the vehicle. Refer to**Lifting and Jacking the Vehicle** in General Information.
2. Drain the engine oil.

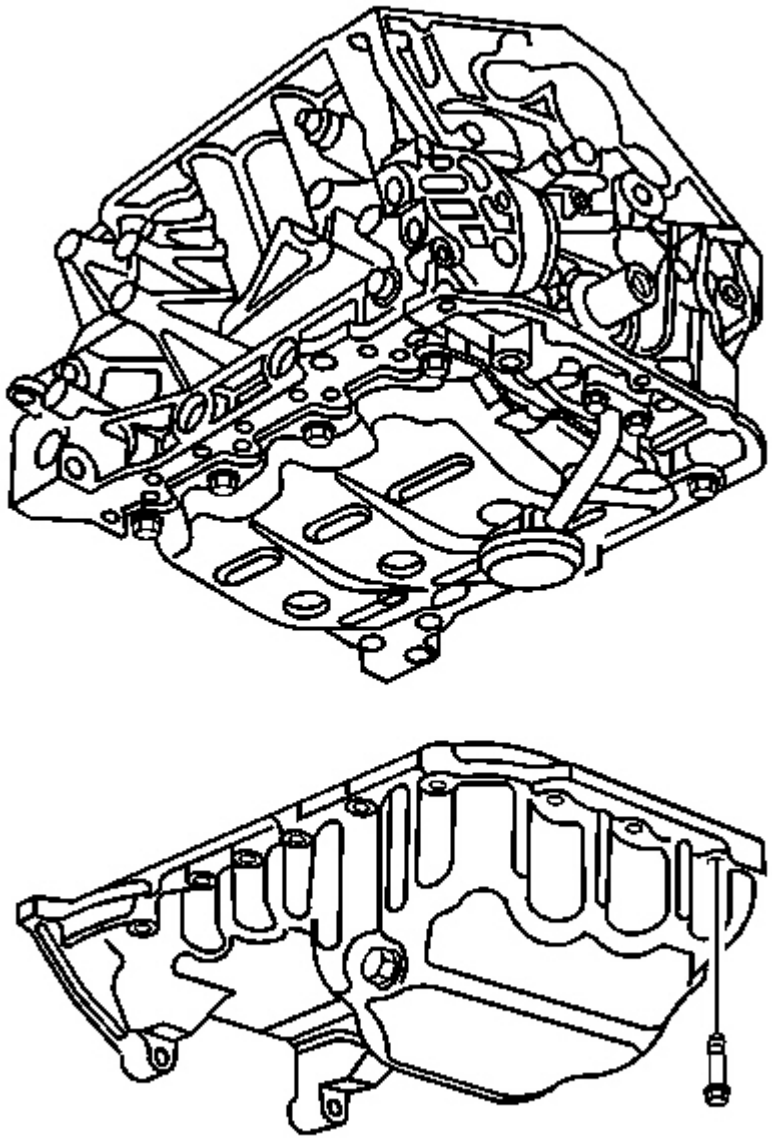


Fig. 96: View Of Oil Pump Pipe
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil pan. Refer to **Oil Pan Replacement** .

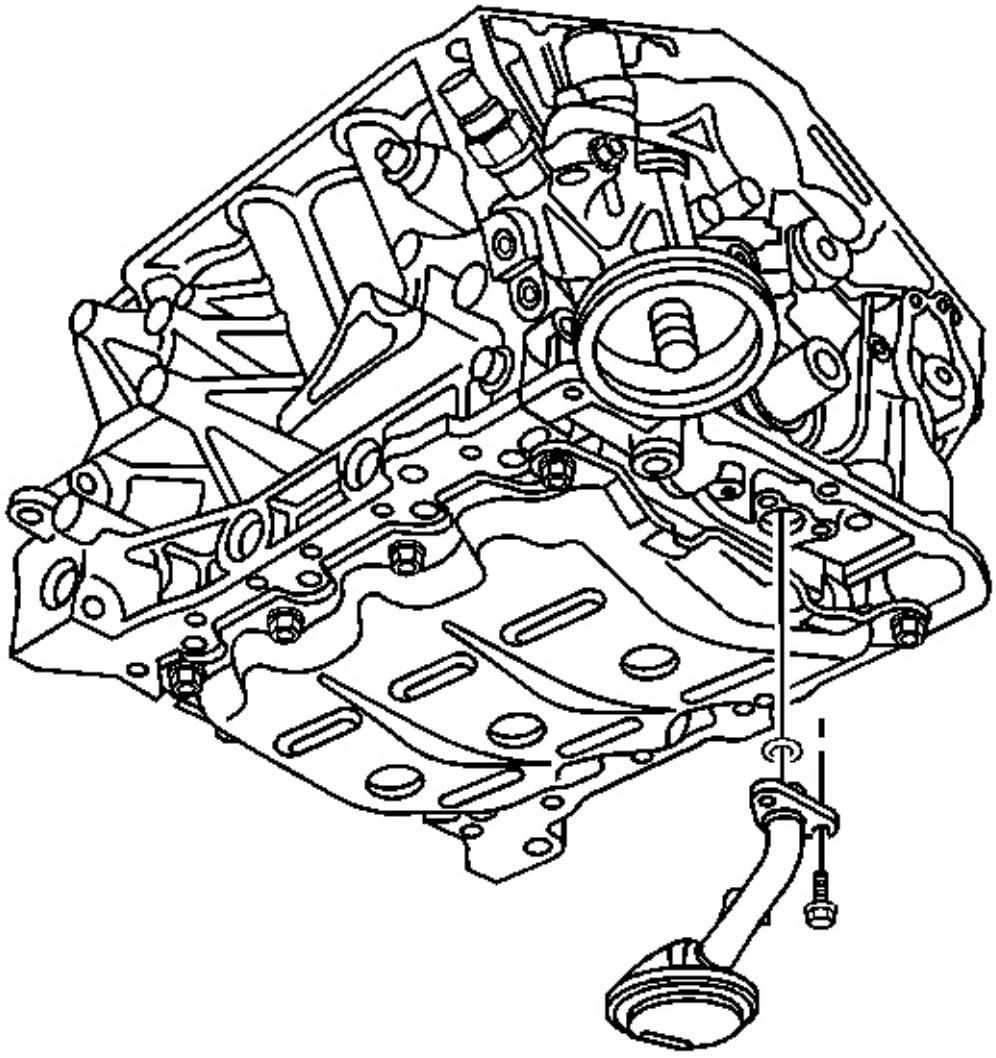


Fig. 97: View Of Oil Pipe Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil pipe bolts.
5. Remove the oil pipe screen assembly.
6. Remove the oil pipe O-ring. Discard.
7. Clean the gasket surfaces.

Installation Procedure

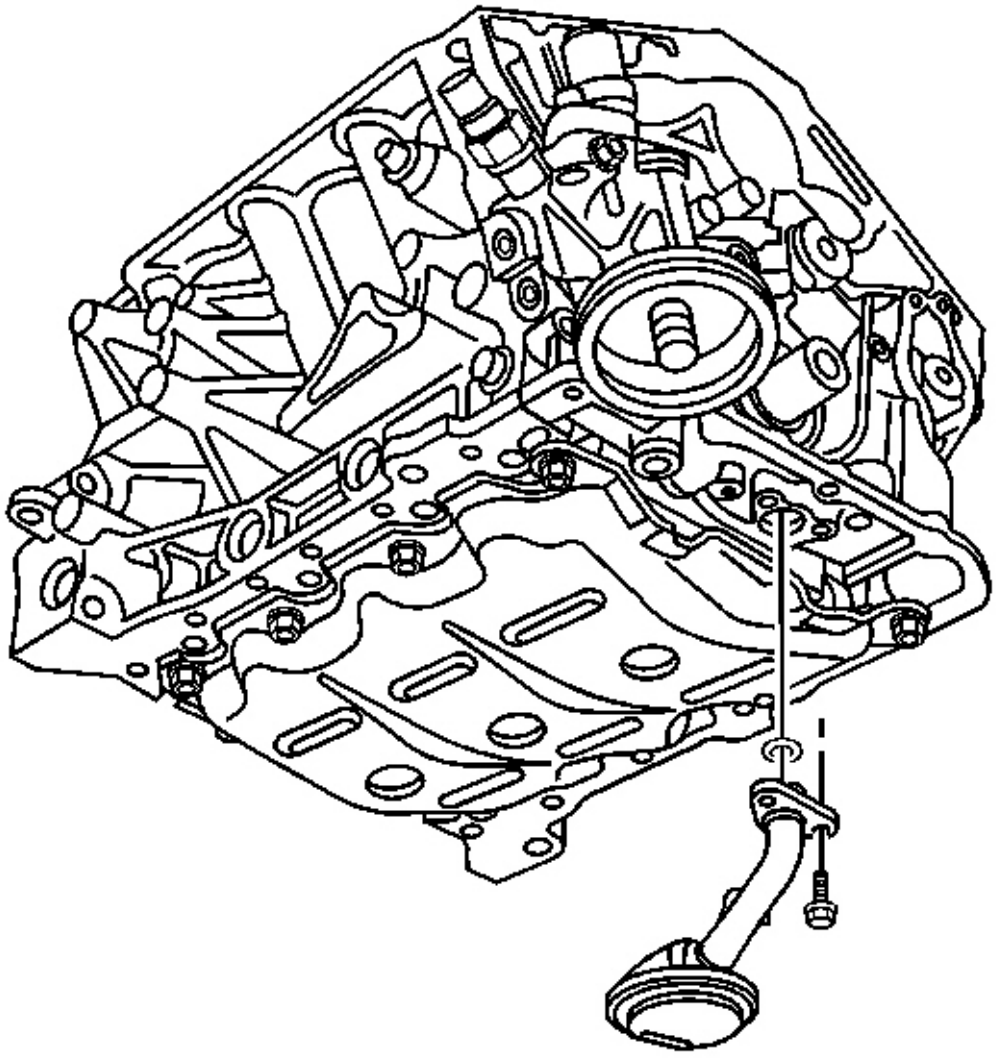


Fig. 98: View Of Oil Pipe Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW oil pump pipe O-ring.
2. Install the oil pipe screen assembly.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the oil pump pipe bolts.

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

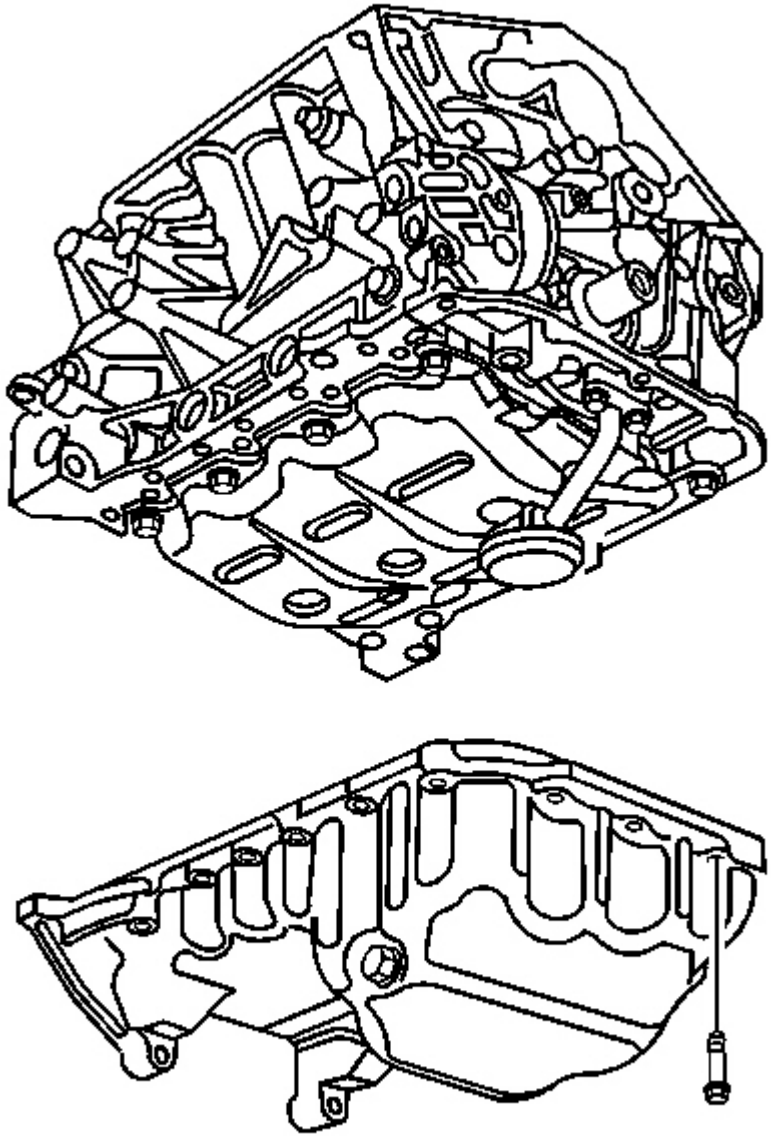


Fig. 99: View Of Oil Pump Pickup Tube
Courtesy of GENERAL MOTORS CORP.

4. Install the oil pan. Refer to **Oil Pan Replacement** .
5. Lower the vehicle.

6. Refill the engine with 4.73 L (5 qt) of oil.
7. Start the vehicle and inspect for leaks and correct oil pressure.

CRANKSHAFT FRONT OIL SEAL REPLACEMENT

Tools Required

- **EN 46342** Driver Handle
- **EN 46347** Crankshaft Front Oil Seal Driver. See **Special Tools and Equipment** .

Removal Procedure

1. Remove the timing belt. Refer to **Timing Belt Replacement** .
2. Remove the crankshaft gear. Refer to **Crankshaft Gear Replacement** .

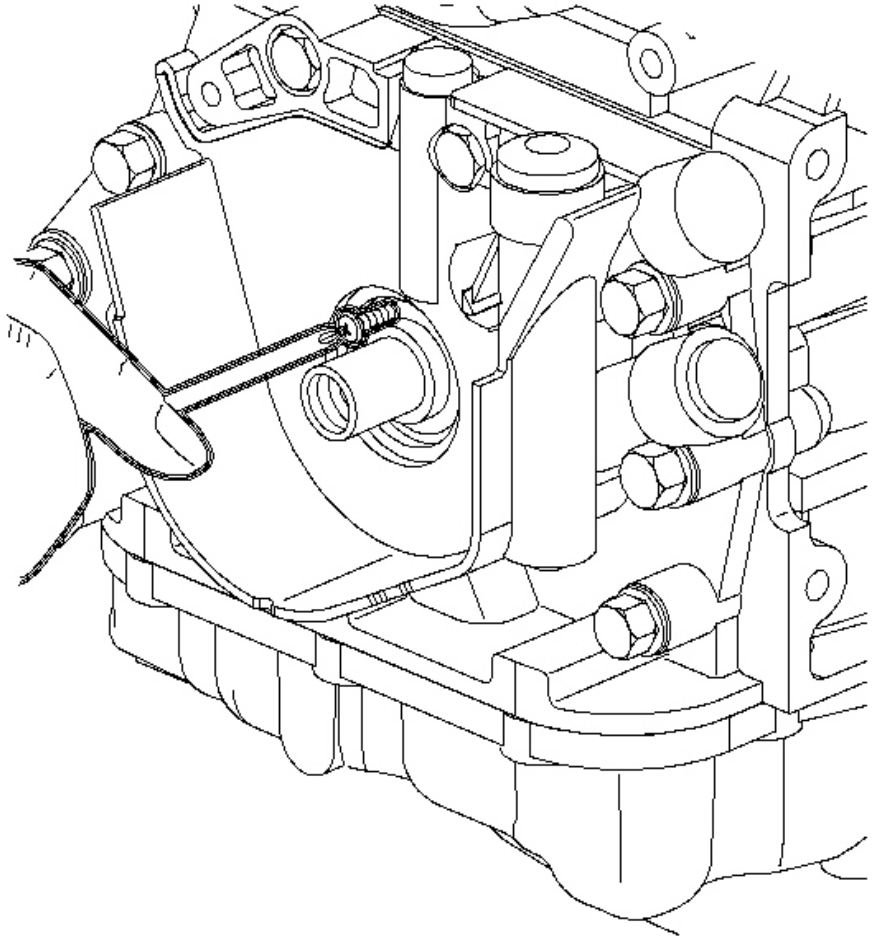


Fig. 100: View Of Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Use caution when drilling the hole so as not to damage the area around and behind the seal.

3. Carefully drill a small, shallow pilot hole into the steel ring of the seal.
4. Screw in a self tapping screw.
5. Use pliers to pull out the front main oil seal.
6. Clean all sealing surfaces.

Installation Procedure

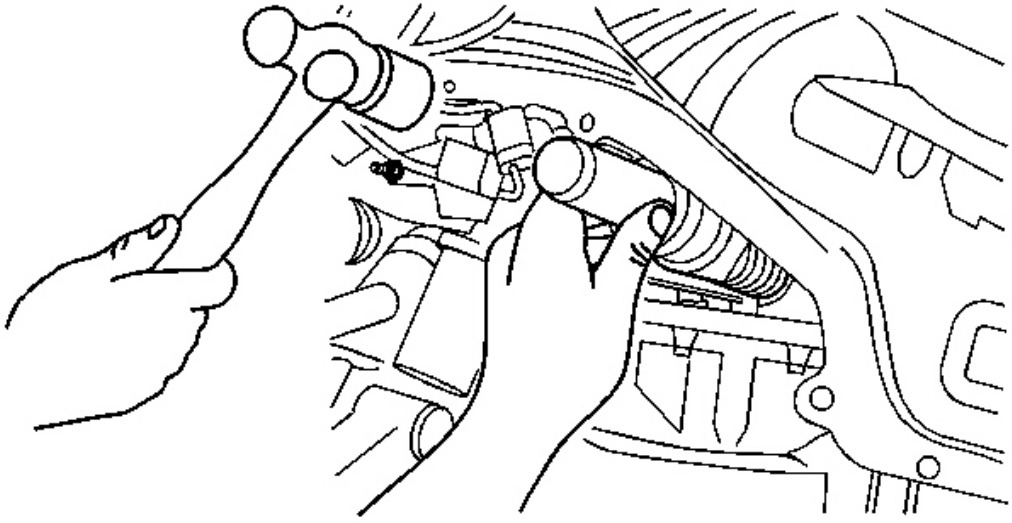


Fig. 101: Installing The Oil Seal On The Oil Pump Housing
Courtesy of GENERAL MOTORS CORP.

1. Coat the lip of the front main oil seal with a small amount of clean engine oil to aid in the installation.
2. Use the **EN 46347** and. See **Special Tools and Equipment** .**EN 46342** to install the oil seal.

   Gently tap and install the new oil seal until the tool bottoms on the oil pump housing.

3. Ensure that the front main oil seal is fully and evenly seated.
4. Install the crankshaft gear. Refer to **Crankshaft Gear Replacement** .
5. Install the timing belt. Refer to **Timing Belt Replacement** .

ENGINE REAR COVER REPLACEMENT

Removal Procedure

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

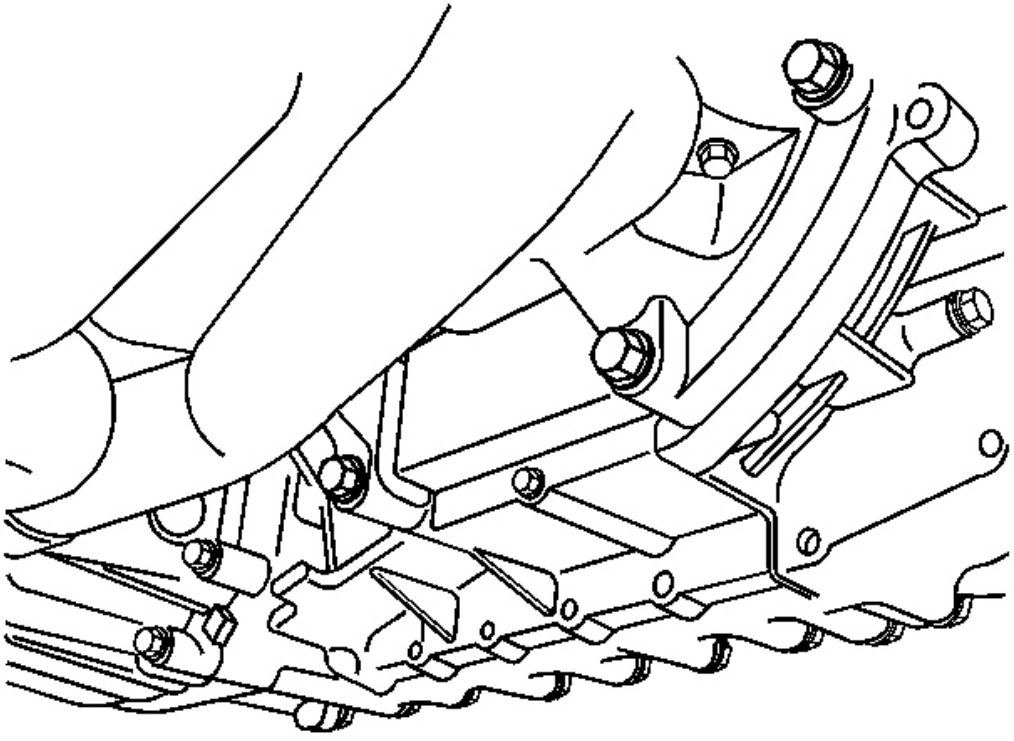


Fig. 102: View Of Engine Rear Cover
Courtesy of GENERAL MOTORS CORP.

2. Remove the rear cover bolts.
3. Remove the rear cover.

Installation Procedure

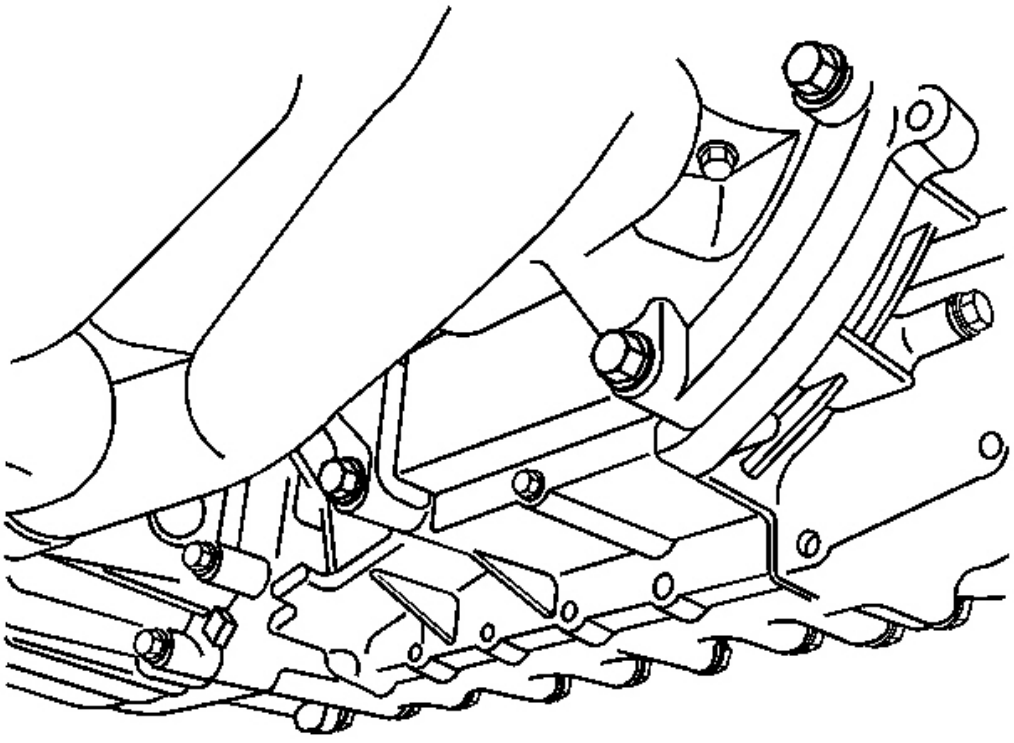


Fig. 103: View Of Engine Rear Cover
Courtesy of GENERAL MOTORS CORP.

1. Install the rear cover.

   NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the rear cover bolts.

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

3. Lower the vehicle.

TIMING BELT COVER REPLACEMENT

Removal Procedure

1. Remove the engine drive belt. Refer to **Drive Belt Replacement** .
2. Remove the right splash shield. Refer to **Splash Shield Replacement - Engine** in Body Front End.

3. Remove the engine balancer using the **EN 46337** . See **Special Tools and Equipment** .

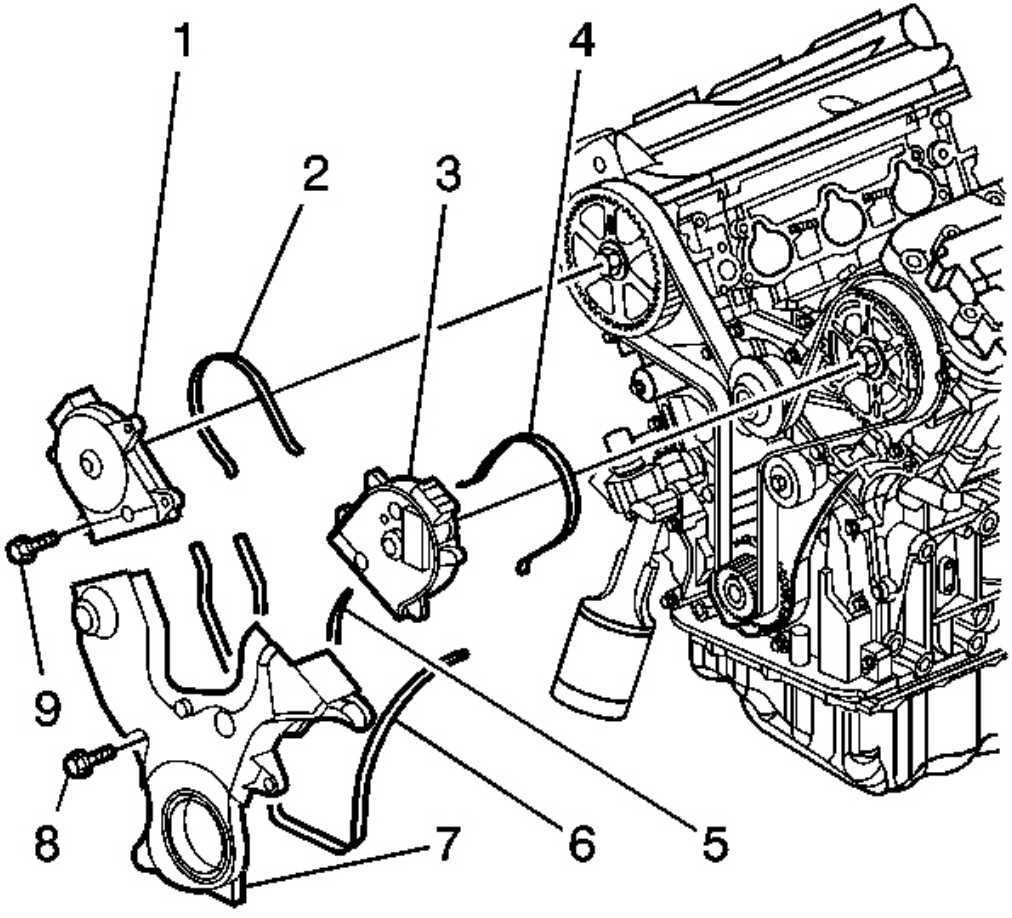


Fig. 104: View Of Timing Belt Cover
Courtesy of GENERAL MOTORS CORP.

4. Remove the timing belt cover bolts (8).
5. Remove the timing belt cover (7).

Installation Procedure

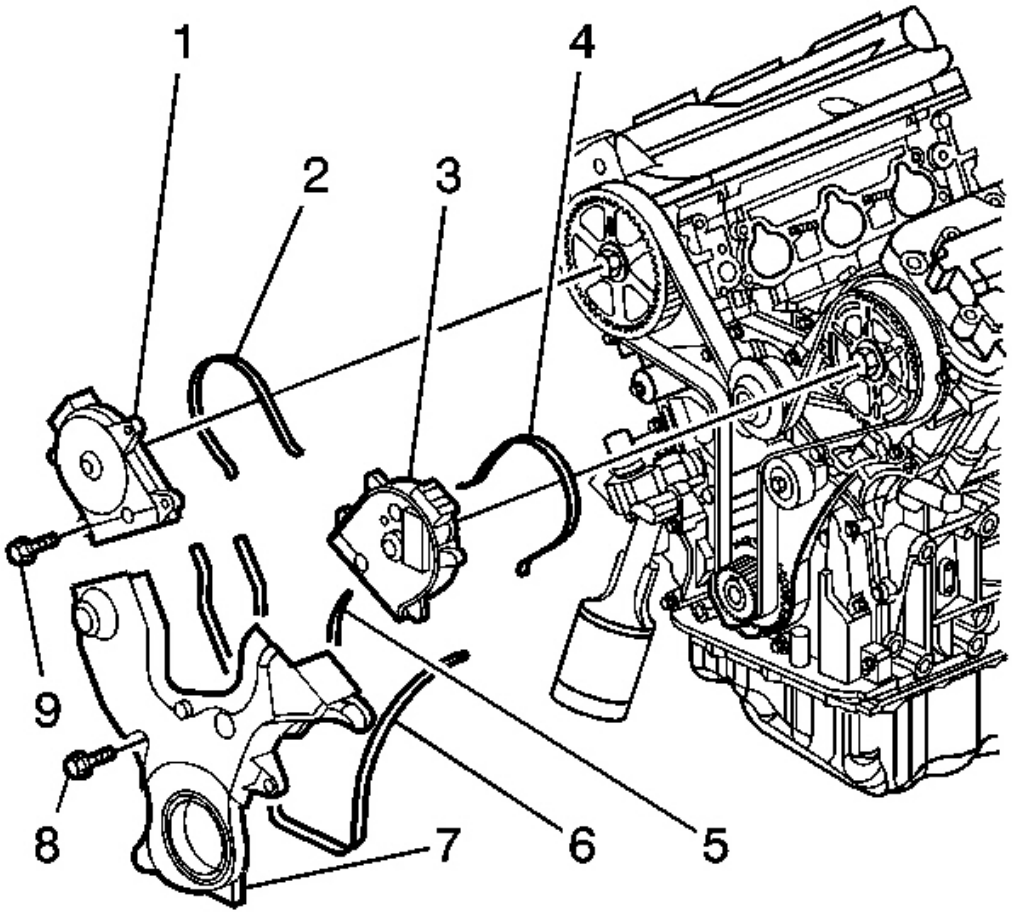


Fig. 105: View Of Timing Belt Cover
Courtesy of GENERAL MOTORS CORP.

1. Install the timing belt cover (7).

NOTE: **Refer to Fastener Notice in Cautions and Notices.**

2. Install the timing belt cover bolts (8).

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

3. Install the engine balancer using the **EN 46337** . See **Special Tools and Equipment** .
4. Install the splash shield. Refer to **Splash Shield Replacement - Engine** in Body Front End.
5. Install the engine drive belt. Refer to **Drive Belt Replacement** .

TIMING BELT REPLACEMENT

Removal Procedure

1. Remove the timing belt cover. Refer to **Timing Belt Cover Replacement** .

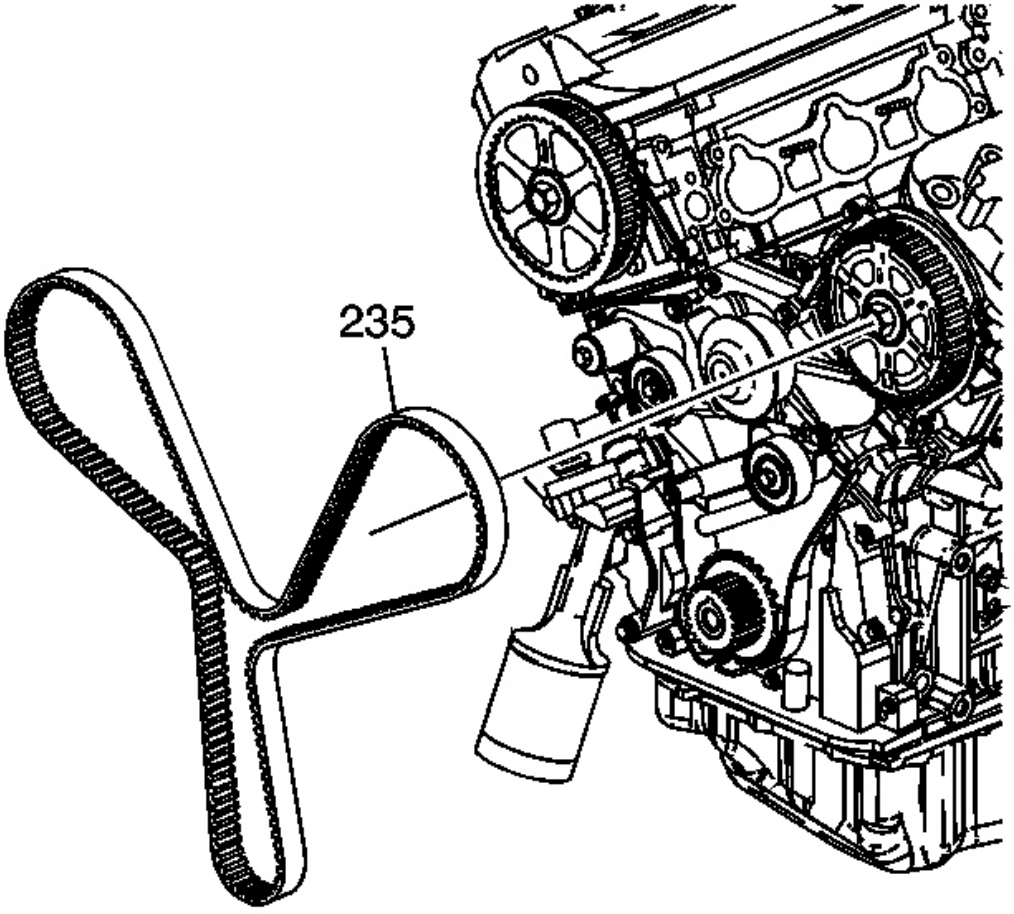


Fig. 106: View Of Timing Belt
Courtesy of GENERAL MOTORS CORP.

2. Remove the timing belt (235). Refer to**Timing Belt Removal** .

Installation Procedure

IMPORTANT: The powertrain control module (PCM) has to perform the idle learn

procedure under the following conditions:

- **Any operation or repair involving the crankshaft, the crankshaft position (CKP) sensor, or the CKP sensor-to-reluctor wheel gap relationship**
- **Timing belt removal or replacement**
- **PCM replacement**
- **Throttle body removal or replacement**
- **Engine assembly replacement**

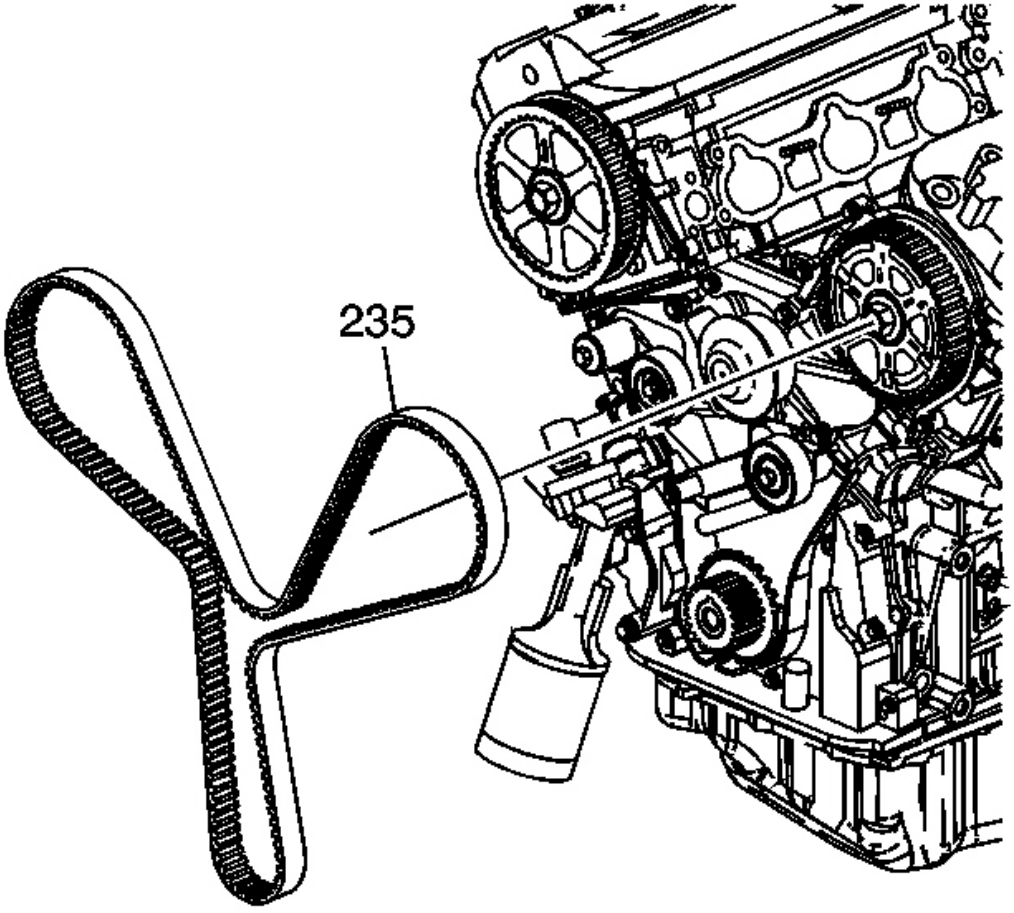


Fig. 107: View Of Timing Belt
Courtesy of GENERAL MOTORS CORP.

1. Install the timing belt (235). Refer to **Timing Belt Installation** .
2. Install the timing belt cover. Refer to **Timing Belt Cover Replacement** .
3. Perform the idle learn procedure. Refer to **Idle Learn Procedure** in Engine Controls - 3.5L (L66).

TIMING BELT TENSIONER REPLACEMENT

Tools Required

EN 46330 Timing Belt Tensioner Retaining Pin. See **Special Tools and Equipment** .

Removal Procedure

1. Remove the timing belt. Refer to**Timing Belt Replacement** .

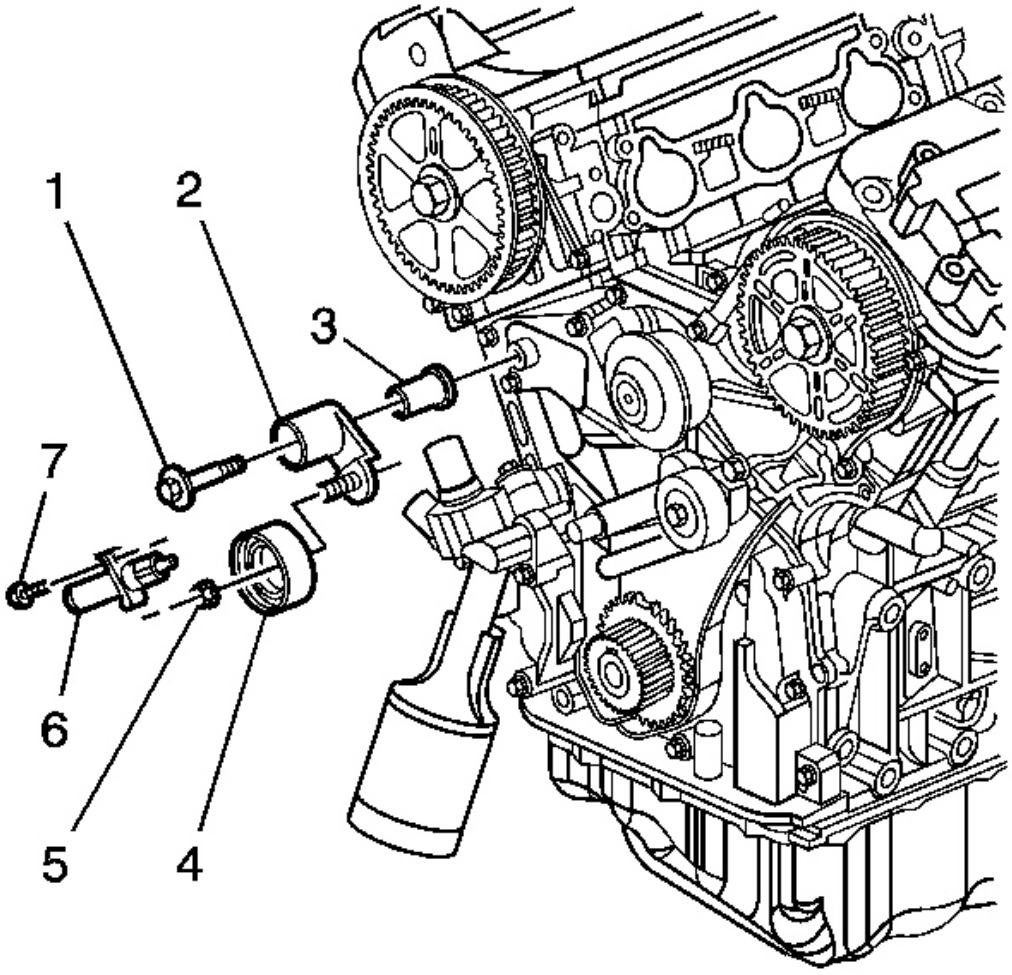


Fig. 108: View Of Timing Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

2. Remove the bolts (7).
3. Remove the tensioner (6).
4. Remove the bolt (1), tensioner pulley assembly (2) and bushing (3).
5. Remove the nut (5) and pulley (4).

Installation Procedure

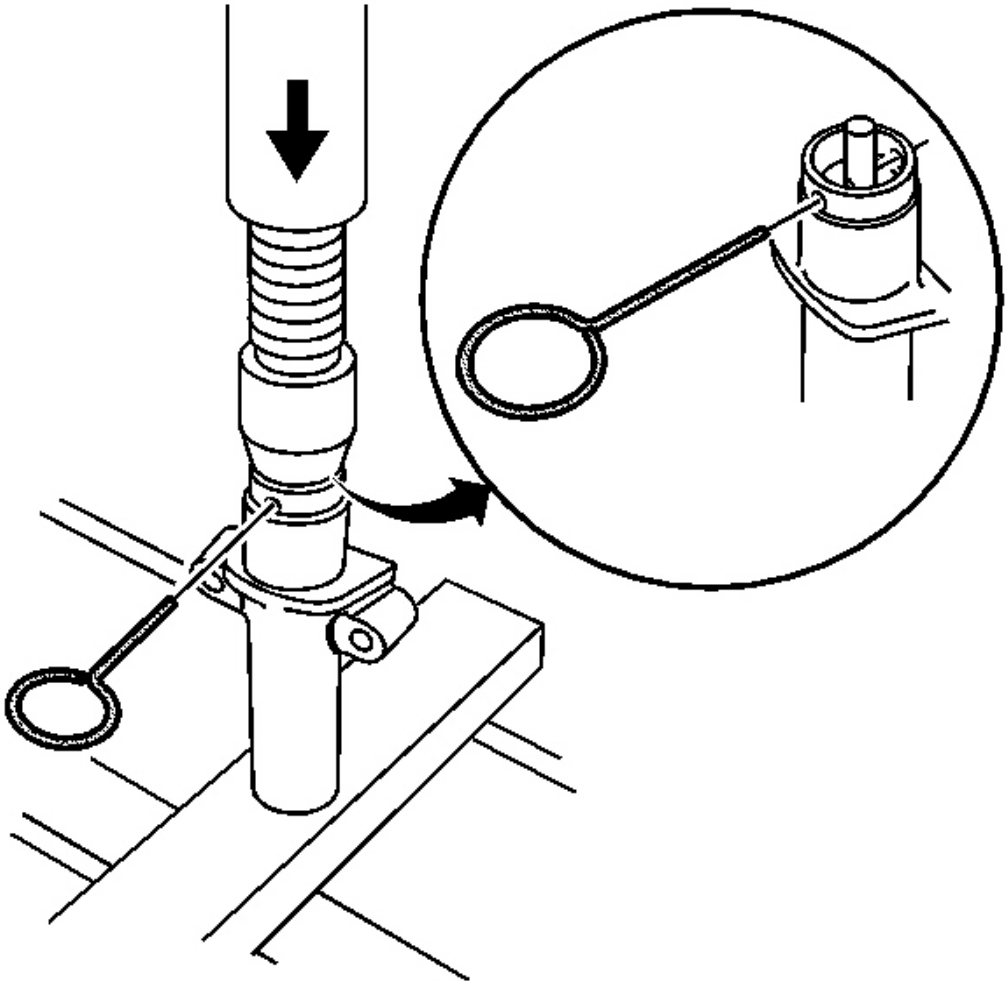


Fig. 109: View Of Hydraulic Press To Compress The Tensioner
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not exceed 9 800 N (2,200 lb) when compressing the rod of the tensioner or component damage may occur.

1. Using a hydraulic press, slowly compress the tensioner.
2. Insert the **EN 46330** through the housing and rod. See **Special Tools and Equipment** .

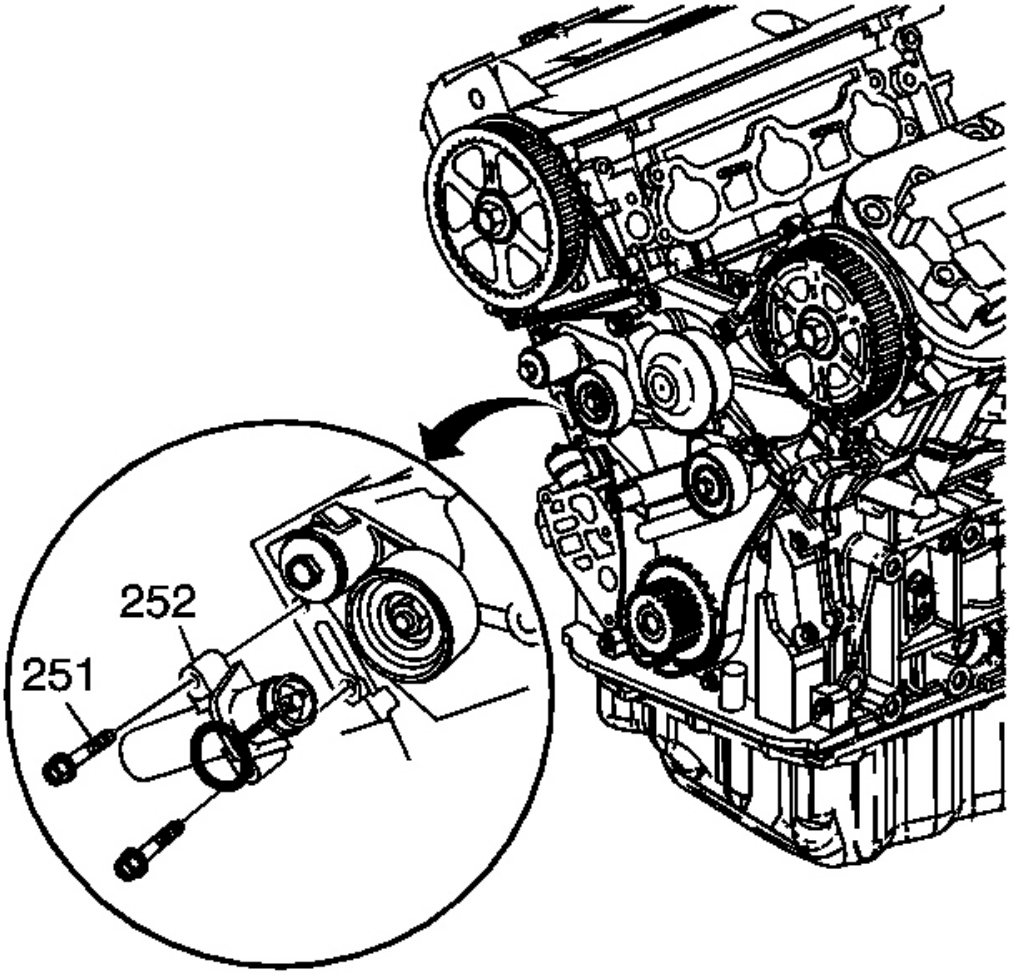


Fig. 110: Identifying Tensioner
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the tensioner (252) and bolts (251).

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

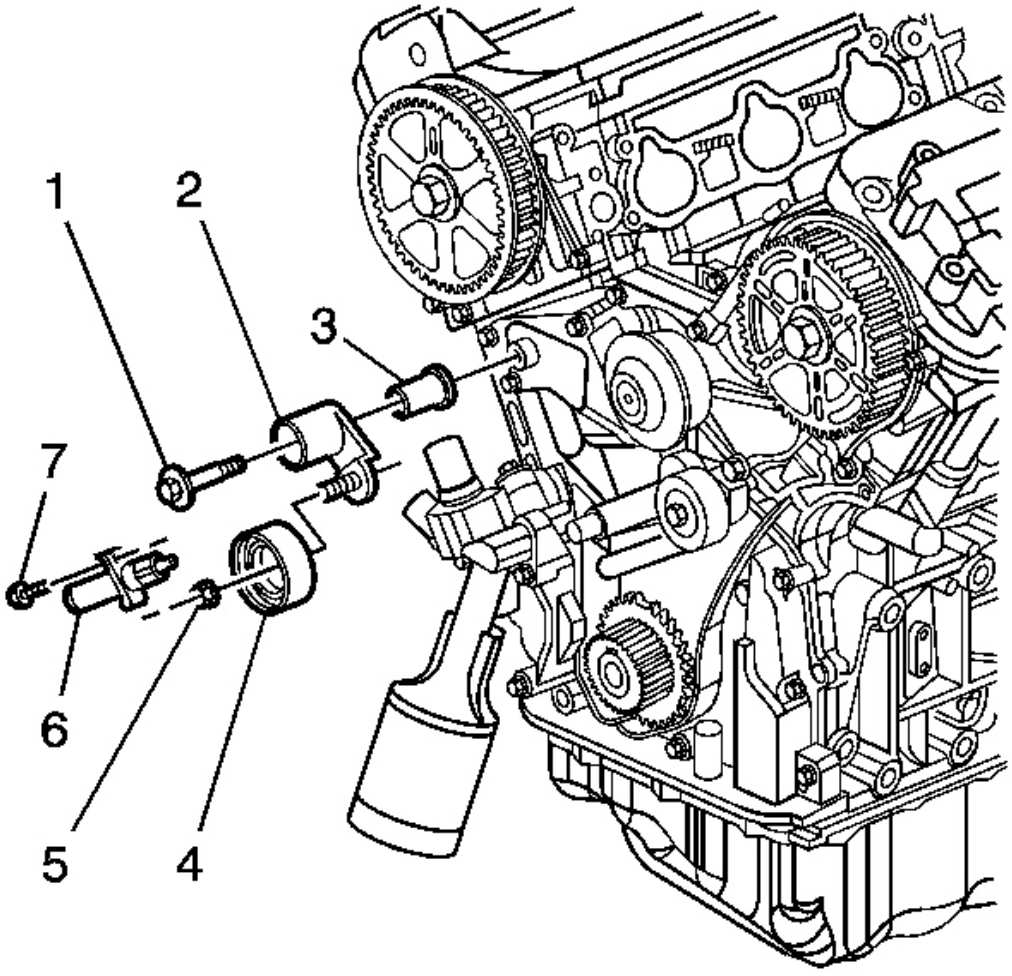


Fig. 111: View Of Timing Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

4. Install the bushing (3), tensioner bracket (2) and bolt (1).

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

5. Install the pulley (4) and nut (5).

   Tighten: Tighten the nut to 80 N.m (59 lb ft).

6. Install the timing belt. Refer to**Timing Belt Replacement** .

CAMSHAFT REPLACEMENT - LEFT

Removal Procedure

1. Remove the battery. Refer to **Battery Replacement** in Engine Electrical.
2. Remove the battery tray. Refer to **Battery Tray Replacement (L61)** or **Battery Tray Replacement (L66)** in Engine Electrical.
3. Drain the engine coolant. Refer to **Draining and Filling Cooling System** in Engine Cooling.
4. Remove the upper radiator hose.
5. Remove the exhaust gas recirculation (EGR) valve. Refer to **Exhaust Gas Recirculation (EGR) Valve Replacement** in Engine Controls - 3.5L (L66).
6. Remove the left rocker arm cover. Refer to **Valve Rocker Arm Cover Replacement - Left** .
7. Remove the left camshaft drive sprocket. Refer to **Camshaft Drive Sprocket Replacement - Left** .

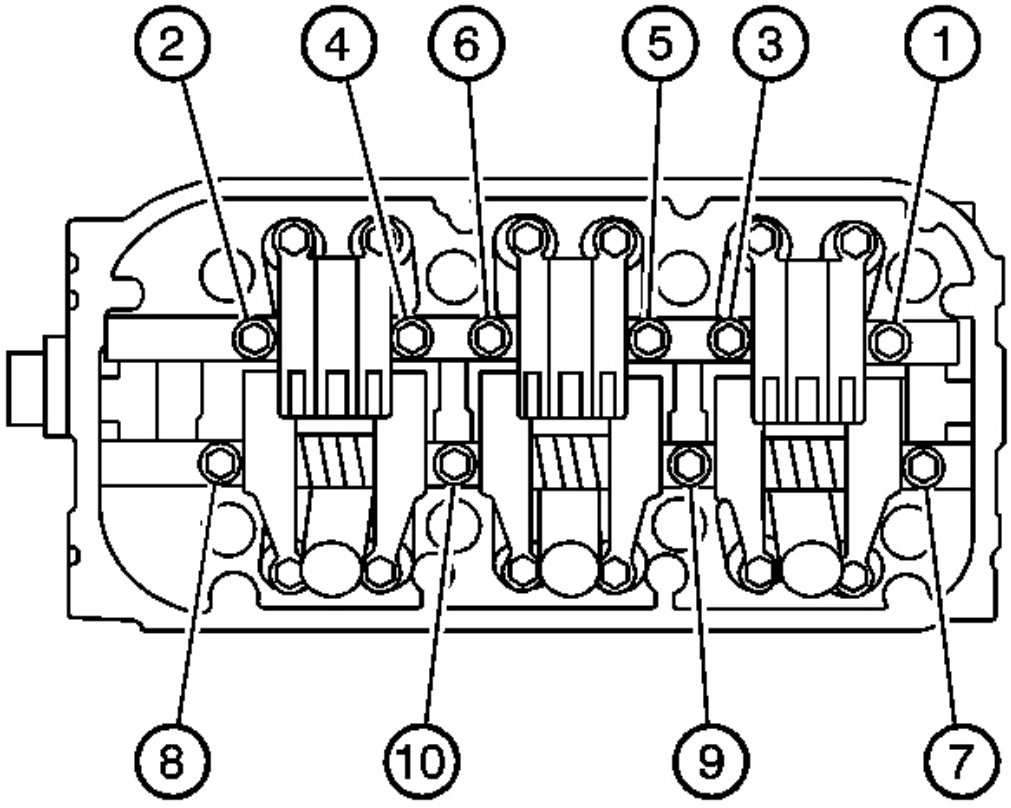


Fig. 112: Identifying Rocker Shaft Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

8. Alternately loosen the rocker shaft retaining bolts a few turns at a time using the loosening sequence.
9. Remove the rocker arm and shaft assembly.

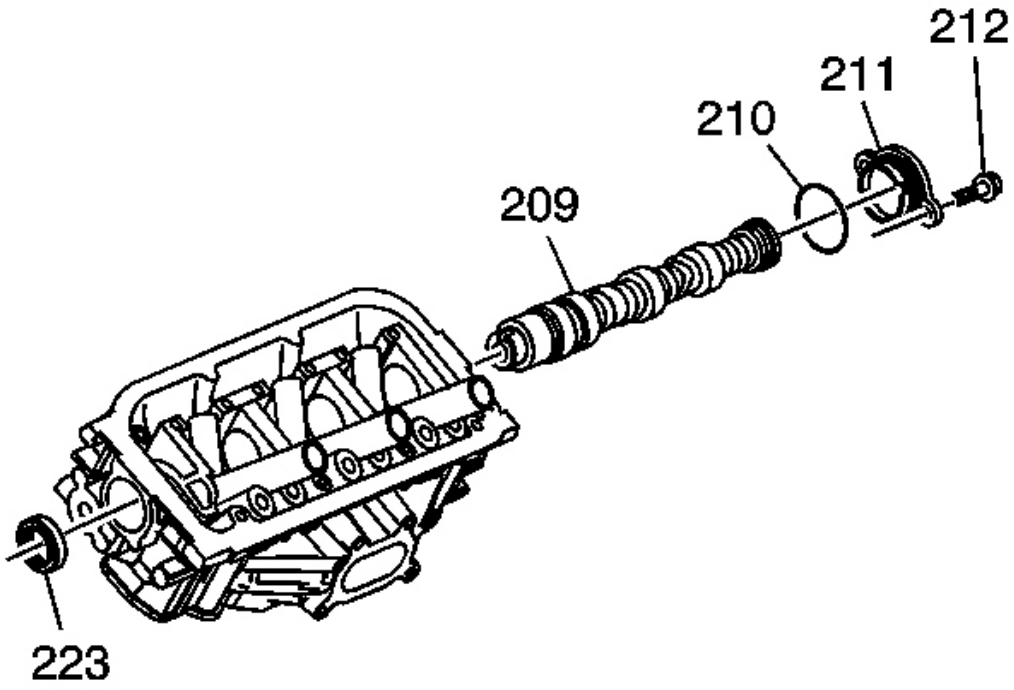


Fig. 113: Identifying Camshaft Journals
Courtesy of GENERAL MOTORS CORP.

10. Remove the rear camshaft cap, bolts, and O-ring.
11. Remove the camshaft from the cylinder head.
12. Remove the camshaft seal.
13. Clean all of the bearing surfaces.
14. Clean all of the sealing surfaces.
15. Clean and inspect the camshafts. Refer to **Camshafts Cleaning and Inspection** .

Installation Procedure

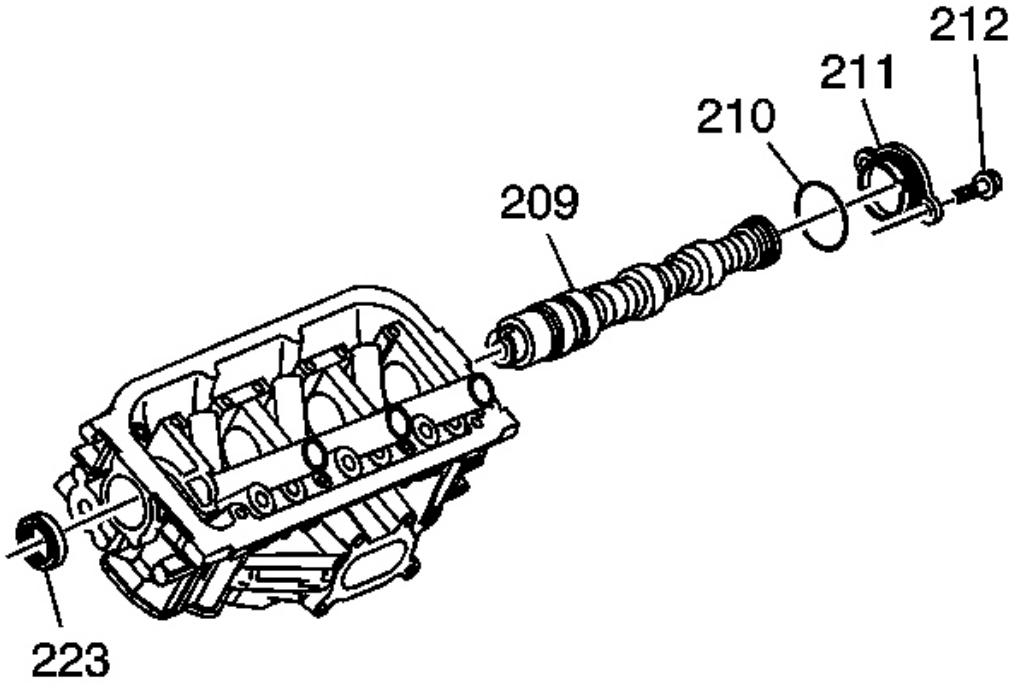


Fig. 114: Identifying Camshaft Journals
Courtesy of GENERAL MOTORS CORP.

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

   NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the camshaft, NEW O-ring, cap, and bolts.

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

3. Install a new camshaft seal. Refer to **Camshaft Oil Seal Replacement** .

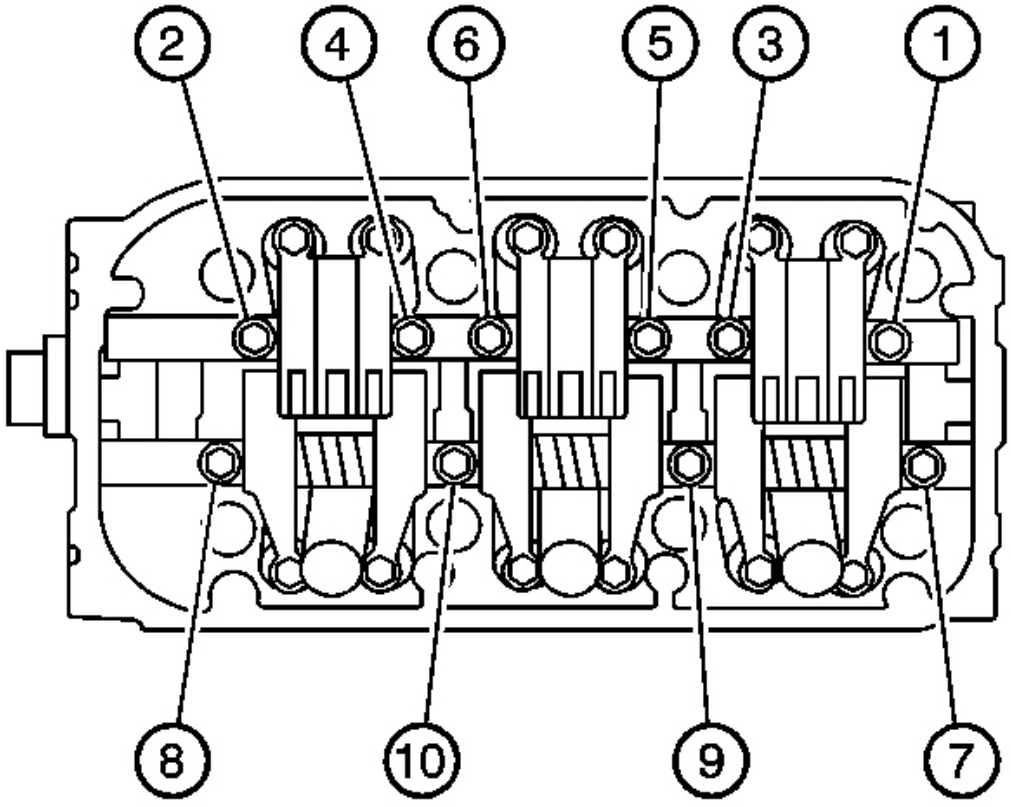


Fig. 115: Identifying Rocker Shaft Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

4. Install the rocker arm and shaft assembly. Refer to **Valve Rocker Arm and Shaft Replacement** .
5. Install the left camshaft drive sprocket. Refer to **Camshaft Drive Sprocket Replacement - Left** .
6. Install the left rocker arm cover. Refer to **Valve Rocker Arm Cover Replacement - Left** .
7. Install the EGR valve. Refer to **Exhaust Gas Recirculation (EGR) Valve Replacement** in Engine Controls - 3.5L (L66).
8. Install the upper radiator hose.
9. Fill the radiator with engine coolant. Refer to **Draining and Filling Cooling System** in Engine Cooling.
10. Install the battery tray. Refer to **Battery Tray Replacement (L61)** or **Battery Tray Replacement (L66)** in Engine Electrical.
11. Install the battery. Refer to **Battery Replacement** in Engine Electrical.

CAMSHAFT REPLACEMENT - RIGHT

Removal Procedure

1. Remove the battery. Refer to**Battery Replacement** in Engine Electrical.
2. Remove the battery tray. Refer to**Battery Tray Replacement (L61)** or **Battery Tray Replacement (L66)** in Engine Electrical.
3. Remove the underhood fuse/relay box.
4. Disconnect the fuel feed line from the fuel rail. Refer to**Fuel Hose/Pipes Replacement - Chassis** in Engine Controls - 3.5L (L66).
5. Disconnect the engine harness connectors to gain access.
6. Remove the powertrain control module (PCM). Refer to**Powertrain Control Module (PCM) Replacement** in Engine Controls - 3.5L (L66).
7. Remove the right rocker arm cover. Refer to**Valve Rocker Arm Cover Replacement - Right** .
8. Remove the right camshaft drive sprocket. Refer to**Camshaft Drive Sprocket Replacement - Right** .

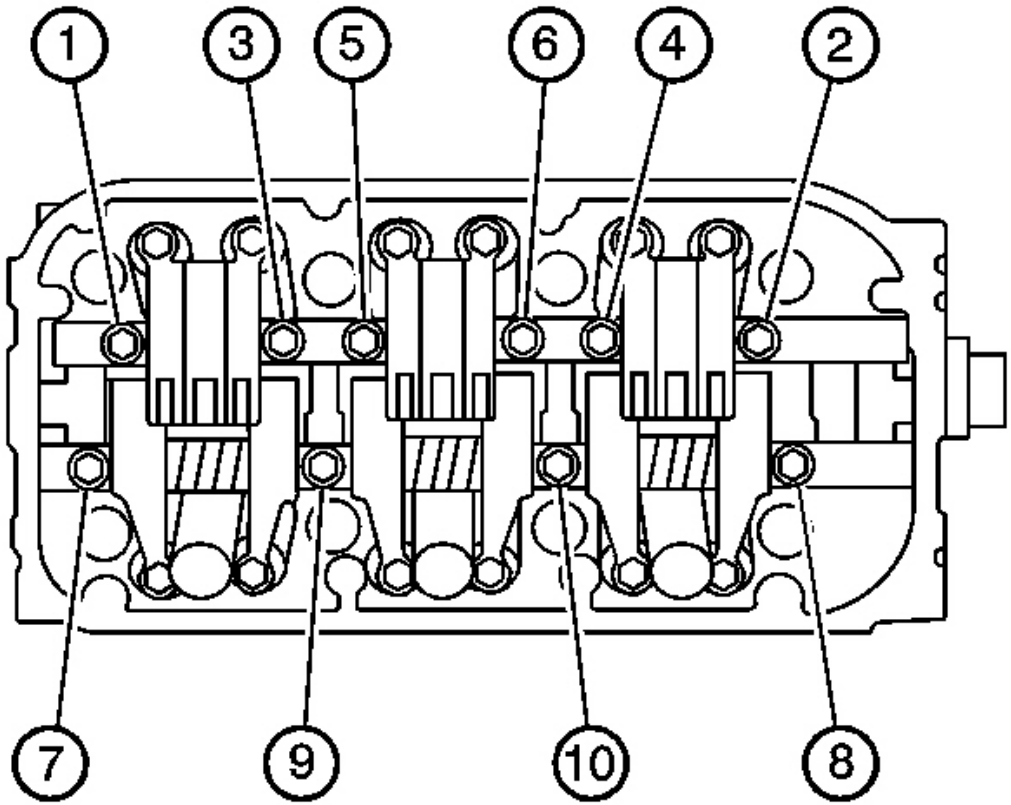


Fig. 116: View Of Right Side Rocker Shaft Retaining Bolts In Sequence
Courtesy of GENERAL MOTORS CORP.

9. Alternately loosen the rocker shaft retaining bolts a few turns at a time using the loosening sequence.
10. Remove the rocker arm and shaft assembly.

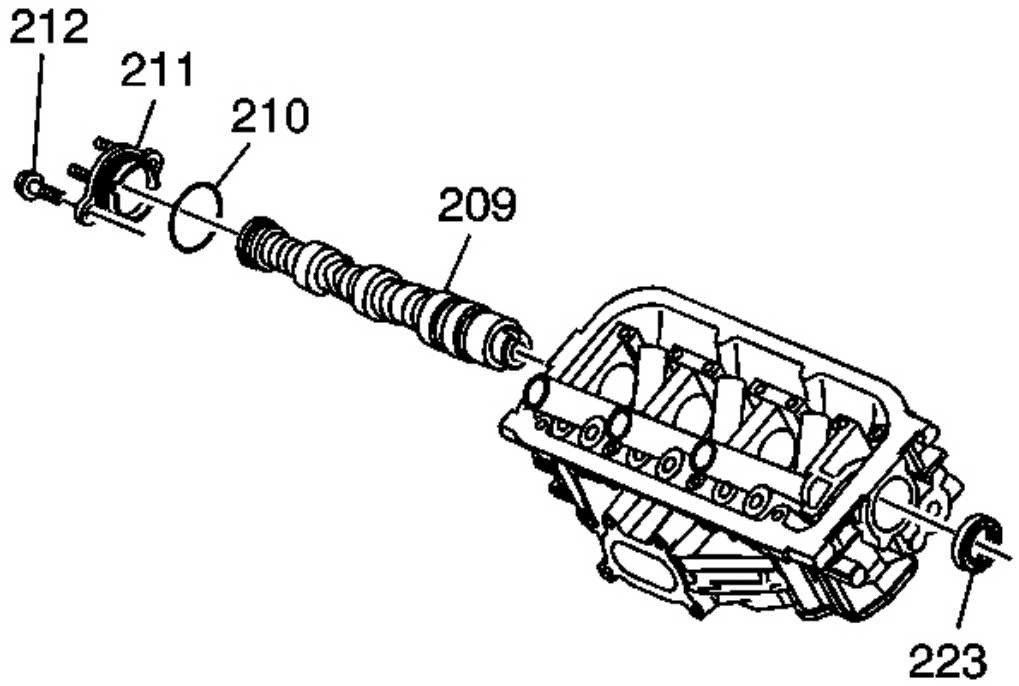


Fig. 117: View Of Camshaft Journals
Courtesy of GENERAL MOTORS CORP.

11. Remove the rear camshaft cap, bolts, and O-ring.
12. Remove the camshaft from the cylinder head.
13. Remove the camshaft seal.
14. Clean all of the bearing surfaces.
15. Clean all of the sealing surfaces.
16. Clean and inspect the camshafts. Refer to**Camshafts Cleaning and Inspection** .

Installation Procedure

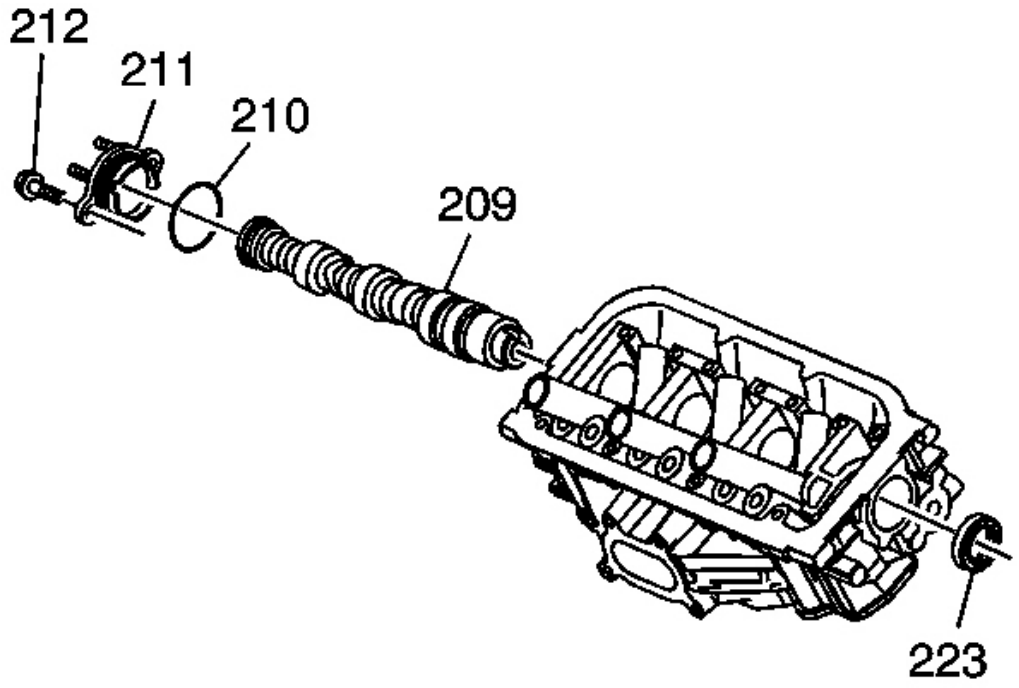


Fig. 118: View Of Camshaft Journals
Courtesy of GENERAL MOTORS CORP.

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

   NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the camshaft, NEW O-ring, cap, and bolts.

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

3. Install a new camshaft seal. Refer to **Camshaft Oil Seal Replacement** .

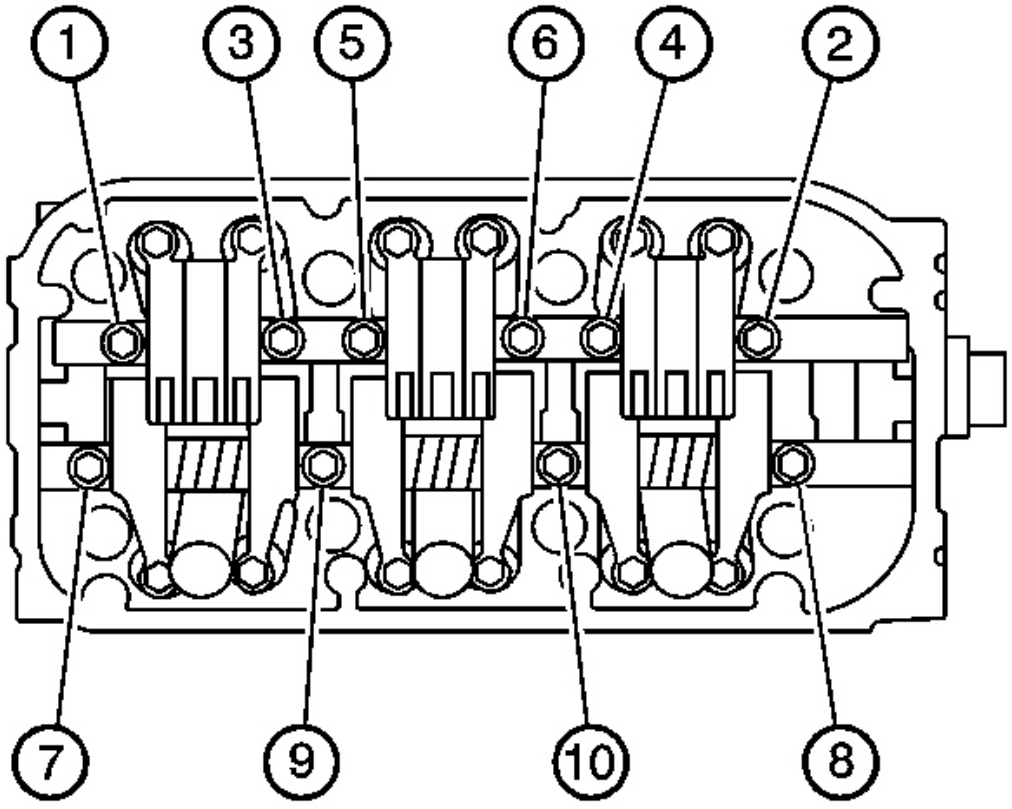


Fig. 119: View Of Right Side Rocker Shaft Retaining Bolts In Sequence
Courtesy of GENERAL MOTORS CORP.

4. Install the rocker arm and shaft assembly. Refer to **Valve Rocker Arm and Shaft Replacement** .
5. Install the right camshaft drive sprocket. Refer to **Camshaft Drive Sprocket Replacement - Right** .
6. Install the right rocker arm cover. Refer to **Valve Rocker Arm Cover Replacement - Right** .
7. Install the PCM. Refer to **Powertrain Control Module (PCM) Replacement** in Engine Controls - 3.5L (L66).
8. Connect the engine harness connectors.
9. Connect the fuel feed line to the fuel rail. Refer to **Fuel Hose/Pipes Replacement - Chassis** in Engine Controls - 3.5L (L66).
10. Install the underhood fuse/relay box.
11. Install the battery tray. Refer to **Battery Tray Replacement (L61)** or **Battery Tray Replacement (L66)** in Engine Electrical.
12. Install the battery. Refer to **Battery Replacement** in Engine Electrical.

TIMING BELT IDLER PULLEY REPLACEMENT

Removal Procedure

1. Remove the timing belt. Refer to**Timing Belt Replacement** .

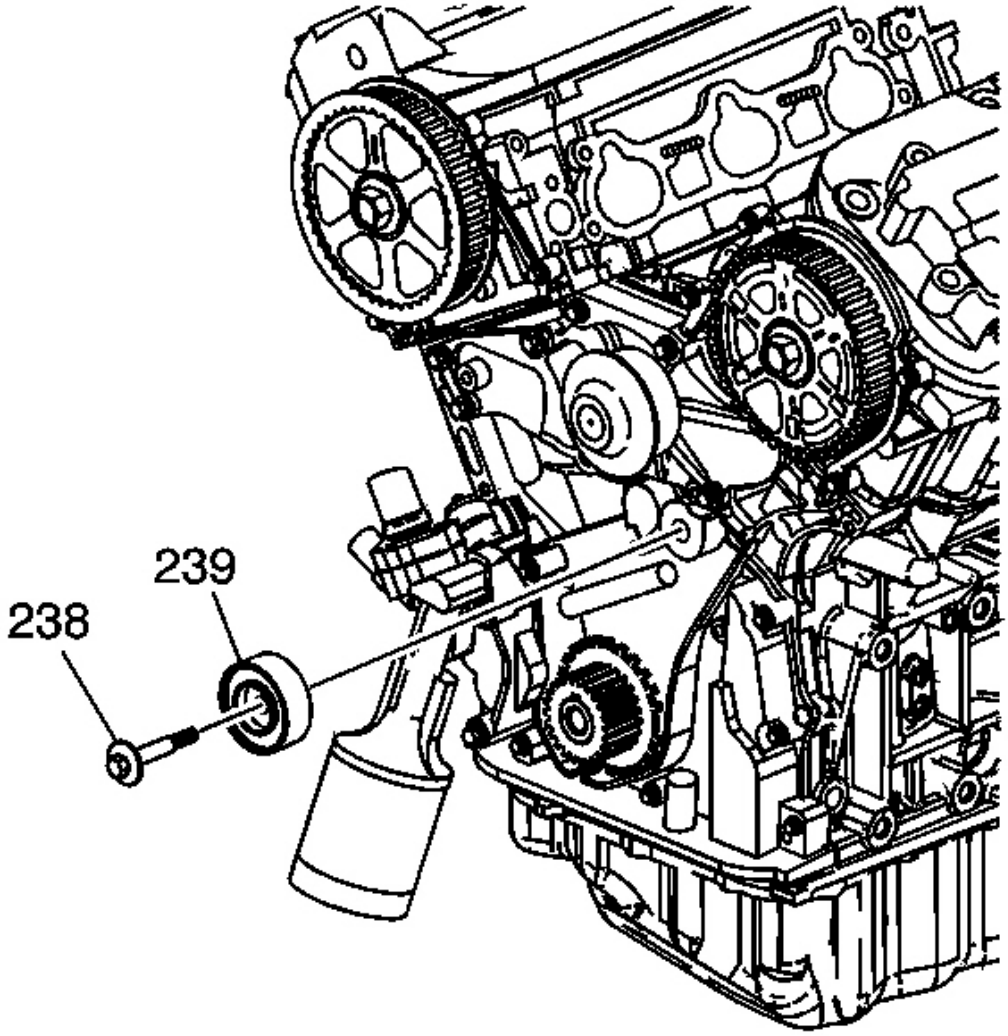


Fig. 120: View Of Timing Belt
Courtesy of GENERAL MOTORS CORP.

2. Remove the bolt (238).
3. Remove the pulley (239).

Installation Procedure

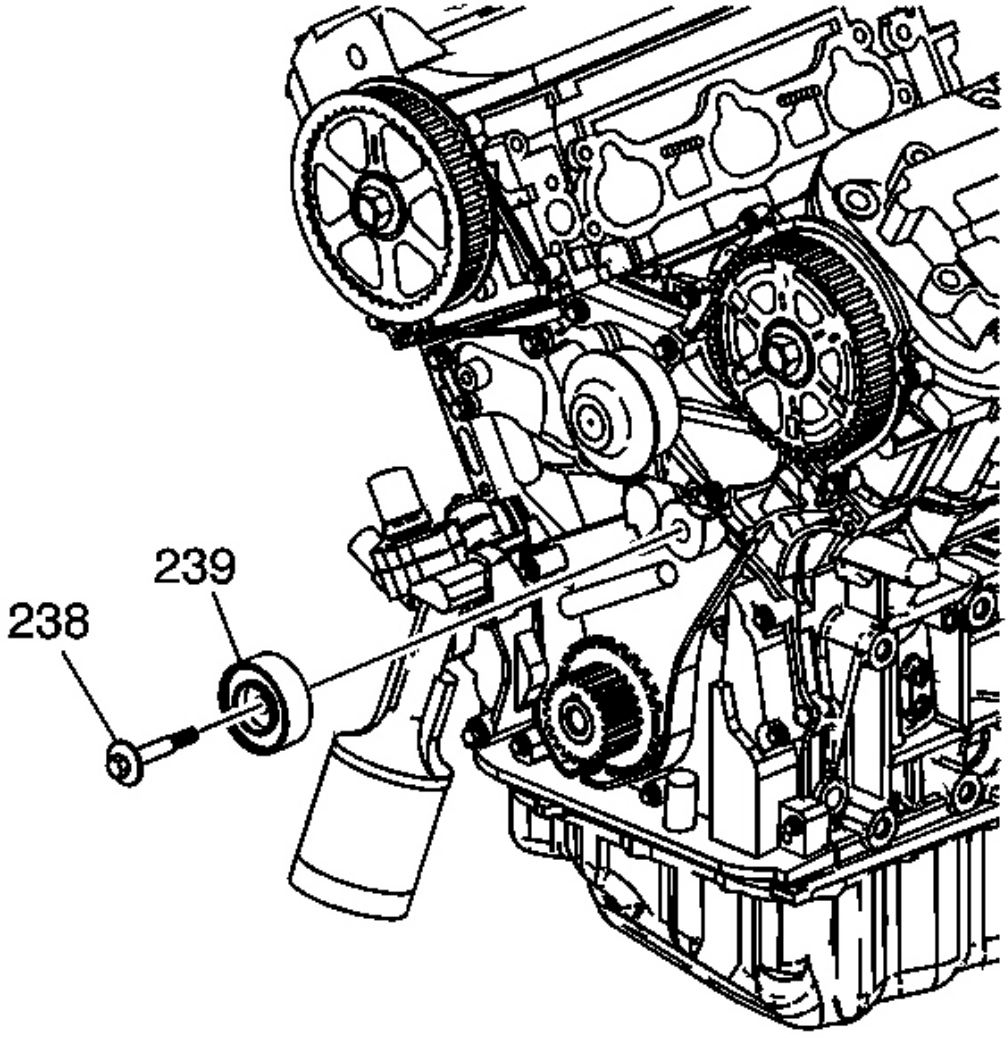


Fig. 121: View Of Timing Belt
Courtesy of GENERAL MOTORS CORP.

1. Install the pulley (239).

IMPORTANT: Do not tighten the idler pulley bolt (238) at this time. The idler pulley bolt is to be tightened during the timing belt installation procedure.

2. Install the bolt (238).
3. Install the timing belt. Refer to**Timing Belt Replacement** .

CAMSHAFT OIL SEAL REPLACEMENT

Removal Procedure

1. Remove the appropriate camshaft sprocket. Refer to**Camshaft Drive Sprocket Replacement - Left** and**Camshaft Drive Sprocket Replacement - Right** .

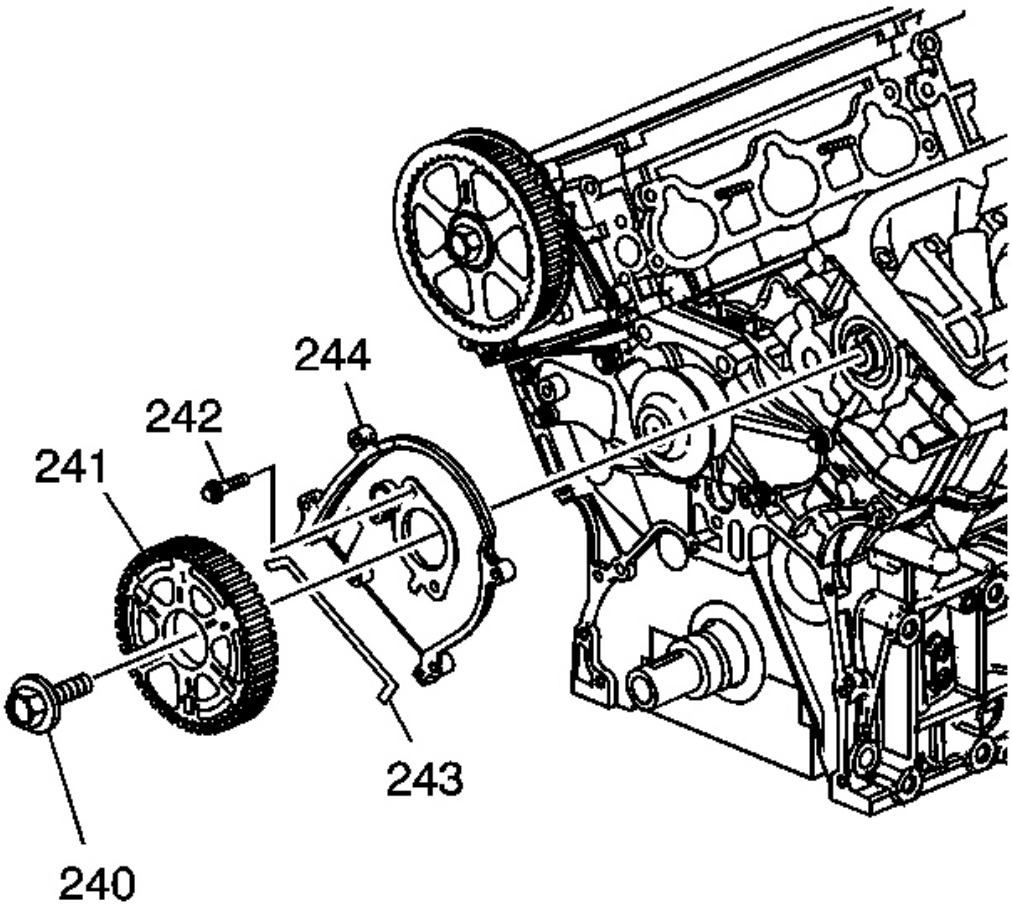


Fig. 122: View Of Camshaft Oil Seal
Courtesy of GENERAL MOTORS CORP.

2. Remove the camshaft cover and bolts.

3. Remove the camshaft oil seal using a flat-bladed tool.

Installation Procedure

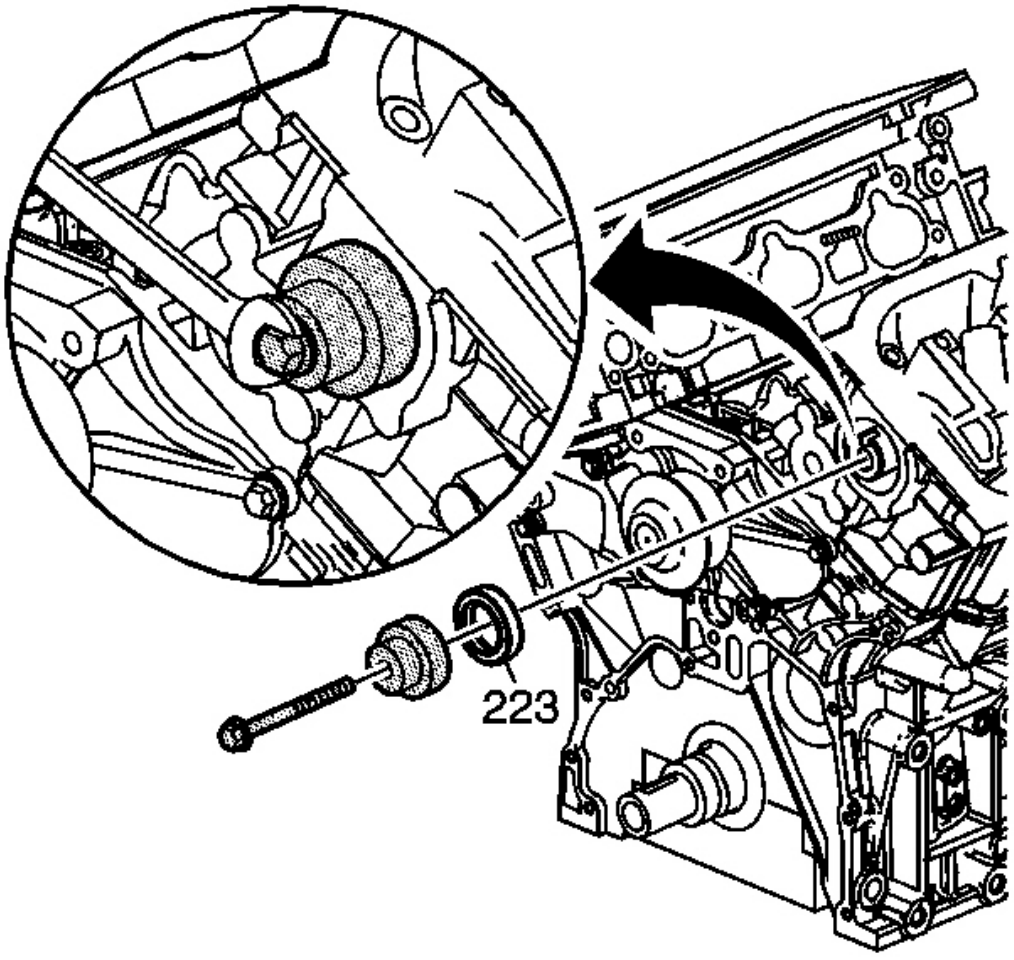


Fig. 123: View Of Seal Into The Cylinder
Courtesy of GENERAL MOTORS CORP.

1. Use the **EN 46334** to install the seal (223) into the cylinder head. See **Special Tools and Equipment** . Rotate the bolt clockwise until the tool bottoms in the cylinder head bore.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the cover, NEW seal, and bolts.

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

3. Install the camshaft sprocket. Refer to **Camshaft Drive Sprocket Replacement - Left** and **Camshaft Drive Sprocket Replacement - Right** .

CAMSHAFT DRIVE SPROCKET REPLACEMENT - LEFT

Tools Required

EN 46337 Timing Belt Alignment Kit. See **Special Tools and Equipment** .

Removal Procedure

1. Remove the timing belt. Refer to **Timing Belt Replacement** .

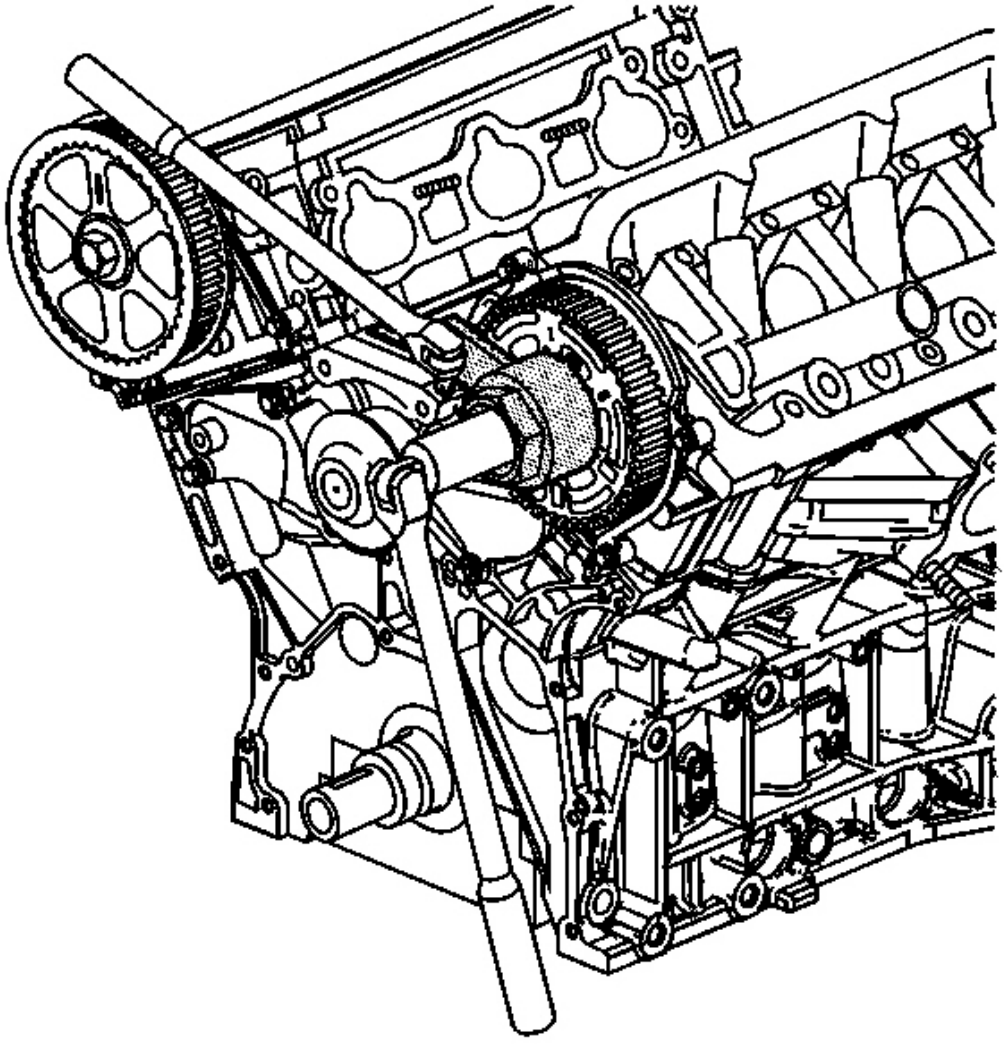


Fig. 124: View Of Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

2. Use the **EN 46337** to retain the camshaft sprocket. See **Special Tools and Equipment** .
3. Remove the camshaft bolt and sprocket.

Installation Procedure

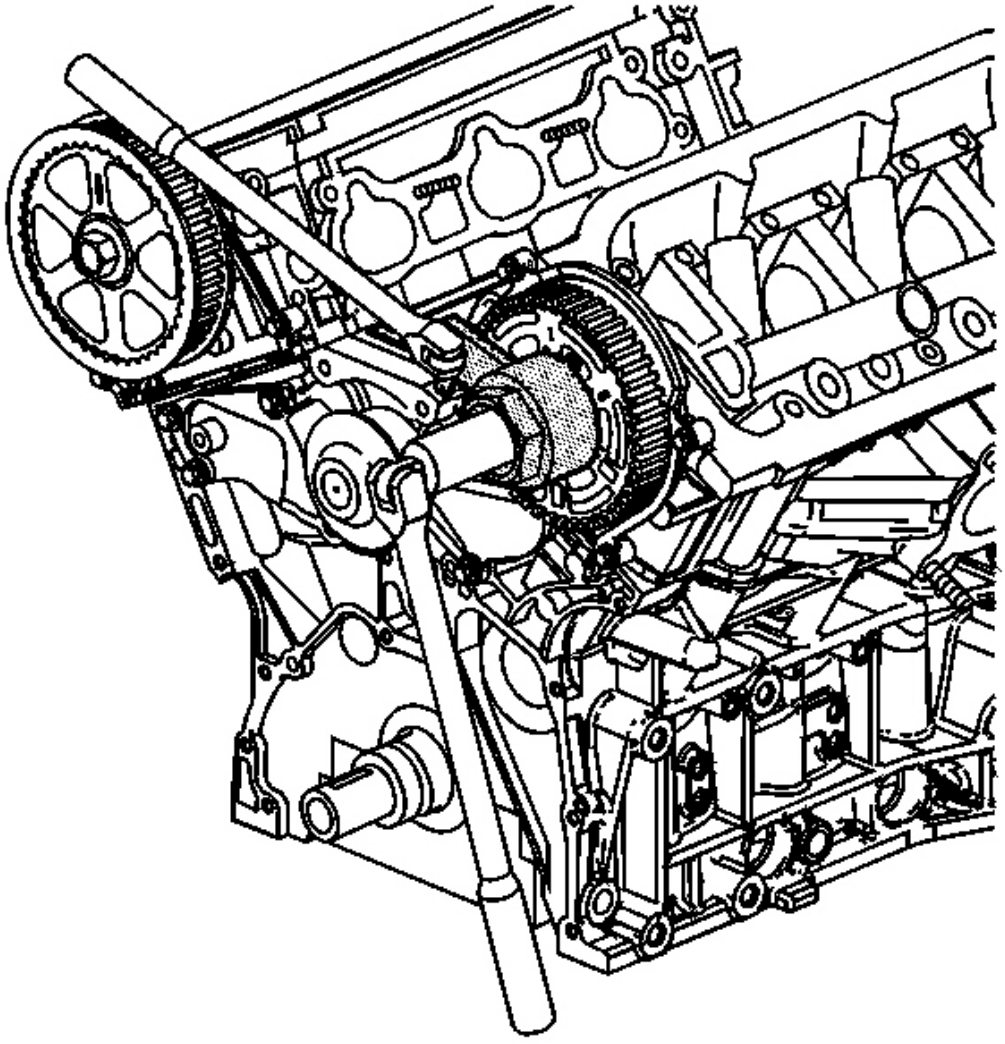


Fig. 125: View Of Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Use the **EN 46337** to retain the camshaft sprocket. See **Special Tools and Equipment** .

   Tighten: Tighten the camshaft sprocket bolt to 90 N.m (67 lb ft).

2. Install and adjust the timing belt. Refer to **Timing Belt Replacement** .

CAMSHAFT DRIVE SPROCKET REPLACEMENT - RIGHT

Tools Required

EN 46337 Timing Belt Alignment Kit. See **Special Tools and Equipment** .

Removal Procedure

1. Remove the powertrain control module (PCM). Refer to **Powertrain Control Module (PCM) Replacement** in Engine Controls.
2. Remove the timing belt. Refer to **Timing Belt Replacement** .

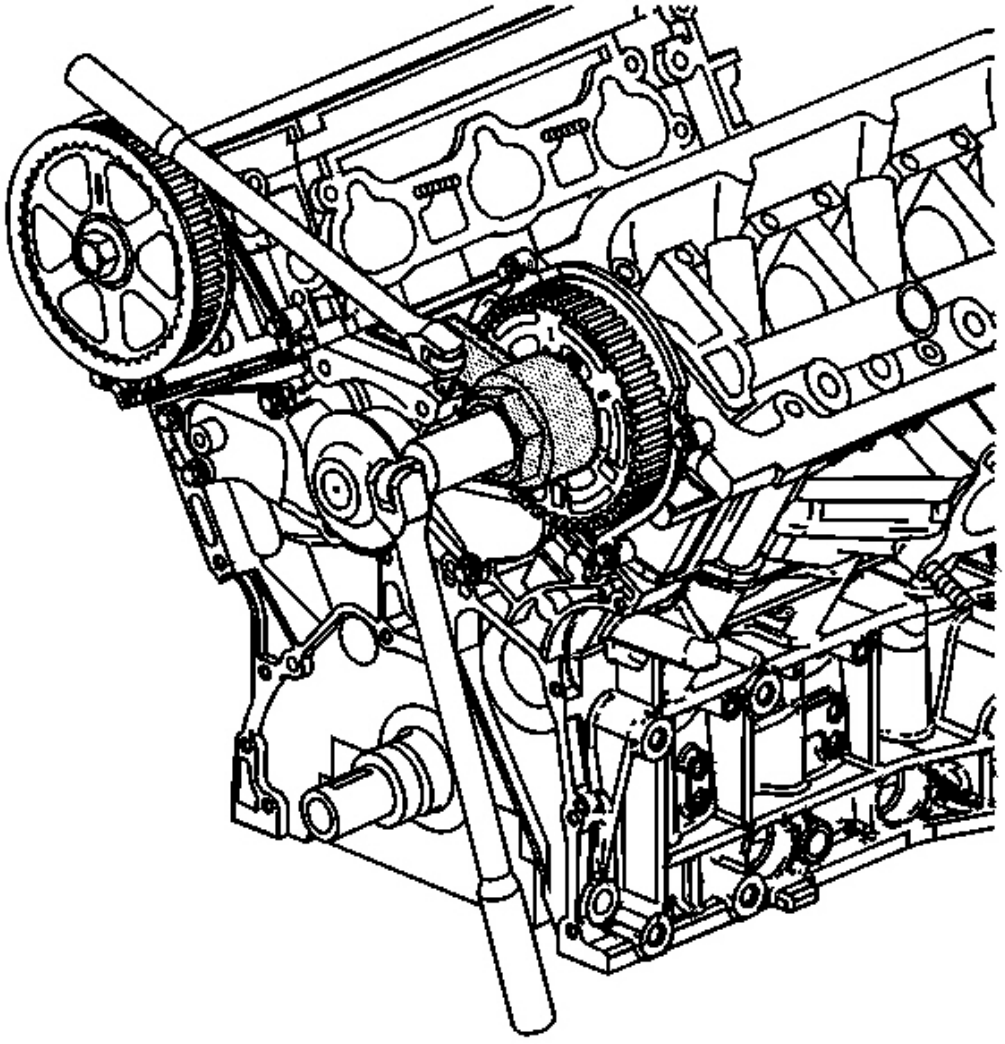


Fig. 126: View Of Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

3. Use the **EN 46337** to retain the camshaft sprocket. See **Special Tools and Equipment** .
4. Remove the camshaft bolt and sprocket.

Installation Procedure

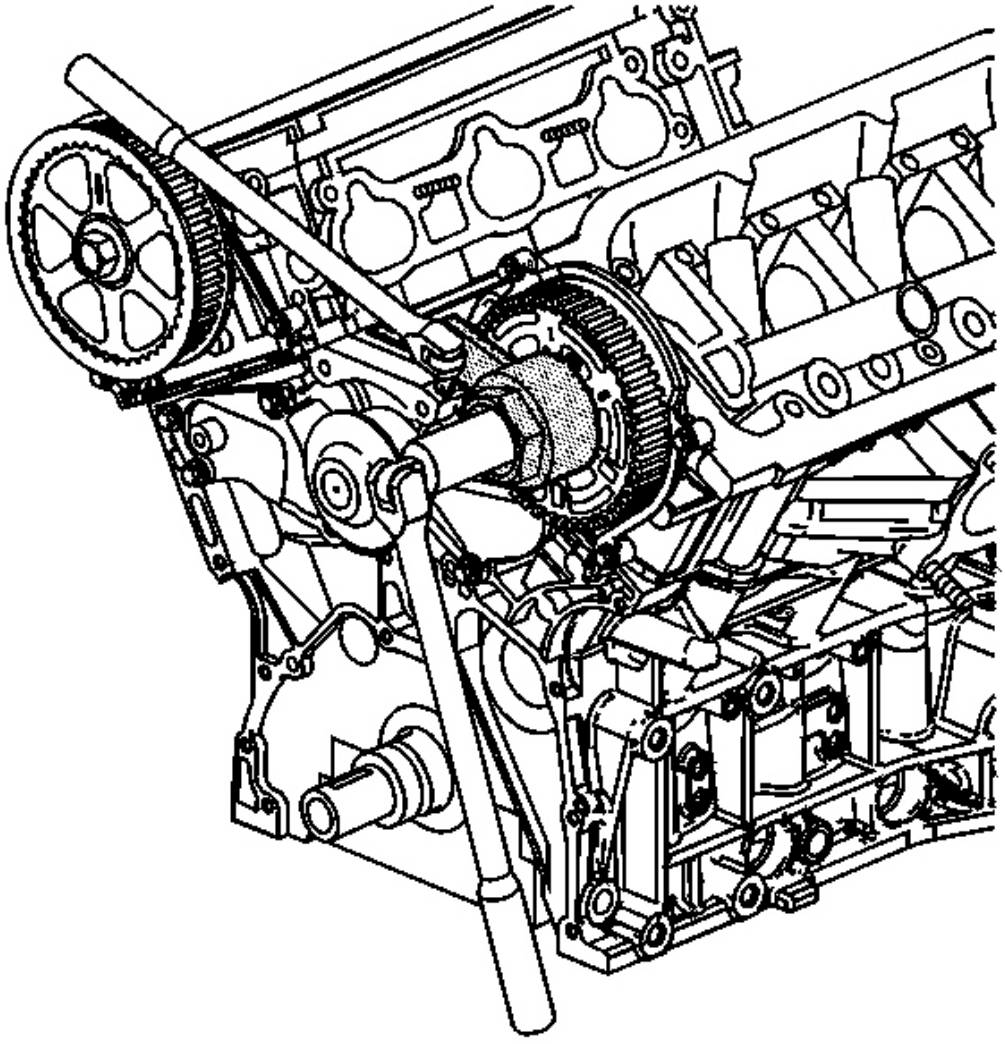


Fig. 127: View Of Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Use the **EN 46337** to retain the camshaft sprocket. See **Special Tools and Equipment** .

   Tighten: Tighten the camshaft sprocket bolt to 90 N.m (67 lb ft).

2. Install and adjust the timing belt. Refer to **Timing Belt Replacement** .

CRANKSHAFT GEAR REPLACEMENT

Removal Procedure

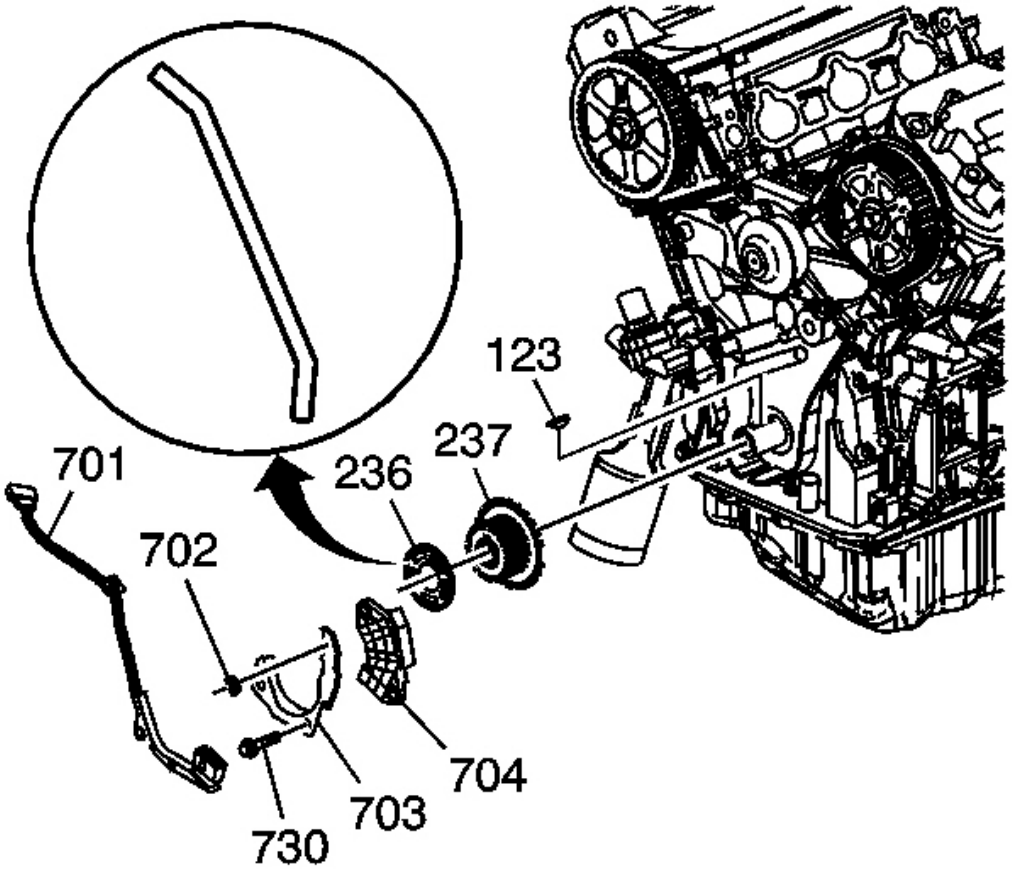


Fig. 128: View Of Crankshaft Gear
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft position sensor. Refer to**Crankshaft Position (CKP) Sensor Replacement** in Engine Controls - 3.5L (L66).

IMPORTANT: The concave area of the guide faces the front of engine.

2. Remove the guide (703).
3. Remove the sprocket and key (237 and 236).

Installation Procedure

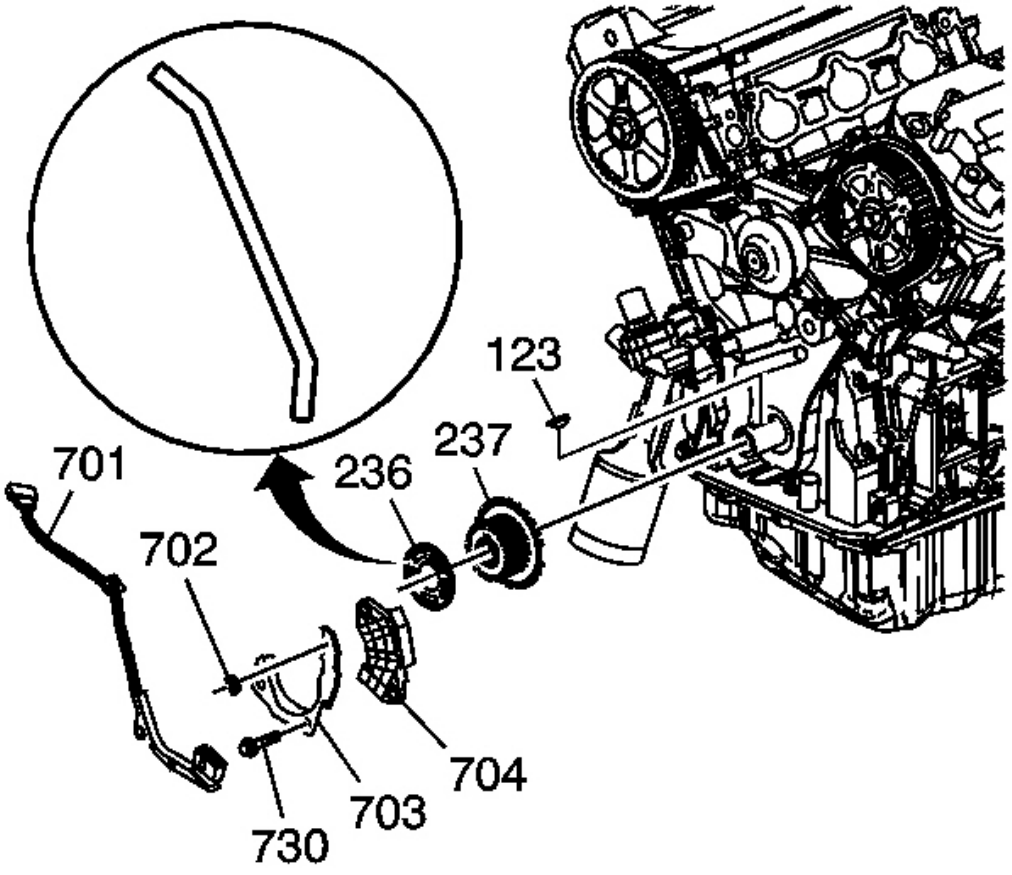


Fig. 129: View Of Crankshaft Gear
Courtesy of GENERAL MOTORS CORP.

1. Install the key and sprocket (236 and 237).
2. Install the guide (703).
3. Install the crankshaft position sensor. Refer to**Crankshaft Position (CKP) Sensor Replacement** in Engine Controls - 3.5L (L66).

CYLINDER HEAD (LEFT) REPLACEMENT

Removal Procedure

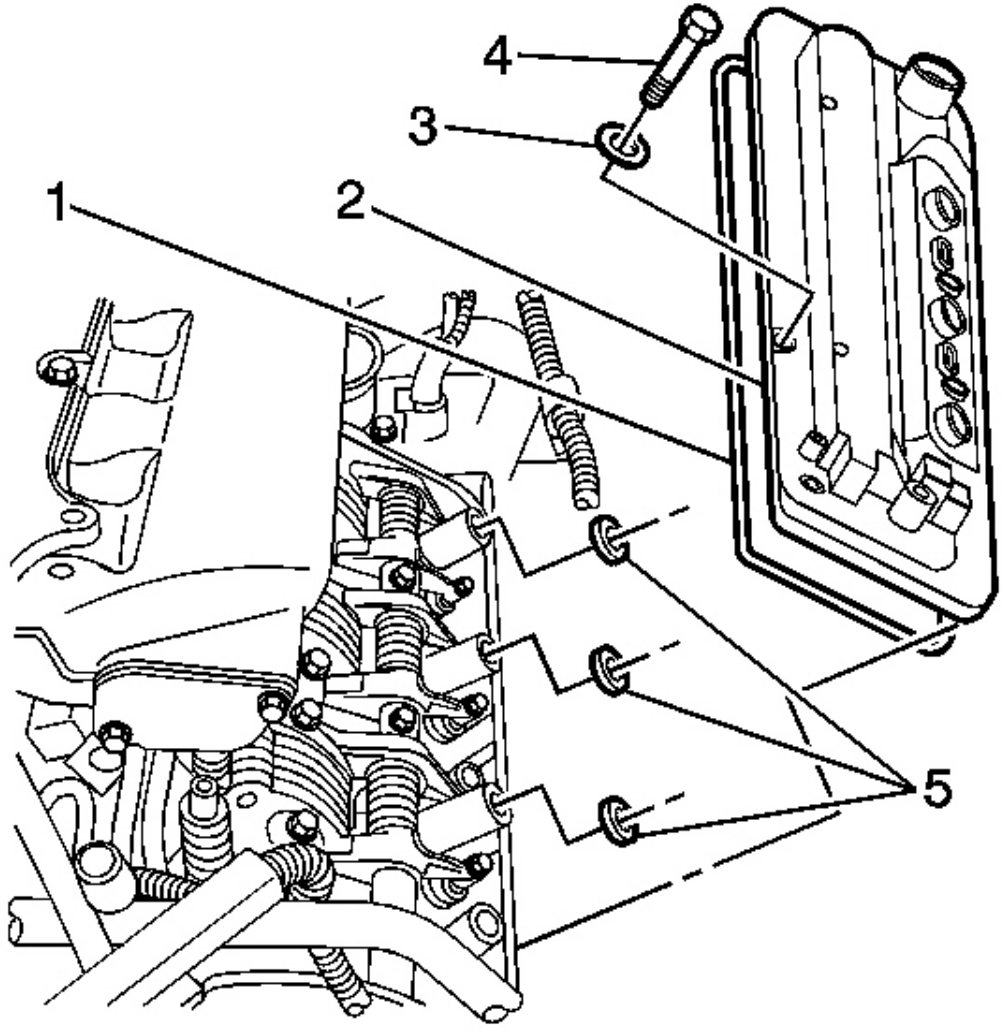


Fig. 130: View Of Cylinder Head
Courtesy of GENERAL MOTORS CORP.

1. Remove the left rocker cover (2). Refer to **Valve Rocker Arm Cover Replacement - Left** .

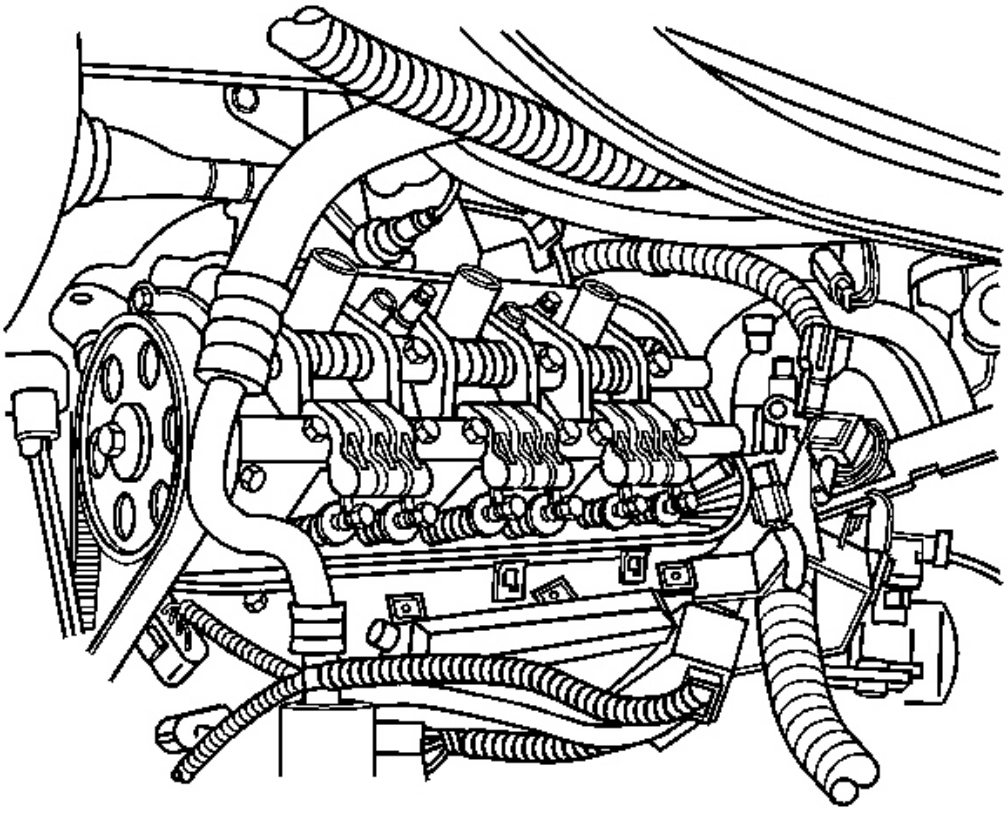


Fig. 131: View Of Rocker Arm & Shaft Assembly
Courtesy of GENERAL MOTORS CORP.

2. Remove the left rocker arm and shaft assembly. Refer to **Valve Rocker Arm and Shaft Replacement** .
3. Remove the timing belt. Refer to **Timing Belt Replacement** .
4. Remove the coolant bridge. Refer to **Coolant Crossover Pipe Replacement** in Engine Cooling.
5. Disconnect the left bank oxygen sensors.
6. Remove the left cylinder head. Refer to **Cylinder Head Removal - Left** .

Installation Procedure

1. Install the left cylinder head. Refer to **Cylinder Head Installation - Left** .
2. Connect the left bank oxygen sensors.
3. Install the coolant bridge. Refer to **Coolant Crossover Pipe Replacement** in Engine Cooling.
4. Install the timing belt. Refer to **Timing Belt Replacement** .

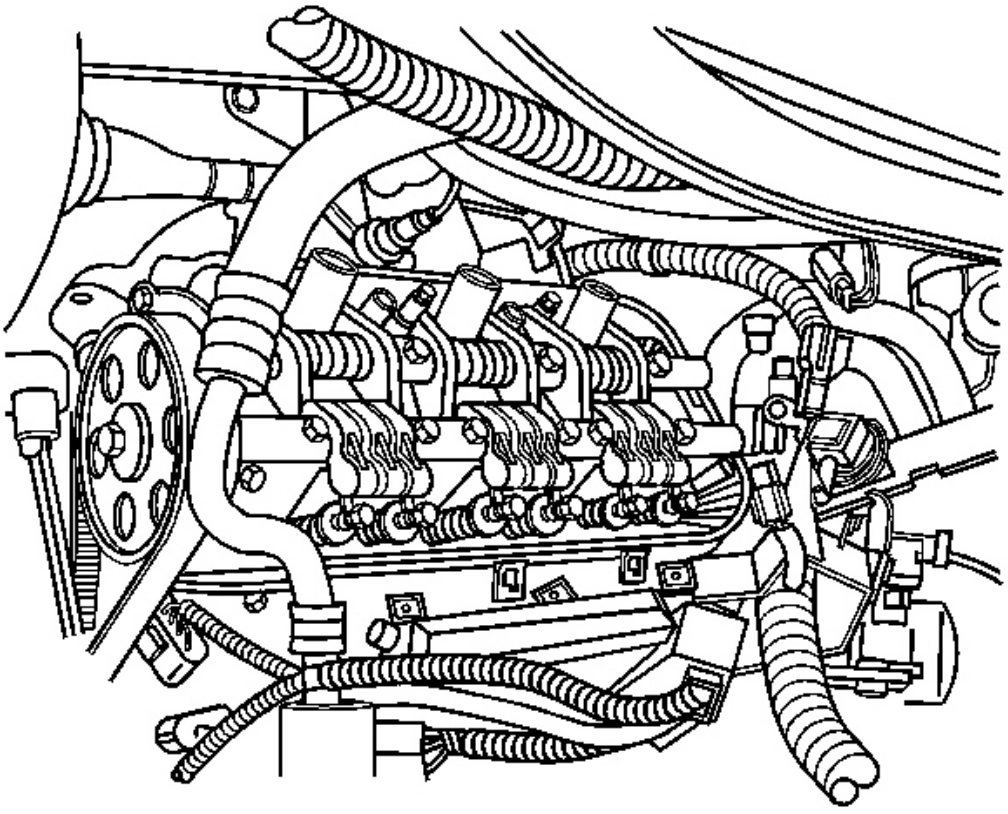


Fig. 132: View Of Rocker Arm & Shaft Assembly
Courtesy of GENERAL MOTORS CORP.

5. Install the left rocker arm and shaft assembly. Refer to **Valve Rocker Arm and Shaft Replacement** .
6. Adjust the valve lash. Refer to **Valve Rocker Arm and Valve Lash Adjuster Replacement** .

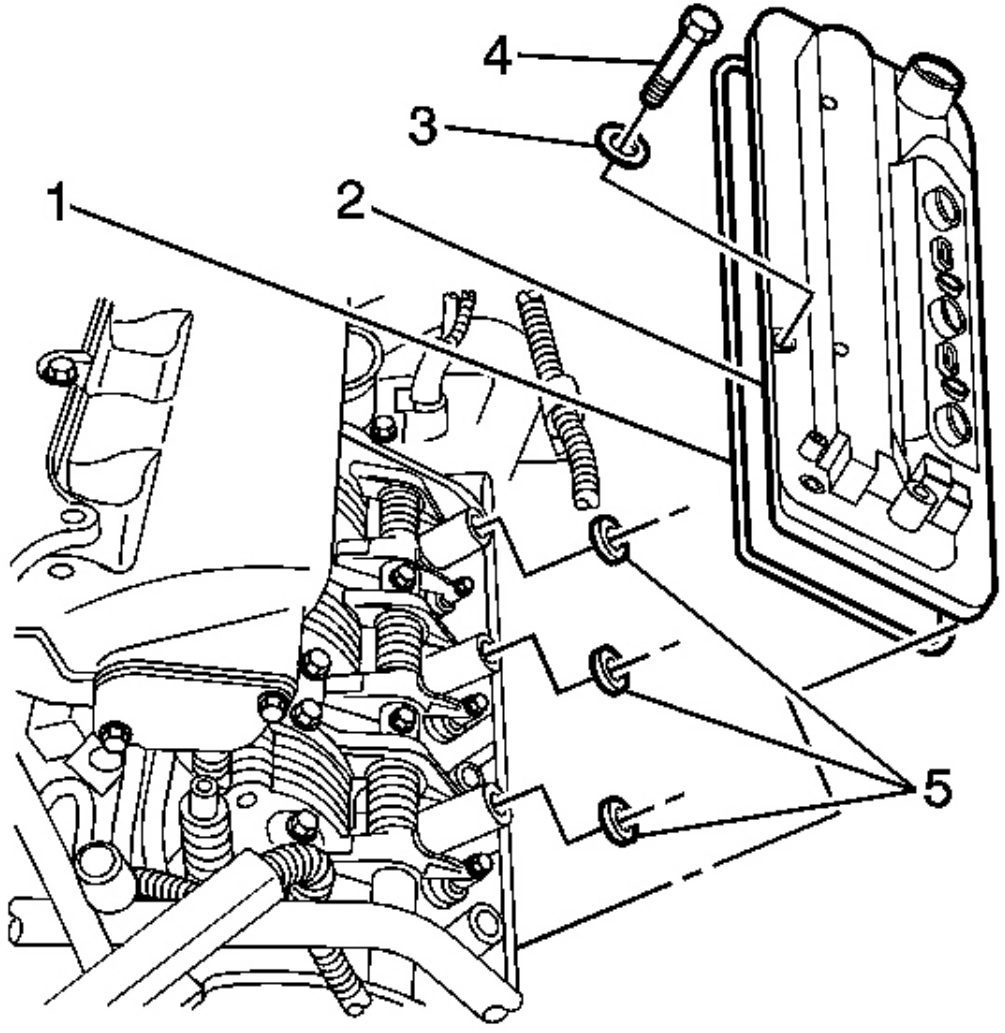


Fig. 133: View Of Left Rocker Cover
Courtesy of GENERAL MOTORS CORP.

7. Install the left rocker cover (2). Refer to**Valve Rocker Arm Cover Replacement - Left** .

CYLINDER HEAD (RIGHT) REPLACEMENT

Removal Procedure

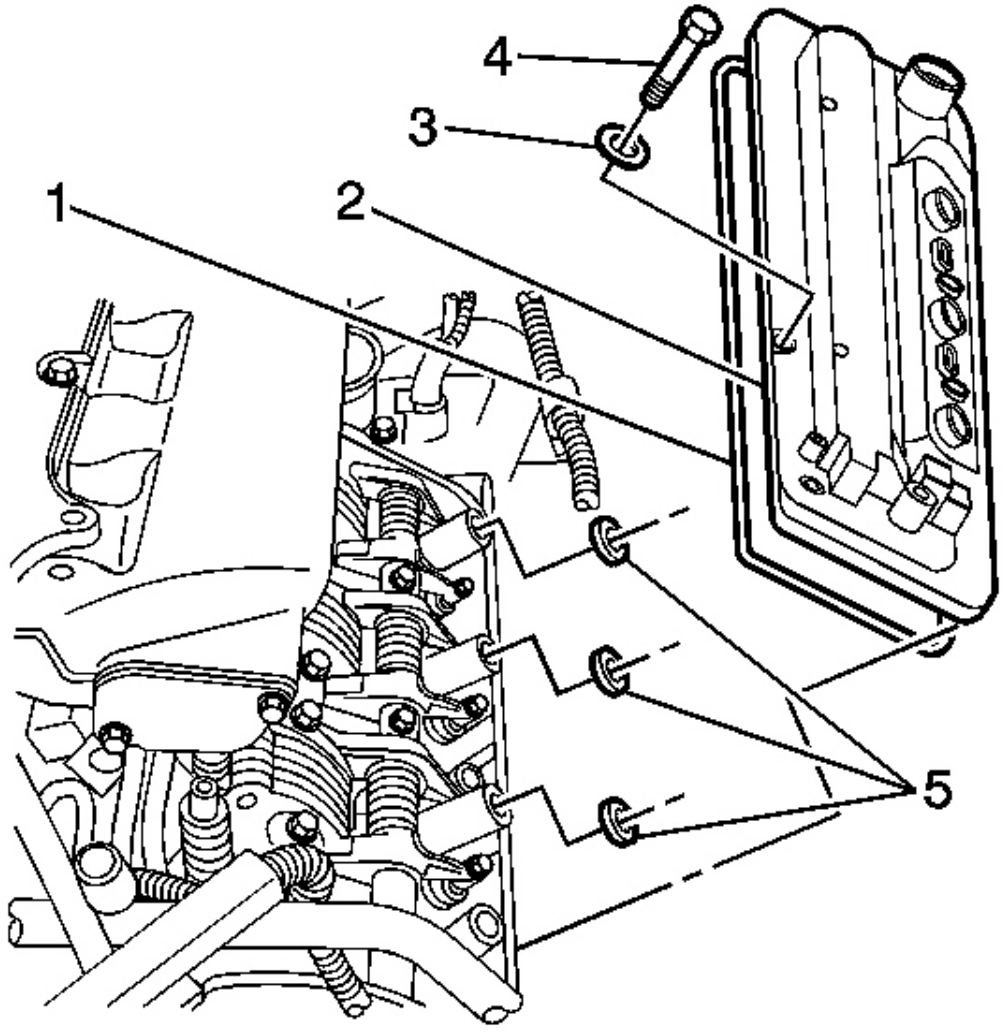


Fig. 134: View Of Cylinder Head
Courtesy of GENERAL MOTORS CORP.

1. Remove the right rocker cover (2). Refer to**Valve Rocker Arm Cover Replacement - Right** .

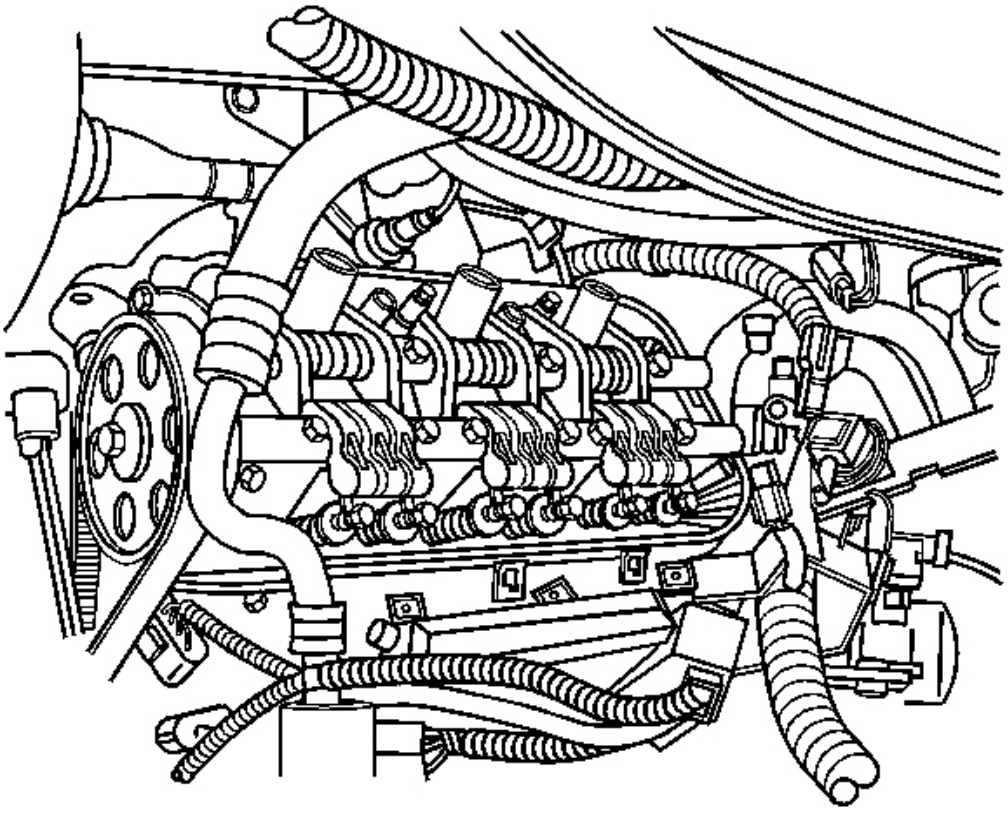


Fig. 135: View Of Rocker Arm & Shaft Assembly
Courtesy of GENERAL MOTORS CORP.

2. Remove the right rocker arm and shaft assembly. Refer to **Valve Rocker Arm and Shaft Replacement** .
3. Remove the timing belt. Refer to **Timing Belt Replacement** .
4. Remove the coolant bridge. Refer to **Coolant Crossover Pipe Replacement** in Engine Cooling.
5. Disconnect the right bank oxygen sensors.
6. Remove the right cylinder head. Refer to **Cylinder Head Removal - Right** .

Installation Procedure

1. Install the right cylinder head. Refer to **Cylinder Head Installation - Right** .
2. Connect the right bank oxygen sensors.
3. Install the coolant bridge. Refer to **Coolant Crossover Pipe Replacement** in Engine Cooling.
4. Install the timing belt. Refer to **Timing Belt Replacement** .

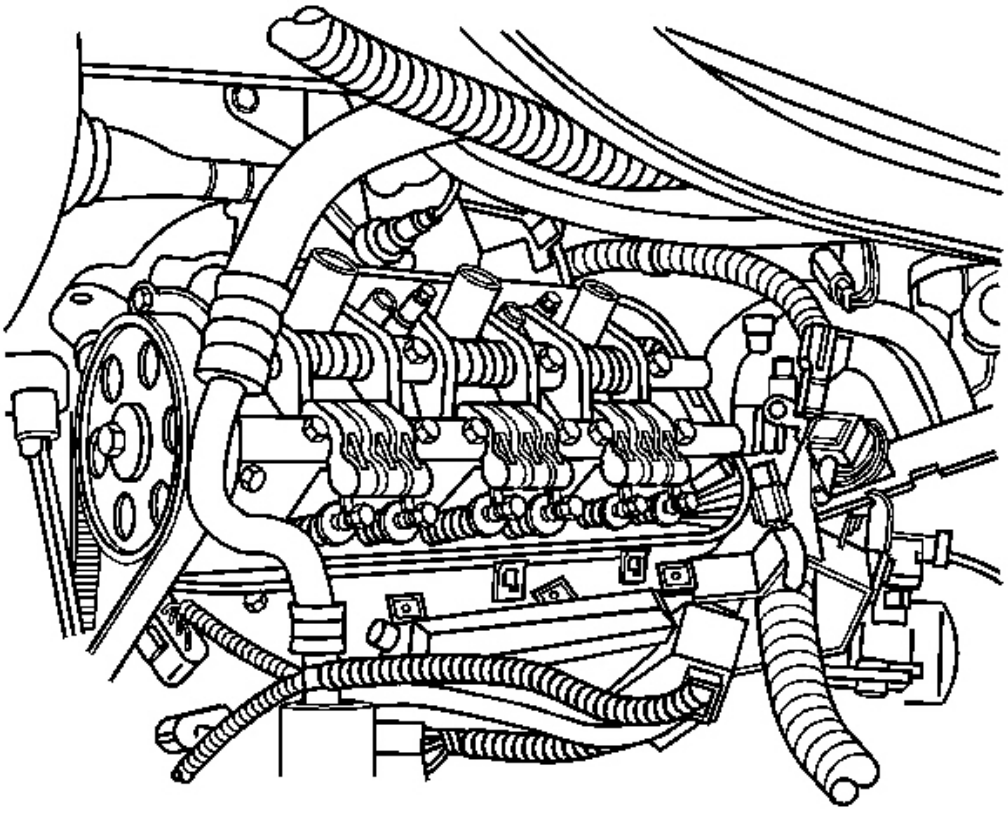


Fig. 136: View Of Rocker Arm & Shaft Assembly
Courtesy of GENERAL MOTORS CORP.

5. Install the right rocker arm and shaft assembly. Refer to **Valve Rocker Arm and Shaft Replacement** .
6. Adjust the valve lash. Refer to **Valve Rocker Arm and Valve Lash Adjuster Replacement** .

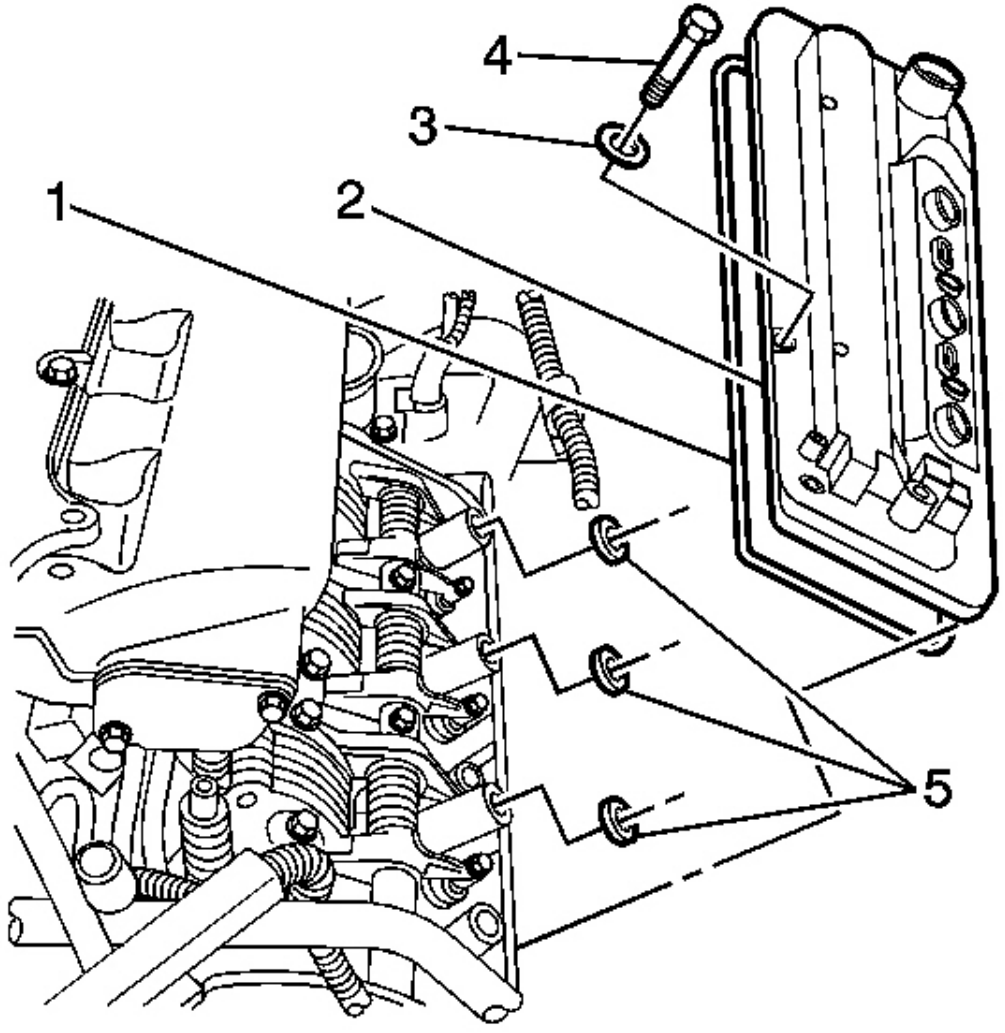


Fig. 137: View Of Right Rocker Cover
Courtesy of GENERAL MOTORS CORP.

7. Install the right rocker cover (2). Refer to **Valve Rocker Arm Cover Replacement - Right** .

ENGINE FLYWHEEL REPLACEMENT

Removal Procedure

1. Remove the transmission. Refer to **Transmission Replacement** .

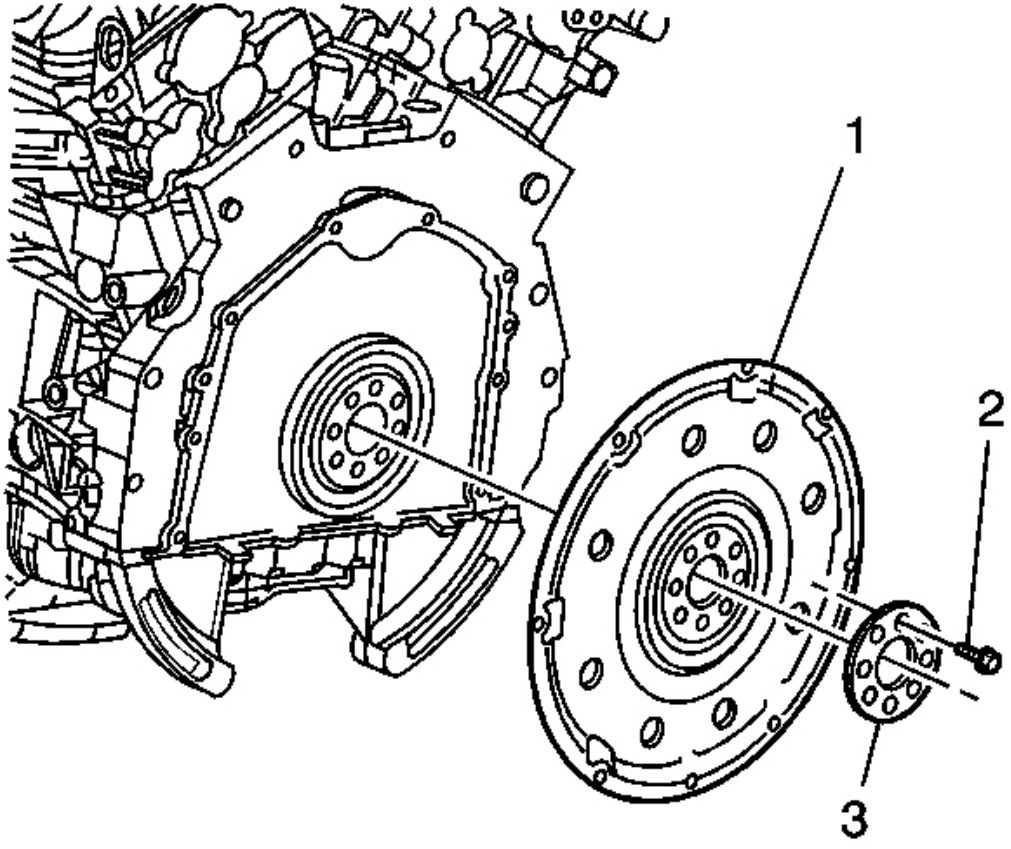


Fig. 138: View Of Engine Flywheel
Courtesy of GENERAL MOTORS CORP.

2. Remove the flywheel bolts (2), and note the position of the flywheel to the crankshaft.
3. Remove the flywheel washer (3) and flywheel (1).

Installation Procedure

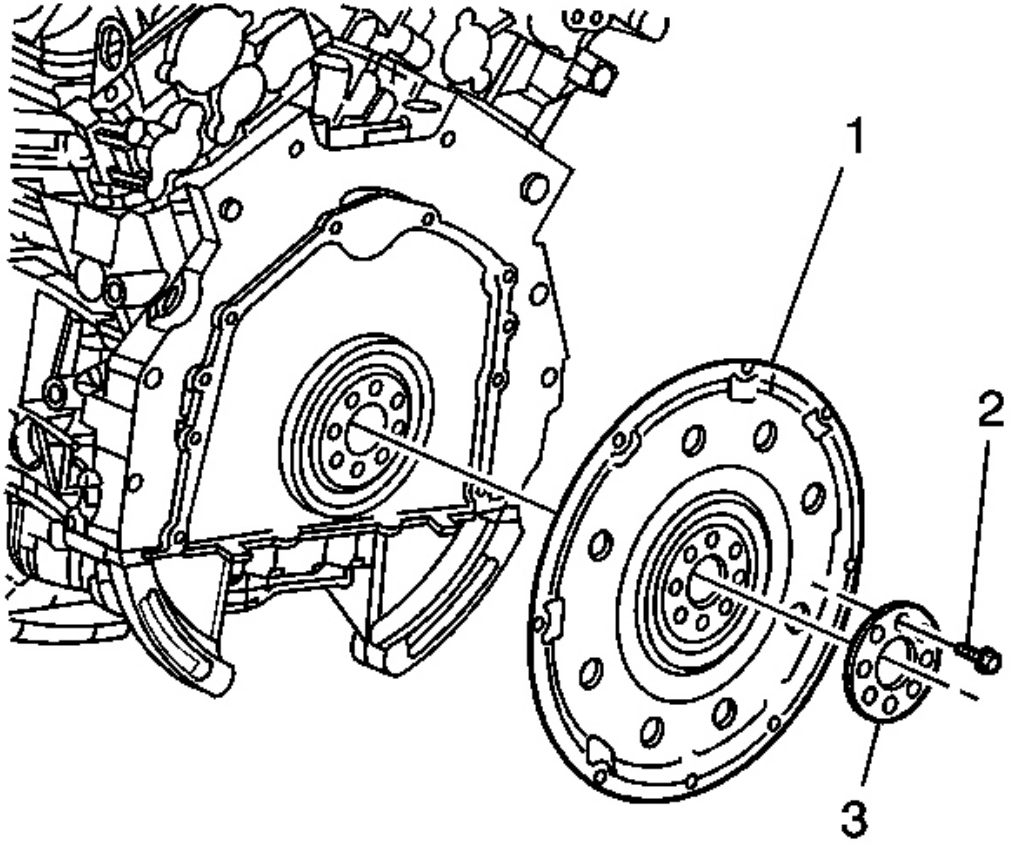


Fig. 139: View Of Engine Flywheel
Courtesy of GENERAL MOTORS CORP.

1. Position the flywheel (1) and flywheel washer (3) on the crankshaft as previously noted.

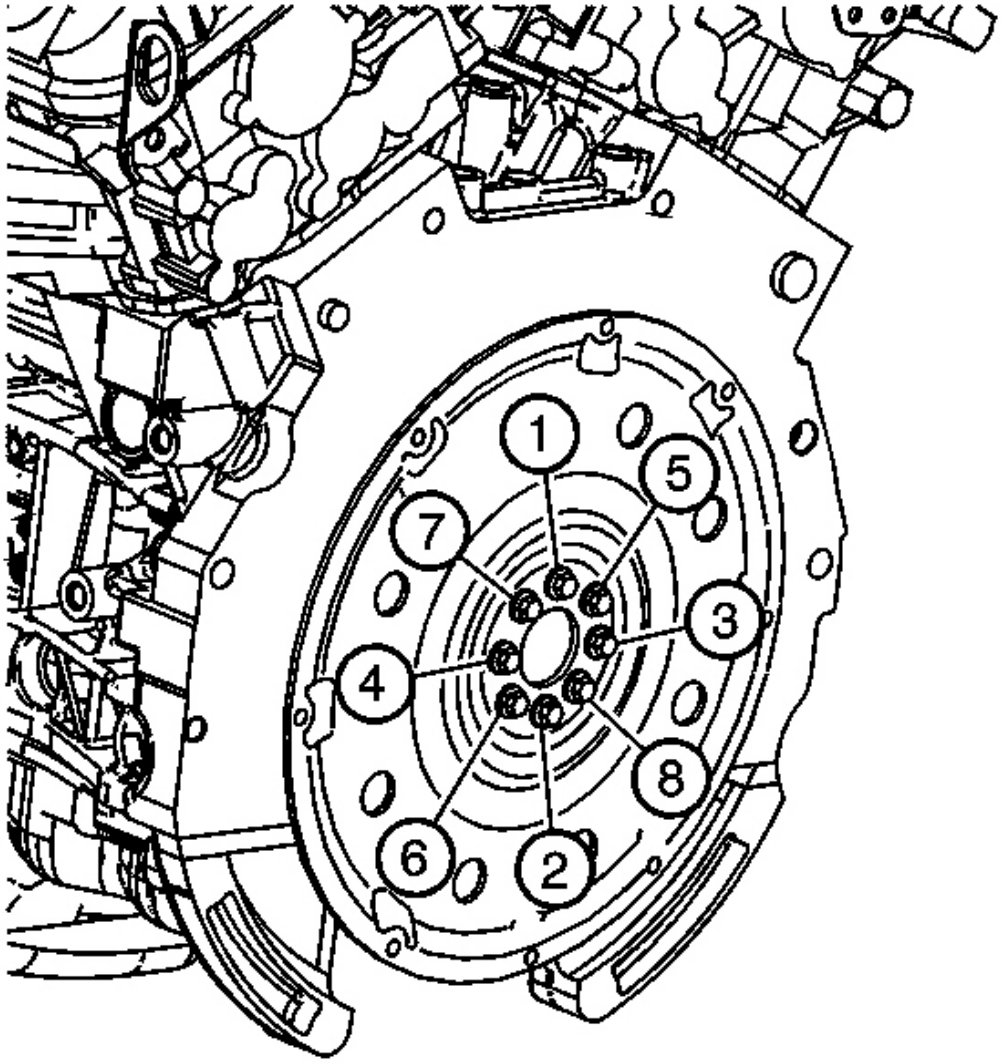


Fig. 140: Identifying Flywheel Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the flywheel bolts (2).
3. Tighten the flywheel bolts in sequence.

Tighten: Tighten the flywheel bolts in sequence to 74 N.m (54 lb ft).

4. Install the transmission. Refer to **Transmission Replacement** .

CRANKSHAFT REAR OIL SEAL REPLACEMENT

Tools Required

- **EN 46342** Driver Handle
- **EN 46351** Crankshaft Rear Oil Seal Driver. See **Special Tools and Equipment** .

Removal Procedure

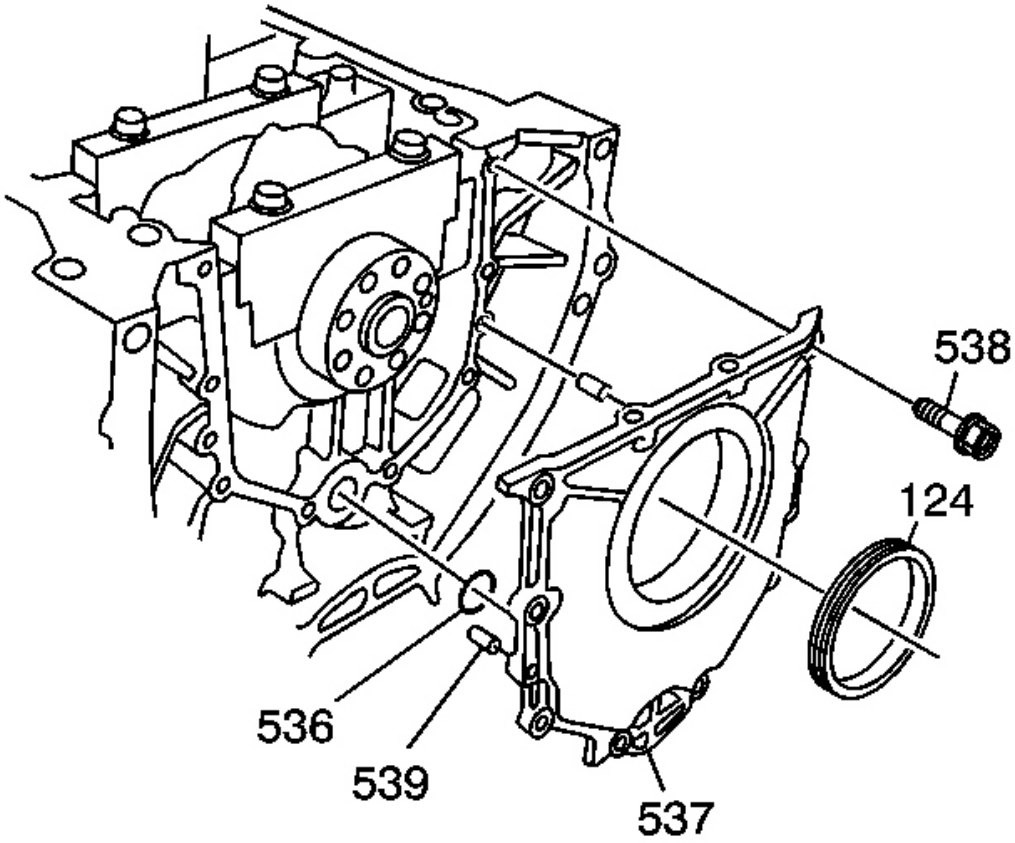


Fig. 141: View Of Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine flywheel. Refer to **Engine Flywheel Replacement** .
2. Remove the seal (124) from the rear cover.

Installation Procedure

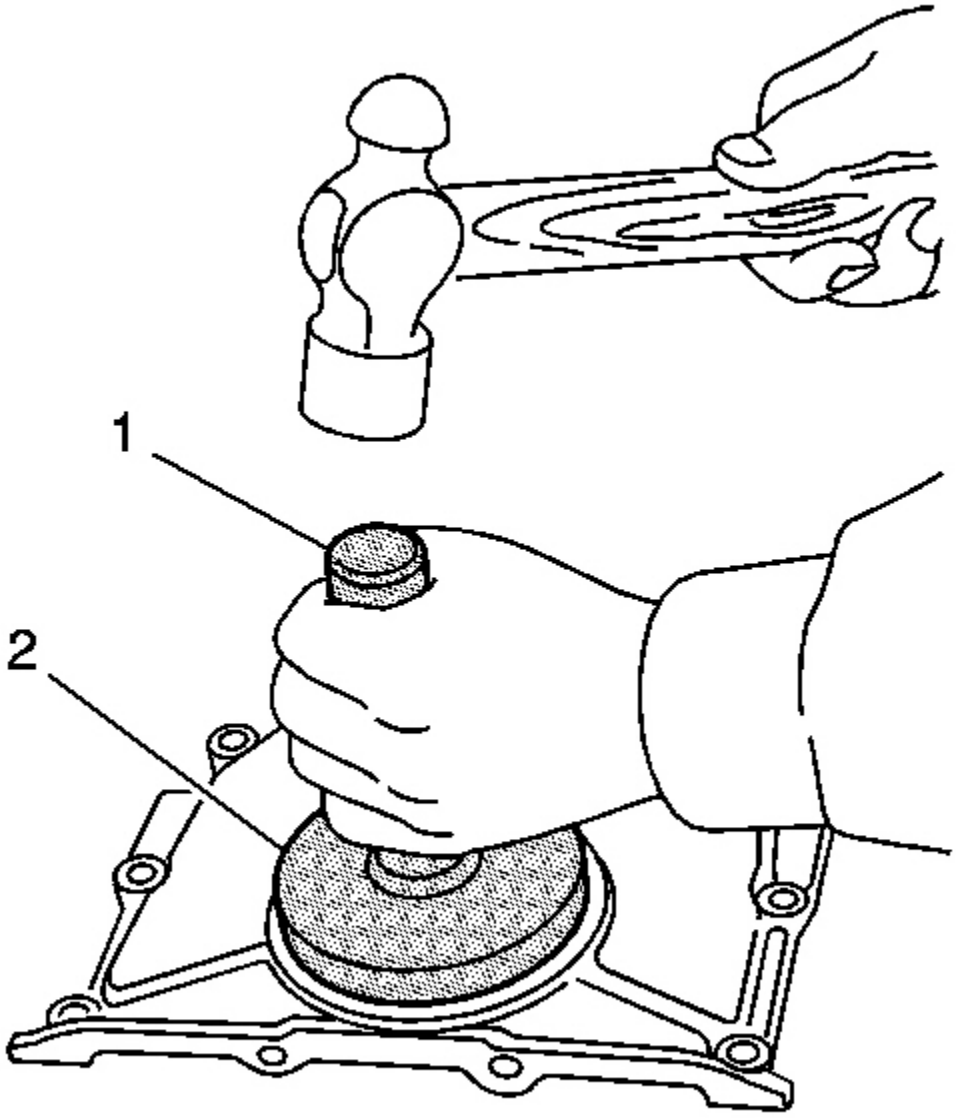


Fig. 142: Identifying Lip Of The Oil Seal With A Light Coat Of Grease
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the lip of the oil seal with a light coat of grease.
2. Use the **EN 46342** (1) and the**EN 46351** (2) in order to install the seal squarely into the housing. See

Special Tools and Equipment .

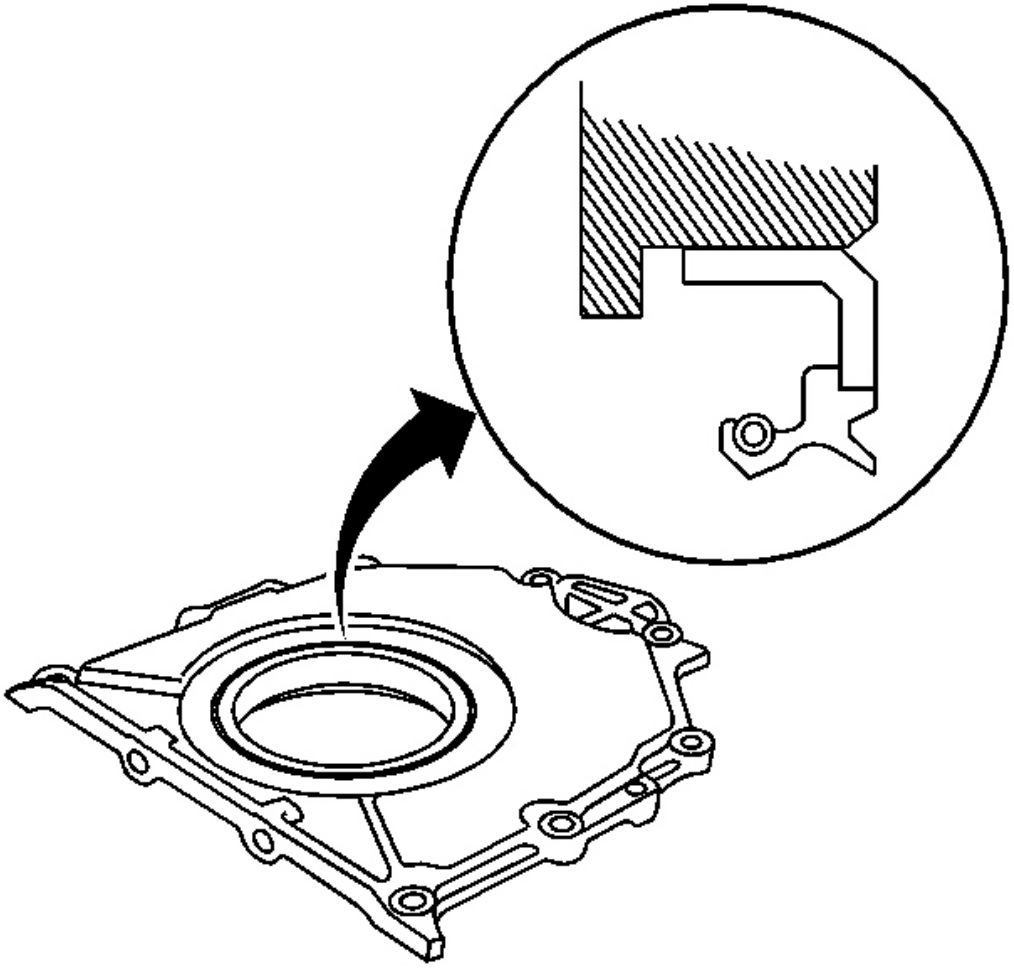


Fig. 143: View Of Crankshaft Oil Seal
Courtesy of GENERAL MOTORS CORP.

3. Drive the new crankshaft oil seal until the tool bottoms onto the housing. A properly installed seal will be flush with the face of the housing.
4. Install the engine flywheel. Refer to **Engine Flywheel Replacement** .

ENGINE REPLACEMENT

Removal Procedure

1. With the tires in the straight forward position, remove the key from the ignition.
2. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
3. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** in Engine Controls.

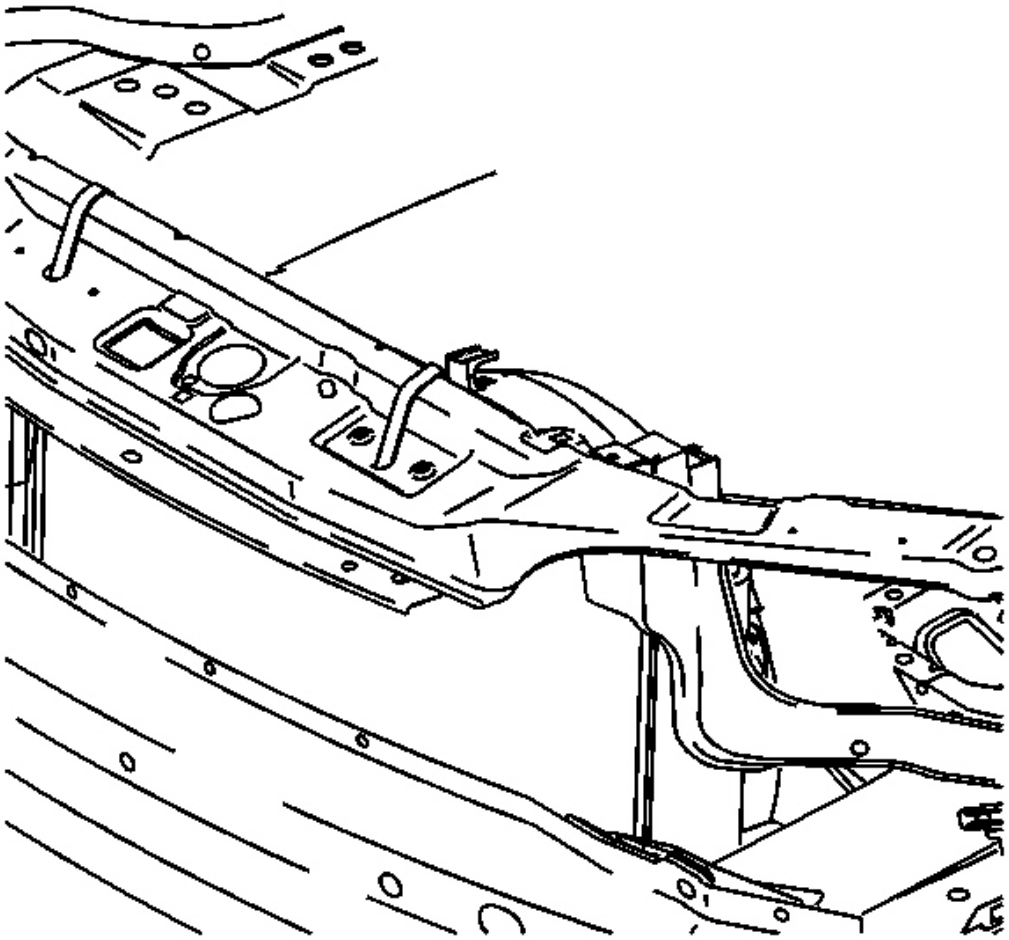


Fig. 144: View Of Cooling Module Support
Courtesy of GENERAL MOTORS CORP.

4. Secure the cooling module to the upper body structure.
5. Remove the battery and battery tray. Refer to **Battery Tray Replacement (L61)** or **Battery Tray Replacement (L66)** in Engine Electrical.
6. Disconnect the transmission shifter cable.

7. Disconnect the wiring harness from the underhood junction block. Refer to **Underhood Electrical Center or Junction Block Replacement** in Wiring Systems.
8. Evacuate the A/C system. Refer to **Refrigerant Recovery and Recharging** in Heating, Ventilation and Air Conditioning.
9. Drain the cooling system. Refer to **Draining and Filling Cooling System** in Engine Cooling.
10. Remove the powertrain control module (PCM). Refer to **Powertrain Control Module (PCM) Replacement** in Engine Controls - 3.5L (L66).
11. Remove the A/C low pressure tube at the front lift bracket.
12. Disconnect the generator positive cable. Refer to **Generator Replacement (L61)** or **Generator Replacement (L66)** in Engine Electrical.
13. Disconnect the A/C high pressure switch harness.
14. Remove the A/C tube from the A/C compressor. Refer to **Compressor Hose Assembly Replacement (L66)** or **Compressor Hose Assembly Replacement (L61)** in Heating, Ventilation, and Air Conditioning.
15. Disconnect the A/C line from the condenser to compressor.
16. Disconnect the coolant reservoir hose from the engine to reservoir.

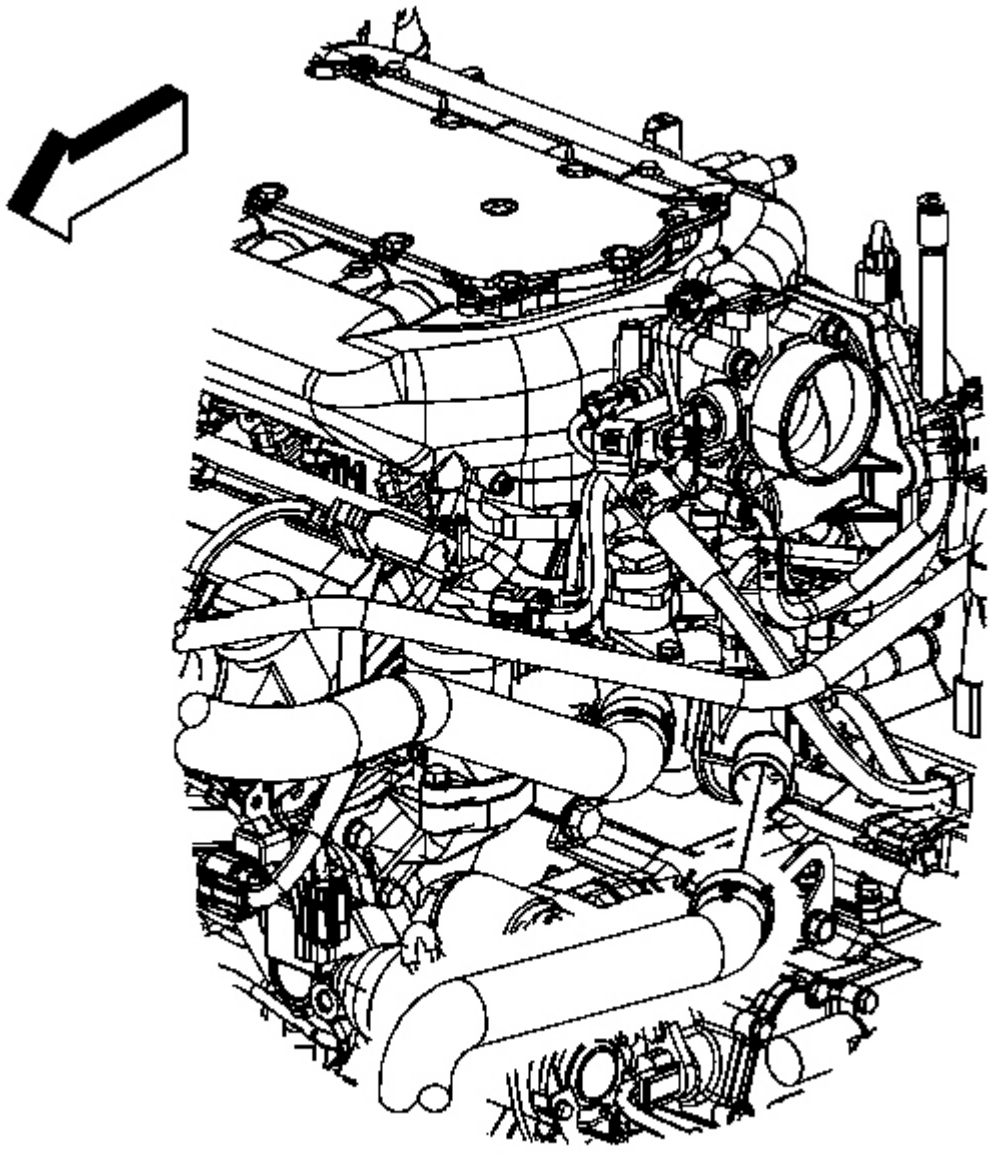


Fig. 145: View Of Radiator Inlet & Outlet Hoses From The Engine
Courtesy of GENERAL MOTORS CORP.

17. Disconnect the radiator inlet and outlet hoses from the engine.

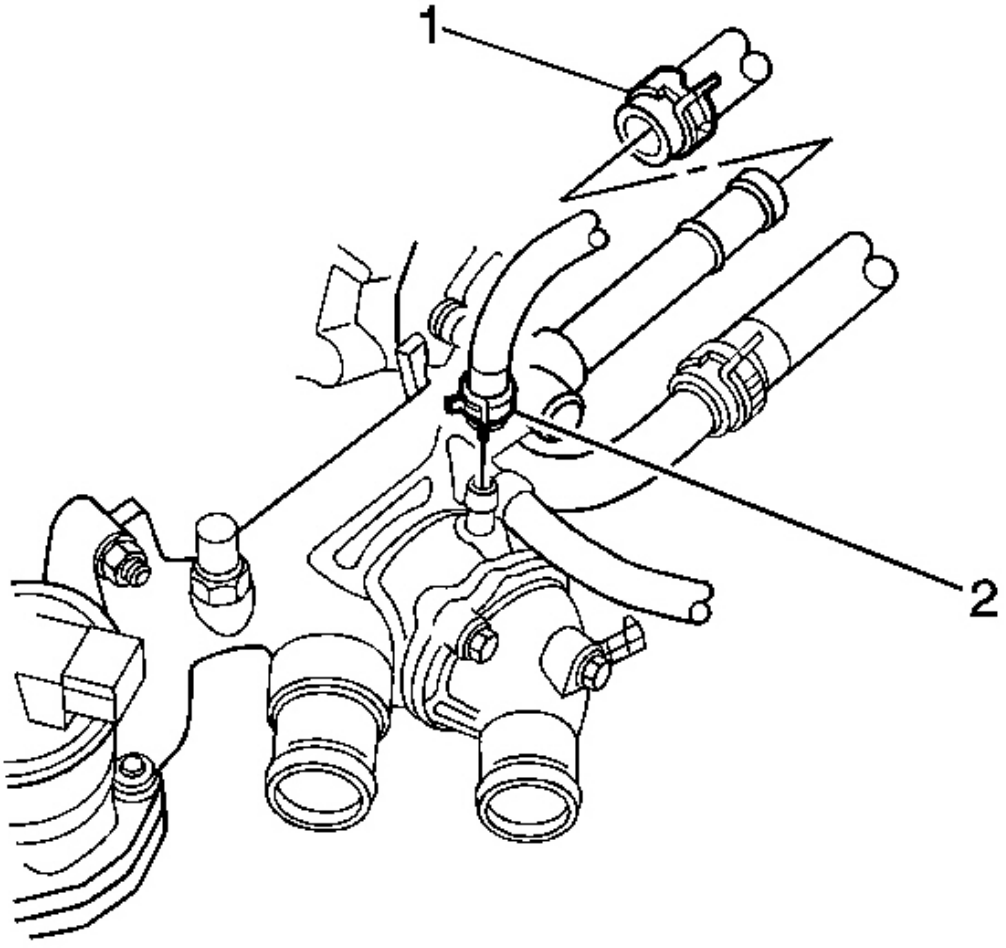


Fig. 146: Identifying Inlet & Outlet Heater Hoses
Courtesy of GENERAL MOTORS CORP.

18. Remove the inlet and outlet heater hoses (1, 2).
19. Remove the starter positive cable.
20. Relieve the fuel pressure. Refer to **Fuel Pressure Relief Procedure** in Engine Controls - 3.5L (L66).
21. Disconnect the fuel feed line.
22. Disconnect the fuel EVAP line.
23. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
24. Remove the lower transaxle-to-engine bolts.
25. Remove the PTU. Refer to **Transfer Case Replacement** in Transfer Case - MJ8

26. Remove the torque convertor inspection cover.
27. Remove the torque convertor to flywheel bolts.
28. Remove the front wheels. Refer to **Tire and Wheel Removal and Installation** in Tires and Wheels.
29. Remove the left wheelhouse liner. Refer to **Wheelhouse Liner Replacement - Front** .
30. Disconnect the transmission cooler lines from the transmission and bracket. Refer to **Transmission Mount Bracket Replacement - Rear** in Manual Transmission - Getrag 5 speed.
31. Remove the left and right tie rod ends from the steering knuckles. Refer to **Rack and Pinion Outer Tie Rod End Replacement** in Power Steering System.
32. Remove the left and right stabilizer bar links. Refer to **Stabilizer Shaft Link Replacement** in Front Suspension.
33. Disconnect the left and right lower ball joints. Refer to **Lower Ball Joint Replacement** in Front Suspension.
34. Remove the left and right axle shaft nuts. Refer to **Wheel Drive Shaft Replacement - Front** in Wheel Drive Shafts.

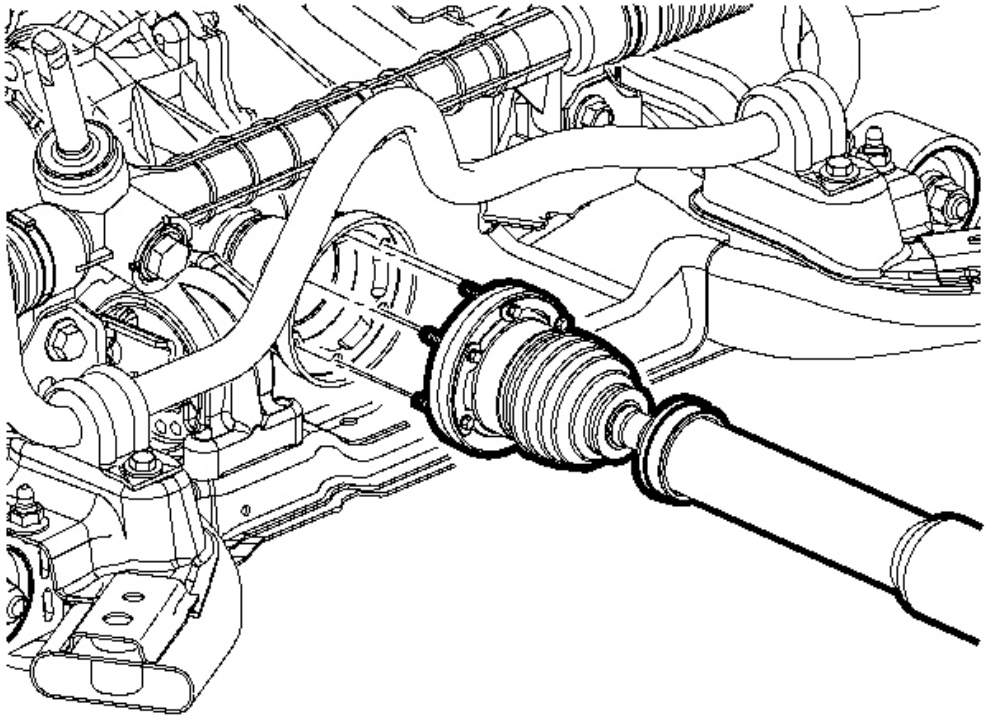


Fig. 147: View Of Propeller Shaft
Courtesy of GENERAL MOTORS CORP.

35. For AWD, remove the propeller shaft completely from the vehicle. Refer to **Propeller Shaft Replacement** in Propeller Shaft.

IMPORTANT: In order to prevent possible SIR system deployment, do not attempt to rotate the steering shaft.

36. Disconnect the intermediate shaft from the steering gear. Refer to **Intermediate Steering Shaft Replacement** in Steering Wheel and Column.
37. Remove the front exhaust pipe. Refer to **Exhaust Manifold Pipe Replacement (L66)** or **Exhaust Manifold Pipe Replacement (L61)** in Engine Exhaust.

38. Remove the 3 front fender pushpins to allow the front fender to flex.
39. Use a paint pen or magic marker to mark the frame to the body position.
40. Support the engine in the cradle with wood blocks.
41. Disconnect the front engine mount from the body. Refer to **Automatic Transmission Mount Replacement - Rear** in Automatic Transmission - 5AT.

IMPORTANT: During the powertrain removal, support the vehicle body by placing a jack at the rear of the vehicle.

42. Position the engine support table under the powertrain assembly.
43. With the table positioned, fully raise the table to contact with the powertrain assembly.
44. Remove the cradle bolts.
45. Slowly lower the table to the floor.

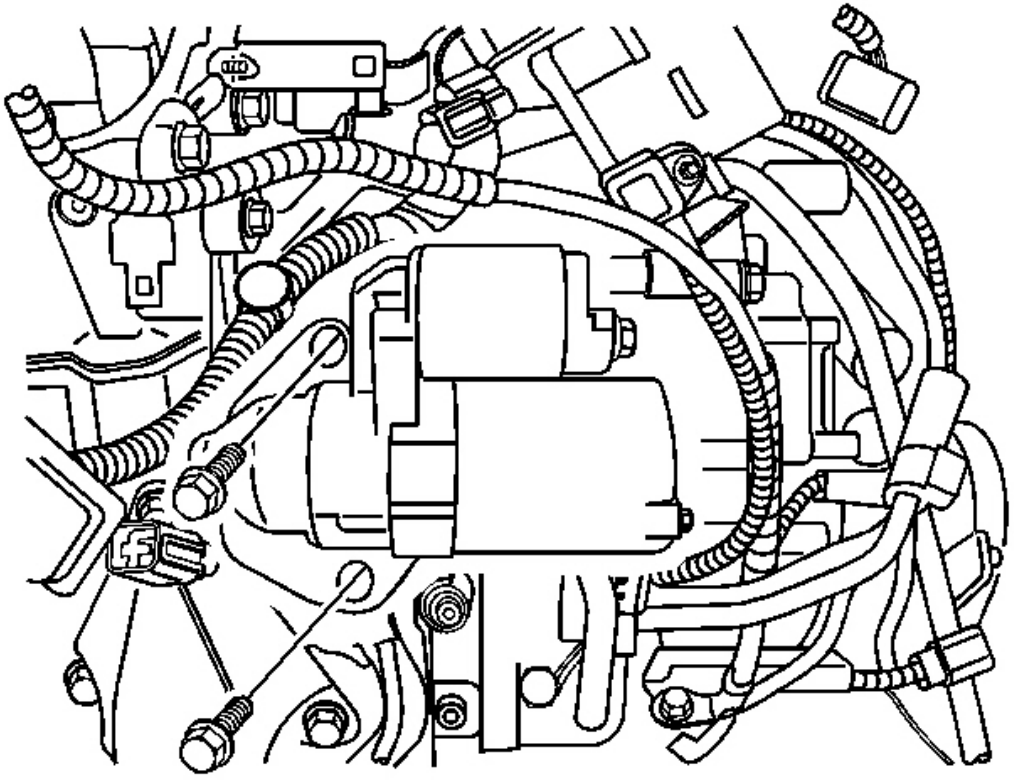


Fig. 148: View Of Starter
Courtesy of GENERAL MOTORS CORP.

46. Remove the starter.
47. Remove the following components:
    1. Remove the A/C compressor. Refer to **Compressor Replacement (L61)** or **Compressor Replacement (L66)** in Heating, Ventilation and Air Conditioning.
    2. Remove the generator. Refer to **Generator Replacement (L61)** or **Generator Replacement (L66)** in Engine Electrical.
    3. Remove the front covers. Refer to **Timing Belt Cover Replacement** .
    4. Remove the rocker covers. Refer to **Valve Rocker Arm Cover Replacement - Left** and **Valve Rocker Arm Cover Replacement - Right** .
    5. Remove the catalytic converters. Refer to **Catalytic Converter Replacement - Left** and **Catalytic Converter Replacement - Right** in Engine Exhaust.
    6. Remove the timing belt. Refer to **Timing Belt Removal** .
    7. Remove the cylinder heads. Refer to **Cylinder Head Removal - Left** and **Cylinder Head Removal - Right** .
48. Remove the front engine mount from the engine. Refer to **Automatic Transmission Mount Replacement - Rear** in Automatic Transmission - 5AT.
49. Remove the right engine mount. Refer to **Engine Mount Replacement - Right** .
50. Separate the engine from the transmission.

Installation Procedure

1. Align the engine to the transmission.

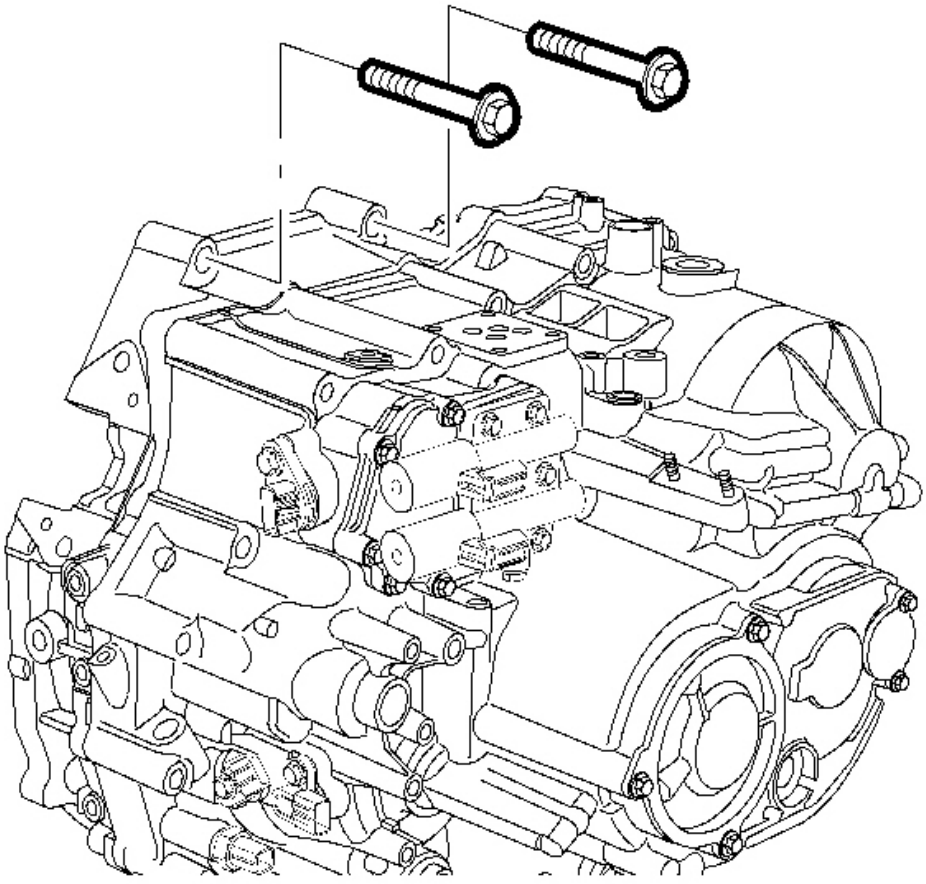


Fig. 149: View Of Transmission-To-Engine Mounting Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Apply sealant Saturn P/N 21485277 (GM P/N 12345382) or equivalent, to the two upper transmission-to-engine bolts only, and install the transmission-to-engine mounting bolts.

   Tighten: Tighten the bolts to 64 N.m (47 lb ft).

3. Install the right engine mount. Refer to **Engine Mount Replacement - Right** .
4. Install the front engine mount to the engine. Refer to **Automatic Transmission Mount Replacement -**

Rear in Automatic Transmission - 5AT.

5. Install the following components:
    1. Install the cylinder heads. Refer to **Cylinder Head Removal - Left** and **Cylinder Head Removal - Right** .
    2. Install the timing belt. Refer to **Timing Belt Removal** .
    3. Install the catalytic converters. Refer to **Catalytic Converter Replacement - Left** and **Catalytic Converter Replacement - Right** in Engine Exhaust.
    4. Install the rocker covers. Refer to **Valve Rocker Arm Cover Replacement - Left** and **Valve Rocker Arm Cover Replacement - Right** .
    5. Install the front covers. Refer to **Timing Belt Cover Replacement** .
    6. Install the generator. Refer to **Generator Replacement (L61)** or **Generator Replacement (L66)** in Engine Electrical.
    7. Install the A/C compressor. Refer to **Compressor Replacement (L61)** or **Compressor Replacement (L66)** in Heating, Ventilation and Air Conditioning.

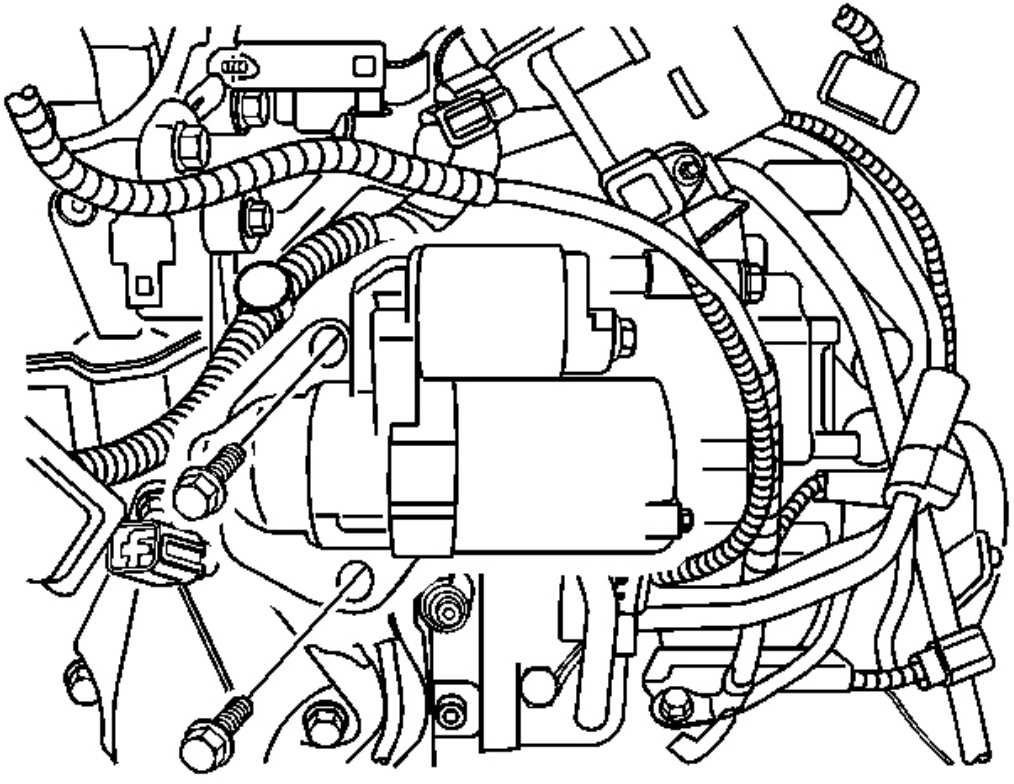


Fig. 150: View Of Starter

Courtesy of GENERAL MOTORS CORP.

6. Install the starter. Refer to **Starter Motor Replacement (L61)** or **Starter Motor Replacement (L66)** in Engine Electrical.
7. Install the powertrain assembly to the vehicle.
8. Install the cradle bolts. Refer to **Frame Replacement (L61)** or **Frame Replacement (L66)** in Frame and Underbody.
9. Remove the engine support table.
10. Install the front engine mount bolts to the body. Refer to **Automatic Transmission Mount Replacement - Rear** in Automatic Transmission - 5AT.
11. Remove the wood blocks from the cradle.
12. Install the lower transaxle-to-engine bolts.

    Tighten: Tighten the bolts to 64 N.m (47 lb ft).

13. Install the PTU. Refer to **Transfer Case Replacement** in Transfer Case - MJ8.
14. Install the torque convertor- to- flywheel bolts.

    Tighten: Tighten the bolts to 12 N.m (9 lb ft).

15. Install the torque convertor inspection cover.

    Tighten: Tighten the bolts to 12 N.m (9 lb ft).

16. Install the 3 front fender pushpins
17. Install the front exhaust pipe. Refer to **Exhaust Manifold Pipe Replacement (L66)** or **Exhaust Manifold Pipe Replacement (L61)** in Engine Exhaust.
18. Connect the intermediate shaft from the steering gear. Refer to **Intermediate Steering Shaft Replacement** in Steering Wheel and Column.
19. Install the propeller shaft. Refer to **Propeller Shaft Replacement** in Propeller Shaft.
20. Install the left and right axle shaft nuts. Refer to **Wheel Drive Shaft Replacement - Front** in Wheel Drive Shafts.
21. Connect the left and right lower ball joints. Refer to **Lower Ball Joint Replacement** in Front Suspension.
22. Install the left and right stabilizer bar links. Refer to **Stabilizer Shaft Link Replacement** in Front Suspension.
23. Install the left and right tie rod ends to the steering knuckles. Refer to **Rack and Pinion Outer Tie Rod End Replacement** in Power Steering System.
24. Connect the transmission cooler lines to the transmission and bracket. Refer to **Transmission Mount Bracket Replacement - Rear** in Manual Transmission - Getrag 5 Speed.
25. Install the left wheelhouse liner. Refer to **Wheelhouse Liner Replacement - Front** in Body Front End.
26. Install the front tires. Refer to **Tire and Wheel Removal and Installation** in Tires and Wheels.
27. Lower the vehicle.

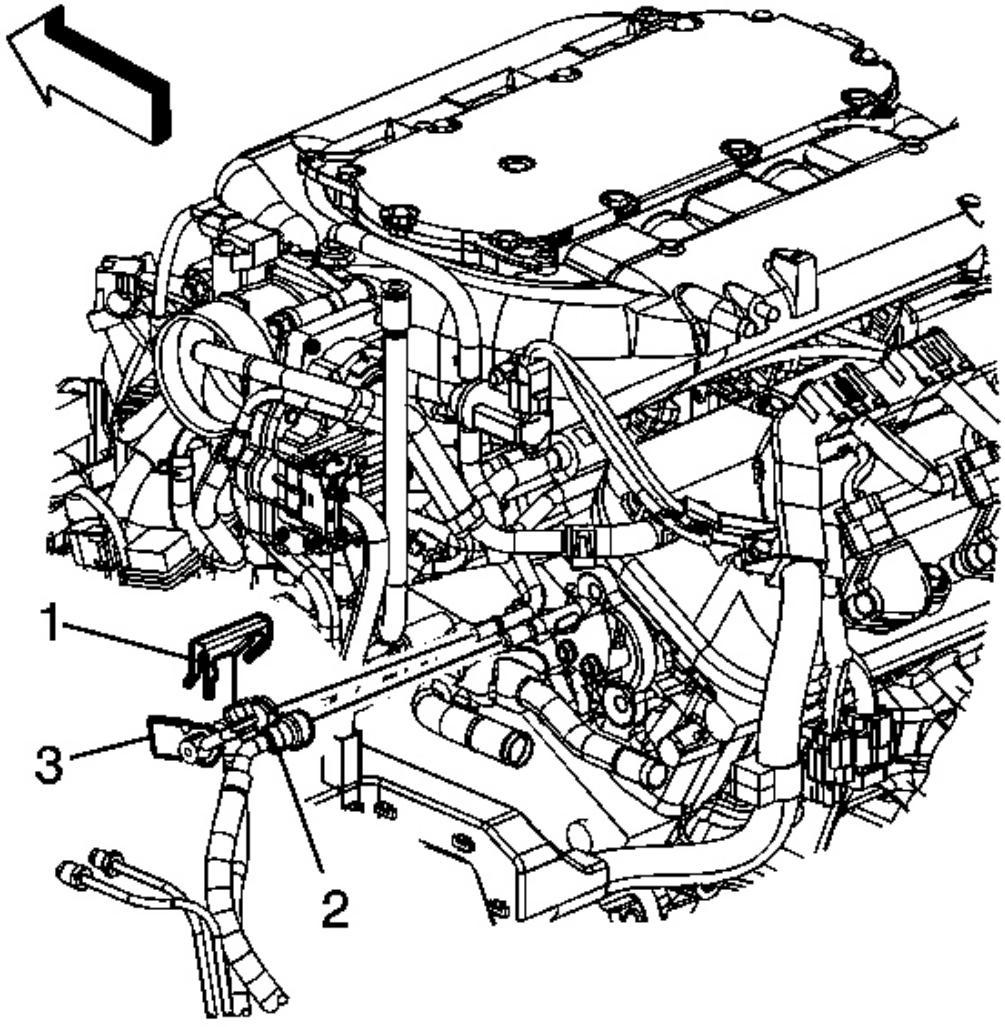


Fig. 151: View Of Fuel EVAP Line
Courtesy of GENERAL MOTORS CORP.

28. Install the fuel EVAP line.
29. Connect the fuel feed line. Refer to **Fuel Hose/Pipes Replacement - Chassis** in Engine Controls.
30. Install the starter positive cable.

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

31. Install the inlet and outlet heater hoses.

32. Connect the inlet and outlet radiator hoses to the engine.
33. Install the A/C tube to the A/C compressor. Refer to **Compressor Hose Assembly Replacement (L66)** or **Compressor Hose Assembly Replacement (L61)** in Heating, Ventilation and Air Conditioning.
34. Connect the coolant reservoir hose from the engine to reservoir.
35. Connect the A/C line from the condenser to compressor.
36. Connect the A/C high pressure switch harness.
37. Connect the generator positive cable and nut.

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

38. Install the A/C lower pressure tube at the front lift bracket. Refer to**Liquid Line Replacement (L61)** or **Liquid Line Replacement (L66)** in Heating, Ventilation and Air Conditioning.
39. Install the PCM. Refer to **Powertrain Control Module (PCM) Replacement** in Engine Controls.

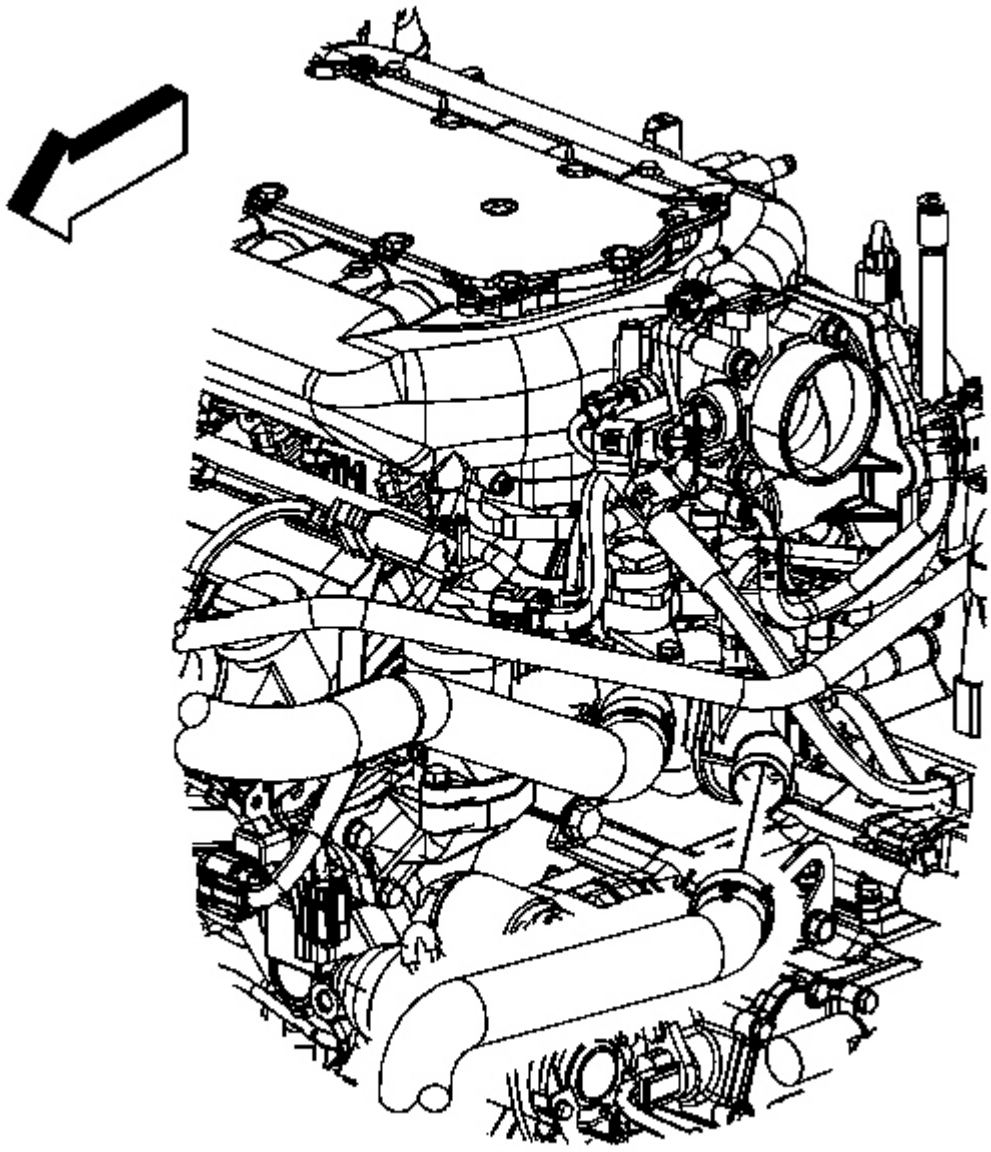


Fig. 152: View Of Radiator Inlet & Outlet Hoses From The Engine
Courtesy of GENERAL MOTORS CORP.

40. Connect the radiator inlet and outlet hoses to the engine.
41. Fill the vehicle with coolant. Refer to **Draining and Filling Cooling System** in Engine Cooling.
42. Connect the wiring harness to the underhood junction block. Refer to **Underhood Electrical Center or**

Junction Block Replacement in Wiring Systems.

43. Connect the transmission shifter cable.

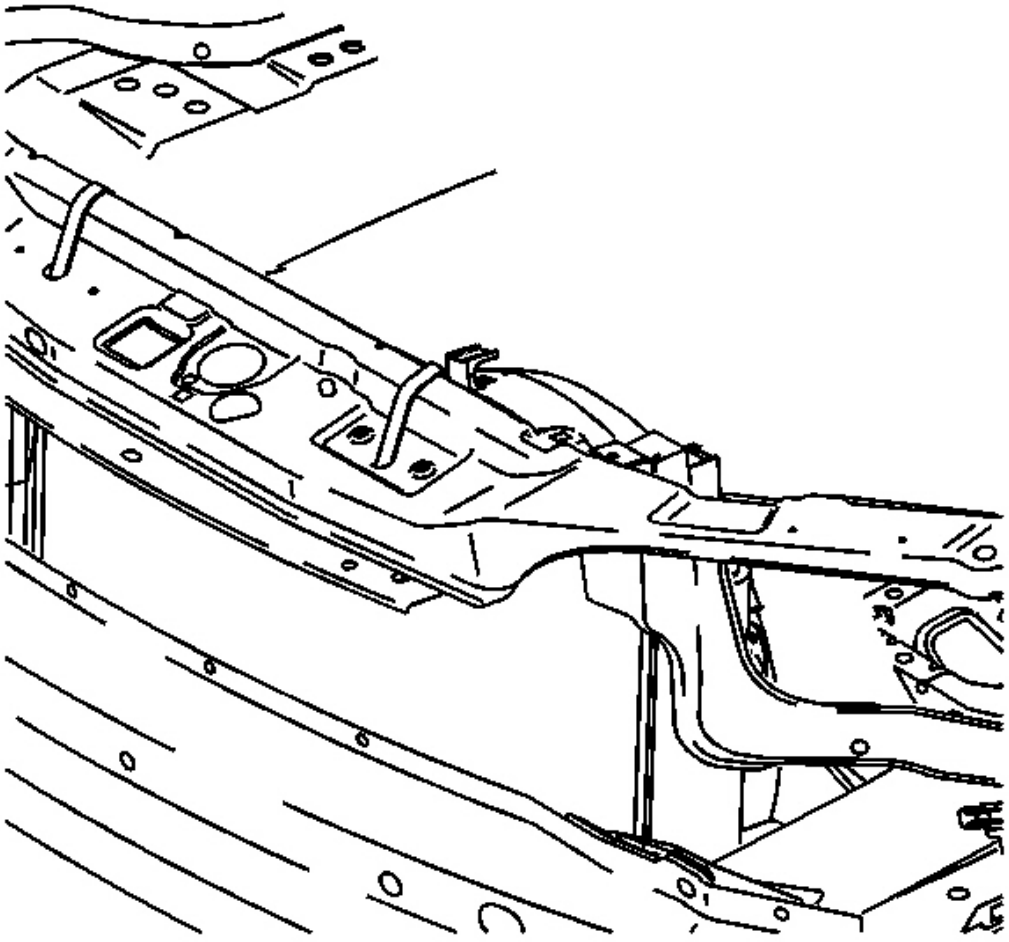


Fig. 153: View Of Cooling Module Support
Courtesy of GENERAL MOTORS CORP.

44. Remove the cooling module support.
45. Install the battery tray and battery. Refer to **Battery Tray Replacement (L61)** or **Battery Tray Replacement (L66)** in Engine Electrical.
46. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** in Engine Controls - 3.5L (L66).
47. Install the air outlet duct assembly. Refer to **Air Cleaner Resonator Outlet Duct Replacement** in Engine Controls - 3.5L (L66).

48. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
49. Perform the idle learn procedure. Refer to**Idle Learn Procedure** in Engine Controls - 3.5L (L66).

ENGINE OIL AND OIL FILTER REPLACEMENT

Removal Procedure

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
2. Position the oil drain pan under the engine oil drain plug.

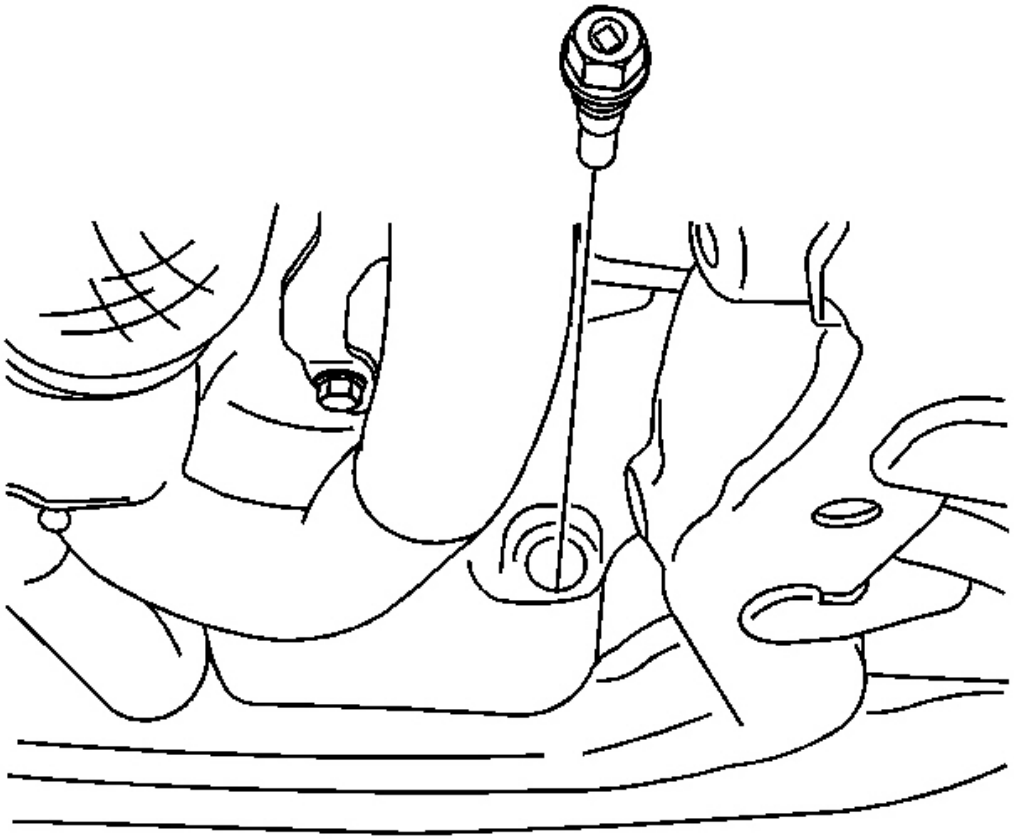


Fig. 154: View Of Engine Oil Drain Plug
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine oil drain plug.
4. Clean and inspect the engine oil drain plug, repair or replace if necessary.

5. Clean and inspect the engine oil drain plug sealing surface on the oil pan, repair or replace oil pan if necessary.

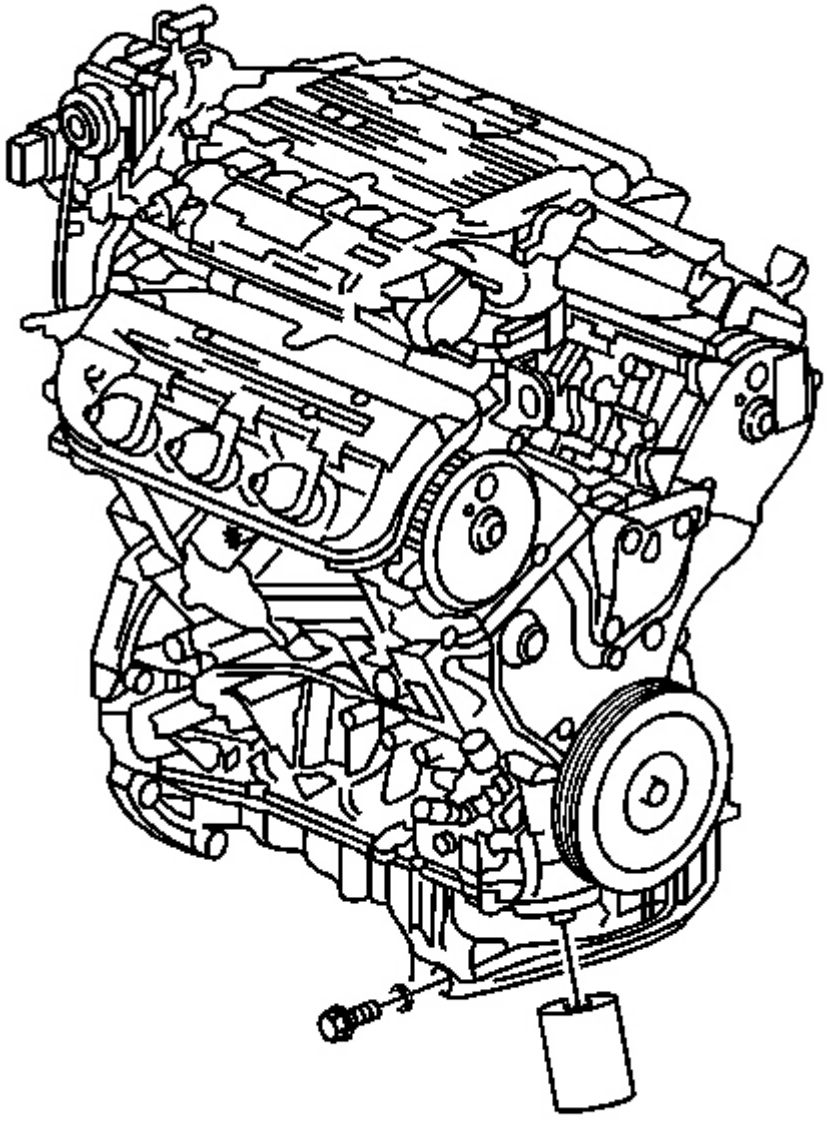


Fig. 155: View Of Oil Filter
Courtesy of GENERAL MOTORS CORP.

6. Remove the oil filter.

7. Clean and inspect the oil filter sealing area, repair or replace if necessary.

Installation Procedure

1. Lightly oil the replacement oil filter gasket with clean oil and install the new oil filter.

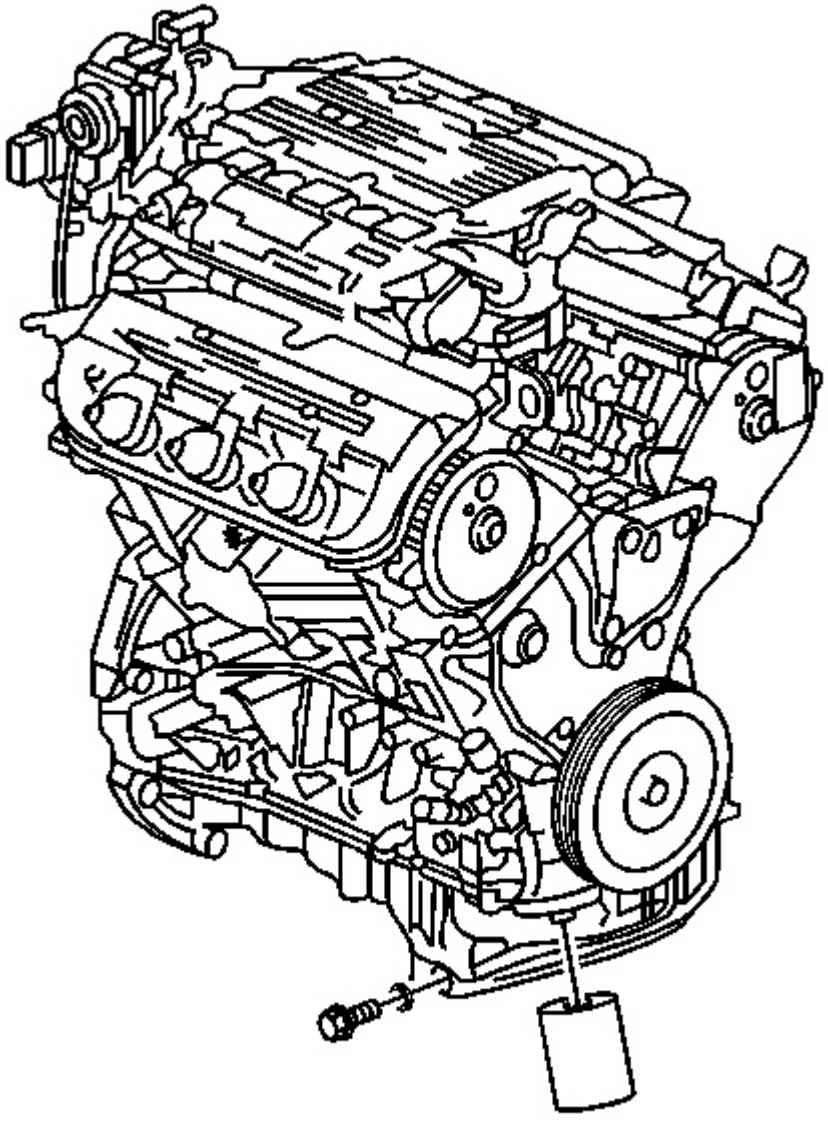


Fig. 156: View Of Oil Filter

Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the new oil filter. Refer to **Maintenance Items** in Maintenance and Lubrication.

   Tighten: Tighten the filter to 7/8 full turn, after the oil filter gasket contacts the oil filter mounting surface.

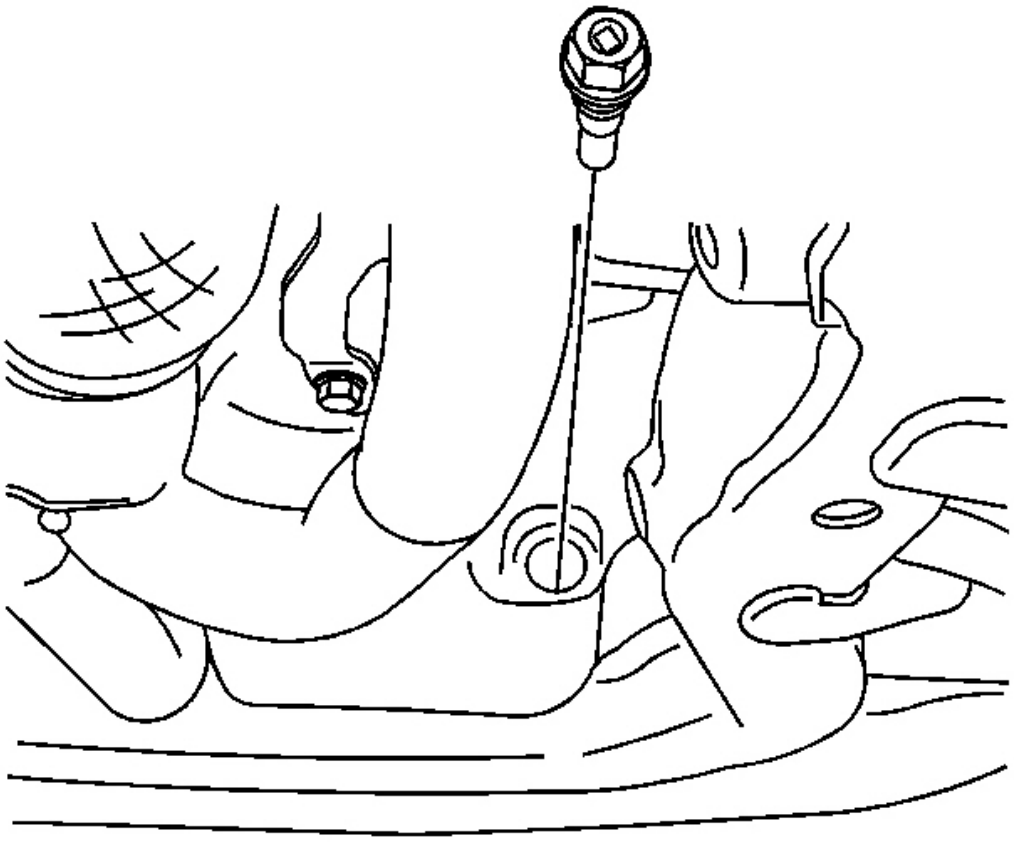


Fig. 157: View Of Engine Oil Drain Plug
Courtesy of GENERAL MOTORS CORP.

3. Install the engine oil drain plug.

   Tighten: Tighten the plug to 39 N.m (29 lb ft).

4. Remove the oil drain pan.
5. Lower the vehicle.
6. Fill the engine with new engine oil. Refer to **Capacities - Approximate Fluid** or **Fluid and Lubricant Recommendations** and **Explanation of Scheduled Services** in Maintenance and Lubrication.

DRAINING FLUIDS AND OIL FILTER REMOVAL

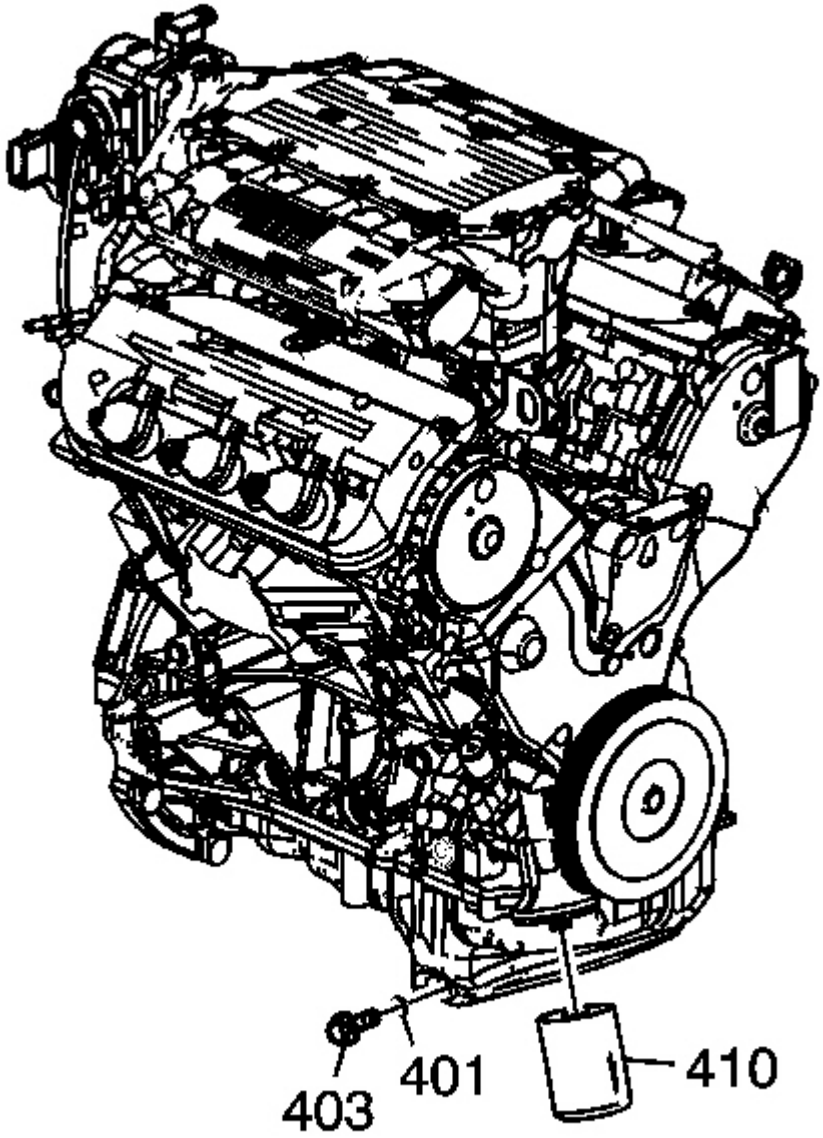


Fig. 158: View Of Oil Filter
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil filter (410).
2. Remove the oil drain plug (403) and O-ring (401) and allow the oil to drain.

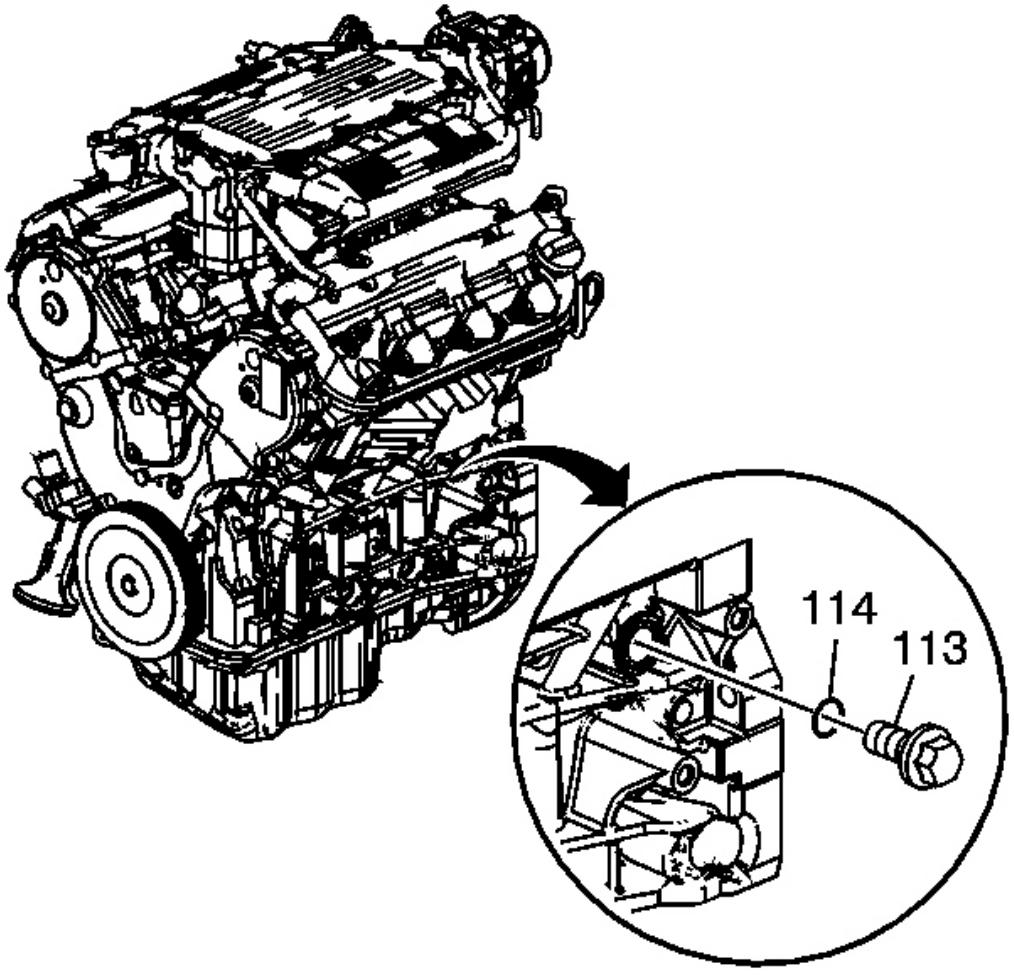


Fig. 159: View Of Left Side Coolant Drain Plug
Courtesy of GENERAL MOTORS CORP.

3. Remove the left side coolant drain plug (113) and washer (114) and allow the coolant to drain.

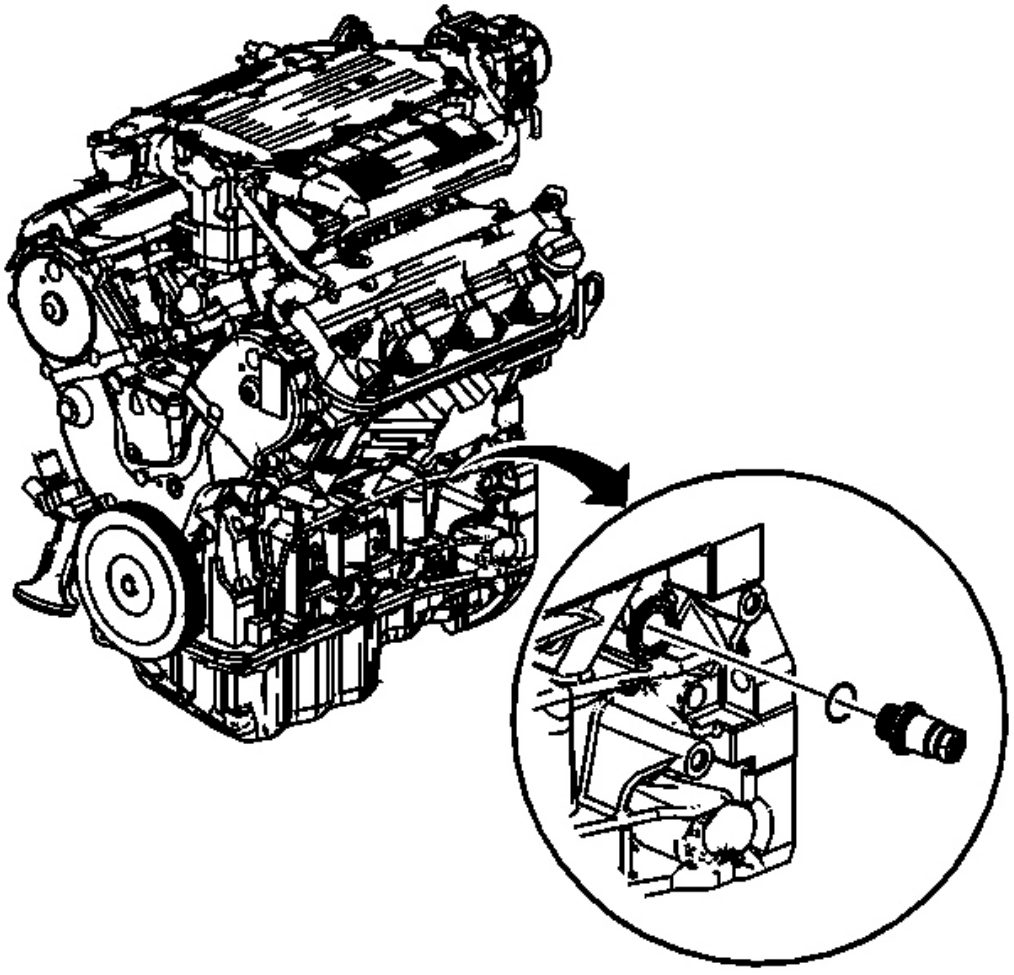


Fig. 160: View Of Block Coolant Heater & Washer
Courtesy of GENERAL MOTORS CORP.

4. Remove the block coolant heater and washer, if applicable, and allow the coolant to drain.

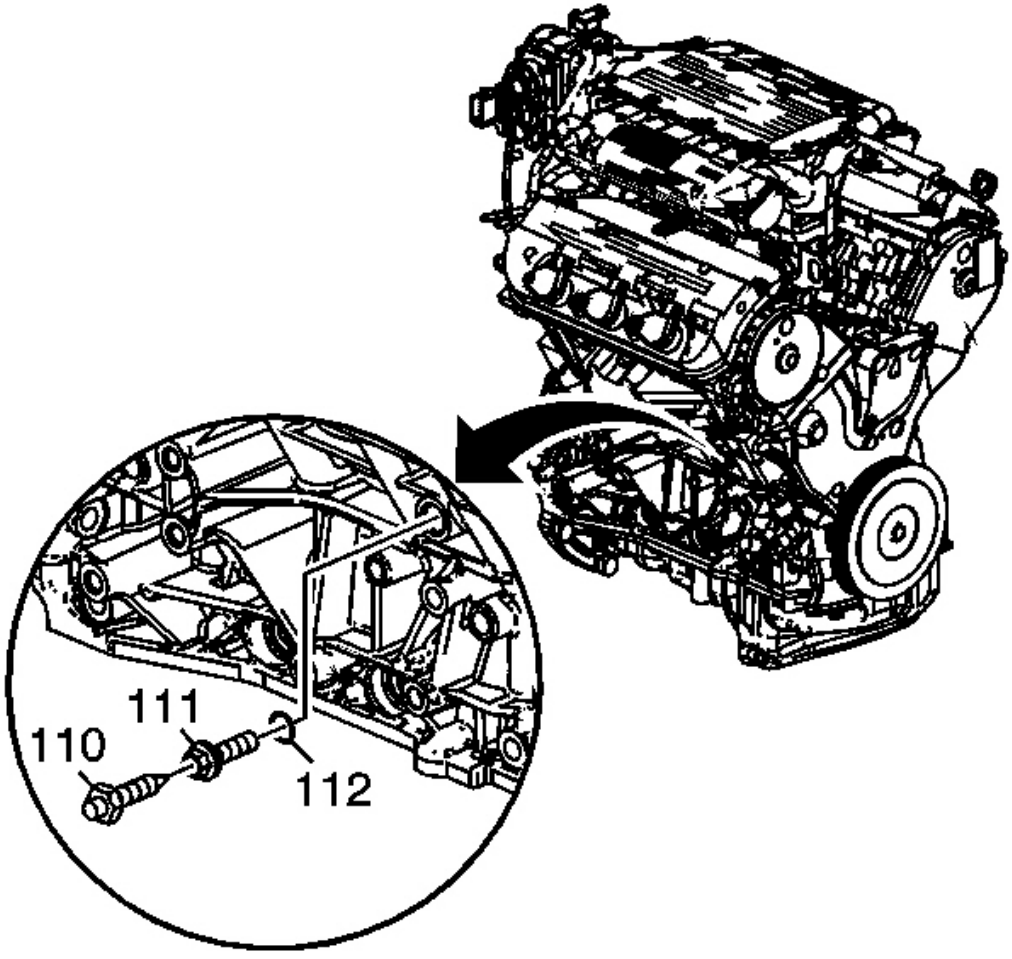


Fig. 161: View Of Coolant Drain Plug
Courtesy of GENERAL MOTORS CORP.

5. Loosen the right side coolant drain plug (110) and allow the coolant to drain.

ENGINE LIFT BRACKET REMOVAL

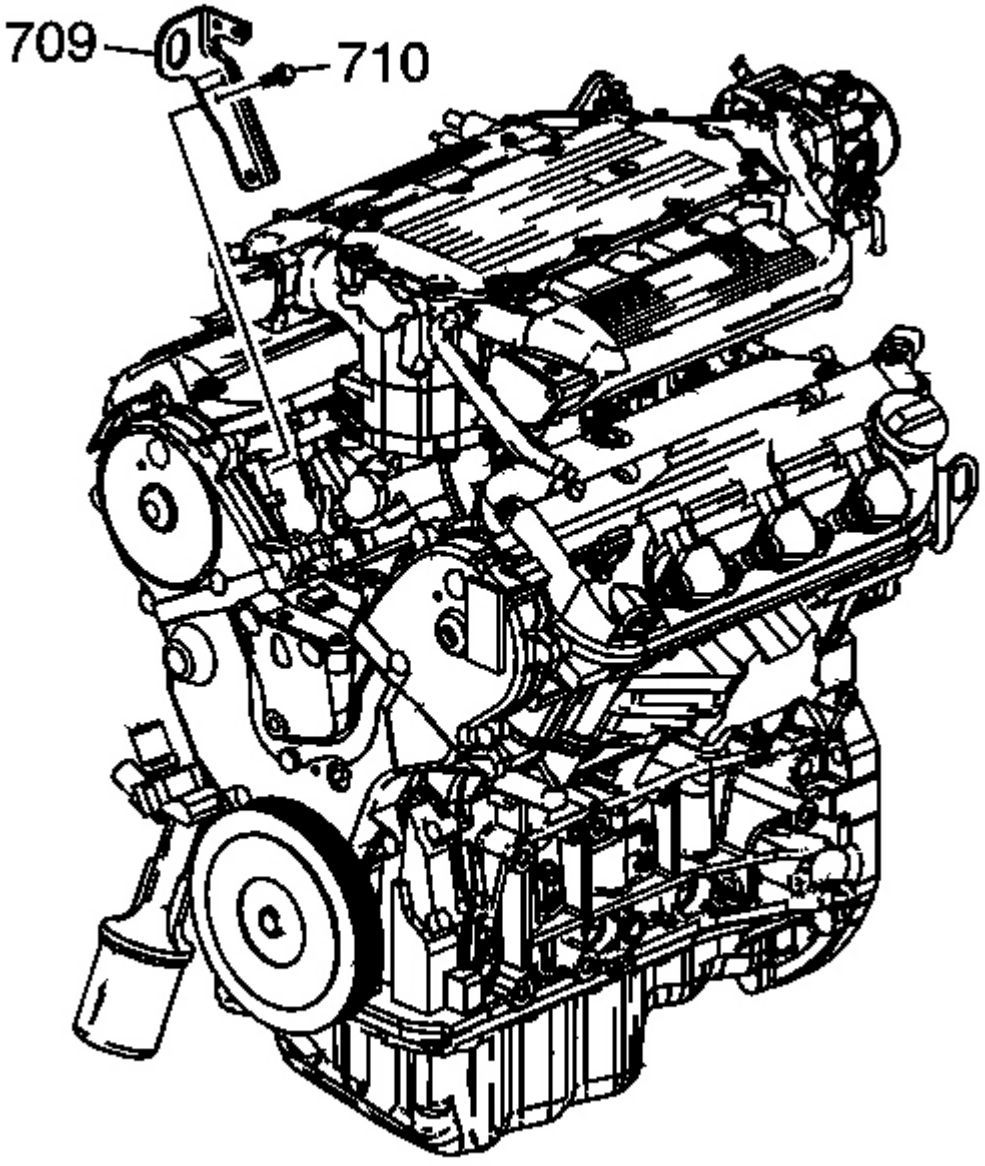


Fig. 162: View Of Engine Bracket
Courtesy of GENERAL MOTORS CORP.

1. Remove the bolts (710).
2. Remove the bracket (709).

ENGINE FLYWHEEL REMOVAL

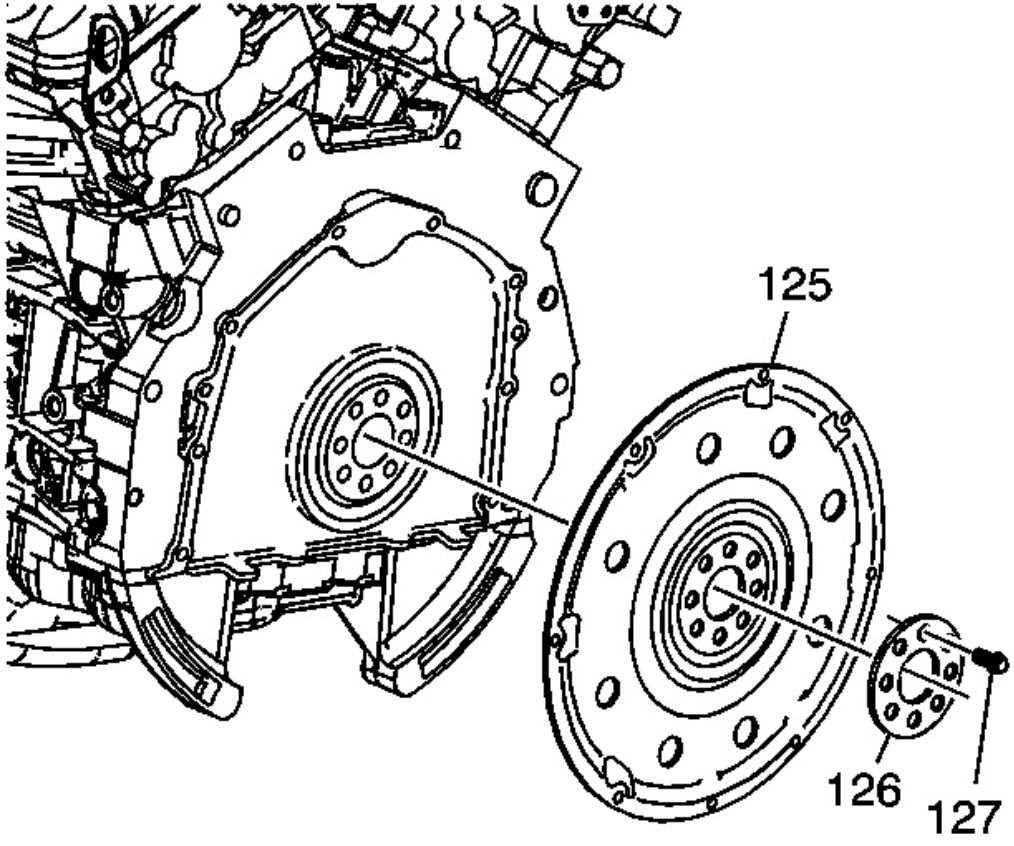


Fig. 163: View Of Engine Flywheel
Courtesy of GENERAL MOTORS CORP.

Remove the bolts (127), washer (126) and flywheel (125).

THROTTLE BODY REMOVAL

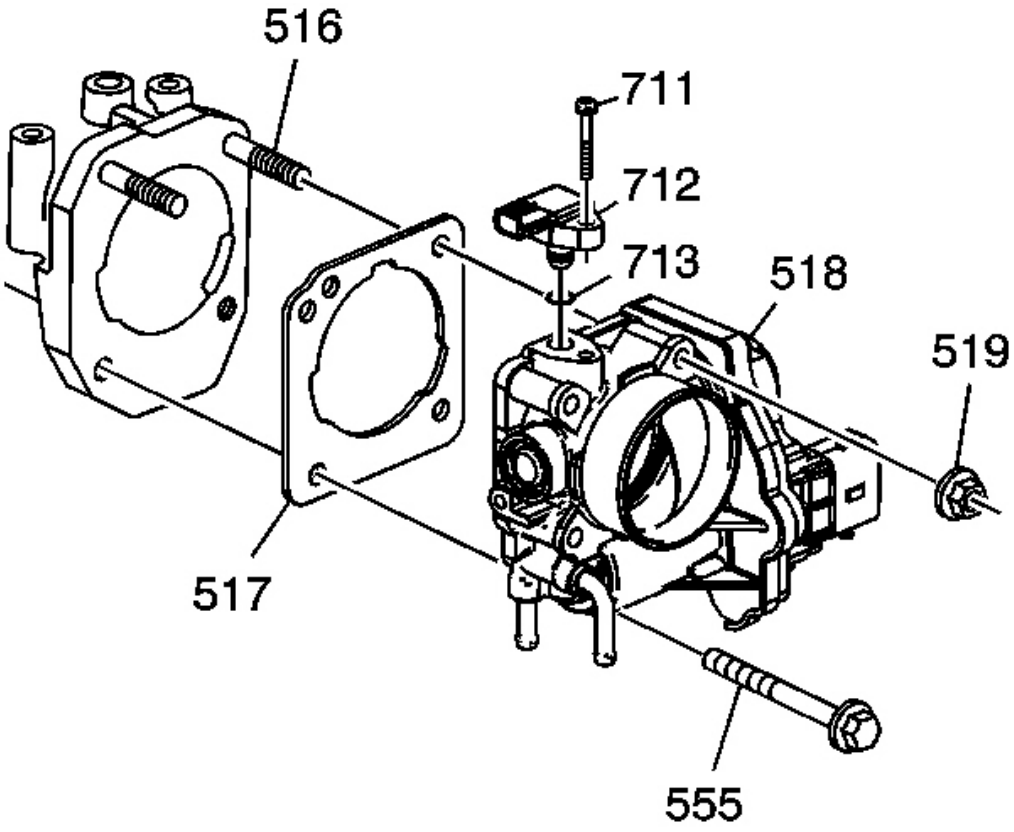


Fig. 164: Identifying Throttle Body
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The powertrain control module (PCM) must perform the idle learn procedure to determine the minimum throttle position and to establish idle speed when any of the following components are replaced:

- **Throttle body**
- **Timing belt**
- **Timing belt drive sprocket**
- **Crankshaft and bearings**

Refer to Idle Learn Procedure .

1. Remove the bolt (711).

2. Remove the manifold absolute pressure (MAP) sensor (712).
3. Remove the O-ring (713) from the sensor, if required.
4. Remove the throttle body coolant hoses.
5. Remove the nuts (519) and bolts (555).
6. Remove the throttle body (518) and gasket (517).
7. Remove the studs (516), if required.

INTAKE MANIFOLD REMOVAL

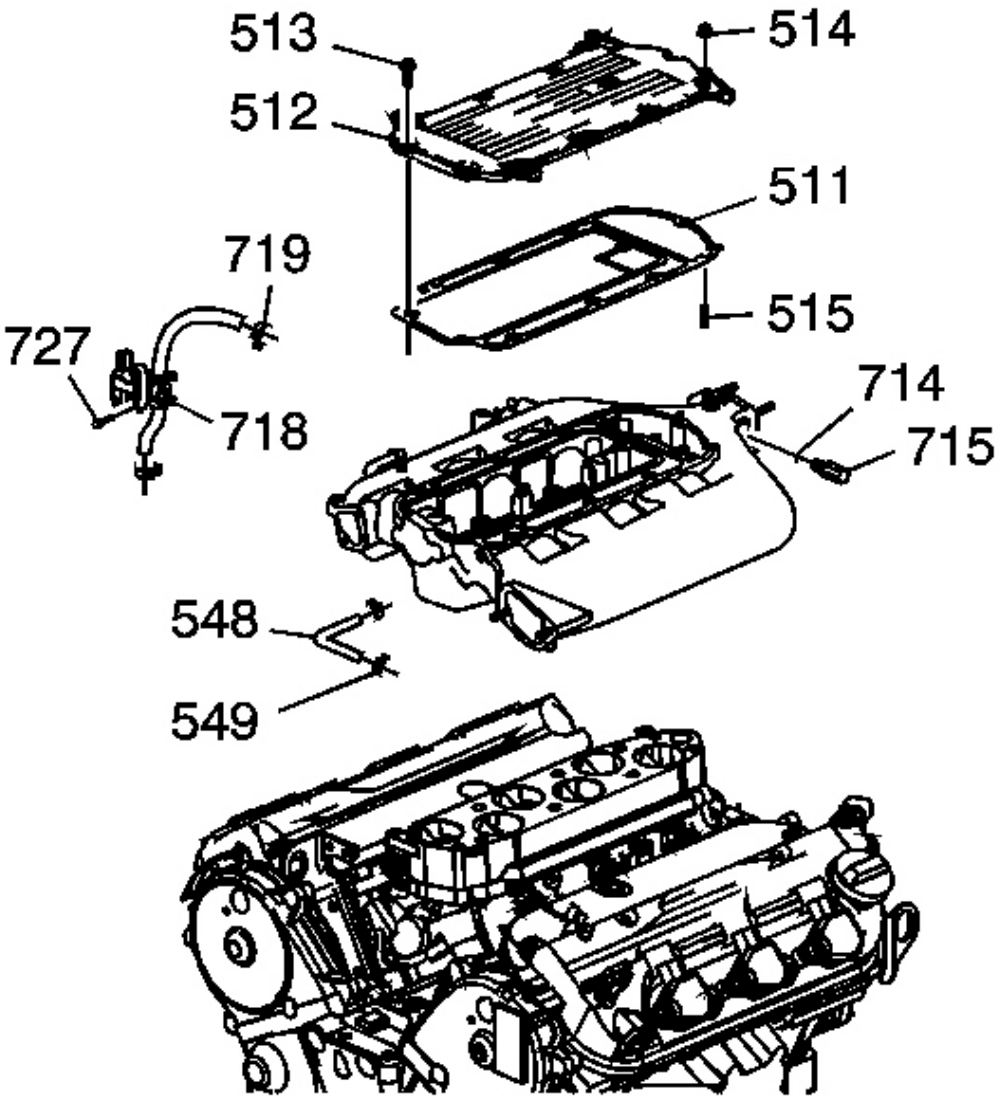


Fig. 165: View Of Intake Manifold
Courtesy of GENERAL MOTORS CORP.

1. Remove the bolts (727), EVAP valve with hoses (718) and clamps (719).
2. Remove the positive crankcase ventilation (PCV) hose (548) and clamps (549).
3. Remove the intake air temperature (IAT) sensor (715) and O-ring (714).
4. Remove the bolts (513) and nuts (514).
5. Remove the cover (512) and gasket (511).

6. Remove the studs (515), if required.

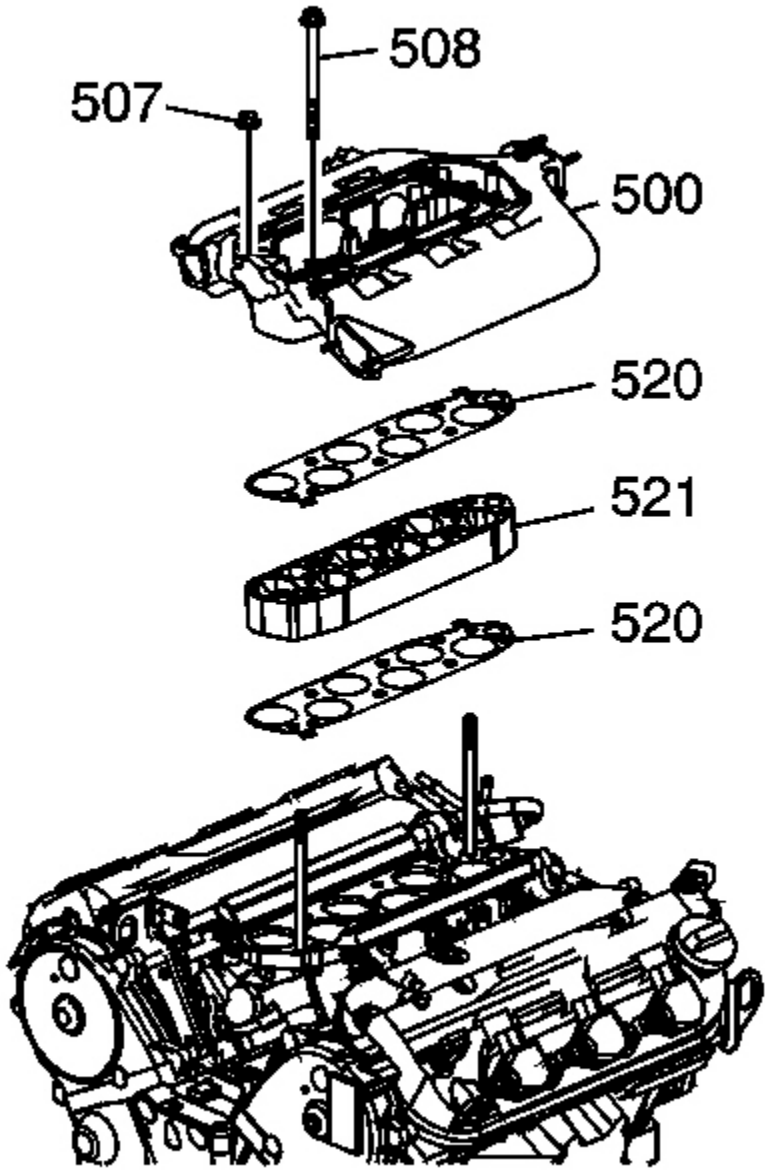


Fig. 166: Identifying Bolts, Nuts, Manifold, Gaskets & Spacer
Courtesy of GENERAL MOTORS CORP.

7. Remove the bolts (508) and nuts (507).

8. Remove the manifold (500), gaskets (520) and spacer (521).

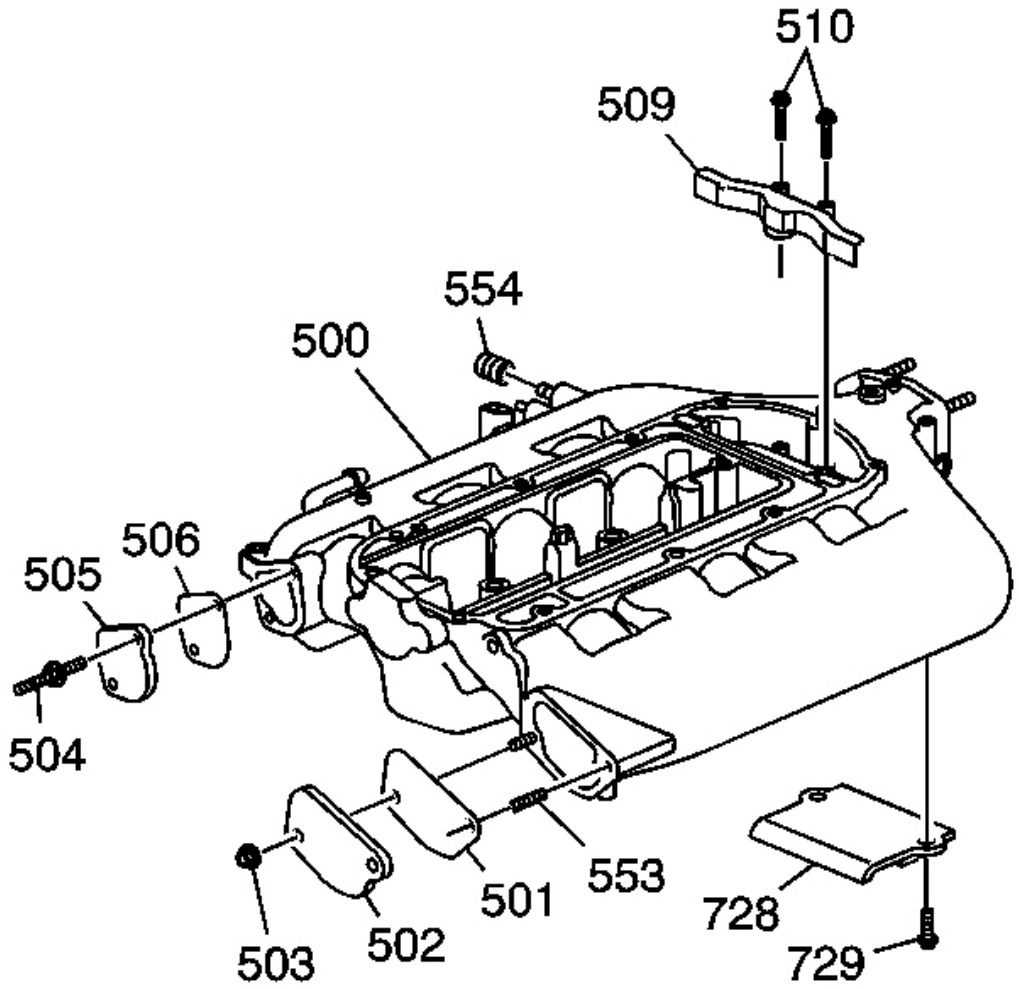


Fig. 167: View Of Exhaust Gas Recirculation, Tube & Bolts
Courtesy of GENERAL MOTORS CORP.

9. Remove the nuts (503) and bolts (504), if required.
10. Remove the covers (502 and 505), gaskets (501 and 506) and studs (553), if required.
11. Remove the bolts (510) and exhaust gas recirculation (EGR) tube (509), if required.
12. Remove the cap (554).
13. Remove the bolts (729) and dampener (728), if required.

FUEL RAIL AND INJECTORS REMOVAL

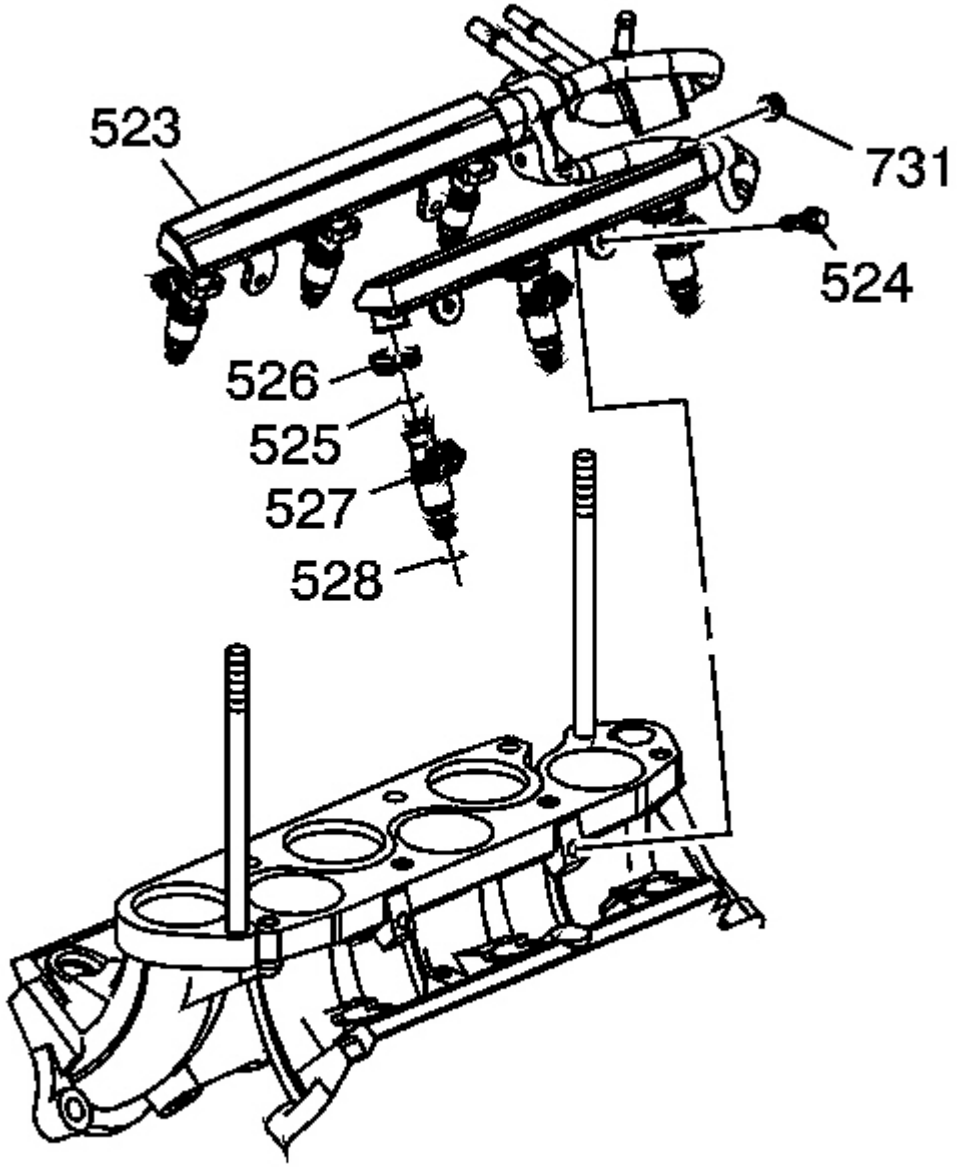


Fig. 168: View Of Fuel Rail & Injectors
Courtesy of GENERAL MOTORS CORP.

1. Remove the nuts (731) and bolts (524).

2. Remove the fuel rail with injectors (523), hoses, and fuel pipe from the manifolds, as an assembly.
3. Remove the clips (526), injectors (527) and O-rings (525 and 528) as required.

CRANKSHAFT BALANCER REMOVAL

Tools Required

EN 46337 Camshaft Sprocket/Crankshaft Balancer Holder. See **Special Tools and Equipment** .

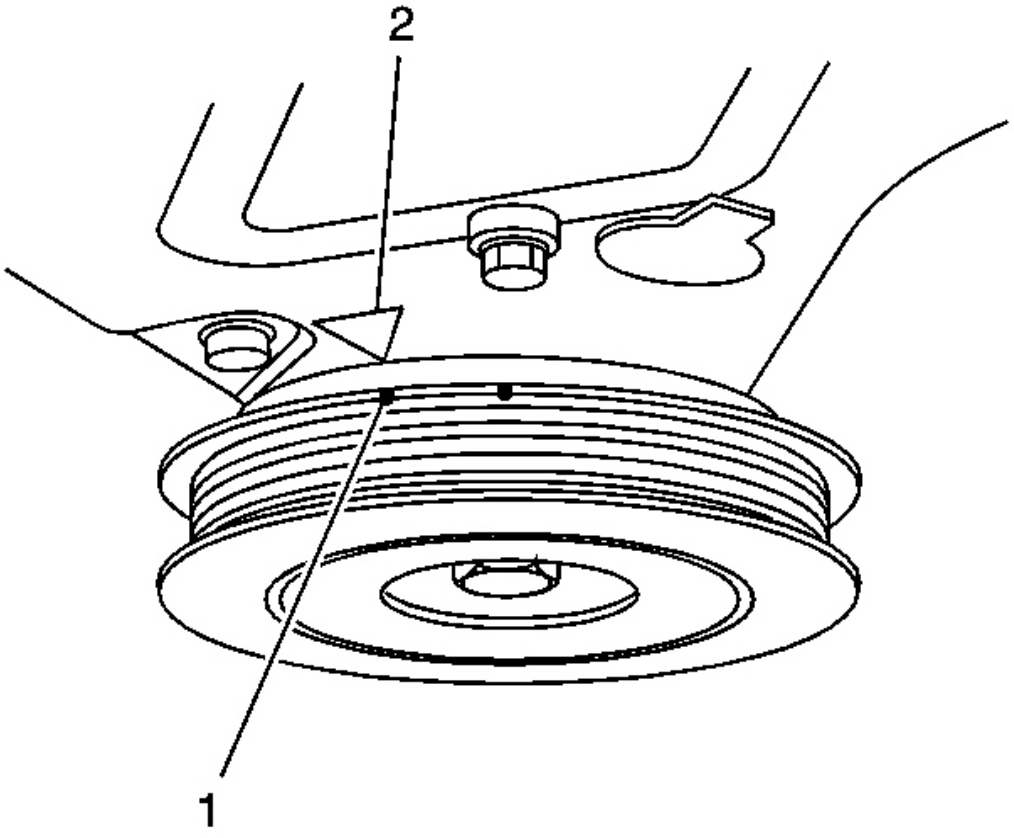


Fig. 169: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If the timing belt is to be removed, the crankshaft balancer must be rotated to position number 1 piston at top dead center (TDC) of compression stroke to avoid valve-to-piston contact.

1. Rotate the balancer and align the white mark on the balancer (1) with the locating tab (2) on the front cover.

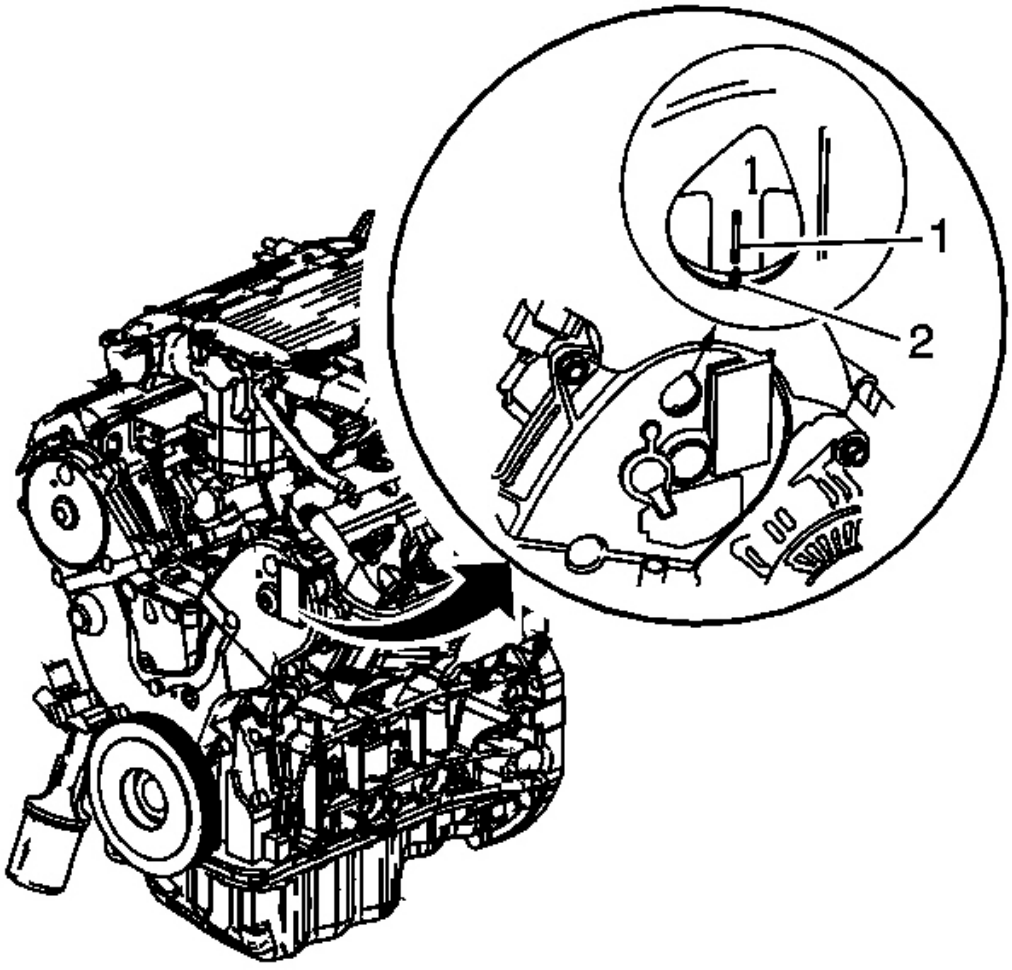


Fig. 170: Aligning The Upper Cover With The Number 1 Cylinder
Courtesy of GENERAL MOTORS CORP.

2. Inspect for cylinder number 1 piston at TDC. The pointer on the upper cover (2) will be aligned with the number 1 cylinder TDC mark (1) on the camshaft sprocket.

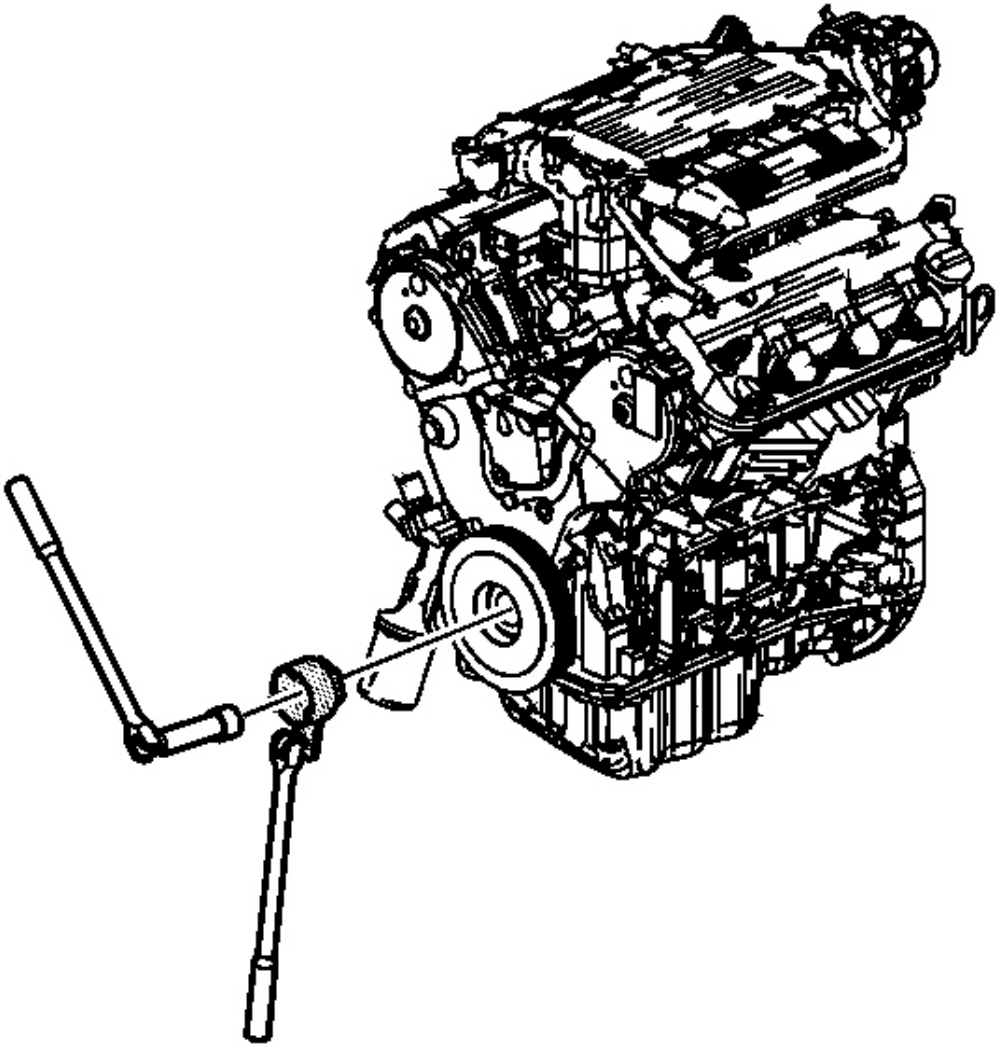


Fig. 171: Using Breaker Bar To Retain The Balancer
Courtesy of GENERAL MOTORS CORP.

3. Use the **EN 46337** and a breaker bar in order to retain the balancer. See **Special Tools and Equipment** .

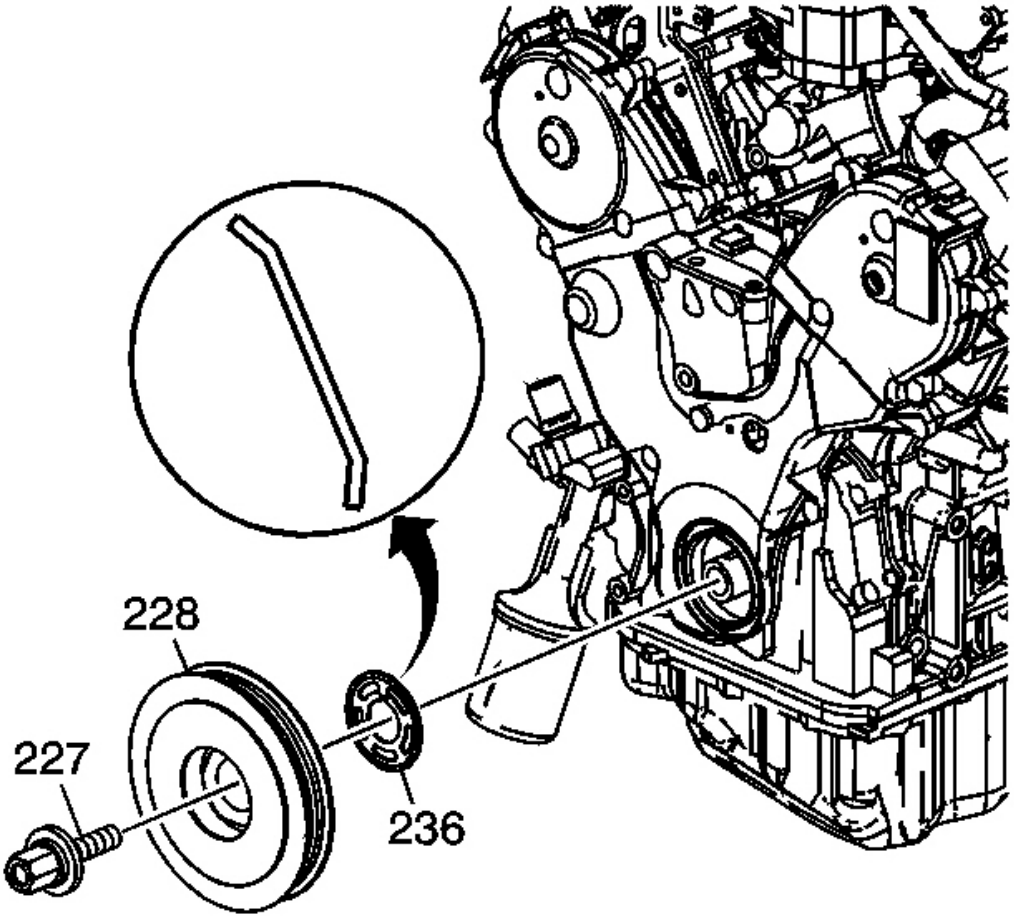


Fig. 172: View Of Bolt, Balancer & Guide
Courtesy of GENERAL MOTORS CORP.

4. Remove the bolt (227), balancer (228) and guide (236).

TIMING BELT COVER REMOVAL

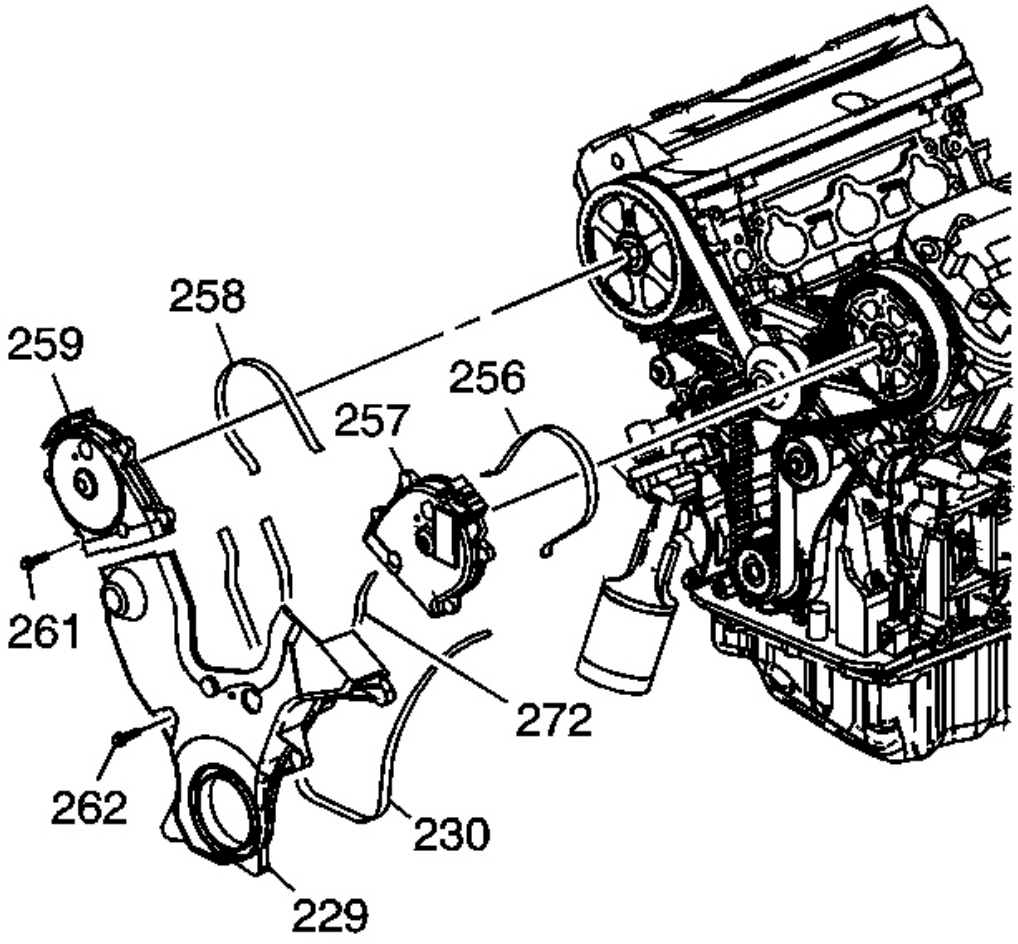


Fig. 173: View Of Timing Belt Cover
Courtesy of GENERAL MOTORS CORP.

1. Remove the bolts (261).
2. Remove the covers (257 and 259).
3. Remove the bolts (262).
4. Remove the cover (229).
5. Remove the seals (230, 256, 258 and 272), if required.

ENGINE MOUNT BRACKET REMOVAL - FRONT

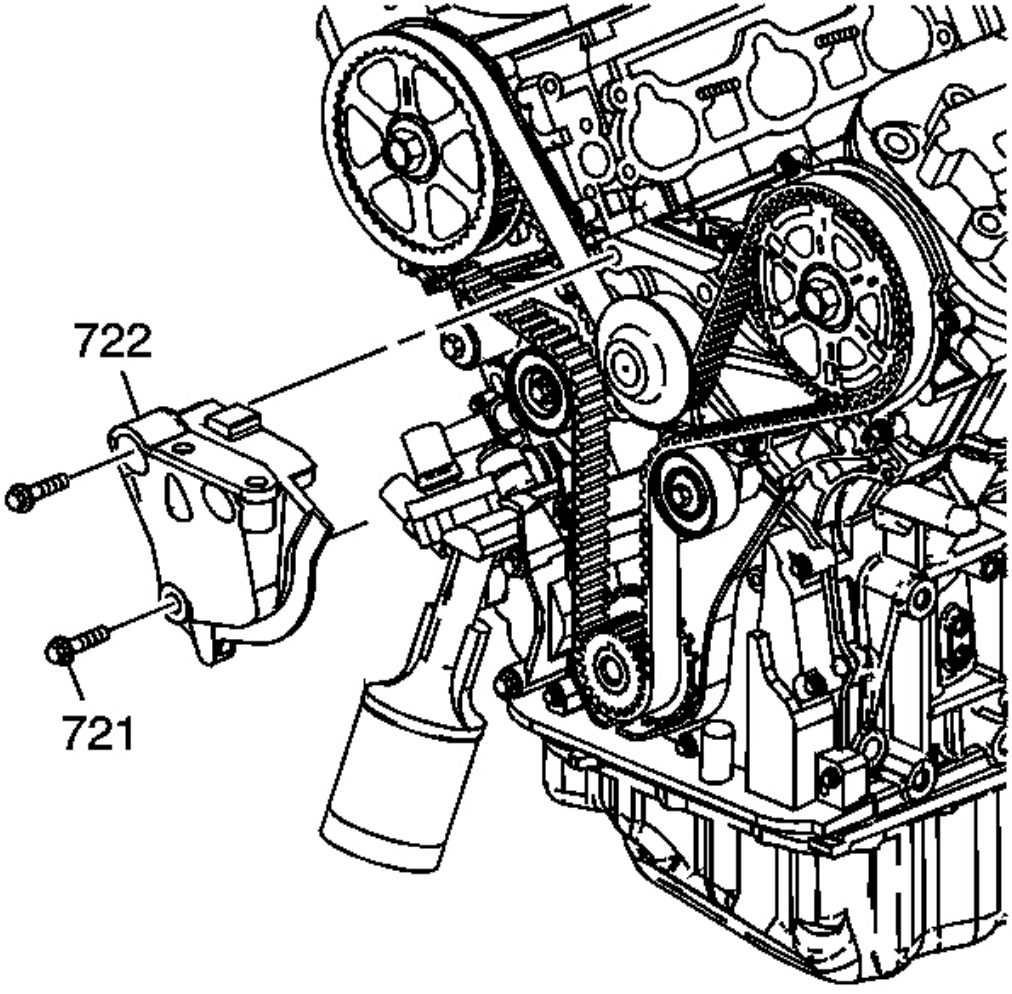


Fig. 174: View Of Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

1. Remove the bolts (721).
2. Remove the mount bracket (722).

TIMING BELT REMOVAL

Tools Required

EN 46331 Timing Belt Tensioner Pulley Retaining Bolt. See **Special Tools and Equipment** .

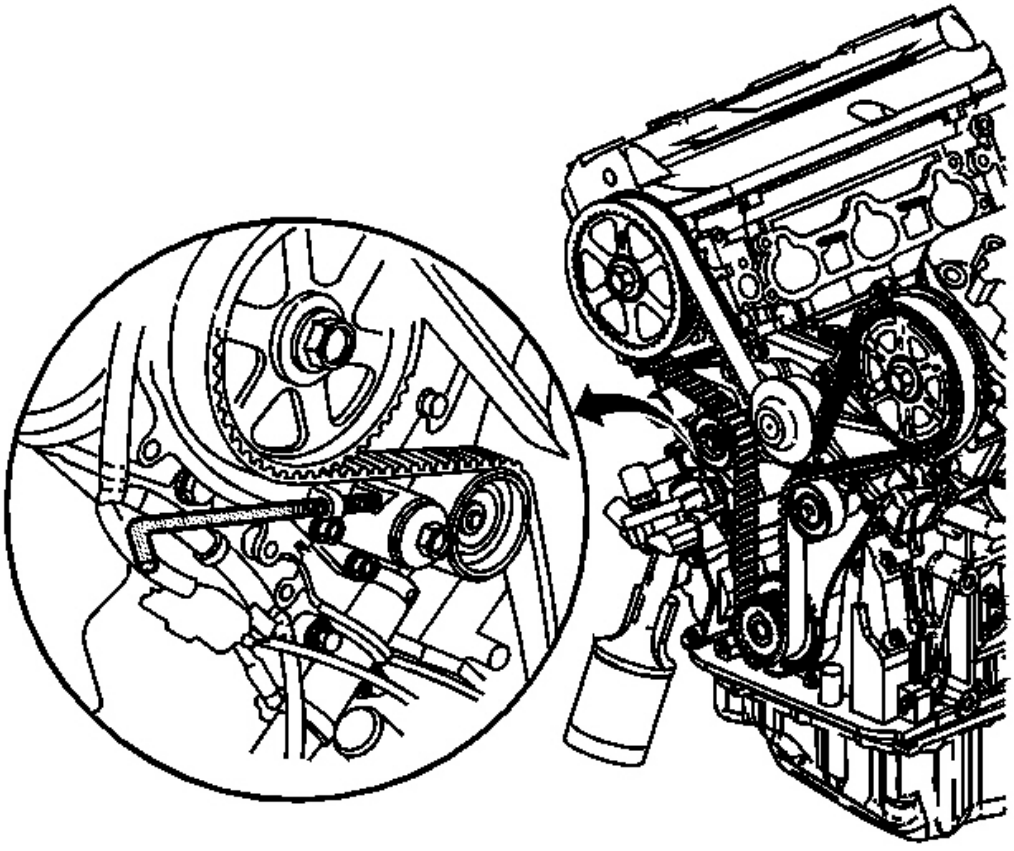


Fig. 175: View Of Timing Belt
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The powertrain control module (PCM) must perform the idle learn procedure to determine the minimum throttle position and to establish idle speed when any of the following components are replaced:

- **Throttle body**
- **Timing belt**
- **Timing belt drive sprocket**
- **Crankshaft and bearings**

Refer to Idle Learn Procedure .

1. Use the **EN 46331** to retain the tensioner pulley. See **Special Tools and Equipment** . Tighten until snug.

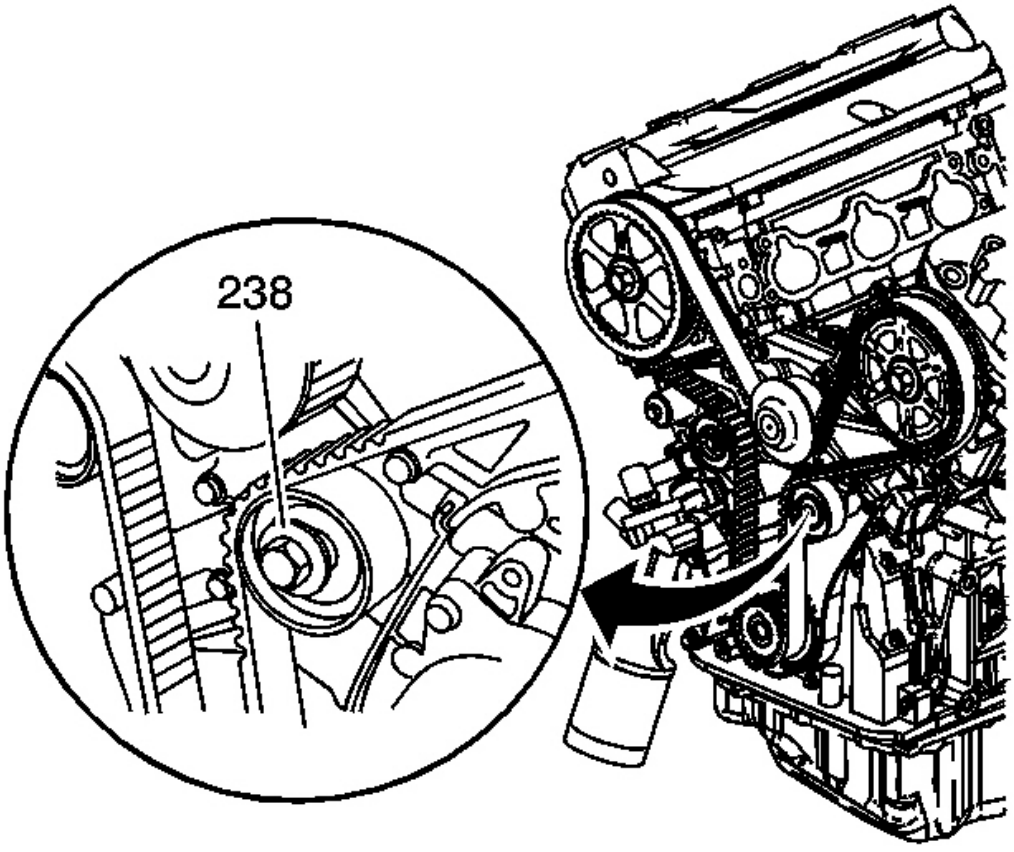


Fig. 176: View Of Idler Pulley Bolt
Courtesy of GENERAL MOTORS CORP.

2. Loosen the idler pulley bolt (238) about 5 or 6 turns.

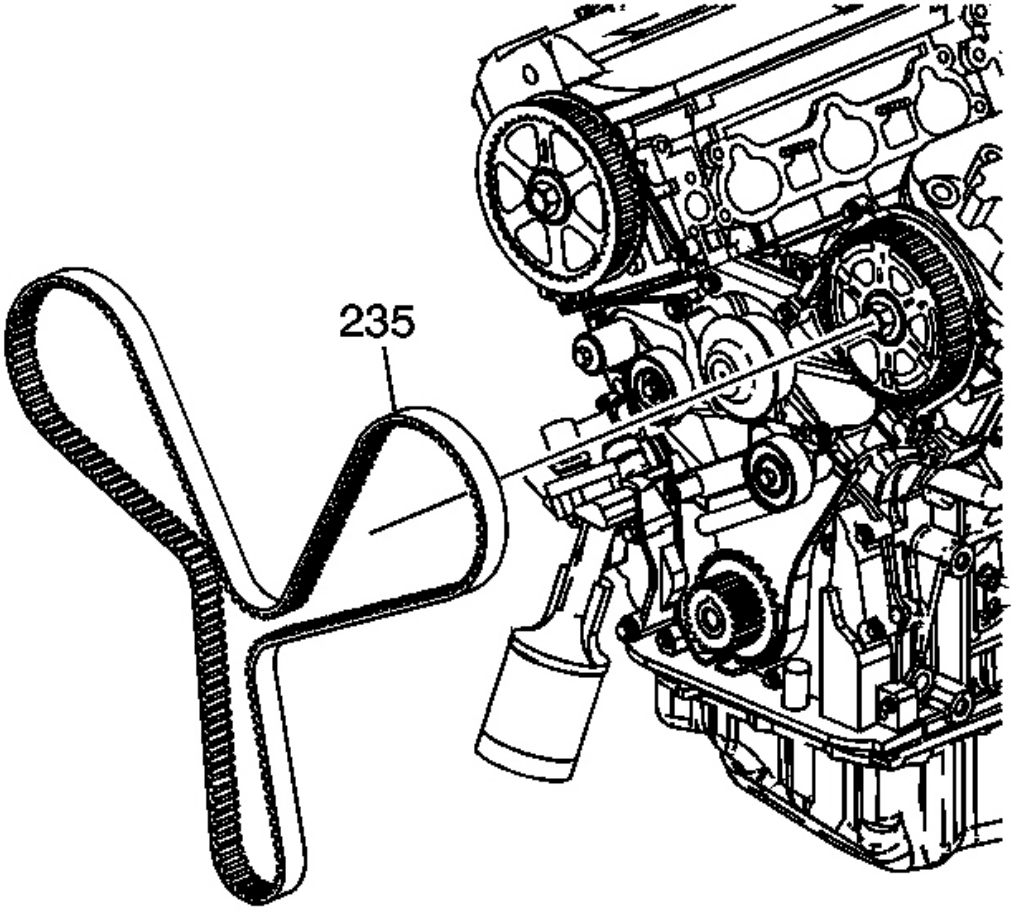


Fig. 177: View Of Timing Belt
Courtesy of GENERAL MOTORS CORP.

3. Remove the belt (235).
4. Remove the **EN 46331** . See **Special Tools and Equipment** .

TIMING BELT TENSIONER REMOVAL

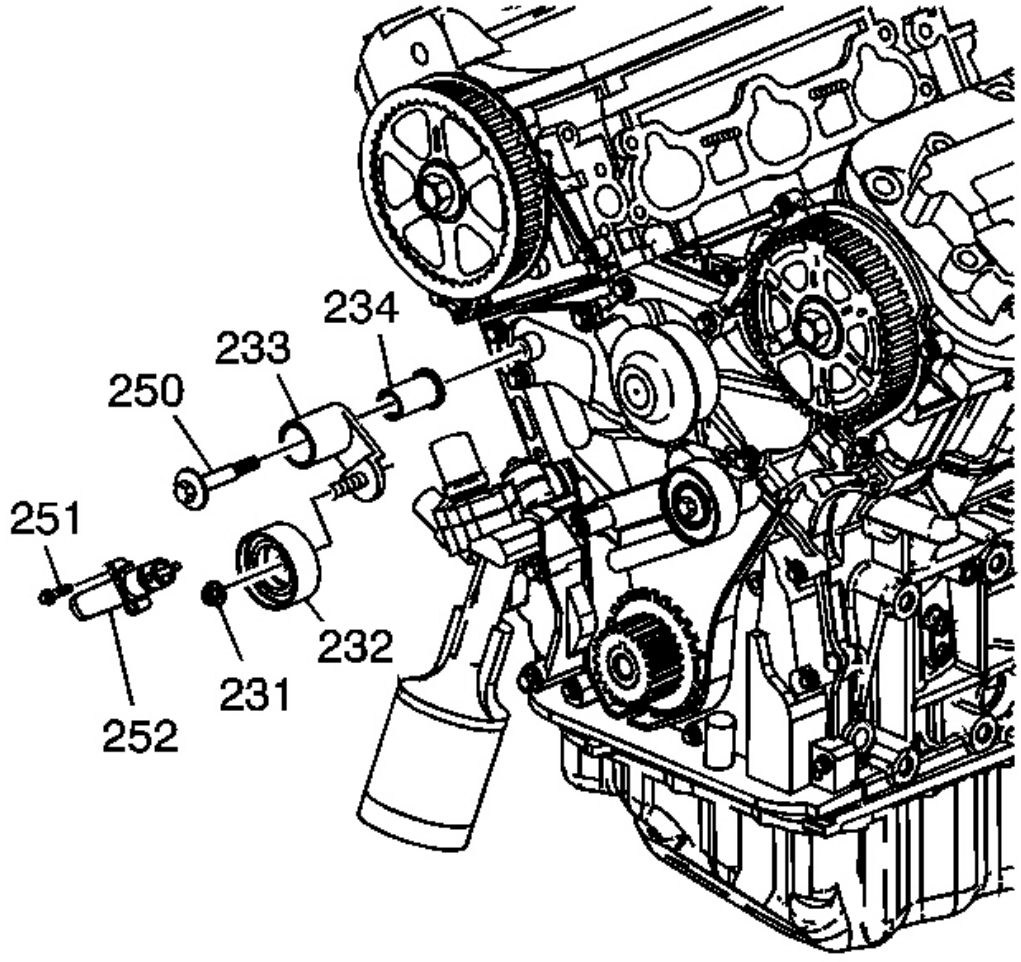


Fig. 178: Identifying Timing Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Remove the bolts (251).
2. Remove the tensioner (252).
3. Remove the bolt (250), tensioner pulley assembly (233) and bushing (234).
4. Remove the nut (231) and pulley (232), if required.

TIMING BELT IDLER PULLEY REMOVAL

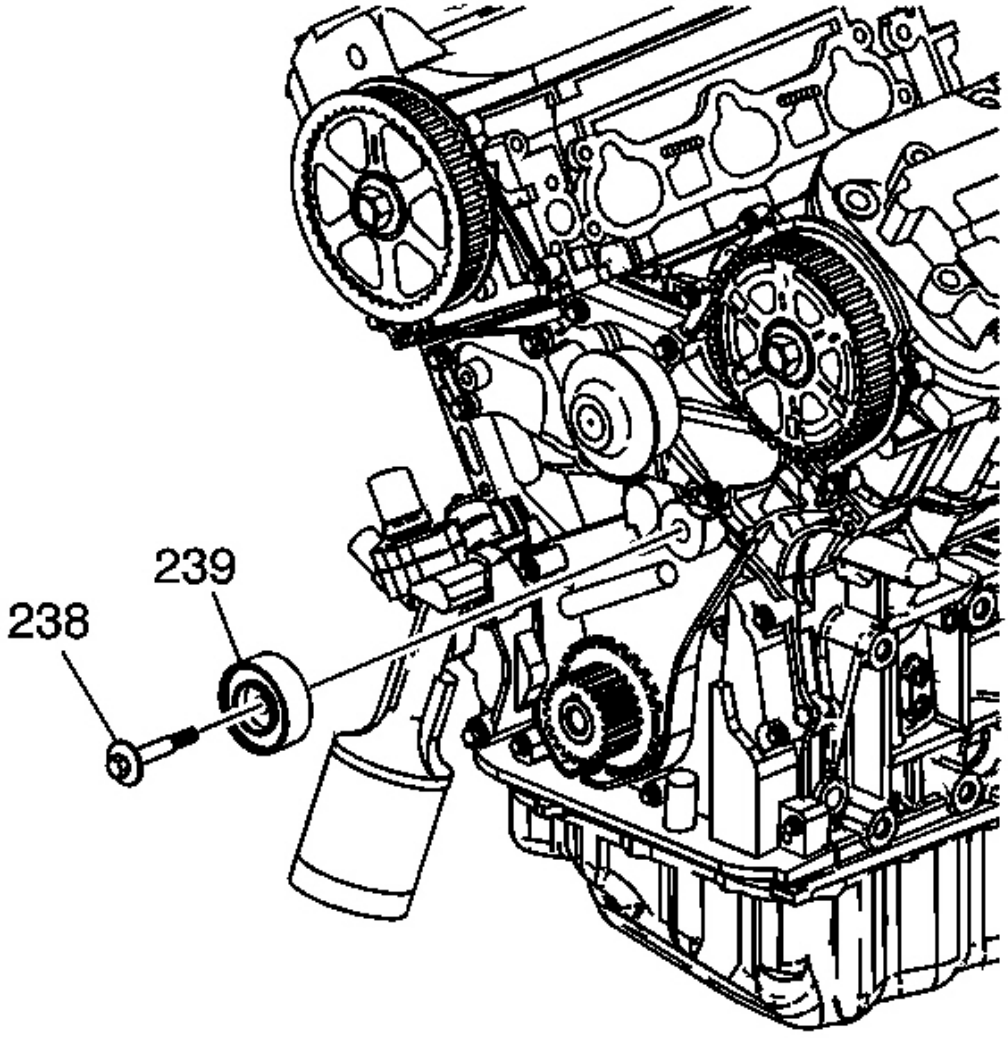


Fig. 179: View Of Timing Belt
Courtesy of GENERAL MOTORS CORP.

1. Remove the bolt (238).
2. Remove the pulley (239).

TIMING BELT DRIVE SPROCKET REMOVAL

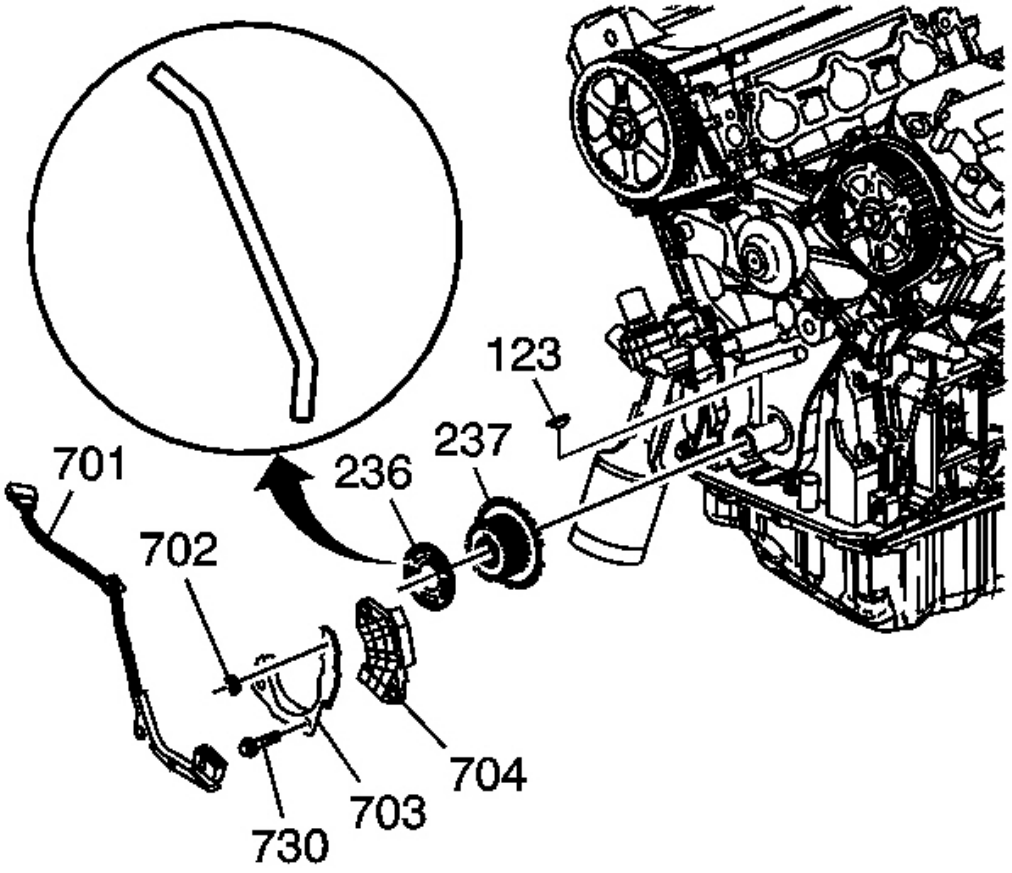


Fig. 180: View Of Timing Belt Sprocket
Courtesy of GENERAL MOTORS CORP.

1. Remove the nut (702), bolts (730), and guide (703).
2. Remove the crankshaft position (CKP) sensor (704) and harness (701).
3. Remove the guide (236). Note, the concave area of the guide faces the front of engine.

IMPORTANT: The powertrain control module (PCM) must perform the idle learn procedure to determine the minimum throttle position and to establish idle speed when any of the following components are replaced:

- **Throttle body**
- **Timing belt**
- **Timing belt drive sprocket**

- **Crankshaft and bearings**

Refer to Idle Learn Procedure .

4. Remove the sprocket (237) and key (123).

WATER PUMP REMOVAL

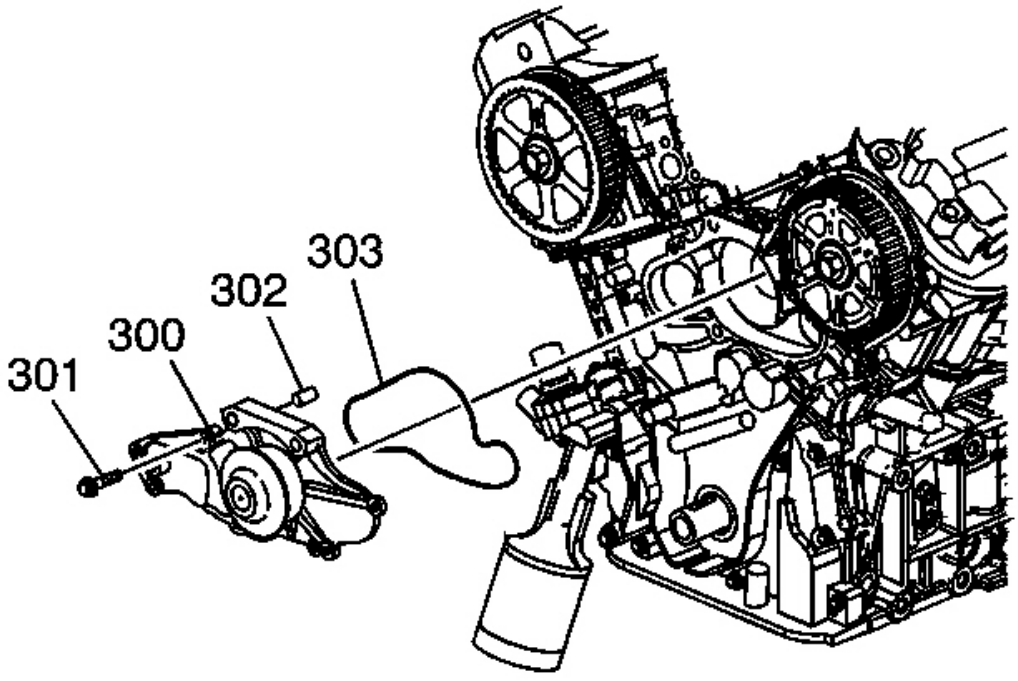


Fig. 181: View Of Water Pump
Courtesy of GENERAL MOTORS CORP.

1. Remove the bolts (301).
2. Remove the water pump (300).
3. Remove the O-ring (303).
4. Remove the pins (302).

COOLANT CROSSOVER PIPE REMOVAL

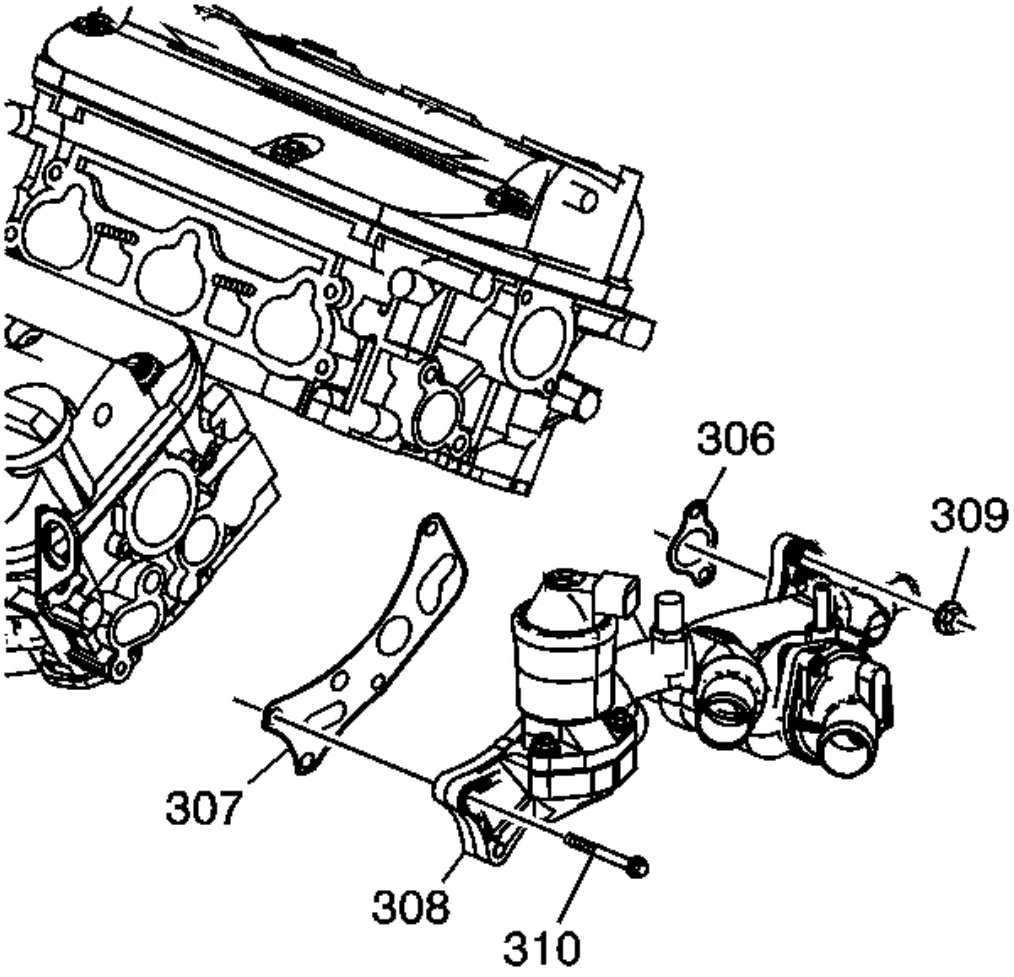


Fig. 182: View Of Coolant Crossover Pipe
Courtesy of GENERAL MOTORS CORP.

1. Remove the throttle body coolant hoses, if required.
2. Remove the nuts (309) and bolts (310).
3. Remove the housing (308) and gaskets (306 and 307).

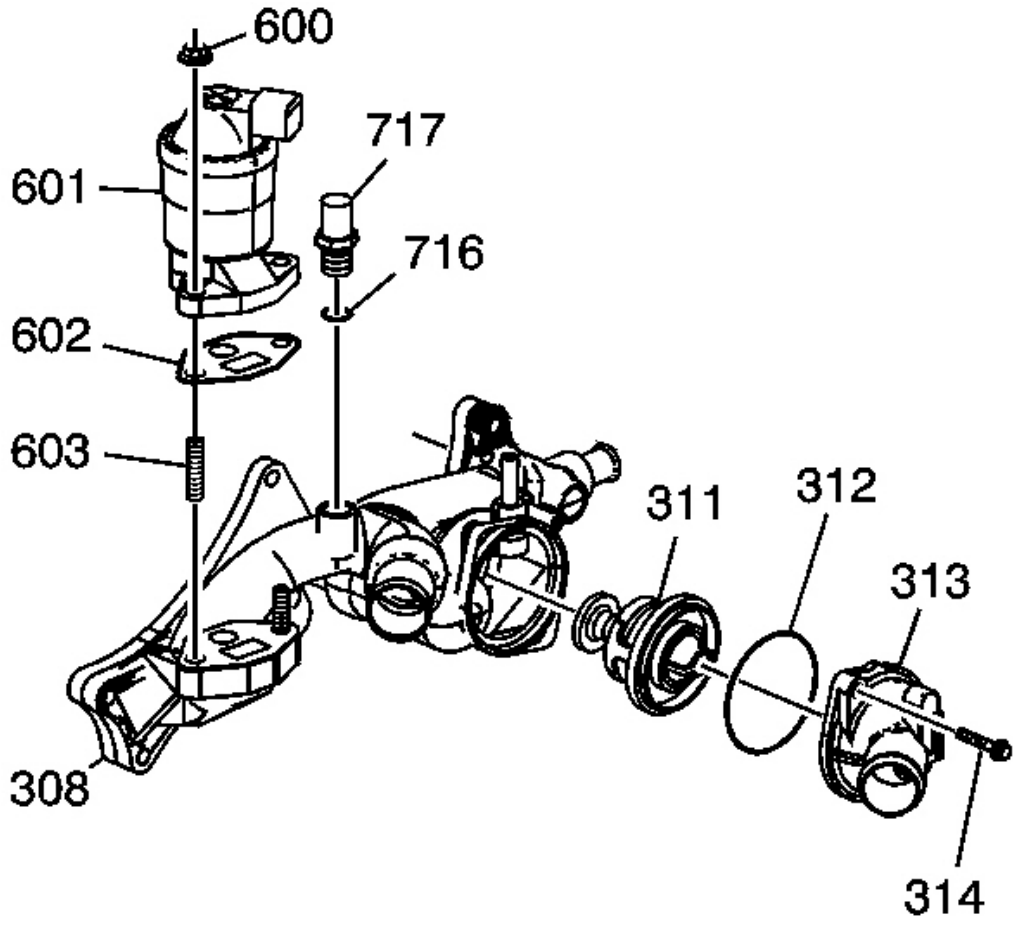


Fig. 183: Identifying Nuts, Exhaust Gas Recirculation, Valve, Gasket & Studs
Courtesy of GENERAL MOTORS CORP.

4. Remove the nuts (600), exhaust gas recirculation (EGR) valve (601), gasket (602) and studs (603), if required.
5. Remove the coolant temperature sensor (CTS) (717) and O-ring (716).
6. Remove the bolts (314), housing (313), O-ring (312) and thermostat (311).

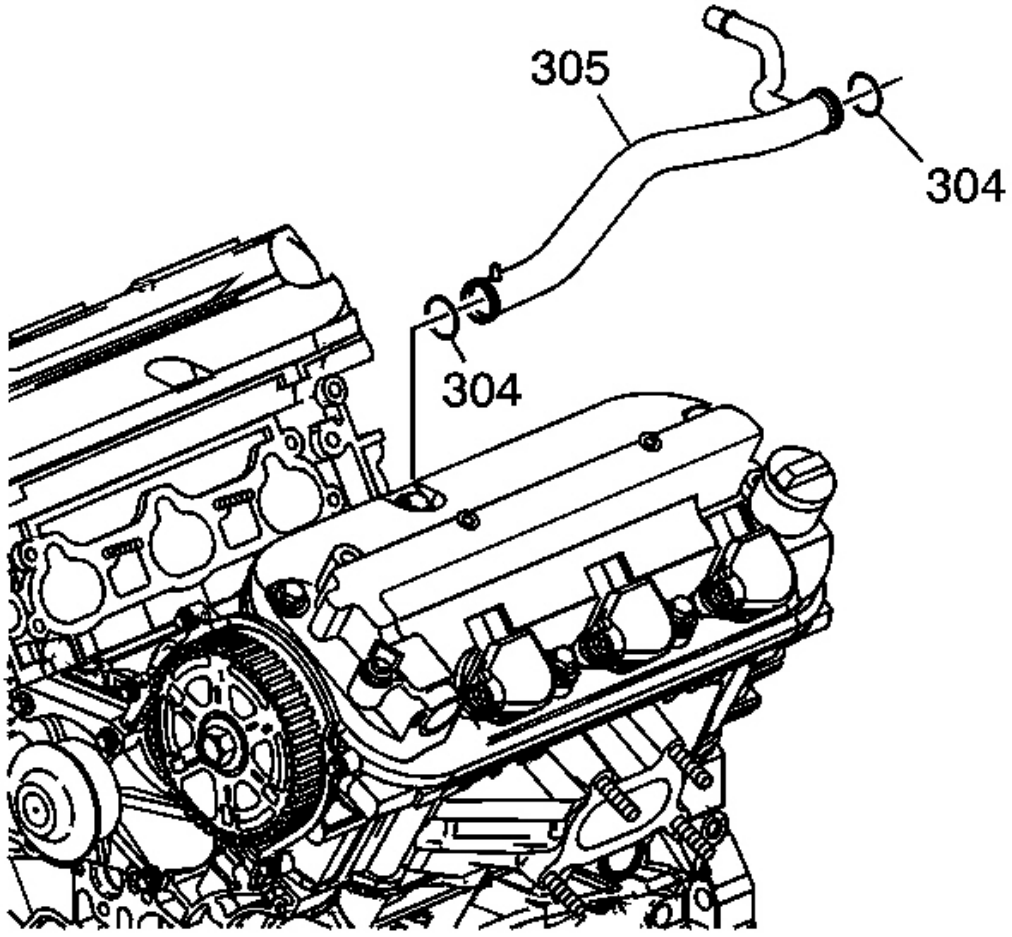


Fig. 184: View Of Coolant Crossover Pipe
Courtesy of GENERAL MOTORS CORP.

7. Remove the coolant crossover pipe (305) and O-rings (304).

VALVE ROCKER ARM COVER REMOVAL - LEFT

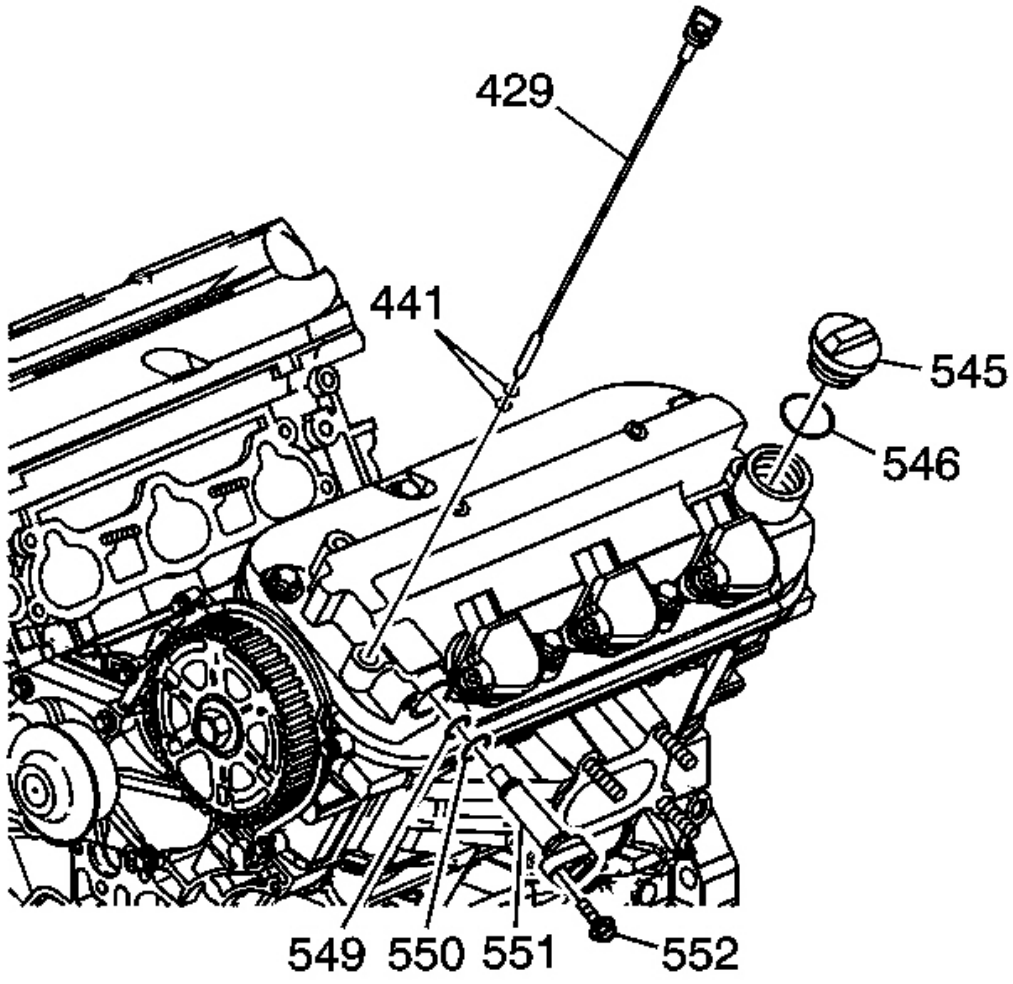


Fig. 185: View Of Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil level indicator (429) and O-rings (441), if required.
2. Remove the oil fill cap (545) and O-ring (546), if required.
3. Remove the bolt (552), positive crankcase ventilation (PCV) valve (551) and O-rings (549, 550), if required.

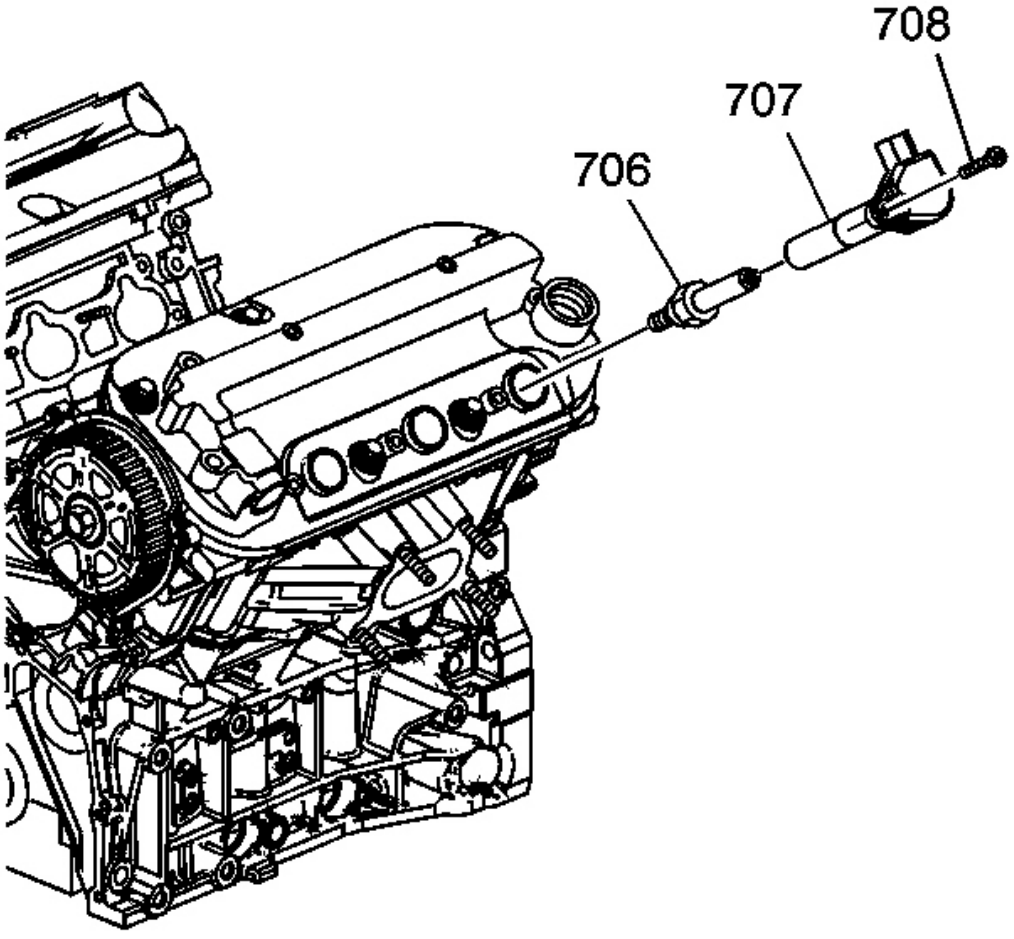


Fig. 186: View Of Bolts & Ignition Coils
Courtesy of GENERAL MOTORS CORP.

4. Remove the bolts (708), ignition coils (707) and spark plugs (706).

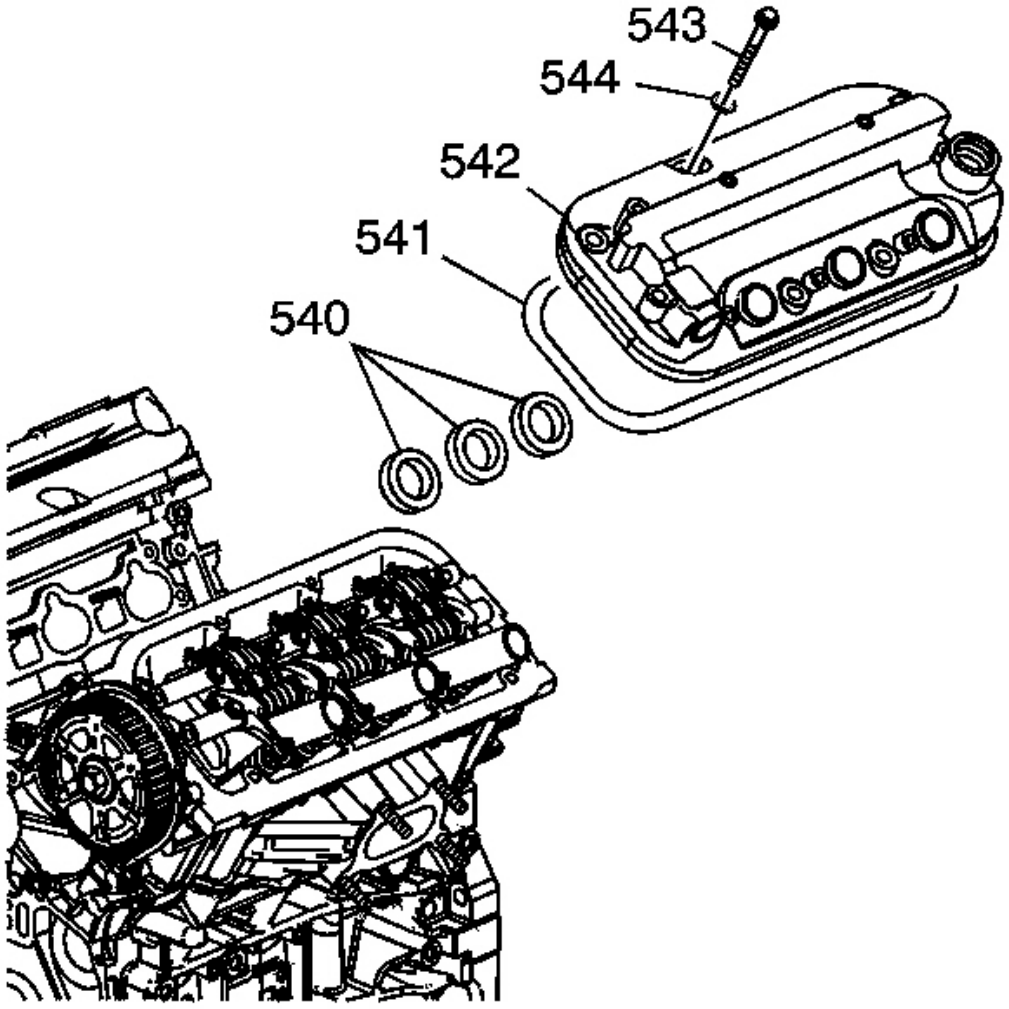


Fig. 187: View Of Seals, Gasket, Cover, Grommets & Bolts
Courtesy of GENERAL MOTORS CORP.

5. Remove the bolts (543), with grommets (544), valve cover (542) and gasket (541).
6. Remove the seals (540), if required.

VALVE ROCKER ARM COVER REMOVAL - RIGHT

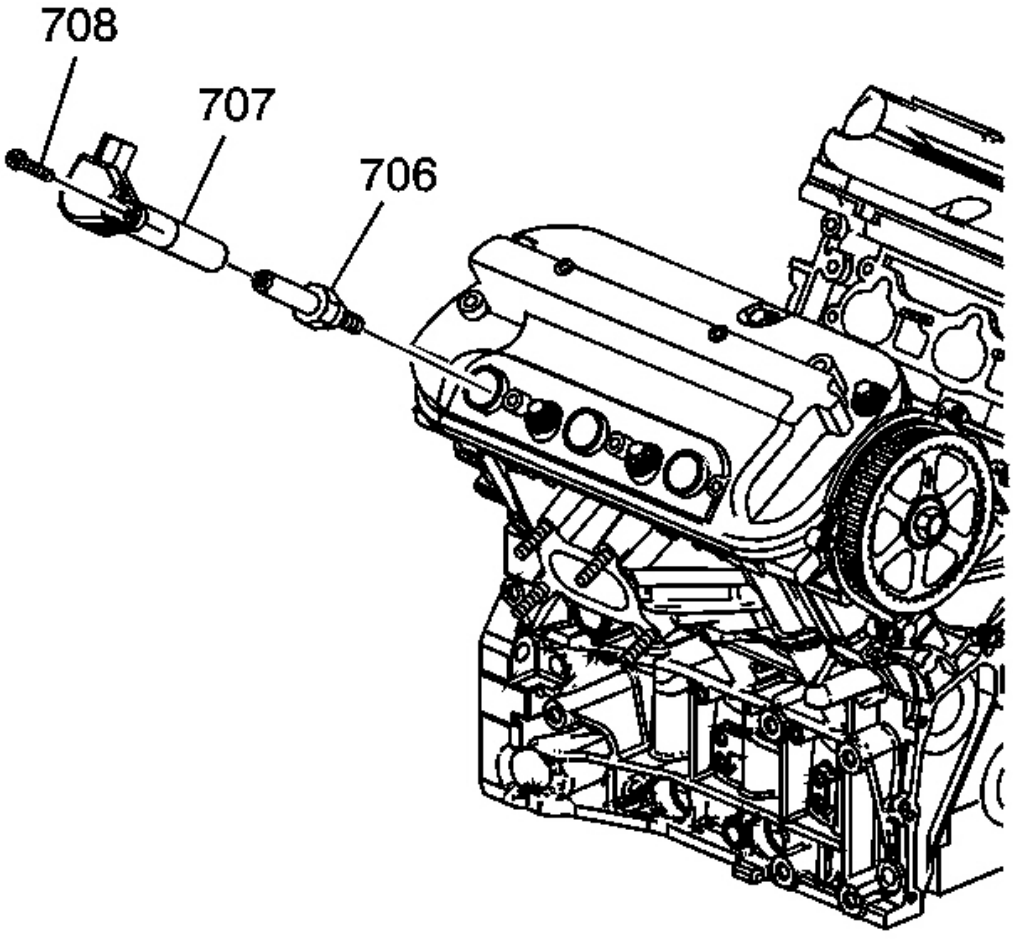


Fig. 188: Identifying Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

1. Remove the bolts (708), ignition coils (707) and spark plugs (706).

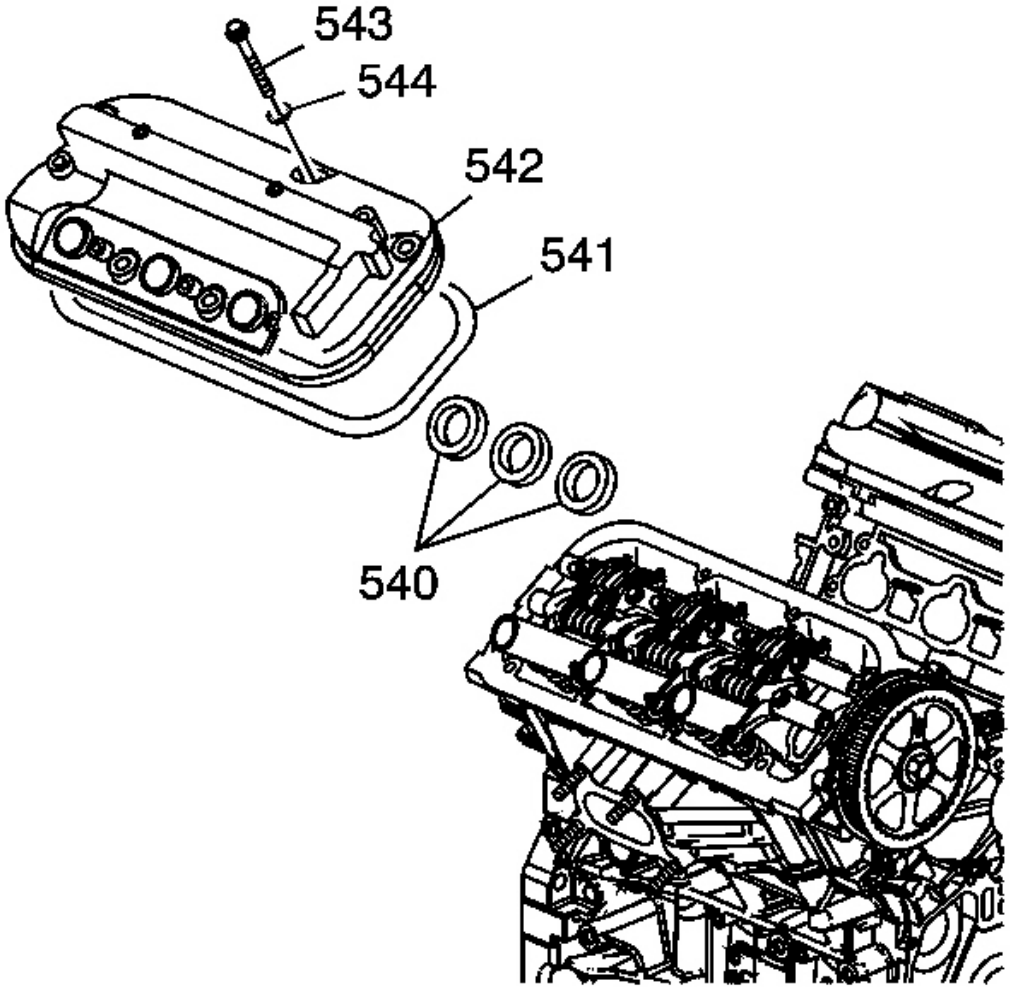


Fig. 189: Identifying Wiring Harness Bracket Bolt
Courtesy of GENERAL MOTORS CORP.

2. Remove the bolts (543), with grommets (544), valve cover (542) and gasket (541).
3. Remove the seals (540), if required.

VALVE ROCKER ARM AND SHAFT REMOVAL

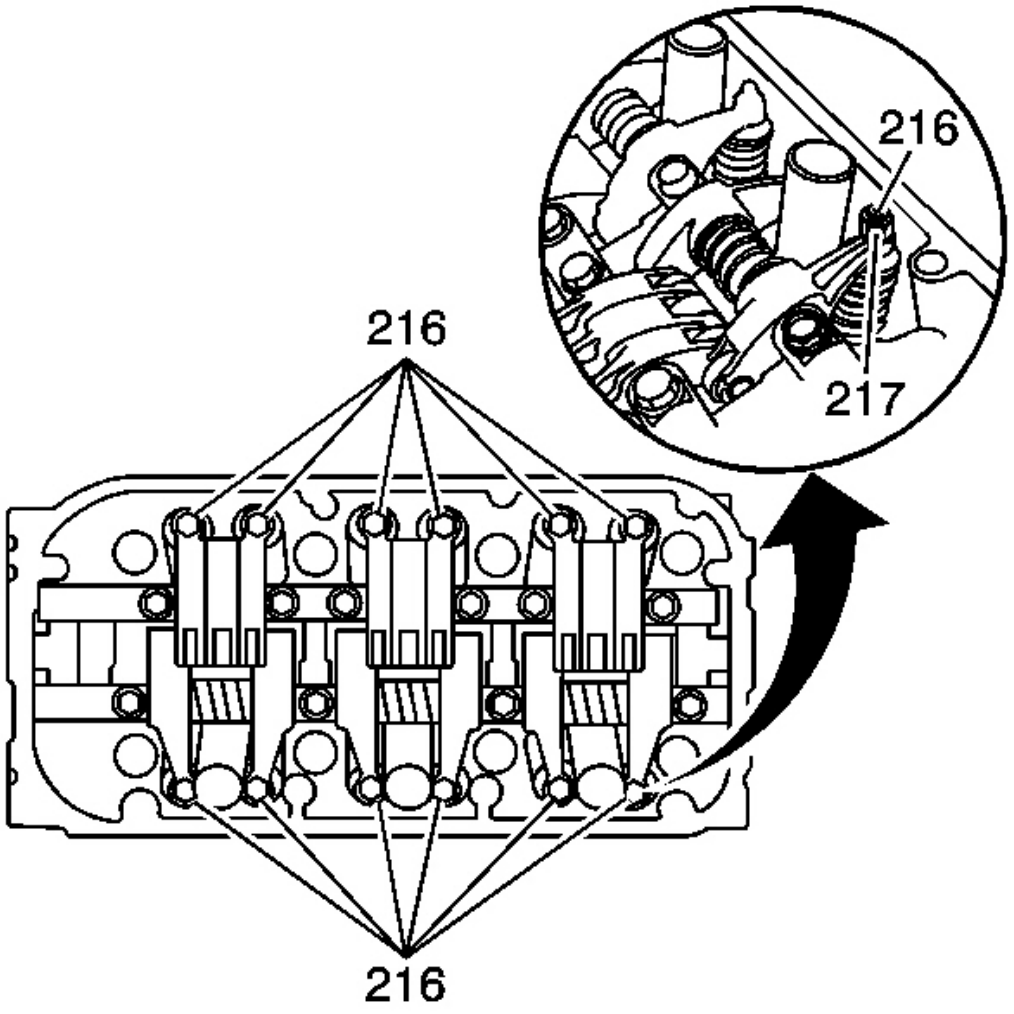


Fig. 190: View Of Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

1. Loosen the adjusting nuts (217) and bolts (216).

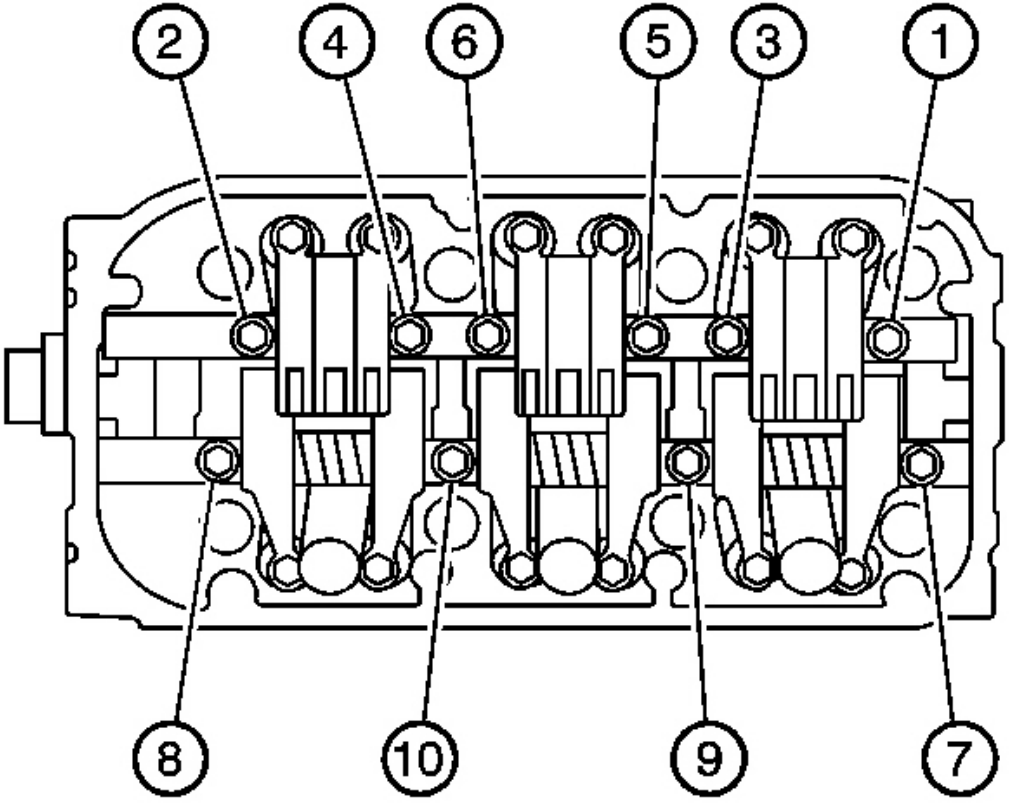


Fig. 191: Identifying Rocker Shaft Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

2. Loosen the left side rocker shaft retaining bolts in sequence. Loosen the shaft mounting bolts 2 turns at a time in sequence, to prevent damaging the valves or rocker arms.

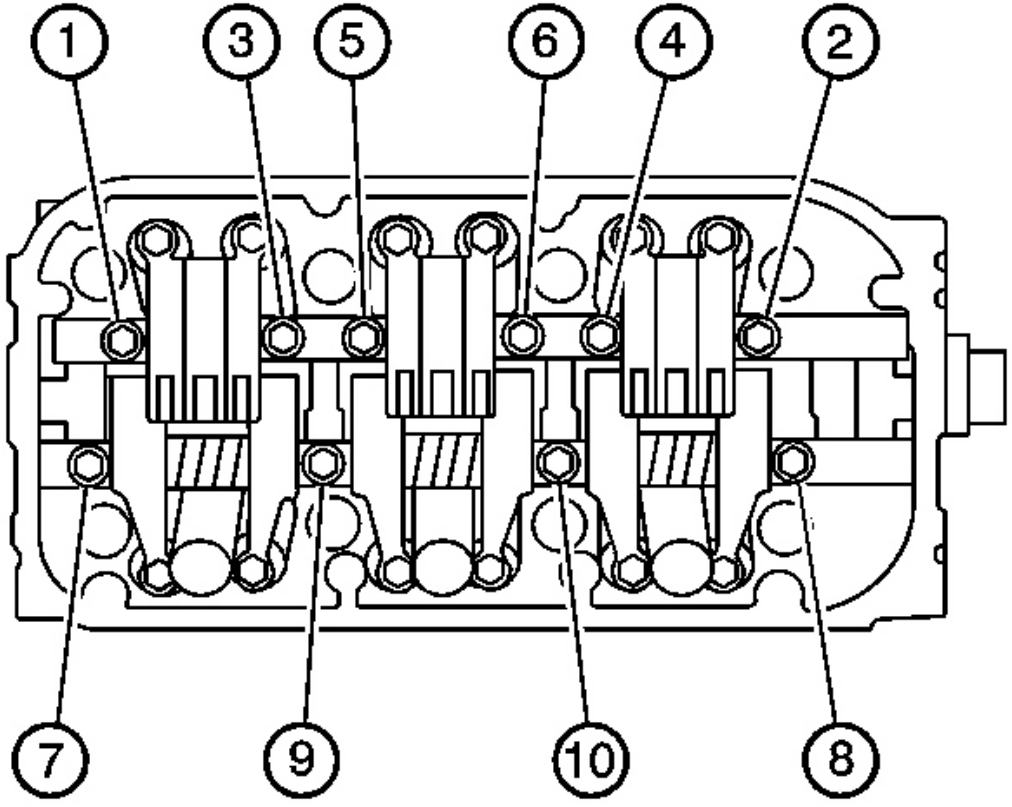


Fig. 192: View Of Right Side Rocker Shaft Retaining Bolts In Sequence
Courtesy of GENERAL MOTORS CORP.

3. Loosen the right side rocker shaft retaining bolts in sequence. Loosen the shaft mounting bolts 2 turns at a time in sequence, to prevent damaging the valves or rocker arms.

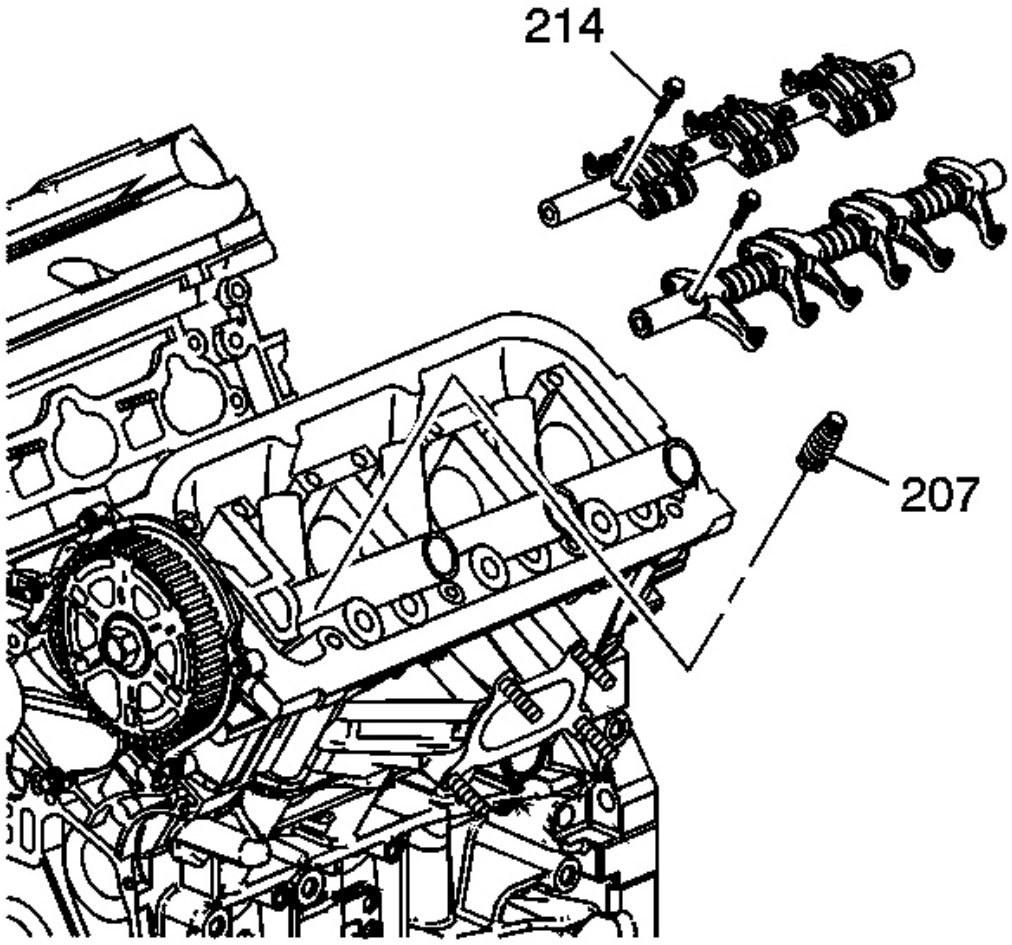


Fig. 193: View Of Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Identify parts as they are removed so they can be installed in their original locations if used again. When removing or installing the rocker arm shaft assembly, do not remove the rocker arm shaft mounting bolts. The bolts will retain the springs and rocker arms on the shaft.

4. Remove the bolts (214) and valve rocker arm and shaft assemblies.
5. Remove the lash adjusters (207).

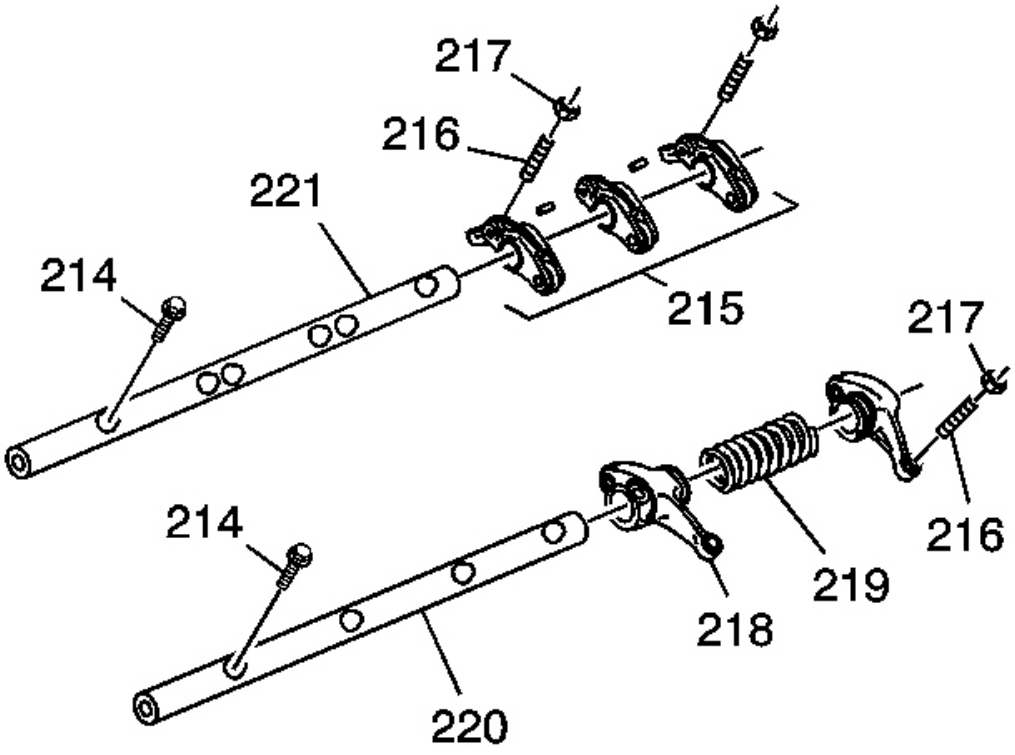


Fig. 194: View Of Intake Valve Rocker Arms
Courtesy of GENERAL MOTORS CORP.

6. Remove the intake valve rocker arms as an assembly (215) from the shaft (221). Refer to **Separating Parts** .
7. Remove the exhaust valve rocker arms (218) and springs (219) from the shaft (220).
8. Remove the nuts (217) and bolts (216), if required.

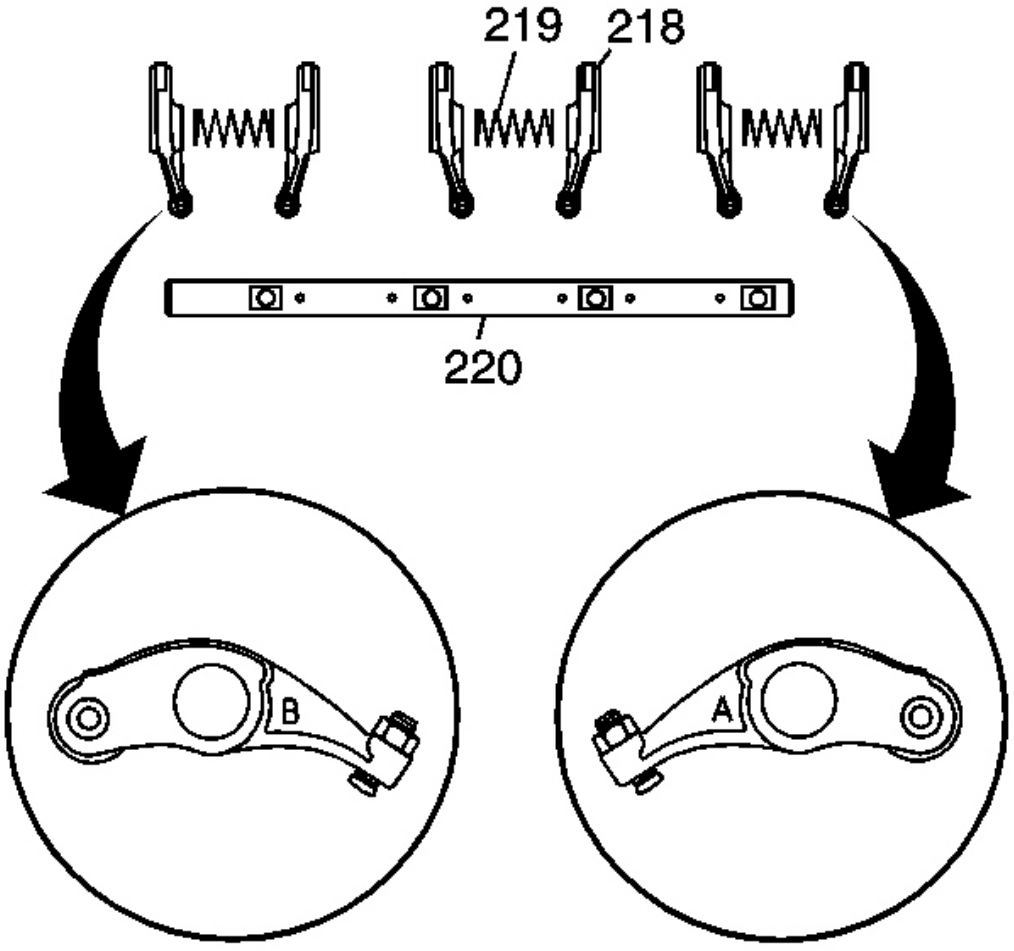


Fig. 195: View Of Exhaust Valve Rocker Arms
Courtesy of GENERAL MOTORS CORP.

9. Note the installed positions of the exhaust valve rocker arms (218).

CAMSHAFT REMOVAL - LEFT

Tools Required

EN 46337 Camshaft Sprocket/Crankshaft Balancer Holder. See **Special Tools and Equipment** .

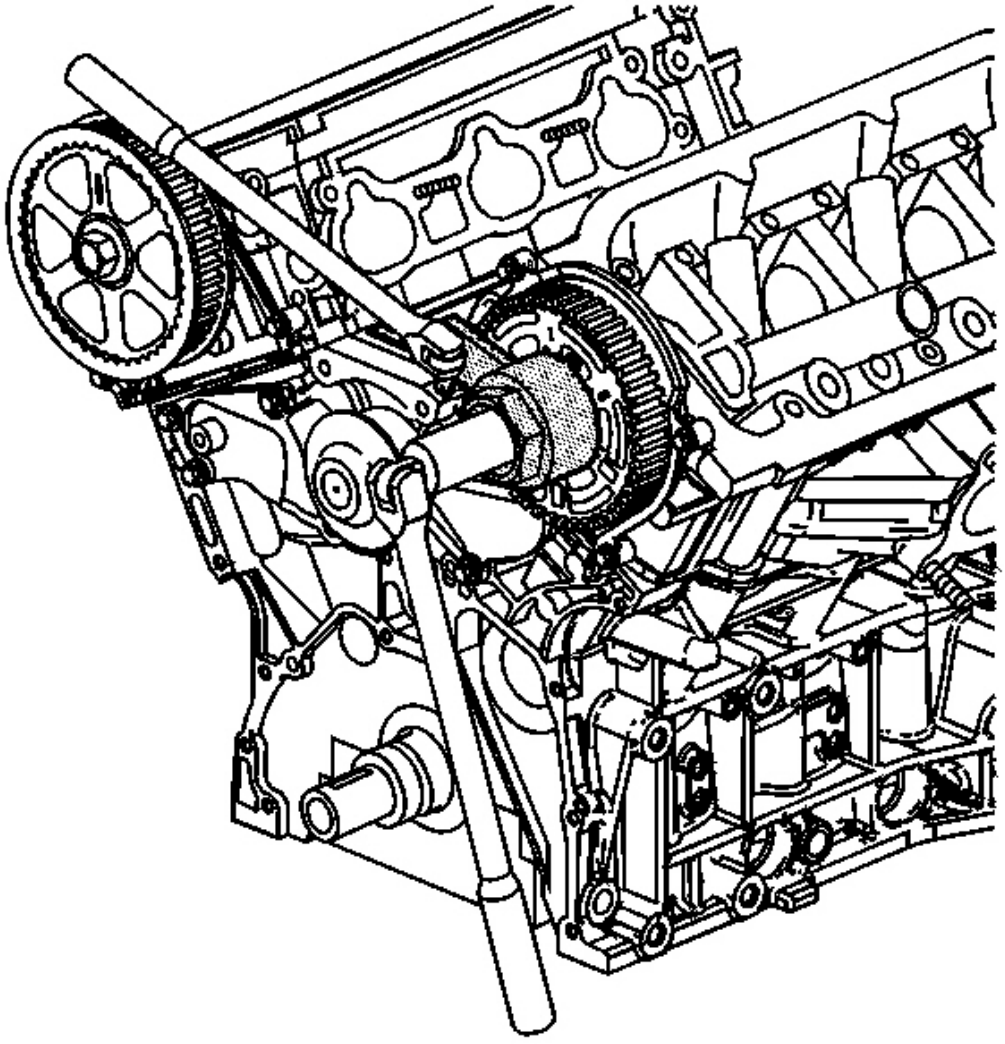


Fig. 196: View Of Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

1. Use the **EN 46337** in order to retain the camshaft sprocket. See **Special Tools and Equipment** .

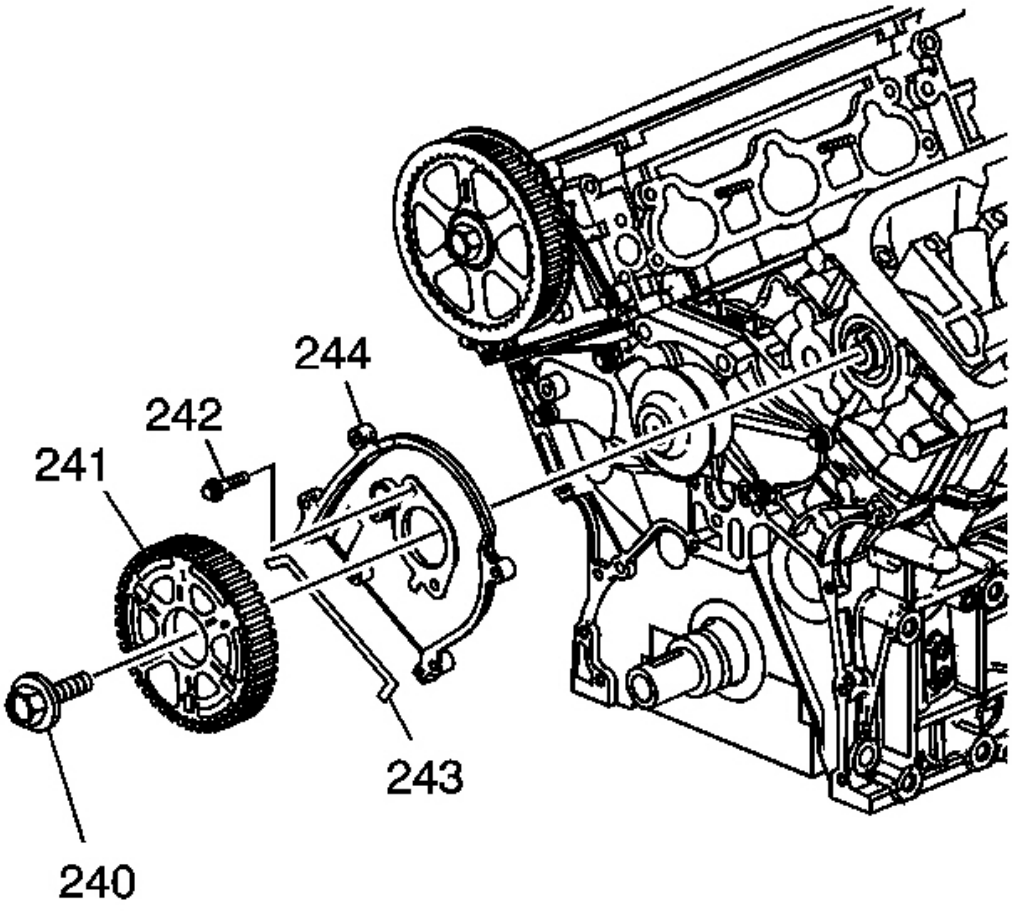


Fig. 197: View Of Camshaft Oil Seal
Courtesy of GENERAL MOTORS CORP.

2. Remove the bolt (240), sprocket (241), bolts (242), cover (244) and seal (243).

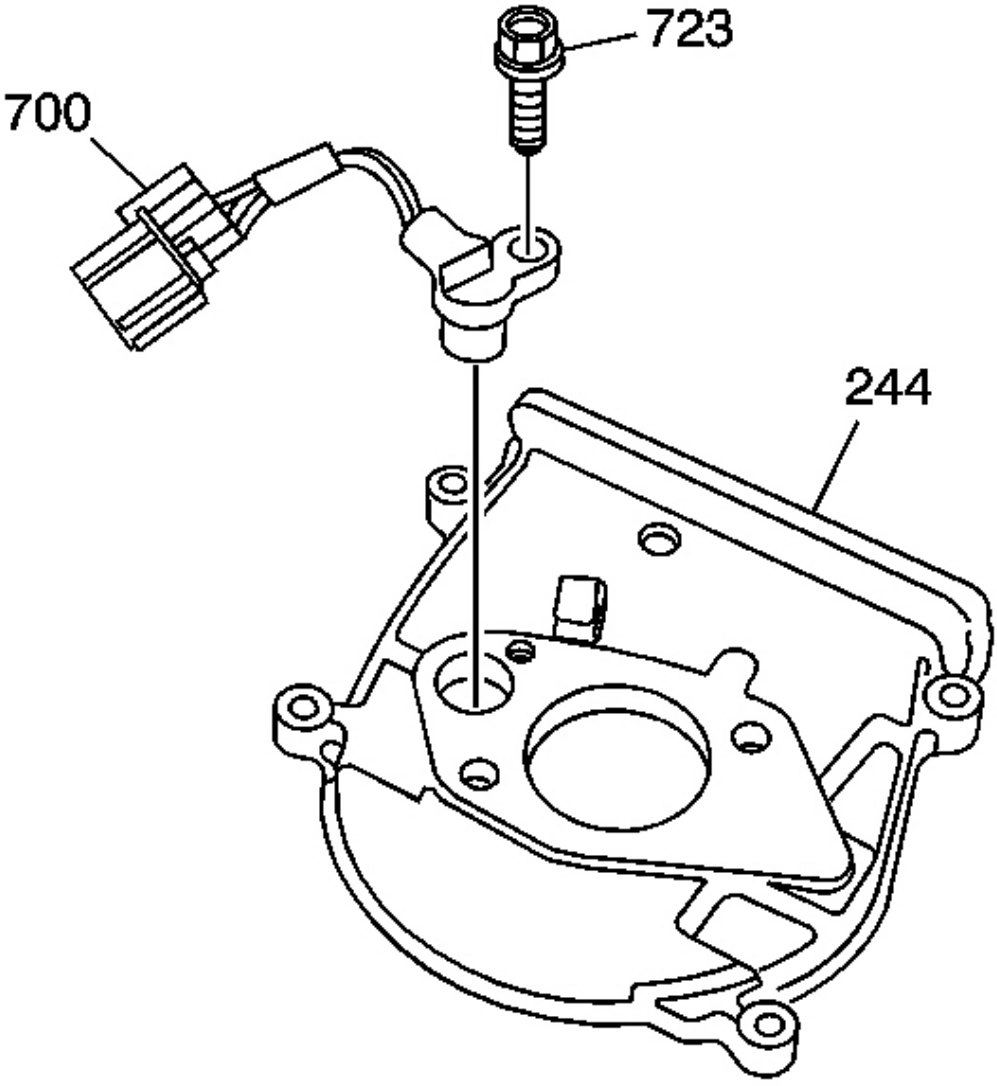


Fig. 198: View Of Bolt & Camshaft Position Sensor
Courtesy of GENERAL MOTORS CORP.

3. Remove the bolt (723) and camshaft position (CMP) sensor (700).

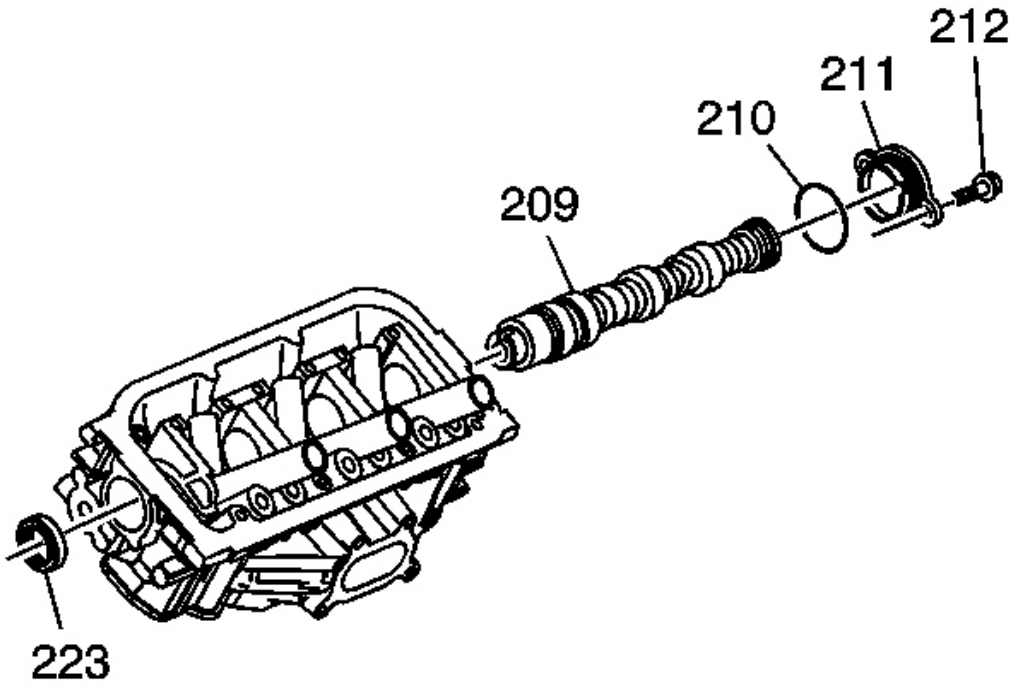


Fig. 199: Identifying Camshaft Journals
Courtesy of GENERAL MOTORS CORP.

4. Remove the bolts (212), cap (211), O-ring (210) and camshaft (209).
5. Remove the seal (223).

CAMSHAFT REMOVAL - RIGHT

Tools Required

EN 46337 Camshaft Sprocket/Crankshaft Balancer Holder. See **Special Tools and Equipment** .

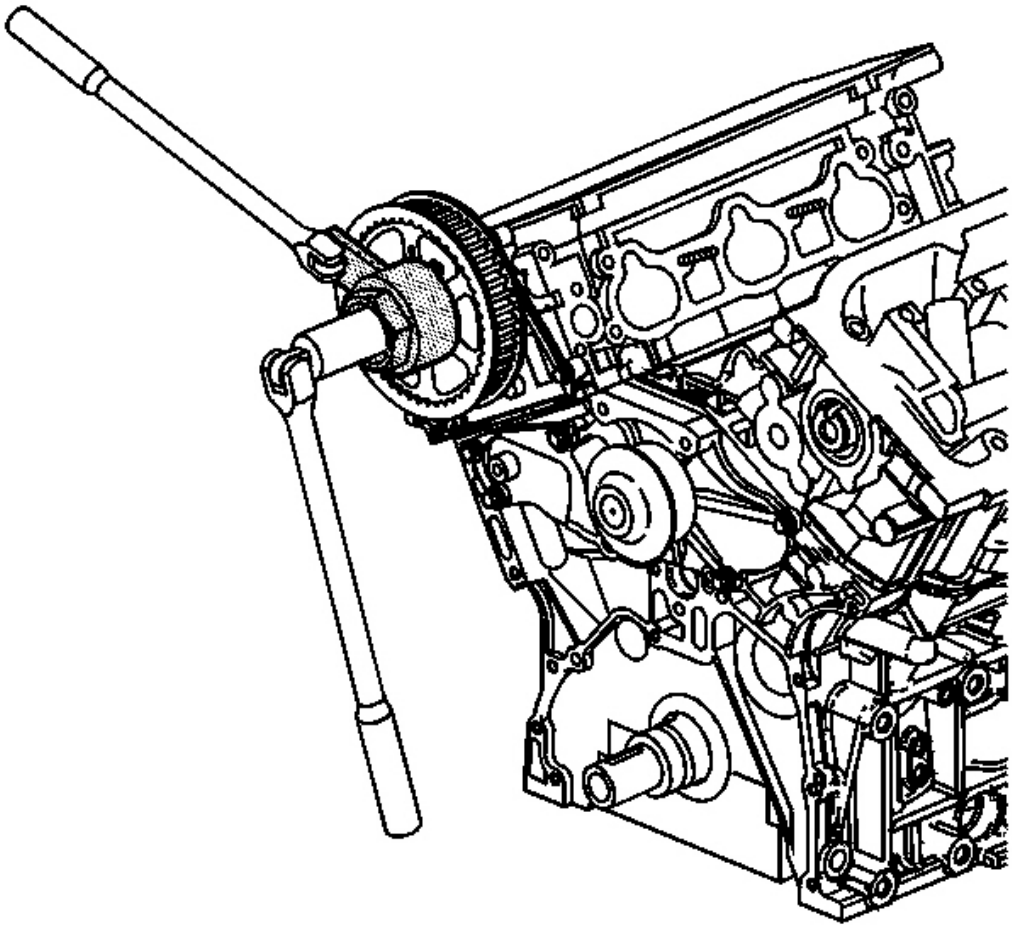


Fig. 200: View Of Camshaft
Courtesy of GENERAL MOTORS CORP.

1. Use the **EN 46337** in order to retain the camshaft sprocket. See **Special Tools and Equipment** .

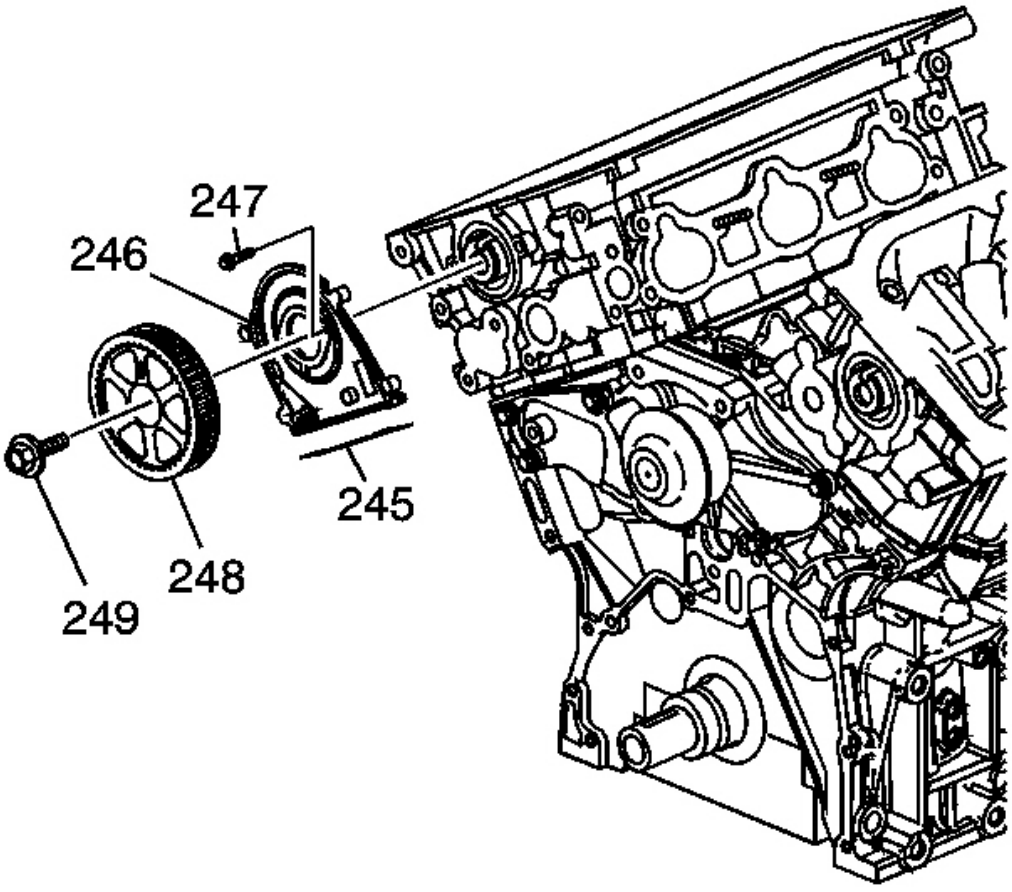


Fig. 201: View Of Bolt, Sprocket, Bolts, Cover & Seal
Courtesy of GENERAL MOTORS CORP.

2. Remove the bolt (249), sprocket (248), bolts (247), cover (246) and seal (245).

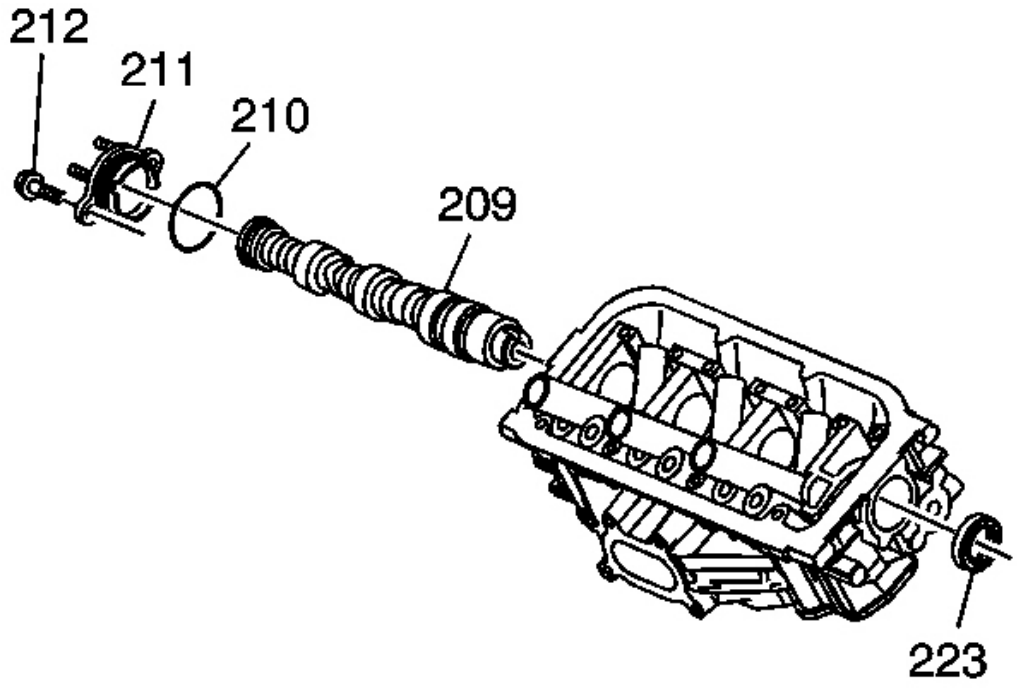


Fig. 202: View Of Camshaft Journals
Courtesy of GENERAL MOTORS CORP.

3. Remove the bolts (212), cap (211), O-ring (210) and camshaft (209).
4. Remove the seal (223).

CYLINDER HEAD REMOVAL - LEFT

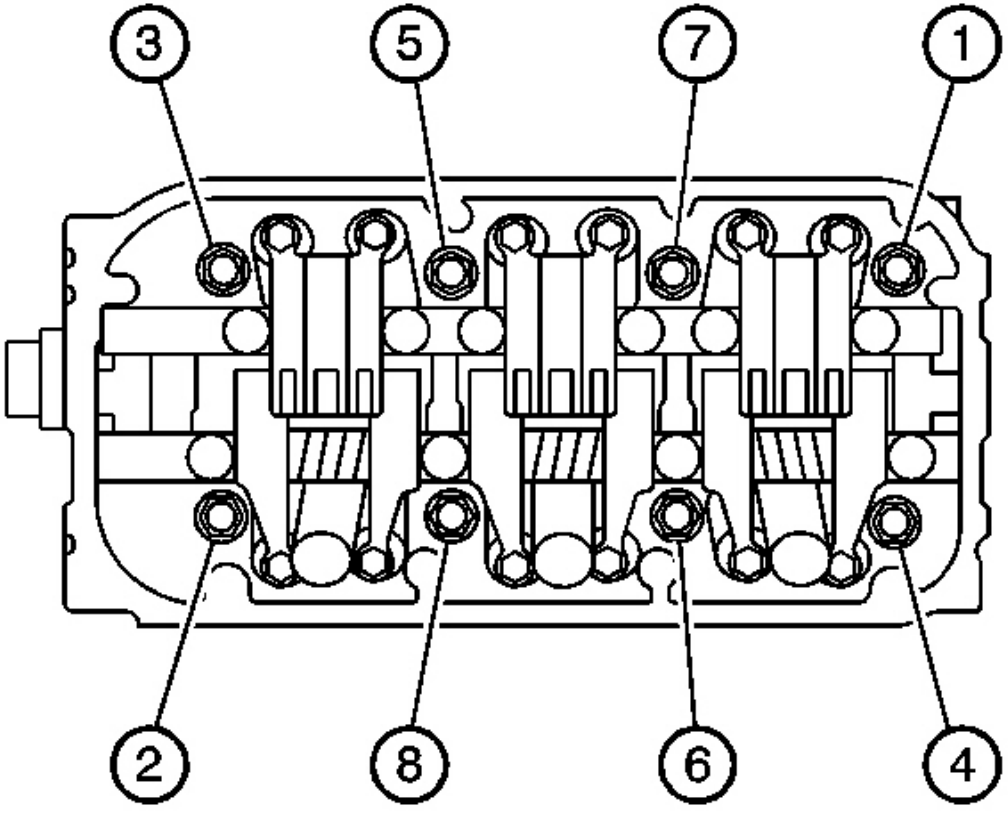


Fig. 203: Identifying Cylinder Head
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Loosen the cylinder head bolts one-third of a turn at a time, in sequence, until all the bolts are loosened.

1. Loosen the cylinder head bolts in sequence.

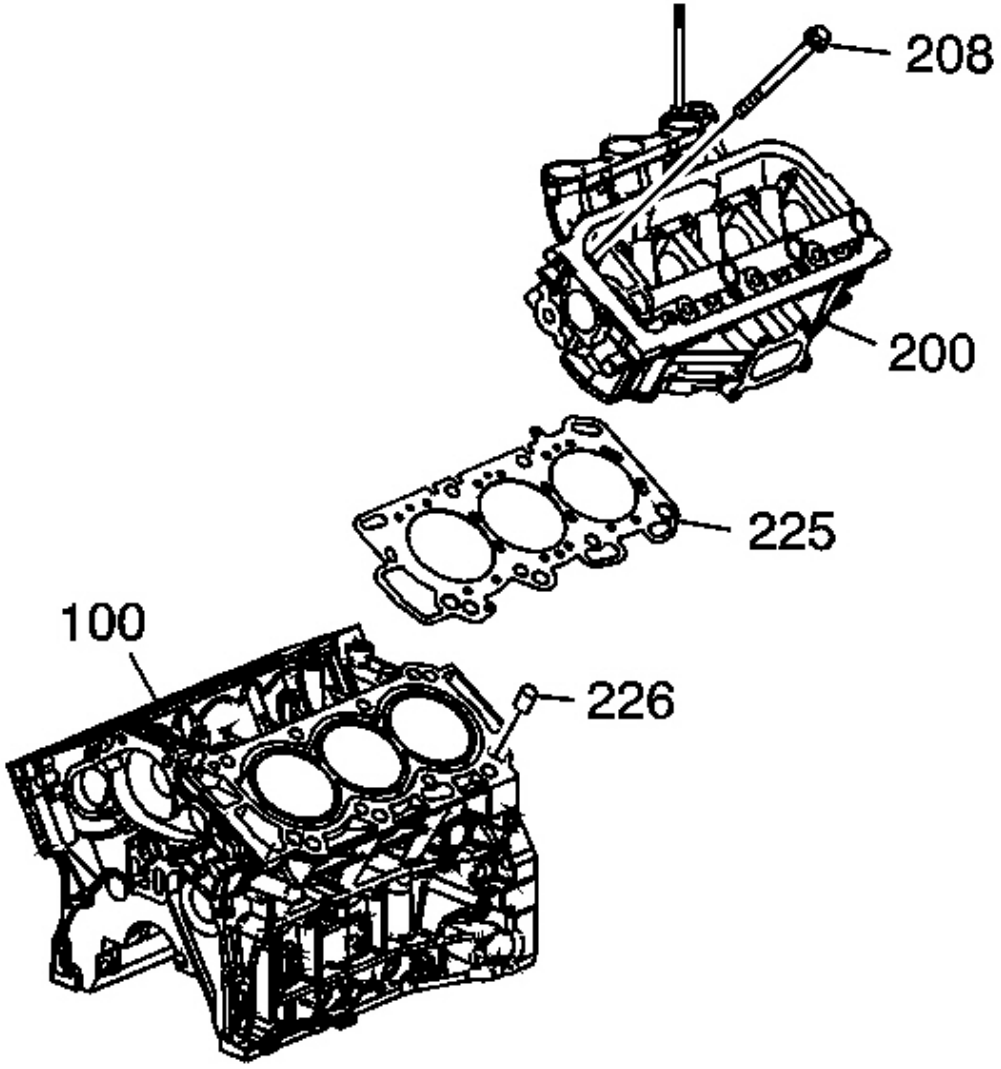


Fig. 204: View Of Bolts, Cylinder Head, Gasket & Pins
Courtesy of GENERAL MOTORS CORP.

2. Remove the bolts (208).
3. Remove the cylinder head (200), gasket (225) and pins (226).

CYLINDER HEAD REMOVAL - RIGHT

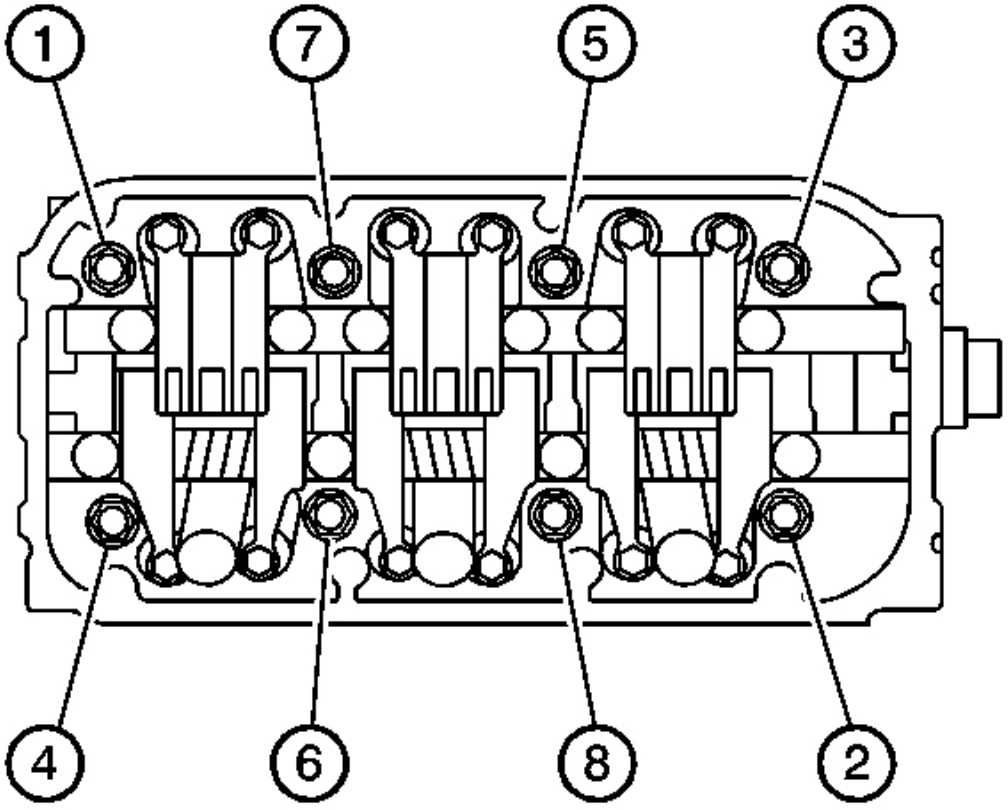


Fig. 205: Identifying Cylinder Head
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Loosen the cylinder head bolts one-third of a turn at a time in sequence, until all the bolts are loosened.

1. Loosen the cylinder head bolts in sequence.

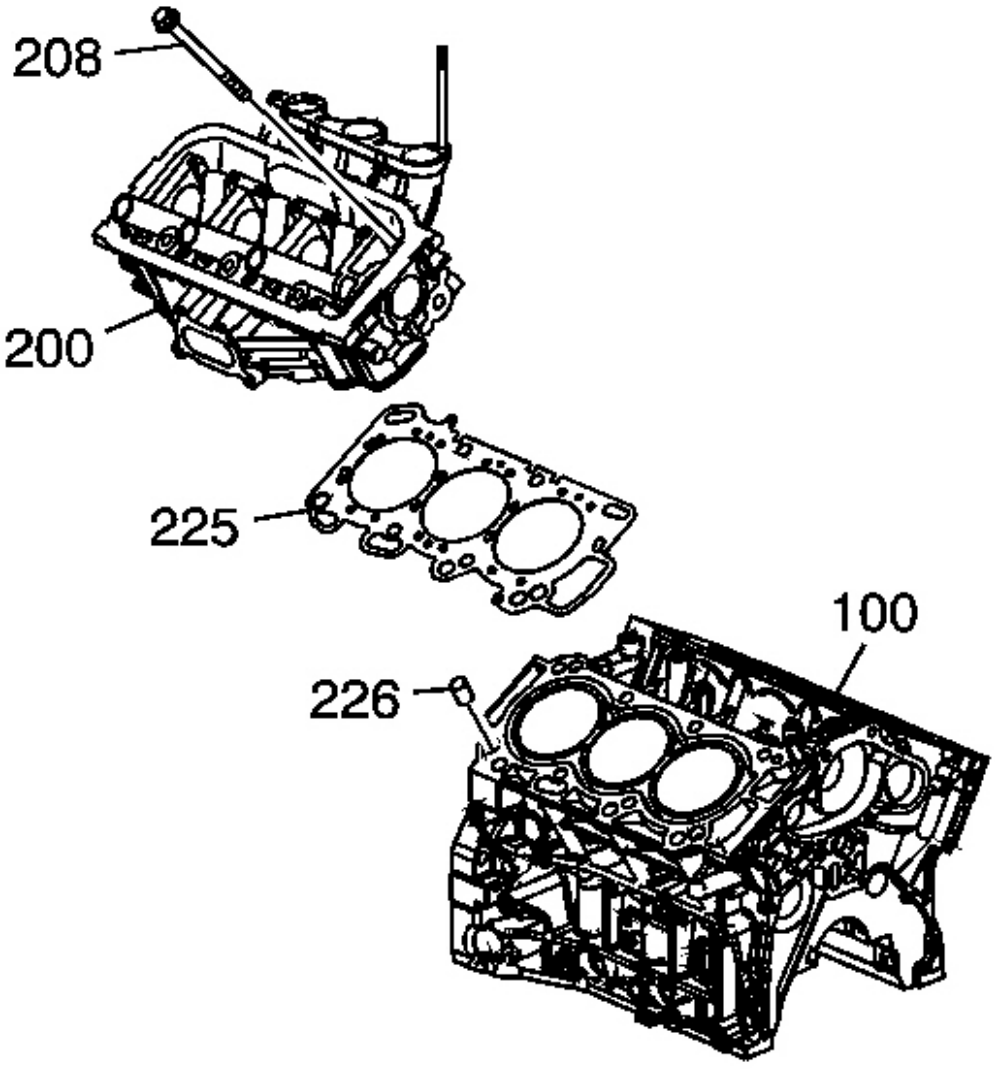


Fig. 206: View Of Bolts & Pins
Courtesy of GENERAL MOTORS CORP.

2. Remove the bolts (208).
3. Remove the cylinder head (200), gasket (225) and pins (226).

FUEL INJECTION MANIFOLD REMOVAL - LEFT

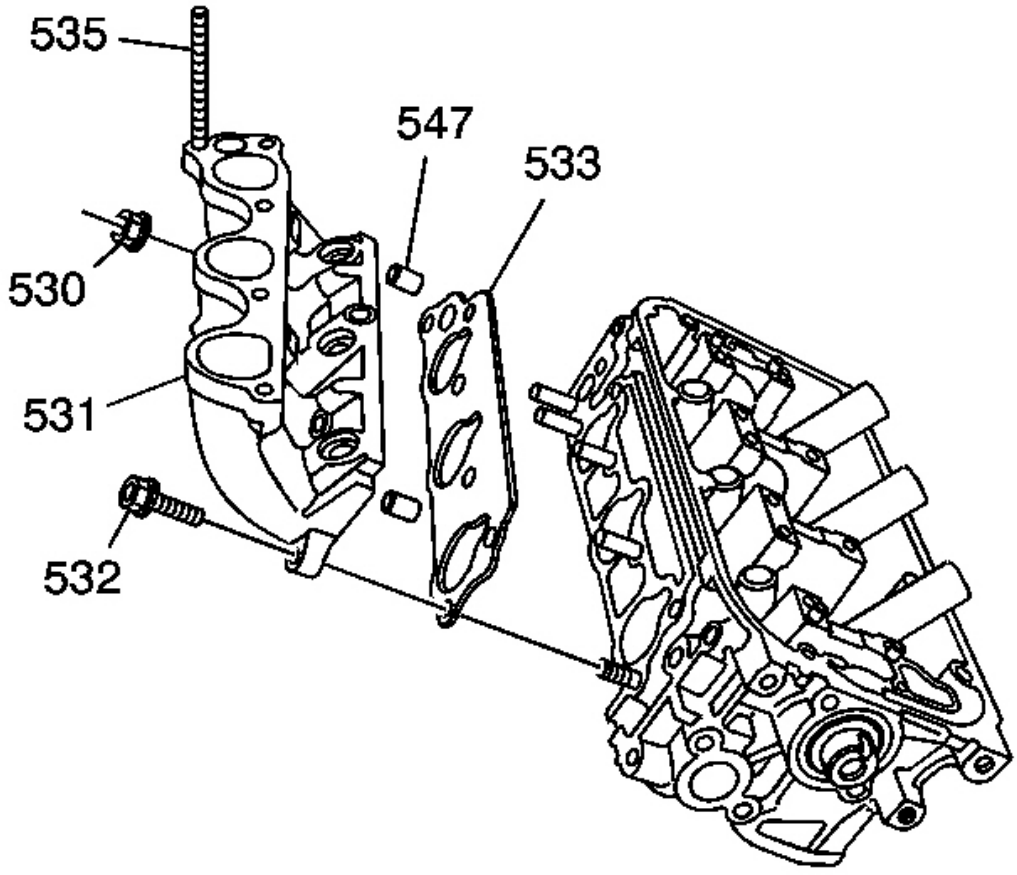


Fig. 207: View Of Fuel Injection Manifold
Courtesy of GENERAL MOTORS CORP.

1. Remove the nuts (530) and bolts (532).
2. Remove the manifold (531), gasket (533) and pins (547).
3. Remove the studs (535), if required.

FUEL INJECTION MANIFOLD REMOVAL - RIGHT

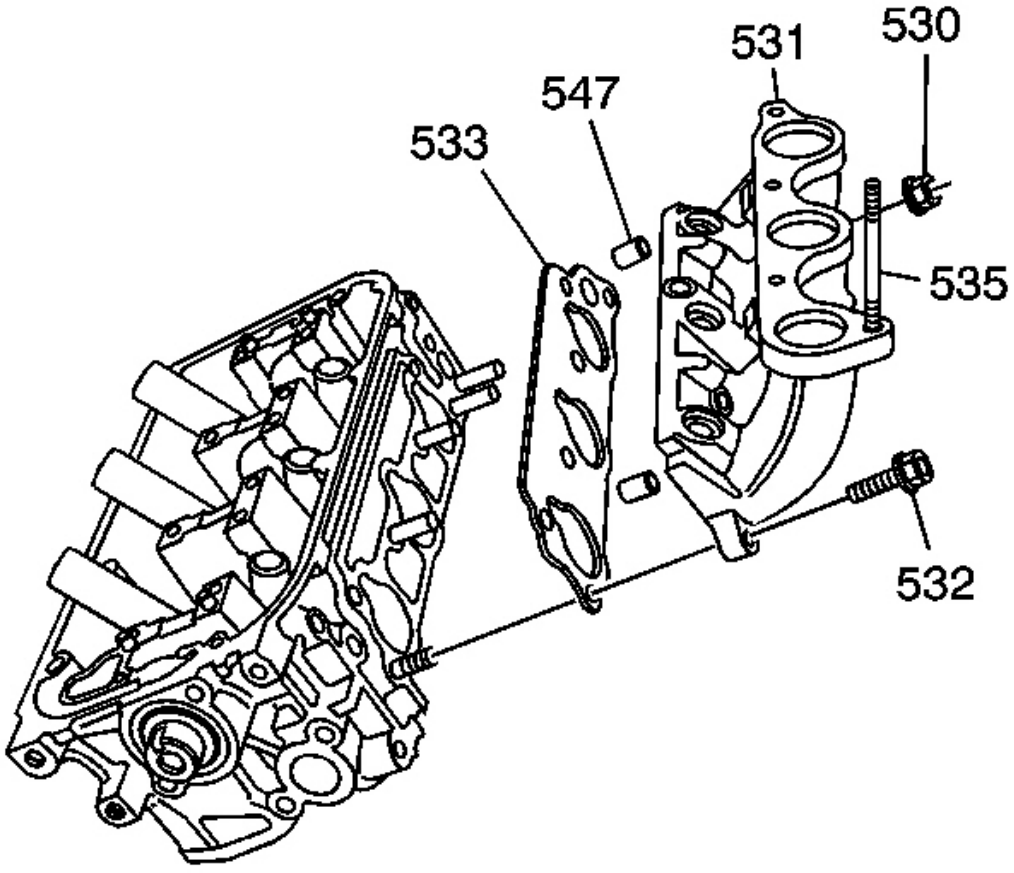


Fig. 208: View Of Fuel Injection Manifold
Courtesy of GENERAL MOTORS CORP.

1. Remove the nuts (530) and bolts (532).
2. Remove the manifold (531), gasket (533) and pins (547).
3. Remove the studs (535), if required.

OIL PAN REMOVAL

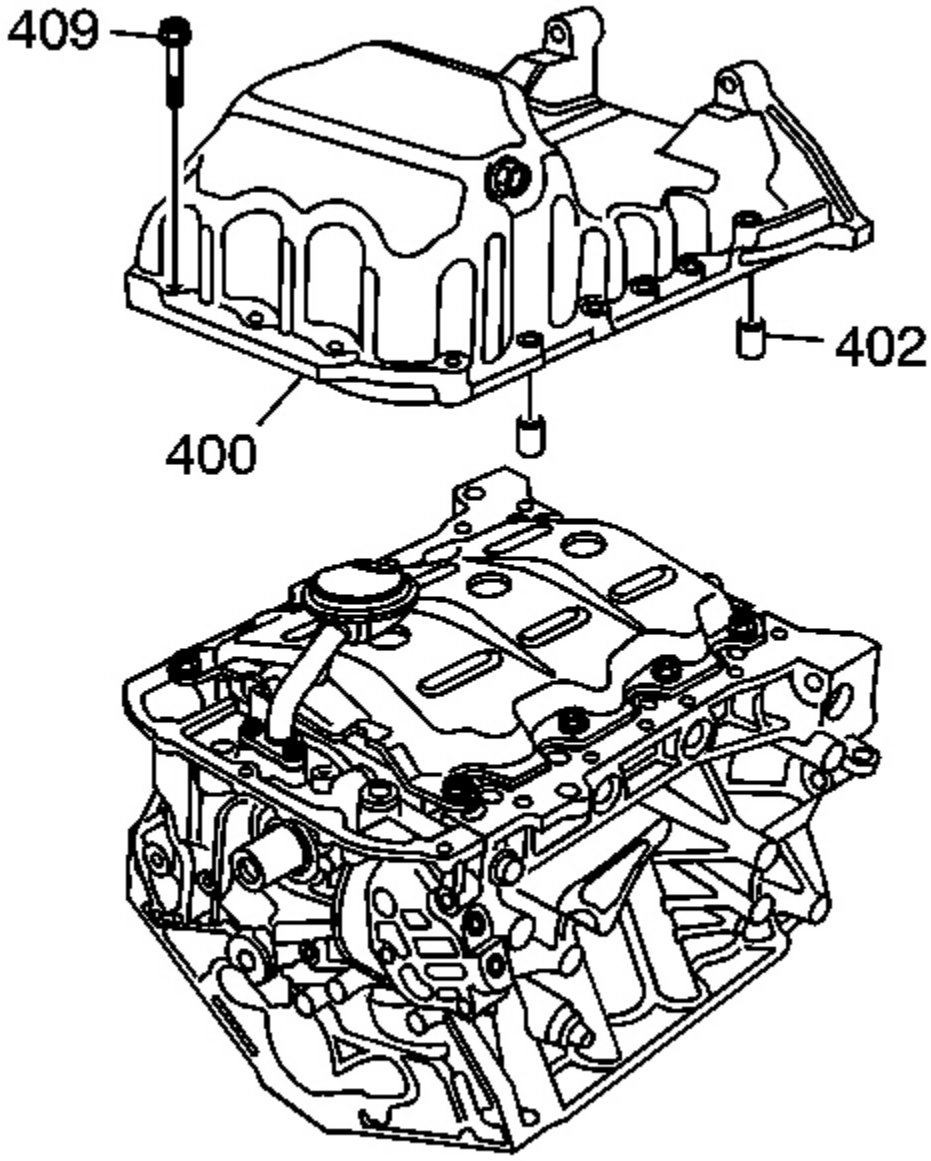


Fig. 209: View Of Oil Pan
Courtesy of GENERAL MOTORS CORP.

1. Remove the bolts (409).
2. Remove the oil pan (400).
3. Remove the pins (402).

4. Clean the sealant from the oil pan and engine block sealing surfaces.

OIL PUMP PIPE AND SCREEN ASSEMBLY REMOVAL

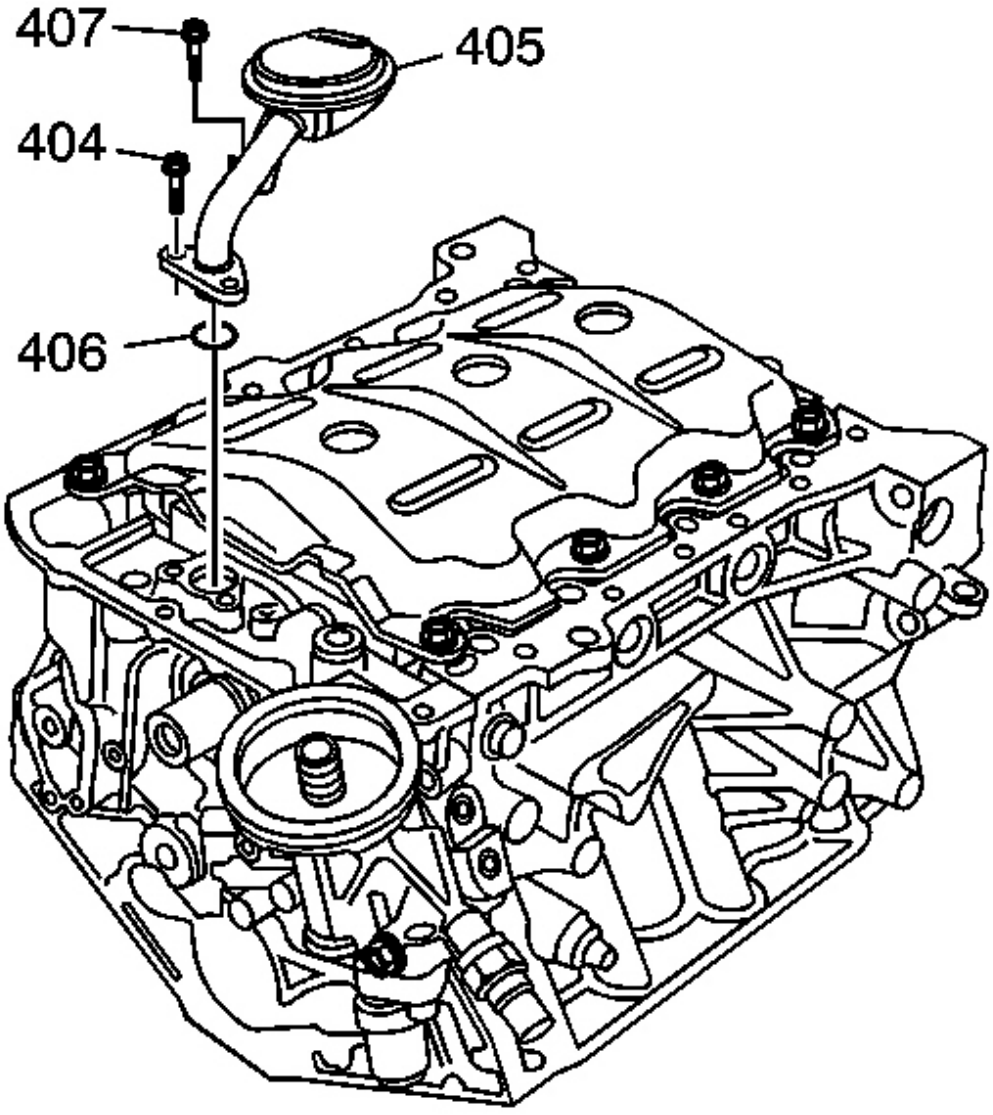


Fig. 210: View Of Screen Assembly
Courtesy of GENERAL MOTORS CORP.

1. Remove the bolts (404, 407).

2. Remove the screen (405) and O-ring (406).

CRANKSHAFT OIL DEFLECTOR REMOVAL

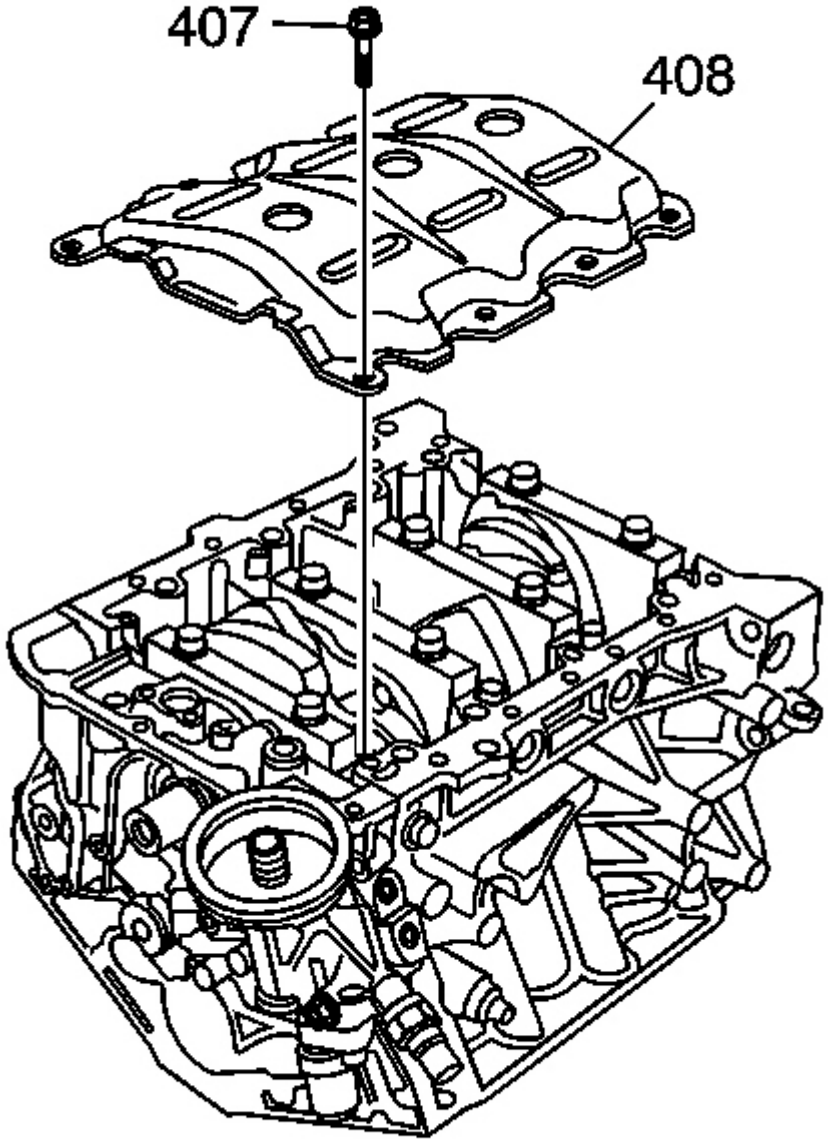


Fig. 211: View Of Crankshaft Oil Deflector
Courtesy of GENERAL MOTORS CORP.

1. Remove the bolts (407).
2. Remove the deflector (408).

OIL FLOW CONTROL MODULE REMOVAL

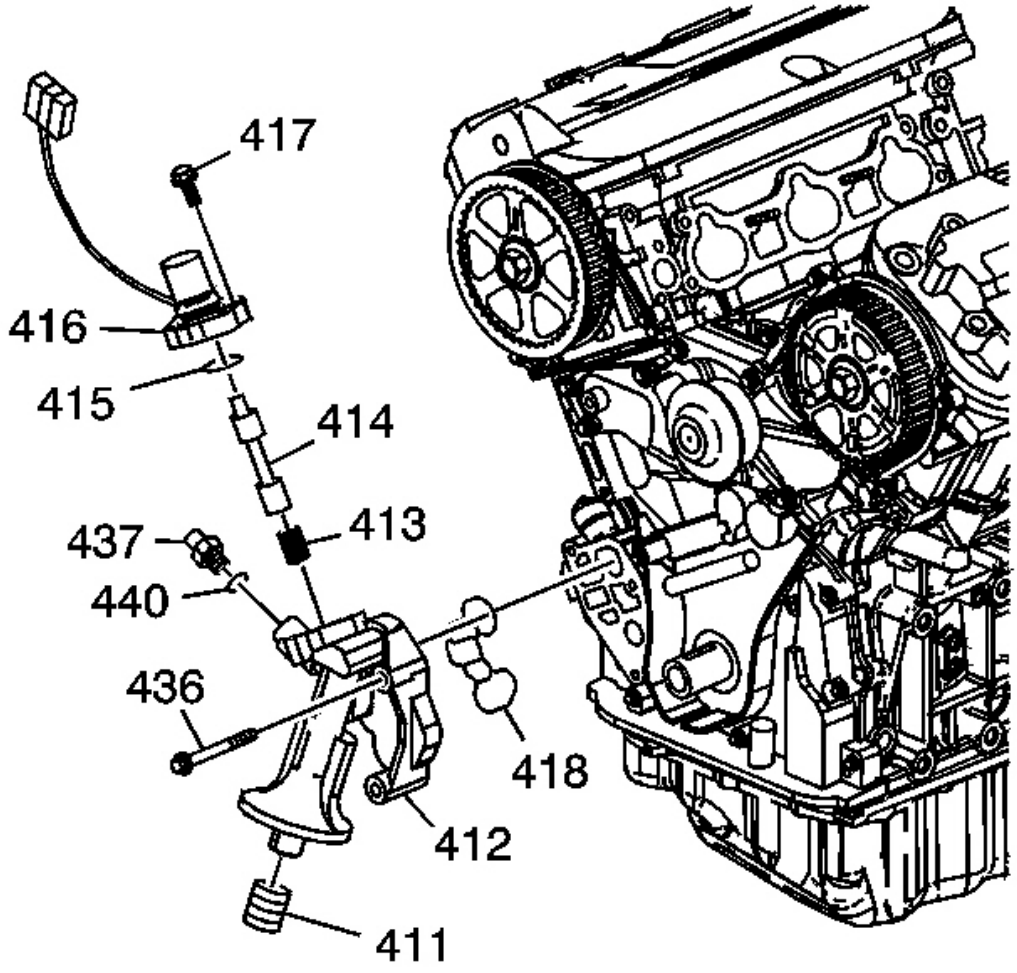


Fig. 212: View Of Oil Control Module
Courtesy of GENERAL MOTORS CORP.

1. Remove the bolts (436).
2. Remove the module (412) and O-ring (418).
3. Remove the bolts (417), solenoid (416) and O-ring (415), if required.
4. Remove the valve (414) and spring (413).

5. Remove the switch (437) and O-ring (440), if required.
6. Remove the fitting (411), if required.

OIL PUMP REMOVAL

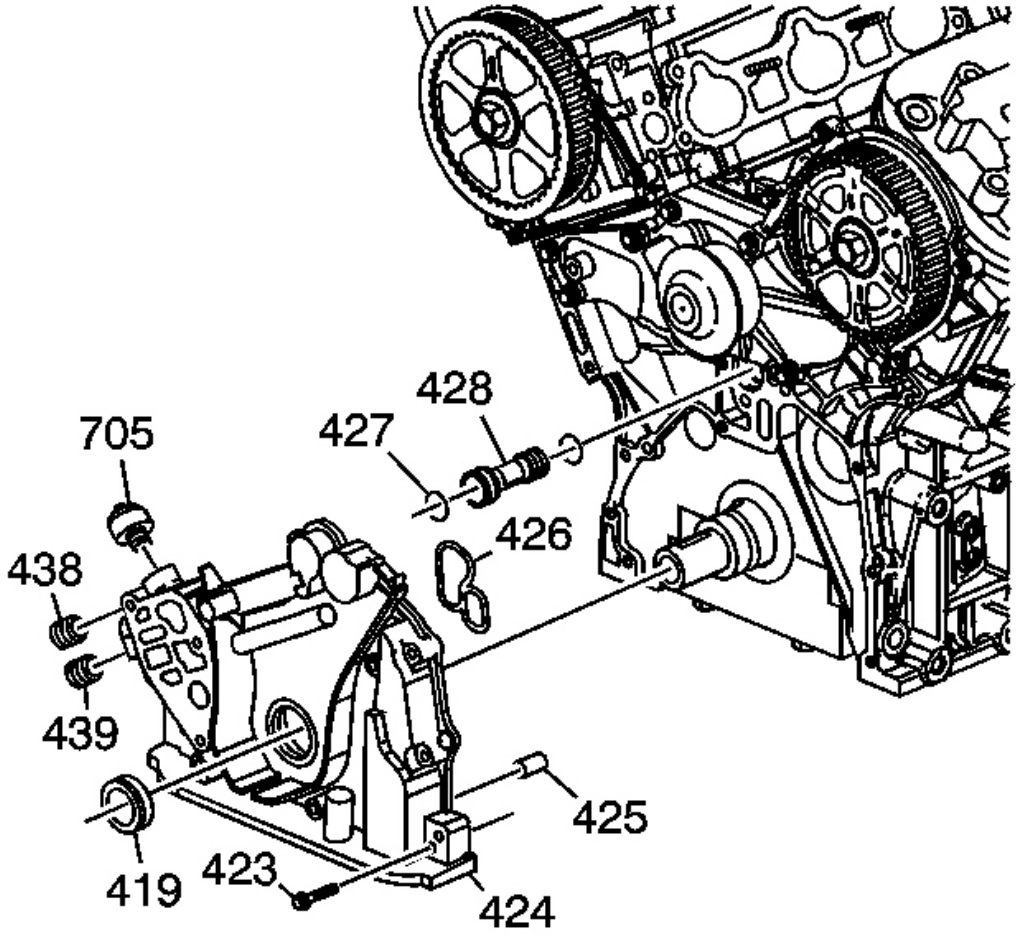


Fig. 213: Exploded View Of Oil Pump Assembly
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pressure sensor (705).
2. Remove the bolts (423).
3. Remove the oil pump assembly (424) and O-ring (406).
4. Remove the pins (425).
5. Remove the oil transfer pipe (428) and O-rings (427).

6. Clean the sealant from the oil pump housing and engine block sealing surfaces.

CRANKSHAFT REAR OIL SEAL AND HOUSING REMOVAL

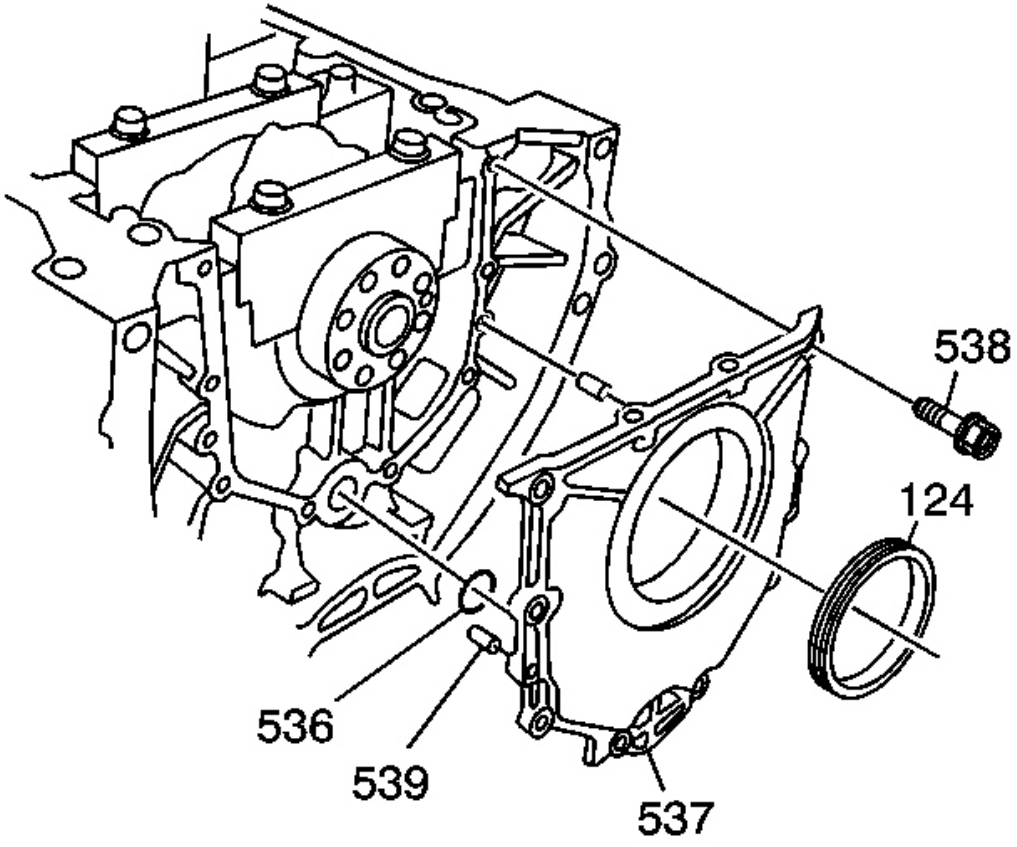


Fig. 214: View Of Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Remove the bolts (538).
2. Remove the housing (537).
3. Remove the O-ring (536).
4. Remove the pins (539).
5. Remove the seal (124) from the housing.
6. Clean the sealant from the housing and engine block sealing surfaces.

PISTON, CONNECTING ROD, AND BEARING REMOVAL

Tools Required

- **J 24270** Cylinder Bore Ridge Reamer. See **Special Tools and Equipment** .**SA9187NE** Cylinder Ridge Reamer. See **Special Tools and Equipment** .
- **J 41742** Connecting Rod Guide Pin

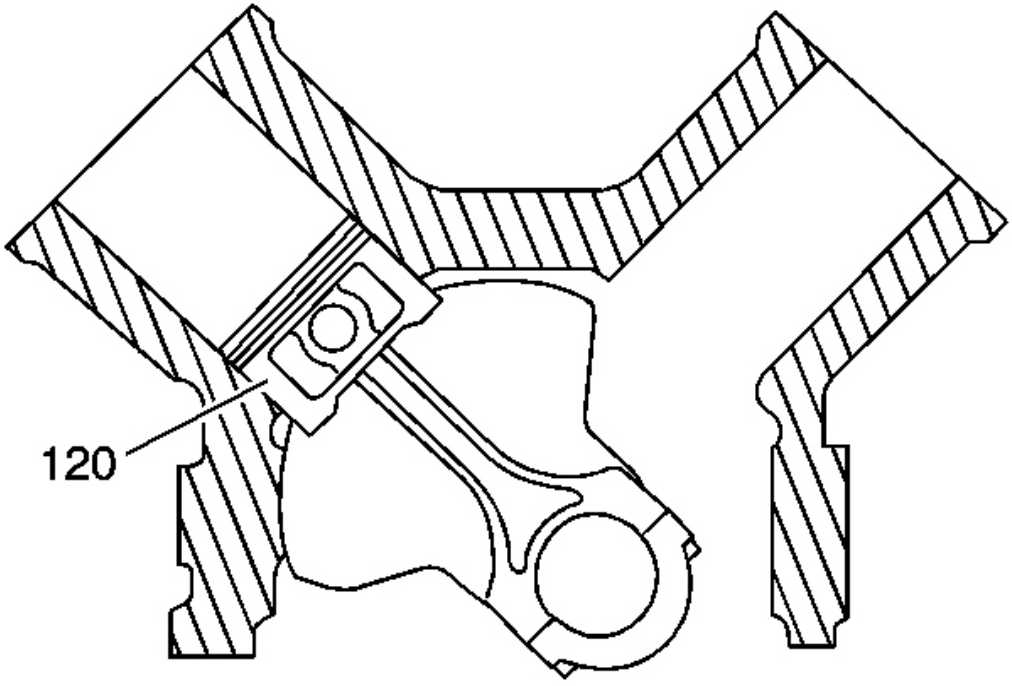


Fig. 215: View Of Piston
Courtesy of GENERAL MOTORS CORP.

1. Rotate the engine to position the piston (120) at bottom dead center (BDC) in the cylinder.

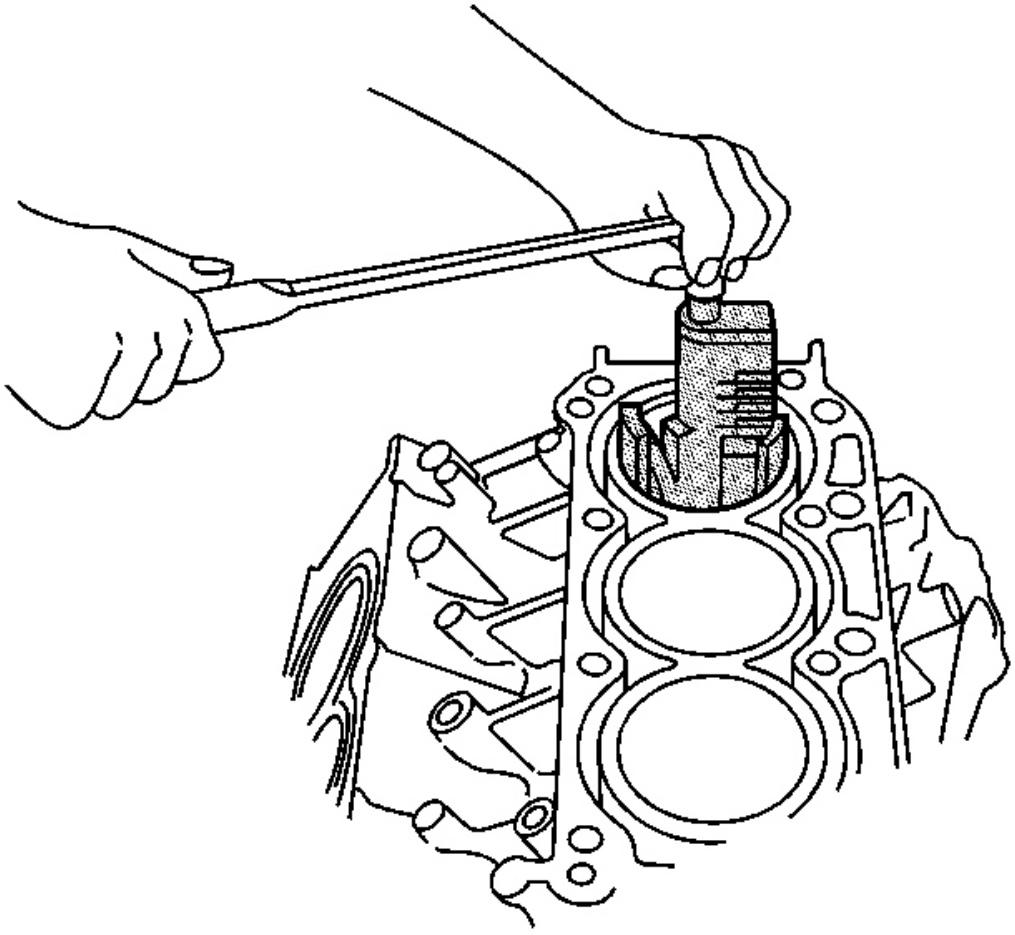


Fig. 216: View Of SA9187NE To Remove The Cylinder Ridge
Courtesy of GENERAL MOTORS CORP.

2. If a ridge of metal or hard carbon can be felt around the top of any cylinder, use the **J 24270** ,. See **Special Tools and Equipment** .**SA9187NE** , or equivalent in order to remove the cylinder ridge. See **Special Tools and Equipment** .

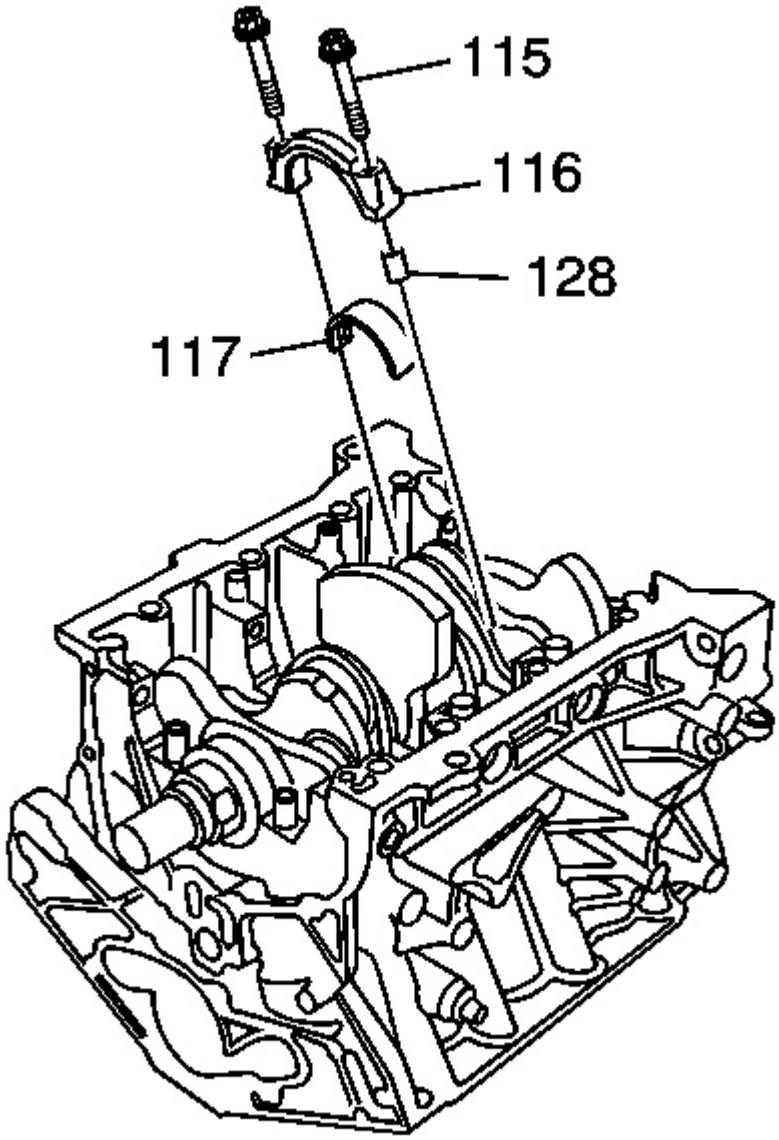


Fig. 217: View Of Bolts, Cap, Pins & Lower Bearing Half
Courtesy of GENERAL MOTORS CORP.

3. Remove the bolts (115), cap (116), pins (128) and lower bearing half (117).

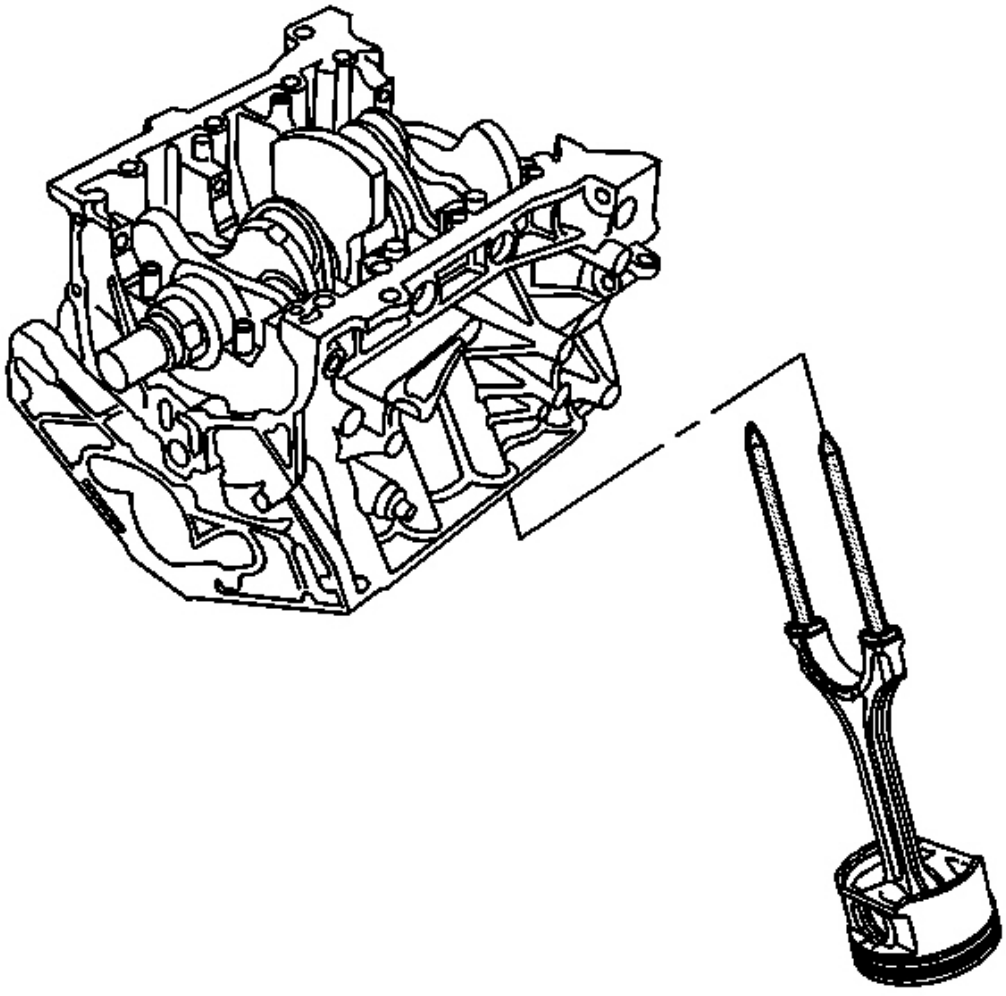


Fig. 218: View Of Connecting Rod & Bearing
Courtesy of GENERAL MOTORS CORP.

4. Use the **J 41742** in order to remove the piston and connecting rod assembly from the block.
5. Remove the upper bearing half from the connecting rod.
6. Install the cap onto the connecting rod and mark or sort the bearings for assembly. Refer to **Separating Parts** .

CRANKSHAFT AND BEARINGS REMOVAL

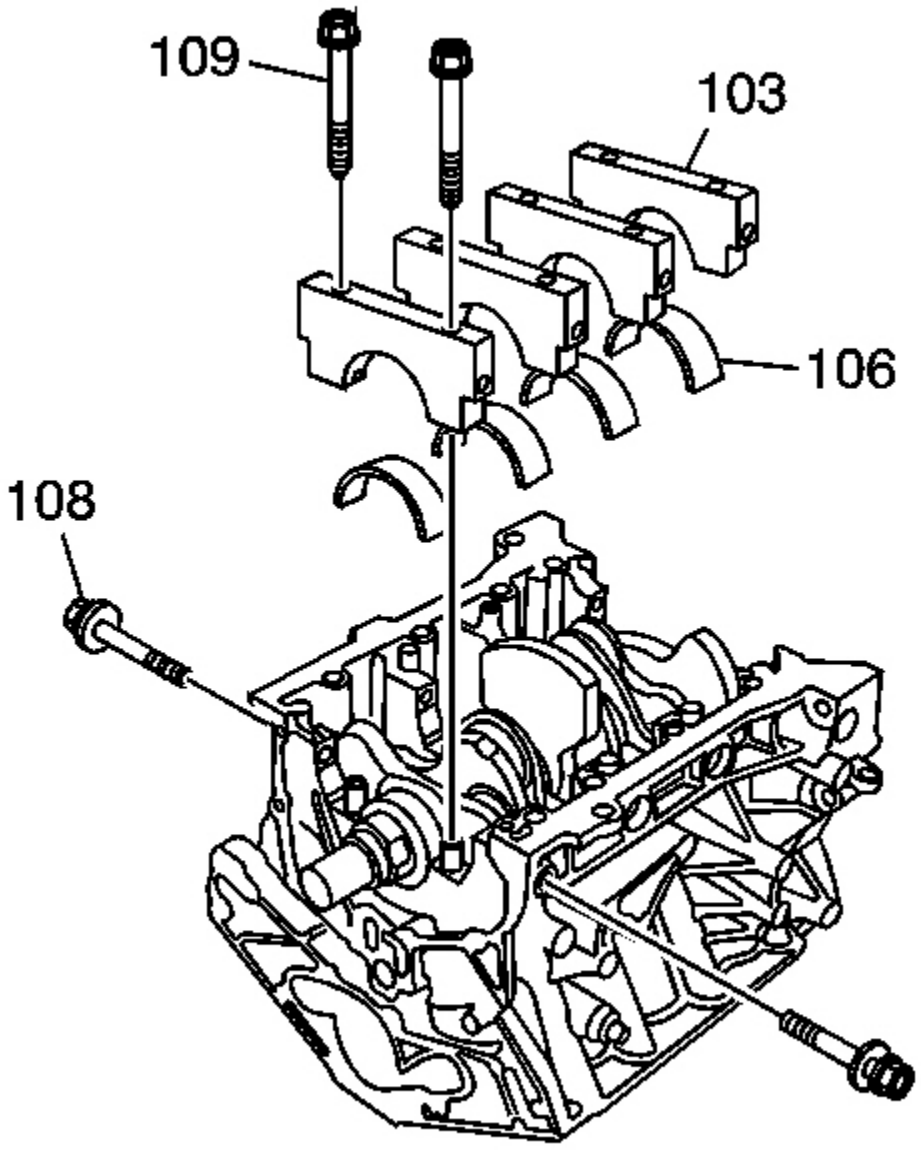


Fig. 219: View Of Bearings
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The powertrain control module (PCM) must perform the idle learn procedure to determine the minimum throttle position and to establish idle speed when any of the following components are replaced:

- **Throttle body**
- **Timing belt**
- **Timing belt drive sprocket**
- **Crankshaft and bearings**

Refer to Idle Learn Procedure .

1. Remove the bearing cap bolts (108, 109).
2. Remove the bearing caps (103) and lower bearings (106). Refer to **Separating Parts** .

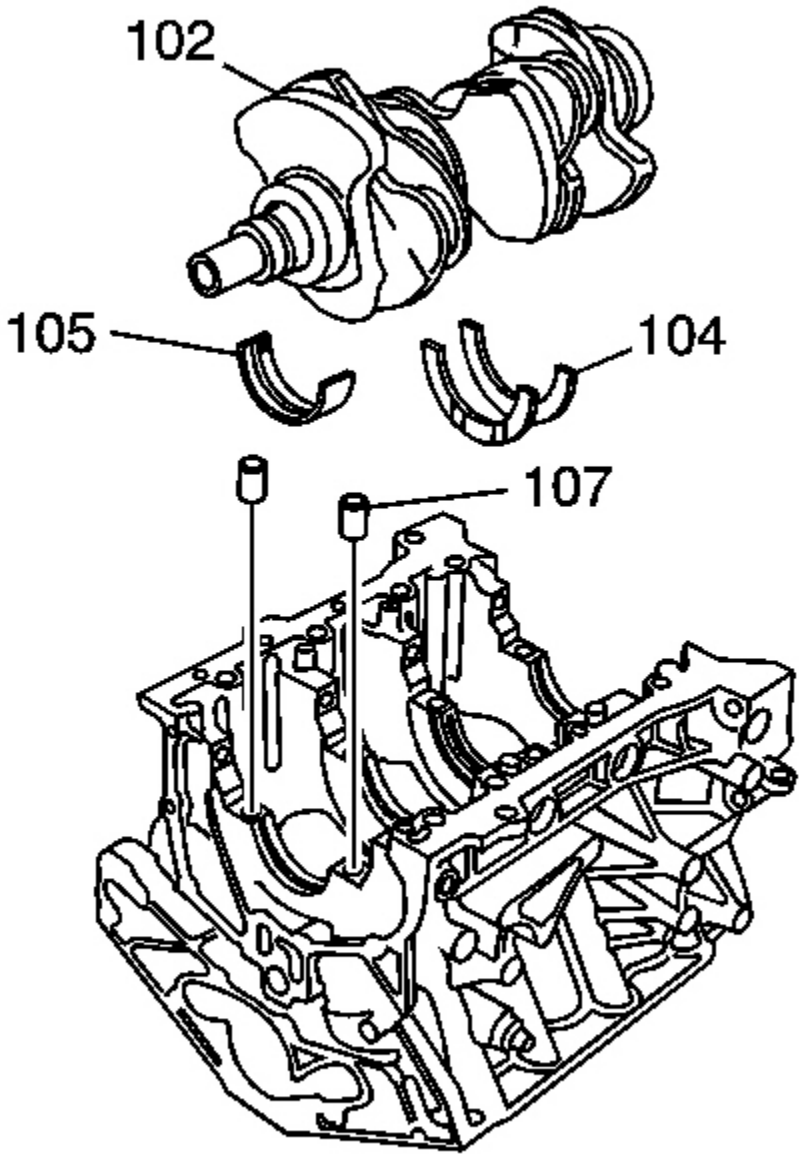


Fig. 220: View Of Crankshaft, Upper Bearings, Thrust Bearings & Pins
Courtesy of GENERAL MOTORS CORP.

3. Remove the crankshaft (102), upper bearings (105) and thrust bearings (104).
4. Remove the pins (107).

ENGINE BLOCK PLUG REMOVAL

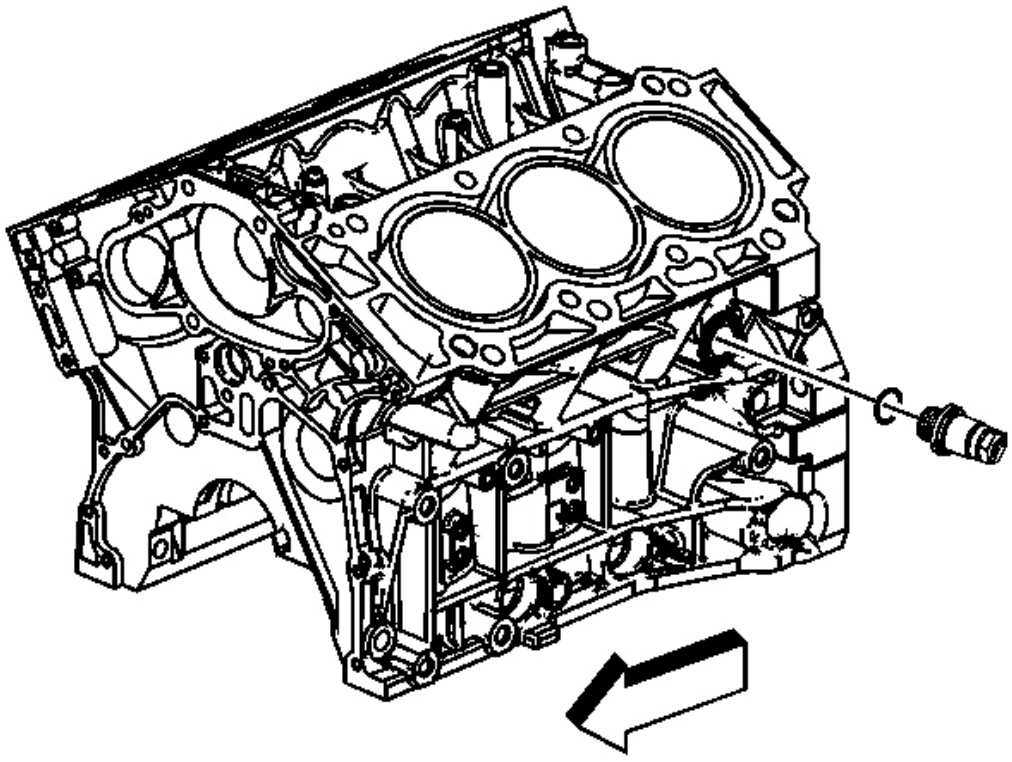


Fig. 221: View Of Engine Block Plug
Courtesy of GENERAL MOTORS CORP.

1. Remove the block coolant heater and washer, if applicable.

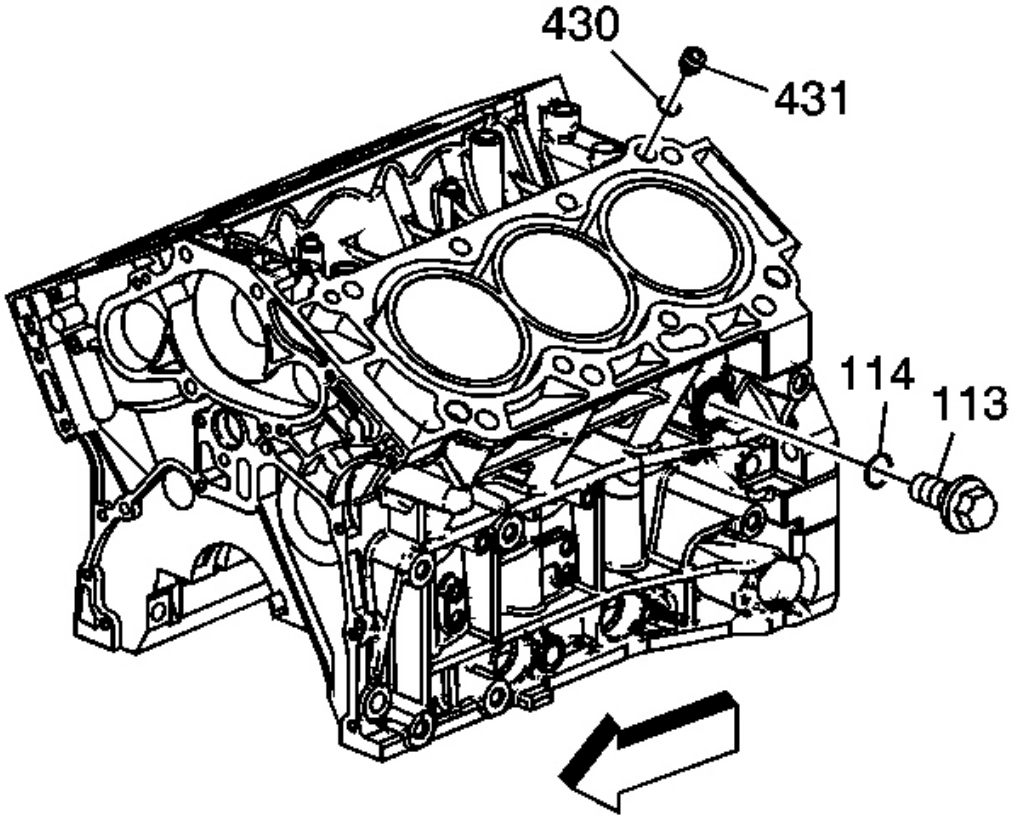


Fig. 222: View Of Coolant Drain Plug, Washer, Restrictor & O-Ring
Courtesy of GENERAL MOTORS CORP.

2. Remove the left side coolant drain plug (113) and washer (114).
3. Remove the restrictor (431) and O-ring (430).

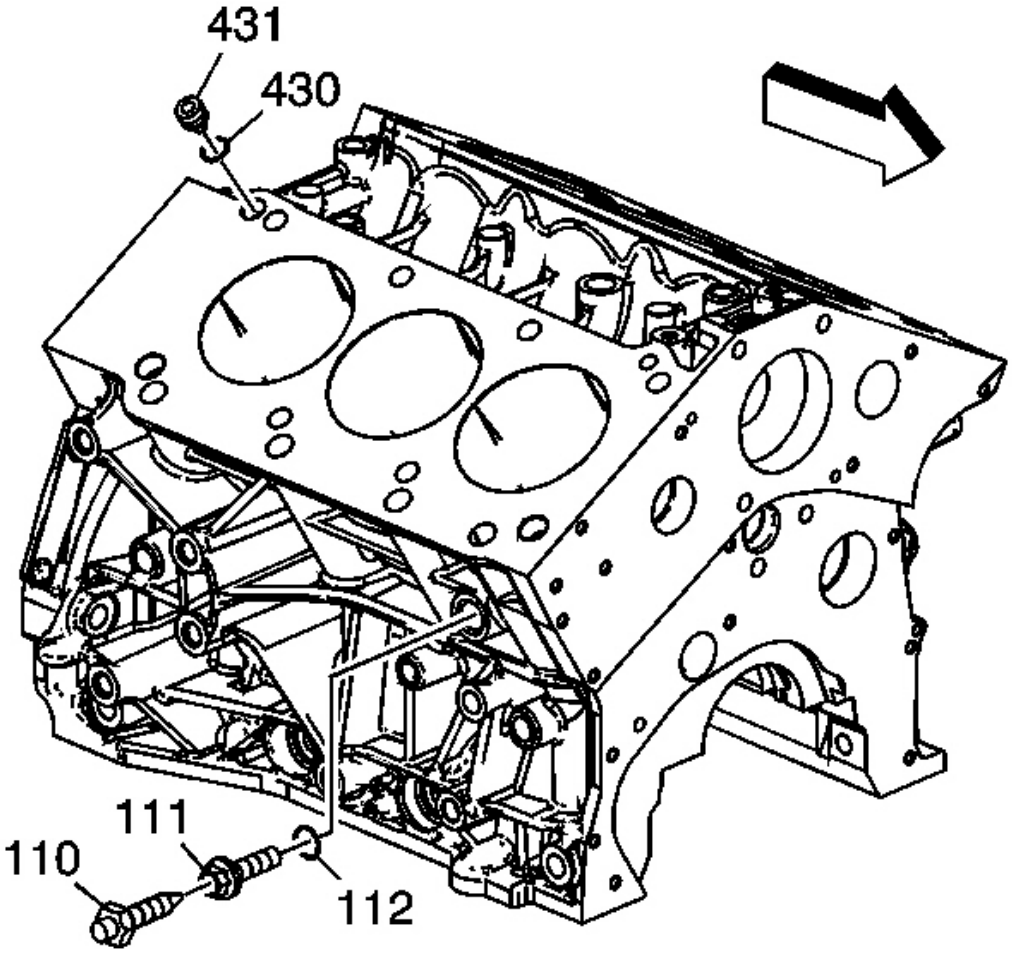


Fig. 223: Identifying Restrictor, O-Ring, Washer, Fitting & Drain Plug
Courtesy of GENERAL MOTORS CORP.

4. Remove the right side coolant drain plug (110), fitting (111) and washer (112).
5. Remove the restrictor (431) and O-ring (430).

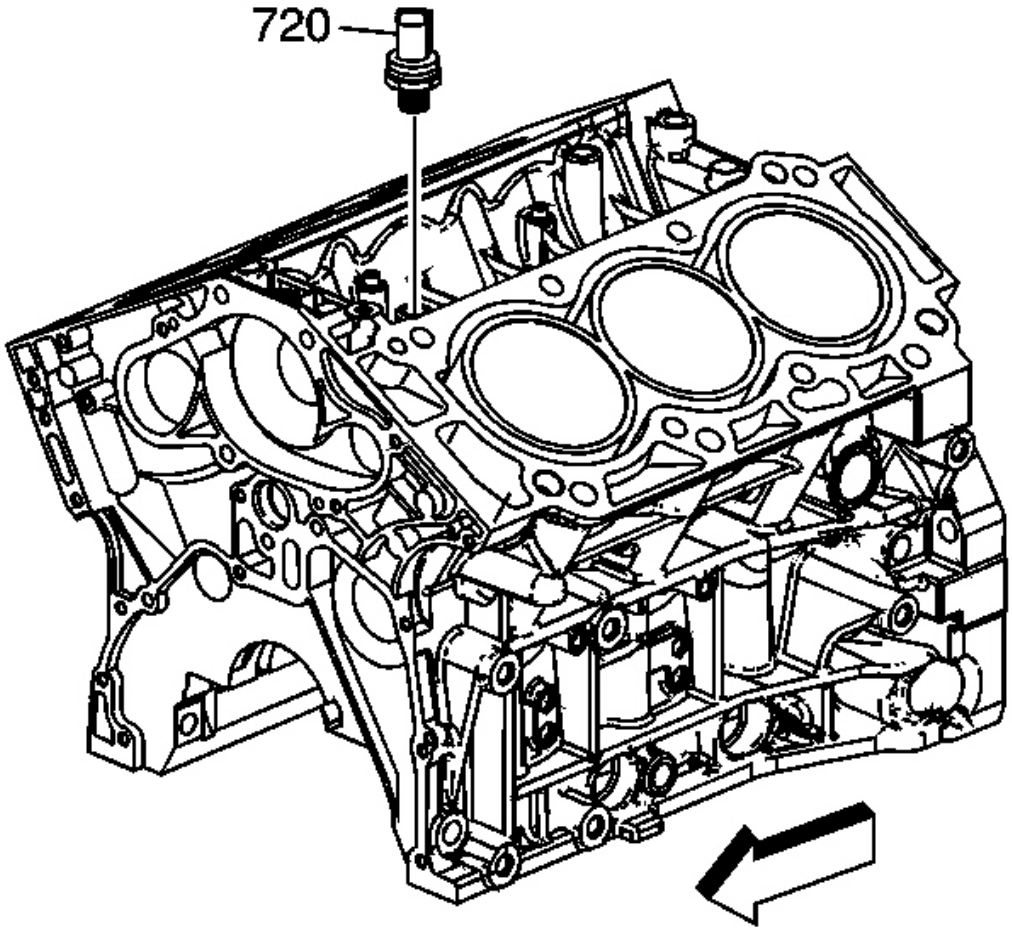


Fig. 224: View Of Know Sensor
Courtesy of GENERAL MOTORS CORP.

6. Remove the knock sensor (720).

ENGINE BLOCK CLEANING AND INSPECTION

Tools Required

SA9178NE-A Dial Bore Gauge

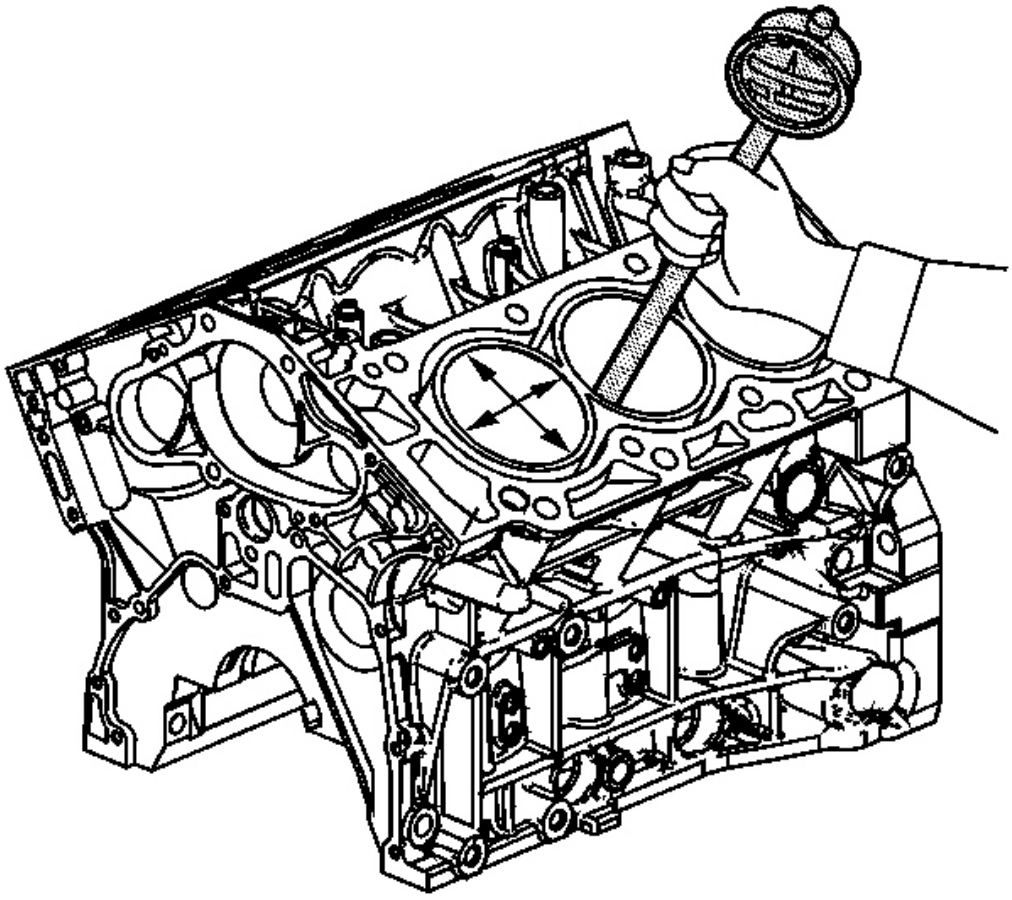


Fig. 225: Identifying Engine Block
Courtesy of GENERAL MOTORS CORP.

1. Using the **SA9178NE-A** , measure the cylinder bore wear and taper.
    1. Measure the bore both parallel and perpendicular to the crankshaft.
    2. Measure the bore at the top, center and bottom of each cylinder. If the bore size or taper exceeds the service limit of 89.065 mm (3.5065 in), the block must be bored and fitted with oversized pistons. Scored or scratched cylinder bores must be honed.

    Specification:

    - Cylinder bore diameter - new: 89.0-89.015 mm (3.5039-3.5045 in)
    - Cylinder bore diameter - service limit: 89.065 mm (3.5065 in)
    - Cylinder bore diameter - with 0.25 mm oversize pistons: 89.25-89.265 mm (3.5138-3.5144 in)

- Maximum reboring limit: 0.25 mm (0.01 in)
- Cylinder bore taper limit: 0.05 mm (0.002 in) measured at the top and bottom of the cylinder bore

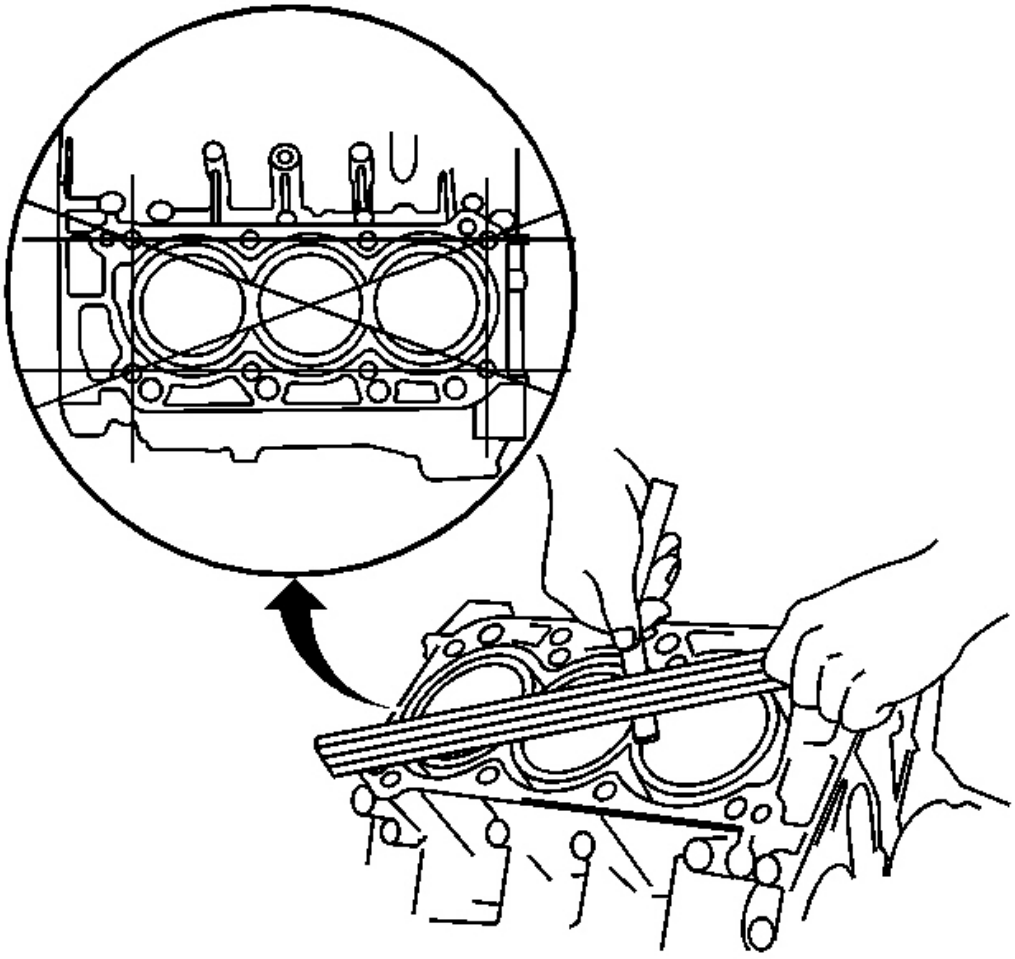


Fig. 226: Measuring The Top Of The Cylinder Block
Courtesy of GENERAL MOTORS CORP.

2. Using a straight edge and feeler gage, measure the top of the cylinder block for warpage.

Specification:

- Cylinder block deck surface flatness - new: 0.07 mm (0.003 in) maximum
- Cylinder block deck surface flatness - service limit: 0.1 mm (0.004 in)

3. Inspect for the following conditions:
    - Gasket sealing surfaces for excessive scratches or gouging
    - Threaded bolt holes for damaged threads
    - Restrictions within the coolant or oil passages

CYLINDER BORING AND HONING

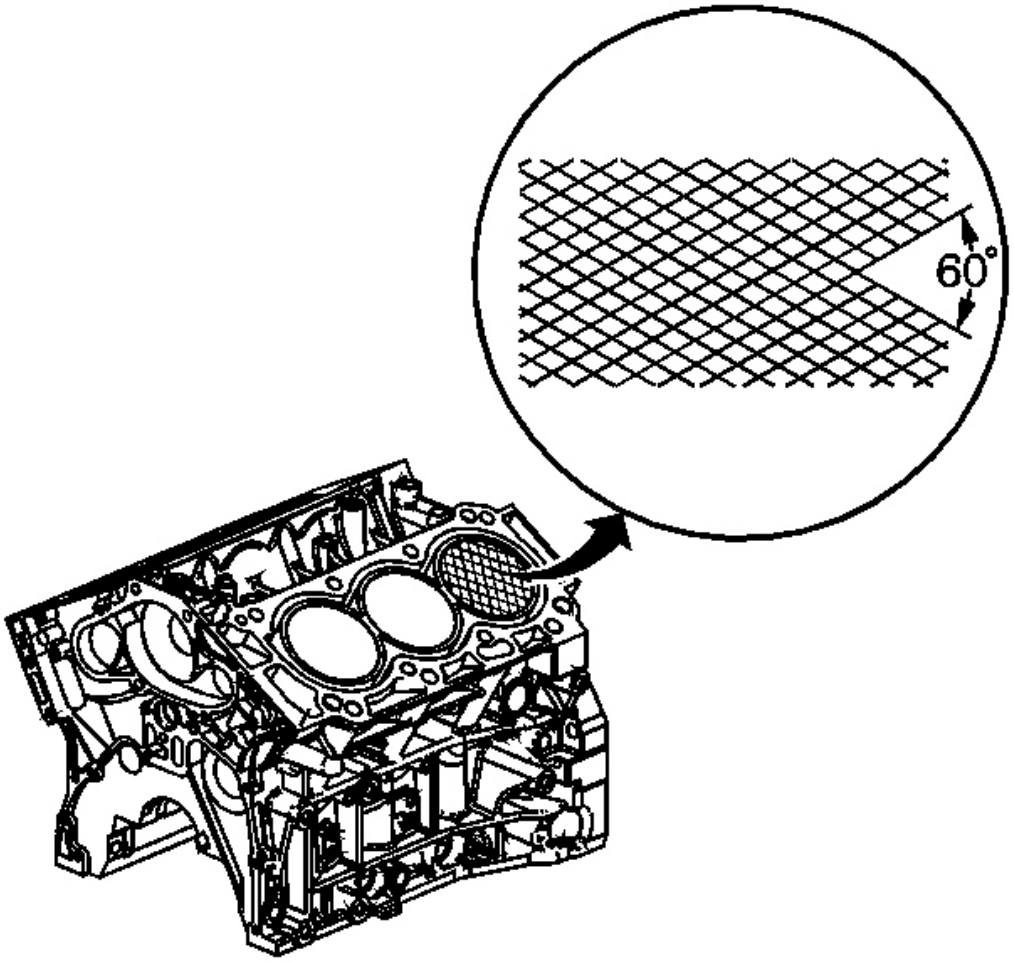


Fig. 227: Measuring Cylinder Bores
Courtesy of GENERAL MOTORS CORP.

1. Measure the cylinder bores. Refer to **Engine Block Cleaning and Inspection** .

IMPORTANT: Use only a rigid type hone with a 400 grit or finer stone. Do not use stones that are worn or broken. If a cylinder bore is to be used again, hone the cylinder and measure the bore again. Only scored or scratched cylinder bores must be honed.

2. Hone the cylinder bores with honing oil and a 400 grit stone in a 60 degree crosshatch pattern.

IMPORTANT: Do not clean the block with solvent.

3. Clean the cylinder block of all metal particles. Wash the cylinder bores with hot soapy water. Dry and oil immediately to prevent rusting.
4. If scoring or scratches are still present in the cylinder bore after honing to the service limit, the cylinder must be bored, honed and fitted with oversize pistons. Some light vertical scoring or scratching is acceptable if it is not deep enough to catch your fingernail and does not run the full length of the bore.

CRANKSHAFT AND BEARINGS CLEANING AND INSPECTION

Tools Required

SA9179NE Dial Indicator

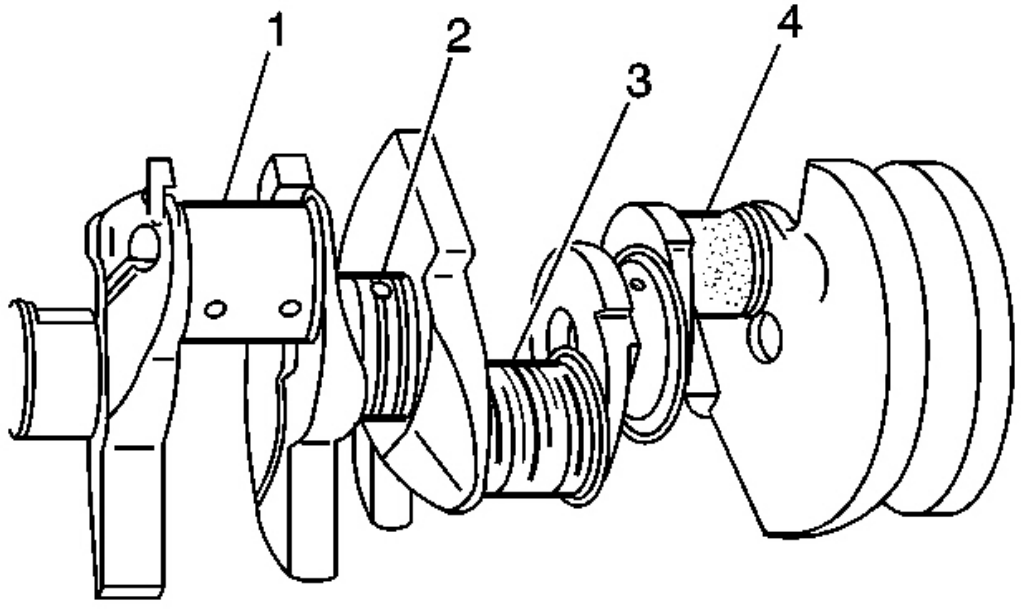


Fig. 228: Crankshaft Inspection Areas

Courtesy of GENERAL MOTORS CORP.

1. Clean the crankshaft oil passages. Remove all debris or restrictions.
2. Inspect the crankshaft for the following conditions:
    - Journals for wear (1)

      Journals should be smooth with no signs of scoring, wear or damage.

    - Grooves or scoring (2)
    - Scratches or wear (3)
    - Pitting or imbedded material (4)

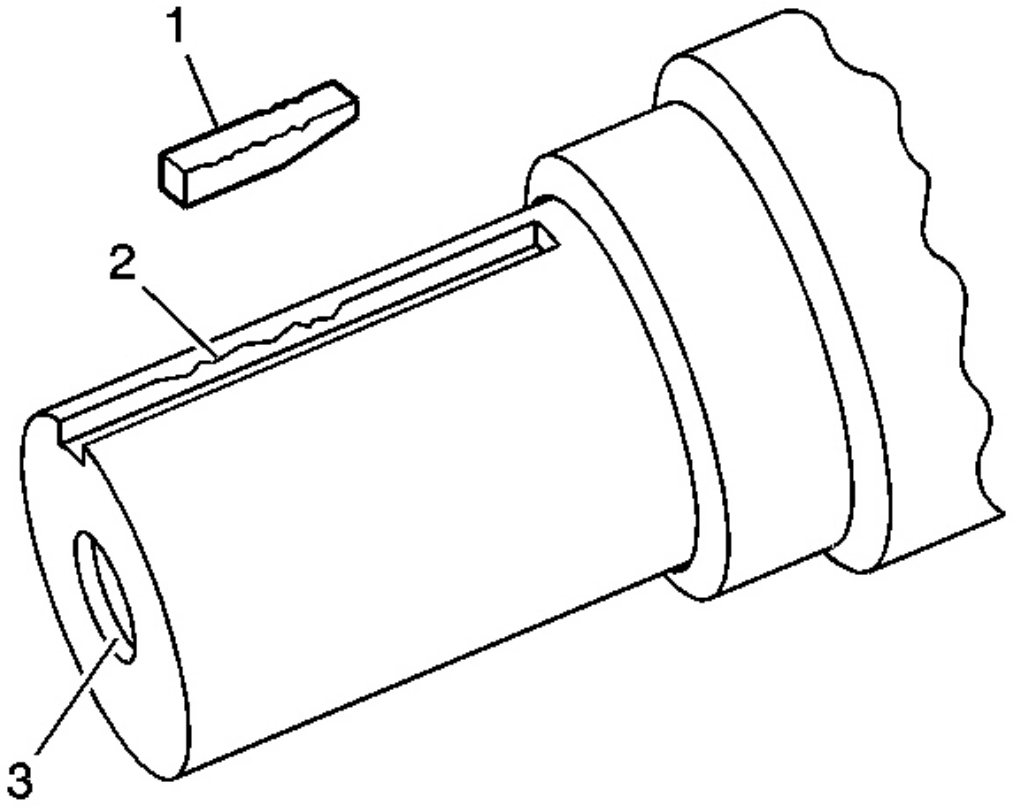


Fig. 229: View Of Damaged Areas
Courtesy of GENERAL MOTORS CORP.

3. Inspect the key (1), keyway (2) and threaded holes (3) for damage.

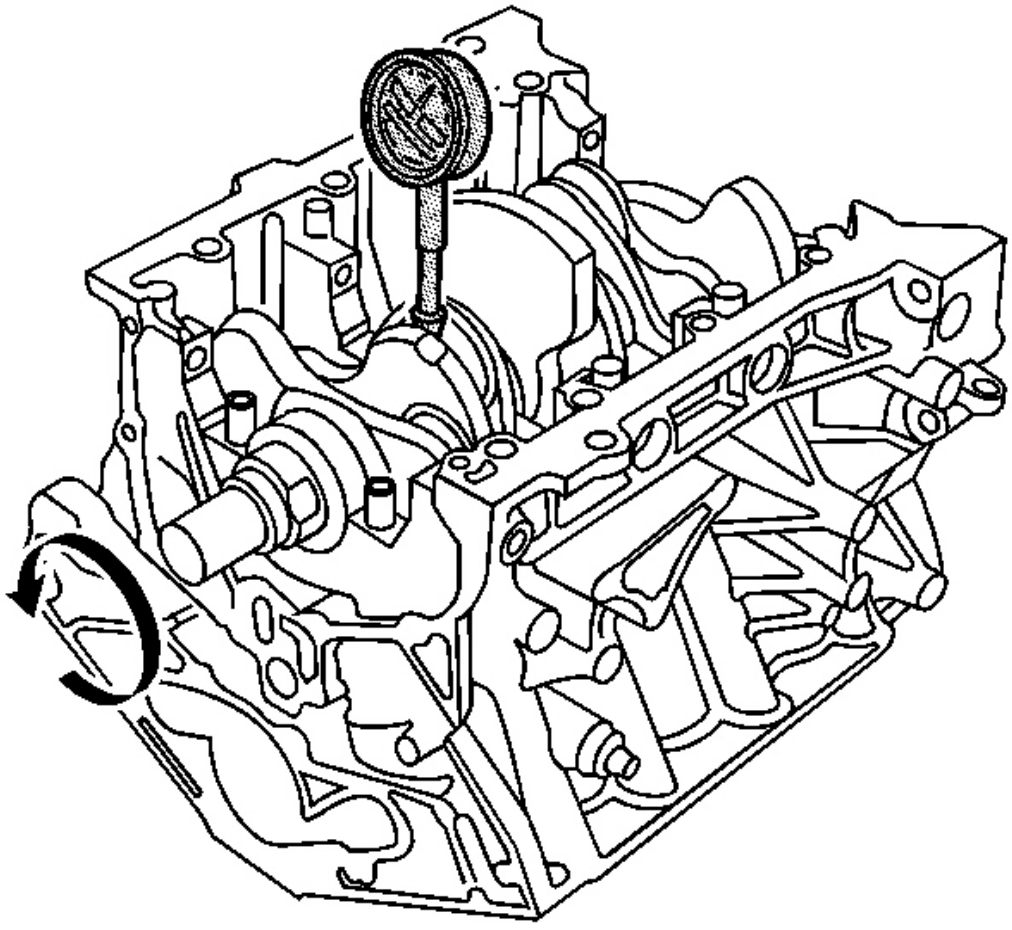


Fig. 230: View Of Front & Rear Upper Main Bearings
Courtesy of GENERAL MOTORS CORP.

4. Install the front and rear upper main bearings to the engine block.
5. Position the crankshaft in the engine block.
6. Use the **SA9179NE** to measure the main journal runout. Rotate the crankshaft two complete revolutions. The difference between the journal measurements must not exceed the service limit.

   Specification:

   - Crankshaft total runout - new: 0.02 mm (0.0008 in)
   - Crankshaft total runout - service limit: 0.03 mm (0.0012 in)

7. Measure the main and connecting rod journals for an out-of-round condition. Measure each journal in 2

places 90 degrees opposite each other. The difference between the measurements on each journal must not exceed the service limit.

Specification:

- Journal out-of-round - new: 0.005 mm (0.0002 in)
- Journal out-of-round - service limit: 0.01 mm (0.0004 in)

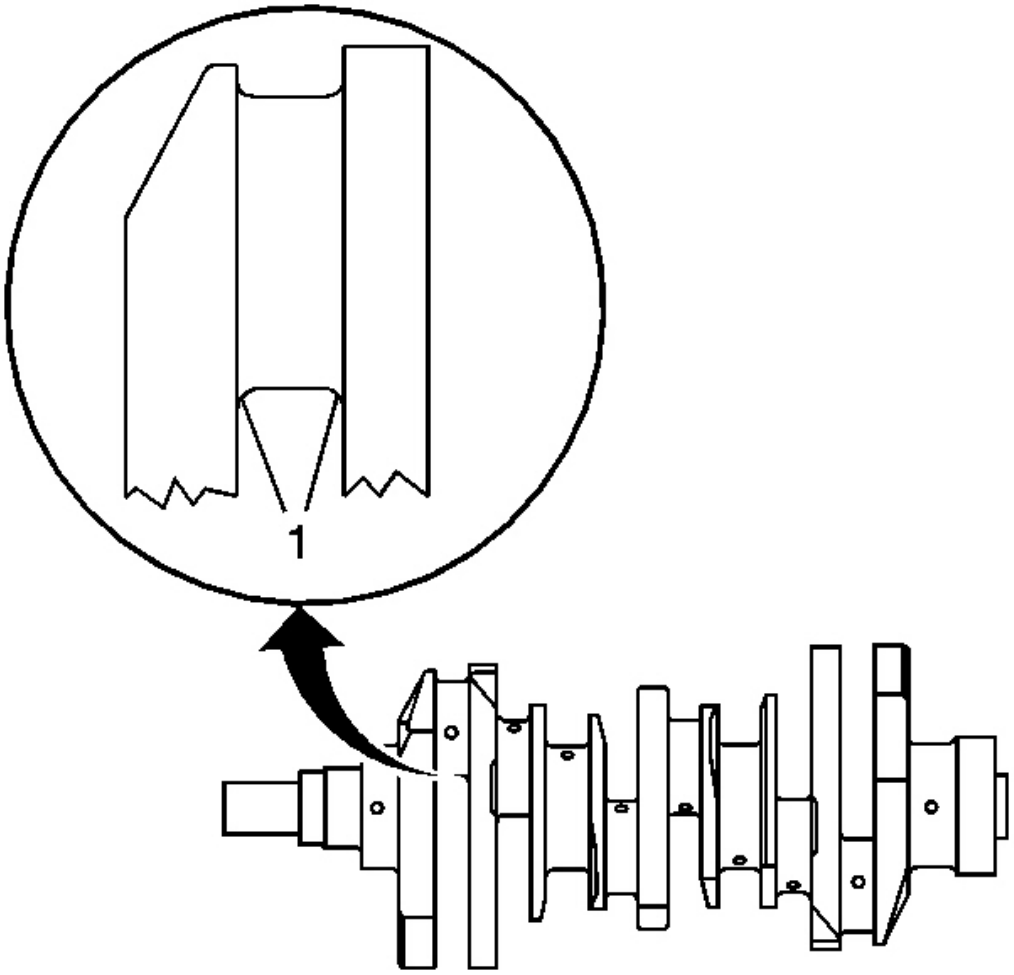


Fig. 231: Measuring The Main & Connecting Rod Journals
Courtesy of GENERAL MOTORS CORP.

8. Measure the main and connecting rod journals for excessive taper. Measure each journal at the edges (1).

Specification:

- Journal taper - new: 0.005 mm (0.0002 in)
- Journal taper - service limit: 0.01 mm (0.0004 in)

Crankshaft End Play Measurement

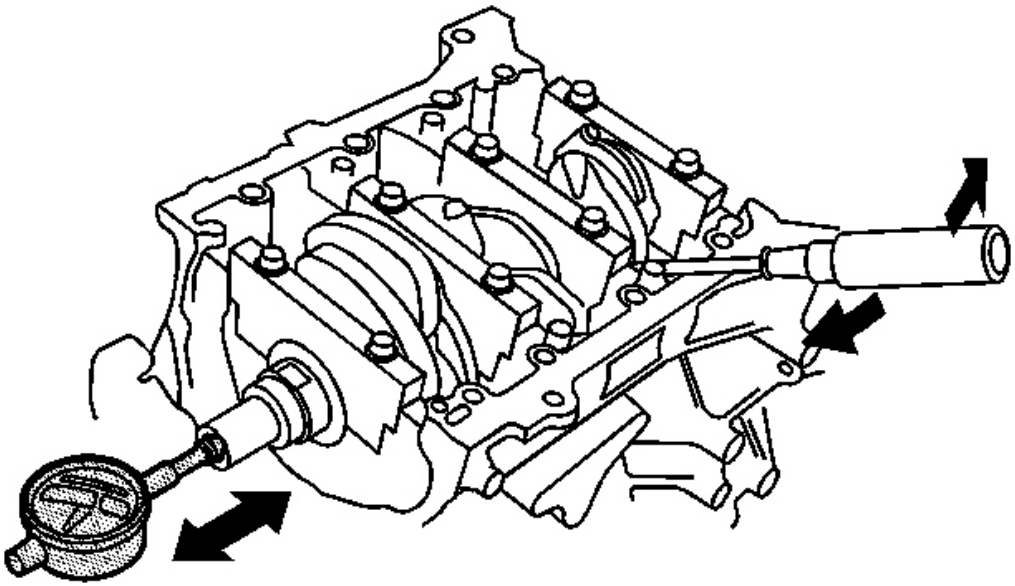


Fig. 232: View Of Crankshaft
Courtesy of GENERAL MOTORS CORP.

1. Push the crankshaft firmly away from the **SA9179NE** and position the tip of the dial indicator against the end of the crankshaft.
2. Zero the dial indicator and push the crankshaft firmly toward the **SA9179NE** . If the end play measurement exceeds the service limit, inspect the thrust washers and the thrust surface of the crankshaft.

   Specification:

   - Crankshaft end play - new: 0.1-0.35 mm (0.004-0.014 in)
   - Crankshaft end play - service limit: 0.45 mm (0.018 in)

3. Replace parts as required. The thrust surface of the crankshaft is a fixed dimension and should not be changed by grinding or shimming.

Connecting Rod Bearing Clearance Measurement

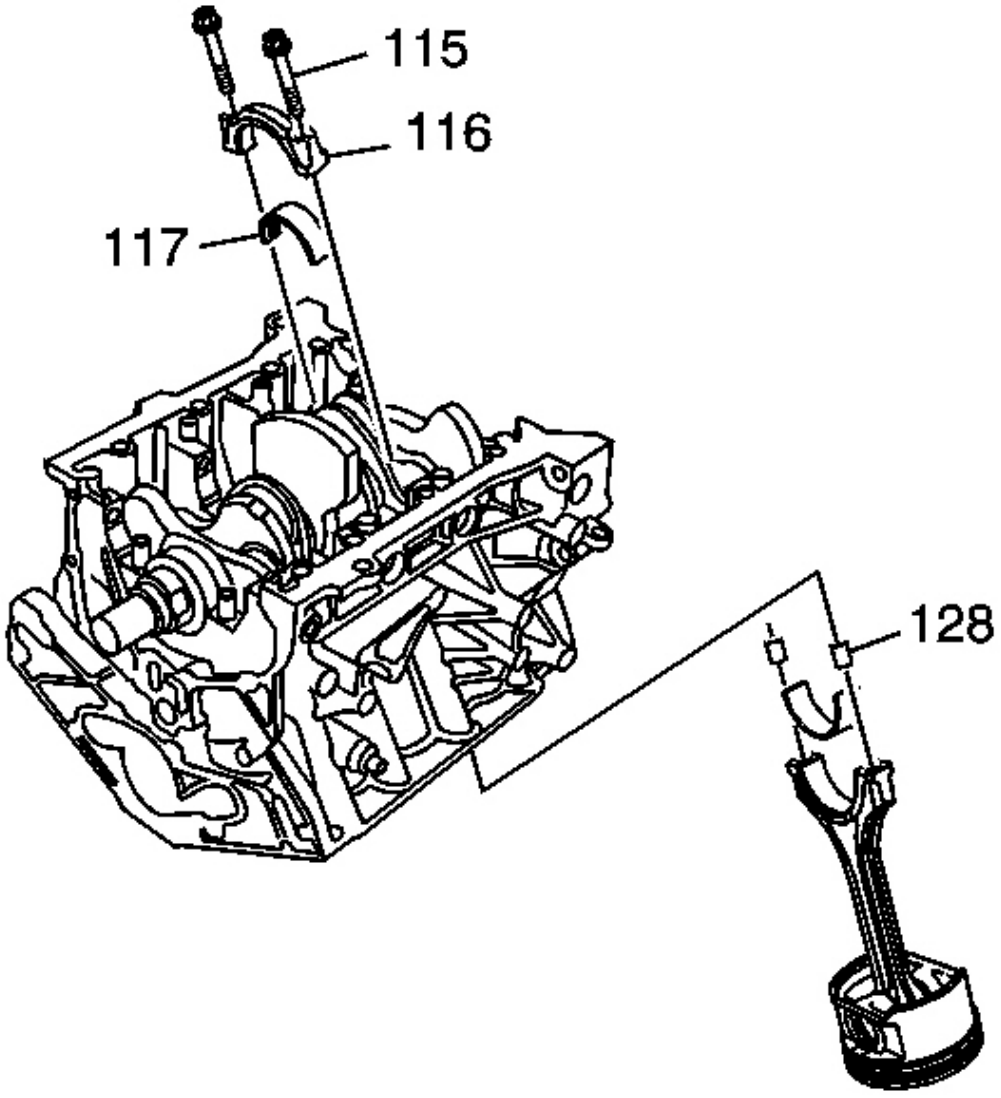


Fig. 233: View Of Connecting Rod Bearing
Courtesy of GENERAL MOTORS CORP.

1. Remove the connecting rod bolts (115), cap (116) and lower bearing half (117).
2. Clean the crankshaft rod journal and bearing half with a clean shop towel.
3. Place 1 strip of plastic gaging material across the rod journal.
4. Install the lower bearing half, cap and bolts. Refer to **Piston, Connecting Rod, and Bearing Installation** .

5. Remove the bolts, bearing cap and bearing half. Refer to **Piston, Connecting Rod, and Bearing Removal** .

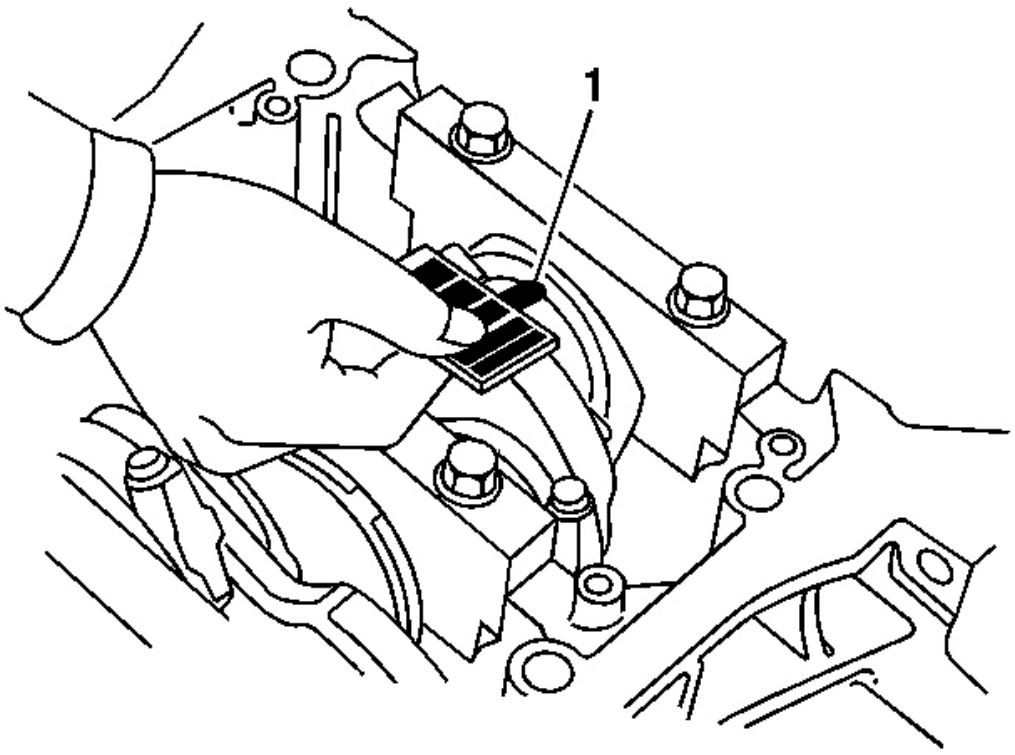


Fig. 234: Measuring The Widest Part Of The Plastic Gaging Material
Courtesy of GENERAL MOTORS CORP.

6. Measure the widest part of the plastic gaging material (1).
7. If the measurement is too wide or too narrow, remove the upper bearing half and install a new complete bearing of the same color and measure again. Do not file, shim or scrape the bearings or caps to adjust clearance.
8. If the plastic gaging measurement is still incorrect, try the next larger or smaller bearing. If the correct clearances cannot be obtained, replace the crankshaft assembly.

Specification:

- Connecting rod bearing-to-journal clearance - new: 0.02-0.044 mm (0.0008-0.0017 in)
- Connecting rod bearing-to-journal clearance - service limit: 0.05 mm (0.002 in)

Crankshaft Main Bearing Clearance Measurement

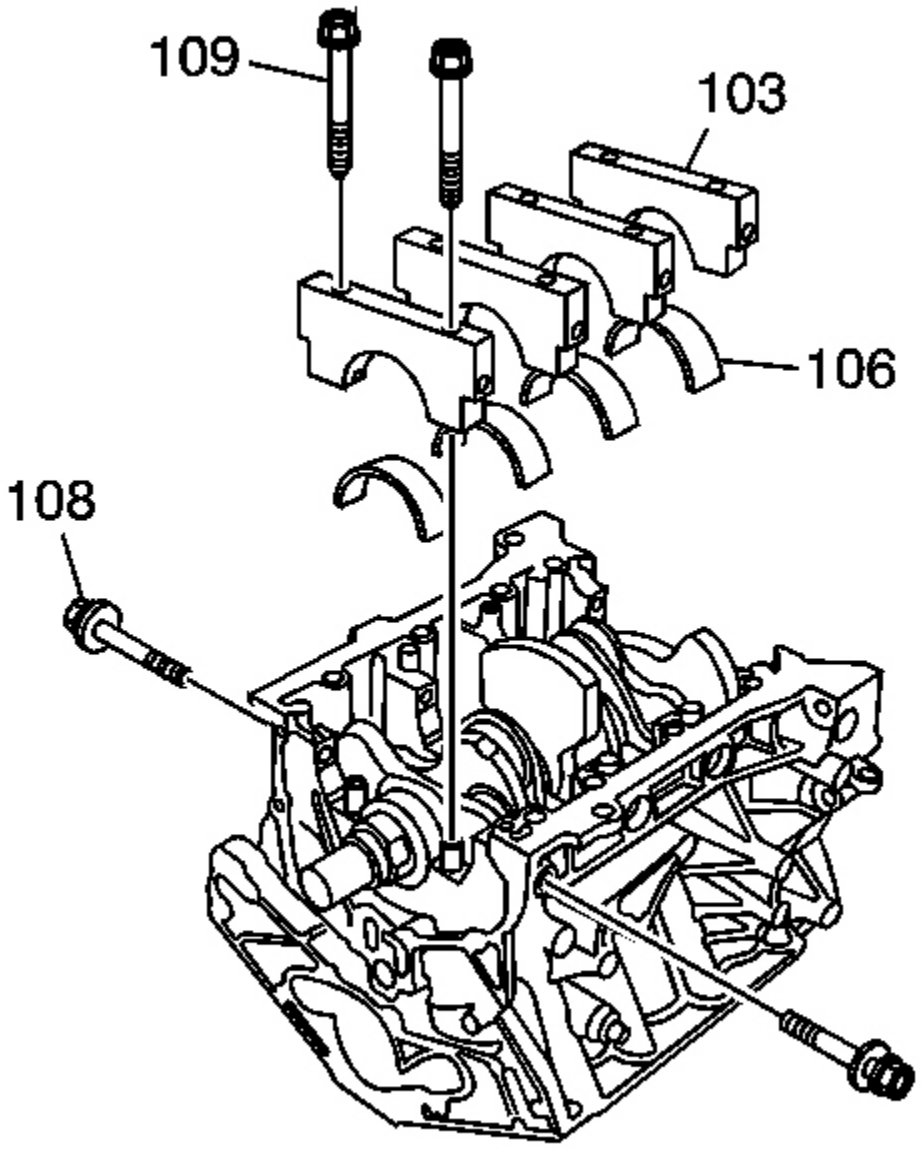


Fig. 235: View Of Bearings
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If the bearing clearance measurement procedure is to performed in-vehicle, the crankshaft must be supported upward with a jack. The weight of the crankshaft and drive plate will flatten the plastic gaging material and contribute to an inaccurate measurement.

1. Remove the bolts (108 and 109) caps (103) and lower bearings (106). Refer to **Crankshaft and Bearings Removal** .
2. Clean each main journal and bearing half with a clean shop towel.
3. Place 1 strip of plastic gaging material across each main journal.
4. Install the bearings, caps and bolts. Refer to **Crankshaft and Bearings Installation** .
5. Remove the bolts, bearing caps and bearings. Refer to **Crankshaft and Bearings Removal** .

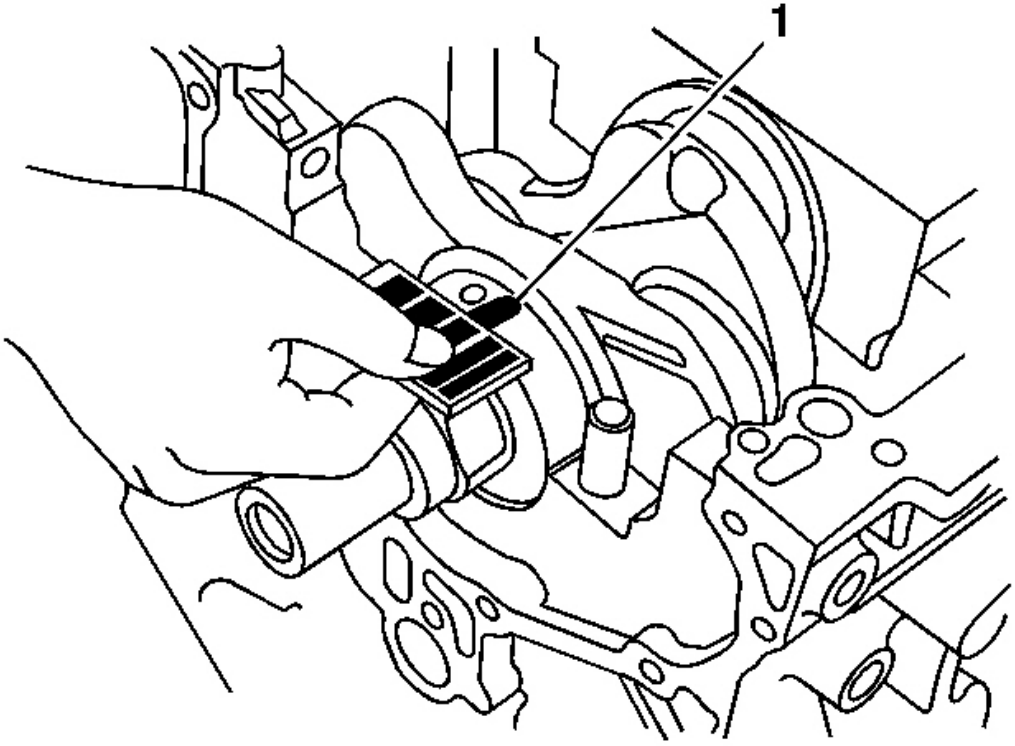


Fig. 236: Measuring The Widest Part Of The Plastic Gaging Material
Courtesy of GENERAL MOTORS CORP.

6. Measure the widest part of the plastic gaging material (1).
7. If the measurement is too wide or too narrow, remove the crankshaft and the bearing upper half. Install a new bearing assembly of the same color and measure again. Do not file, shim or scrape the bearings or caps to adjust the clearance.
8. If the plastic gaging measurement is still incorrect, try the next larger or smaller bearing. If the correct clearances cannot be obtained, replace the crankshaft assembly.

Specification:

- Main bearing-to-journal clearance - new: 0.02-0.044 mm (0.0008-0.0017 in)
- Main bearing-to-journal clearance - service limit: 0.05 mm (0.002 in)

Main Bearing Selection

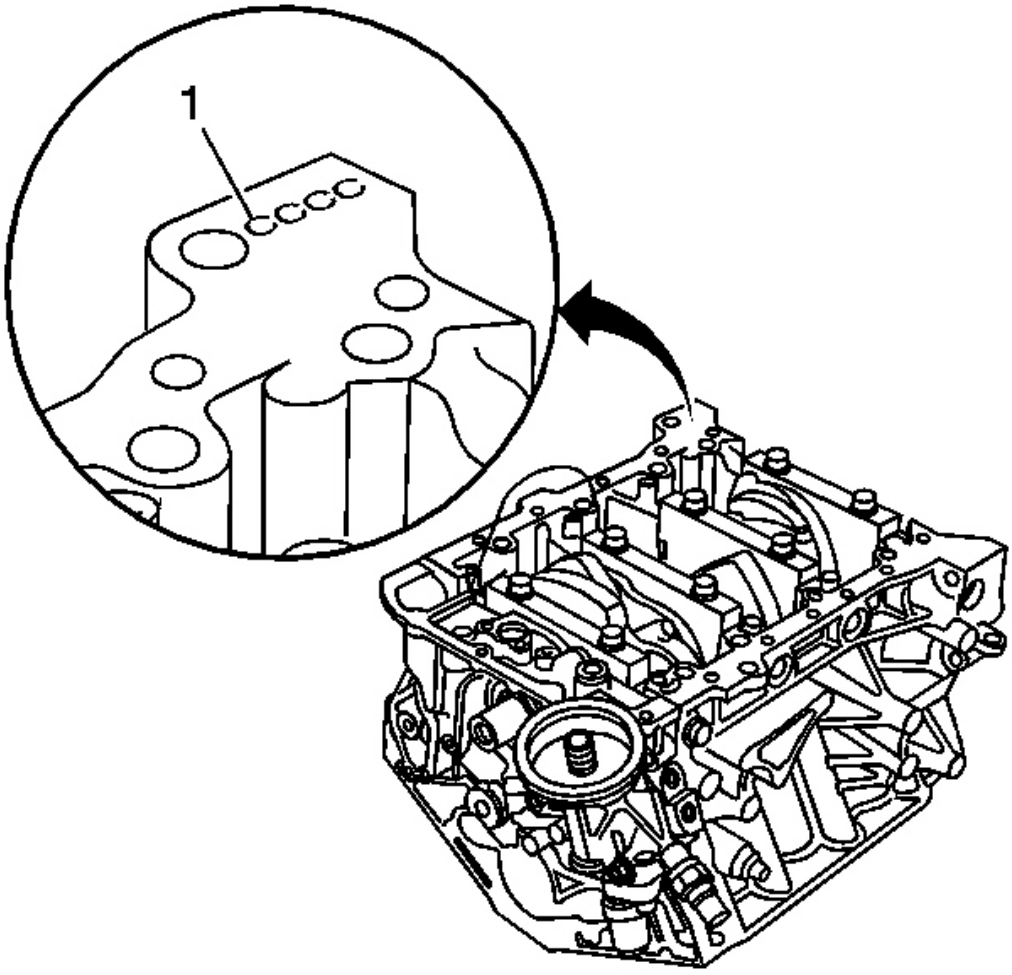


Fig. 237: View Of Main Bearing
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Letters or bars have been stamped on the oil pan surface of the block, as a code for the inside diameter (I.D.) size of each of the 4 main journal bores. Use the block and crankshaft markings to choose the correct size bearings. If the codes are not legible due to dirt or debris, do not scrub

with a wire brush or scraper. Clean them only with solvent or detergent.

1. Locate the main journal bore diameter markings on the engine block rear flange. The first letter or bar (1) identifies crankshaft main journal number 1.

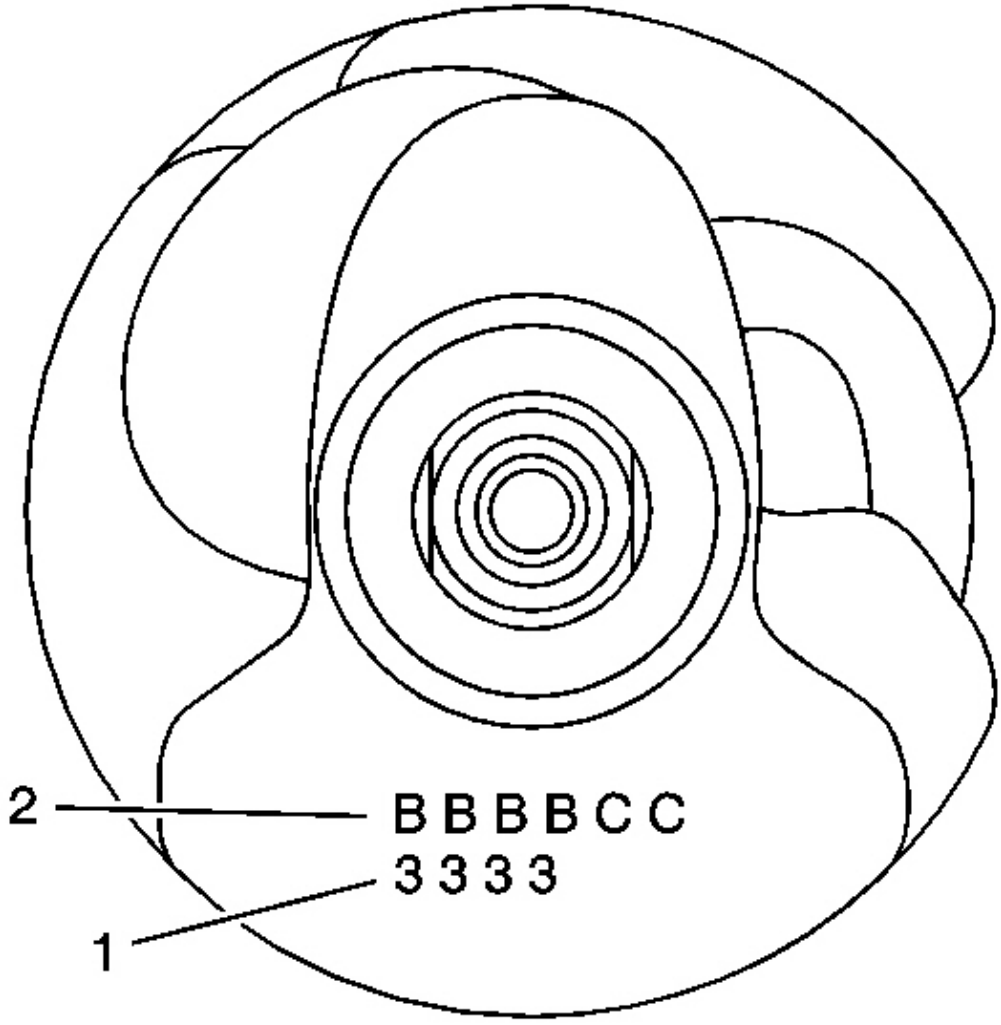


Fig. 238: Locating The Main Journal
Courtesy of GENERAL MOTORS CORP.

2. Locate the main journal outside diameter (O.D.) markings on the front of the crankshaft. The first number (1) identifies crankshaft main journal number 1.

3. Select the main journal bearings. Refer to **Crankshaft Bearings Selection Specifications** .

Connecting Rod Bearing Selection

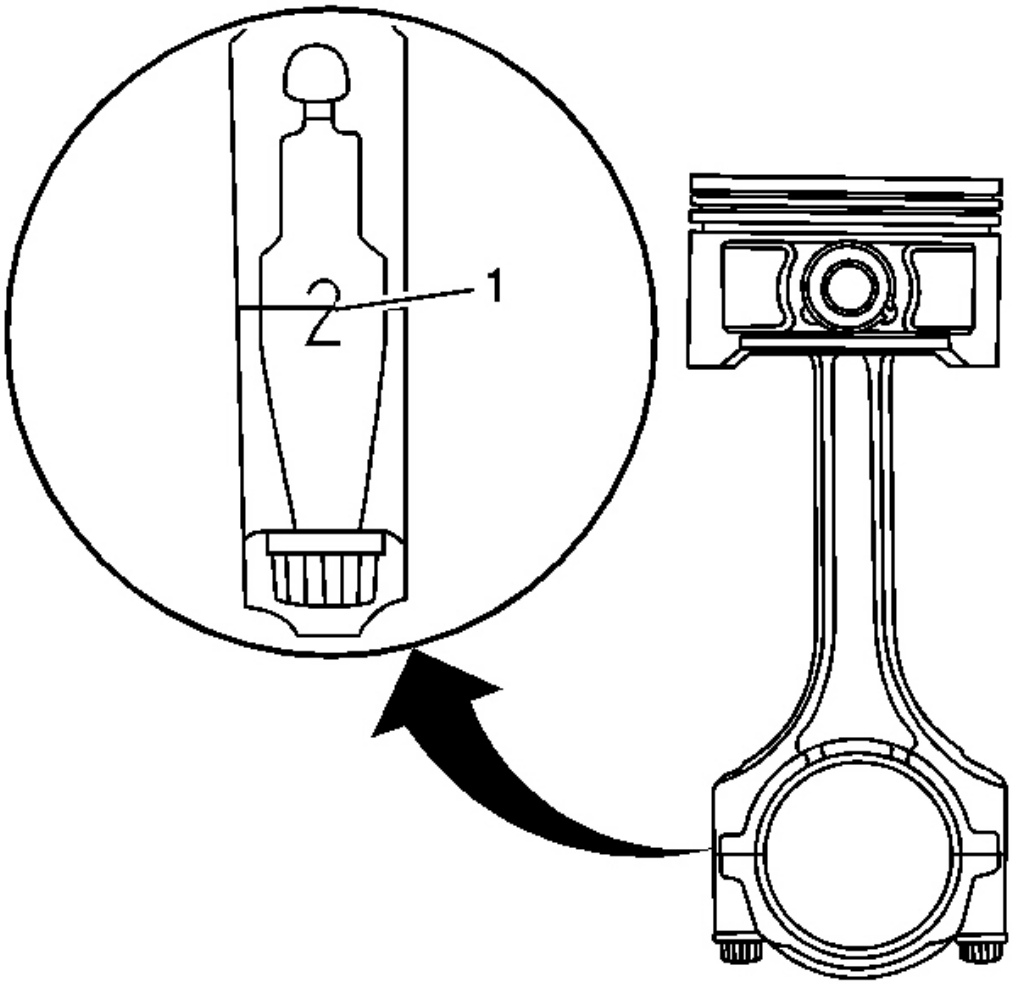


Fig. 239: View Of Connecting Rod
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Each connecting rod falls into 1 of 4 tolerance ranges from 0.0-0.024 mm (0.0-0.0009 in) in 0.006 mm (0.0002 in) increments depending on the inside diameter (I.D.) size of the big end bore. The connecting rod is then stamped with a number or bar indicating the range. It may be common for the connecting rods on the engine assembly to**

be of a different I.D. size range and stamping.

- **Numbers or bars have been stamped on the side of each connecting rod (1) as a code for the I.D. size of the journal end. Use the connecting rod and crankshaft markings to choose the correct size bearings. If the codes are not legible due to dirt or debris, do not scrub with a wire brush or scraper. Clean them only with solvent or detergent.**

1. Locate the journal bore diameter marking (1) on the side of the connecting rod.

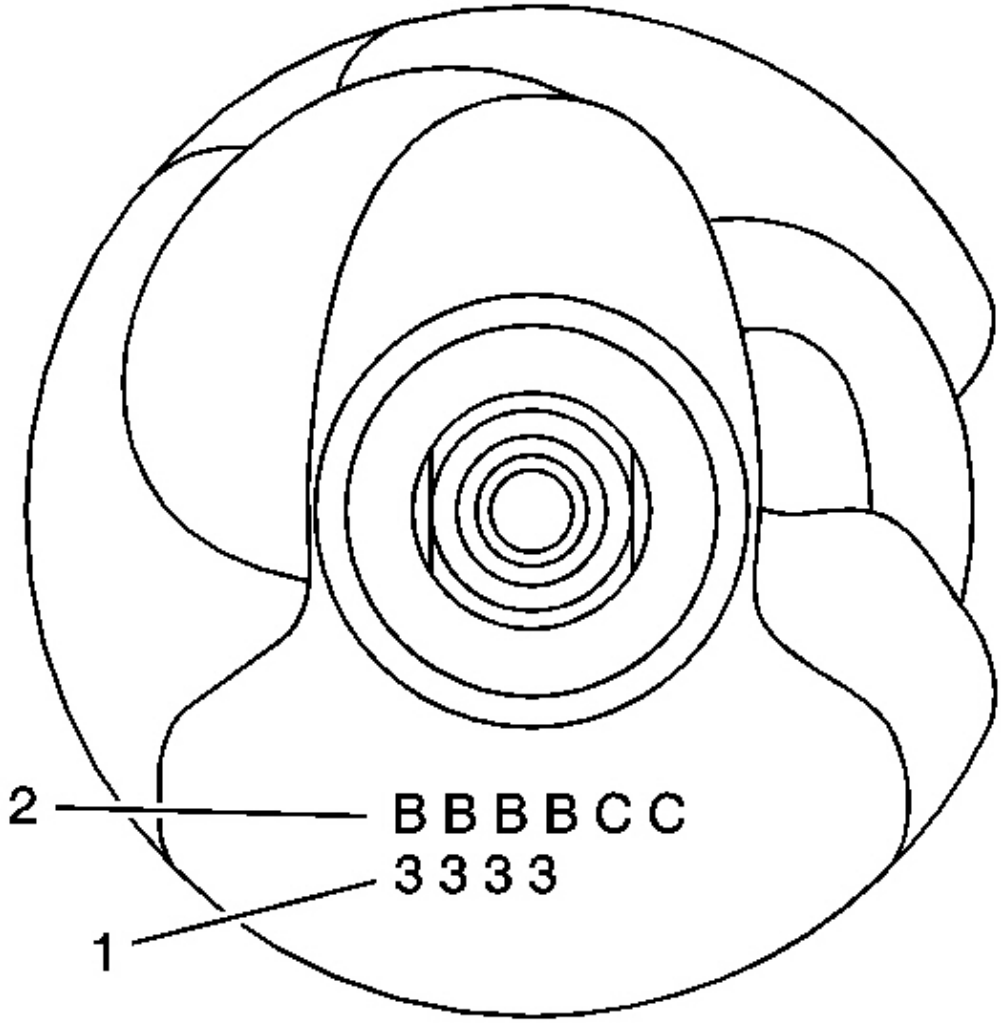


Fig. 240: Locating The Main Journal
Courtesy of GENERAL MOTORS CORP.

2. Locate the connecting journal diameter marking on the front of the crankshaft. The first letter (2) identifies connecting rod journal number 1.
3. Select the connecting rod journal bearings. Refer to **Connecting Rod Bearings Selection Specifications** .

CRANKSHAFT BALANCER CLEANING AND INSPECTION

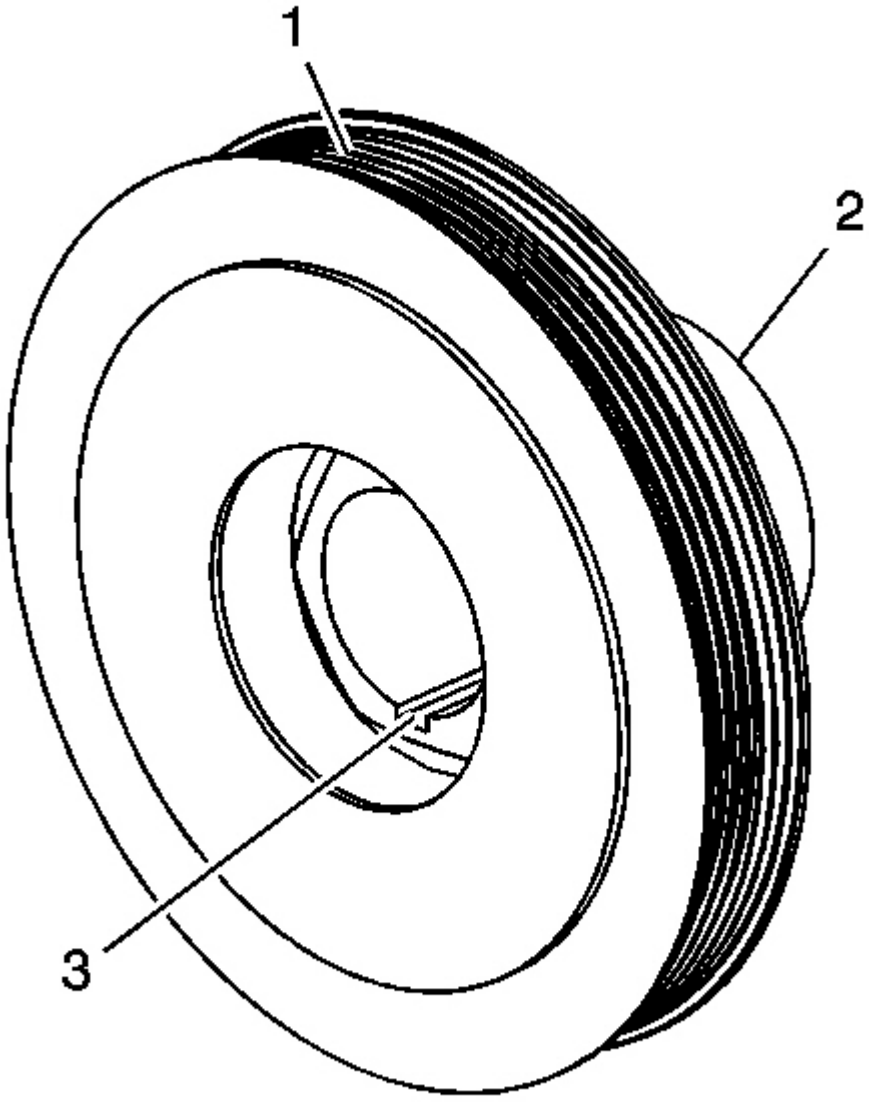


Fig. 241: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

1. Clean the grooves of the pulley. Remove all dirt or debris.
2. Inspect the balancer for the following conditions:
    - Worn or damaged belt grooves (1)
    - Excessive grooves, wear, or damage to the seal surface (2)

- Damaged keyway groove (3)

PISTON AND CONNECTING ROD DISASSEMBLE

Tools Required

J 25070 Heat Gun or equivalent

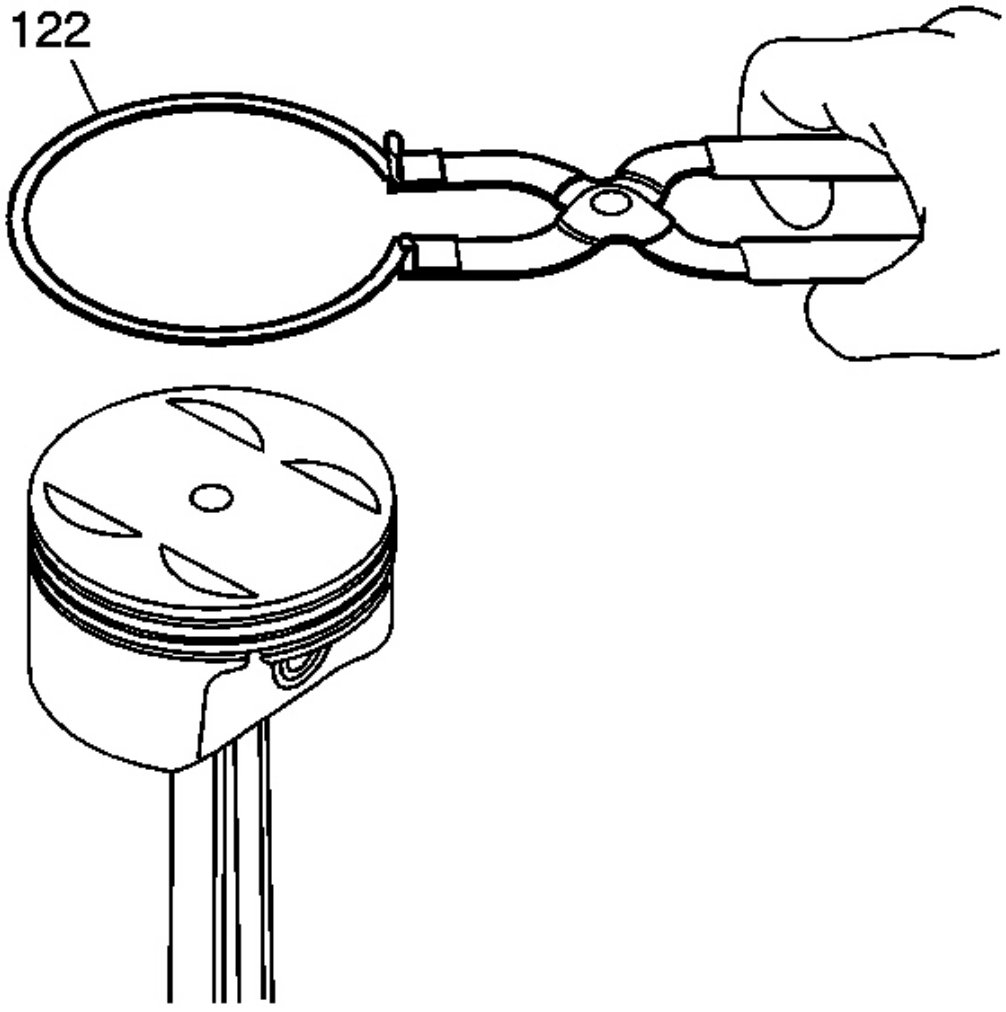


Fig. 242: View Of Piston Rings
Courtesy of GENERAL MOTORS CORP.

1. Remove the piston rings (122) from the piston.

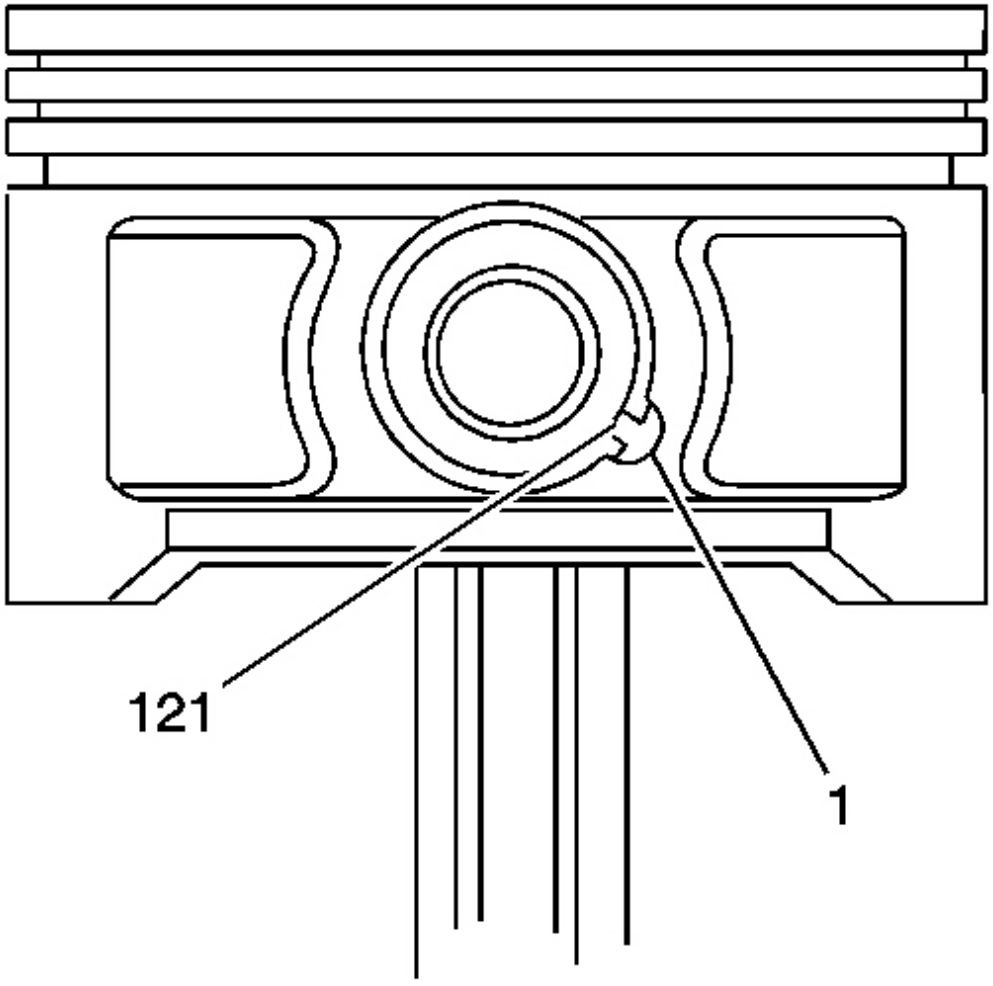


Fig. 243: View Of Piston Pin Retaining Clips
Courtesy of GENERAL MOTORS CORP.

2. Apply clean engine oil to the piston pin retaining clips (121).
3. Rotate the clips and position the clip end gap to the cutout area of the piston pin bore (1).

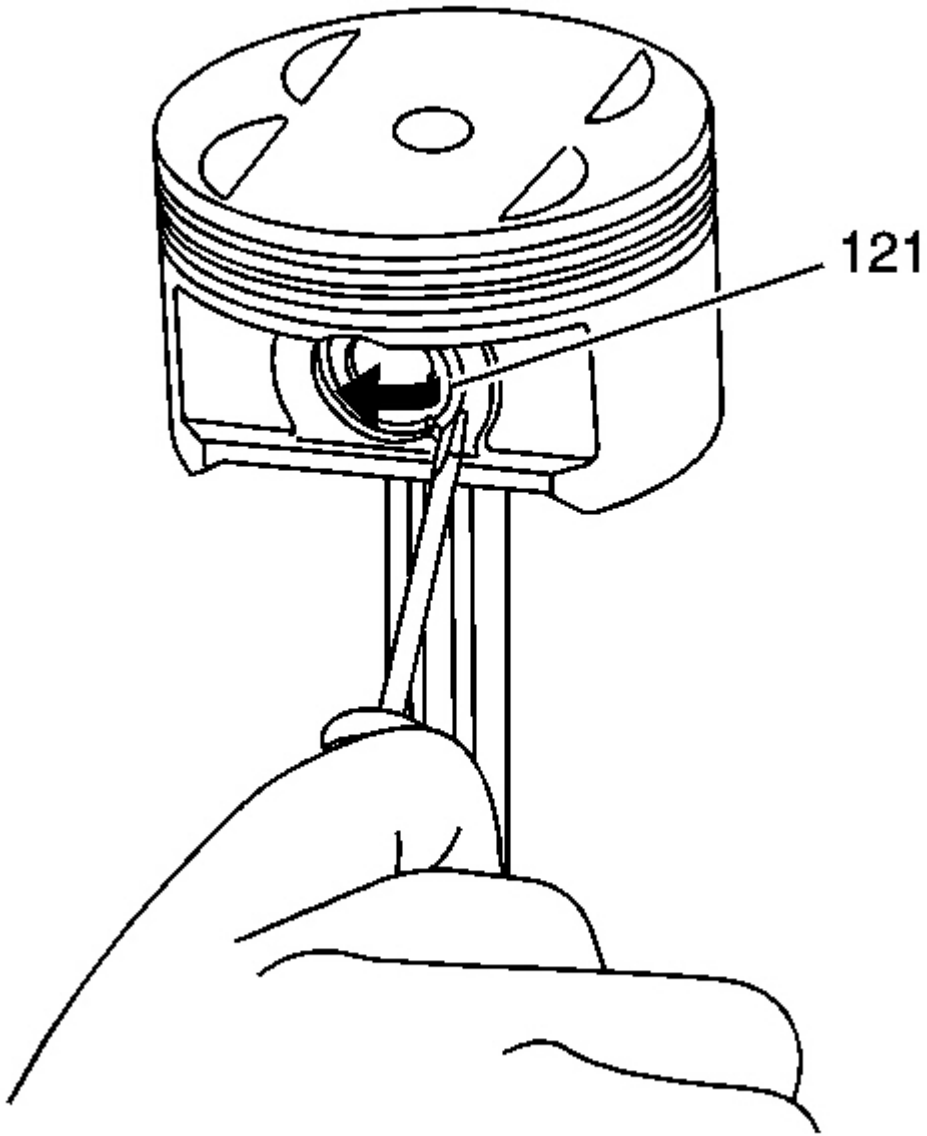


Fig. 244: View Of Clips
Courtesy of GENERAL MOTORS CORP.

4. Remove the clips (121). Start in the cutout area of the piston pin bore.

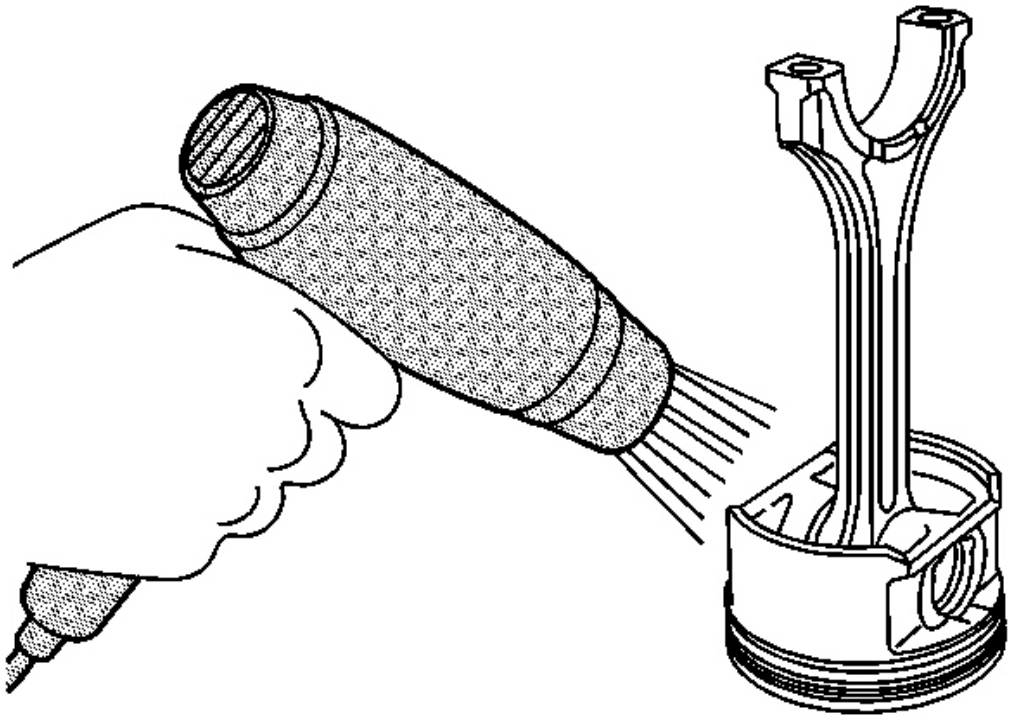


Fig. 245: View Of Piston & Connecting Rod Assembly
Courtesy of GENERAL MOTORS CORP.

5. Use the **J 25070** or equivalent to heat the piston and connecting rod assembly to approximately 70°C (158°F).

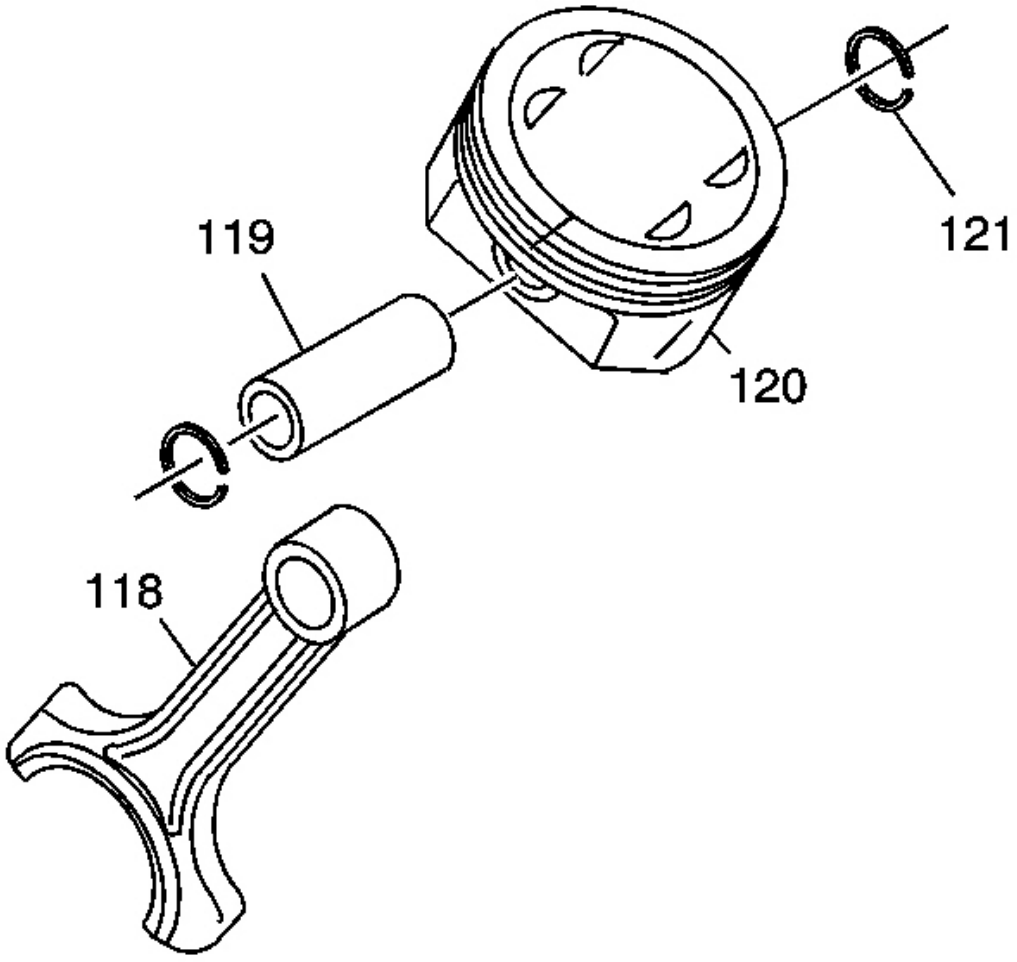


Fig. 246: View Of Pin, Piston & Connecting Rod
Courtesy of GENERAL MOTORS CORP.

6. Remove the pin (119) from the piston (120) and connecting rod (118).

PISTON, CONNECTING ROD, AND BEARINGS CLEANING AND INSPECTION

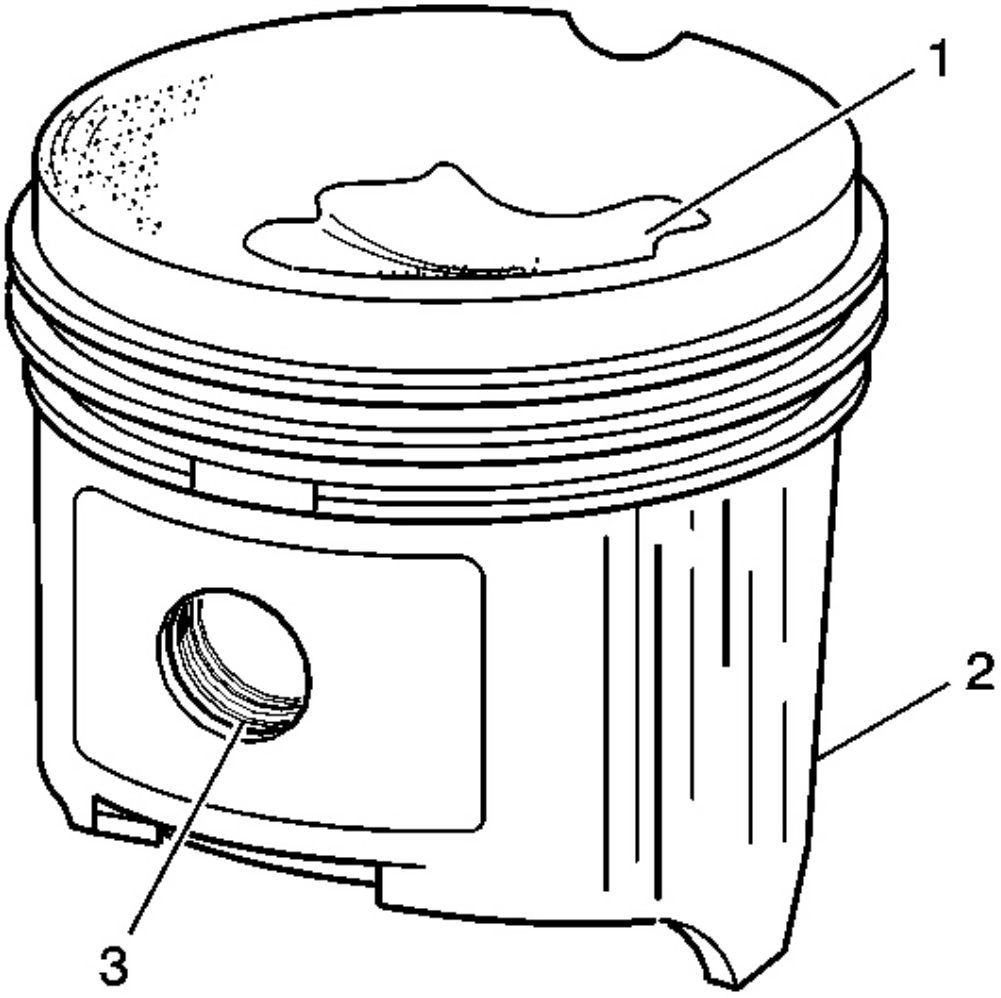


Fig. 247: Inspecting Piston For Damage
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Inspect the piston, pin and connecting rod with the components at room temperature. Do not use a wire brush to clean the piston ring grooves. Do not cut the ring grooves deeper with a groove cleaning tool.

1. Inspect the piston for the following conditions:
   - Distortion or cracking
   - Eroded areas (1) at the top of the piston

- Scuffed or damaged skirt (2)
- Scoring to the piston pin bore (3)

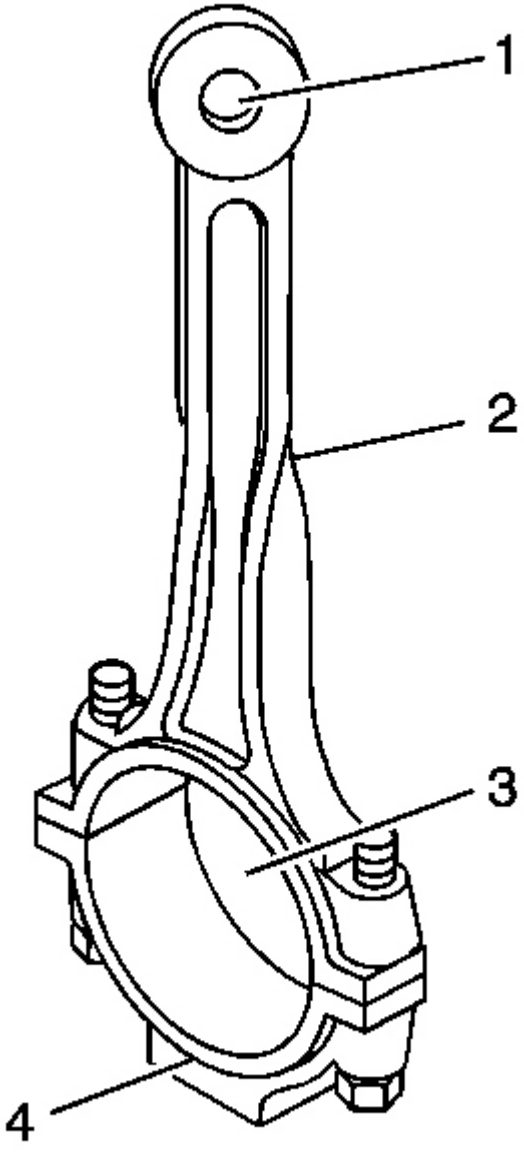


Fig. 248: Inspecting Connecting Rod
Courtesy of GENERAL MOTORS CORP.

2. Inspect the connecting rod for the following conditions:
    - Twisting (2)
    - Nicks or gouging in the pin or bearing bores (1 and 3)
    - Proper fit of the connecting rod and cap (4)

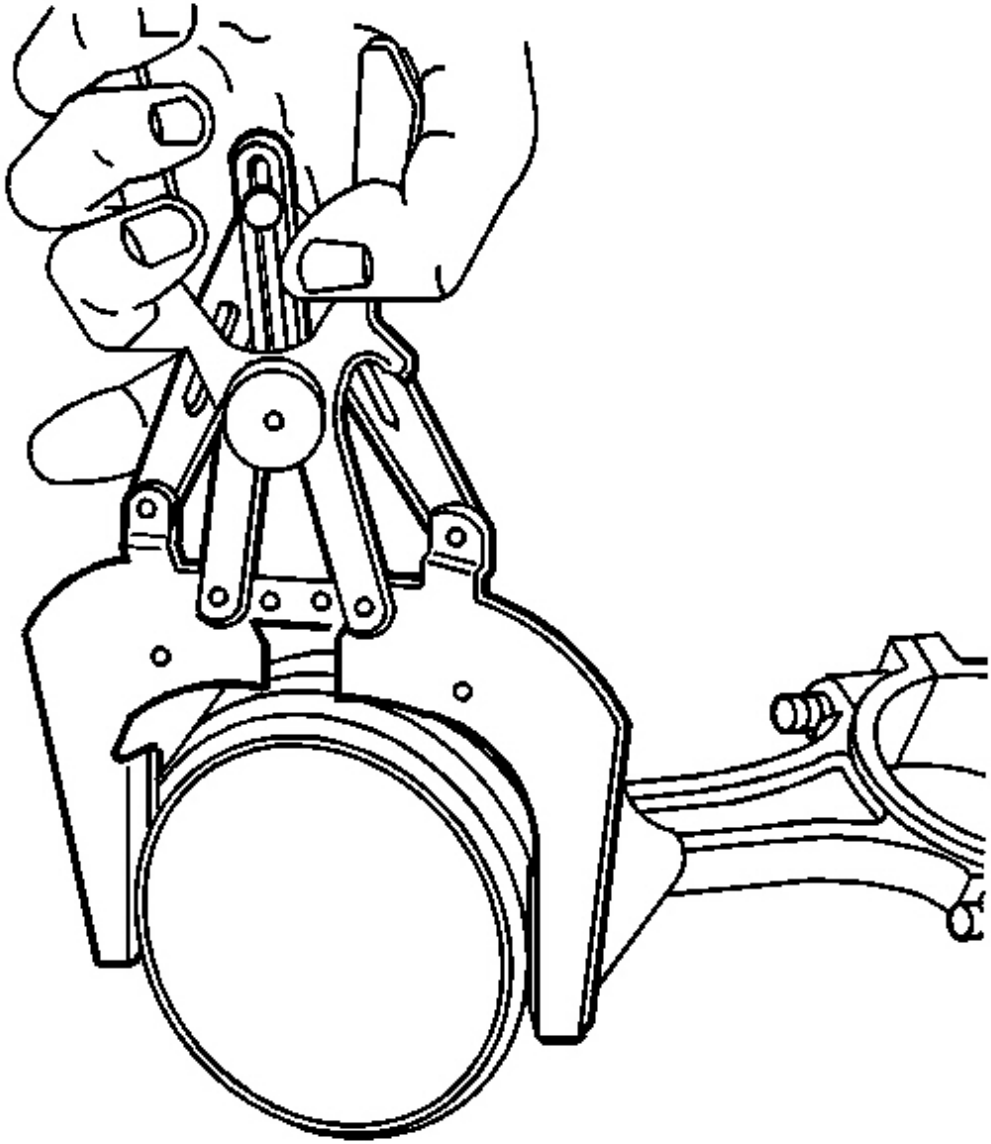


Fig. 249: Cleaning Piston Ring Grooves

Courtesy of GENERAL MOTORS CORP.

3. Clean all the piston ring grooves thoroughly with a ring groove cleaning tool.

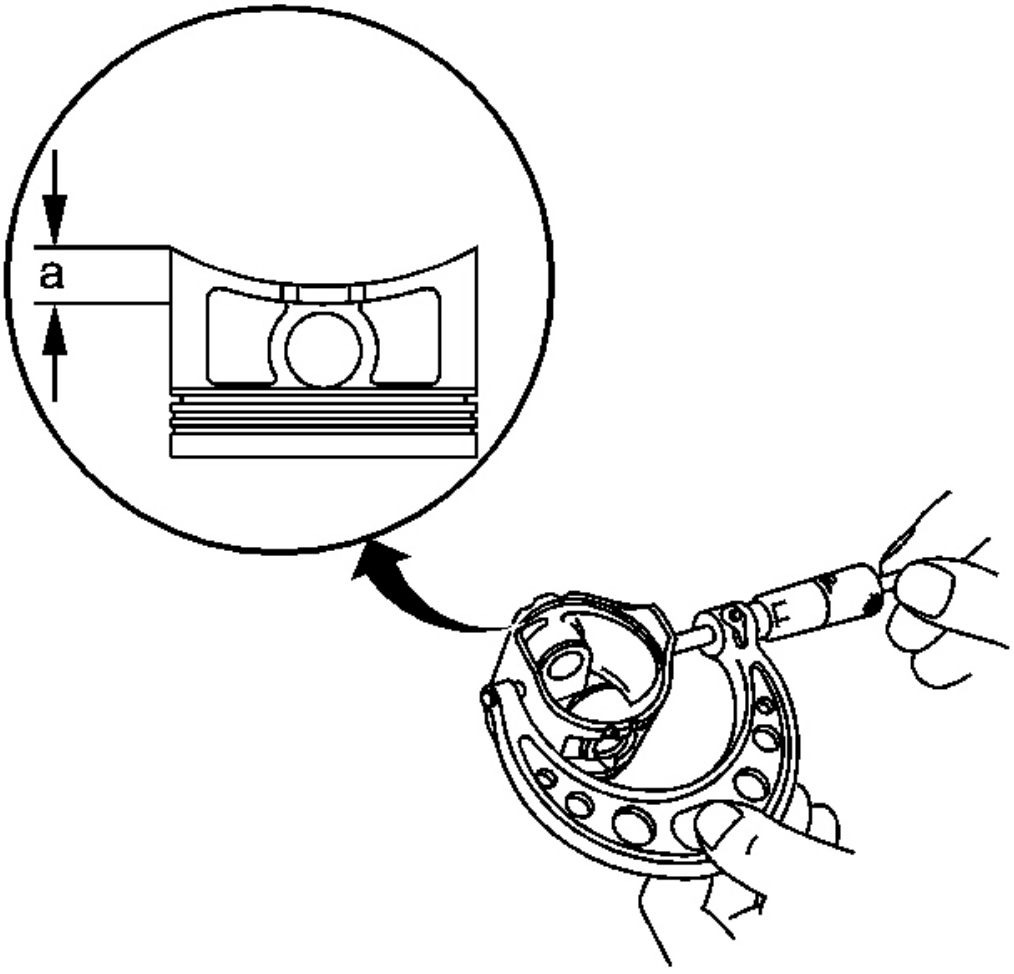


Fig. 250: Measuring Piston Diameter
Courtesy of GENERAL MOTORS CORP.

4. Measure the piston diameter at a point 16 mm (0.63 in) from the bottom of the skirt (a).

Specification:

- Piston diameter - new: 88.975-88.985 mm (3.5029-3.5033 in)
- Piston diameter - service limit: 88.965 mm (3.5026 in)

- 0.25 mm (0.0098 in) oversize piston diameter: 89.225-89.235 mm (3.5128-3.5132 in)

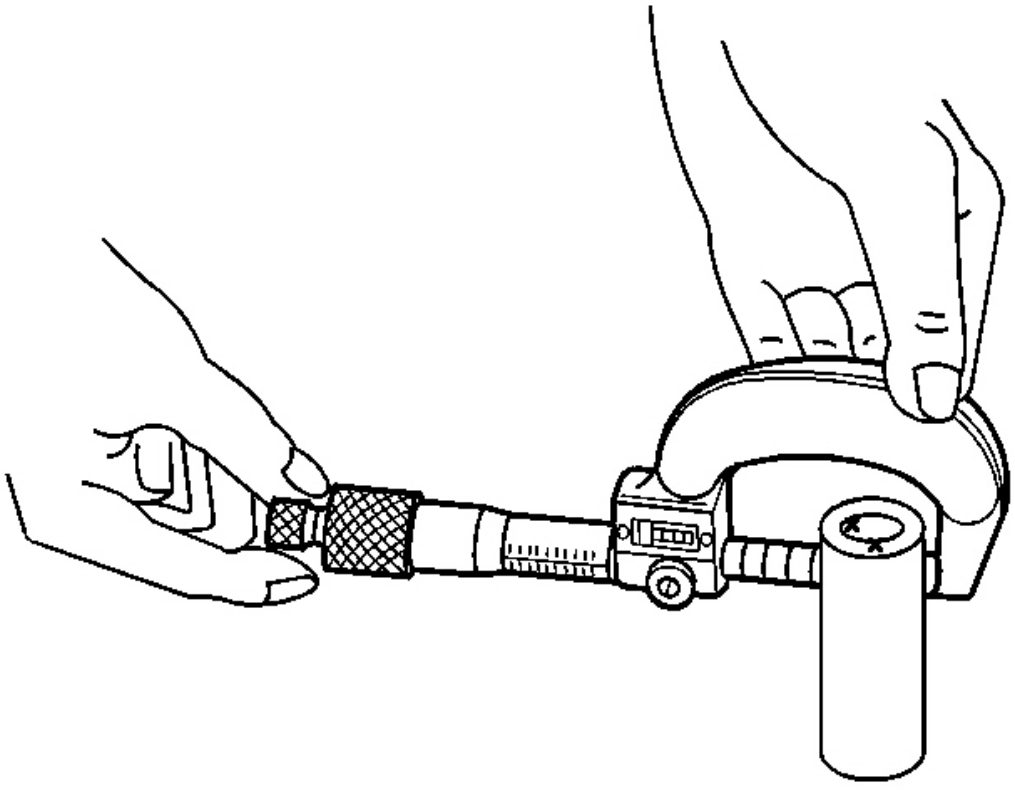


Fig. 251: Measuring Piston Pin Diameter
Courtesy of GENERAL MOTORS CORP.

5. Measure the piston pin diameter.

Specification:

- Piston pin diameter - new: 21.962-21.965 mm (0.8646-0.8648 in)
- Piston pin diameter - service: 21.954 mm (0.8643 in)

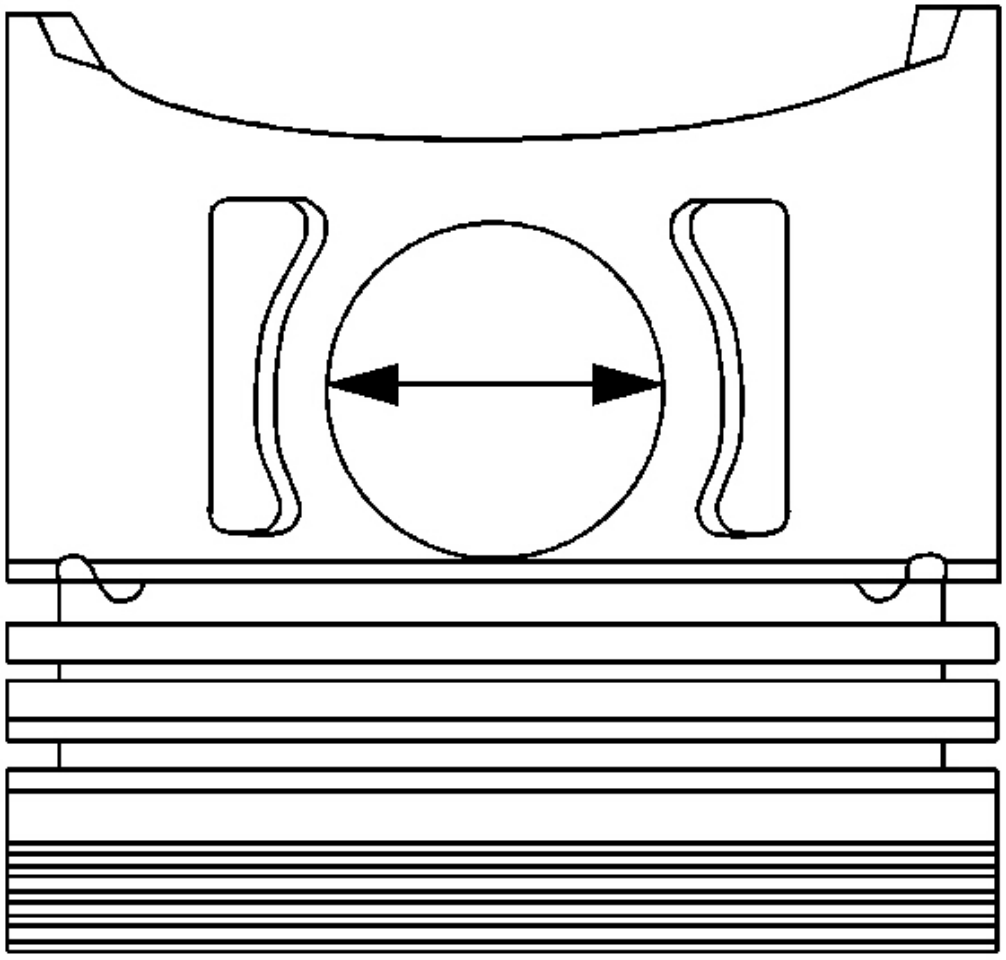


Fig. 252: Measuring Piston Pin Bore
Courtesy of GENERAL MOTORS CORP.

6. Measure the piston pin bore.
7. Calculate the pin-to-bore clearance.

Specification:

- Piston pin-to-bore clearance - new: -0.005 to +0.001 mm (-0.0002 to +0.00004 in)
- Piston pin-to-bore clearance - service limit: 0.004 mm (0.0002 in)

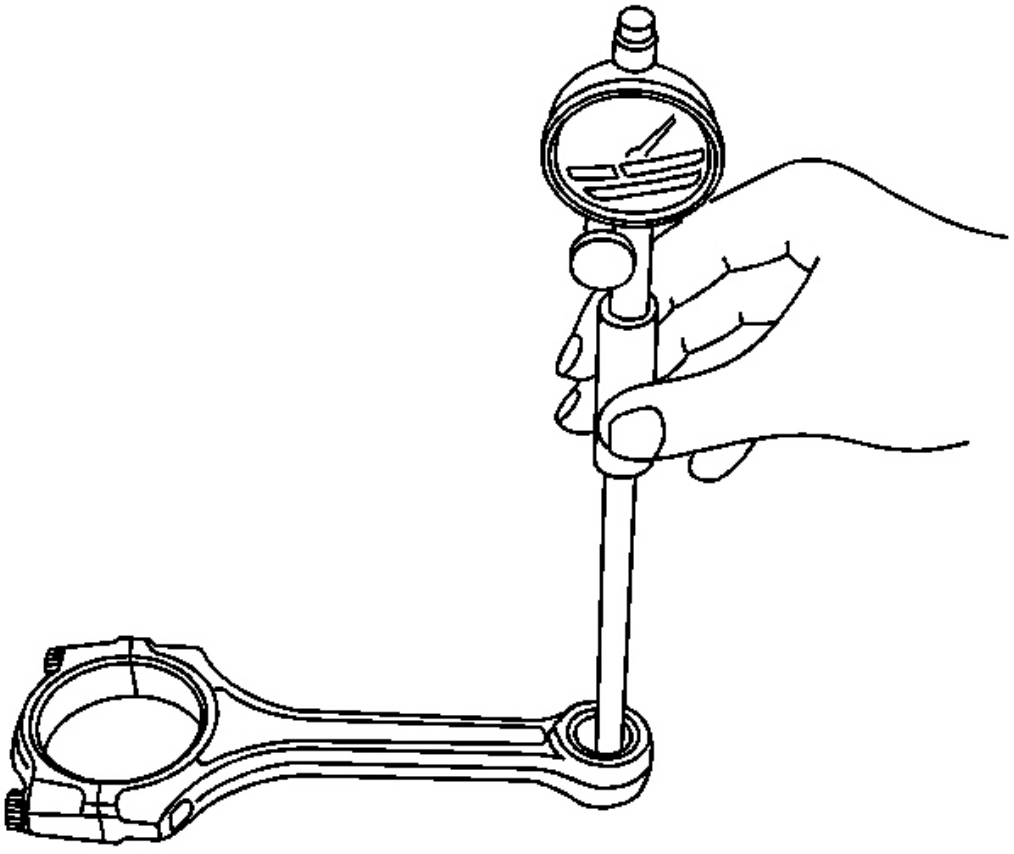


Fig. 253: Measuring Connecting Rod Pin Bore
Courtesy of GENERAL MOTORS CORP.

8. Measure the connecting rod pin bore.
9. Calculate the piston pin-to-connecting rod clearance.

Specification:

- Piston pin-to-connecting rod clearance - new: 0.005-0.014 mm (0.0002-0.0006 in)
- Piston pin-to-connecting rod clearance - service limit: 0.019 mm (0.0007 in)

Connecting Rod Bolt Inspection

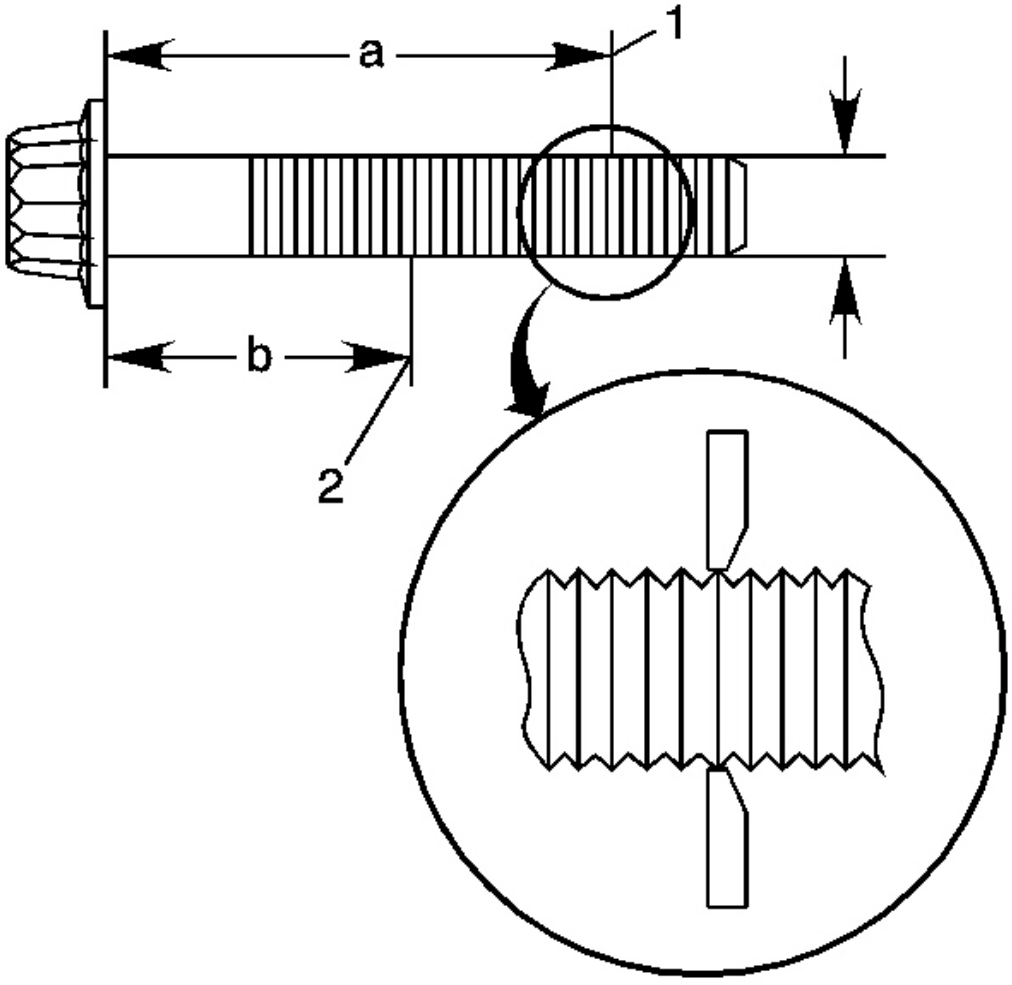


Fig. 254: Measuring Diameter Of Connecting Rod Bolt
Courtesy of GENERAL MOTORS CORP.

1. Measure the diameter of each connecting rod bolt at the 2 measurement points (1 and 2) - 35 mm (1.38 in) (a) and 20 mm (0.79 in) (b).
2. Calculate the difference between the 2 measurements. If the difference between the 2 measurements exceeds the specification, replace the bolt.

Specification: Connecting rod bolt - difference in diameter: 0.0-0.1 mm (0.0-0.004 in)

Piston Selection

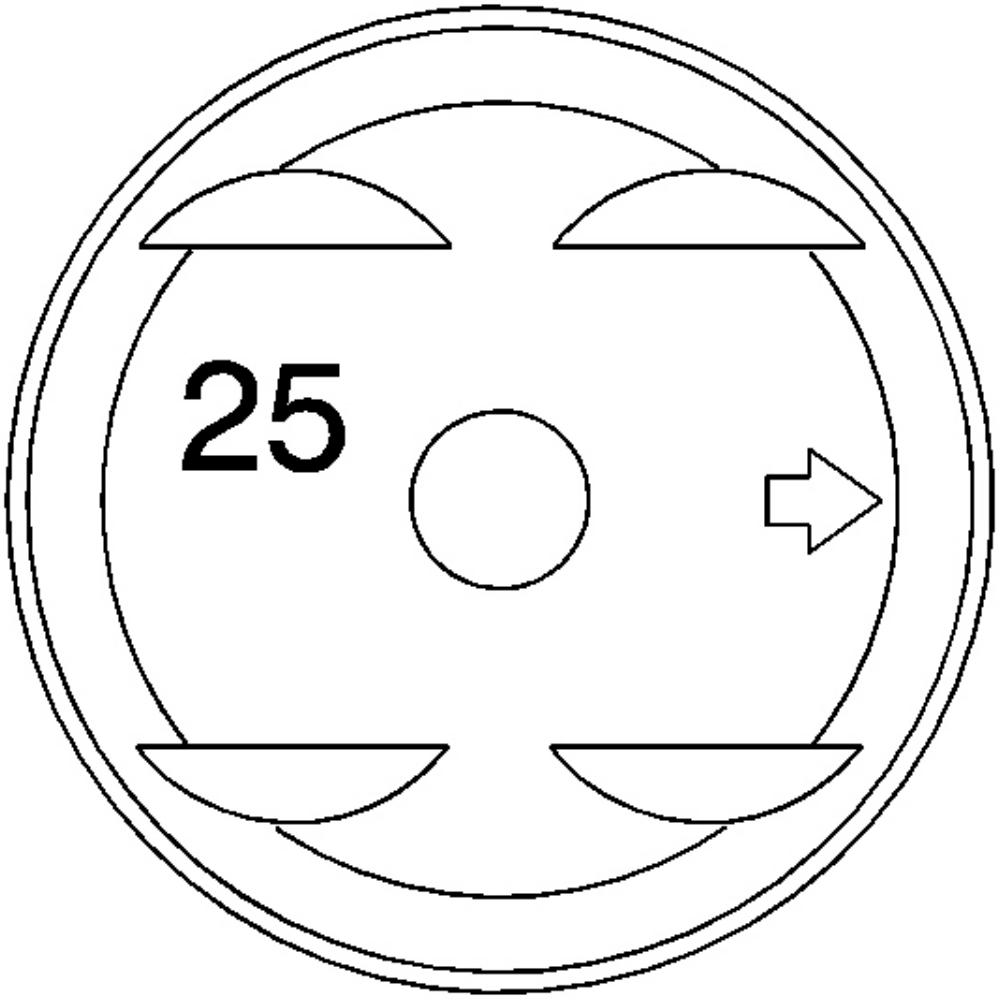


Fig. 255: Measuring Piston Diameter
Courtesy of GENERAL MOTORS CORP.

1. Measure the piston diameter.
2. Measure the cylinder bore diameter. Refer to **Engine Block Cleaning and Inspection** .
3. Calculate the clearance between the piston and the cylinder bore.

Specification:

- Piston-to-bore clearance - new: 0.015-0.04 mm (0.0006-0.0016 in)
- Piston-to-bore clearance - service limit: 0.08 mm (0.003 in)

4. A 0.25 mm (0.010 in) oversize piston can be identified by the numbers 25 on the top of the piston.

Piston Ring Selection

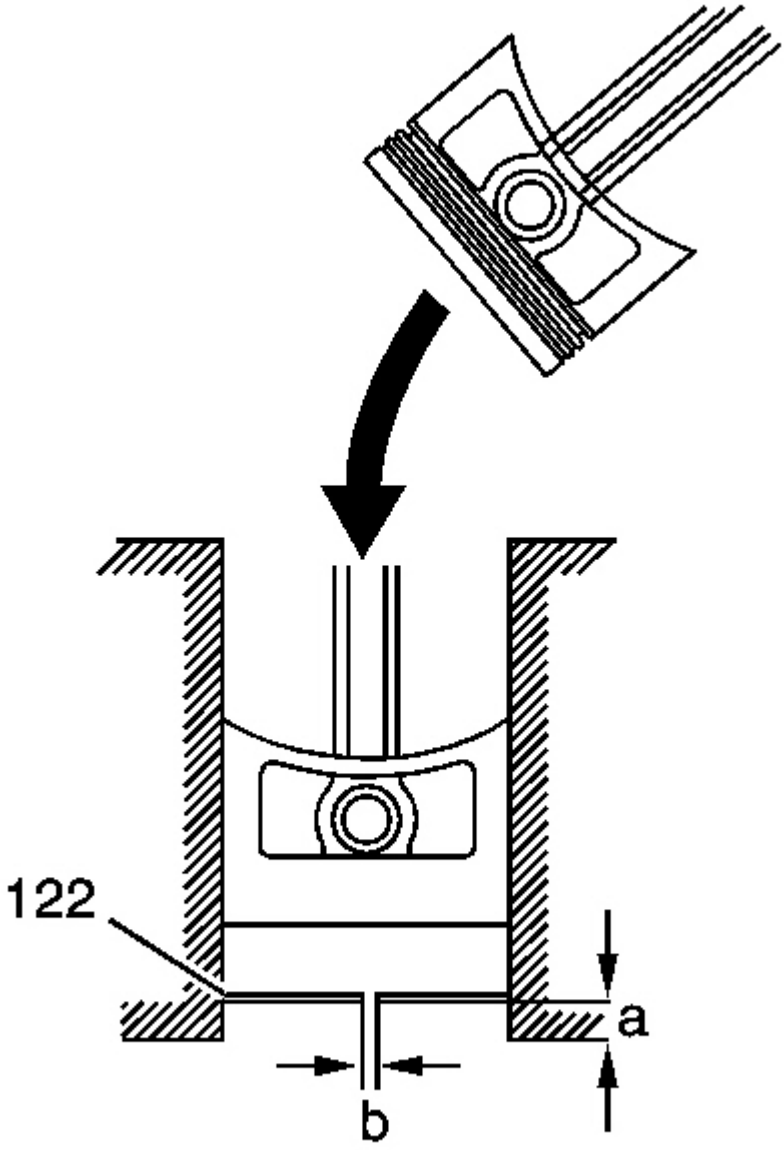


Fig. 256: View Of Piston Ring
Courtesy of GENERAL MOTORS CORP.

1. Insert the piston ring (122) into the cylinder 15-20 mm (0.6-0.8 in) (a) from the bottom of the bore.
2. Measure the piston ring end gap (b) with a feeler gage.
    1. If the gap is too small, check to see if you have the proper rings for the application.
    2. If the gap is too large, check the cylinder bore diameter against the wear limits. Refer to **Engine Block Cleaning and Inspection** .
    3. If the bore diameter exceeds the service limit, the cylinder block must be bored and fitted with oversize pistons and piston rings.

        Specification:

        - Piston ring end gap - top ring - production: 0.2-0.35 mm (0.008-0.014 in)
        - Piston ring end gap - second ring - production: 0.4-0.55 mm (0.016-0.022 in)
        - Piston ring end gap - oil ring - production: 0.2-0.7 mm (0.008-0.028 in)
        - Piston ring end gap - top ring - service limit: 0.6 mm (0.024 in)
        - Piston ring end gap - second ring - service limit: 0.7 mm (0.028 in)
        - Piston ring end gap - oil ring - service limit: 0.8 mm (0.031 in)

PISTON AND CONNECTING ROD ASSEMBLE

Tools Required

J 25070 Heat Gun or equivalent

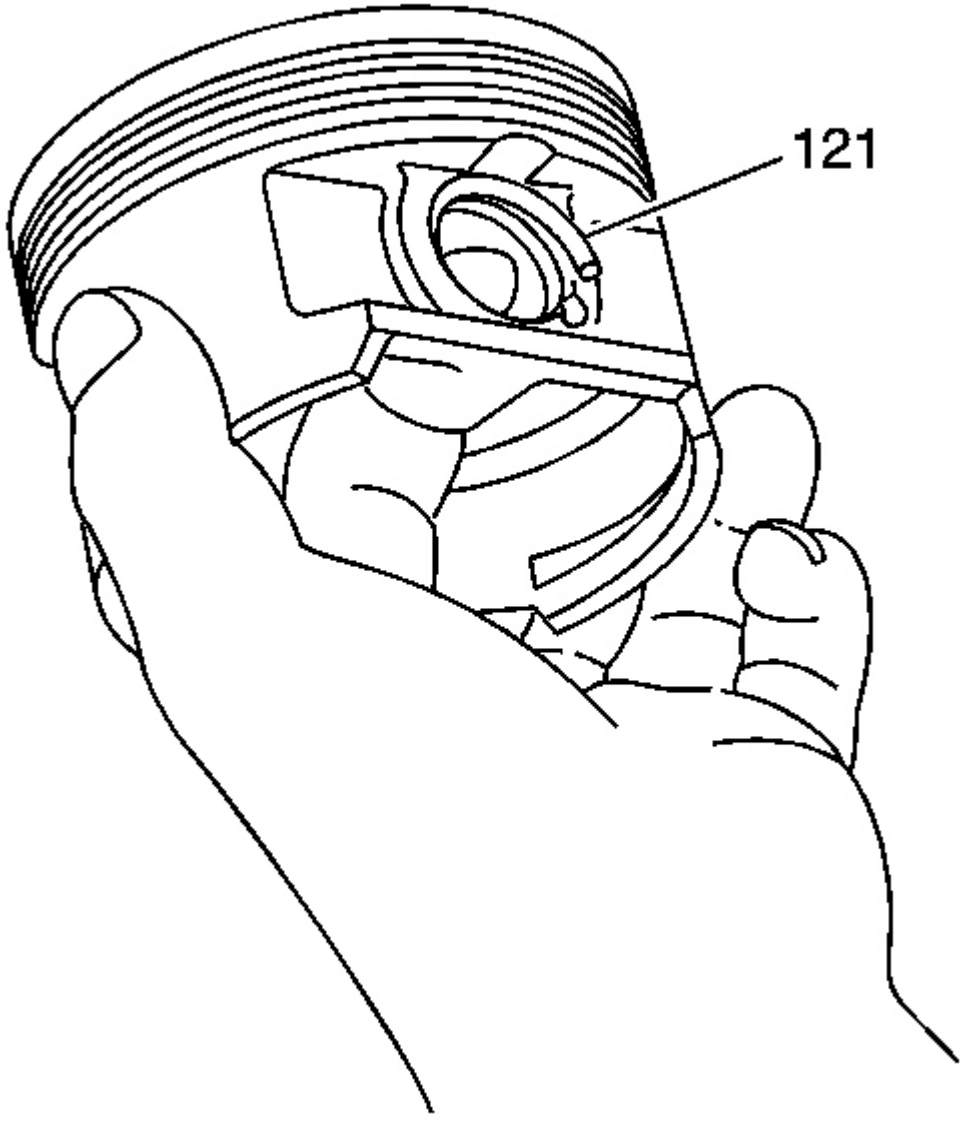


Fig. 257: View Of Connecting Rod
Courtesy of GENERAL MOTORS CORP.

1. Install 1 retaining clip (121).
2. Apply clean engine oil to the piston pin bore, piston pin, and connecting rod pin bore.

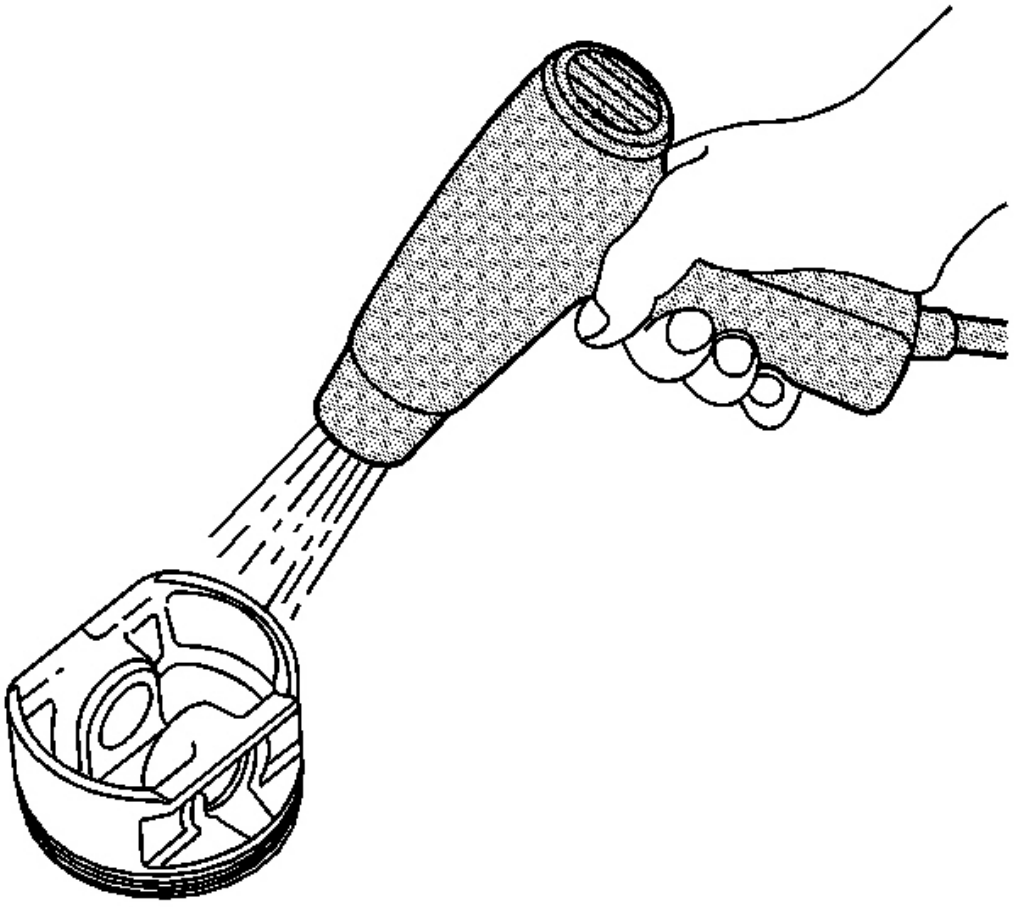


Fig. 258: Using J 25070
Courtesy of GENERAL MOTORS CORP.

3. Use the **J 25070** or equivalent in order to heat the piston to approximately 70°C (158°F).

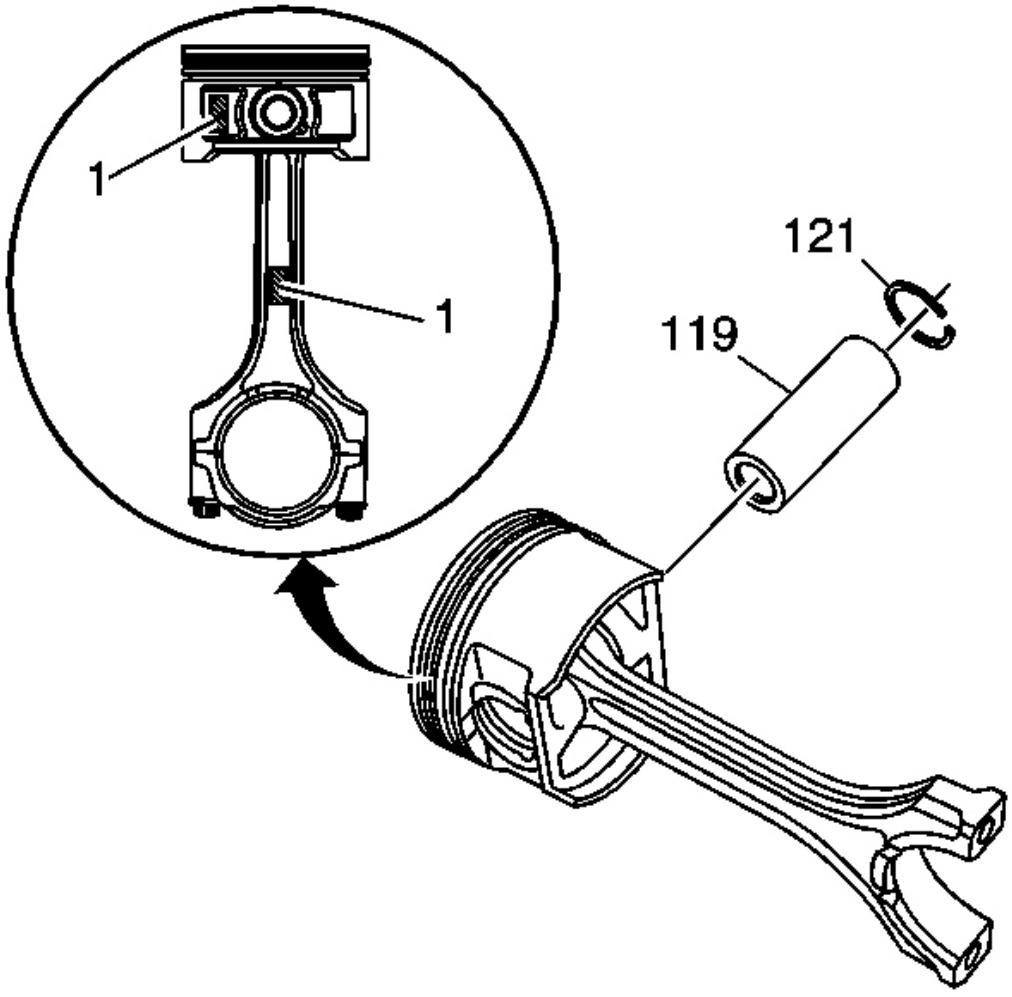


Fig. 259: View Of Piston Pin & Clip
Courtesy of GENERAL MOTORS CORP.

4. Assemble the piston and connecting rod with the alignment marks (1) on the same side.
5. Install the piston pin (119) and clip (121).

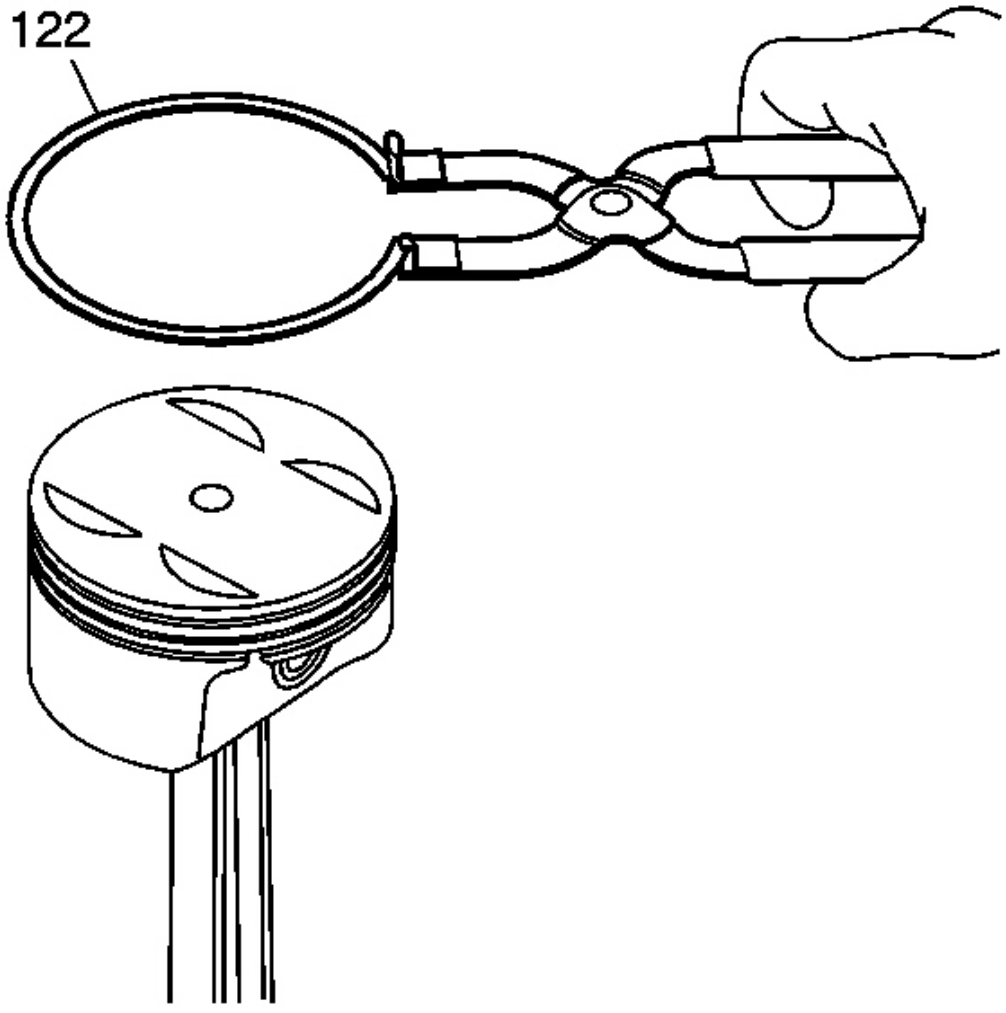


Fig. 260: View Of Piston Rings
Courtesy of GENERAL MOTORS CORP.

6. Install the piston rings (122).

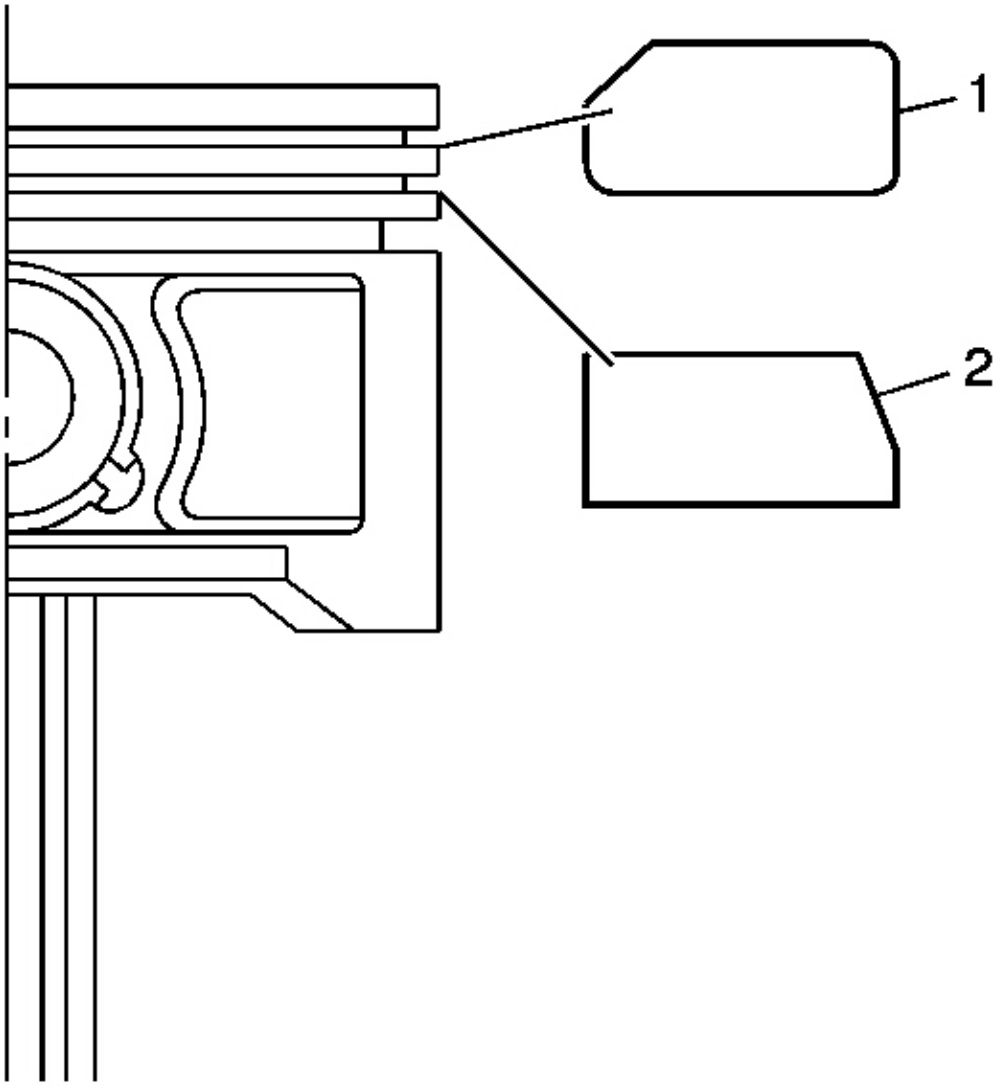


Fig. 261: View Of Manufacturing Identification Marks
Courtesy of GENERAL MOTORS CORP.

7. The top compression ring (1) has a 1D identification mark. The second compression ring (2) has a 2C identification mark. The manufacturing identification marks must face the top of the piston.

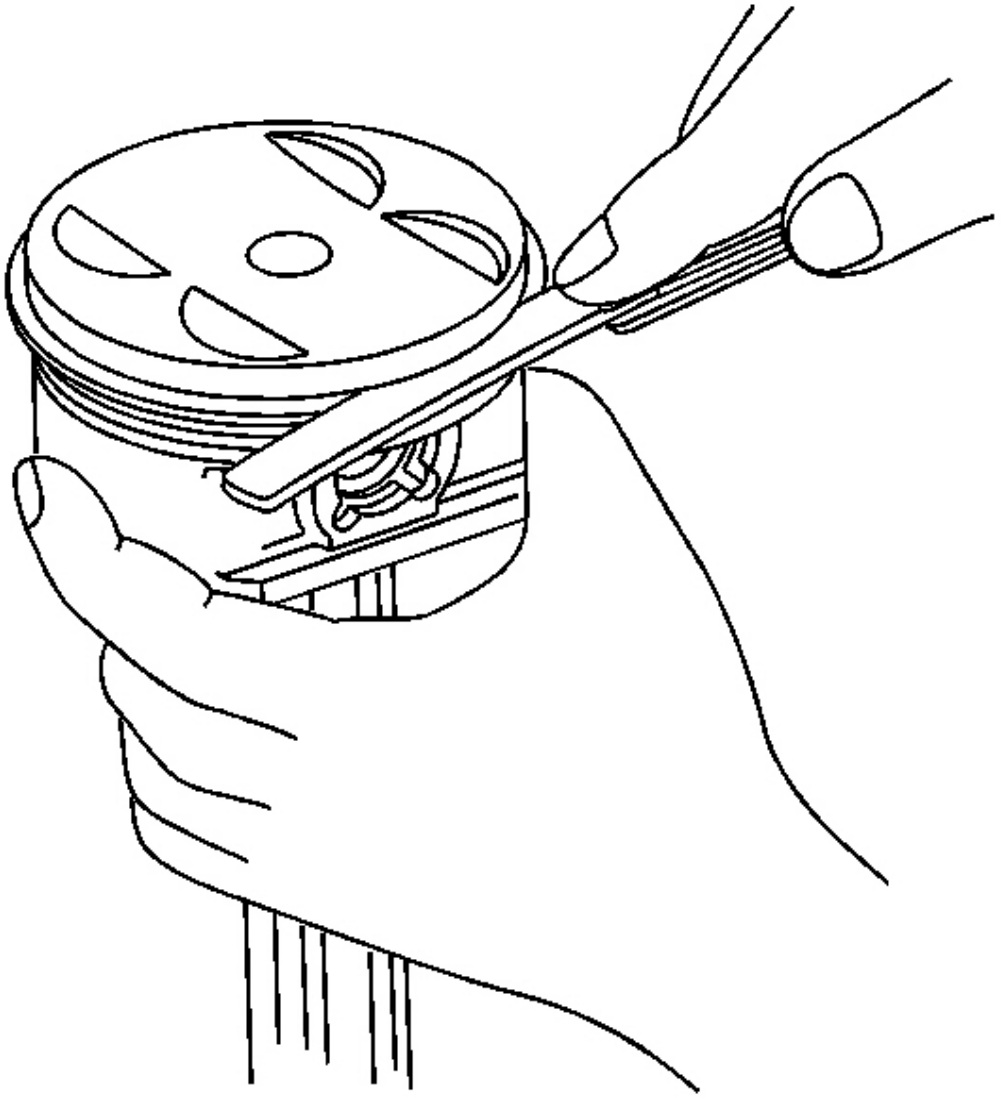


Fig. 262: Measuring Ring-To-Groove Clearance
Courtesy of GENERAL MOTORS CORP.

8. Using a feeler gage, measure the ring-to-groove clearance.

Specification:

- Top compression ring clearance - new: 0.055-0.08 mm (0.0022-0.0031 in)
- Top compression ring clearance - service limit: 0.15 mm (0.006 in)

- Second compression ring clearance - new: 0.03-0.055 mm (0.0012-0.0022 in)
- Second compression ring clearance - service limit: 0.13 mm (0.005 in)

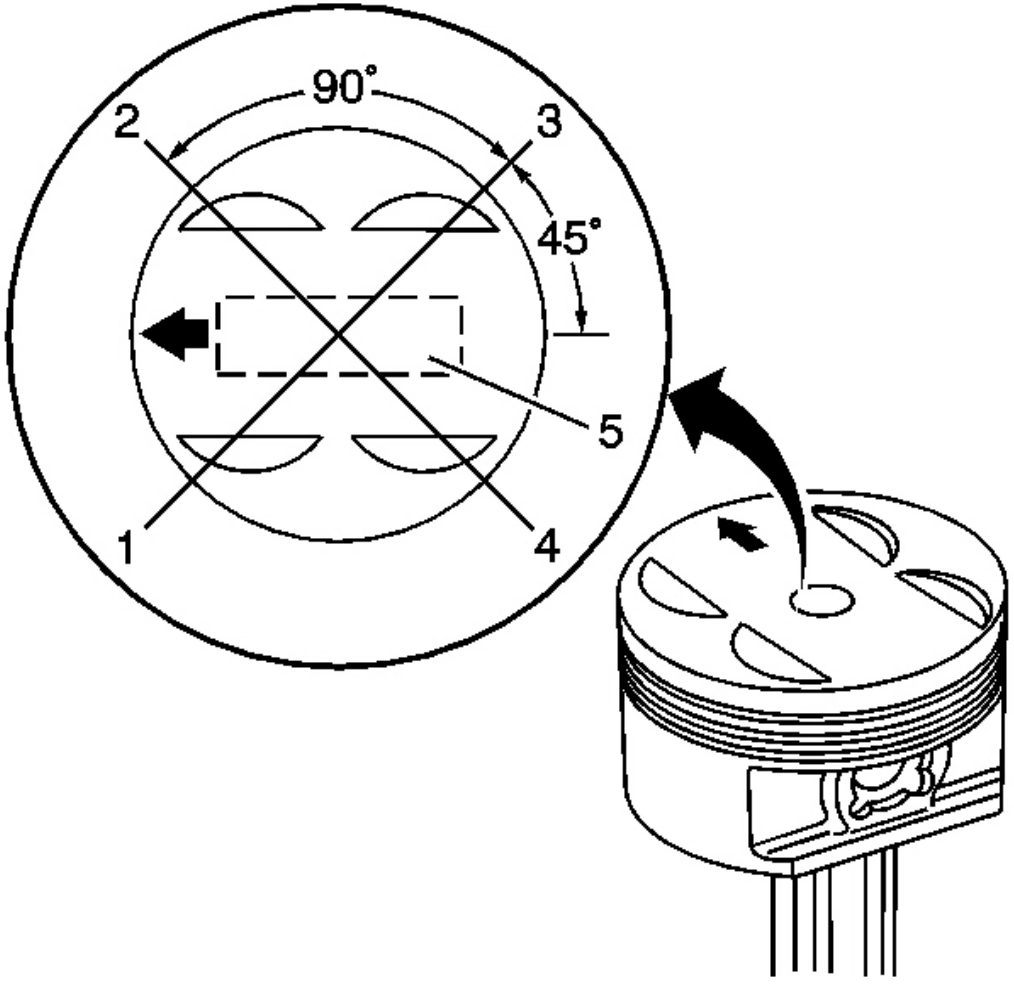


Fig. 263: View Of Piston Rings
Courtesy of GENERAL MOTORS CORP.

9. Rotate the piston rings in order to position the end gaps. Do not position any ring gap at the piston thrust surface. Do not position any ring gap in line with the piston pin and pin bore.
    - Top compression ring (1)
    - Oil spacer ring (1)
    - Oil rings (2, 4)

- Second compression ring (3)
- Piston pin (5)

CAMSHAFTS CLEANING AND INSPECTION

Tools Required

- **J 7872** Magnetic Base Dial Indicator
- **SA9179NE** Dial Indicator

Camshaft Inspection

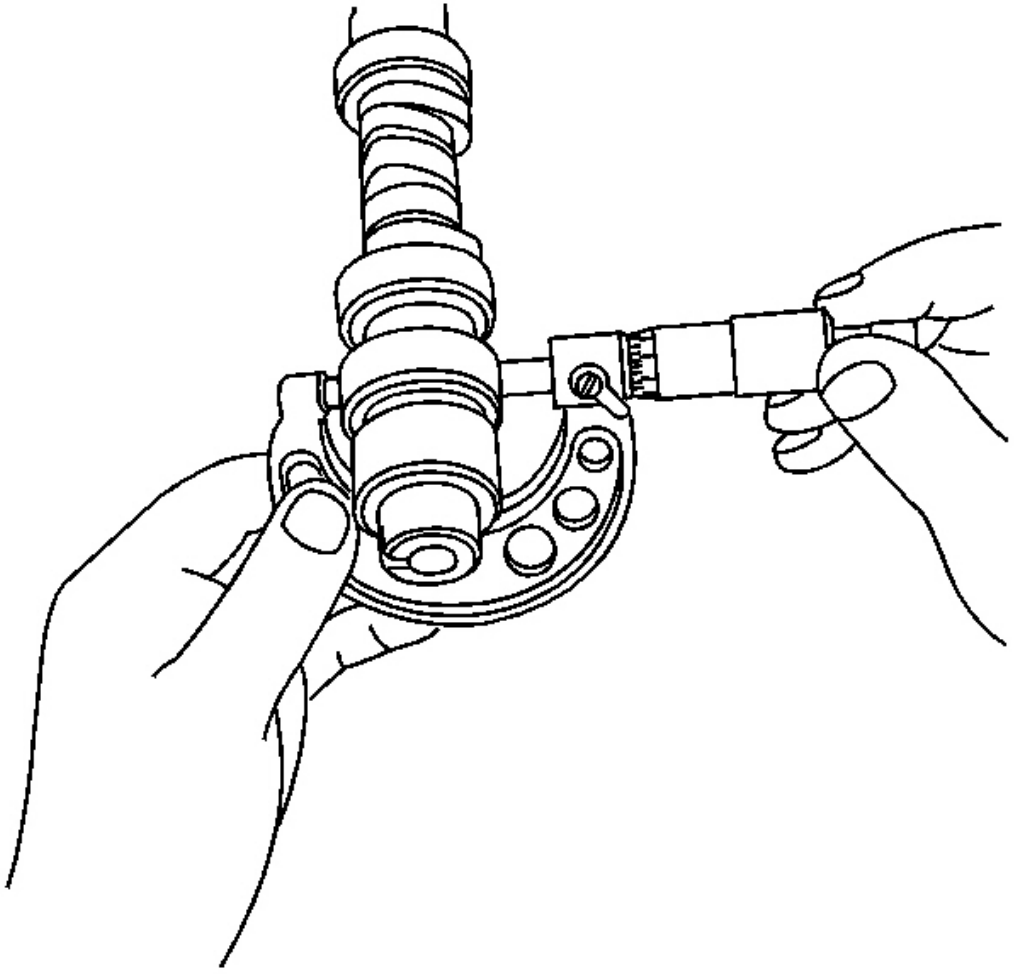


Fig. 264: Cleaning Camshaft
Courtesy of GENERAL MOTORS CORP.

1. Clean the camshaft and inspect for pitted, scored or excessively worn lobes.
2. Measure the diameter of each bearing journal.

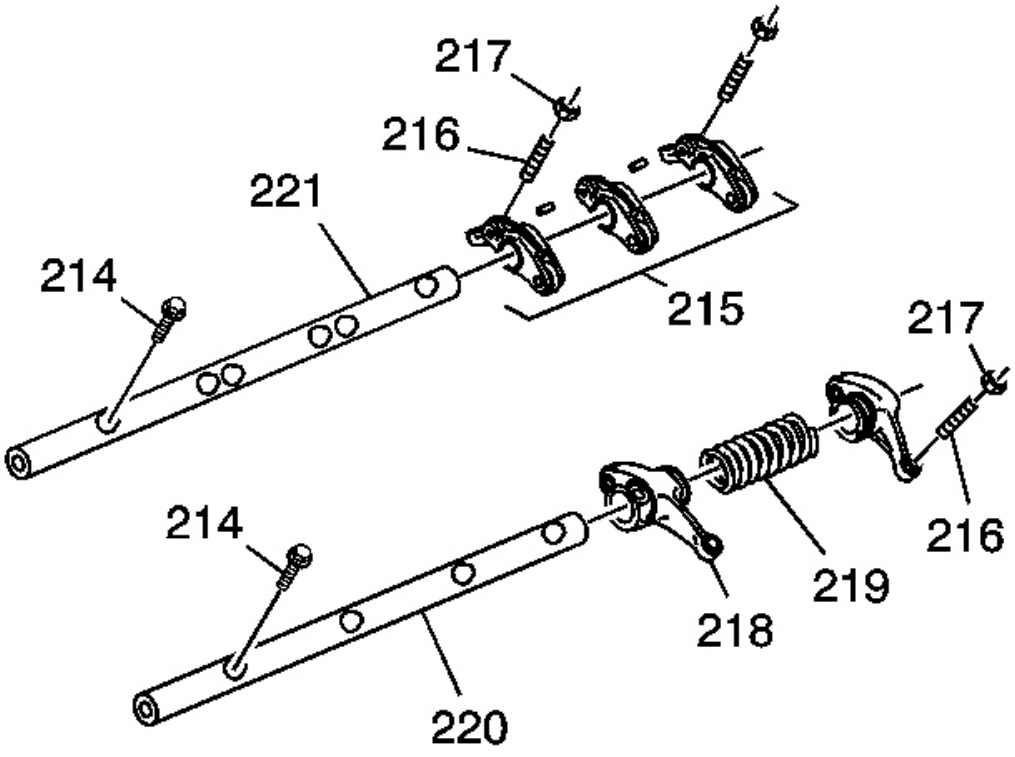


Fig. 265: View Of Intake Valve Rocker Arms
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: In order to properly measure the camshaft journal bores, the rocker arm shafts must be bolted to the cylinder heads.

3. Remove the rocker arms (215, 218) and springs (219) from the shafts (220, 221).
4. Lubricate the bolt threads and flanges with clean engine oil.
5. Install the rocker arm shafts and bolts to the cylinder heads.

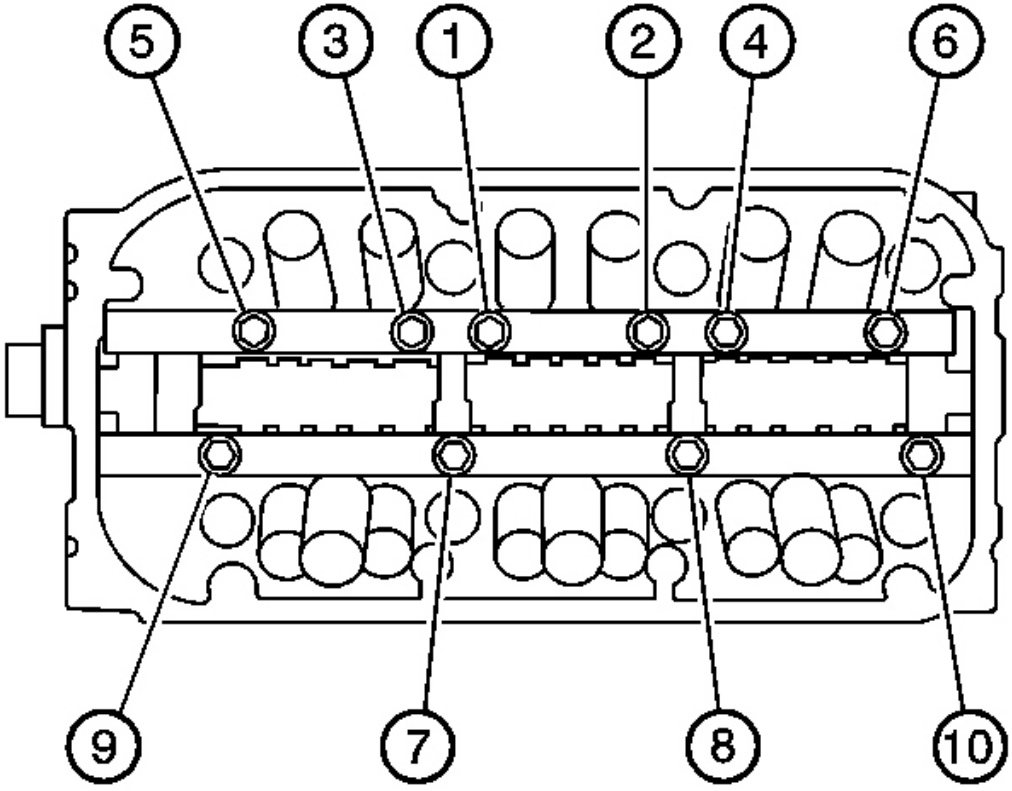


Fig. 266: View Of Cylinder Head Rocker Shaft Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

6. Tighten the left cylinder head rocker shaft bolts in sequence.

Tighten:

1. Tighten the bolts a first pass to 12 N.m (106 lb in).
2. Tighten the bolts a final pass to 24 N.m (17 lb ft).

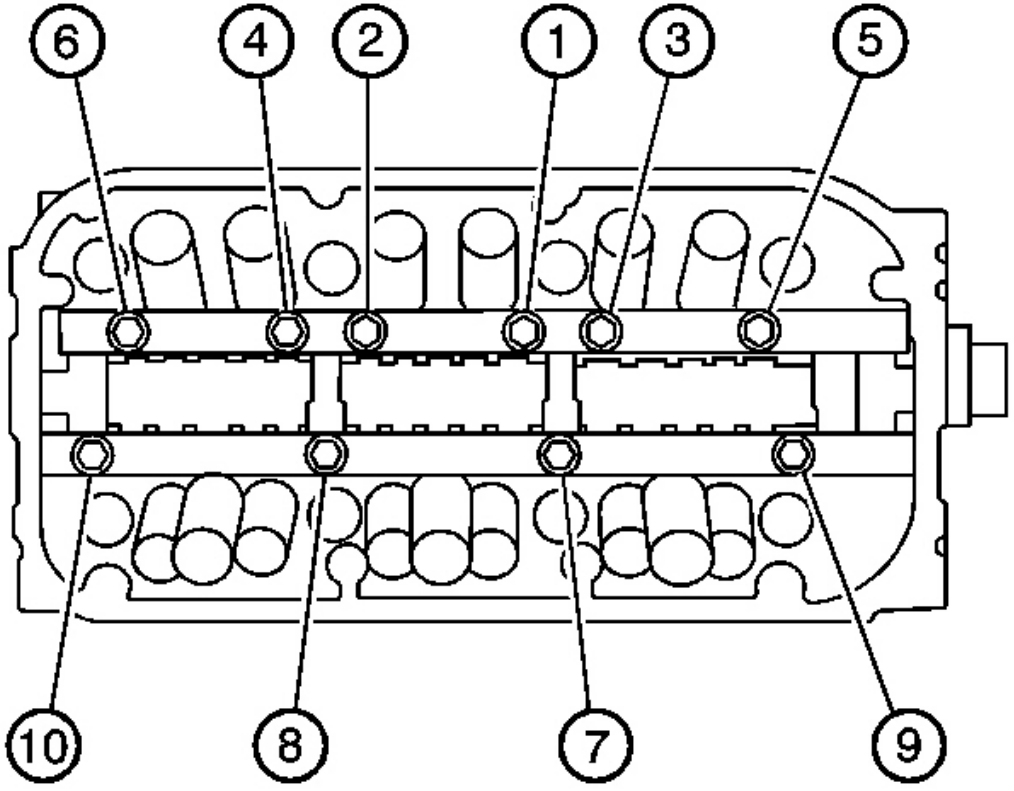


Fig. 267: Identifying Cylinder Head Rocker Shaft Bolts
Courtesy of GENERAL MOTORS CORP.

7. Tighten the right cylinder head rocker shaft bolts in sequence.

   Tighten:

   1. Tighten the bolts a first pass to 12 N.m (106 lb in).
   2. Tighten the bolts a final pass to 24 N.m (17 lb ft).

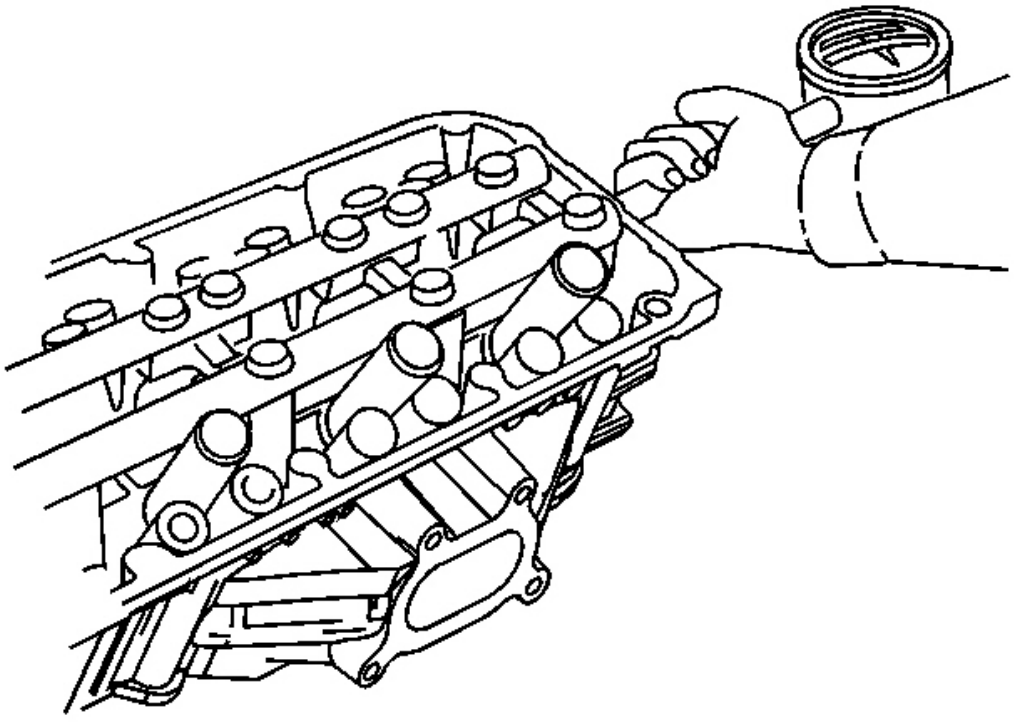


Fig. 268: Measuring The Inside Diameter (I.D.) Of Camshaft Bearing Surface
Courtesy of GENERAL MOTORS CORP.

8. Clean the bearing surfaces in the cylinder head and measure the inside diameter (I.D.) of each camshaft bearing surface. Also check for an out-of-round condition.
9. Calculate the camshaft-to-journal clearance.

Specification:

- Camshaft-to-journal clearance - new: 0.05-0.2 mm (0.002-0.008 in)
- Camshaft-to-journal clearance - service limit: 0.2 mm (0.008 in)

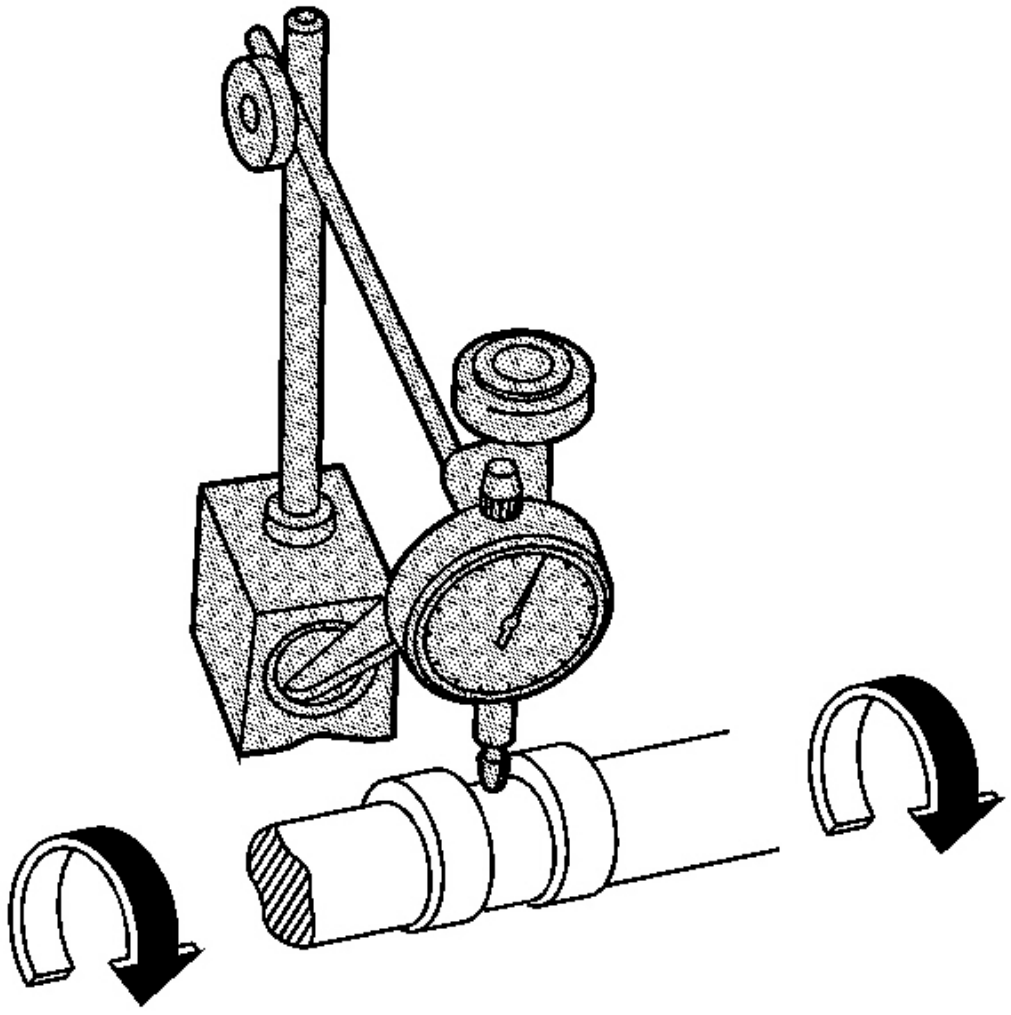


Fig. 269: View Of Camshaft Onto V-Blocks
Courtesy of GENERAL MOTORS CORP.

10. Install the camshaft into V-blocks and use the **J 7872** to measure the runout.

    Specification:

    - Camshaft total runout - new: 0.03 mm (0.001 in)
    - Camshaft total runout - service limit: 0.04 mm (0.002 in)

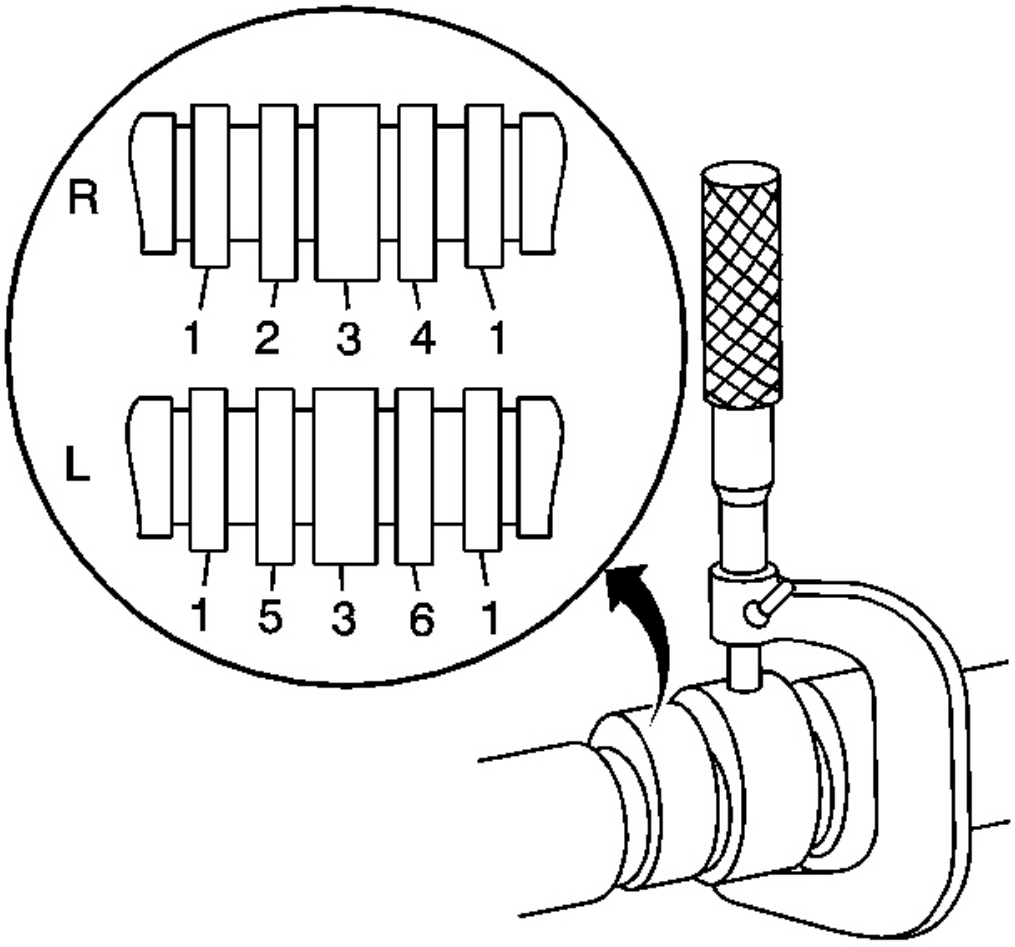


Fig. 270: Identifying Camshaft Lobes
Courtesy of GENERAL MOTORS CORP.

11. Identify the camshaft lobes.
    - Exhaust (1)
    - Intake primary - right cylinder head (2)
    - Intake mid (3)
    - Intake secondary - right cylinder head (4)
    - Intake secondary - left cylinder head (5)
    - Intake primary - left cylinder head (6)
12. Measure the camshaft lobe height. If the measurement is less than the specification, replace the camshaft.

Specification:

- Intake primary lobe height: 35.041 mm (1.3796 in)
- Intake mid lobe height: 36.445 mm (1.4348 in)
- Intake secondary lobe height: 35.284 mm (1.3891 in)
- Exhaust lobe height: 36.326 mm (1.4302 in)

Measuring Camshaft End Play

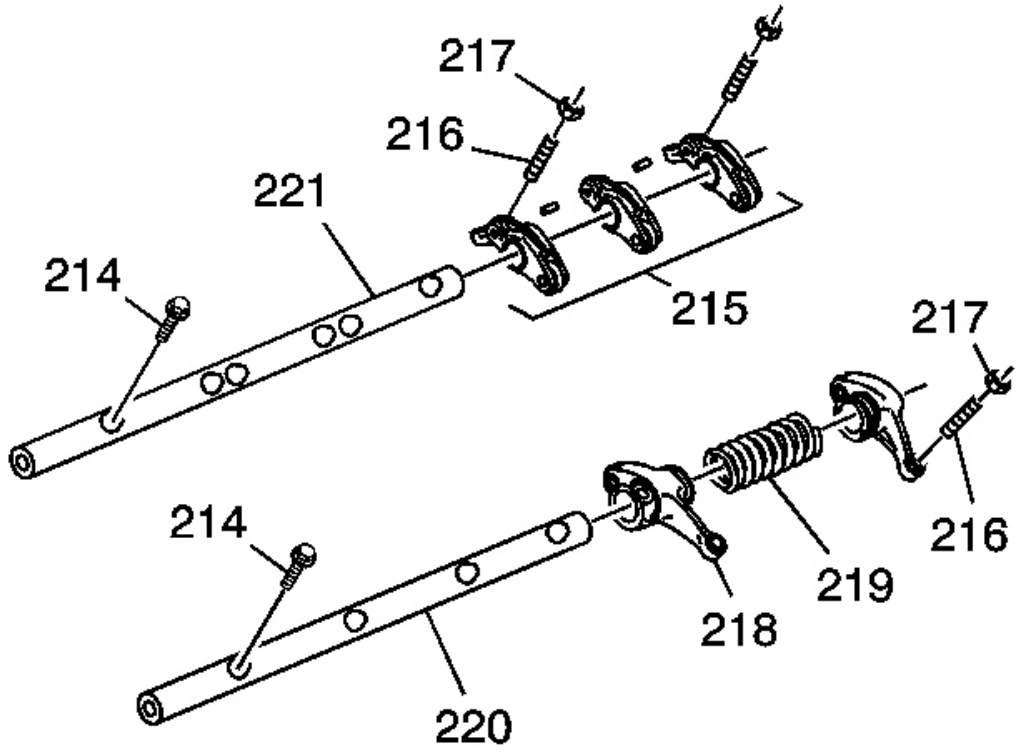


Fig. 271: View Of Intake Valve Rocker Arms
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: In order to properly measure camshaft end play, the rocker arm shafts must be bolted to the cylinder heads.

1. Remove the rocker arms (215 and 218) and springs (219) from the shafts (220 and 221).
2. Lubricate the bolt (214) threads and flanges with clean engine oil.
3. Install the rocker arm shafts (220, 221) and bolts (214) to the cylinder heads.

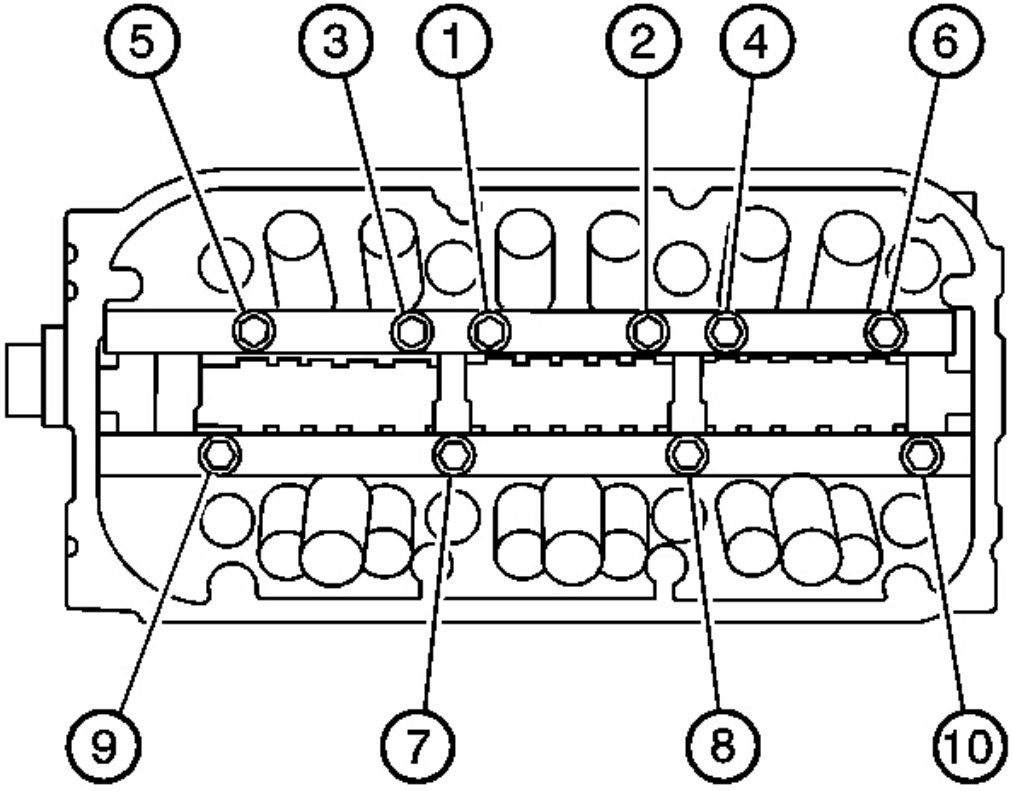


Fig. 272: View Of Cylinder Head Rocker Shaft Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Tighten the left cylinder head rocker shaft bolts in sequence.

Tighten:

1. Tighten the bolts a first pass to 12 N.m (106 lb in).
2. Tighten the bolts a final pass to 24 N.m (17 lb ft).

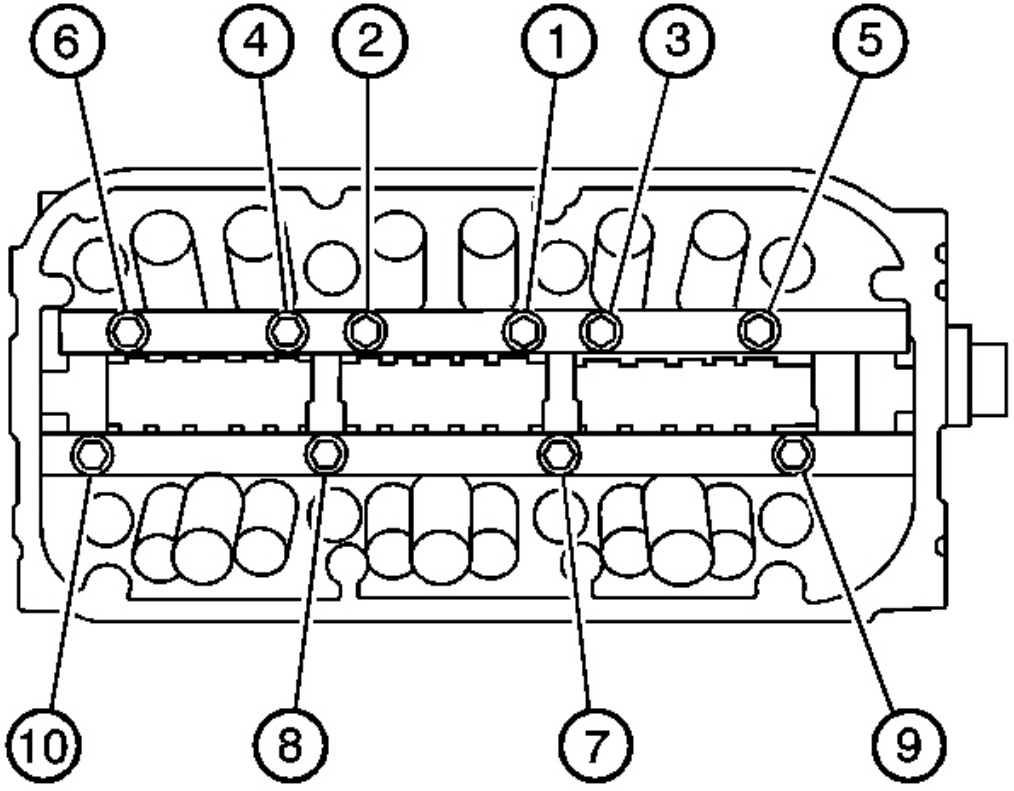


Fig. 273: Identifying Cylinder Head Rocker Shaft Bolts
Courtesy of GENERAL MOTORS CORP.

5. Tighten the right cylinder head rocker shaft bolts in sequence.

   Tighten:

   1. Tighten the bolts a first pass to 12 N.m (106 lb in).
   2. Tighten the bolts a final pass to 24 N.m (17 lb ft).

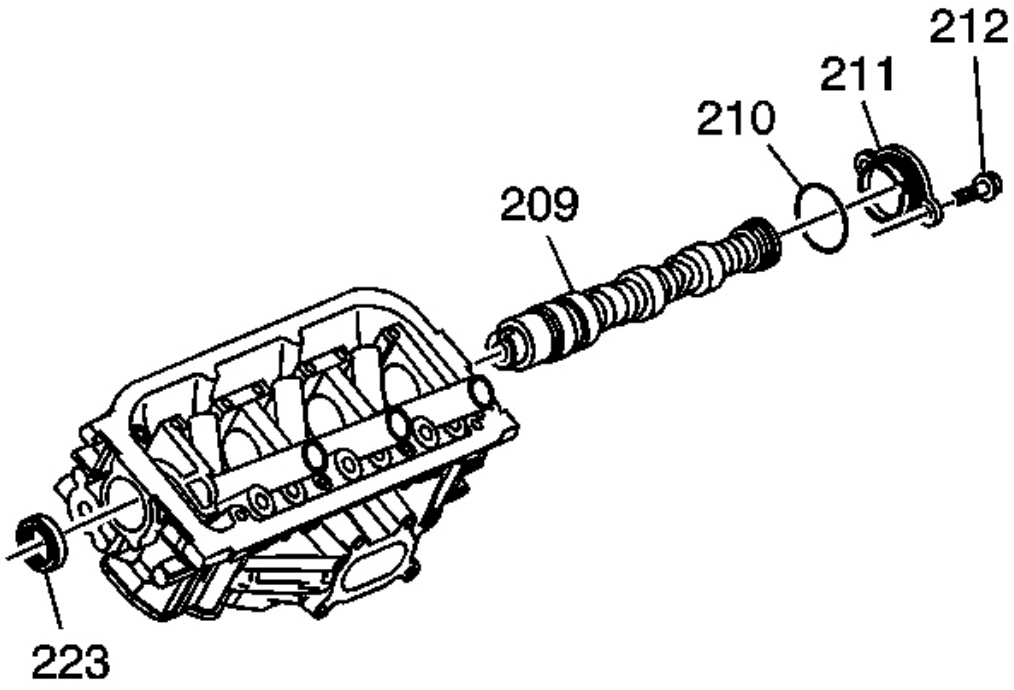


Fig. 274: Identifying Camshaft Journals
Courtesy of GENERAL MOTORS CORP.

6. Install the camshafts (209), caps (211), and bolts (212).

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

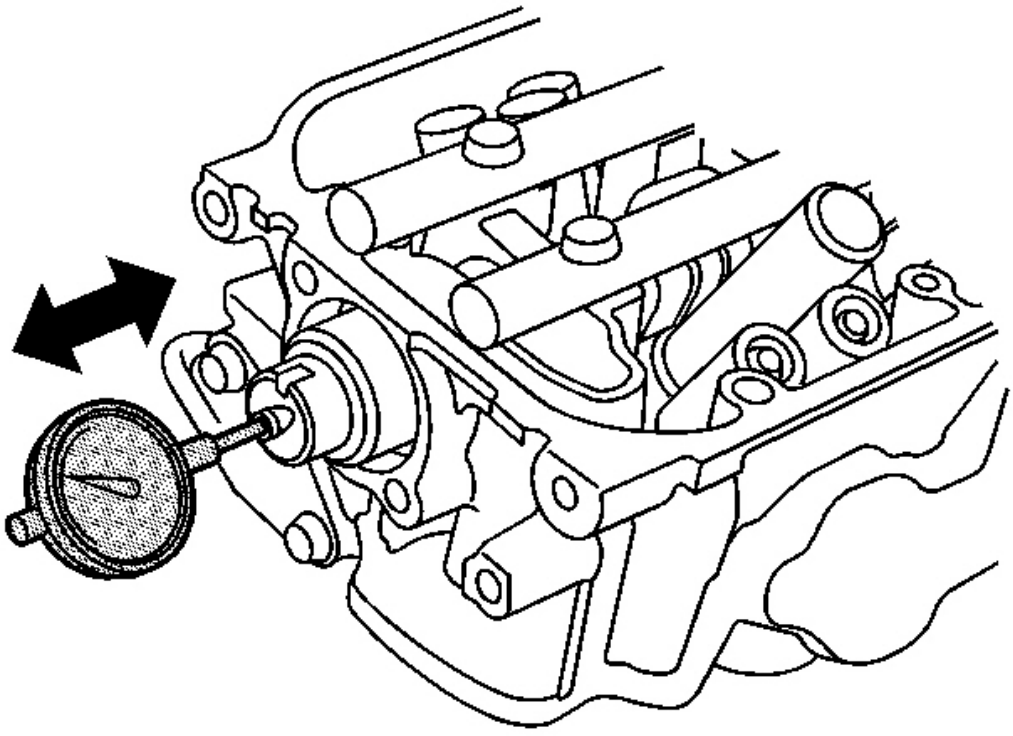


Fig. 275: View Of Camshaft Pushing It Toward The Rear Of The Cylinder Head
Courtesy of GENERAL MOTORS CORP.

7. Seat the camshaft by pushing it toward the rear of the cylinder head.
8. Use the **SA9179NE** in order to measure the end play. Zero the dial indicator against the end of the camshaft. Push the camshaft forward and rearward and measure the end play.

Specification:

- Camshaft end play - new: 0.05-0.2 mm (0.002-0.008 in)
- Camshaft end play - service limit: 0.2 mm (0.008 in)

CAMSHAFT TIMING DRIVE COMPONENTS CLEANING AND INSPECTION

Tools Required

EN 46330 Timing Belt Tensioner Retaining Pin. See **Special Tools and Equipment** .

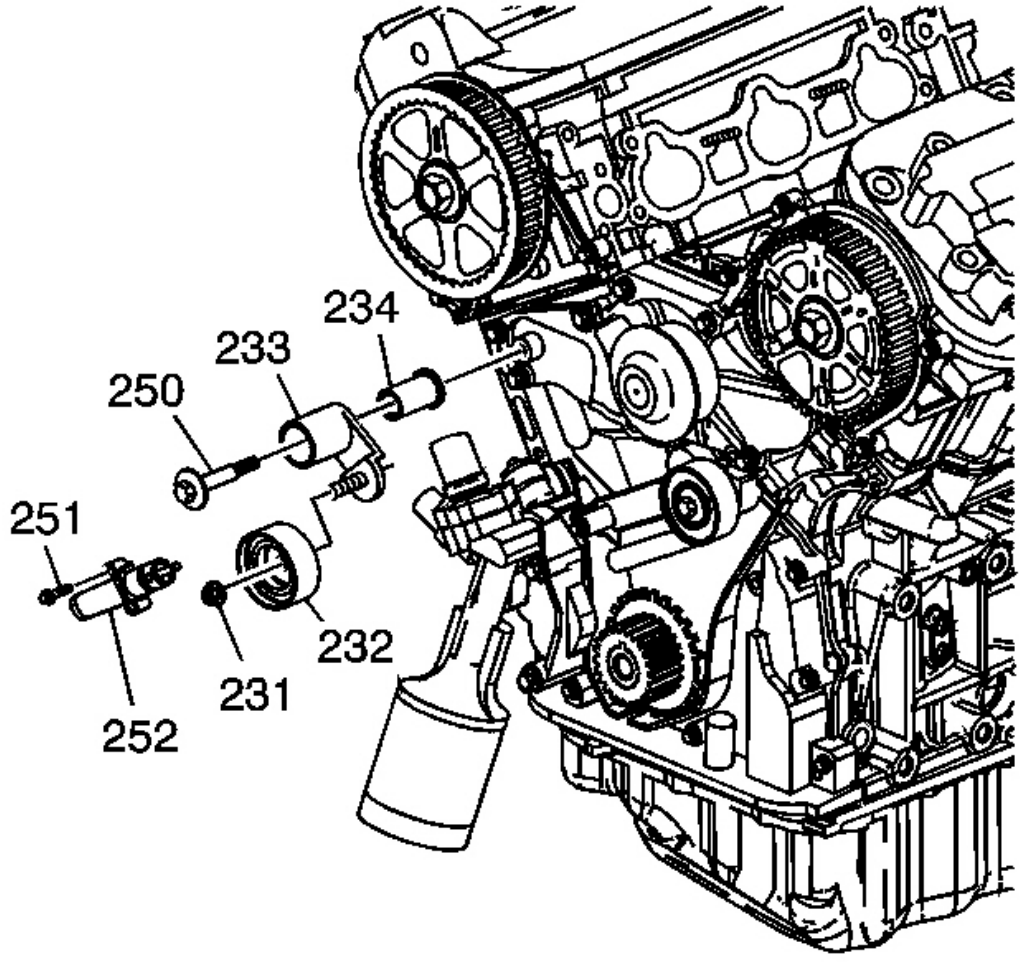


Fig. 276: View Of Camshaft Timing Components
Courtesy of GENERAL MOTORS CORP.

1. Inspect the tensioner pulley (232) for a grooved or worn belt contact surface or worn bearing.

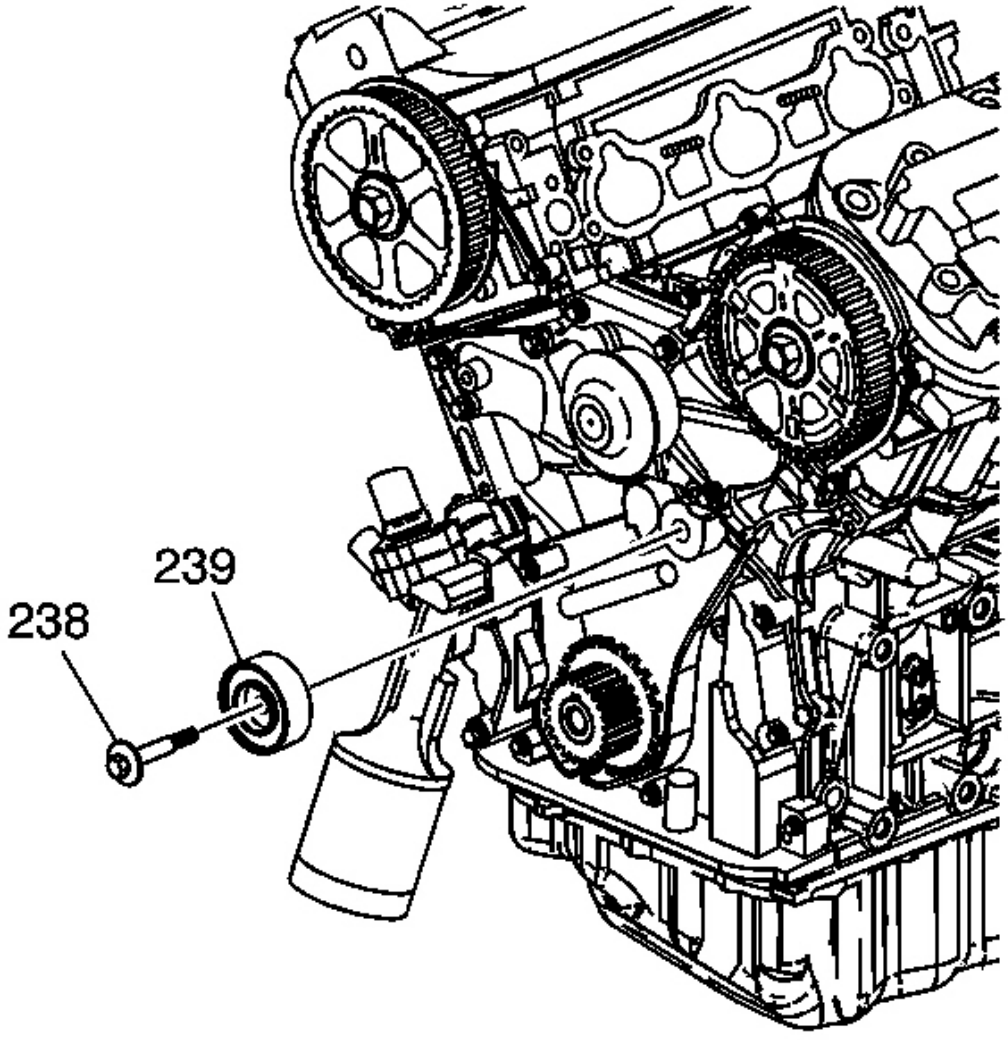


Fig. 277: View Of Timing Belt
Courtesy of GENERAL MOTORS CORP.

2. Inspect the idler pulley (239) for a grooved or worn belt contact surface or worn bearing.
3. Inspect the camshaft and crankshaft sprockets for wear or other damage.

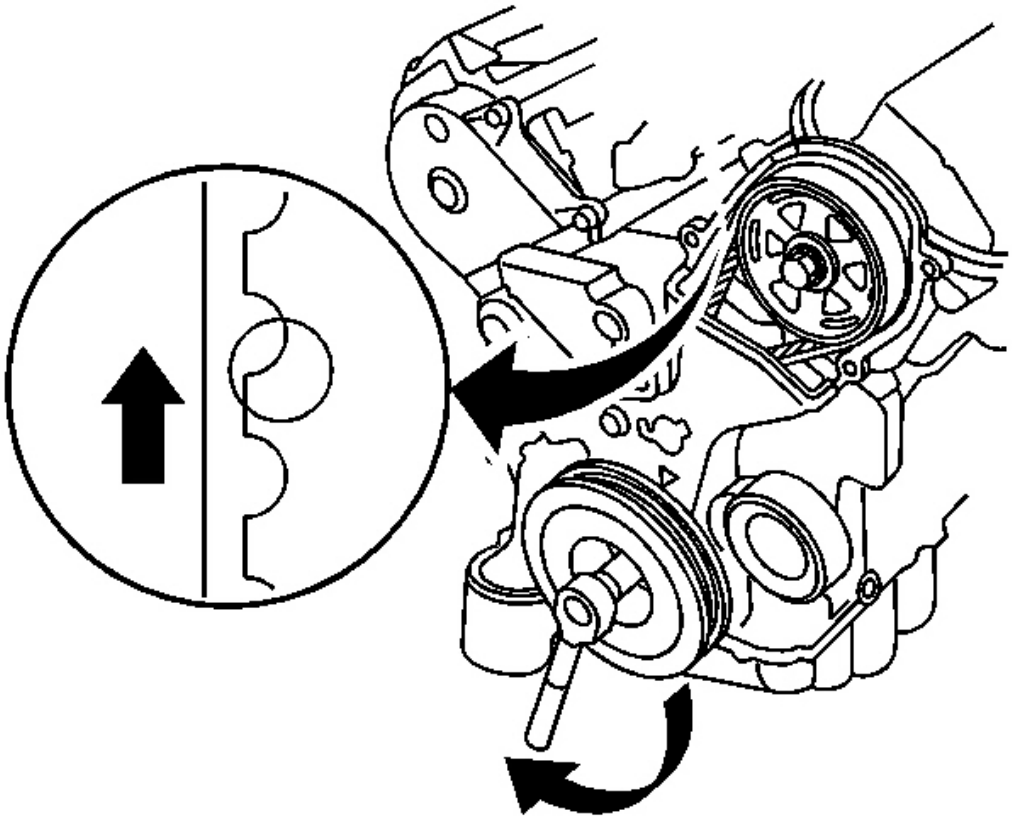


Fig. 278: View Of Belt For Damage
Courtesy of GENERAL MOTORS CORP.

4. Inspect the belt for cracking, missing or damaged teeth.
5. Inspect for oil or coolant soaking. Replace the belt if it is oil or coolant soaked. Remove any residual oil or coolant on the belt.

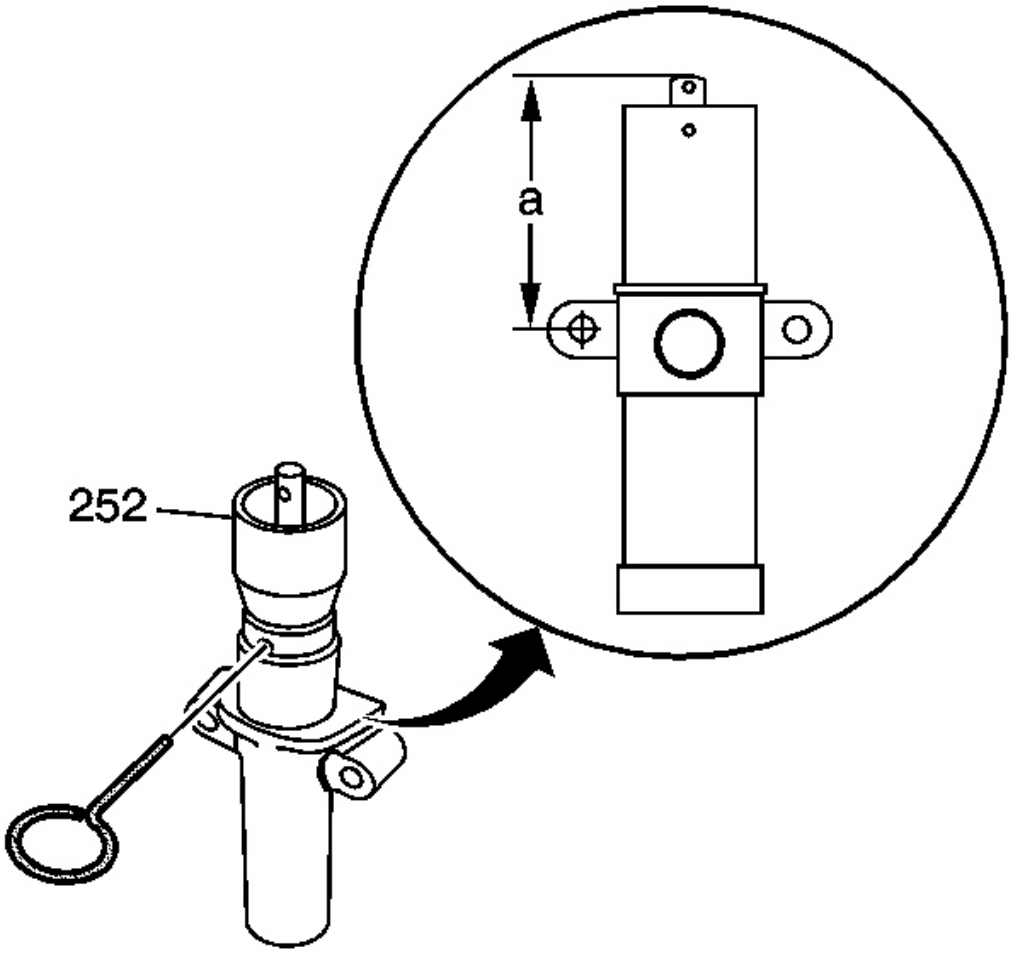


Fig. 279: Measuring The Dimension Of The Rod At Full Stroke
Courtesy of GENERAL MOTORS CORP.

6. Remove the **EN 46330** from the tensioner (252). See **Special Tools and Equipment** . The tensioner rod should move outward from the housing and extend to full stroke.
7. Measure the dimension of the rod at full stroke (a). If the rod extended measures less than or exceeds the specification, replace the tensioner assembly.

   Specification: Tensioner rod fully extended: 48.8-58.7 mm (1.92-2.31 in)

8. Push on the rod with normal hand pressure. The rod should exert excessive resistance and should not retract easily into the housing. If the rod can be retracted into the housing using normal hand pressure, measure the tensioner spring for proper load.

Specification:

- Tensioner spring load: 151 N (34 lb) at 58.7 mm (2.31 in)
- Tensioner spring load: 185 N (41.5 lb) at 54.4 mm (2.14 in)
- Tensioner spring load: 228 N (51 lb) at 48.8 mm (1.92 in)

VALVE ROCKER ARM AND SHAFT CLEANING AND INSPECTION

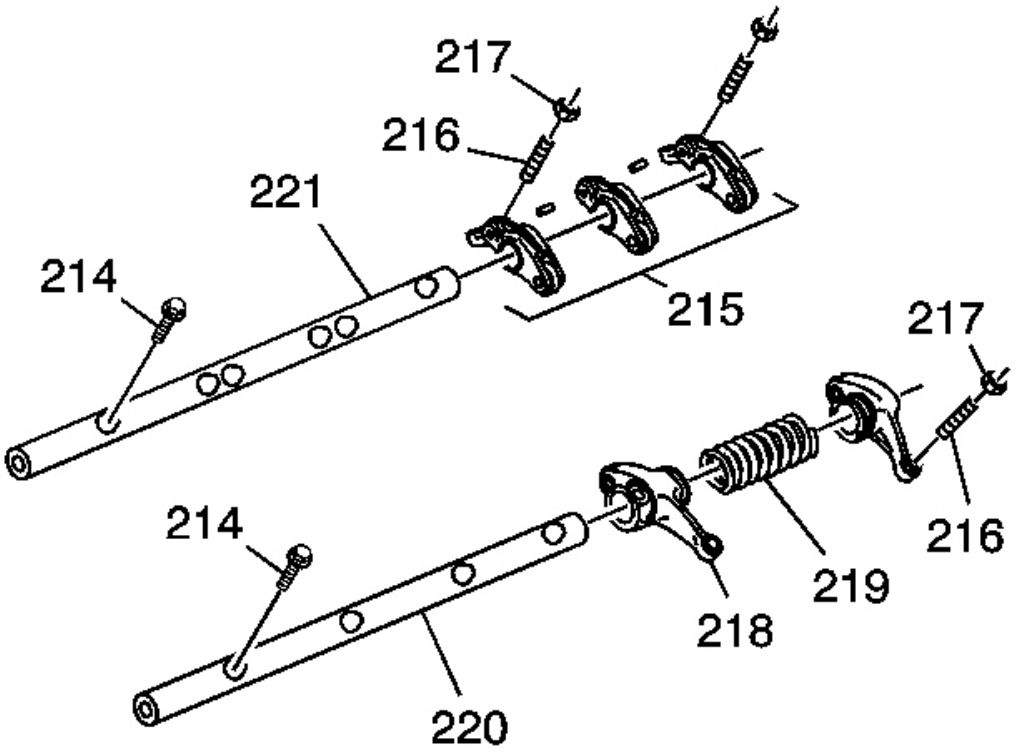


Fig. 280: View Of Rocker Arm Shafts
Courtesy of GENERAL MOTORS CORP.

1. Inspect the rocker arm shafts (220, 221) for scoring or excessive wear.

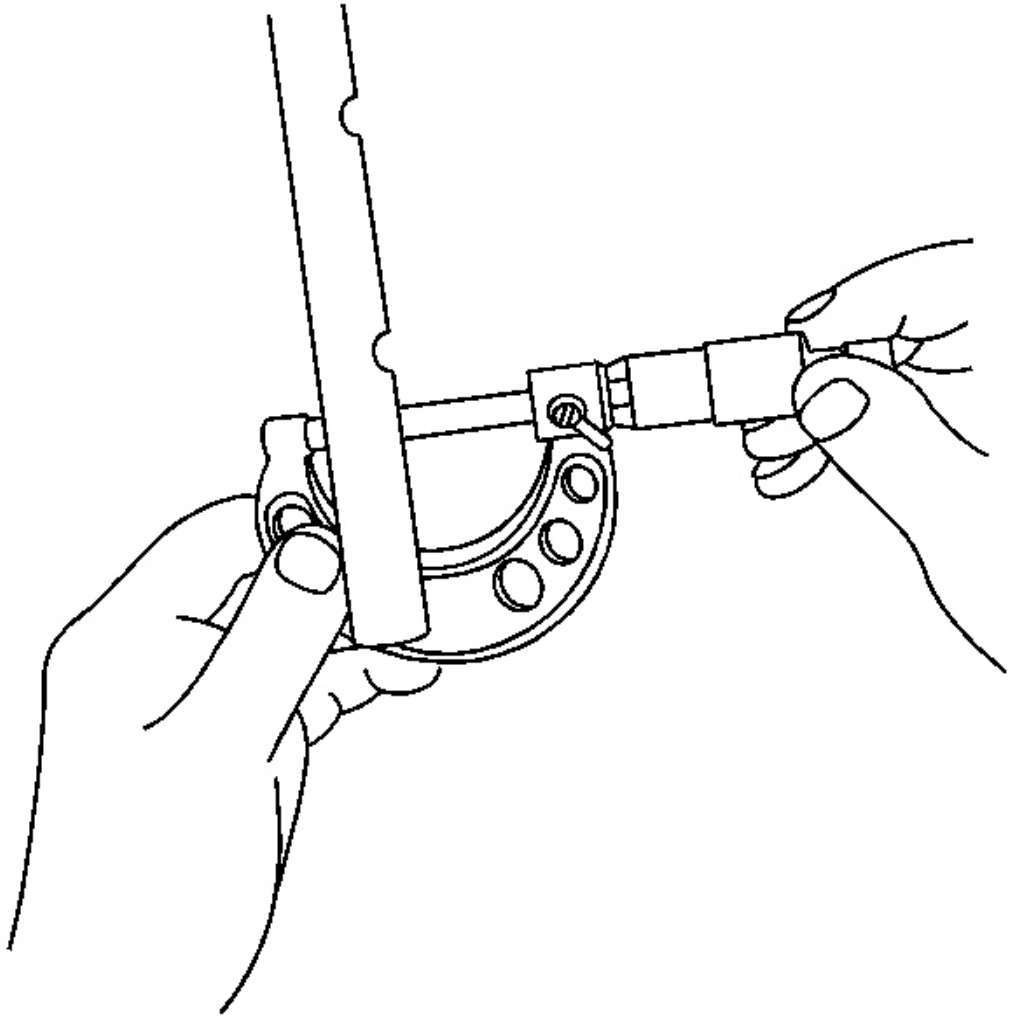


Fig. 281: Measuring The Diameter Of The Rocker Arm Shafts
Courtesy of GENERAL MOTORS CORP.

2. Measure the diameter of the rocker arm shafts.

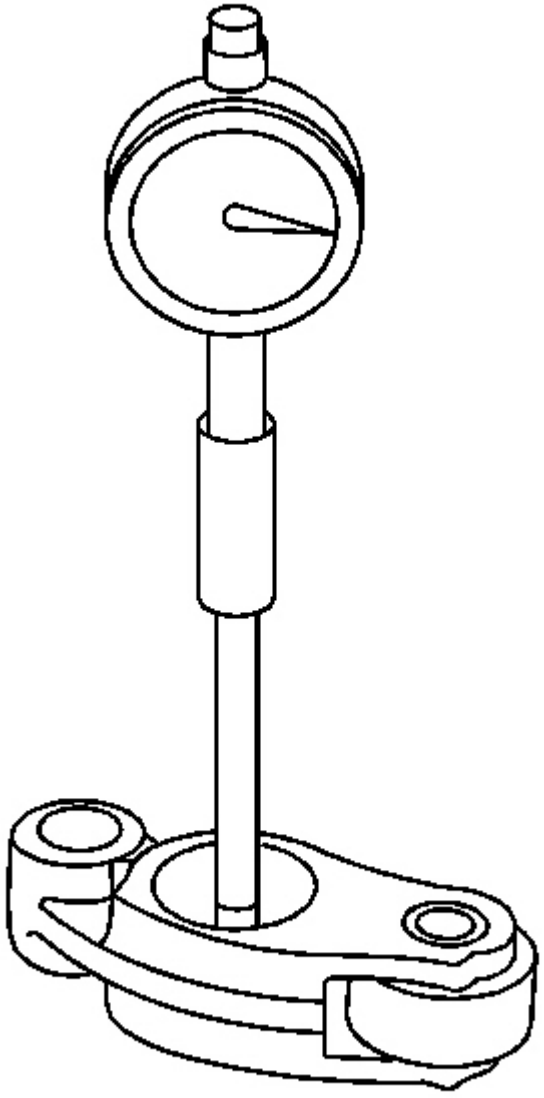


Fig. 282: Measuring The Inside Diameter Of The Rocker Arm Bores
Courtesy of GENERAL MOTORS CORP.

3. Measure the inside diameter of the rocker arm bores. Check for an out-of-round condition.

   Specification: Rocker arm shaft bore diameter: 20.02-20.05 mm (0.788-0.789 in)

4. Repeat the measurements for all rocker arms and shafts. Determine the shaft-to-rocker arm clearance. If

the clearance exceeds the service limit, replace the shaft and all rocker arms with excessive clearance.

Specification:

- Intake rocker arm-to-shaft clearance - new: 0.026-0.067 mm (0.001-0.0026 in)
- Intake rocker arm-to-shaft clearance - service limit: 0.067 mm (0.0026 in)
- Exhaust rocker arm-to-shaft clearance - new: 0.026-0.077 mm (0.001-0.003 in)
- Exhaust rocker arm-to-shaft clearance - service limit: 0.077 mm (0.003 in)

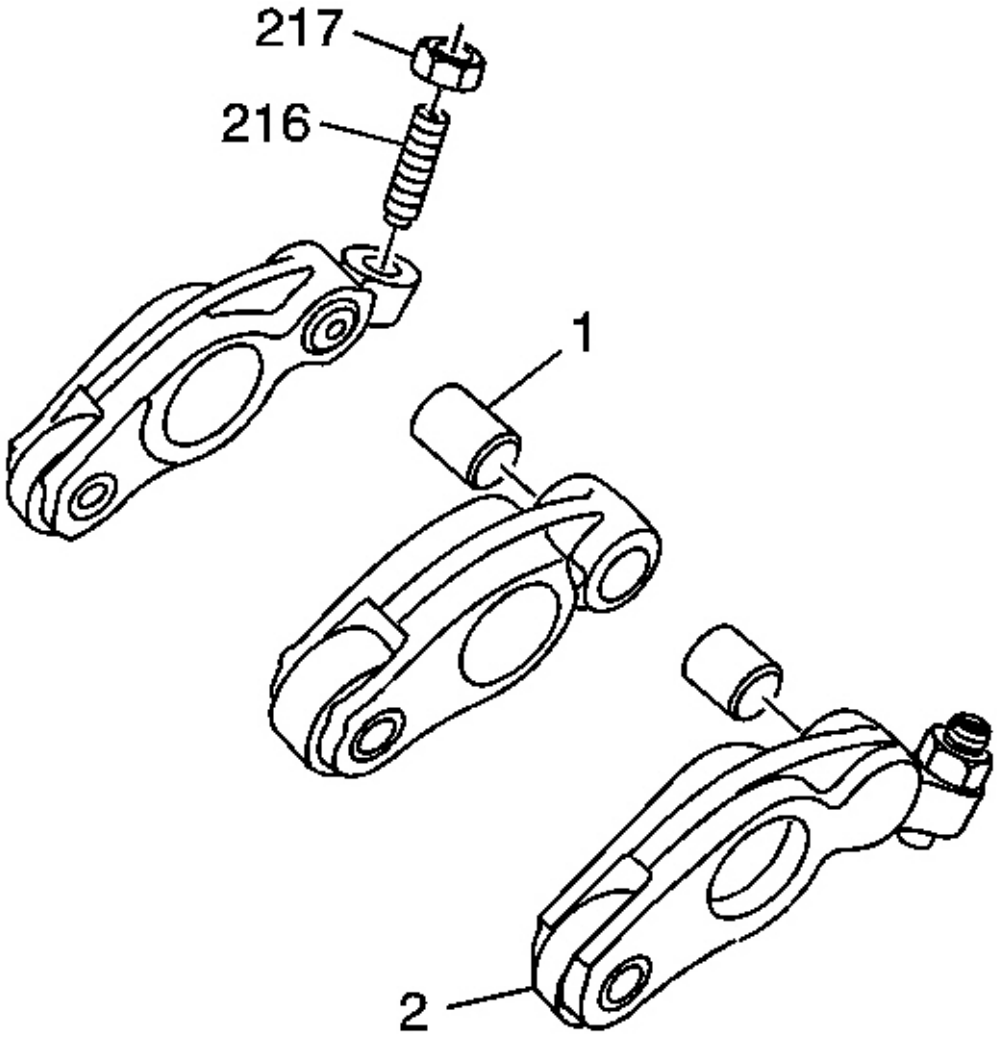


Fig. 283: View Of Intake Rocker Arm Pistons

Courtesy of GENERAL MOTORS CORP.

5. Inspect the intake rocker arm pistons (1). Push the pistons manually. If the pistons do not move smoothly within the bores, replace the rocker arms and pistons as an assembly.
6. Inspect the locking nuts (217) and bolts (216) for damaged threads.
7. Inspect for worn rollers (2), loose rollers or rollers with flat spots.

VALVE LASH ADJUSTER CLEANING AND INSPECTION

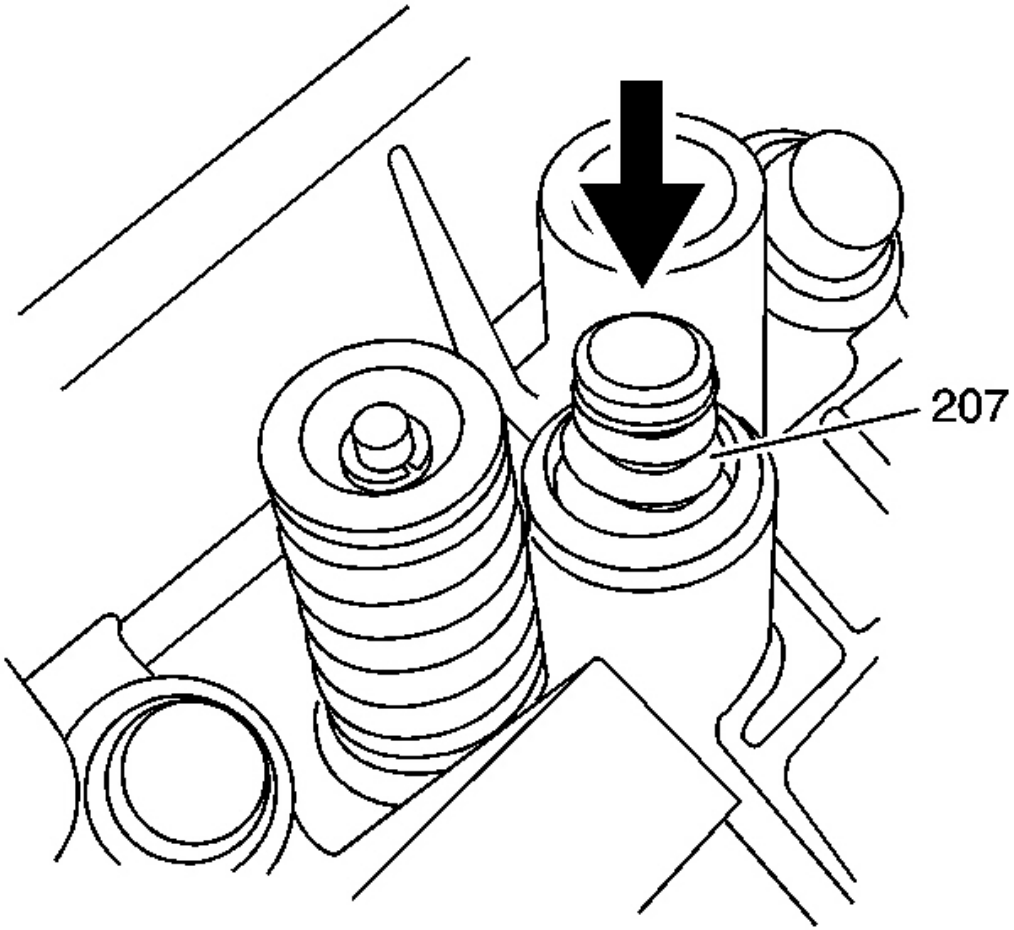


Fig. 284: View Of Valve Lash Adjuster
Courtesy of GENERAL MOTORS CORP.

1. Inspect the valve lash adjusters (207) for proper operation. Push on the adjuster with your finger. If it

does not move smoothly within the bore, replace the component.

2. Inspect for a collapsed spring or broken coils.

CYLINDER HEAD DISASSEMBLE

Tools Required

- **EN 46353** Valve Spring Compressor Attachment - Head Off-Vehicle. See **Special Tools and Equipment** .
- **SA9102E-A** Valve Seal Remover/Replacer. See **Special Tools and Equipment** .
- **SA9124E** Regulator Valve Remover/Replacer. See **Special Tools and Equipment** .

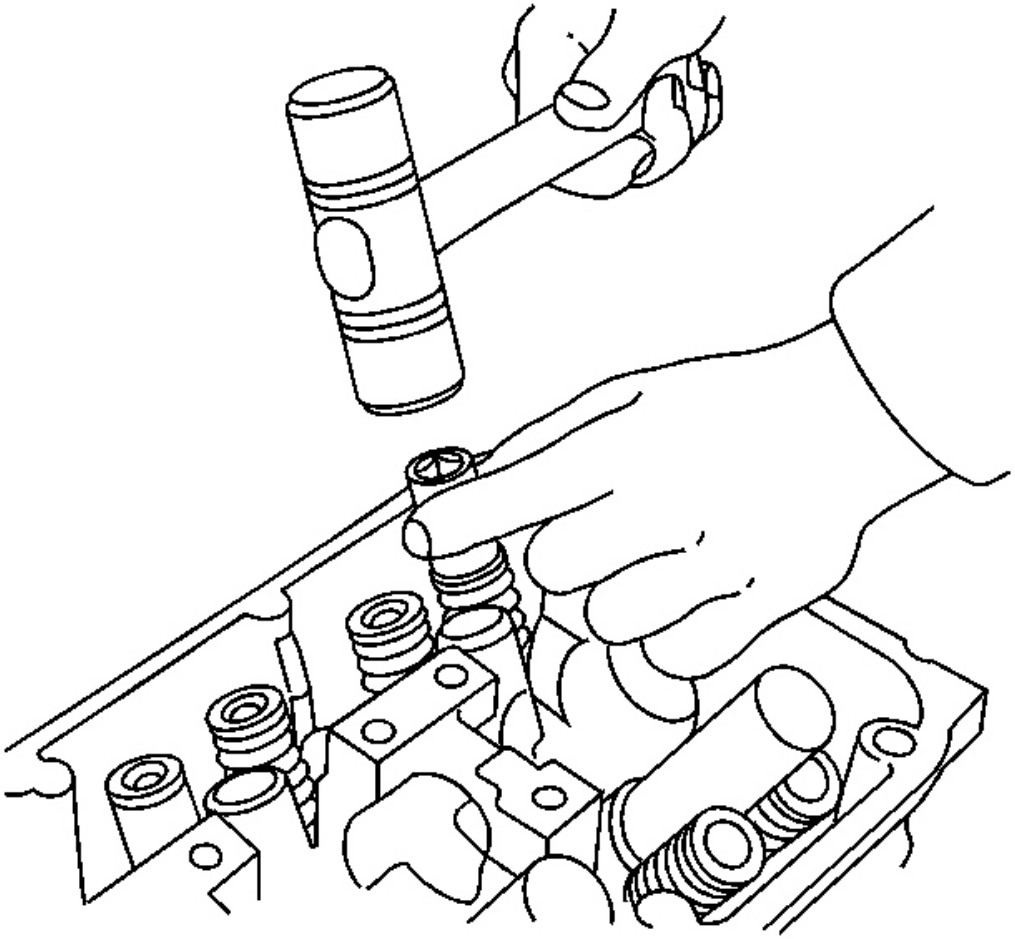


Fig. 285: View Of Cylinder Head

Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Mark or sort parts during disassembly. Refer to Separating Parts .

1. Using an appropriate size socket and a plastic-faced hammer, lightly tap the valve cap in order to loosen the keys.

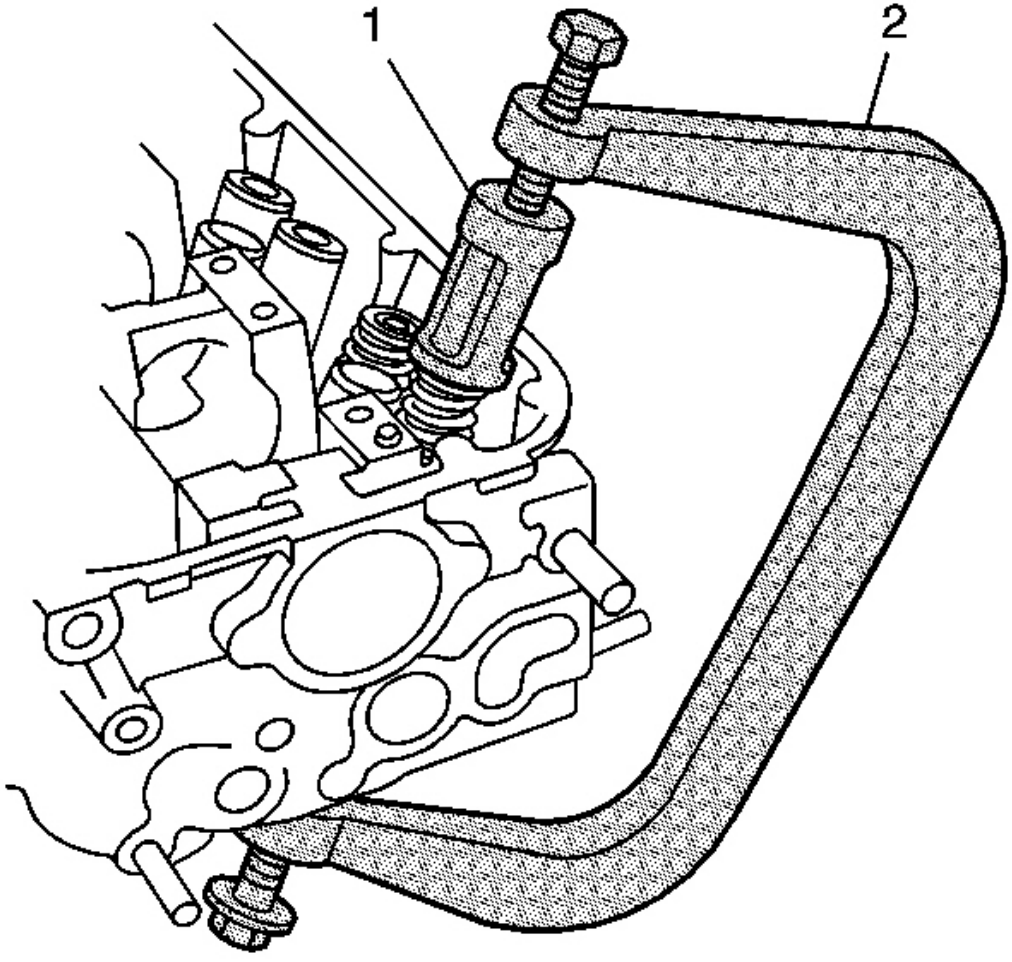


Fig. 286: View Of Valve Stem Keys
Courtesy of GENERAL MOTORS CORP.

2. Use the **SA9124E** (2). See **Special Tools and Equipment** .**EN 46353** (1) in order to compress the valve spring. See **Special Tools and Equipment** .

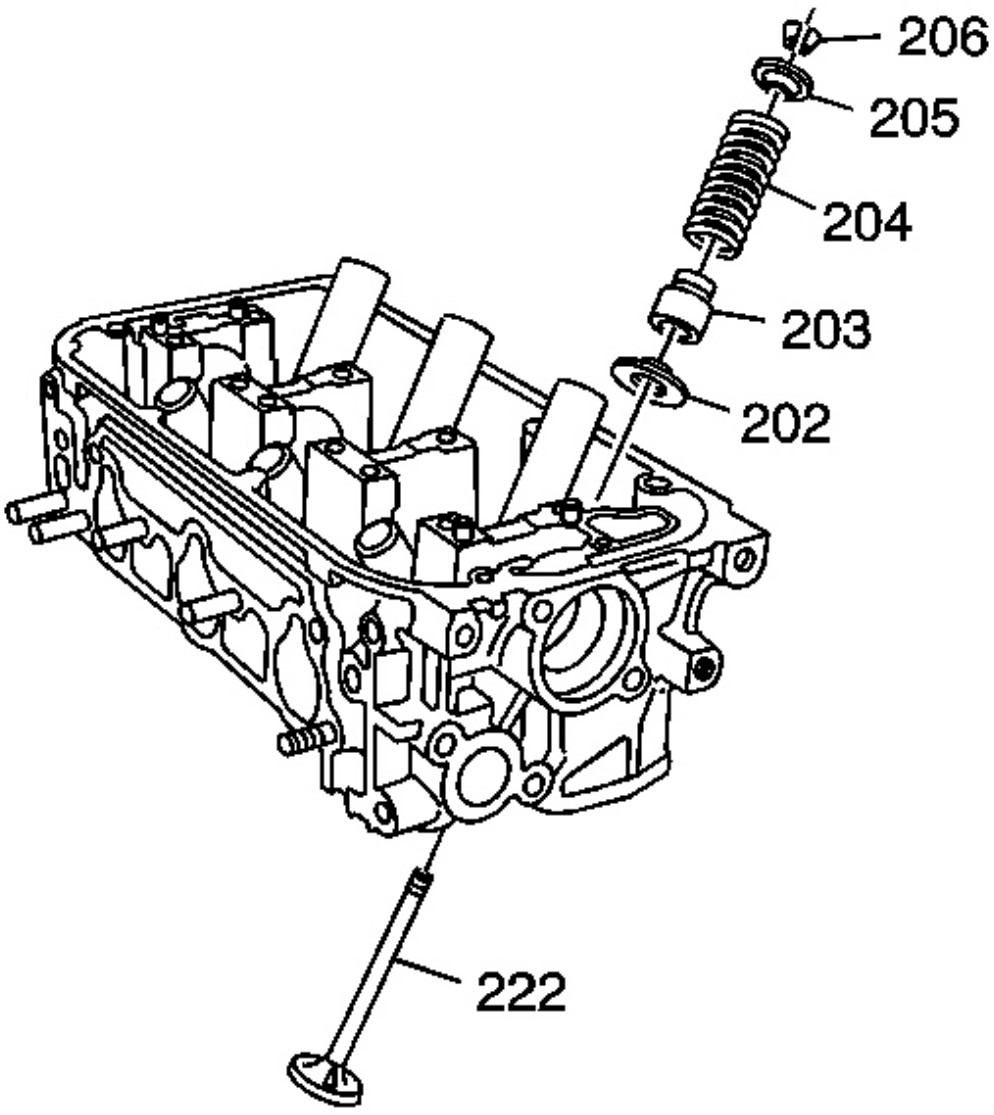


Fig. 287: View Of Keys, Cap, Spring & Valve
Courtesy of GENERAL MOTORS CORP.

3. Remove the keys (206), cap (205), spring (204), and valve (222).

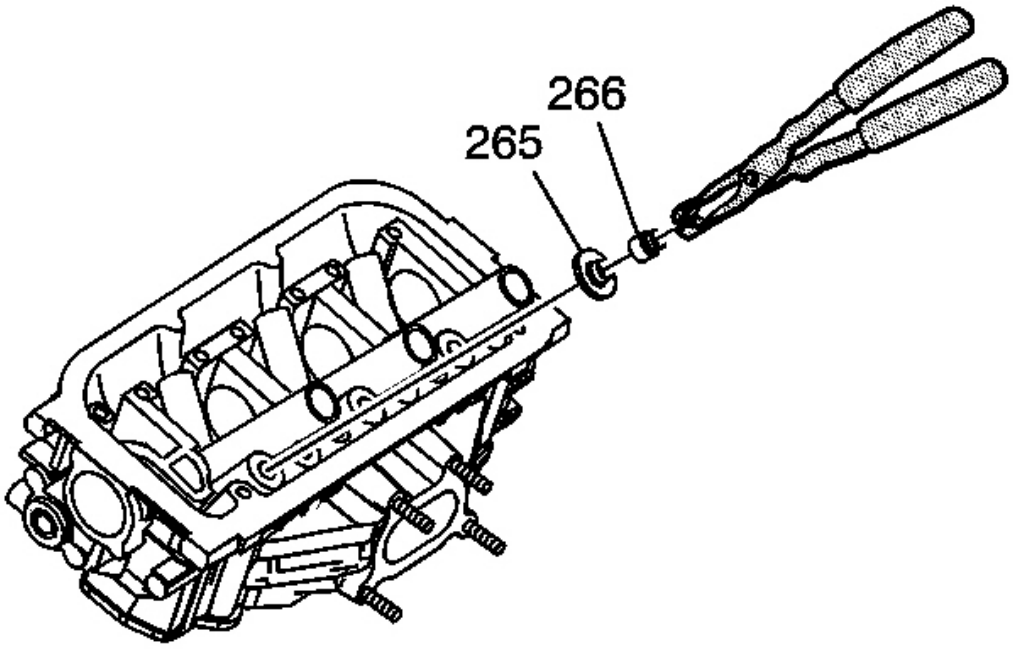


Fig. 288: View Of Seal & Seat
Courtesy of GENERAL MOTORS CORP.

4. Using the **SA9102E-A** , remove the seal (266) and seat (265). See **Special Tools and Equipment** .

CYLINDER HEAD CLEANING AND INSPECTION

1. Inspect the cylinder head for the following conditions:
    - Damaged sealing surfaces
    - Damaged bolt hole threads
    - Loose spark plug tubes
    - Worn or loose valve seats
    - Carbon build-up in the combustion chambers

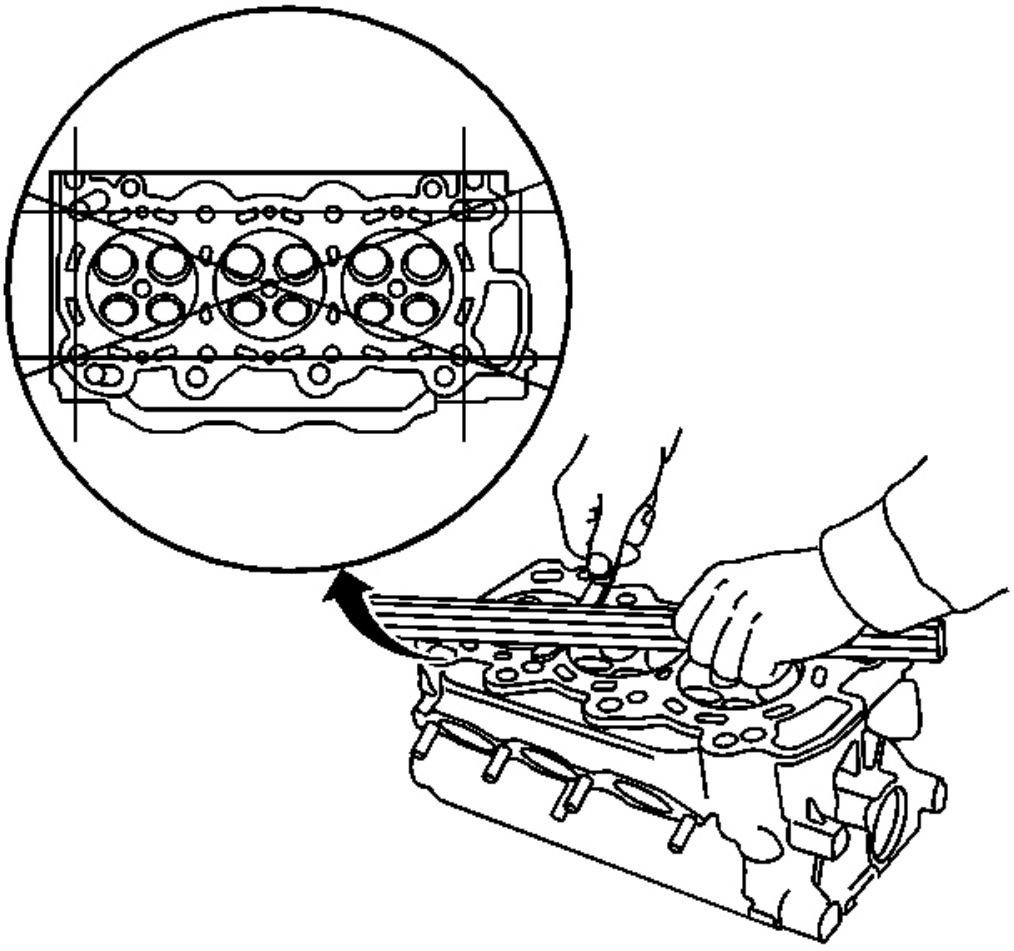


Fig. 289: Inspecting Cylinder Head
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If the camshaft-to-journal clearances are not within specifications, the cylinder head cannot be used again. Refer to Camshafts Cleaning and Inspection .

2. Using a straight edge and feeler gage, measure the cylinder head for warpage. Measure along the edges and across the center of the cylinder head.
    - If the measurement is less than 0.05 mm (0.002 in), cylinder head resurfacing is not required.
    - If the measurement is between 0.05-0.2 mm (0.002-0.008 in), resurface the cylinder head.
    - Maximum resurface limit is 0.2 mm (0.008 in) based on a cylinder head height of 121 mm (4.762 in).

3. Measure the cylinder head height. Measure from the block surface to the valve cover sealing surface.

   Specification:
   - Cylinder head height - new: 120.95-121.05 mm (4.762-4.766 in)
   - Cylinder head height - service limit: 120.95 mm (4.762 in)

VALVE GUIDE REAMING/VALVE AND SEAT GRINDING

Tools Required

- **EN 46341** Valve Guide Driver. See **Special Tools and Equipment** .
- **EN 46345** Valve Guide Reamer. See **Special Tools and Equipment** .
- **SA9179NE** Dial Indicator

Valve Inspection

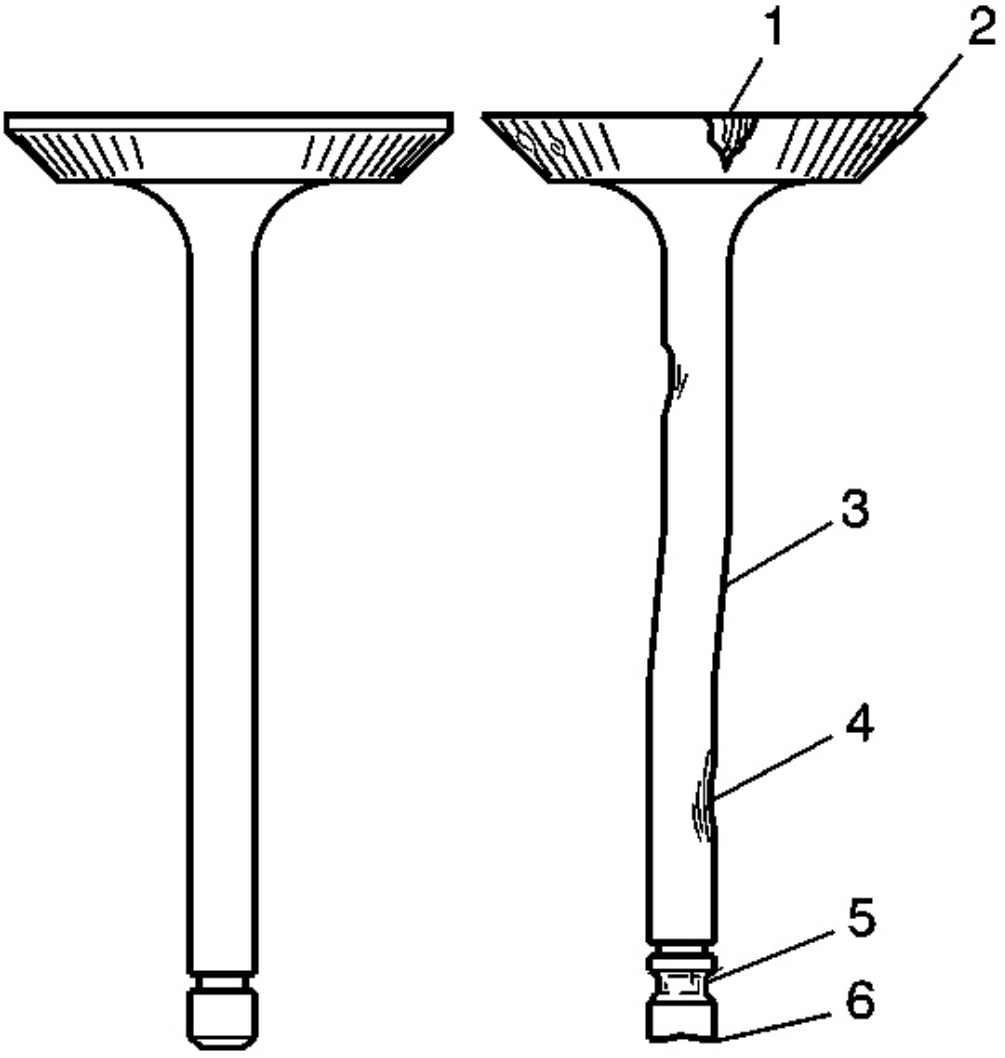


Fig. 290: Inspecting Valves For Damage
Courtesy of GENERAL MOTORS CORP.

1. Inspect the valve stems for scoring, wear or warpage.
    - A valve stem that has excessive scoring (3 or 4) or wear (4 or 6) must be replaced.
    - A valve guide that is worn and has excessive stem-to-guide clearance must be replaced.
2. Inspect the valve for the following conditions:
    - Burnt or eroded areas (1)
    - A worn margin (2)

- A bent stem (3)
- A worn or scored stem (4)
- A worn key groove (5)
- A worn stem tip (6)

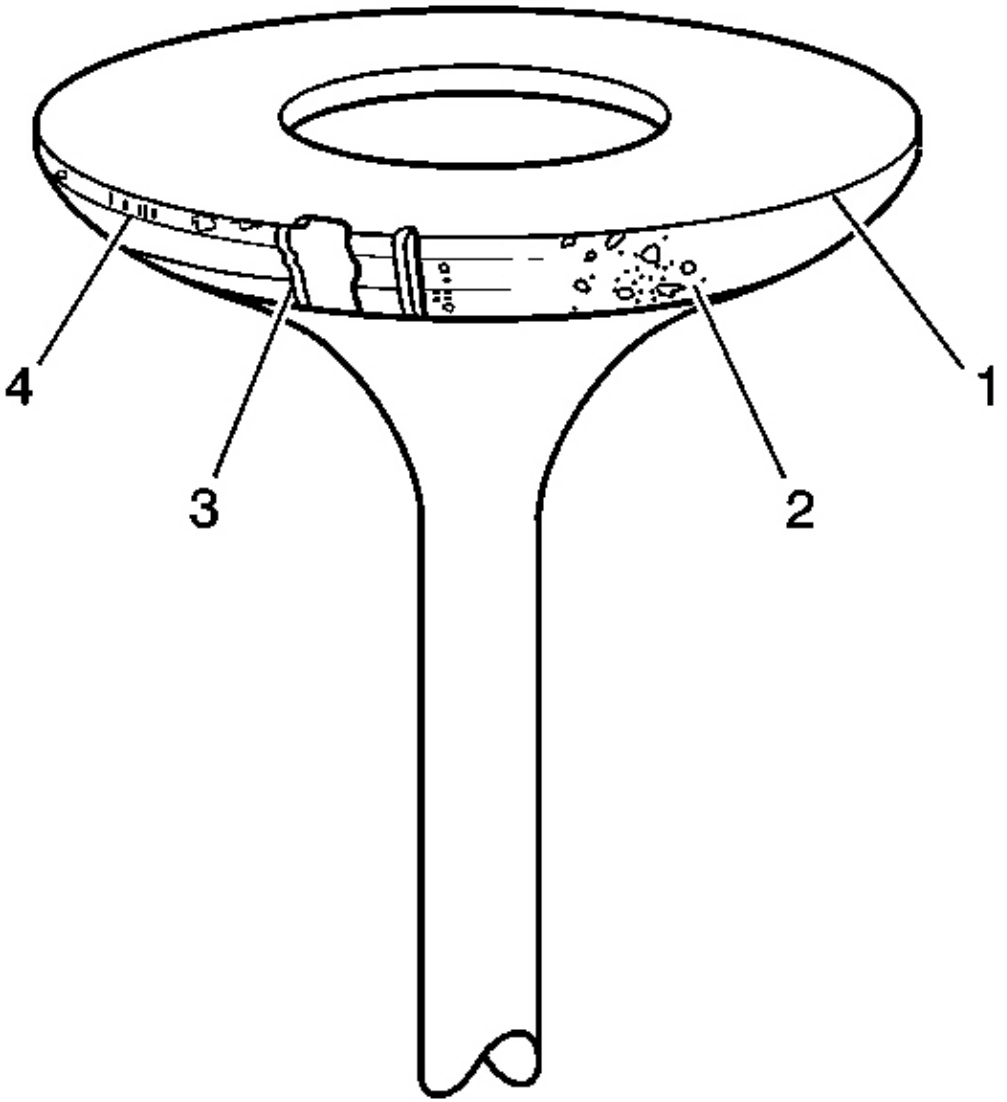


Fig. 291: Inspecting Valve Face
Courtesy of GENERAL MOTORS CORP.

3. Inspect the valve face for the following conditions:
    - Worn or no margin (1 or 4)
    - Pitted surfaces (2)
    - Burnt or eroded areas (3)

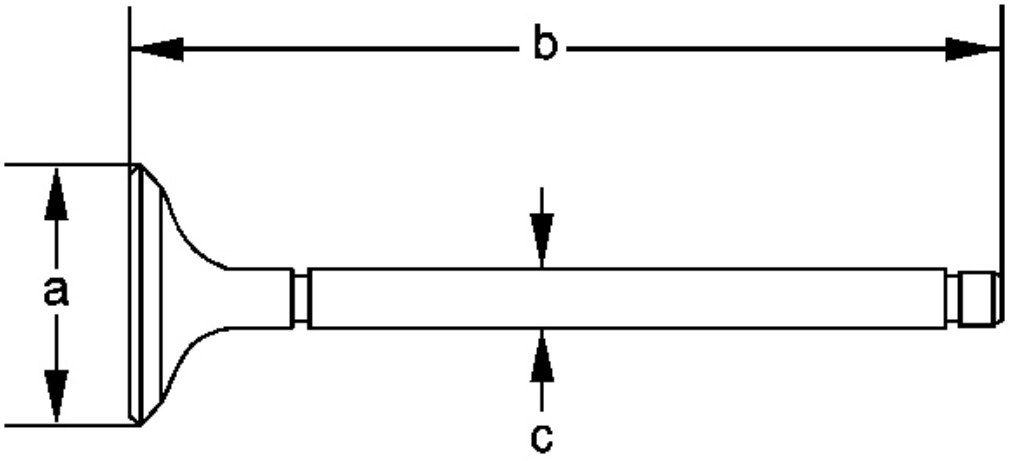


Fig. 292: Measuring The Valve
Courtesy of GENERAL MOTORS CORP.

4. Measure the valve.

    Specification:
    - Intake valve head diameter (a): 34.9-35.1 mm (1.374-1.382 in)
    - Intake valve overall length (b): 115.7-116.3 mm (4.555-4.579 in)
    - Intake valve stem diameter (c) - new: 5.485-5.495 mm (0.2159-0.2163 in)
    - Intake valve stem diameter (c) - service limit: 5.455 mm (0.2148 in)
    - Exhaust valve head diameter (a): 29.9-30.1 mm (1.177-1.185 in)
    - Exhaust valve overall length (b): 113.9-114.5 mm (4.484-4.508 in)
    - Exhaust valve stem diameter (c) - new: 5.45-5.46 mm (0.2146-0.215 in)
    - Exhaust valve stem diameter (c) - service limit: 5.42 mm (0.2134 in)

Measuring Valve Stem-to-Guide Clearance - Dial Indicator Method

Fig. 293: Measuring The Guide-To-Stem Clearance
Courtesy of GENERAL MOTORS CORP.

1. Slide the valve out of the guide, approximately 10 mm (0.4 in), in order to measure the guide-to-stem clearance with the **SA9179NE** . Rock the stem in the direction of the normal thrust.
    - If the measurement exceeds the service limit, install a new valve and measure again.
    - If the measurement is within the service limit, assemble using existing valve.
    - If the measurement with a new valve exceeds the service limit, replace the valve guide.
2. Compare the measurements to the specifications.

Specification:

- Intake valve stem-to-guide clearance - new: 0.02-0.045 mm (0.0008-0.0018 in)
- Intake valve stem-to-guide clearance - service limit: 0.08 mm (0.003 in)
- Exhaust valve stem-to-guide clearance - new: 0.055-0.08 mm (0.0022-0.0031 in)

- Exhaust valve stem-to-guide clearance - service limit: 0.11 mm (0.004 in)

Measuring Valve Stem-to-Guide Clearance - Micrometer Method

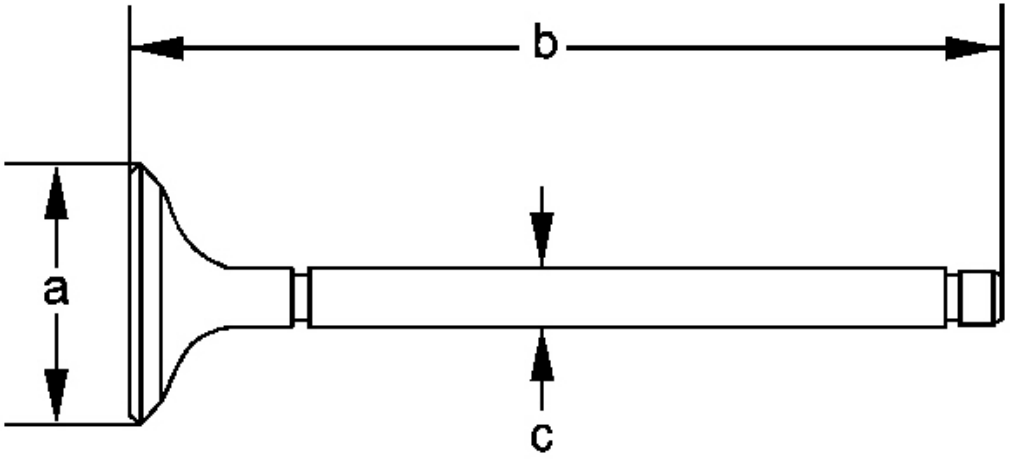


Fig. 294: Measuring The Valve
Courtesy of GENERAL MOTORS CORP.

1. Measure the outside diameter (O.D.) of the valve stem (c). Take measurements in 3 places along the stem.
2. Measure the inside diameter (I.D.) of the valve guide (a). Take measurements in 3 places along the guide bore.
3. Calculate the stem-to-guide clearance (b).

Specification:

- Intake valve stem-to-guide clearance - new: 0.02-0.045 mm (0.0008-0.0018 in)
- Intake valve stem-to-guide clearance - service limit: 0.08 mm (0.003 in)
- Exhaust valve stem-to-guide clearance - new: 0.055-0.08 mm (0.0022-0.0031 in)
- Exhaust valve stem-to-guide clearance - service limit: 0.11 mm (0.004 in)

Valve Guide Replacement

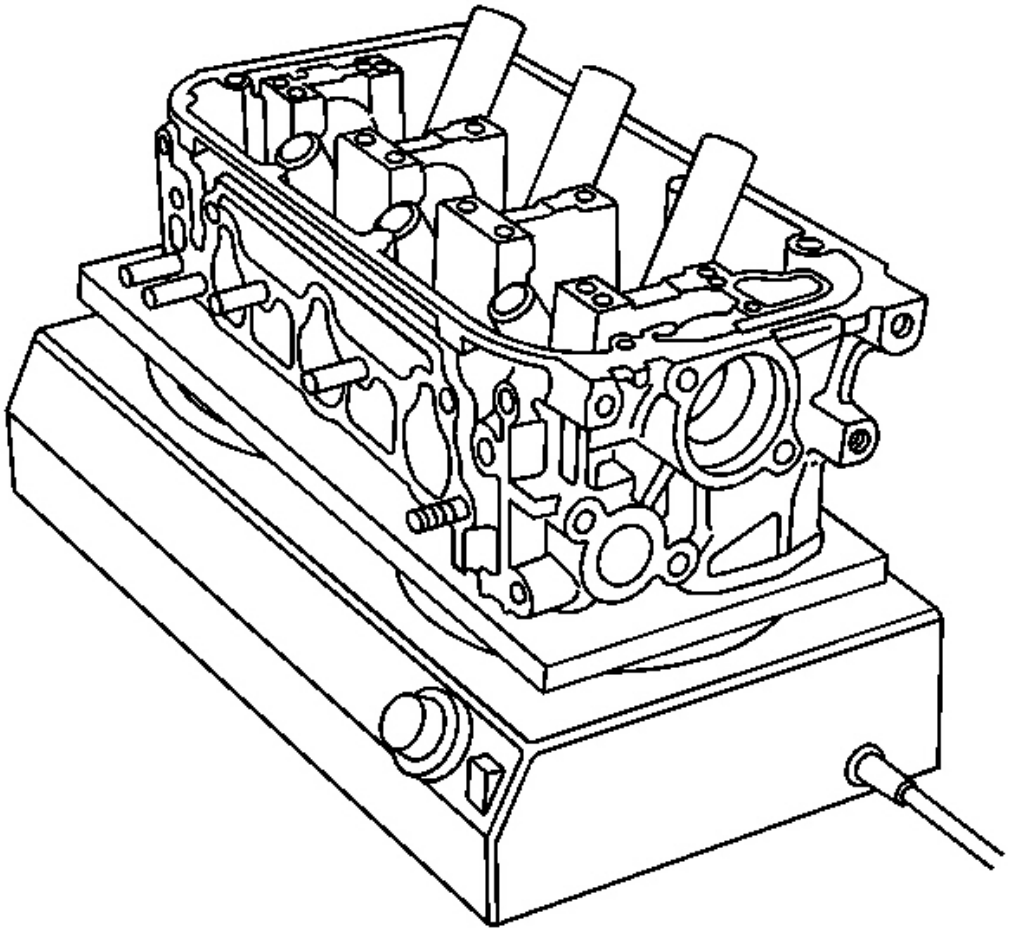


Fig. 295: View Of Valve Guide
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not heat the cylinder head in excess of 150°C (300°F). Excessive heating of the cylinder head may loosen the valve seats.

1. Select the proper replacement guides and chill them in a freezer for approximately 1 hour.
2. Use a hot plate or an oven to evenly heat the cylinder head to 150°C (300°F). Monitor the temperature with a thermometer.

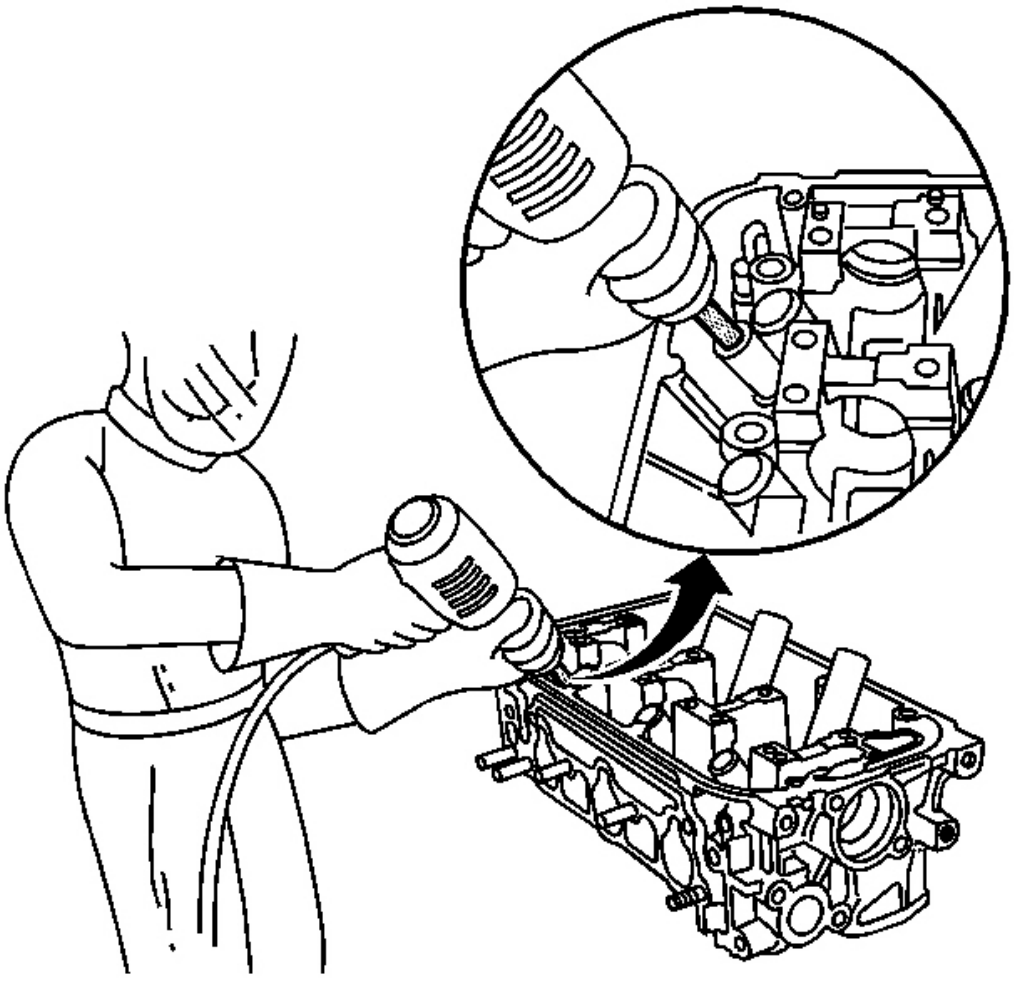


Fig. 296: View Of Air Hammer To Drive The Guide Out Of The Cylinder Head
Courtesy of GENERAL MOTORS CORP.

3. Working from the camshaft, or top, side, use the **EN 46341** and an air hammer in order to drive the guide approximately 2 mm (0. See **Special Tools and Equipment** .1 in) towards the combustion chamber. This action will remove some of the carbon from the guide and ease in guide removal.

IMPORTANT: Drill the guides only in extreme cases. Use extreme care not to break the guide and damage the cylinder head.

4. Turn the head over and use the **EN 46341** and an air hammer to drive the guide out of the cylinder head. See **Special Tools and Equipment** . If the valve guide will not move, enlarge the guide bore with an 8 mm (5/16 in) drill bit.

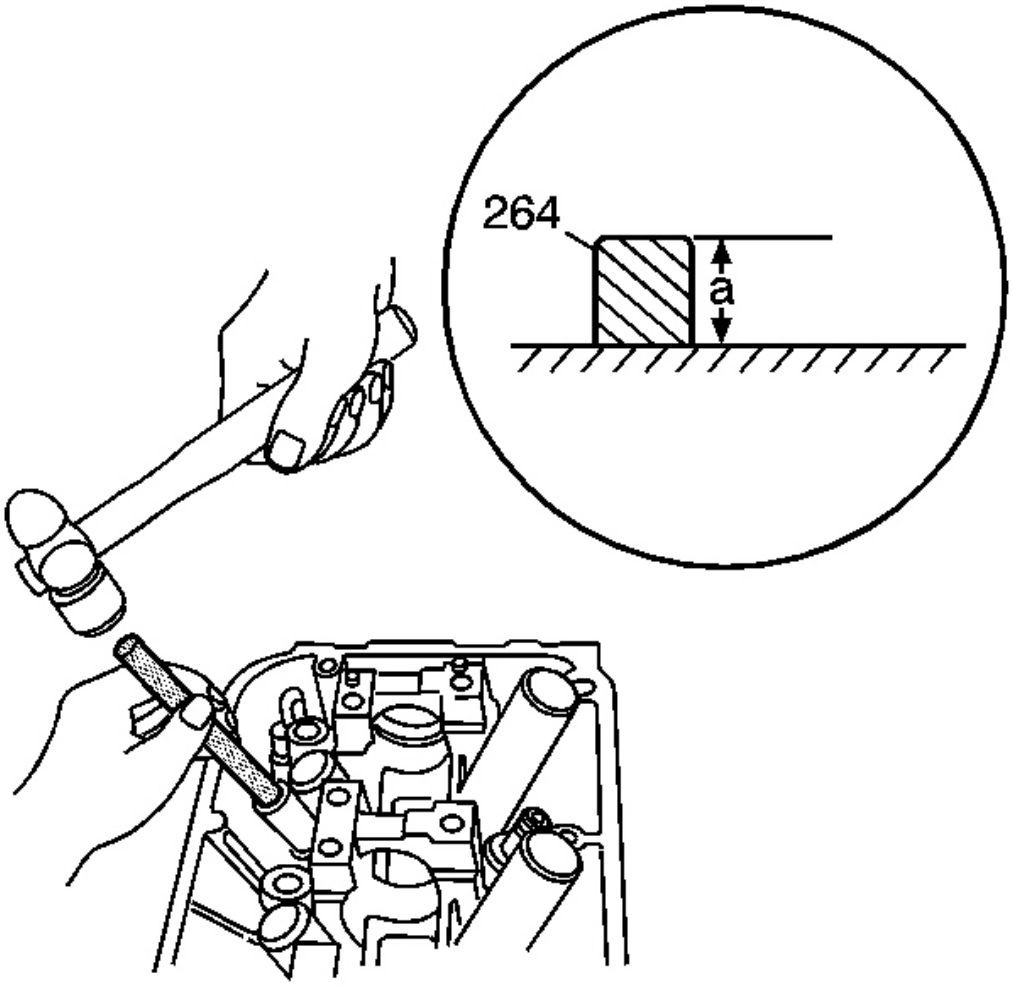


Fig. 297: Measuring The Guide For The Properly Installed Height
Courtesy of GENERAL MOTORS CORP.

5. Use the **EN 46341** in order to install the NEW guides into the cylinder head. See **Special Tools and Equipment** . Remove the valve guides, one at a time from the freezer, just prior to installation.
6. Measure the guide (264) for the properly installed height (a).

Specification:

- Intake valve guide installed height: 21.20-22.2 mm (0.835-0.874 in)
- Exhaust valve guide installed height: 20.63-21.63 mm (0.812-0.852 in)

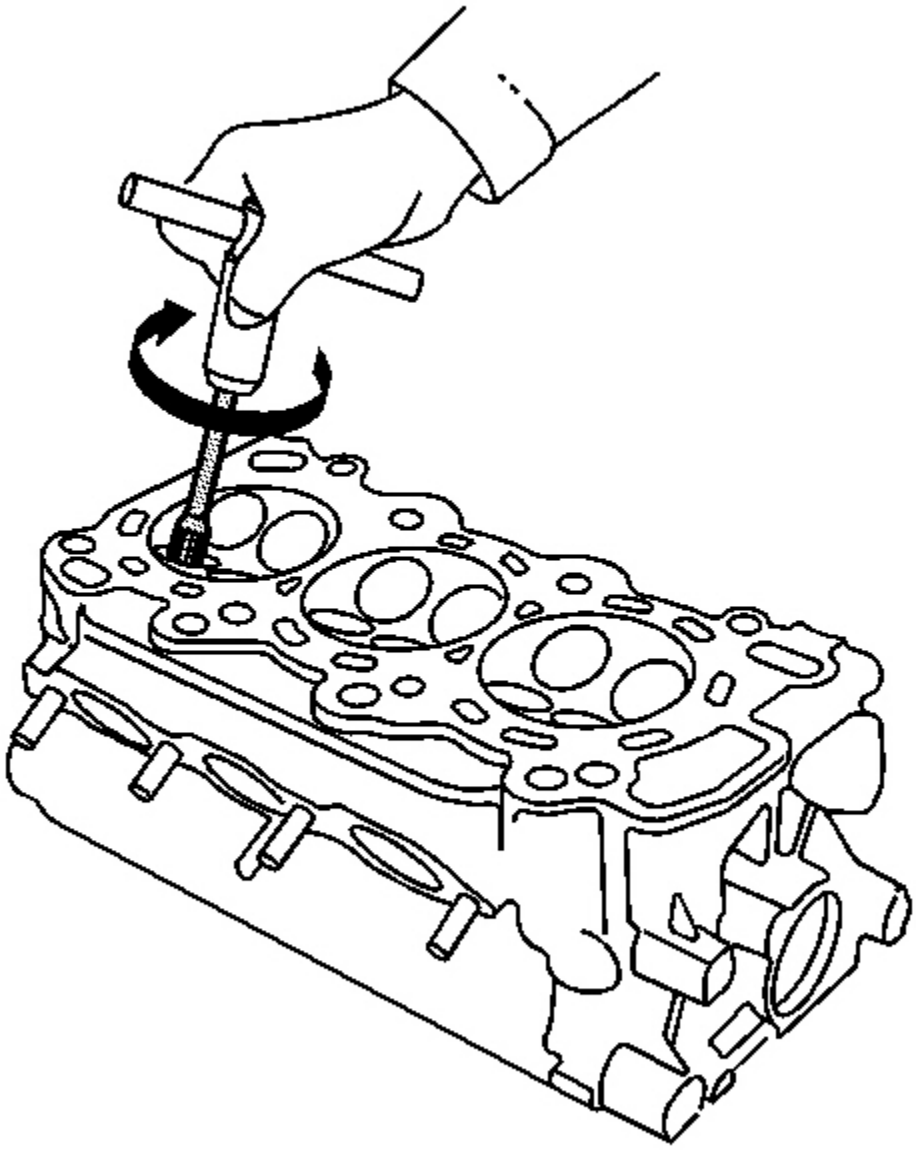


Fig. 298: View Of Reamer Clockwise While Removing From The Guide Bore
Courtesy of GENERAL MOTORS CORP.

7. Coat the **EN 46345** and the valve guide with cutting oil. See **Special Tools and Equipment** .
8. Use the **EN 46345** to ream the guide to the proper size. See **Special Tools and Equipment** . Rotate the reamer clockwise the full length of the guide bore. Continue to rotate the reamer clockwise while removing from the guide bore.

9. Clean the guide in detergent and water to remove cutting residue.
10. Measure the valve stem-to-guide clearance. The valve should slide freely in the guide without exerting pressure.

Valve Seat Reconditioning

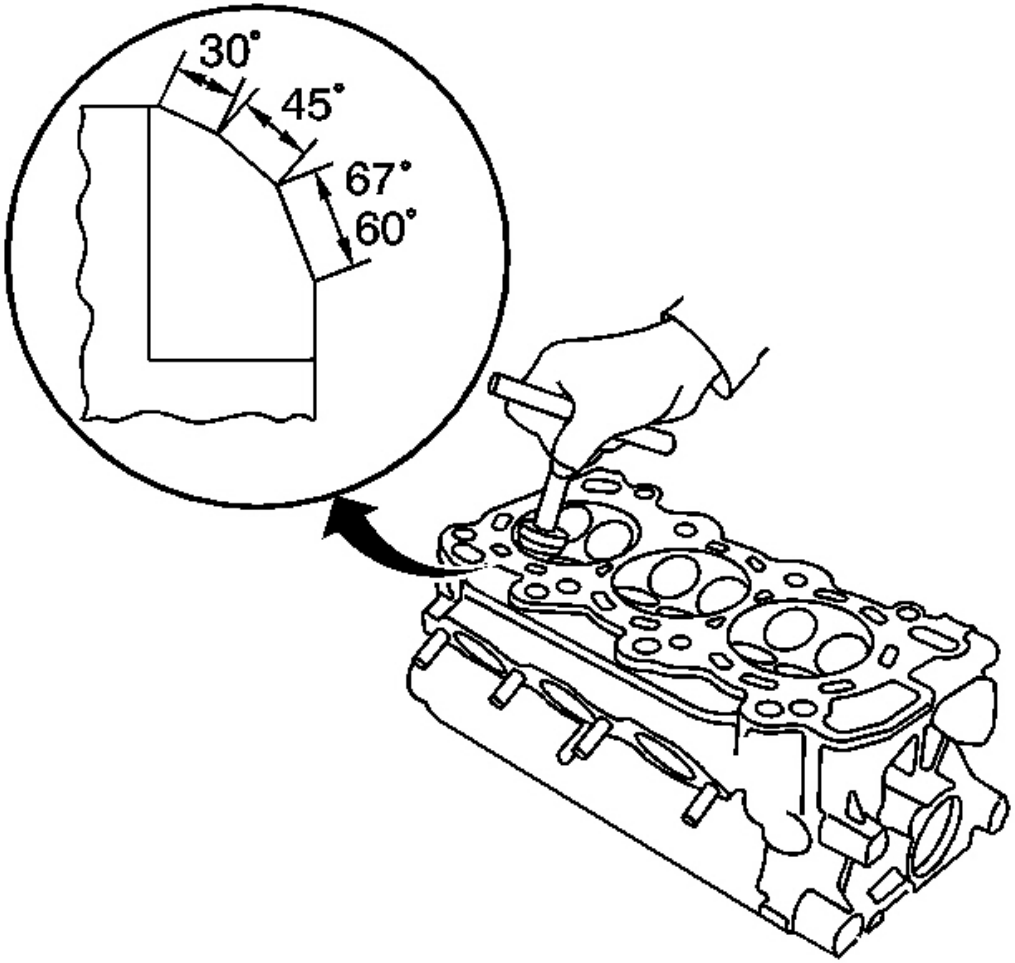


Fig. 299: View Of Valve Seats Using A Seat Cutting Tool
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If the valve guides are worn, they must be replaced prior to cutting the valve seats.

1. Renew the valve seats using a seat cutting tool.
    1. Carefully cut a 45 degree seat, removing only enough material to ensure a smooth and concentric seat.
    2. Bevel the upper edge of the seat with a 30 degree cutter.
    3. Bevel the lower edge of the intake valve seat with a 67 degree cutter.
    4. Bevel the lower edge of the exhaust valve seat with a 60 degree cutter.
    5. Make 1 additional light pass with a 45 degree cutter in order to remove any possible burrs created during the cutting process.

    Specification:

    - Valve seat width - new: 1.25-1.55 mm (0.049-0.061 in)
    - Valve seat width - service limit: 2.0 mm (0.079 in)

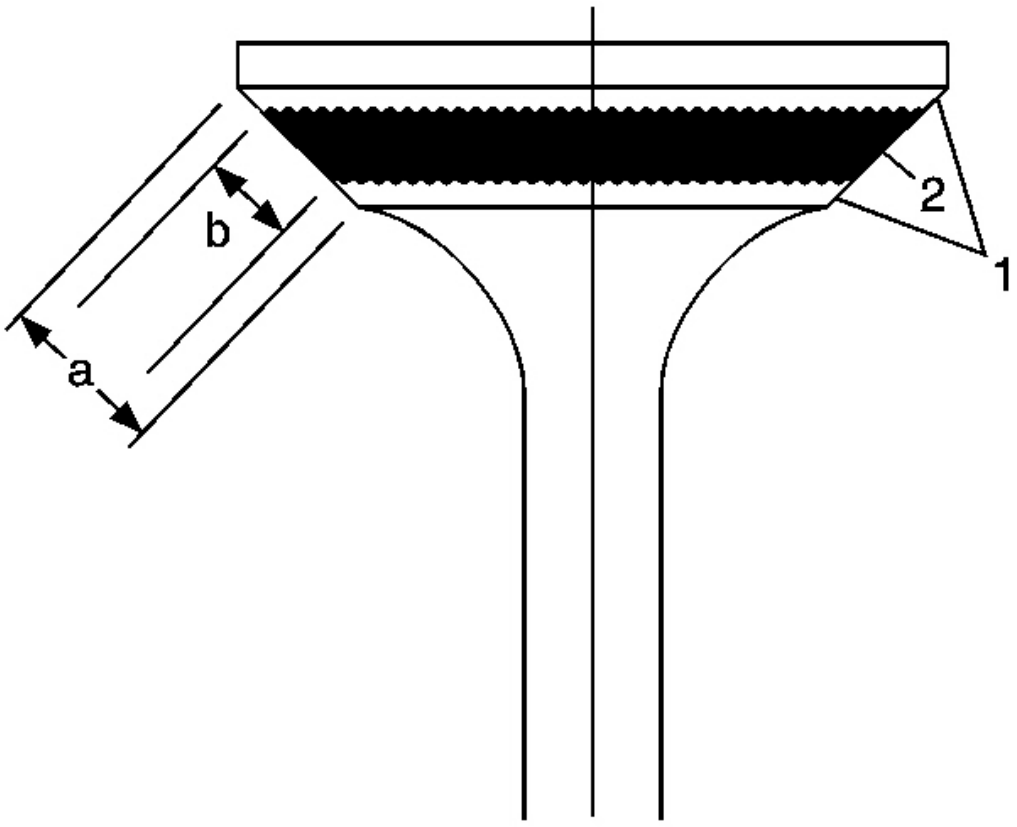


Fig. 300: View Of Valve Seating Surface
Courtesy of GENERAL MOTORS CORP.

2. After resurfacing the valve and/or seat, inspect for even valve seating. Apply Gear Pattern Checking Grease GM P/N 1052351 (Canadian P/N 10953497) or equivalent to the valve face (1). Insert the valve in its original location in the cylinder head. Lift and snap the valve closed against the seat several times.
3. The actual valve seating surface (2) should be centered on the seat.
    - If the seat surface is too high or closer to the valve stem, a second cut with the 67 degree intake or 60 degree exhaust cutter must be made. An additional pass with the 45 degree cutter must also be made prior to completion.
    - If the seat surface is too low or closer to the large end of the valve, a second cut with the 30 degree cutter must be made. An additional pass with the 45 degree cutter must also be made prior to completion.

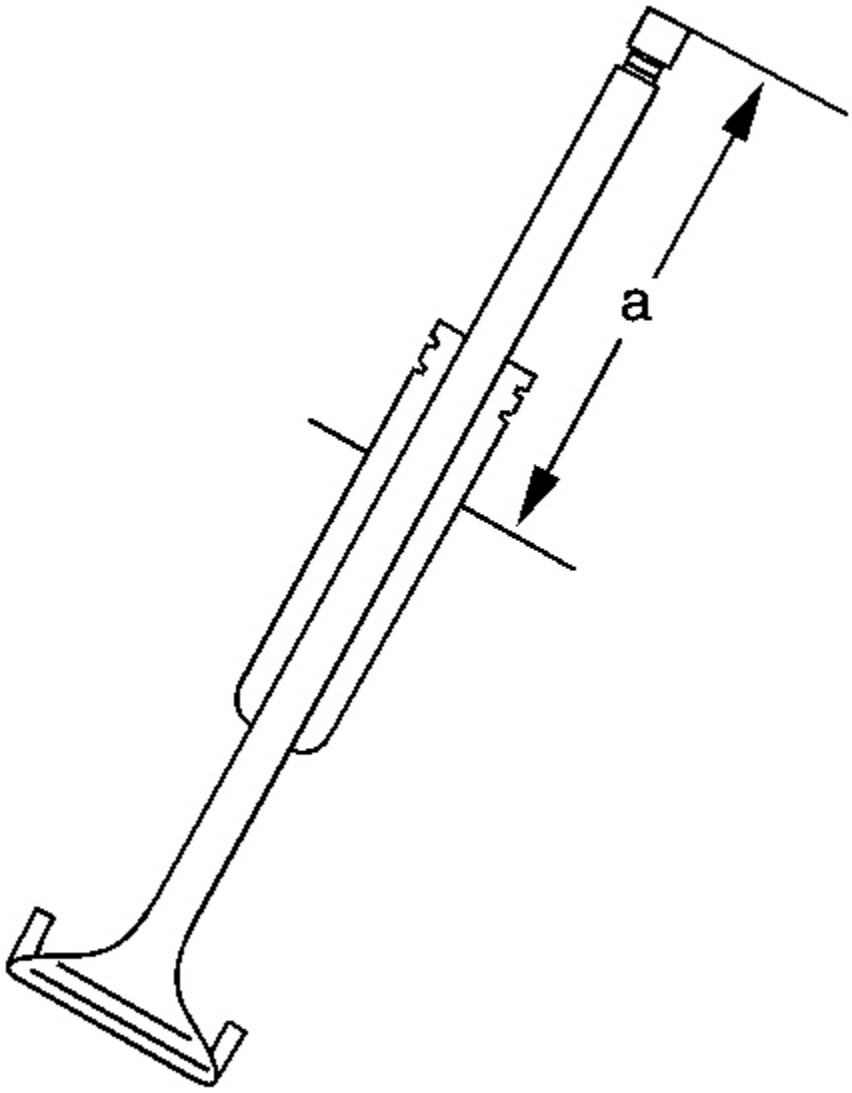


Fig. 301: Measuring The Valve Stem Installed Height
Courtesy of GENERAL MOTORS CORP.

4. Insert the intake and exhaust valves into the cylinder head.
    1. Measure the valve stem installed height (a).
    2. If the valve stem installed height is over the service limit, replace the valve and measure again.
    3. If the installed height remains over the service limit, replace the cylinder head.

Specification:

- Intake valve stem installed height - new: 46.75-47.55 mm (1.841-1.872 in)
- Intake valve stem installed height - service limit: 47.8 mm (1.882 in)
- Exhaust valve stem installed height - new: 46.68-47.48 mm (1.838-1.869 in)
- Exhaust valve stem installed height - service limit: 47.73 mm (1.879 in)

CYLINDER HEAD ASSEMBLE

Tools Required

- **EN 46336** Valve Guide Seal Installer. See **Special Tools and Equipment** .
- **EN 46353** Valve Spring Compressor Attachment - Head Off-Vehicle. See **Special Tools and Equipment** .
- **SA9124E** Regulator Valve Remover/Replacer. See **Special Tools and Equipment** .

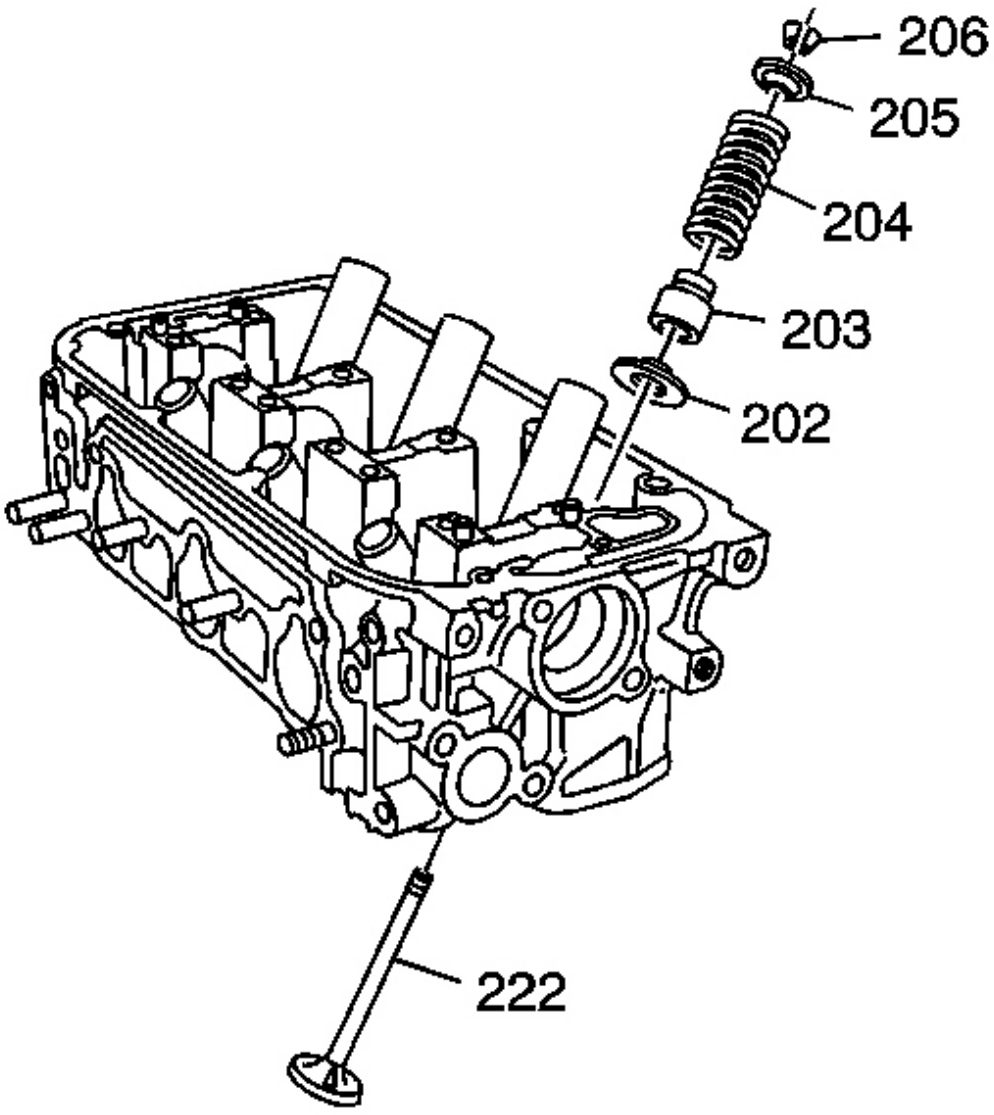


Fig. 302: View Of Cylinder Head
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If using the components again, return the components to their original location and position. Refer to Separating Parts .

1. Install the seats (202).

2. Lubricate the valve stem oil seals (203) with clean engine oil.

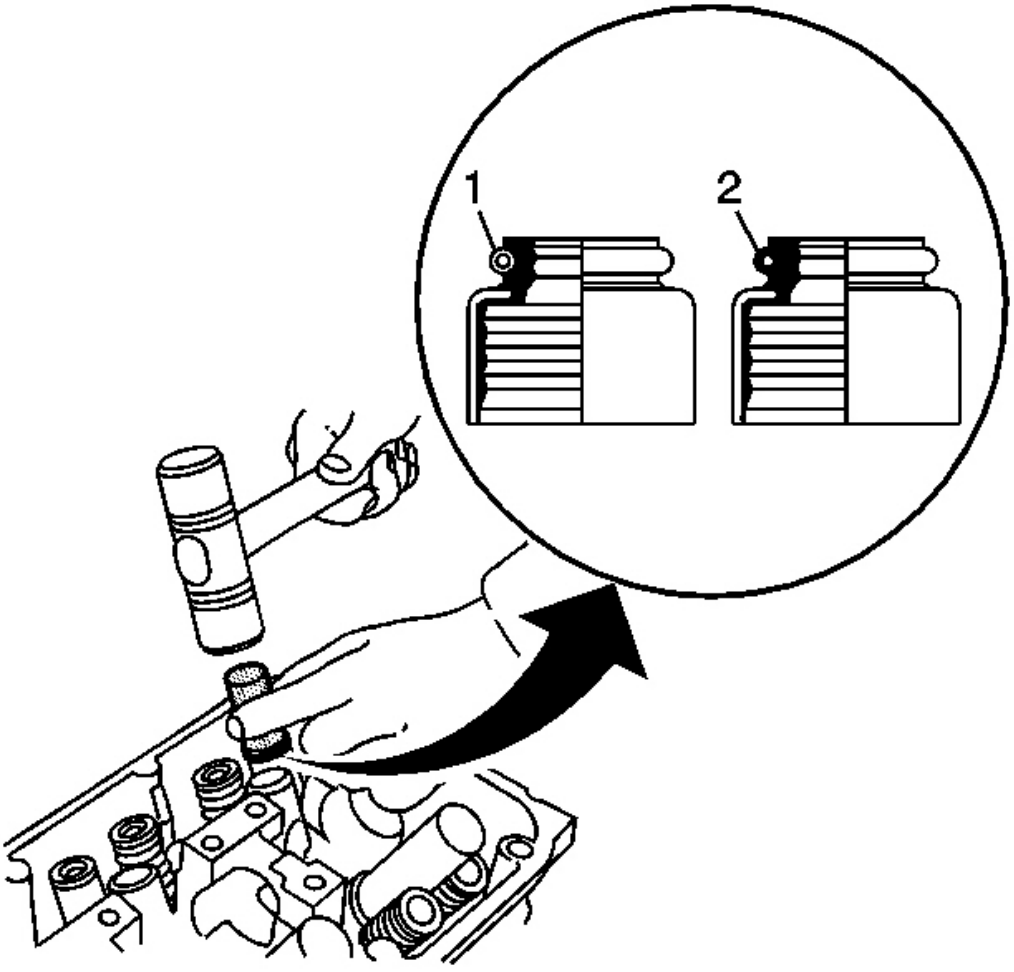


Fig. 303: View Of Valve Stem Oil Seals Onto The Guides
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Intake and exhaust seals are NOT interchangeable.

3. Use the **EN 46336** in order to install the valve stem oil seals onto the guides. See **Special Tools and Equipment** . Intake valve seals have a white spring (1). Exhaust valve seals have a black spring (2).

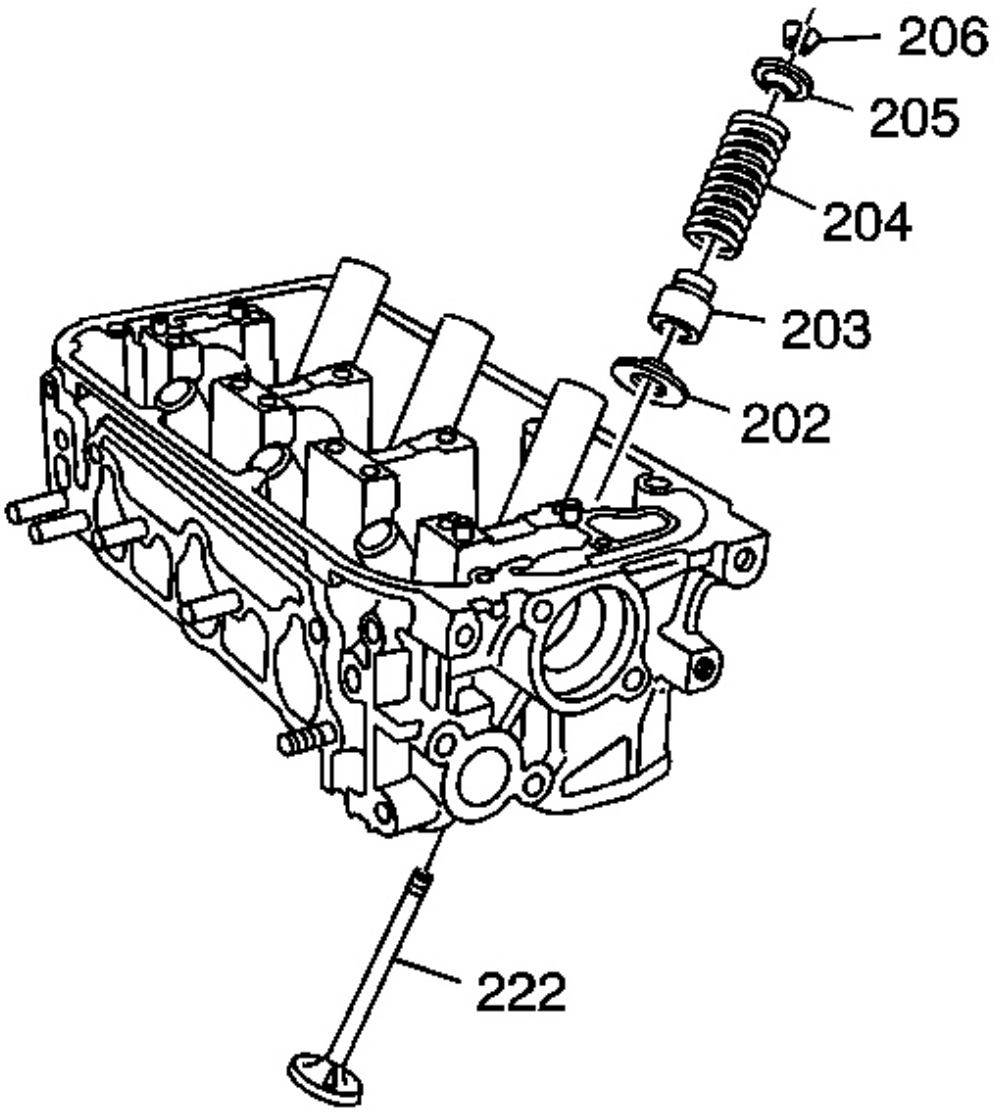


Fig. 304: View Of Keys, Cap, Spring & Valve
Courtesy of GENERAL MOTORS CORP.

4. Install the valves (222), springs (204) and caps (205).

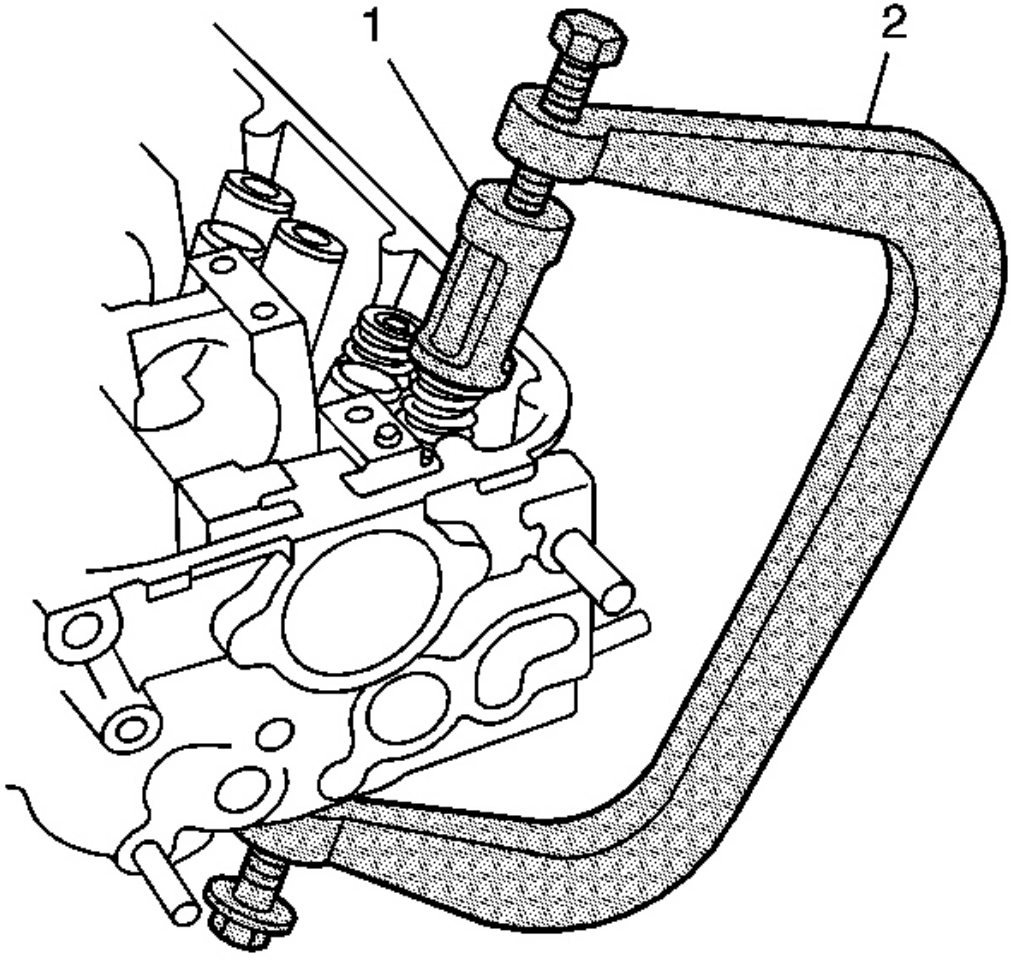


Fig. 305: View Of Valve Stem Keys
Courtesy of GENERAL MOTORS CORP.

5. Use the **SA9124E** (2) and the. See **Special Tools and Equipment** .**EN 46353** (1) in order to compress the valve spring. See **Special Tools and Equipment** .
6. Install the valve stem keys and remove the **SA9124E** (2) and. See **Special Tools and Equipment** .**EN 46353** (1). See **Special Tools and Equipment** .

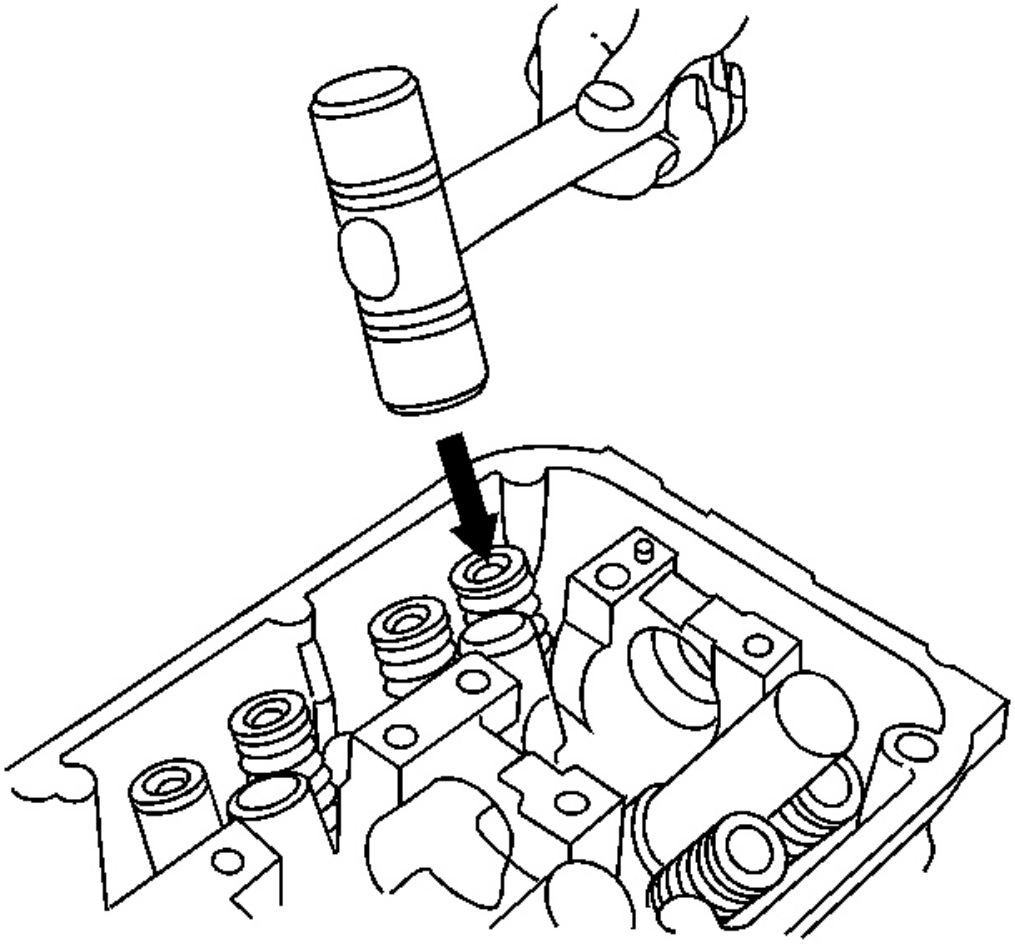


Fig. 306: Tapping The End Of Each Valve Stem
Courtesy of GENERAL MOTORS CORP.

7. Using a plastic-faced hammer, lightly tap the end of each valve stem 2-3 times to ensure proper seating of the valve and keys.

OIL PUMP DISASSEMBLE

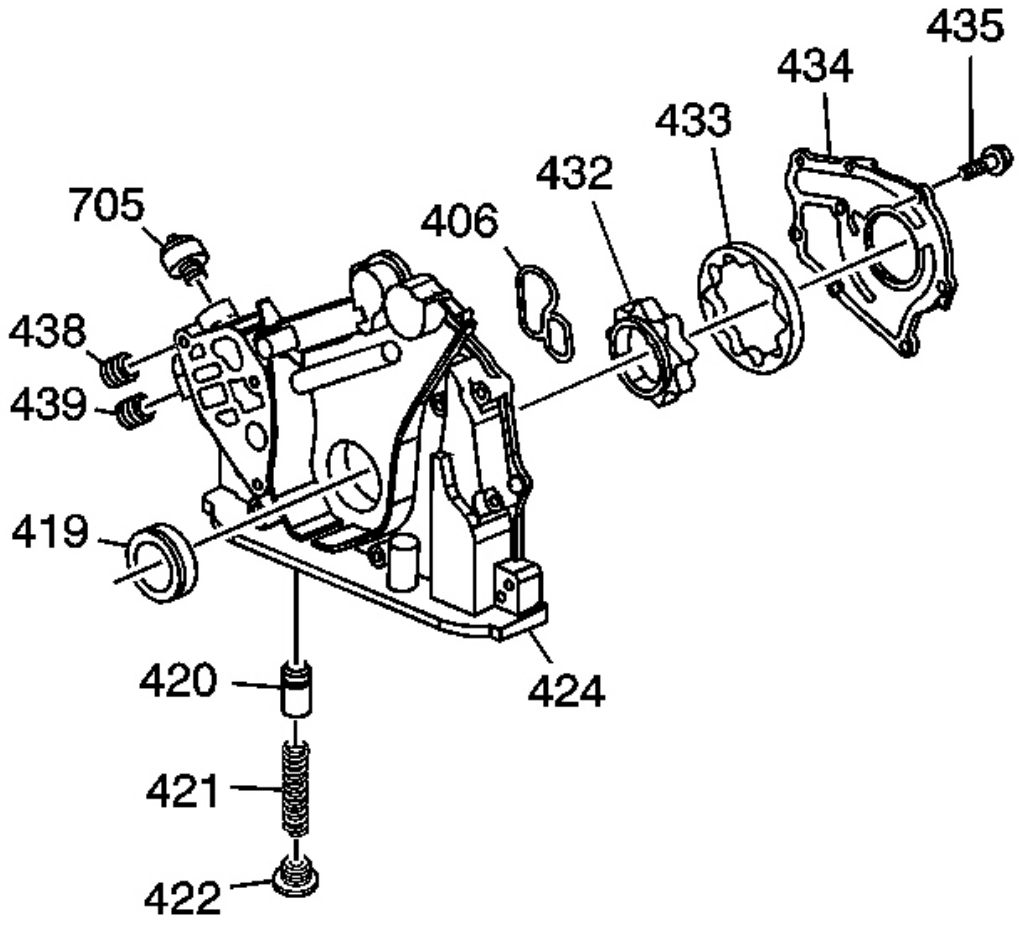


Fig. 307: Identifying Oil Pump Disassemble
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pressure switch (705).
2. Remove the crankshaft front oil seal (419).
3. Remove the O-ring (406).
4. Remove the bolts (435) and cover (434).
5. Mark the inner and outer rotors with a paint stick in order to return to original direction during assembly.
6. Remove the inner rotor (432) and outer rotor (433).
7. Remove the bolt (422), spring (421), and valve (420).
8. Remove the plugs (438 and 439).

OIL PUMP CLEANING AND INSPECTION

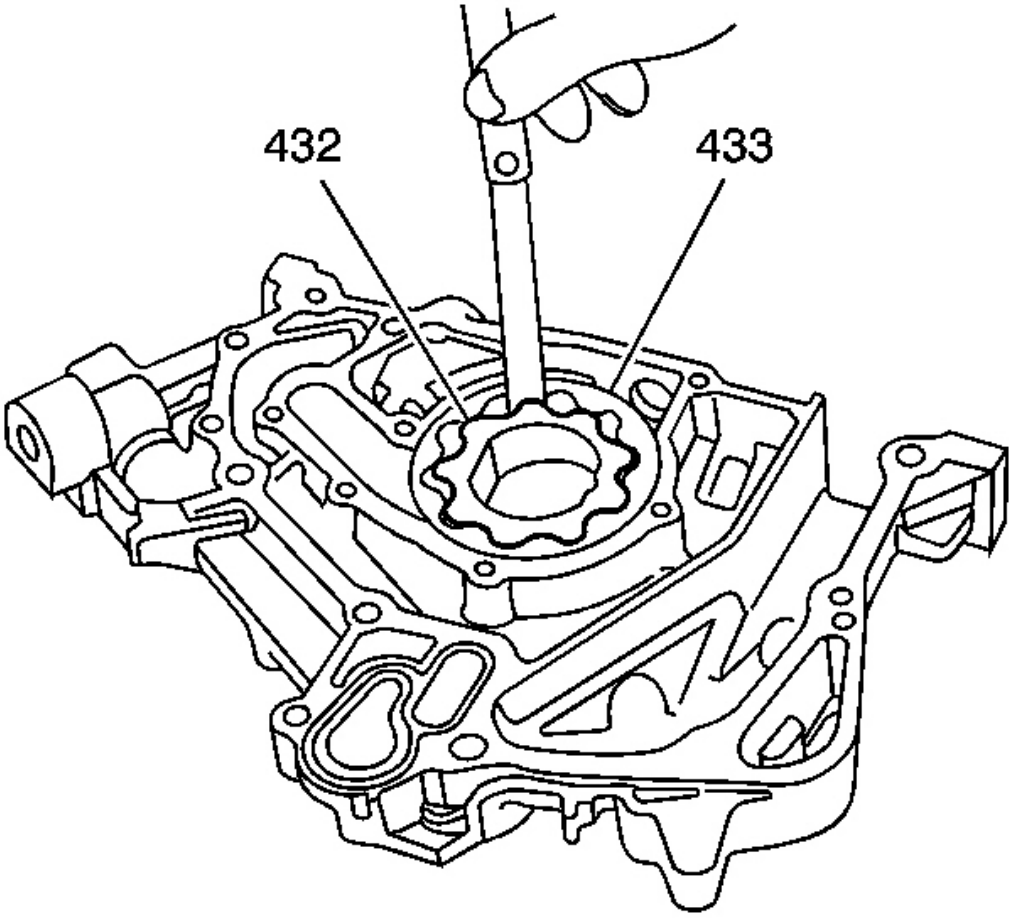


Fig. 308: Measuring The Inner Rotor & The Outer Rotor
Courtesy of GENERAL MOTORS CORP.

1. Disassemble the oil pump. Refer to **Oil Pump Disassemble** .
2. Measure the inner-to-outer rotor radial clearance. Use a feeler gage to measure between the inner rotor (432) and the outer rotor (433).

   If the clearance exceeds the service limit, replace the oil pump assembly.

   Specification:

   - Oil pump inner rotor-to-outer rotor radial clearance - new: 0.04-0.16 mm (0.002-0.0063 in)
   - Oil pump inner rotor-to-outer rotor radial clearance - service limit: 0.2 mm (0.008 in)

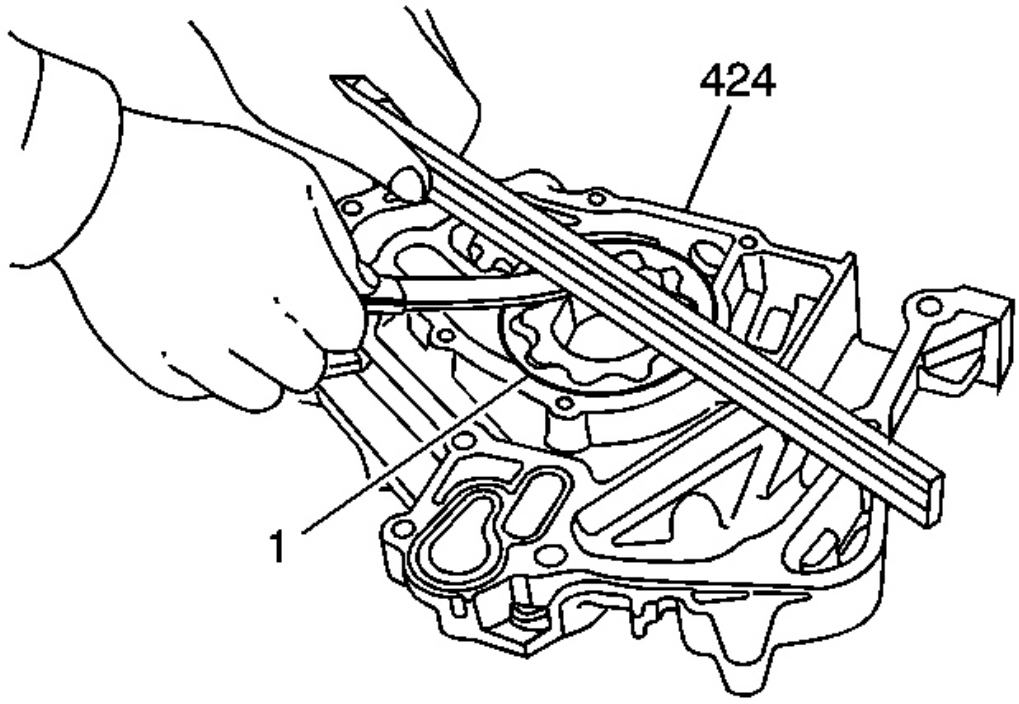


Fig. 309: Measuring The Housing-To-Rotor Axial Clearance
Courtesy of GENERAL MOTORS CORP.

3. Measure the housing-to-rotor axial clearance. Use a feeler gage and a straight edge to measure between both rotors (1) and the straight edge.

   If the clearance exceeds the service limit, replace the oil pump assembly.

   Specification:

   - Housing-to-rotor axial clearance - new: 0.02-0.07 mm (0.001-0.003 in)
   - Housing-to-rotor axial clearance - service limit: 0.12 mm (0.005 in)

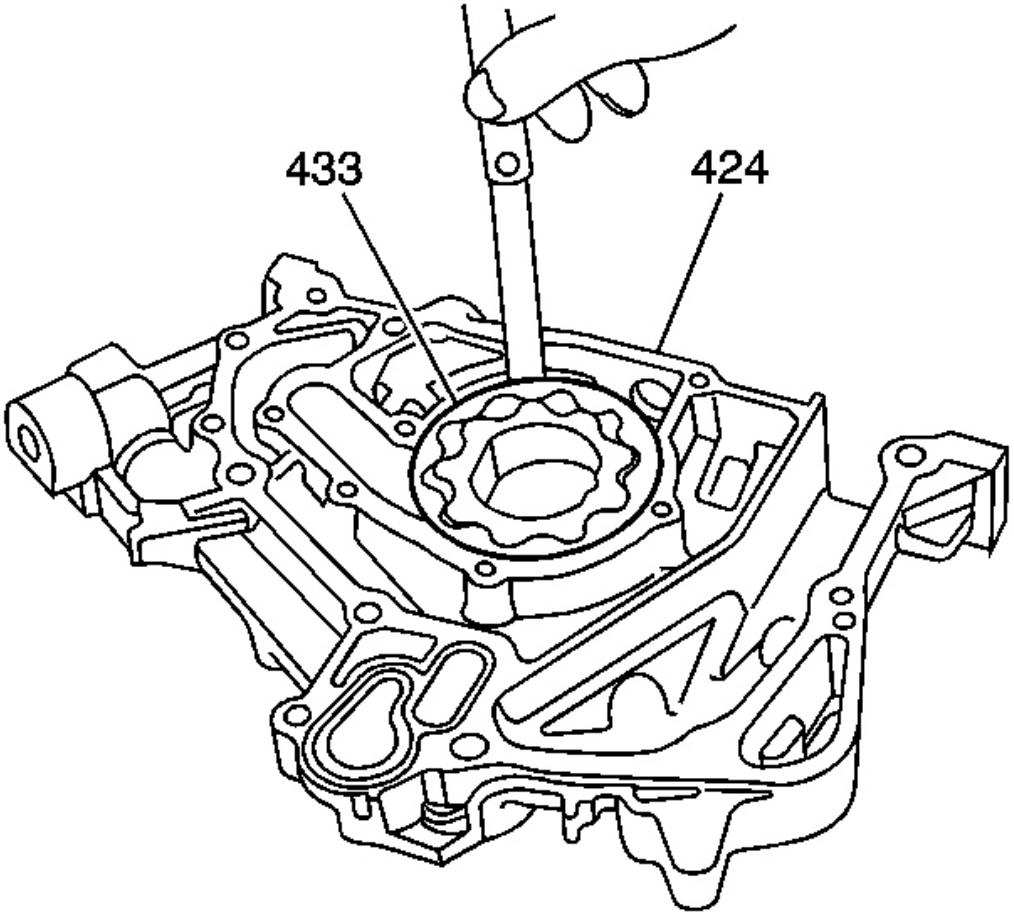


Fig. 310: Measuring The Outer Rotor & The Pump Housing Using A Feeler Gage
Courtesy of GENERAL MOTORS CORP.

4. Measure the housing-to-outer rotor radial clearance. Use a feeler gage to measure between the outer rotor (433) and the pump housing (424).

   If the clearance exceeds the service limit, replace the oil pump assembly.

   Specification:

   - Housing-to-outer rotor radial clearance - new: 0.10-0.19 mm (0.004-0.007 in)
   - Housing-to-outer rotor radial clearance - service limit: 0.2 mm (0.008 in)

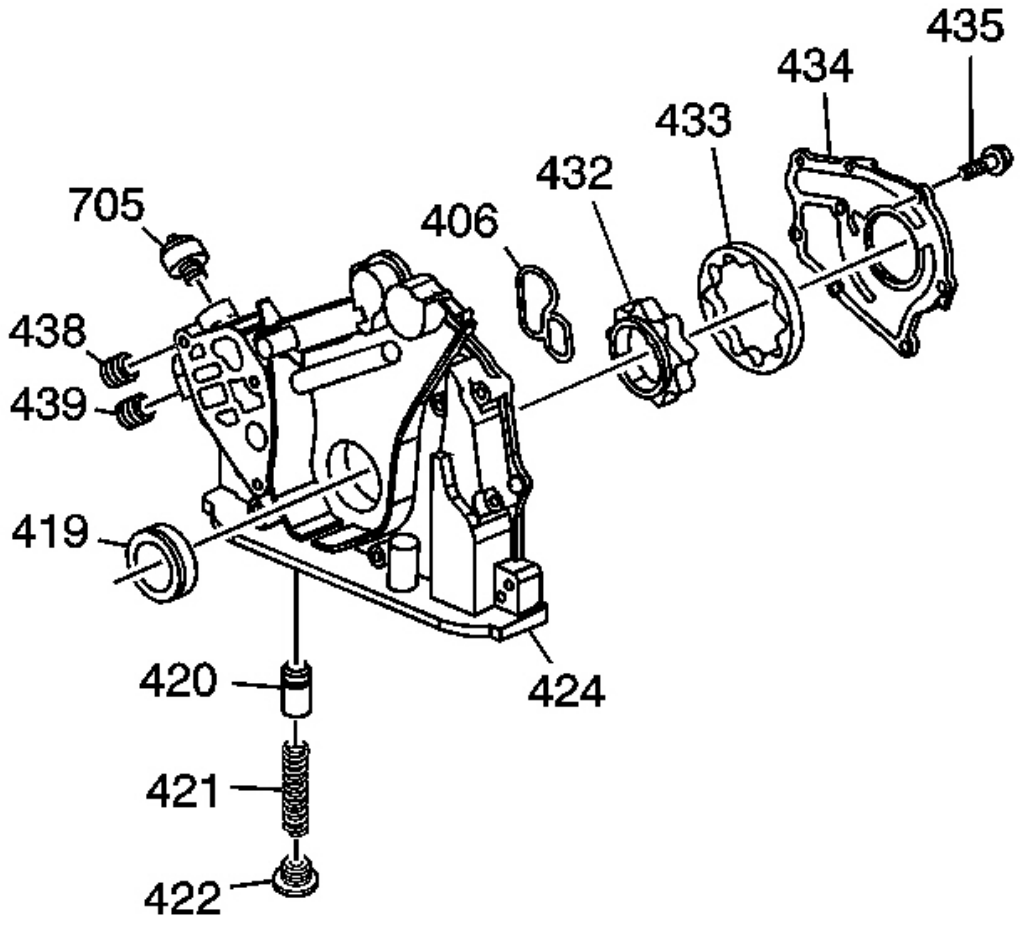


Fig. 311: Identifying Oil Pump Disassemble
Courtesy of GENERAL MOTORS CORP.

5. Inspect both rotors (432 and 433) for scoring or other damage.
6. Inspect the valve (420) and valve bore for scoring or other damage. The valve must move freely in the bore.
7. Inspect for a collapsed or broken spring (421).
8. Inspect the sealing surfaces for damage.
9. Inspect the oil passages for debris or restrictions.
10. Assemble the oil pump. Refer to **Oil Pump Assemble** .

OIL PUMP ASSEMBLE

Tools Required

- **EN 46342** Driver Handle
- **EN 46347** Crankshaft Front Oil Seal Driver. See **Special Tools and Equipment** .

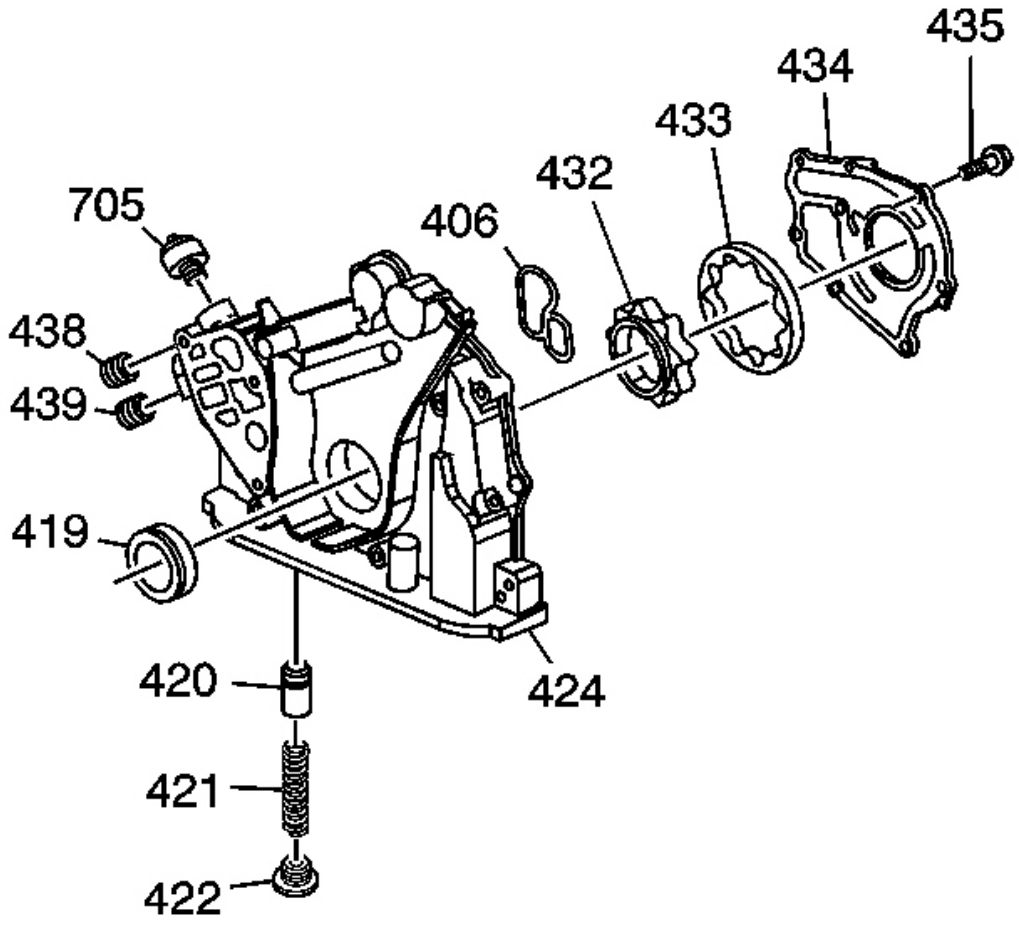


Fig. 312: Identifying Oil Pump Disassemble
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the rotors (432, 433) and valve (420) with clean engine oil.
2. Install the rotors (432, 433) to original direction.
3. Install the cover (434).
4. Apply threadlock GM P/N 12346240 (Canadian P/N 10953493) or equivalent to the threads of the bolts (435).

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Install the bolts (435).

   Tighten: Tighten the bolts to 6 N.m (53 lb in).

6. Apply sealant GM P/N 12346240 (Canadian P/N 10953493) to the threads of the bolt (422).
7. Install the valve (420), spring (421) and bolt (422). The valve must slide freely in the housing bore.

   Tighten: Tighten the bolt to 39 N.m (28 lb ft).

8. Apply sealant GM P/N 12346240 (Canadian P/N 10953493) or equivalent to the threads of the switch (705).
9. Install the switch (705).

   Tighten: Tighten the switch to 18 N.m (13 lb ft).

10. Apply sealant GM P/N 12346240 (Canadian P/N 10953493) to the threads of the plugs (438, 439).
11. Install the plugs (438, 439).

    Tighten:

    1. Tighten plug (438) to 44 N.m (32.5 lb ft).
    2. Tighten plug (439) to 34.3 N.m (25.3 lb ft).

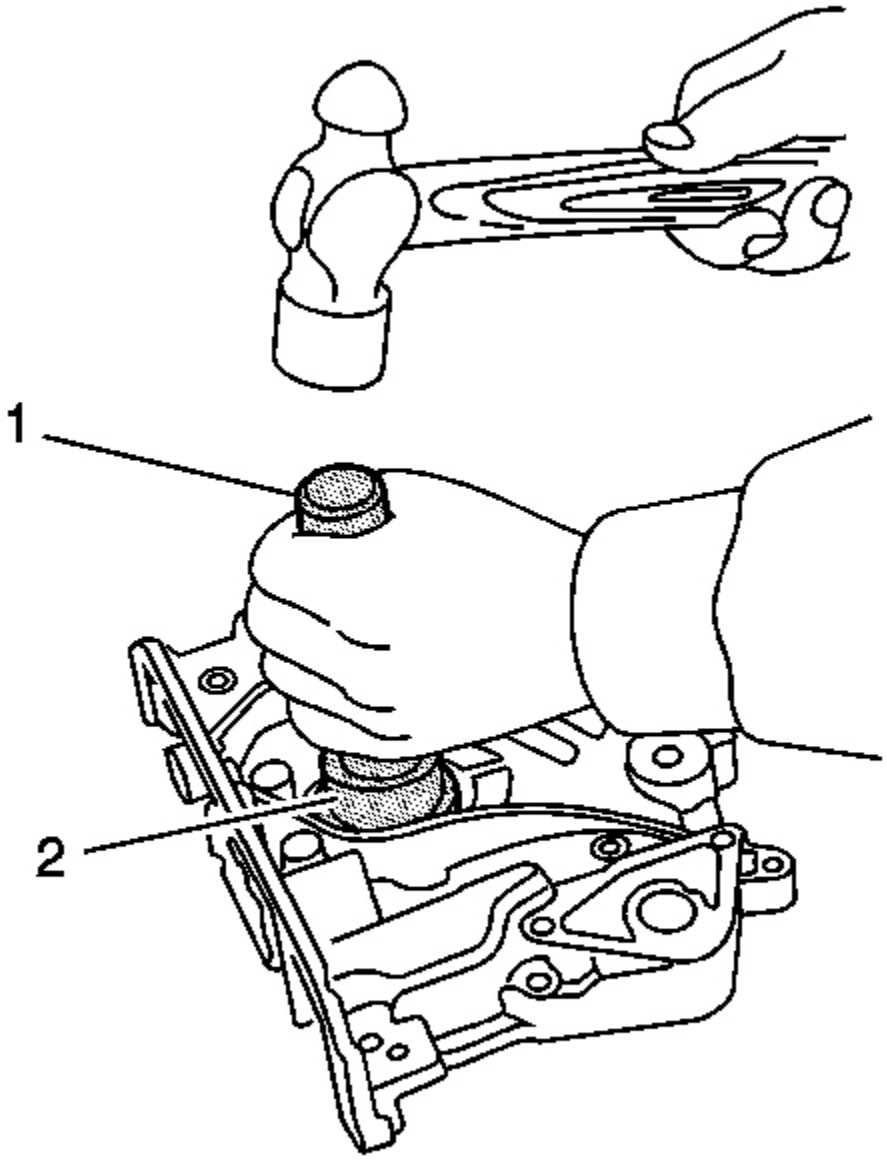


Fig. 313: View Of Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

12. Use the **EN 46347** (2) and the. See **Special Tools and Equipment** .**EN 46342** (1) in order to install the oil seal. Gently tap and install the NEW oil seal until the tool bottoms on the oil pump housing.

OIL FLOW CONTROL MODULE CLEANING AND INSPECTION

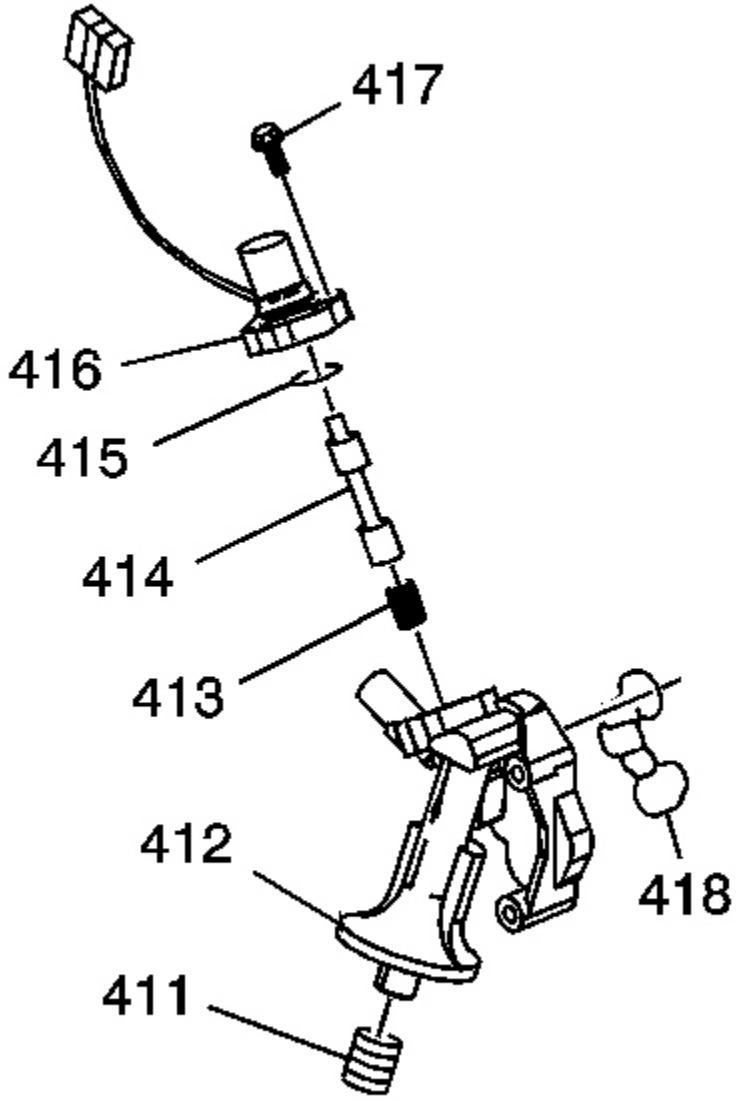


Fig. 314: View Of Module Control
Courtesy of GENERAL MOTORS CORP.

1. Inspect the module housing (412) for the following conditions:
    - Damaged sealing surfaces
    - Restrictions within the oil passages

- A worn or scored valve bore

  The valve (414) must move freely within the bore.

2. Inspect the solenoid (416) for damaged wires or electrical connector.
3. Using an ohm meter, test the solenoid wiring. If the measurement is infinity or greater than 14-30 ohms, replace the solenoid.
4. Inspect for a plugged screen (418).
5. Inspect for damaged threads on the oil filter fitting (411).
6. Inspect the valve (414) for scoring.
7. Inspect for a broken valve spring (413).

VALVE ROCKER ARM COVER CLEANING AND INSPECTION

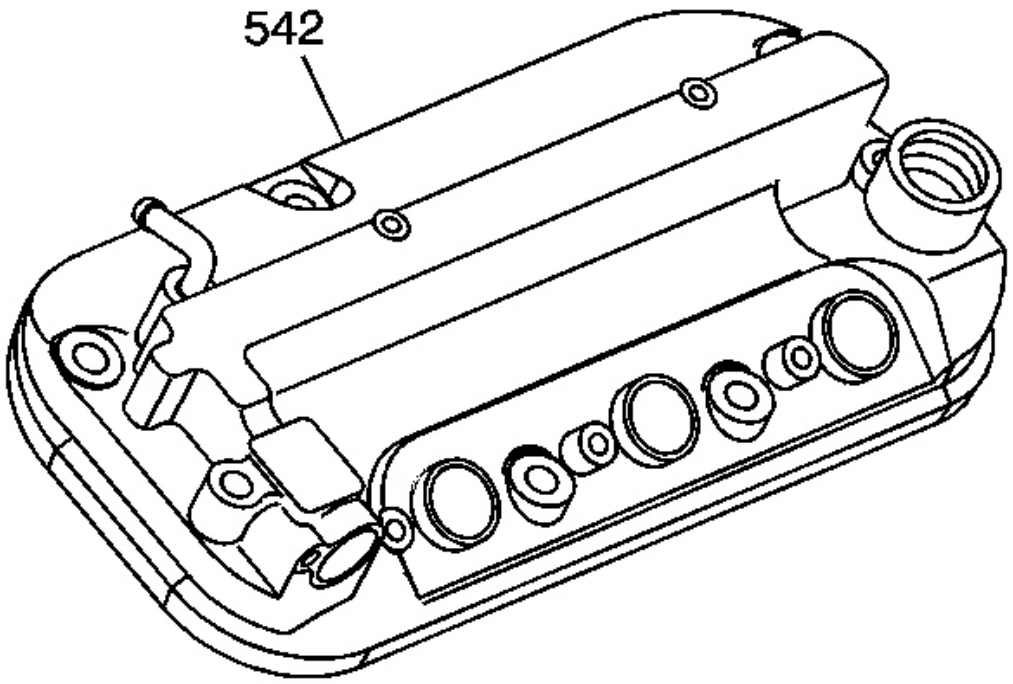


Fig. 315: View Of Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

Inspect the valve rocker arm covers (542) for the following conditions:

- Damaged sealing surfaces
- Damaged bolt hole threads
- Restrictions within the positive crankcase ventilation (PCV) system passages

OIL PAN CLEANING AND INSPECTION

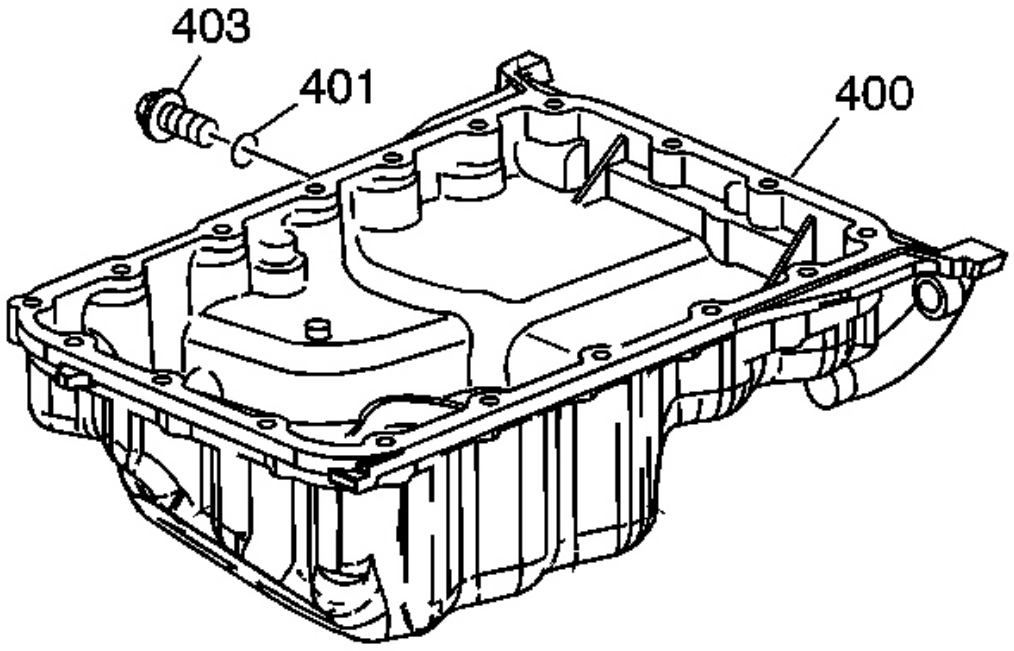


Fig. 316: View Of Oil Pan
Courtesy of GENERAL MOTORS CORP.

Inspect the oil pan (400) for the following conditions:

- A damaged sealing surface
- Damaged drain plug (403) or oil pan threads
- Damage to the exterior of the pan

INTAKE MANIFOLD CLEANING AND INSPECTION

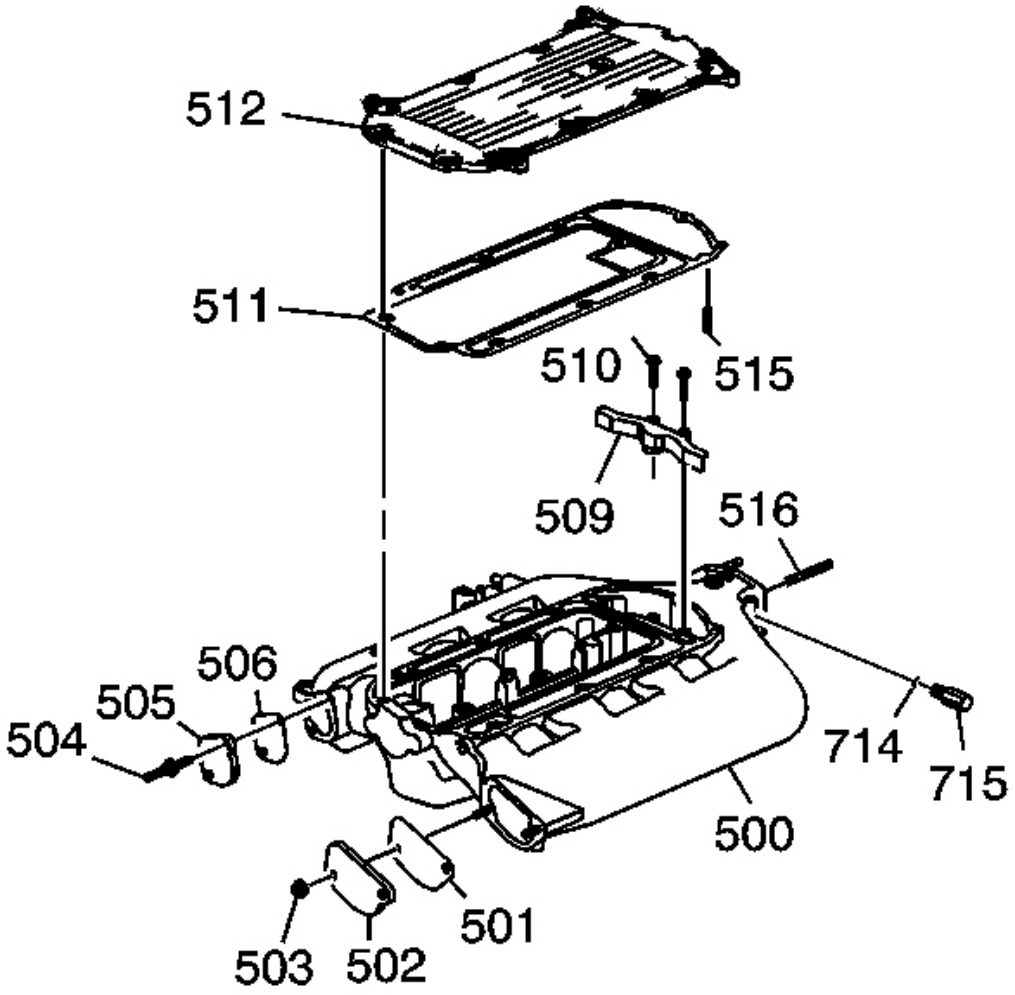


Fig. 317: View Of Intake Manifold
Courtesy of GENERAL MOTORS CORP.

Inspect the manifold (500) for the following conditions:

- Damaged sealing surfaces
- Damaged or loose throttle body studs (516)
- Loose covers (502 and 505) or damaged or missing gaskets (501 and 506)
- Plugged or loose exhaust gas recirculation (EGR) tube (509)
- Damage to the exterior of the manifold
- Damaged bolt hole threads

WATER PUMP CLEANING AND INSPECTION

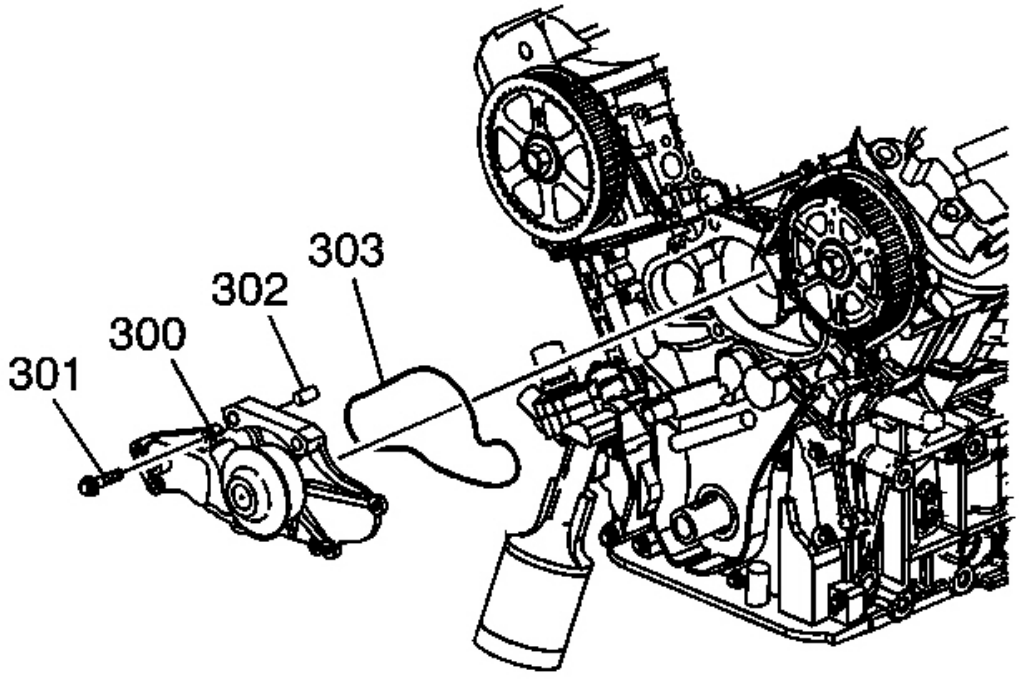


Fig. 318: View Of Water Pump
Courtesy of GENERAL MOTORS CORP.

Inspect the water pump (300) for the following conditions:

- Gasket sealing surfaces for excessive scratches or gouging
- Restrictions within the coolant passages
- Excessive side-to-side play in the pulley shaft
- A loose belt pulley or a pulley with excessive wear in the belt tracking area
- Leakage at the vent hole

  A stain around the vent hole is acceptable. If leakage occurs, such as dripping with the engine running or the cooling system pressurized, replace the water pump.

SERVICE PRIOR TO ASSEMBLY

- Dirt or debris will cause premature wear of the rebuilt engine. Clean all the components.

Refer to **Cleanliness and Care** .

- Use the proper tools to measure components when checking for excessive wear. Components that are not within the manufacturers specifications must be repaired or replaced.
- When the components are reinstalled into an engine, return the components to their original location, position and direction.

  Refer to **Separating Parts** .

- During assembly, lubricate all the moving parts with clean engine oil. This will provide initial lubrication when the engine is first started.

ENGINE PRELUBING

Tools Required

- **J 45299** Engine Preluber
- **EN 46333** Oil Pressure Testing Adapter. See **Special Tools and Equipment** .

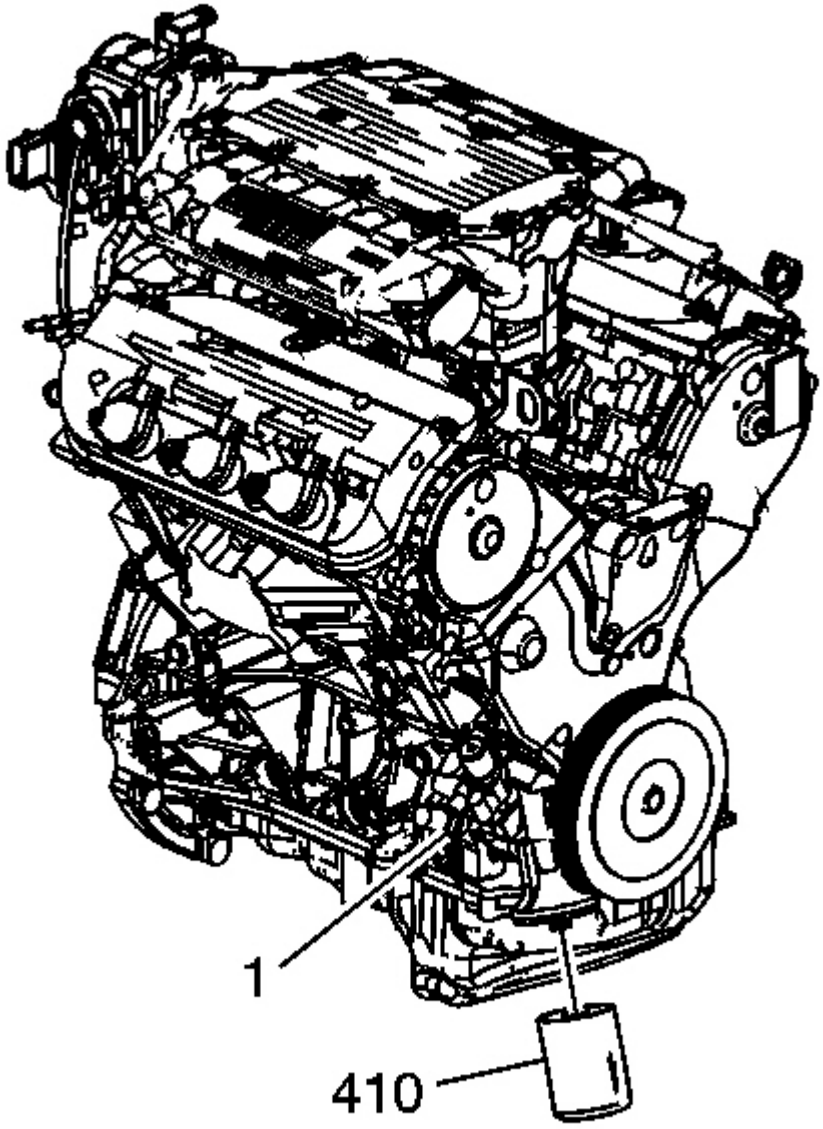


Fig. 319: View Of Engine Prelubing
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: A constant and continuous flow of clean engine oil is required in order to properly prime the engine. Be sure to use an approved engine oil as specified in the owners manual.

1. Remove the engine oil filter (410) and fill with clean engine oil.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the oil filter.

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

3. Remove the oil pressure switch (1).
4. Install the **EN 46333** . See **Special Tools and Equipment** .

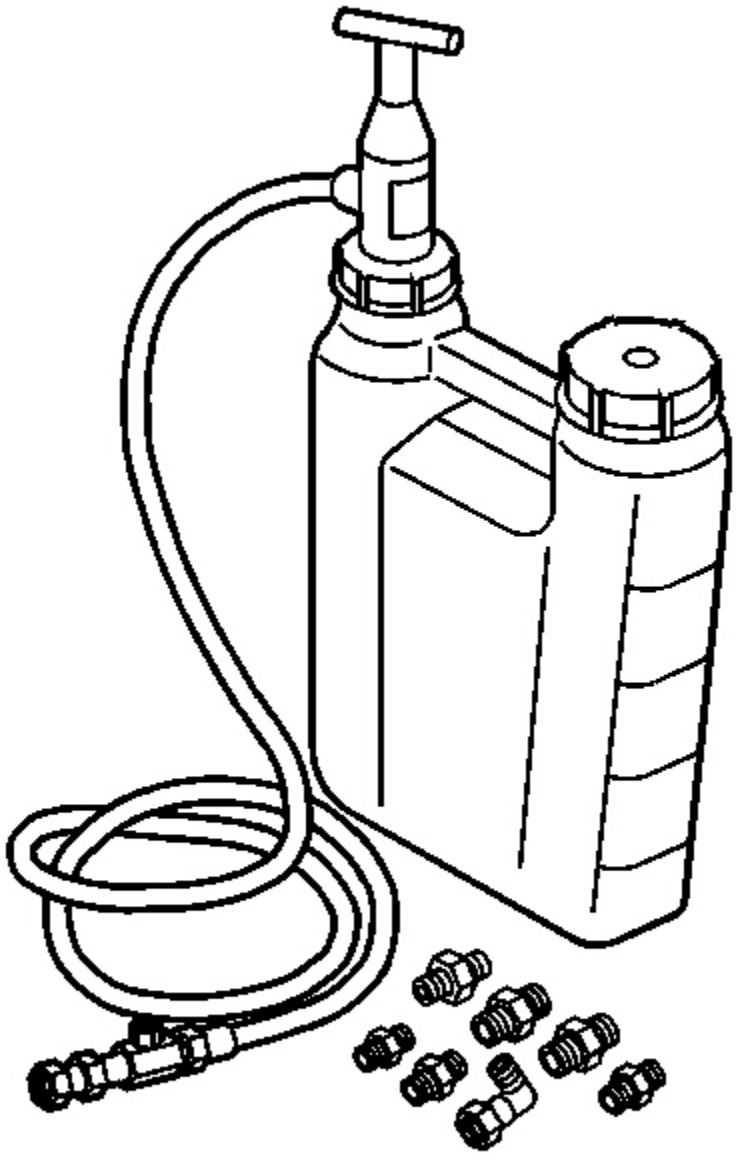


Fig. 320: Identifying J 45299
Courtesy of GENERAL MOTORS CORP.

5. Install the flexible hose to the **EN 46333** and open the valve. See **Special Tools and Equipment** .
6. Pump the handle on the **J 45299** in order to flow a minimum of 1-1.9 liters (1-2 quarts) engine oil. Observe the flow of engine oil through the flexible hose and into the engine assembly.

7. Close the valve and remove the flexible hose and adapter from the engine.
8. Install the oil pressure sensor to the engine.

   Tighten: Tighten the switch to 18 N.m (13 lb ft).

9. Top-off the engine oil to the proper level.

ENGINE BLOCK PLUG INSTALLATION

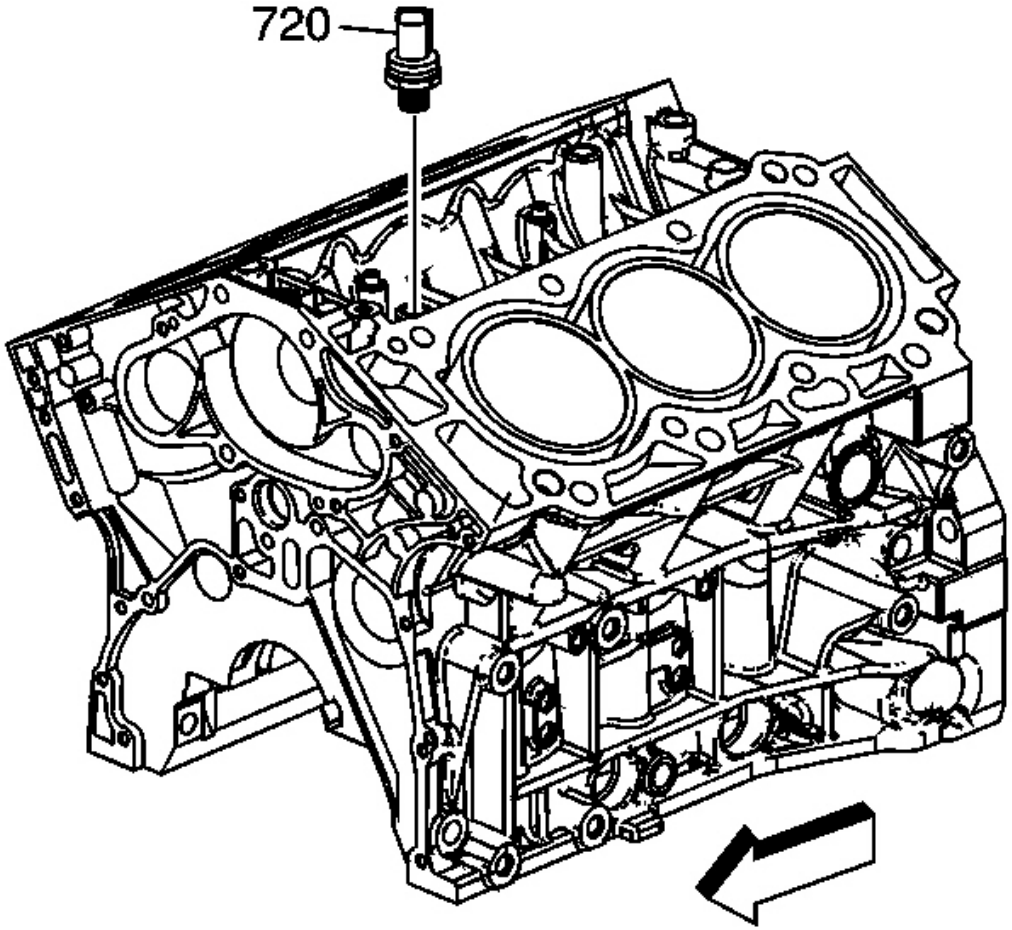


Fig. 321: View Of Engine Block Plug
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the knock sensor (720).

   Tighten: Tighten the knock sensor to 31 N.m (23 lb ft).

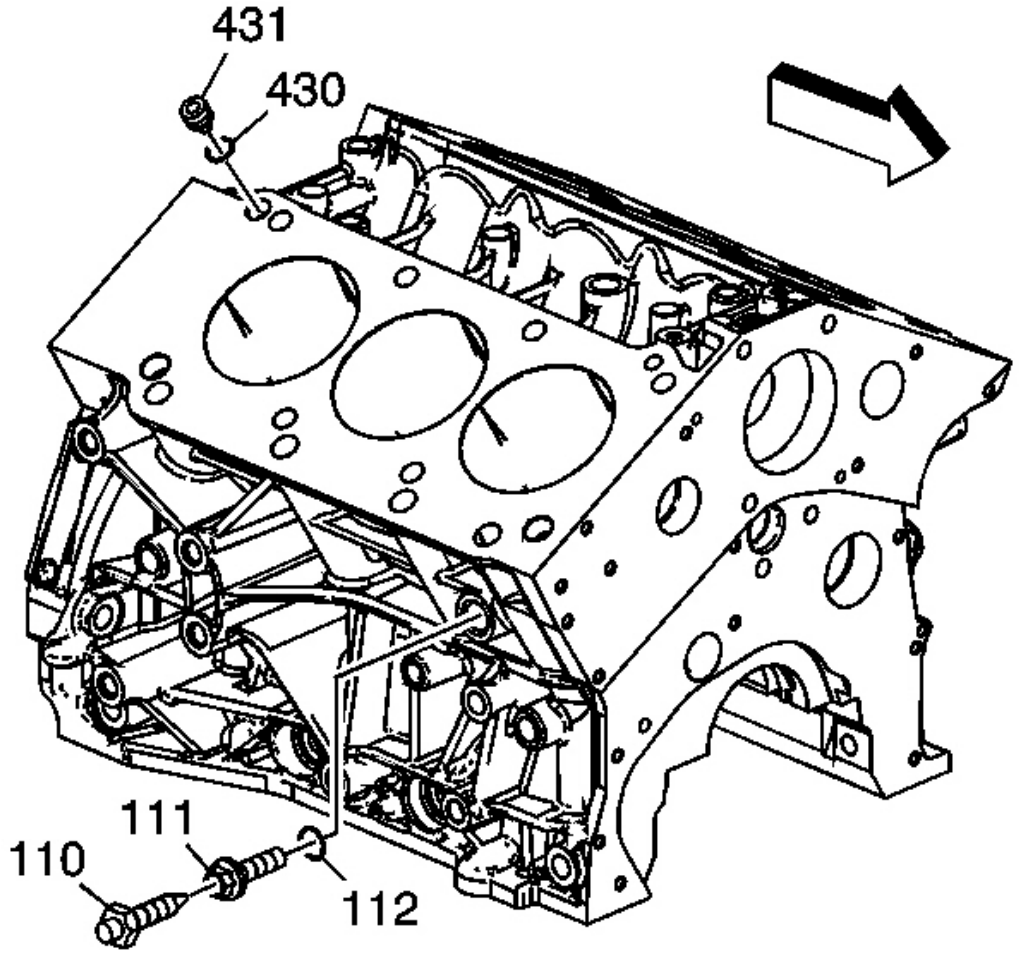


Fig. 322: Identifying Restrictor, O-Ring, Washer, Fitting & Drain Plug
Courtesy of GENERAL MOTORS CORP.

2. Install the restrictor (431) and NEW O-ring (430).
3. Install the right side washer (112), fitting (111) and drain plug (110).

   Tighten:

   1. Tighten the fitting to 39.2 N.m (28.9 lb ft).

2. Tighten the drain plug to 9.8 N.m (87 lb in).

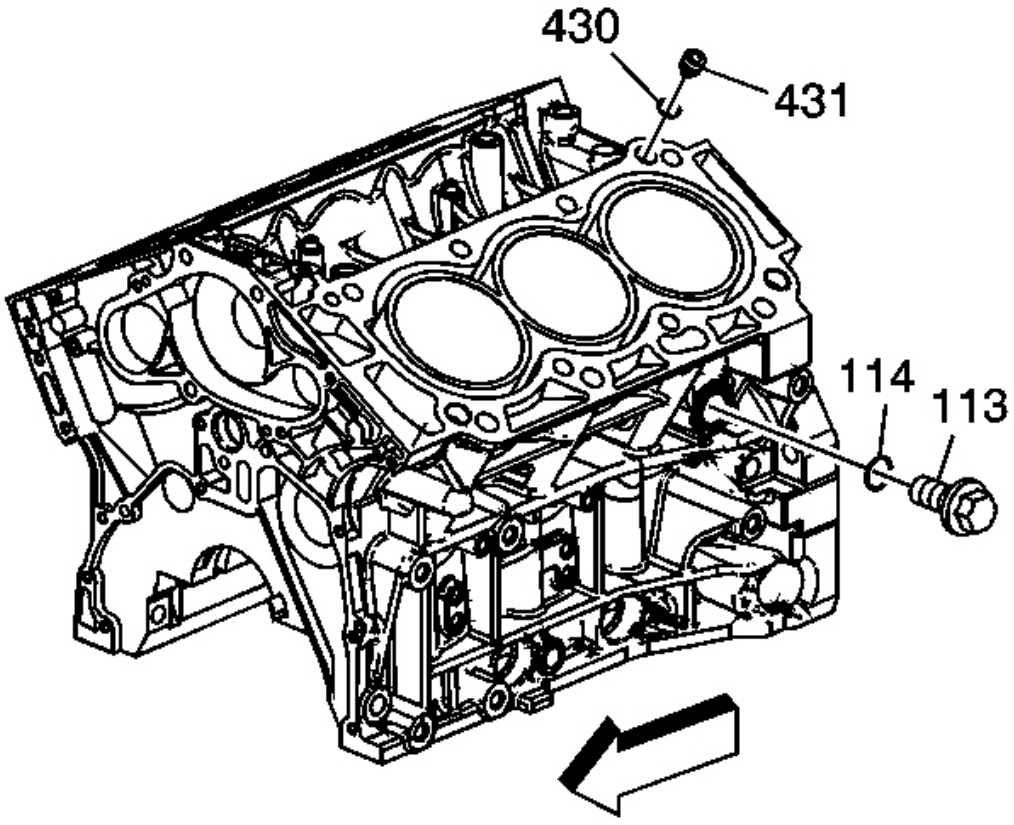


Fig. 323: View Of Coolant Drain Plug, Washer, Restrictor & O-Ring
Courtesy of GENERAL MOTORS CORP.

4. Install the restrictor (431) and NEW O-ring (430).
5. Install the left side washer (114) and drain plug (113).

Tighten: Tighten the drain plug to 78.5 N.m (57.9 lb ft).

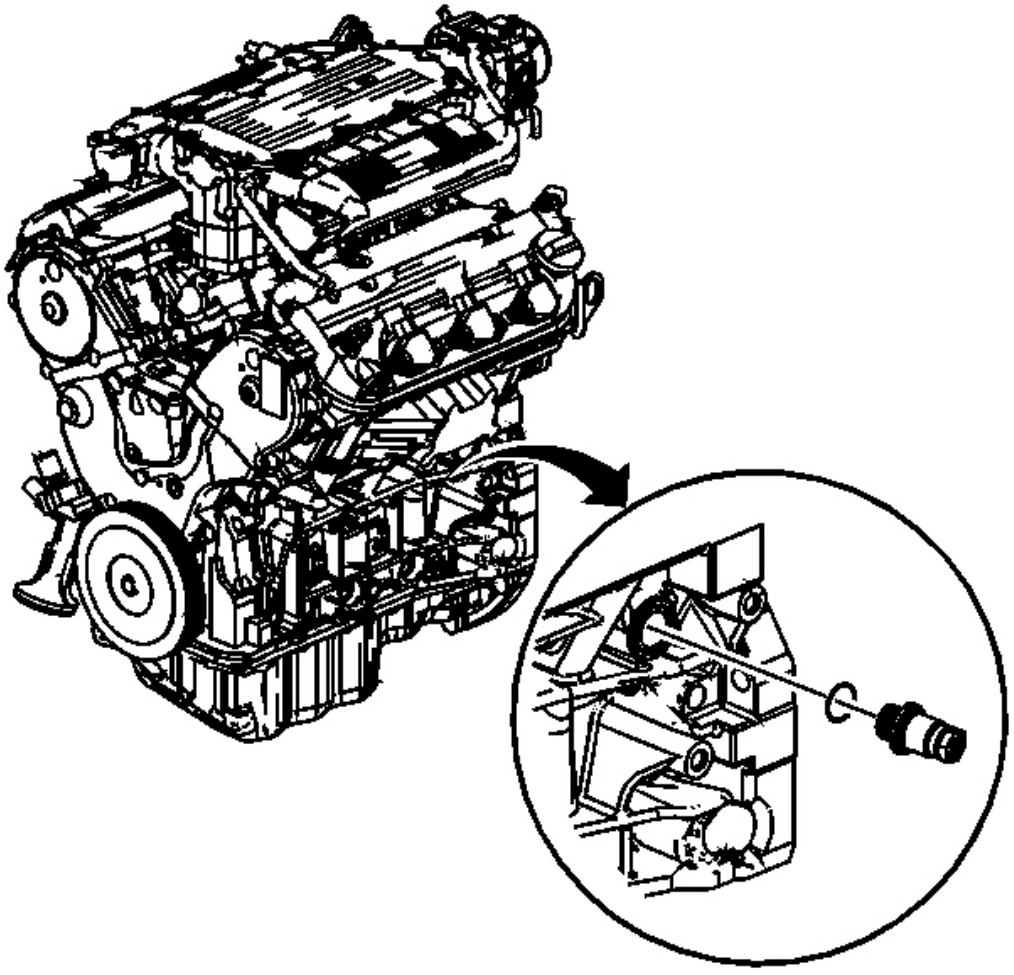


Fig. 324: View Of Block Coolant Heater & Washer
Courtesy of GENERAL MOTORS CORP.

6. Install the block coolant heater and washer, if applicable.

   Tighten: Tighten the heater to 60 N.m (44 lb ft).

CRANKSHAFT AND BEARINGS INSTALLATION

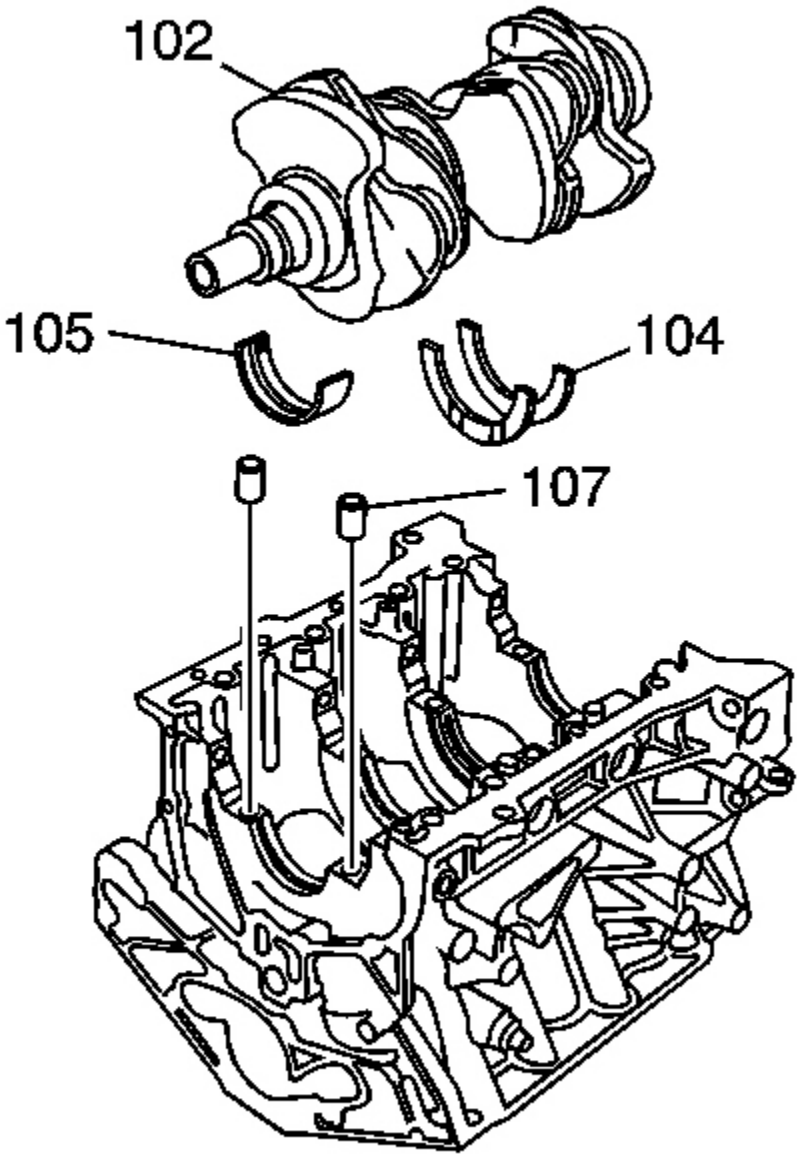


Fig. 325: View Of Bearings
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The powertrain control module (PCM) must perform the idle learn procedure to determine the minimum throttle position and to establish idle speed when any of the following components are replaced:

- **Throttle body**
- **Timing belt**
- **Timing belt drive sprocket**
- **Crankshaft and bearings**

Refer to Idle Learn Procedure .

1. Install the pins (107).
2. Lubricate the bearings (104 and 105) and crankshaft bearing surfaces with clean engine oil.
3. Install the upper bearings (105) to the block.
4. Install the crankshaft (102).

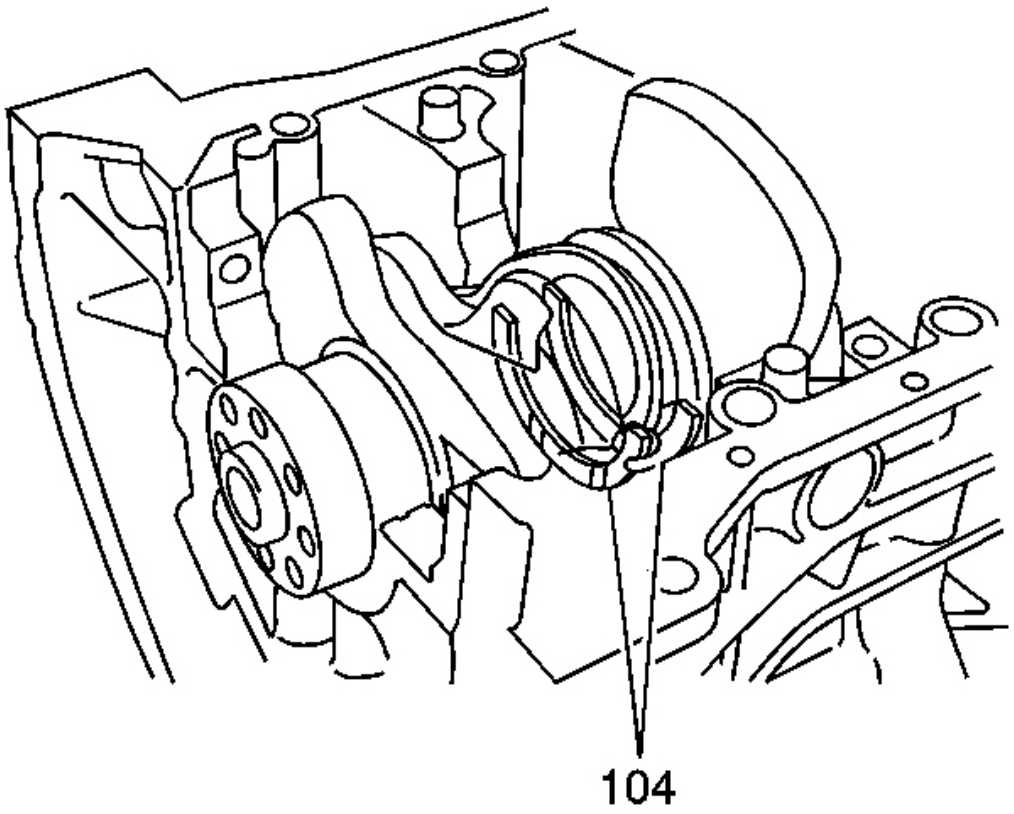


Fig. 326: View Of Thrust Bearings
Courtesy of GENERAL MOTORS CORP.

5. Install the thrust bearings (104) to number 3 journal.

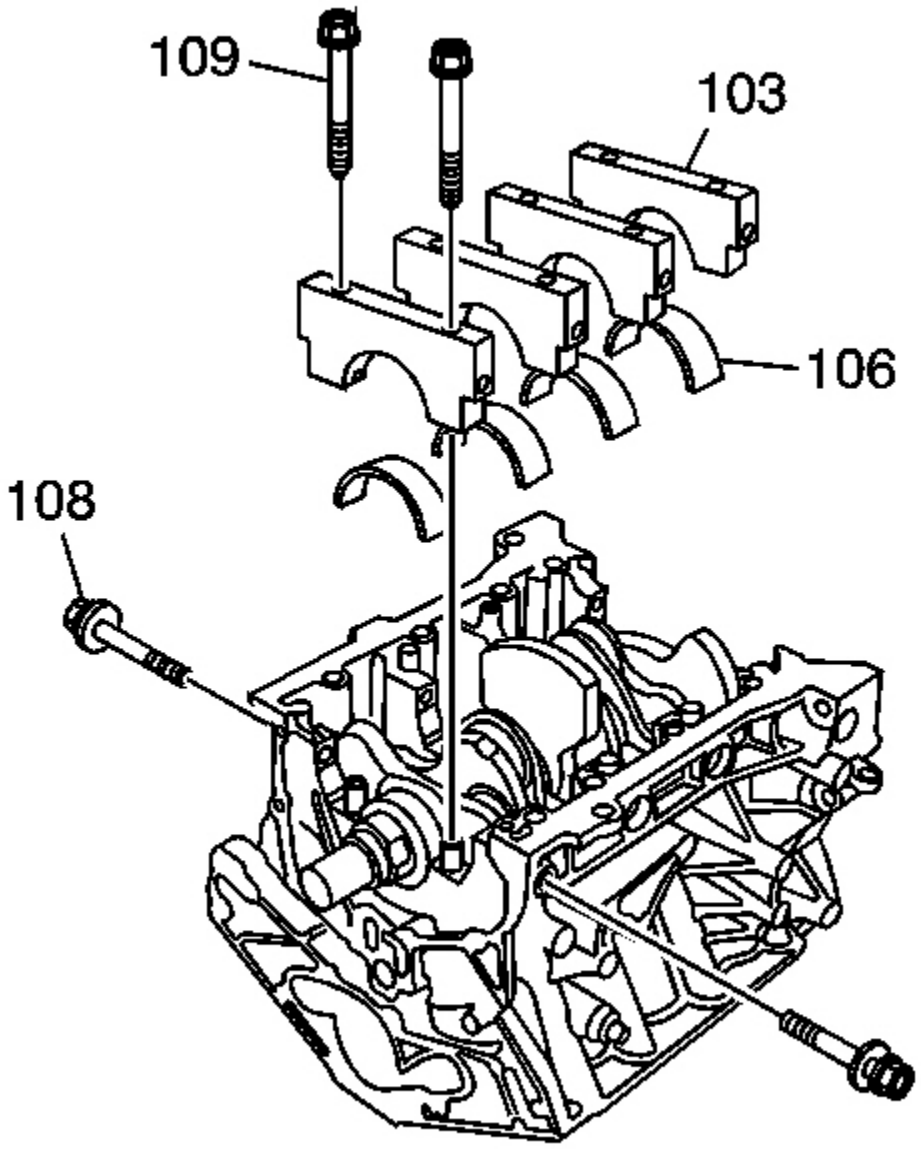


Fig. 327: View Of Bearings
Courtesy of GENERAL MOTORS CORP.

6. Install the lower bearings (106) and bearing caps (103).

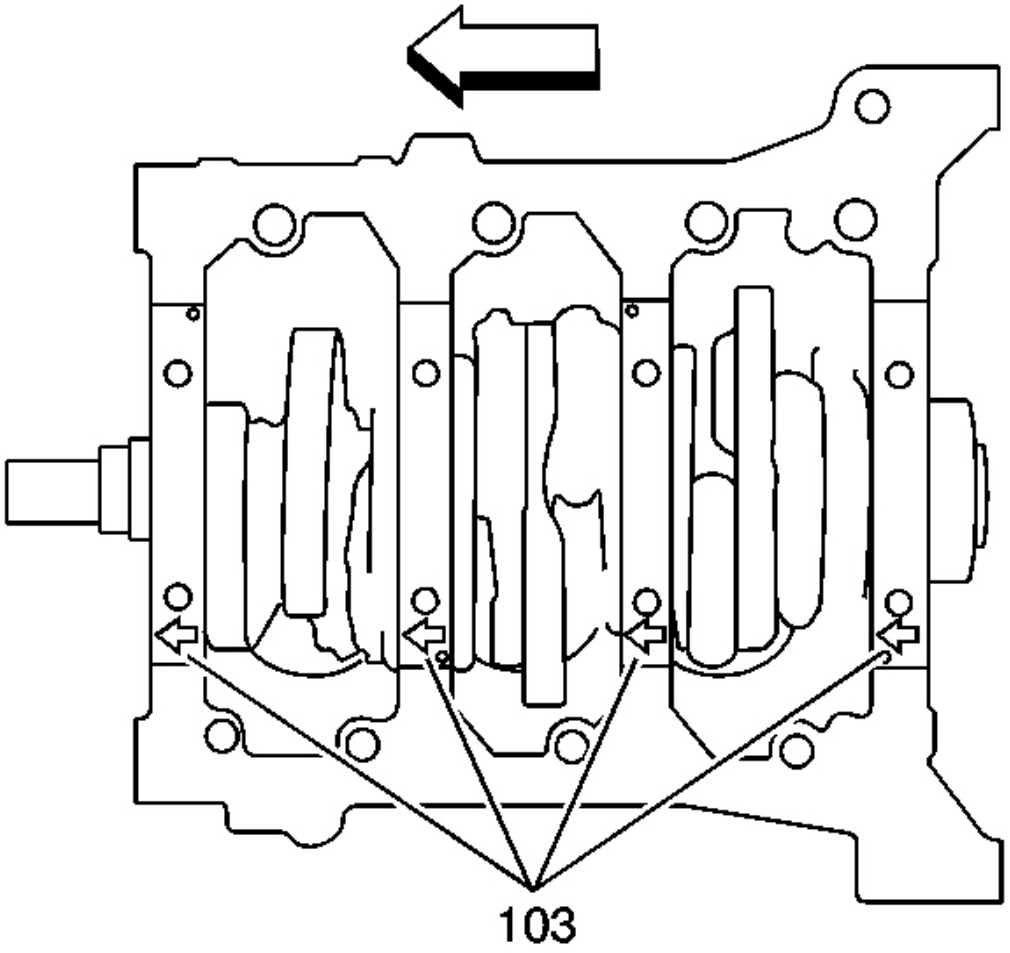


Fig. 328: View Of Bearing Caps
Courtesy of GENERAL MOTORS CORP.

7. Install the bearing caps (103) with the alignment arrow facing the front of the engine.

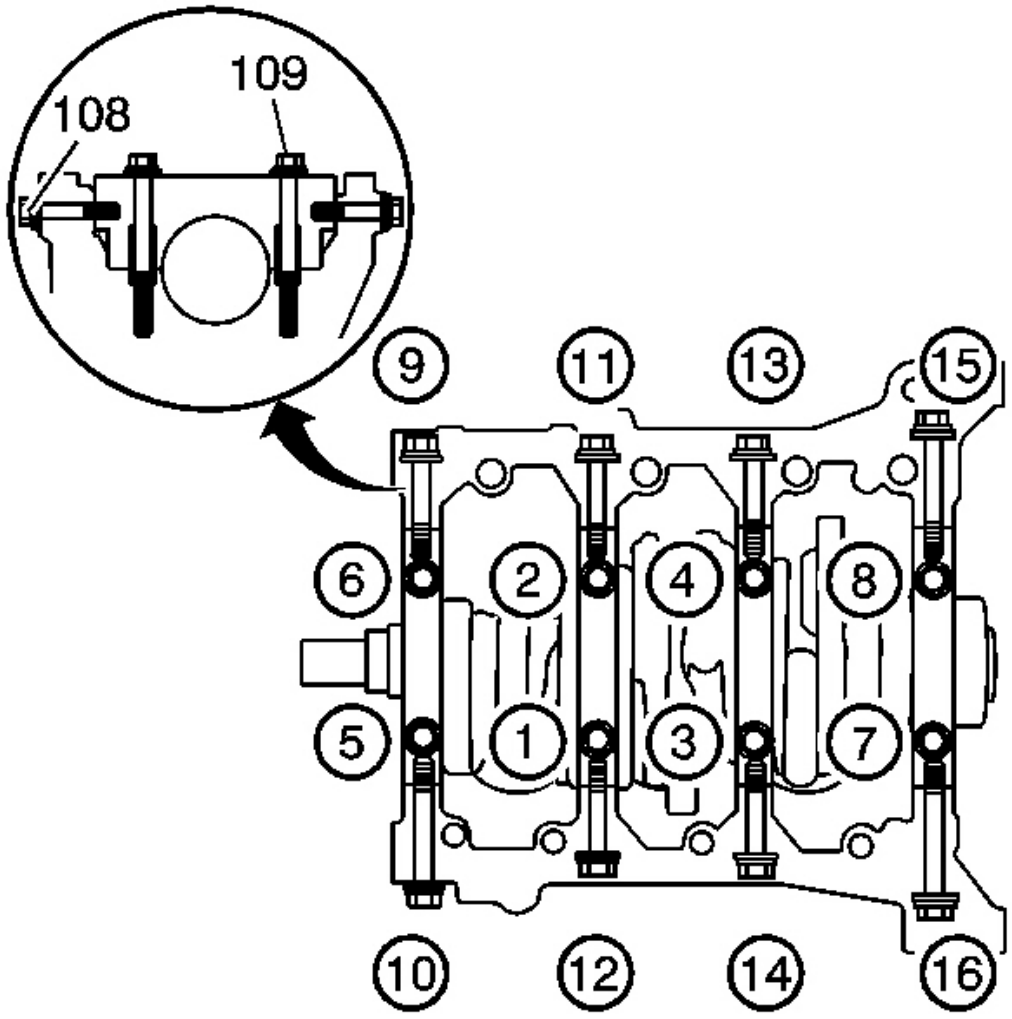


Fig. 329: View Of Bolt, Threads & Flanges With Clean Engine Oil
Courtesy of GENERAL MOTORS CORP.

8. Lubricate the bolt (108 and 109) threads and flanges with clean engine oil.

NOTE: Refer to Fastener Notice in Cautions and Notices.

9. Install the bolts (108 and 109).

Tighten:

1. Tighten the bolts (109) in sequence to 74 N.m (54 lb ft).

2. Tighten the bolts (108) in sequence to 49 N.m (36 lb ft).

10. Measure the crankshaft end-play. Refer to **Crankshaft and Bearings Cleaning and Inspection** .

PISTON, CONNECTING ROD, AND BEARING INSTALLATION

Tools Required

- **J 8037** Ring Compressor
- **J 41742** Connecting Rod Guide Pin
- **J 45059** Angle Meter or **SA9140E** Torque Angle Gage

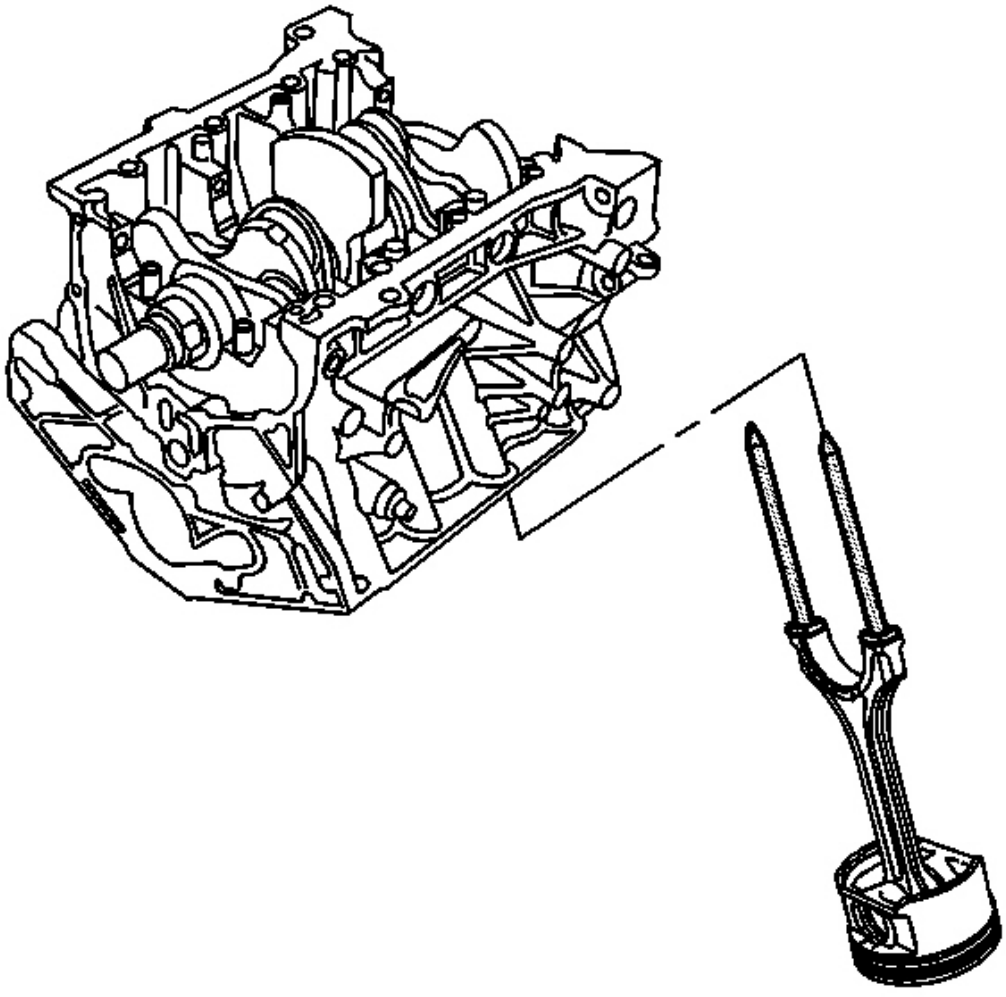


Fig. 330: View Of Connecting Rod & Bearing
Courtesy of GENERAL MOTORS CORP.

1. Install the upper bearing half to the connecting rod.
2. Install the **J 41742** to the connecting rod in order to guide the connecting rod onto the crankshaft journal.

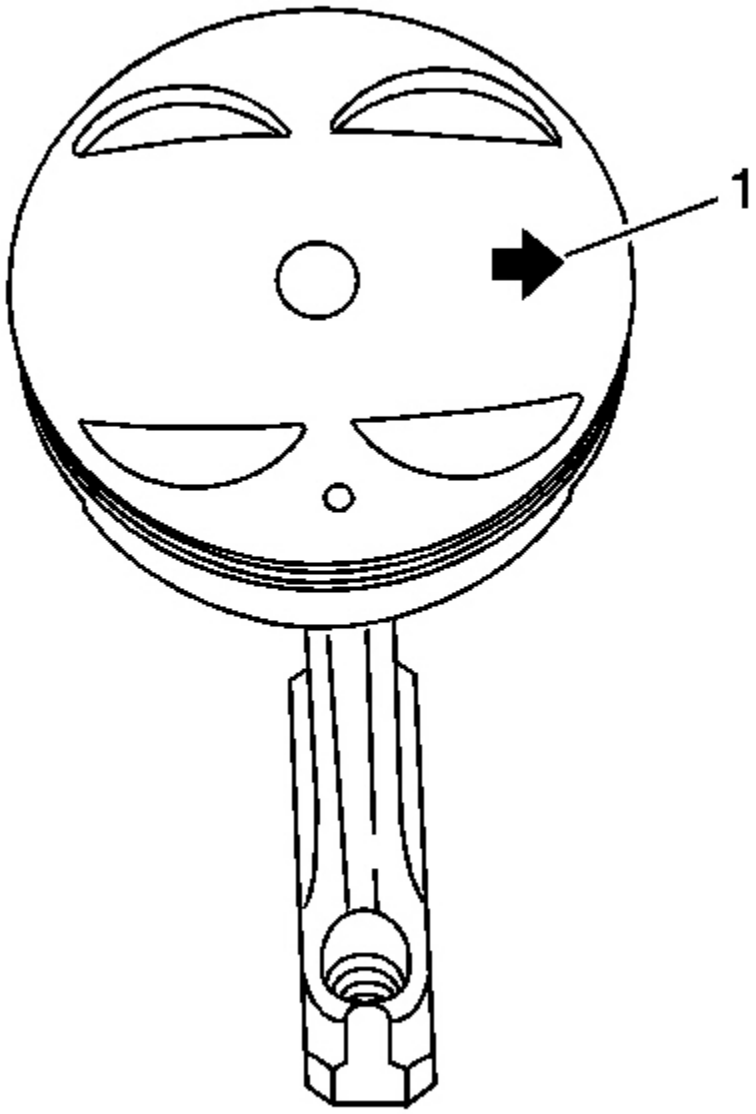


Fig. 331: View Of Piston Into The Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

3. Install the piston into the cylinder bore with the arrow or mark (1) on the top of the piston facing the front of the engine.

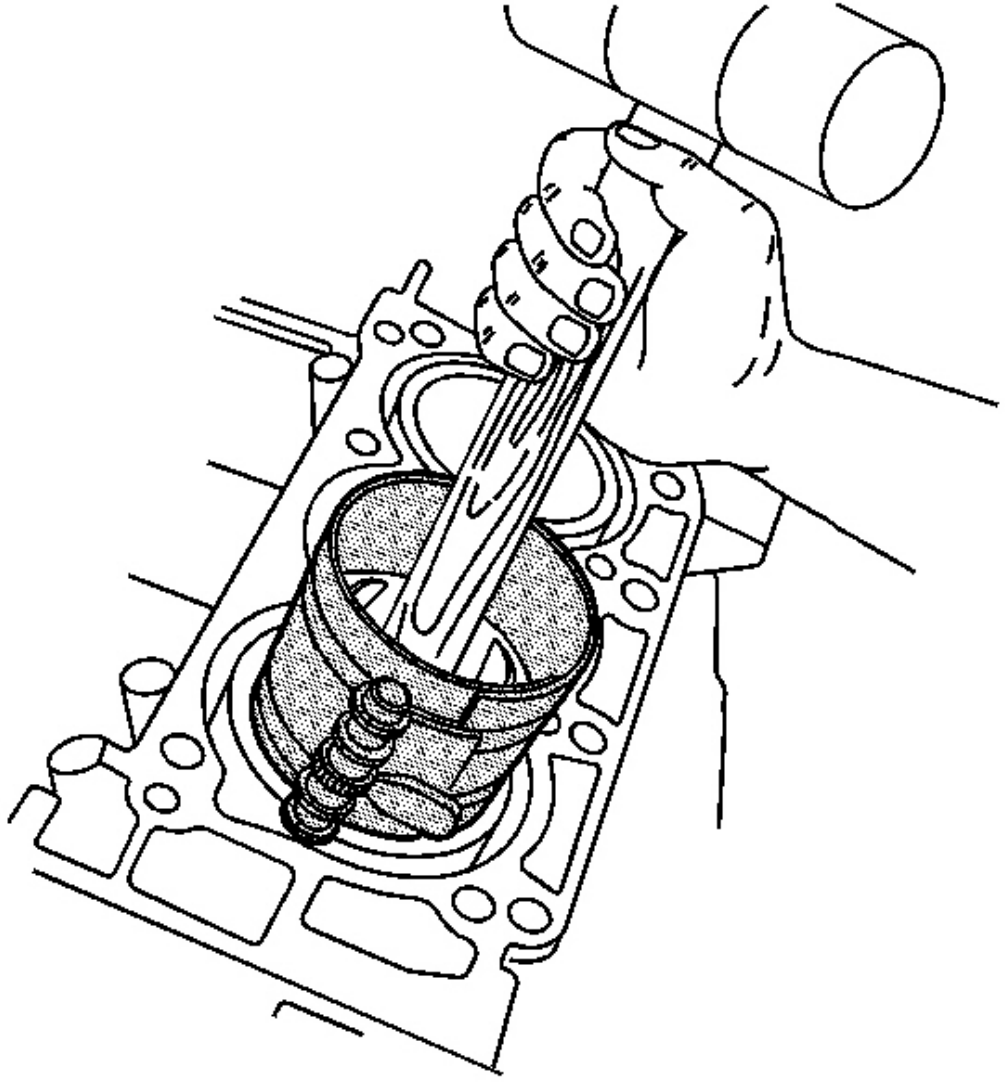


Fig. 332: Tapping The Top Of The Piston
Courtesy of GENERAL MOTORS CORP.

4. Hold the **J 8037** firmly against the engine block. Using a wooden hammer handle, lightly tap the top of the piston until all of the piston rings enter the cylinder bore.

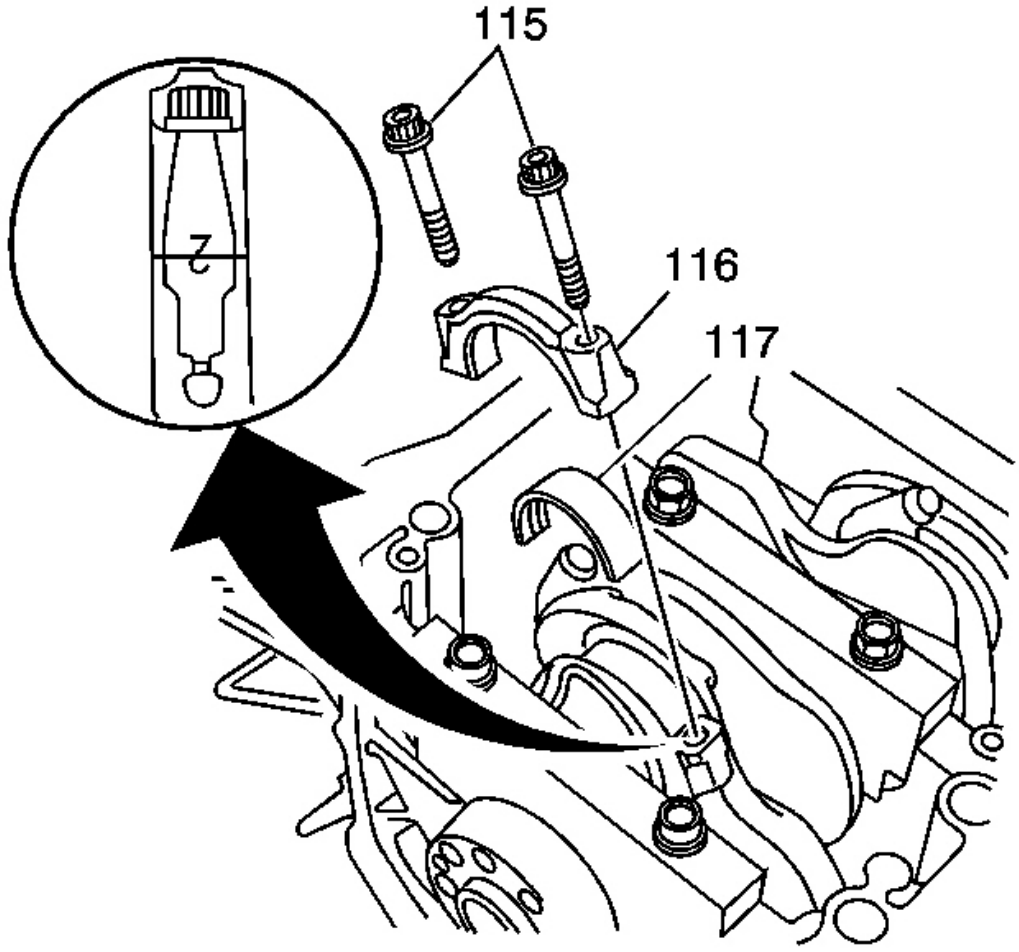


Fig. 333: View Of Lower Bearing Half, Cap & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Install the lower bearing half (117), cap (116) and bolts (115).

Tighten:

1. Tighten the bolts a first pass to 20 N.m (14 lb ft).
2. Tighten the bolts a final pass an additional 90 degrees using the **J 45059** or **SA9140E** .

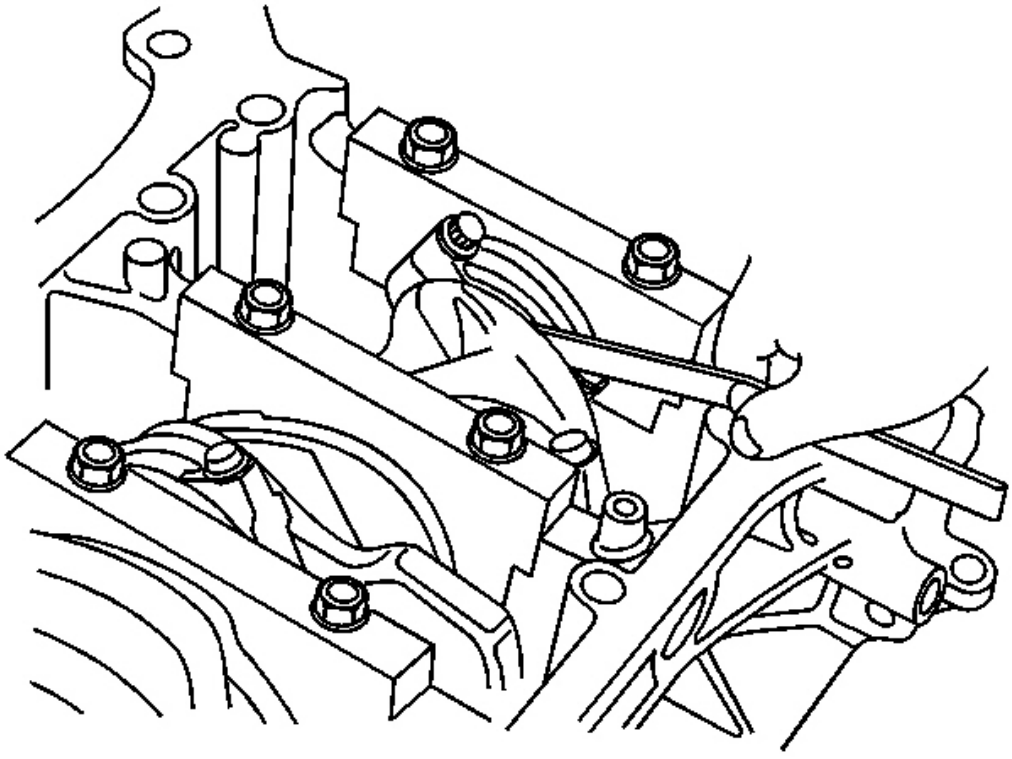


Fig. 334: Measuring The Connecting Rod End-Play
Courtesy of GENERAL MOTORS CORP.

6. Measure the connecting rod end-play. Insert a feeler gage between the connecting rod and crankshaft.

   Specification:
   - Connecting rod end play - new: 0.15-0.35 mm (0.006-0.014 in)
   - Connecting rod end play - service limit: 0.45 mm (0.018 in)

7. If the connecting rod end-play is not within the service limit, install a new connecting rod and measure again. If it is still not within the service limit, replace the crankshaft.

CRANKSHAFT REAR OIL SEAL AND HOUSING INSTALLATION

Tools Required

- **EN 46342** Driver Handle
- **EN 46351** Crankshaft Rear Oil Seal Driver. See **Special Tools and Equipment** .

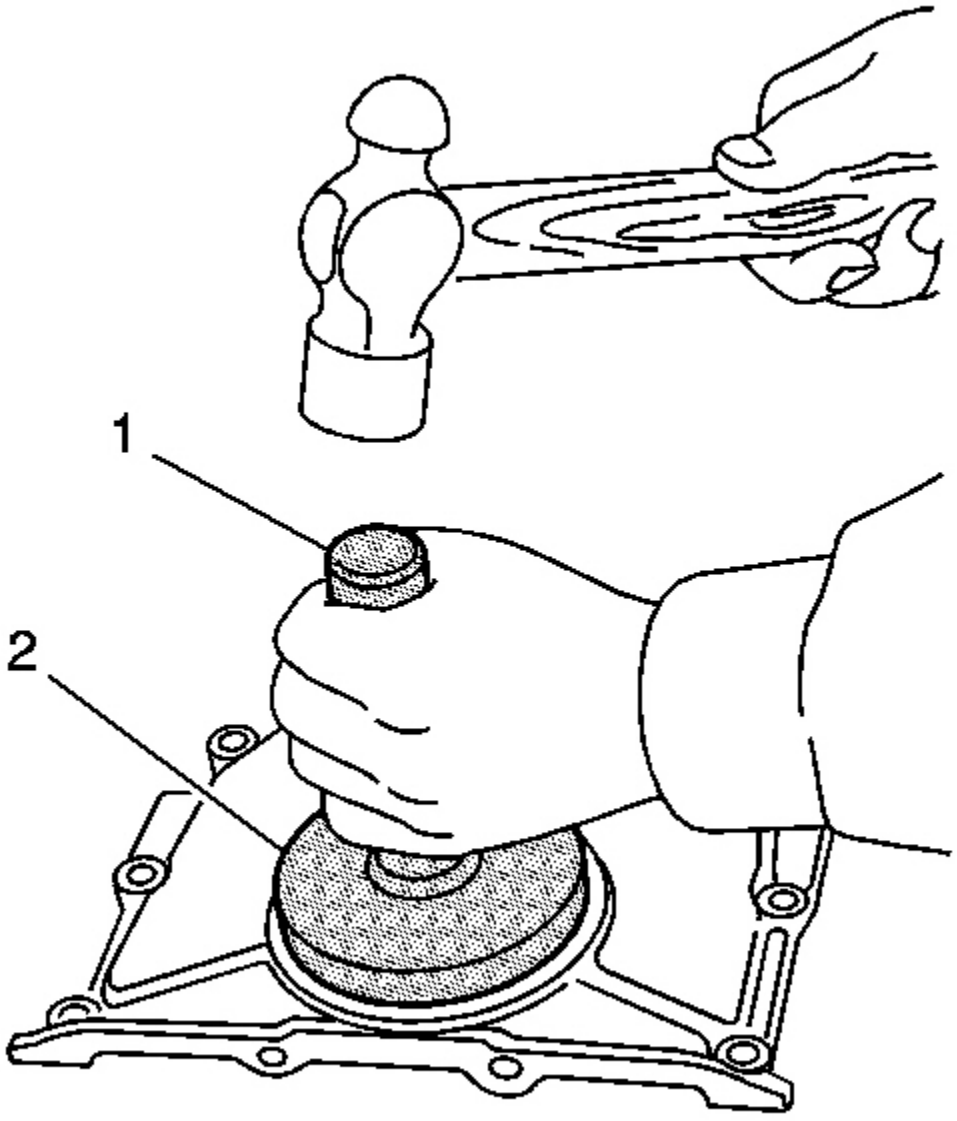


Fig. 335: Identifying Lip Of The Oil Seal With A Light Coat Of Grease
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the lip of the oil seal with a light coat of grease.
2. Use the **EN 46342** (1) and the **EN 46351** (2) in order to install the seal squarely into the housing. See **Special Tools and Equipment** .

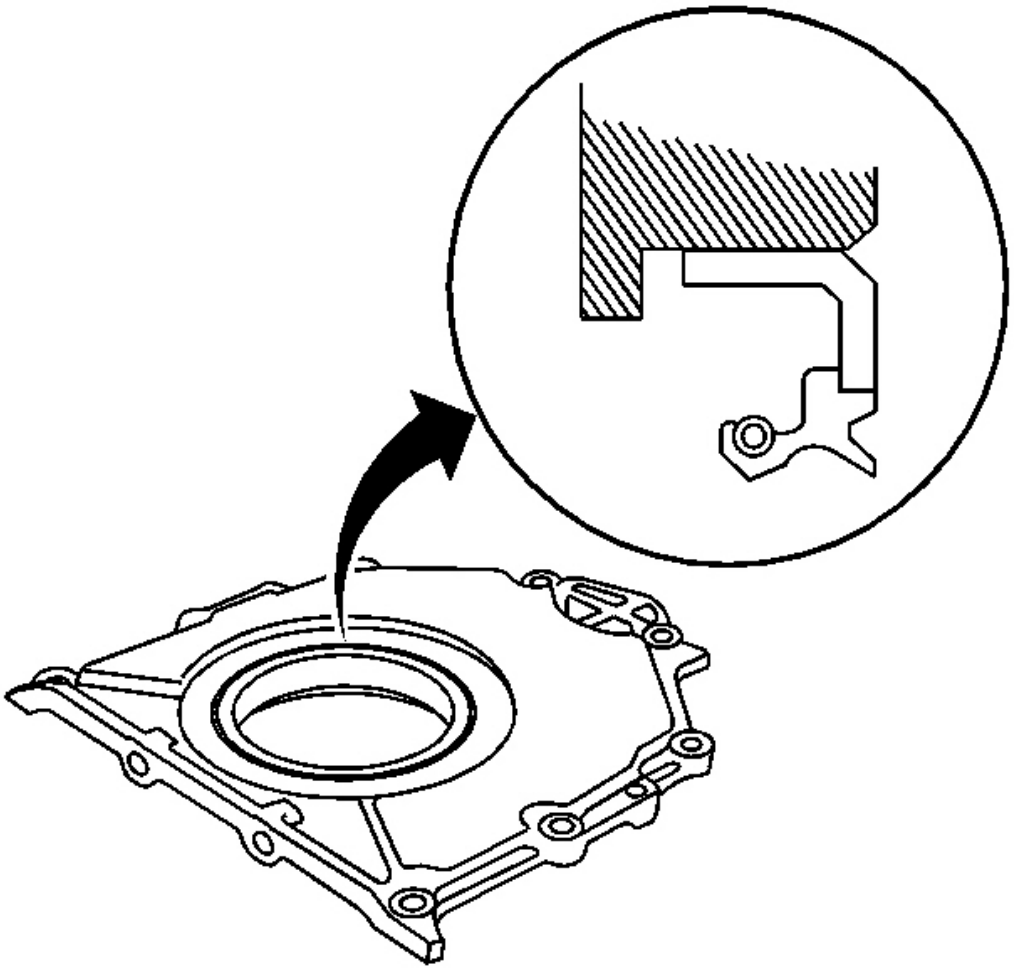


Fig. 336: View Of Crankshaft Oil Seal
Courtesy of GENERAL MOTORS CORP.

3. Drive the new crankshaft oil seal until the tool bottoms onto the housing. A properly installed seal will be flush with the face of the housing.

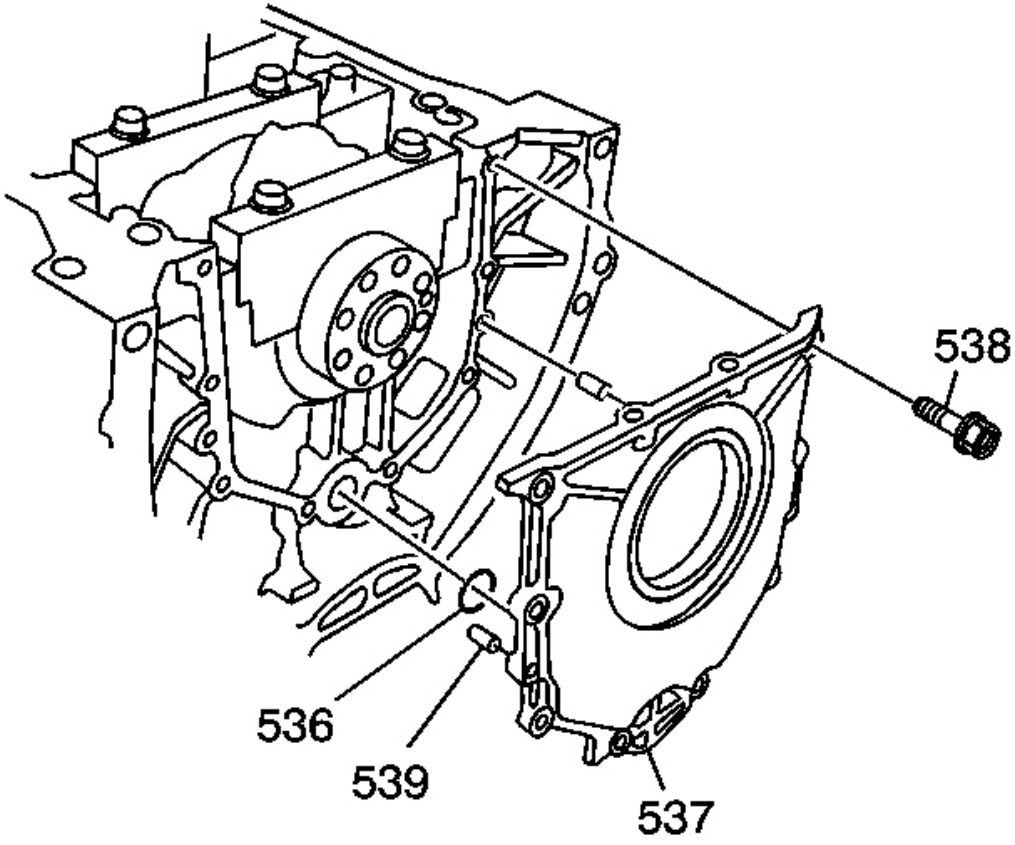


Fig. 337: View Of Housing & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Clean and dry the engine block and housing mating surfaces.
5. Apply sealant GM P/N 12346240 (Canadian P/N 10953493) or equivalent evenly to the mating surface of the housing.
6. Install the pins (539).
7. Install the O-ring seal (536).

NOTE: Refer to Fastener Notice in Cautions and Notices.

8. Install the housing (537) and bolts (538).

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

CRANKSHAFT FRONT OIL SEAL INSTALLATION

Tools Required

- **EN 46342** Driver Handle
- **EN 46347** Crankshaft Front Oil Seal Driver. See **Special Tools and Equipment** .

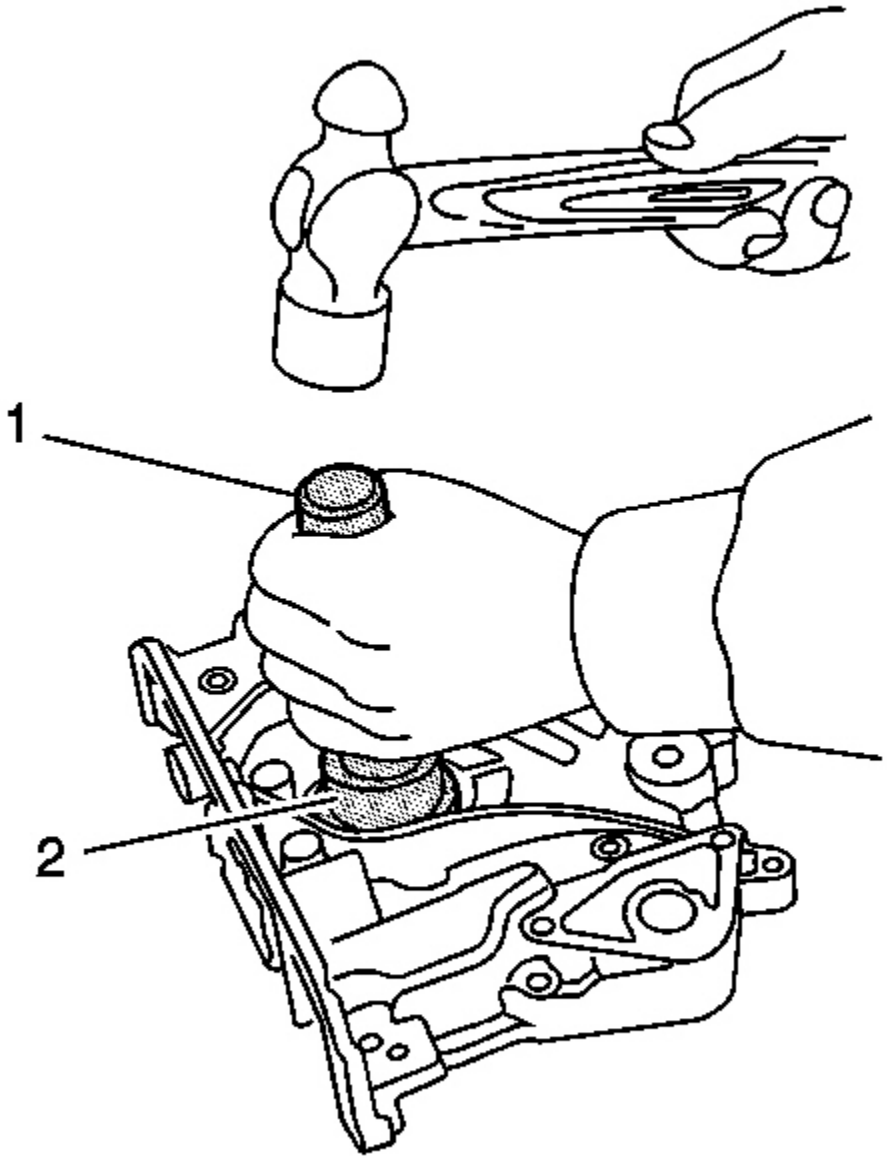


Fig. 338: View Of Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

Use the **EN 46342** (1) and the **EN 46347** (2) to install the oil seal. See **Special Tools and Equipment** . Gently tap and install the NEW oil seal until the tool bottoms on the oil pump housing.

OIL PUMP INSTALLATION

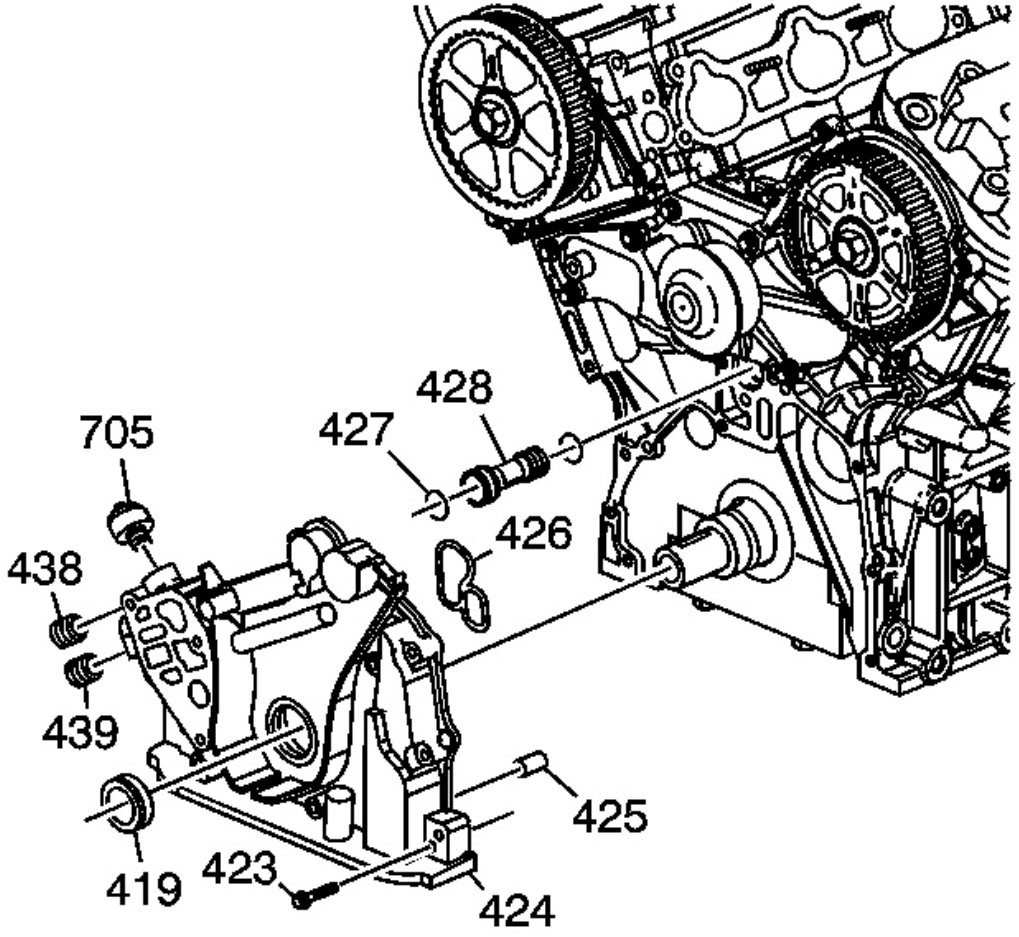


Fig. 339: Exploded View Of Oil Pump Assembly
Courtesy of GENERAL MOTORS CORP.

1. Install NEW O-rings (427) onto the oil transfer pipe (428).
2. Install the pipe (428) into the block.
3. Apply sealant GM P/N 12346240 (Canadian P/N 10953493) or equivalent evenly to the block mating surface of the oil pump housing and to the inner threads of the bolt holes.
4. Install the pins (425).
5. Install a NEW O-ring (426).

NOTE: Refer to Fastener Notice in Cautions and Notices.

6. Install the oil pump assembly (424) and bolts (423). Align the flat surfaces of the oil pump inner rotor with the flat surfaces of the crankshaft.

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

7. Apply sealant GM P/N 12346240 (Canadian P/N 10953493) or equivalent to the threads of the switch (705).
8. Install the oil pressure switch (705).

   Tighten: Tighten the switch to 18 N.m (13 lb ft).

TIMING BELT DRIVE SPROCKET INSTALLATION

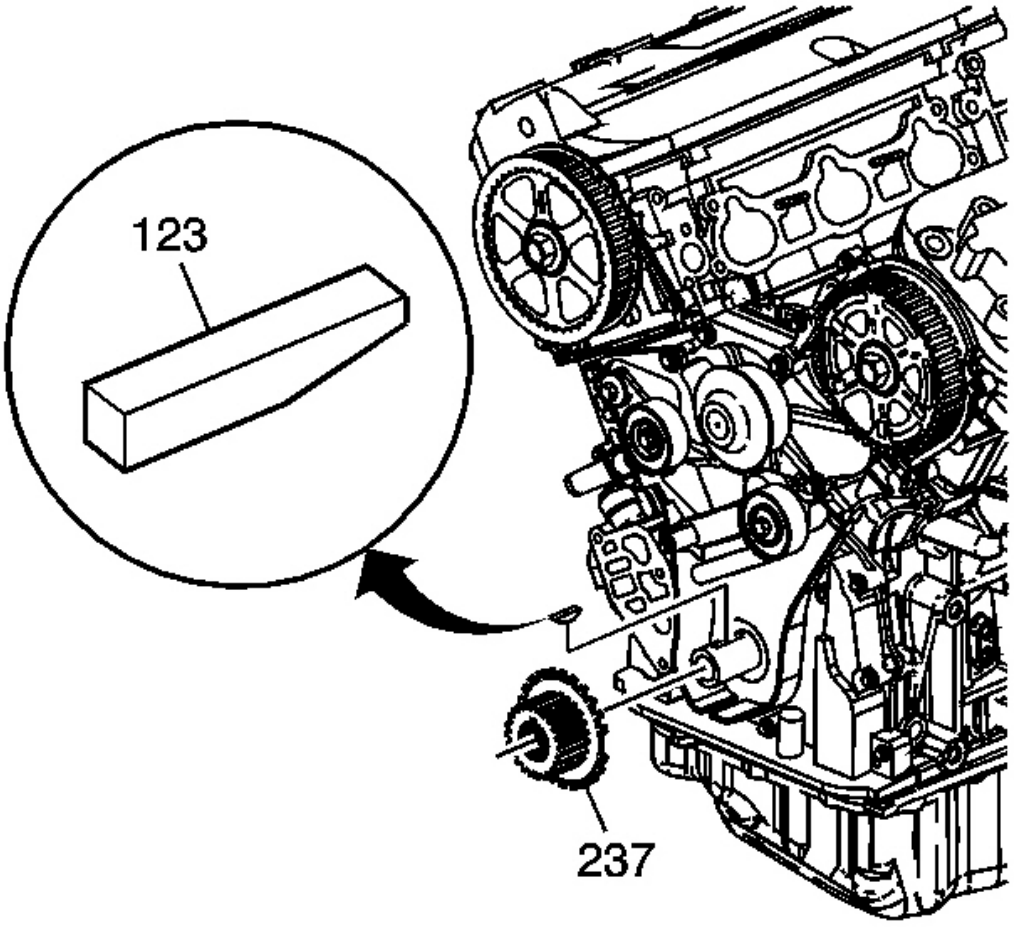


Fig. 340: View Of Timing Belt Drive Sprocket

Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The powertrain control module (PCM) must perform the idle learn procedure to determine the minimum throttle position and to establish idle speed when any of the following components are replaced:

- **Throttle body**
- **Timing belt**
- **Timing belt drive sprocket**
- **Crankshaft and bearings**

Refer to Idle Learn Procedure .

1. Install the key (123) and sprocket (237).

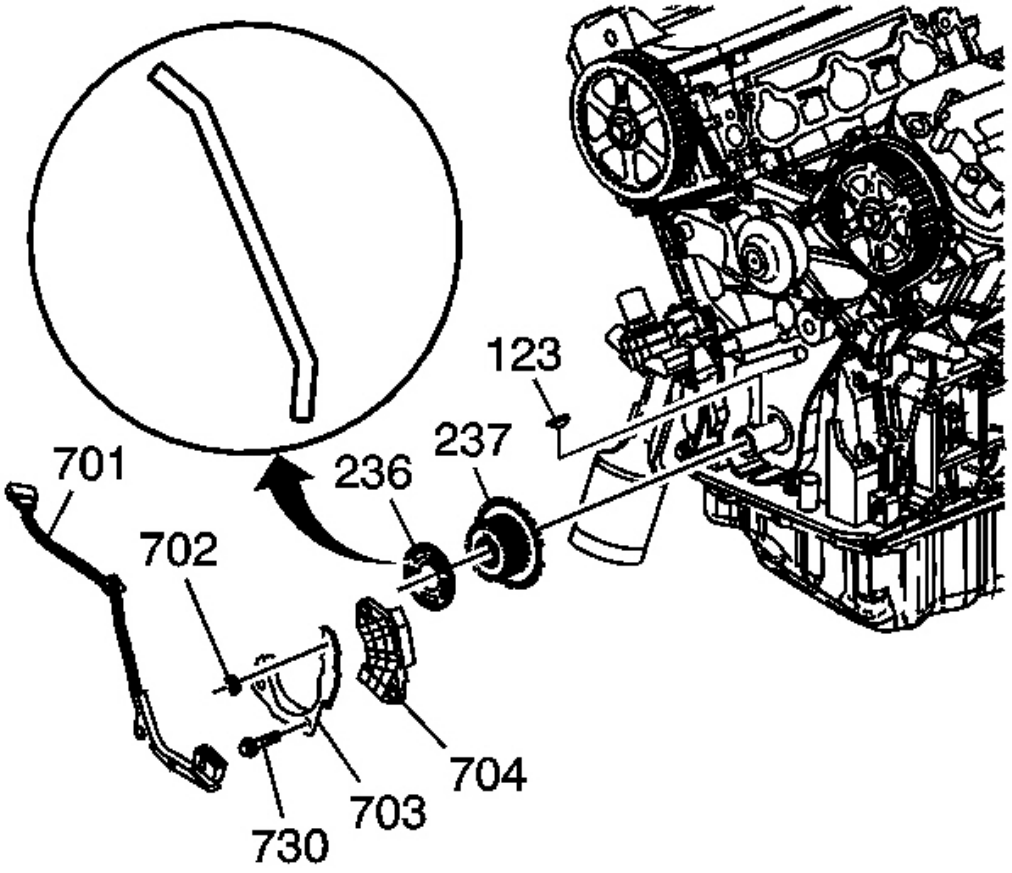


Fig. 341: View Of Crankshaft Gear
Courtesy of GENERAL MOTORS CORP.

2. Install the guide (236).
3. Install the crankshaft position (CKP) sensor (704) and harness (701).

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the guide (703), nuts (702), and bolts (730).

Tighten: Tighten the nuts and bolts to 9.8 N.m (87 lb in).

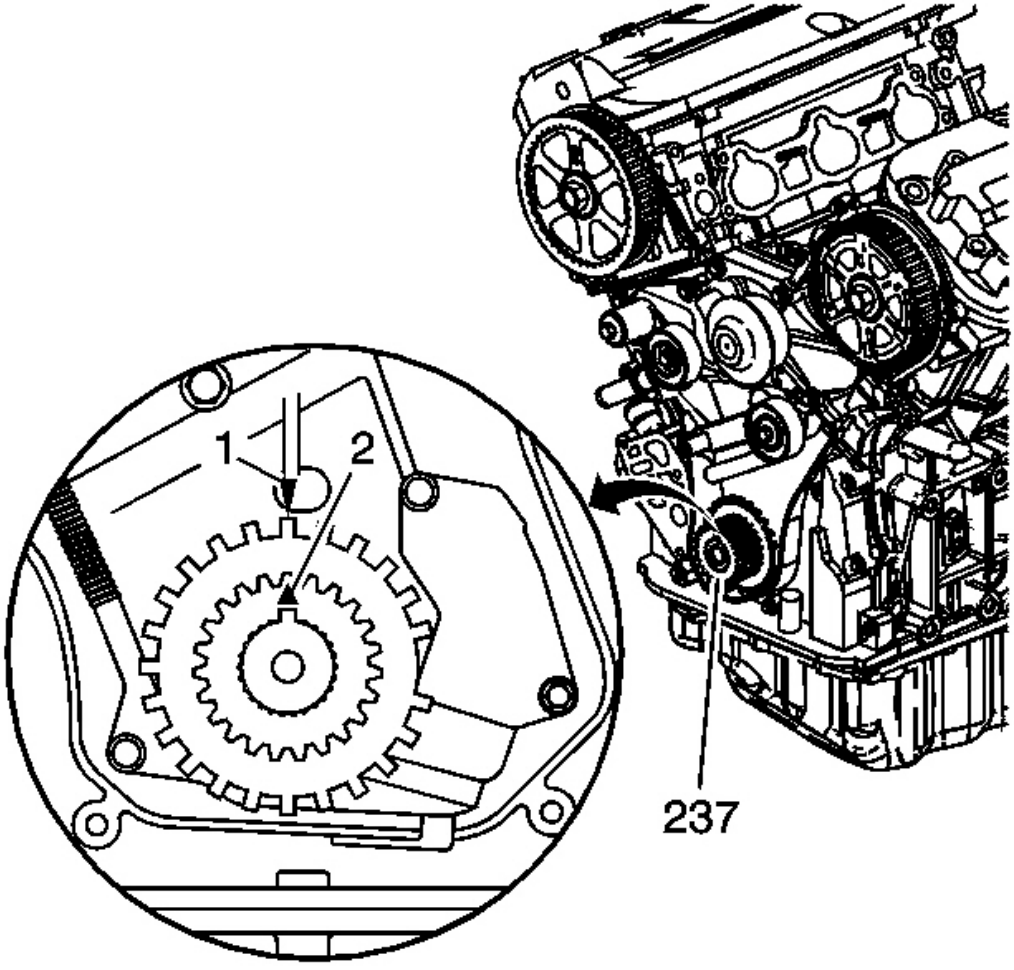


Fig. 342: View Of Crankshaft To Align The Mark On The Sprocket With The Pointer
Courtesy of GENERAL MOTORS CORP.

5. Rotate the crankshaft to align the mark (2) on the sprocket (237) with the pointer (1) on the oil pump housing.

OIL FLOW CONTROL MODULE INSTALLATION

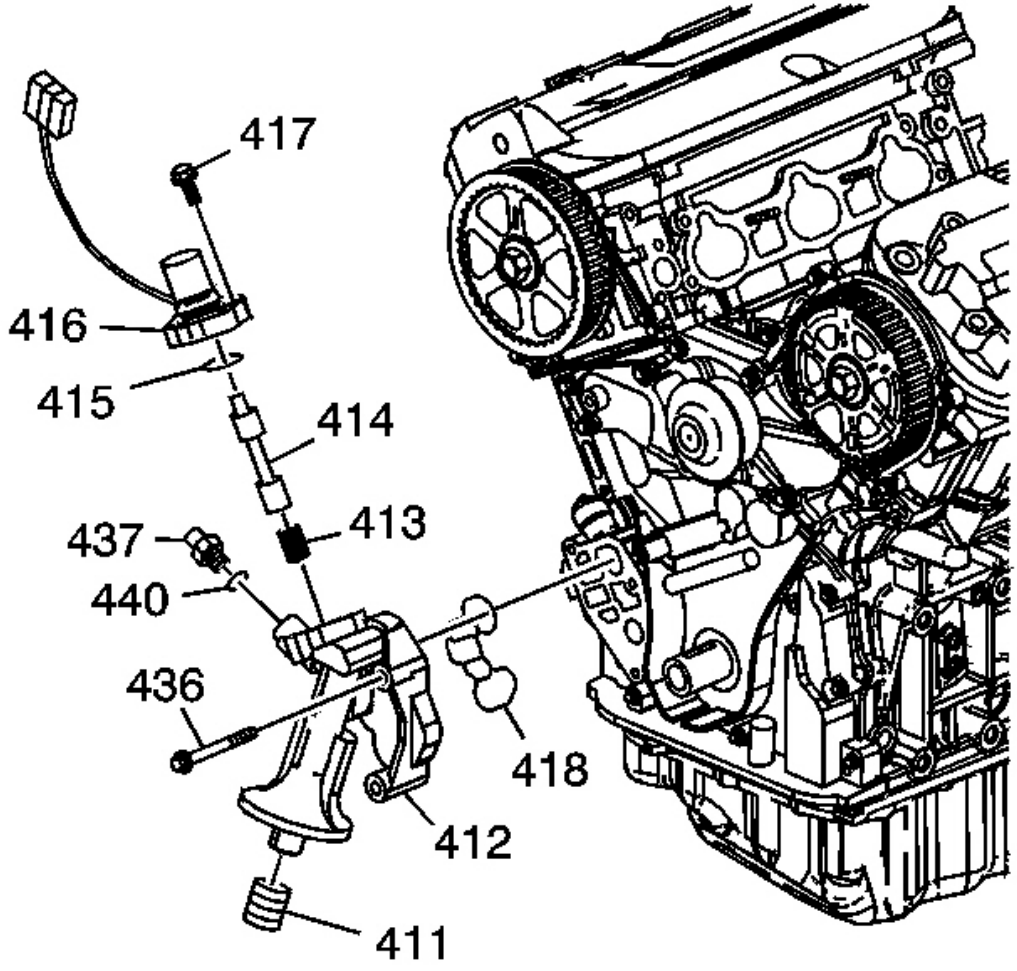


Fig. 343: View Of Oil Control Module
Courtesy of GENERAL MOTORS CORP.

1. Install the spring (413) and valve (414). The valve must move freely in the bore.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the NEW O-ring (415), solenoid (416) and bolts (417).

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

3. Install a NEW O-ring (418).

4. Install the module (412) and bolts (436).

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

5. Install 2 M20 x 1.5 mm nuts onto the fitting (411).
6. Install the fitting (411), if required.

   Tighten: Tighten the fitting to 49 N.m (36 lb ft).

7. Remove the 2 M20 x 1.5 mm nuts from the fitting.
8. Install a NEW O-ring (440) and switch (437).

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

CRANKSHAFT OIL DEFLECTOR INSTALLATION

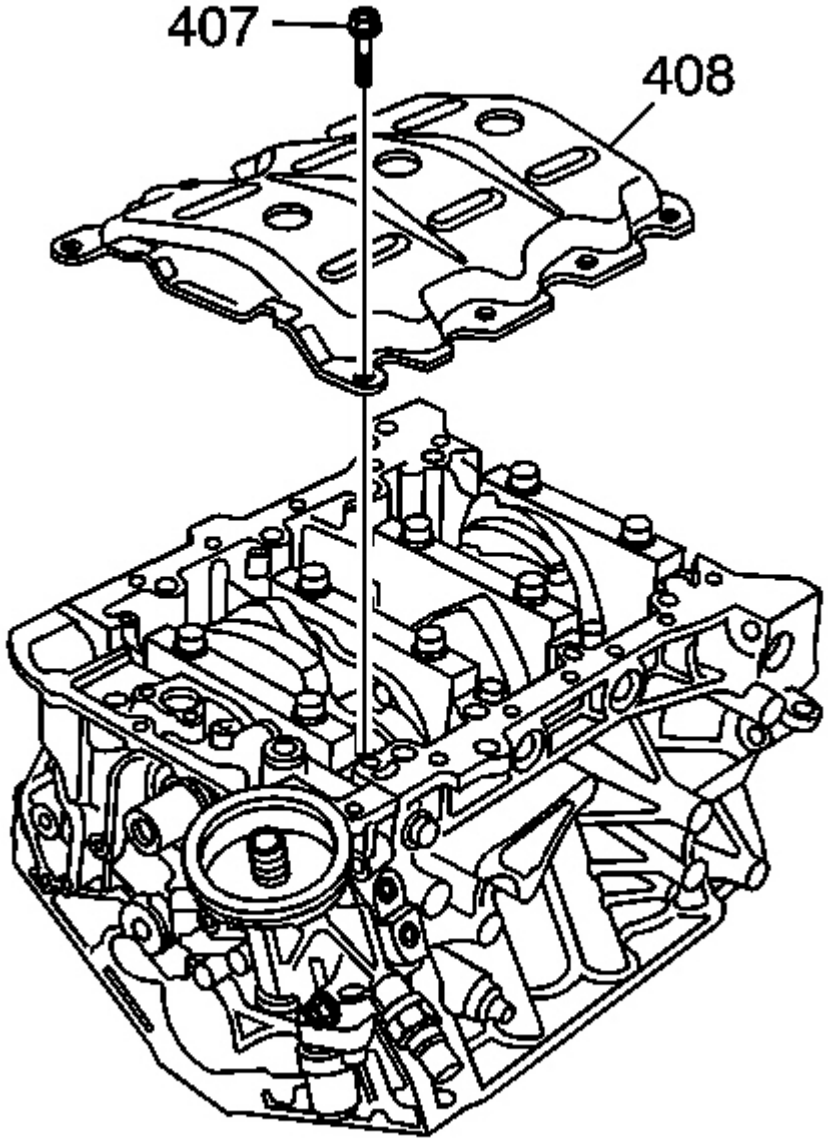


Fig. 344: View Of Crankshaft Oil Deflector
Courtesy of GENERAL MOTORS CORP.

1. Install the deflector (408).

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the bolts (407).

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

OIL PUMP PIPE AND SCREEN ASSEMBLY INSTALLATION

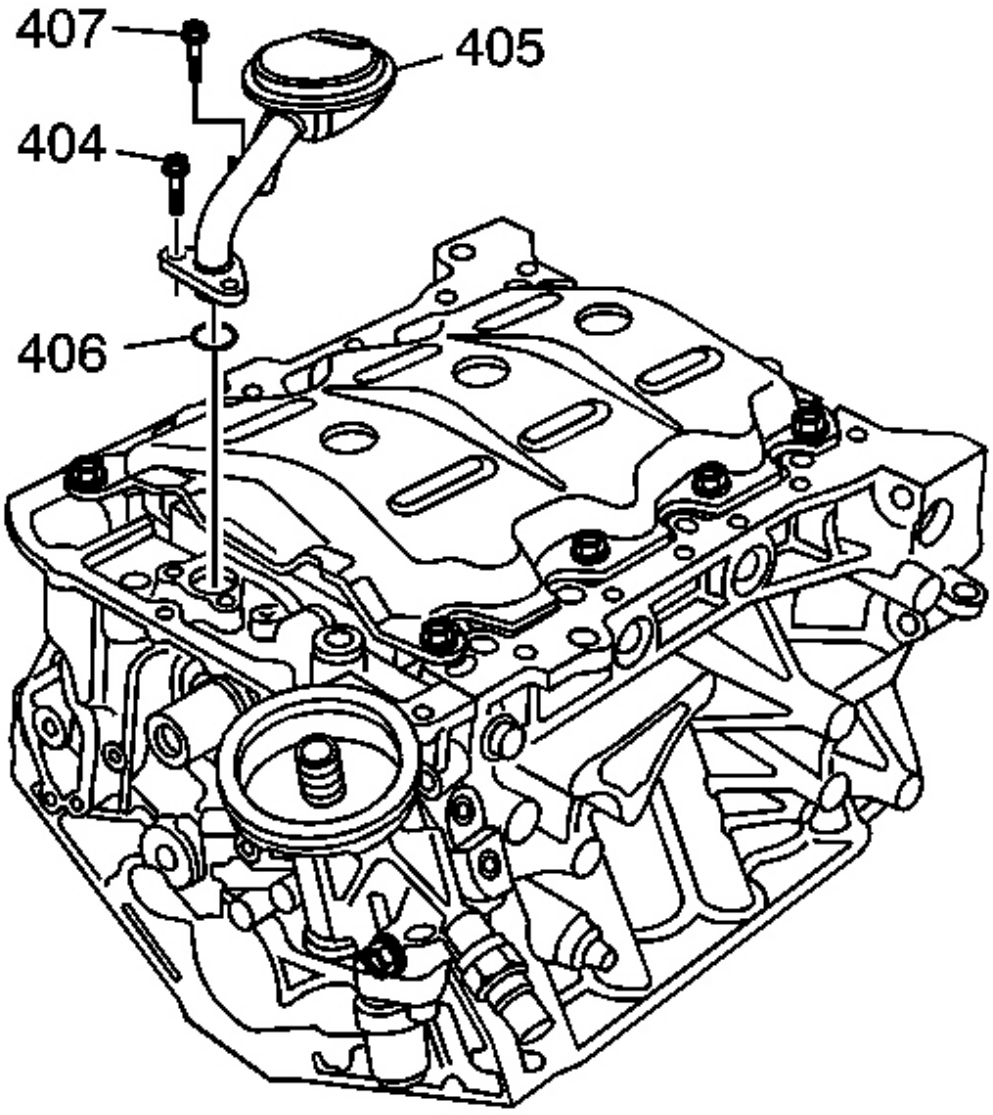


Fig. 345: View Of Screen Assembly
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW O-ring (406).

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the screen (405) and bolts (404, 407).

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

OIL PAN INSTALLATION

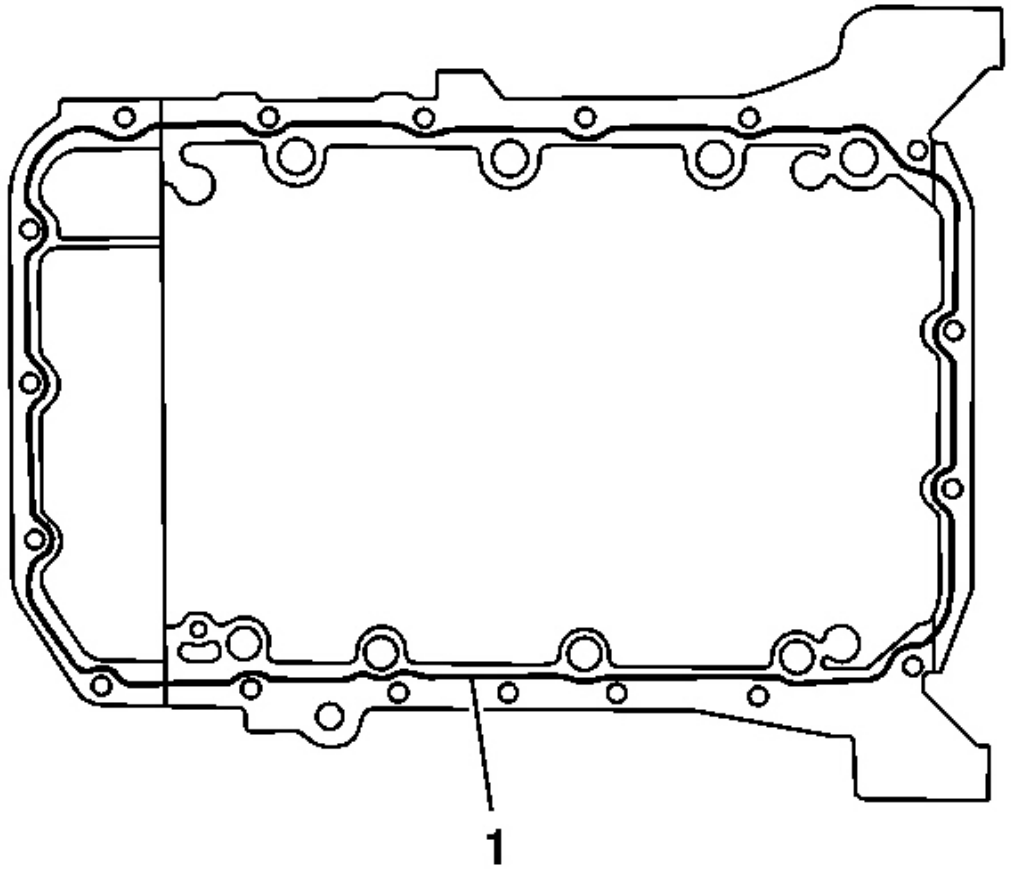


Fig. 346: View Of Oil Pan
Courtesy of GENERAL MOTORS CORP.

1. Clean and dry the oil pan mating surfaces.

2. Apply sealant GM P/N 12346240 (Canadian P/N 10953493) or equivalent evenly to the oil pan mating surface (1) of the engine block.

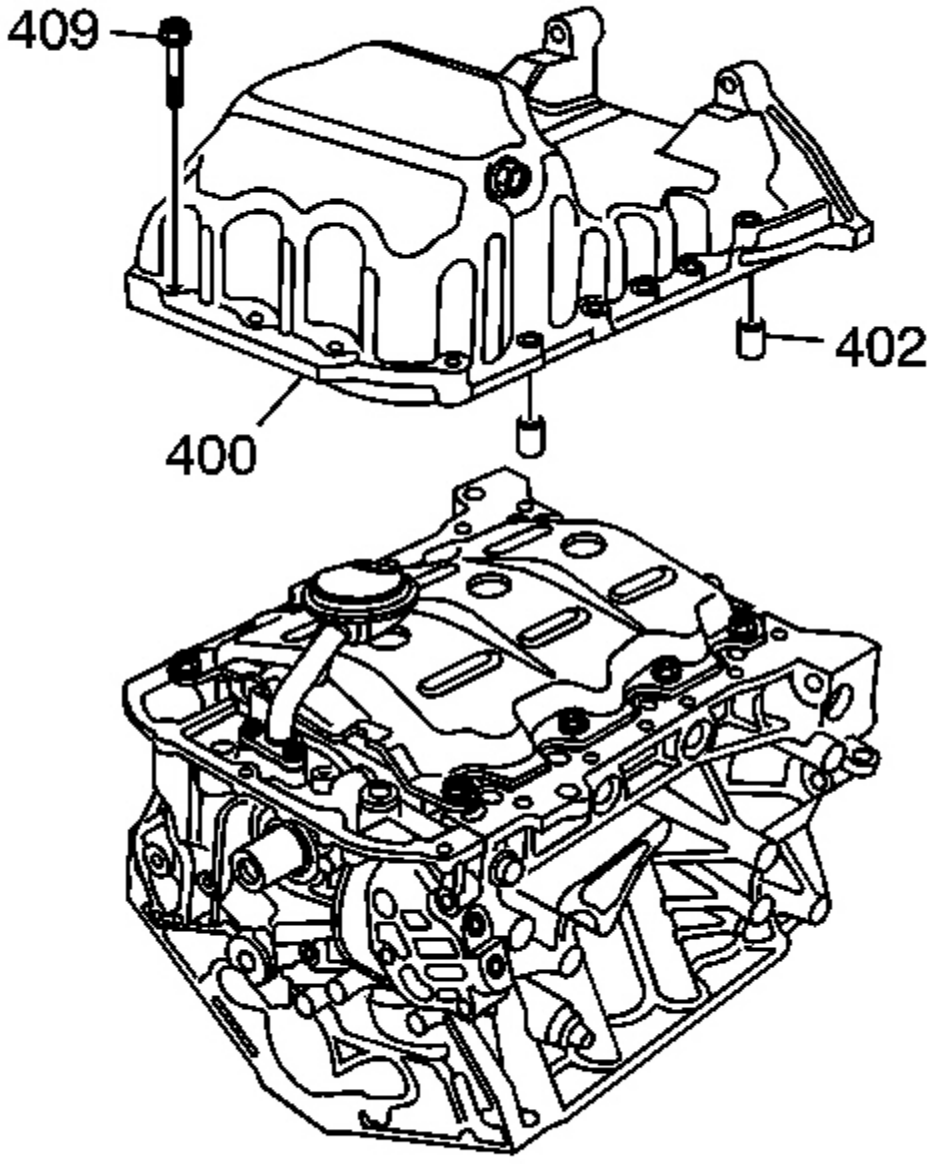


Fig. 347: View Of Pins, Oil Pan & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Install the pins (402).
4. Install the oil pan (400).

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Install the bolts (409).

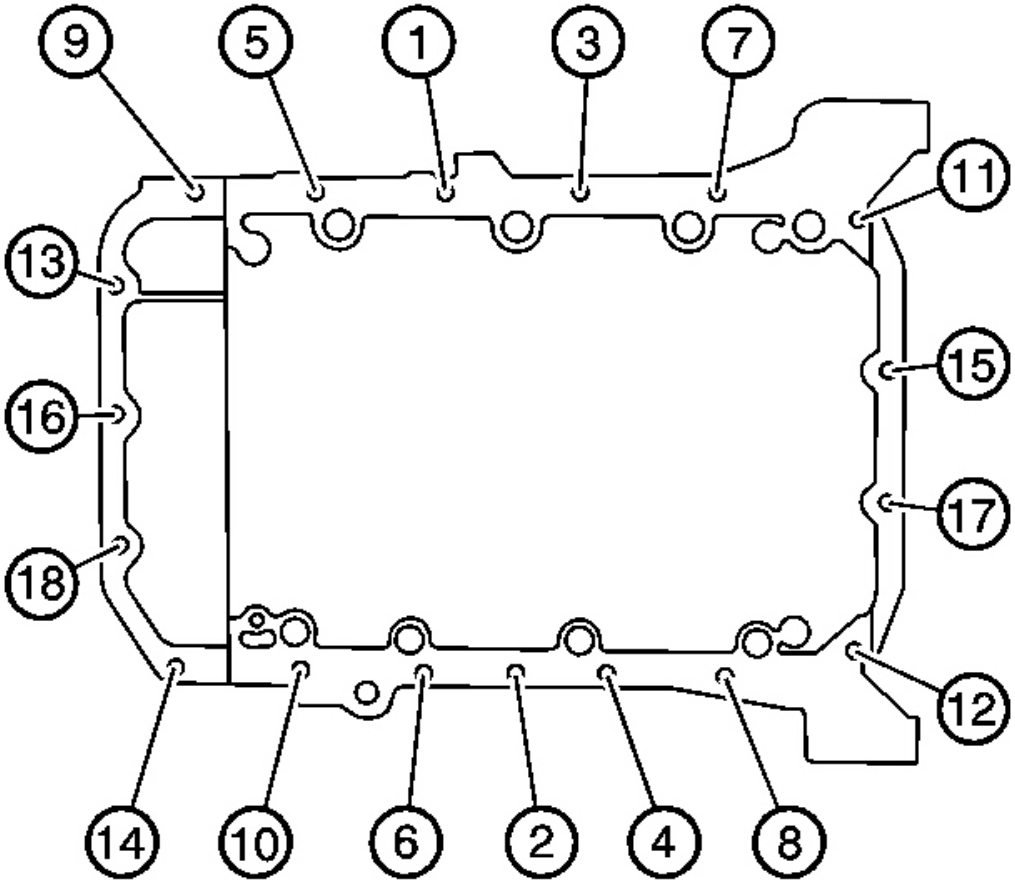


Fig. 348: Identifying Bolts
Courtesy of GENERAL MOTORS CORP.

6. Tighten the bolts.

Tighten:

1. Tighten the bolts in sequence a first pass to 6 N.m (53 lb in).

2. Tighten the bolts in sequence a final pass to 12 N.m (106 lb in).

FUEL INJECTION MANIFOLD INSTALLATION - LEFT

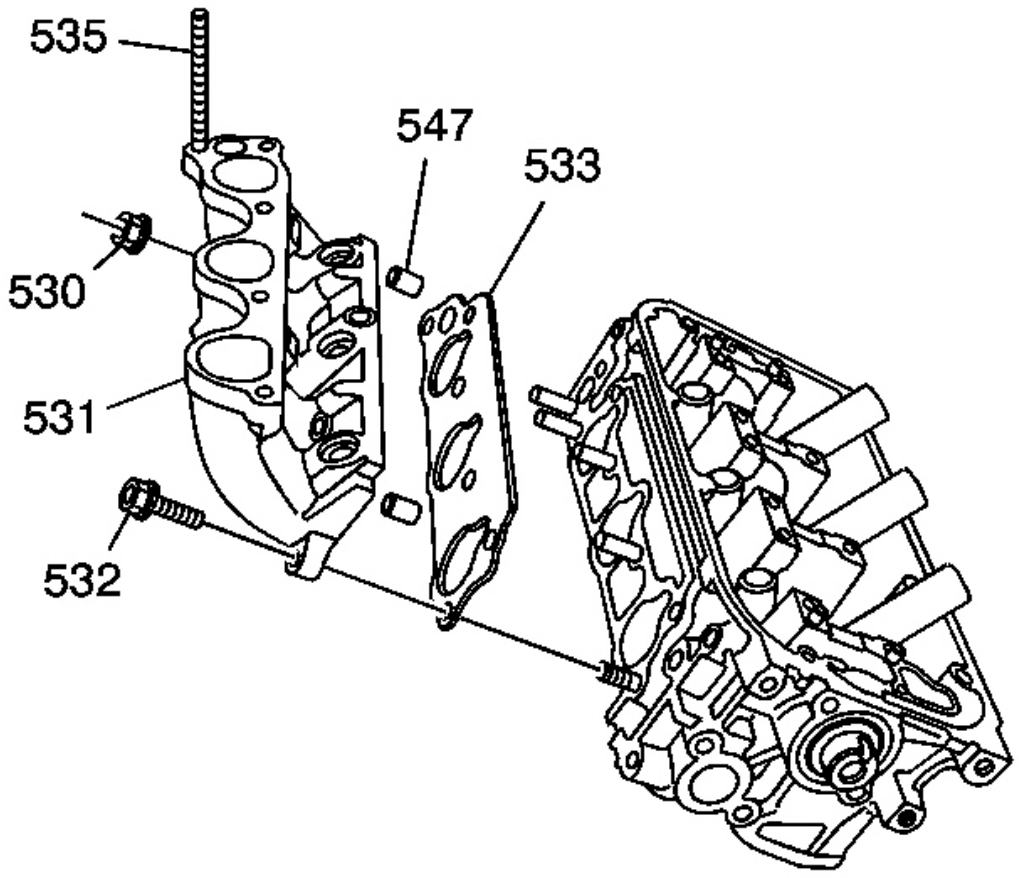


Fig. 349: View Of Fuel Injection Manifold
Courtesy of GENERAL MOTORS CORP.

1. Install the pins (547).
2. Install the gasket (533) and manifold (531).

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the nuts (530) and bolts (532).

Tighten: Tighten the nuts and bolts to 22 N.m (16 lb ft).

4. Install the stud (535).

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

FUEL INJECTION MANIFOLD INSTALLATION - RIGHT

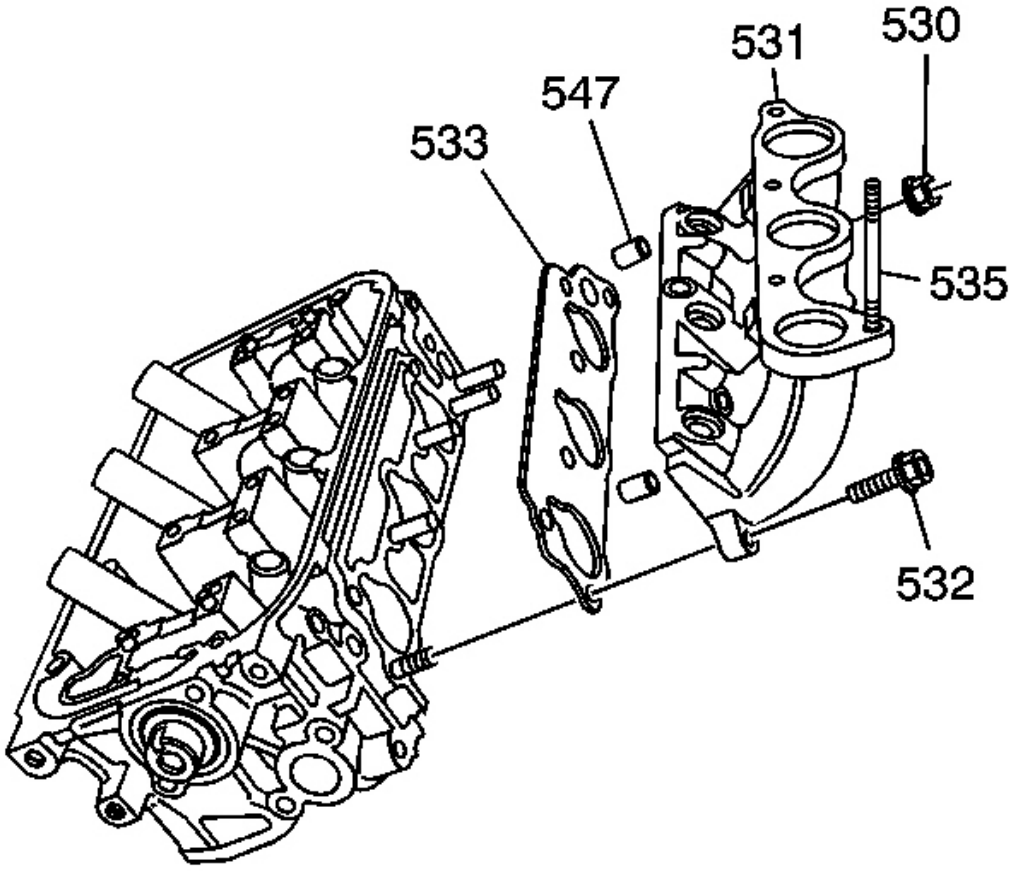


Fig. 350: View Of Fuel Injection Manifold
Courtesy of GENERAL MOTORS CORP.

1. Install the pins (547).
2. Install the gasket (533) and manifold (531).

   NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the nuts (530) and bolts (532).

Tighten: Tighten the nuts and bolts to 22 N.m (16 lb ft).

4. Install the stud (535).

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

CYLINDER HEAD INSTALLATION - LEFT

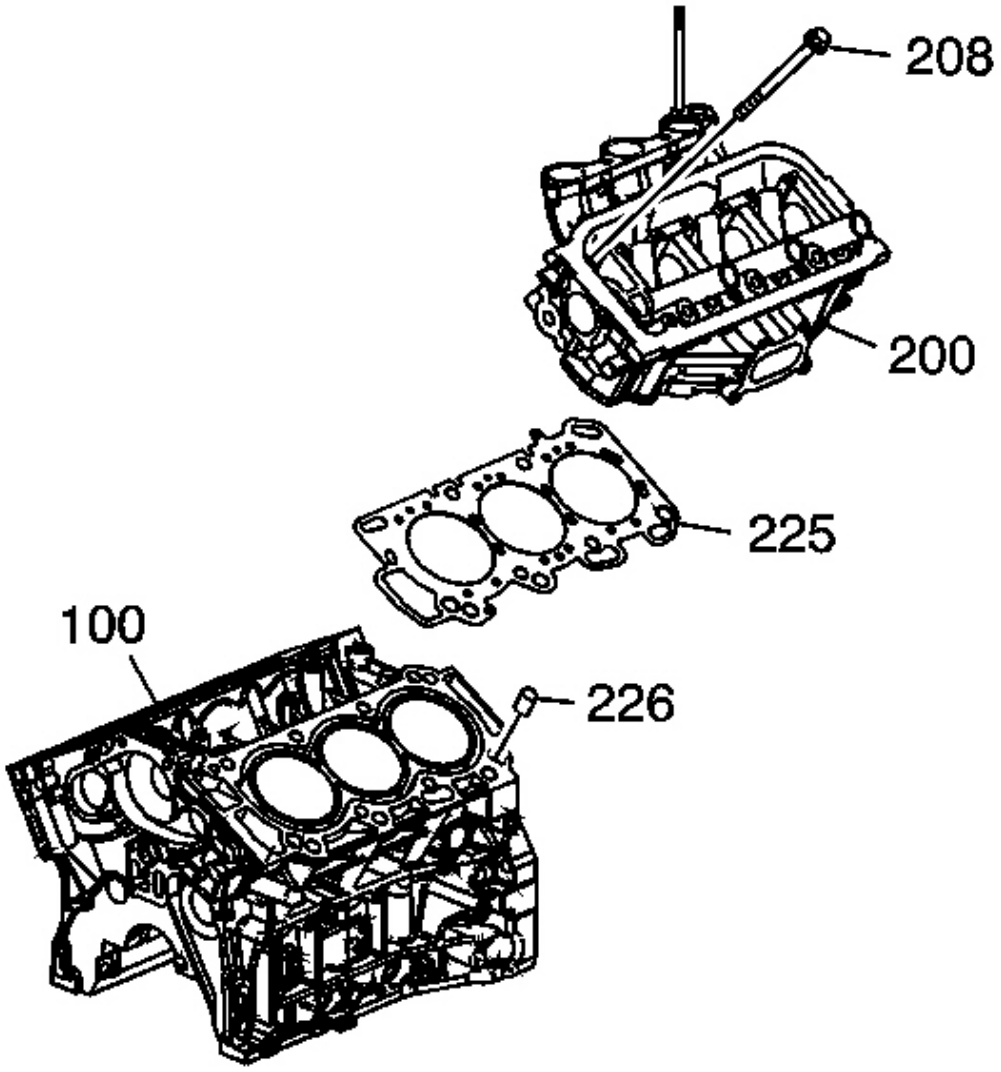


Fig. 351: View Of Cylinder Head

Courtesy of GENERAL MOTORS CORP.

1. Install the pins (226), NEW gasket (225) and cylinder head (200).
2. Apply clean engine oil to the threads and flanges of the cylinder head bolts (208).

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the bolts (208).

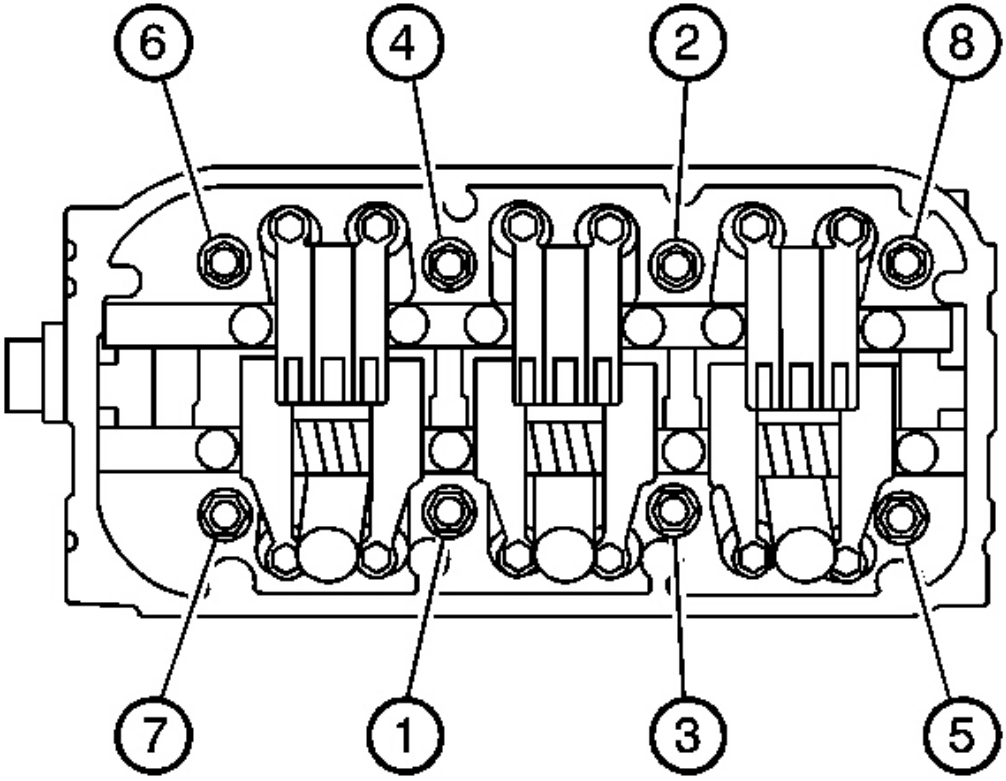


Fig. 352: View Of Bolts In Sequence
Courtesy of GENERAL MOTORS CORP.

4. Tighten the bolts in sequence.

Tighten:

1. Tighten the bolts a first pass in sequence to 39 N.m (29 lb ft).
2. Tighten the bolts a second pass in sequence to 69 N.m (51 lb ft).

3. Tighten the bolts a final pass in sequence to 98.1 N.m (72.3 lb ft).

CYLINDER HEAD INSTALLATION - RIGHT

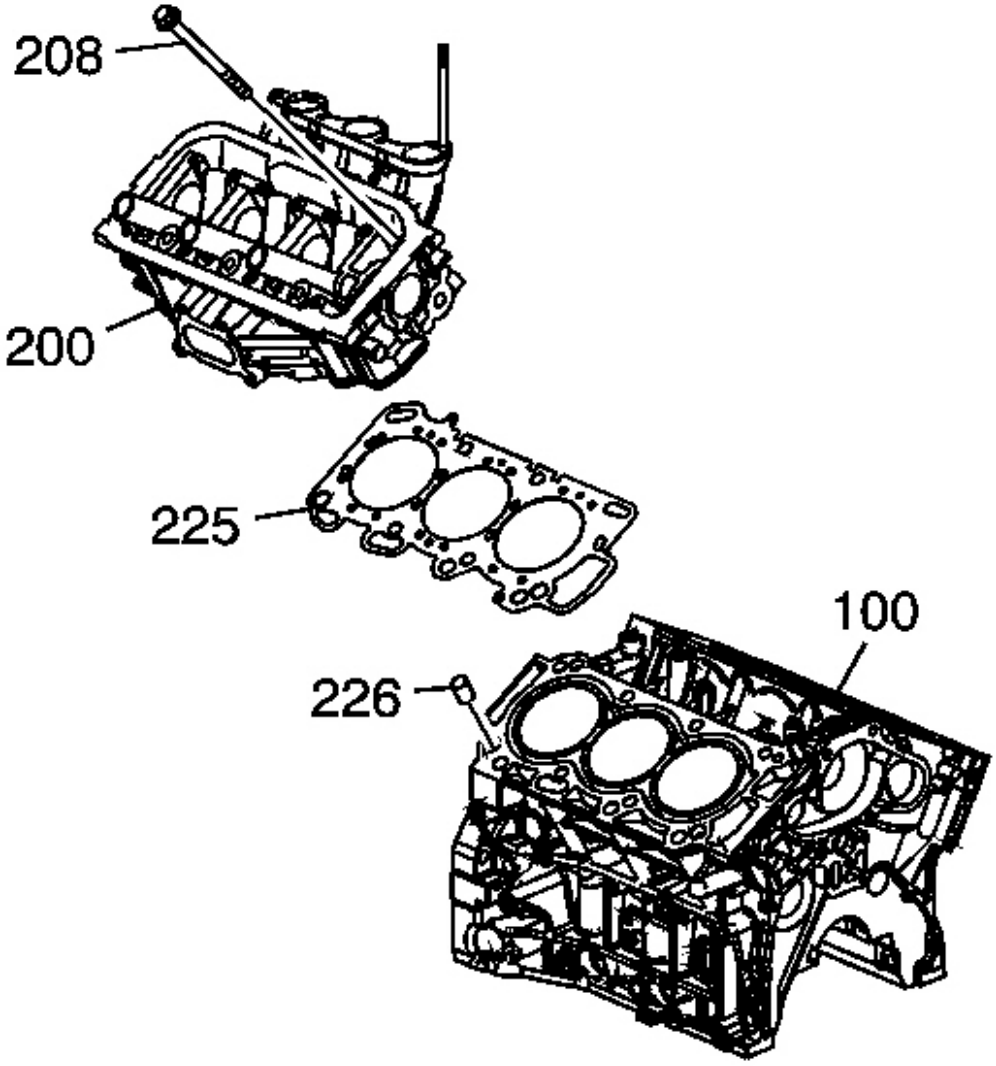


Fig. 353: Identifying Cylinder Head
Courtesy of GENERAL MOTORS CORP.

1. Install the pins (226), NEW gasket (225) and cylinder head (200).
2. Apply clean engine oil to the threads and flanges of the cylinder head bolts (208).

NOTE: **Refer to Fastener Notice in Cautions and Notices.**

3. Install the bolts (208).

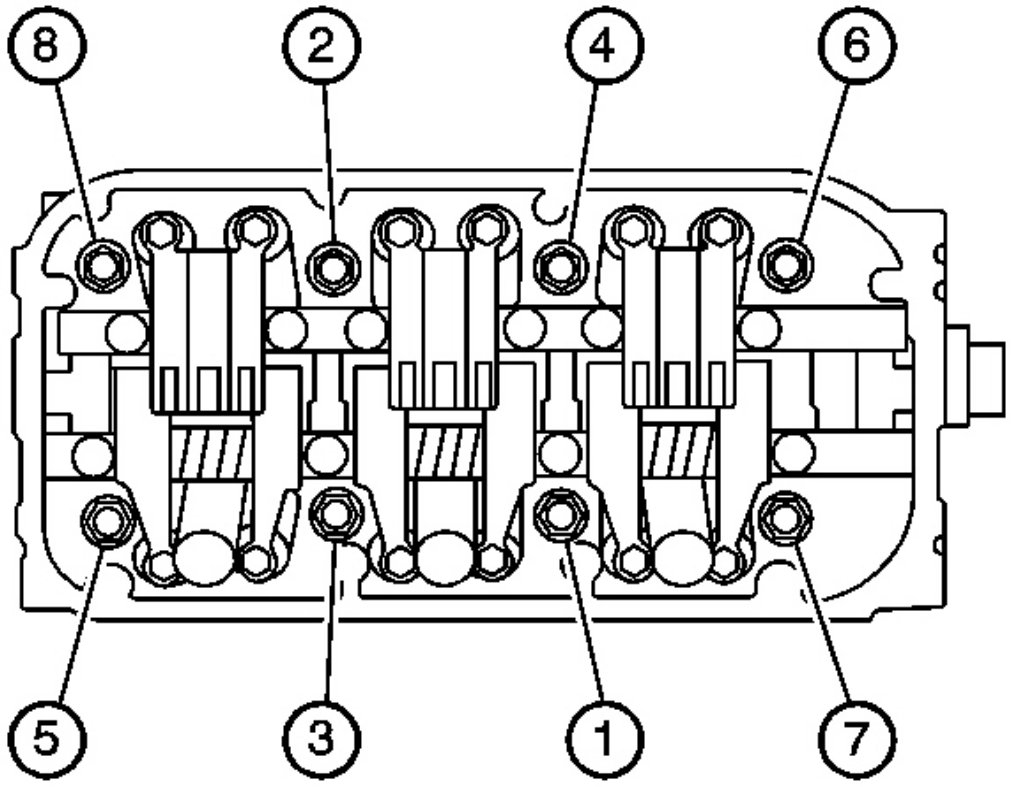


Fig. 354: View Of Bolts In Sequence
Courtesy of GENERAL MOTORS CORP.

4. Tighten the bolts in sequence.

Tighten:

1. Tighten the bolts a first pass in sequence to 39 N.m (29 lb ft).
2. Tighten the bolts a second pass in sequence to 69 N.m (51 lb ft).
3. Tighten the bolts a final pass in sequence to 98.1 N.m (72.3 lb ft).

CAMSHAFT INSTALLATION - LEFT

Tools Required

- **EN 46334** Camshaft Oil Seal Driver. See **Special Tools and Equipment** .
- **EN 46337** Camshaft Sprocket/Crankshaft Balancer Holder. See **Special Tools and Equipment** .

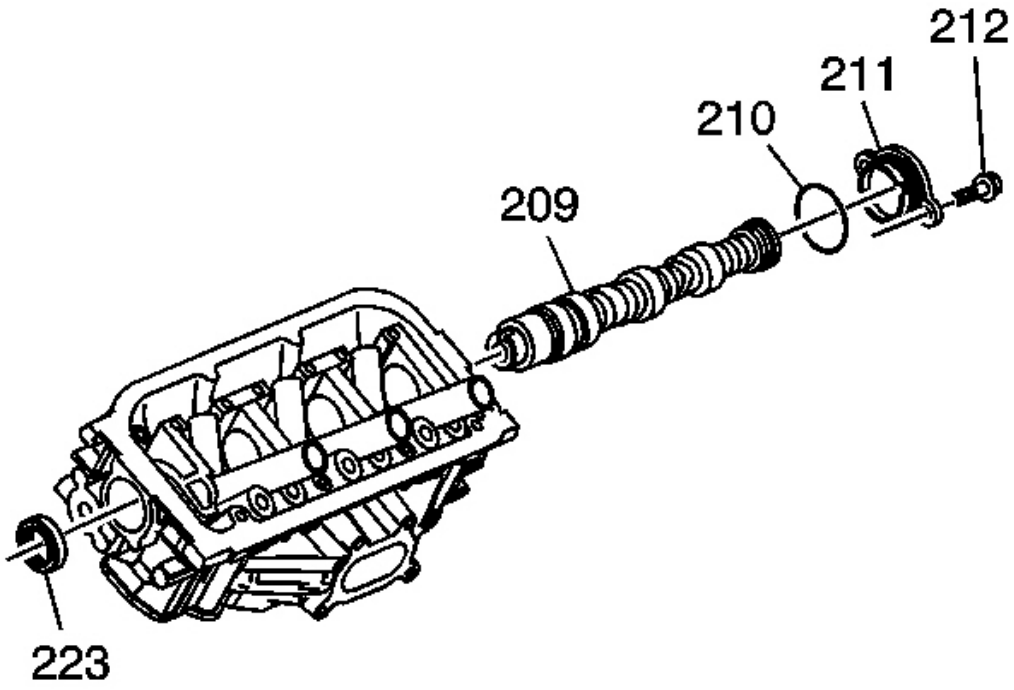


Fig. 355: Identifying Camshaft Journals
Courtesy of GENERAL MOTORS CORP.

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

   NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the camshaft (209), NEW O-ring (210), cap (211) and bolts (212).

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

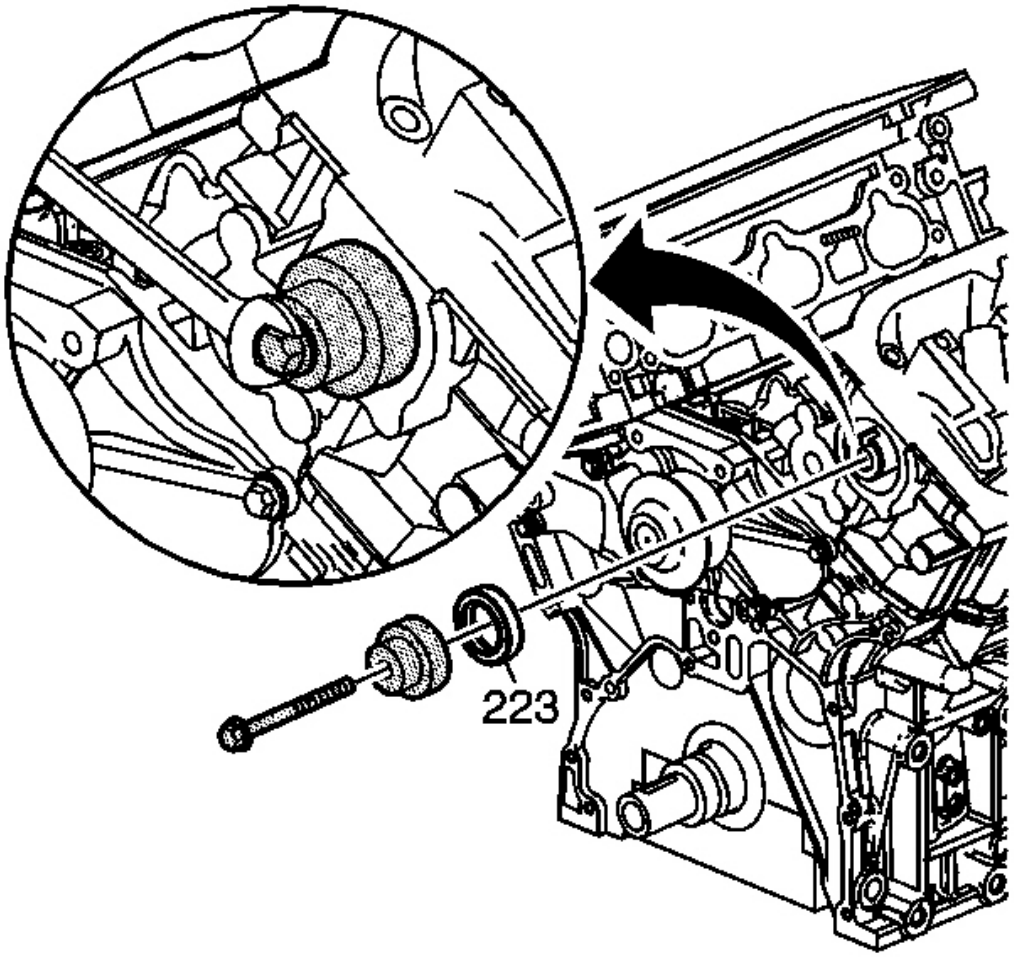


Fig. 356: View Of Seal Into The Cylinder
Courtesy of GENERAL MOTORS CORP.

3. Use the **EN 46334** in order to install the seal (223) into the cylinder head. See **Special Tools and Equipment** . Rotate the bolt clockwise until the tool bottoms in the cylinder head bore.

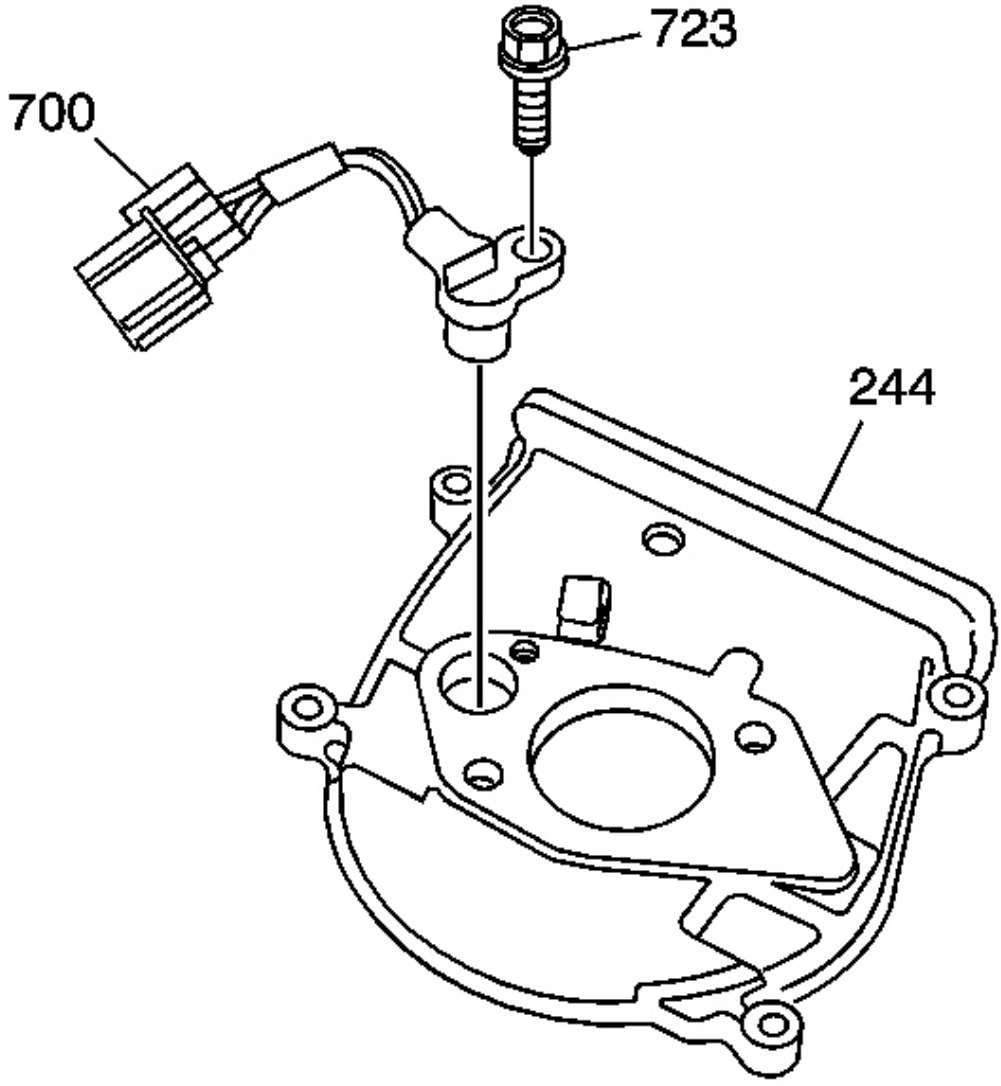


Fig. 357: View Of Bolt & Camshaft Position Sensor
Courtesy of GENERAL MOTORS CORP.

4. Install the camshaft position (CMP) sensor (700) and bolt (723).

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

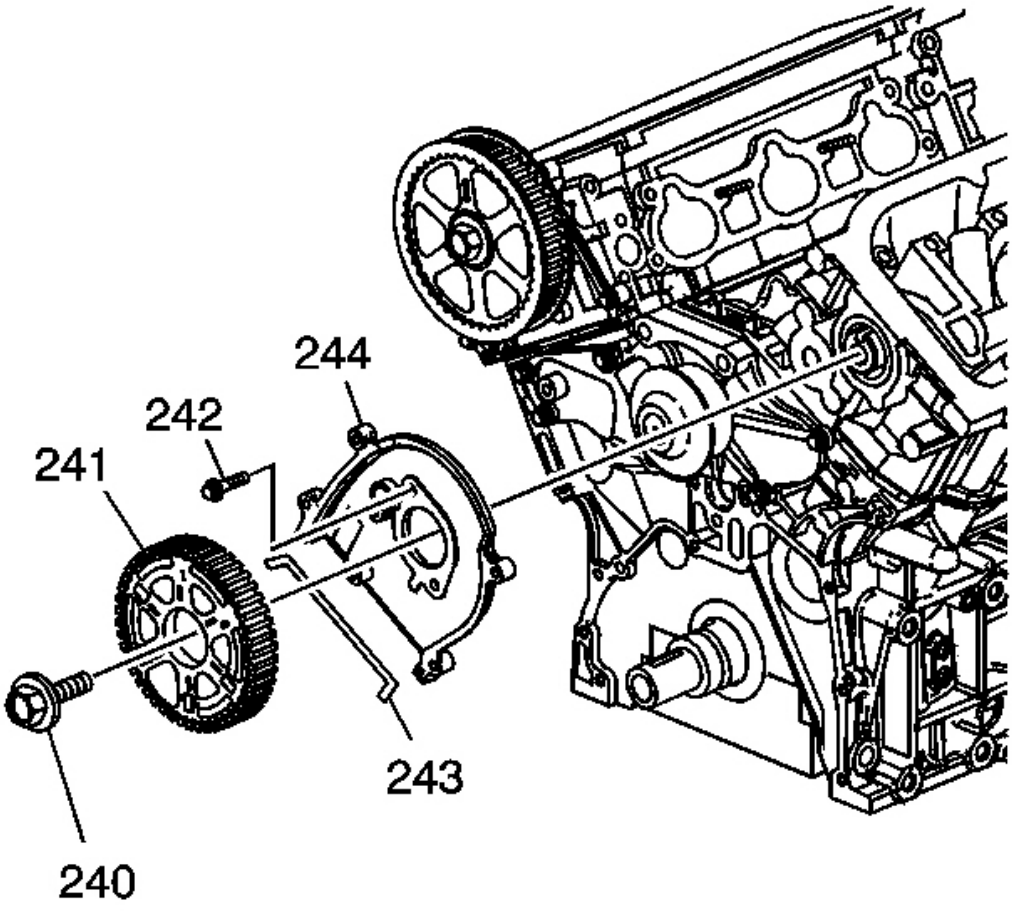


Fig. 358: View Of Camshaft Oil Seal
Courtesy of GENERAL MOTORS CORP.

5. Install the cover (244), NEW seal (243) and bolts (242).

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

6. Install the sprocket (241) and bolt (240).

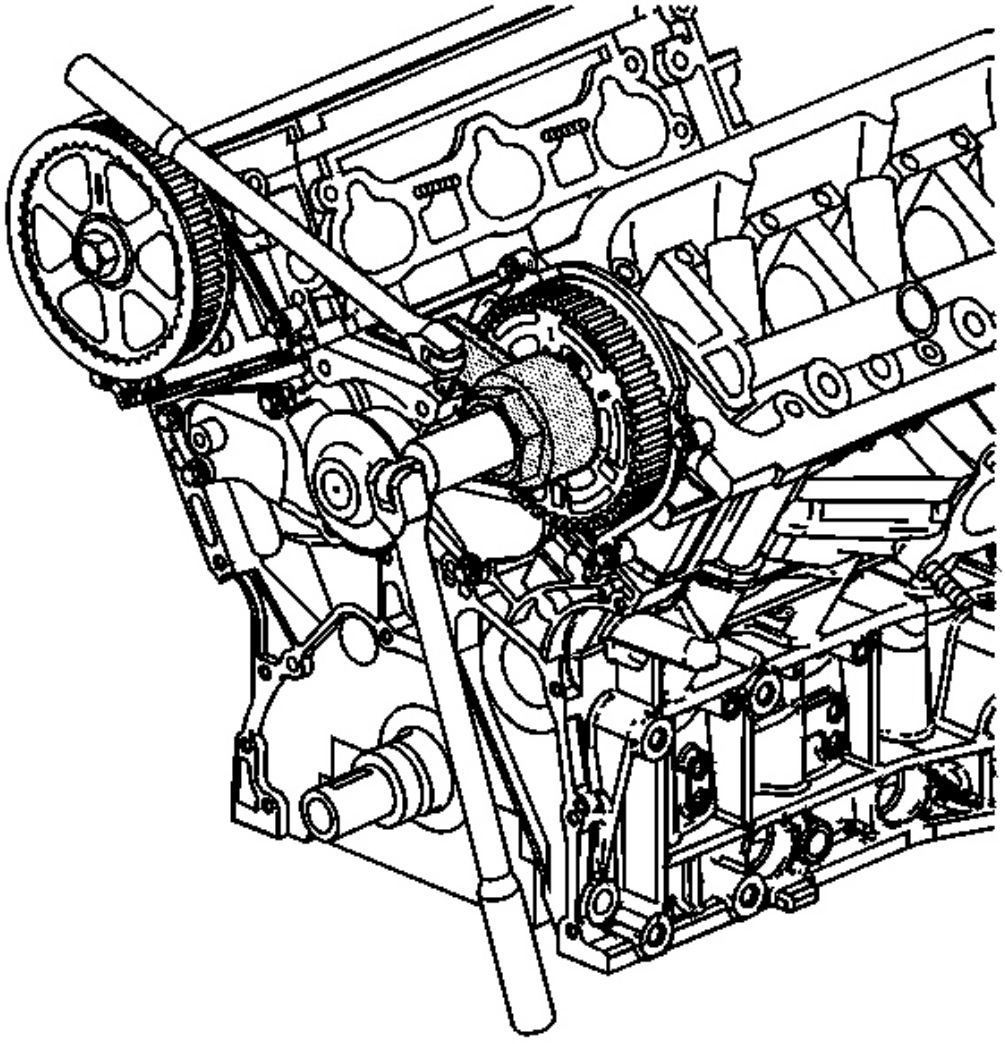


Fig. 359: View Of Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

7. Use the **EN 46337** in order to retain the camshaft sprocket. See **Special Tools and Equipment** .

   Tighten: Tighten the bolt to 90 N.m (67 lb ft).

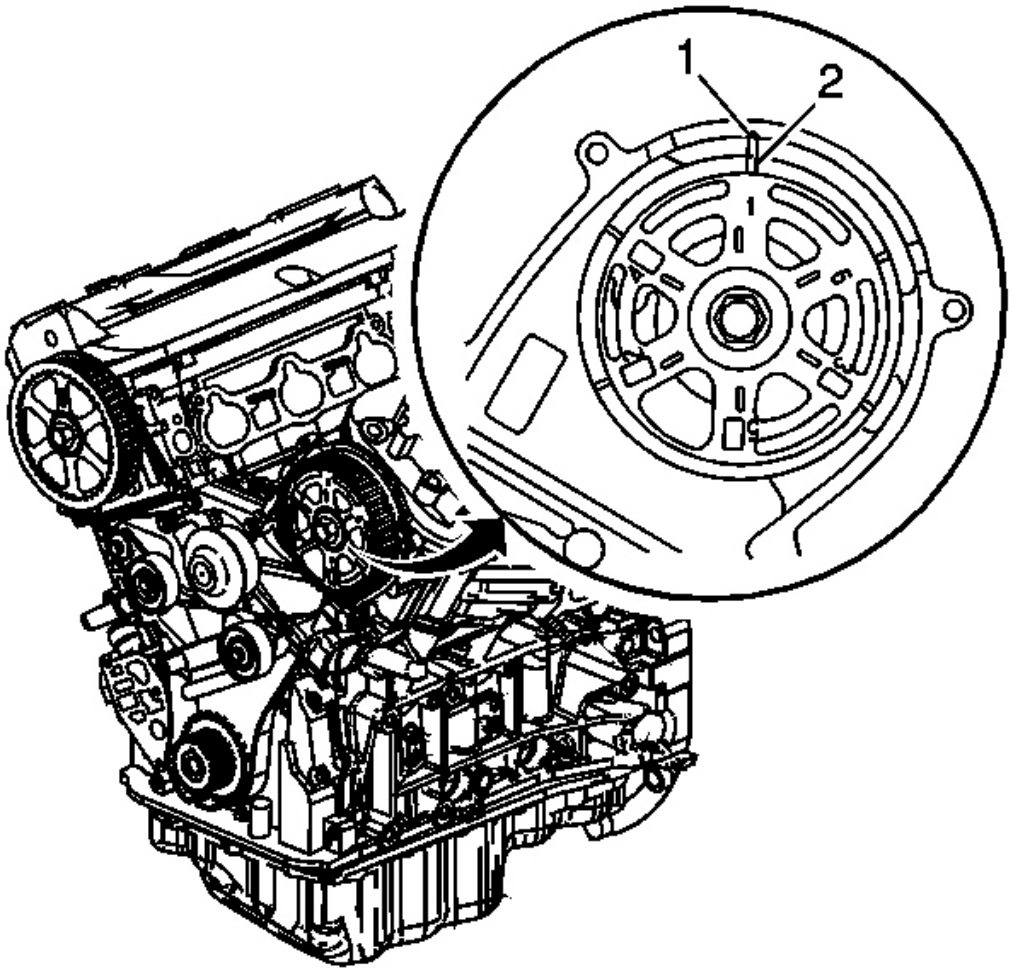


Fig. 360: Aligning The Mark On The Sprocket With The Pointer
Courtesy of GENERAL MOTORS CORP.

8. Rotate the camshaft to align the number 1 cylinder top dead center (TDC) mark on the sprocket (2) with the pointer on the rear cover (1).

CAMSHAFT INSTALLATION - RIGHT

Tools Required

- **EN 46334** Camshaft Oil Seal Driver. See **Special Tools and Equipment** .
- **EN 46337** Camshaft Sprocket/Crankshaft Balancer Holder. See **Special Tools and Equipment** .

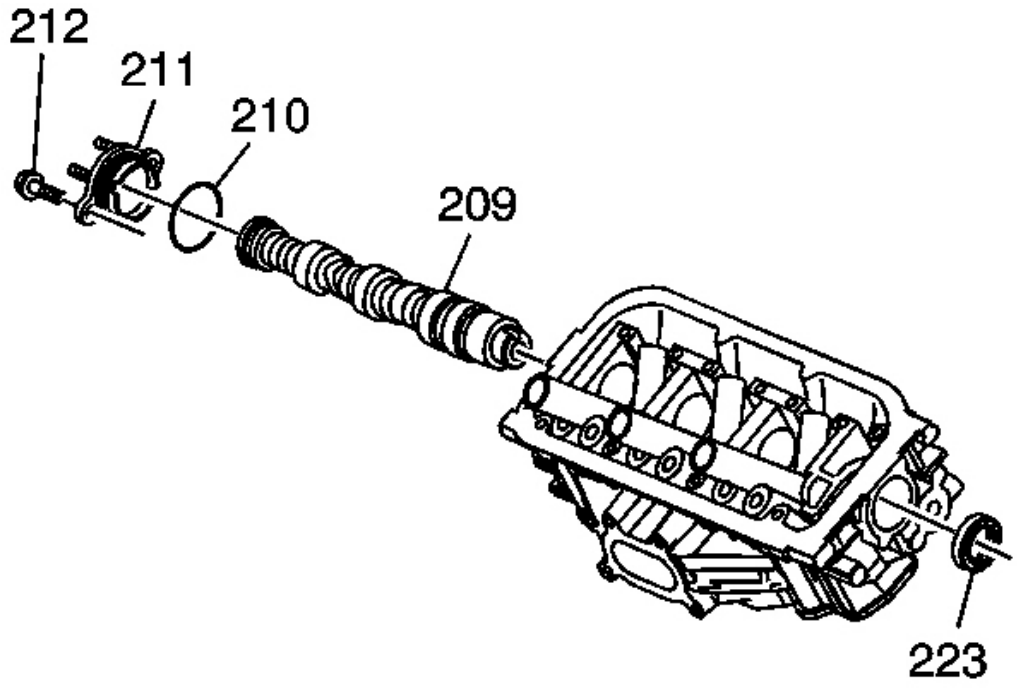


Fig. 361: View Of Camshaft Journals
Courtesy of GENERAL MOTORS CORP.

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

NOTE: **Refer to Fastener Notice in Cautions and Notices.**

2. Install the camshaft (209), NEW O-ring (210), cap (211) and bolts (212).

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

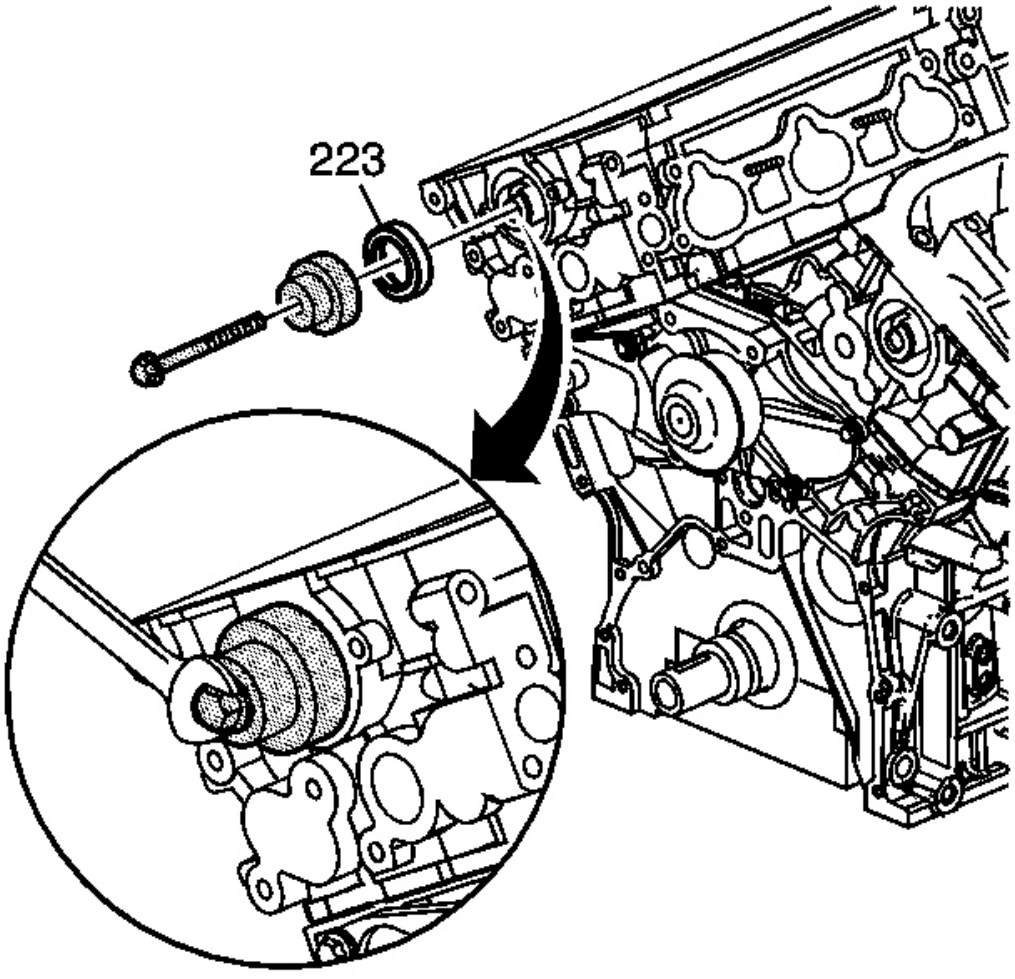


Fig. 362: View Of Seal Onto The Cylinder Head
Courtesy of GENERAL MOTORS CORP.

3. Use the **EN 46334** in order to install the seal (223) into the cylinder head. See **Special Tools and Equipment** . Rotate the bolt clockwise until the tool bottoms in the cylinder head bore.

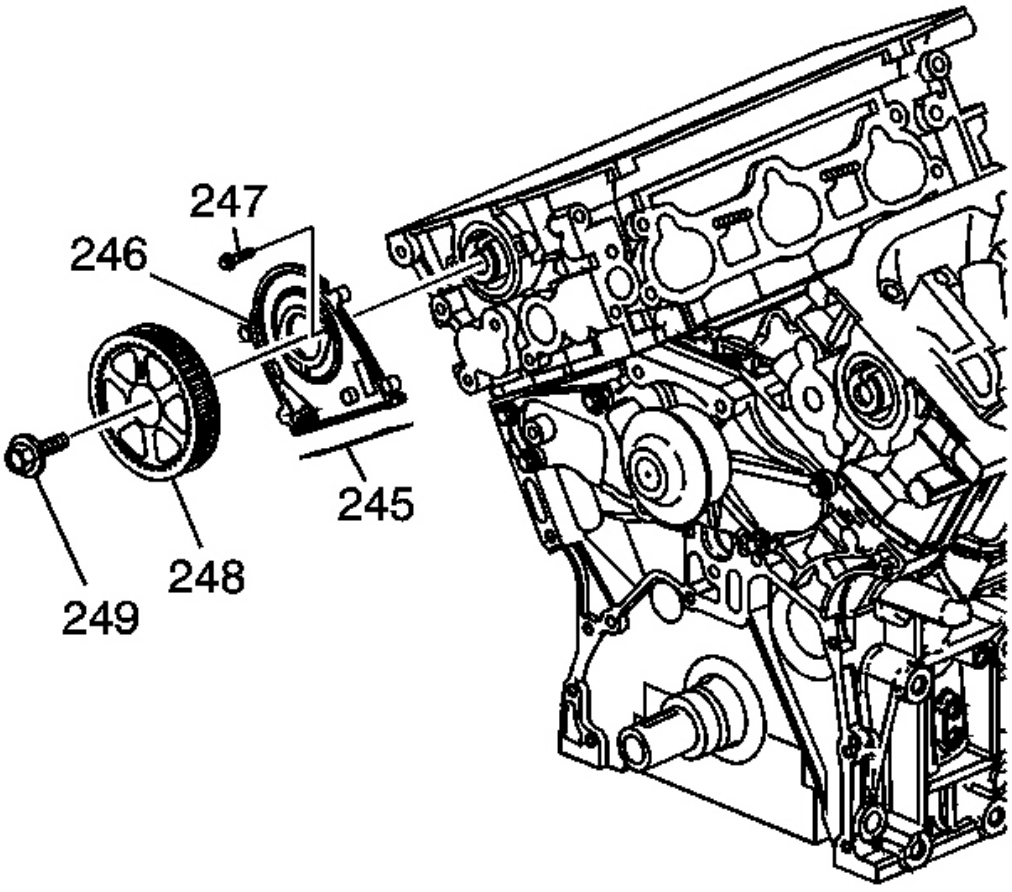


Fig. 363: View Of Bolt, Sprocket, Bolts, Cover & Seal
Courtesy of GENERAL MOTORS CORP.

4. Install the cover (246), NEW seal (245) and bolts (247).

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

5. Install the sprocket (248) and bolt (249).

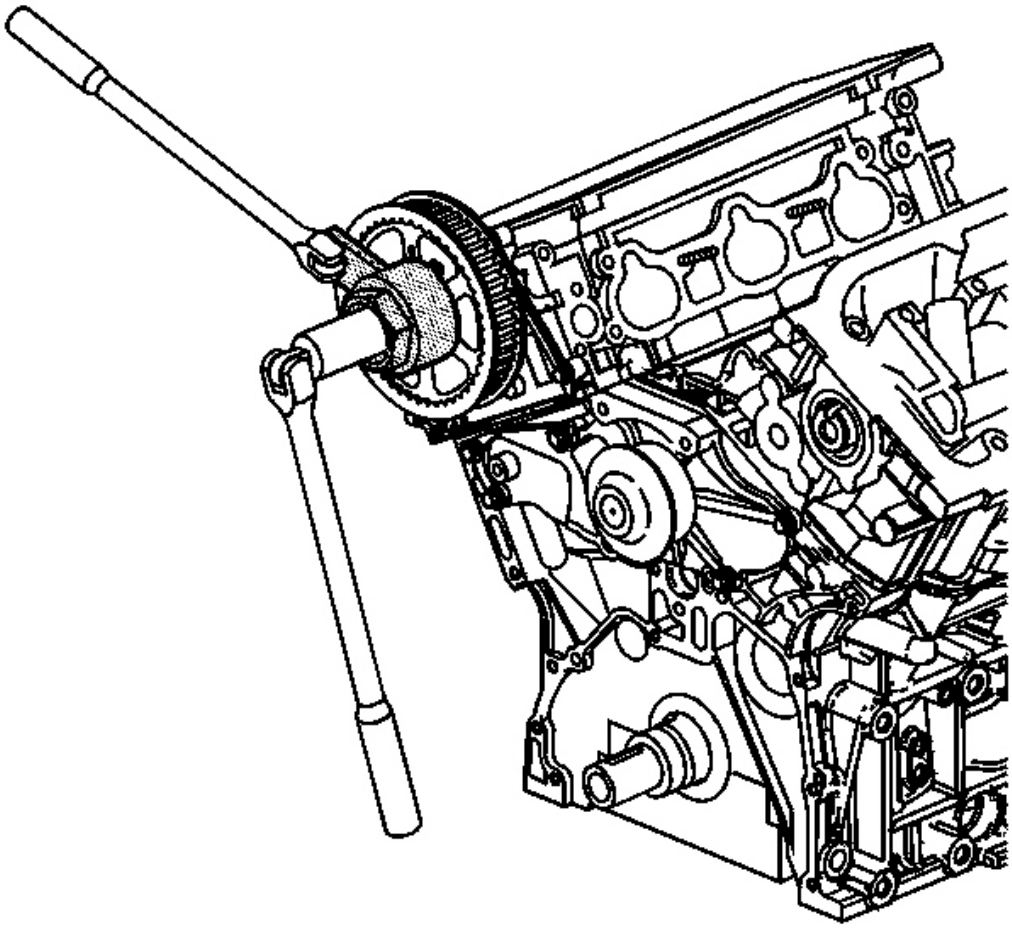


Fig. 364: View Of Camshaft
Courtesy of GENERAL MOTORS CORP.

6. Use the **EN 46337** to retain the camshaft sprocket. See **Special Tools and Equipment** .

   Tighten: Tighten the bolt to 90 N.m (67 lb ft).

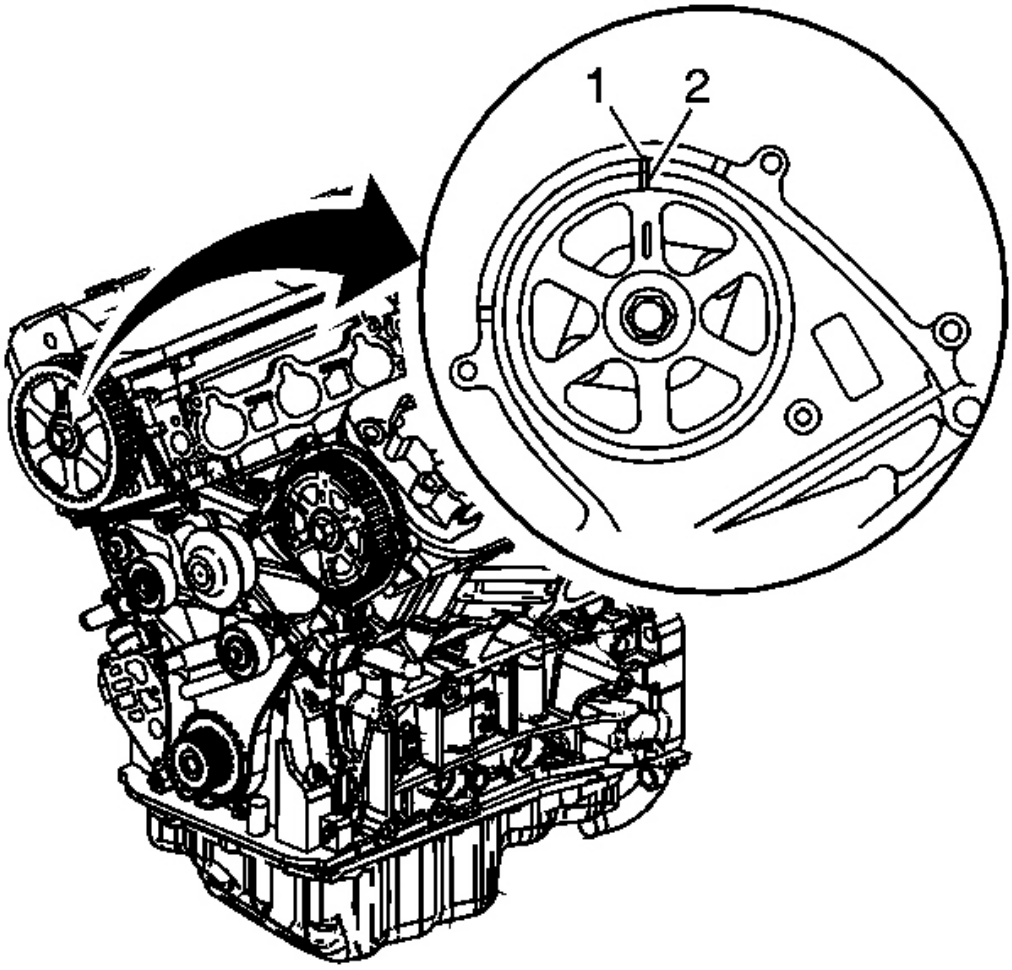


Fig. 365: Aligning The Mark On The Sprocket With The Pointer On The Rear Cover
Courtesy of GENERAL MOTORS CORP.

7. Rotate the camshaft to align the mark on the sprocket (2) with the pointer on the rear cover (1).

VALVE ROCKER ARM AND SHAFT INSTALLATION

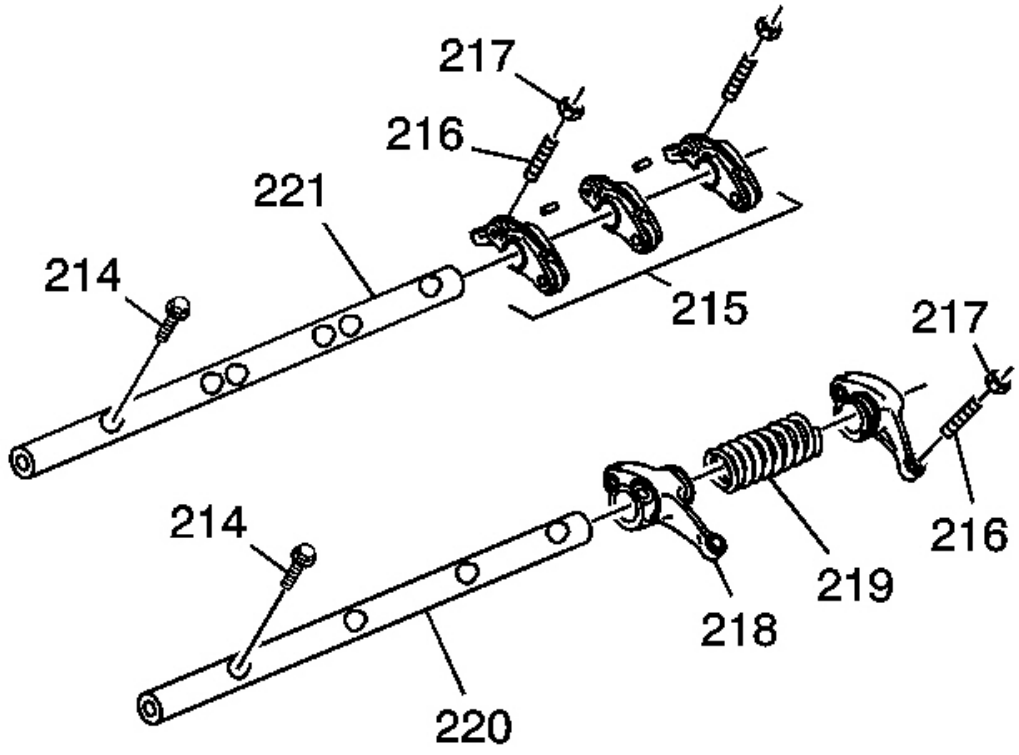


Fig. 366: View Of Rocker Arm Shaft
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Identify parts as they are removed so they can be installed in their original locations if used again. When removing or installing the rocker arm shaft assembly, do not remove the rocker arm shaft mounting bolts. The bolts will retain the springs and rocker arms onto the shafts.

1. Install the bolts (216) and nuts (217). Do not tighten the nuts at this time.
2. Install the intake valve rocker arm assemblies (215) onto the shaft (221).
3. Install the bolts (214) to the shaft (221).

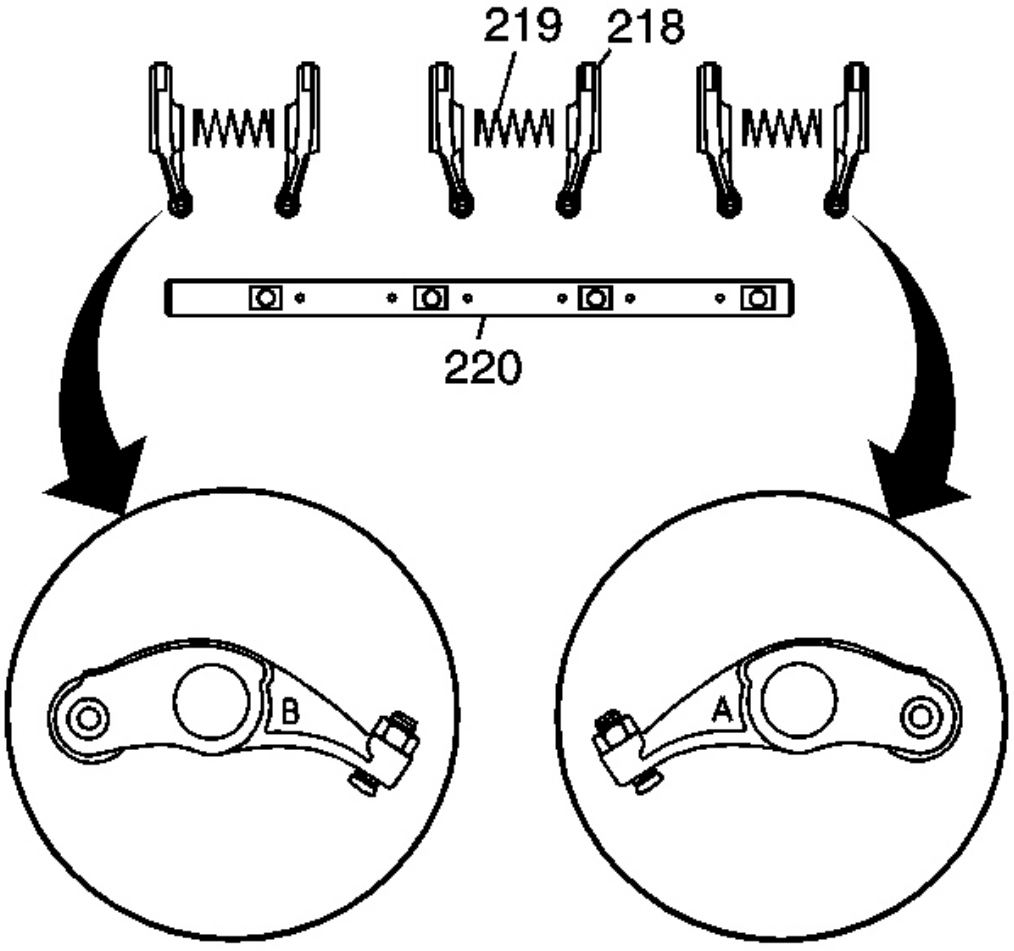


Fig. 367: View Of Exhaust Valve Rocker Arms & Springs Onto The Shaft
Courtesy of GENERAL MOTORS CORP.

4. Install the exhaust valve rocker arms (218) and springs (219) onto the shaft (220).
5. Note the installed position of the exhaust valve rocker arms (218).
6. Install the bolts to the shaft (220).

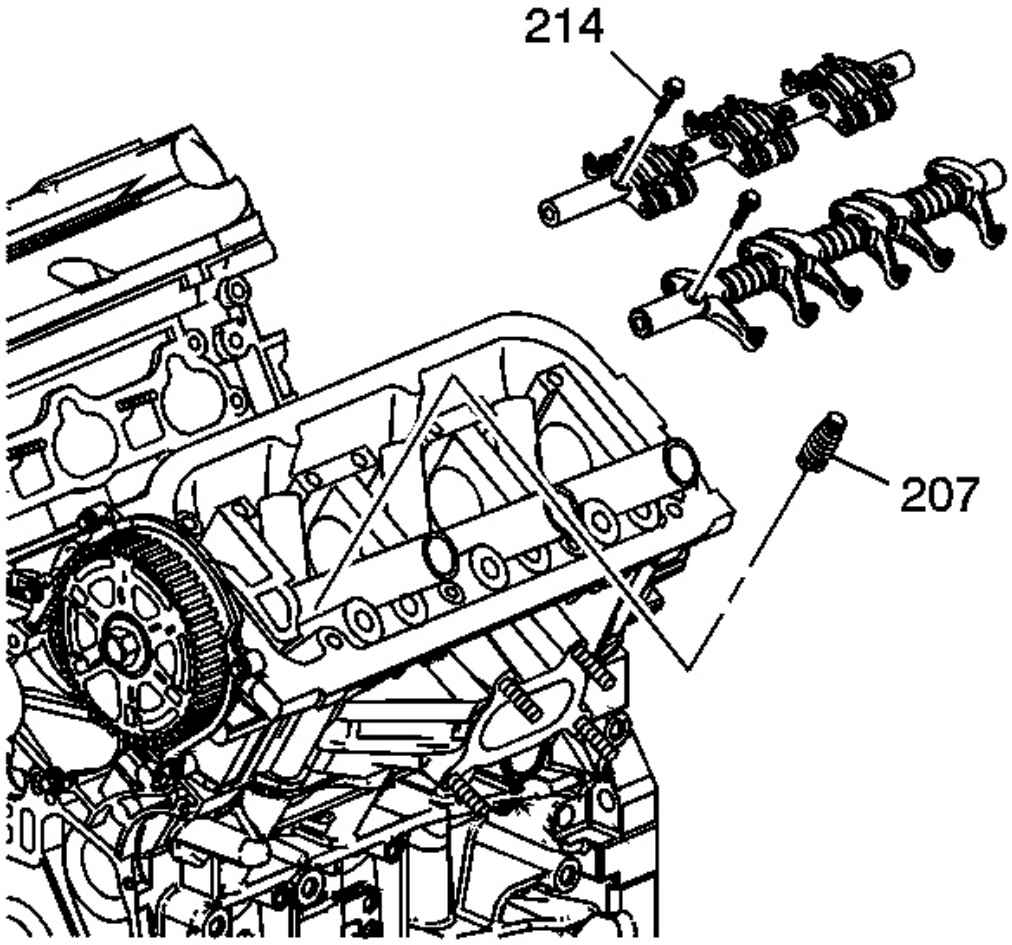


Fig. 368: View Of Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

7. Install the lash adjusters (207).

NOTE: **Refer to Fastener Notice in Cautions and Notices.**

IMPORTANT: The intake rocker arm shaft front locating pin serves as an oil passage for intake rocker arm control system operation. During assembly, use care to locate the shaft onto the pin. Replace pins that are bent or damaged.

8. Install the intake and exhaust rocker arm and shaft assemblies and bolts (214).

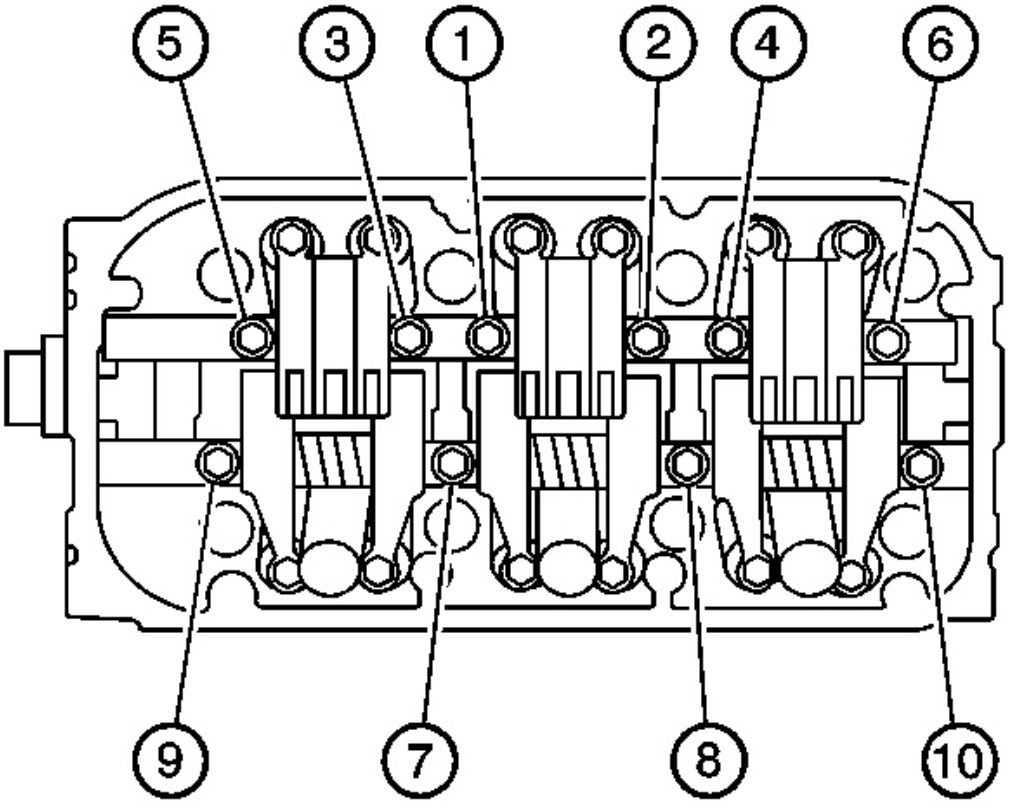


Fig. 369: View Of Left Side Rocker Shaft Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

9. Tighten the left side rocker shaft retaining bolts in sequence. Tighten the bolts 2 turns at a time in sequence, to ensure that the rocker arms do not bind on the valves.

   Tighten:

   1. Tighten the bolts in sequence a first pass to 12 N.m (106 lb in).
   2. Tighten the bolts in sequence a final pass to 24 N.m (17 lb ft).

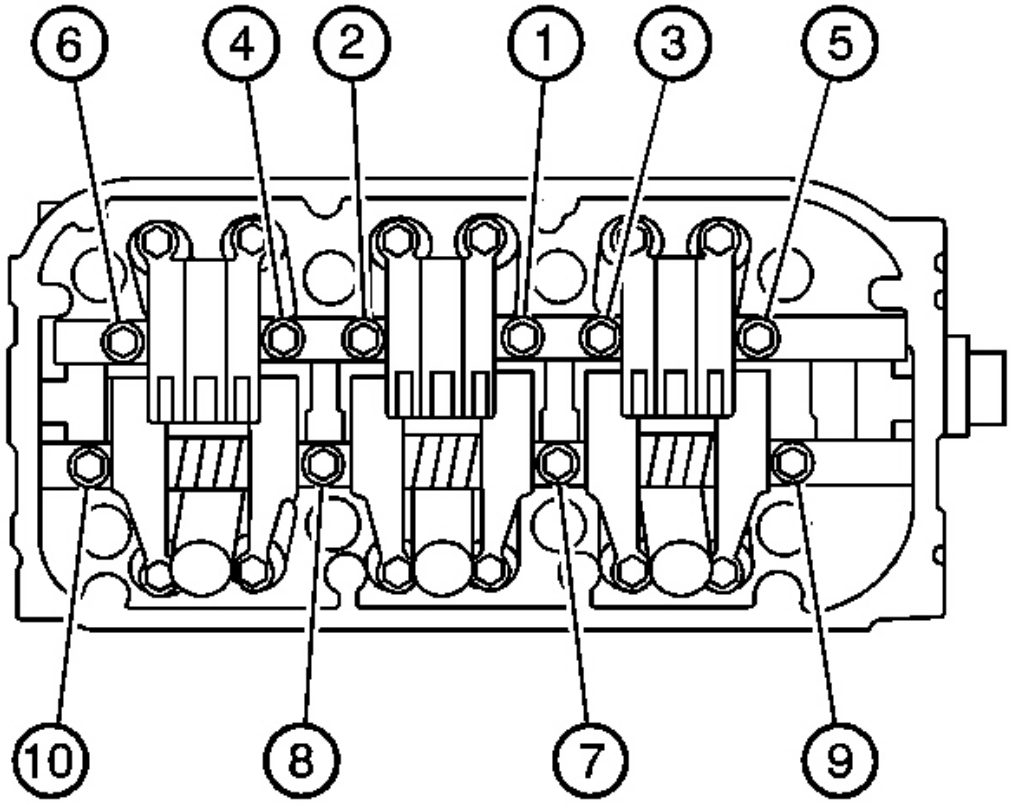


Fig. 370: Identifying Right Side Rocker Shaft Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

10. Tighten the right side rocker shaft retaining bolts in sequence. Tighten the bolts 2 turns at a time in sequence, to ensure that the rocker arms do not bind on the valves.

WATER PUMP INSTALLATION

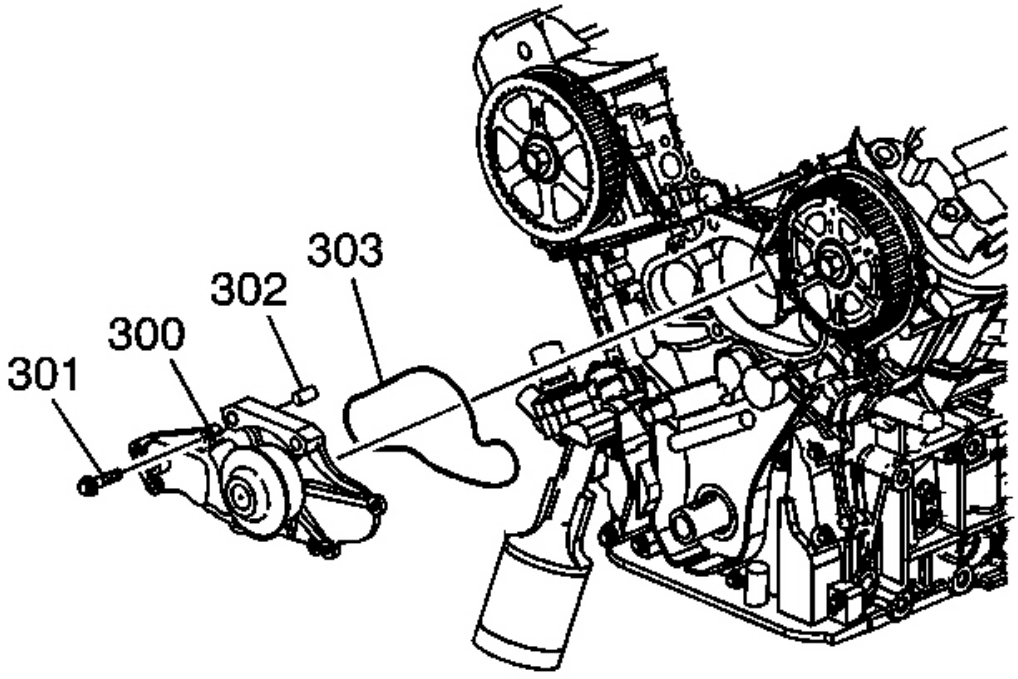


Fig. 371: View Of Water Pump
Courtesy of GENERAL MOTORS CORP.

1. Inspect and clean the O-ring groove and mating surfaces.
2. Install the pins (302).
3. Install the water pump (300) with NEW O-ring seal (303).

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the bolts (301).

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

TIMING BELT IDLER PULLEY INSTALLATION

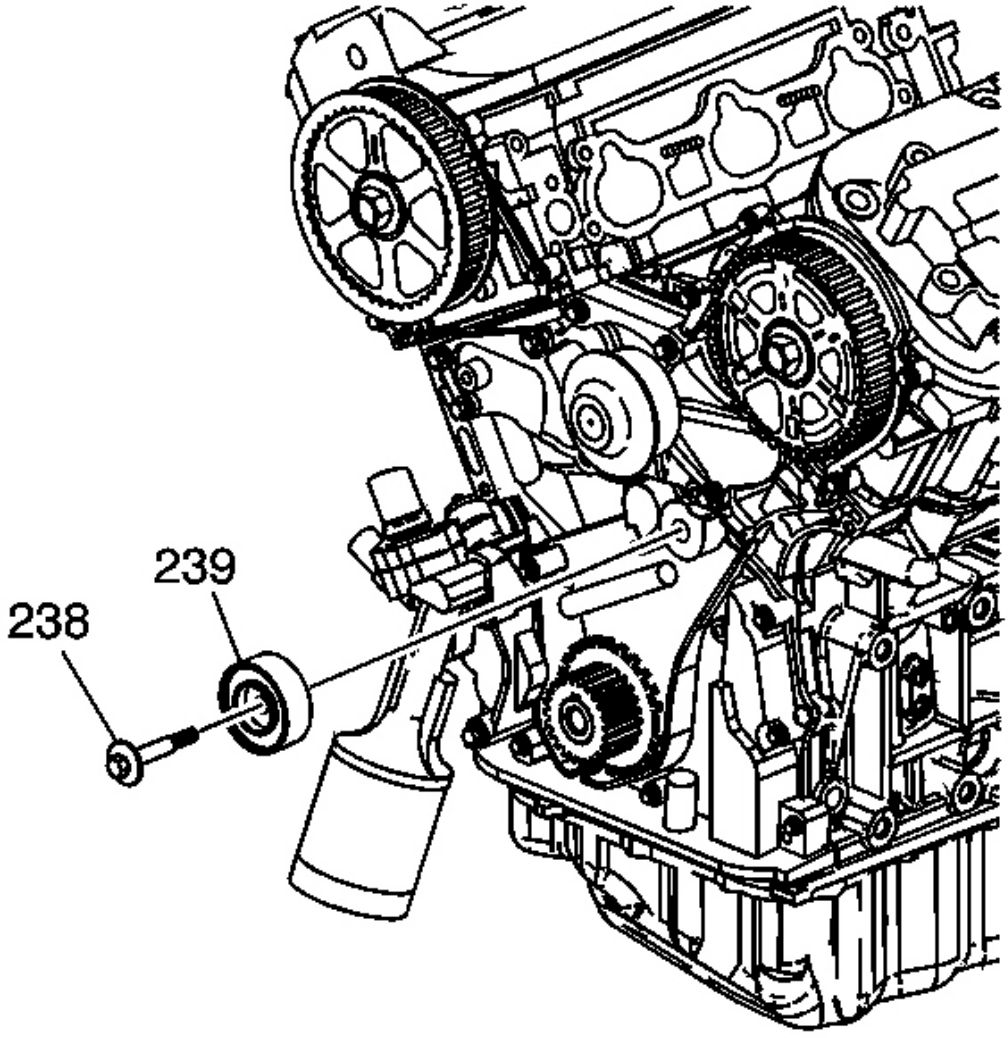


Fig. 372: View Of Timing Belt
Courtesy of GENERAL MOTORS CORP.

1. Apply GM P/N 12346240 (Canadian P/N 10953493) to the threads of the idler pulley bolt.

IMPORTANT: Do not tighten the idler pulley bolt (238) at this time. The idler pulley bolt is to be tightened during the timing belt installation procedure.

2. Install the pulley (239) and bolt (238).

TIMING BELT TENSIONER INSTALLATION

Tools Required

EN 46330 Timing Belt Tensioner Retaining Pin. See **Special Tools and Equipment** .

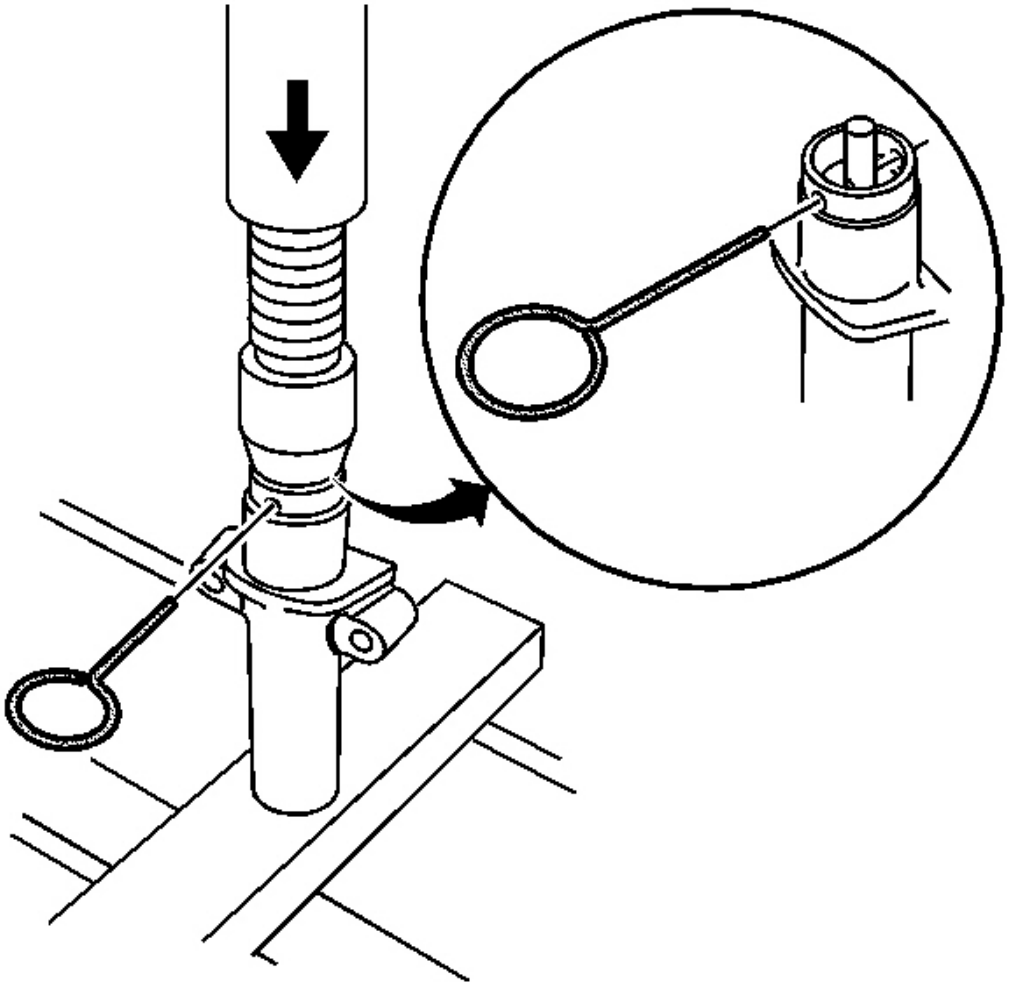


Fig. 373: View Of Timing Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not exceed 9 800 N (2,200 lb) when compressing the rod of the tensioner or component damage may occur.

1. Using a hydraulic press, slowly compress the tensioner.
2. Insert the **EN 46330** through the housing and rod. See **Special Tools and Equipment** .

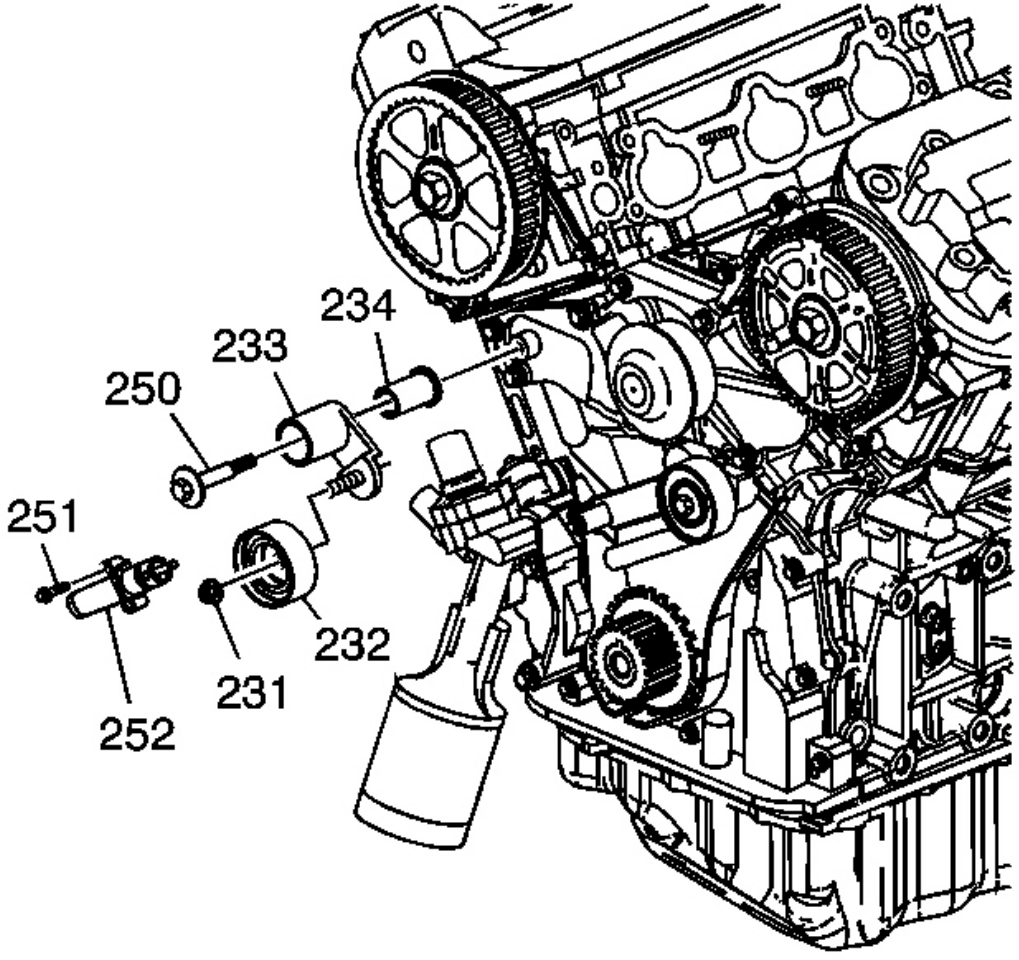


Fig. 374: Identifying Timing Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the bushing (234), tensioner bracket (233) and bolt (250).

   Tighten: Tighten the bolt to 25 N.m (19 lb ft).

4. Install the pulley (232) and nut (231).

Tighten: Tighten the nut to 80 N.m (59 lb ft).

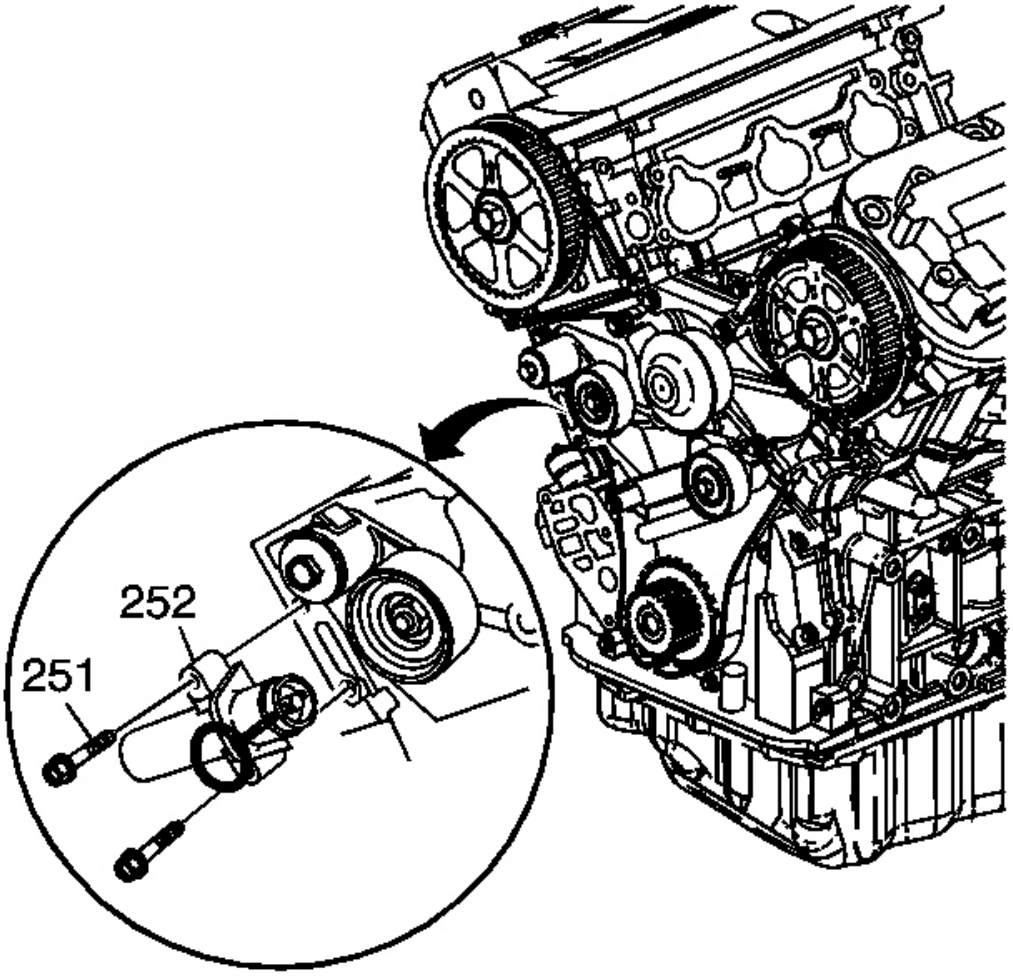


Fig. 375: Identifying Tensioner
Courtesy of GENERAL MOTORS CORP.

5. Install the tensioner (252) and bolts (251).

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

TIMING BELT INSTALLATION

Tools Required

- **EN 46330** Timing Belt Tensioner Retaining Pin. See **Special Tools and Equipment** .
- **EN 46331** Timing Belt Tensioner Pulley Retaining Bolt. See **Special Tools and Equipment** .
- **EN 46337** Camshaft Sprocket/Crankshaft Balancer Holder. See **Special Tools and Equipment** .

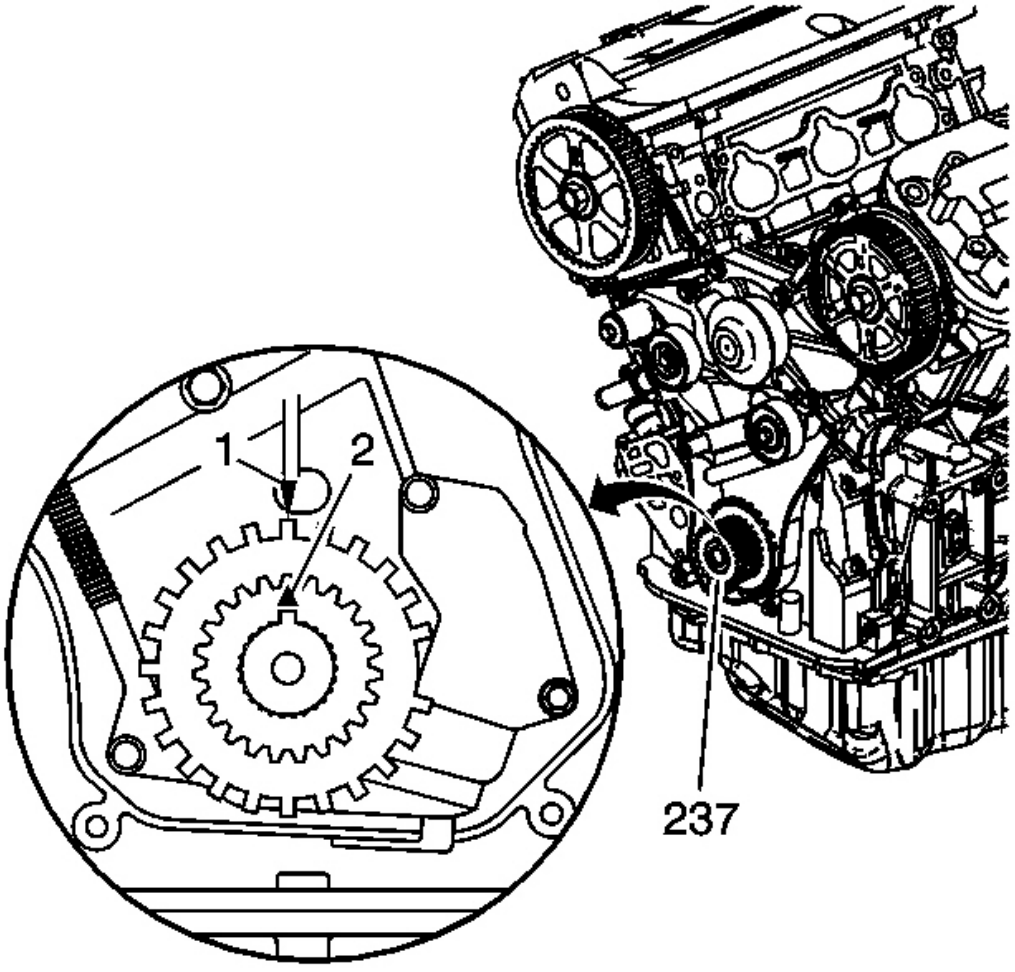


Fig. 376: View Of Crankshaft To Align The Mark On The Sprocket With The Pointer
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The powertrain control module (PCM) must perform the idle learn procedure to determine the minimum throttle position and to establish idle speed when any of the following components are replaced:

- **Throttle body**

- **Timing belt**
- **Timing belt drive sprocket**
- **Crankshaft and bearings**

Refer to Idle Learn Procedure .

1. Clean the belt sprockets and covers.
2. Rotate the crankshaft and align the top dead center (TDC) mark (2) on the sprocket (237) with the pointer on the oil pump housing (1).

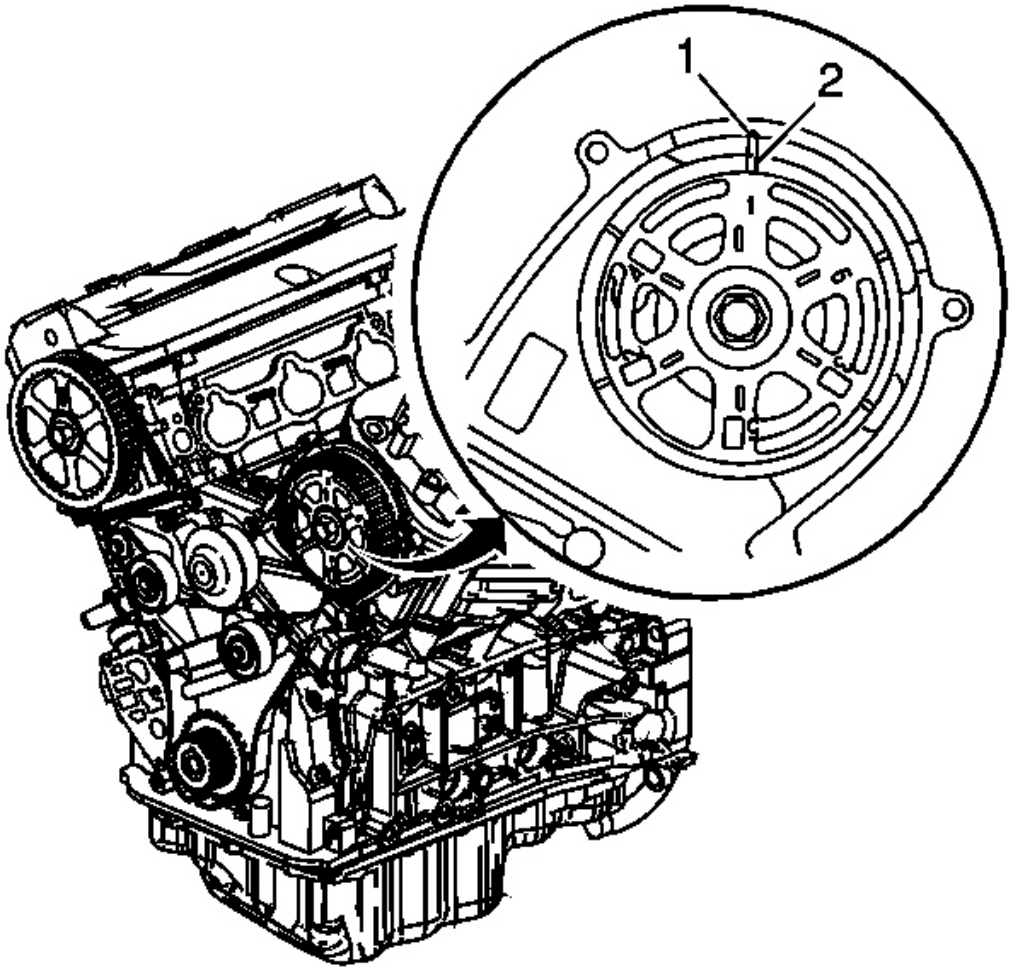


Fig. 377: Aligning The Mark On The Sprocket With The Pointer
Courtesy of GENERAL MOTORS CORP.

3. Rotate the left camshaft sprocket to TDC by aligning the mark (2) on the sprocket with the pointer (1) on the cover.

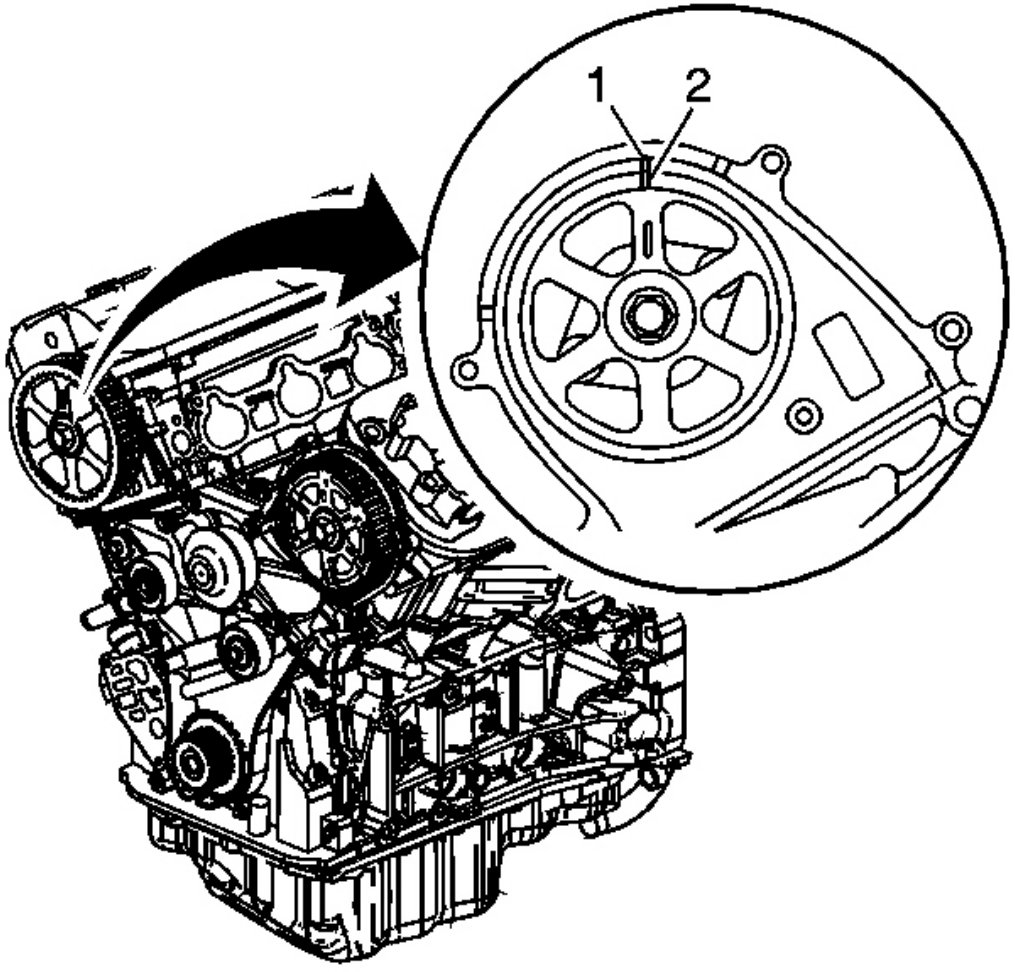


Fig. 378: Aligning The Mark On The Sprocket With The Pointer On The Rear Cover
Courtesy of GENERAL MOTORS CORP.

4. Rotate the right camshaft sprocket to TDC by aligning the mark (2) on the sprocket with the pointer (1) on the cover.

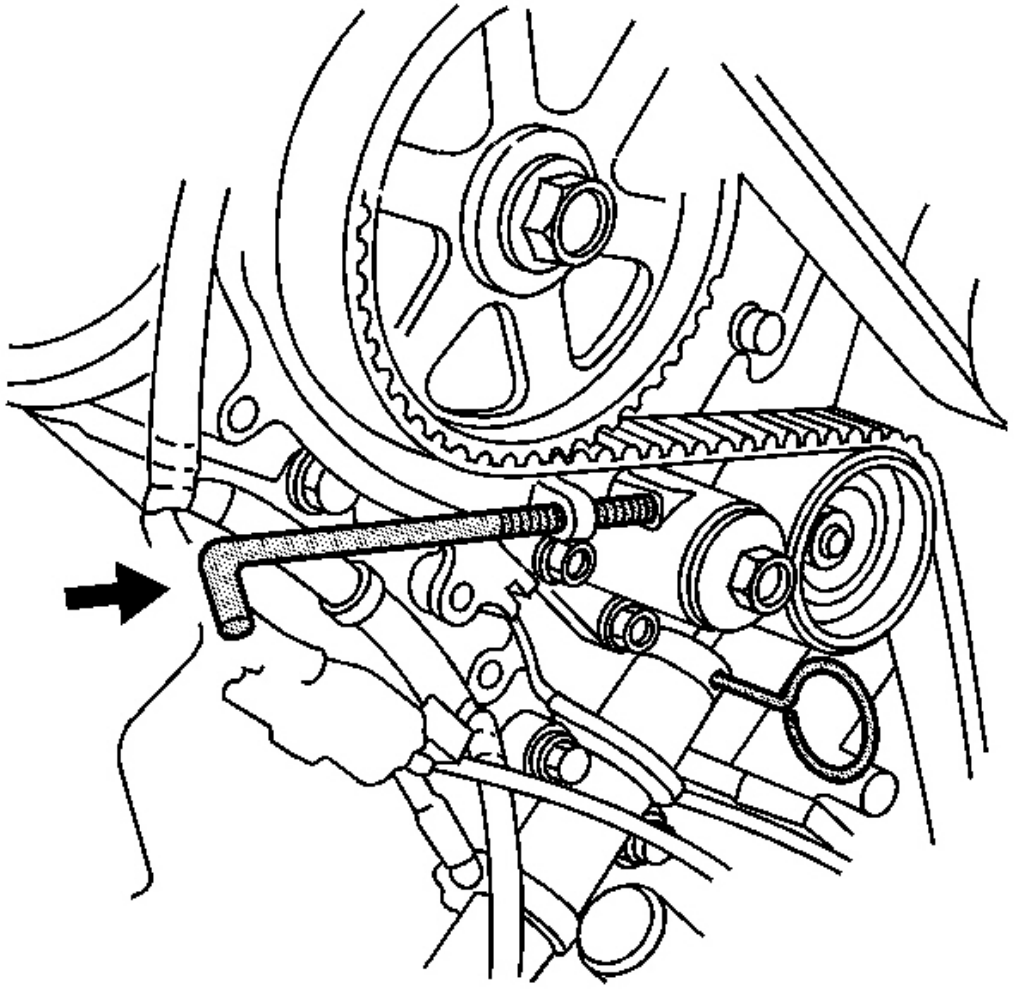


Fig. 379: View Of EN 46331 On The Timing Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

5. Install the **EN 46331** . See **Special Tools and Equipment** . Screw the **EN 46331** all the way in by hand, until the tool contacts the timing belt tensioner. See **Special Tools and Equipment** . Tighten until snug.

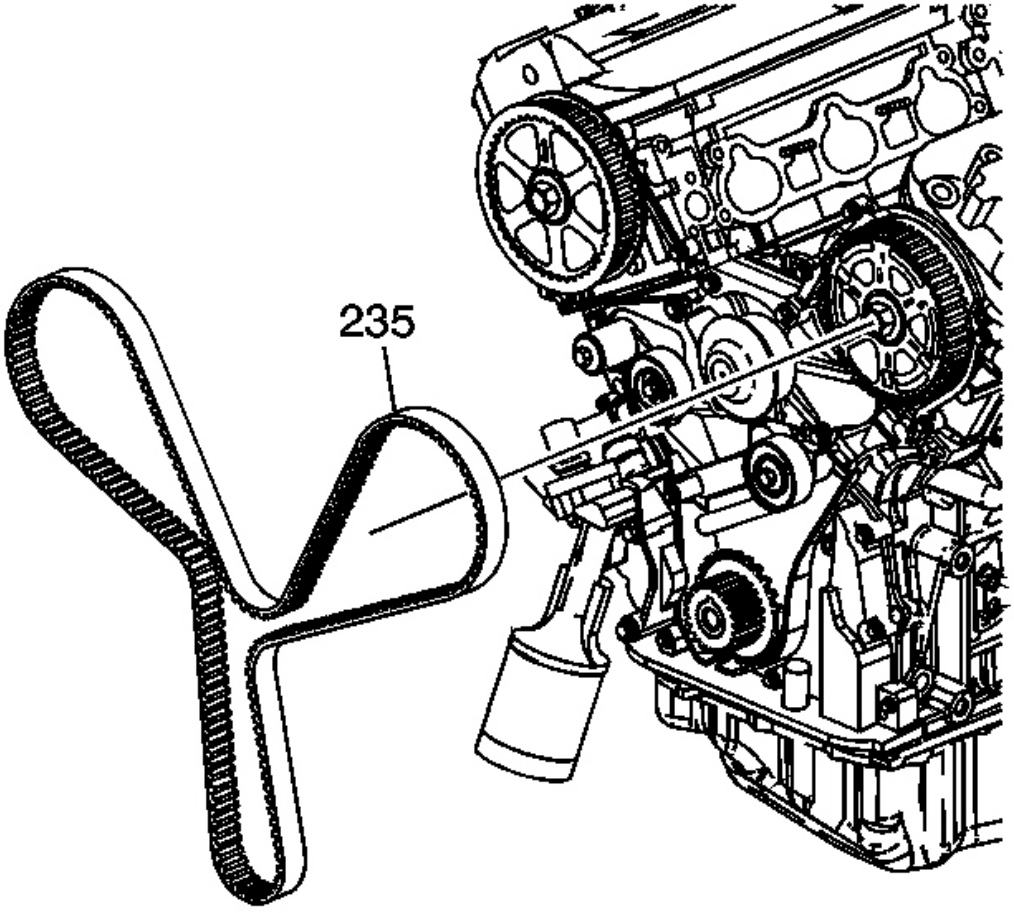


Fig. 380: View Of Timing Belt
Courtesy of GENERAL MOTORS CORP.

6. Install the belt (235) onto the sprockets. Install the timing belt in a clockwise sequence starting with the tensioner pulley. Refer to **Camshaft Timing Belt Alignment Diagram** .

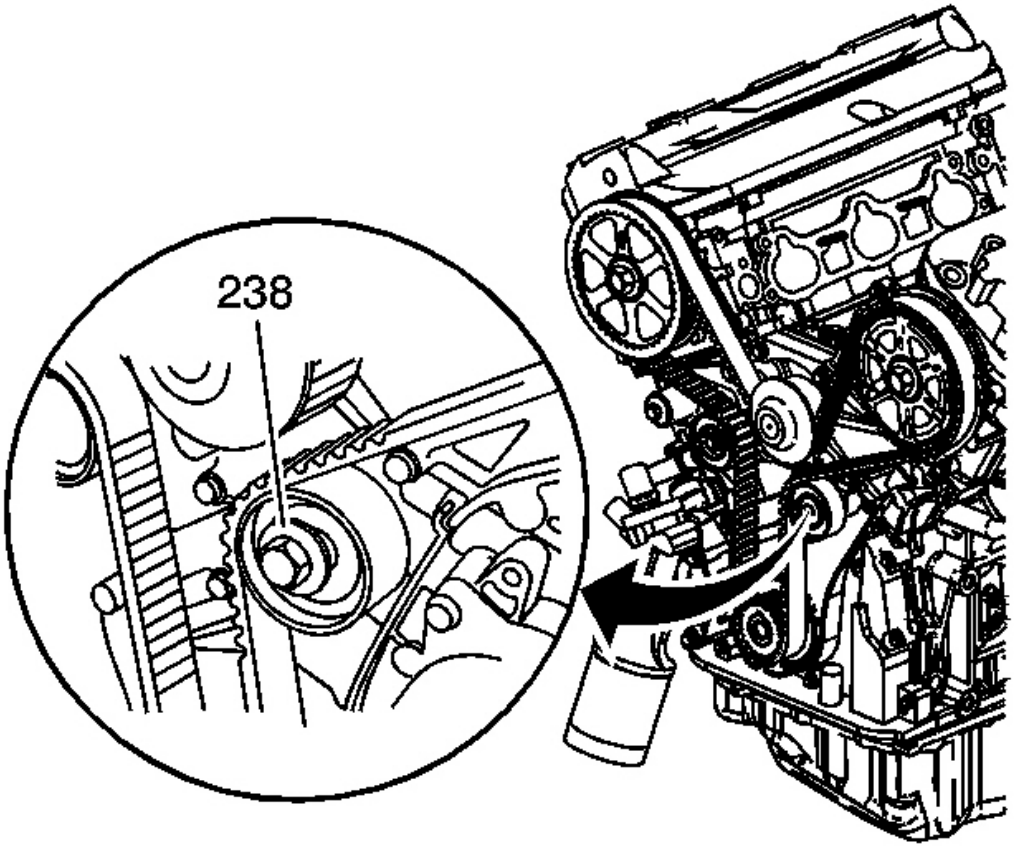


Fig. 381: View Of Idler Pulley Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

7. Tighten the idler pulley bolt (238).

   Tighten: Tighten the bolt to 44 N.m (33 lb ft).

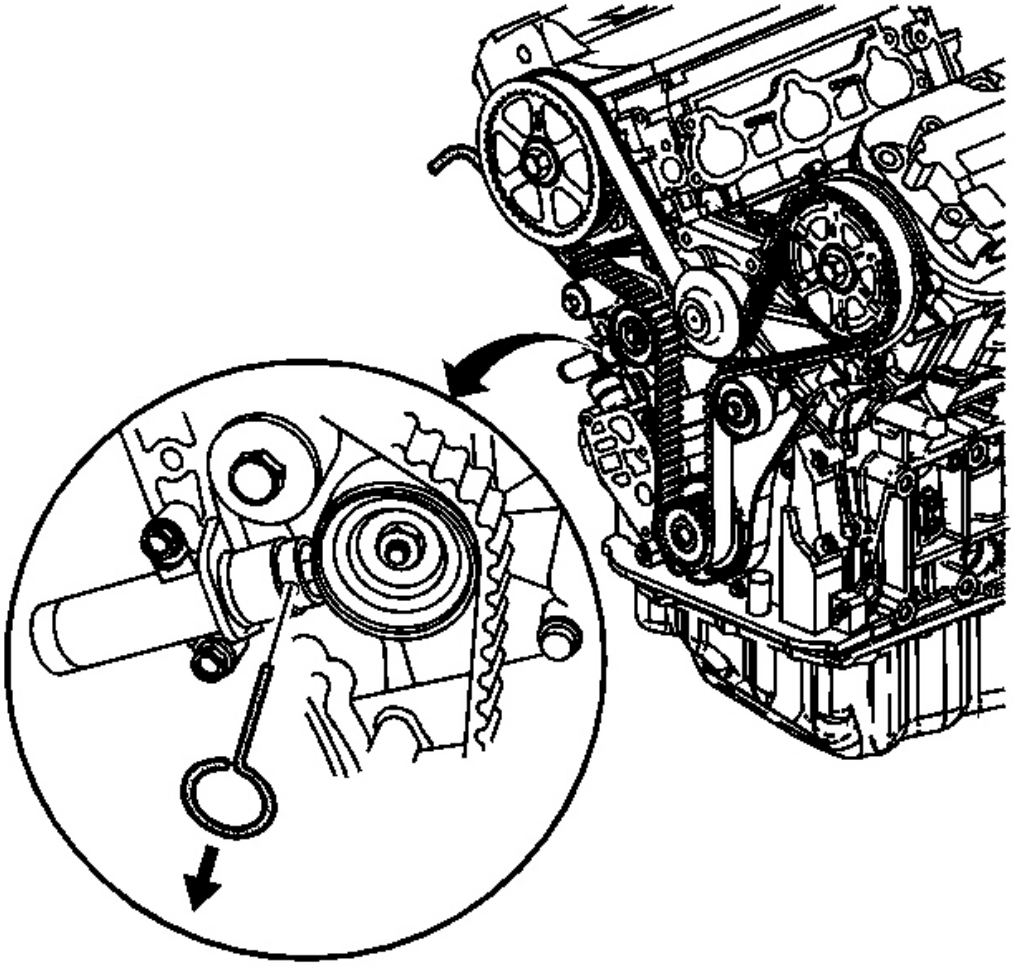


Fig. 382: View Of EN 46330
Courtesy of GENERAL MOTORS CORP.

8. Remove the **EN 46330** . See **Special Tools and Equipment** .

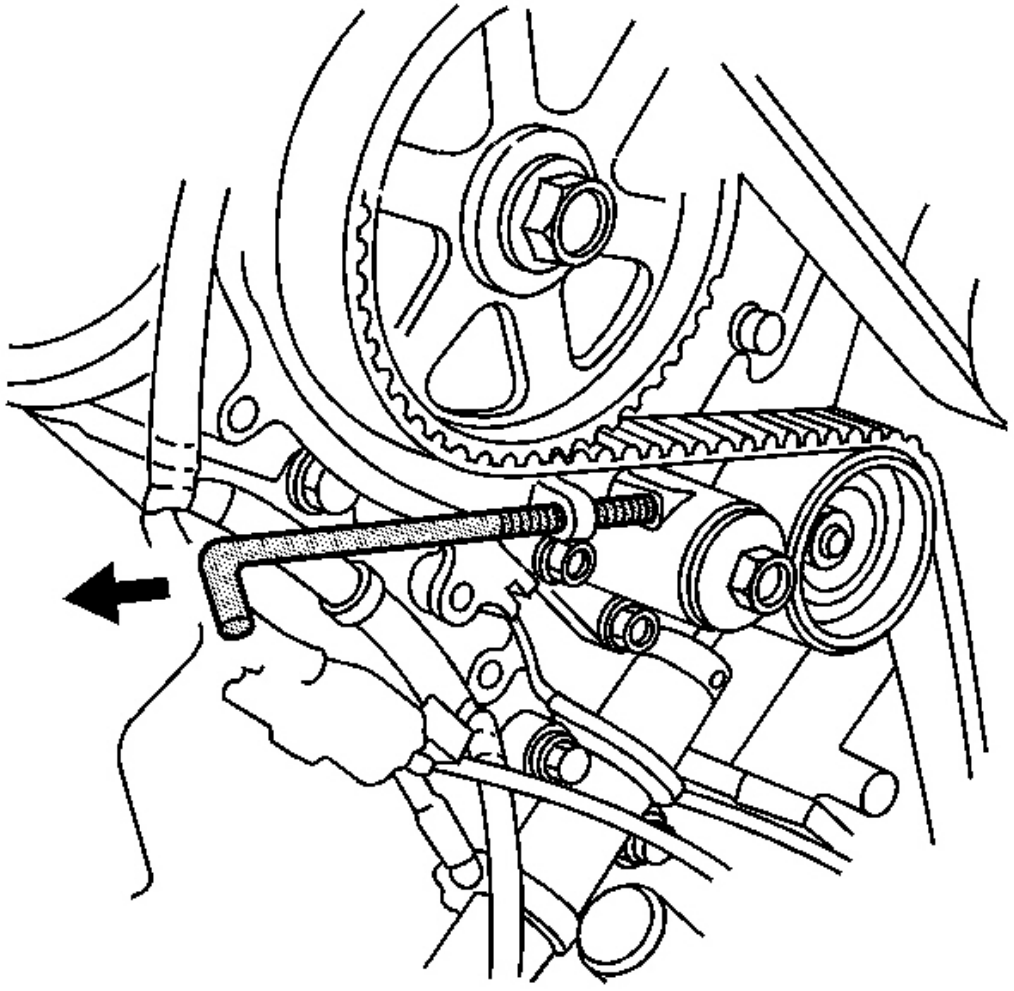


Fig. 383: View Of EN 46331
Courtesy of GENERAL MOTORS CORP.

9. Remove the **EN 46331** . See **Special Tools and Equipment** .

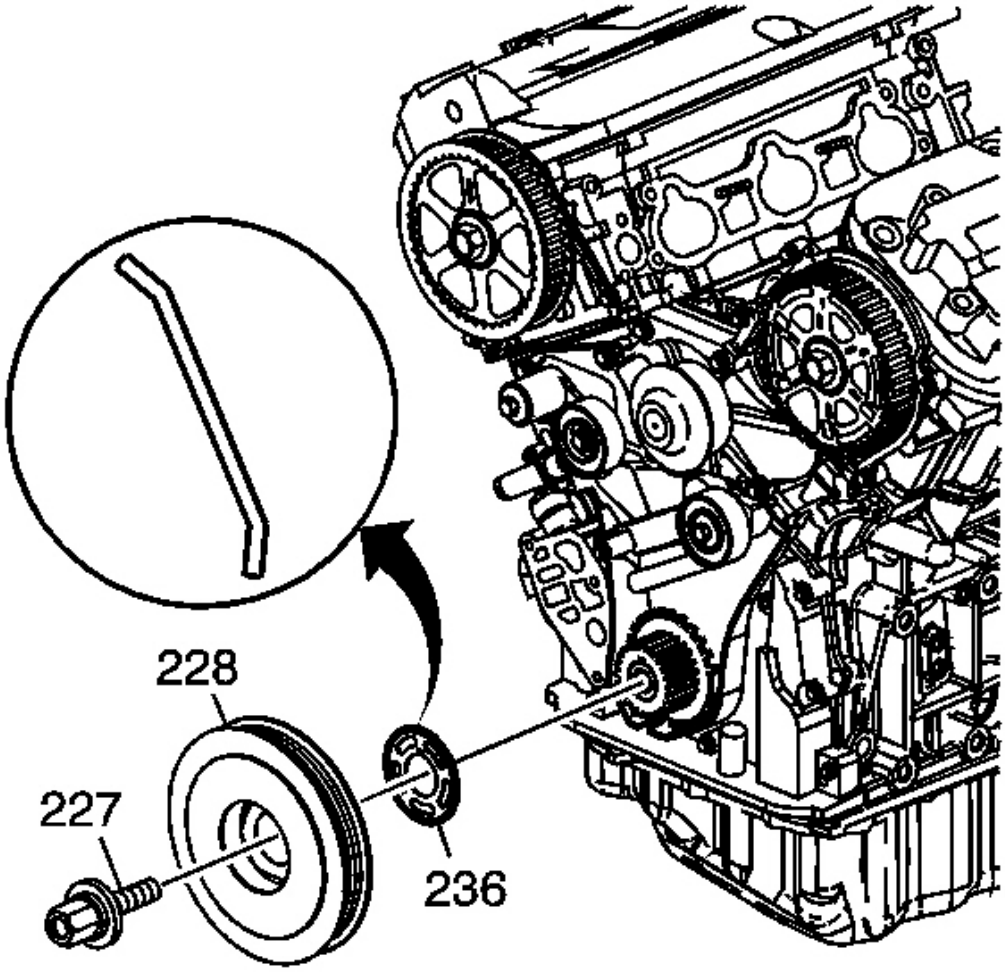


Fig. 384: View Of Guide, Balancer & Bolt
Courtesy of GENERAL MOTORS CORP.

10. Install the guide (236), balancer (228), and bolt (227). Tighten the bolt until snug.

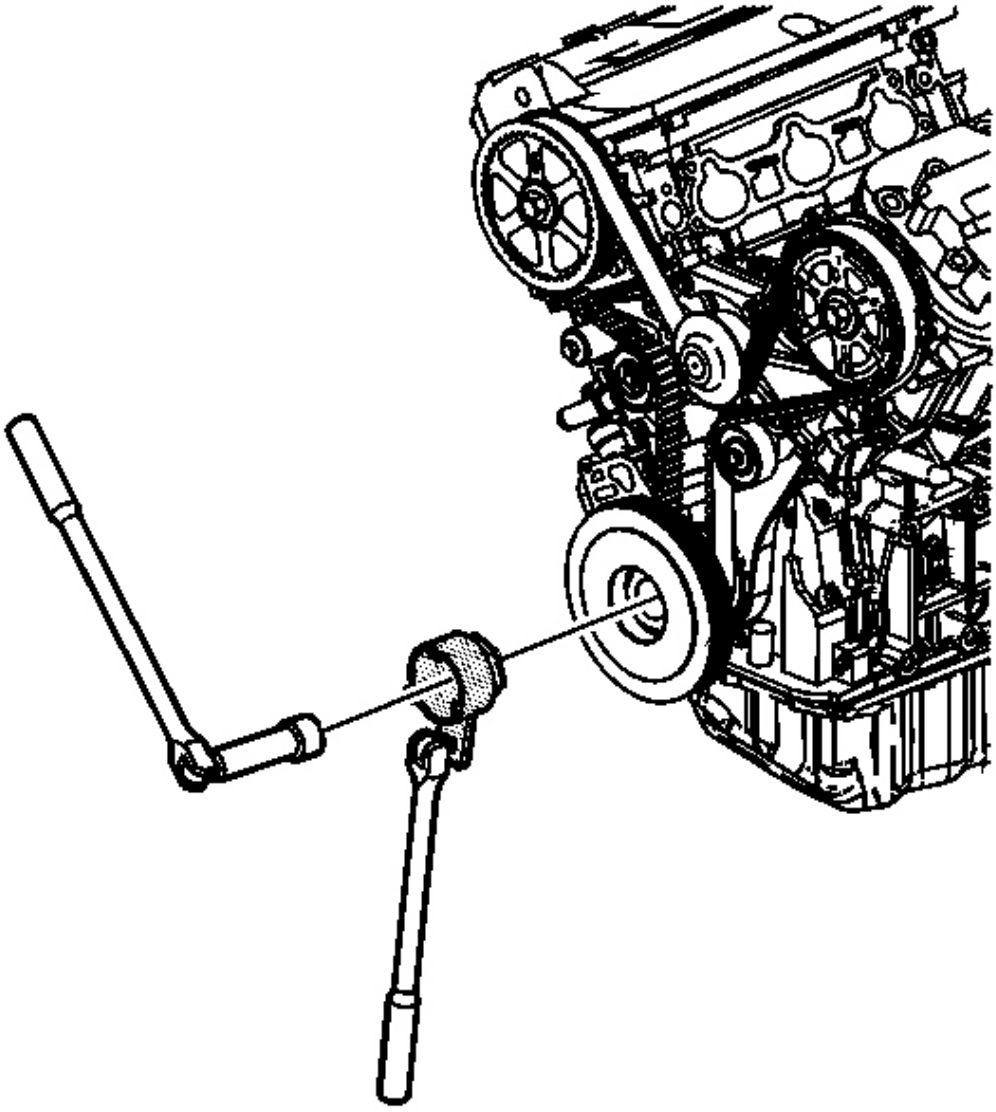


Fig. 385: Positioning The Timing Belt On The Sprockets
Courtesy of GENERAL MOTORS CORP.

11. Using the **EN 46337** , rotate the crankshaft clockwise about 5 or 6 complete revolutions to position the timing belt on the sprockets. See **Special Tools and Equipment** .

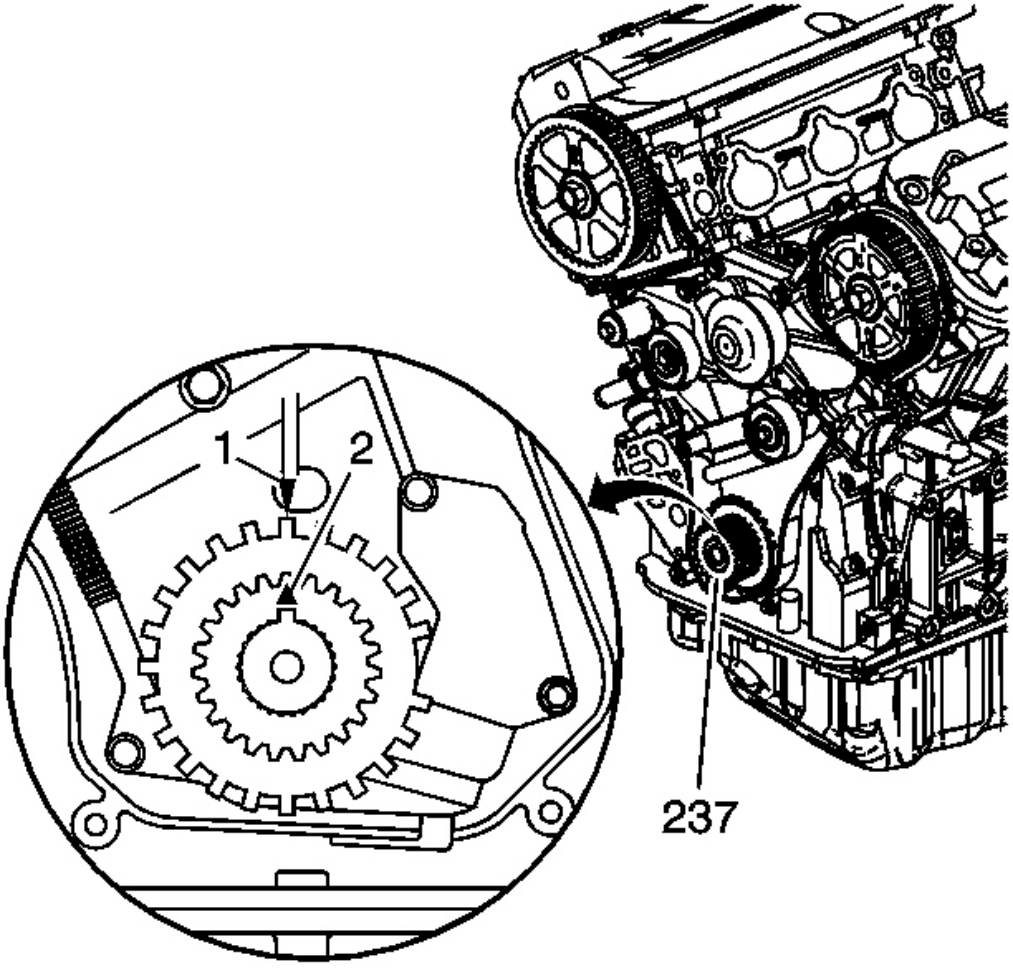


Fig. 386: View Of Crankshaft To Align The Mark On The Sprocket With The Pointer
Courtesy of GENERAL MOTORS CORP.

12. Align the mark (2) on the sprocket with the pointer (1) on the oil pump housing.

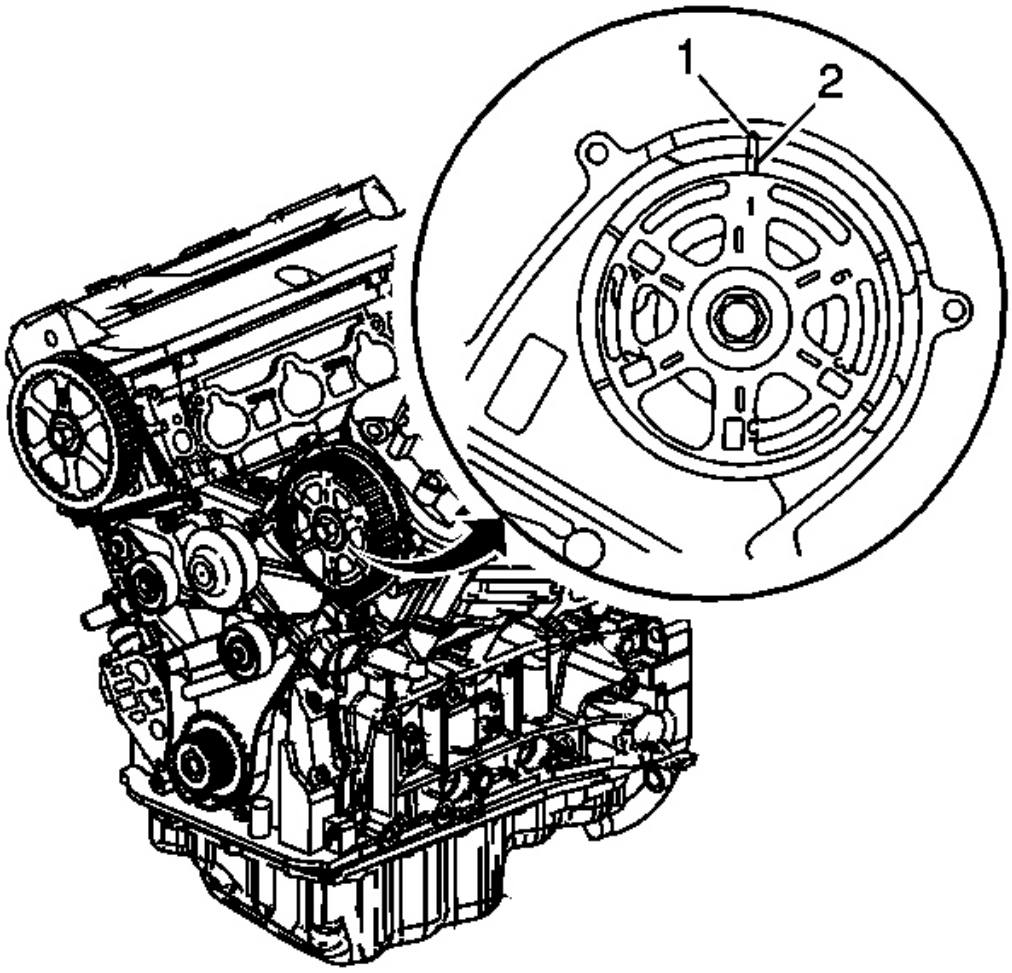


Fig. 387: Aligning The Mark On The Sprocket With The Pointer
Courtesy of GENERAL MOTORS CORP.

13. Inspect the left camshaft sprocket for proper alignment. The TDC mark (2) on the sprocket should align with the pointer (1) on the cover.

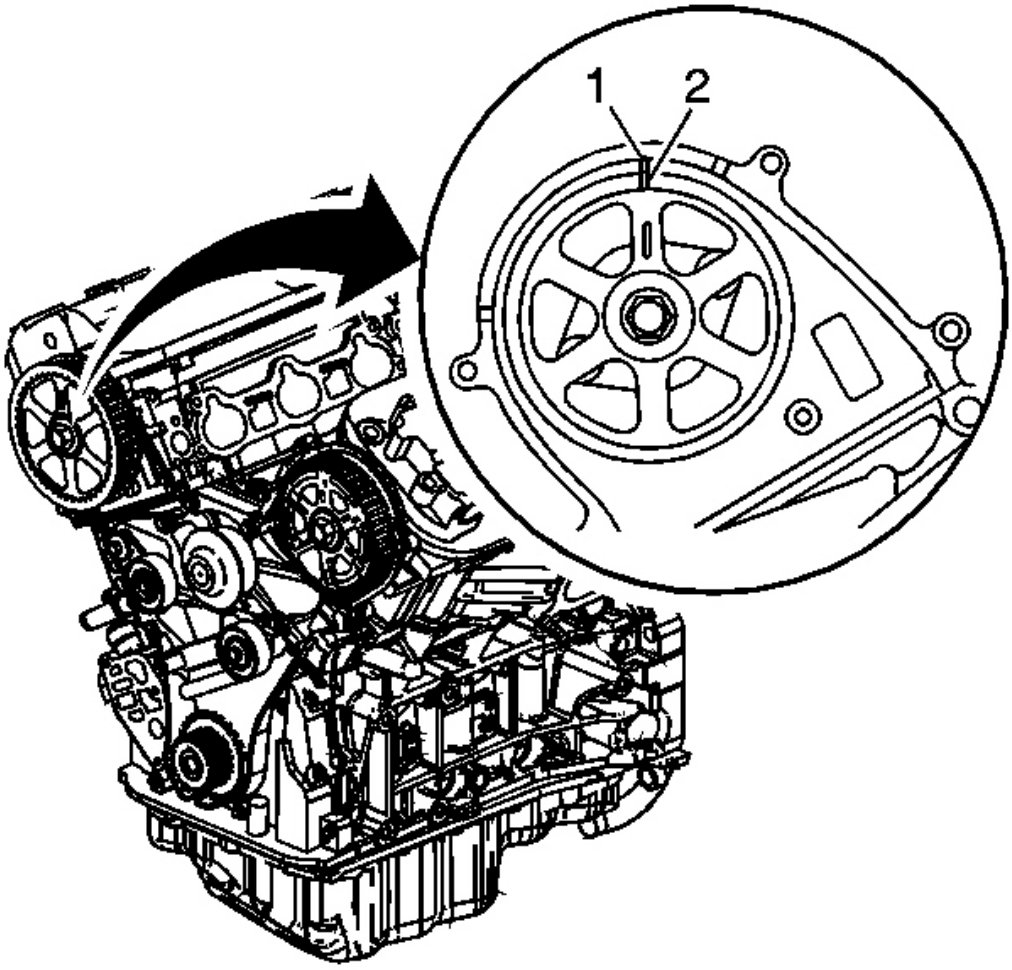


Fig. 388: Aligning The Mark On The Sprocket With The Pointer On The Rear Cover
Courtesy of GENERAL MOTORS CORP.

14. Inspect the right camshaft sprocket for proper alignment. The TDC mark (2) on the sprocket should align with the pointer (1) on the cover.

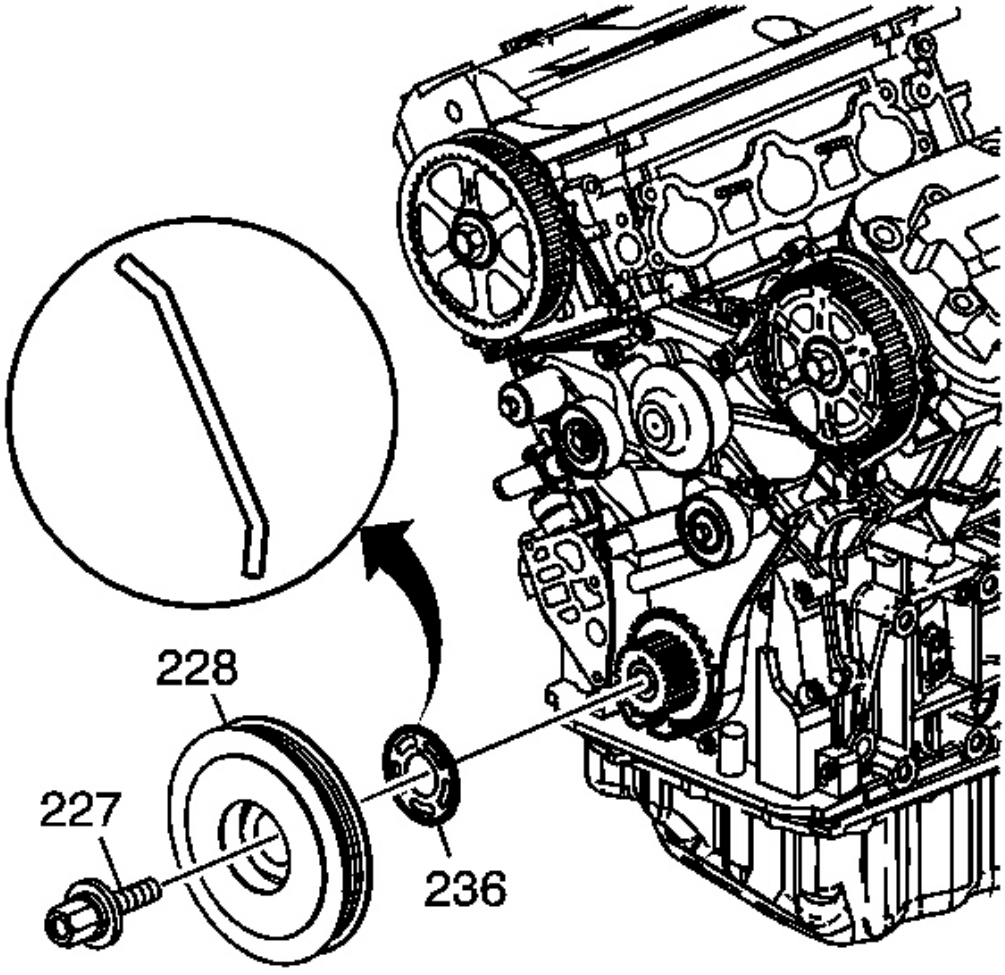


Fig. 389: View Of Guide, Balancer & Bolt
Courtesy of GENERAL MOTORS CORP.

15. Remove the bolt (227), balancer (228) and guide (236).

ENGINE MOUNT BRACKET INSTALLATION - FRONT

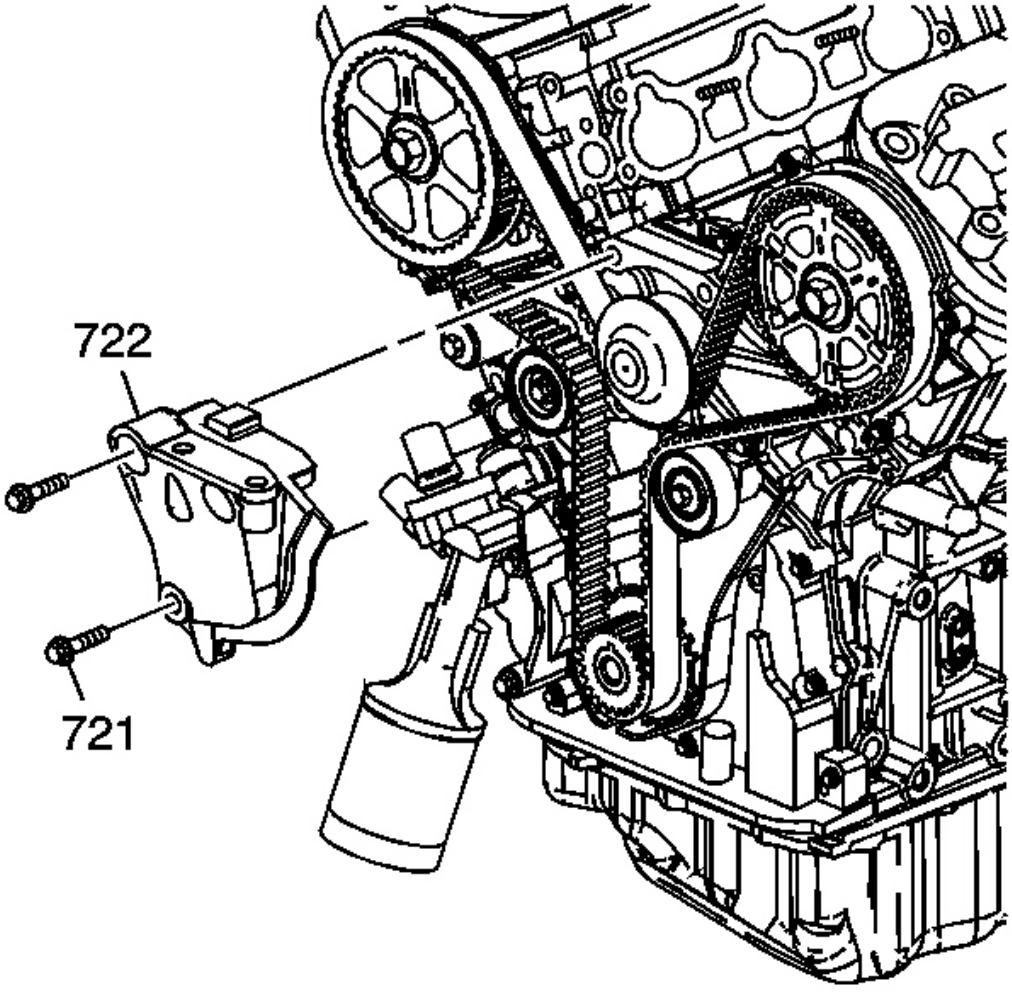


Fig. 390: View Of Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

1. Install the mount bracket (722).

IMPORTANT: Three bolts retain the mount bracket to the engine. Apply sealant to the threads of the lower bolt only.

2. Apply sealant Saturn P/N 21485277, GM P/N 12345382, (Canadian P/N 10953489) or equivalent to the bolt (721) threads.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the bolts.

   Tighten: Tighten the bolts to 44 N.m (33 lb ft).

TIMING BELT COVER INSTALLATION

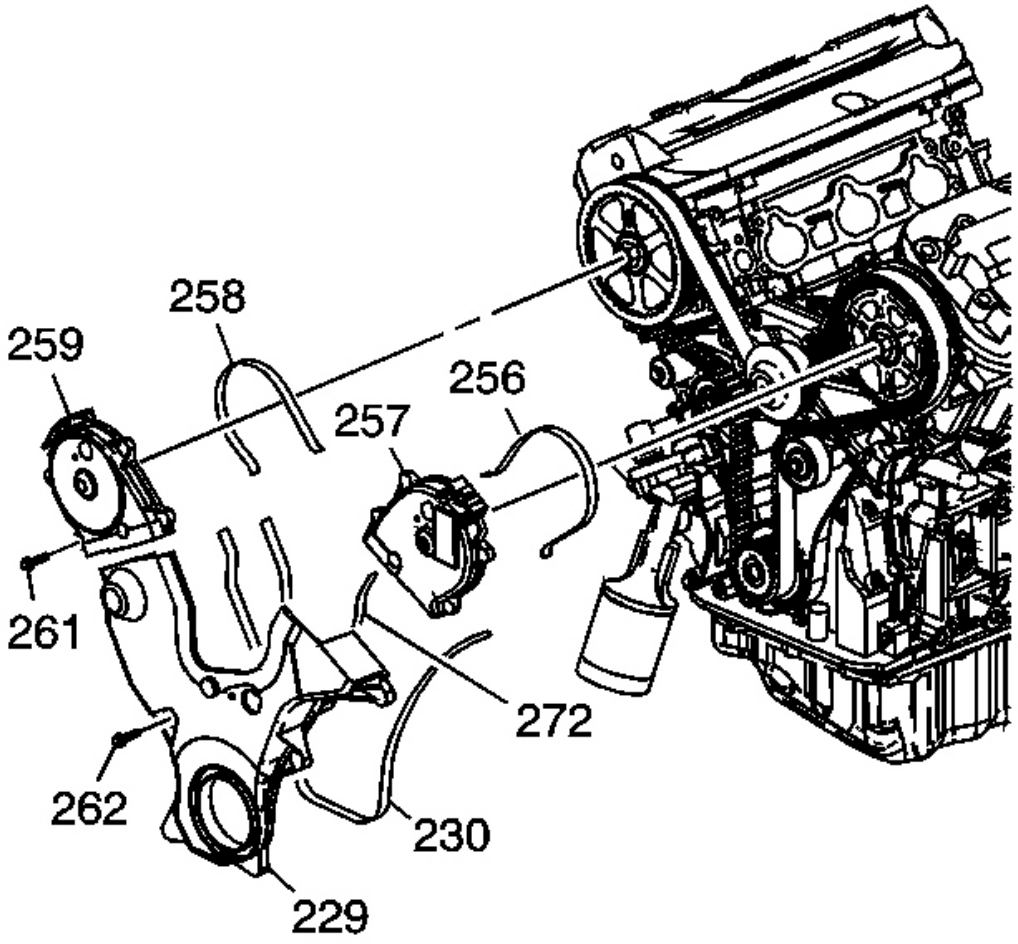


Fig. 391: View Of Timing Belt Cover
Courtesy of GENERAL MOTORS CORP.

1. Install the seals (230, 256, 258 and 272).
2. Install the cover (229).

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the bolts (262).

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

4. Install the covers (257 and 259).
5. Install the bolts (261).

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

CRANKSHAFT BALANCER INSTALLATION

Tools Required

EN 46337 Camshaft Sprocket/Crankshaft Balancer Holder. See **Special Tools and Equipment** .

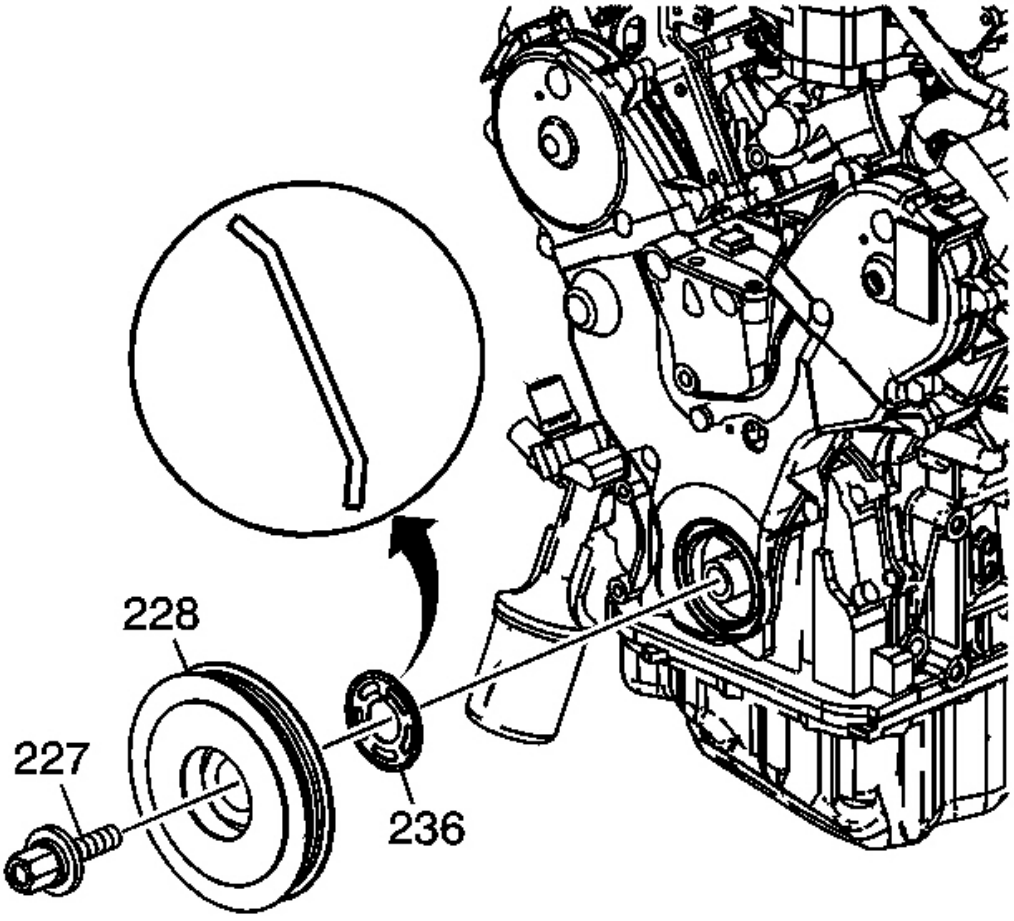


Fig. 392: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

1. Clean all oil from the balancer (228), guide (236), bolt (227) and crankshaft.
2. Lubricate the threads of the bolt (227) with clean engine oil.
3. Install the guide (236), balancer (228) and bolt (227). Install the guide with the concave surface facing the balancer.

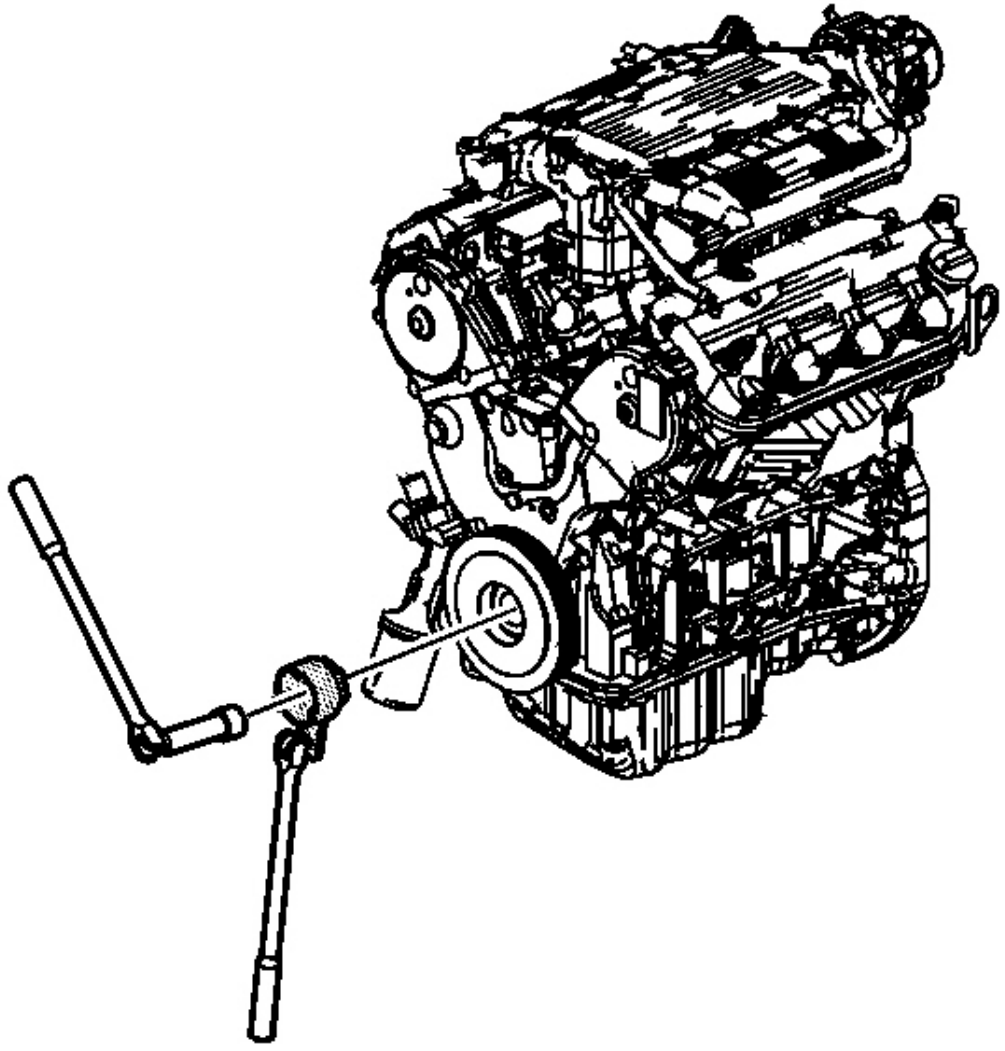


Fig. 393: Using Breaker Bar To Retain The Balancer
Courtesy of GENERAL MOTORS CORP.

4. Use the **EN 46337** and a breaker bar in order to retain the crankshaft balancer. See **Special Tools and Equipment** .

   NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Tighten the balancer bolt.

Tighten: Tighten the bolt to 245 N.m (181 lb ft).

VALVE LASH ADJUSTMENT

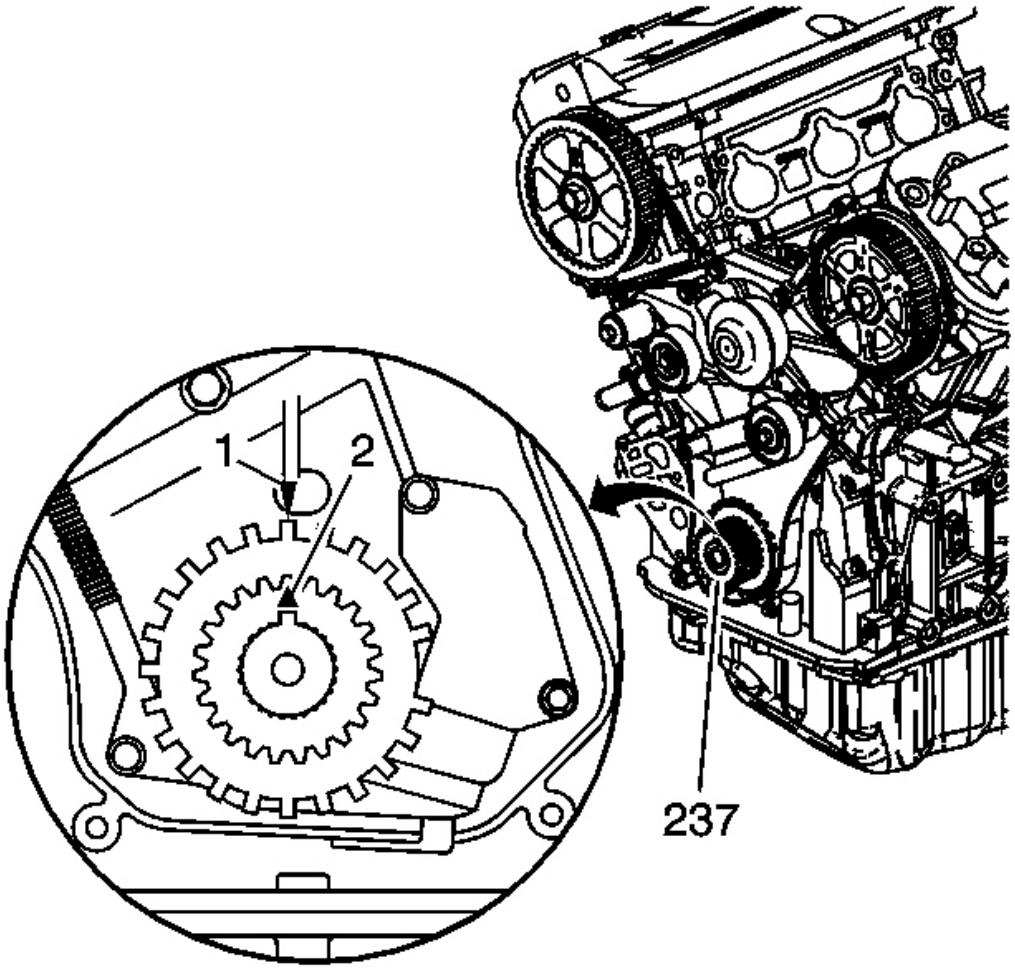


Fig. 394: View Of Valve Lash
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Adjust the valves only when the cylinder head temperature is less than 38°C (100°F).

1. Rotate the crankshaft to align the mark (2) on the sprocket (237) with the pointer (1) on the oil pump housing.

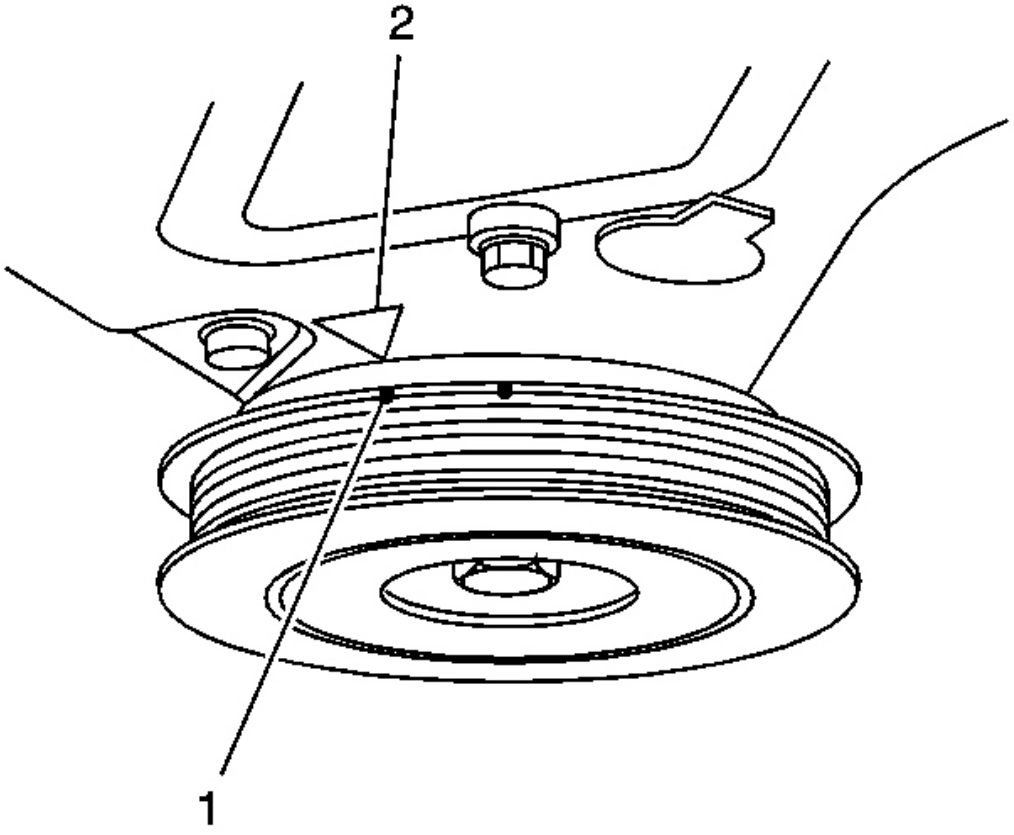


Fig. 395: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

2. Rotate the crankshaft balancer and align the white mark (1) on the balancer with the locating tab (2) on the front cover.

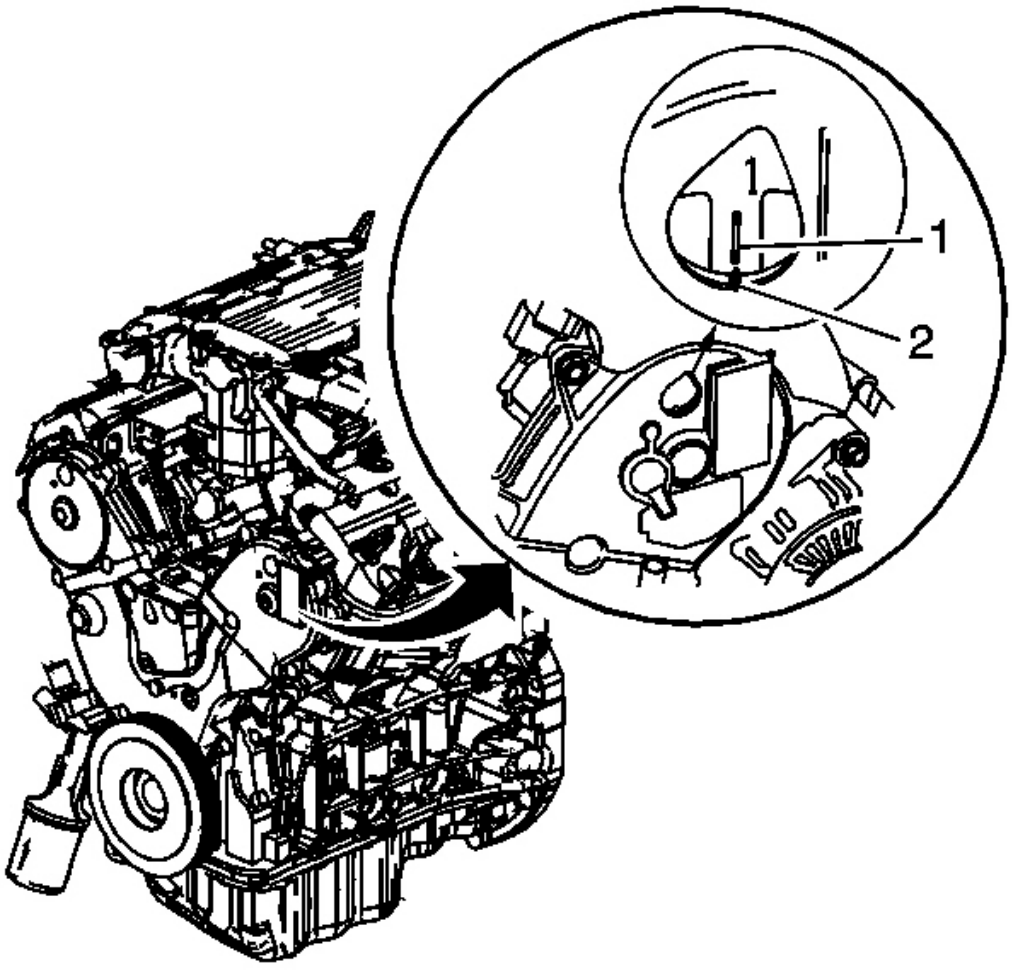


Fig. 396: Aligning The Upper Cover With The Number 1 Cylinder
Courtesy of GENERAL MOTORS CORP.

3. Inspect cylinder number 1 for top dead center (TDC) position. The mark (2) on the front cover should be aligned with the mark (1) on the sprocket.

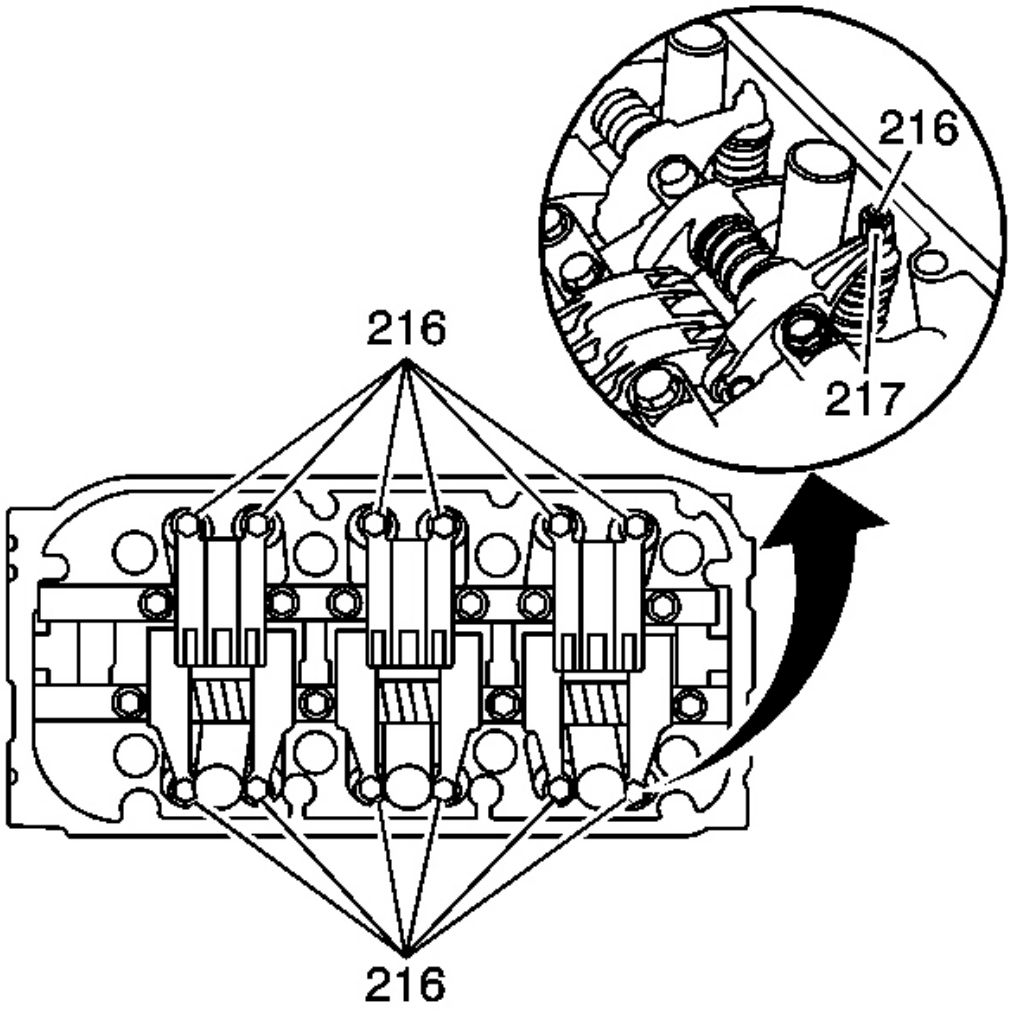


Fig. 397: Identifying Adjusting Bolt & Nut
Courtesy of GENERAL MOTORS CORP.

4. Identify the adjusting bolt (216) and nut (217) locations.

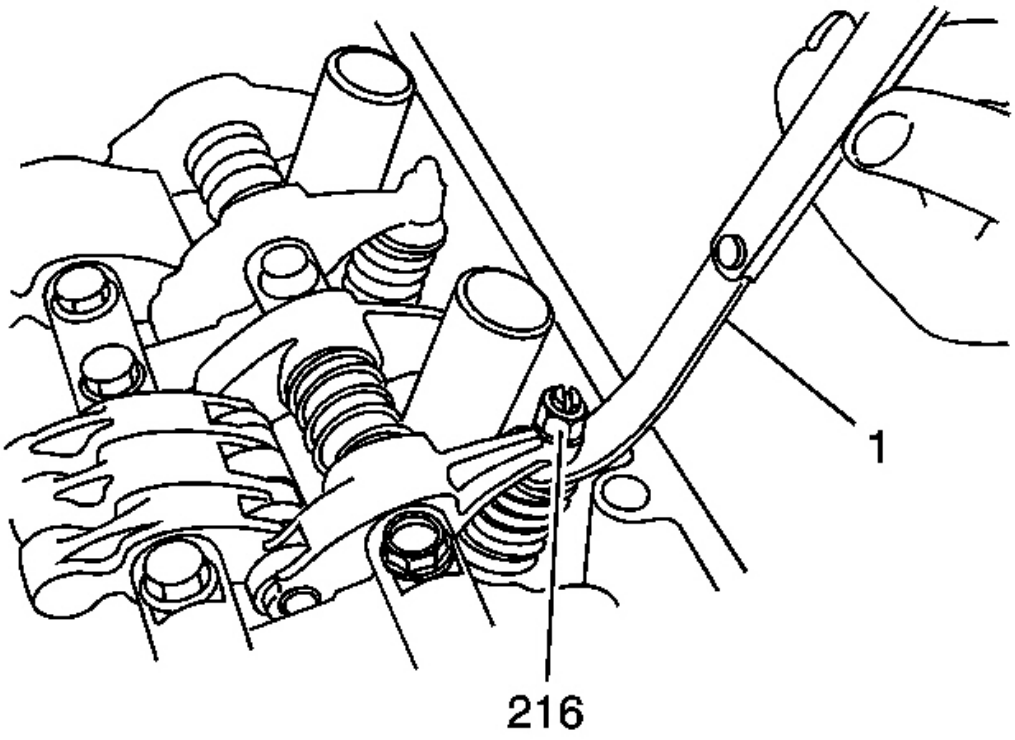


Fig. 398: View Of Feeler Gage Between The Adjusting Screws & The Ends Of The Valve Stems
Courtesy of GENERAL MOTORS CORP.

5. Select the proper thickness feeler gage.

   Specification:

   - Intake valve adjustment: 0.2-0.24 mm (0.008-0.009 in)
   - Exhaust valve adjustment: 0.28-0.32 mm (0.011-0.013 in)

6. Insert a feeler gage (1) between the adjusting screws (216) and the ends of the valve stems for cylinder number 1. Slide the feeler gage back and forth, adjusting the screws, until you feel a slight amount of drag. If you feel too much drag, loosen the locknut and turn the adjusting screw (216) until the drag on the feeler gage is correct.
7. Tighten the locknut and check the clearance again. Repeat the adjustment if necessary.

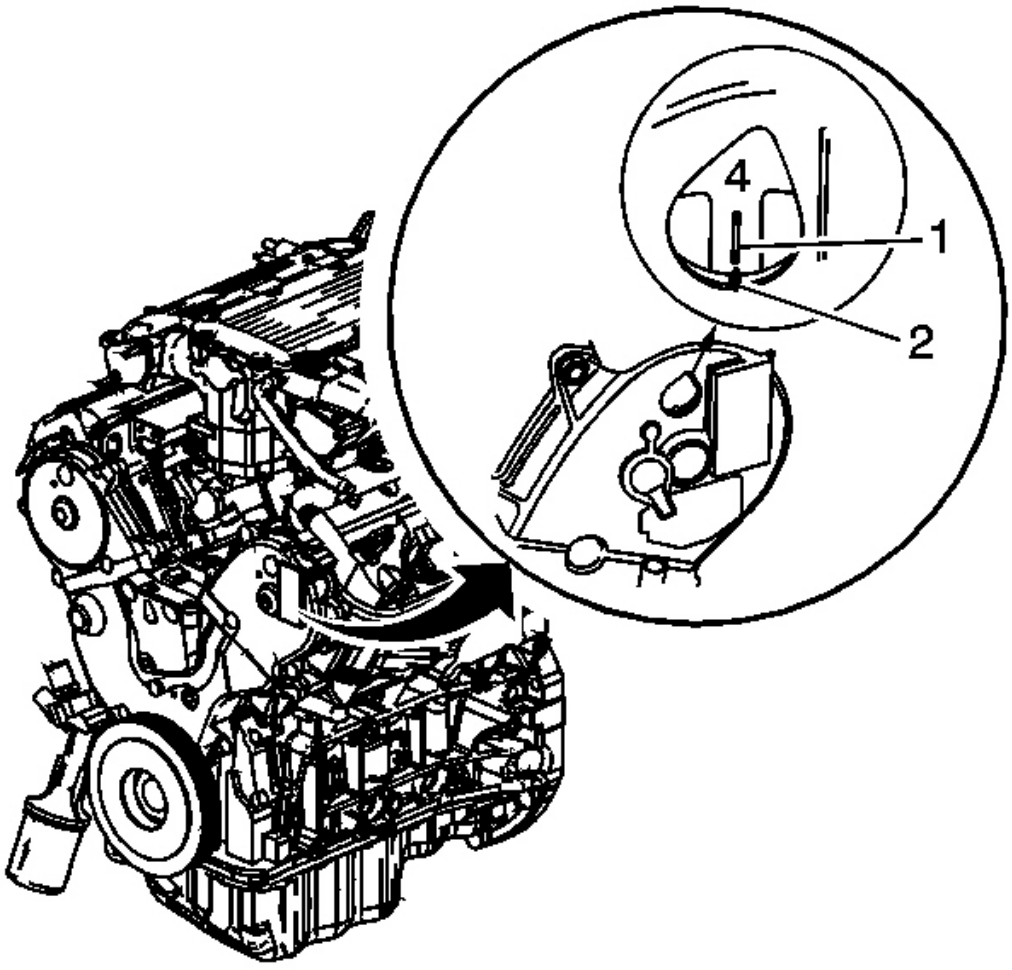


Fig. 399: View Of The Adjusting Cylinder Number 4 Valve Clearance
Courtesy of GENERAL MOTORS CORP.

8. Rotate the engine clockwise and position number 4 piston at TDC. Align the mark (2) on the front cover with the TDC mark (1) on the sprocket.
9. Check and adjust cylinder number 4 valve clearance as required.

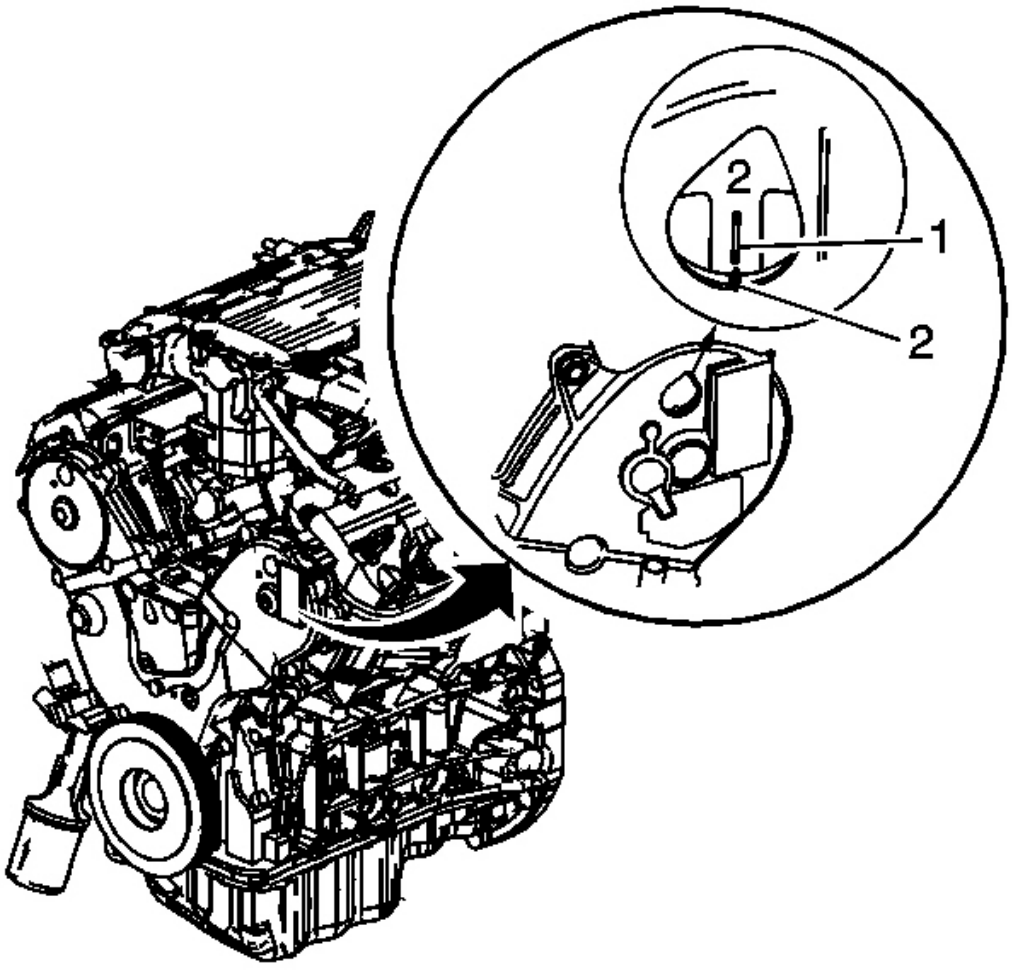


Fig. 400: View Of The Adjusting Cylinder Number 2 Valve Clearance
Courtesy of GENERAL MOTORS CORP.

10. Rotate the engine and position number 2 piston at TDC. Align the mark (2) on the front cover with the TDC mark (1) on the sprocket.
11. Check and adjust cylinder number 2 valve clearance as required.

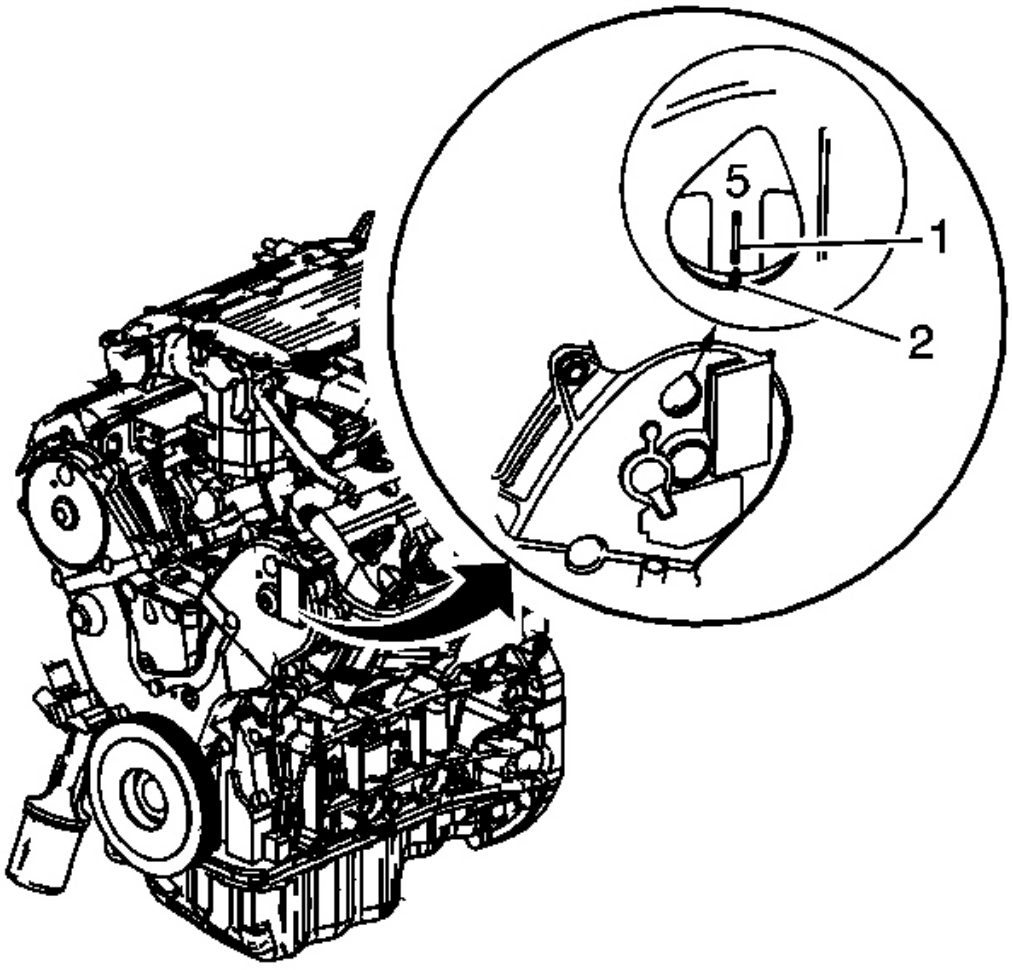


Fig. 401: View Of The Adjusting Cylinder Number 5 Valve Clearance
Courtesy of GENERAL MOTORS CORP.

12. Rotate the engine and position number 5 piston at TDC. Align the mark (2) on the front cover with the TDC mark (1) on the sprocket.
13. Check and adjust cylinder number 5 valve clearance as required.

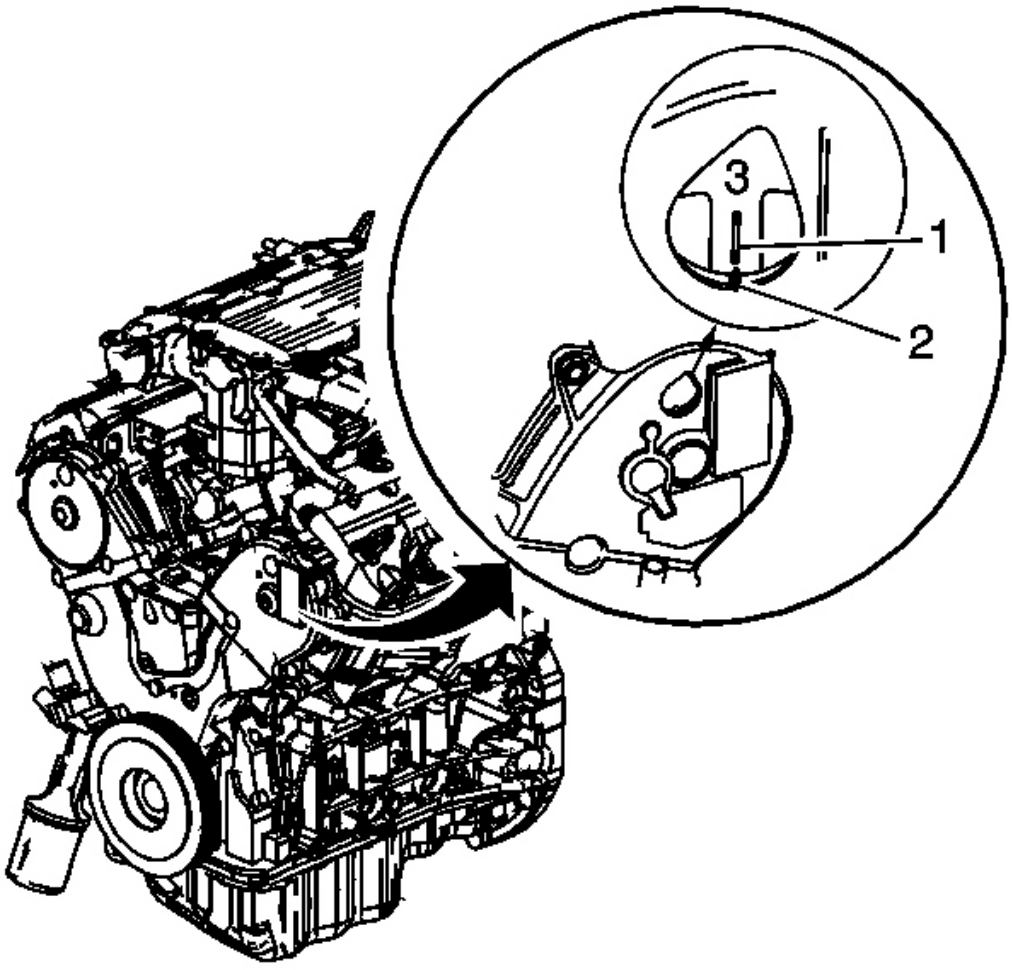


Fig. 402: View Of The Adjusting Cylinder Number 3 Valve Clearance
Courtesy of GENERAL MOTORS CORP.

14. Rotate the engine and position number 3 piston at TDC. Align the mark (2) on the front cover with the TDC mark (1) on the sprocket.
15. Check and adjust cylinder number 3 valve clearance as required.

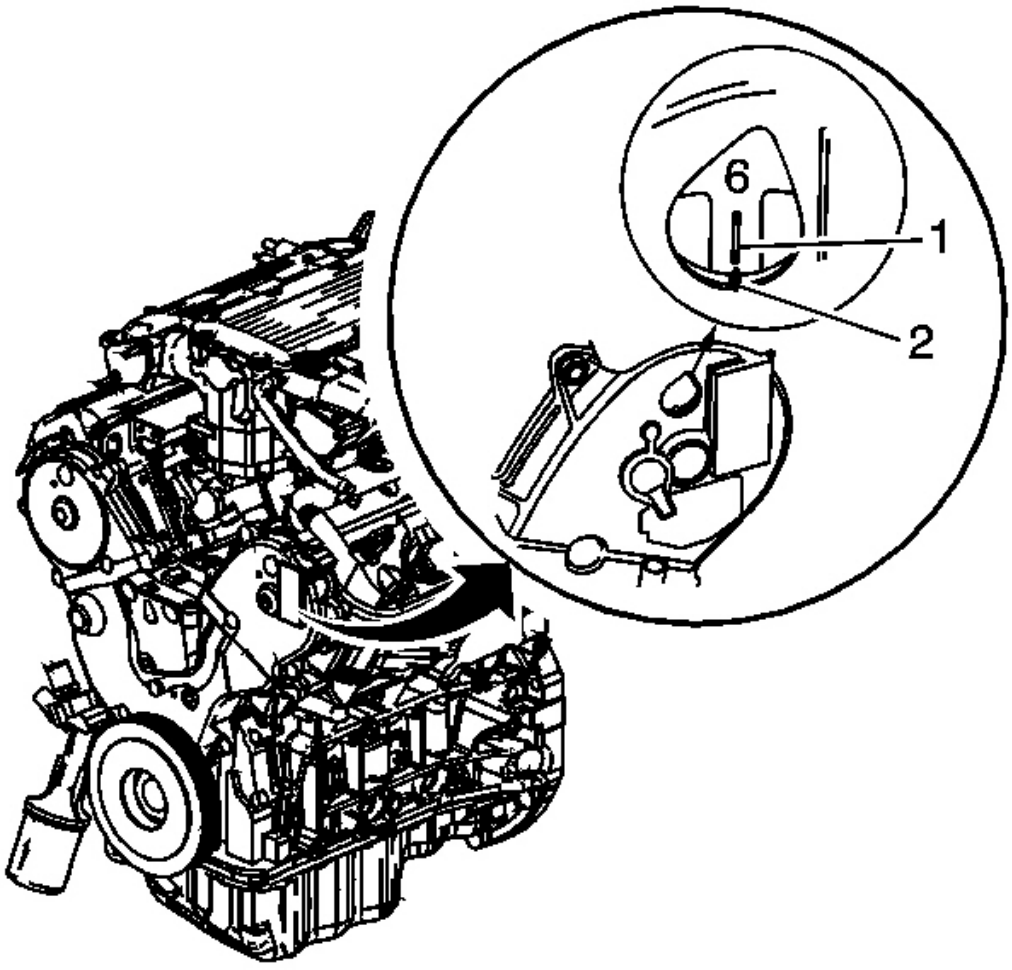


Fig. 403: View Of The Adjusting Cylinder Number 6 Valve Clearance
Courtesy of GENERAL MOTORS CORP.

16. Rotate the engine and position number 6 piston at TDC. Align the mark (2) on the front cover with the TDC mark (1) on the sprocket.
17. Check and adjust cylinder number 6 valve clearance as required.

VALVE ROCKER ARM COVER INSTALLATION - LEFT

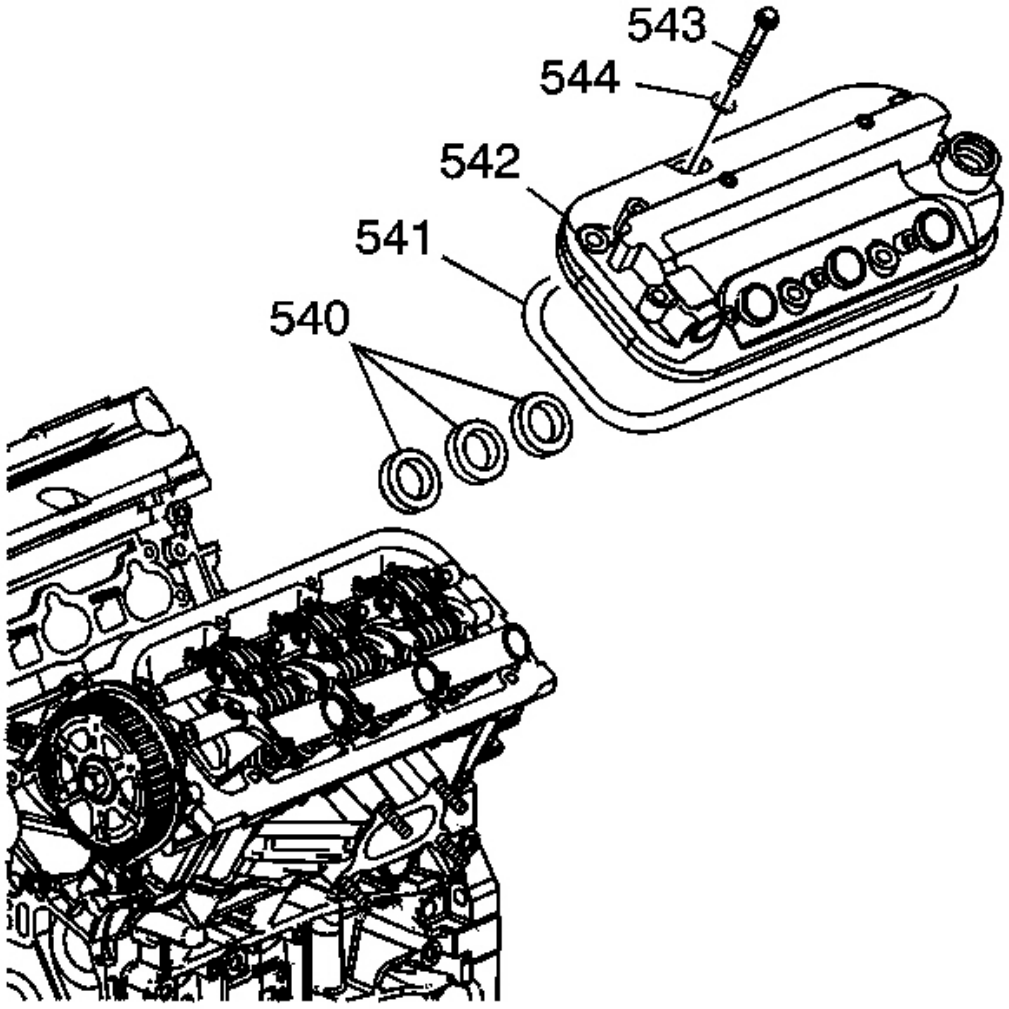


Fig. 404: View Of Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install NEW seals (540), NEW gasket (541), cover (542), and bolts (543).

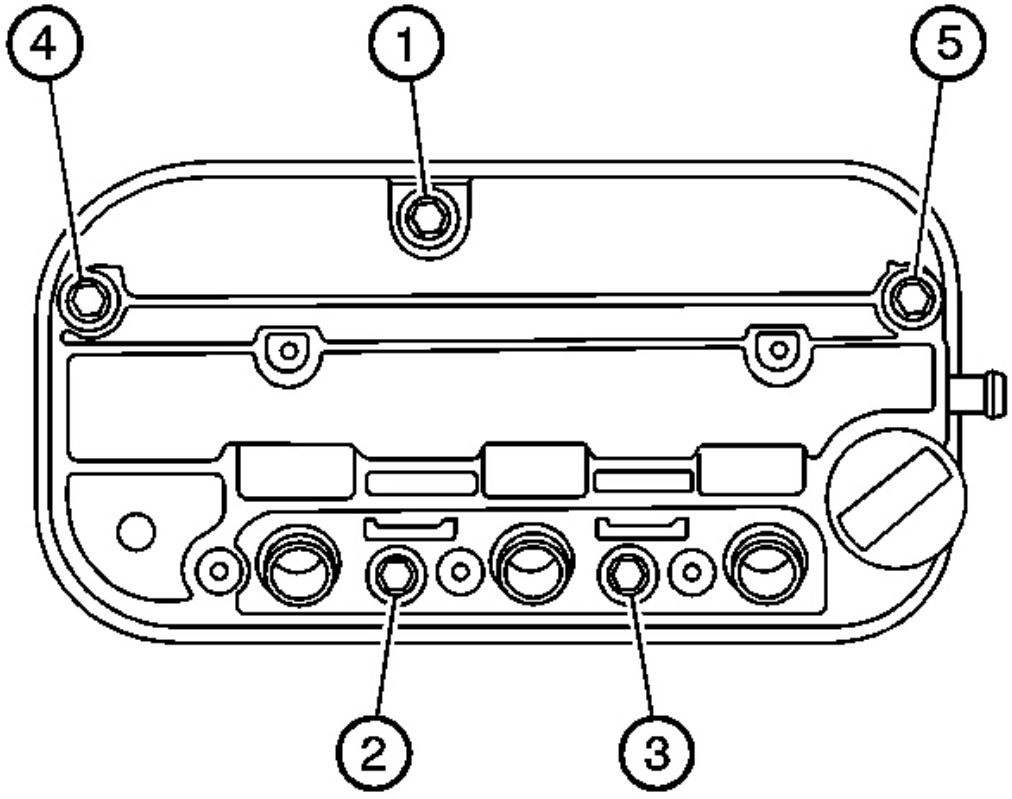


Fig. 405: Identifying Bolts In Sequence
Courtesy of GENERAL MOTORS CORP.

2. Tighten the bolts in sequence.

   Tighten:

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

3. Apply anti-seize compound GM P/N 21485279 to the threads of the spark plugs.

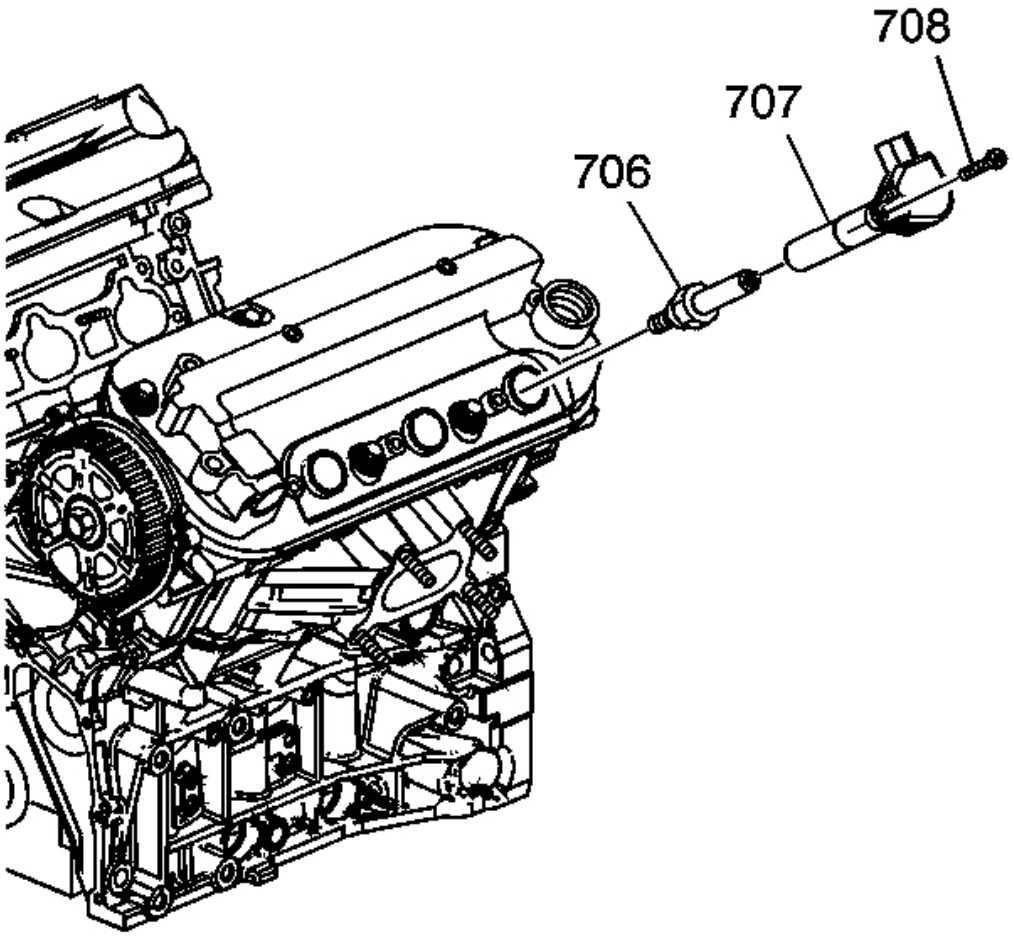


Fig. 406: View Of Bolts & Ignition Coils
Courtesy of GENERAL MOTORS CORP.

4. Install the spark plugs (706).

   Tighten: Tighten the spark plugs to 18 N.m (13 lb ft).

5. Install the ignition coils (707) and bolts (708).

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

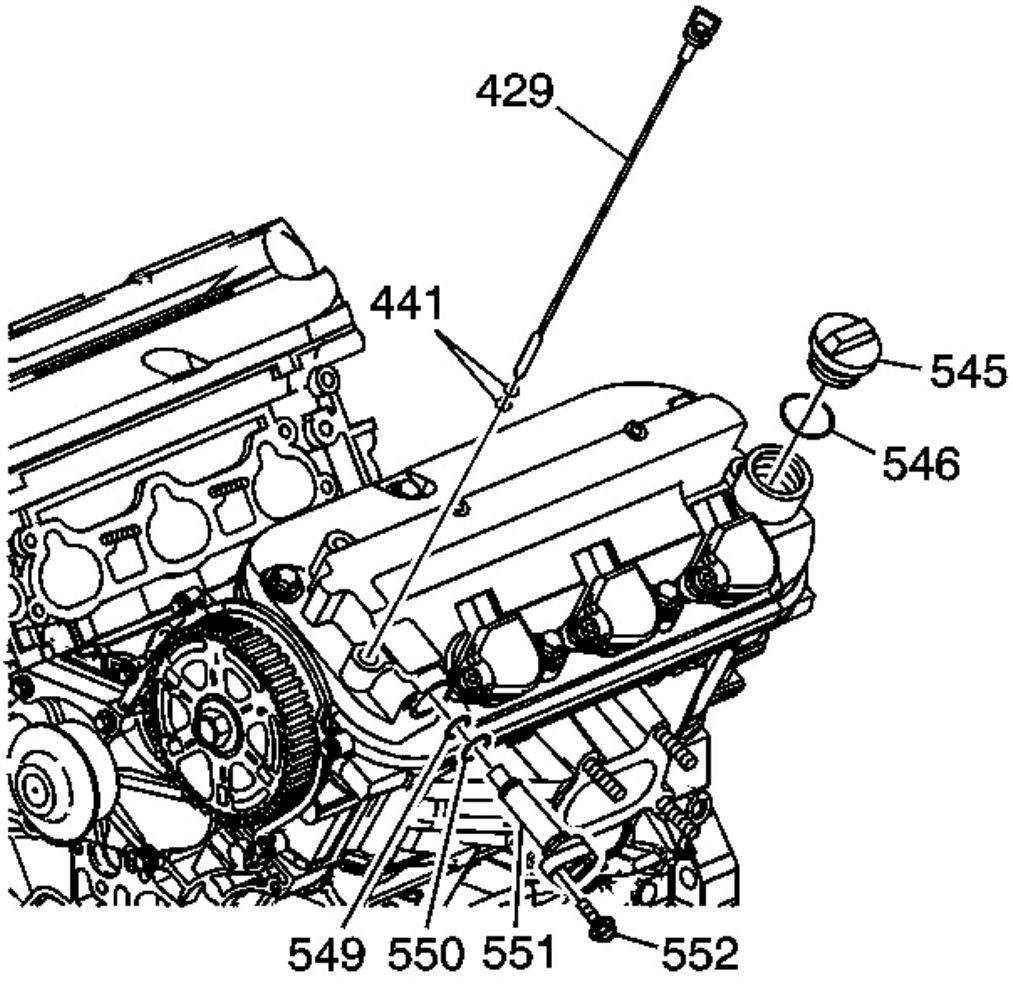


Fig. 407: Identifying Oil Level Indicator, O-rings, Positive Crankcase Ventilation, Valve, Bolts & Cap
Courtesy of GENERAL MOTORS CORP.

6. Install the oil level indicator (429) and NEW O-rings (441).
7. Install the NEW O-rings (549 and 550), positive crankcase ventilation (PCV) valve (551) and bolt (552).

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

8. Install the NEW O-ring (546) and cap (545).

VALVE ROCKER ARM COVER INSTALLATION - RIGHT

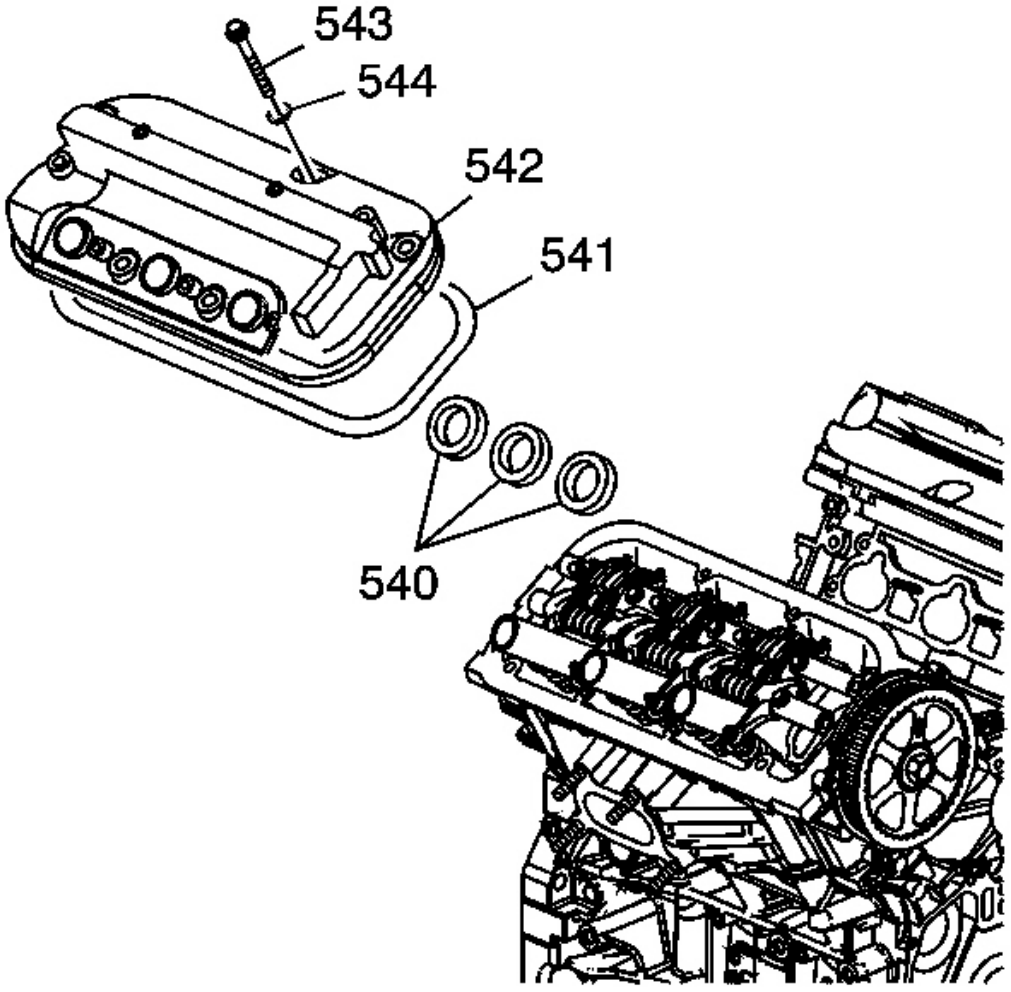


Fig. 408: View Of Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install NEW seals (540), NEW gasket (541), cover (542), NEW grommets (544) and bolts (543).

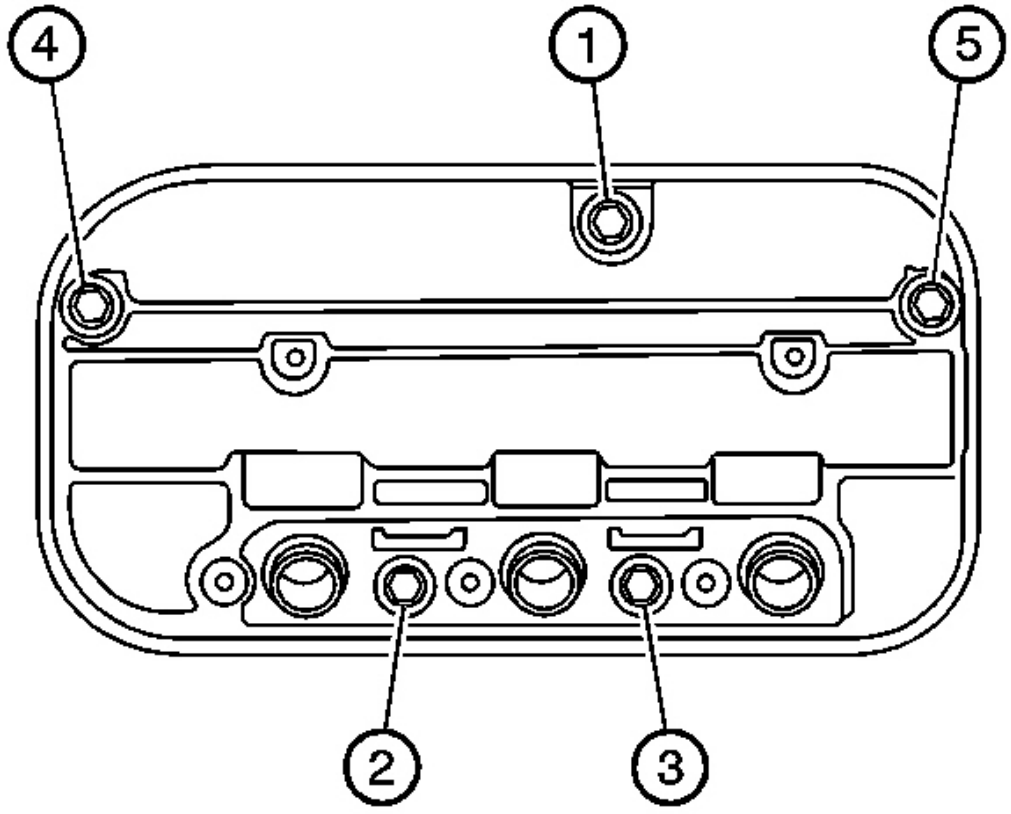


Fig. 409: View Of Bolts In Sequence
Courtesy of GENERAL MOTORS CORP.

2. Tighten the bolts in sequence.

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

3. Apply anti-seize compound GM P/N 21485279 to the threads of the spark plugs.

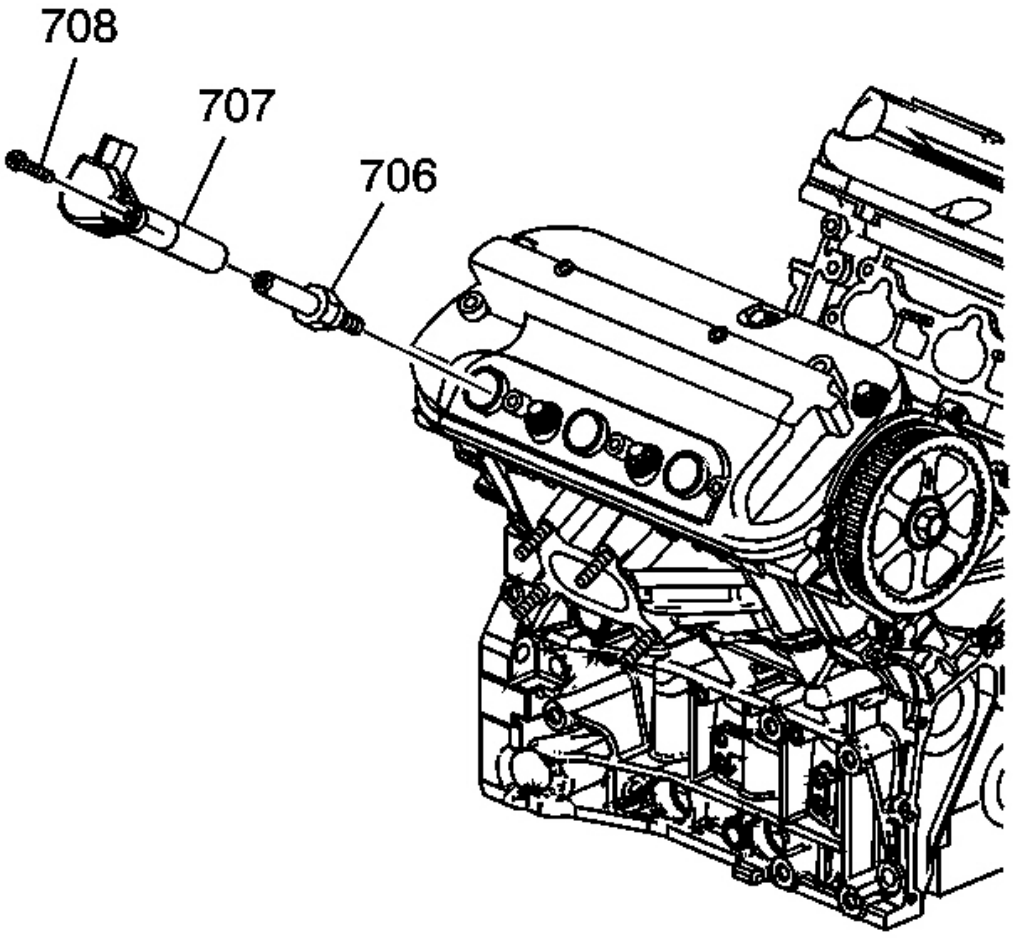


Fig. 410: Identifying Spark Plugs, Ignition Coils & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Install the spark plugs (706).

   Tighten: Tighten the spark plugs to 18 N.m (13 lb ft).

5. Install the ignition coils (707) and bolts (708).

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

COOLANT CROSSOVER PIPE INSTALLATION

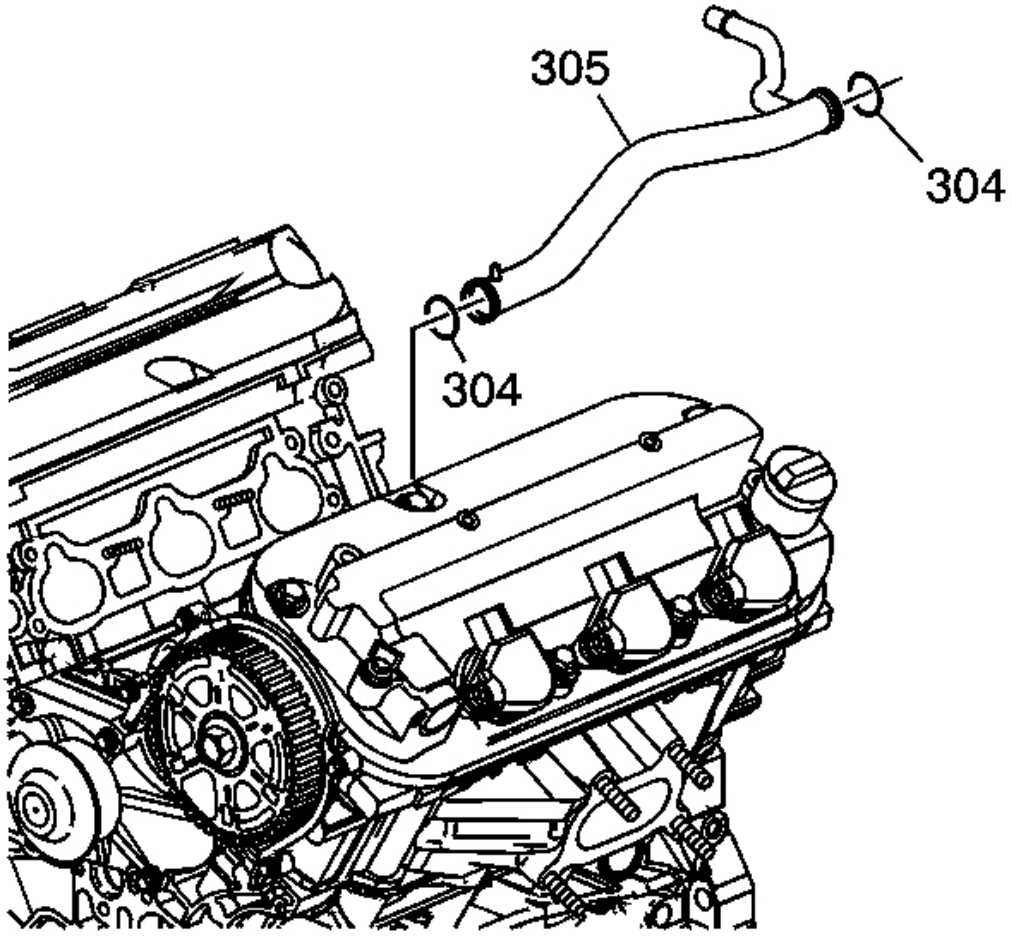


Fig. 411: View Of Coolant Crossover Pipe
Courtesy of GENERAL MOTORS CORP.

1. Install the coolant crossover pipe (305) and NEW O-ring seals (304).

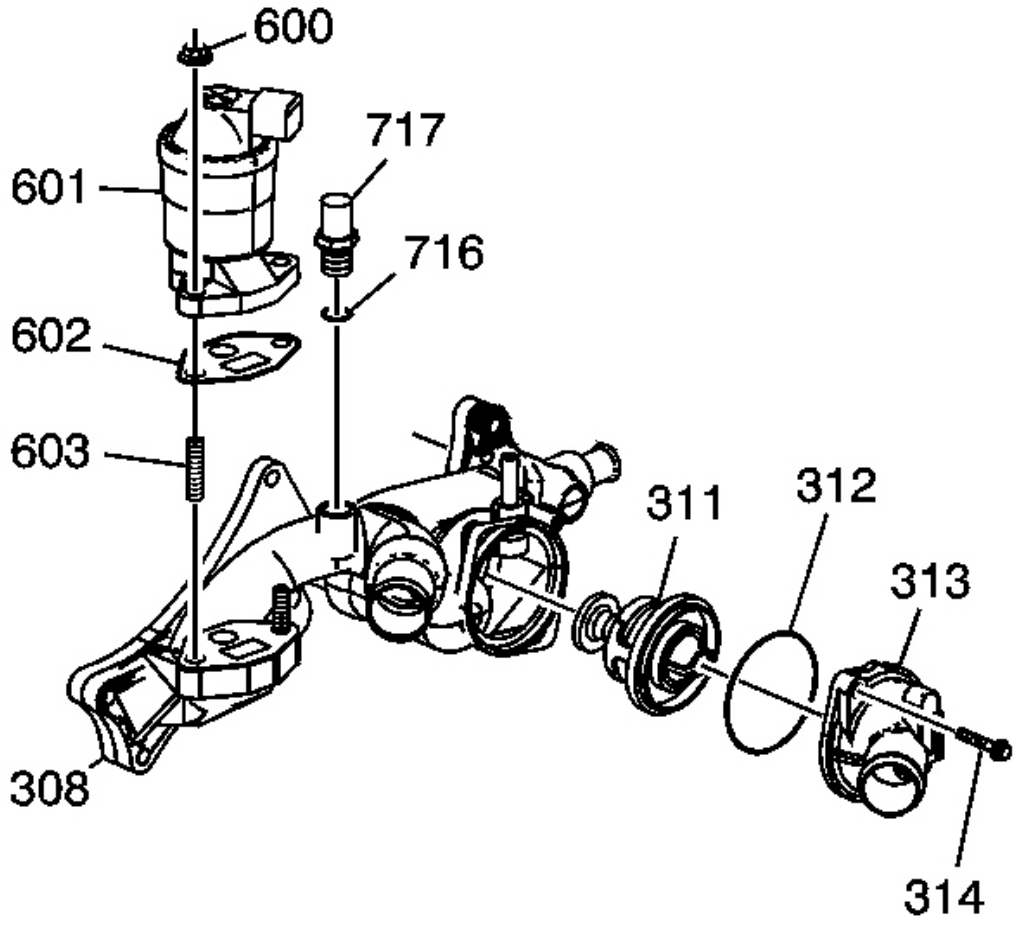


Fig. 412: Identifying Nuts, Exhaust Gas Recirculation, Valve, Gasket & Studs
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the thermostat (311), NEW O-ring (312), housing (313) and bolts (314). Align the notch in the housing with the alignment flange of the thermostat.

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

3. Install the coolant temperature sensor (CTS) (717) and NEW O-ring (716).

   Tighten: Tighten the sensor to 18 N.m (13 lb ft).

4. Install the studs (603).

   Tighten: Tighten the studs to 10 N.m (88 lb in).

5. Install the exhaust gas recirculation (EGR) valve (601), NEW gasket (602) and nuts (600).

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

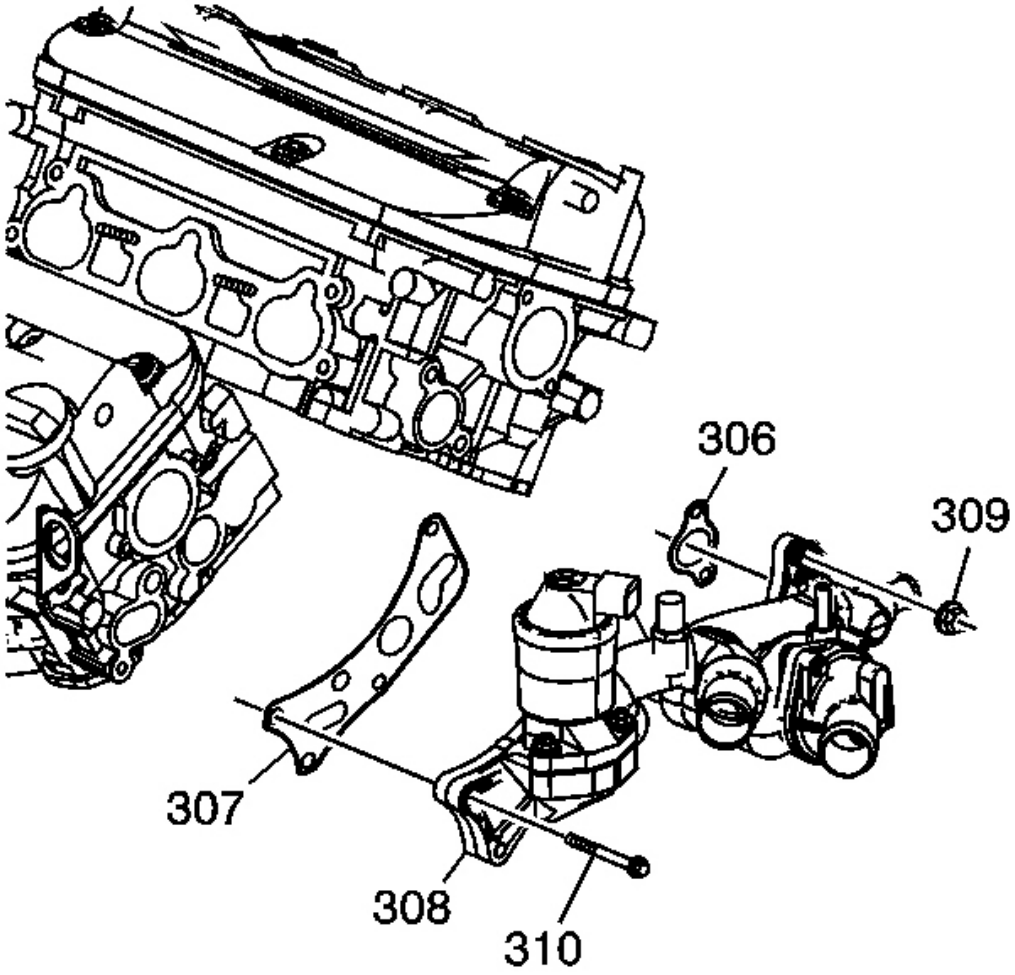


Fig. 413: View Of Gaskets, Housing, Bolts & Nuts
Courtesy of GENERAL MOTORS CORP.

6. Install NEW gaskets (306 and 307), housing (308), bolts (309) and nuts (310).

Tighten: Tighten the nuts and bolts to 22 N.m (16 lb ft).

FUEL RAIL AND INJECTORS INSTALLATION

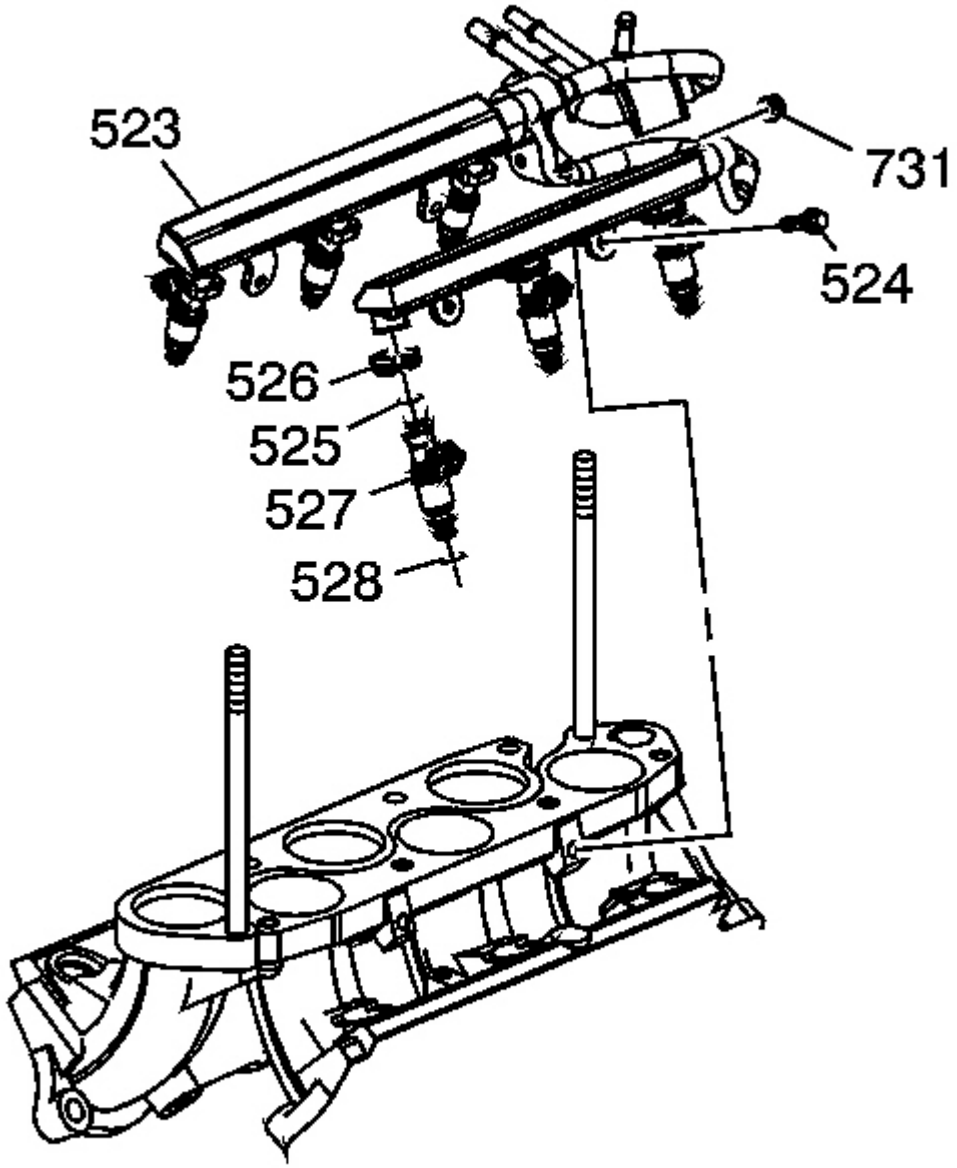


Fig. 414: View Of Fuel Rail & Injectors
Courtesy of GENERAL MOTORS CORP.

1. Install new O-rings (525 and 528) to the injectors (527).
2. Install the injectors (527) and clips (526) to the fuel rails.
3. Install the fuel rail and injectors (523), hoses, and fuel pipe to the manifolds as an assembly.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the bolts (524) and nuts (731).

Tighten:

1. Tighten the bolts to 9.8 N.m (87 lb in).
2. Tighten the nuts to 12 N.m (106 lb in).

INTAKE MANIFOLD INSTALLATION

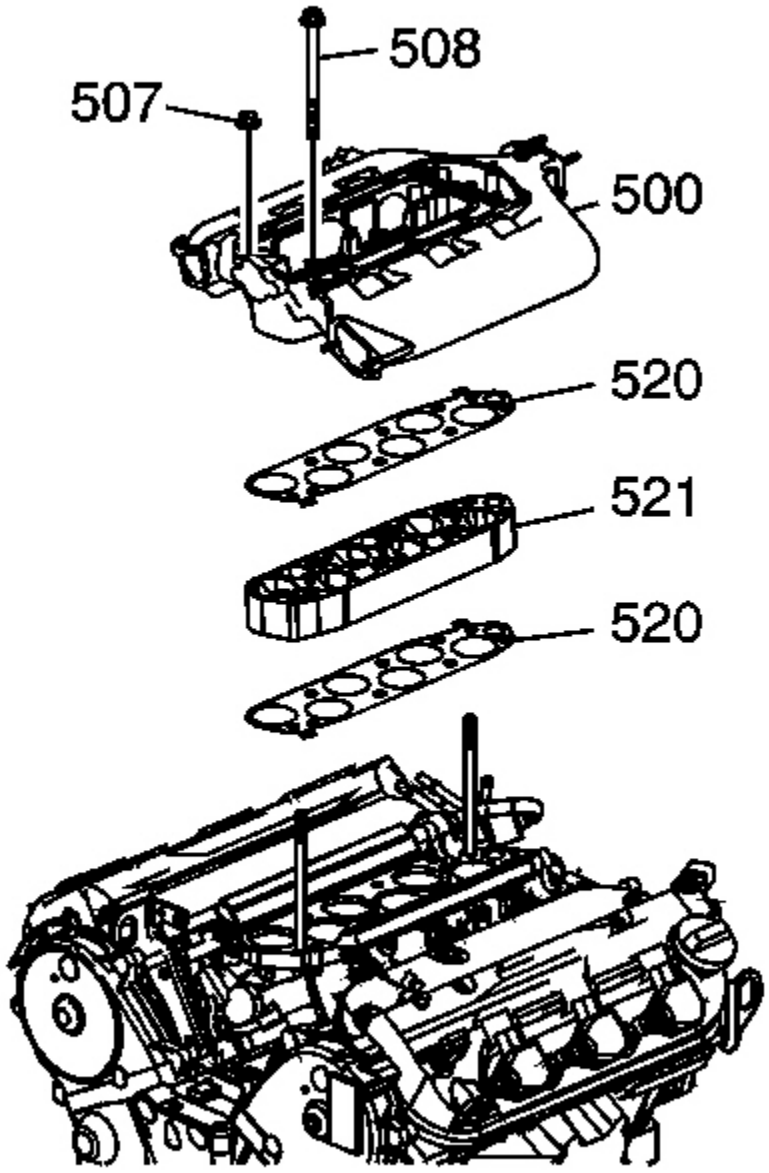


Fig. 415: View Of Intake Manifold
Courtesy of GENERAL MOTORS CORP.

1. Install the gaskets (520) and spacer (521).

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the manifold (500), bolts (508) and nuts (507).

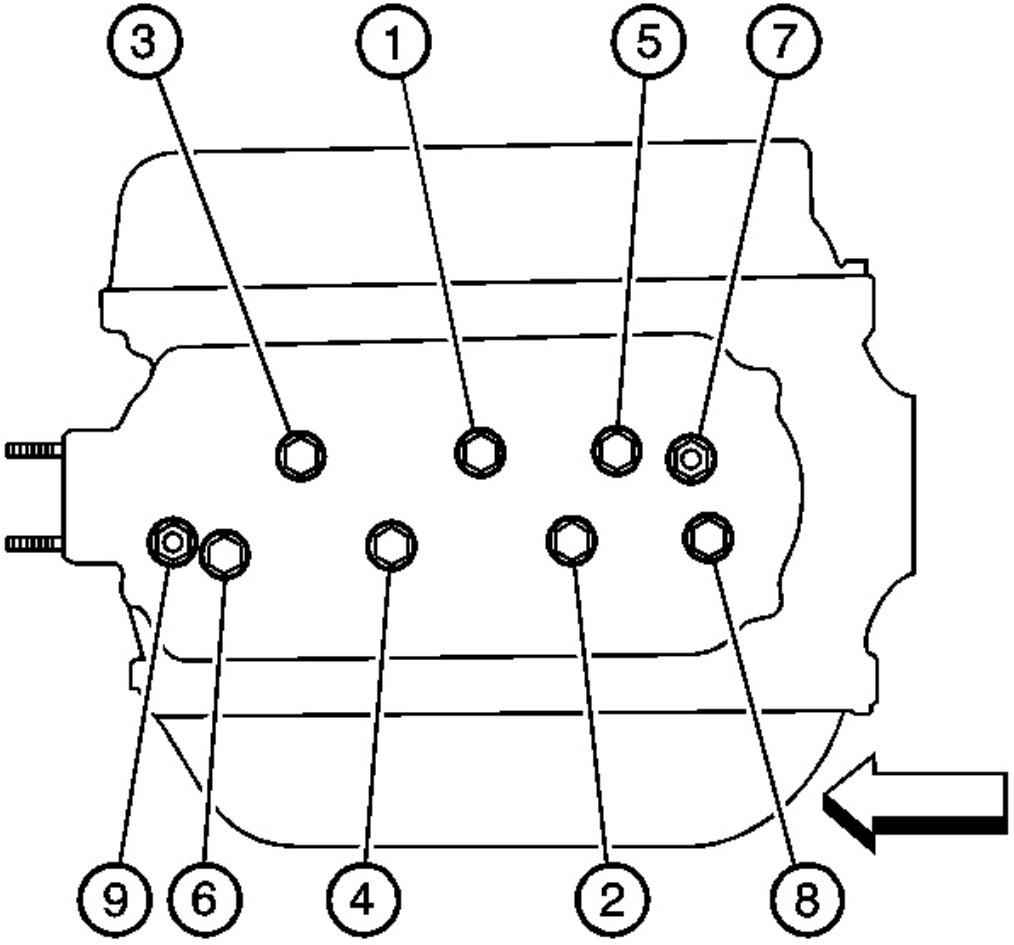


Fig. 416: Identifying Nuts & Bolts In Sequence
Courtesy of GENERAL MOTORS CORP.

3. Tighten the nuts and bolts in sequence.

Tighten:

1. Tighten the nuts and bolts in sequence a first pass to 11 N.m (8 lb ft).
2. Tighten the nuts and bolts in sequence a final pass to 22 N.m (16 lb ft).

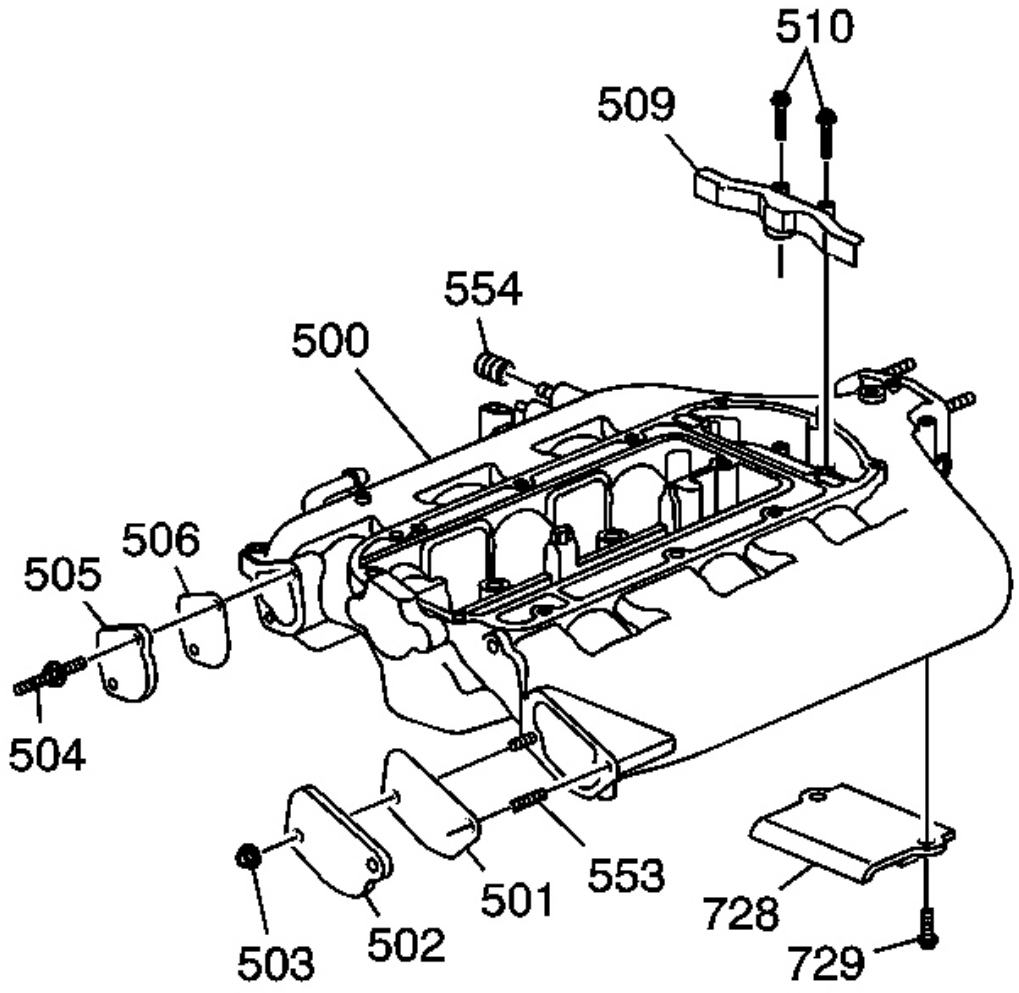


Fig. 417: View Of Exhaust Gas Recirculation, Tube & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Install the exhaust gas recirculation (EGR) tube (509) and bolts (510).

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

5. Install the studs (553), gaskets (501 and 506) and covers (502 and 505).
6. Install the bolts (504) and nuts (503).

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

7. Install the dampener (728) and bolts (729).

   Tighten: Tighten the bolts to 21 N.m (15.9 lb ft).

8. Install the cap (554).

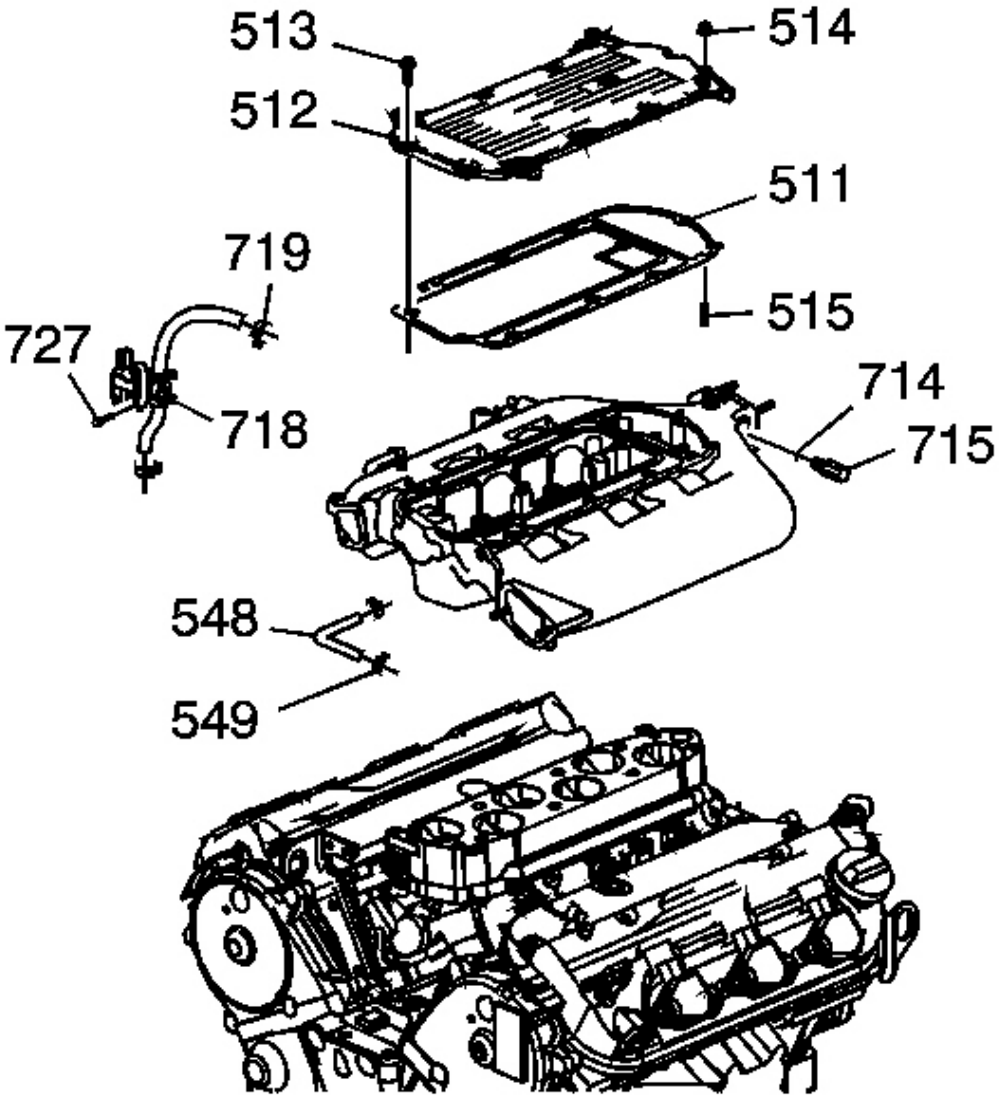


Fig. 418: View Of Intake Manifold
Courtesy of GENERAL MOTORS CORP.

9. Install the studs (515), gasket (511), cover (512), nuts (514) and bolts (513).

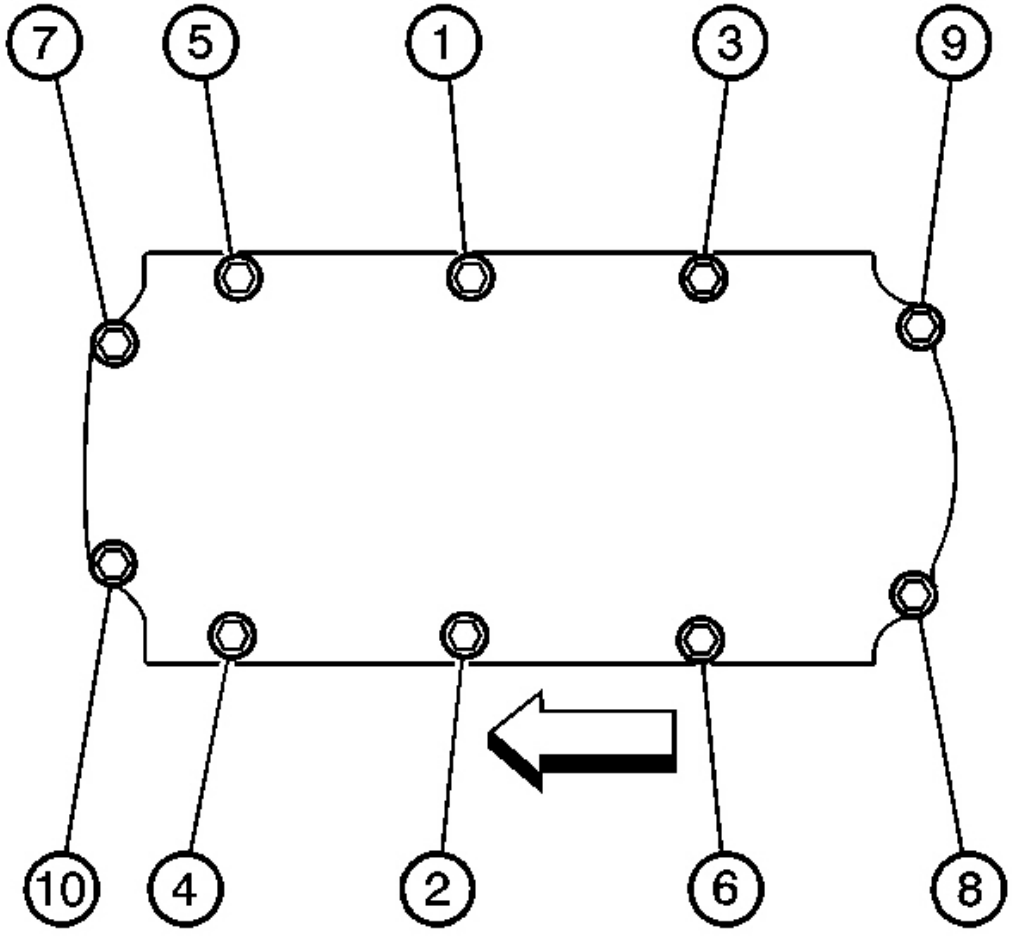


Fig. 419: View Of Nuts & Bolts In Sequence
Courtesy of GENERAL MOTORS CORP.

10. Tighten the nuts and bolts in sequence.

Tighten:

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

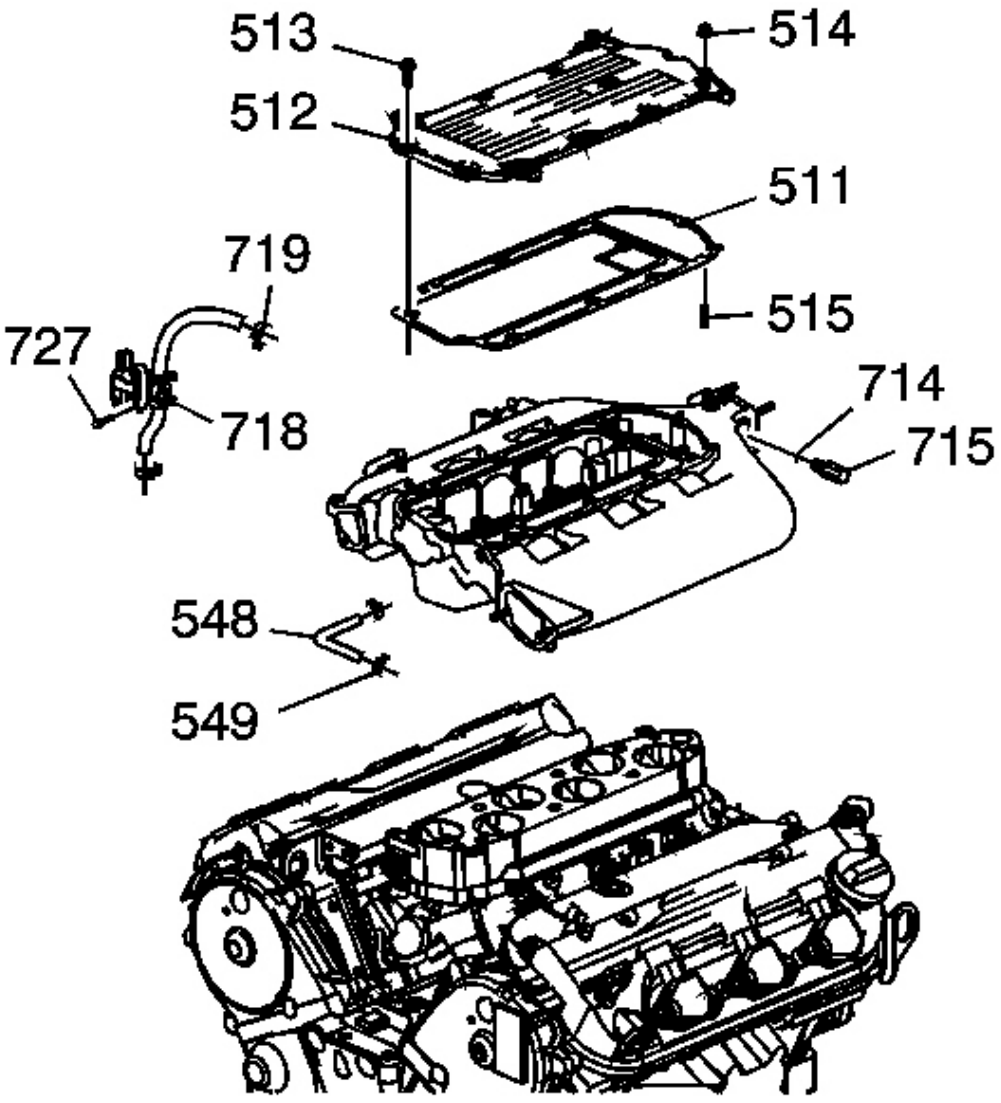


Fig. 420: View Of Intake Manifold
Courtesy of GENERAL MOTORS CORP.

11. Install the positive crankcase ventilation (PCV) hose (548) and clamps (549).
12. Install the EVAP valve (718), with hoses, clamps (719) and bolts (727).

Tighten: Tighten the bolts to 9.8 N.m (87 lb in).

13. Install the intake air temperature (IAT) sensor (715) and NEW O-ring (714).

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

THROTTLE BODY INSTALLATION

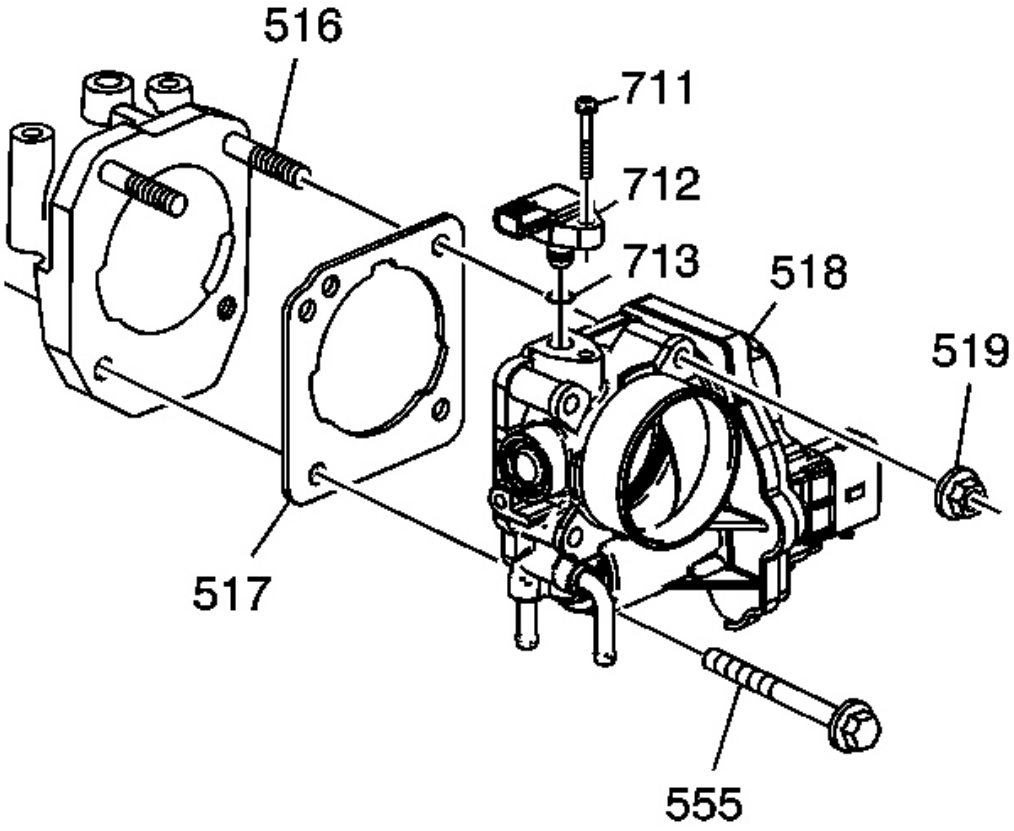


Fig. 421: Identifying Throttle Body
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT: The powertrain control module (PCM) must perform the idle learn procedure to determine the minimum throttle position and to establish idle speed when any of the following components are replaced:

- **Throttle body**

- **Timing belt**
- **Timing belt drive sprocket**
- **Crankshaft and bearings**

Refer to Idle Learn Procedure .

1. Install the studs (516), if required.

   Tighten: Tighten the studs to 7.8 N.m (69 lb in).

2. Install the gasket (517) and throttle body (518).
3. Install the nuts (519) and bolts (555).

   Tighten: Tighten the nuts and bolts to 22 N.m (16 lb ft).

4. Install a NEW O-ring (713).
5. Install the MAP sensor (712) and bolt (711).

   Tighten: Tighten the bolt to 3.4 N.m (30 lb in).

6. Install the throttle body coolant hoses.

ENGINE FLYWHEEL INSTALLATION

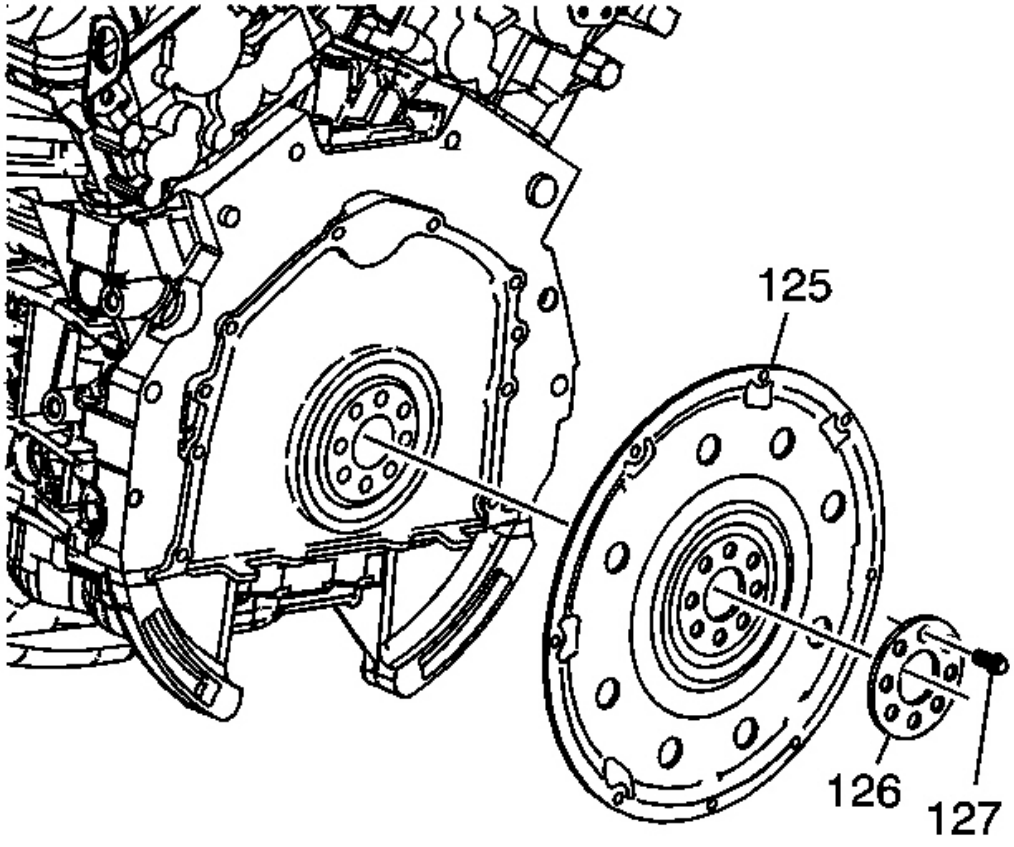


Fig. 422: View Of Engine Flywheel
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the flywheel (125), washer (126) and bolts (127).

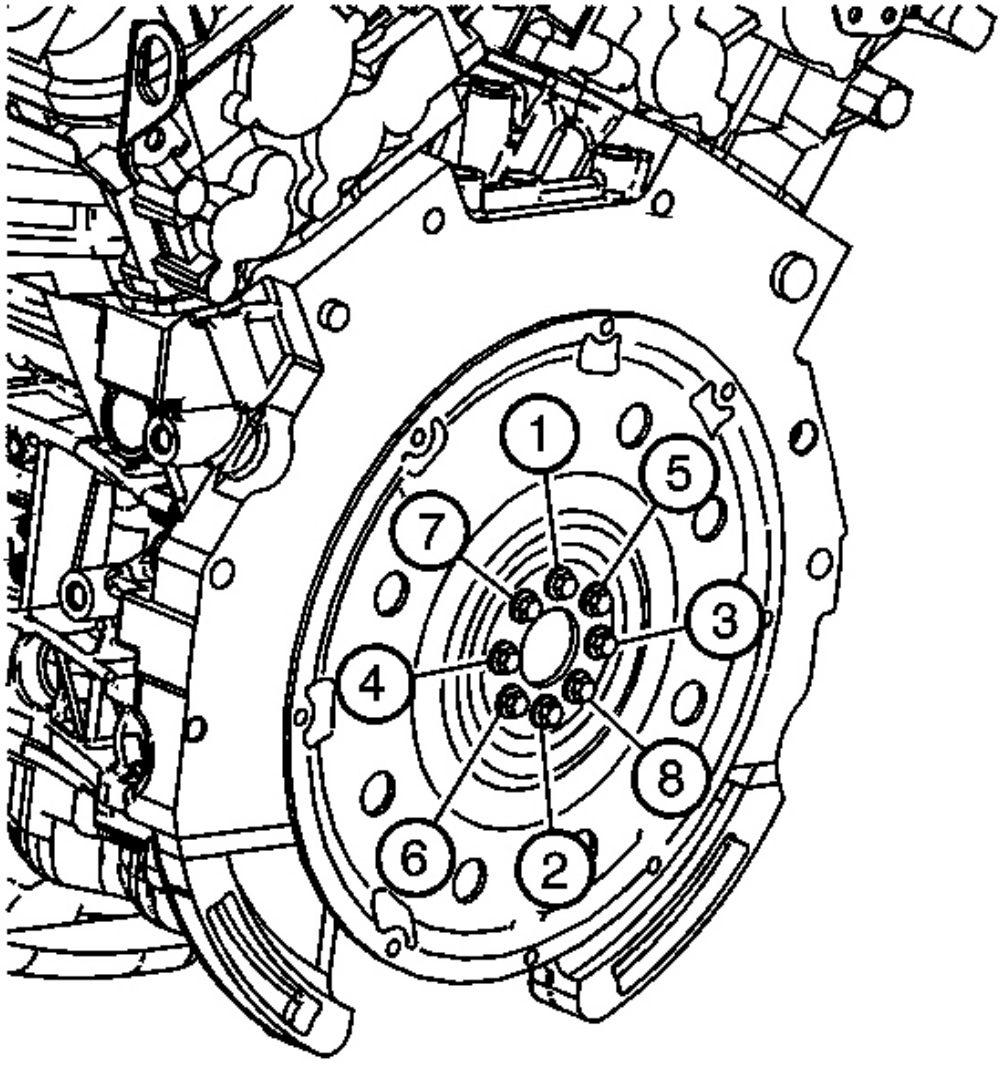


Fig. 423: Identifying Flywheel Bolts
Courtesy of GENERAL MOTORS CORP.

2. Tighten the bolts in sequence.

   Tighten: Tighten the bolts in sequence to 74 N.m (54 lb ft).

ENGINE LIFT BRACKET INSTALLATION

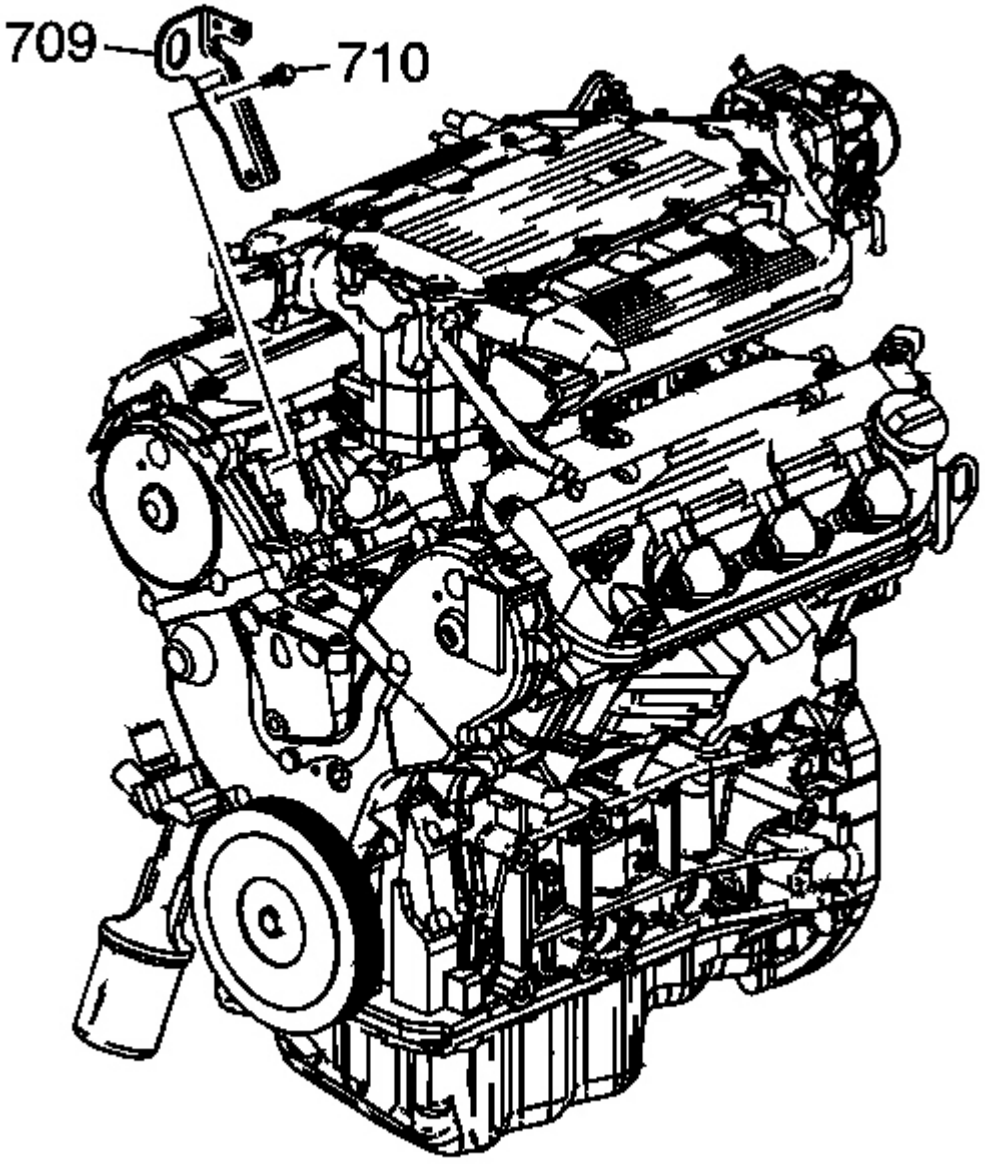


Fig. 424: View Of Engine Bracket
Courtesy of GENERAL MOTORS CORP.

1. Install the bracket (709).

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the bolts (710).

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

DESCRIPTION AND OPERATION

CRANKCASE VENTILATION SYSTEM INSPECTION/DIAGNOSIS

Crankcase Ventilation System Inspection/Diagnosis

If an engine is idling rough, check for a clogged PCV valve. Replace if required. Use the following procedure:

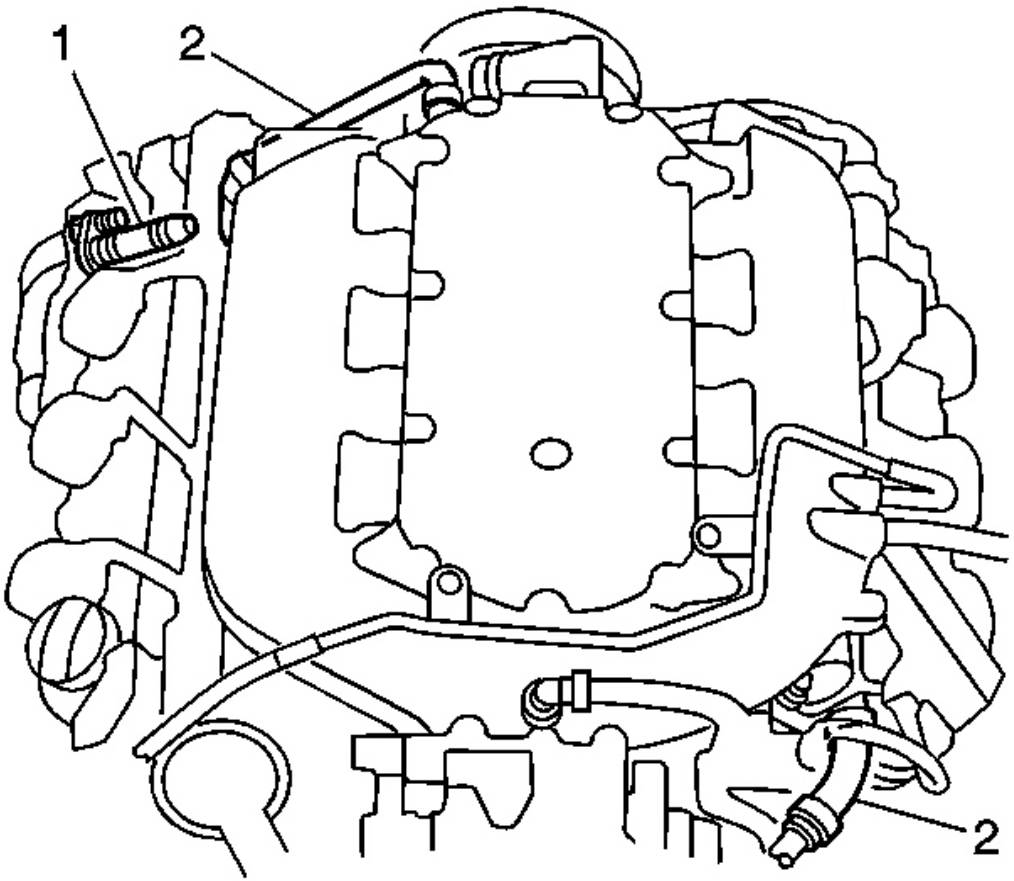


Fig. 425: View Of Crankcase Ventilation System
Courtesy of GENERAL MOTORS CORP.

1. Check the PCV valve (1), hoses (2), and connections for leaks or restrictions.
2. At idle, listen to the PCV valve (1) with a stethoscope as you lightly pinch the PCV hose (2) with your fingers or pliers for several times. Each time the hose is pinched, the valve should click.
3. If there is no clicking should, check the PCV valve grommet for cracks or damage. If the grommet is OK, replace the PCV valve and recheck.

With this system, any blow-by in excess of the system capacity is exhausted into the intake manifold and is drawn into the engine. Proper operation of the crankcase ventilation system is dependent upon a sealed engine. If oil sludging or dilution is noted, and the crankcase ventilation system is functioning properly, check engine for possible cause and correct to ensure that the system will function as intended.

CRANKCASE VENTILATION SYSTEM DESCRIPTION

Crankcase Ventilation System Description

A crankcase ventilation system is used to consume crankcase vapors in the combustion process instead of venting them to the atmosphere. Fresh air from the throttle body is supplied to the crankcase, mixed with blow-by gases, then passed through the PCV valve into the intake manifold.

Operation

The primary control is through the positive crankcase ventilation (PCV) valve which meters the flow at a rate depending on the inlet vacuum. To maintain idle quality, the PCV valve restricts the flow when the inlet vacuum is high. If abnormal operating conditions arise, the system is designed to allow excessive amounts of blow-by gases to back flow through the crankcase vent into the throttle body to be consumed by normal combustion.

Results of Incorrect Operation

A plugged valve may cause the following conditions:

- Rough idle
- Stalling or slow idle speed
- Oil deterioration

A leaking valve would cause

- Rough idle
- Stalling
- High idle speed

DRIVE BELT SYSTEM DESCRIPTION

Drive Belt System Description

The drive belt system consists of the following components:

- The drive belt
- The drive belt tensioner
- The crankshaft balancer pulley
- The accessory drive components
    - The generator
    - The A/C compressor, if equipped

The drive belt is thin so that it can bend backwards and has several ribs to match the groves in the pulleys. The drive belts are made of different types of rubbers (chloroprene or EPDM) and have different layers or plys containing either fiber cloth or cords for reinforcement.

Both sides of the drive belt may be used to drive the different accessory drive components. When the back side of the drive belt is used to drive a pulley, the pulley is smooth.

The drive belt id pulled by the crankshaft balancer pulley across the accessory drive component pulleys. The spring loaded drive belt tensioner keeps constant tension on the drive belt to prevent the drive belt from slipping. The drive belt tensioner arm will move when loads are applied to the drive belt by the accessory drive components and the crankshaft.

The drive belt system may have an idler pulley, which is used to add wrap to the adjacent pulleys. Some systems use an idler pulley in place of an accessory drive component when the vehicle is not equipped with the accessory.

ENGINE COMPONENT DESCRIPTION

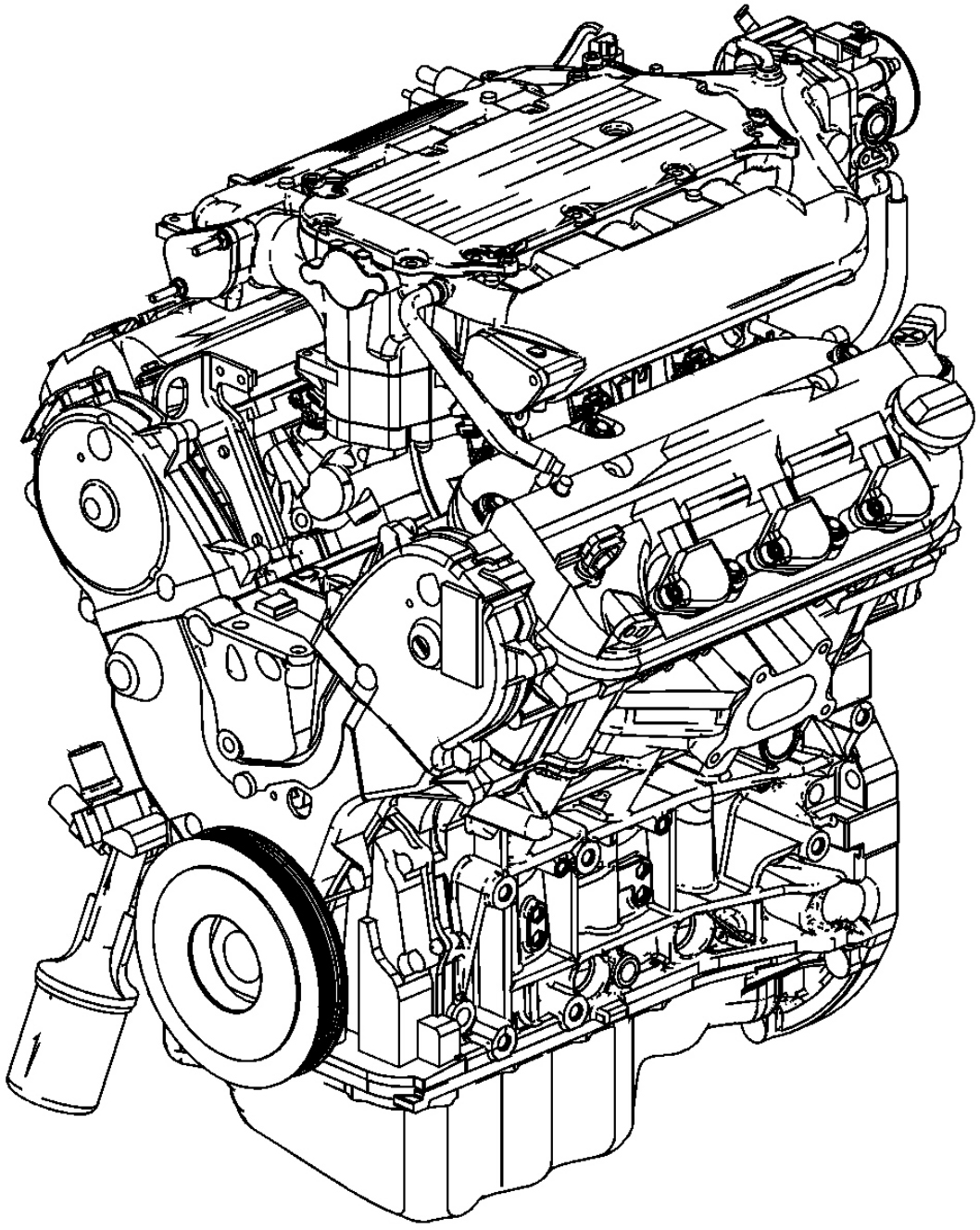


Fig. 426: View Of Engine Component
Courtesy of GENERAL MOTORS CORP.

The 3.5L, 4-stroke, single overhead cam (SOHC) engine is identified as RPO L66 and VIN U. The V6 engine is a 24 valve variable valve timing and lift electronic control design.

Intake Manifold

The cast aluminum intake manifold incorporates passages for air intake to each cylinder and a passage for the exhaust gas recirculation (EGR) system. The drive-by-wire throttle body and the intake air temperature (IAT) sensor are mounted to the intake manifold. The positive crankcase ventilation (PCV) hose and evaporative emission (EVAP) valve are connected to vacuum fittings on the manifold.

Camshaft Drive System

The crankshaft drive sprocket rotates the timing belt and in-turn rotates the camshaft sprockets. Belt tension is provided by the hydraulic auto-tensioner assembly. The hydraulic auto-tensioner automatically compensates for tension variations caused by changes in belt temperature. A timing belt idler pulley and a timing belt tensioner pulley are also incorporated into the design. 2 steel camshafts, 1 per bank, are used to operate both intake and exhaust rocker arms. The timing belt also drives the water pump assembly.

Valve Train

1 intake and 1 exhaust rocker arm shaft are used for each cylinder bank. Rocker shafts are retained to the cylinder heads by bolts. 5 roller type rocker arms are used for each cylinder, 3 intake and 2 exhaust. The rocker arms pivot on the rocker shafts. Each rocker arm has a nut and bolt type mechanical adjuster. Periodic valve adjustment is required. Refer to **Intake Rocker Arm Control System Operation** .

Cylinder Head

The cast aluminum cylinder heads have 2 intake and 2 exhaust valves per cylinder. The cylinder head has line-bored camshaft journals. This design eliminates the use of bearing caps and retaining bolts and improves the ease of assembly. The single overhead camshaft is installed into the cylinder head from the rear or back-side of the head. The camshaft cap retains the camshaft and controls camshaft end-play. The valve rocker arm shafts are directly fastened onto the cylinder head with 1 dowel pin at each end of the shaft for positioning. The valve guides and valve seats are pressed into the head. The valve guides are replaceable, but must be reamed for proper guide-to-valve stem clearance after installation. The catalytic converters mount directly to the side of each cylinder head.

Piston and Connecting Rod Assemblies

The pistons are cast aluminum with a flat top design. Piston skirts are coated to reduce friction. Each piston uses 2 compression rings and 1 3-piece oil control ring assembly. The piston pin is a full-floating design and is retained to the connecting rod by clips located in each end of the piston pin bore. The connecting rod and rod cap are positioned and aligned by a dowel pin and retained by bolts.

Crankshaft

The crankshaft is of a cast iron design. The crankshaft is supported by 4 main bearings. The bearings are retained by bearing caps which are machined with the engine block for proper alignment and clearance. Journal number 3 is the thrust journal. Flat areas on the front of the crankshaft drive the oil pump assembly. A keyway and key on the front of the crankshaft align and position the timing belt drive sprocket and crankshaft balancer.

Engine Block

The cast aluminum V-shaped engine block is a deep-skirt design with 4 main bearing caps. The iron cylinder liners are a cast in place design. Coolant jackets encircle the cylinders. The 4 cast-iron bearing caps are cross-bolted to the engine block and each are retained by 2 vertically and 2 horizontally located bolts. Right side cylinders are numbered front-to-rear as 1-2-3. Left side cylinders are numbered front-to-rear 4-5-6. The firing order is 1-4-2-5-3-6.

Oil Pan

The cast aluminum oil pan retains the engine oil sump. The oil pan is positioned to the engine block by dowel pins and sealed to the engine block with an RTV type sealant.

Ignition

The V6 engine uses a coil-on-plug direct-ignition design. The camshaft position (CMP) sensor is mounted to the left-upper rear timing belt cover. The left camshaft sprocket has 3 spokes, or protrusions, incorporated into the rear of the sprocket that are used to create the camshaft sensor input signal. The dual-sensor crankshaft position (CKP) sensor assembly is located at the front of the engine at the oil pump housing. The timing belt drive sprocket has 22 spokes, or protrusions, incorporated into the rear edge of the sprocket that are used to create the crankshaft sensor input signal.

INTAKE ROCKER ARM CONTROL SYSTEM OPERATION

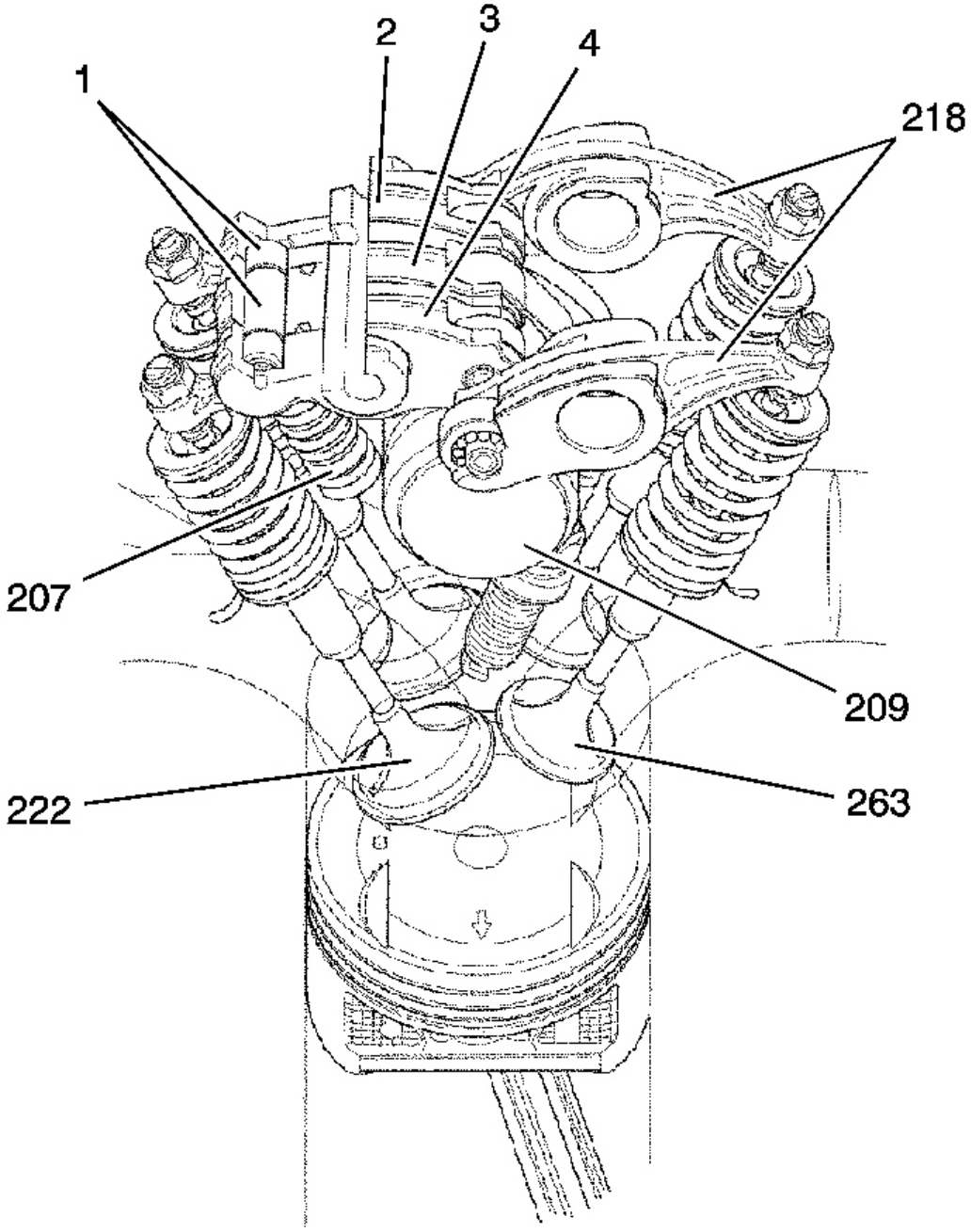


Fig. 427: View Of Intake Rocker Arm Control System
Courtesy of GENERAL MOTORS CORP.

The intake rocker arm control system is designed to change valve timing and lift, depending on engine speed,

vehicle speed, engine load, and other sensor inputs, by controlling intake valve rocker arm actuation. The intake rocker arm control system achieves low-end torque and low fuel consumption when operating in the low engine speed range, while maintaining high power output when operating in the high engine speed range. The engine has a normal 4 valve per cylinder arrangement. At low engine speed, the primary (4) and secondary (2) intake valve rocker arms operate at normal lift. At high engine speed, the primary (4) and secondary (2) intake rocker arms are mechanically connected to the mid intake rocker arm (3) to allow high valve lift. Synchronizing pistons (1) connect and disconnect the 3 intake rocker arms. Hydraulic pressure against a timing piston moves the synchronizing piston outward. A stopper piston and return spring move the synchronizing piston back or inward when hydraulic pressure is reduced.

The system consists of the following components:

- A spool valve assembly with solenoid
- An oil pressure switch
- Valve lash adjusters-lost motion assemblies
- An intake rocker arm assembly with moving-internal pistons

Low Speed Operation

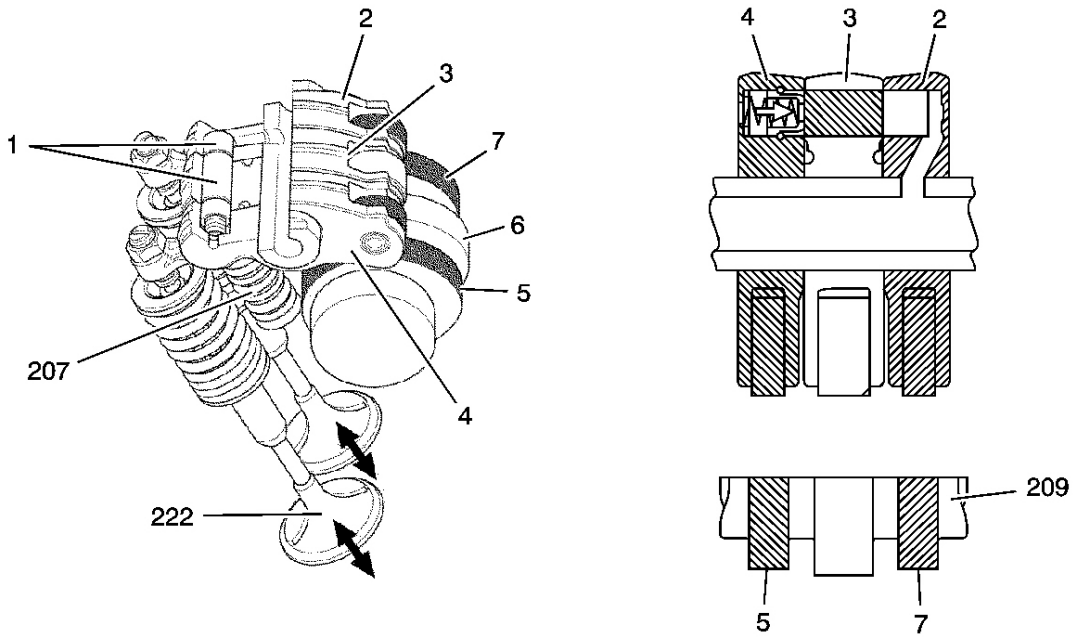


Fig. 428: View Of Primary & Secondary Rocker Arms
Courtesy of GENERAL MOTORS CORP.

The primary (4) and secondary (2) rocker arms are not connected to the mid rocker arm (3) and are driven separately by the camshaft lobes (5 and 7). Even though the mid rocker arm (3) is following the center camshaft lobe (6), it has no effect on the opening and closing of the valves in the low RPM range. The valve lash adjuster

(207) absorbs the lost motion action of the mid rocker arm.

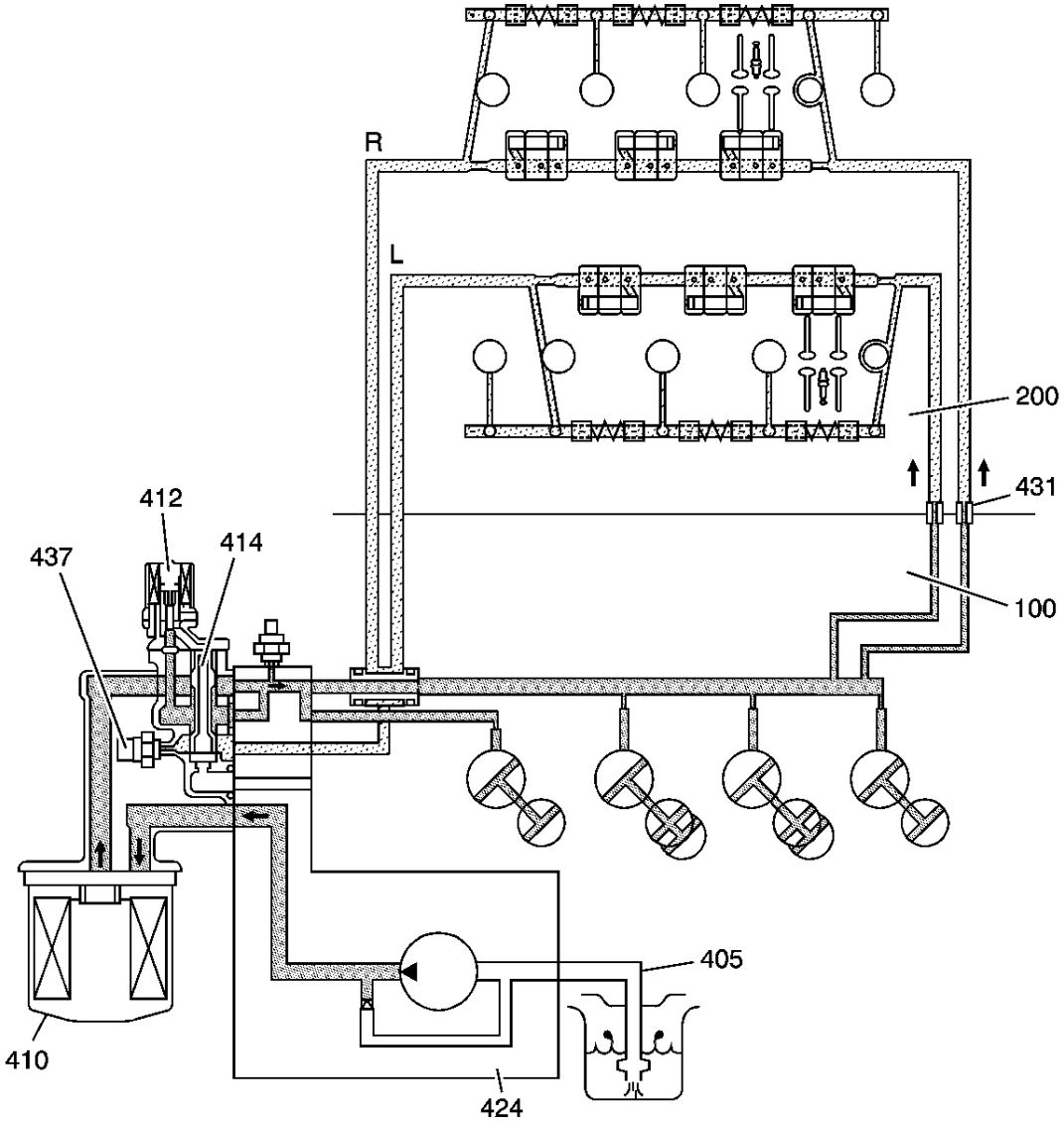


Fig. 429: View Of Engine Oil Flow Diagram
Courtesy of GENERAL MOTORS CORP.

The oil is pulled from the oil sump through the screen (405). Oil pressure generated in the oil pump (424) is supplied through the oil filter (410) to the engine block (100). The oil pressure is then directed to the cylinder heads (200) for rocker arm and camshaft lubrication. The oil restrictors (431) located within the upper engine block reduce the oil pressure to eliminate intake rocker arm piston actuation.

High Speed Operation

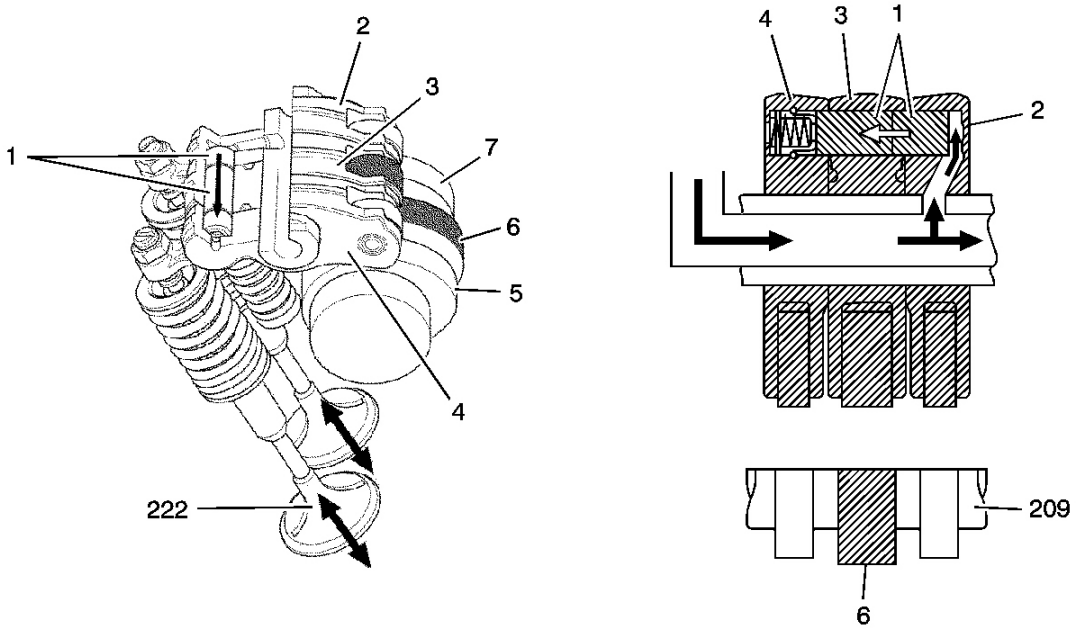


Fig. 430: View Of Synchronizing Pistons
Courtesy of GENERAL MOTORS CORP.

The synchronizing pistons (1) move in the direction, as indicated, to mechanically connect the primary (4), secondary (2), and mid (3) rocker arms. The 3 rocker arms move as a single unit and are driven by the high range camshaft lobe (6). In this mode of operation, the valve timing and lift are set for high speed operation.

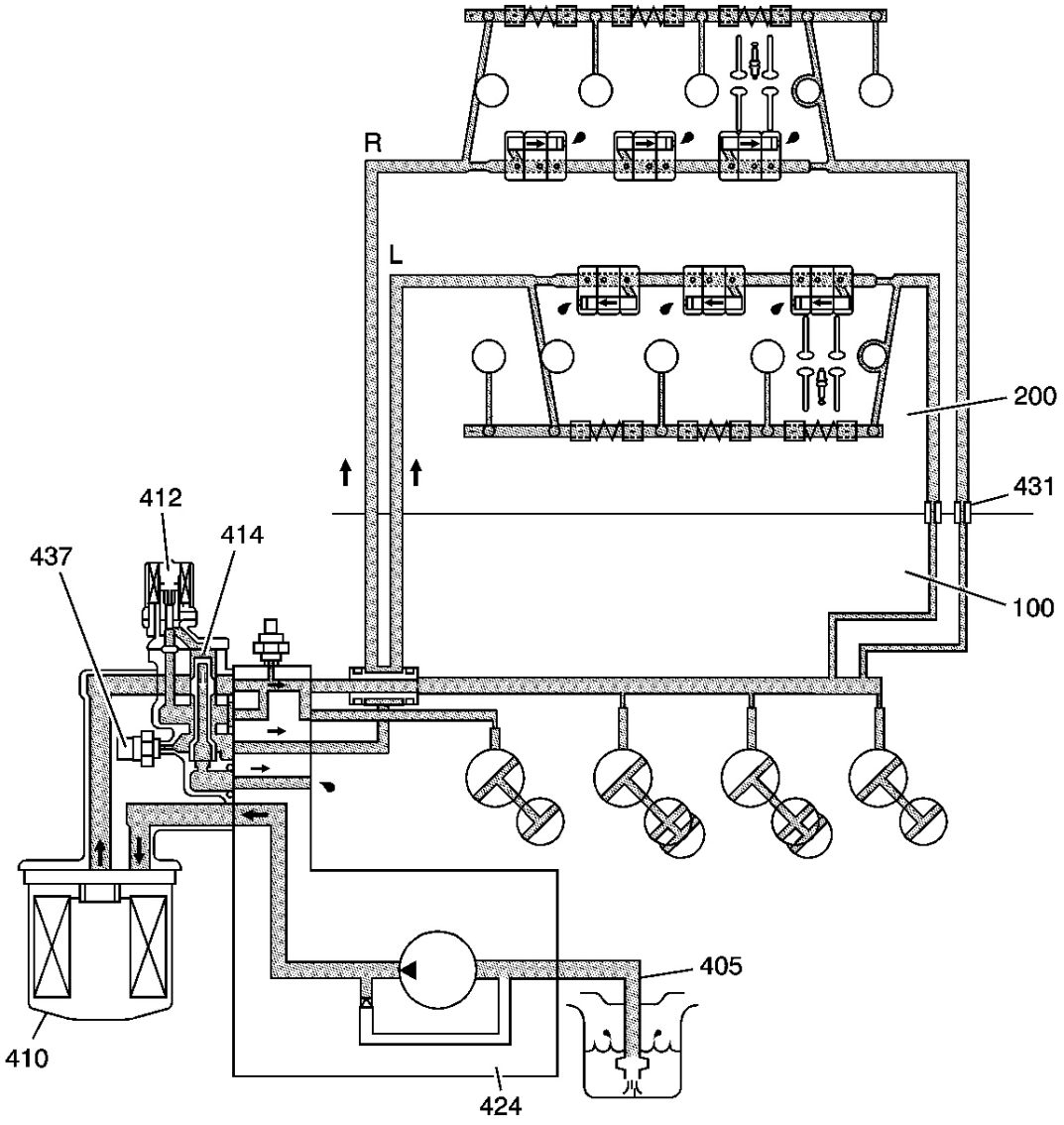


Fig. 431: View Of Engine Oil Flow Diagram
Courtesy of GENERAL MOTORS CORP.

The oil is pulled from the oil sump through the screen (405). Oil pressure is generated in the oil pump (424) and is supplied through the oil filter (410) to the oil flow control module. The solenoid valve (412) is energized, moving the spool valve (414). Increased oil pressure is then supplied to the synchronizing pistons, which move to connect the primary, secondary, and mid rocker arms.

Valve Lash Adjuster

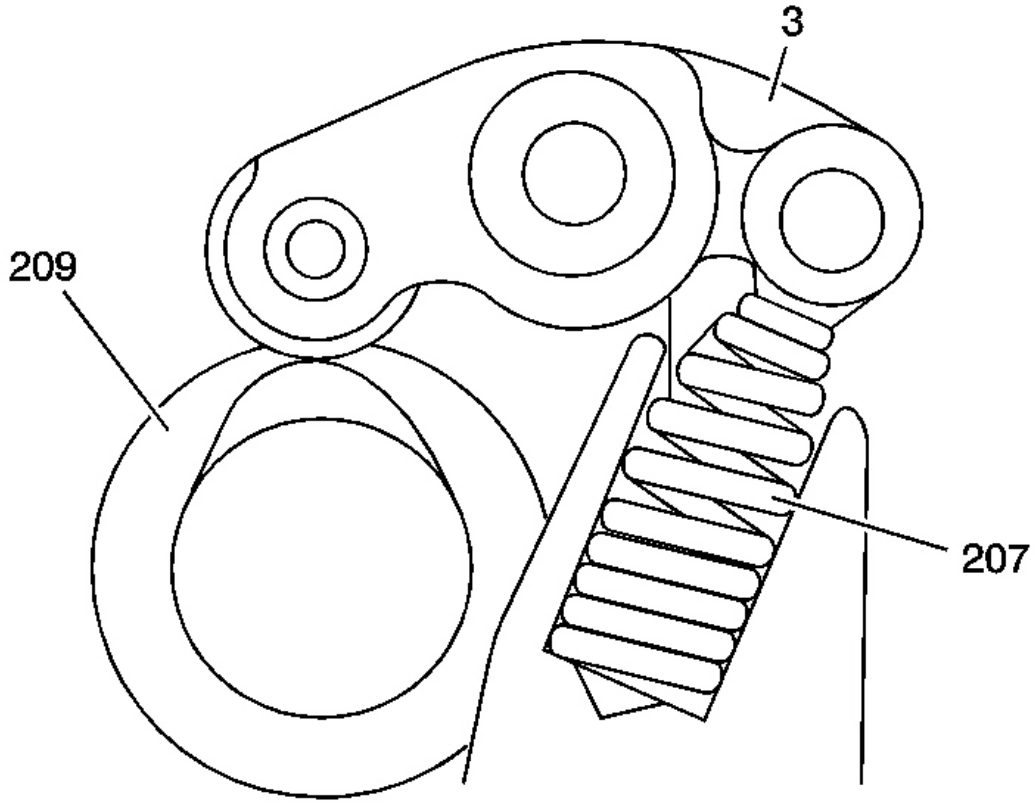


Fig. 432: View Of Lash Adjuster
Courtesy of GENERAL MOTORS CORP.

The lash adjuster, or lost motion assembly (207), includes a spring and retainer. The lash adjuster is in constant contact with the mid (3) rocker arm. At low speeds, the lash adjuster suppresses unnecessary movement of the mid rocker arm. The lash adjuster functions as an auxiliary spring at high speeds to ensure smooth valve operation.

Electrical System Components

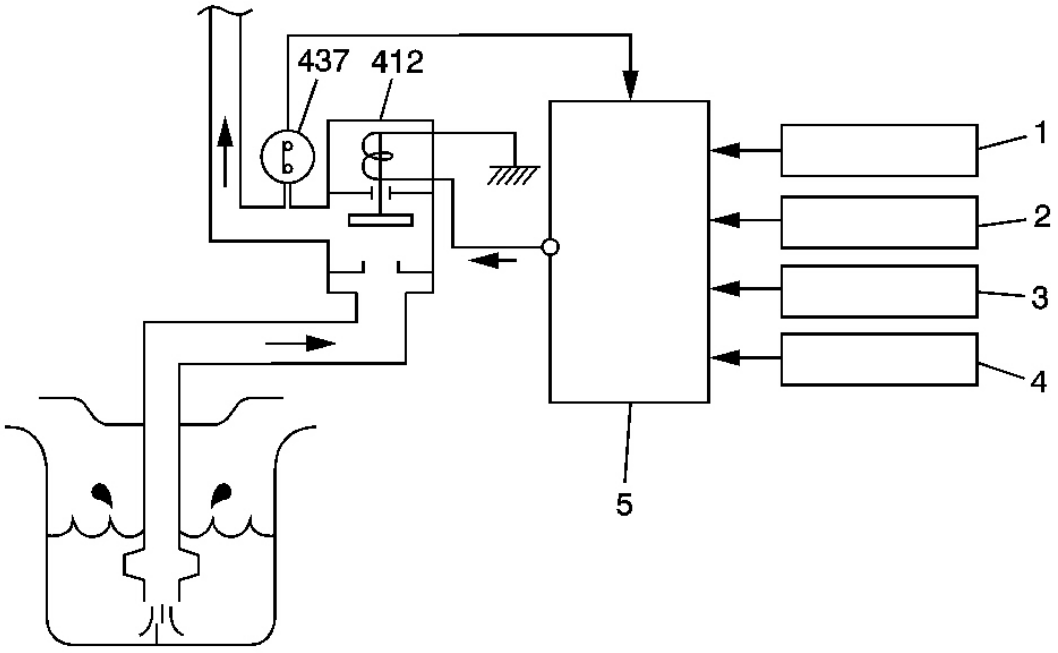


Fig. 433: View of Oil Flow Control Module Components
Courtesy of GENERAL MOTORS CORP.

The PCM (5) constantly monitors the changes in engine status, such as engine speed (1), engine load (2), vehicle speed (3), and coolant temperature (4). The PCM directs the oil flow control module (412) to provide higher oil pressure to the intake valve rocker arms as required. The oil pressure switch (437) provides a signal to the PCM that oil pressure is present.

The following criteria is required for intake rocker arm activation:

- Engine speed of 4,400 RPM or greater
- Engine coolant temperature (ECT) sensor reading of 10°C (50°F) or greater
- Battery voltage of 10.5 volts or greater
- Transmission shift lever in a position other than P or N
- Engine has been running for longer than 5 seconds
- Additional information can be found within engine controls information. Refer to **Rocker Arm Oil Control System Description** in Engine Controls - 3.5L (L66).

Spool Valve and Oil Pressure Switch

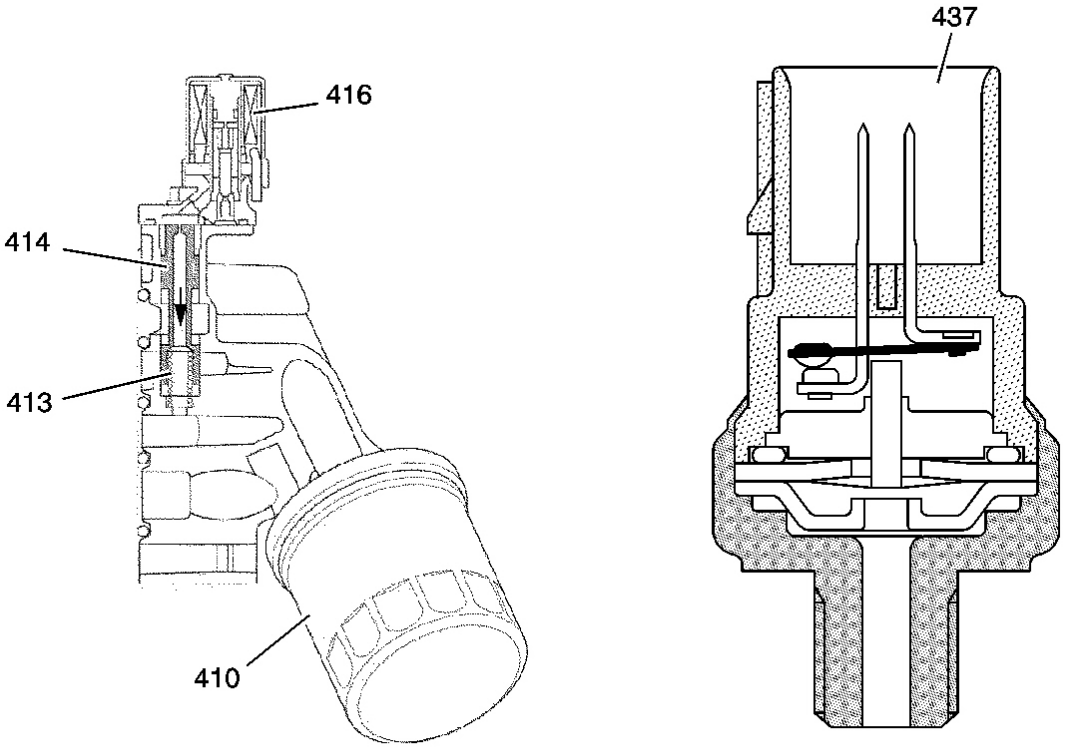


Fig. 434: View Of Spool Valve Assembly
Courtesy of GENERAL MOTORS CORP.

The spool valve assembly, or oil flow control module, is mounted to the front right of the engine block at the oil pump housing. The module consists of an oil filter (410), solenoid (416), spool valve (414) and spring (413). The module controls oil flow between the oil pump and the synchronizing pistons of the intake rocker arms. When the solenoid is activated, the oil pressure pushes the spool valve downward. The spool valve then opens the oil passage, and hydraulic pressure is applied to the synchronizing pistons, thus activating the intake rocker arm control system. The oil pressure sensor (437) is located on the housing by the solenoid valve and is in a normally closed position. The switch is used to detect oil pressure and to activate the intake rocker arm control system. The PCM provides 5 volts to the switch, the switch opens through the body, the solenoid is energized, and oil pressure applied.

LUBRICATION DESCRIPTION

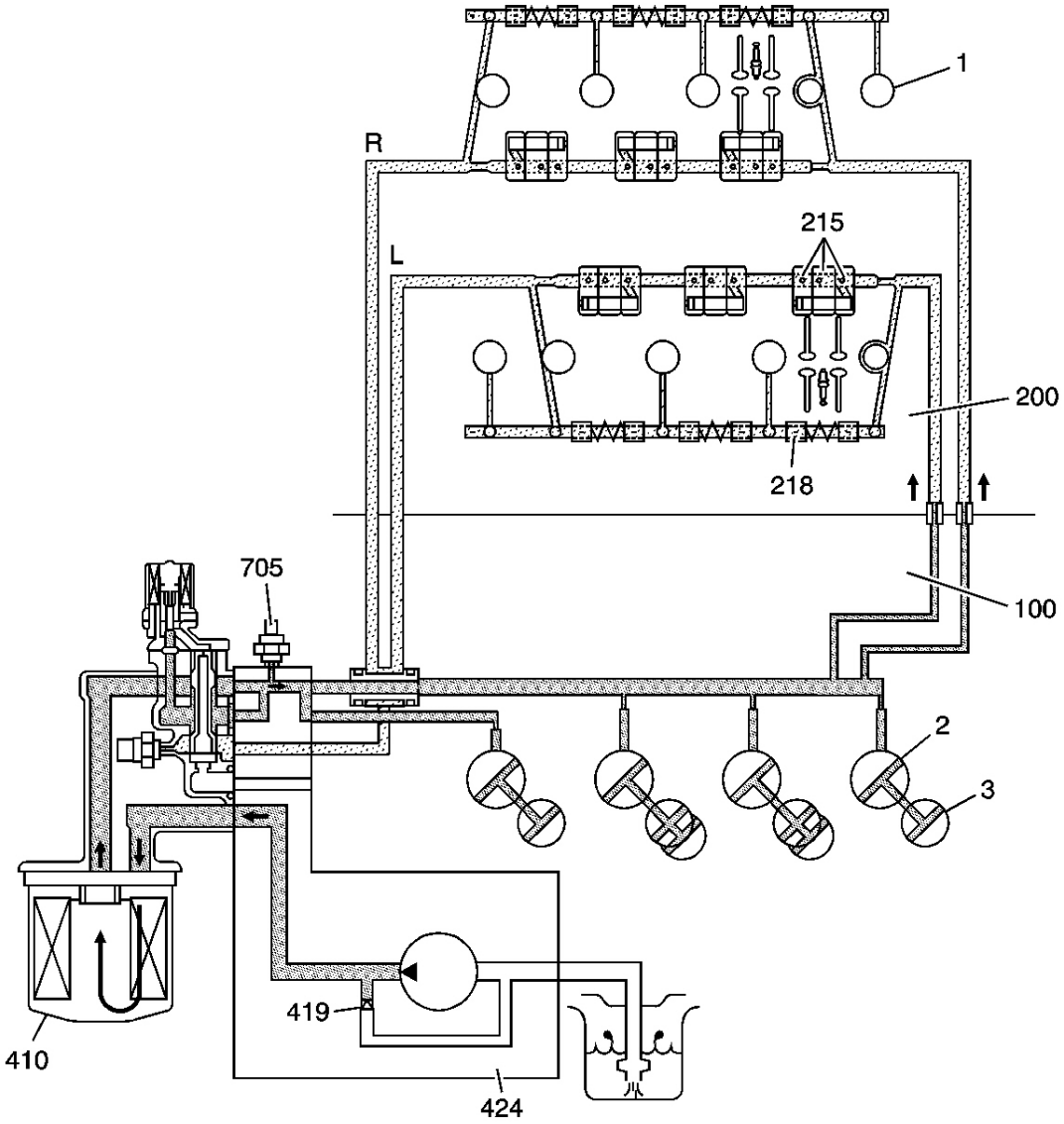


Fig. 435: View Of Oil Pump Assembly
Courtesy of GENERAL MOTORS CORP.

Oil is pulled from the oil pan sump by the crankshaft driven oil pump (424) assembly. The oil pump forces pressurized oil from the pump through the oil filter (410), to the engine block (100) main oil gallery. A regulator valve (419) located within the oil pump housing, controls pressure and vents excess oil back to the inlet side of the oil pump. The main oil gallery distributes pressurized oil to the main (2) and connecting rod (3) bearings. Oil then flows to the cylinder heads (200) and lubricates the camshafts (1) and rocker arms (215 and 218). The engine oil pressure switch (705) is a normally closed switch and is mounted onto the oil pump housing. The oil pressure switch is designed to warn the driver in the event engine oil pressure drops below the recommended value.

Oil Filter

The oil filter (410) is threaded onto the oil flow control module housing. Incorporated into the oil filter design are check and bypass valves. The check valve prevents oil from draining out of the engine oil galleries when the engine is not running. The bypass valve allows oil to bypass the filter element in the event of a restriction within the filter.

INTRODUCTION

CLEANLINESS AND CARE

- Throughout this section, it should be understood that proper cleaning and protection of machined surfaces and friction areas is part of the repair procedure. This is considered standard shop practice even if not specifically stated.
- When any internal engine parts are serviced, care and cleanliness is important.
- When components are removed for service, they should be marked, organized or retained in a specific order for reassembly.

  Refer to **Separating Parts** .

- At the time of installation, components should be installed in the same location and with the same mating surface as when removed.
- An automobile engine is a combination of many machined, honed, polished and lapped surfaces with tolerances that are measured in millimeters or thousandths of an inch. These surfaces should be covered or protected to avoid component damage.
- A liberal coating of clean engine oil should be applied to friction areas during assembly.
- Proper lubrication will protect and lubricate friction surfaces during initial operation.

REPLACING ENGINE GASKETS

Tools Required

J 28410 Gasket Remover. See **Special Tools and Equipment** .

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. See **Special Tools and Equipment** .
- Care must be used to avoid gouging or scraping the sealing surfaces.
- Do not use any other method or technique to remove sealant or gasket material from a part.
- Do not use abrasive pads, sand paper, or power tools to clean the gasket surfaces.
  - These methods of cleaning can cause damage to the component sealing surfaces.
  - Abrasive pads also produce a fine grit that the oil filter cannot remove from the oil.
  - This grit is abrasive and has been known to cause internal engine damage.

Assembling Components

- When assembling components, use only the sealant specified or equivalent in the service procedure.
- Sealing surfaces should be clean and free of debris or oil.
- Specific components such as crankshaft oil seals or valve stem oil seals may require lubrication during assembly.
- Components requiring lubrication will be identified in the service procedure.
- When applying sealant to a component, apply the amount specified in the service procedure.
- Do not allow the sealant to enter into any blind threaded holes, as it may prevent the bolt from clamping properly or cause component damage when tightened.
- Tighten bolts to specifications. Do not overtighten.

USE OF ROOM TEMPERATURE VULCANIZING (RTV) AND ANAEROBIC SEALER

Pipe Joint Compound

IMPORTANT: Three types of sealer are commonly used in engines. These are room temperature vulcanizing (RTV) sealer, anaerobic gasket eliminator sealer, and pipe joint compound. The correct sealer and amount must be used in the proper location to prevent oil leaks. DO NOT interchange the 3 types of sealers. Use only the specific sealer or the equivalent as recommended in the service procedure.

- Pipe joint compound is a pliable sealer that does not completely harden. This type 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
    - 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** .

  NOTE: Refer to Sealant Notice in Cautions and Notices.

- Apply the pipe joint compound to a clean surface. Use a bead size or quantity as specified in the procedure. Run the bead to the inside of any bolt holes.
- Apply a continuous bead of pipe joint compound to one sealing surface. Sealing surfaces to be resealed must be clean and dry.
- Tighten the bolts to specifications. Do not overtighten.

RTV Sealer

- RTV sealant hardens when exposed to air. This type sealer is used where two non-rigid parts, such as the intake manifold and the engine block, are assembled together.
- Do not use RTV sealant in areas where extreme temperatures are expected.

  These areas include:

    - Exhaust manifold
    - Head gasket
    - 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** .

  NOTE: Refer to Sealant Notice in Cautions and Notices.

- 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.
- 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 2 rigid parts, such as castings, are assembled together. When 2 rigid parts are disassembled and no sealer or gasket is readily noticeable, the parts were probably assembled using a gasket eliminator.
- Follow all safety recommendations and directions that are on the container.

To remove the sealant or the gasket material, refer to **Replacing Engine Gaskets** .

- Apply a continuous bead of gasket eliminator to one flange. Surfaces to be sealed must be clean and dry.

NOTE: Refer to Sealant Notice in Cautions and Notices.

- Spread the sealer evenly with your finger to get a uniform coating on the sealing surface.

IMPORTANT: 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.

- Tighten bolts to specifications. Do not overtighten.
- After properly tightening the fasteners, remove the excess sealer from the outside of the joint.

SEPARATING PARTS

IMPORTANT: Many internal engine components will develop specific wear patterns on their friction surfaces.
When disassembling the engine, internal components MUST be separated, marked, or organized in a way to ensure 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
- Rocker arm position onto the rocker arm shafts
- Valve to the valve guide
- Engine block main bearing cap location and direction
- Oil pump drive and driven gears

TOOLS AND EQUIPMENT

Special tools are listed and illustrated throughout this section with a complete listing at the end of the section. These tools, or their equivalents, are specially designed to quickly and safely accomplish the operations for which they are intended. The use of these special tools will also minimize possible damage to engine components. Some precision measuring tools are required for inspection of certain critical components. Torque wrenches and a torque angle meter are necessary for the proper tightening of various fasteners.

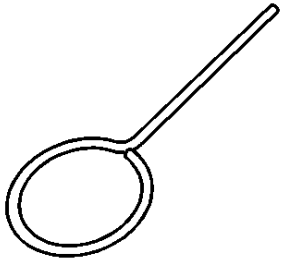
To properly service the engine assembly, the following items should be readily available:

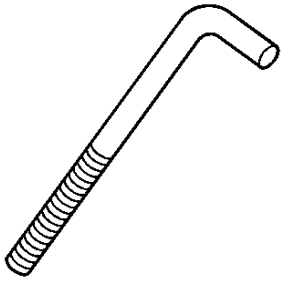
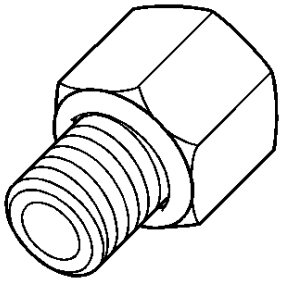
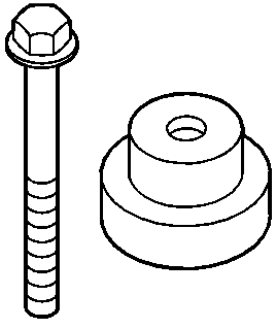
- Approved eye protection and safety gloves
- A clean, well lit, work area
- A suitable parts cleaning tank
- A compressed air supply
- Trays or storage containers to keep parts and fasteners organized
- An adequate set of hand tools
- Approved engine repair stand
- An approved engine lifting device that will adequately support the weight of the components

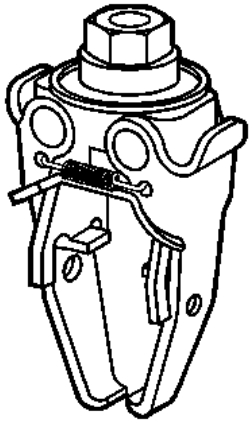
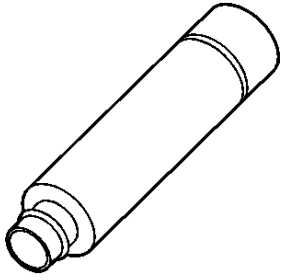
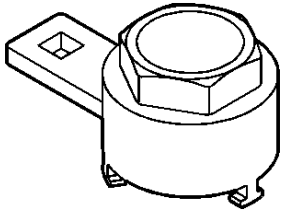
SPECIAL TOOLS AND EQUIPMENT

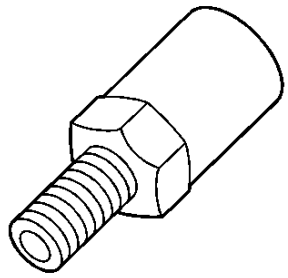
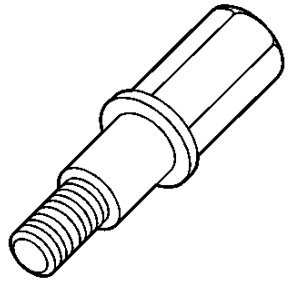
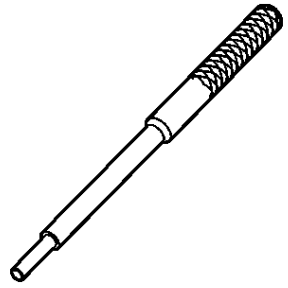
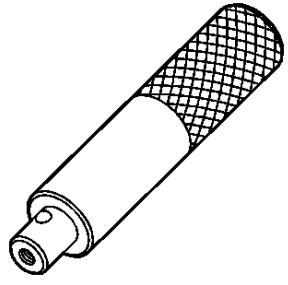
SPECIAL TOOLS

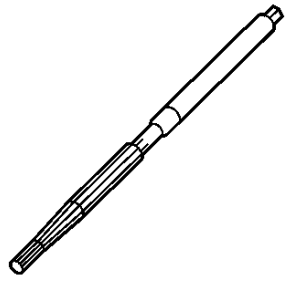
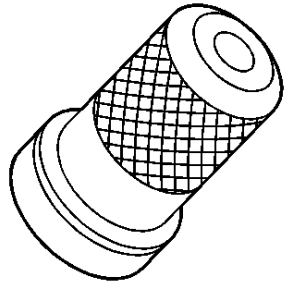
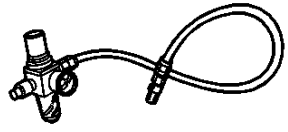
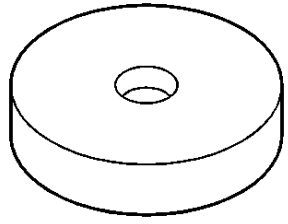
Special Tools

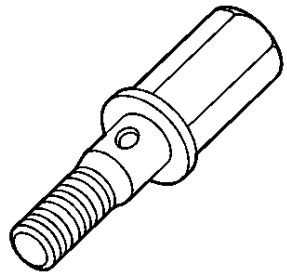
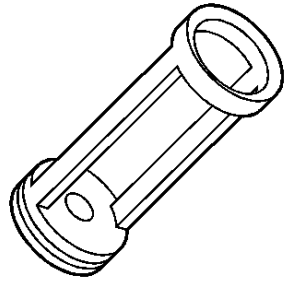
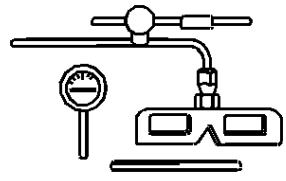
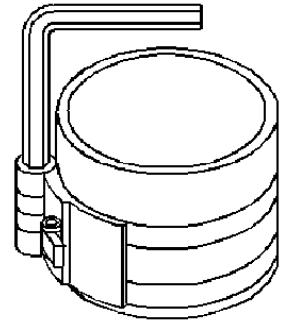
Illustration	Tool Number/Description
	EN 46330 Timing Belt Tensioner Retaining Pin
	EN 46331 Timing Belt Tensioner Pulley Retaining Bolt

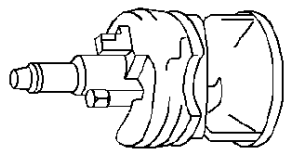
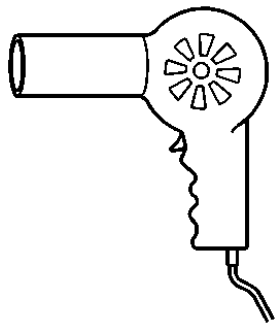
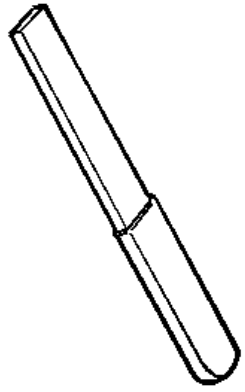
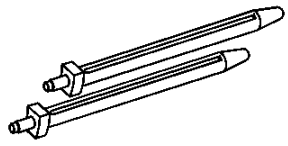
	
	EN 46333 Oil Pressure Testing Adapter
	EN 46334 Camshaft Oil Seal Driver
	EN 46335 Valve Spring Compressor - Head On-Vehicle

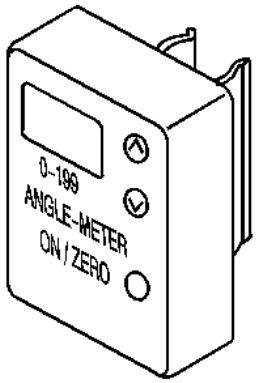
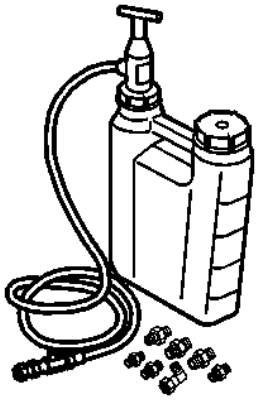
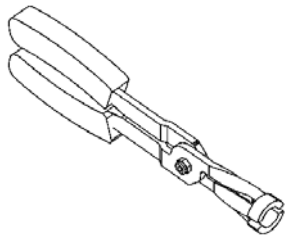
	
	EN 46336 Valve Guide Seal Installer
	EN 46337 Camshaft Sprocket/Crankshaft Balancer Holder
	EN 46339 Intake Rocker Arm Testing Adapter

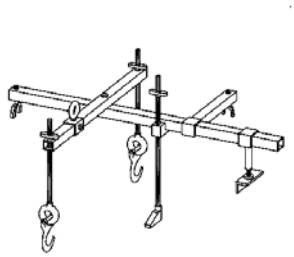
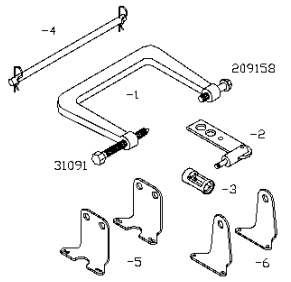
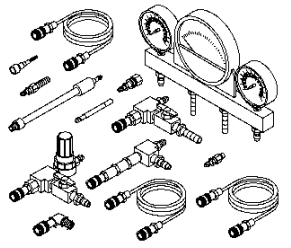
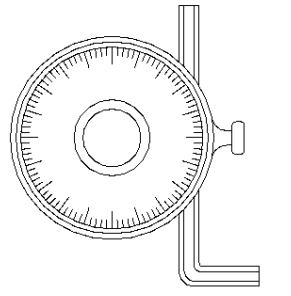
	
	EN 46340 Intake Rocker Arm Testing Air Stopper
	EN 46341 Valve Guide Driver
	EN 46342 Driver Handle

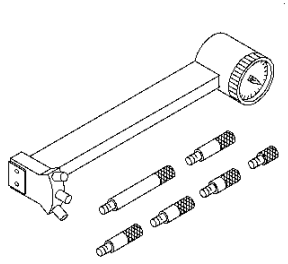
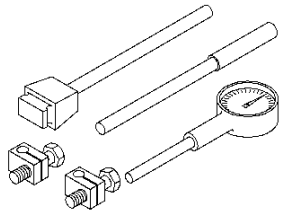
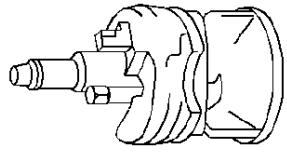
	EN 46345 Valve Guide Reamer
	EN 46347 Crankshaft Front Oil Seal Driver
	EN 46348 Intake Rocker Arm Testing Air Pressure Regulator and Hose
	EN 46351 Crankshaft Rear Oil Seal Driver
	EN 46352 Intake Rocker Arm Testing Air Adapter

	
	EN 46353 Valve Spring Compressor Attachment - Head Off-Vehicle
	J 7872 Magnetic Base Dial Indicator
	J 8037 Ring Compressor

	J 24270 Cylinder Bore Ridge Reamer
	J 25070 Heat Gun - 500-750 F
	J 28410 Gasket Remover
	J 41742 Connecting Rod Guide Pin

	J 45059 Angle Meter
	J 45299 Engine Preluber
	SA9102E-A Valve Seal Remover/Replacer

	SA9105E Engine Support Fixture - 3-Bar
	SA9124E Regulator Valve Remover/Replacer
	SA9127E Gage Bar Set
	SA9140E Torque Angle Gage

	SA9178NE-A Dial Bore Gage
	SA9179NE Dial Indicator
	SA9187NE Cylinder Ridge Reamer