2004 ENGINE

Engine Mechanical - 2.2L (L61) - Classic

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 Bearing Carrier to Block Bolt	10 N.m	89 lb in
Balance Shaft Chain Guide Bolt	10 N.m	89 lb in
Balance Shaft Chain Guide - Adjustable - 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	66 lb ft
Connecting Rod Bolt		
• First Pass	25 N.m	18 lb ft
• Final Pass	100 degrees	
Coolant Air Bleed Hose Fitting	15 N.m	11 lb ft
Crankshaft Bearing - Lower Crankcase to Block		
• 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
E.G.R. Cover Bolt	25 N.m	18 lb in
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
EVAP Emission Canister Valve Nut	22 N.m	16 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
Flywheel Bolt		
• First Pass	53 N.m	39 lb ft
• Final Pass	25 degrees	
Flywheel to Torque Converter Bolt	62 N.m	46 lb ft
• Final Pass	25 degrees	
Front Cover to Block Bolt	25 N.m	18 lb ft
Fuel Pipe Bracket Bolt	10 N.m	89 lb in
Fuel Rail Bracket Stud	10 N.m	89 lb in
Generator to Block Bolt	23 N.m	17 lb ft
Heat Shield to Exhaust Manifold Bolt	23 N.m	17 lb ft
Intake Camshaft Rear Bearing 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 Bolt	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 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 - Rear - 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 Bolt	25 N.m	18 lb ft
Spark plug	20 N.m	15 lb ft

Starter Motor to Block Bolt	53 N.m	39 lb ft
Thermostat Housing to Block Bolts	10 N.m	89 lb in
Throttle Body Bolt	10 N.m	89 lb in
Throttle Body Nut	10 N.m	89 lb in
Throttle Body Stud	6 N.m	53 lb in
Timing Chain Guide - Adjustable - Bolt	10 N.m	89 lb in
Timing Chain Guide - Fixed - Bolt	10 N.m	89 lb in
Timing Chain Guide - Upper - Bolt	10 N.m	89 lb in
Timing Chain Oil Nozzle Bolt	10 N.m	89 lb in
Transmission Bellhousing Bolt	90 N.m	66 lb ft
Transmission Brace Bolt	72 N.m	53 lb ft
Vent Tube to Cylinder Head	15 N.m	11 lb ft
Water Jacket Drain Plug	20 N.m	15 lb ft
Water Pipe Support Bracket	10 N.m	89 lb in
Water Pipe Support Bracket Bolt	10 N.m	89 lb in
Water Pump Access Cover Bolt	7 N.m	62 lb in
Water Pump/Balance Shaft Chain Tensioner Bolt	10 N.m	89 lb in
Water Pump Bolts	25 N.m	18 lb ft
Water Pump Sprocket Bolt	10 N.m	89 lb in

ENGINE MECHANICAL SPECIFICATIONS

Engine Mechanical Specifications

Application	Specification	
	Metric	English
General Data		
• Engine Type	Inline 4 Cylinder	
• Displacement	2.2 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		
• Camshaft End Play	0.040-0.144 mm	0.0016-0.0057 in
• Camshaft Journal Diameter	26.935-26.960 mm	1.0604-1.0614 in
• Camshaft Thrust Surface	21.000-21.052 mm	0.8268-0.8252 in
Connecting Rod		
• Connecting Rod Bearing Clearance	0.029-0.069 mm	0.0011-0.0027 in
• Connecting Rod Bore Diameter - Bearing End	52.118-52.134 mm	2.0519-2.05252 in
• Connecting Rod Bore Diameter - Pin End	20.007-20.021 mm	0.7877-0.7882 in
• Connecting Rod Side Clearance	0.070-0.370 mm	0.0028-0.0146 in
• Connecting Rod Straightness - Bend - Maximum	0.021 mm	0.0083 in
• Connecting Rod Straightness - Twist - Maximum	0.04 mm	0.0157 in
Crankshaft		
• Connecting Rod Journal Diameter	49.000-49.014 mm	1.9291-1.9297 in
• 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

• Valves - Valve Stem Diameter - Exhaust	5.935-5.950 mm	0.2337-0.2343 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	GM Part Number	
		United States	Canada
# 6 Intake Rear Camshaft Cap	Sealant	1052942	10953466
Balance Shaft Bearings	Engine Oil	5 W 30 or equivalent	5 W 30 or equivalent
Block to Bedplate Joint	Sealant	12346286	10953477
Cam Lobes	Engine Oil	5 W 30 or equivalent	5 W 30 or equivalent
Crank Sensor O-ring	Engine Oil	5 W 30 or equivalent	5 W 30 or equivalent
Cylinder Bores	Engine Oil	5 W 30 or equivalent	5 W 30 or equivalent
Cylinder Head Plugs	Sealant	12345382	10953489
Engine Block Threaded Plugs	Sealant	12346004	10953480
Engine Block to Bedplate	Sealant	12346286	10953472
Engine Oil	5.5 quarts	5 W 30 or equivalent	5 W 30 or equivalent
Engine Oil Level Indicator Tube O-rings	Lubricant	12345501	992704
Fuel Injector O-rings	Engine Oil	5 W 30 or equivalent	5 W 30 or equivalent
Intake and Exhaust Valve Stems	Lubricant	12345501	992704
Main Bearings	Engine Oil 5 W 30 or equivalent	12345501	992704
Oil Filter Cap - Threads and O-ring Lead-in Chamfers	Engine Oil	5 W 30 or equivalent	5 W 30 or equivalent
Oil Pan to Bedplate Joint	Sealant	12346286	10953472

Oil Pump - Pump Elements	Engine Oil	5 W 30 or equivalent	5 W 30 or equivalent
Piston Pin to Piston/Rod - Pin Bores of Piston and Rod	Engine Oil	5 W 30 or equivalent	5 W 30 or equivalent
Rod Bearings - Rod Pins of Crankshaft	Engine Oil	5 W 30 or equivalent	5 W 30 or equivalent
Stationary Hydraulic Lash Adjusters	Engine Oil	12345501	992704
Timing Chain Guide Bolt Access Hole Plug	Sealant	12345382	10953489
Valve Rocker Arm/Valve Tip	Engine Oil Supplement	12345501	992704
Water Feed Tube O-rings	Lubricant	Antifreeze	Antifreeze

THREAD REPAIR SPECIFICATIONS

Engine Block - Front View

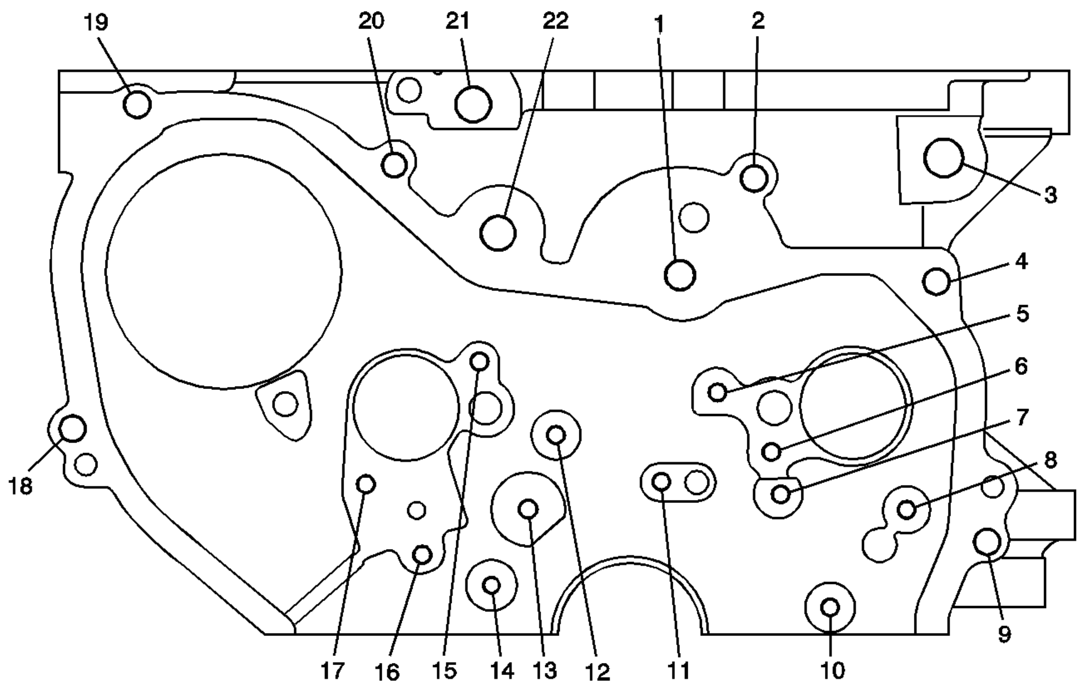


Fig. 1: Engine Block - Front View
Courtesy of GENERAL MOTORS CORP.

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

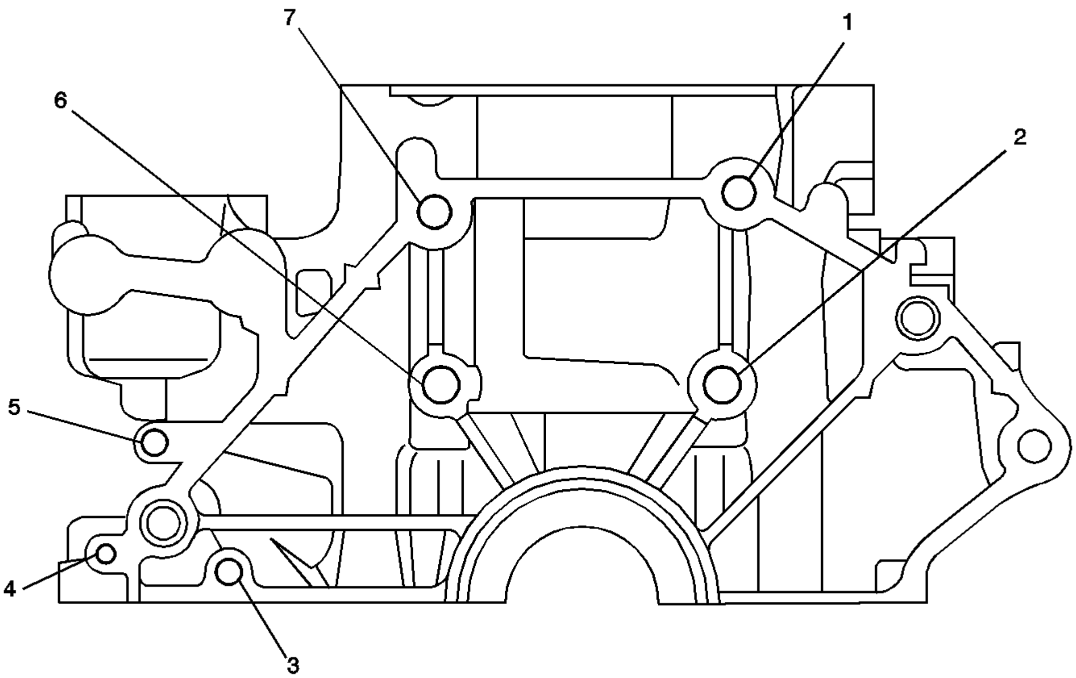


Fig. 2: Engine Block - Back View
Courtesy of GENERAL MOTORS CORP.

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

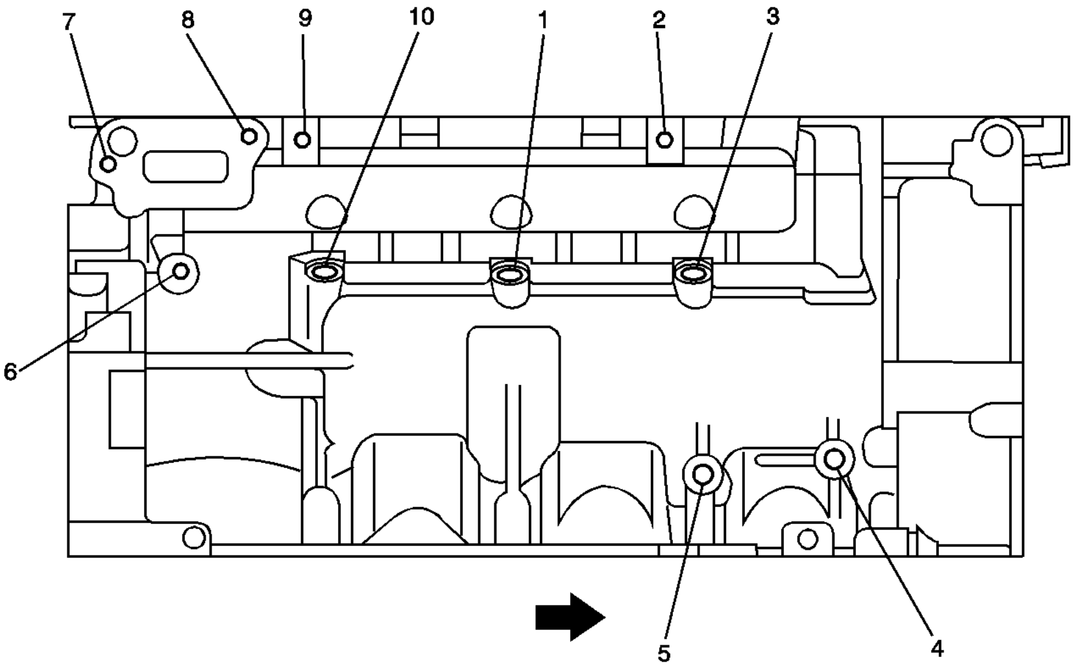


Fig. 3: Engine Block - Left Side View
Courtesy of GENERAL MOTORS CORP.

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

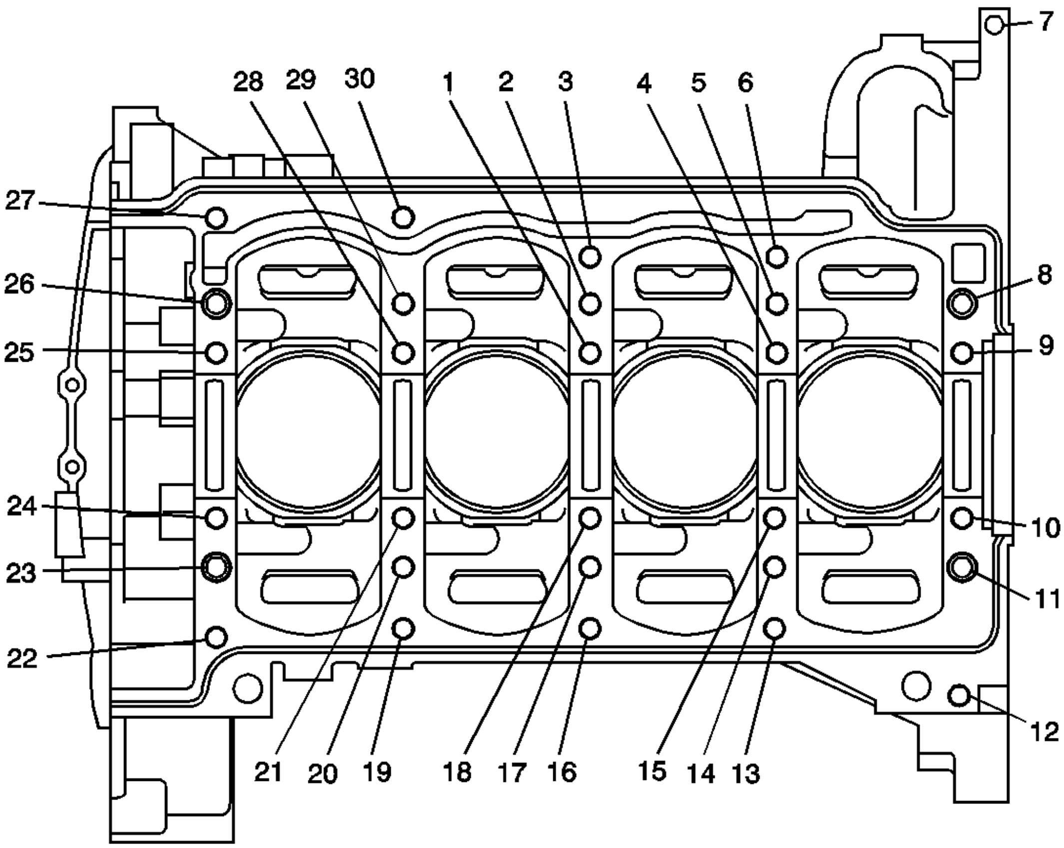


Fig. 4: Engine Block - Bottom View
Courtesy of GENERAL MOTORS CORP.

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 1.5	514	511	N/A	512	513	60	2.362	53.5	2.11
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
27	M8 x 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

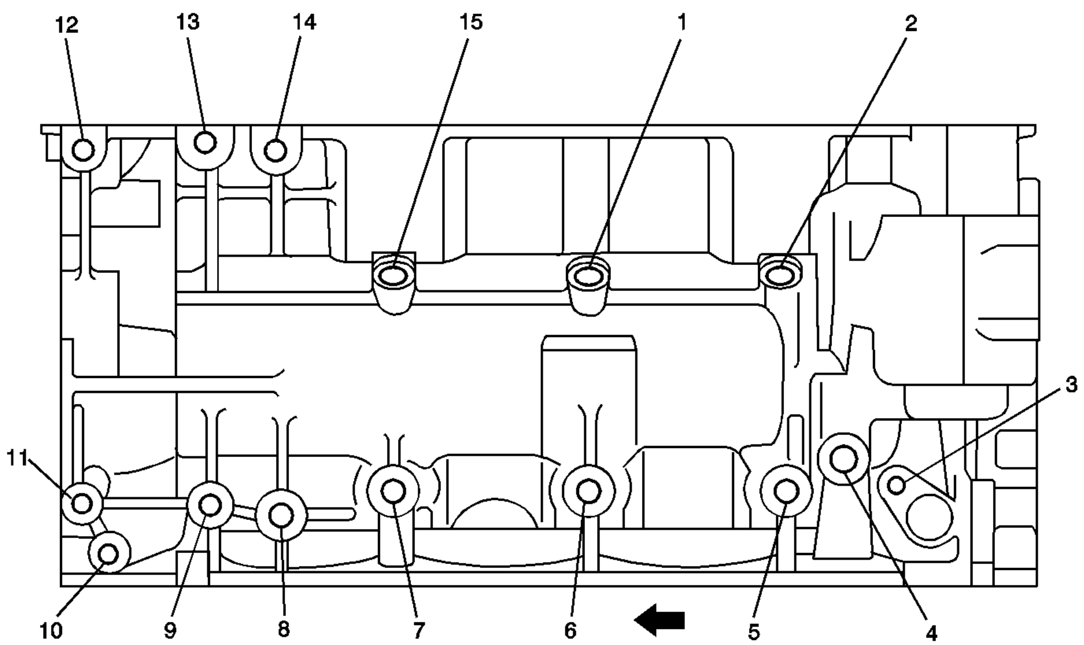


Fig. 5: Engine Block - Right Side View
Courtesy of GENERAL MOTORS CORP.

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

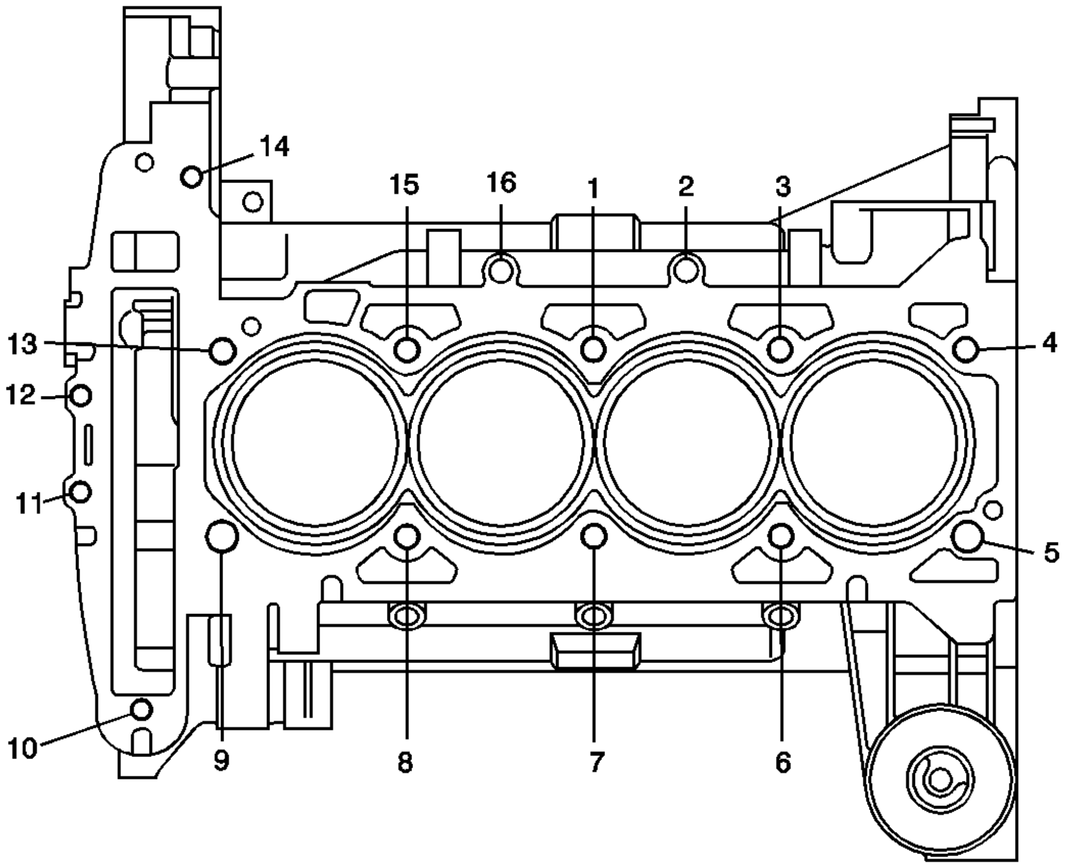


Fig. 6: Engine Block - Top View
Courtesy of GENERAL MOTORS CORP.

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

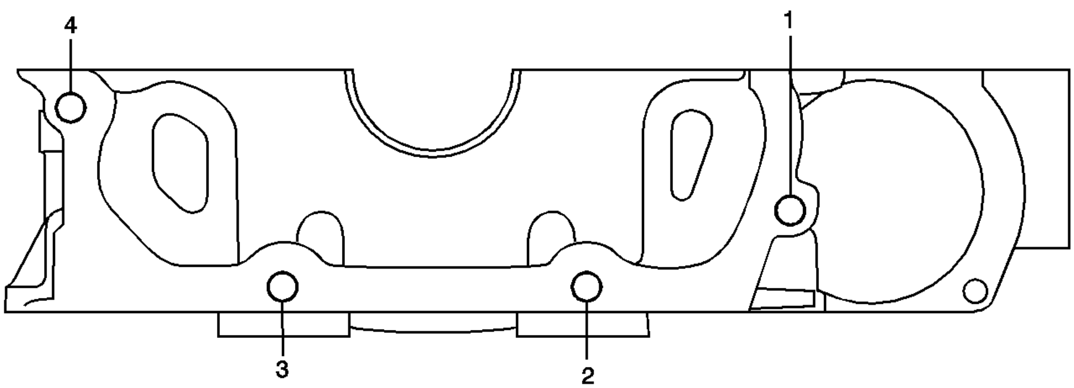


Fig. 7: Lower Crankcase - Front View
Courtesy of GENERAL MOTORS CORP.

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

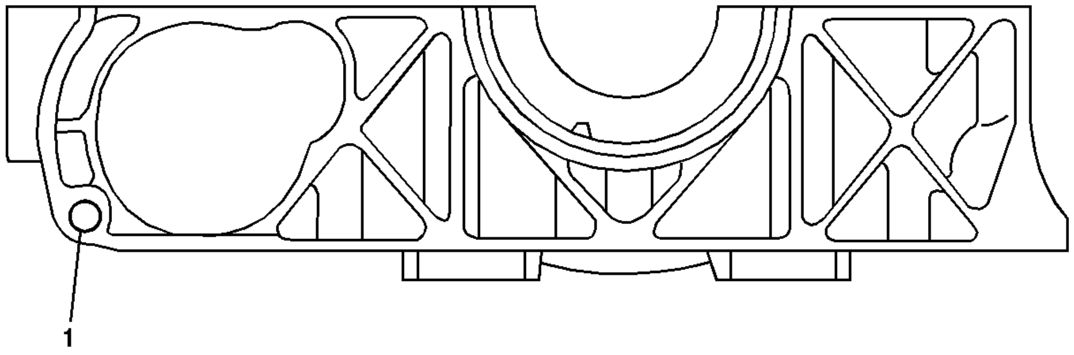


Fig. 8: Lower Crankcase - Back View
Courtesy of GENERAL MOTORS CORP.

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

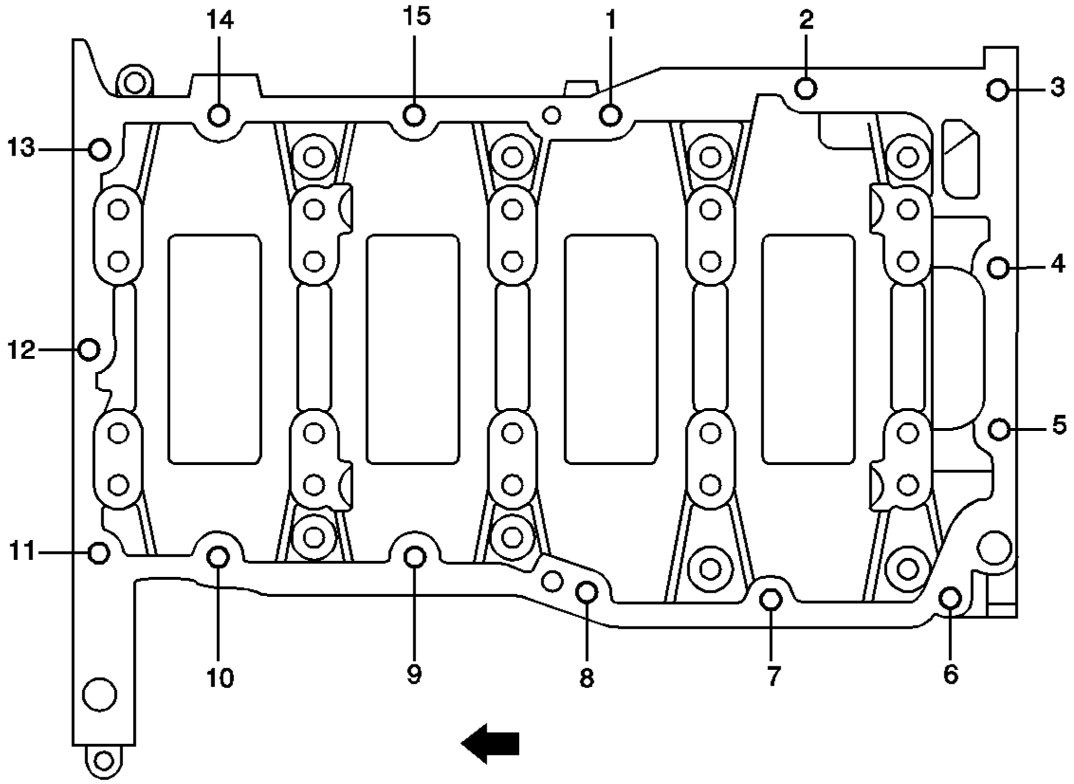


Fig. 9: Lower Crankcase - Bottom View
Courtesy of GENERAL MOTORS CORP.

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
7	M8 x 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

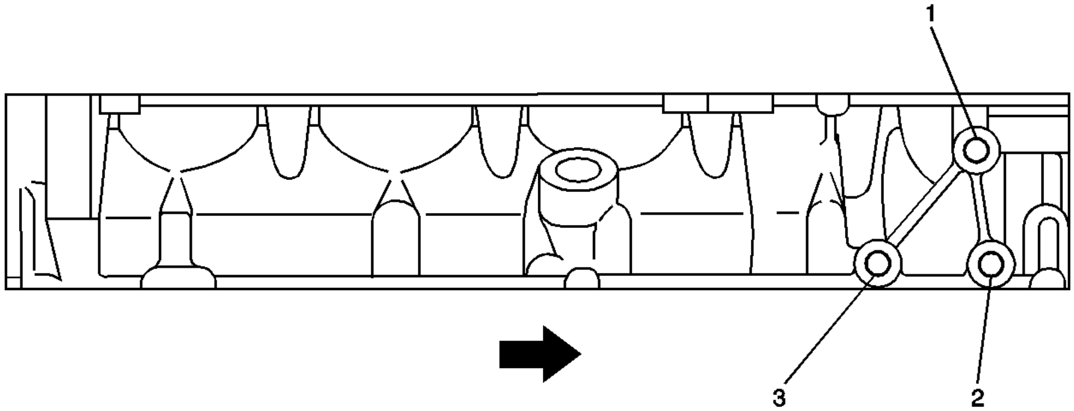


Fig. 10: Lower Crankcase - Left View
Courtesy of GENERAL MOTORS CORP.

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
2	M10 x 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

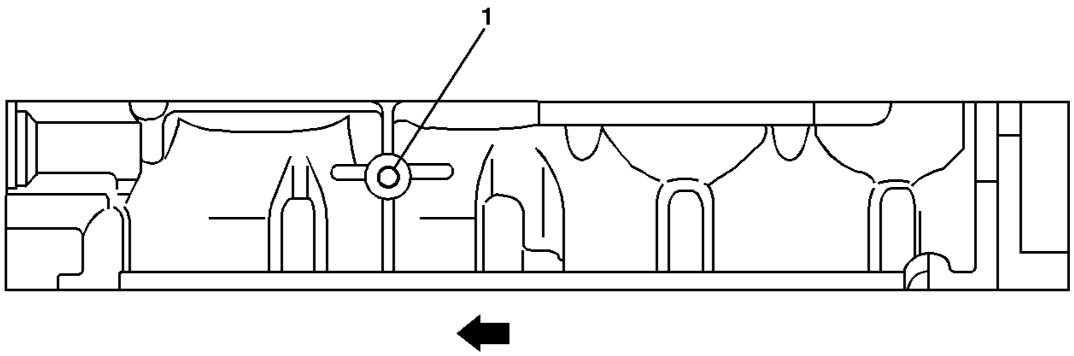


Fig. 11: Lower Crankcase - Right View
Courtesy of GENERAL MOTORS CORP.

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

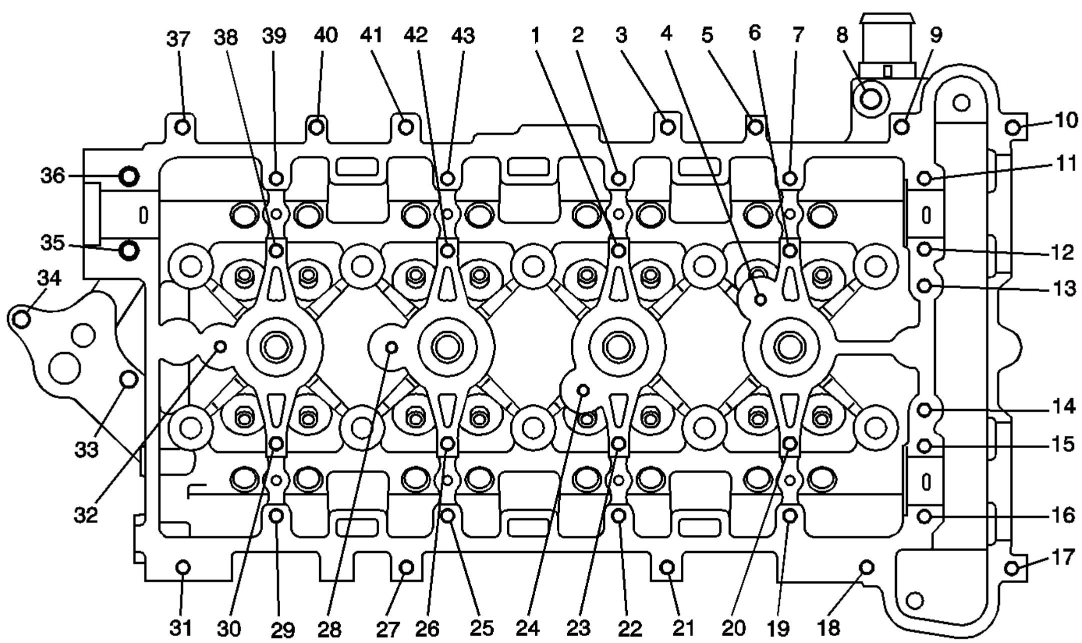


Fig. 12: Cylinder Head - Top View

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

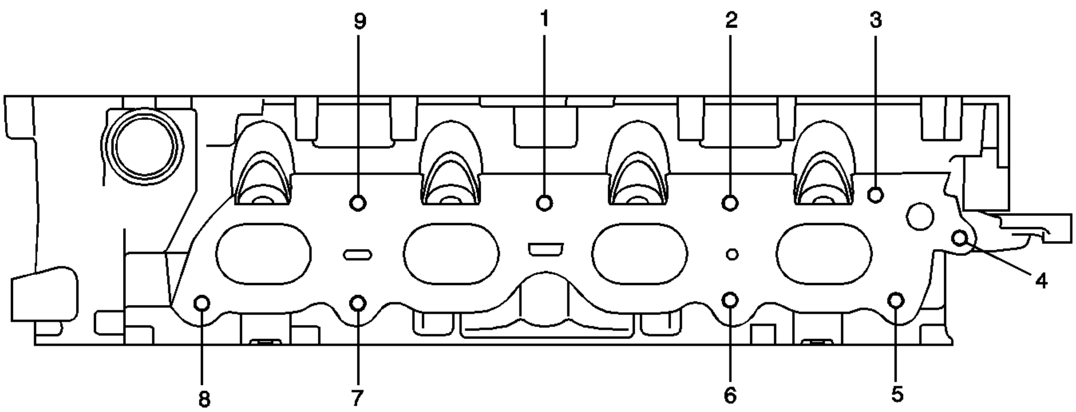


Fig. 13: Cylinder Head - Intake Manifold Deck View
Courtesy of GENERAL MOTORS CORP.

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

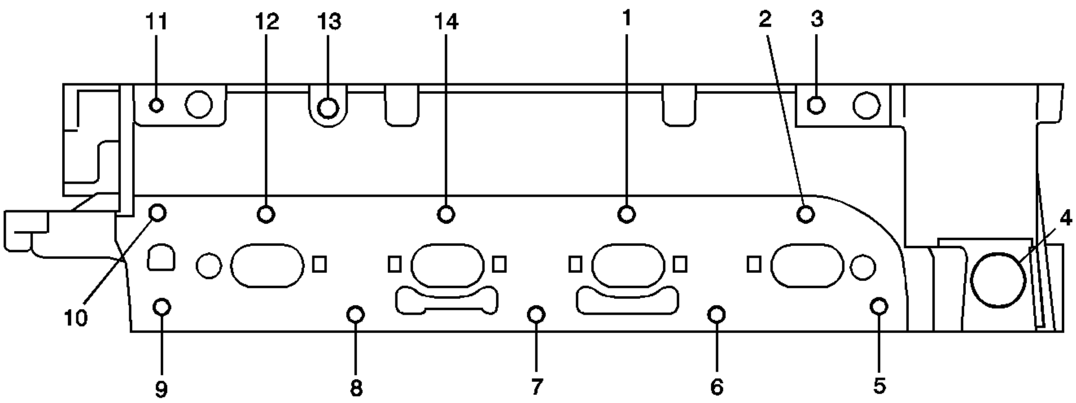


Fig. 14: Cylinder Head - Exhaust Manifold Deck View
Courtesy of GENERAL MOTORS CORP.

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

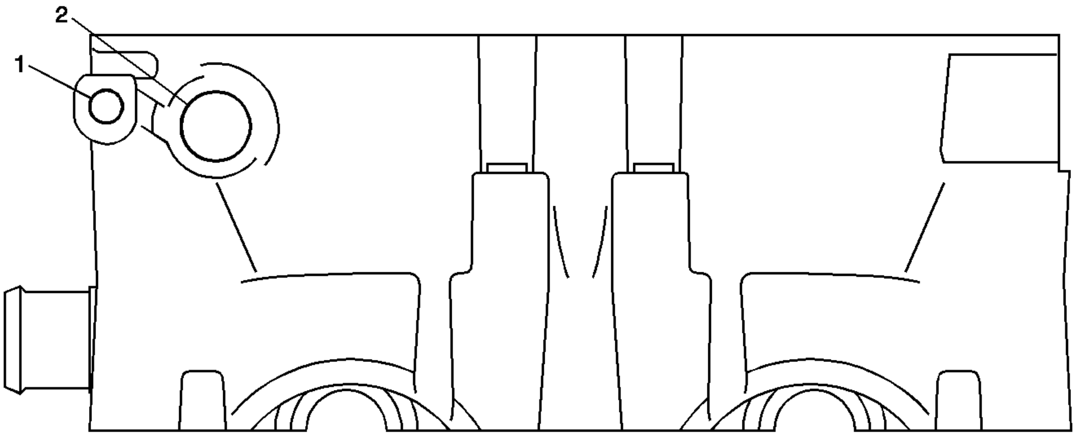


Fig. 15: Cylinder Head - Front View
Courtesy of GENERAL MOTORS CORP.

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

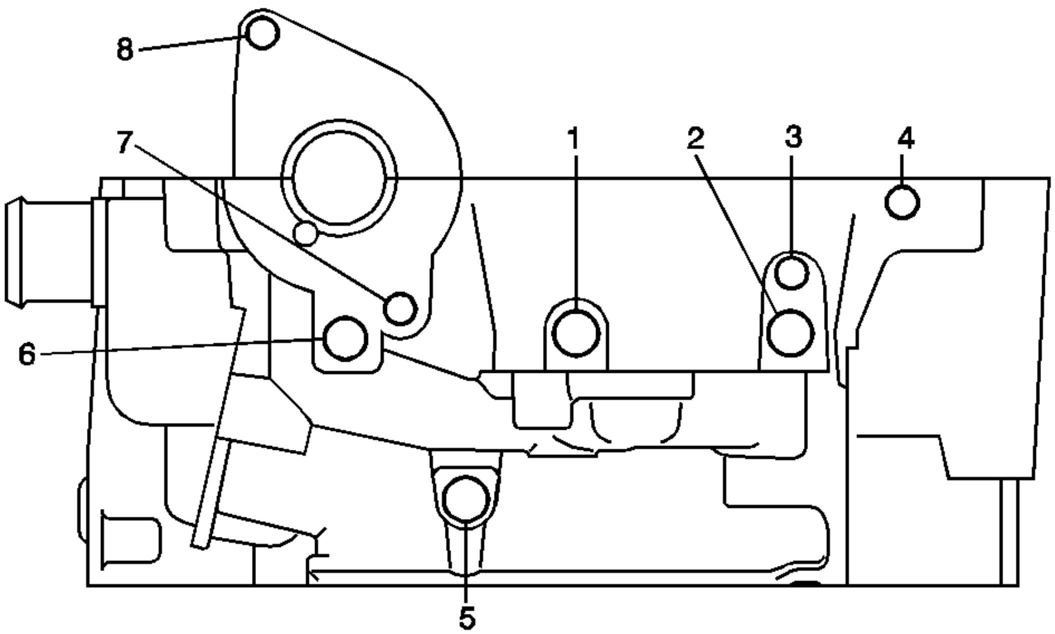


Fig. 16: Cylinder Head - Back View
Courtesy of GENERAL MOTORS CORP.

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 Flange	206	207	208	209	25	0.984	THRU	

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

Cylinder Head - Bottom View

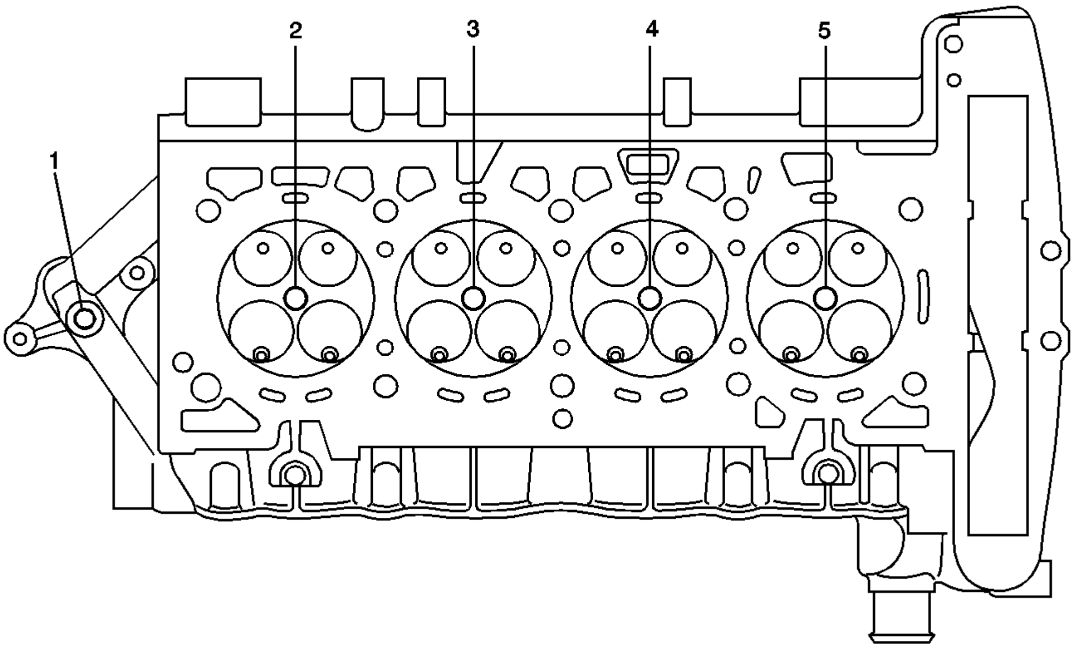


Fig. 17: Cylinder Head - Bottom View
Courtesy of GENERAL MOTORS CORP.

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

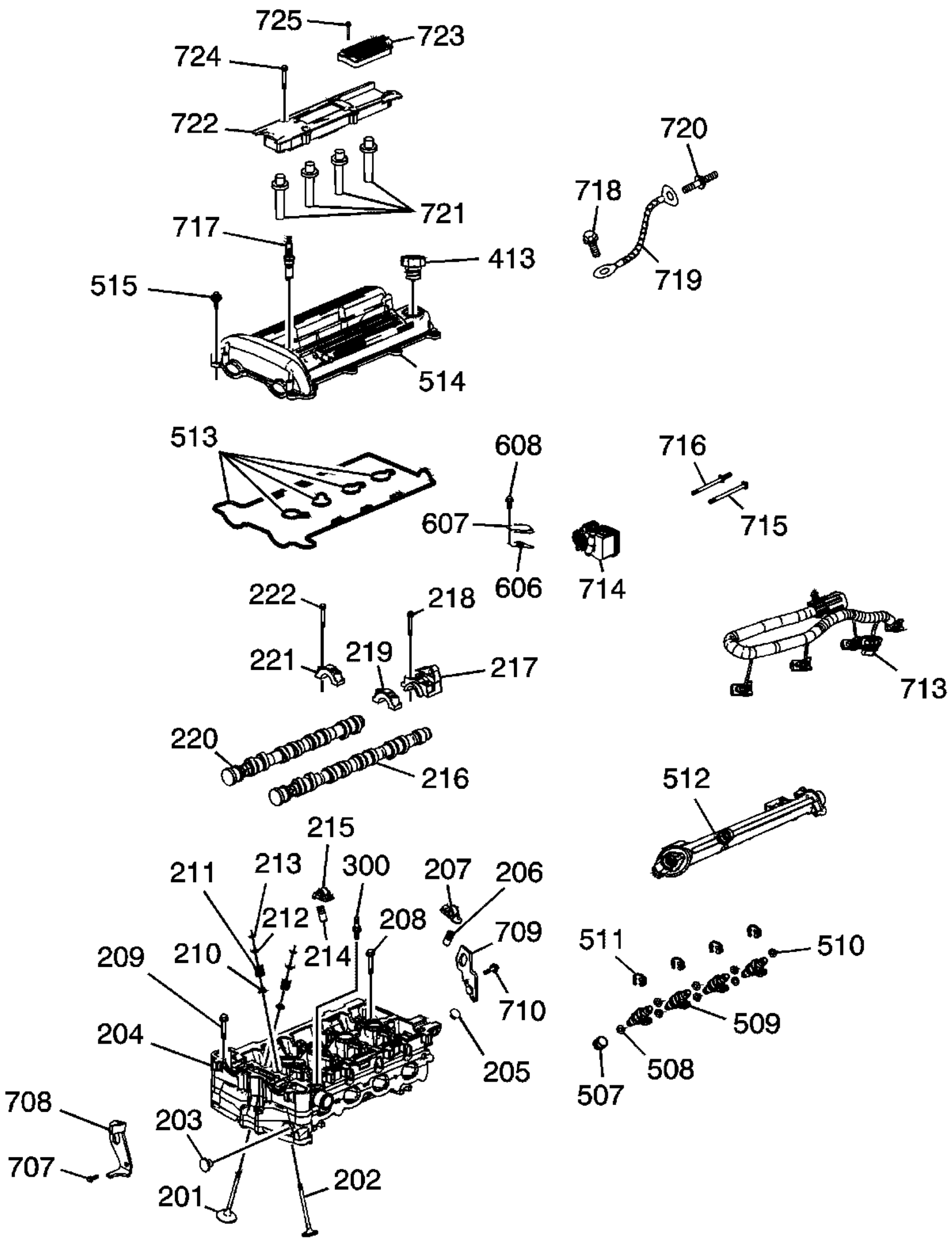


Fig. 18: Cylinder Head and Components
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
201	Exhaust Valve

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

	Power Steering Pump Bolt
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

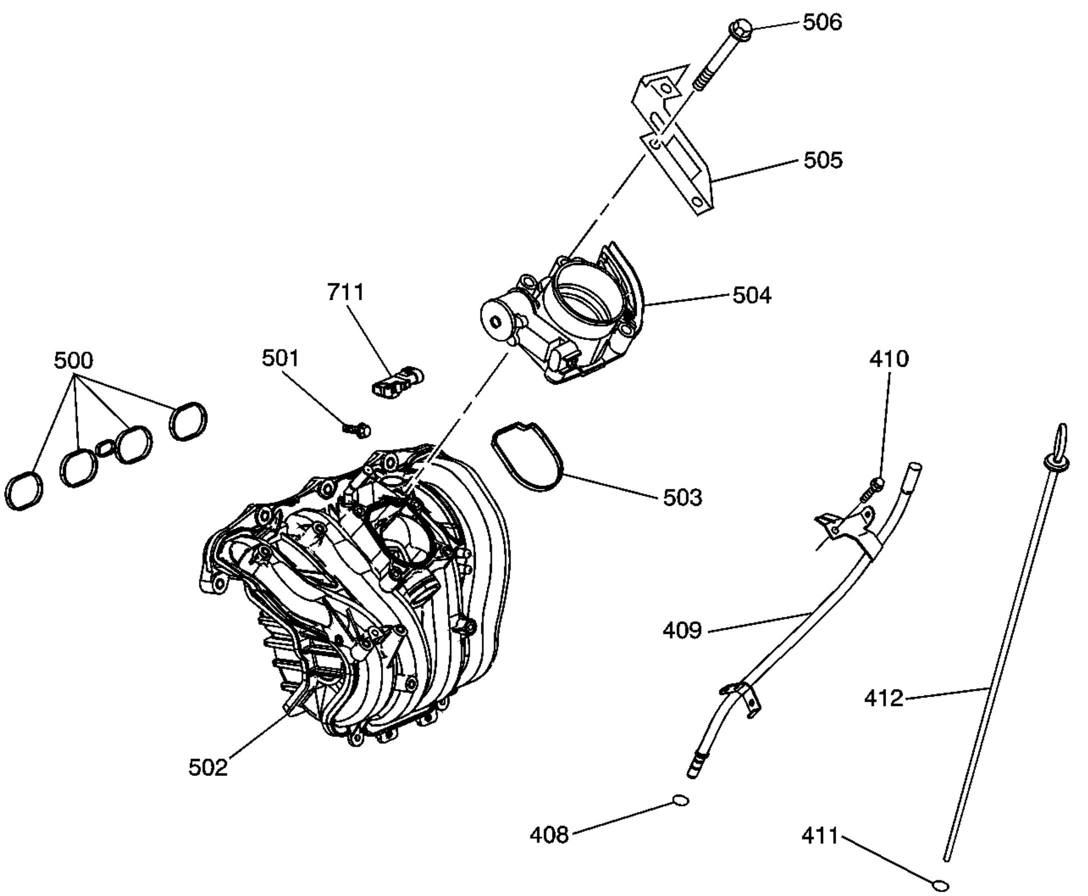


Fig. 19: Intake Manifold and Components
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
408	Oil Indicator Tube O-ring

409	Oil Indicator Tube
410	Oil Indicator Tube Bolt
411	Oil Indicator O-ring
412	Oil Indicator
500	Intake Manifold Gasket
501	Intake Manifold Bolt
502	Intake Manifold
503	Throttle Body Seal
504	Throttle Body
505	Accelerator Control Cable Bracket
506	Throttle Body Bolt
711	Map Sensor

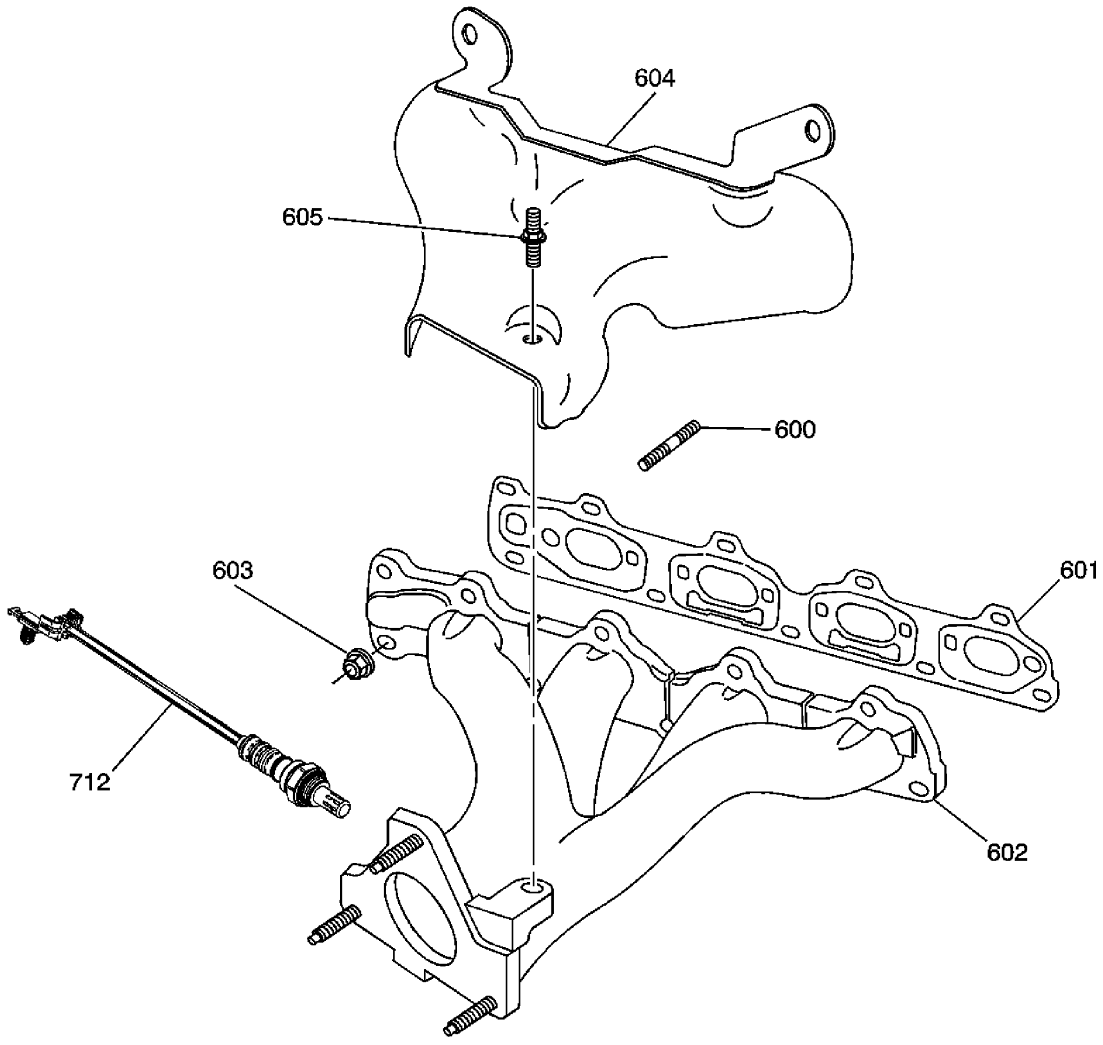


Fig. 20: Exhaust Manifold and Components

Courtesy of GENERAL MOTORS CORP.

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

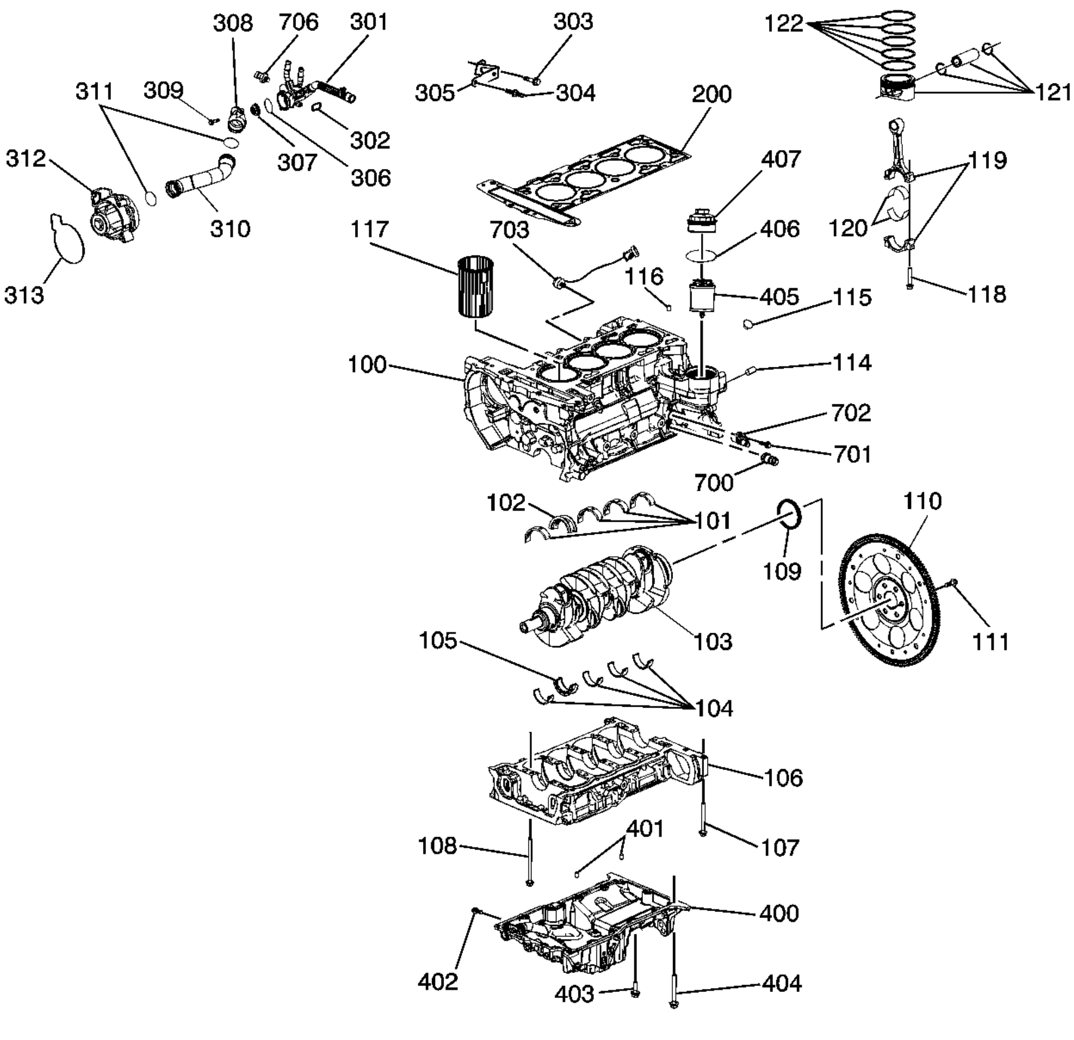


Fig. 21: Engine Block and Components
Courtesy of GENERAL MOTORS CORP.

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

	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

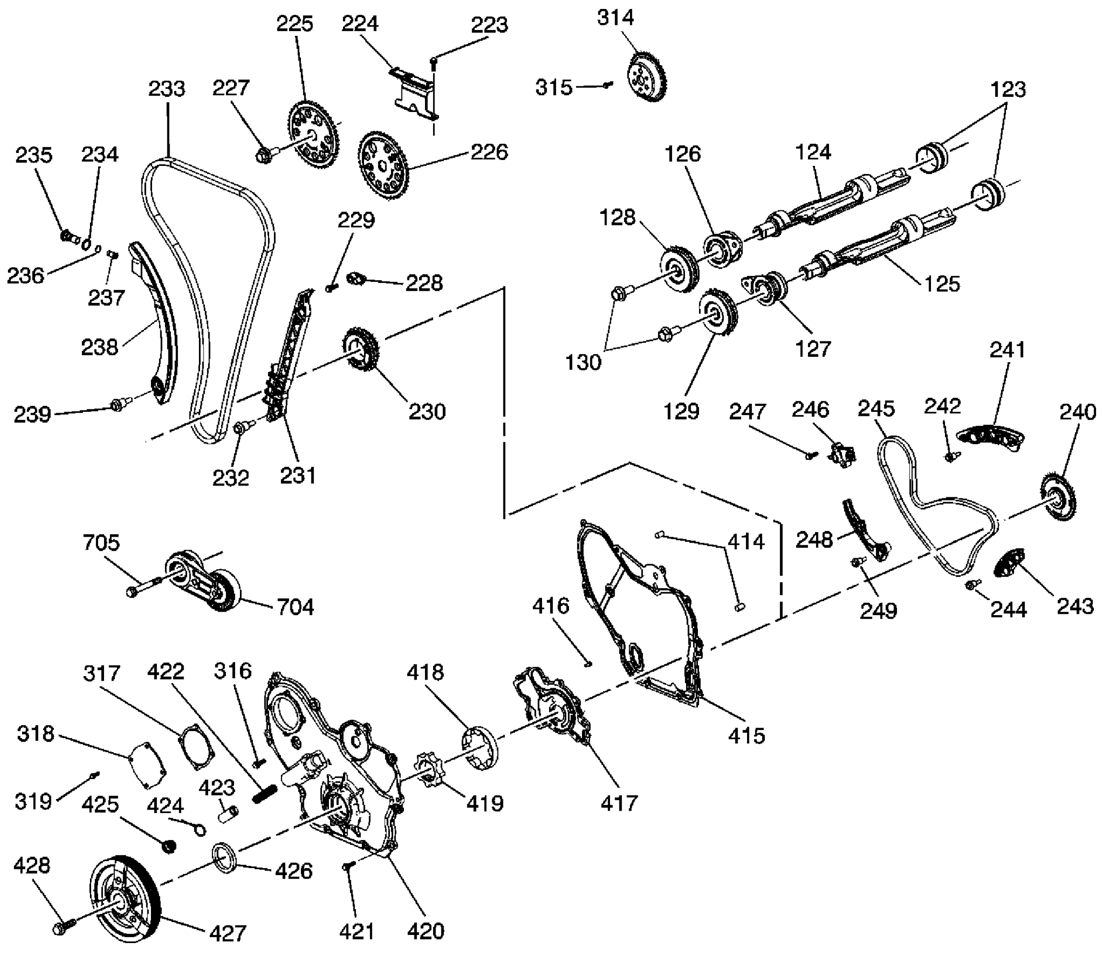


Fig. 22: Timing Chain and Components
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
123	Balance Shaft Rear Bearing
124	Exhaust Balance Shaft
125	Intake Balance Shaft
126	Exhaust Balance Shaft Bearing Carrier

127	Intake Balance Shaft Bearing Carrier
128	Exhaust Balance Shaft Drive Sprocket
129	Intake Balance Shaft Drive Sprocket
130	Balance Shaft Drive Sprocket Bolts
223	Upper Timing Chain Guide Bolt
224	Upper Timing Chain Guide
225	Exhaust Camshaft 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

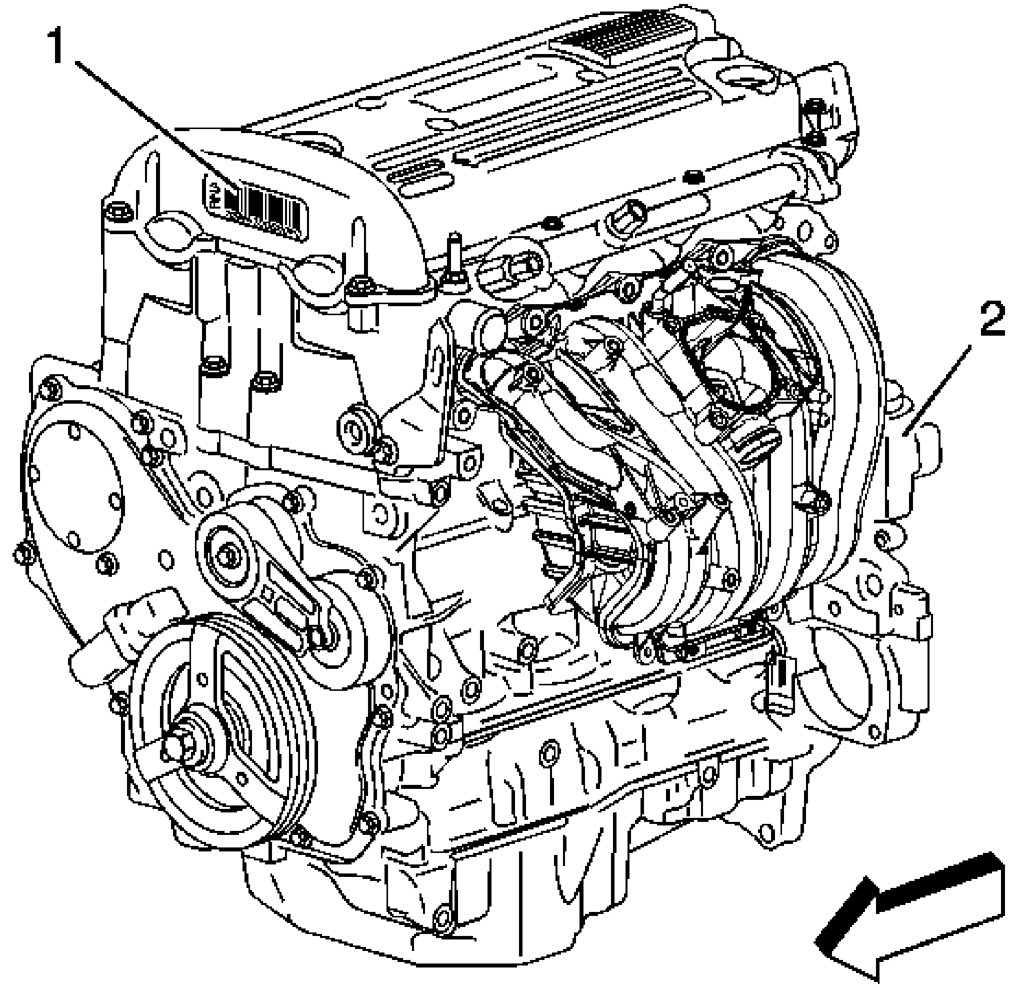


Fig. 23: Identifying Broadcast Code Label & Partial VIN
Courtesy of GENERAL MOTORS CORP.

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).

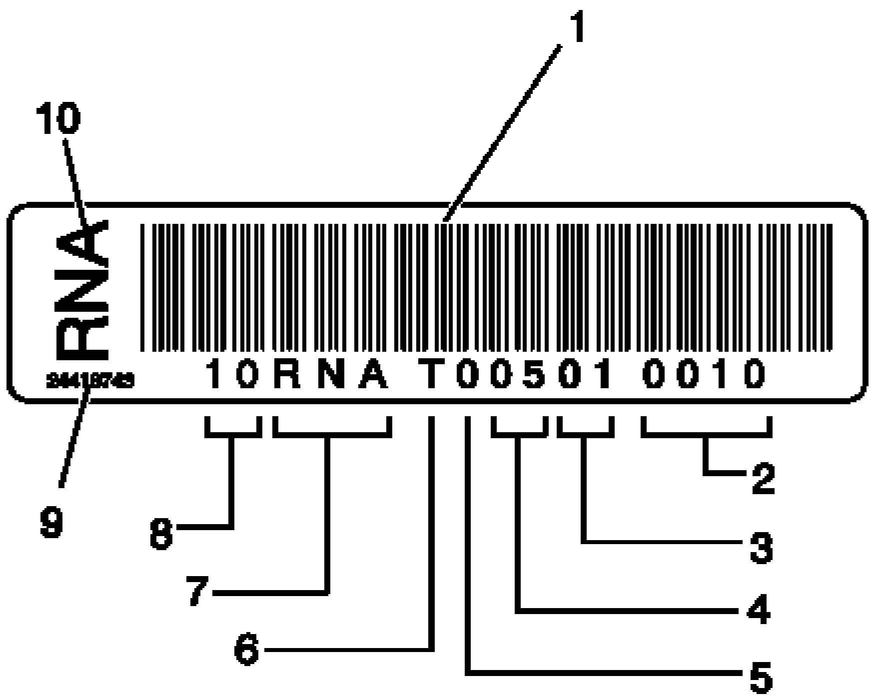


Fig. 24: View Of Broadcast Code Label
Courtesy of GENERAL MOTORS CORP.

- 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**, **Engine Component Description**, Drive Belt System Description, **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 A Diagnostic System Check 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**, **Engine Component Description**, and **Lubrication Description**.

All diagnosis on a vehicle should follow a logical process. Strategy based diagnostics is a uniform approach for repairing all systems. The diagnostic flow may always be used in order to resolve a system problem. 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 switch, and severe reluctor ring damage may cause additional pulses and effect fuel and spark delivery to the point of generating a P0300 DTC or P0336.	Replace the sensor and/or crankshaft as required.

BASE ENGINE MISFIRE WITH ABNORMAL INTERNAL LOWER ENGINE NOISES

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. See **Special Tools and Equipment**.

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. See **Special Tools and Equipment**.

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. See **Special Tools and Equipment**.
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-21867-850 Oil Pressure Gage Adapter. See **Special Tools and Equipment**.

- 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-21867-850** 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**
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**
	Clean the drive belt pulleys with a suitable wire brush.		

5	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 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**
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 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:
  o Pilling, the accumulation of rubber dust that forms small balls or strings in the drive belt pulley groove
  o The separation of the drive belt
  o 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 (2.2L - L61)** 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.			
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 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

Tools Required

J 23600-B Belt Tension Gauge. See **Special Tools and Equipment**.

1. Run the engine, with no accessories on, until the engine is warmed up. Shut the engine off and read the belt tension using the **J 23600-B** placed halfway between the generator and the power steering pump. Note the reading and remove the **J 23600-B** . See **Special Tools and Equipment**.
2. Start the engine with the accessories off and allow the system to stabilize for 15 seconds. Turn the engine off. Using a 15 mm socket, apply clockwise force (tighten) to the tensioner pulley bolt. Release the force and immediately take a tension reading without disturbing belt tensioner position.
3. Using the same wrench, apply a counterclockwise force to the tensioner pulley bolt and raise the pulley to eliminate all tension. Slowly lower the pulley to the belt and take a tensioner reading without disturbing the belt tensioner position.
4. Average the three readings. If the average of the three readings is not between 133-222 N (30-50 lb) and the bolt is within the tensioners operating range, replace the tensioner.

REPAIR INSTRUCTIONS

ON-VEHICLE REPAIR INSTRUCTIONS

Drive Belt Replacement

Removal Procedure

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
2. Remove the front fender liner. Refer to **Front Fender Liner Replacement** .

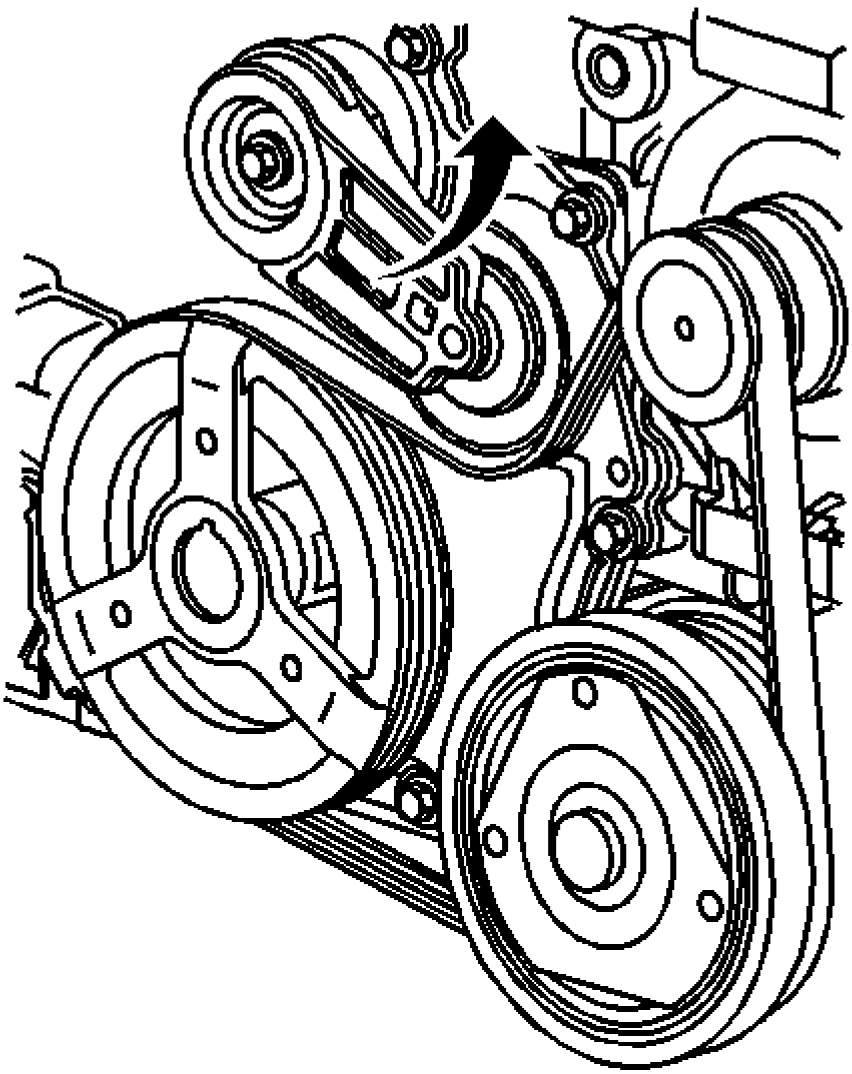


Fig. 25: View of Drive Belt Routing And Tensioner
Courtesy of GENERAL MOTORS CORP.

3. Rotate the drive belt tensioner counterclockwise to release the spring tension.
4. Remove the drive belt.

Installation Procedure

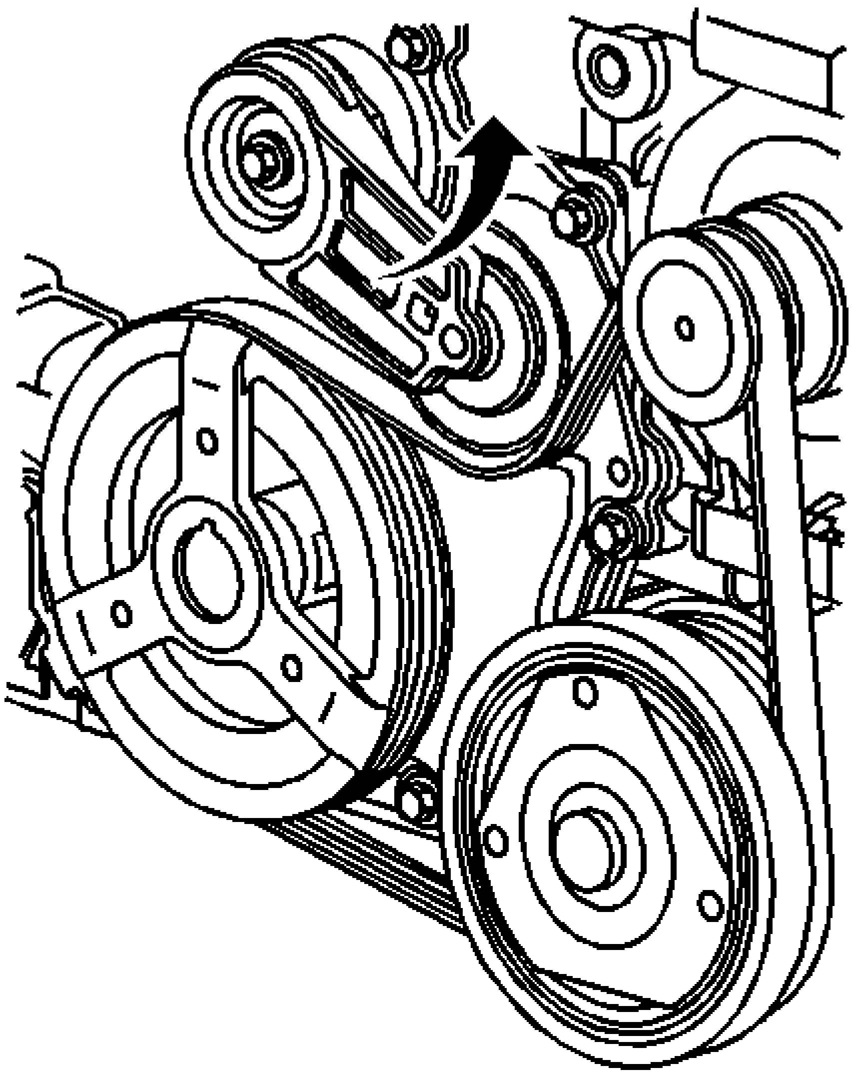


Fig. 26: View of Drive Belt Routing And Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Rotate the drive belt tensioner counterclockwise to release the spring tension.
2. Install the drive belt.
3. Install the front fender liner. Refer to **Front Fender Liner Replacement** .
4. Lower the vehicle.

Drive Belt Tensioner Replacement

Tools Required

J 45025 . See **Special Tools and Equipment**.

Removal Procedure

1. Remove the drive belt. Refer to **Drive Belt Replacement**.

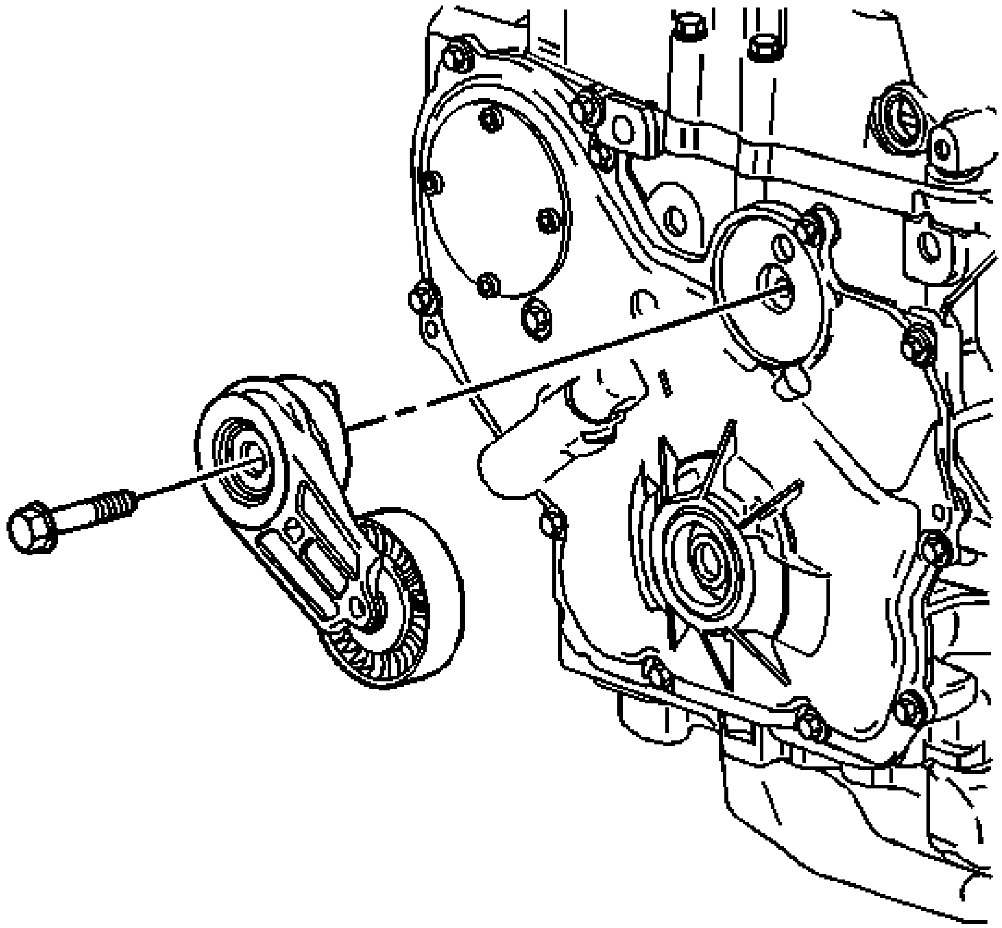


Fig. 27: View Of Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

2. Remove the drive belt tensioner bolt.
3. Remove the drive belt tensioner.

Installation Procedure

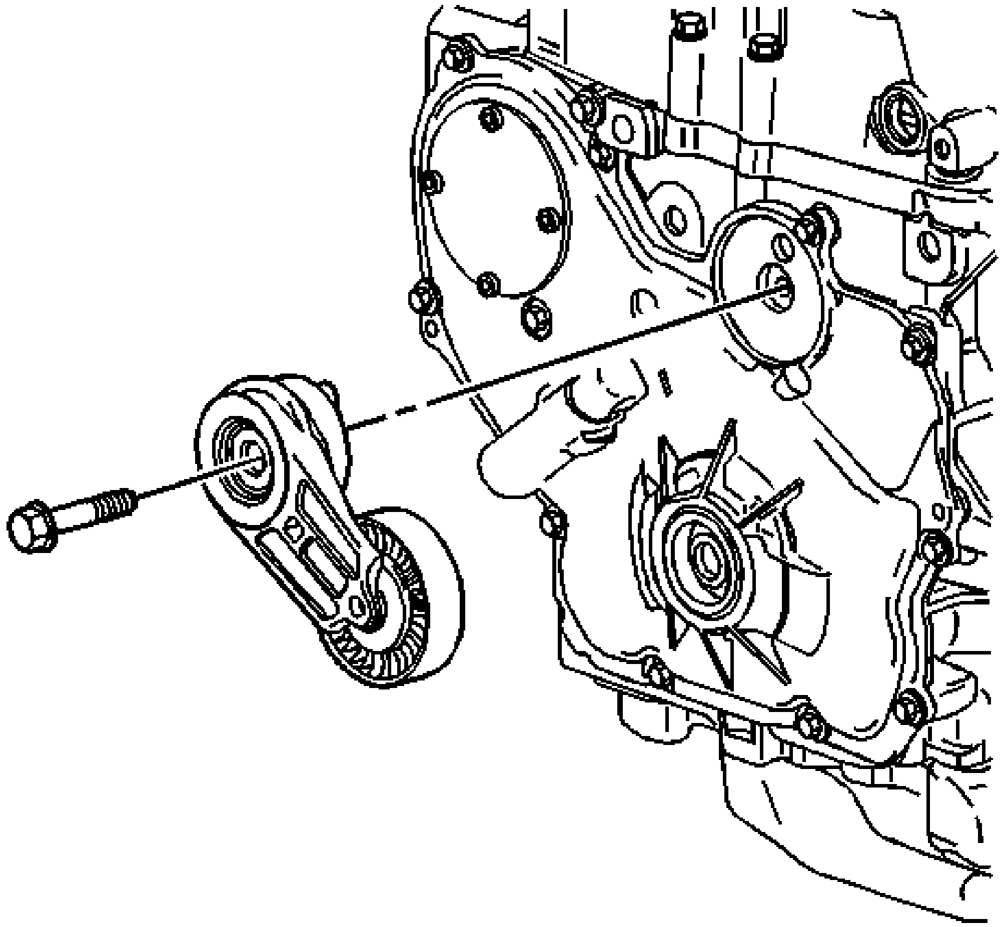


Fig. 28: View Of Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Install the drive belt tensioner.

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

IMPORTANT: **In order to obtain the proper torque when using any torque wrench adapter you must use the following formula: Pre-set Torque = Torque Wrench Length x Torque Desired divided by Torque Wrench Length + Extension Length.**

2. Install the drive belt tensioner bolt.

   Use a **J 45025** to tighten the drive belt tensioner bolt. See **Special Tools and Equipment**.

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

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

Engine Oil Pressure Sensor and/or Switch Replacement

Removal Procedure

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
2. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
3. Disconnect the engine oil pressure sensor electrical connector.

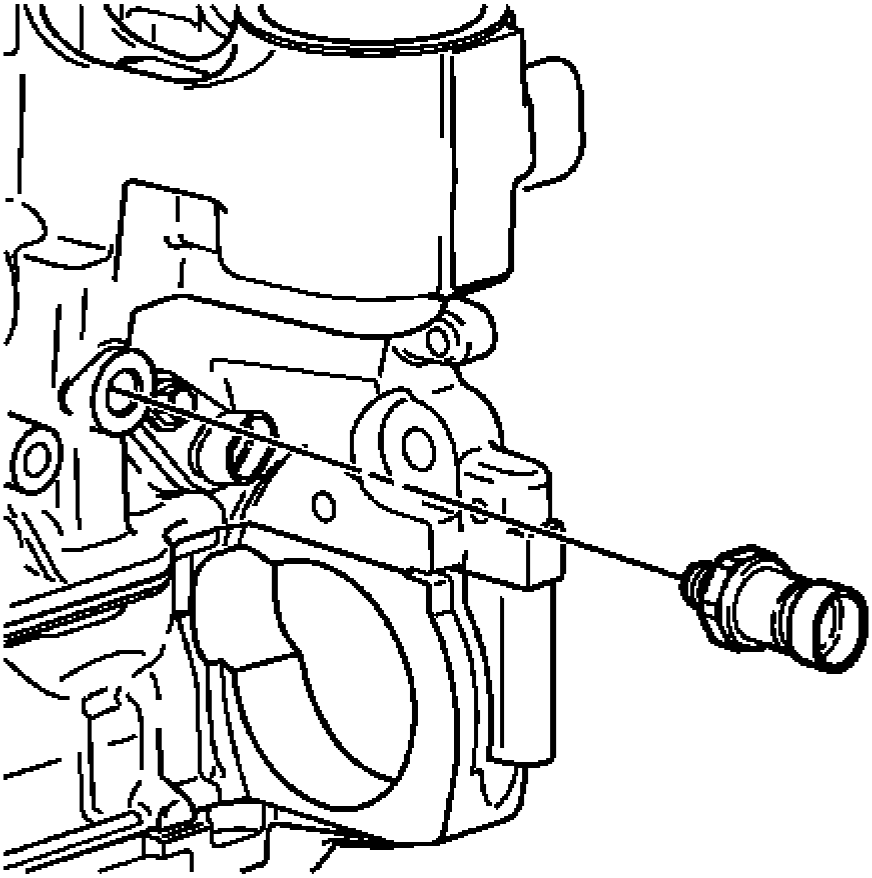


Fig. 29: View Of Engine Oil Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

4. Remove the engine oil pressure sensor.

Installation Procedure

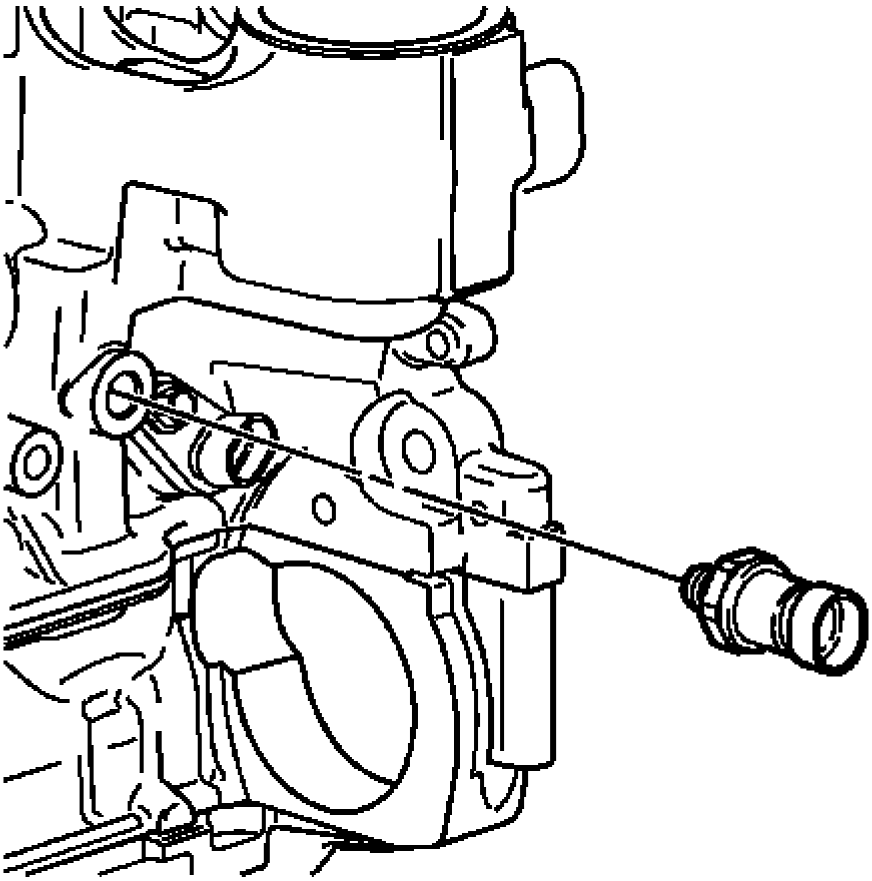


Fig. 30: View Of Engine Oil Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the engine oil pressure sensor.

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

2. Connect the engine oil pressure sensor electrical connector.
3. Lower the vehicle.
4. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.

Engine Mount Inspection

IMPORTANT: Torque axis mounting systems allow more engine movement than other mounting systems. The engine movement is the design intent of the mounting system. Do not replace the torque axis mounts unless the

mount or the rubber is damaged.

1. Raise the engine in order to apply slight tension on the engine mount.
2. Replace the engine mount if any of the following conditions exist:
   - The hard rubber surface is covered with heat cracks
   - The rubber is separated from the engine mount metal plate
   - The rubber is split through the center
3. Lower the engine.
4. Check the engine mount fastener torque.

Engine Mount Bracket Replacement

Removal Procedure

1. Remove engine mount. Refer to **Engine Mount Replacement**.

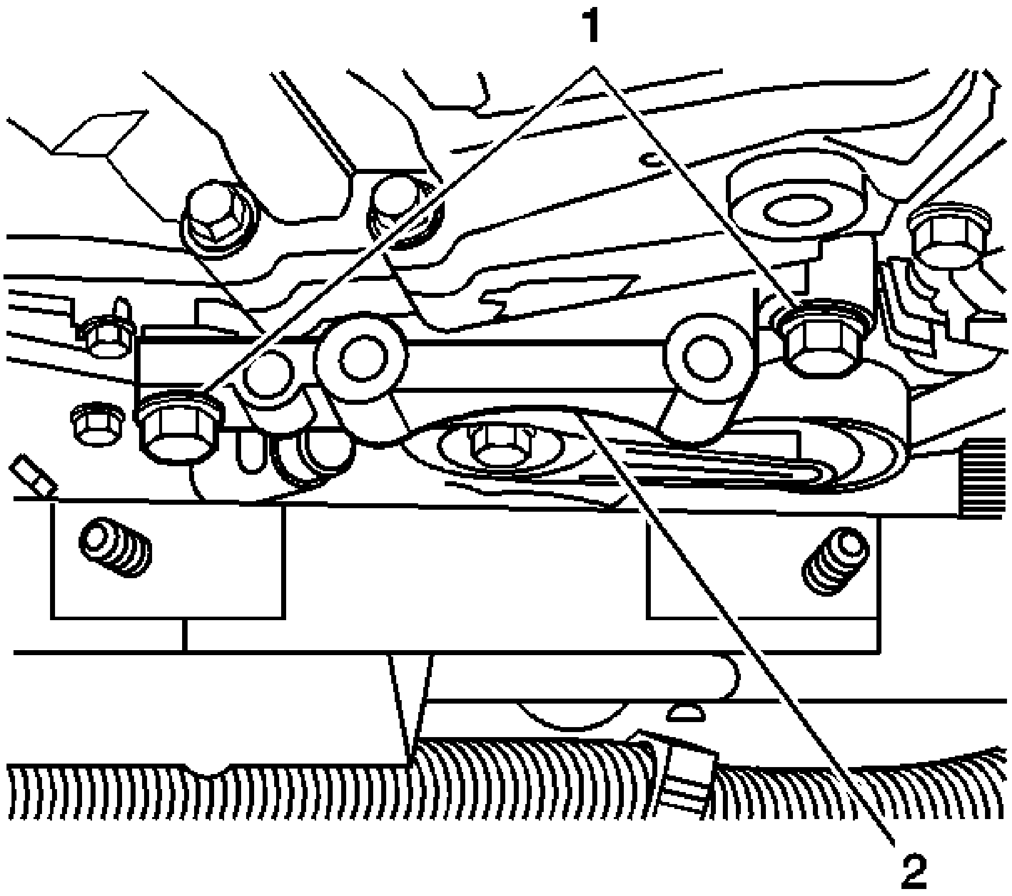


Fig. 31: Identifying Engine Mount Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

1. Install the engine mount bracket to the vehicle (2).

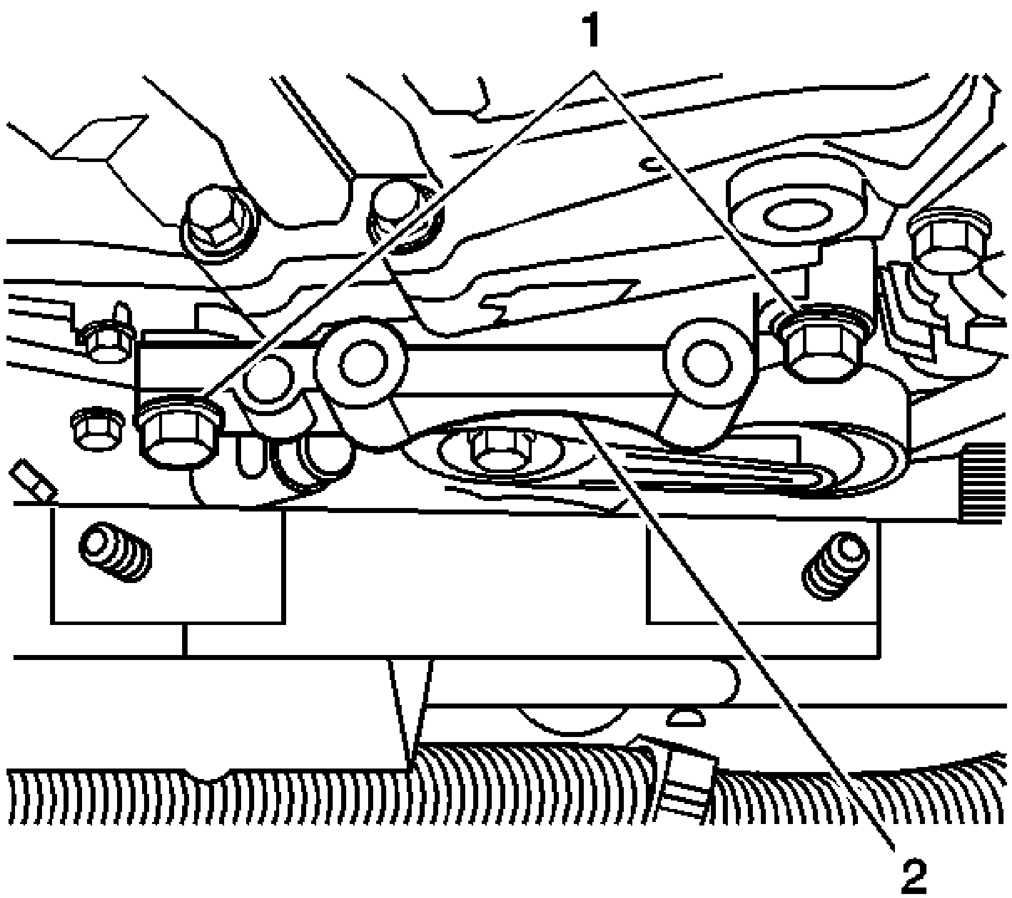


Fig. 32: Identifying Engine Mount Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

2. Install the engine mount bracket bolts (1).

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the engine mount bracket bolts.

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

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

Engine Mount Replacement

Removal Procedure

1. Remove the cruise control module. Refer to **Cruise Control Module Replacement** in Cruise Control.

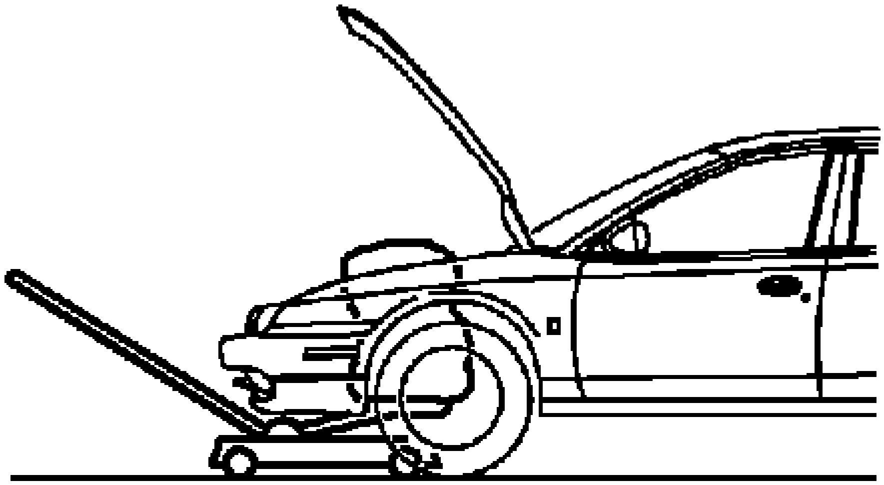


Fig. 33: View of Proper Engine Support
Courtesy of GENERAL MOTORS CORP.

2. Support the engine at the oil pan with a floor jack and a block of wood.

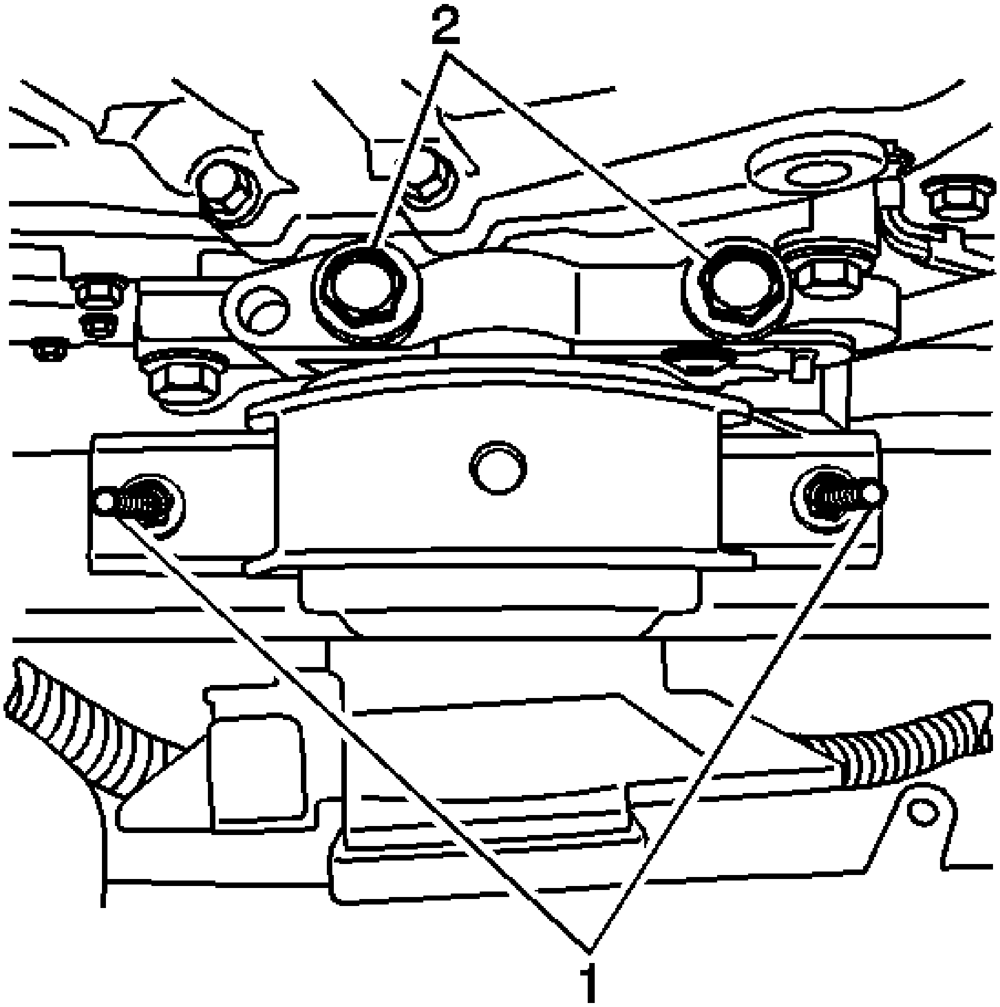


Fig. 34: Identifying Engine Mount Body Nuts & Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine mount to body nuts (1).
4. Remove the engine mount to bracket bolts (2).
5. Remove the engine mount.

Installation Procedure

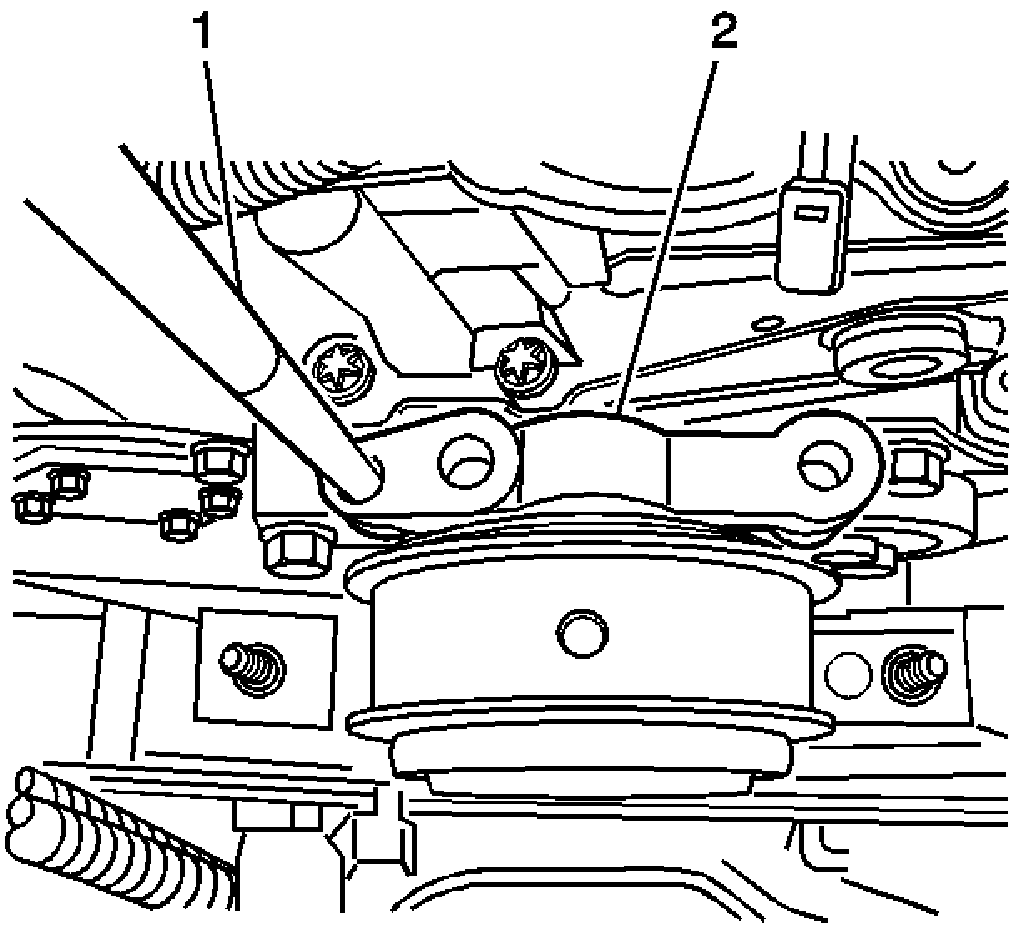


Fig. 35: View of Engine Mount Alignment
Courtesy of GENERAL MOTORS CORP.

1. Using a dowel (1), align the engine mount (2) to the engine mount bracket.

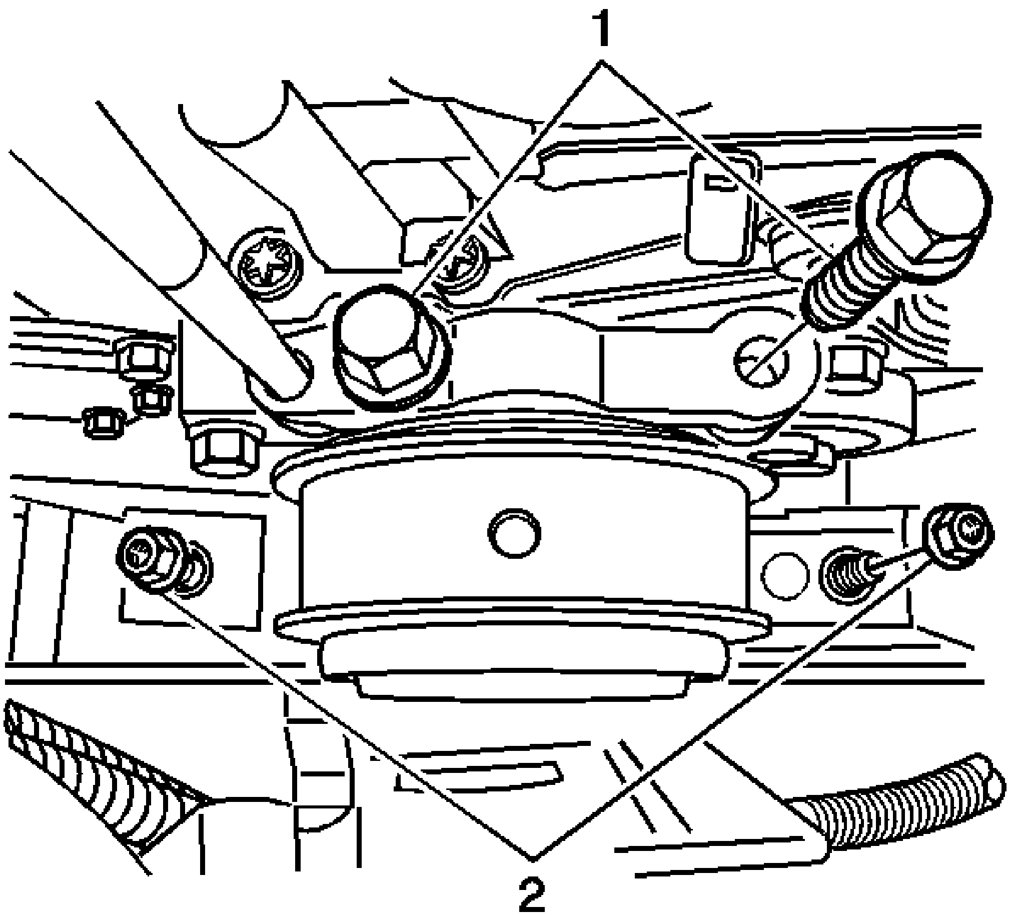


Fig. 36: Identifying Engine Mount Nuts
Courtesy of GENERAL MOTORS CORP.

2. Install the engine mount nuts (1).

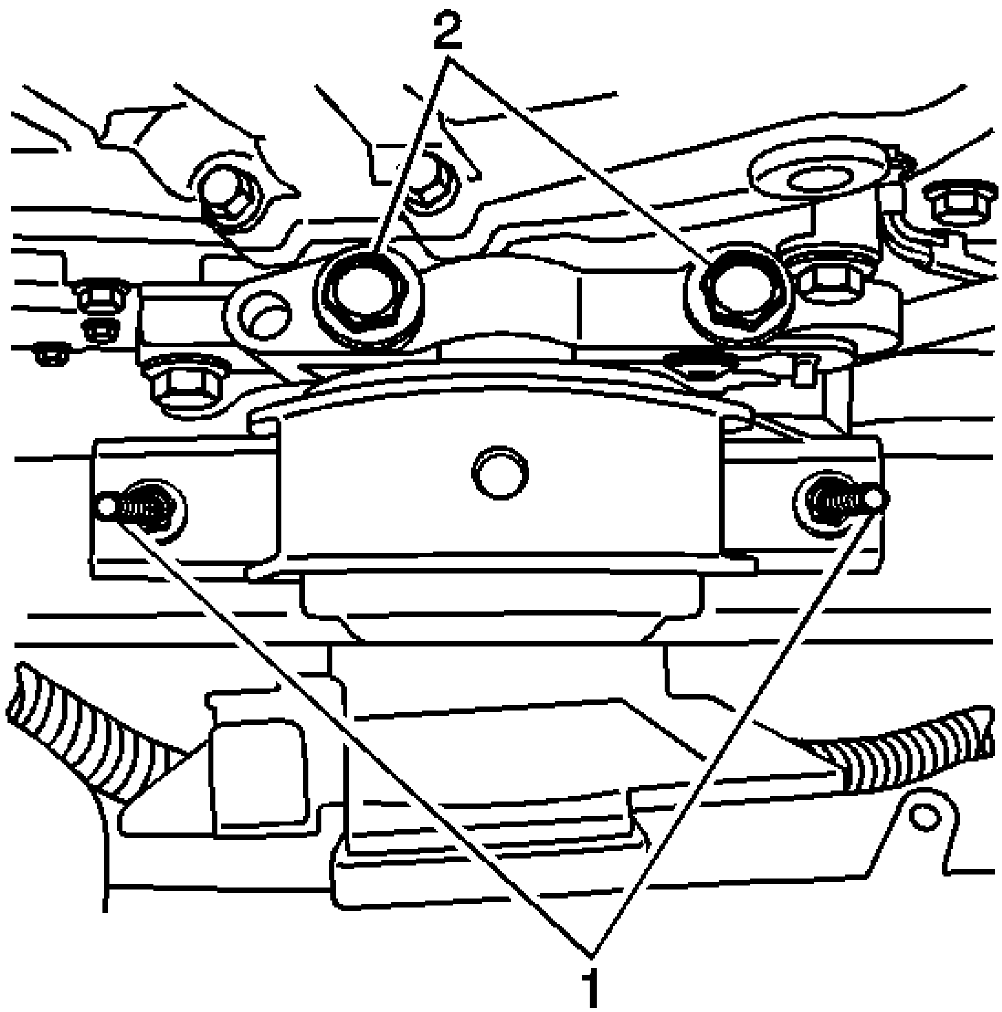


Fig. 37: Identifying Engine Mount Body Nuts & Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

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

3. Install the engine mount bolts (2).

Tighten:

- Tighten the engine mount nuts to 66 N.m (49 lb ft).
- Tighten the engine mount bolts to 110 N.m (81 lb ft).

4. Remove the cruise control module. Refer to **Cruise Control Module Replacement** in Cruise Control.

Engine Support Fixture

Tools Required

- **J 28467-B** Universal Engine Support Fixture. See **Special Tools and Equipment**.
- **J 42451** Engine Lift Bracket. See **Special Tools and Equipment**.
- **J-28467-501** Engine Support Fixture Adapters. See **Special Tools and Equipment**.

Installation Procedure

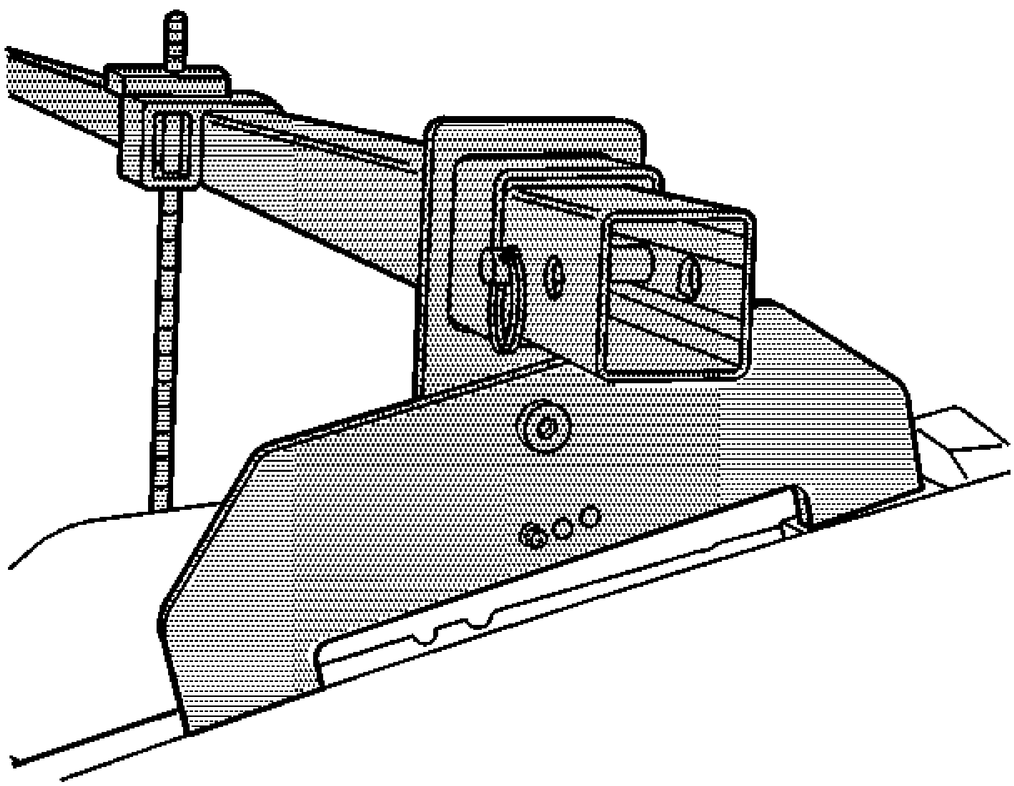


Fig. 38: View Of Engine Lift Bracket
Courtesy of GENERAL MOTORS CORP.

1. Install the **J 42451** to the right rear of the cylinder head. See **Special Tools and Equipment**.
2. Install the **J 28467-B** and **J-28467-501** to the vehicle. See **Special Tools and Equipment**.

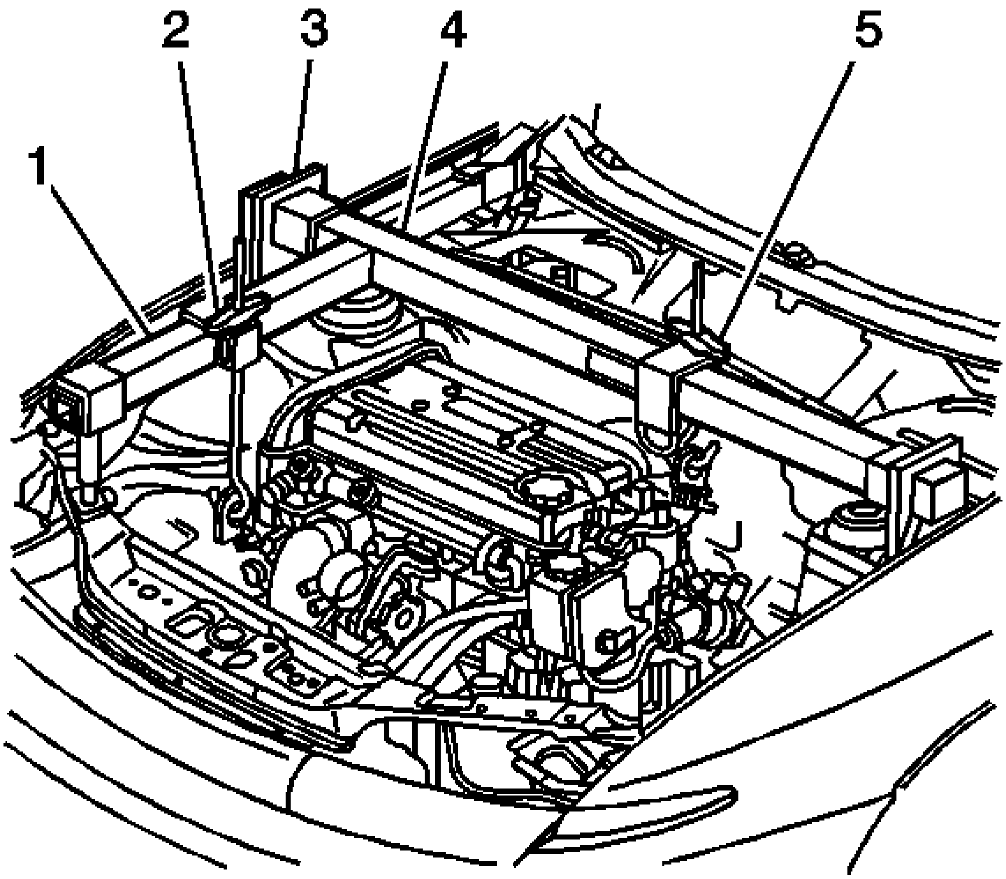


Fig. 39: Identifying J 28467-7 & J28467-8
Courtesy of GENERAL MOTORS CORP.

3. Install the J 28467-7 (2) to the engine front lift bracket.
4. Install the J 28467-8 (5) to the **J 42451** at the rear of the cylinder head. See **Special Tools and Equipment**.

Oil Level Indicator and Tube Replacement

Removal Procedure

1. Remove the air cleaner outlet resonator. Refer to **Air Cleaner Outlet Resonator Replacement** in Engine Controls 2.2L (L61).
2. Unclip the electrical wiring harness from the oil level indicator tube.

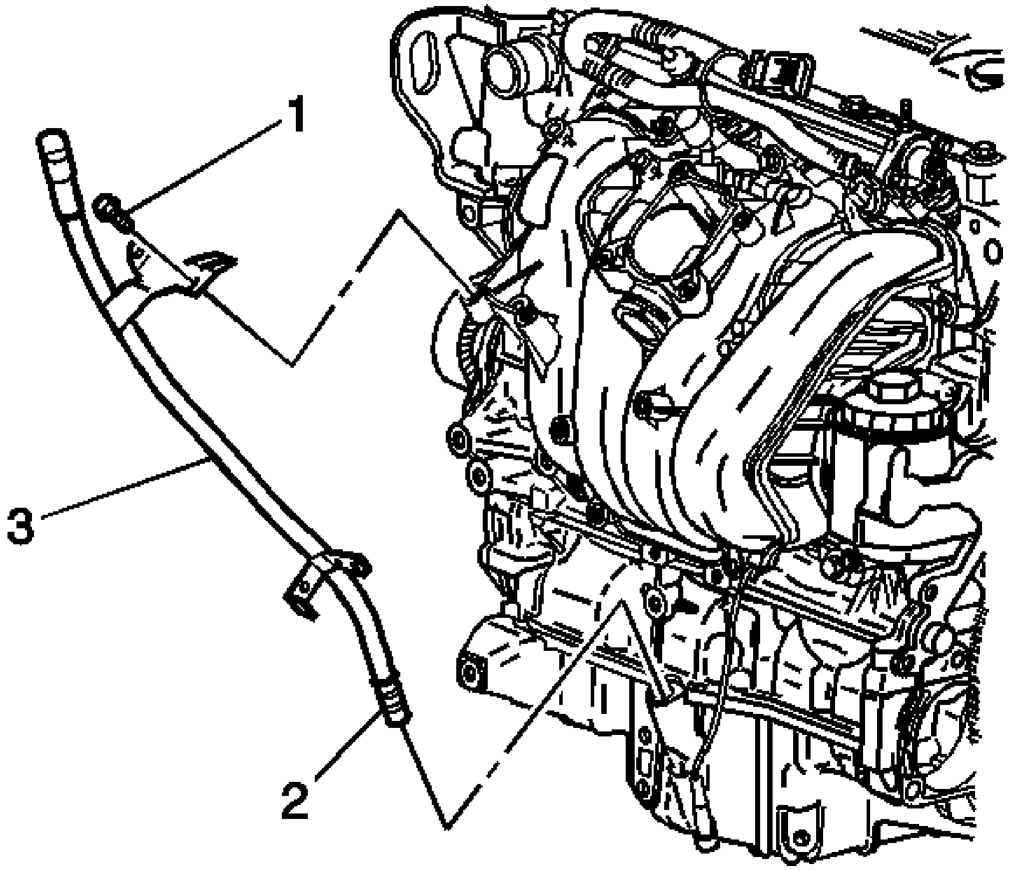


Fig. 40: View of Oil Level Indicator
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil level indicator tube bolt (1).
4. Remove the oil level indicator tube (3).
5. Remove the oil level indicator tube seal (2).

Installation Procedure

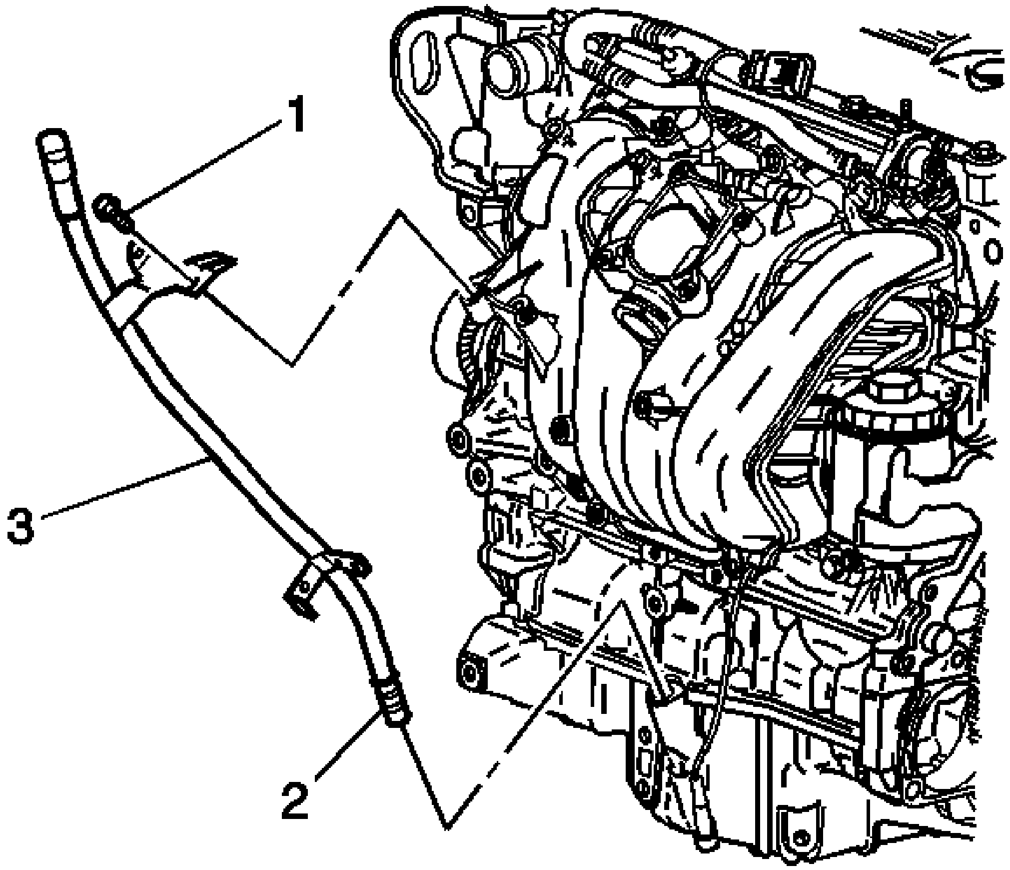


Fig. 41: View of Oil Level Indicator
Courtesy of GENERAL MOTORS CORP.

1. Install the oil level indicator tube seal (2).
2. Install the oil level indicator tube (3).
3. Clip the electrical wiring harness to the oil level indicator tube.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the oil level indicator tube bolt (1).

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

5. Install the air cleaner outlet resonator. Refer to **Air Cleaner Outlet Resonator Replacement** in Engine Controls 2.2L (L61).

Crankcase Ventilation Hoses/Pipes Replacement

Removal Procedure

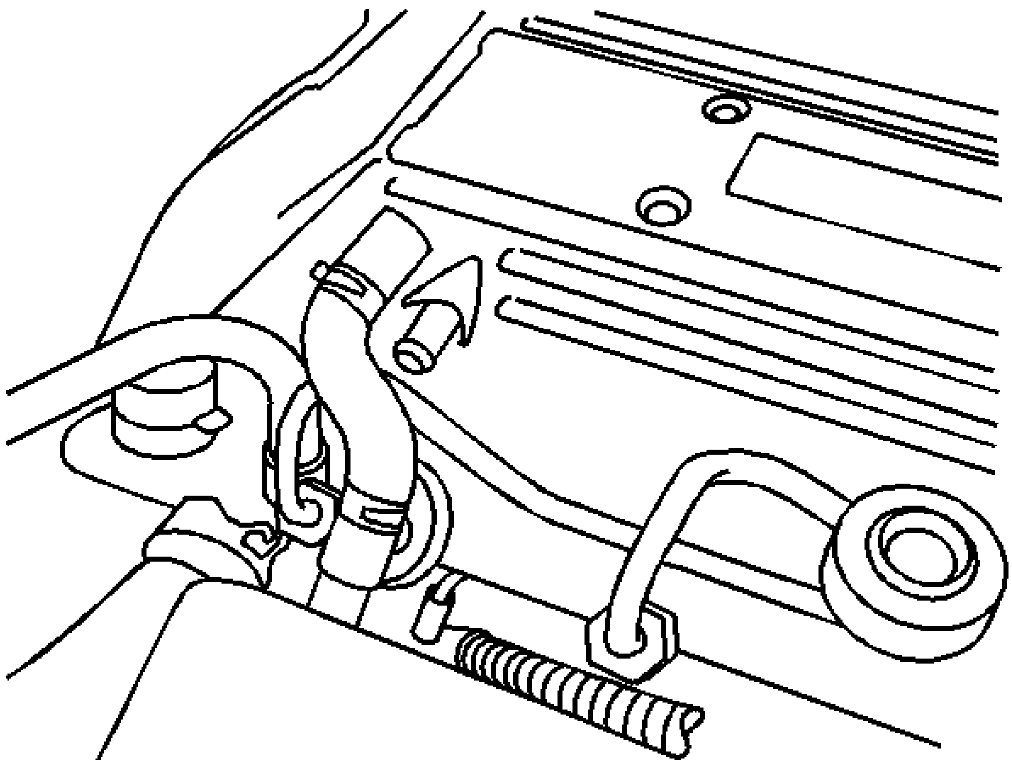


Fig. 42: View of Crankcase Ventilation Hose
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the crankcase ventilation hose from the camshaft cover.
2. Disconnect the crankcase ventilation hose from the intake manifold.

Installation Procedure

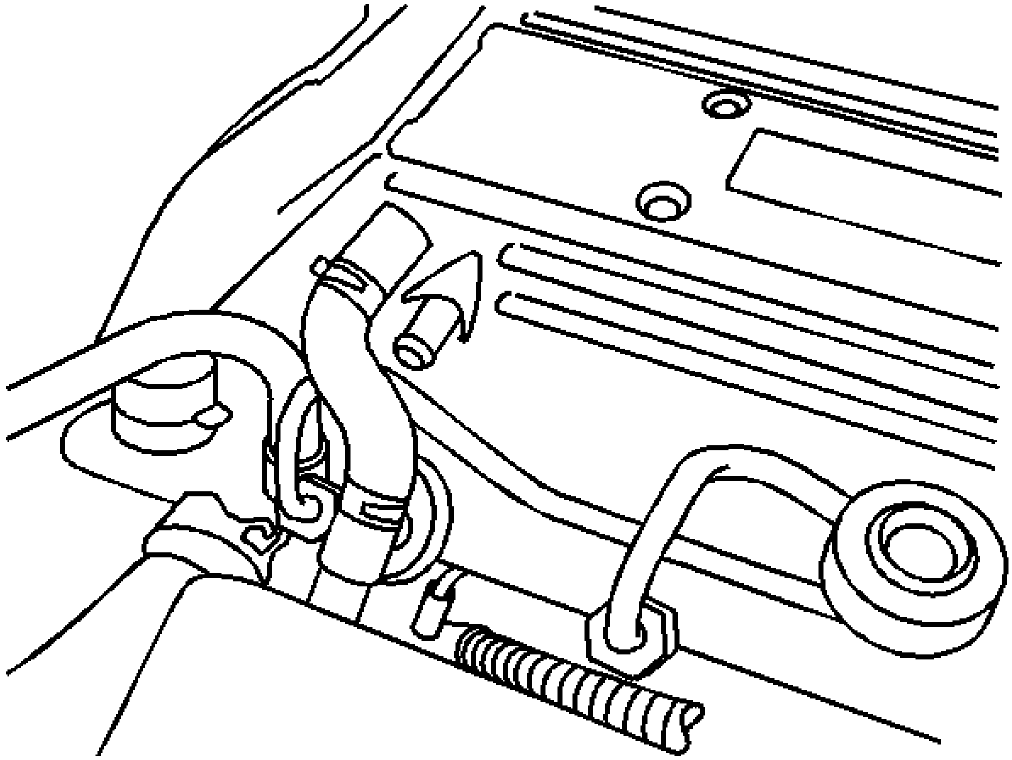


Fig. 43: View of Crankcase Ventilation Hose
Courtesy of GENERAL MOTORS CORP.

1. Connect the crankcase ventilation hose to the camshaft cover.
2. Connect the crankcase ventilation hose to the intake manifold.

Intake Manifold Replacement

Removal Procedure

1. Remove the air inlet duct and resonator.
2. Disconnect the IAC electrical connector.
3. Disconnect the TPS electrical connector.
4. Disconnect the MAP sensor electrical connector.
5. Disconnect the EVAP hose.
6. Disconnect the PCV hose.
7. Disconnect the purge solenoid tube.

8. Disconnect the brake booster hose.
9. Remove the oil level indicator tube bolt.
10. Disconnect the accelerator and cruise control cables.

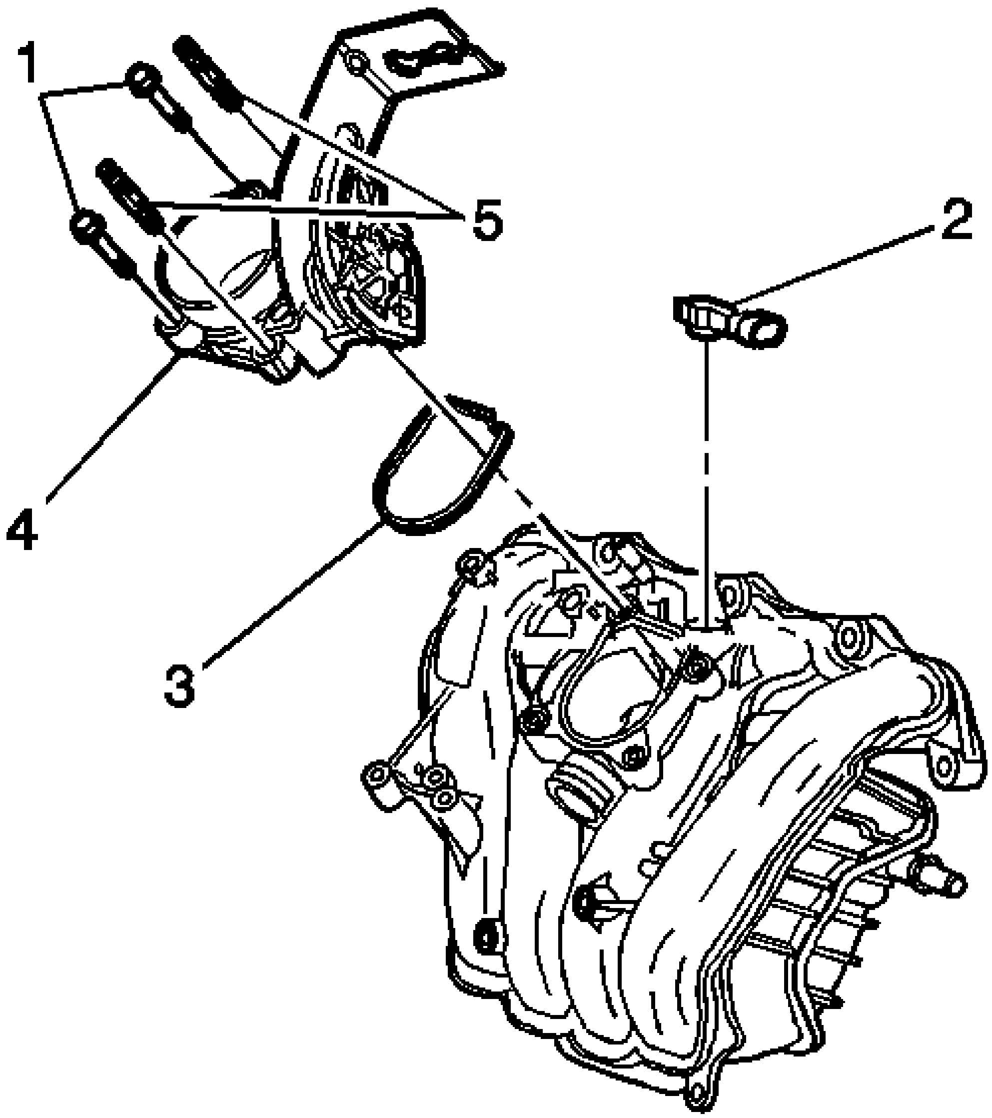


Fig. 44: Exploded View Of Throttle Body
Courtesy of GENERAL MOTORS CORP.

11. Remove the throttle body.

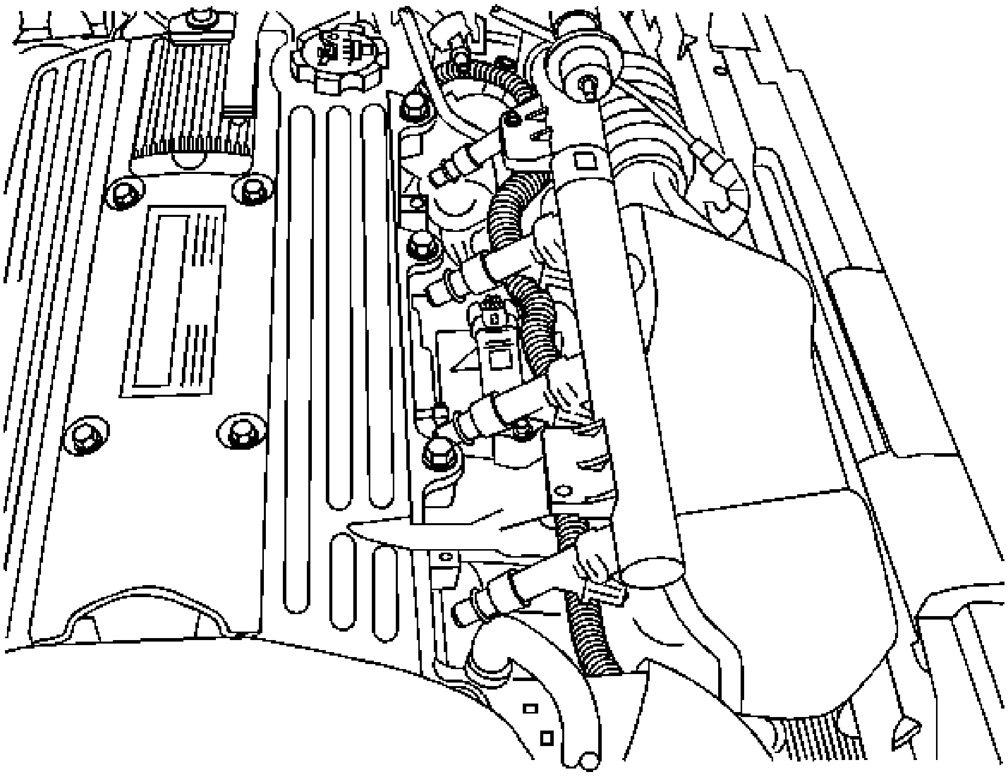


Fig. 45: View of Fuel Rail
Courtesy of GENERAL MOTORS CORP.

12. Remove the fuel rail. Refer to **Fuel Rail Assembly Replacement** in Engine Controls-2.2 (L61).

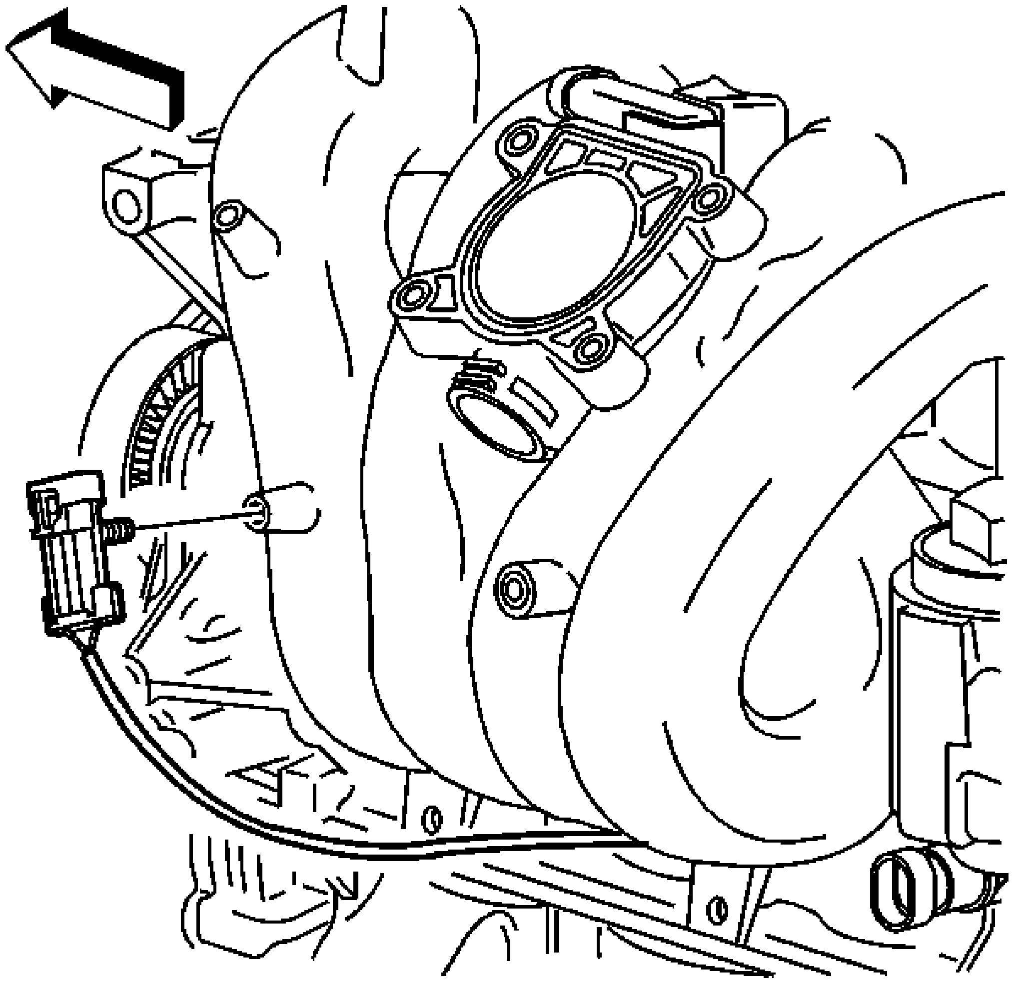


Fig. 46: View Of Knock Sensor Connector
Courtesy of GENERAL MOTORS CORP.

13. Remove the knock sensor connector from the intake manifold.

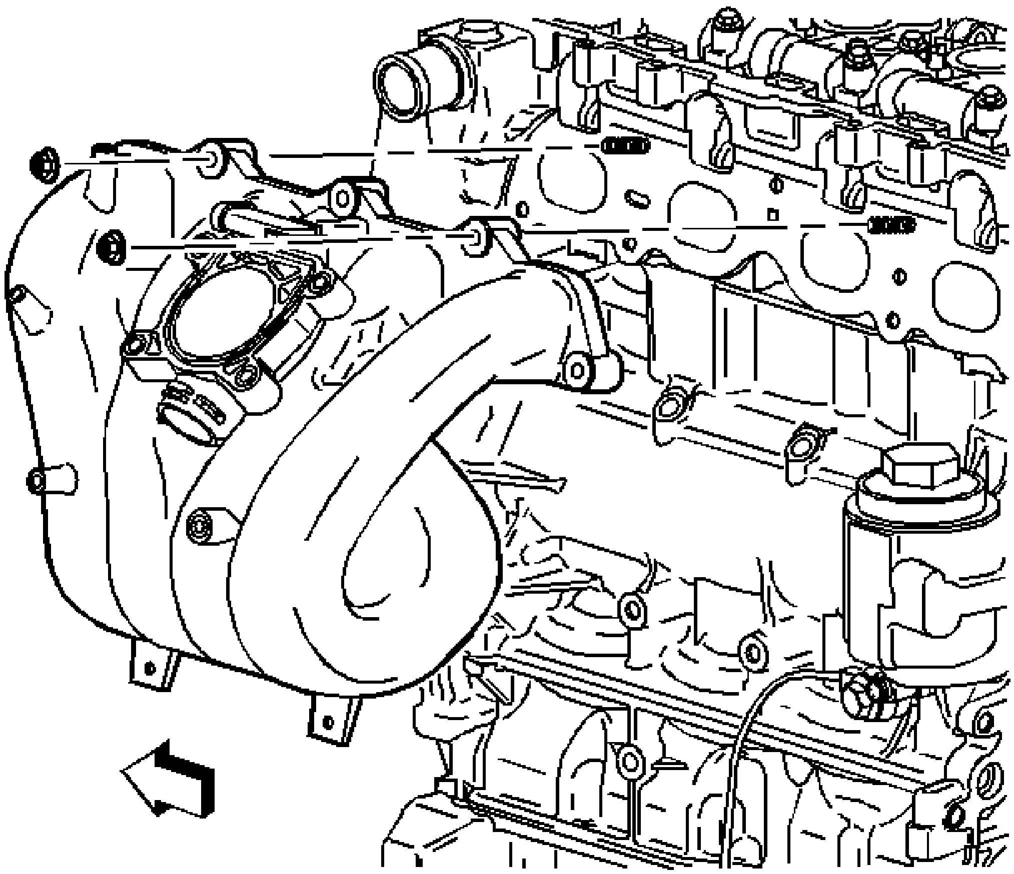


Fig. 47: View Of Intake Manifold
Courtesy of GENERAL MOTORS CORP.

14. Remove the intake manifold nuts and bolts.
15. Remove the intake manifold.
16. Remove the intake manifold gasket, if necessary. The gasket is reusable if the gasket is not damaged.

Installation Procedure

1. If removed, install the intake manifold gasket.
2. Install the intake manifold.

NOTE: Refer to Fastener Notice in Cautions and Notices.

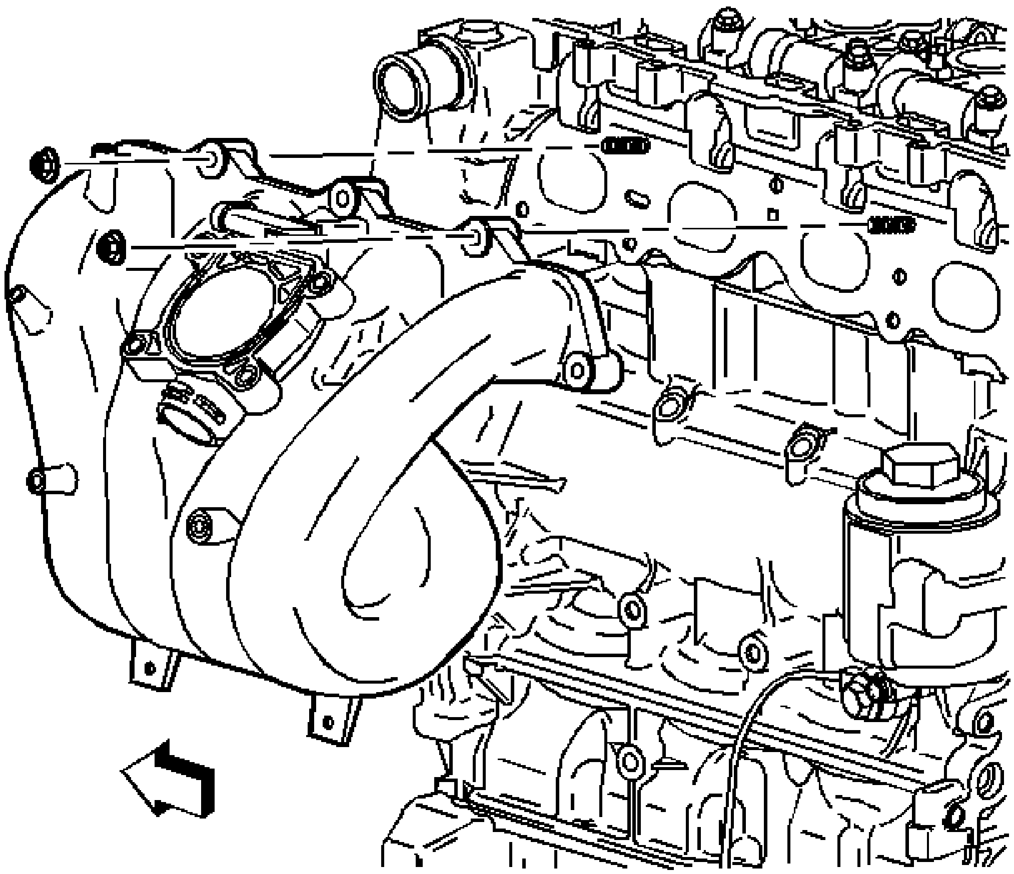


Fig. 48: View Of Intake Manifold
Courtesy of GENERAL MOTORS CORP.

3. Install the intake manifold nuts and bolts.

   Tighten: Tighten the intake manifold nuts and bolts to 10 N.m (89 lb in).

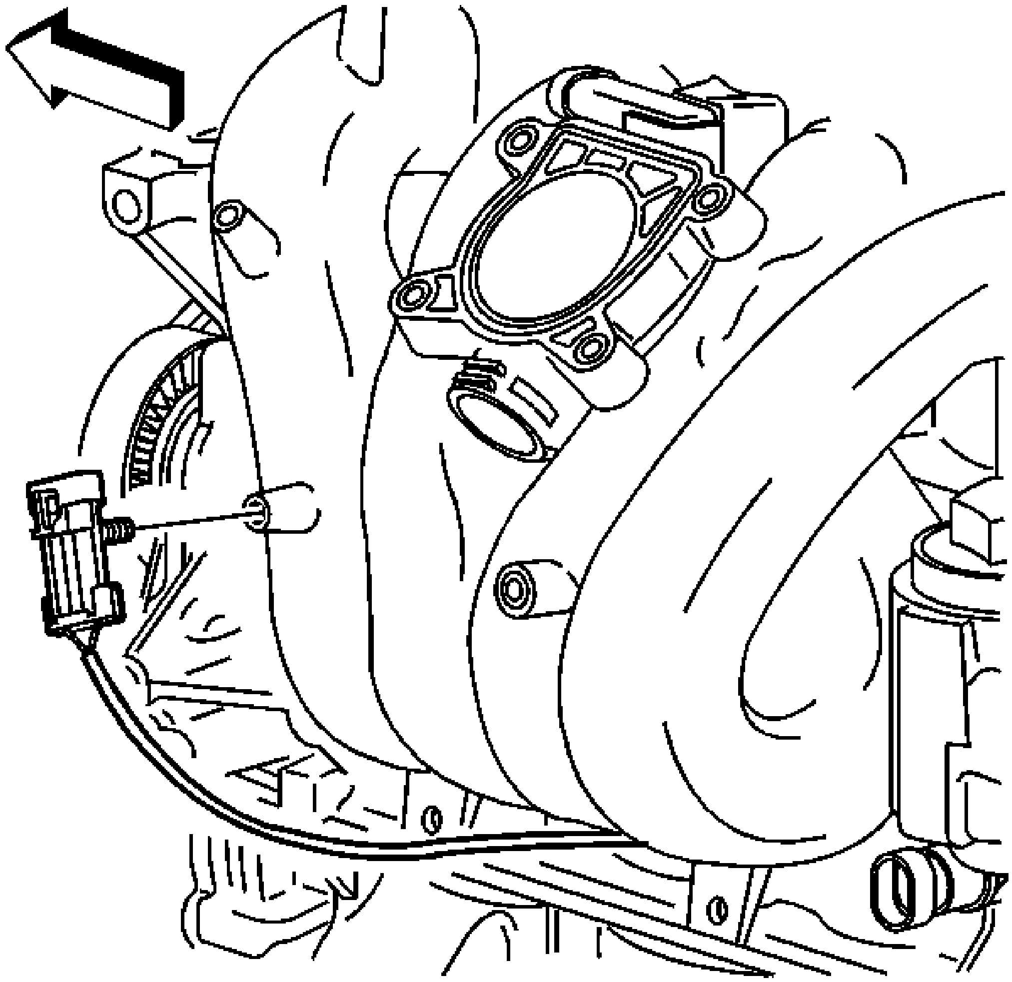


Fig. 49: View Of Knock Sensor Connector
Courtesy of GENERAL MOTORS CORP.

4. Install the knock sensor connector to the intake manifold.

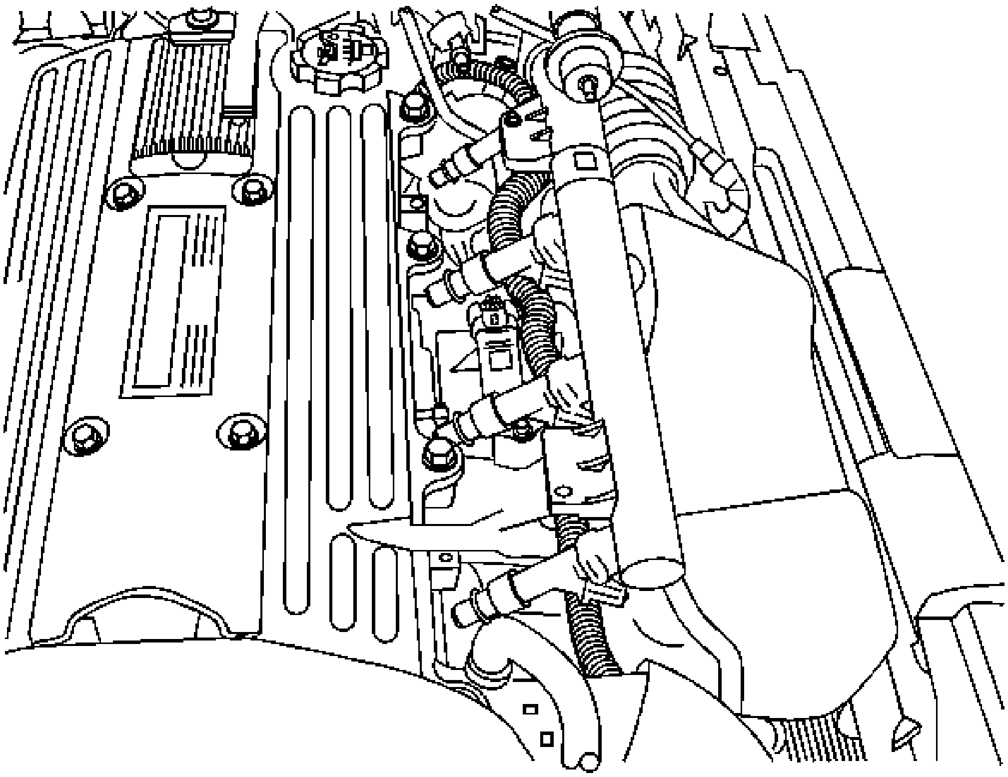


Fig. 50: View of Fuel Rail
Courtesy of GENERAL MOTORS CORP.

5. Install the fuel rail. Refer to **Fuel Rail Assembly Replacement** in Engine Controls-2.2L (L61).

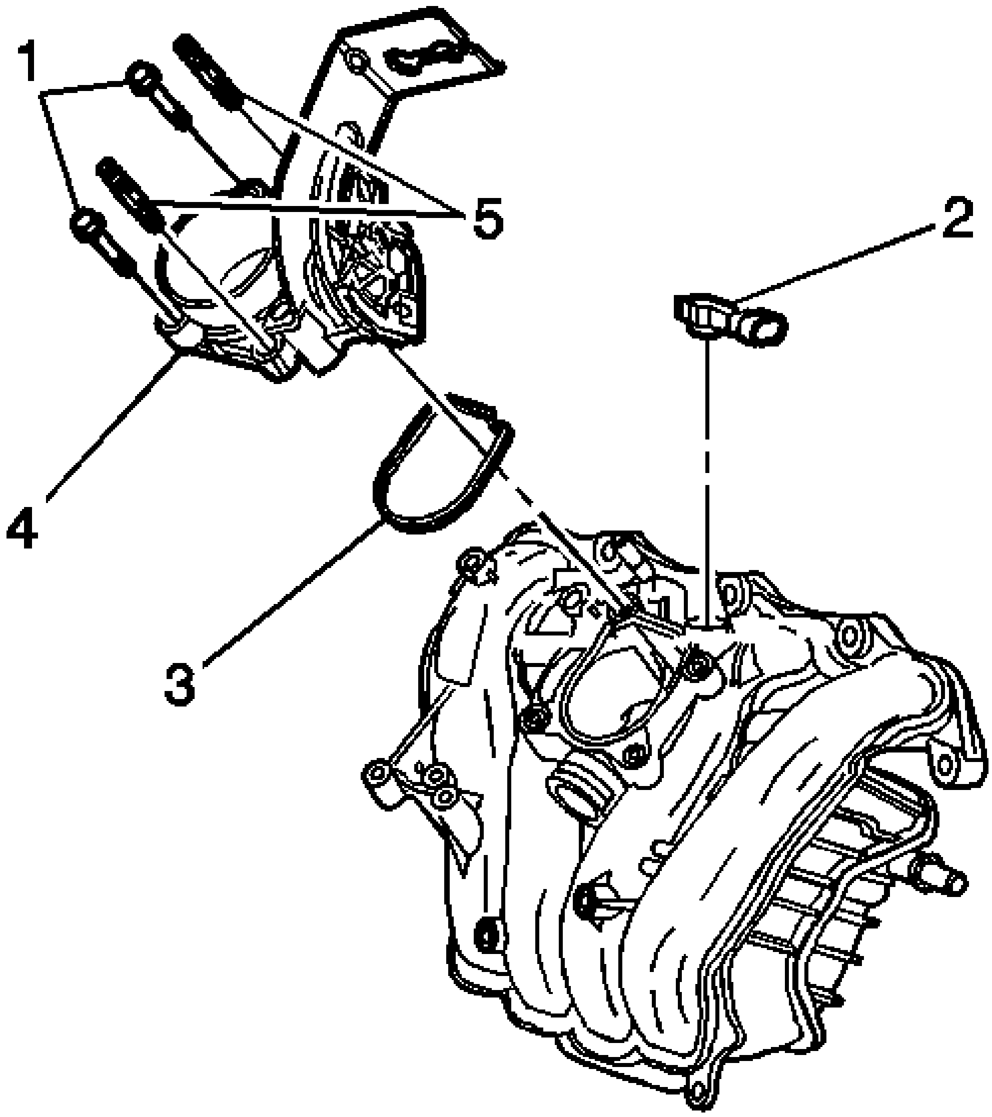


Fig. 51: Exploded View Of Throttle Body
Courtesy of GENERAL MOTORS CORP.

6. Install the throttle body. Refer to **Throttle Body Assembly Replacement** in Engine Controls 2.2L.
7. Connect the IAC electrical connector.
8. Connect the TPS electrical connector.
9. Connect the MAP sensor electrical connector.

10. Connect the EVAP hose.
11. Connect the PCV hose.
12. Connect the purge solenoid tube.
13. Connect the brake booster hose.
14. Install the oil level indicator tube bolt.
15. Connect the accelerator and the cruise control cables.
16. Install the air inlet duct and resonator.

Crankshaft Balancer Replacement

Tools Required

J 38122-A Harmonic Balancer Holder

Removal Procedure

1. Remove the engine drive belt. Refer to **Drive Belt Replacement**.

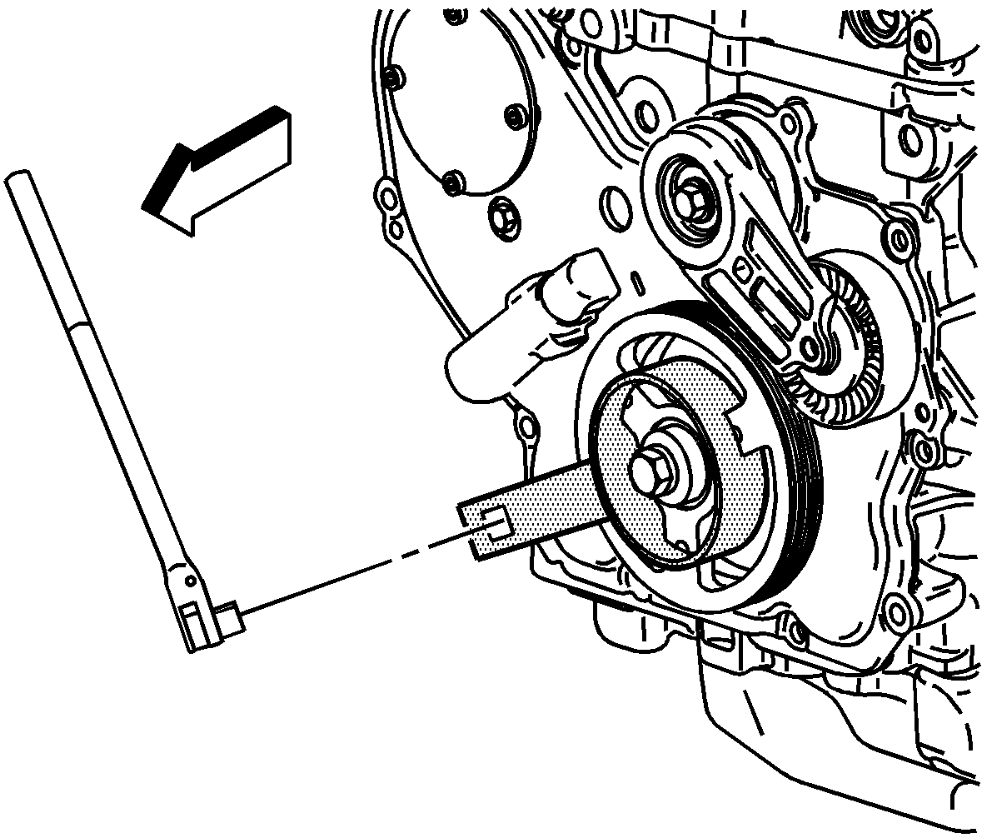


Fig. 52: View Of Harmonic Balancer Holder J38122-A
Courtesy of GENERAL MOTORS CORP.

2. Use J 38122-A to prevent the crankshaft from rotating while loosening the crankshaft balancer bolt.
3. Remove the crankshaft balancer bolt. Discard the bolt.

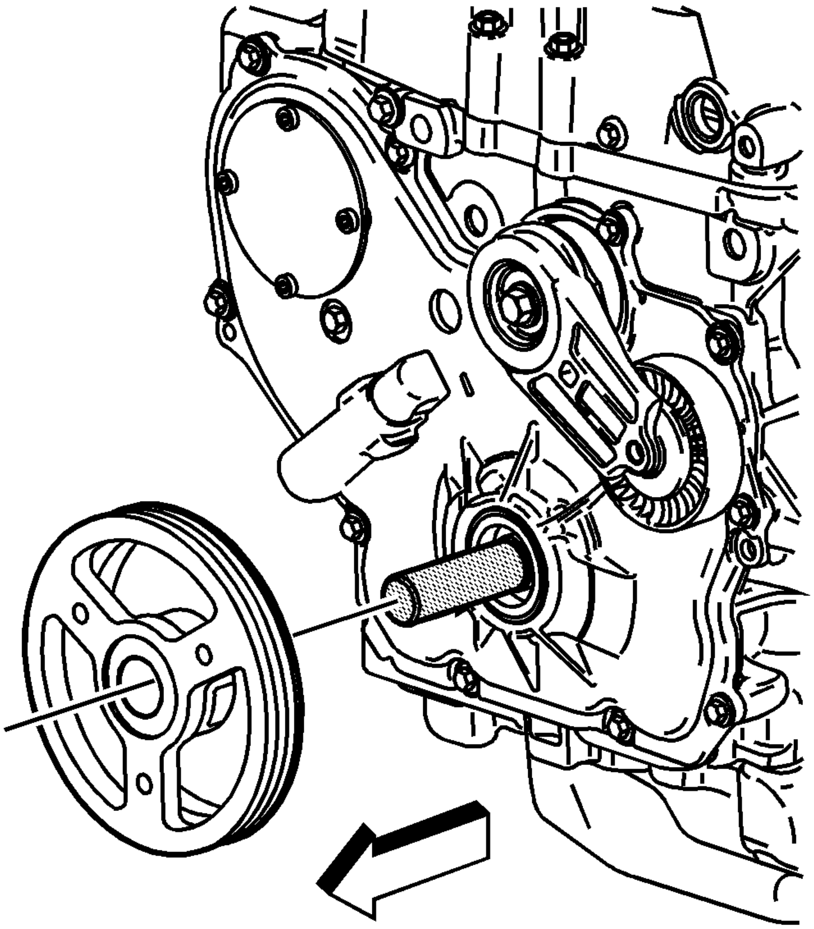


Fig. 53: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

4. Remove the crankshaft balancer.

Installation Procedure

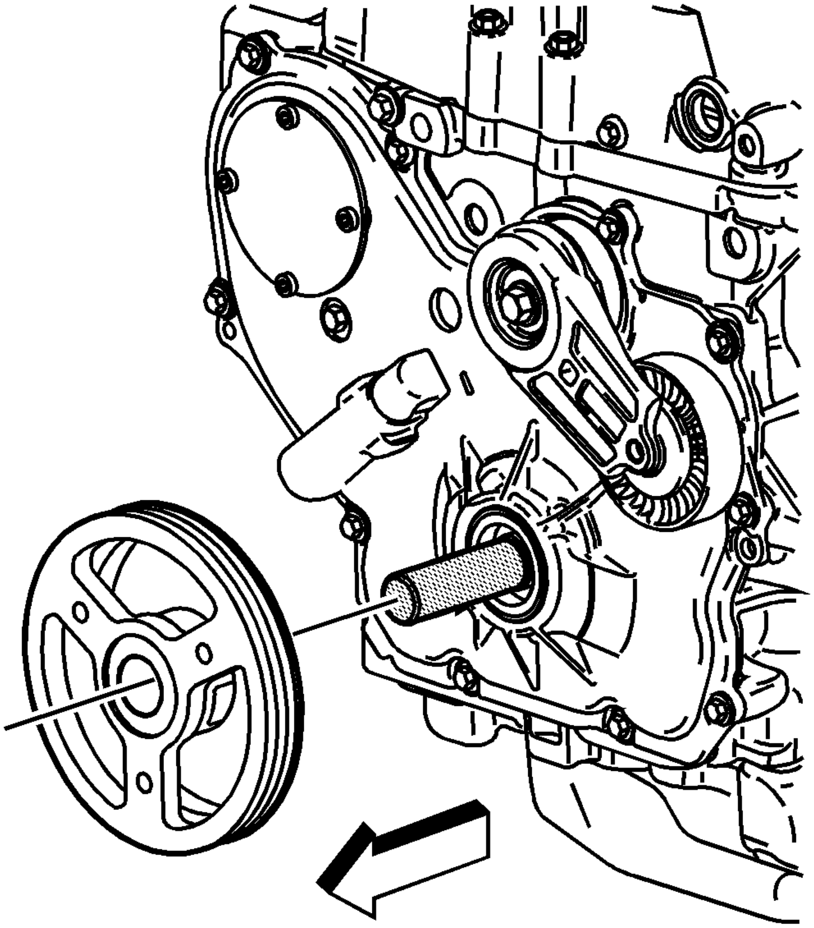


Fig. 54: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

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

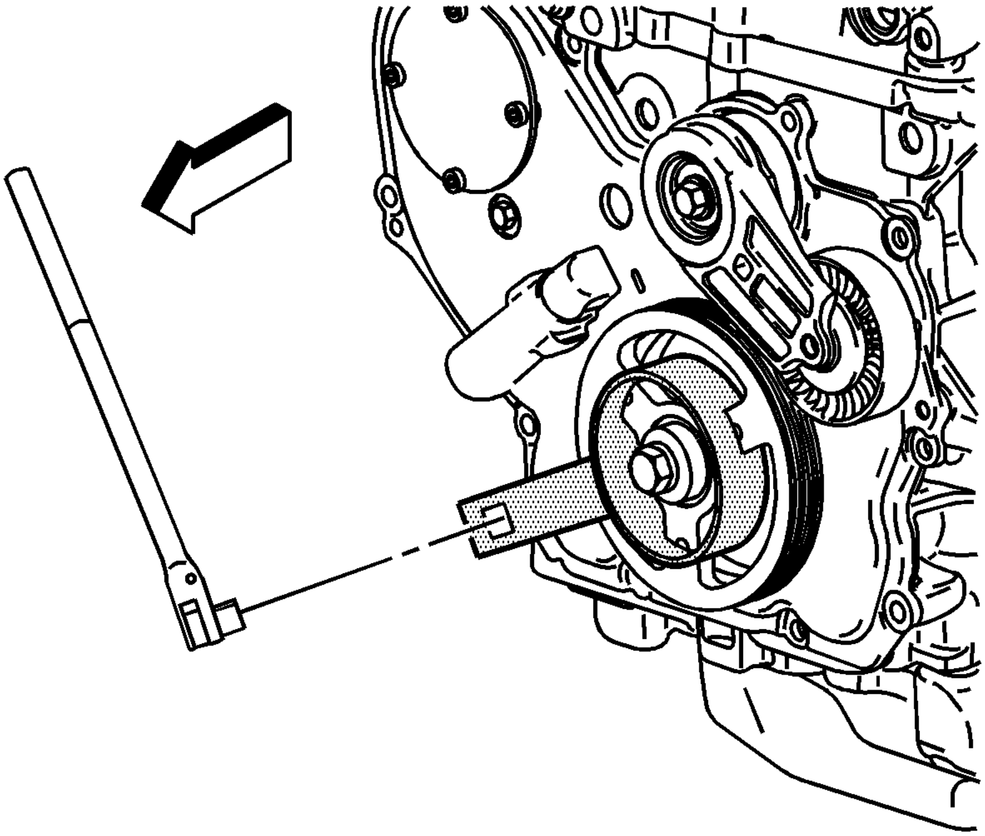


Fig. 55: View Of Harmonic Balancer Holder J38122-A
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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

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

4. Install the engine drive belt. Refer to **Drive Belt Replacement**.

Crankshaft Front Oil Seal Replacement

Tools Required

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

Removal Procedure

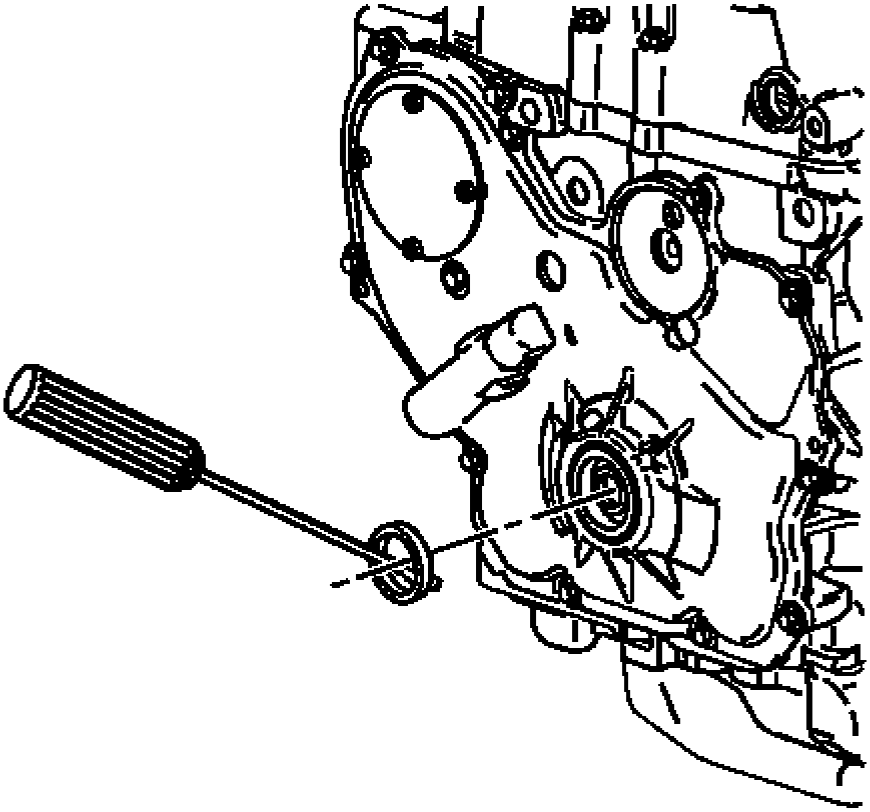


Fig. 56: Crankshaft Balancer Removal
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

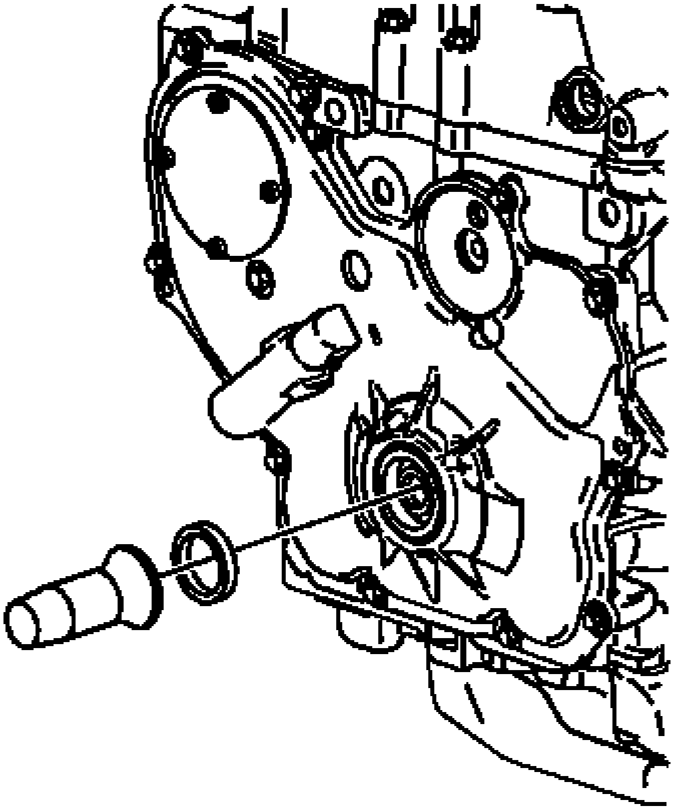


Fig. 57: View of Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

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

Engine Front Cover Replacement

1. Remove the crankcase balancer. Refer to **Crankshaft Balancer Replacement**.

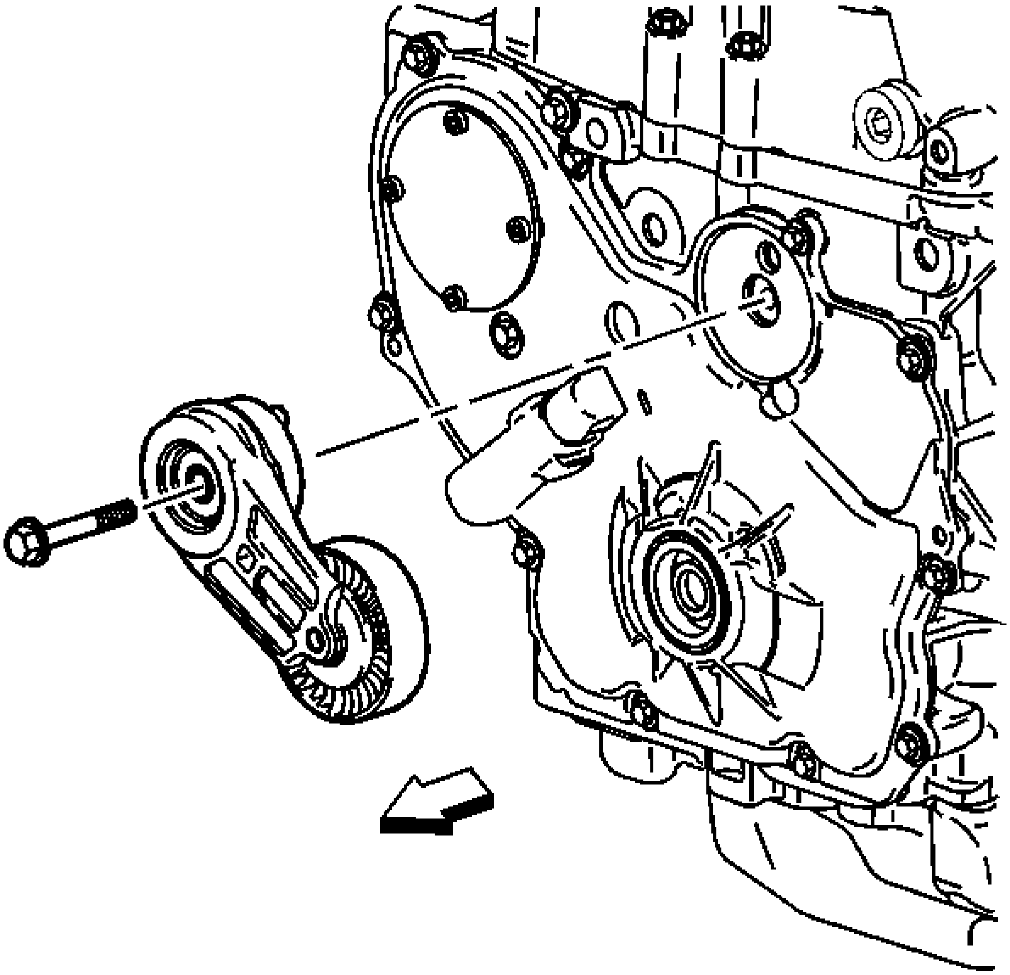


Fig. 58: View Of Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

2. Remove the drive belt tensioner.

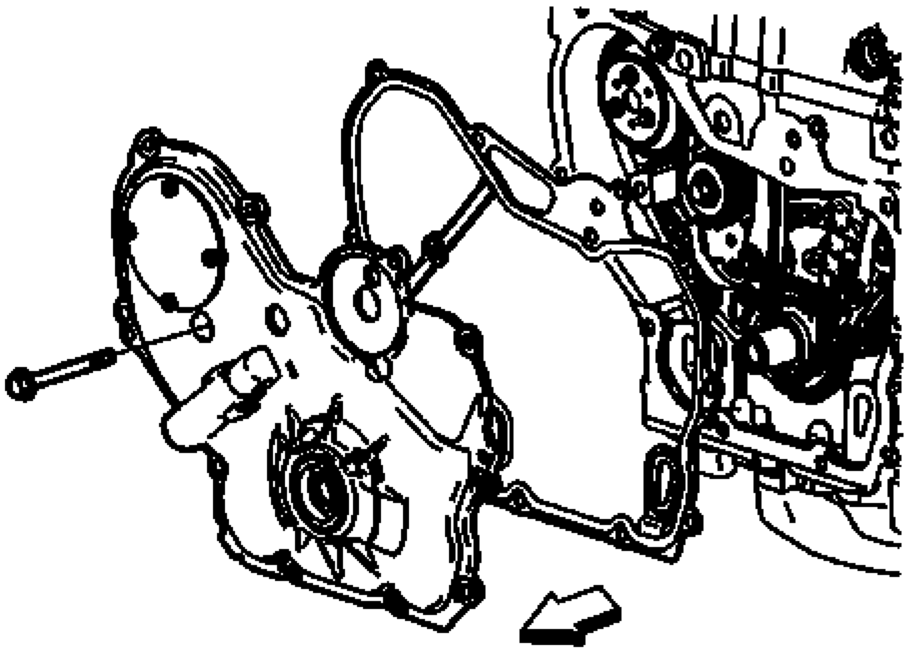


Fig. 59: View Of Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

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

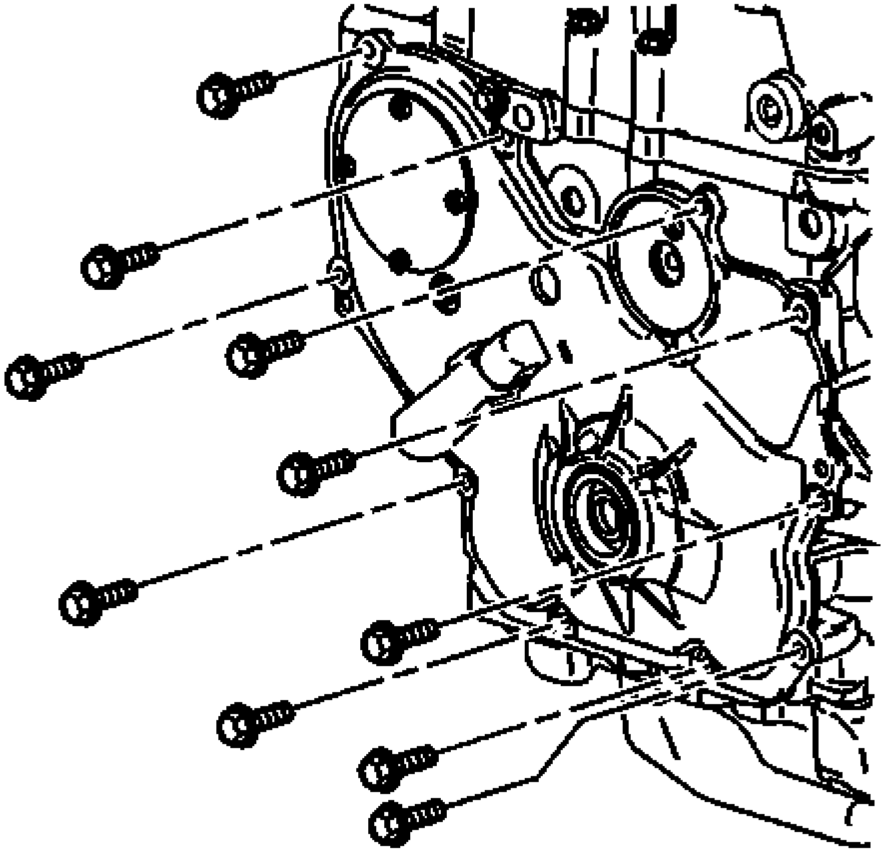


Fig. 60: View Of Engine Front Cover Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the remaining engine front cover bolts.
5. Remove the engine front cover.
   - If the engine front cover gasket is damaged.
   - Remove the front engine mount. Refer to **Engine Mount Replacement**.
   - Remove the engine front cover gasket if it is damaged.

Installation Procedure

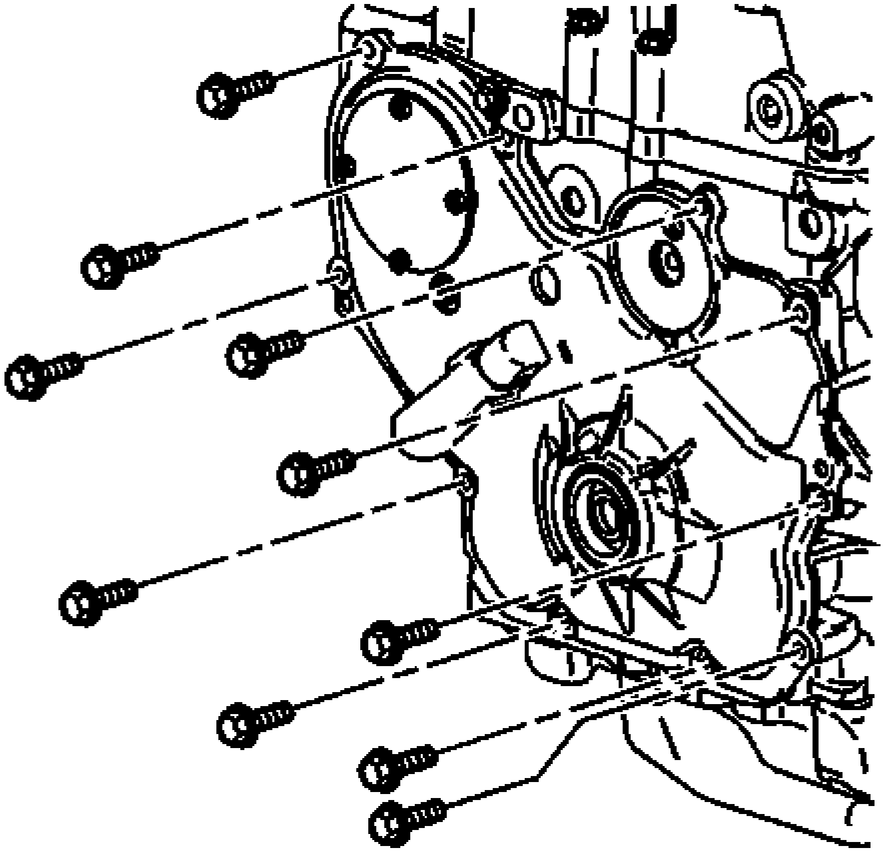


Fig. 61: View Of Engine Front Cover Bolts
Courtesy of GENERAL MOTORS CORP.

1. If removed install a new engine front cover gasket.
2. Install the front engine mount. Refer to **Engine Mount Replacement**.
3. Install the engine front cover.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the engine front cover bolts.

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

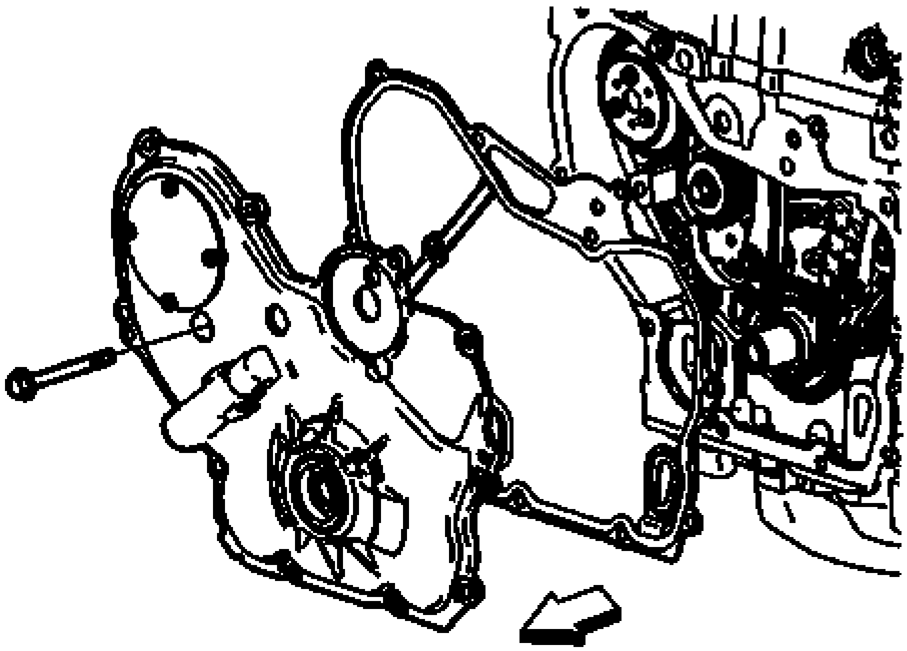


Fig. 62: View Of Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

5. Install the water pump bolt.

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

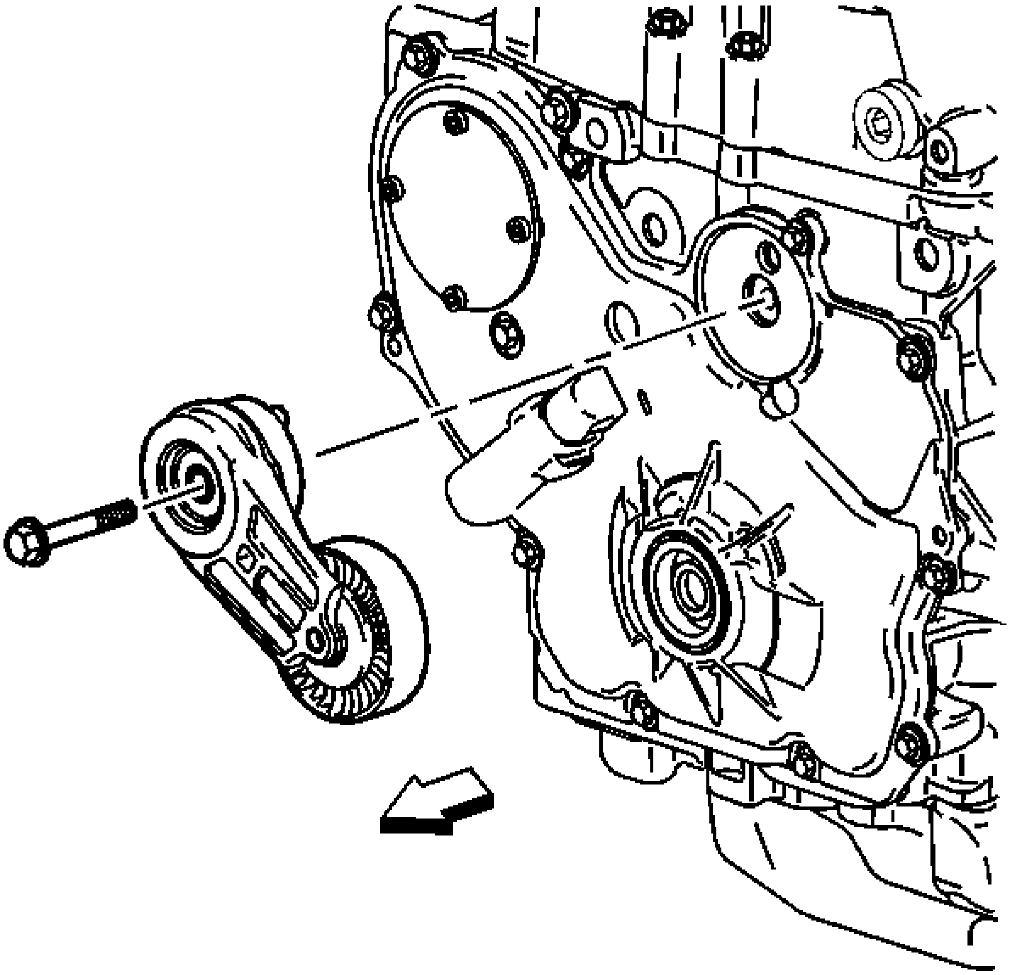


Fig. 63: View Of Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

6. Install the drive belt tensioner.
7. Install the drive belt tensioner bolt.

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

8. Install the crankcase balancer. Refer to **Crankshaft Balancer Replacement**.

Timing Chain, Sprockets, and/or Tensioner Replacement

Removal Procedure

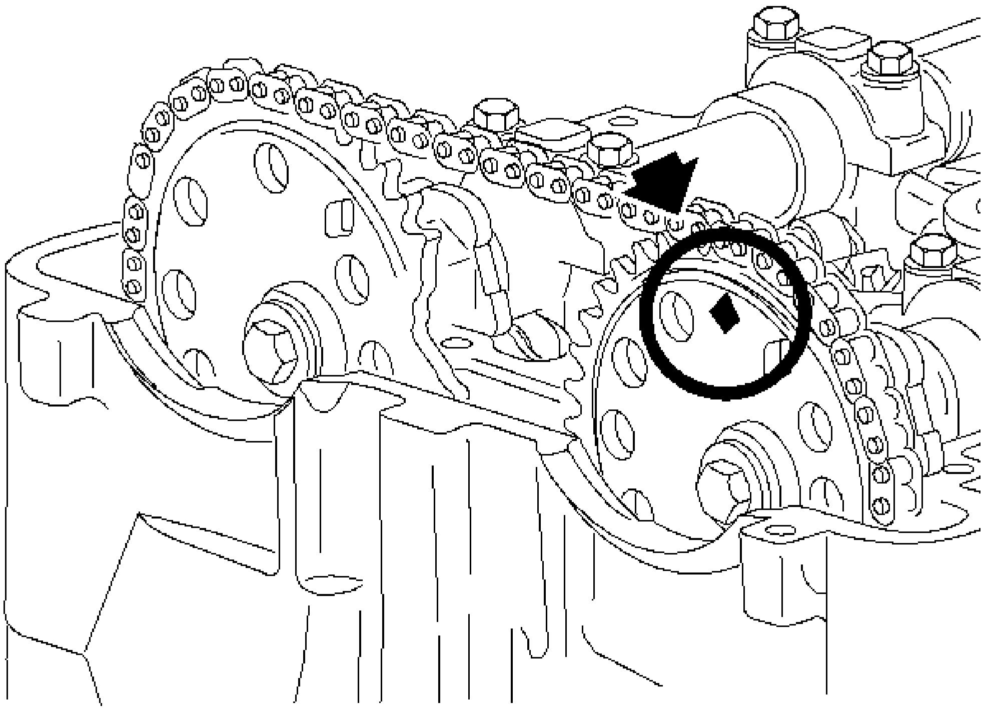


Fig. 64: Identifying Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

1. Remove the camshaft cover. Refer to **Camshaft Cover Replacement**.
2. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
3. Remove the engine front cover. Refer to **Engine Front Cover Replacement**.
4. Lower the vehicle.

> **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.**

5. 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.

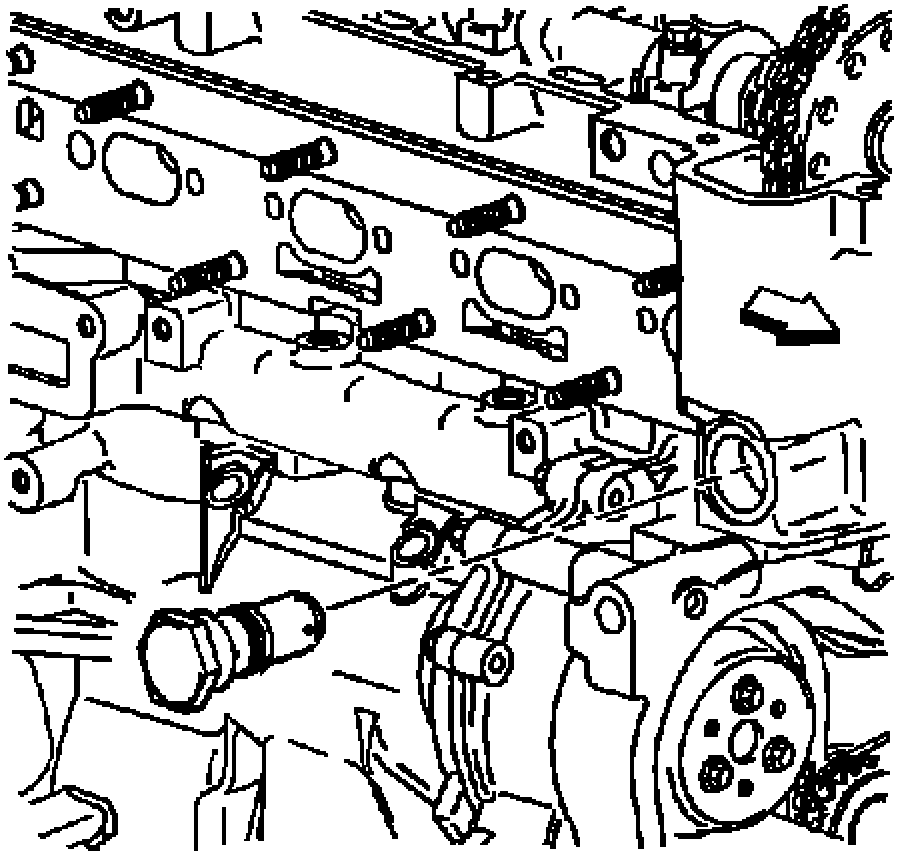


Fig. 65: Identifying Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

6. Remove the timing chain tensioner.

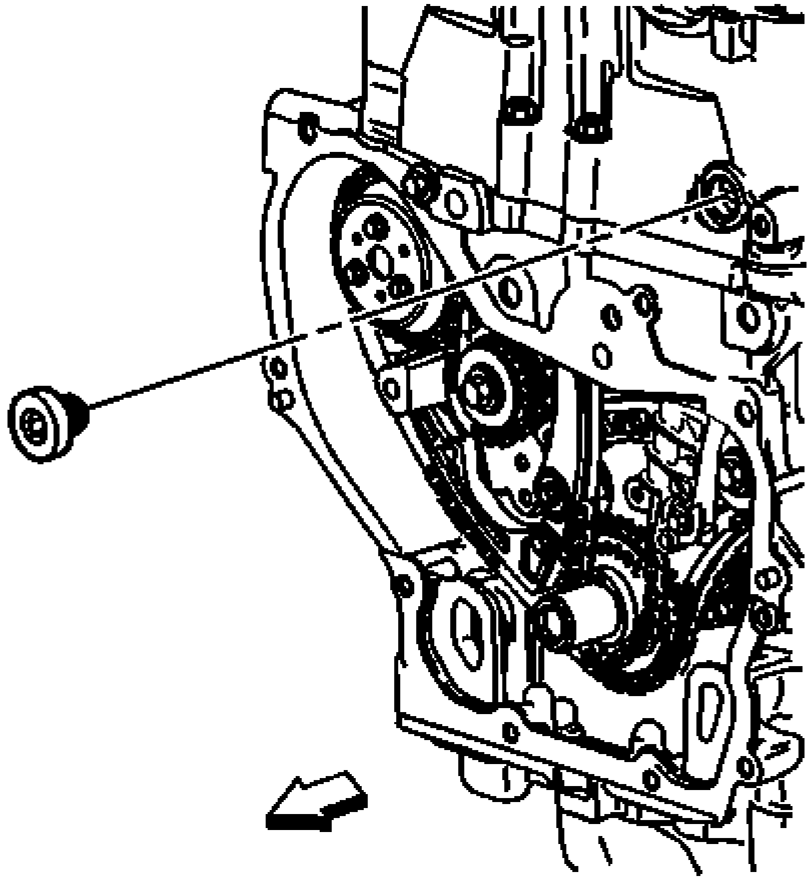


Fig. 66: View Of Fixed Timing Chain Guide Access Plug
Courtesy of GENERAL MOTORS CORP.

7. Remove the fixed timing chain guide access plug.

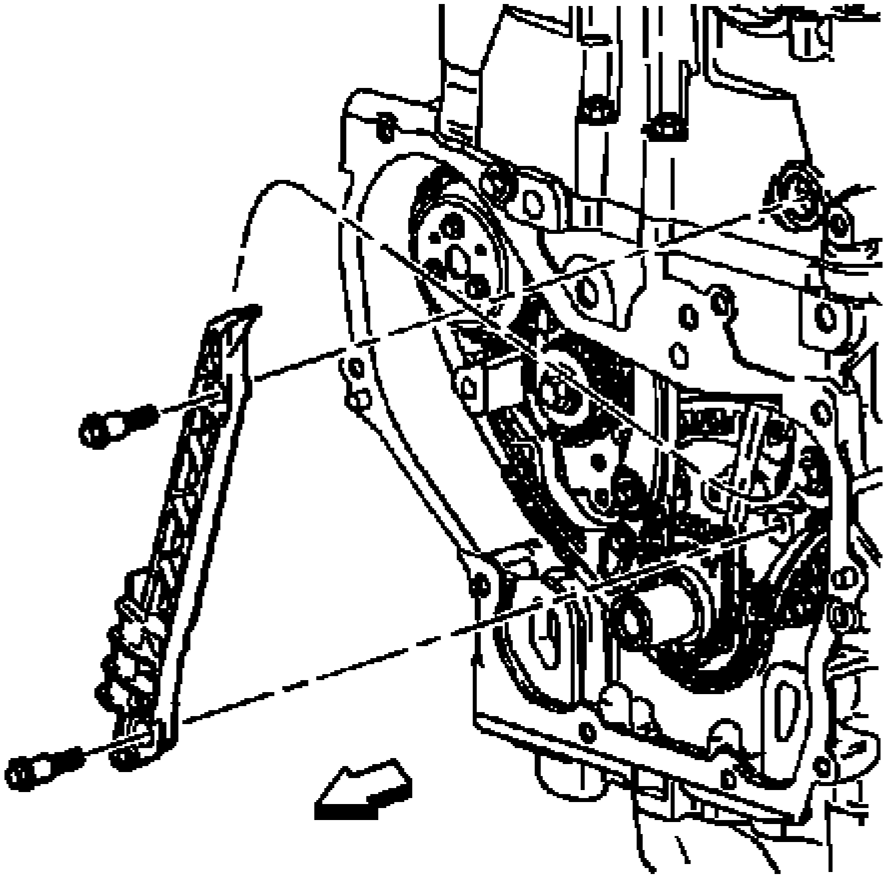


Fig. 67: View Of Fixed Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

8. Remove the fixed timing chain guide.

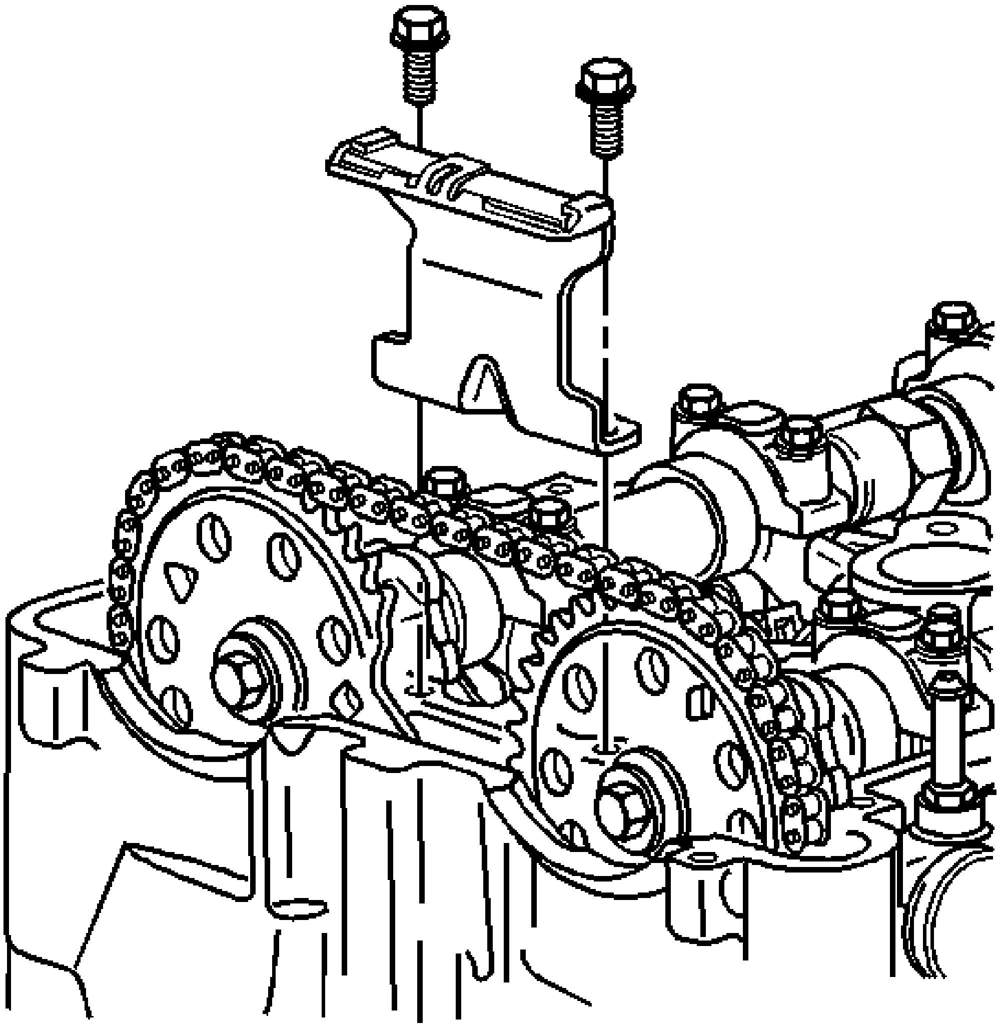


Fig. 68: View of Upper Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

9. Remove the upper timing chain guide.

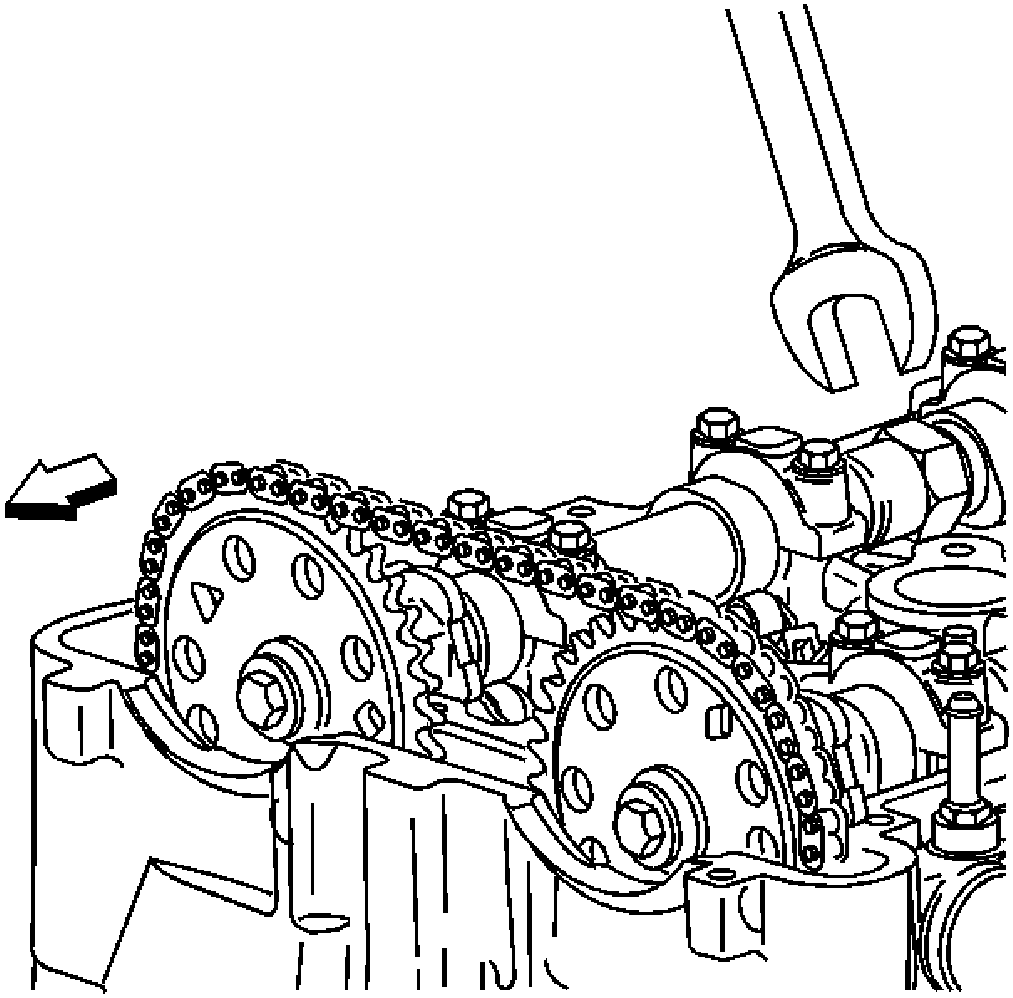


Fig. 69: Using 24 mm Wrench To Align Camshaft
Courtesy of GENERAL MOTORS CORP.

10. Use a 24 mm wrench to hold the camshafts from turning.

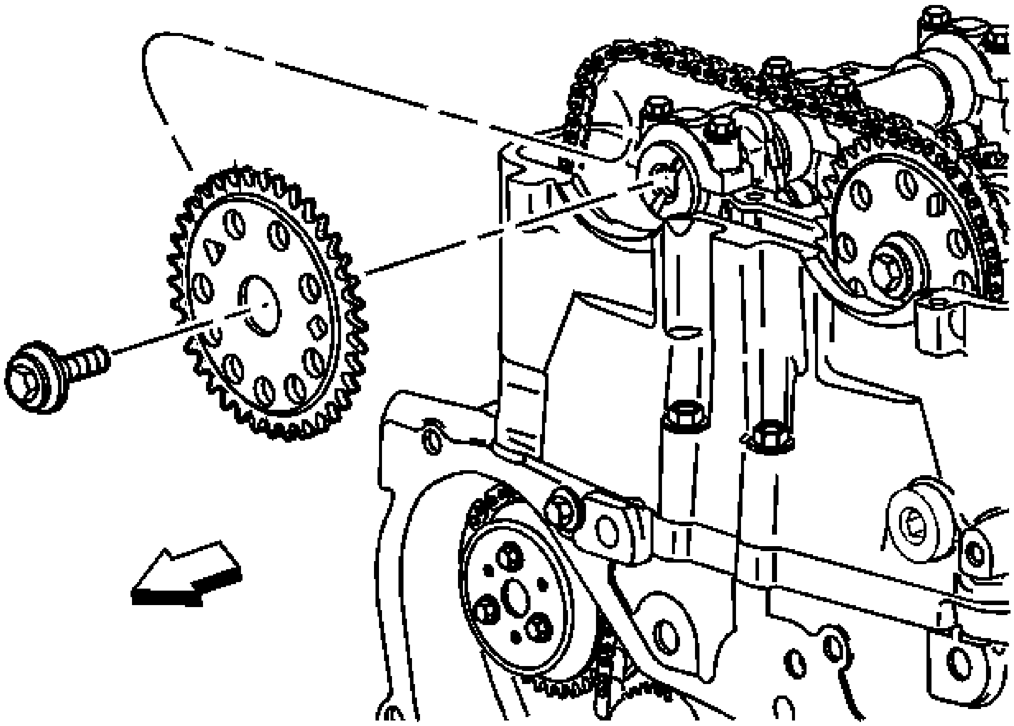


Fig. 70: Identifying Exhaust Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

11. Remove the exhaust camshaft sprocket bolt and discard.
12. Remove the exhaust camshaft sprocket.

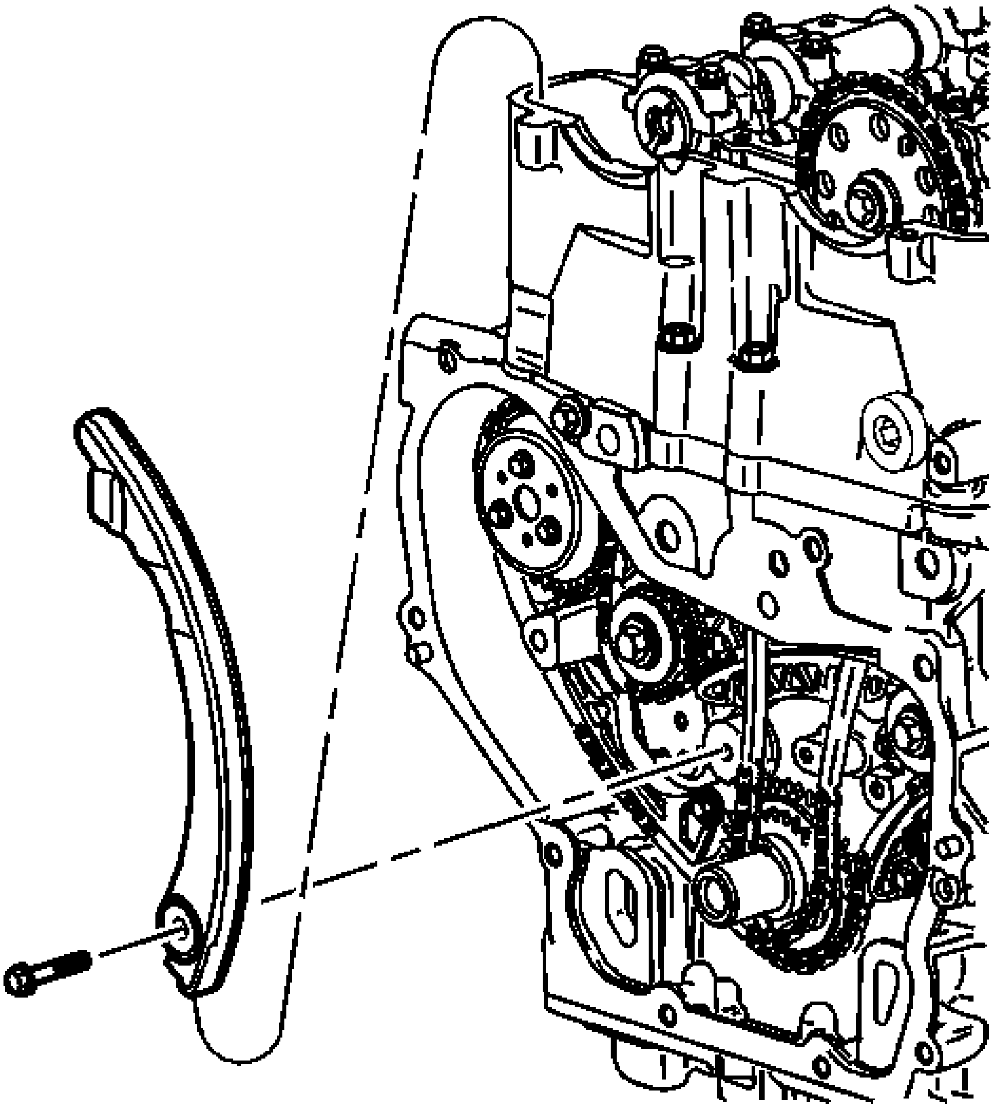


Fig. 71: View Of Timing Chain Tensioner Guide
Courtesy of GENERAL MOTORS CORP.

13. Remove the timing chain tensioner guide.

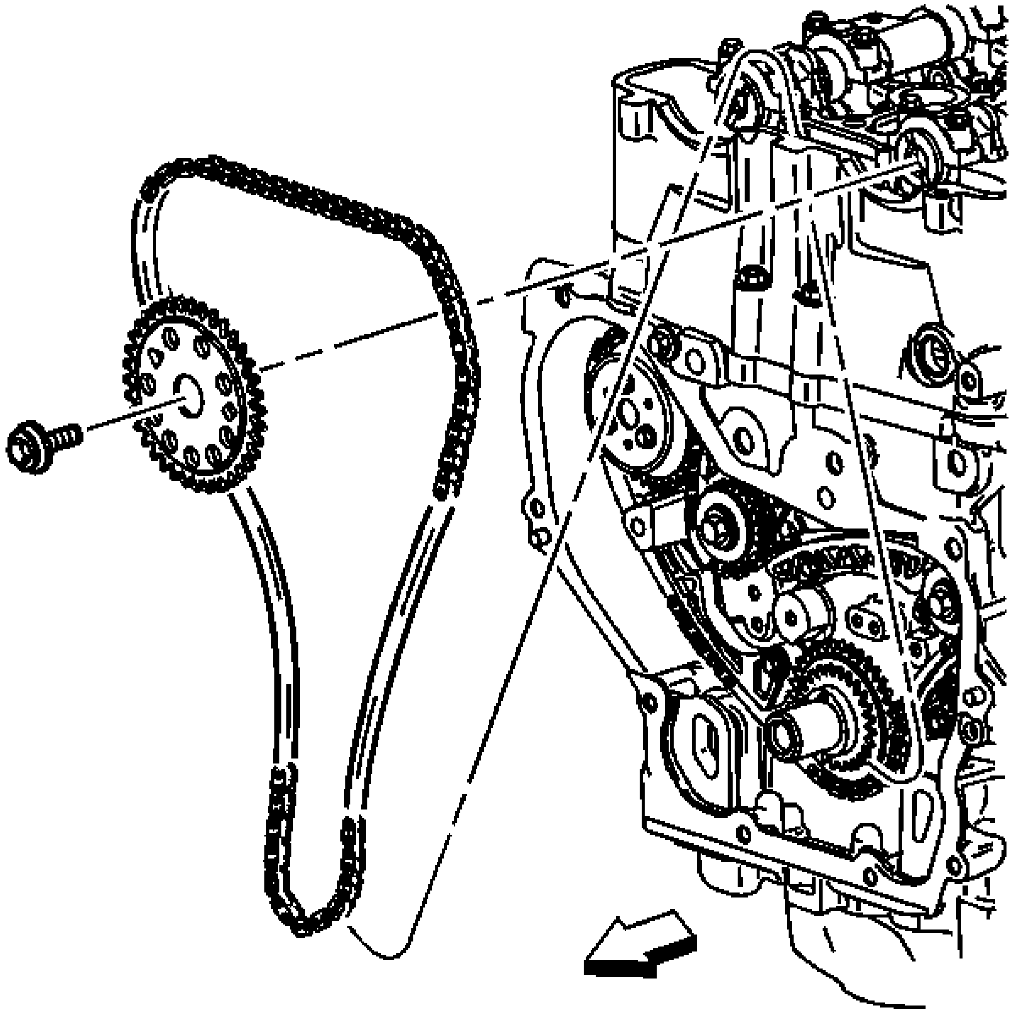


Fig. 72: View Of Intake Camshaft Sprocket And Chain
Courtesy of GENERAL MOTORS CORP.

14. Remove the intake camshaft sprocket bolt and discard.
15. Remove the intake camshaft sprocket.
16. Remove the timing chain through the top of the cylinder head.

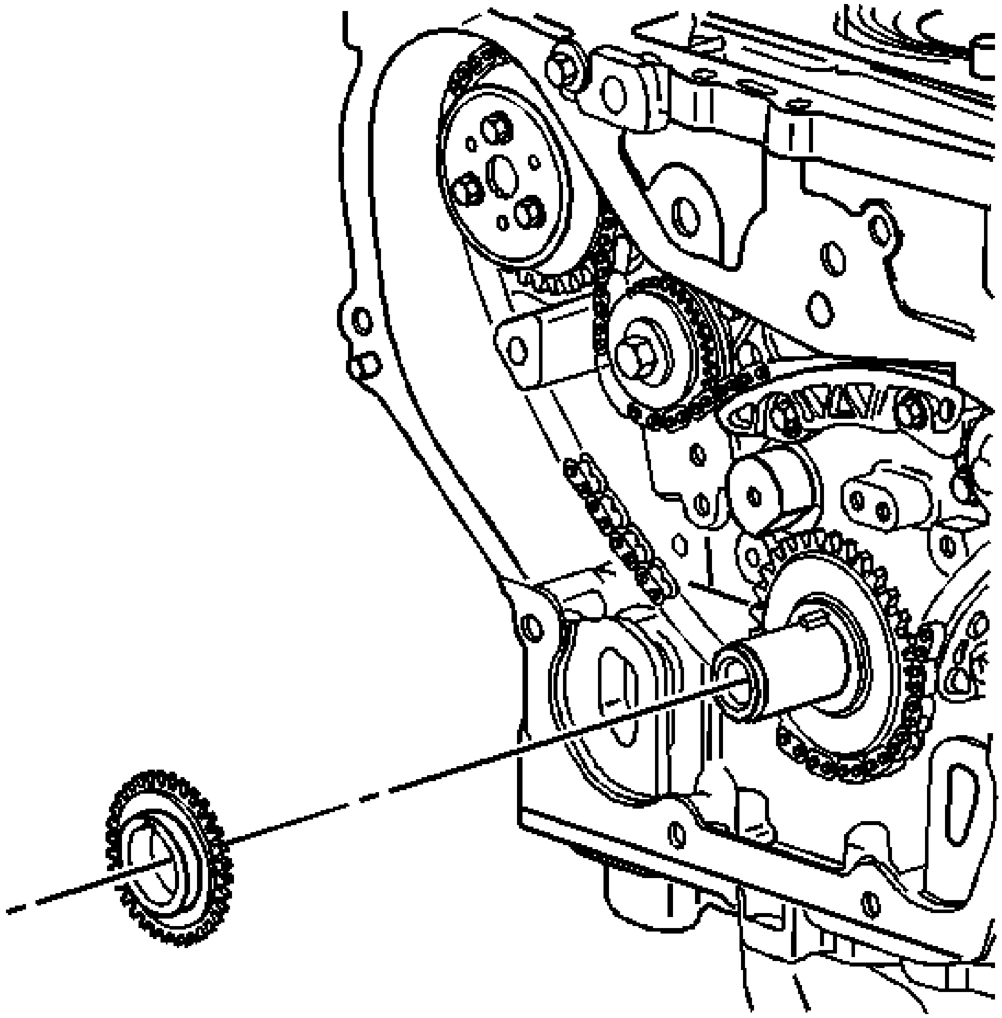


Fig. 73: View of Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

17. Remove the crankshaft sprocket.

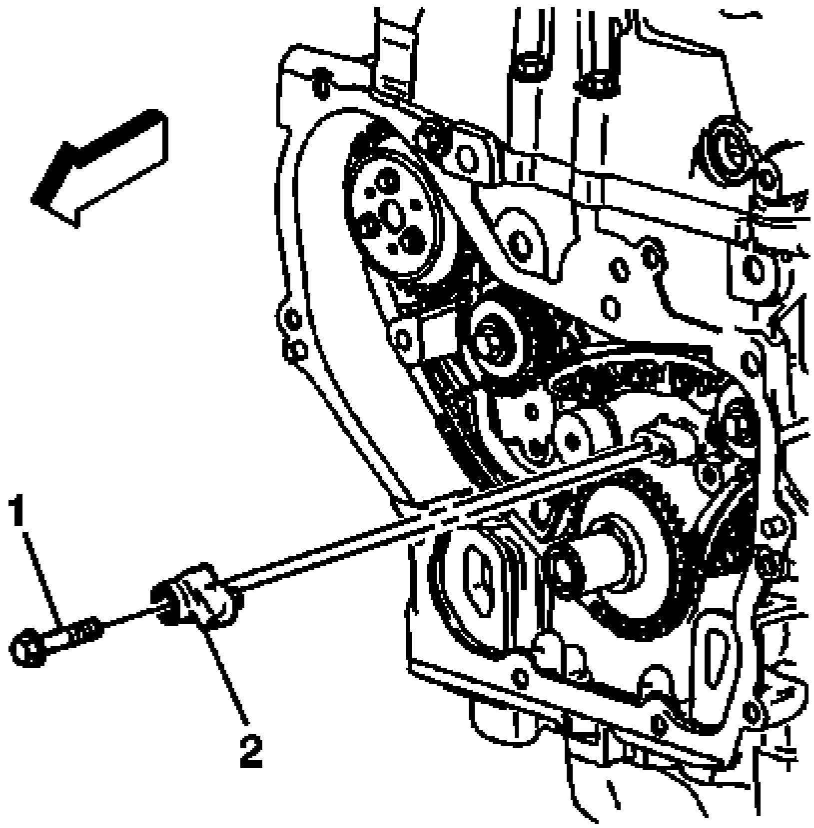


Fig. 74: View Of Oil Nozzle & Bolt
Courtesy of GENERAL MOTORS CORP.

18. Remove the oil nozzle and bolt.

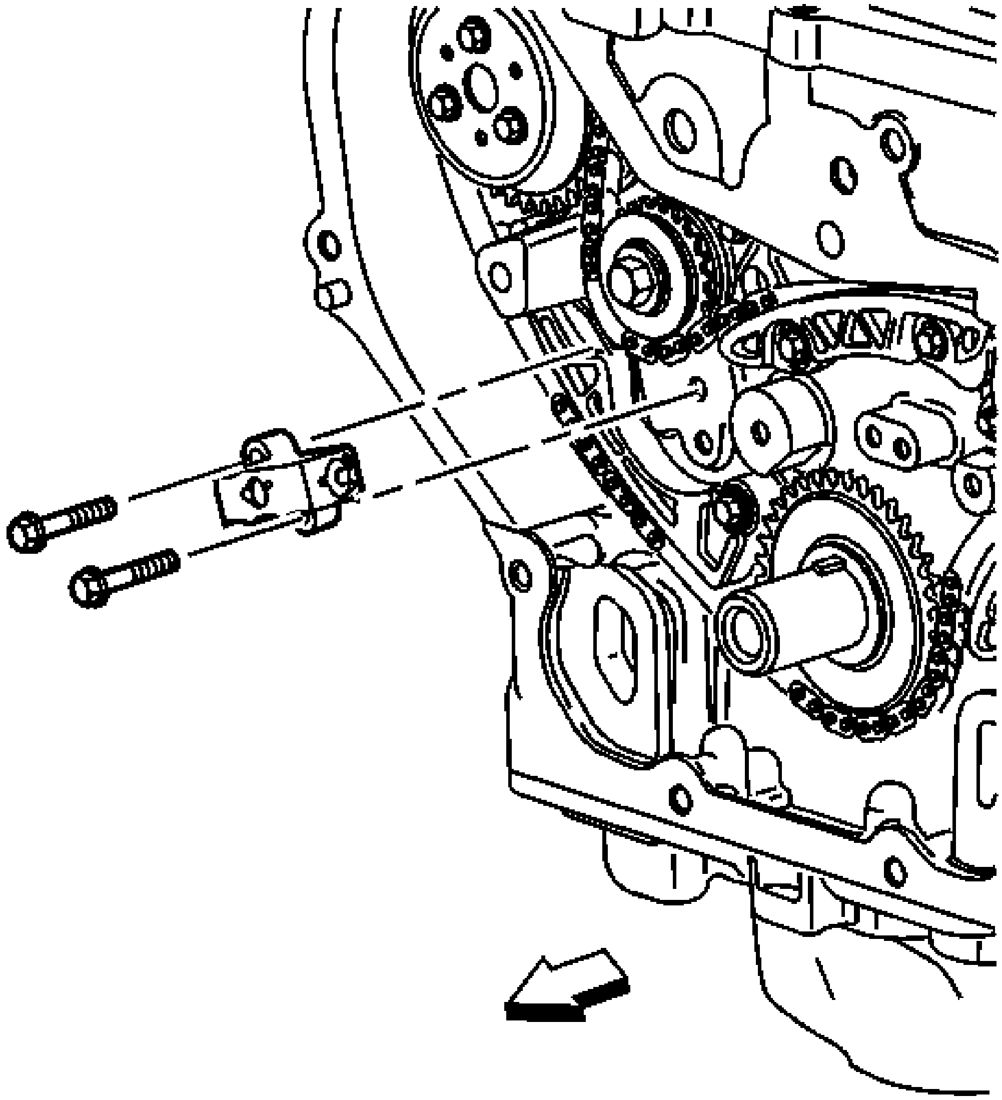


Fig. 75: Identifying Balance Shaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

19. Remove the balance shaft drive chain tensioner.

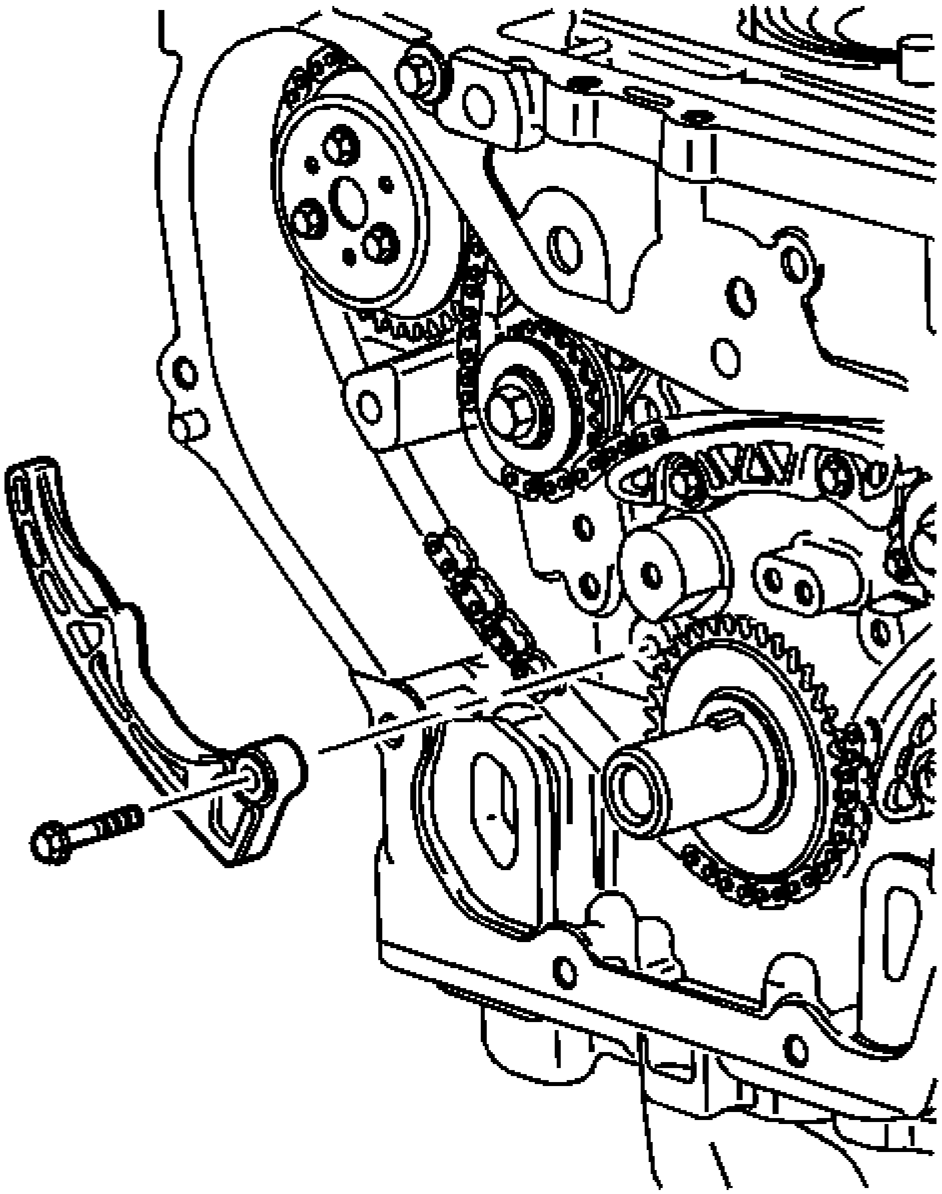


Fig. 76: View Of Adjustable Balance Shaft Chain Guide
Courtesy of GENERAL MOTORS CORP.

20. Remove the adjustable balance shaft chain guide.

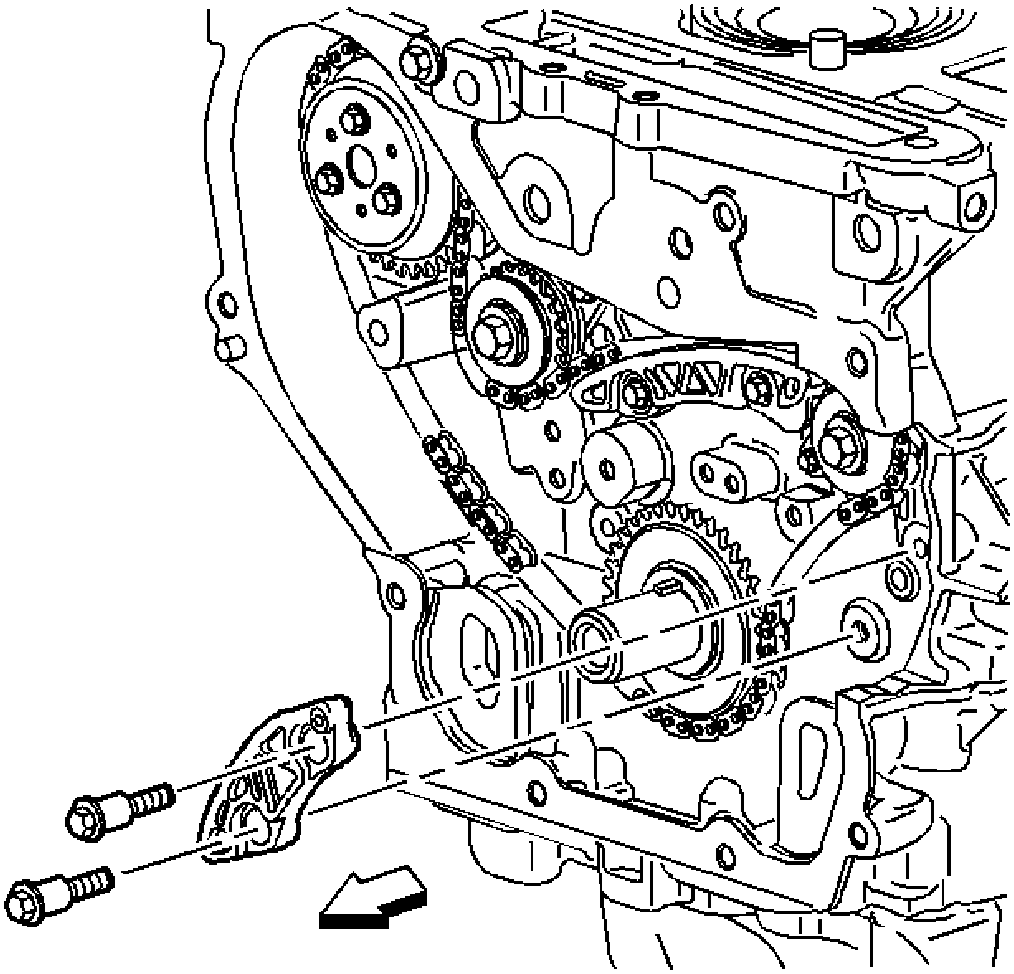


Fig. 77: Exploded View Of Small Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

21. Remove the small balance shaft drive chain guide.

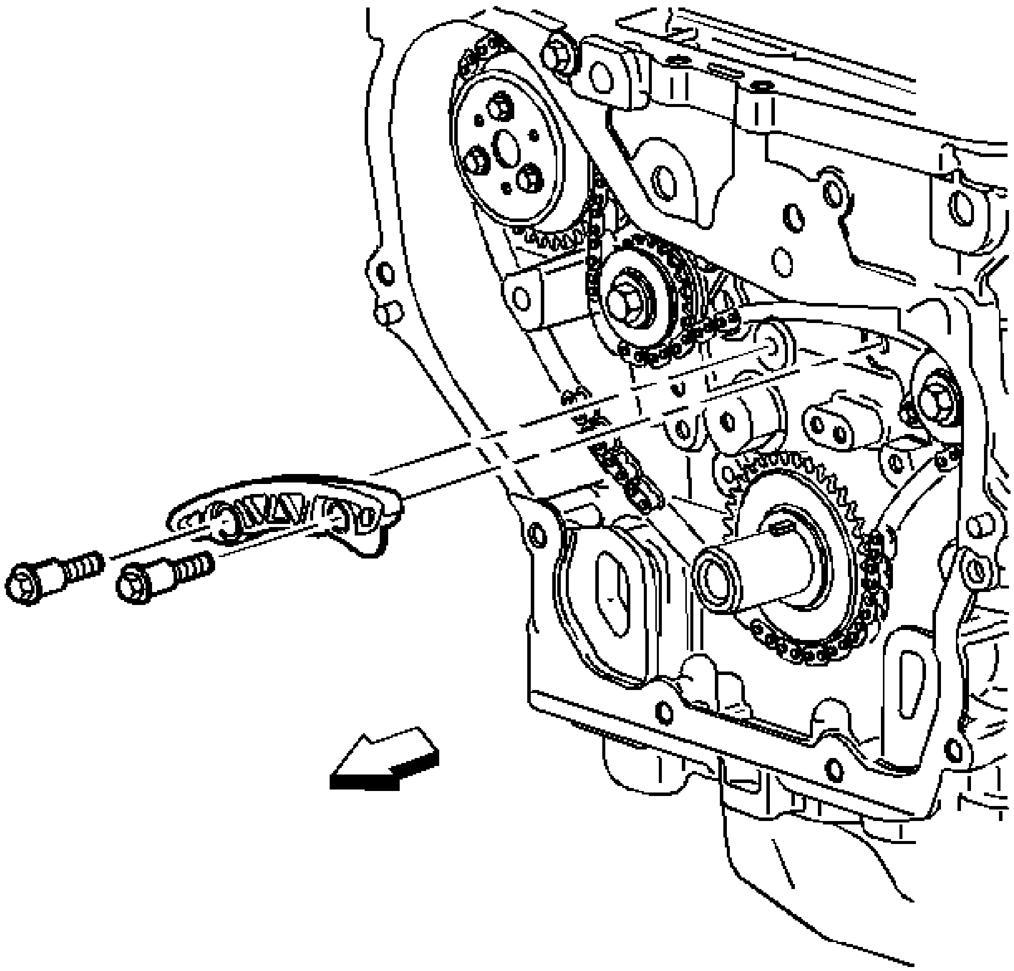


Fig. 78: View Of Upper Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

22. Remove the upper balance shaft drive chain guide.

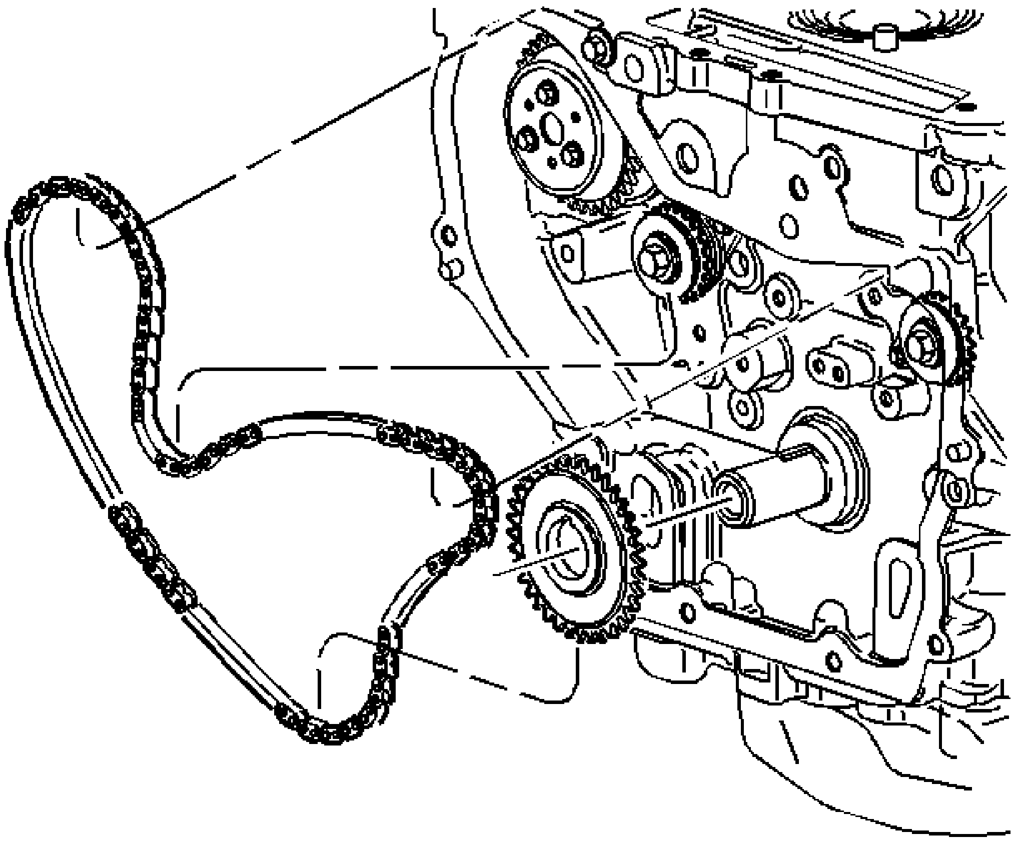


Fig. 79: Identifying Upper Balance Shaft Drive Chain/Sprocket
Courtesy of GENERAL MOTORS CORP.

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

23. Remove the balance shaft drive chain.

Installation Procedure

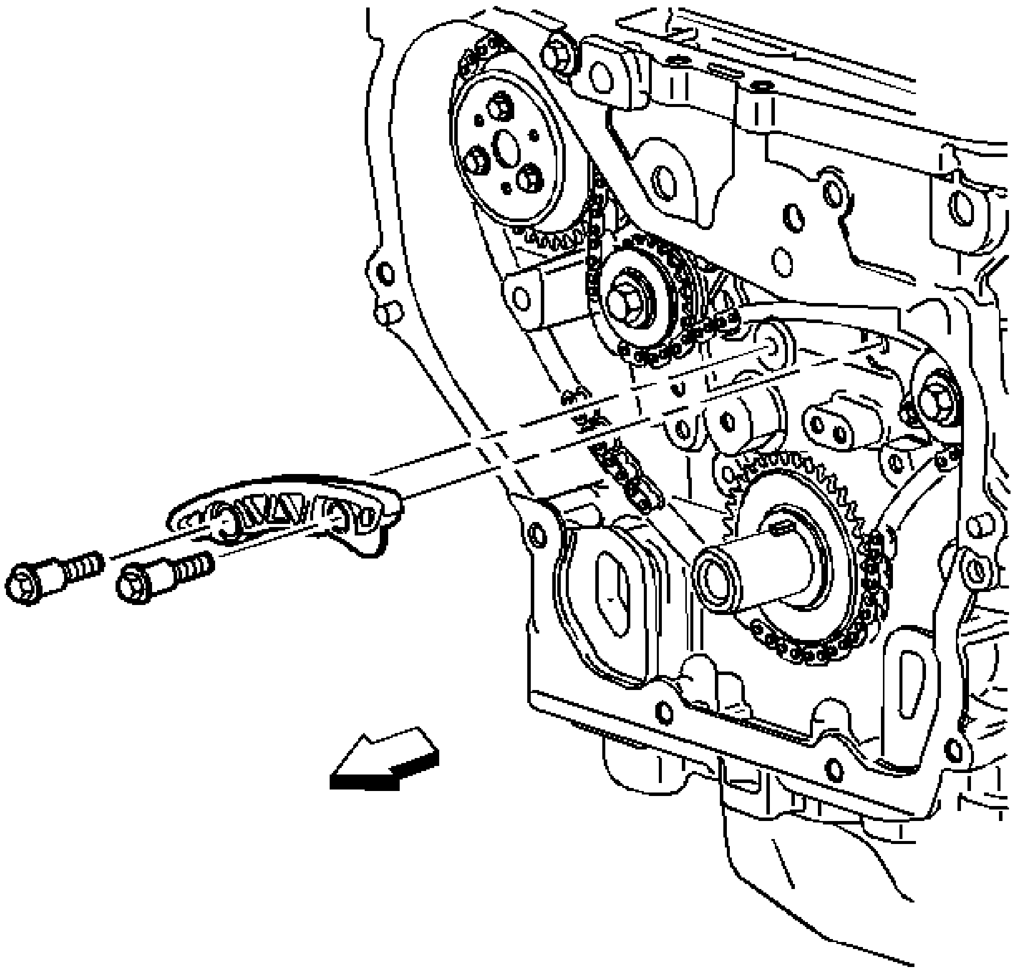


Fig. 80: View Of Upper Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Fastener Notice .**

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.

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

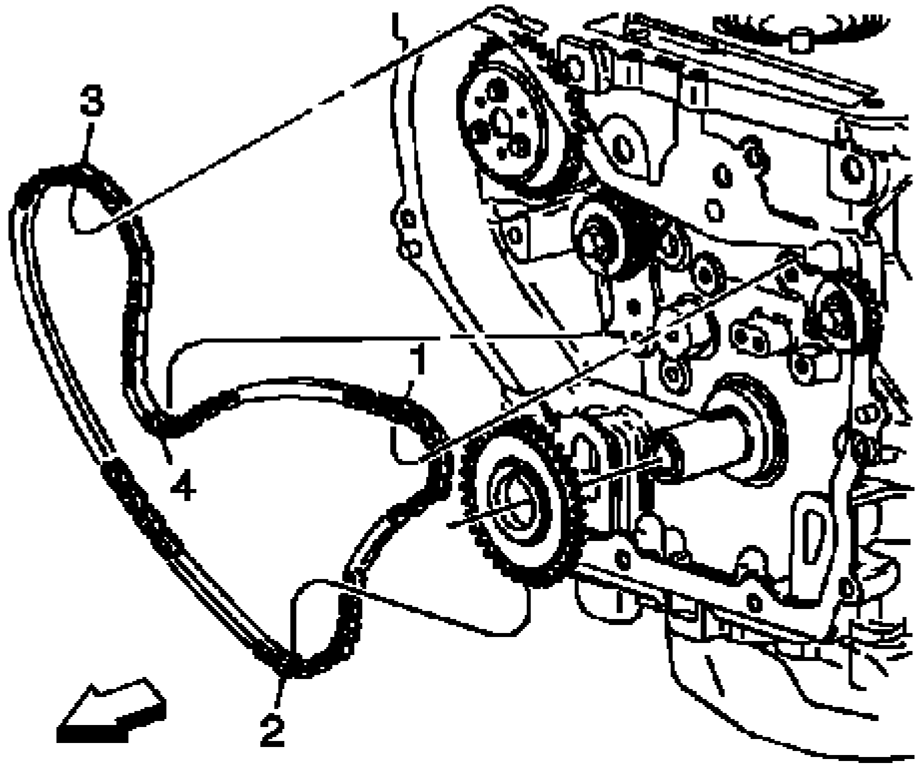


Fig. 81: Aligning Balance Shaft Drive Chain
Courtesy of GENERAL MOTORS CORP.

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. Use the following procedure to line up the links with the sprockets:

   Orient the chain so that the copper colored and chrome links are visible.

3. Place the copper 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 chrome 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 (alignment is not critical).
6. Align the last chrome link (4) with the timing mark on the exhaust side balance shaft drive sprocket.

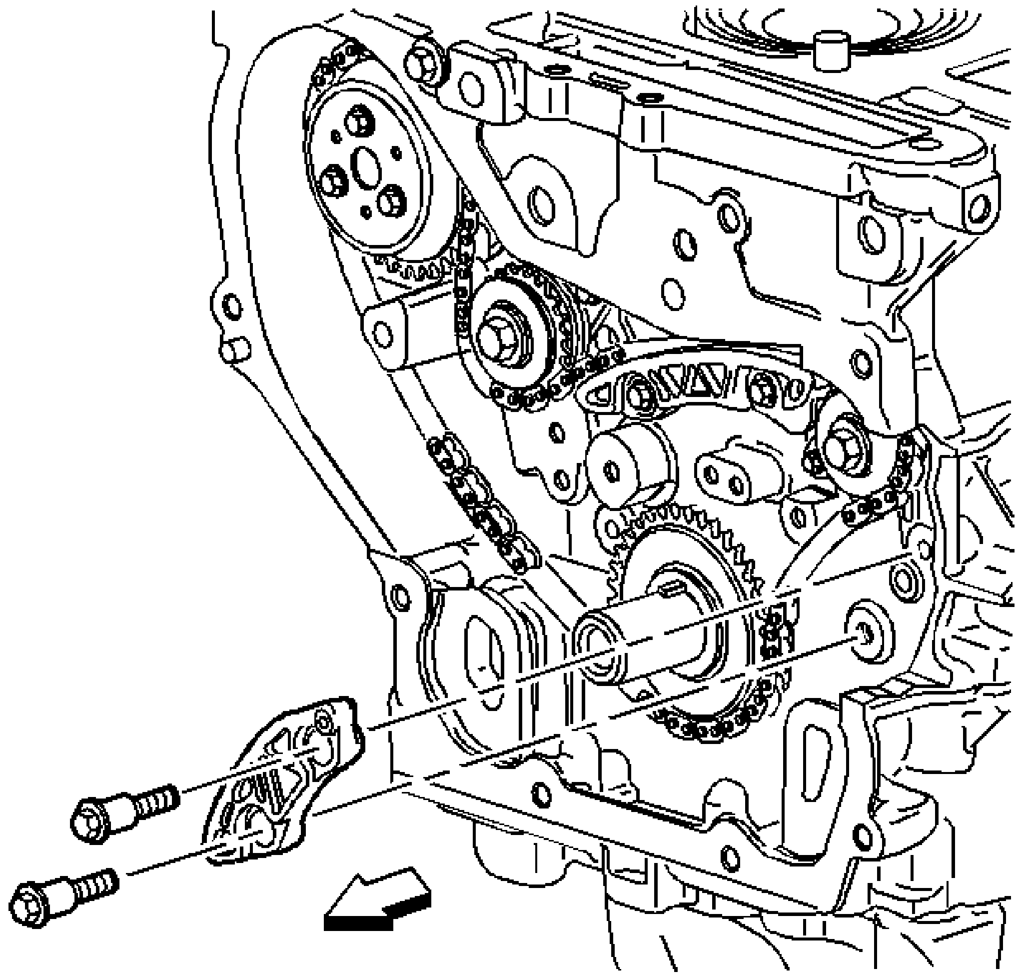


Fig. 82: Exploded View Of Small Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

7. Install the small balance shaft chain guide.
8. Tighten the balance shaft chain guide bolts.

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

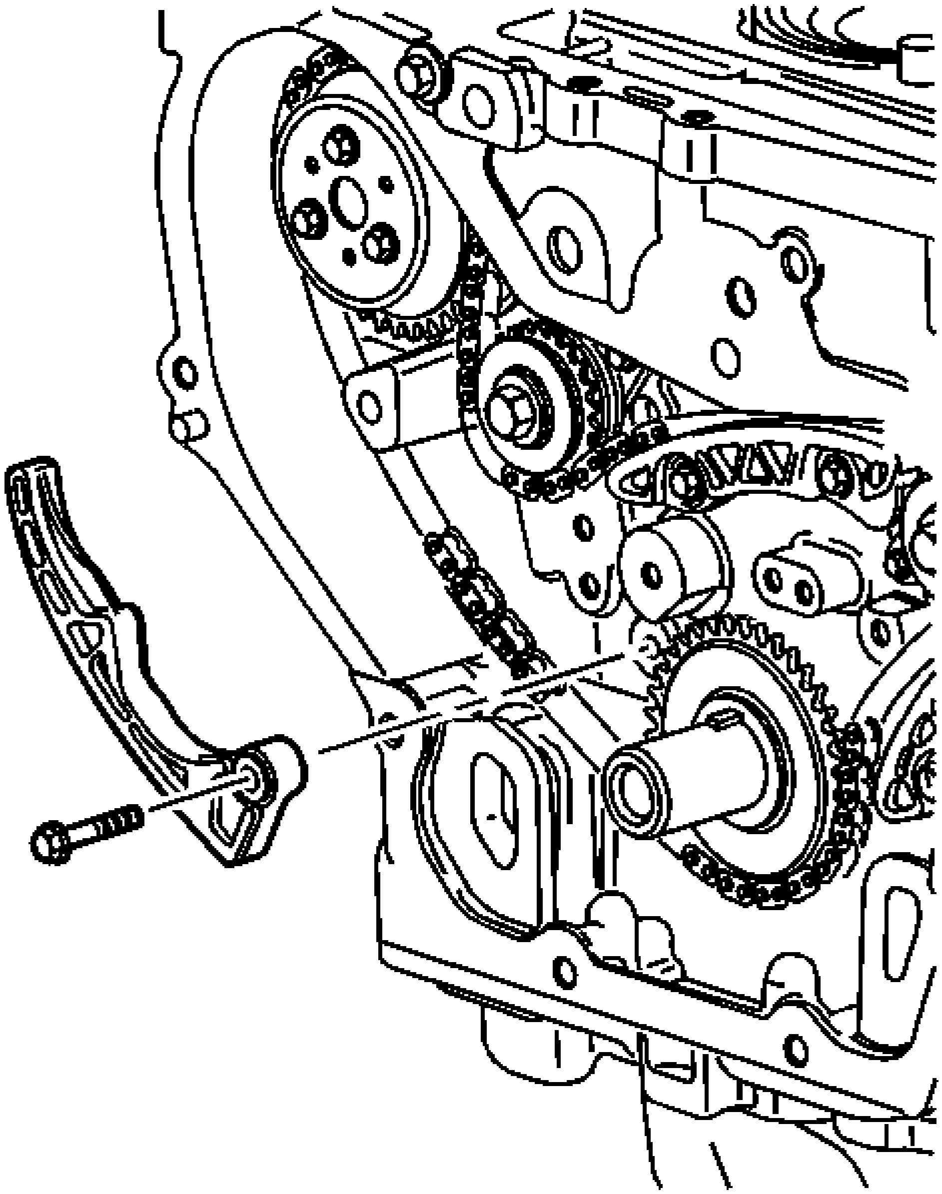


Fig. 83: View Of Adjustable Balance Shaft Chain Guide
Courtesy of GENERAL MOTORS CORP.

9. Install the adjustable balance shaft drive chain guide.

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

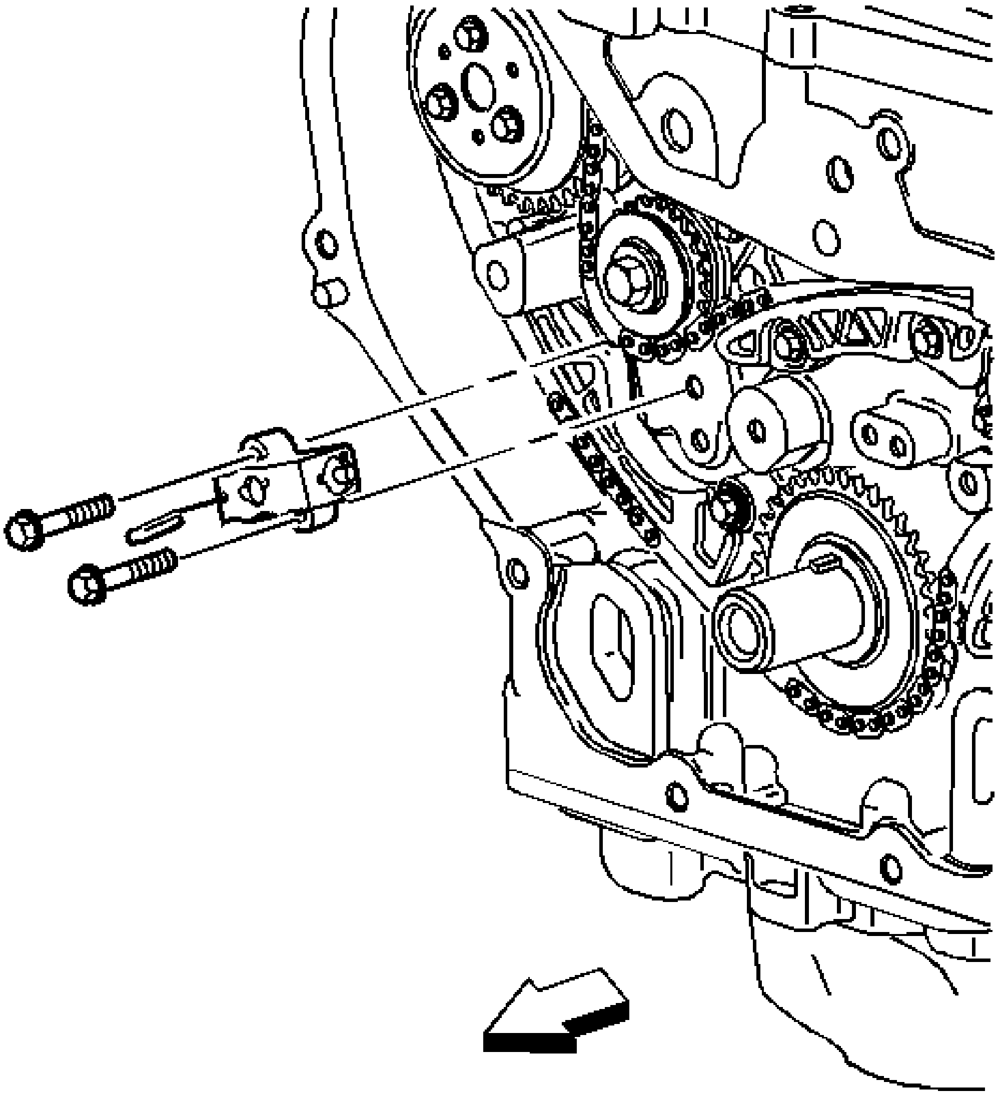


Fig. 84: View Of Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

10. Turn the tensioner plunger 90 degrees in its bore and compress the plunger until a paper clip can be inserted through the hole in the plunger body and into hole in the tensioner plunger.
11. Install the timing chain tensioner.
12. Tighten the chain tensioner bolts.

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

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

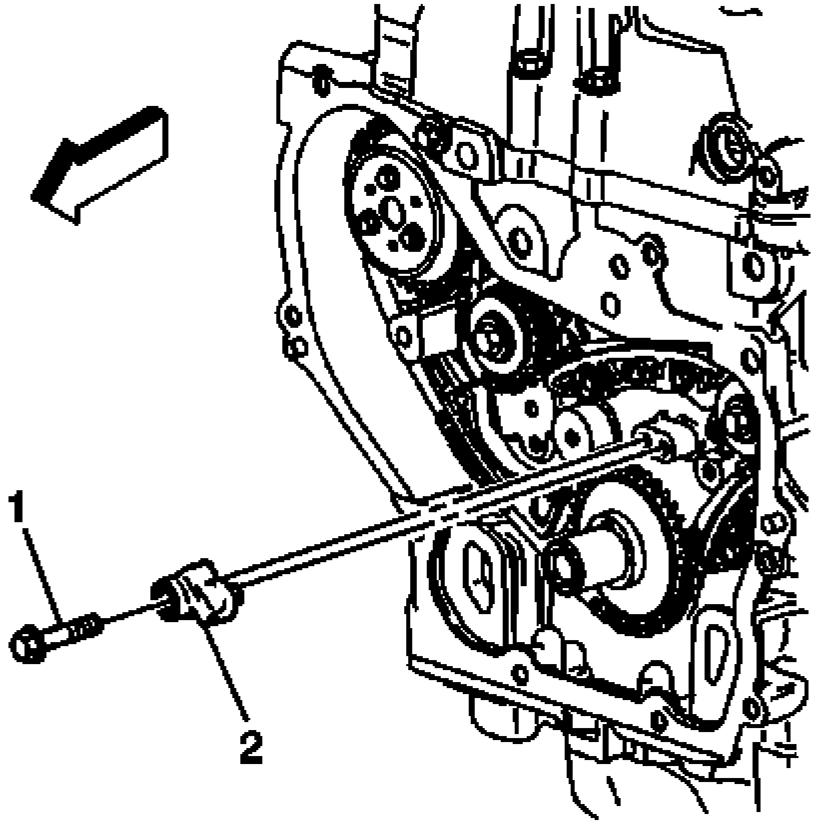


Fig. 85: View Of Oil Nozzle & Bolt
Courtesy of GENERAL MOTORS CORP.

14. Install the oil nozzle and bolt.

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

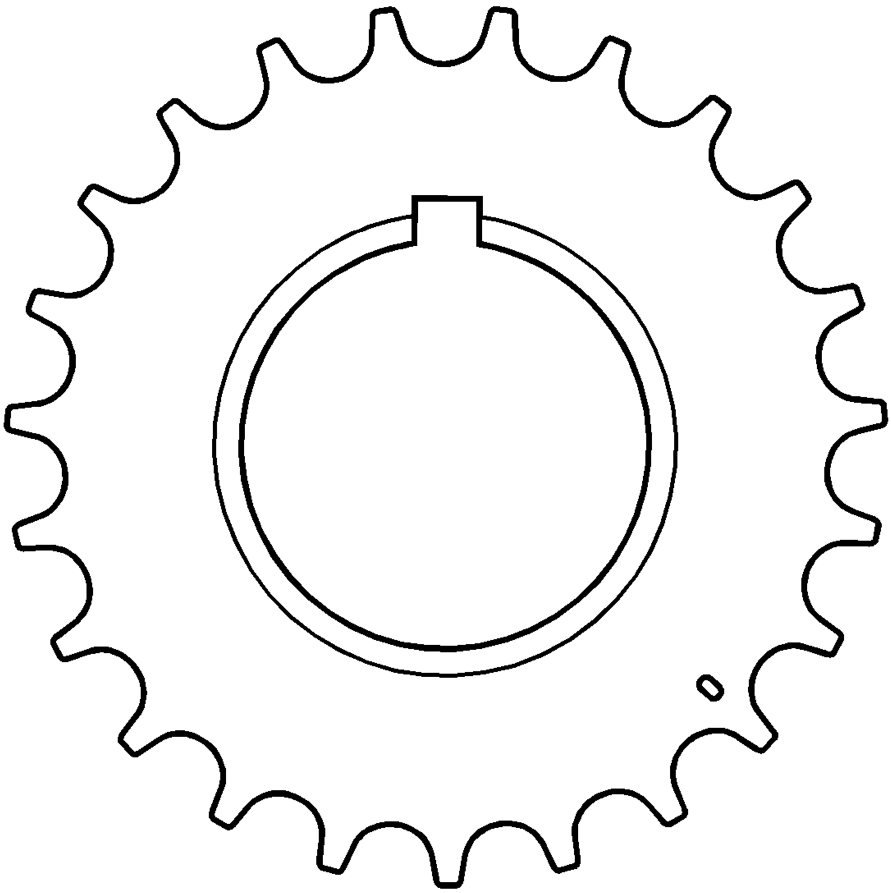


Fig. 86: View Of Crankshaft Sprocket Timing Mark
Courtesy of GENERAL MOTORS CORP.

15. Install the crankshaft sprocket with timing mark at the 5 o'clock position.

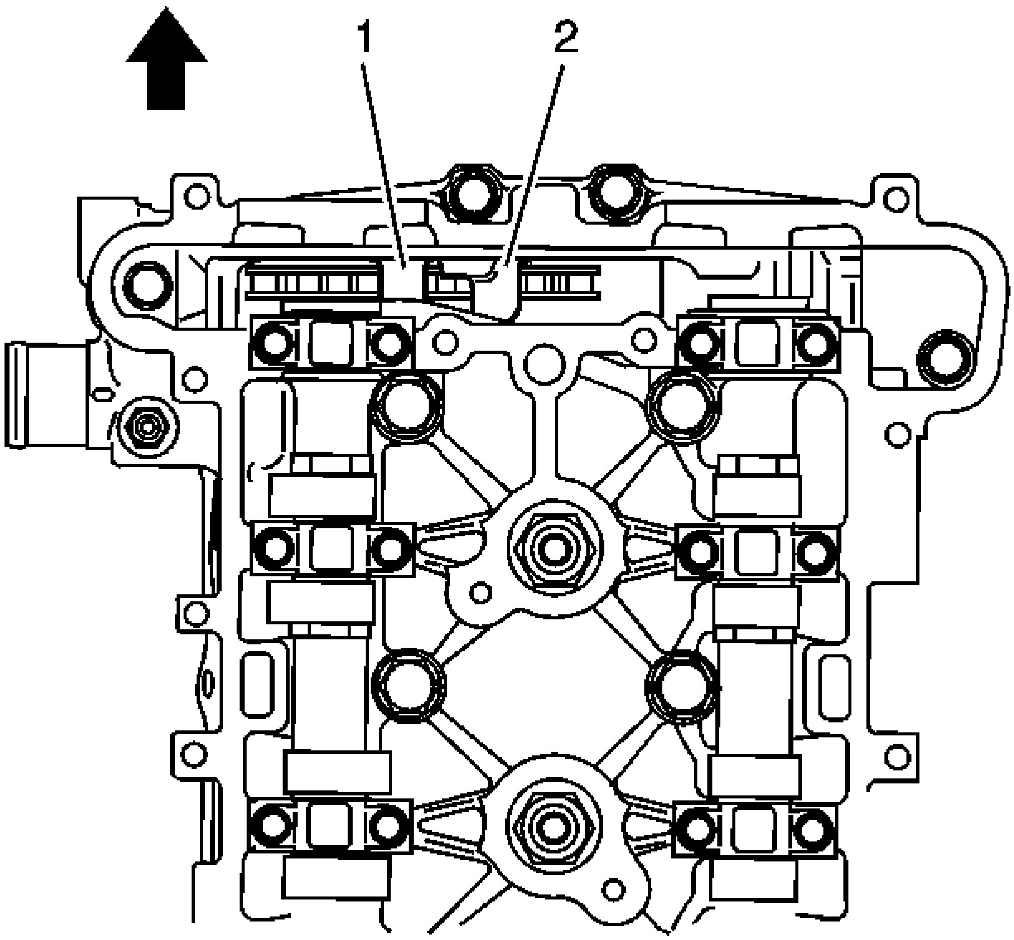


Fig. 87: Locating Cylinder Block Bosses
Courtesy of GENERAL MOTORS CORP.

16. Lower the timing chain through the opening in the top of the cylinder head. Carefully ensure that the chain goes around both sides of the cylinder block bosses (1, 2).

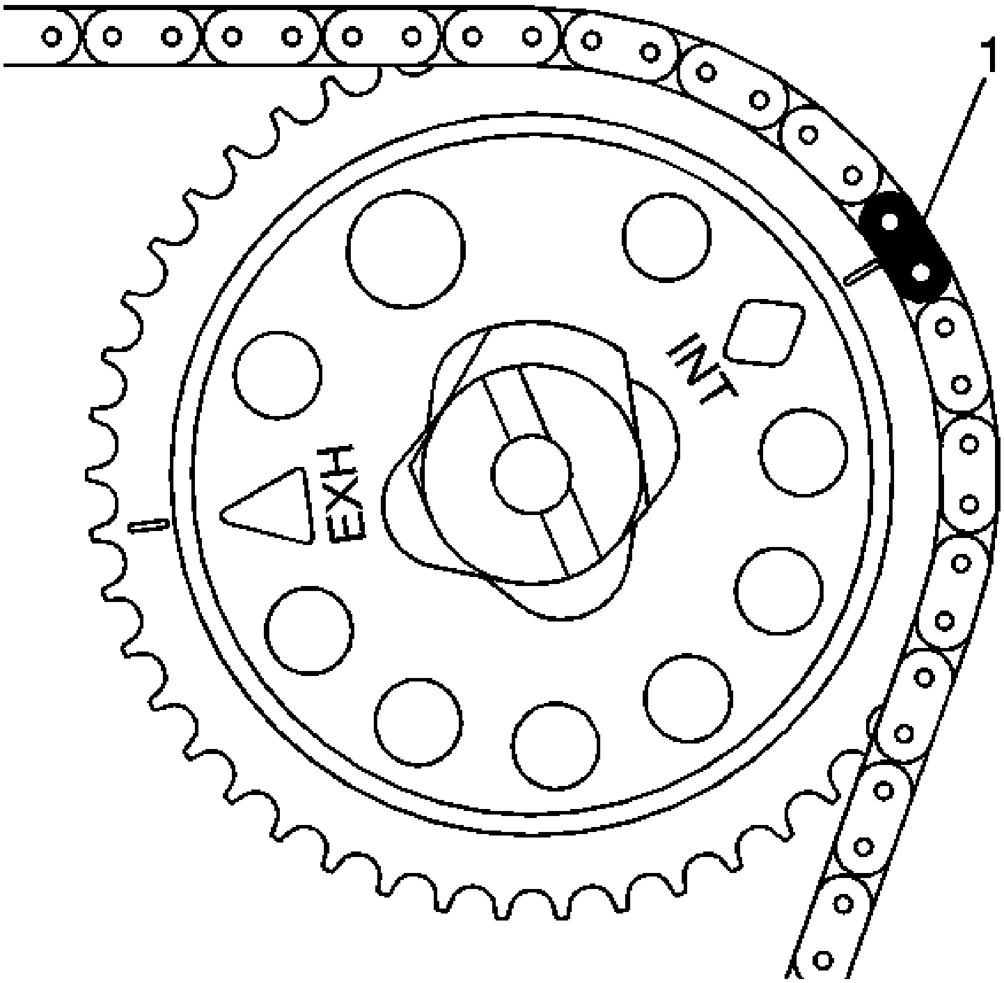


Fig. 88: Aligning Timing Chain Link & Intake Sprocket Timing Mark
Courtesy of GENERAL MOTORS CORP.

17. Install the intake camshaft sprocket with the INT diamond at the 2 o'clock position.
18. Hand tighten a NEW intake camshaft sprocket bolt.
19. Route the timing chain around the crankshaft sprocket with the matching colored link aligning with the timing mark.
20. Route the timing chain around the intake camshaft sprocket with the uniquely colored link (1) aligning with the INT diamond.

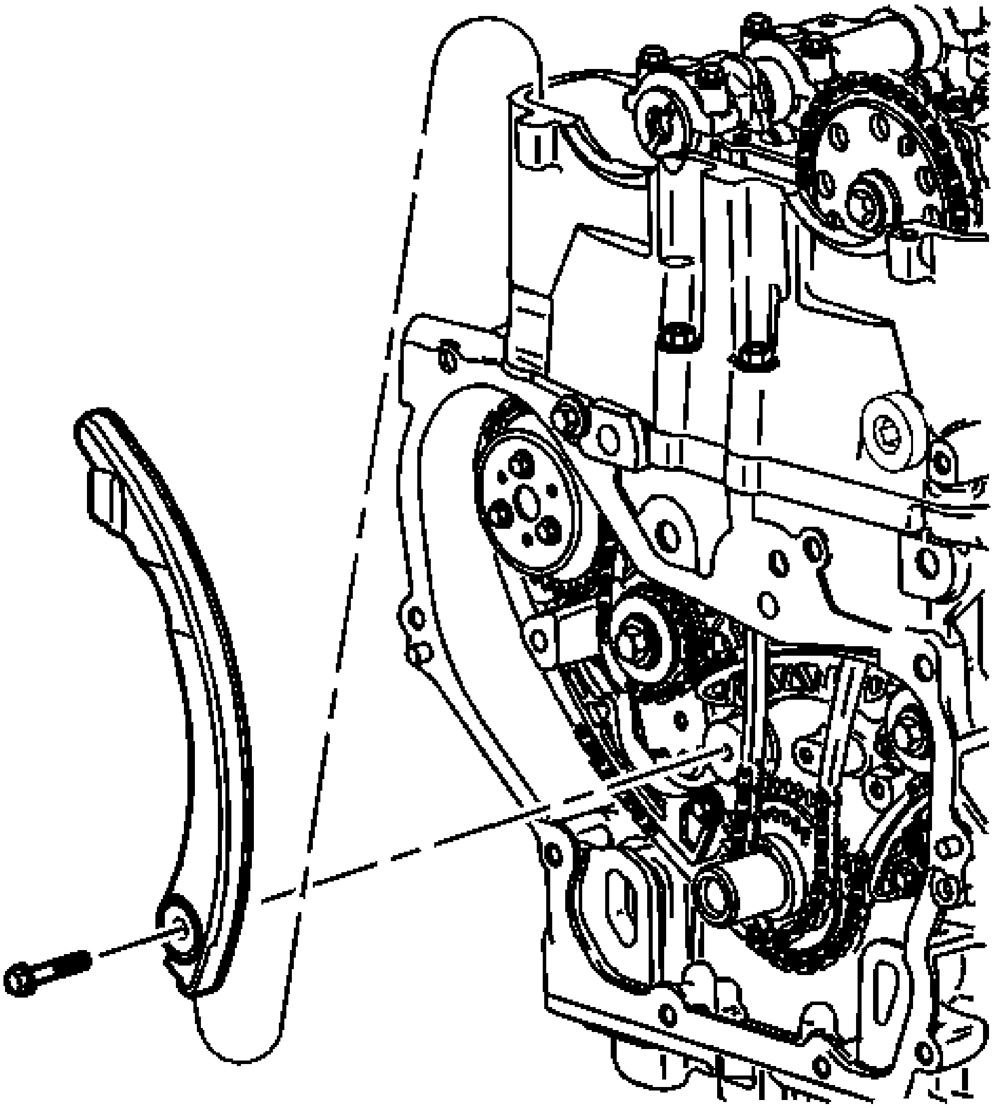


Fig. 89: View Of Timing Chain Tensioner Guide
Courtesy of GENERAL MOTORS CORP.

21. Install the timing chain tensioner guide through the opening in the top of the cylinder head.

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

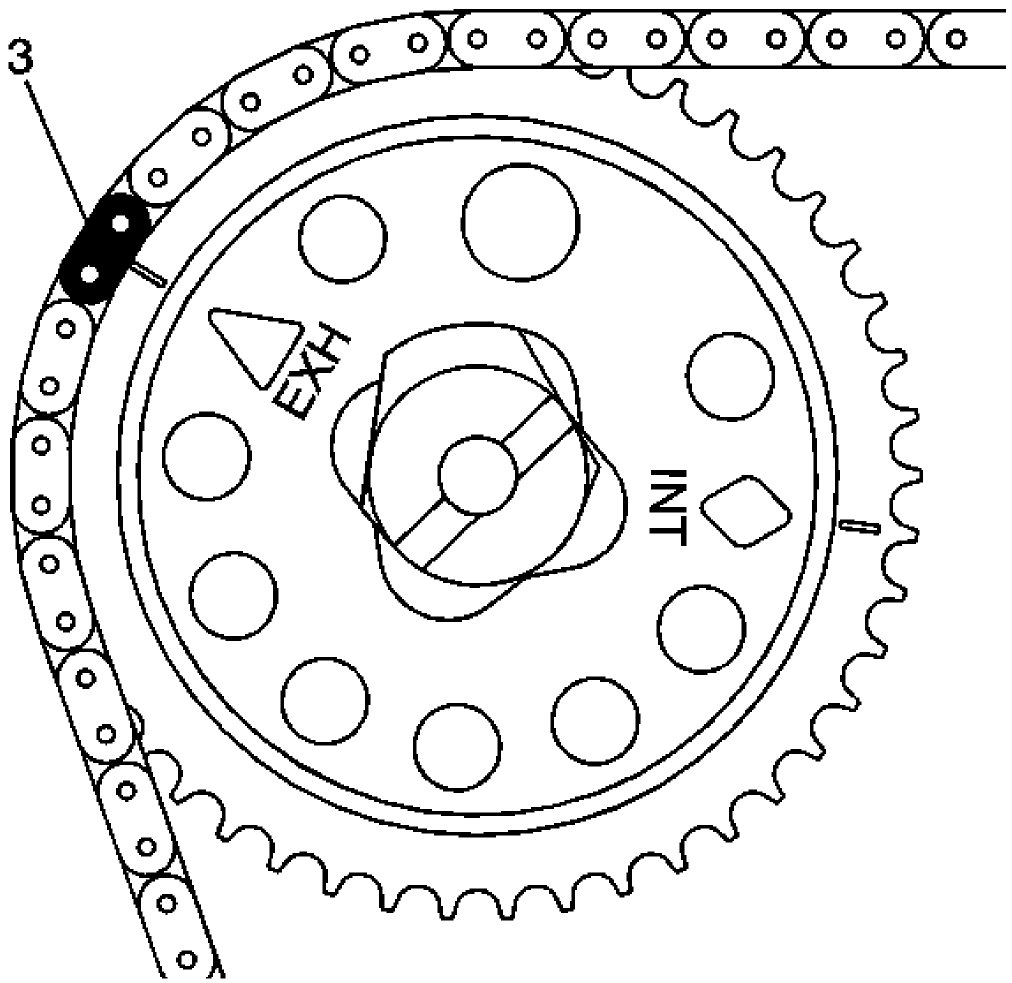


Fig. 90: Aligning Timing Chain Link & Exhaust Timing Mark
Courtesy of GENERAL MOTORS CORP.

22. Install the exhaust camshaft sprocket with the timing chain matching colored link (3) at EXH triangle aligned at the 10 o'clock position.

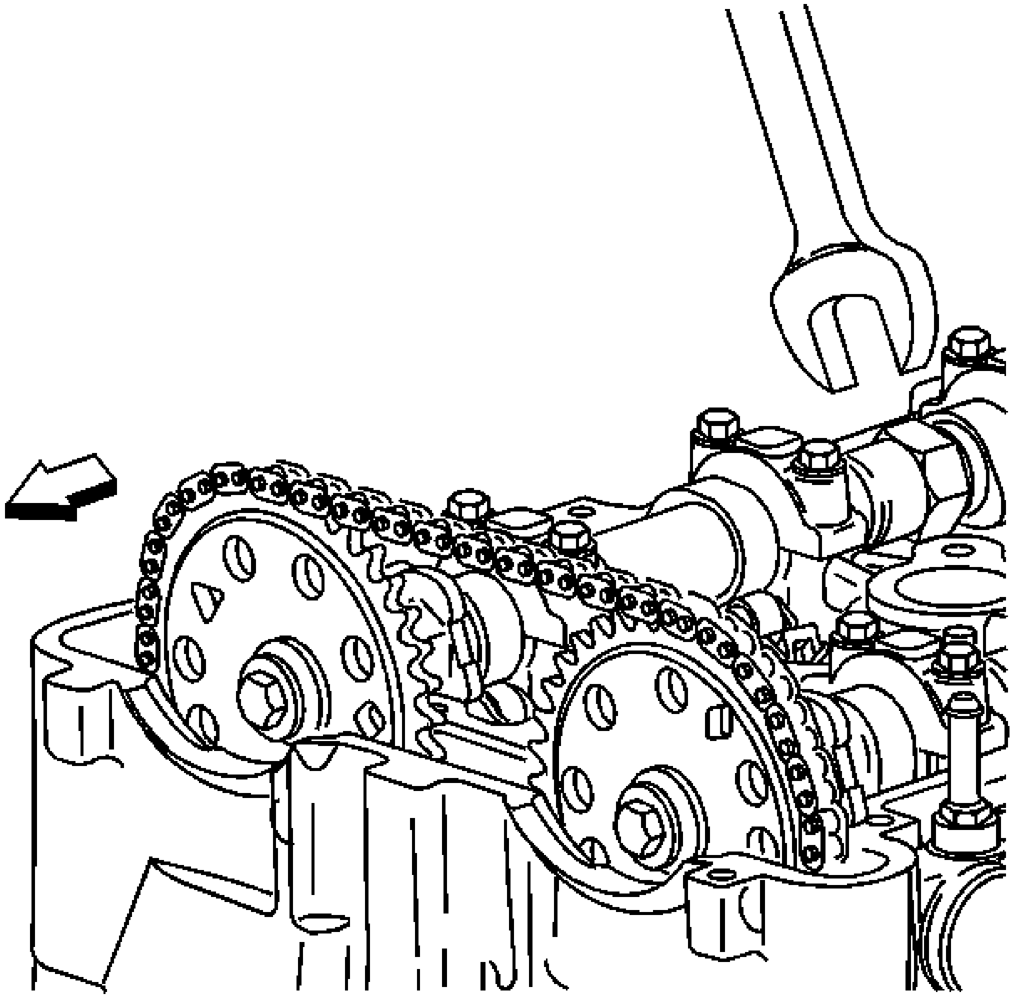


Fig. 91: Using 24 mm Wrench To Align Camshaft
Courtesy of GENERAL MOTORS CORP.

23. Use a 24 mm wrench to rotate the camshaft slightly, until exhaust sprocket aligns with the camshaft.
24. Hand tighten the NEW exhaust camshaft sprocket bolt.

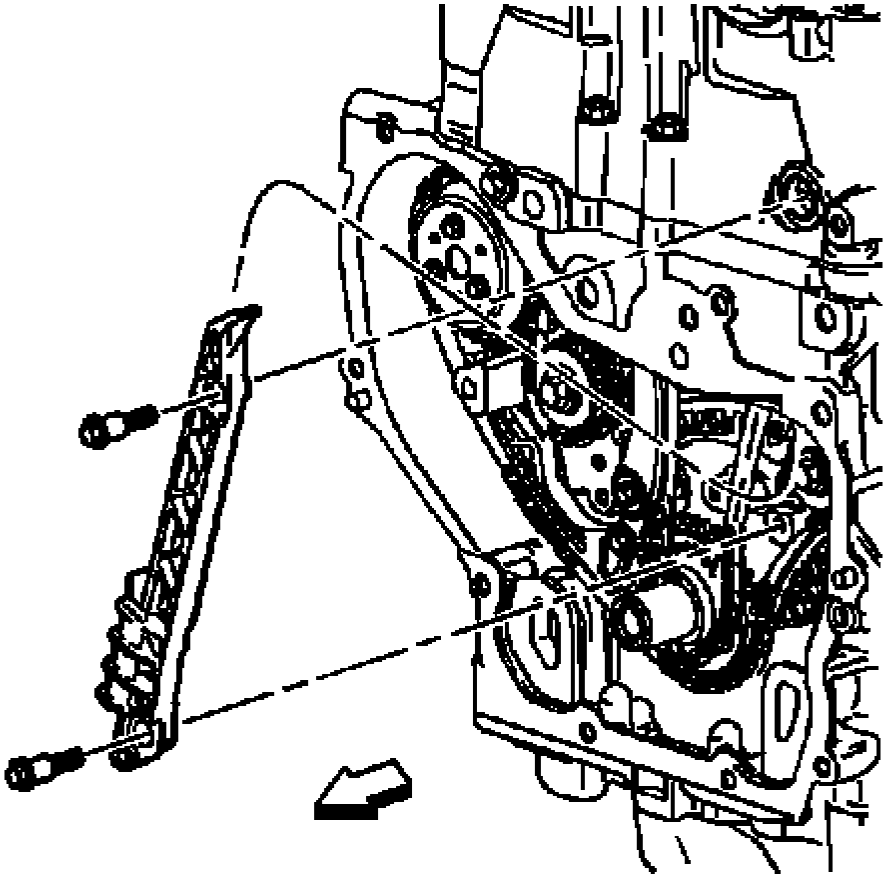


Fig. 92: View Of Fixed Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

25. Install the fixed timing chain guide.

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

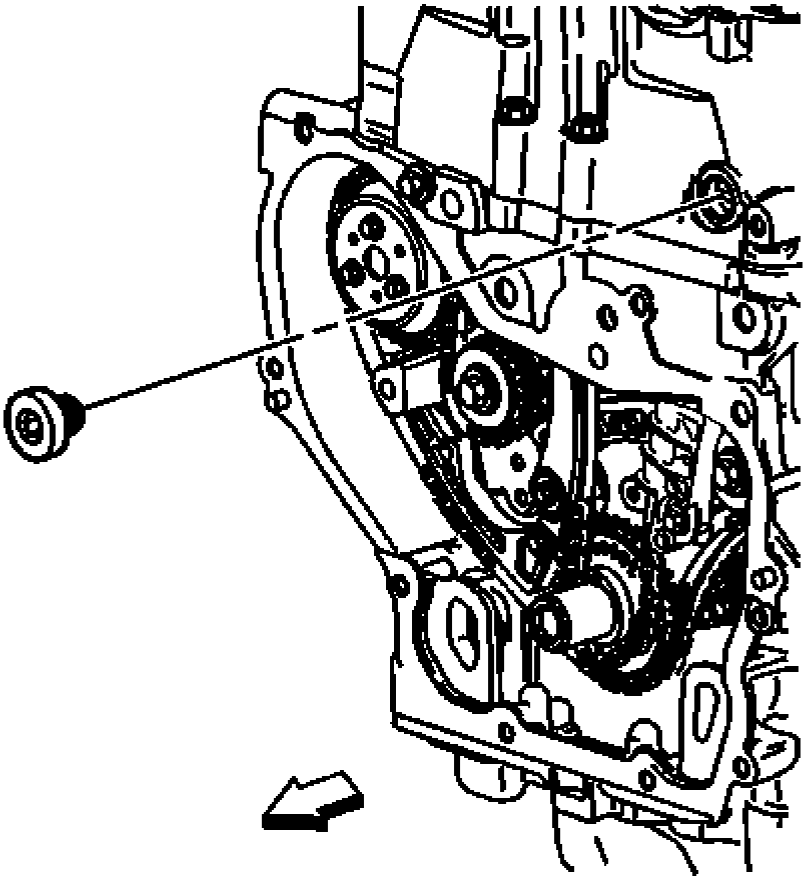


Fig. 93: View Of Fixed Timing Chain Guide Access Plug
Courtesy of GENERAL MOTORS CORP.

26. Apply sealant, GM P/N 12345382 (Canadian P/N 1095349) compound to thread and install the timing chain guide bolt access hole plug.

    Tighten: Tighten the chain guide plug to 90 N.m (66 lb ft).

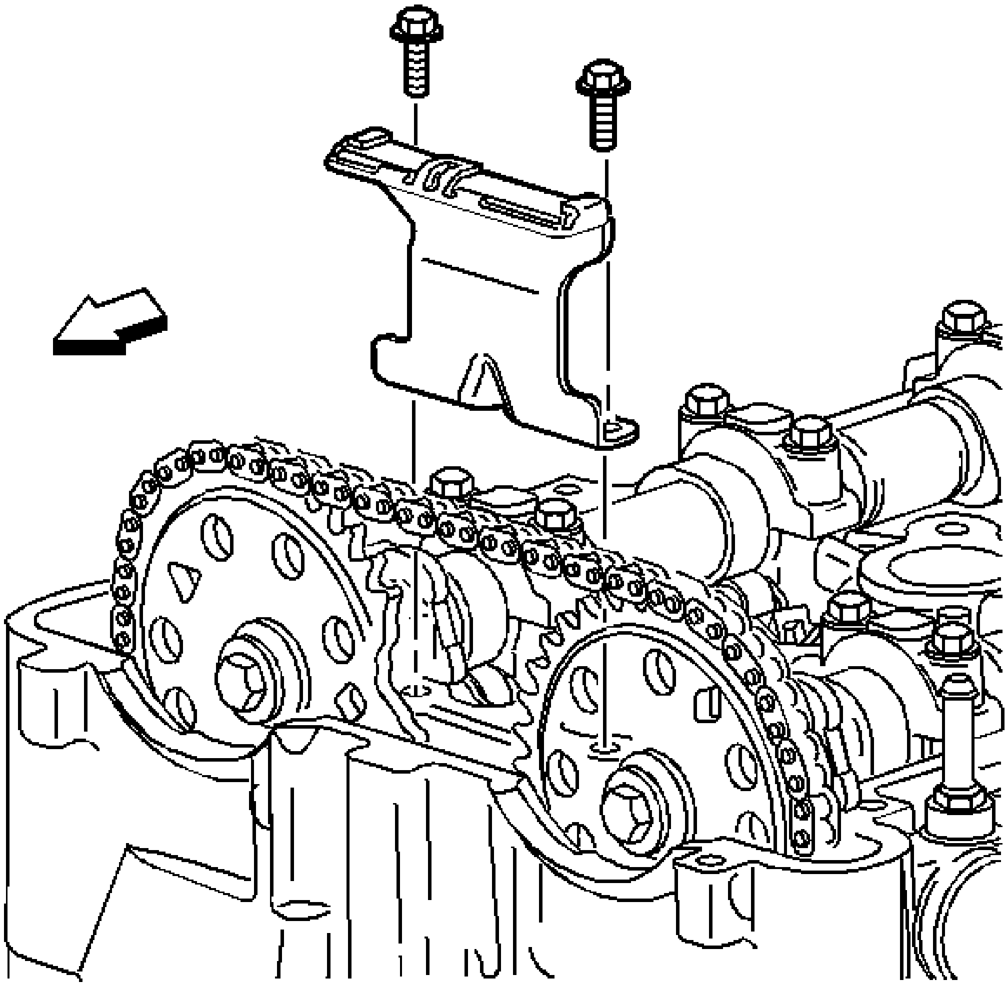


Fig. 94: View Of Upper Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

27. Install the timing chain upper guide.

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

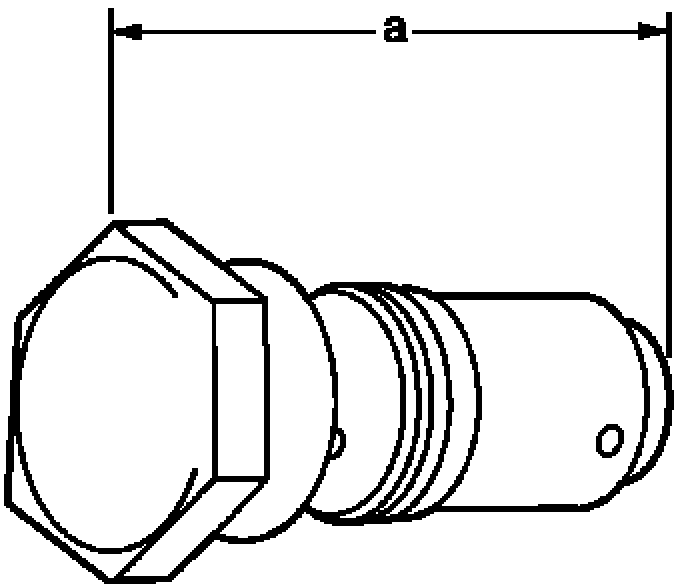


Fig. 95: Measuring Timing Chain Tensioner Assembly
Courtesy of GENERAL MOTORS CORP.

28. Inspect the timing chain tensioner. If the timing chain tensioner, O-ring seal, or washer is damaged, replace the timing chain tensioner.
29. 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.

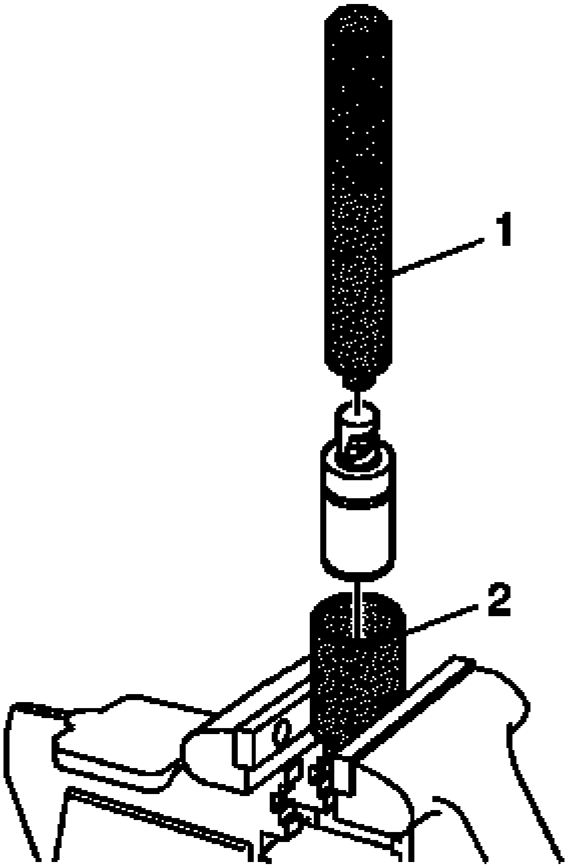


Fig. 96: Compressing Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

30. 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.

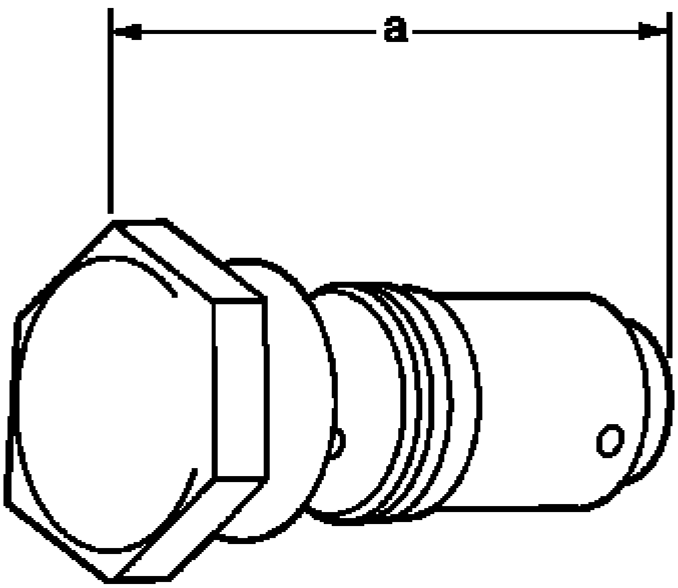


Fig. 97: Measuring Timing Chain Tensioner Assembly
Courtesy of GENERAL MOTORS CORP.

31. 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.
32. 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.
33. 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.

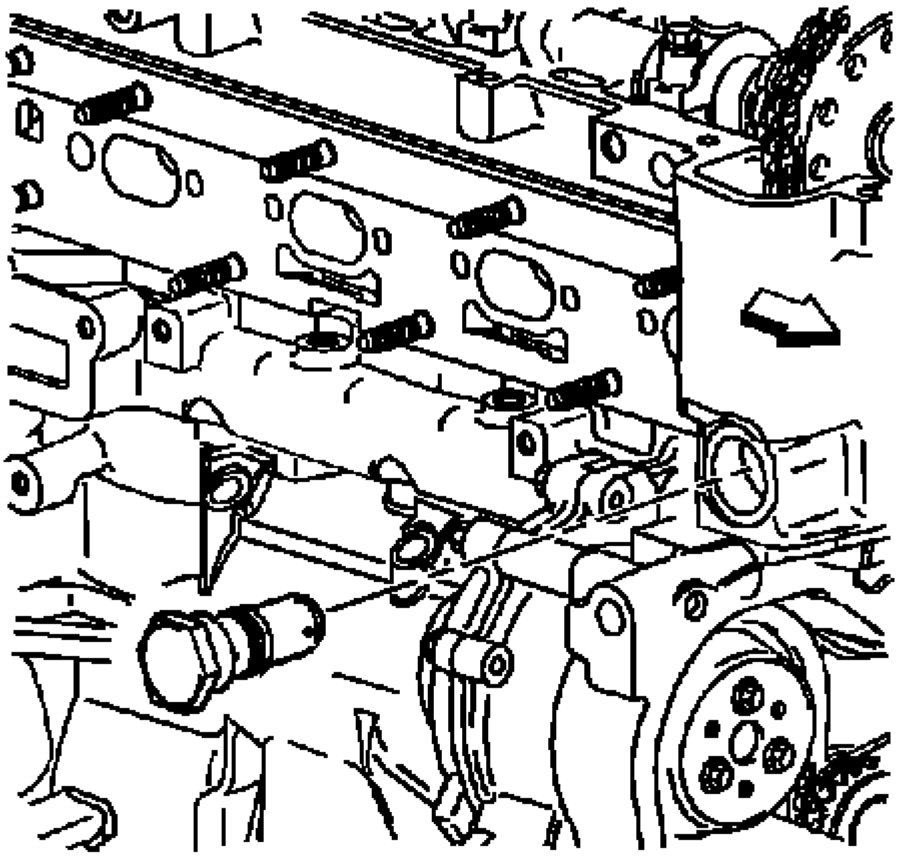


Fig. 98: Identifying Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

34. Install the timing chain tensioner.

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

35. Use a suitable tool with a rubber tip on the end. Feed the tool down through the camshaft drive chant to rest on the timing chain. Then give a sharp jolt diagonally downwards to release the tensioner.

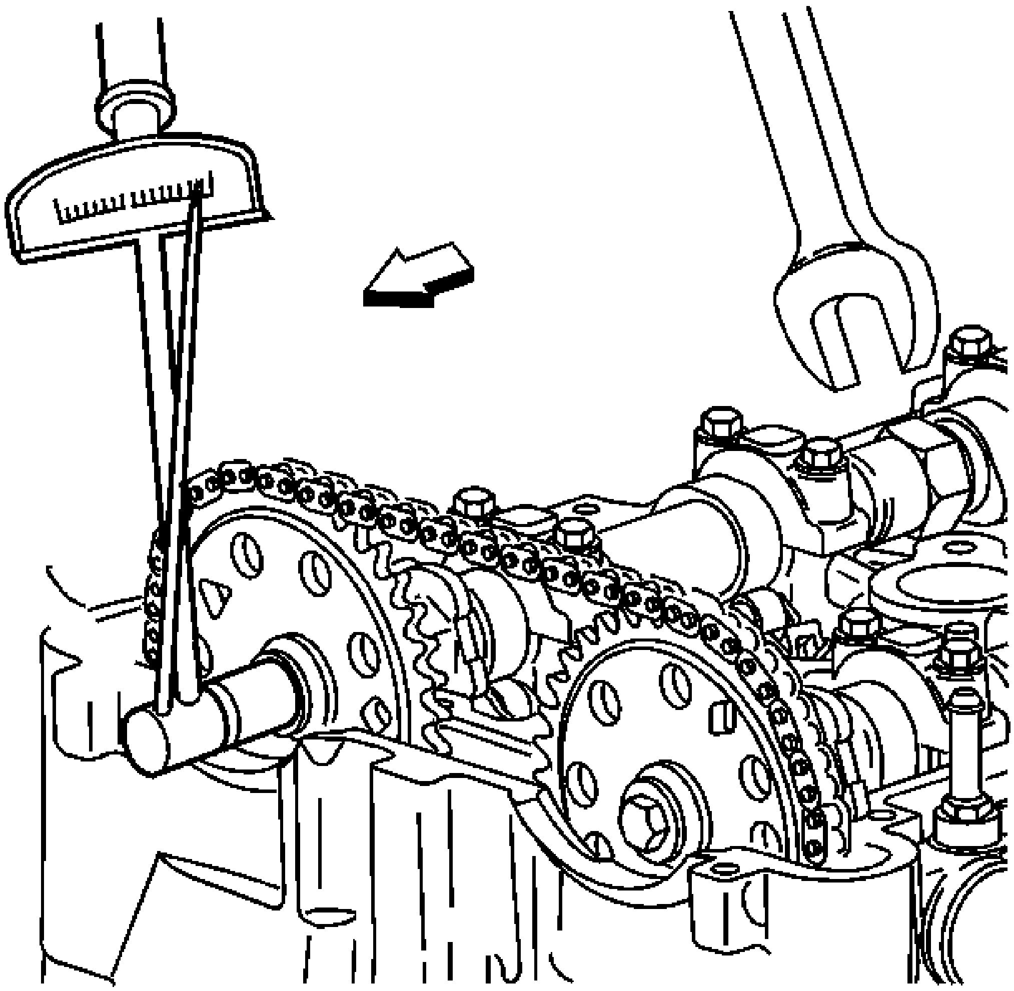


Fig. 99: Holding Camshaft Stationary With Wrench On Hex Casting On Camshaft
Courtesy of GENERAL MOTORS CORP.

36. Use a 24 mm wrench to hold the camshaft.

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

37. Install the camshaft cover. Refer to **Camshaft Cover Replacement**.
38. Raise the vehicle.
39. Install the engine front cover. Refer to **Engine Front Cover Replacement**.
40. Lower the vehicle.
41. Connect negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** .

Camshaft Cover Replacement

Removal Procedure

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
2. Remove the air outlet resonator. Refer to **Air Cleaner Outlet Resonator Replacement** in Engine Controls-2.2L (L61).
3. Remove the accelerator and cruise control cables bracket.
4. Remove the PCV hose.
5. Remove the fuel line brackets.
6. Remove the brake booster hose/pipe from it's bracket.

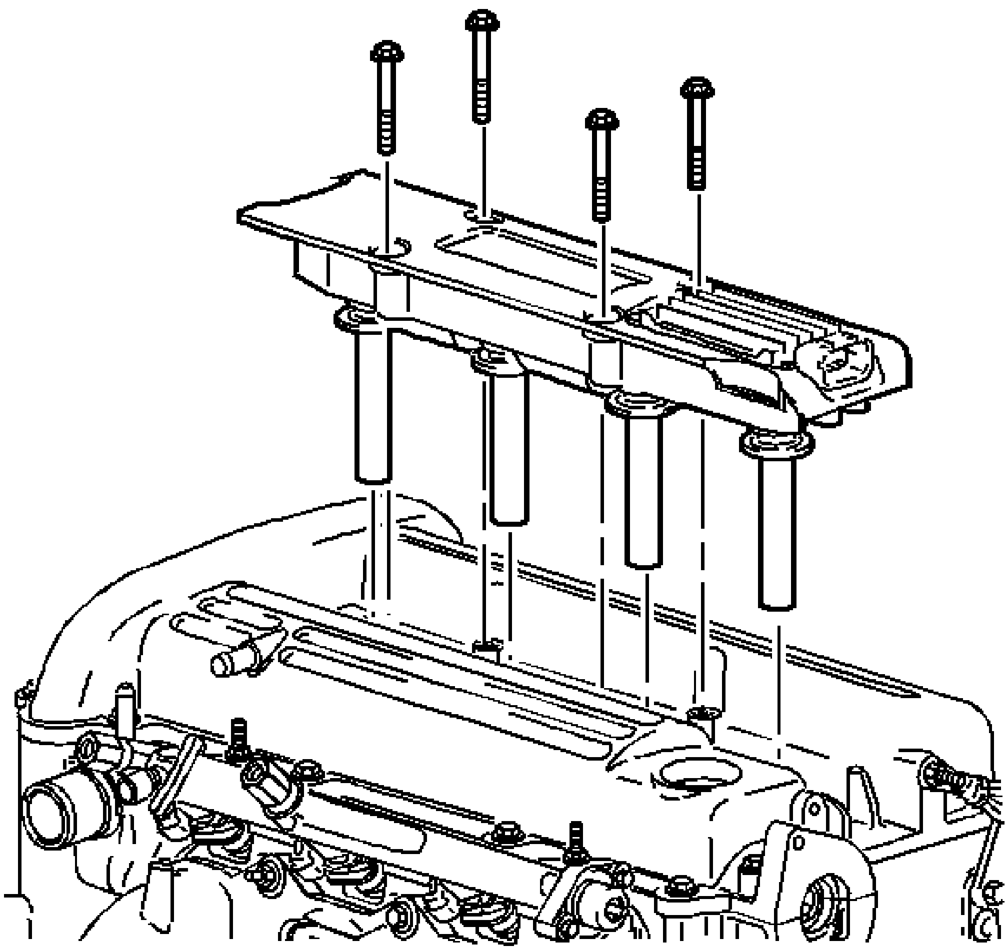


Fig. 100: View Of Ignition Coil & Module Assembly
Courtesy of GENERAL MOTORS CORP.

7. Remove the ignition coil and module assembly.

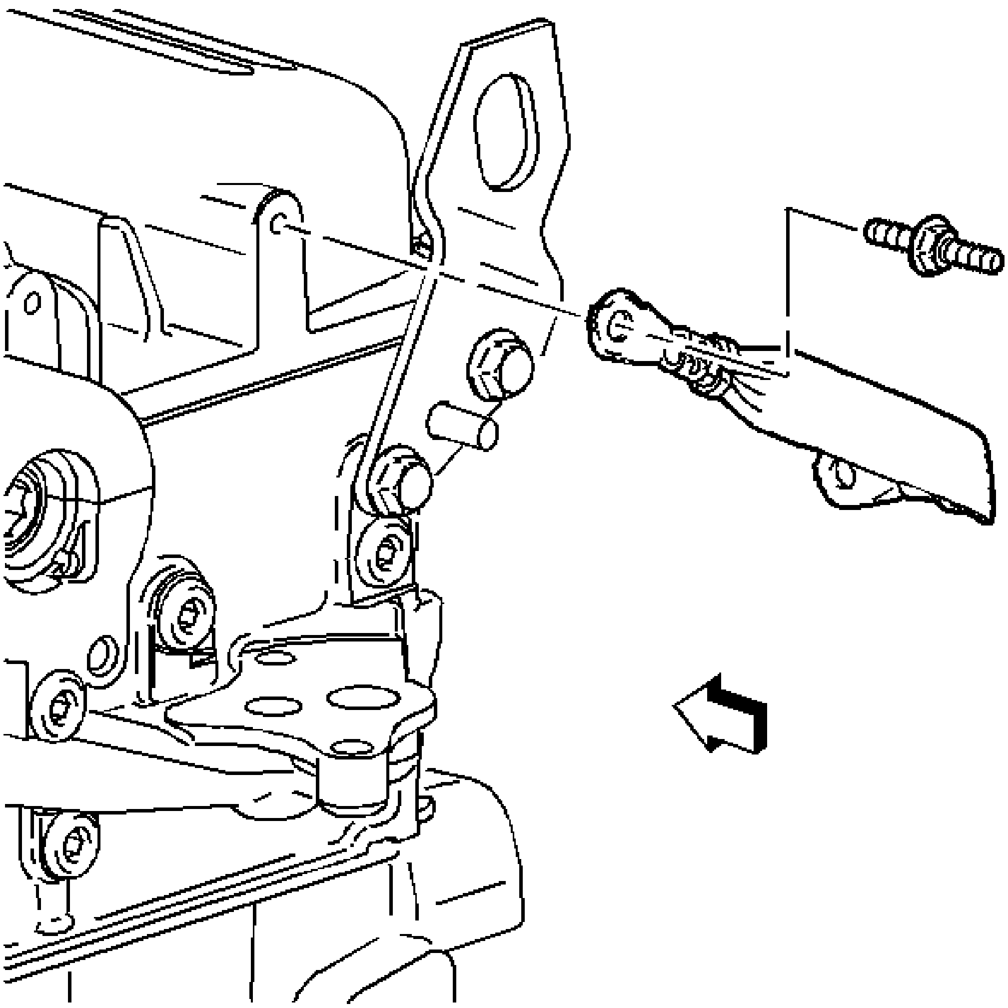


Fig. 101: View Of Camshaft Cover Ground Strap
Courtesy of GENERAL MOTORS CORP.

8. Remove the ground strap.

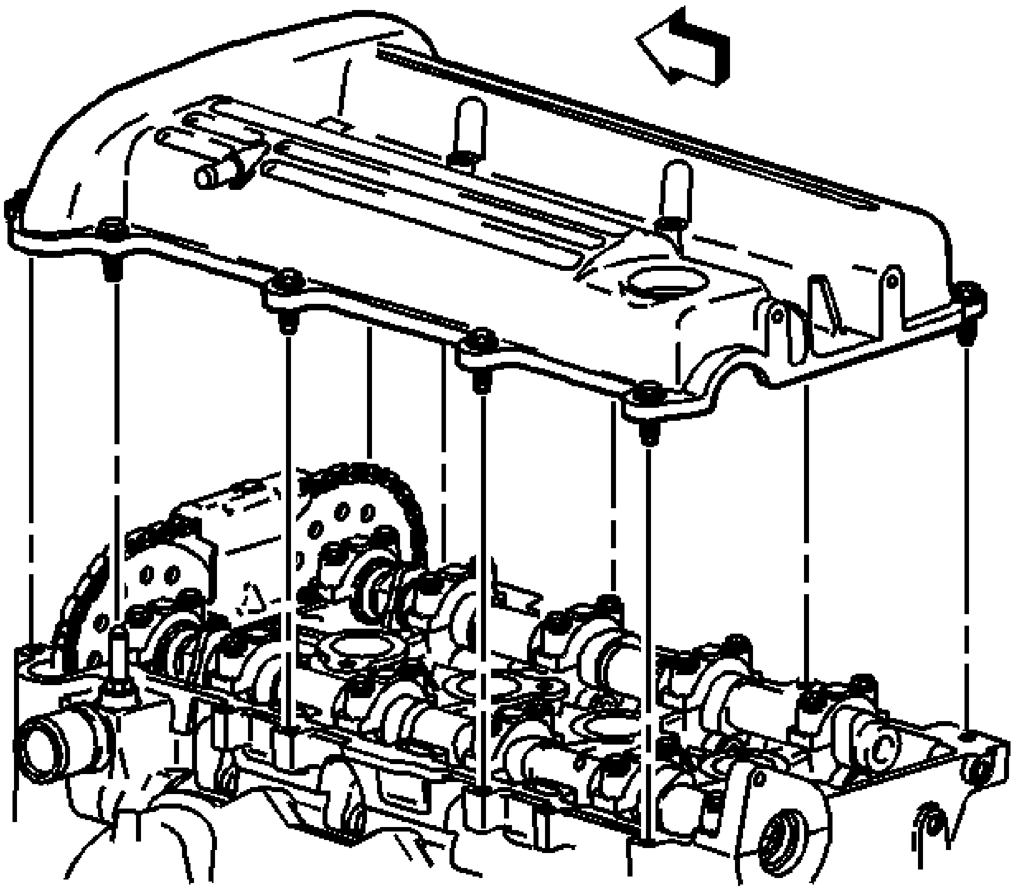


Fig. 102: View Of Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

9. Remove the camshaft cover bolts.
10. Remove the camshaft cover.

Installation Procedure

NOTE: Refer to Fastener Notice in Cautions and Notices.

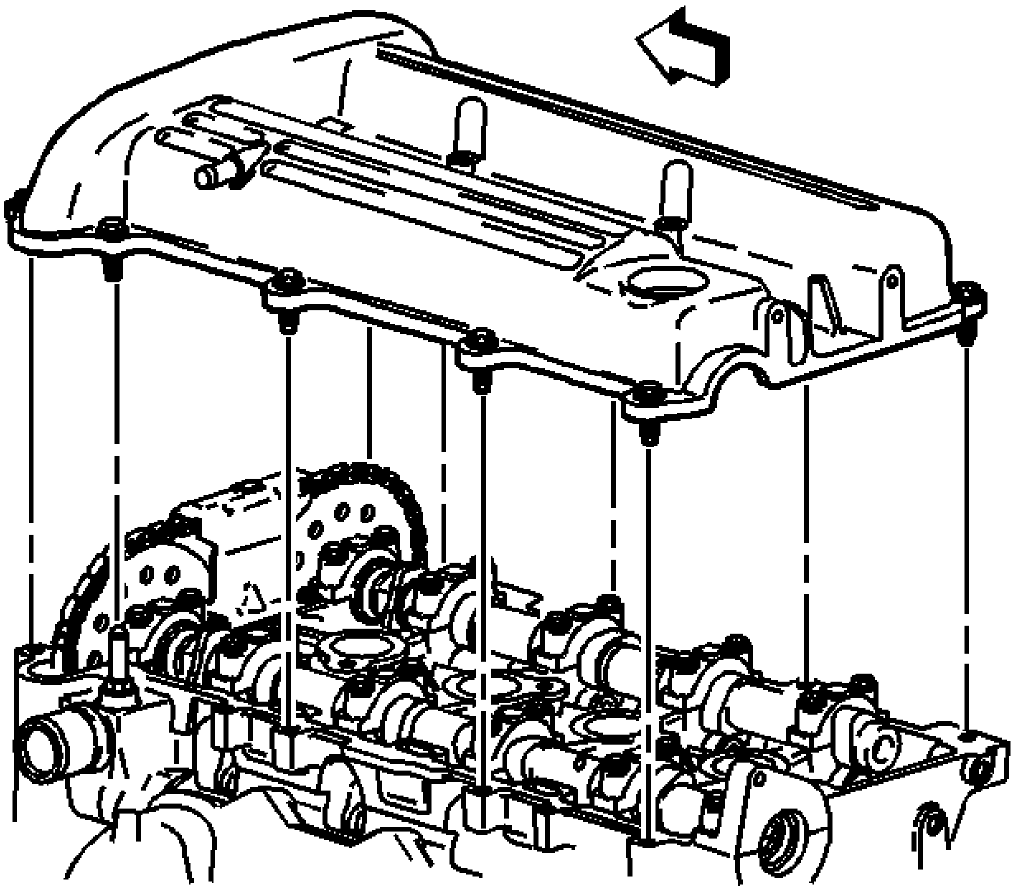


Fig. 103: View Of Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

1. Install the camshaft cover and bolts.

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

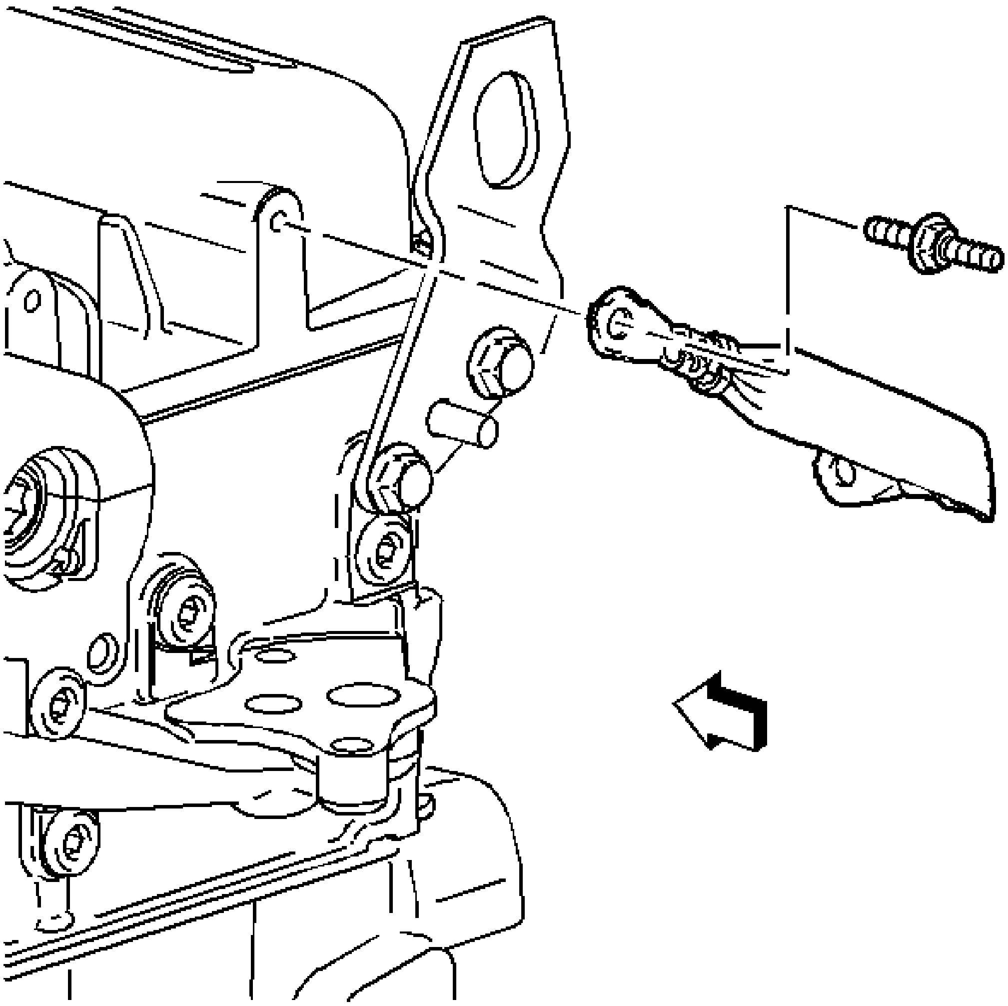


Fig. 104: View Of Camshaft Cover Ground Strap
Courtesy of GENERAL MOTORS CORP.

2. Install the ground strap.

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

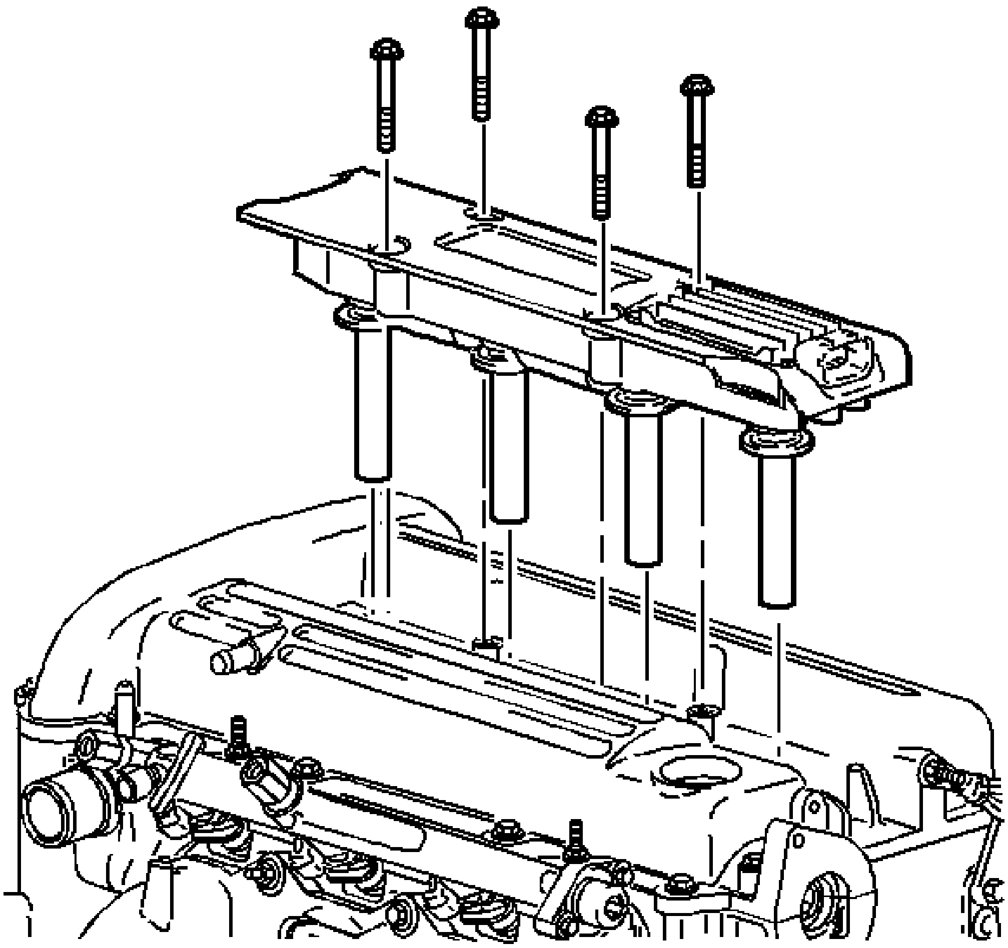


Fig. 105: View Of Ignition Coil & Module Assembly
Courtesy of GENERAL MOTORS CORP.

3. Install the ignition coil and module assembly.

   Tighten: Tighten the ignition coil and module assembly bolt to 10 N.m (89 lb in).

4. Install the brake booster hose/pipe to it's bracket.
5. Install the fuel line bracket.

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

6. Install the accelerator and cruise control cables bracket.

Tighten: Tighten the accelerator and cruise control cables bracket bolt to 10 N.m (89 lb in).

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

Intake Camshaft and Lifter Replacement

Tools Required

J 43655 Camshaft Sprocket Holding Tool

Removal Procedure

1. Remove the camshaft cover. Refer to **Camshaft Cover Replacement**.

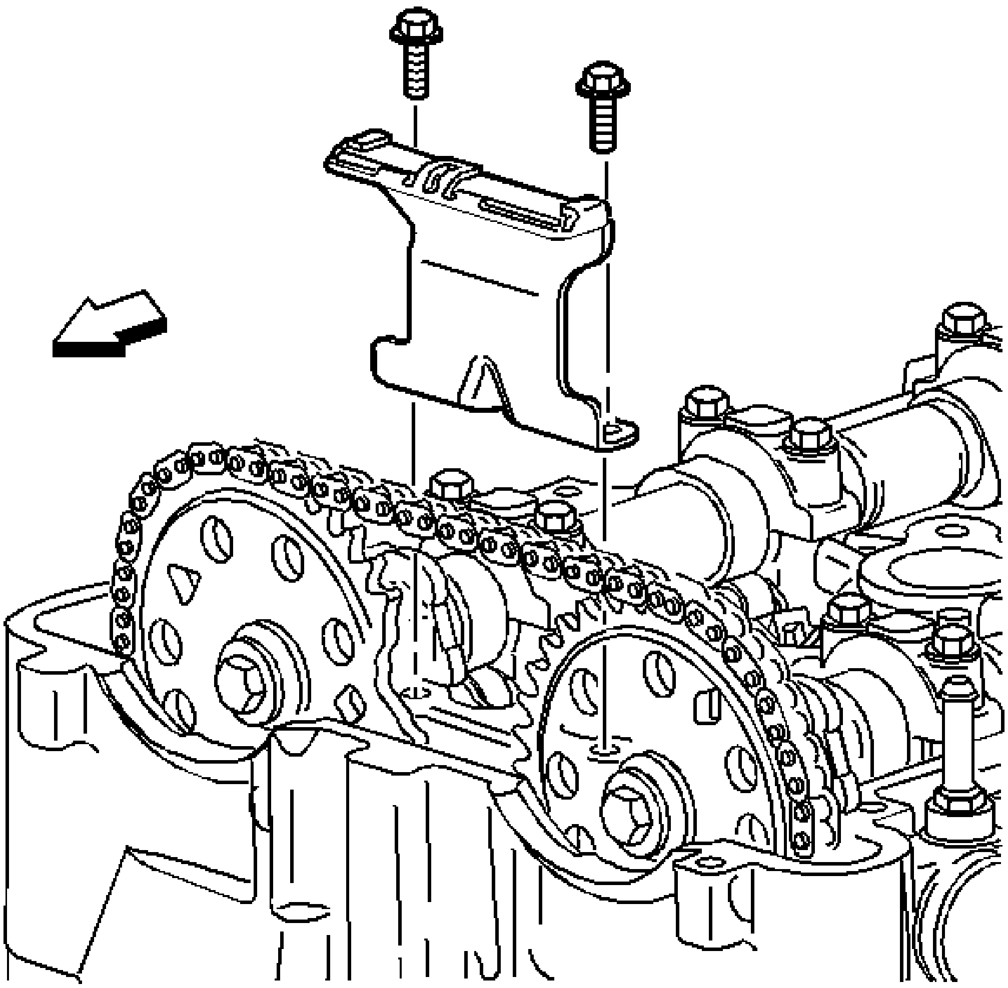


Fig. 106: View Of Upper Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

2. Remove the upper timing chain guide.

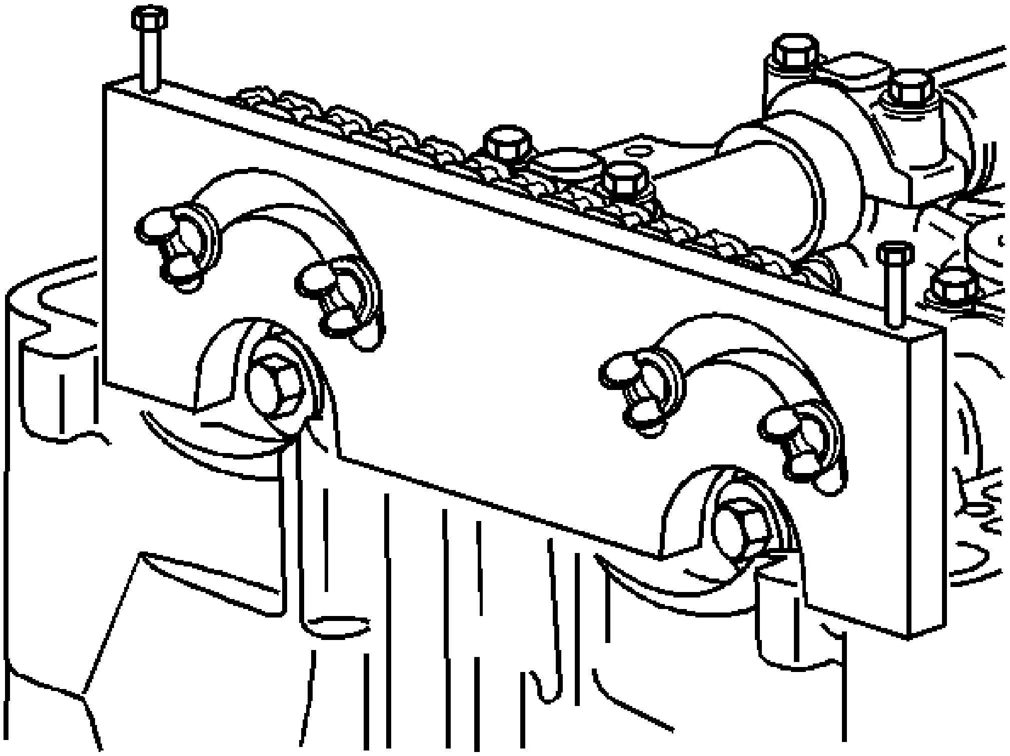


Fig. 107: View Of Camshaft Sprocket Holding Tool
Courtesy of GENERAL MOTORS CORP.

3. Install the J 43655 .

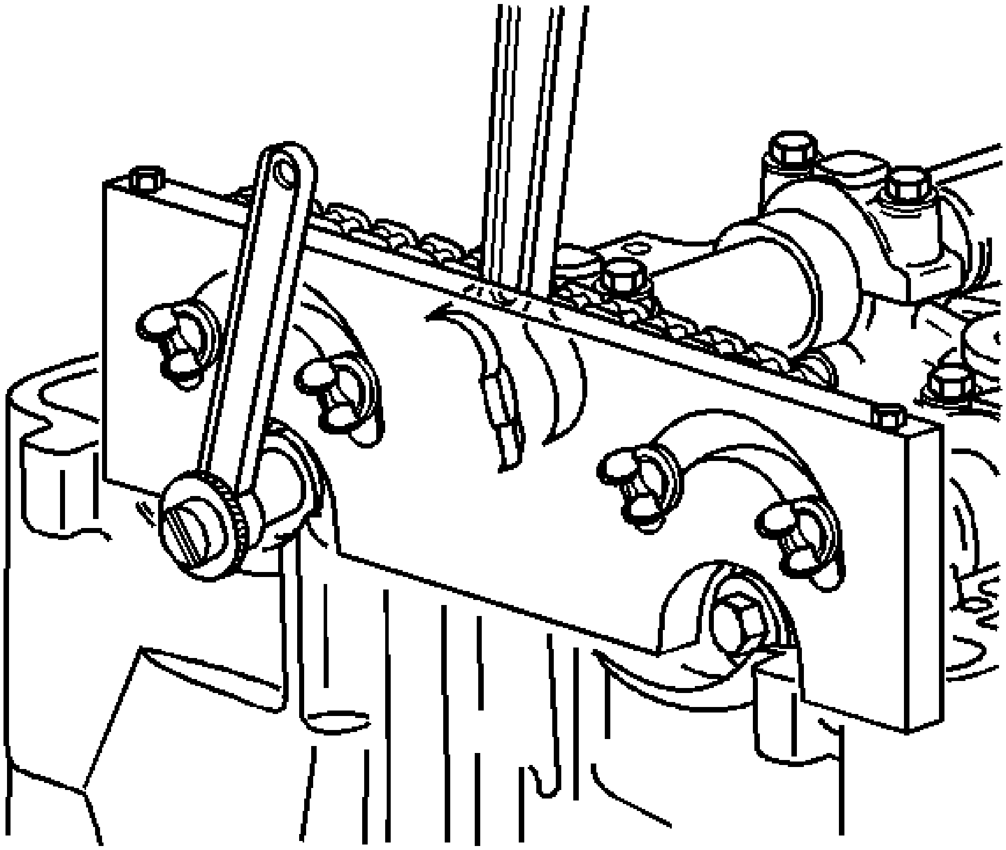


Fig. 108: Removing/Installing Camshaft Timing Sprocket Retaining Bolts & Washers
Courtesy of GENERAL MOTORS CORP.

4. Remove both the intake and exhaust camshaft sprocket bolts and discard.
5. Slide the camshaft sprockets forward.

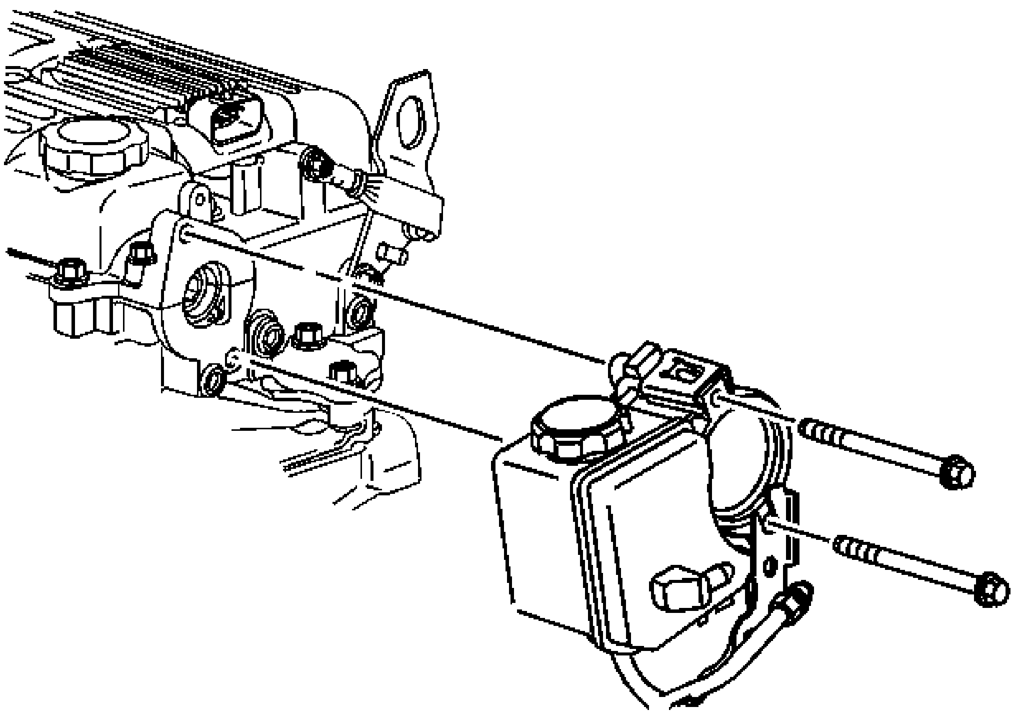


Fig. 109: View Of Power Steering Pump
Courtesy of GENERAL MOTORS CORP.

6. Remove the power steering pump bolts and set pump aside.

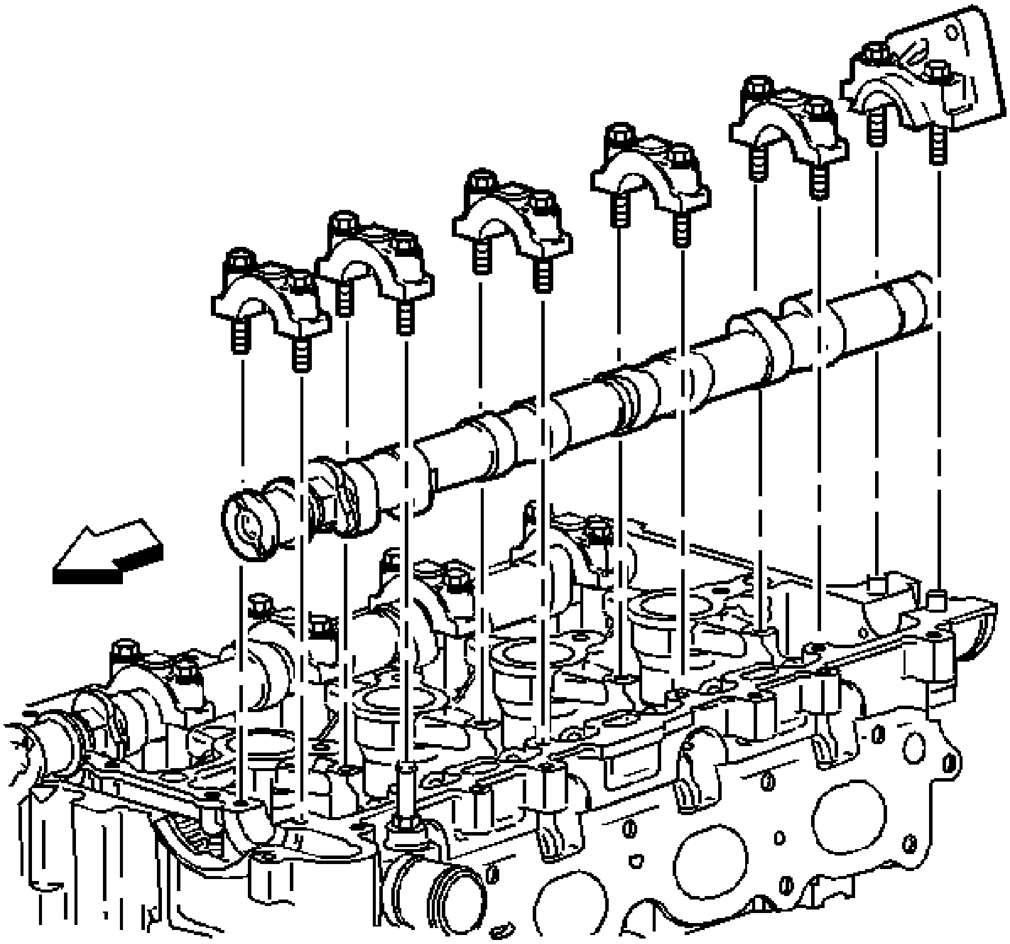


Fig. 110: View Of Intake Camshaft And Caps
Courtesy of GENERAL MOTORS CORP.

7. Mark bearing caps to ensure they are installed in the original position.

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

8. Remove the bearing caps.
9. Remove the intake camshaft.

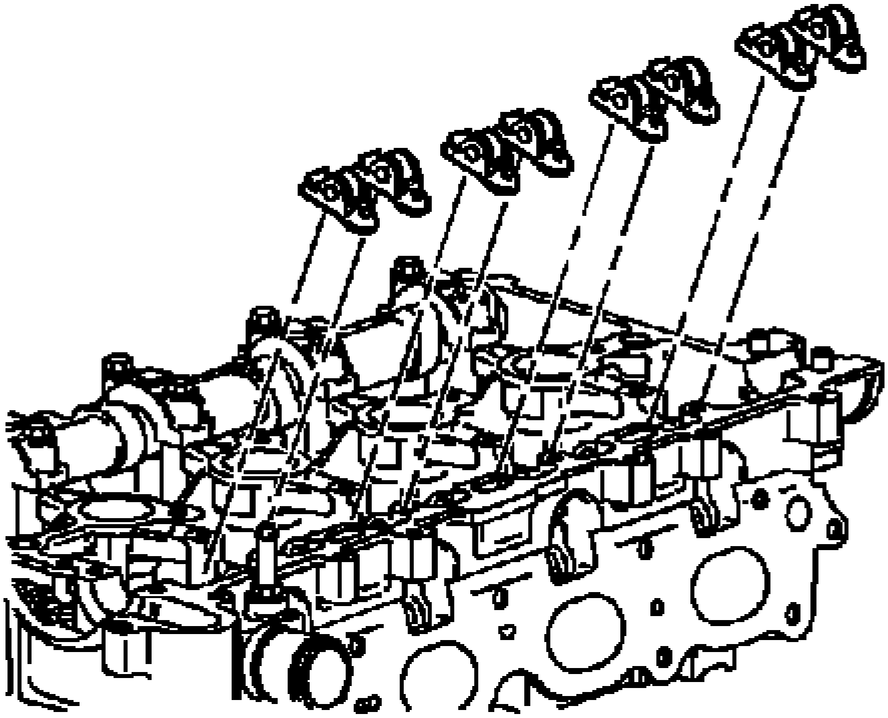


Fig. 111: View Of Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

10. Remove the camshaft roller followers.

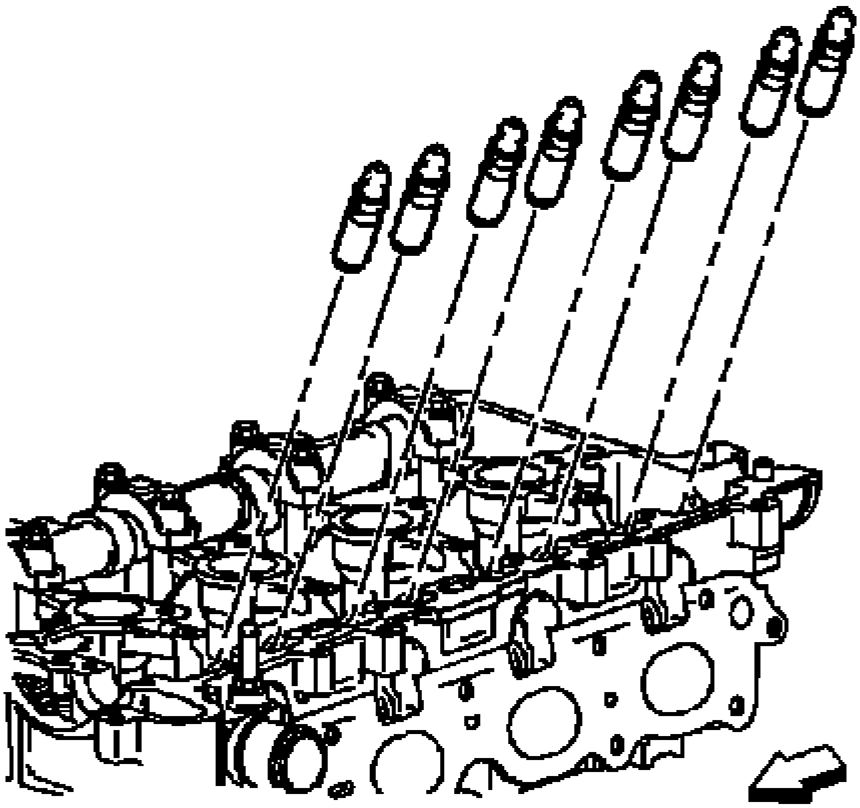


Fig. 112: View Of Hydraulic Element Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

11. Remove the hydraulic element lash adjusters.

Installation Procedure

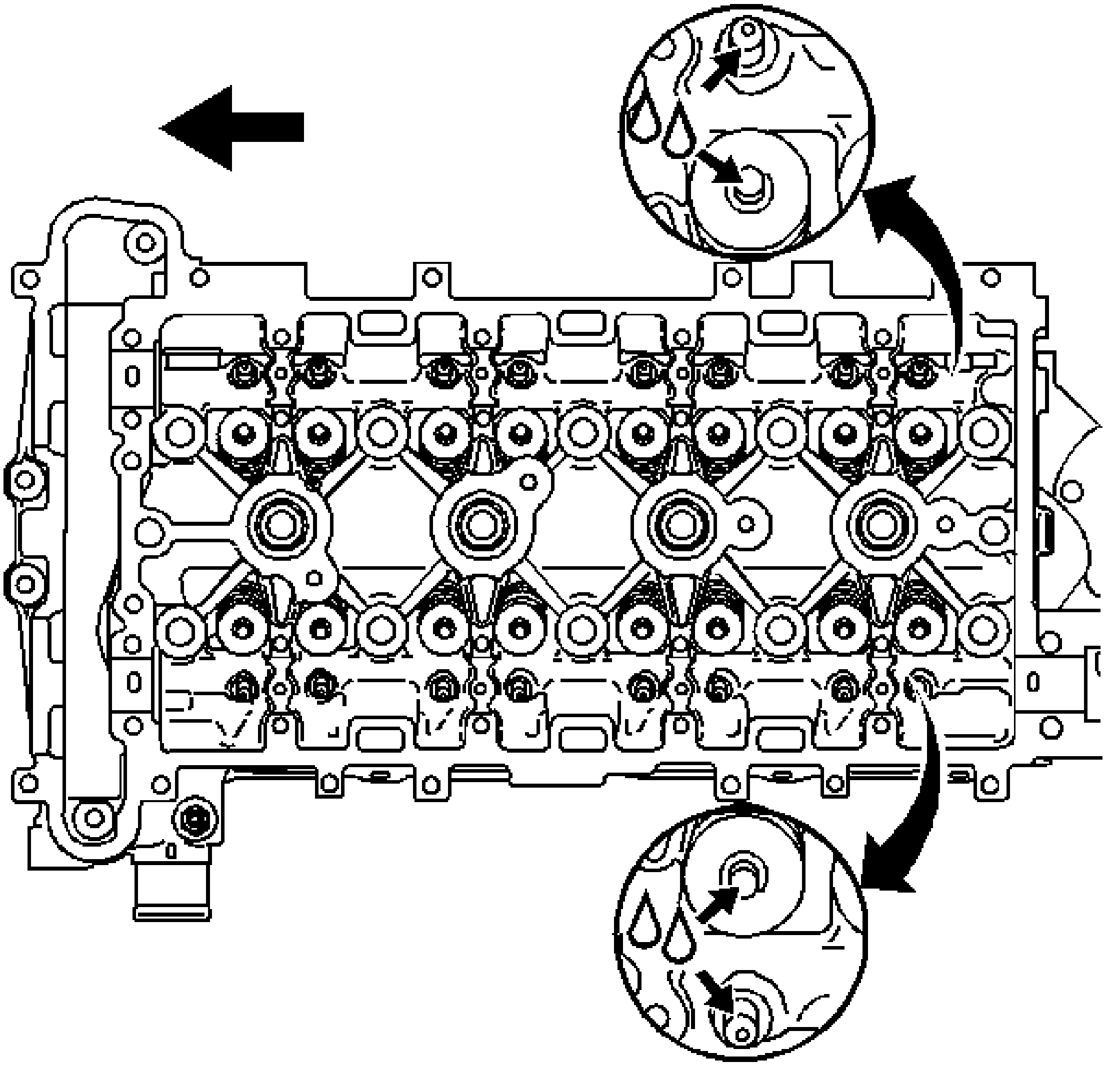


Fig. 113: Lubricating Valve Tips
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the valve tips.

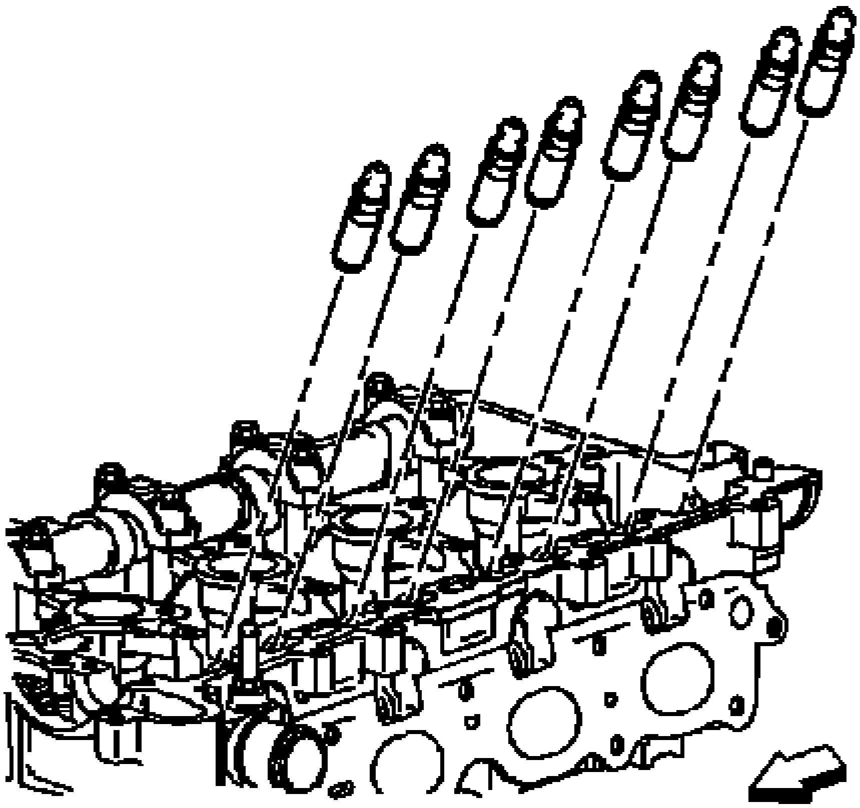


Fig. 114: View Of Hydraulic Element Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

2. Install the hydraulic element lash adjusters.

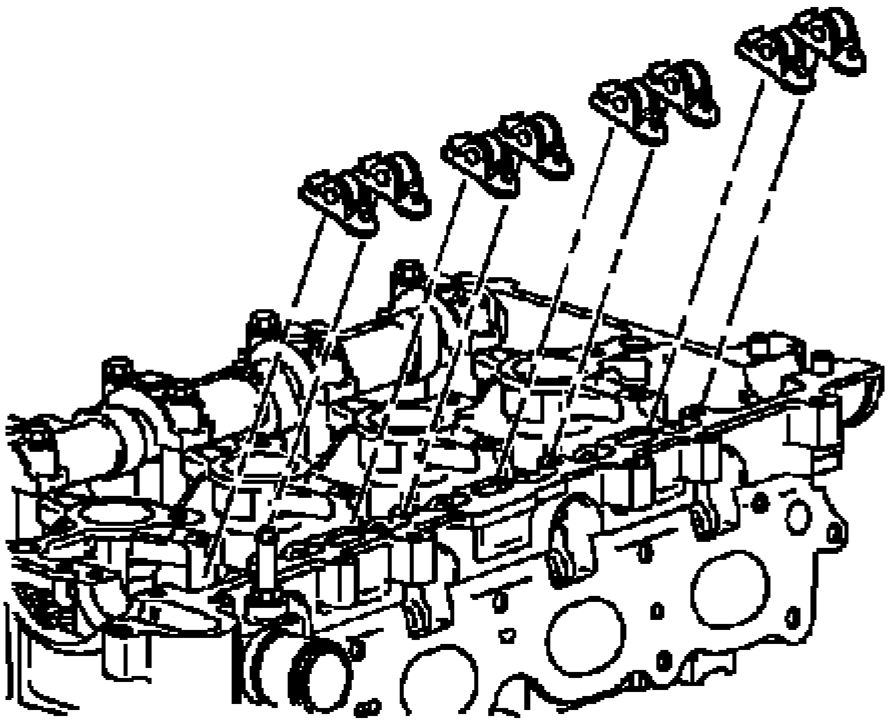


Fig. 115: View Of Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

3. Install the camshaft roller followers.

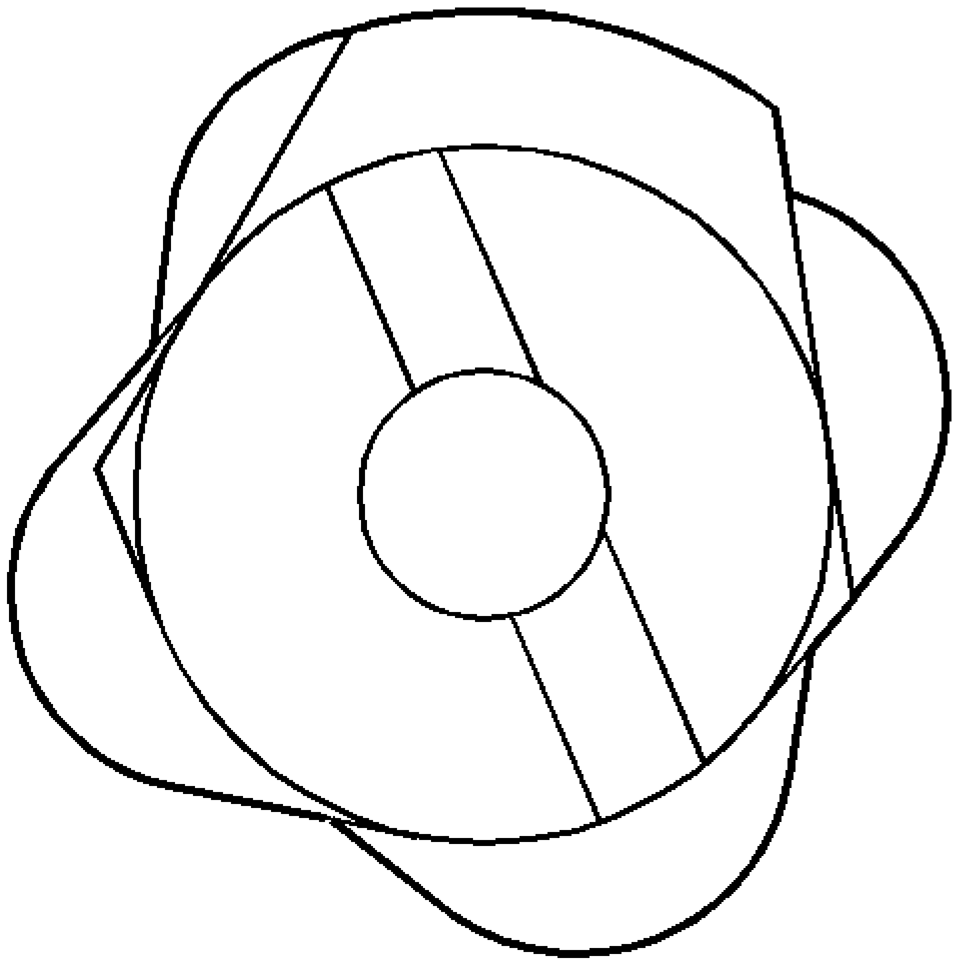


Fig. 116: View Of Camshaft Alignment Notches
Courtesy of GENERAL MOTORS CORP.

4. Ensure that the alignment notches are aligned with the camshaft sprocket.

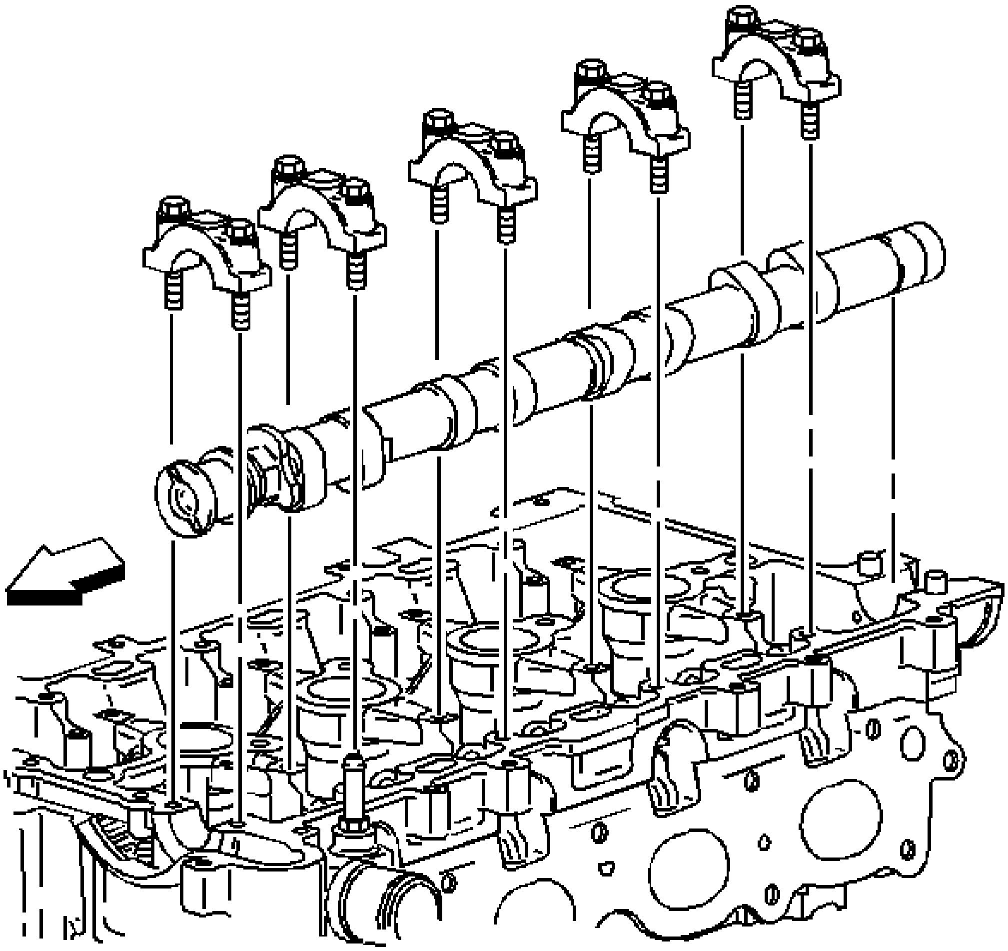


Fig. 117: View Of Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

5. Install the intake camshaft.
6. Install the camshaft bearing caps.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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

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

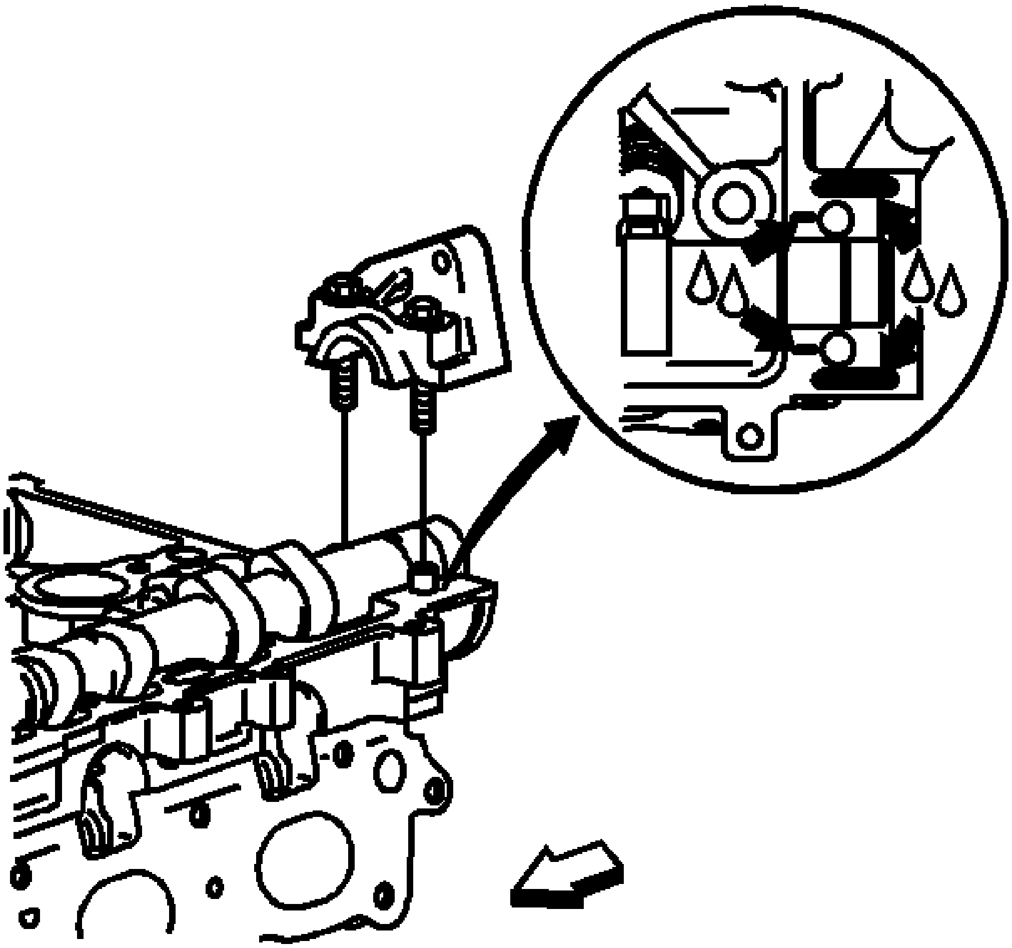


Fig. 118: Applying Camshaft Bearing Cap Sealer To Rear Cap
Courtesy of GENERAL MOTORS CORP.

8. Apply anaerobic sealer, 5 mm (0.197 in) bead, GM P/N 1052942 (Canadian P/N 10953466) to the rear intake camshaft bearing cap.
9. Install the rear intake camshaft bearing cap bolts.

   Tighten: Tighten the bolts to 25 N.m (19 lb ft).

10. Install camshaft sprockets onto the camshafts.
11. Hand tighten NEW camshaft sprocket bolts.
12. Remove the J 43655 .

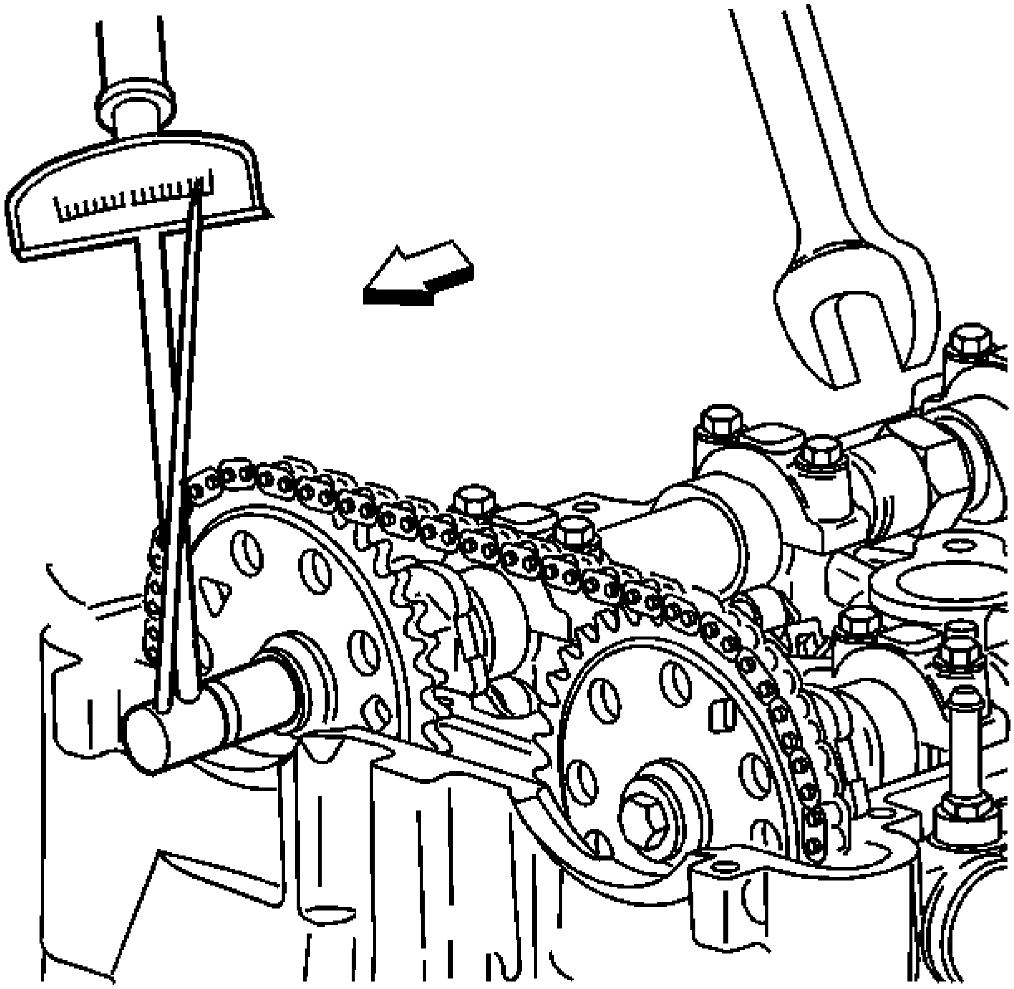


Fig. 119: Holding Camshaft Stationary With Wrench On Hex Casting On Camshaft
Courtesy of GENERAL MOTORS CORP.

13. Tighten the camshaft sprocket bolts.

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

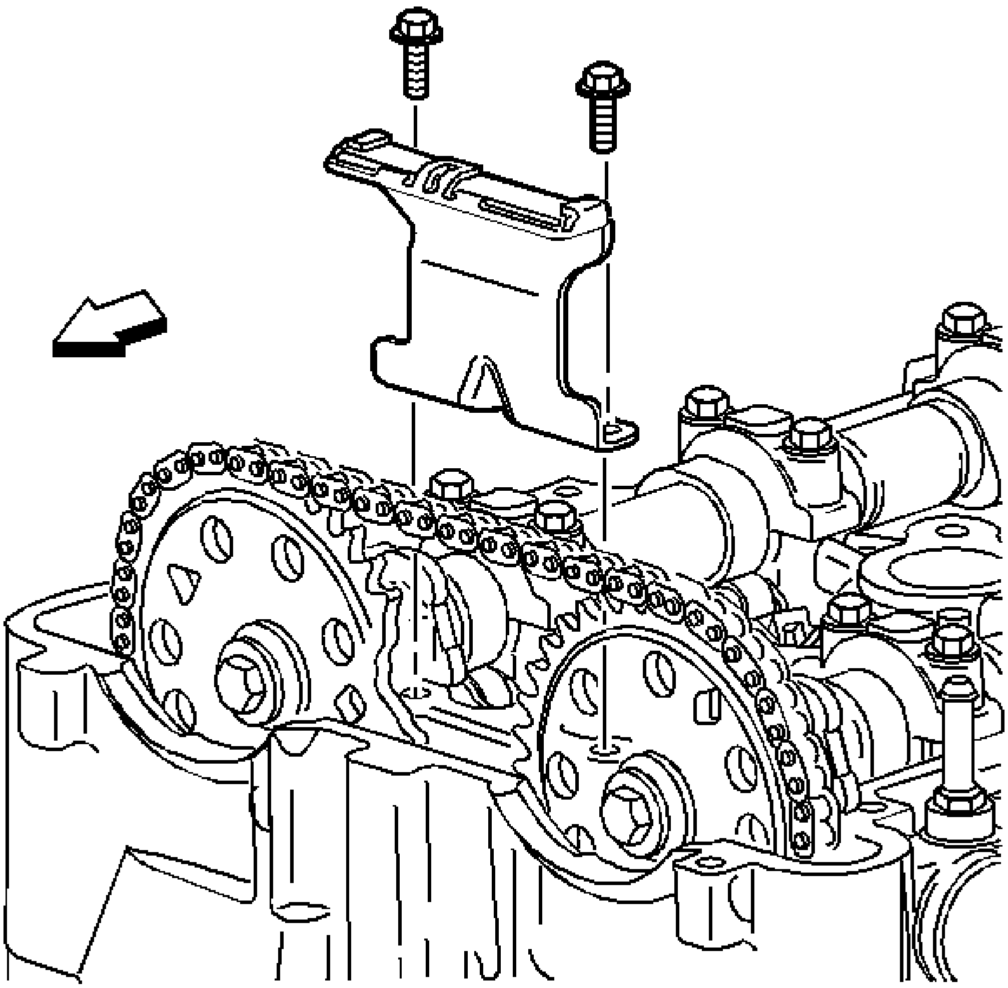


Fig. 120: View Of Upper Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

14. Install the upper timing chain guide.

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

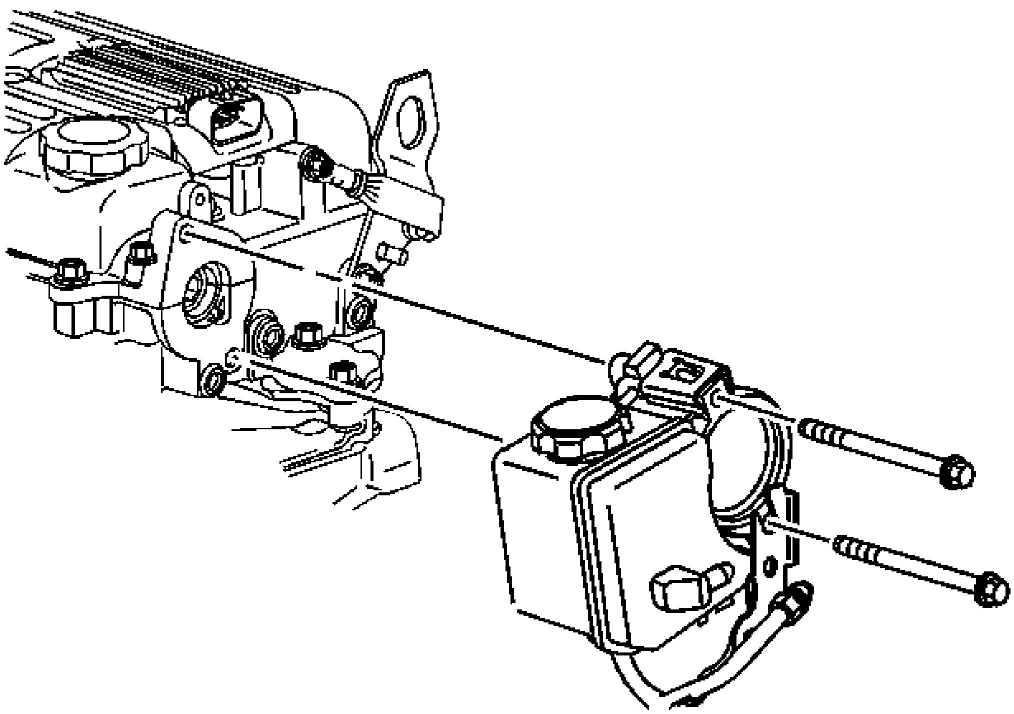


Fig. 121: View Of Power Steering Pump
Courtesy of GENERAL MOTORS CORP.

15. Install the power steering pump.

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

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

Exhaust Camshaft and Lifter Replacement

Tools Required

J 43655 Camshaft Sprocket Holding Tool

Removal Procedure

1. Remove the camshaft cover. Refer to **Camshaft Cover Replacement**.

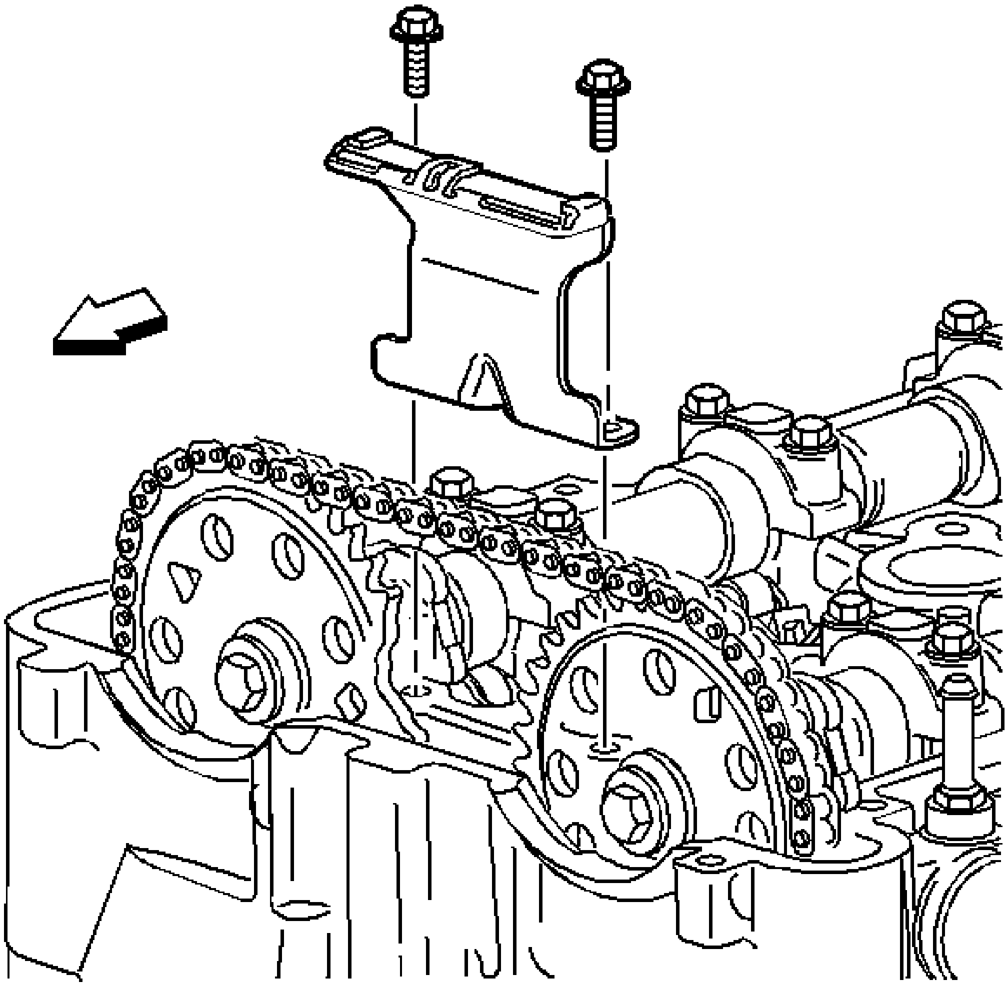


Fig. 122: View Of Upper Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

2. Remove the upper timing chain guide.

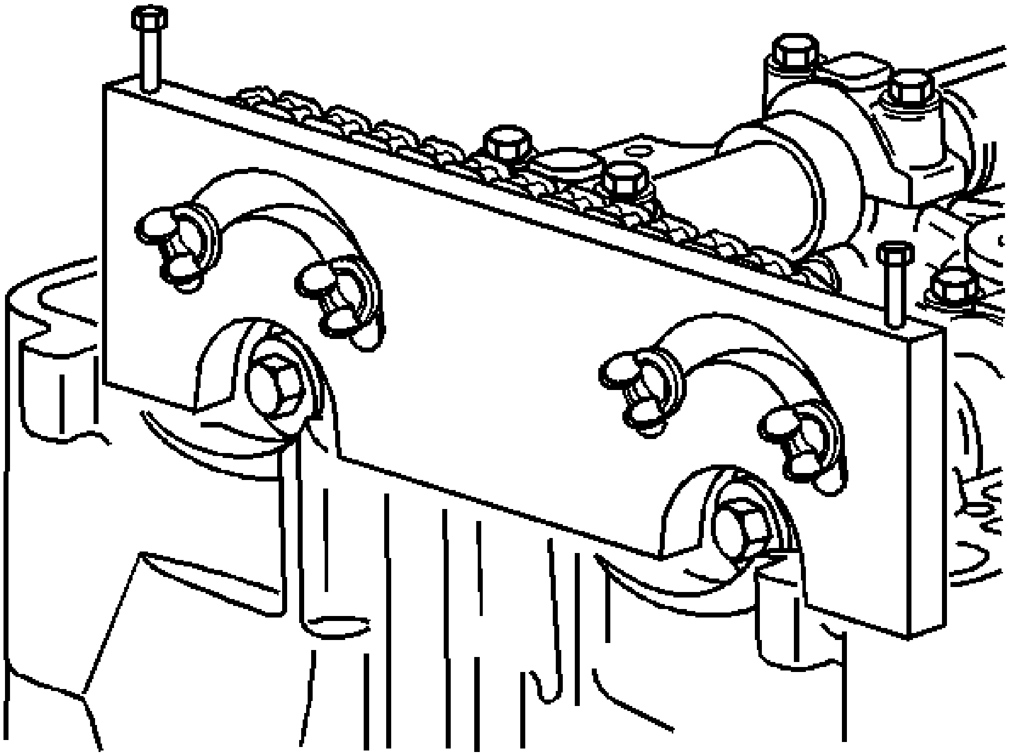


Fig. 123: View Of Camshaft Sprocket Holding Tool
Courtesy of GENERAL MOTORS CORP.

3. Install the J 43655 .

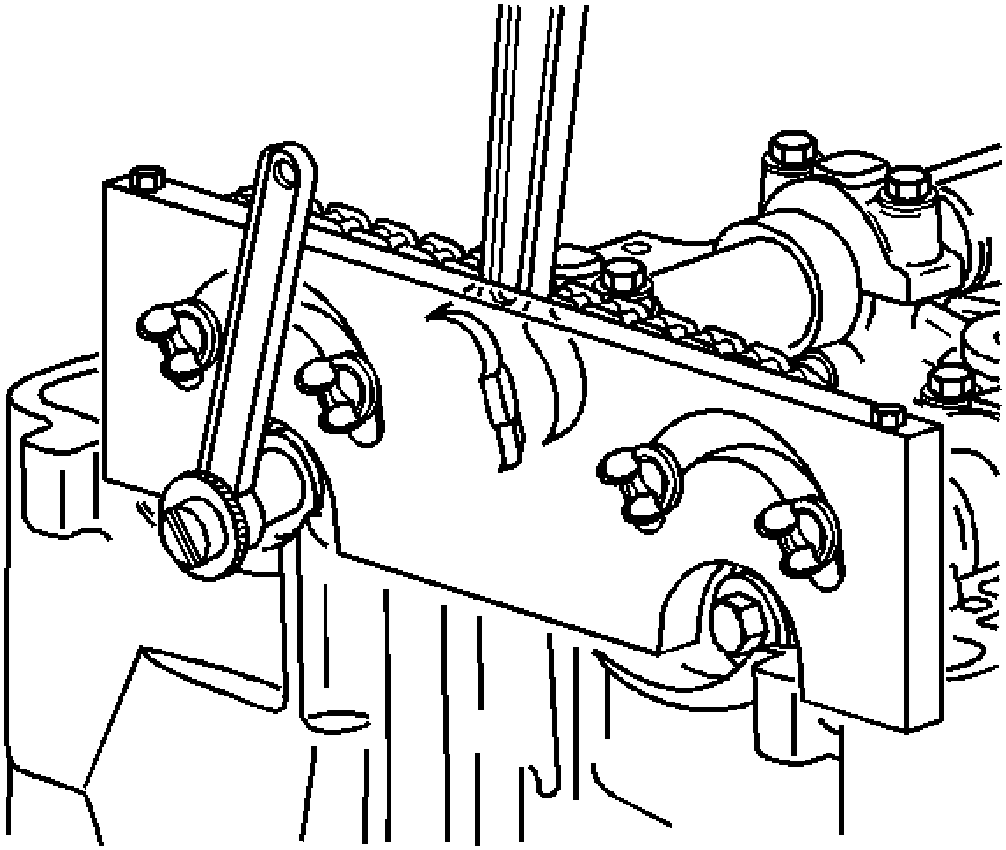


Fig. 124: Removing/Installing Camshaft Timing Sprocket Retaining Bolts & Washers
Courtesy of GENERAL MOTORS CORP.

4. Remove both the intake and the exhaust camshaft sprocket bolts and discard.
5. Slide the camshaft sprockets forward.

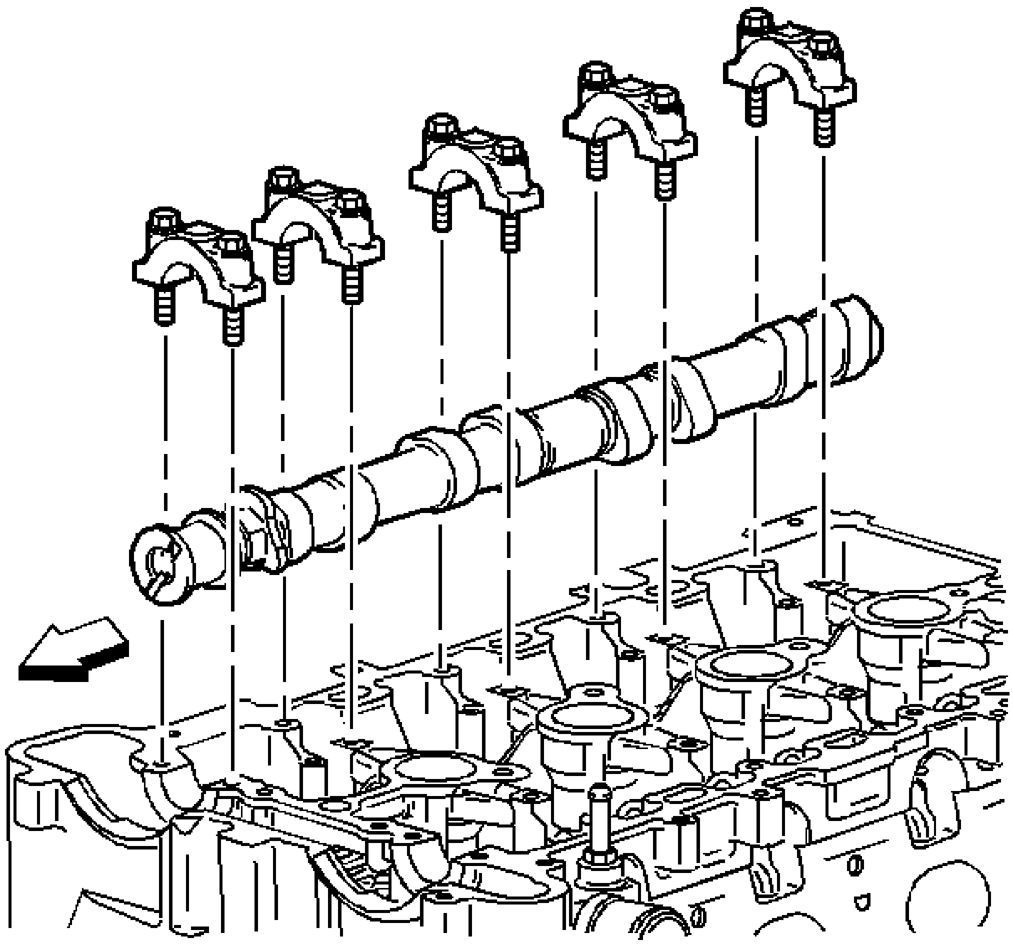


Fig. 125: View Of Camshaft & Bearing Caps
Courtesy of GENERAL MOTORS CORP.

6. Mark the bearing caps to ensure that the bearing caps are installed in the original position.

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

7. Remove the bearing caps.
8. Remove the exhaust camshaft.

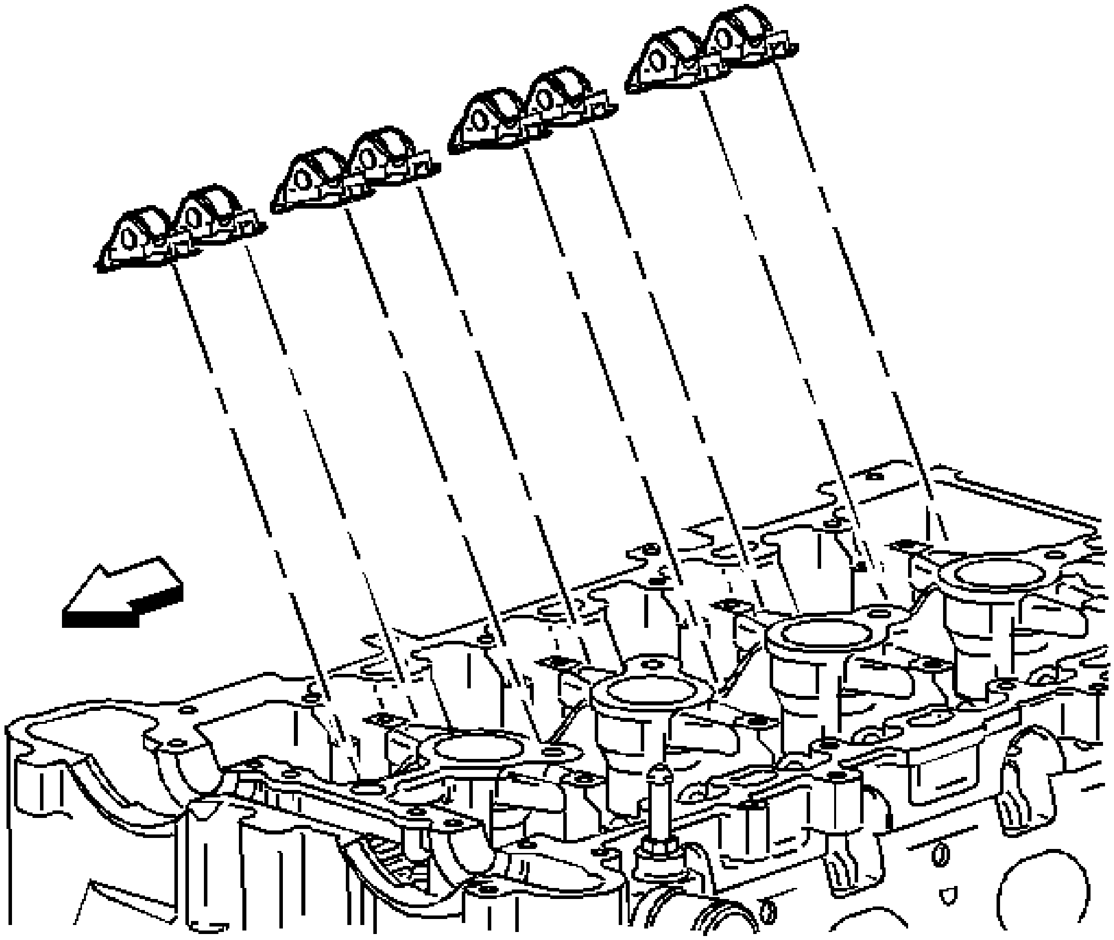


Fig. 126: Identifying Exhaust Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

9. Remove the camshaft roller followers.

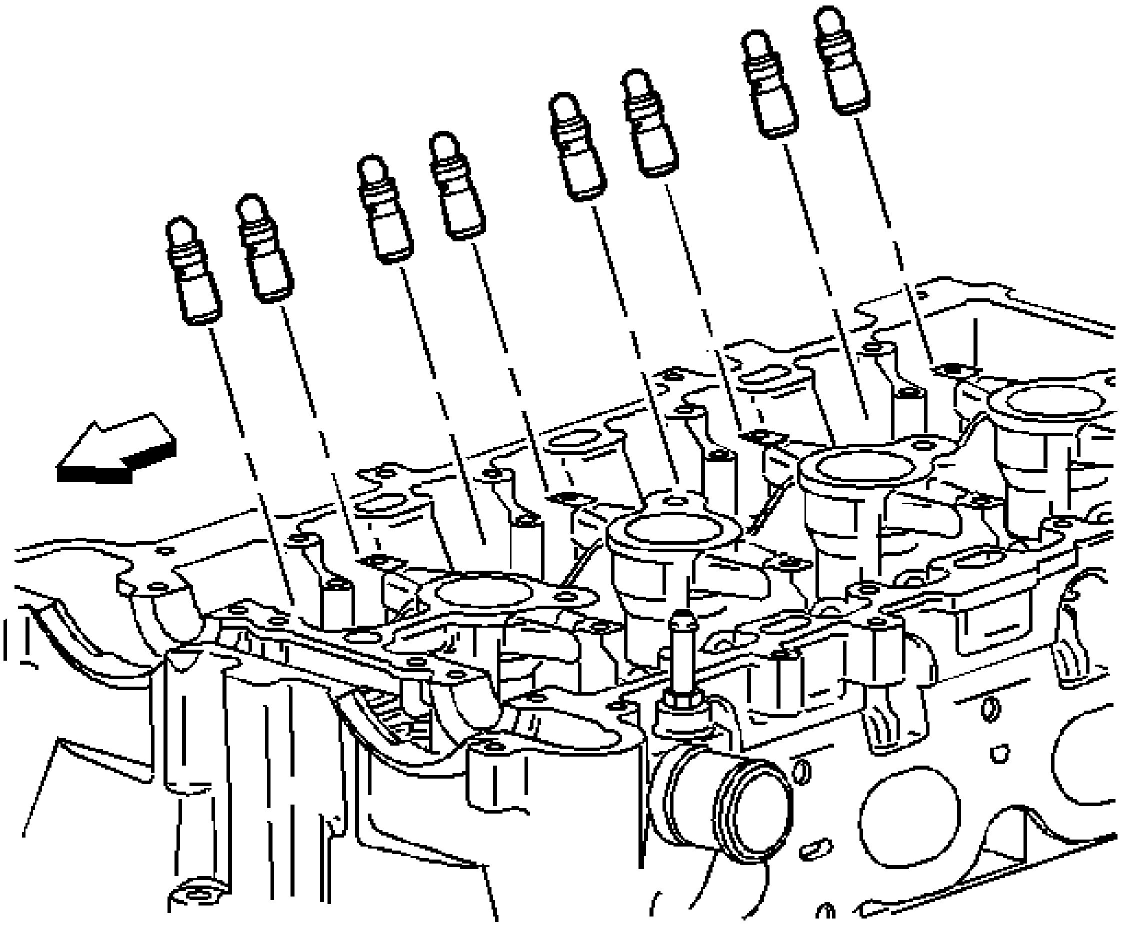


Fig. 127: View Of Hydraulic Element Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

10. Remove the hydraulic element lash adjusters.

Installation Procedure

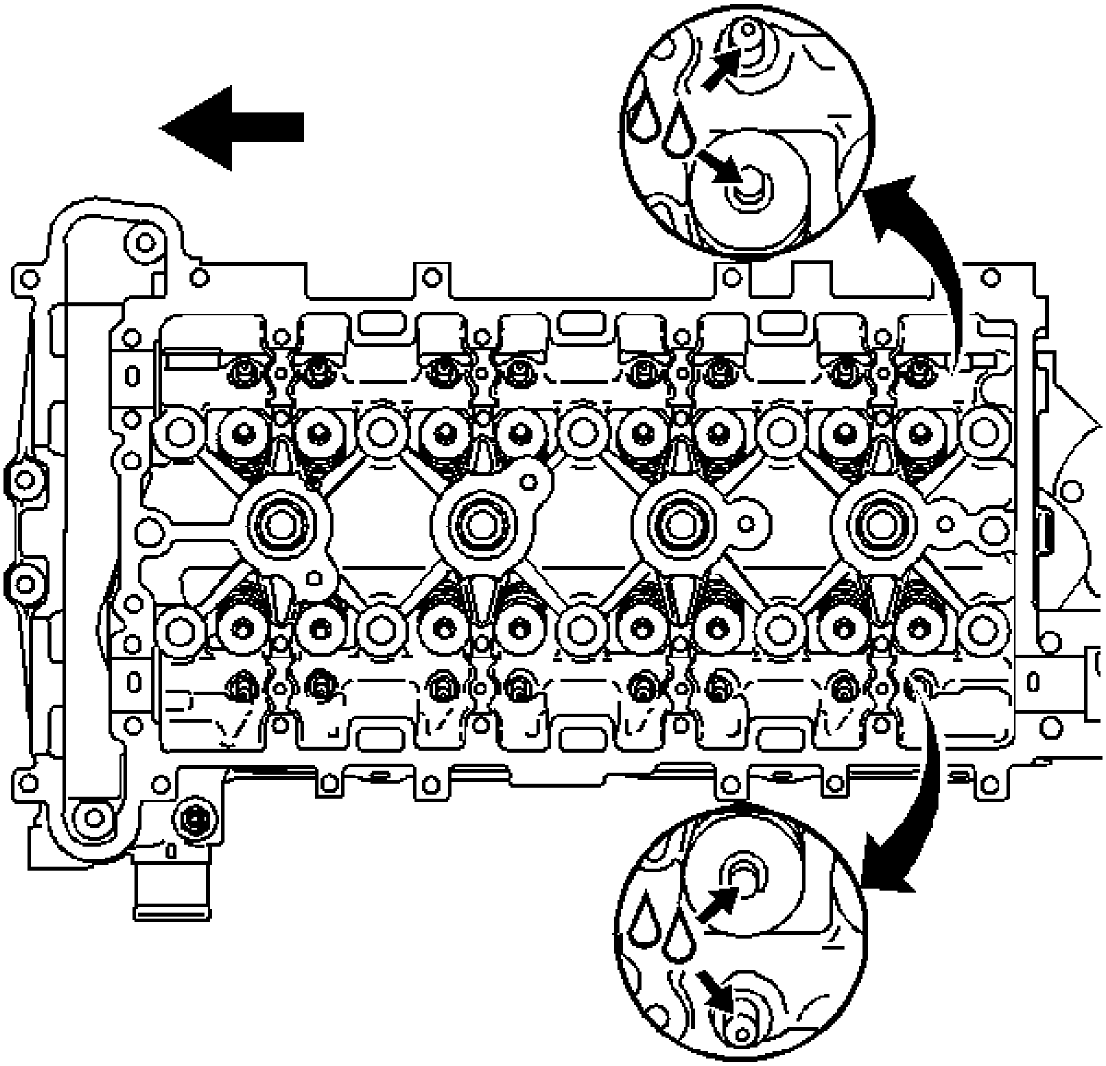


Fig. 128: Lubricating Valve Tips
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the valve tips.

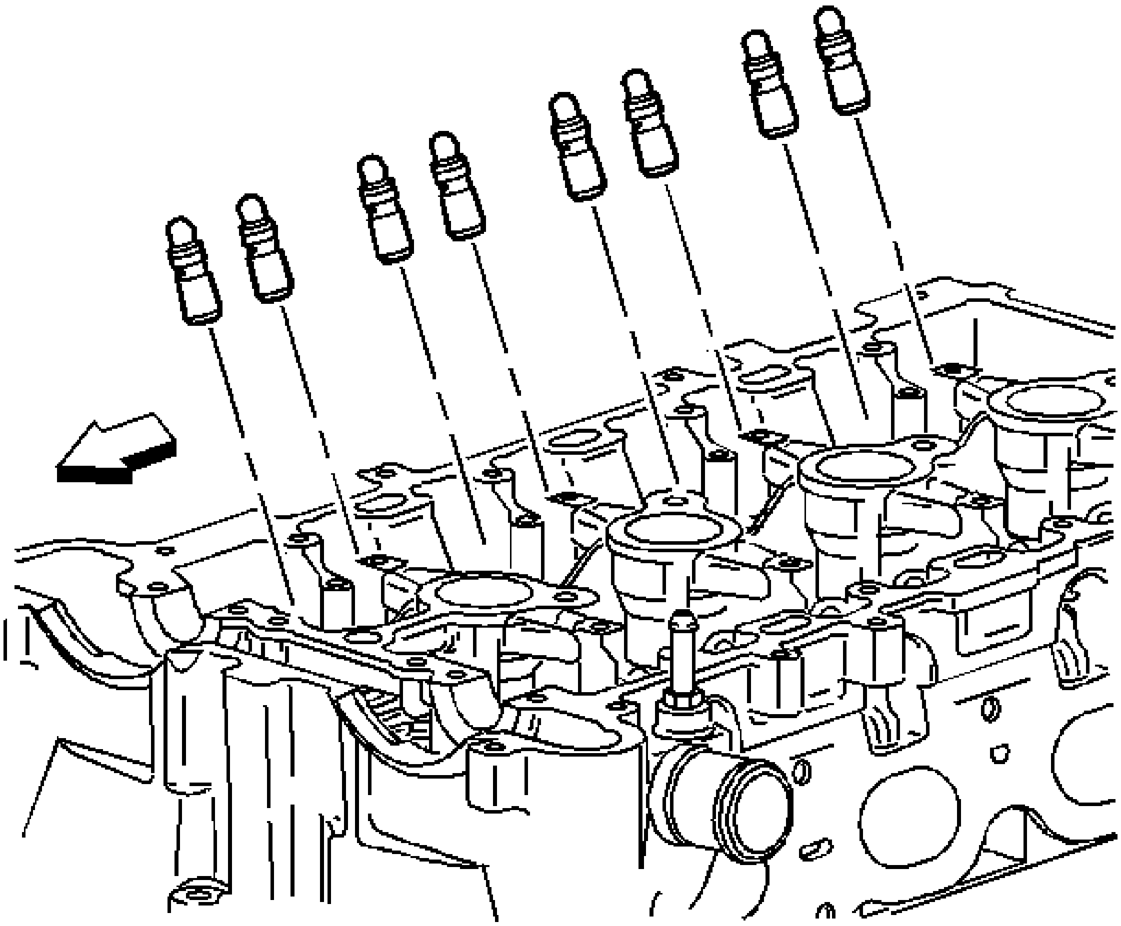


Fig. 129: View Of Hydraulic Element Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

2. Install the hydraulic element lash adjusters.

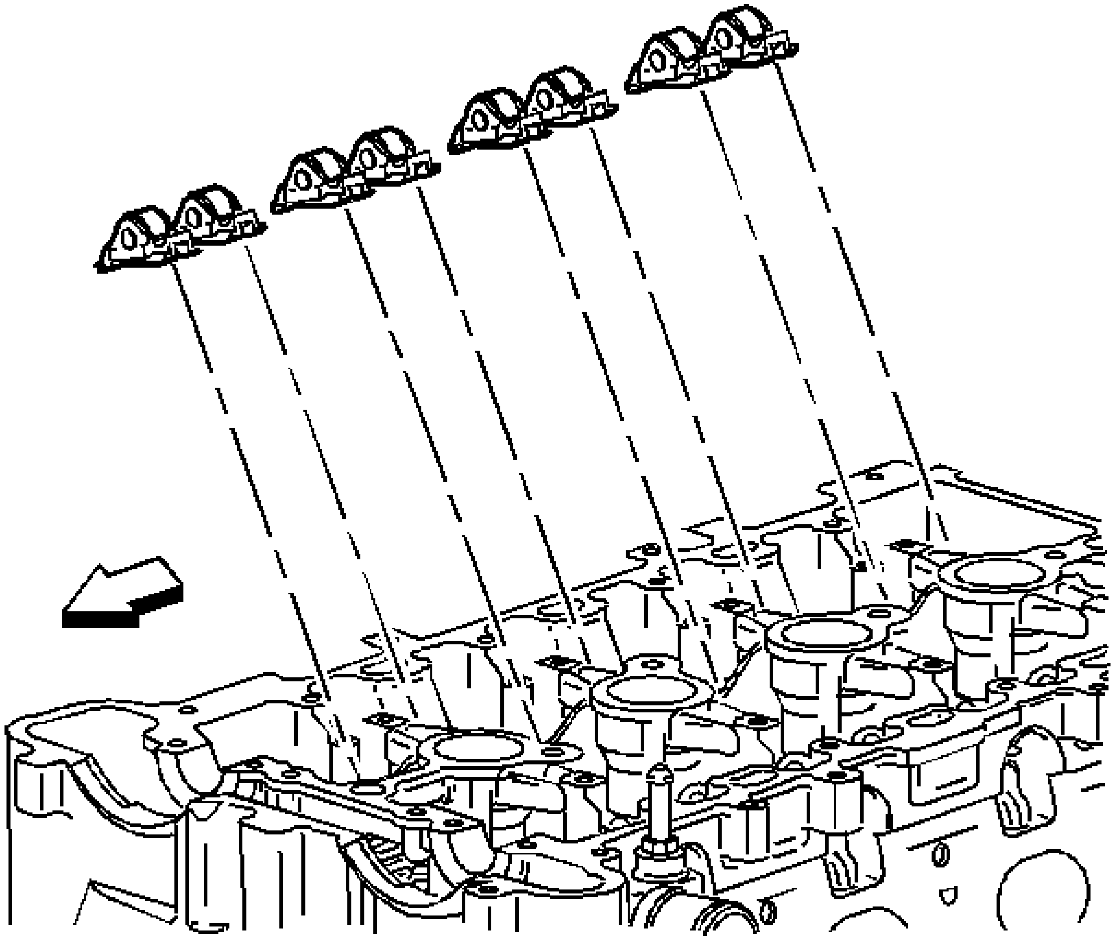


Fig. 130: Identifying Exhaust Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

3. Install the camshaft roller followers.

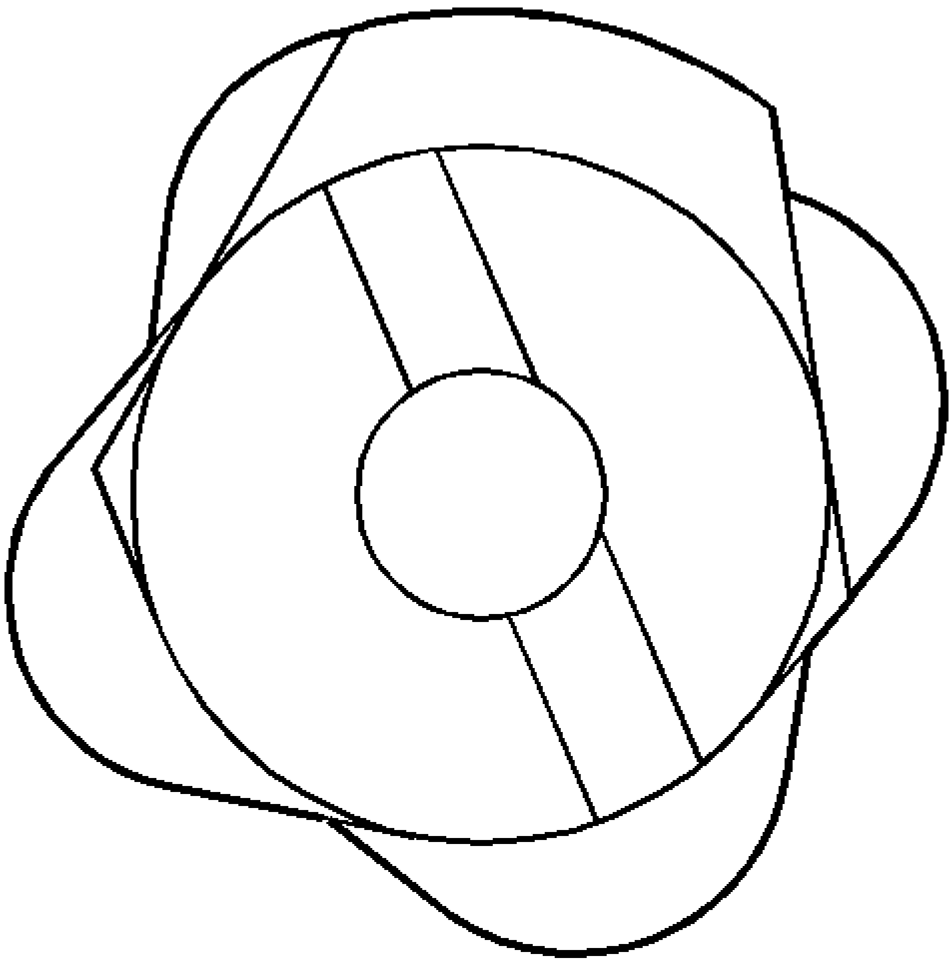


Fig. 131: View Of Camshaft Alignment Notches
Courtesy of GENERAL MOTORS CORP.

4. Ensure that the alignment notches are aligned with the camshaft sprocket.

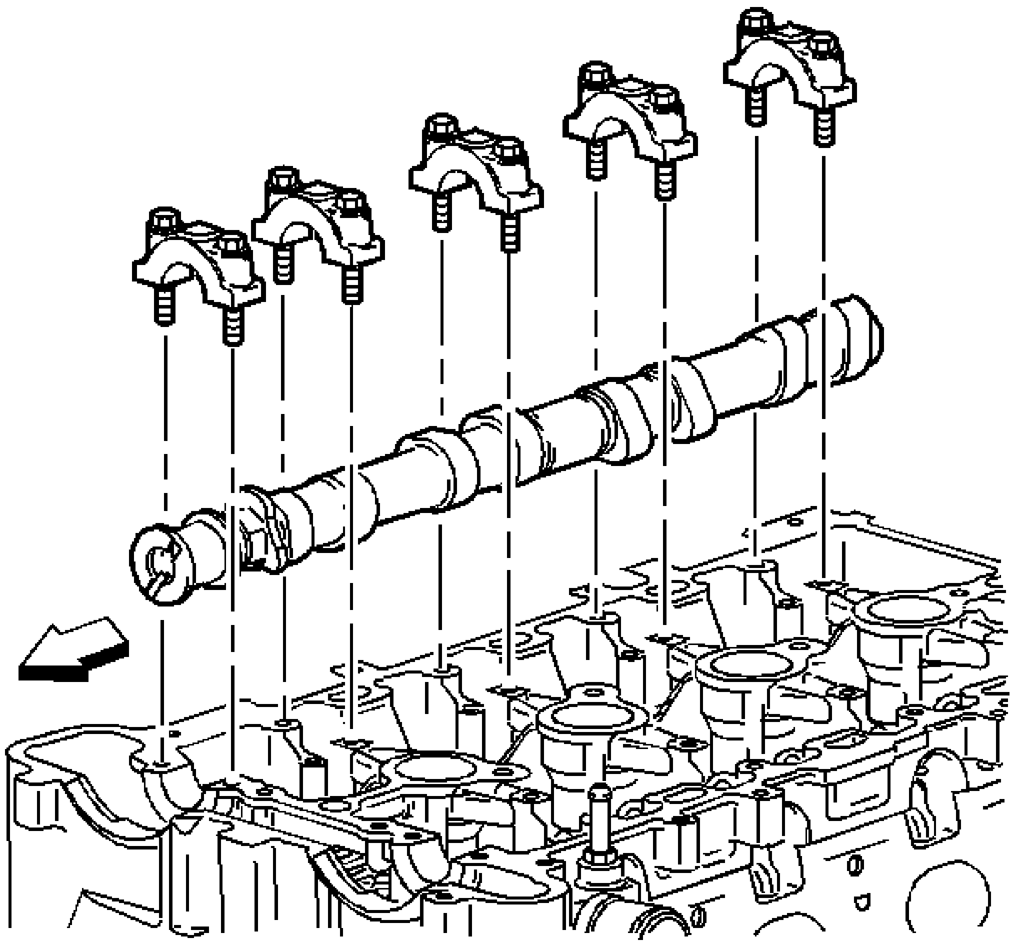


Fig. 132: View Of Camshaft & Bearing Caps
Courtesy of GENERAL MOTORS CORP.

5. Install the exhaust camshaft.
6. Install the camshaft bearing caps.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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

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

8. Install camshaft sprockets onto the camshafts.

9. Hand tighten NEW camshaft sprocket bolts.
10. Remove the J 43655 .

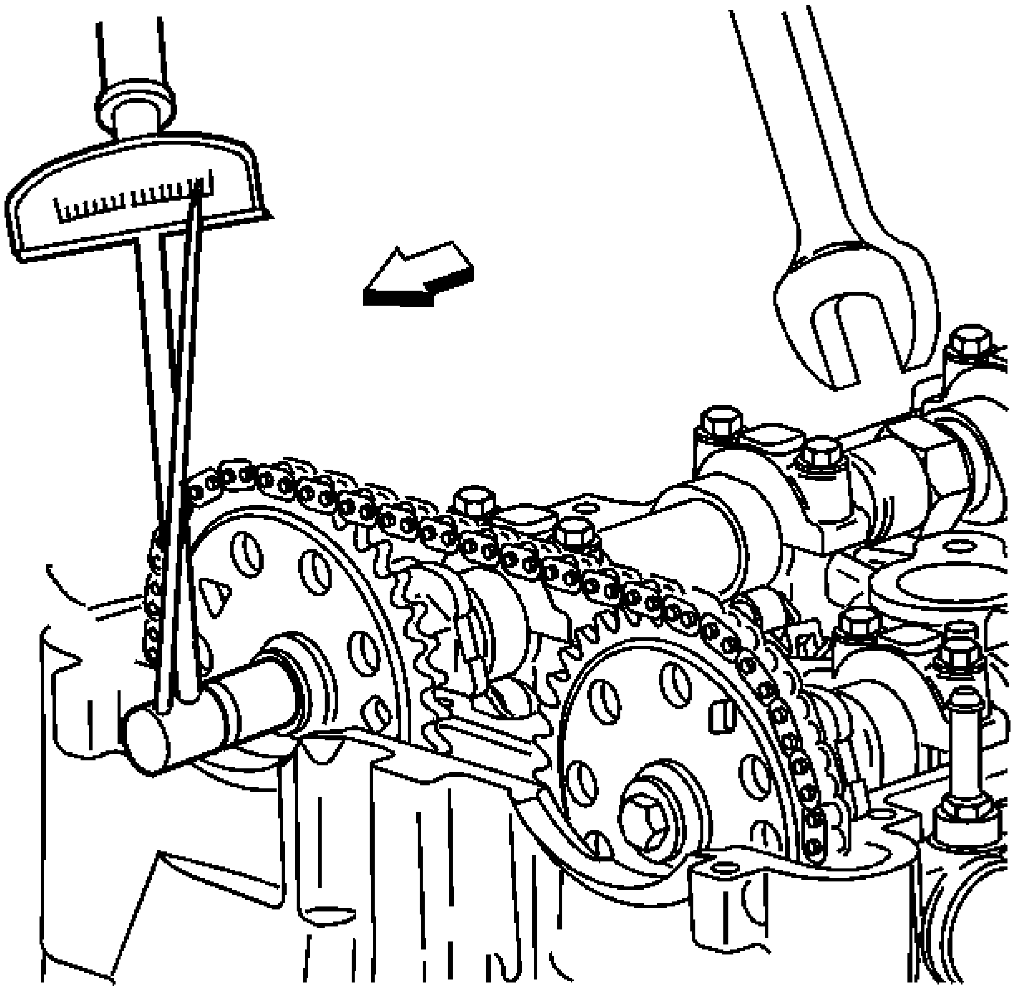


Fig. 133: Holding Camshaft Stationary With Wrench On Hex Casting On Camshaft
Courtesy of GENERAL MOTORS CORP.

11. Tighten the camshaft sprocket bolts.

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

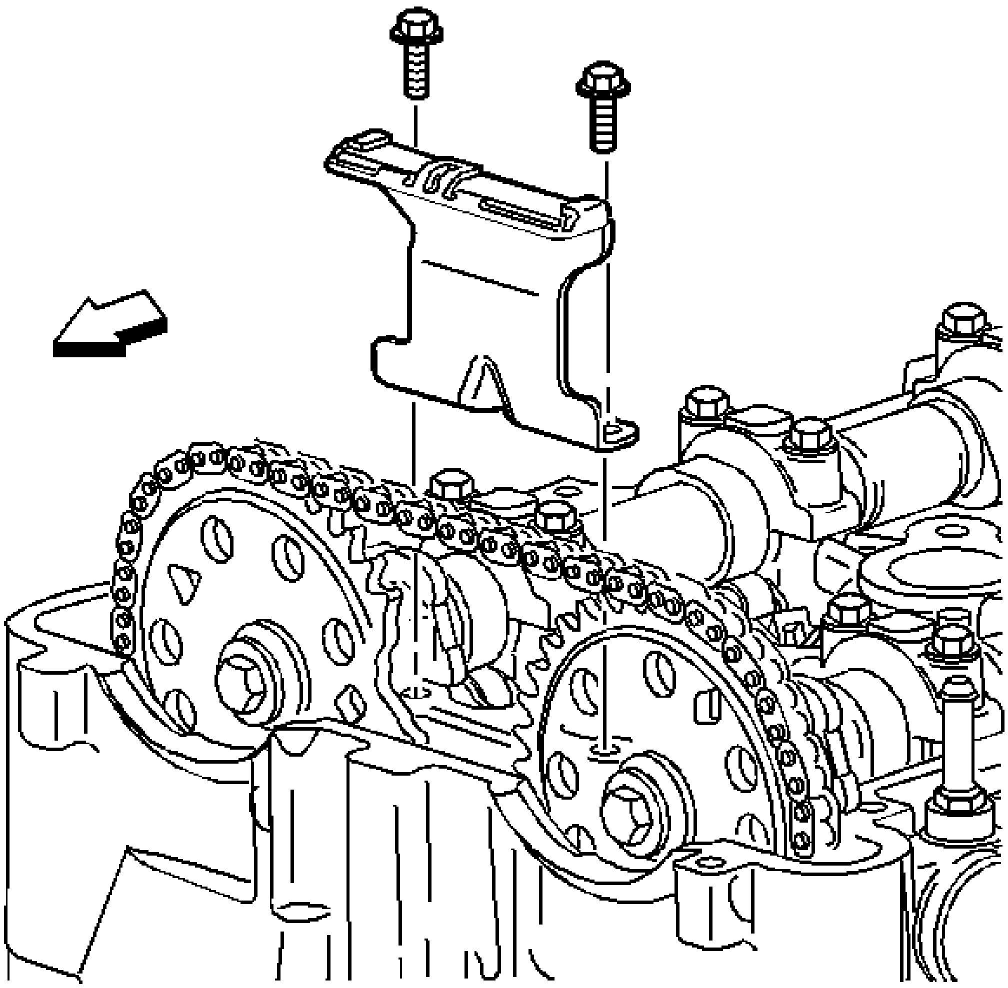


Fig. 134: View Of Upper Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

12. Install the upper timing chain guide.

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

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

Cylinder Head Replacement

Tools Required

J 36660-A Torque Angle Meter

Removal Procedure

1. Disconnect negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
2. Remove the intake manifold. Refer to **Intake Manifold Replacement**.

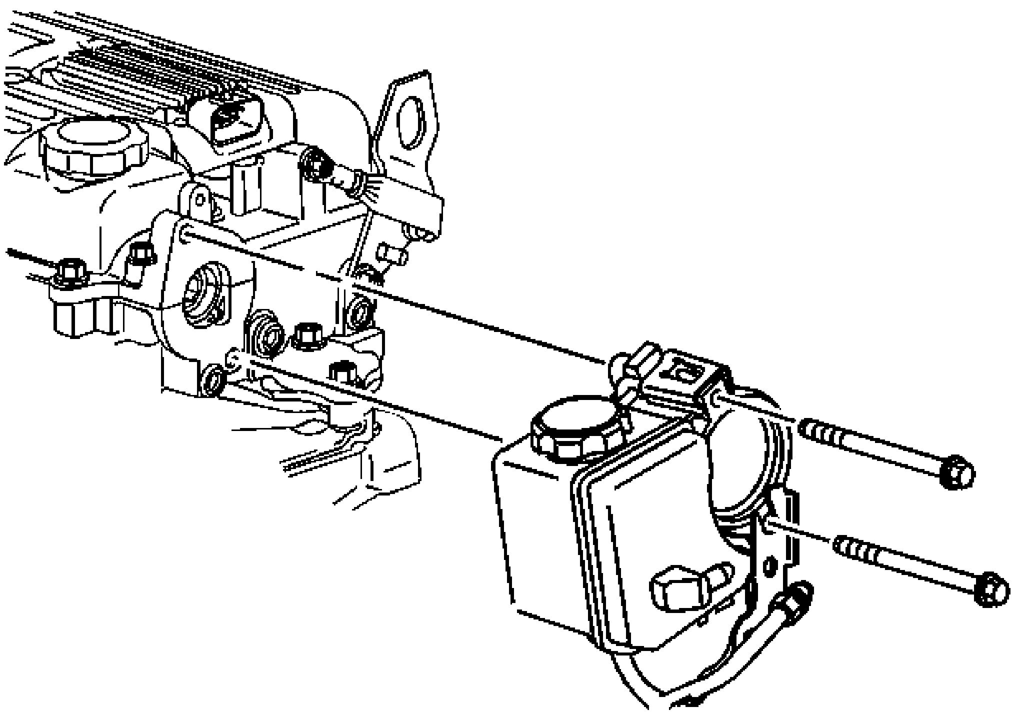


Fig. 135: View Of Power Steering Pump
Courtesy of GENERAL MOTORS CORP.

3. Remove the power steering pump bolts and set pump aside.
4. Remove the exhaust manifold. Refer to **Exhaust Manifold Replacement (2.2L (L61))** in Engine Exhaust.
5. Remove the timing chain. Refer to **Timing Chain, Sprockets, and/or Tensioner Replacement**.
6. Drain the cooling system. Refer to **Draining and Filling Cooling System** in Engine Cooling.

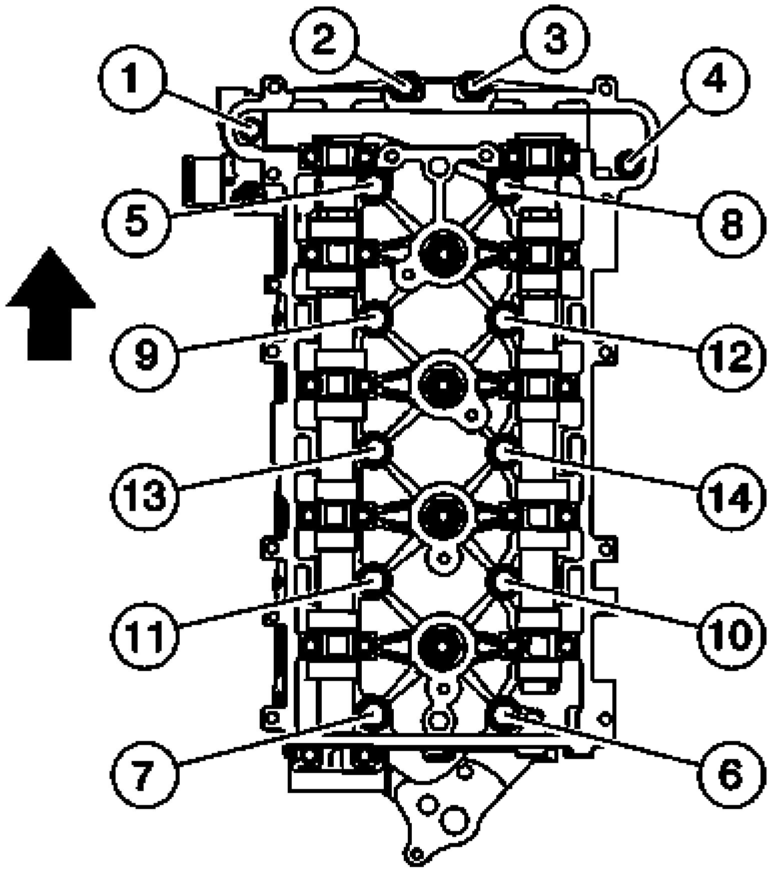


Fig. 136: Cylinder Head Bolt Removal Sequence
Courtesy of GENERAL MOTORS CORP.

7. Remove the cylinder head bolts in sequence and discard.

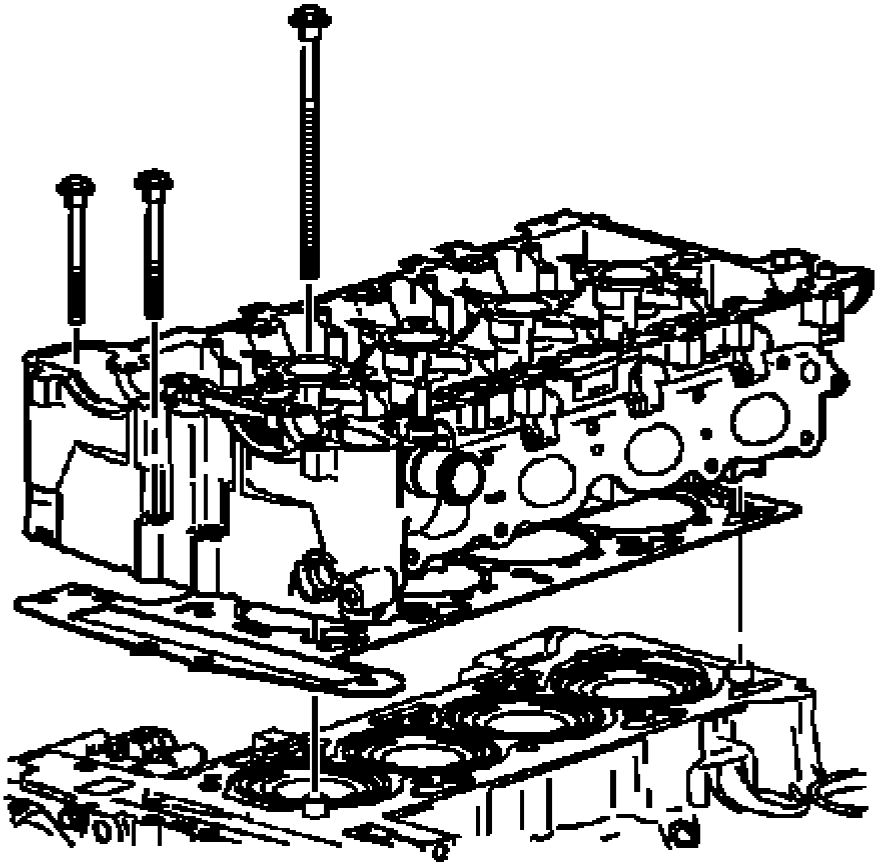


Fig. 137: View Of Cylinder Head And Gasket
Courtesy of GENERAL MOTORS CORP.

8. Remove the cylinder head and gasket.
9. Clean all gasket surfaces.

Installation Procedure

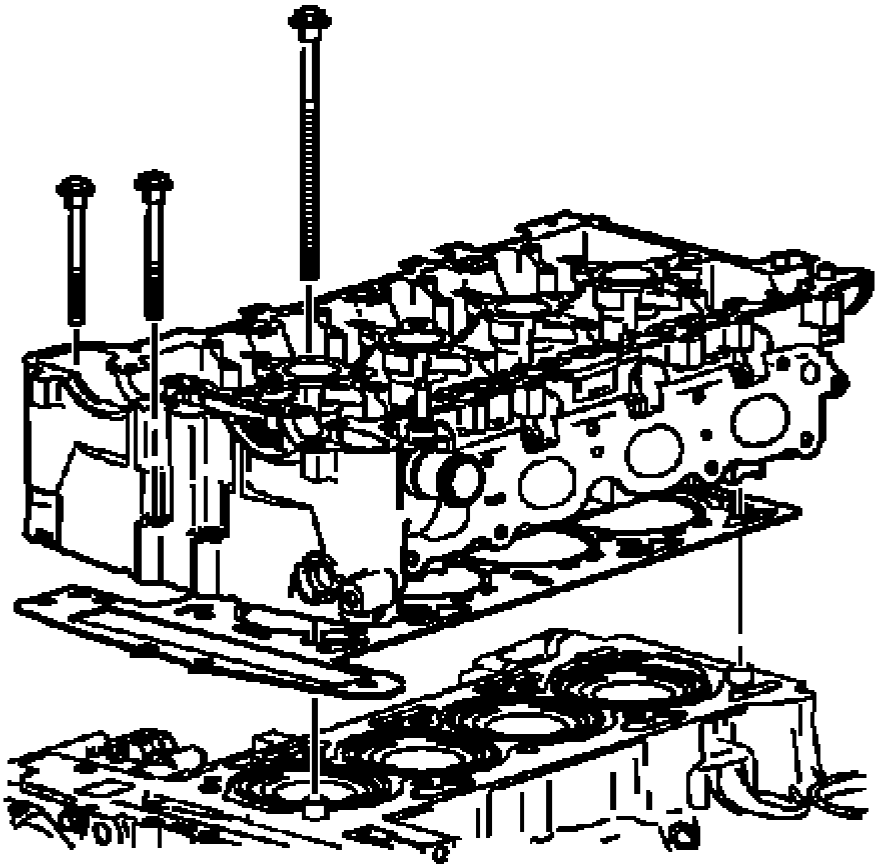


Fig. 138: View Of Cylinder Head And Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install the cylinder head and gasket.
2. Install NEW cylinder head bolts.

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

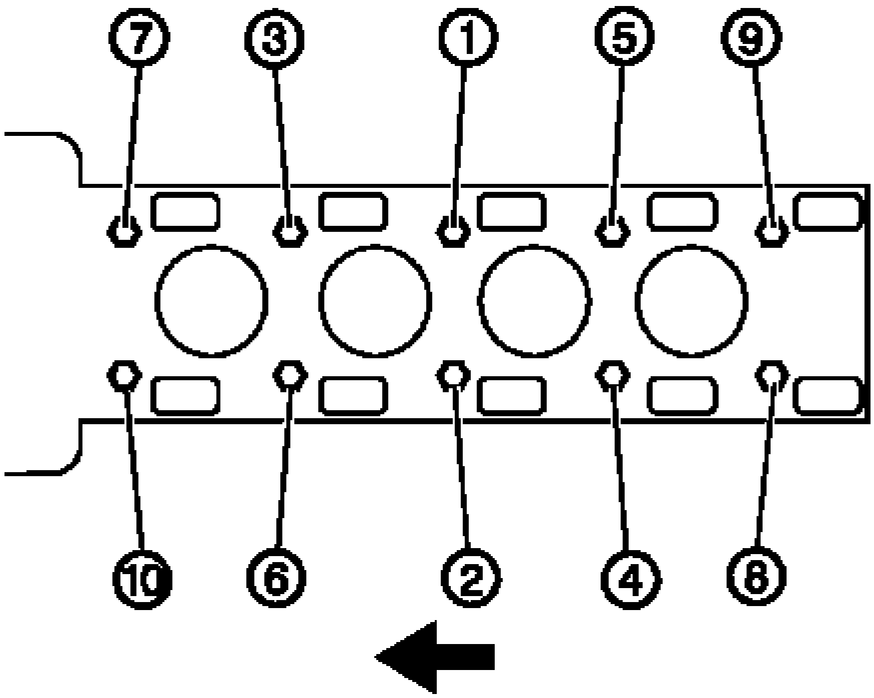


Fig. 139: Identifying Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

3. Tighten the cylinder head bolts in sequence.

   Tighten: Tighten the cylinder head bolts to 30 N.m (22 lb ft) plus 155 degrees.

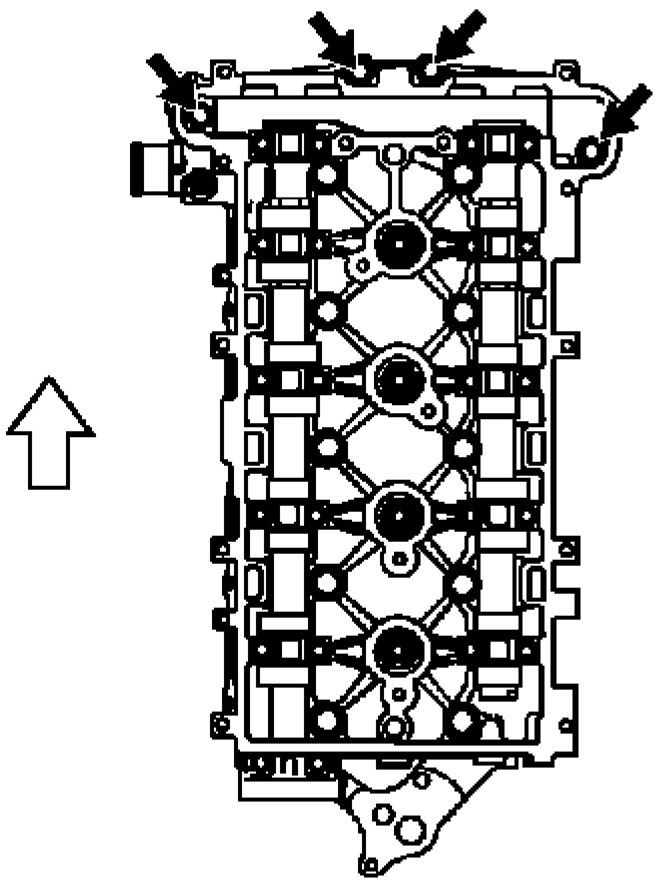


Fig. 140: Locating Front Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

4. Install the NEW front cylinder head bolts.

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

5. Install the timing chain. Refer to **Timing Chain, Sprockets, and/or Tensioner Replacement**.
6. Install the exhaust manifold. Refer to **Exhaust Manifold Replacement (2.2L (L61))** in Engine Exhaust.
7. Lower the vehicle.
8. Install the intake manifold. Refer to **Intake Manifold Replacement**.

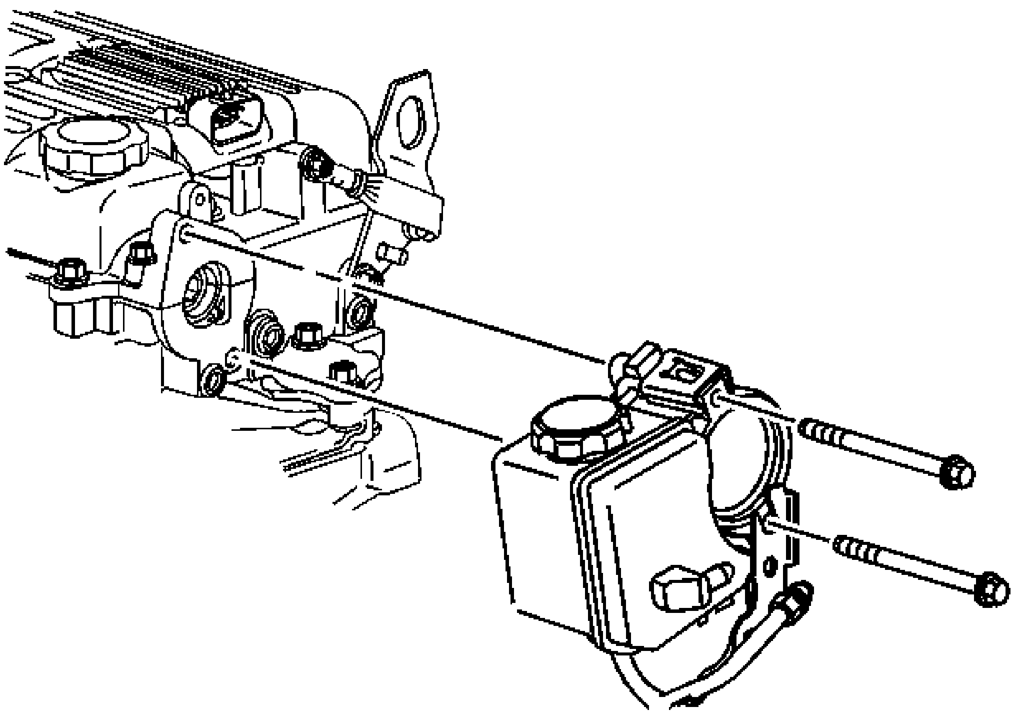


Fig. 141: View Of Power Steering Pump
Courtesy of GENERAL MOTORS CORP.

9. Install the power steering pump.

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

10. Fill the cooling system. Refer to **Draining and Filling Cooling System** in Engine Cooling.
11. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.

Oil Pan Replacement

Removal Procedure

1. Install the engine support fixture. Refer to **Engine Support Fixture**
2. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.

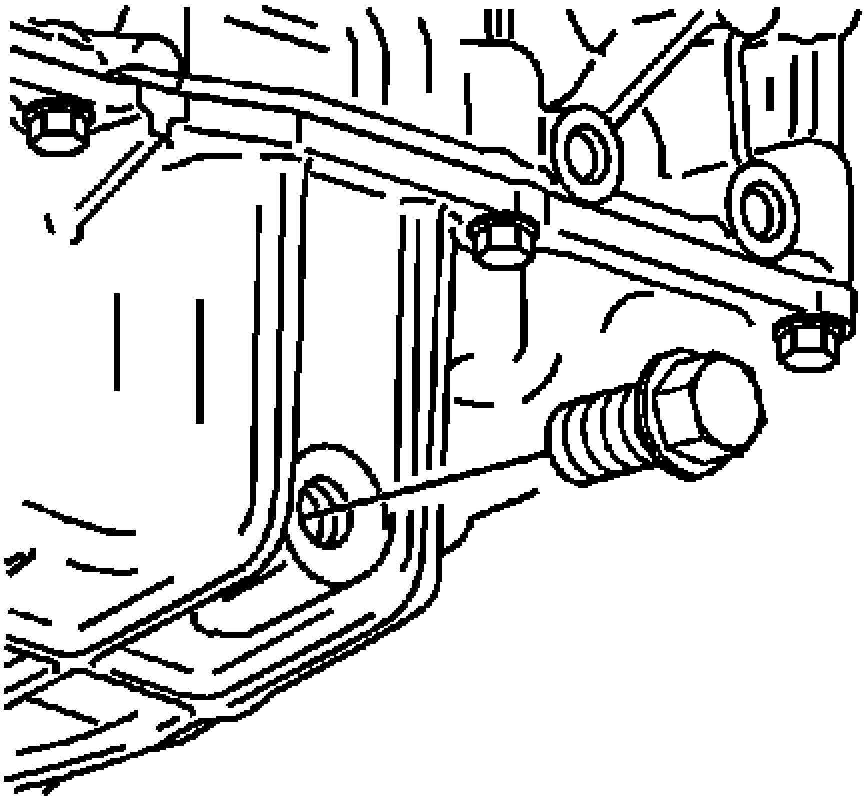


Fig. 142: View Of Oil Pan Drain Bolt
Courtesy of GENERAL MOTORS CORP.

3. Drain the engine oil.
4. Remove the lower AC compressor bolts.
5. Loosen the upper AC compressor bolts.
6. Loosen the left side frame bolts.
7. Remove the right side frame bolts.

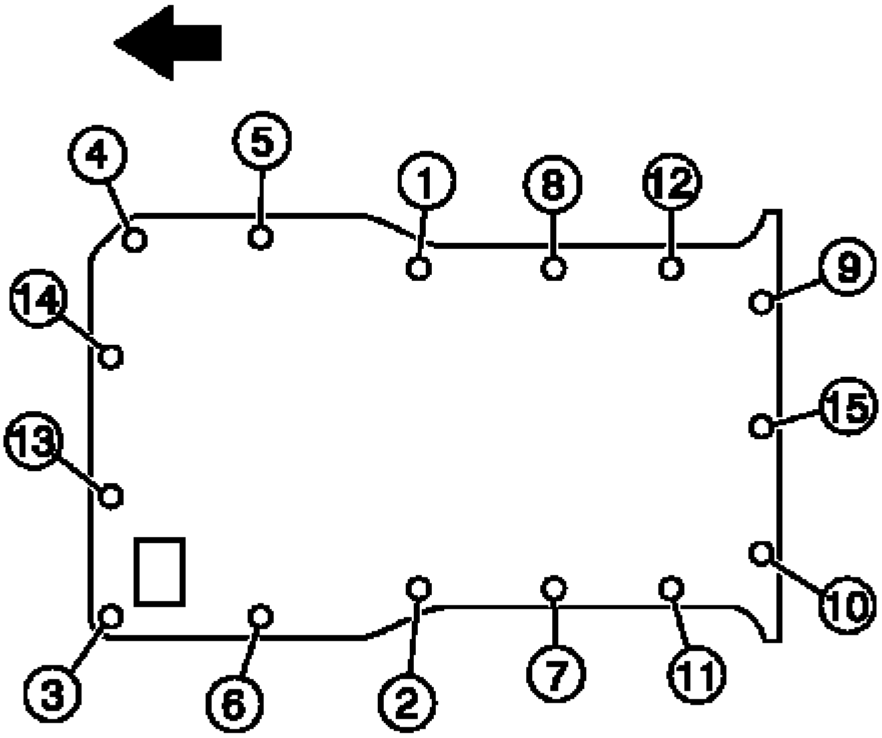


Fig. 143: Identifying Oil Pan Bolts Removal & Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

8. Remove the oil pan bolts.

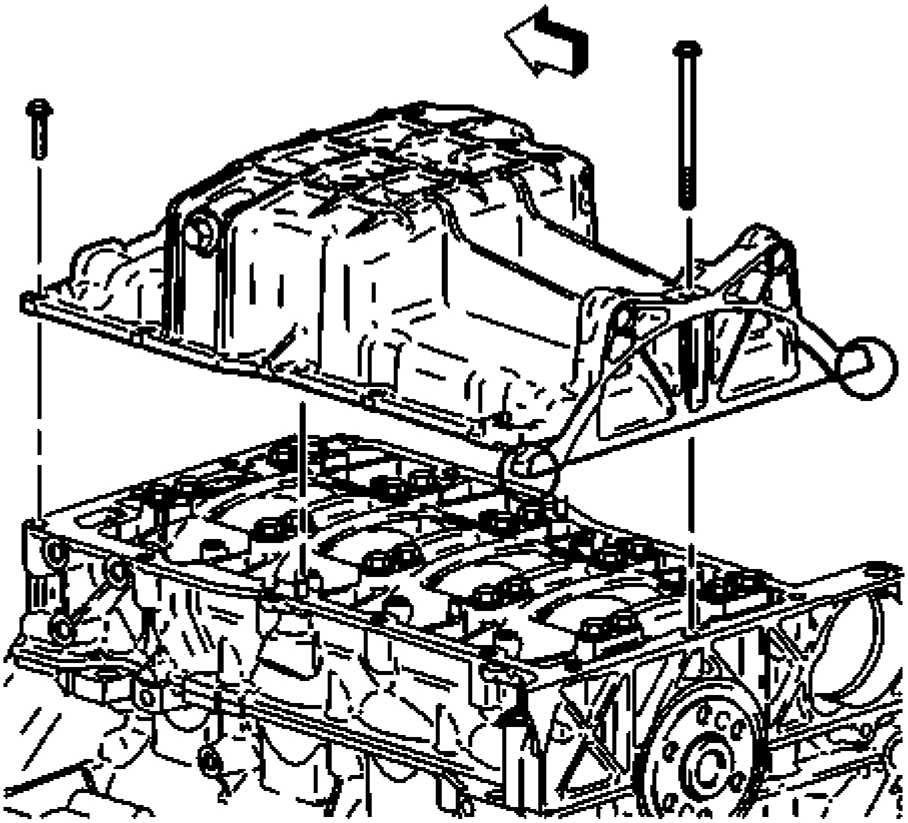


Fig. 144: View Of Oil Pan
Courtesy of GENERAL MOTORS CORP.

9. Remove the oil pan

Installation Procedure

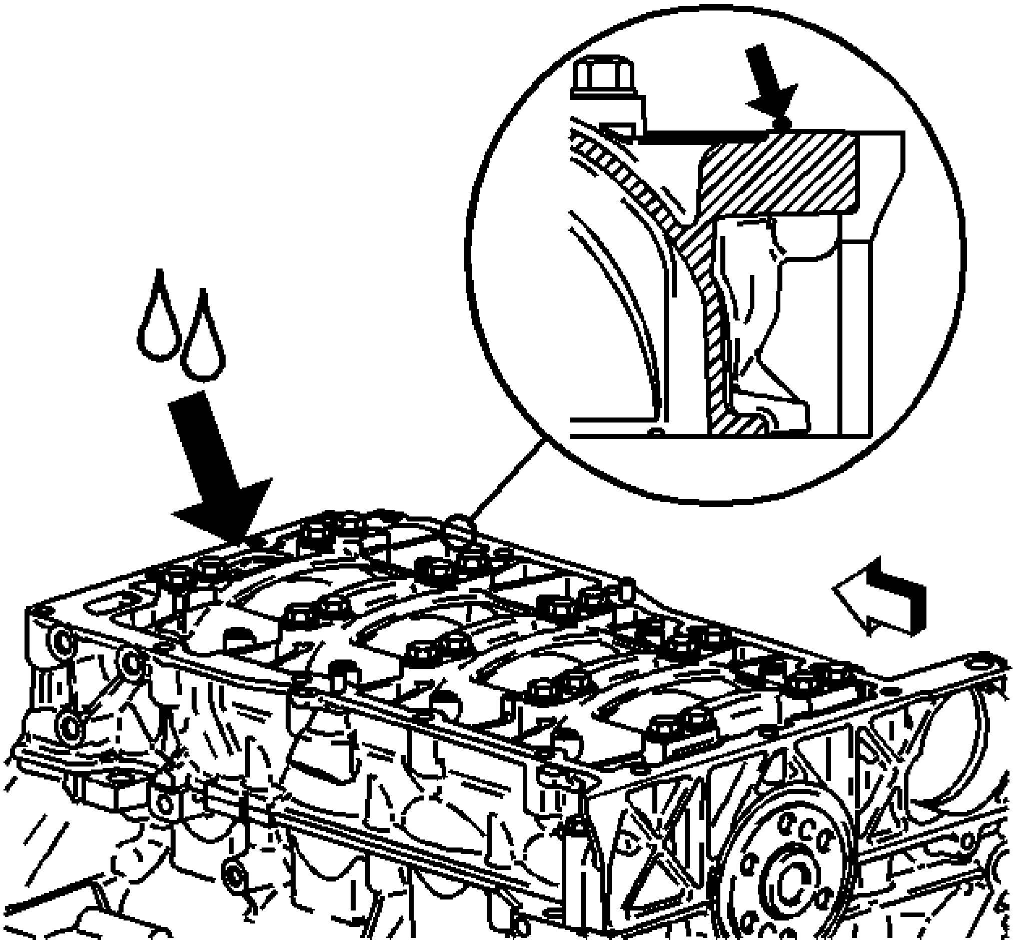


Fig. 145: Applying RTV Around Perimeter Of Oil Pan & Oil Suction Port Opening
Courtesy of GENERAL MOTORS CORP.

1. Make sure that the oil pan and mounting surface on the lower crankcase are free of all oil and debris.
2. Apply a 2 mm bead of RTV GM P/N United States 12346286, GM P/N Canada 10953472 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.

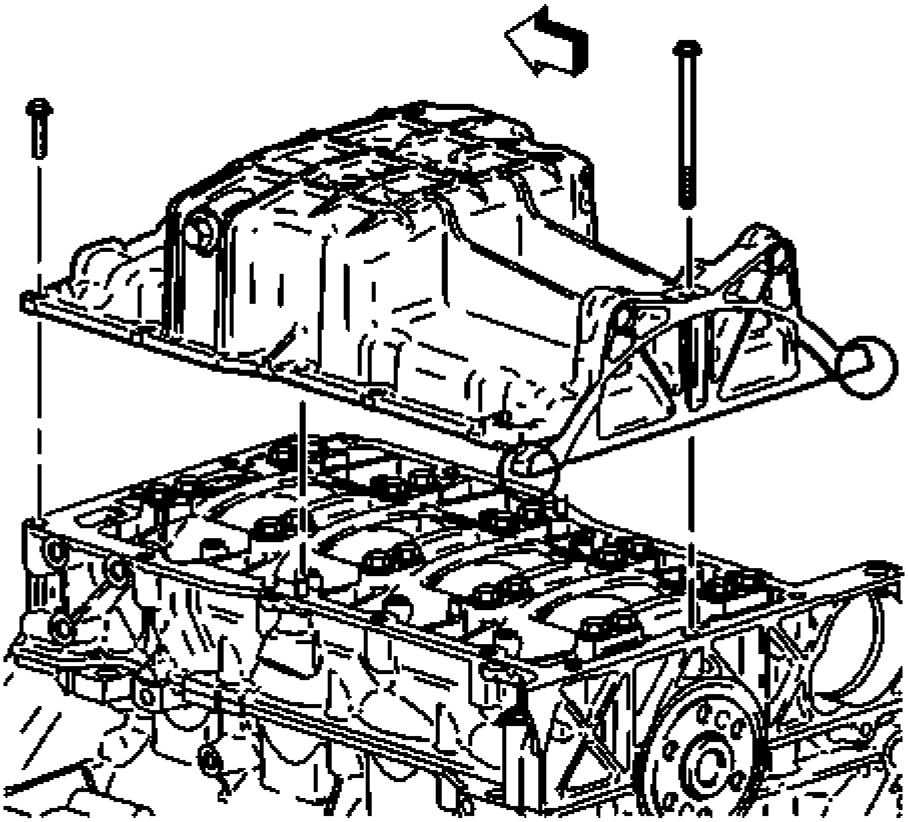


Fig. 146: View Of Oil Pan
Courtesy of GENERAL MOTORS CORP.

3. Install the oil pan.

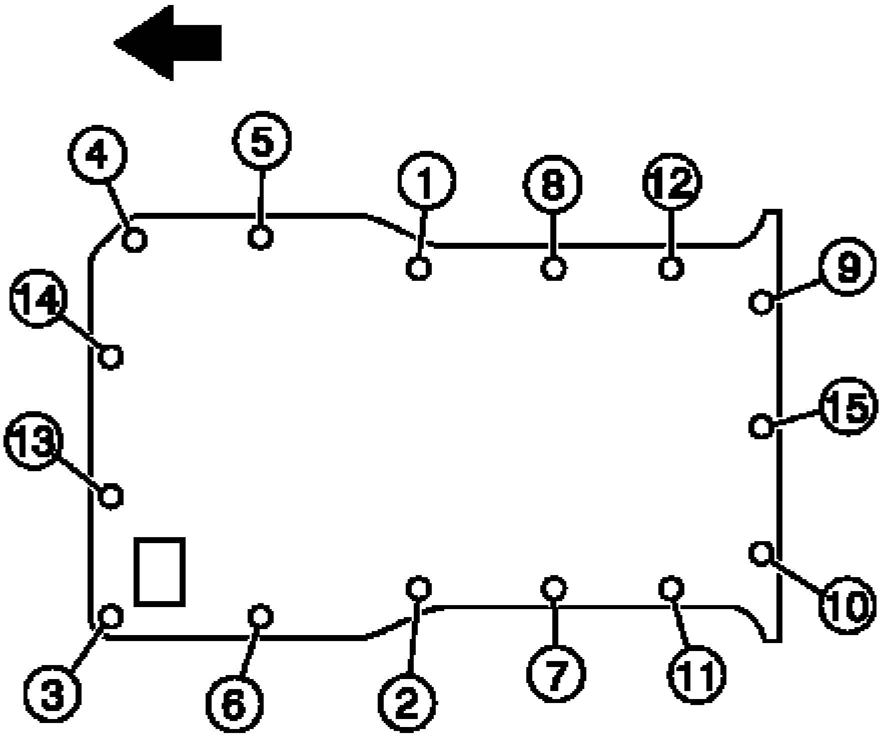


Fig. 147: Identifying Oil Pan Bolts Removal & Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the oil pan bolts.

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

5. Tighten the left side frame bolts. Refer to **Frame Replacement** .
6. Tighten the right side frame bolts. Refer to **Frame Replacement** .
7. Install the AC compressor bolts. Refer to **Compressor Replacement** in Heating, Ventilation and Air Conditioning.
8. Lower the vehicle.
9. Remove the engine support fixture.
10. Fill the engine oil to the proper level.

Crankshaft Rear Oil Seal Replacement

Tools Required

J 42067 Rear Main Seal Installer. See **Special Tools and Equipment**.

Removal Procedure

1. Remove the transmission. Refer to **Transmission Replacement** in Automatic Transmission - 4T40-E/4T45-E.
2. Remove the flywheel.

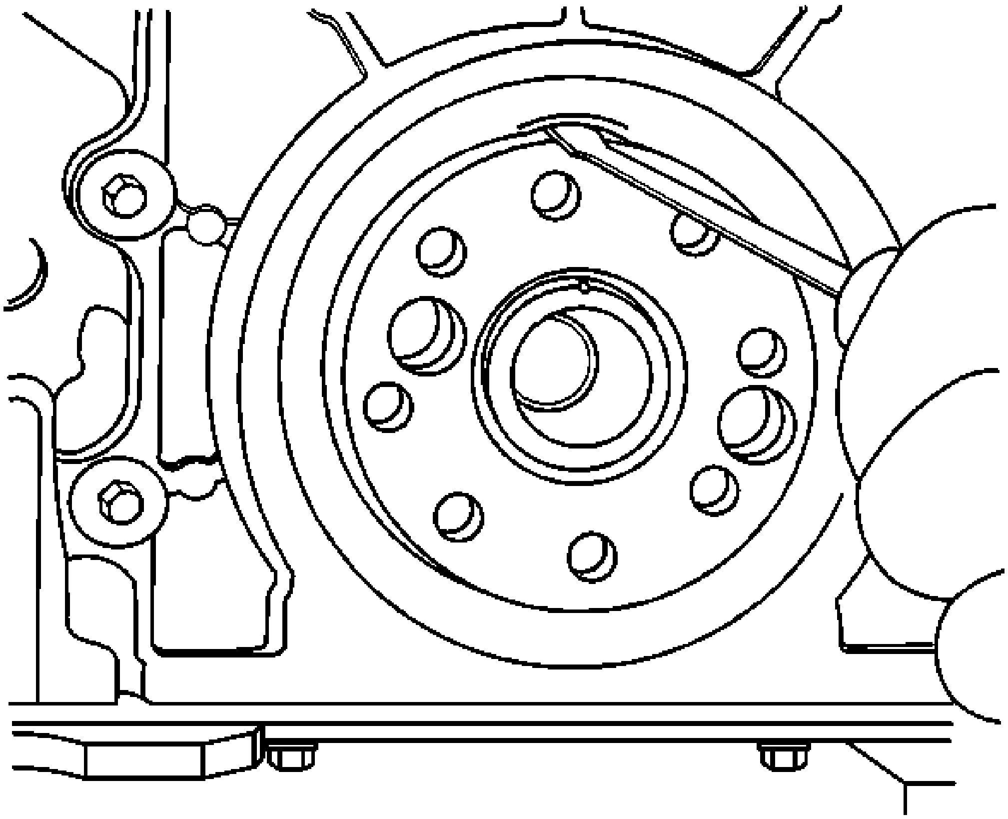


Fig. 148: View Of Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Make sure not to damage the outside diameter of the crankshaft or chamber with any tool.

3. Pry the crankshaft rear oil seal with a flat bladed tool.

Installation Procedure

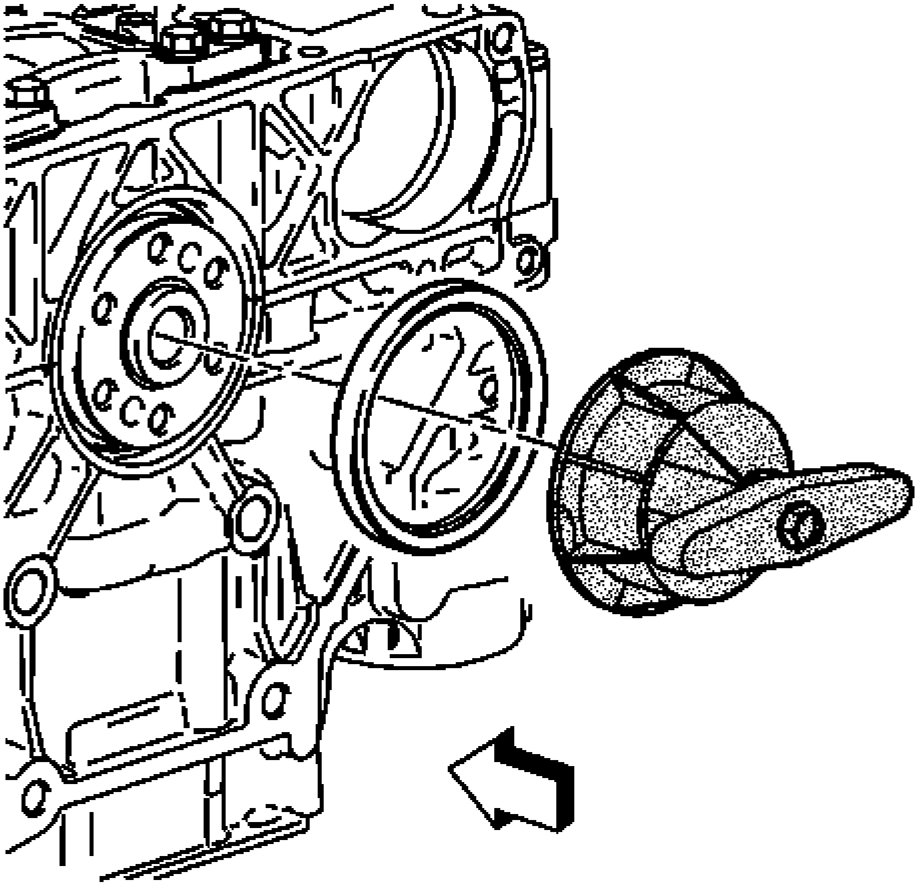


Fig. 149: Installing Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Use the **J 42067** and install the seal. See **Special Tools and Equipment**.

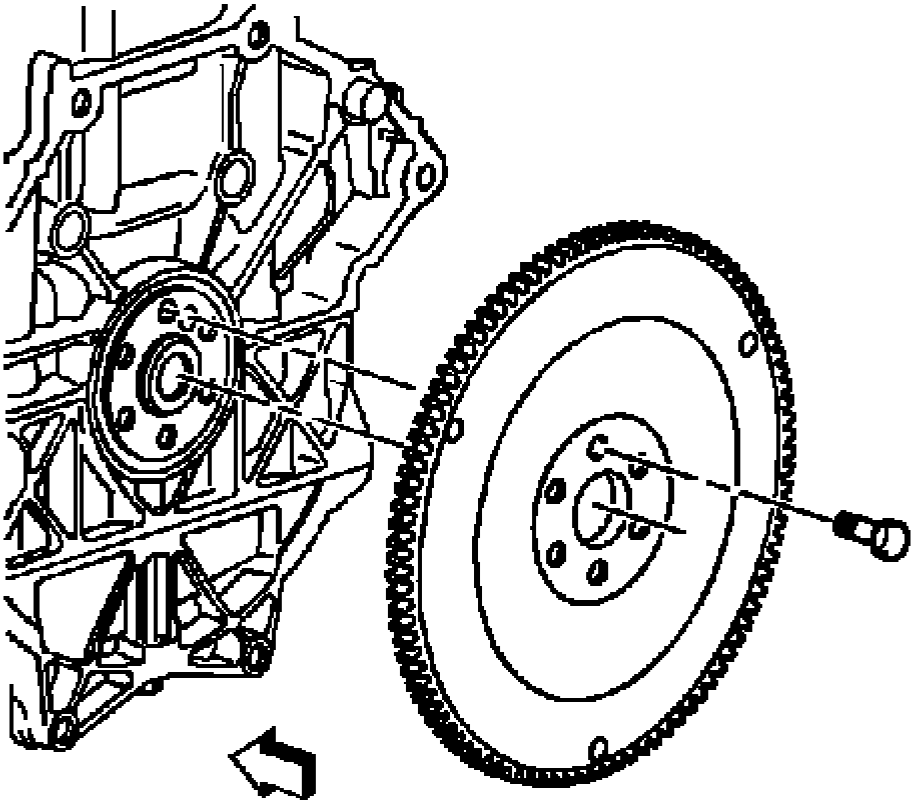


Fig. 150: View Of Flywheel
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the flywheel.

   Tighten: Tighten the flywheel bolts to 53 N.m (39 lb ft) plus 25 degrees.

3. Install the transmission. Refer to **Transmission Replacement** in Automatic Transmission - 4T40-E/4T45-E.

Engine Flywheel Replacement

Removal Procedure

1. Remove the transmission. Refer to **Transmission Replacement** in Automatic Transmission - 4T40-E/4T45-E.

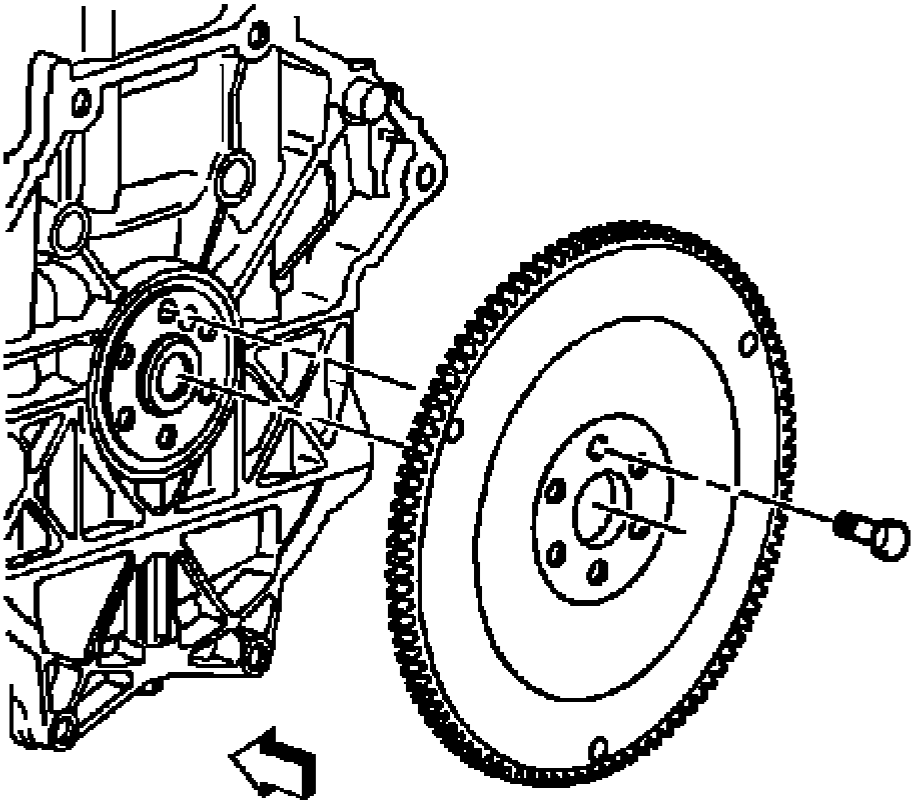


Fig. 151: View Of Flywheel
Courtesy of GENERAL MOTORS CORP.

2. Remove the flywheel.

Installation Procedure

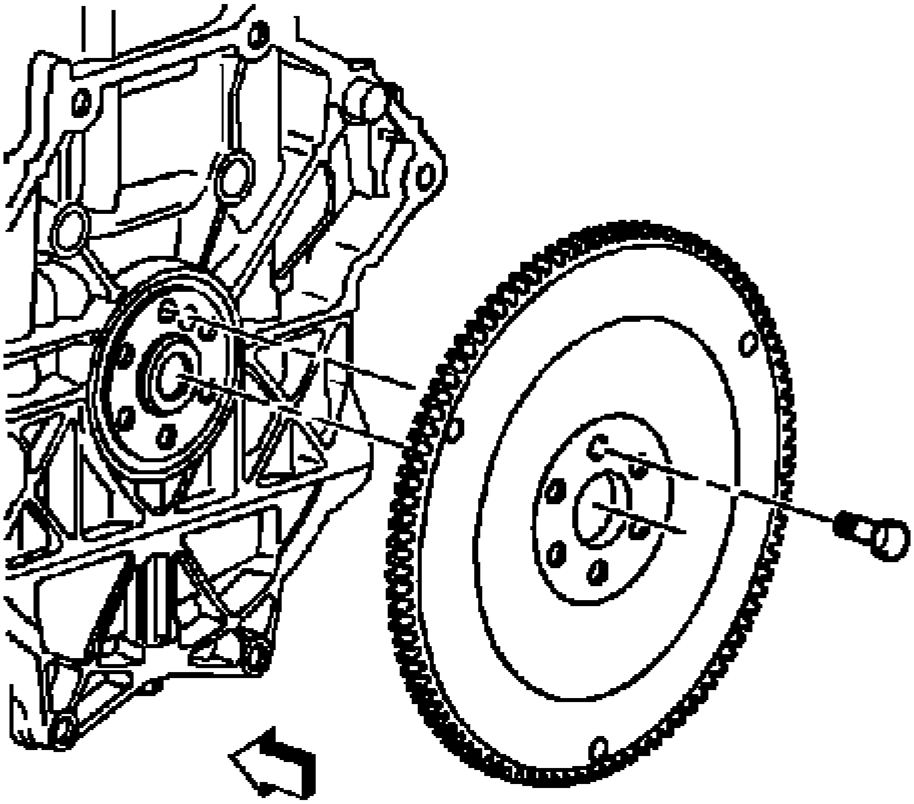


Fig. 152: View Of Flywheel
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the flywheel.

   Tighten: Tighten the flywheel bolts to 53 N.m (39 lb ft) plus 25 degrees.

2. Install the transmission. Refer to **Transmission Replacement** in Automatic Transmission - 4T40-E/4T45-E.

Cylinder Sleeve Replacement

Tools Required

EN 45680-850 Cylinder Sleeve Removal and Installation Kit

Removal Procedure

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

3. Remove the piston and connecting rod. Refer to **Piston, Connecting Rod, and Bearing Removal**.
4. Inspect the condition of the piston. Refer to **Piston, Connecting Rod, and Bearings Cleaning and Inspection**.

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

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

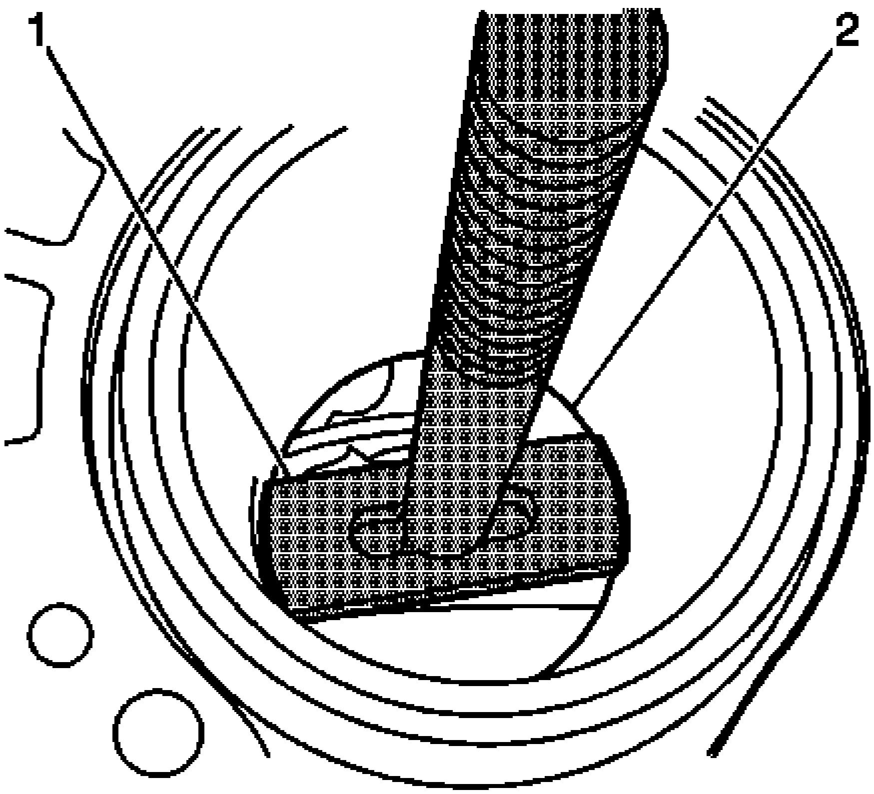


Fig. 153: Identifying Cylinder Bore Sleeve Puller EN 45680-852 Shoe & Sleeve
Courtesy of GENERAL MOTORS CORP.

5. Rotate the crankshaft so that the counterweight is to the right side and the connecting rod journal is to the left side and not in alignment with the cylinder bore.
6. Install the cylinder bore sleeve puller EN 45680-852 (1) through the cylinder bore.

NOTE: Ensure that the shoe is flat against the bottom of the cylinder bore liner or

damage to the cylinder bore liner puller EN45680-852 will occur.

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

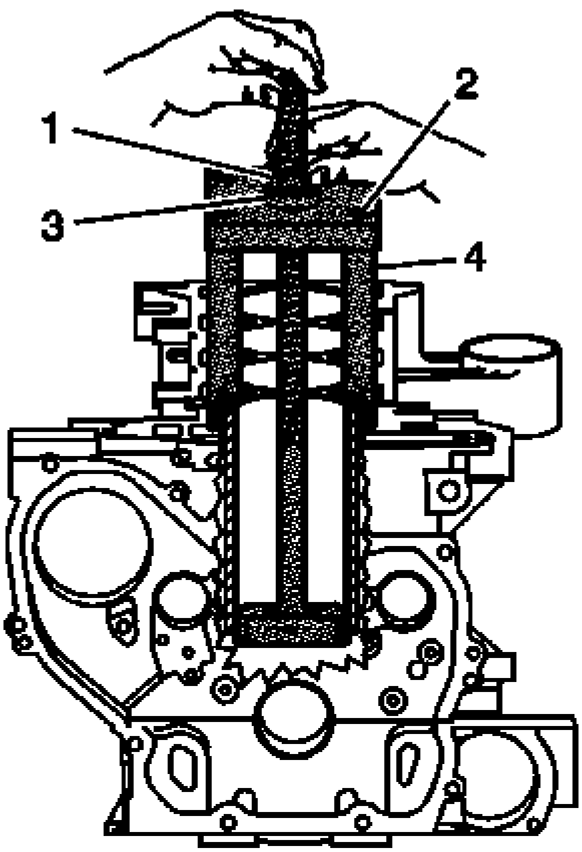


Fig. 154: Aligning Cylinder Bore Sleeve Puller
Courtesy of GENERAL MOTORS CORP.

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

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

IMPORTANT: **Use four old cylinder head bolts for the attaching bolts.**

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

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

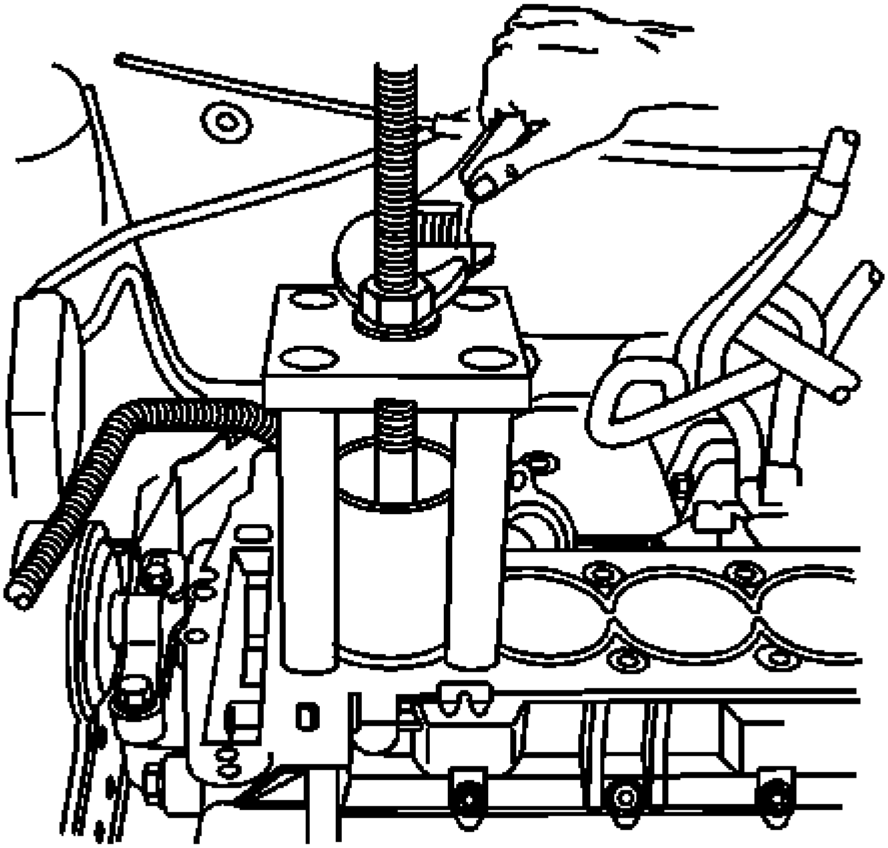


Fig. 155: Cylinder Bore Sleeve Removal
Courtesy of GENERAL MOTORS CORP.

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

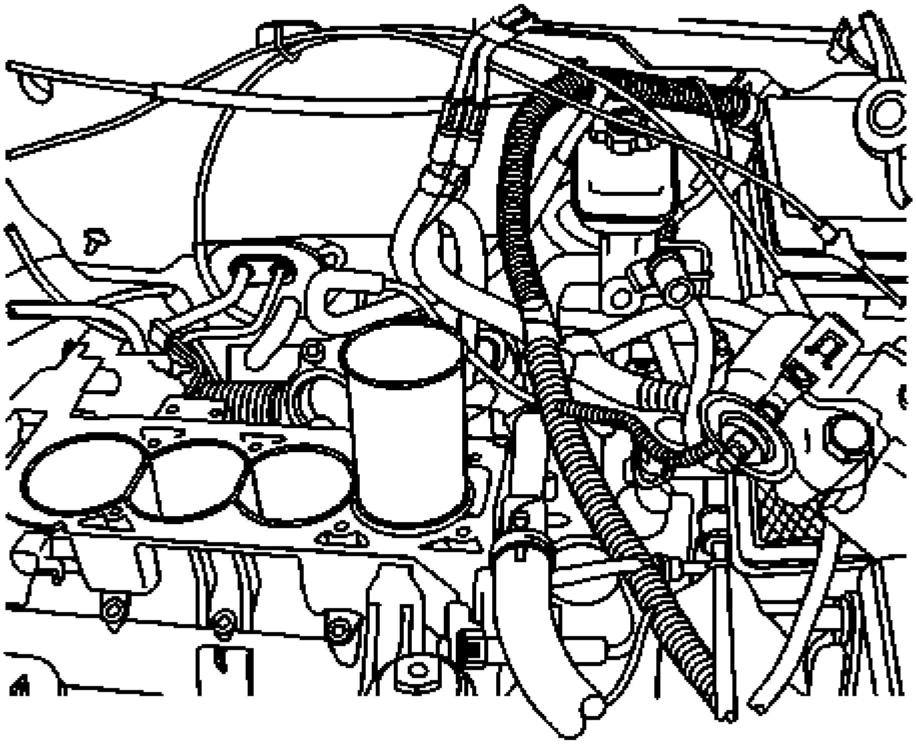


Fig. 156: View of Cylinder Bore Liner Sleeve from Engine Block
Courtesy of GENERAL MOTORS CORP.

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

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

Installation Procedure

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

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

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

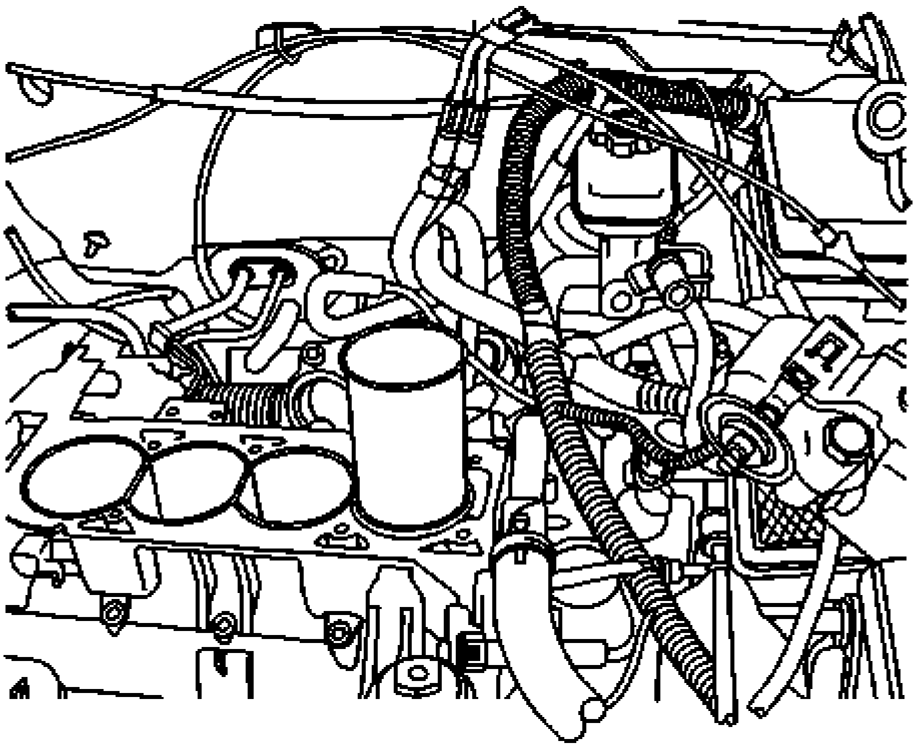


Fig. 157: View of Cylinder Bore Sleeve Replacement into Cylinder Block
Courtesy of GENERAL MOTORS CORP.

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

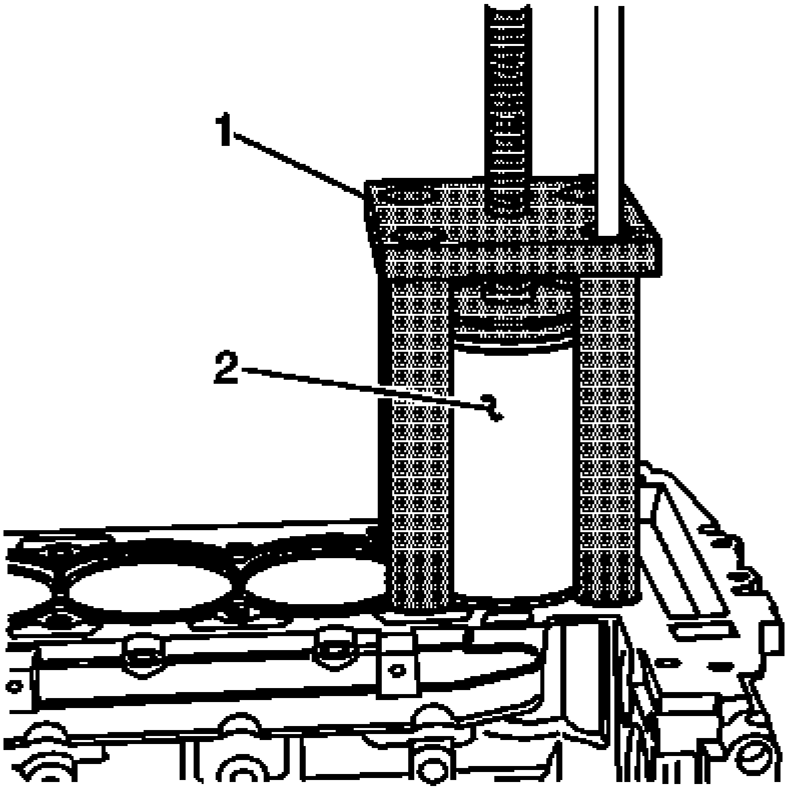


Fig. 158: Identifying Fixture EV 45680-851 & Cylinder Bore Sleeve
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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

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

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

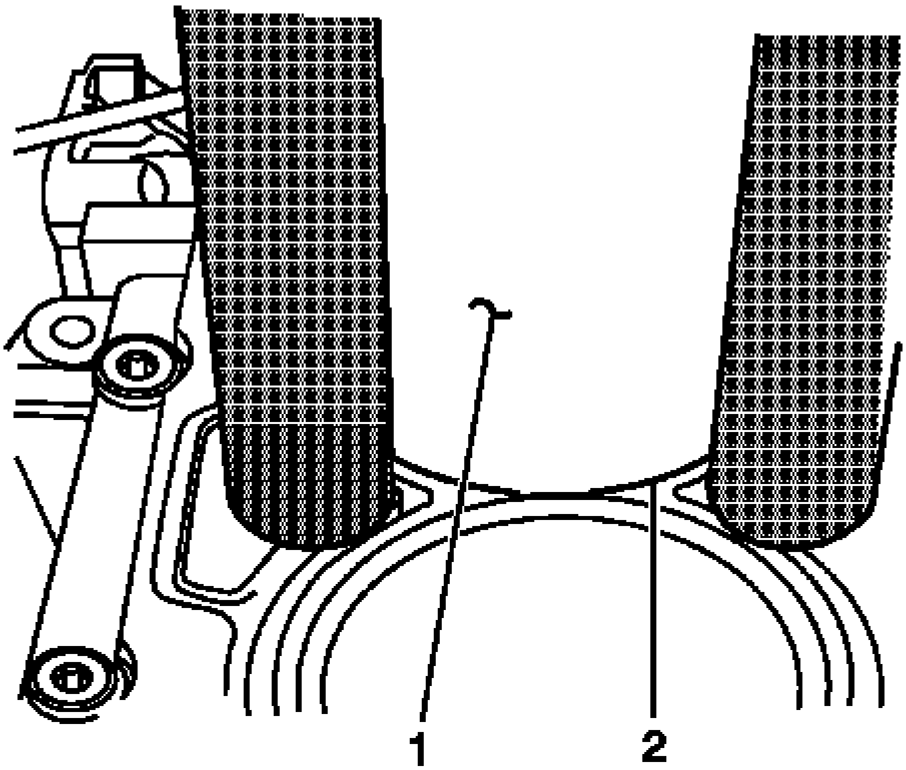


Fig. 159: View of Cylinder Bore Sleeve Alignment
Courtesy of GENERAL MOTORS CORP.

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

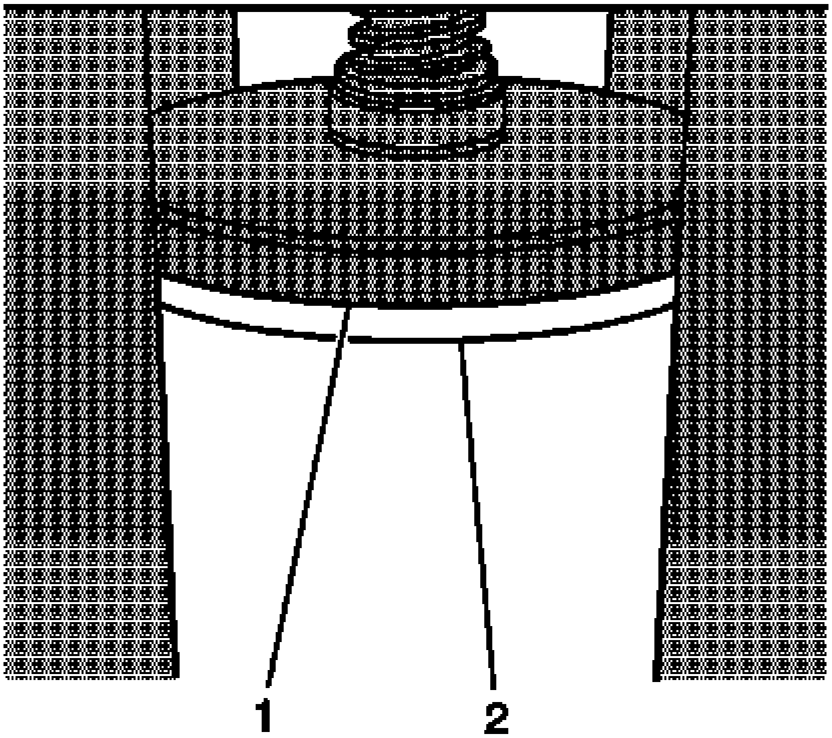


Fig. 160: Aligning of Installation Arbor & Cylinder Bore Sleeve
Courtesy of GENERAL MOTORS CORP.

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

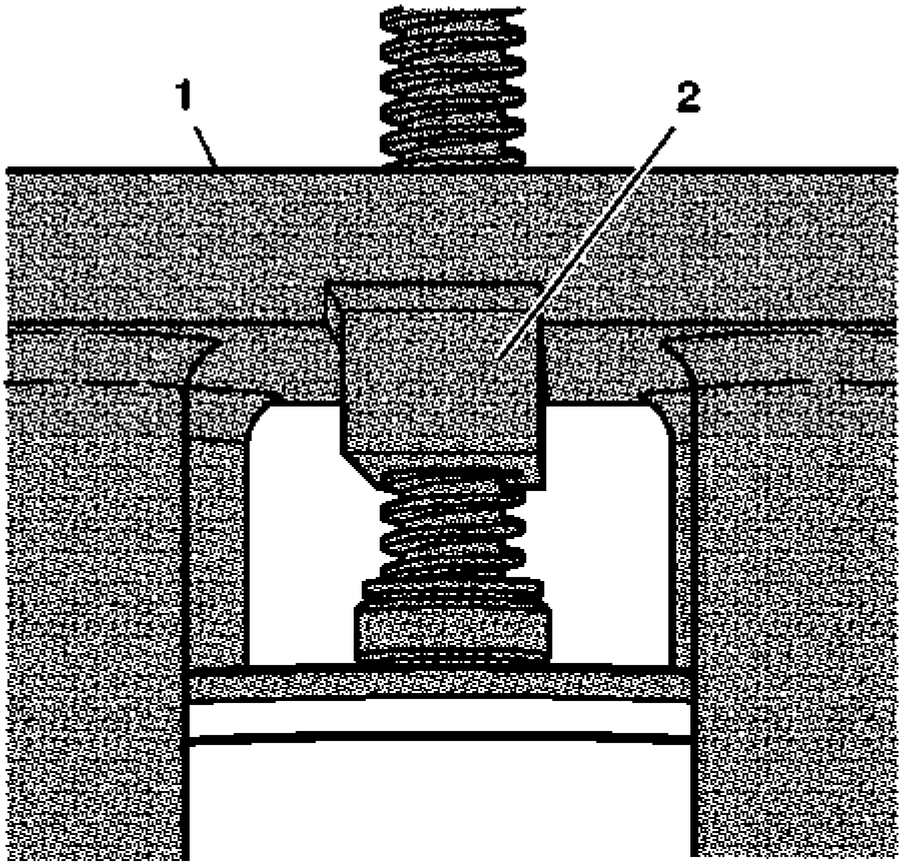


Fig. 161: View Of Pusher Block
Courtesy of GENERAL MOTORS CORP.

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

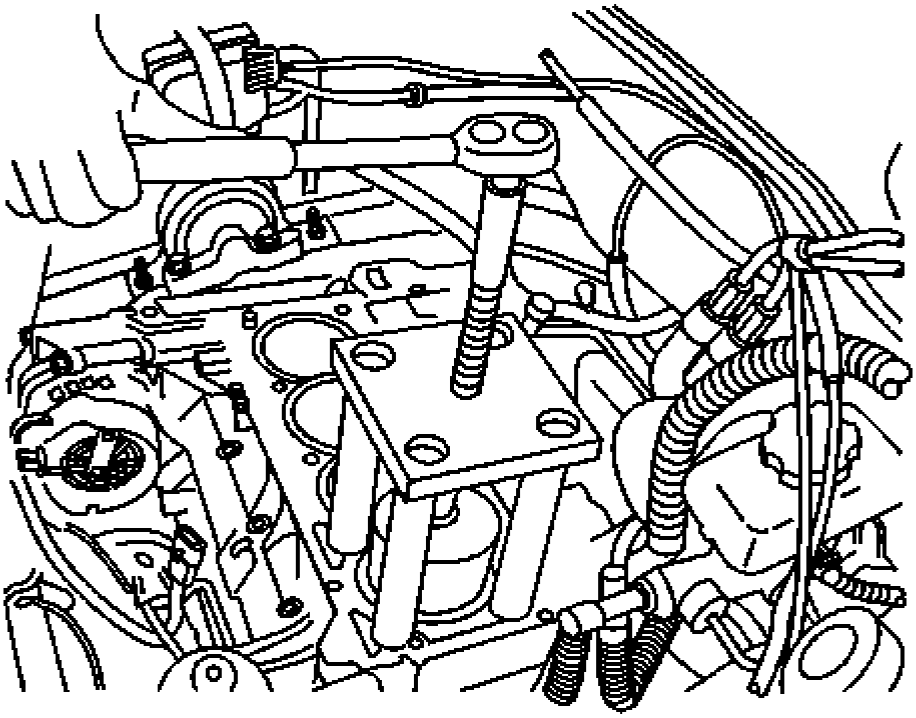


Fig. 162: Threaded Shaft Rotation
Courtesy of GENERAL MOTORS CORP.

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

7. Using a ratchet, rotate the threaded shaft of fixture EN 45680-851/cylinder bore sleeve installer EN 45680-853 assembly in order to install the cylinder bore sleeve into the engine block.
8. Do not completely seat the cylinder bore sleeve in the block. Leave approximately 1/16 inch of the cylinder bore sleeve above the surface of the cylinder block.

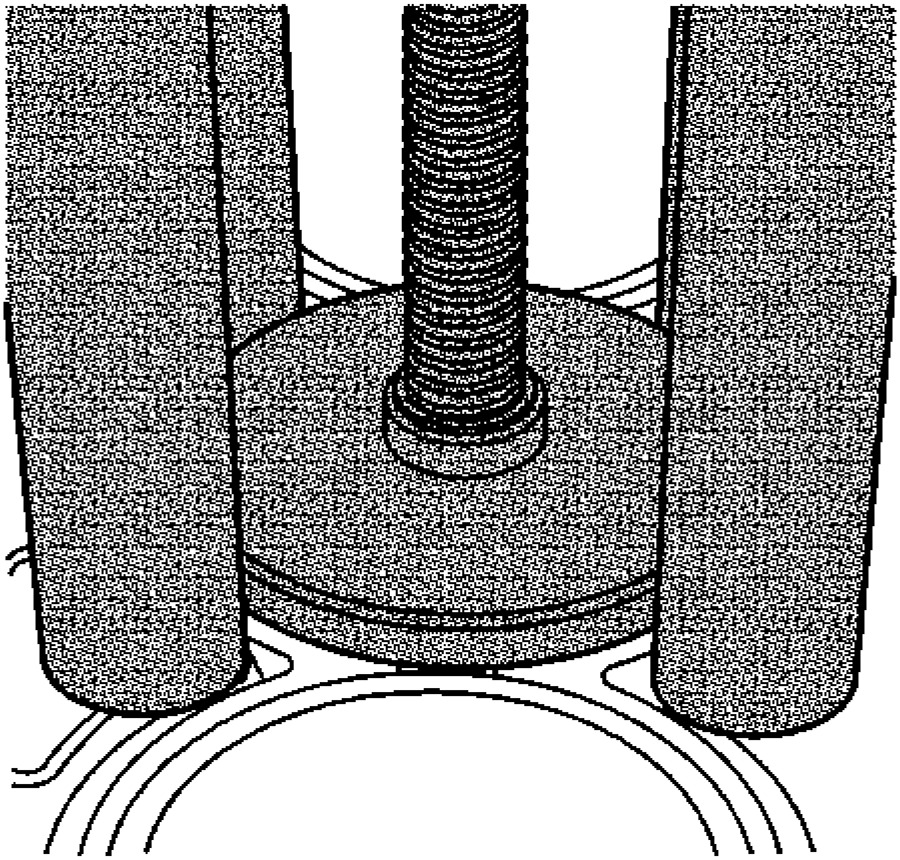


Fig. 163: Seating Cylinder Bore Sleeve Completely Using Tool
Courtesy of GENERAL MOTORS CORP.

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

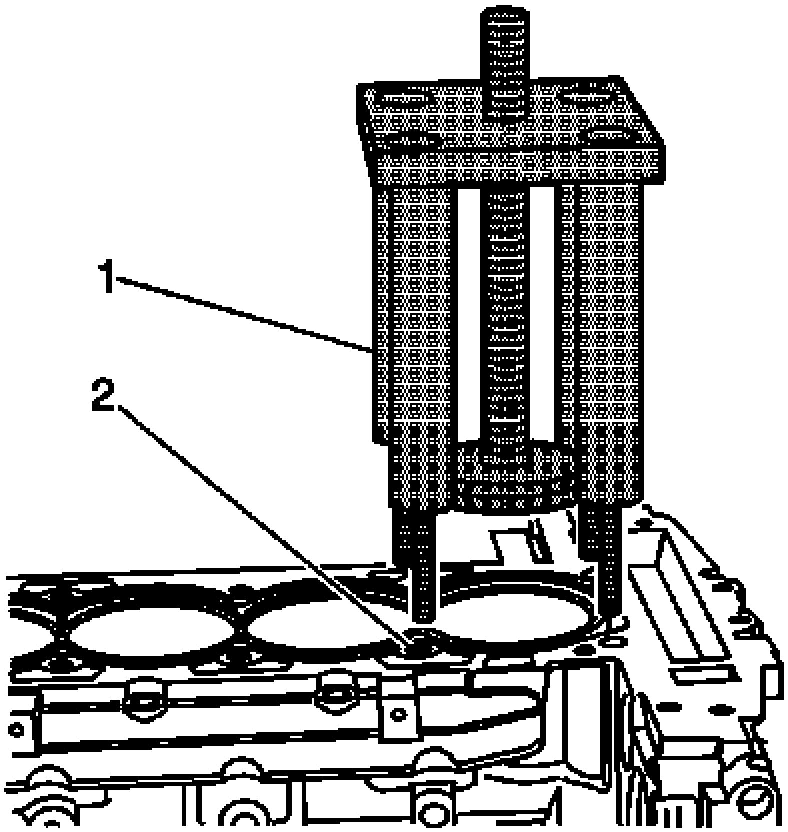


Fig. 164: Cylinder Bore Sleeve Installer Removal from Cylinder Block
Courtesy of GENERAL MOTORS CORP.

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

Cylinder Liner Trimming

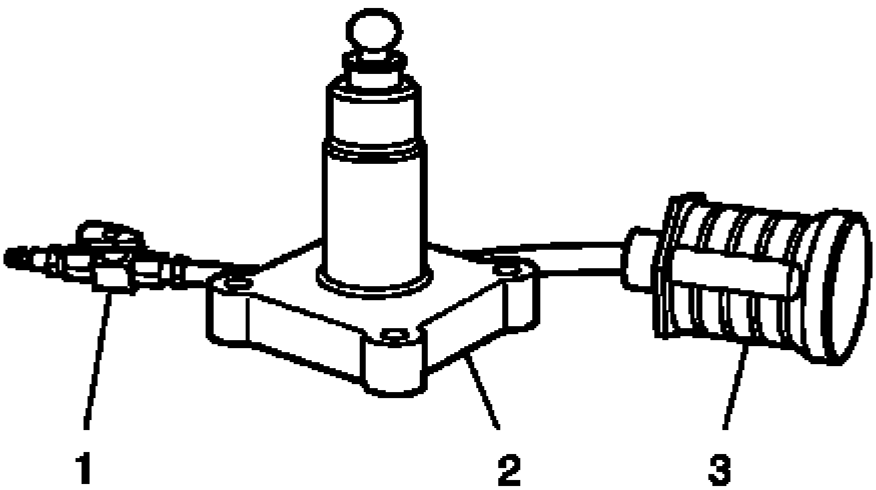


Fig. 165: Cylinder Liner Trimming Tools View (1 Of 2)
Courtesy of GENERAL MOTORS CORP.

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

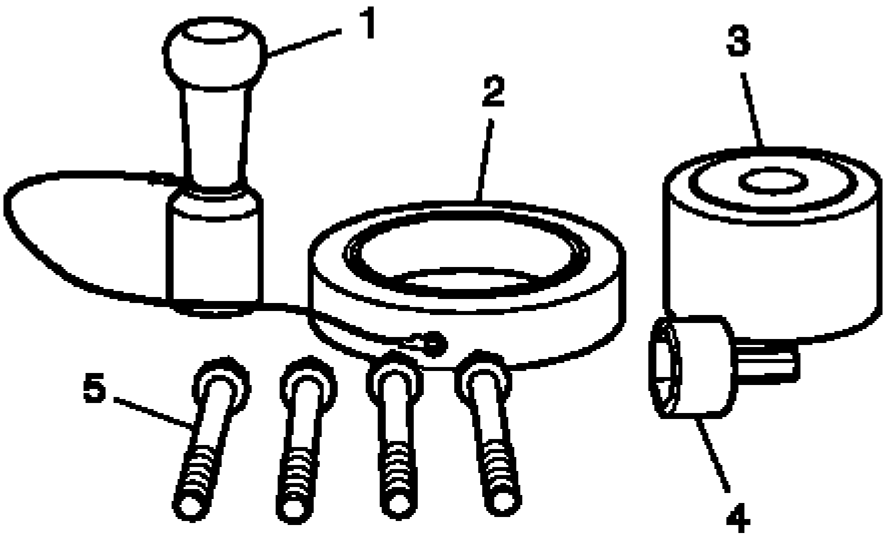


Fig. 166: Cylinder Liner Trimming Tools View (2 Of 2)
Courtesy of GENERAL MOTORS CORP.

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

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

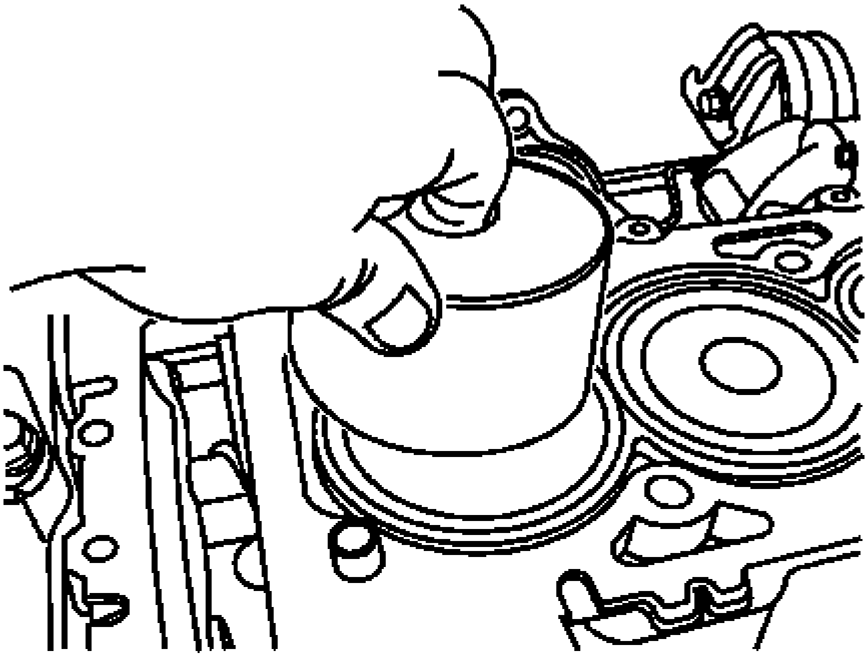


Fig. 167: Placement of Metal Shaving Catch Plug into Cylinder Bore Sleeve
Courtesy of GENERAL MOTORS CORP.

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

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

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

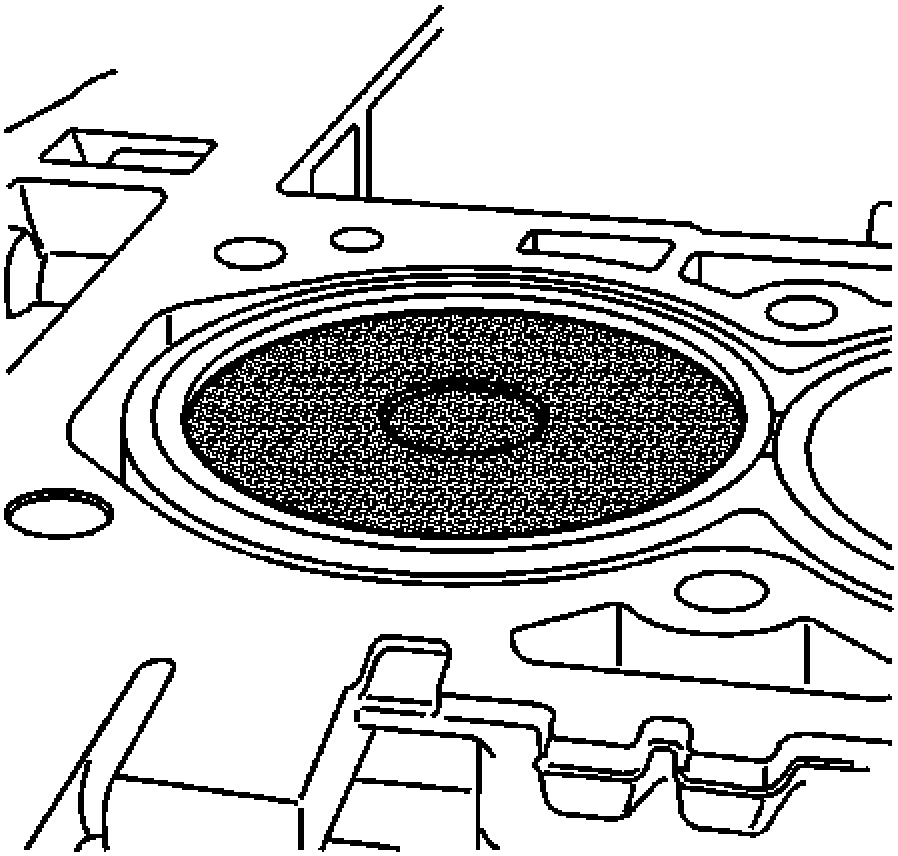


Fig. 168: Identifying Catch Plug Positioning
Courtesy of GENERAL MOTORS CORP.

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

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

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

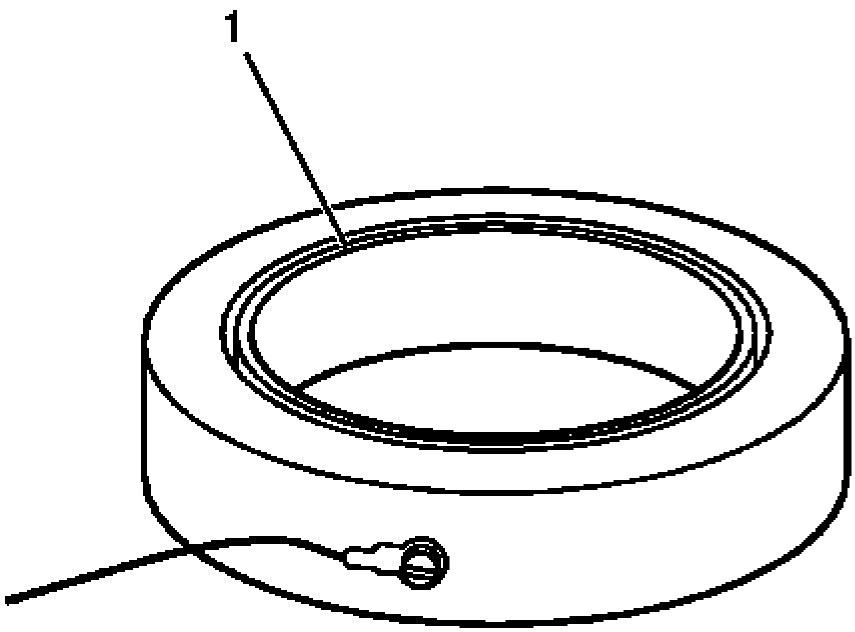


Fig. 169: Identifying Set Gauge Ring Groove
Courtesy of GENERAL MOTORS CORP.

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

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

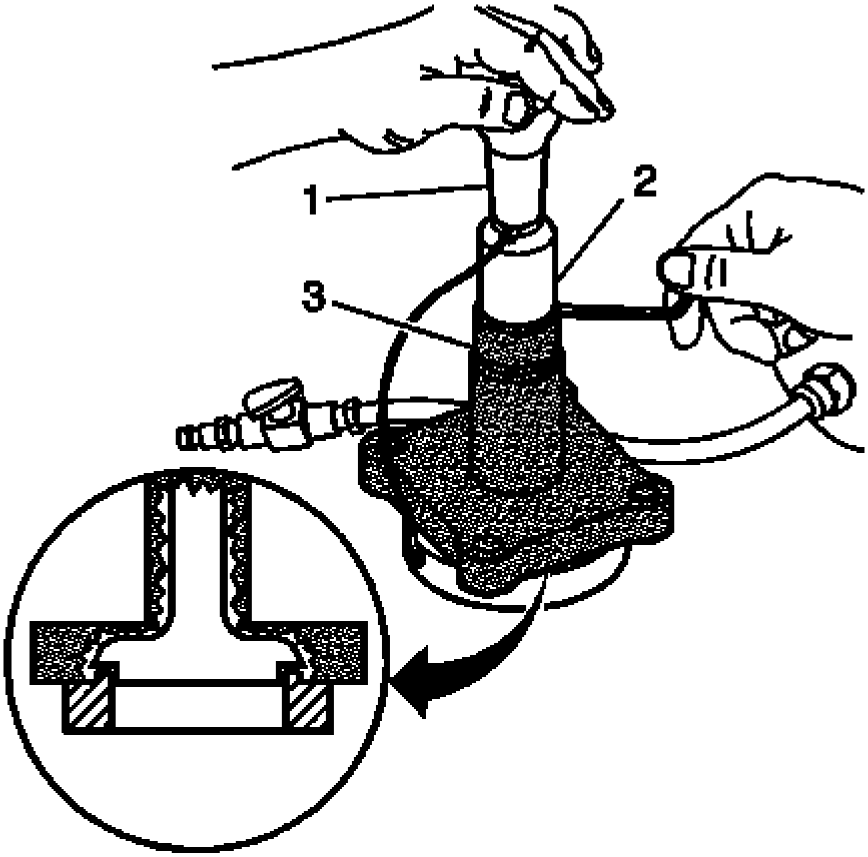


Fig. 170: View Of Trim Tool Assembly Components And Positioning
Courtesy of GENERAL MOTORS CORP.

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

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

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

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

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

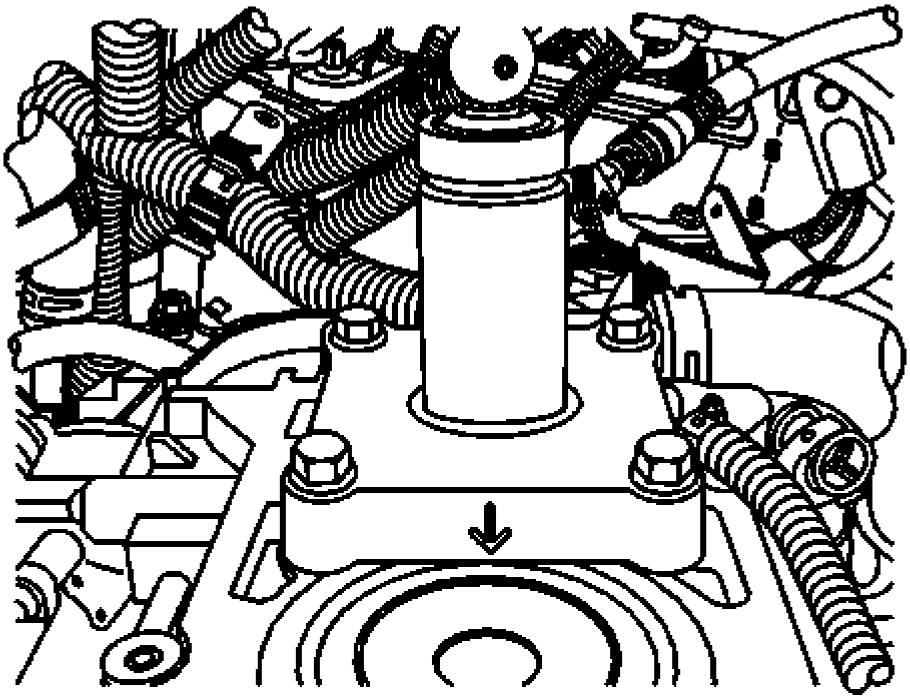


Fig. 171: View of Trim Tool Assembly EN 45680-861
Courtesy of GENERAL MOTORS CORP.

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

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

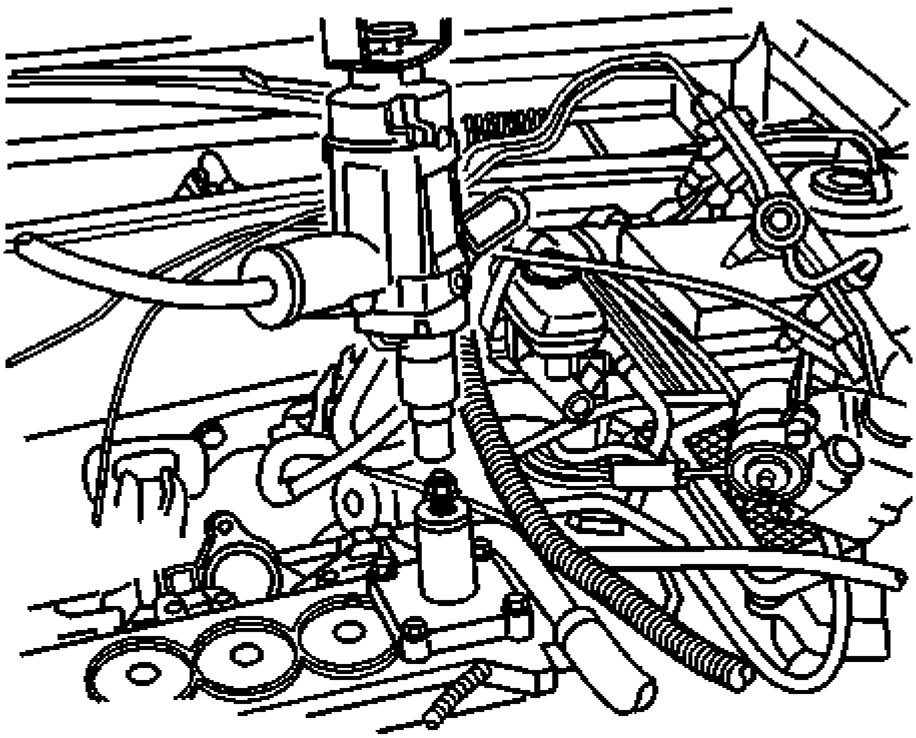


Fig. 172: View of Trimming of Cylinder
Courtesy of GENERAL MOTORS CORP.

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

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

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

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

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

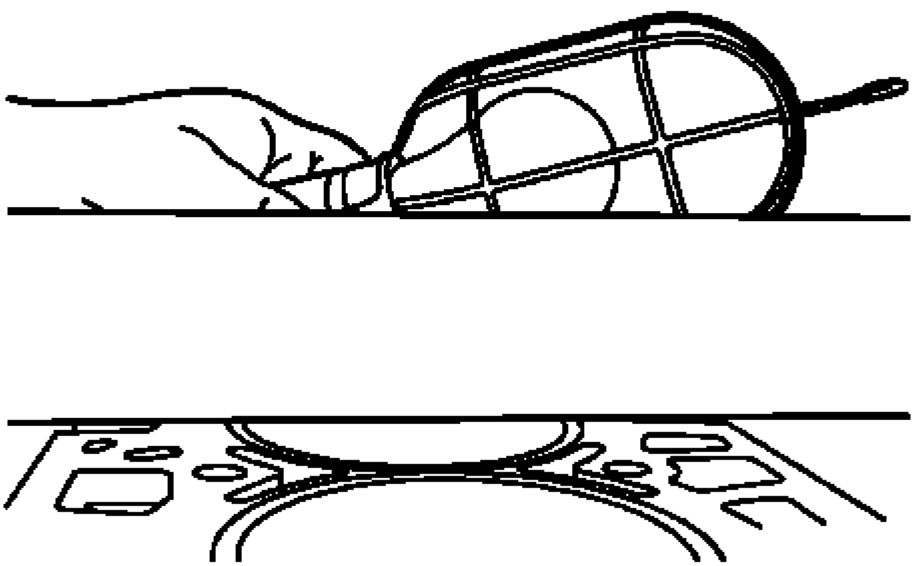


Fig. 173: Checking Cylinder Block Deck Surface With Straight Edge
Courtesy of GENERAL MOTORS CORP.

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

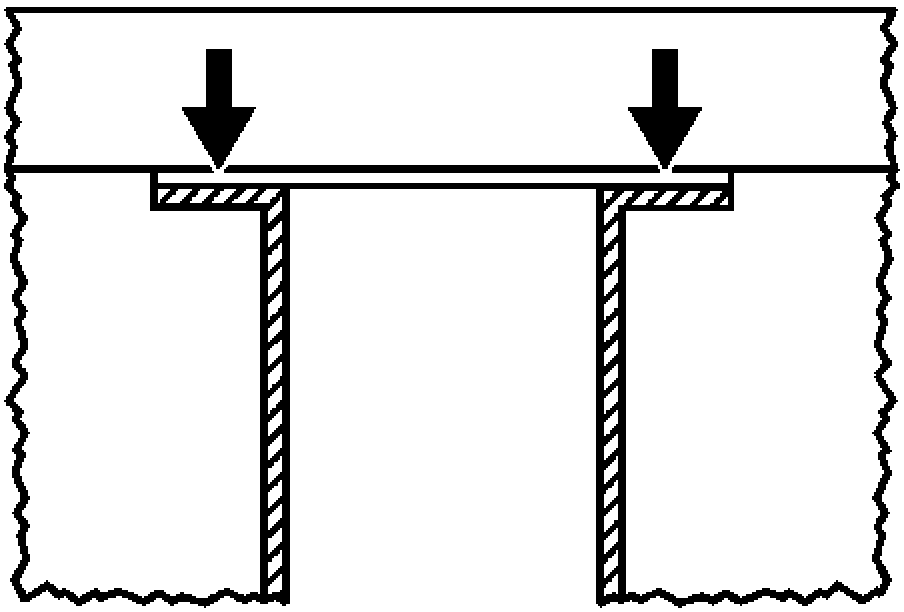


Fig. 174: View Of Improperly Cut Cylinder Bore Sleeve
Courtesy of GENERAL MOTORS CORP.

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

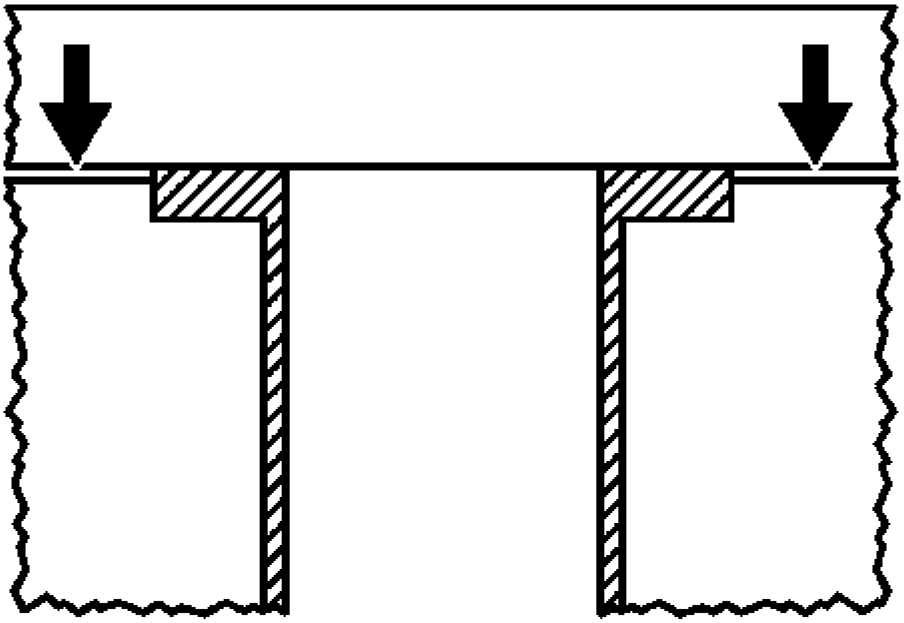


Fig. 175: View Of For Properly Cut Cylinder Bore Sleeve
Courtesy of GENERAL MOTORS CORP.

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

Engine Replacement

Tools Required

J 42451 Engine Lift Bracket. See **Special Tools and Equipment**.

Removal Procedure

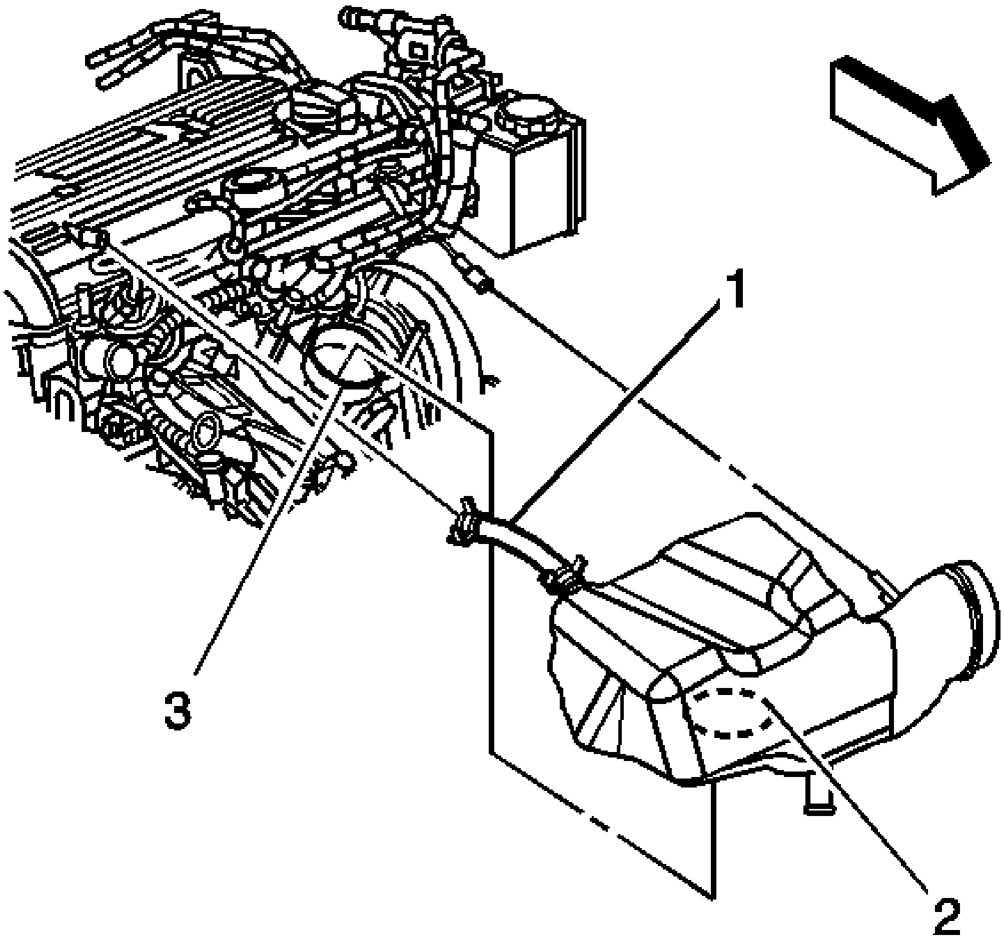


Fig. 176: Exploded View Of Air Inlet Duct & Resonator
Courtesy of GENERAL MOTORS CORP.

1. Remove the hood. Refer to **Hood Replacement** in Body Front End.
2. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
3. Remove the air inlet duct and resonator (2). Refer to **Air Cleaner Outlet Resonator Replacement** in Engine Controls-2.2L.

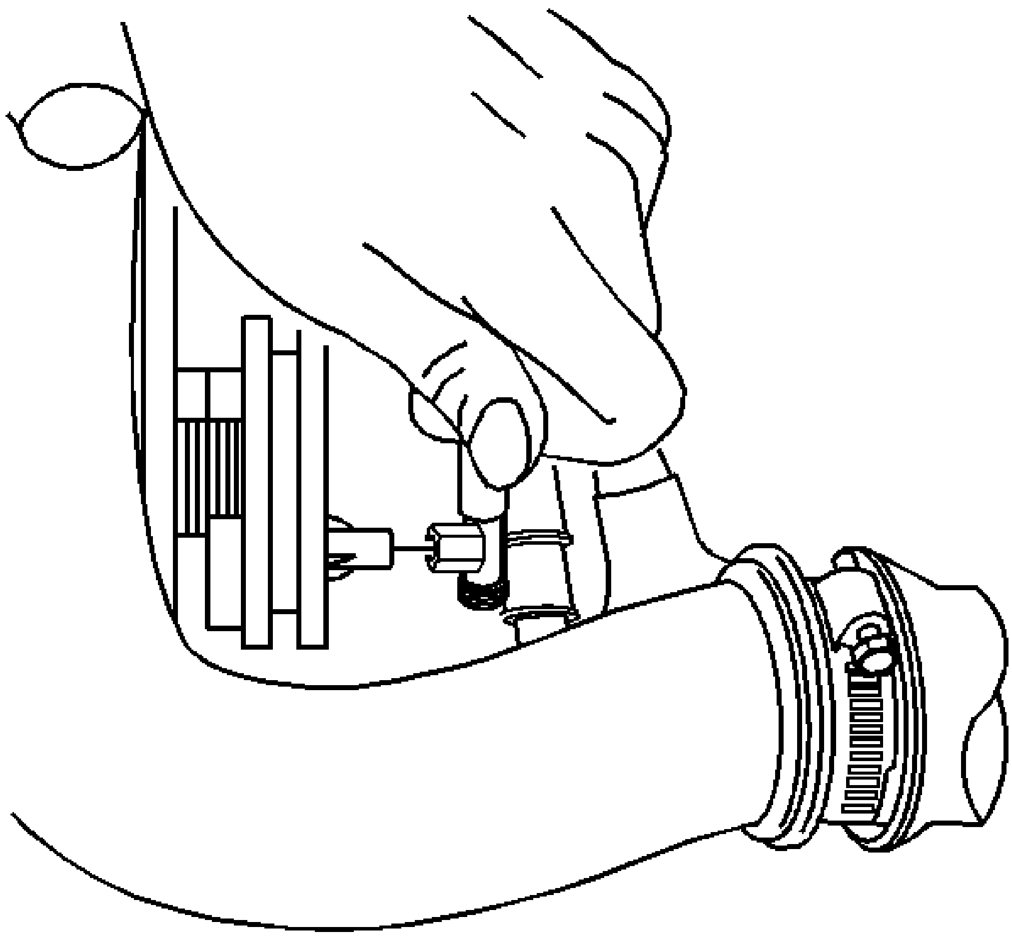


Fig. 177: View Of Cruise Control Cable At Throttle Body Cam Lever
Courtesy of GENERAL MOTORS CORP.

4. Disconnect the accelerator and cruise control cable. Refer to **Accelerator Controls Cable Replacement** in Engine Controls - 2.2L (L61).
5. Disconnect the brake booster hose at the brake booster.

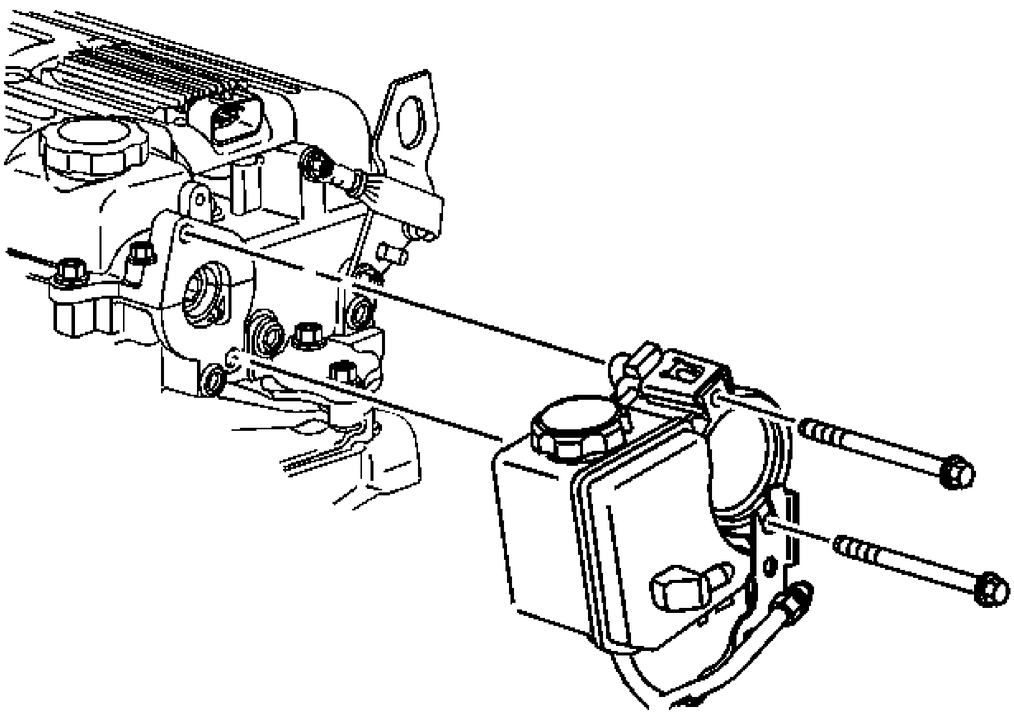


Fig. 178: View Of Power Steering Pump
Courtesy of GENERAL MOTORS CORP.

6. Remove the power steering pump bolts and set pump aside.
7. Disconnect fuel lines. Refer to **Fuel Hose/Pipes Replacement - Engine Compartment (Fuel Pipes)** **Fuel Hose/Pipes Replacement - Engine Compartment (Fuel Hoses)** in Engine Controls - 2.2L (L61).
8. Drain the cooling system. Refer to **Draining and Filling Cooling System** in Engine Cooling.

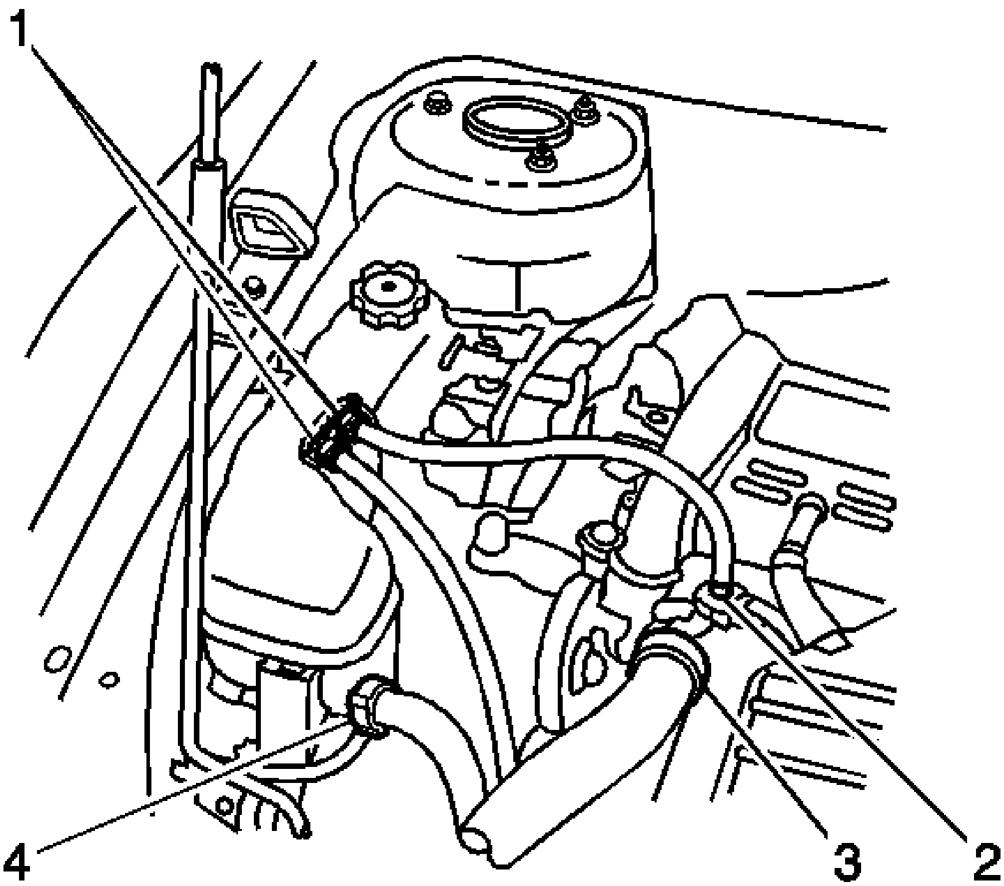


Fig. 179: Radiator Outer & Inlet Hose View
Courtesy of GENERAL MOTORS CORP.

9. Remove the radiator inlet hose (3). Refer to **Radiator Hose Replacement - Inlet** in Engine Cooling.
10. Remove surge tank to cylinder head hose (2).
11. Disconnect the surge tank to radiator outlet hose (3).

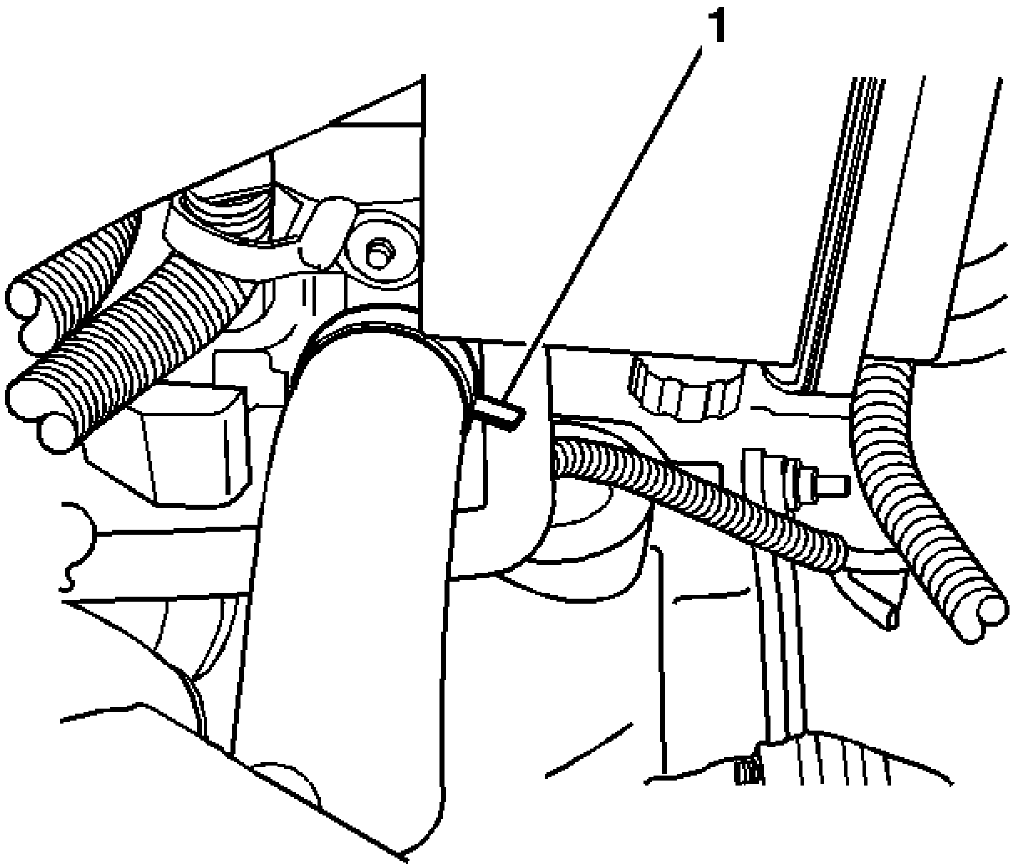


Fig. 180: View Of Radiator Outlet Hose
Courtesy of GENERAL MOTORS CORP.

12. Remove the radiator outlet hose (1). Refer to **Radiator Hose Replacement - Outlet** in Engine Cooling.

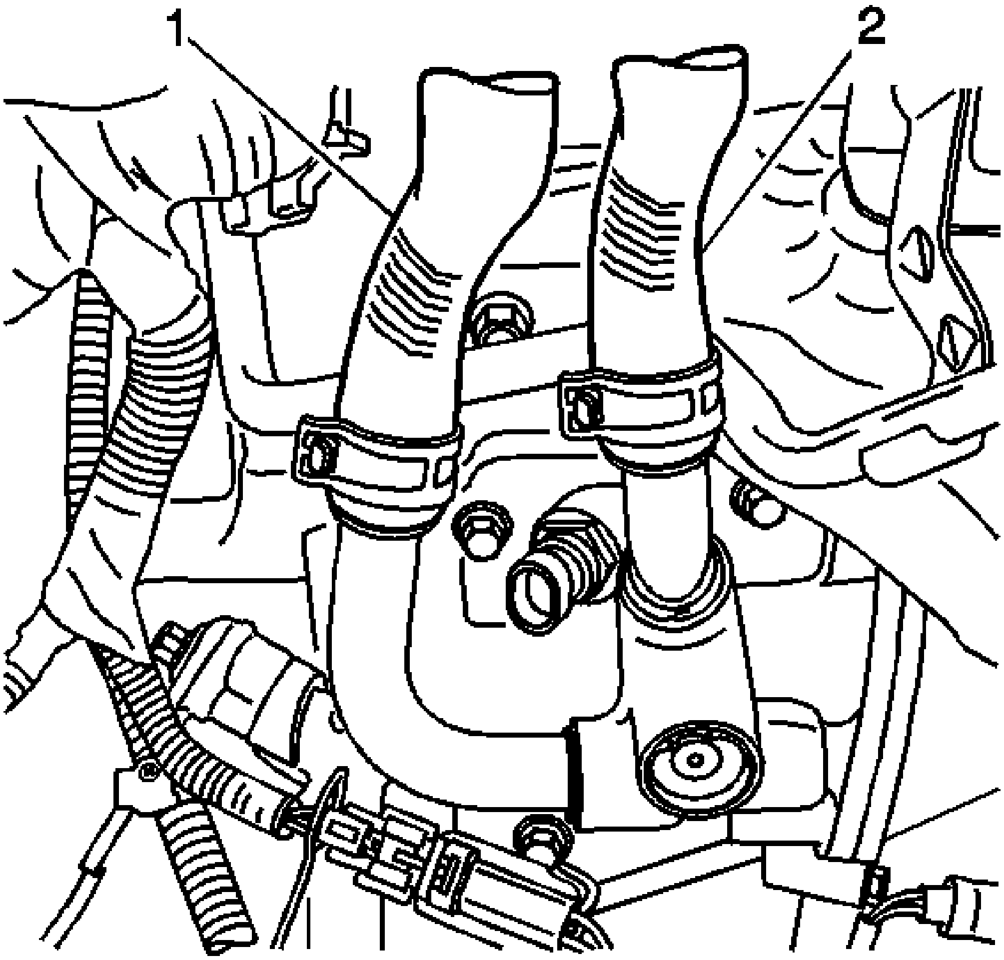


Fig. 181: View Of Inlet & Outlet Heater Hose
Courtesy of GENERAL MOTORS CORP.

13. Remove the inlet heater hose (1) and outlet heater hose (2). Refer to **Heater Hose Replacement - Inlet** and to **Heater Hose Replacement - Outlet** in HVAC.
14. Remove the bolt retaining the surge tank outlet hose to the intake manifold.
15. Disconnect the following electrical connectors:
    - IAC motor
    - TPS
    - Map sensor
    - Crankshaft sensor
    - Camshaft sensor

- Oil pressure sensor
- Purge solenoid
- Ignition coil and module assembly
- O2 sensor
- Vehicle speed sensor
- Engine temperature sensor
- Back-up lamp switch

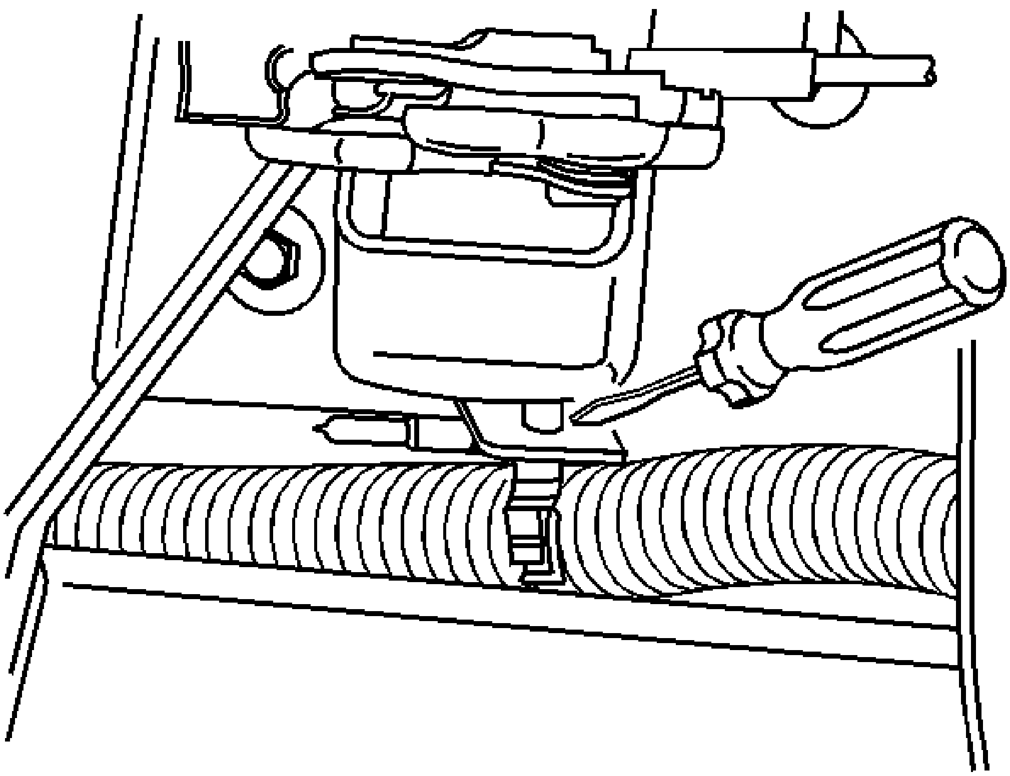


Fig. 182: View of Electrical Harness to be Unclipped
Courtesy of GENERAL MOTORS CORP.

16. Unclip the electrical harness from the engine and set aside.
17. Remove the upper transmission bellhousing bolts.
18. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
19. Remove the engine drive belt. Refer to **Drive Belt Replacement**.
20. Remove the AC compressor bolts and set the compressor aside.

21. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
22. Disconnect the generator electrical connectors.
23. Disconnect the starter electrical connectors.
24. Drain the engine oil.
25. Disconnect the front exhaust pipe from the exhaust manifold.
26. Remove the starter. Refer to **Starter Motor Replacement (2.2L (L61))** in Engine Electrical.

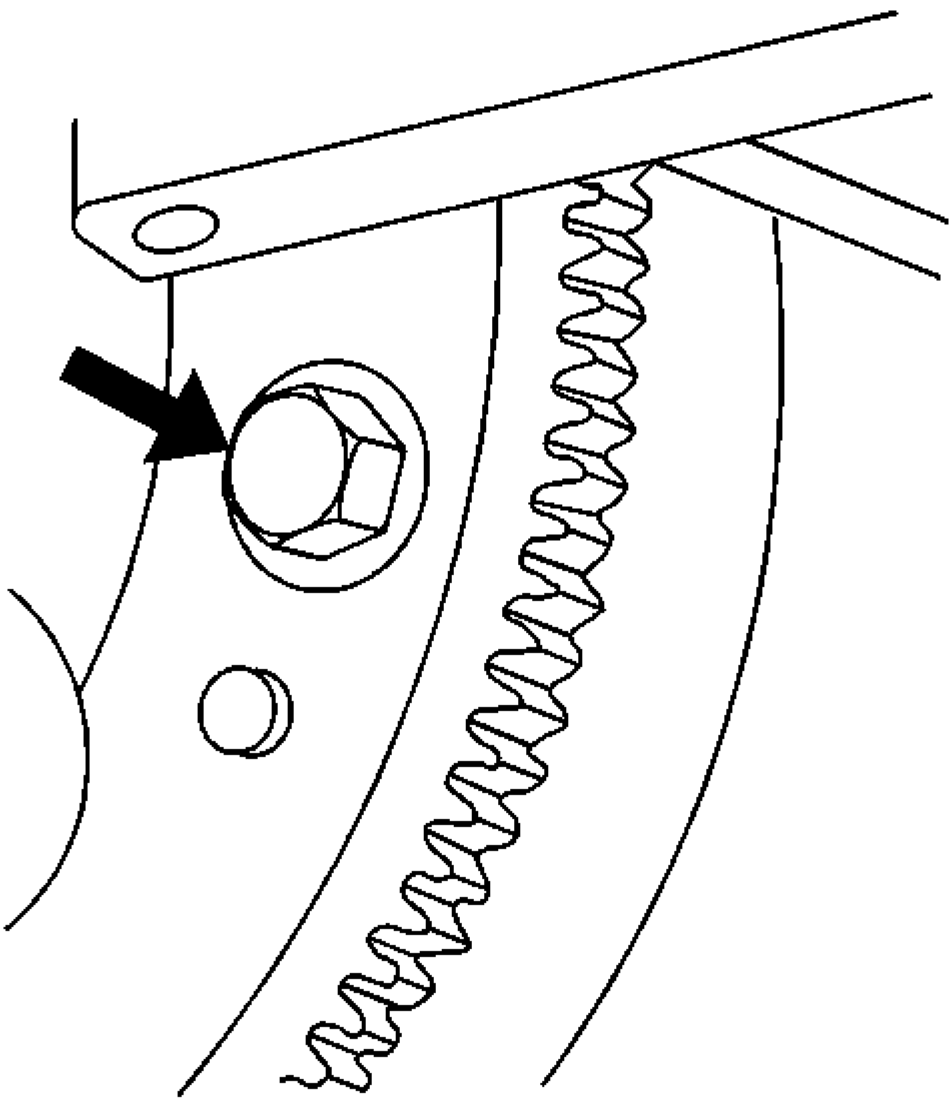


Fig. 183: View Of Flywheel To Torque Converter Bolts
Courtesy of GENERAL MOTORS CORP.

27. Remove the flywheel to torque convertor bolts.

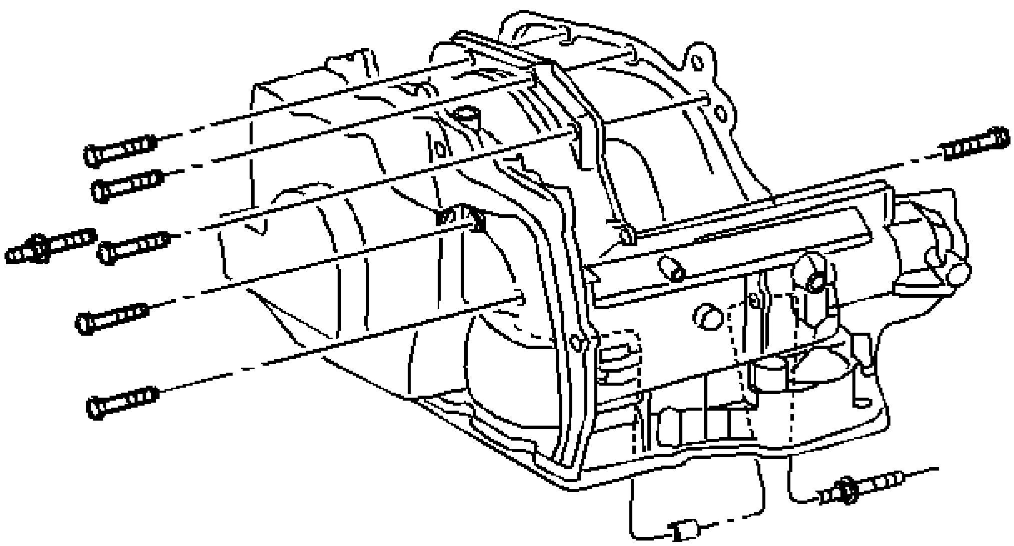


Fig. 184: Identifying Lower Transmission To Engine Bolts And Stud
Courtesy of GENERAL MOTORS CORP.

28. Remove the lower transmission bellhousing bolts.

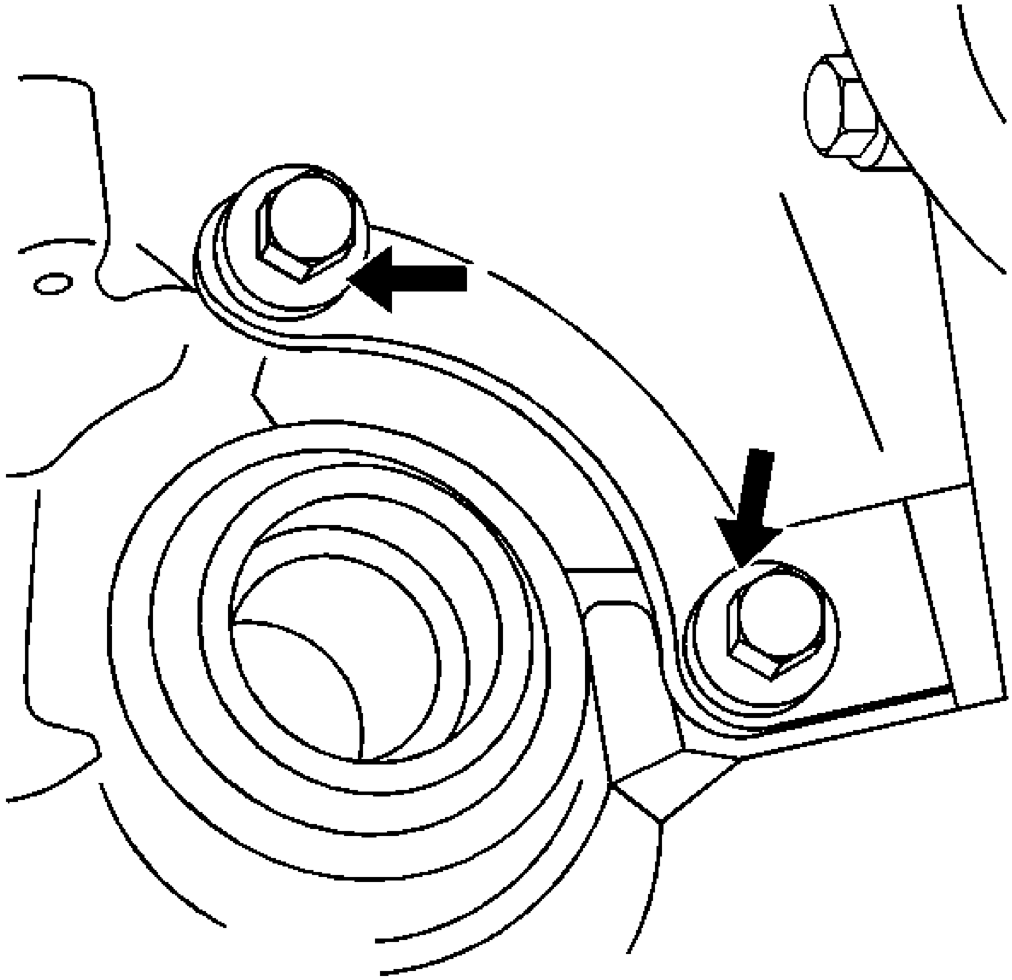


Fig. 185: Identifying Transmission-To-Engine Brace Bolts
Courtesy of GENERAL MOTORS CORP.

29. Remove the transmission to engine brace.
30. Lower the vehicle.
31. Install **J 42451** or equivalent to the right rear of the cylinder head. See **Special Tools and Equipment**.
32. Install an engine hoist to the engine.
33. Remove the front engine mount.
34. Remove the upper transmission bellhousing bolts.
35. Separate the engine and the transmission.
36. Remove the engine from the vehicle.

37. Remove the engine flywheel.
38. Mount the engine to an engine stand.
39. Remove the following components:
    - Oil filter cap and filter. Refer to **Engine Oil and Oil Filter Replacement**.
    - Exhaust manifold
    - Exhaust manifold studs
    - Intake manifold
    - Intake manifold studs
    - Engine mount bracket
    - Engine lift brackets
    - Camshaft cover and seal
    - Fuel rail
    - Engine block heater
    - Water pump
    - Drive belt tensioner
    - Thermostat housing and feed pipe
    - Generator
    - Oil level indicator and tube
    - Crankshaft sensor
    - Camshaft sensor
    - Oil pressure sensor
    - Ignition coil and module assembly
    - Crankshaft balancer
40. Remove the engine from the stand.
41. Remove **J 42451** or equivalent to the right rear of the cylinder head. See **Special Tools and Equipment**.

Installation Procedure

1. Install **J 42451** or equivalent to the right rear of the cylinder head. See **Special Tools and Equipment**.
2. Mount the engine to a stand.
3. Install the following components:
    - Oil filter cap and filter. Refer to **Engine Oil and Oil Filter Replacement**.
    - Exhaust manifold studs
    - Exhaust manifold
    - Intake manifold studs
    - Intake manifold
    - Engine mount bracket
    - Engine lift brackets

- Camshaft cover and seal
- Fuel rail
- Engine block heater
- Water pump
- Drive belt tensioner
- Thermostat housing and feed pipe
- Generator
- Oil level indicator and tube
- Crankshaft sensor
- Camshaft sensor
- Oil pressure sensor
- Ignition coil and module assembly
- Crankshaft balancer

4. Install an engine hoist to the engine.
5. Remove the engine from the engine stand.
6. Install the flywheel. Refer to **Engine Flywheel Replacement**.
7. Install the engine to the vehicle.
8. Remove **J 42451** or equivalent to the right rear of the cylinder head. See **Special Tools and Equipment**.
9. Align the engine to the transmission.

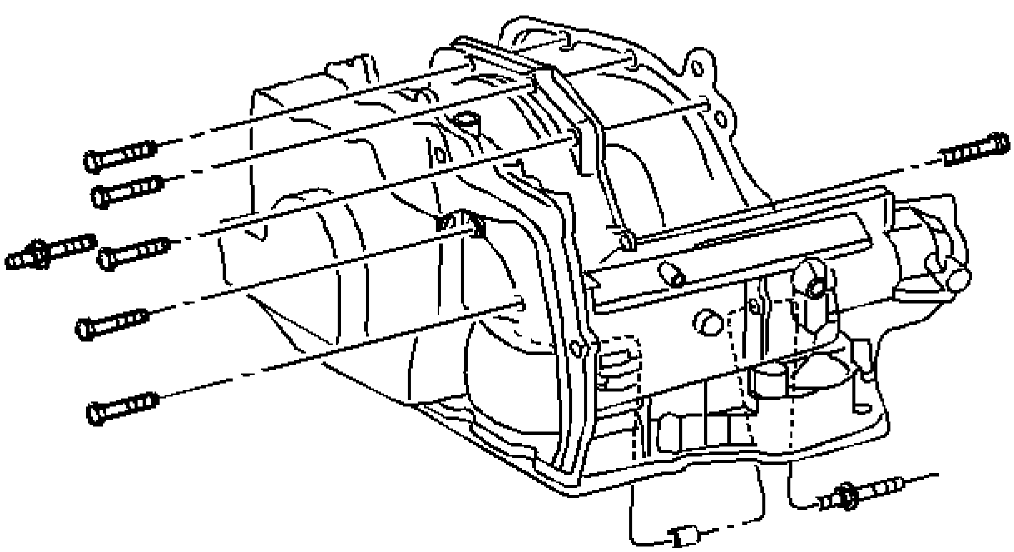


Fig. 186: Identifying Lower Transmission To Engine Bolts And Stud

Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

10. Install the upper bell housing bolts

    Tighten: Tighten the bolts to 90 N.m (66 lb ft).

11. Install the front engine mount. Refer to **Engine Mount Bracket Replacement**.
12. Remove the engine hoist.
13. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
14. Install the lower bell housing bolts.

    Tighten: Tighten the bolts to 90 N.m (66 lb ft).

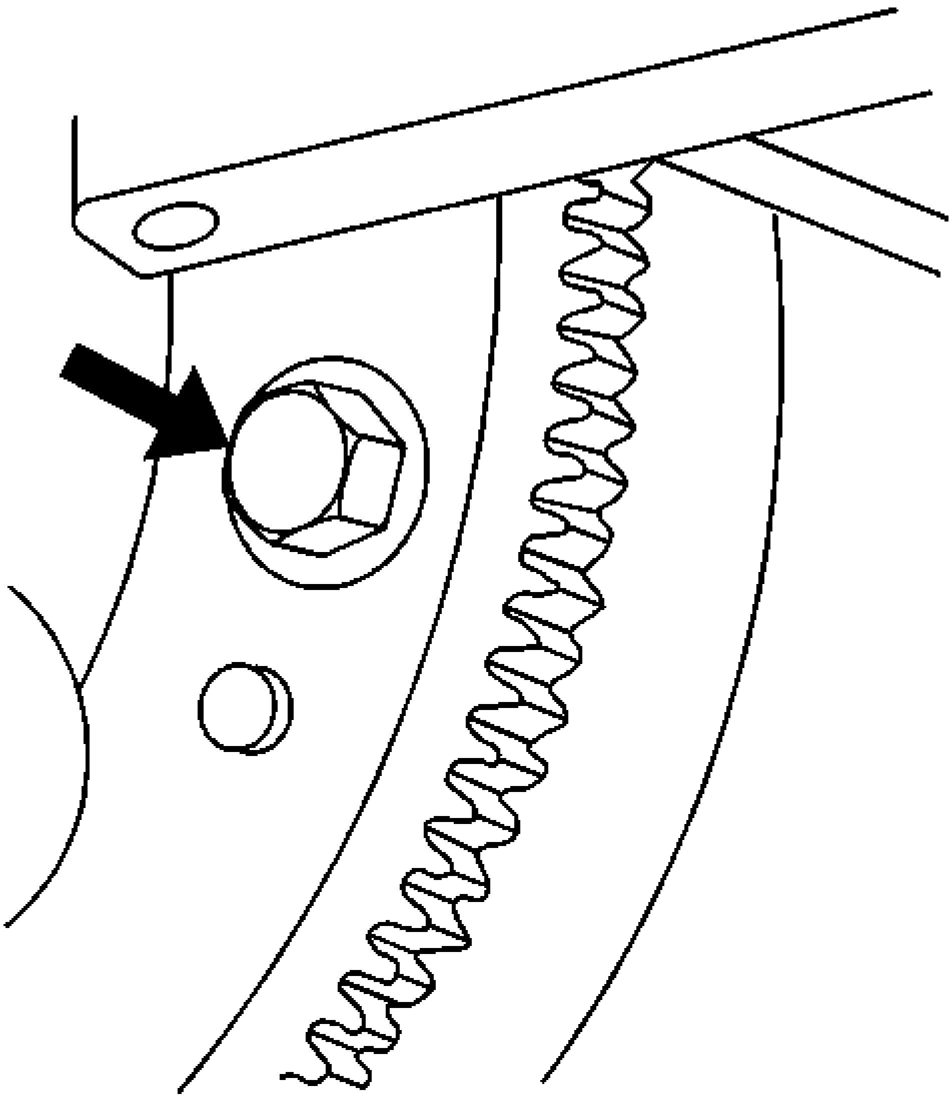


Fig. 187: View Of Flywheel To Torque Converter Bolts
Courtesy of GENERAL MOTORS CORP.

15. Install the torque convertor bolts.

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

16. Install the starter. Refer to **Starter Motor Replacement (2.2L (L61))** in Engine Electrical.

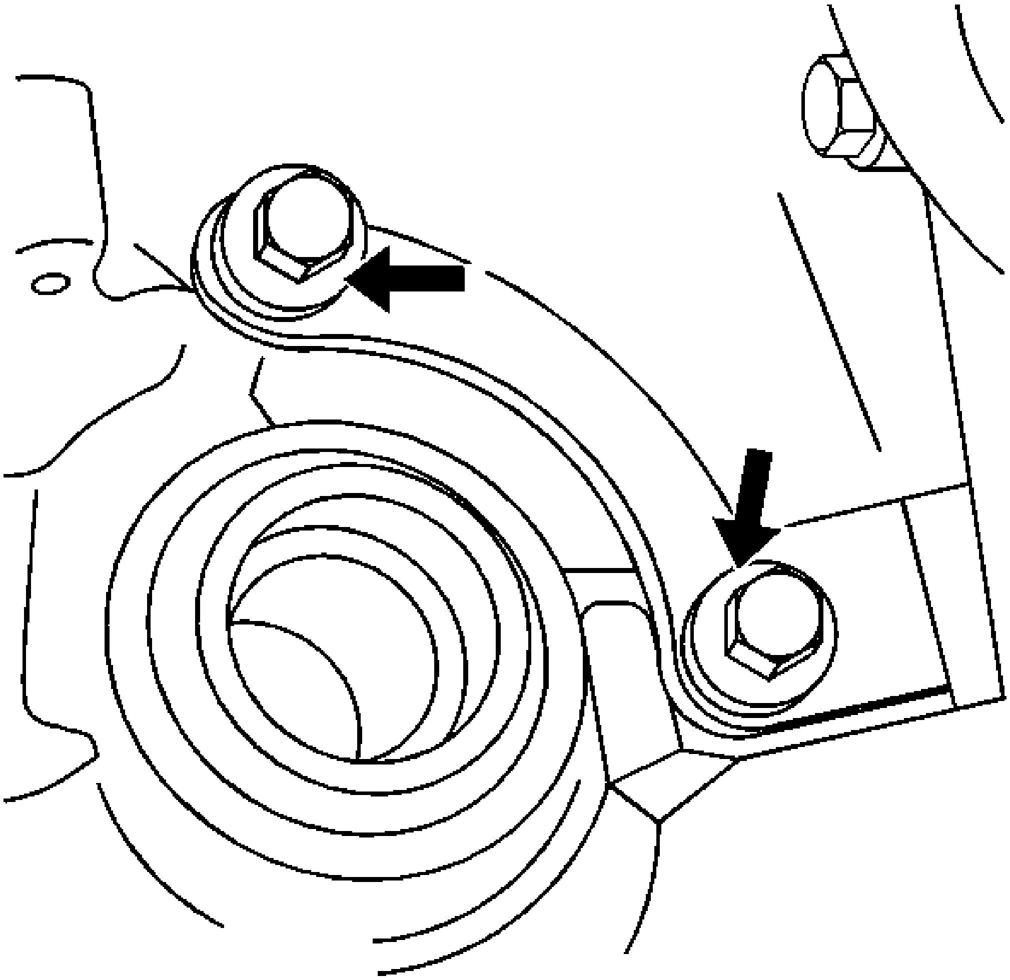


Fig. 188: Identifying Transmission-To-Engine Brace Bolts
Courtesy of GENERAL MOTORS CORP.

17. Install the brace from the transmission to the engine.

    Tighten: Tighten the brace bolts to 72 N.m (53 lb ft).

18. Connect the front exhaust pipe to the exhaust manifold.
19. Connect the generator electrical connectors.
20. Connect the starter electrical connectors.
21. Install the AC compressor to the engine.
22. Install the engine drive belt. Refer to **Drive Belt Replacement**.

23. Lower the vehicle.
24. Connect the following electrical connectors:
    - IAC motor
    - TPS
    - Map sensor
    - Crankshaft sensor
    - Camshaft sensor
    - Oil pressure sensor
    - Purge solenoid
    - Ignition coil and module assembly
    - O2 sensor
    - Vehicle speed sensor
    - Engine temperature sensor

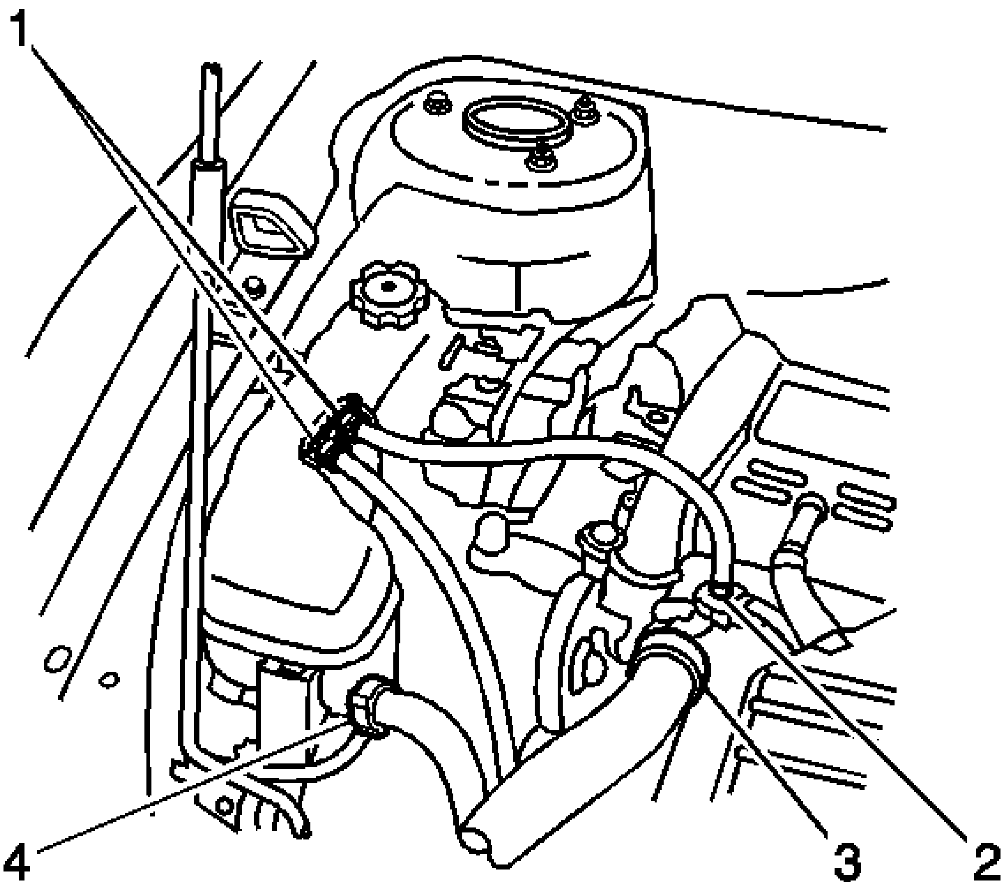


Fig. 189: Radiator Outer & Inlet Hose View
Courtesy of GENERAL MOTORS CORP.

25. Install the radiator inlet hose (3). Refer to **Radiator Hose Replacement - Inlet** in Engine Cooling.
26. Install the surge tank to cylinder head hose (2).
27. Connect the surge tank to radiator outlet hose (3).

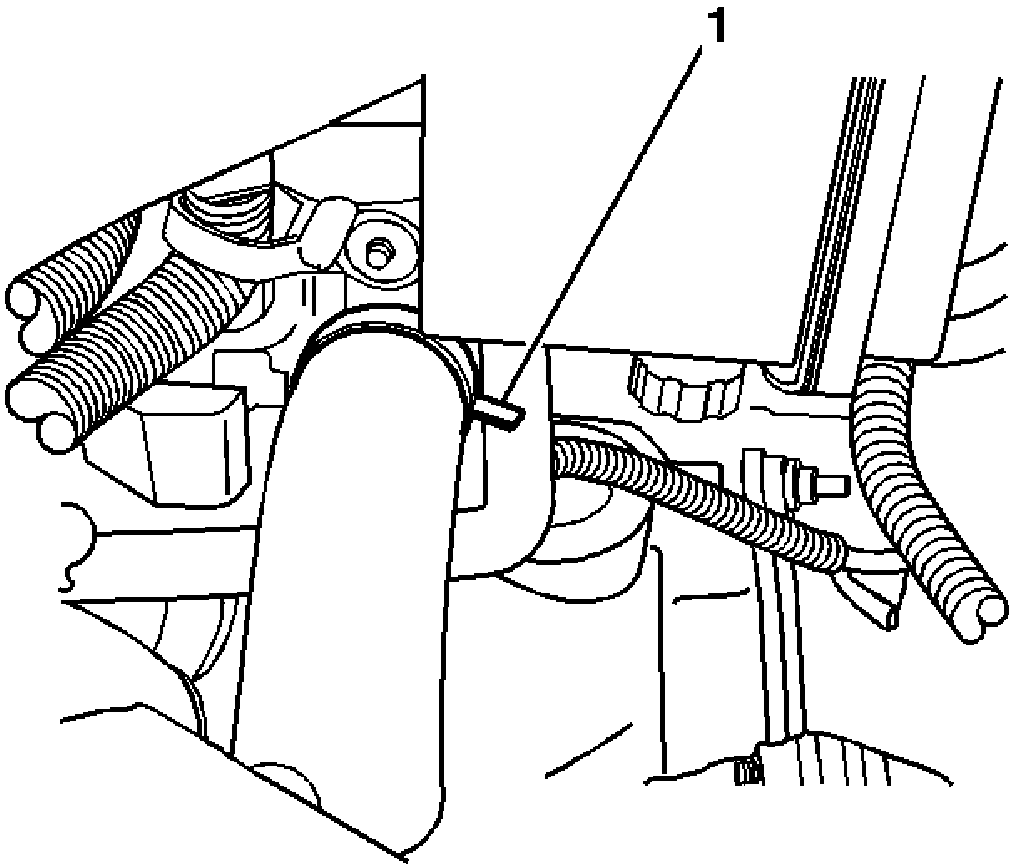


Fig. 190: View Of Radiator Outlet Hose
Courtesy of GENERAL MOTORS CORP.

28. Install the radiator outlet hose (1). Refer to **Radiator Hose Replacement - Outlet** in Engine Cooling.

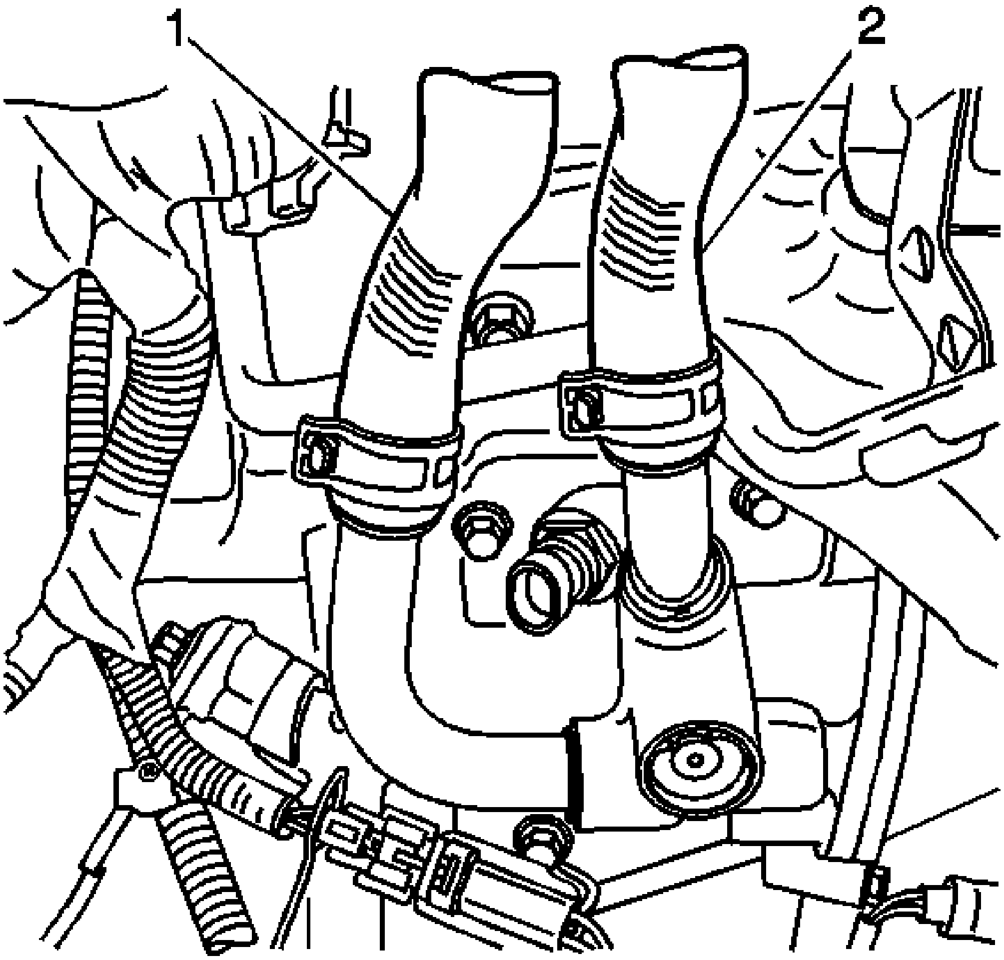


Fig. 191: View Of Inlet & Outlet Heater Hose
Courtesy of GENERAL MOTORS CORP.

29. Install the inlet (1) and outlet (2) heater hoses. Refer to **Heater Hose Replacement - Inlet** and to **Heater Hose Replacement - Outlet** in HVAC.
30. Install the bolt securing the surge tank outlet hose to the intake manifold.

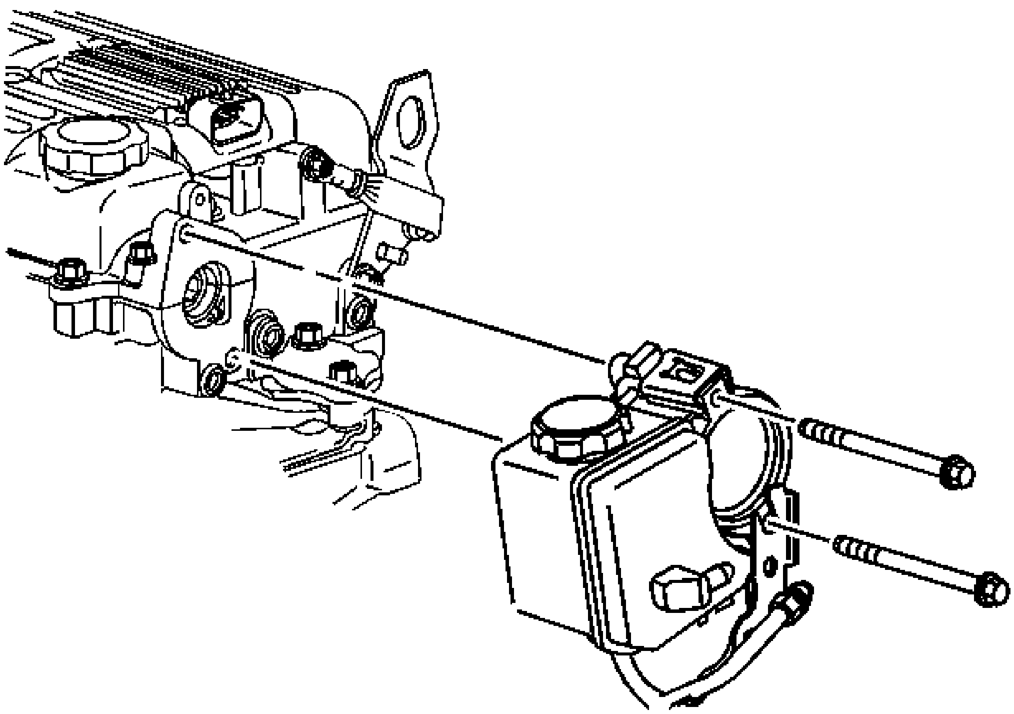


Fig. 192: View Of Power Steering Pump
Courtesy of GENERAL MOTORS CORP.

31. Install the power steering pump.

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

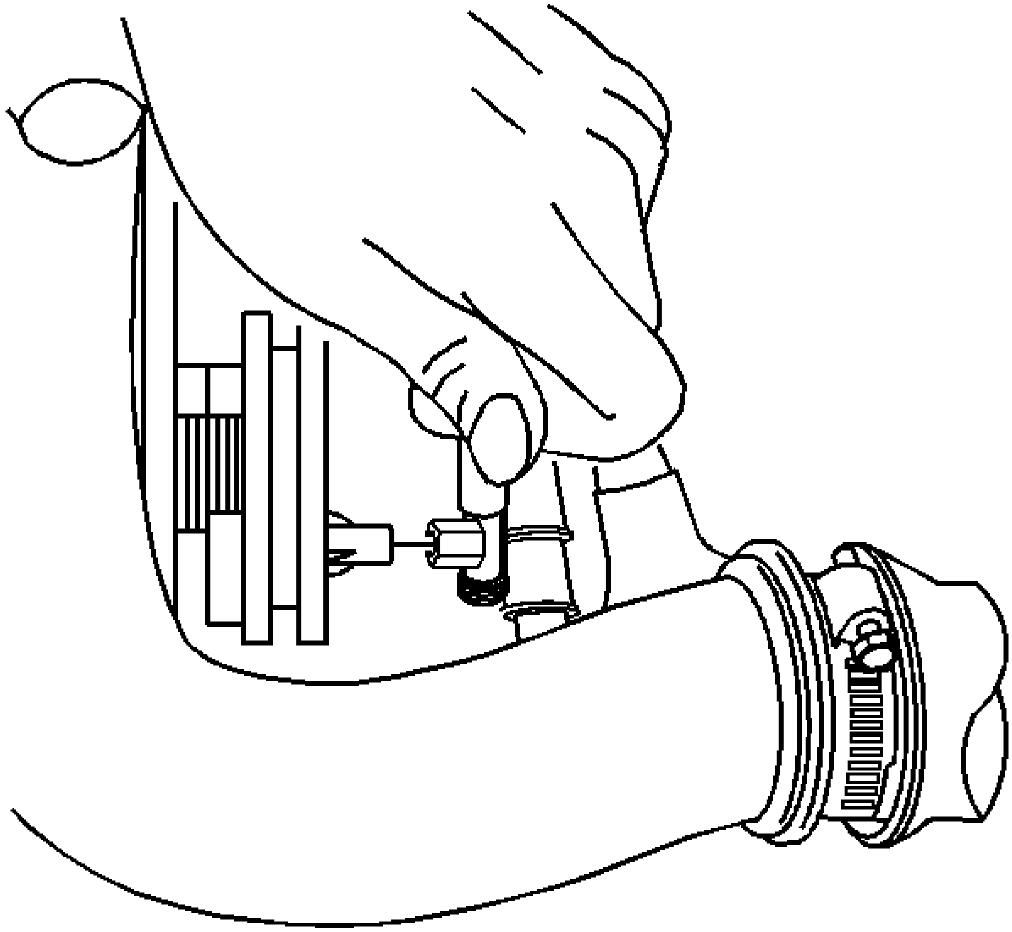


Fig. 193: View Of Cruise Control Cable At Throttle Body Cam Lever
Courtesy of GENERAL MOTORS CORP.

32. Connect the accelerator and cruise control cables. Refer to **Accelerator Controls Cable Replacement** in Engine Controls - 2.2L (L61).
33. Connect the brake booster hose.
34. Connect the fuel lines. Refer to **Fuel Hose/Pipes Replacement - Engine Compartment (Fuel Pipes)** **Fuel Hose/Pipes Replacement - Engine Compartment (Fuel Hoses)** in Engine Controls - 2.2L (L61).

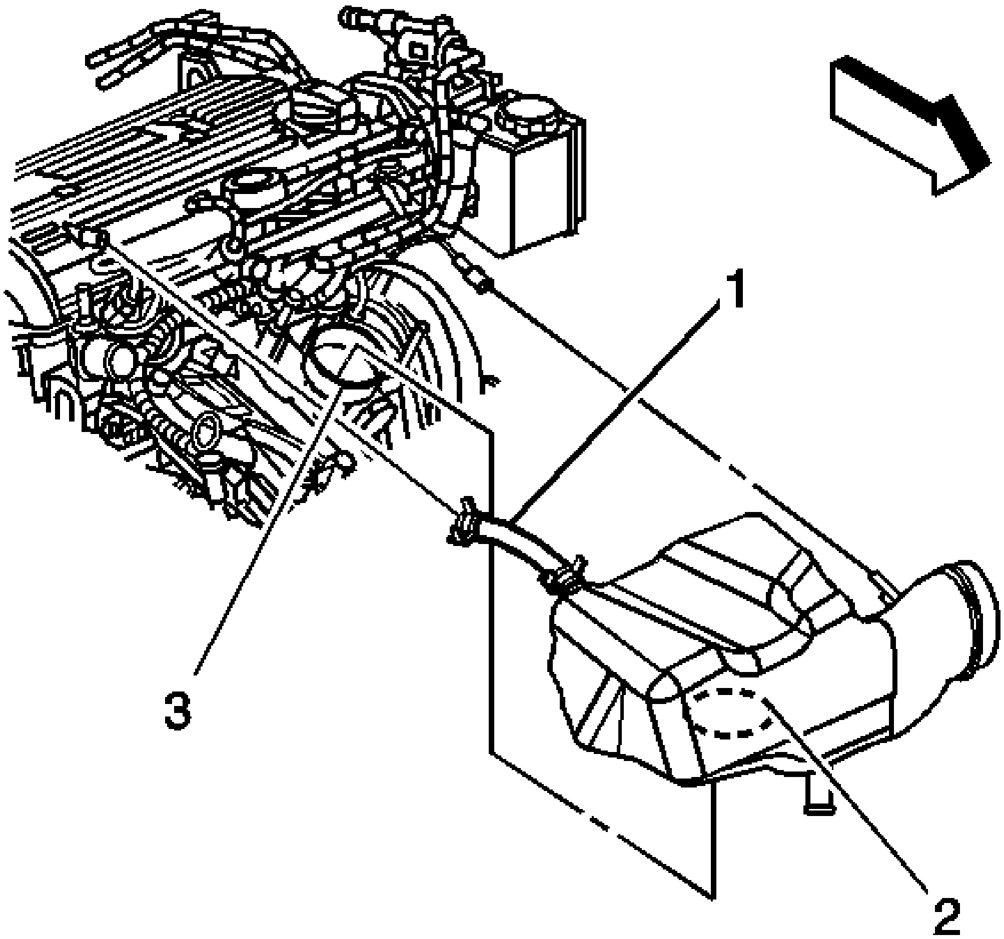


Fig. 194: Exploded View Of Air Inlet Duct & Resonator
Courtesy of GENERAL MOTORS CORP.

35. Install the air inlet duct and resonator (2). Refer to **Air Cleaner Outlet Resonator Replacement** in Engine Controls - 2.2L (L61).
36. Fill the engine with oil. Refer to **Capacities - Approximate Fluid** in Maintenance and Lubrication
37. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
38. Fill the cooling system. Refer to **Draining and Filling Cooling System** in Engine Cooling.
39. Install the hood. Refer to **Hood Replacement** in Body Front End.

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. Place a drain pan under the oil drain plug.

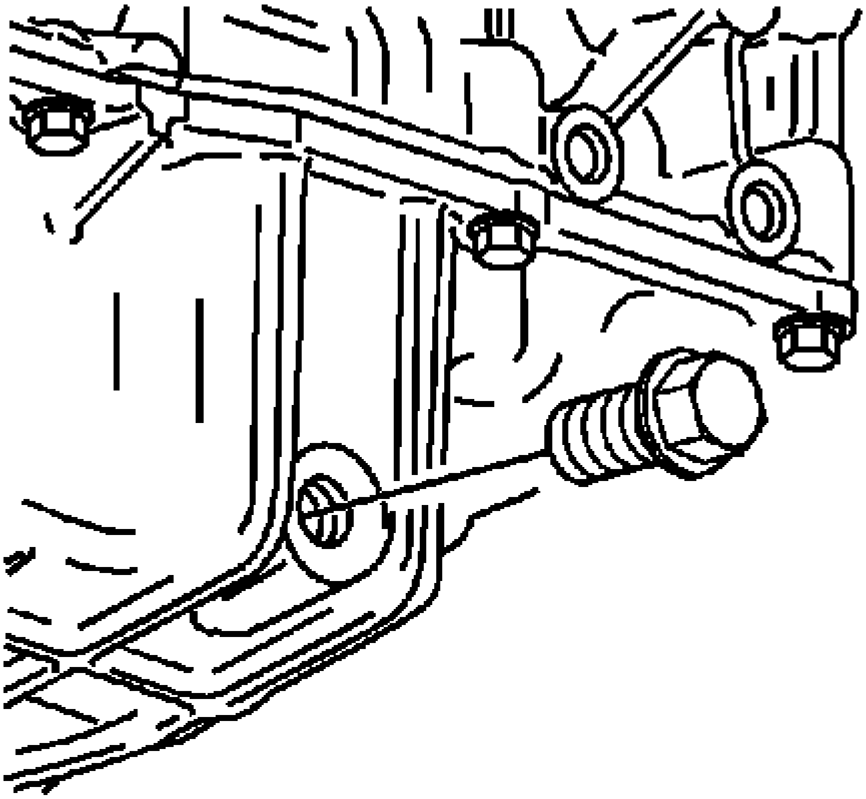


Fig. 195: View Of Oil Pan Drain Bolt
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil pan drain plug.

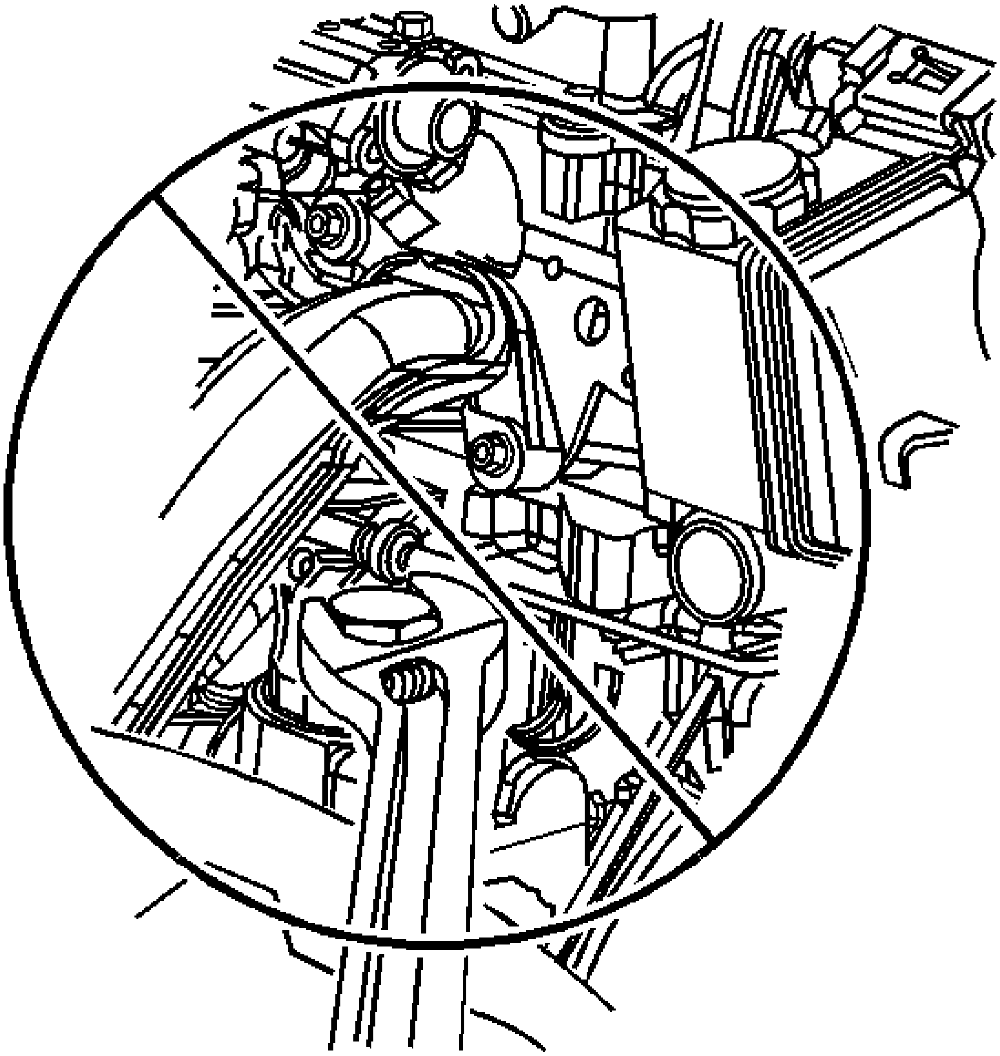


Fig. 196: View of Incorrect Wrench to Use on the Hex on Top of the Oil Filter Cap
Courtesy of GENERAL MOTORS CORP.

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

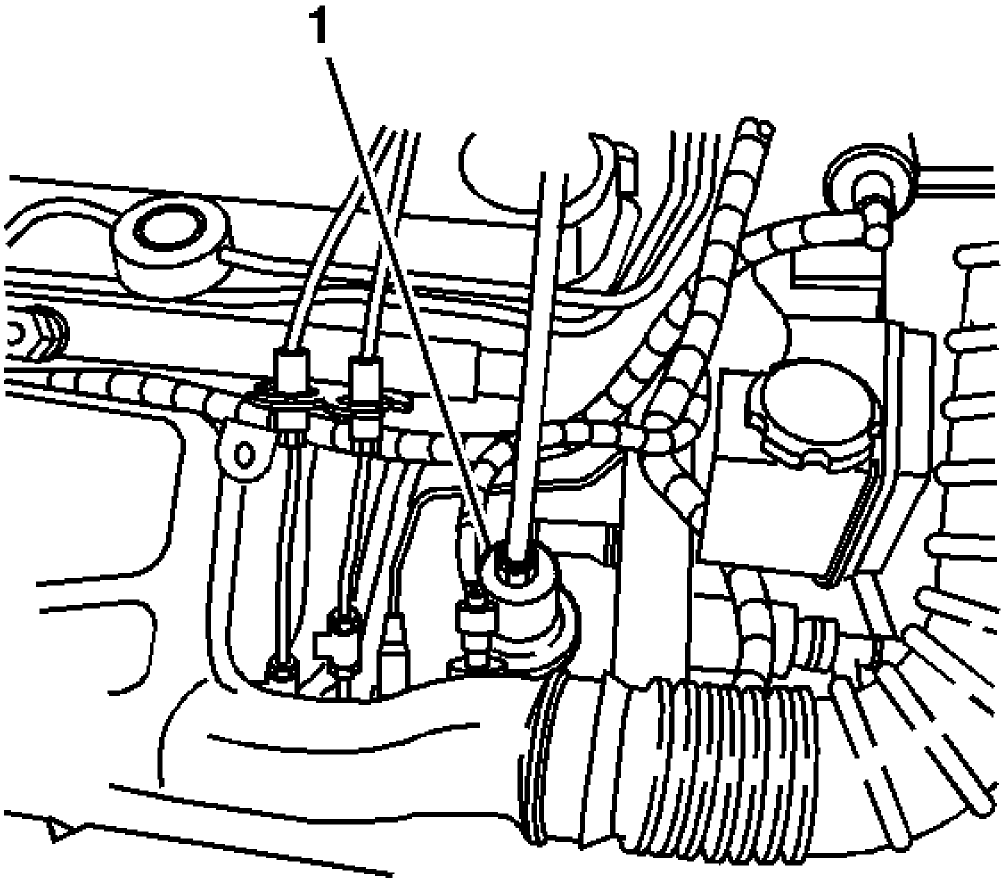


Fig. 197: Identifying Hex on Top of the Oil Filter Cap
Courtesy of GENERAL MOTORS CORP.

5. Use a 32 mm (1 1/4 in) socket (1) on the hex on the top of the oil filter cap, or an Oil Filter Wrench on the outside diameter of the oil filter cap.

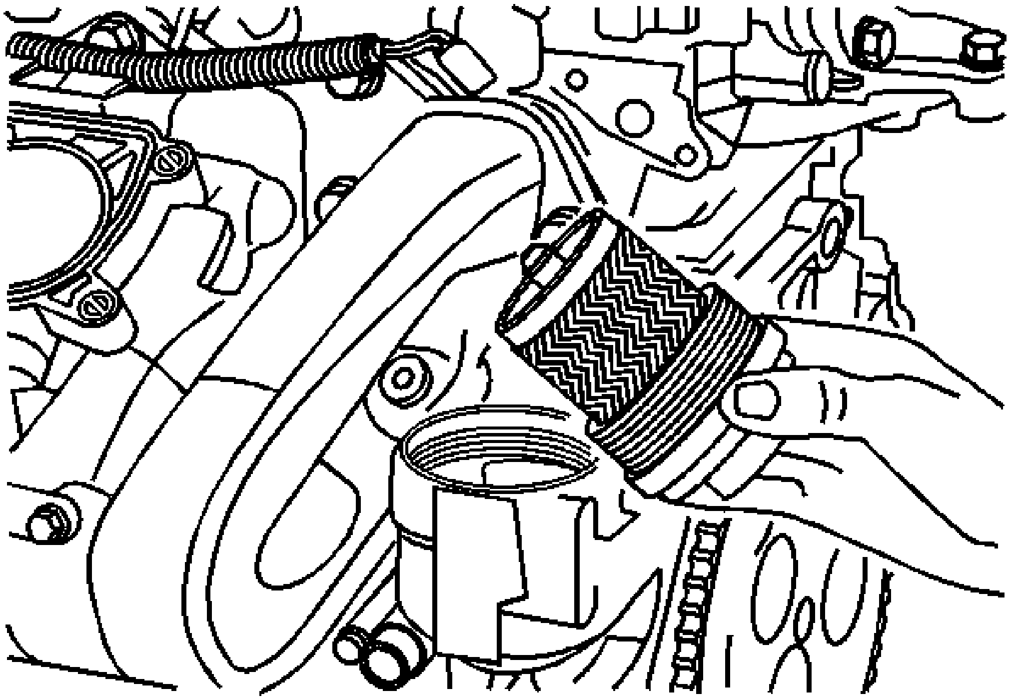


Fig. 198: View Of Oil Filter
Courtesy of GENERAL MOTORS CORP.

6. Remove the oil filter cap with filter.
7. Remove the filter from the cap.

Installation Procedure

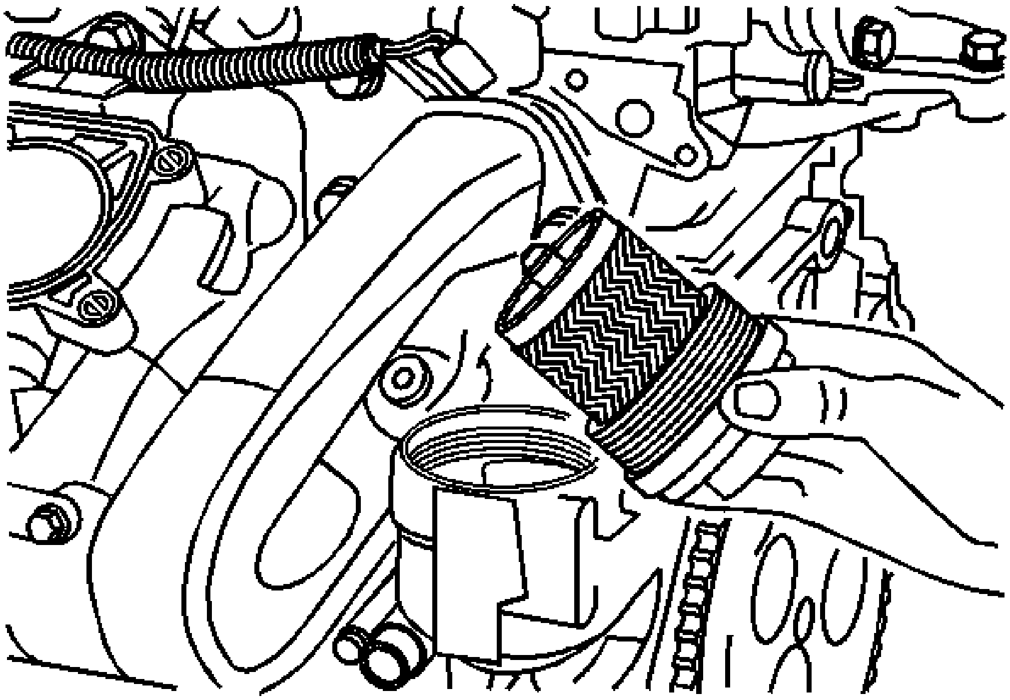


Fig. 199: View Of Oil Filter
Courtesy of GENERAL MOTORS CORP.

1. Install the filter to the cap.
2. Install the oil filter cap with filter.

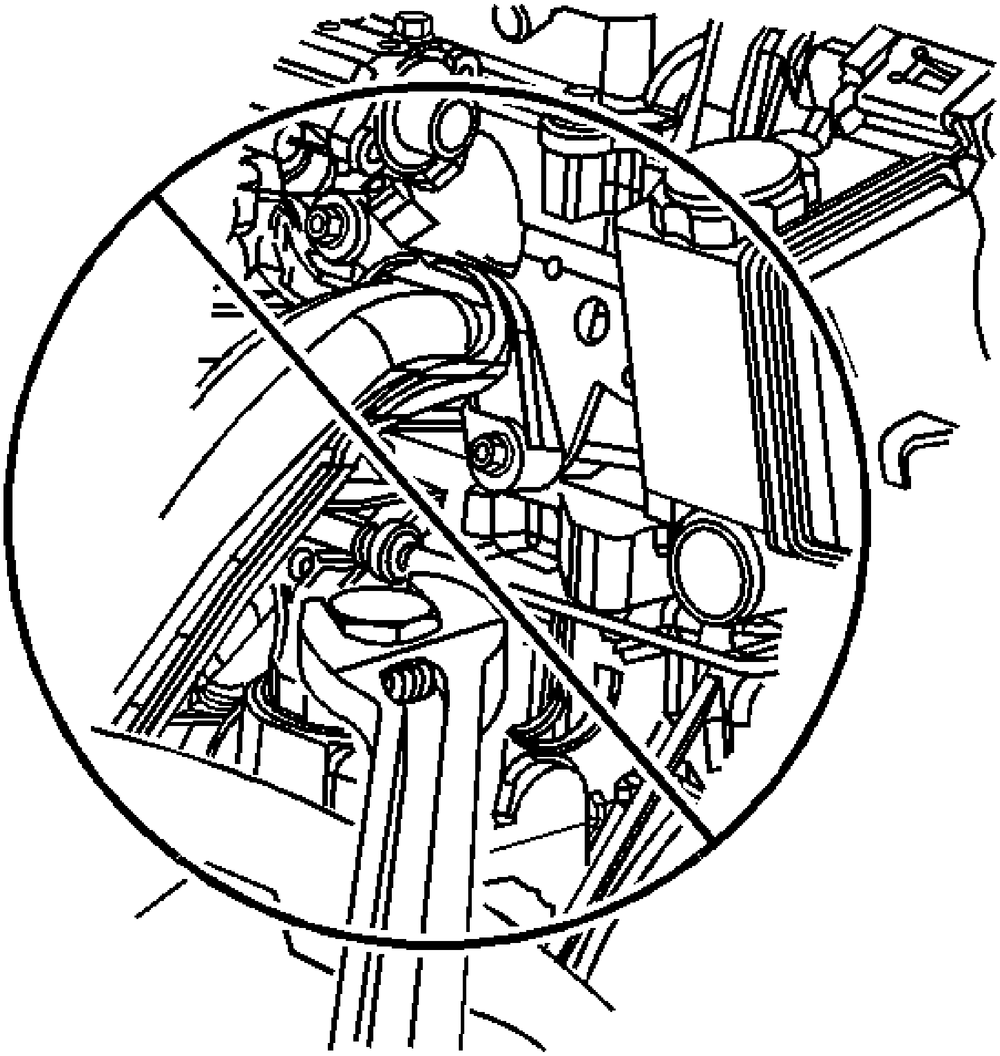


Fig. 200: View of Incorrect Wrench to Use on the Hex on Top of the Oil Filter Cap
Courtesy of GENERAL MOTORS CORP.

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

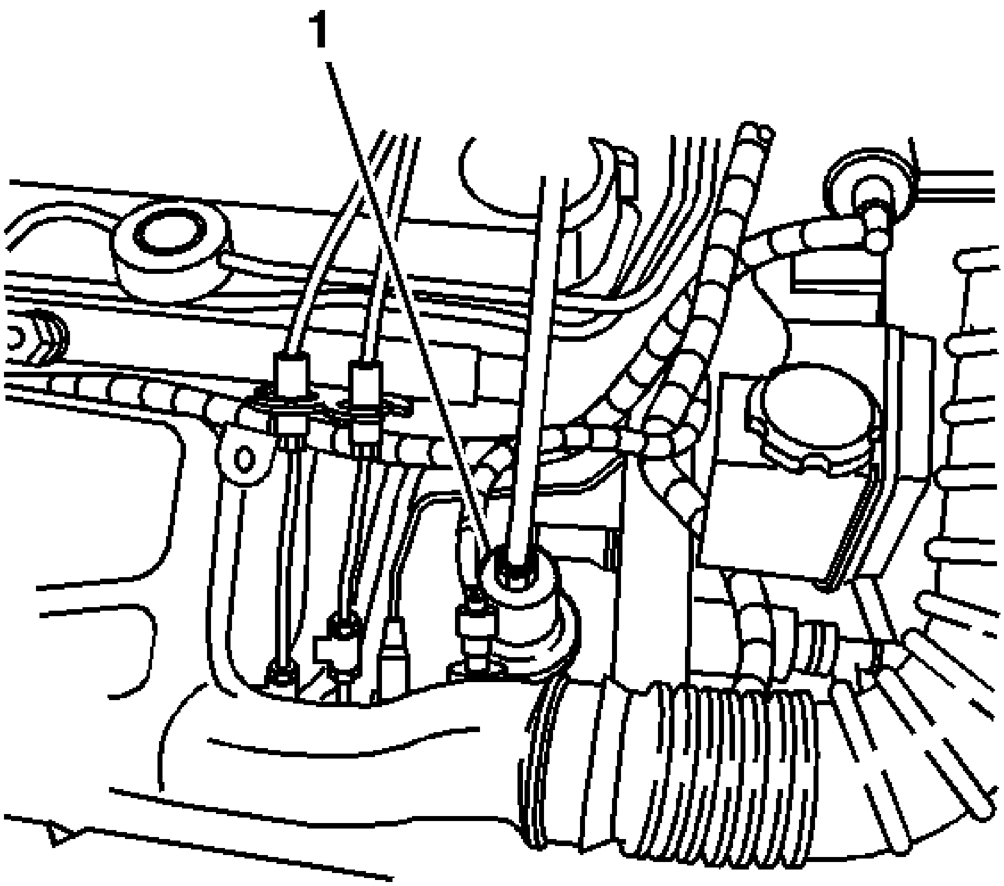


Fig. 201: Identifying Hex on Top of the Oil Filter Cap
Courtesy of GENERAL MOTORS CORP.

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

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Use a 32 mm (1 1/4 in) socket (1) on the hex on the top of the oil filter cap, or an Oil Filter Wrench on the outside diameter of the oil filter cap.

   Tighten: Tighten the oil filter cap until fully seated, DO NOT exceed 25 N.m (18 lb ft).

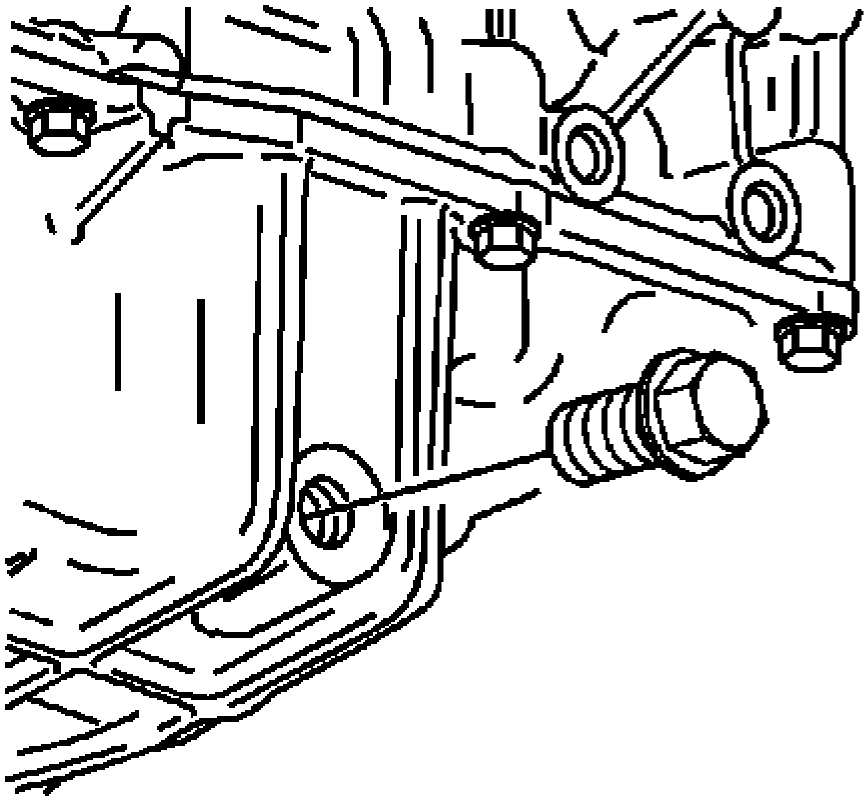


Fig. 202: View Of Oil Pan Drain Bolt
Courtesy of GENERAL MOTORS CORP.

5. Install the oil pan drain plug.

   Tighten: Tighten the oil pan drain plug to 25 N.m (18 lb ft).

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

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**.

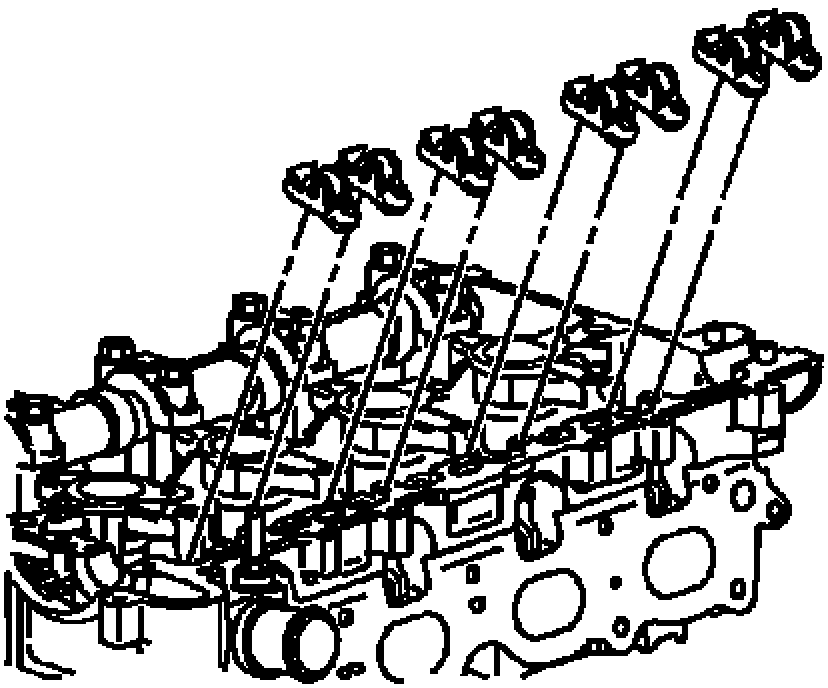


Fig. 203: Identifying Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

2. Remove the camshaft roller followers.

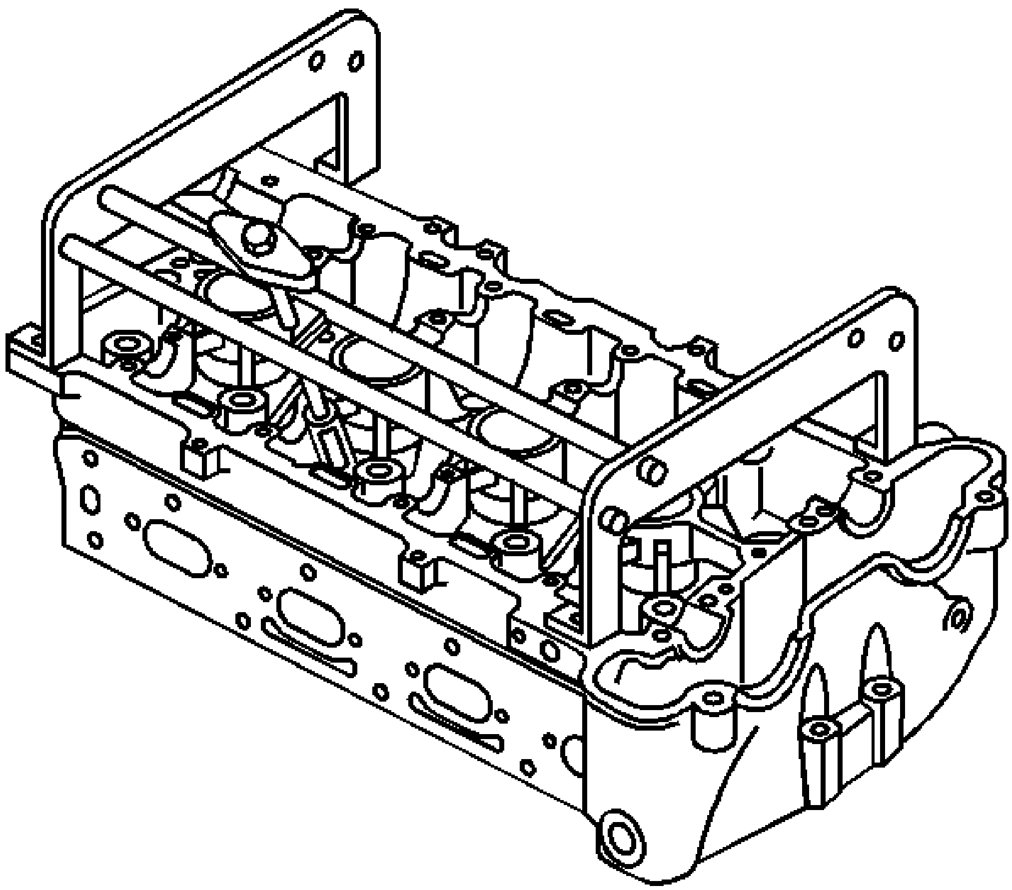


Fig. 204: View Of Valve Spring Compressor
Courtesy of GENERAL MOTORS CORP.

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).

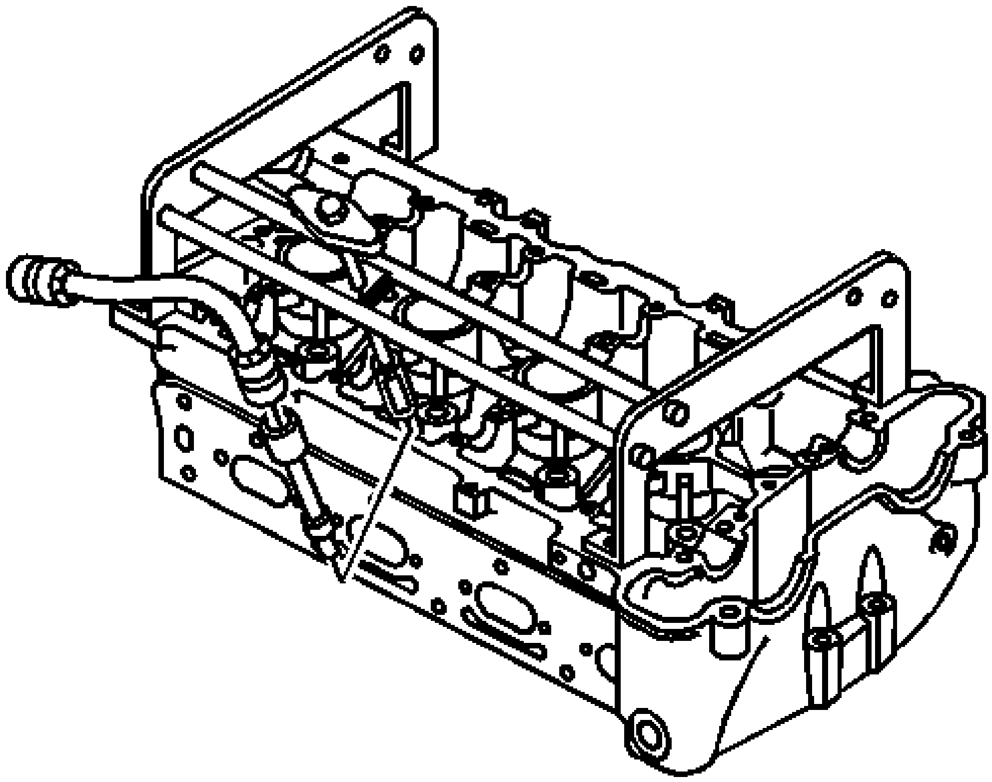


Fig. 205: View Of Air Hose Adaptor
Courtesy of GENERAL MOTORS CORP.

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.

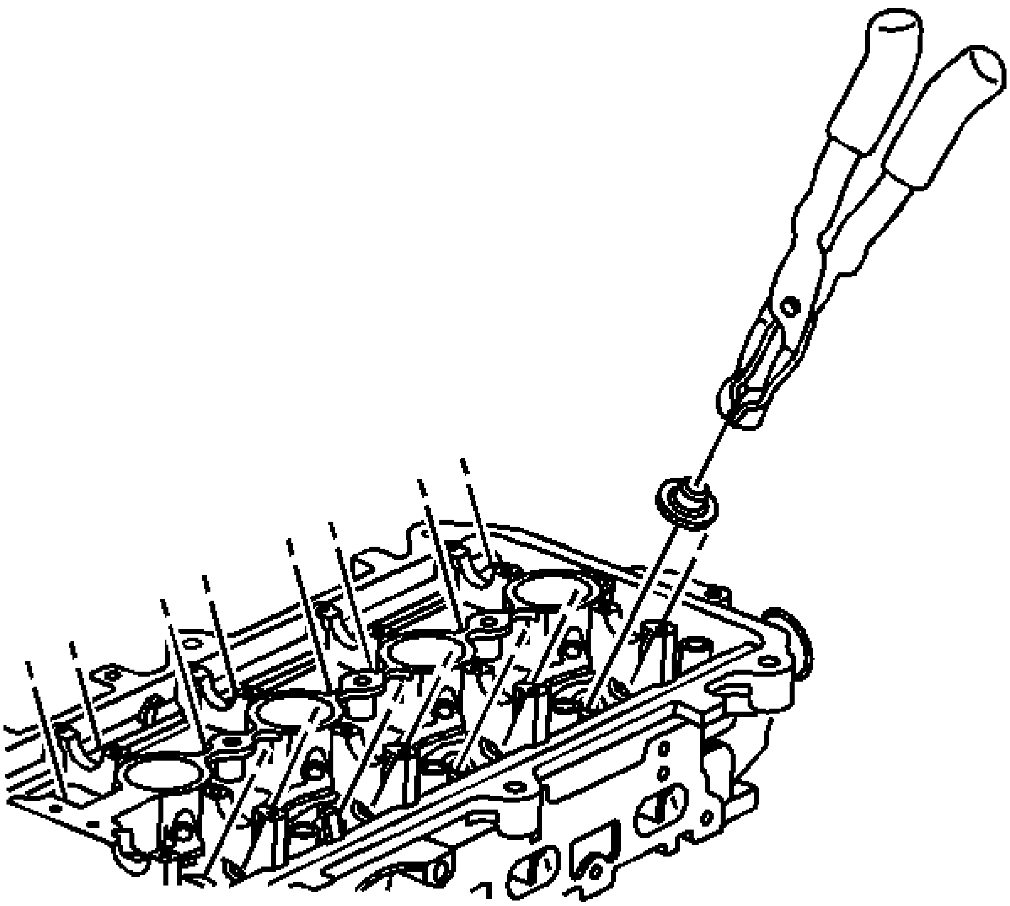


Fig. 206: View Of J 36017 & Valve Seal
Courtesy of GENERAL MOTORS CORP.

10. Using the **J 36017** remove the valve seal. See **Special Tools and Equipment**.

Installation Procedure

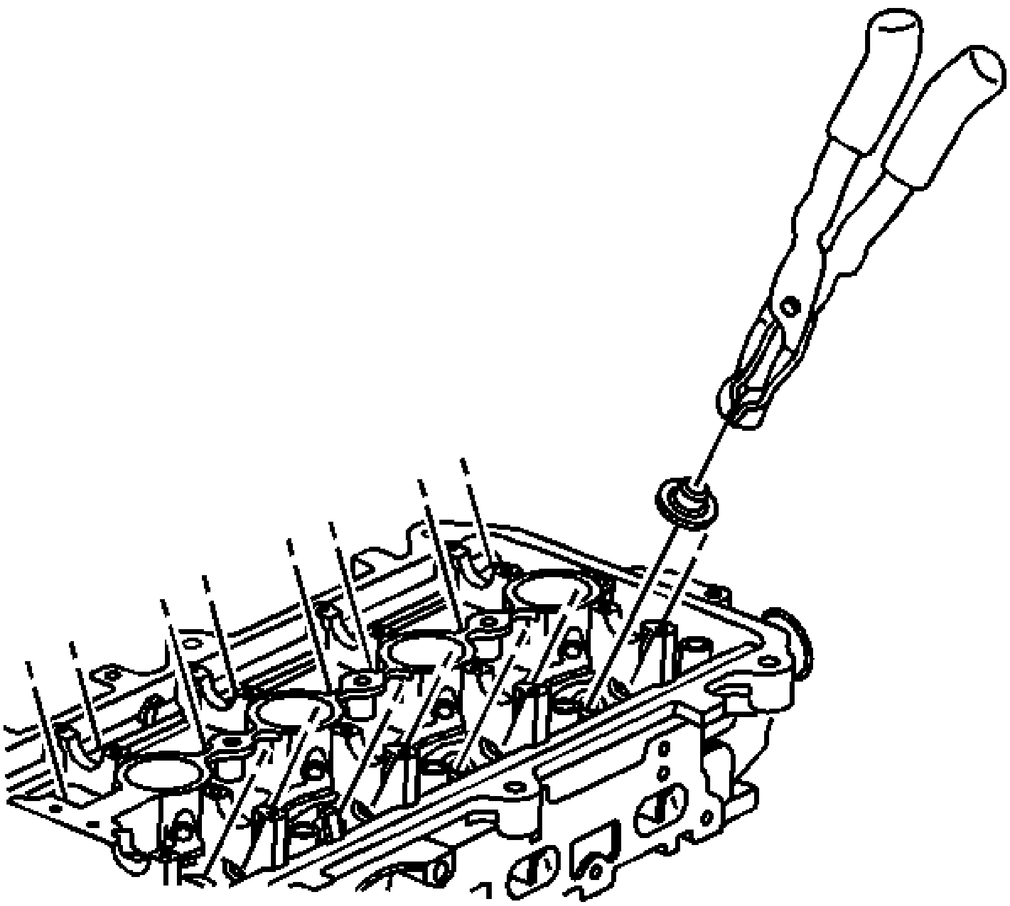


Fig. 207: View Of J 36017 & Valve Seal
Courtesy of GENERAL MOTORS CORP.

1. Using the **J 36017** install the valve seal. See **Special Tools and Equipment**.

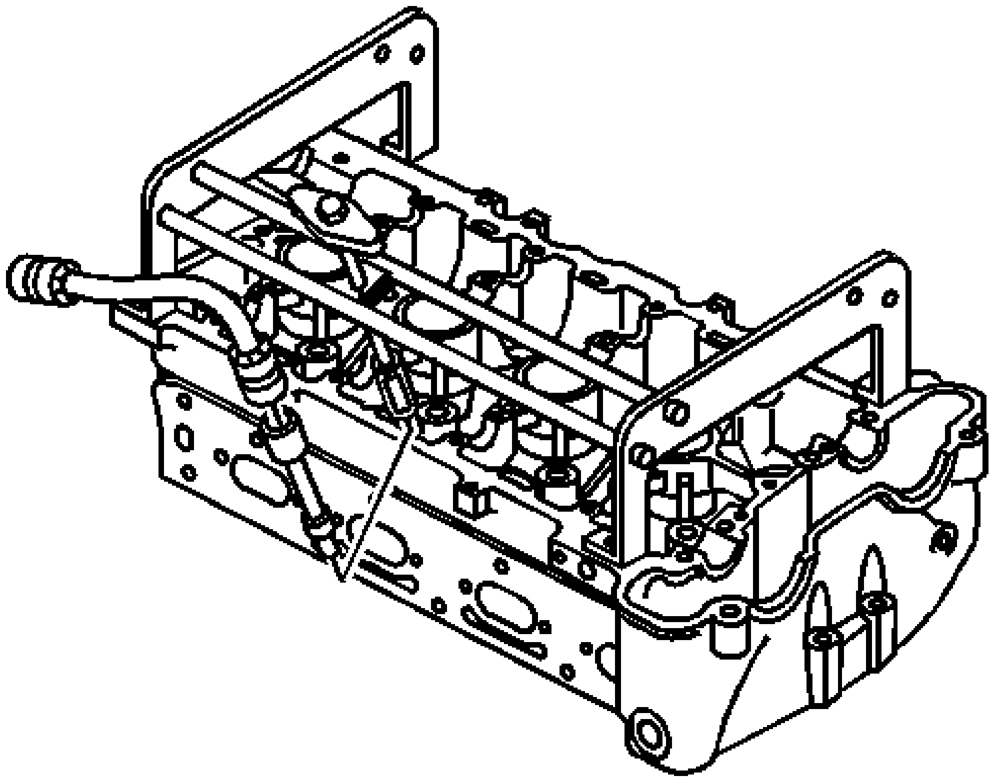


Fig. 208: View Of Air Hose Adaptor
Courtesy of GENERAL MOTORS CORP.

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.

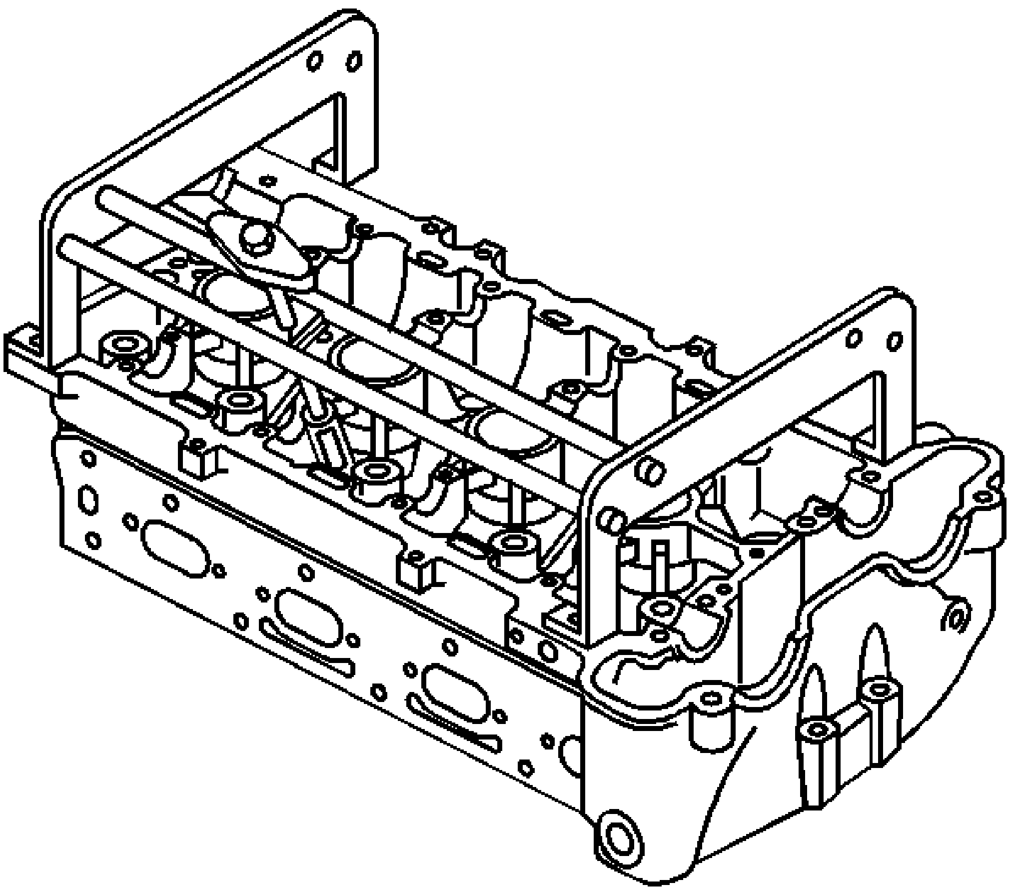


Fig. 209: View Of Valve Spring Compressor
Courtesy of GENERAL MOTORS CORP.

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).

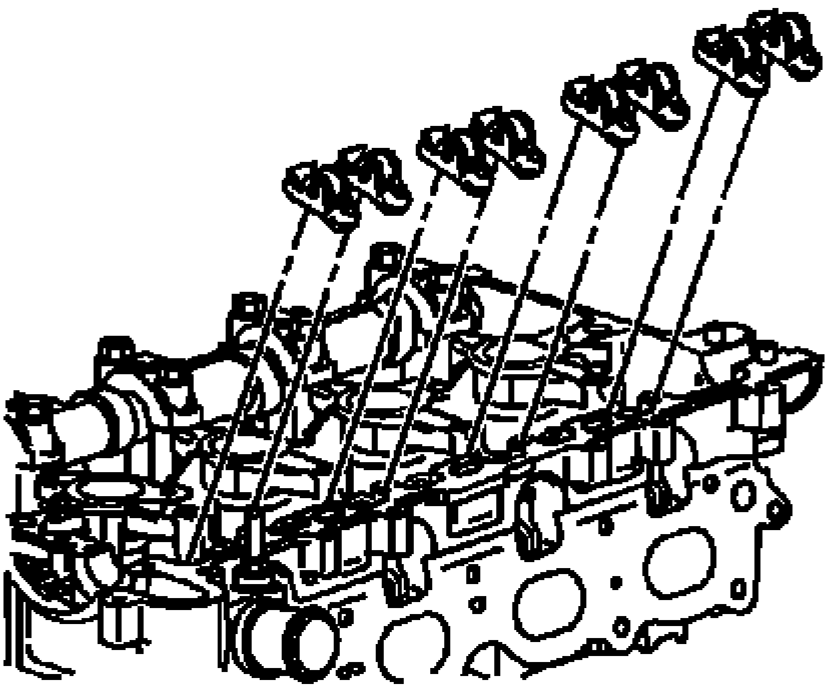


Fig. 210: Identifying Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

8. Install the camshaft roller followers.
9. Install the camshaft. Refer to **Intake Camshaft and Lifter Replacement** or **Exhaust Camshaft and Lifter Replacement**.

OFF-VEHICLE REPAIR INSTRUCTIONS

Draining Fluids and Oil Filter Removal

Tools Required

J 44887 Oil Filter Wrench. See **Special Tools and Equipment**.

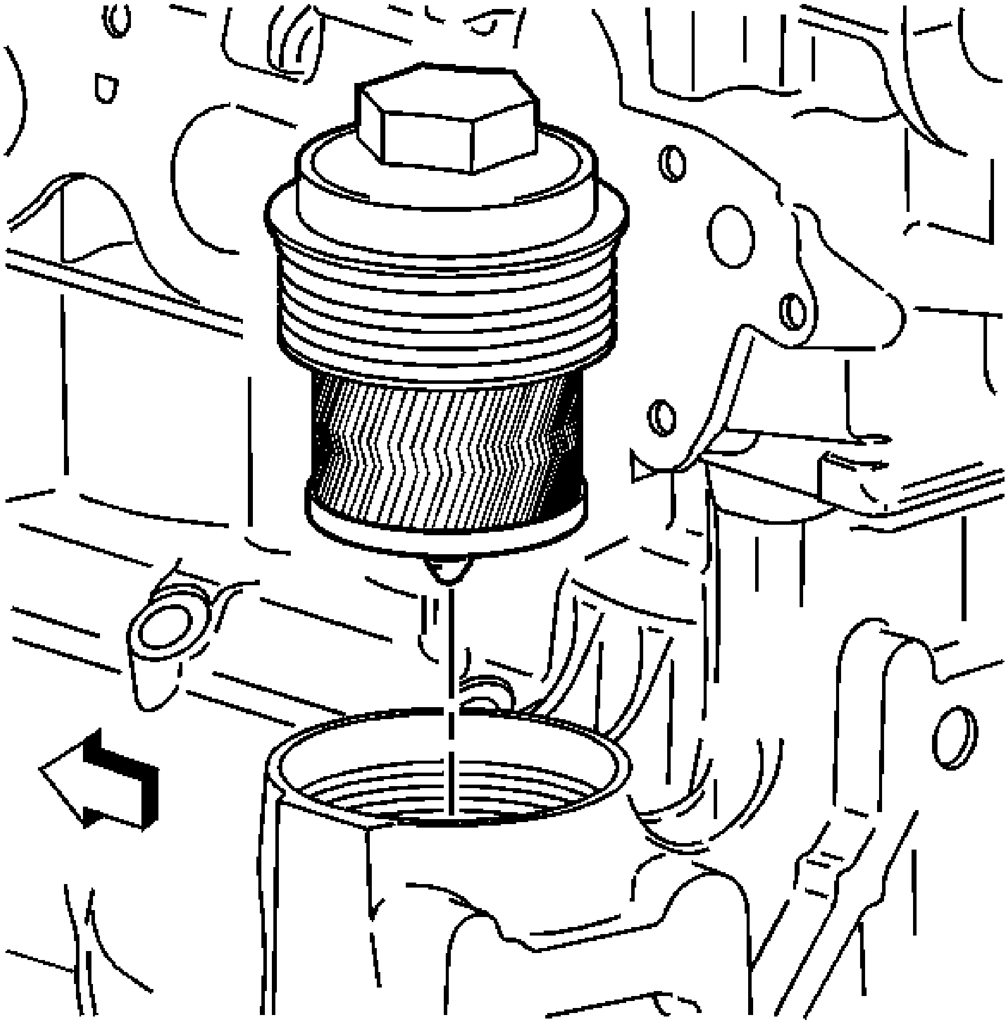


Fig. 211: Identifying Oil Filter Housing
Courtesy of GENERAL MOTORS CORP.

1. Use **J 44887** to remove the oil filter cap. See **Special Tools and Equipment**. 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 jacket.
6. Apply sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent to the water pump drain plug.
7. Install the water pump drain plug.

   Tighten: Tighten the water pump drain plug to 20 N.m (15 lb ft).

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

Engine Flywheel Removal

Tools Required

J 38122-A Harmonic Balancer Holder

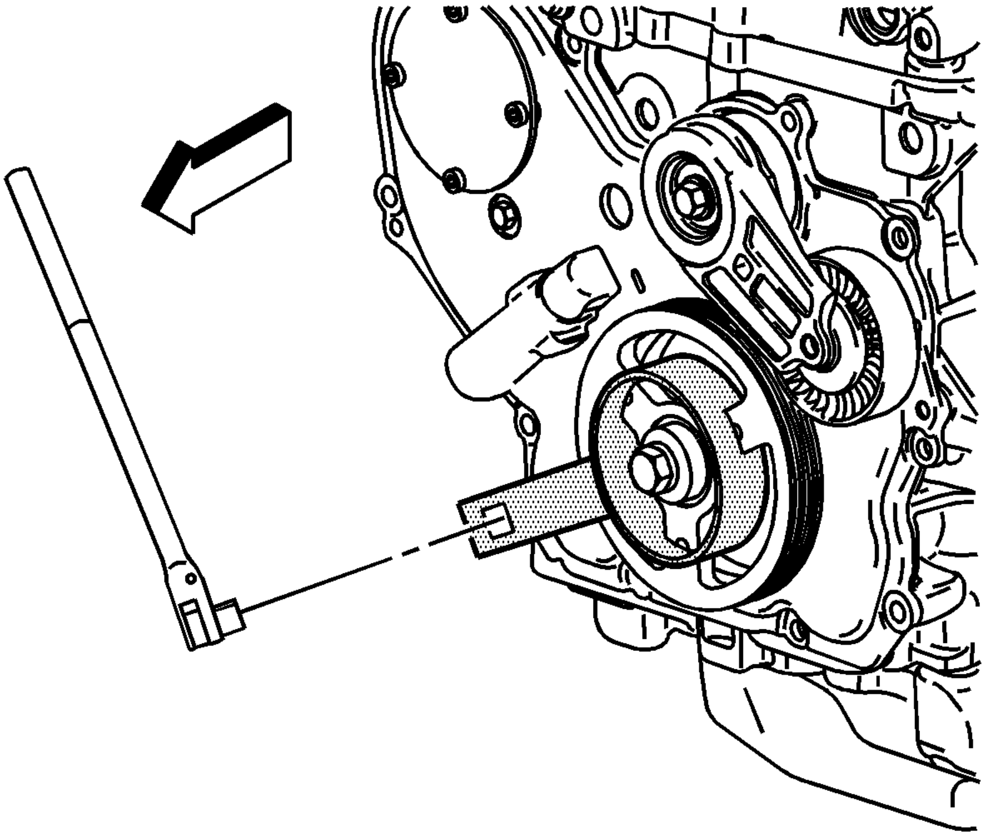


Fig. 212: View Of Harmonic Balancer Holder J38122-A
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: It may be necessary to remove the chamfer (bevel) from the edge of an 18 mm socket in order to get full socket engagement on the thin headed flywheel bolts.
Do not orientate the flywheel to the crankshaft. It is balanced separately from the engine.

1. Remove the flywheel attaching bolt. Use the J 38122-A to prevent crankshaft rotation.

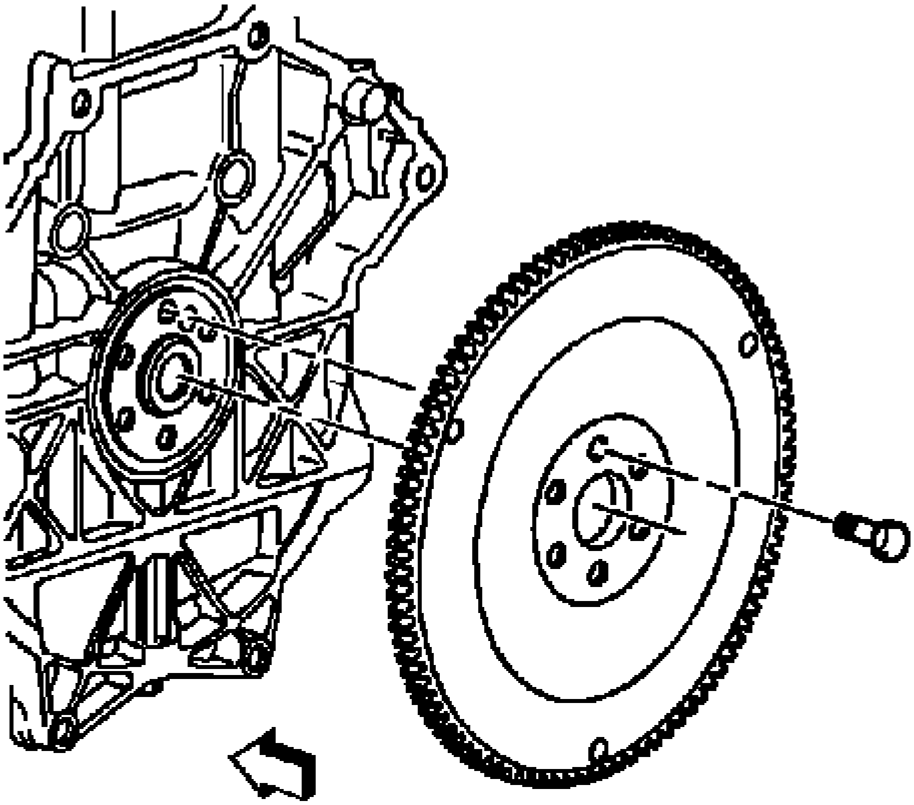


Fig. 213: View Of Flywheel
Courtesy of GENERAL MOTORS CORP.

2. Remove the flywheel retainer.
3. Remove the flywheel.
4. 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

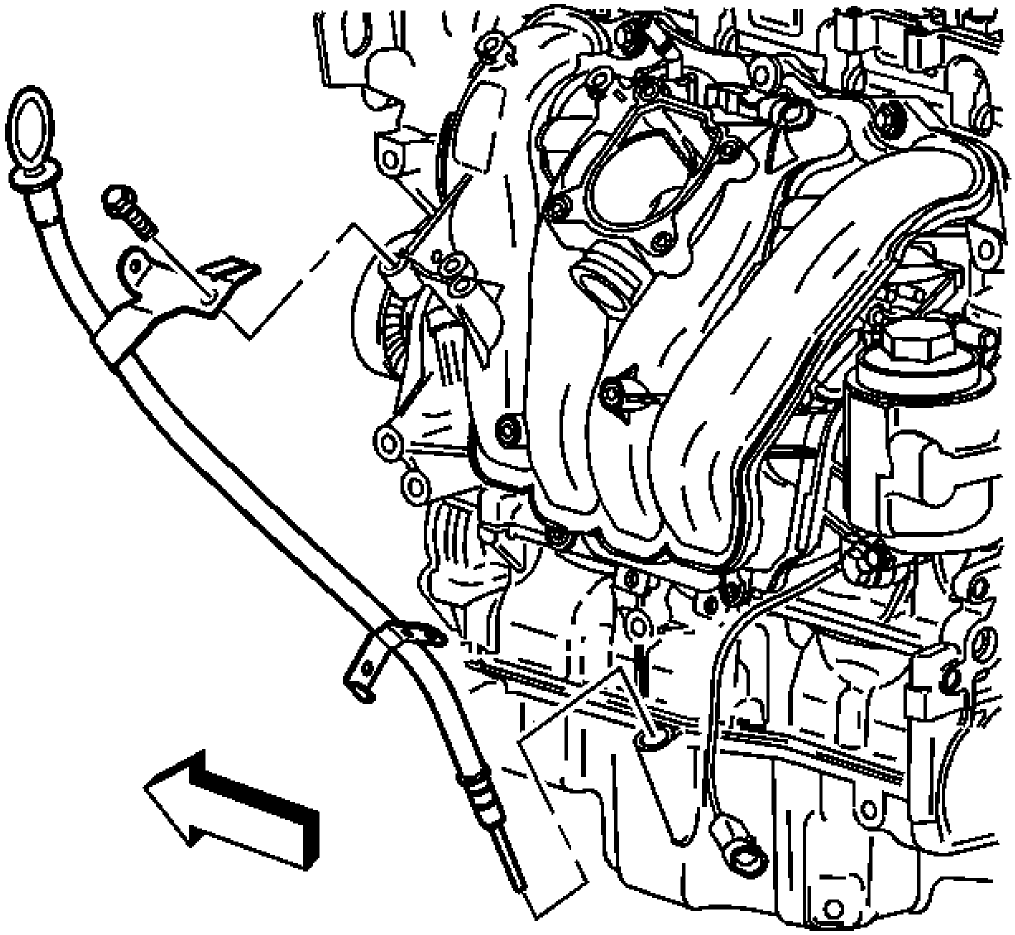


Fig. 214: View of Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

1. Remove knock sensor connector from the oil level indicator tube.
2. Remove the electrical wiring harness from the oil level indicator tube.
3. Remove the oil level indicator tube bracket to the intake manifold bolt.
4. Remove the oil level indicator and the oil level indicator tube from the oil pan.

Exhaust Manifold Removal

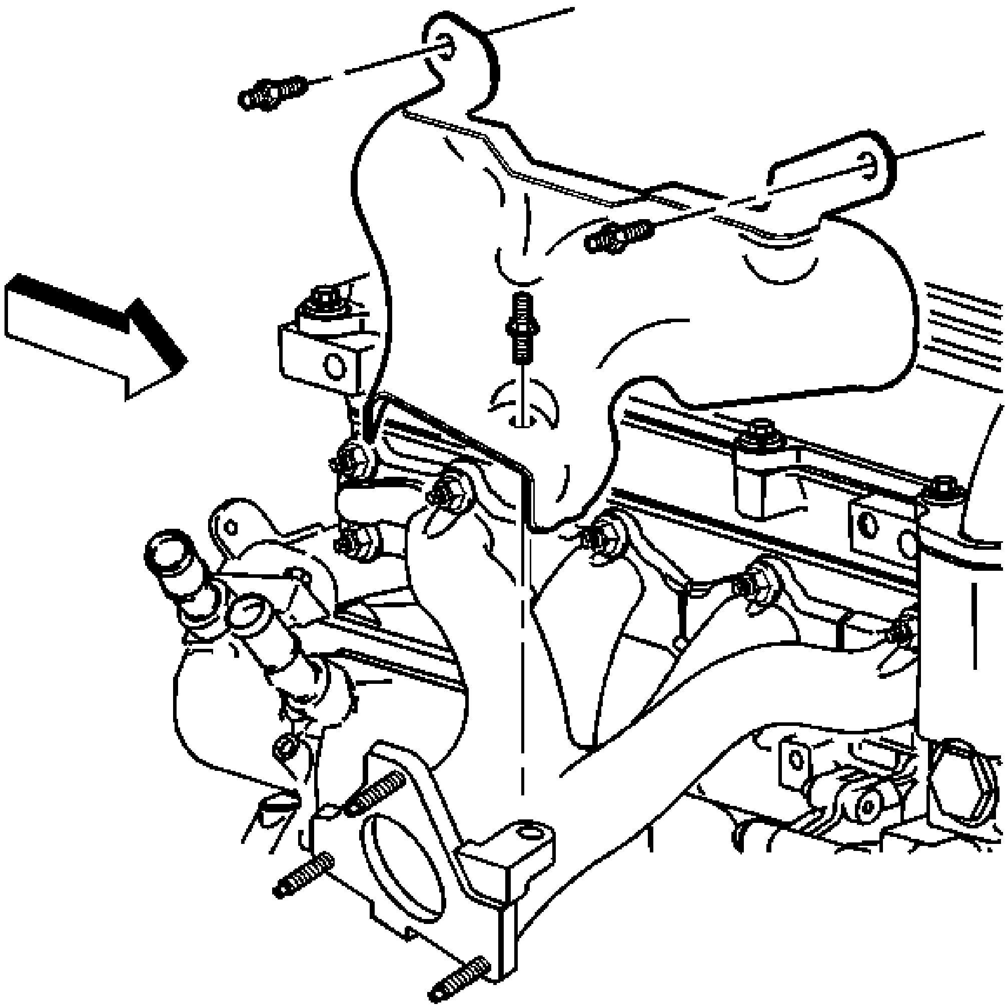


Fig. 215: Removing & Installing Exhaust Manifold Heat Shield
Courtesy of GENERAL MOTORS CORP.

1. Remove the exhaust manifold heat shield.

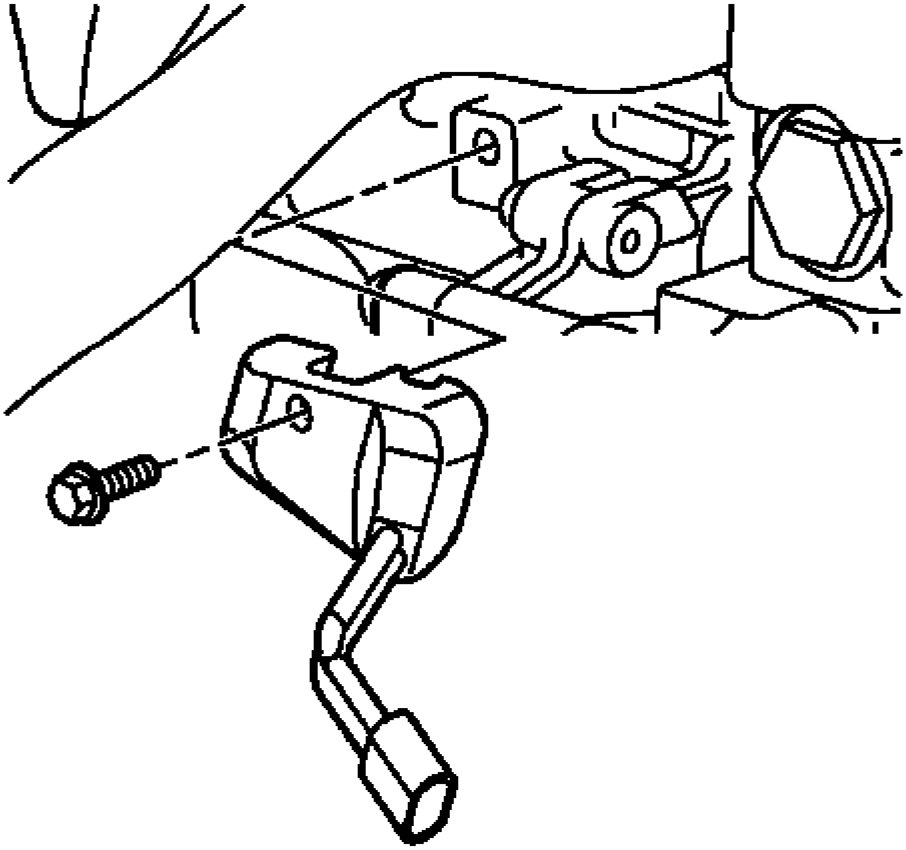


Fig. 216: View Of Block Heater
Courtesy of GENERAL MOTORS CORP.

2. Remove the block heater if equipped.

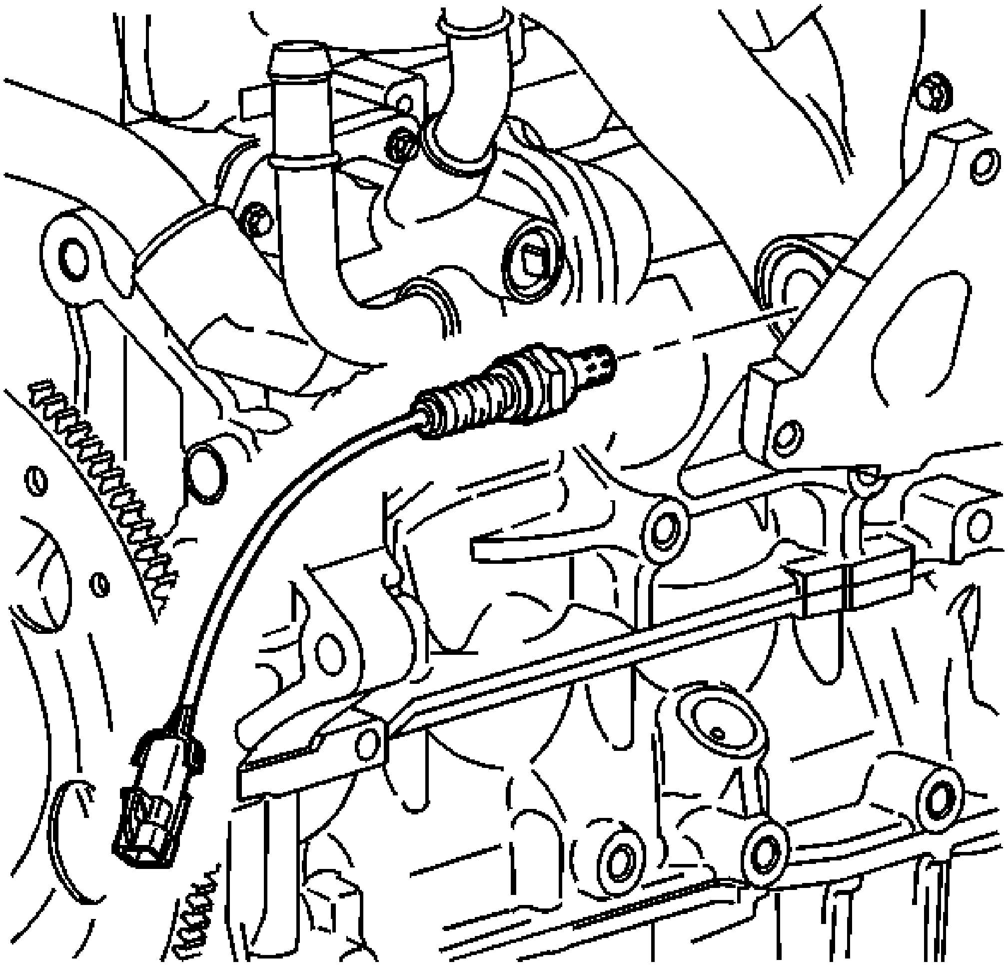


Fig. 217: Identifying Oxygen Sensor
Courtesy of GENERAL MOTORS CORP.

3. Remove the oxygen sensor.

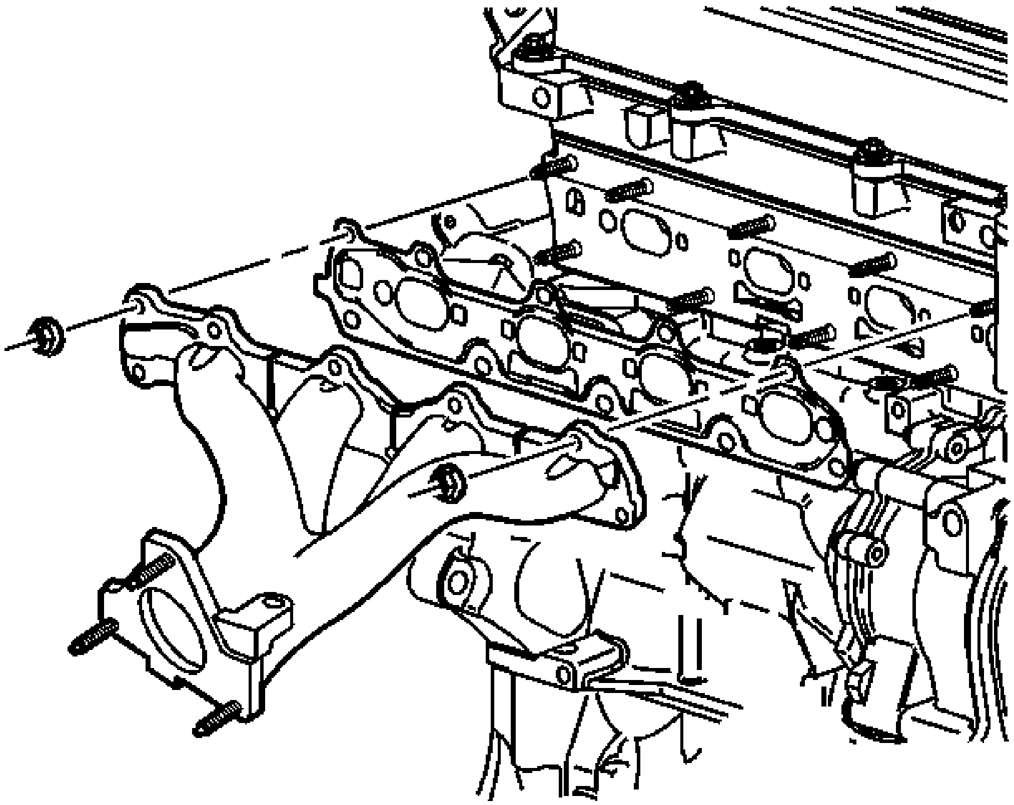


Fig. 218: View Of Exhaust Manifold & Gasket
Courtesy of GENERAL MOTORS CORP.

4. Remove and discard the exhaust manifold to cylinder head retaining nuts.
5. Remove the exhaust manifold.
6. Clean all of the sealing surfaces.
7. If the exhaust manifold is being replaced, transfer the following parts:
   - The exhaust manifold heat shield
   - The oxygen sensor

Intake Manifold Removal

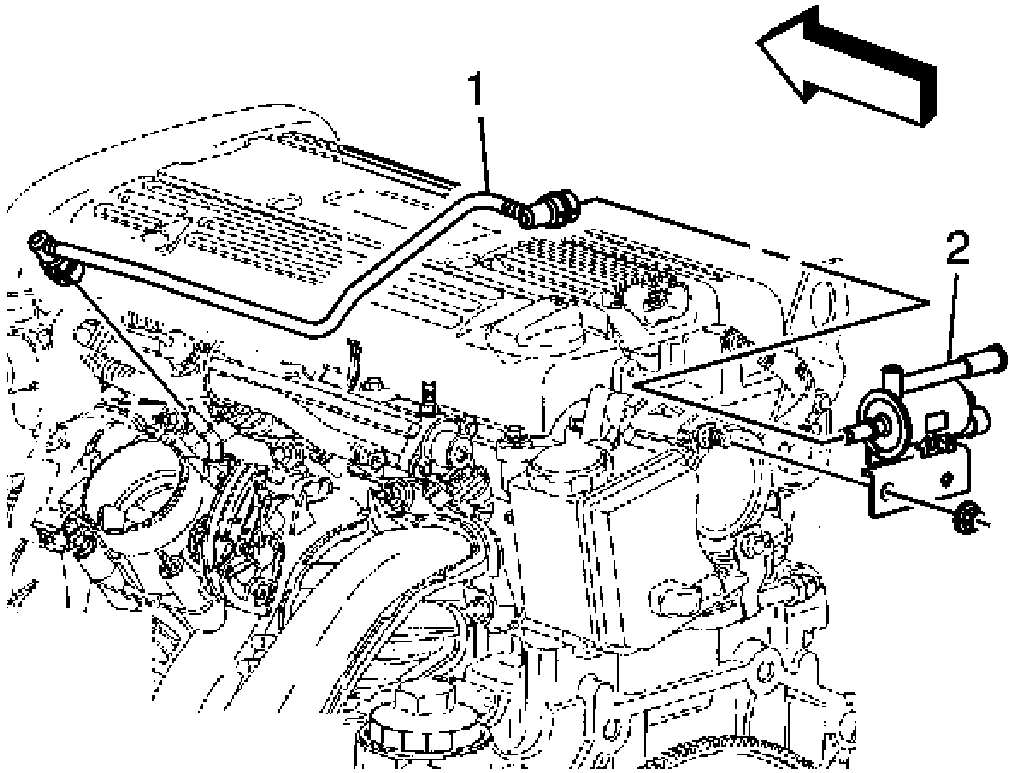


Fig. 219: View of EVAP Emission Canister Valve Tube & Canister Valve
Courtesy of GENERAL MOTORS CORP.

NOTE: **Never attempt to remove the intake manifold from a hot engine, allow the engine to cool to ambient temperature. The intake manifold is made of a composite plastic and can be damaged if it is removed when the engine is hot.**

1. Remove the EVAP emission canister valve tube (1).
2. Remove the EVAP emission canister valve (2).

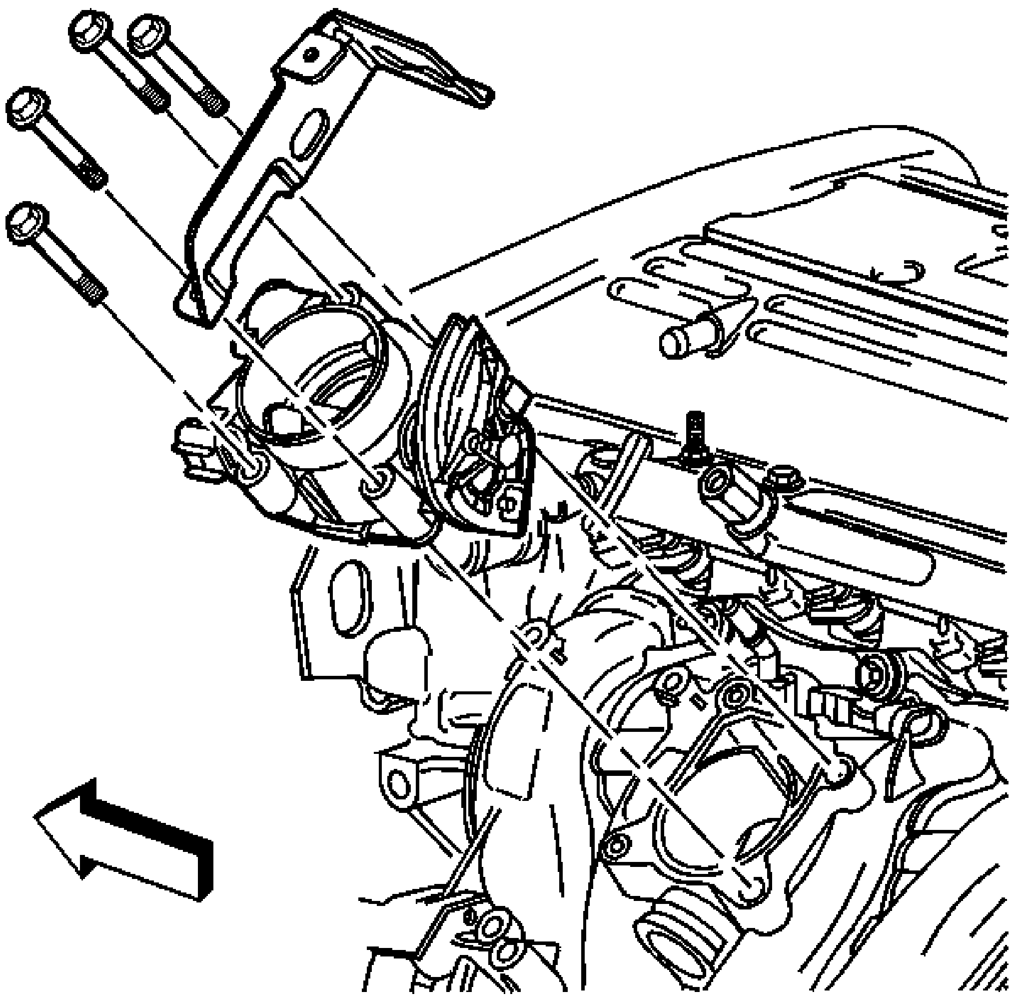


Fig. 220: Exploded View Of Throttle Body & Accelerator Control Cable Bracket
Courtesy of GENERAL MOTORS CORP.

3. Remove the throttle body and the accelerator control cable bracket.

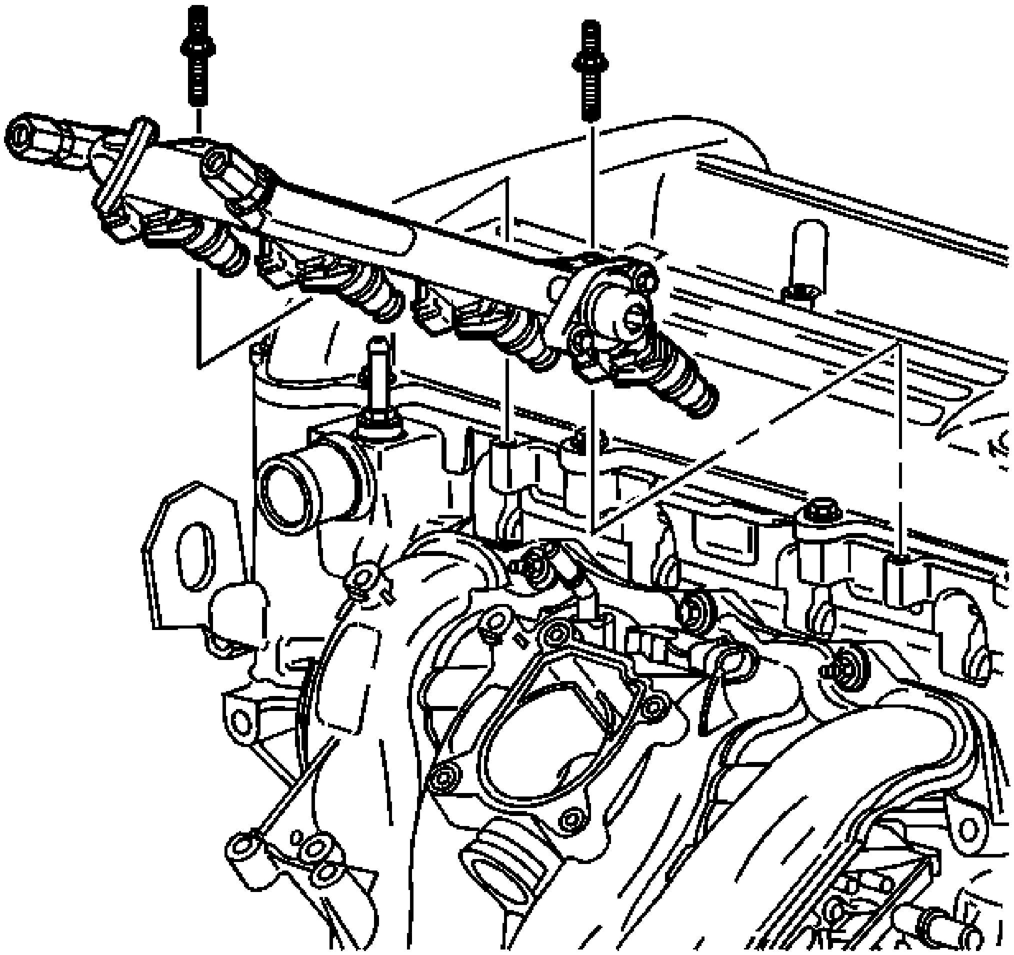


Fig. 221: View Of Fuel Rail Assembly
Courtesy of GENERAL MOTORS CORP.

4. Remove fuel pipes and clip. Remove the fuel rail assembly.
5. Remove the fuel injector tip insulators and discard.

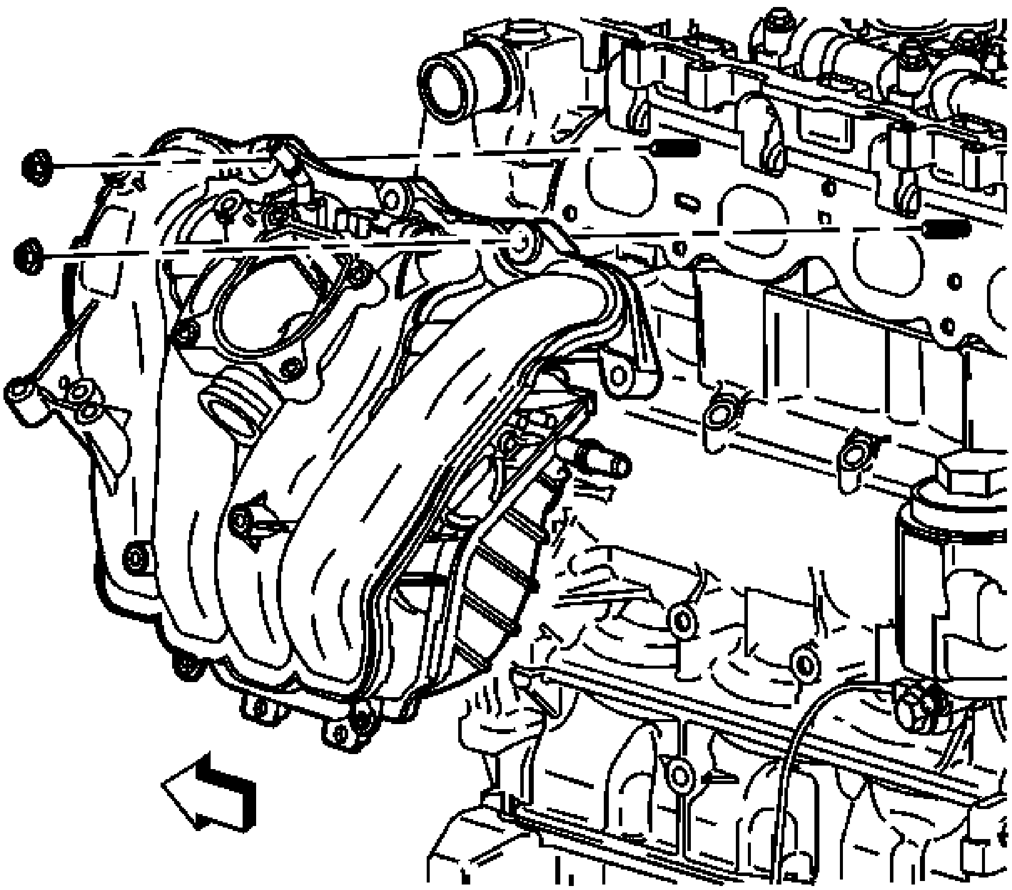


Fig. 222: Removing & Installing Intake Manifold
Courtesy of GENERAL MOTORS CORP.

6. Remove the intake manifold retaining nuts and bolts.
7. Remove the intake manifold.
8. Remove the intake manifold gasket, if necessary. The gasket can be used again if it is not damaged.
9. If the intake manifold needs to be replaced, transfer the throttle body to the new intake manifold.

Crankshaft Damper Removal

Tools Required

J 38122-A Harmonic Balancer Holder

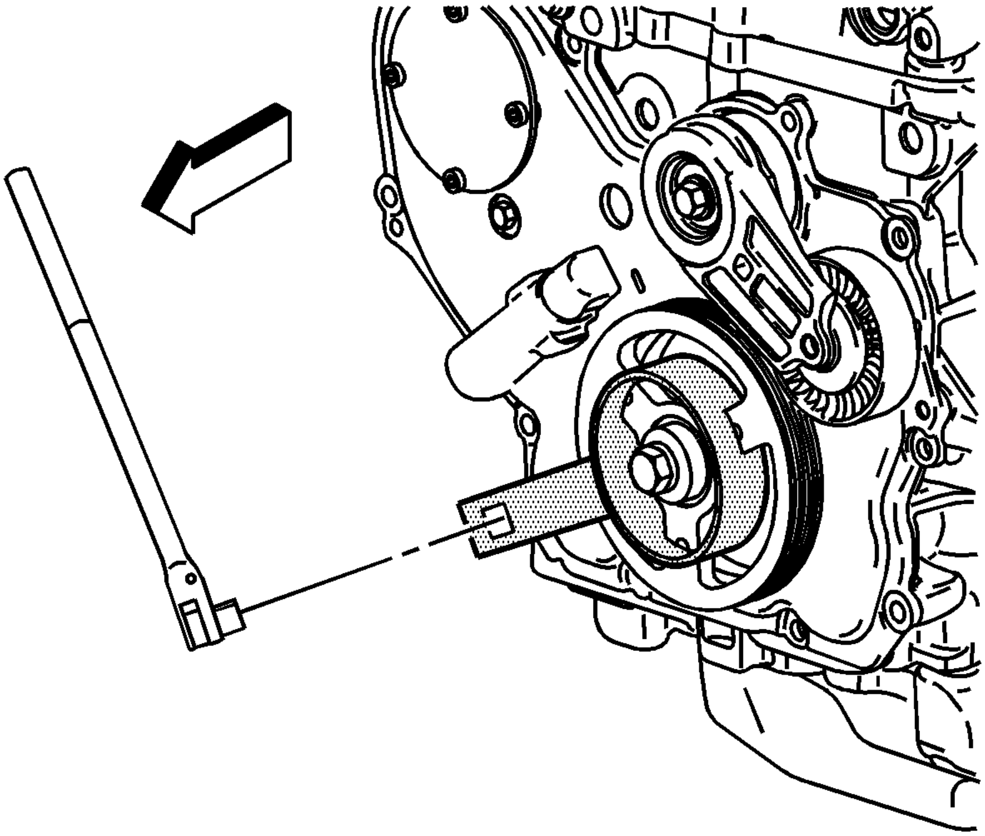


Fig. 223: View Of Harmonic Balancer Holder J38122-A
Courtesy of GENERAL MOTORS CORP.

1. Install the J 38122-A .
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.

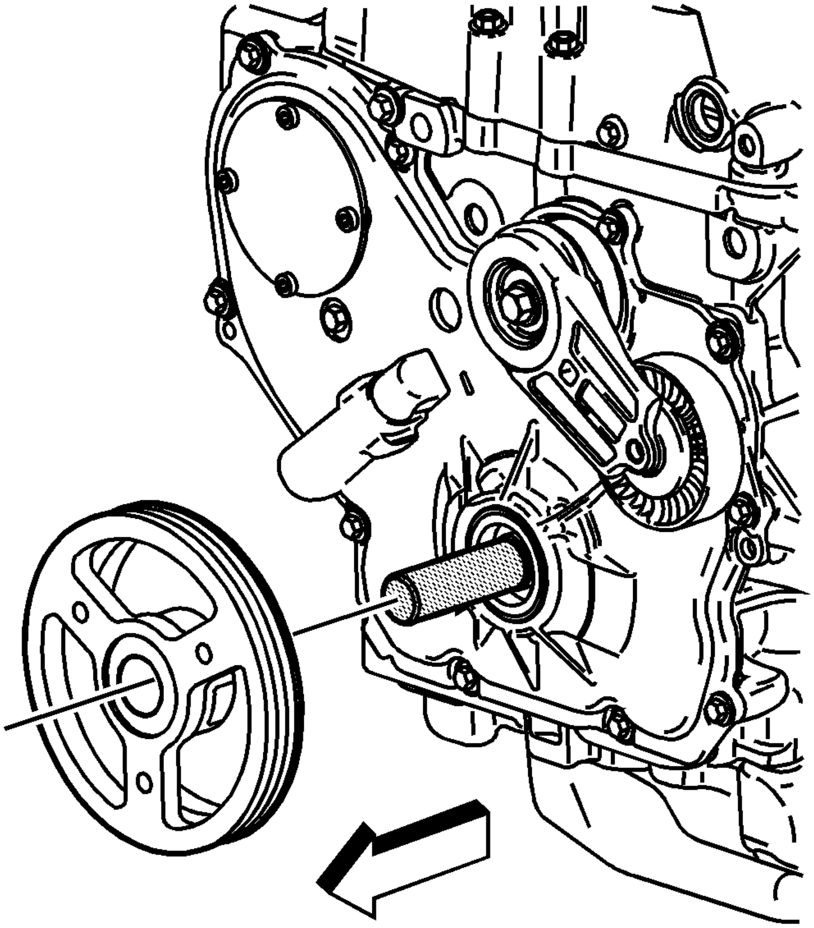


Fig. 224: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

3. Remove the damper assembly.

Camshaft Cover Removal

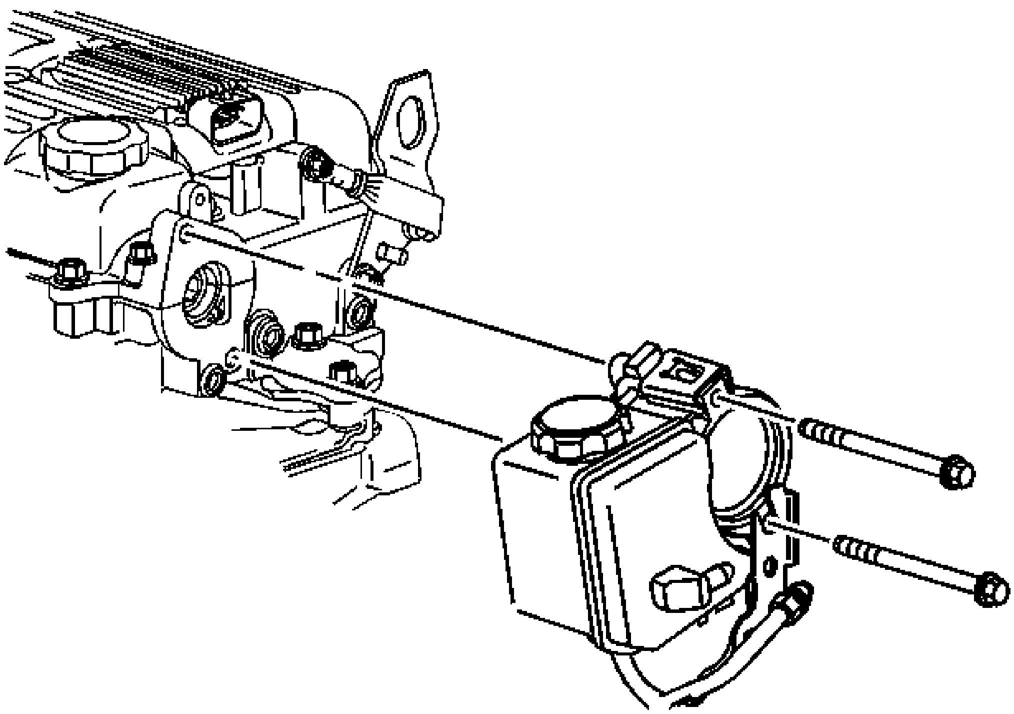


Fig. 225: View Of Power Steering Pump
Courtesy of GENERAL MOTORS CORP.

1. Remove the power steering pump, if equipped.

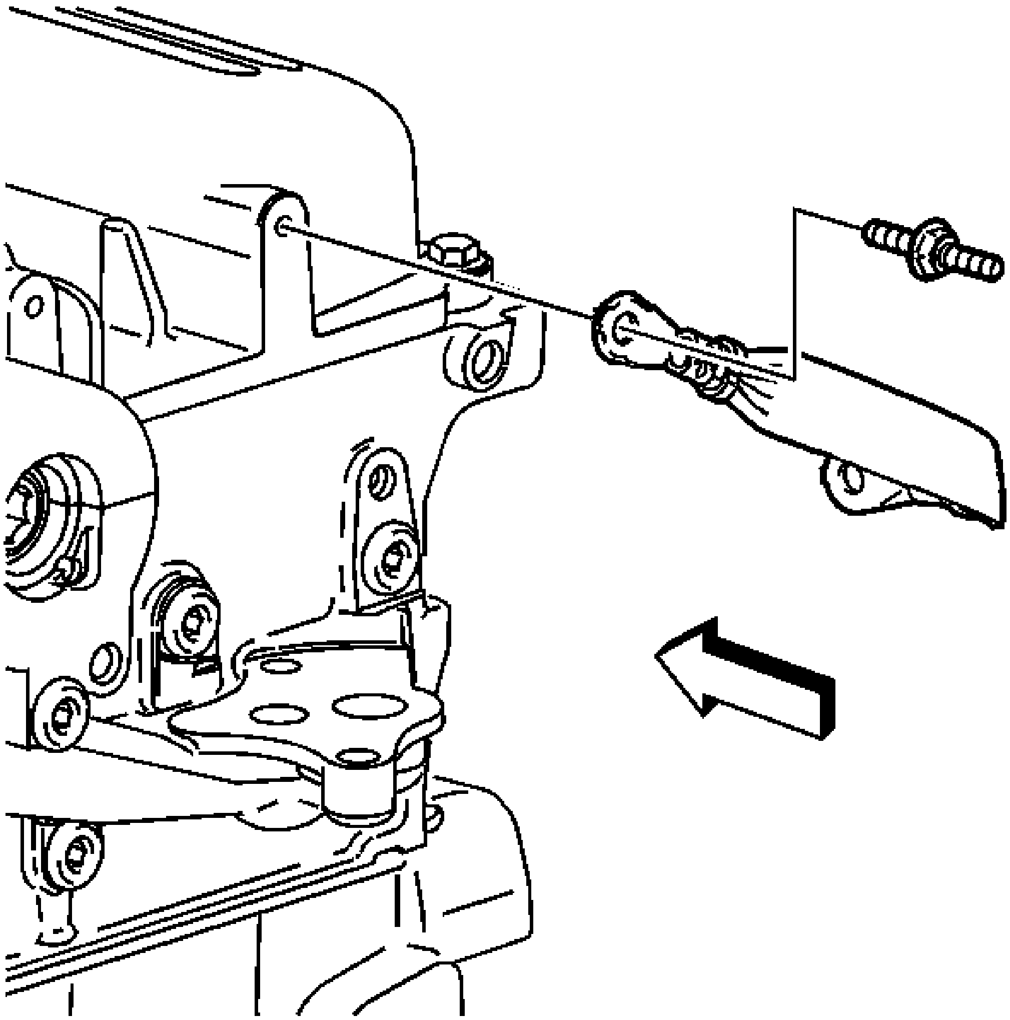


Fig. 226: View of Camshaft Cover Grounding Strap
Courtesy of GENERAL MOTORS CORP.

2. Remove the camshaft cover grounding strap.

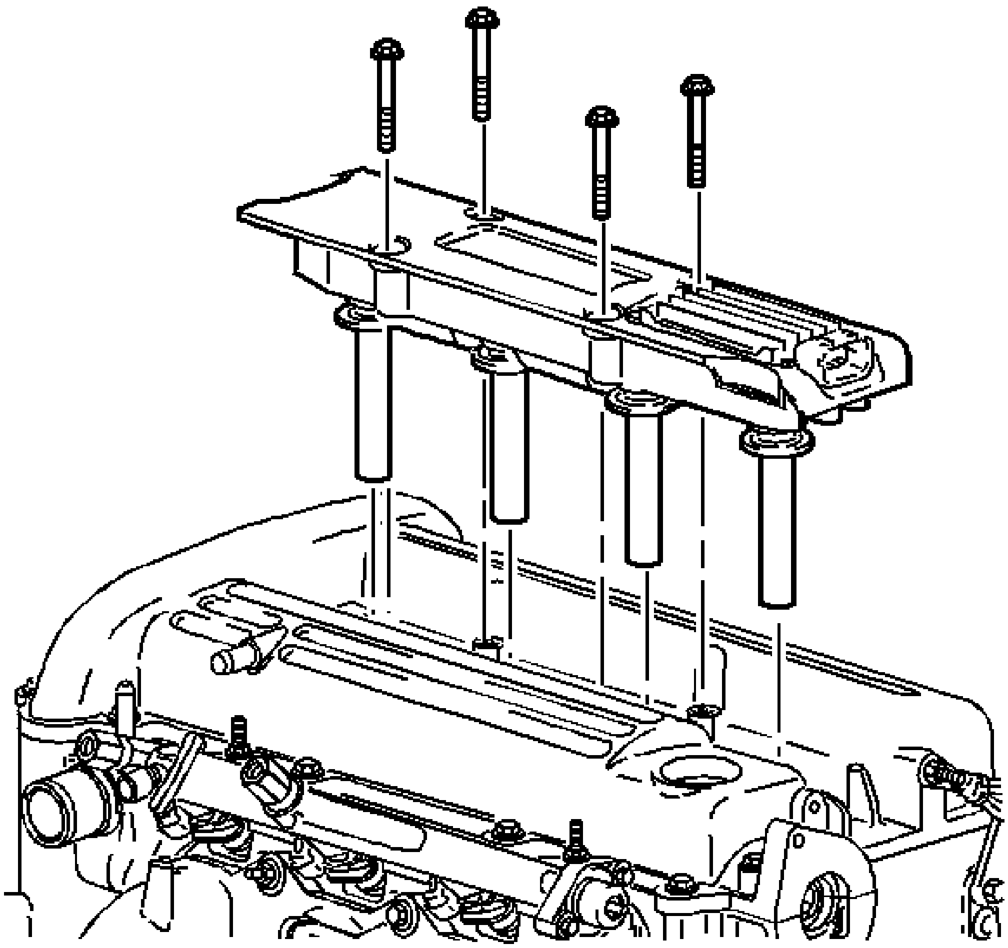


Fig. 227: View Of Ignition Coil & Module Assembly
Courtesy of GENERAL MOTORS CORP.

3. Remove the ignition module and coil assembly.

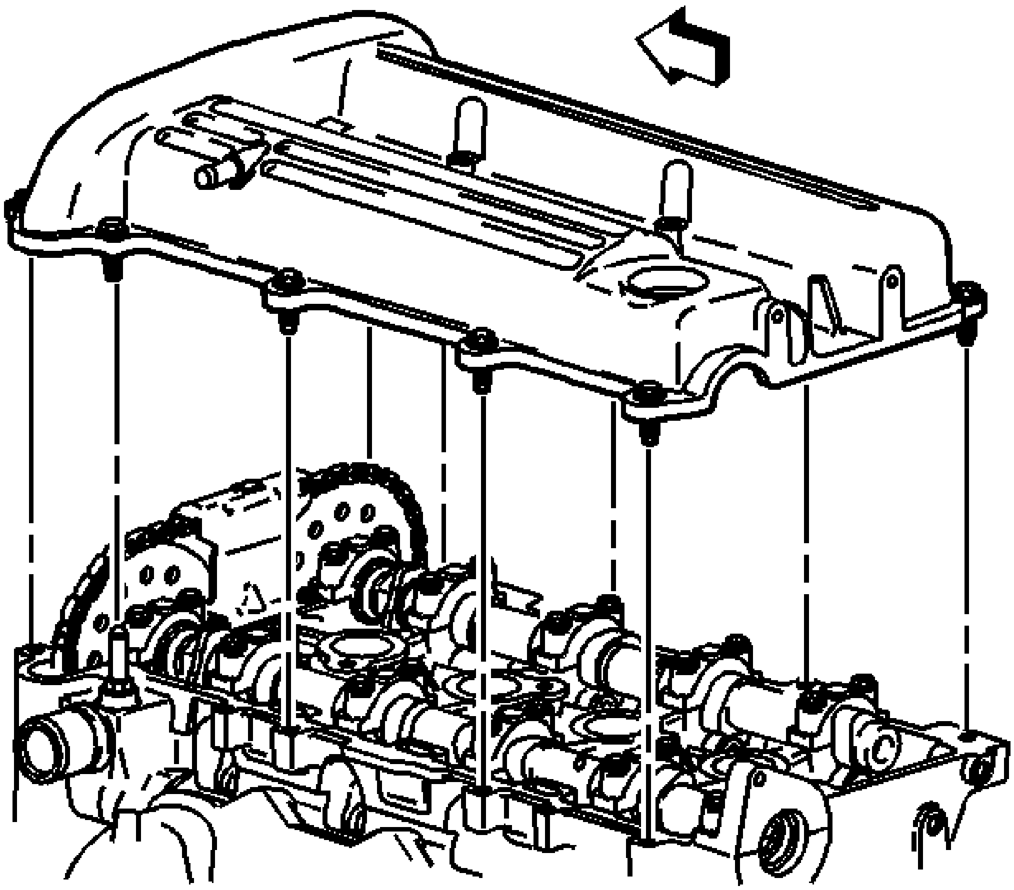


Fig. 228: View Of Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

4. Remove the camshaft cover assembly.

Engine Front Cover and Oil Pump Removal

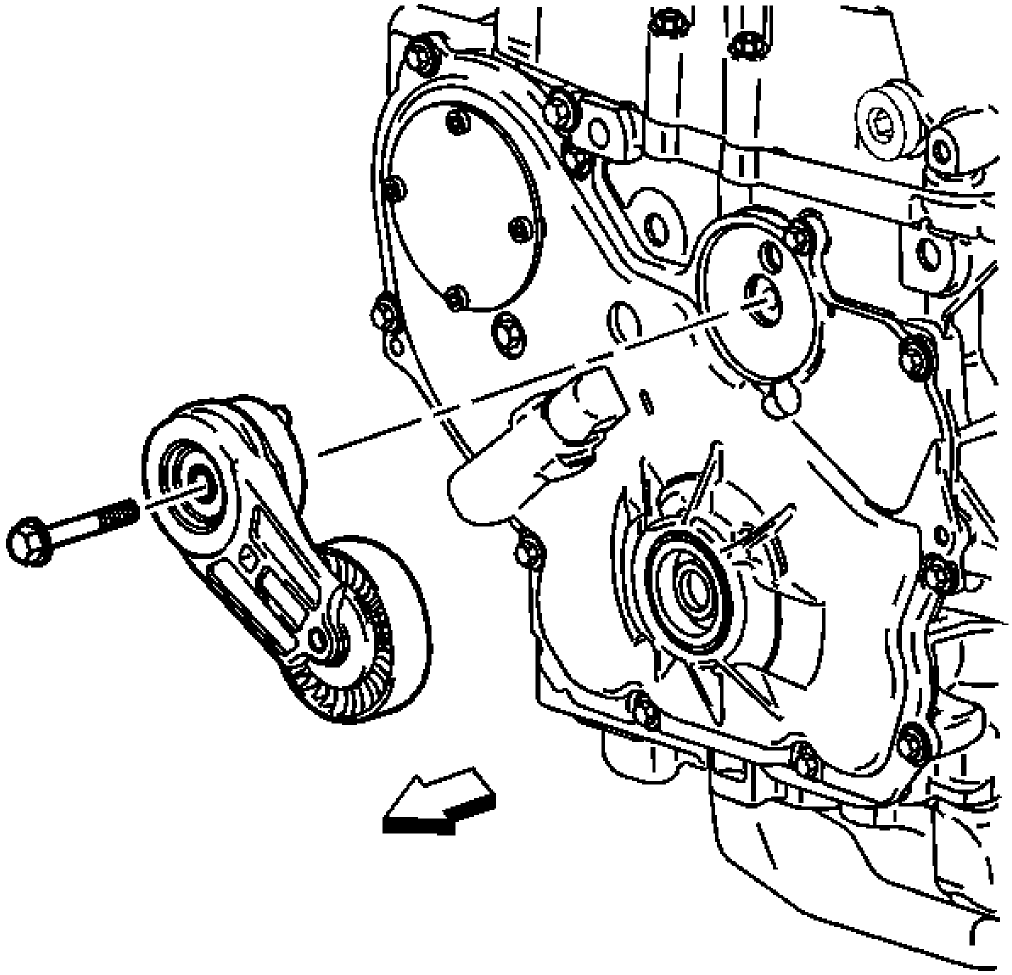


Fig. 229: View Of Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

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

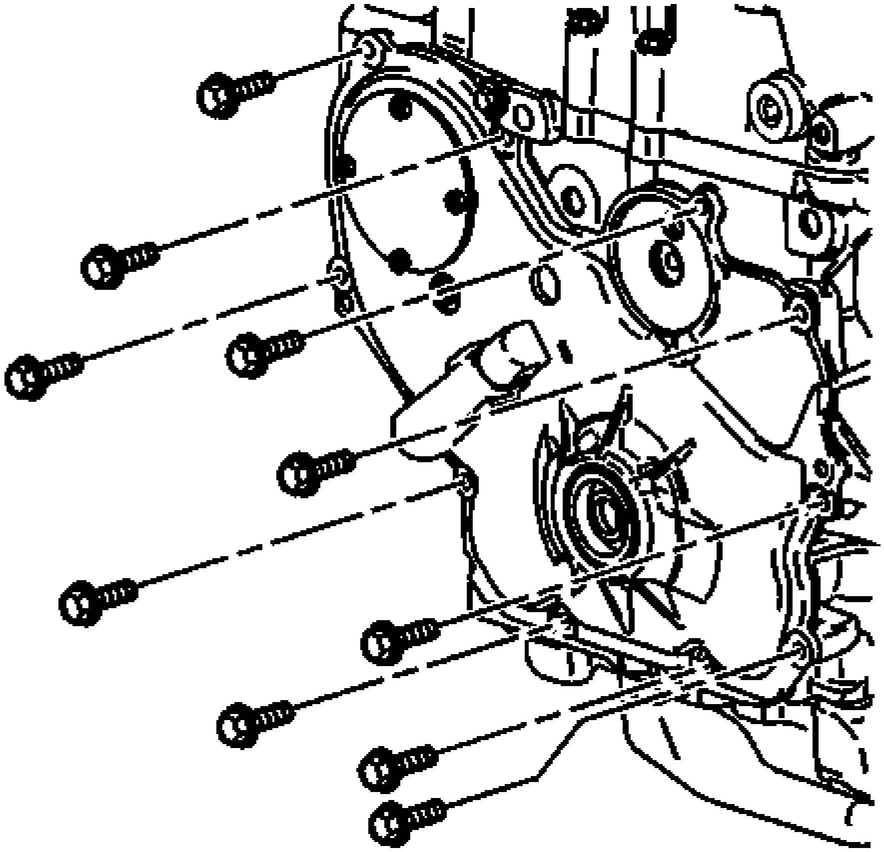


Fig. 230: View Of Engine Front Cover Bolts
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine front cover bolts.

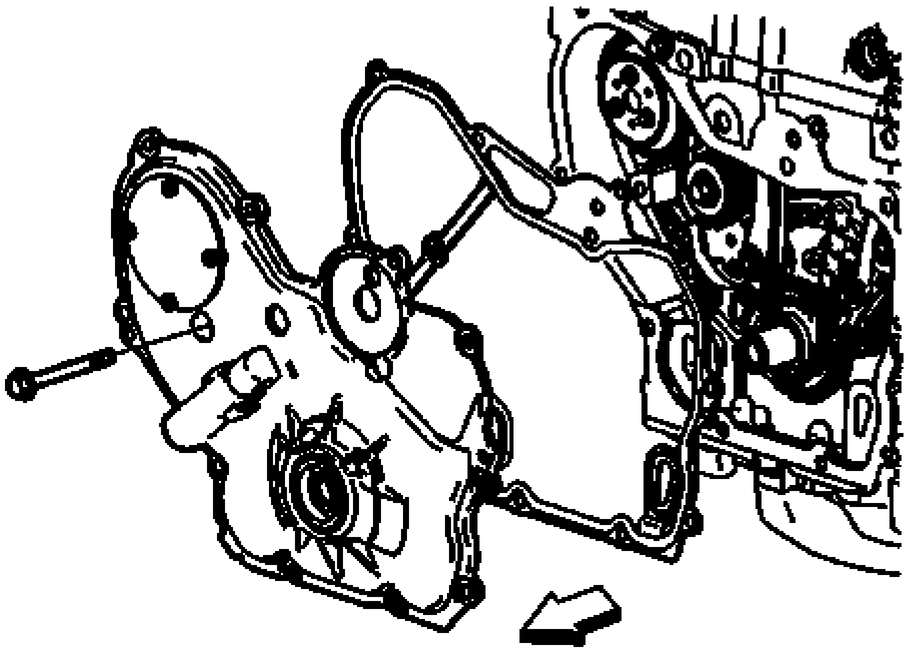


Fig. 231: View Of Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

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

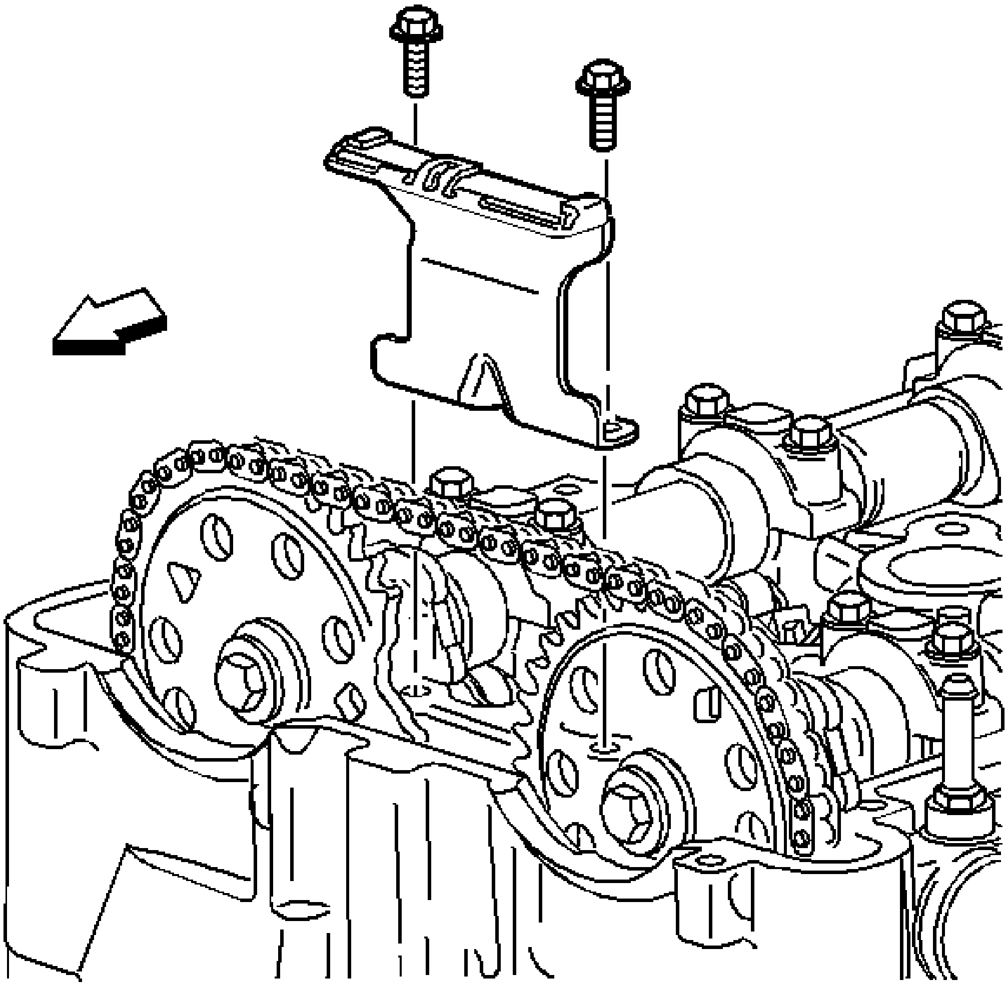


Fig. 232: View Of Upper Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

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

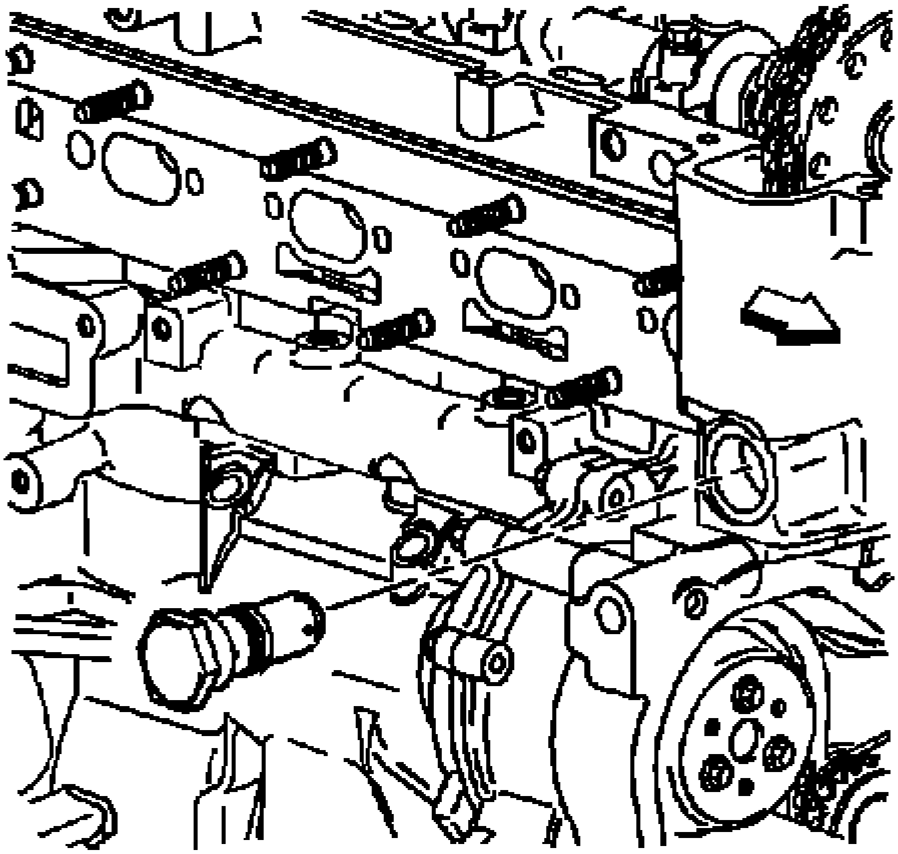


Fig. 233: Identifying Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

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

3. Remove the timing chain tensioner plunger.

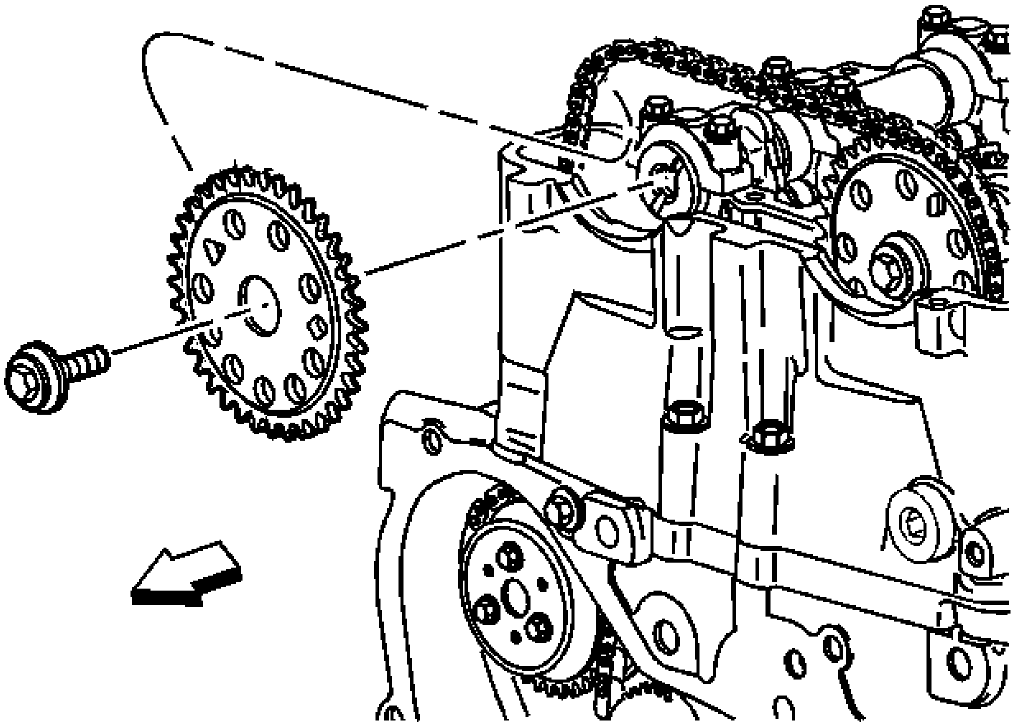


Fig. 234: Identifying Exhaust Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

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.

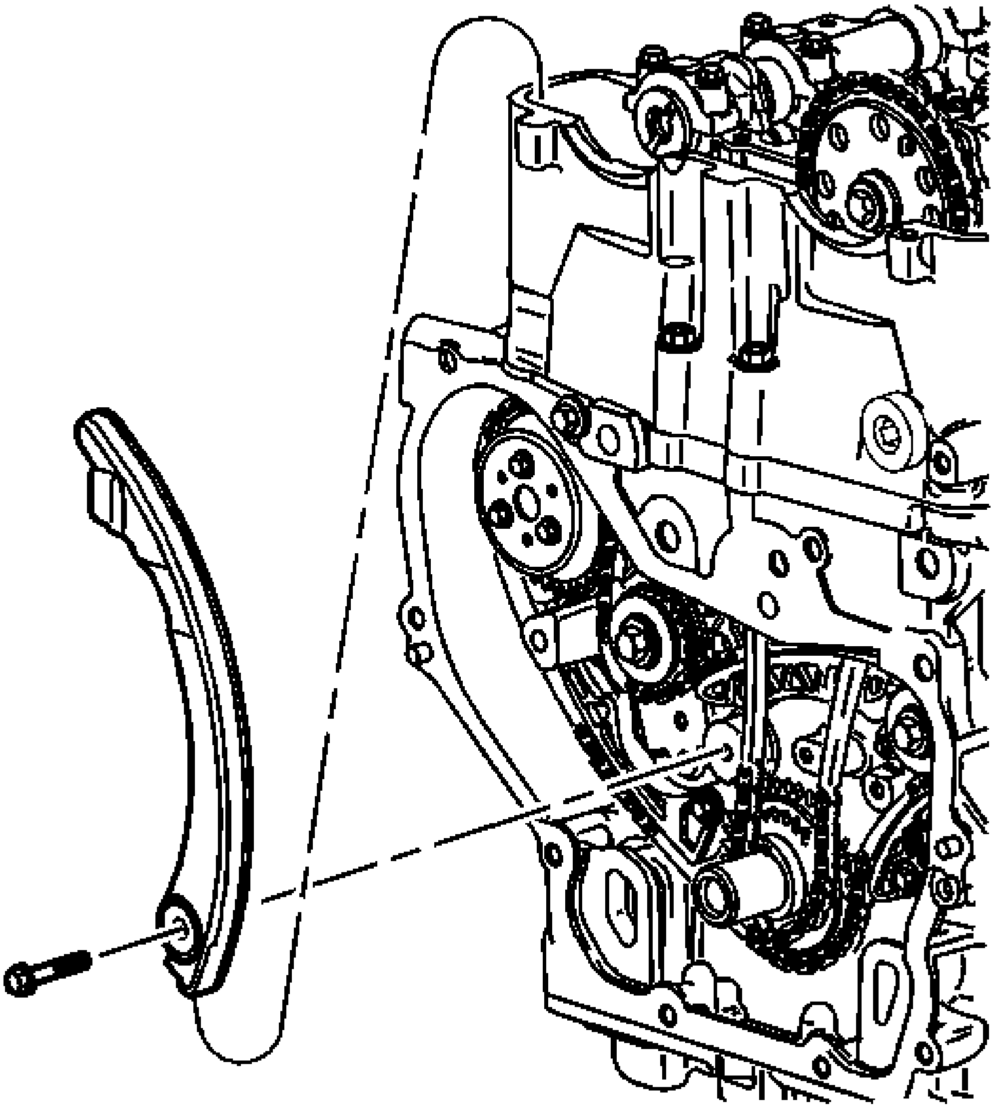


Fig. 235: View Of Timing Chain Tensioner Guide
Courtesy of GENERAL MOTORS CORP.

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

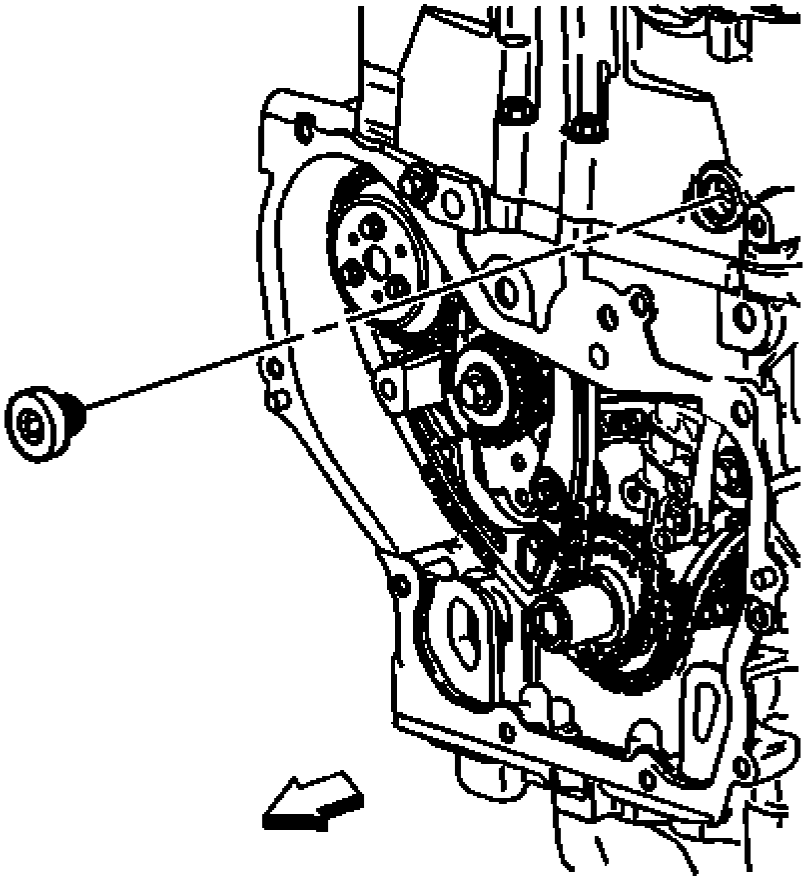


Fig. 236: View Of Fixed Timing Chain Guide Access Plug
Courtesy of GENERAL MOTORS CORP.

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

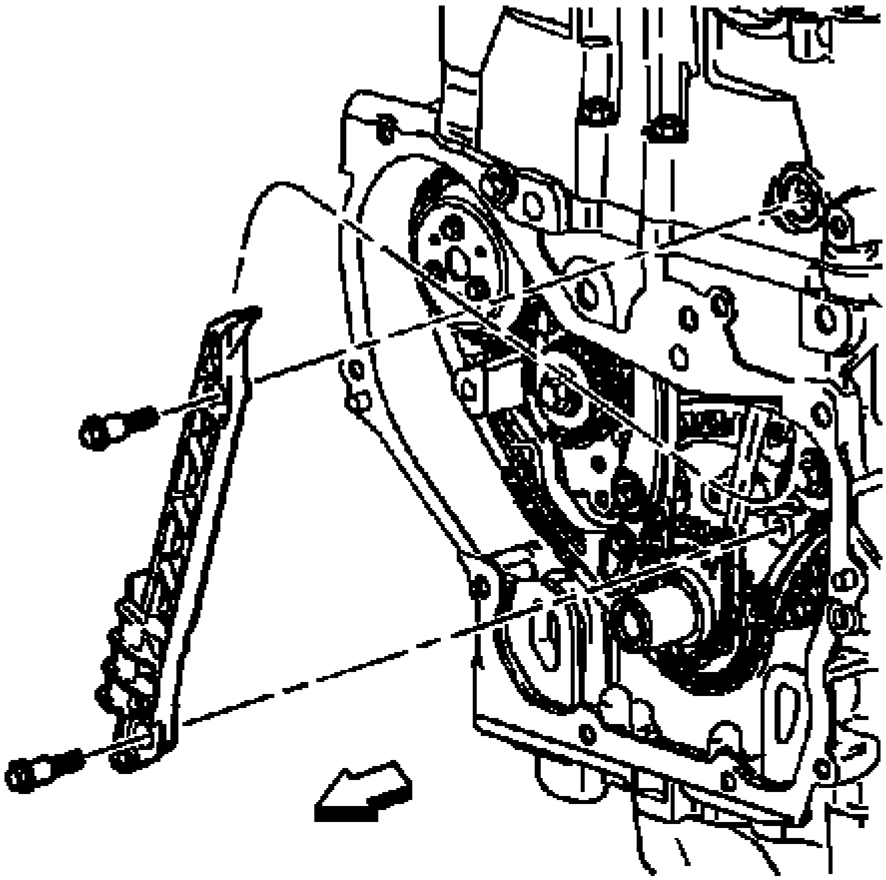


Fig. 237: View Of Fixed Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

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

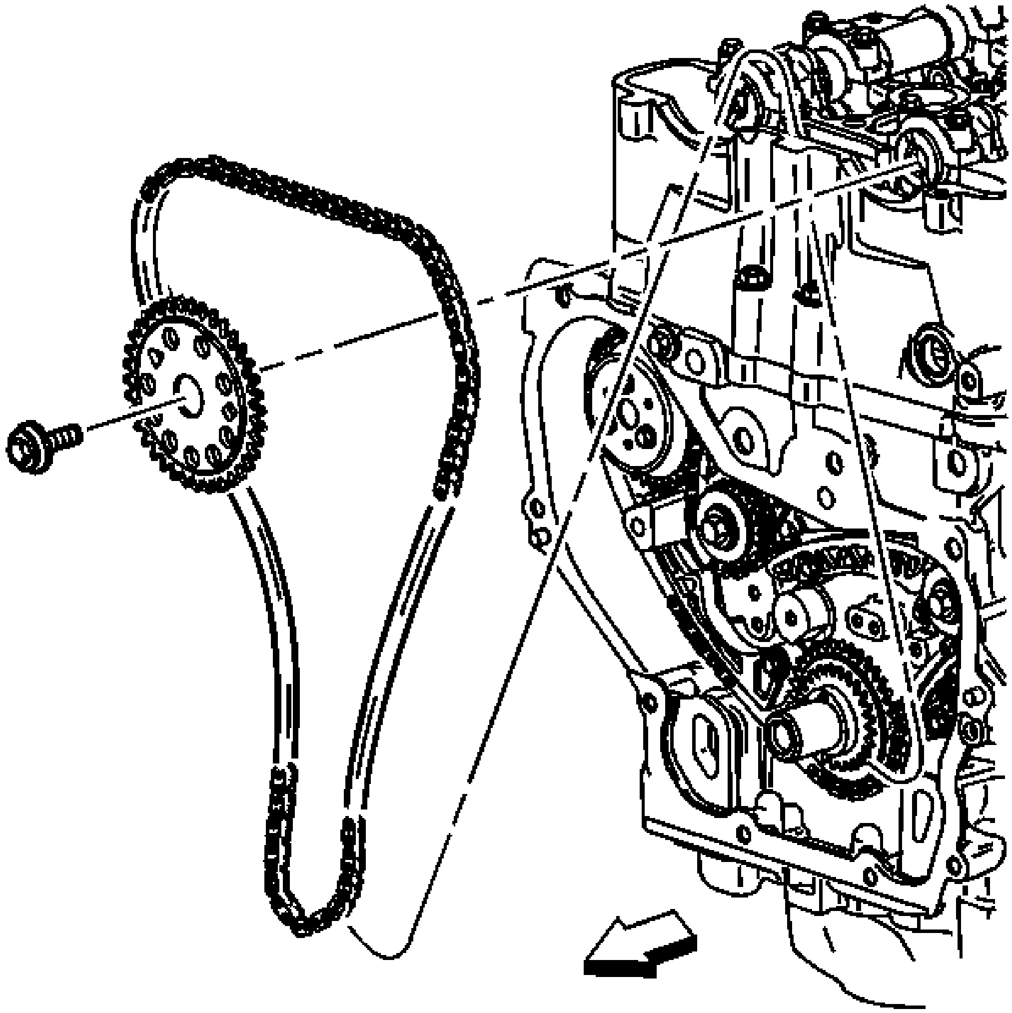


Fig. 238: View Of Intake Camshaft Sprocket And Chain
Courtesy of GENERAL MOTORS CORP.

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

    Discard the bolt.

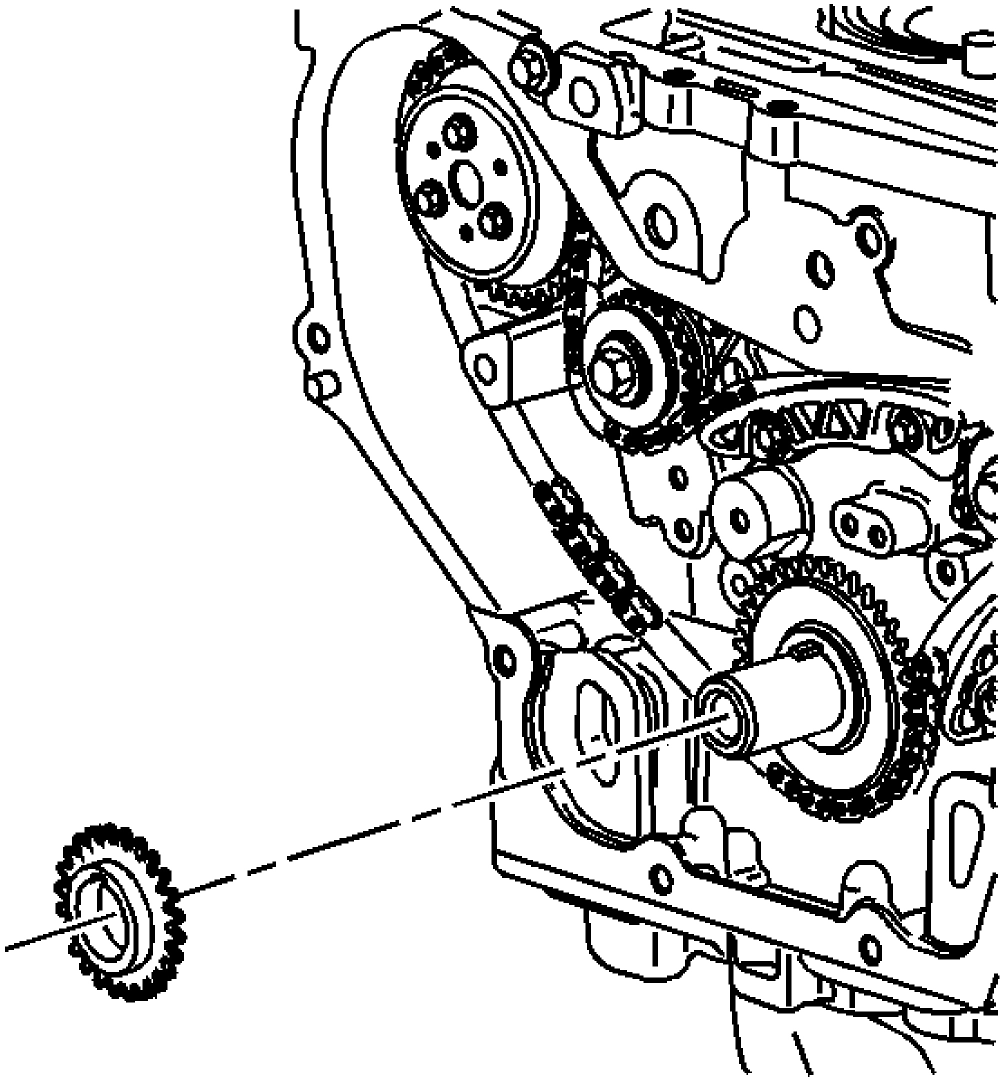


Fig. 239: View of Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

13. Remove the crankshaft sprocket.

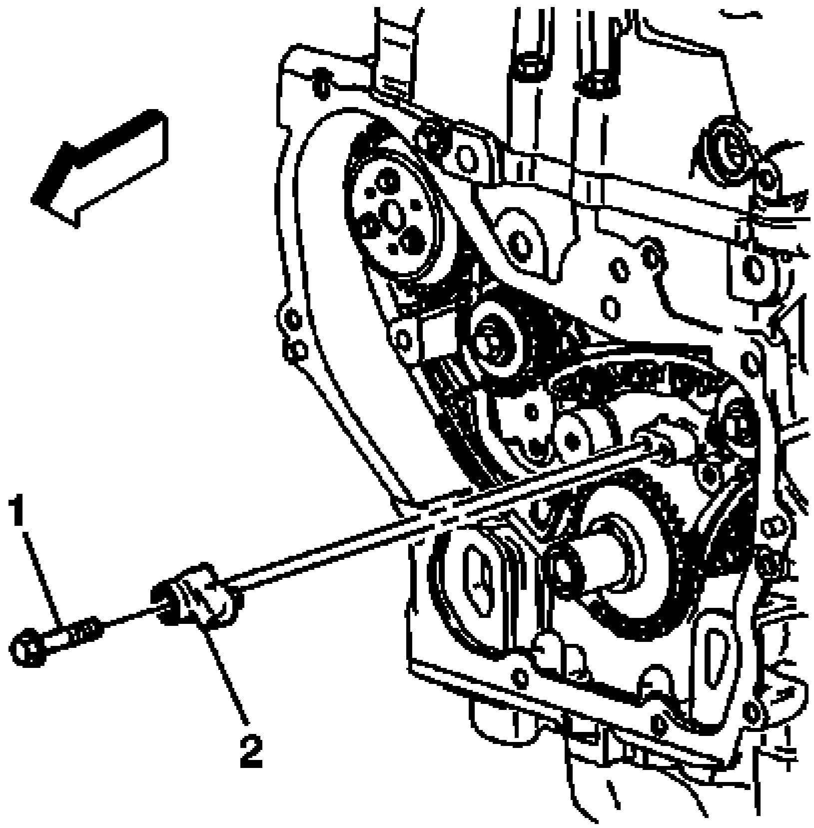


Fig. 240: View Of Oil Nozzle & Bolt
Courtesy of GENERAL MOTORS CORP.

14. Remove the oil nozzle and bolt.

Intake Camshaft, Follower, and Adjuster Removal

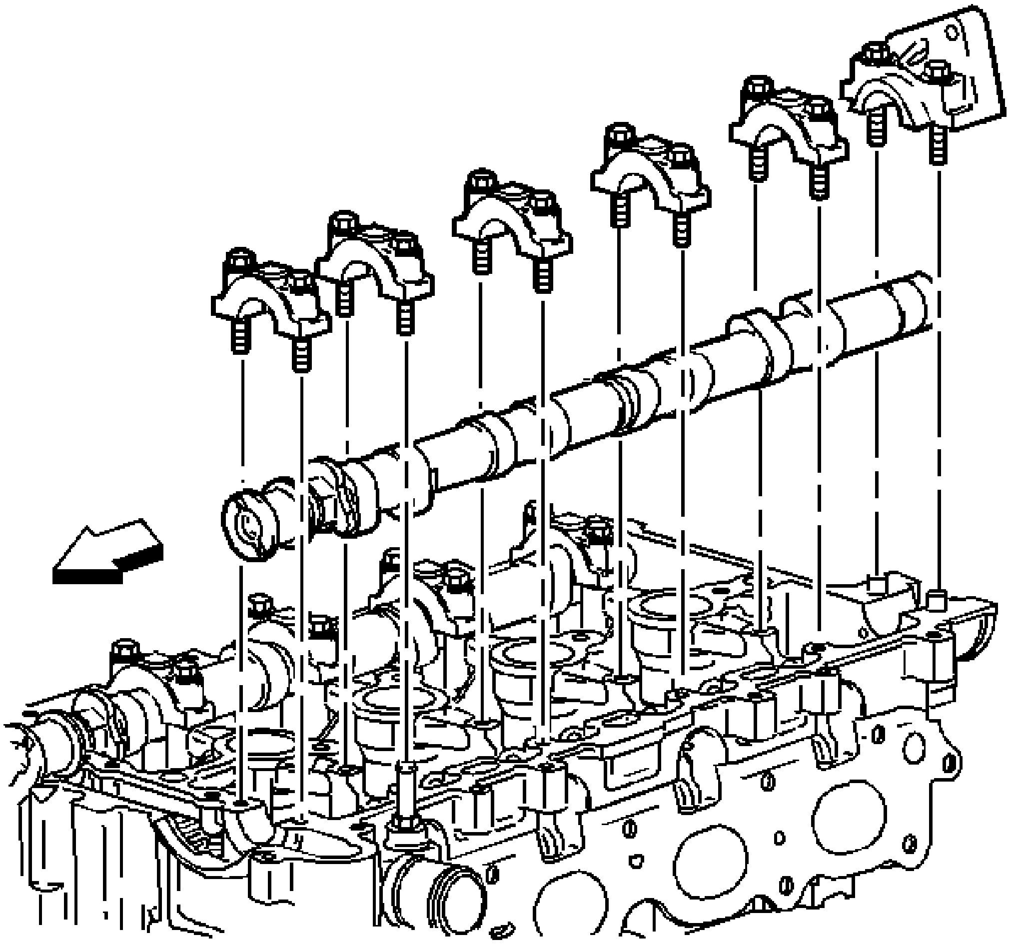


Fig. 241: View Of Intake Camshaft And Caps
Courtesy of GENERAL MOTORS CORP.

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

1. Mark 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.

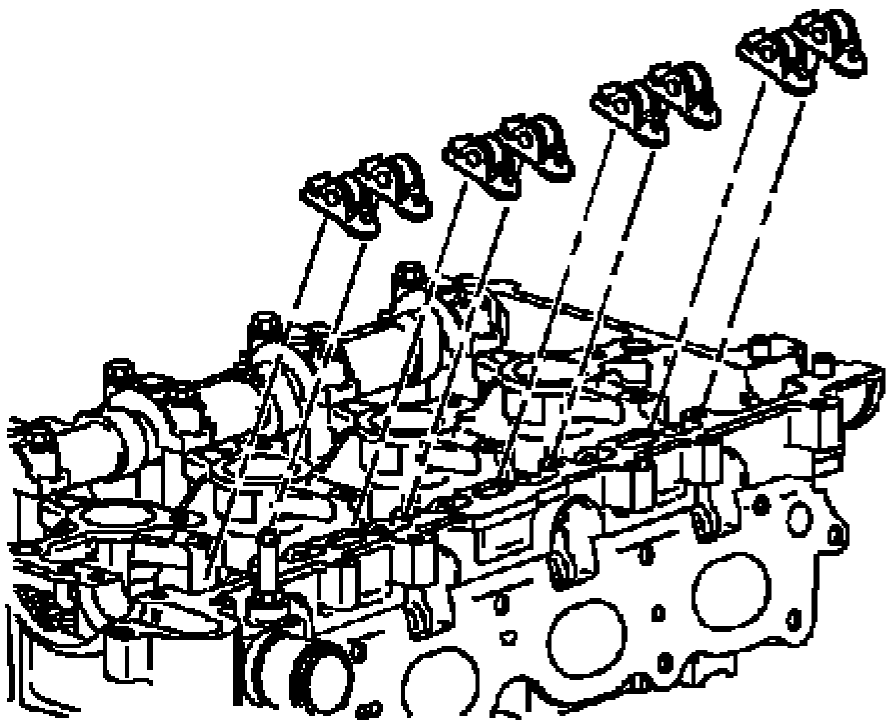


Fig. 242: View Of Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

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.

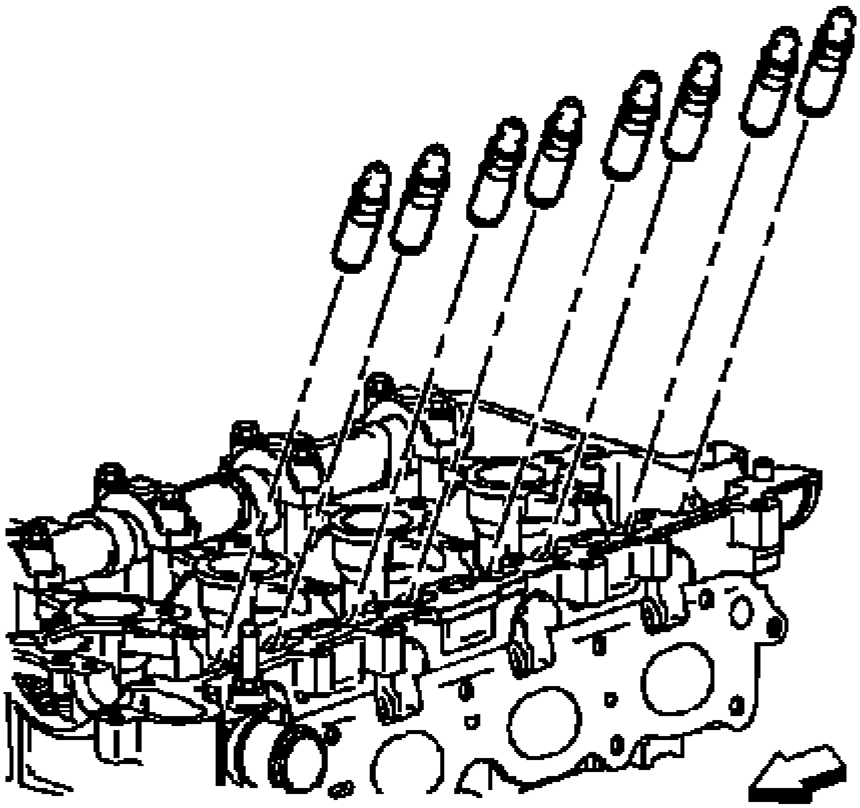


Fig. 243: View Of Hydraulic Element Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

6. Remove the hydraulic element adjusters.

Exhaust Camshaft, Follower, and Adjuster Removal

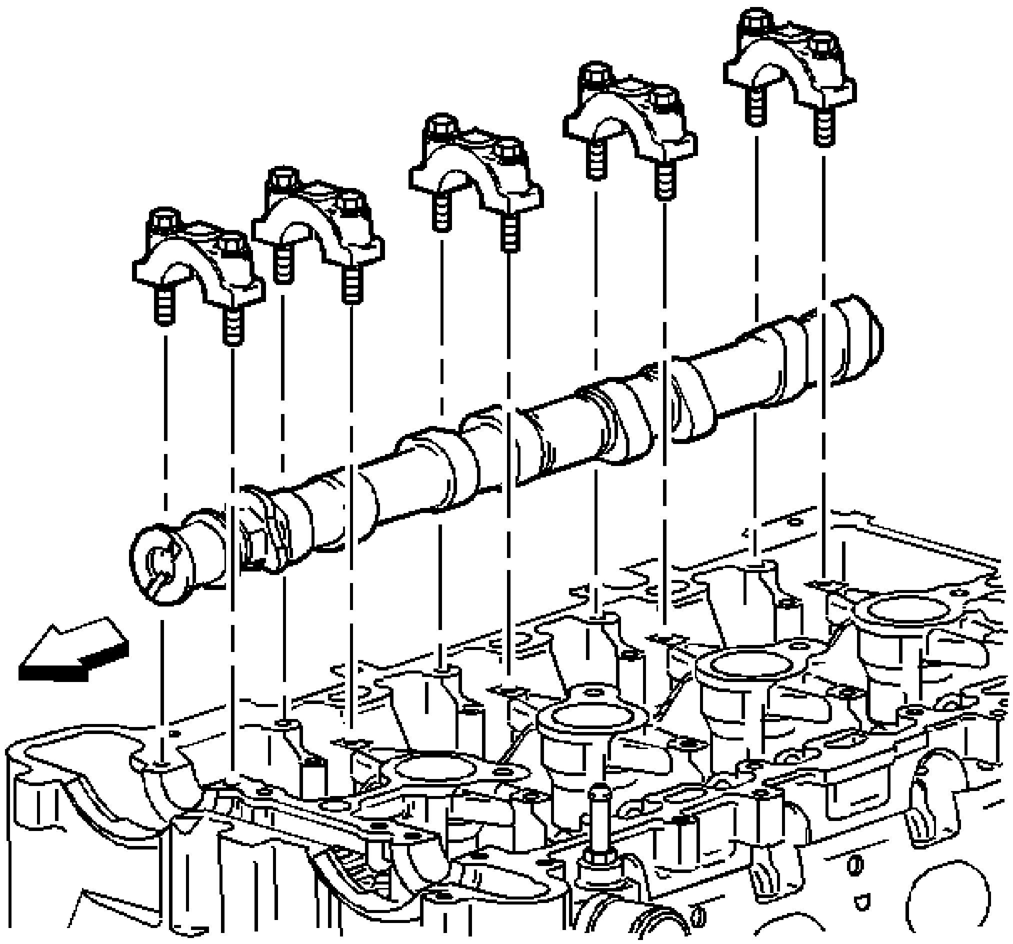


Fig. 244: View Of Camshaft & Bearing Caps
Courtesy of GENERAL MOTORS CORP.

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

1. Mark 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.

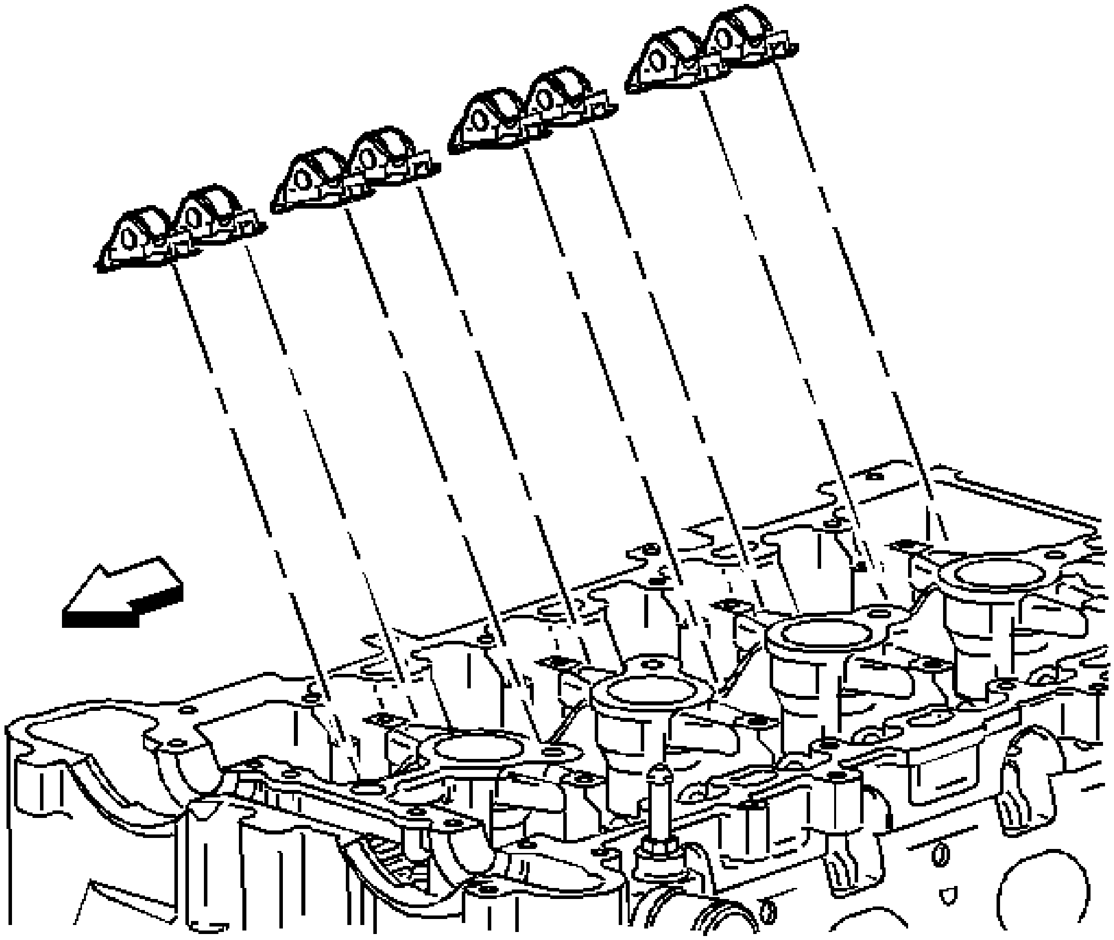


Fig. 245: Identifying Exhaust Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

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.

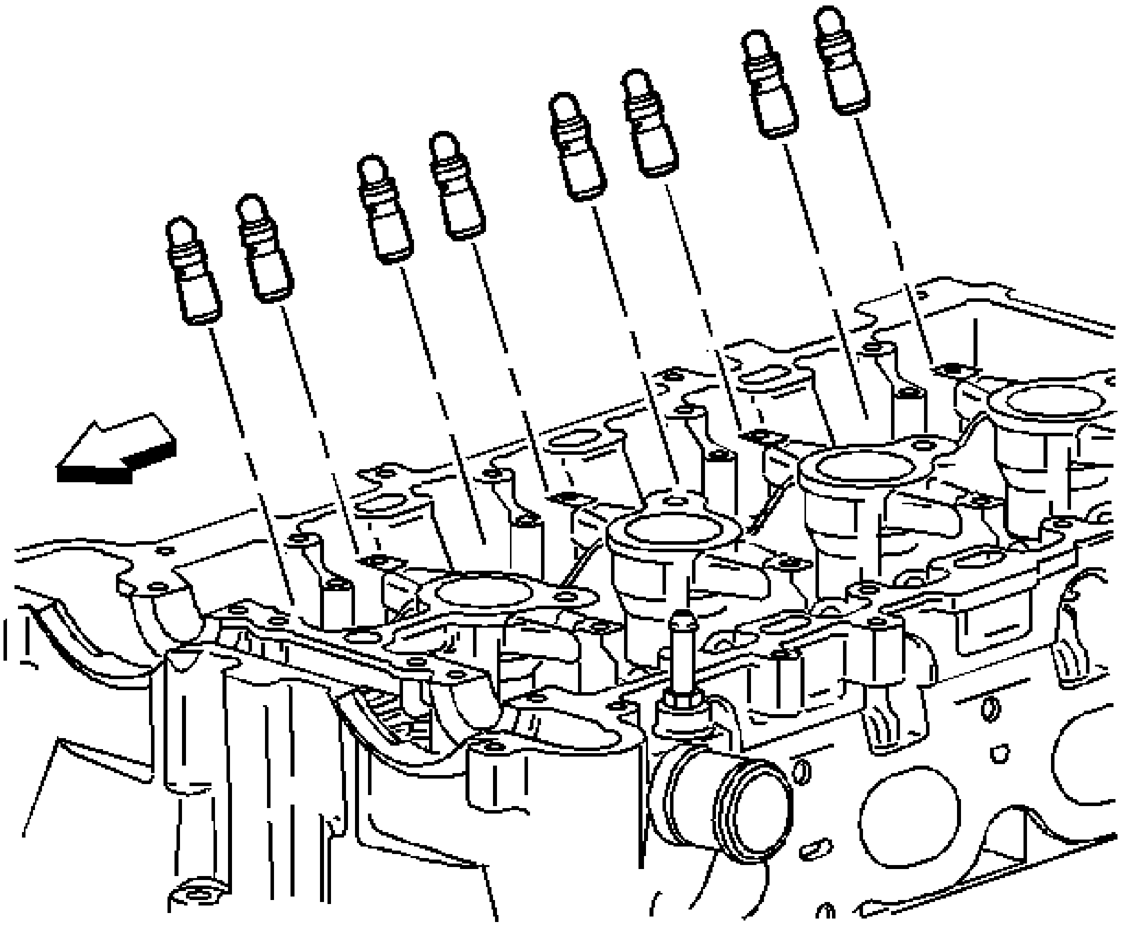


Fig. 246: View Of Hydraulic Element Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

6. Remove the hydraulic element adjusters.

Balance Shaft Drive Chain and Tensioner Removal

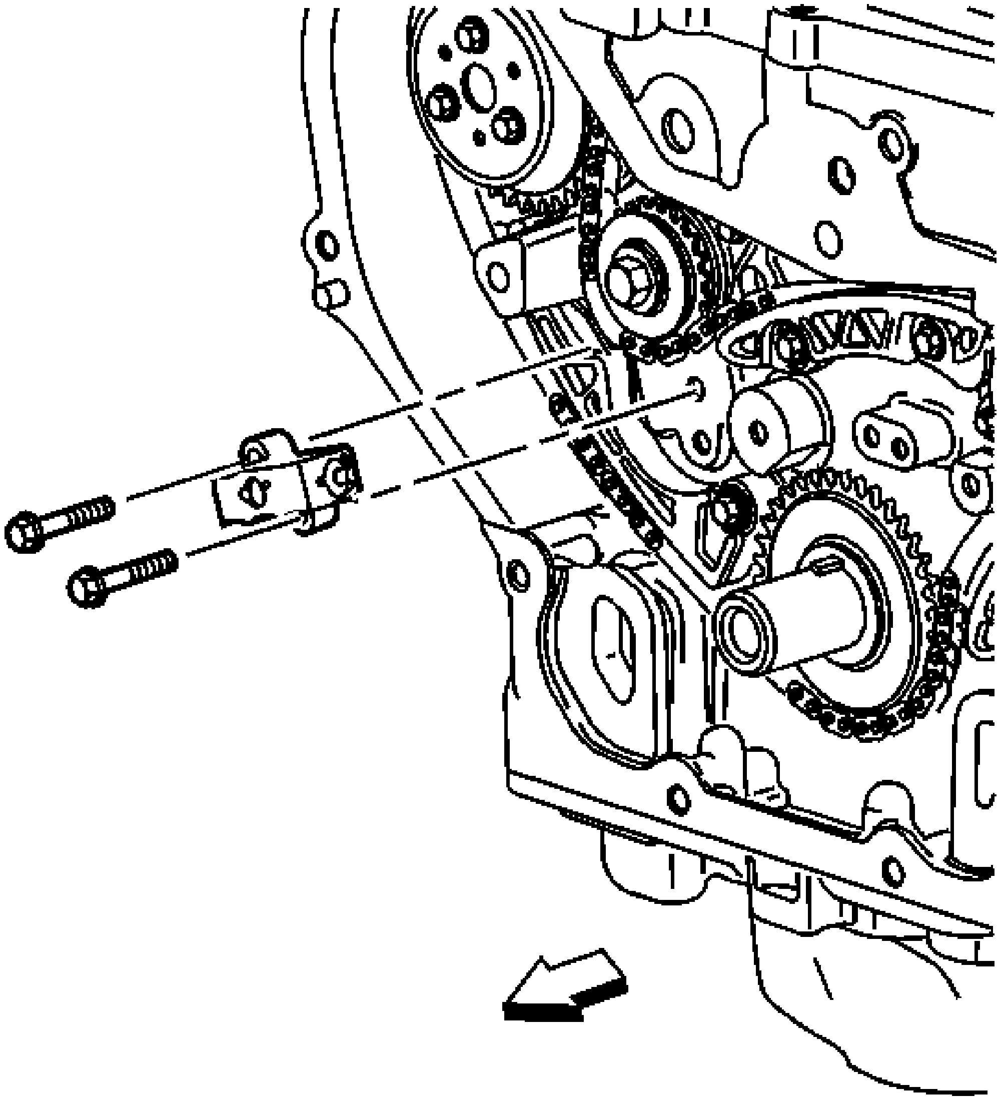


Fig. 247: Identifying Balance Shaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

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

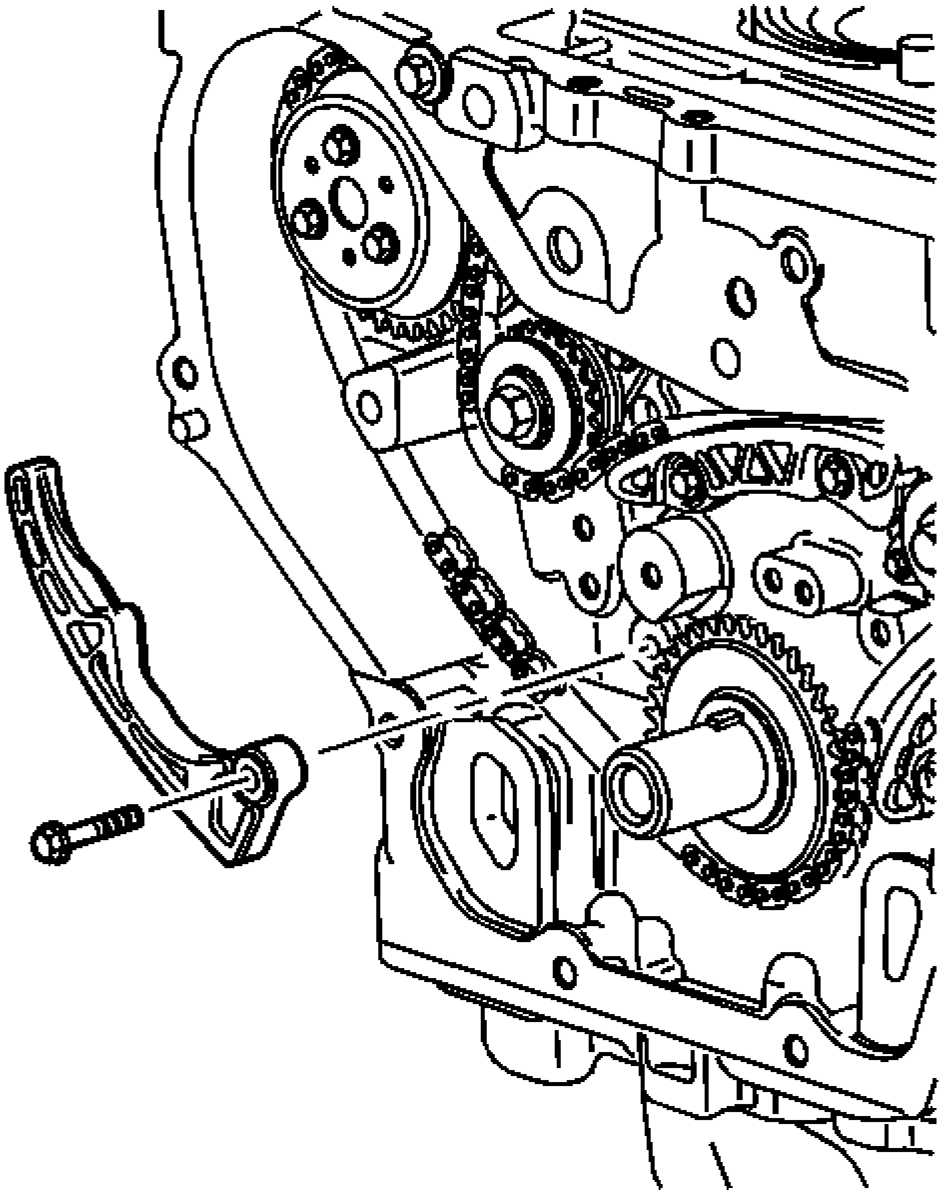


Fig. 248: View Of Adjustable Balance Shaft Chain Guide
Courtesy of GENERAL MOTORS CORP.

3. Remove the adjustable balance shaft chain guide bolt.
4. Remove the adjustable balance shaft chain guide.

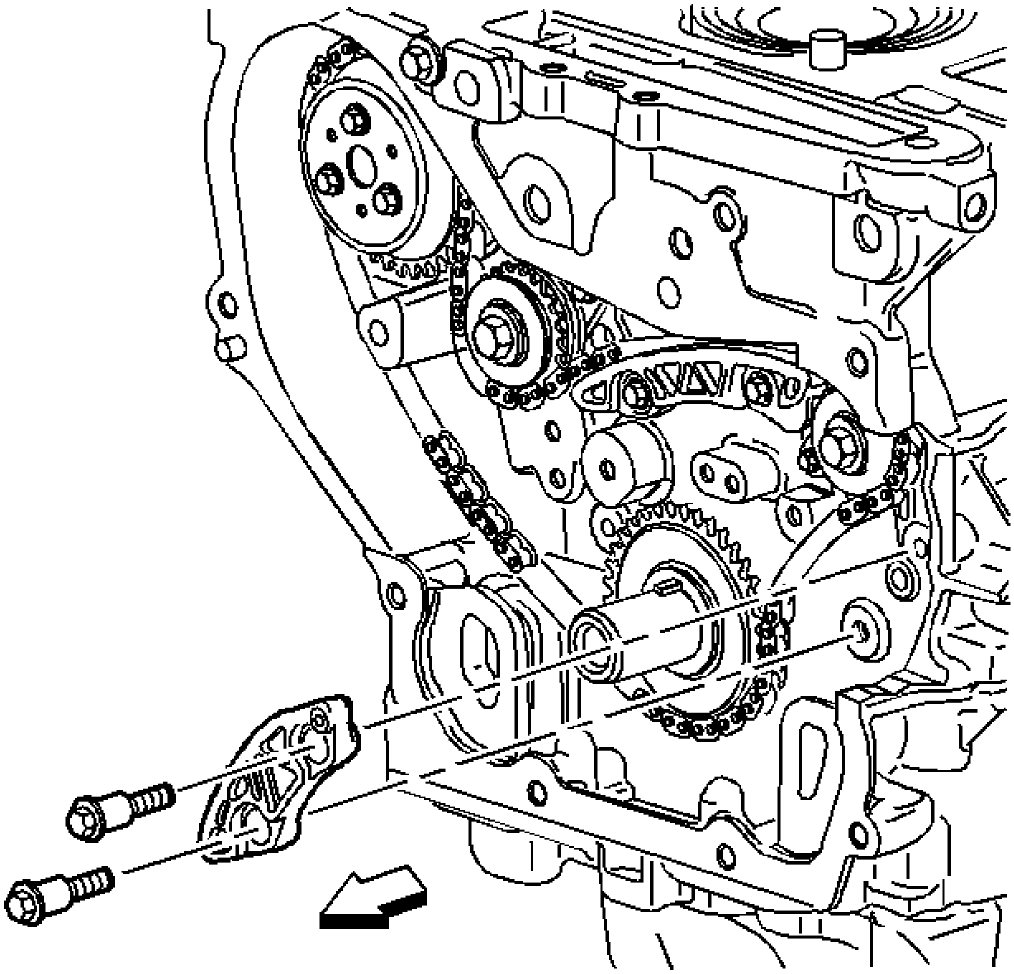


Fig. 249: Exploded View Of Small Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

5. Remove the small balance shaft drive chain guide bolts.
6. Remove the small balance shaft drive chain guide.

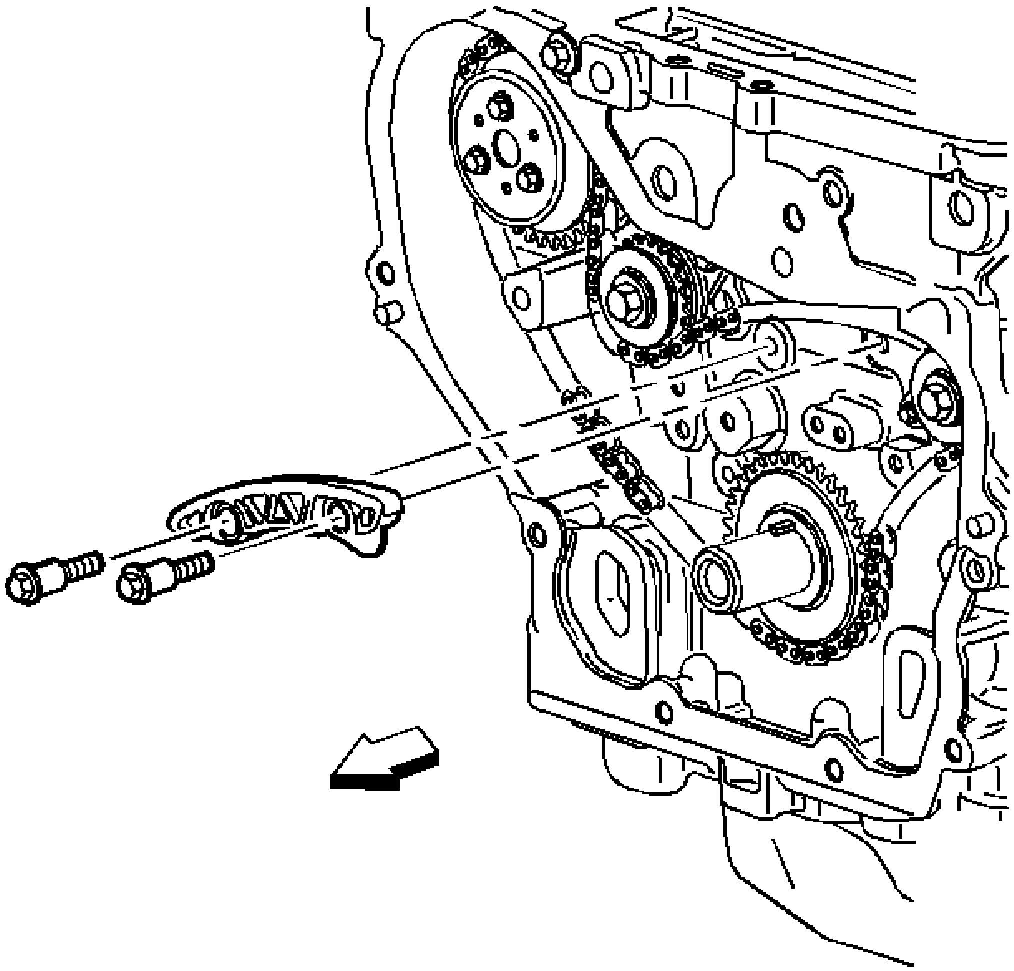


Fig. 250: View Of Upper Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

7. Remove the upper balance shaft drive chain guide bolts.
8. Remove the upper balance shaft drive chain guide.

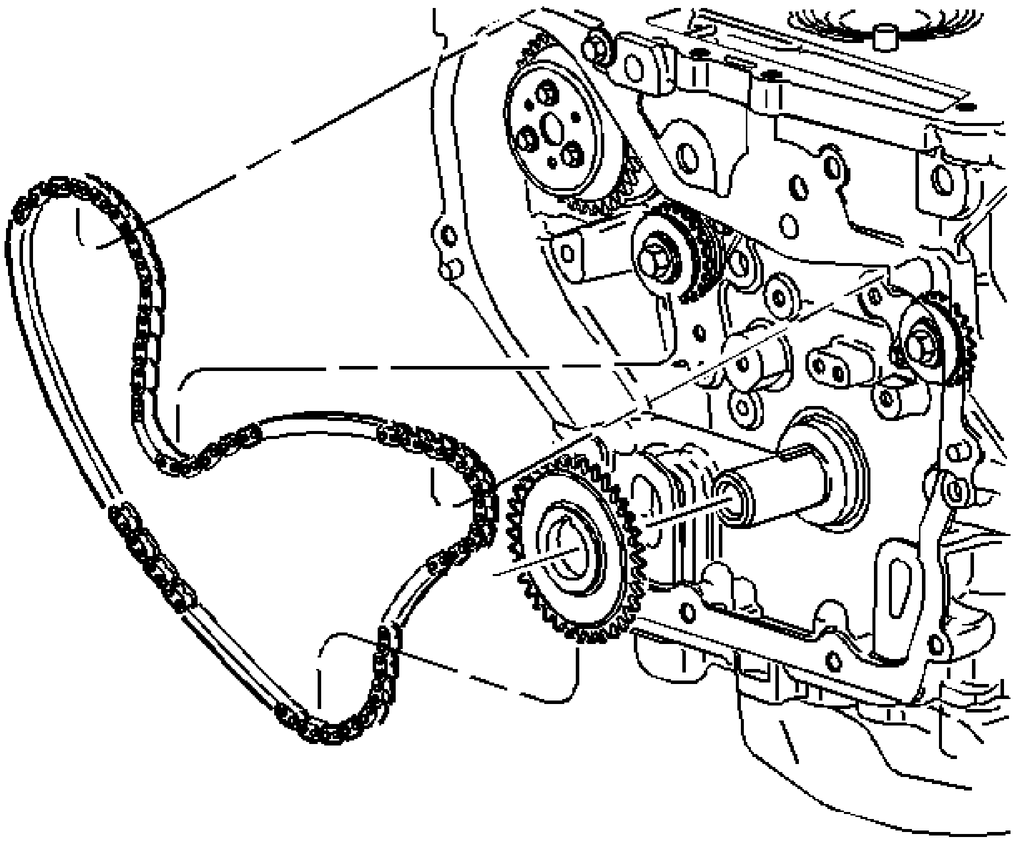


Fig. 251: Identifying Upper Balance Shaft Drive Chain/Sprocket
Courtesy of GENERAL MOTORS CORP.

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

9. Remove the balance shaft drive chain.
10. Remove the balance shaft drive sprocket.

Balance Shaft Removal

Tools Required

J 43650 Balancer Shaft Bearing Remover and Installer. See **Special Tools and Equipment**.

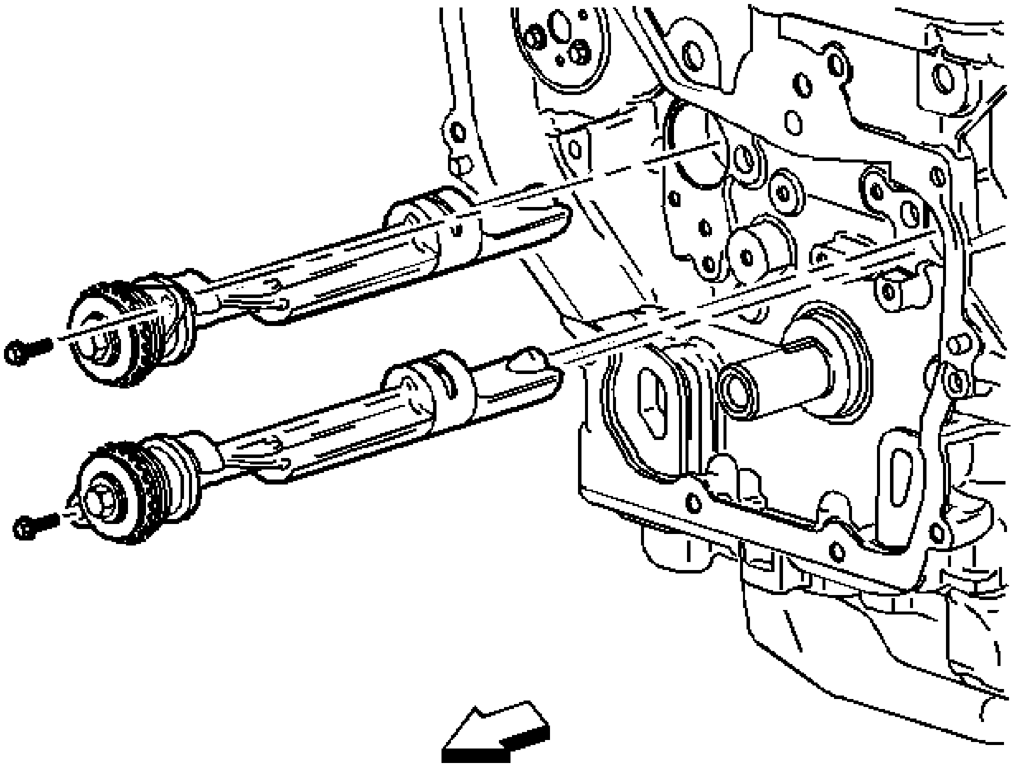


Fig. 252: View Of Balance Shafts assemblies
Courtesy of GENERAL MOTORS CORP.

1. Remove the balance shaft bearing carrier bolts.

IMPORTANT:

- **It is possible to install the intake side balance shaft into the exhaust side and vice versa. Please use care not to install the balance shafts into the wrong bores. Engine vibration will result.**
- **Do not remove the bolt holding the sprocket.**

2. Remove the balance shaft assemblies.

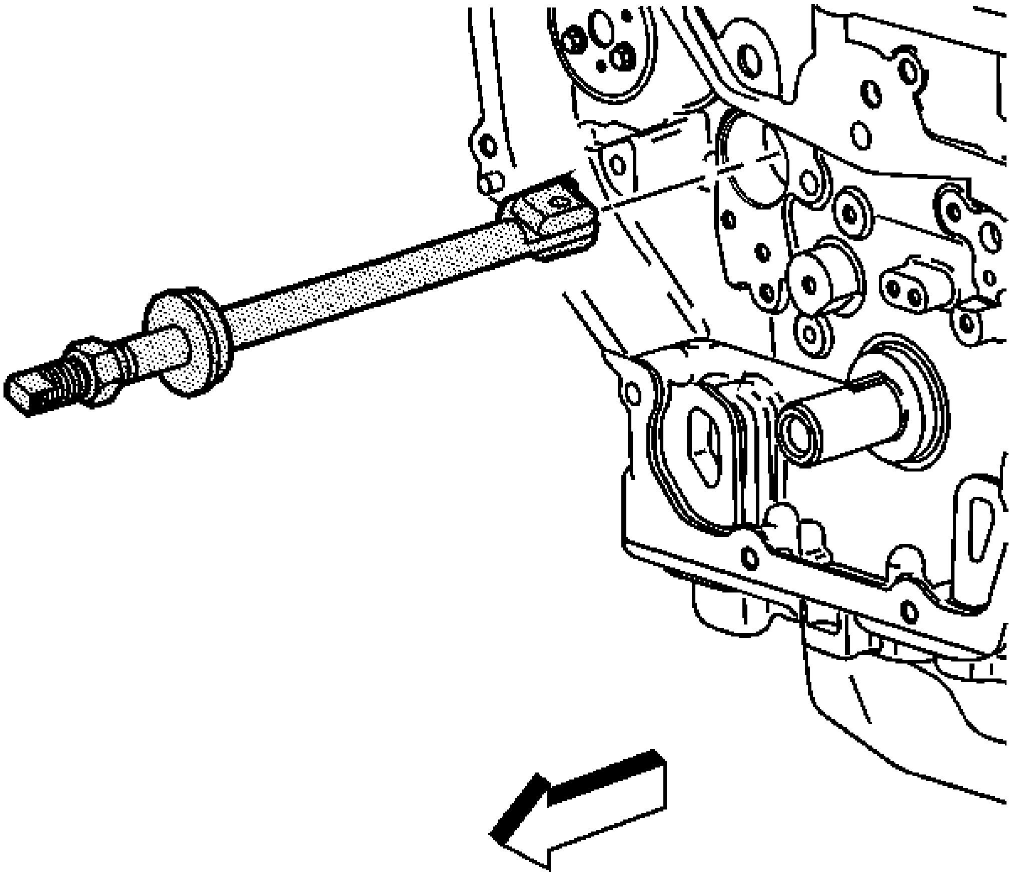


Fig. 253: View of J 46350
Courtesy of GENERAL MOTORS CORP.

NOTE: **Proper centering of the tool is required on the balance shaft bushing. If the tool is not properly centered then damage to the bearing bore and block will occur.**

3. Install the **J 43650** into the balance shaft hole. See **Special Tools and Equipment**. Insert the tool with the foot parallel to the shaft.

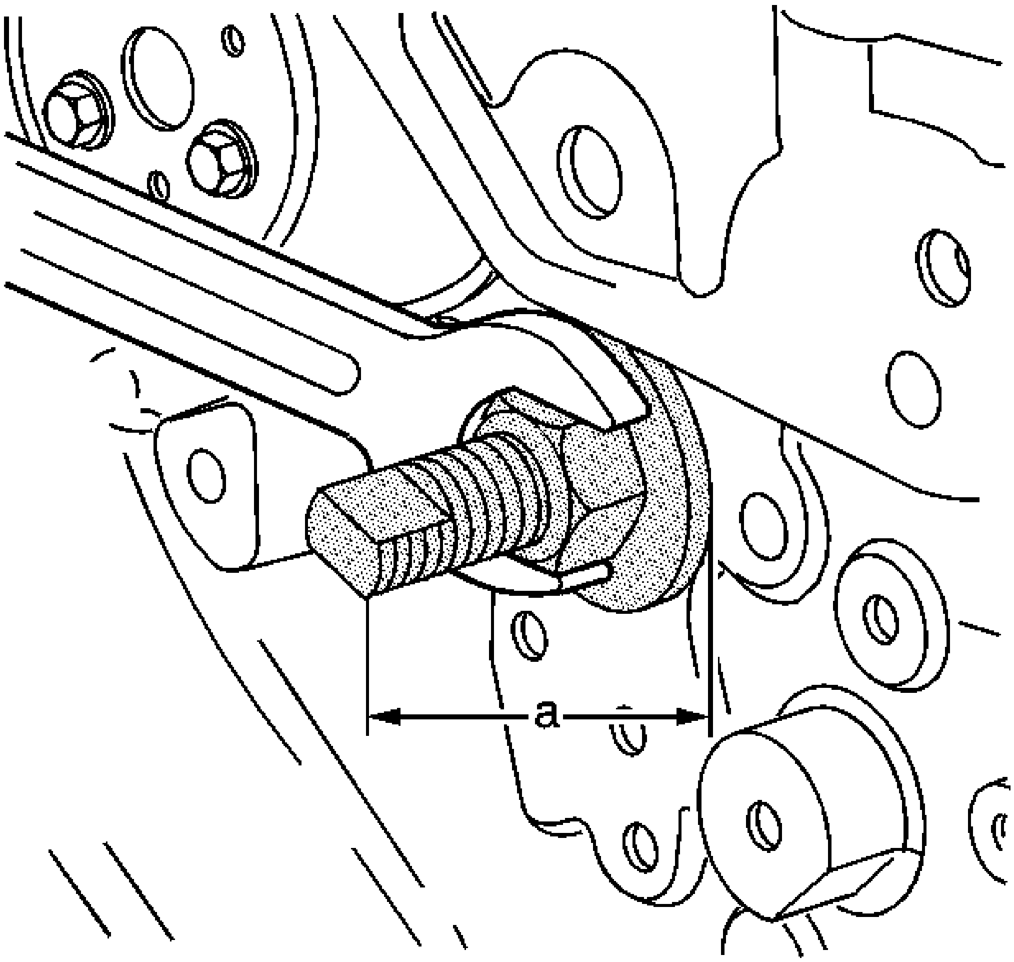


Fig. 254: View of Correct Angle of J 43650
Courtesy of GENERAL MOTORS CORP.

4. When the **J 43650** is inserted in the block turn the **J 43650** so that the foot becomes perpendicular to the shaft. See **Special Tools and Equipment**.
5. Center the foot of the **J 43650** on the balance shaft bushing. See **Special Tools and Equipment**.
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.

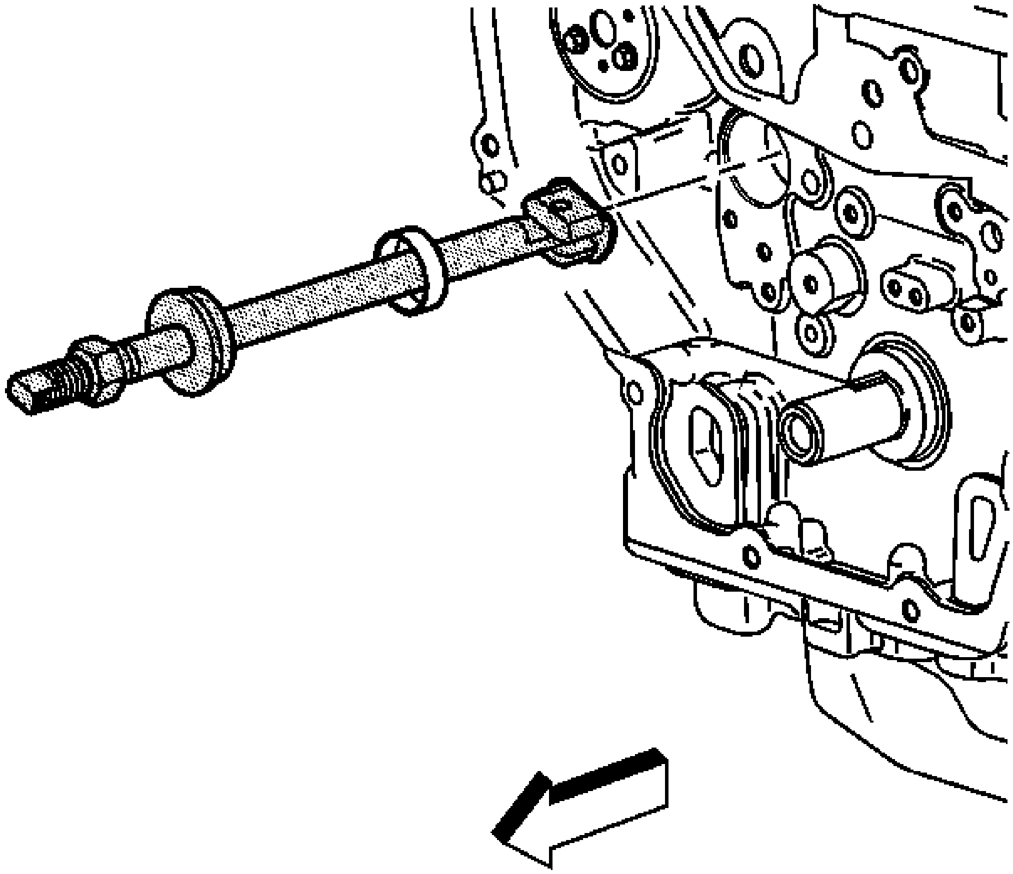


Fig. 255: View of J 43650
Courtesy of GENERAL MOTORS CORP.

7. Tighten the nut on the **J 43650** until the tension releases. When the tension releases, remove the **J 43650** and the balance shaft bushing. See **Special Tools and Equipment**.

Water Pump Removal

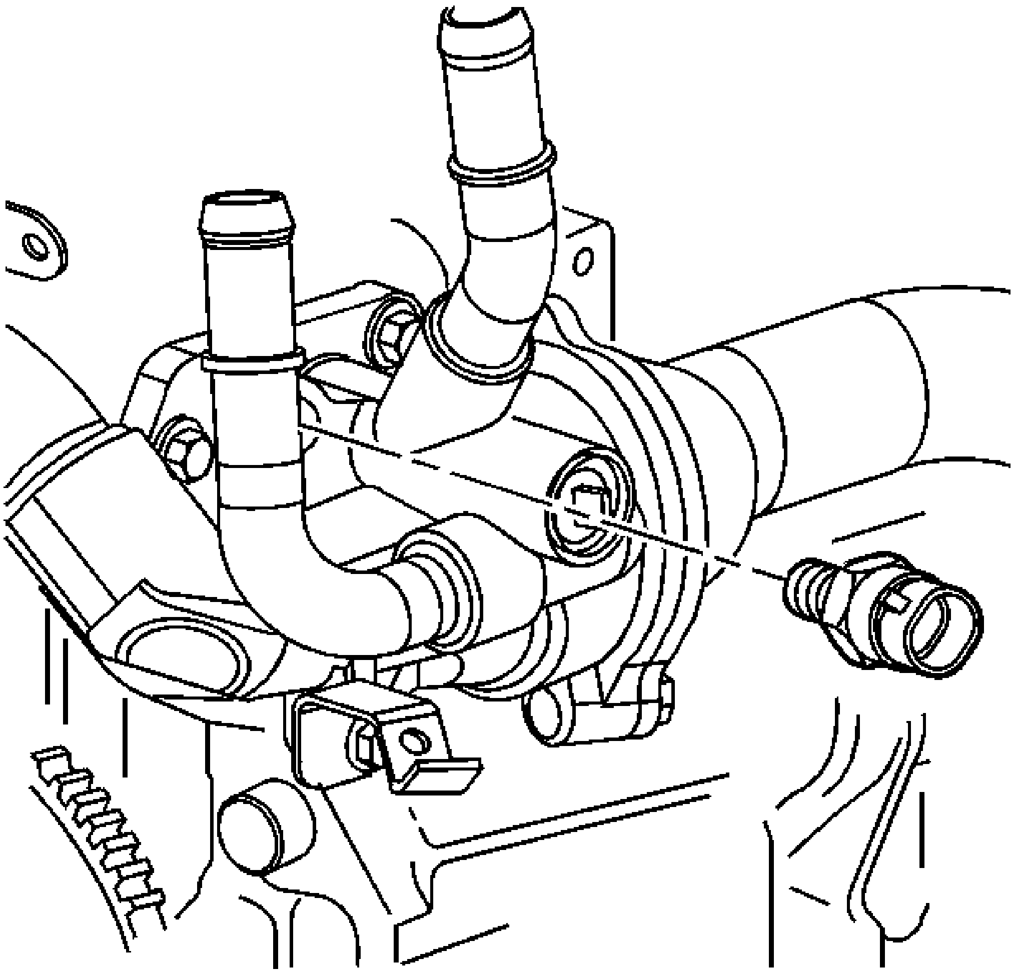


Fig. 256: View Of Engine Coolant Temperature Sensor
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine coolant temperature sensor.

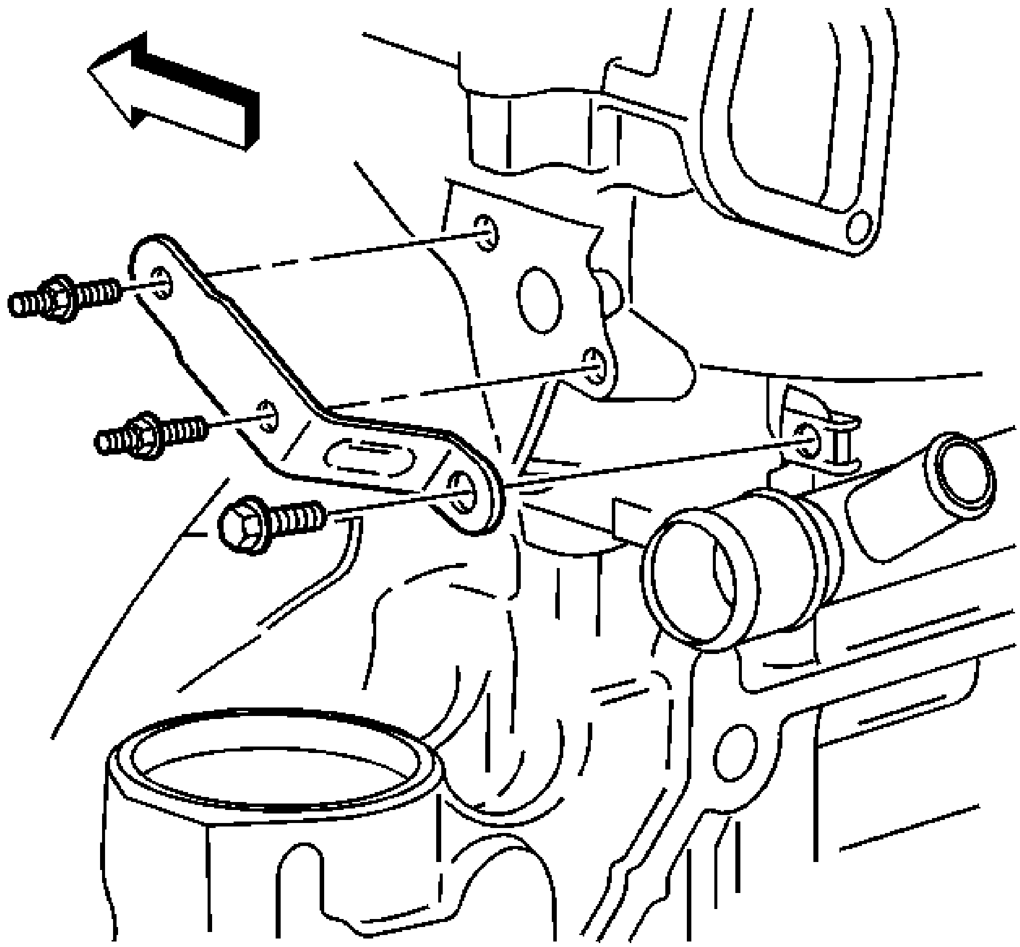


Fig. 257: View Of Water Pipe Support Bracket
Courtesy of GENERAL MOTORS CORP.

2. Remove the water pipe support bracket and bolts.

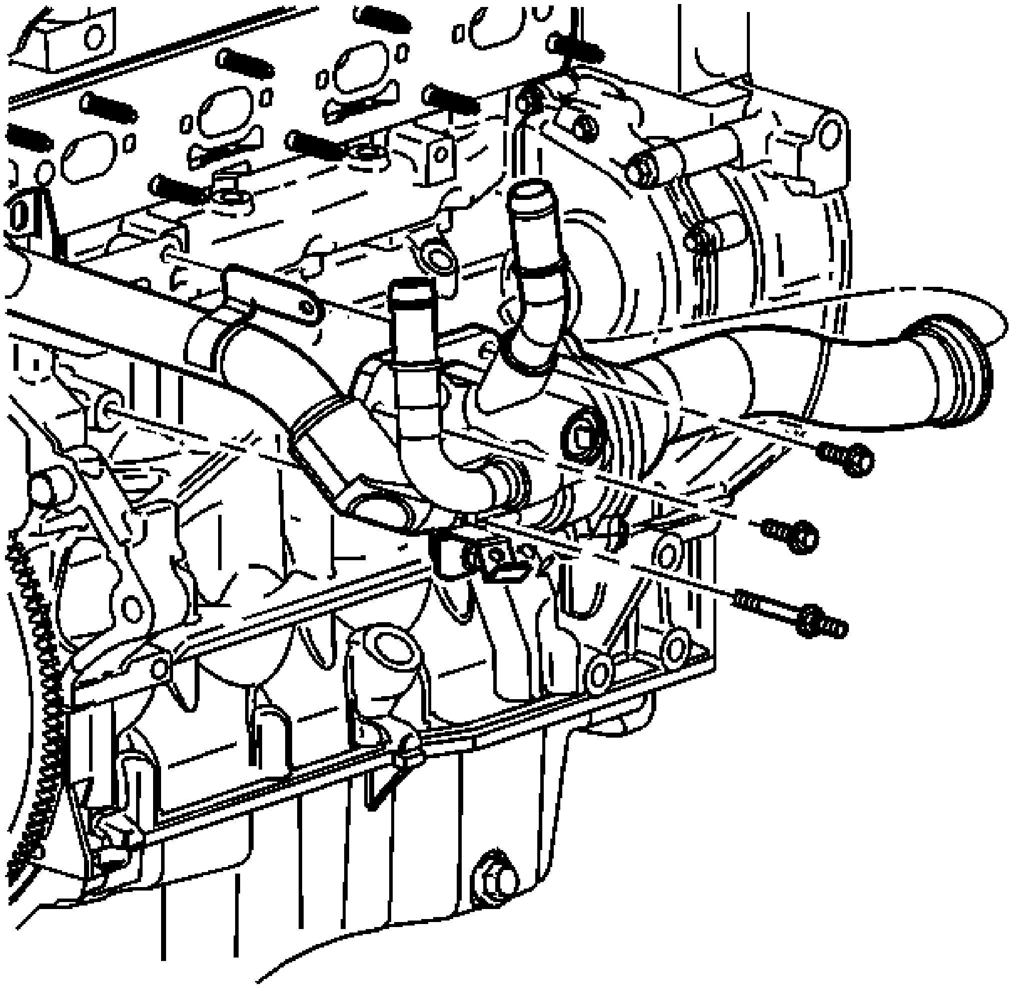


Fig. 258: Identifying Thermostat & Water Feed Pipe Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

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.

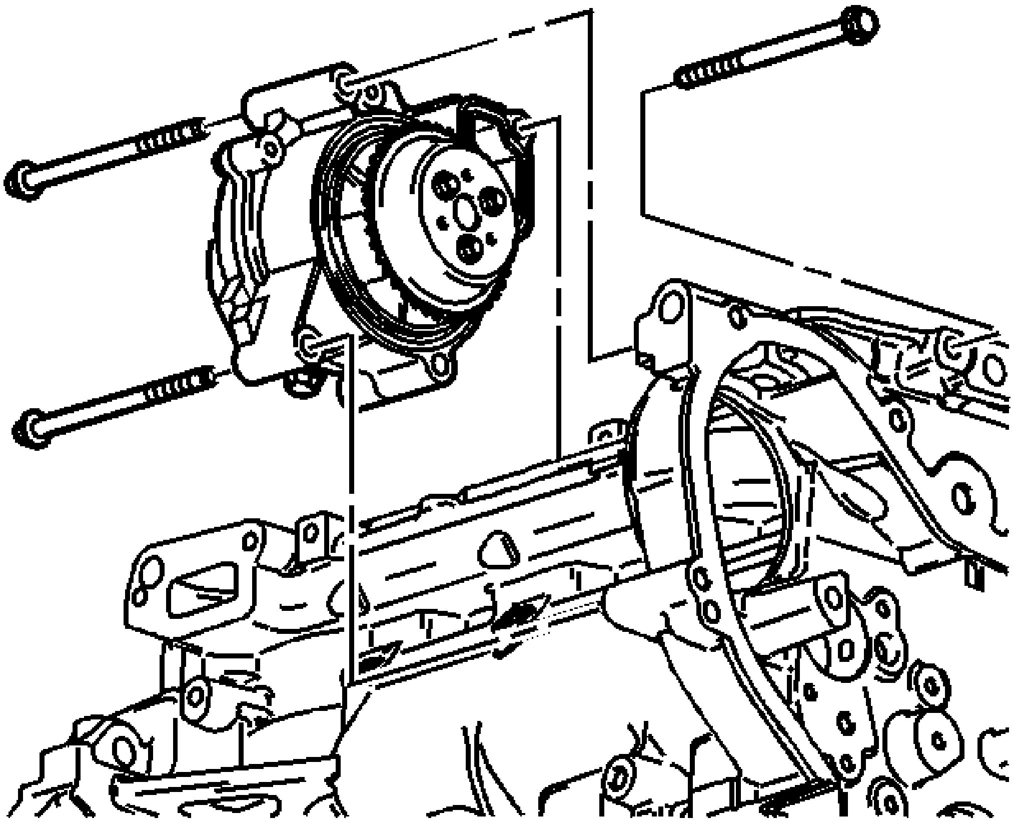


Fig. 259: View Of Water Pump Assembly
Courtesy of GENERAL MOTORS CORP.

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**.

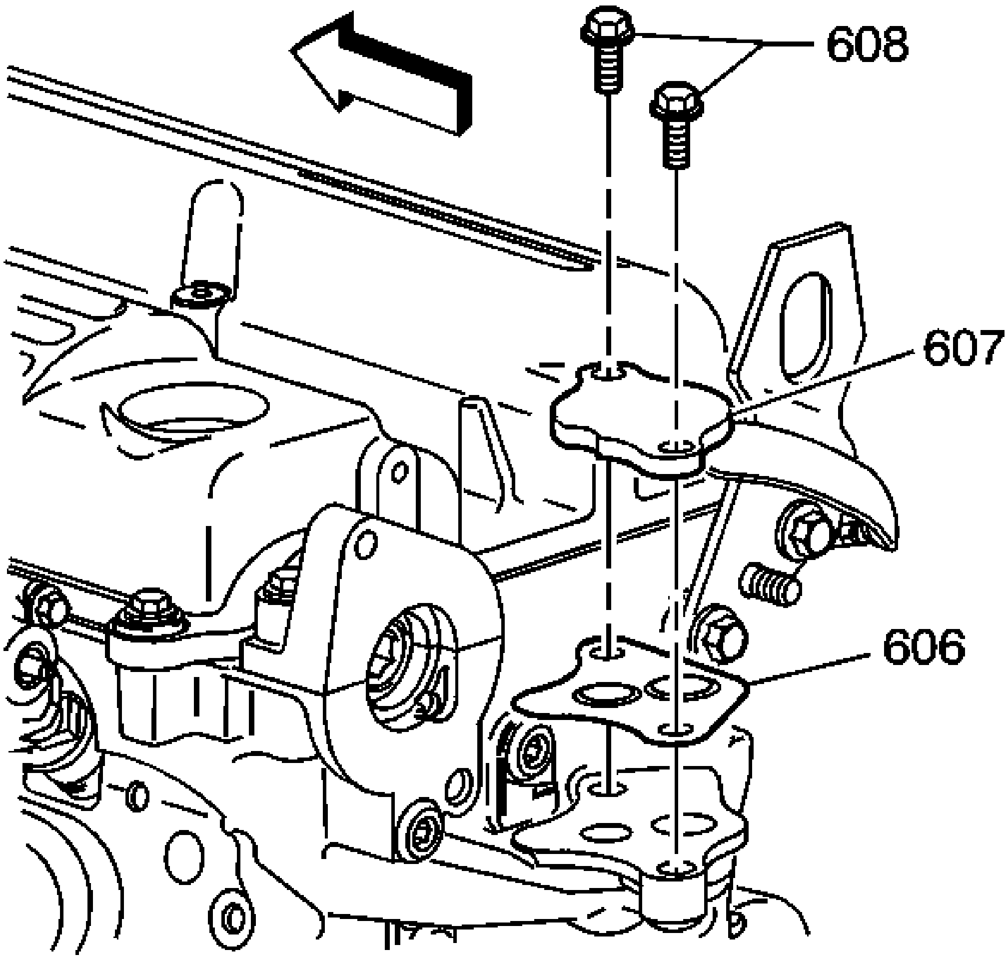


Fig. 260: View of EGR Cover
Courtesy of GENERAL MOTORS CORP.

1. Remove the EGR cover (607), the bolts (608), and the EGR cover gasket (606).

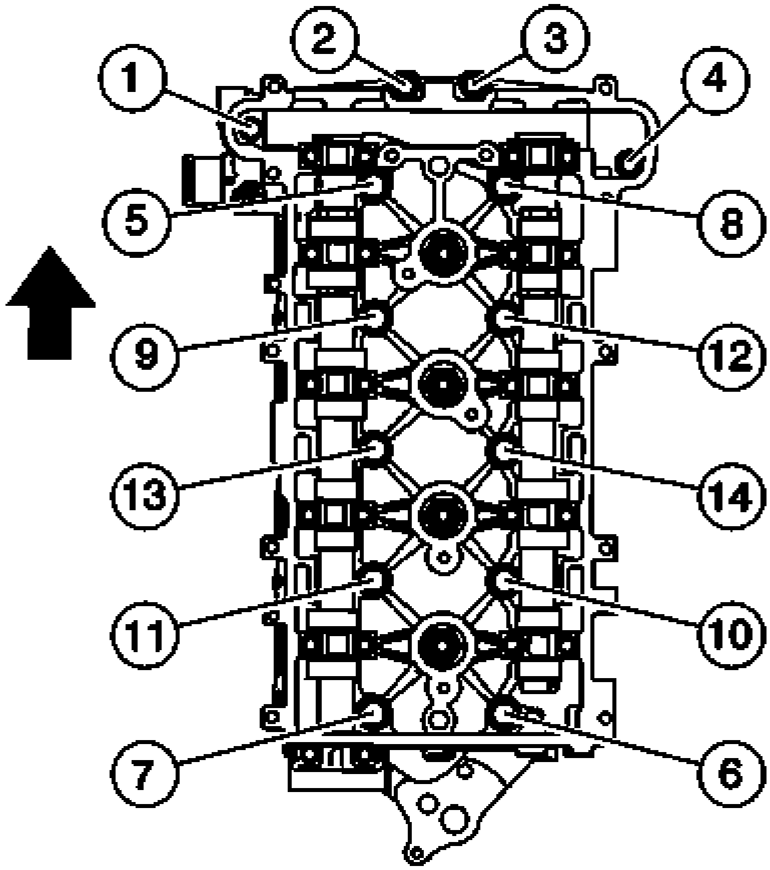


Fig. 261: Cylinder Head Bolt Removal Sequence
Courtesy of GENERAL MOTORS CORP.

2. Remove the cylinder head to the block bolts in sequence.

   Discard the bolts.

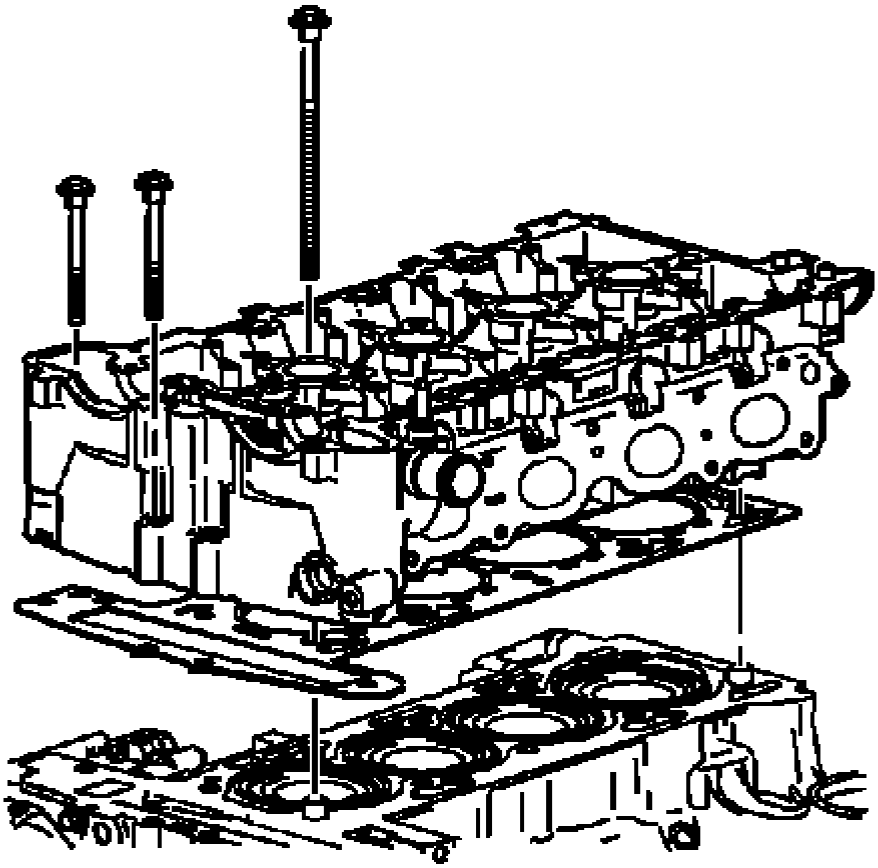


Fig. 262: View Of Cylinder Head And Gasket
Courtesy of GENERAL MOTORS CORP.

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

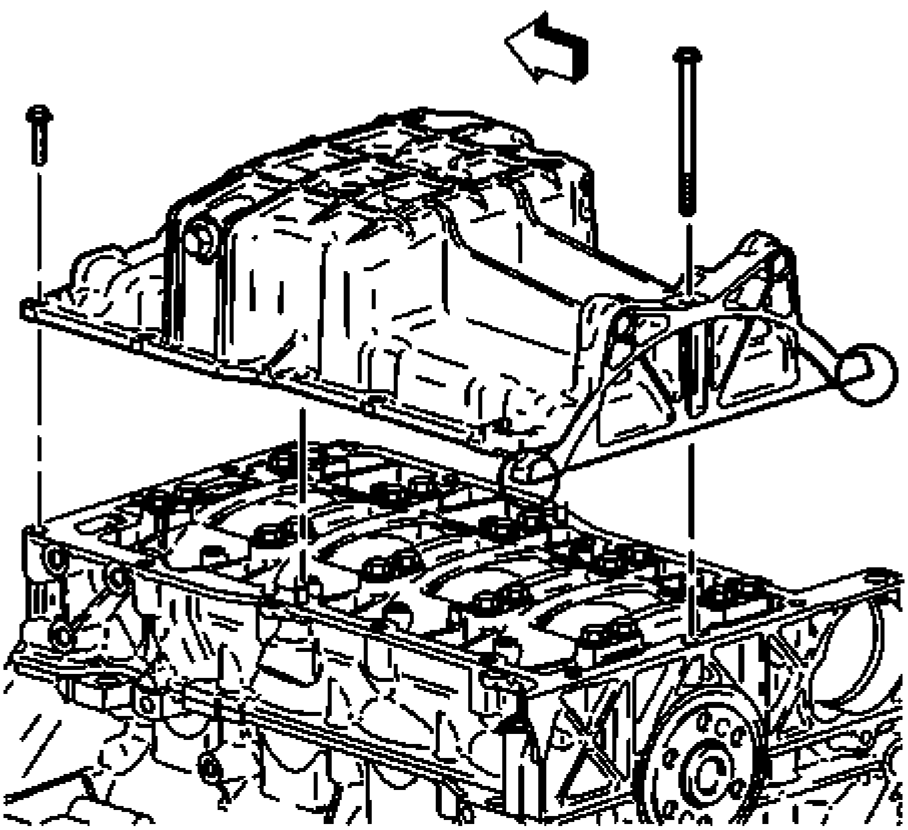


Fig. 263: View Of Oil Pan
Courtesy of GENERAL MOTORS CORP.

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**.

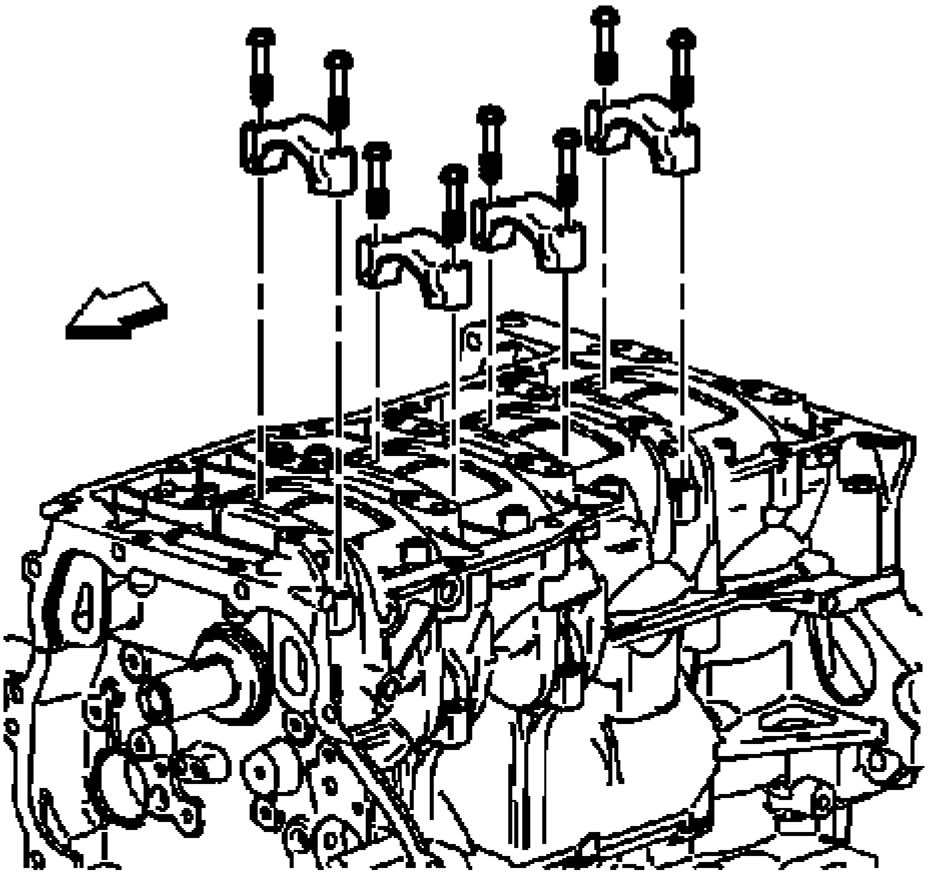


Fig. 264: View Of Connecting Rod Nuts And Caps
Courtesy of GENERAL MOTORS CORP.

1. Rotate the crankshaft to a position where the connecting rod bolts are the most accessible.
2. Mark the connecting rod and cap with the cylinder position. Also mark their orientation. This will ensure the caps and connecting rods are re-assembled properly.
3. Remove any ridge at the top of the cylinder bore to avoid damage to the piston ring lands.
4. Remove the connecting rod bolts.
5. Remove the connecting rod cap.

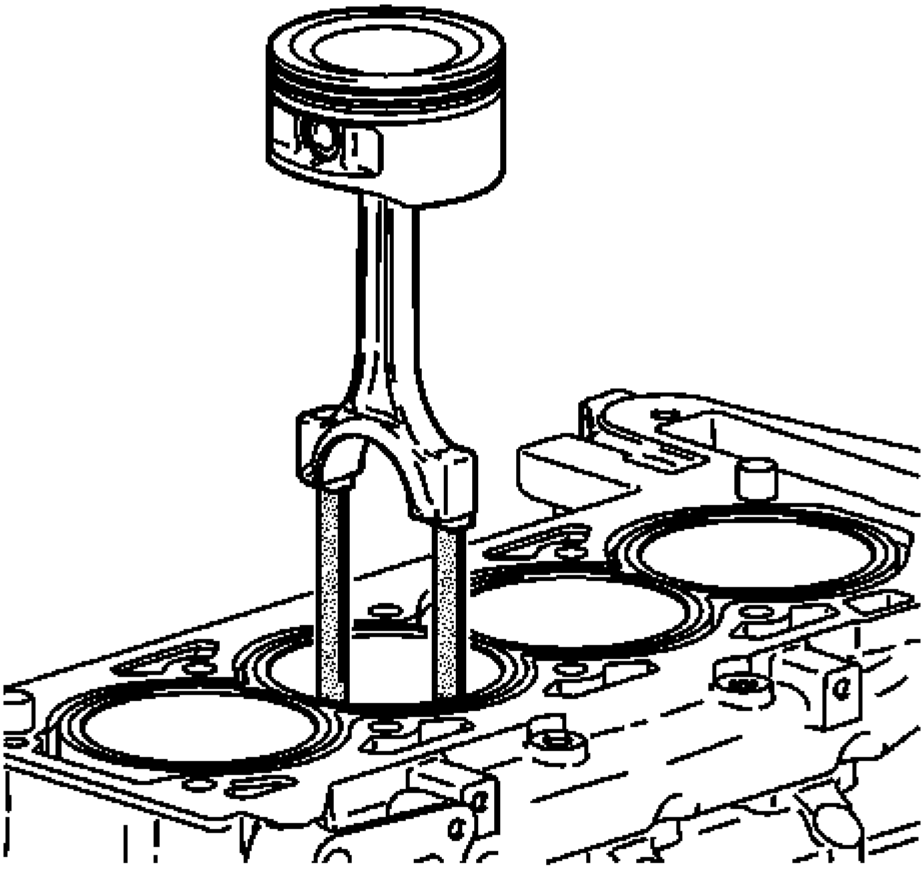


Fig. 265: J-43966-1 Installed Into Connecting Rod Bolt Holes
Courtesy of GENERAL MOTORS CORP.

6. Install **J-43966-1** on the connecting rod bolts before removing the piston and connecting rod assembly. See **Special Tools and Equipment**.
7. Remove the piston and connecting rod assembly.

Lower Crankcase Removal

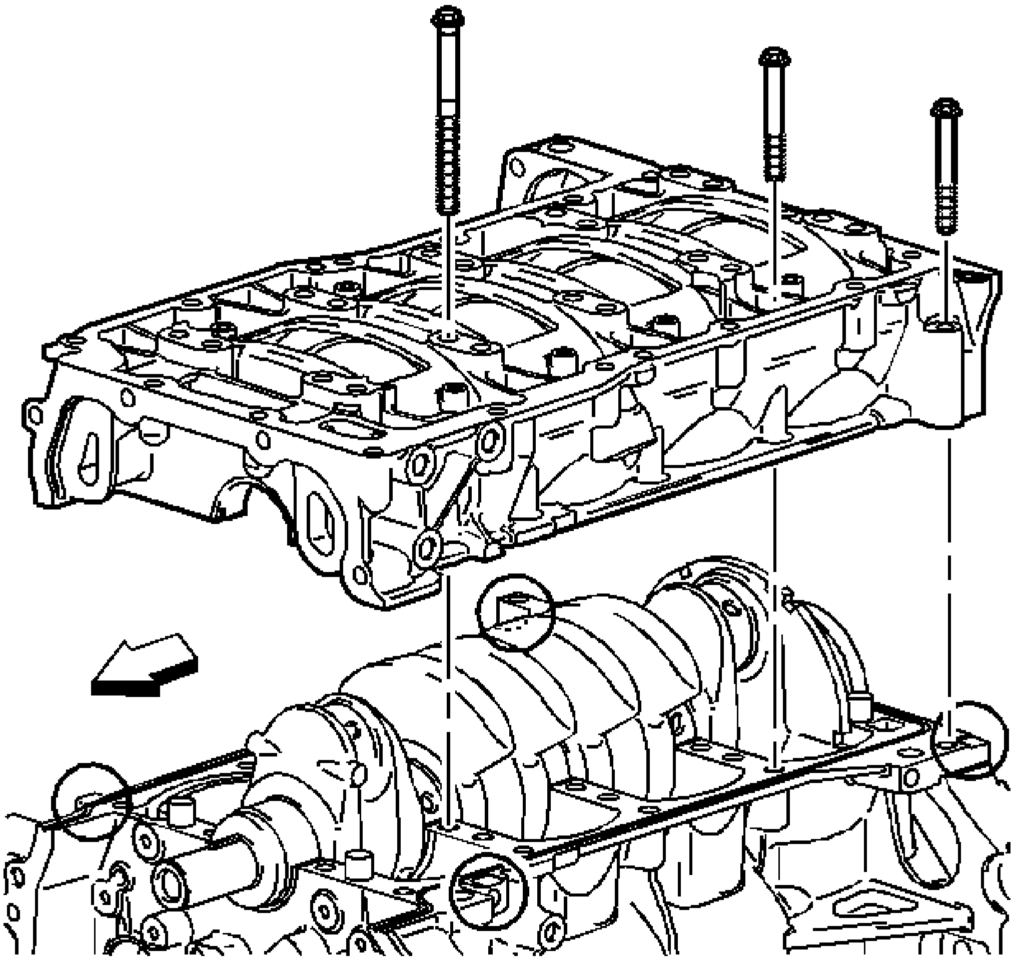


Fig. 266: View Of Upper & Lower Crankcase W/Bolts
Courtesy of GENERAL MOTORS CORP.

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

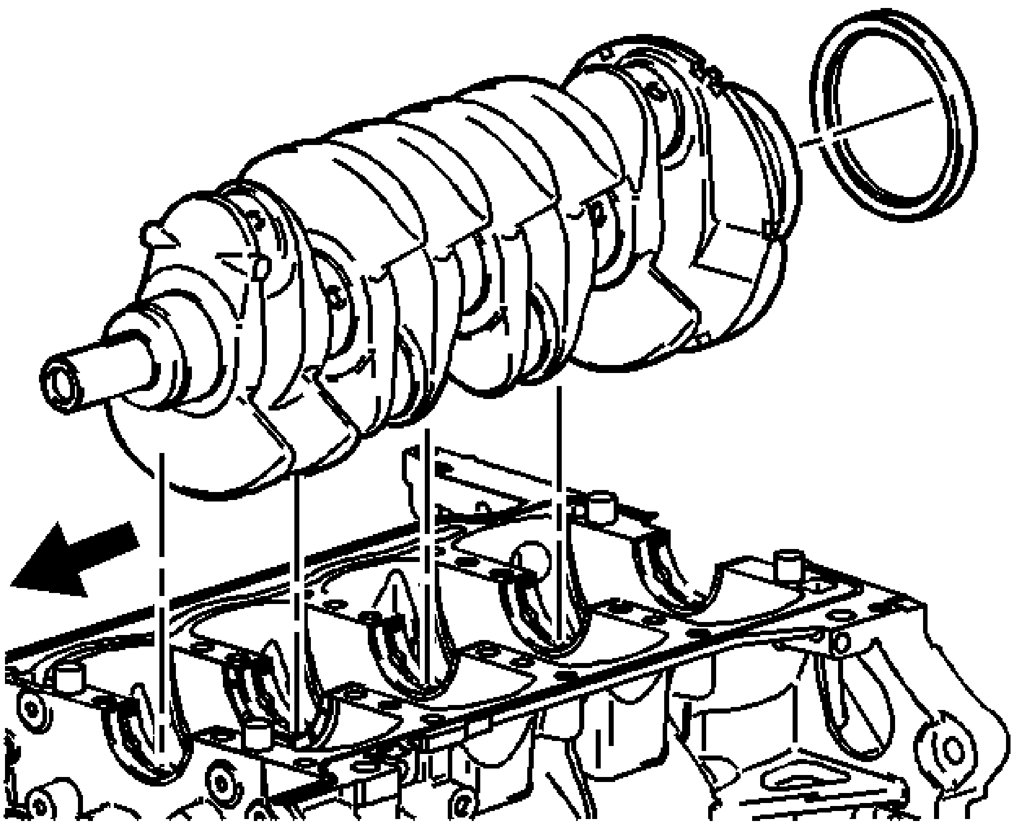


Fig. 267: View of Crankshaft
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft from the block.
2. Remove the crankshaft rear oil seal from the block.

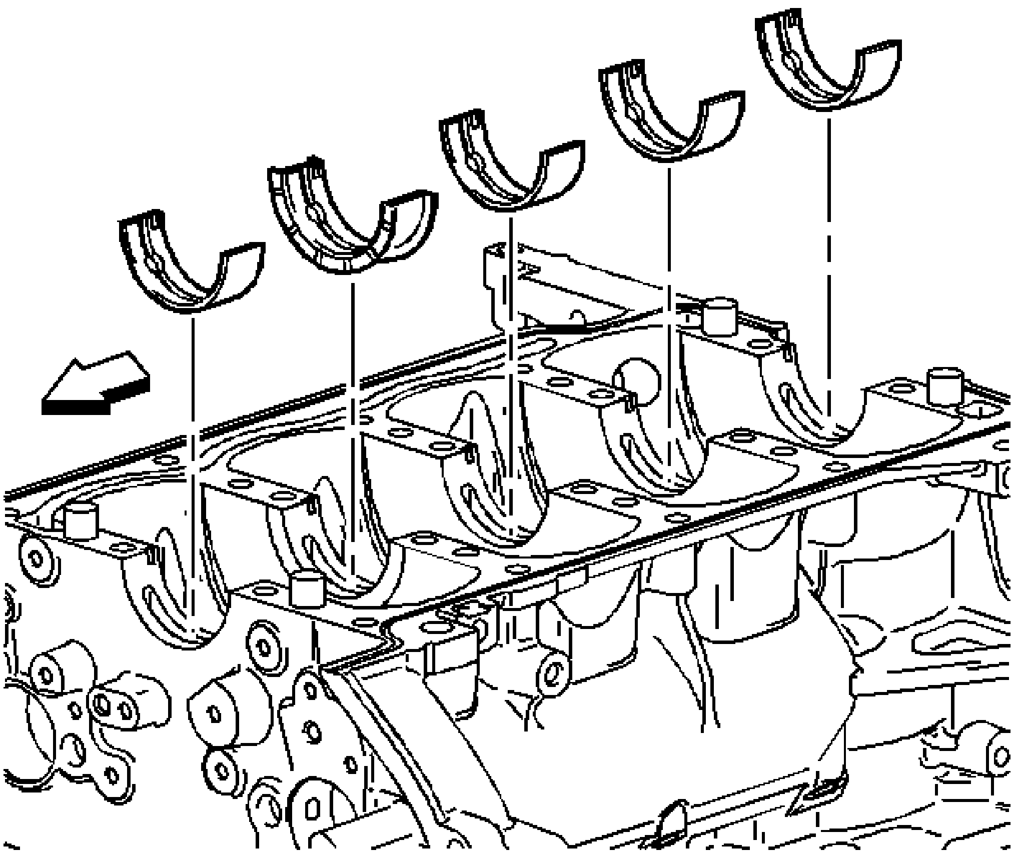


Fig. 268: View Of Crankshaft Bearing Inserts
Courtesy of GENERAL MOTORS CORP.

3. Remove the bearing inserts from the block.

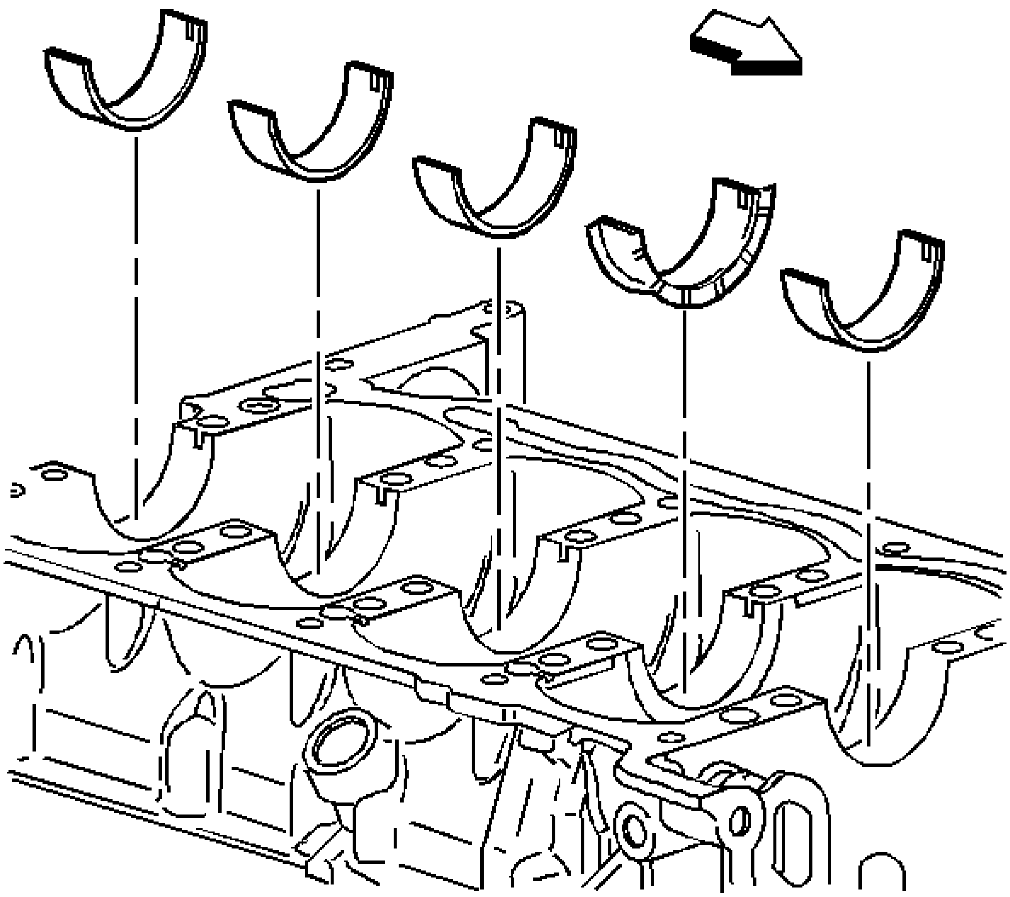


Fig. 269: Identifying Crankshaft Bearing Inserts
Courtesy of GENERAL MOTORS CORP.

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

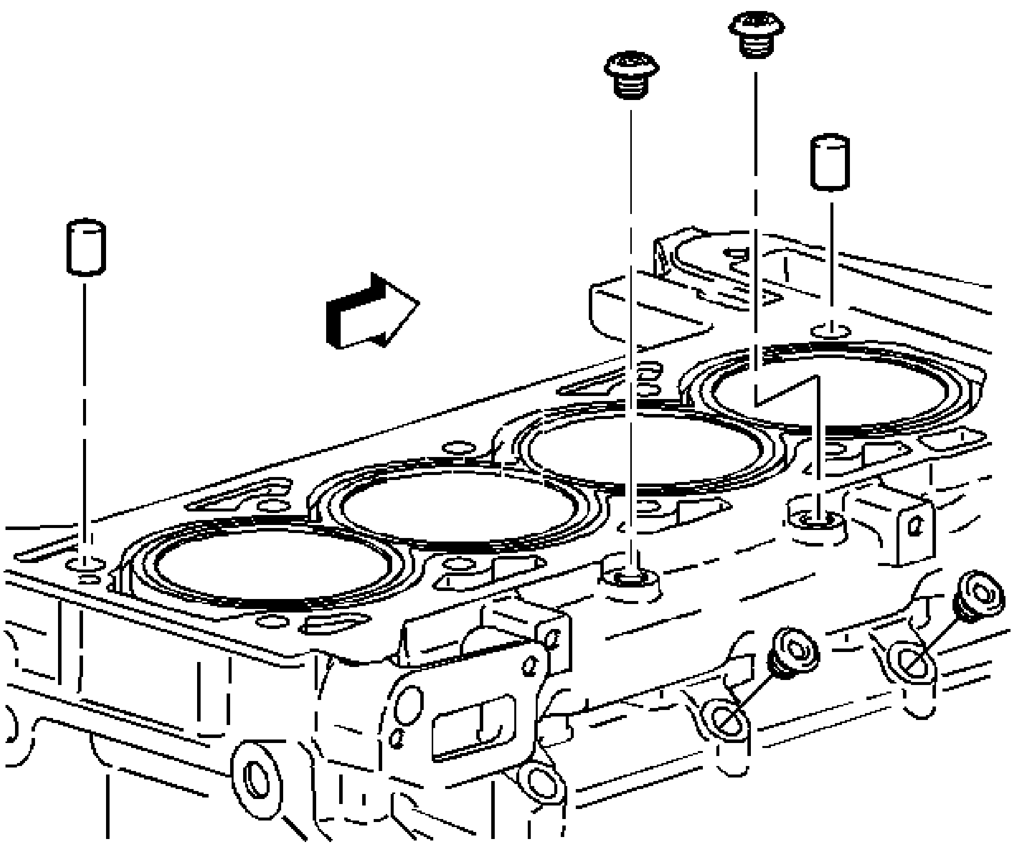


Fig. 270: View Of Oil Passage Plug, Oil Flow Check Valve & Water Jacket Drain Plug

Courtesy of GENERAL MOTORS CORP.

1. Remove the water jacket drain plug.
2. Remove the oil flow check valve.
3. Remove the rear oil passage plug.
4. Remove the 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.

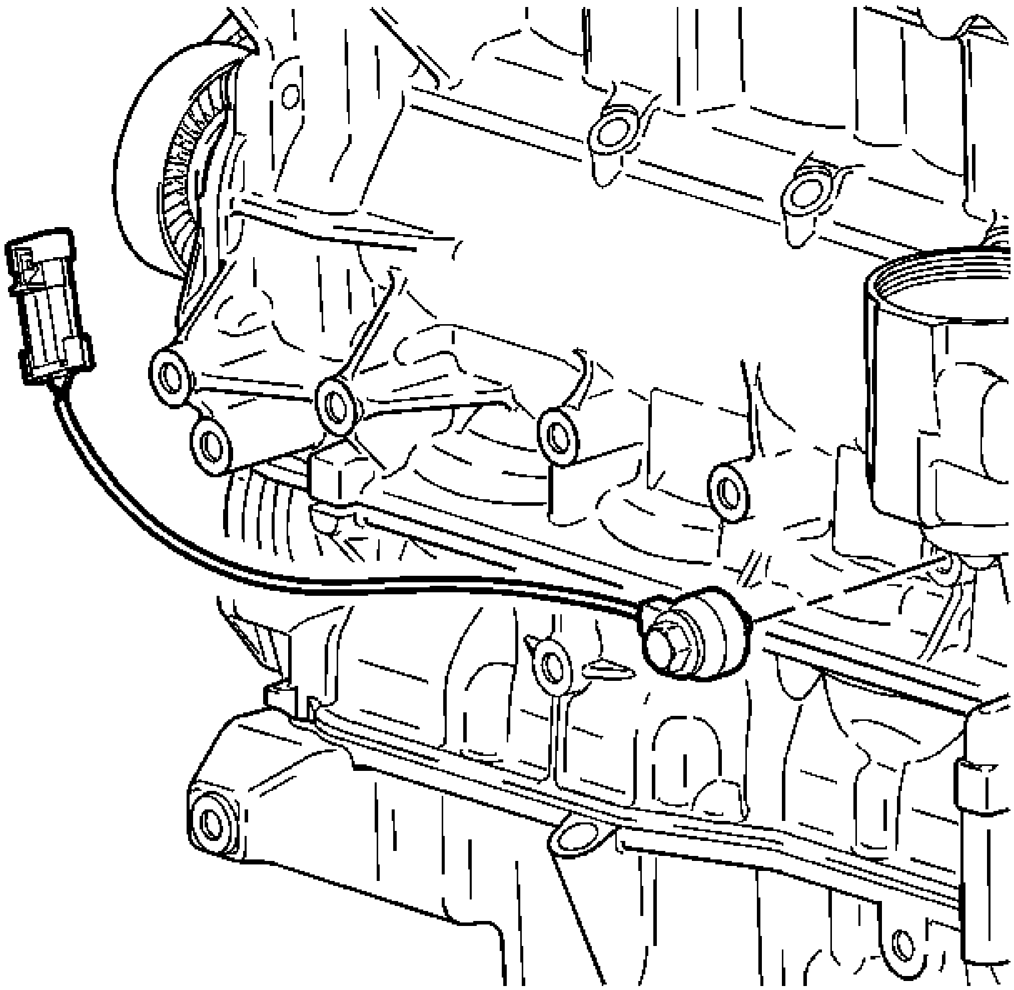


Fig. 271: View of Knock Sensor
Courtesy of GENERAL MOTORS CORP.

7. Remove the knock sensor and bolt.

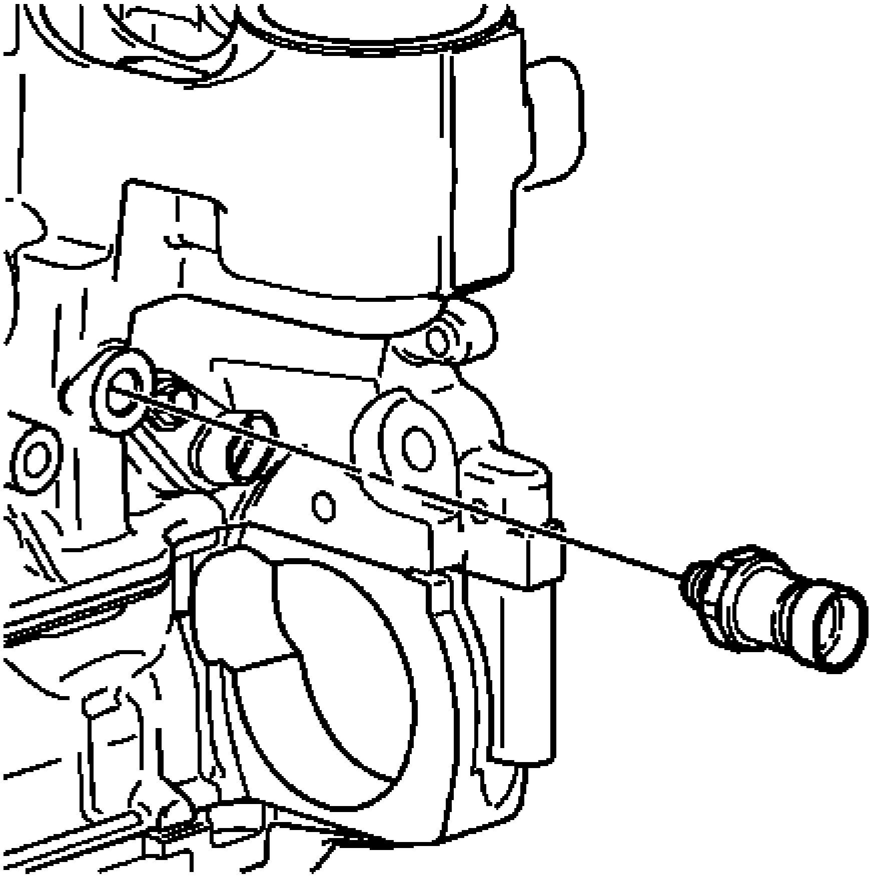


Fig. 272: View Of Engine Oil Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

8. Remove the oil pressure switch.

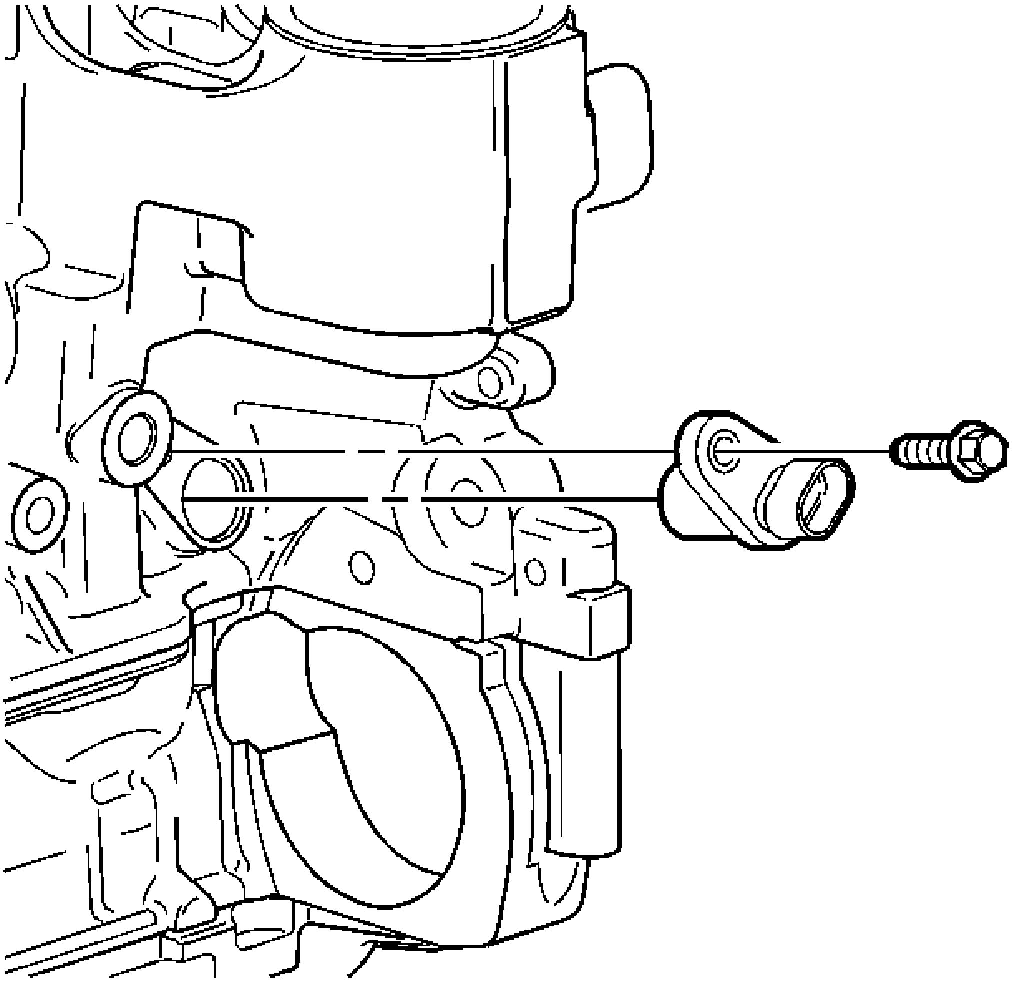


Fig. 273: View Of Crankshaft Position Sensor
Courtesy of GENERAL MOTORS CORP.

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**.

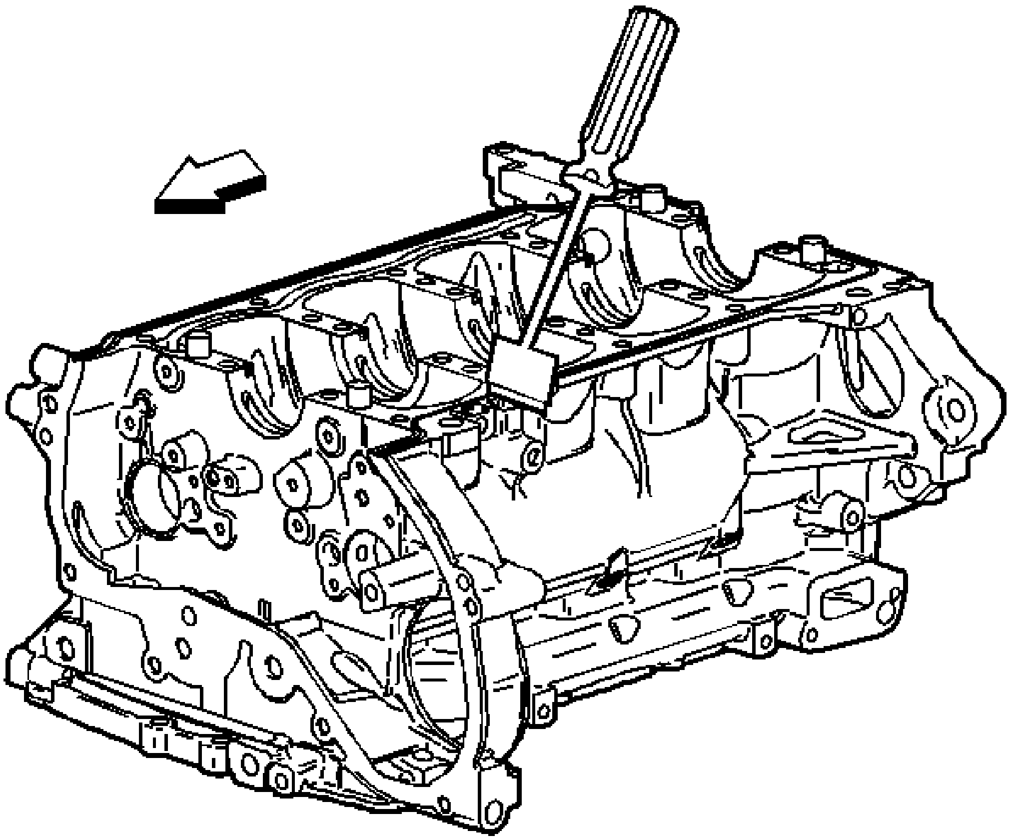


Fig. 274: View of Gasket Mating Surfaces
Courtesy of GENERAL MOTORS CORP.

1. Clean the sealing material from the gasket mating surfaces.
2. Clean the engine block and lower crankcase in a cleaning tank with solvent appropriate for aluminum.
3. Flush the engine block with clean water or steam.
4. Clean the oil passages.
5. Clean the blind holes.
6. Spray the cylinder bores and the machined surfaces with engine oil.
7. Inspect the threaded holes. Clean the threaded holes with a rifle brush. If necessary, drill out the holes and install thread inserts. Refer to **Thread Repair**.

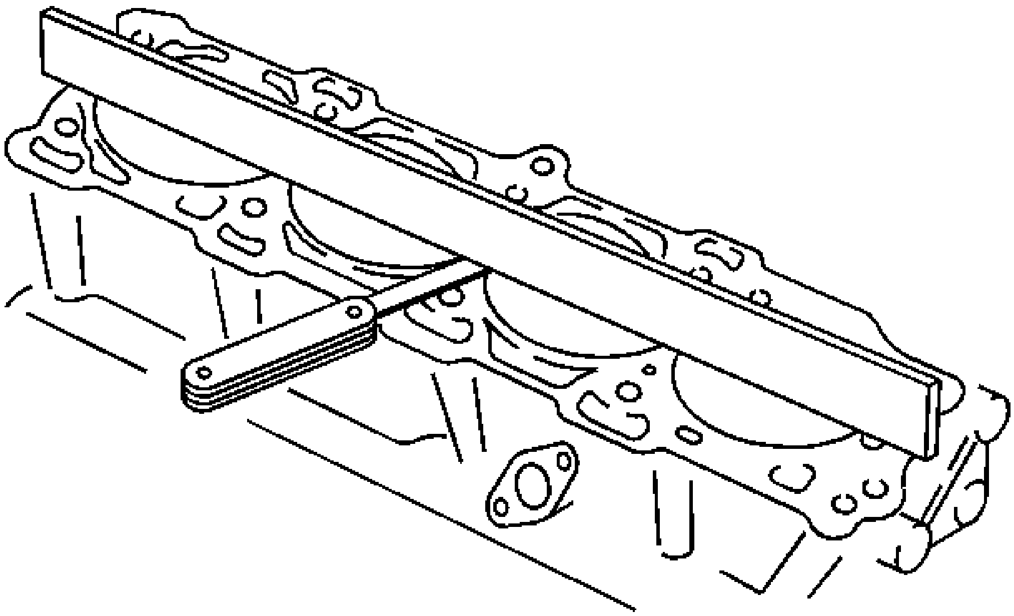


Fig. 275: Using Straight Edge & Feeler to Check Deck Surface for Flatness
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not attempt to machine the lower crankcase to engine block surfaces.

8. Use a straight edge and a feeler gage to check the deck surface for flatness. Carefully machine minor irregularities. Replace the block if more than 0.254 mm (0.010 in) must be removed.
9. Inspect the oil pan rail for nicks. Inspect the front cover attaching area for nicks. Use a flat mill file to remove any nicks.

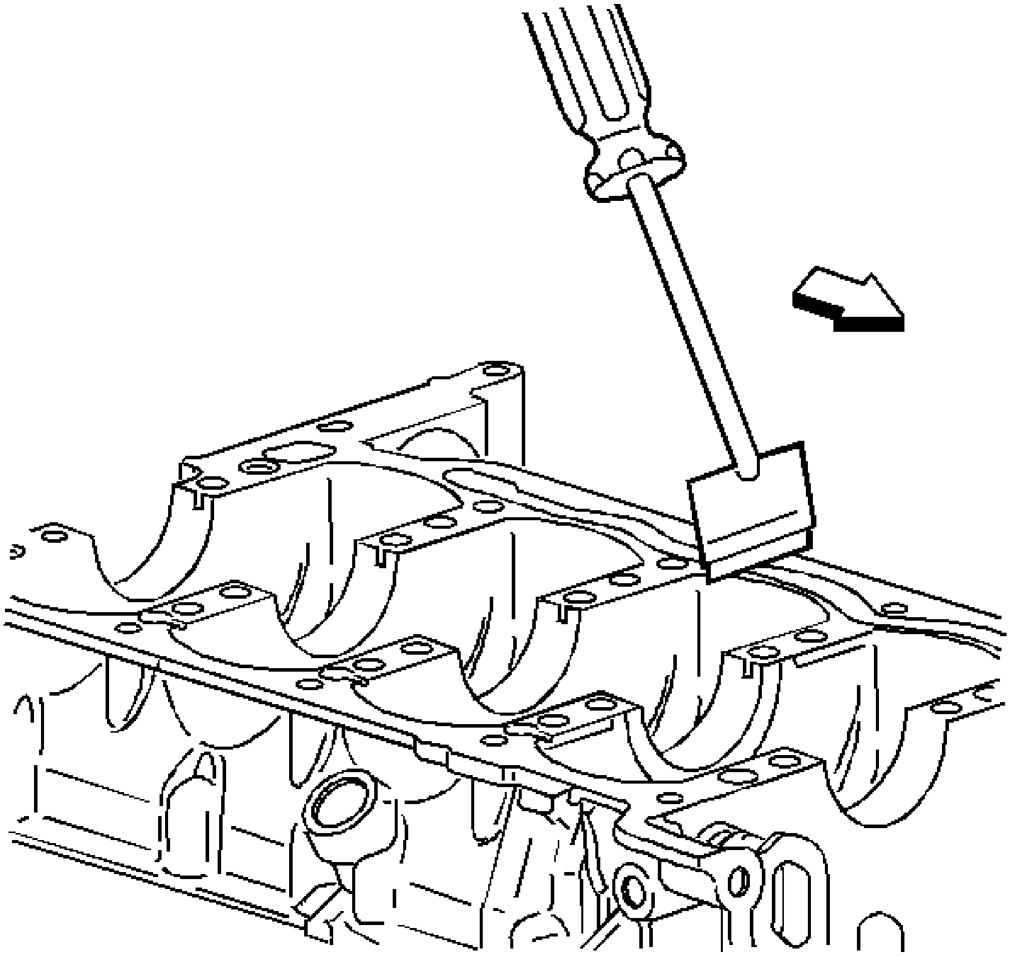


Fig. 276: View of Gasket Mating Surfaces on Lower Crankcase Engine Block Side
Courtesy of GENERAL MOTORS CORP.

10. Clean the sealing material from the gasket mating surfaces on the lower crankcase engine block side.

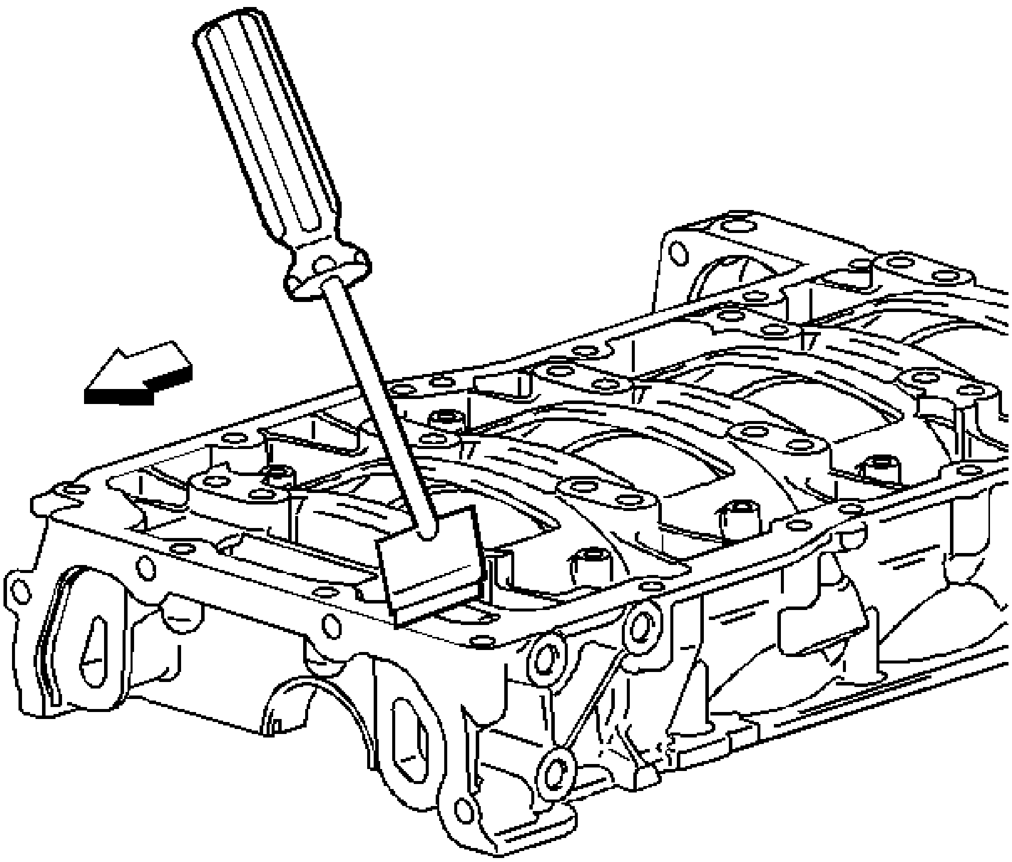


Fig. 277: View of Gasket Mating Surfaces on Lower Crankcase Oil Pan Side
Courtesy of GENERAL MOTORS CORP.

11. Clean the sealing material from the gasket mating surfaces on the lower crankcase oil pan side.

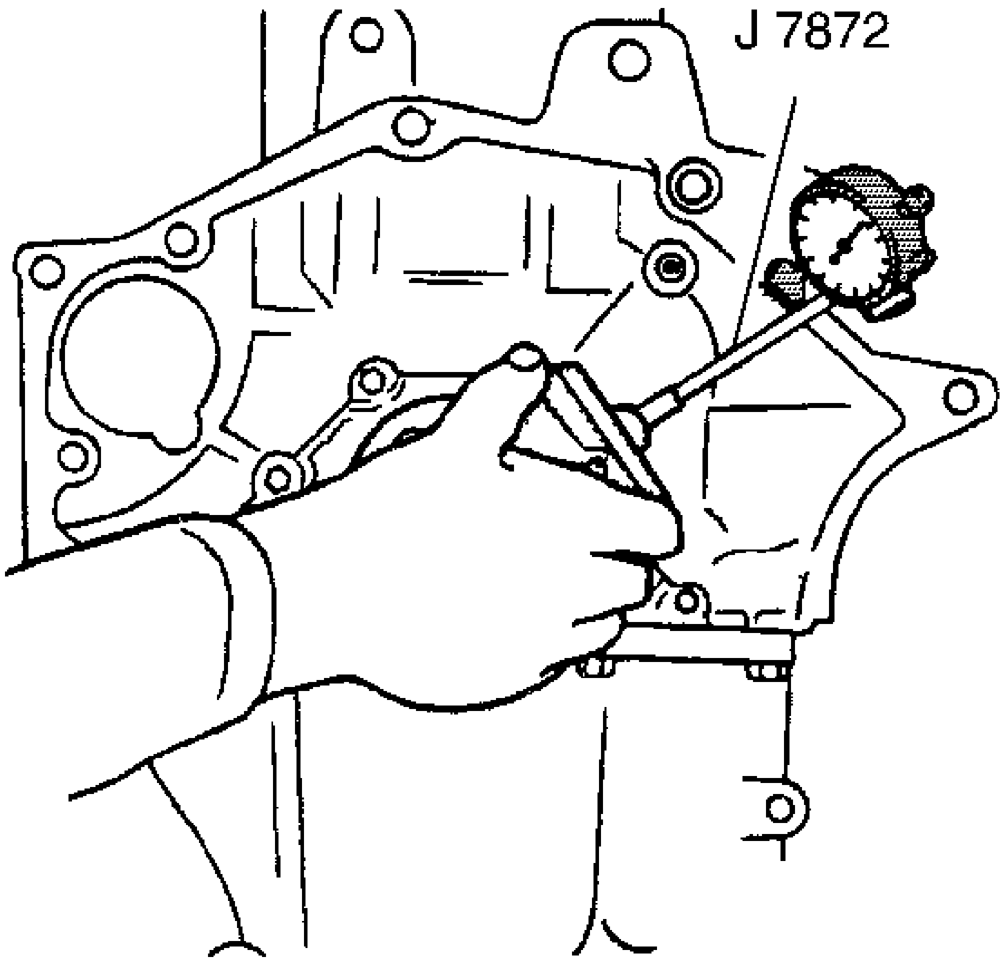


Fig. 278: View of Transmission Face
Courtesy of GENERAL MOTORS CORP.

12. Inspect the mating surfaces of the transmission face.

NOTE: A broken flywheel may result if the transmission case mating surface is not flat.

13. Use the following procedure in order to measure the engine block flange runout at the mounting bolt hole bosses:
    1. Temporarily install the crankshaft. 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).

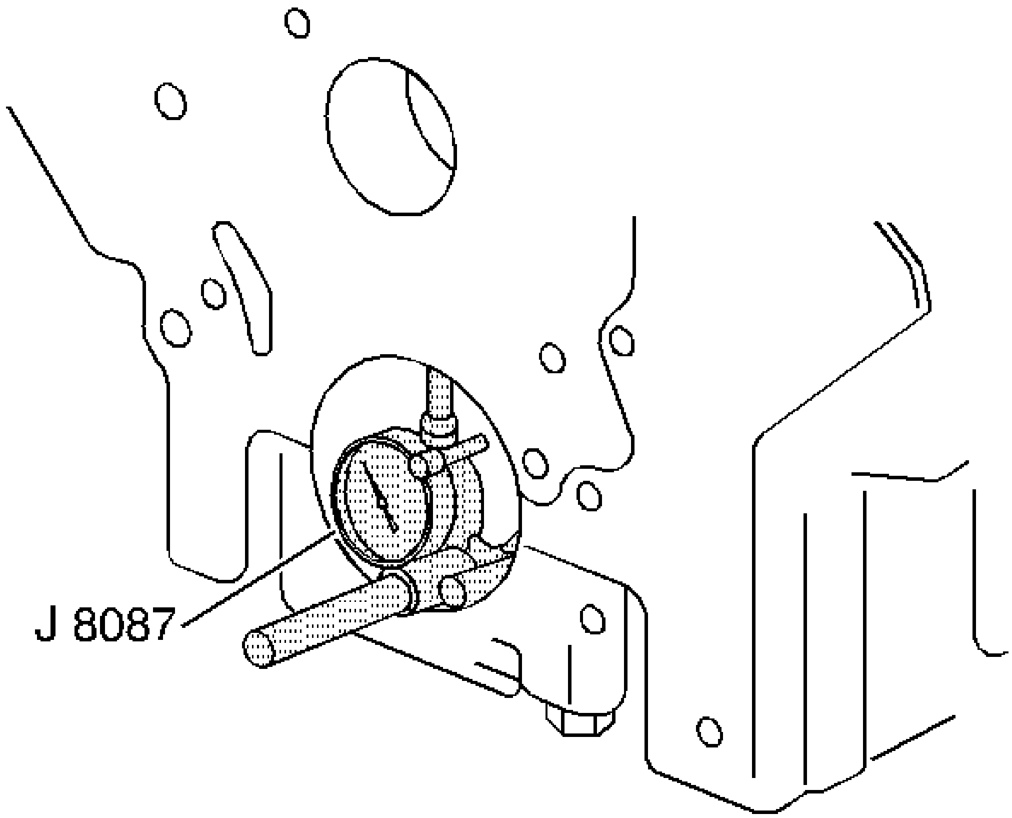


Fig. 279: Inspecting Crankshaft Main Bearing Bores
Courtesy of GENERAL MOTORS CORP.

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.

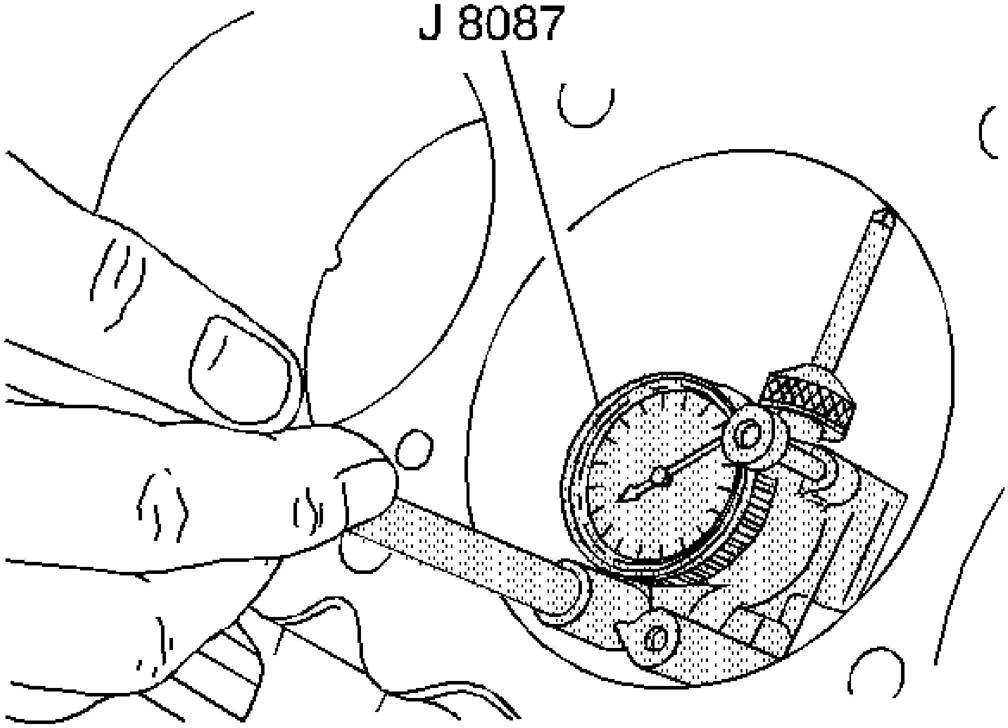


Fig. 280: Inspecting Cylinder Bores Using J 8087
Courtesy of GENERAL MOTORS CORP.

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, install a NEW cylinder bore liner. Refer to **Cylinder Sleeve Removal** and **Cylinder Sleeve Installation**.

Cylinder Honing

Tools Required

J 8087 Cylinder Bore Gage. See **Special Tools and Equipment**.

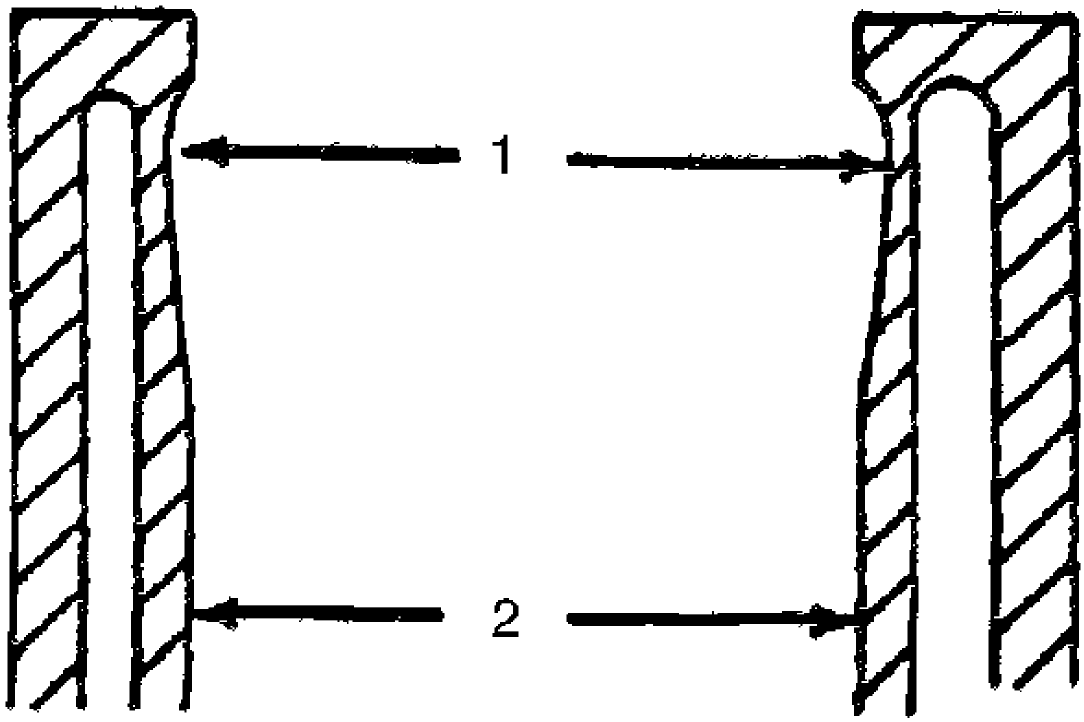


Fig. 281: Measuring Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

1. Measure the cylinder bore for out-of-round and taper.
2. Measure dimension (1) at 13 mm (1/2 in) below the head gasket surface. Measure dimension (2) at 100 mm (4 in) below the head gasket surface.

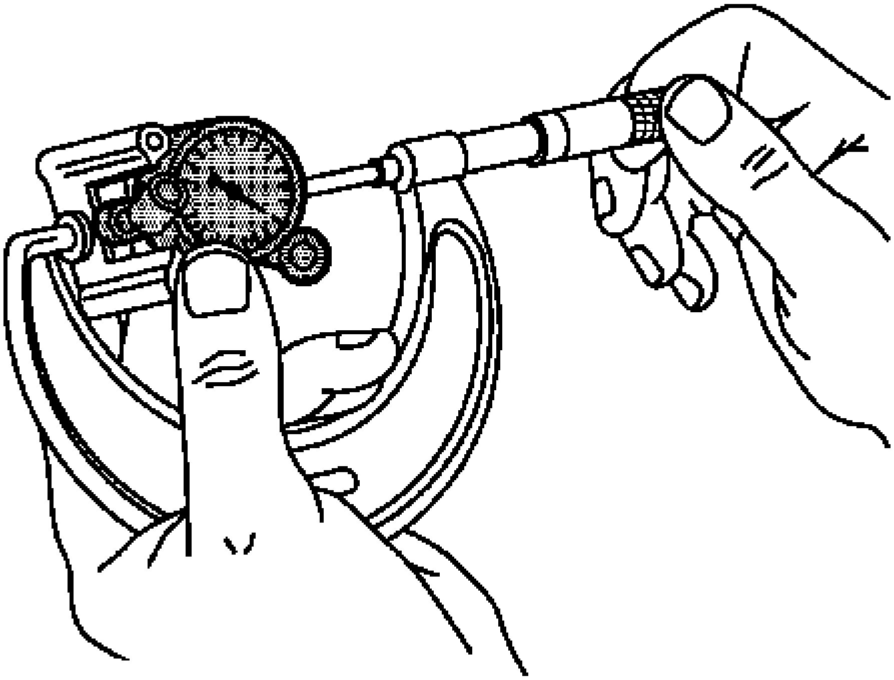


Fig. 282: Measuring Bore Gauge With Micrometer
Courtesy of GENERAL MOTORS CORP.

3. Measure the cylinder bores by setting the **J 8087** dial at zero in the cylinder at the point of the desired measurement. 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, install a new cylinder bore sleeve. Refer to **Cylinder Sleeve Removal** and **Cylinder Sleeve Installation**.
7. If honing is not required, clean the cylinder bores with hot water and detergent. Apply clean engine oil to the bore after washing and drying the bore.

Cylinder Sleeve Removal

Tools Required

EN-45680-400 Cylinder Sleeve Removal and Installation Kit. See **Special Tools and Equipment**.

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

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

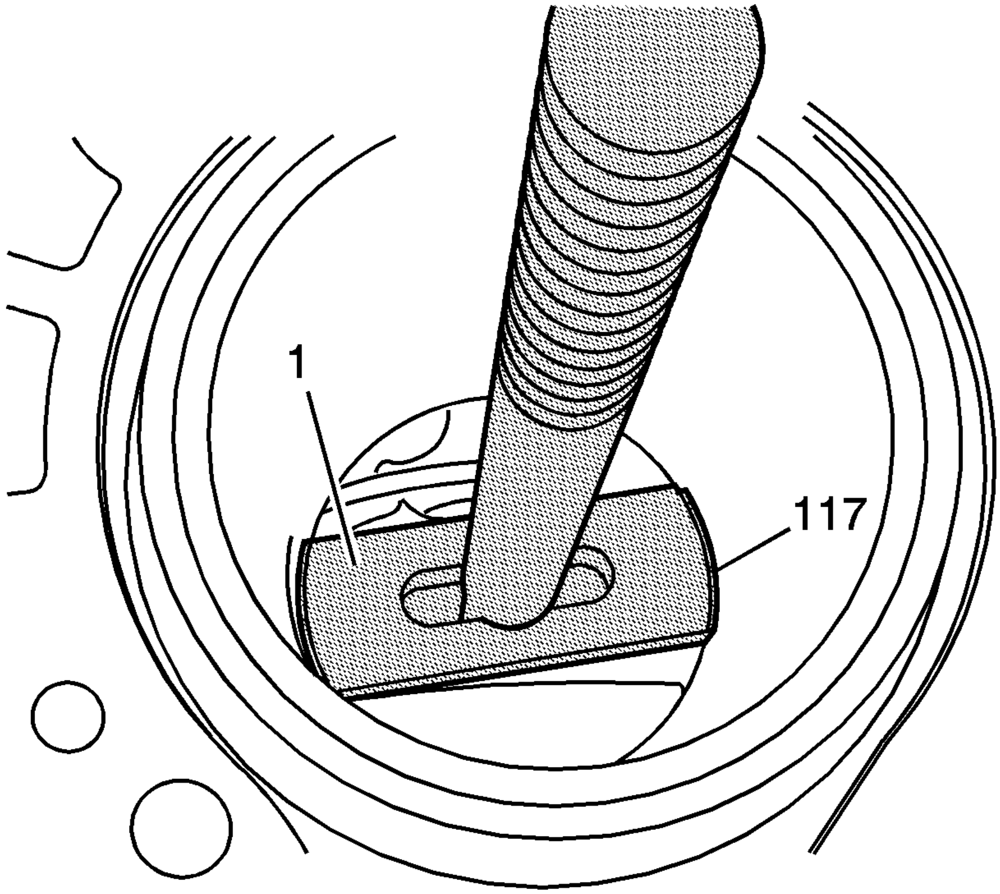


Fig. 283: View Of Cylinder Bore Liner Puller
Courtesy of GENERAL MOTORS CORP.

1. If the crankshaft is still installed, rotate the crankshaft so that the counterweight is to the right side and the connecting rod journal is to the left side and not in alignment with the cylinder bore.
2. Install the cylinder bore sleeve puller (1) through the cylinder bore.

NOTE: Ensure that the shoe is flat against the bottom of the cylinder bore sleeve

or damage to the cylinder bore sleeve puller will occur.

3. Align the shoe (1) of the cylinder bore sleeve puller to the bottom of the cylinder bore sleeve (117).

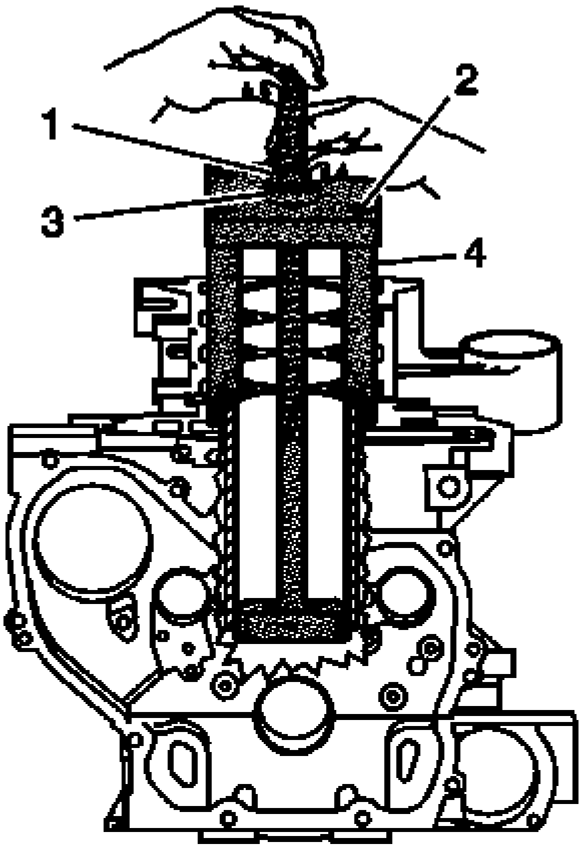


Fig. 284: Aligning Cylinder Bore Sleeve Puller
Courtesy of GENERAL MOTORS CORP.

4. Hold the threaded shaft of the cylinder bore sleeve puller upward in order to retain the shoe alignment to the bottom of the cylinder bore sleeve.
5. Install the fixture (4) onto the threaded shaft of the cylinder bore sleeve puller and the engine block.
6. Install the bearing (3) and the nut (1).
7. Tighten the nut (1) to the bearing (3).

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

IMPORTANT: **Use four old cylinder head bolts for the attaching bolts.**

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

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

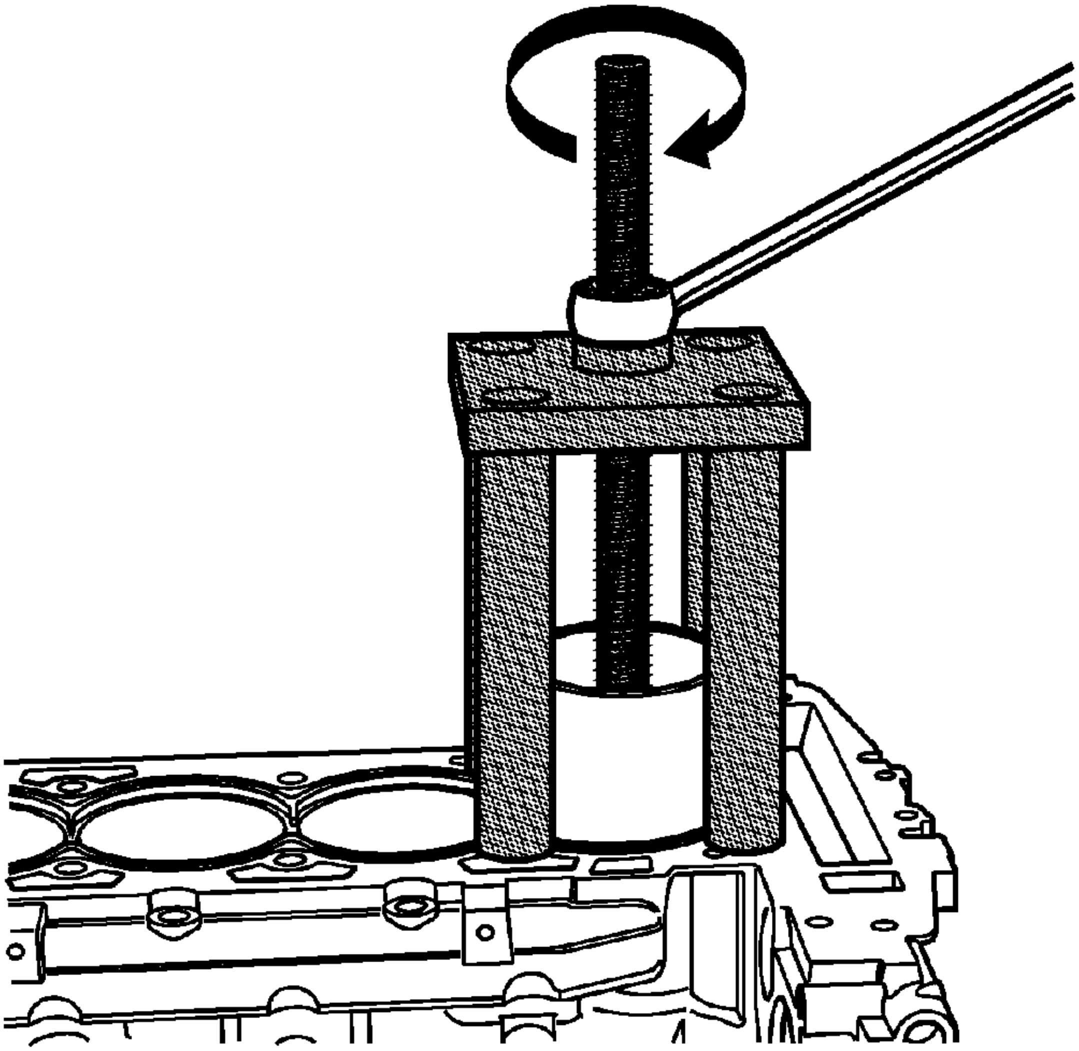


Fig. 285: Removing Cylinder Bore Sleeve By Rotating Nut
Courtesy of GENERAL MOTORS CORP.

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

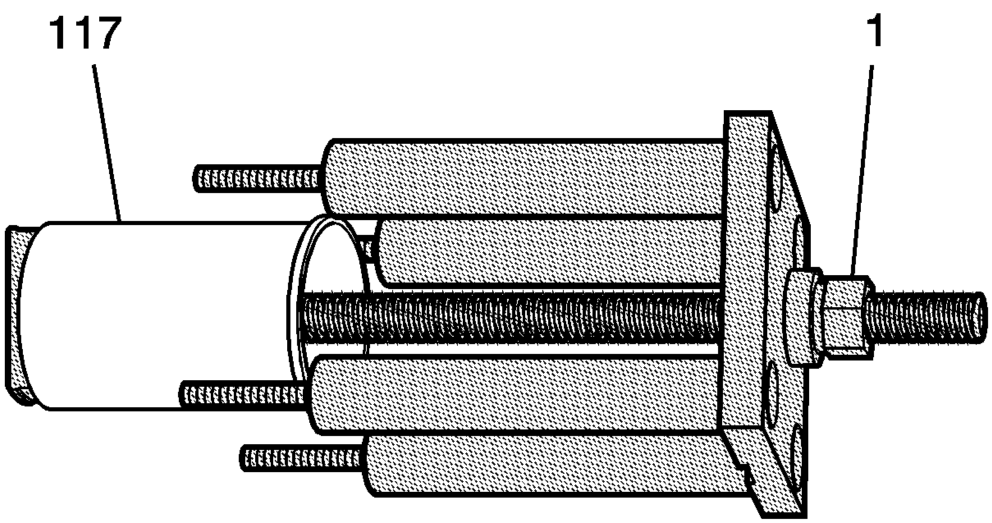


Fig. 286: Removing Cylinder Bore Sleeve
Courtesy of GENERAL MOTORS CORP.

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

10. Remove the fixture, cylinder bore sleeve puller, and the cylinder bore sleeve (117) from the engine block.
11. Loosen the nut (1) to remove the cylinder bore sleeve (117).
12. Inspect the cylinder bore in the cylinder block for cracks or damage. If cracked or damaged, replace the cylinder block.
13. Inspect the piston, piston rings, and connecting rod for damage. Refer to **Piston, Connecting Rod, and Bearings Cleaning and Inspection**.

Cylinder Sleeve Installation

Tools Required

EN-45680-400 Cylinder Sleeve Removal and Installation Kit. See **Special Tools and Equipment**.

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

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

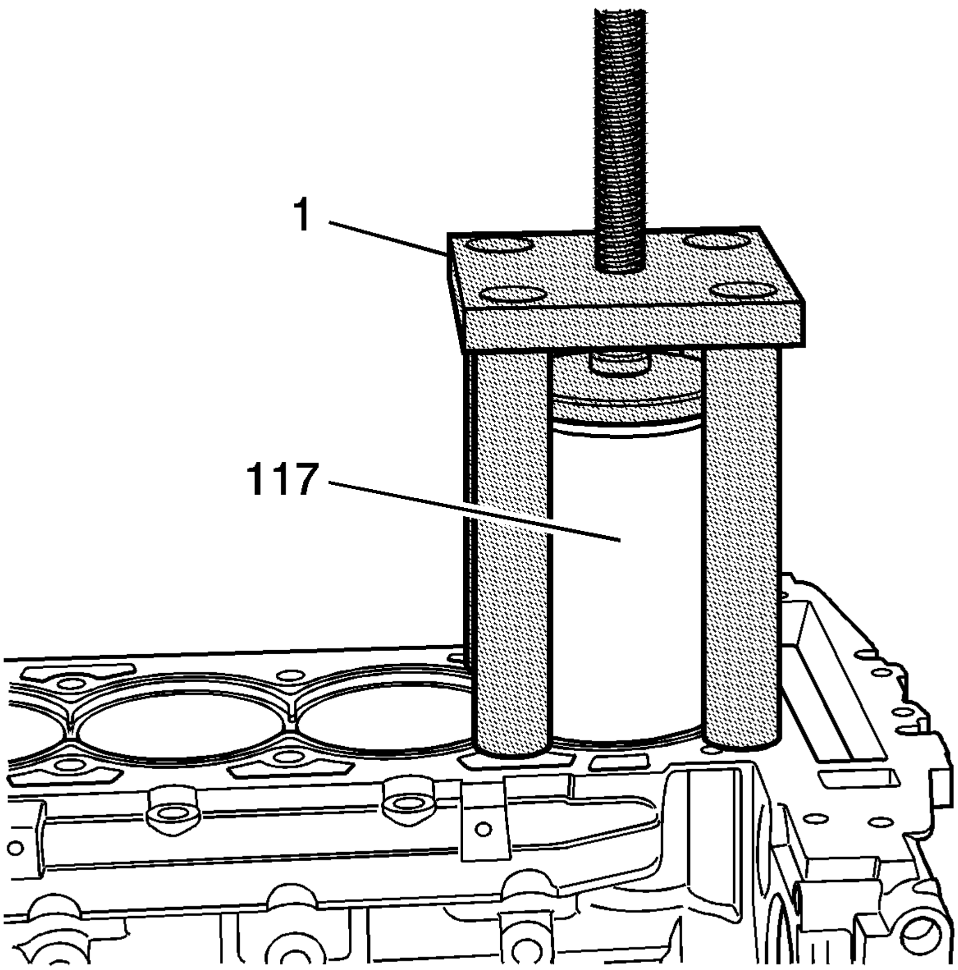


Fig. 287: View Of Cylinder Bore Sleeve Fixture
Courtesy of GENERAL MOTORS CORP.

1. Place the NEW cylinder bore sleeve (117) onto the cylinder block.
2. Install the fixture (1) over the cylinder bore sleeve (117) and onto the cylinder block. Do not apply downward pressure to the cylinder bore sleeve (117).

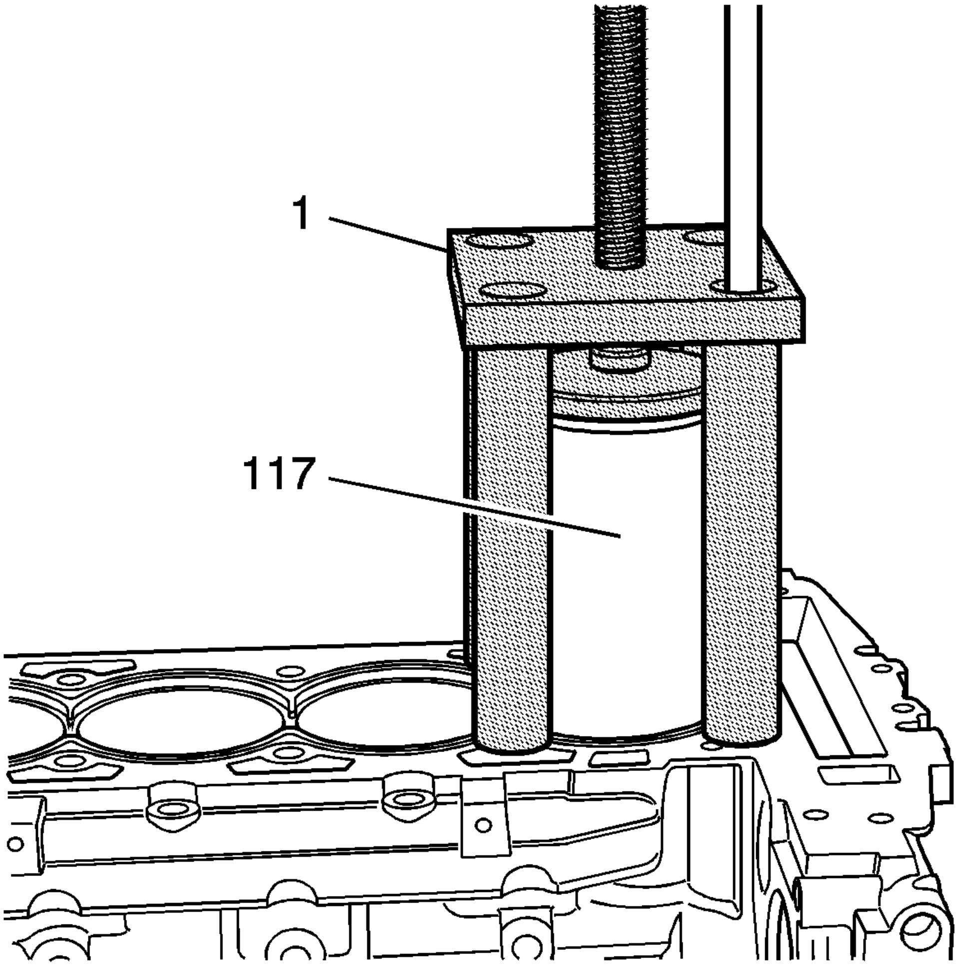


Fig. 288: Installing Cylinder Bore Sleeve Puller Attachment Bolts
Courtesy of GENERAL MOTORS CORP.

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

3. Insert the 4 attachment bolts into the legs of the fixture (1).

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Tighten the 4 attachment bolts. Do not apply downward pressure to the cylinder bore sleeve (117).

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

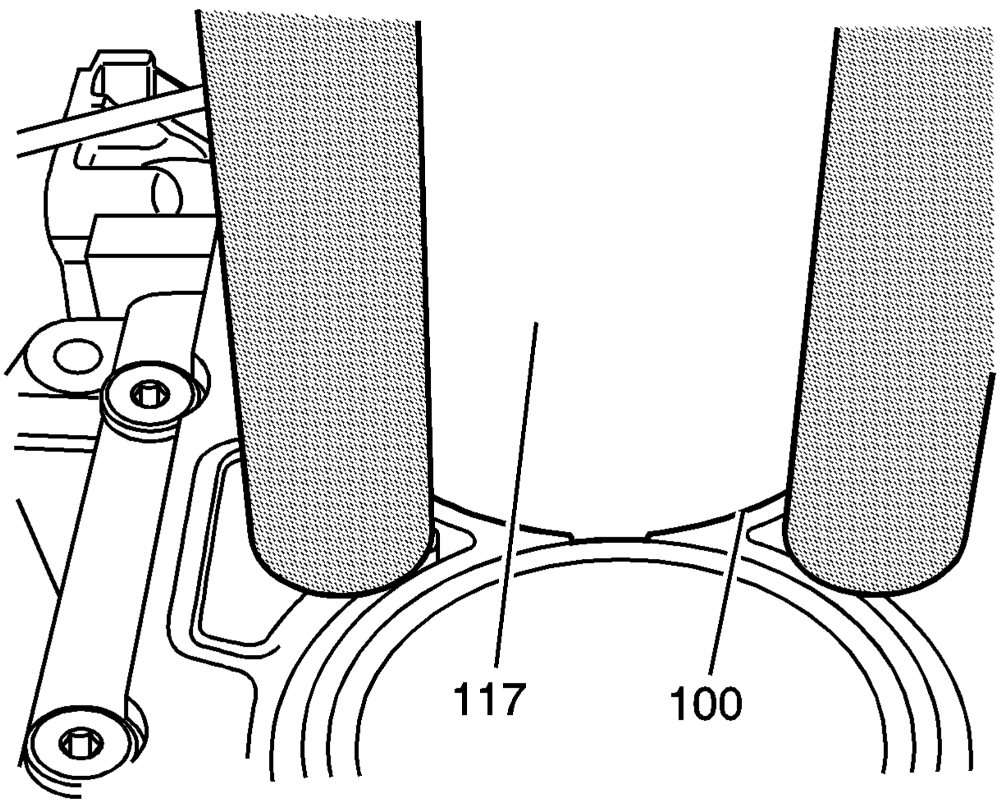


Fig. 289: View Of Proper Liner Alignment
Courtesy of GENERAL MOTORS CORP.

5. Align the bottom of the cylinder bore sleeve (117) with the cylinder bore of the block (100).

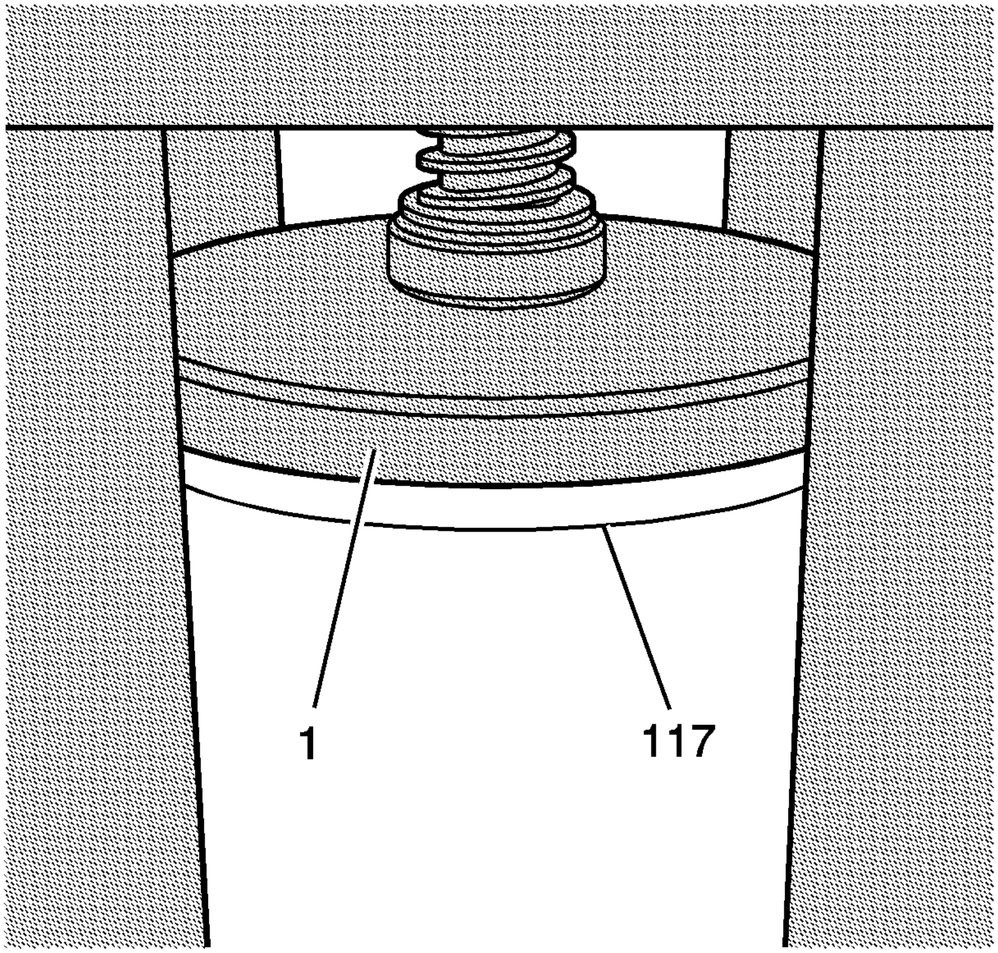


Fig. 290: View Of Installation Arbor
Courtesy of GENERAL MOTORS CORP.

6. Align the installation arbor (1) onto the top of the cylinder bore sleeve (117).

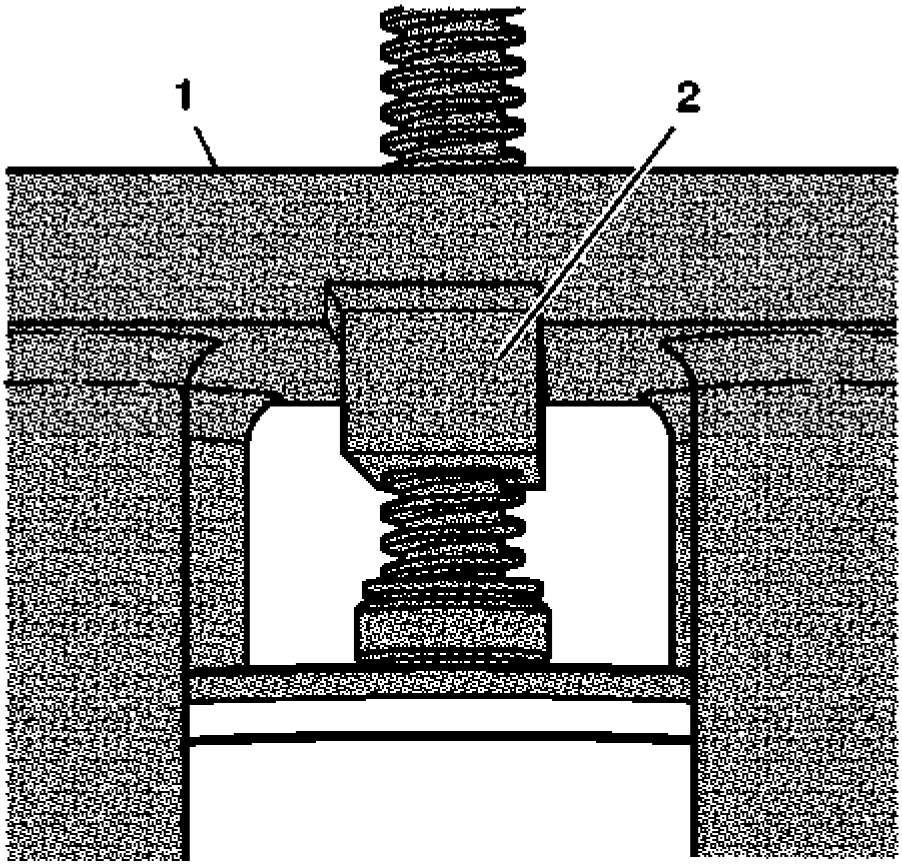


Fig. 291: View Of Pusher Block
Courtesy of GENERAL MOTORS CORP.

7. Align the pusher block (2) into the groove of fixture (1).

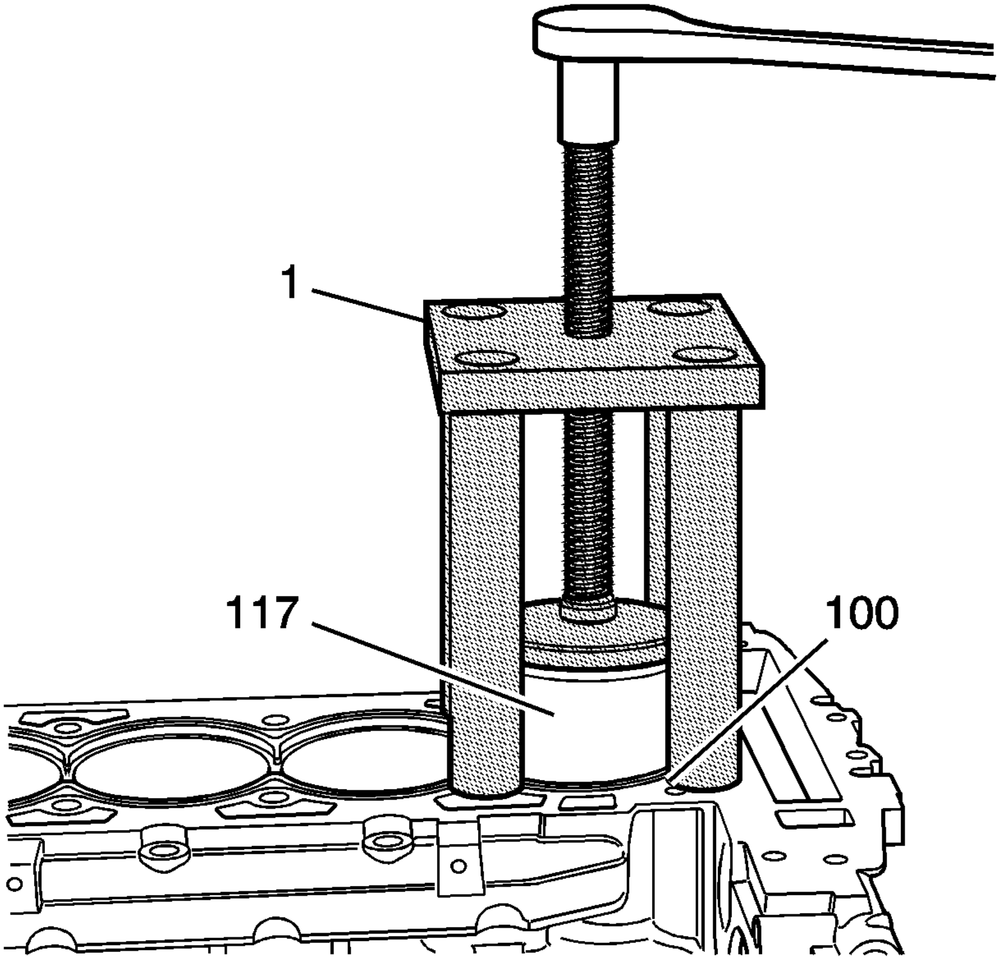


Fig. 292: Installing Cylinder Bore Sleeve Into Engine Block Using Tool
Courtesy of GENERAL MOTORS CORP.

NOTE: **Do not use any air powered or electric tools to rotate the threaded shaft of the fixture EN 45680-401/cylinder bore sleeve installer EN 45680-403 assembly or damage to the cylinder bore sleeve will occur.**

8. Using a ratchet, rotate the threaded shaft of fixture (1) in order to install the cylinder bore sleeve (117) into the engine block (100).
9. Do not completely seat the cylinder bore sleeve in the block. Leave approximately 1/16 inch of the cylinder bore sleeve above the surface of the cylinder block.

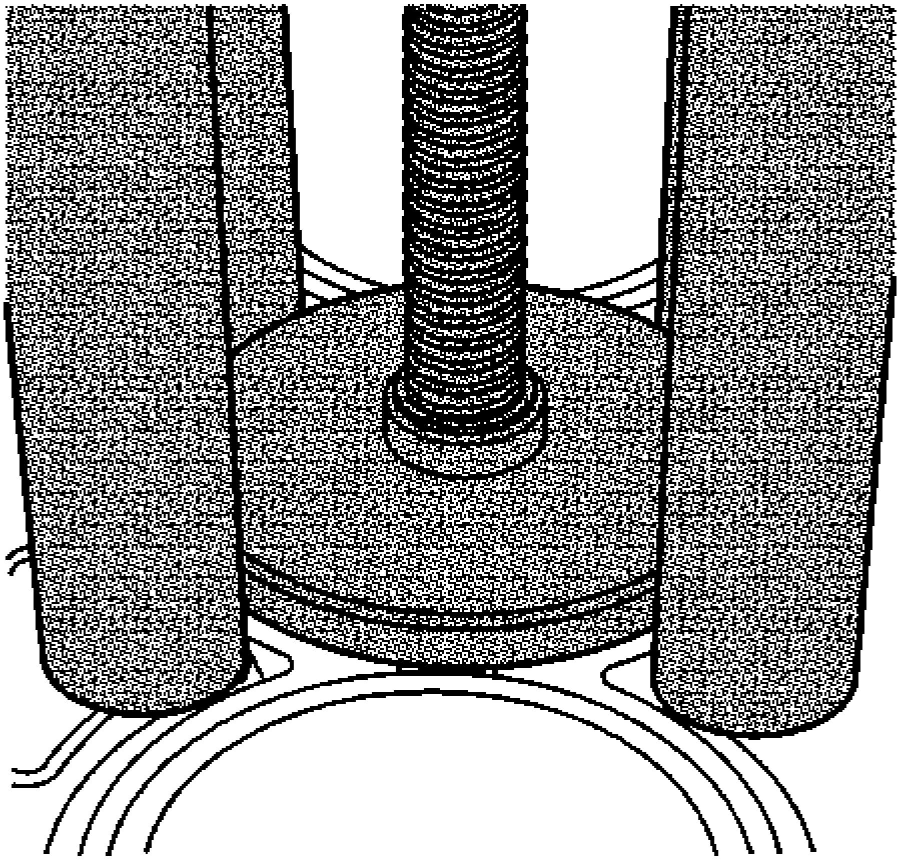


Fig. 293: Seating Cylinder Bore Sleeve Completely Using Tool
Courtesy of GENERAL MOTORS CORP.

10. Using a torque wrench, torque the threaded shaft to 102 N.m (75 lb ft) to completely seat the cylinder bore sleeve in the cylinder block. With the cylinder bore sleeve properly installed, a minimal portion of the cylinder bore sleeve flange will protrude above the block deck surface.

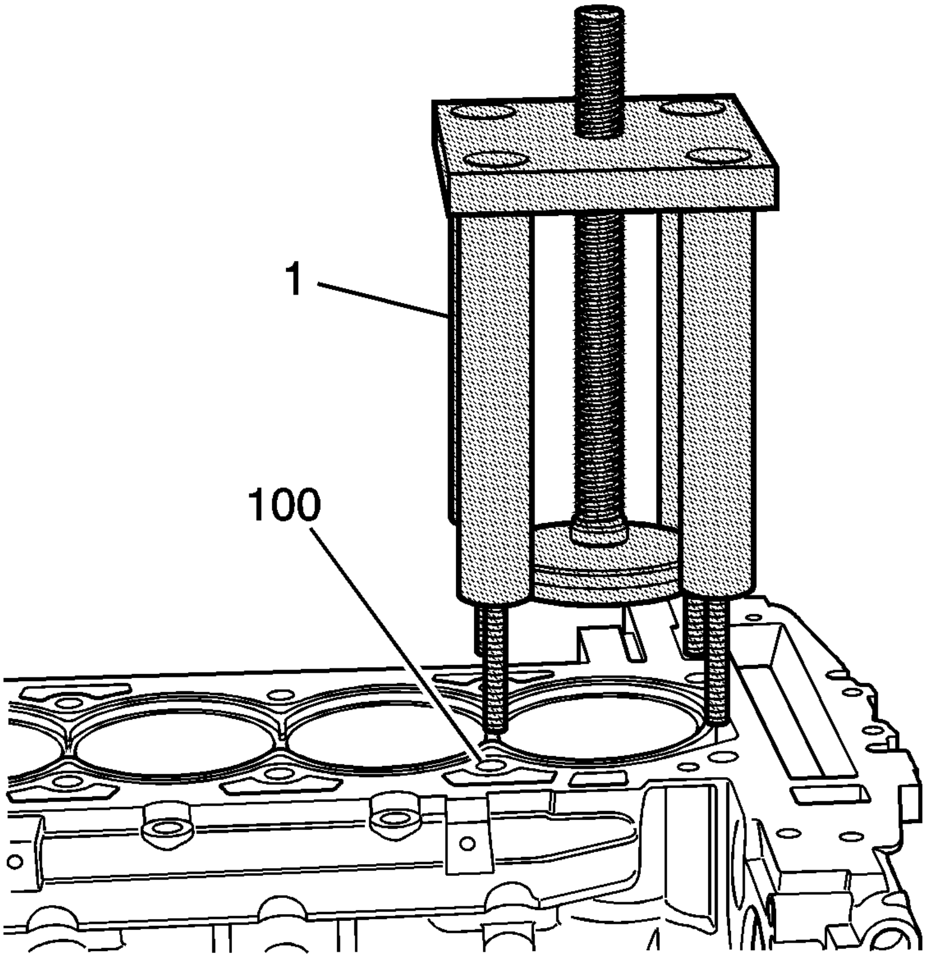


Fig. 294: View Of Service Tool Assembly
Courtesy of GENERAL MOTORS CORP.

11. Remove the fixture (1) from the cylinder block (100).

Cylinder Sleeve Trimming

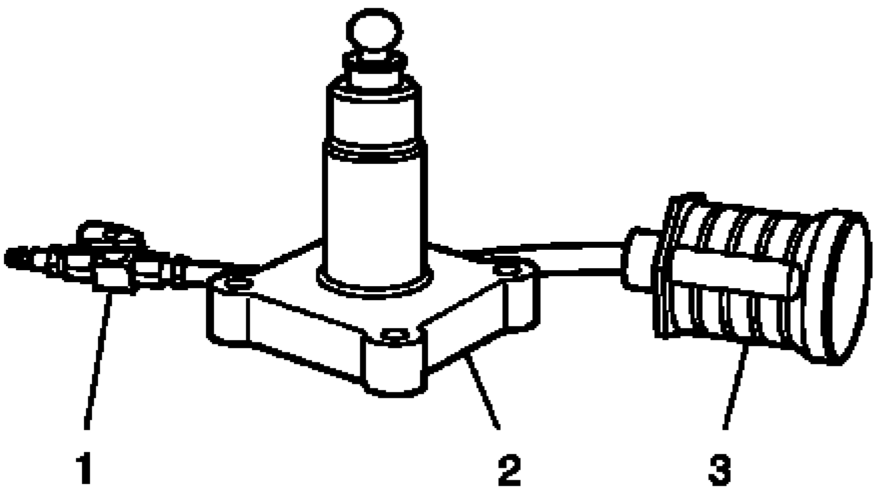


Fig. 295: Cylinder Liner Trimming Tools View (1 Of 2)
Courtesy of GENERAL MOTORS CORP.

- EN 45680-865 Debris Collector (3)
- EN 45680-411 Trim Tool Assembly (2)
- Air Control Valve (1)
- Drill Motor with 1/2 inch chuck, 1 1/8 hp, 7 amps, triple gear reduction, and a 450-600 RPM rotational speed in a clockwise direction

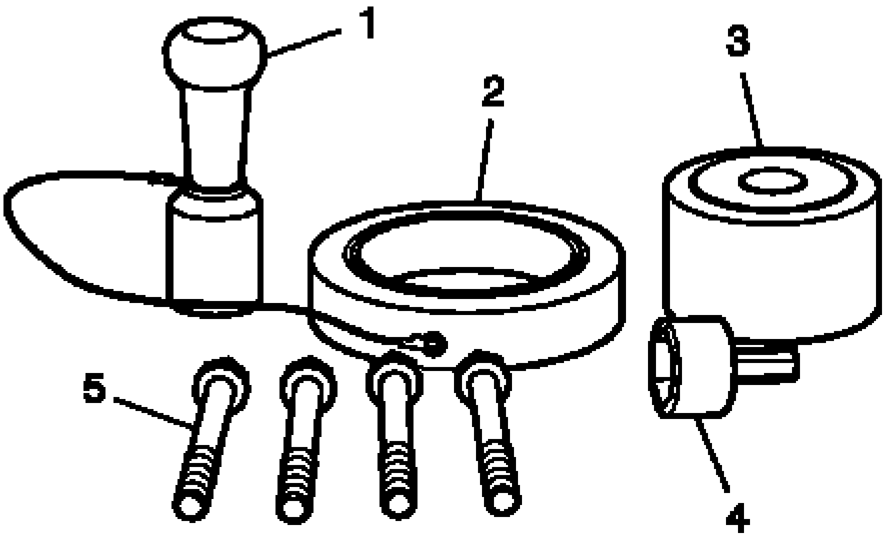


Fig. 296: Cylinder Liner Trimming Tools View (2 Of 2)
Courtesy of GENERAL MOTORS CORP.

- Trim Tool Preloader (1)
- EN 45680-412 Set Gage Ring (2)
- EN 45680-413 Metal Shavings Catch Plug (3)
- EN 45680-866 Drive Adapter (4)
- EN 45680-414 Bolts (5)

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

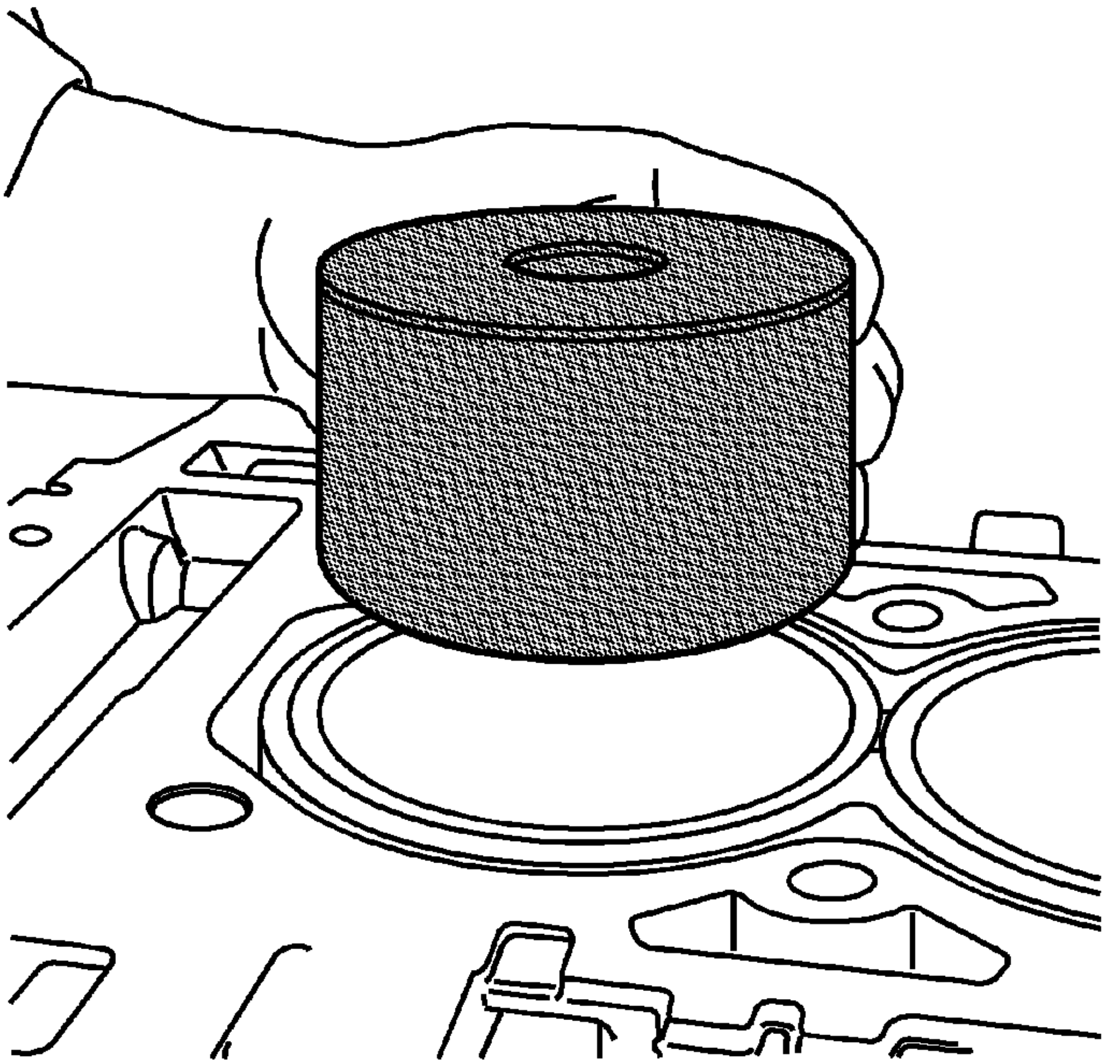


Fig. 297: Placing Metal Shaving Catch Plug Into Cylinder Bore Sleeve
Courtesy of GENERAL MOTORS CORP.

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

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

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

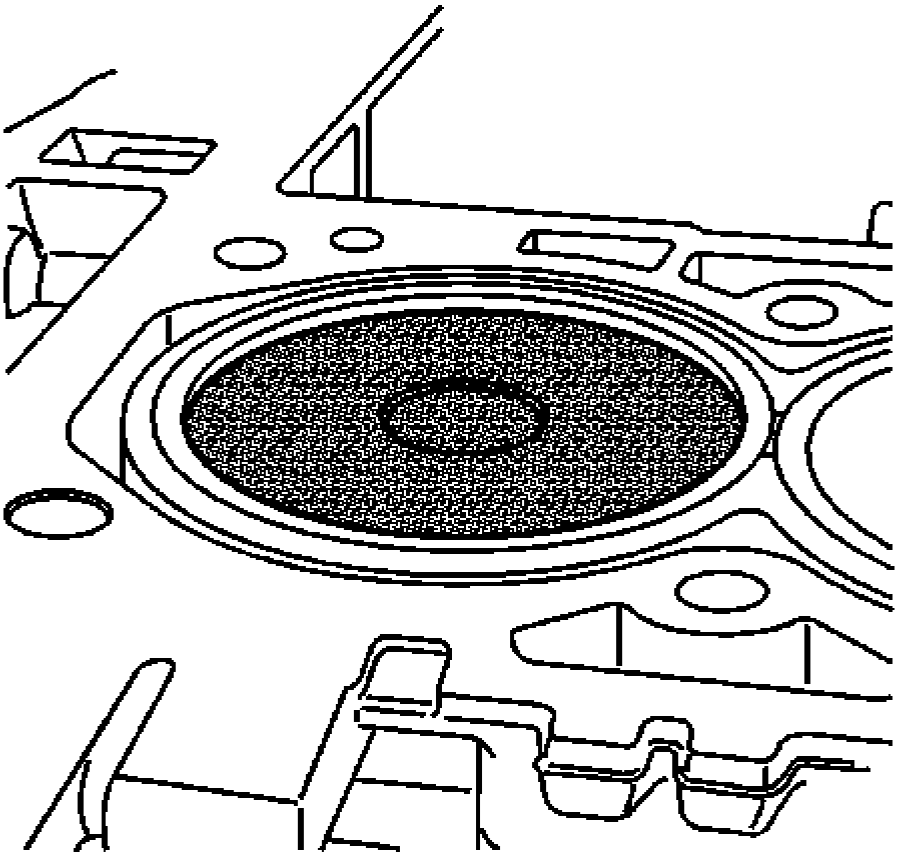


Fig. 298: Identifying Catch Plug Positioning
Courtesy of GENERAL MOTORS CORP.

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

NOTE: **Installing the metal shaving catch plug above the recommended depth will cause damage to the metal shaving catch plug.**

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

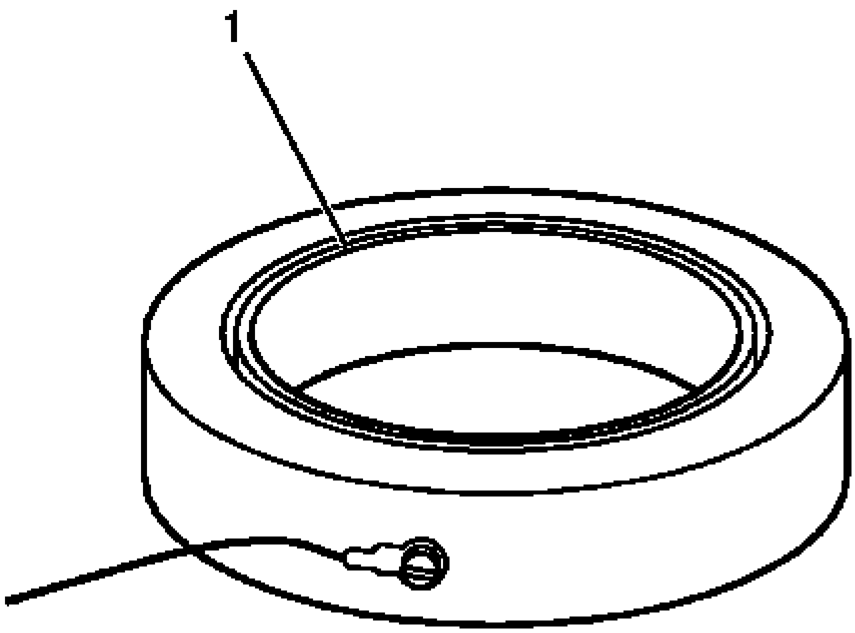


Fig. 299: Identifying Set Gauge Ring Groove
Courtesy of GENERAL MOTORS CORP.

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

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

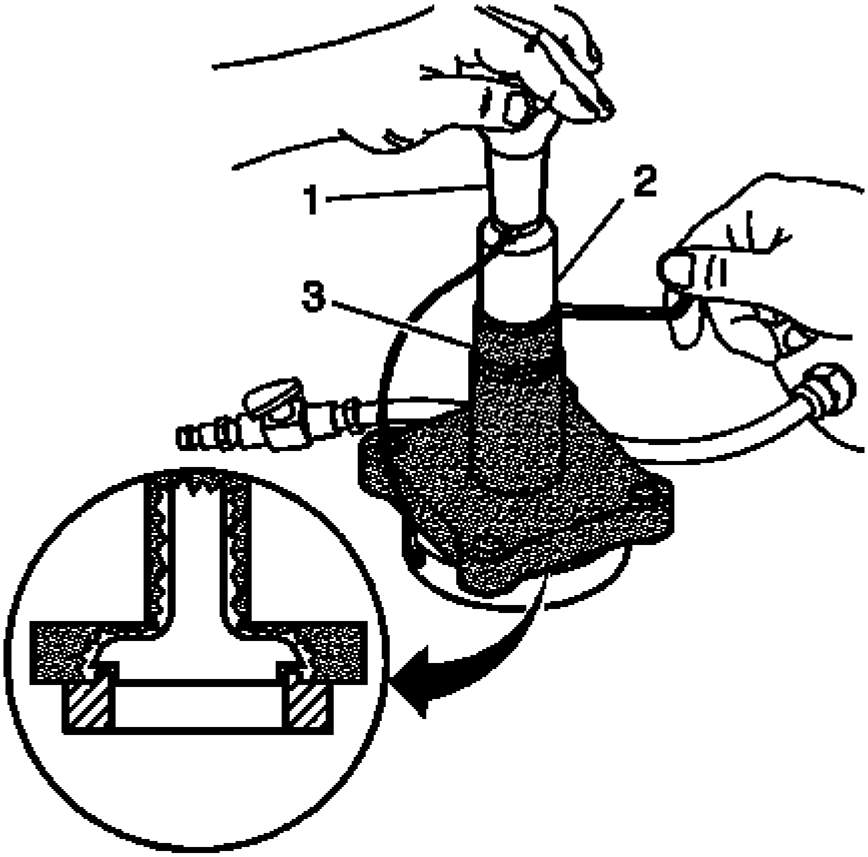


Fig. 300: View Of Trim Tool Assembly Components And Positioning
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure that the set gage ring surfaces are clean.

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

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

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

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

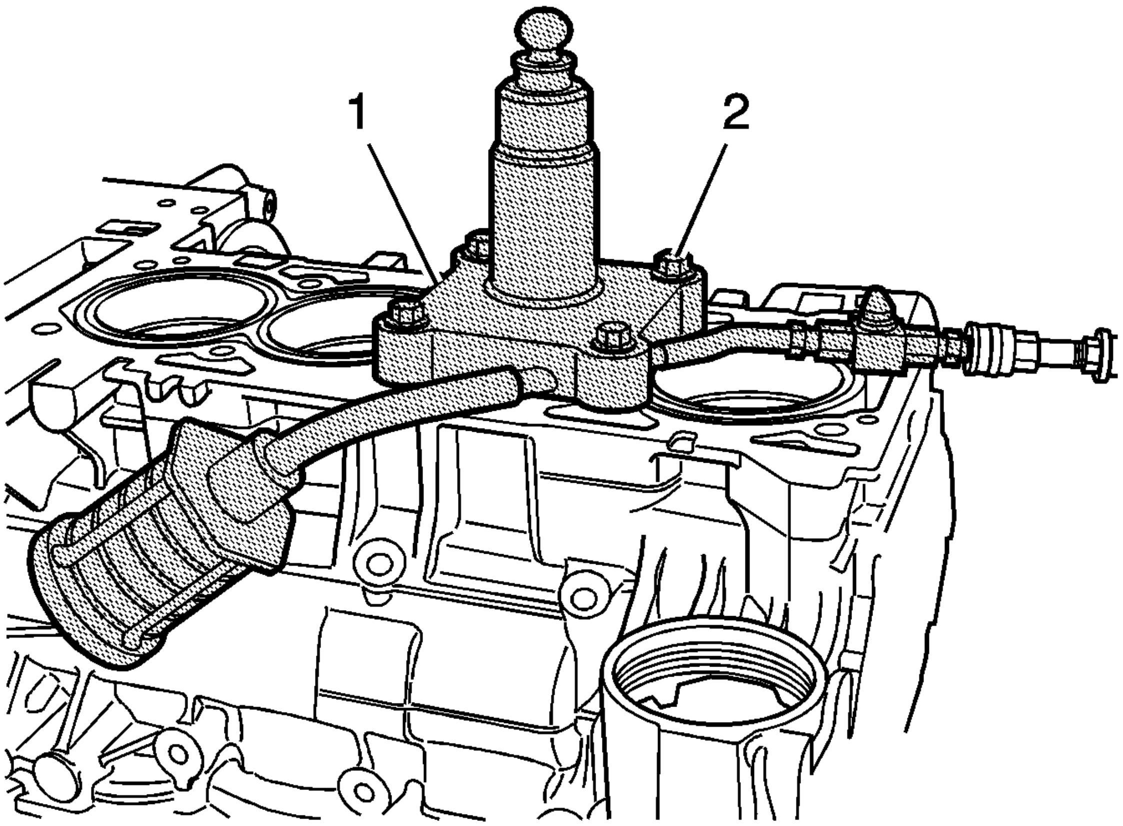


Fig. 301: Identifying Directional Arrow & Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

10. Place the trim tool assembly onto the cylinder to be trimmed with the directional arrow (1) pointing in line with the crankshaft centerline and the front of the block.
11. Install the 4 bolts (2) into the cylinder head bolt holes in the block.

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

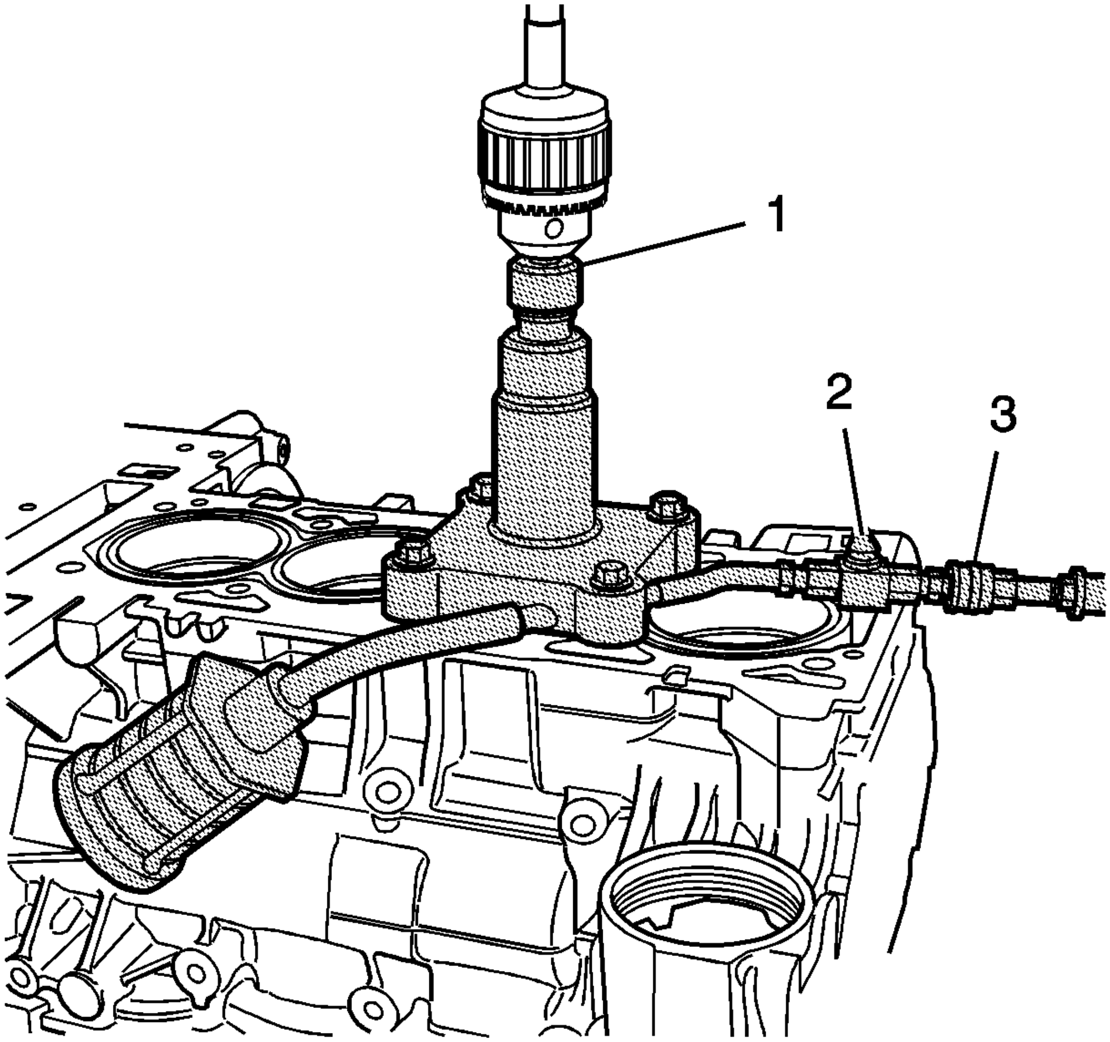


Fig. 302: View of Drive Adapter
Courtesy of GENERAL MOTORS CORP.

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

12. Fasten drive adapter (1) into the drill chuck.

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

13. Connect a compressed air supply (75-125 psi) to the male quick connect (3) located on trim tool assembly. Turn the compressed air valve (2) to the open position. This starts the venturi vacuum system that will catch the metal shavings.

14. Place the drive adapter and drill assembly (1) vertically onto the drive adapter end of trim tool assembly. Do not apply downward force on the drill until full rotational speed has been reached. After reaching full rotational speed, gradually apply downward force until the cutting action is complete in approximately 5 seconds.
15. Remove the drive adapter (1) and drill assembly from the trim tool assembly.
16. Turn off the compressed air valve (2).
17. Remove the trim tool assembly from the engine block.
18. Remove any material shavings that may be found on the metal shaving catch plug.
19. Wipe the cylinder bore sleeve and surrounding areas free of any powder residue and then remove the metal shaving catch plug.

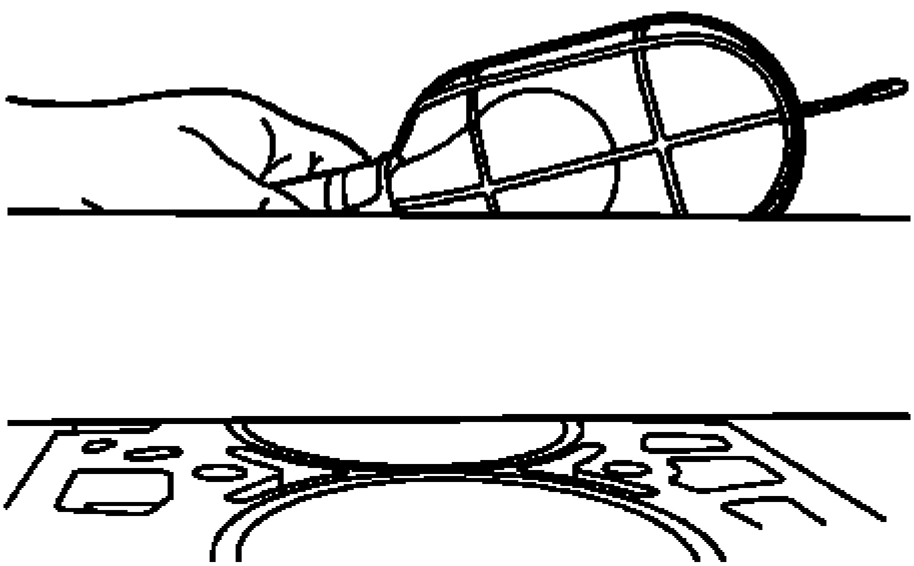


Fig. 303: Checking Cylinder Block Deck Surface With Straight Edge
Courtesy of GENERAL MOTORS CORP.

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

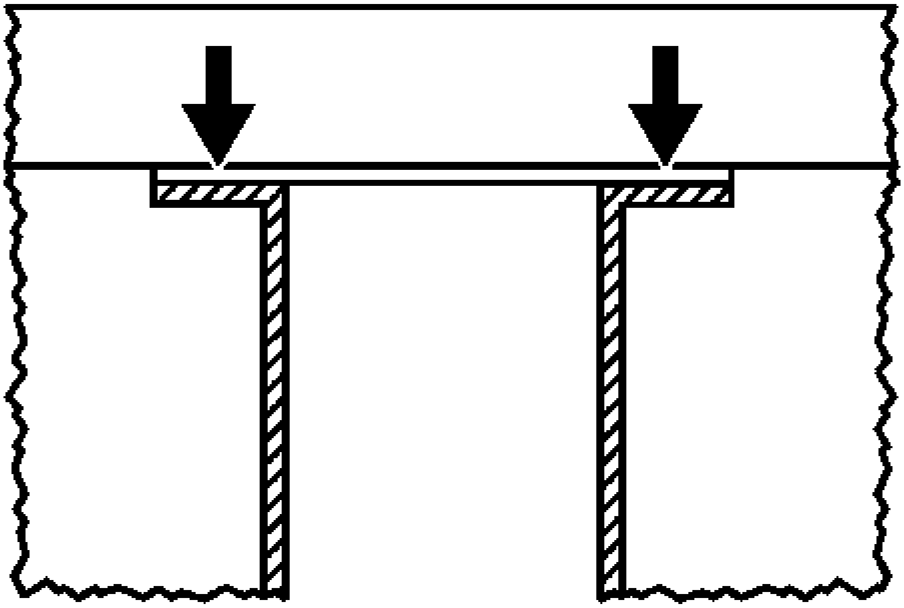


Fig. 304: View Of Improperly Cut Cylinder Bore Sleeve
Courtesy of GENERAL MOTORS CORP.

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

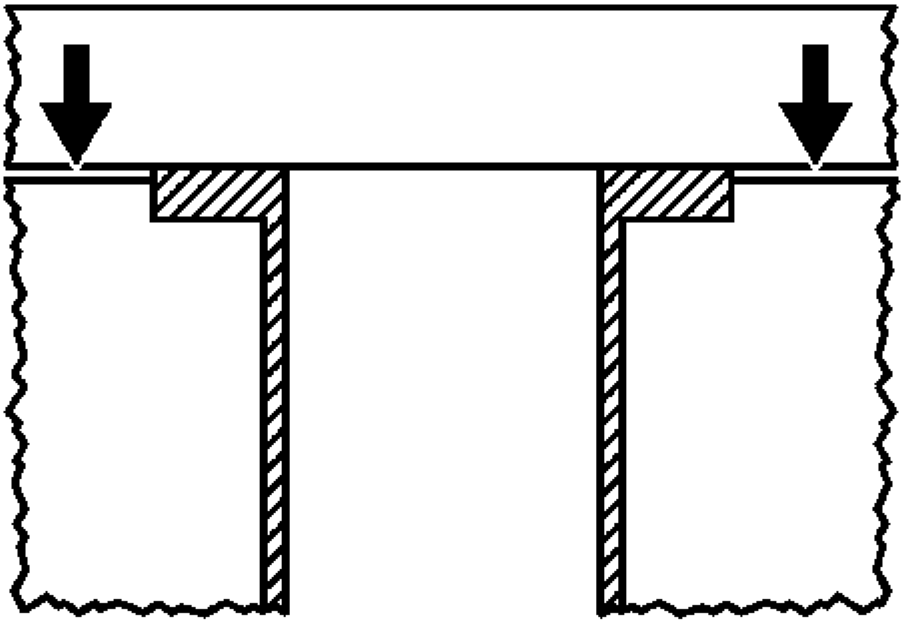


Fig. 305: View Of For Properly Cut Cylinder Bore Sleeve
Courtesy of GENERAL MOTORS CORP.

23. Looking at the front of the straight edge, check to see if light is protruding through the bottom of the straight edge and the top of the cylinder block deck surface. If light is present on both sides of the cylinder block, the cylinder bore sleeve is cut correctly.
24. Proceed to the next bore sleeve to be trimmed repeating steps 10-23 if necessary.

Crankshaft Balancer Cleaning and Inspection

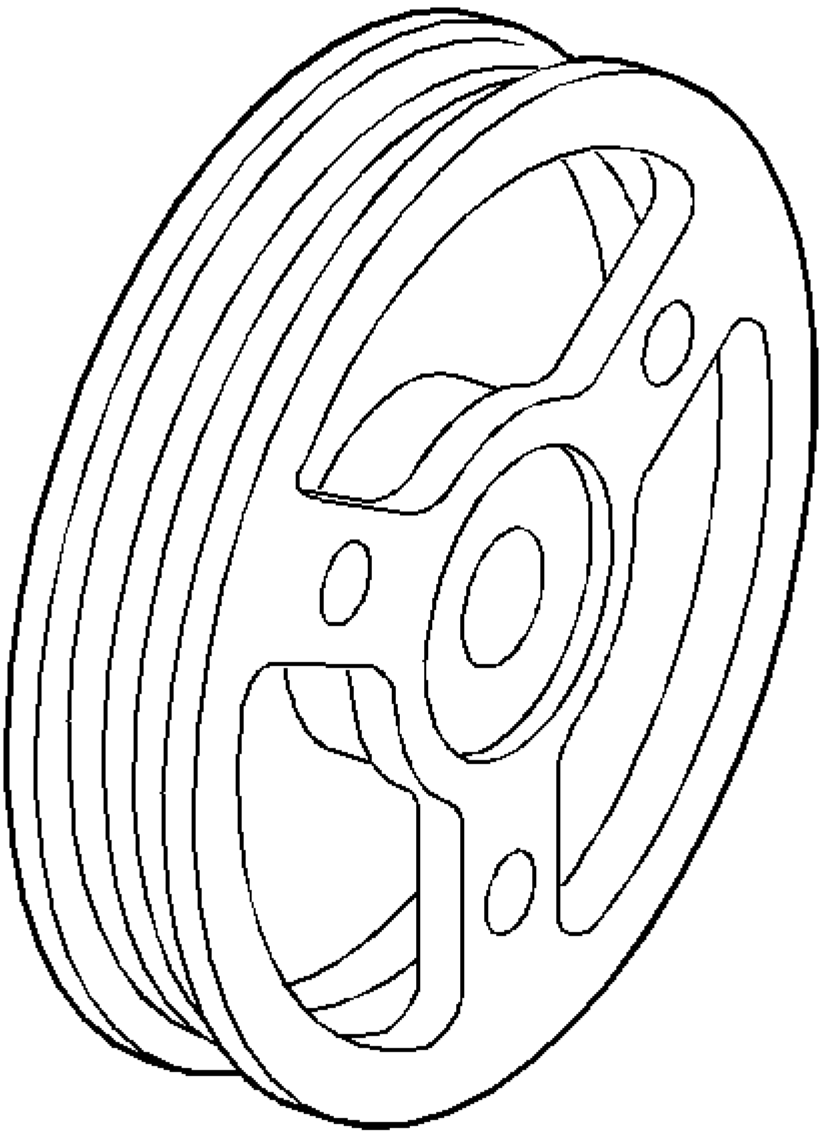


Fig. 306: View of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

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

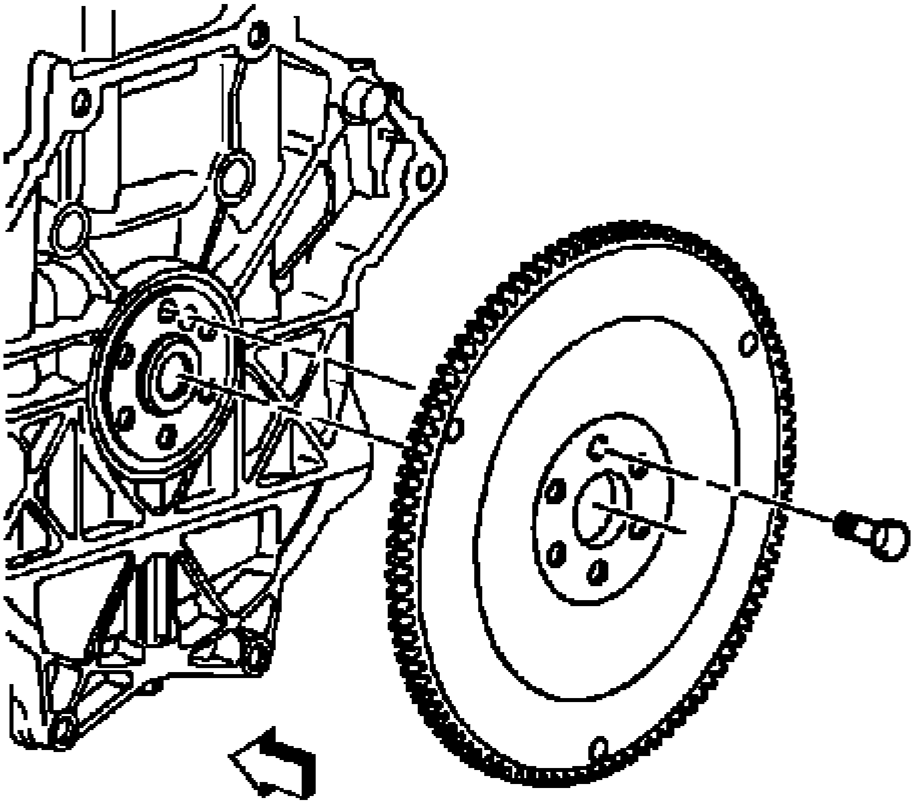


Fig. 307: View Of Flywheel
Courtesy of GENERAL MOTORS CORP.

1. Clean the flywheel in solvent.

CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

2. Dry the flywheel with compressed air.
3. 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**.

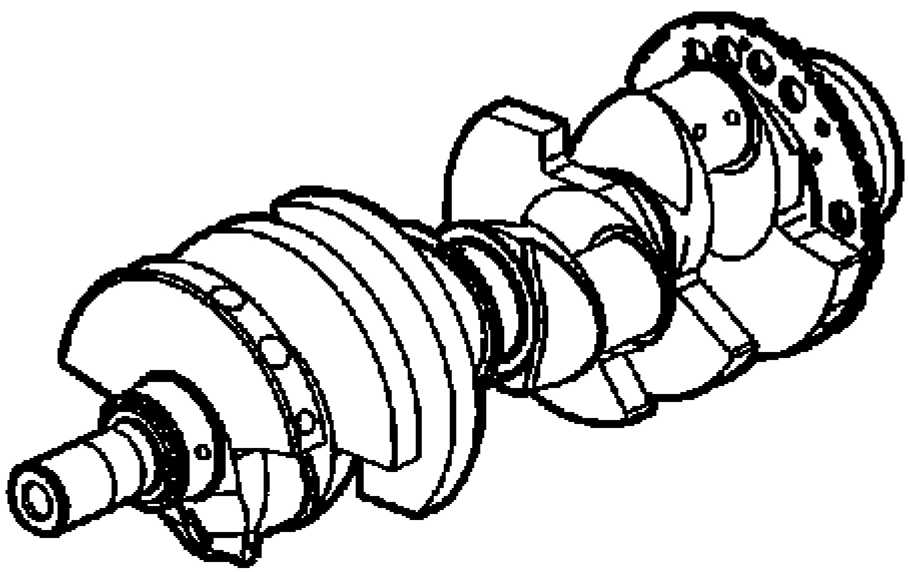


Fig. 308: View Of Crankshaft
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Use care when handling the crankshaft. Avoid damage to the bearing surfaces or the lobes of the crankshaft position reluctor ring. Damage to the teeth of the crankshaft position reluctor ring may effect OBD II system performance.

1. Clean the crankshaft with solvent.
2. Thoroughly clean all oil passages and inspect for restrictions or burrs.

CAUTION: Refer to Safety Glasses Caution 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.

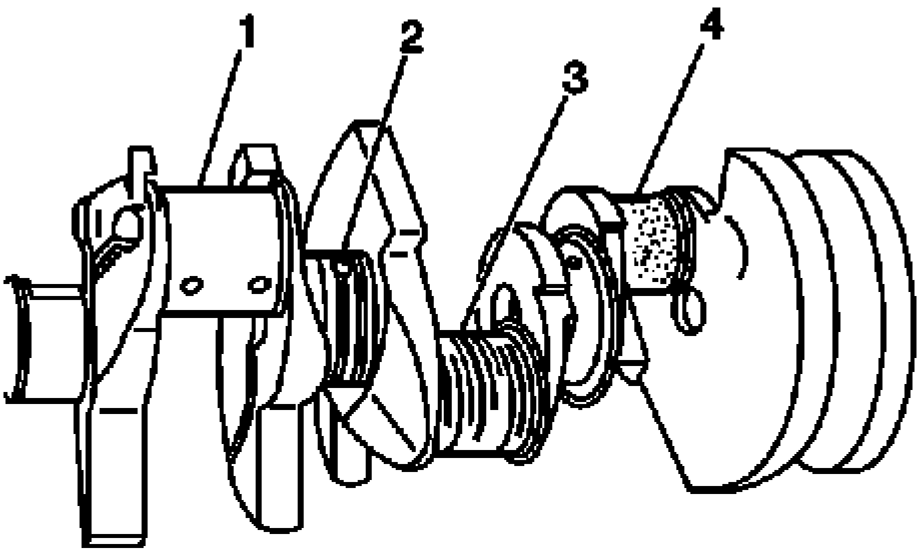


Fig. 309: Identifying Different Crankshaft Journal Wear Patterns
Courtesy of GENERAL MOTORS CORP.

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).

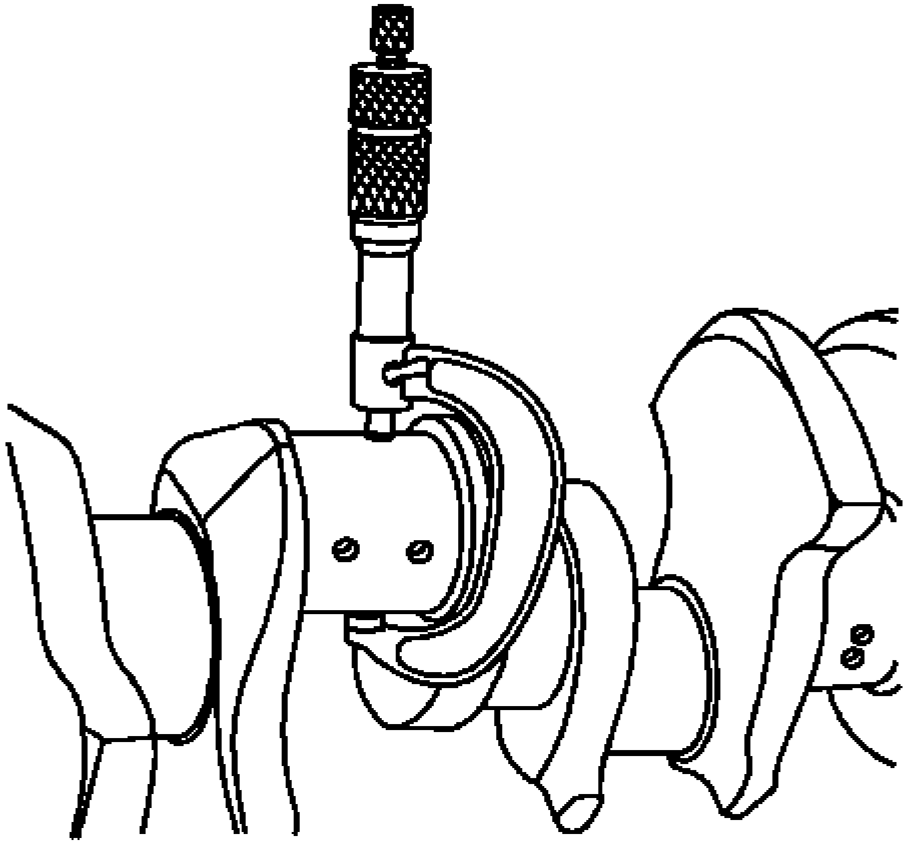


Fig. 310: Measuring Crankshaft Journals
Courtesy of GENERAL MOTORS CORP.

9. Measure the crankshaft journals for out-of-round.
10. Measure the crankshaft journals for taper.

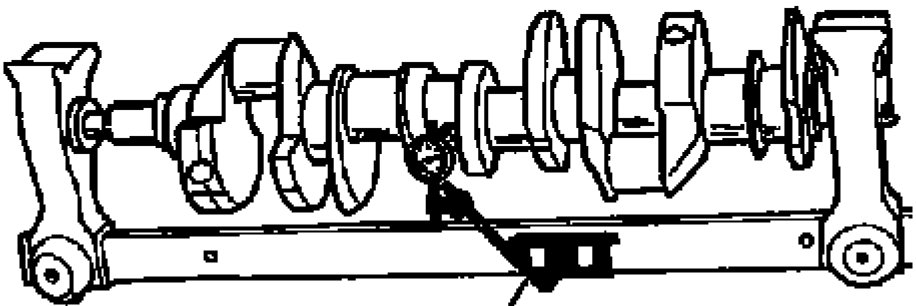


Fig. 311: Measuring Crankshaft Runout
Courtesy of GENERAL MOTORS CORP.

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.

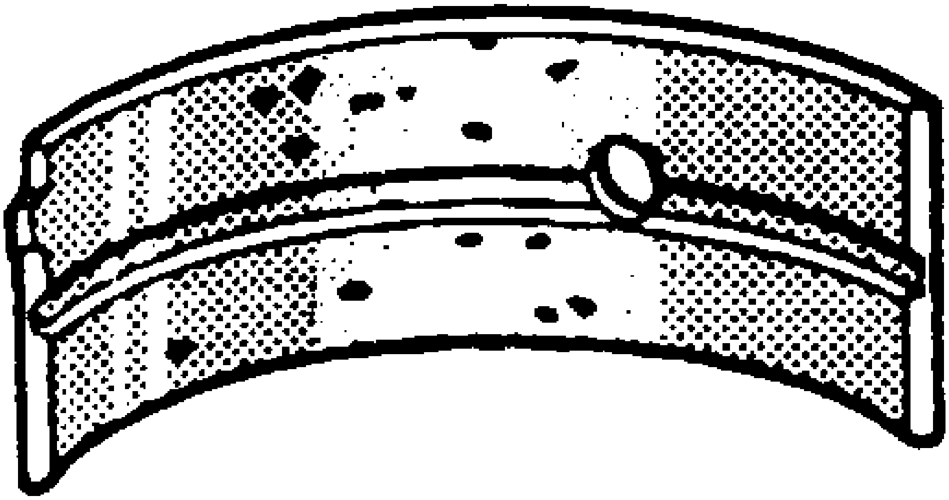


Fig. 312: Identifying Crankshaft Bearing Craters Or Pockets
Courtesy of GENERAL MOTORS CORP.

15. Inspect crankshaft bearings for craters or pockets. Flattened sections on the bearing halves also indicate fatigue.

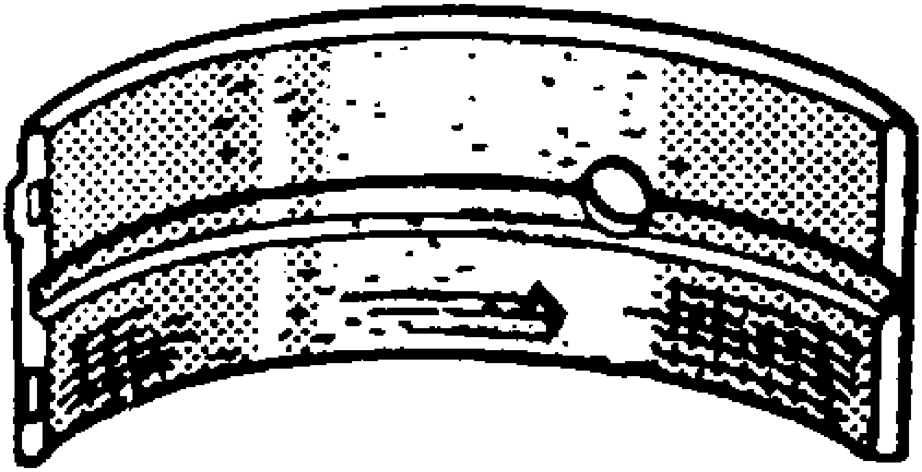


Fig. 313: Identifying Connecting Rod Bearing Scoring Or Discoloration
Courtesy of GENERAL MOTORS CORP.

16. Inspect the crankshaft bearings for excessive scoring or discoloration.
17. Inspect the crankshaft bearings for dirt or debris imbedded into the bearing material.

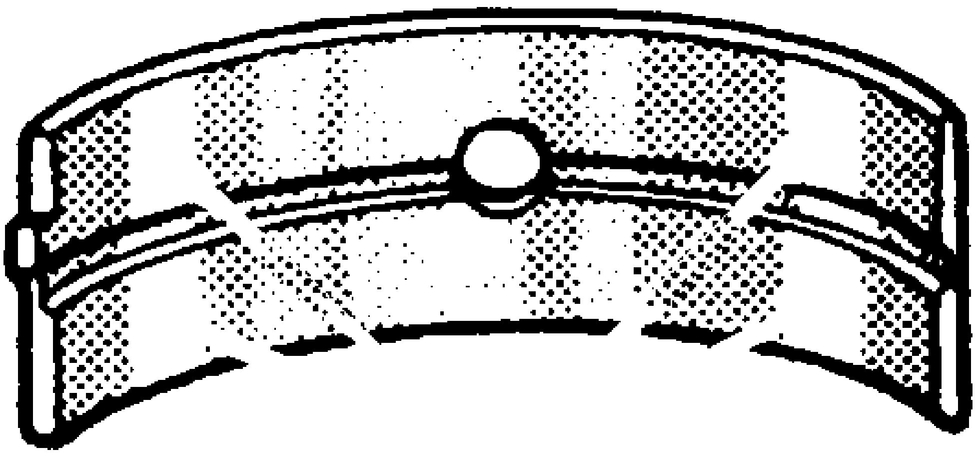


Fig. 314: Crankshaft Bearing Polished Sections (Improper Seating)
Courtesy of GENERAL MOTORS CORP.

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**.

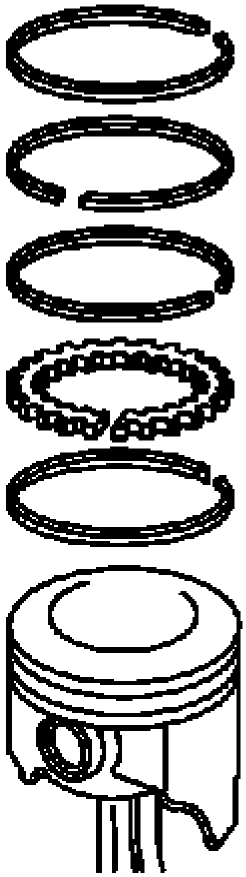


Fig. 315: Exploded View Of Piston Rings
Courtesy of GENERAL MOTORS CORP.

CAUTION: Handle the piston carefully. Worn piston rings are sharp and may cause bodily injury.

1. Disassemble the piston rings. Use a suitable tool in order to expand the rings. The piston rings must not be reused.

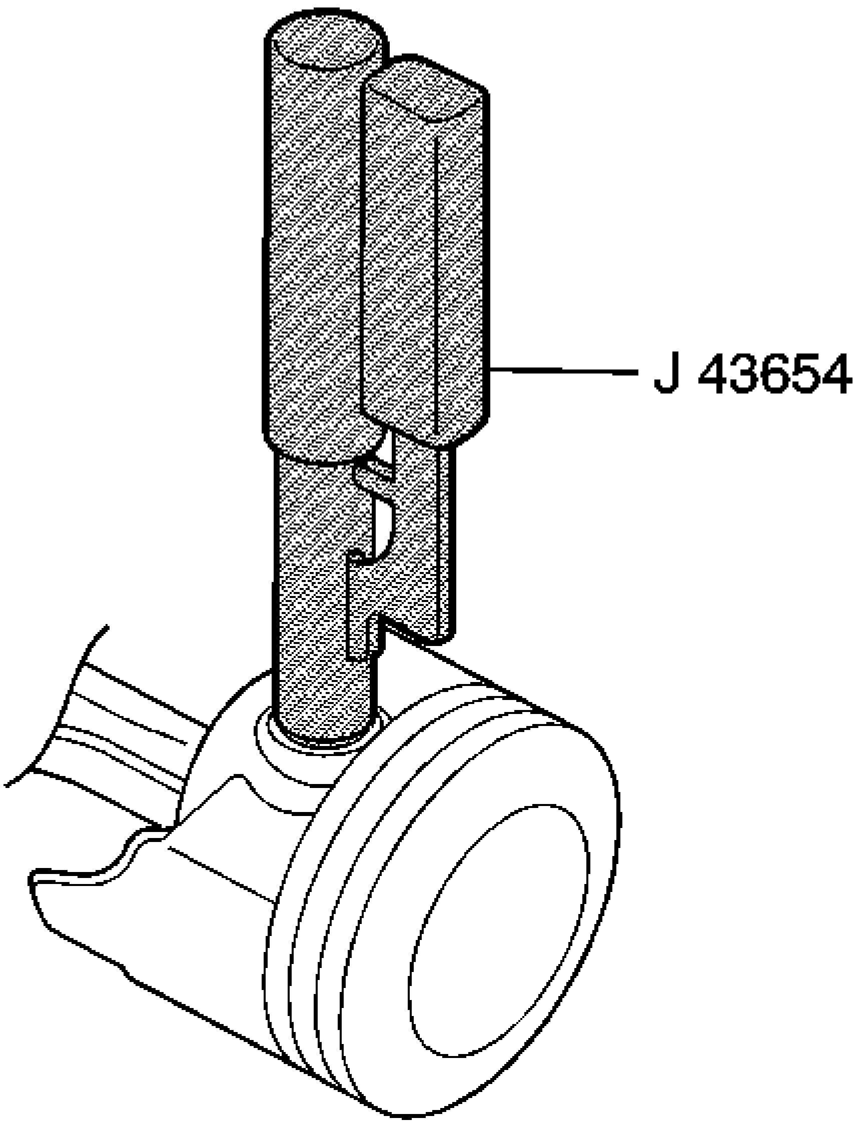


Fig. 316: Piston Pin Clip Remover & Installer
Courtesy of GENERAL MOTORS CORP.

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**.

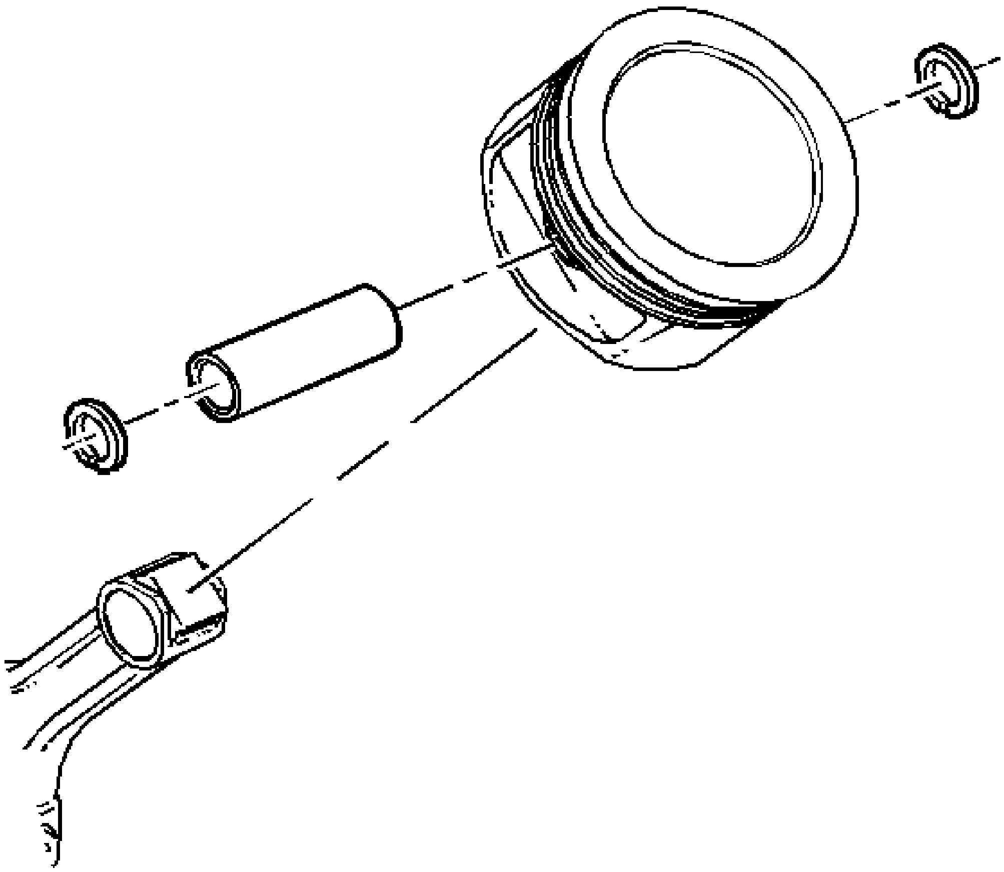


Fig. 317: View Of Piston Pin, Piston, Clips & Connecting Rod
Courtesy of GENERAL MOTORS CORP.

3. Remove the piston pin.

Piston, Connecting Rod, and Bearings Cleaning and Inspection

Connecting Rod Measurement

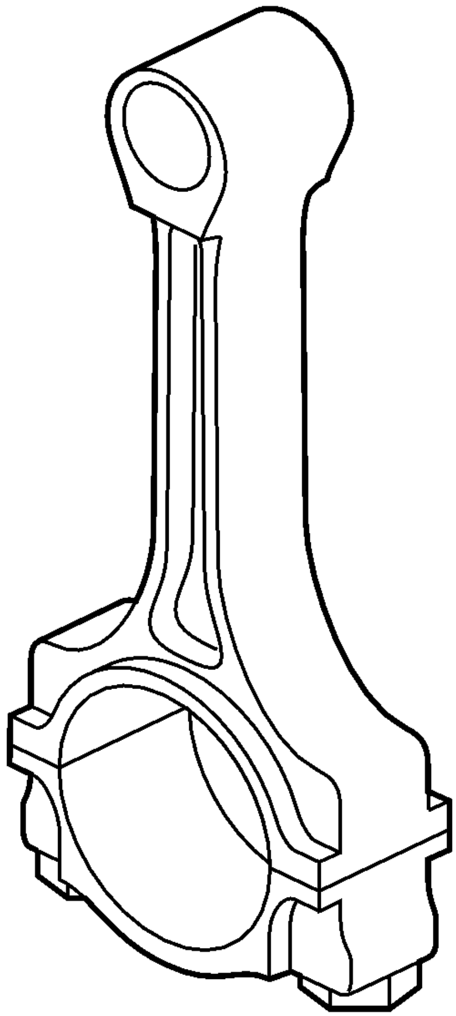


Fig. 318: View of Connecting Rod
Courtesy of GENERAL MOTORS CORP.

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

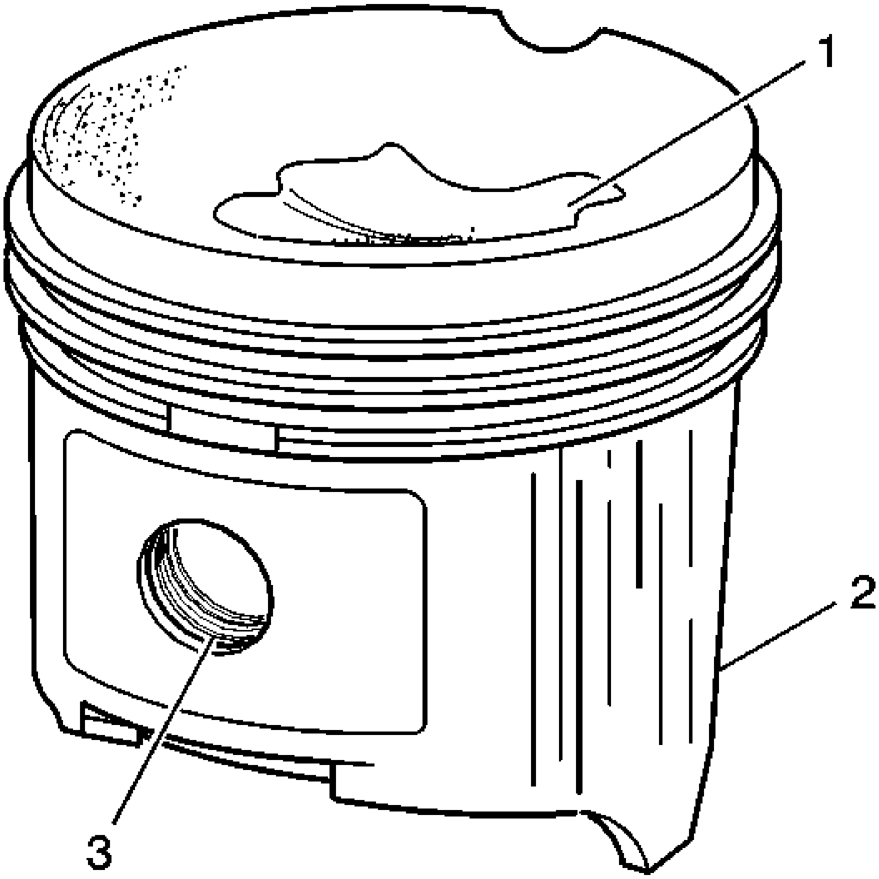


Fig. 319: Identifying Piston Damage Inspection Areas
Courtesy of GENERAL MOTORS CORP.

1. Clean the piston skirts and the pins with a cleaning solvent. DO NOT wire brush any part of the piston.
2. Clean the piston ring grooves with a groove cleaner. Make sure oil ring holes and slots are clean.
3. Inspect the pistons for the following conditions:
    - Cracked ring lands, skirts, or pin bosses
    - Ring grooves for nicks, burrs that may cause binding
    - Warped or worn ring lands
    - Eroded areas at the top of the piston (1)

- 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.

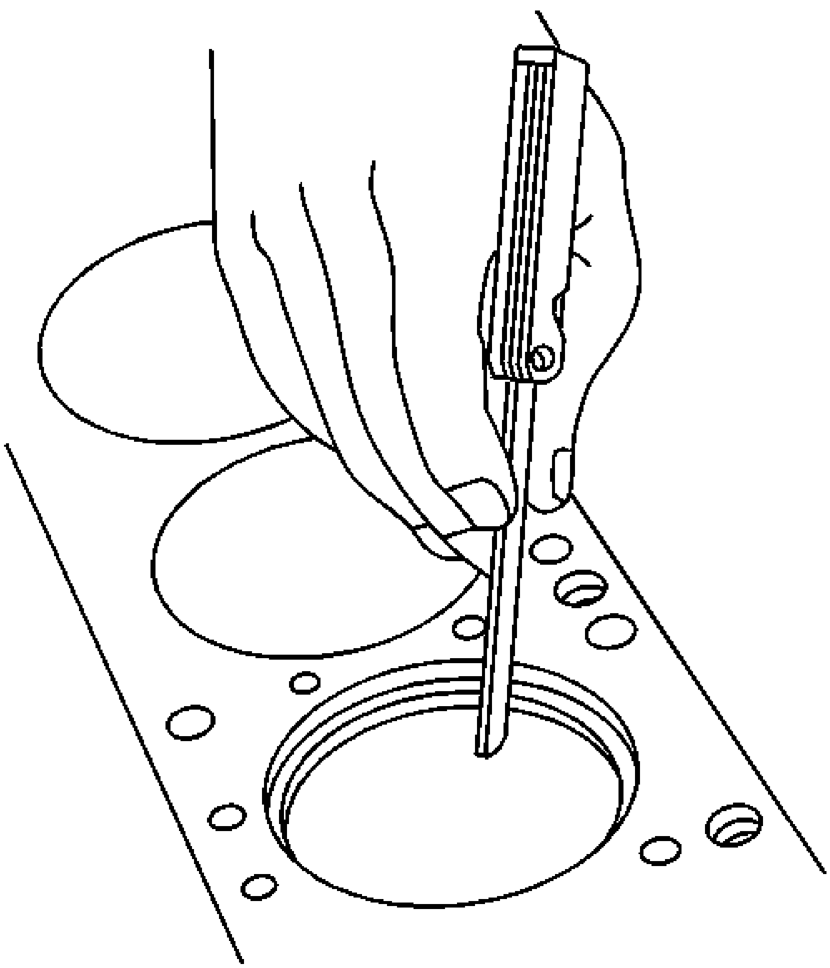


Fig. 320: Measuring Piston Ring End Gap
Courtesy of GENERAL MOTORS CORP.

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.

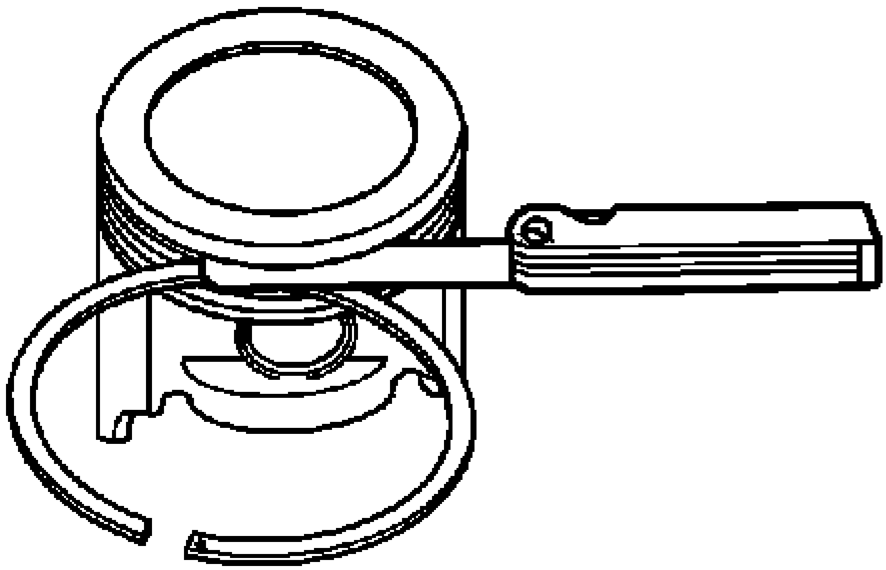


Fig. 321: Measuring Piston Ring Side Clearance
Courtesy of GENERAL MOTORS CORP.

7. Measure the piston ring side clearance using the following procedure:
   1. Roll the piston ring entirely around the piston ring groove. If any binding is caused by a distorted piston ring, replace the ring.
   2. With the piston ring on the piston, use feeler gages to check clearance at multiple locations.

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.

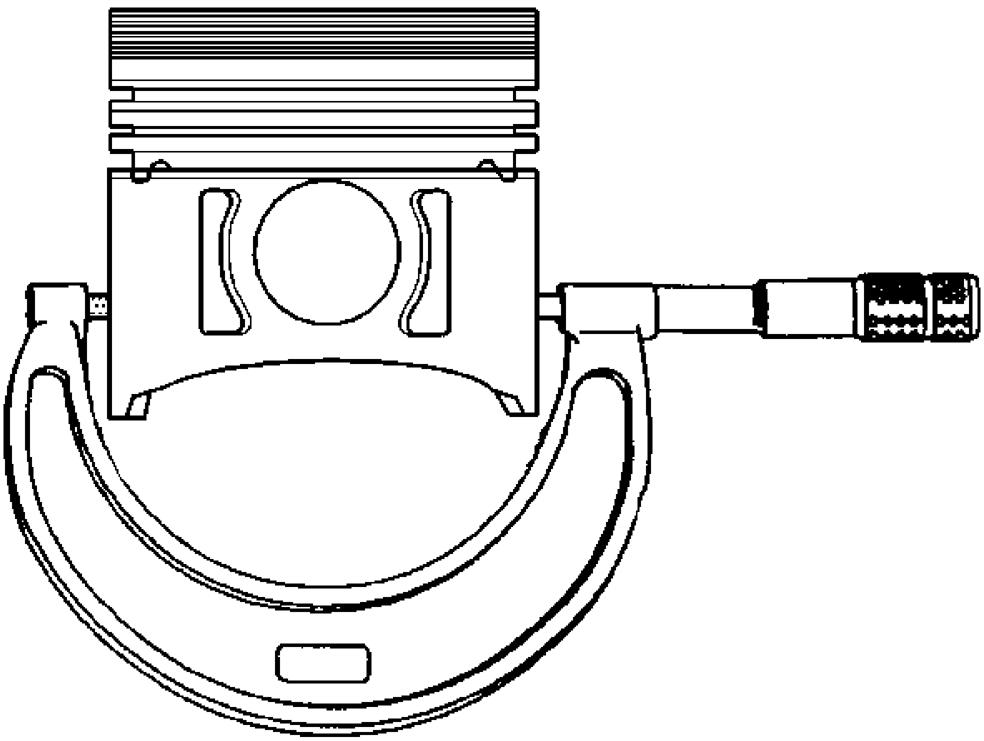


Fig. 322: Measuring Piston Diameter
Courtesy of GENERAL MOTORS CORP.

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

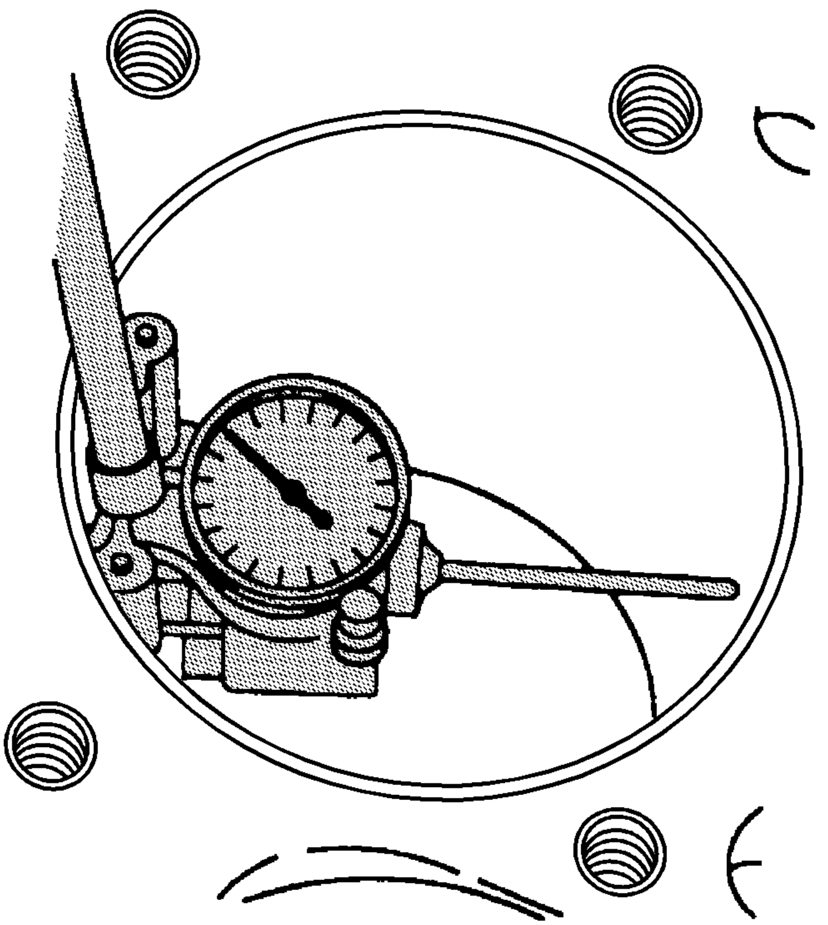


Fig. 323: Measuring Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Measurements of all components should be taken with the components at normal room temperature.
For proper piston fit, the engine block cylinder bores must not have excessive wear or taper.
A used piston and pin set may be reinstalled if, after cleaning and

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.

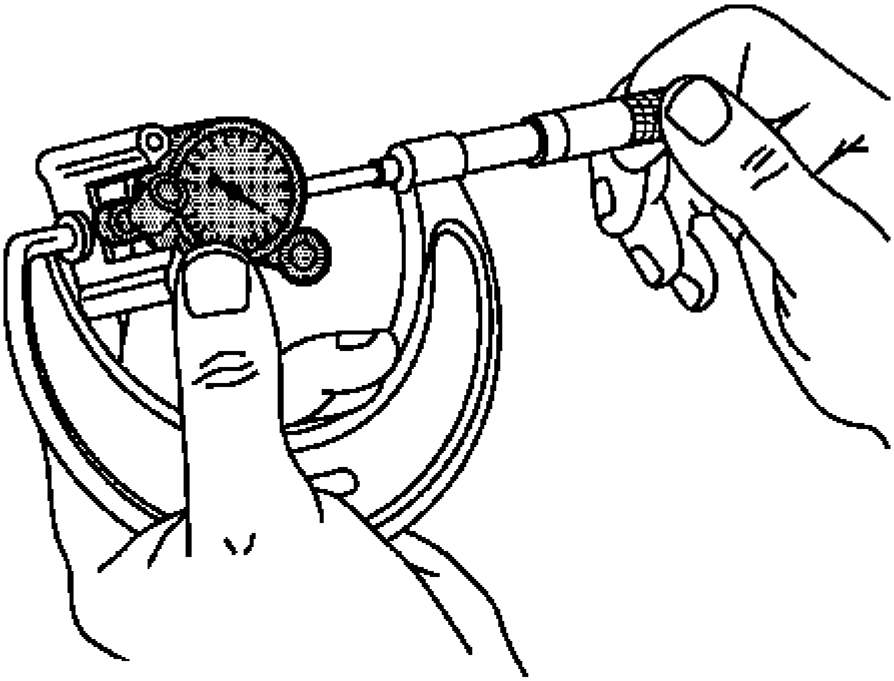


Fig. 324: Measuring Bore Gauge With Micrometer
Courtesy of GENERAL MOTORS CORP.

4. Measure the bore gauge with a micrometer and record the reading.

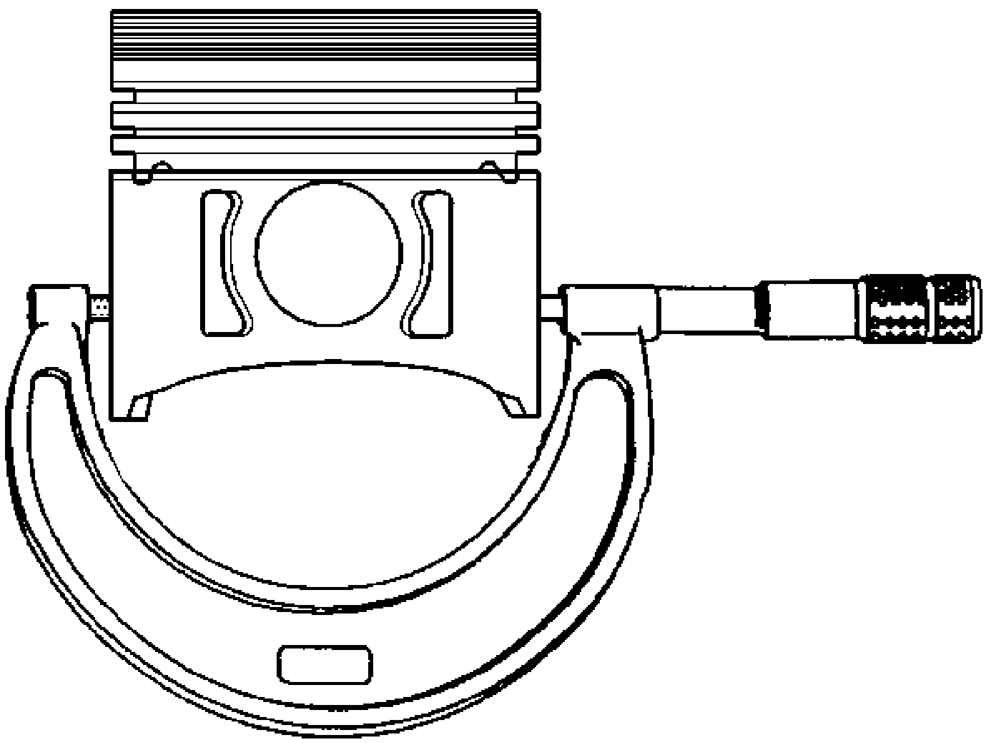


Fig. 325: Measuring Piston Diameter
Courtesy of GENERAL MOTORS CORP.

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

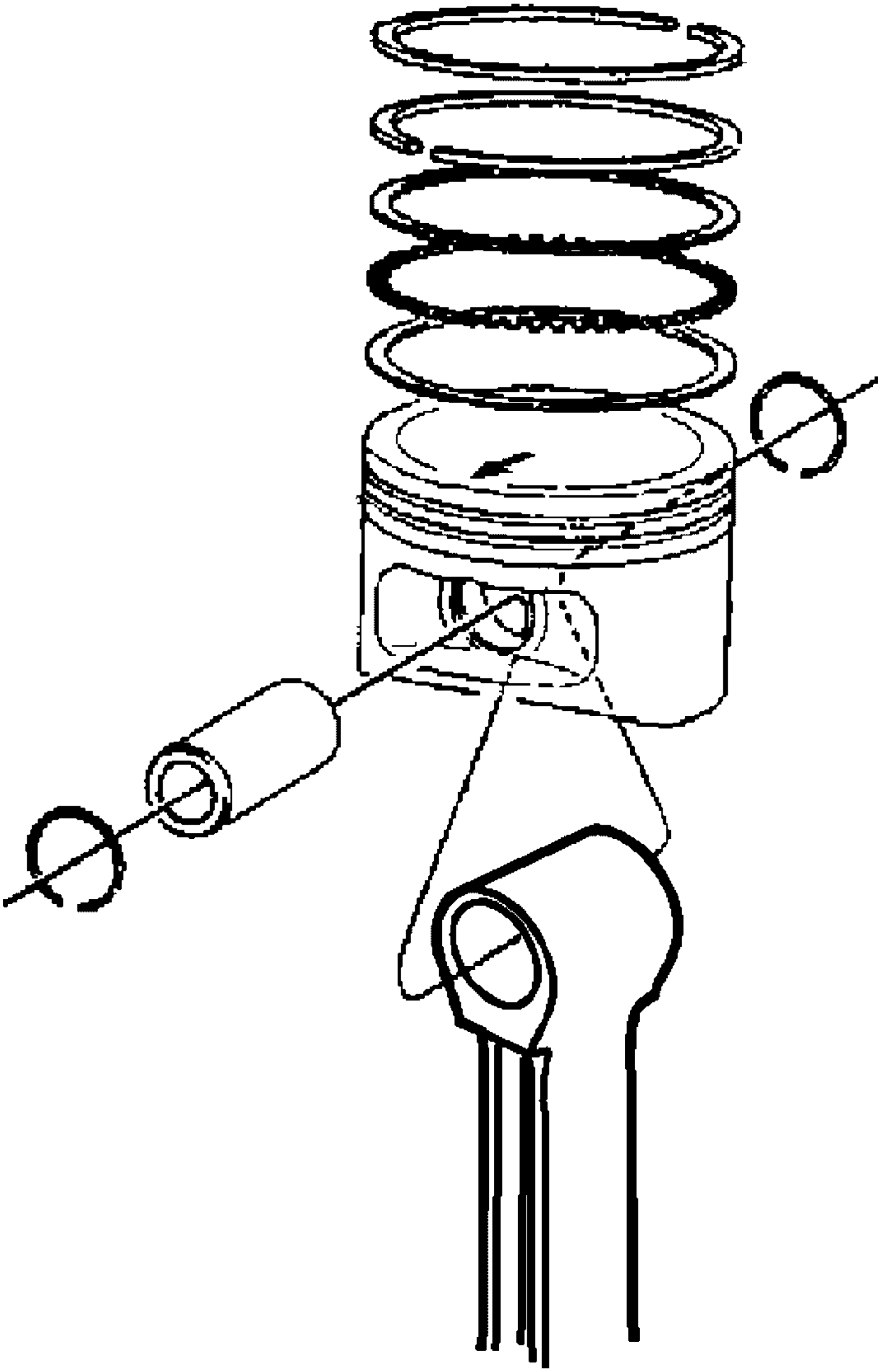


Fig. 326: View of Connecting Rod & Piston
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Install the piston onto the connecting rod with the arrow oriented toward the front of the engine.

1. Assemble the connecting rod and the piston.

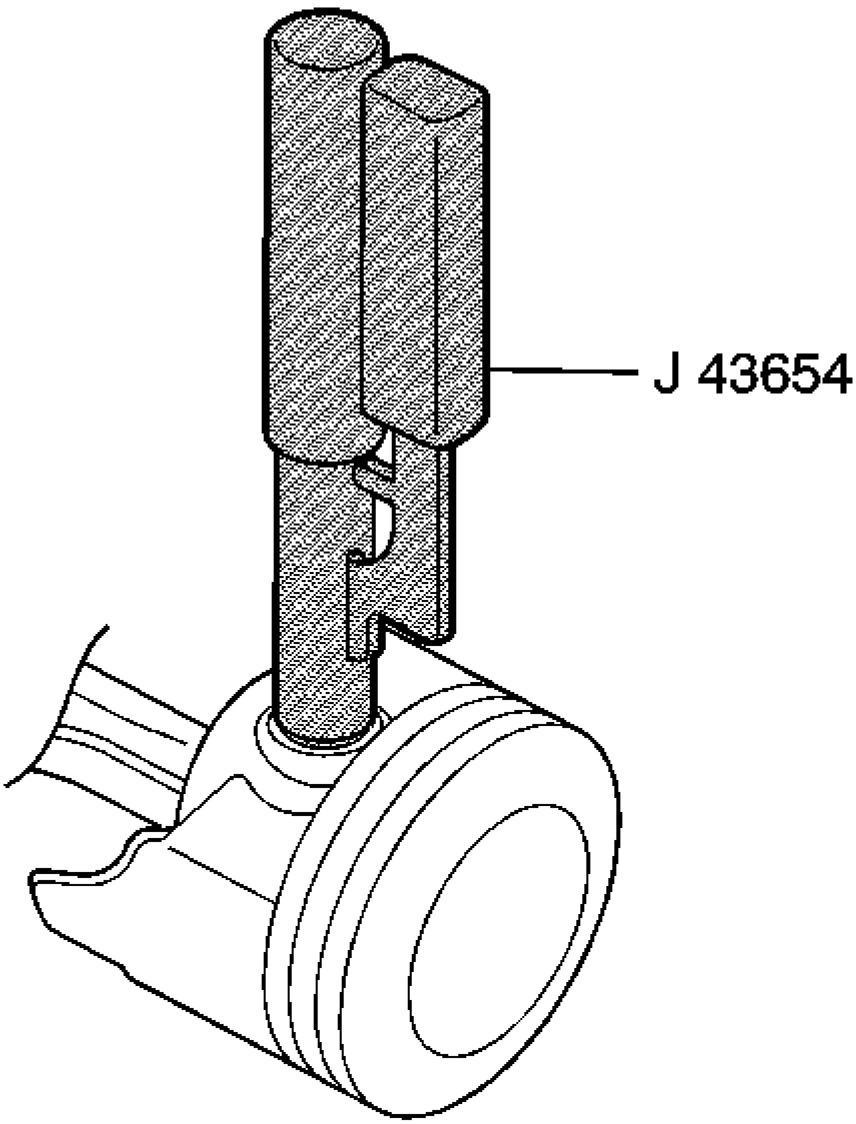


Fig. 327: Piston Pin Clip Remover & Installer
Courtesy of GENERAL MOTORS CORP.

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.

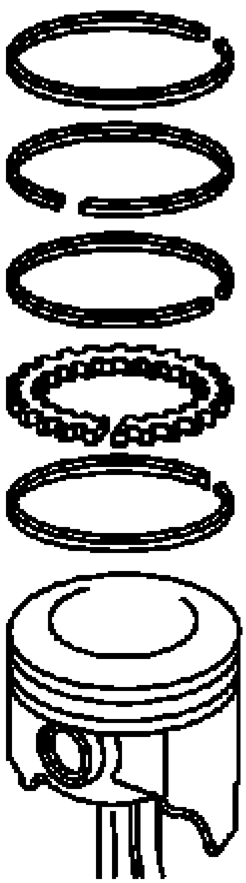


Fig. 328: Exploded View Of Piston Rings
Courtesy of GENERAL MOTORS CORP.

NOTE: Use a piston ring expander to install the piston rings. The rings may be damaged if expanded more than necessary.

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

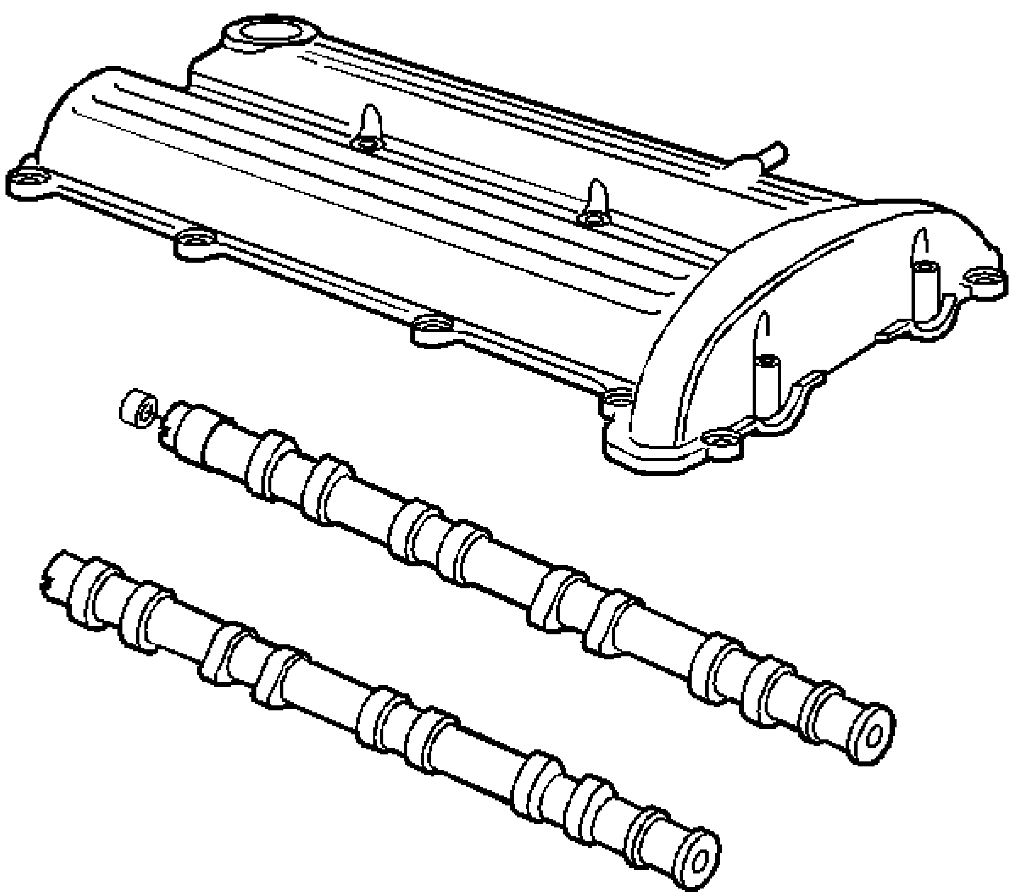


Fig. 329: View of Camshaft
Courtesy of GENERAL MOTORS CORP.

- 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

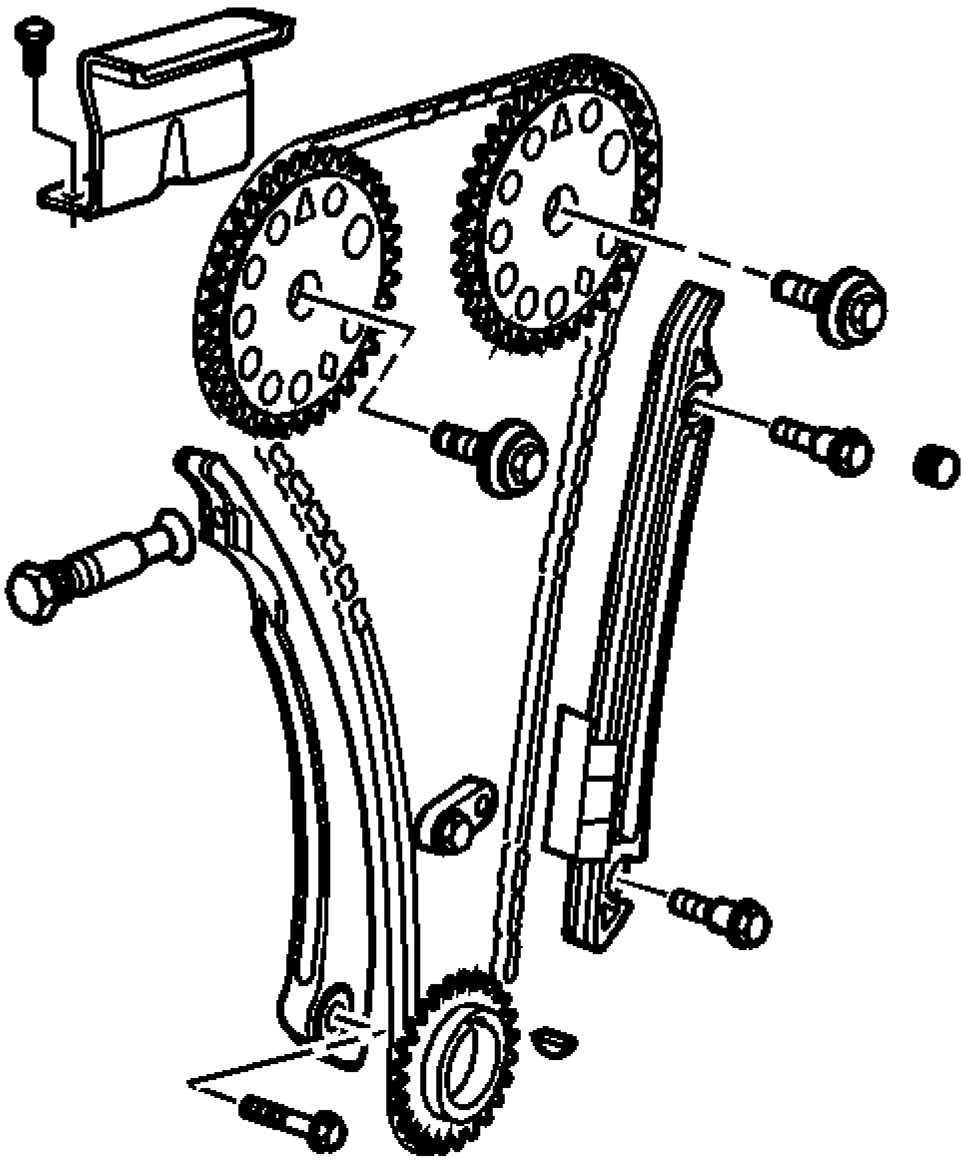


Fig. 330: View of Timing Chain Guides
Courtesy of GENERAL MOTORS CORP.

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

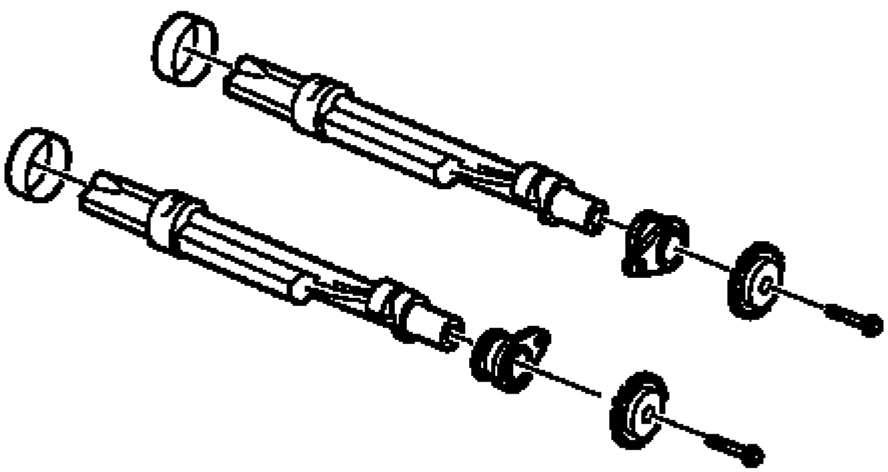


Fig. 331: View of Balance Shafts
Courtesy of GENERAL MOTORS CORP.

1. Clean the balance shafts in solvent.
2. Remove the balance shaft front bearing carriers from the balance shafts.
3. Inspect the bearing surfaces on the balance shafts for scoring or unusual wear.

4. Inspect the balance shaft drive sprockets for wear, damage, or missing teeth. When installing new balance shaft drive sprockets tighten to 55 N.m (41 lb ft).
5. Measure the rear bearing journals on the balance shafts, the journals should be 36.723-36.743 mm (1.4458-1.4466 in) in diameter.
6. Measure the front bearing journals on the balance shafts, the front bearing journals should be 20.020-20.000 mm (0.7881-0.7874 in) in diameter.
7. When the balance shafts have been installed in the engine block, check for smooth rotation, sticking, binding, or roughness.

Balance Shaft Drive Chain and Sprockets Cleaning and Inspection

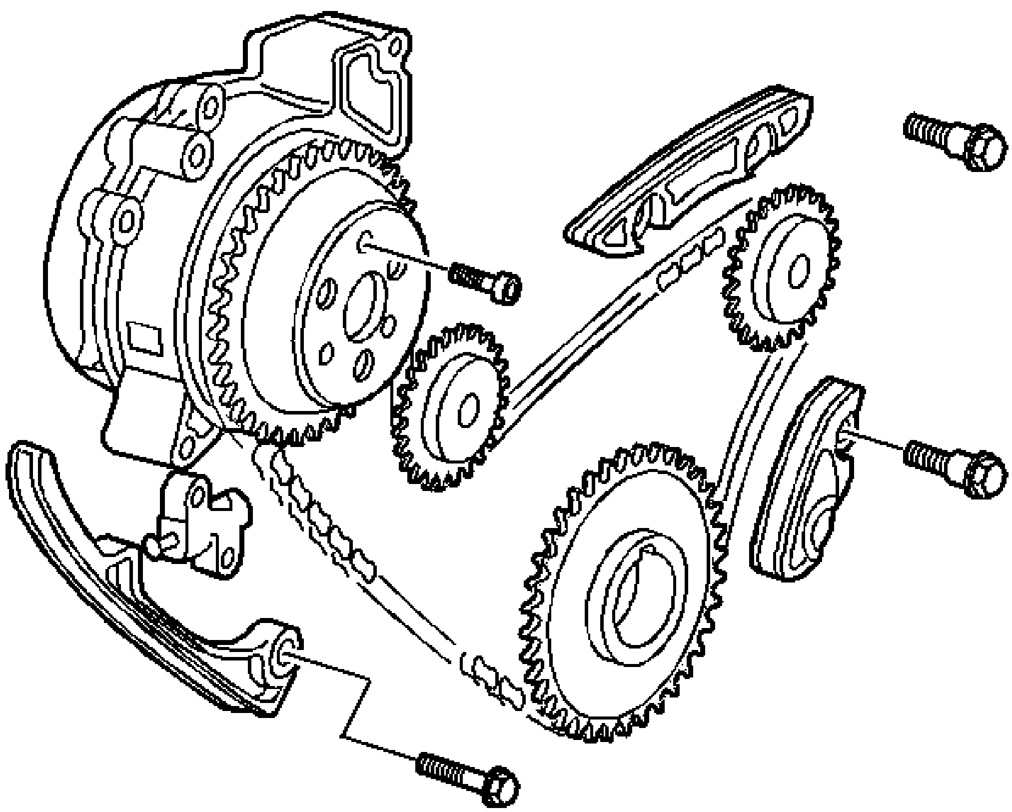


Fig. 332: View of Balance Shaft Drive Chain Guides
Courtesy of GENERAL MOTORS CORP.

1. Inspect the balance shaft drive chain guides for cracking or wear.
2. Replace the balance shaft drive chain guides if wear exceeds 1.12 mm (0.045 in) depth on the chain guide surface.

3. Inspect the balance shaft drive chain tensioner guide shoe for wear.

   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 (off car). See **Special Tools and Equipment**.

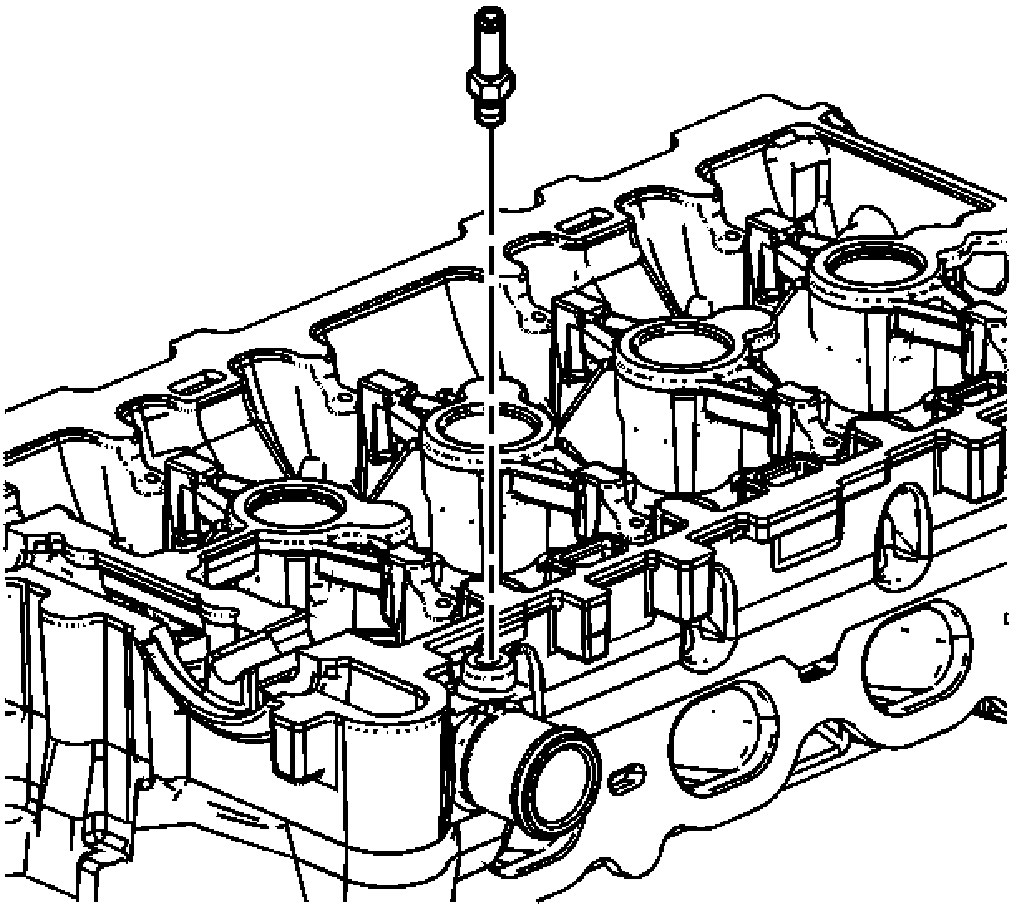


Fig. 333: Identifying Cylinder Head Air Bleed Tube
Courtesy of GENERAL MOTORS CORP.

1. Remove the coolant air bleed hose fitting.

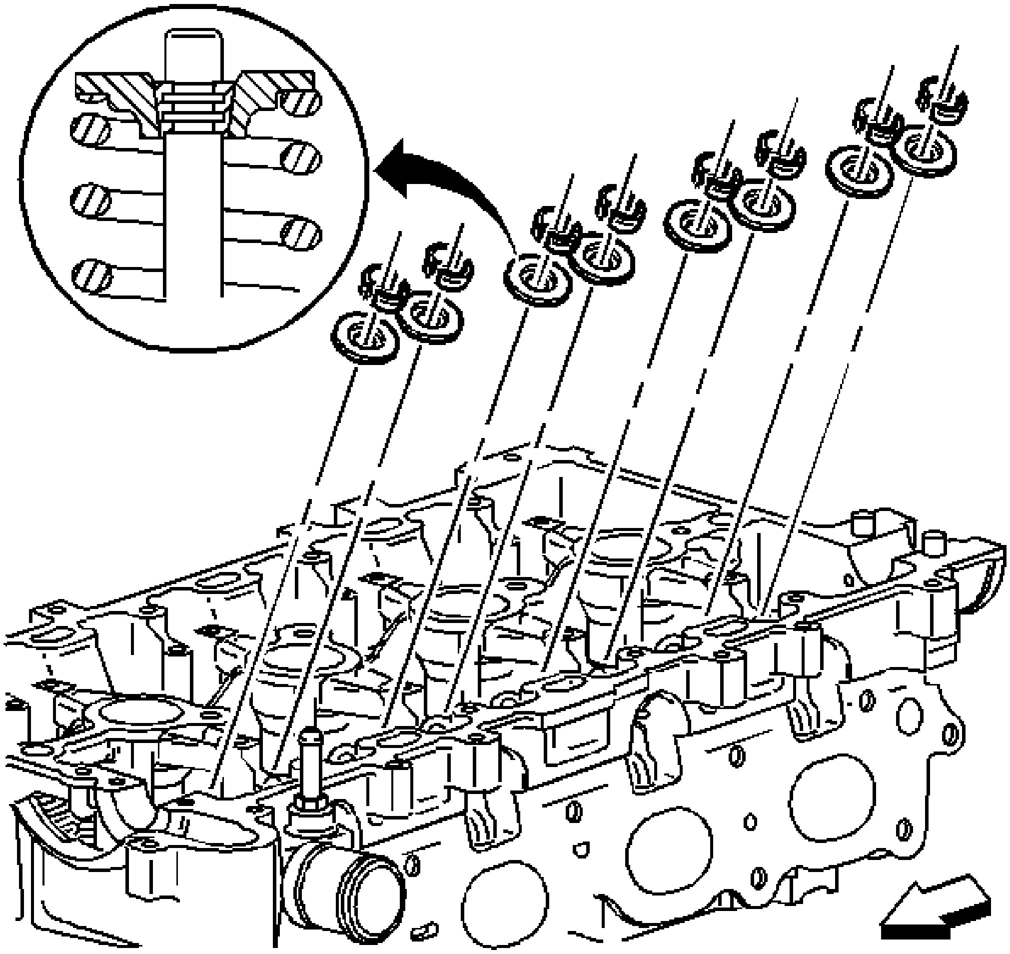


Fig. 334: Identifying Valve Spring Retainers
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure that the valve train components are kept together and identified in order for proper re-installation in their original position.

2. Using the **J 8062** and the**J 43963** , compress the valve spring. 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. See **Special Tools and Equipment**.
5. Remove the retainer.

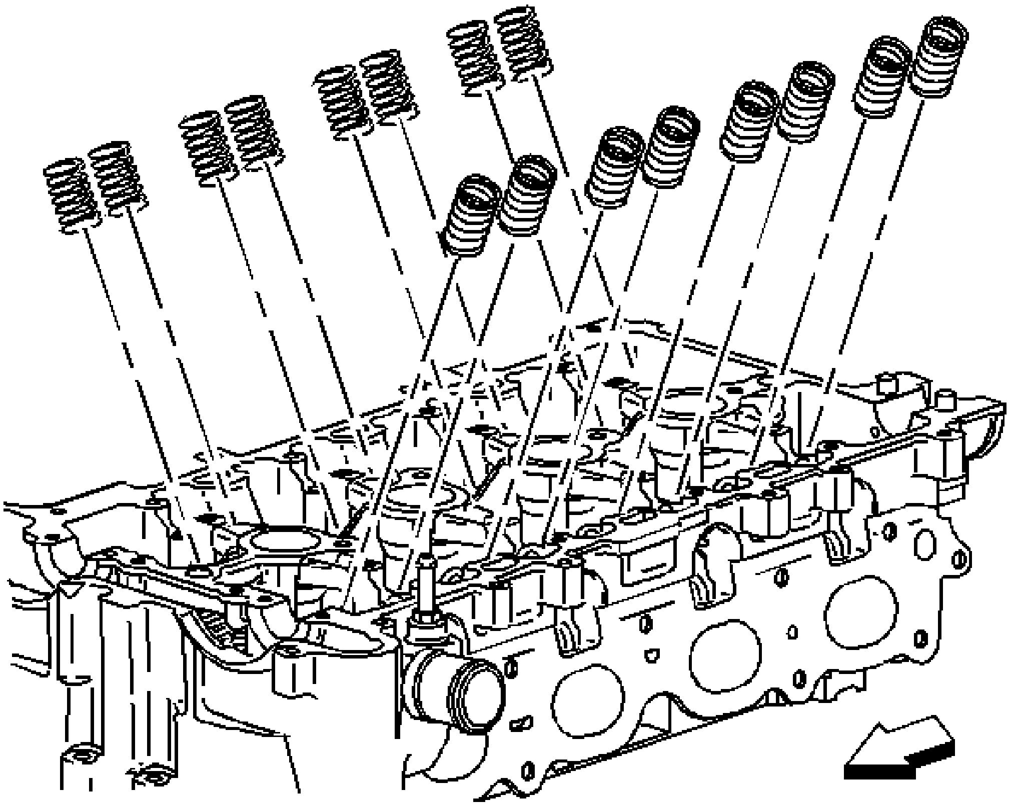


Fig. 335: View Of Valve Springs
Courtesy of GENERAL MOTORS CORP.

6. Remove the spring.

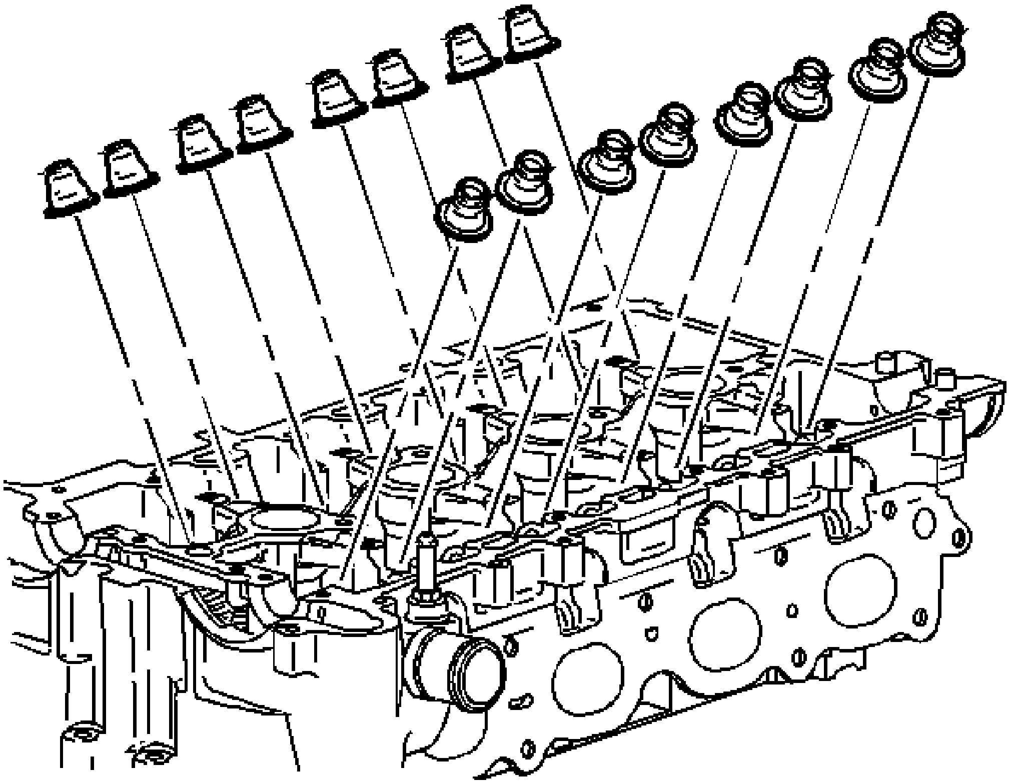


Fig. 336: View of Valve Seal
Courtesy of GENERAL MOTORS CORP.

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.

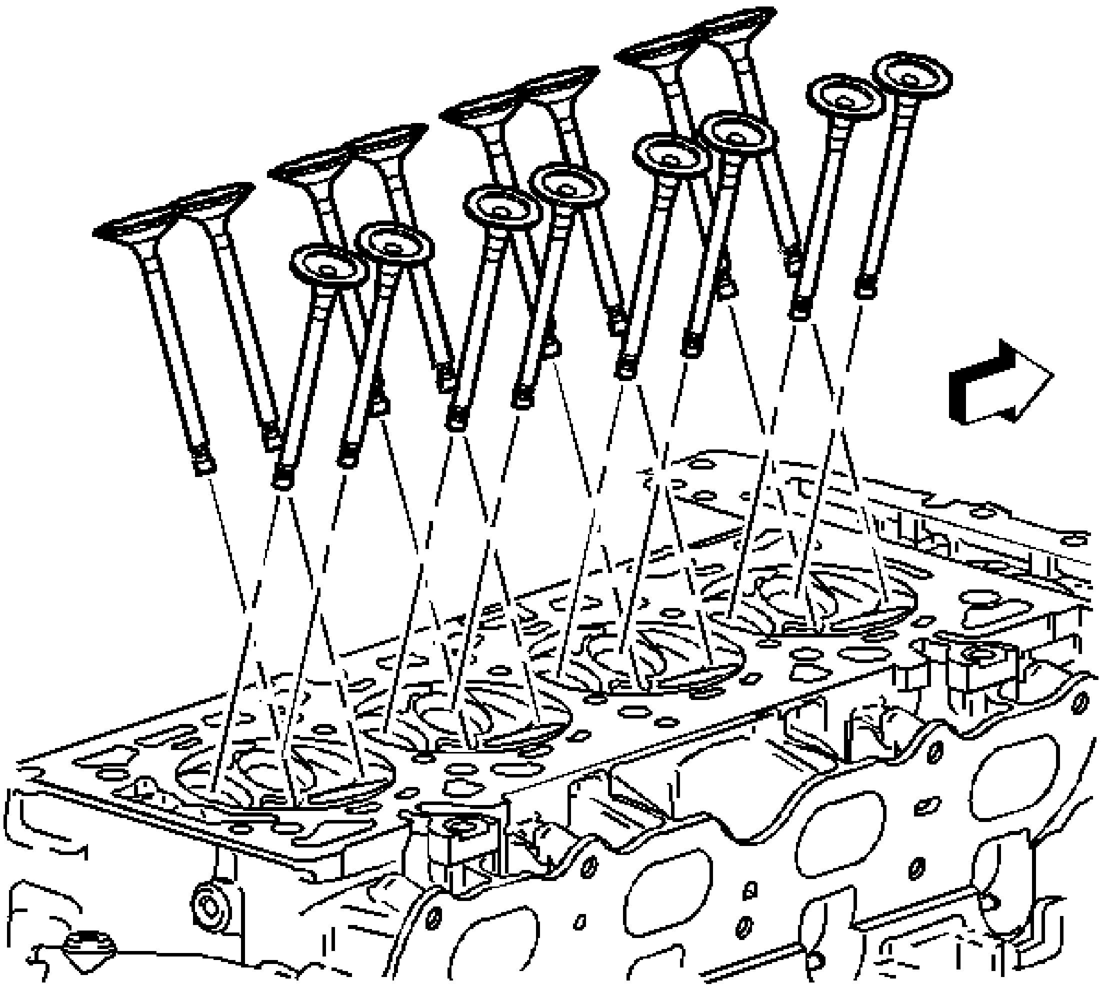


Fig. 337: Identifying Engine Valves
Courtesy of GENERAL MOTORS CORP.

8. Remove the valve.
9. Remove the remaining valves.

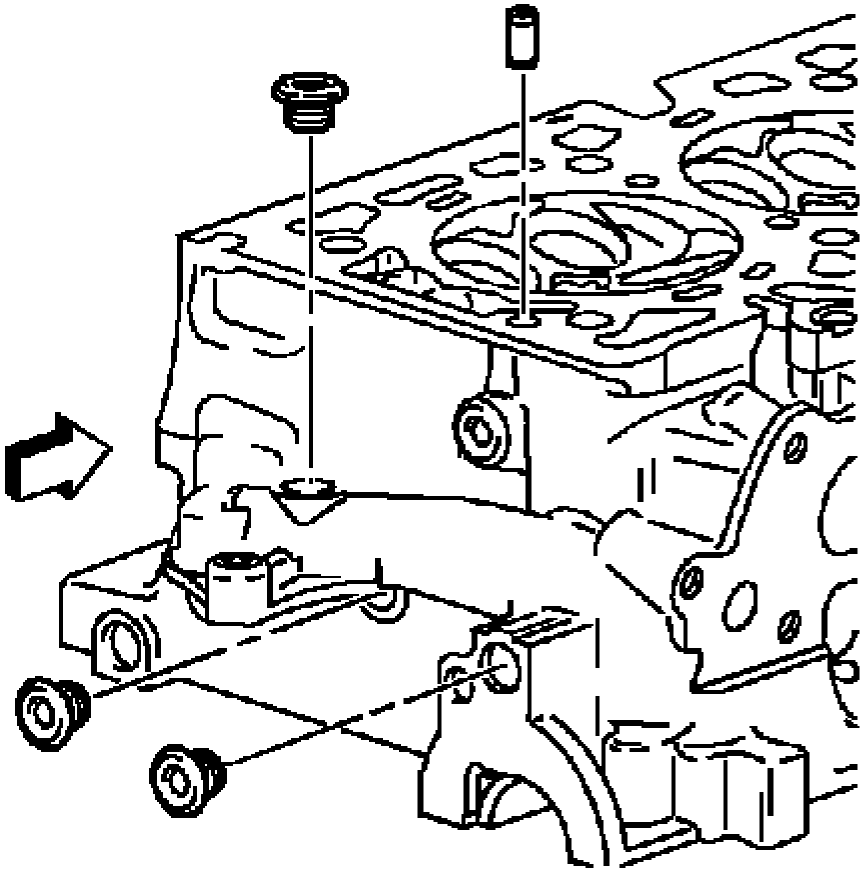


Fig. 338: View Of Cylinder Head Plugs
Courtesy of GENERAL MOTORS CORP.

10. Remove the cylinder head plugs.

Cylinder Head Cleaning and Inspection

Valve Cleaning and Inspection

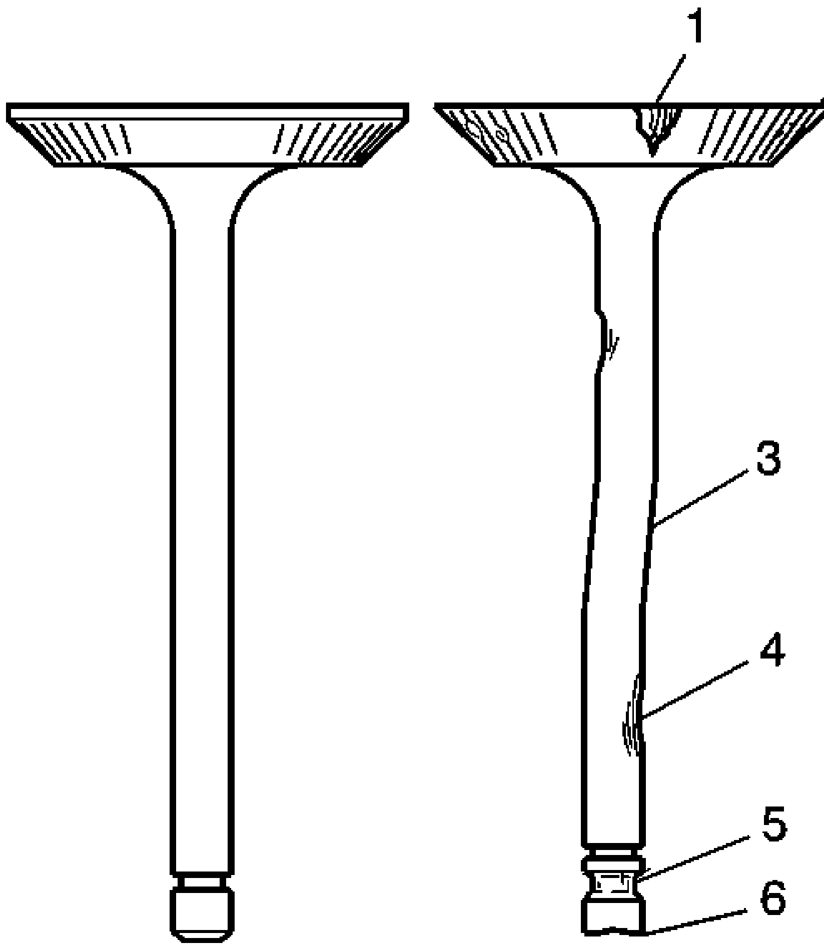


Fig. 339: Identifying Inspection Points For Valves Damage
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not scratch the valve stem with the wire brush.

1. Clean the valves of carbon, oil and varnish. Carbon can be removed with a wire brush. Varnish can be removed by soaking in Parts Immersion Solvent GM P/N 12345368 (Canadian P/N 10953514) or equivalent.
2. Clean the valve guides.
3. Inspect the valve stem for wear (4).
4. Inspect the valve keeper groove for chipping or wear (5). Replace the valve if chipped or worn.
5. Inspect the valve face for burning or cracking (1). If pieces are broken off, inspect the corresponding piston and cylinder head area for damage.
6. Inspect the valve stem for burrs and scratches. Burrs and minor scratches may be removed with an oil stone.
7. Inspect the valve stem for straightness and the valve head for bending or distortion (3) using V blocks.

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

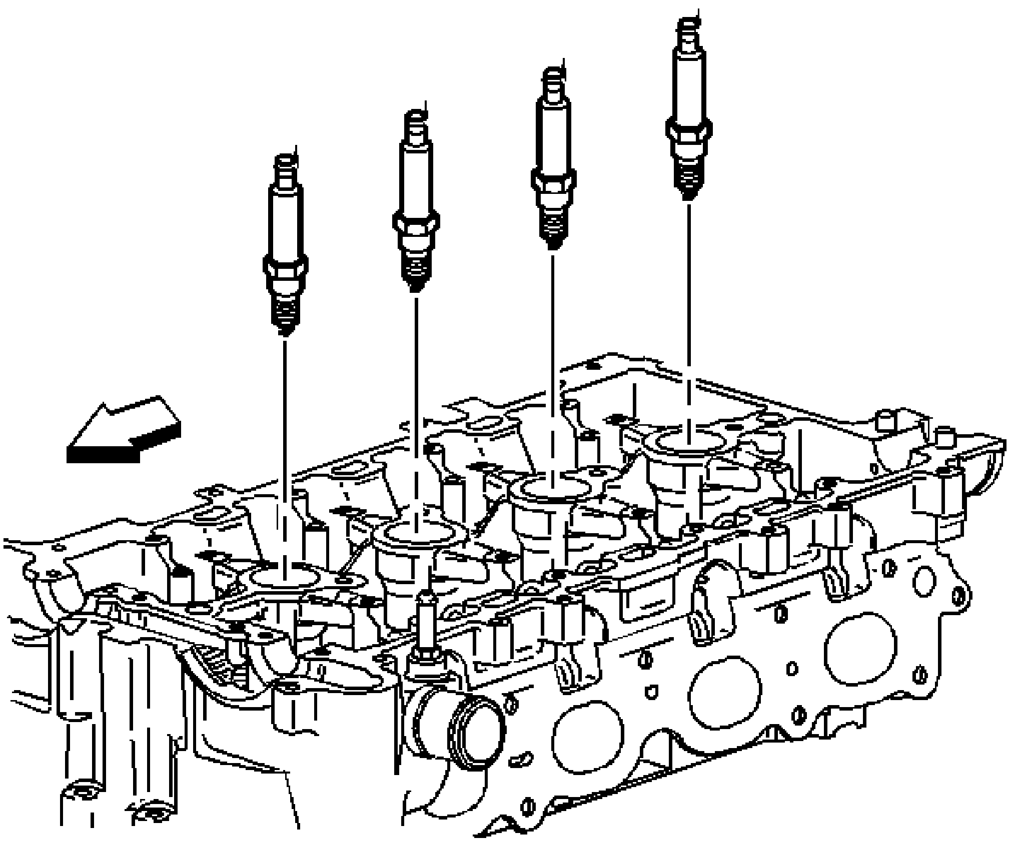


Fig. 340: View of Spark Plugs
Courtesy of GENERAL MOTORS CORP.

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:
    1. Improper installation
    2. Loose or warped cylinder head

3. Missing, off location or not fully seated dowel pins
4. Corrosion in the seal area around the coolant passages
5. Chips or debris in the cylinder head bolt holes
6. Bolt holes in the cylinder block not drilled or tapped deep enough
7. Other

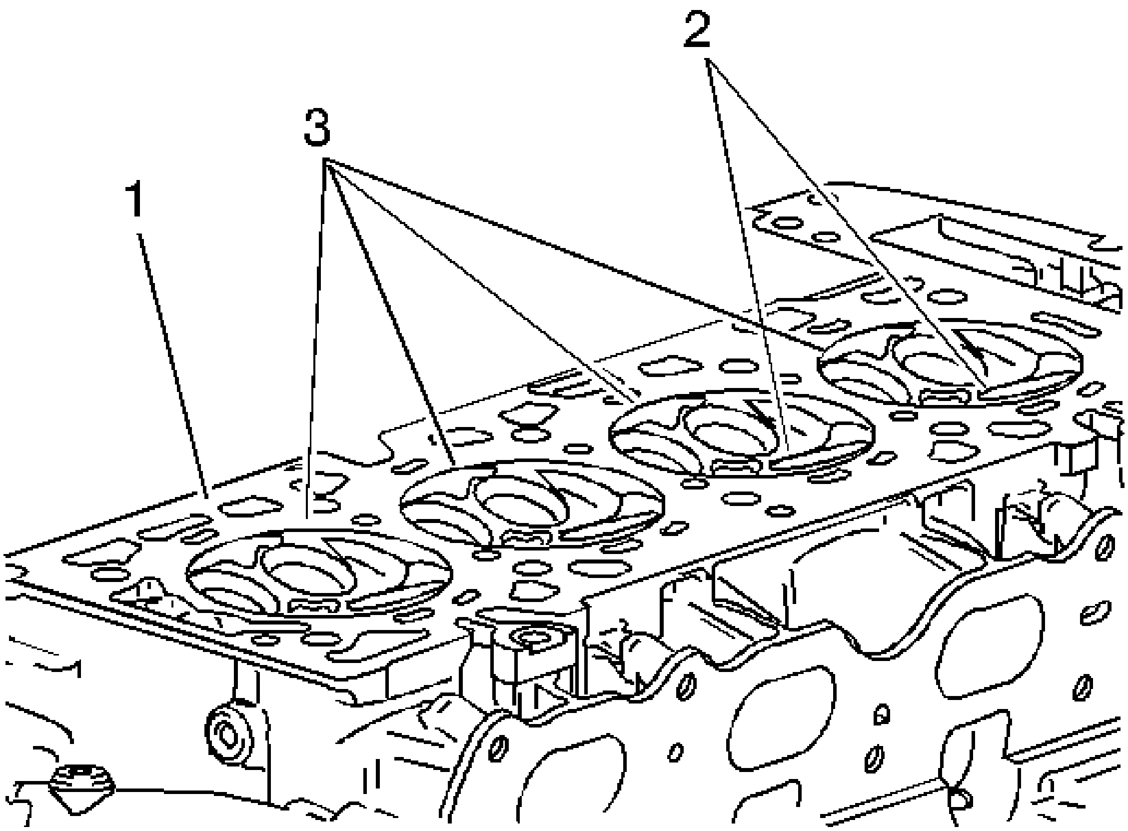


Fig. 341: View of Cylinder Head Gasket Surface
Courtesy of GENERAL MOTORS CORP.

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.

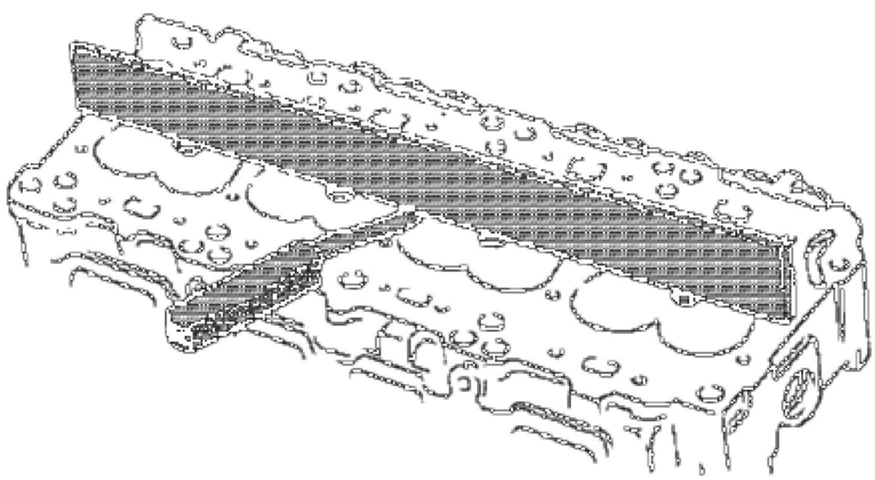


Fig. 342: Inspecting Cylinder Head Deck Surface for Flatness

Courtesy of GENERAL MOTORS CORP.

13. Inspect the cylinder head deck surface for flatness. Refer to **Engine Mechanical Specifications**.
14. Inspect all the threaded holes for damage. Threads may be reconditioned with thread inserts.
15. Inspect the sealing surfaces.

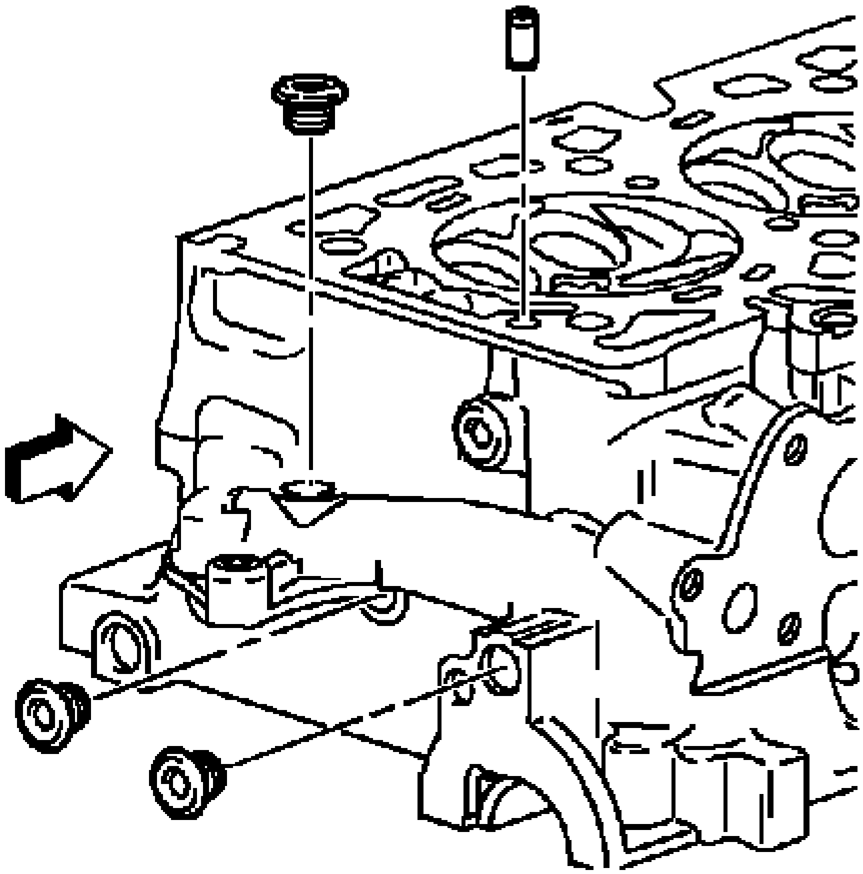


Fig. 343: View Of Cylinder Head Plugs
Courtesy of GENERAL MOTORS CORP.

16. Inspect the cylinder head plugs.

Cylinder Head Assemble

Tools Required

- **J 8062** Valve Spring Compressor. See **Special Tools and Equipment**.
- **J 9666** Valve Spring Tester. See **Special Tools and Equipment**.
- **J 43963** Valve Spring Compressor (off car). See **Special Tools and Equipment**.

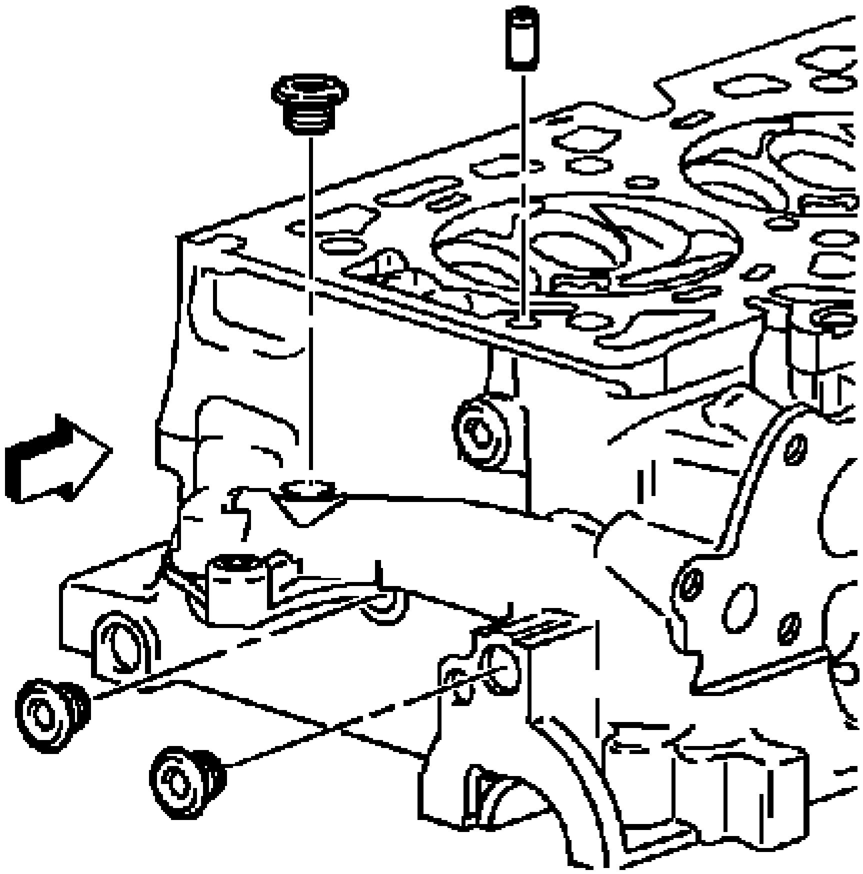


Fig. 344: View Of Cylinder Head Plugs
Courtesy of GENERAL MOTORS CORP.

NOTE: **In order to avoid damage, install the spark plugs after the cylinder head has been installed on the engine.**

1. Install NEW cylinder head plugs. Coat the plugs with sealer GM P/N 12345382 (Canadian P/N 10953489) or equivalent.

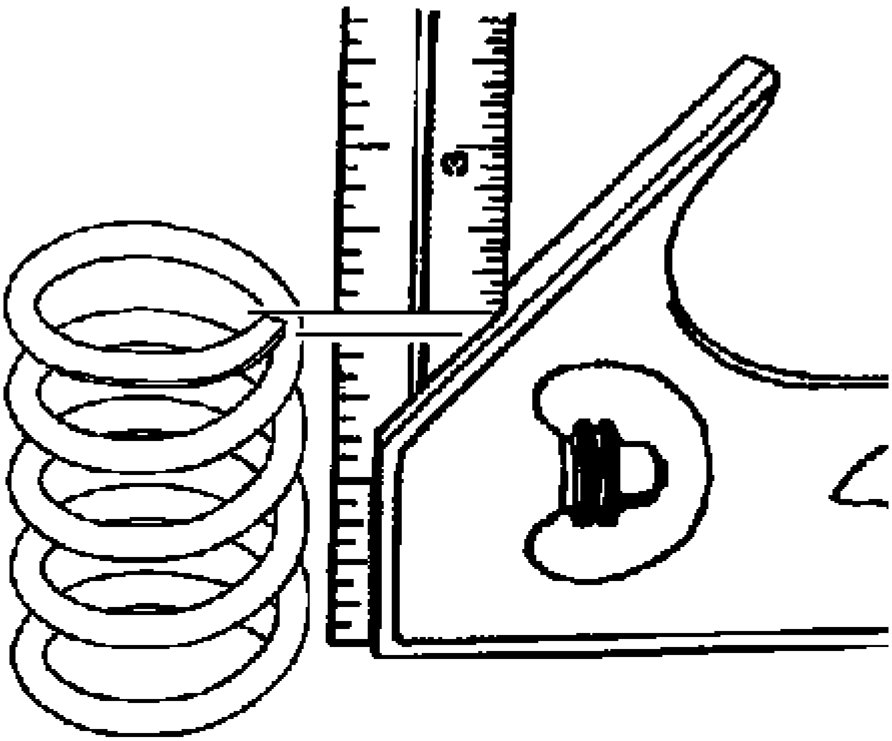


Fig. 345: Inspecting Valve Spring For Squareness
Courtesy of GENERAL MOTORS CORP.

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

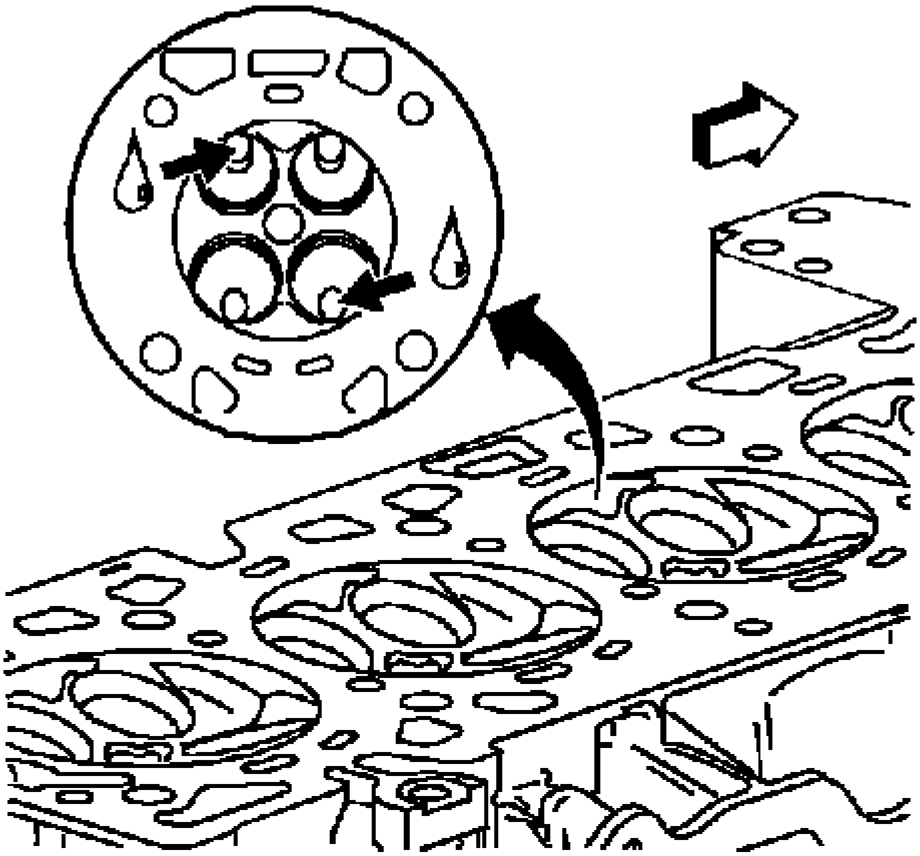


Fig. 346: View of Valve Assembly
Courtesy of GENERAL MOTORS CORP.

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.

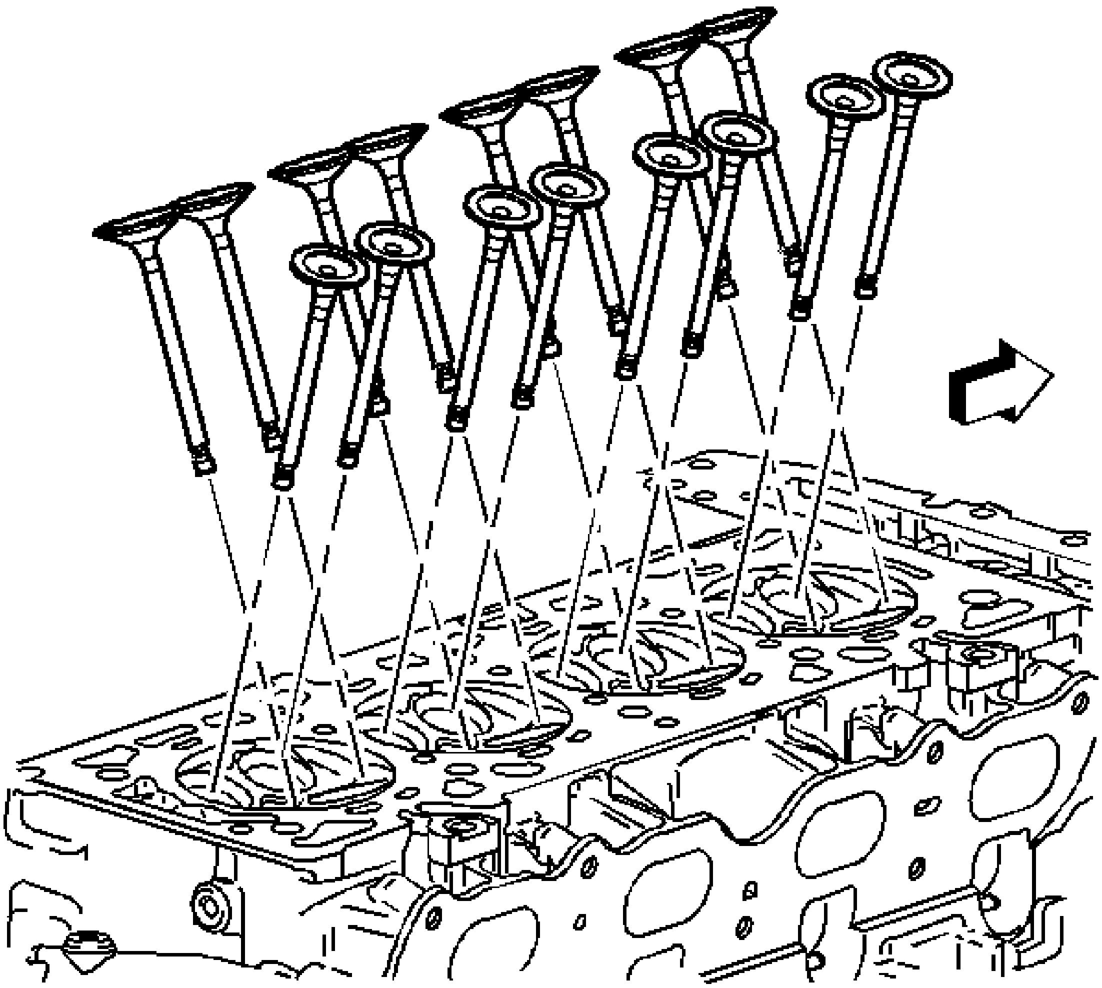


Fig. 347: Identifying Engine Valves
Courtesy of GENERAL MOTORS CORP.

6. Replace the valves, if required.

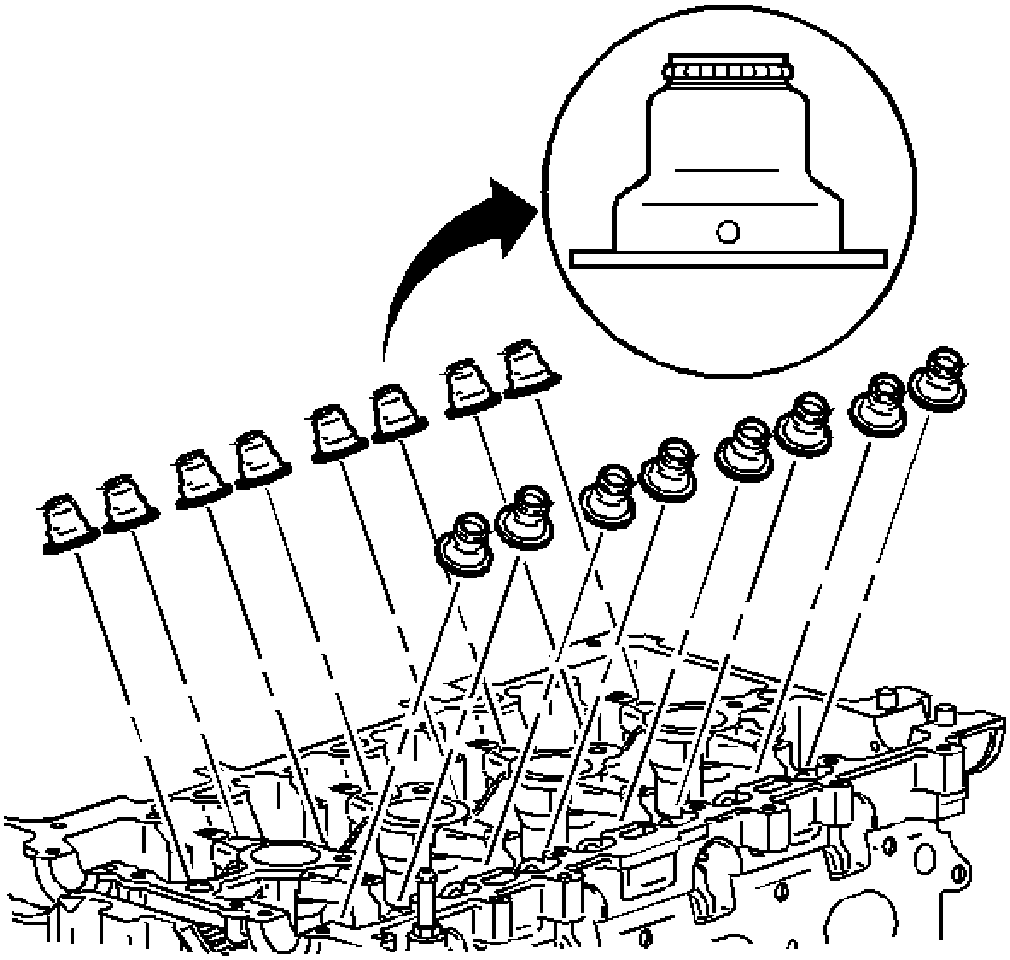


Fig. 348: View of Valve Seals
Courtesy of GENERAL MOTORS CORP.

7. Install the new valve seals. Fully seat the seals on the valve guides.

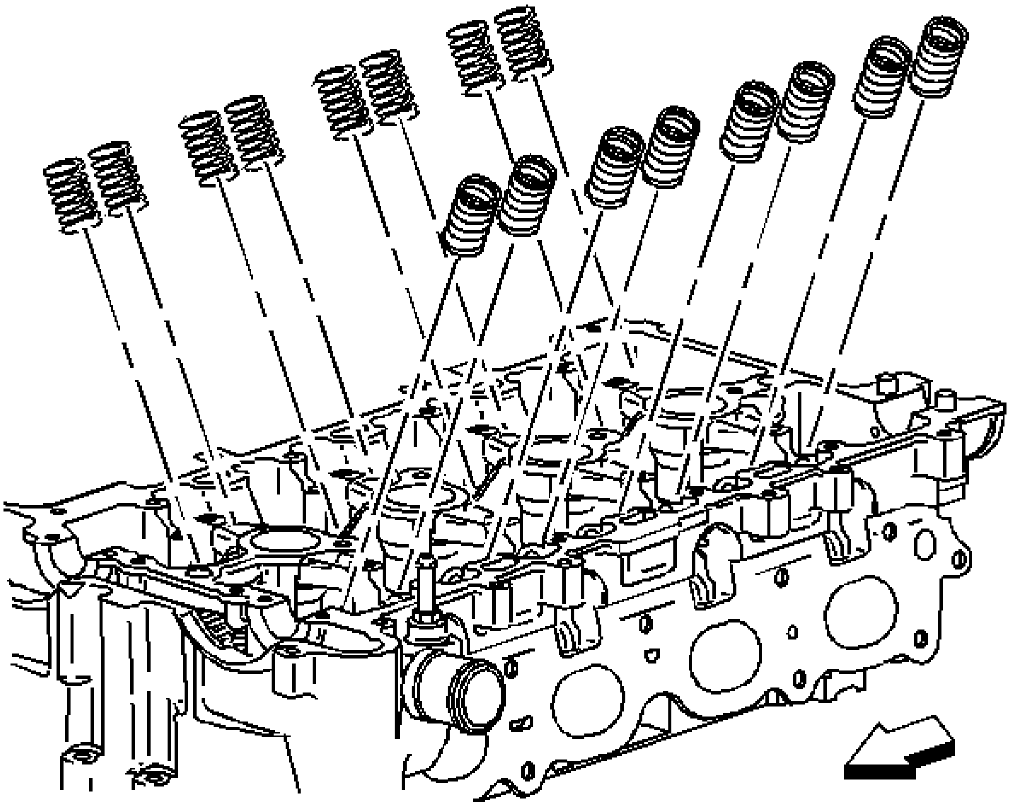


Fig. 349: View Of Valve Springs
Courtesy of GENERAL MOTORS CORP.

8. Install the spring.

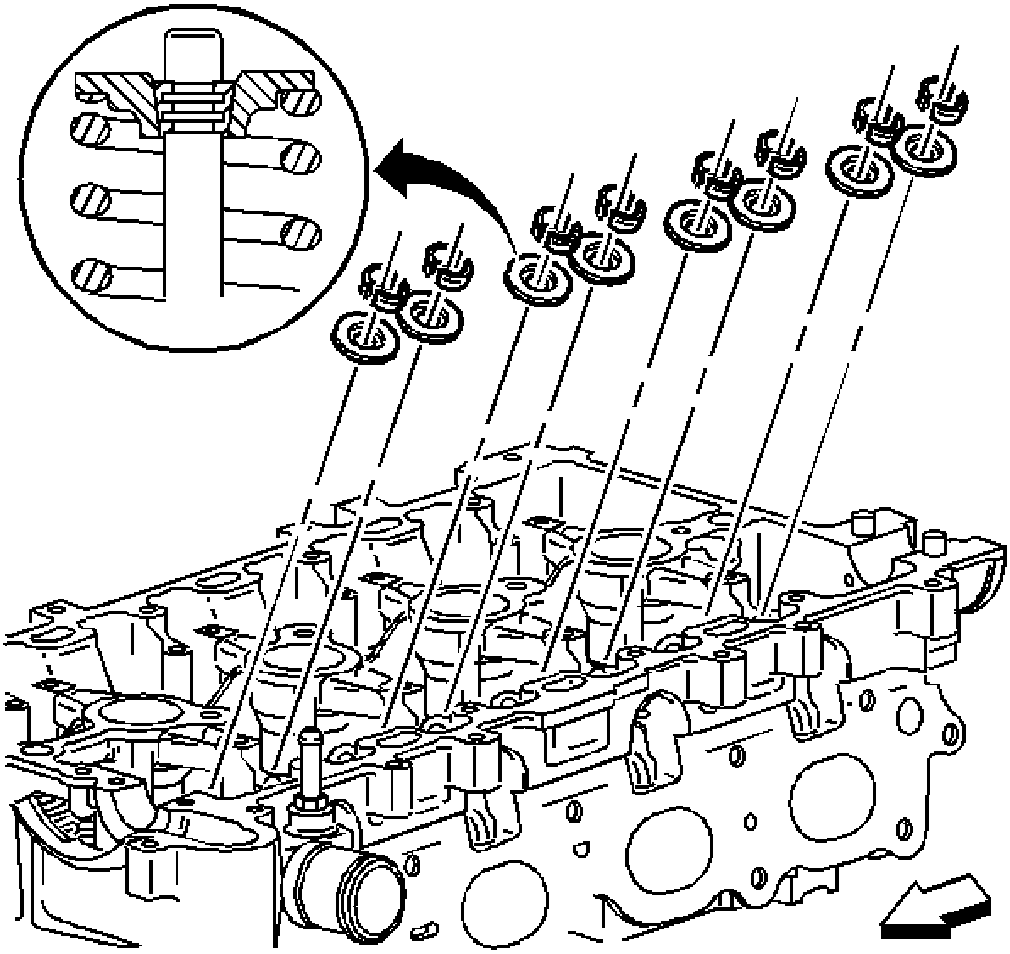


Fig. 350: Identifying Valve Spring Retainers
Courtesy of GENERAL MOTORS CORP.

9. Install the retainer.
10. Using the **J 8062** and the **J 43963** , compress the valve spring. See **Special Tools and Equipment**.
11. Install the valve keys.
12. Slowly release the **J 8062** and the **J 43963** from the valve/spring assembly. See **Special Tools and Equipment**.
13. Inspect for proper valve key seating.

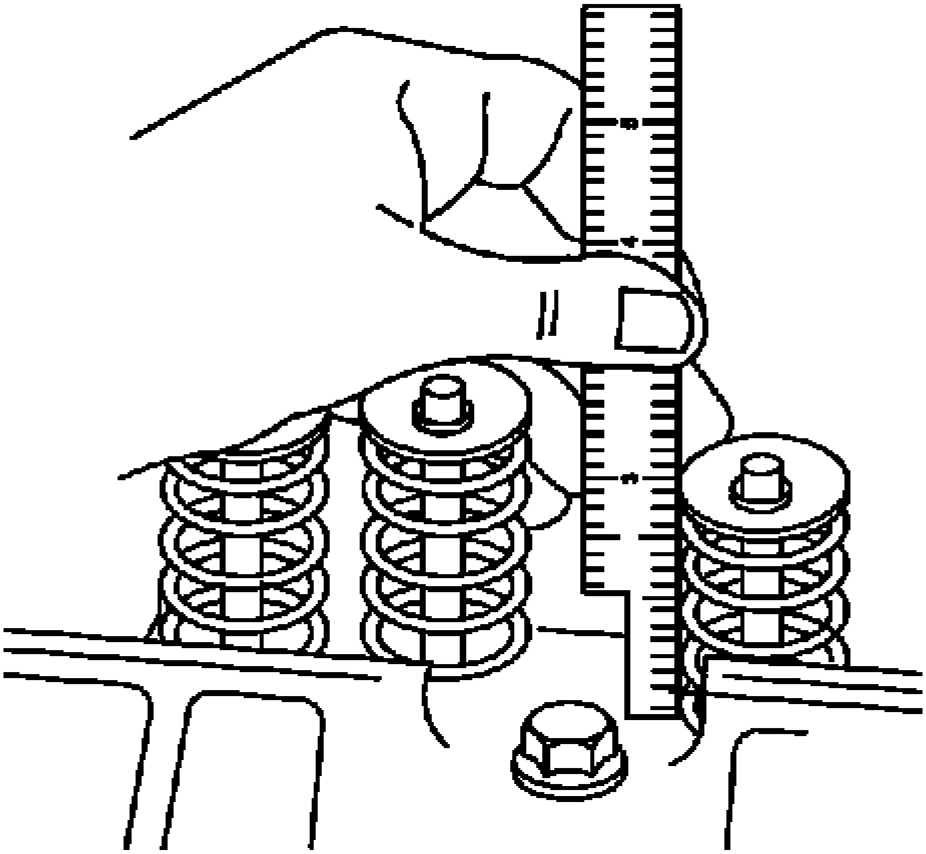


Fig. 351: Measuring Valve Spring Installed Height
Courtesy of GENERAL MOTORS CORP.

14. Measure the valve installed height using a ruler. Measure from the base of the valve spring to the top of the valve. Refer to **Engine Mechanical Specifications** for the correct specification.
15. Install the remaining valves, springs, and other components.

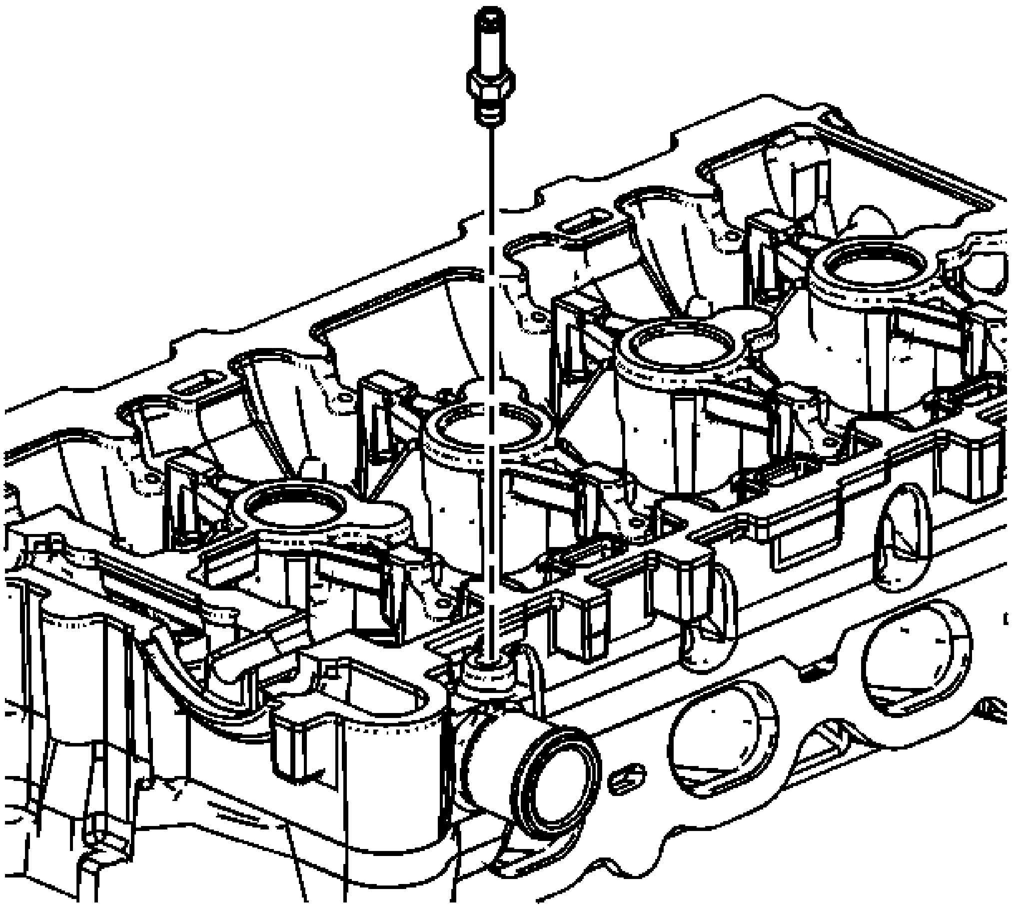


Fig. 352: Identifying Cylinder Head Air Bleed Tube
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

16. Install the cylinder head air bleed tube.

    Tighten: Tighten the bolts to 15 N.m (133 lb in).

Oil Pump Disassemble

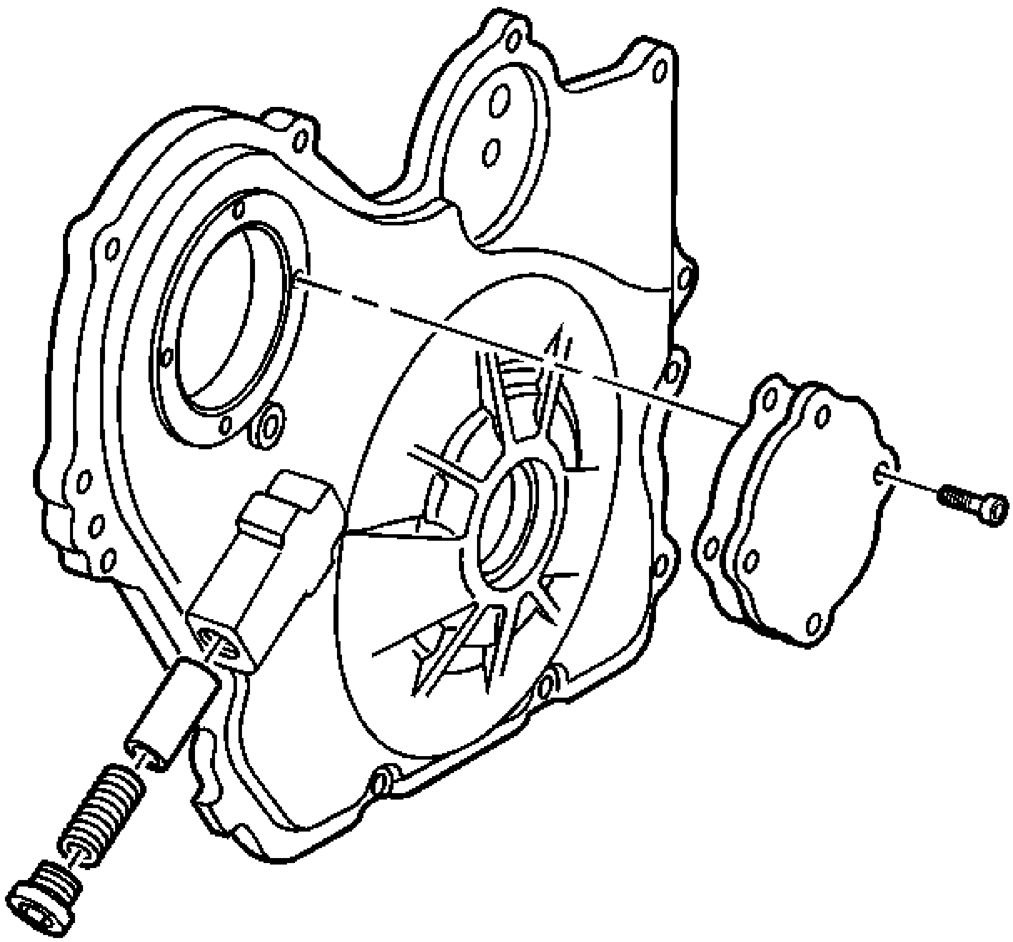


Fig. 353: View Of Pressure Relief Valve
Courtesy of GENERAL MOTORS CORP.

1. Disassemble the pressure relief valve.

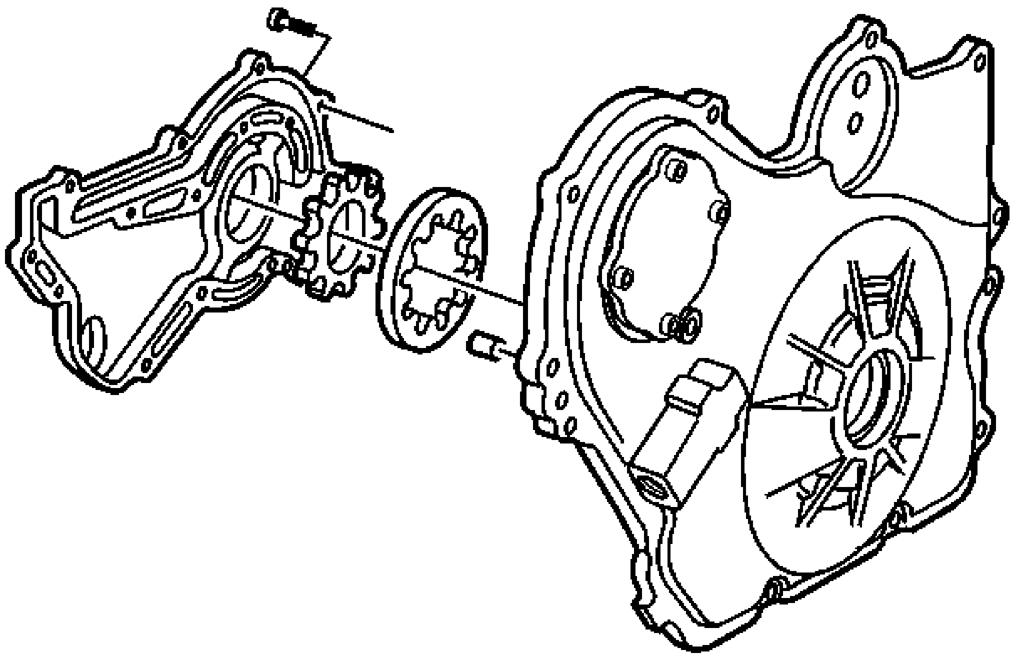


Fig. 354: Exploded View Of Oil Pump Assembly
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil pump gerotor cover and bolts.
3. Clean all of the parts in cleaning solvent. Remove varnish, sludge and dirt.
4. Inspect the oil pump for wear and scoring. Insure that all components are within specifications. Refer to **Engine Mechanical Specifications**.

   Replace the front cover and oil pump assembly if it is out of specification or damaged.

Oil Pump Assemble

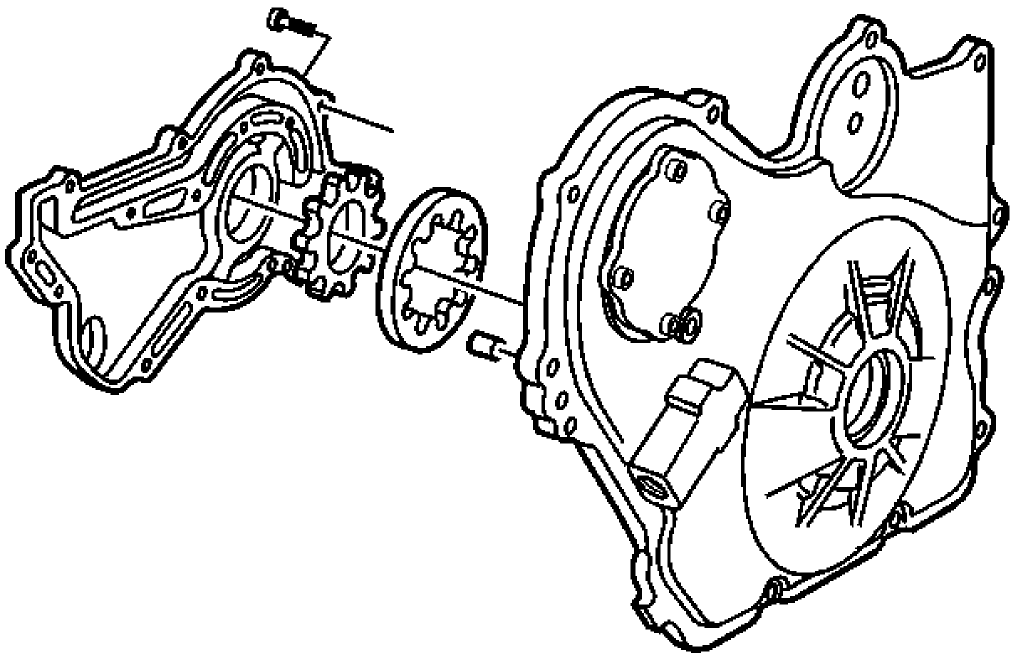


Fig. 355: Exploded View Of Oil Pump Assembly
Courtesy of GENERAL MOTORS CORP.

1. Lubricate all oil pump parts with engine oil.
2. Install the inner gear into the outer gear.

IMPORTANT: If gears are improperly installed in the front cover, the gerotor cover will not bolt on.

3. Install the gears together into the front cover with the hub of the center gear facing the front cover.

NOTE: Refer to Fastener Notice 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).

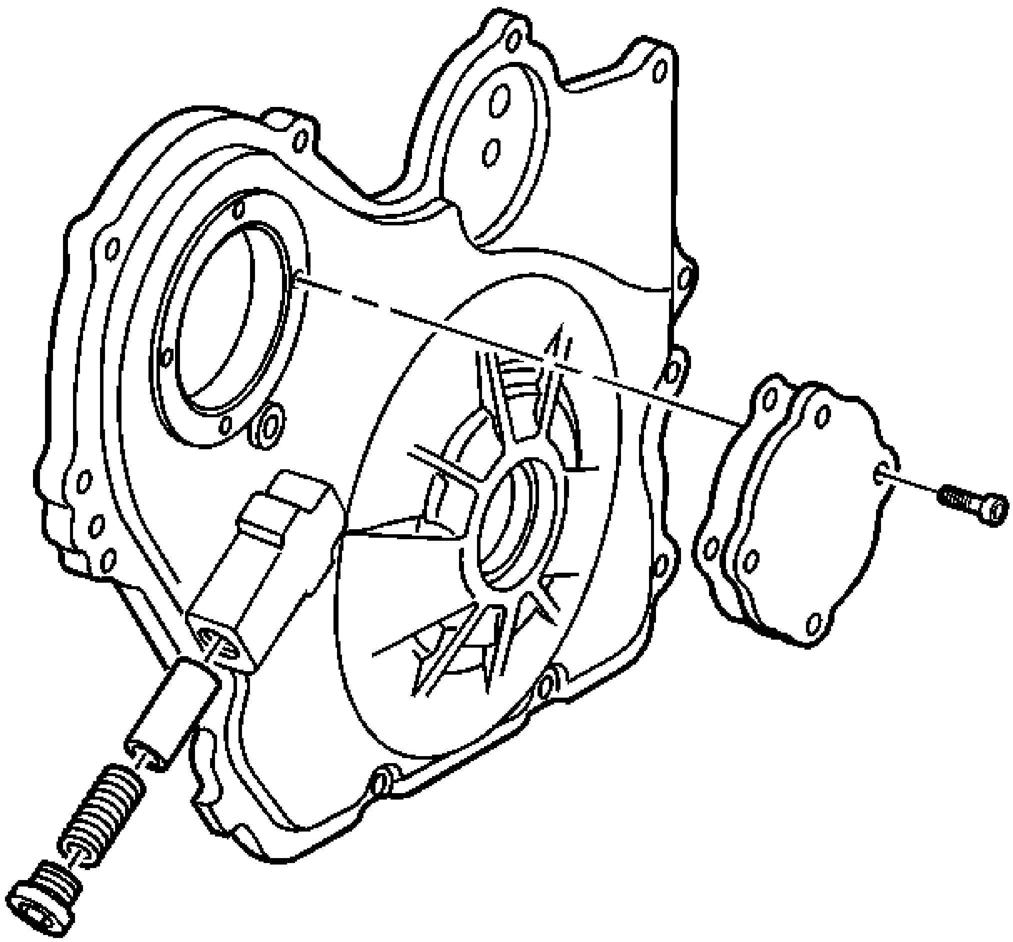


Fig. 356: View Of Pressure Relief Valve
Courtesy of GENERAL MOTORS CORP.

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

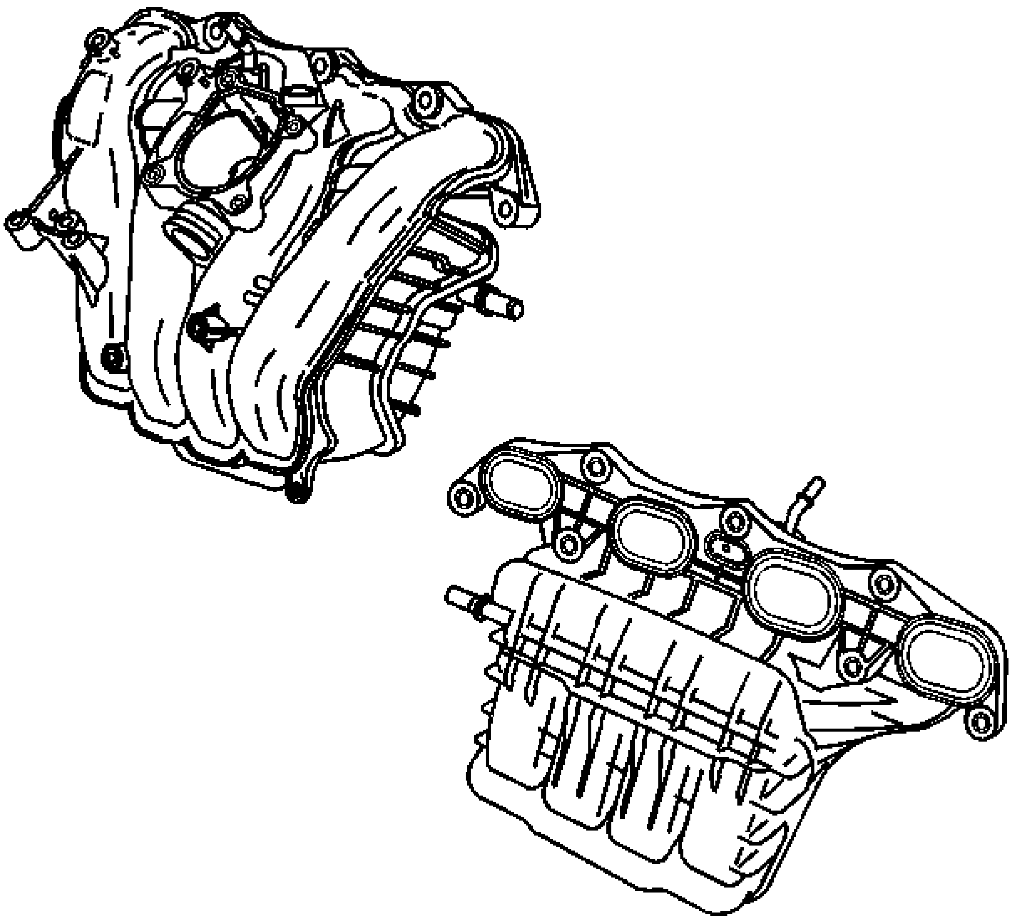


Fig. 357: View of Intake Manifold
Courtesy of GENERAL MOTORS CORP.

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.

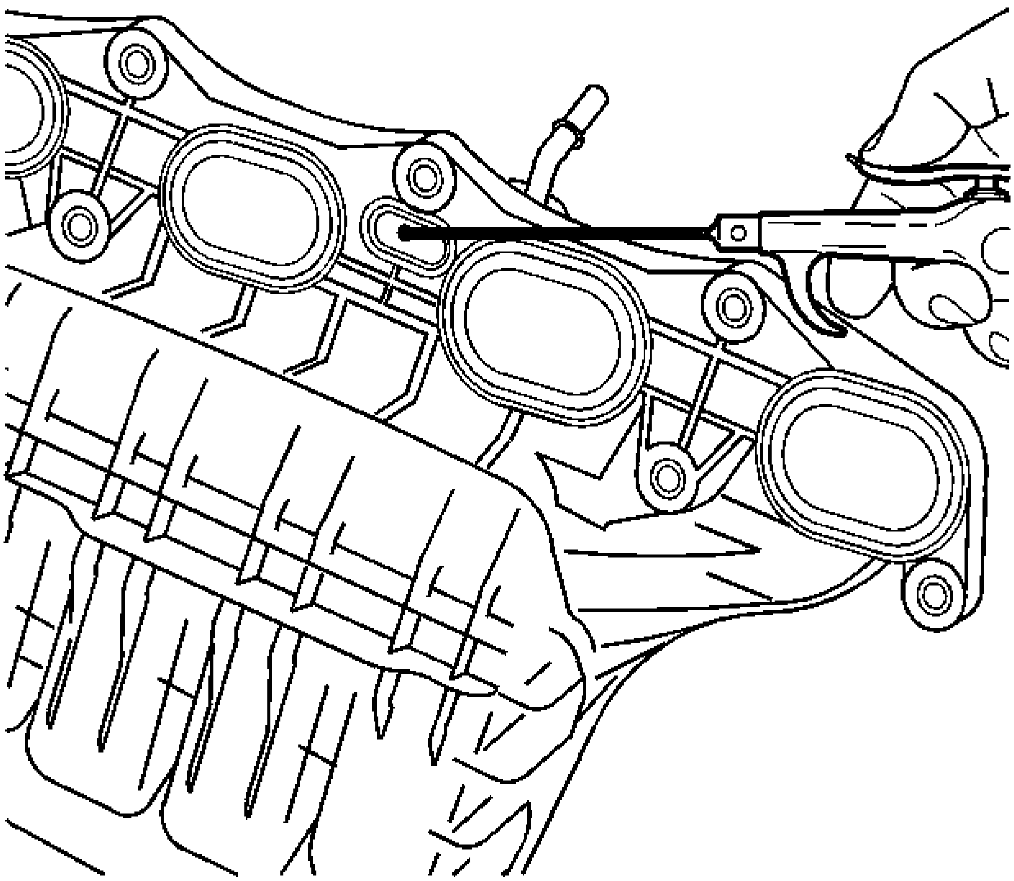


Fig. 358: Identifying Crankcase Ventilation Passages
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

5. Clean the crankcase ventilation passages with compressed air if necessary. Use a maximum of 172 kPa (25 psi) of air pressure.
6. Replace the intake manifold as necessary.

Exhaust Manifold Cleaning and Inspection

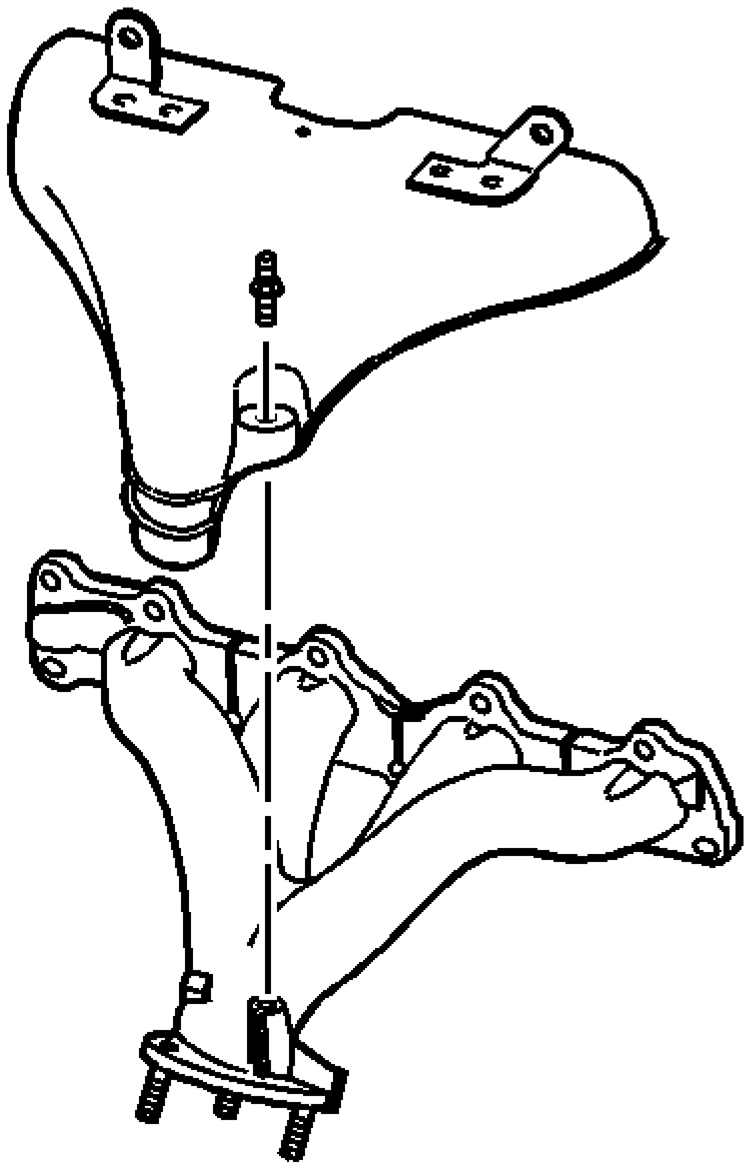


Fig. 359: View of Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

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.

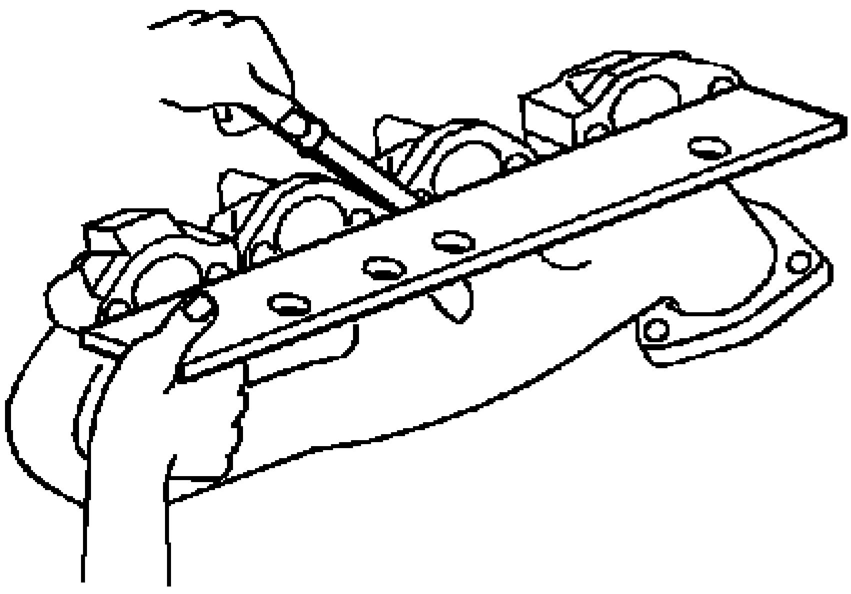


Fig. 360: Measuring Exhaust Manifold To Cylinder Head Surface For Warpage
Courtesy of GENERAL MOTORS CORP.

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

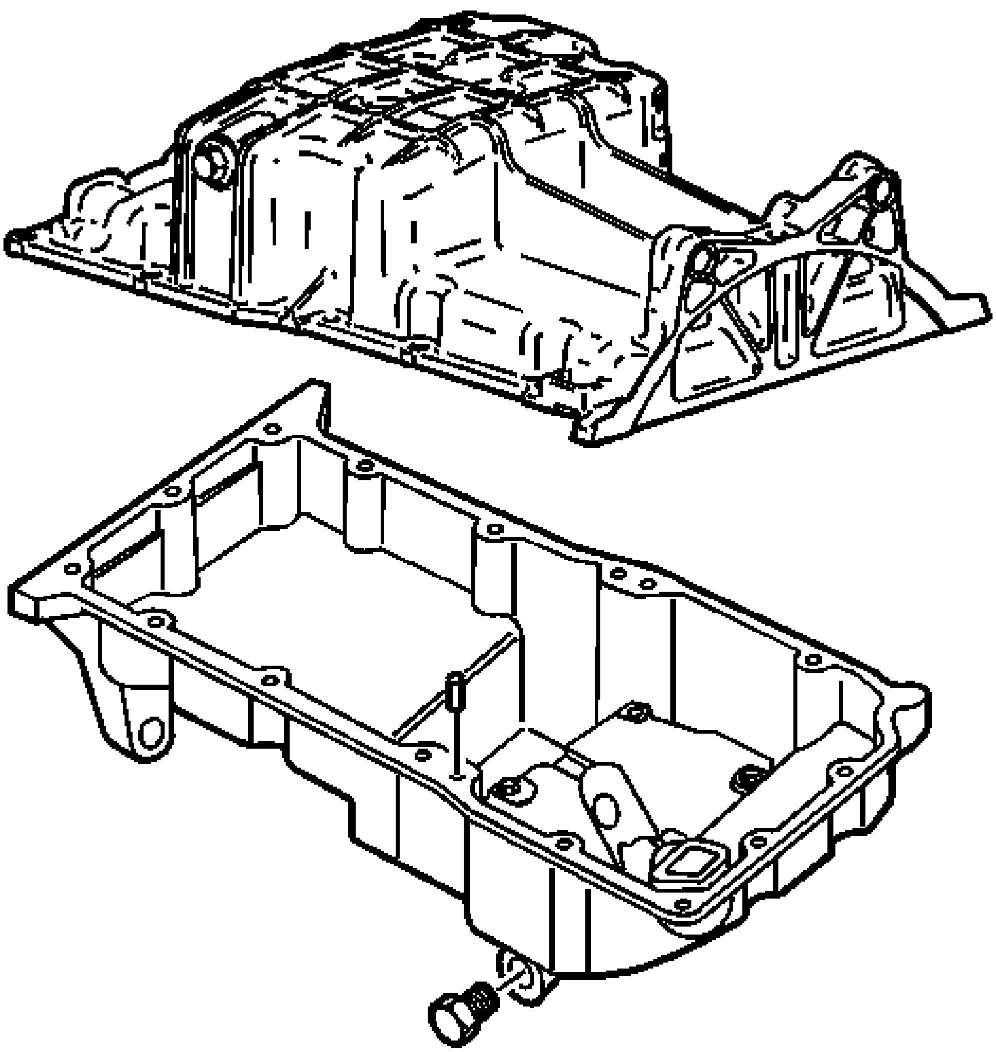


Fig. 361: View of Oil Pan
Courtesy of GENERAL MOTORS CORP.

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

General Thread Repair

Tools Required

J 42385-850 Thread Repair Kit. See **Special Tools and Equipment**.

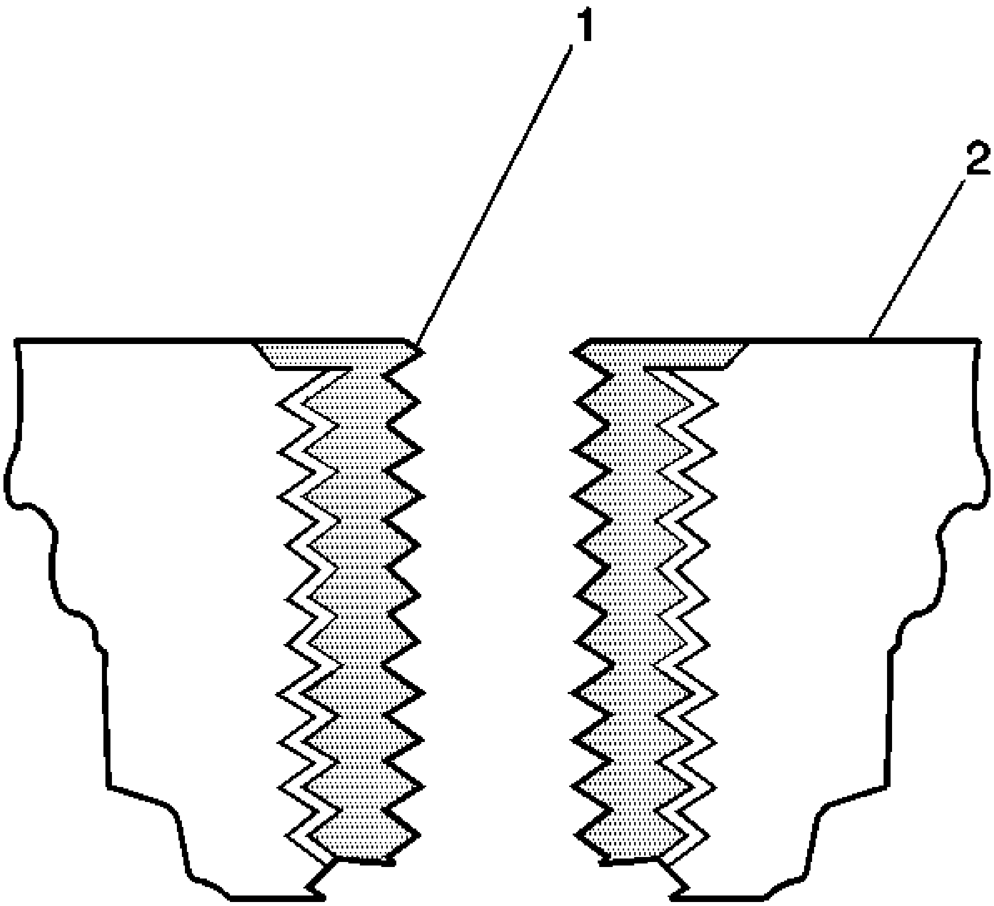


Fig. 362: View Of Bushing Type Insert & Base Material
Courtesy of GENERAL MOTORS CORP.

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.

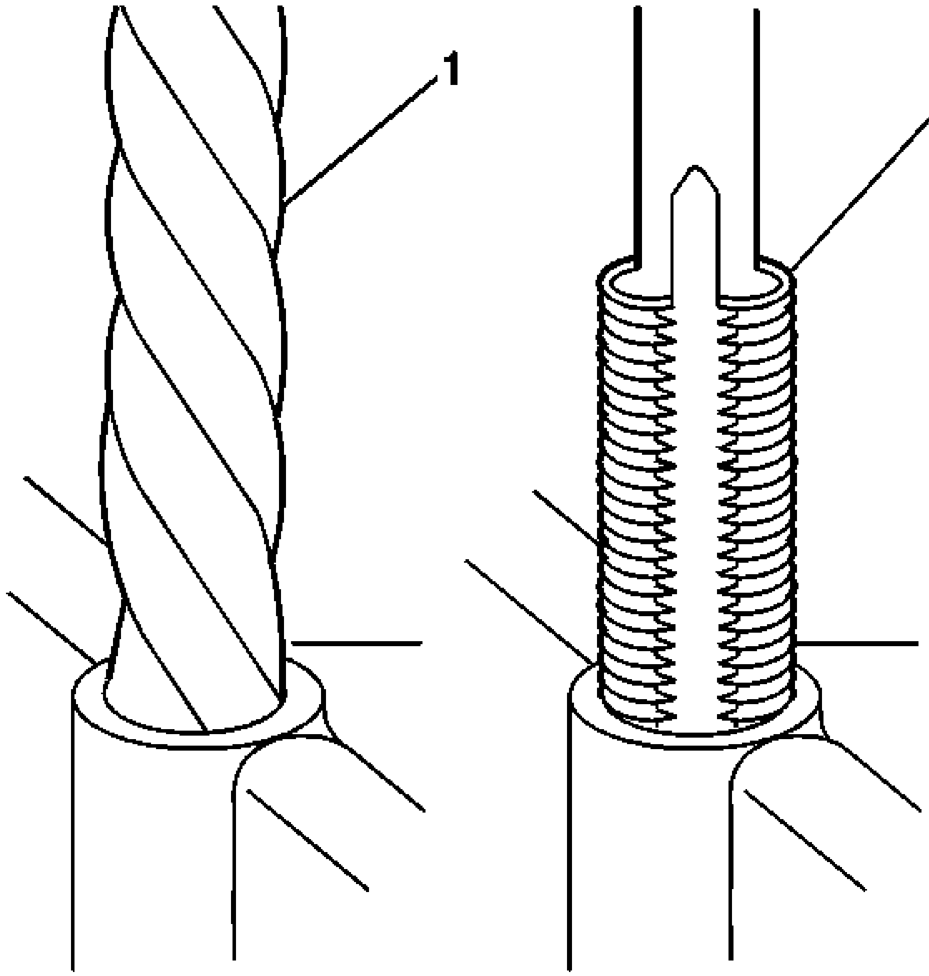


Fig. 363: Drilling & Tapping Threads
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

IMPORTANT: The use of a cutting type fluid GM P/N 1052864 (Canadian P/N 992881), WD 40®, or equivalent, is recommended when performing the drilling, counterboring, and tapping procedures.
Driver oil MUST be used on the installer driver tool.
The tool kits are designed for use with either a suitable tap wrench or drill motor.

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.

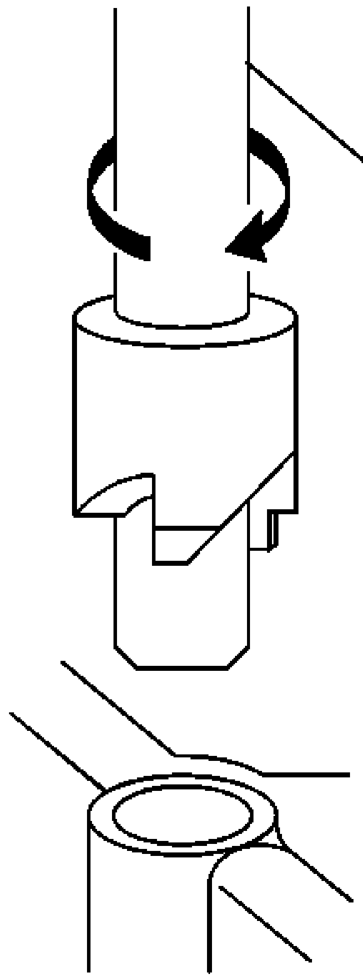


Fig. 364: View Of Counterbore Drill
Courtesy of GENERAL MOTORS CORP.

3. Counterbore the hole to the full depth permitted by the tool (1).
4. Using compressed air, clean out any chips.

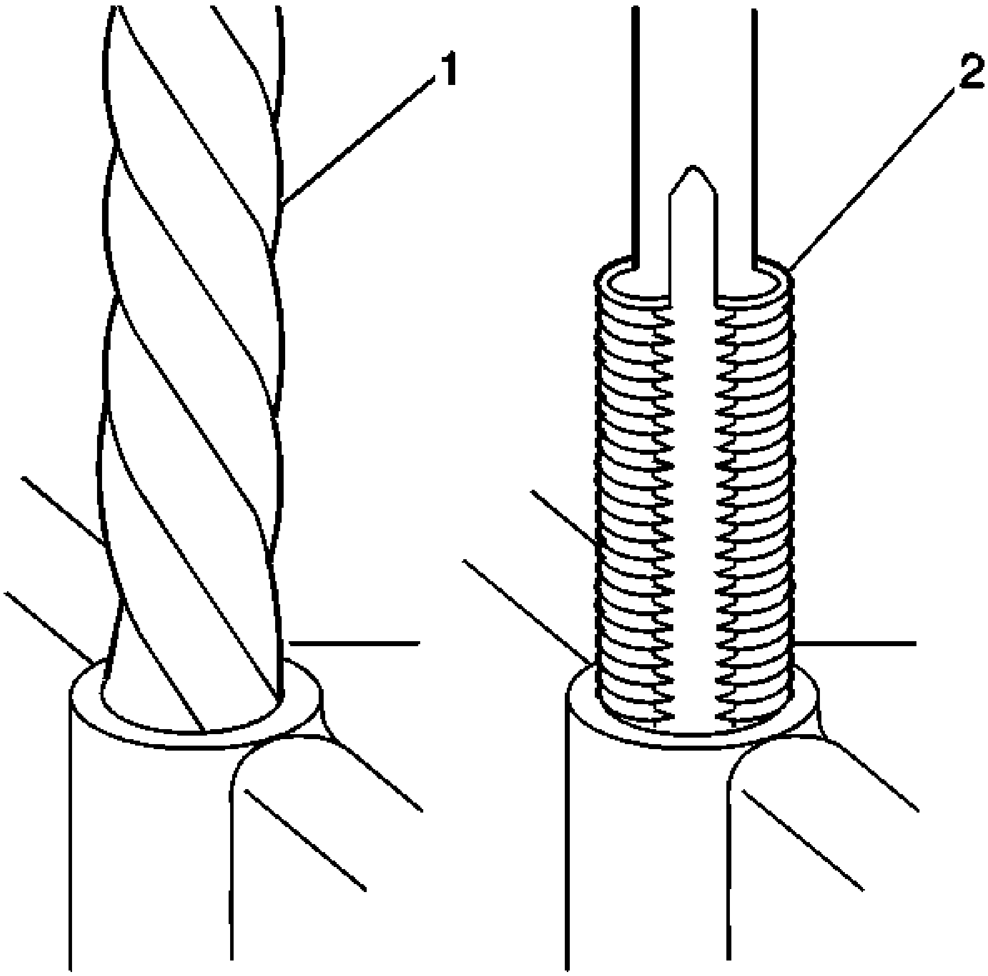


Fig. 365: Drilling & Tapping Threads
Courtesy of GENERAL MOTORS CORP.

5. Using a tap wrench (2), tap the threads of the drilled hole.
   - M6 inserts require a minimum tap depth of 15 mm (0.59 in).
   - M8 inserts require a minimum tap depth of 20 mm (0.79 in).
   - M10 inserts require a minimum tap depth of 23.5 mm (0.93 in).
6. Using compressed air, clean out any chips.
7. Spray cleaner GM P/N 12346139, GM P/N 12377981 (Canadian P/N 10953463) or equivalent, into the hole.
8. Using compressed air, clean any cutting oil and chips out of the hole.

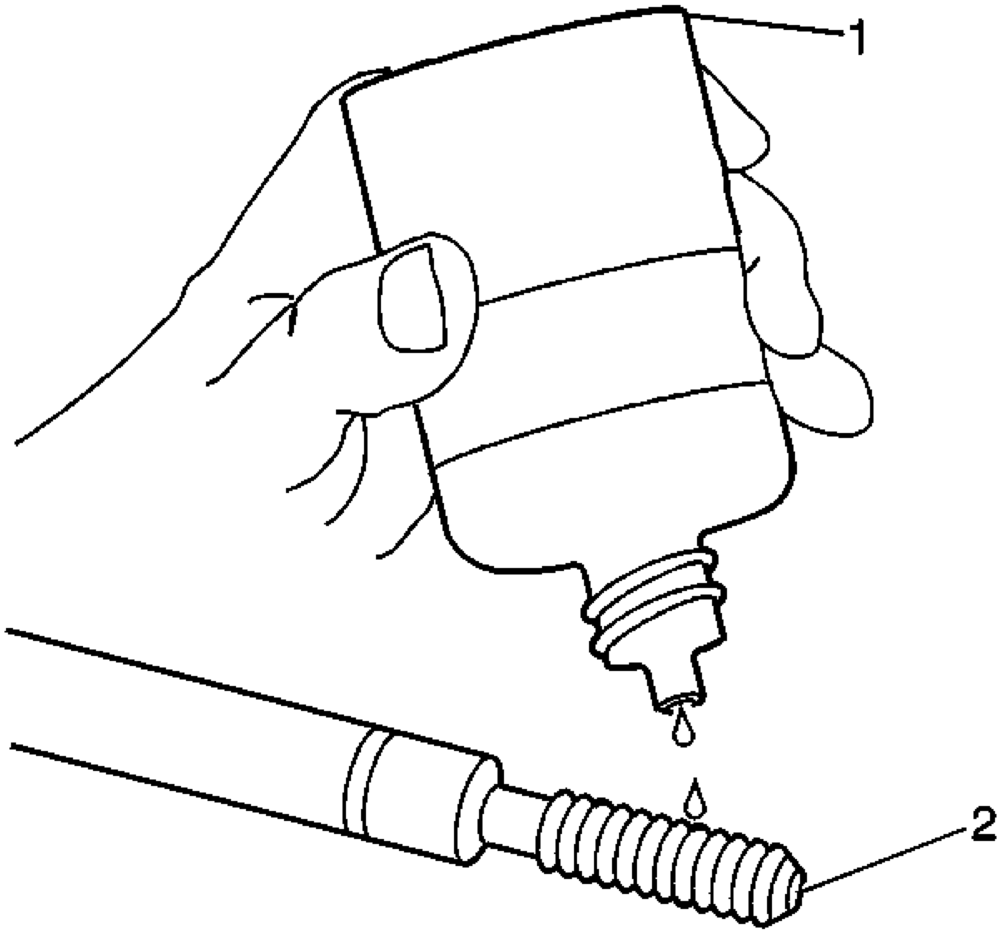


Fig. 366: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

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).

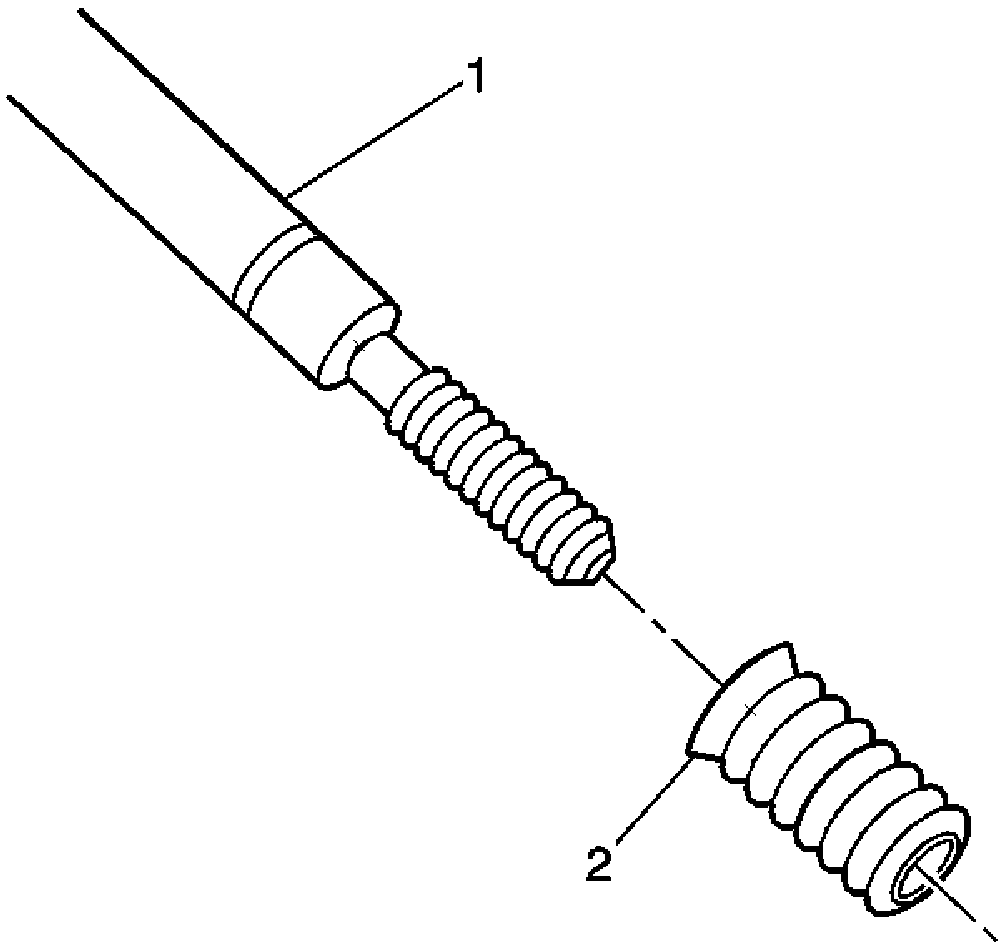


Fig. 367: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

10. Install the insert (2) onto the driver tool (1).

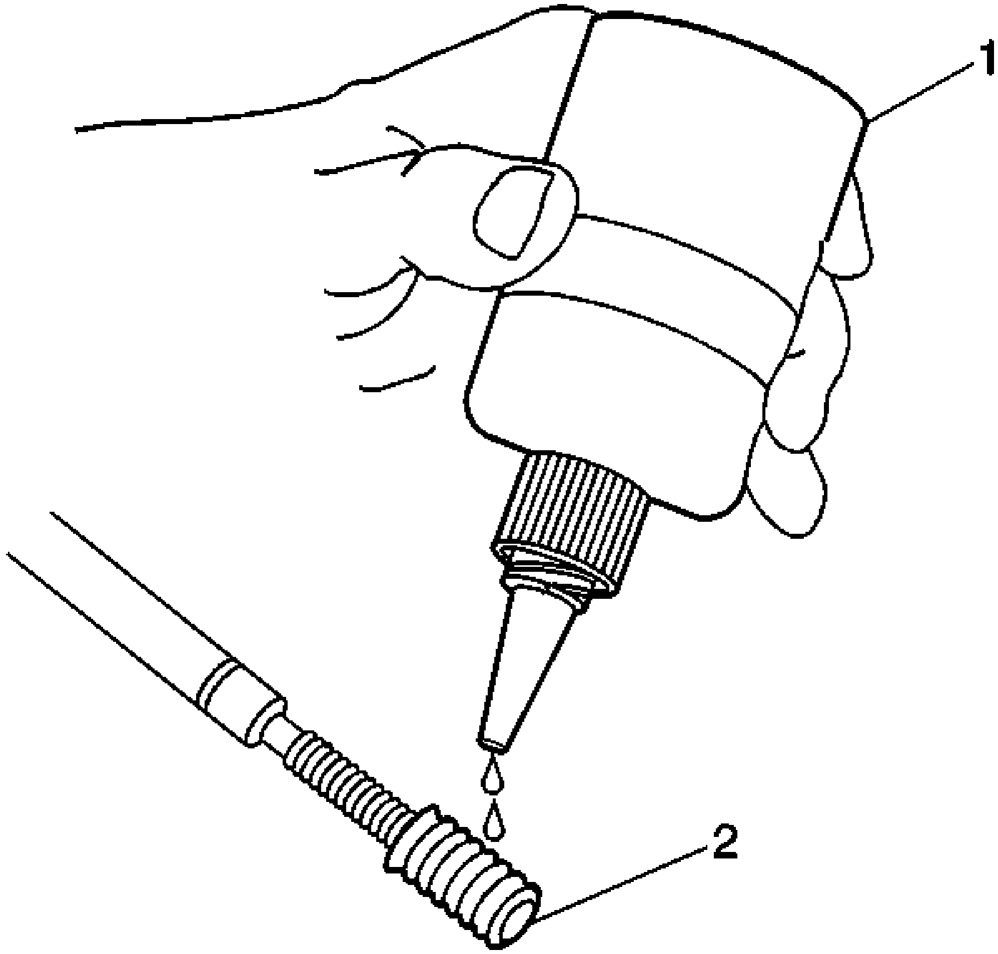


Fig. 368: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

11. Apply threadlock LOCTITE™ 277, J 42385-109 (1), or equivalent to the insert OD threads (2).

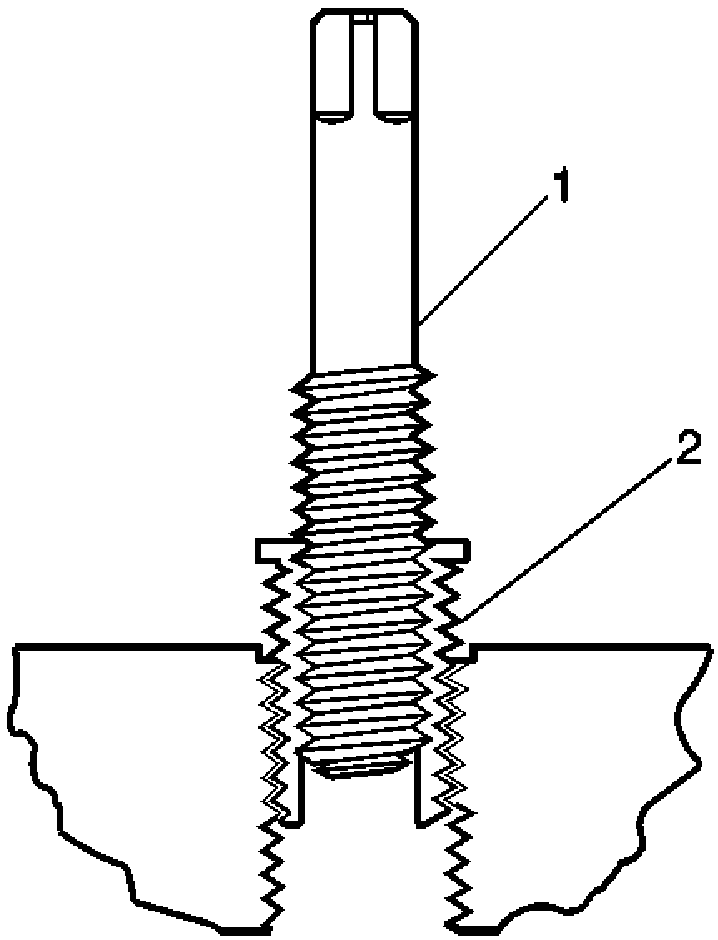


Fig. 369: Installing Insert Into Tapped Bolt Hole
Courtesy of GENERAL MOTORS CORP.

12. Install the insert (2) into the hole.

    Install the insert until the flange of the insert contacts the counterbored surface. Continue to rotate the installer tool (1) through the insert.

    The installer tool will tighten up before screwing completely through the insert. This is acceptable. You are forming the bottom threads of the insert and mechanically locking the insert to the base material threads.

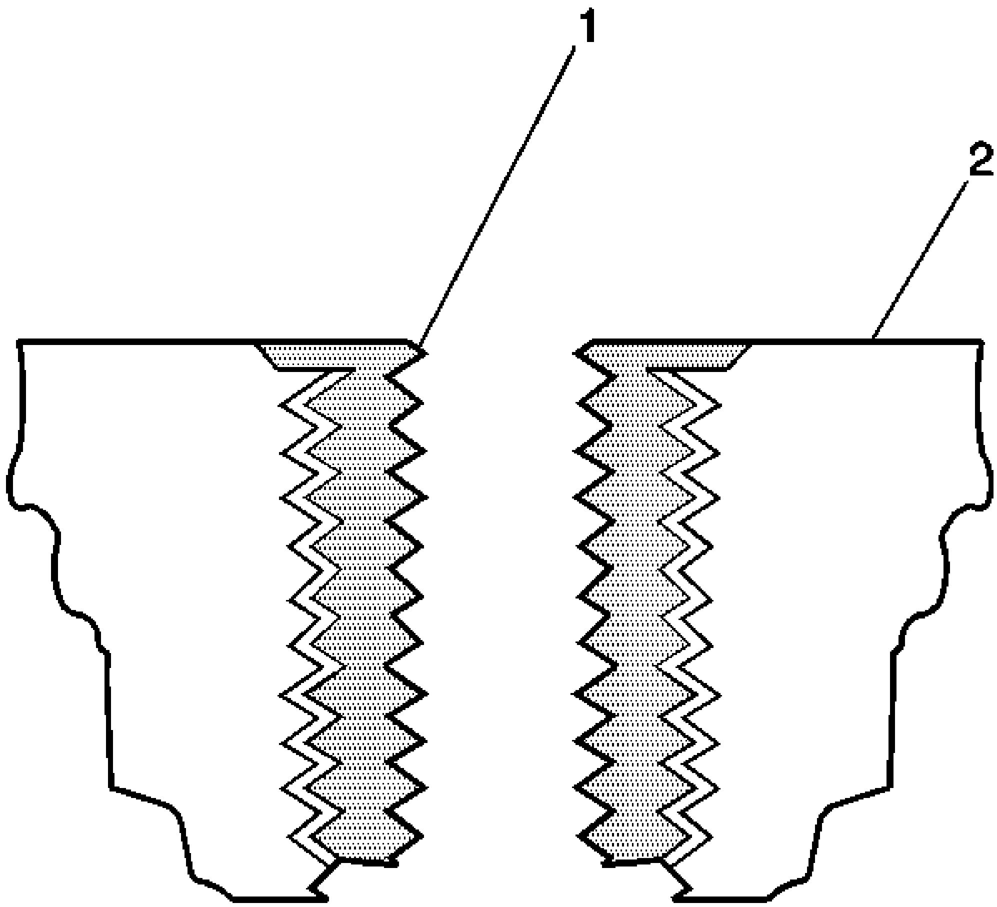


Fig. 370: View Of Bushing Type Insert & Base Material
Courtesy of GENERAL MOTORS CORP.

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

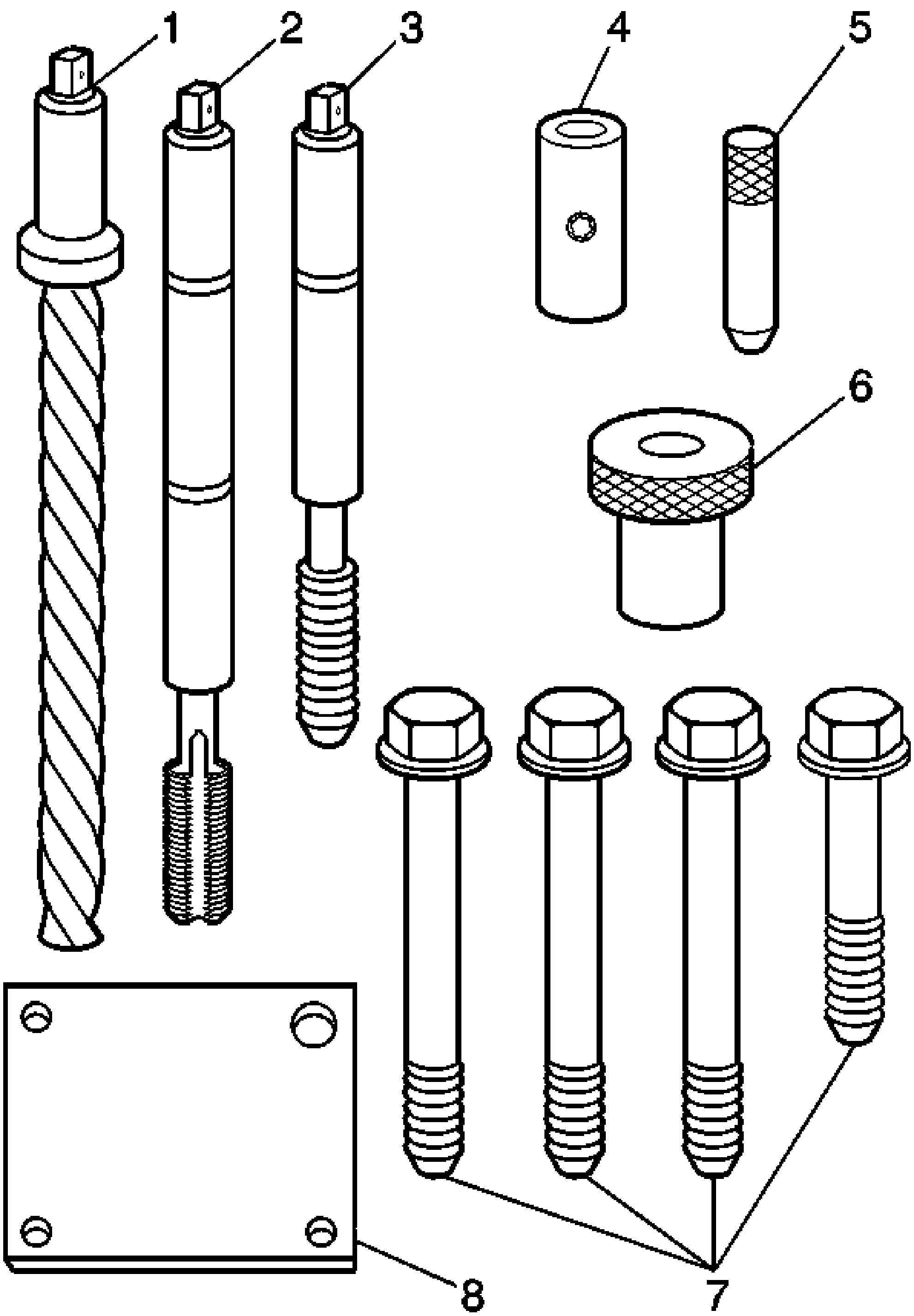


Fig. 371: Identifying Thread Repair Kit Components
Courtesy of GENERAL MOTORS CORP.

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)

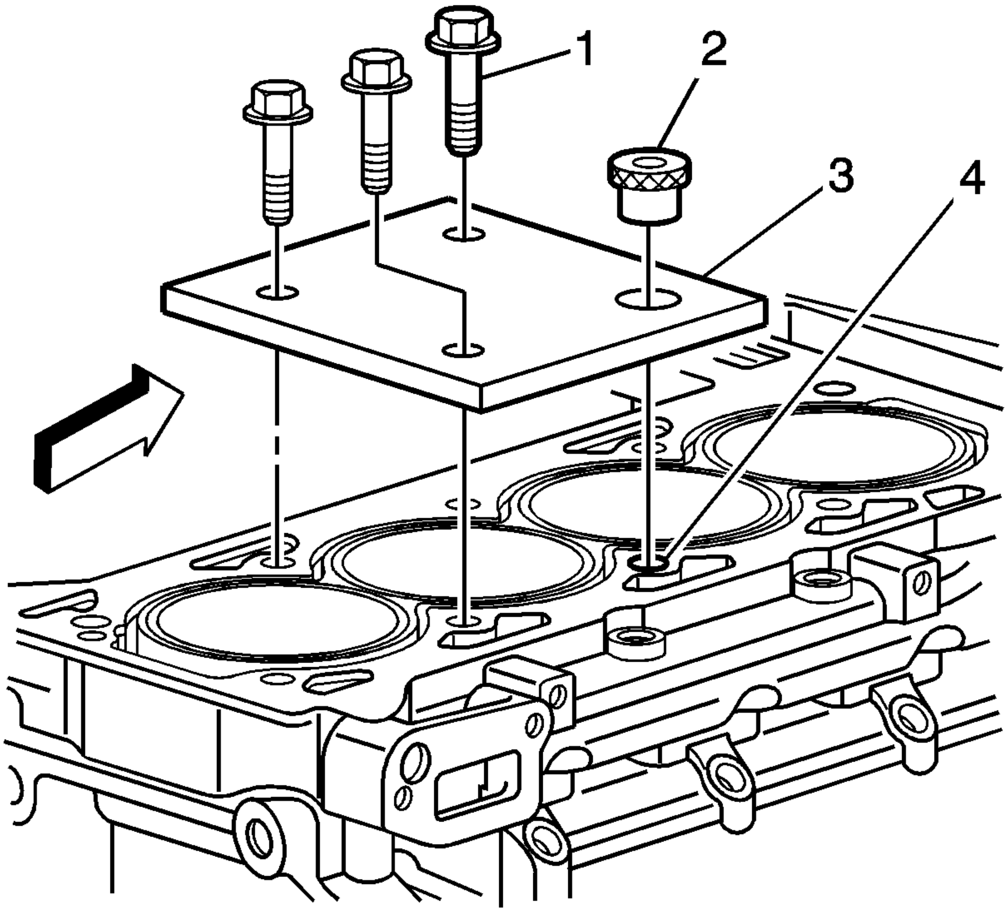


Fig. 372: Identifying Fixture Plate. Bolts, & Bushing
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

IMPORTANT: The use of a cutting type fluid GM P/N 1052864 (Canadian P/N 992881), WD 40®, or equivalent, is recommended when performing the drilling 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).

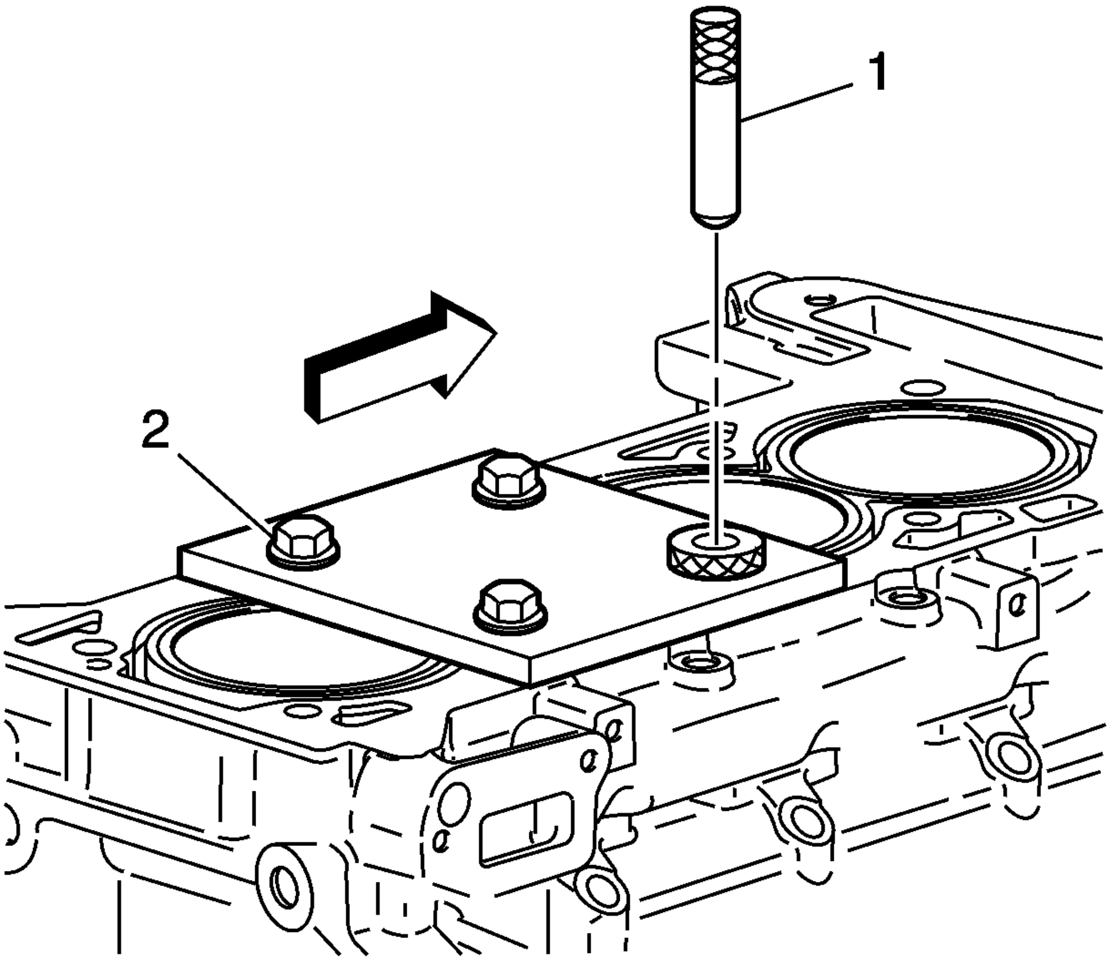


Fig. 373: Identifying Alignment Pin & Fixture Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

3. Position the alignment pin (1) through the bushing and into the hole.
4. With the alignment pin in the desired hole, tighten the fixture retaining bolts (2).
5. Remove the alignment pin from the hole.

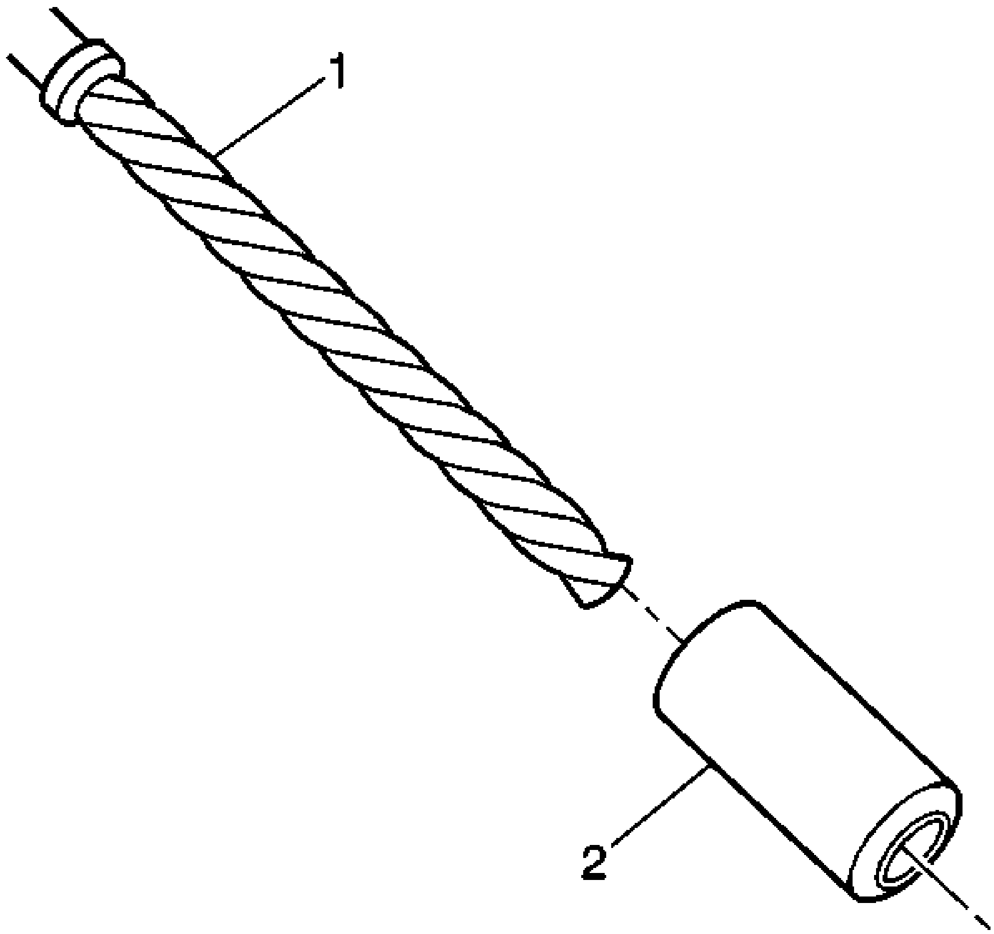


Fig. 374: View Of Stop Collar & Counterbore Drill
Courtesy of GENERAL MOTORS CORP.

6. Install the sleeve (2) onto the drill (1), if required.

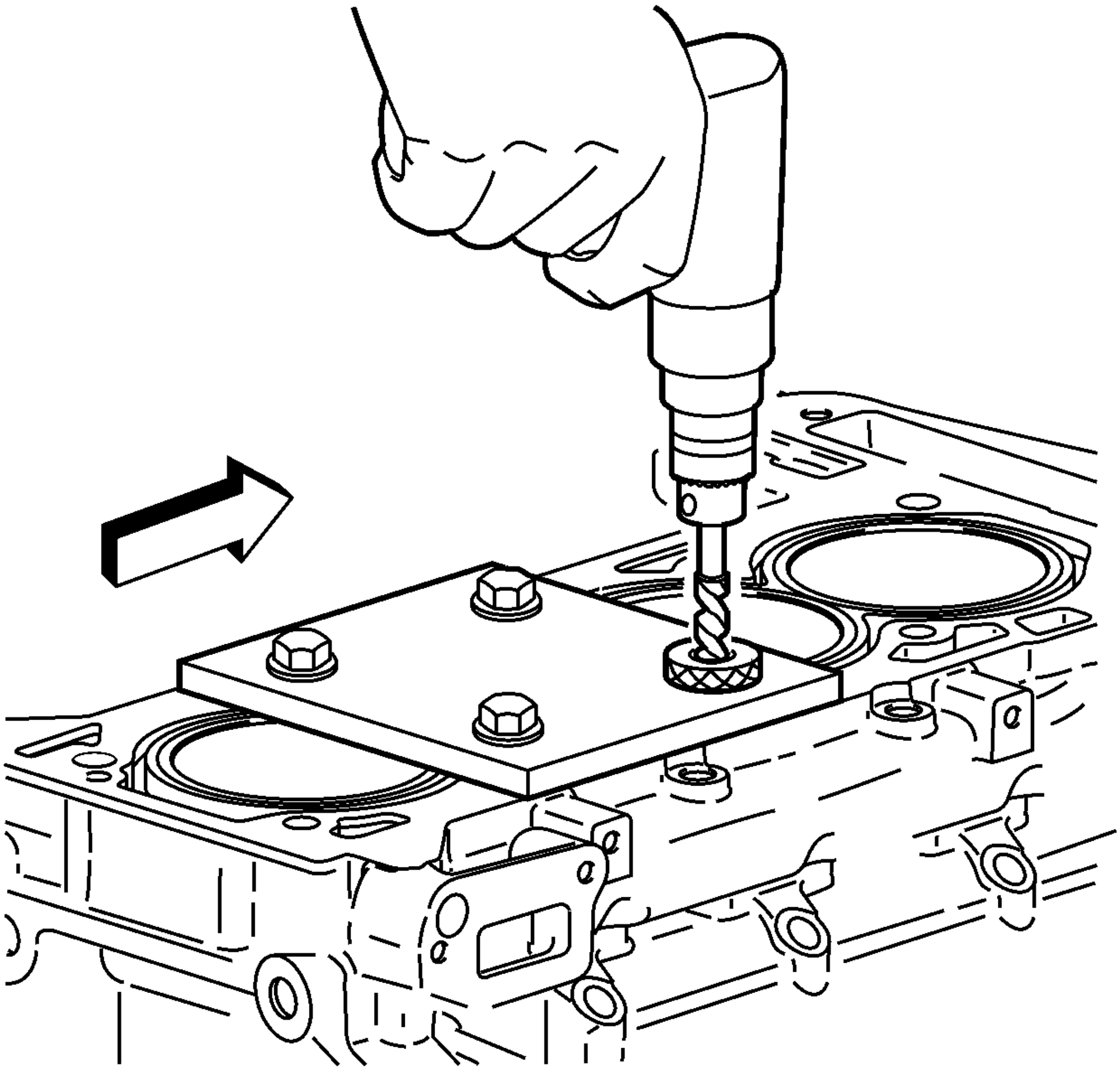


Fig. 375: View of Reaming Process
Courtesy of GENERAL MOTORS CORP.

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.

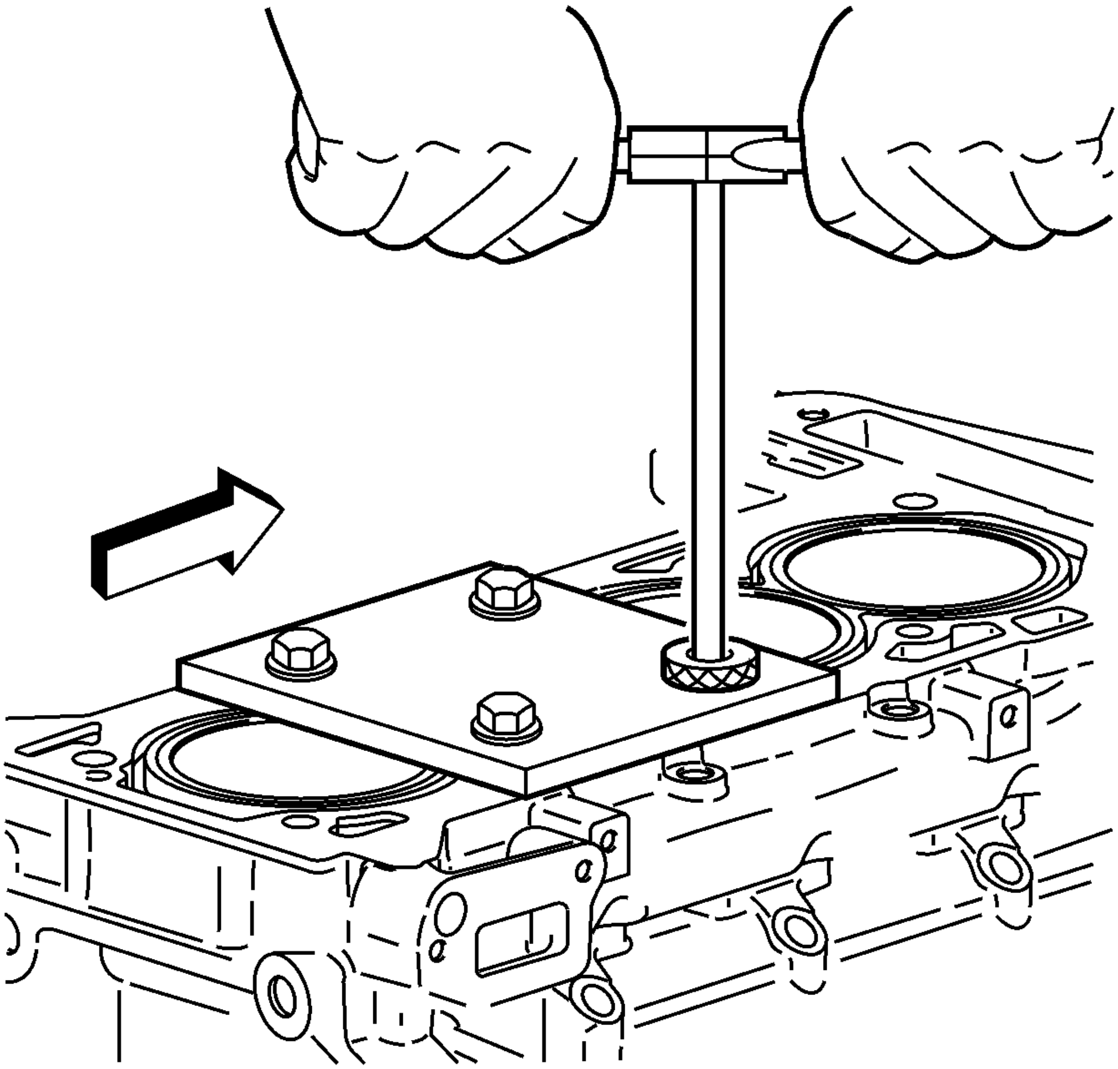


Fig. 376: Tapping Threads of Drilled Hole
Courtesy of GENERAL MOTORS CORP.

9. Using a tap wrench, tap the threads of the drilled hole.

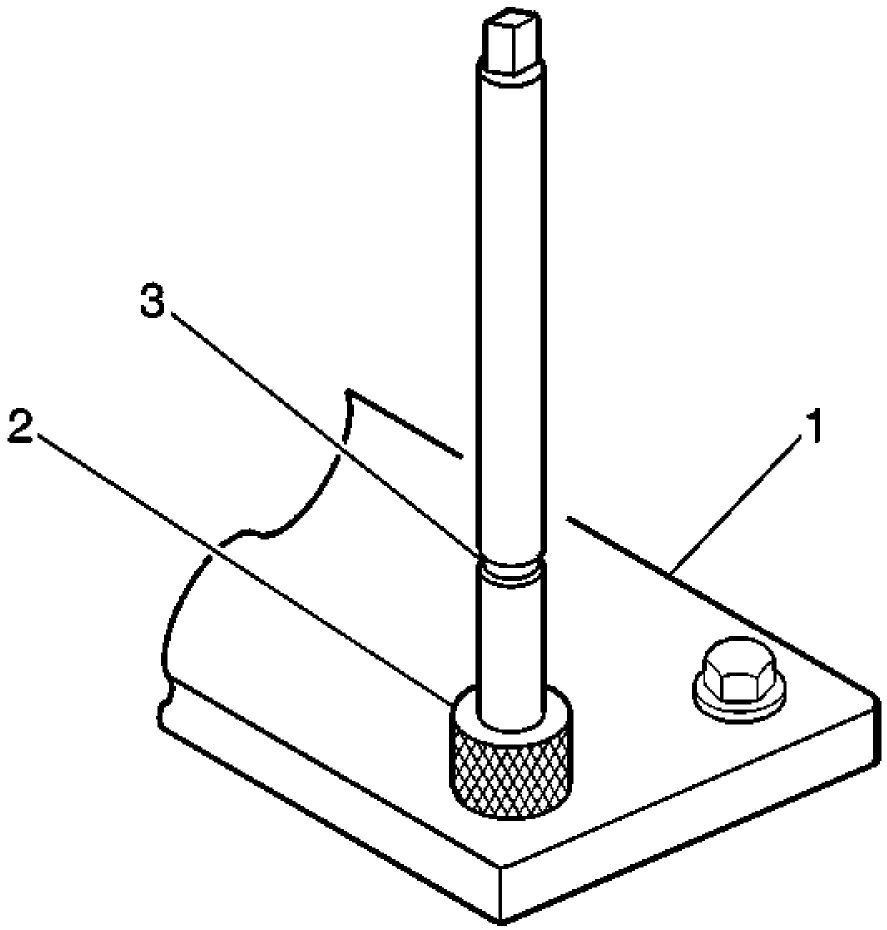


Fig. 377: View Of Fixture Plate, Drill Bushing & Tool Marking
Courtesy of GENERAL MOTORS CORP.

10. Using a TAP wrench, tap the threads of the drilled hole.

    In order to tap the new threads to the proper depth, rotate the tap into the hole until the mark (3) on the tap align with the top of the drill bushing (2).

11. Remove the fixture plate (1), bushing (2), and bolts.
12. Using compressed air, clean out any chips.
13. Spray cleaner GM P/N 12346139 or GM P/N 1237798 (Canadian P/N 10953463), or equivalent, into the hole.
14. Using compressed air, clean any cutting oil and chips out of the hole.

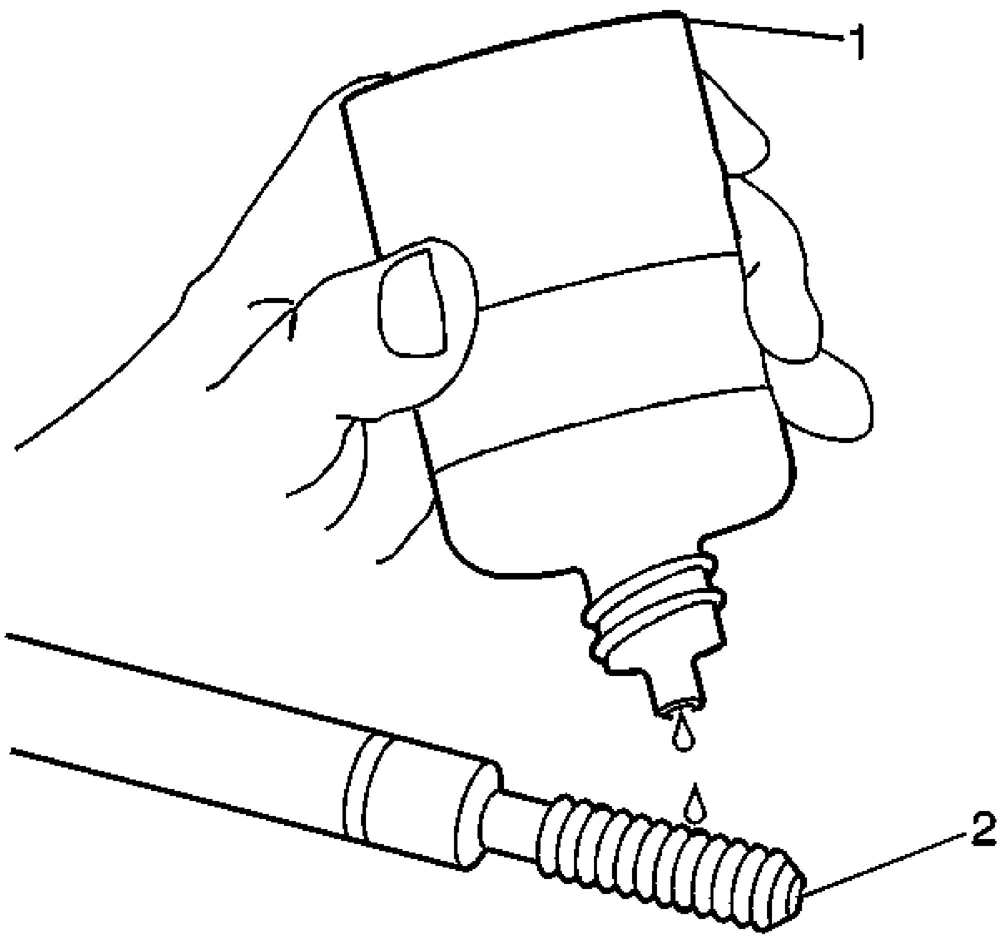


Fig. 378: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

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).

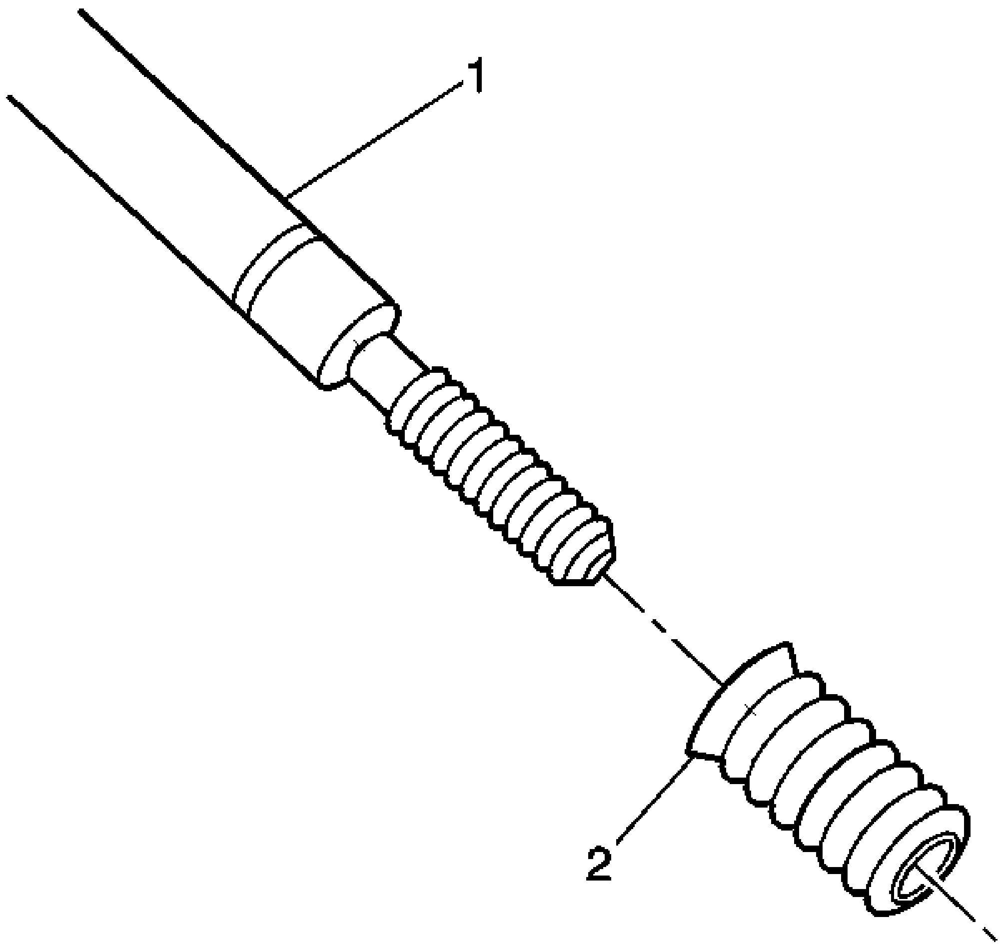


Fig. 379: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

16. Install the insert (2) onto the driver tool (1).

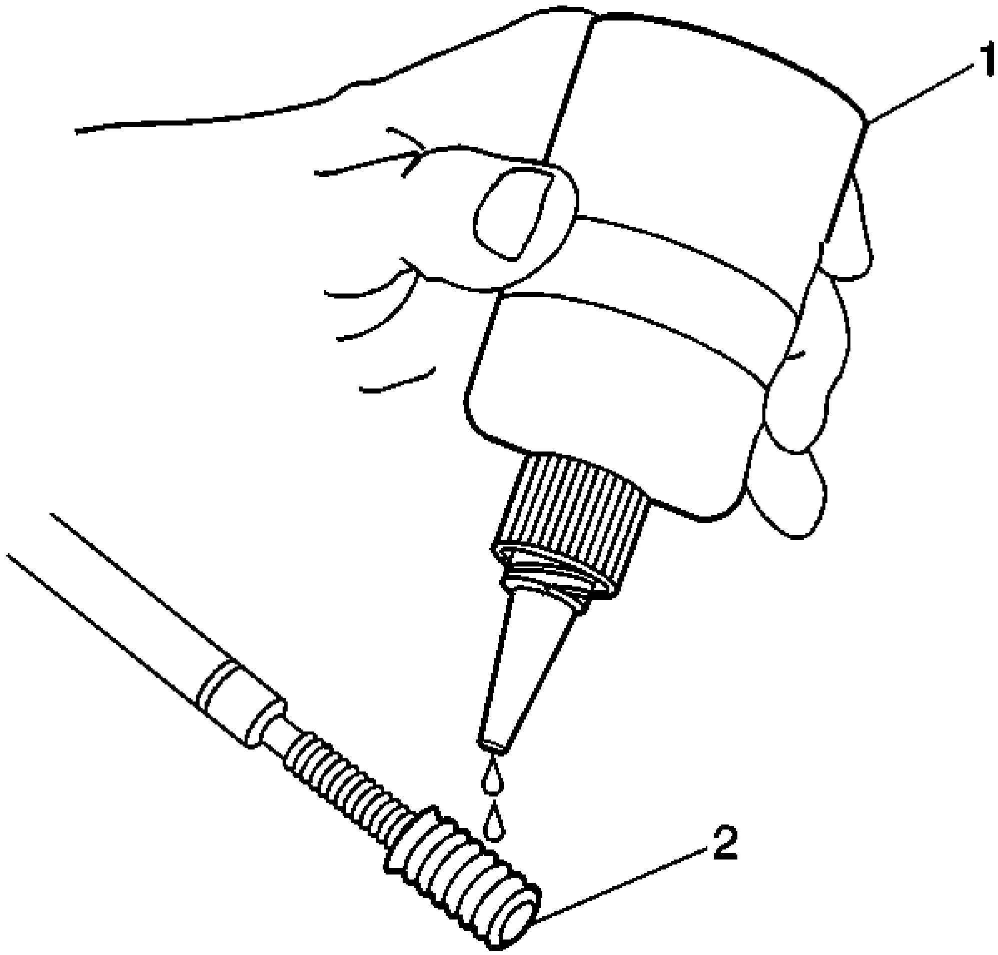


Fig. 380: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

17. Apply threadlock LOCTITE™ 277, J 42385-109 (1), or equivalent to the insert OD threads (2).

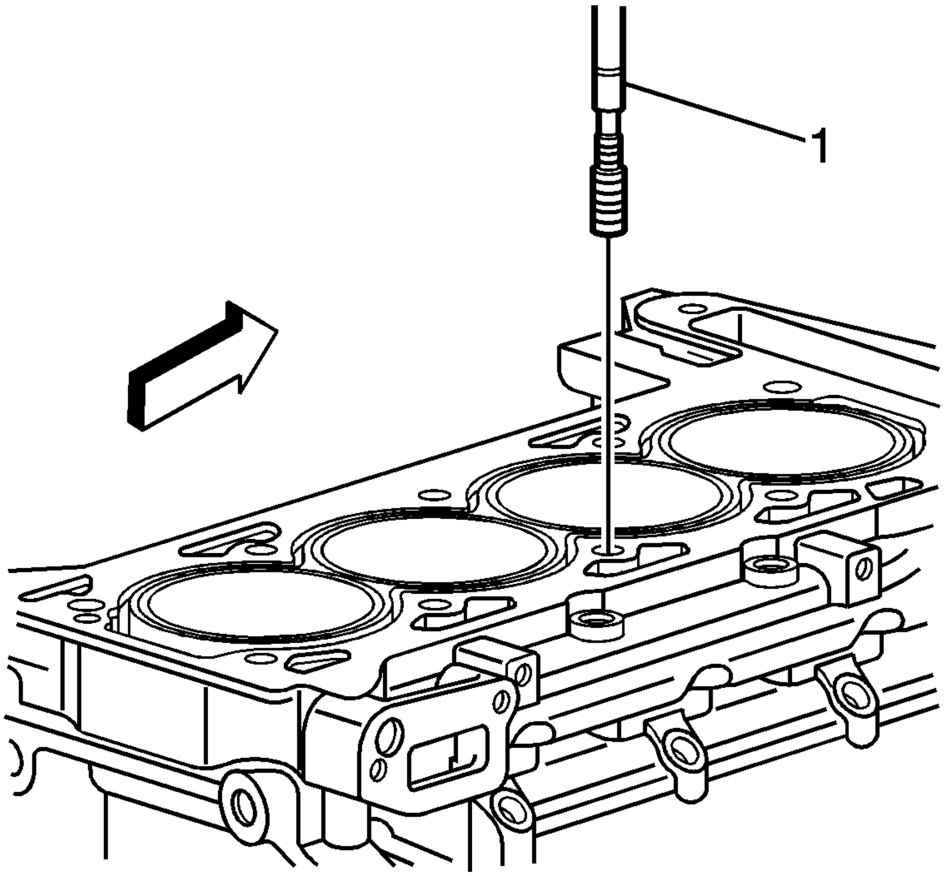


Fig. 381: View of Driver Tool
Courtesy of GENERAL MOTORS CORP.

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

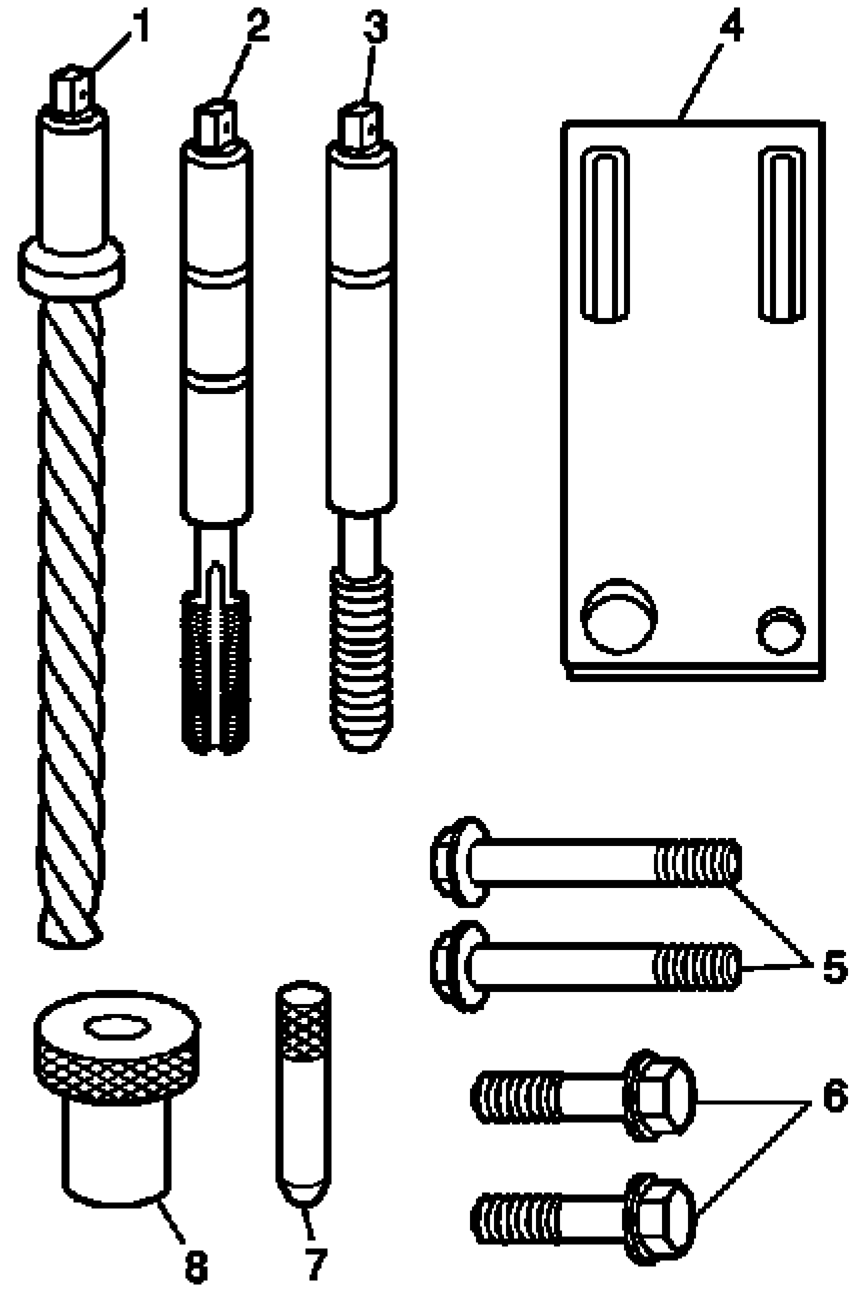


Fig. 382: Identifying Thread Repair Kit Components
Courtesy of GENERAL MOTORS CORP.

1. The main cap bolt hole thread repair kit consists of the following items:
   - Drill (1)
   - Tap (2)
   - Installer (3)

- Fixture Plate (4)
- Long Bolts (5)
- Short Bolts (6)
- Alignment Pin (7)
- Bushing (8)

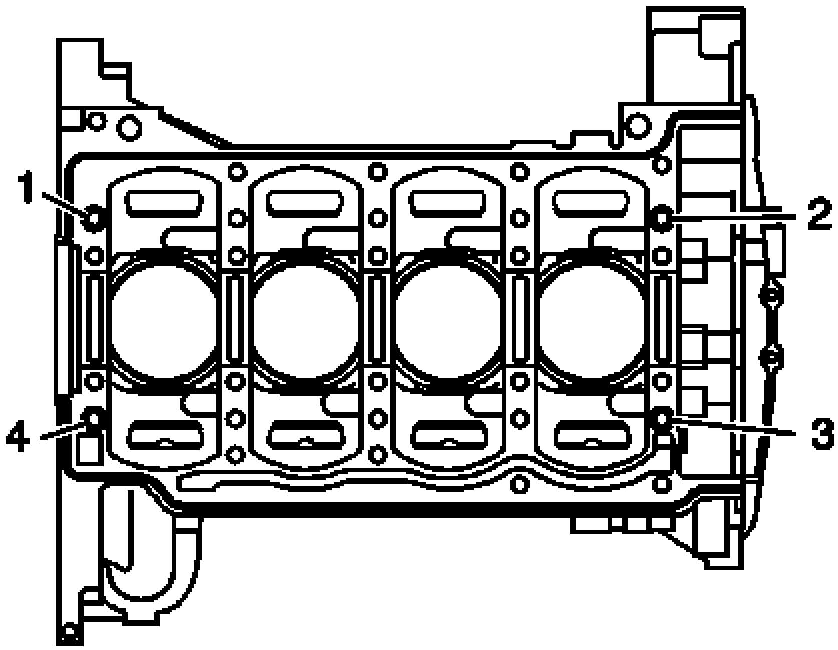


Fig. 383: Identifying Alignment Dowel Pins
Courtesy of GENERAL MOTORS CORP.

2. Remove the alignment dowel pins from the holes (1-4), if necessary.

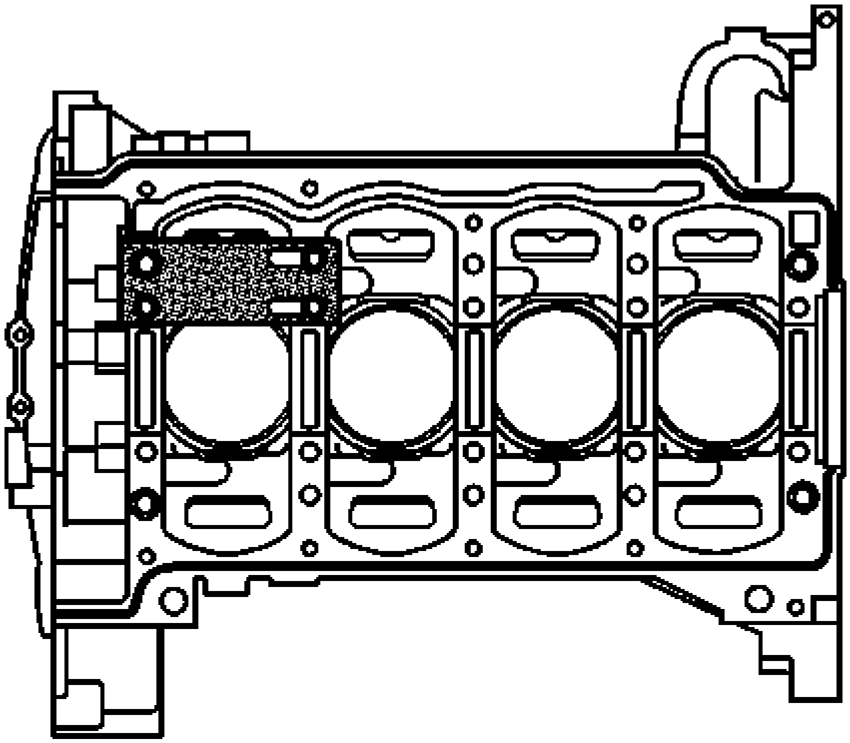


Fig. 384: View of Fixture Plate on Engine Block
Courtesy of GENERAL MOTORS CORP.

3. Install the fixture plate, bolt, and bushing, onto the engine block.

   Position the fixture plate and bushing over the hole that is to be repaired.

4. Position the alignment pin in the desired hole and tighten the fixture retaining bolts.
5. Drill out the damaged hole.
6. Using compressed air, clean out any chips.

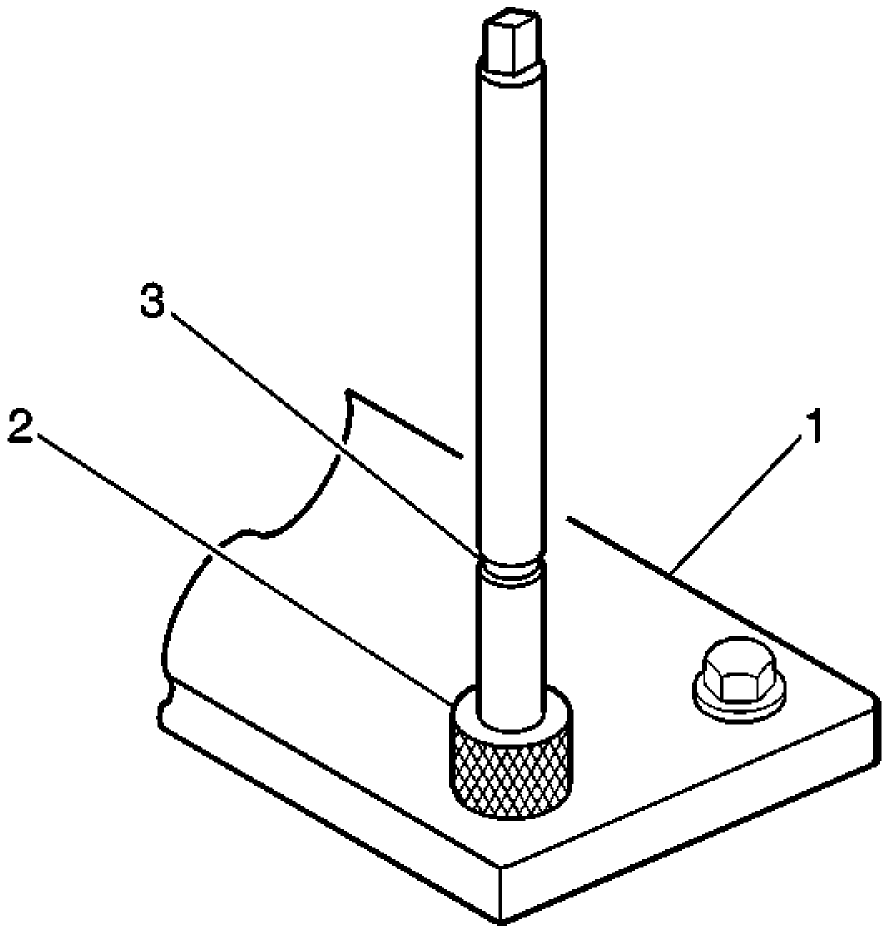


Fig. 385: View Of Fixture Plate, Drill Bushing & Tool Marking
Courtesy of GENERAL MOTORS CORP.

7. Using a tap wrench, tap the threads of the drilled hole.

   In order to tap the new threads to the proper depth, rotate the tap into the hole until the mark (3) on the tap aligns with the top of the bushing (2).

8. Using compressed air, clean out any chips.
9. Spray cleaner GM P/N 12346139 (Canadian P/N 10953463) or equivalent, into the hole.
10. Using compressed air, clean any cutting oil and chips out of the hole.

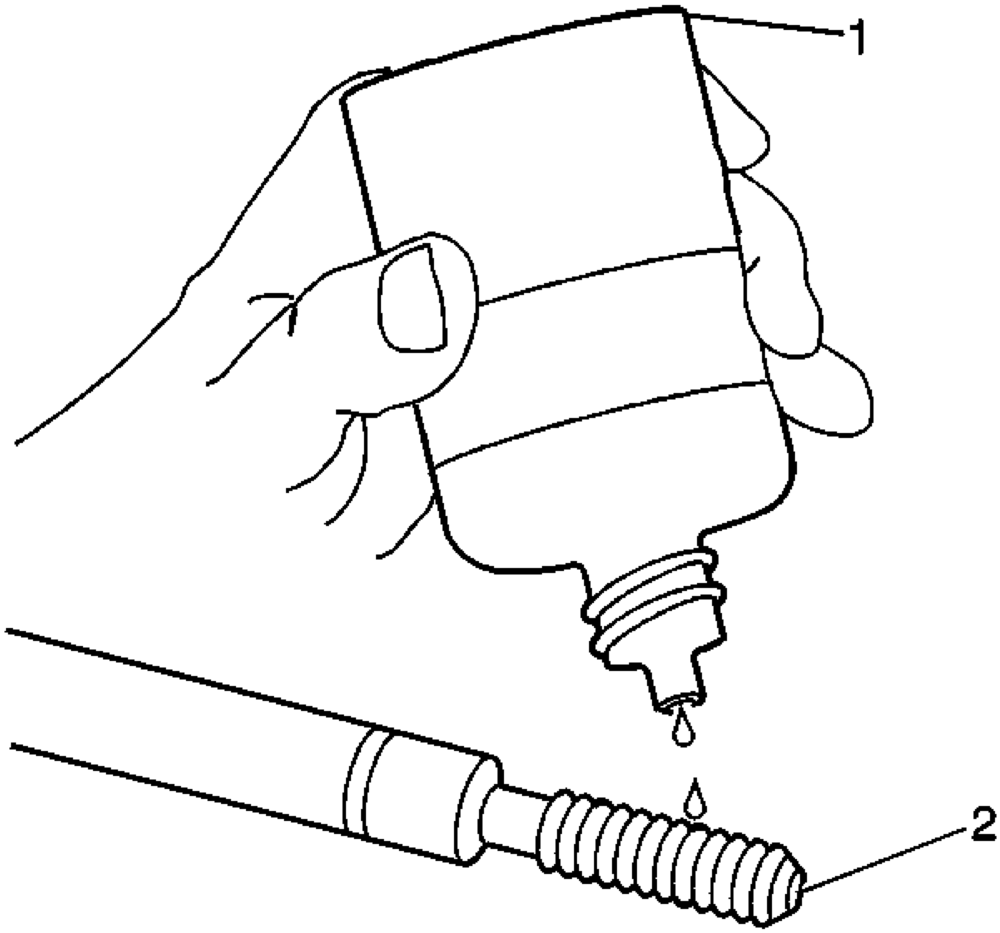


Fig. 386: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

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).

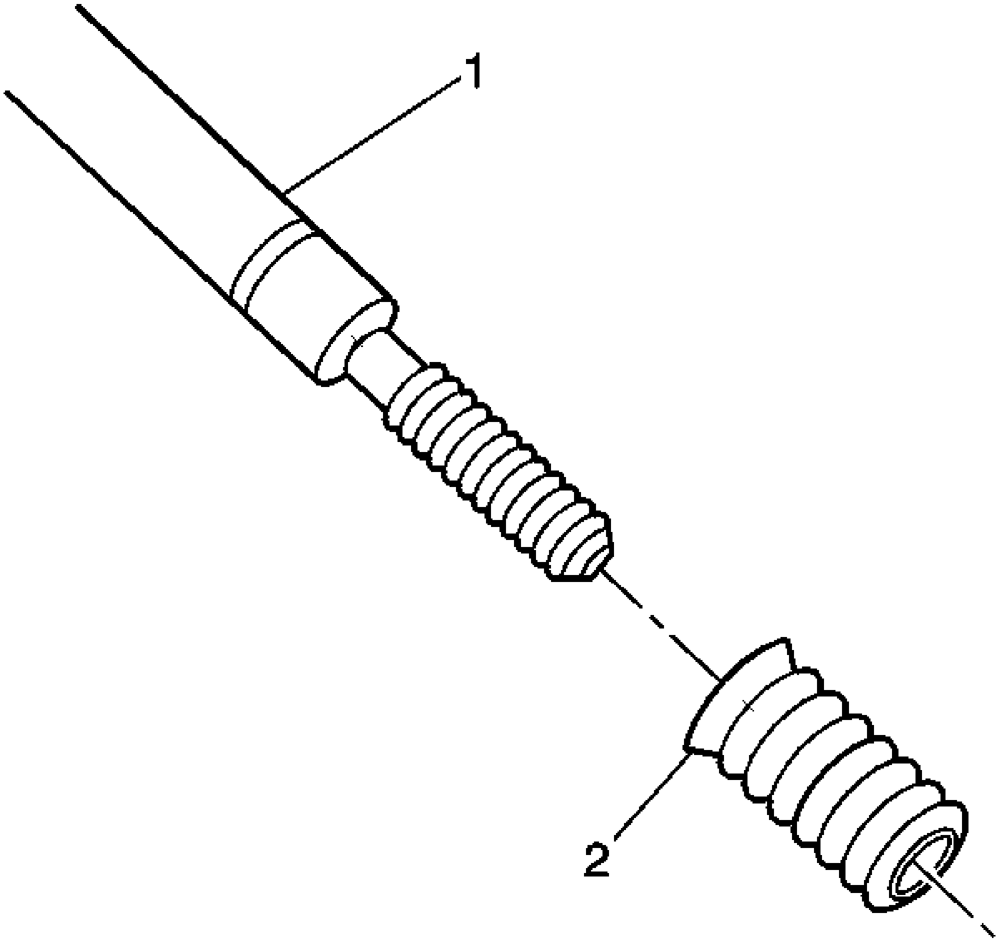


Fig. 387: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

12. Install the insert (2) onto the driver tool (1).

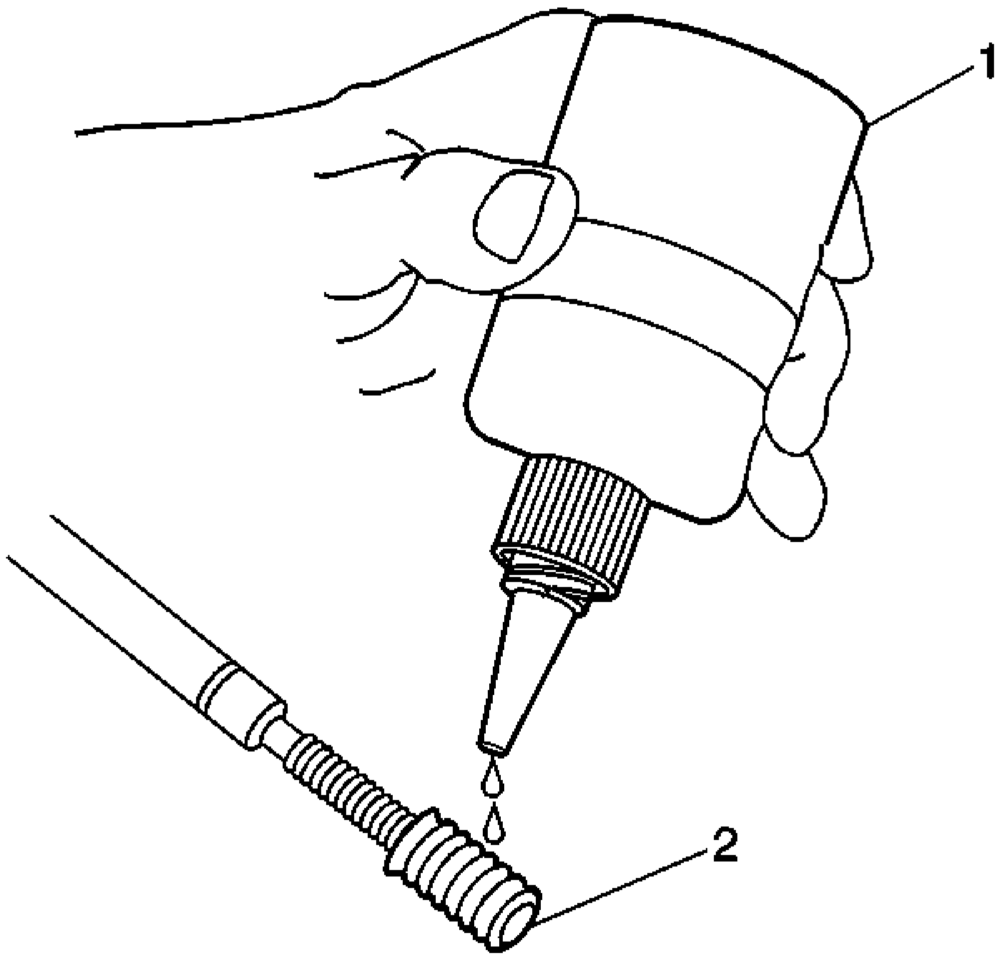


Fig. 388: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

13. Apply threadlock LOCTITE™ 277, J 42385-109 (1), or equivalent to the insert OD threads (2).

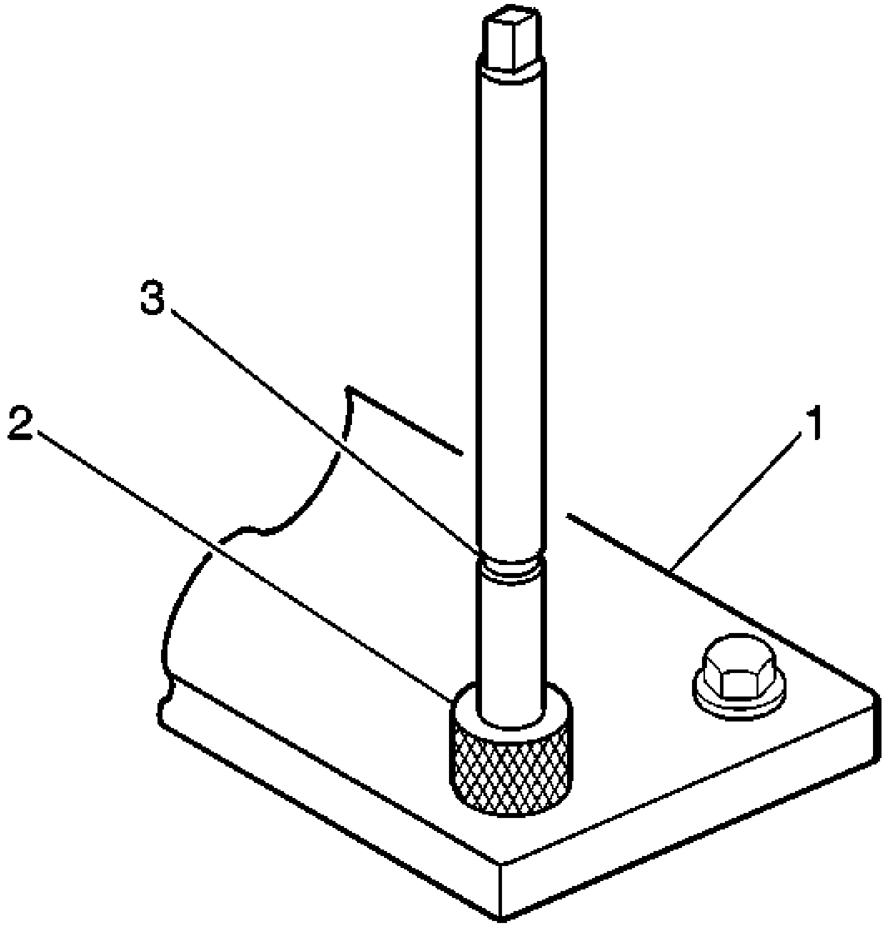


Fig. 389: View Of Fixture Plate, Drill Bushing & Tool Marking
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The fixture plate and bushing remains installed onto the engine block during the insert installation procedure.

14. Install the insert and driver through the bushing (2), fixture plate (1) and into the hole.

    Rotate the driver tool until the mark on the tool (3) aligns with the top of the bushing (2).

    The installer tool will tighten up before screwing completely through the insert. This is acceptable. You are forming the bottom threads of the insert and mechanically locking the insert to the base material threads.

15. Remove the driver, bushing (2), fixture plate (1), and bolts.

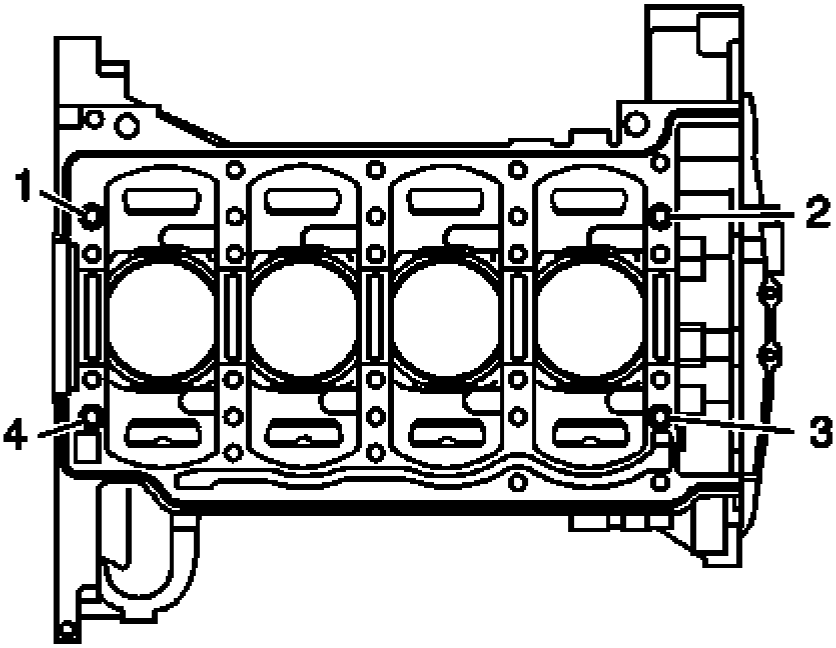


Fig. 390: Identifying Alignment Dowel Pins
Courtesy of GENERAL MOTORS CORP.

16. Install the alignment dowel pins in holes (1-4), if necessary.

Service Prior to Assembly

The importance of cleanliness during assembly cannot be overstated. Dirt or debris will cause engine damage. An automobile engine is a combination of many machined, honed, polished and lapped surfaces with tolerances that are measured in ten thousandths of an inch. When any internal engine parts are serviced, care and cleanliness are important. A liberal coating of engine oil should be applied to friction areas during assembly in order to protect and lubricate the surfaces on initial operation. Throughout this section, it should be understood that proper cleaning and protection of machined surfaces and friction areas are part of the repair procedure. This is considered standard shop practice even if not specifically stated.

Lubricate all moving parts with engine oil or a specified assembly lubricant. This will provide lubrication for initial start up.

Engine Prelubing

Tools Required

J 45299 Engine Preluber. See **Special Tools and Equipment**.

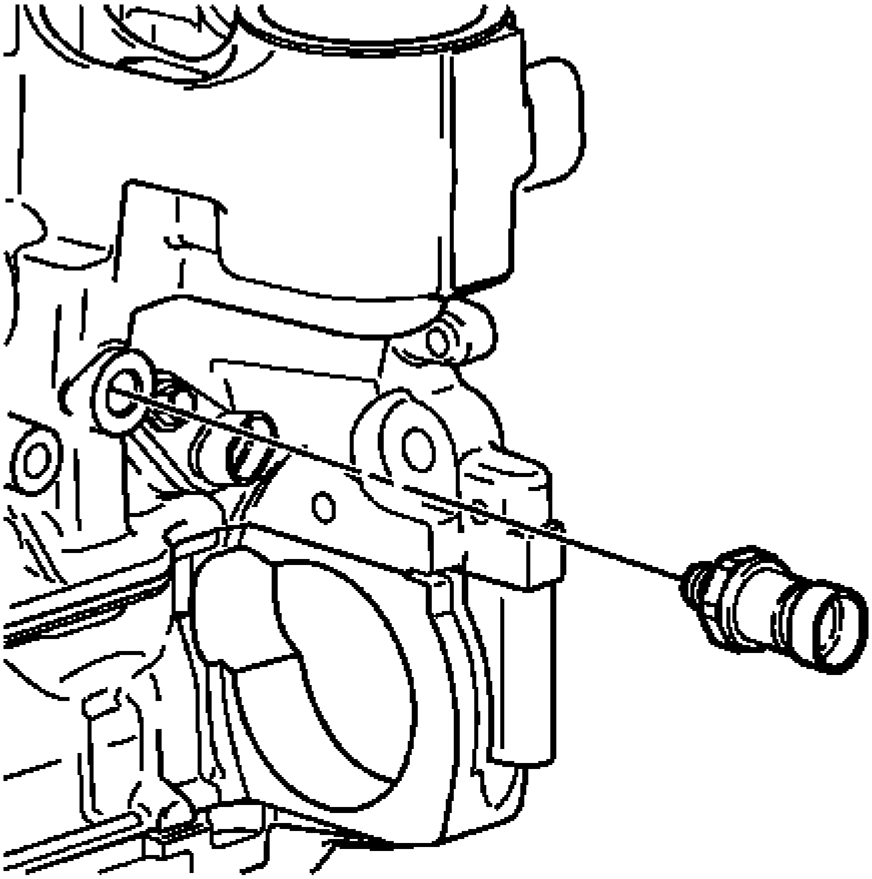


Fig. 391: View Of Engine Oil Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

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.

1. Locate the oil pressure switch and remove.
2. Install the M12 x 1.75 adapter P/N 509376.

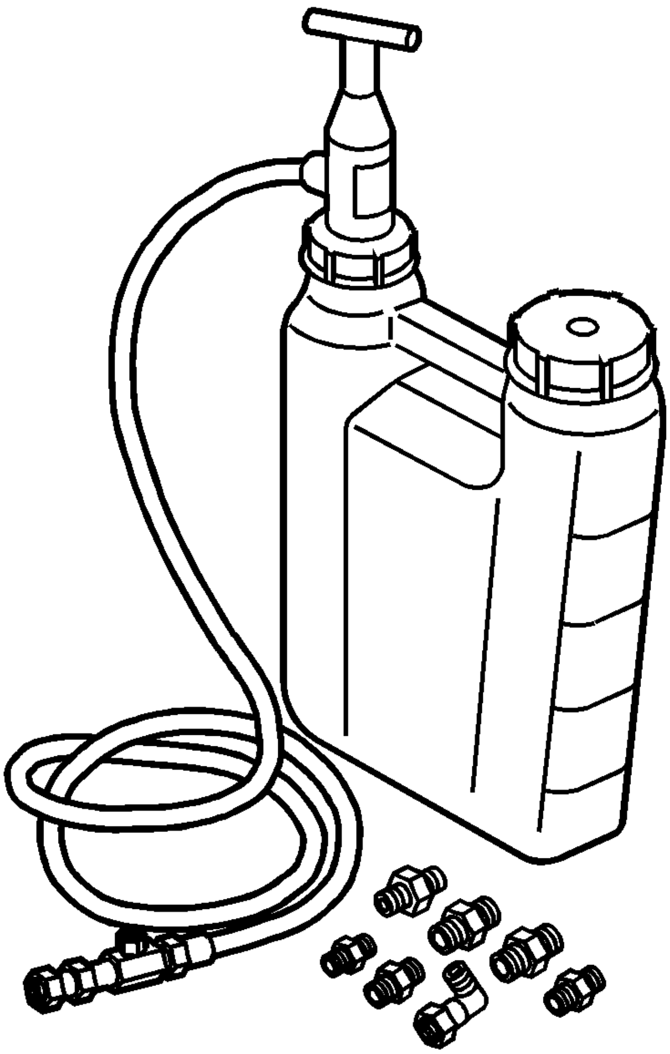


Fig. 392: Identifying Engine Preluber J 45299
Courtesy of GENERAL MOTORS CORP.

3. Install the flexible hose to the adapter and open the valve.
4. Pump the handle on the **J 45299** in order to flow a minimum of 1-1. 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

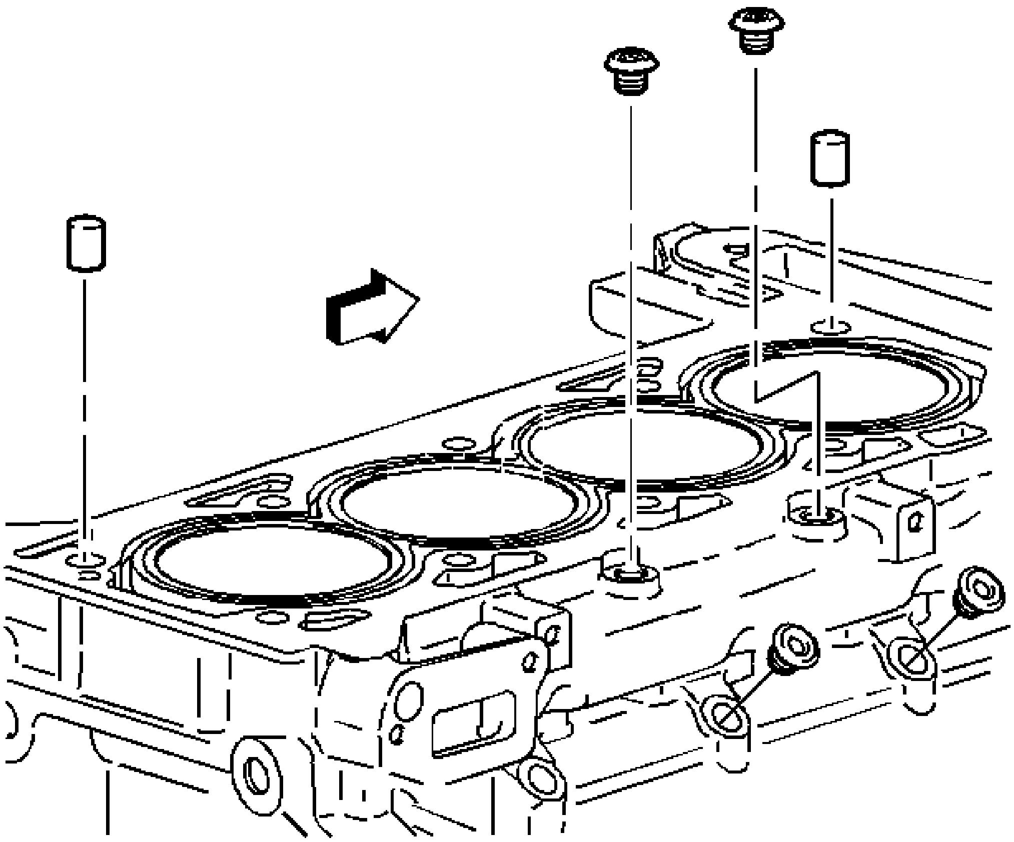


Fig. 393: View Of Oil Passage Plug, Oil Flow Check Valve & Water Jacket Drain Plug
Courtesy of GENERAL MOTORS CORP.

1. Install the drain plug in the water pump.
2. Apply gasket paste GM P/N United States 12346004, GM P/N Canada 10953480 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 gasket paste GM P/N United States 12346004, GM P/N Canada 10953480 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 gasket paste GM P/N United States 12346004, GM P/N Canada 10953480 to the plug before installation.

Tighten: Tighten the oil passage plugs to 35 N.m (26 lb ft).

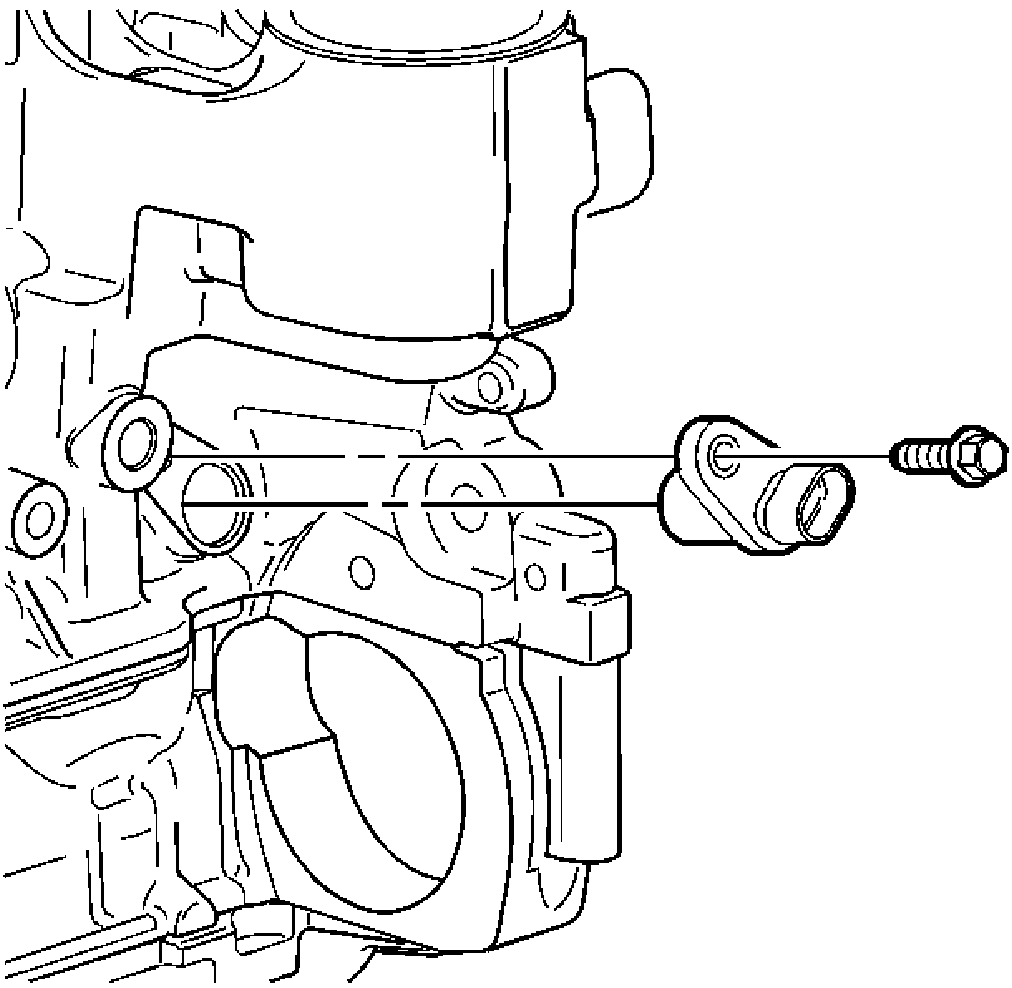


Fig. 394: View Of Crankshaft Position Sensor
Courtesy of GENERAL MOTORS CORP.

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).

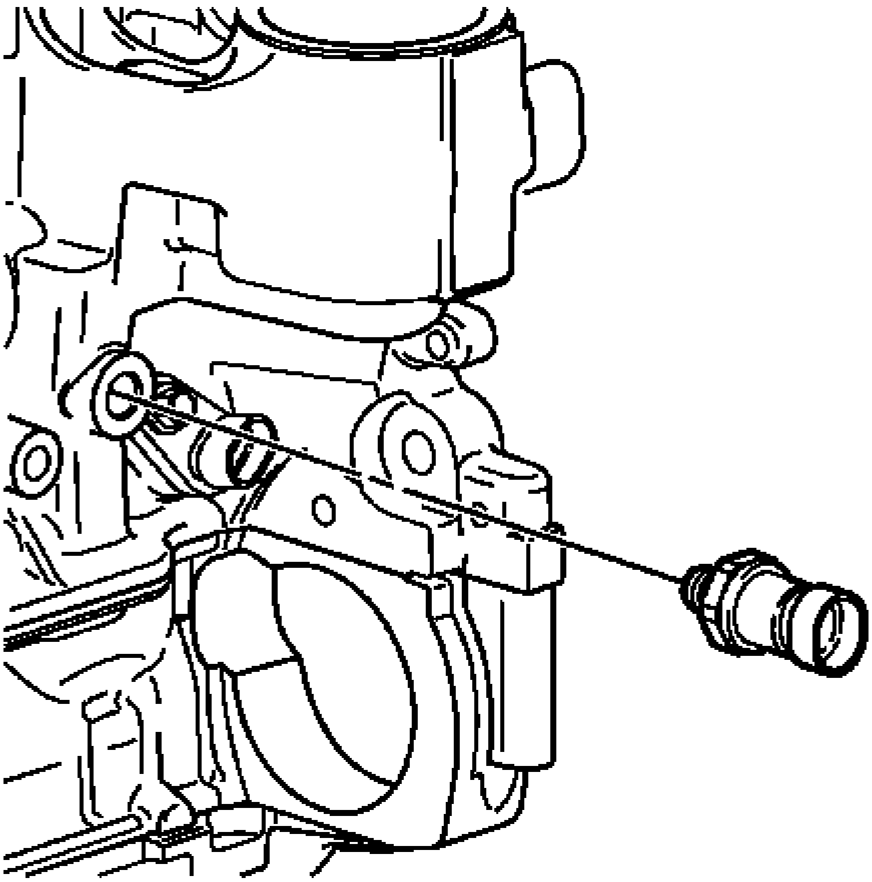


Fig. 395: View Of Engine Oil Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

10. Install the oil pressure switch.

    Tighten: Tighten the oil pressure switch to 10 N.m (89 lb in).

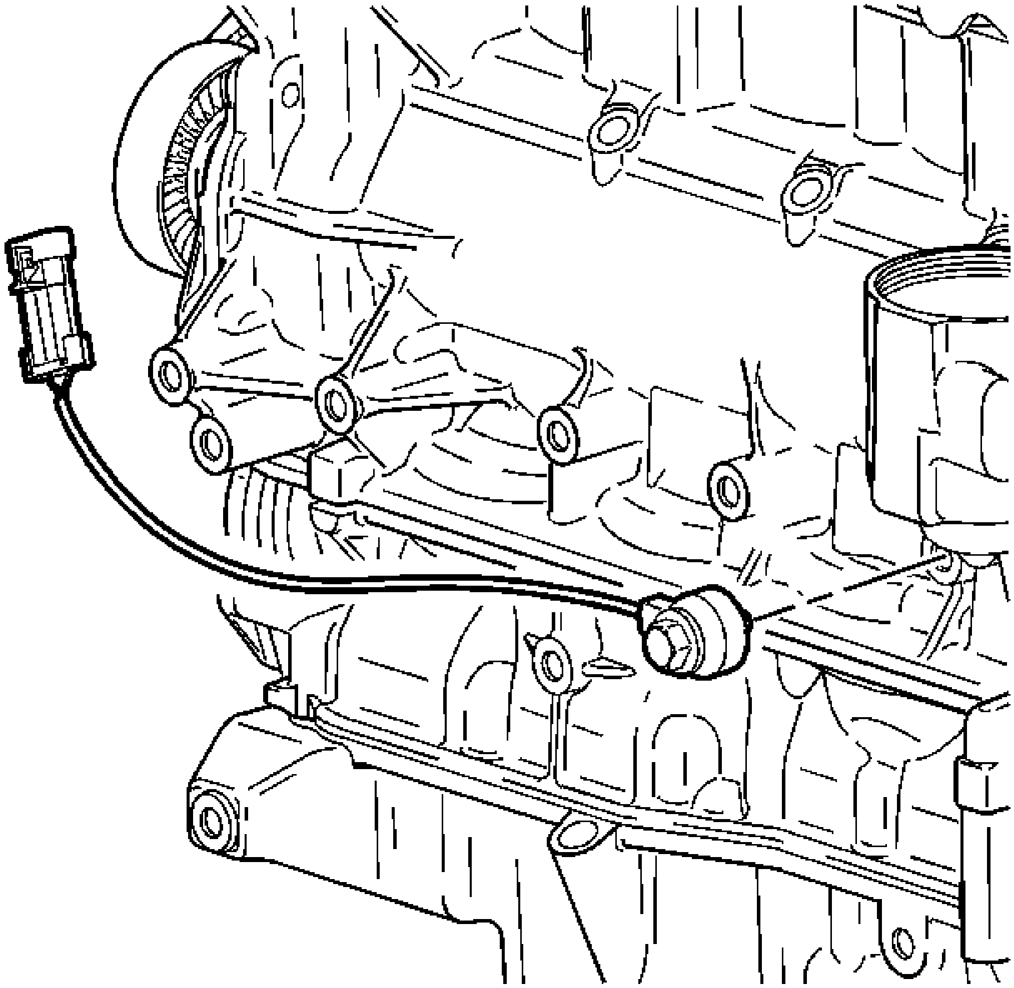


Fig. 396: View of Knock Sensor
Courtesy of GENERAL MOTORS CORP.

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** Cylinder Bore Checking Gage. See **Special Tools and Equipment**.
- **J 45059** Angle Meter. See **Special Tools and Equipment**.

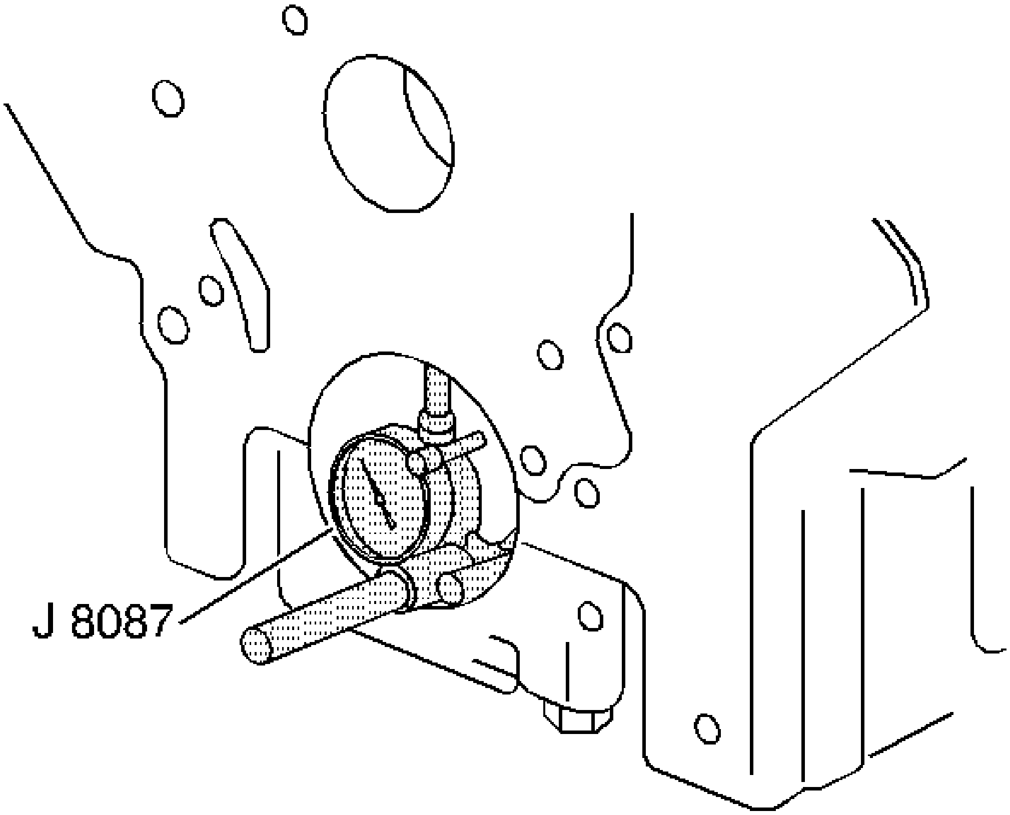


Fig. 397: Inspecting Crankshaft Main Bearing Bores
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If crankshaft bearing failure is due to other than normal wear, investigate the cause. Inspect the crankshaft or connecting rod bearing bores.

Inspect the connecting rod bearing bores or crankshaft main bearing bores using the following procedure:

- Tighten the bedplate to specification using the **J 45059** . See **Special Tools and Equipment**.
- Measure the bearing bore for taper and out-of-round using the **J 8087** . 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.

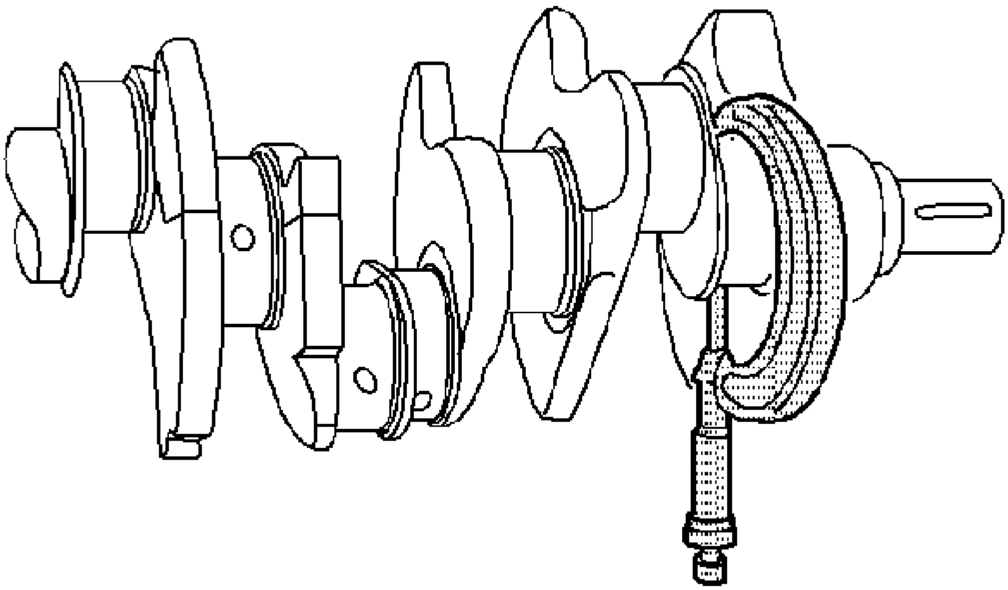


Fig. 398: Measuring Crankshaft Bearing Journal Diameter
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not mix inserts of different nominal size in the same bearing bore.

2. To measure bearing clearance using Method A, use the following procedure:
    1. Measure the crankshaft bearing journal diameter with a micrometer in several places, 90 degrees apart. Average the measurements.
    2. Measure the crankshaft bearing journal taper and runout.
    3. Install the lower crankcase and tighten the bearing cap bolts to specification.
    4. Measure bearing 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.

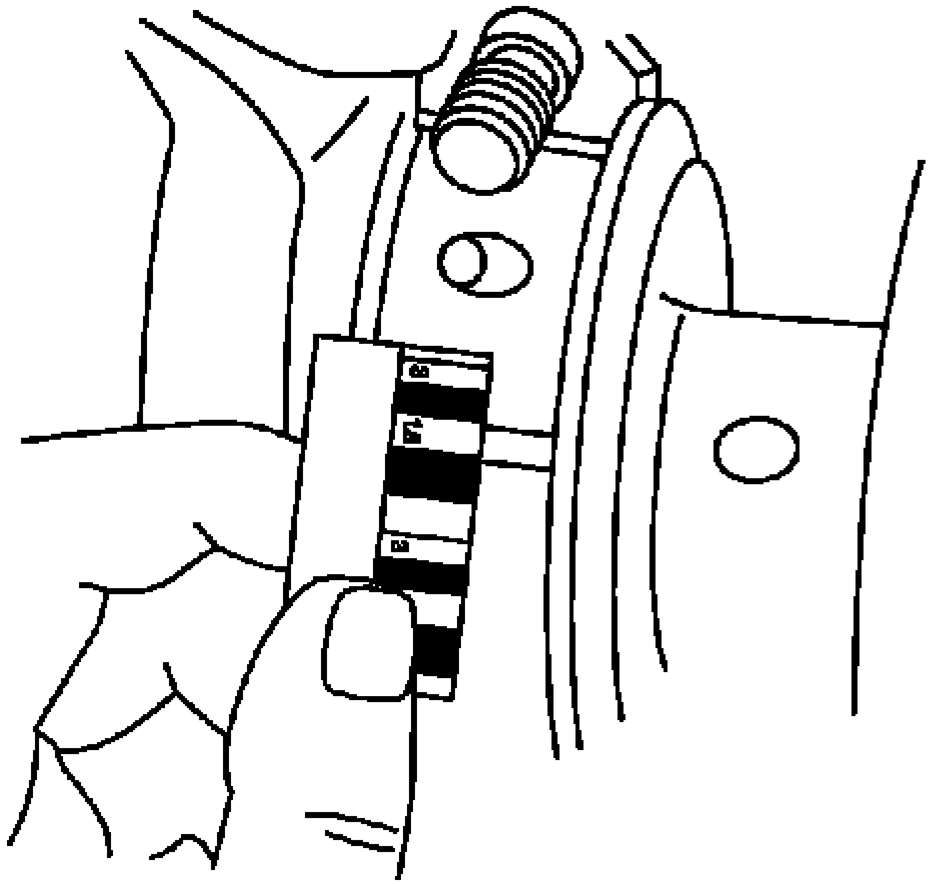


Fig. 399: Measuring Gaging Plastic
Courtesy of GENERAL MOTORS CORP.

3. To measure bearing clearance using Method B, use the following procedure:
    1. Clean the used bearing inserts.
    2. Install the used bearing inserts.
    3. Place a piece of gaging plastic across the entire bearing width.
    4. Install the bearing caps.

    NOTE: **In order to prevent the possibility of cylinder block or crankshaft bearing cap damage, the crankshaft bearing caps are tapped into the cylinder block cavity using a brass, lead, or a leather mallet before the attaching bolts are installed. Do not use attaching bolts to pull the crankshaft bearing caps into the seats. Failure to use this process may damage a cylinder block or a bearing cap.**

    5. Install the bearing cap bolts to specification.

    IMPORTANT: **Do not rotate the crankshaft.**

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**.

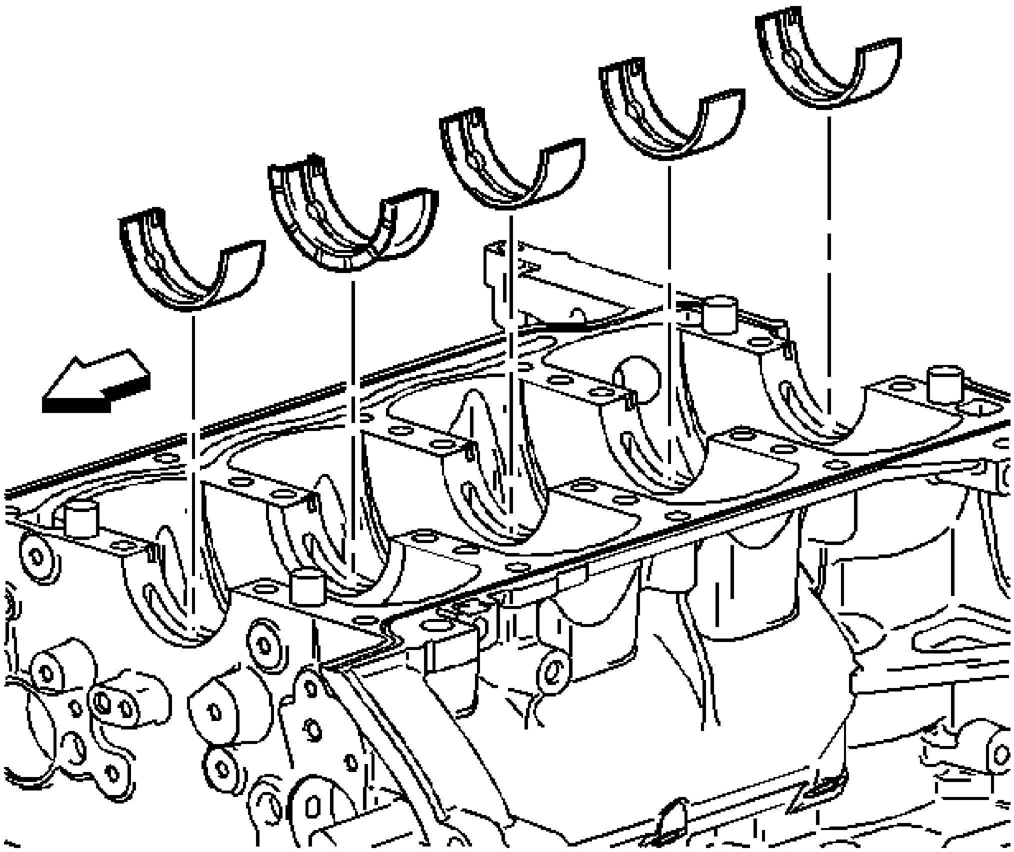


Fig. 400: View Of Crankshaft Bearing Inserts
Courtesy of GENERAL MOTORS CORP.

1. Install the upper crankshaft bearings and lubricate bearing surfaces with engine oil.

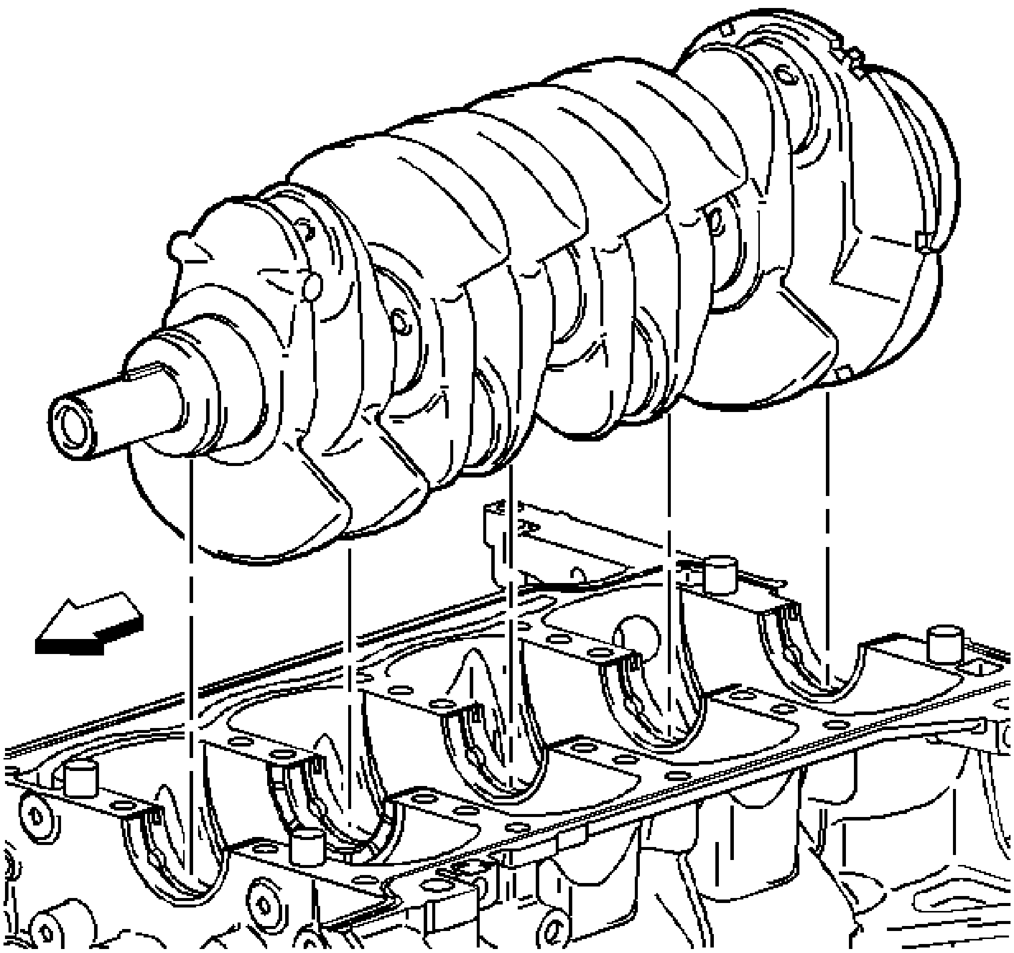


Fig. 401: View of Crankshaft
Courtesy of GENERAL MOTORS CORP.

2. Install the crankshaft on the journals.

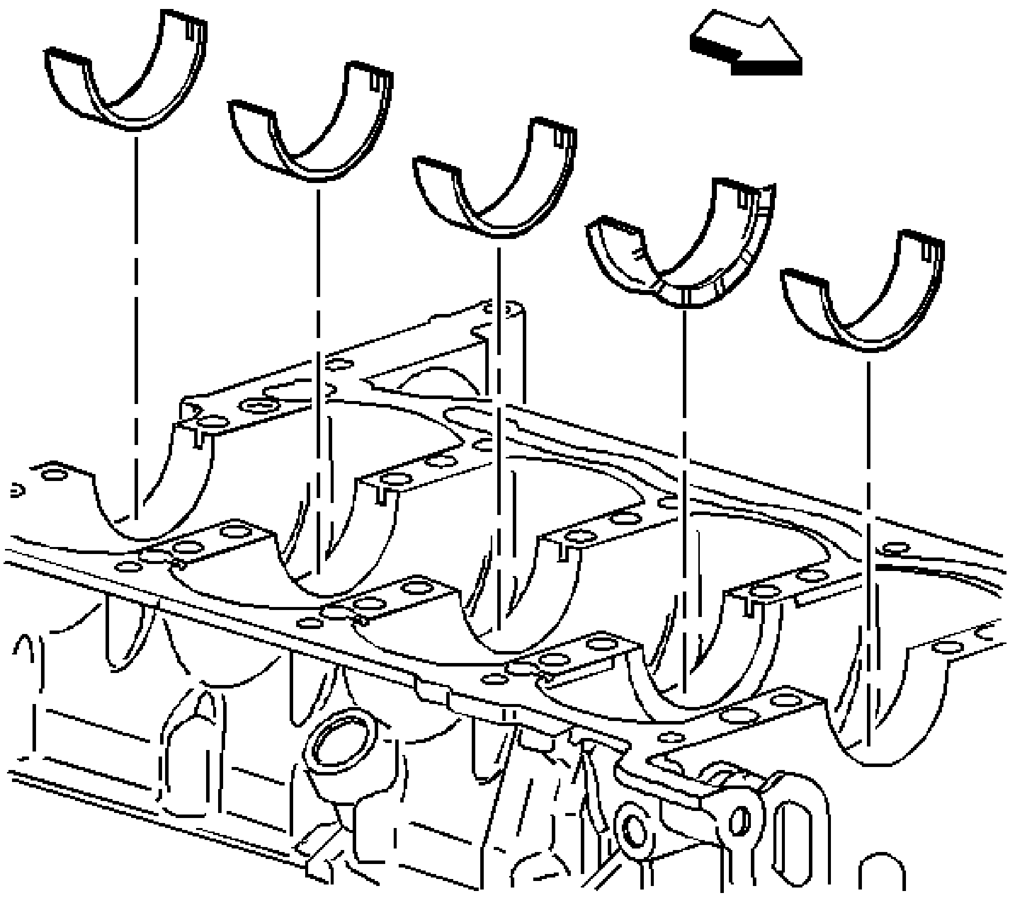


Fig. 402: Identifying Crankshaft Bearing Inserts
Courtesy of GENERAL MOTORS CORP.

3. Install the lower bearing halves, without grooves, into the lower crankcase. Apply oil to bearing surfaces.

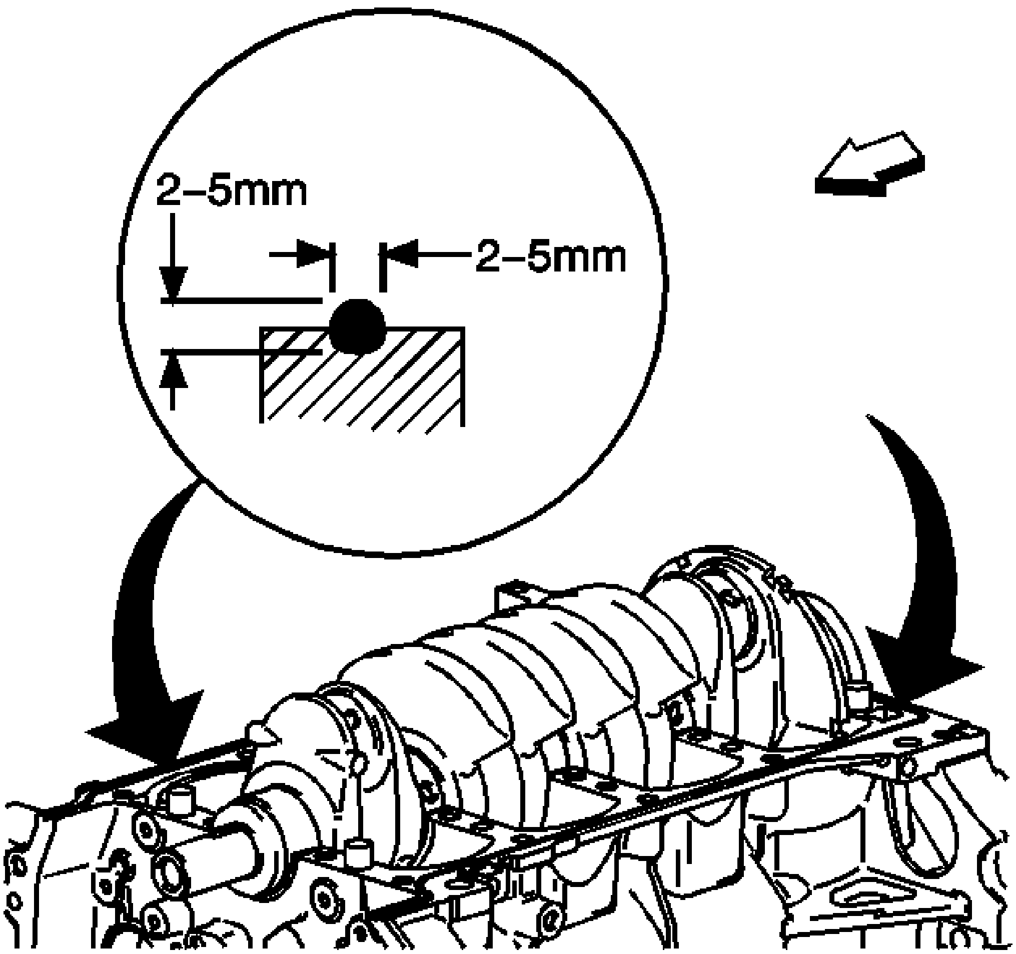


Fig. 403: Applying of Sealant to Engine Block Surfaces & Bedplate Mating Surfaces
Courtesy of GENERAL MOTORS CORP.

4. Apply sealer GM P/N 12346286 (Canadian P/N 10953472) to the surfaces of the engine block to bedplate mating surfaces.

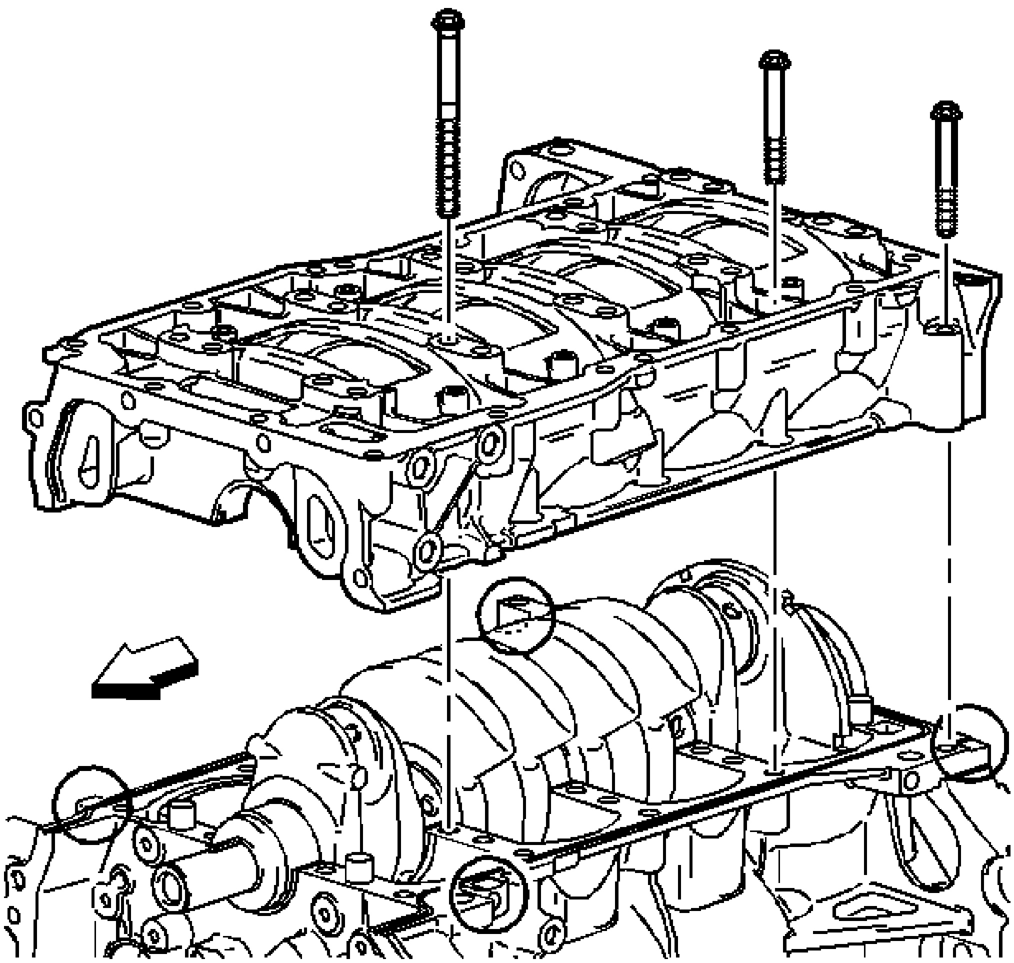


Fig. 404: View Of Upper & Lower Crankcase W/Bolts
Courtesy of GENERAL MOTORS CORP.

5. Install the lower crankcase. Tap gently into place with a suitable tool if necessary. Ensure it is aligned properly on the dowels.

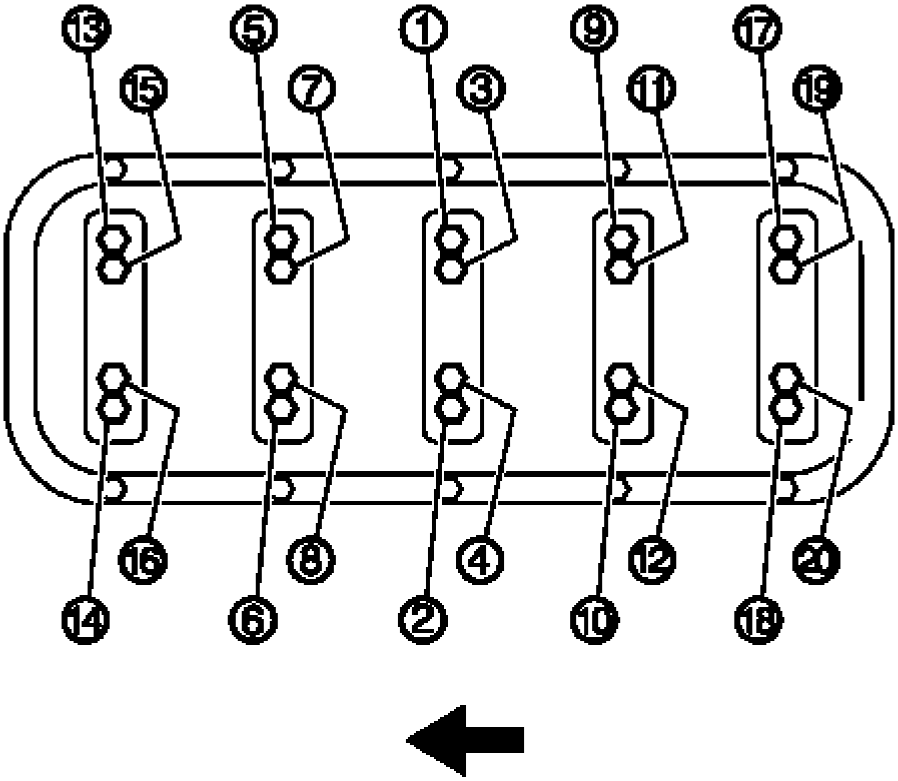


Fig. 405: Identifying Crankshaft Bearing Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

6. Install the NEW crankshaft bearing bolts in sequence finger tight.
    1. Tighten the crankshaft bearing bolts in sequence.

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

    2. Tighten the crankshaft bearing bolts in sequence using the **J 45059** . See **Special Tools and Equipment**.

        Tighten: Tighten the crankshaft bearing bolts 70 degrees using the torque angle meter.

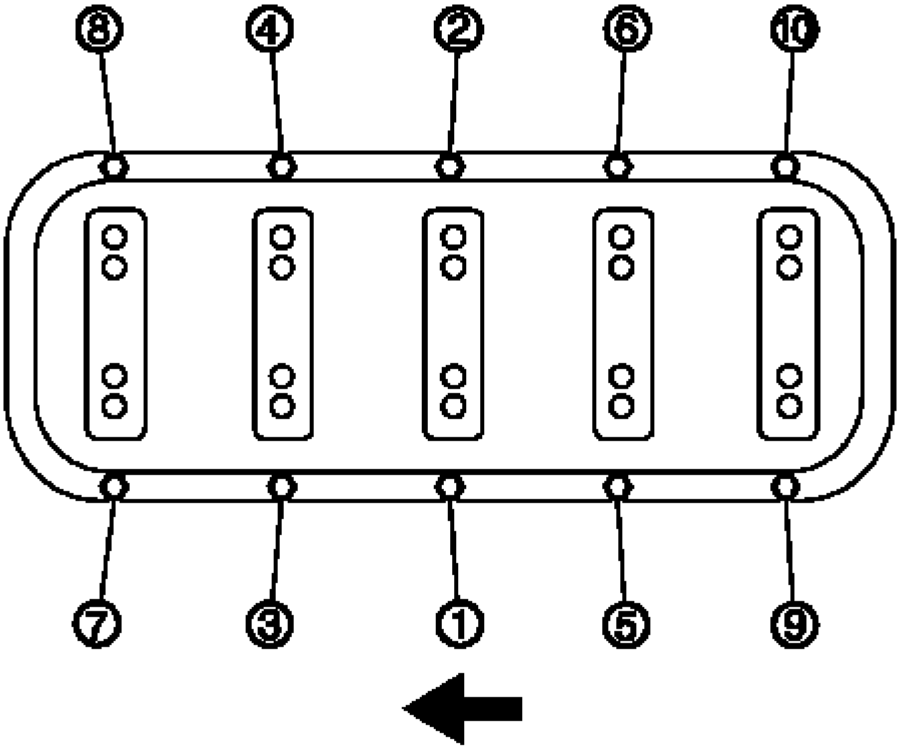


Fig. 406: Lower Crankcase Perimeter Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

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**.

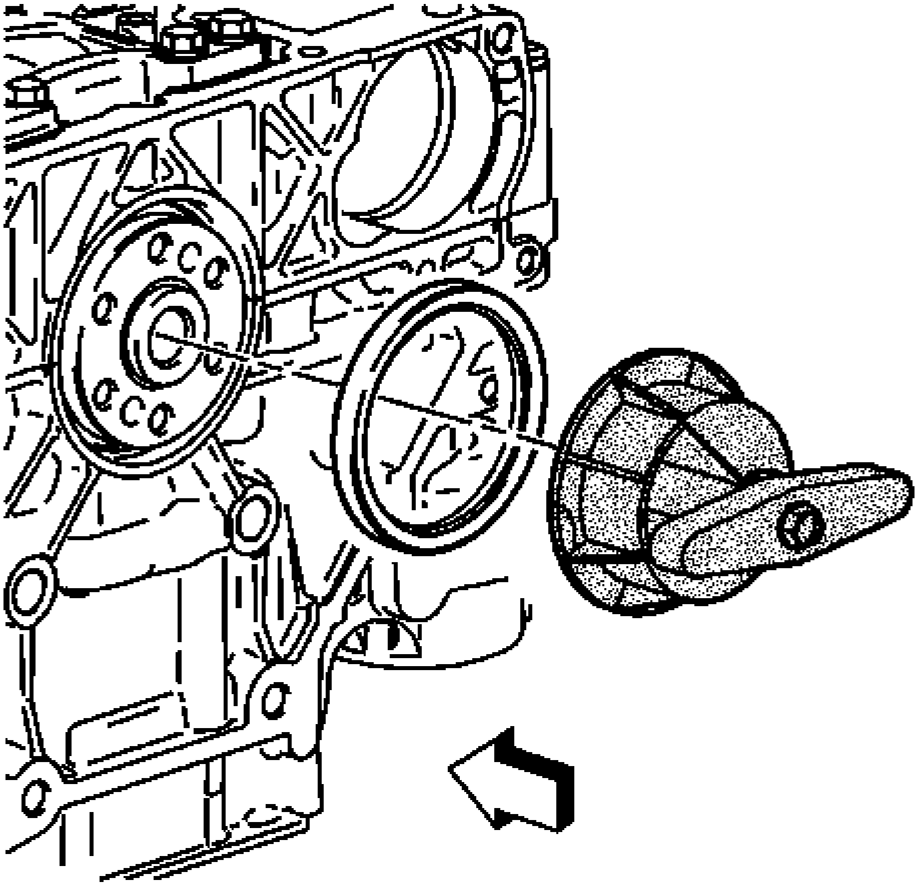


Fig. 407: Installing Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Remove excess sealer from seal recess.
2. Lubricate the outside diameter of the new crankshaft seal with clean engine oil.
3. Using the **J 42067** , press the new crankshaft seal into the housing. 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**.

Piston, Connecting Rod, and Bearing Installation

Tools Required

- **J 8037** Piston Ring Compressor. See **Special Tools and Equipment**.
- **J 45059** Angle Meter. See **Special Tools and Equipment**.
- **J-43966-1** Connecting Rod Guides. See **Special Tools and Equipment**.

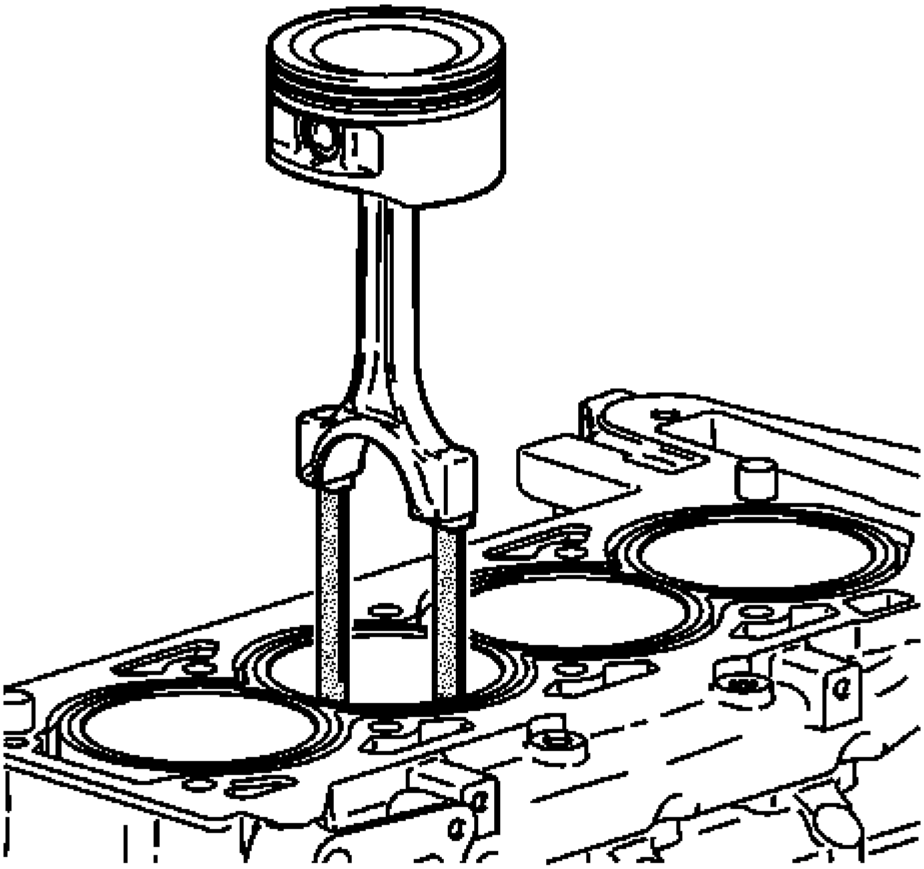


Fig. 408: J-43966-1 Installed Into Connecting Rod Bolt Holes
Courtesy of GENERAL MOTORS CORP.

1. Install the connecting rod bearings. Use NEW bearings.
    1. Install the bearing inserts into the connecting rod and the connecting rod cap.
    2. Lubricate the connecting rod bearings with engine oil.
2. Install the **J-43966-1** into the connecting rod bolt holes. See **Special Tools 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** 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** 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.

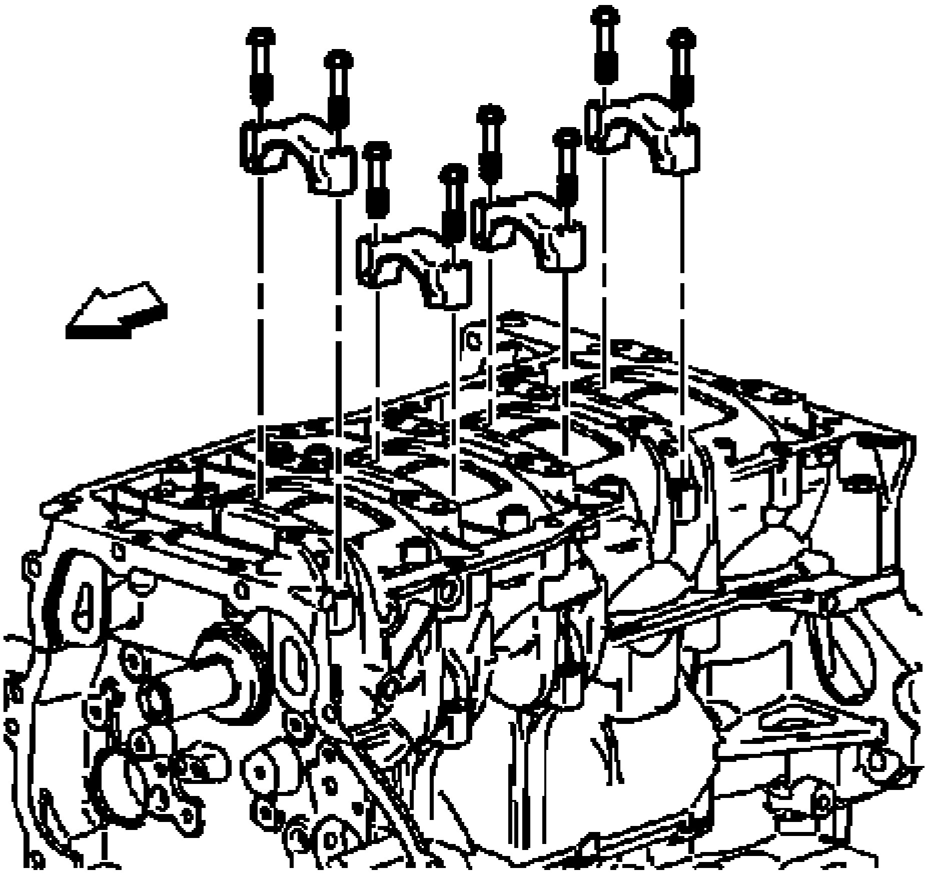


Fig. 409: View Of Connecting Rod Nuts And Caps
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure that the connecting rod cap is properly oriented on the connecting rod.

4. Install the connecting rod cap.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Install the connecting rod bolts. Always use new bolts.

   Tighten: Tighten the connecting rod bolts to 25 N.m (18 lb ft), plus 100 degrees using the **J 45059** . See **Special Tools and Equipment**.

6. Install the remaining connecting rods and piston assemblies.

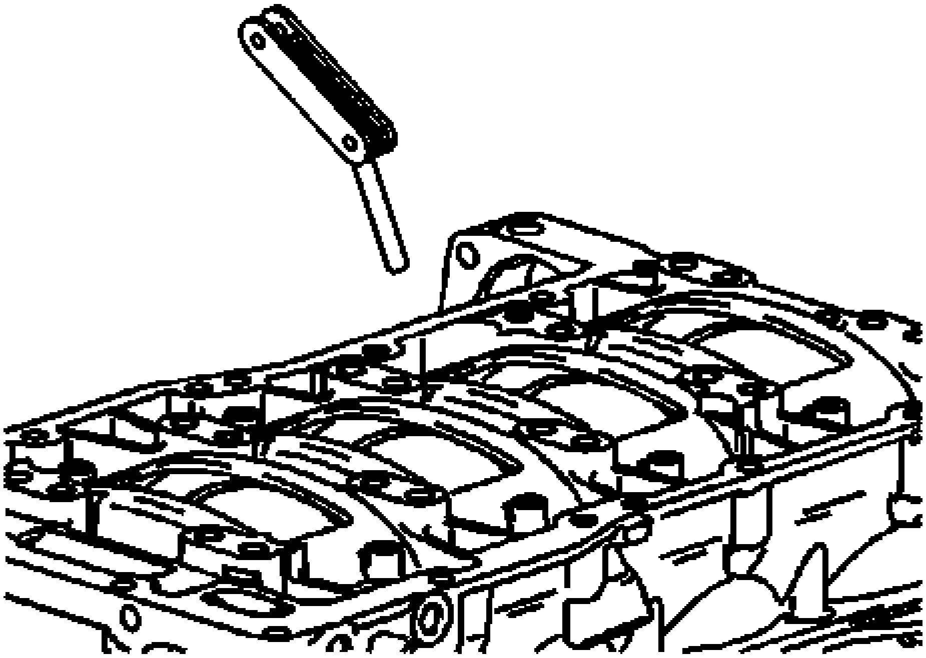


Fig. 410: Measuring Connecting Rod Side Clearance
Courtesy of GENERAL MOTORS CORP.

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**.

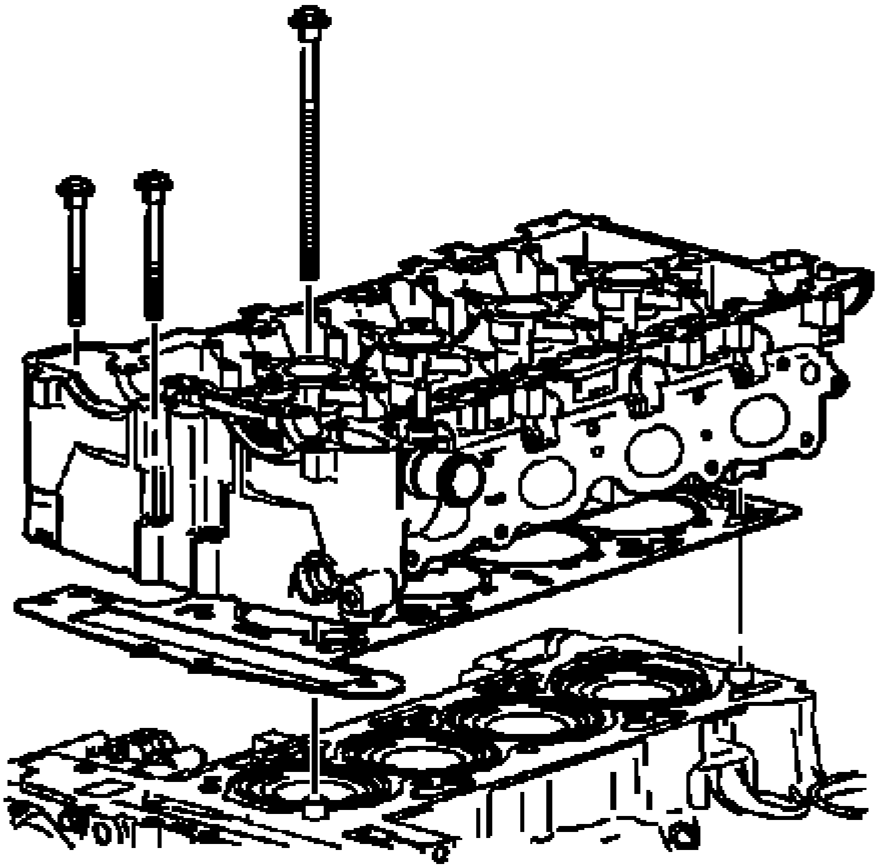


Fig. 411: View Of Cylinder Head And Gasket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not use any sealing material.

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

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.

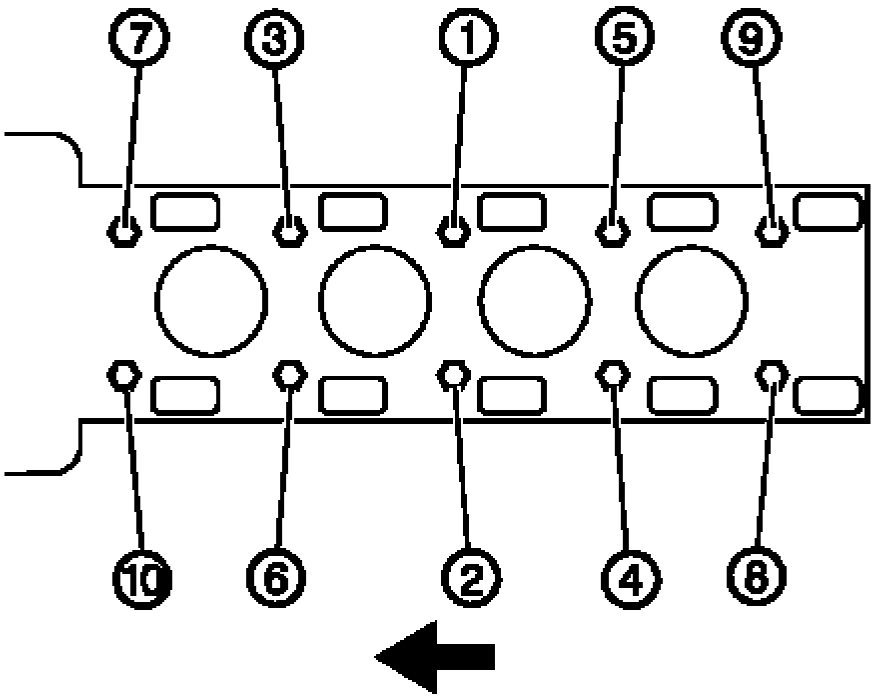


Fig. 412: Identifying Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

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**.

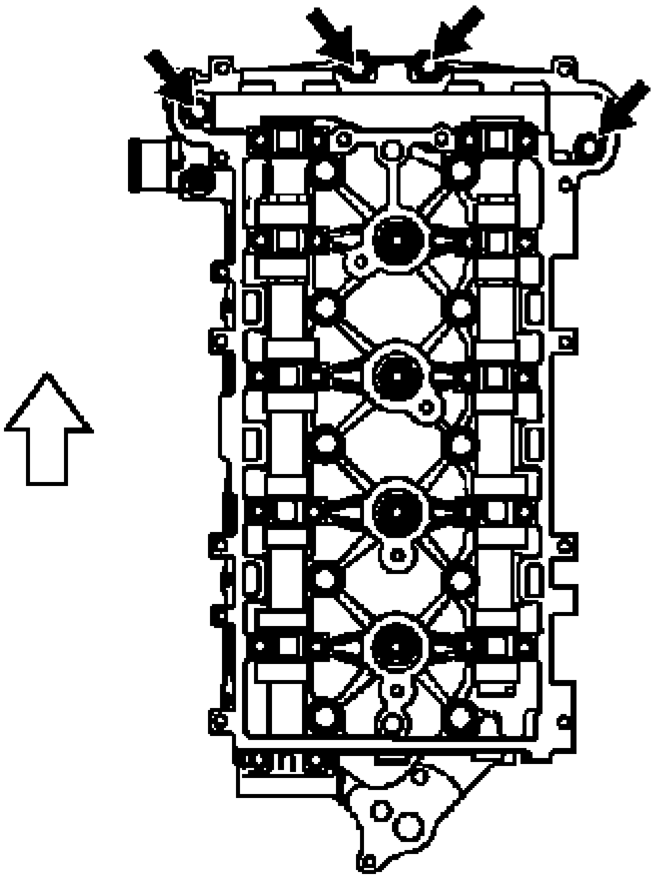


Fig. 413: Locating Front Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

5. Install the front cylinder head bolts.

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

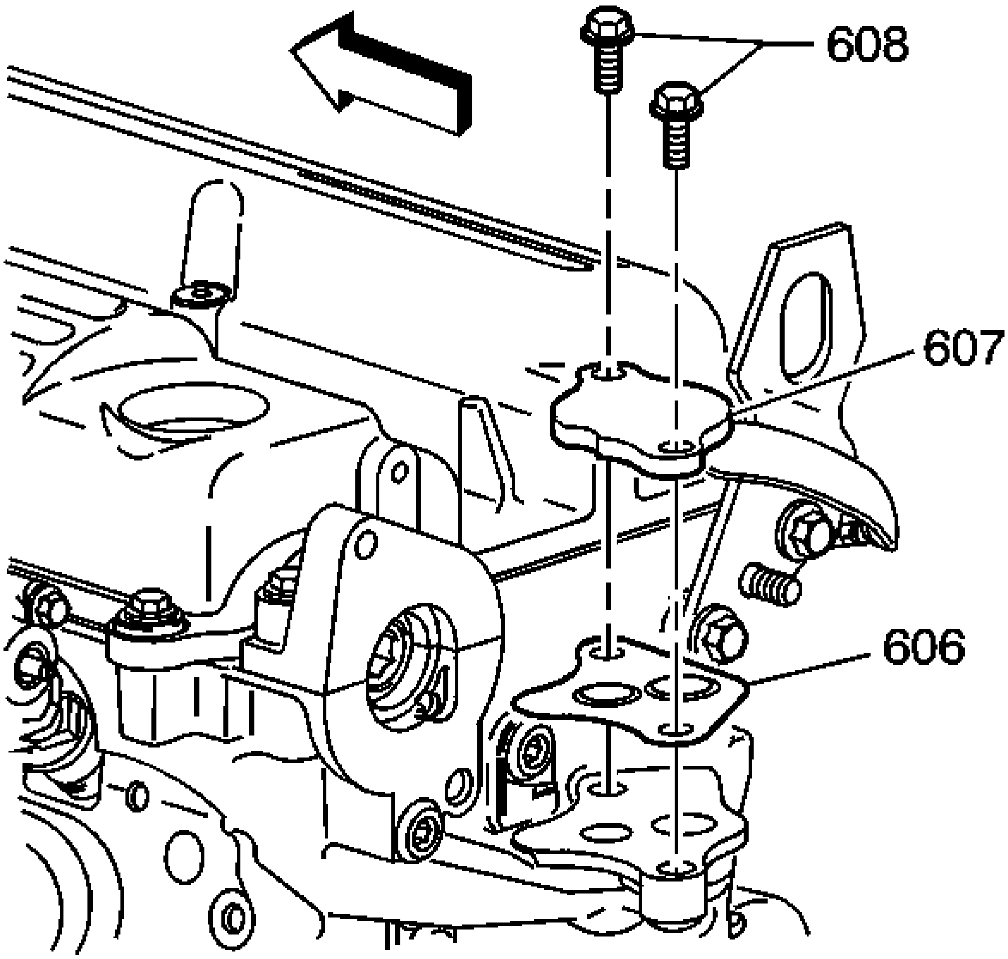


Fig. 414: View of EGR Cover
Courtesy of GENERAL MOTORS CORP.

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

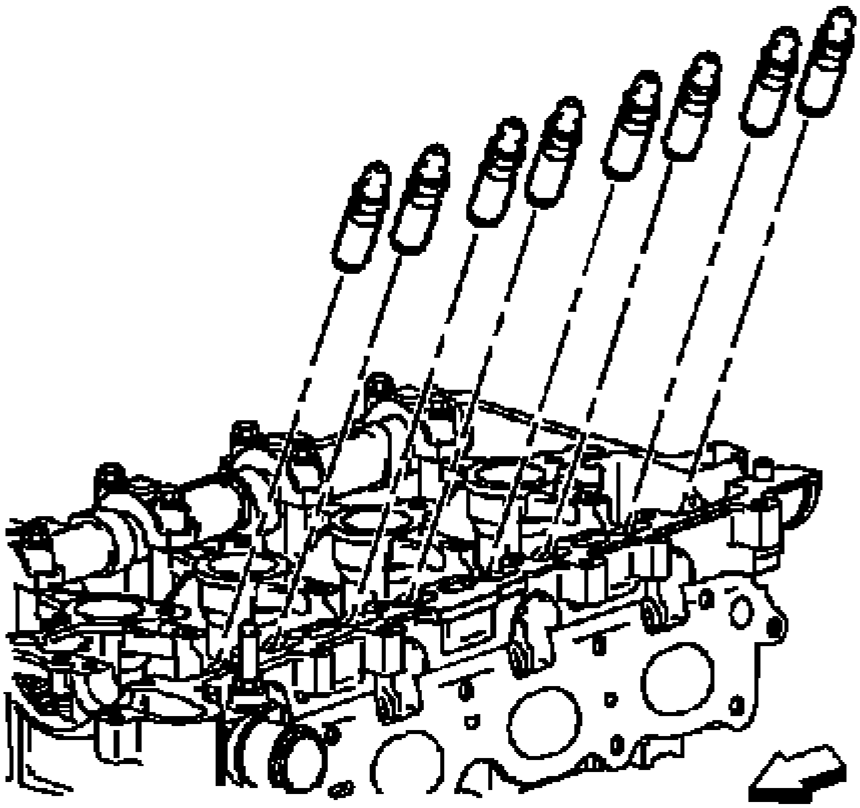


Fig. 415: View Of Hydraulic Element Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

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

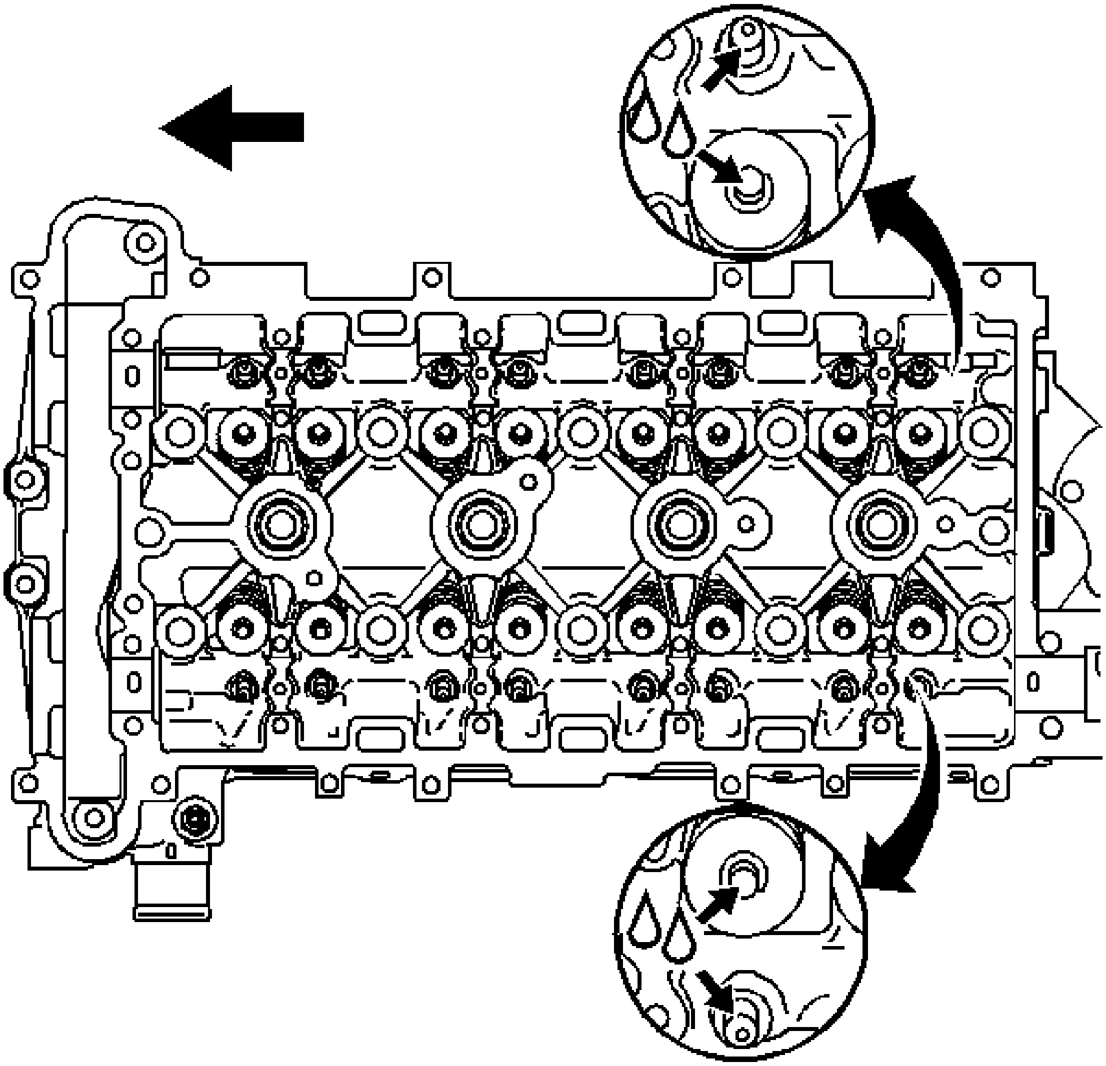


Fig. 416: Lubricating Valve Tips
Courtesy of GENERAL MOTORS CORP.

3. Lubricate the valve tips.

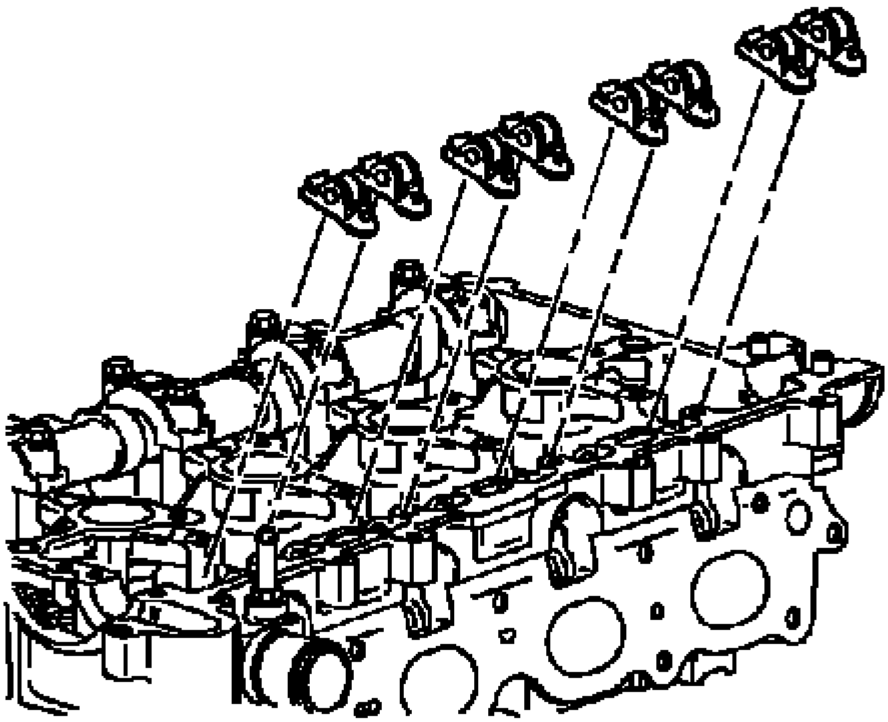


Fig. 417: View Of Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

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 adjustor. Lubricate roller followers with GM P/N 12345501 (Canadian P/N 992704) or equivalent.

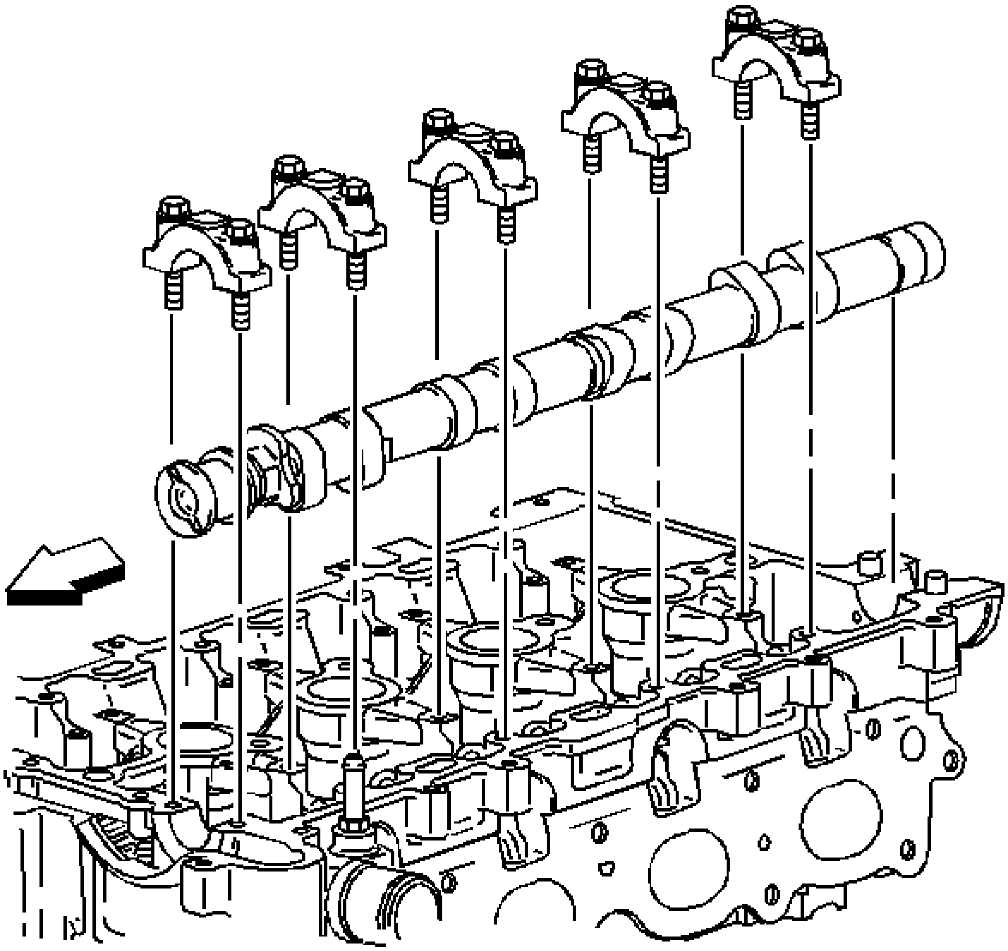


Fig. 418: View Of Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

5. Set the intake camshaft on top of the roller followers in the camshaft bearing journals. Lubricate with GM P/N 12345501 (Canadian P/N 992704) or equivalent.
6. Install the camshaft bearing caps and hand start the camshaft cap bolts.

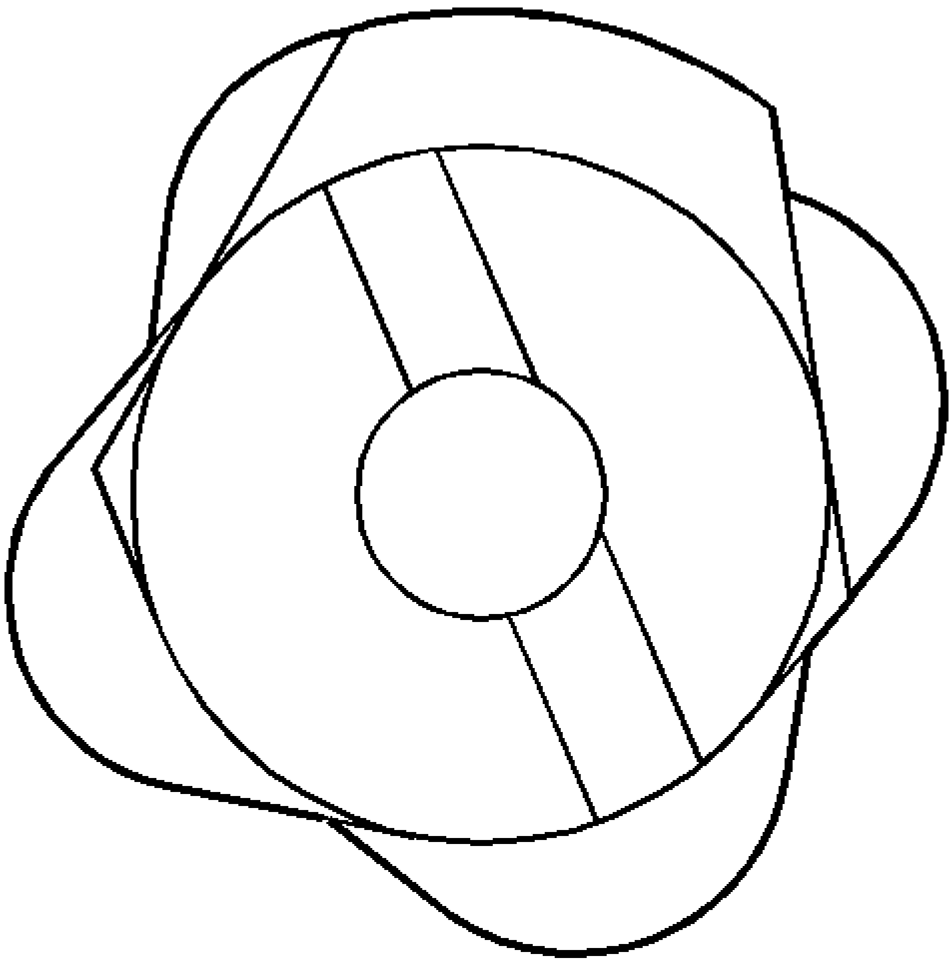


Fig. 419: View Of Camshaft Alignment Notches
Courtesy of GENERAL MOTORS CORP.

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).

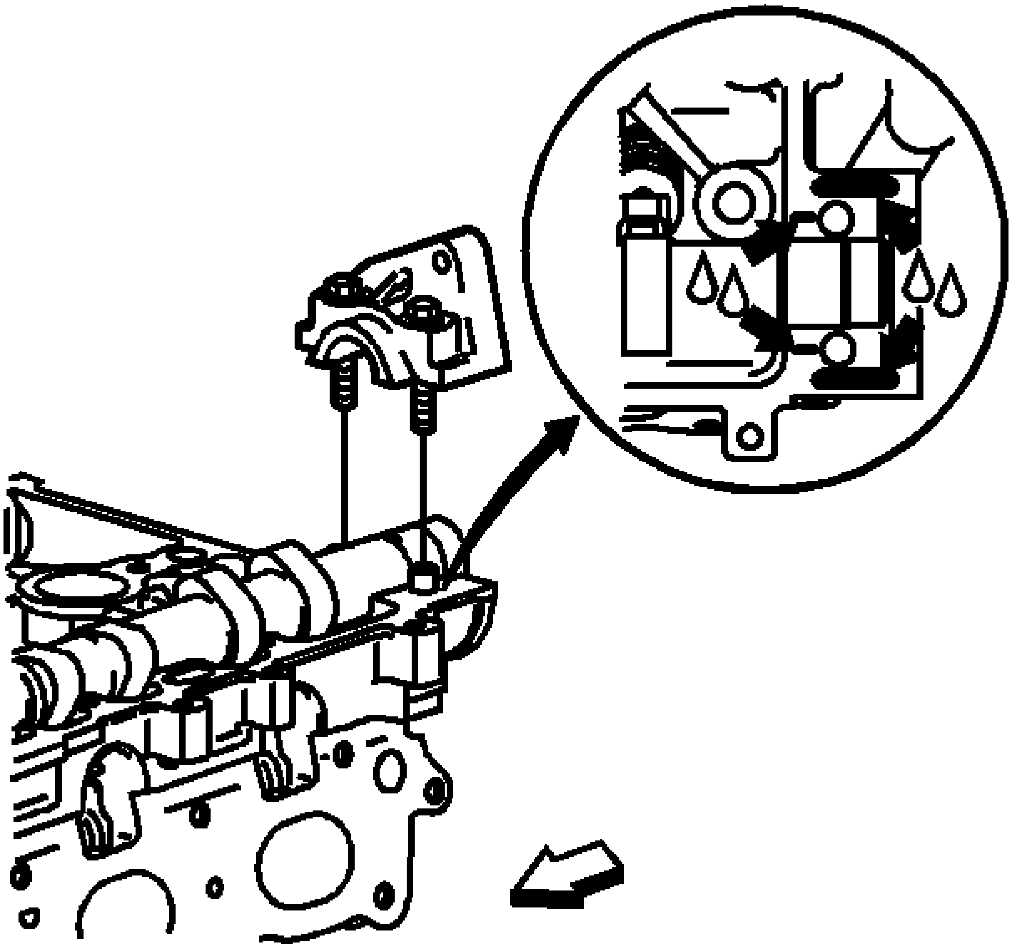


Fig. 420: Applying Camshaft Bearing Cap Sealer To Rear Cap
Courtesy of GENERAL MOTORS CORP.

9. Apply anaerobic sealer, 3.5 mm (0.138 in) bead, GM P/N 1052942 (Canadian P/N 10953466) or equivalent 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

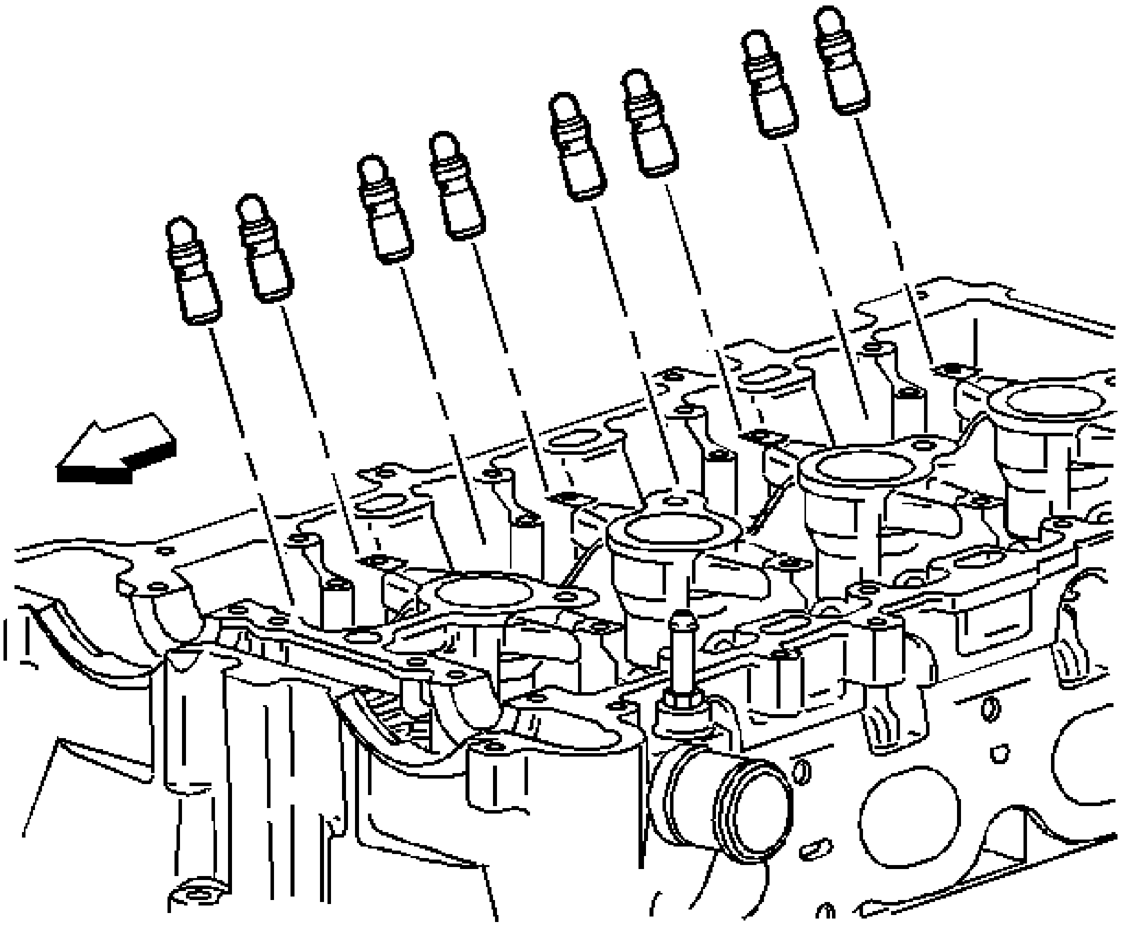


Fig. 421: View Of Hydraulic Element Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

1. Install the hydraulic element lash adjusters into their bores in the cylinder head. Apply lubricant GM P/N 12345501 (Canadian P/N 992704) or equivalent to hydraulic element lash adjuster.

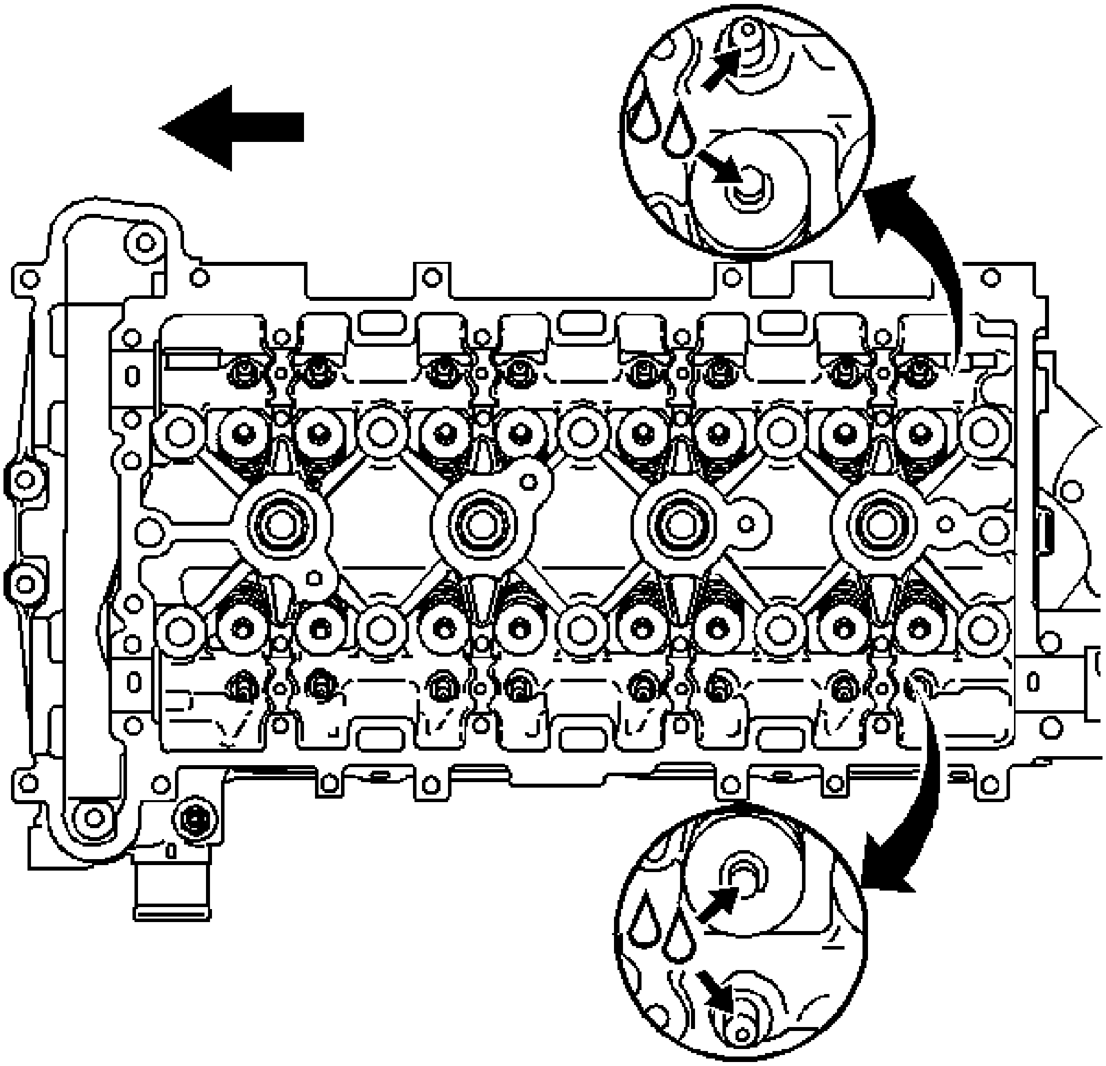


Fig. 422: Lubricating Valve Tips
Courtesy of GENERAL MOTORS CORP.

2. Lubricate the valve tips with GM P/N 12345501 (Canadian P/N 992704) or equivalent.

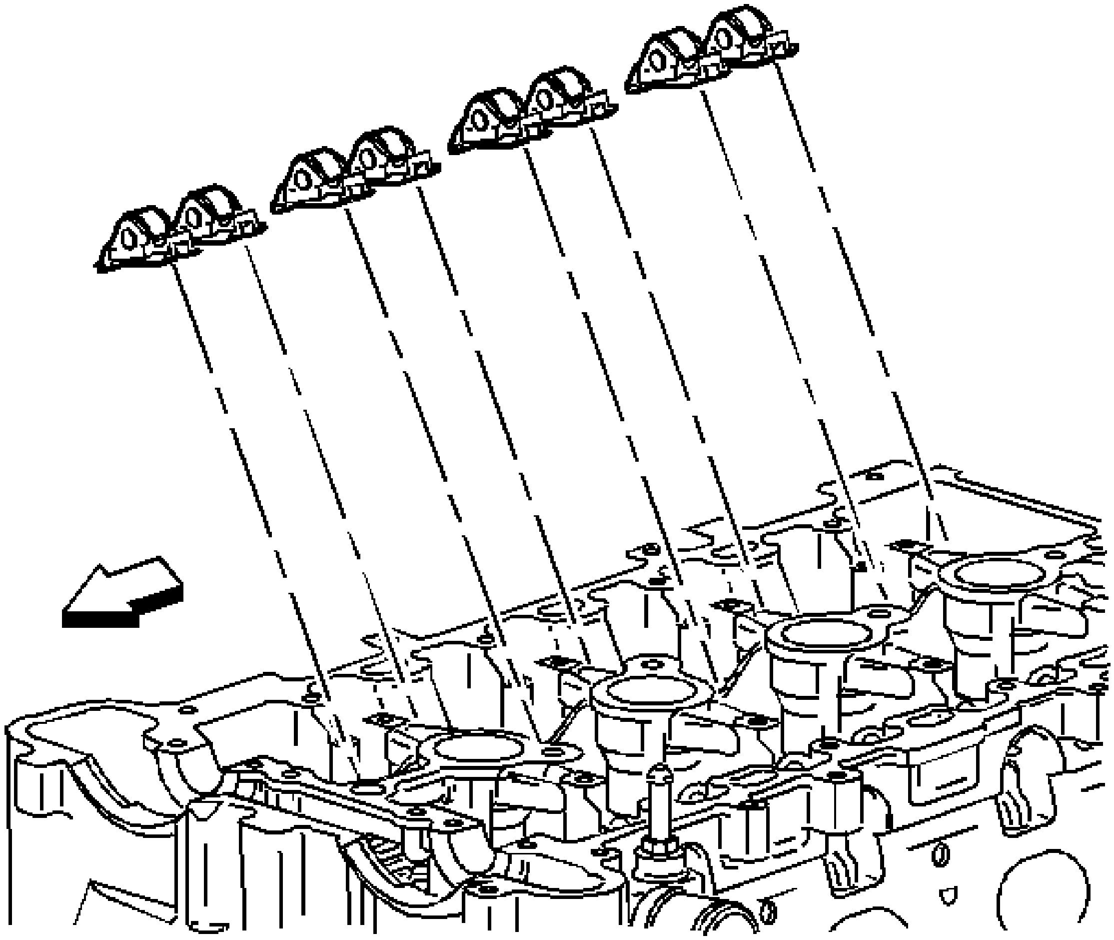


Fig. 423: Identifying Exhaust Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

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

3. Position the roller followers on the tip of the valve stem and on the lash adjustor, apply lubricant GM P/N 12345501 (Canadian P/N 992704) or equivalent.

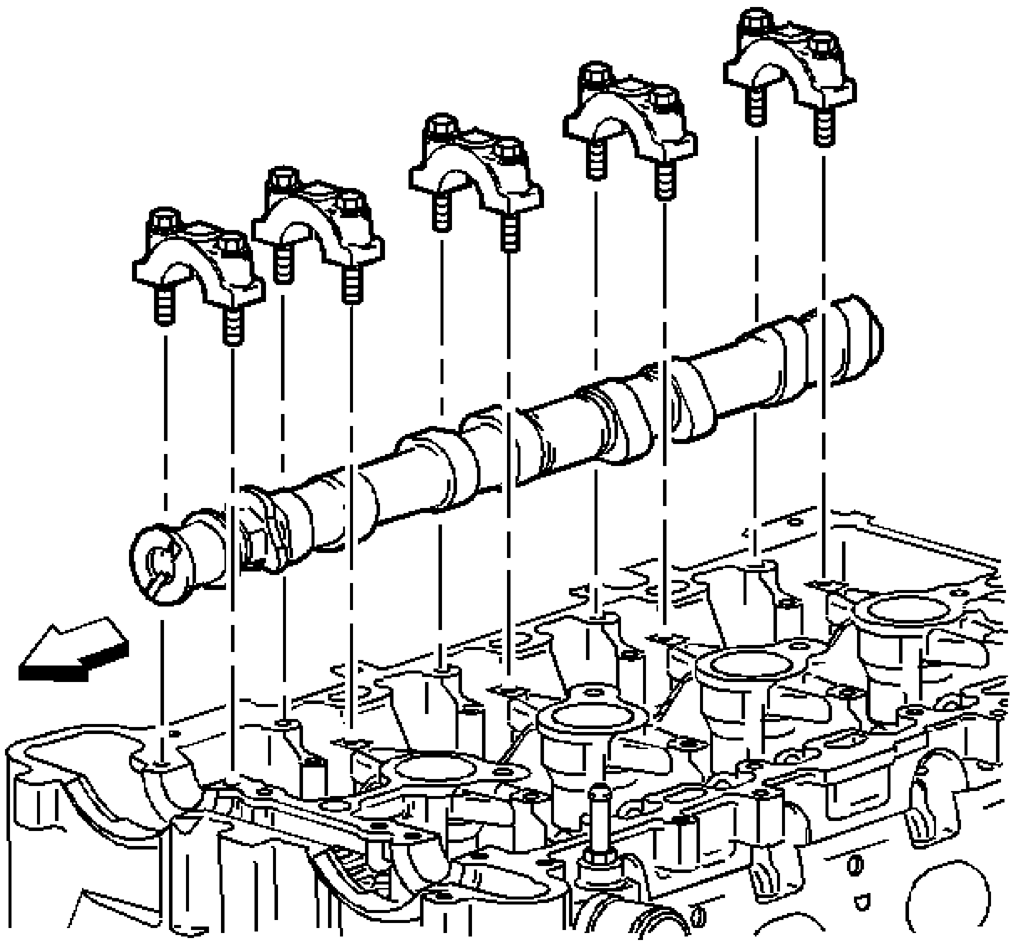


Fig. 424: View Of Camshaft & Bearing Caps
Courtesy of GENERAL MOTORS CORP.

4. Set the exhaust camshaft on top of the roller followers in the camshaft bearing journals. Lubricate with GM P/N 12345501 (Canadian P/N 992704) or equivalent.
5. Install the camshaft bearing caps and hand start the camshaft cap bolts.

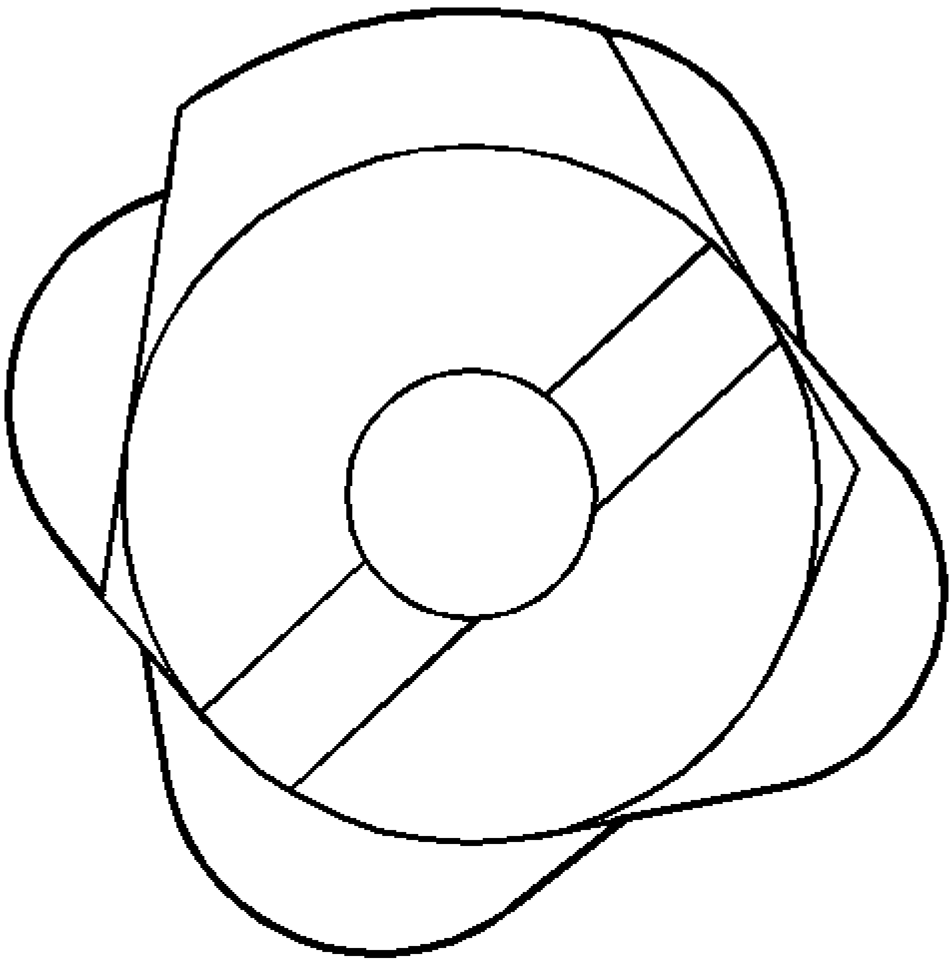


Fig. 425: View of Timing Chain Sprocket
Courtesy of GENERAL MOTORS CORP.

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

6. The timing chain sprocket alignment notch should be oriented to the 2 o' clock position.
7. Tighten the camshaft bearing cap bolts in increments of 3 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**.

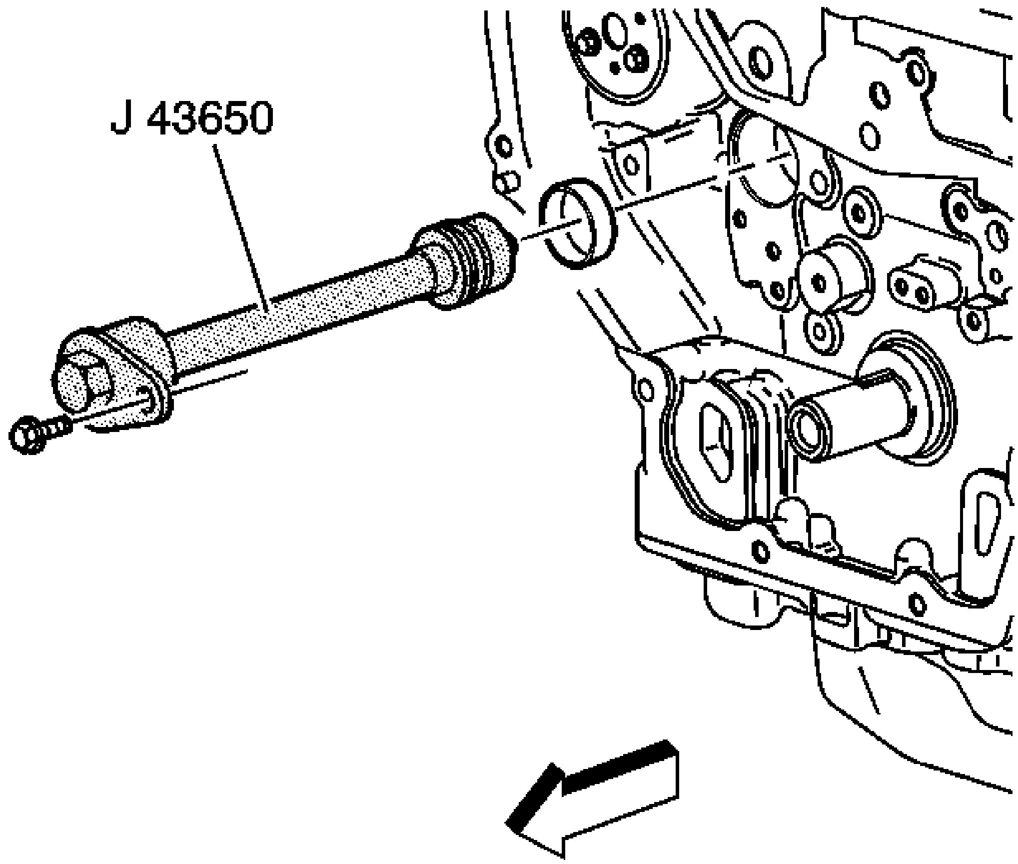


Fig. 426: View of Balance Shaft
Courtesy of GENERAL MOTORS CORP.

1. Install the balance shaft bushing using the **J 43650** . See **Special Tools and Equipment**.

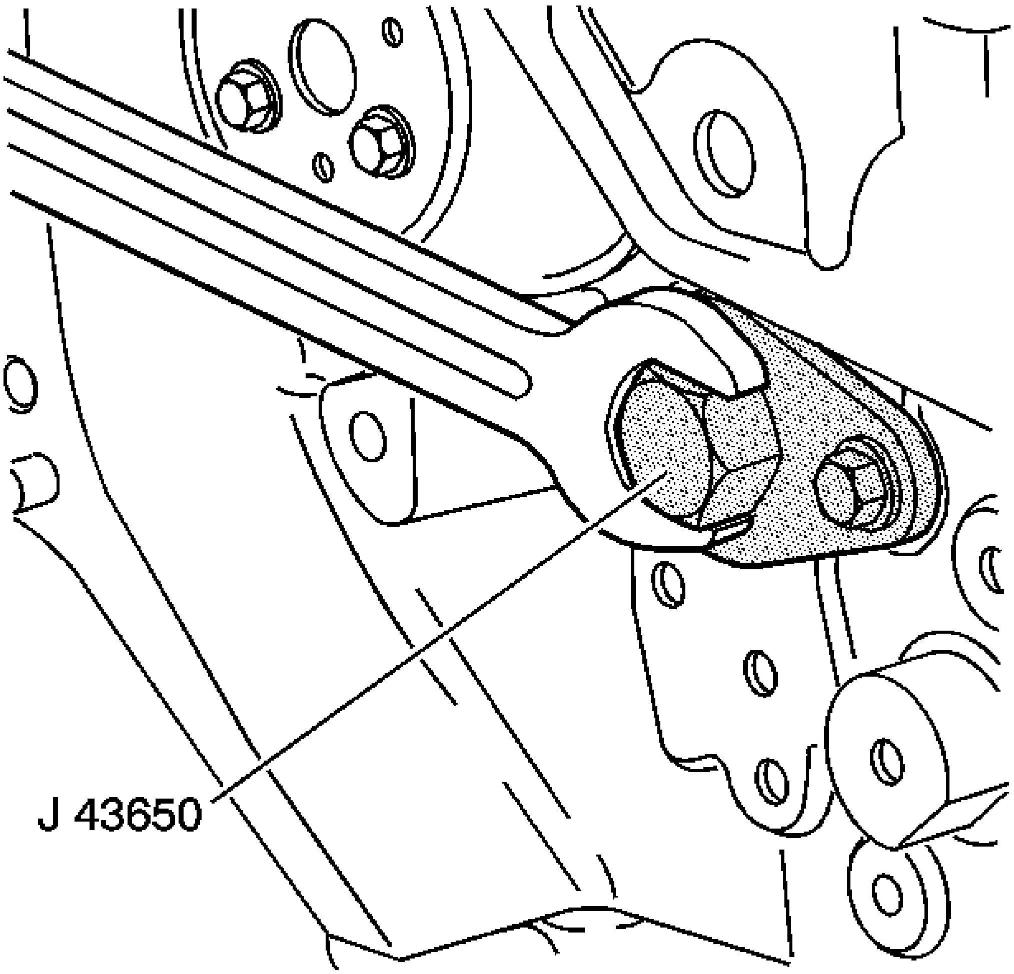


Fig. 427: View of J 43650
Courtesy of GENERAL MOTORS CORP.

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**.

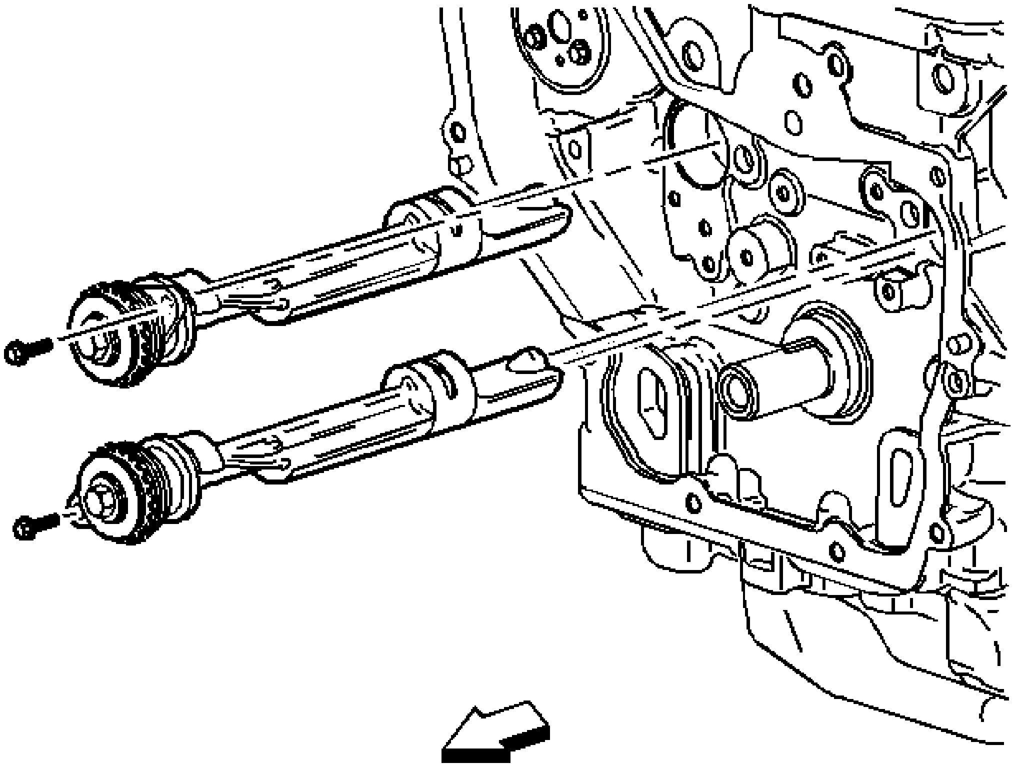


Fig. 428: View Of Balance Shafts assemblies
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If the balance shafts are not properly timed to the engine, the engine may vibrate or make noise.
Install the balance shaft assemblies to the engine using the following steps:

4. Place the number one piston at 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.

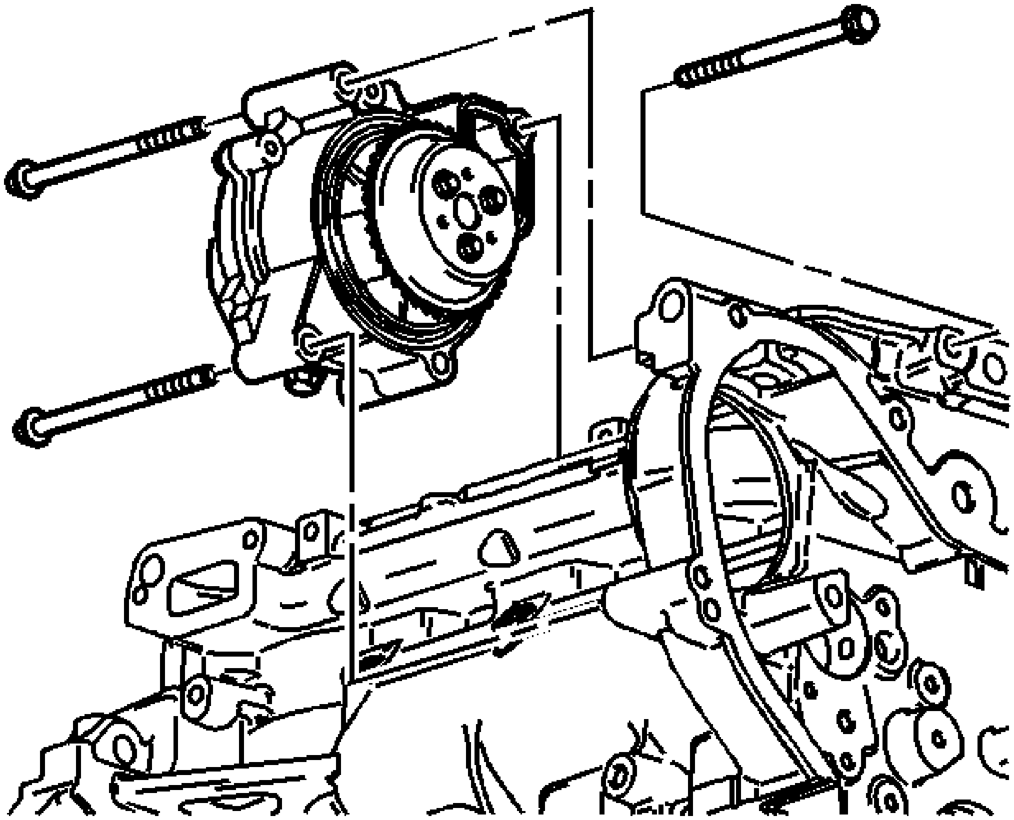


Fig. 429: View Of Water Pump Assembly
Courtesy of GENERAL MOTORS CORP.

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 GM P/N 12346004 (Canadian P/N 10953480) or equivalent to the water pump drain plug.
5. Install the water pump drain plug, if necessary.

   Tighten: Tighten the water pump drain plug to 20 N.m (15 lb ft).

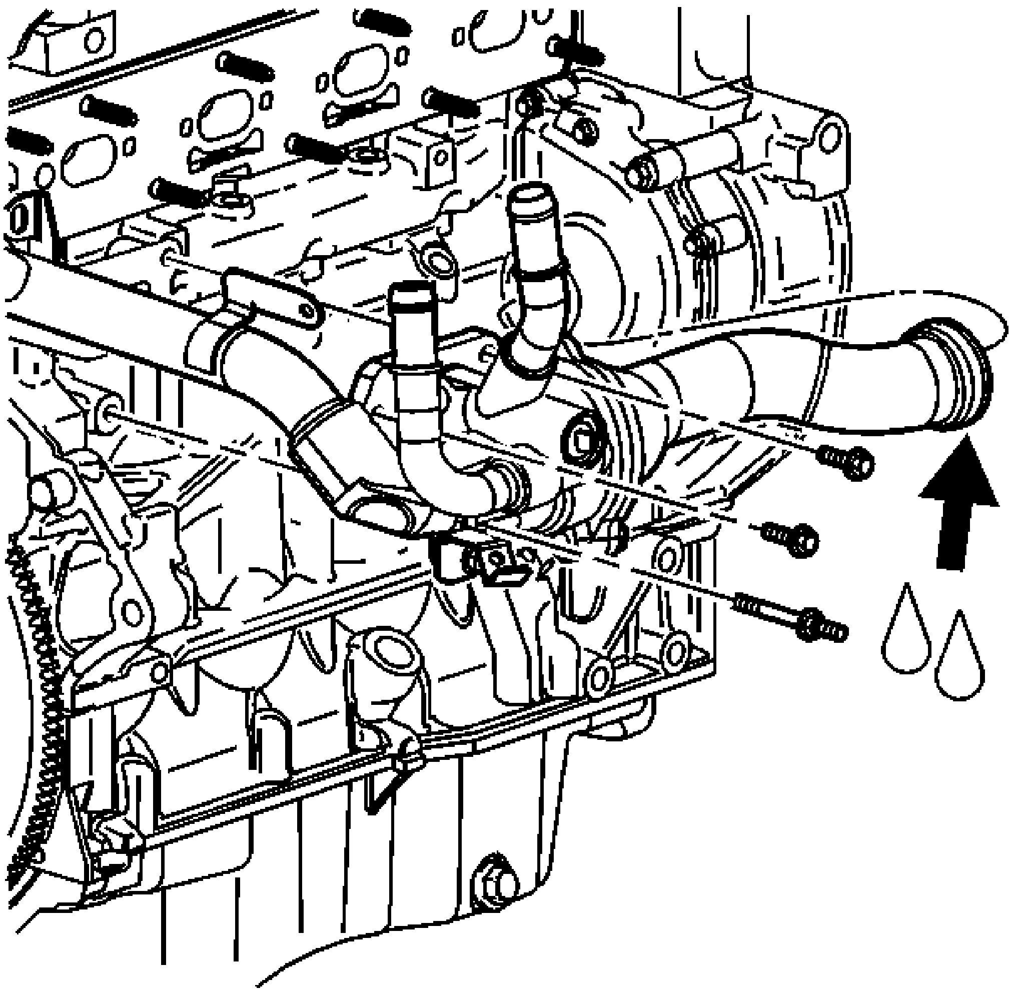


Fig. 430: View of Water Feed Tube
Courtesy of GENERAL MOTORS CORP.

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).

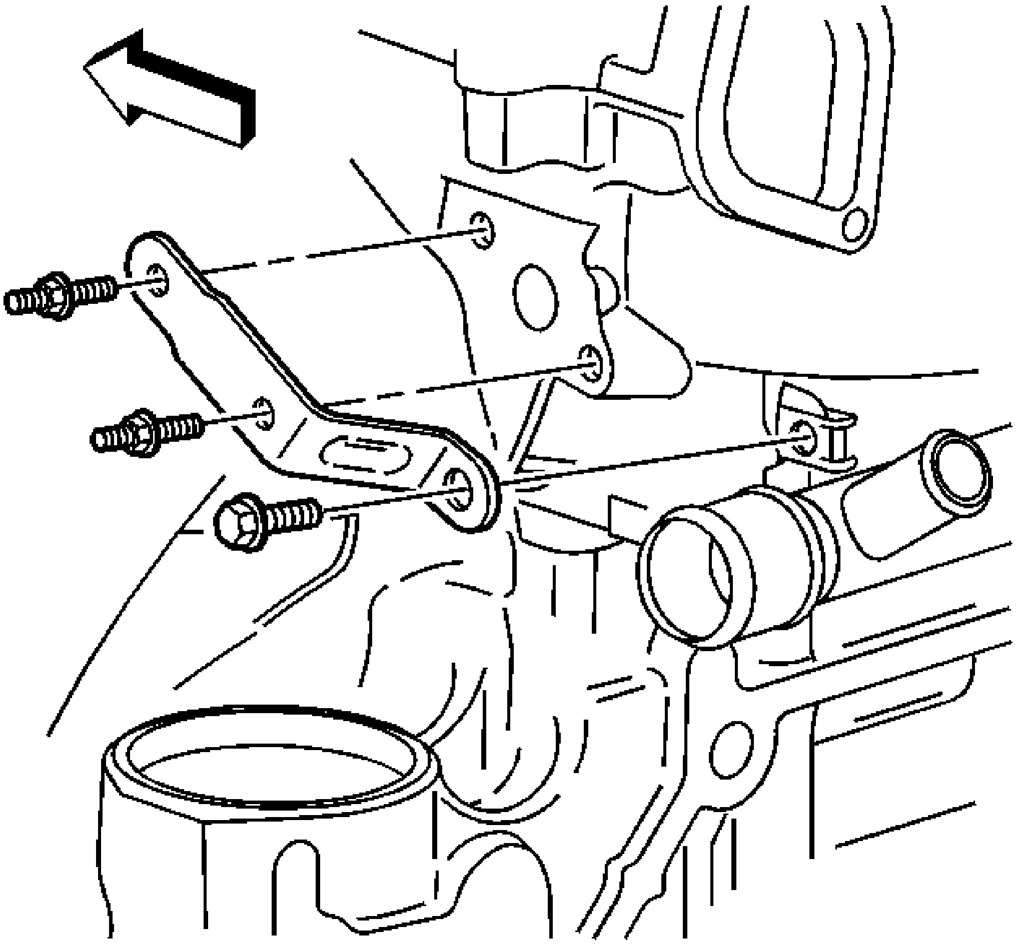


Fig. 431: View Of Water Pipe Support Bracket
Courtesy of GENERAL MOTORS CORP.

10. Install the water pipe support bracket and bolts.

    Tighten: Tighten the water pipe support bracket bolts to 10 N.m (89 lb in).

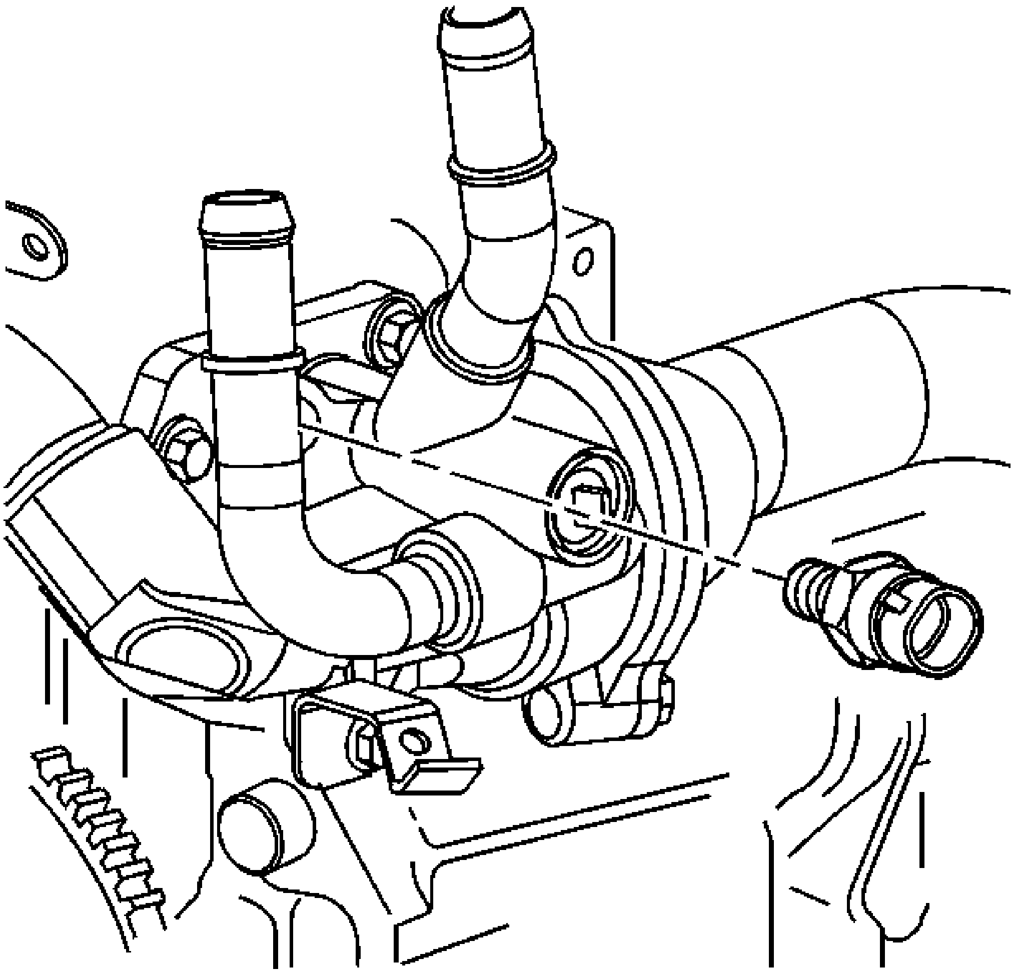


Fig. 432: View Of Engine Coolant Temperature Sensor
Courtesy of GENERAL MOTORS CORP.

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

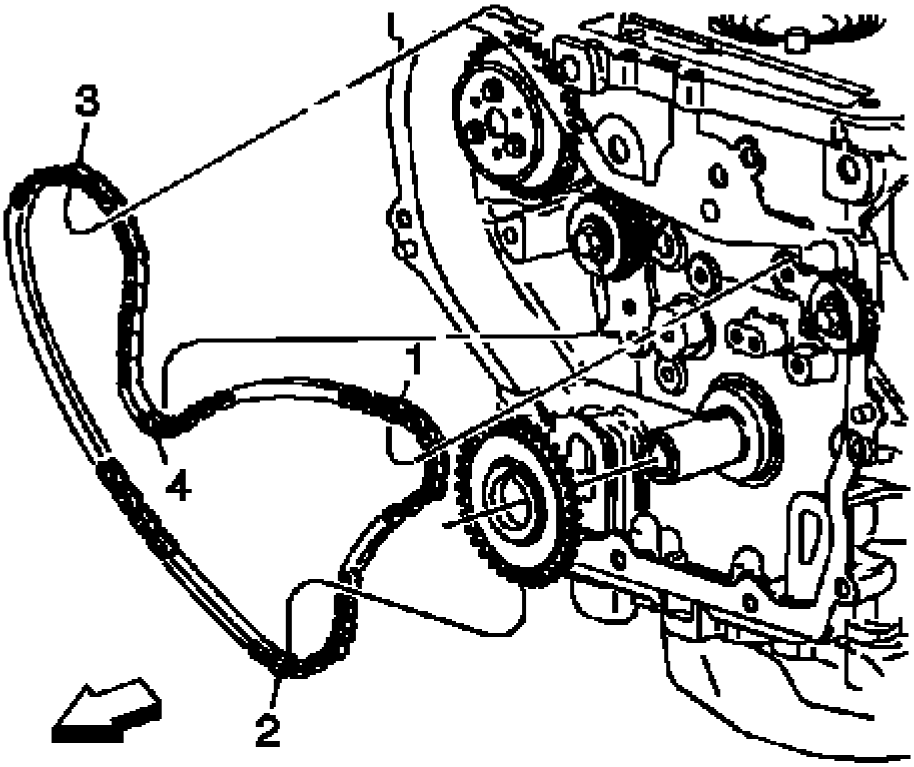


Fig. 433: Aligning Balance Shaft Drive Chain
Courtesy of GENERAL MOTORS CORP.

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

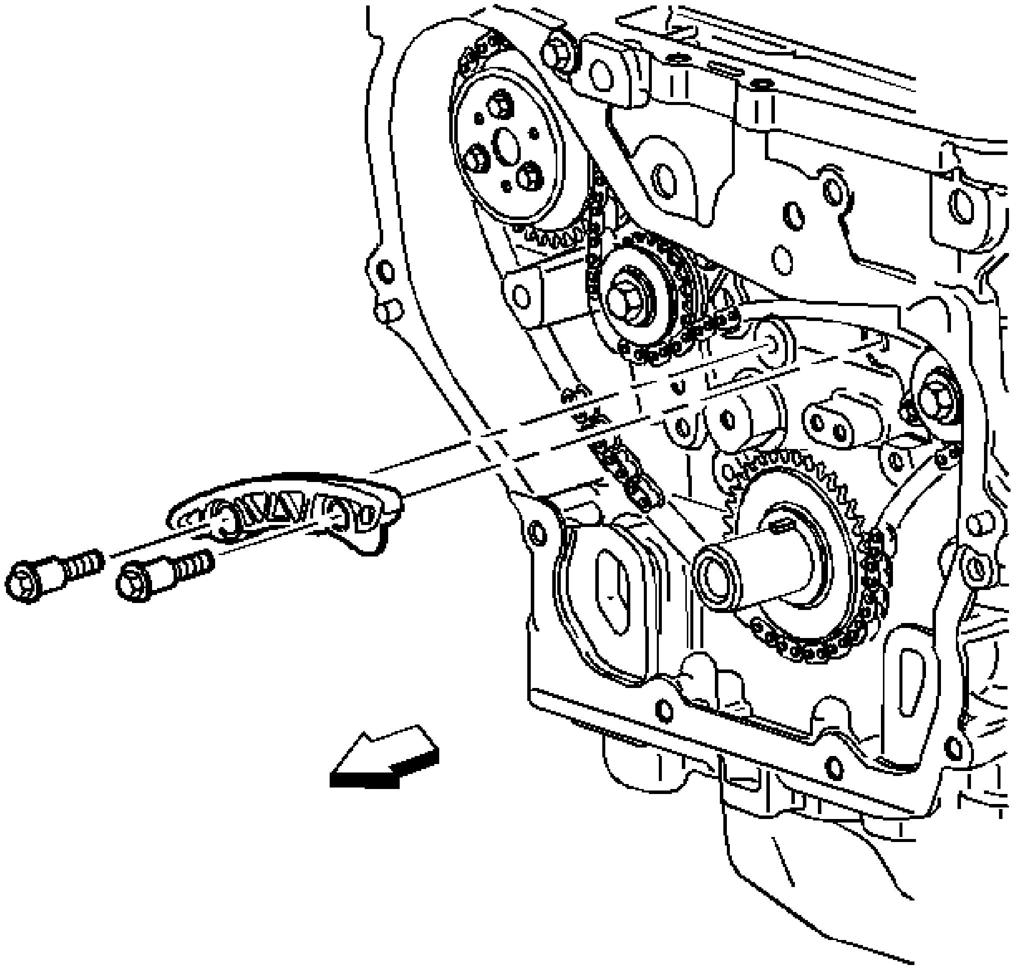


Fig. 434: View Of Upper Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

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).

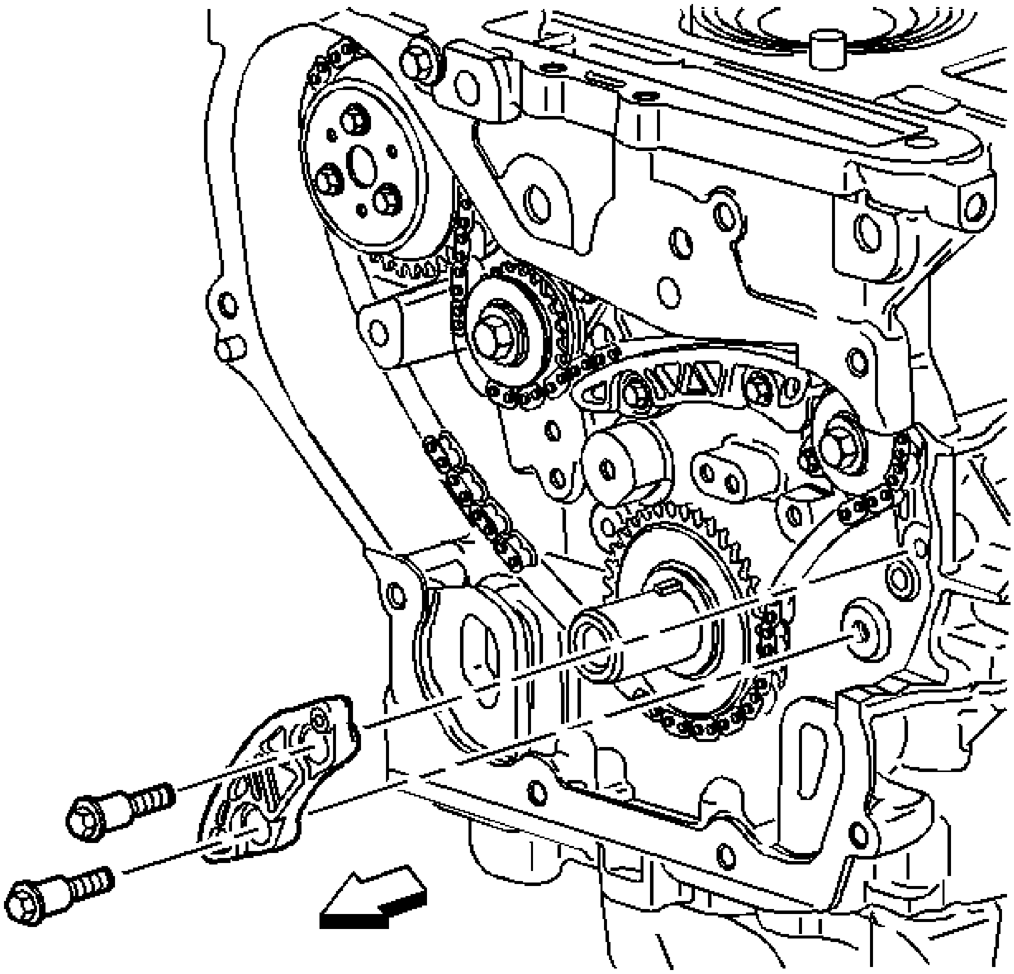


Fig. 435: Exploded View Of Small Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

2. Install the small balance shaft chain guide.
3. Install the balance shaft chain guide bolts.

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

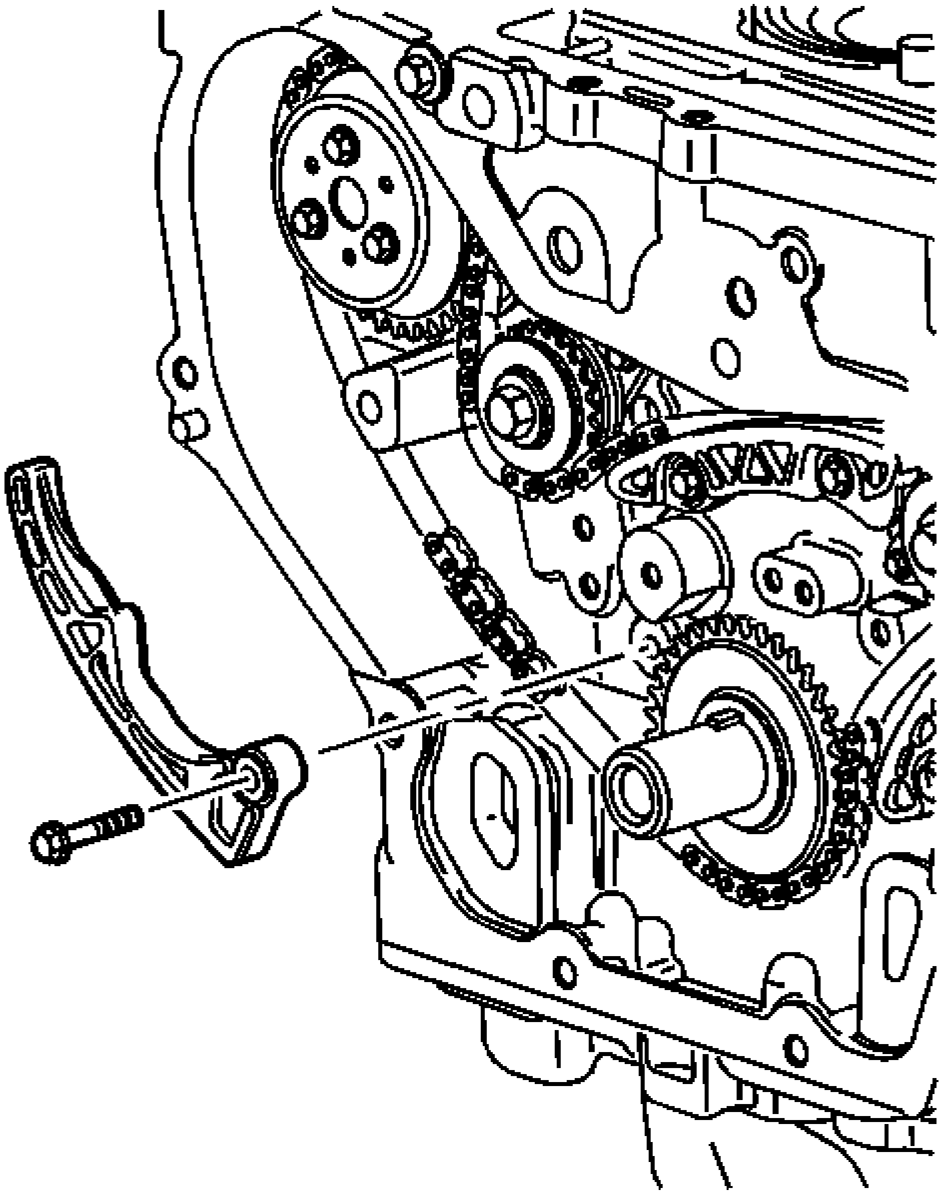


Fig. 436: View Of Adjustable Balance Shaft Chain Guide
Courtesy of GENERAL MOTORS CORP.

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).

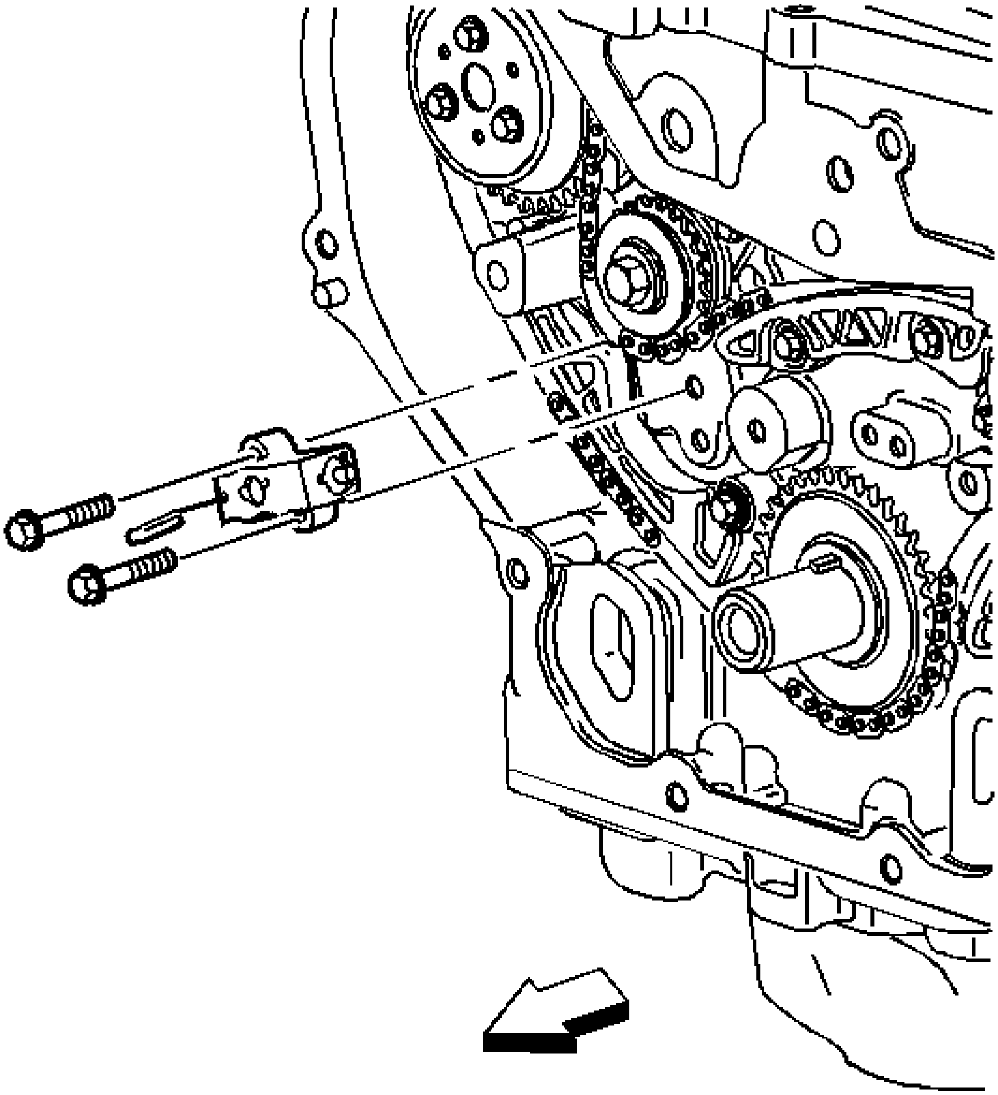


Fig. 437: View Of Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

6. Reset the timing chain tensioner by performing the following steps:
    1. Turn the tensioner plunger 90 degrees in its bore and compress the plunger.
    2. Turn the tensioner back to the original 12 o'clock position and insert a paper clip through the hole in the plunger body and into the hole in the tensioner plunger.

7. Install the timing chain tensioner.
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**.

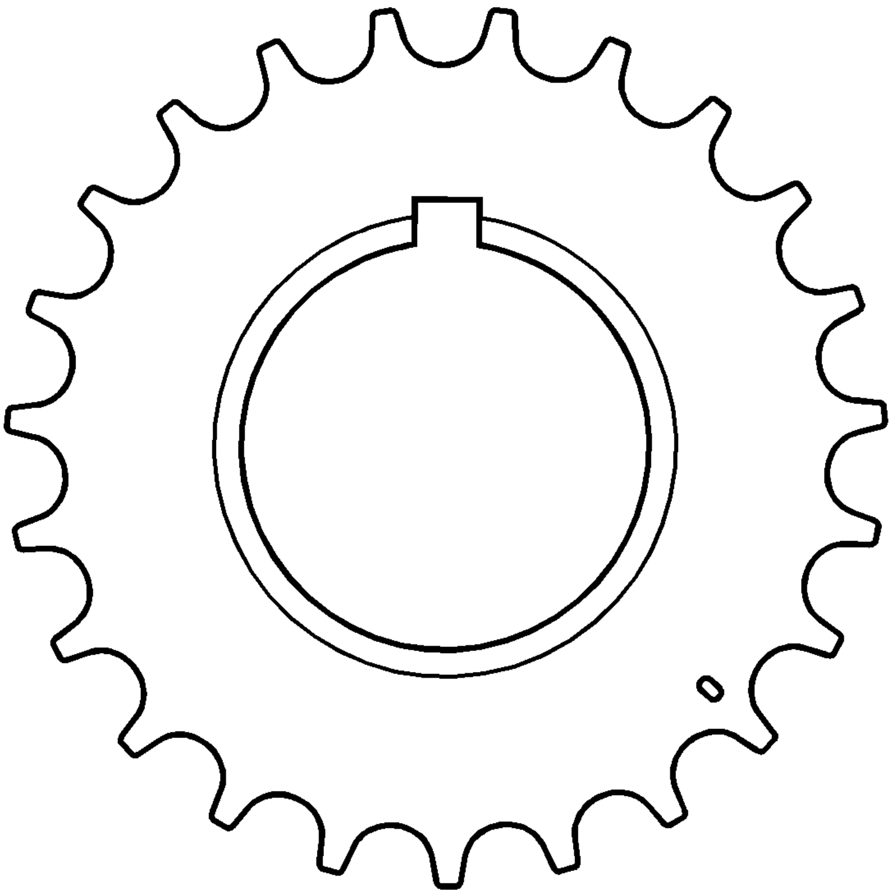


Fig. 438: View Of Crankshaft Sprocket Timing Mark
Courtesy of GENERAL MOTORS CORP.

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

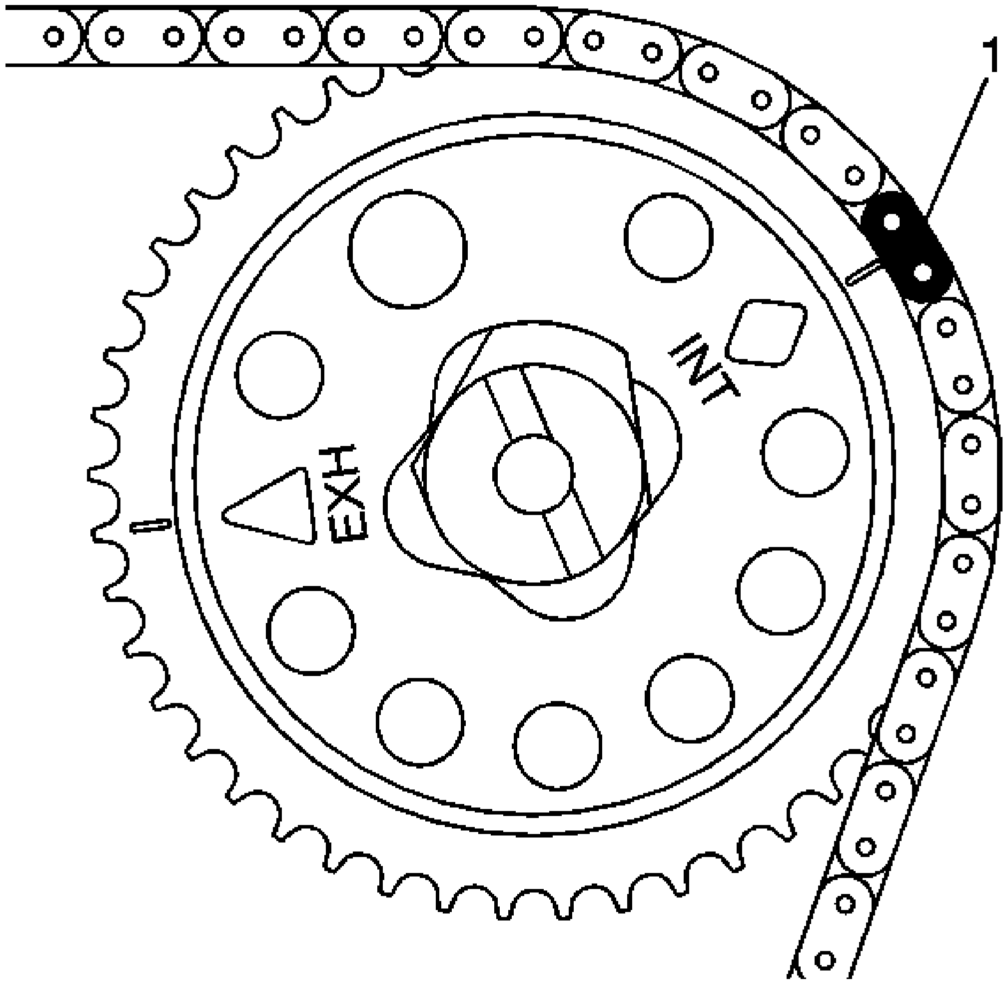


Fig. 439: Aligning Timing Chain Link & Intake Sprocket Timing Mark
Courtesy of GENERAL MOTORS CORP.

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.

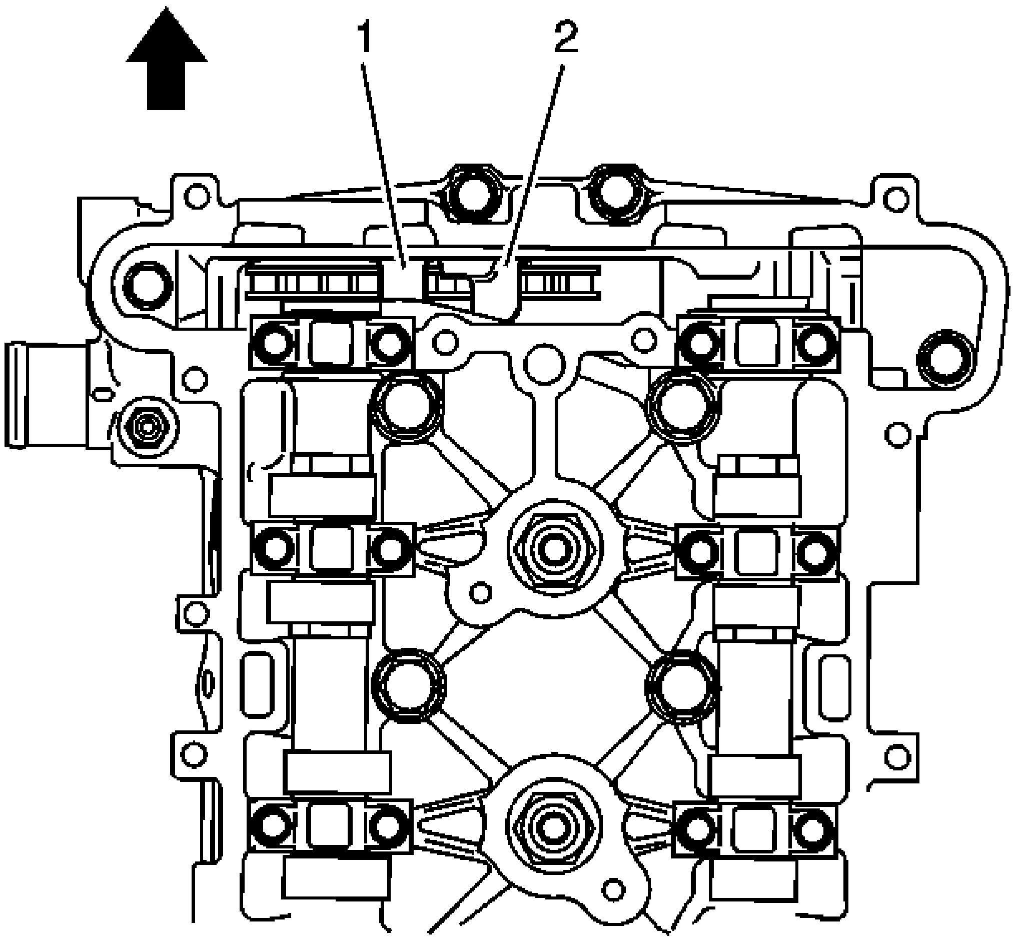


Fig. 440: Locating Cylinder Block Bosses
Courtesy of GENERAL MOTORS CORP.

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

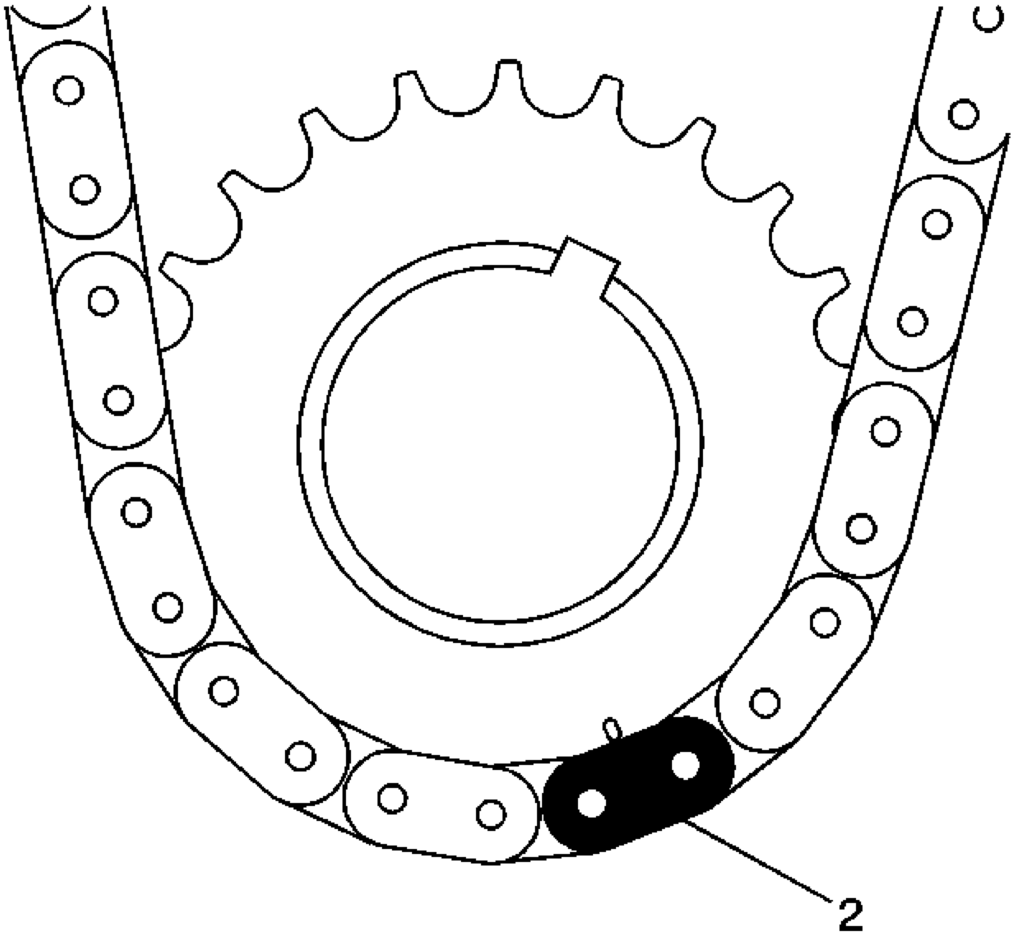


Fig. 441: Identifying Timing Chain Colored Link & Crankshaft Sprocket Timing Mark
Courtesy of GENERAL MOTORS CORP.

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.

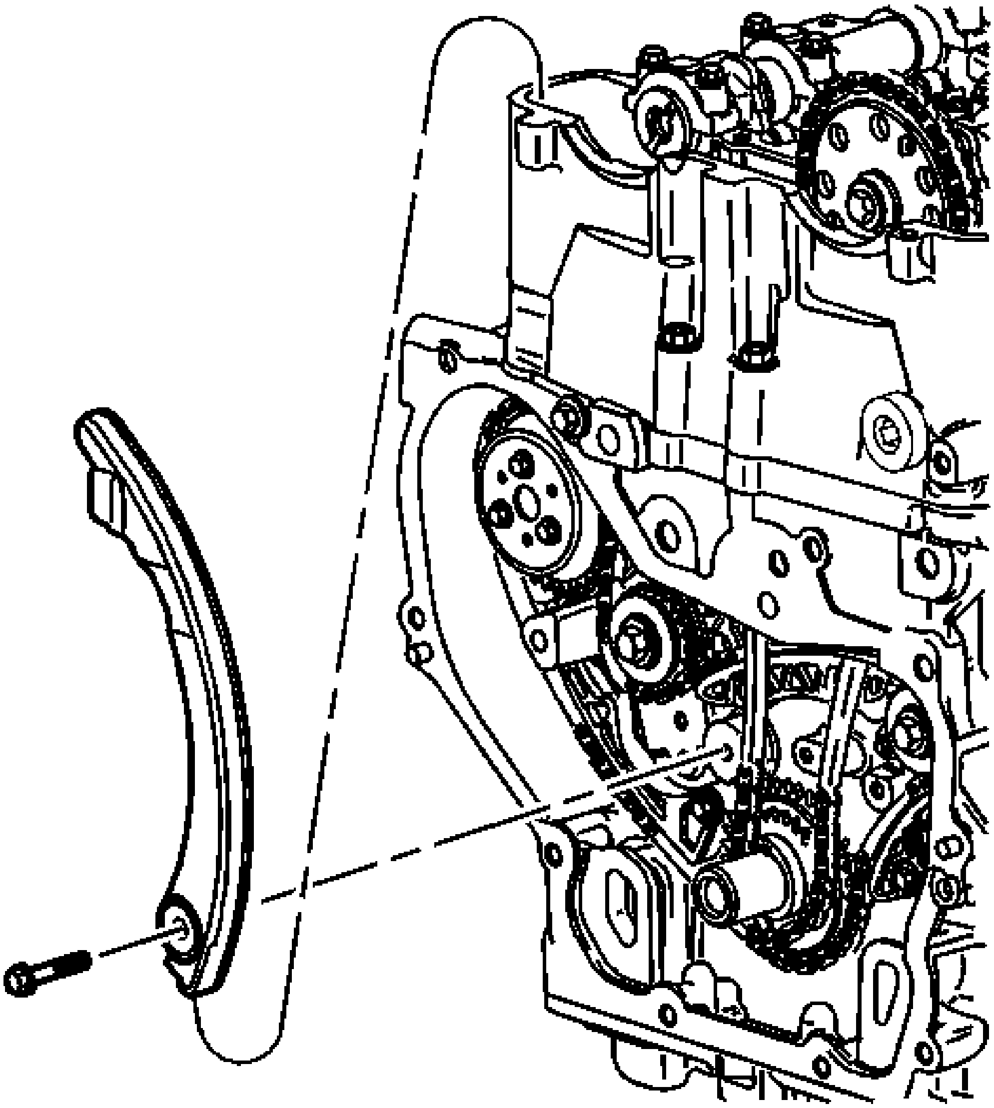


Fig. 442: View Of Timing Chain Tensioner Guide
Courtesy of GENERAL MOTORS CORP.

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).

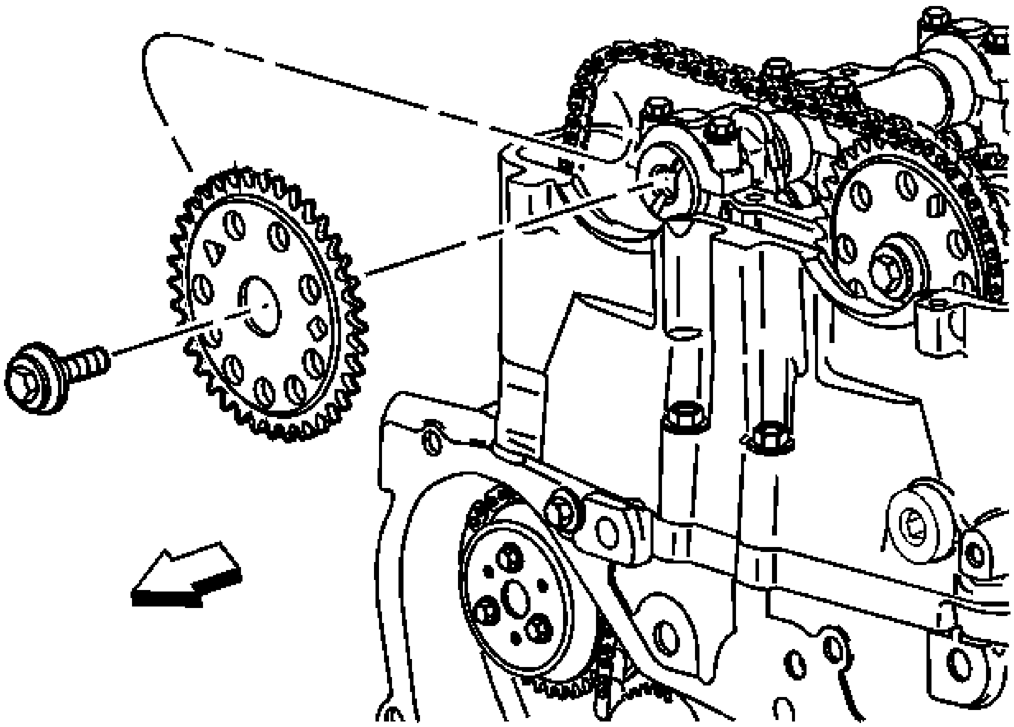


Fig. 443: Identifying Exhaust Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Always install new sprocket bolts.

6. Install the exhaust camshaft sprocket and a new bolt loosely onto the exhaust camshaft.

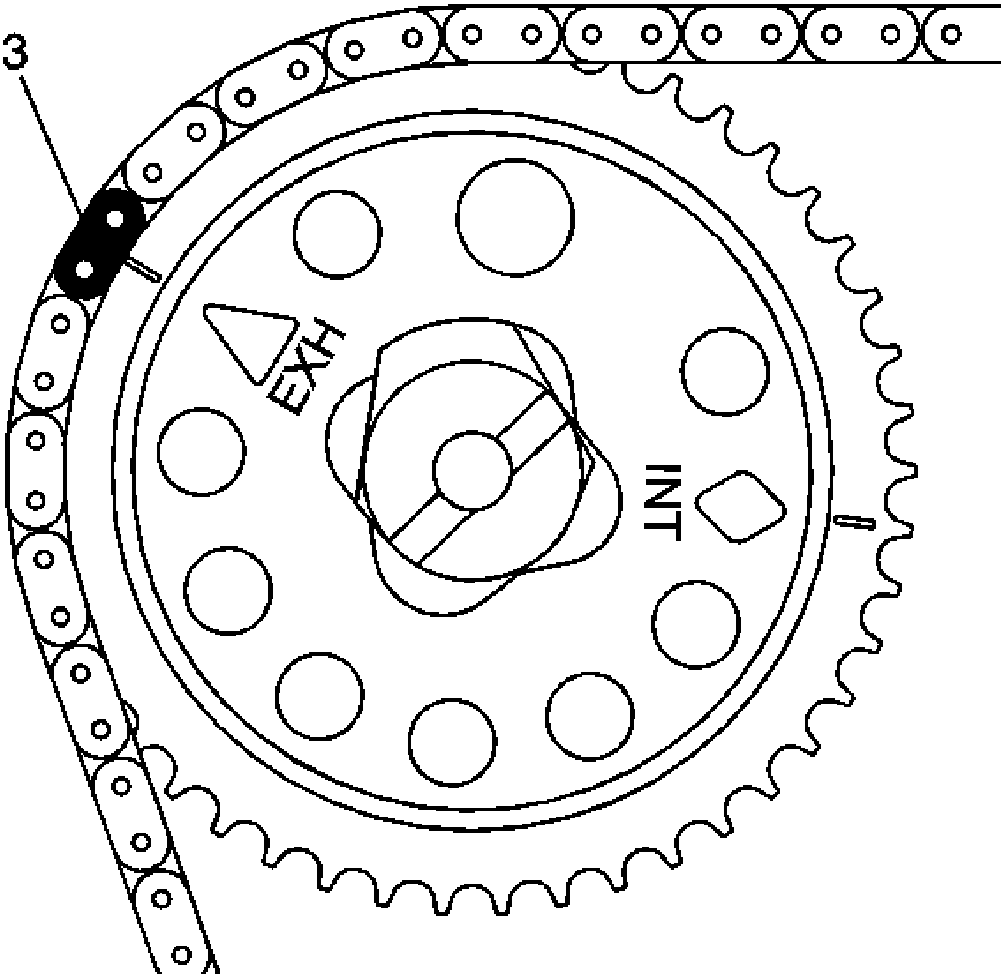


Fig. 444: Aligning Timing Chain Link & Exhaust Timing Mark
Courtesy of GENERAL MOTORS CORP.

7. Align the timing mark on the sprocket with the last matching colored link (3). Install the bolt finger tight.

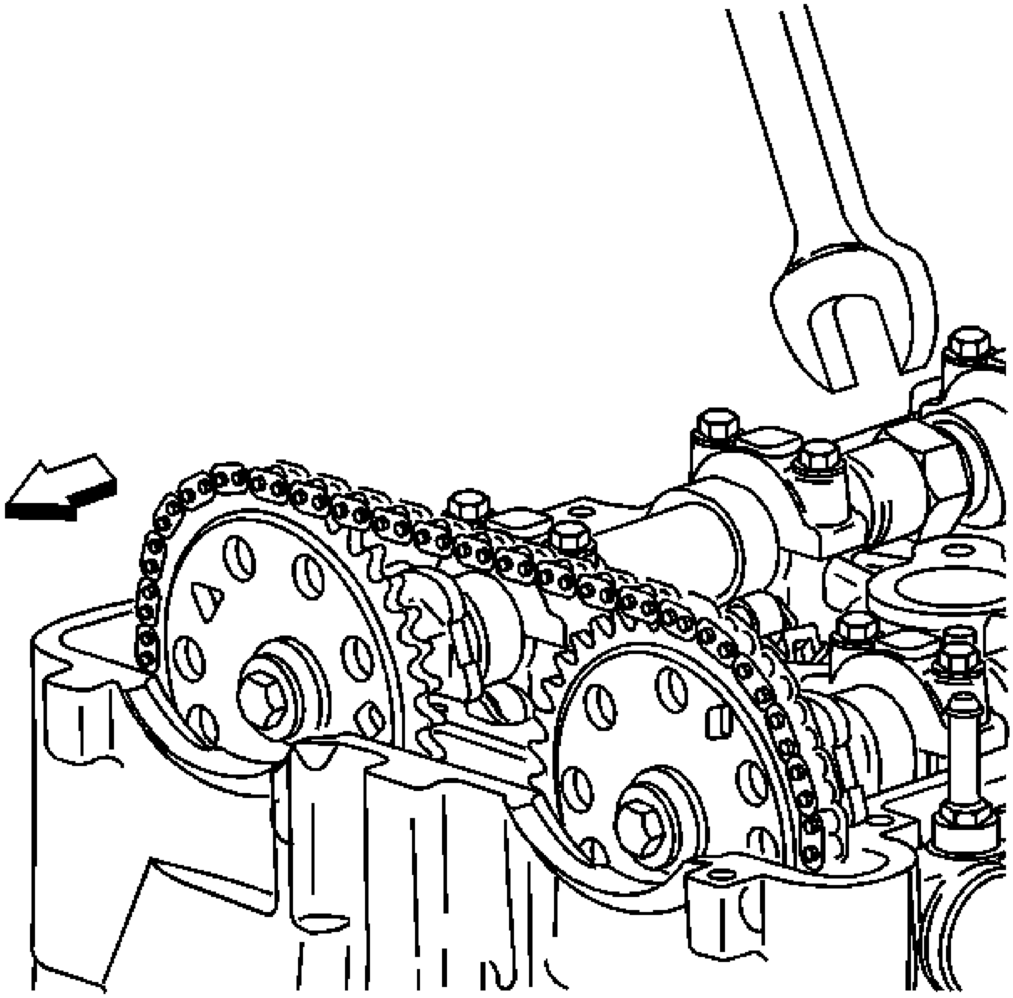


Fig. 445: Using 24 mm Wrench To Align Camshaft
Courtesy of GENERAL MOTORS CORP.

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

8. If the camshaft is 180 degrees out of time, use the following procedure to re-align the cam.

   Using a 24 mm wrench, first turn the intake camshaft until the alignment feature on the back of the camshaft 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.

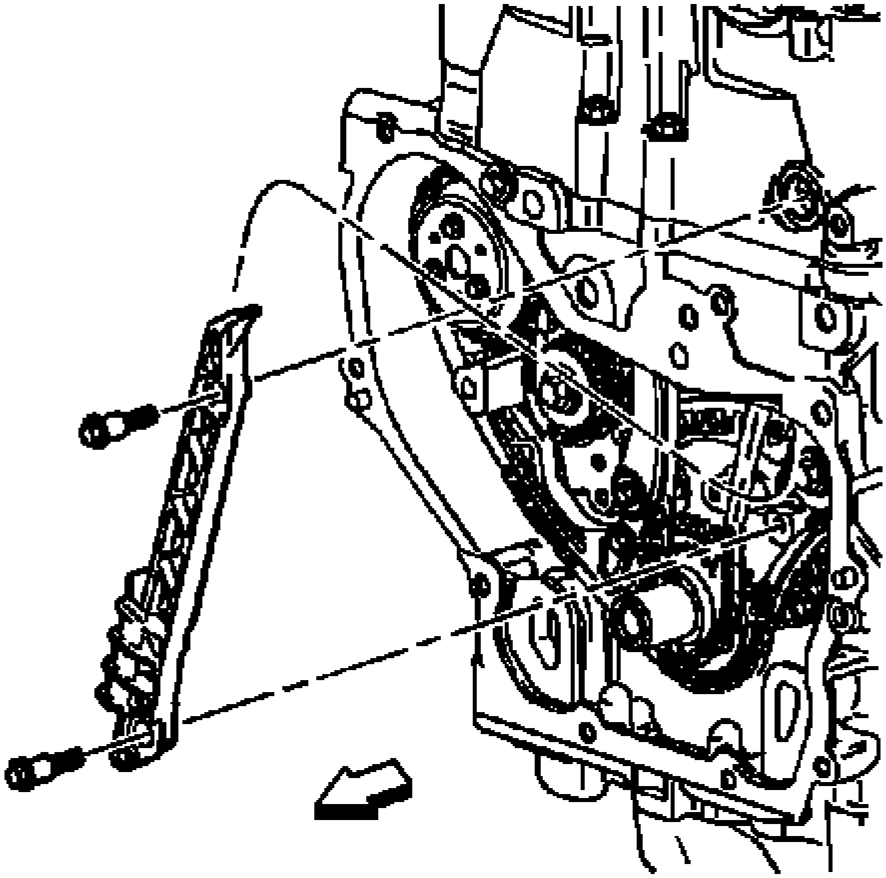


Fig. 446: View Of Fixed Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

11. Install the fixed timing chain guide.

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

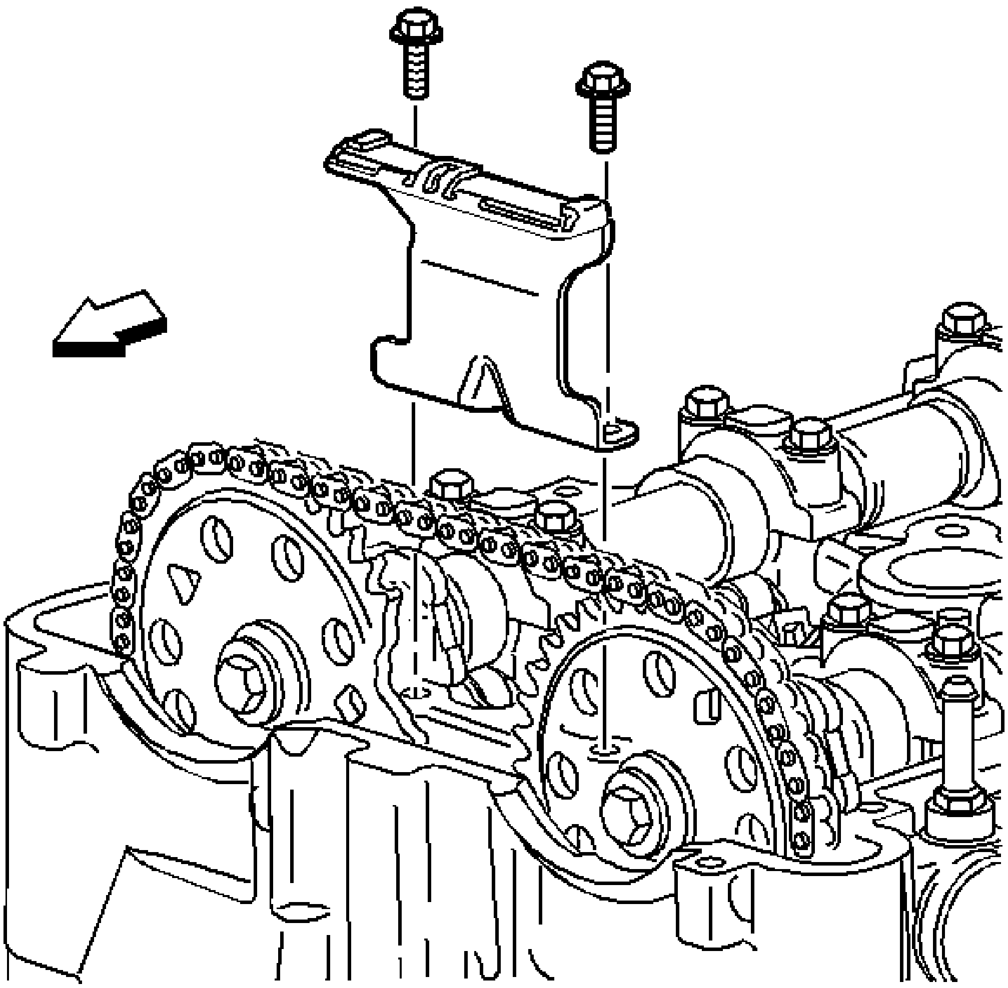


Fig. 447: View Of Upper Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

12. Install the upper timing chain guide.

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

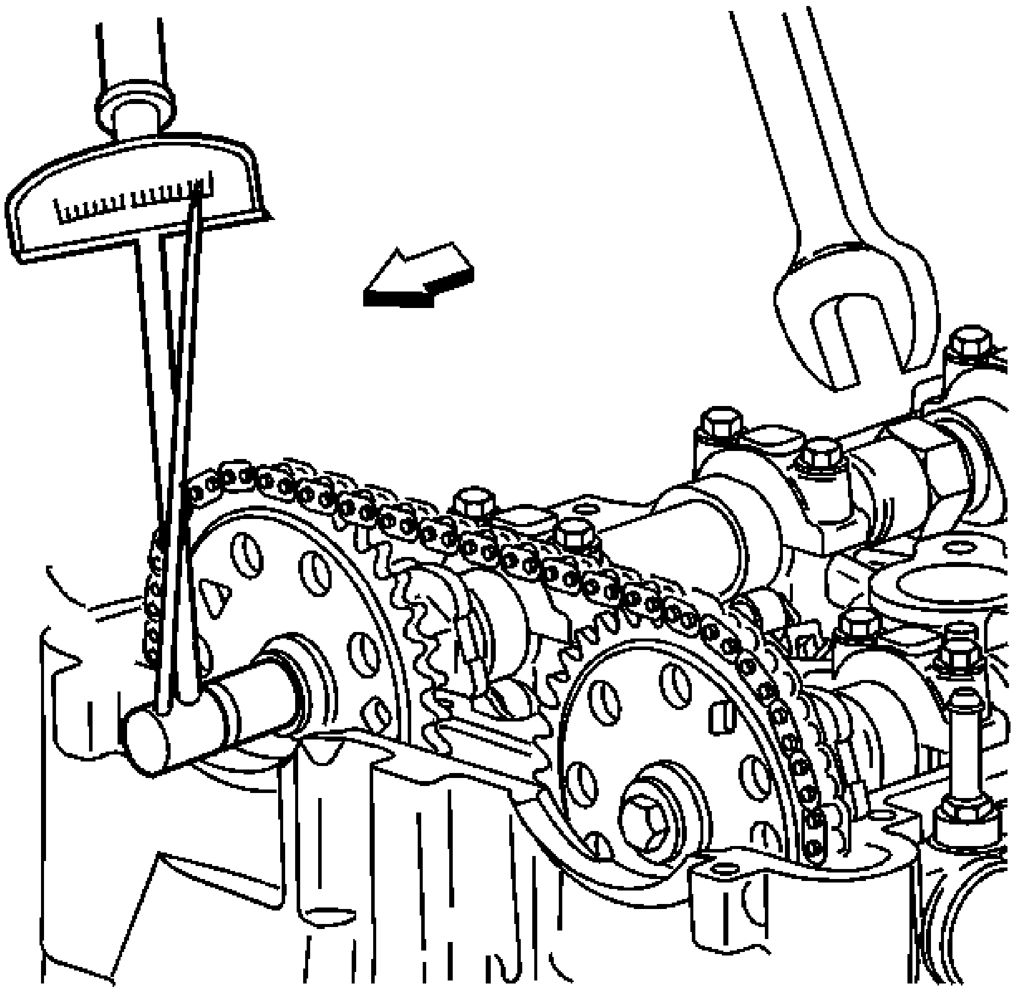


Fig. 448: Holding Camshaft Stationary With Wrench On Hex Casting On Camshaft
Courtesy of GENERAL MOTORS CORP.

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 the **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 the **J**

45059 . See **Special Tools and Equipment**.

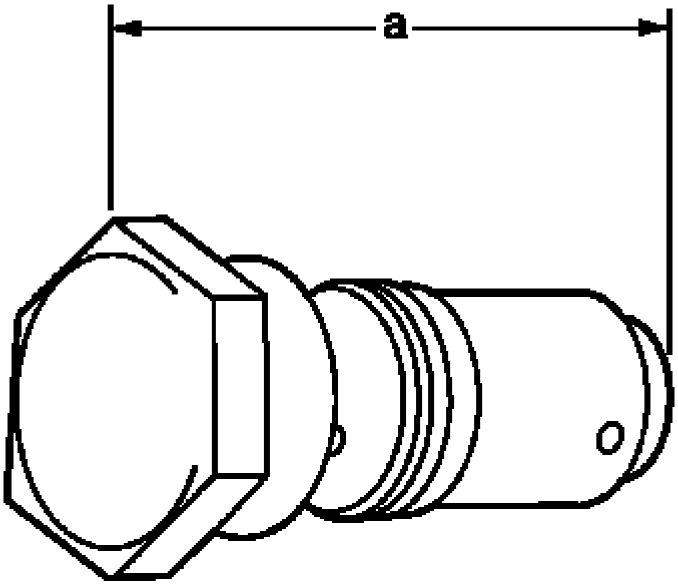


Fig. 449: Measuring Timing Chain Tensioner Assembly
Courtesy of GENERAL MOTORS CORP.

15. Inspect the timing chain tensioner. If the timing chain tensioner, O-ring seal, or washer is damaged, replace the timing chain tensioner.
16. 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.

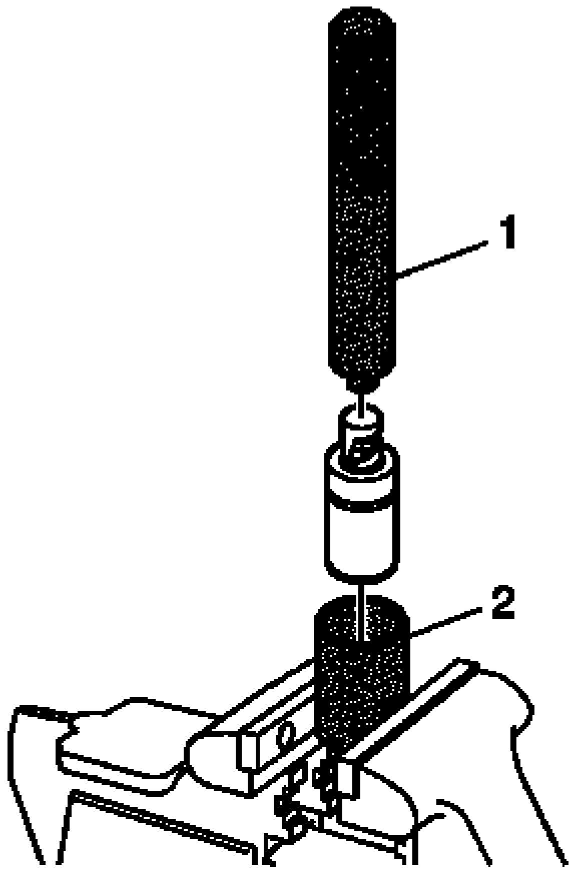


Fig. 450: Compressing Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

17. 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.

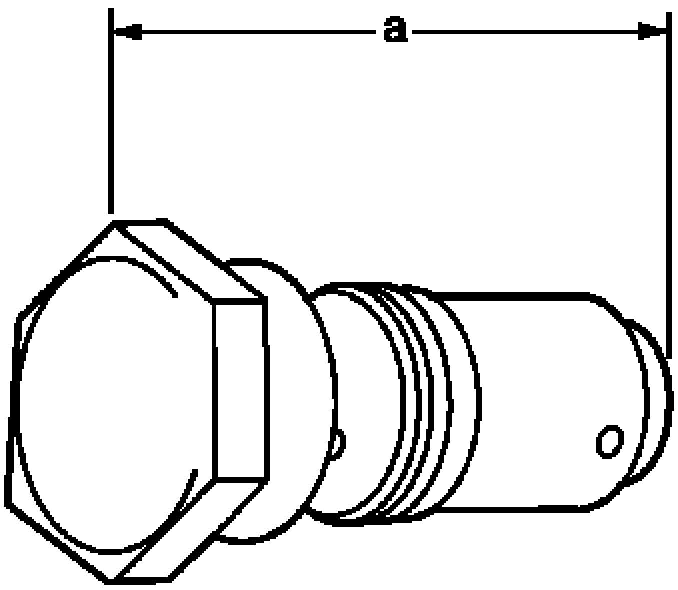


Fig. 451: Measuring Timing Chain Tensioner Assembly
Courtesy of GENERAL MOTORS CORP.

18. 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.
19. 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.
20. 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 17.1 and 17.4.

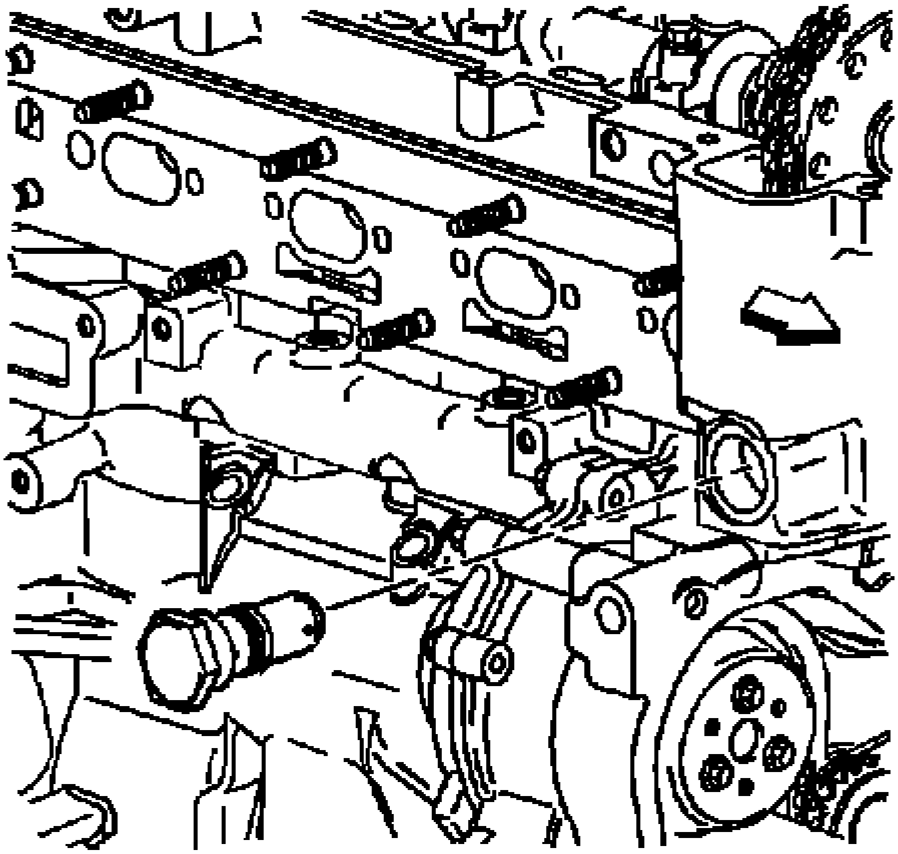


Fig. 452: Identifying Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

21. Inspect to ensure all dirt and debris is removed from the timing chain tensioner threaded hole in the cylinder head.
22. Install the new timing chain tensioner assembly.

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

23. 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.

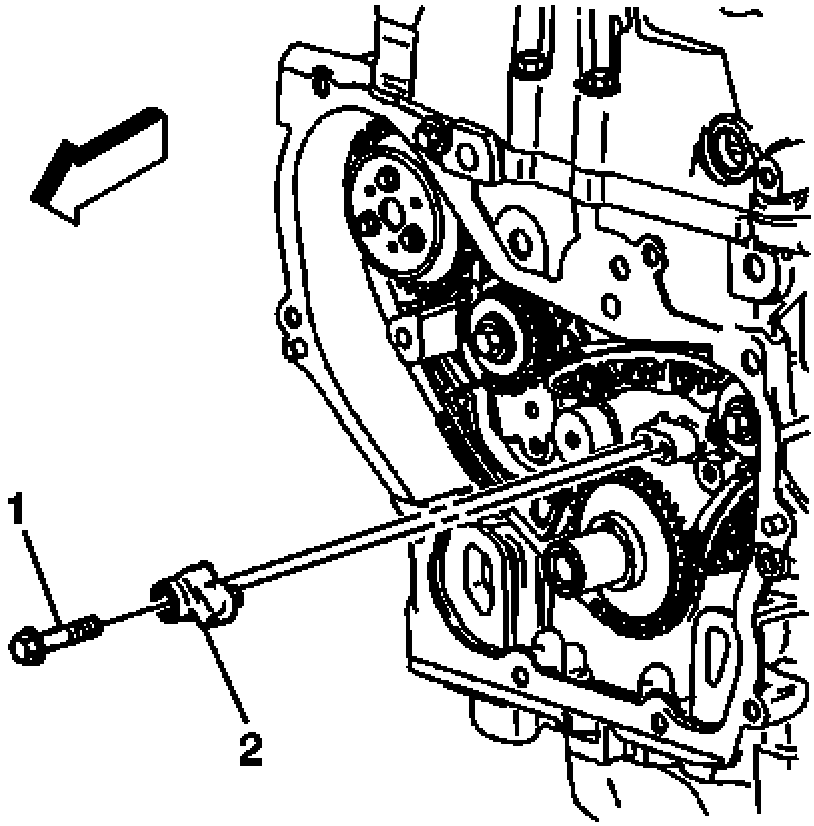


Fig. 453: View Of Oil Nozzle & Bolt
Courtesy of GENERAL MOTORS CORP.

24. Install the timing chain oiling nozzle.

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

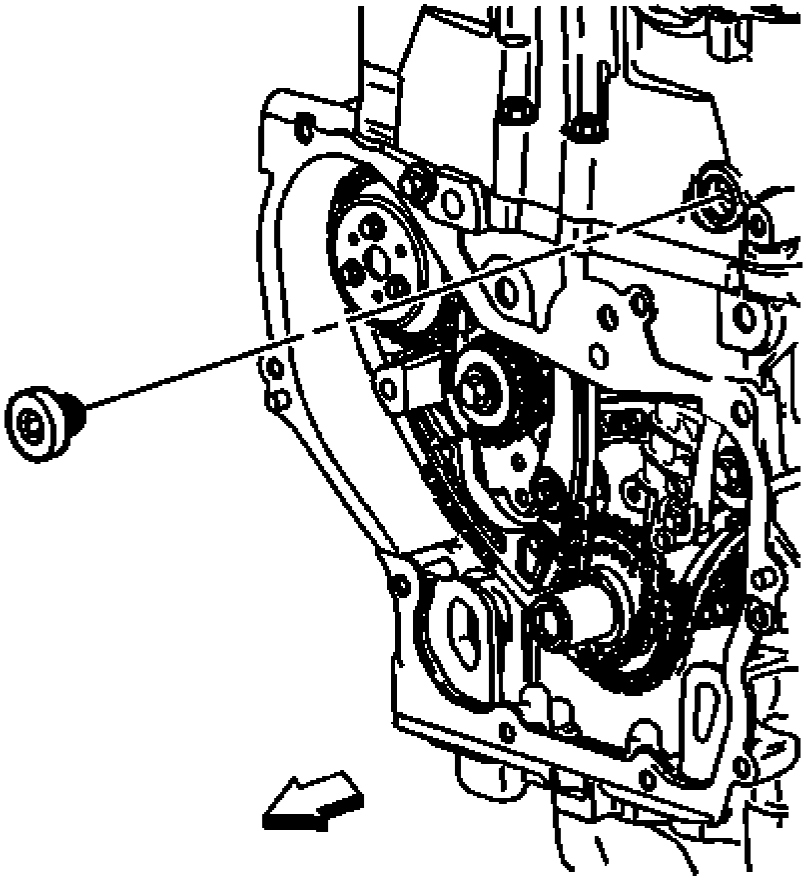


Fig. 454: View Of Fixed Timing Chain Guide Access Plug
Courtesy of GENERAL MOTORS CORP.

25. Apply sealant GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the thread, and install the timing chain guide bolt access hole plug.

    Tighten: Tighten the access hole plug to 90 N.m (66 lb ft).

Crankshaft Front Oil Seal Installation

Tools Required

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

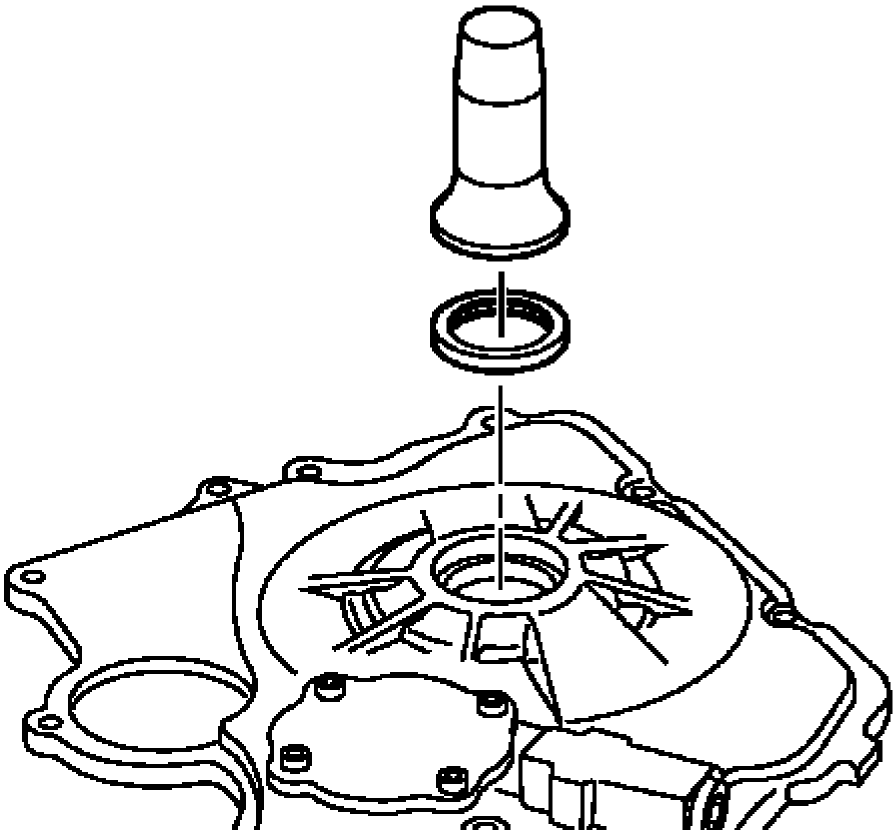


Fig. 455: Installation of Seal
Courtesy of GENERAL MOTORS CORP.

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

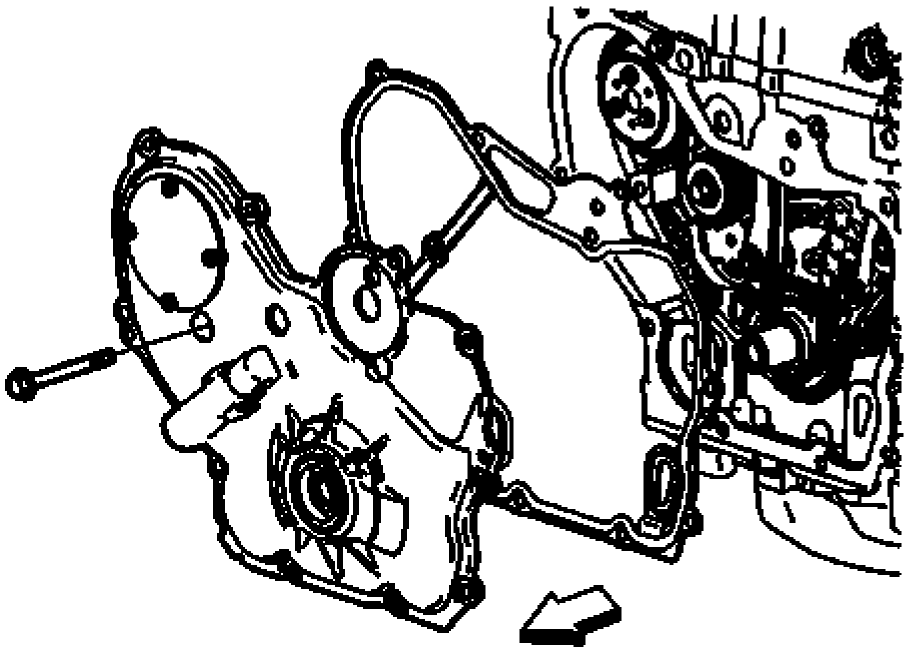


Fig. 456: View Of Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

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).

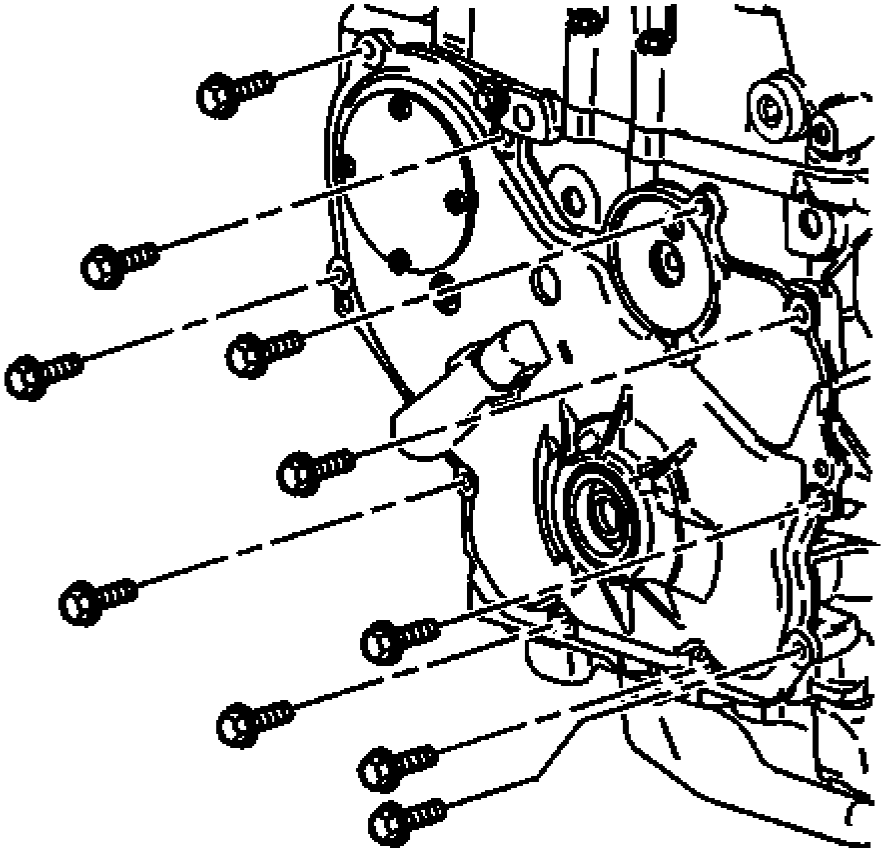


Fig. 457: View Of Engine Front Cover Bolts
Courtesy of GENERAL MOTORS CORP.

3. Install the engine front cover bolts.

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

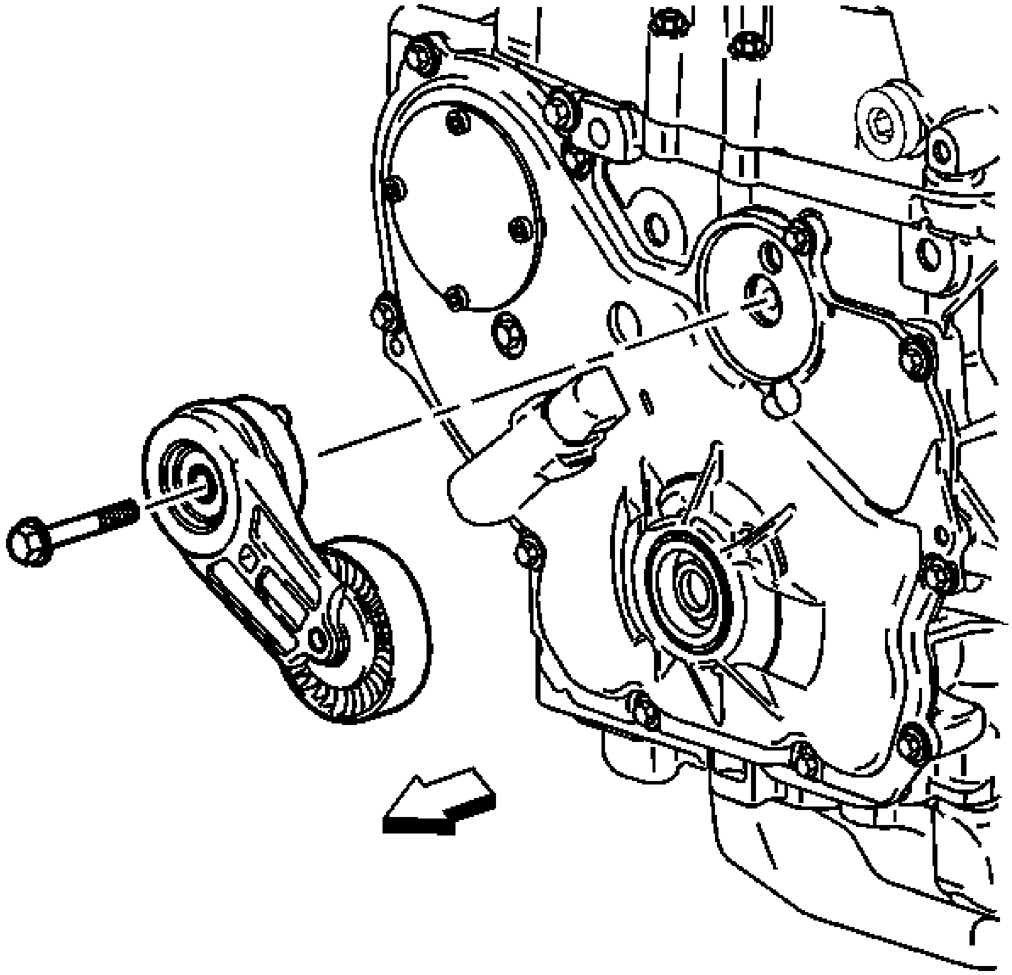


Fig. 458: View Of Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

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

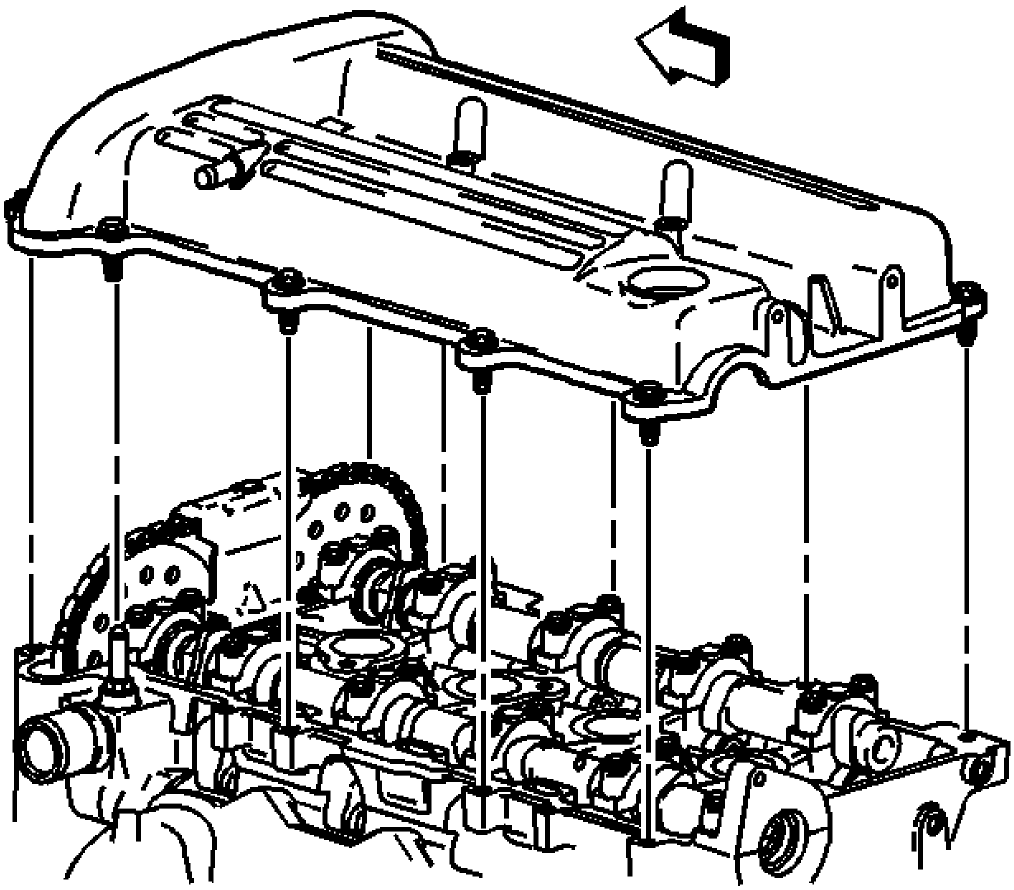


Fig. 459: View Of Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

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).

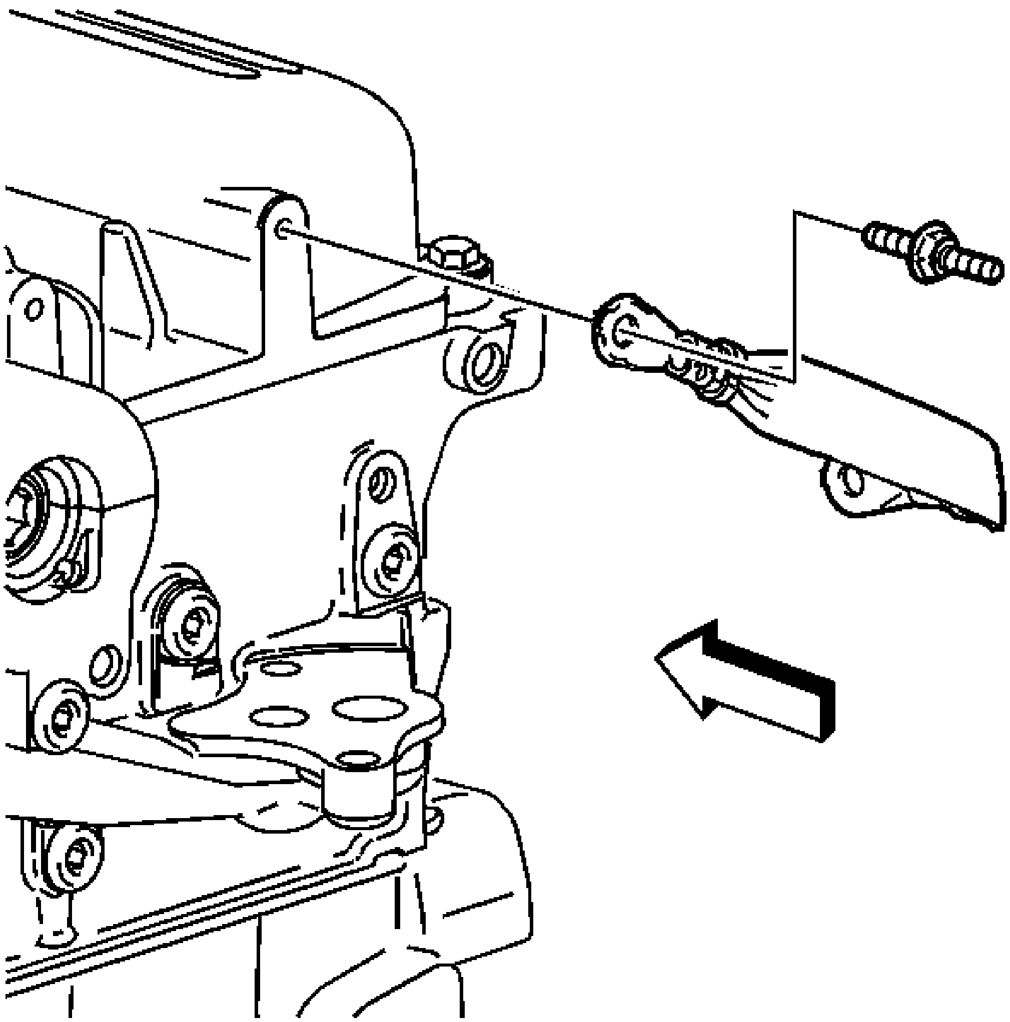


Fig. 460: View Of Camshaft Cover Grounding Strap
Courtesy of GENERAL MOTORS CORP.

3. Install the ground strap.

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

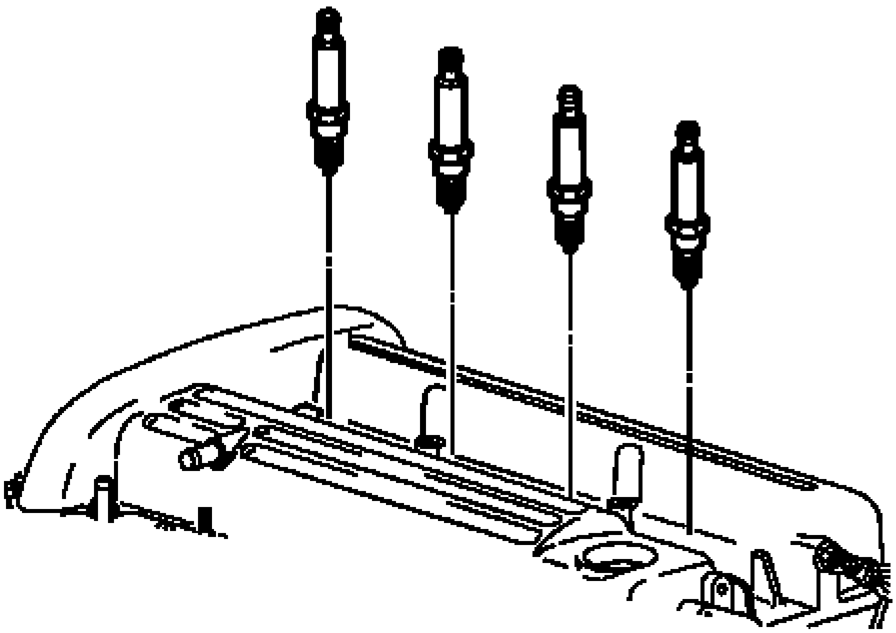


Fig. 461: View Of Spark Plugs
Courtesy of GENERAL MOTORS CORP.

4. Install the spark plugs.

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

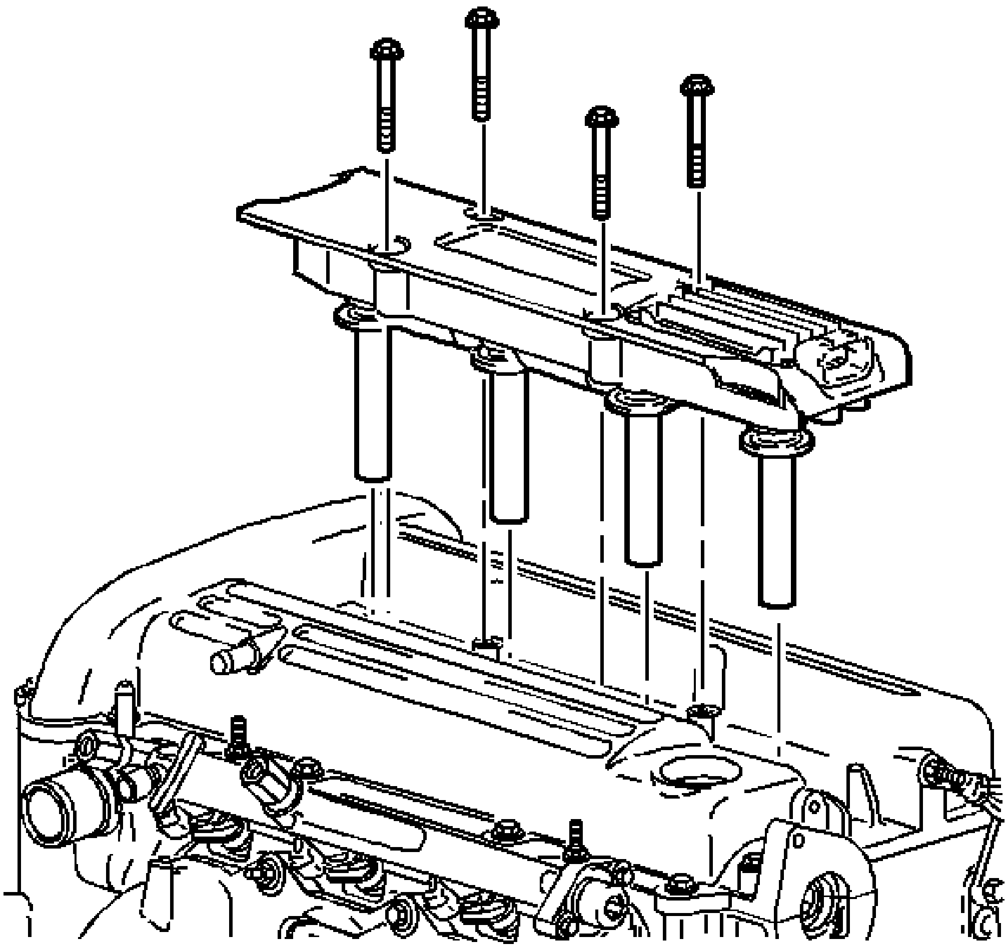


Fig. 462: View Of Ignition Coil & Module Assembly
Courtesy of GENERAL MOTORS CORP.

5. 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).

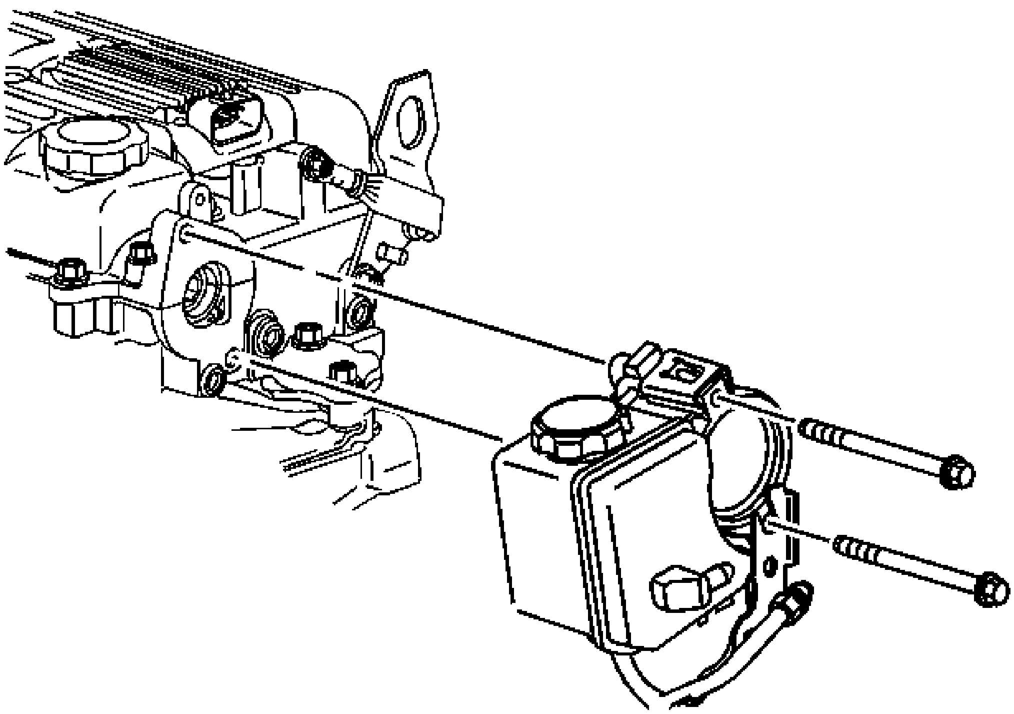


Fig. 463: View Of Power Steering Pump
Courtesy of GENERAL MOTORS CORP.

6. Install the power steering pump.

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

Oil Pan Installation

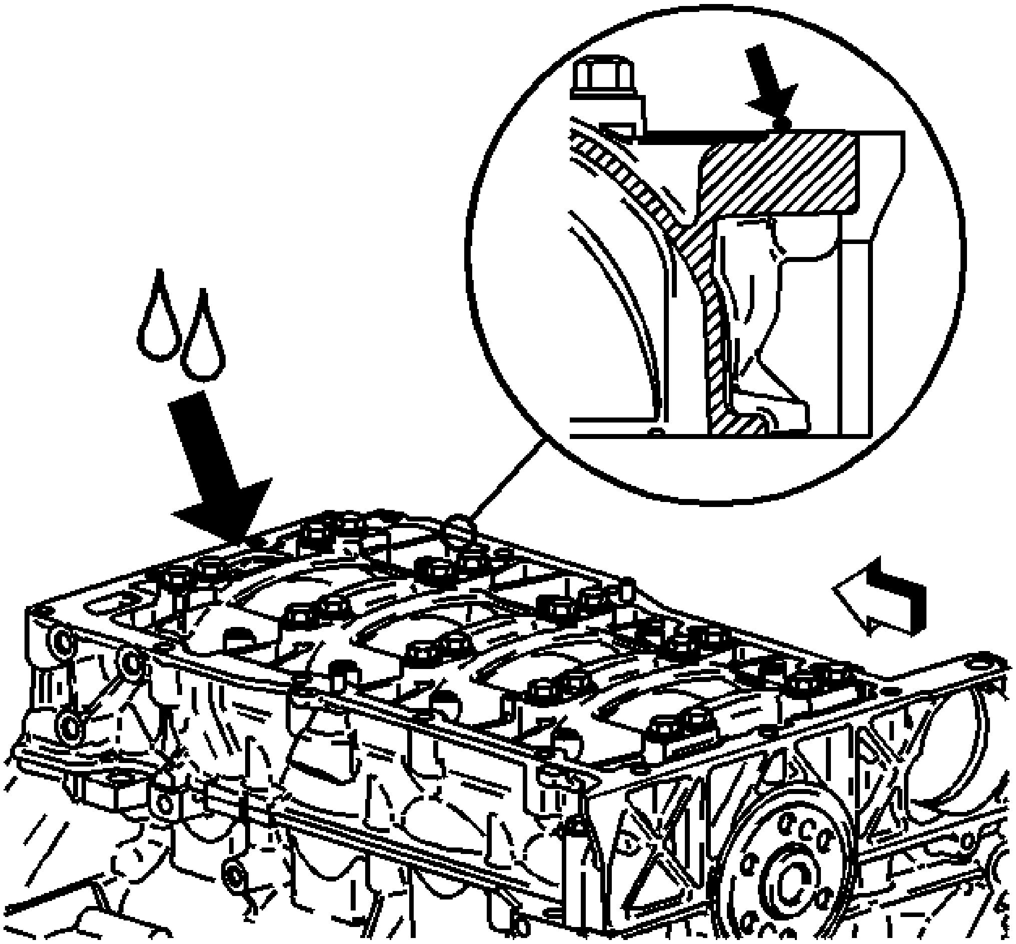


Fig. 464: Applying RTV Around Perimeter Of Oil Pan & Oil Suction Port Opening
Courtesy of GENERAL MOTORS CORP.

1. Make sure that the oil pan and mounting surface on the lower crankcase are free of all oil and debris.
2. Apply a 2 mm bead of GM P/N 12346286 (Canadian P/N 10953472) or equivalent around the perimeter of the oil pan and the oil suction port opening.

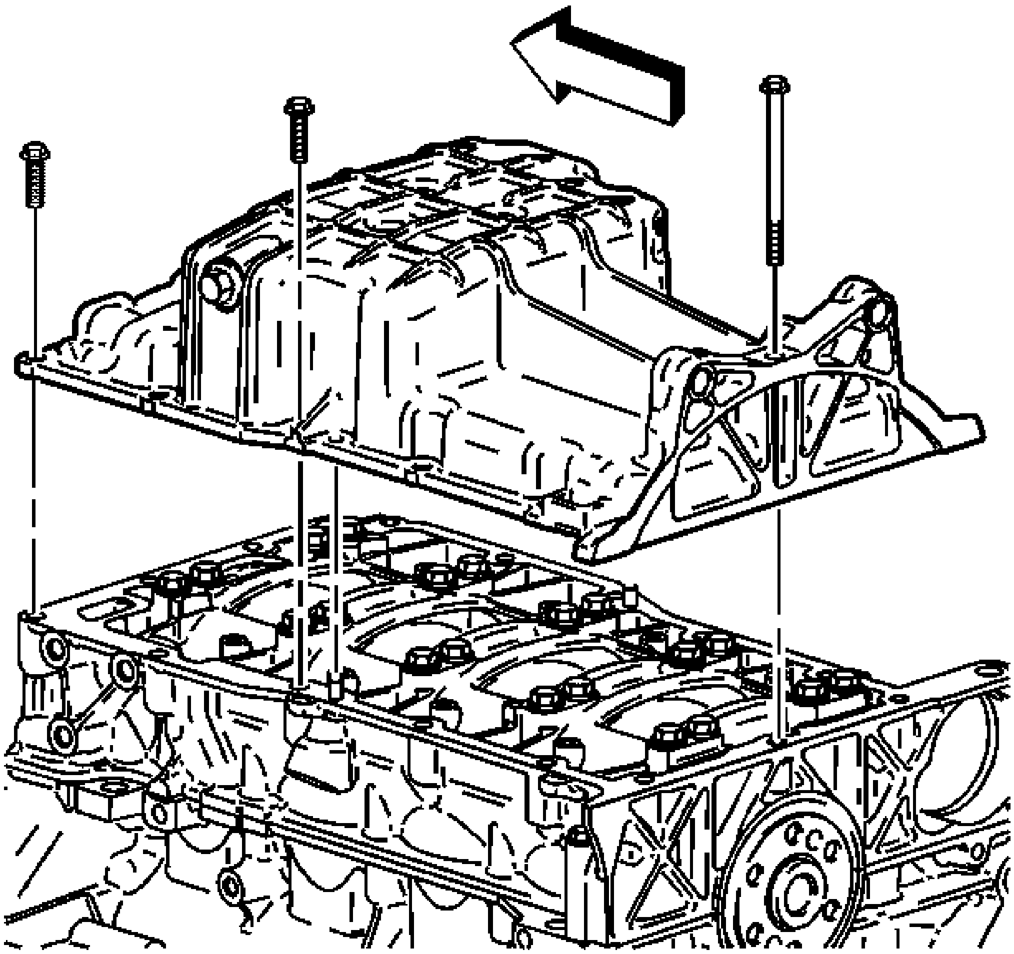


Fig. 465: View of Oil Pan Installation
Courtesy of GENERAL MOTORS CORP.

3. Install the oil pan.

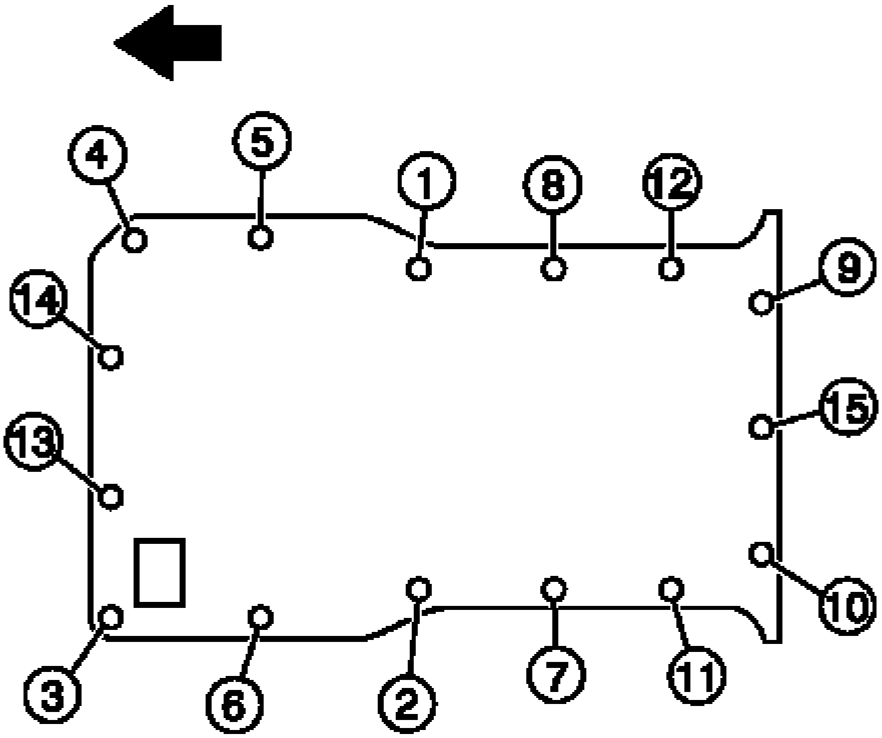


Fig. 466: Identifying Oil Pan Bolts Removal & Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

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

4. Install the oil pan bolts.

   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**.

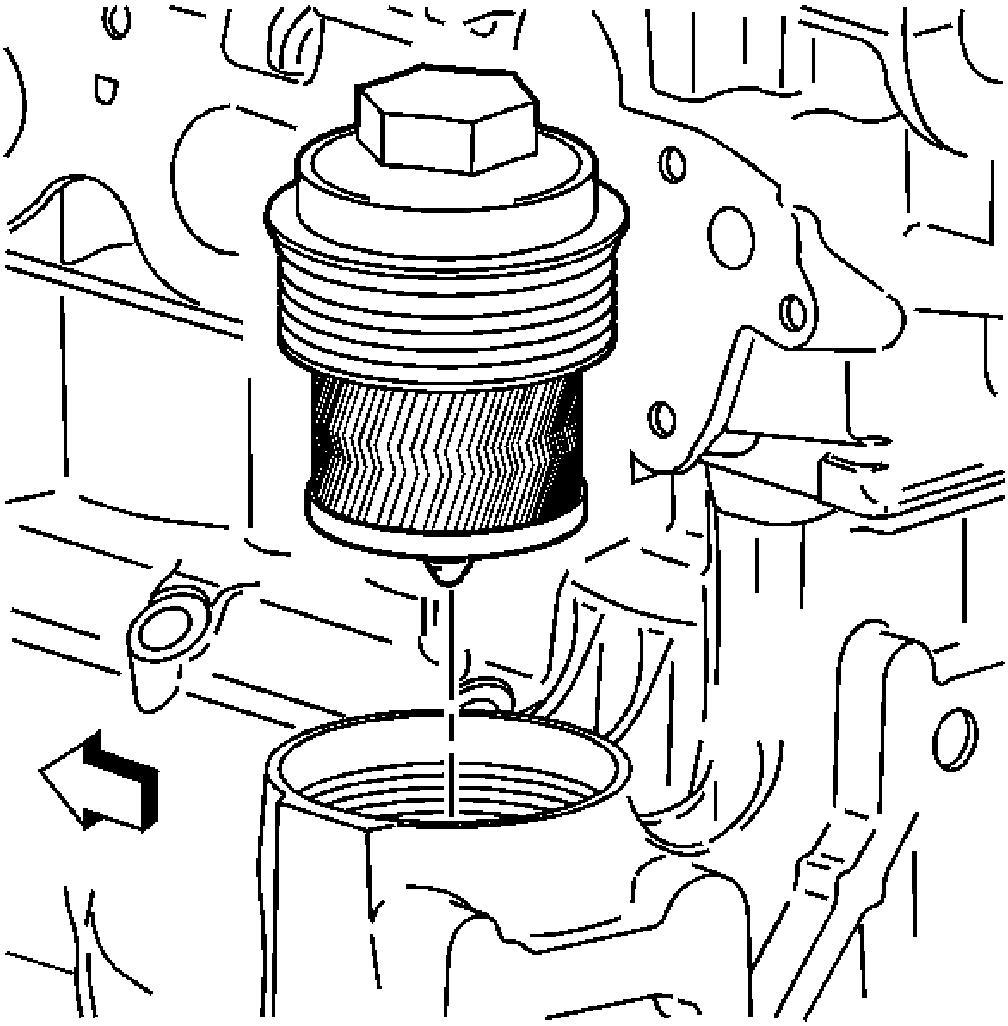


Fig. 467: Identifying Oil Filter Housing
Courtesy of GENERAL MOTORS CORP.

1. Install a new oil filter on the oil filter cap.
2. Lubricate the O-ring on the oil filter cap with 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

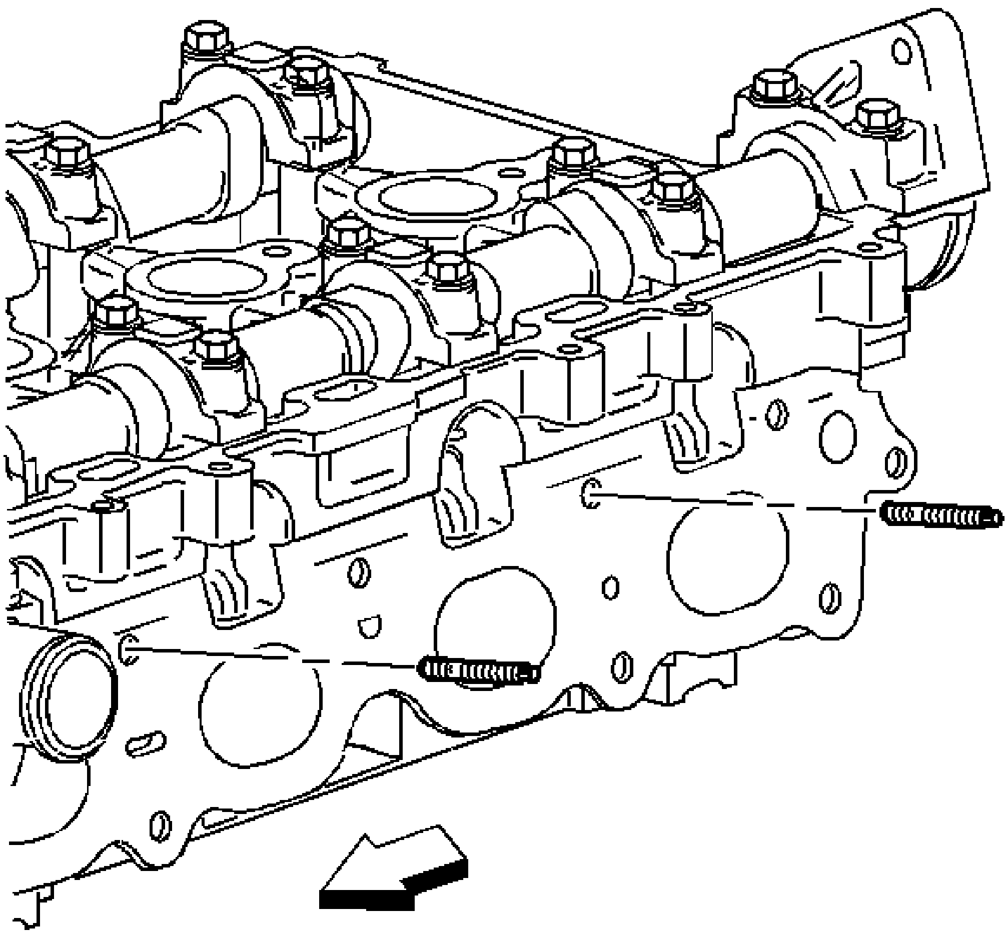


Fig. 468: Identifying Intake Manifold Fasteners
Courtesy of GENERAL MOTORS CORP.

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 5 N.m (44 lb in).

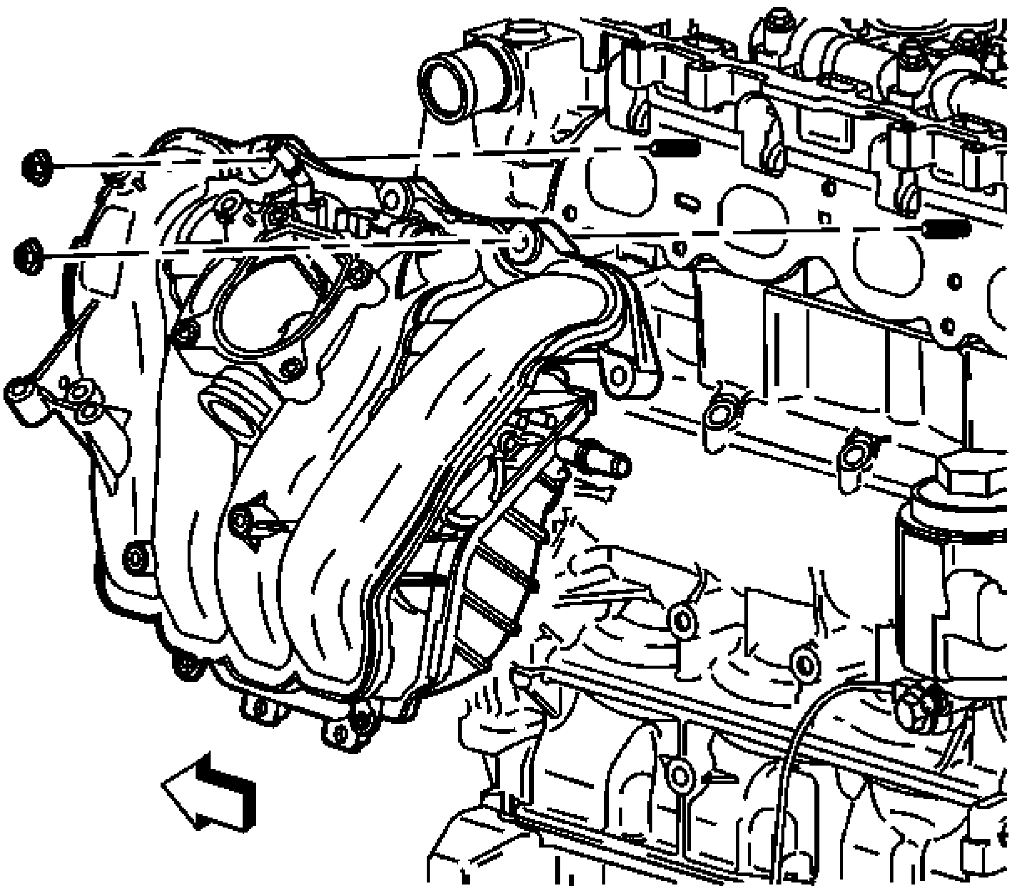


Fig. 469: Removing & Installing Intake Manifold
Courtesy of GENERAL MOTORS CORP.

2. Install a new intake manifold gasket on the intake manifold.
3. Install the intake manifold.
4. Install the intake manifold bolts and nuts. Follow the tightening sequence.

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

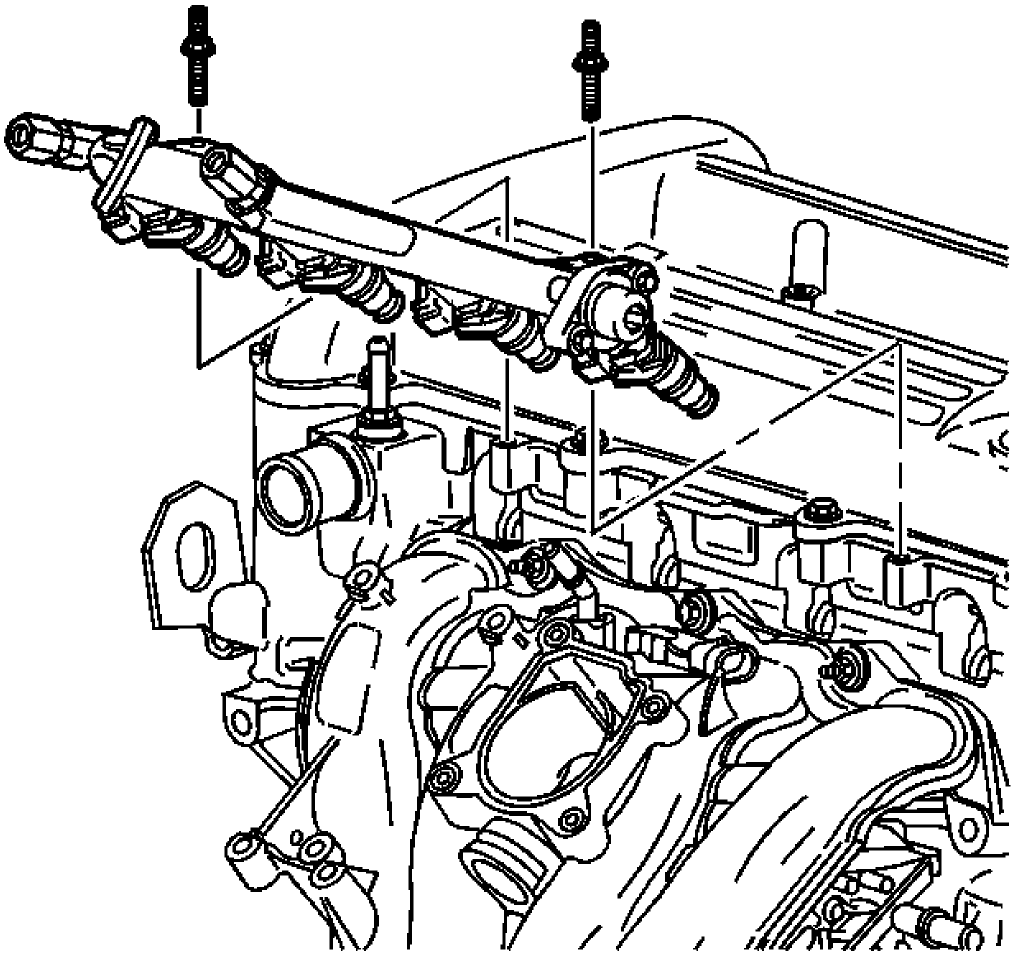


Fig. 470: View Of Fuel Rail Assembly
Courtesy of GENERAL MOTORS CORP.

5. Lubricate the fuel injector tip insulators with engine oil.
6. Install new fuel injector tip insulators.
7. Lubricate the fuel injector oil rings with engine oil.
8. Install the fuel rail assembly.
9. Install the fuel rail stud.

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

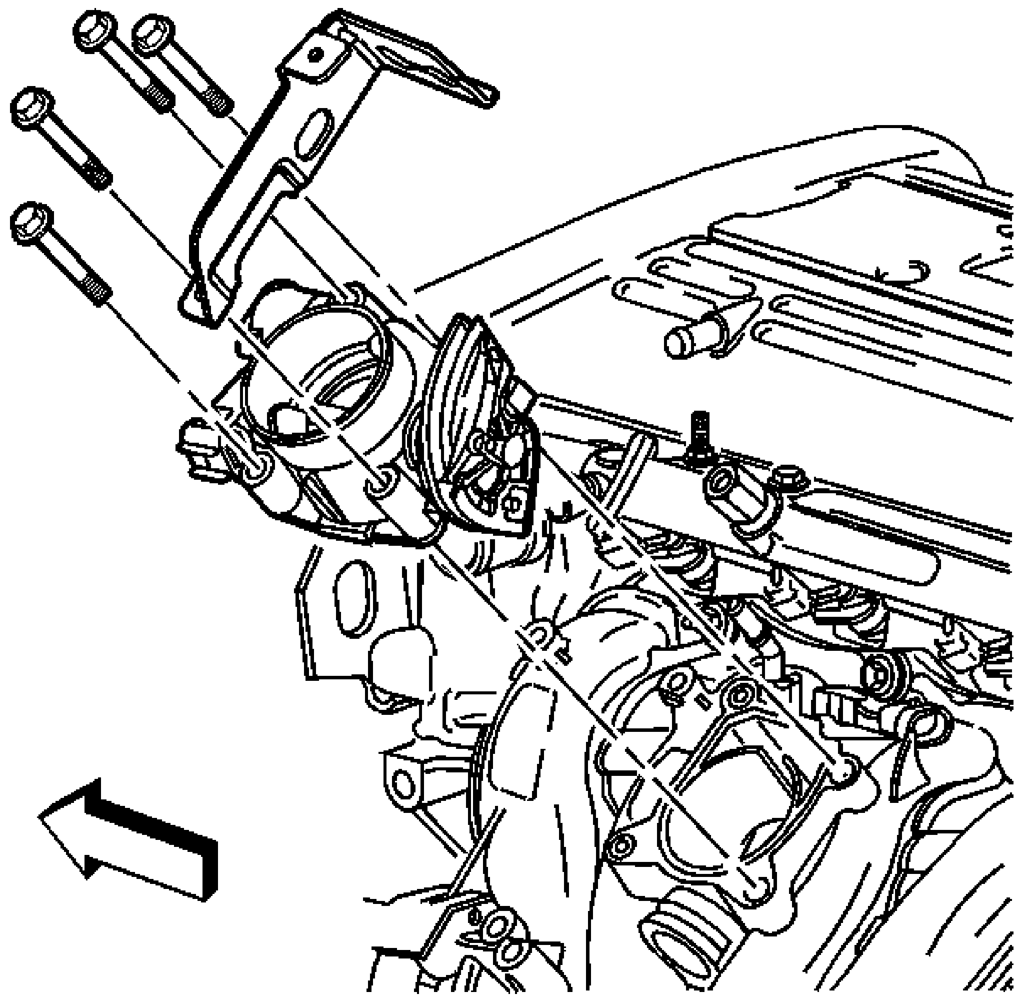


Fig. 471: Exploded View Of Throttle Body & Accelerator Control Cable Bracket
Courtesy of GENERAL MOTORS CORP.

10. Install a new throttle body gasket.
11. Install the throttle body and the accelerator control cable bracket.

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

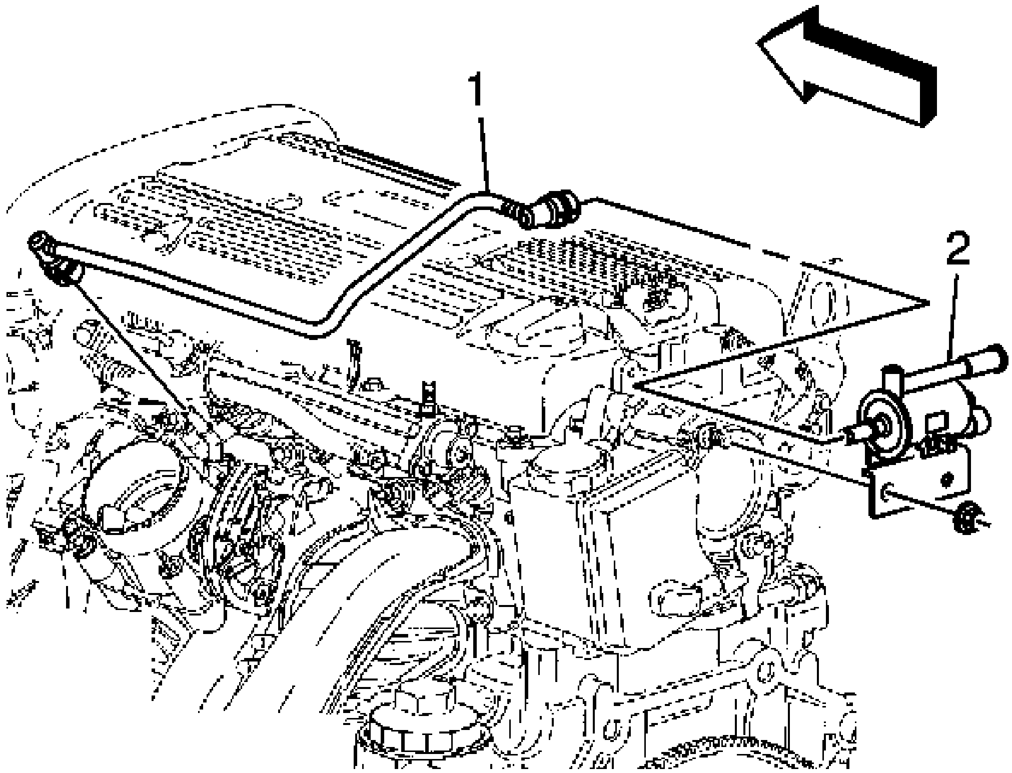


Fig. 472: View of EVAP Emission Canister Valve Tube & Canister Valve
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure that the rear metal tab of the EVAP emission canister valve is resting on the power steering pump metal body.

12. Install the EVAP emission canister valve (2).

    Tighten: Tighten the EVAP canister valve to 22 N.m (16 lb ft).

13. Install the EVAP emission canister valve tube (1).

Crankshaft Damper Installation

- J 38122-A Harmonic Balancer Holder
- **J 45059** Angle Meter. See **Special Tools and Equipment**.

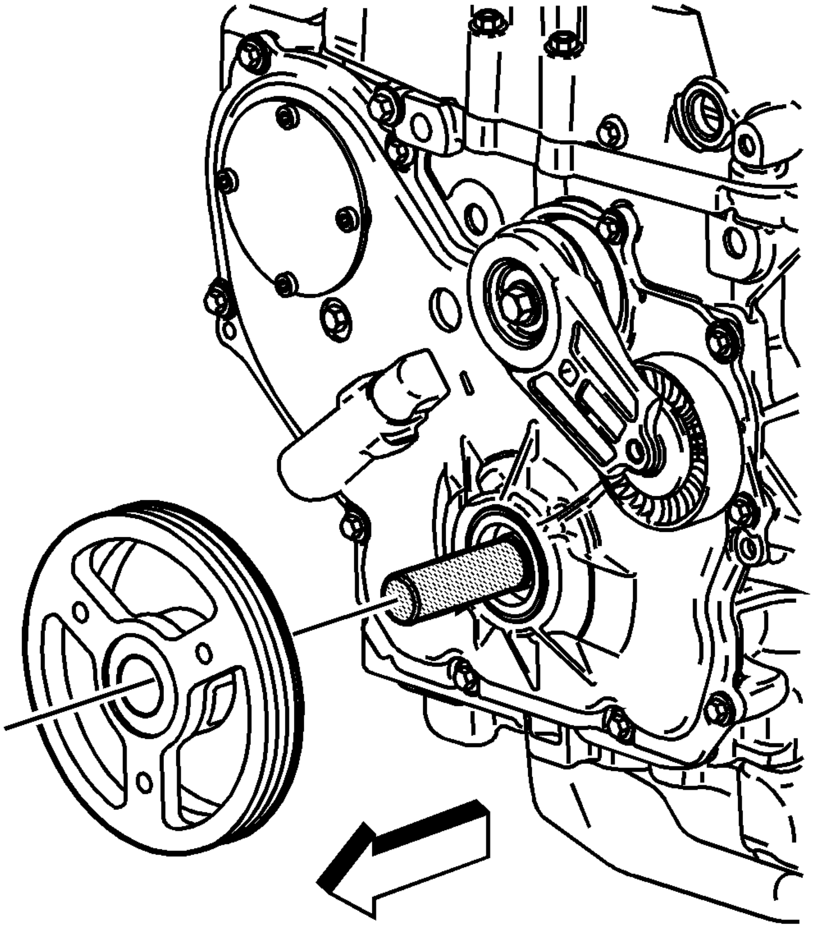


Fig. 473: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

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.

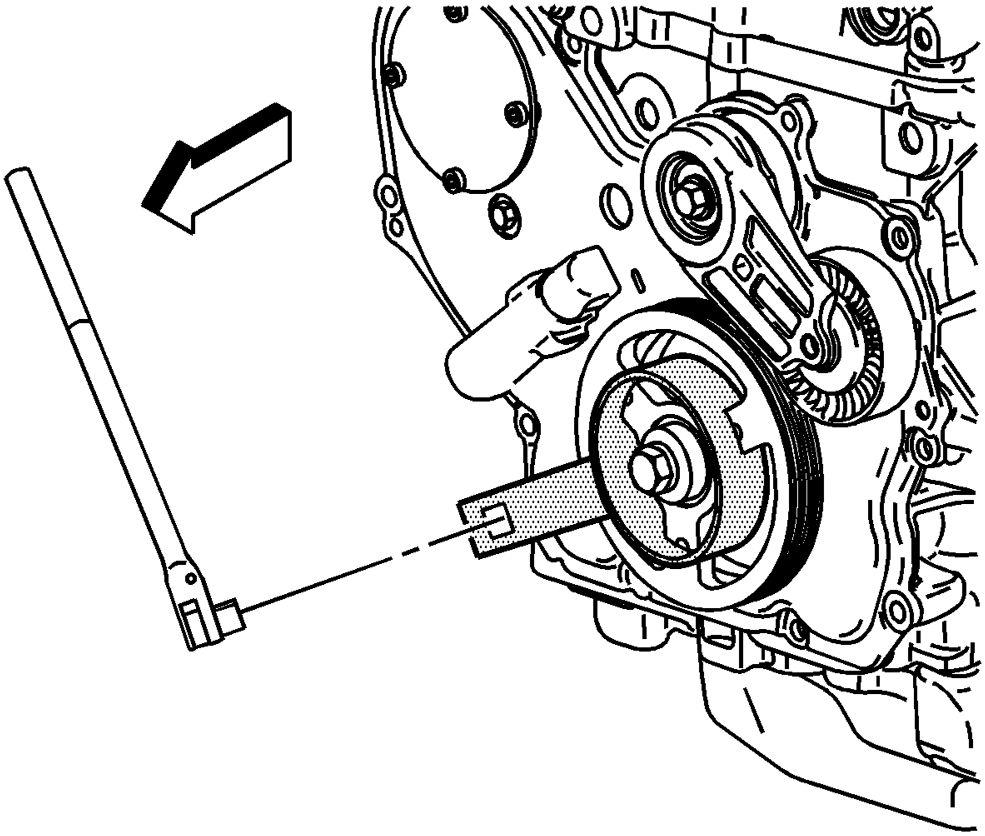


Fig. 474: View Of Harmonic Balancer Holder J38122-A
Courtesy of GENERAL MOTORS CORP.

2. Install the J 38122-A .

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.

   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

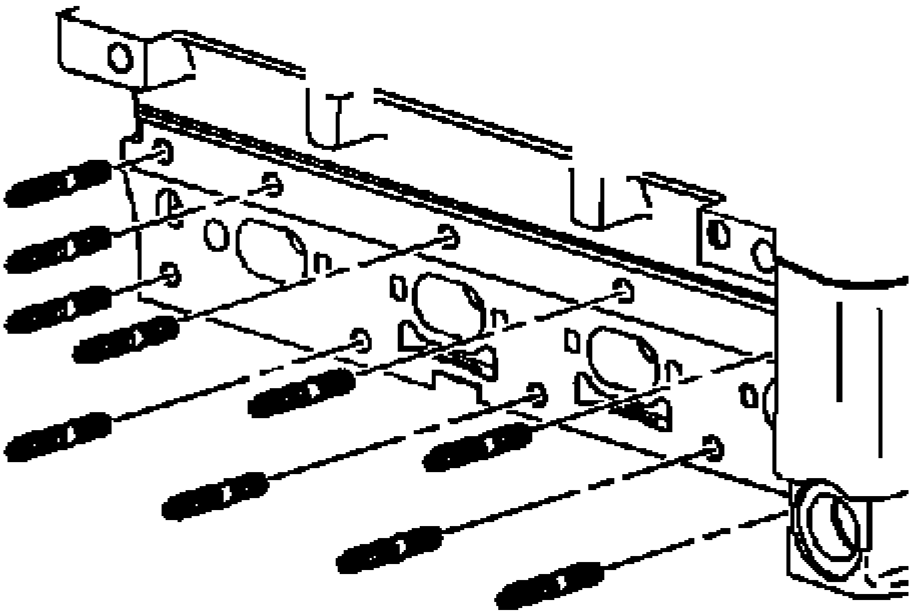


Fig. 475: View of Exhaust Manifold Studs
Courtesy of GENERAL MOTORS CORP.

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).

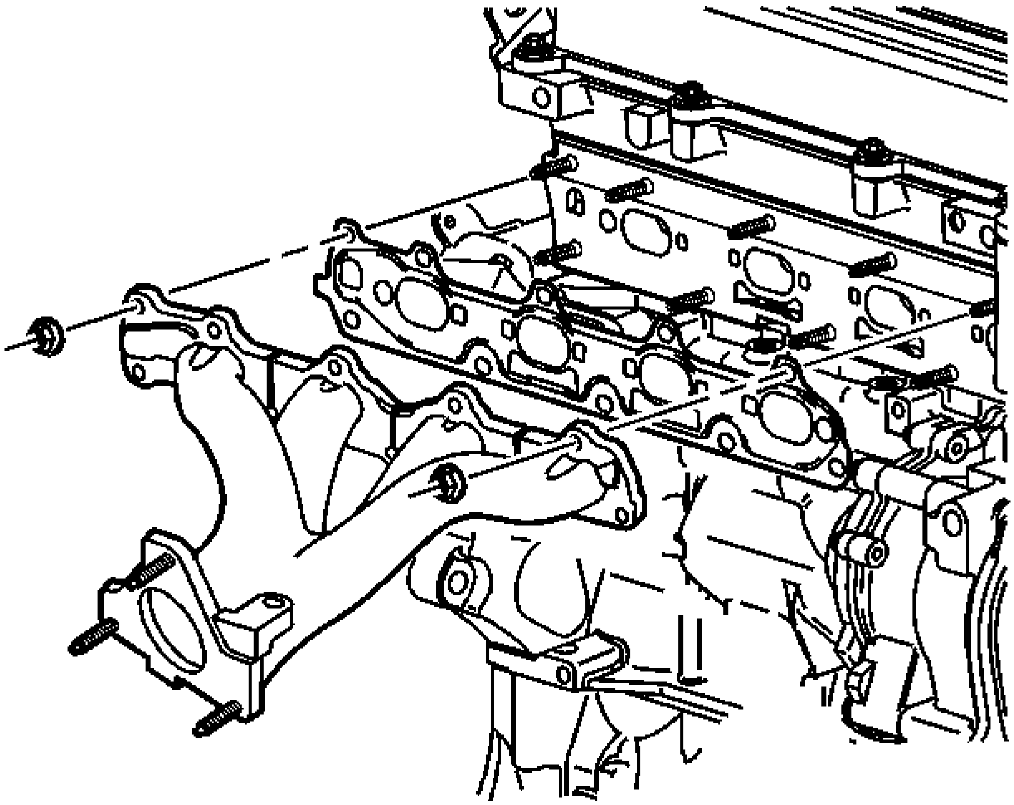


Fig. 476: View Of Exhaust Manifold & Gasket
Courtesy of GENERAL MOTORS CORP.

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.

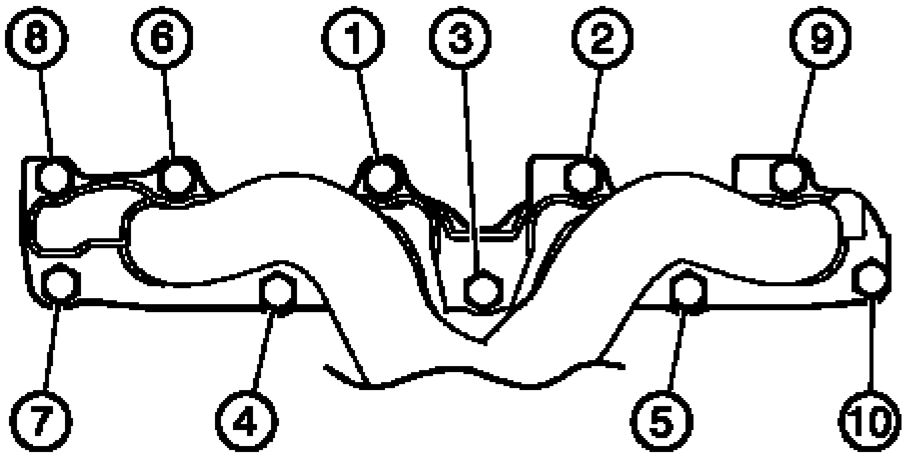


Fig. 477: Exhaust Manifold Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

5. Tighten the NEW exhaust manifold to cylinder head retaining nuts in sequence.

   Tighten: Tighten the nuts to 14 N.m (124 lb in).

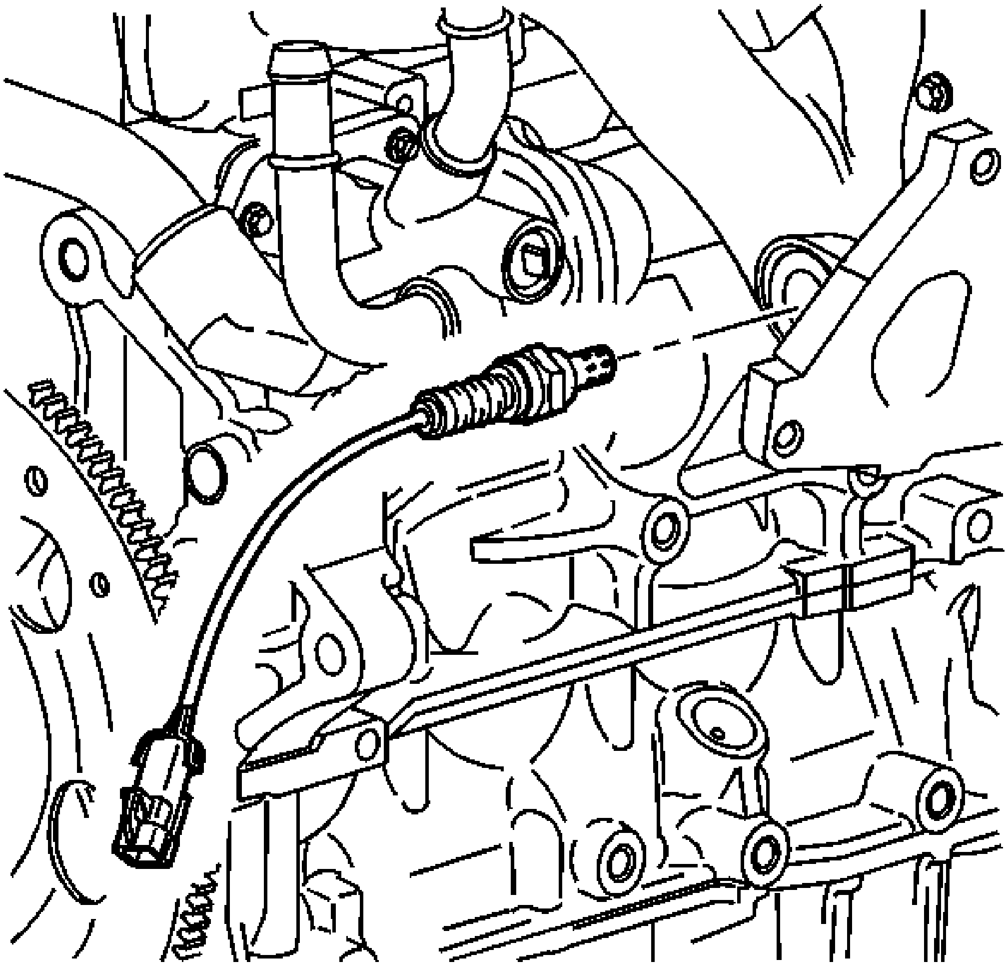


Fig. 478: Identifying Oxygen Sensor
Courtesy of GENERAL MOTORS CORP.

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).

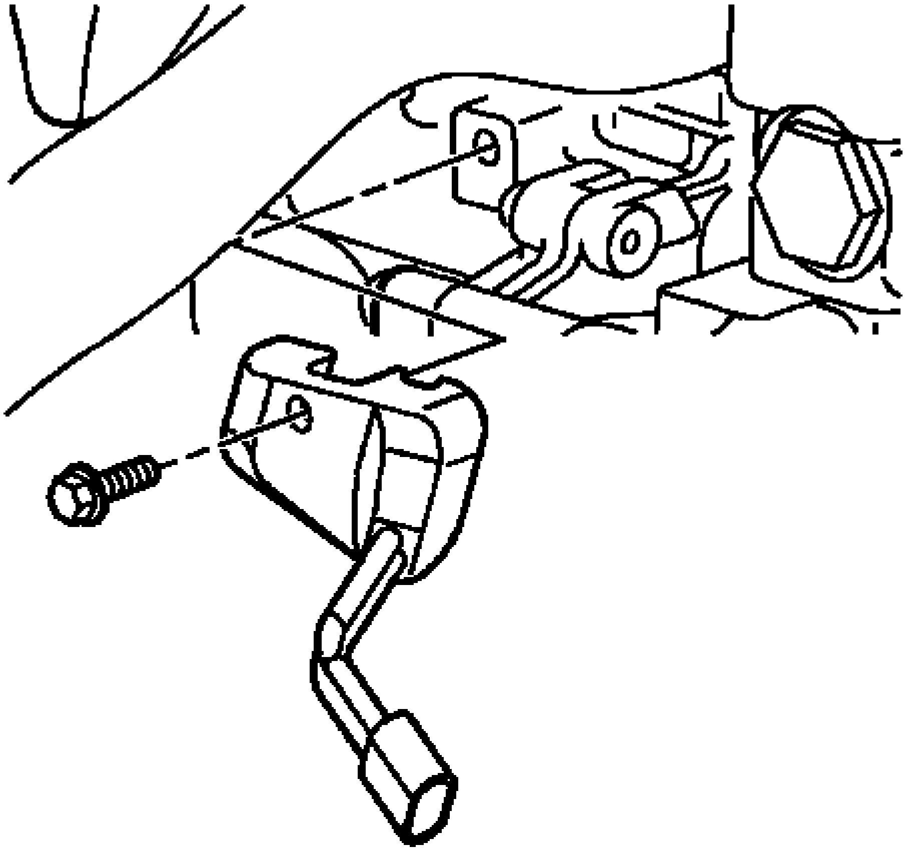


Fig. 479: View Of Block Heater
Courtesy of GENERAL MOTORS CORP.

8. Install the block heater and bolt, if equipped.

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

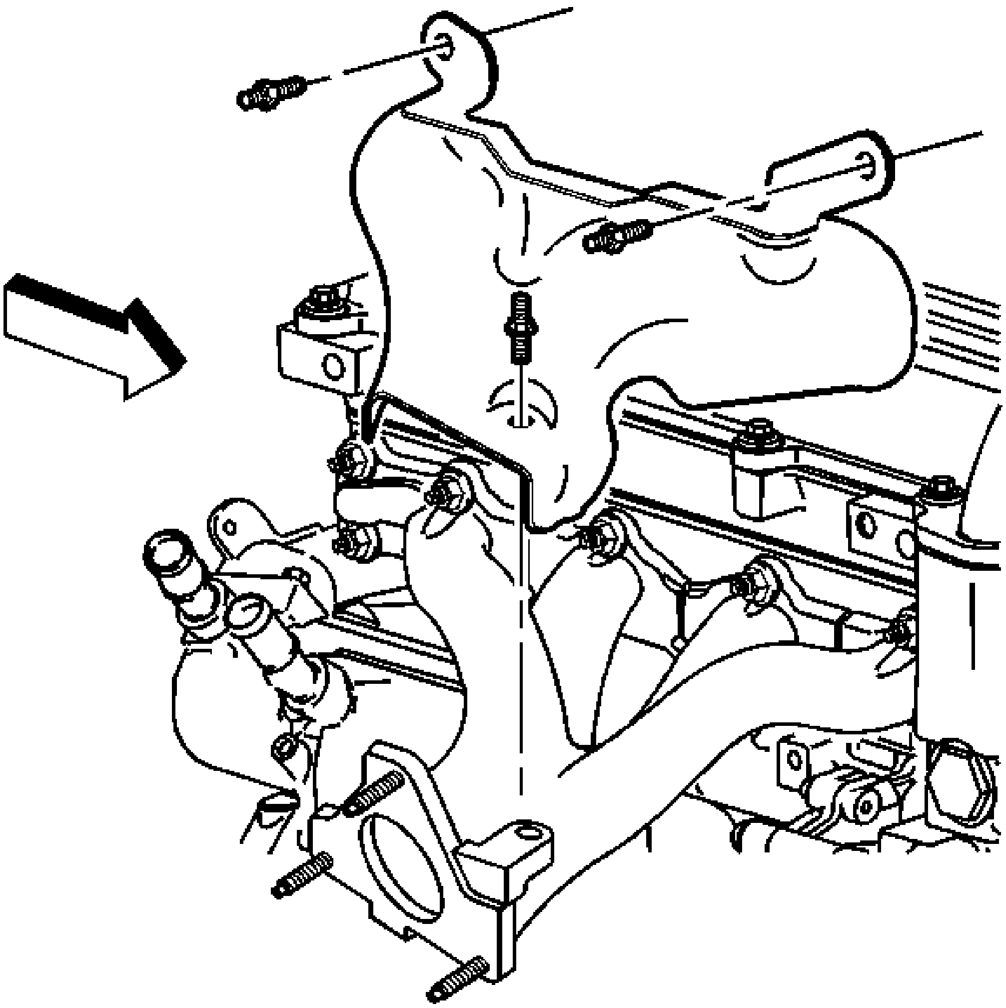


Fig. 480: Removing & Installing Exhaust Manifold Heat Shield
Courtesy of GENERAL MOTORS CORP.

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

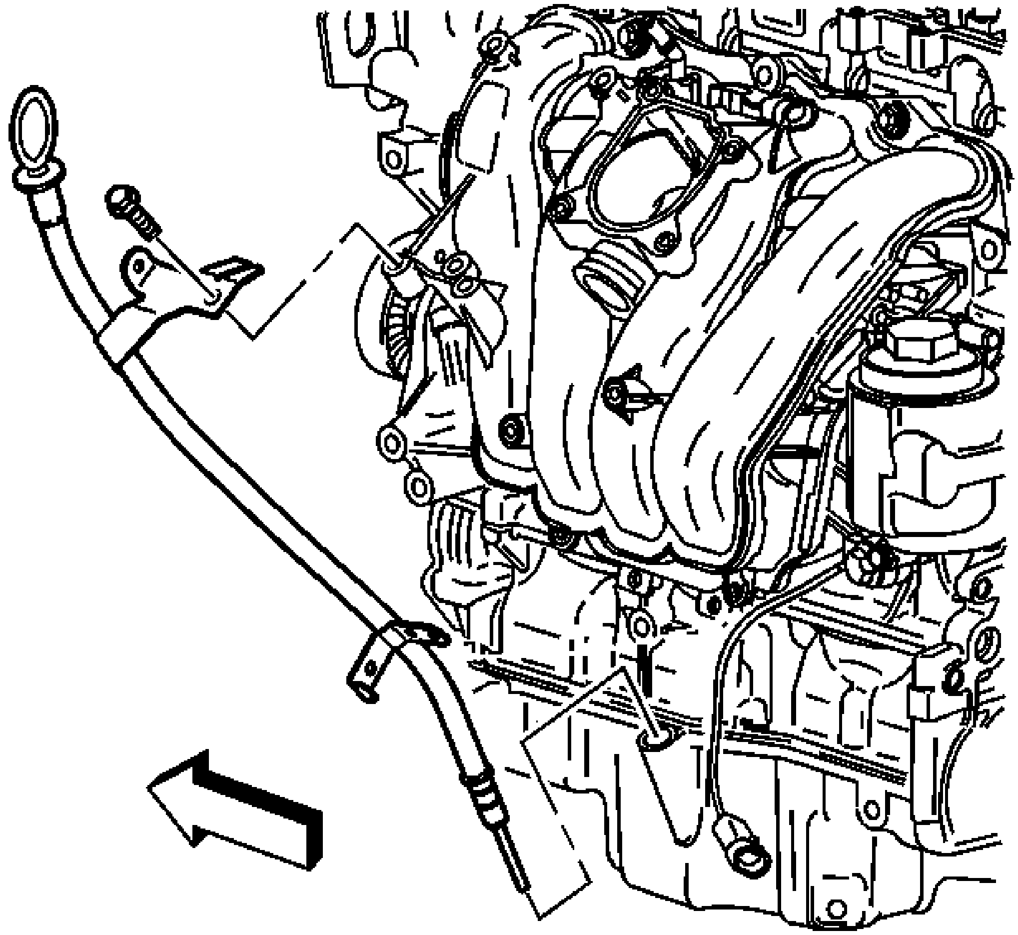


Fig. 481: View of Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the oil level indicator tube O-ring with GM P/N 12345501 (Canadian P/N 992704) or equivalent.
2. Install the oil level indicator and the oil level indicator tube into the oil pan.

NOTE: **Refer to Fastener Notice 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
- **J 45059** Angle Meter. See **Special Tools and Equipment**.

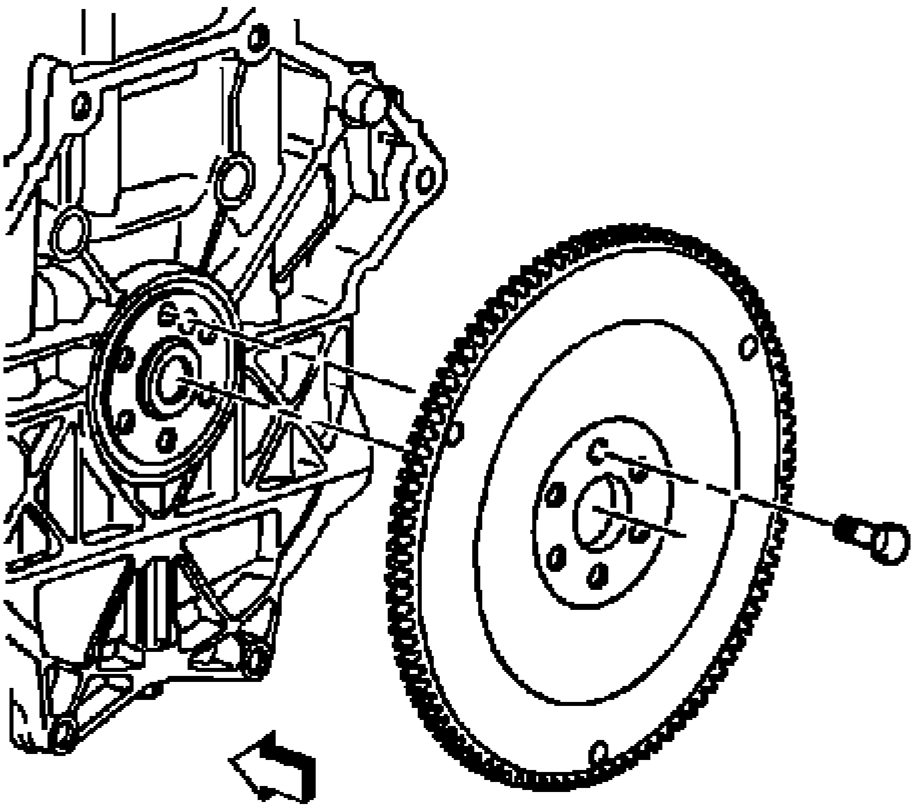


Fig. 482: View Of Flywheel
Courtesy of GENERAL MOTORS CORP.

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.

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

CRANKCASE VENTILATION SYSTEM DESCRIPTION

General Description

A crankcase ventilation system is used to consume crankcase vapors in the combustion process instead of venting them to atmosphere. Fresh air from the intake system is supplied to the crankcase, mixed with blow by gases and then passed through a calibrated orifice into the intake manifold.

Operation

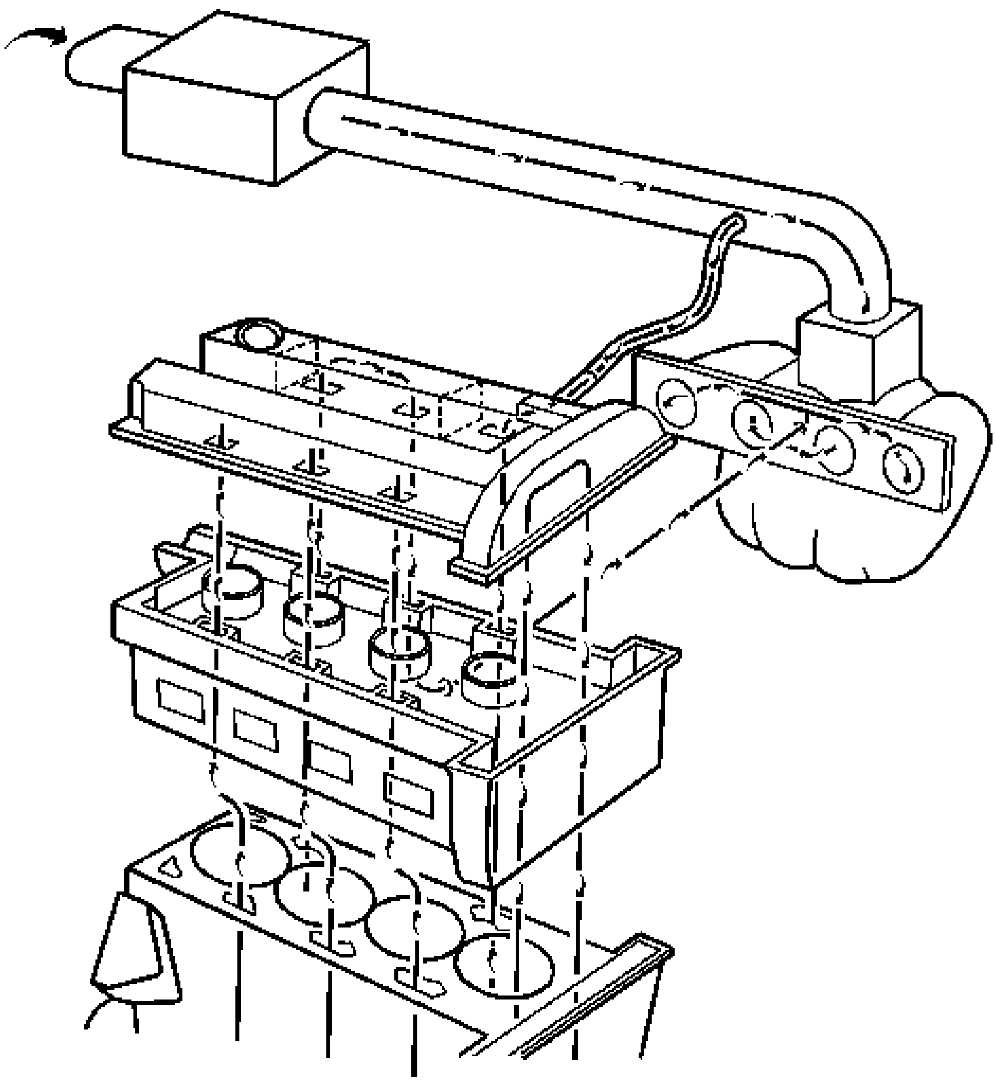


Fig. 483: View of Positive Crankcase Ventilation Orifice
Courtesy of GENERAL MOTORS CORP.

The primary control is through the positive crankcase ventilation (PCV) orifice which meters the flow at a rate depending on inlet vacuum. The PCV orifice is an integral part of the camshaft cover. If abnormal operating conditions occur, the system is designed to allow excessive amounts of blow by gases to back flow through the crankcase vent into the intake system to be consumed by normal combustion.

Results of Incorrect Operation

A plugged orifice may cause the following conditions:

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

A leaking orifice may cause the following conditions:

- Rough idle
- Stalling
- High idle speed

DRIVE BELT SYSTEM DESCRIPTION

The drive belt system consists of the following components:

- The drive belt
- The drive belt tensioner
- The 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 grooves 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 is pulled by the crankshaft balancer pulley across the accessory drive component pulleys. The spring loaded drive belt tensioner keeps constant tension on the drive belt to prevent the drive belt from slipping. The drive belt tensioner arm will move when loads are applied to the drive belt by the accessory drive components and the crankshaft.

The drive belt system may have an idler pulley, which is used to add wrap to the adjacent pulleys. Some systems use an idler pulley in place of an accessory drive component when the vehicle is not equipped with the accessory.

ENGINE COMPONENT DESCRIPTION

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

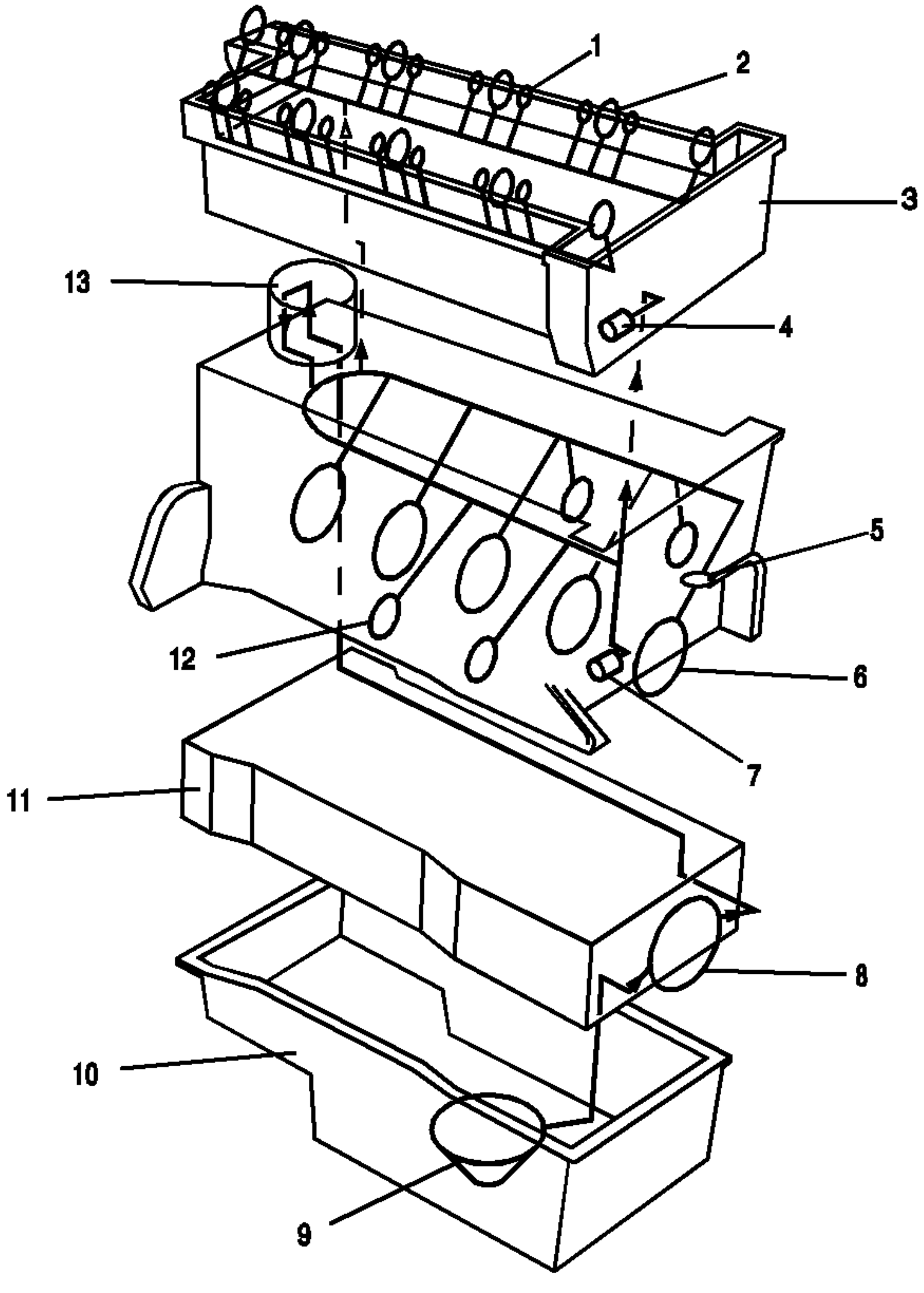


Fig. 484: Lubrication System
Courtesy of GENERAL MOTORS CORP.

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. 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 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.

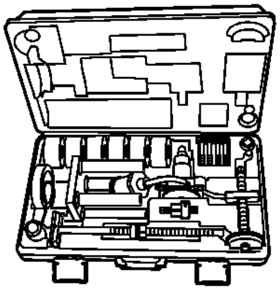
To properly service the engine assembly, the following items should be readily available:

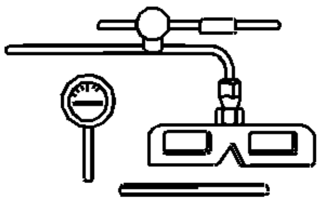
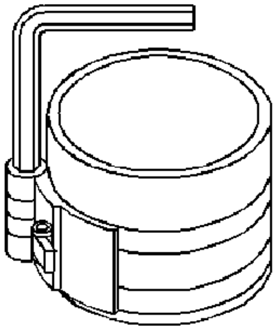
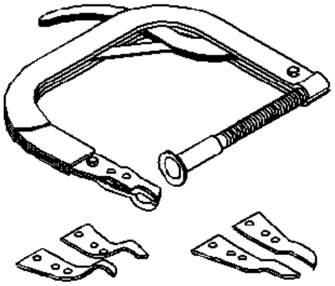
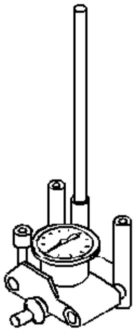
- Approved eye protection and safety gloves
- A clean, well lit, work area
- A suitable parts cleaning tank
- A compressed air supply
- Trays or storage containers to keep parts and fasteners organized
- An adequate set of hand tools
- Approved engine repair stand
- An approved engine lifting device that will adequately support the weight of the components

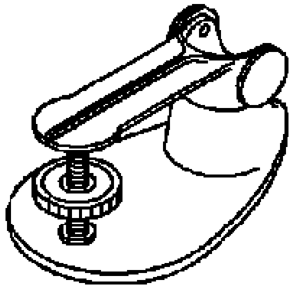
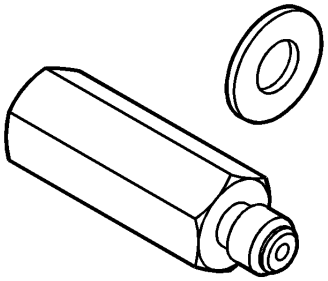
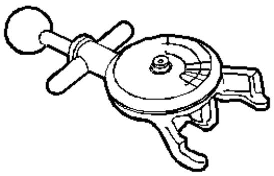
SPECIAL TOOLS AND EQUIPMENT

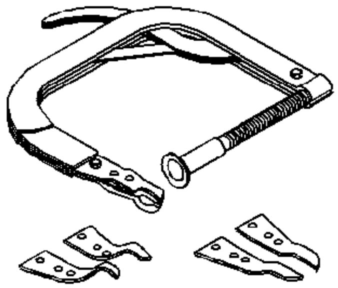
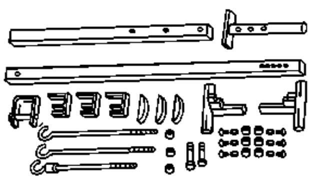
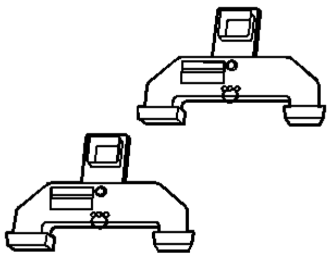
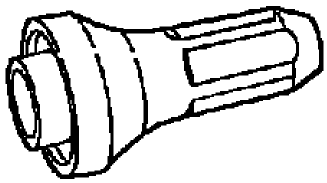
SPECIAL TOOLS

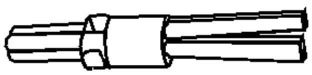
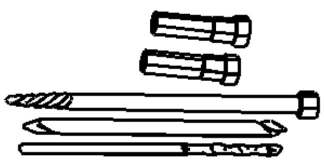
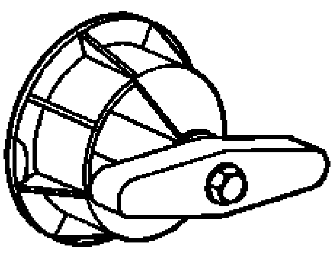
Special Tools

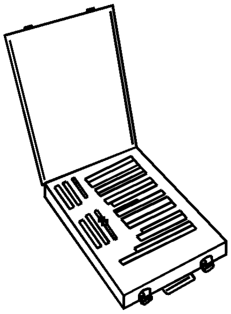
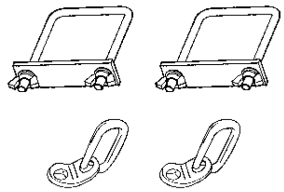
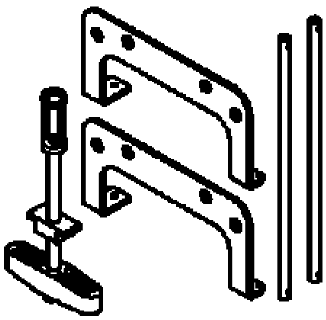
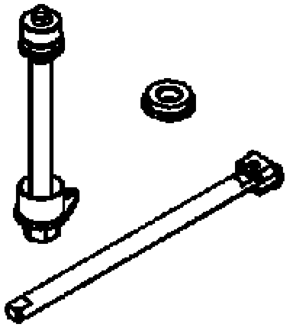
Illustration	Tool Number/Description
	EN 45680-400 Cylinder Sleeve Removal and Installation Kit

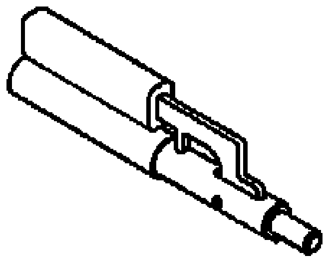
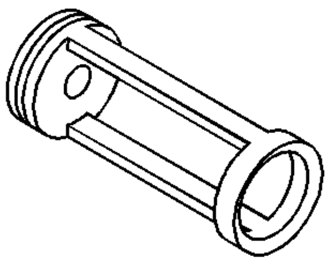
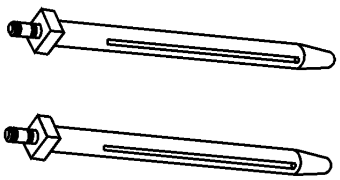
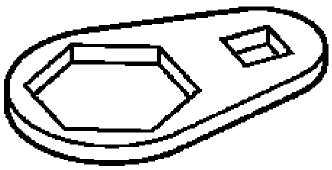
	EN 46745 Piston Pin Retainer Remover and Installer
	J 7872 Magnetic Base Dial Indicator Set
	J 8037 Ring Compressor
	J 8062 Valve Spring Compressor - Head Off
	J 8087 Cylinder Bore Gage

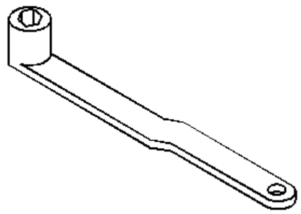
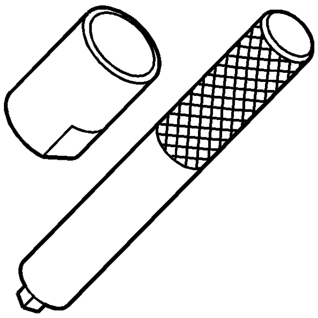
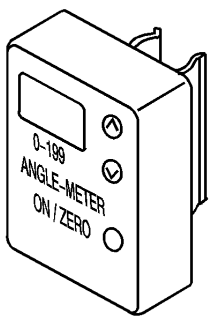
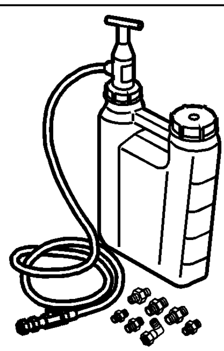
	J 9666 Valve Spring Tester
	J 21867-850 Oil Pressure Gage Adapter
	J 23600-B Belt Tension Gage
	J 28410 Gasket Remover
	J 28428-E High-Intensity Black Light Kit

	
	J 28467-B Universal Engine Support Fixture
	J 28467-501 Engine Support Fixture Adapters
	J 35268-A Camshaft/Front Main Seal Installer
	J 35667-A Cylinder Head Leakdown Tester

	
	J 36017 Valve Guide Seal Remover
	J 38188 Cylinder Head Broken Bolt Extractor Kit
	J 42067 Rear Main Seal Installer
	J 42385-850 Thread Repair Kit

	
	J 42451 Engine Support Adapter Set
	J 43649 Valve Spring Compressor
	J 43650 Balance Shaft Bearing Remover and Installer
	J 43654 Piston Pin Retainer Remover and Installer

	
	J 43963 Valve Spring Compressor (off car)
	J 43966-1 Connecting Rod Guides
	J 44887 Oil Filter Wrench
	J 45025 Torque Wrench Adapter

	
	J 45027 Tensioner Tool
	J 45059 Angle Meter
	J 45299 Engine Pre-Luber