

2018 ENGINE**Engine Mechanical - 1.6L (LH7) Diesel - Equinox & Terrain****SPECIFICATIONS****FASTENER SPECIFICATIONS****Single Use Non-Threaded Fasteners/Components****NOTE:**

All fasteners/components listed in this table MUST BE DISCARDED and replaced with NEW after removal.

Application
Air Conditioning Compressor Hose Seal
Camshaft Housing Gasket
Catalytic Converter Gasket
Charge Air Bypass Valve Vacuum Hose Seal
Crankshaft Front Oil Seal
Crankshaft Rear Oil Seal
Cylinder Head Gasket
Engine Cooler Outlet Pipe Seal
Engine Core Hole Plug
Engine Oil Level Indicator Switch O-Ring Seal
Exhaust Gas Recirculation Cooler Housing Gasket
Exhaust Gas Recirculation Cooler Outlet Pipe Seal
Exhaust Gas Recirculation Cooler Pipe Gasket
Exhaust Gas Recirculation Valve Gasket
Exhaust Gas Recirculation Valve Seat Gasket
Exhaust Manifold Gasket
Exhaust Pressure Differential Sensor Pipe Clamp
Fuel Injection Fuel Return Hose Clamp
Fuel Injection Pump Seal Ring
Fuel Injector Fuel Return Hose Clamp
Fuel Injector Gasket
Fuel Injector Return Hose Clip
Fuel Return Hose Clamp
Intake Manifold Gasket
Oil Cooler Adapter Gasket
Oil Filter Cap Bolt Gasket
Oil Filter Cap O-Ring
Oil Filter Cap Seal
Oil Filter Seal
Oil Pan Drain Plug Gasket
Power Brake Booster Inlet Hose Connector Fitting Seal
Throttle Body Assembly Gasket
Timing Chain Lower Cover Gasket
Turbocharger Coolant Feed And Return Pipe Bracket Gasket
Turbocharger Coolant Feed Pipe Clamp
Turbocharger Coolant Feed Pipe Gasket
Turbocharger Gasket
Turbocharger Oil Feed Pipe Gasket

NOTE:

All fasteners/components listed in this table MUST BE DISCARDED and replaced with NEW after removal.

Application
Turbocharger Oil Return Pipe Gasket
Valve Stem Oil Seal
Water Pump Seal

Single Use Threaded Fastener/Component Tightening Specifications**NOTE:**

All fasteners/components listed in this table MUST BE DISCARDED and replaced with NEW after removal.

Application	Specification
	Metric (English)
Automatic Transmission Flex Plate Bolt	
• First Pass:	60 N.m (44 lb ft)
• Final Pass:	45 degrees
Catalytic Converter Clamp	
• First Pass:	6 N.m (53 lb in)
• Final Pass:	25 N.m (18 lb ft)
Connecting Bearing Cap Bolt	
• First Pass:	25 N.m (18 lb ft)
• Final Pass:	110 degrees
Crankshaft Pulley Bolt	
• First Pass:	50 N.m (37 lb ft)
• Final Pass:	45 degrees
Cylinder Head Bolt	
• First Pass:	50 N.m (37 lb ft)
• Second Pass:	90 degrees
• Third Pass:	90 degrees
• Final Pass:	90 degrees
Cylinder Head Outer Bolt	
• First Pass:	20 N.m (15 lb ft)

NOTE:

All fasteners/components listed in this table MUST BE DISCARDED and replaced with NEW after removal.

Application	Specification
	Metric (English)
Final Pass:	45 degrees
Engine Mount Bracket Bolt	
First Pass:	58 N.m (43 lb ft)
Final Pass:	60 - 75 degrees
Exhaust Manifold Bolt	
First Pass:	27 N.m (20 lb ft)
Second Pass:	27 N.m (20 lb ft)
Final Pass:	27 N.m (20 lb ft)
Fuel Injector Bracket Bolt	
First Pass:	10 N.m (89 lb in)
Final Pass:	60 degrees
Fuel Injection Fuel Feed Pipe - Fuel Injection Pump To Fuel Rail	28 N.m (21 lb ft)
Fuel Injection Fuel Feed Pipe - Fuel Rail To Fuel Injector	28 N.m (21 lb ft)
Fuel Injection Fuel Rail Fuel Pressure Sensor	35 N.m (26 lb ft)
Main Bearing Bolt	
First Pass:	50 N.m (37 lb ft)
Second Pass:	90 degrees
Final Pass:	90 degrees
Oil Pump Sprocket Bolt	
First Pass:	25 N.m (18 lb ft)
Final Pass:	60 degrees

Reusable Threaded Fastener Tightening Specifications

NOTE:

All fasteners listed in this table can be reused after removal.

Application	Specification
	Metric (English)

NOTE:***All fasteners listed in this table can be reused after removal.***

Application	Specification
	Metric (English)
Air Cleaner Outlet Duct Clamp	3.5 N.m (31 lb in)
Air Conditioning Compressor Bolt	22 N.m (16 lb ft)
Air Conditioning Compressor Hose Bolt	22 N.m (16 lb ft)
Air Conditioning Compressor Nut	22 N.m (16 lb ft)
Camshaft Housing Bolt	10 N.m (89 lb in)
Camshaft Position Sensor Bolt	10 N.m (89 lb in)
Camshaft Rear Cap Bolt	25 N.m (18 lb ft)
Camshaft Sprocket Bolt	25 N.m (18 lb ft)
Catalytic Converter Bracket Nut	22 N.m (16 lb ft)
Catalytic Converter Heat Shield Bolt	9 N.m (80 lb in)
Charger Air Bypass Valve Vacuum Hose Bracket Bolt	10 N.m (89 lb in)
Crankshaft Position Sensor Bolt	10 N.m (89 lb in)
Diesel Fuel Separator Bolt	10 N.m (89 lb in)
Drive Belt Idler Pulley Bolt	58 N.m (43 lb ft)
Drive Belt Tensioner Bolt	55 N.m (41 lb ft)
Engine Block Coolant Drain Hole Plug	65 N.m (48 lb ft)
Engine Block Oil Gallery Plug	65 N.m (48 lb ft)
Engine Block Stud	20 N.m (15 lb ft)
Engine Coolant Temperature Sensor	33 N.m (24 lb ft)
Engine Cooler Outlet Pipe Bolt	25 N.m (18 lb ft)
Engine Lift Bracket Bolt	58 N.m (43 lb ft)
Engine Oil Heater Bolt	9 N.m (80 lb in)
Engine Oil Level Indicator Switch Bolt	10 N.m (89 lb in)
Engine Oil Pressure Sensor	35 N.m (26 lb ft)
Engine Oil Pressure Switch	35 N.m (26 lb ft)
Exhaust Camshaft Bearing Cap Bolt	10 N.m (89 lb in)
Exhaust Gas Recirculation Cooler Bolt	25 N.m (18 lb ft)
Exhaust Gas Recirculation Cooler Outlet Pipe Bolt	10 N.m (89 lb in)
Exhaust Gas Recirculation Cooler Temperature Sensor	45 N.m (33 lb ft)
Exhaust Gas Recirculation Pipe Bolt	10 N.m (89 lb in)
Exhaust Gas Recirculation Vacuum Regulator Solenoid Valve Bolt	7 N.m (62 lb in)
Exhaust Gas Recirculation Valve Bolt	10 N.m (89 lb in)
Exhaust Particulate Sensor Control Module Bracket Bolt	9 N.m (80 lb in)
Exhaust Pressure Differential Sensor Bolt	9 N.m (80 lb in)
Exhaust Pressure Differential Sensor Pipe Bracket Bolt	9 N.m (80 lb in)
Exhaust Temperature Sensor	45 N.m (33 lb ft)
Exhaust Temperature Sensor Electrical Connector Bracket Bolt	9 N.m (80 lb in)
Exhaust Temperature Wiring Harness Bracket Bolt	10 N.m (89 lb in)
Fuel Injection Fuel Feed Pipe Bracket Bolt	9 N.m (80 lb in)
Fuel Injection Fuel Pump Bolt	25 N.m (18 lb ft)
Fuel Injection Fuel Rail Bolt	25 N.m (18 lb ft)
Fuel Injection Fuel Rail Fuel Pressure Sensor Wire Bracket Bolt	9 N.m (80 lb in)
Fuel Injection Fuel Rail Pressure Sensor Wiring Harness Bracket Bolt	9 N.m (80 lb in)
Fuel Injection Fuel Return Pipe Bracket Bolt	7 N.m (62 lb in)
Fuel Injection Pipe Bracket Bolt	9 N.m (80 lb in)
Fuel Injection Pump Driven Sprocket Nut	64 N.m (47 lb ft)

NOTE:***All fasteners listed in this table can be reused after removal.***

Application	Specification
	Metric (English)
Generator Bolt	22 N.m (16 lb ft)
Glow Plug	16.5 N.m (12 lb ft)
Heated Oxygen Sensor	45 N.m (33 lb ft)
Intake Air Pressure and Temperature Sensor Bolt	1.6 N.m (14 lb in)
Intake Camshaft Bearing Cap Bolt	10 N.m (89 lb in)
Intake Manifold Bolt	12 N.m (106 lb in)
Intake Manifold Brace Bolt	10 N.m (89 lb in)
Lower Crankcase Bolt	34 N.m (25 lb ft)
Nitrogen Oxides Sensor	50 N.m (37 lb ft)
Nitrogen Oxides Sensor Control Module Nut	9 N.m (80 lb in)
Oil Cooler Bolt	25 N.m (18 lb ft)
Oil Filter Cap	25 N.m (18 lb ft)
Oil Filter Cap Bolt	10 N.m (89 lb in)
Oil Pan Baffle Bolt	10 N.m (89 lb in)
Oil Pan Bolt	25 N.m (18 lb ft)
Oil Pan Drain Plug	25 N.m (18 lb ft)
Oil Pump Bolt	25 N.m (18 lb ft)
Oil Pump Drive Chain Tensioner Bolt (M6)	10 N.m (89 lb in)
Oil Pump Drive Chain Tensioner Bolt (M8)	25 N.m (18 lb ft)
Piston Oil Nozzle Bolt	10 N.m (89 lb in)
Piston Oil Nozzle Oil Control Solenoid Valve Bolt	10 N.m (89 lb in)
Power Brake Booster Inlet Hose Connector Fitting Bolt	10 N.m (89 lb in)
Starter Bolt	22 N.m (16 lb ft)
Thermostat Bypass Pipe Bolt	10 N.m (89 lb in)
Thermostat Bypass Pipe Bracket Bolt	10 N.m (89 lb in)
Throttle Body Assembly Bolt	10 N.m (89 lb in)
Timing Chain Idler Sprocket Bolt	25 N.m (18 lb ft)
Timing Chain Lower Cover Bolt	25 N.m (18 lb ft)
Timing Chain Lower Guide Bolt	10 N.m (89 lb in)
Timing Chain Tensioner Bolt	10 N.m (89 lb in)
Timing Chain Tensioner Shoe Bolt	25 N.m (18 lb ft)
Timing Chain Upper Cover Bolt	25 N.m (18 lb ft)
Timing Chain Upper Cover Sleeve	25 N.m (18 lb ft)
Timing Chain Upper Cover Sleeve Bolt	25 N.m (18 lb ft)
Timing Chain Upper Guide Bolt	11 N.m (97 lb in)
Turbocharger Coolant Feed Pipe Bolt	10 N.m (89 lb in)
Turbocharger Coolant Feed Pipe Bracket Nut	10 N.m (89 lb in)
Turbocharger Coolant Feed Pipe Hollow Bolt	25 N.m (18 lb ft)
Turbocharger Heat Shield Bolt	9 N.m (80 lb in)
Turbocharger Heat Shield Nut	9 N.m (80 lb in)
Turbocharger Nut	30 N.m (22 lb ft)
Turbocharger Oil Feed Pipe Bolt	10 N.m (89 lb in)
Turbocharger Oil Feed Pipe Bracket Bolt	10 N.m (89 lb in)
Turbocharger Oil Feed Pipe Hollow Bolt	25 N.m (18 lb ft)
Turbocharger Oil Return Pipe Bolt (M6)	10 N.m (89 lb in)
Turbocharger Oil Return Pipe Bolt (M8)	25 N.m (18 lb ft)
Turbocharger Wastegate Actuator Pipe Bracket Bolt	10 N.m (89 lb in)
Turbocharger Wastegate Actuator Pipe Nut	10 N.m (89 lb in)
Water Pump Bolt	25 N.m (18 lb ft)

APPROXIMATE FLUID CAPACITIES

Application	Specification	
	Metric	English
Engine Cooling System Capacity	5.9 liters	6.23 quarts
Engine Oil Capacity	5 liters	5.28 quarts

ENGINE MECHANICAL SPECIFICATIONS

Application	Specification	
	Metric	English
General Data		
• RPO	LH7	
• Engine Type	4-Cylinder Inline	
• Displacement	1598 ccm	97.5 cu in
• Bore Diameter	79.7 mm	3.14 in
• Stroke	80.1 mm	3.15 in
• Bore Distance	88.7 mm	3.49 in
• Compression Ratio	16.0:1	
• Output @ Engine Speed	100 kW / 4000 RPM	
• Torque @ Engine Speed	320 N.m / 2000 RPM	236 lb ft / 2000 RPM
• Idle Speed	800 RPM	
• No-Load max. Speed	5500 RPM	
• Compression	2000 kPa	290 PSI
• Leakage of Pressure	< 25% per Cylinder	
• Injection Pressure of the Common Rail System	200 MPa	29008 PSI
Engine Management		
• ECM Type	E98 D1P	
• Injection Pressure Pump Type	D1P	

Application	Specification	
	Metric	English
Injector Type	Denso - G3.5S	
Firing Order	1 - 3 - 4 - 2	
Glow Plug Type	without Pressure Sensor	
Glow Plug Voltage	4.4 Volt	
Oil Circulation System		
Engine Oil Filling with Oil Filter	Refer to Approximate Fluid Capacities	
Engine Oil Filling between "min." and "max."	1.0 L	1.06 quarts
Engine Oil Quality	ACEA C3 or A3/B4	
Engine Oil Viscosity	0W-30, 5W-30, 0W-40, 5W-40	
Disposal of Engine Oil	For disposal the engine oil follow safety regulations and national legislation.	
Oil Consumption / 1000 km	max 0.6 L	max 0.63 quarts
Oil Pump		
Oil Pump Type	2 Steps Variable Displacement Oil Pump with Solenoid Control	
Oil Pressure with Idle Speed and under hot running conditions		
Solenoid: On	> 100 kPa / 800 RPM	
Solenoid: Off	> 100 kPa / 800 RPM	
Oil Pressure with 4000 RPM under hot running conditions		
Solenoid: On	260-280 kPa / 4000 RPM	
Solenoid: Off	660-680 kPa / 4000 RPM	
Coolant System		
Type of Coolant Pump	Non Switchable Water Pump	
Filling	Refer to Approximate Fluid Capacities	

Application	Specification	
	Metric	English
Coolant Flow Cylinder Block inlet with 4000 RPM	167 L / min	44.12 gal / min
Coolant Flow Radiator Flow with 4000 RPM	130 L / min	34.34 gal / min
Coolant pressurization	240 kPa	34.8 PSI
Thermostat		
Type	Thermal Controlled Thermostat	
Start to Opening	88Â°C	190.4Â°F
Fully Open	102Â°C	215.6Â°F
Cylinder Head Gasket		
Cylinder Head Gasket Thickness / Piston Projection Dimension (identification mark on Position I)	1.06-1.20 mm / 0.193 - 0.350 mm	0.042-0.047 in / 0.008 - 0.014 in
Cylinder Head Gasket Thickness / Piston Projection Dimension (identification mark on Position II)	1.155-1.305 mm / 0.350 - 0.450 mm	0.045-0.051 in / 0.014 - 0.018 in
Cylinder Head Gasket Thickness / Piston Projection Dimension (identification mark on Position III)	1.255-1.405 mm / 0.450 - 0.565 mm	0.049-0.055 in / 0.018 - 0.022 in
Cylinder Head		
Cylinder Head Height	127 Â± 0.15 mm	5.000 Â± 0.006 in
Maximum Sag of Cylinder Head	0.10 mm	0.0039 in
Valve Seat Angle at Valve Head	45 degrees Â± 20 minutes	45 degrees Â± 0.33 degrees
Valve Guide External Diameter Standard	9.528-9.539 mm	0.3751-0.3756 in
Valves		
Valve Stem Diameter - Intake	4.969-4.985 mm	0.1956-0.1963 in
Valve Stem Diameter - Exhaust	4.959-4.975 mm	0.1952-0.1959 in
Valve Spring Length - Unstressed	42.87 mm	1.688 in
Valve Spring Length - 22.8 - 25.2 daN	32.0 mm	1.260 in
Valve Spring Length - 44.2 - 44.7 daN	24.0 mm	0.945 in

Application	Specification	
	Metric	English
Valve Diameter Intake	26.54-26.8 mm	1.0449-1.0551 in
Valve Diameter Exhaust	24.24-24.5 mm	0.9543-0.9646 in
Engine Block		
Engine Block Height	220.25 mm	8.67 in
Conrod Length	135 mm	5.32 in
Compression Height	46.65 mm	1.84 in
Cylinder Bore		
Cylinder Bore Diameter	79.692-79.708 mm	3.1375-3.1381 in
Oval Diameter Range	$\hat{A} \pm 0.013$ mm	$\hat{A} \pm 0.0005$ in
Oversize Cylinder Bore Diameter	0.25 mm	0.0098 in
Camshaft		
Camshaft Bearing Journal Diameter - 1-4 Bearing Journal	23.948 $\hat{A} \pm 0.012$ mm	0.9428 $\hat{A} \pm 0.0005$ in
Camshaft Bearing Journal Diameter - Rear Bearing Journal	28.448 $\hat{A} \pm 0.012$ mm	1.1200 $\hat{A} \pm 0.0005$ in
Camshaft Axial Clearance	0.090-0.190 mm	0.0035-0.0075 in
Camshaft Bearing		
Camshaft Bearing Diameter - 1-4 Bearing Journal	24.000-24.020 mm	0.9448-0.9457 mm
Camshaft Bearing Diameter - Rear Bearing Journal	28.500-28.520 mm	1.1220-1.1228 in
Connecting Rod		
Con Rod Bearing Bushing Internal Diameter	29.017-29.031 mm	1.1424-1.1429 in
Con Rod Big End Bore Diameter	52.992-53.008 mm	2.0863-2.0869 in
Connecting Rod Bearing	$\hat{A}$	$\hat{A}$
Con Rod Bearing Shell Thickness (Upper Shell - Blue - Class B)	1.469-1.473 mm	0.0578-0.0580 in
Con Rod Bearing Shell Thickness (Lower Shell - Blue - Class B)	1.469-1.473 mm	0.0578-0.0580 in

Application	Specification	
	Metric	English
Con Rod Bearing Shell Thickness (Upper Shell - Yellow - Class C)	1.473-1.477 mm	0.0580-0.0581 in
Con Rod Bearing Shell Thickness (Lower Shell - Yellow - Class C)	1.473-1.477 mm	0.0580-0.0581 in
Con Rod Bearing Shell Thickness (Upper Shell - Green - Class D)	1.477-1.481 mm	0.0581-0.0583 in
Con Rod Bearing Shell Thickness (Lower Shell - Green - Class D)	1.477-1.481 mm	0.0581-0.0583 in
Con Rod Bearing Shell Thickness (Upper Shell - Black - Class E)	1.481-1.485 mm	0.0583-0.0585 in
Con Rod Bearing Shell Thickness (Lower Shell - Black - Class E)	1.481-1.485 mm	0.0583-0.0585 in
Con Rod Bearing Shell Thickness Oversize (Upper Shell)	1.535-1.545 mm	0.0604-0.0608 in
Con Rod Bearing Shell Thickness Oversize (Lower Shell)	1.535-1.541 mm	0.0604-0.0607 in
Con Rod Bearing Clearance	0.072-0.02 mm	0.0028-0.0008 in
Crankshaft		
Main Bearing Journal Diameter Standard Size	52.982-52.998 mm	2.0859-2.0865 in
Main Bearing Journal Diameter Undersize	52.855-52.871 mm	2.0809-2.0815 in
Crankshaft Journal Width for Thrust Bearing	25.810-25.890 mm	1.0161-1.0193 in
Connecting Rod Bearing Journal Diameter	49.992-50.008 mm	1.9682-1.9688 in
Main Bearing		
Main Bearing Shell Thickness Standard Size	2.261-2.269 mm	0.0890-0.0893 in
Main Bearing Shell Thickness Oversize	2.324-2.332 mm	0.0915-0.0918 in
Axial Thrust Washers Thickness	2.000-2.030 mm	0.0787-0.0799 in
Axial Clearance	0.110-0.330 mm	0.0043-0.0130 in

Application	Specification	
	Metric	English
Main Bearing Clearance	0.038-0.086 mm	0.0015-0.0034 in
Engine Block		
Bearing Bore Diameter in Cylinder Block	57.551 Å± 0.007 mm	2.2658 Å± 0.00028 in
Piston		
Piston Diameter	79.655 Å± 0.007 mm	3.1360 Å± 0.00028 in
Piston Projection Dimension	0.193-0.565 mm	0.0076-0.0222 in
Piston Pin Diameter	28.997-29.000 mm	1.1416-1.1417 in
Piston Pin Eye Diameter	29.008-29.013 mm	1.1420-1.1422 in
Clearance Piston Pin in Piston	0.008-0.016 mm	0.0003-0.0006 in
Clearance Piston Pin in Con Rod	0.017-0.034 mm	0.0007-0.0013 in
Piston Weight Difference	Å± 0.005 kg	
Piston Rings		
Compression Ring 1 - Thickness	1.47-1.495 mm	0.0579-0.0589 in
Compression Ring 2 - Thickness	1.47-1.495 mm	0.0579-0.0589 in
Oil Scraper Ring - Thickness	1.97-1.99 mm	0.0776-0.0783 in
Compression Ring 1 - Axial Clearance	0.115-0.16 mm	0.0045-0.0063 in
Compression Ring 2 - Axial Clearance	0.095-0.14 mm	0.0037-0.0055 in
Oil Scraper Ring - Axial Clearance	0.025-0.065 mm	0.0010-0.0026 in
Compression Ring 1 - Gap	0.20-0.35 mm	0.0079-0.0137 in
Compression Ring 2 - Gap	0.5-0.7 mm	0.0197-0.0276 in
Oil Scraper Ring - Gap	0.25-0.5 mm	0.0098-0.0197 in

ADHESIVES, FLUIDS, LUBRICANTS, AND SEALERS

Application	Type of Material	GM Part Number

Application	Type of Material	United States Part Number	Canada Part Number
Anti-Seize Compound	Lubricant	88862477	88862478
Bolt Connections	Threadlocker	12345382	10953489
Engine Oil	DEXOS2, 5W-30	19354306	19354309
Exhaust Emission Reduction Fluid	Fluid	19286291	88865654
Oil Pan Sealant	Sealant	12378521	10953476
Top Engine Cleaner	Cleaner	1052626	993026

SCHEMATIC WIRING DIAGRAMS

ENGINE MECHANICAL WIRING SCHEMATICS (1.6L (LH7))

Oil Pressure Control (LH7)

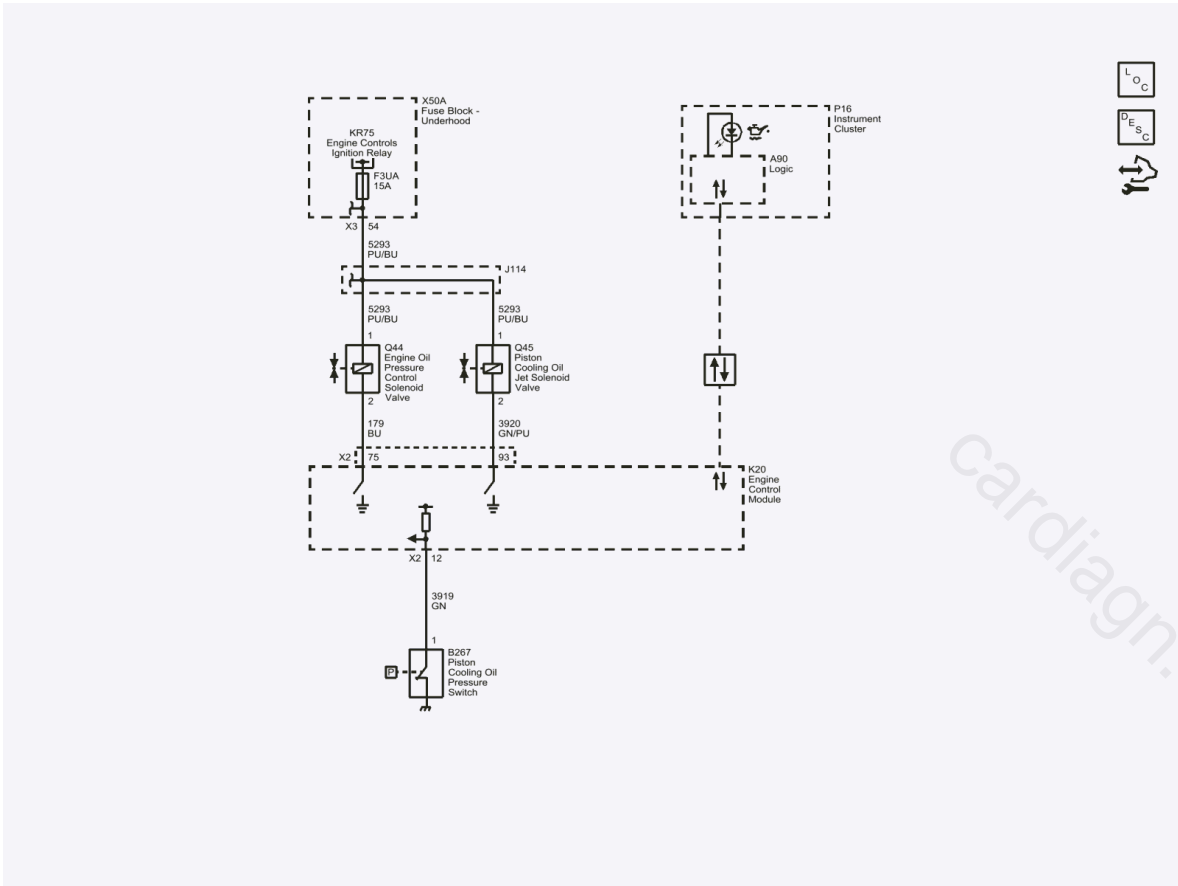


Fig. 1: Oil Pressure Control (LH7)
Courtesy of GENERAL MOTORS COMPANY

COMPONENT LOCATOR

DISASSEMBLED VIEWS

Intake Manifold

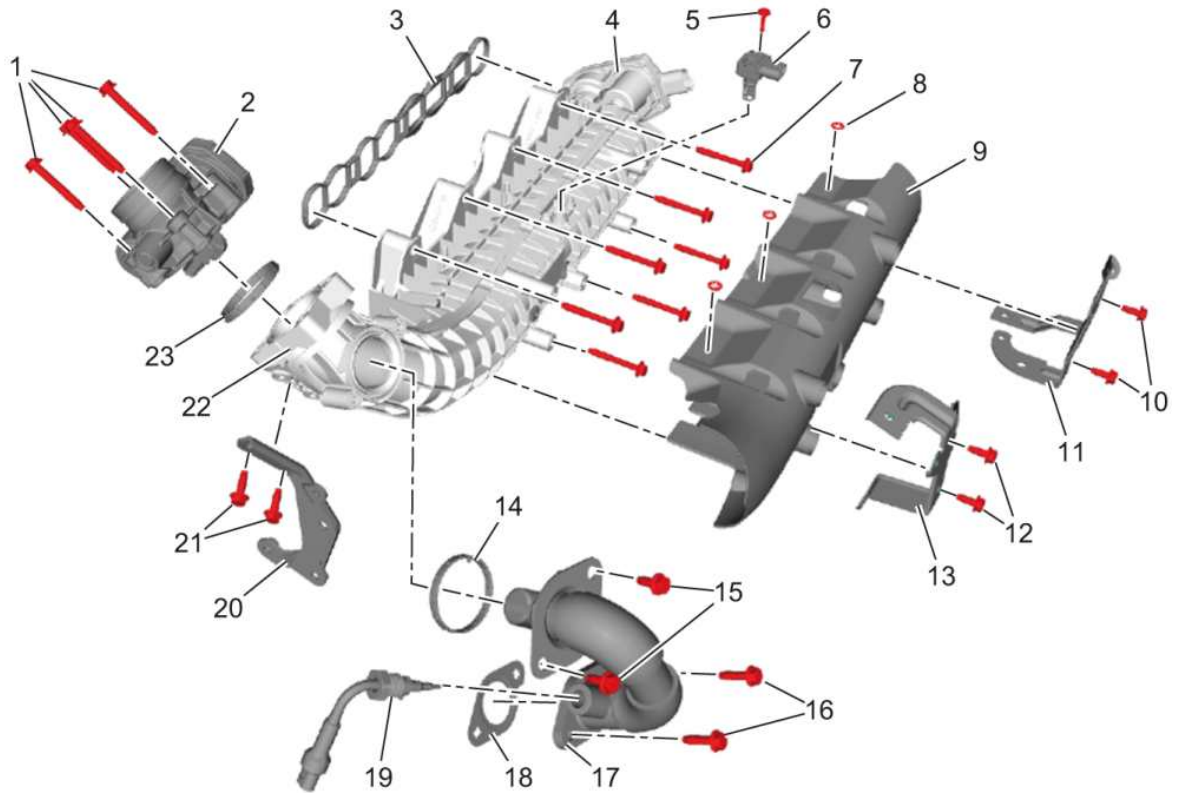


Fig. 2: Intake Manifold Components
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Throttle Body Bolt
2	Throttle Body
3	Intake Manifold Gasket
4	Intake Manifold Runner Control Valve Actuator
5	Intake Air Pressure and Temperature Sensor Bolt
6	Intake Air Pressure and Temperature Sensor
7	Intake Manifold Bolt
8	Intake Manifold Cover Washer
9	Intake Manifold Cover
10	Fuel Injection Fuel Return Pipe Bracket Bolt
11	Fuel Injection Fuel Return Pipe Bracket
12	Fuel Injection Fuel Rail Pressure Sensor Wiring Harness Bracket Bolt
13	Fuel Injection Fuel Rail Pressure Sensor Wiring Harness Bracket
14	Exhaust Gas Recirculation Cooler Outlet Pipe Seal
15	Exhaust Gas Recirculation Cooler Outlet Pipe Bolt
16	Exhaust Gas Recirculation Cooler Outlet Pipe Bolt
17	Exhaust Gas Recirculation Cooler Outlet Pipe
18	Exhaust Gas Recirculation Cooler Outlet Pipe Gasket
19	Exhaust Gas Recirculation Cooler Temperature Sensor-Position 2
20	Intake Manifold Brace
21	Intake Manifold Brace Bolt
22	Intake Manifold
23	Throttle Body Seal

Turbocharger

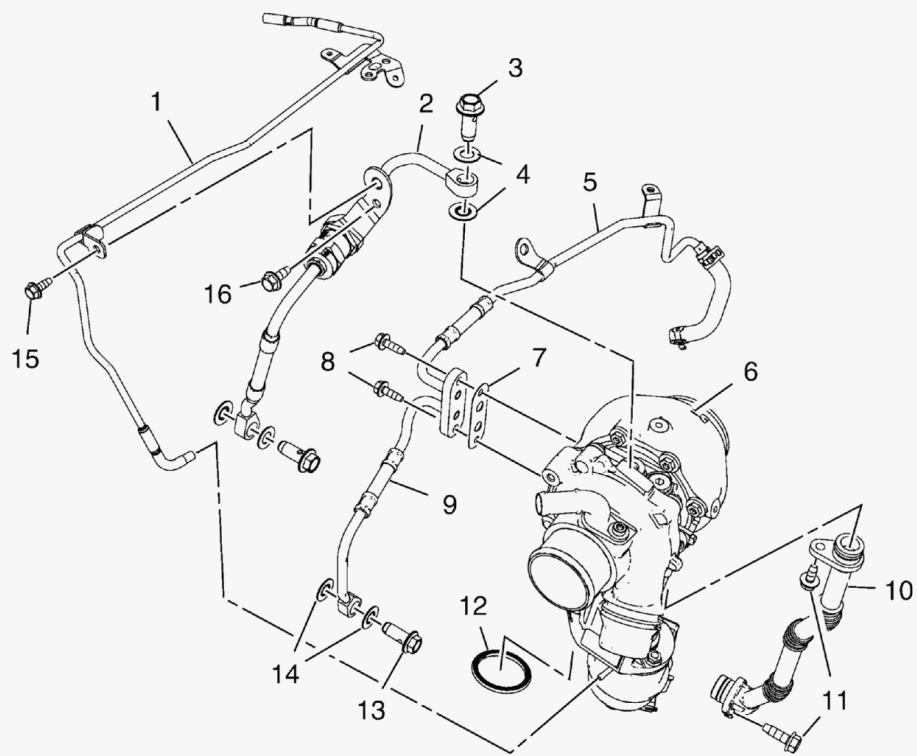


Fig. 3: Turbocharger Components
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Turbocharger Wastegate Actuator Pipe
2	Turbocharger Oil Feed Pipe
3	Turbocharger Oil Feed Pipe Bolt
4	Turbocharger Oil Feed Pipe Gaskets
5	Turbocharger Coolant Return Pipe
6	Turbocharger
7	Turbocharger Coolant Feed and Return Pipe Gasket
8	Turbocharger Coolant Feed and Return Pipe Bolts
9	Turbocharger Coolant Feed Pipe
10	Turbocharger Oil Return Pipe
11	Turbocharger Oil Return Pipe Bolts
12	Turbocharger Gasket
13	Turbocharger Coolant Feed Pipe Bolt
14	Turbocharger Coolant Feed Pipe Gaskets
15	Turbocharger Wastegate Actuator Pipe Bracket Bolt
16	Turbocharger Oil Feed Pipe Bracket Bolt

Exhaust Manifold

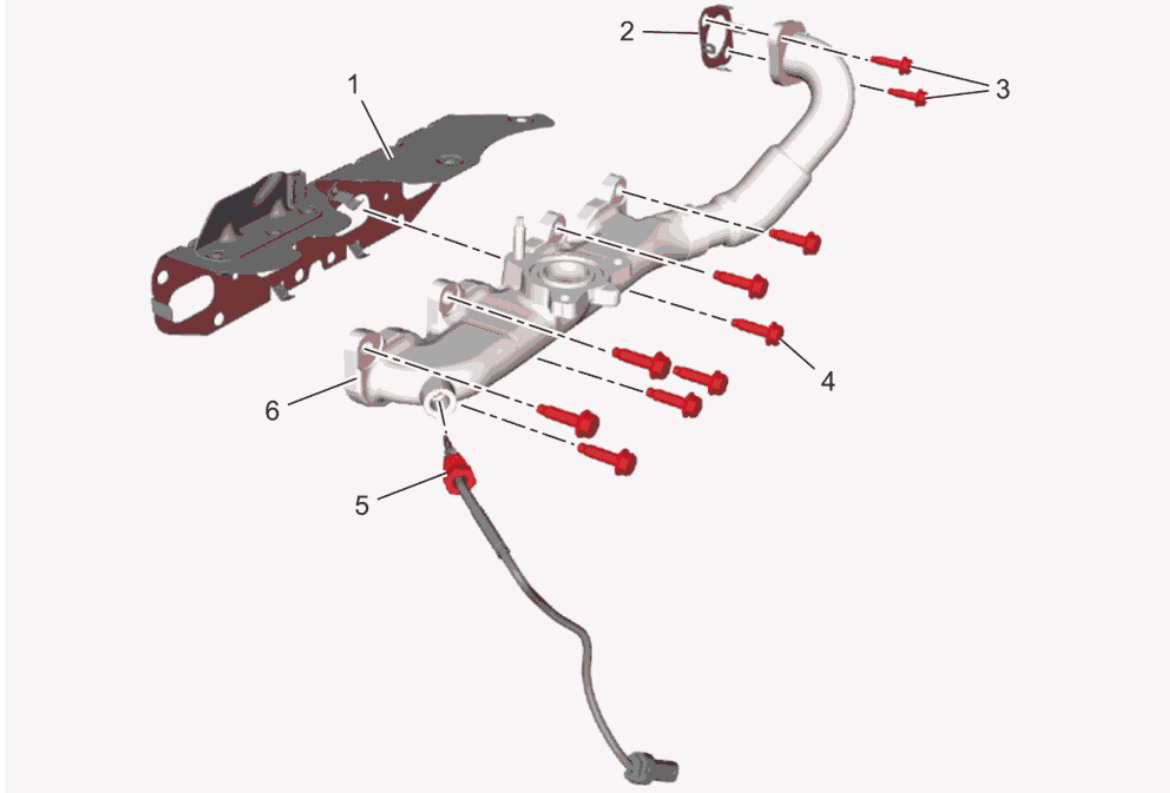


Fig. 4: Exhaust Manifold Components
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Exhaust Manifold Gasket
2	Exhaust Gas Recirculation Pipe Gasket
3	Exhaust Gas Recirculation Pipe Bolt
4	Exhaust Manifold Bolt
5	Exhaust Gas Recirculation Cooler Temperature Sensor-Position 1
6	Exhaust Manifold

Fuel Injection Fuel System

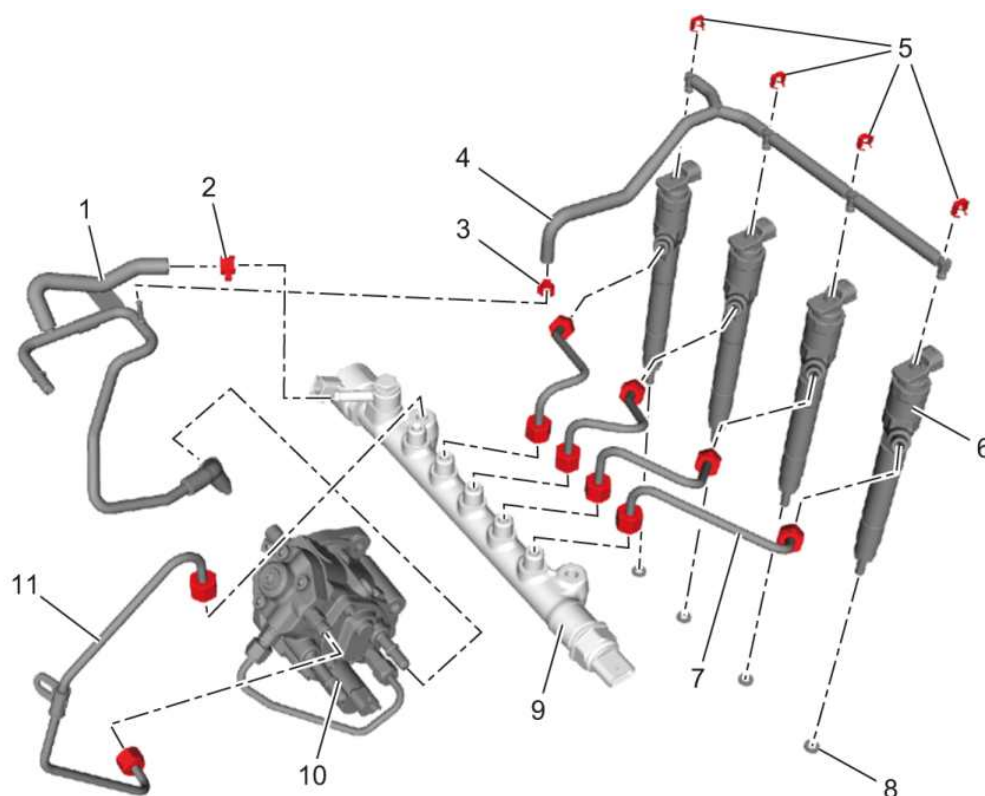


Fig. 5: Fuel Injection Fuel System Components
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Diesel Fuel Separator
2	Diesel Fuel Separator Hose Clamp
3	Fuel Return Hose Clamp
4	Fuel Return Hose
5	Fuel Return Hose Clip
6	Fuel Injector
7	Fuel Injection Fuel Feed Pipe - Fuel Rail to Fuel Injector
8	Fuel Injector Seal Ring
9	Fuel Rail
10	Fuel Injection Pump
11	Fuel Injection Fuel Feed Pipe - Fuel Injection Pump to Fuel Rail

Timing Chain System

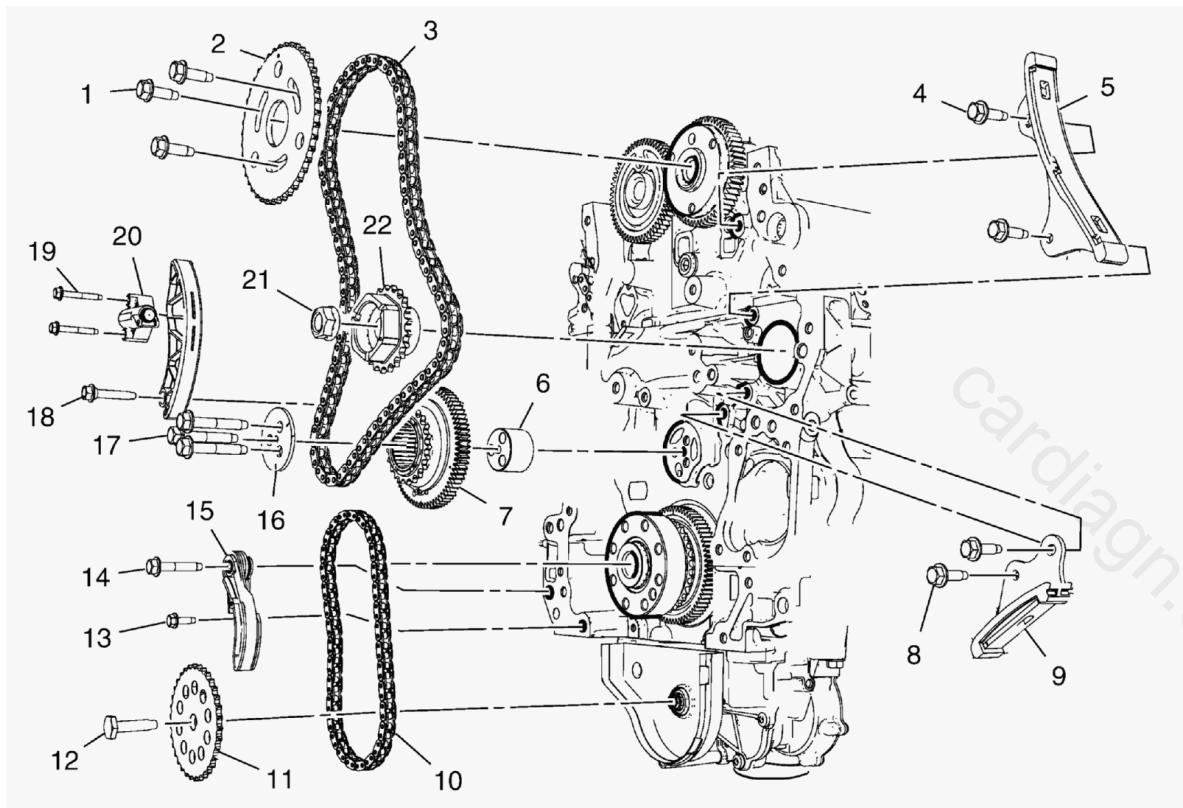


Fig. 6: Timing Chain System Components
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Camshaft Sprocket Bolts
2	Camshaft Sprocket
3	Timing Chain
4	Timing Chain Upper Guide Bolts
5	Timing Chain Upper Guide
6	Gear Shaft Distributor
7	Timing Chain Idler Sprocket
8	Timing Chain Lower Guide Bolts
9	Timing Chain Lower Guide
10	Oil Pump Drive Chain
11	Oil pump Sprocket
12	Oil Pump Sprocket Bolt
13	Oil Pump Drive Chain Tensioner Bolts
14	Oil Pump Drive Chain Tensioner Shoe Bolt
15	Oil Pump Drive Chain Tensioner
16	Timing Chain Idler Sprocket Bearing Plate

Callout	Component Name
17	Timing Chain Idler Sprocket Bolts
18	Timing Chain Tensioner Shoe Bolt
19	Timing Chain Tensioner Bolts
20	Timing Chain Tensioner
21	Fuel Injection Fuel Pump Sprocket Bolt
22	Fuel Injection Fuel Pump Sprocket

Camshaft Housing

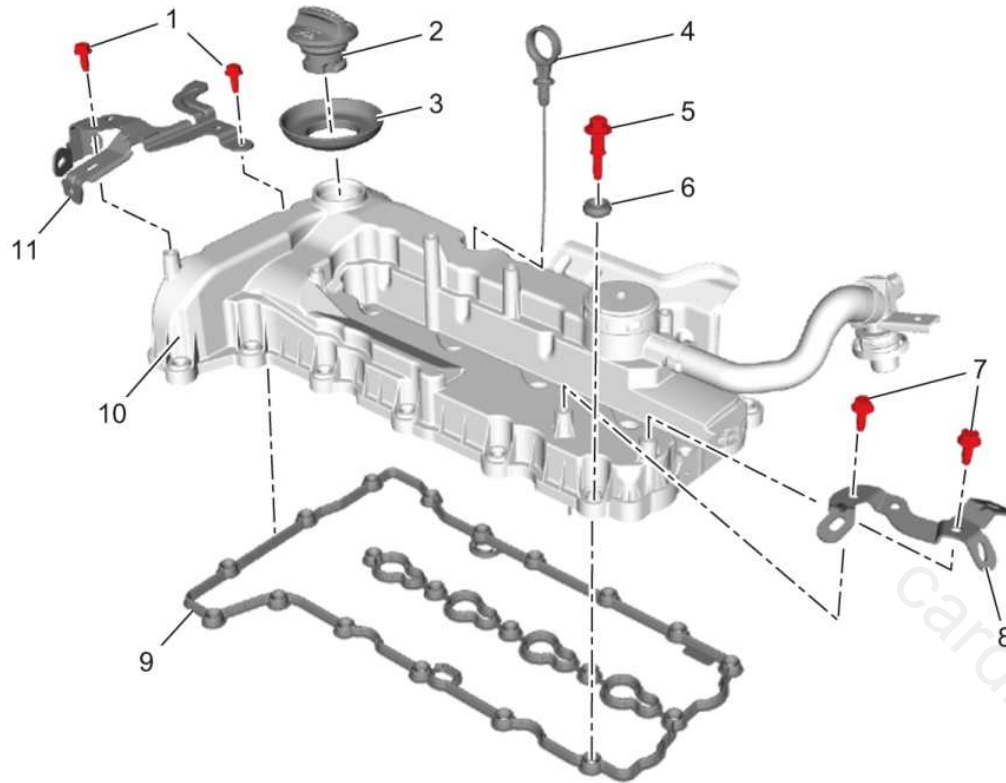


Fig. 7: Camshaft Housing Components

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Wiring Harness Bracket Bolt
2	Oil Filler Cap
3	Oil Filler Tube Gasket
4	Oil Level Indicator
5	Camshaft Housing Cover Bolt
6	Camshaft Housing Cover Insulator
7	Wiring Harness Bracket Bolt
8	Wiring Harness Bracket
9	Camshaft Housing Cover Gasket
10	Camshaft Housing
11	Wiring Harness Bracket

Cylinder Head

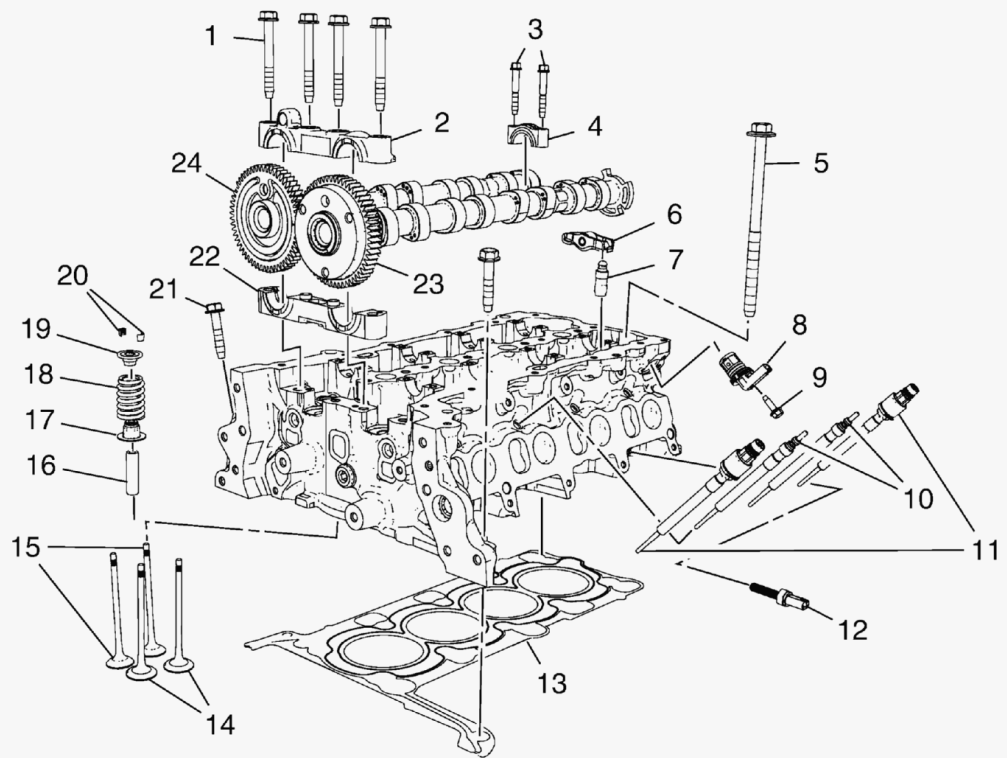


Fig. 8: Cylinder Head Components

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Camshaft Bearing Rear Cap Bolts
2	Camshaft Bearing Rear Cap
3	Camshaft Bearing Cap Bolts
4	Camshaft Bearing Cap
5	Cylinder Head Bolts
6	Valve Lifter Roller
7	Valve Lifter
8	Camshaft Position Sensor
9	Camshaft Position Sensor Bolt
10	Glow Plugs without Pressure Sensor
11	Glow Plugs with Pressure Sensor
12	Engine Metal Temperature Sensor
13	Cylinder Head Gasket
14	Intake Valves
15	Exhaust Valves
16	Valve Guides
17	Valve Stem Oil Seal
18	Valve Spring
19	Valve Spring Retainer
20	Valve Stem Keys
21	Cylinder Head Outer Bolts
22	Camshaft Lower Rear Bearing
23	Intake Camshaft
24	Exhaust Camshaft

Engine Block

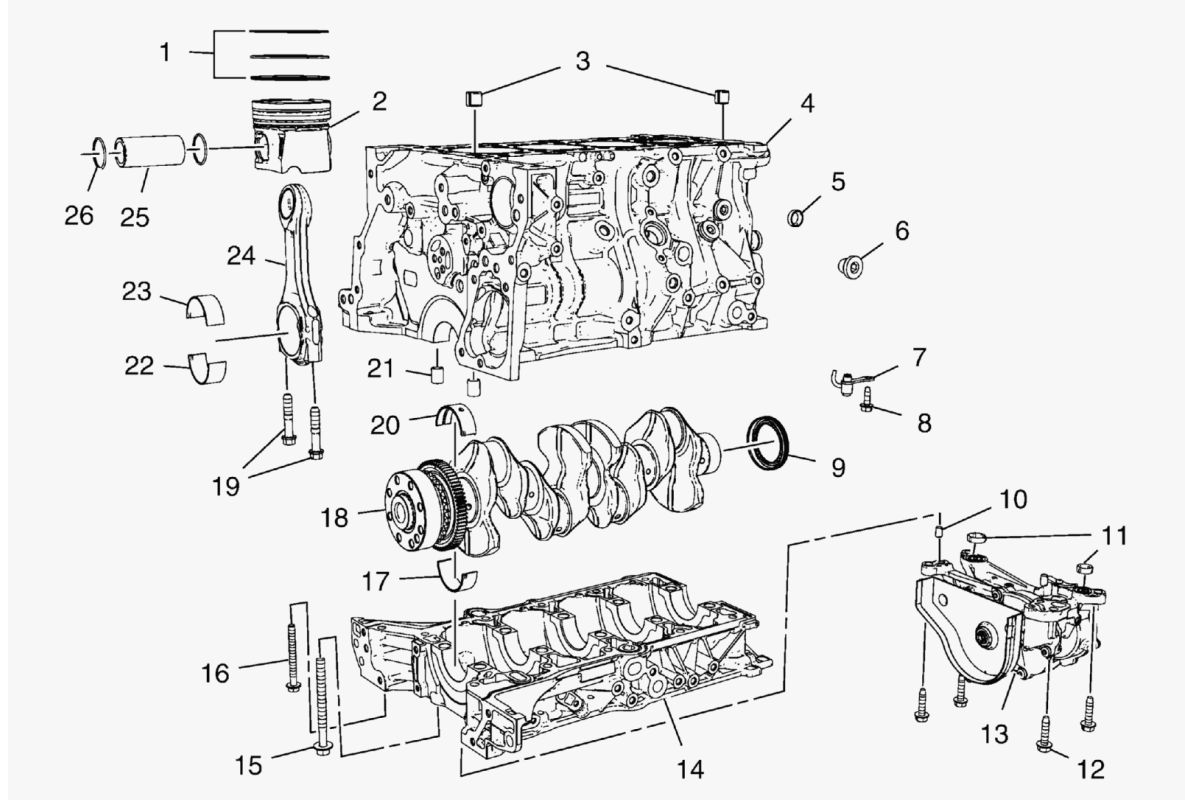


Fig. 9: Engine Block Components

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Piston Rings
2	Piston
3	Cylinder Head Locating Pins
4	Engine Block
5	Oil Gallery Plug
6	Oil Gallery Plug Bolt
7	Piston Oil Nozzle
8	Piston Oil Nozzle Bolt
9	Crankshaft Front Oil Seal
10	Oil Pump Locating Pin
11	Oil and Power Brake Booster Pump Gasket
12	Oil and Power Brake Booster Pump Bolts
13	Oil and Power Brake Booster Pump
14	Lower Crankcase
15	Lower Crankcase Bearing Bolts
16	Lower Crankcase Bolts
17	Crankshaft Lower Bearing
18	Crankshaft
19	Connecting Rod Bearing Cap Bolts
20	Crankshaft Upper Bearing
21	Crankcase Locating Pins
22	Connecting Rod Lower Bearings
23	Connecting Rod Upper Bearings
24	Connecting Rod
25	Piston Pin
26	Piston Pin Retainer

ENGINE IDENTIFICATION

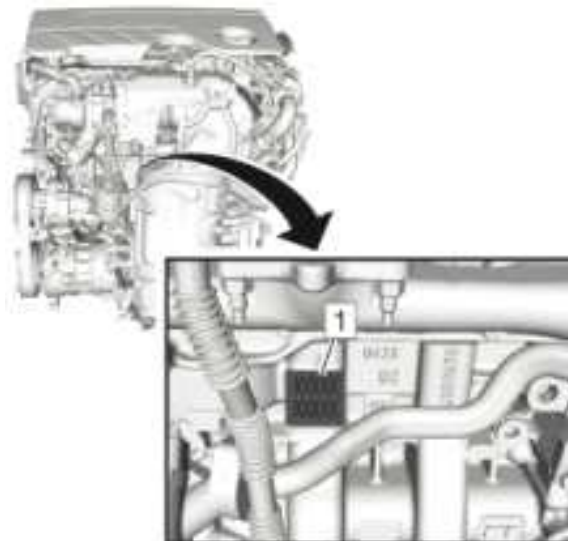


Fig. 10: Broadcast Code Label

Courtesy of GENERAL MOTORS COMPANY

1. Identification can be made through the use of the broadcast code label (1) on the engine.

DIAGNOSTIC INFORMATION AND PROCEDURES

DTC P06DA-P06DE: ENGINE OIL PRESSURE CONTROL SOLENOID VALVE CONTROL CIRCUIT/ENGINE OIL PRESSURE CONTROL SOLENOID VALVE STUCK

Diagnostic Instructions

- Perform the Diagnostic System Check prior to using this diagnostic procedure: [Diagnostic System Check - Vehicle](#)
- Review the description of Strategy Based Diagnosis: [Strategy Based Diagnosis](#)
- An overview of each diagnostic category can be found here: [Diagnostic Procedure Instructions](#)

DTC Descriptor

DTC P06DA

Engine Oil Pressure Control Solenoid Valve Control Circuit

DTC P06DB

Engine Oil Pressure Control Solenoid Valve Control Circuit Low Voltage

DTC P06DC

Engine Oil Pressure Control Solenoid Valve Control Circuit High Voltage

DTC P06DD

Engine Oil Pressure Control Solenoid Valve Stuck Off

DTC P06DE

Engine Oil Pressure Control Solenoid Valve Stuck On

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition	P06DA, P06DB*	P06DA, P06DB	-	-
Control	P06DB	P06DA	P06DC	P06DD, P06DE

* Additional DTCs may set.

Circuit/System Description

Circuit	Description
Ignition	Supplied from a fuse.
Control	The output circuit is switched to ground to activate the component.

Component	Description
K20 Engine Control Module	The control module controls a series of actuators to ensure optimal engine performance. The control module does this by reading values from a variety of sensors, interprets the data and adjusts the engine actuators accordingly.
Q44 Engine Oil Pressure Control Solenoid Valve	A solenoid valve is an electro-mechanically operated valve. The valve is controlled by an electric current through the solenoid.

The engine oil pressure control solenoid valve is used to control engine oil pressure inside the mechanical engine oil pump. The control module controls the commanded state of the solenoid valve based on the following inputs:

- Engine Speed
- Calculated Engine Oil Temperature
- Engine Oil Pressure
- Engine Run Time

When the solenoid valve is commanded Off, oil pressure is higher. When the solenoid valve is commanded On, oil pressure is lower.

Conditions for Running the DTC

DTC P06DA, P06DB, P06DC

- Ignition Voltage = Greater than 11 V
- Engine = Running

Frequency the DTC runs = Continuously

DTC P06DD, P06DE

- DTC P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0117, P0118, P0119, P0128, P0335, P0336, P0521, P0522, P0523, P06DA, P06DB, P06DC, P06DE, P111E, P2227, P2228, P2229, P2230 = Not set
- Engine = Running - For greater than 10 s
- Engine Speed = 1, 400 to 2, 640 RPM
- Barometric Pressure = Greater than 70 kPa (10 PSI)
- Engine Oil Temperature = 50 to 100°C (122 to 212°F)
- Engine Oil Pressure Control Solenoid Valve = On - For greater than 1.6 s

Frequency the DTC runs = Continuously

Conditions for Setting the DTC

DTC P06DA, P06DB, P06DC

Control Circuit = Commanded state does not match the actual state - For greater than 1 s

DTC P06DD, P06DE

Engine Oil Pressure = Less than a predefined threshold

Actions Taken When the DTC Sets

- DTCs listed in the DTC Descriptor Category = Type B DTC - Exceptions listed below

DTC P06DB, P06DD, P06DE = Type A DTC

- Engine Oil Pressure Control Solenoid Valve = Off
- Reduced Engine Power = Active

Conditions for Clearing the DTC

- DTCs listed in the DTC Descriptor Category = Type B DTC - Exceptions listed below
- DTC P06DB, P06DD, P06DE = Type A DTC

Reference Information

Schematic Reference

Engine Mechanical Wiring Schematics (1.6L (LH7))

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

Electrical Information Reference

- Circuit Testing
- Connector Repairs
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References

Circuit/System Verification

NOTE: The engine oil level and condition is critical to the correct operation of the system.

1. Ignition - On/Vehicle - In Service Mode
2. Verify there are no DTCs set related to the following system/component:
 - B35B Engine Oil Level Sensor
 - B37B Engine Oil Pressure Sensor
 - B37 Engine Oil Pressure Switch
 - **If other DTCs are set**

Refer to: Diagnostic Trouble Code (DTC) List - Vehicle

- **Go to next step: If no other DTCs are set**
3. Verify the condition does not exist: Engine Oil - Contaminated/Dirty/Fill Level = Low
 - **If a condition exists**

Repair as necessary

- **Go to next step: If no condition exists**
4. Perform the scan tool control function: Engine Oil Pressure Control Solenoid Valve - Low Pressure - High Pressure

Verify the scan tool parameter:

- Engine Oil Pressure Control Solenoid Valve Control Circuit Low Voltage Test Status = OK or Not Run
- Engine Oil Pressure Control Solenoid Valve Control Circuit Open Test Status = OK or Not Run
- Engine Oil Pressure Control Solenoid Valve Control Circuit High Voltage Test Status = OK or Not Run
- **If not the specified state**

Refer to: Circuit/System Testing

- **Go to next step: If the specified state**

5. Ignition - On/Vehicle - In Service Mode

6. Verify the scan tool parameter:

- Engine Oil Pressure Control Solenoid Valve Control Circuit Low Voltage Test Status = OK or Not Run
- Engine Oil Pressure Control Solenoid Valve Control Circuit Open Test Status = OK or Not Run
- Engine Oil Pressure Control Solenoid Valve Control Circuit High Voltage Test Status = OK or Not Run
- Perform the action while monitoring the parameter:
- Wiggle the harness and connector: Q44 Engine Oil Pressure Control Solenoid Valve
- Wiggle the harness and connector: K20 Engine Control Module
- **If not the specified state**

Repair as necessary - Wiring/Terminal(s)/Electrical Connector(s)

- **Go to next step: If the specified state**

7. Engine running.

8. Perform the following steps:

1. Increase the engine speed slowly to 1, 800 RPM.

NOTE: Using the scan tool line graph function may make it easier to identify if the value changes.

2. Perform the scan tool control function: Engine Oil Pressure Control Solenoid Valve - Low Pressure

Verify the scan tool parameter: Engine Oil Pressure = Change is greater than 30 kPa (4 PSI)

- If the change is 30 kPa (4 PSI) or less - Replace the component: Q44 Engine Oil Pressure Control Solenoid Valve
 - If the change is greater than 30 kPa (4 PSI)
9. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.

Verify the DTC does not set.

- **If the DTC sets**

Refer to: Circuit/System Testing

- **Go to next step: If the DTC is not set**

10. All OK.

Circuit/System Testing

1. Ignition/Vehicle & All vehicle systems - Off
2. Disconnect the electrical connector: Q44 Engine Oil Pressure Control Solenoid Valve
3. Ignition - On/Vehicle - In Service Mode
4. Verify a test lamp turns On between the test points: Ignition circuit terminal 1 & Ground
 - **If the test lamp does not turn On and the circuit fuse is OK**
 1. Ignition/Vehicle - Off & Remove - Test lamp
 2. Test for less than 2 ohms between the test points: Ignition circuit terminal 1 & Output terminal @ Fuse

- If 2 ohms or greater - Repair the open/high resistance in the circuit.
- If less than 2 ohms - Verify the fuse is OK and there is voltage at the fuse.
- **If the test lamp does not turn On and the circuit fuse is open**

1. Ignition/Vehicle - Off & Remove - Test lamp

NOTE: **The ignition circuit supplies voltage to other components. Test all circuits for a short to ground or test all components for being shorted.**

2. Test for infinite resistance between the test points: Ignition circuit terminal 1 & Ground

- If less than infinite resistance - Repair the short to ground on the circuit.
- If infinite resistance - Replace the component: Q44 Engine Oil Pressure Control Solenoid Valve

• **Go to next step: If the test lamp turns On**

5. Verify a test lamp does not turn On between the test points: Control circuit terminal 2 & B+

• **If the test lamp turns On**

1. Ignition/Vehicle - Off & Remove - Test lamp

2. Disconnect the electrical connector: K20 Engine Control Module

3. Test for infinite resistance between the test points: Control circuit terminal 2 @ Component harness & Ground

- If less than infinite resistance - Repair the short to ground on the circuit.
- If infinite resistance - Replace the component: K20 Engine Control Module

• **Go to next step: If the test lamp does not turn On**

6. Remove - Test Lamp

7. Perform the scan tool control function: Engine Oil Pressure Control Solenoid Valve - Low Pressure

Verify the scan tool parameter: Engine Oil Pressure Control Solenoid Valve Control Circuit High Voltage Test Status = OK or Not Run

• **If not the specified state**

1. Ignition/Vehicle - Off

2. Disconnect the electrical connector: K20 Engine Control Module

3. Ignition - On/Vehicle - In Service Mode

4. Test for less than 1 V between the test points: Control circuit terminal 2 @ Component harness & Ground

- If 1 V or greater - Repair the short to voltage on the circuit.
- If less than 1 V - Replace the component: K20 Engine Control Module

• **Go to next step: If the specified state**

8. Connect a 3 A fused jumper wire between the test points: Control circuit terminal 2 & Ignition circuit terminal 1/A

9. Perform the scan tool control function: Engine Oil Pressure Control Solenoid Valve - Low Pressure

Verify the scan tool parameter: Engine Oil Pressure Control Solenoid Valve Control Circuit High Voltage Test Status = Malfunction

• **If not the specified state**

1. Ignition/Vehicle - Off & Remove - Jumper wire(s)

2. Disconnect the electrical connector: K20 Engine Control Module

3. Test for less than 2 ohms between the test points: Control circuit terminal 2 @ Component harness & The other end of the circuit @ Control module harness

- If 2 ohms or greater - Repair the open/high resistance in the circuit.
- If less than 2 ohms - Replace the component: K20 Engine Control Module

• **Go to next step: If the specified state**

10. Test or replace the component: Q44 Engine Oil Pressure Control Solenoid Valve

Static Test

1. Ignition/Vehicle - Off
2. Disconnect the electrical connector: Q44 Engine Oil Pressure Control Solenoid Valve
3. Test for 10 to 30 ohms between the test points: Control terminal 2 & Ignition terminal 1

- **If not between 10 and 30 ohms**

Replace the component: Q44 Engine Oil Pressure Control Solenoid Valve

- **Go to next step: If between 10 and 30 ohms**

4. Test for infinite resistance between the test points: Each terminal of the component & The component's housing

- **If less than infinite resistance**

Replace the component: Q44 Engine Oil Pressure Control Solenoid Valve

- **Go to next step: If infinite resistance**

5. All OK.

Dynamic Test

1. Ignition/Vehicle - Off
2. Disconnect the electrical connector: Q44 Engine Oil Pressure Control Solenoid Valve
3. Connect a 3 A fused jumper wire between the test points: Ignition terminal 1 & 12 V

CAUTION: Complete the testing as quickly as possible in order to prevent overheating and damaging the component.

4. Momentarily connect a jumper wire between the test points: Control terminal 2 & Ground

Verify the component turns On and Off when connecting and disconnecting the jumper wire: Q44 Engine Oil Pressure Control Solenoid Valve

- **If the component does not turn On and Off**

Replace the component: Q44 Engine Oil Pressure Control Solenoid Valve

- **Go to next step: If the component turns On and Off**

5. All OK.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair: [Diagnostic Repair Verification](#)

- Refer to [Oil Pump Flow Control Solenoid Valve Replacement \(AWD\)](#), [Oil Pump Flow Control Solenoid Valve Replacement \(FWD\)](#) - Q44 Engine Oil Pressure Control Solenoid Valve
- For control module replacement, programming, and setup refer to: [Control Module References](#)

DTC P25A9, P25AA, OR P25AB: PISTON COOLING OIL JET SOLENOID VALVE CONTROL CIRCUIT

Diagnostic Instructions

- Perform the Diagnostic System Check prior to using this diagnostic procedure: [Diagnostic System Check - Vehicle](#)
- Review the description of Strategy Based Diagnosis: [Strategy Based Diagnosis](#)
- An overview of each diagnostic category can be found here: [Diagnostic Procedure Instructions](#)

DTC Descriptor

DTC P25A9

Piston Cooling Oil Jet Solenoid Valve Control Circuit

DTC P25AA

Piston Cooling Oil Jet Solenoid Valve Control Circuit Low Voltage

DTC P25AB

Piston Cooling Oil Jet Solenoid Valve Control Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition	P25AA*	P25A9, P25AA, P25AC	-	-
Control	P25AA	P25A9	P25AB	-
* Additional DTCs may set.				

Circuit/System Description

For an overview of the component/system, refer to: [Lubrication Description](#)

Circuit	Description
Ignition	Supplied from a fuse.
Control	The output circuit is switched to ground to activate the component.

Component	Description
Q45 Piston Cooling Oil Jet Solenoid Valve	A solenoid valve is an electro-mechanically operated valve. The valve is controlled by an electric current through the solenoid.
K20 Engine Control Module	The control module controls a series of actuators to ensure optimal engine performance. The control module does this by reading values from a variety of sensors, interprets the data and adjusts the engine actuators accordingly.

Conditions for Running the DTC

DTC P25A9, P25AA, P25AB

- Ignition Voltage = Greater than 11 V
- Engine = Running

Frequency the DTC runs = Continuously - After the running conditions are met

Conditions for Setting the DTC

DTC P25A9, P25AA, P25AB

Control Circuit = Commanded state does not match the actual state - For greater than 1 s

Actions Taken When the DTC Sets

DTCs listed in the DTC Descriptor Category = Type B DTC

Conditions for Clearing the DTC

DTCs listed in the DTC Descriptor Category = Type B DTC

Reference Information

Schematic Reference

[Engine Controls Wiring Schematics \(1.6L \(LH7\)\)](#)

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

Electrical Information Reference

- [Circuit Testing](#)
- [Connector Repairs](#)
- [Testing for Intermittent Conditions and Poor Connections](#)
- [Wiring Repairs](#)

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References

Circuit/System Verification

NOTE: The engine oil level and condition is critical to the correct operation of the system.

1. Ignition - On/Vehicle - In Service Mode
2. Perform the scan tool control function: Piston Cooling Oil Jet Solenoid Valve - On and Off

Verify the scan tool parameter:

- Piston Cooling Oil Jet Solenoid Valve Control Circuit High Voltage Test Status = OK or Not Run
- Piston Cooling Oil Jet Solenoid Valve Control Circuit Low Voltage Test Status = OK or Not Run
- Piston Cooling Oil Jet Solenoid Valve Control Circuit Open Test Status = OK or Not Run
- **If not the specified state**

Refer to: Circuit/System Testing

- **Go to next step: If the specified state**

3. Perform the scan tool control function: Piston Cooling Oil Jet Solenoid Valve - On and Off

Verify the scan tool parameter:

- Piston Cooling Oil Jet Solenoid Valve Control Circuit High Voltage Test Status = OK or Not Run
- Piston Cooling Oil Jet Solenoid Valve Control Circuit Low Voltage Test Status = OK or Not Run
- Piston Cooling Oil Jet Solenoid Valve Control Circuit Open Test Status = OK or Not Run
- Perform the action while monitoring the parameter:
- Wiggle the harness and connector: Q45 Piston Cooling Oil Jet Solenoid Valve
- Wiggle the harness and connector: K20 Engine Control Module
- **If not the specified state**

Repair as necessary - Wiring/Terminal(s)/Electrical Connector(s)

- **Go to next step: If the specified state**

4. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.

Verify the DTC does not set.

- **If the DTC sets**

- **Go to next step: If the DTC is not set**

5. All OK.

Circuit/System Testing

1. Ignition/Vehicle & All vehicle systems - Off
2. Disconnect the electrical connector: Q45 Piston Cooling Oil Jet Solenoid Valve
3. Ignition - On/Vehicle - In Service Mode
4. Verify a test lamp turns On between the test points: Ignition circuit terminal 1 & Ground
 - **If the test lamp does not turn On and the circuit fuse is OK**
 1. Ignition/Vehicle - Off & Remove - Test lamp
 2. Test for less than 2 ohms between the test points: Ignition circuit terminal 1 & Output terminal @ Fuse
 - If 2 ohms or greater - Repair the open/high resistance in the circuit.
 - If less than 2 ohms - Verify the fuse is OK and there is voltage at the fuse.
 - **If the test lamp does not turn On and the circuit fuse is open**
 1. Ignition/Vehicle - Off & Remove - Test lamp
 2. Connect the electrical connector: Q45 Piston Cooling Oil Jet Solenoid Valve
 3. Ignition - On/Vehicle - In Service Mode
 4. Replace the component: Fuse
 5. Verify the fuse does not open.
 - If the fuse opens and there are components connected to the circuit - Disconnect a component and repeat step 4.4
 - If the fuse opens with all components disconnected from the circuit - Repair the short to ground on the circuit.
 - If the fuse does not open after disconnecting a component from the circuit - Replace the component disconnected last.
 - If the fuse does not open with all components connected.
 6. Verify the fuse does not open when any of the components are activated.
 - If the fuse opens - Replace the component that caused the fuse to open when activated.
 - If the fuse does not open.
 7. All OK.
5. Verify a test lamp does not turn On between the test points: Control circuit terminal 2 & B+
 - **If the test lamp turns On**
 1. Ignition/Vehicle - Off & Remove - Test lamp
 2. Disconnect the electrical connector: K20 Engine Control Module
 3. Test for infinite resistance between the test points: Control circuit terminal 2 @ Component harness & Ground
 - If less than infinite resistance - Repair the short to ground on the circuit.
 - If infinite resistance - Replace the component: K20 Engine Control Module
 - **Go to next step: If the test lamp does not turn On**
6. Remove - Test Lamp
7. Perform the scan tool control function: Piston Cooling Oil Jet Solenoid Valve - On

Verify the scan tool parameter: Piston Cooling Oil Jet Solenoid Valve Control Circuit High Voltage Test Status = OK or Not Run

- **If not the specified state**
 1. Ignition/Vehicle - Off
 2. Disconnect the electrical connector: K20 Engine Control Module
 3. Ignition - On/Vehicle - In Service Mode

4. Test for less than 1 V between the test points: Control circuit terminal 2 @ Component harness & Ground

- If 1 V or greater - Repair the short to voltage on the circuit.
- If less than 1 V - Replace the component: K20 Engine Control Module

• **Go to next step: If the specified state**

8. Connect a 3 A fused jumper wire between the test points: Control circuit terminal 2 & Ignition circuit terminal 1

9. Perform the scan tool control function: Piston Cooling Oil Jet Solenoid Valve - On

Verify the scan tool parameter: Piston Cooling Oil Jet Solenoid Valve Control Circuit High Voltage Test Status = Malfunction

• **If not the specified state**

1. Ignition/Vehicle - Off & Remove - Jumper wire(s)

2. Disconnect the electrical connector: X2 @ K20 Engine Control Module

3. Test for less than 2 ohms between the test points: Control circuit terminal 2 @ Component harness & The other end of the circuit @ Control module harness

- If 2 ohms or greater - Repair the open/high resistance in the circuit.
- If less than 2 ohms - Replace the component: K20 Engine Control Module

• **Go to next step: If the specified state**

10. Test or replace the component: Q45 Piston Cooling Oil Jet Solenoid Valve

Component Testing

Static Test

1. Ignition/Vehicle - Off

2. Disconnect the electrical connector: Q45 Piston Cooling Oil Jet Solenoid Valve

3. Test for 10 to 30 ohms between the test points: Control terminal 2 & Ignition terminal 1

• **If not between 10 and 30 ohms**

Replace the component: Q45 Piston Cooling Oil Jet Solenoid Valve

• **Go to next step: If between 10 and 30 ohms**

4. Test for infinite resistance between the test points: Each terminal of the component & The component's housing

• **If less than infinite resistance**

Replace the component: Q45 Piston Cooling Oil Jet Solenoid Valve

• **Go to next step: If infinite resistance**

5. All OK.

Dynamic Test

1. Ignition/Vehicle - Off

2. Disconnect the electrical connector: Q45 Piston Cooling Oil Jet Solenoid Valve

3. Connect a 3 A fused jumper wire between the test points: Ignition terminal 1 & 12 V

CAUTION: Complete the testing as quickly as possible in order to prevent overheating and damaging the component.

4. Momentarily connect a jumper wire between the test points: Control terminal 2 & Ground

Verify the component turns On and Off when connecting and disconnecting the jumper wire: Q45 Piston Cooling Oil Jet Solenoid Valve

• **If the component does not turn On and Off**

Replace the component: Q45 Piston Cooling Oil Jet Solenoid Valve

- **Go to next step: If the component turns On and Off**

5. All OK.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair: [Diagnostic Repair Verification](#)

- Refer to [Piston Oil Nozzle Oil Control Solenoid Valve Replacement \(AWD\) Piston Oil Nozzle Oil Control Solenoid Valve Replacement \(FWD\)](#) - Q45 Piston Cooling Oil Jet Solenoid Valve
- For control module replacement, programming, and setup refer to: [Control Module References](#)

DTC P25AC OR P25AD: PISTON COOLING OIL JET STUCK OFF/ON

Diagnostic Instructions

- Perform the Diagnostic System Check prior to using this diagnostic procedure: [Diagnostic System Check - Vehicle](#)
- Review the description of Strategy Based Diagnosis: [Strategy Based Diagnosis](#)
- An overview of each diagnostic category can be found here: [Diagnostic Procedure Instructions](#)

DTC Descriptor

DTC P25AC

Piston Cooling Oil Jet Stuck Off

DTC P25AD

Piston Cooling Oil Jet Stuck On

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Signal	P25AD	P25AC	P25AC	-
Ground	-	P25AC	-	-

Circuit/System Description

For an overview of the component/system, refer to: [Lubrication Description](#)

Circuit	Description
Signal	The control module input circuit has an internal resistance connected to 12 V.
Ground	Chassis Ground

Component	Description
B267 Piston Cooling Oil Pressure Switch	The pressure sensor generates a voltage signal.
K20 Engine Control Module	The control module controls a series of actuators to ensure optimal engine performance. The control module does this by reading values from a variety of sensors, interprets the data and adjusts the engine actuators accordingly.

Conditions for Running the DTC

- Ignition Voltage = Greater than 11 V
- Engine = Running

Frequency the DTC runs = Continuously - After the running conditions are met

Conditions for Setting the DTC

Commanded state does not match the actual state

Actions Taken When the DTC Sets

DTCs listed in the DTC Descriptor Category = Type B DTC

Conditions for Clearing the DTC

DTCs listed in the DTC Descriptor Category = Type B DTC

Reference Information

Schematic Reference

Engine Controls Wiring Schematics (1.6L (LH7))

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

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- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References

Circuit/System Verification

NOTE: **The engine oil level and condition is critical to the correct operation of the system.**

1. Ignition - On/Vehicle - In Service Mode
2. Verify there are no DTCs set related to the following system/component:
 - Q45 Piston Cooling Oil Jet Solenoid Valve
 - B35B Engine Oil Level Sensor
 - B37B Engine Oil Pressure Sensor
 - B37 Engine Oil Pressure Switch
 - **If other DTCs are set**

Refer to: **Diagnostic Trouble Code (DTC) List - Vehicle**
 - **Go to next step: If no other DTCs are set**
3. Verify the condition does not exist: Engine Oil - Contaminated/Dirty/Fill Level = Low
 - **If a condition exists**

Repair as necessary
 - **Go to next step: If no condition exists**
4. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.

Verify the DTC does not set.

- **If the DTC sets**

Refer to: Circuit/System Testing

- **Go to next step: If the DTC is not set**

5. All OK.

Circuit/System Testing

NOTE: It may take up to 2 min for all vehicle systems to power down before an accurate ground or low reference circuit continuity test can be performed.

1. Ignition/Vehicle & All vehicle systems - Off
2. Disconnect the electrical connector: B267 Piston Cooling Oil Pressure Switch
3. Ignition - On/Vehicle - In Service Mode
4. Test for battery voltage between the test points: Signal circuit terminal 1 & Ground
 - **If less than battery voltage**
 1. Ignition/Vehicle - Off
 2. Disconnect the electrical connector: K20 Engine Control Module
 3. Test for infinite resistance between the test points: Signal circuit terminal 1 & Ground
 - If less than infinite resistance - Repair the short to ground on the circuit.
 - If infinite resistance
 4. Test for less than 2 ohms between the test points: Signal circuit terminal 1 @ Component harness & Terminal 12 X2 @ Control module harness
 - If 2 ohms or greater - Repair the open/high resistance in the circuit.
 - If less than 2 ohms - Replace the component: K20 Engine Control Module
 - **Go to next step: If battery voltage**
5. Ignition/Vehicle - Off
6. Disconnect the electrical connector: K20 Engine Control Module
7. Ignition - On/Vehicle - In Service Mode
8. Test for less than 1 V between the test points: Signal circuit terminal 1 @ Component harness & Ground
 - **If 1 V or greater - Repair the short to voltage on the circuit.**
 - **Go to next step: If less than 1 V**
9. Test or replace the component: B267 Piston Cooling Oil Pressure Switch

Component Testing

1. Ignition/Vehicle - Off
2. Disconnect the electrical connector: B267 Piston Cooling Oil Pressure Switch
3. Test for less than 60 ohms between the test points: Signal terminal 1 & The component's housing
 - **If less than infinite resistance**

Replace the component: B267 Piston Cooling Oil Pressure Switch
 - **Go to next step: If infinite resistance**
4. All OK.

Dynamic Test

1. Ignition/Vehicle - Off
2. Disconnect the electrical connector: B267 Piston Cooling Oil Pressure Switch
3. Connect a DMM between the test points: Signal circuit terminal 1 @ Component & Ground
4. Engine Running
5. Verify the DMM transitions to infinite resistance when above 2650 RPMs.

- **If not in the specified range or does not change**

Replace the component: B267 Piston Cooling Oil Pressure Switch

- **Go to next step: If infinite resistance**

6. All OK.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair: [Diagnostic Repair Verification](#)

- Refer to [Engine Oil Pressure Switch Replacement](#) - B267 Piston Cooling Oil Pressure Switch
- For control module replacement, programming, and setup refer to: [Control Module References](#)

SYMPTOMS - ENGINE MECHANICAL

Strategy Based Diagnostics

1. Perform the [Diagnostic System Check - Vehicle](#) before using the symptom tables, if applicable.
2. Review the system operations in order to familiarize yourself with the system functions. Refer to [Disassembled Views](#), [Engine Component Description](#), and [Lubrication Description](#).

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

Visual/Physical Inspection

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

Intermittent

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

Symptom List

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

- [Base Engine Misfire without Internal Engine Noises](#)
- [Base Engine Misfire with Abnormal Internal Lower Engine Noises](#)
- [Base Engine Misfire with Abnormal Valve Train Noise](#)
- [Base Engine Misfire with Coolant Consumption](#)
- [Base Engine Misfire with Excessive Oil Consumption](#)
- [Engine Noise on Start-Up, but Only Lasting a Few Seconds](#)
- [Upper Engine Noise, Regardless of Engine Speed](#)
- [Lower Engine Noise, Regardless of Engine Speed](#)
- [Engine Noise Under Load](#)
- [Engine Will Not Crank - Crankshaft Will Not Rotate](#)
- Engine Compression Test
- [Oil Consumption Diagnosis](#)
- [Oil Pressure Diagnosis and Testing](#)
- [Oil Leak Diagnosis](#)

- Fuel in Engine Oil
- Drive Belt Chirping, Squeal, and Whine Diagnosis
- Drive Belt Rumbling and Vibration Diagnosis
- Drive Belt Falls Off and Excessive Wear Diagnosis
- Drive Belt Tensioner Diagnosis
- Turbocharger Lack of Oil Supply
- Turbocharger Oil Leak From Compressor Seal
- Turbocharger Oil Leak From Turbine Seal
- Turbocharger Whine Noise
- Turbocharger Hissing Noise

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/automatic transmission flex plate or crankshaft balancer. A misfire code may be present without an actual misfire condition.	Repair or replace the flywheel/automatic transmission flex plate 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.
Improperly installed or leaking charge air cooler tube.	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 manifold absolute pressure (MAP) sensor or intake air pressure temp (TMAP) sensor. The sealing grommet of the MAP sensor should not be torn or damaged.	Repair or replace the MAP sensor and/or the TMAP 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.

Cause	Correction
Excessive oil pressure A lubrication system with excessive oil pressure may lead to excessive valve lifter pump up and loss of compression.	1. Perform an oil pressure test. Refer to Oil Pressure Diagnosis and Testing. 2. 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.	1. Inspect for spark plugs saturated by coolant. 2. Inspect the cylinder heads, engine block, and/or head gaskets. 3. Repair or replace, as required.
Worn piston rings Oil consumption may or may not cause the engine to misfire.	1. Inspect the spark plugs for oil deposits. 2. Inspect the cylinders for a loss of compression. 3. Perform cylinder leak down and compression testing to identify the cause. 4. 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 DTC P0300 may be set. • Systems with mechanical communications, high voltage switch, and severe reluctor ring damage may cause additional pulses and affect fuel and spark delivery to the point of generating a DTC P0300 or P0336.	Replace the sensor and/or crankshaft reluctor ring, as required.

BASE ENGINE MISFIRE WITH ABNORMAL INTERNAL LOWER ENGINE NOISES

Cause	Correction
Abnormalities, severe cracking, bumps or missing areas in the accessory drive belt Abnormalities in the accessory drive system and/or components may cause engine RPM variations, 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/automatic transmission flex plate or crankshaft balancer A misfire code may be present without an actual misfire condition.	Repair or replace the flywheel/automatic transmission flex plate and/or balancer as required.

Cause	Correction
Loose torque converter bolts A misfire code may be present without an actual misfire condition.	Inspect the torque converter bolts and automatic transmission flex plate. Repair or replace as required.
Worn piston rings Oil consumption may or may not cause the engine to misfire.	1. Inspect the cylinders for a loss of compression. 2. Perform cylinder leak down and compression testing to determine the cause. 3. 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 misfire code without an actual misfire condition.	Replace the crankshaft and bearings as required.
Overfilled crankcase	1. Check engine oil level with vehicle on a level surface. 2. Correct any overfilled condition. 3. Inspect for fuel leaks into the crankcase. 4. Repair any fuel leaks.

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 belt	Replace the timing belt and sprockets as required.
Worn camshaft lobes	Replace the camshaft and valve lash adjusters.
Sticking valve	Replace as required.
Worn or damaged pushrods	1. Inspect the pushrods for excessive wear, bent condition or broken tip. 2. Replace as required.
Broken valve springs	Inspect valve springs and replace as required.
Excessive valve lash	Inspect the valve lash adjusters and replace as required.

BASE ENGINE MISFIRE WITH COOLANT CONSUMPTION

Inspection	Action
DEFINITION: Base engine misfire with coolant consumption	
Preliminary Inspection	Verify that there are no external coolant leaks. Refer to Symptoms - Engine Cooling .
Isolate Affected Cylinders	• Cylinder balance test with scan tool • Cooling system pressurization • Inspection of glow plugs • Compression test

Inspection	Action
EGR System Inspection	- Inspect EGR valve and intake system for evidence of coolant leakage. - Replace the EGR cooler if any problem is found.
Cylinder Head Gasket Leakage	- Remove cylinder heads of the affected cylinder bank and inspect for damage. - Replace components as necessary.
Cylinder Head or Engine Block Damage.	- Inspect the cylinder head for cracks. - Inspect the cylinder block for damage. - Inspect the cylinder block to head mating surface for straightness. - Replace components as necessary.

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. - Perform the cylinder leak down and compression testing to determine the cause. - Repair or replace, as required.

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

Cause	Correction
Incorrect oil filter without anti-drain back feature	Install the correct oil filter.
Incorrect oil viscosity	- Drain the oil. - Install the correct viscosity oil.
High valve lash adjuster leak down rate	Replace the lash adjusters 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.
Malfunctioning camshaft position actuators - improper oil viscosity or contamination. The result is camshaft actuator locking pin does not lock	- Verify correct engine oil viscosity by changing the engine oil and filter. Reevaluate the concern. - Isolate the noise to a specific camshaft position actuator. - Replace the camshaft actuator, oil and filter.

Cause	Correction
Excessive piston-to-cylinder bore clearance	1. Inspect the piston and piston skirt, connecting rod, and cylinder bore. 2. Repair or replace all damaged components.

UPPER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Cause	Correction
Low oil pressure	1. Perform an oil pressure test. Refer to Oil Pressure Diagnosis and Testing. 2. Repair or replace, as required.
Loose and/or worn valve rocker arm attachments	1. Inspect the valve rocker arm stud, nut, or bolt. 2. 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 the timing chain tensioners.
Worn engine camshaft lobes	1. Inspect the engine camshaft lobes. 2. 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

Cause	Correction

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.
Leaking and/or sticking fuel injection nozzle. A stuck fuel injection nozzle can cause a noise similar to a damaged piston, rod or rod bearing.	- Use the cylinder balance diagnostic procedure to help locate the cylinder that is the source of the noise. - If you cannot locate the cylinder that is the source of the noise, diagnose the engine for mechanical damage. - If it has been determined that the fuel injection nozzle is causing the noise, replace the fuel injection nozzle.
Loose or damaged crankshaft balancer	- Inspect the crankshaft balancer. - 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.
Misaligned or bent connecting rod	- Inspect connecting rod and connecting rod bearings. - Repair or replace all damaged components.
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

Cause	Correction
Excessive crankshaft bearing clearance	Inspect the following components, and repair as required: • The crankshaft bearings • The crankshaft journals
Incorrect piston, piston pin, and connecting rod installation. Pistons must be installed with the mark or dimple on the top of the piston, facing the front of the engine. Piston pins must be centered in the connecting rod pin bore.	1. Verify the pistons, piston pins and connecting rods are installed correctly. 2. Repair as required.
Oil pump pickup tube or screen bent or loose	1. Inspect the oil pump pickup tube and/or screen. 2. Repair or replace all damaged components.

ENGINE NOISE UNDER LOAD

Cause	Correction
Low oil pressure	1. Perform an oil pressure test. Refer to Oil Pressure Diagnosis and Testing. 2. Repair or replace as required.
Loose or damaged flywheel/automatic transmission flex plate	1. Inspect the flywheel/automatic transmission flex plate bolts and flywheel/automatic transmission flex plate. 2. Repair as required.
Excessive connecting rod bearing clearance	Inspect the following components, and repair as required: • The connecting rod bearings • The connecting rods • The crankshaft
Excessive crankshaft bearing clearance	Inspect the following components, and repair as required: • The crankshaft bearings • The crankshaft journals • The cylinder block crankshaft bearing bore
Excessive piston-to-cylinder bore clearance	1. Inspect the piston rings for low ring tension, broken or worn rings, inspect cylinder bore. 2. Repair or replace all damaged components.
Excessive crankshaft thrust bearing clearance	1. Inspect the crankshaft end play and crankshaft thrust bearings. 2. Repair or replace all damaged components.

ENGINE WILL NOT CRANK - CRANKSHAFT WILL NOT ROTATE

Cause	Correction

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

COOLANT IN COMBUSTION CHAMBER

Inspection	Action

Inspection	Action
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 "over temperature" condition which may cause engine component damage.	
Preliminary Inspection	Verify that there are no external coolant leaks. Refer to Loss of Coolant .
Isolate Affected Cylinders	1. Cylinder balance test with scan tool 2. Cooling system pressurization 3. Compression test
EGR System Inspection	1. Inspect EGR valve and intake system for evidence of coolant leakage. 2. Replace the EGR cooler if any problem is found.
Cylinder Head Gasket Leakage	Remove cylinder heads of the affected cylinder bank and inspect for damage. Replace components as necessary.
Cylinder Head or Engine Block Damage	1. Inspect the cylinder heads for cracks. 2. Inspect the cylinder block for damage. 3. Inspect the cylinder block to head mating surface for straightness. 4. Replace components as necessary.

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 compression test. Two cylinders "side-by-side" on the engine block with low compression may indicate a failed cylinder head gasket.	
Faulty external engine oil cooler	Replace the components as required.
Faulty cylinder head gasket	Replace the head gasket and components as required. Refer to Cylinder Head Cleaning and Inspection , and Cylinder Head Replacement .
Warped cylinder head	Replace the cylinder head. Refer to Cylinder Head Replacement .
Cracked cylinder head	Replace the cylinder head and gasket. Refer to Cylinder Head Replacement .
Cracked cylinder liner or engine block	Replace the components as required.
Cylinder head, block, or manifold porosity	Replace the components as required.

FUEL IN ENGINE OIL

DEFINITION: If fuel is suspected of leaking into the crankcase, the following procedure should be performed to verify the condition.

1. Remove the oil level indicator and allow oil to drop onto a clean white paper towel.
2. If the oil is diluted with fuel, it will become apparent as the towel wicks the fuel away from the drop of oil on the towel. The fuel will expand out in a ring around the oil droplet.

3. If fuel dilution is apparent, inspect the vehicle for aftermarket performance accessories that may cause damage to the injection pump. After repairs are completed, perform the test again to verify the condition is corrected.
4. If no fuel dilution is present, verify the oil level and correct as needed.

ENGINE COMPRESSION TEST

Special Tools

- **EN-51110** Compression and Cylinder Leakdown Test Adapter
- **EN-26999** Compression Gauge

Equivalent regional tools: [Special Tools](#)

Technical Requirements

- Ensure that the vehicle battery is in good condition, and fully charged or the battery is connected to a battery charger. The battery voltage should be $> 12,5 \text{ V}$.
- Operate the vehicle until the engine is at normal operating temperature. The engine oil temperature should be $> 80^{\circ}\text{C}$ ($> 176^{\circ}\text{F}$).

Preliminary Procedures

1. Remove Fuel Injector. Refer to [Fuel Injector Replacement](#)
2. Remove Fuel Pump Relay
 - For component location refer to [Engine Controls Wiring Schematics \(1.6L \(LH7\)\)](#).
 - For removal procedure refer to [Relay Replacement \(Attached to Wire Harness\) Relay Replacement \(Within an Electrical Center\)](#).

WARNING: Refer to [Eye Protection Warning](#)

3. Crank the engine with the starter motor for 5 seconds to remove any foreign substances from the cylinders.

Installation Procedure

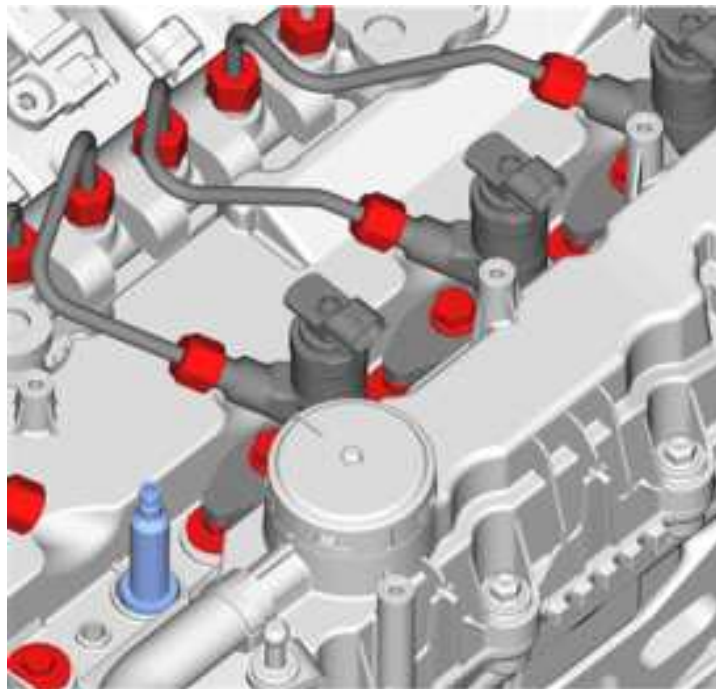


Fig. 11: Compression And Cylinder Leakdown Test Adapter
Courtesy of GENERAL MOTORS COMPANY

1. Install the **EN-51110** Compression and Cylinder Leakdown Test Adapter into the fuel injector bore.
2. Connect the **EN-26999** gauge to the adapter (1).

Measurement Procedure

1. Check the compression of cylinder 1:

WARNING: Refer to [Eye Protection Warning](#)

CAUTION: Do not add oil to any cylinder during a compression test as extensive engine damage may result.

NOTE:

- Engine revs at least 300/min.
- A second technician is required.

1. Turn the ignition ON, with the engine OFF.
2. Using the vehicle starter motor to crank the engine.
3. Observe the gauge and note the reading as the compression test is being performed

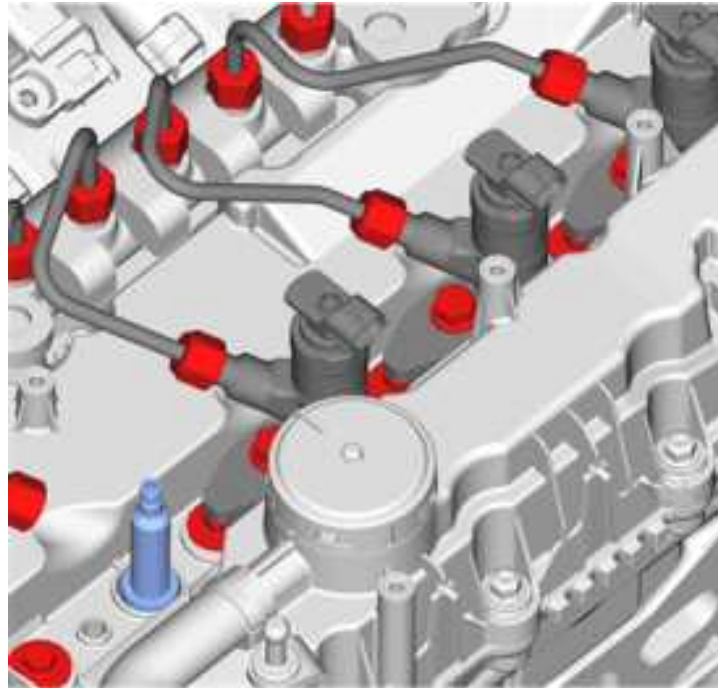


Fig. 12: Compression And Cylinder Leakdown Test Adapter
Courtesy of GENERAL MOTORS COMPANY

4. Remove the assembled compression adapter along with the **EN-51110** Compression and Cylinder Leakdown Test Adapter.
2. Repeat the procedure for all remaining cylinders.
3. Compare the compression value from all cylinders.
4. There should not be more than 10 percent difference between a suspect cylinder and the average compression of all 4 cylinders. For compression values refer to [Engine Mechanical Specifications](#).
5. If one or more cylinders fails to meet the specified compression range, refer to [Cylinder Leakage Test](#) for finding the leakage.

Subsequent Procedures

1. Install Fuel Pump Relay
 - For component location refer to [Engine Controls Wiring Schematics \(1.6L \(LH7\)\)](#) .
 - For installation procedure refer to [Relay Replacement \(Attached to Wire Harness\) Relay Replacement \(Within an Electrical Center\)](#) .
2. Install Fuel Injector. Refer to [Fuel Injector Replacement](#)

CYLINDER LEAKAGE TEST

WARNING: Unless directed otherwise, the ignition must be OFF with the key removed, and all electrical loads must be OFF before servicing any electrical component. Disconnect the negative battery cable to prevent an electrical spark should a tool or equipment come in contact with an exposed electrical terminal. Failure to follow these

precautions may result in personal injury and/or damage to the vehicle or its components.

For Vehicles equipped with OnStar® (UE1) with Back Up Battery:

The Back Up Battery is a redundant power supply to allow limited OnStar® functionality in the event of a main vehicle battery power disruption to the VCIM (OnStar® module). Do not disconnect the main vehicle battery or remove the OnStar® fuse with the ignition key in any position other than OFF. Retained accessory power should be allowed to time out or be disabled (simply opening the driver door should disable retained accessory power) before disconnecting power. Disconnecting power to the OnStar® module in any way while the ignition is On or with retained accessory power activated may cause activation of the OnStar® Back-Up Battery system and will discharge and permanently damage the back-up battery. Once the Back-Up Battery is activated it will stay on until it has completely discharged. The back-up battery is not rechargeable and once activated the back-up battery must be replaced.

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

- Worn, burnt, or stuck valves
- Damaged piston
- Worn piston rings
- Worn or scored cylinder bore
- Damaged cylinder head gasket
- Cracked or damaged cylinder head
- Cracked or damaged engine block

Special Tools

- EN-35667-A Cylinder Leakdown Tester
- EN-51140 Crankshaft Fixing Tool
- EN-51110 Compression and Cylinder Leakdown Test Adapter

Equivalent regional tools: [Special Tools](#)

Preliminary Procedures

1. Disconnect Battery Negative Cable. Refer to [Battery Negative Cable Disconnection and Connection \(KL9\)](#)
2. Remove Fuel Injector. Refer to [Fuel Injector Replacement](#)
3. Remove Crankshaft Pulley. Refer to [Crankshaft Pulley Replacement](#)

Installation Procedure

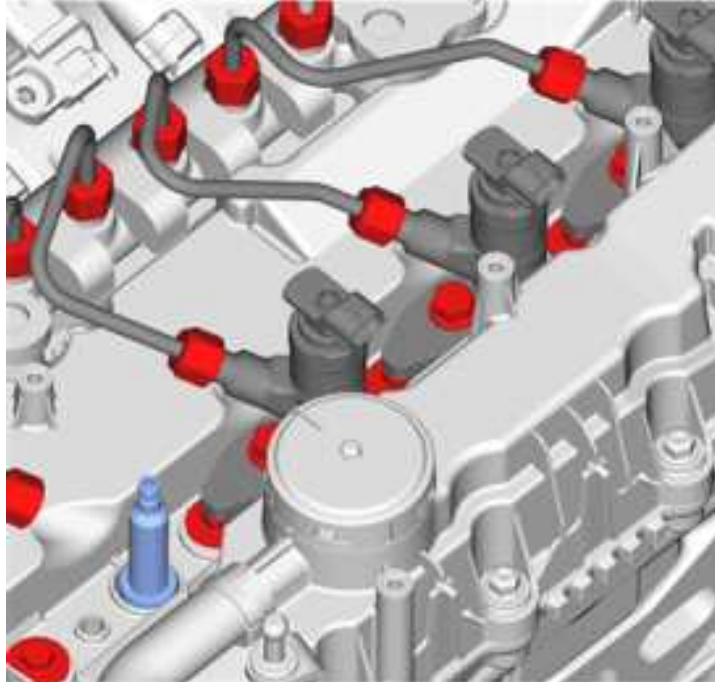


Fig. 13: Compression And Cylinder Leakdown Test Adapter
Courtesy of GENERAL MOTORS COMPANY

1. Install the **EN-51110** Compression and Cylinder Leakdown Test Adapter into the fuel injector bore.
2. Install the **EN-35667-A** Cylinder Leakdown Tester to the leakage adapter (1).

Measurement Procedure

Cylinder 1:

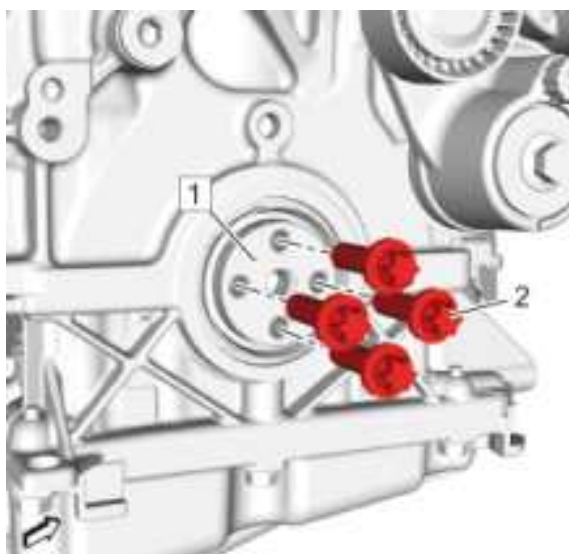


Fig. 14: Crankshaft And Crankshaft Pulley Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Install Crankshaft Pulley Bolts (2) (Qty: 4) @ Crankshaft (1)

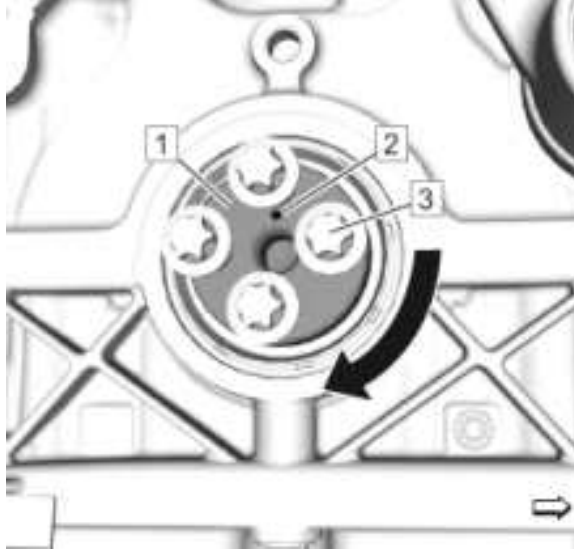


Fig. 15: Rotating Crankshaft Clockwise Until Matching Mark Is At Top

Courtesy of GENERAL MOTORS COMPANY

NOTE: If air leakage sounds at the intake manifold tube and exhaust system tailpipe rotate the crankshaft 360 degrees.

2. Adjust the piston of cylinder 1 at top dead center (TDC) of compression stroke.
 1. Rotate the crankshaft (1) in direction of arrow until the matching mark (2) is at the top. Use a pry bar at the 4 crankshaft pulley bolts (3).

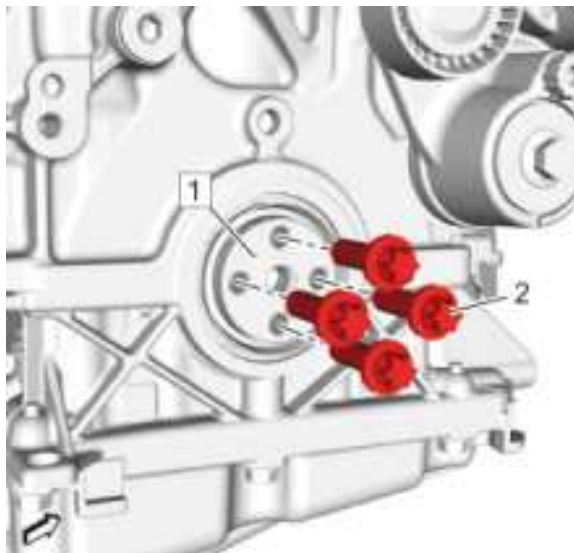


Fig. 16: Crankshaft And Crankshaft Pulley Bolts

Courtesy of GENERAL MOTORS COMPANY

3. Remove Crankshaft Pulley Bolts (2) (Qty: 4) @ Crankshaft (1)

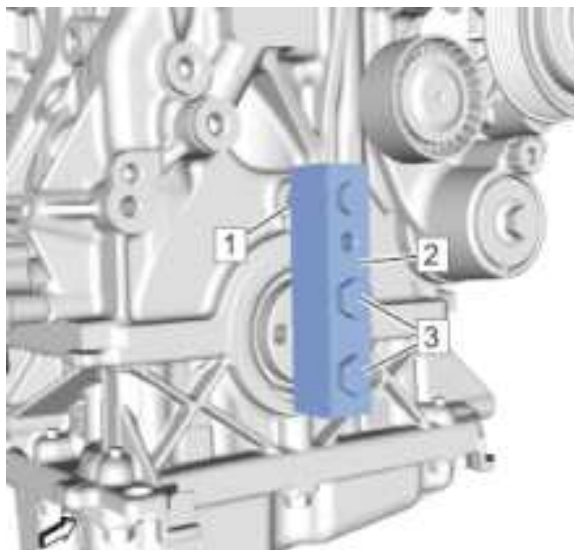


Fig. 17: Crankshaft Fixing Tool, Pin And Bolts
Courtesy of GENERAL MOTORS COMPANY

4. Install the **EN-51140** fixing tool (2).
5. Guide the fixing pin (1) into the engine block bore.
6. Install and tighten Bolts (3) (Qty: 2)
7. Lower the vehicle.
8. Apply shop air pressure to the tester and adjust according to the manufacturers instructions.
9. Record the cylinder leakage value. For cylinder leakage value refer to **Engine Mechanical Specifications**. In excessive leakage situations, inspect for the following conditions:
 - Air leakage sounds at the intake manifold tube, may indicate a worn, stuck or burnt intake valve.
 - Air leakage sounds at the exhaust system tailpipe may indicate a worn, burnt, or stuck exhaust valve, broken valve spring, incorrect valve lash or damaged valve train components.
 - Air leakage sounds from the crankcase, oil level indicator tube, or oil fill tube 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 engine block, cylinder head or gasket.
10. Raise the vehicle.

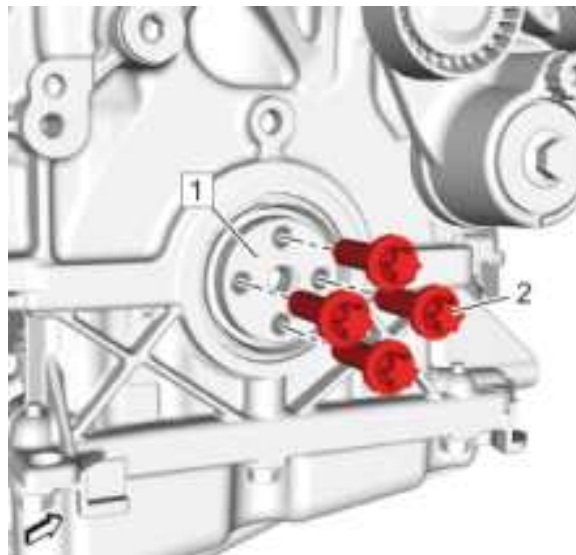
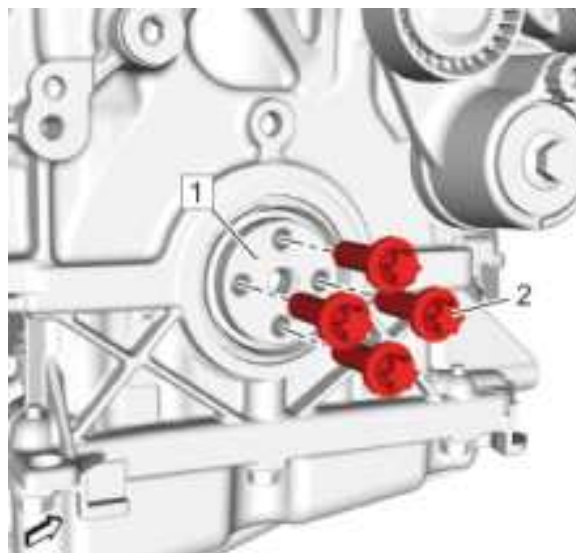


Fig. 18: Crankshaft And Crankshaft Pulley Bolts
Courtesy of GENERAL MOTORS COMPANY

11. Remove Bolts (2) (Qty: 4)
12. Remove the **EN-51140** fixing tool (2).

Cylinder 3:



1. Install Crankshaft Pulley Bolts (2) (Qty: 4) @ Crankshaft (1)

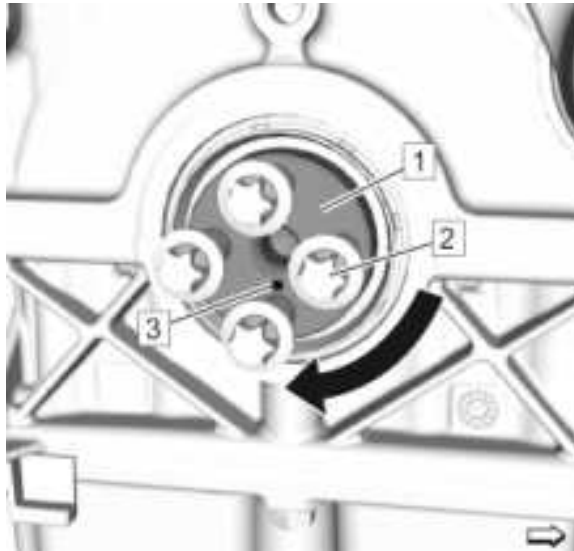


Fig. 20: Rotating Crankshaft 180 Degrees Clockwise Until Matching Mark Is At Bottom
Courtesy of GENERAL MOTORS COMPANY

2. Adjust the piston of cylinder 3 at top dead center (TDC) of compression stroke.
 1. Rotate the crankshaft (1) 180 degrees in direction of arrow until the matching mark (3) is at the bottom.
Use a pry bar at the 4 crankshaft pulley bolts (2).
3. Repeat the procedure from cylinder 1 step 2 and perform the leakage test on cylinder 3 and record the value.

Cylinder 4:

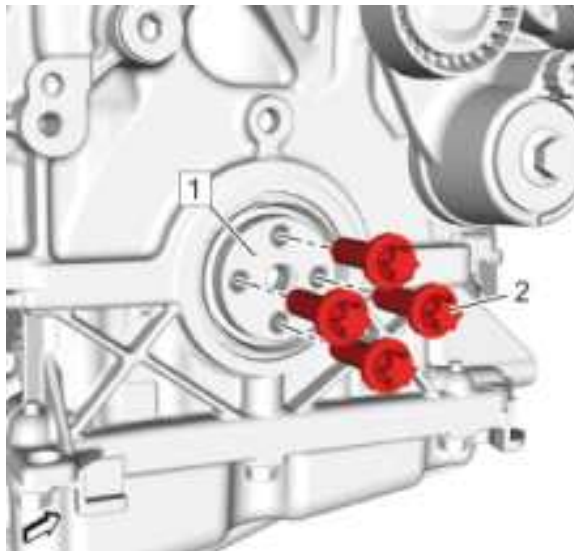


Fig. 21: Crankshaft And Crankshaft Pulley Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Install Crankshaft Pulley Bolts (2) (Qty: 4) @ Crankshaft (1)

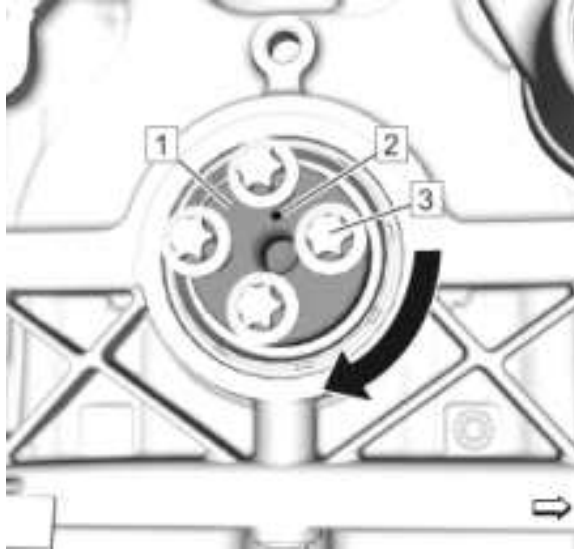


Fig. 22: Rotating Crankshaft Clockwise Until Matching Mark Is At Top
Courtesy of GENERAL MOTORS COMPANY

2. Place the piston of cylinder 4 at top dead center (TDC) of compression stroke.
 1. Rotate the crankshaft (1) 180 degrees in direction of arrow until the matching mark (2) is at the top. Use a pry bar at the 4 crankshaft pulley bolts (3).
3. Repeat the procedure from cylinder 1 step 2 and perform the leakage test on cylinder 4 and record the value.

Cylinder 2:

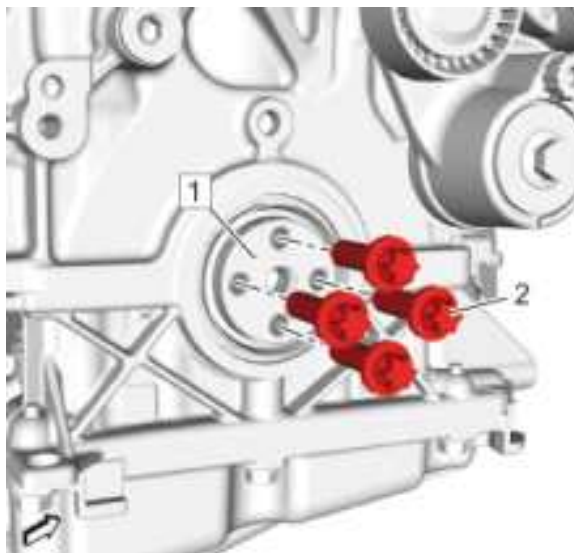
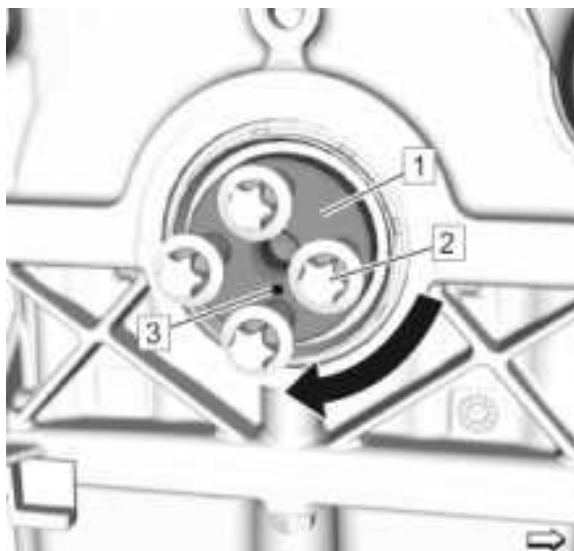


Fig. 23: Crankshaft And Crankshaft Pulley Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Install Crankshaft Pulley Bolts (2) (Qty: 4) @ Crankshaft (1)



2. Place the piston of cylinder 2 at top dead center (TDC) of compression stroke.
 1. Rotate the crankshaft (1) 180 degrees in direction of arrow until the matching mark (3) is at the bottom. Use a pry bar at the 4 crankshaft pulley bolts (2).
3. Repeat the procedure from cylinder 1 step 2 and perform the leakage test on cylinder 2 and record the value.

Subsequent Procedures

1. Install Crankshaft Pulley. Refer to [Crankshaft Pulley Replacement](#)
2. Connect Battery Negative Cable. Refer to [Battery Negative Cable Disconnection and Connection \(KL9\)](#)
3. Install Fuel Injector. Refer to [Fuel Injector Replacement](#)

OIL CONSUMPTION DIAGNOSIS

Explanation

NOTE: Oil consumption for a combustion engine refers to the amount of oil consumed as a result of the combustion process. Oil consumption is not to be equated with oil loss resulting from leaks from components such as the oil pan and cylinder head cover.

- The role of the engine oil is to:
 1. Separate surfaces that slide against each other by means of an oil film, i.e. to prevent dry friction.
 2. Dissipate heat generated by friction.
 3. Lead away combustion residue.
- This task involves the consumption of a certain amount of oil. It is therefore wrong to assume that future enhancements of the combustion engine may produce an engine which has zero oil consumption.
- Outside operating conditions, driving style and manufacturing tolerances do, however, have an impact on oil consumption.
- It is imperative that oil be filled when the level has fallen below the "MIN" mark on the dipstick.
- It is also important to ensure that the oil level is not above the "MAX" mark on the dipstick as this could result in increased oil consumption.
- As oil consumption is affected by technical factors, the conclusion is reached that the engine does not consume oil in special operating conditions that lead to oil dilution.
- During conditions such as frequent cold starts and driving before the engine reaches operating temperature, it is only the oil flowing back to the oil pan that carries away scalding fuel components and precipitates. This "dilutes" the oil and leads to the erroneous assumption that the engine consumes no oil.
- Such diluted oil loses its ability to lubricate and could cause engine damage if the prescribed oil change intervals are not observed.
- Driving in predominately urban traffic and frequently running a cold engine at rpms above idle speed are the main causes of oil dilution.
- As oil consumption does not stabilize until after a few thousand kilometers of travel, oil consumption measurements are not reliable until after a distance of about 7, 500 km.
- The oil standard is merely used for monitoring and cannot be used for measurement purposes. In principle, the engine must have stopped for at least 5 minutes or 10 minutes before checking the oil level. If the maximum amount of oil added during an oil change does not agree with the max. on the oil dip stick, then this will be accounted for by the necessary manufacturing tolerances.

Measuring Procedure

NOTE: All information on permissible engine oil consumption and capacities are found in the Owner's Manual.

1. Before measuring consumption, ensure that the engine is not losing oil due to leakage.
2. The check is carried out with the vehicle parked on a level surface with the engine at operating temperature (engine oil temperature at least 80°C).
3. Drain the engine oil immediately after switching off the engine - drainage time = approx. 30 minutes (this value has been obtained through technical trials).

4. The quantity of drained engine oil is determined via a measuring container. The container is then filled with fresh oil up to the maximum engine oil capacity minus the volume remaining in the unchanged oil filter.
5. With this engine oil quantity, the customer should be able to travel at 1000 km without needing to top up engine oil (the distance profile and customer driving style should be maintained).
6. Then, the preceding procedure (points 1 and 2) should be repeated with the exact same engine drainage time.
7. The oil quantity now "missing" from the measuring container is equal to the engine oil consumption for that distance.
8. Oil consumption is calculated as follows:
 - $(\text{filled oil quantity (l)} - \text{drained oil quantity (l)}) / \text{total distance driven (km)} \times 1000 = \text{oil consumption (l/1000 km)}$

CRANKCASE VENTILATION SYSTEM INSPECTION/DIAGNOSIS

Symptom	Correction
External oil leak	Inspect for any of the following conditions: • Restricted or kinked positive crankcase ventilation (PCV) hose or engine vent hose • Damaged, incorrect, or incorrectly installed PCV hose • Excessive crankcase pressure
Rough Idle	Inspect for any of the following conditions: • Restricted or kinked PCV hose or engine vent hose • Leaking (damaged) PCV hose • Vacuum hoses worn or not properly installed
Stalling or slow idle speed	Inspect for any of the following conditions: • Restricted or kinked engine vent hose • Leaking (damaged) PCV hose
High idle speed	Inspect for a leaking (damaged) PCV hose
Sludge in the engine	Inspect for restricted or kinked PCV hose or engine vent hose

OIL PRESSURE DIAGNOSIS AND TESTING

Special Tools

- **GE-498-B** Oil Pressure Gauge
- **EN-21867-850** Oil Pressure Gage Adapter

Equivalent regional tools: [Special Tools](#)

Removal Procedure

1. Disconnect the battery negative cable. Refer to [Battery Negative Cable Disconnection and Connection \(KL9\)](#).
2. Raise and support the vehicle. Refer to [Lifting and Jacking the Vehicle](#).
3. Remove the exhaust front pipe. Refer to [Exhaust Front Pipe Replacement \(LH7\)](#).

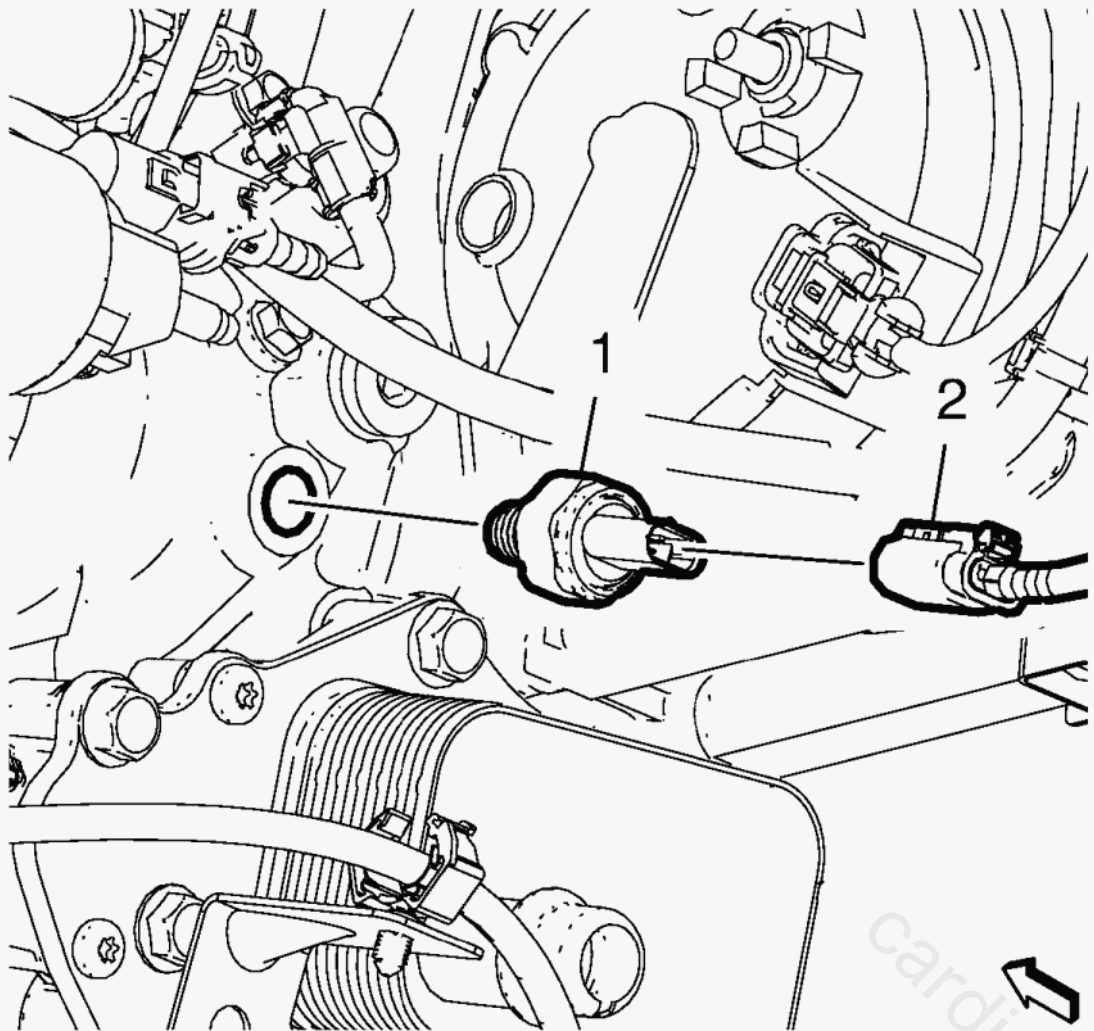


Fig. 25: Oil Pressure Sensor And Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

4. Disconnect the oil pressure sensor electrical connector (2) from the engine oil pressure sensor (1).
5. Remove the oil pressure sensor (1).

Measuring Procedure

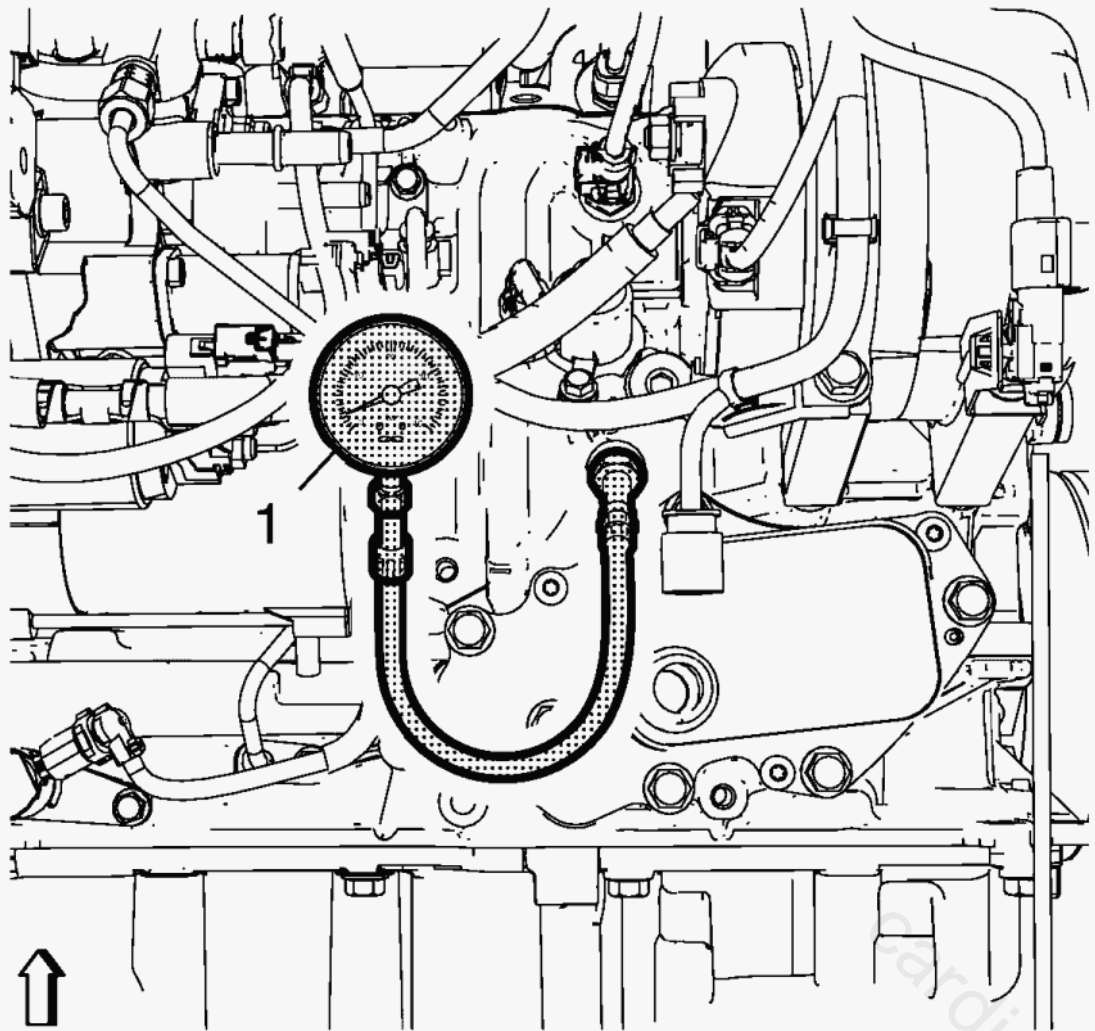


Fig. 26: Oil Pressure Gauge And Adapter

Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to [Component Fastener Tightening Caution](#) .

1. Install the **EN-21867-850** adapter to the engine block and tighten to 35 N.m (26 lb ft).
2. Install the **GE-498-B** Oil Pressure Gauge (1) to the **EN-21867-850** Oil Pressure Gage Adapter.
3. Install the exhaust front pipe. Refer to [Exhaust Front Pipe Replacement \(LH7\)](#).
4. Lower the vehicle.
5. Connect the battery negative cable. Refer to [Battery Negative Cable Disconnection and Connection \(KL9\)](#).
6. Start the engine.

NOTE: The oil temperature should be between 80Â°C (176Â°F) and 100Â°C (212Â°F).

7. Measure the oil pressure. Compare the engine oil pressure with the nominal value. Refer to [Engine Mechanical Specifications](#)
8. Stop engine.
9. If the engine oil pressure is below specifications, inspect the engine for one or more of the following conditions:
 - Oil pump worn or dirty. Refer to [Oil and Power Brake Booster Pump Replacement](#)
 - Oil suction gallery clogged or dirty. Refer to [Oil Pan Cleaning and Inspection](#)
 - Cracked, porous or restricted oil galleries.
 - Oil pressure relief valve malfunction.

Installation Procedure

1. Disconnect the battery negative cable. Refer to [Battery Negative Cable Disconnection and Connection \(KL9\)](#).

2. Raise the vehicle.
3. Remove the exhaust front pipe. Refer to [Exhaust Front Pipe Replacement \(LH7\)](#).
4. Remove the **GE-498-B** Oil Pressure Gauge.
5. Remove the **EN-21867-850** Oil Pressure Gage Adapter.

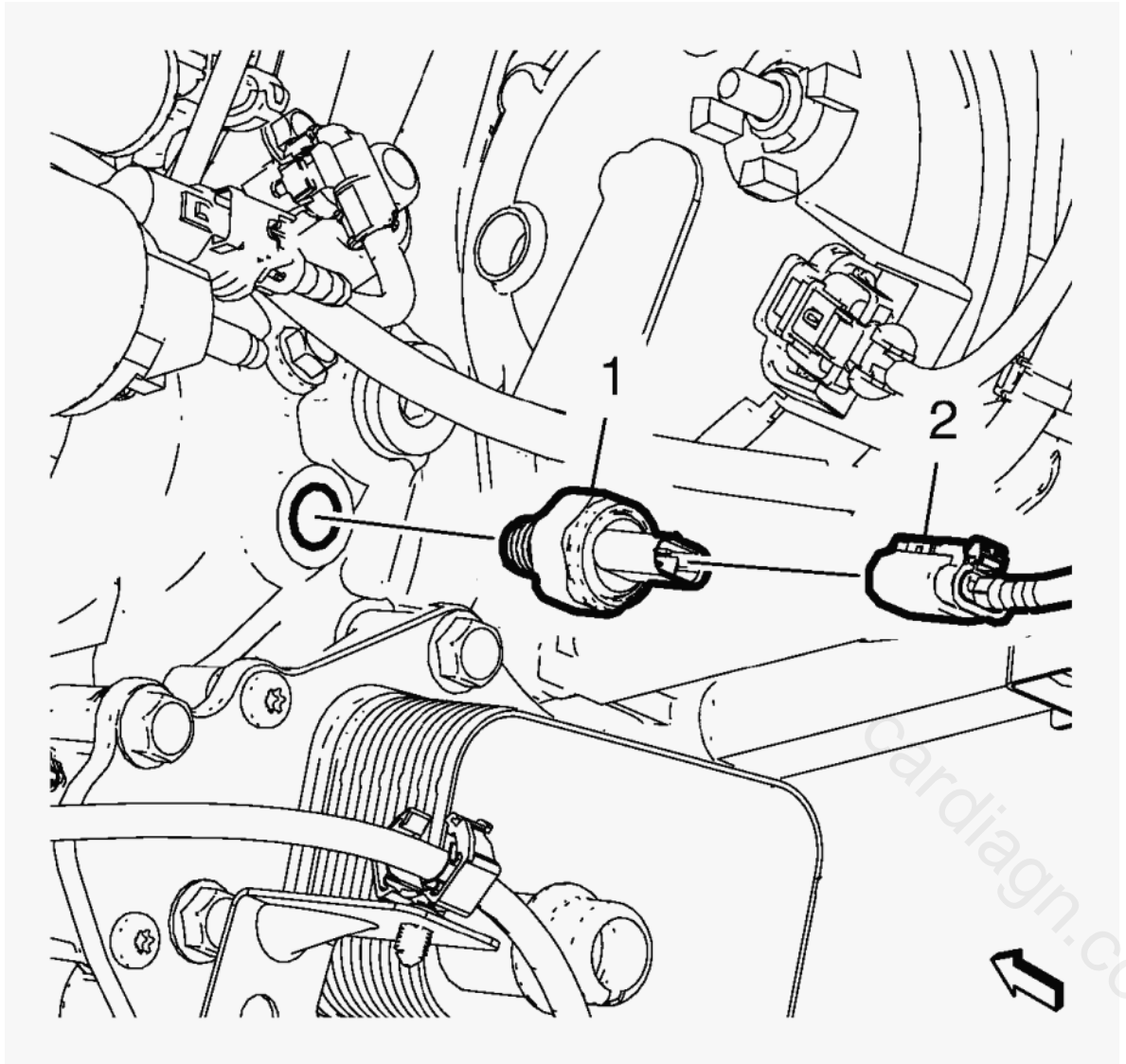


Fig. 27: Oil Pressure Sensor And Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

6. Install the engine oil pressure sensor (1) to the engine block and tighten to 35 N.m (26 lb ft).
7. Connect the electrical connector (2) to the engine oil pressure sensor (1).
8. Install the exhaust front pipe. Refer to [Exhaust Front Pipe Replacement \(LH7\)](#).
9. Lower the vehicle.
10. Connect the battery negative cable. Refer to [Battery Negative Cable Disconnection and Connection \(KL9\)](#).

OIL LEAK DIAGNOSIS

Special Tools

BO-42220 Universal Leak Detection Lamp

For equivalent regional tools, refer to [Special Tools](#).

Step	Action	Yes	No

Step	Action	Yes	No
CAUTION: Do not use belt dressing on the drive belt. Belt dressing causes the breakdown of the composition of the drive belt. Failure to follow this recommendation will damage the drive belt.			
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

Step	Action	Yes	No
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 the BO-42220 lamp, 12 Volt UV in order to identify the type of fluid, and the approximate location of the leak. Refer to the manufacturer's instructions when using the tool. Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 9
9	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	System OK
10	1. Inspect the engine for mechanical damage. Special interest should be shown to the following areas: 2. Inspect the engine for customer modifications. • Higher than recommended fluid levels • Higher than recommended fluid pressures • Plugged or malfunctioning fluid filters or pressure bypass valves • 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 Is there mechanical damage, or customer modifications to the engine?	Go to Step 11	System OK

Step	Action	Yes	No
11	Repair or replace all damaged or modified components. Did you complete the repair?	Go to Step 1	--

DRIVE BELT CHIRPING, SQUEAL, AND WHINE DIAGNOSIS

Diagnostic Aids

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

Test Description

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

2

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

3

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

4

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

6

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

10

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

12

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

14

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

15

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

16

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

17

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

19

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

Step	Action	Yes	No
CAUTION: Do not use belt dressing on the drive belt. Belt dressing causes the breakdown of the composition of the drive belt. Failure to follow this recommendation will damage the drive belt.			
DEFINITION: The following items are indications of chirping: - A high pitched noise that is heard once per revolution of the drive belt or a pulley. - Chirping may occur on cold damp start-ups and will subside once the vehicle reaches normal operating temp.			
DEFINITION: The following items are indications of drive belt squeal: - A loud screeching noise that is caused by a slipping drive belt. This is unusual for a drive belt with multiple ribs. - The noise occurs when a heavy load is applied to the drive belt, such as an air conditioning compressor engagement snapping the throttle, or slipping on a seized pulley or a faulty accessory drive component.			
DEFINITION: The following items are indications of drive belt whine: - A high pitched continuous noise. - The noise may be caused by an accessory drive component failed bearing.			
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Engine Mechanical
2	Verify that there is a chirping, squeal or whine noise. Does the engine make the chirping squeal or whine noise?	Go to Step 3	Go to Diagnostic Aids

Step	Action	Yes	No
3	1. Remove the drive belt. If the engine has multiple drive belts, remove the belts one at a time and perform the test below each time a belt is removed. 2. Operate the engine for no longer than 30 - 40 seconds. 3. Repeat this test if necessary by removing the remaining belt(s). Does the chirping, squeal or whine noise still exist?	Go to Symptoms - Engine Mechanical	Go to Step 4
4	If diagnosing a chirping noise, inspect for severe pilling exceeding 1/3 of the belt groove depth. If diagnosing a squeal or whine noise, proceed to step 13. Do the belt grooves have pilling?	Go to Step 5	Go to Step 6
5	Clean the drive belt pulleys with a suitable wire brush. Did you complete the repair?	Go to Step 20	Go to Step 6
6	Inspect for misalignment of the pulleys. Are any of the pulleys misaligned?	Go to Step 7	Go to Step 8
7	Replace or repair any misaligned pulleys. Did you complete the repair?	Go to Step 20	Go to Step 8
8	Inspect for bent or cracked brackets. Did you find any bent or cracked brackets?	Go to Step 9	Go to Step 10
9	Replace any bent or cracked brackets. Did you complete the repair?	Go to Step 20	Go to Step 10
10	Inspect for improper, loose or missing fasteners. Did you find the condition?	Go to Step 11	Go to Step 12
11	CAUTION: Refer to Fastener Caution . 1. Tighten any loose fasteners. Refer to Fastener Specifications. 2. Replace any improper or missing fasteners. Did you complete the repair?	Go to Step 20	Go to Step 12
12	Inspect for a bent pulley. Did you find the condition?	Go to Step 18	Go to Step 19
13	Inspect for an accessory drive component seized bearing or a faulty accessory drive component. Did you find and correct the condition? If diagnosing a whine noise and the condition still exist, proceed to Diagnostic Aids.	Go to Step 20	Go to Step 14
14	Test the drive belt tensioner for proper operation. Refer to Drive Belt Tensioner Diagnosis Did you find and correct the condition?	Go to Step 20	Go to Step 15
15	Inspect for the correct drive belt length. Did you find and correct the condition?	Go to Step 20	Go to Step 16
16	Inspect for misalignment of a pulley. Did you find and correct the condition?	Go to Step 20	Go to Step 17
17	Inspect for the correct pulley size. Did you find and correct the condition?	Go to Step 20	Go to Diagnostic Aids
18	Replace the bent pulley. Did you complete the repair?	Go to Step 20	Go to Step 19

Step	Action	Yes	No
19	Replace the generator and A/C compressor belt. Refer to Generator and Air Conditioning Compressor Belt Replacement . Did you complete the repair?	Go to Step 20	Go to Diagnostic Aids
20	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 3

DRIVE BELT RUMBLING AND VIBRATION DIAGNOSIS

Diagnostic Aids

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

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

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

Test Description

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

2

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

3

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

4

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

5

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

9

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

11

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

12

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

Step	Action	Yes	No
DEFINITION: The following items are indications of drive belt rumbling: • A low pitch tapping, knocking, or thumping noise heard at or just above idle. • Heard once per revolution of the drive belt or a pulley. • Rumbling may be caused from: • Pilling, the accumulation of rubber dust that forms small balls (pills) or strings in the drive belt pulley groove • The separation of the drive belt • A damaged drive belt DEFINITION: The following items are indications of drive belt vibration: • The vibration is engine-speed related. • The vibration may be sensitive to accessory load.			
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Engine Mechanical
2	Verify that there is a rumbling noise or that the vibration is engine related. Does the engine make the rumbling noise or vibration?	Go to Step 3	Go to Diagnostic Aids
3	1. Remove the drive belt. If the engine has multiple drive belts, remove the belts one at a time and perform the test below each time a belt is removed. 2. Operate the engine for no longer than 30 - 40 seconds. 3. Repeat this test if necessary by removing the remaining belt(s). Does the rumbling or vibration still exist?	Go to Symptoms - Engine Mechanical	Go to Step 4
4	Inspect the drive belts for wear, damage, separation, sections of missing ribs, and debris build-up. Did you find any of these conditions?	Go to Step 7	Go to Step 5
5	Inspect for severe pilling of more than 1/3 of the drive belt pulley grooves. Did you find severe pilling?	Go to Step 6	Go to Step 7
6	1. Clean the drive belt pulleys using a suitable wire brush. 2. Reinstall the drive belts. Did you correct the condition?	Go to Step 8	Go to Step 7
7	Install a new drive belt. Did you complete the replacement?	Go to Step 8	Go to Step 9
8	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 9
9	Inspect for improper, loose or missing fasteners. Did you find any of these conditions?	Go to Step 10	Go to Step 11

Step	Action	Yes	No
10	CAUTION: Refer to <u>Fastener Caution</u> . 1. Tighten any loose fasteners. Refer to <u>Fastener Specifications</u> . 2. Replace improper or missing fasteners. Did you complete the repair?	Go to Step 12	Go to Step 11
11	Inspect for bent or cracked brackets. Did you find and correct 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 3

DRIVE BELT FALLS OFF AND EXCESSIVE WEAR DIAGNOSIS

Diagnostic Aids

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

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

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

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

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

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

Test Description

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

2

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

4

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

5

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

6

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

7

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

13

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

14

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

15

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

Step	Action	Yes	No
DEFINITION: The drive belt falls off the pulleys or may not ride correctly on the pulleys.			
DEFINITION: Wear at the outside ribs of the drive belt due to an incorrectly installed drive belt.			
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Engine Mechanical
2	If diagnosing high wear, proceed to step 13. If diagnosing a drive belt that falls off, inspect for a damaged drive belt. Did you find the condition?	Go to Step 3	Go to Step 4
3	Install a new generator and A/C compressor belt. Refer to Generator and Air Conditioning Compressor 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 correct the condition?	Go to Step 12	Go to Step 5
5	Inspect for a bent or dented pulley. Did you find and correct the condition?	Go to Step 12	Go to Step 6
6	Inspect for a bent or a cracked bracket. Did you find and correct the condition?	Go to Step 12	Go to Step 7
7	Inspect for improper, loose or missing fasteners. Did you find loose or missing fasteners?	Go to Step 8	Go to Step 9
8	CAUTION: Refer to Fastener Caution . 1. Tighten any loose fasteners. Refer to Fastener Specifications . 2. Replace improper or missing fasteners. Does the drive belt continue to fall off?	Go to Step 9	System OK
9	Test the drive belt tensioner for operating correctly. Refer to Drive Belt 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 correct 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

Step	Action	Yes	No
13	Inspect the generator and A/C compressor belt for the proper installation. Refer to Generator and Air Conditioning Compressor Belt Replacement . Did you find this condition?	Go to Step 16	Go to Step 14
14	Inspect for the proper drive belt. Did you find this condition?	Go to Step 16	Go to Step 15
15	Inspect for the drive belt rubbing against a bracket, hose, or wiring harness. Did you find and correct the condition?	Go to Step 17	Go to Diagnostic Aids
16	Replace the generator and A/C compressor belt. Refer to Generator and Air Conditioning Compressor Belt Replacement . Did you complete the replacement?	Go to Step 17	-
17	Operate the system in order to verify the repair. Did you correct the condition?	System OK	-

DRIVE BELT TENSIONER DIAGNOSIS

Step	Action	Yes	No
CAUTION: Allowing the drive belt tensioner to snap into the free position may result in damage to the tensioner.			
1	1. Remove the generator and A/C compressor belt. Refer to Generator and Air Conditioning Compressor Belt Replacement . 2. Inspect the drive belt tensioner pulley. Is the drive belt tensioner pulley loose or misaligned?	Go to Step 4	Go to Step 2
2	Rotate the drive belt tensioner. Does the tensioner rotate without any unusual resistance or binding?	Go to Step 3	Go to Step 4
3	1. Use a torque wrench in order to measure the torque required to move the tensioner off of the stop. 2. Use a torque wrench on a known good tensioner in order to measure the torque required to move the tensioner off of the stop. Is the first torque reading within 10 percent of the second torque reading?	System OK	Go to Step 4
4	Replace the drive belt tensioner. Refer to Drive Belt Tensioner Replacement . Is the repair complete?	System OK	-

TURBOCHARGER WHINE NOISE

Cause	Correction
NOTE: Some whine noise is normal. Compare to a known good vehicle.	
Leaking charge air cooler/pipes/hoses	Inspect for leaks in charge air cooler/pipes/hoses.
Worn turbocharger bearings	Visually inspect for evidence of compressor wheel to housing contact. If the turbocharger bearings are worn or damaged, inspect for a Turbocharger Lack of Oil Supply .

Cause	Correction
Intake system leaks or obstructions	1. With the engine off, pressurize the intake system and inspect for intake manifold leaks. 2. Inspect for obstructions in the intake manifolds.

TURBOCHARGER HISSING NOISE

Condition	Action
Air inlet leaks or obstructions	Inspect the turbocharger inlet pipes/hoses for leaks or obstructions.
Leaking charge air cooler/pipes/hoses	Inspect the charge air cooler/pipes/hoses for leaks or obstructions.
Leaking or restricted exhaust system	1. Inspect the exhaust system for a leak. 2. Inspect the exhaust system for a restrictions.
Intake system leaks or obstructions	1. Inspect the intake manifold for a leak. 2. Inspect the intake manifold for restrictions.

TURBOCHARGER OIL LEAK FROM COMPRESSOR SEAL

Condition	Action
NOTE: Oil in the turbocharger air inlet pipe, oil on the compressor wheel, and oil throughout the charge air cooler system is normal with a closed PCV system. Do not attempt repairs for this condition.	
Restricted air system	Inspect for clogged air filter element or restricted air inlet system.
Restricted exhaust system	Inspect for a restricted exhaust.
Leaking exhaust system	Inspect for exhaust manifold leaks.
Poor oil drainage from turbocharger	Inspect for restricted turbocharger oil drain pipe.
Restricted crankcase ventilation system	Inspect for restricted crankcase ventilation system.
Worn internal engine components	Inspect for excessive blowby or engine oil consumption.

TURBOCHARGER OIL LEAK FROM TURBINE SEAL

Condition	Action
Poor oil drainage from turbocharger	Inspect for a restricted turbocharger oil drain pipe.
Restricted crankcase ventilation system	Inspect for a restricted crankcase ventilation system.
Worn internal engine components	Inspect for excessive blowby or engine oil consumption.

TURBOCHARGER LACK OF OIL SUPPLY

Condition	Action
Restricted oil supply pipe	Inspect for restricted turbocharger oil feed pipe. Refer to Turbocharger Oil Feed Pipe Replacement .
Leakage of oil at the oil supply pipe	Inspect for the turbocharger oil supply pipe.

DUAL MASS FLYWHEEL DIAGNOSIS

Check for Thermal Overload

NOTE: These quick information shall help to carry out a correct diagnosis in case of a customer complaint.

Through friction of clutch plate on the friction surface of the dual mass flywheel temperatures up to 200Â°C can arise during normal driving. At sliding clutch or through operating errors much higher temperatures can arise. These temperatures must not cause mandatory a reduced lifetime of the dual mass flywheel.

Possible indications for a high thermal load are:

- Tarnish (bluish) as well as local hotspots on friction surface
- Tarnish (bluish) near of mounting area and riveting area of clutch

If all other checkable features are well, the dual mass flywheel can stay in the vehicle.

Possible indications for a too high thermal load are:

- Cracks
- Fusion zones on friction surface (material smear)
- Scores in friction surface (for example through clutch lining riveting at destroyed or worn clutch plate)
- Tarnish (bluish) which reaches up to bearing area of dual mass flywheel
- Bluish discoloration of locating pins (3 locating pins in outer zone of dual mass flywheel)

In these cases the dual mass flywheel has to be replaced.

Overview Dual Mass Flywheel

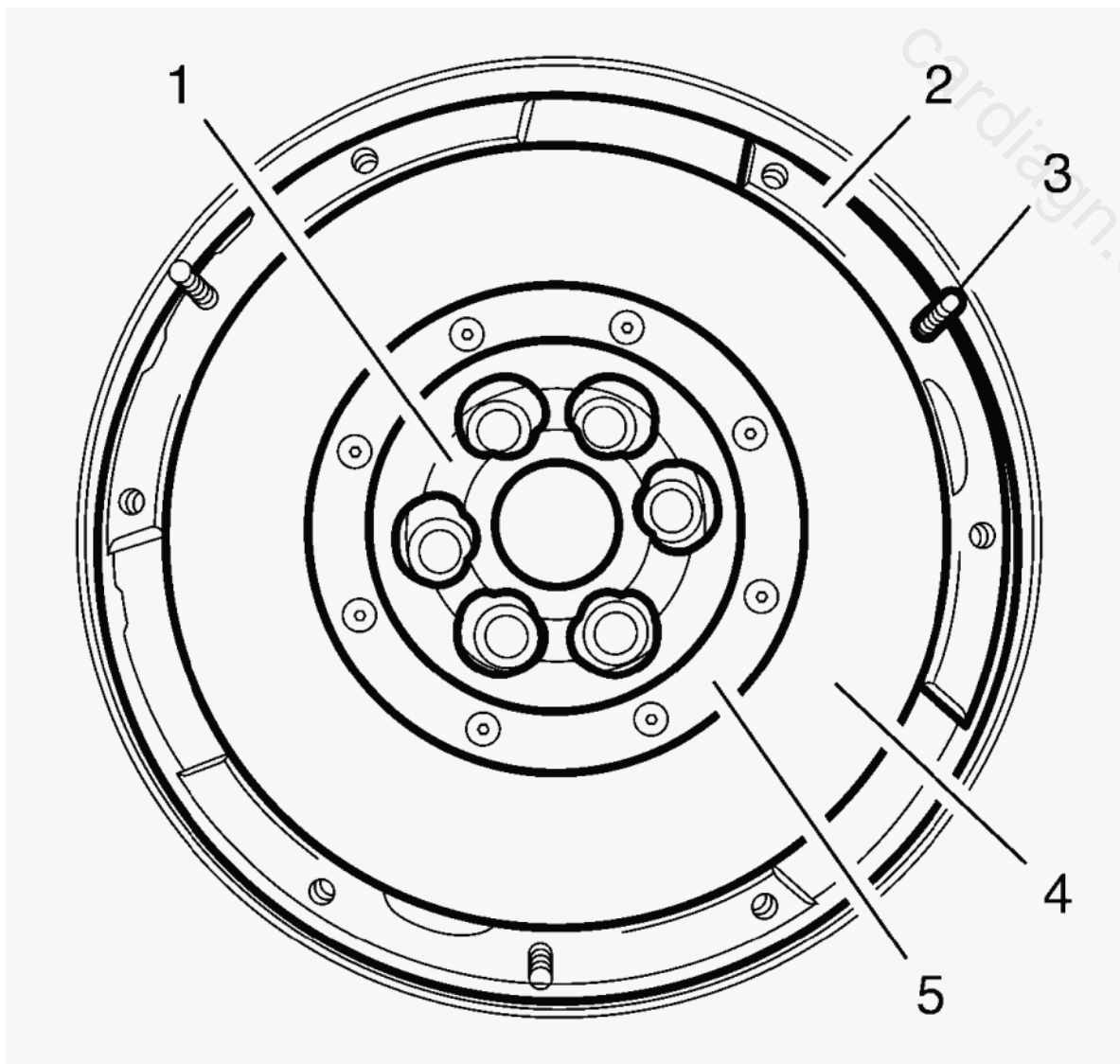


Fig. 28: Dual Mass Flywheel Components

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name

Callout	Component Name
1	Bearing Area
2	Mounting Area Pressure Plate
3	Locating Pins
4	Friction Surface
5	Riveting Area

Exploded View Dual Mass Flywheel with Additional Mass

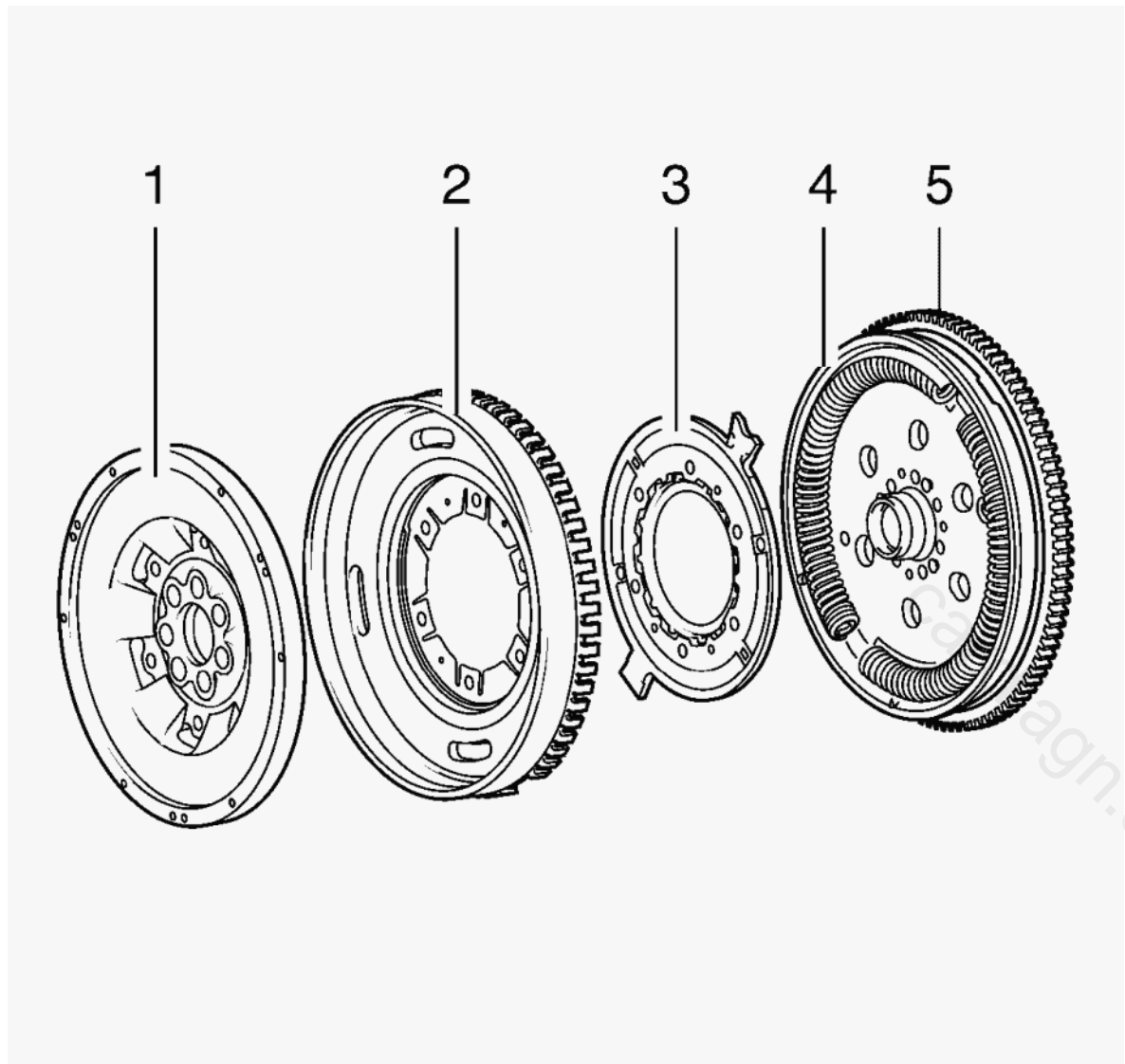


Fig. 29: Dual Mass Flywheel With Additional Mass Components

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Secondary Flywheel Mass
2	Additional Mass, Coupled with Cover and Pulse-Generator Ring
3	Flange
4	Primary Flywheel Mass with Bowed Springs and Plain Bearing/Bearing Bolt
5	Toothed Ring

Check for Damaged Components

All following checking procedures have to be carried out at installed dual mass flywheel. For visual check at vehicle very bright light and a additional bright and small pocket lamp is necessary. Damages like grease on primary flywheel and loose ore missing balance weights cannot be checked at installed condition. During visual check material alteration can be stated which eliminate a further operating suitability.

For comparison different damages at dual mass flywheel with the corresponding further procedure are presented here.

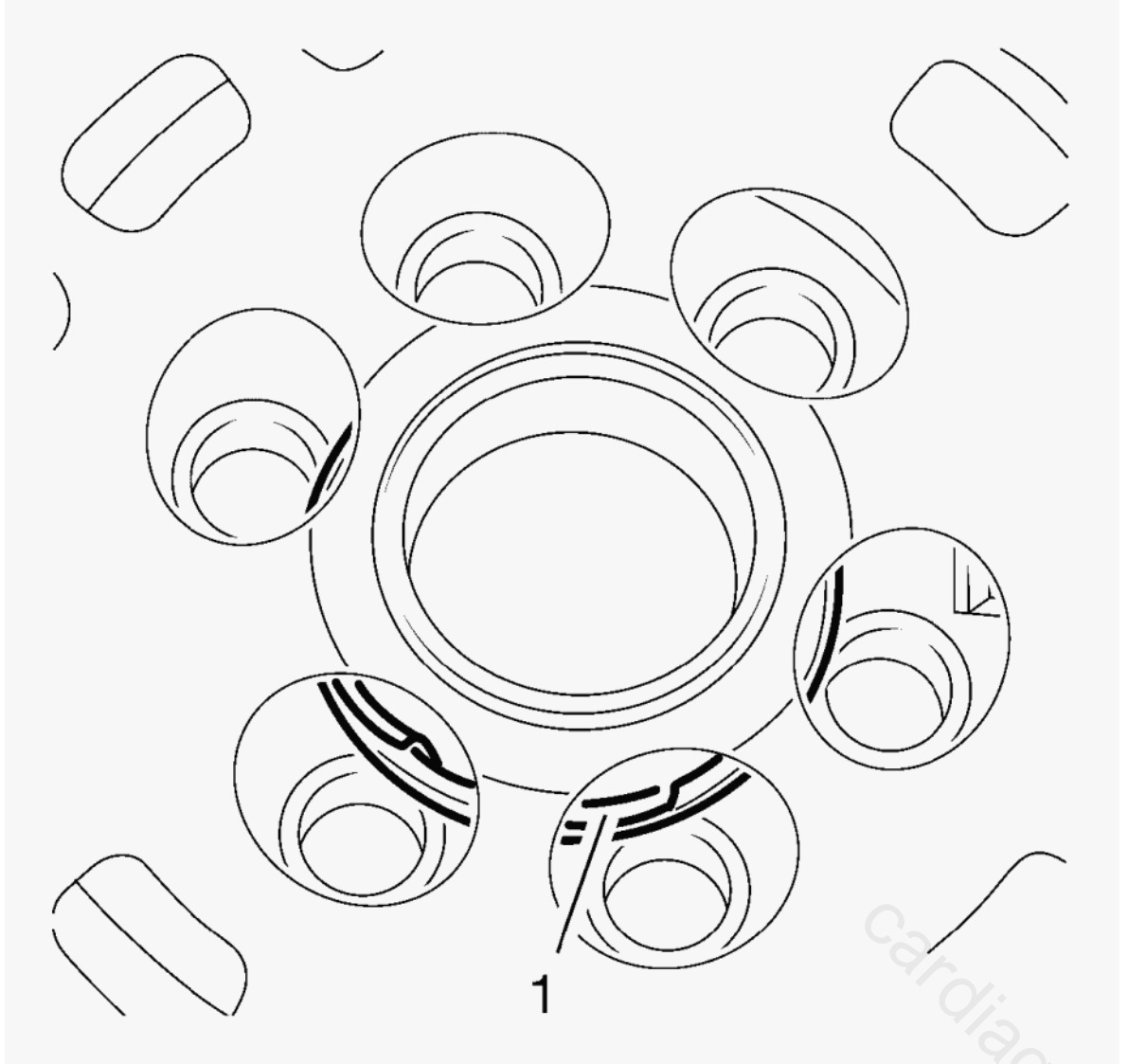


Fig. 30: Plain Bearing

Courtesy of GENERAL MOTORS COMPANY

NOTE: In case of mechanical damages at plain bearing the dual mass flywheel has to be replaced.

1. Inspect plain bearing (1) for damages.

Dependent of the manufacturer damages can be detected through ventilation openings of secondary flywheel. Parts of the bearing (1) are detached or lie loose around the bearing bolt.

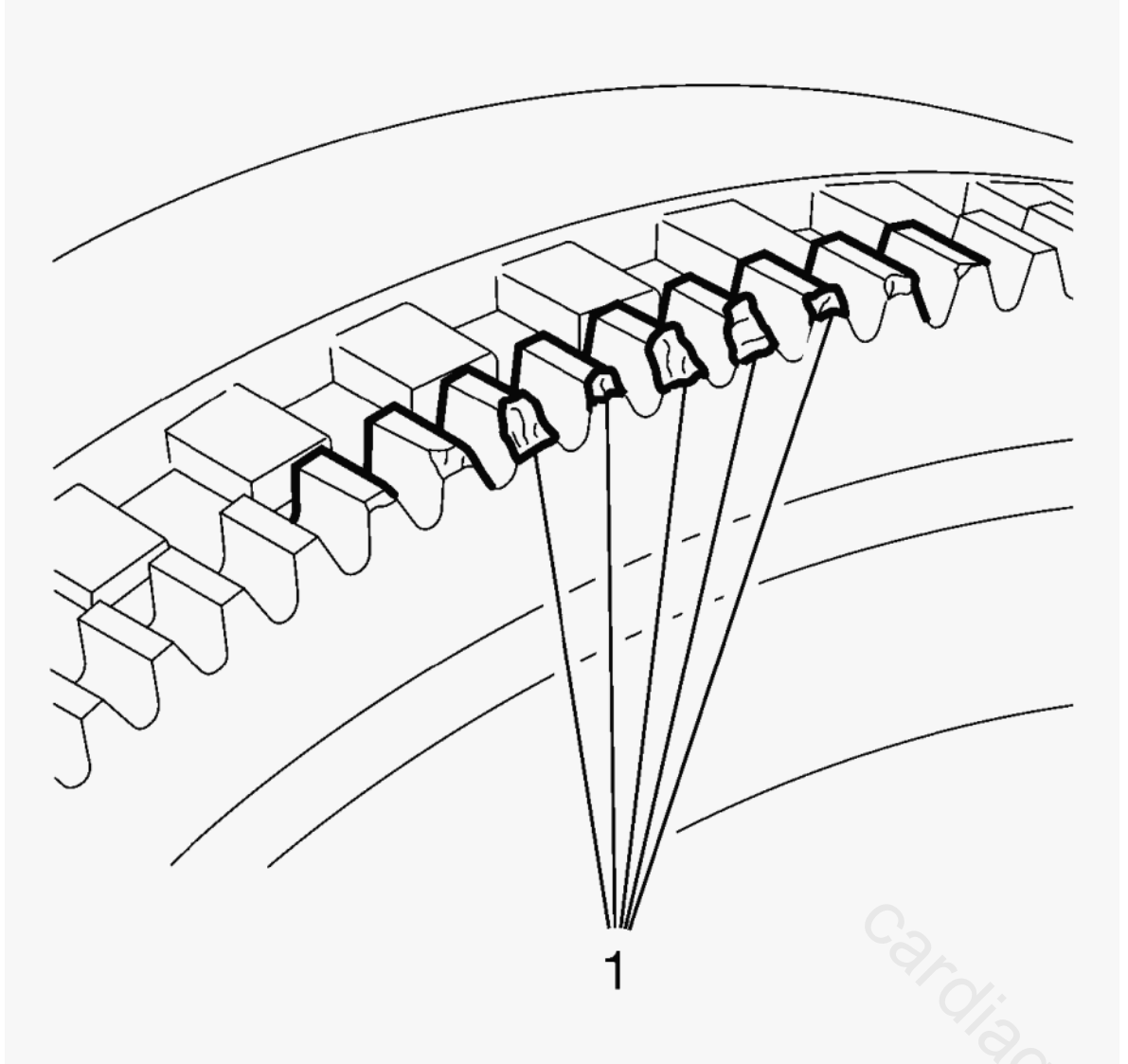


Fig. 31: Toothed Ring

Courtesy of GENERAL MOTORS COMPANY

NOTE: Light abrasion on frontal areas of teeth is allowed. If problems occur during starting the engine the dual mass flywheel has to be replaced.

2. Inspect toothed ring (1) for damages.

The toothed ring is needed to start the engine. Through a lot of starting procedures and/or an incorrect engaging starter signs of abrasion can occur on teeth of the toothed ring. The profile of damages can reach from only low signs of abrasion up to heavy material removal. The installation of a pulse-generator ring depends on the manufacturer.

The image shows signs of abrasion and mechanical damages at toothed ring (1), they occur through abrasion due to a lot of starting procedures. In this case the dual mass flywheel has to be replaced.

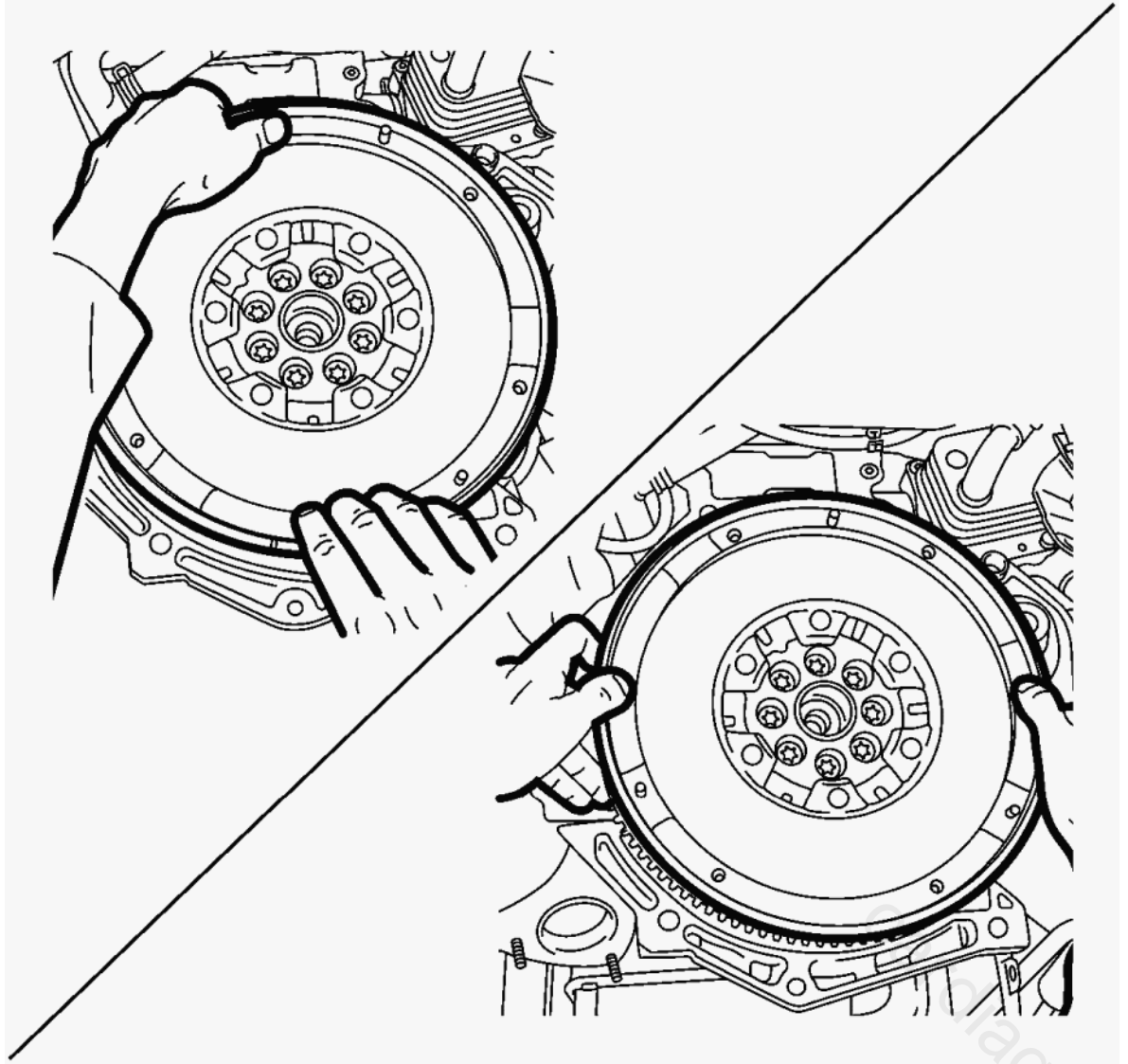


Fig. 32: Inspecting Tilt Clearance

Courtesy of GENERAL MOTORS COMPANY

NOTE: The check must be carried out only by hand without any tools.

3. Inspect tilt clearance.

At dual mass flywheel the additional-mass ring looms over the gap between primary and secondary flywheel.

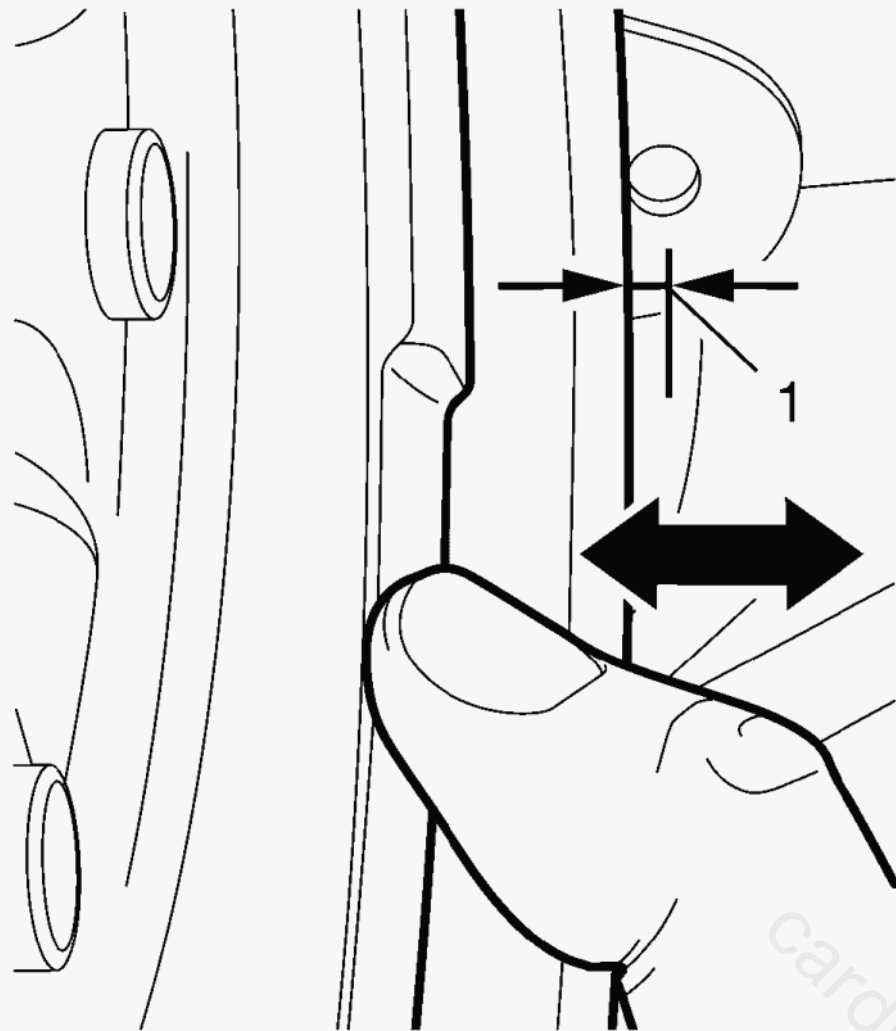


Fig. 33: Tilt Clearance Height

Courtesy of GENERAL MOTORS COMPANY

NOTE: An absolute clear measurement is not possible with this check due to the different applied forces of the several workshop employees during the check and the different clearance of tilt play between the different suppliers.

4. Embrace dual mass flywheel and apply thumbs onto the outer radius of secondary flywheel.
5. Apply pressure onto the secondary flywheel alternating on upper, lower, left and right side

During the tilt clearance check a functional metal rattling noise may occur.

A tilt play (1) is normal and does not require a replacement of the DMF, Check whether the free angle and the spring pressure are available on both sides. If the rotation of the flywheel at one or both sides impossible the flywheel is defective and has to be replaced.

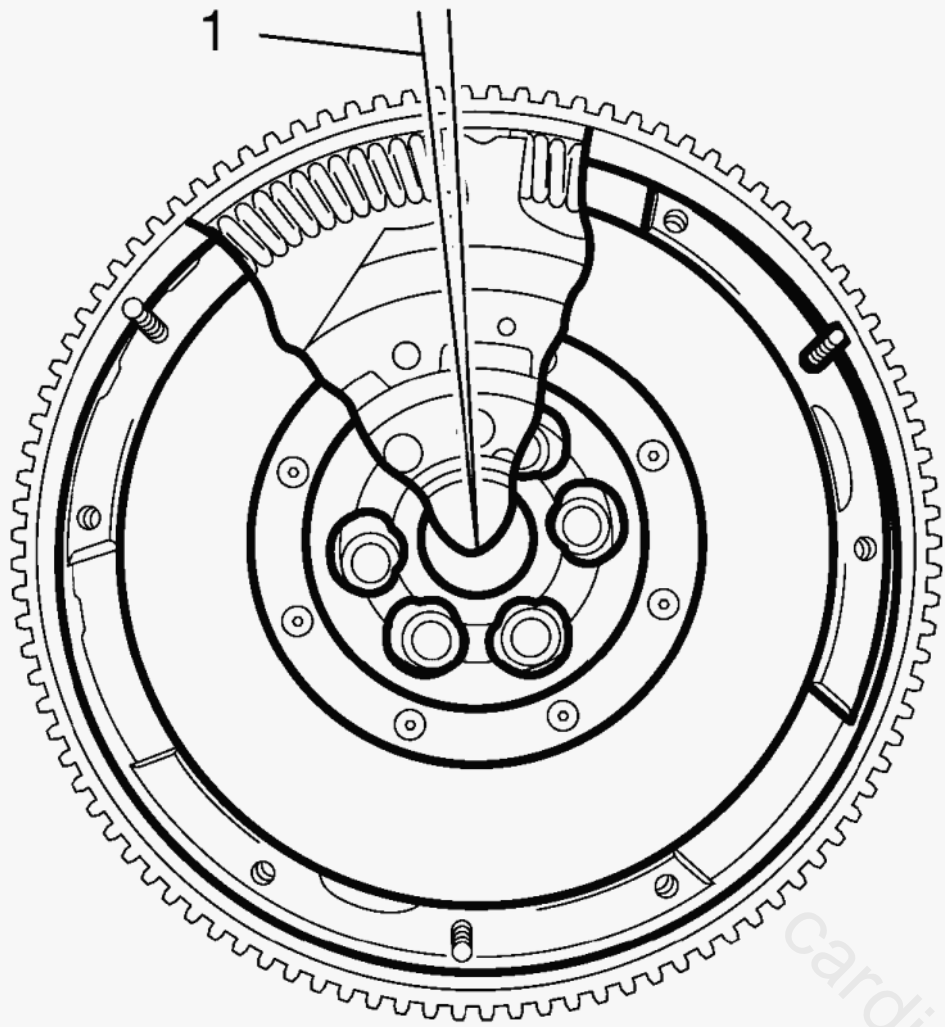


Fig. 34: Tilt Clearance Angle

Courtesy of GENERAL MOTORS COMPANY

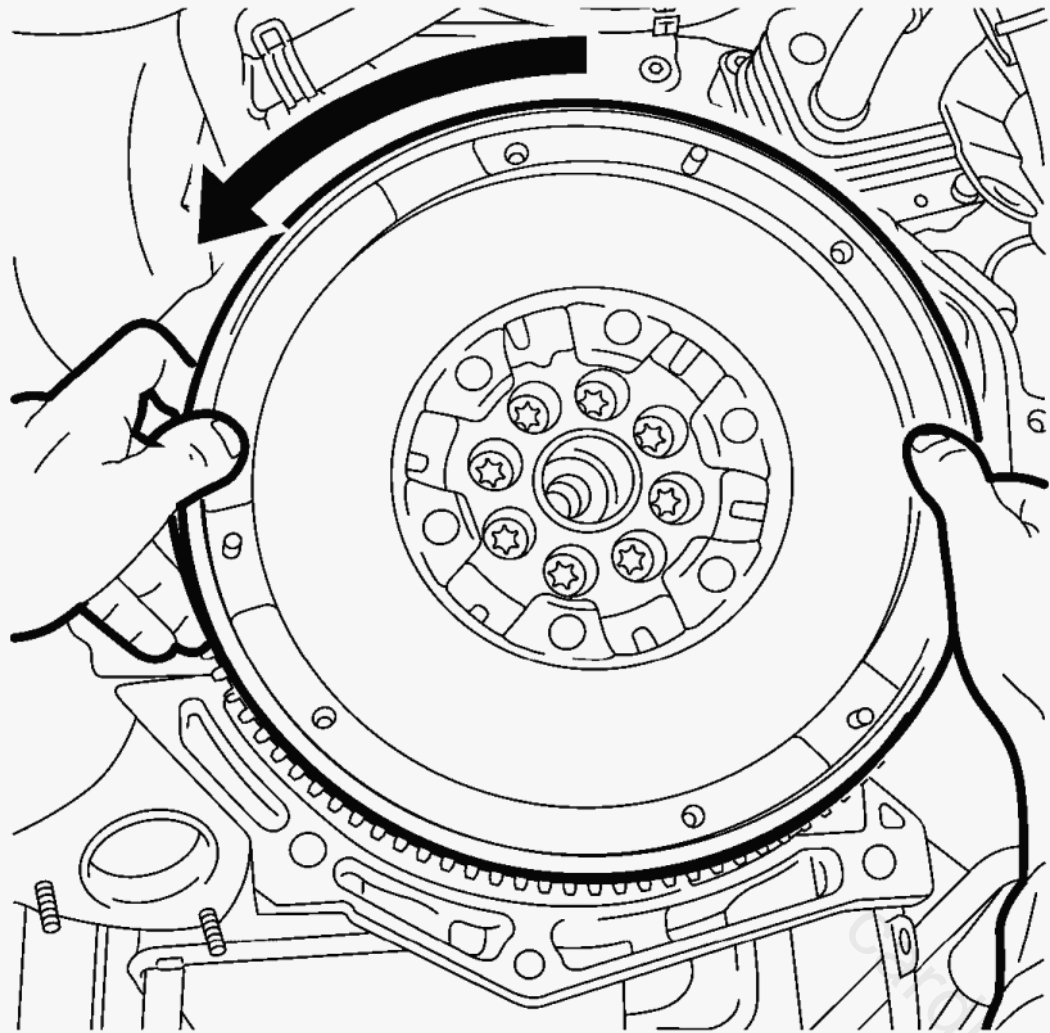


Fig. 35: Rotating Secondary Flywheel Anti-Clockwise
Courtesy of GENERAL MOTORS COMPANY

6. Inspect clearance angle (1).

Before the inspection of the clearance angle the dual mass flywheel should be rotated several times clockwise and anti-clockwise to receive a feeling for the resistance of the springs. In addition unusual loud clicking noise or possible rattle, crunch, grinding noise can be sounded out during rotating the dual mass flywheel.

If the rotation of the flywheel is impossible the flywheel is defective and has to be replaced.

The clearance angle is the angle (1) about the secondary and the primary flywheel can be turned light against each other. Thereby the flange wings are moved in the duct of the bowed springs without adjoining the bowed springs.

Is the secondary flywheel rotated beyond this point the bowed springs in the duct are moved to spring arrestor in the primary flywheel/cover. Now the both spring are tensioned.

1. Rotate secondary flywheel anti-clockwise (arrow) until the elastic counterforce (spring force) is clear noticeable.
2. Release secondary flywheel slowly until the bowed springs are relaxed, so no counterforce acts onto the springs.

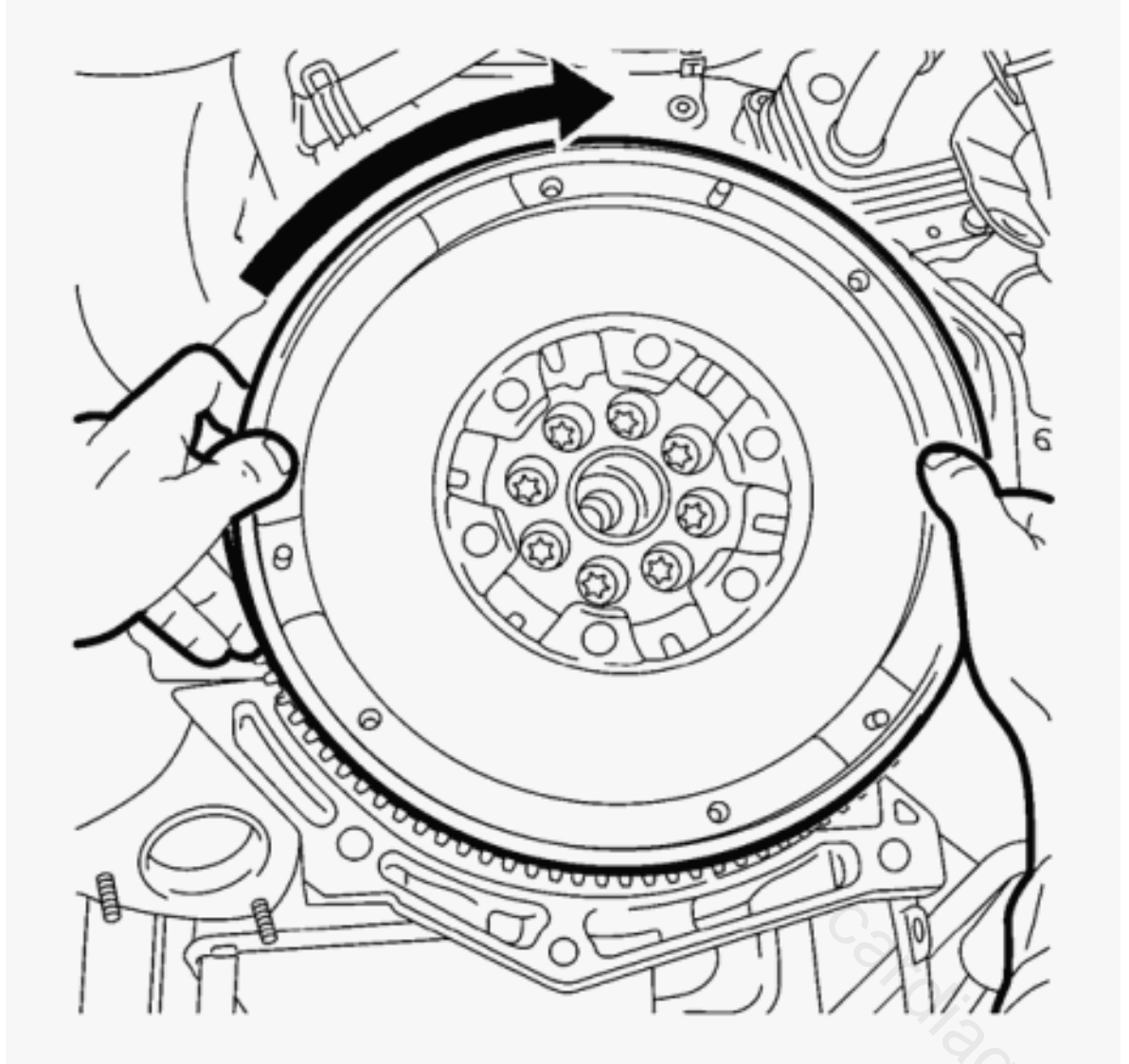


Fig. 36: Rotating Secondary Flywheel Clockwise
Courtesy of GENERAL MOTORS COMPANY

3. Rotate secondary flywheel clockwise until the elastic counterforce is clear noticeable.
4. Release secondary flywheel slowly until the bowed springs are relaxed.
7. ALWAYS replace the engine flywheel if following conditions are given:
 - The dual mass flywheel be rotated in one or both direction with no elastic counterforce.
 - The dual mass flywheel cannot be rotated.
 - During rotating the dual mass flywheel a hard metallic arrestor is audible or noticeable and there is no elastic counterforce.

REPAIR INSTRUCTIONS - ON VEHICLE

GENERATOR AND AIR CONDITIONING COMPRESSOR BELT REPLACEMENT

Removal Procedure

1. Remove Front Wheelhouse Liner Right Side. Refer to [Front Wheelhouse Liner Replacement - Right Side \(Equinox\)](#), [Front Wheelhouse Liner Replacement - Right Side \(Terrain\)](#).

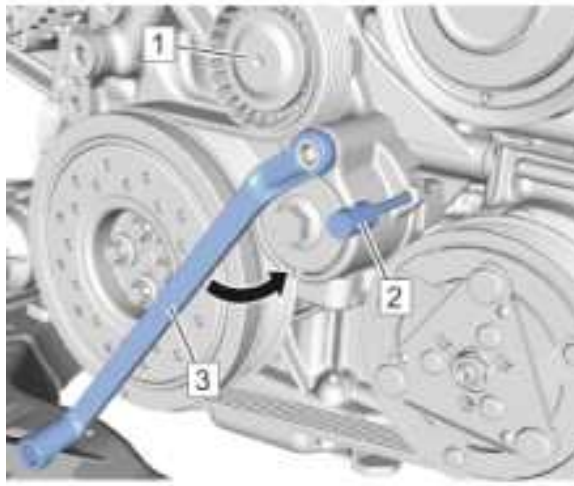


Fig. 37: Drive Belt Tensioner, Wrench And Fixing Pin
Courtesy of GENERAL MOTORS COMPANY

2. Tension the drive belt tensioner (1)
 1. Install a wrench (3) to the drive belt tensioner.
 2. Push the drive belt tensioner in arrow direction until a suitable fixing pin (2) can be installed to the bore.

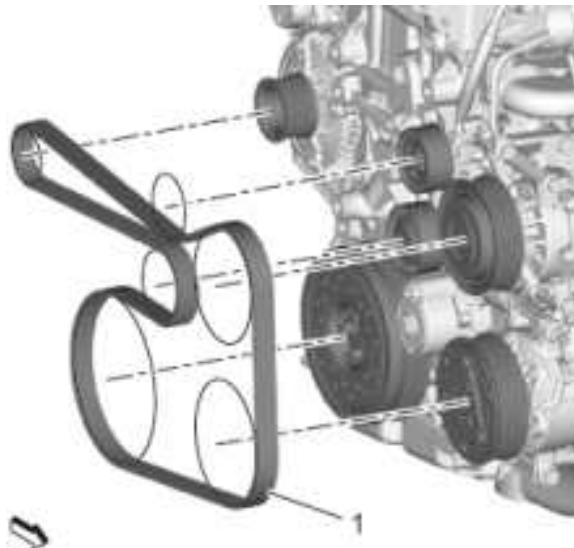
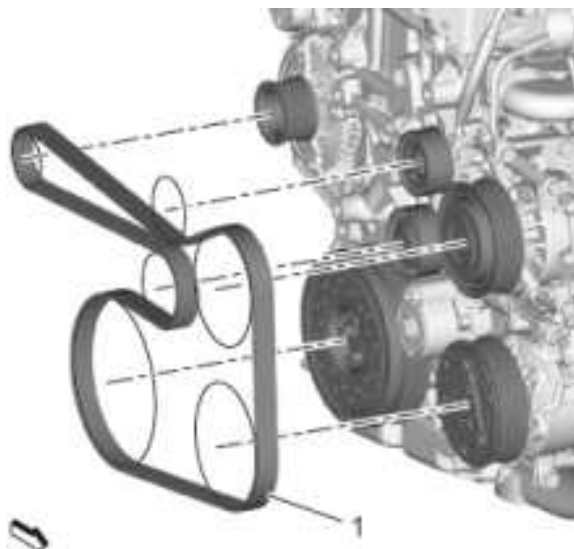


Fig. 38: Generator And Air Conditioning Compressor Belt
Courtesy of GENERAL MOTORS COMPANY

3. Remove Generator and Air Conditioning Compressor Belt (1)

Installation Procedure



1. Install Generator and Air Conditioning Compressor Belt (1)

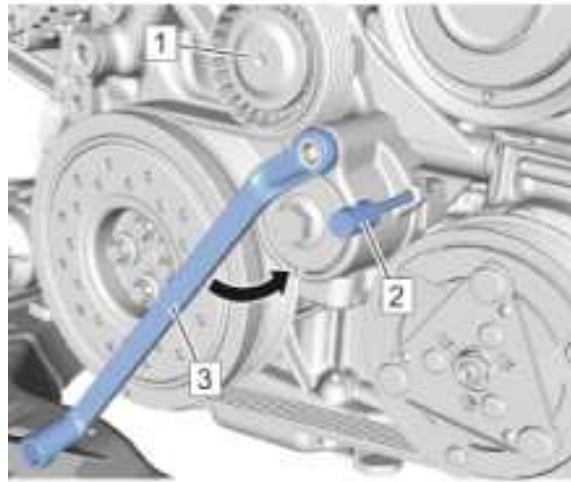


Fig. 40: Drive Belt Tensioner, Wrench And Fixing Pin
Courtesy of GENERAL MOTORS COMPANY

2. Tension the drive belt tensioner (1).
 1. Install a wrench (3) to the drive belt tensioner.
 2. Push the drive belt tensioner in arrow direction until the suitable fixing pin (2) can be removed from the bore.
 3. Release the drive belt tensioner.
3. Install Front Wheelhouse Liner Right Side. Refer to [Front Wheelhouse Liner Replacement - Right Side \(Equinox\)](#), [Front Wheelhouse Liner Replacement - Right Side \(Terrain\)](#)

BELT IDLER PULLEY REPLACEMENT

Removal Procedure

1. Remove Generator and Air Conditioning Compressor Belt. Refer to [Generator and Air Conditioning Compressor Belt Replacement](#)

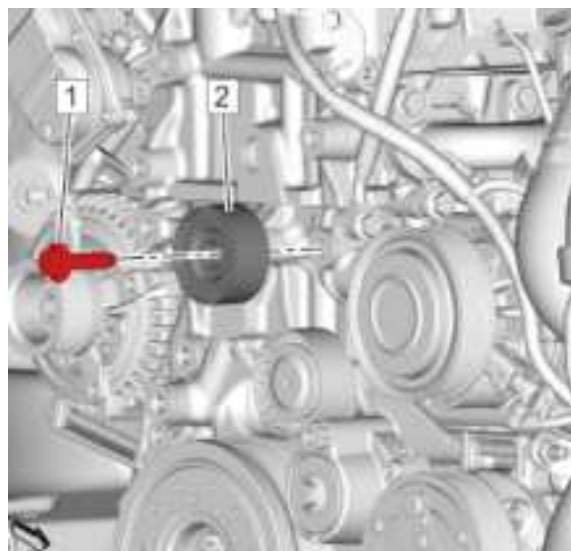


Fig. 41: Belt Idler Pulley And Bolt
Courtesy of GENERAL MOTORS COMPANY

2. Remove Belt Idler Pulley Bolt (1)
3. Remove Belt Idler Pulley (2)

Installation Procedure

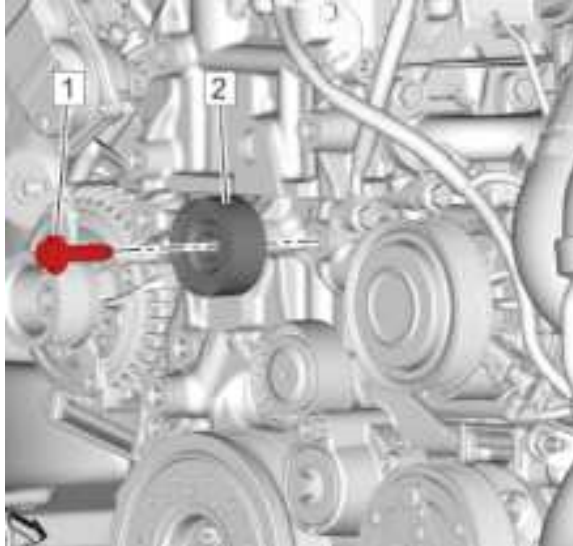


Fig. 42: Belt Idler Pulley And Bolt

Courtesy of GENERAL MOTORS COMPANY

1. Install Belt Idler Pulley (2)

CAUTION: Refer to: [Fastener Caution](#)

2. Install and tighten Belt Idler Pulley Bolt (1) to 58 N.m (43 lb ft)
3. Install Generator and Air Conditioning Compressor Belt. Refer to [Generator and Air Conditioning Compressor Belt Replacement](#)

DRIVE BELT TENSIONER REPLACEMENT

Removal Procedure

1. Remove the drive belt. Refer to [Generator and Air Conditioning Compressor Belt Replacement](#)

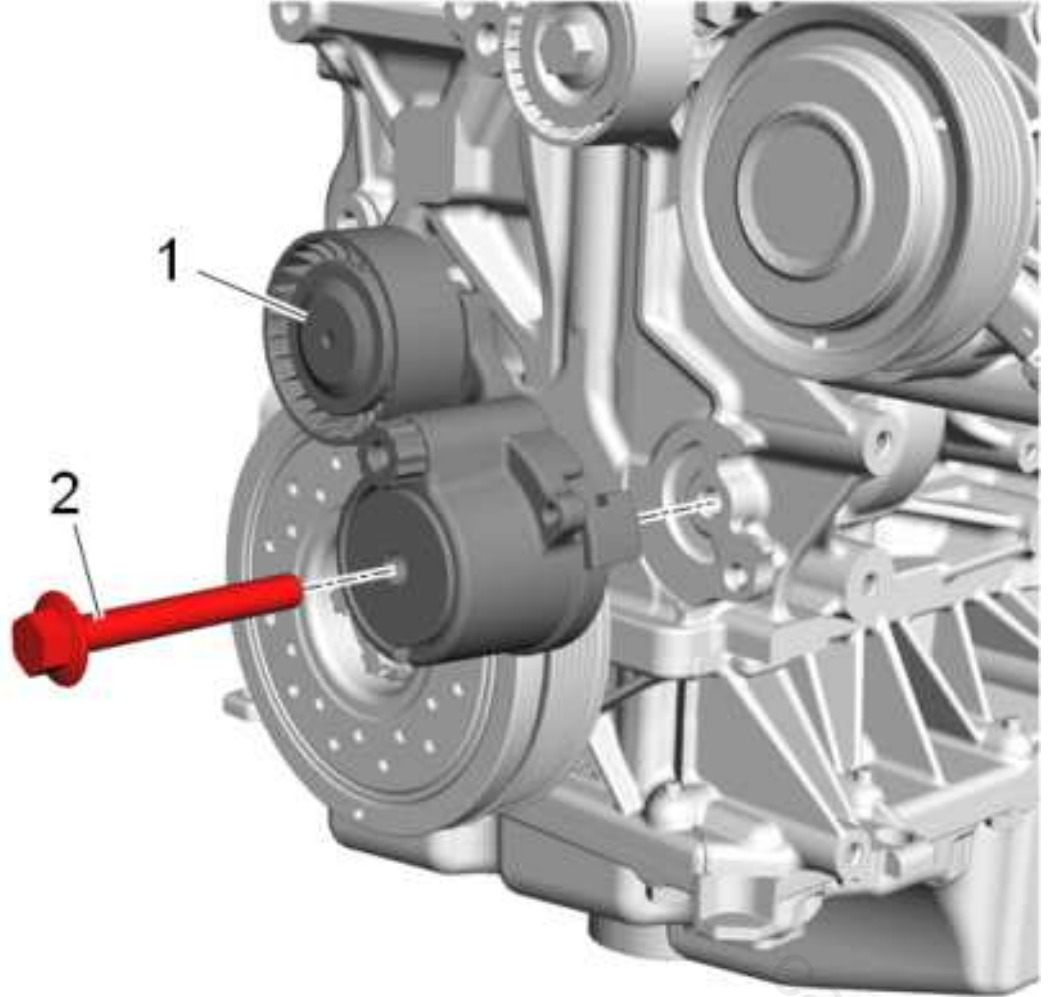


Fig. 43: Drive Belt Tensioner And Bolt
Courtesy of GENERAL MOTORS COMPANY

2. Remove the drive belt tensioner bolt (2).
3. Remove the drive belt tensioner (1).

Installation Procedure

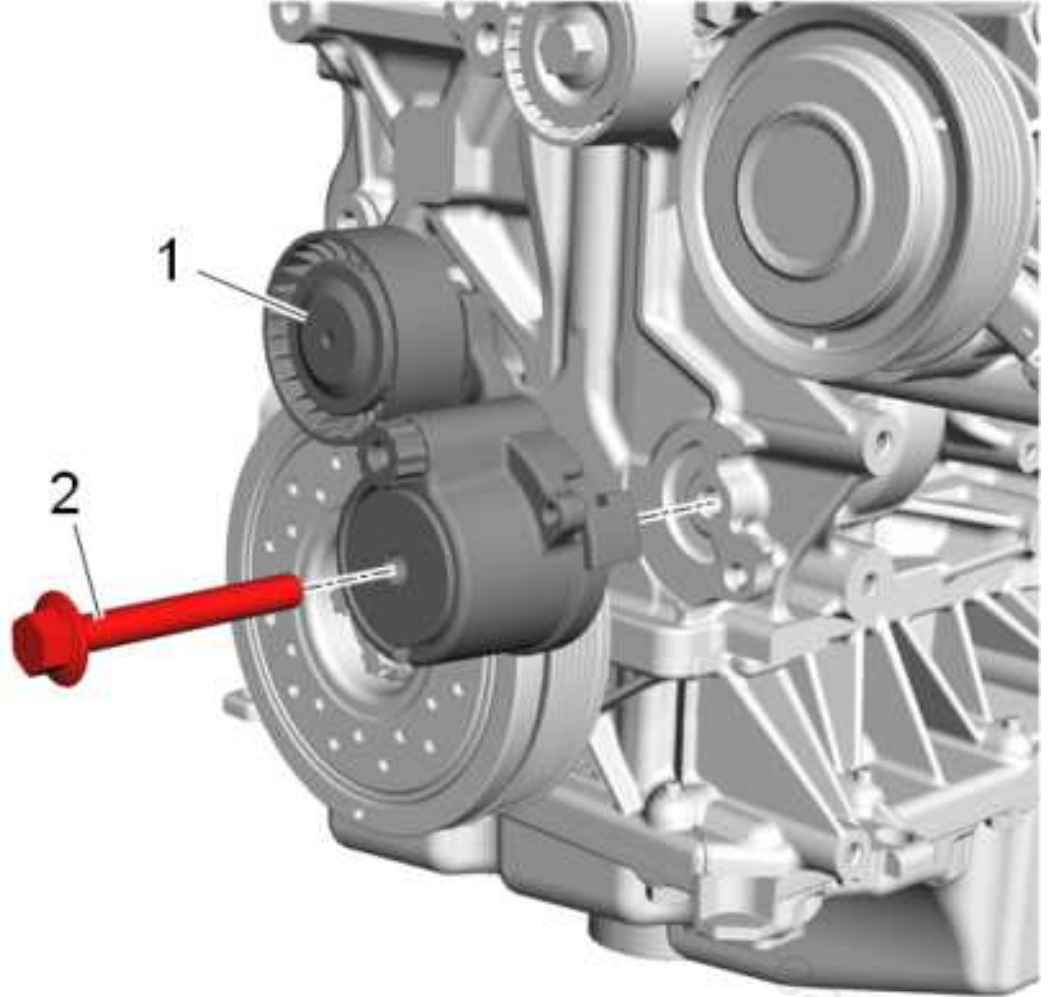


Fig. 44: Drive Belt Tensioner And Bolt
Courtesy of GENERAL MOTORS COMPANY

1. Install the drive belt tensioner (1).

CAUTION: Refer to [Fastener Caution](#) .

2. Install the drive belt tensioner bolt (2) and tighten to 55 N.m (41 lb ft).
3. Install the drive belt. Refer to [Generator and Air Conditioning Compressor Belt Replacement](#)

ENGINE MOUNT REPLACEMENT

Special Tools

EN-45059 Angle Meter

Equivalent regional tools: [Special Tools](#)

Removal Procedure

1. Remove Intake Manifold Cover. Refer to [Intake Manifold Cover Replacement](#)
2. Remove Air Cleaner Assembly. Refer to [Air Cleaner Assembly Replacement](#)
3. Install Engine Support Fixture. Refer to [Engine Support Fixture](#)

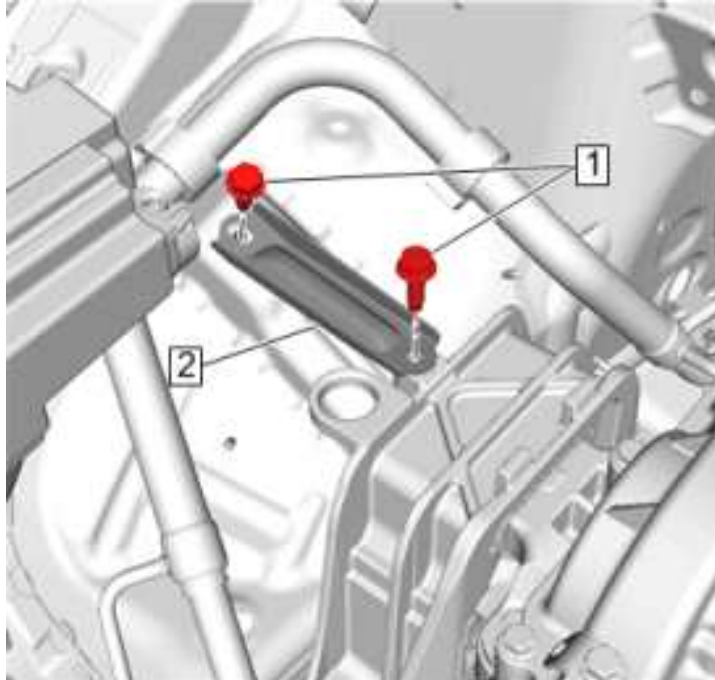


Fig. 45: Engine Mount Brace And Bolts
Courtesy of GENERAL MOTORS COMPANY

4. Remove Engine Mount Brace Bolts (1) (Qty: 2)
5. Remove Engine Mount Brace (2)



Fig. 46: Engine Mount And Bolts
Courtesy of GENERAL MOTORS COMPANY

6. Remove Engine Mount Bolts (1) (Qty: 2)
7. Remove and DISCARD Engine Mount Engine Side Bolt (2)
8. Remove and DISCARD Engine Mount Engine Side Bolt (3)
9. Remove Engine Mount (4)

Installation Procedure

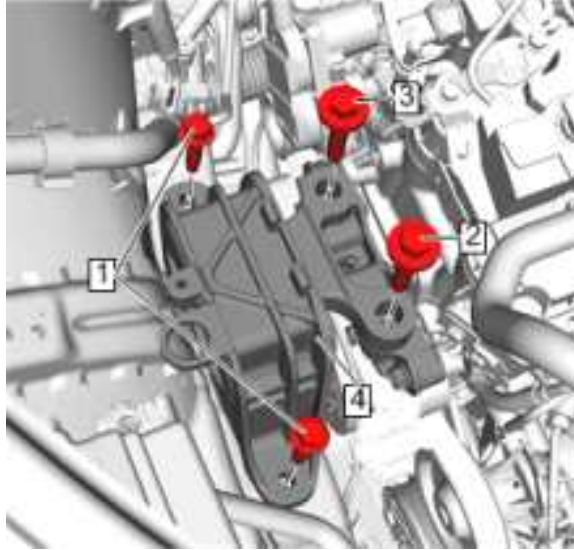


Fig. 47: Engine Mount And Bolts

Courtesy of GENERAL MOTORS COMPANY

1. Install Engine Mount (4)

CAUTION: Refer to [Fastener Caution](#)

2. Install and tighten Engine Mount Bolts (1) (Qty: 2) to 100 N.m (74 lb ft)

CAUTION: Refer to [Torque-to-Yield Fastener Caution](#)

3. Install NEW Engine Mount Engine Side Bolt (2, 3)
4. Tighten Engine Mount Engine Side Bolt (2)
 1. First Pass: 35 N.m (26 lb ft)
5. Tighten Engine Mount Engine Side Bolt (3)
 1. First Pass: 35 N.m (26 lb ft)
6. Tighten Engine Mount Engine Side Bolt (2, 3)
 1. Second Pass: 100 N.m (74 lb ft)
 2. Final Pass: 60 - 75 degrees - **EN-45059** Angle Meter

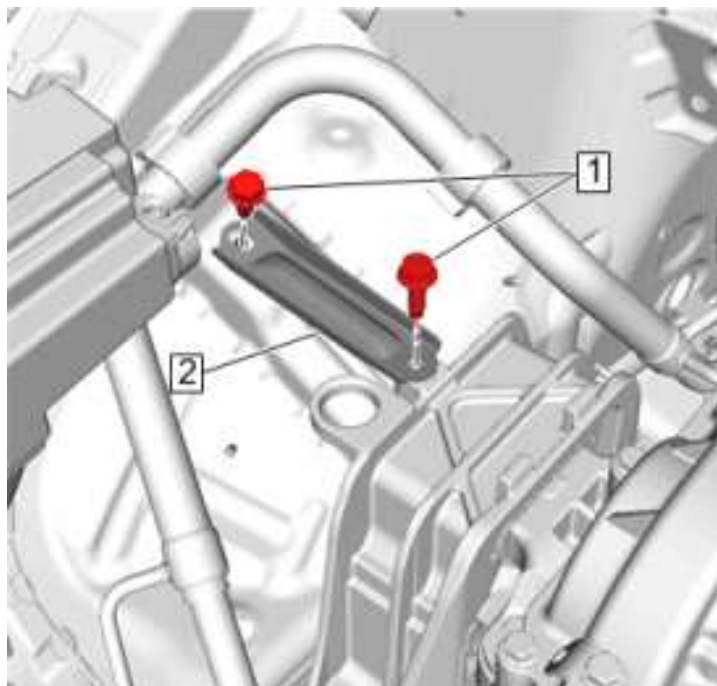


Fig. 48: Engine Mount Brace And Bolts

Courtesy of GENERAL MOTORS COMPANY

7. Install Engine Mount Brace (2)

8. Install and tighten Engine Mount Brace Bolts (1) (Qty: 2) to 22 N.m (16 lb ft)
9. Remove Engine Support Fixture. Refer to [Engine Support Fixture](#)
10. Install Air Cleaner Assembly. Refer to [Air Cleaner Assembly Replacement](#)
11. Install Intake Manifold Cover. Refer to [Intake Manifold Cover Replacement](#)

ENGINE MOUNT BRACKET REPLACEMENT

Special Tools

EN-45059 Angle Meter

Equivalent regional tools: [Special Tools](#)

Removal Procedure

1. Remove the engine mount. Refer to [Engine Mount Replacement](#)

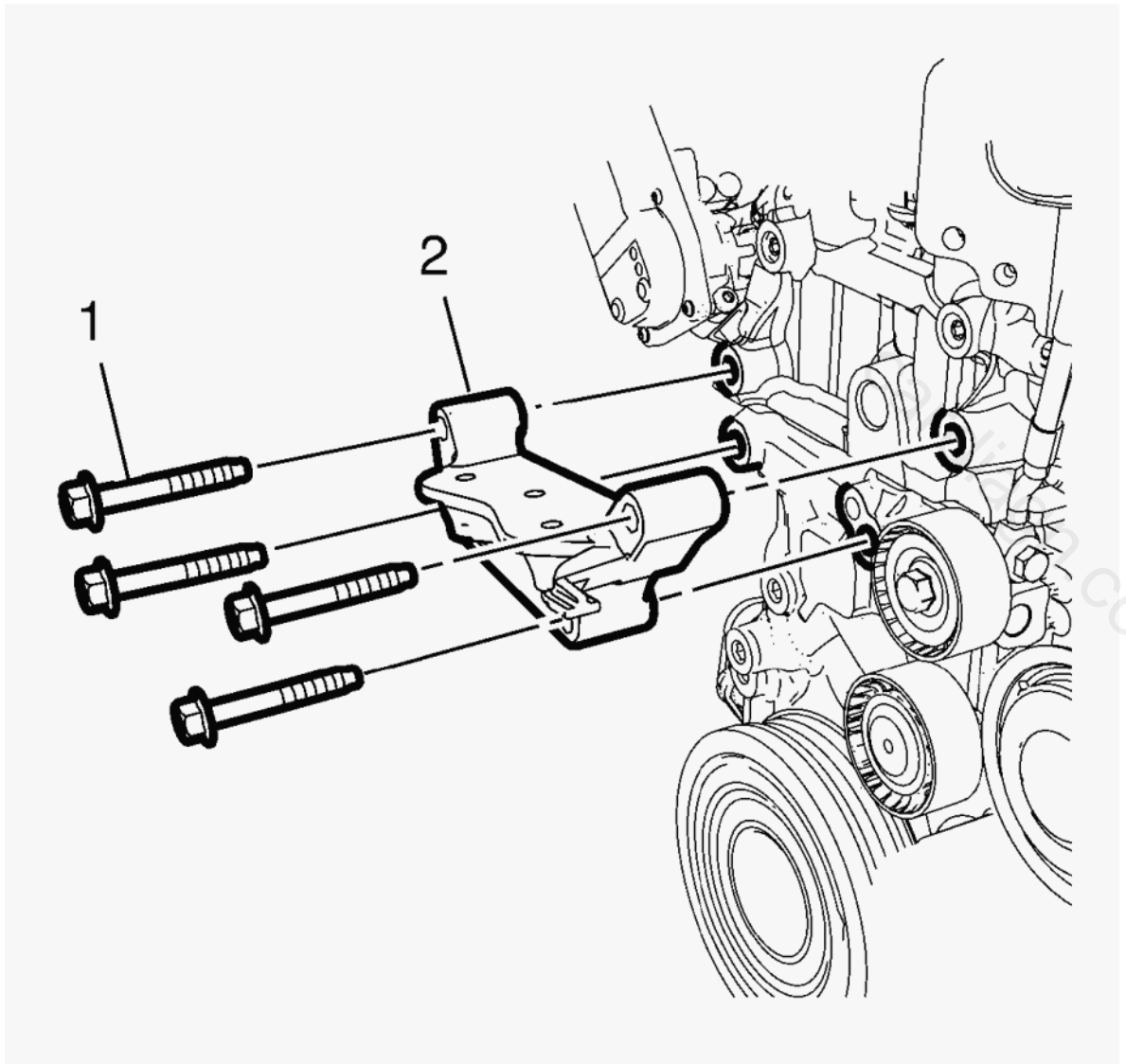


Fig. 49: Engine Mount Bracket And Bolts
Courtesy of GENERAL MOTORS COMPANY

2. Remove Engine Mount Bracket Bolts (1) (Qty: 4)
3. Remove Engine Mount Bracket (2)

Installation Procedure

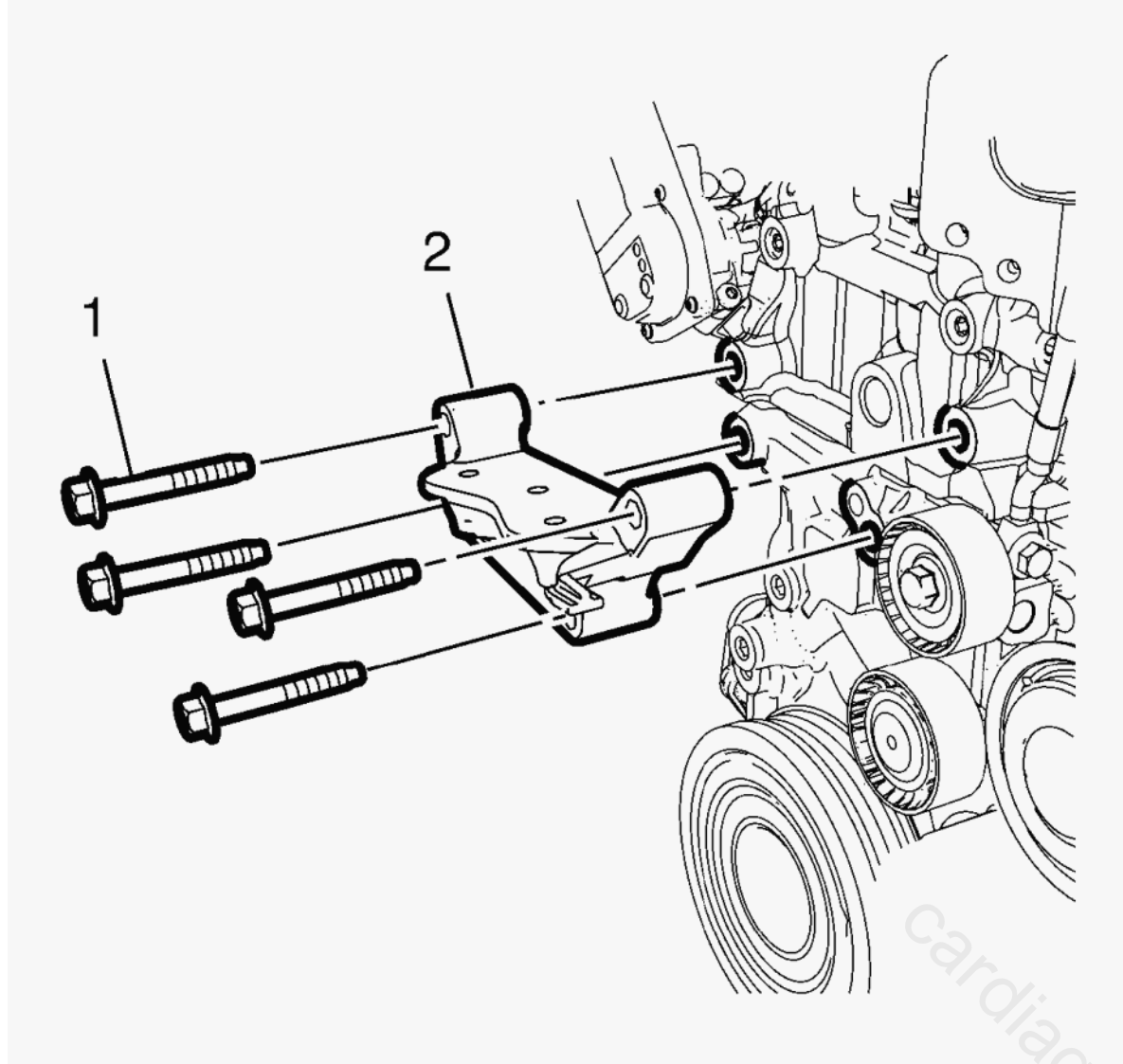


Fig. 50: Engine Mount Bracket And Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Install Engine Mount Bracket (2)

CAUTION: Refer to [Fastener Caution](#)

2. Install NEW Engine Mount Bracket Bolts (1) (Qty: 4) and Hand tighten

CAUTION: Refer to [Torque-to-Yield Fastener Caution](#)

3. Tighten Engine Mount Bracket Bolts (1) (Qty: 4) in sequence:
 1. First Pass: 58 N.m (43 lb ft)
 2. Final Pass: 60 - 75 degrees - Use the special tool: **EN-45059** Angle Meter
4. Install the engine mount. Refer to [Engine Mount Replacement](#)

CAMSHAFT HOUSING REPLACEMENT

Removal Procedure

1. Disconnect the battery negative cable. Refer to [Battery Negative Cable Disconnection and Connection \(KL9\)](#).
2. Remove Fuel Injectors (Qty: 4). Refer to [Fuel Injector Replacement](#)

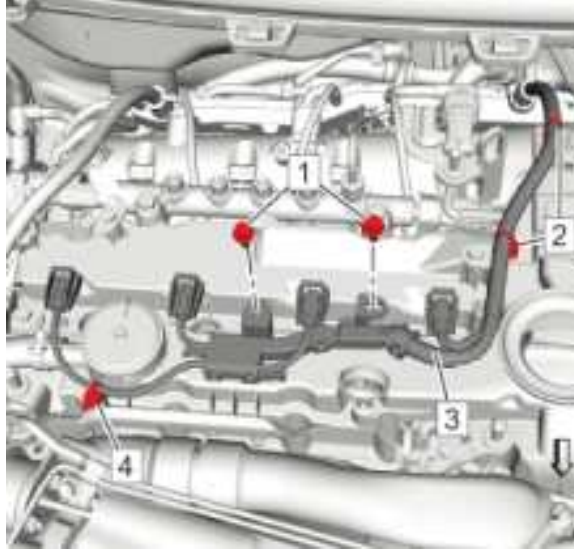


Fig. 51: Engine Wiring Harness, Conduit Bolts And Clips
Courtesy of GENERAL MOTORS COMPANY

3. Remove Engine Wiring Harness Conduit Bolts (1) (Qty: 2)
4. Unclip Wiring Harness Clips (2, 4) (Qty: 3)
5. Position aside Engine Wiring Harness (3)

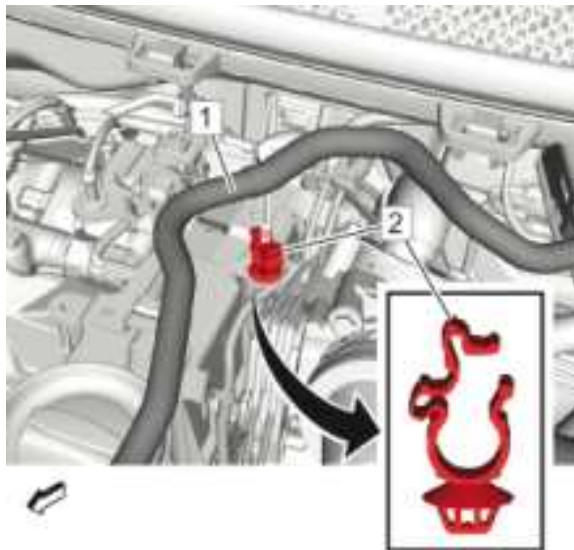


Fig. 52: Engine Coolant Air Bleed Hose And Retainer Clip
Courtesy of GENERAL MOTORS COMPANY

6. Unclip Engine Coolant Air Bleed Hose (1) @ Retainer Clip (2)
7. Position aside Engine Coolant Air Bleed Hose (1)

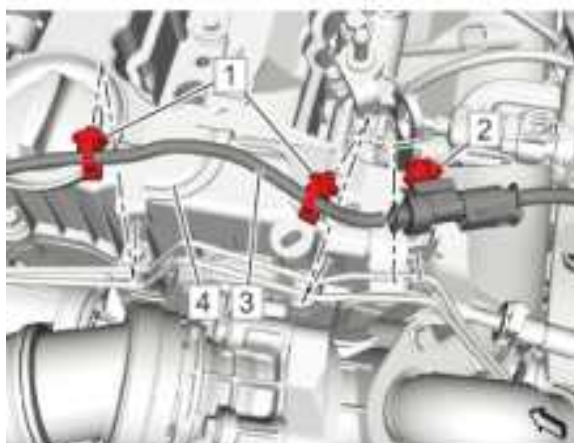


Fig. 53: Wiring Harness, Exhaust Temperature Sensor Bracket And Clips
Courtesy of GENERAL MOTORS COMPANY

8. Unclip Wiring Harness Clips (1) (Qty: 2) @ Exhaust Temperature Sensor Bracket (4)
9. Unclip Clip (2) @ Exhaust Temperature Sensor Bracket (4)
10. Position aside Wiring Harness (3)

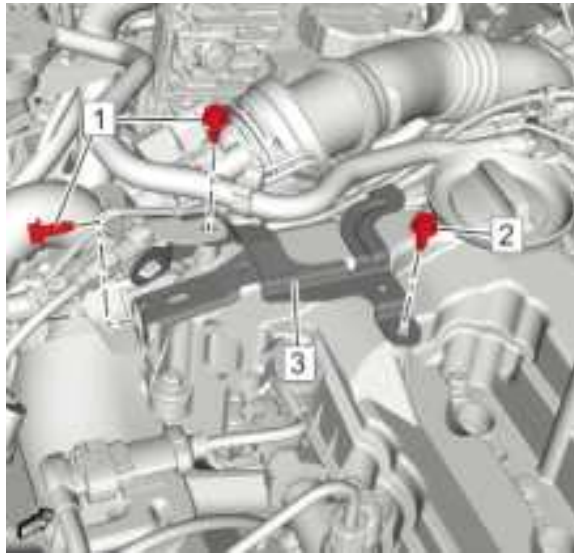


Fig. 54: Exhaust Temperature Sensor Electrical Connector Bracket And Bolts
Courtesy of GENERAL MOTORS COMPANY

11. Remove Exhaust Temperature Sensor Electrical Connector Bracket Bolts (1, 2) (Qty: 3)
12. Remove Exhaust Temperature Sensor Electrical Connector Bracket (3)

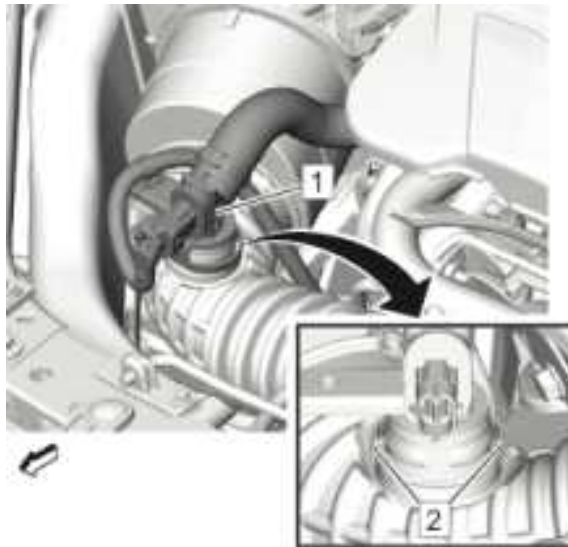


Fig. 55: Positive Crankcase Ventilation Heater And Checkered Places
Courtesy of GENERAL MOTORS COMPANY

13. Remove Positive Crankcase Ventilation Heater (1)
 1. Press the positive crankcase ventilation heater at the 2 checkered places (2).
 2. Pull the positive crankcase ventilation heater up to remove.

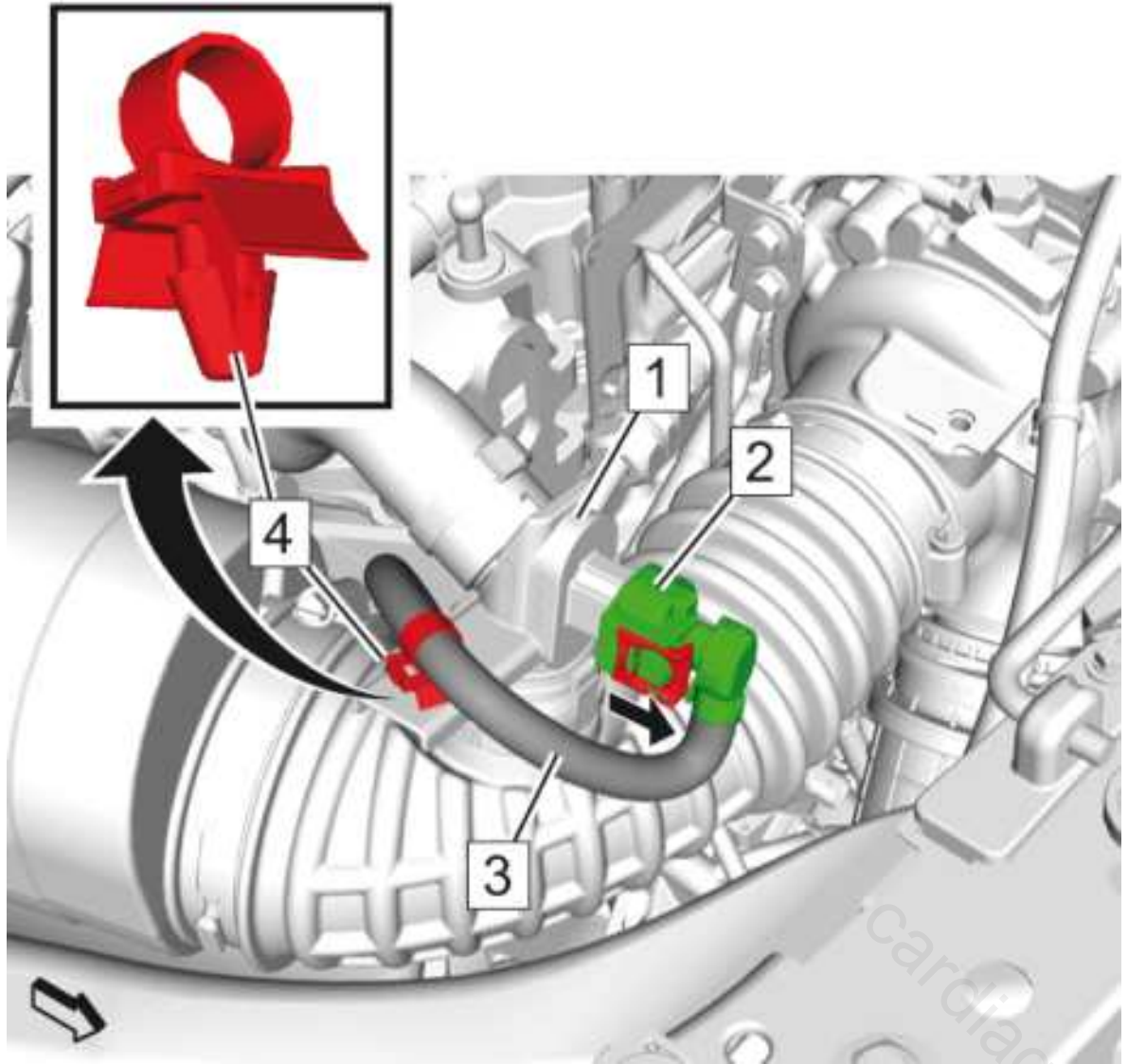


Fig. 56: Electrical Connector, PCV Heater, Wiring Harness And Clip
 Courtesy of GENERAL MOTORS COMPANY

14. Disconnect Electrical Connector (2) @ Positive Crankcase Ventilation Heater (1)
15. Unclip Wiring Harness Clip (4)
16. Position aside Wiring Harness (3)

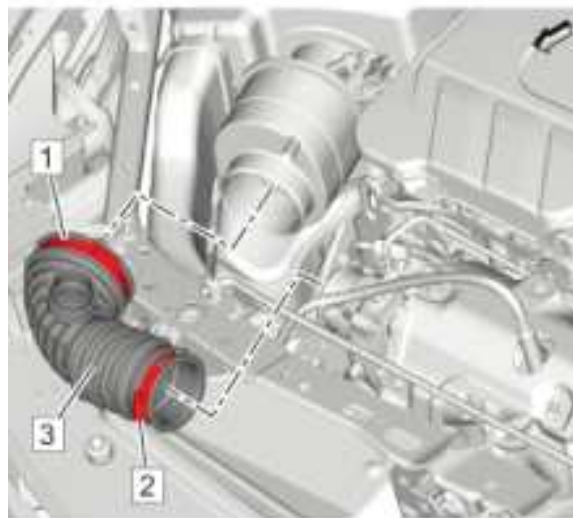


Fig. 57: Air Cleaner Outlet Duct And Clamps
 Courtesy of GENERAL MOTORS COMPANY

17. Loosen Air Cleaner Outlet Duct Clamps (1, 2) (Qty: 2)
18. Remove Air Cleaner Outlet Duct (3)



Fig. 58: Engine Lift Bracket, Bolt And Clips
Courtesy of GENERAL MOTORS COMPANY

19. Unclip Wiring Harness Clips (3) (Qty: 2)
20. Remove Engine Lift Bracket Bolt (2)
21. Remove Engine Lift Bracket (1)

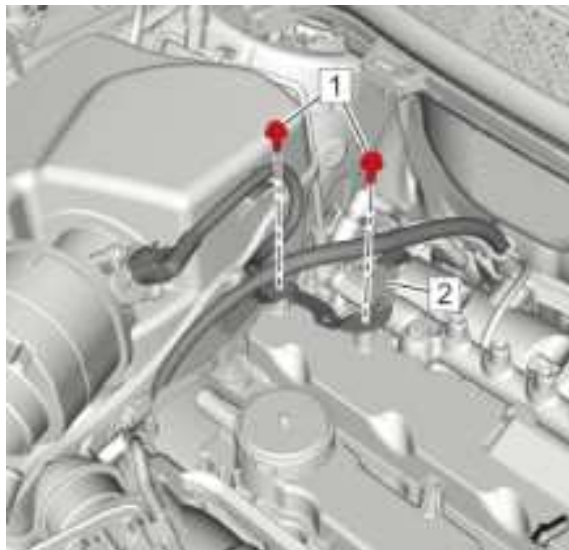
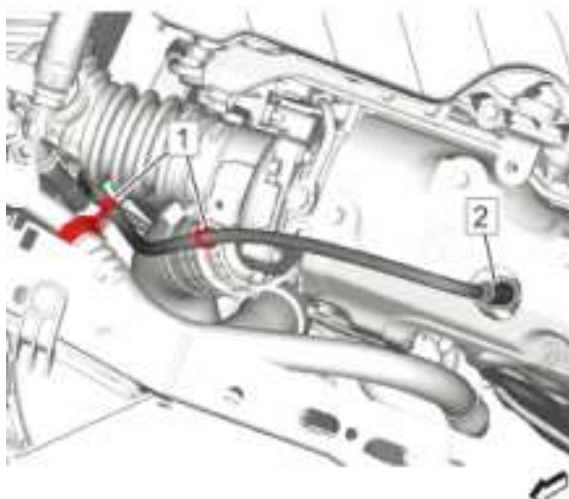


Fig. 59: Engine Control Module Wiring Harness Bracket And Bolts
Courtesy of GENERAL MOTORS COMPANY

22. Remove Engine Control Module and Engine Wiring Harness Bracket Bolts (1) (Qty: 2)
23. Position aside Engine Control Module Wiring Harness Bracket (2)



NOTE: Do not bend the cable sharply at the base of either the sensing unit or sensor ECU in the final mounting position.

24. Remove Nitrogen Oxides Sensor (2)

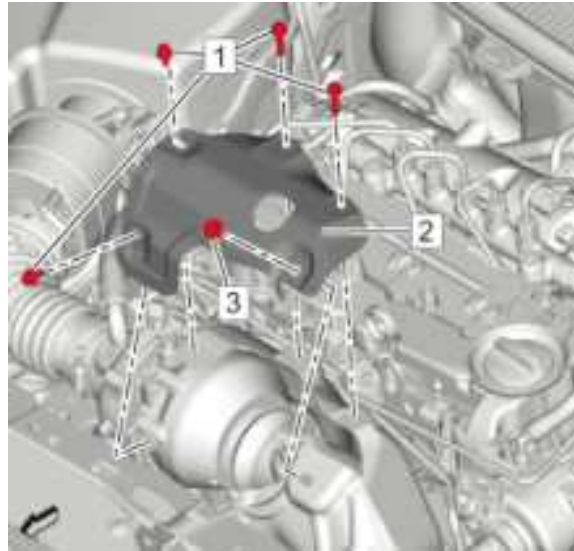


Fig. 61: Turbocharger Heat Shield, Bolts And Nut
Courtesy of GENERAL MOTORS COMPANY

25. Remove Turbocharger Heat Shield Bolts (1) (Qty: 4)

26. Remove Turbocharger Heat Shield Nut (3)

27. Remove Turbocharger Heat Shield (2)

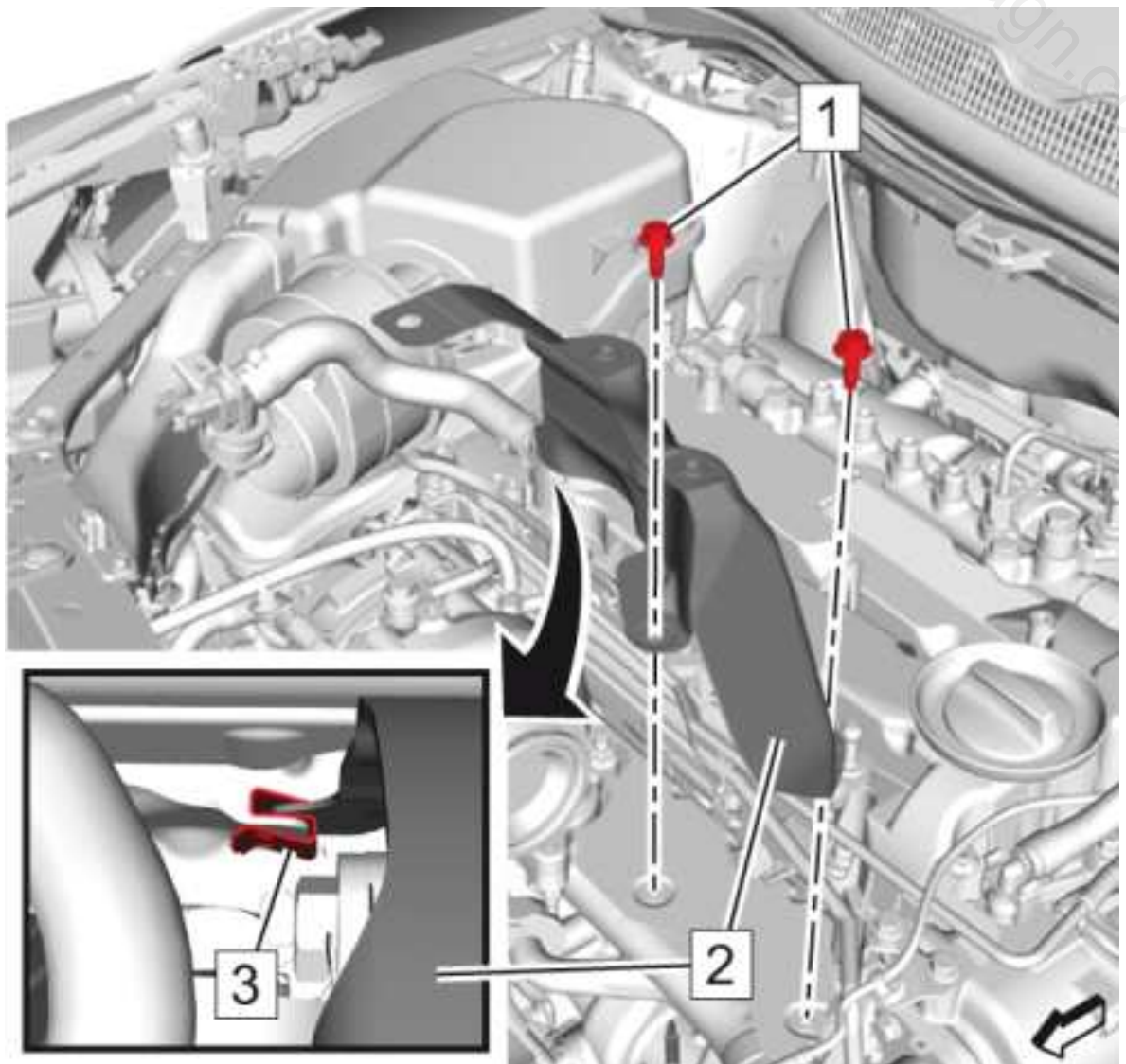


Fig. 62: Turbocharger Heat Shield, Bolts And Clamp
Courtesy of GENERAL MOTORS COMPANY

28. Remove Turbocharger Heat Shield Bolts (1) (Qty: 2)
29. Unclip Turbocharger Heat Shield (2) @ Clamp (3)
30. Remove Turbocharger Heat Shield (2)

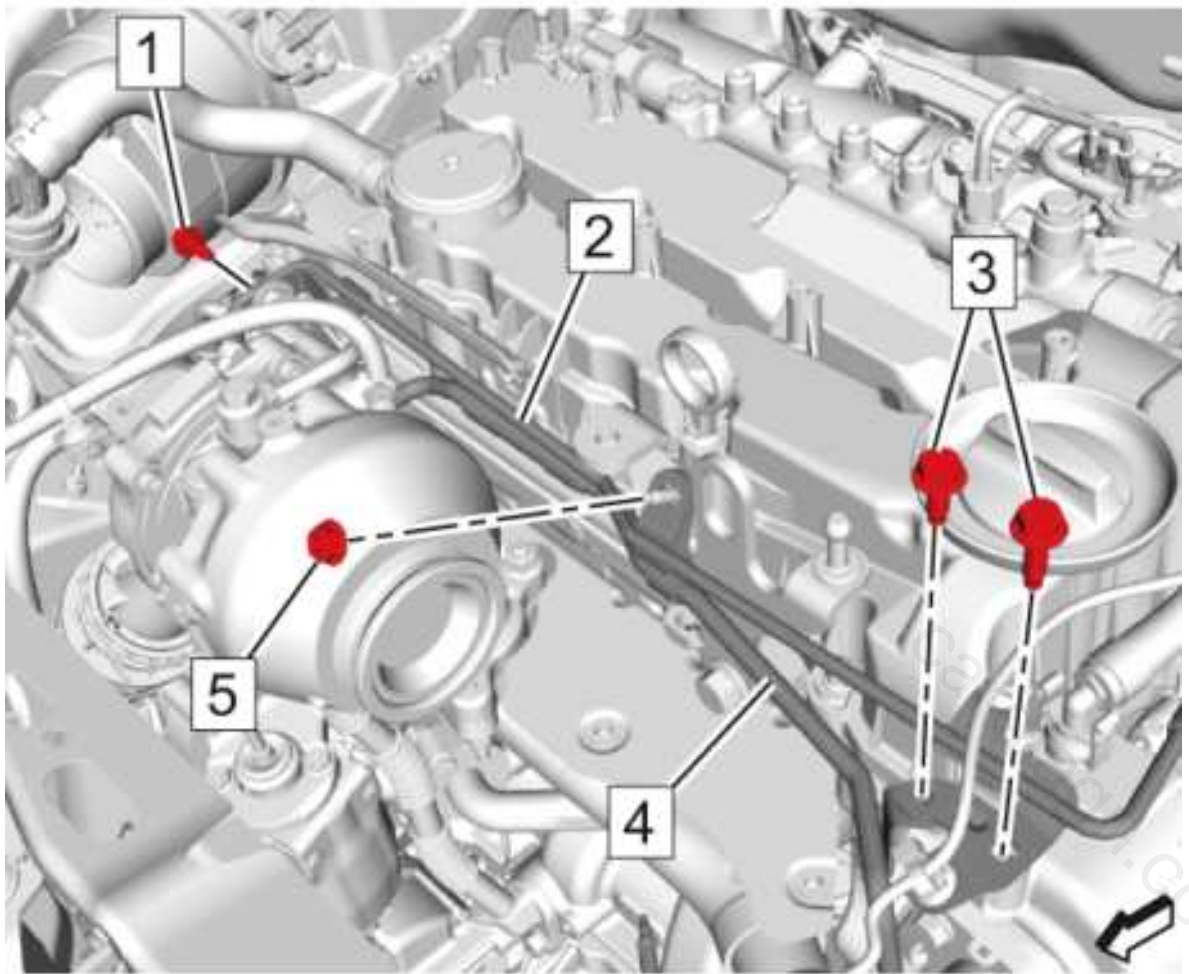


Fig. 63: Turbocharger Wastegate Actuator Pipe, Bolts, Nut And Turbocharger Coolant Feed Pipe
Courtesy of GENERAL MOTORS COMPANY

31. Remove Turbocharger Wastegate Actuator Pipe Bolts (1, 3) (Qty: 3)
32. Remove the turbocharger wastegate actuator pipe nut (5).
33. Position aside Turbocharger Wastegate Actuator Pipe (2)
34. Position aside Turbocharger Coolant Feed Pipe (4)

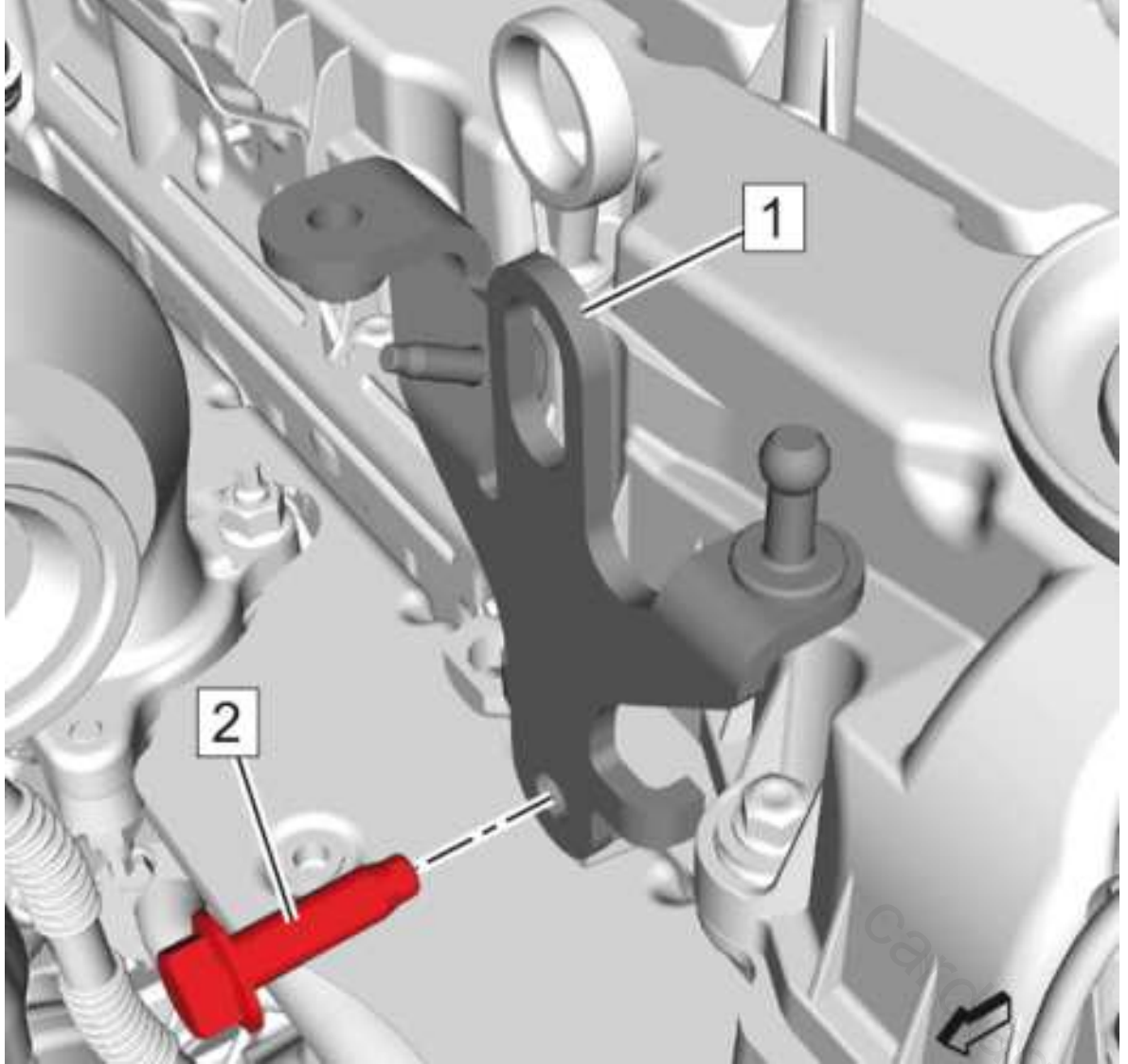


Fig. 64: Engine Lift Bracket And Bolt

Courtesy of GENERAL MOTORS COMPANY

- 35. Remove Engine Lift Bracket Bolt (2)
- 36. Remove Engine Lift Bracket (1)

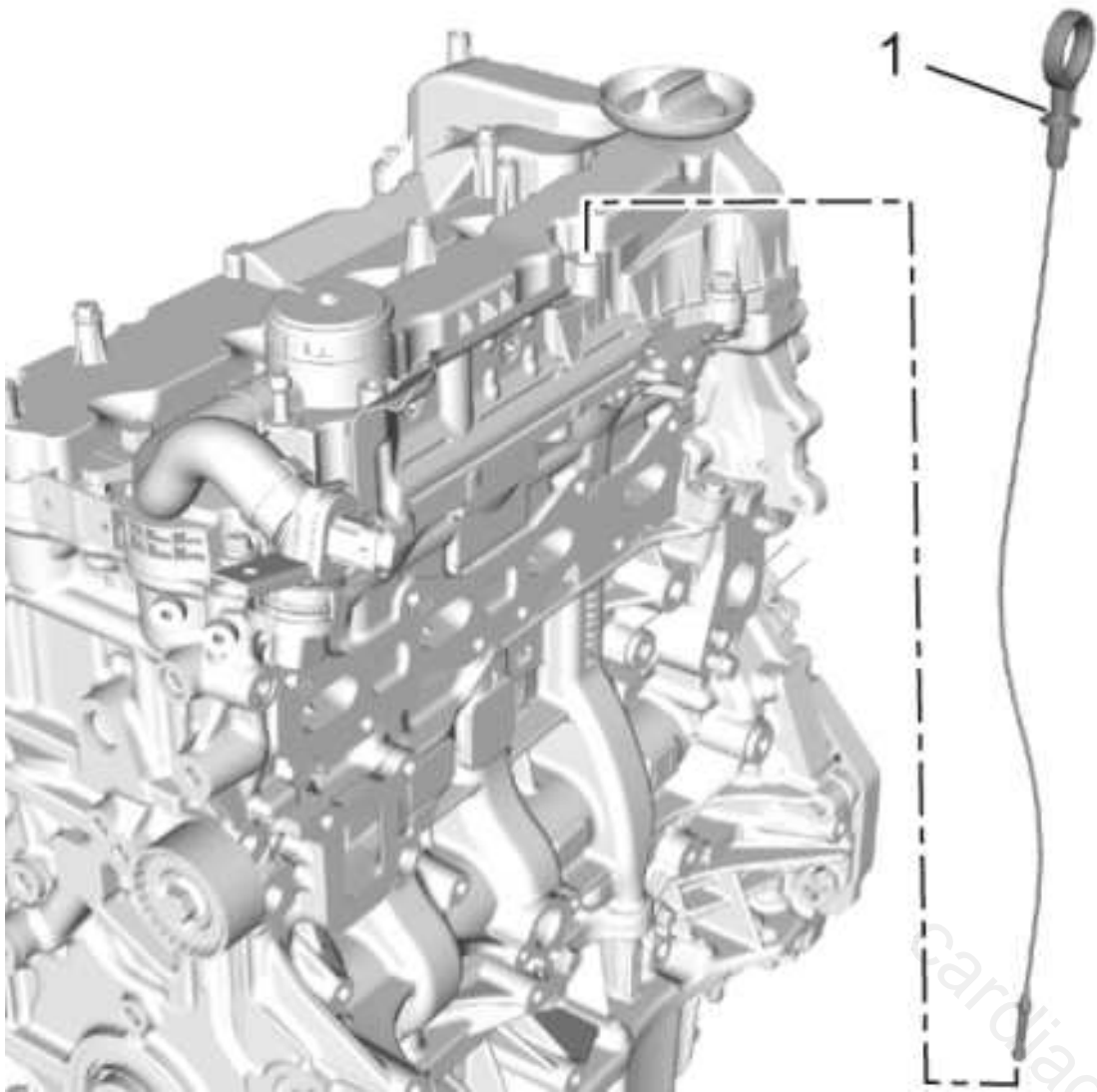


Fig. 65: Engine Oil Level Indicator

Courtesy of GENERAL MOTORS COMPANY

37. Remove Engine Oil Level Indicator (1)

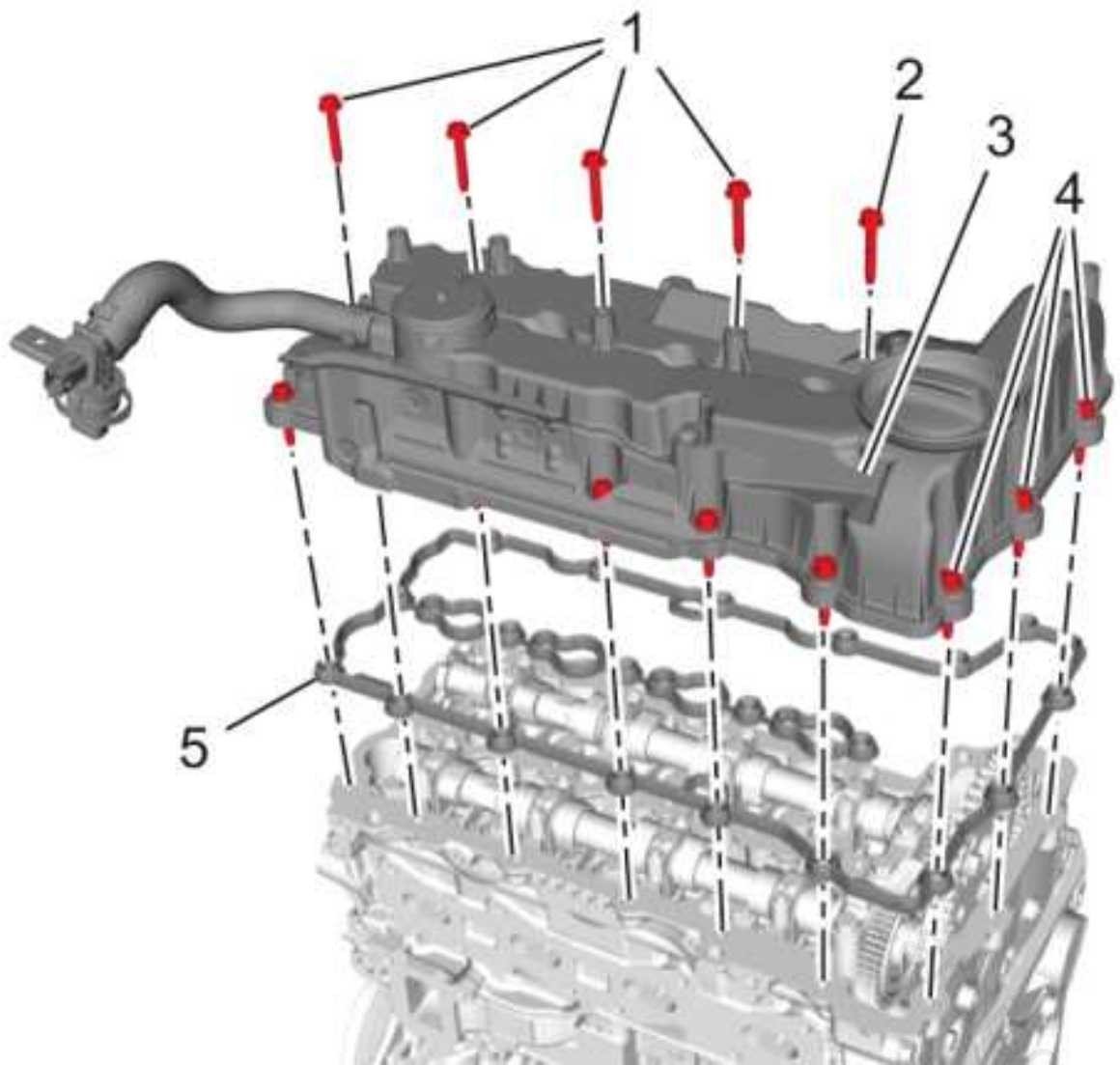


Fig. 66: Camshaft Housing, Bolts And Gasket
 Courtesy of GENERAL MOTORS COMPANY

NOTE: Mind the different bolts.

- 38. Remove Camshaft Housing Bolt - Outer (4) (Qty: 15)
- 39. Remove Camshaft Housing Bolt - Inner (1, 2) (Qty: 5)
- 40. Remove Camshaft Housing (3)
- 41. Remove and DISCARD Camshaft Housing Gasket (5)

Installation Procedure

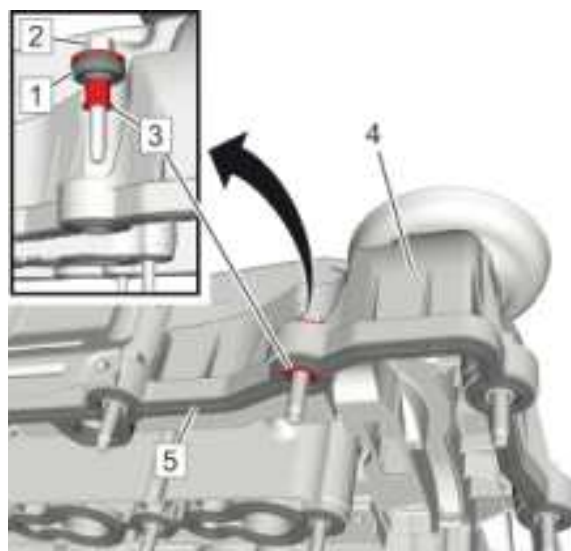


Fig. 67: Camshaft Housing, Gasket, Bolts, Bushings And Insulators
Courtesy of GENERAL MOTORS COMPANY

1. Install NEW Camshaft Housing Gasket (5) @ Camshaft Housing (4)
2. Install Camshaft Housing Bolt (2) (Qty: 20) @ Camshaft Housing (4)
3. Ensure the camshaft housing bolt bushings (3) and the camshaft housing cover insulators (1) are seated properly.

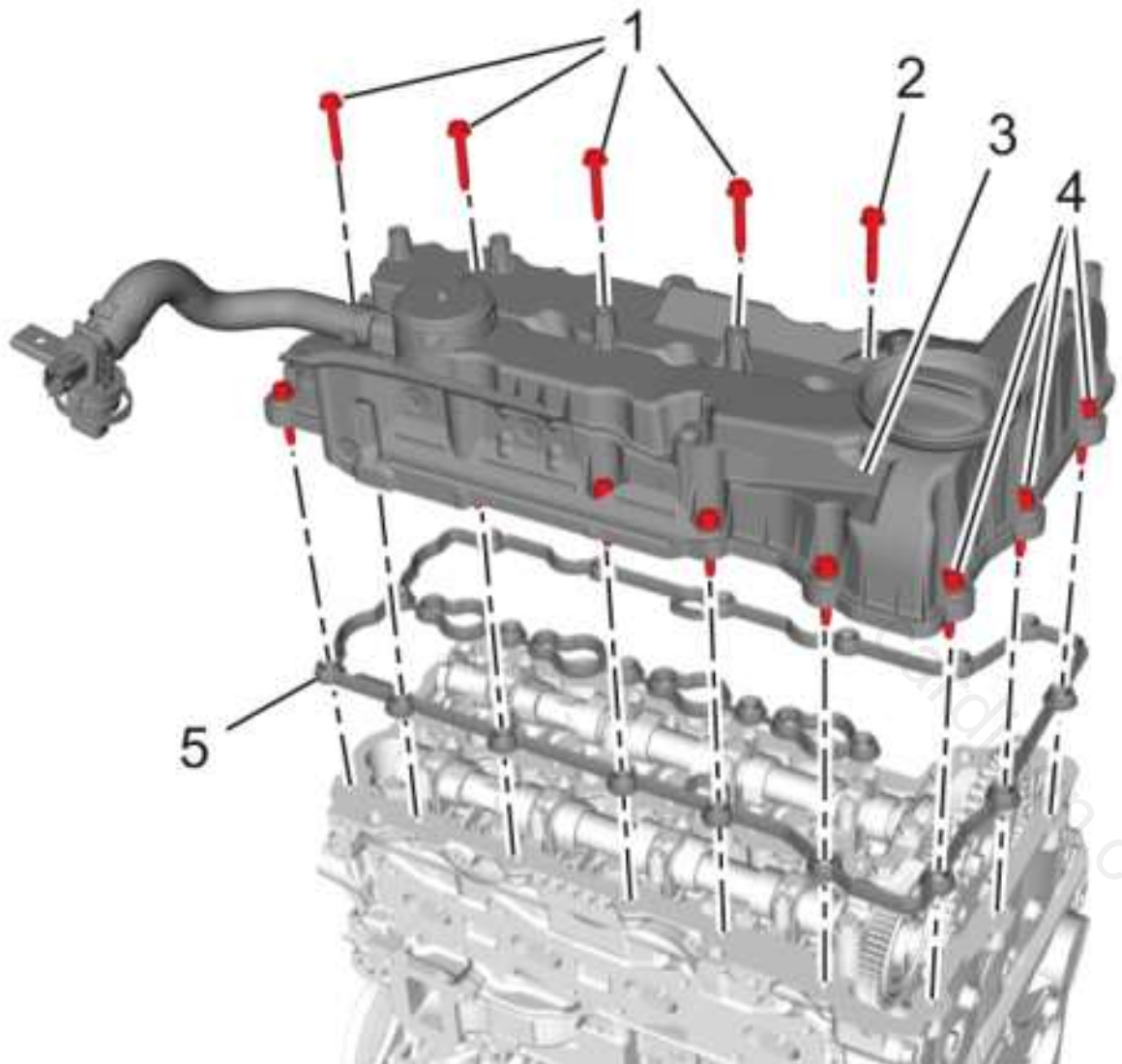


Fig. 68: Camshaft Housing, Bolts And Gasket
Courtesy of GENERAL MOTORS COMPANY

NOTE: Mind the different bolts.

4. Install the camshaft housing cover (3) along with the camshaft housing gasket (5) and the 20 camshaft housing bolts (1, 2, 4).
5. Hand tighten Camshaft Housing Bolts (1, 2, 4) (Qty: 20)

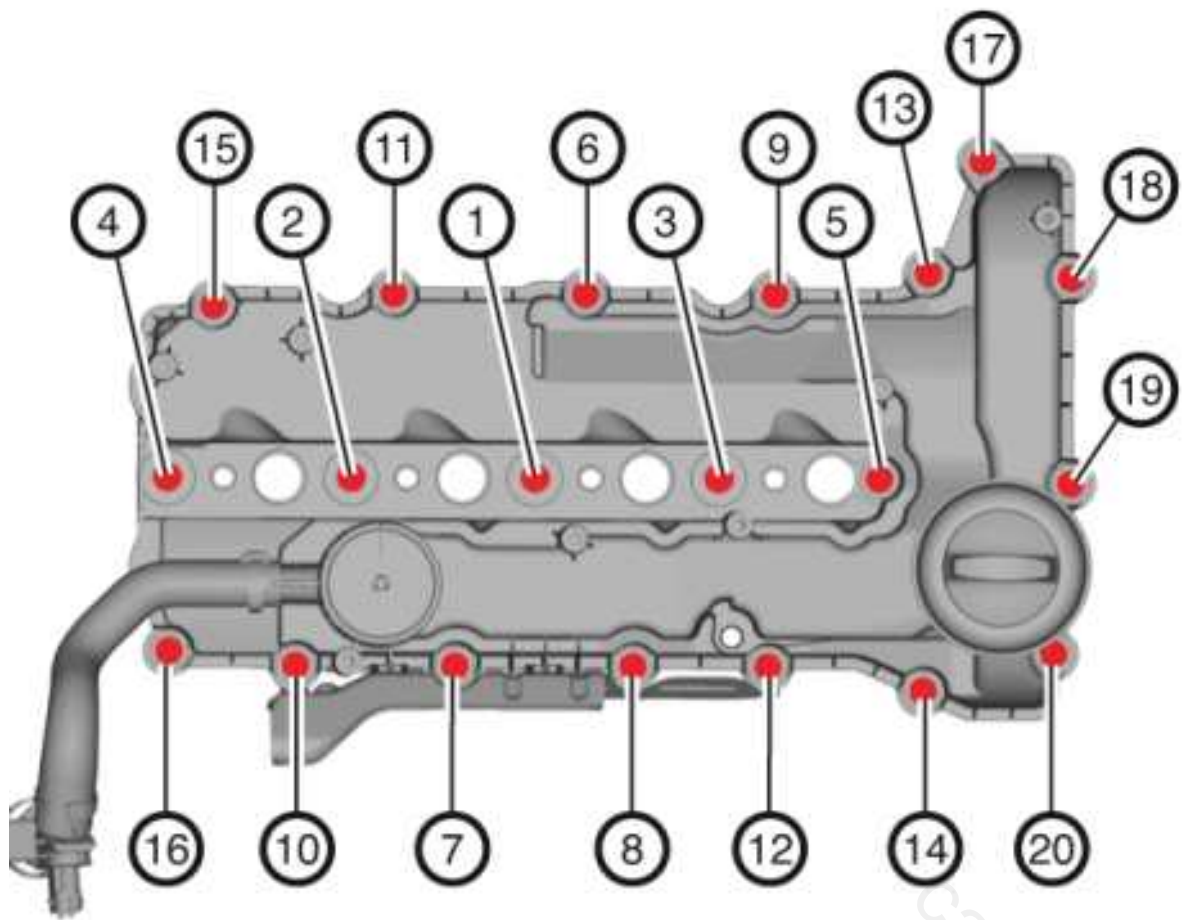


Fig. 69: Camshaft Housing Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution**

6. Tighten Camshaft Housing Bolts in sequence (Qty: 20) to 10 N.m (89 lb in)

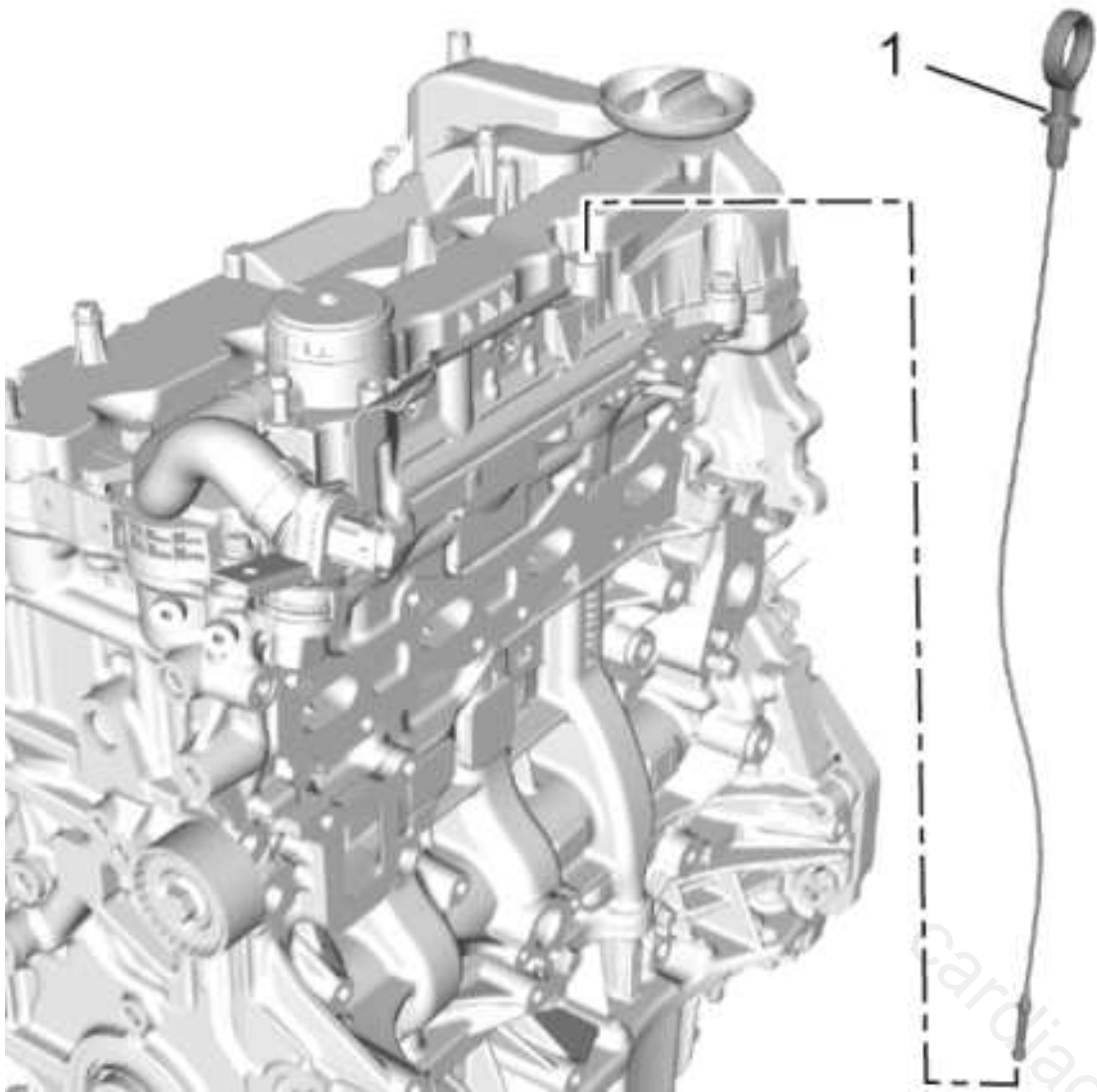


Fig. 70: Engine Oil Level Indicator

Courtesy of GENERAL MOTORS COMPANY

7. Install Engine Oil Level Indicator (1)

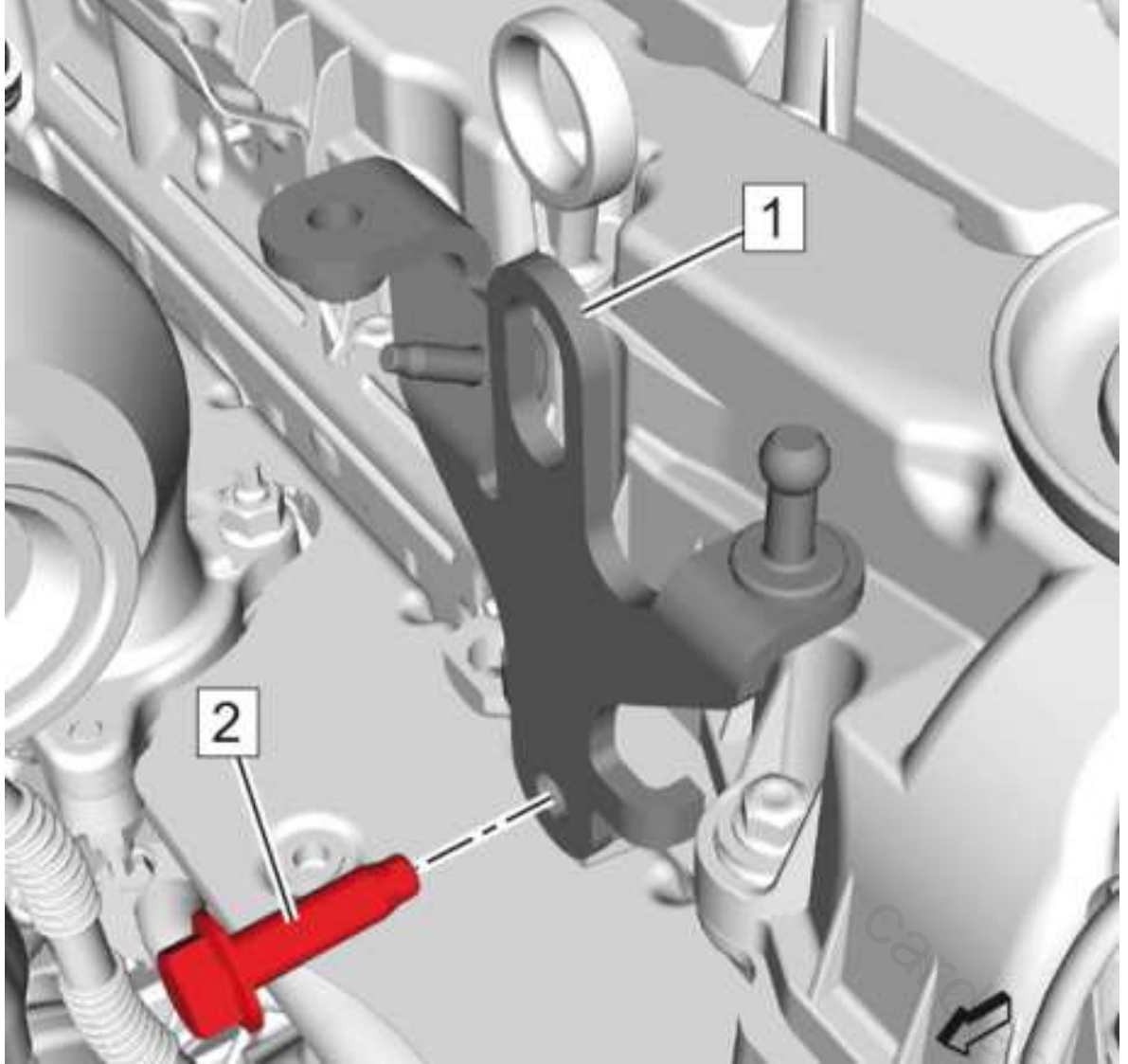


Fig. 71: Engine Lift Bracket And Bolt

Courtesy of GENERAL MOTORS COMPANY

8. Install Engine Lift Bracket (1)
9. Install and tighten Engine Lift Bracket Bolt (2) to 58 N.m (43 lb ft)

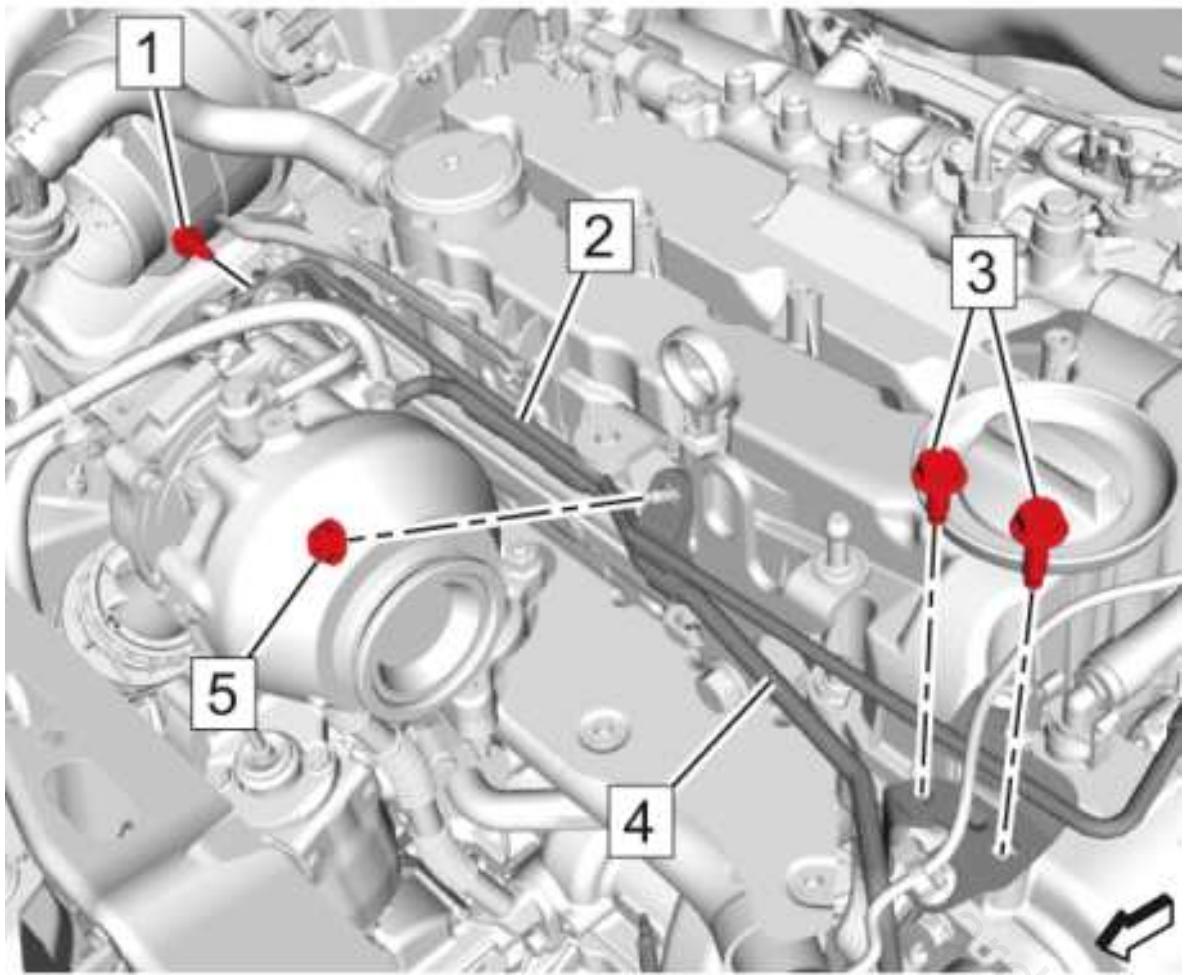


Fig. 72: Turbocharger Wastegate Actuator Pipe, Bolts, Nut And Turbocharger Coolant Feed Pipe
Courtesy of GENERAL MOTORS COMPANY

10. Reposition Turbocharger Coolant Feed Pipe (4)
11. Reposition Turbocharger Wastegate Actuator Pipe (2)
12. Install the turbocharger wastegate actuator pipe nut (5) and tighten to 10 N.m (89 lb in)
13. Install and tighten Turbocharger Wastegate Actuator Pipe Bolts (1, 3) (Qty: 3) to 10 N.m (89 lb in)

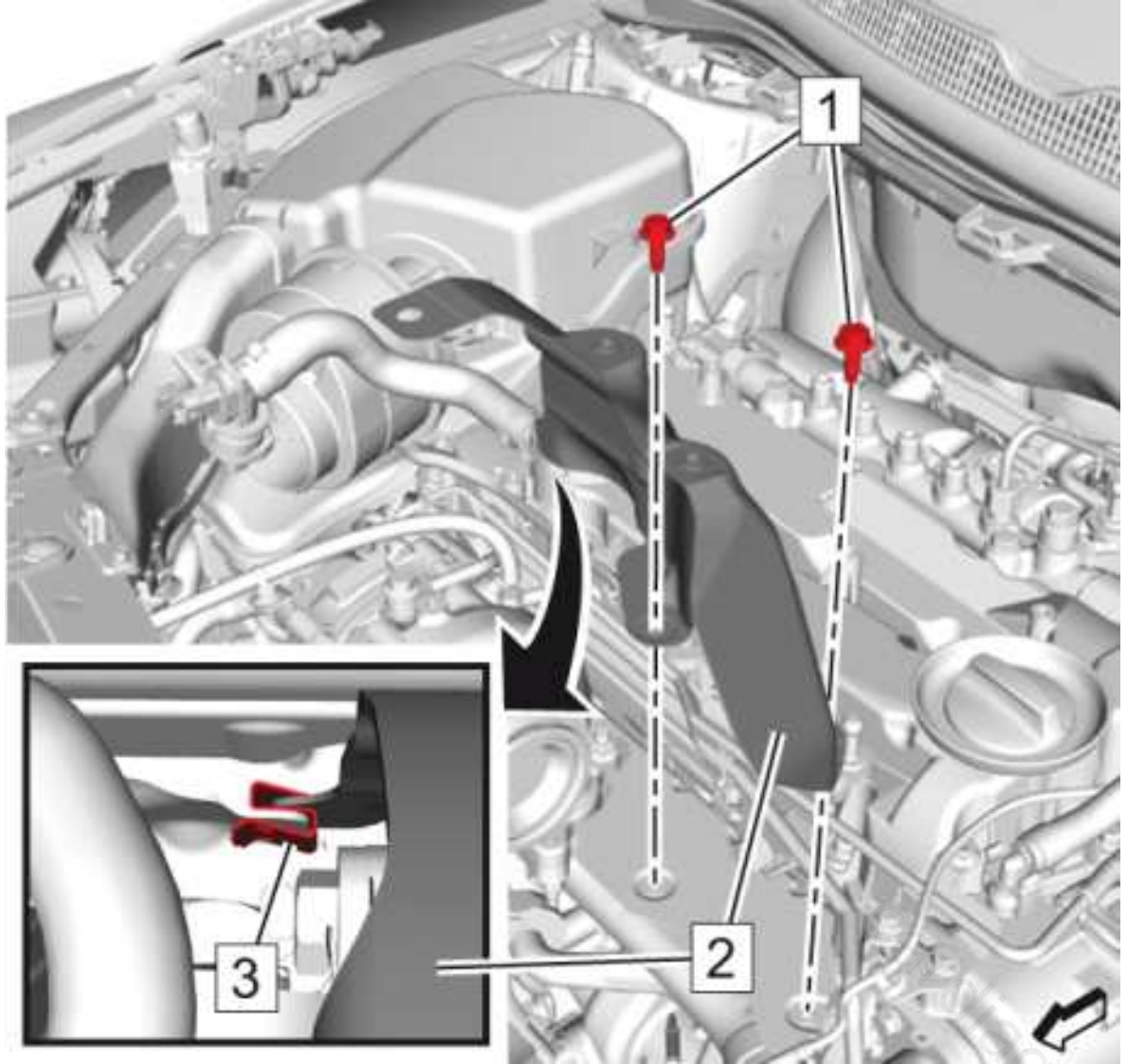


Fig. 73: Turbocharger Heat Shield, Bolts And Clamp
 Courtesy of GENERAL MOTORS COMPANY

14. Install Turbocharger Heat Shield (2)
15. Install Turbocharger Heat Shield (2) @ Clamp (3)
16. Install and tighten Turbocharger Heat Shield Bolts (1) (Qty: 2) to 10 N.m (89 lb in)

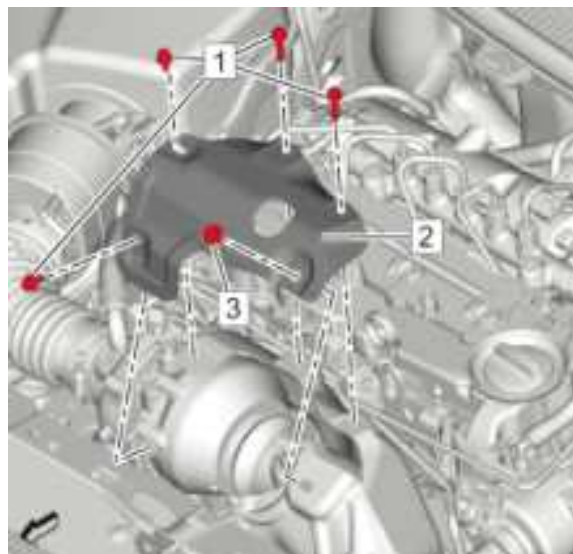


Fig. 74: Turbocharger Heat Shield, Bolts And Nut
 Courtesy of GENERAL MOTORS COMPANY

17. Install Turbocharger Heat Shield (2)
18. Install and tighten Turbocharger Heat Shield Nut (3) to 9 N.m (80 lb in)
19. Install and tighten Turbocharger Heat Shield Bolts (1) (Qty: 4) to 9 N.m (80 lb in)

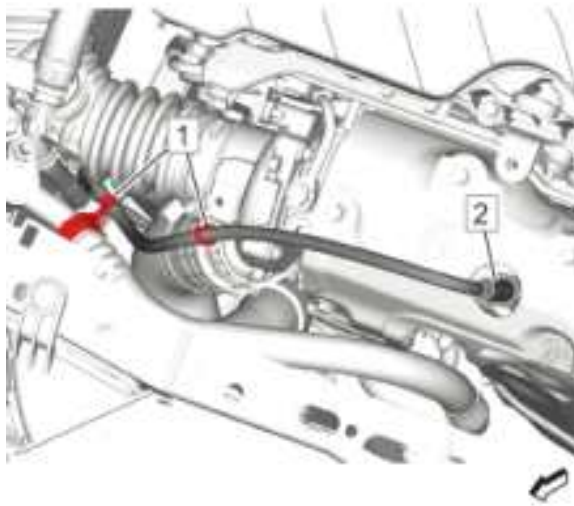


Fig. 75: Nitrogen Oxides Sensor And Wiring Harness Retainers

Courtesy of GENERAL MOTORS COMPANY

NOTE: Do not bend the cable sharply at the base of either the sensing unit or sensor ECU in the final mounting position

20. Install and tighten Nitrogen Oxides Sensor (2) to 50 N.m (37 lb ft)

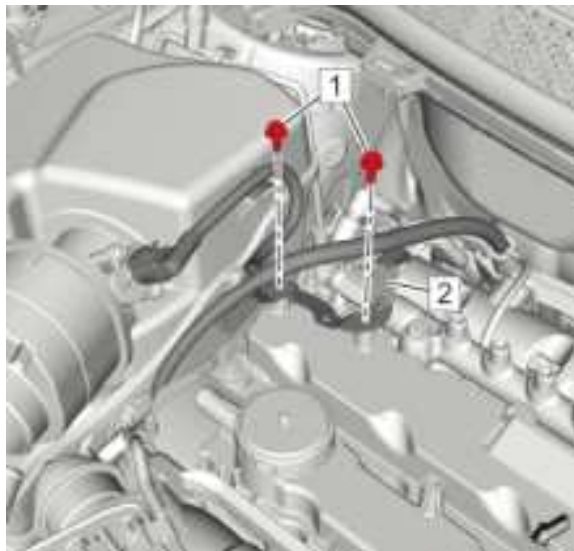


Fig. 76: Engine Control Module Wiring Harness Bracket And Bolts

Courtesy of GENERAL MOTORS COMPANY

21. Reposition Engine Control Module Wiring Harness Bracket (2)
22. Install and tighten Engine Control Module and Engine Wiring Harness Bracket Bolts (1) (Qty: 2) to 9 N.m (80 lb in)



Fig. 77: Engine Lift Bracket, Bolt And Clips
Courtesy of GENERAL MOTORS COMPANY

23. Install Engine Lift Bracket (1)
24. Install and tighten Engine Lift Bracket Bolt (2) to 58 N.m (43 lb ft)
25. Install Wiring Harness Clips (3) (Qty: 2)

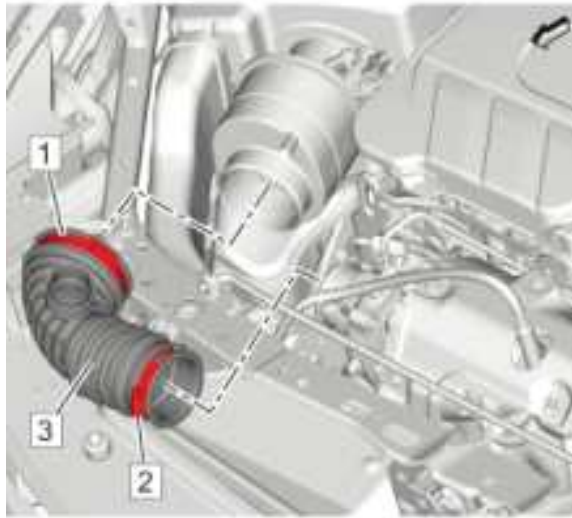


Fig. 78: Air Cleaner Outlet Duct And Clamps
Courtesy of GENERAL MOTORS COMPANY

NOTE: Ensure the outlet duct is fully seated to the mating surfaces before clamping. Verify that the cuff is not rolled under.

26. Install Air Cleaner Outlet Duct (3)

CAUTION: Refer to [Fastener Caution](#)

27. Tighten Air Cleaner Outlet Duct Clamps (1, 2) (Qty: 2) to 3.5 N.m (31 lb in)

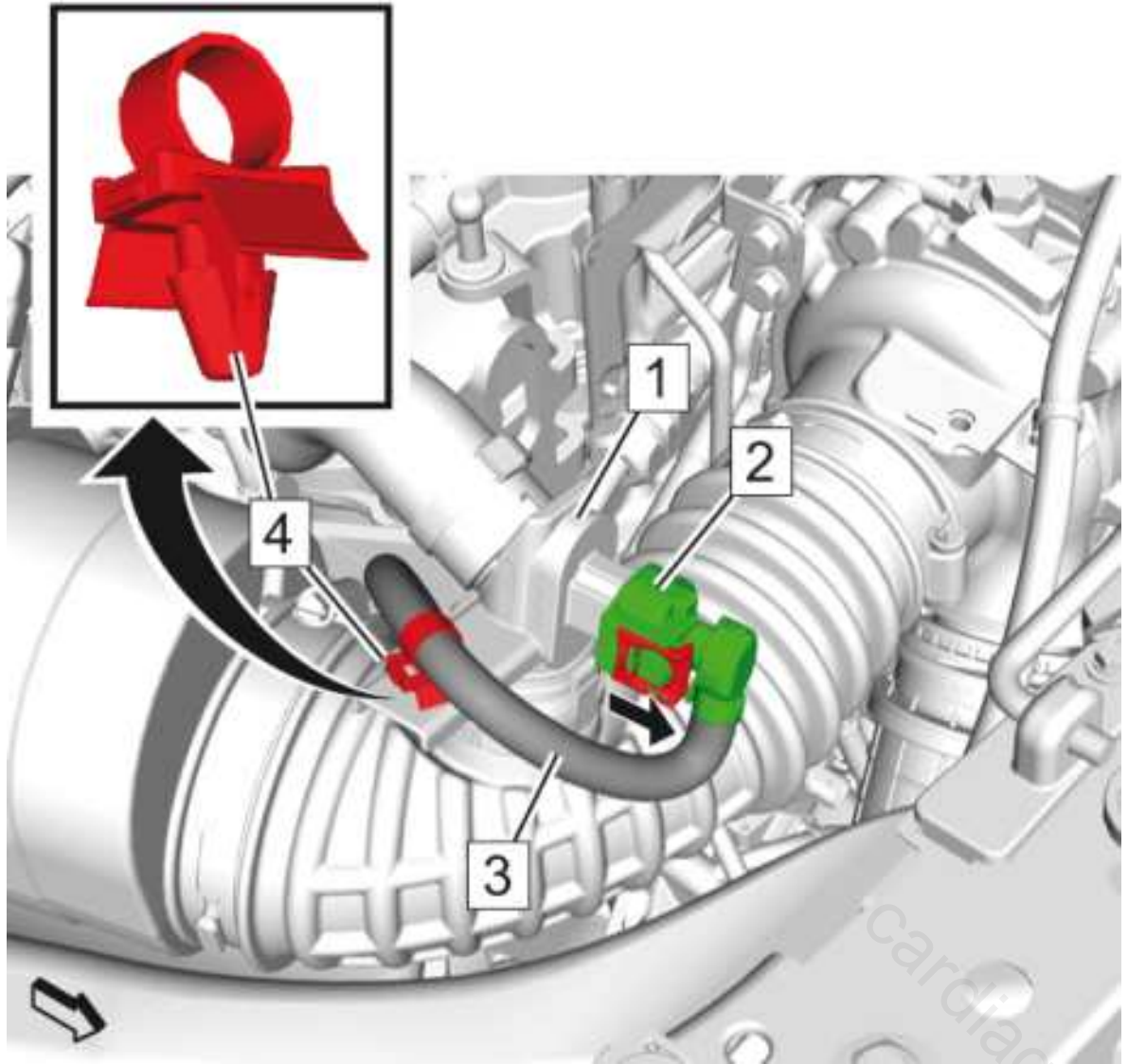


Fig. 79: Electrical Connector, PCV Heater, Wiring Harness And Clip
 Courtesy of GENERAL MOTORS COMPANY

28. Reposition Wiring Harness (3)
29. Connect Electrical Connector (2) @ Positive Crankcase Ventilation Heater (1)
30. Install Wiring Harness Clip (4)

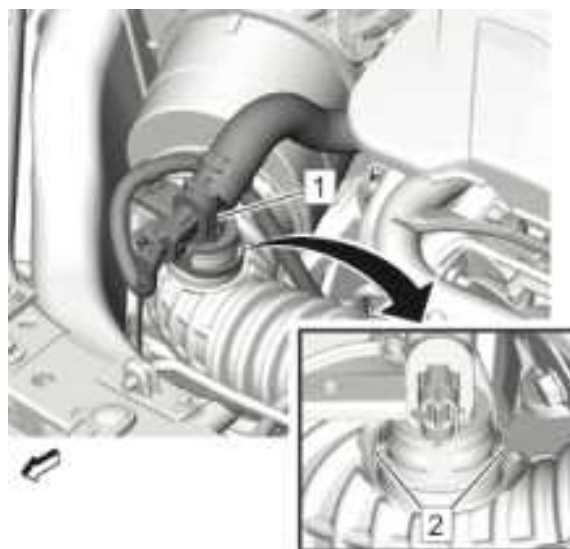


Fig. 80: Positive Crankcase Ventilation Heater And Checkered Places
 Courtesy of GENERAL MOTORS COMPANY

NOTE: There must be a noticeable click noise.

31. Install Positive Crankcase Ventilation Heater (1)

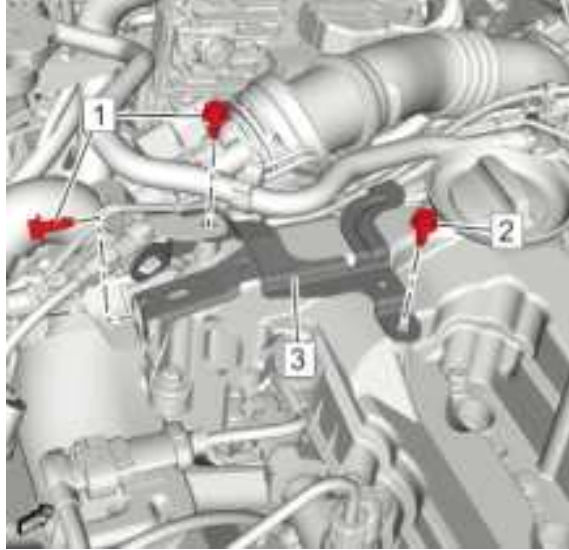


Fig. 81: Exhaust Temperature Sensor Electrical Connector Bracket And Bolts
Courtesy of GENERAL MOTORS COMPANY

32. Install Exhaust Temperature Sensor Electrical Connector Bracket (3)
33. Install and tighten Exhaust Temperature Sensor Electrical Connector Bracket Bolts (1, 2) (Qty: 3) to 9 N.m (80 lb in)

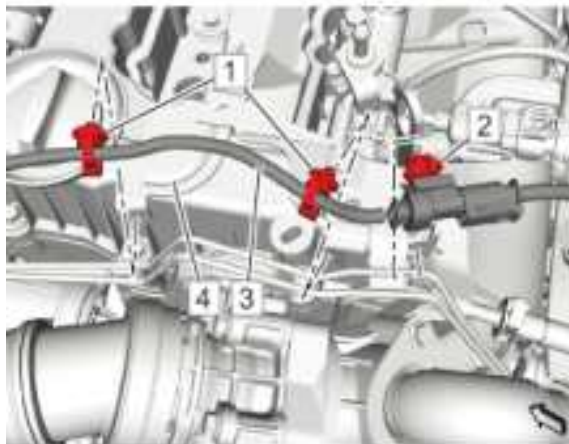


Fig. 82: Wiring Harness, Exhaust Temperature Sensor Bracket And Clips
Courtesy of GENERAL MOTORS COMPANY

34. Reposition Wiring Harness (3)
35. Install Clip (2) @ Exhaust Temperature Sensor Bracket (4)
36. Install Wiring Harness Clips (1) (Qty: 2) @ Exhaust Temperature Sensor Bracket (4)

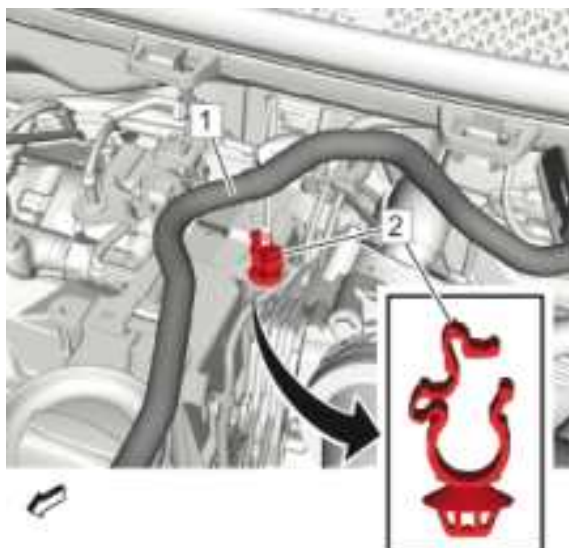


Fig. 83: Engine Coolant Air Bleed Hose And Retainer Clip
Courtesy of GENERAL MOTORS COMPANY

37. Reposition Engine Coolant Air Bleed Hose (1)
38. Install Engine Coolant Air Bleed Hose (1) @ Retainer Clip (2)

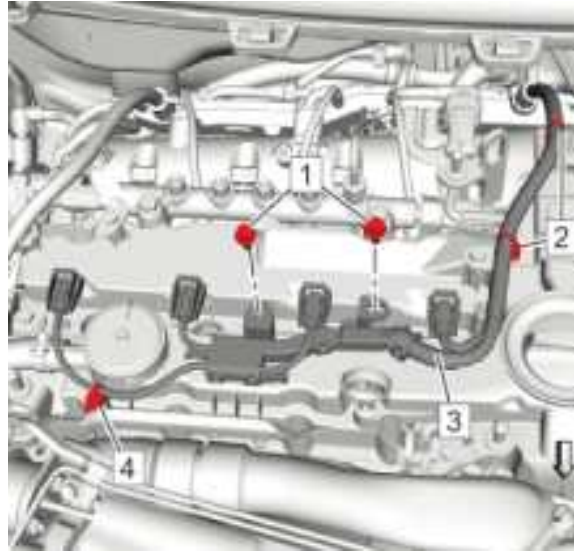


Fig. 84: Engine Wiring Harness, Conduit Bolts And Clips
Courtesy of GENERAL MOTORS COMPANY

39. Reposition Engine Wiring Harness (3)
40. Install Wiring Harness Clips (2, 4) (Qty: 3)
41. Install and tighten Engine Wiring Harness Conduit Bolts (1) (Qty: 2) to 9 N.m (80 lb in)
42. Install Fuel Injectors (Qty: 4). Refer to [Fuel Injector Replacement](#)
43. Connect the battery negative cable. Refer to [Battery Negative Cable Disconnection and Connection \(KL9\)](#)

CAMSHAFT TIMING CHAIN REPLACEMENT

Special Tools

- **EN-50513** Fixing Pin
- **EN-51140** Crankshaft Fixing Tool
- **EN-51143** Camshaft Sprocket Fixing Tool

Equivalent regional tools: [Special Tools](#)

Removal Procedure

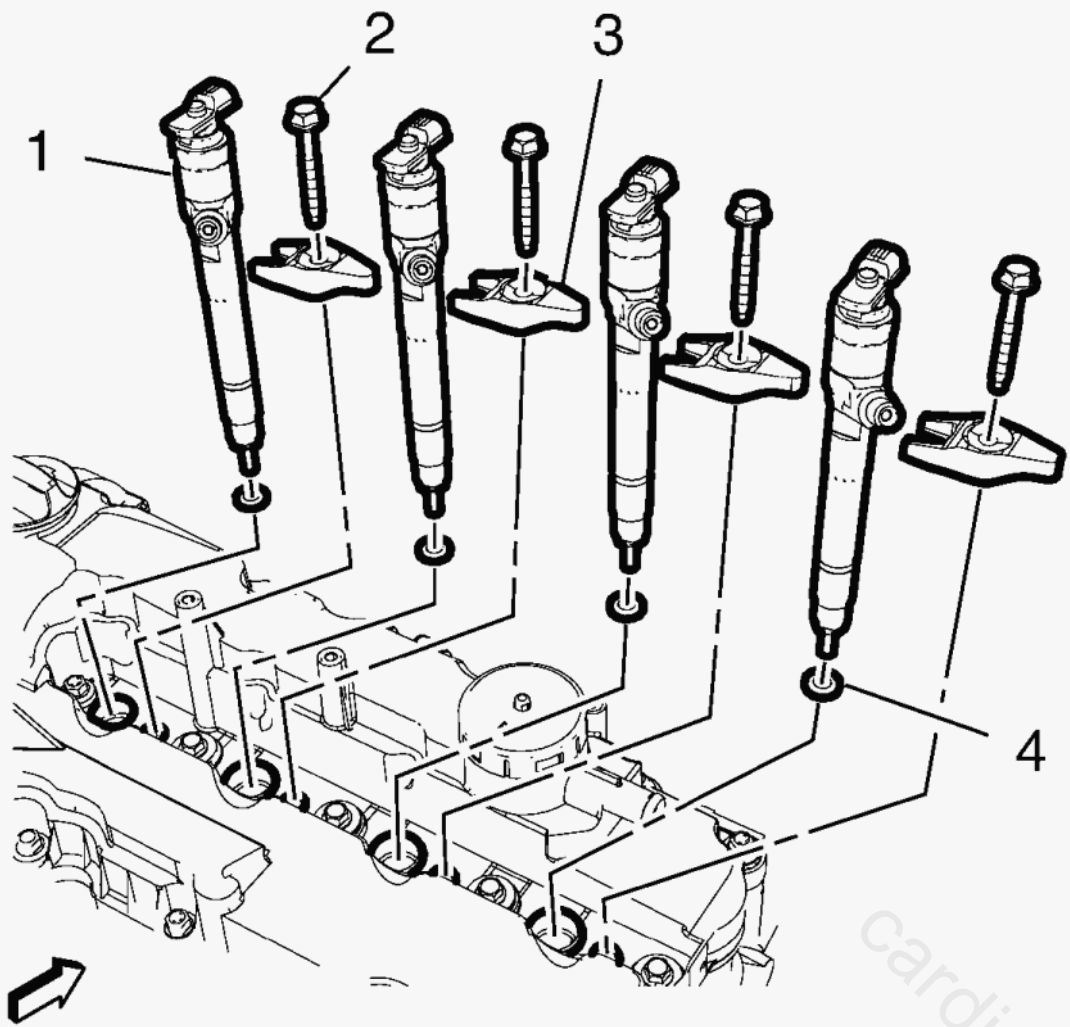


Fig. 85: Fuel Injectors, Bolts And Retainers
Courtesy of GENERAL MOTORS COMPANY

1. Remove Fuel Injectors (1) (Qty: 4). Refer to [Fuel Injector Replacement](#)

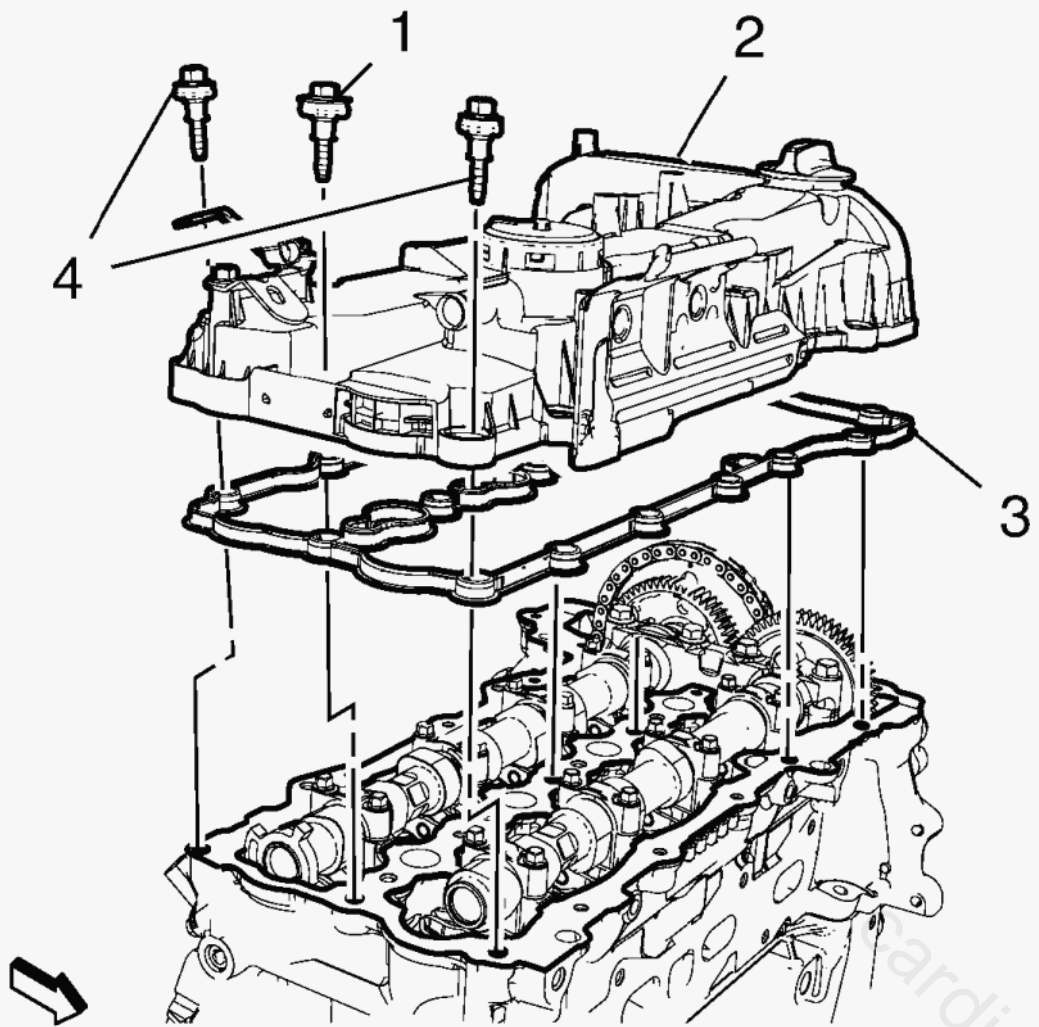


Fig. 86: Camshaft Housing, Bolts And Gasket
Courtesy of GENERAL MOTORS COMPANY

2. Remove Camshaft Housing (2). Refer to [Camshaft Housing Replacement](#)

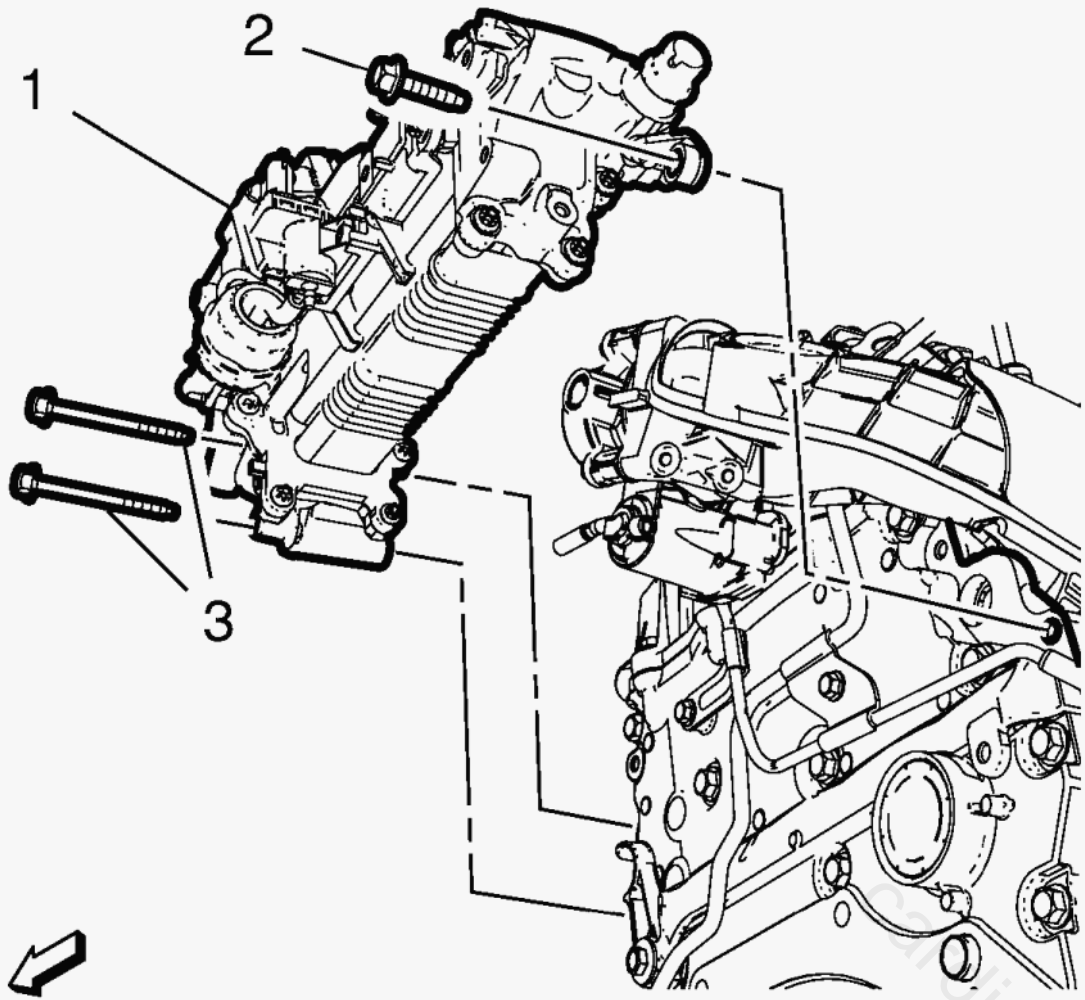


Fig. 87: Exhaust Gas Recirculation Cooler Housing
 Courtesy of GENERAL MOTORS COMPANY

3. Remove Exhaust Gas Recirculation Cooler Housing (1). Refer to [Exhaust Gas Recirculation Cooler Housing Replacement](#)
4. Remove Oxidation Catalytic Converter. Refer to [Oxidation Catalytic Converter Replacement \(LH7\)](#)

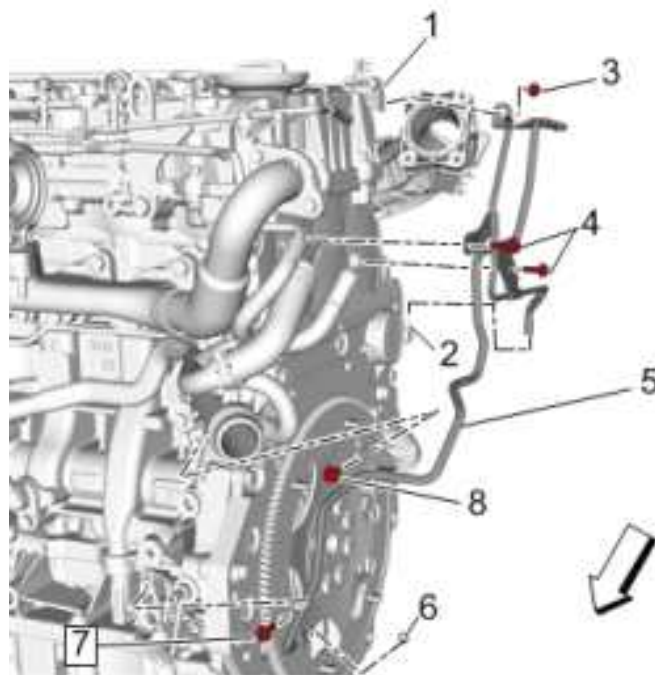


Fig. 88: Power Brake Booster Inlet Hose Connector Fitting And Components
 Courtesy of GENERAL MOTORS COMPANY

5. Remove Power Brake Booster Inlet Hose Connector Fitting (5). Refer to [Power Brake Booster Inlet Hose Connector Fitting Replacement](#)

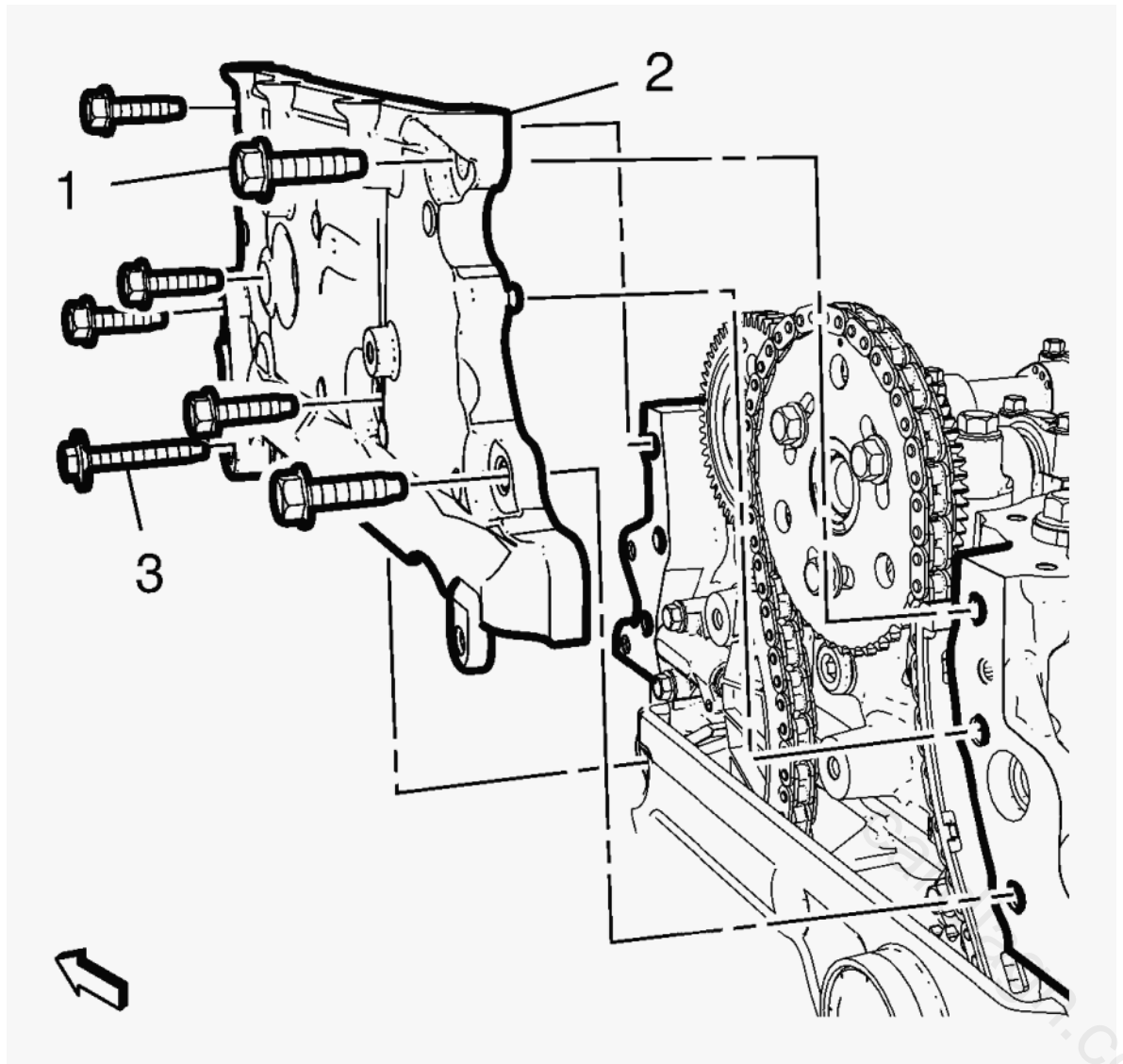


Fig. 89: Timing Chain Upper Cover And Bolts
Courtesy of GENERAL MOTORS COMPANY

6. Remove Timing Chain Upper Cover (2). Refer to [Timing Chain Upper Cover Replacement](#)

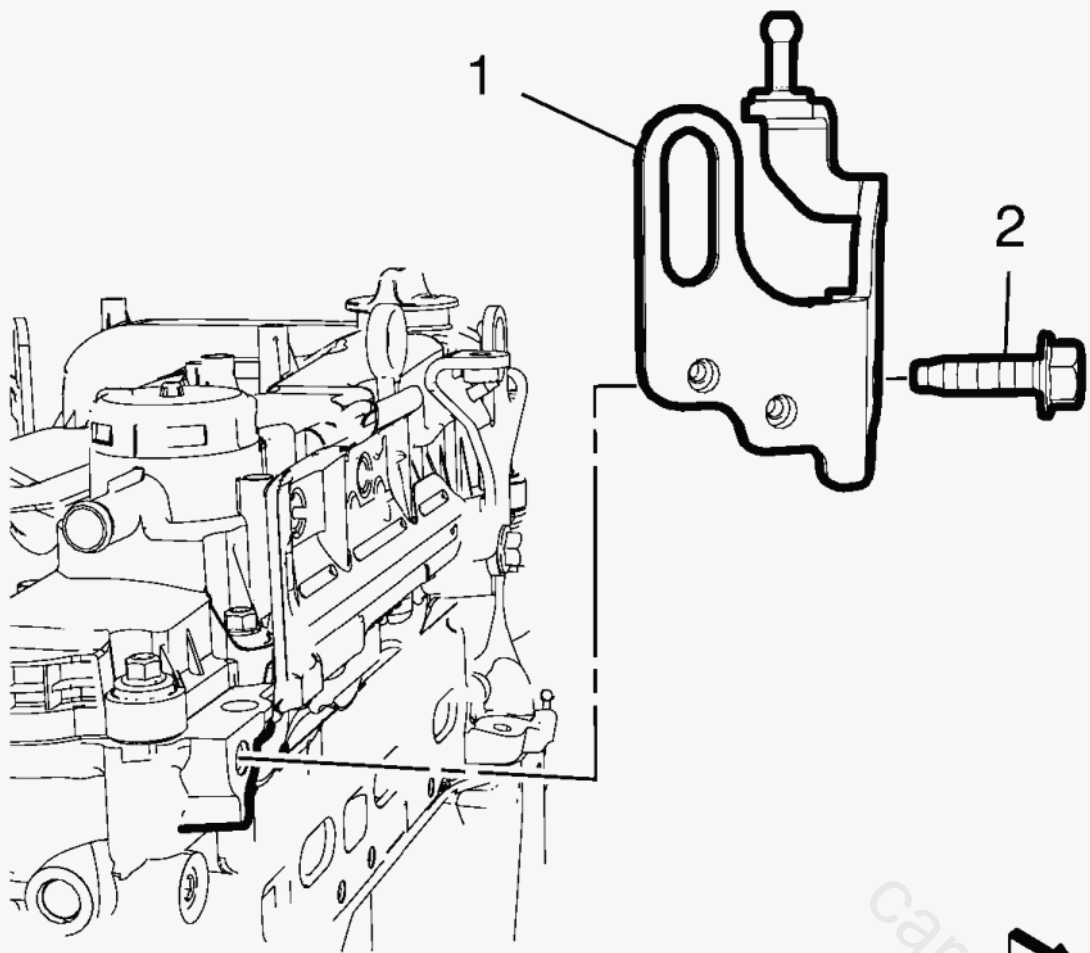


Fig. 90: Engine Lift Bracket And Bolt

Courtesy of GENERAL MOTORS COMPANY

7. Install Engine Lift Bracket - Right Side (1) @ Cylinder Head

CAUTION: Refer to **Fastener Caution**

8. Install and tighten Engine Lift Bracket Bolt (2) to 58 N.m (43 lb ft)

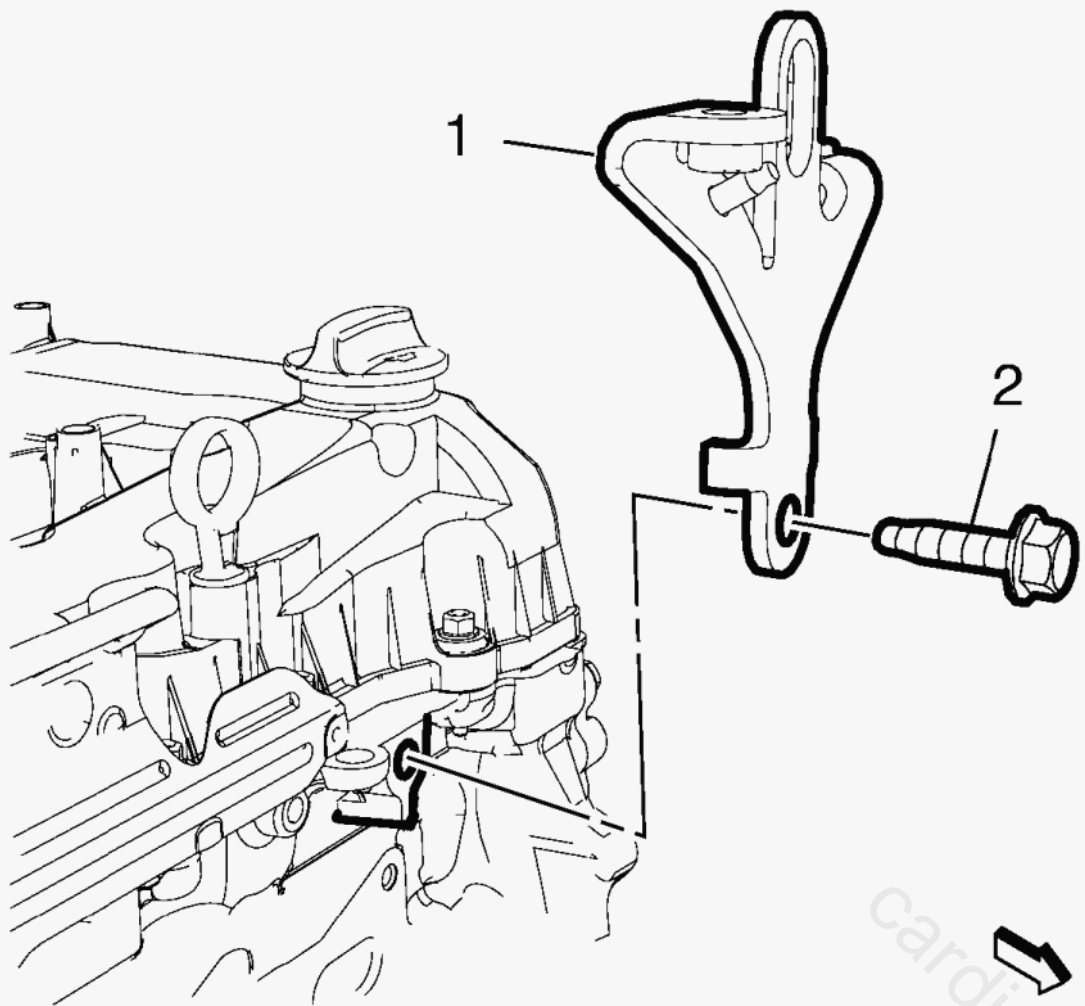


Fig. 91: Engine Lift Bracket And Bolt

Courtesy of GENERAL MOTORS COMPANY

9. Install Engine Lift Bracket - Left Side (1) @ Cylinder Head
10. Install and tighten Engine Lift Bracket Bolt (2) to 58 N.m (43 lb ft)
11. Remove Transmission. Refer to [**Transmission Replacement \(Front Wheel Drive\)**](#) [**Transmission Replacement \(All Wheel Drive\)**](#)

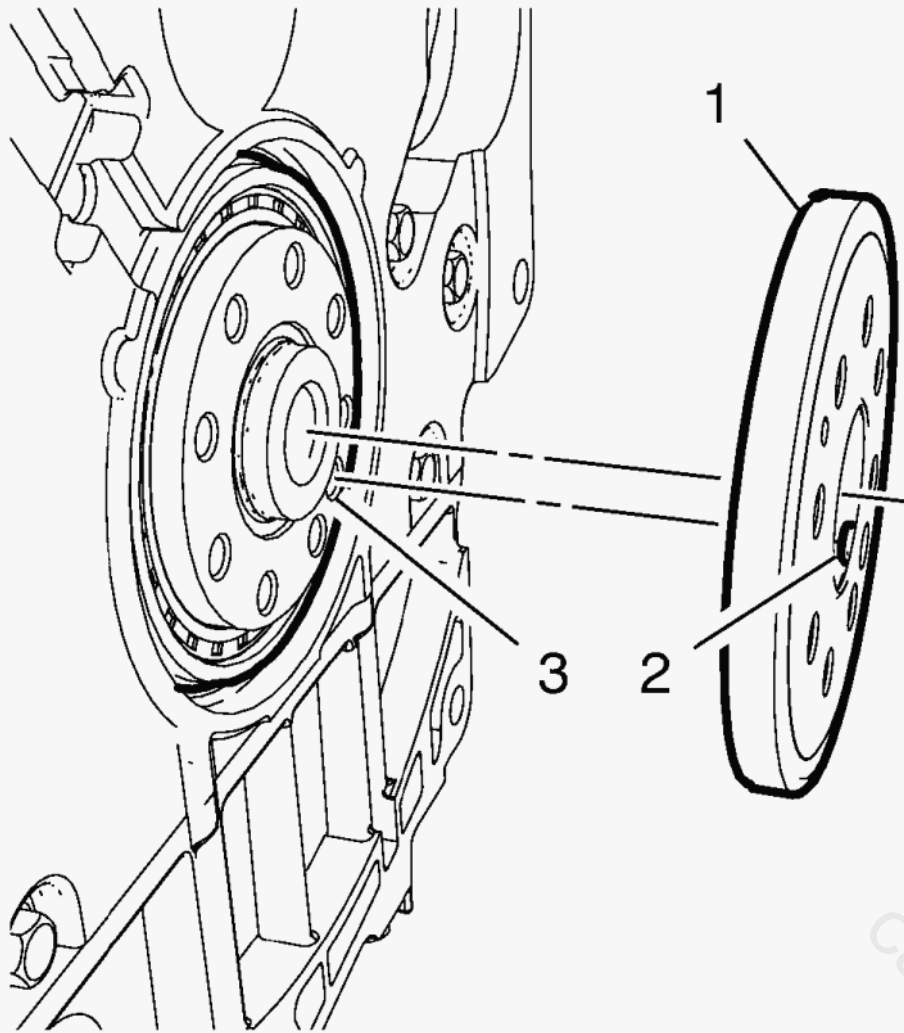


Fig. 92: Crankshaft Position Sensor Reluctor Ring
Courtesy of GENERAL MOTORS COMPANY

12. Remove Crankshaft Position Sensor Reluctor Ring (1). Refer to [Crankshaft Position Sensor Reluctor Ring Replacement](#)

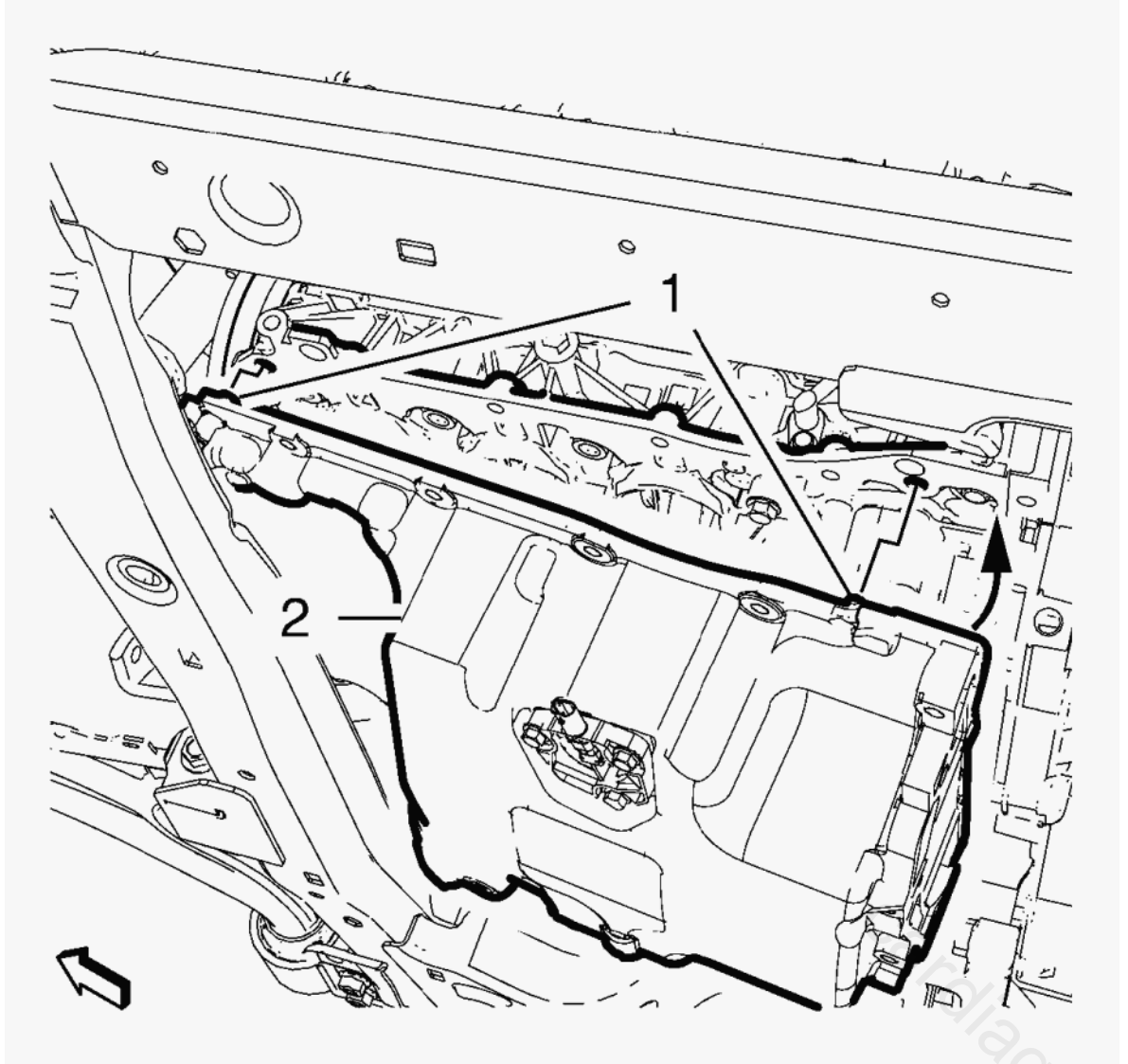


Fig. 93: Oil Pan

Courtesy of GENERAL MOTORS COMPANY

13. Remove Oil Pan (2). Refer to [Oil Pan Replacement](#)

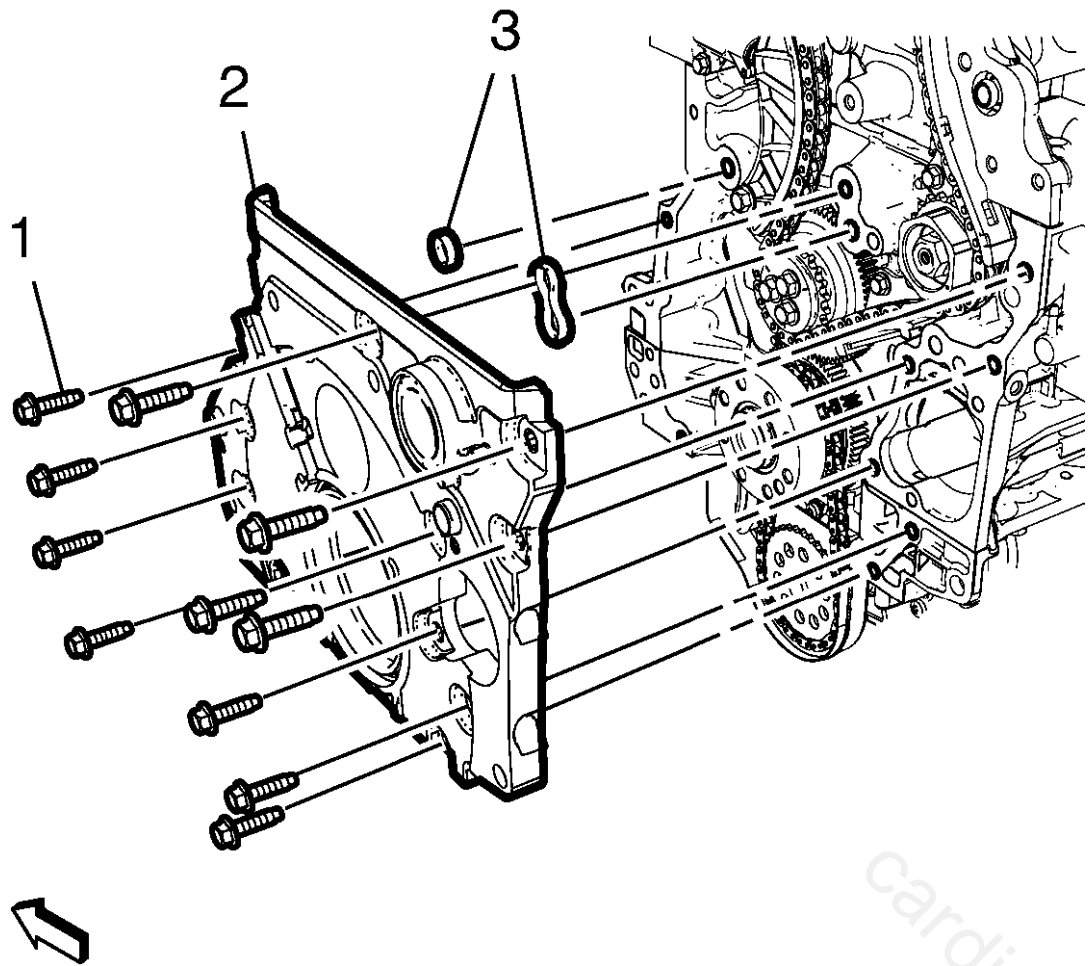


Fig. 94: Timing Chain Lower Cover, Bolts And Gaskets
Courtesy of GENERAL MOTORS COMPANY

14. Remove Timing Chain Lower Cover (2). Refer to [Timing Chain Lower Cover Replacement](#)

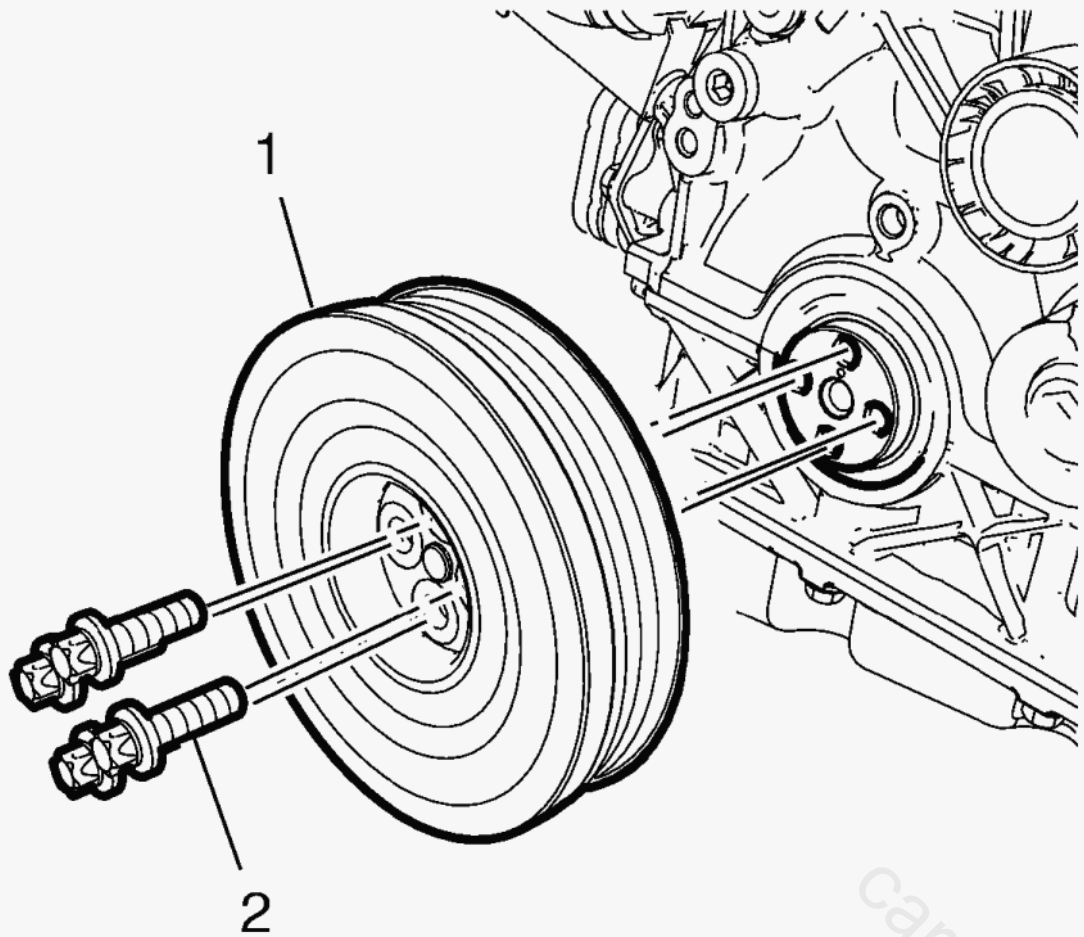


Fig. 95: Crankshaft Pulley And Bolts

Courtesy of GENERAL MOTORS COMPANY

15. Remove Crankshaft Pulley (1). Refer to [Crankshaft Pulley Replacement](#)

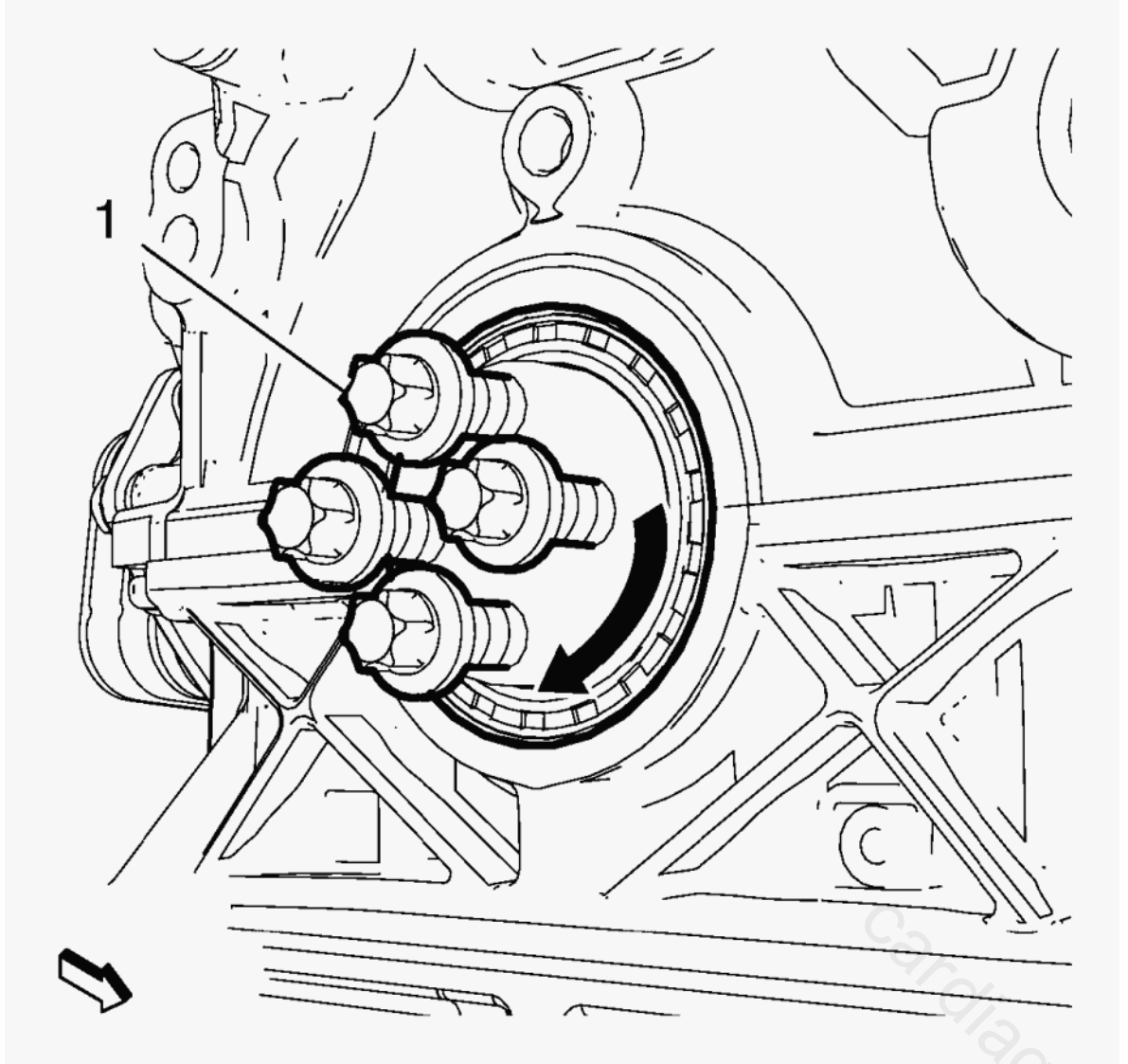


Fig. 96: Crankshaft Pulley Bolts

Courtesy of GENERAL MOTORS COMPANY

16. Install Crankshaft Pulley Bolts (1) (Qty: 4)
17. Lower the vehicle.

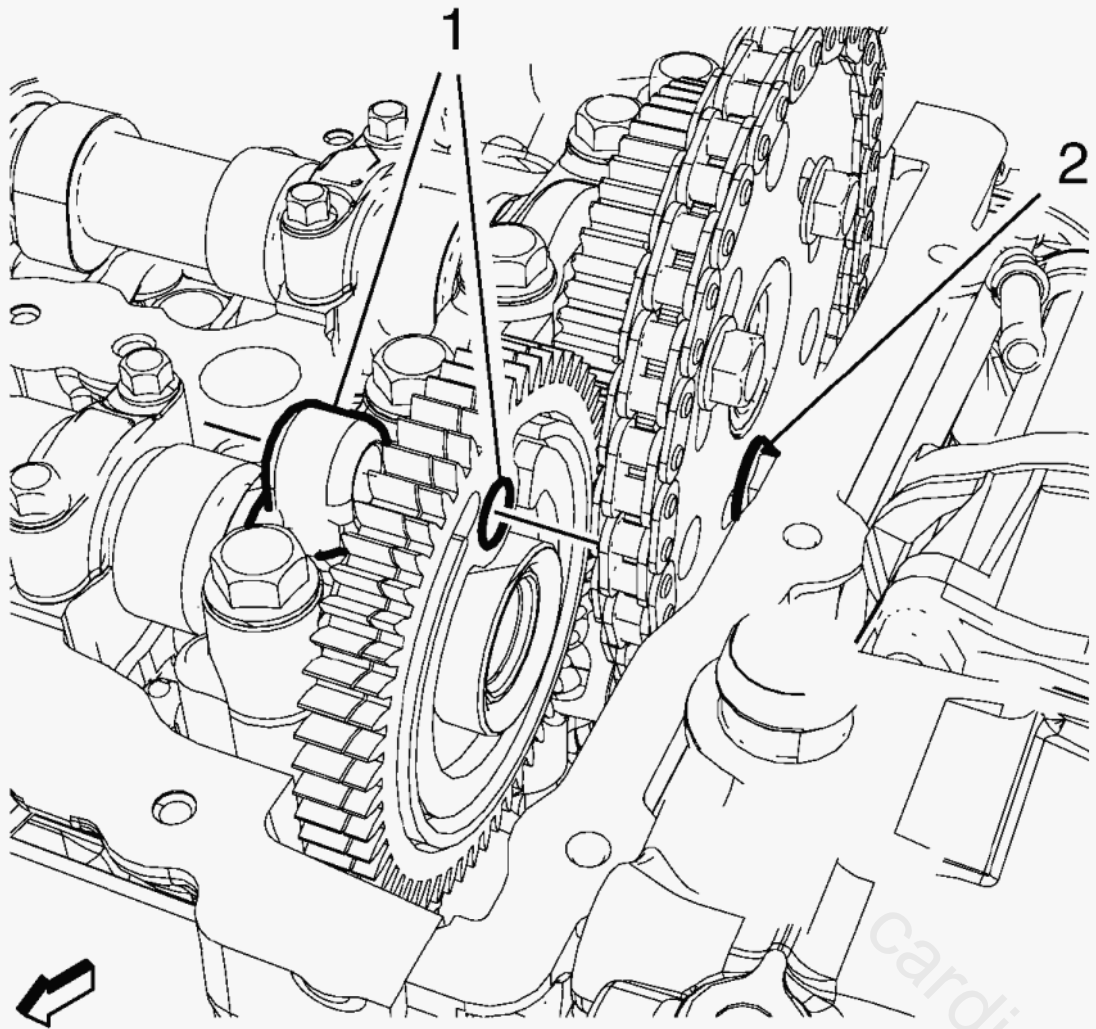


Fig. 97: Aligning Bores

Courtesy of GENERAL MOTORS COMPANY

NOTE: If the bores are not aligned, turn the crankshaft at the crankshaft pulley bolts.

18. Check if the bores (1) are aligned.

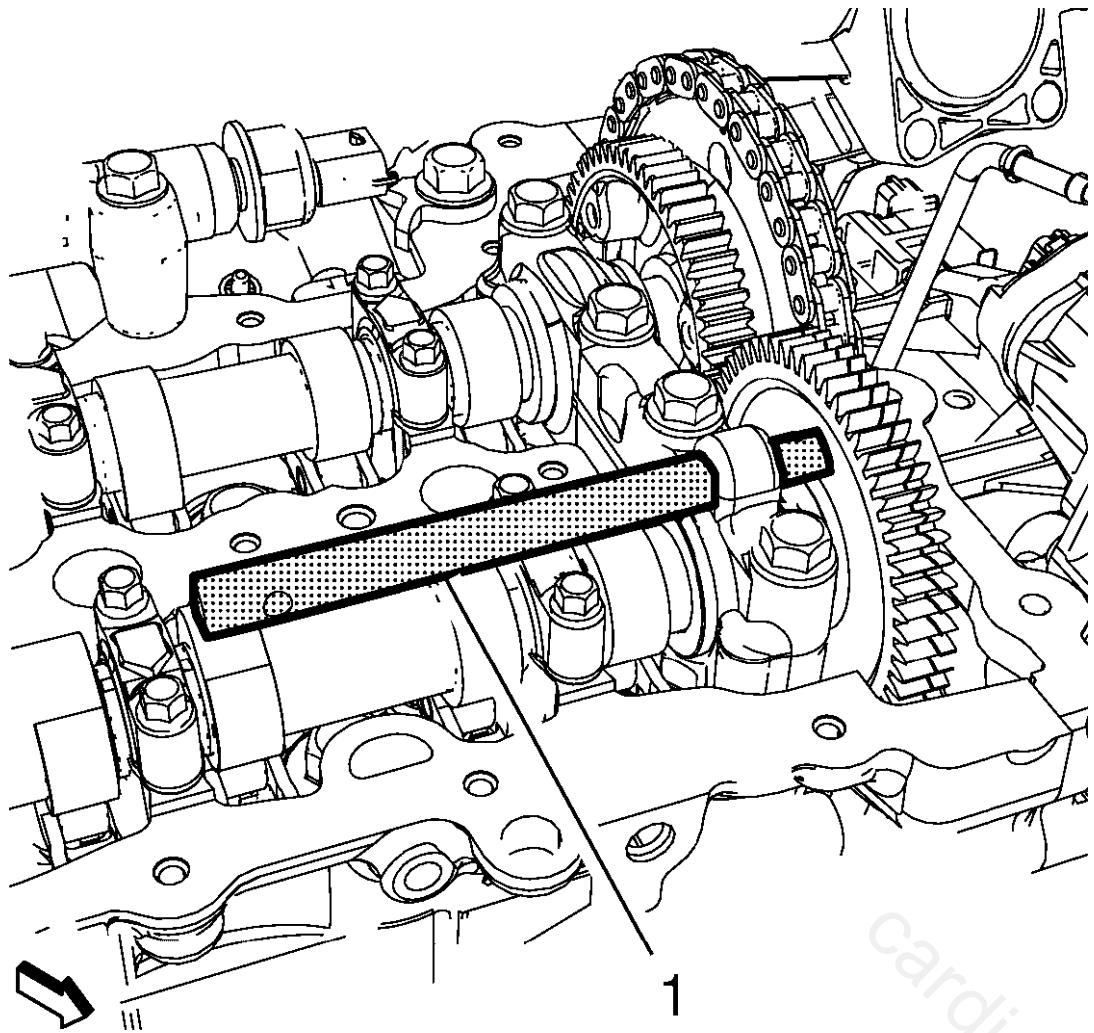


Fig. 98: Camshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

19. Turn the exhaust camshaft at the hexagon so far so that the **EN-51143** fixing tool (1) can be installed.
20. Raise the vehicle.

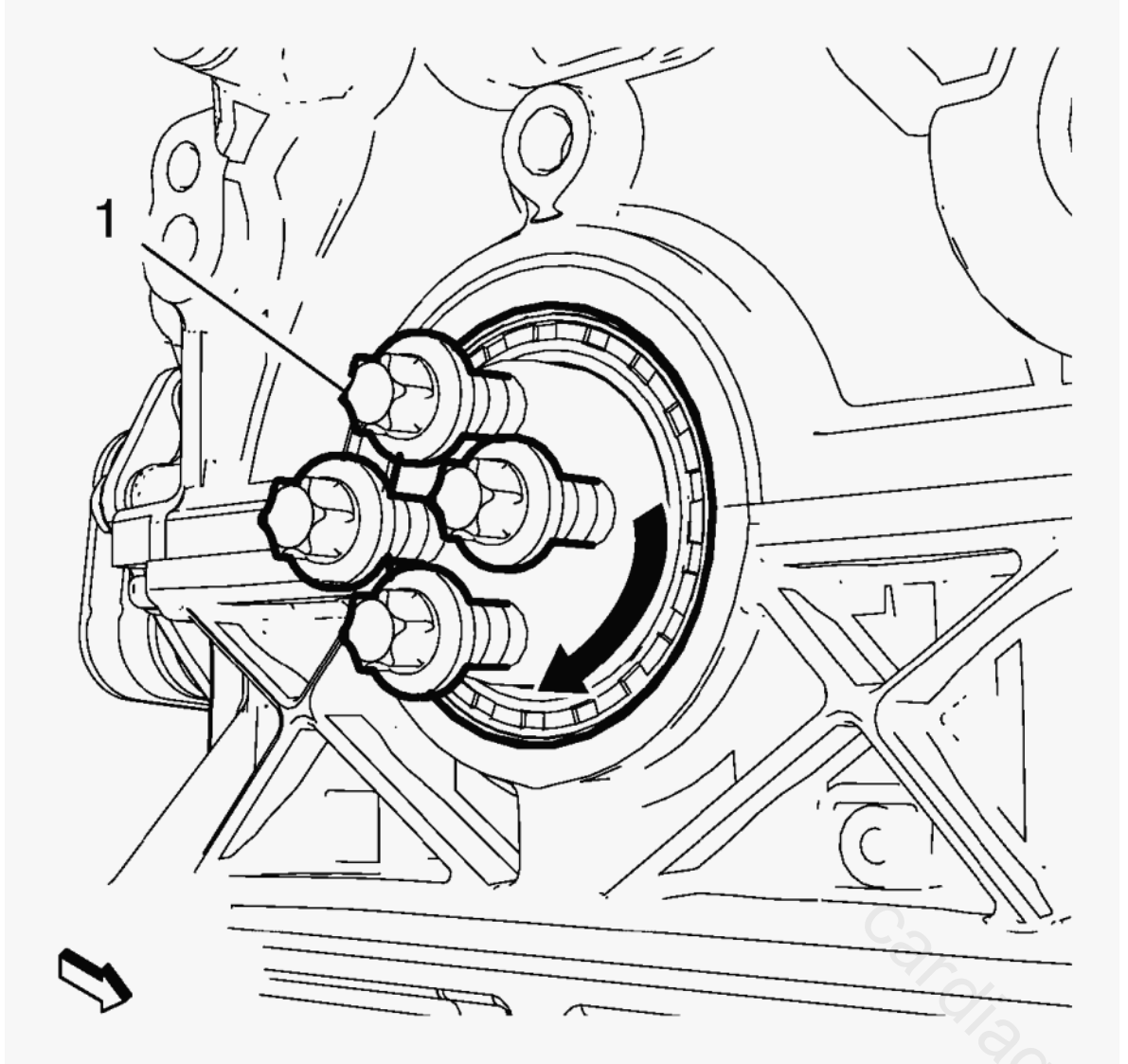


Fig. 99: Crankshaft Pulley Bolts

Courtesy of GENERAL MOTORS COMPANY

21. Remove Crankshaft Pulley Bolts (1) (Qty: 4)

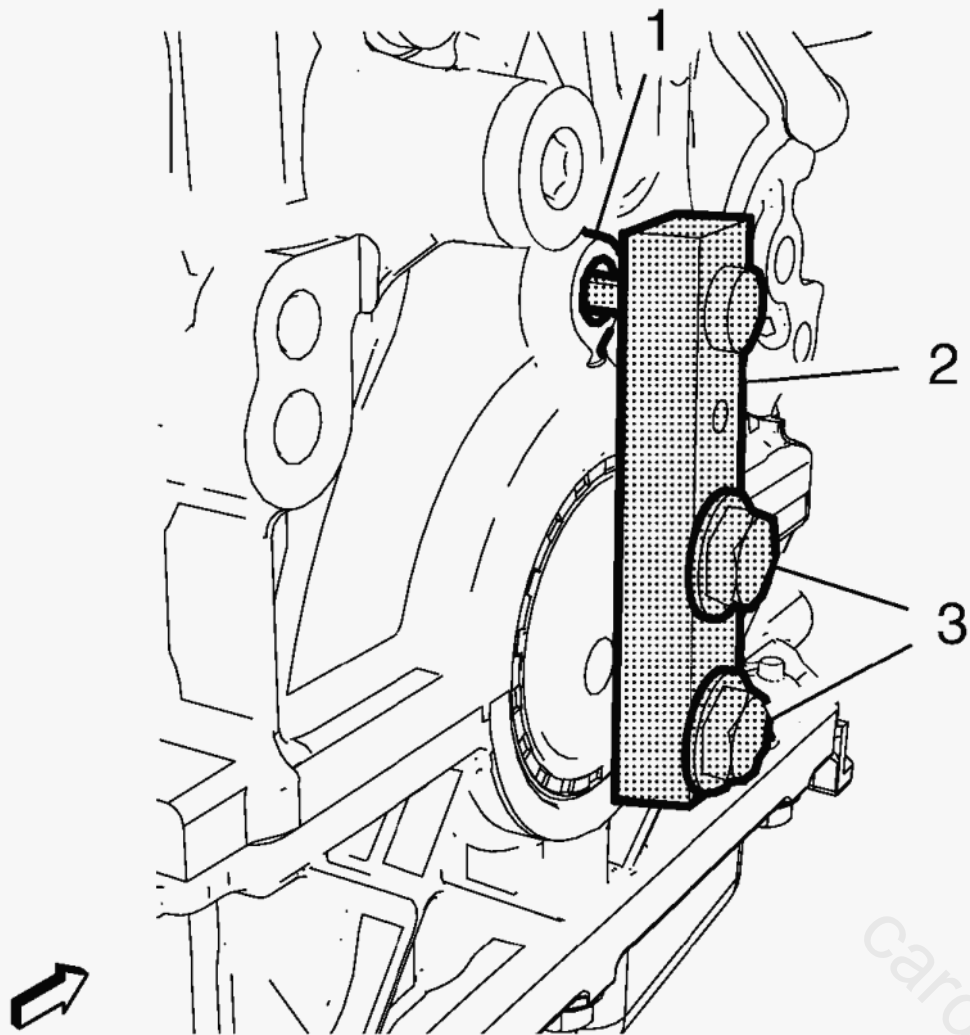


Fig. 100: Crankshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

22. Install **EN-51140** Fixing Tool (2)
23. Install the fixing pin into the engine block bore (1) and tighten the 2 bolts (3).
24. If the **EN-51140** fixing tool can not installed. Refer to [Camshaft Timing Chain Adjustment](#)
25. Lower the vehicle.

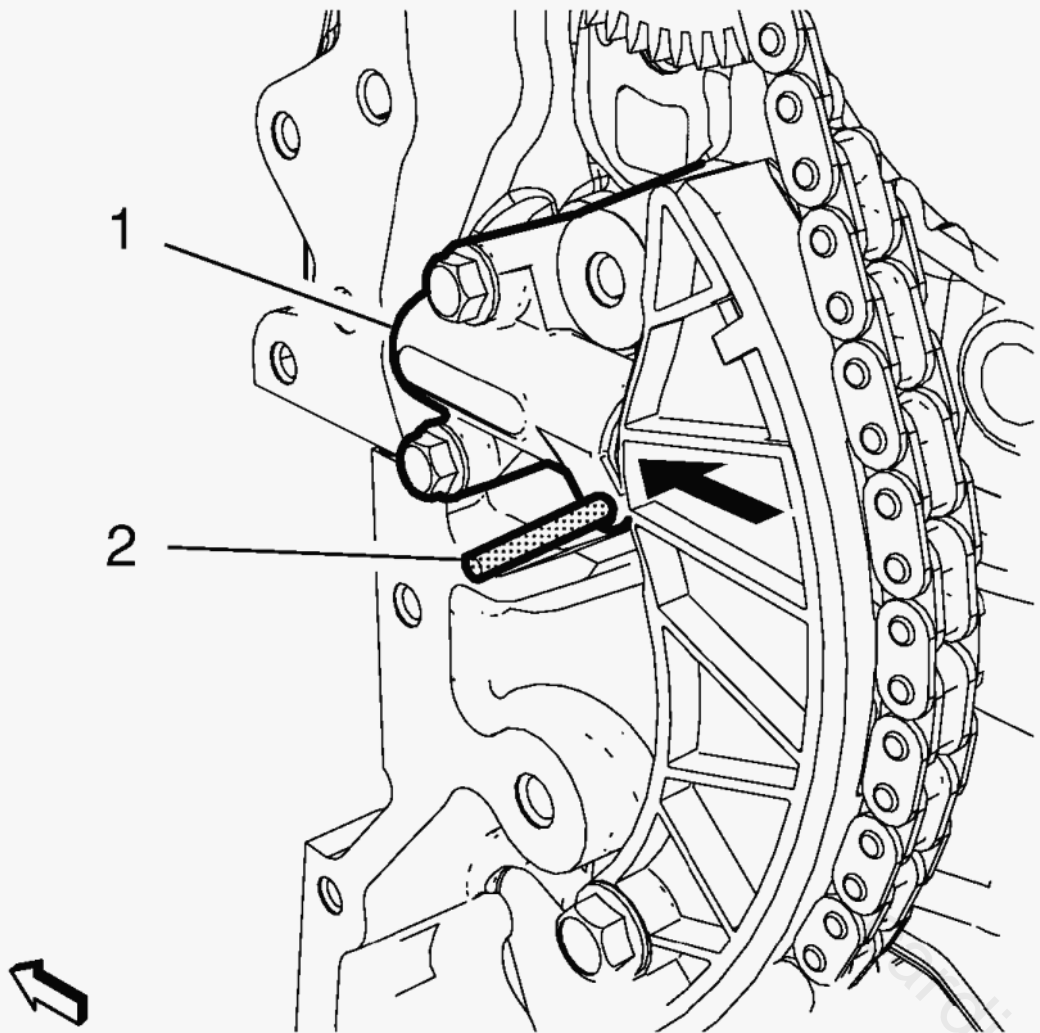


Fig. 101: Timing Chain Tensioner And Pin

Courtesy of GENERAL MOTORS COMPANY

26. Tension the timing chain tensioner (1) in arrow direction.
27. Install EN-50513 Pin (2)

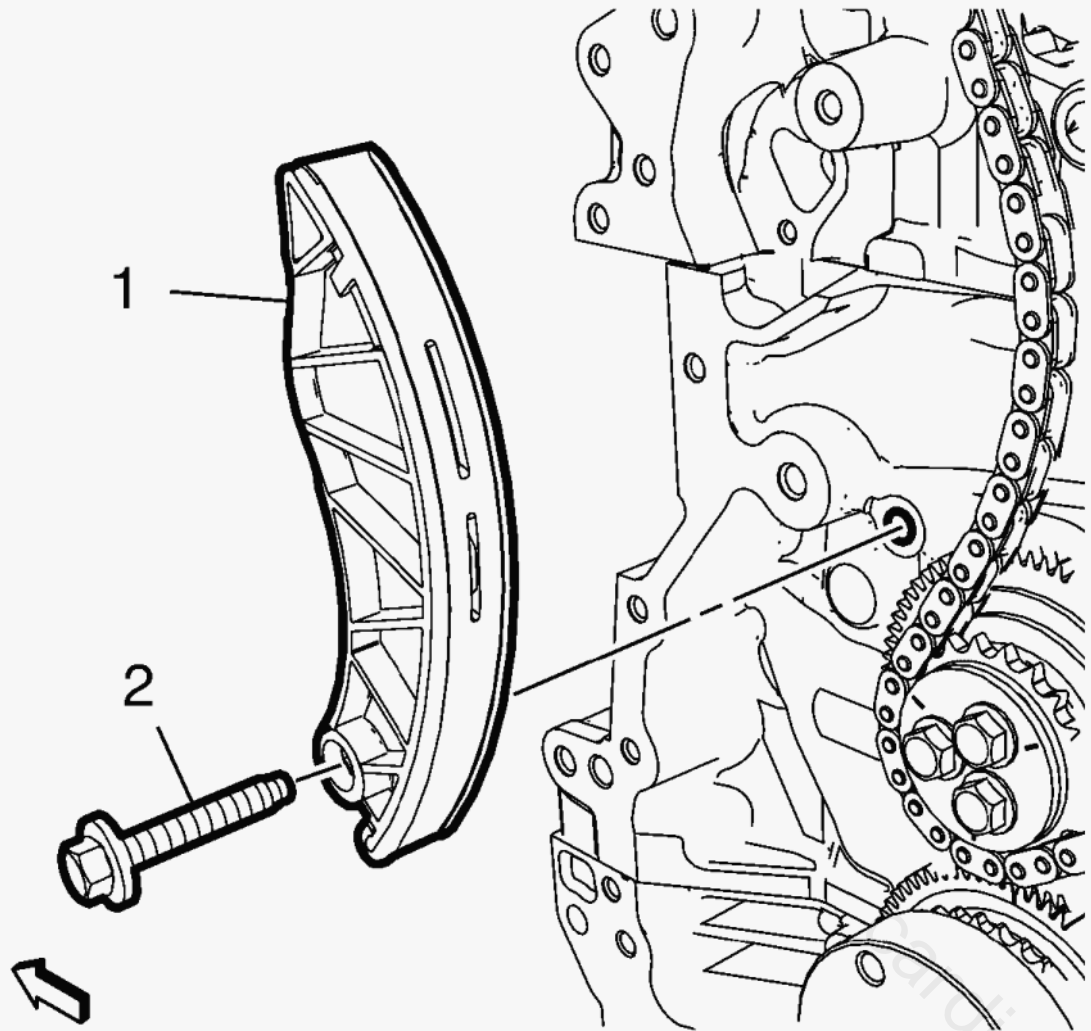


Fig. 102: Timing Chain Tensioner Shoe And Bolt
Courtesy of GENERAL MOTORS COMPANY

28. Remove Timing Chain Tensioner Shoe Bolt (2)
29. Remove Timing Chain Tensioner Shoe (1)

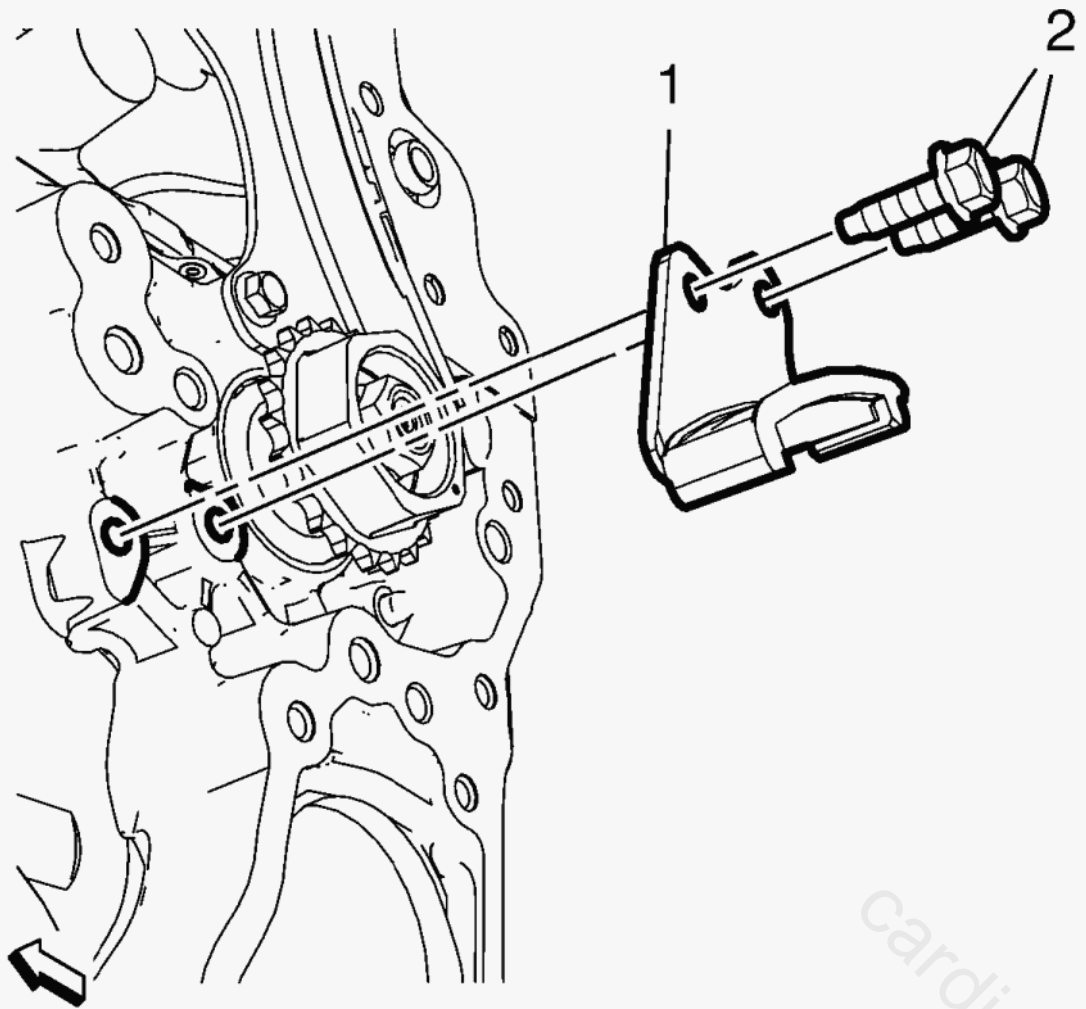


Fig. 103: Timing Chain Lower Guide And Bolts
Courtesy of GENERAL MOTORS COMPANY

30. Remove Timing Chain Lower Guide Bolts (2) (Qty: 2)
31. Remove Timing Chain Lower Guide (1)

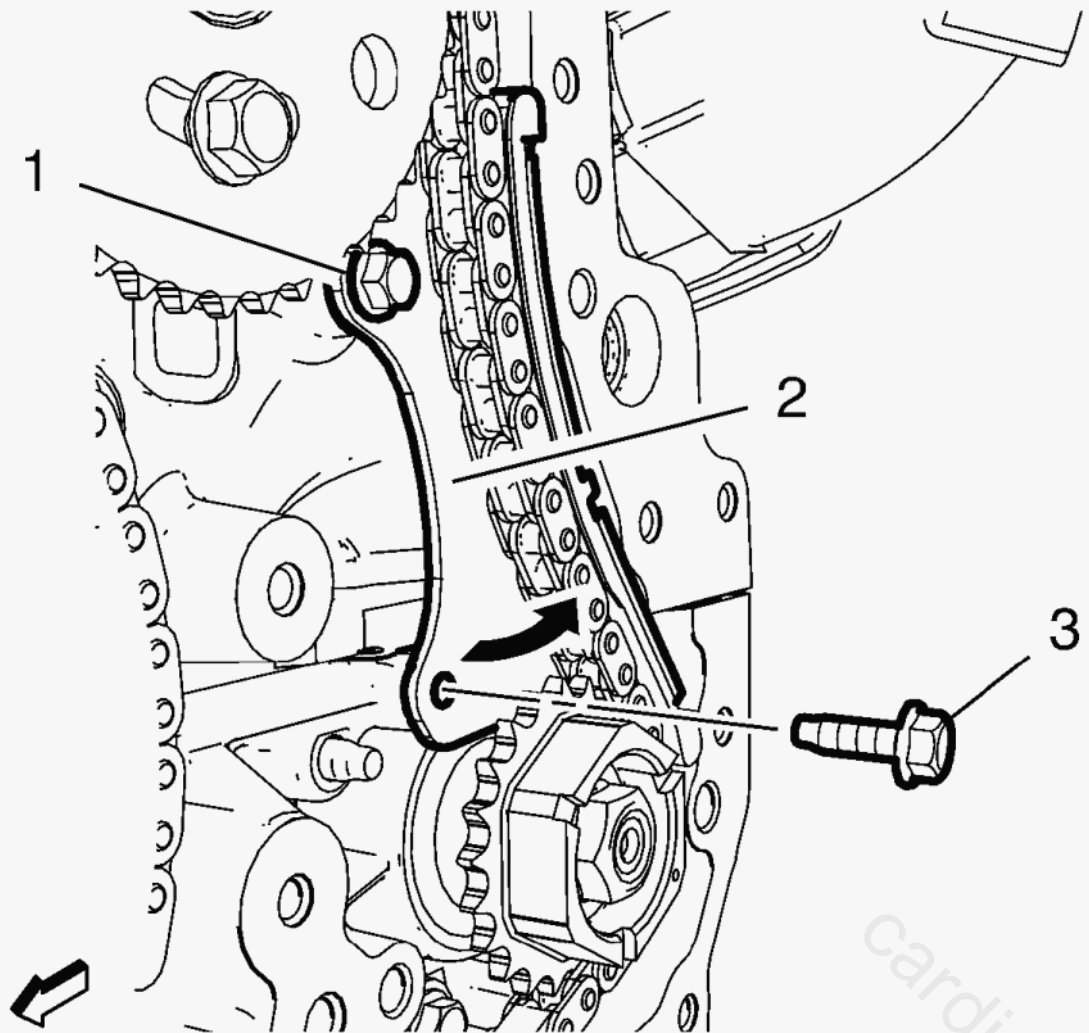


Fig. 104: Timing Chain Upper Guide And Bolts
Courtesy of GENERAL MOTORS COMPANY

- 32. Loosen Timing Chain Upper Guide Bolt (1)
- 33. Remove Timing Chain Upper Guide Bolt (3)
- 34. Move the timing chain upper guide in the direction of arrow.

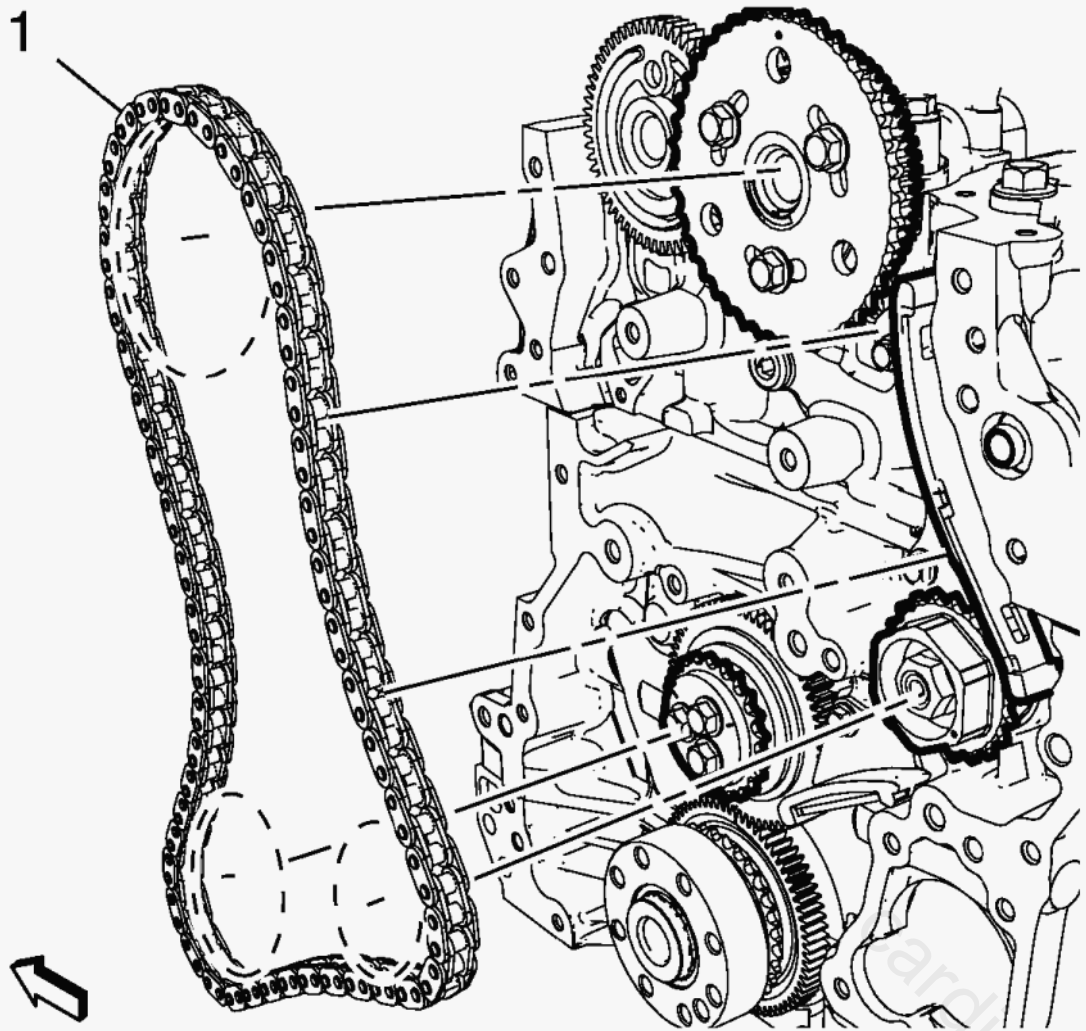


Fig. 105: Timing Chain

Courtesy of GENERAL MOTORS COMPANY

35. Remove Timing Chain (1)

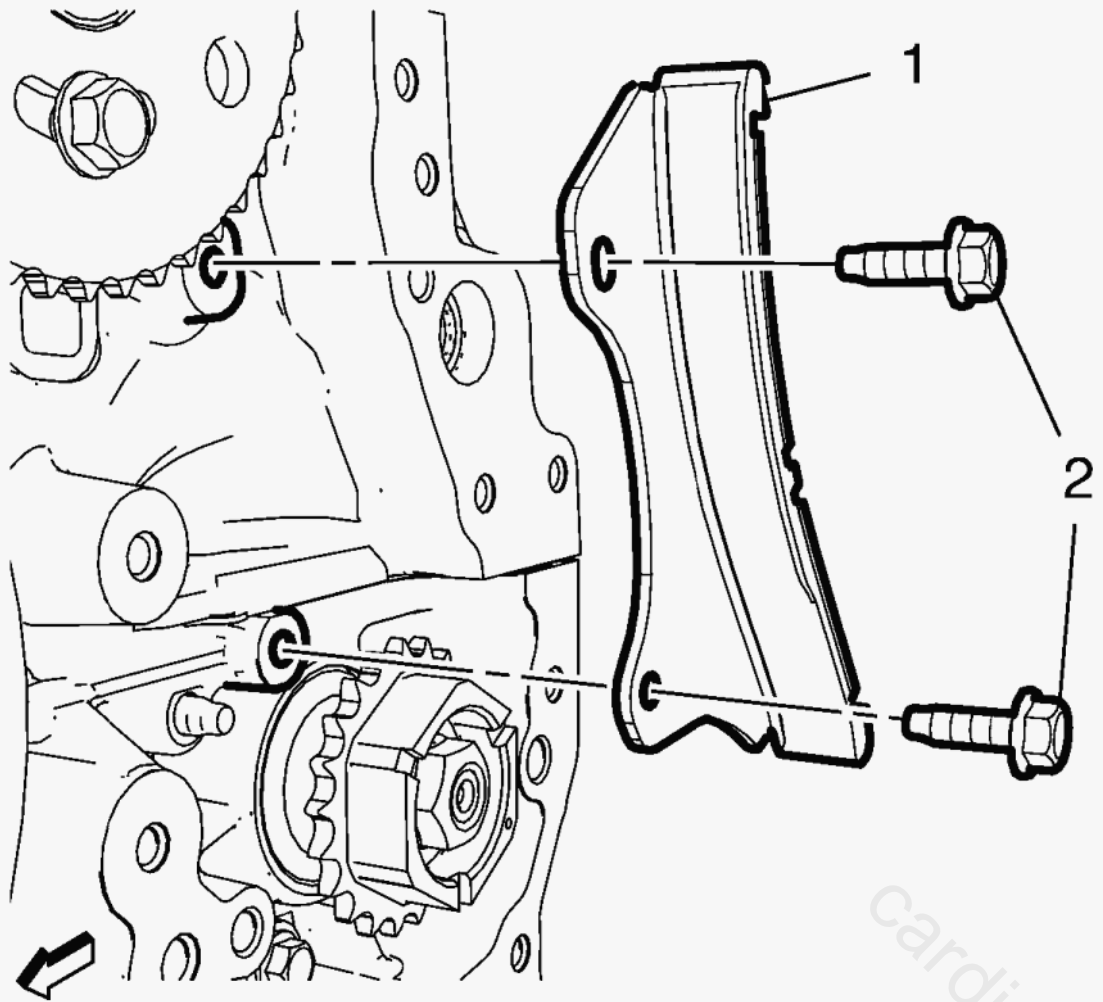


Fig. 106: Timing Chain Upper Guide And Bolts
Courtesy of GENERAL MOTORS COMPANY

36. Remove the upper timing chain upper guide bolt (2).
37. Remove Timing Chain Upper Guide (1)

Installation Procedure

NOTE: Before installing the camshaft timing chain, check the components of the timing chain system for damage and wear.

1. Check the components of the timing chain system for damage and wear:
 - Timing chain guides with plastic attachment
 - Timing chain tensioner and timing chain tensioner shoe with plastic attachment
 - Timing chain and all timing chain sprockets
 - Oil pump sprocket
 - Oil pump drive chain tensioner

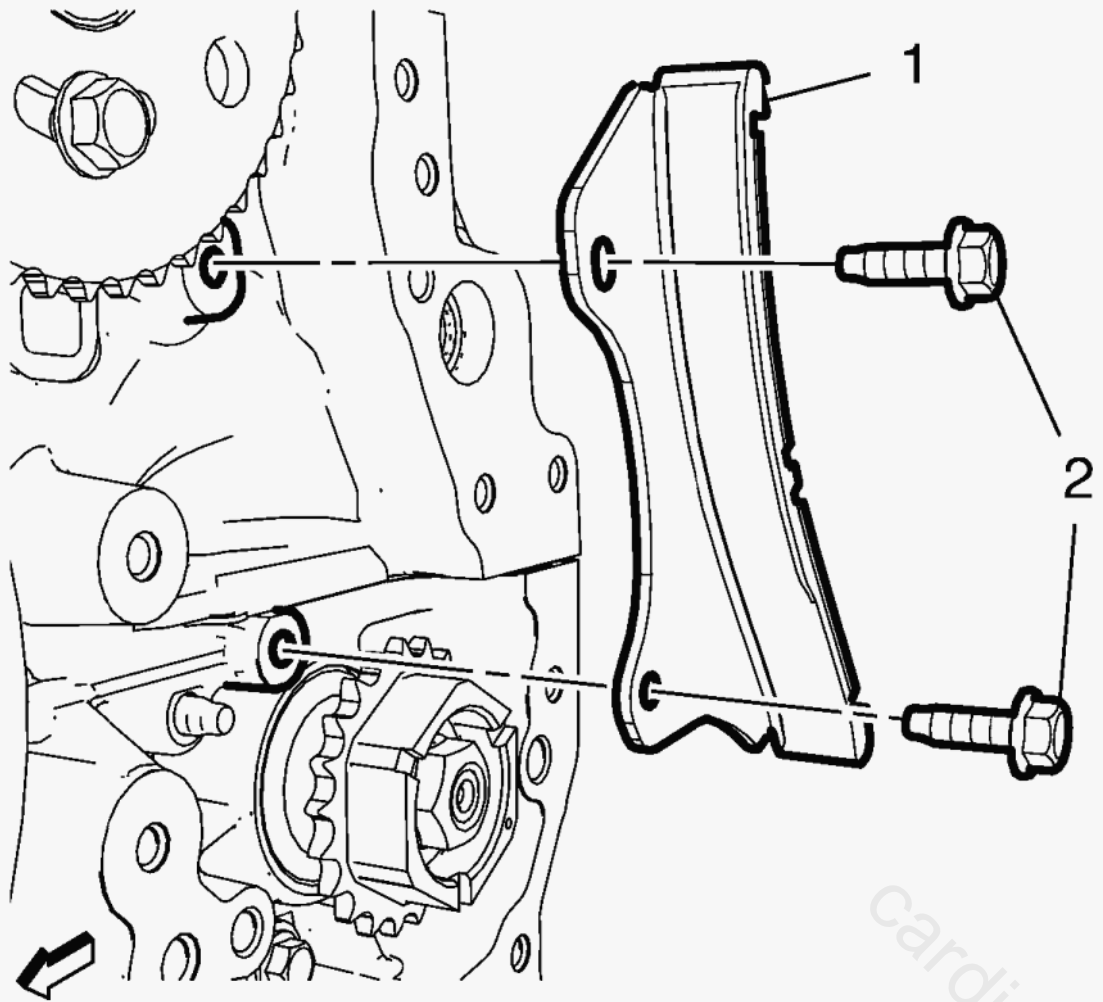


Fig. 107: Timing Chain Upper Guide And Bolts
Courtesy of GENERAL MOTORS COMPANY

2. Re-cut thread at cylinder head and engine block for the 2 timing chain upper guide bolts (2).
3. Install Timing Chain Upper Guide (1)

NOTE: The tightening procedure of the timing chain upper guide bolts should be completed within 10 minutes.

4. Apply thread lock agent to the upper timing chain upper guide bolt (2).

NOTE: Do not tighten the upper timing chain upper guide bolt before the camshaft timing chain is installed.

5. Install the upper timing chain upper guide bolt (2).

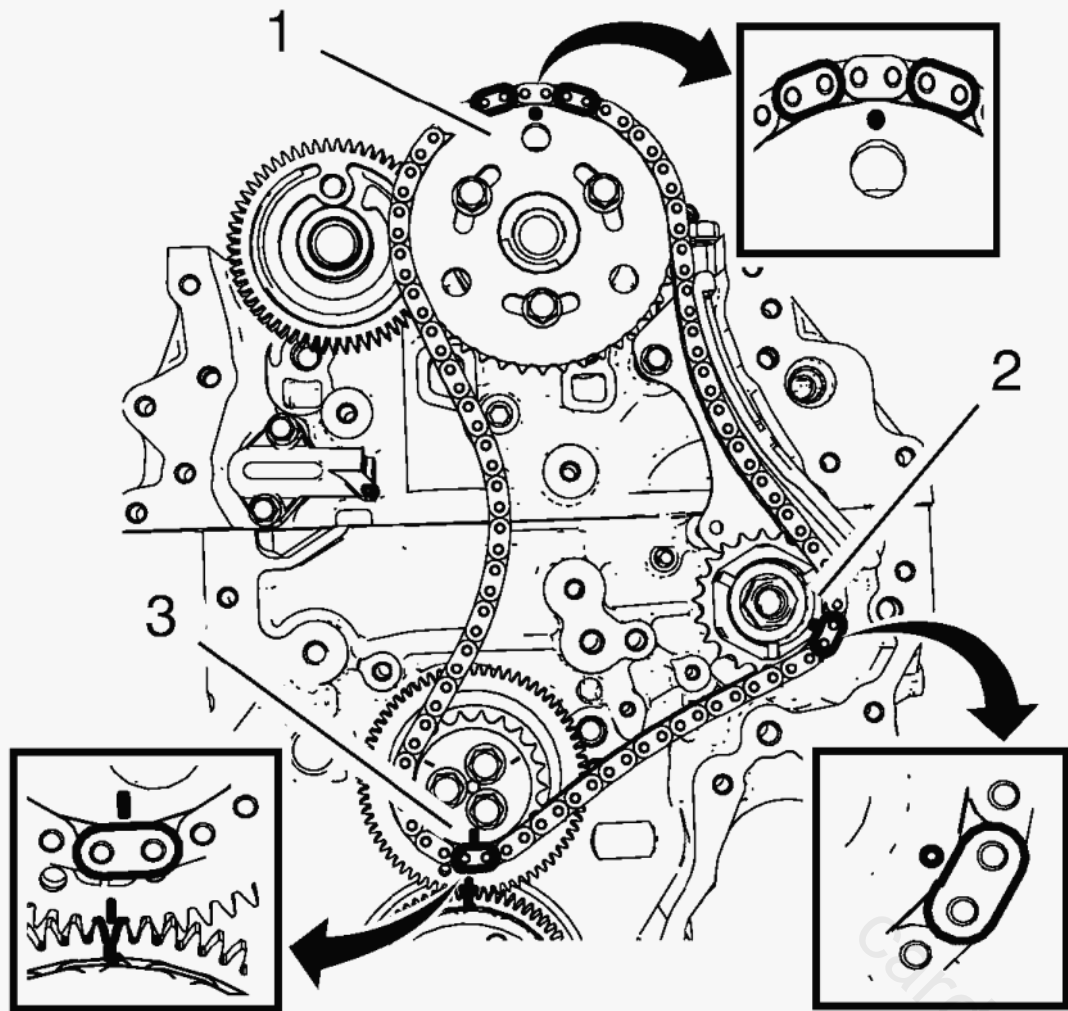


Fig. 108: Aligning Timing Chain Marked Chain Links
Courtesy of GENERAL MOTORS COMPANY

6. Install the timing chain with the marked chain links as shown and follow the installation sequence:
1. Install the timing chain in the first step to the fuel injection pump sprocket (2).
 2. Install the timing chain in the second step to the camshaft sprocket (1).
 3. Install the timing chain in the final step to the timing chain idler sprocket (3).

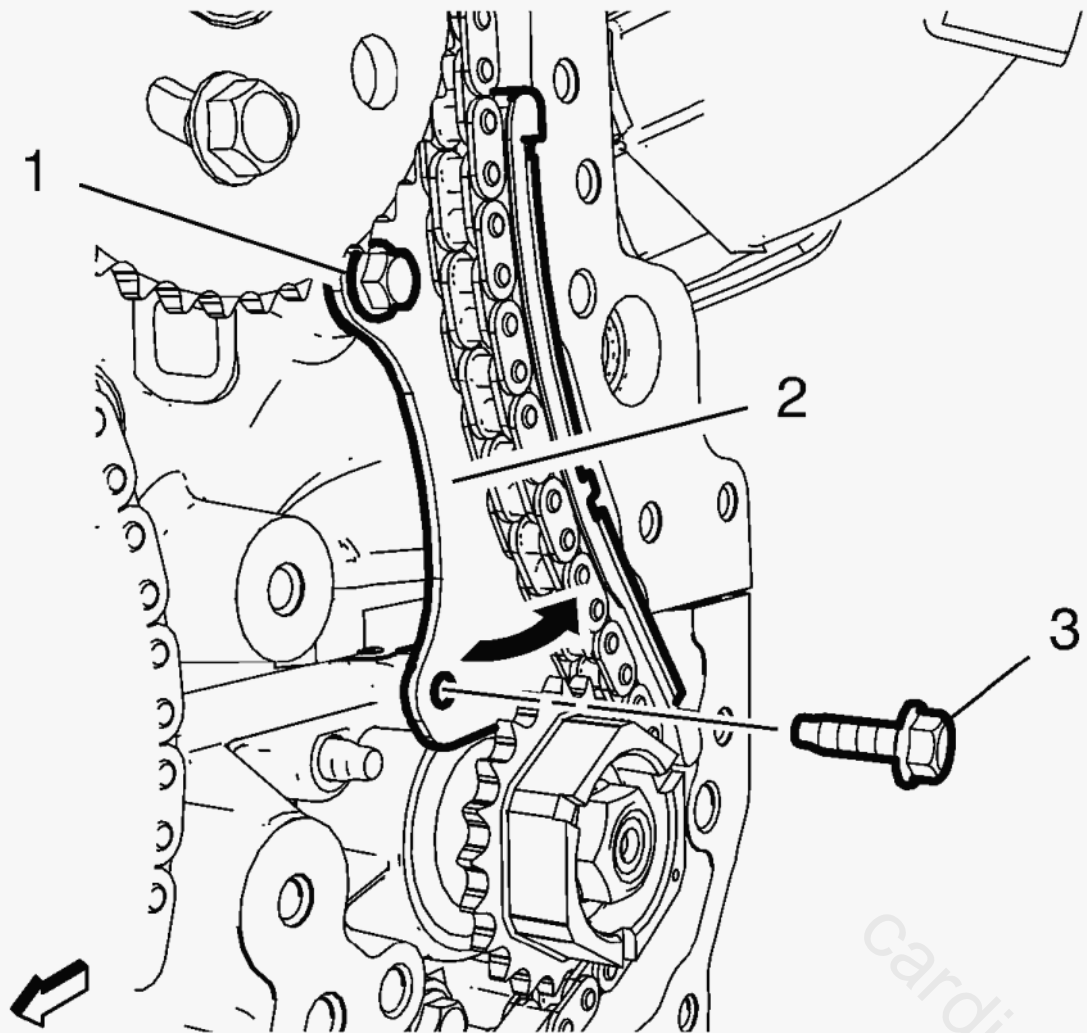


Fig. 109: Timing Chain Upper Guide And Bolts
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution**

7. Apply thread lock agent to the lower timing chain upper guide bolt (3). Refer to **Adhesives, Fluids, Lubricants, and Sealers**
8. Install and tighten Timing Chain Upper Guide Bolt (3) to 11 N.m (97 lb in)
9. Tighten Timing Chain Upper Guide Bolt (1) to 11 N.m (97 lb in)

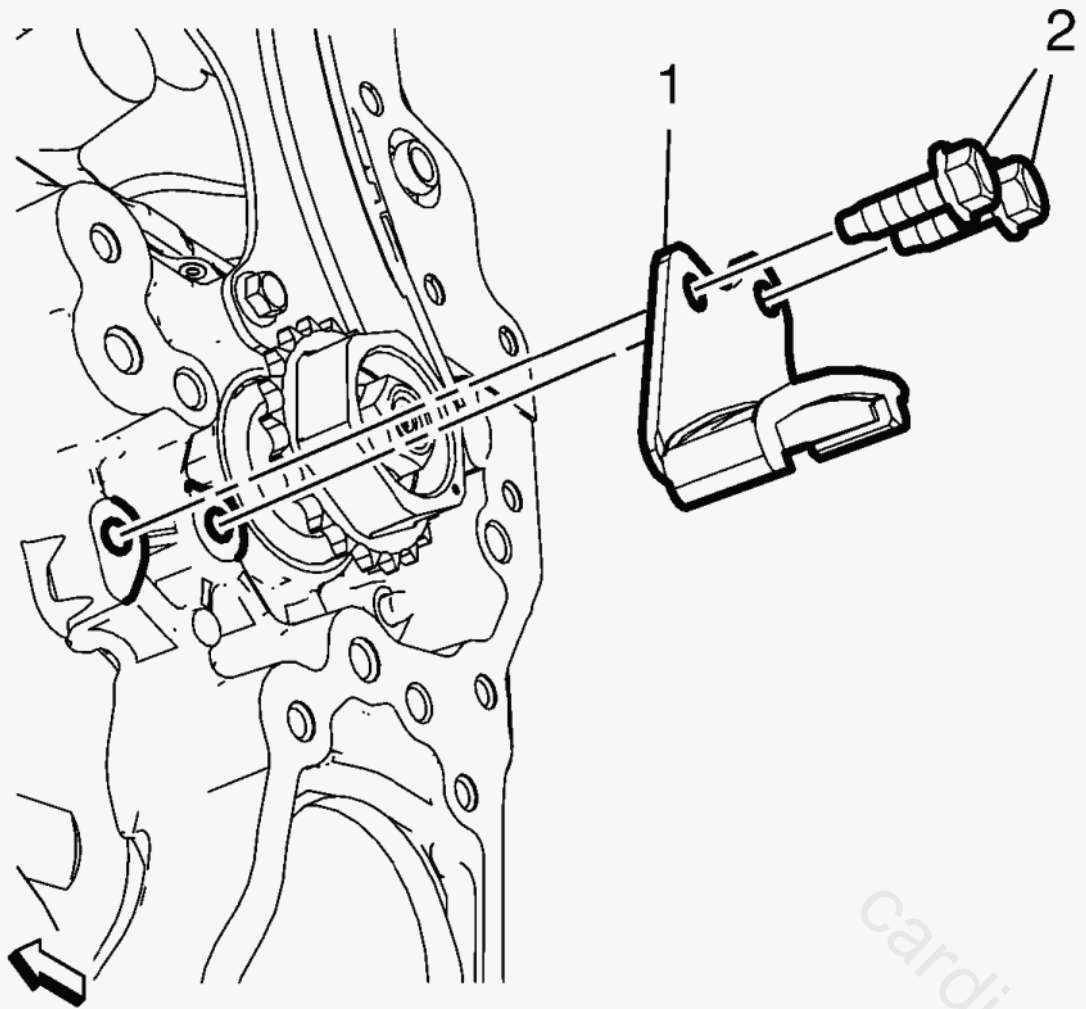


Fig. 110: Timing Chain Lower Guide And Bolts
Courtesy of GENERAL MOTORS COMPANY

10. Install Timing Chain Lower Guide (1)
11. Install and tighten Timing Chain Lower Guide Bolts (2) (Qty: 2) to 10 N.m (89 lb in)

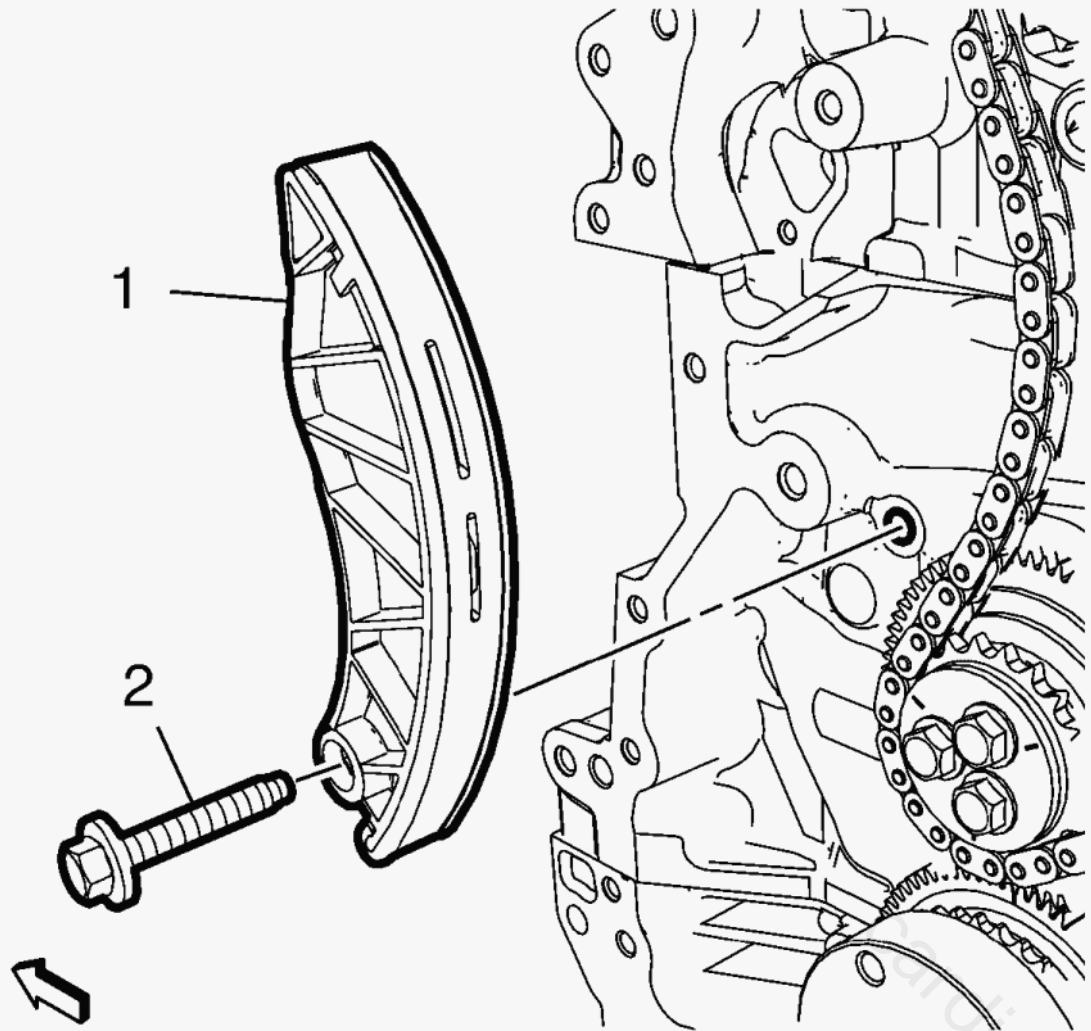


Fig. 111: Timing Chain Tensioner Shoe And Bolt
Courtesy of GENERAL MOTORS COMPANY

12. Install Timing Chain Tensioner Shoe (1)
13. Install and tighten Timing Chain Tensioner Shoe Bolt (2) to 25 N.m (18 lb ft)

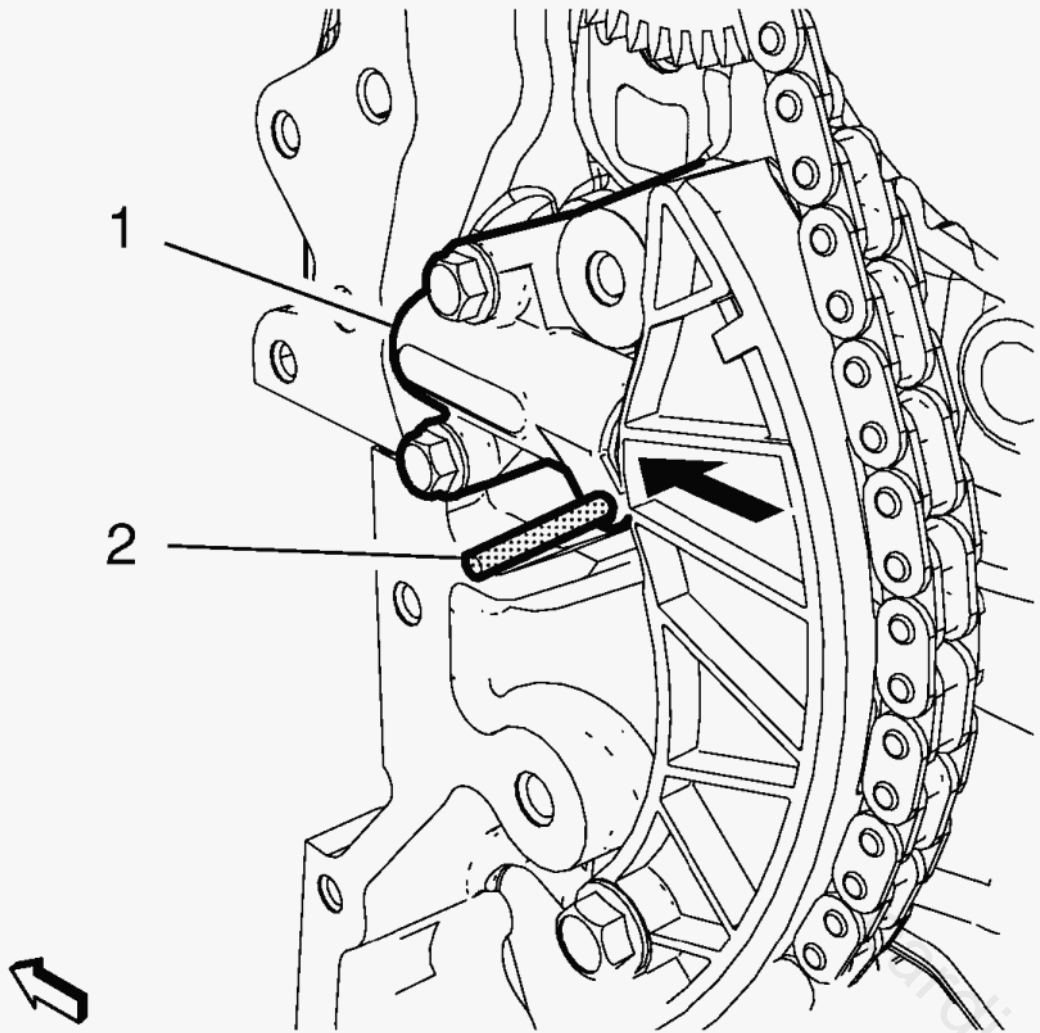


Fig. 112: Timing Chain Tensioner And Pin
Courtesy of GENERAL MOTORS COMPANY

14. Remove EN-50513 Pin (2)

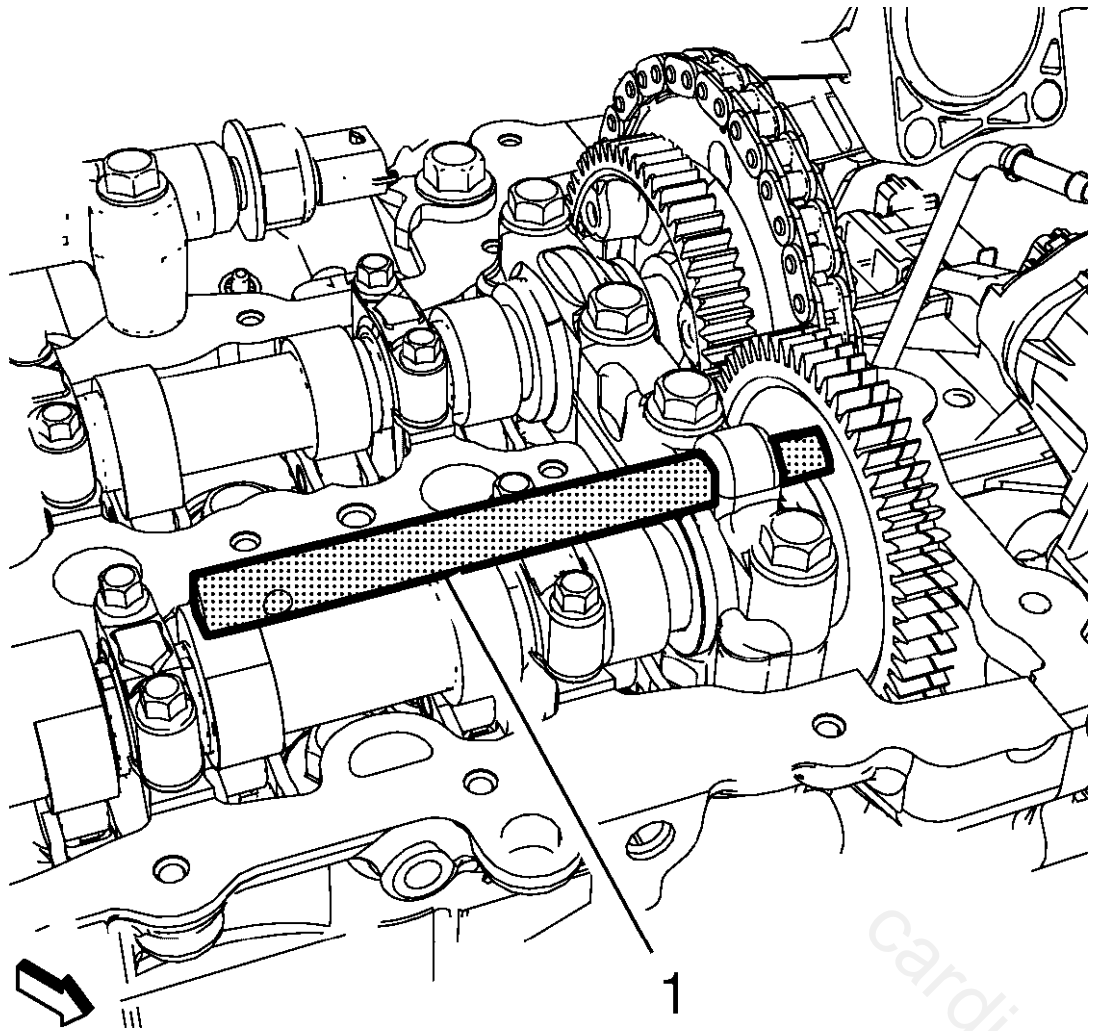


Fig. 113: Camshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

15. Remove EN-51143 Fixing Tool (1)
16. Raise the vehicle.

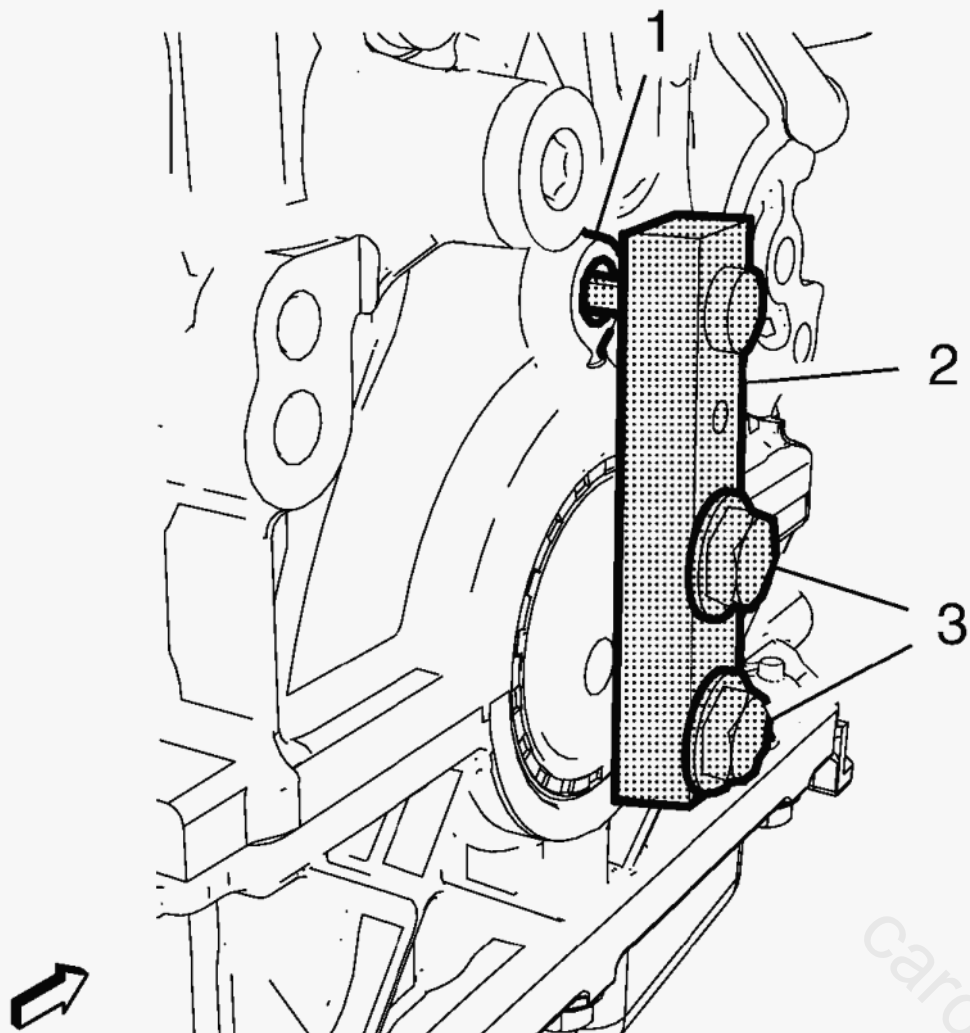


Fig. 114: Crankshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

17. Remove Bolts (3) (Qty: 2)
18. Remove **EN-51143** Fixing Tool (2)

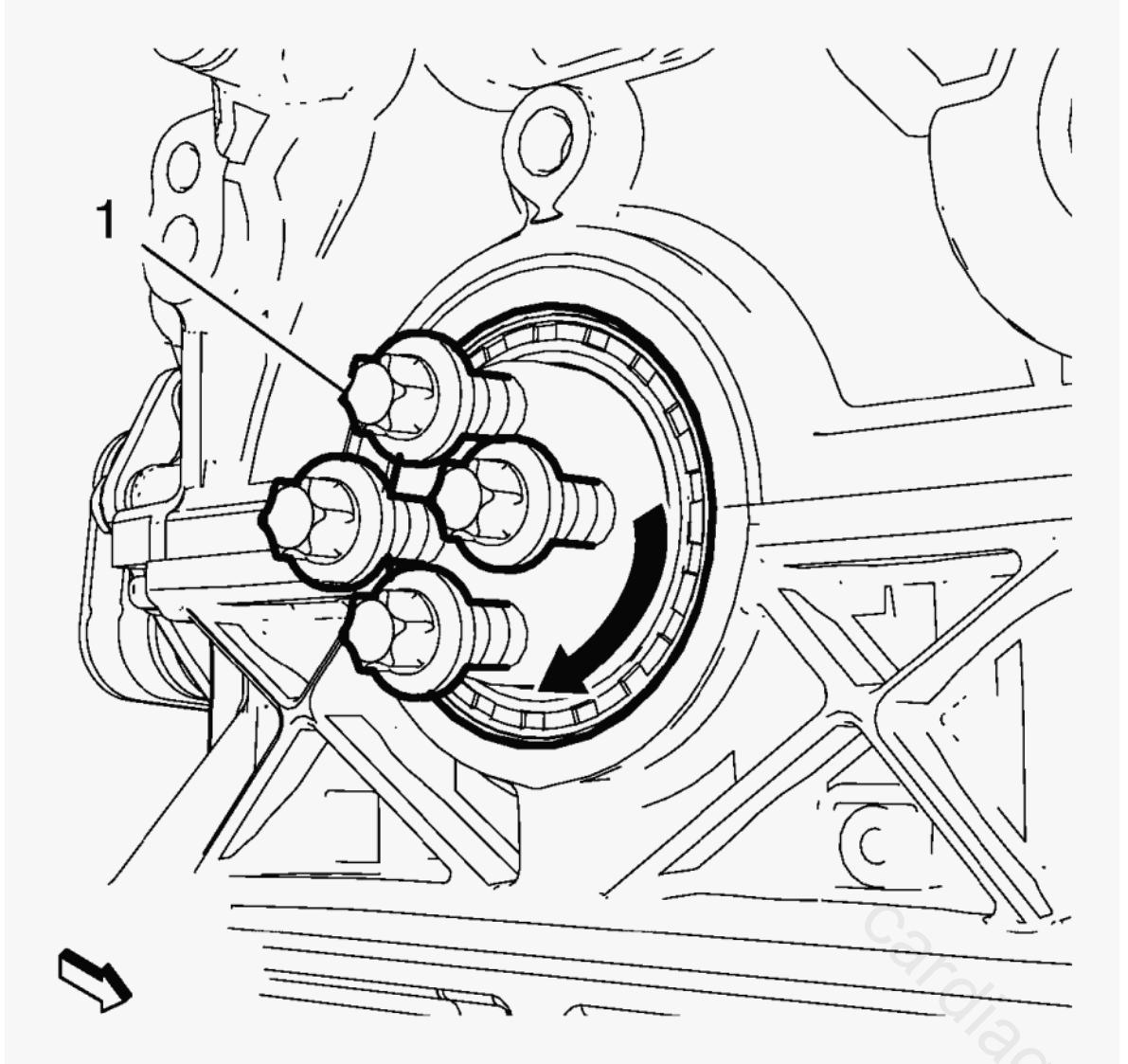


Fig. 115: Crankshaft Pulley Bolts

Courtesy of GENERAL MOTORS COMPANY

19. Install Crankshaft Pulley Bolts (1) (Qty: 4)

Rotate the crankshaft 720 degrees in direction of arrow. Use a pry bar at the 4 crankshaft pulley bolts (1).

20. Remove Crankshaft Pulley Bolts (1) (Qty: 4)

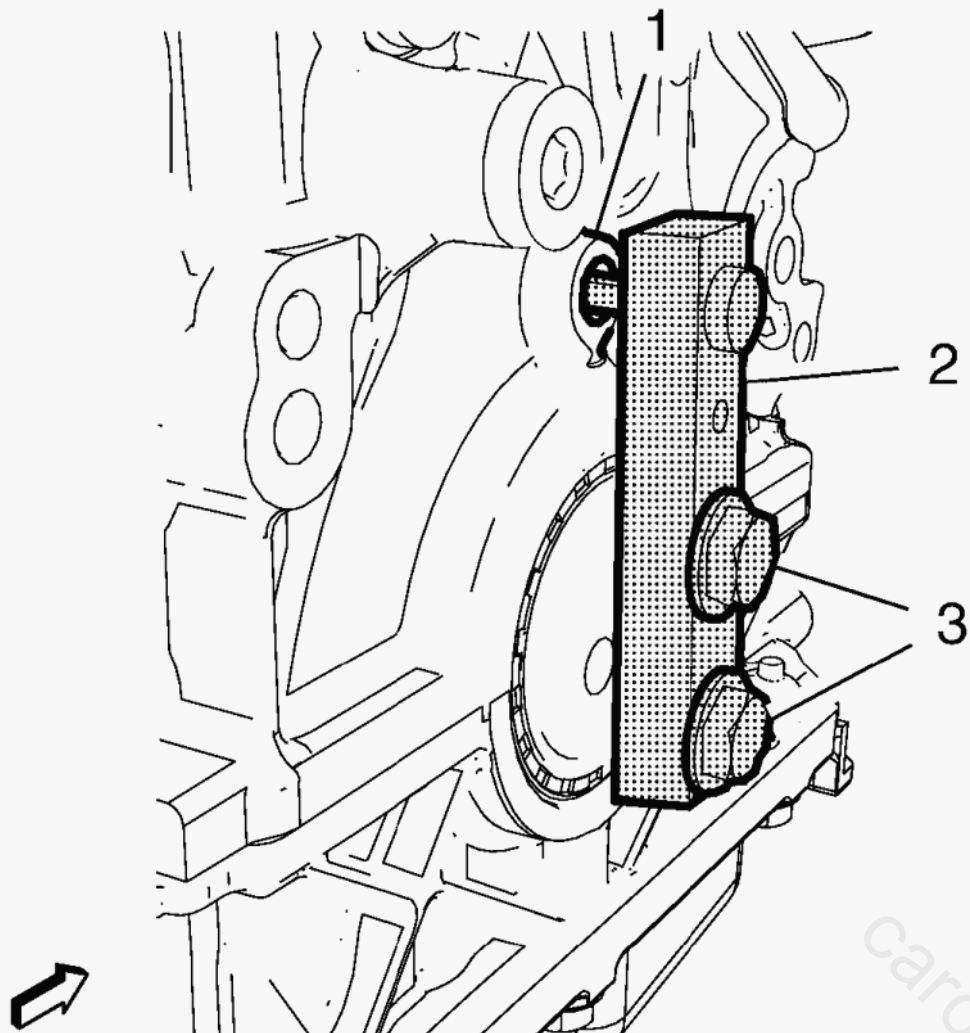


Fig. 116: Crankshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

21. Install **EN-51140** Fixing Tool (2)
22. Install Bolts (3) (Qty: 2)
23. Lower the vehicle.

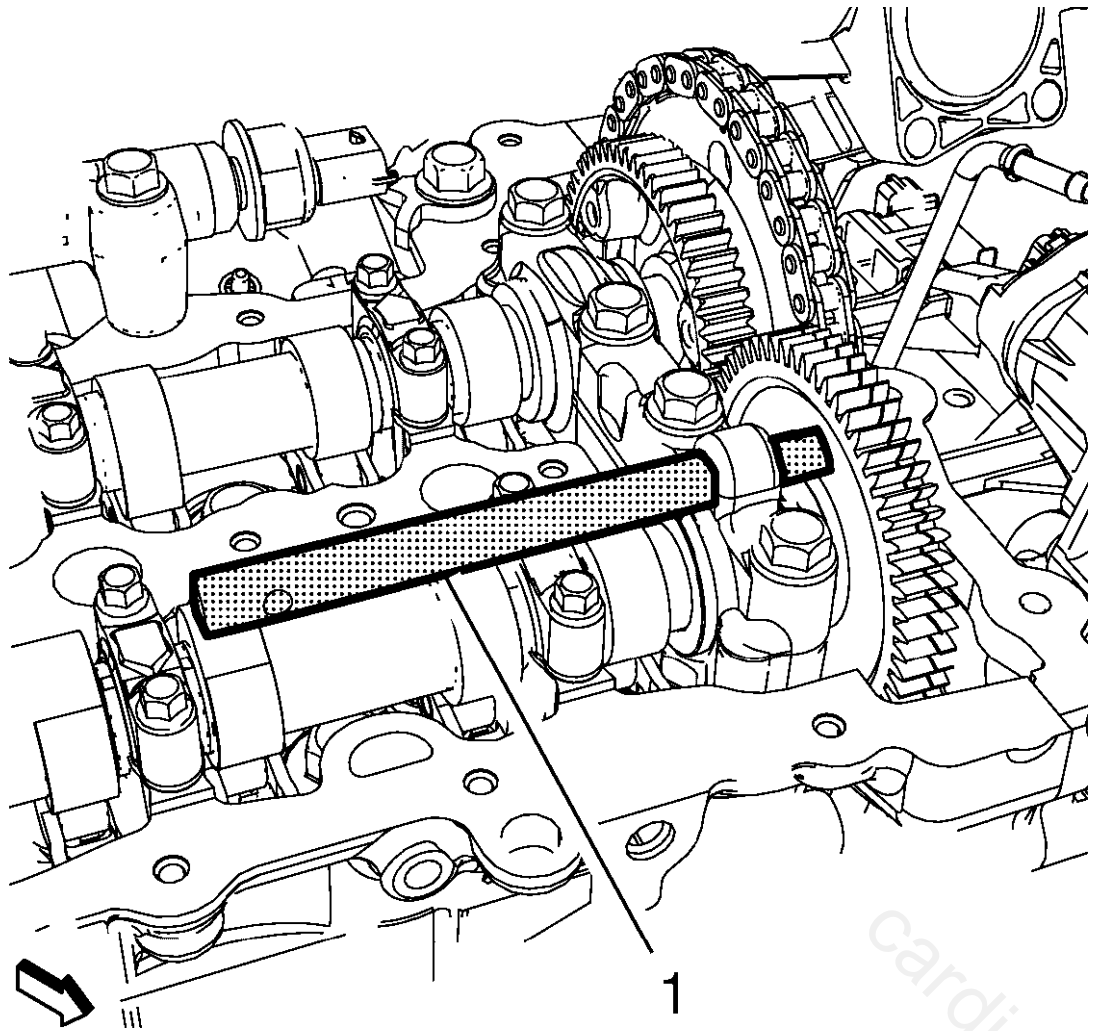


Fig. 117: Camshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

24. Install **EN-51143** Fixing Tool (1)
25. If the fixing pin does not fit into the camshaft sprocket bore, the camshaft timing must be adjusted. Refer to [Camshaft Timing Chain Adjustment](#)
26. Remove **EN-51143** Fixing Tool (1)
27. Raise the vehicle.

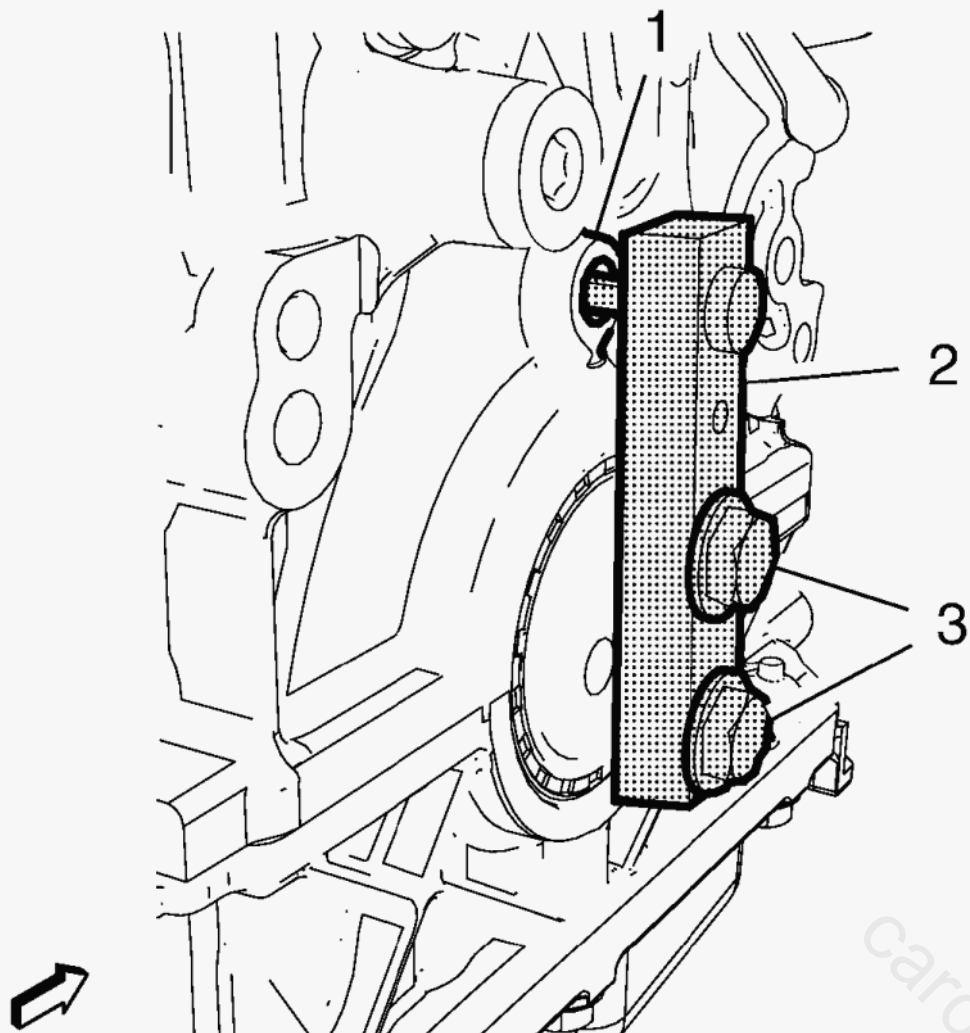


Fig. 118: Crankshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

- 28. Remove Bolts (3) (Qty: 2)
- 29. Remove **EN-51140** Fixing Tool (2)

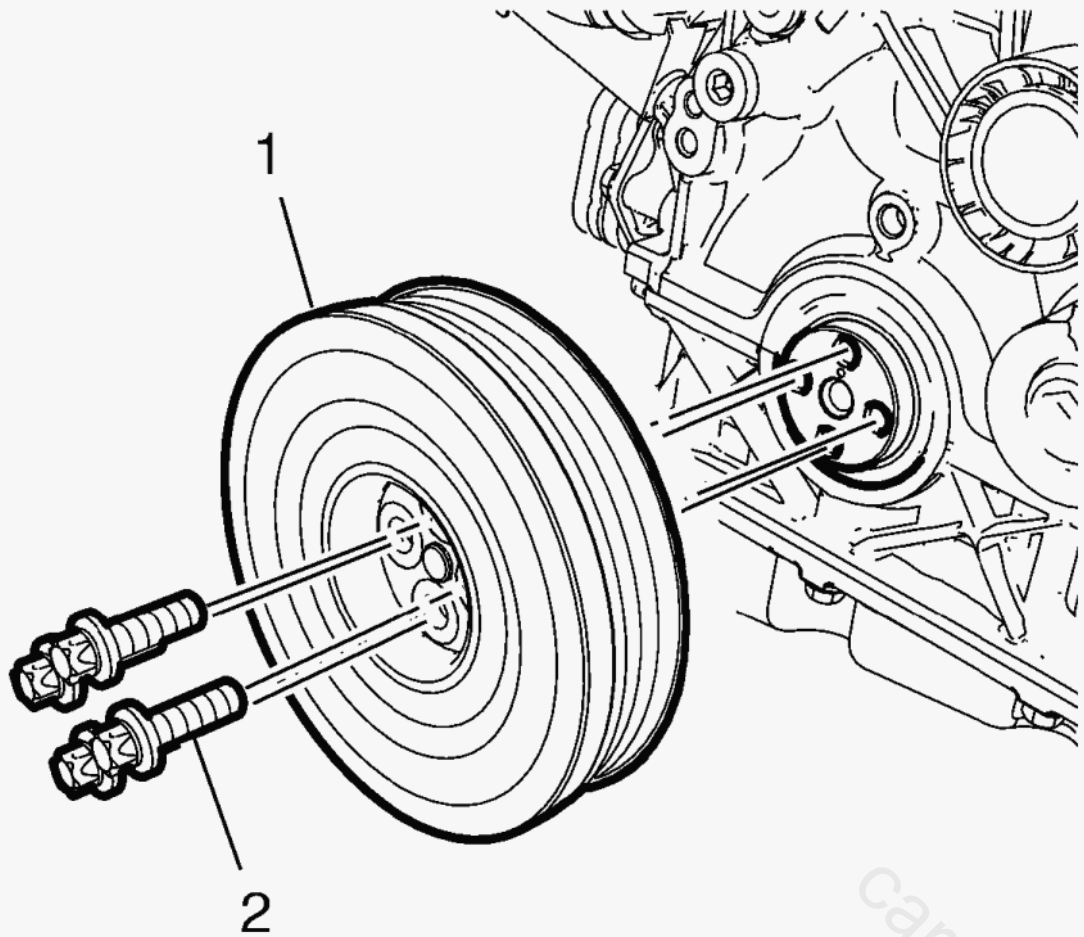


Fig. 119: Crankshaft Pulley And Bolts

Courtesy of GENERAL MOTORS COMPANY

30. Install Crankshaft Pulley (1). Refer to [Crankshaft Pulley Replacement](#)

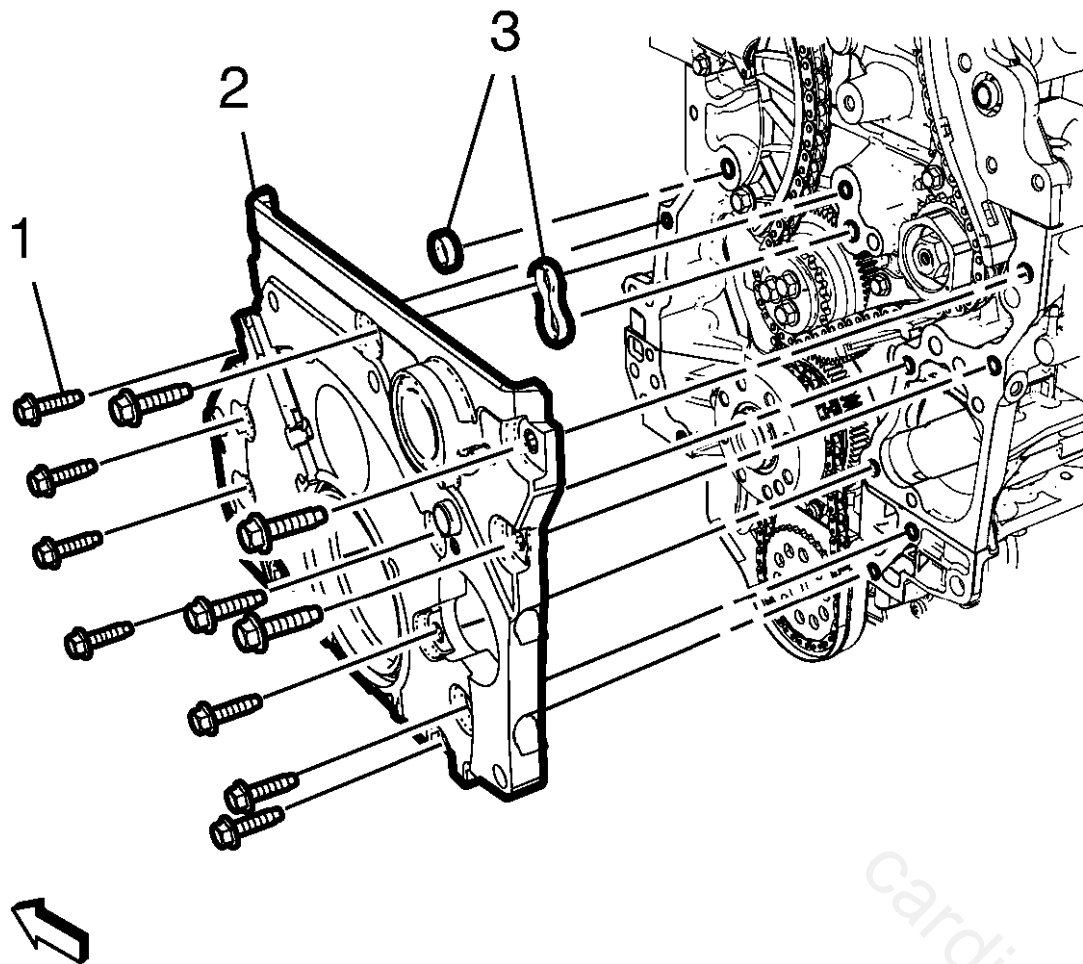


Fig. 120: Timing Chain Lower Cover, Bolts And Gaskets
Courtesy of GENERAL MOTORS COMPANY

31. Install Timing Chain Lower Cover (2). Refer to [Timing Chain Lower Cover Replacement](#)

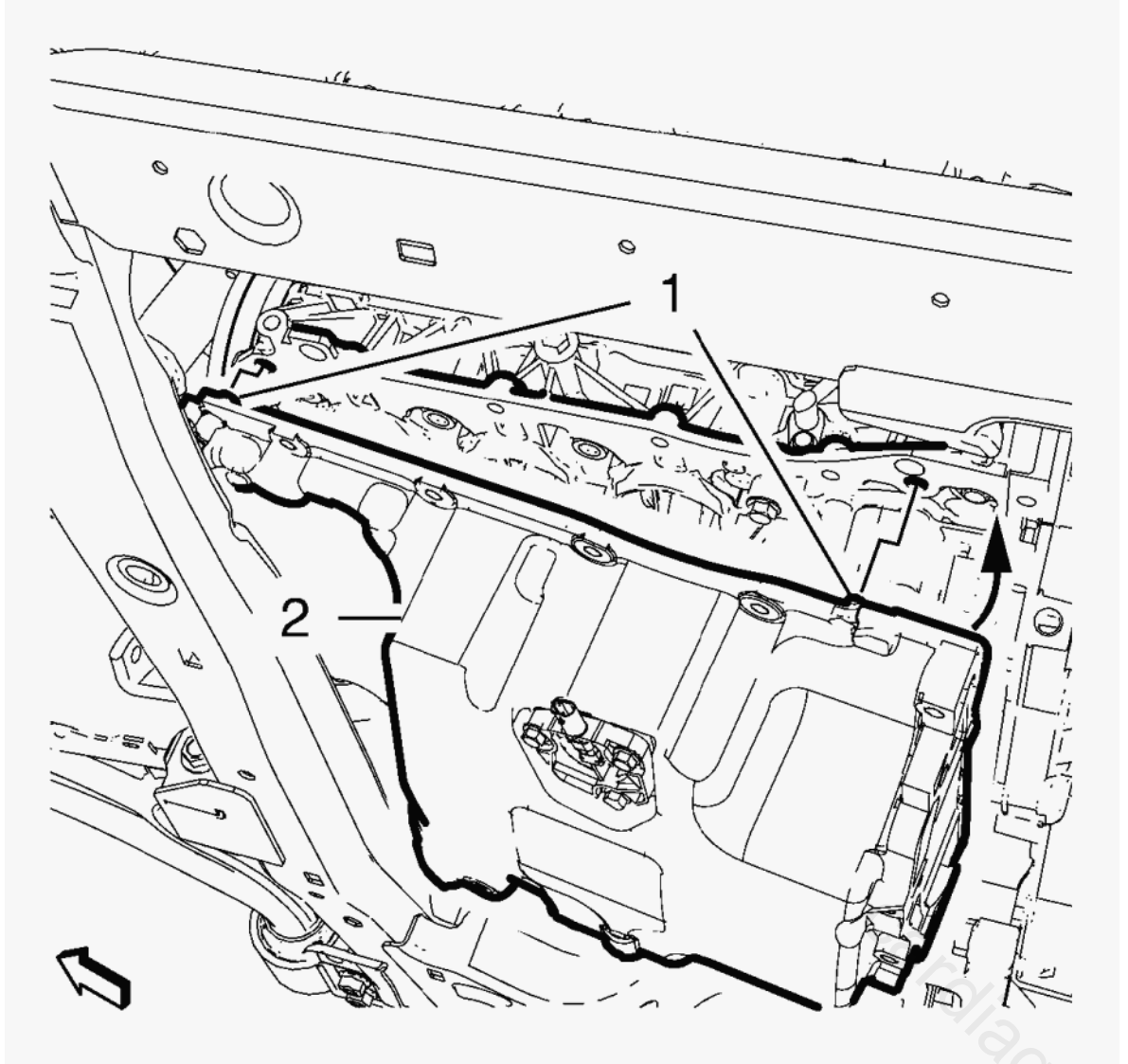


Fig. 121: Oil Pan

Courtesy of GENERAL MOTORS COMPANY

32. Install Oil Pan (2). Refer to [Oil Pan Replacement](#)

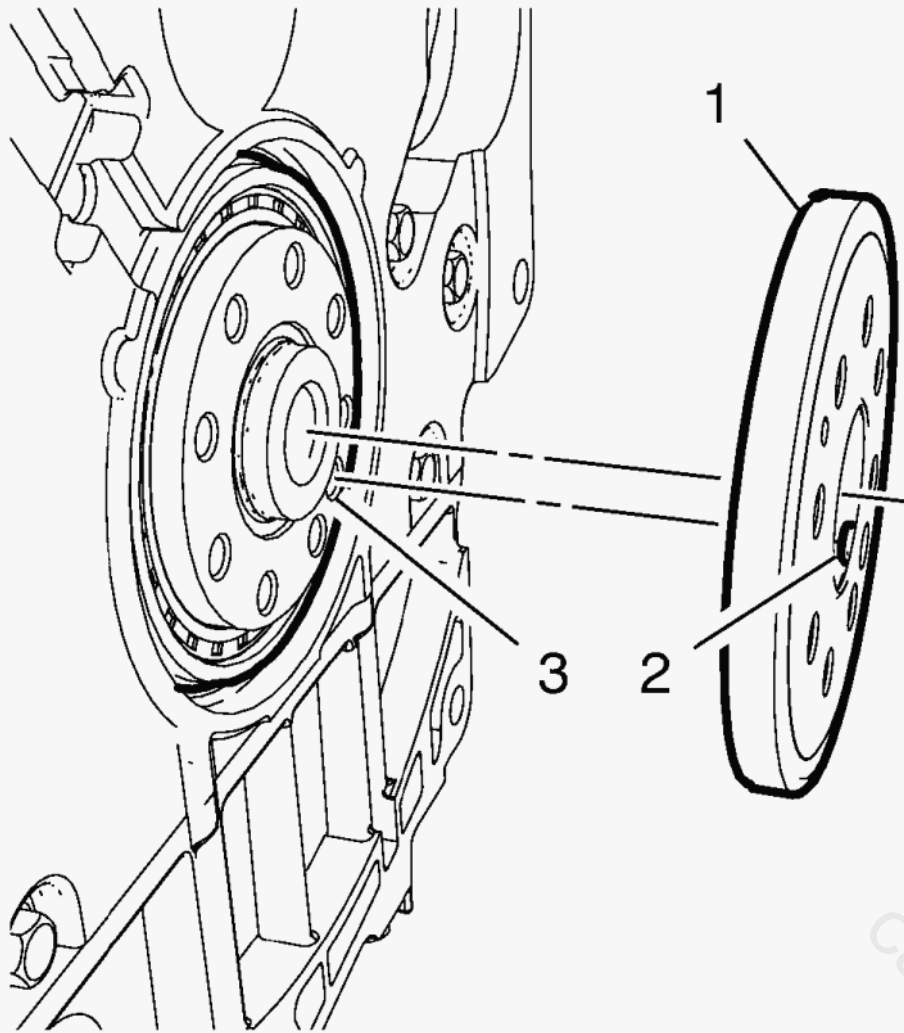


Fig. 122: Crankshaft Position Sensor Reluctor Ring
Courtesy of GENERAL MOTORS COMPANY

33. Install Crankshaft Position Sensor Reluctor Ring (1). Refer to [Crankshaft Position Sensor Reluctor Ring Replacement](#)
34. Install Transmission. Refer to [Transmission Replacement \(Front Wheel Drive\)](#) [Transmission Replacement \(All Wheel Drive\)](#)

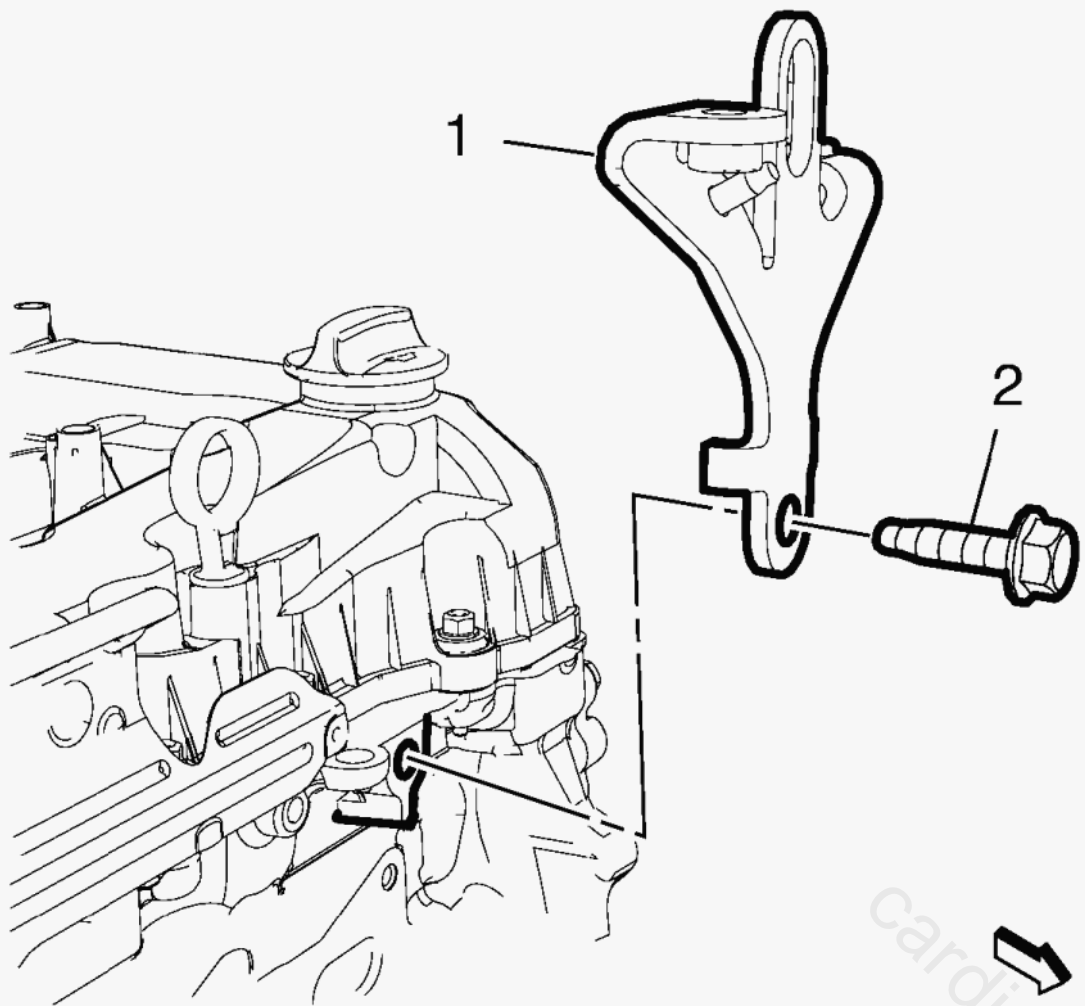


Fig. 123: Engine Lift Bracket And Bolt

Courtesy of GENERAL MOTORS COMPANY

35. Remove Engine Lift Bracket Bolt (2)
36. Remove Engine Lift Bracket - Left Side (1) @ Cylinder Head

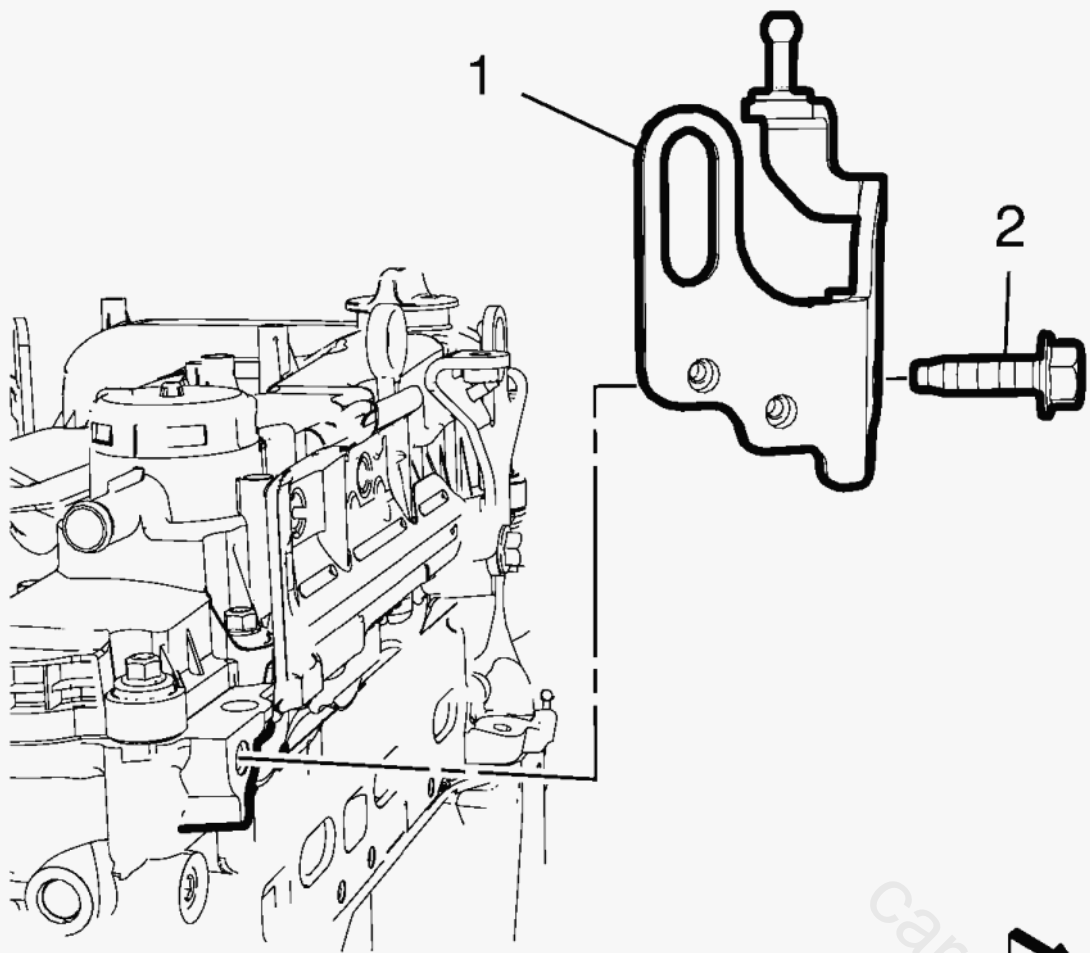


Fig. 124: Engine Lift Bracket And Bolt

Courtesy of GENERAL MOTORS COMPANY

37. Remove Engine Lift Bracket Bolt (2)
38. Remove Engine Lift Bracket - Right Side (1) @ Cylinder Head

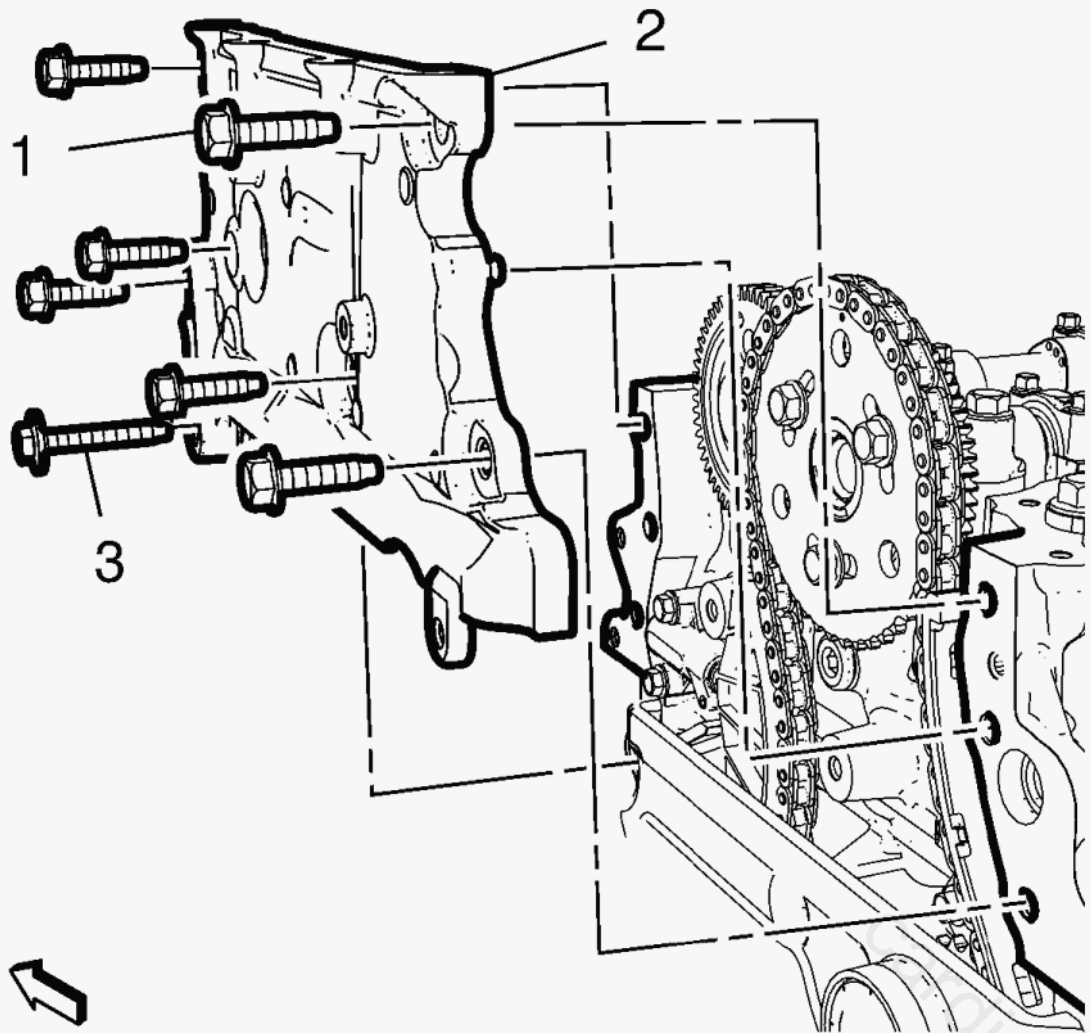


Fig. 125: Timing Chain Upper Cover And Bolts
 Courtesy of GENERAL MOTORS COMPANY

39. Install Timing Chain Upper Cover (2). Refer to [Timing Chain Upper Cover Replacement](#)

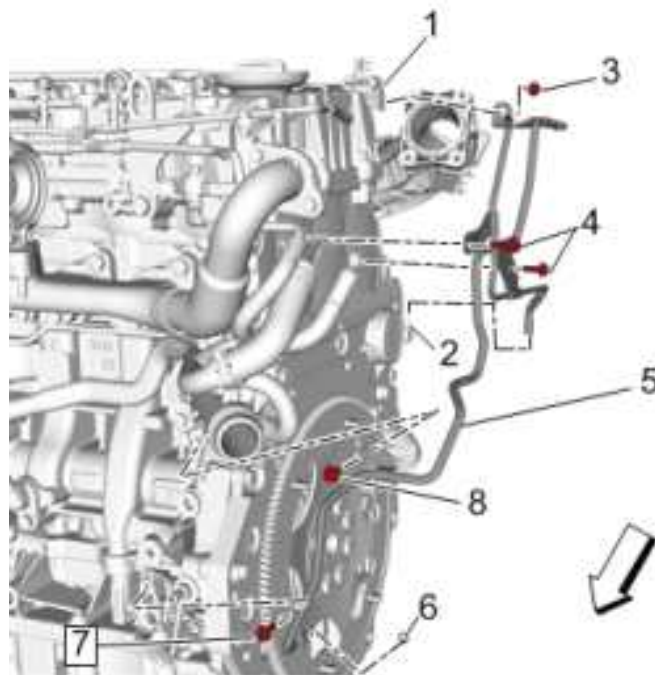


Fig. 126: Power Brake Booster Inlet Hose Connector Fitting And Components
 Courtesy of GENERAL MOTORS COMPANY

40. Install Power Brake Booster Inlet Hose Connector Fitting (5). Refer to [Power Brake Booster Inlet Hose Connector Fitting Replacement](#)

41. Install Oxidation Catalytic Converter. Refer to [Oxidation Catalytic Converter Replacement \(LH7\)](#).

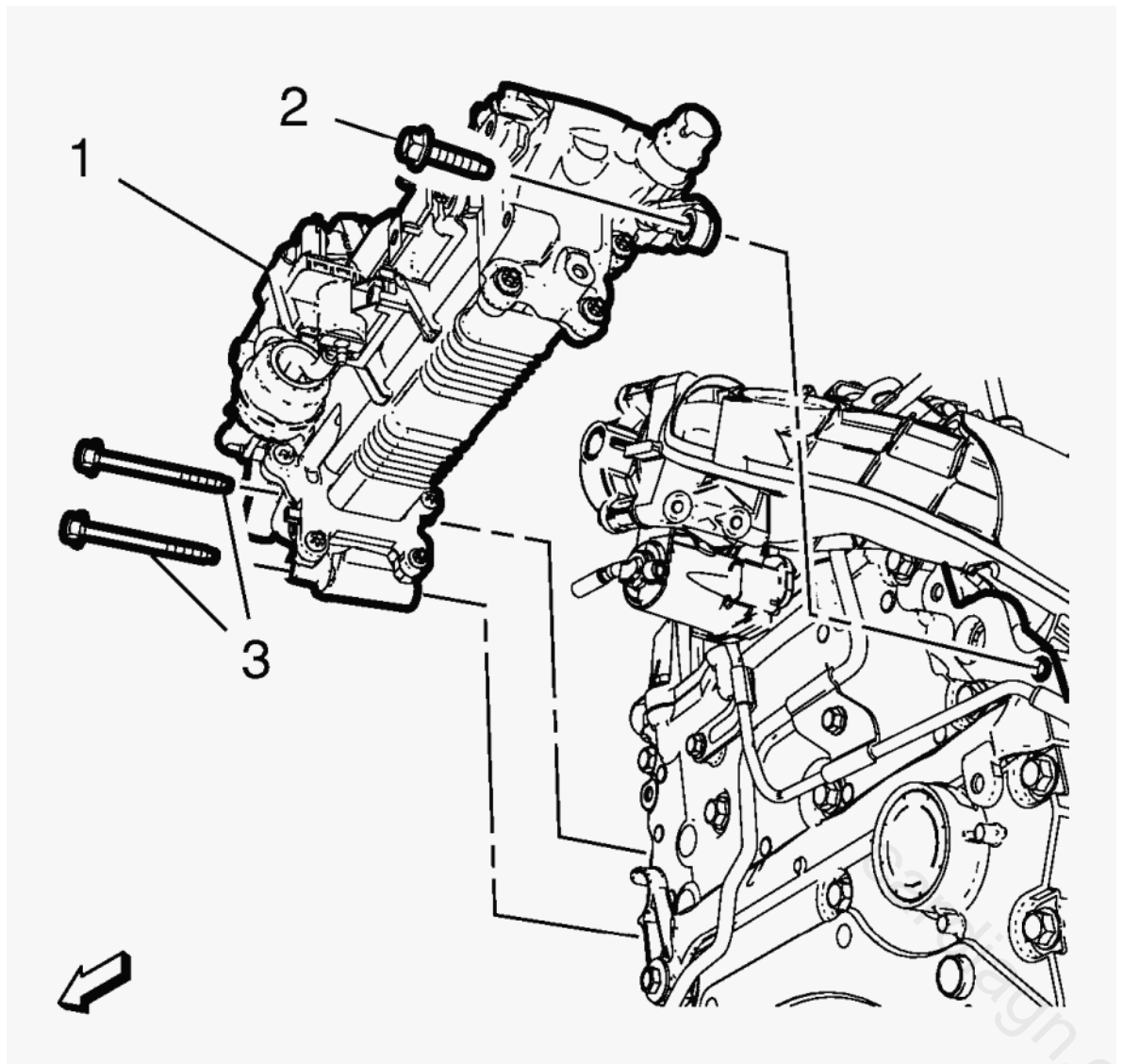


Fig. 127: Exhaust Gas Recirculation Cooler Housing
Courtesy of GENERAL MOTORS COMPANY

42. Install Exhaust Gas Recirculation Cooler Housing (1). Refer to [Exhaust Gas Recirculation Cooler Housing Replacement](#)

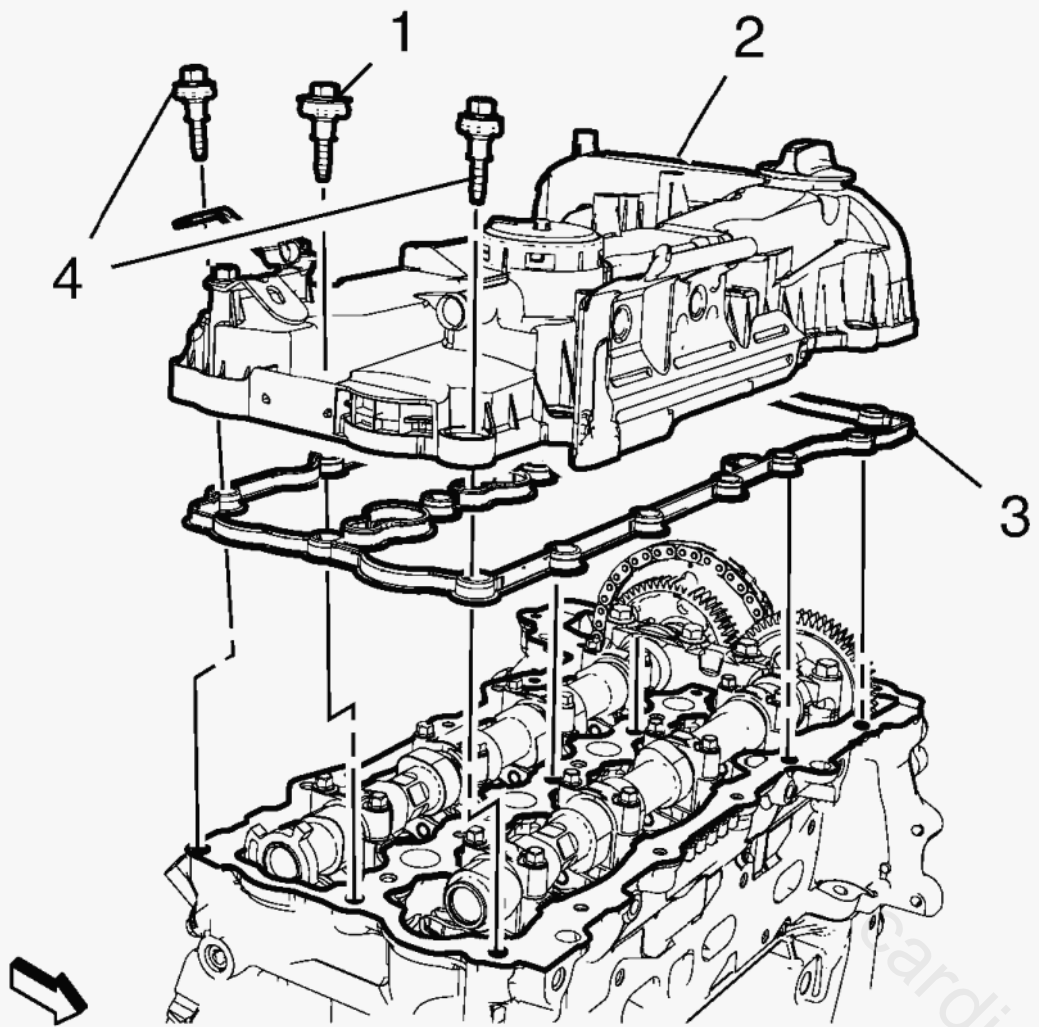


Fig. 128: Camshaft Housing, Bolts And Gasket
Courtesy of GENERAL MOTORS COMPANY

43. Install Camshaft Housing (2). Refer to [Camshaft Housing Replacement](#)

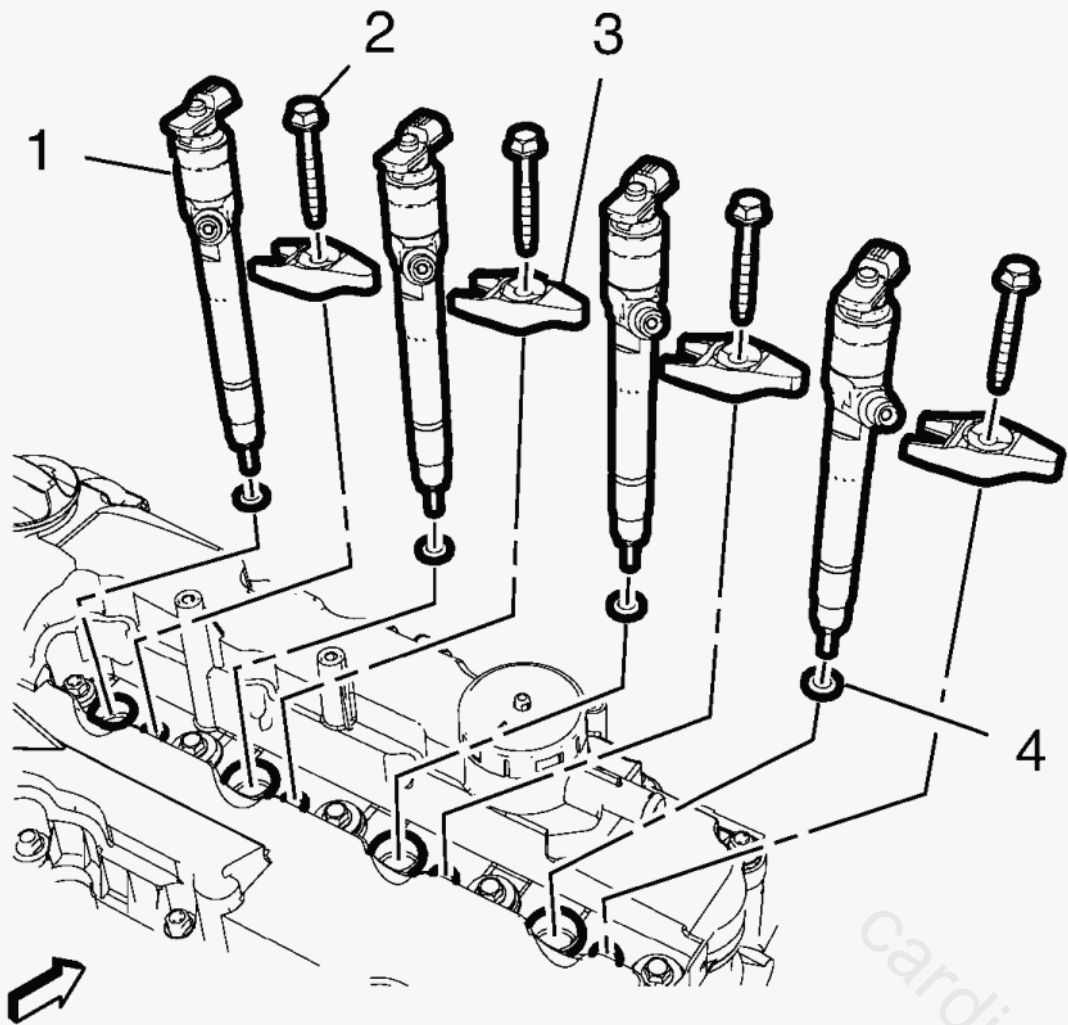


Fig. 129: Fuel Injectors, Bolts And Retainers
Courtesy of GENERAL MOTORS COMPANY

44. Install Fuel Injectors (1) (Qty: 4). Refer to [Fuel Injector Replacement](#)

CAMSHAFT SPROCKET REPLACEMENT

Special Tools

- EN-50513 Fixing Pin
- EN-51140 Crankshaft Fixing Tool
- EN-51143 Camshaft Sprocket Fixing Tool

For equivalent regional tools, refer to [Special Tools](#).

Removal Procedure

1. Remove the timing chain upper cover. Refer to [Timing Chain Upper Cover Replacement](#).
2. Remove the crankshaft pulley. Refer to [Crankshaft Pulley Replacement](#).

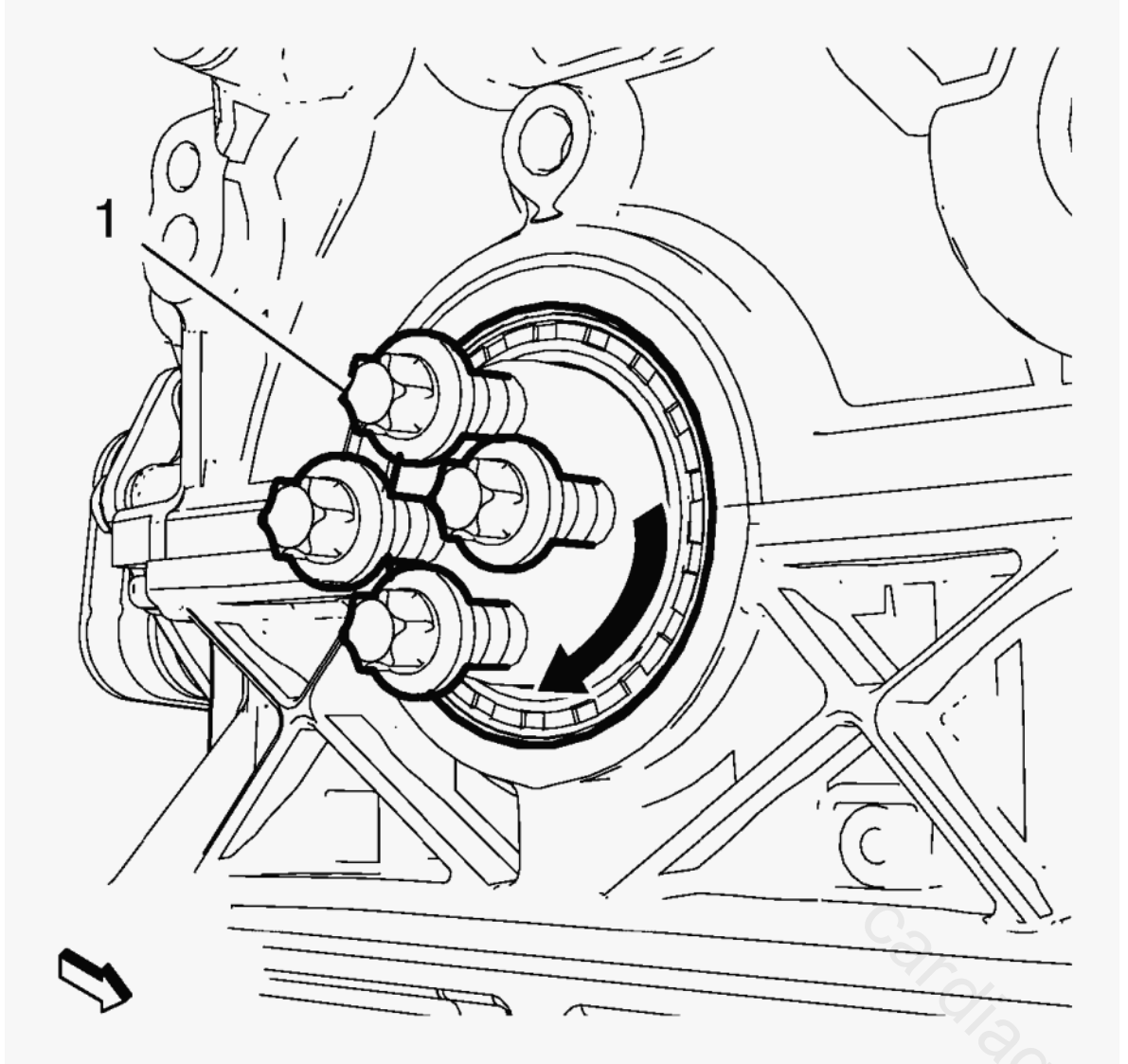


Fig. 130: Crankshaft Pulley Bolts

Courtesy of GENERAL MOTORS COMPANY

3. Install the 4 crankshaft pulley bolts (1).

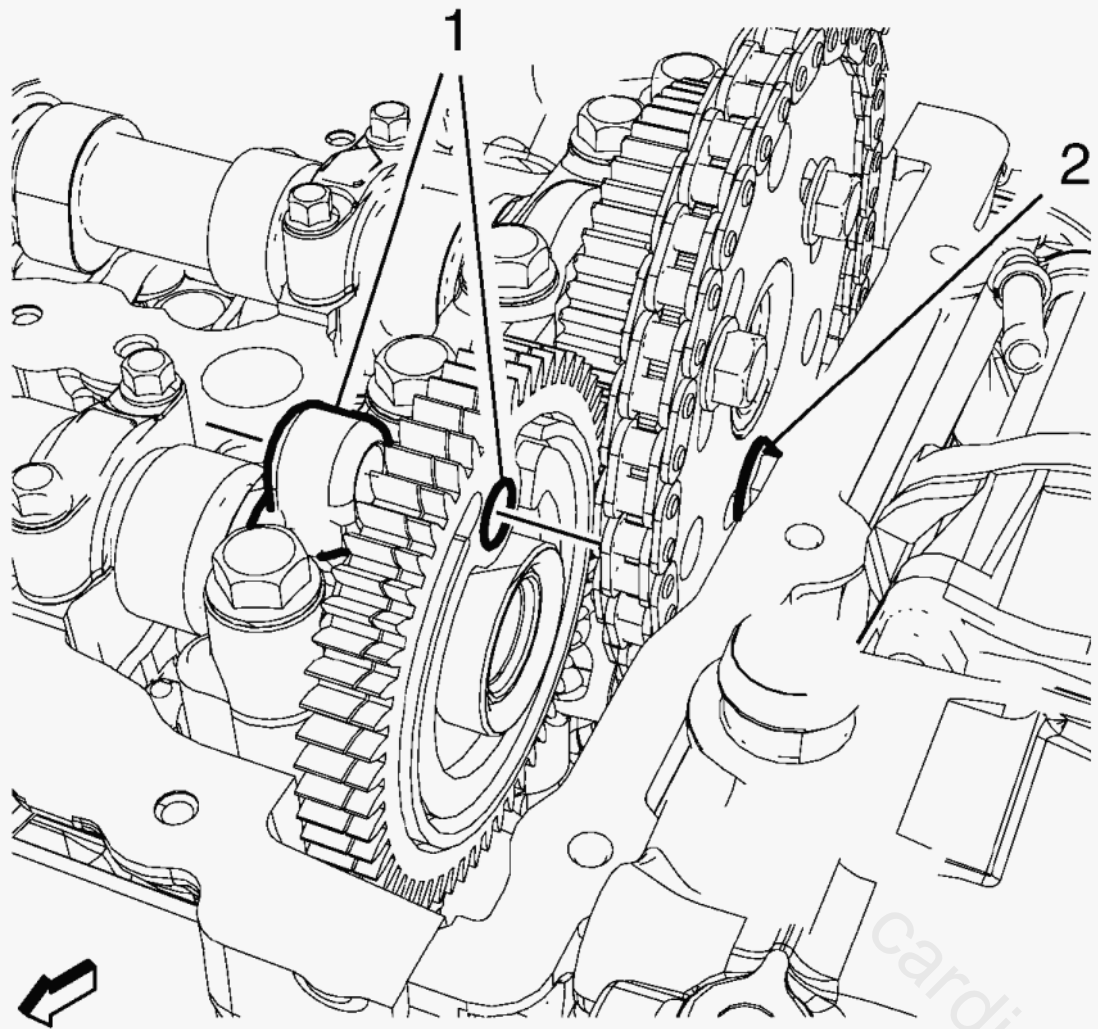


Fig. 131: Aligning Bores

Courtesy of GENERAL MOTORS COMPANY

NOTE: If the bores not aligned turn the crankshaft at the crankshaft pulley bolts.

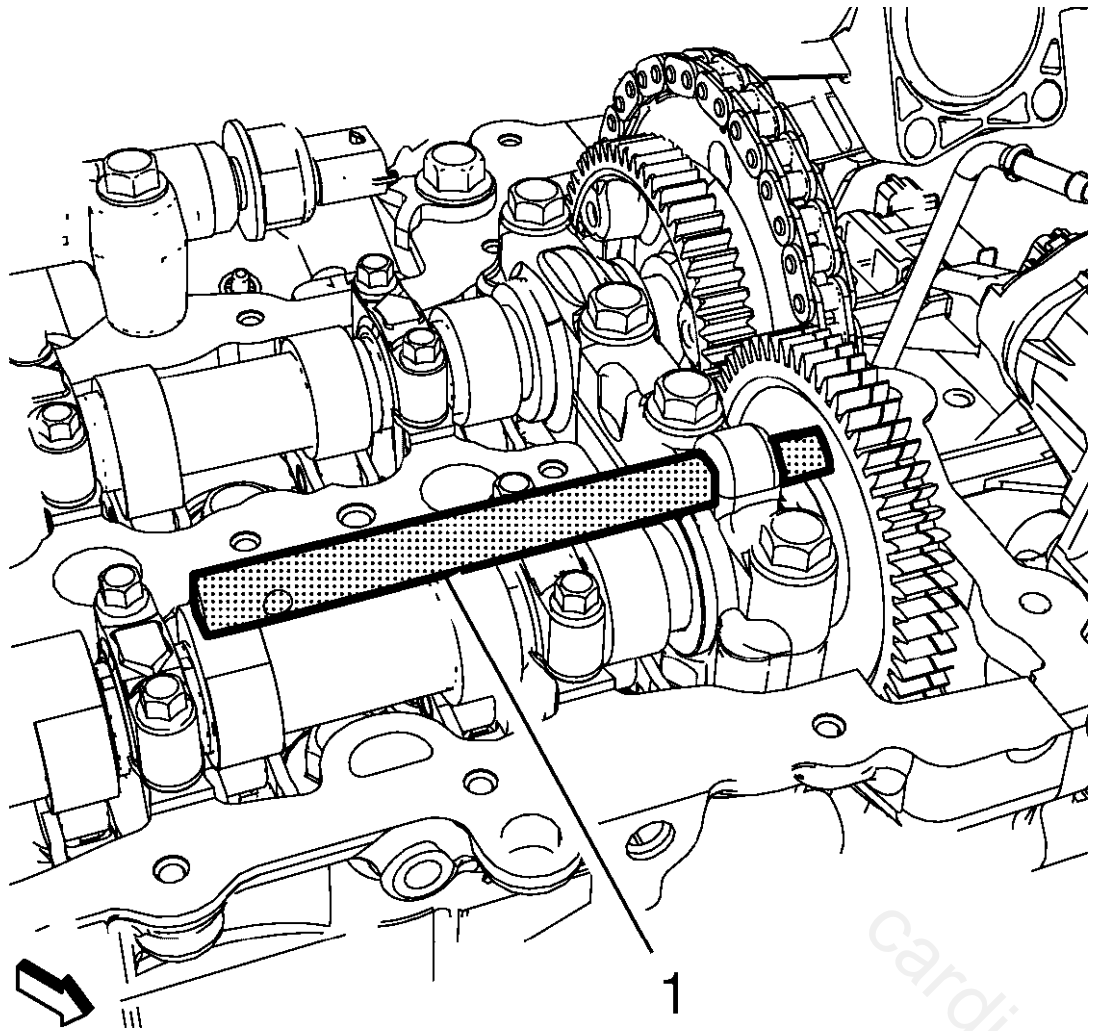


Fig. 132: Camshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

4. Check if the bores (1) are aligned.

Turn the exhaust camshaft at the hexagon so far if the **EN-51143** fixing tool (1) can be installed.

5. Raise and support the vehicle. Refer to [Lifting and Jacking the Vehicle](#) .

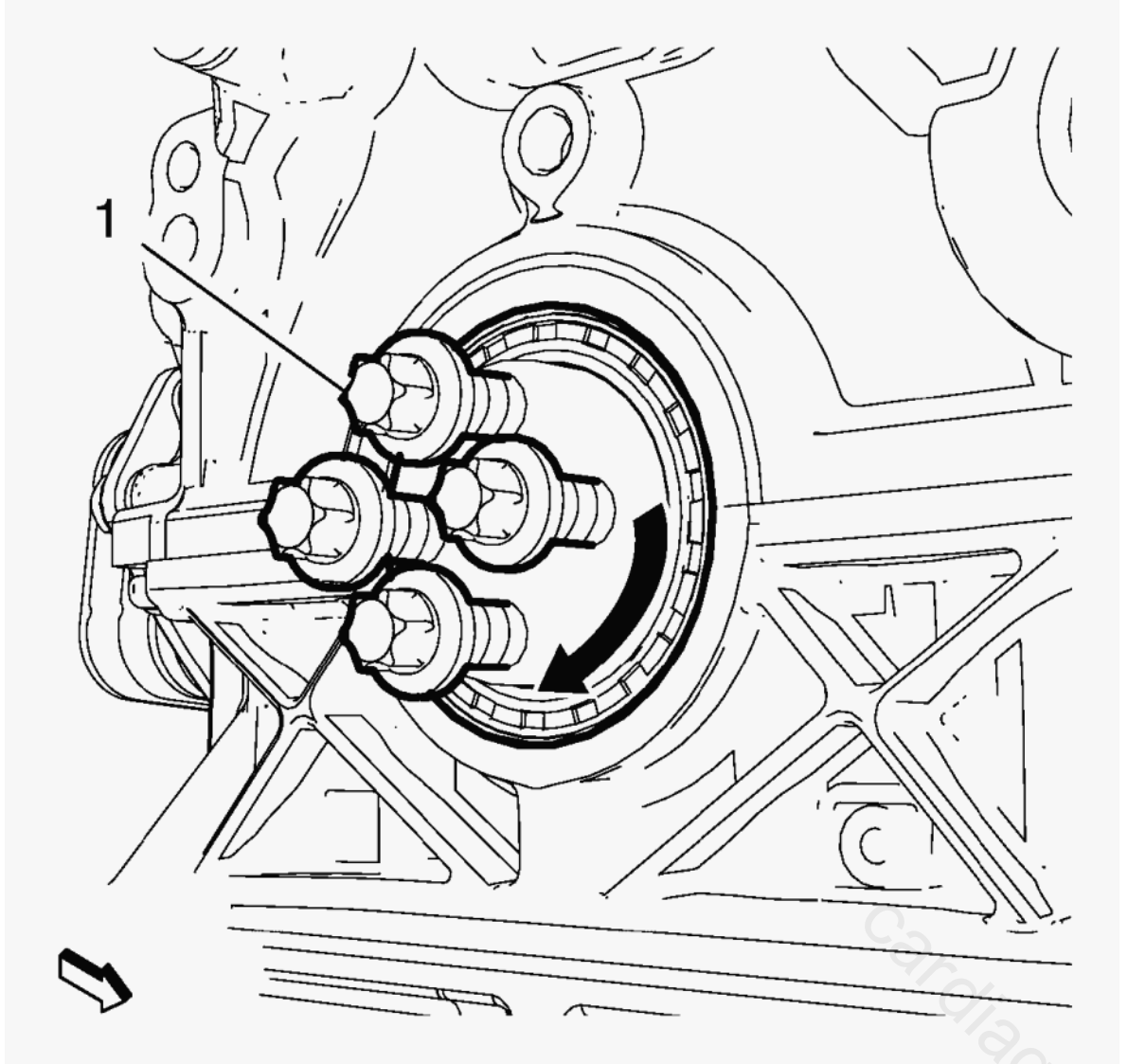


Fig. 133: Crankshaft Pulley Bolts

Courtesy of GENERAL MOTORS COMPANY

6. Remove the 4 crankshaft pulley bolts (1).

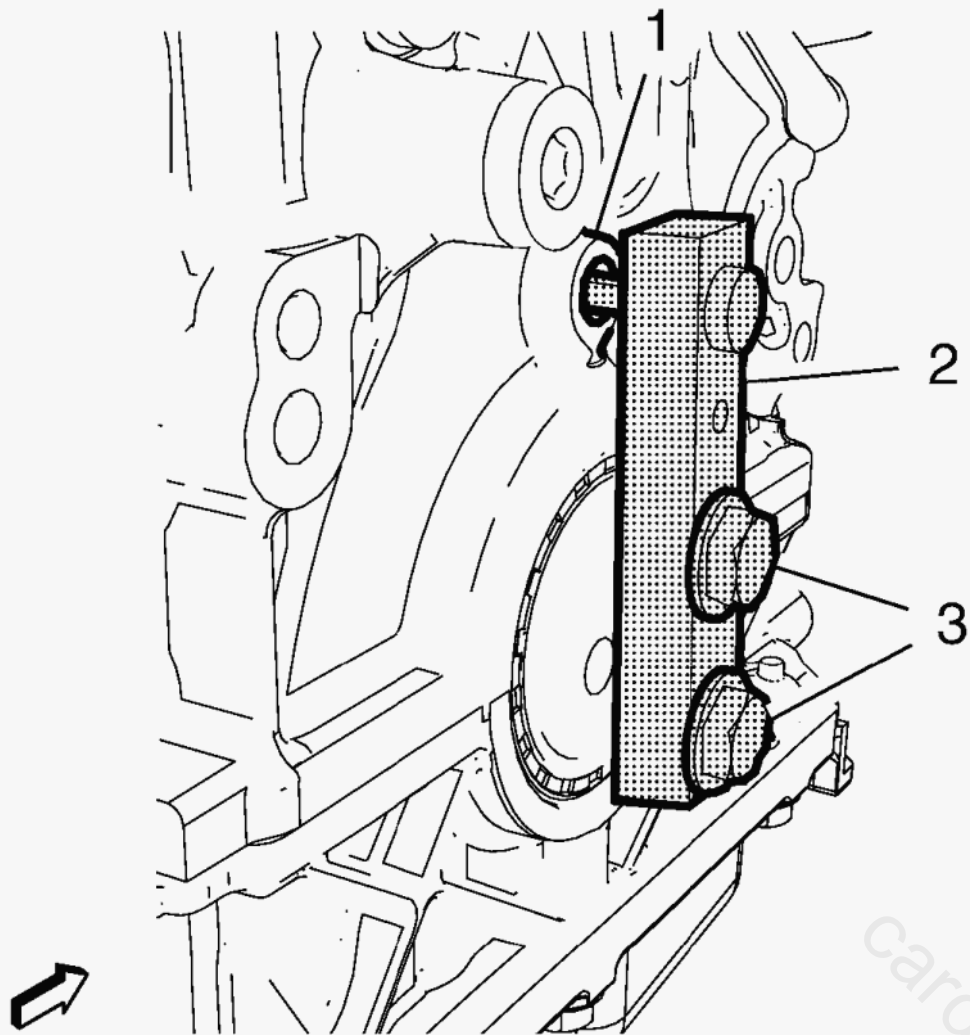


Fig. 134: Crankshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

7. Install **EN-51140** fixing tool (2).
8. Install the fixing pin into the engine block bore (1) and tighten the 2 bolts (3).
9. If the **EN-51140** fixing tool can not installed. Refer to [Camshaft Timing Chain Adjustment](#).
10. Lower the vehicle.

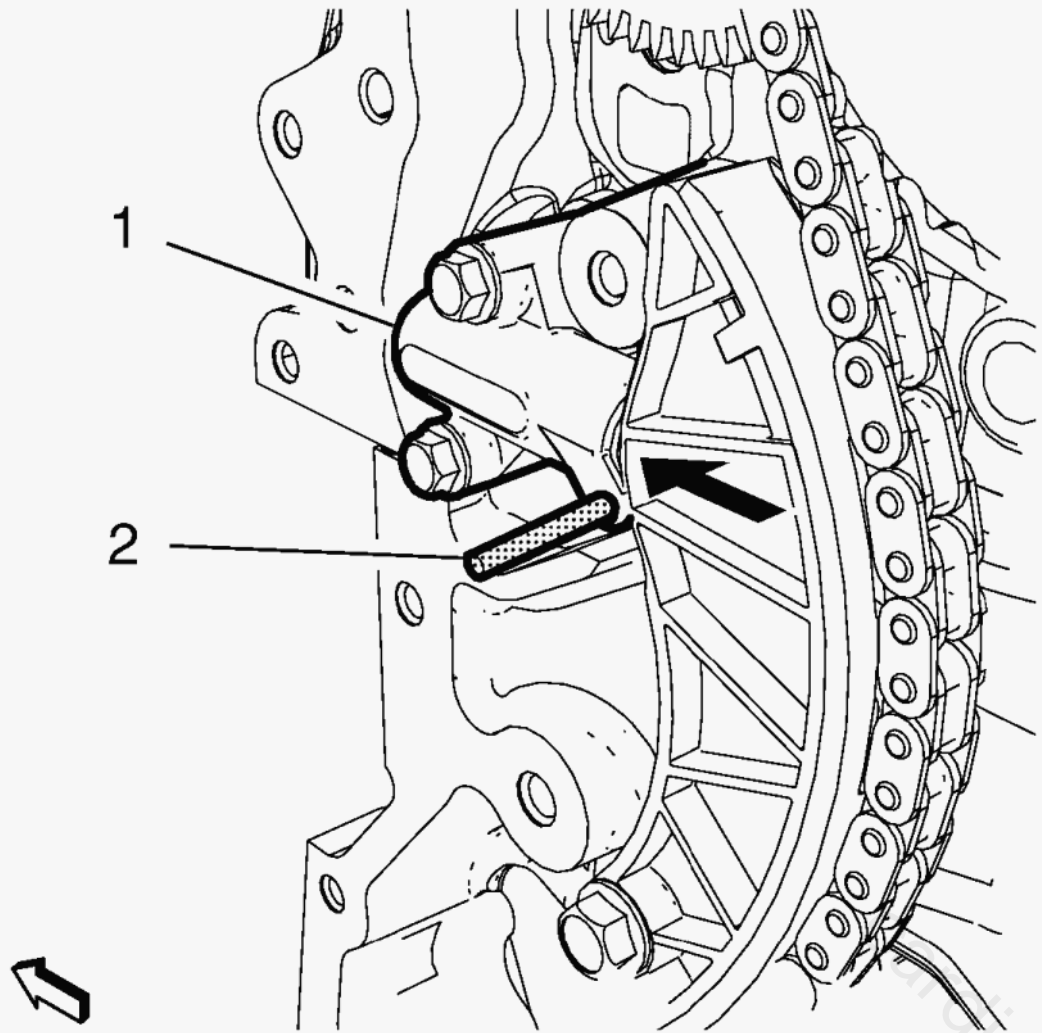


Fig. 135: Timing Chain Tensioner And Pin

Courtesy of GENERAL MOTORS COMPANY

11. Tension the timing chain tensioner (1) in arrow direction.
12. Install the EN-50513 pin (2).

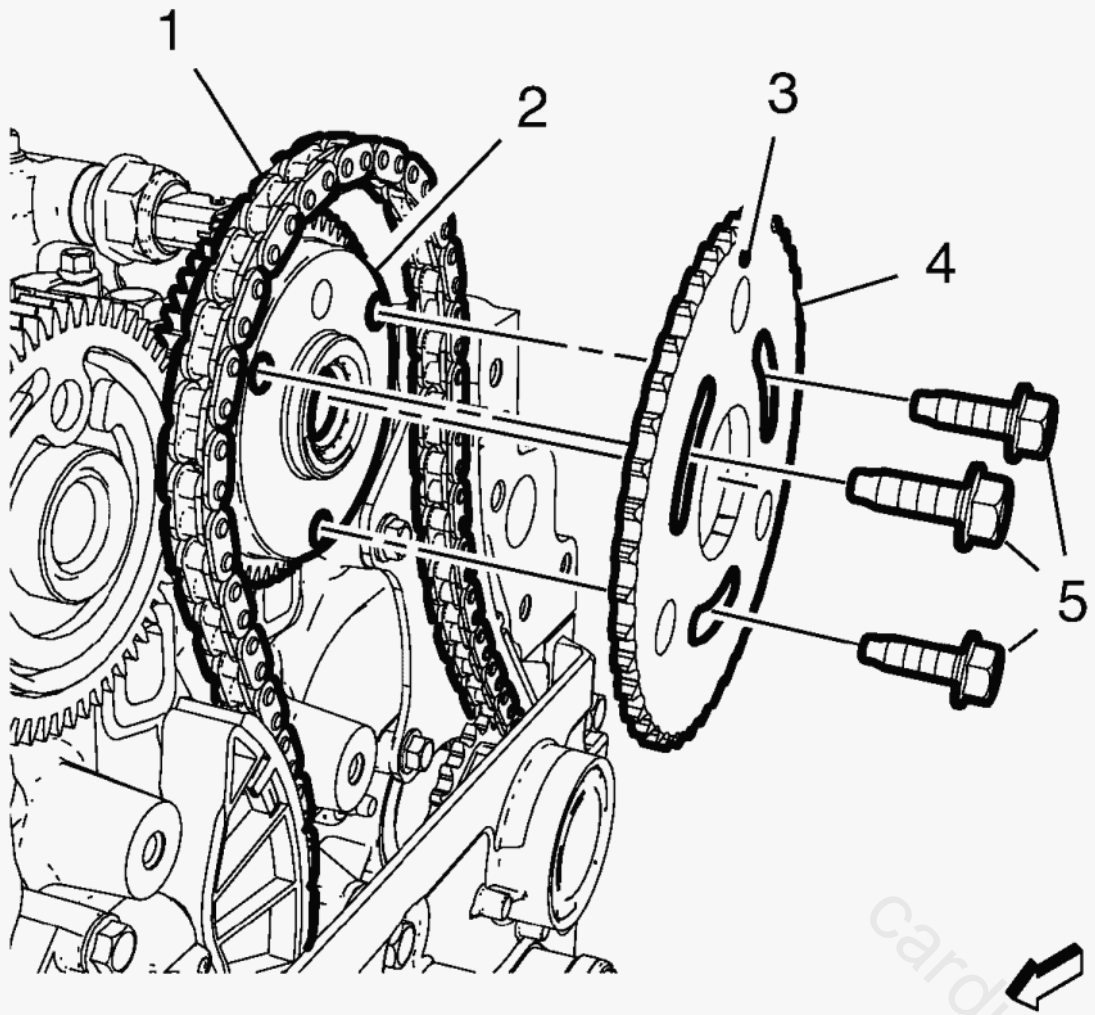


Fig. 136: Camshaft Sprocket, Bolts, Intake Camshaft And Timing Chain
Courtesy of GENERAL MOTORS COMPANY

13. Remove the 3 camshaft sprocket bolts (5), counterhold with a wrench at the camshaft hexagon.
14. Remove the camshaft sprocket (4) from the intake camshaft (2).
15. Deposit the camshaft timing chain (1) onto the upper timing chain cover.

Installation Procedure

NOTE: Before installing the camshaft sprocket, check the components of the timing chain system for damage and wear.

1. Check the components of the timing chain system for damage and wear:
 - Timing chain guides with plastic attachment
 - Timing chain tensioner and timing chain tensioner shoe with plastic attachment
 - Timing chain and all timing chain sprockets
 - Oil pump sprocket
 - Oil pump drive chain tensioner

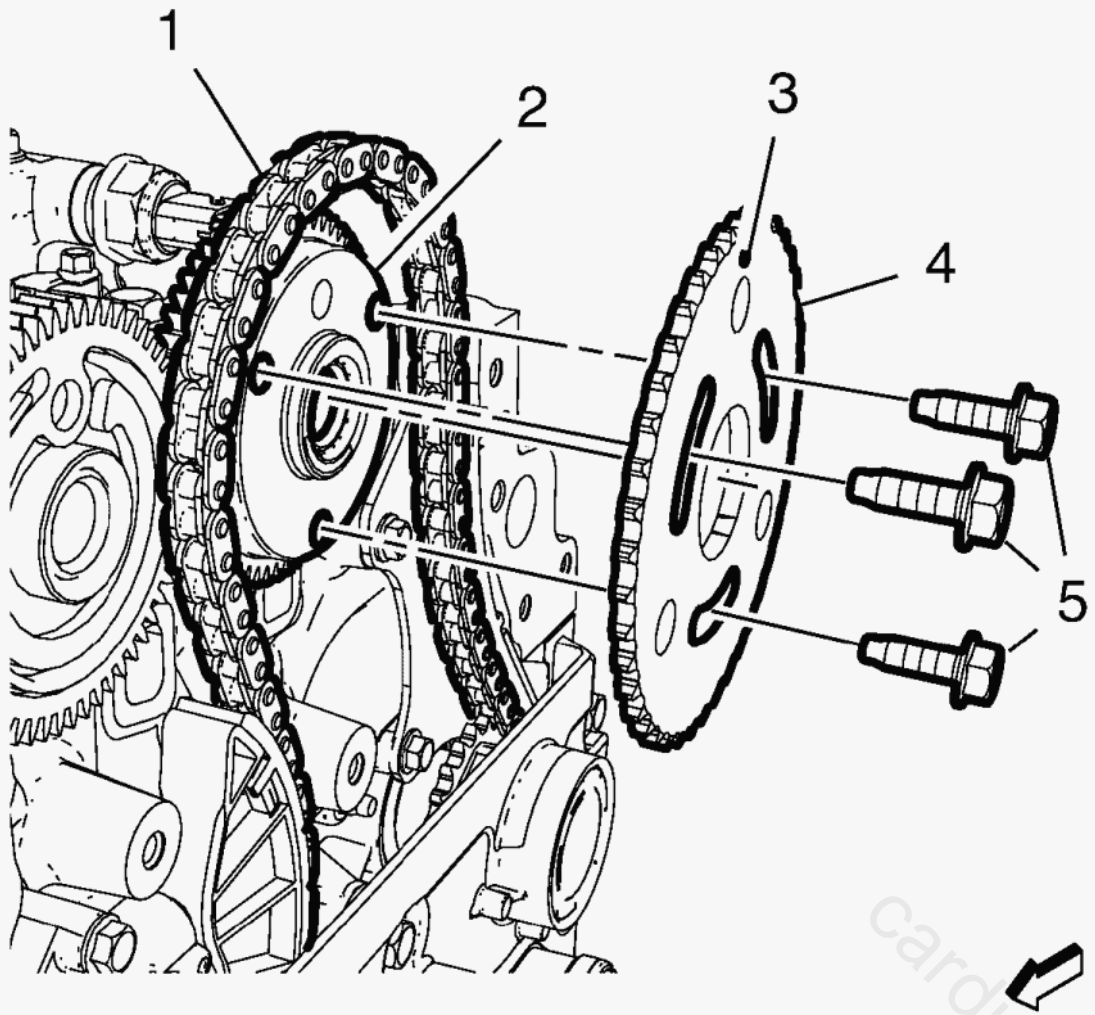


Fig. 137: Camshaft Sprocket, Bolts, Intake Camshaft And Timing Chain
Courtesy of GENERAL MOTORS COMPANY

2. Position the camshaft sprocket mark (3) at a 12 o'clock position and install the camshaft sprocket (4) to the camshaft timing chain (1).
3. Install the camshaft sprocket (3) to intake camshaft (2).

CAUTION: Refer to **Fastener Caution** .

4. Install the 3 camshaft sprocket bolts (5) and tighten to 25 N.m (18 lb ft), counterhold with a wrench at the camshaft hexagon.

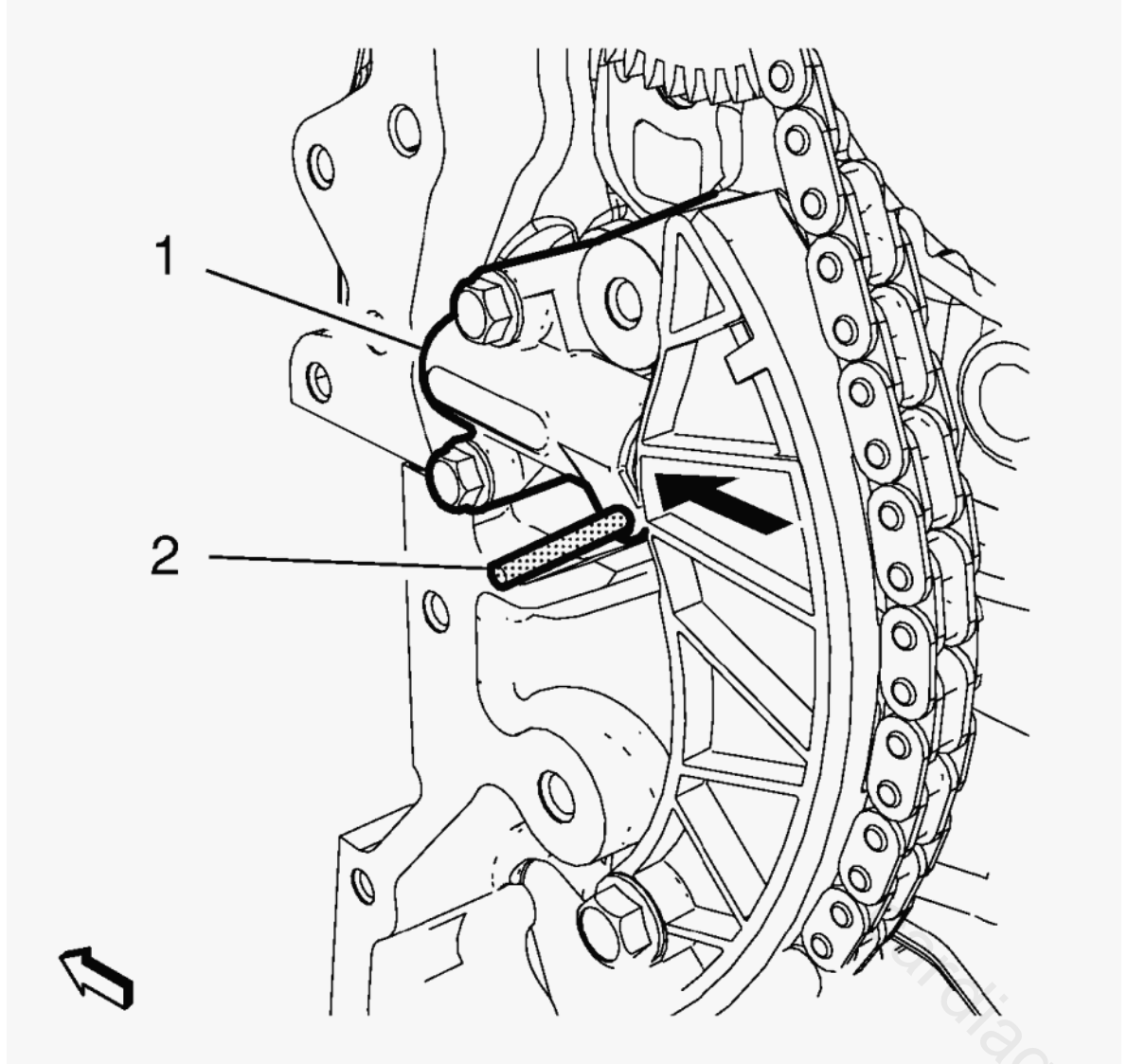


Fig. 138: Timing Chain Tensioner And Pin
Courtesy of GENERAL MOTORS COMPANY

5. Remove the EN-50513 pin (2).

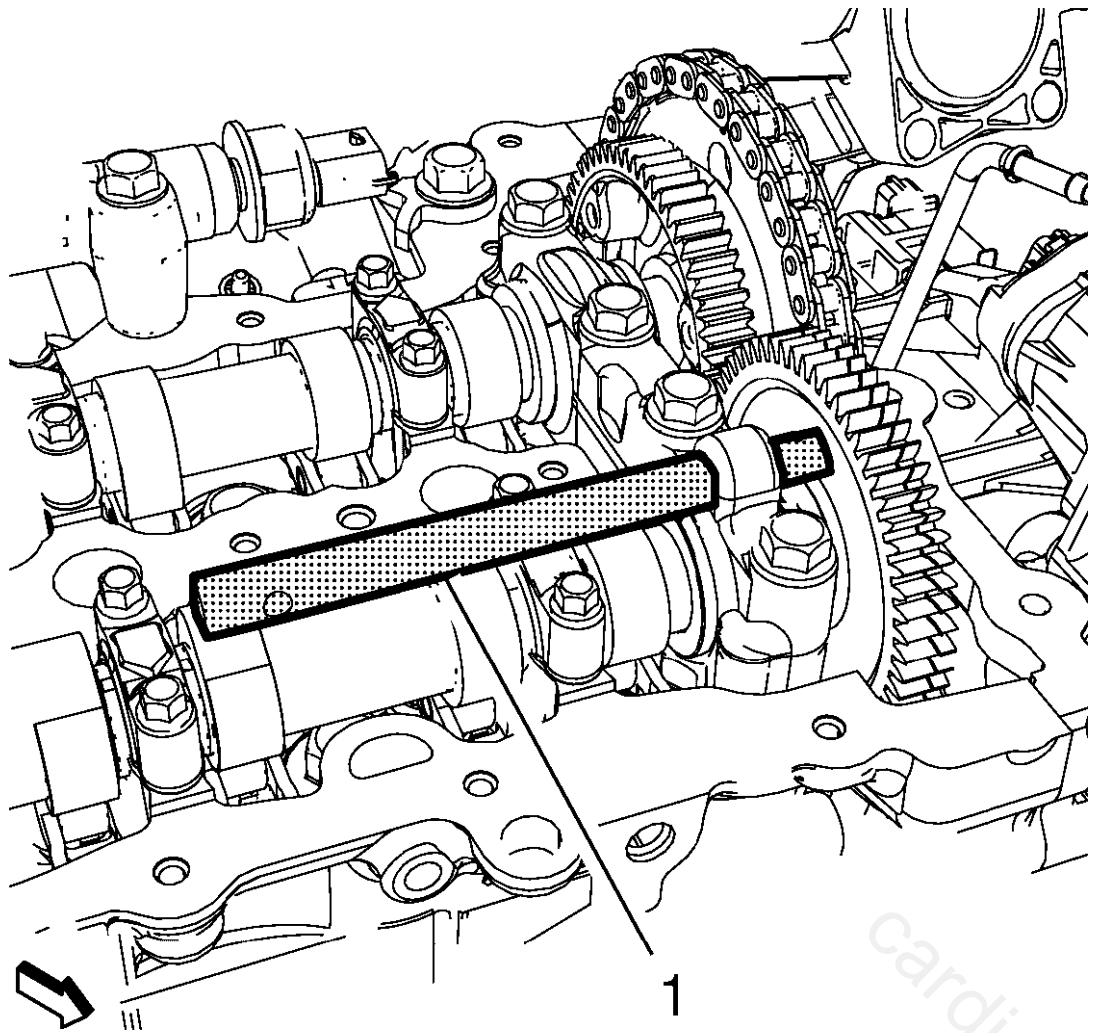


Fig. 139: Camshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

6. Remove the **EN-51143** fixing tool (1).
7. Raise the vehicle.

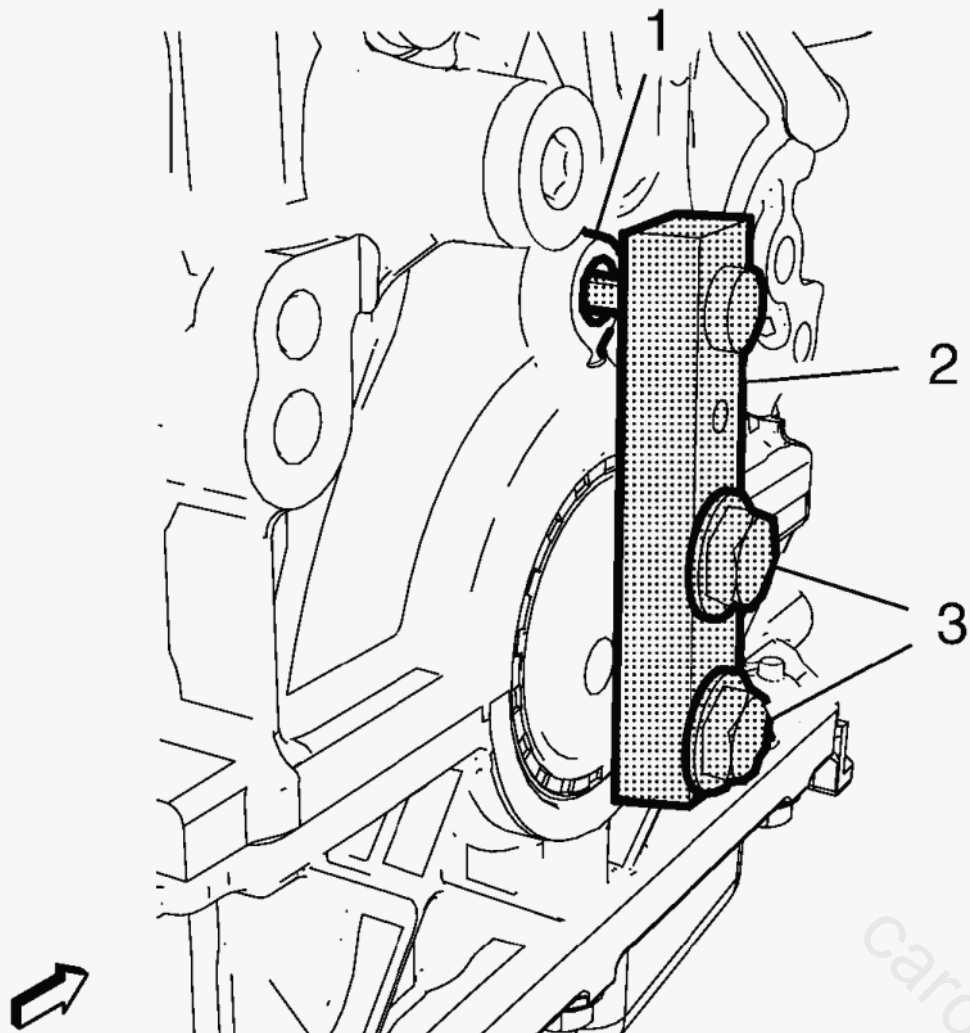


Fig. 140: Crankshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

8. Remove the 2 bolts (3).
9. Remove the **EN-51140** fixing tool (2).

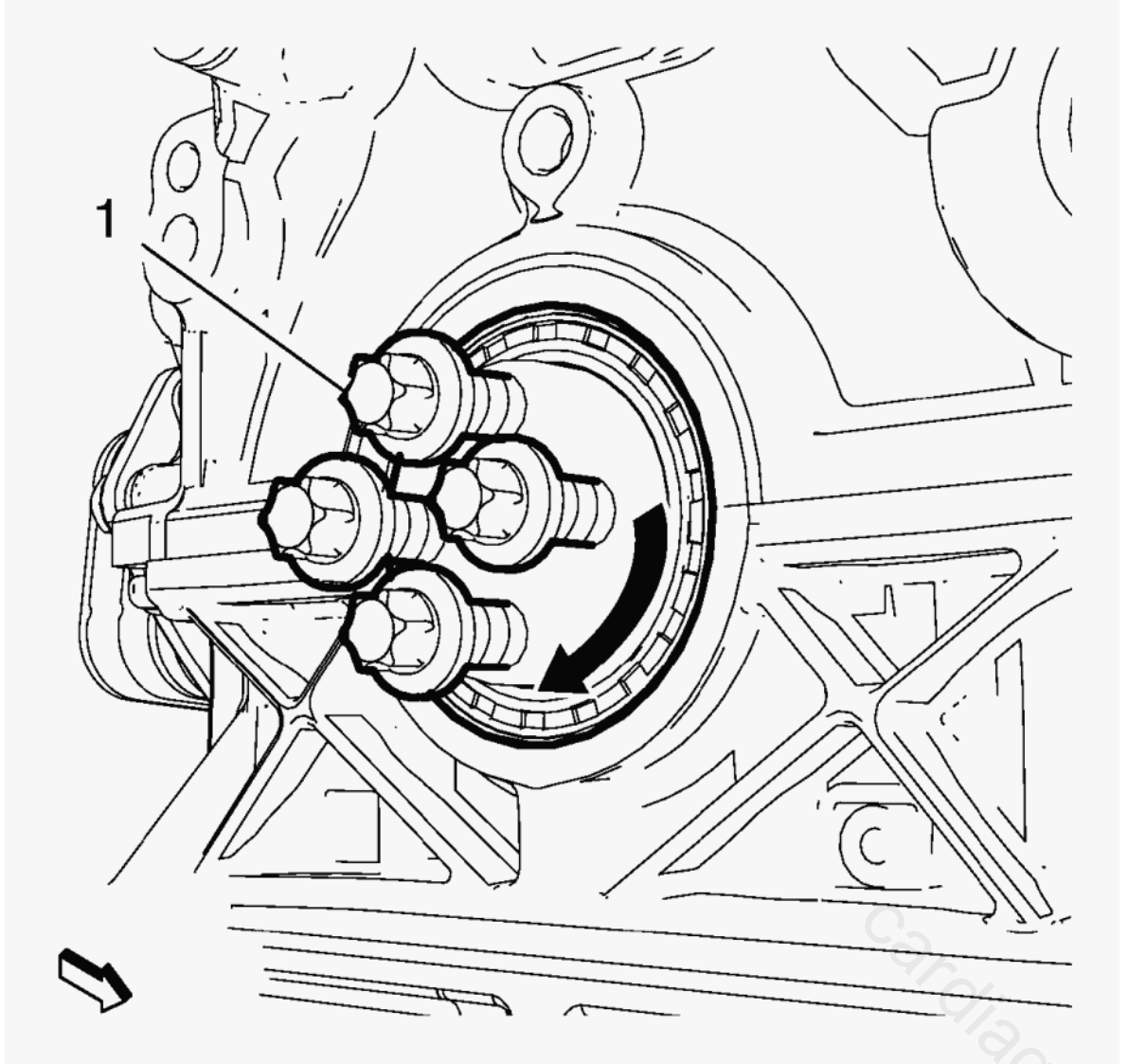


Fig. 141: Crankshaft Pulley Bolts

Courtesy of GENERAL MOTORS COMPANY

10. Install the 4 crankshaft pulley bolts (1).

Rotate the crankshaft 720 degrees in direction of arrow. Use a pry bar at the 4 crankshaft pulley bolts (1).

11. Remove the 4 crankshaft pulley bolts (1).
12. Check the camshaft timing. Refer to [Camshaft Timing Chain Inspection](#).
13. Install the crankshaft pulley. Refer to [Crankshaft Pulley Replacement](#).
14. Install the timing chain upper cover. Refer to [Timing Chain Upper Cover Replacement](#)

CAMSHAFT REPLACEMENT

Special Tools

- **EN-50509** Split Intake Camshaft Sprocket Fixing Tool
- **EN-51140** Crankshaft Fixing Tool
- **EN-51143** Camshaft Sprocket Fixing Tool
- **EN-51188** Timing Chain Camshaft Sprocket Fixing Tool

Equivalent regional tools: [Special Tools](#)

Removal Procedure

1. Disconnect the battery negative cable. Refer to [Battery Negative Cable Disconnection and Connection \(KL9\)](#).
2. Remove Throttle Body Assembly. Refer to [Throttle Body Assembly Replacement](#)
3. Remove Camshaft Housing. Refer to [Camshaft Housing Replacement](#)

4. Remove Crankshaft Pulley. Refer to [Crankshaft Pulley Replacement](#)
5. Lower the vehicle. Refer to [Lifting and Jacking the Vehicle](#)

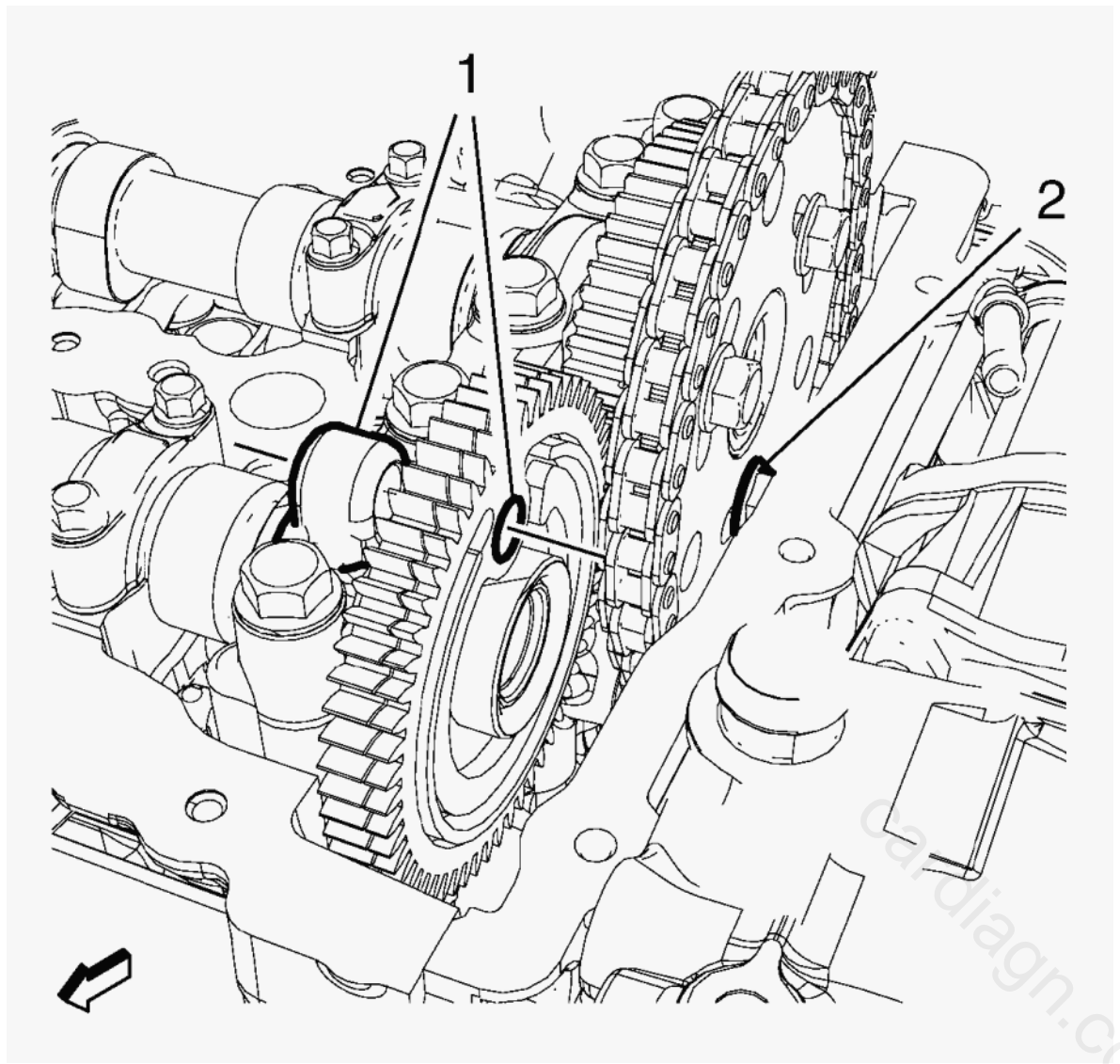


Fig. 142: Aligning Bores

Courtesy of GENERAL MOTORS COMPANY

NOTE: To locate the correct camshaft sprocket bolt (2) check the TDC position.

6. Check if the bores (1) are aligned.
7. Raise the vehicle.

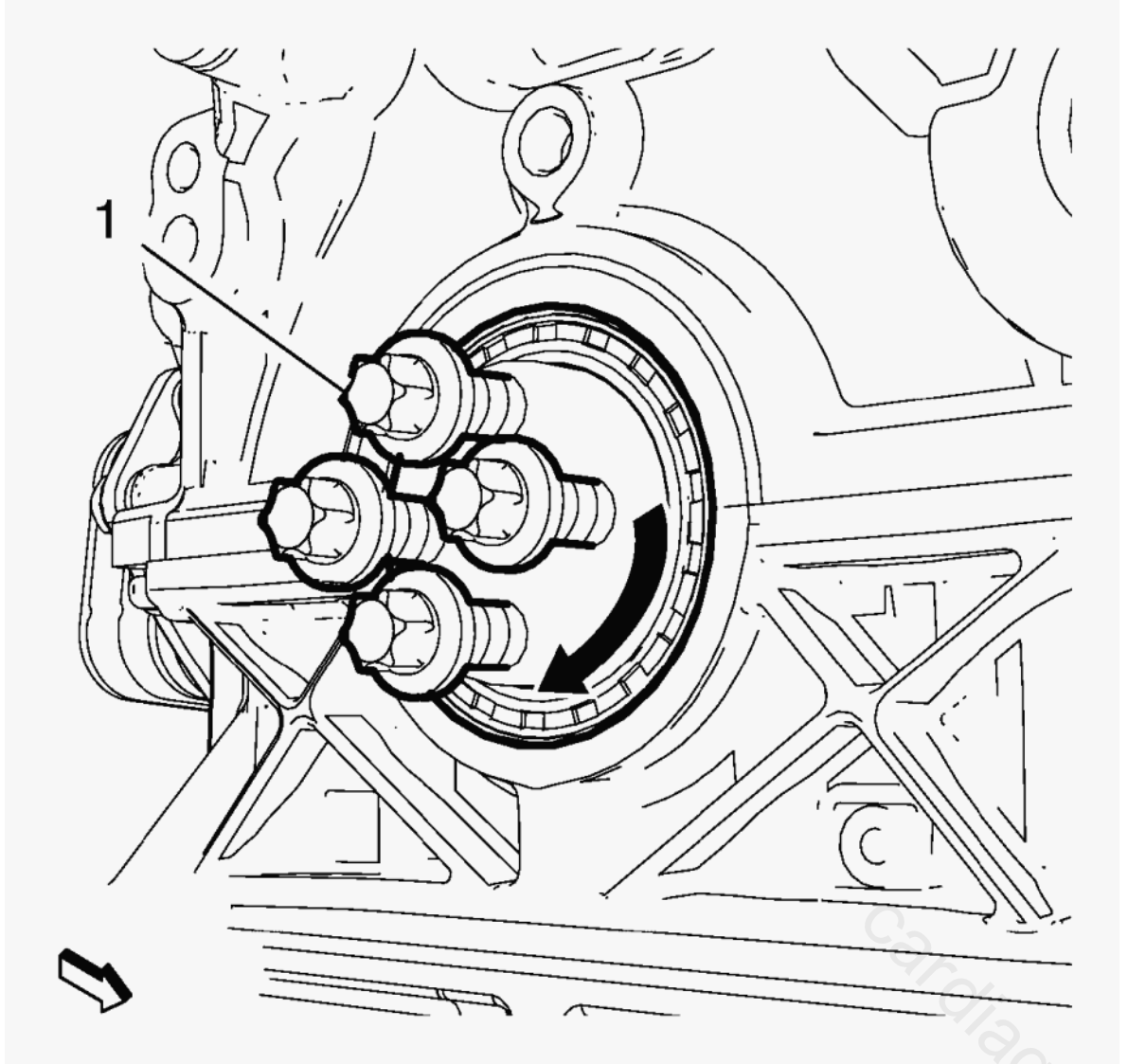


Fig. 143: Crankshaft Pulley Bolts

Courtesy of GENERAL MOTORS COMPANY

8. Install the 4 crankshaft pulley bolts (1).
9. Rotate the crankshaft 360 degrees in direction of arrow. Use a pry bar.
10. Lower the vehicle.

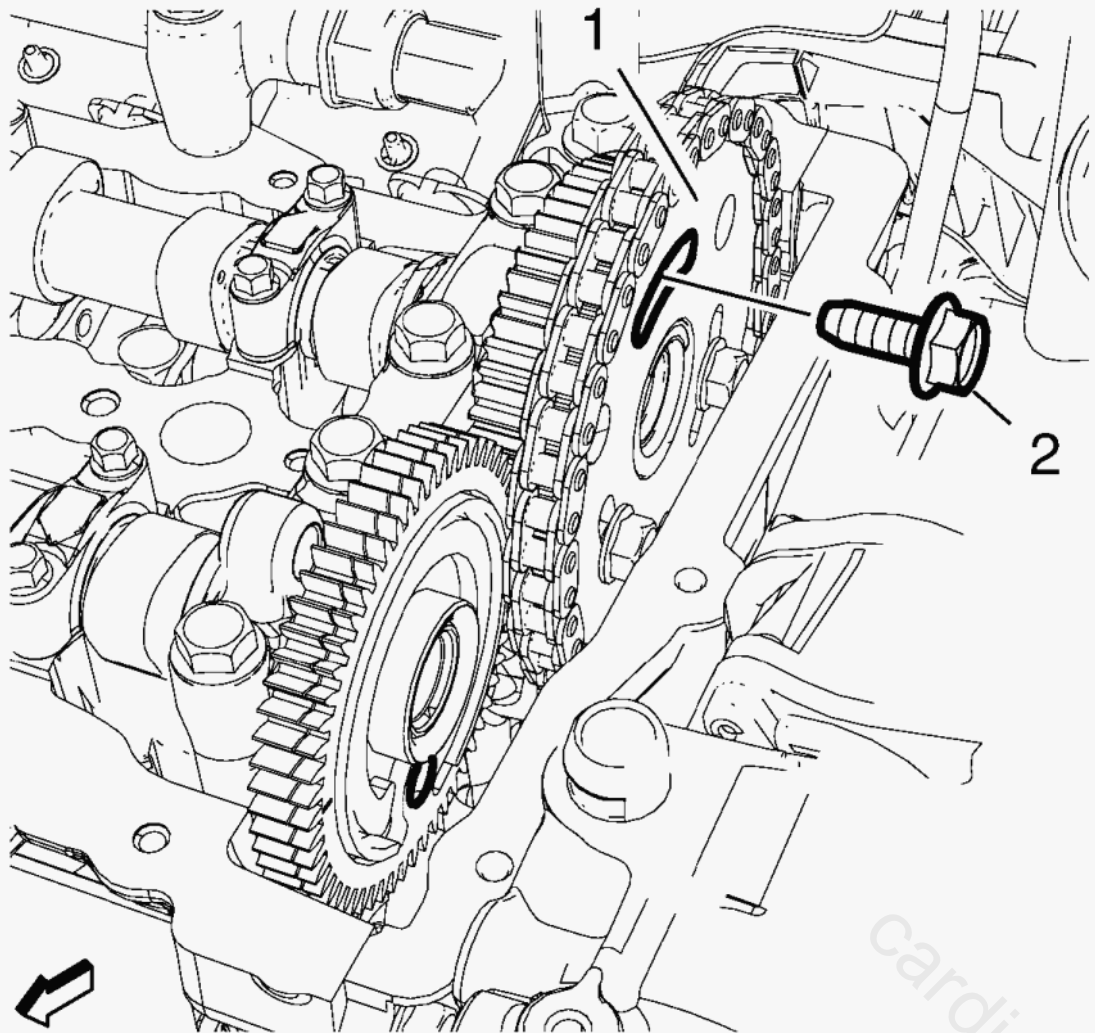


Fig. 144: Camshaft Sprocket And Bolt

Courtesy of GENERAL MOTORS COMPANY

NOTE: Cover the timing case with a lint-free cloth.

11. Remove the camshaft sprocket bolt (2) from the intake camshaft sprocket (1). Counterhold with a wrench at the camshaft hexagon.
12. Raise the vehicle.

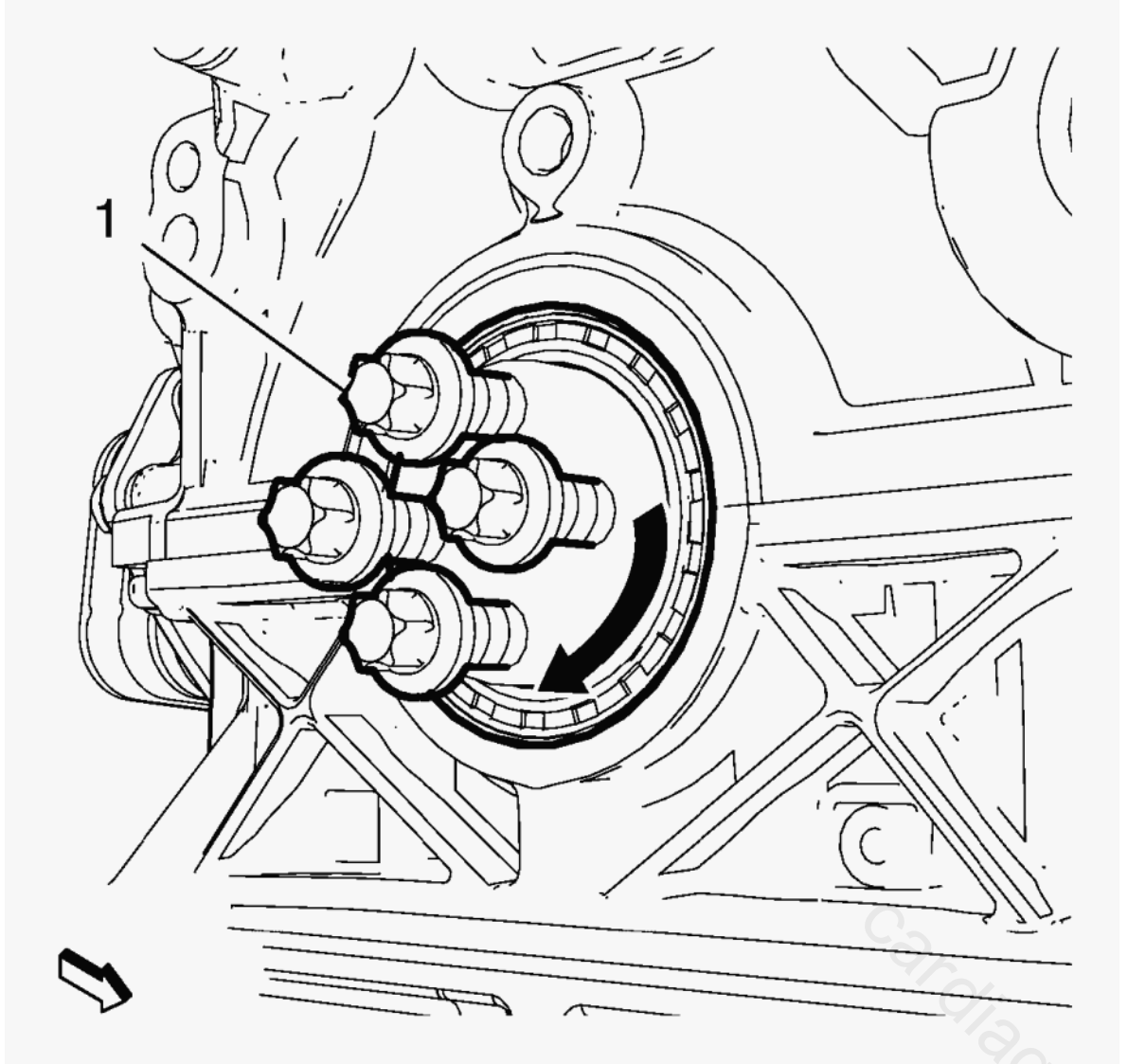


Fig. 145: Crankshaft Pulley Bolts

Courtesy of GENERAL MOTORS COMPANY

13. Rotate the crankshaft 360 degrees in direction of arrow. Use a pry bar at the 4 crankshaft pulley bolts (1).
14. Remove the 4 crankshaft pulley bolts (1).

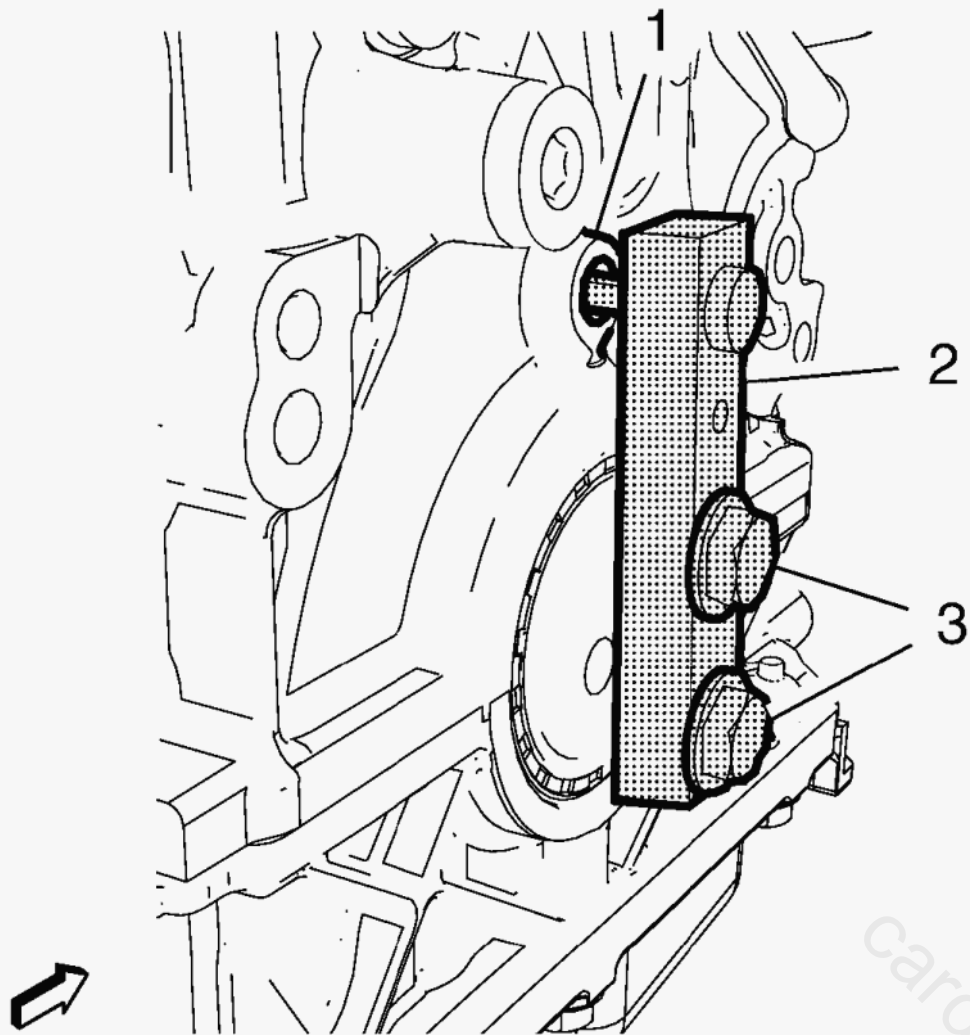


Fig. 146: Crankshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

15. Install the **EN-51140** fixing tool (2).
16. Install the fixing pin into the engine block bore (1) and tighten the 2 bolts (3).
17. Lower the vehicle.

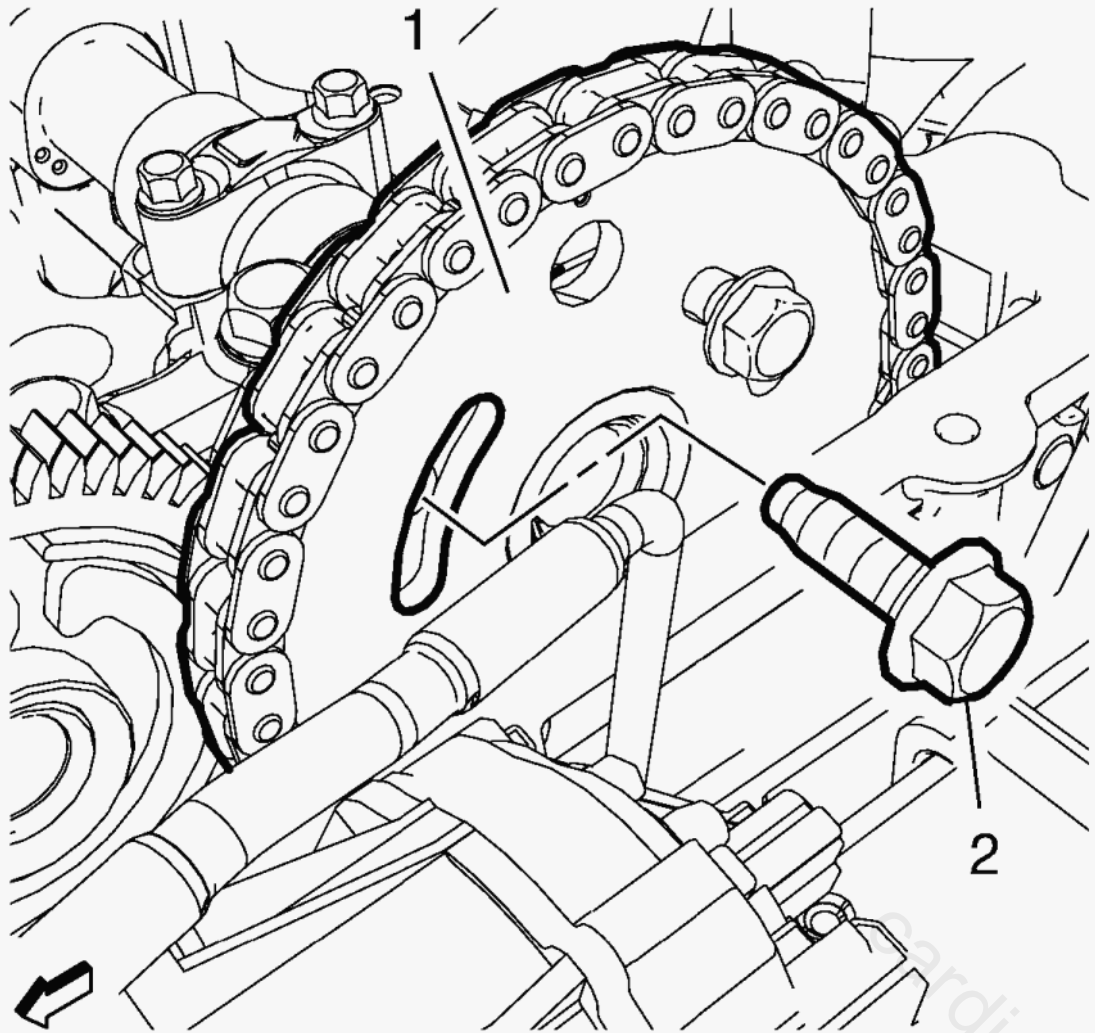


Fig. 147: Camshaft Sprocket And Bolt

Courtesy of GENERAL MOTORS COMPANY

NOTE: Cover the timing case with a lint-free cloth.

18. Remove the camshaft sprocket bolt (2) from the camshaft sprocket (1). Counterhold with a wrench at the camshaft hexagon.

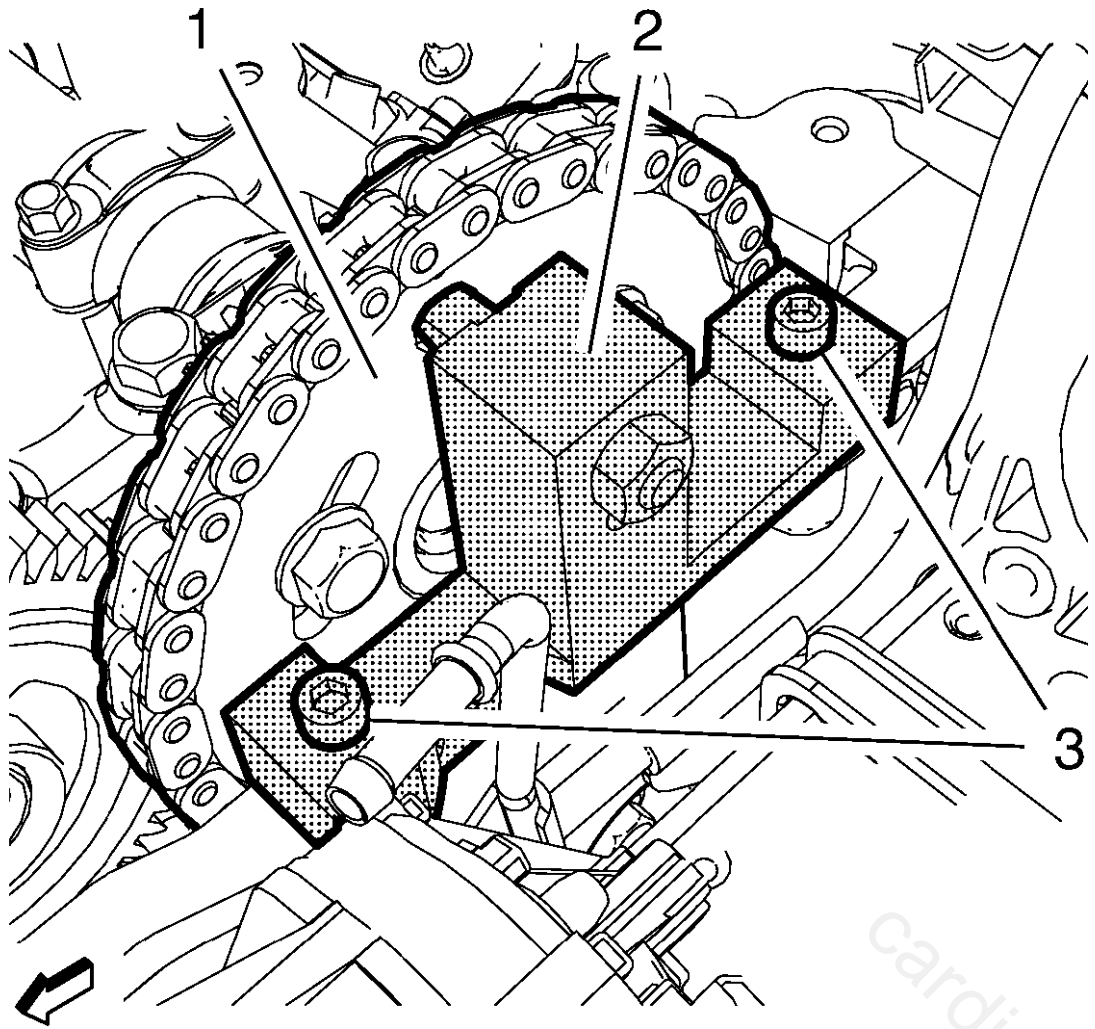


Fig. 148: Timing Chain Camshaft Sprocket Fixing Tool
Courtesy of GENERAL MOTORS COMPANY

19. Install the **EN-51188** fixing tool (2) to fix the camshaft sprocket (1).
20. Install the 2 bolts (3).

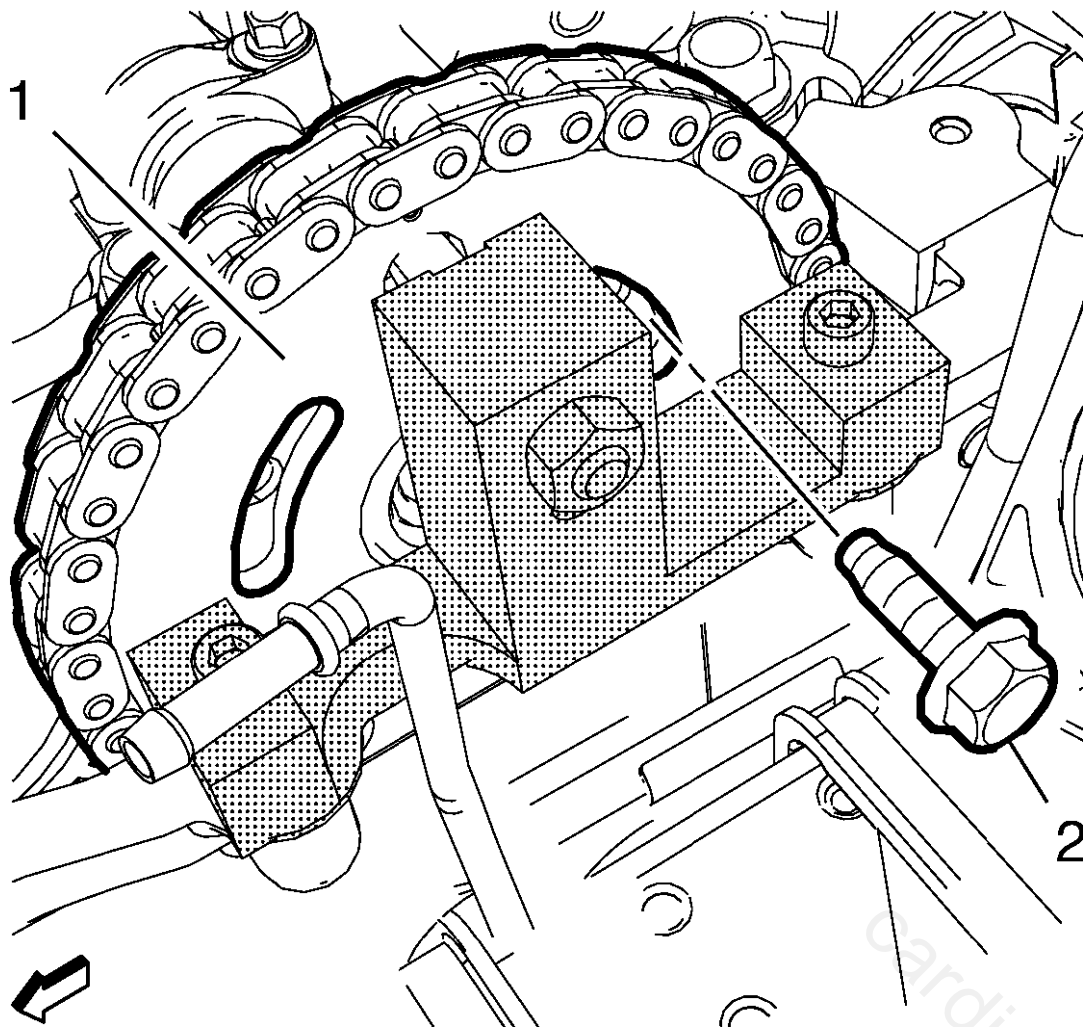


Fig. 149: Camshaft Sprocket And Bolts

Courtesy of GENERAL MOTORS COMPANY

NOTE: Cover the timing case with a lint-free cloth.

21. Remove the camshaft sprocket bolt (2) from the camshaft sprocket (1). Counterhold with a wrench at the camshaft hexagon.

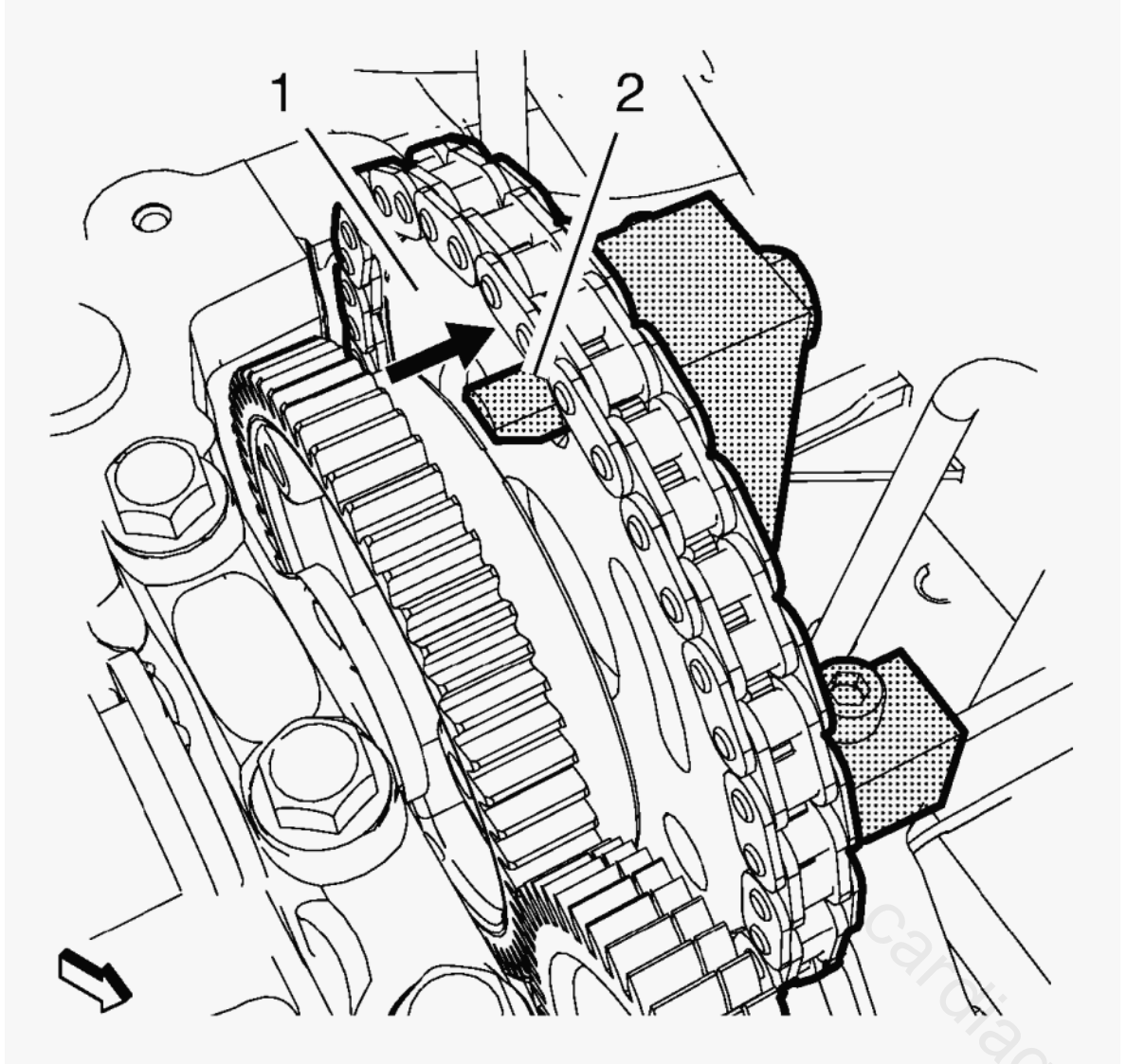


Fig. 150: Camshaft Sprocket Over Pin Of Timing Chain Camshaft Sprocket Fixing Tool
Courtesy of GENERAL MOTORS COMPANY

NOTE: Do not move the camshaft sprocket onto the EN-51188 fixing tool if the intake camshaft was removed.

22. Slide the camshaft sprocket (1) over the pin (2) of the **EN-51188** fixing tool in arrow direction.

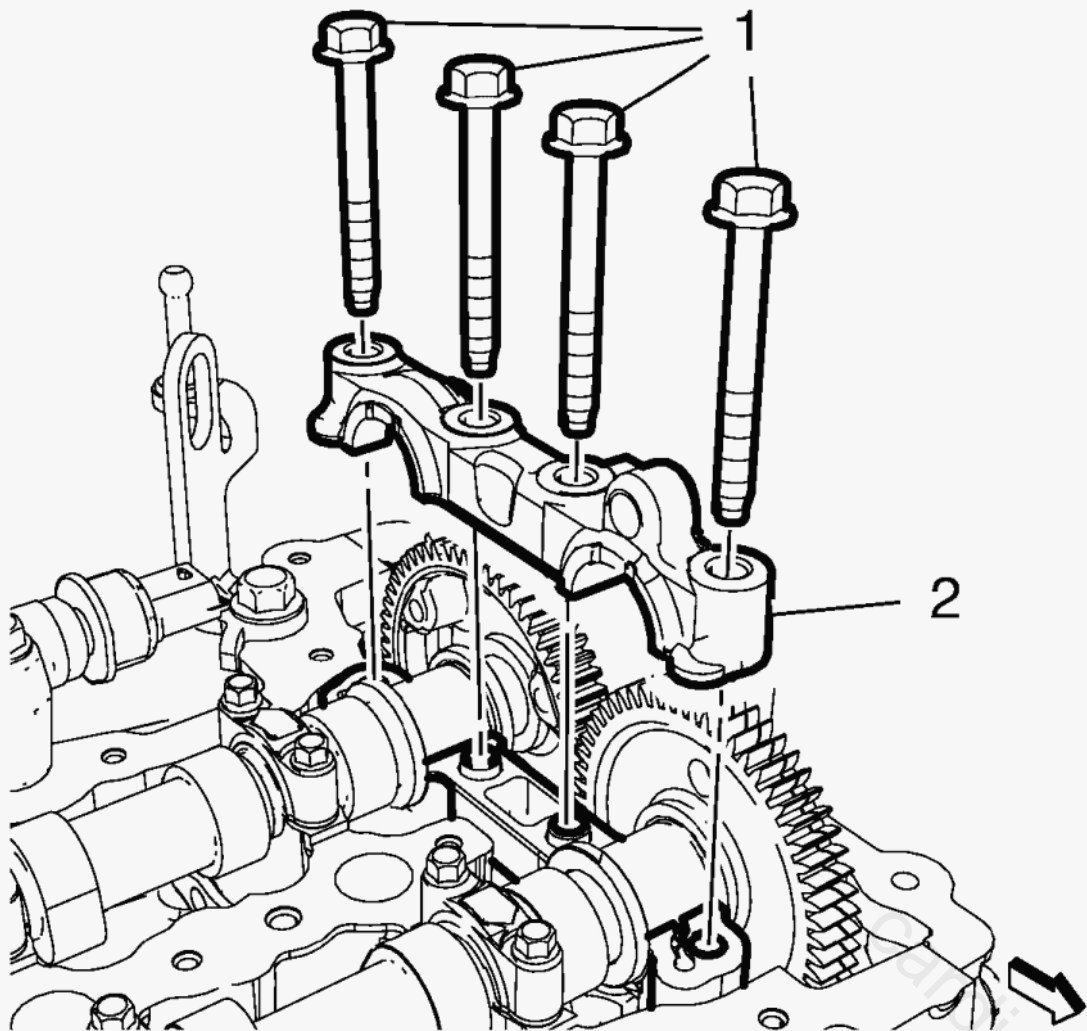


Fig. 151: Camshaft Bearing Rear Cap And Bolts
Courtesy of GENERAL MOTORS COMPANY

23. Remove the 4 camshaft bearing rear cap bolts (1).
24. Remove the camshaft bearing rear cap (2).

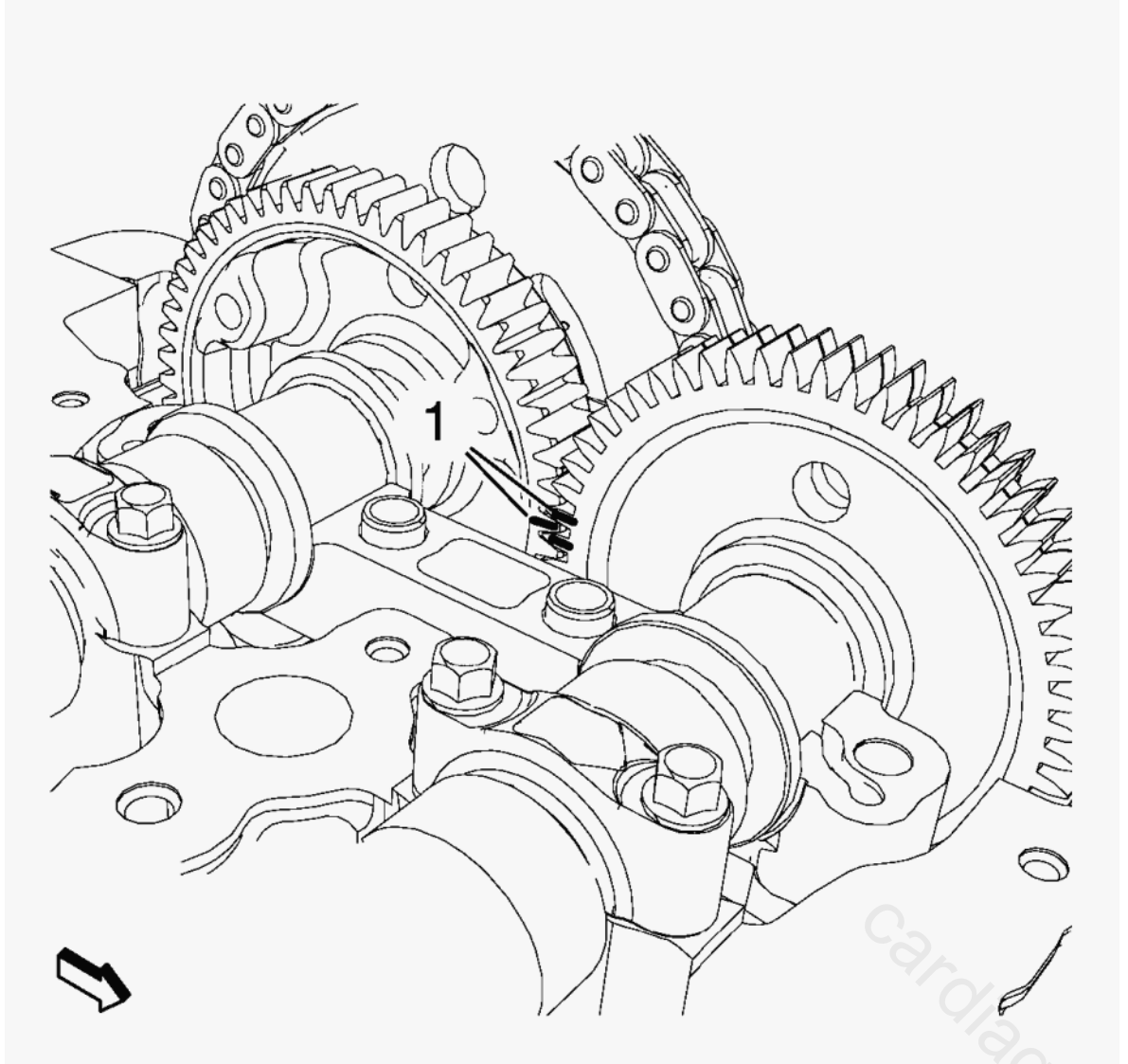


Fig. 152: Marking Exhaust Camshaft Sprocket And Intake Camshaft Sprocket With Paint Marks
Courtesy of GENERAL MOTORS COMPANY

NOTE: Mark the camshaft sprockets if the camshafts will be reinstalled.

25. Mark the exhaust camshaft sprocket and intake camshaft sprocket with paint marks (1).

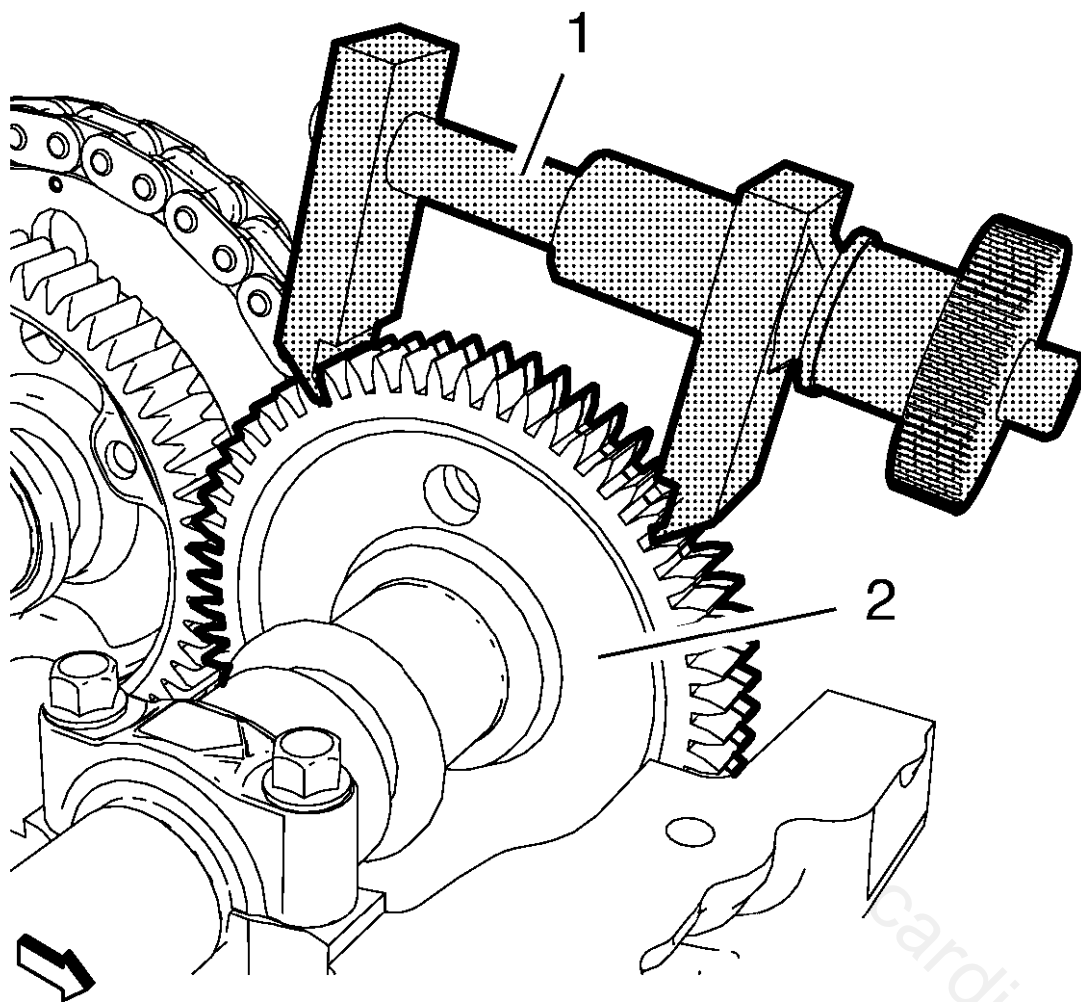


Fig. 153: Split Intake Camshaft Sprocket Fixing Tool
Courtesy of GENERAL MOTORS COMPANY

26. Install the EN-50509 fixing tool (1) to the exhaust camshaft sprocket (2).

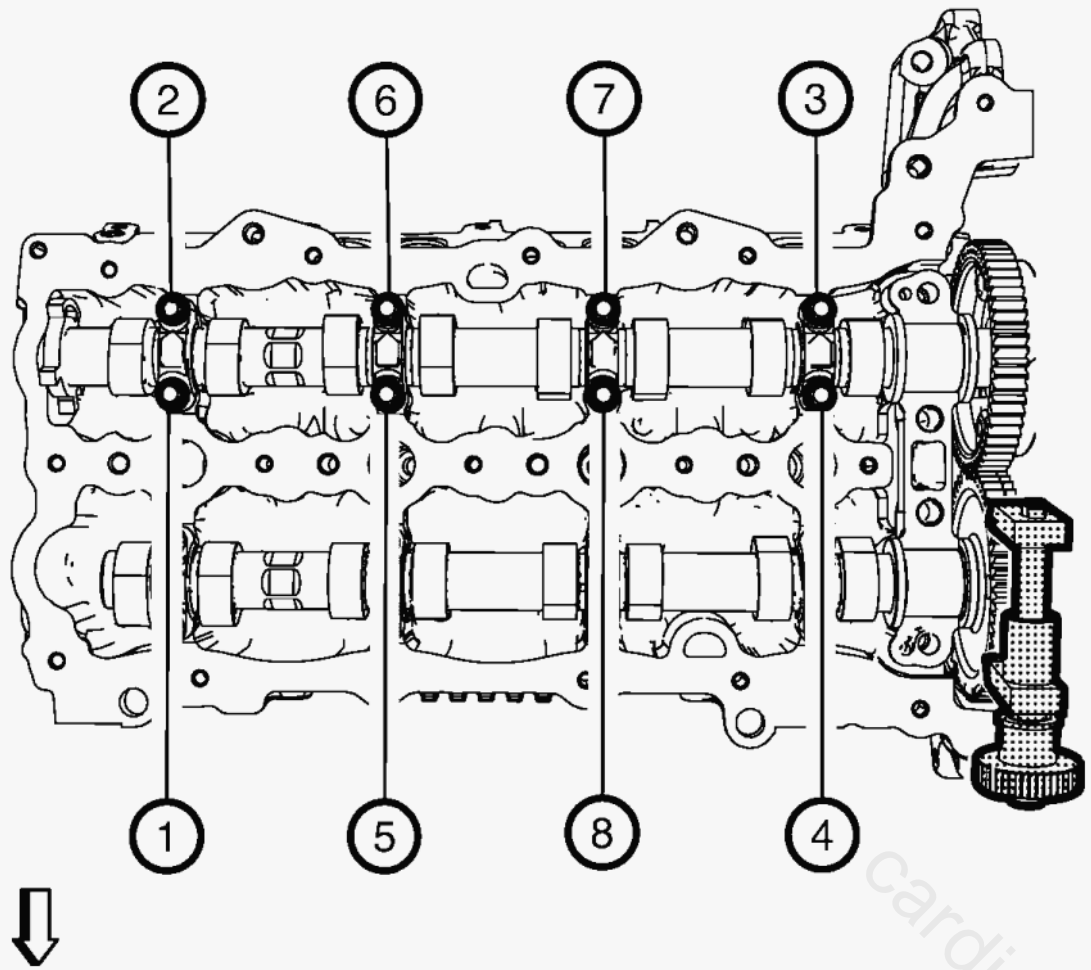


Fig. 154: Intake Camshaft Bearing Cap Bolt Loosening Sequence
Courtesy of GENERAL MOTORS COMPANY

27. Loosen the 8 intake camshaft bearing cap bolts in sequence as shown.

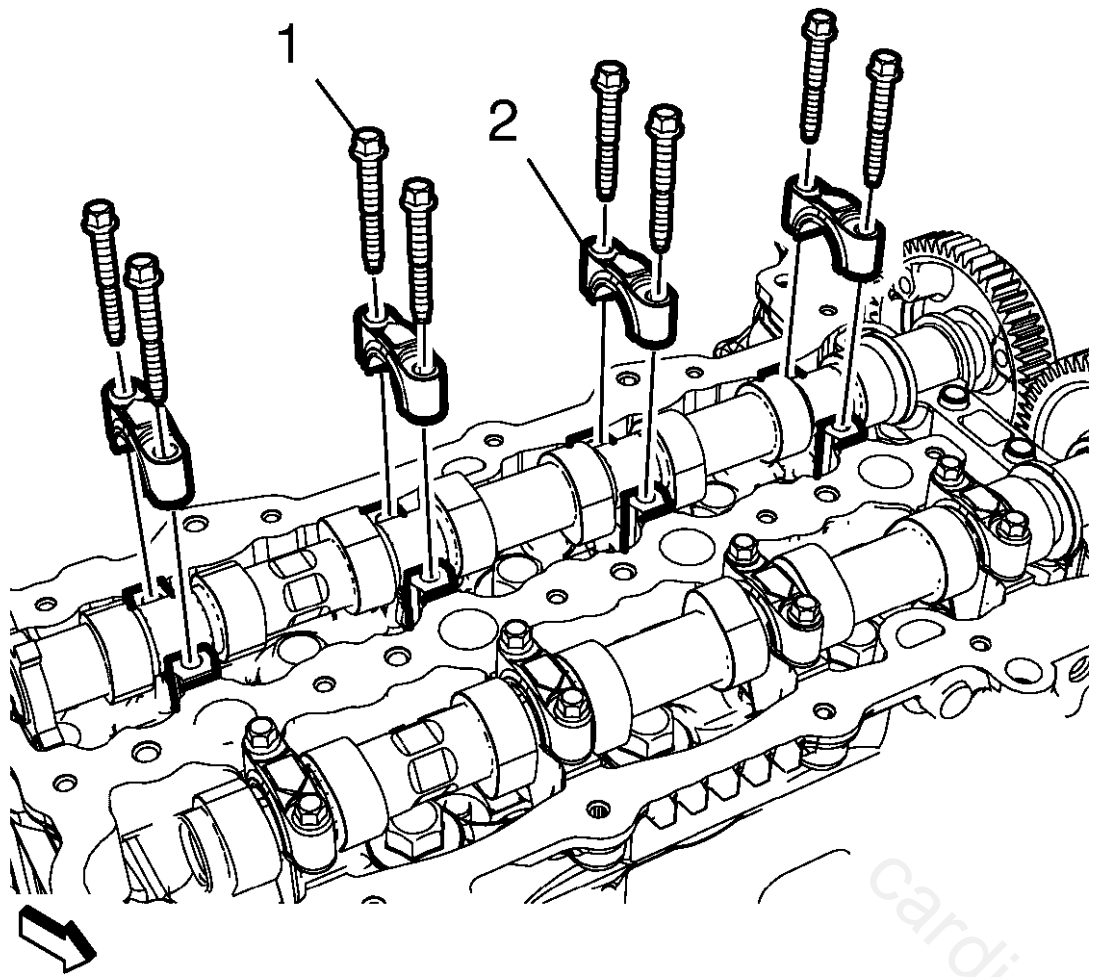


Fig. 155: Intake Camshaft Bearing Caps And Bolts
Courtesy of GENERAL MOTORS COMPANY

28. Remove the 8 intake camshaft bearing cap bolts (1).
29. Remove the 4 intake camshaft bearing caps (2) and lay aside in the order they were removed.

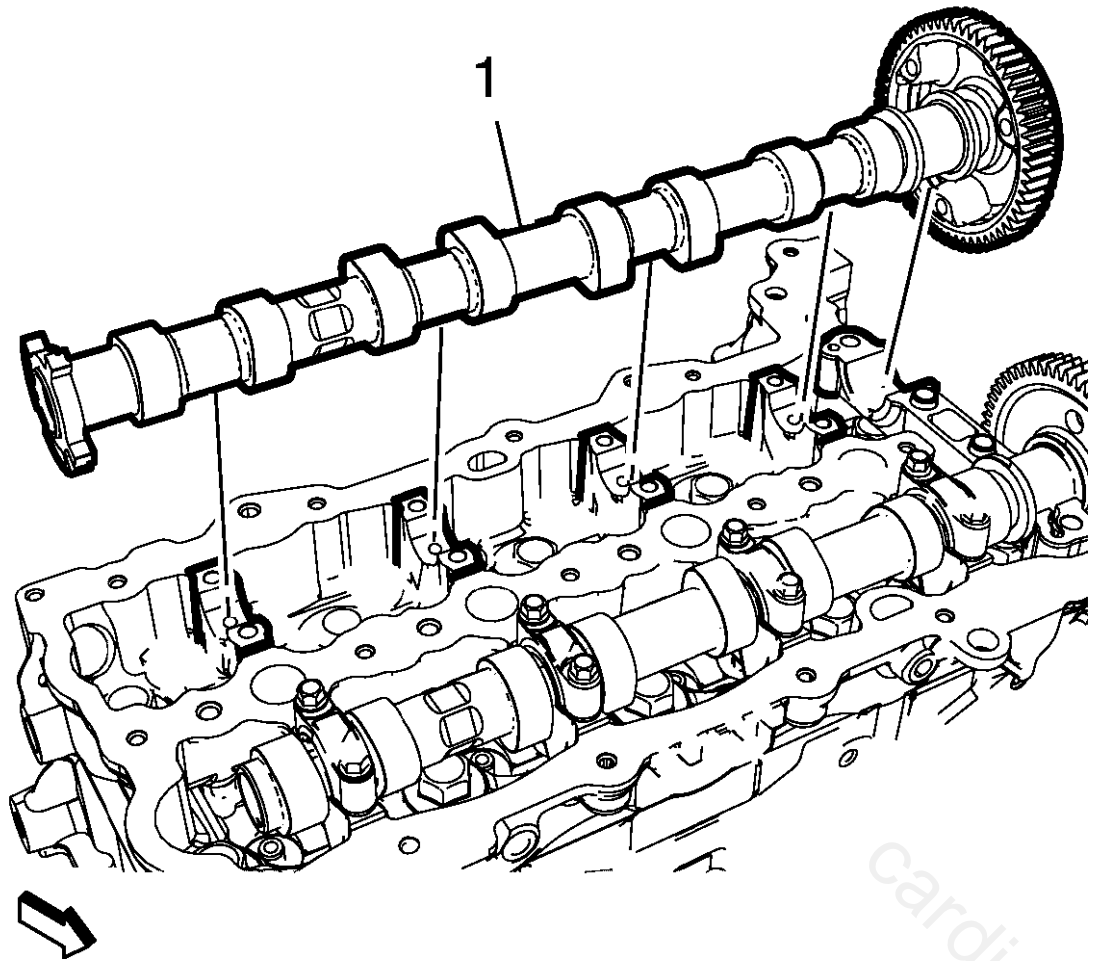


Fig. 156: Intake Camshaft

Courtesy of GENERAL MOTORS COMPANY

30. Remove the intake camshaft (1).

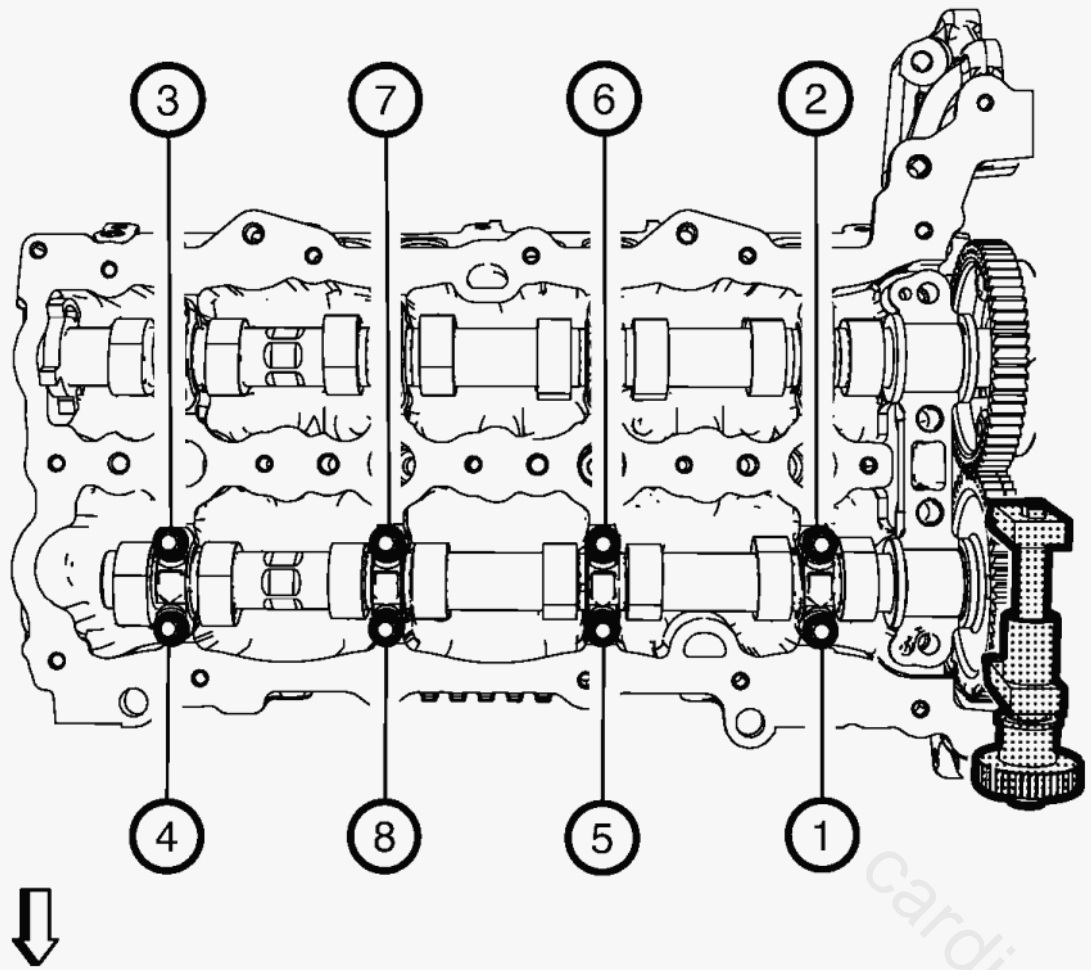


Fig. 157: Exhaust Camshaft Bearing Cap Bolt Loosening Sequence
Courtesy of GENERAL MOTORS COMPANY

31. Loosen the 8 exhaust camshaft bearing cap bolts in sequence as shown.

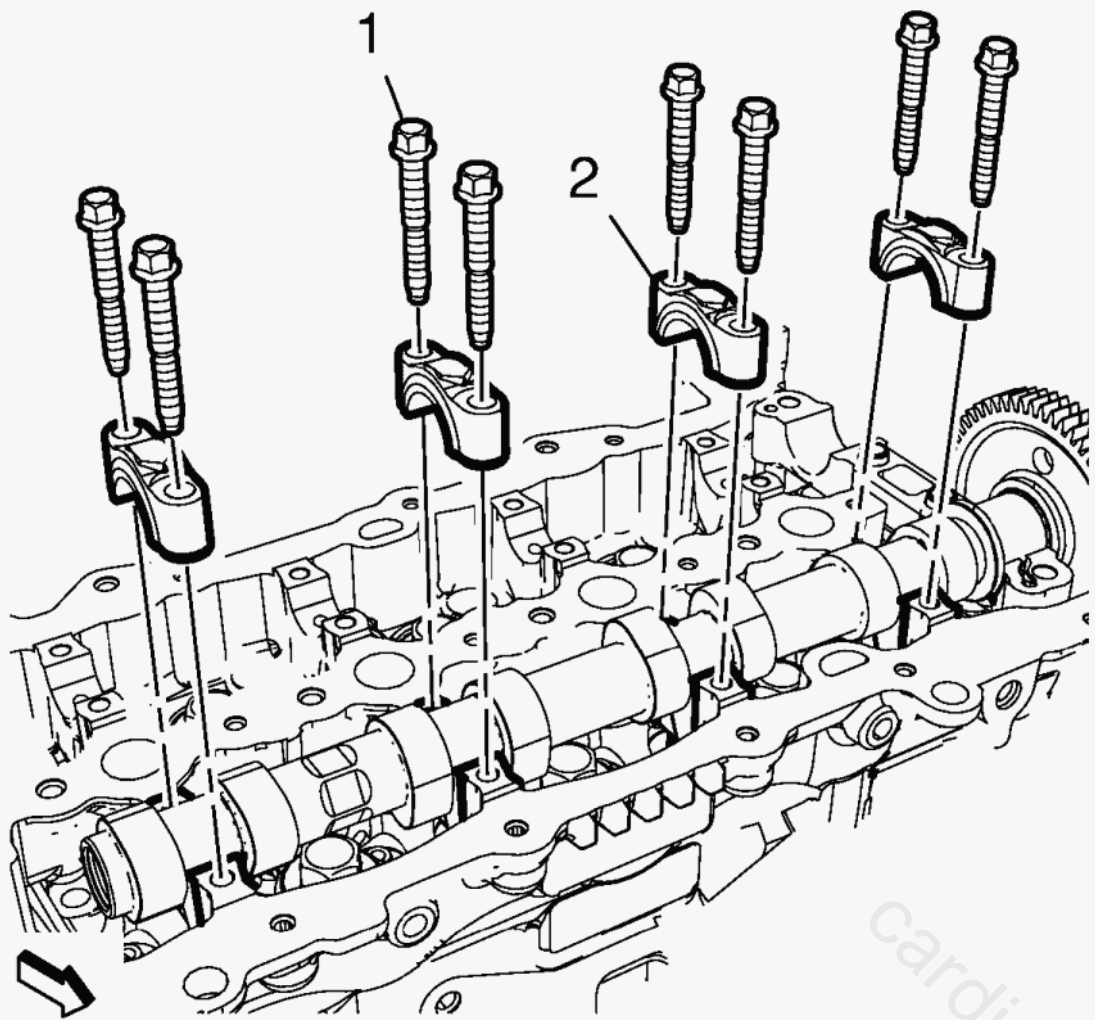


Fig. 158: Exhaust Camshaft Bearing Caps And Bolts
Courtesy of GENERAL MOTORS COMPANY

32. Remove the 8 exhaust camshaft bearing cap bolts (1).
33. Remove the 4 exhaust camshaft bearing caps (2) and lay aside in the order they were removed.

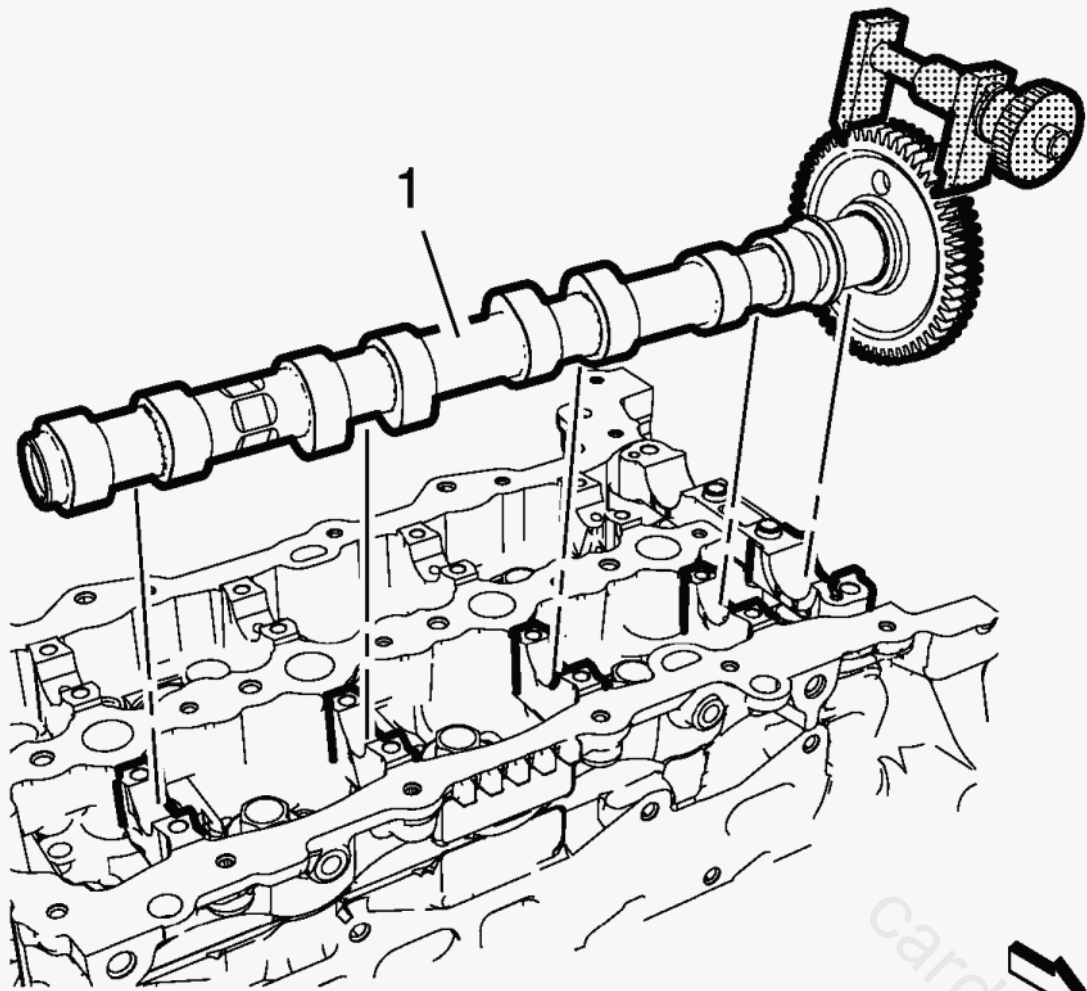


Fig. 159: Exhaust Camshaft

Courtesy of GENERAL MOTORS COMPANY

NOTE: If the exhaust camshaft will be reinstalled, do not remove the EN-50509 fixing tool.

34. Remove the exhaust camshaft (1).

Installation Procedure

NOTE: Before installing the camshaft, check the components of the timing chain system for damage and wear.

1. Check the components of the timing chain system for damage and wear:
 - Timing chain guides with plastic attachment
 - Timing chain tensioner and timing chain tensioner shoe with plastic attachment
 - Timing chain and all timing chain sprockets
 - Oil pump sprocket
 - Oil pump drive chain tensioner

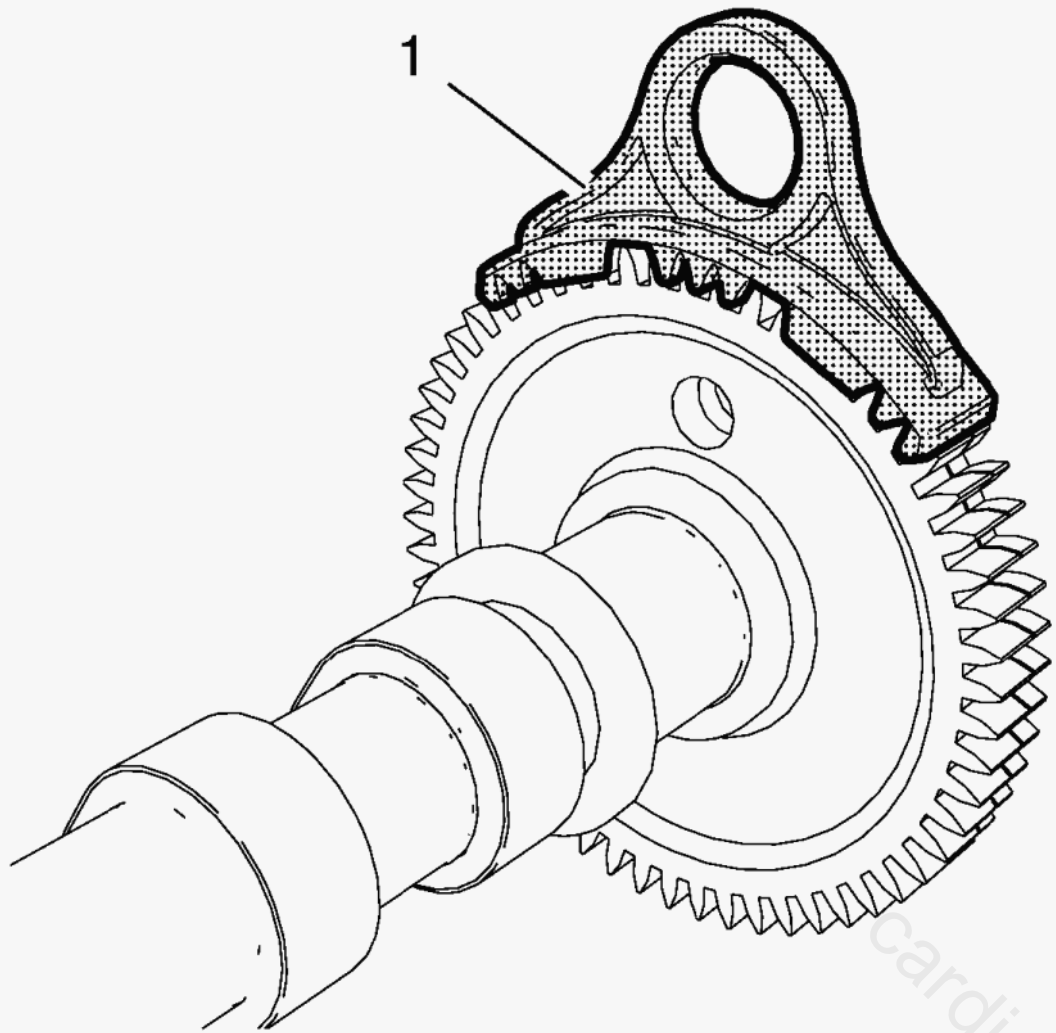


Fig. 160: Transport Lock

Courtesy of GENERAL MOTORS COMPANY

2. When installing a NEW exhaust camshaft do not remove the transport lock (1) before the exhaust camshaft and intake camshaft are installed.

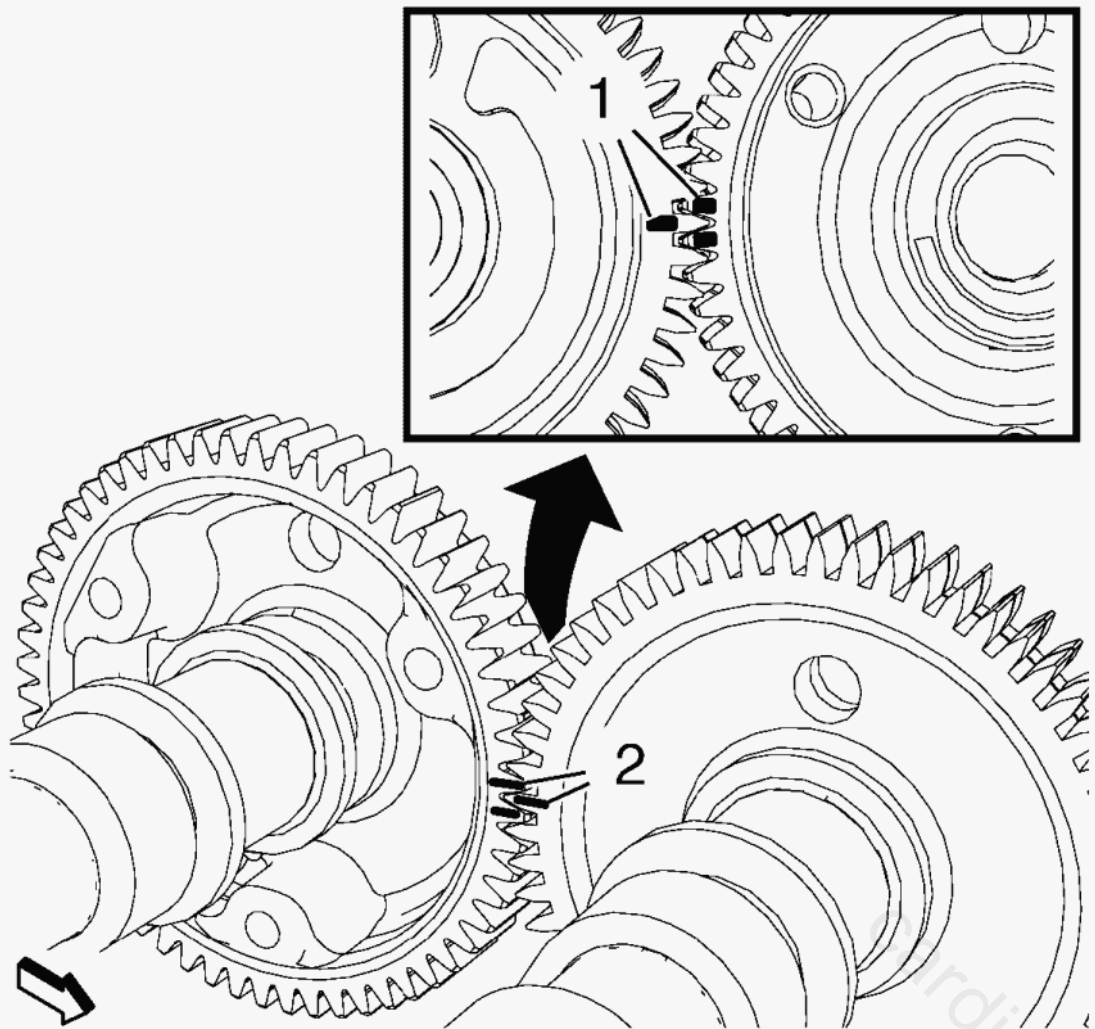


Fig. 161: Marking Camshaft Sprockets With Paint Marks By Transmitting Front Marks
Courtesy of GENERAL MOTORS COMPANY

NOTE: If new camshafts are used, transfer the front marks (1) to the back.

3. Mark the exhaust camshaft sprocket and intake camshaft sprocket with paint marks (2), by transferring the front marks (1).

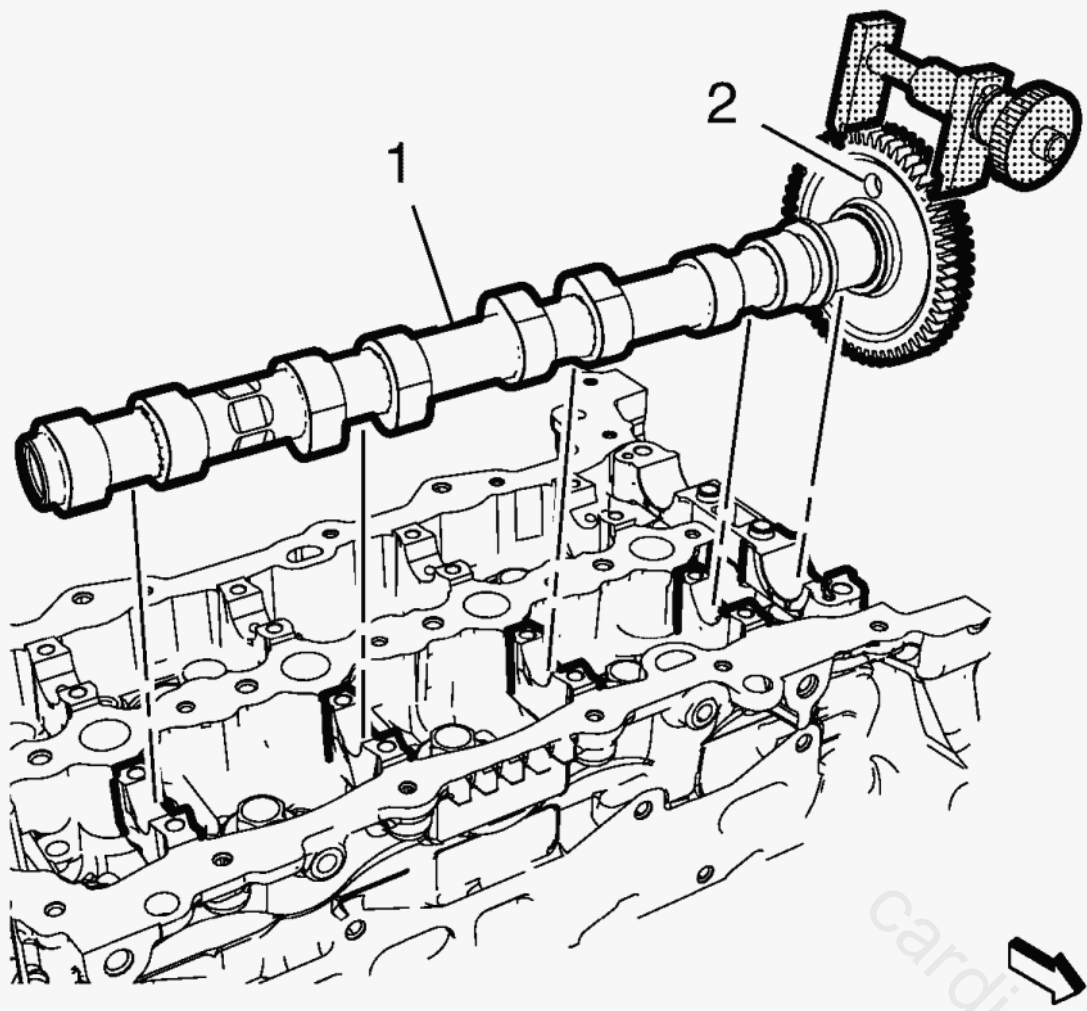


Fig. 162: Exhaust Camshaft With Bore Of Camshaft Sprocket Upwards
Courtesy of GENERAL MOTORS COMPANY

4. Coat all bearing surfaces with engine oil.
5. Install the exhaust camshaft (1). Ensure the bore (2) of the camshaft sprocket is positioned upwards.

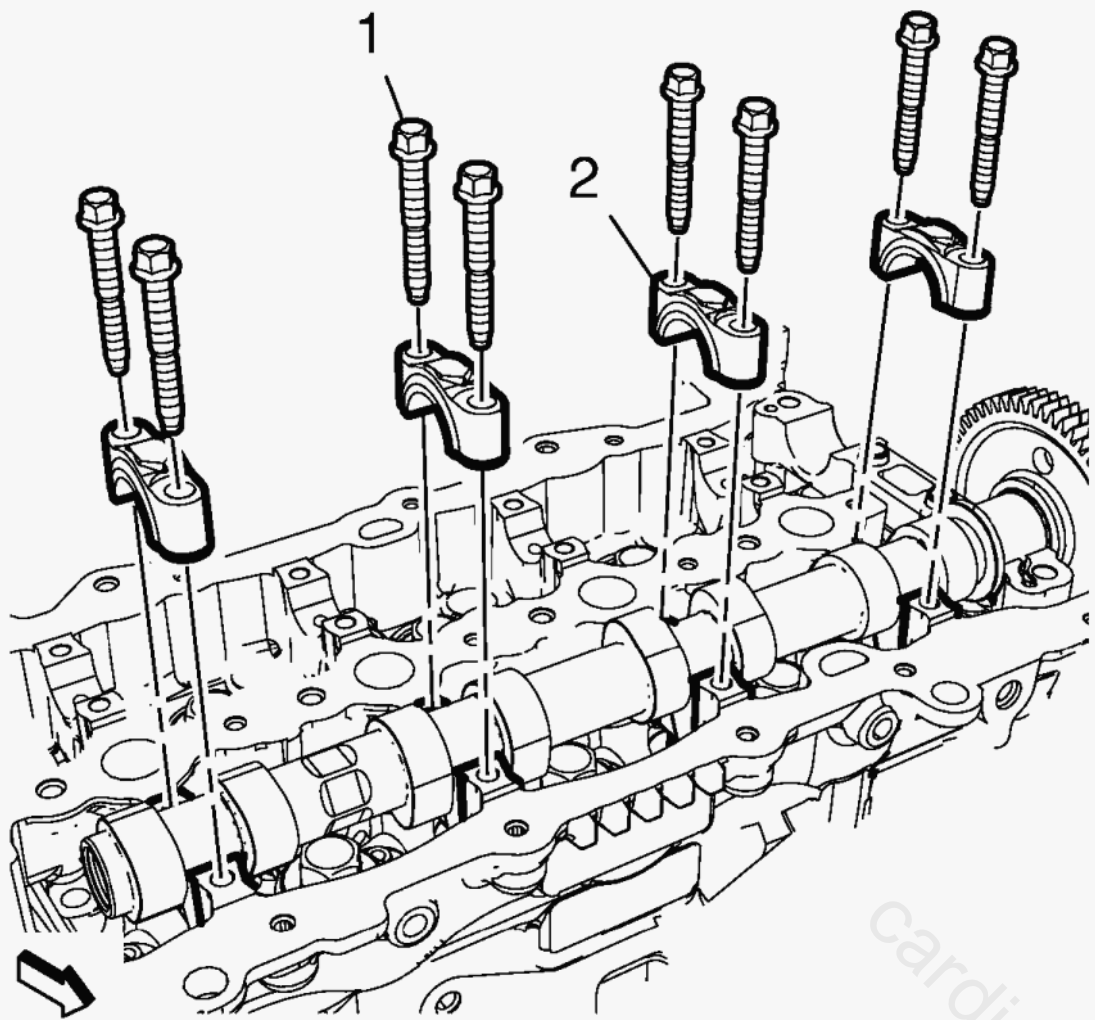


Fig. 163: Exhaust Camshaft Bearing Caps And Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: Note the arrows marks on the camshaft bearing caps, which show on the outside of the cylinder head.

6. Install the exhaust camshaft bearing caps (2) in the order as they were removed.
7. Install the exhaust camshaft bearing cap bolts (1).

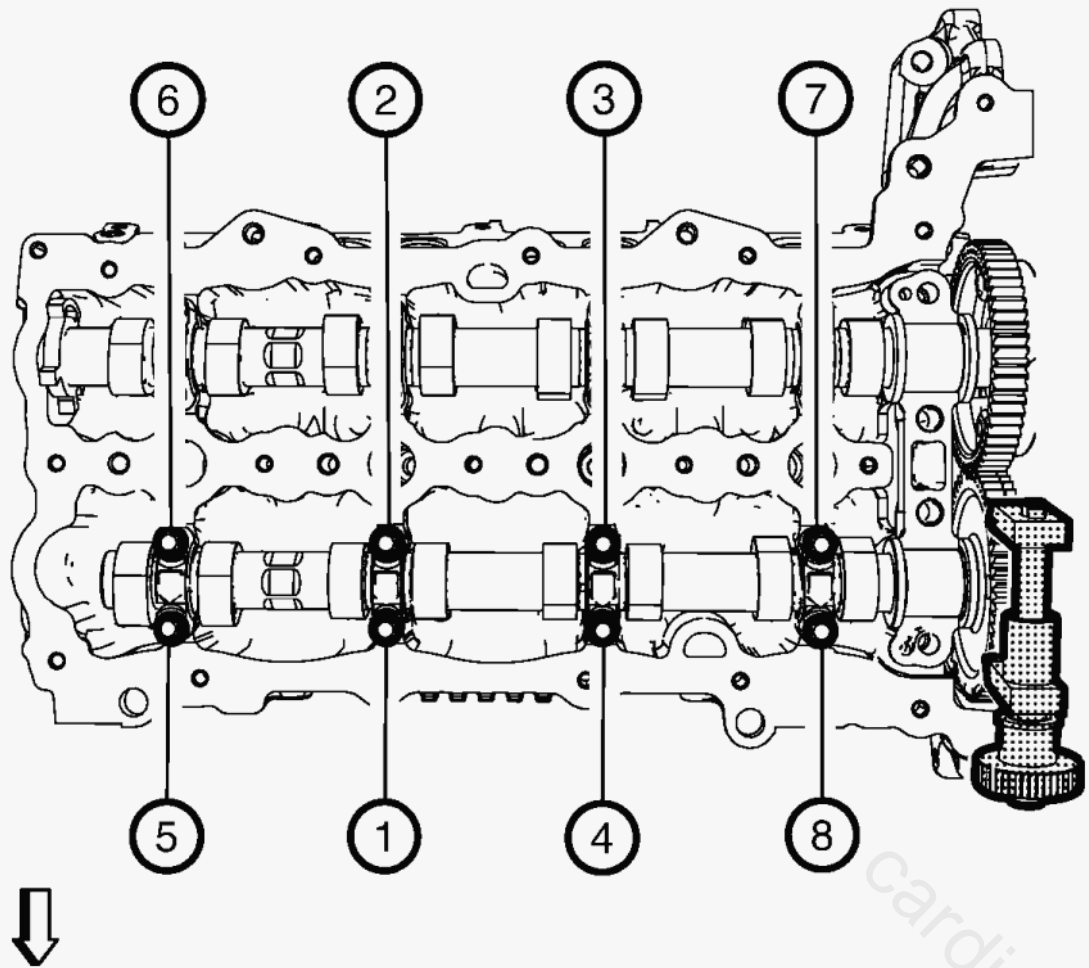


Fig. 164: Exhaust Camshaft Bearing Cap Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution** .

8. Tighten the 8 exhaust camshaft bearing cap bolts in the sequence shown to 10 N.m (89 lb in).

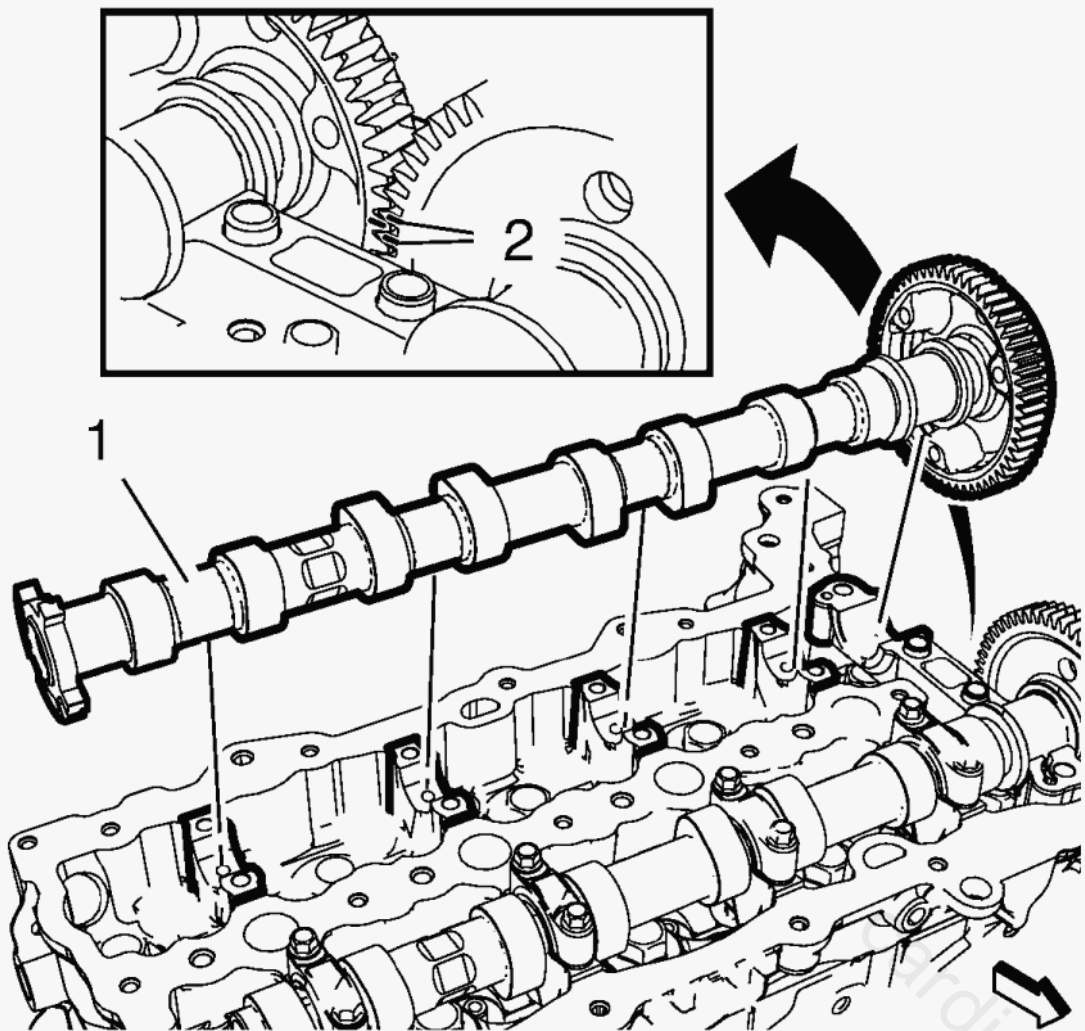


Fig. 165: Intake Camshaft With Camshaft Sprocket Marks Aligned
Courtesy of GENERAL MOTORS COMPANY

9. Coat all bearing surfaces with engine oil.

NOTE: Ensure the marks (2) of the camshaft sprocket are aligned.

10. Install the intake camshaft (1).

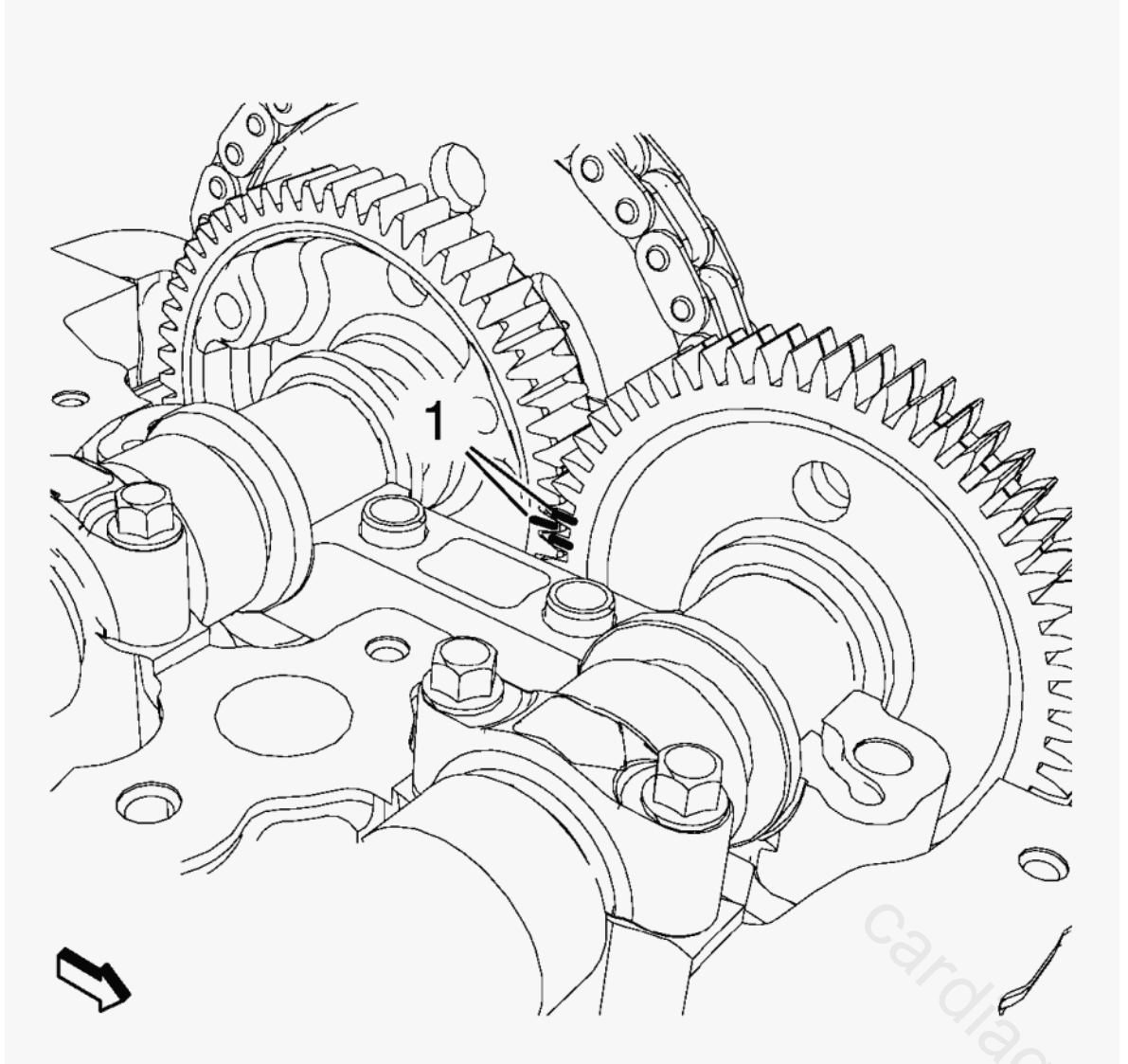


Fig. 166: Marking Exhaust Camshaft Sprocket And Intake Camshaft Sprocket With Paint Marks
Courtesy of GENERAL MOTORS COMPANY

11. Check the marks (1) on the camshaft sprockets to ensure they are aligned.

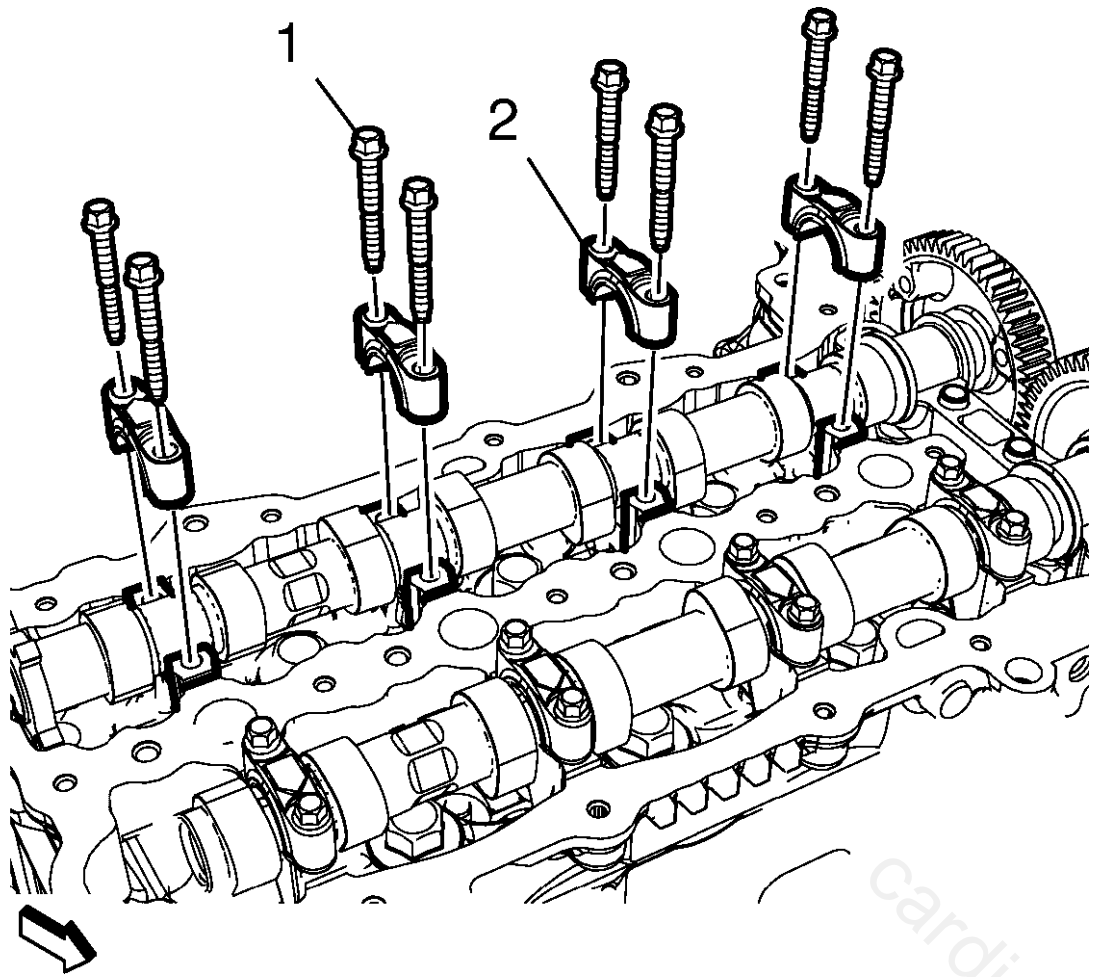


Fig. 167: Intake Camshaft Bearing Caps And Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: Note the arrow marks on the camshaft bearing caps, which show the outside of the cylinder head.

12. Install the 4 intake camshaft bearing caps (2) in the order as they were removed.
13. Install the 8 intake camshaft bearing cap bolts (1).

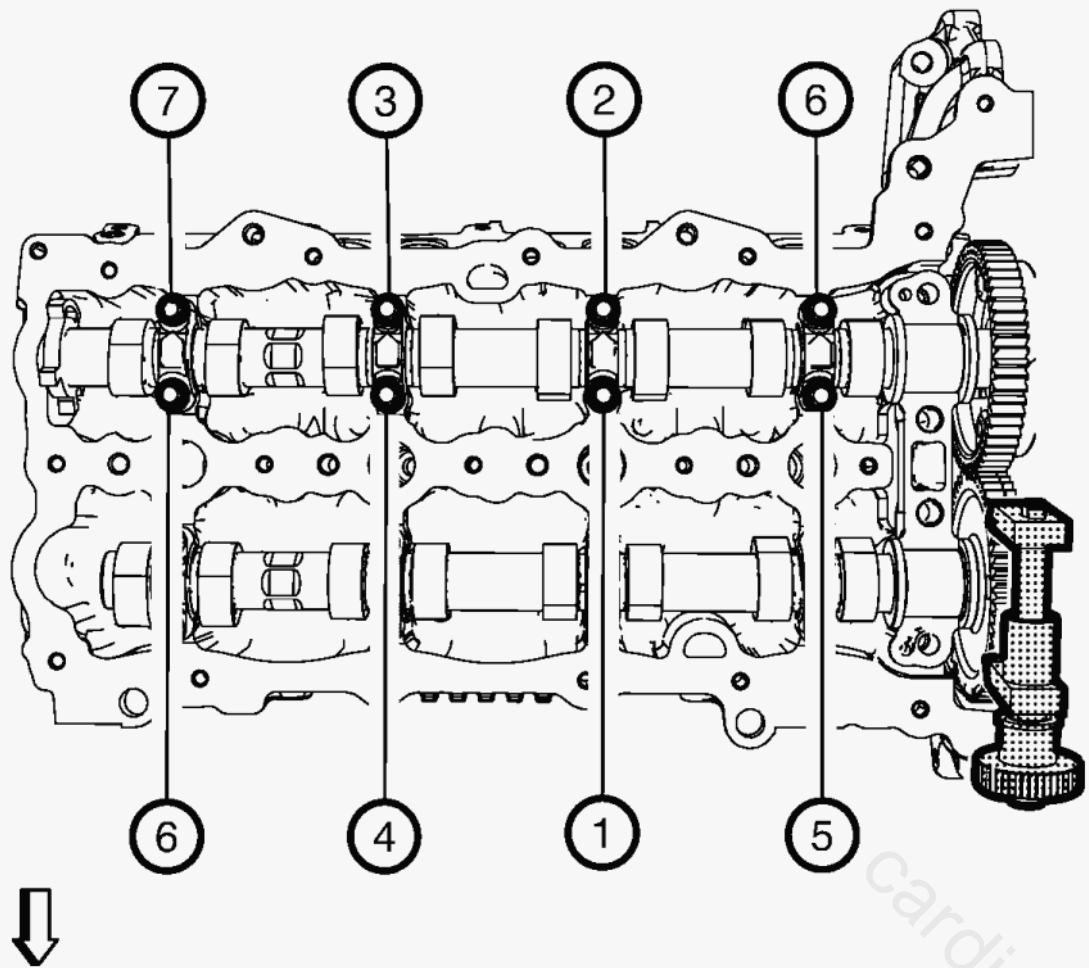


Fig. 168: Intake Camshaft Bearing Cap Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

14. Tighten the 8 intake camshaft bearing cap bolts in the sequence shown to 10 N.m (89 lb in).

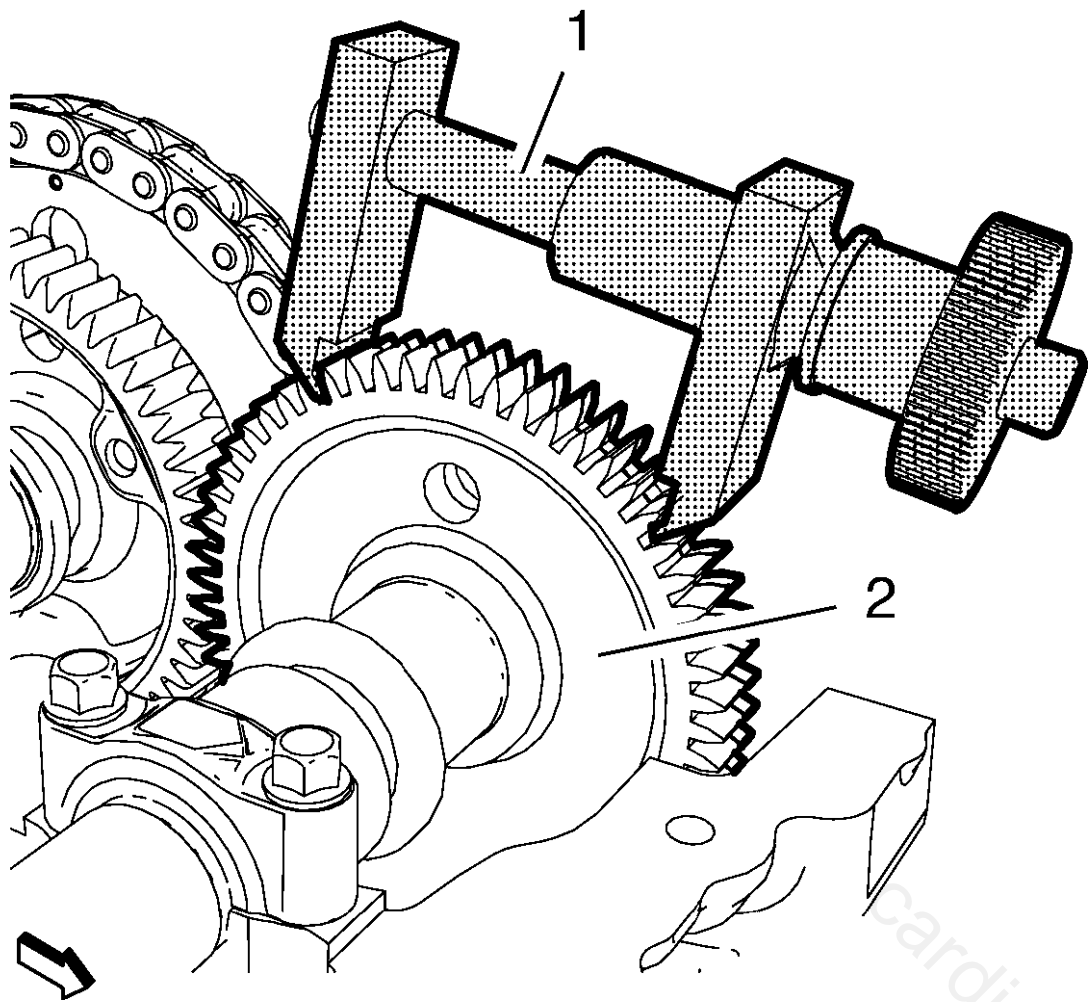


Fig. 169: Split Intake Camshaft Sprocket Fixing Tool
Courtesy of GENERAL MOTORS COMPANY

15. Remove the **EN-50509** fixing tool (1) or the transport lock from the exhaust camshaft sprocket (2).

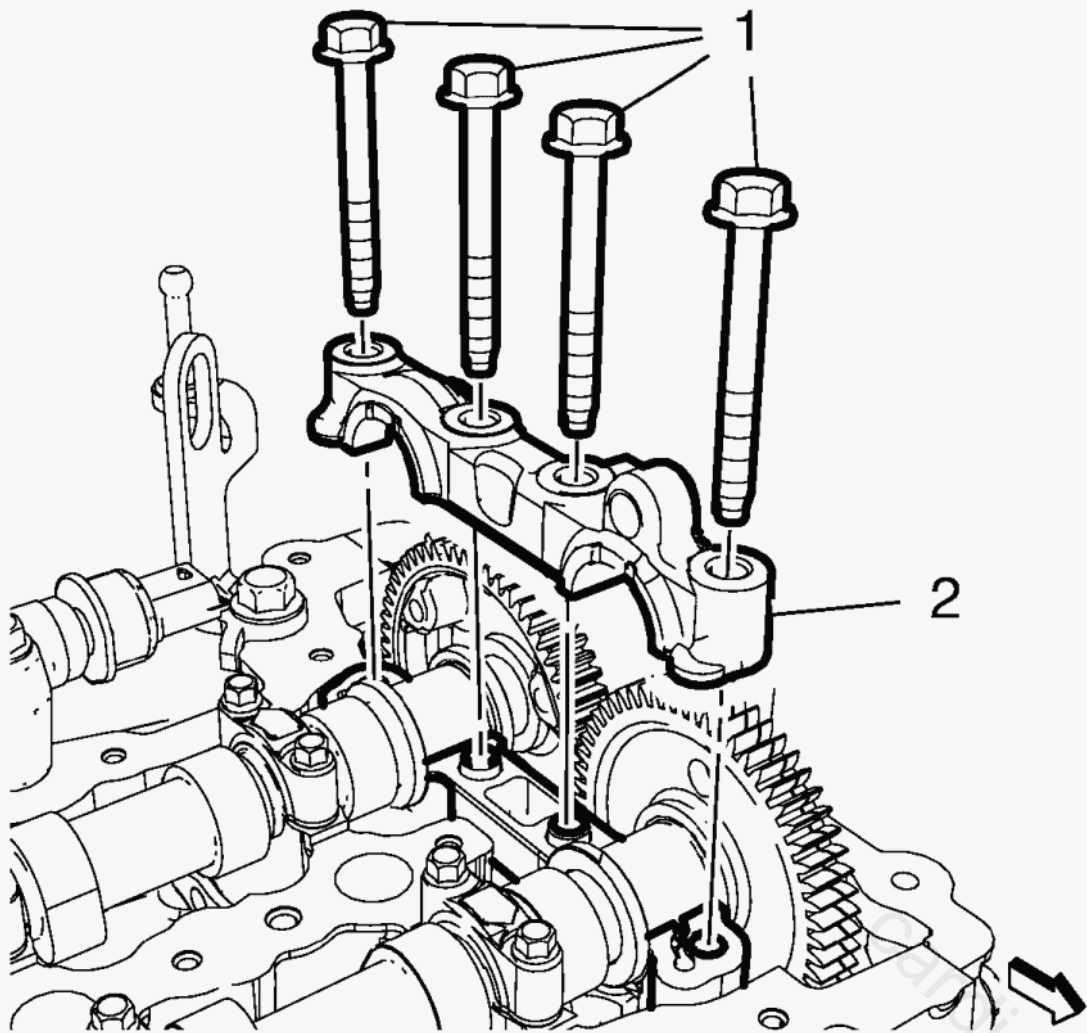


Fig. 170: Camshaft Bearing Rear Cap And Bolts
Courtesy of GENERAL MOTORS COMPANY

16. Coat all bearing surfaces with engine oil.
17. Install the camshaft bearing rear cap (2).
18. Install the 4 camshaft bearing rear cap bolts (1).

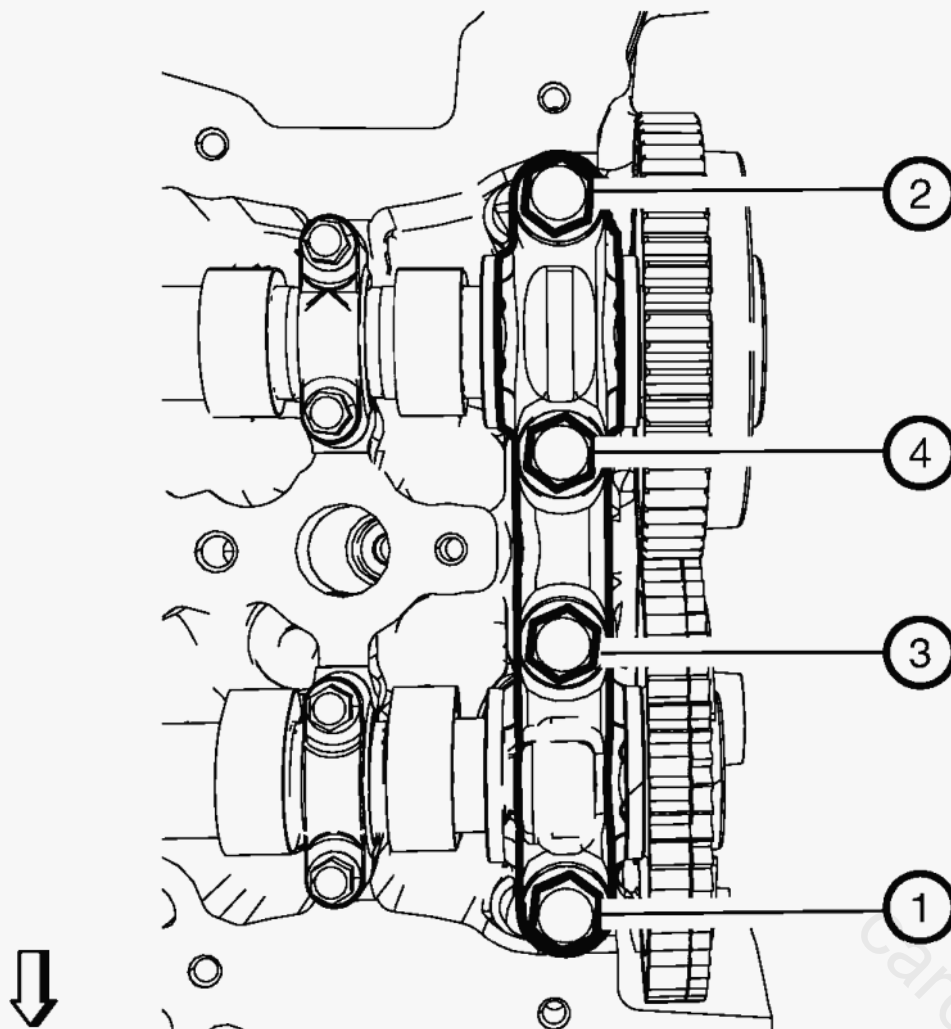


Fig. 171: Camshaft Rear Cap Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

19. Tighten the 4 camshaft rear cap bolts in the sequence shown to 25 N.m (18 lb ft).

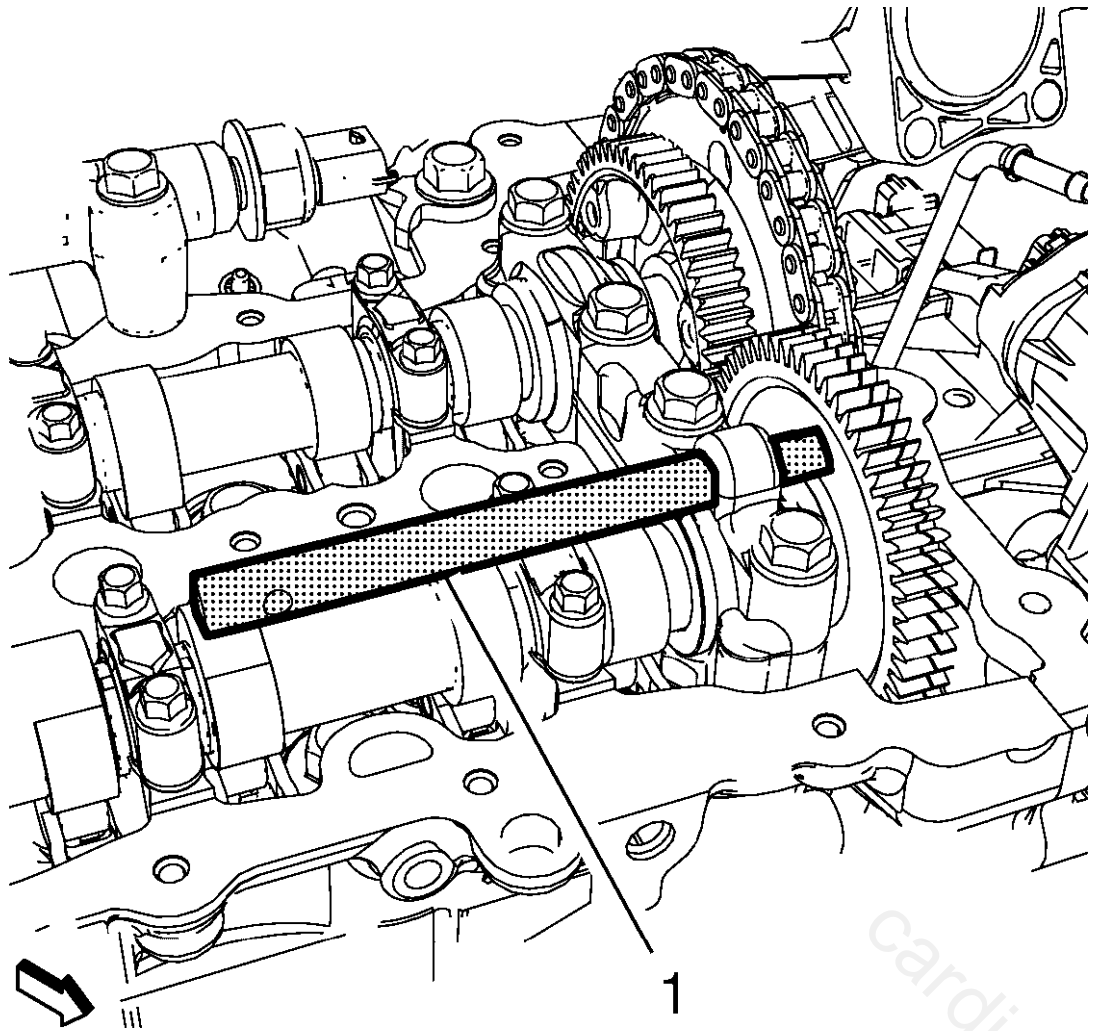


Fig. 172: Camshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

20. Install the EN-51143 fixing tool (1), by carefully turning the hexagon of the camshaft.

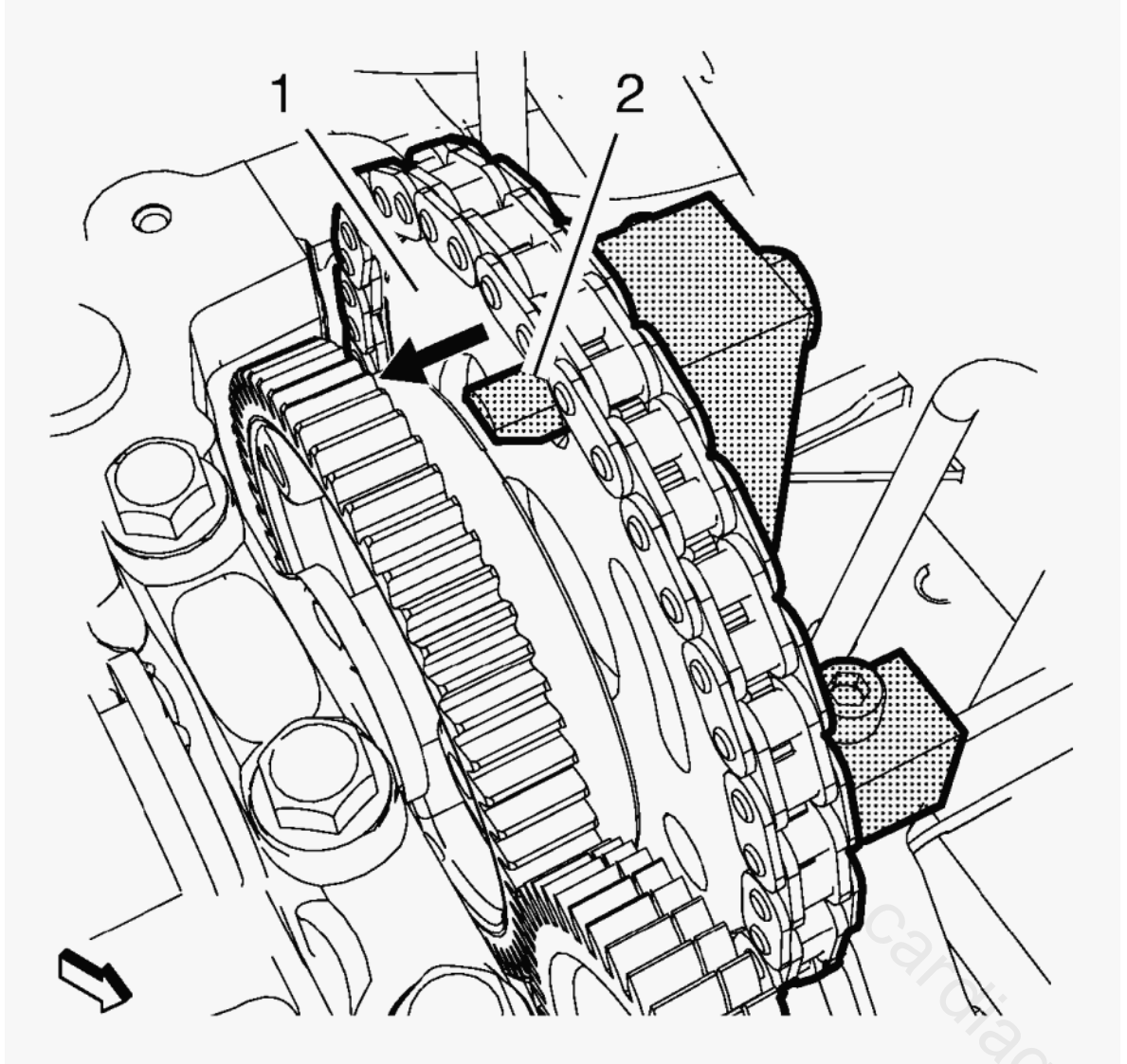


Fig. 173: Camshaft Sprocket Over Pin Of Timing Chain Camshaft Sprocket Fixing Tool
Courtesy of GENERAL MOTORS COMPANY

21. Slide the camshaft sprocket (1) over the pin (2) of the **EN-51188** fixing tool in arrow direction.

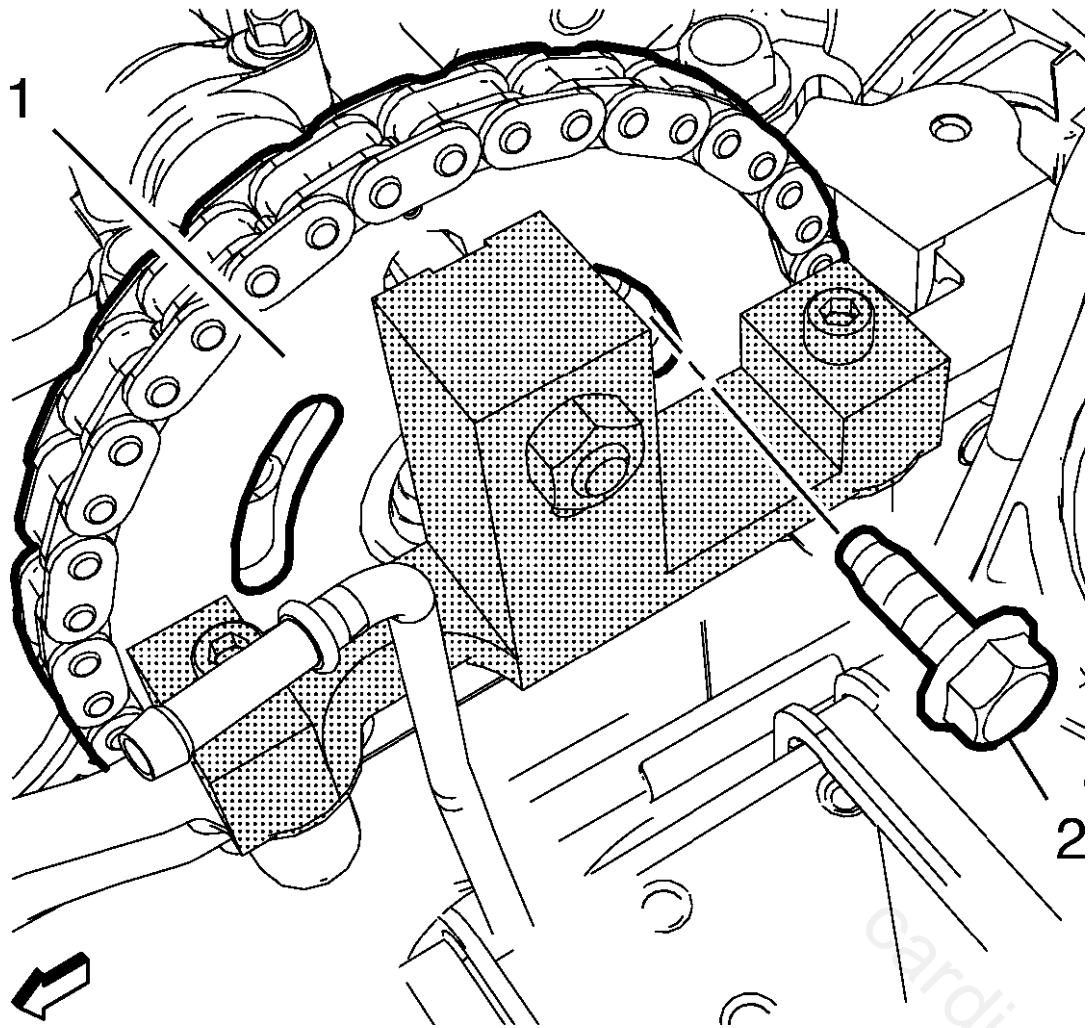


Fig. 174: Camshaft Sprocket And Bolts

Courtesy of GENERAL MOTORS COMPANY

NOTE: Cover the timing case with a lint-free cloth.

22. Check that the camshaft sprocket (1) on the camshaft is properly installed.
23. Install the camshaft sprocket bolts (2), counterhold with a wrench at the camshaft hexagon, and tighten to 25 N.m (18 lb ft).

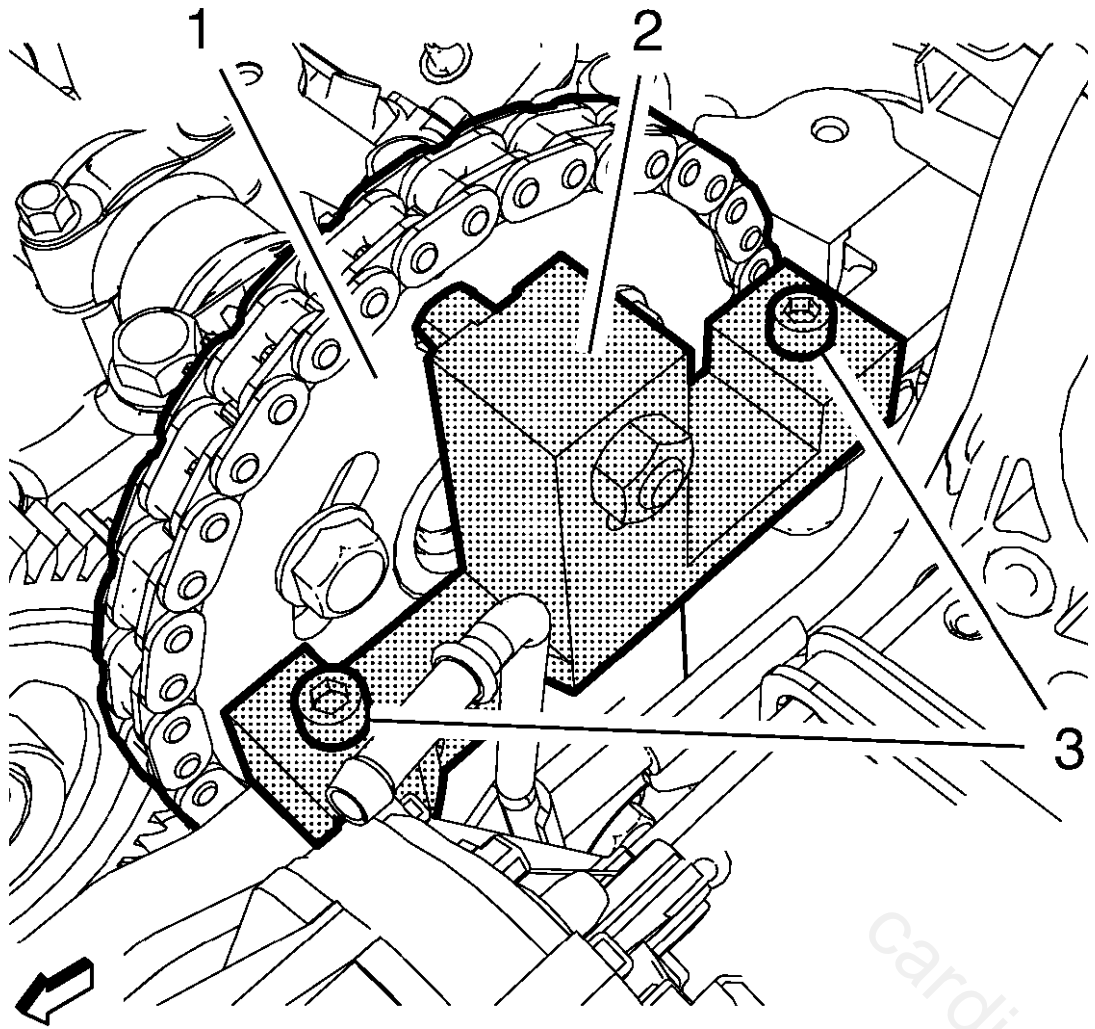


Fig. 175: Timing Chain Camshaft Sprocket Fixing Tool
Courtesy of GENERAL MOTORS COMPANY

- 24. Remove the 2 bolts (3).
- 25. Remove the **EN-51188** fixing tool (2).

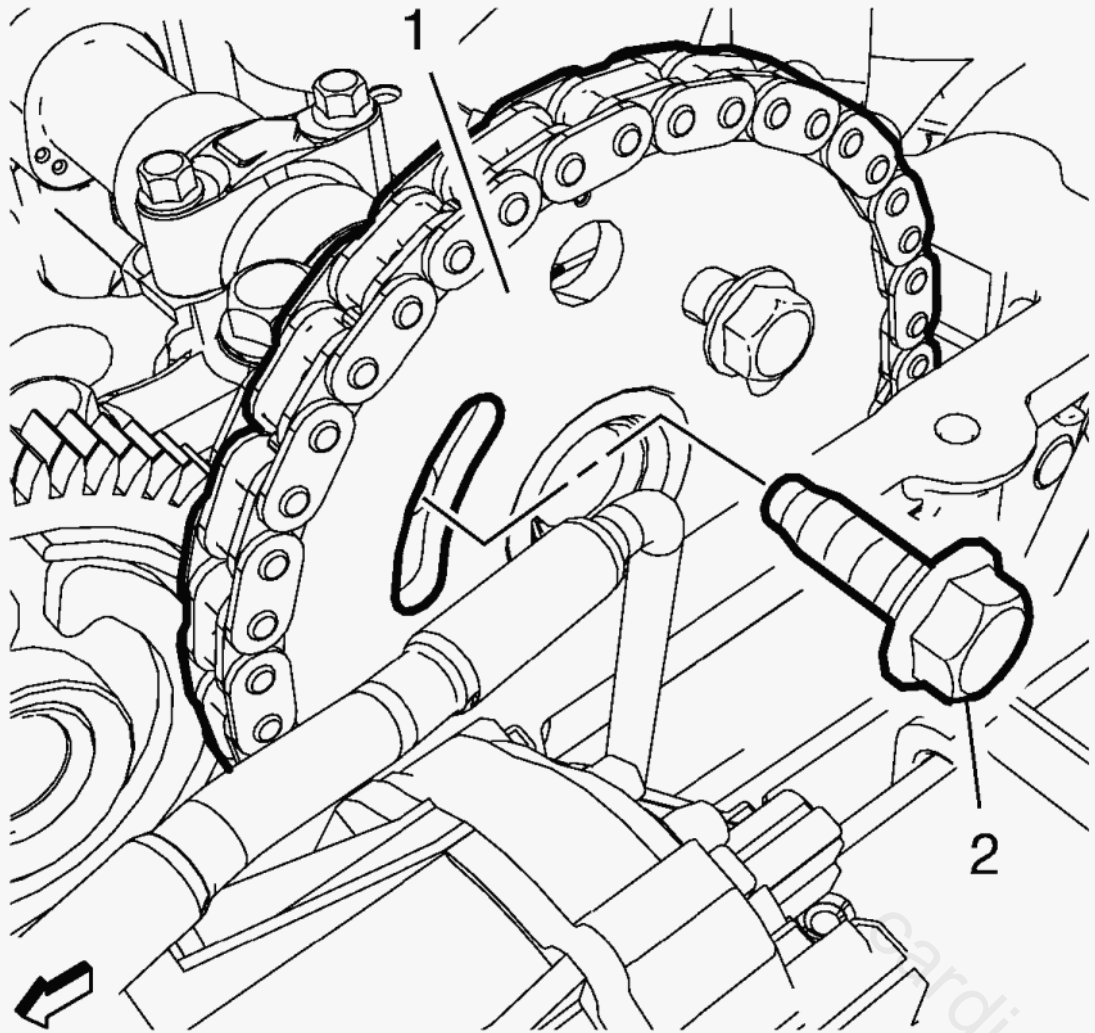


Fig. 176: Camshaft Sprocket And Bolt

Courtesy of GENERAL MOTORS COMPANY

NOTE: Cover the timing case with a lint-free cloth.

26. Install the camshaft sprocket bolt (2) to the camshaft sprocket (1), counterhold with a wrench at the camshaft hexagon, and tighten to 25 N.m (18 lb ft).

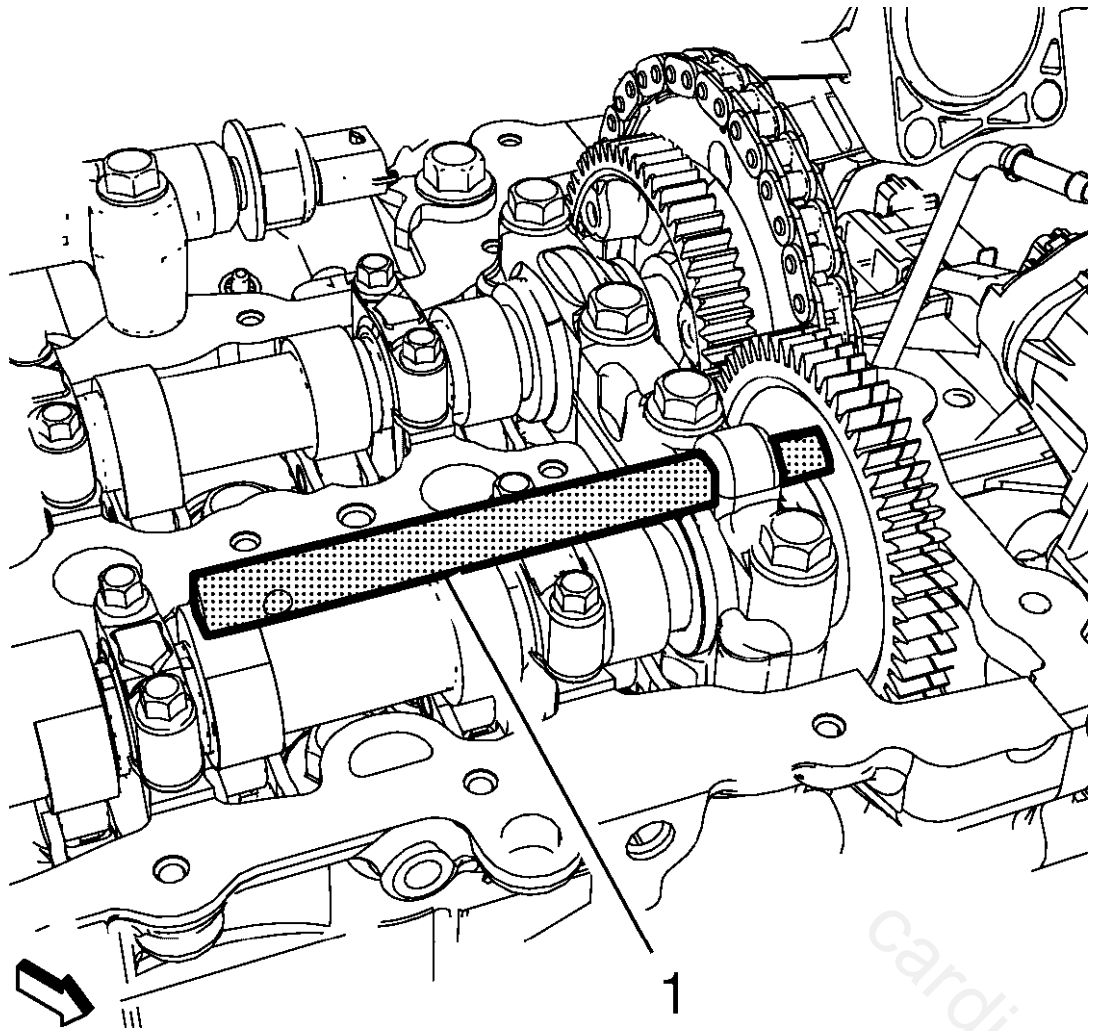


Fig. 177: Camshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

27. Remove the **EN-51143** fixing tool (1).
28. Raise the vehicle.

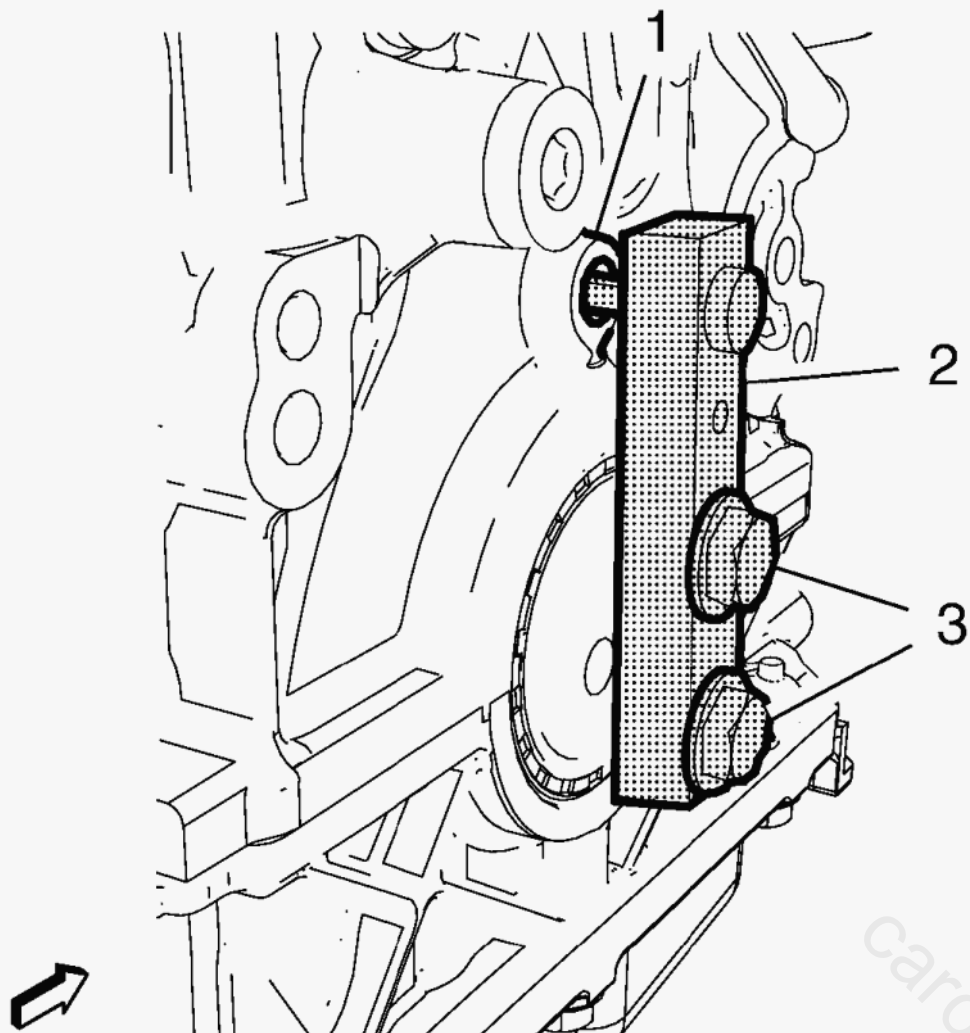


Fig. 178: Crankshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

29. Remove the 2 bolts (3).
30. Remove the **EN-51140** fixing tool (2).

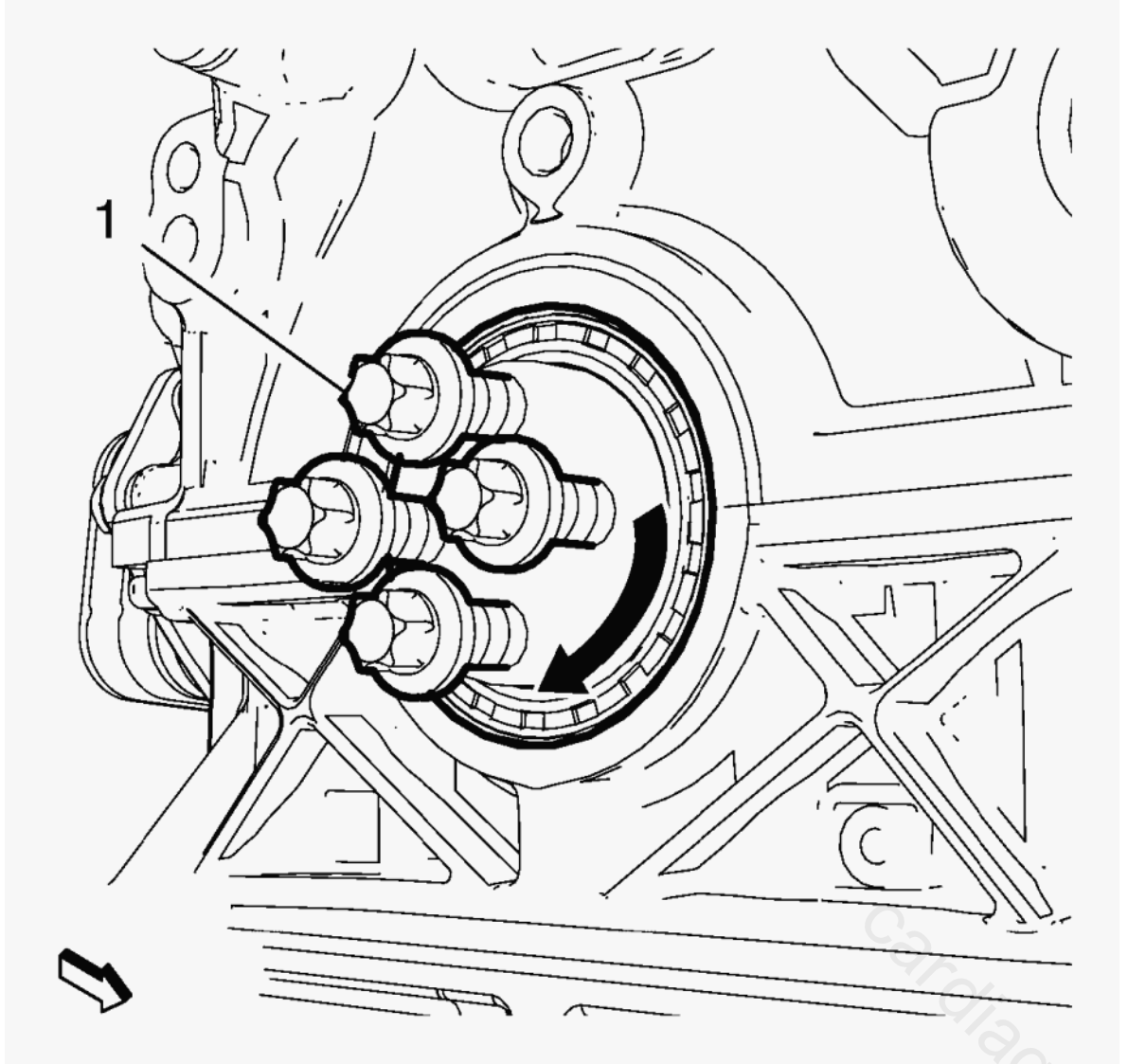


Fig. 179: Crankshaft Pulley Bolts

Courtesy of GENERAL MOTORS COMPANY

31. Install the 4 crankshaft pulley bolts (1).

Rotate the crankshaft 360 degrees in direction of arrow. Use a pry bar at the 4 crankshaft pulley bolts (1).

32. Lower the vehicle.

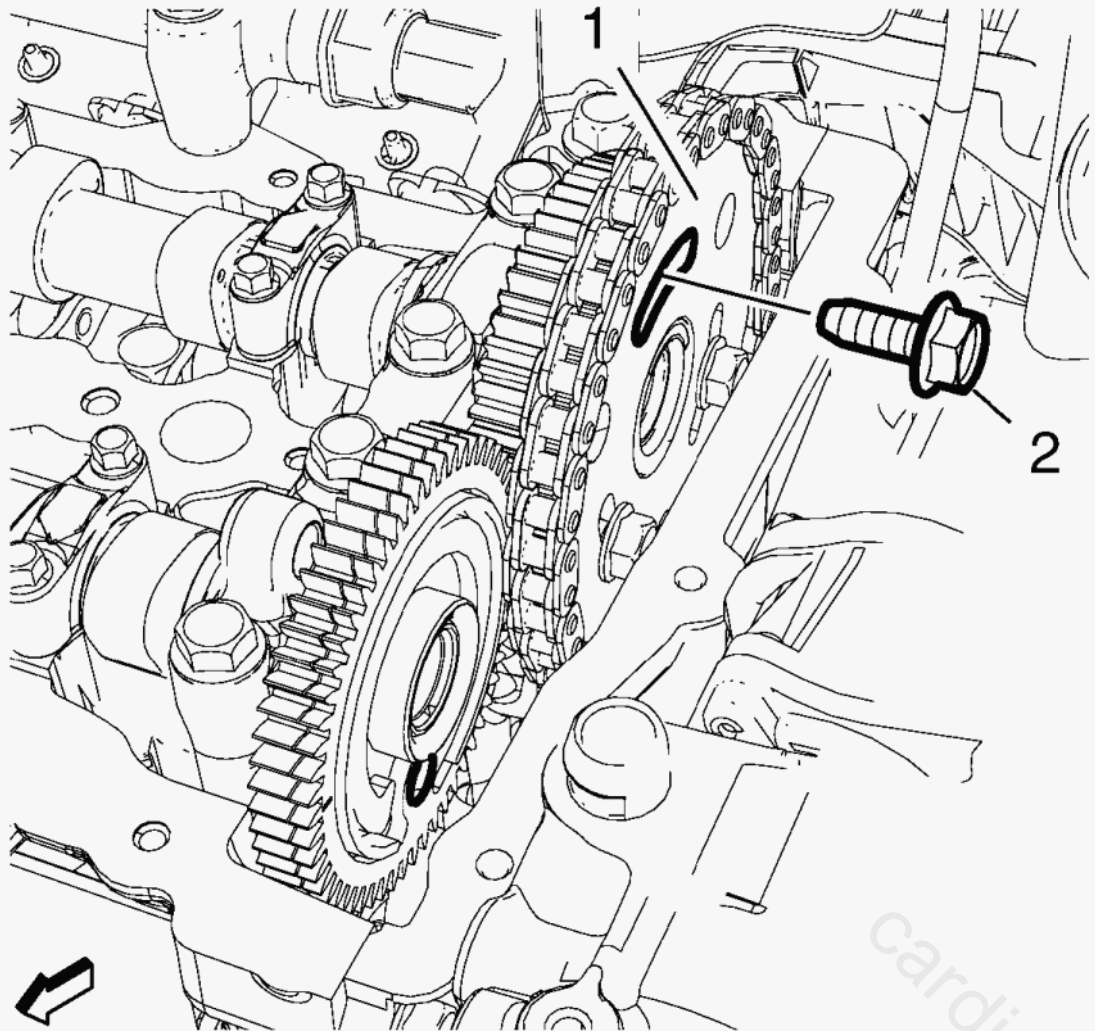


Fig. 180: Camshaft Sprocket And Bolt

Courtesy of GENERAL MOTORS COMPANY

NOTE: Cover the timing case with a lint-free cloth.

33. Install the camshaft sprocket bolt (2), counterhold with a wrench at the camshaft hexagon, and tighten to 25 N.m (18 lb ft).
34. Raise the vehicle.

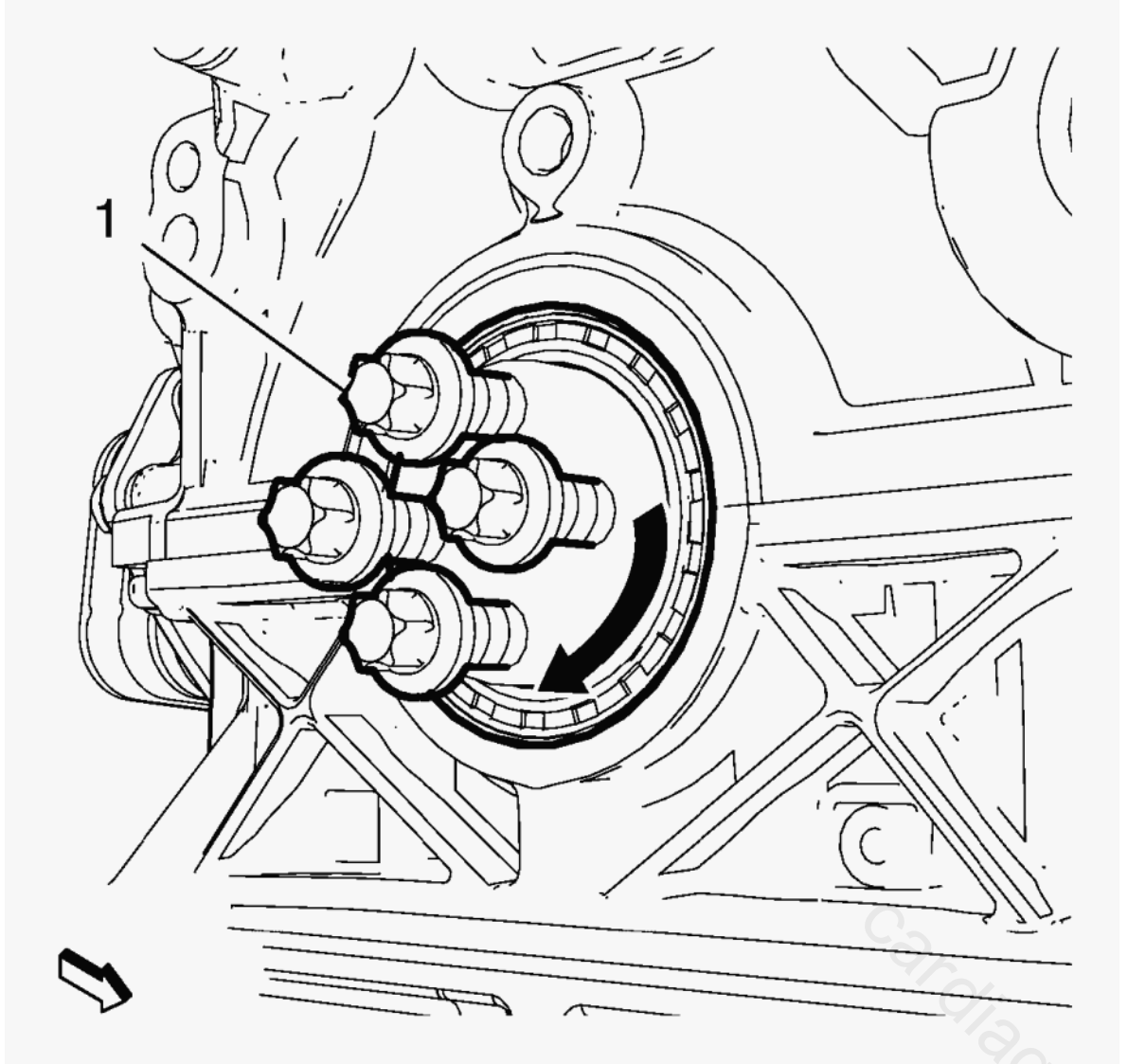


Fig. 181: Crankshaft Pulley Bolts

Courtesy of GENERAL MOTORS COMPANY

35. Rotate the crankshaft 360 degrees in direction of arrow. Use a pry bar.
36. Remove the 4 crankshaft pulley bolts (1).

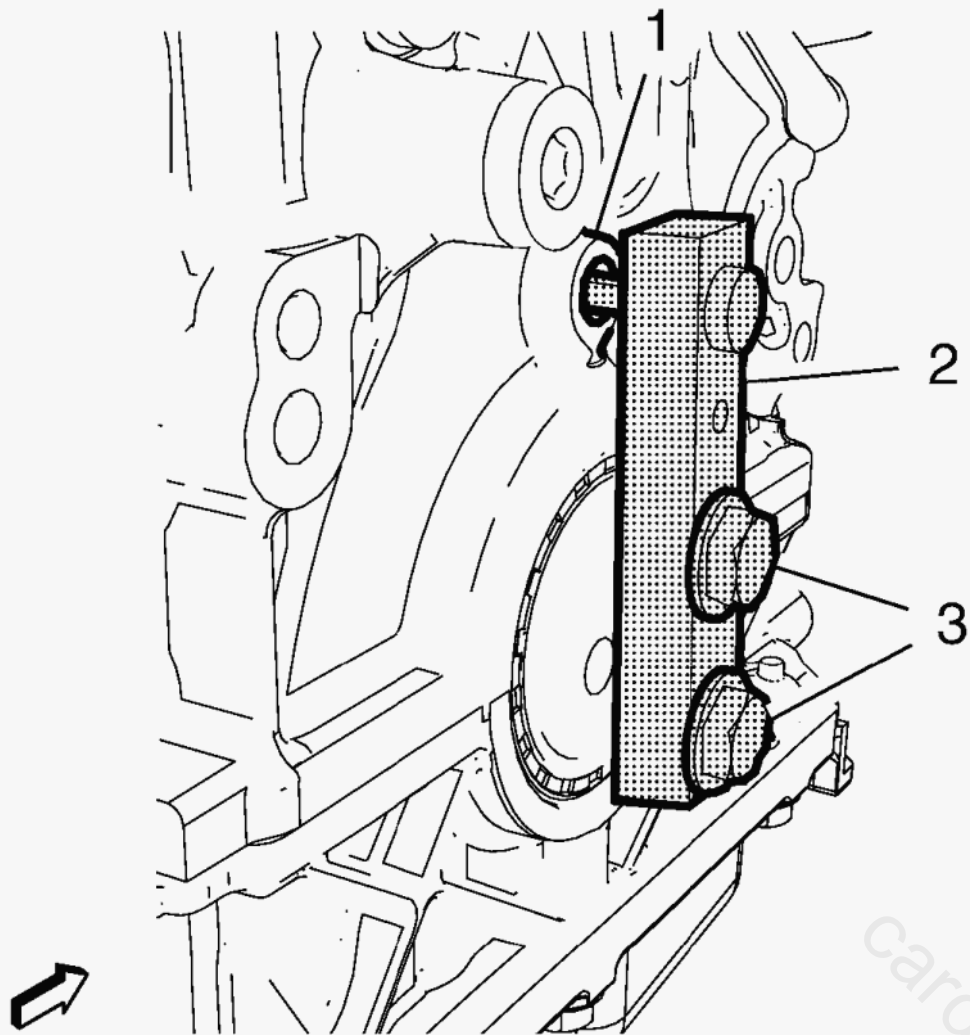


Fig. 182: Crankshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

37. Install the **EN-51140** fixing tool (2).
38. Install the fixing pin into the engine block bore (1) and tighten the 2 bolts (3).
39. Lower the vehicle.

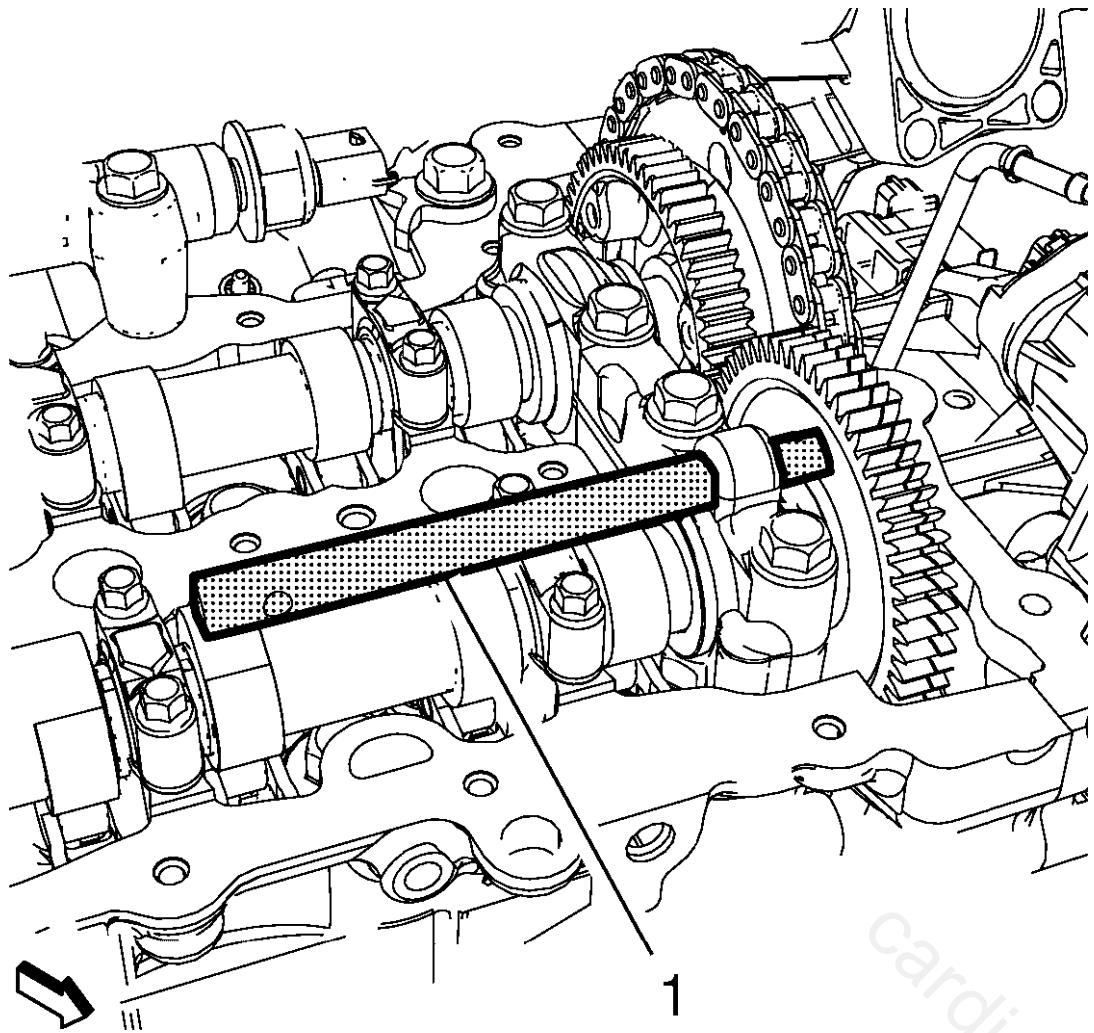


Fig. 183: Camshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

NOTE: If the EN-51143 fixing tool does not fit, adjust timing.

40. Install the **EN-51143** fixing tool (1), by carefully turning the hexagon of the camshaft.
41. Remove the **EN-51143** fixing tool.
42. Raise the vehicle.

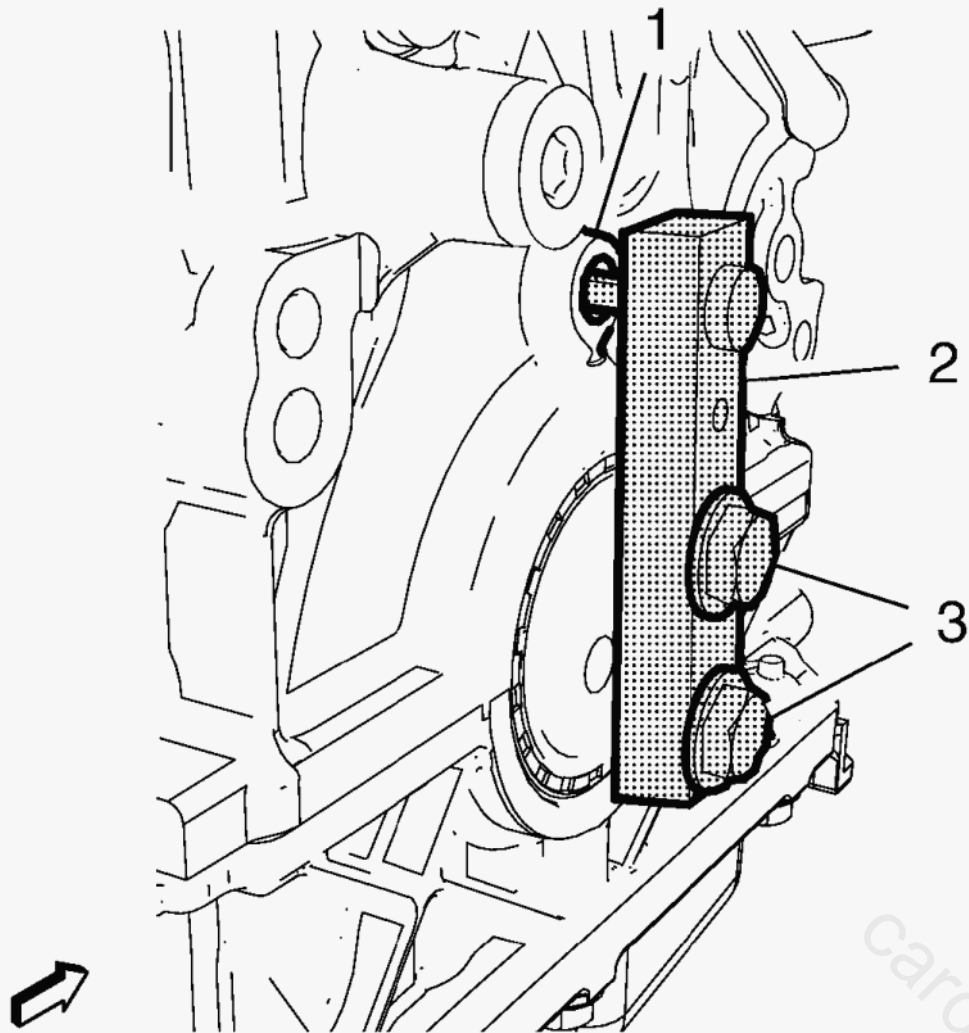


Fig. 184: Crankshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

43. Remove the 2 bolts (3).
44. Remove the **EN-51140** fixing tool (2).
45. Install Crankshaft Pulley. Refer to [Crankshaft Pulley Replacement](#)
46. Install Camshaft Housing. Refer to [Camshaft Housing Replacement](#)
47. Install Throttle Body Assembly. Refer to [Throttle Body Assembly Replacement](#)
48. Connect the battery negative cable. Refer to [Battery Negative Cable Disconnection and Connection \(KL9\)](#)

INTAKE CAMSHAFT REPLACEMENT

Special Tools

- **EN-50509** Split Intake Camshaft Sprocket Fixing Tool
- **EN-51140** Crankshaft Fixing Tool
- **EN-51143** Camshaft Sprocket Fixing Tool
- **EN-51188** Timing Chain Camshaft Sprocket Fixing Tool

Equivalent regional tools: [Special Tools](#)

Removal Procedure

1. Disconnect the battery negative cable. Refer to [Battery Negative Cable Disconnection and Connection \(KL9\)](#)
2. Remove Throttle Body Assembly. Refer to [Throttle Body Assembly Replacement](#)
3. Remove Camshaft Housing. Refer to [Camshaft Housing Replacement](#)
4. Remove Crankshaft Pulley. Refer to [Crankshaft Pulley Replacement](#)

5. Lower the vehicle. Refer to [Lifting and Jacking the Vehicle](#)

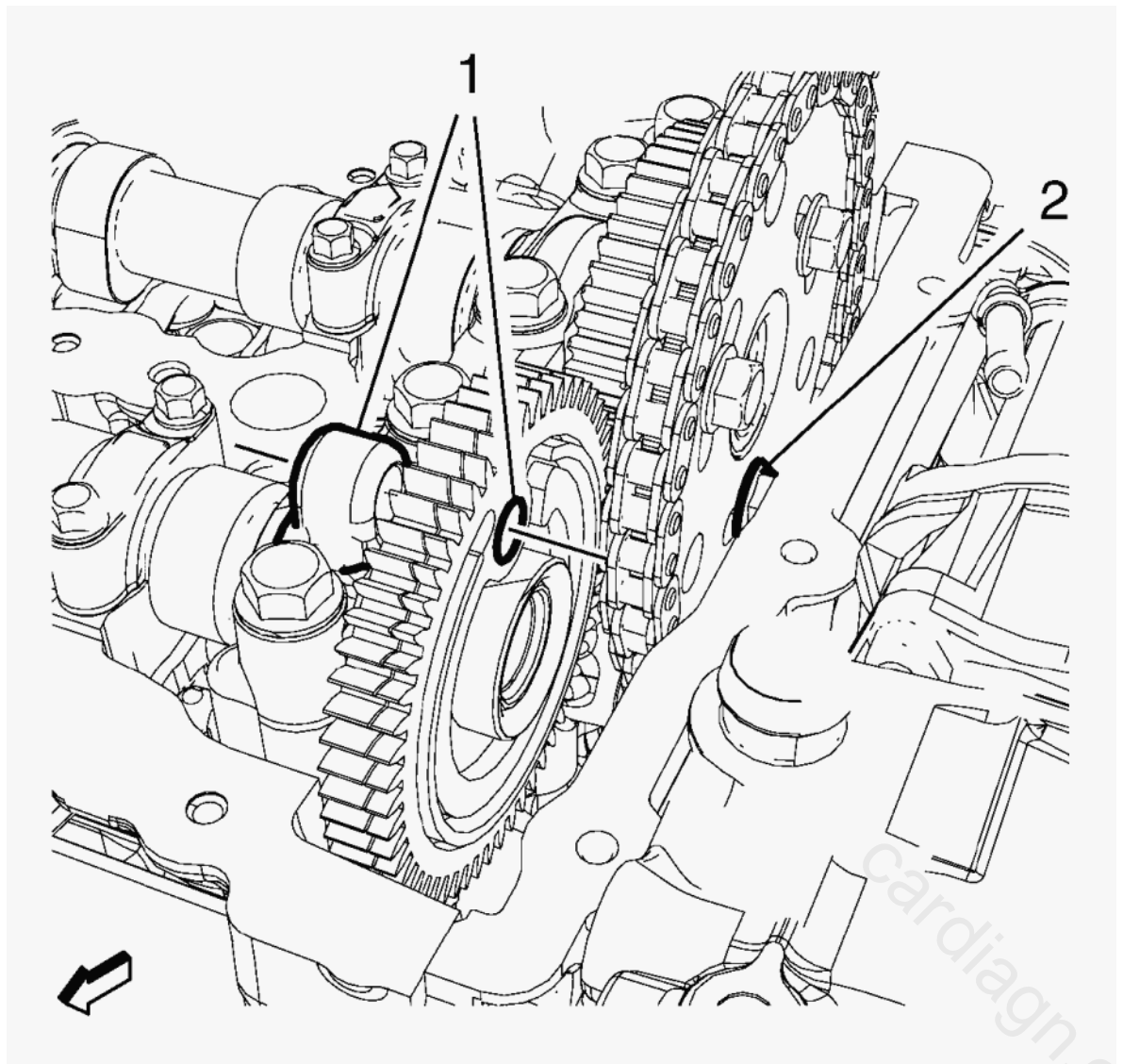


Fig. 185: Aligning Bores

Courtesy of GENERAL MOTORS COMPANY

6. Check the Top Dead Center (TDC) position to locate the correct camshaft sprocket bolt (2) that is to be removed first.
7. Check if the bores (1) are aligned.
8. If the bores are aligned, raise the vehicle.

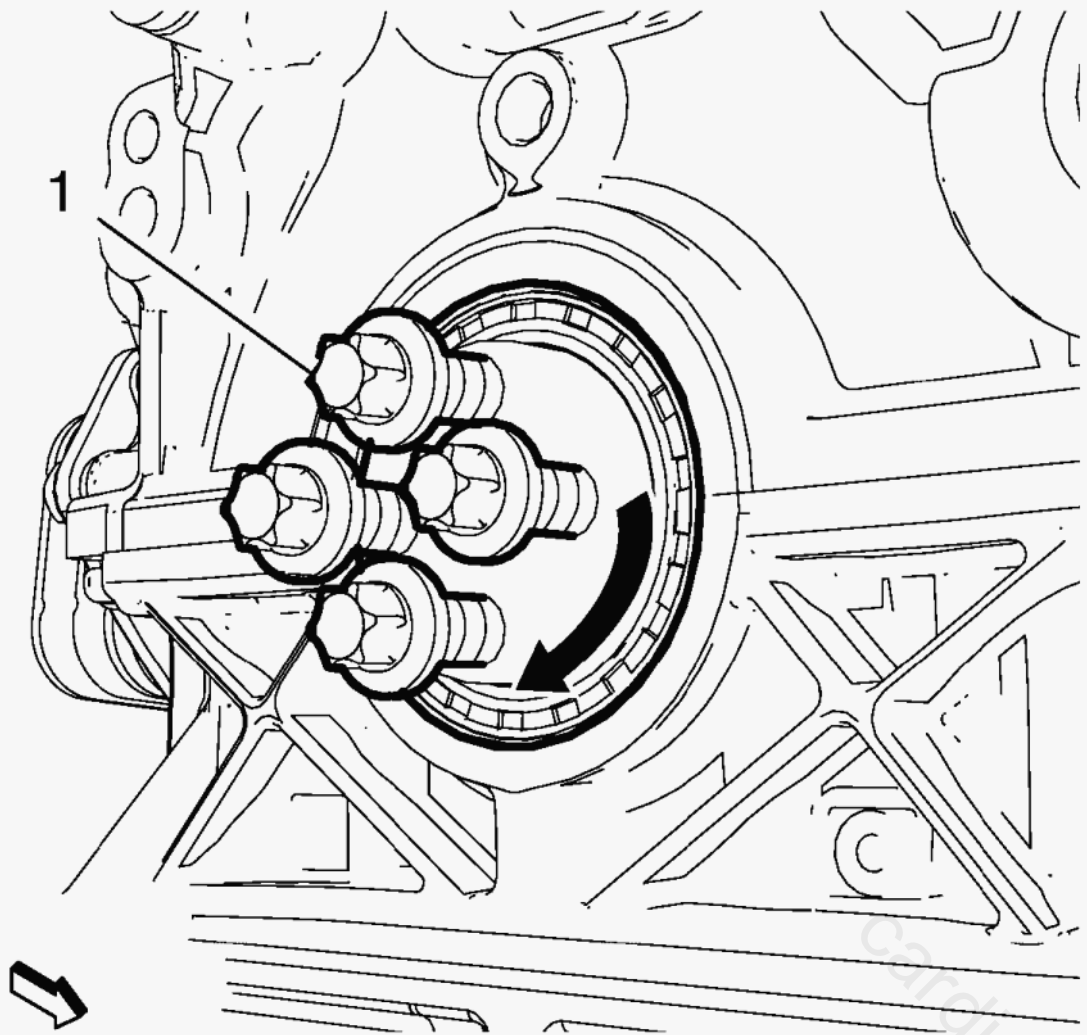


Fig. 186: Crankshaft Pulley Bolts

Courtesy of GENERAL MOTORS COMPANY

9. Install the 4 crankshaft pulley bolts (1).
10. Rotate the crankshaft 360 degrees in direction of arrow. Use a suitable flat bladed tool.
11. Lower the vehicle.

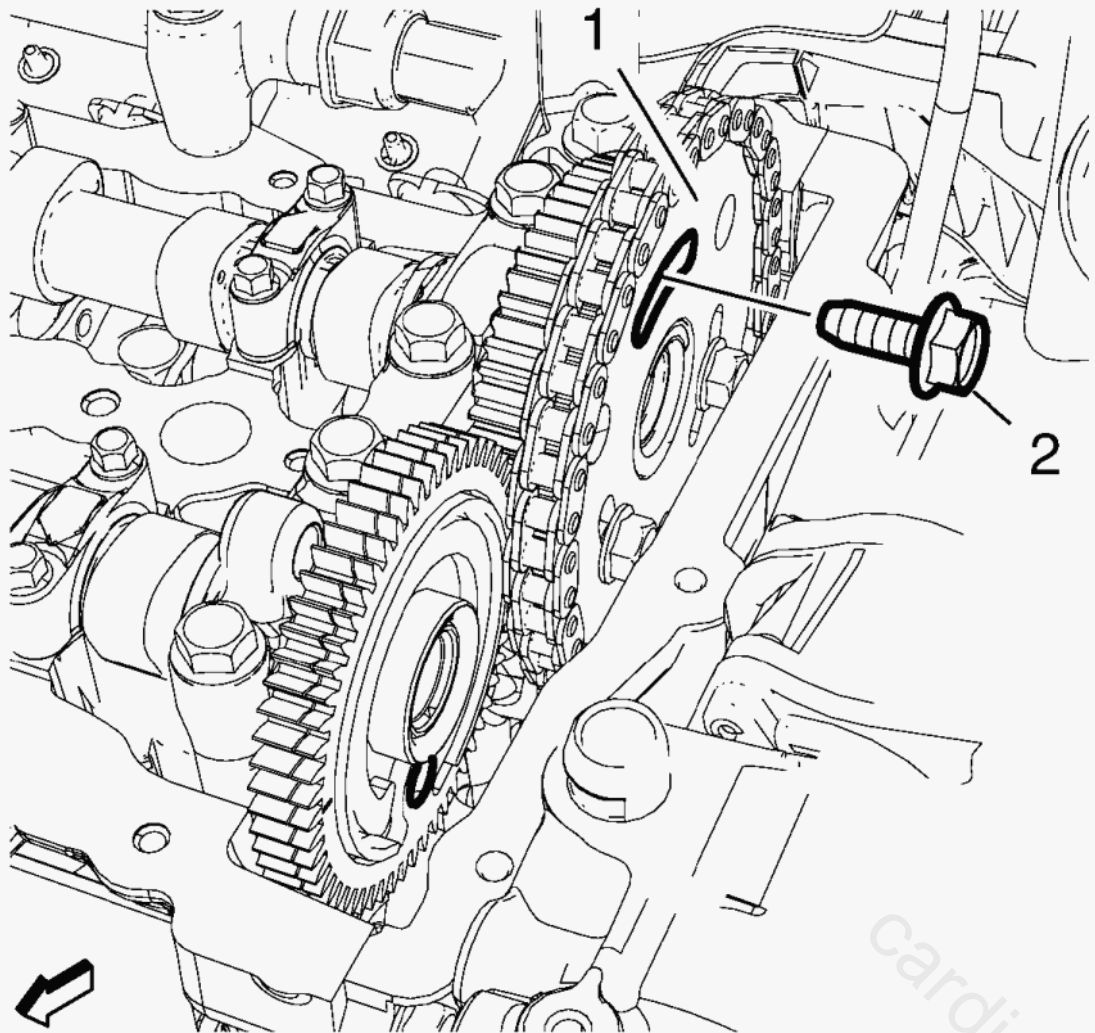


Fig. 187: Camshaft Sprocket And Bolt

Courtesy of GENERAL MOTORS COMPANY

12. Remove the camshaft sprocket bolt (2) from the intake camshaft sprocket (1). Counterhold with a wrench at the camshaft hexagon.
13. Raise the vehicle.

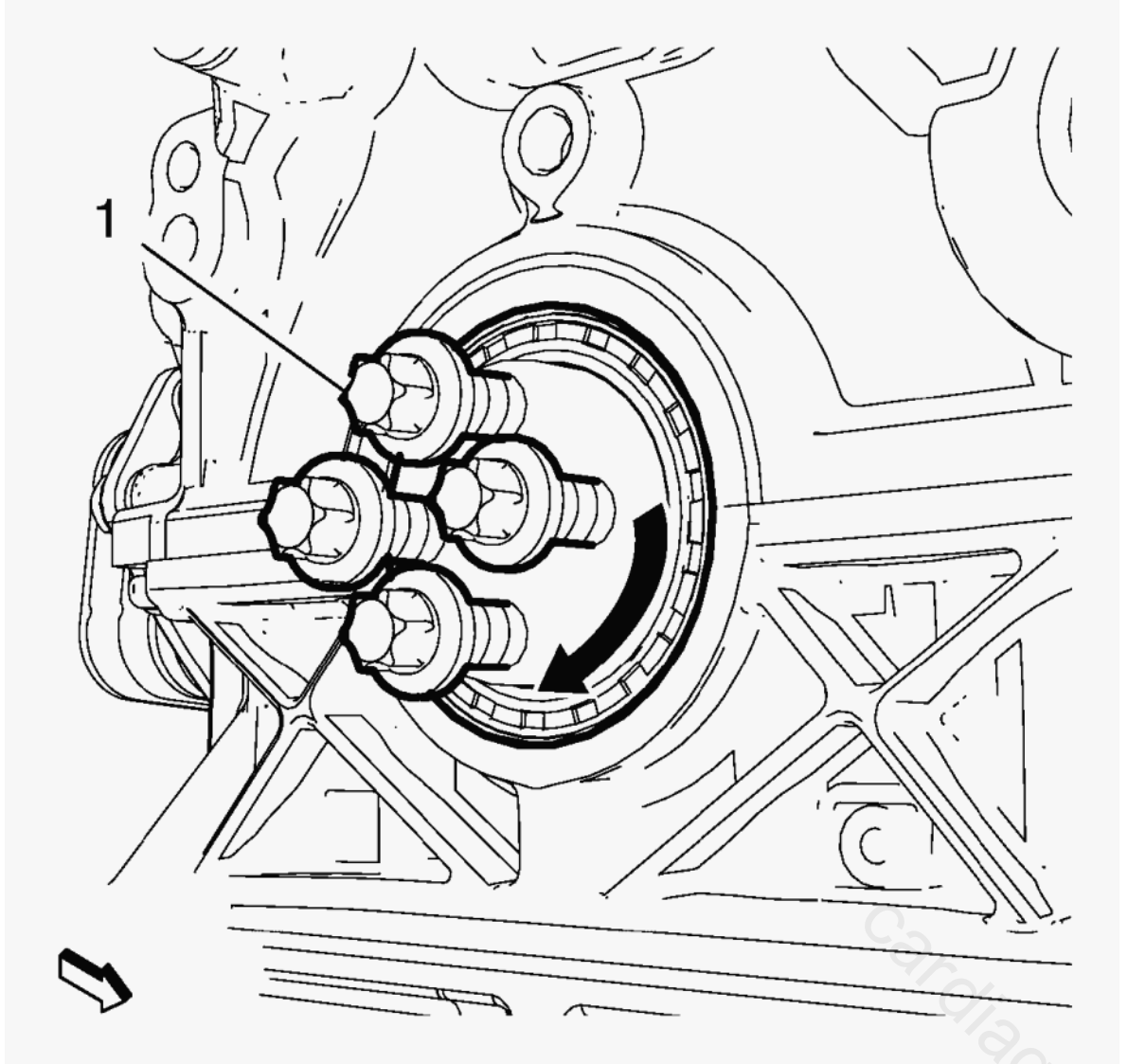


Fig. 188: Crankshaft Pulley Bolts

Courtesy of GENERAL MOTORS COMPANY

14. Rotate the crankshaft 360 degrees in direction of arrow. Use a suitable flat bladed tool at the 4 crankshaft pulley bolts (1).
15. Remove the 4 crankshaft pulley bolts (1).

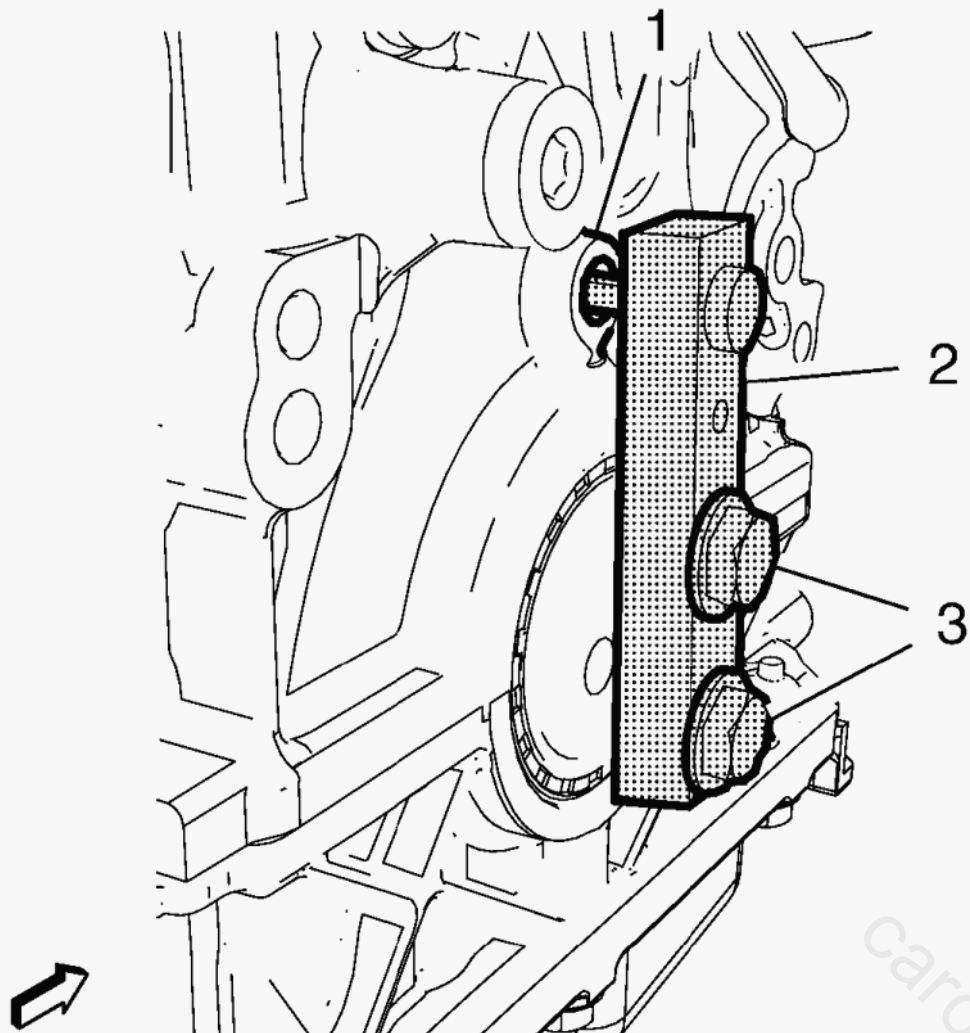


Fig. 189: Crankshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

16. Install the **EN-51140** fixing tool (2).
17. Install the fixing pin into the engine block bore (1) and tighten the 2 bolts (3).
18. Lower the vehicle.

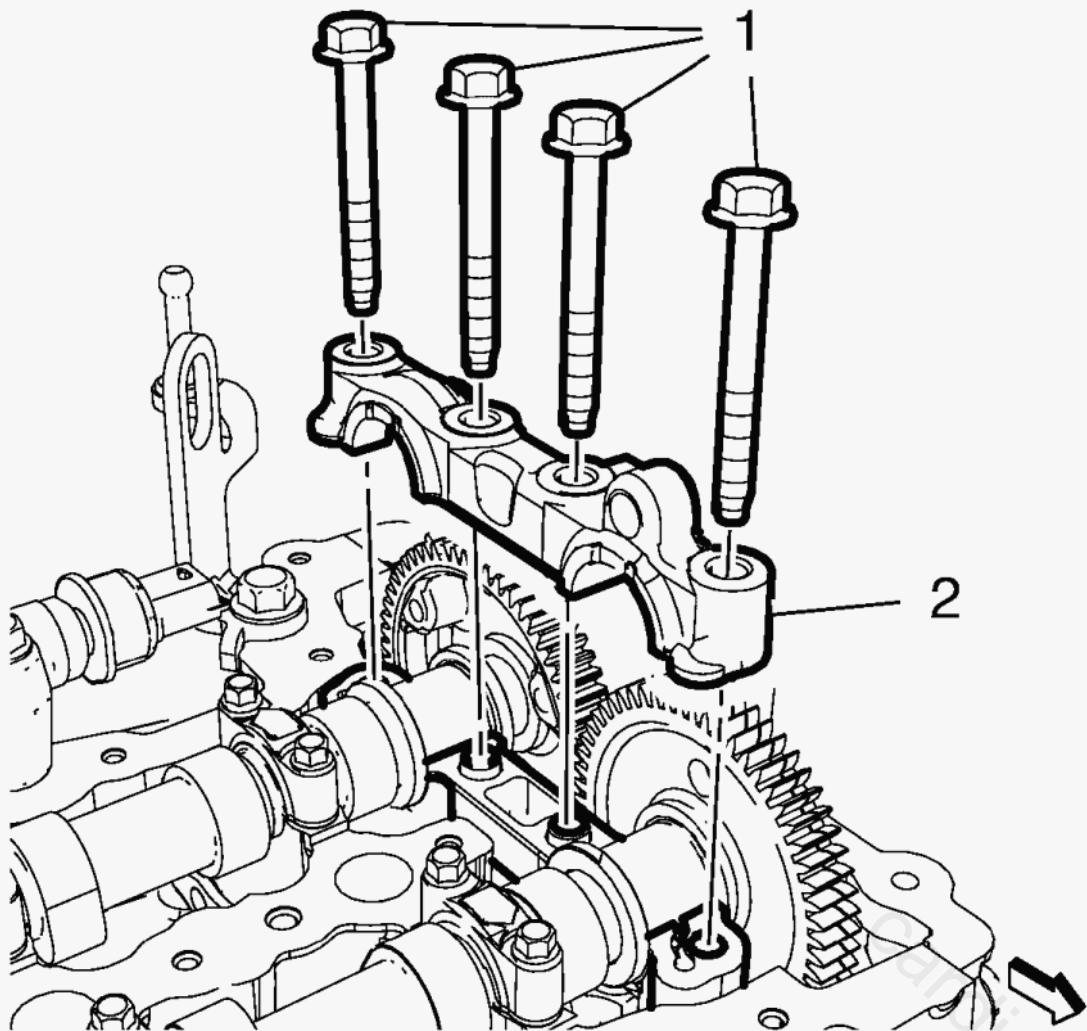


Fig. 190: Camshaft Bearing Rear Cap And Bolts
 Courtesy of GENERAL MOTORS COMPANY

19. Remove the 4 camshaft bearing rear cap bolts (1).
20. Remove the camshaft bearing rear cap (2).

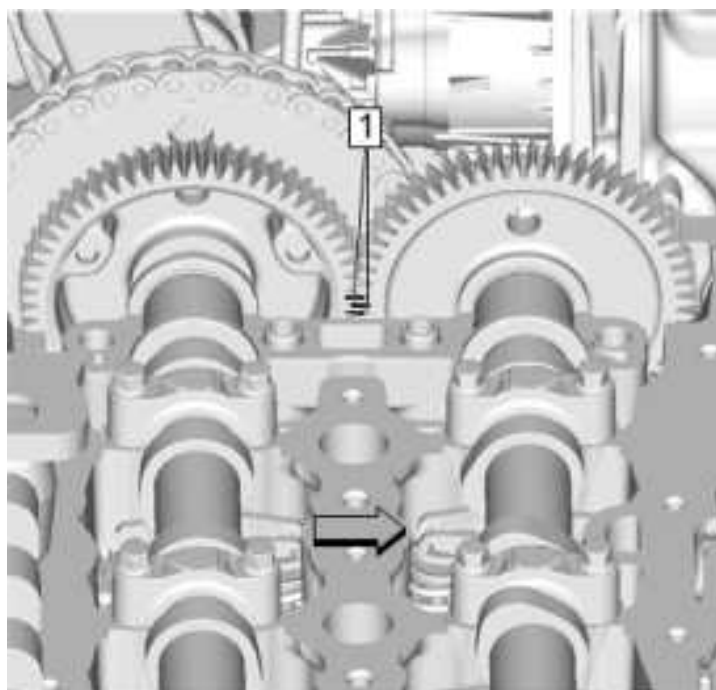


Fig. 191: Mark Backside Of Both Cam Gears With Paint Marks
 Courtesy of GENERAL MOTORS COMPANY

21. Mark the backside of both cam gears with paint marks (1).

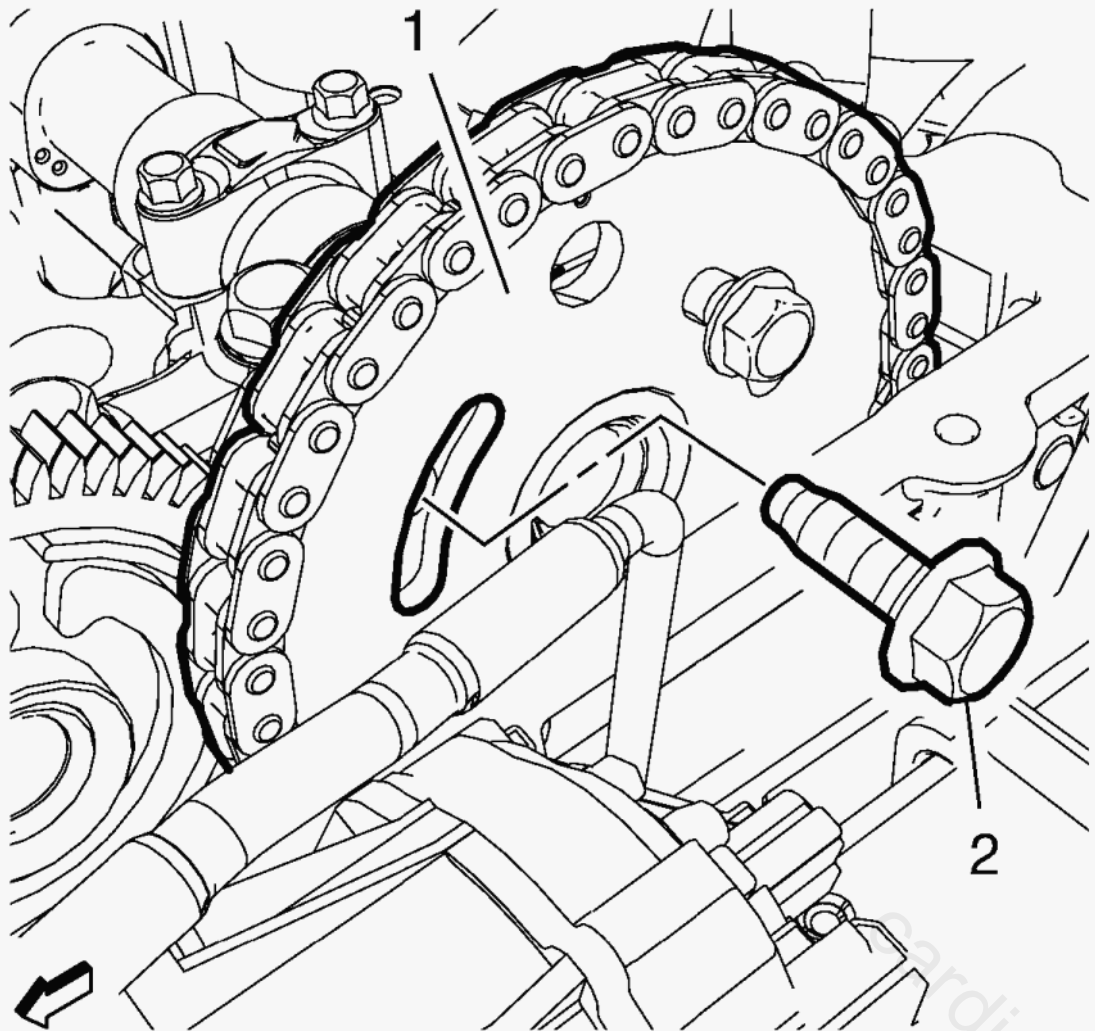


Fig. 192: Camshaft Sprocket And Bolt

Courtesy of GENERAL MOTORS COMPANY

22. Remove the camshaft sprocket bolt (2) from the camshaft sprocket (1). Counterhold with a wrench at the camshaft hexagon.

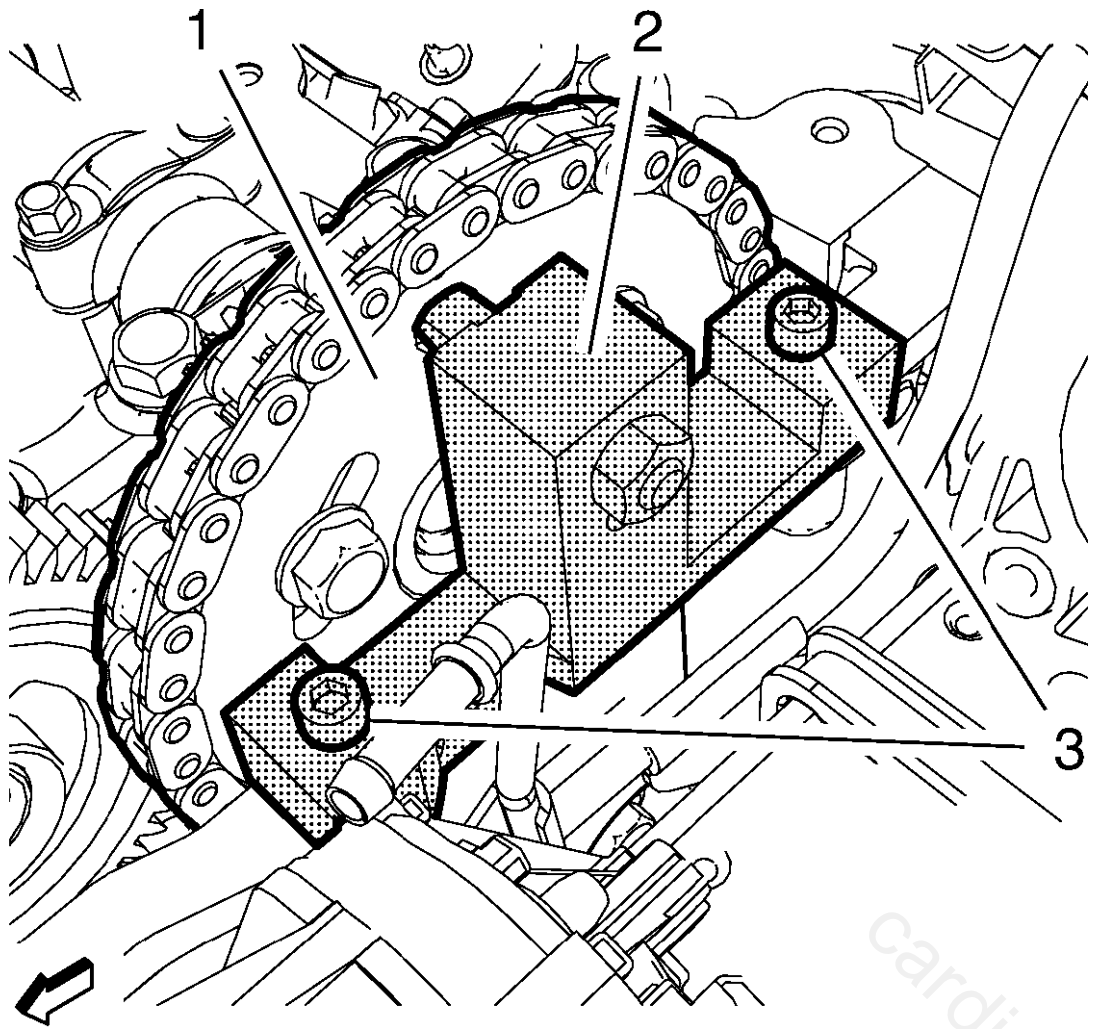


Fig. 193: Timing Chain Camshaft Sprocket Fixing Tool
Courtesy of GENERAL MOTORS COMPANY

23. Install the **EN-51188** fixing tool (2) to fix the camshaft sprocket (1).
24. Install the 2 bolts (3).

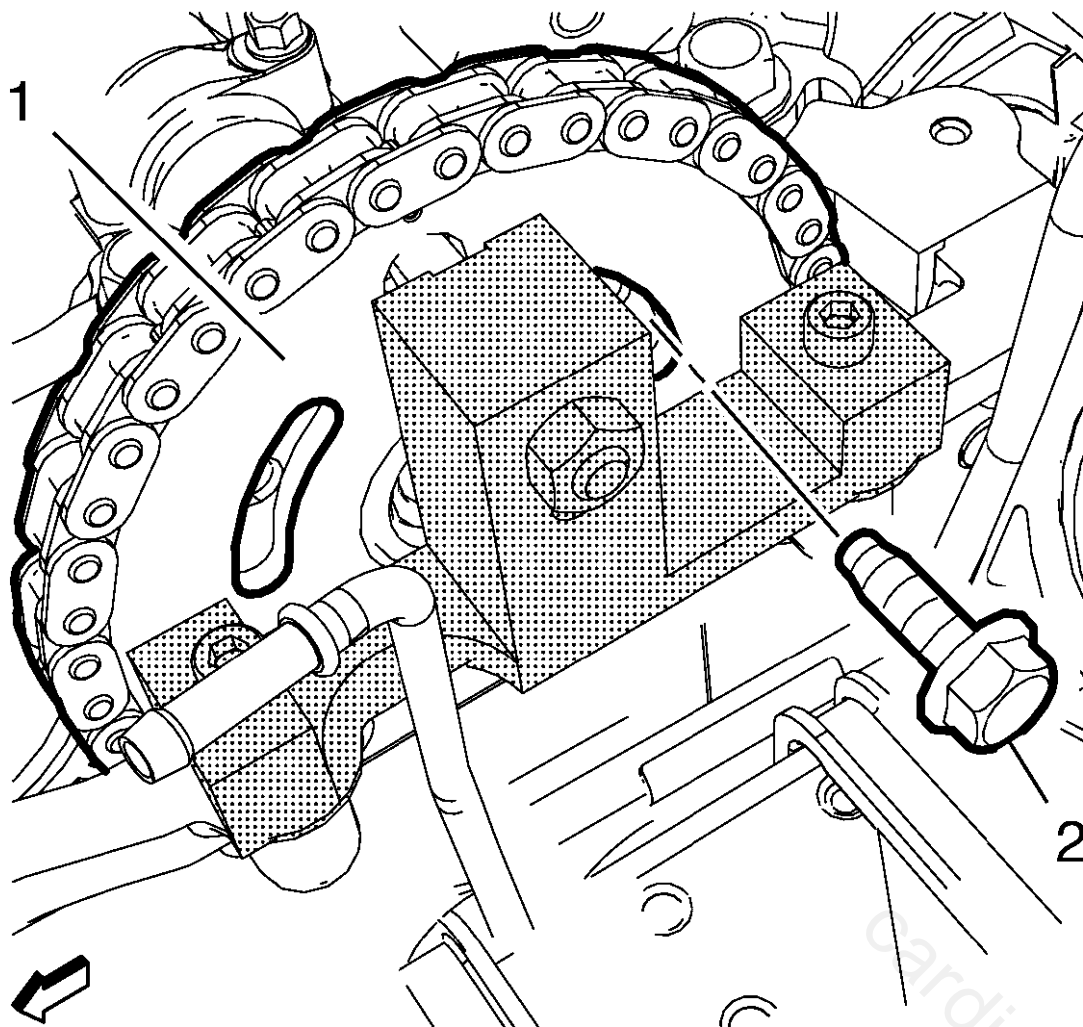


Fig. 194: Camshaft Sprocket And Bolts

Courtesy of GENERAL MOTORS COMPANY

25. Remove the camshaft sprocket bolt (2) from the camshaft sprocket (1). Counterhold with a wrench at the camshaft hexagon.

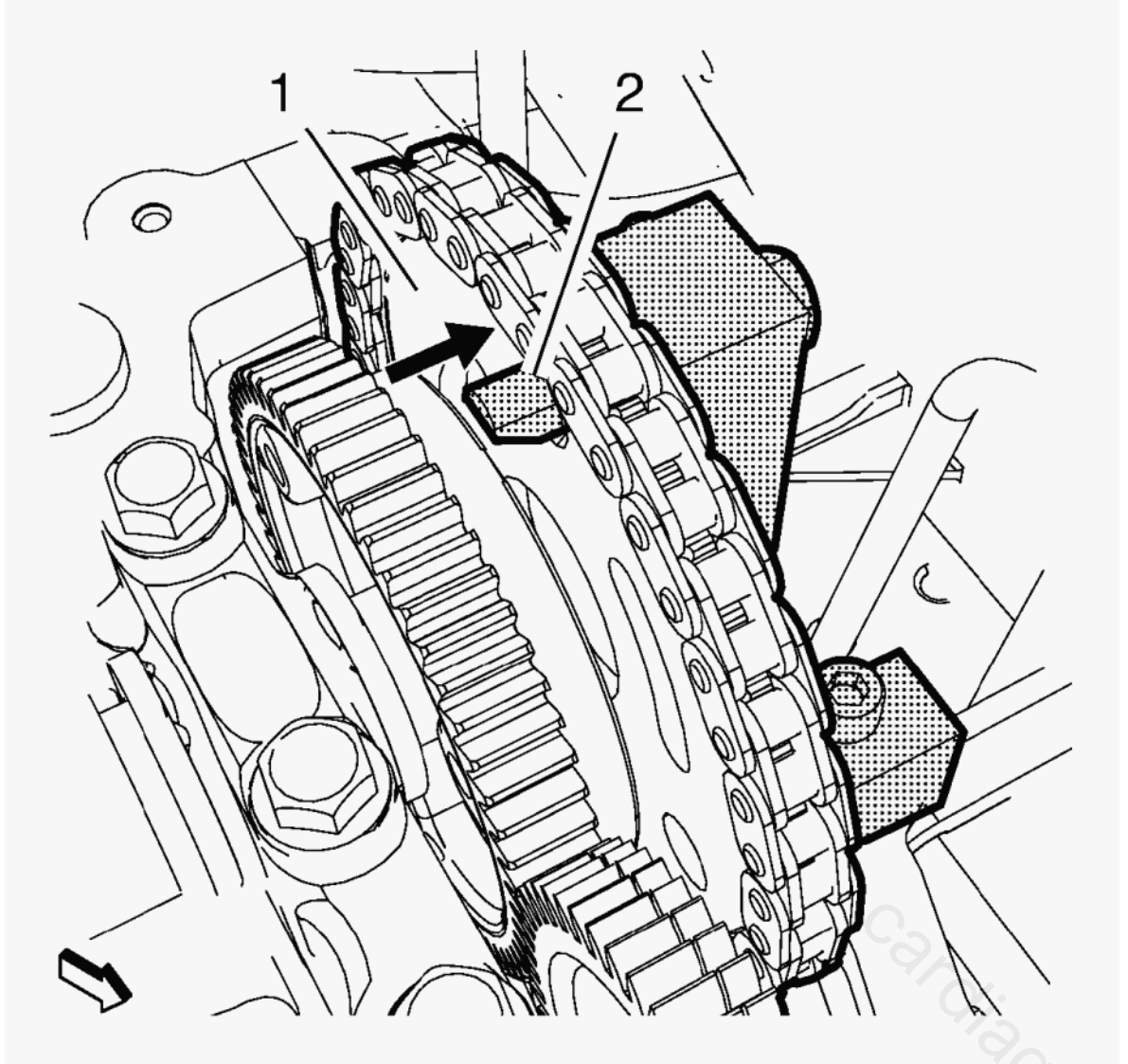


Fig. 195: Camshaft Sprocket Over Pin Of Timing Chain Camshaft Sprocket Fixing Tool
Courtesy of GENERAL MOTORS COMPANY

26. Slide the camshaft sprocket (1) over the pin (2) of the **EN-51188** fixing tool in arrow direction.

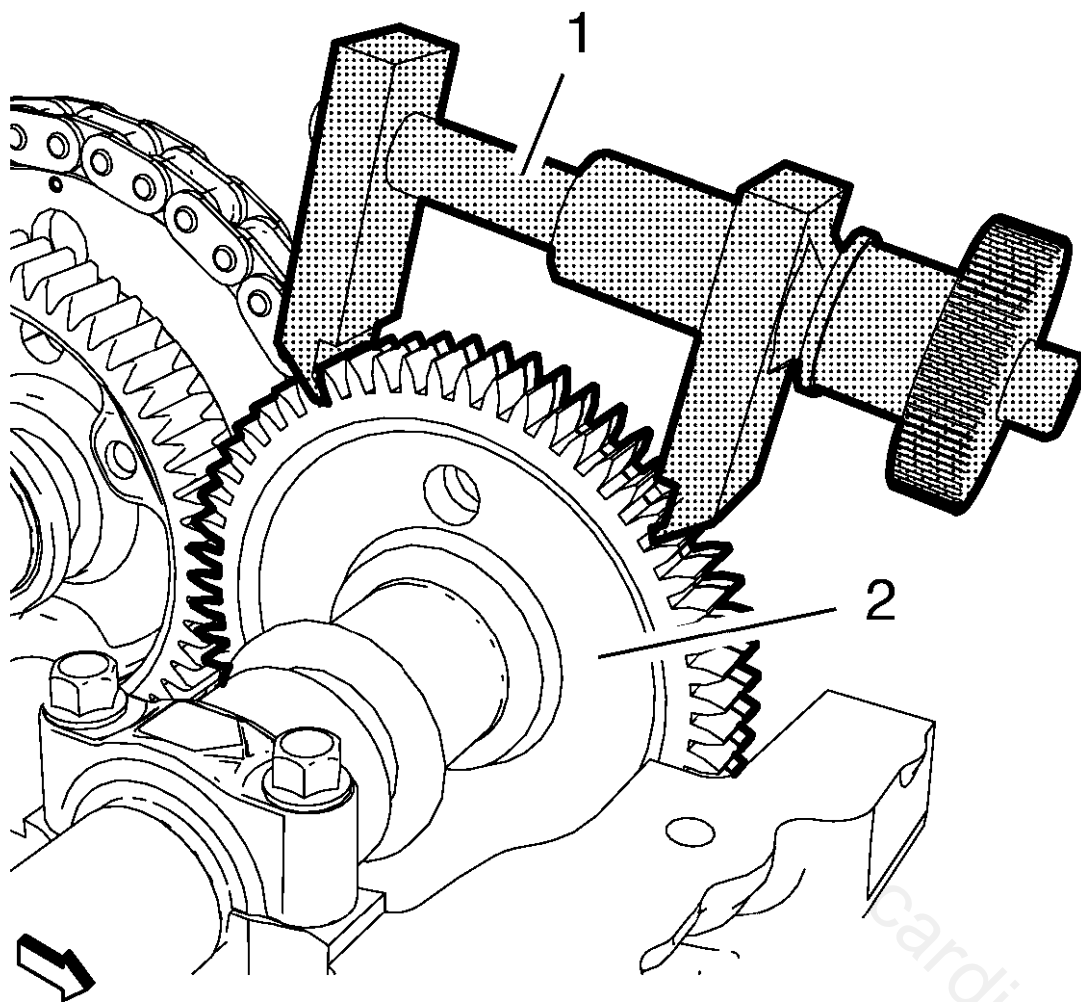


Fig. 196: Split Intake Camshaft Sprocket Fixing Tool
Courtesy of GENERAL MOTORS COMPANY

27. Install the EN-50509 fixing tool (1) to the exhaust camshaft sprocket (2).

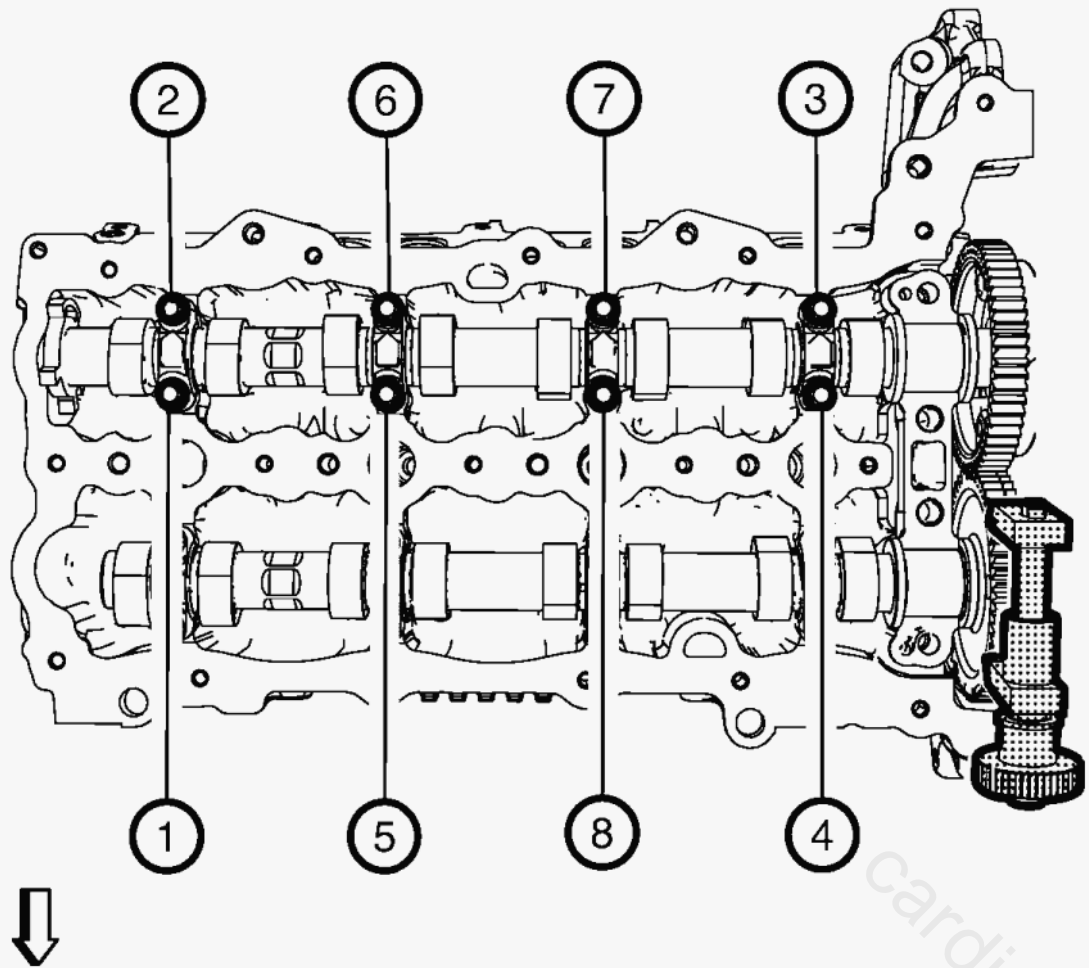


Fig. 197: Intake Camshaft Bearing Cap Bolt Loosening Sequence
 Courtesy of GENERAL MOTORS COMPANY

28. Loosen the 8 intake camshaft bearing cap bolts in sequence as shown.

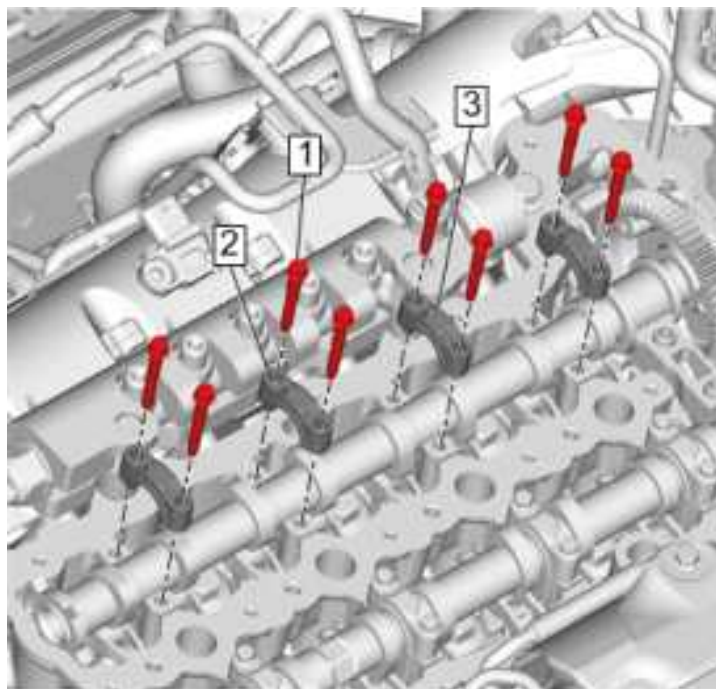


Fig. 198: Intake Camshaft Bearing Caps And Bolts
 Courtesy of GENERAL MOTORS COMPANY

NOTE: Note the direction of the arrows (3) on the camshaft bearing caps pointing to outside of the cylinder head.

29. Remove the 8 intake camshaft bearing cap bolts (1).

30. Remove the 4 intake camshaft bearing caps (2) and lay aside in the order as they were removed.

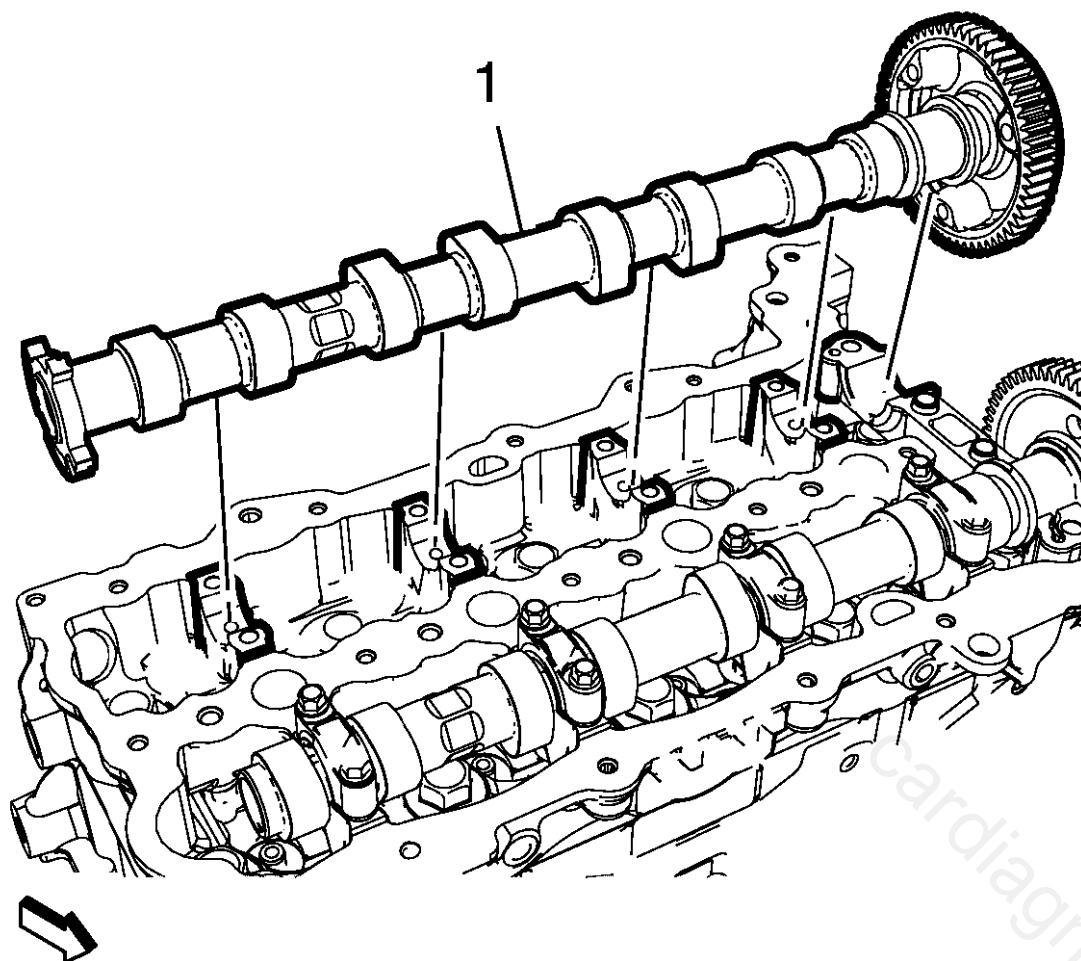


Fig. 199: Intake Camshaft

Courtesy of GENERAL MOTORS COMPANY

31. Remove the intake camshaft (1).

32. Cover the timing case with a lint free cloth.

Installation Procedure

NOTE: Before installing the intake camshaft, check the components of the timing chain system for damage and wear.

1. Check the components of the timing chain system for damage and wear:

- Timing chain guides with plastic attachment
- Timing chain tensioner and timing chain tensioner shoe with plastic attachment
- Timing chain and all timing chain sprockets
- Oil pump sprocket
- Oil pump drive chain tensioner

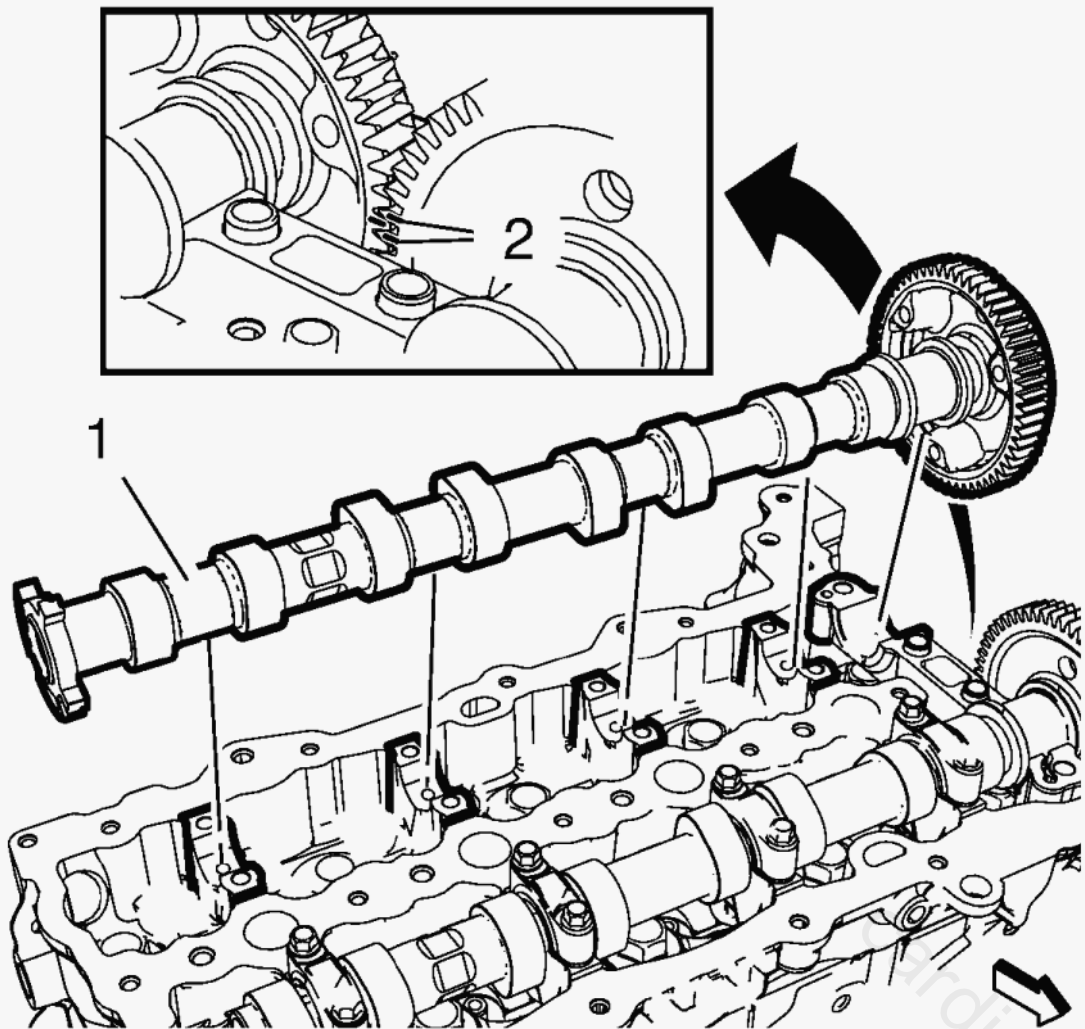


Fig. 200: Intake Camshaft With Camshaft Sprocket Marks Aligned
Courtesy of GENERAL MOTORS COMPANY

2. Coat all bearing surfaces with engine oil.

NOTE: Ensure the marks (2) of the camshaft sprocket are aligned.

3. Install the intake camshaft (1).

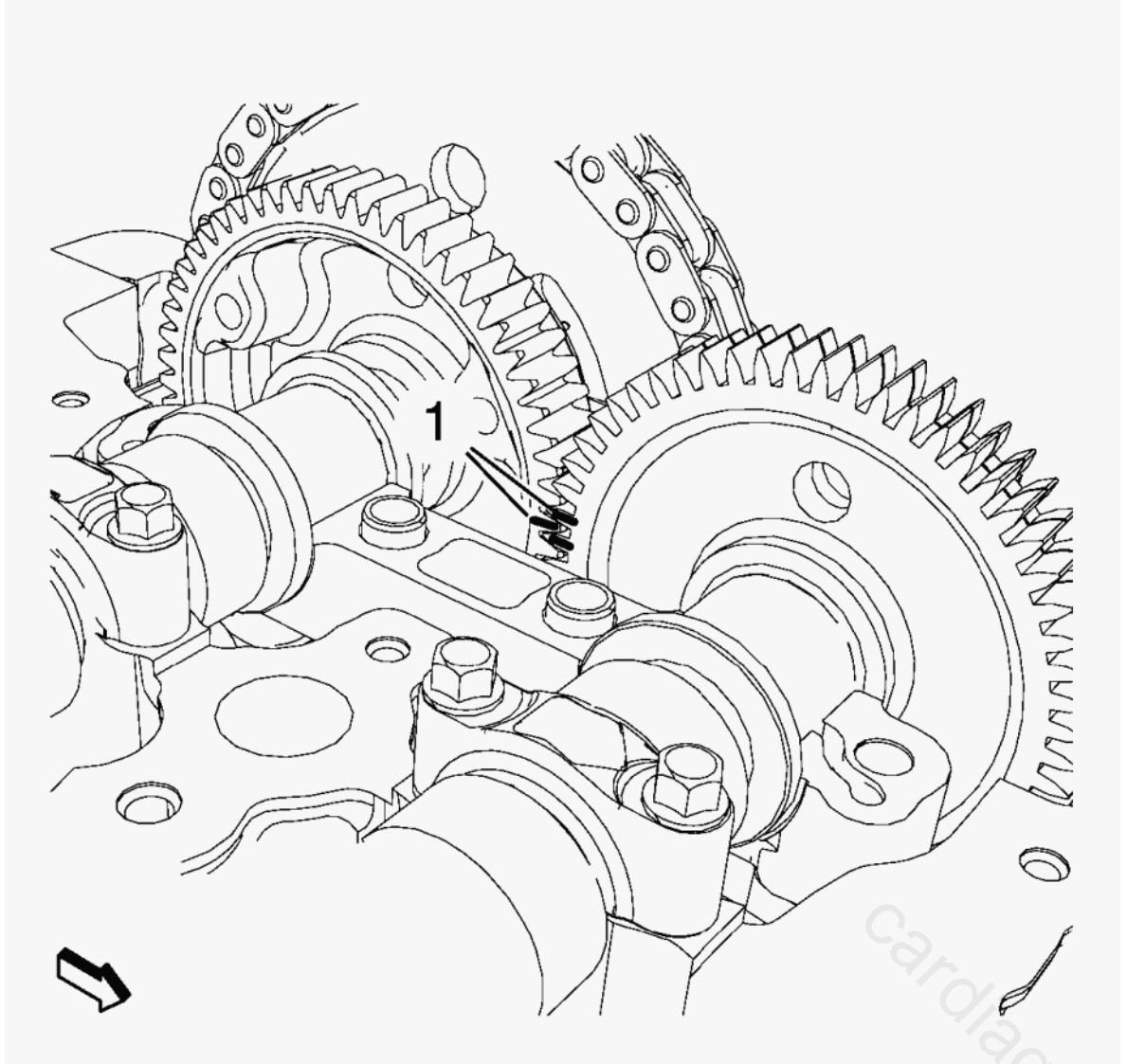


Fig. 201: Marking Exhaust Camshaft Sprocket And Intake Camshaft Sprocket With Paint Marks
 Courtesy of GENERAL MOTORS COMPANY

4. Check the marks (1) of the camshaft sprockets to ensure they are aligned.

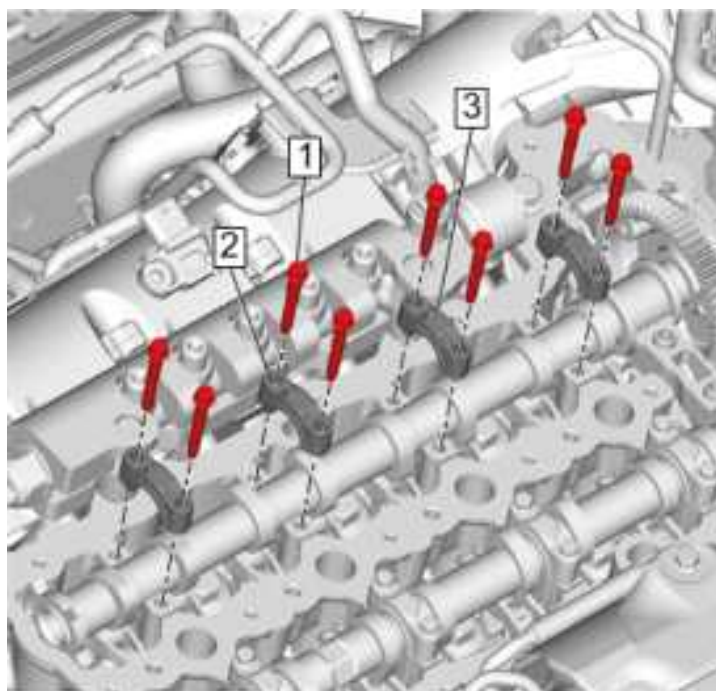


Fig. 202: Intake Camshaft Bearing Caps And Bolts
 Courtesy of GENERAL MOTORS COMPANY

NOTE: Note the direction of the arrows (3) on the camshaft bearing caps pointing to outside of the cylinder head.

5. Install the 4 intake camshaft bearing caps (2) in the order as they were removed.
6. Install the 8 intake camshaft bearing cap bolts (1).

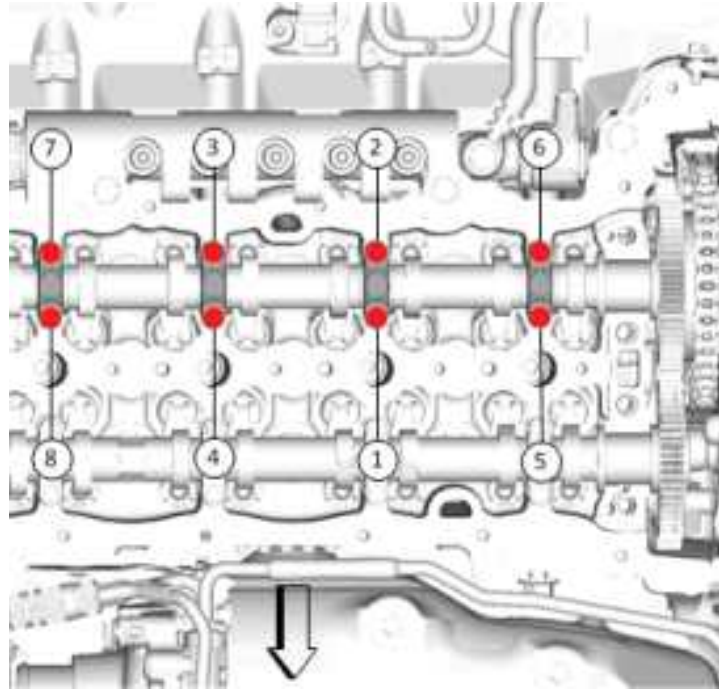
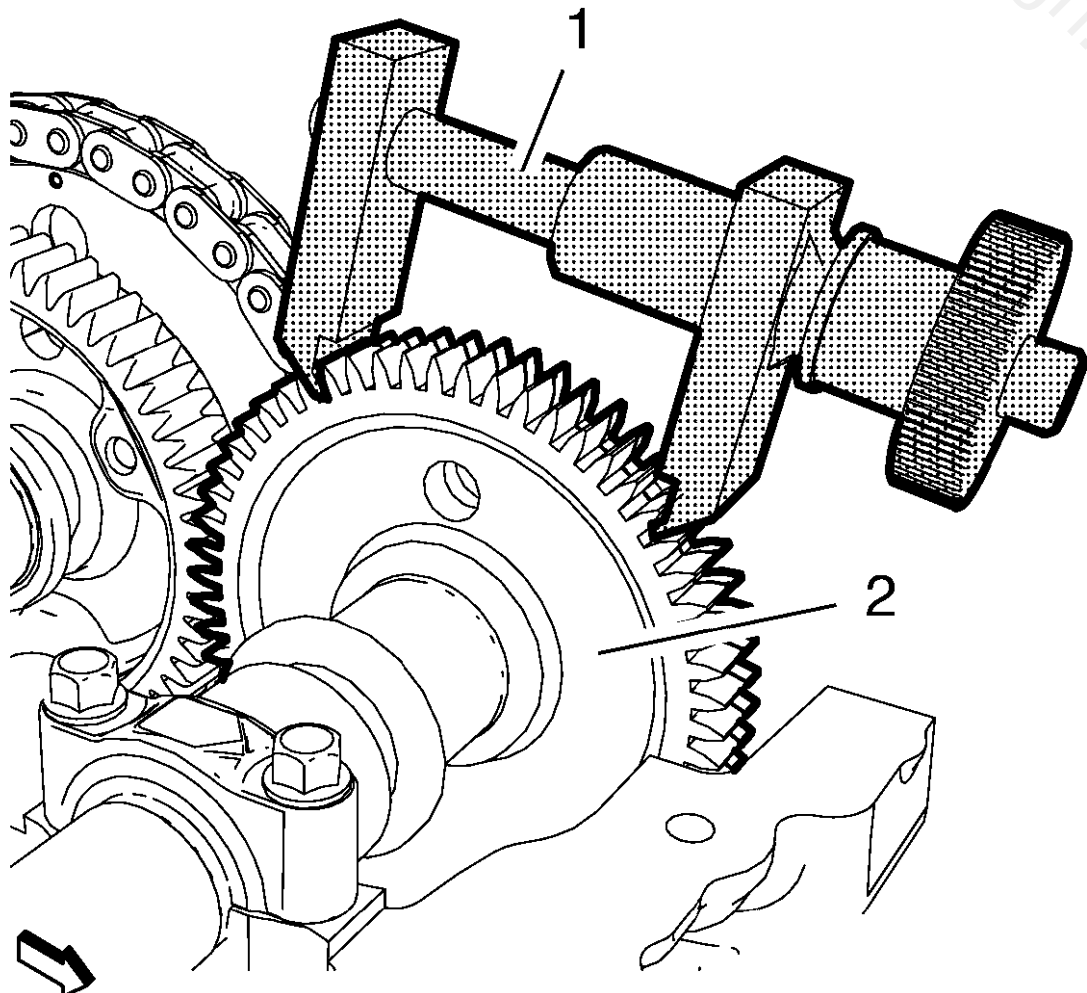


Fig. 203: Intake Camshaft Bearing Cap Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to [Fastener Caution](#) .

7. Tighten the 8 intake camshaft bearing cap bolts in sequence as shown to 10 N.m (89 lb in).



8. Remove the **EN-50509** fixing tool (1) or the transport lock from the exhaust camshaft sprocket (2).

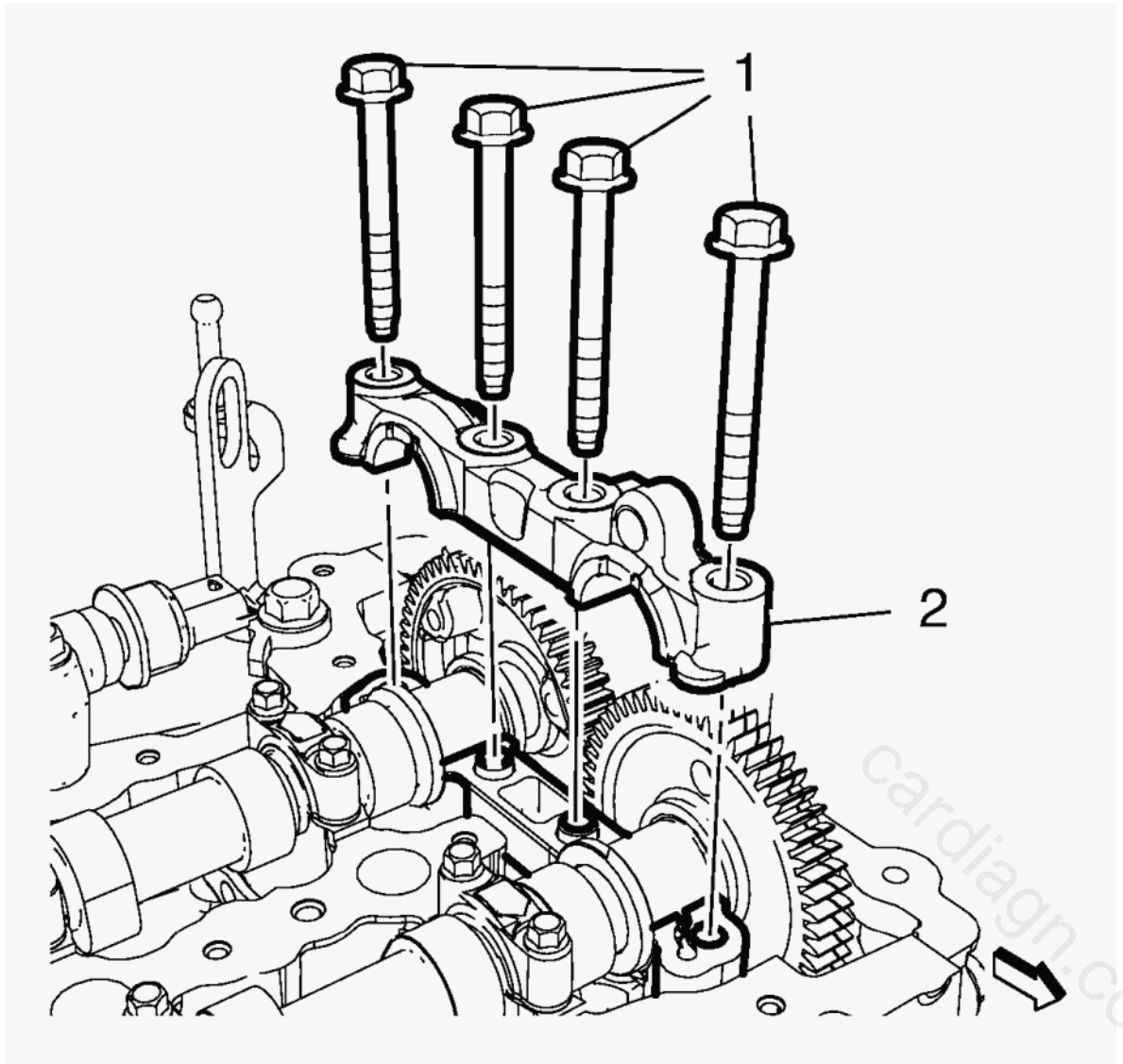


Fig. 205: Camshaft Bearing Rear Cap And Bolts
Courtesy of GENERAL MOTORS COMPANY

9. Coat all bearing surfaces with engine oil.
10. Install the camshaft bearing rear cap (2).
11. Install the 4 camshaft bearing rear cap bolts (1).

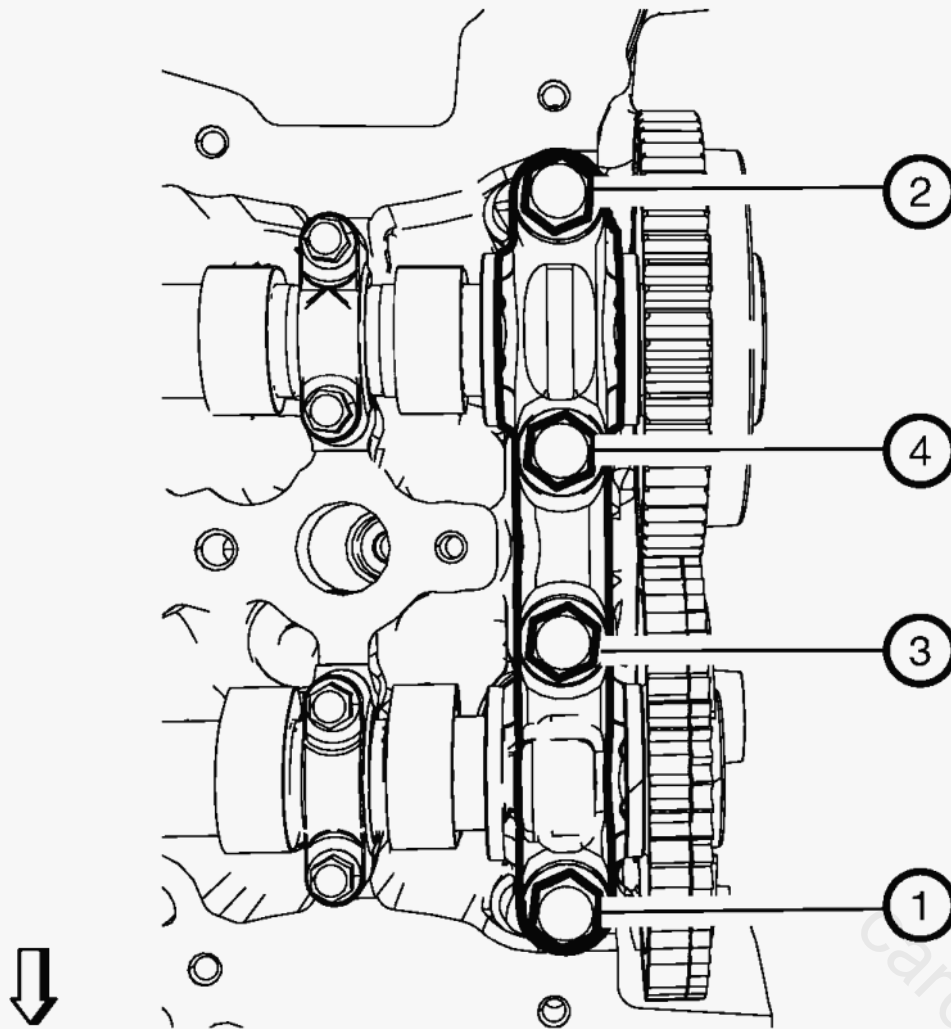


Fig. 206: Camshaft Rear Cap Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

12. Tighten the 4 camshaft rear cap bolts in sequence as shown to 25 N.m (18 lb ft).

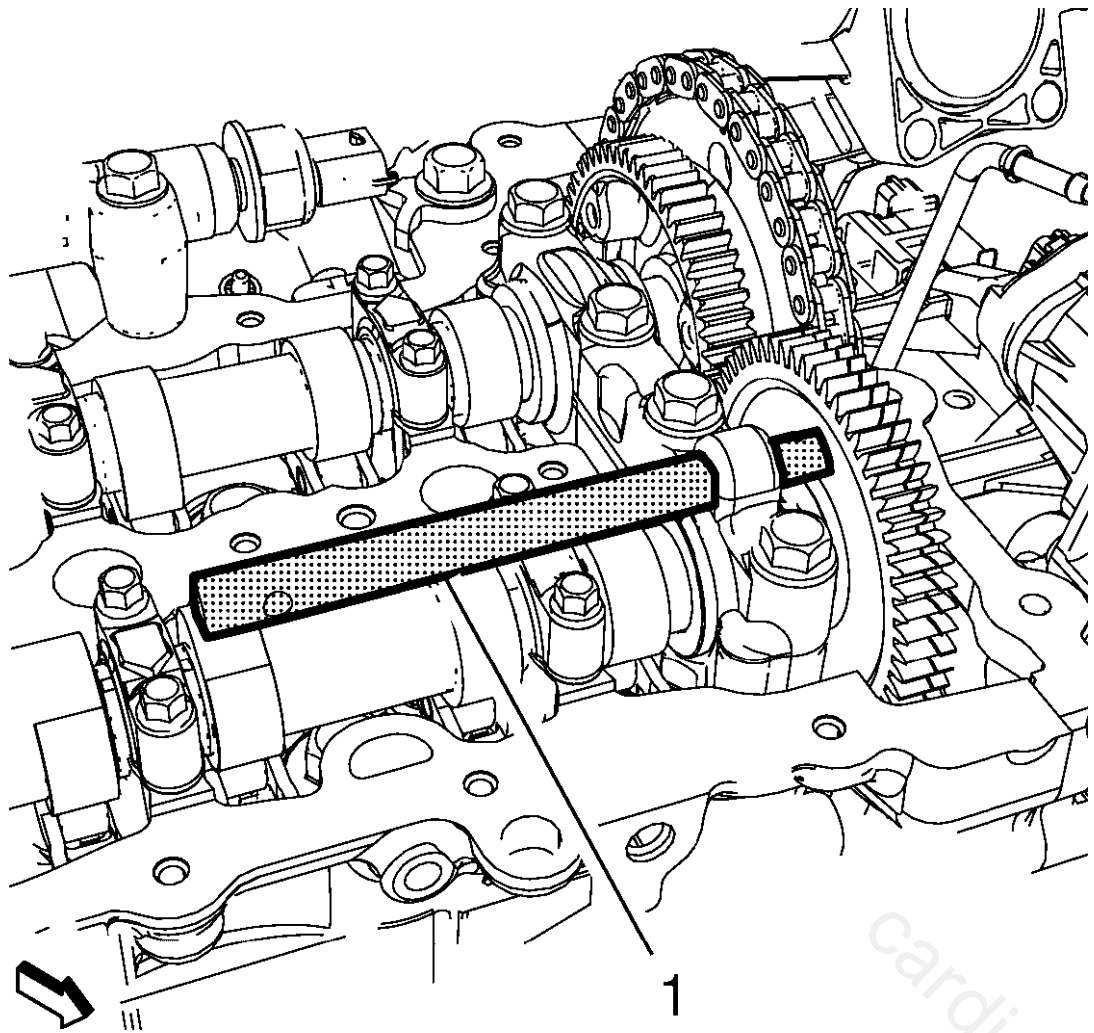


Fig. 207: Camshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

13. To check for proper alignment, install the **EN-51143** fixing tool (1), by carefully turning the hexagon of the camshaft.

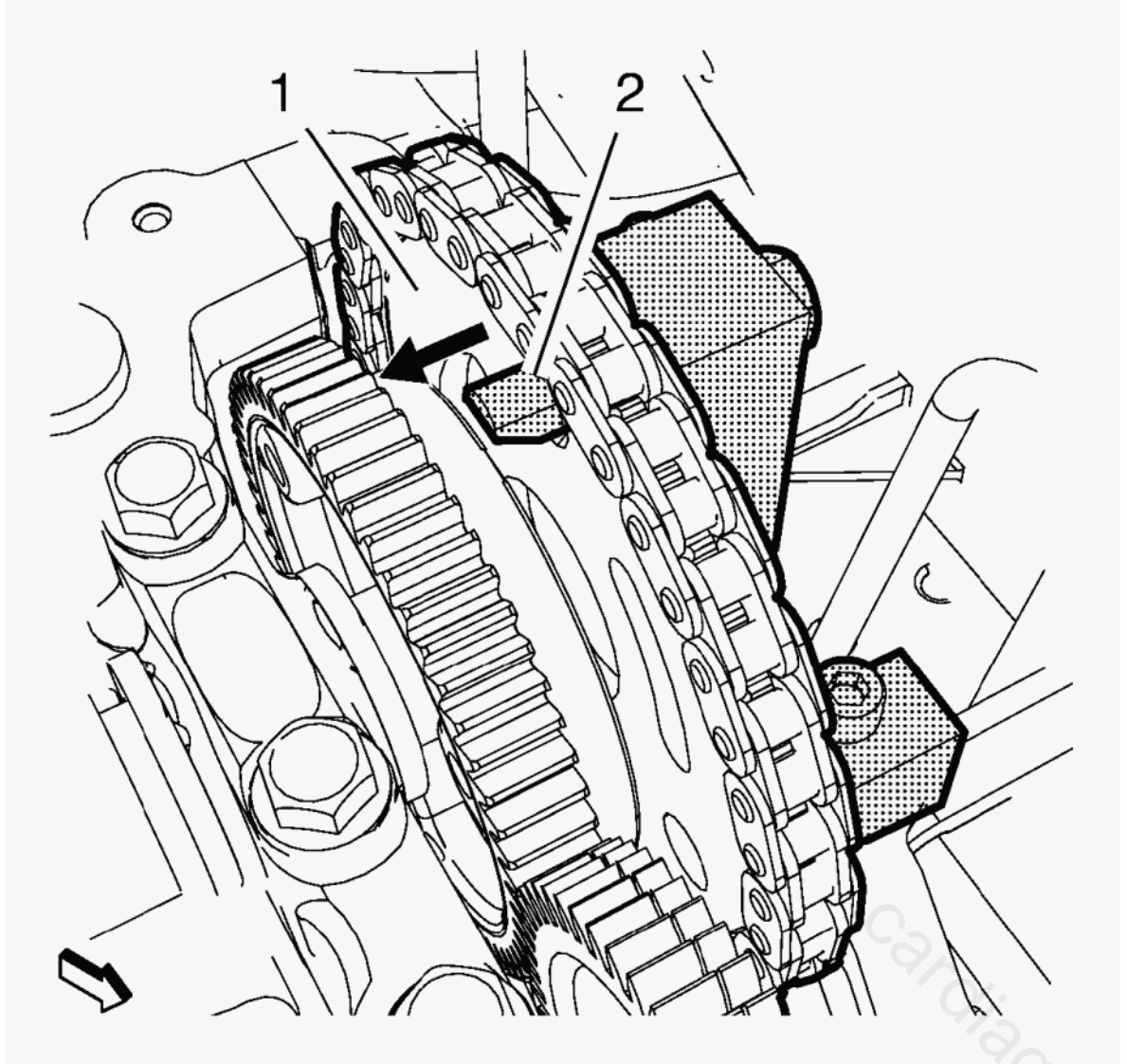


Fig. 208: Camshaft Sprocket Over Pin Of Timing Chain Camshaft Sprocket Fixing Tool
Courtesy of GENERAL MOTORS COMPANY

14. Slide the camshaft sprocket (1) over the pin (2) of the **EN-51188** fixing tool in arrow direction.

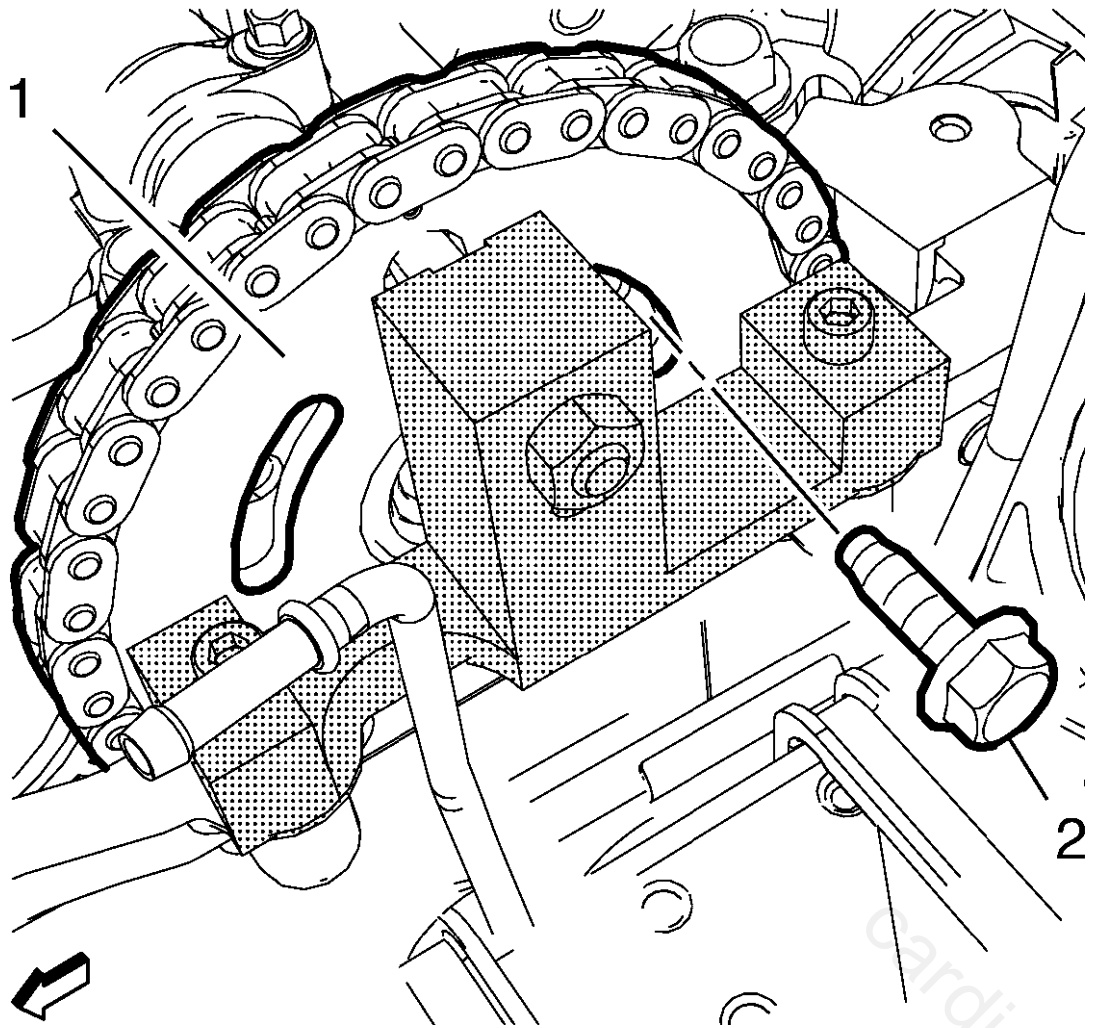


Fig. 209: Camshaft Sprocket And Bolts

Courtesy of GENERAL MOTORS COMPANY

15. Check that the camshaft sprocket (1) on the camshaft is properly applied.
16. Install the camshaft sprocket bolts (2), counterhold with a wrench at the camshaft hexagon, and tighten to 25 N.m (18 lb ft).

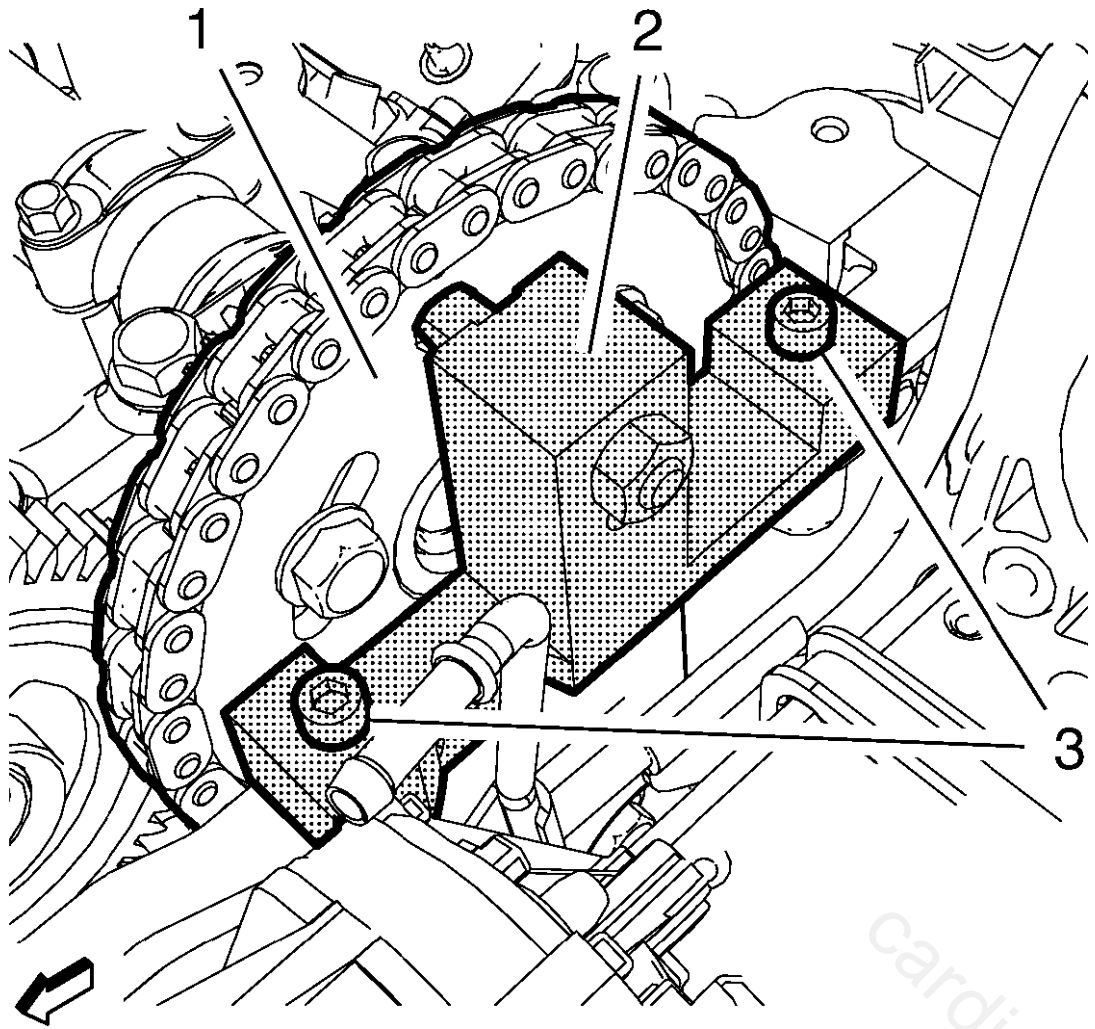


Fig. 210: Timing Chain Camshaft Sprocket Fixing Tool
Courtesy of GENERAL MOTORS COMPANY

17. Remove the 2 bolts (3).
18. Remove **EN-51188** fixing tool (2).

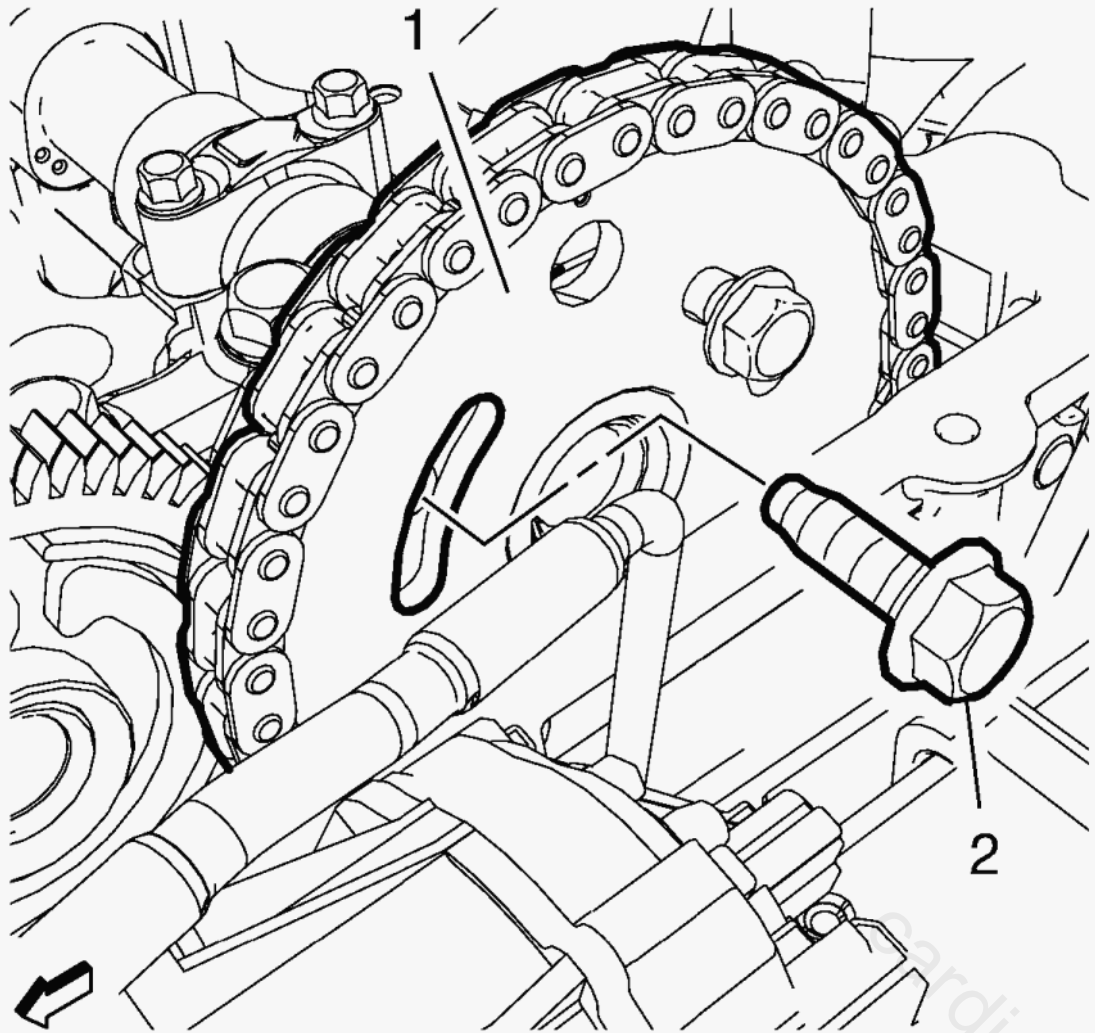


Fig. 211: Camshaft Sprocket And Bolt

Courtesy of GENERAL MOTORS COMPANY

NOTE: Cover the timing case with a lint-free cloth.

19. Install the camshaft sprocket bolt (2) to the camshaft sprocket (1), counterhold with a wrench at the camshaft hexagon, and tighten to 25 N.m (18 lb ft).

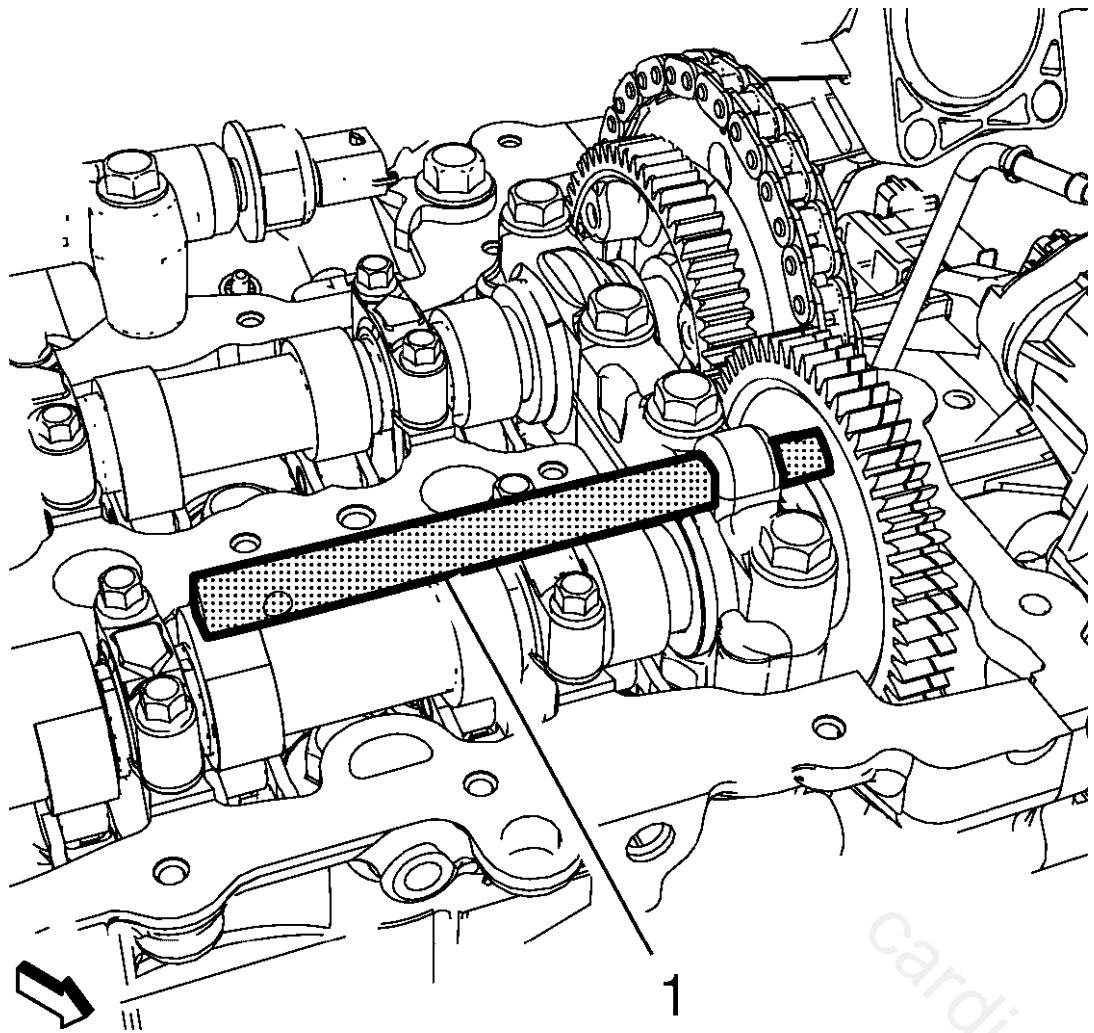


Fig. 212: Camshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

20. Remove the **EN-51143** fixing tool (1).
21. Raise the vehicle.

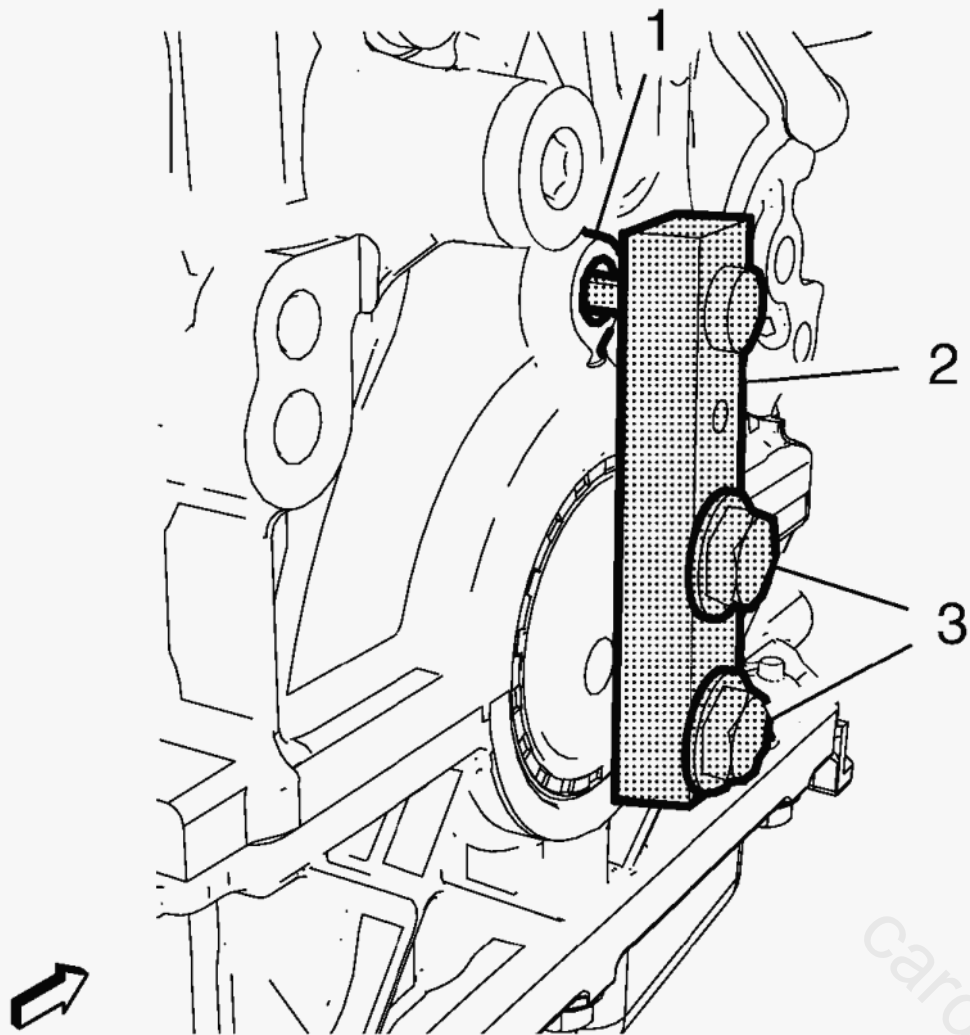


Fig. 213: Crankshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

22. Remove the 2 bolts (3).
23. Remove the **EN-51140** fixing tool (2).

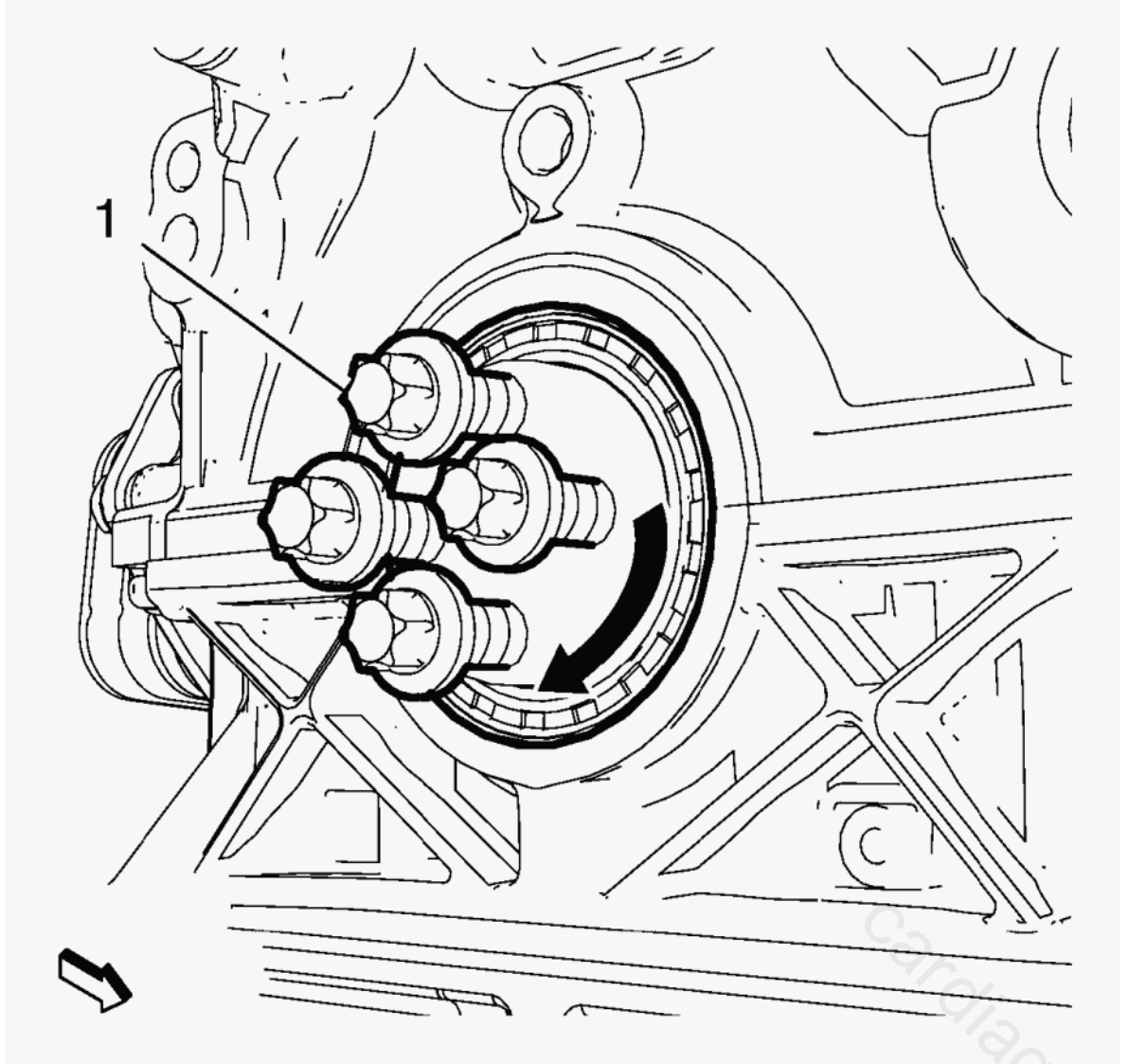


Fig. 214: Crankshaft Pulley Bolts

Courtesy of GENERAL MOTORS COMPANY

24. Install the 4 crankshaft pulley bolts (1).

Rotate the crankshaft 360 degrees in direction of arrow. Use a suitable flat bladed tool at the 4 crankshaft pulley bolts (1).

25. Lower the vehicle.

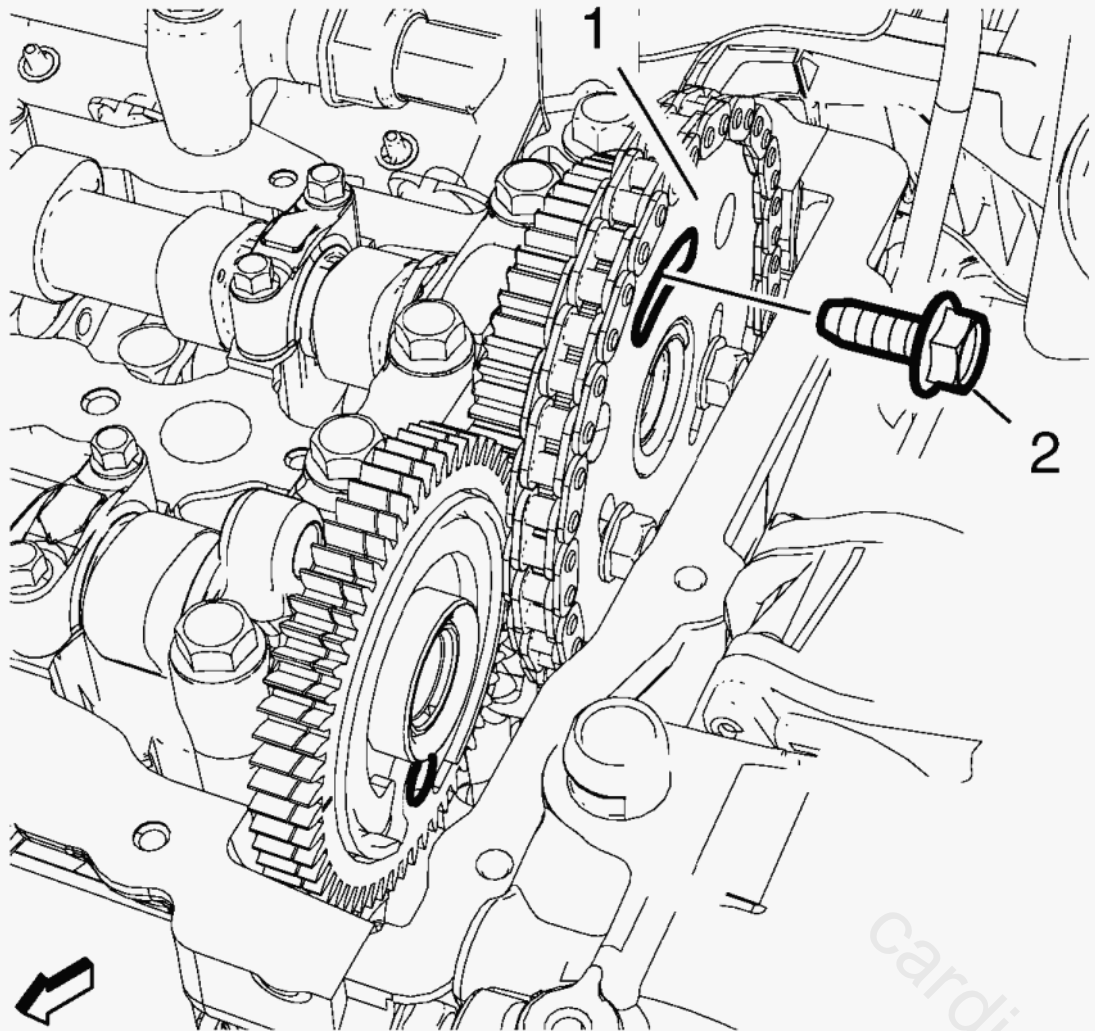


Fig. 215: Camshaft Sprocket And Bolt

Courtesy of GENERAL MOTORS COMPANY

NOTE: Cover the timing case with a lint-free cloth.

26. Install the camshaft sprocket bolt (2), counterhold with a wrench at the camshaft hexagon, and tighten to 25 N.m (18 lb ft).
27. Raise the vehicle.

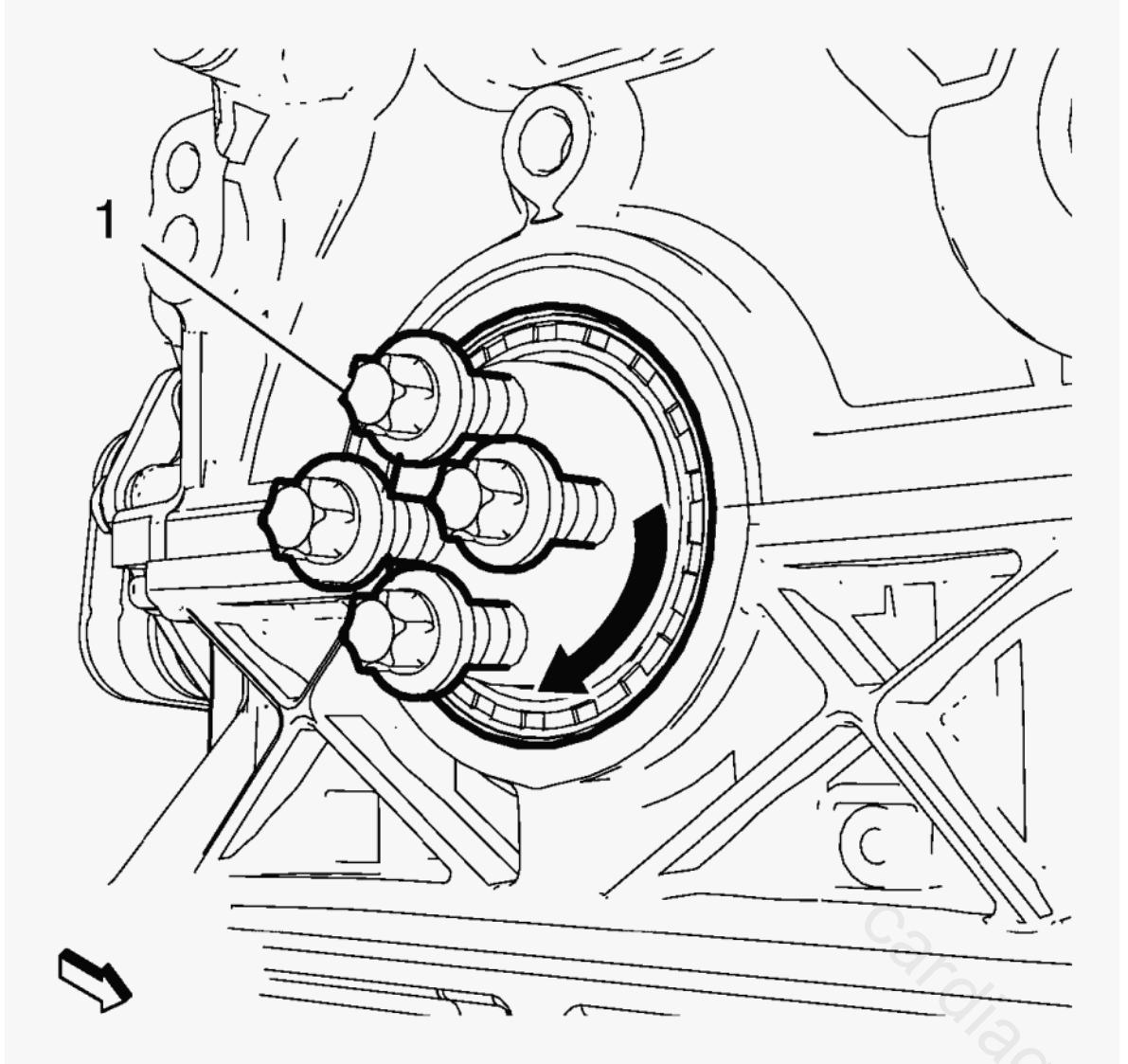


Fig. 216: Crankshaft Pulley Bolts

Courtesy of GENERAL MOTORS COMPANY

28. Rotate the crankshaft 360 degrees in direction of arrow. Use a suitable flat bladed tool.
29. Remove the 4 crankshaft pulley bolts (1).

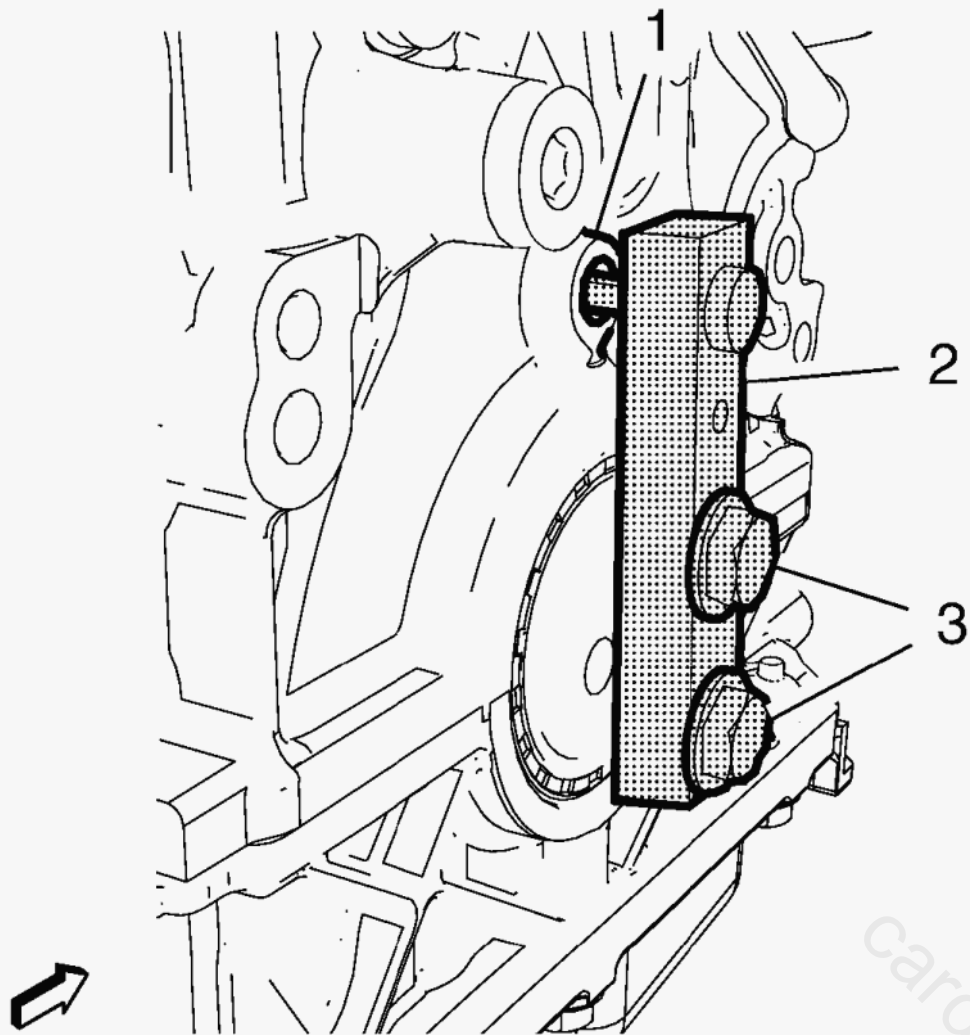


Fig. 217: Crankshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

30. Install the **EN-51140** fixing tool (2).
31. Install the fixing pin into the engine block bore (1) and tighten the 2 bolts (3).
32. Lower the vehicle.

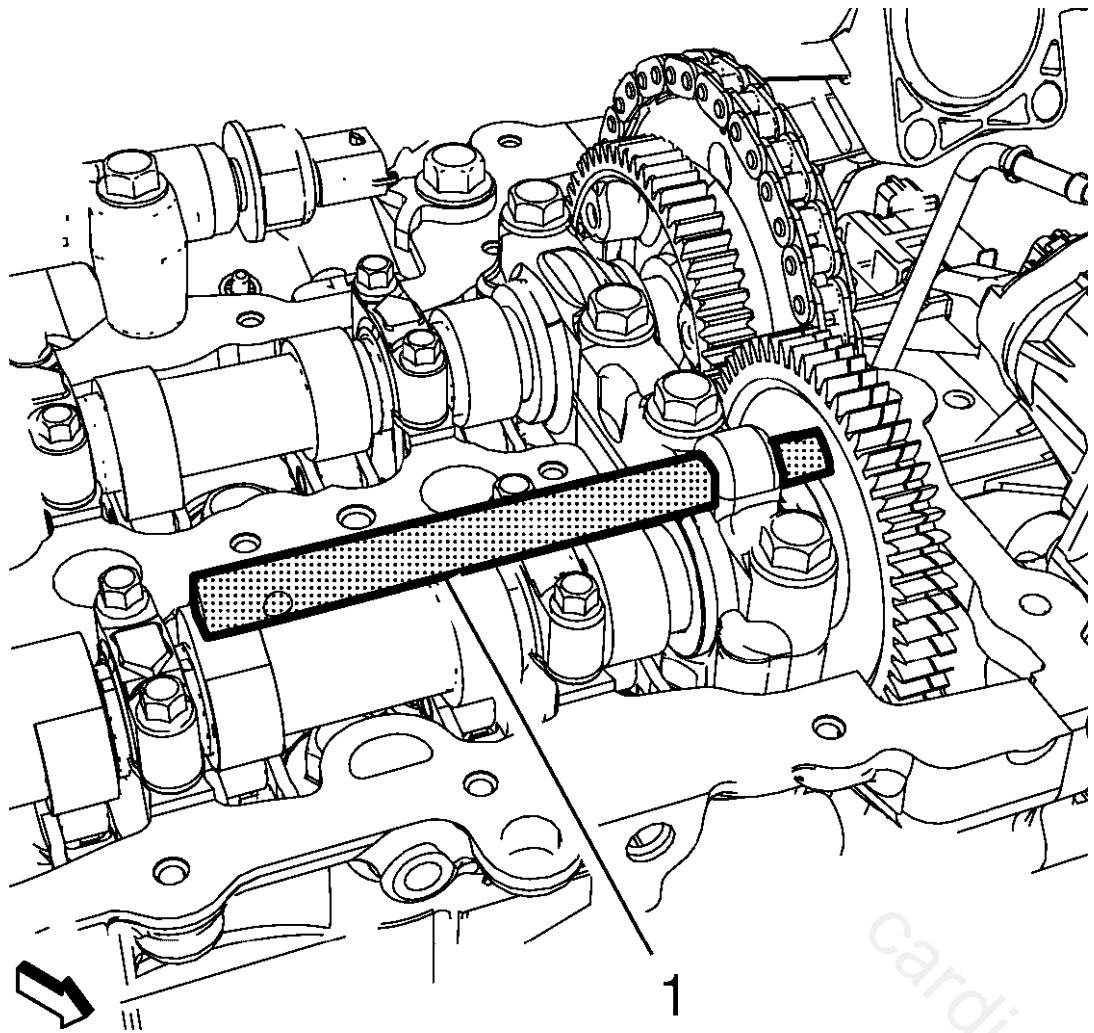


Fig. 218: Camshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

NOTE: If the EN-51143 fixing tool does not fit, adjust timing.

33. Install the **EN-51143** fixing tool (1), by carefully turning the hexagon of the camshaft.
34. Remove the **EN-51143** fixing tool.
35. Raise the vehicle.

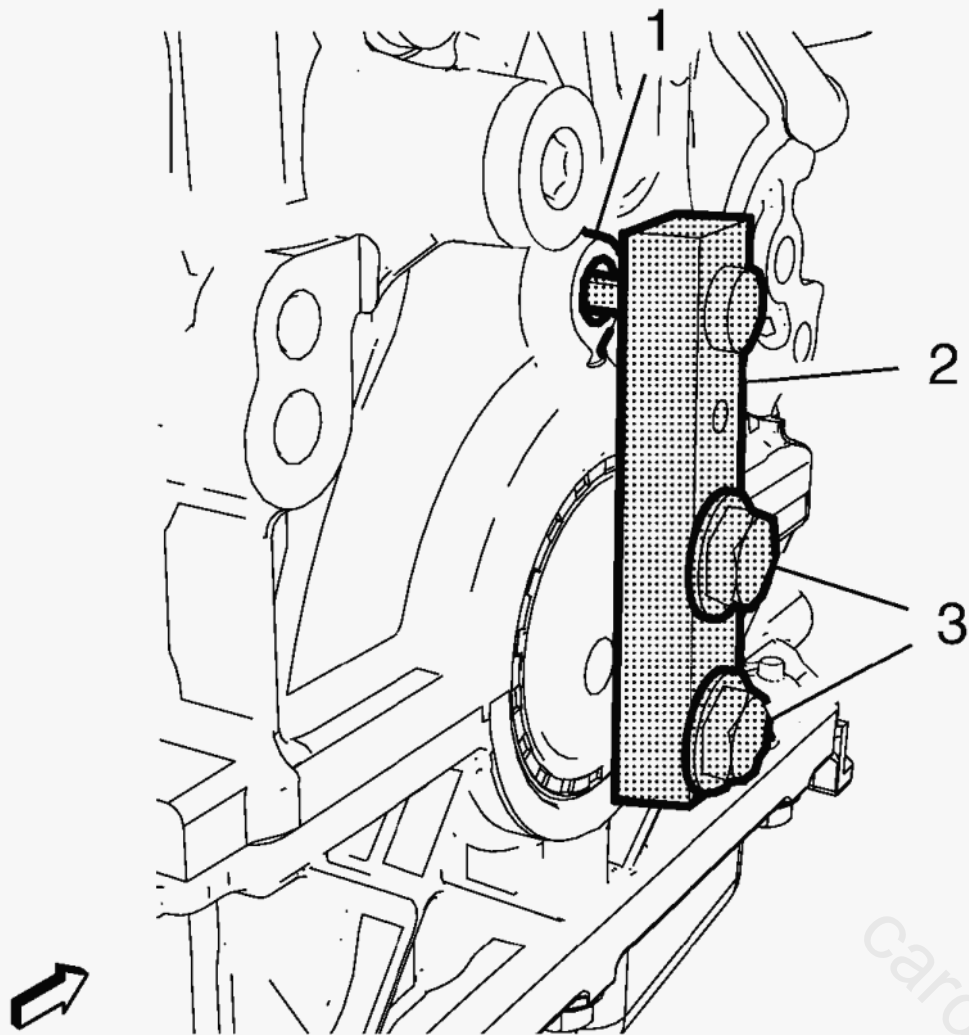


Fig. 219: Crankshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

36. Remove the 2 bolts (3).
37. Remove the **EN-51140** fixing tool (2).
38. Install Crankshaft Pulley. Refer to [Crankshaft Pulley Replacement](#)
39. Install Camshaft Housing. Refer to [Camshaft Housing Replacement](#)
40. Install Throttle Body Assembly. Refer to [Throttle Body Assembly Replacement](#)
41. Connect the battery negative cable. Refer to [Battery Negative Cable Disconnection and Connection \(KL9\)](#)

EXHAUST CAMSHAFT REPLACEMENT

Special Tools

- **EN-50509** Split Intake Camshaft Sprocket Fixing Tool
- **EN-51140** Crankshaft Fixing Tool
- **EN-51143** Camshaft Sprocket Fixing Tool

Equivalent regional tools: [Special Tools](#)

Removal Procedure

1. Disconnect the battery negative cable. Refer to [Battery Negative Cable Disconnection and Connection \(KL9\)](#)
2. Remove Throttle Body Assembly. Refer to [Throttle Body Assembly Replacement](#)
3. Remove Camshaft Housing. Refer to [Camshaft Housing Replacement](#)
4. Remove Crankshaft Pulley. Refer to [Crankshaft Pulley Replacement](#)
5. Lower the vehicle. Refer to [Lifting and Jacking the Vehicle](#)

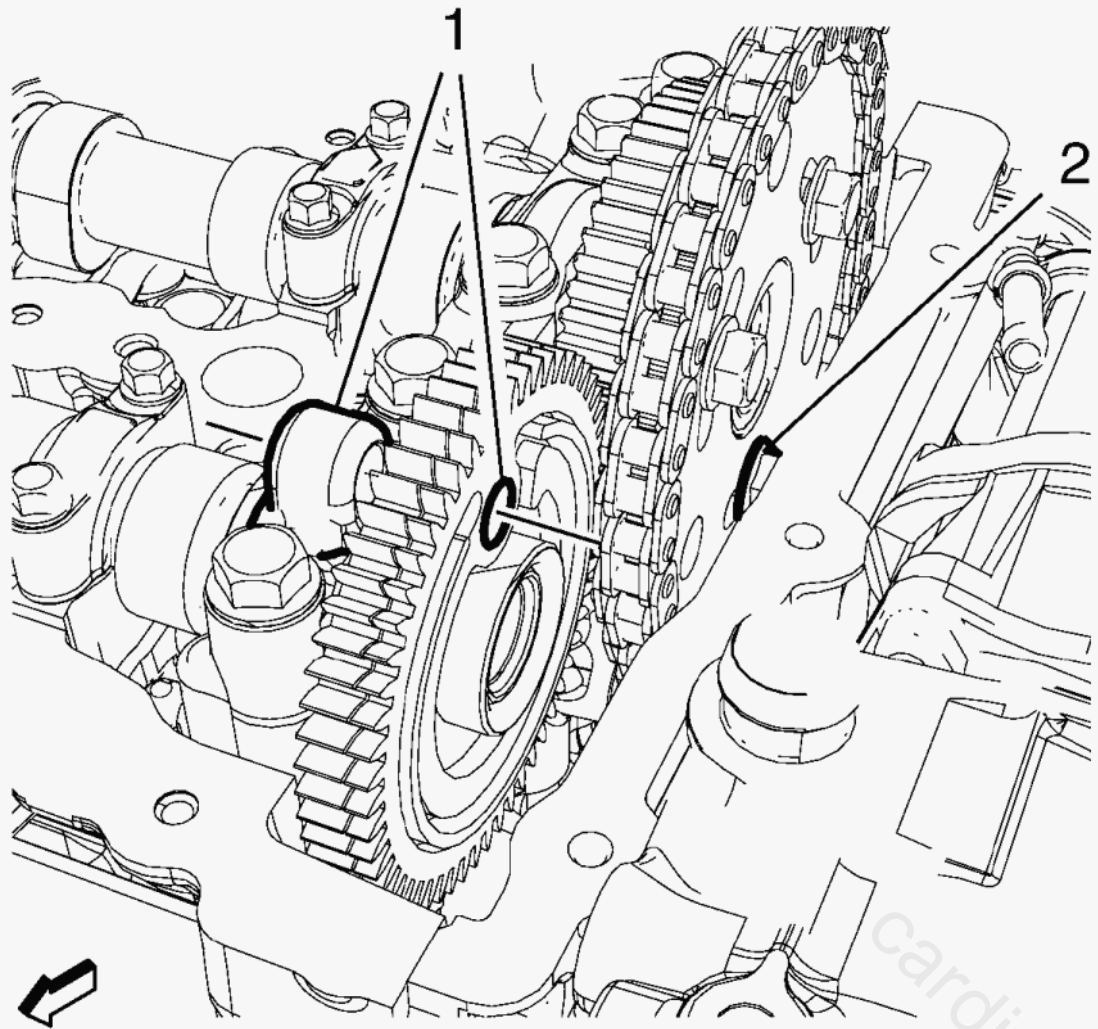


Fig. 220: Aligning Bores

Courtesy of GENERAL MOTORS COMPANY

6. Check if the bores (1) are aligned.
7. Raise the vehicle.

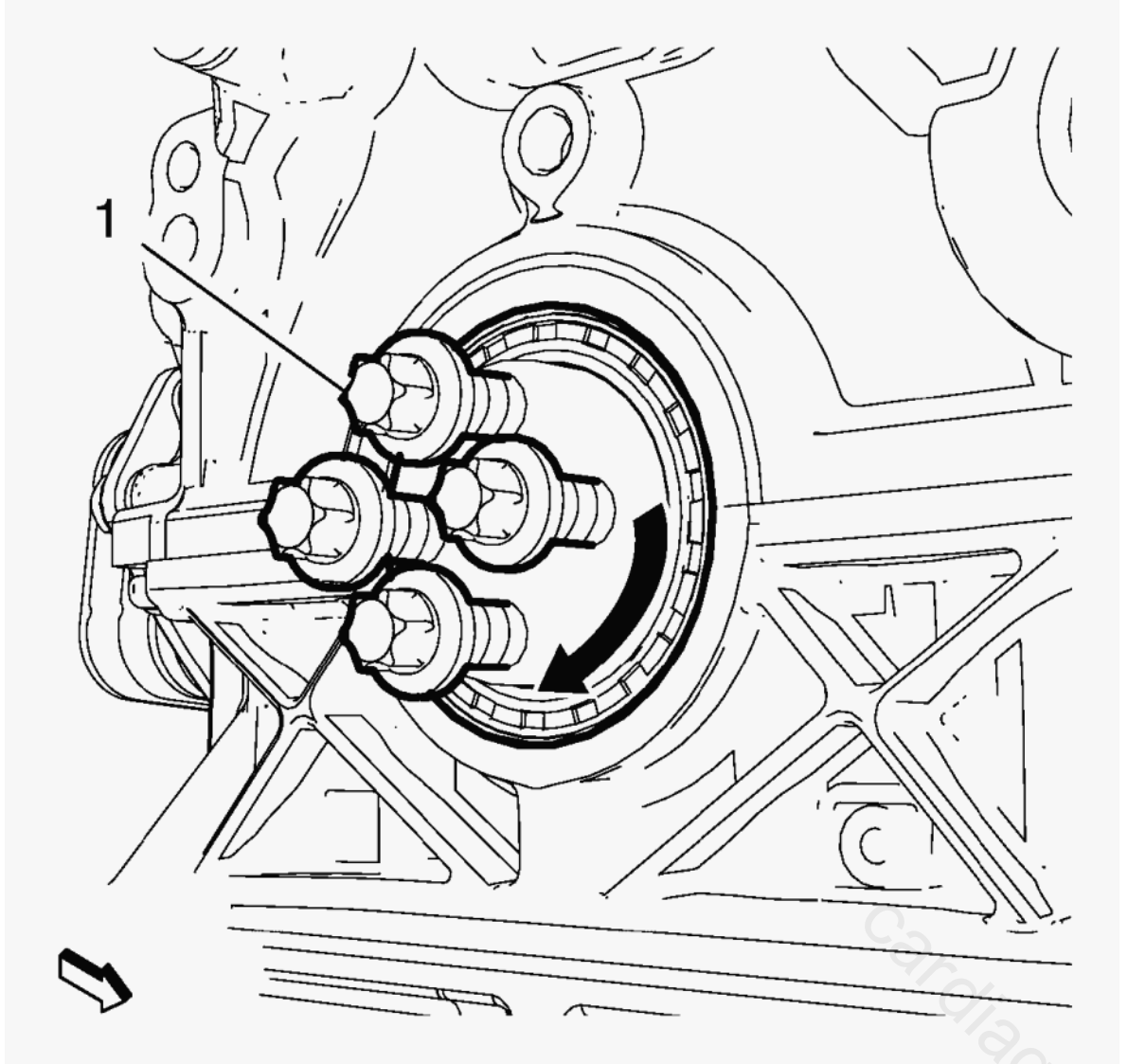


Fig. 221: Crankshaft Pulley Bolts

Courtesy of GENERAL MOTORS COMPANY

8. Install the 4 crankshaft pulley bolts (1).
9. Rotate the crankshaft in the direction of the arrow until the exhaust cam bores are aligned. Use a suitable flat bladed tool.
10. Raise the vehicle.

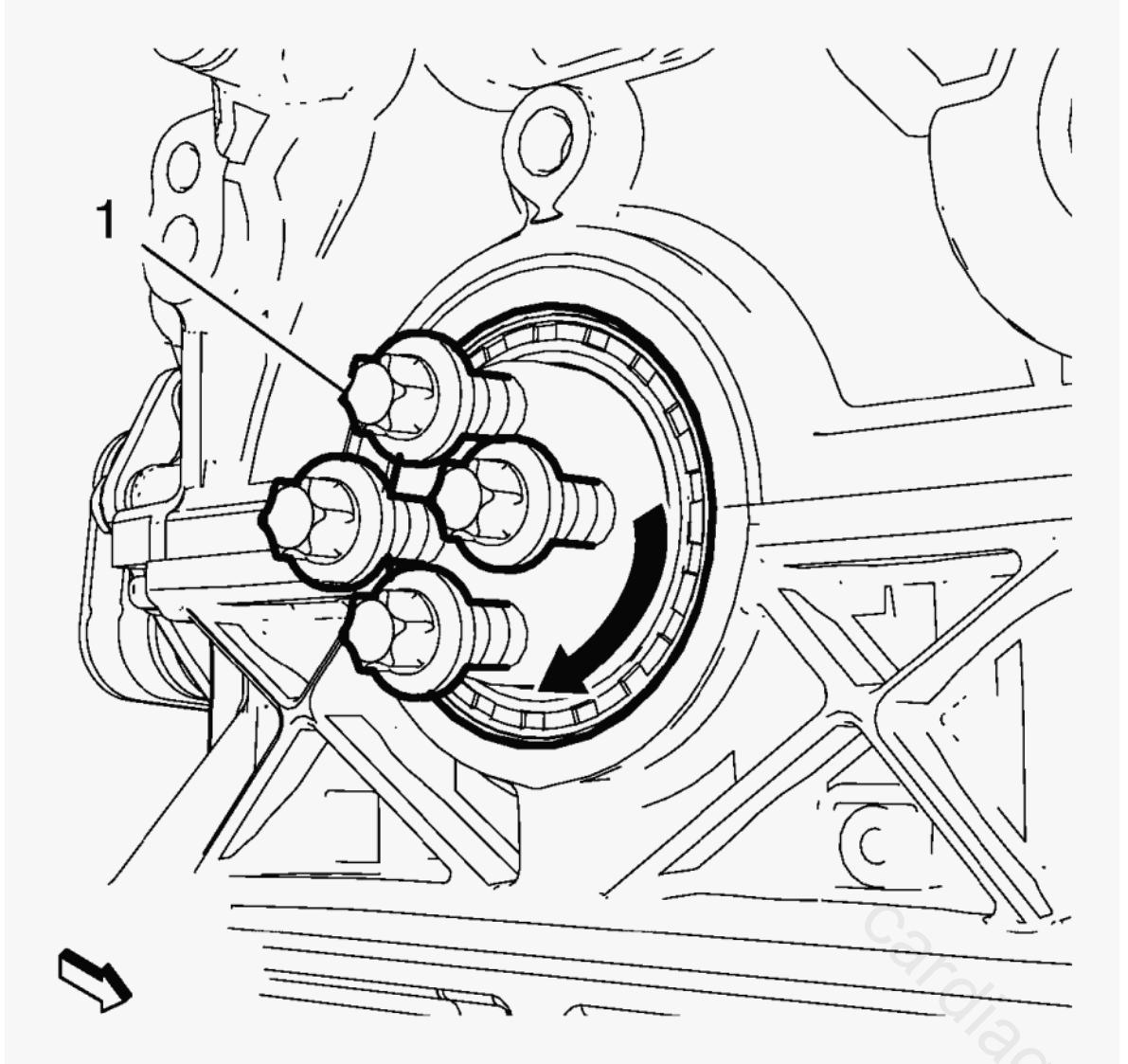


Fig. 222: Crankshaft Pulley Bolts

Courtesy of GENERAL MOTORS COMPANY

11. Remove the 4 crankshaft pulley bolts (1).

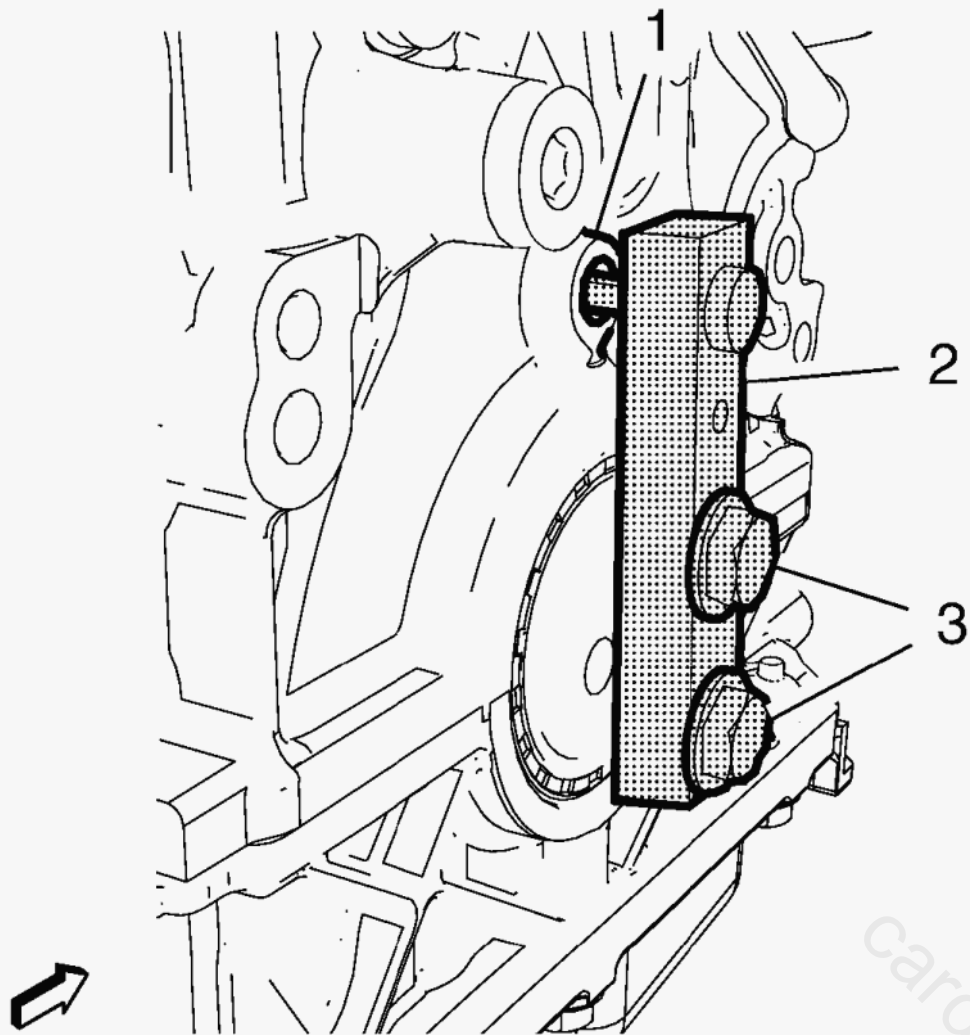


Fig. 223: Crankshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

12. Install the **EN-51140** fixing tool (2).
13. Install the fixing pin into the engine block bore (1) and tighten the 2 bolts (3).
14. Lower the vehicle.
15. Install the 2 bolts (3).

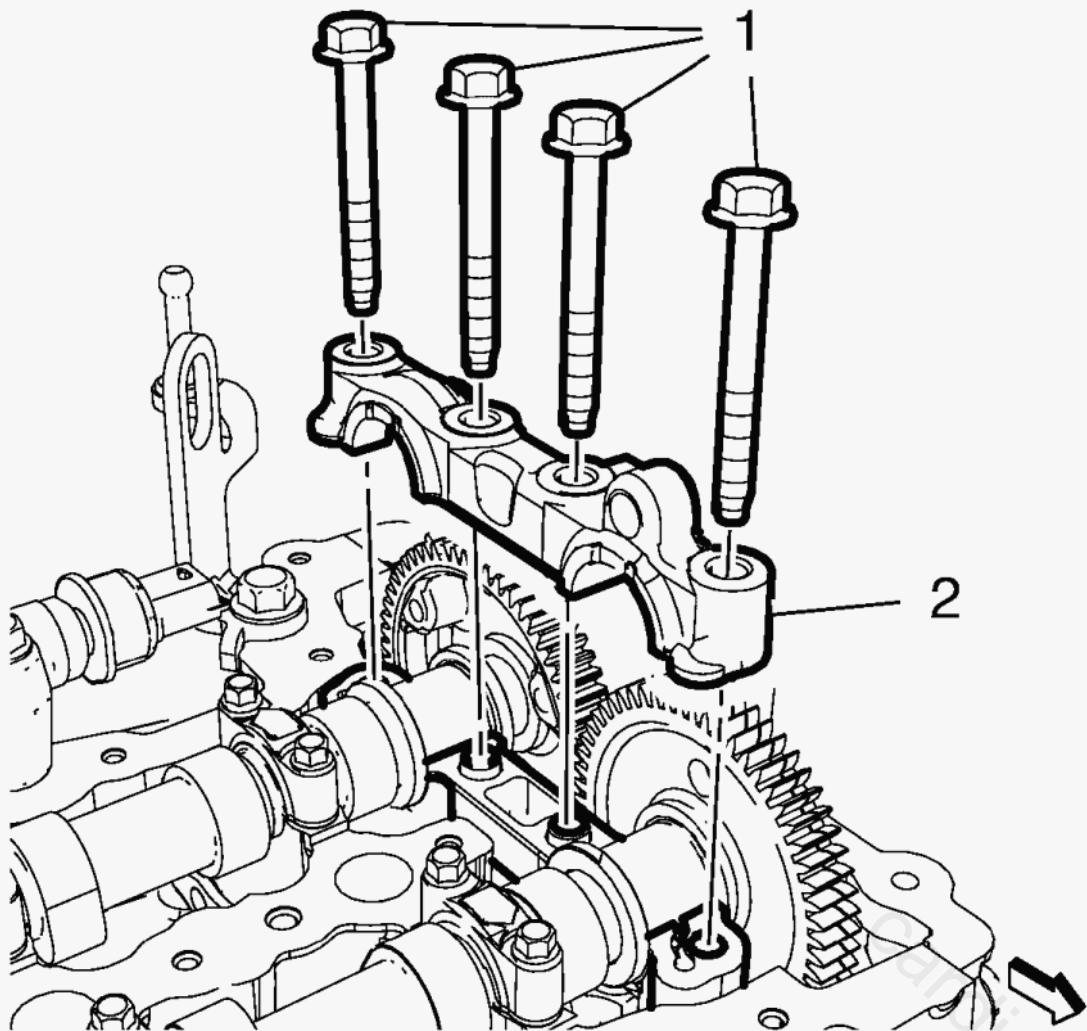


Fig. 224: Camshaft Bearing Rear Cap And Bolts
Courtesy of GENERAL MOTORS COMPANY

16. Remove the 4 camshaft bearing rear cap bolts (1).
17. Remove the camshaft bearing rear cap (2).

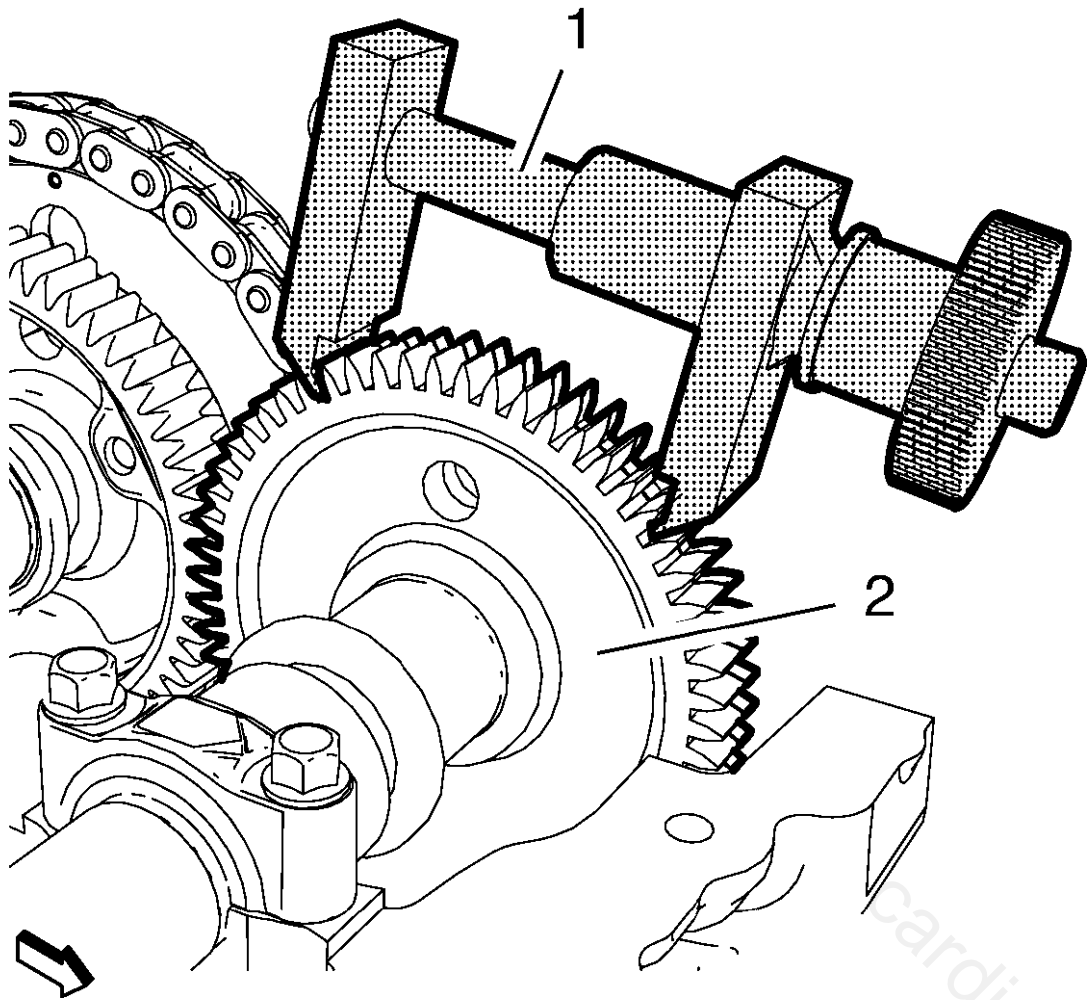


Fig. 225: Split Intake Camshaft Sprocket Fixing Tool
 Courtesy of GENERAL MOTORS COMPANY

18. Install the EN-50509 fixing tool (1) to the exhaust camshaft sprocket (2).

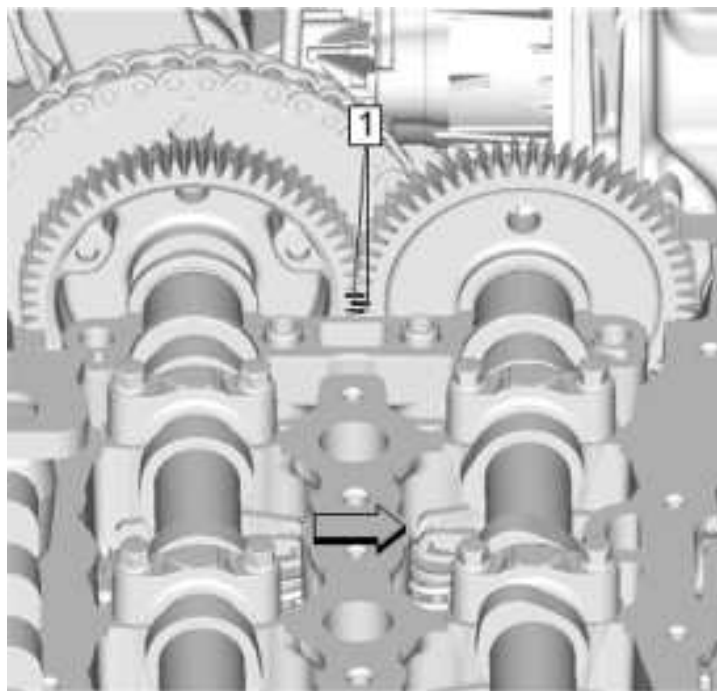


Fig. 226: Mark Backside Of Both Cam Gears With Paint Marks
 Courtesy of GENERAL MOTORS COMPANY

19. Mark the backside of both cam gears with paint marks (1).

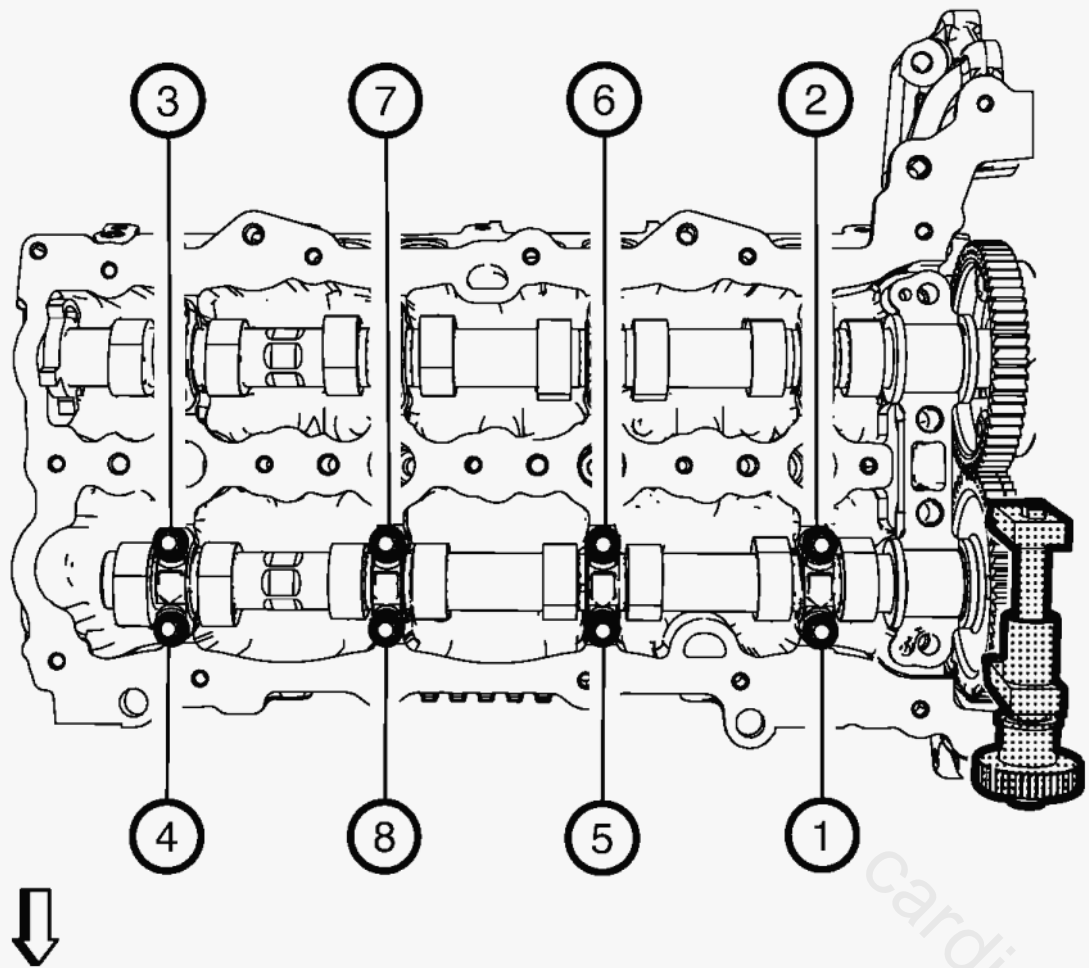


Fig. 227: Exhaust Camshaft Bearing Cap Bolt Loosening Sequence
 Courtesy of GENERAL MOTORS COMPANY

20. Loosen the 8 exhaust camshaft bearing cap bolts in sequence shown.

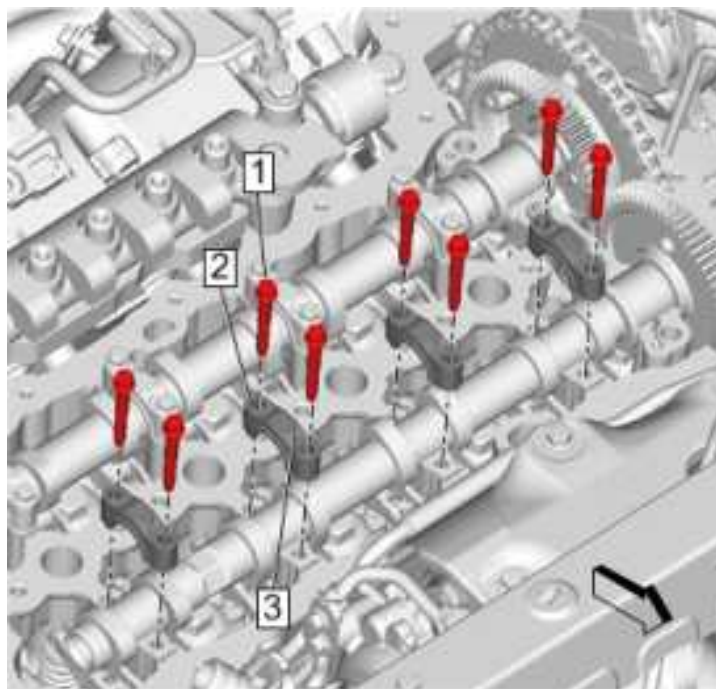


Fig. 228: Exhaust Camshaft Bearing Caps And Bolts
 Courtesy of GENERAL MOTORS COMPANY

NOTE: Note the direction of the arrows (3) on the camshaft bearing caps pointing to outside of the cylinder head.

21. Remove the 8 exhaust camshaft bearing cap bolts (1).

22. Remove the 4 exhaust camshaft bearing caps (2) and lay aside in the order they were removed.

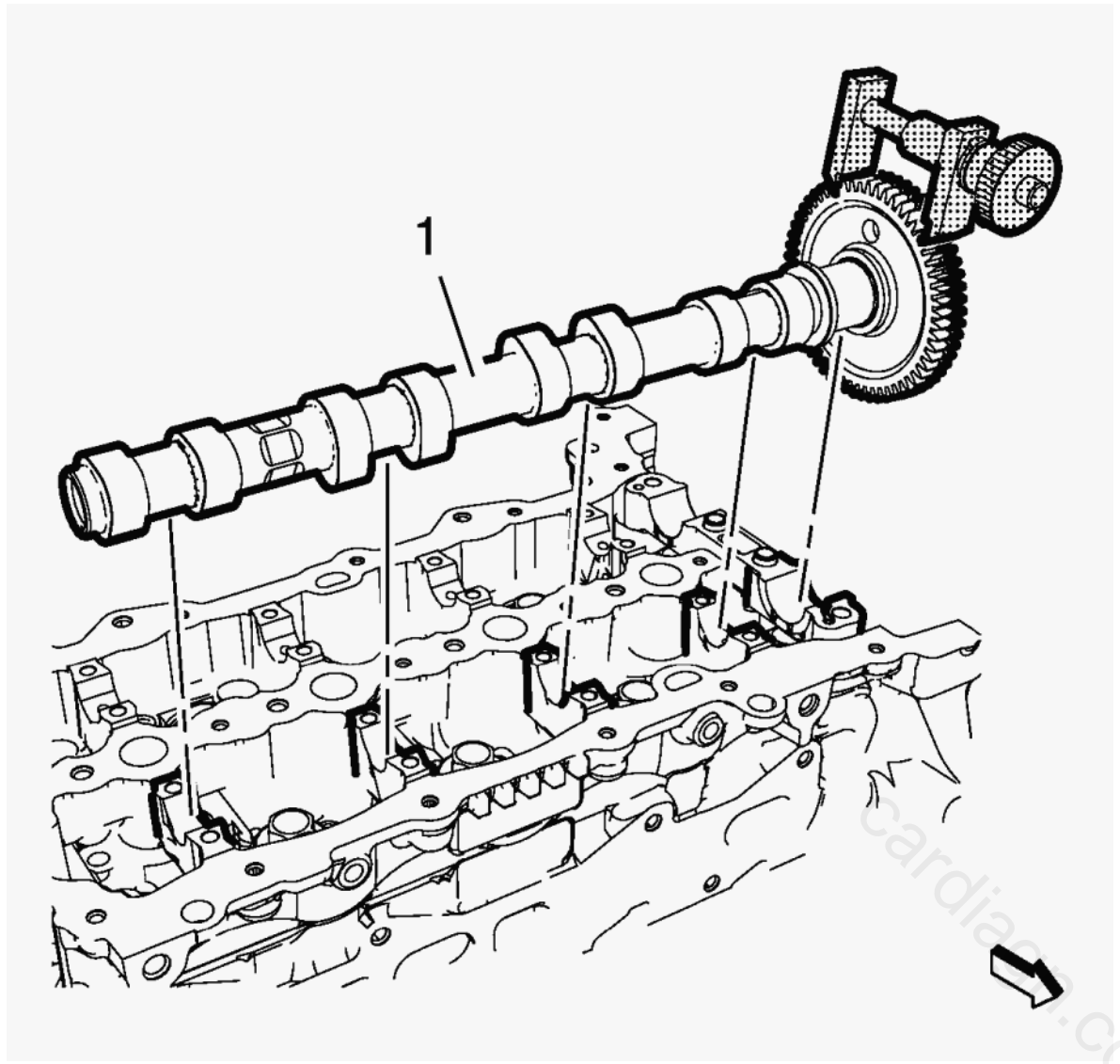


Fig. 229: Exhaust Camshaft

Courtesy of GENERAL MOTORS COMPANY

NOTE: If the exhaust camshaft is to be reinstalled, do not remove the EN-50509 fixing tool.

23. Remove the exhaust camshaft (1).

24. Cover the timing case with a lint free cloth.

Installation Procedure

NOTE: Before installing the exhaust camshaft, check the components of the timing chain system for damage and wear.

1. Check the components of the timing chain system for damage and wear:

- Timing chain guides with plastic attachment
- Timing chain tensioner and timing chain tensioner shoe with plastic attachment
- Timing chain and all timing chain sprockets
- Oil pump sprocket
- Oil pump drive chain tensioner

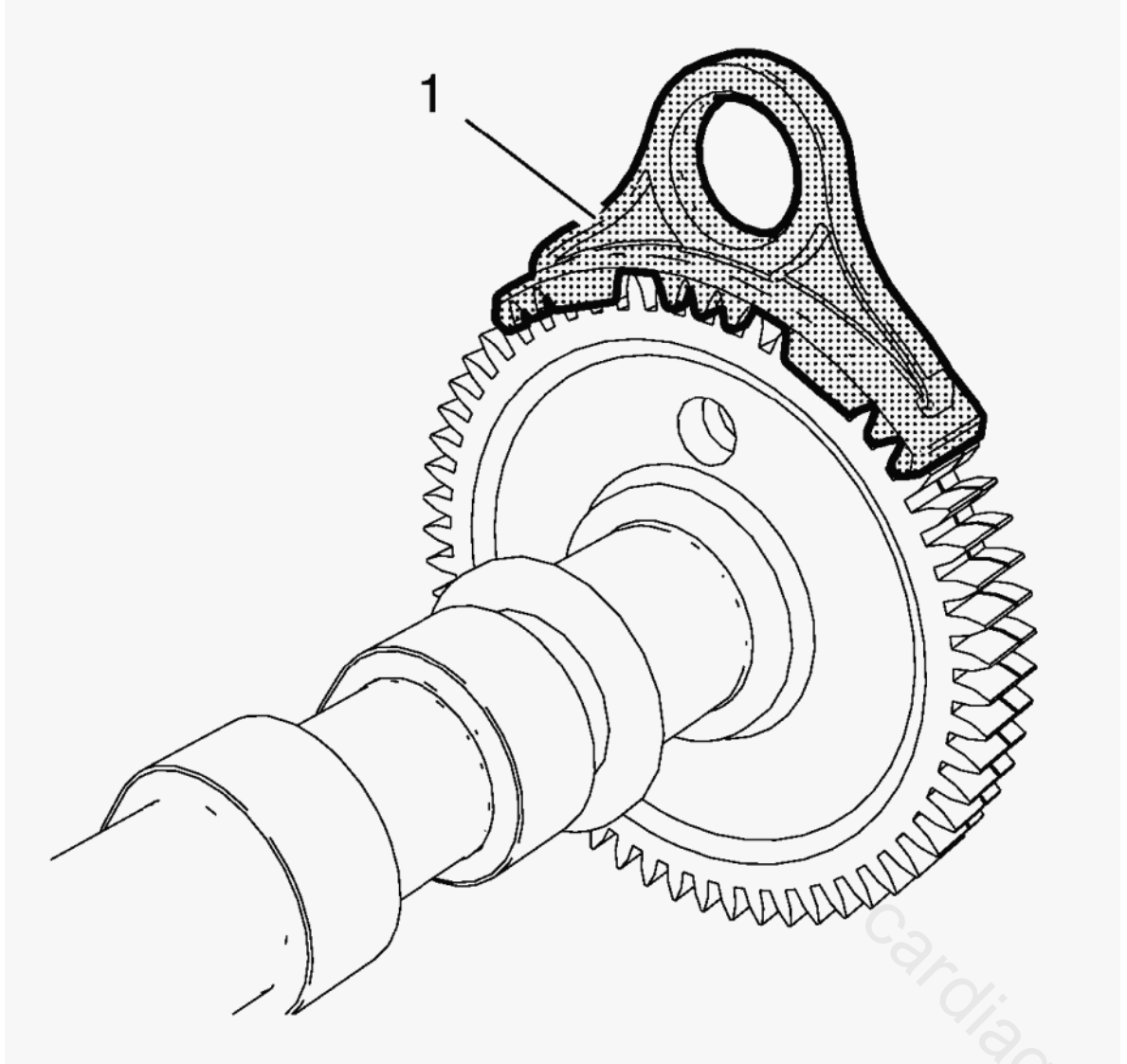


Fig. 230: Transport Lock

Courtesy of GENERAL MOTORS COMPANY

2. For installation of a NEW exhaust camshaft do not remove the transport lock (1) before the exhaust camshaft and intake camshaft are installed.

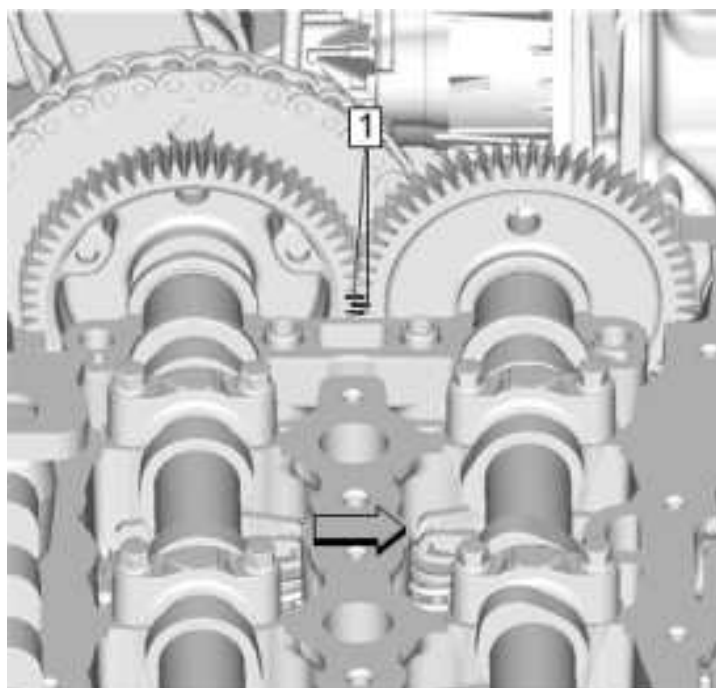


Fig. 231: Mark Backside Of Both Cam Gears With Paint Marks

Courtesy of GENERAL MOTORS COMPANY

3. Transfer the rear marks (1) onto the back of the new camshaft sprocket.

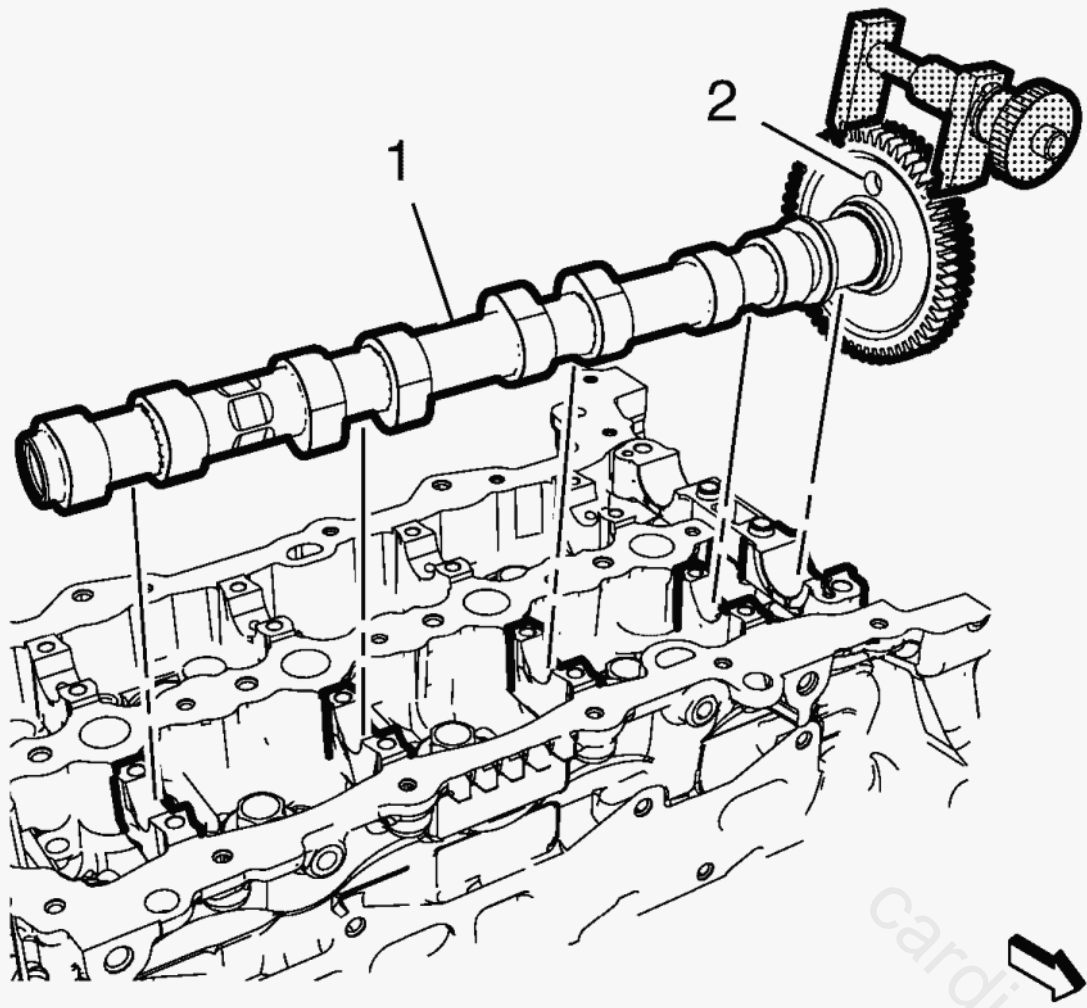


Fig. 232: Exhaust Camshaft With Bore Of Camshaft Sprocket Upwards
Courtesy of GENERAL MOTORS COMPANY

4. Coat all bearing surfaces with engine oil.
5. Install the exhaust camshaft (1), ensure the bore (2) of the camshaft sprocket shows upwards and the marks are aligned.

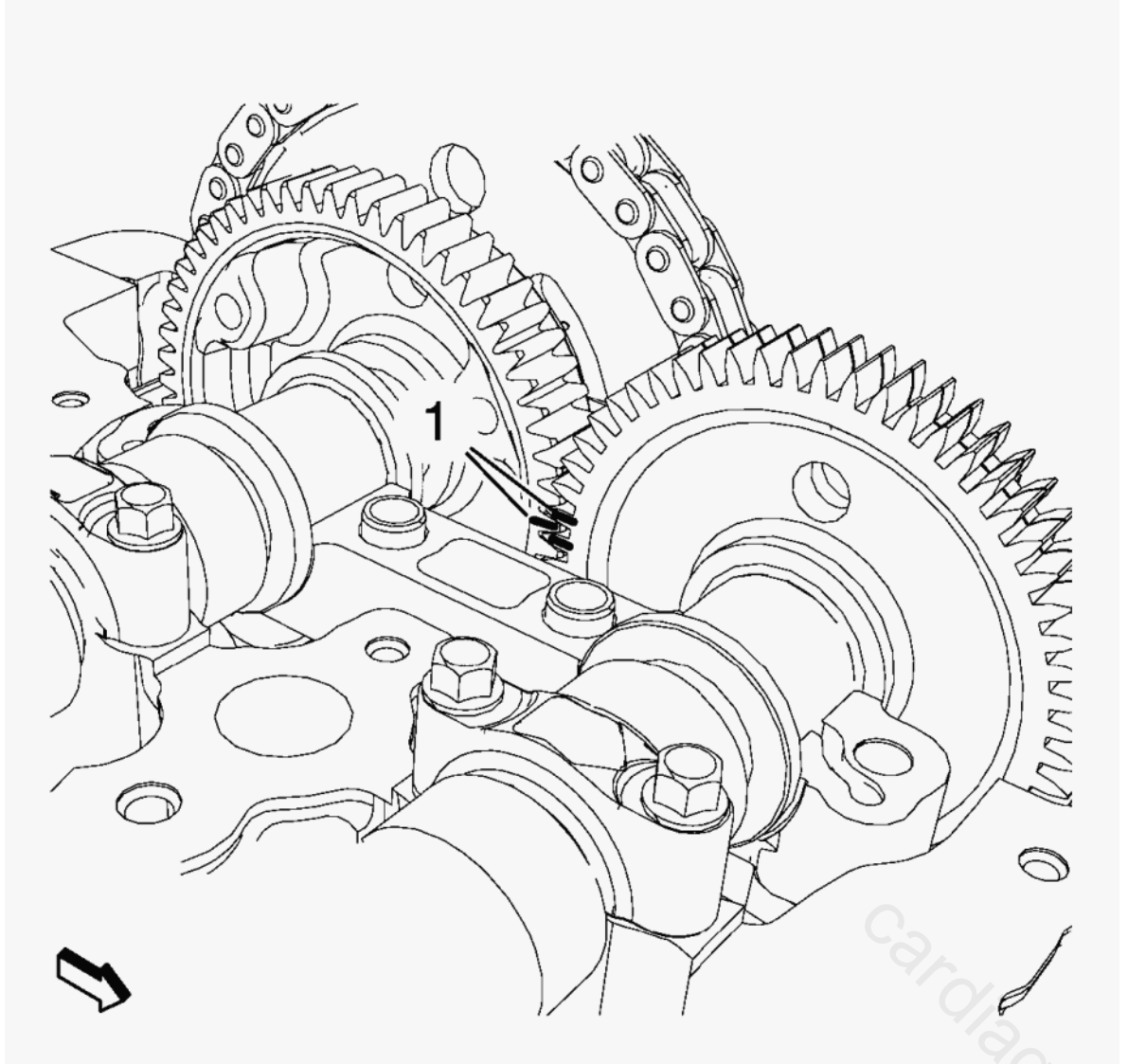


Fig. 233: Marking Exhaust Camshaft Sprocket And Intake Camshaft Sprocket With Paint Marks
 Courtesy of GENERAL MOTORS COMPANY

6. Check the marks (1) of the camshaft sprockets whether they are aligned.

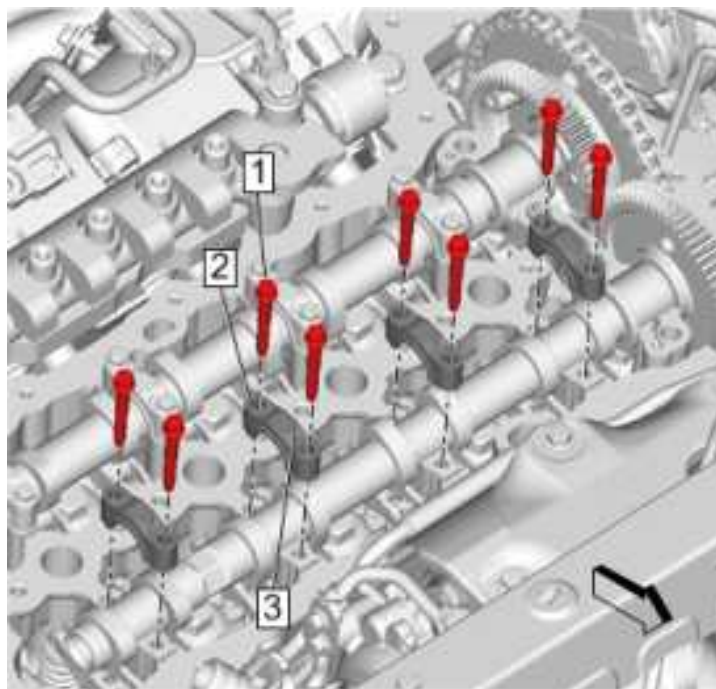


Fig. 234: Exhaust Camshaft Bearing Caps And Bolts
 Courtesy of GENERAL MOTORS COMPANY

NOTE: Note the direction of the arrows (3) on the camshaft bearing caps pointing to outside of the cylinder head.

7. Install the 4 exhaust camshaft bearing caps (2) in the order they were removed.
8. Install the 8 exhaust camshaft bearing cap bolts (1).

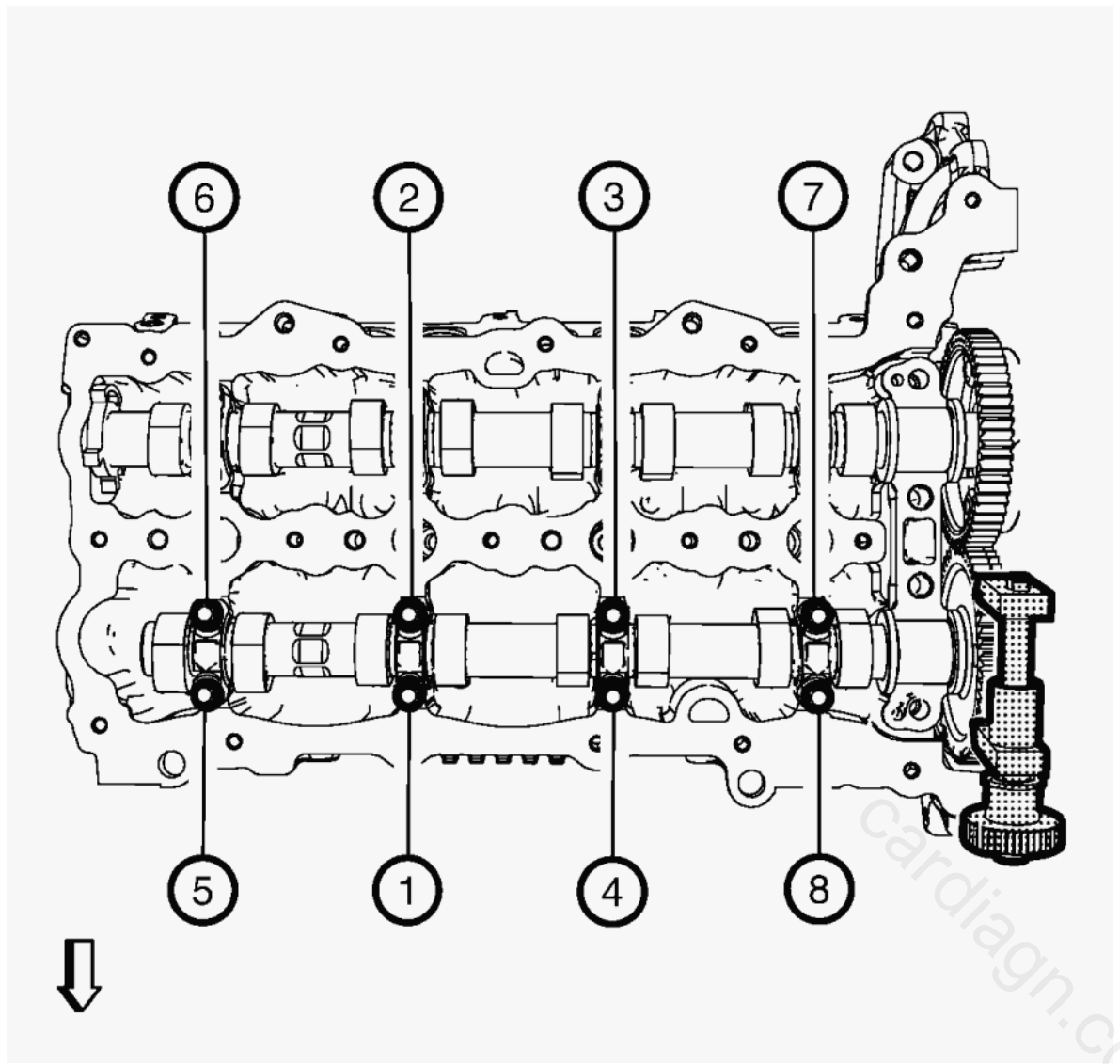


Fig. 235: Exhaust Camshaft Bearing Cap Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution** .

9. Tighten the 8 exhaust camshaft bearing cap bolts in sequence shown to 10 N.m (89 lb in).

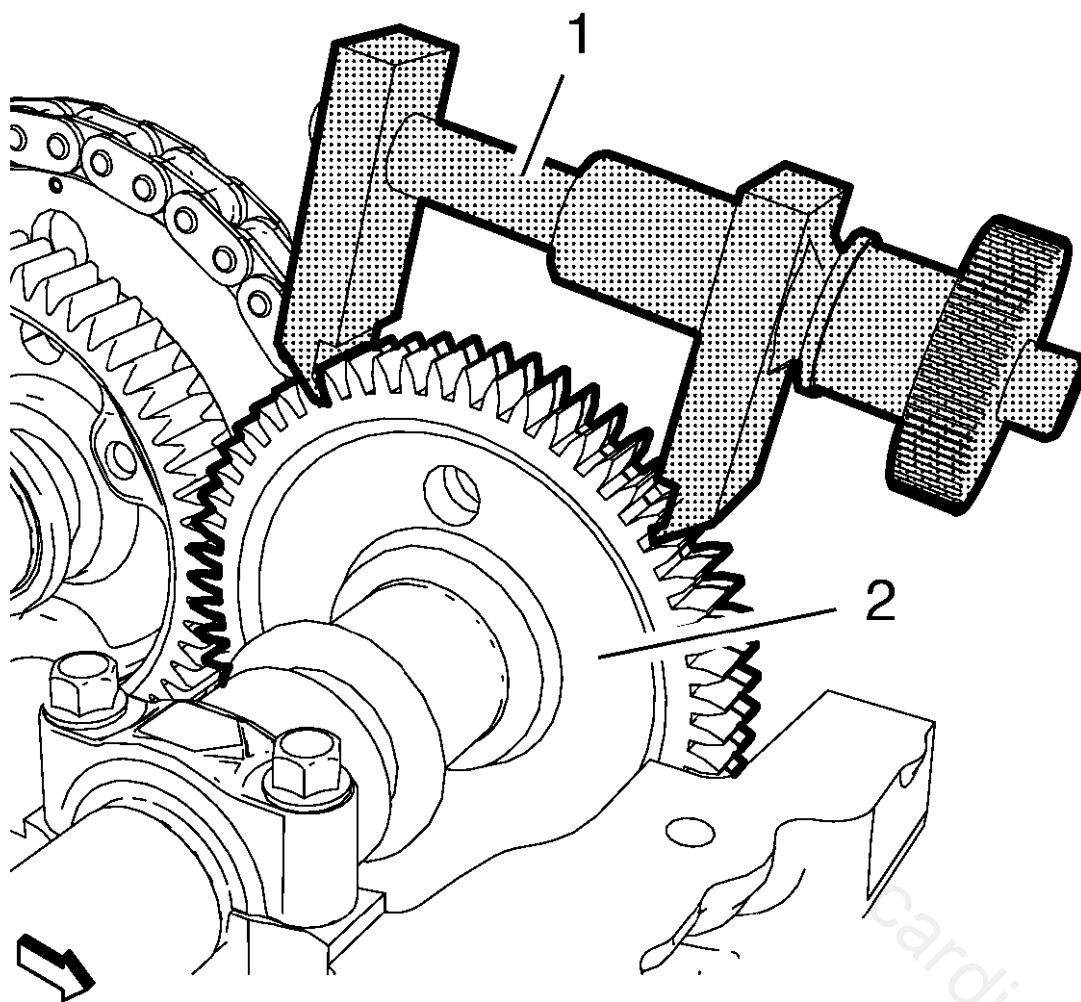


Fig. 236: Split Intake Camshaft Sprocket Fixing Tool
Courtesy of GENERAL MOTORS COMPANY

10. Remove the **EN-50509** fixing tool (1) or the transport lock from the exhaust camshaft sprocket (2).

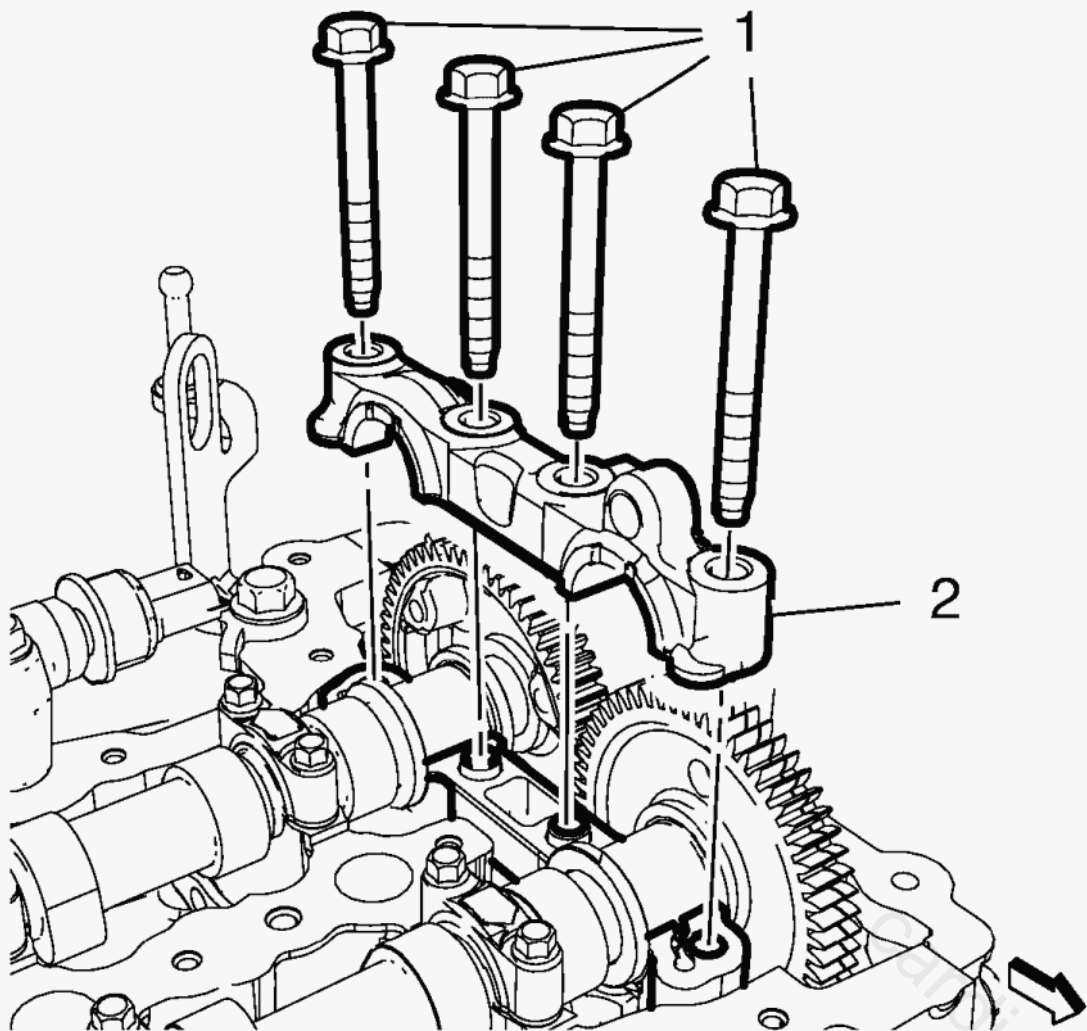


Fig. 237: Camshaft Bearing Rear Cap And Bolts
Courtesy of GENERAL MOTORS COMPANY

11. Coat all bearing surfaces with engine oil.
12. Install the camshaft bearing rear cap (2).
13. Install the 4 camshaft bearing rear cap bolts (1).

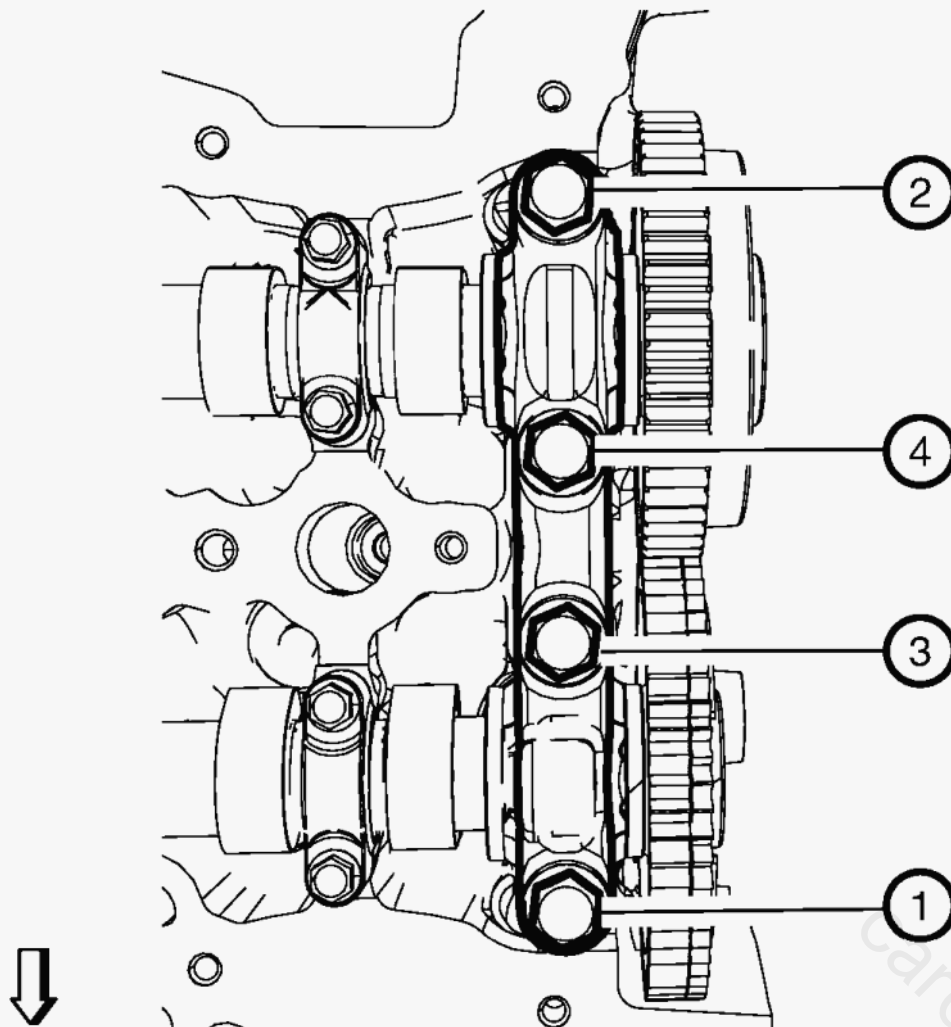


Fig. 238: Camshaft Rear Cap Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

14. Tighten the 4 camshaft rear cap bolts in sequence shown to 25 N.m (18 lb ft).

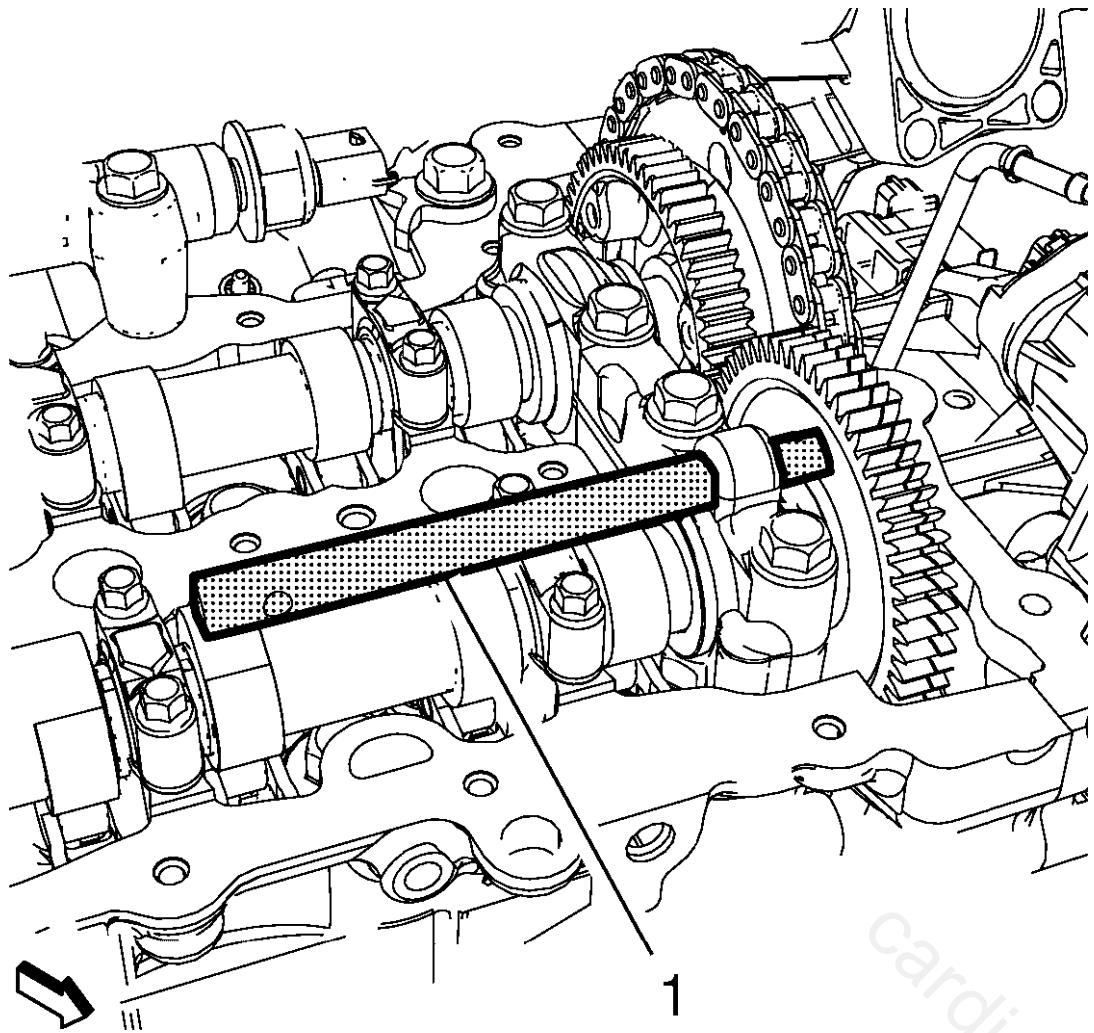


Fig. 239: Camshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

15. To check for proper alignment, install the **EN-51143** fixing tool (1), by carefully turning the hexagon of the camshaft.
16. Remove **EN-51188** fixing tool (2).

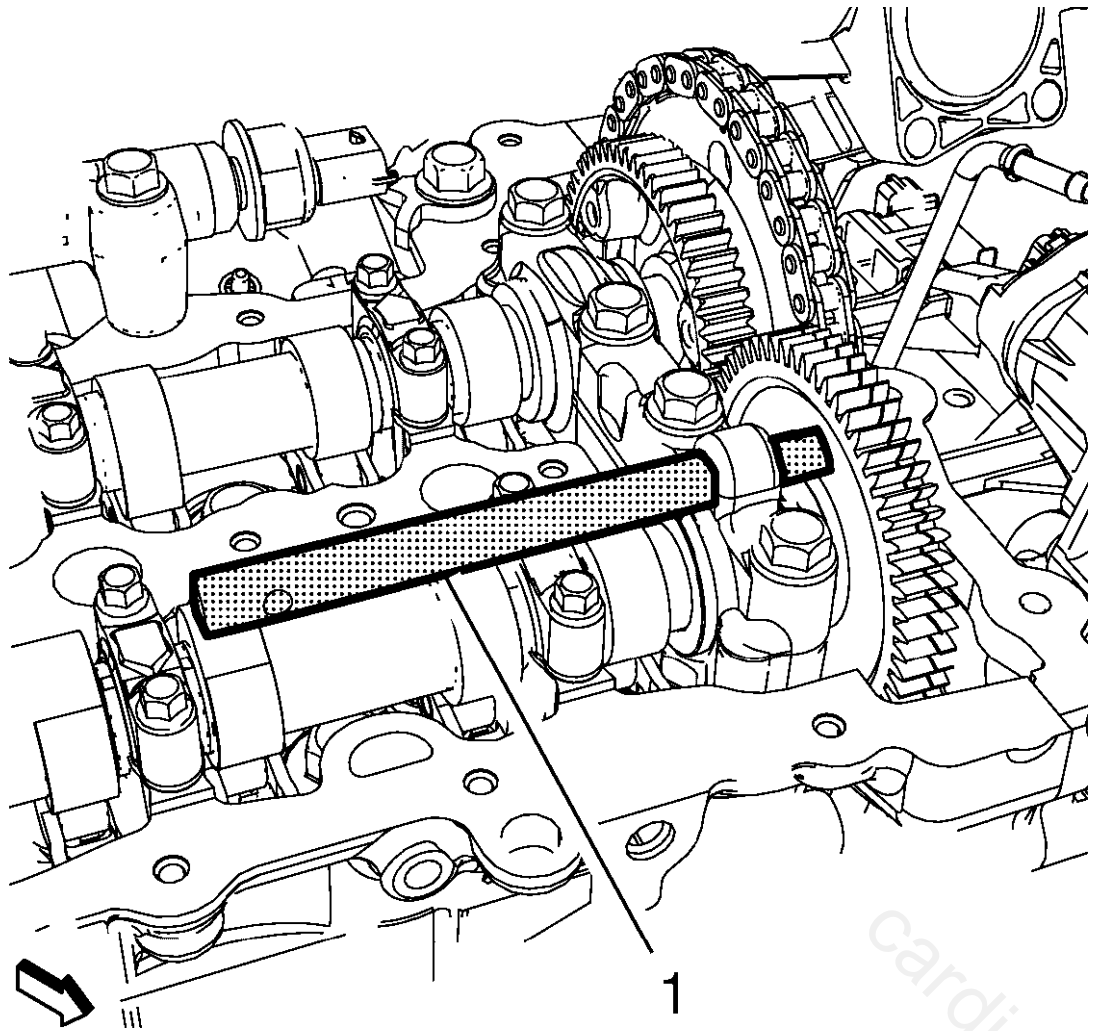


Fig. 240: Camshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

17. Remove the **EN-51143** fixing tool (1).
18. Raise the vehicle.
19. Remove the 4 crankshaft pulley bolts (1).
20. Install the fixing pin into the engine block bore (1) and tighten the 2 bolts (3).
21. Lower the vehicle.

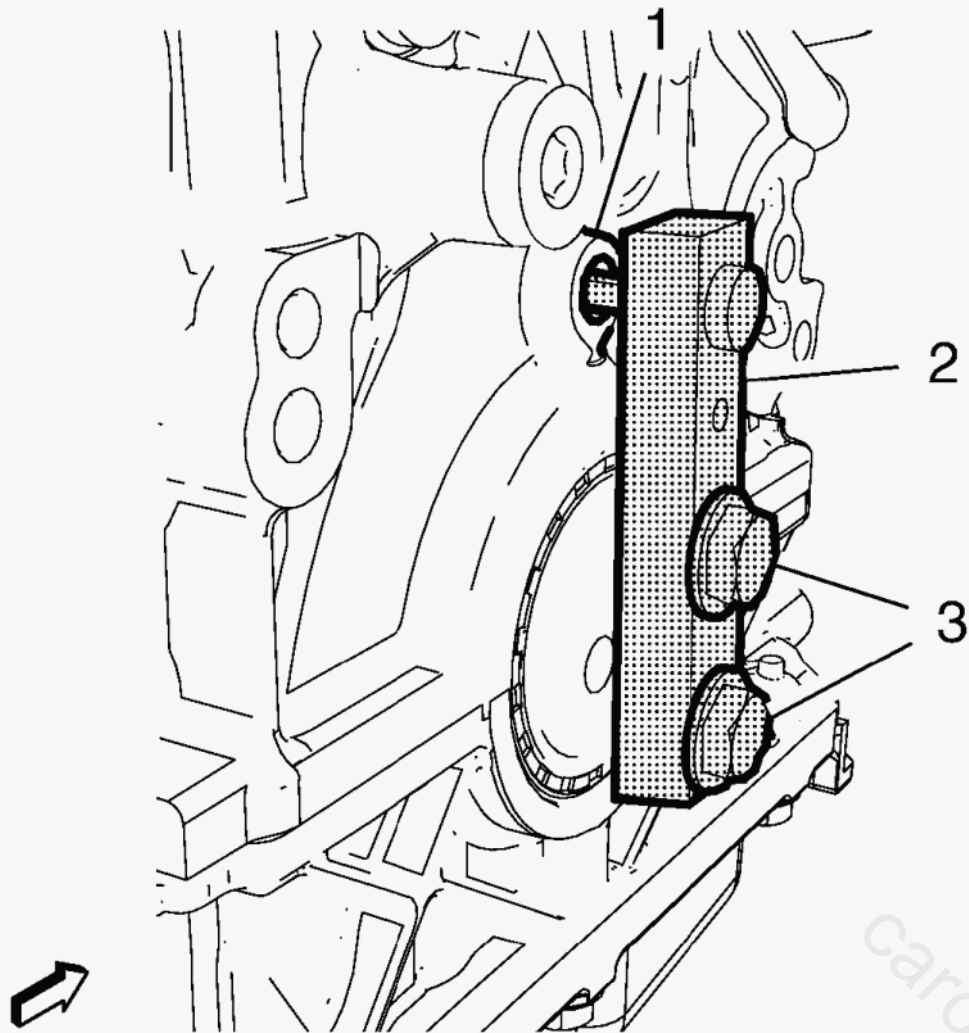


Fig. 241: Crankshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

22. Remove the 2 bolts (3).
23. Remove the **EN-51140** fixing tool (2).
24. Install Crankshaft Pulley. Refer to [Crankshaft Pulley Replacement](#)
25. Install Camshaft Housing. Refer to [Camshaft Housing Replacement](#)
26. Install Throttle Body Assembly. Refer to [Throttle Body Assembly Replacement](#)
27. Connect the battery negative cable. Refer to [Battery Negative Cable Disconnection and Connection \(KL9\)](#)

TIMING CHAIN IDLER SPROCKET REPLACEMENT

Special Tools

EN-51141 Intermediate Drive Gear Fixing Tool

For equivalent regional tools, refer to [Special Tools](#).

Removal Procedure

1. Remove the camshaft timing chain. Refer to [Camshaft Timing Chain Replacement](#)

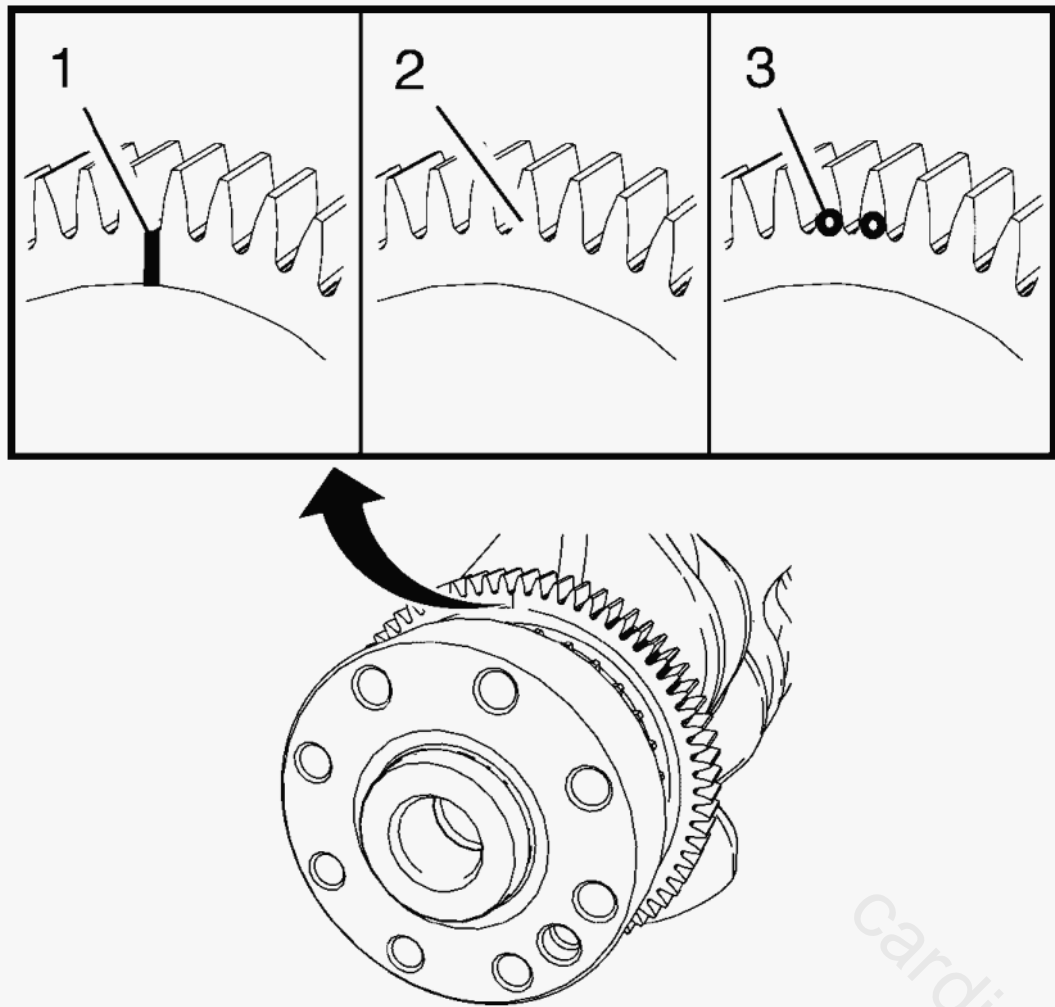


Fig. 242: Crankshaft Sprocket Marks

Courtesy of GENERAL MOTORS COMPANY

NOTE: Depending on the crankshaft, two different marks (1) and (3) or none (2) can be located on the crankshaft sprocket.

2. Mark the crankshaft sprocket align with the timing chain idler sprocket if there is no mark.

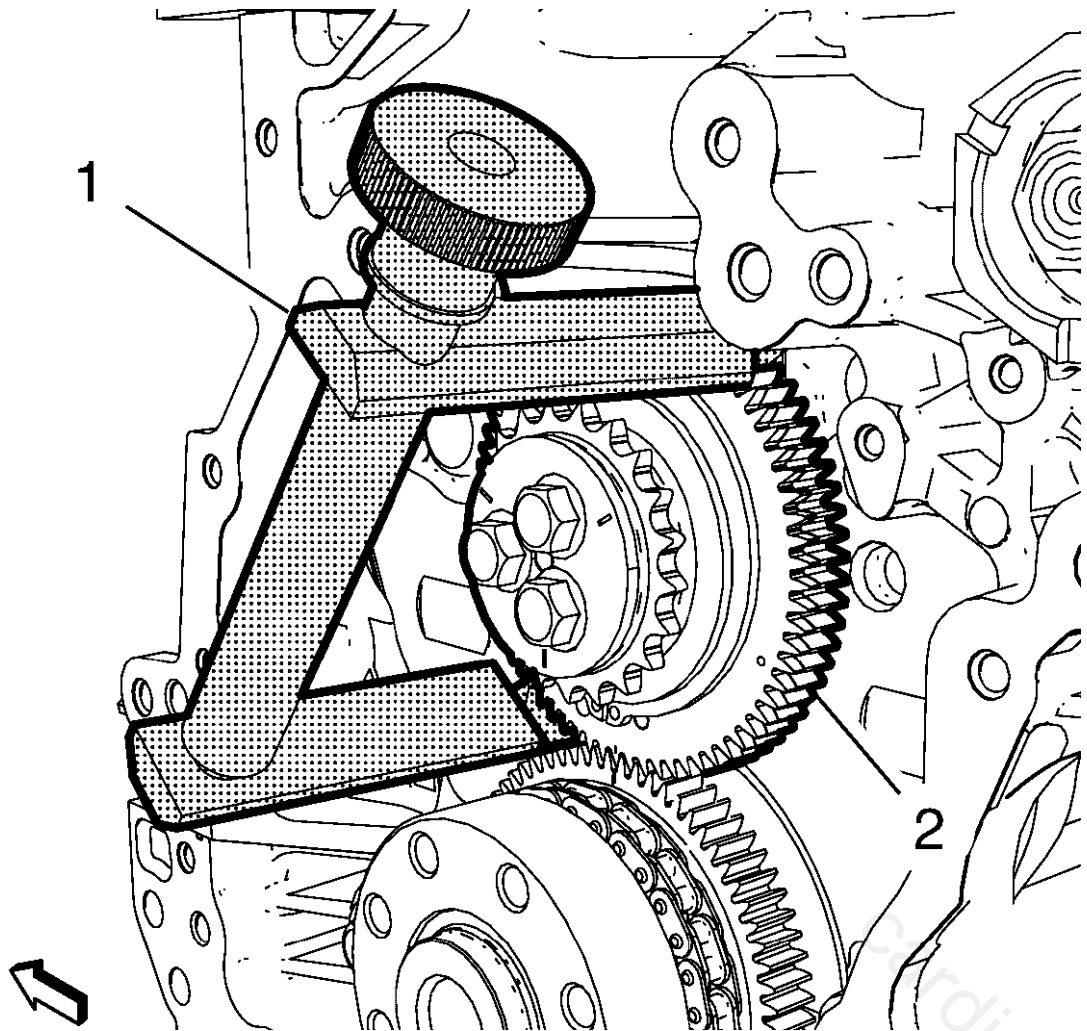


Fig. 243: Intermediate Drive Gear Fixing Tool And Timing Chain Idler Sprocket
 Courtesy of GENERAL MOTORS COMPANY

3. Install the EN-51141 fixing tool (1) to the timing chain idler sprocket (2).

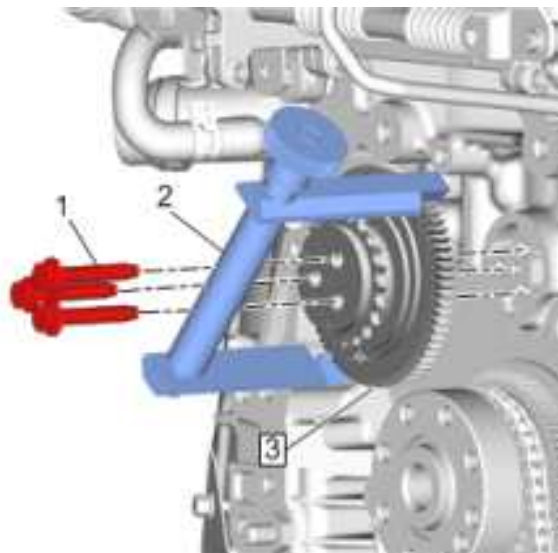


Fig. 244: Timing Chain Idler Sprocket, Bolts And Intermediate Drive Gear Fixing Tool
 Courtesy of GENERAL MOTORS COMPANY

4. Remove the 3 timing chain idler sprocket bolts (1).

NOTE: If the timing chain idler sprocket will be reused, do not remove the EN-51141 fixing tool (2).

5. Remove the timing chain idler sprocket (3) from the engine block.

NOTE: Before installing the timing chain idler sprocket, check the components of the timing chain system for damage and wear.

1. Check the components of the timing chain system for damage and wear:
 - Timing chain guides with plastic attachment
 - Timing chain tensioner and timing chain tensioner shoe with plastic attachment
 - Timing chain and all timing chain sprockets
 - Oil pump sprocket
 - Oil pump drive chain tensioner

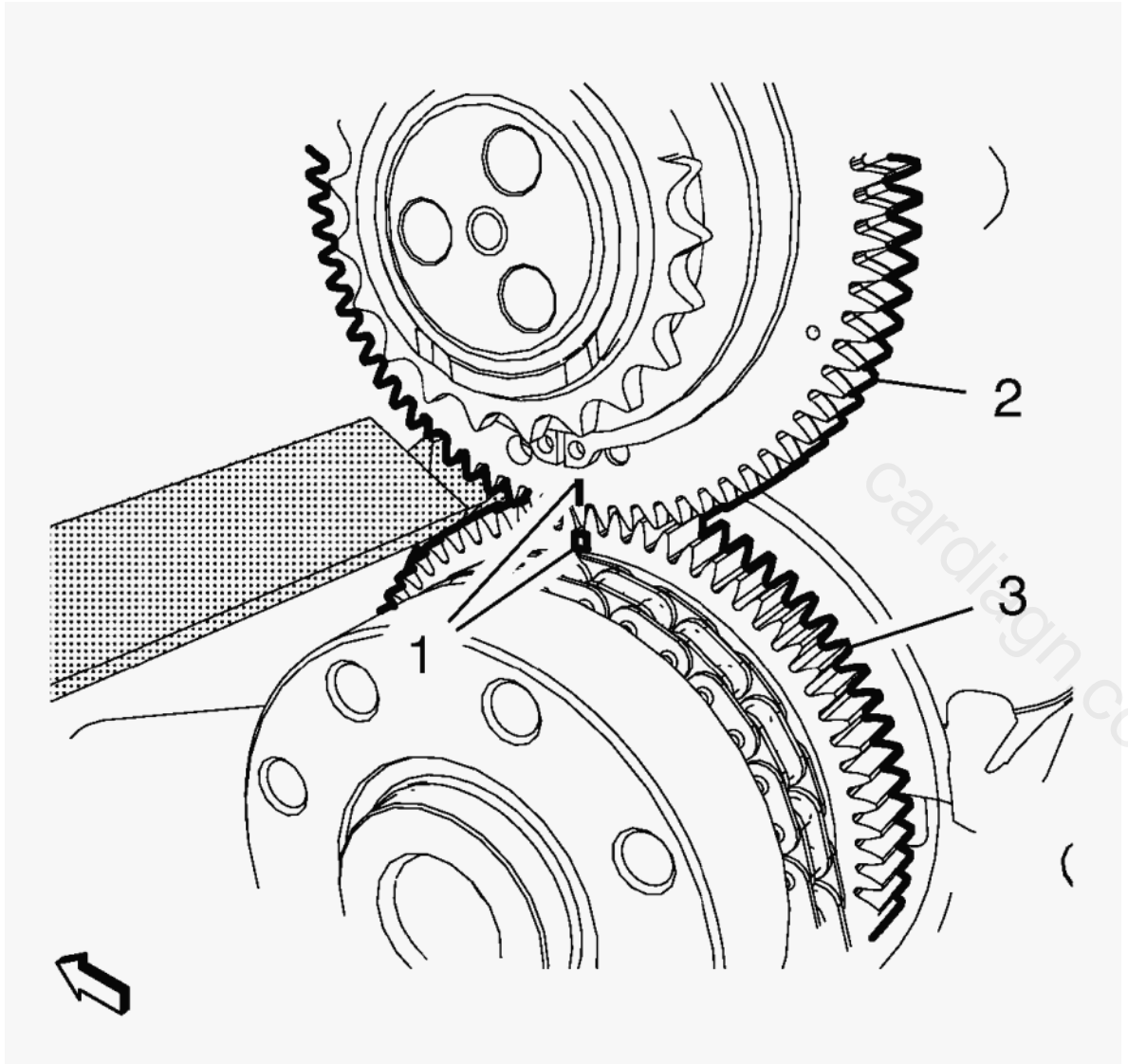


Fig. 245: Timing Chain Idler Sprocket, Alignment Marks And Crankshaft Sprocket
Courtesy of GENERAL MOTORS COMPANY

2. Install the timing chain idler sprocket (2), by align the marks (1) with the timing chain idler sprocket and the crankshaft sprocket (3).

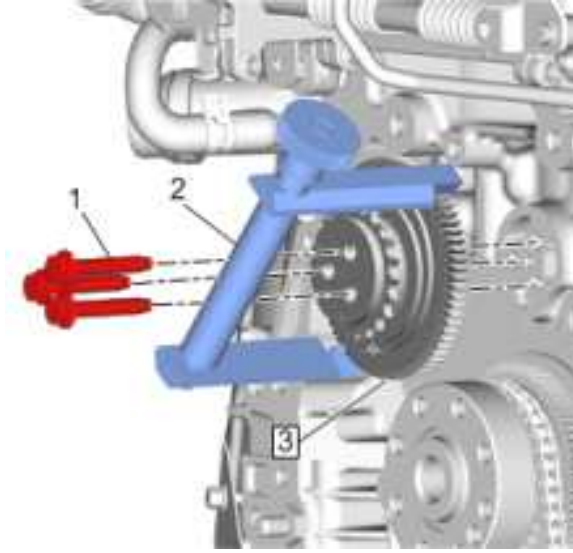


Fig. 246: Timing Chain Idler Sprocket, Bolts And Intermediate Drive Gear Fixing Tool
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to [Fastener Caution](#) .

3. Install the 3 timing chain idler sprocket bolts (1) and tighten to 25 N.m (18 lb ft).
4. Remove the **EN-51141** fixing tool (2).
5. Install the camshaft timing chain. Refer to [Camshaft Timing Chain Replacement](#)

TIMING CHAIN LOWER COVER REPLACEMENT

Removal Procedure

1. Remove Timing Chain Upper Cover. Refer to [Timing Chain Upper Cover Replacement](#).
2. Remove Oil Pan. Refer to [Oil Pan Replacement](#).

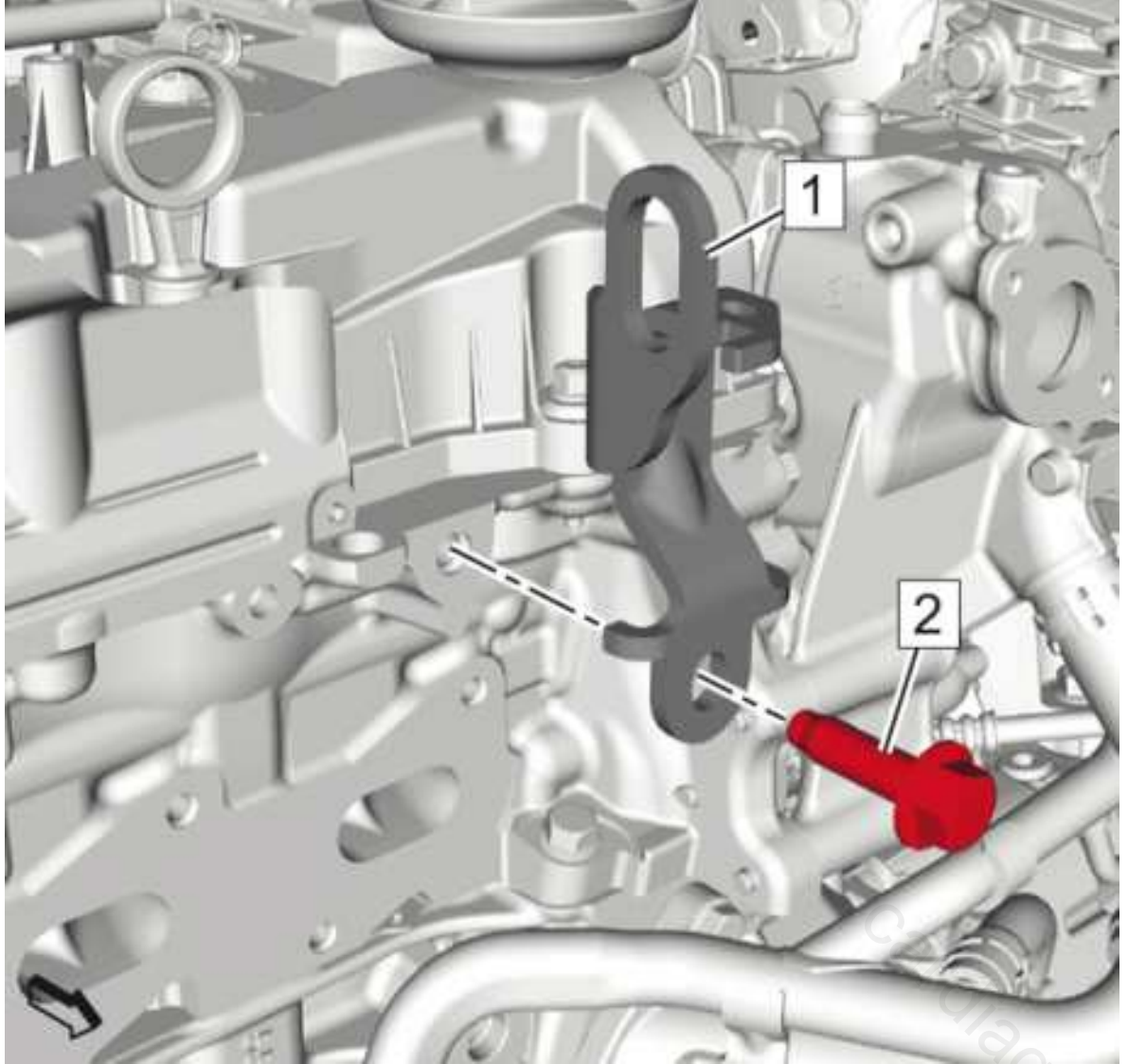


Fig. 247: Engine Lift Bracket And Bolt
Courtesy of GENERAL MOTORS COMPANY

3. Install Engine Lift Bracket-Left Side (1)

CAUTION: Refer to **Fastener Caution**

4. Install and tighten Engine Lift Bracket Bolt (2) to 58 N.m (43 lb ft)

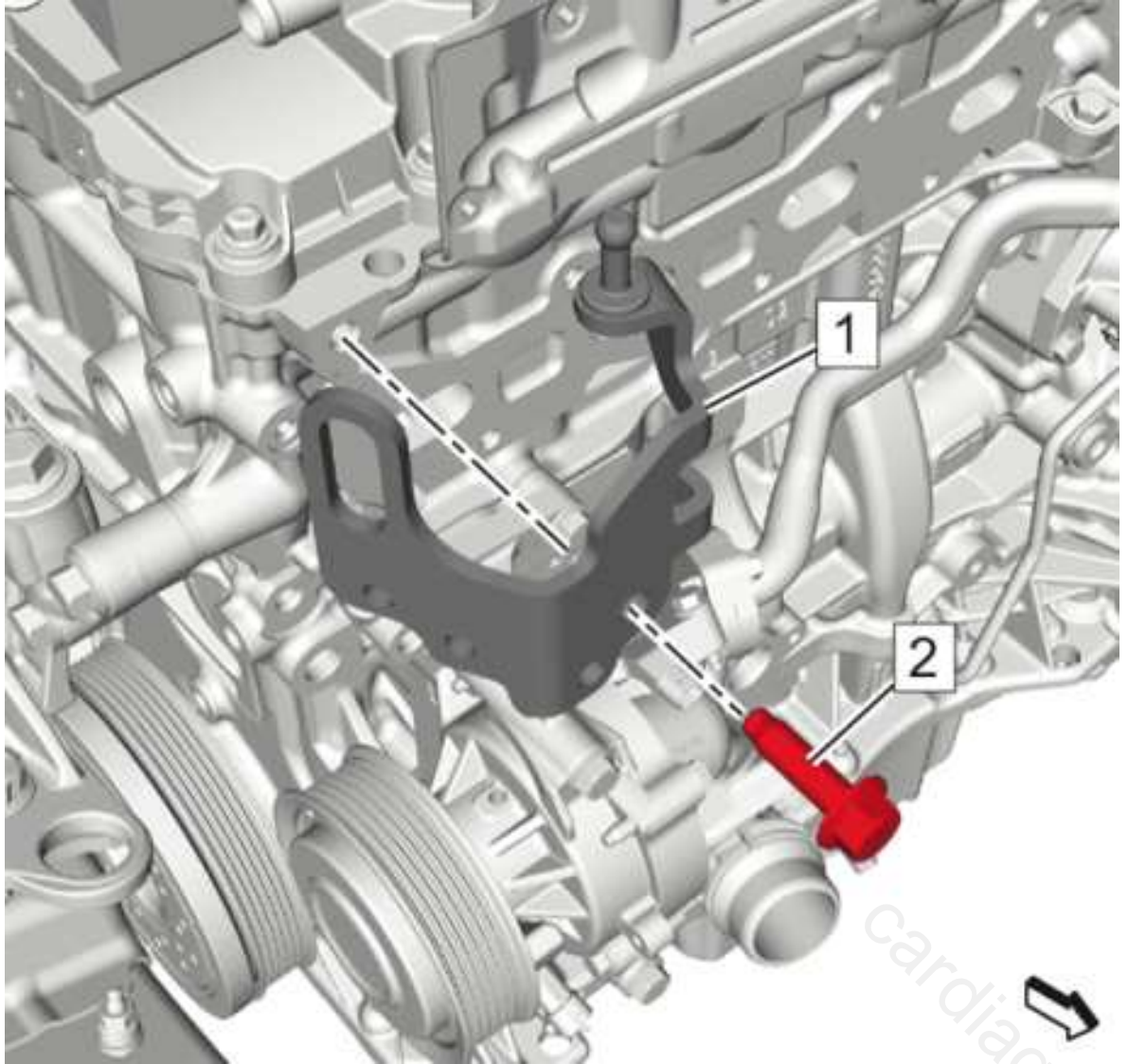


Fig. 248: Engine Lift Bracket And Bolt

Courtesy of GENERAL MOTORS COMPANY

5. Install Engine Lift Bracket-Right Side (1)
6. Install and tighten Engine Lift Bracket Bolt (2) to 58 N.m (43 lb ft).
7. Remove Crankshaft Position Reluctor Ring. Refer to [Crankshaft Position Sensor Reluctor Ring Replacement](#).

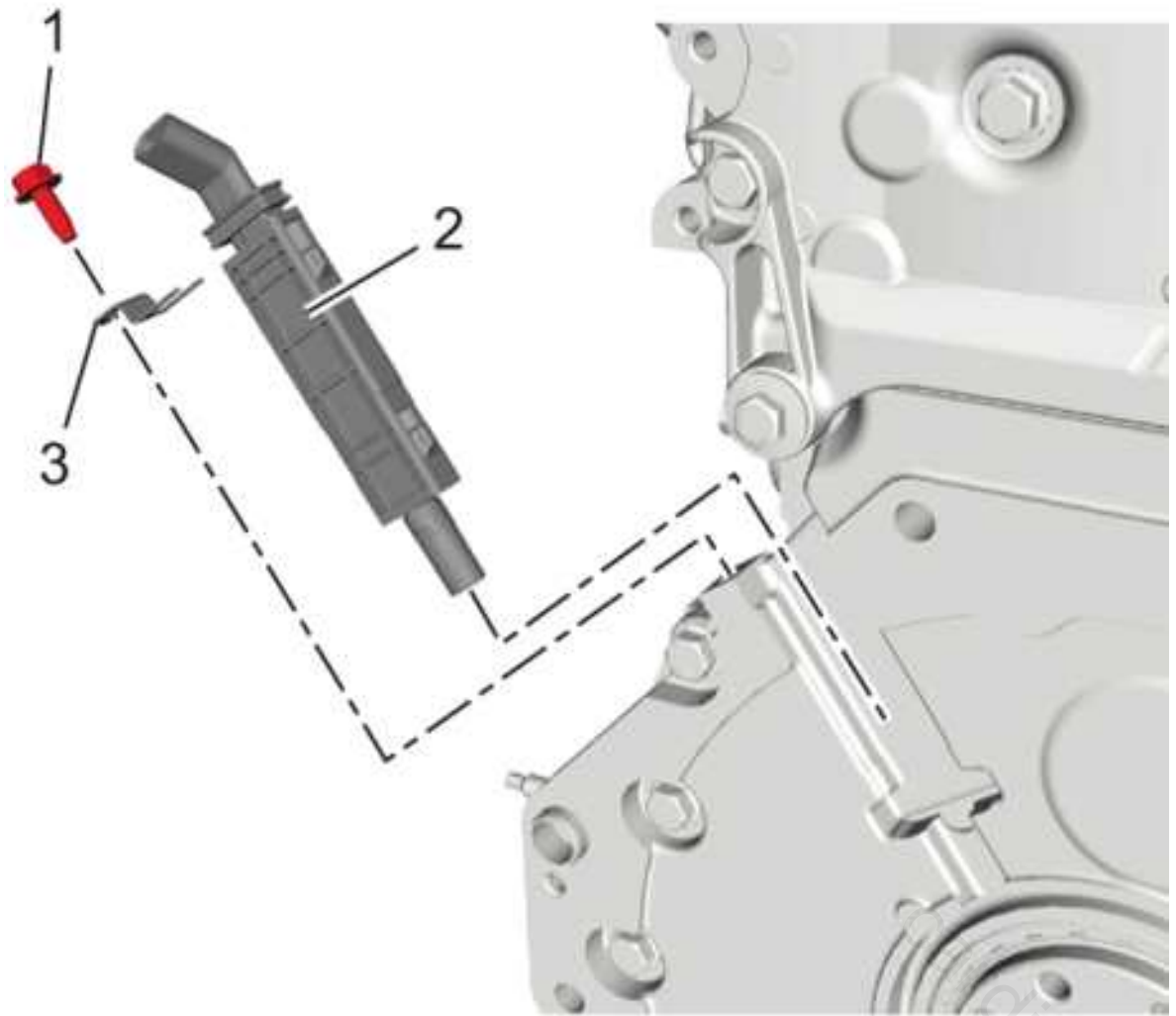


Fig. 249: Crankshaft Position Sensor, Bolt And Retainer Spring
Courtesy of GENERAL MOTORS COMPANY

8. Remove Crankshaft Position Sensor Bolt (1)
9. Remove the crankshaft position sensor retainer spring (3).
10. Remove Crankshaft Position Sensor (2)

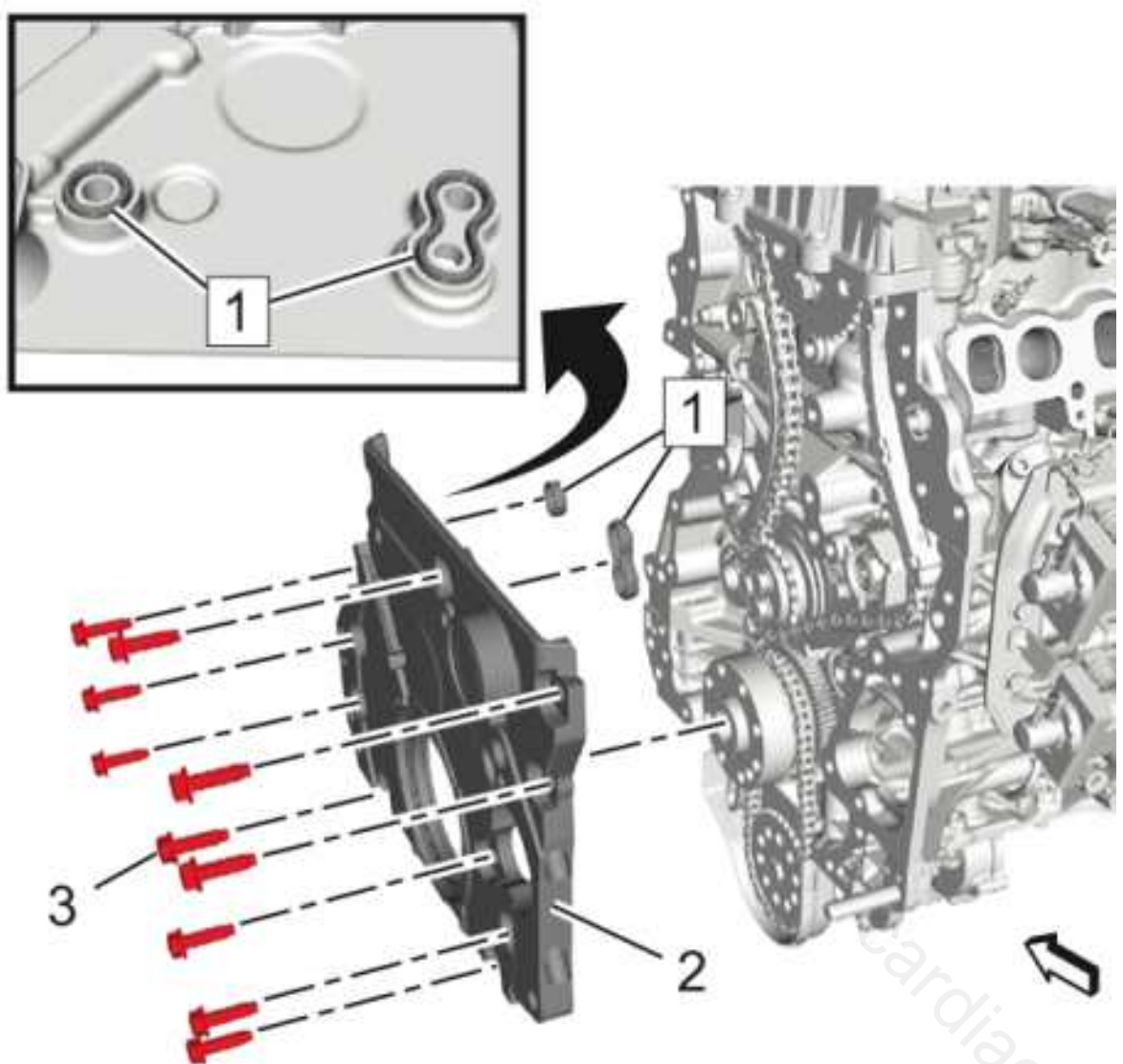


Fig. 250: Timing Chain Lower Cover, Bolts And Gaskets
Courtesy of GENERAL MOTORS COMPANY

11. Remove the 11 timing chain lower cover bolts (1).
12. Remove Timing Chain Lower Cover (2) - Use a suitable tool.
13. Remove and DISCARD the gaskets. (3) (Qty: 2)
14. Remove the crankshaft rear oil seal, if the timing chain lower cover reused.

Installation Procedure

NOTE: Before installing the timing chain lower cover, check the components of the timing chain system for damage and wear.

1. Check the components of the timing chain system for damage and wear:
 - Timing chain guides with plastic attachment
 - Timing chain tensioner and timing chain tensioner shoe with plastic attachment
 - Timing chain and all timing chain sprockets
 - Oil pump sprocket
 - Oil pump drive chain tensioner
2. Clean all sealing surfaces.

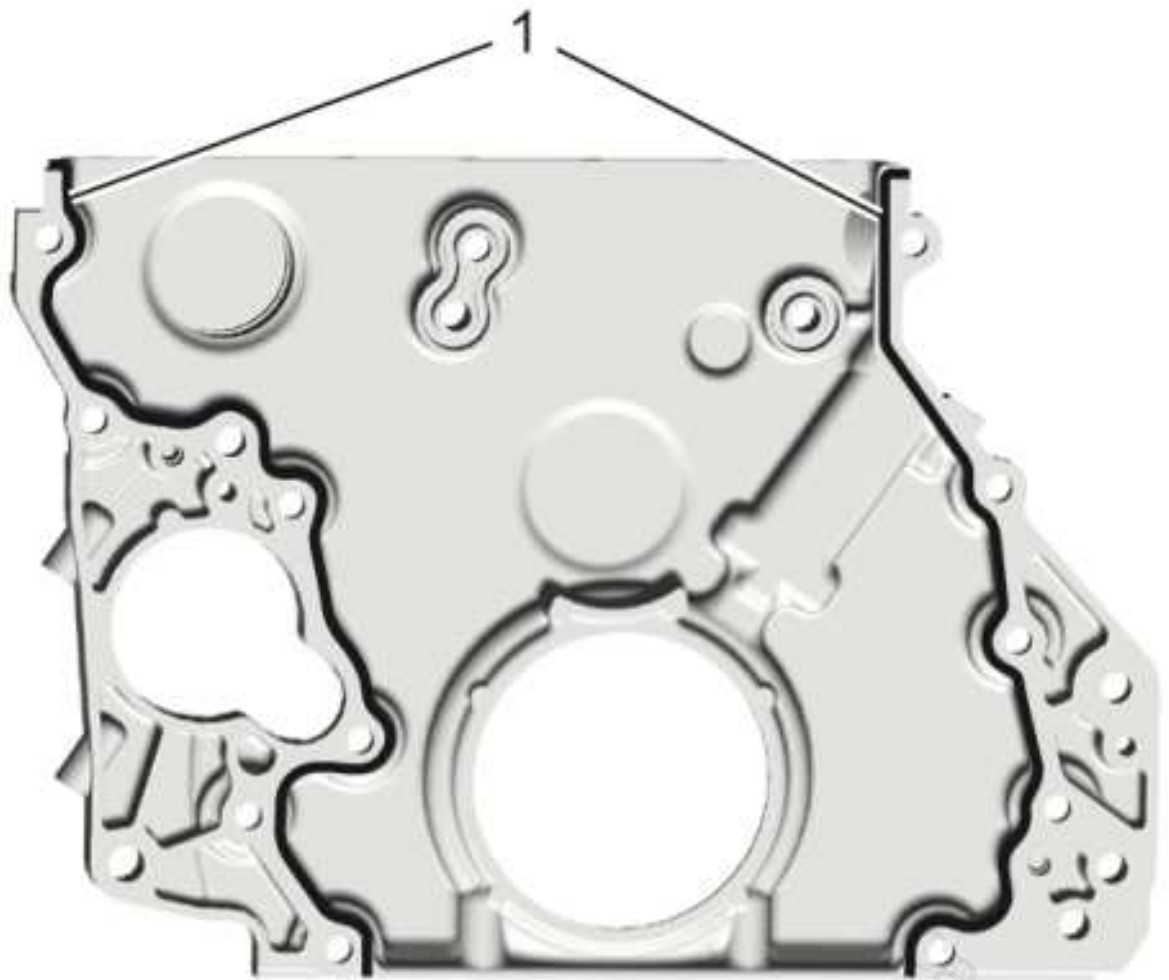


Fig. 251: Silicone Sealing Compound Application Area
Courtesy of GENERAL MOTORS COMPANY

NOTE: The complete installation procedure of the timing chain lower cover should be done in 20 minutes.

3. Apply silicone sealing compound (1) to the timing chain lower cover sealing surface. The thickness of the sealing bead should be 2.0 - 3.0 mm (0.079 - 0.118 in)

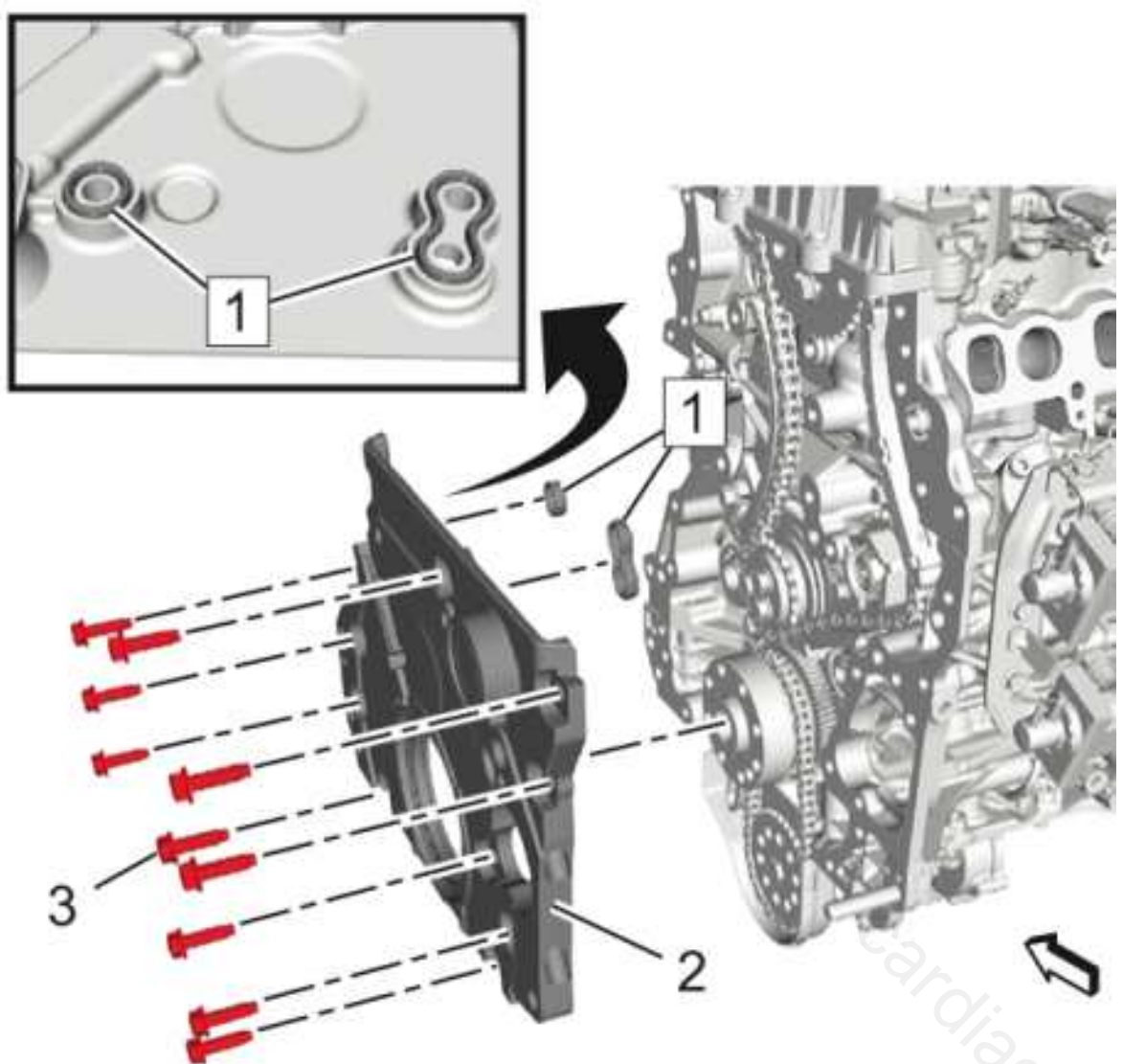


Fig. 252: Timing Chain Lower Cover, Bolts And Gaskets
Courtesy of GENERAL MOTORS COMPANY

4. Install NEW gaskets. (3) (Qty: 2)
5. Install Timing Chain Lower Cover (2)
6. Install the 11 timing chain lower cover bolts (1).

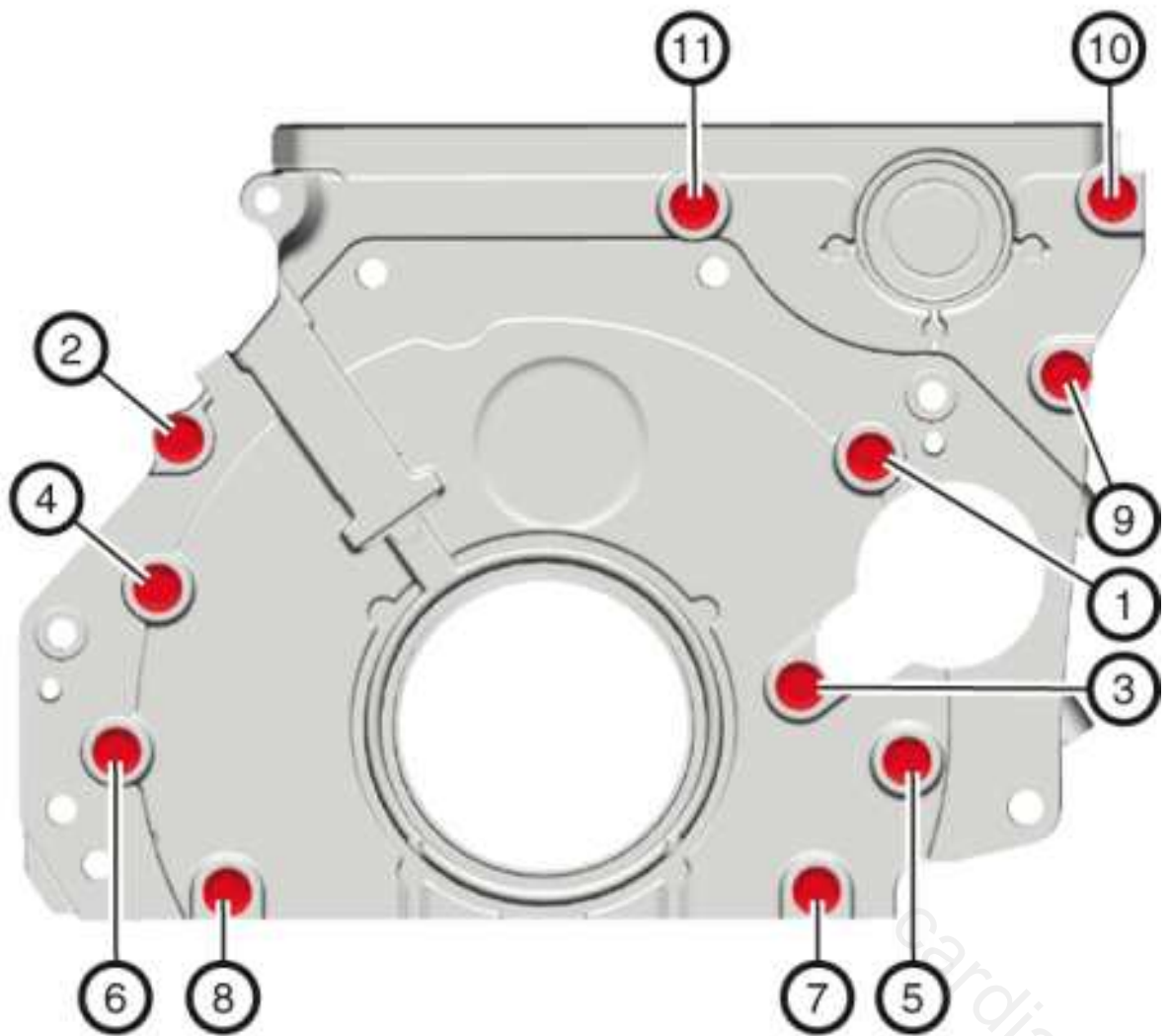


Fig. 253: Timing Chain Lower Cover Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

7. Tighten the bolts in the sequence shown. (Qty: 11) to 25 N.m (18 lb ft).

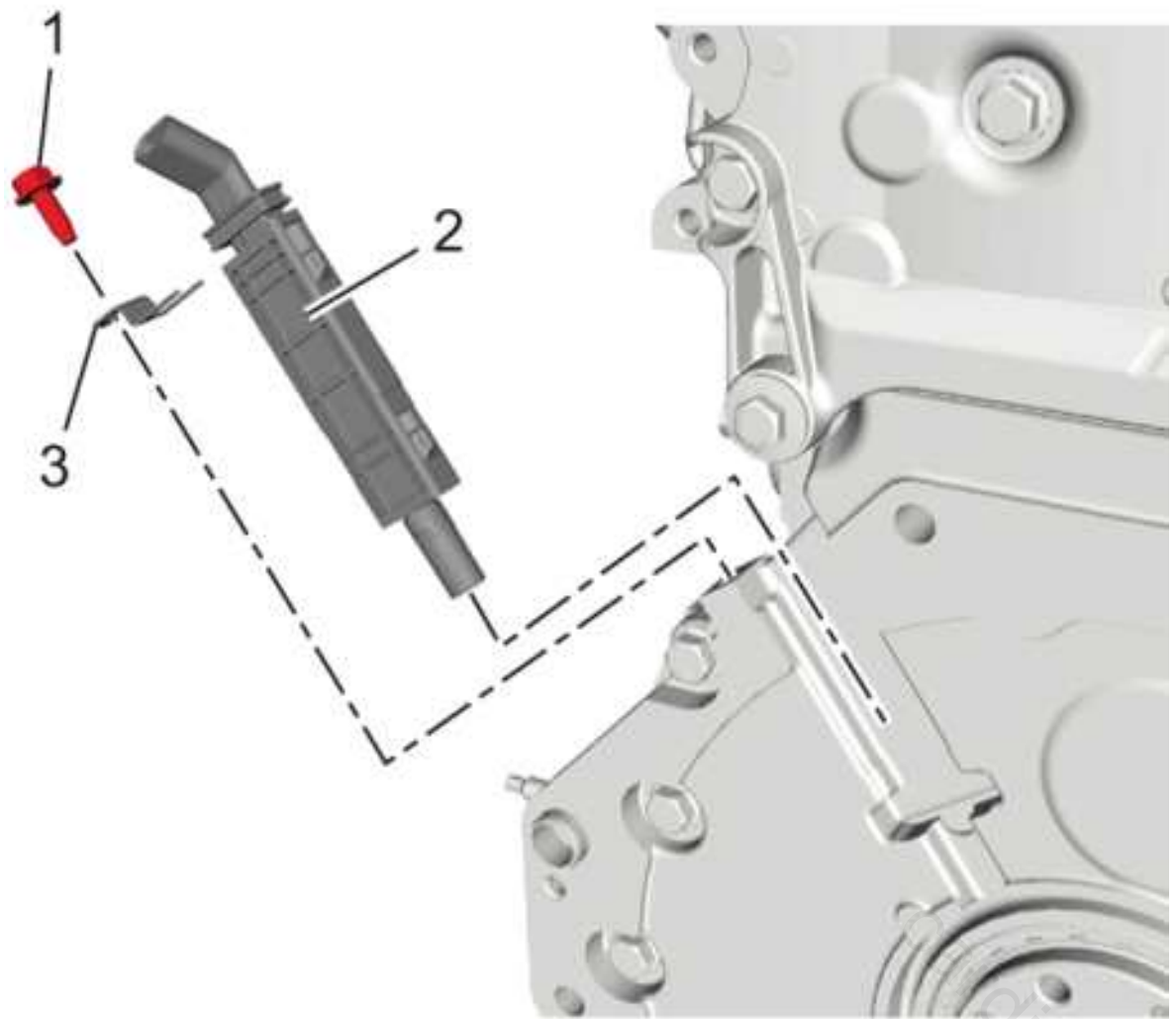


Fig. 254: Crankshaft Position Sensor, Bolt And Retainer Spring
Courtesy of GENERAL MOTORS COMPANY

8. Install Crankshaft Position Sensor (2)
9. Install the crankshaft position sensor retainer spring (3).
10. Install and tighten Crankshaft Position Sensor Bolt (1) to 10 N.m (89 lb in)
11. Install Crankshaft Rear Oil Seal. Refer to [Crankshaft Rear Oil Seal Replacement](#)
12. Install Crankshaft Position Sensor Reluctor Ring. Refer to [Crankshaft Position Sensor Reluctor Ring Replacement](#)

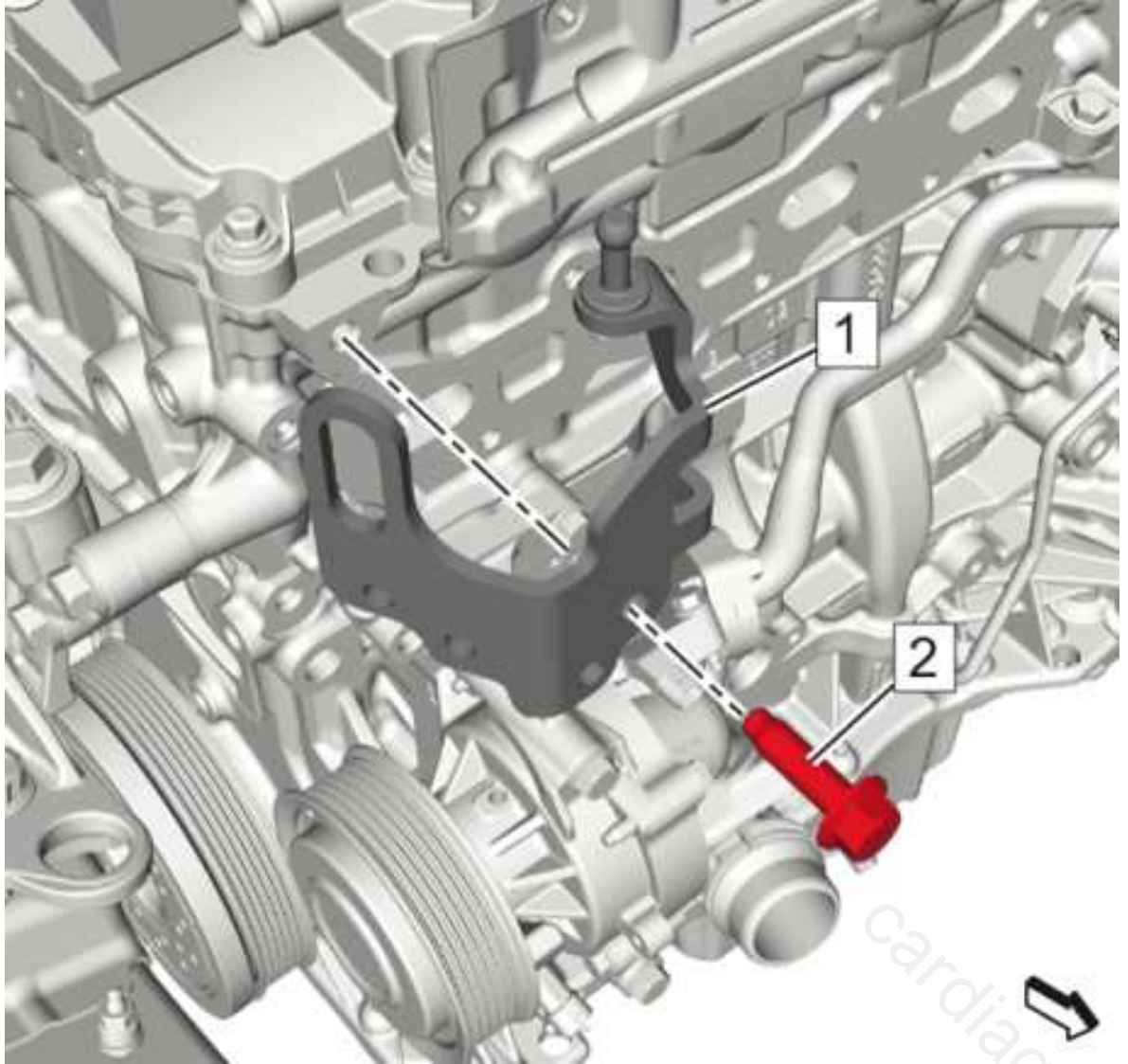


Fig. 255: Engine Lift Bracket And Bolt

Courtesy of GENERAL MOTORS COMPANY

13. Remove Engine Lift Bracket Bolt (2)
14. Remove Engine Lift Bracket-Right Side (1)

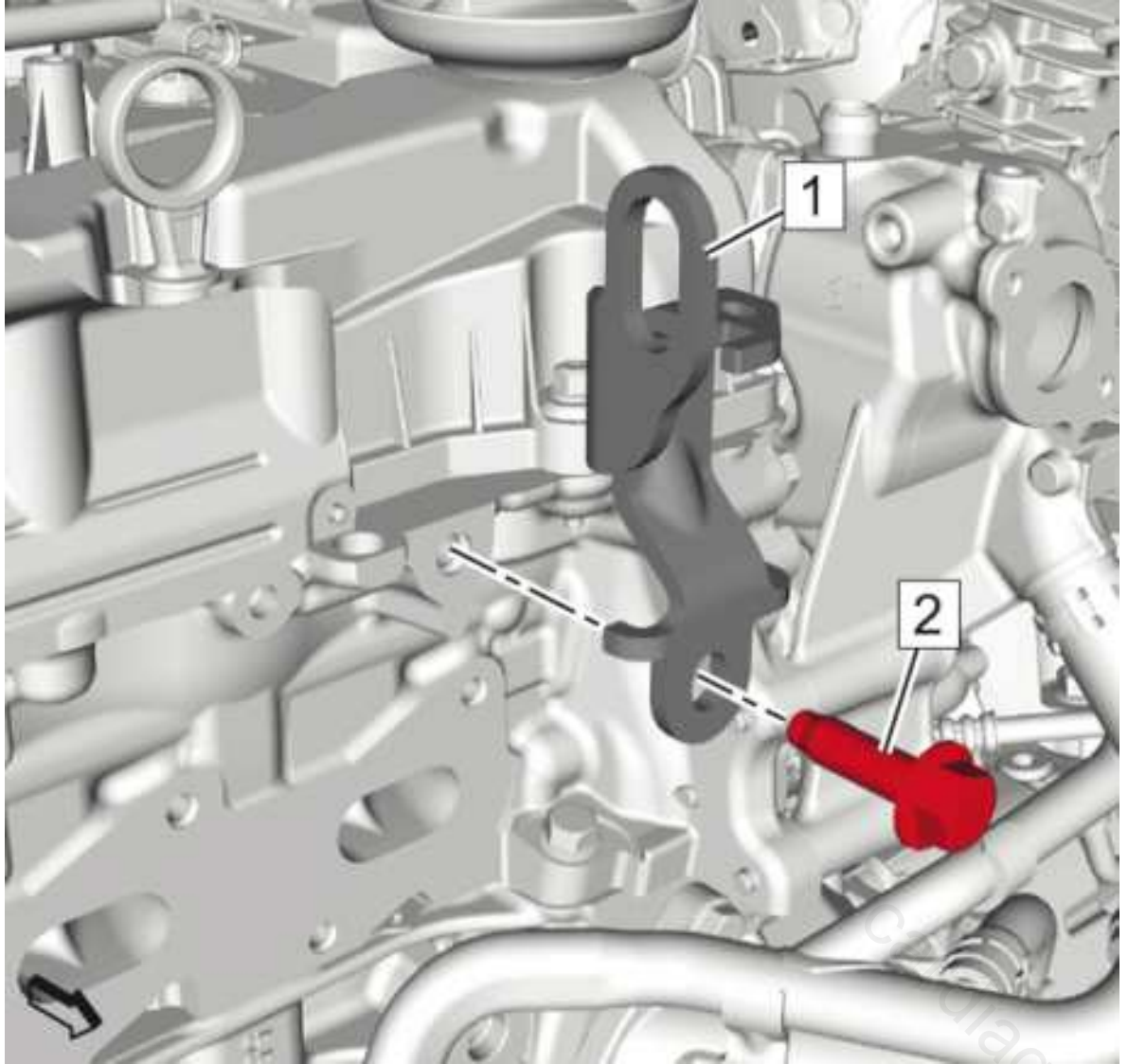


Fig. 256: Engine Lift Bracket And Bolt

Courtesy of GENERAL MOTORS COMPANY

15. Remove Engine Lift Bracket Bolt (2)
16. Remove Engine Lift Bracket-Left Side (1)
17. Install Oil Pan. Refer to [Oil Pan Replacement](#)
18. Install Timing Chain Upper Cover. Refer to [Timing Chain Upper Cover Replacement](#)

TIMING CHAIN LOWER GUIDE REPLACEMENT

Special Tools

- **EN-50513** Fixing Pin
- **EN-51140** Crankshaft Fixing Tool
- **EN-51143** Camshaft Sprocket Fixing Tool

For equivalent regional tools, refer to [Special Tools](#).

Removal Procedure

1. Remove the timing chain lower cover. Refer to [Timing Chain Lower Cover Replacement](#).
2. Remove the crankshaft pulley. Refer to [Crankshaft Pulley Replacement](#).

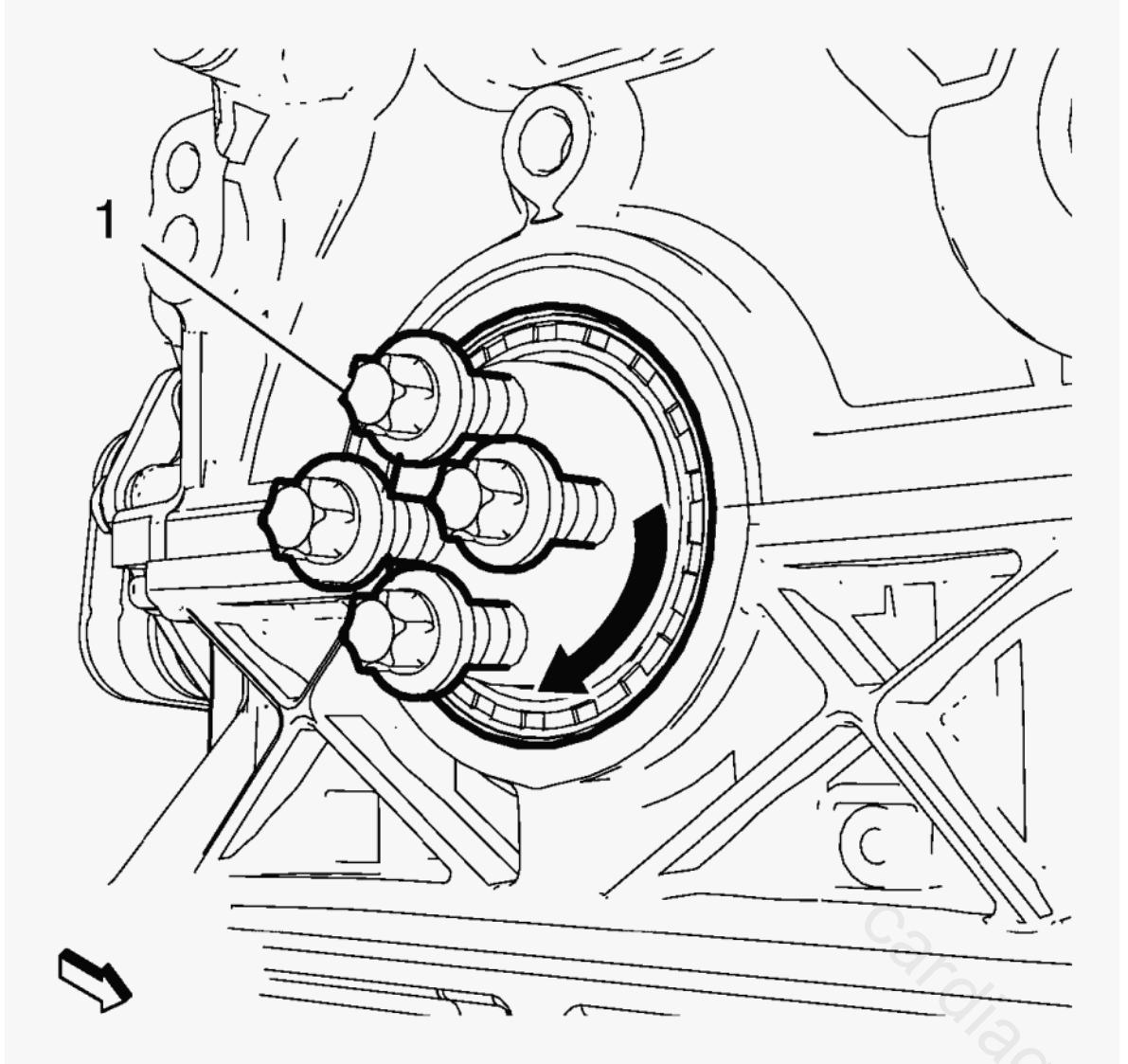


Fig. 257: Crankshaft Pulley Bolts

Courtesy of GENERAL MOTORS COMPANY

3. Install the 4 crankshaft pulley bolts (1).

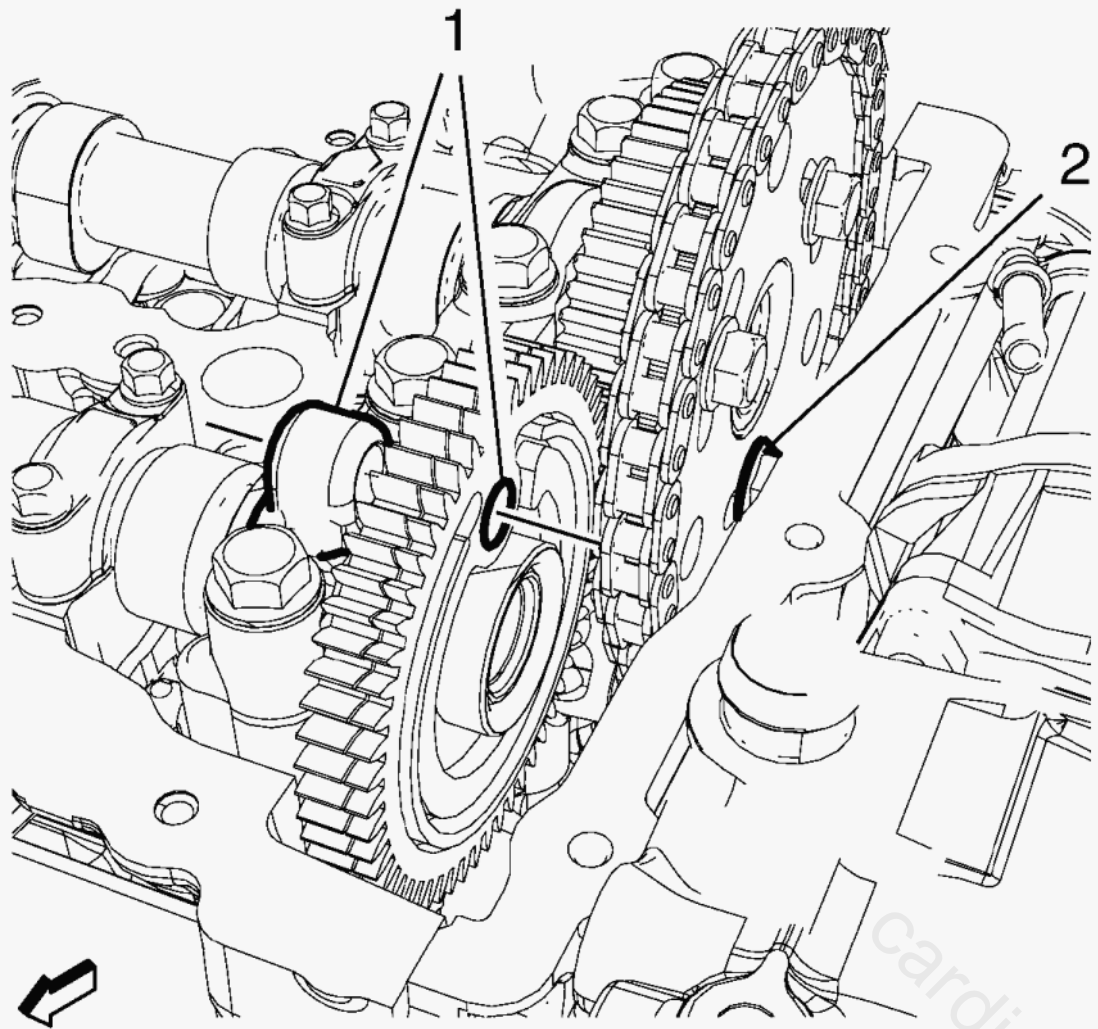


Fig. 258: Aligning Bores

Courtesy of GENERAL MOTORS COMPANY

NOTE: If the bores not aligned turn the crankshaft at the crankshaft pulley bolts.

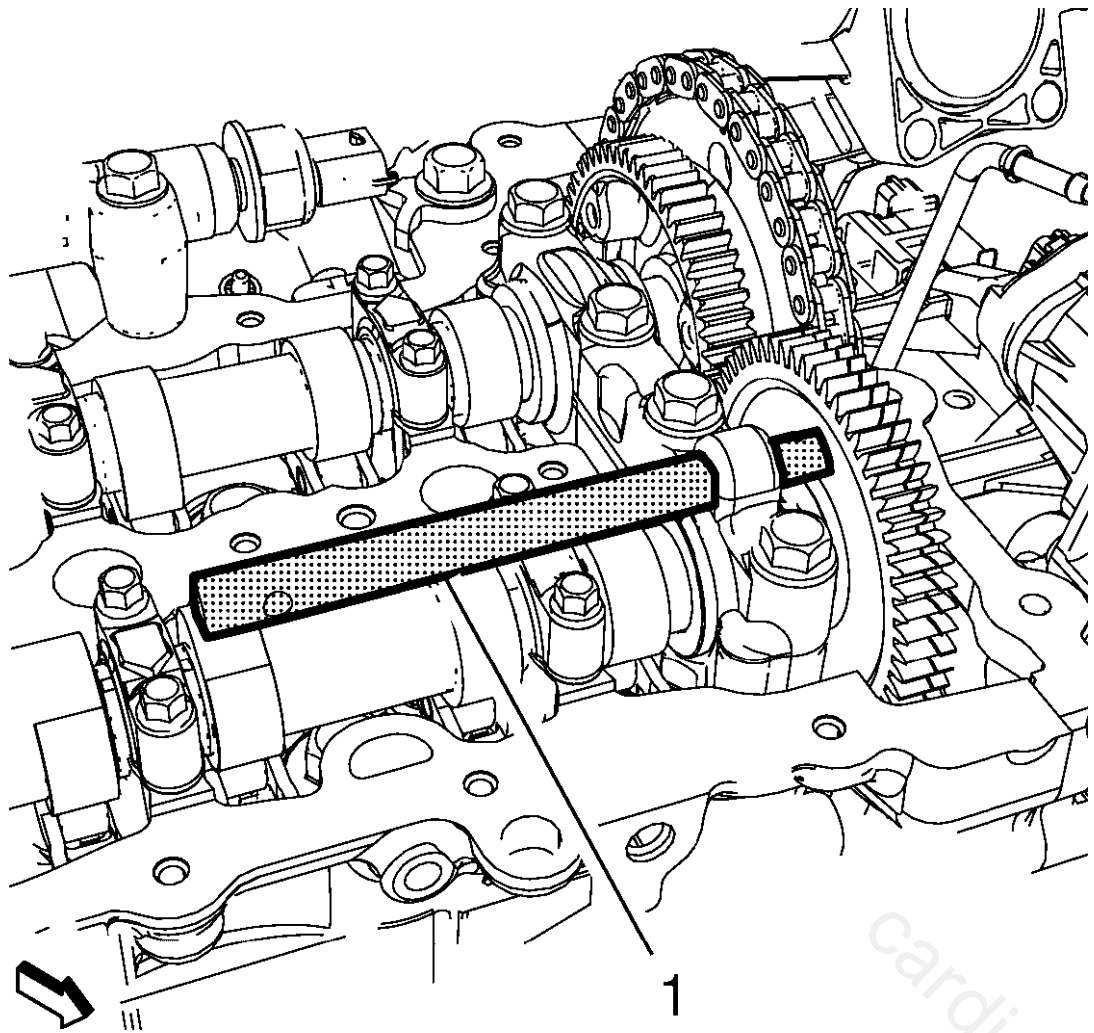


Fig. 259: Camshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

4. Check if the bores (1) are aligned.

Turn the exhaust camshaft at the hexagon so far if the **EN-51143** fixing tool (1) can be installed.

5. Raise and support the vehicle. Refer to [Lifting and Jacking the Vehicle](#) .

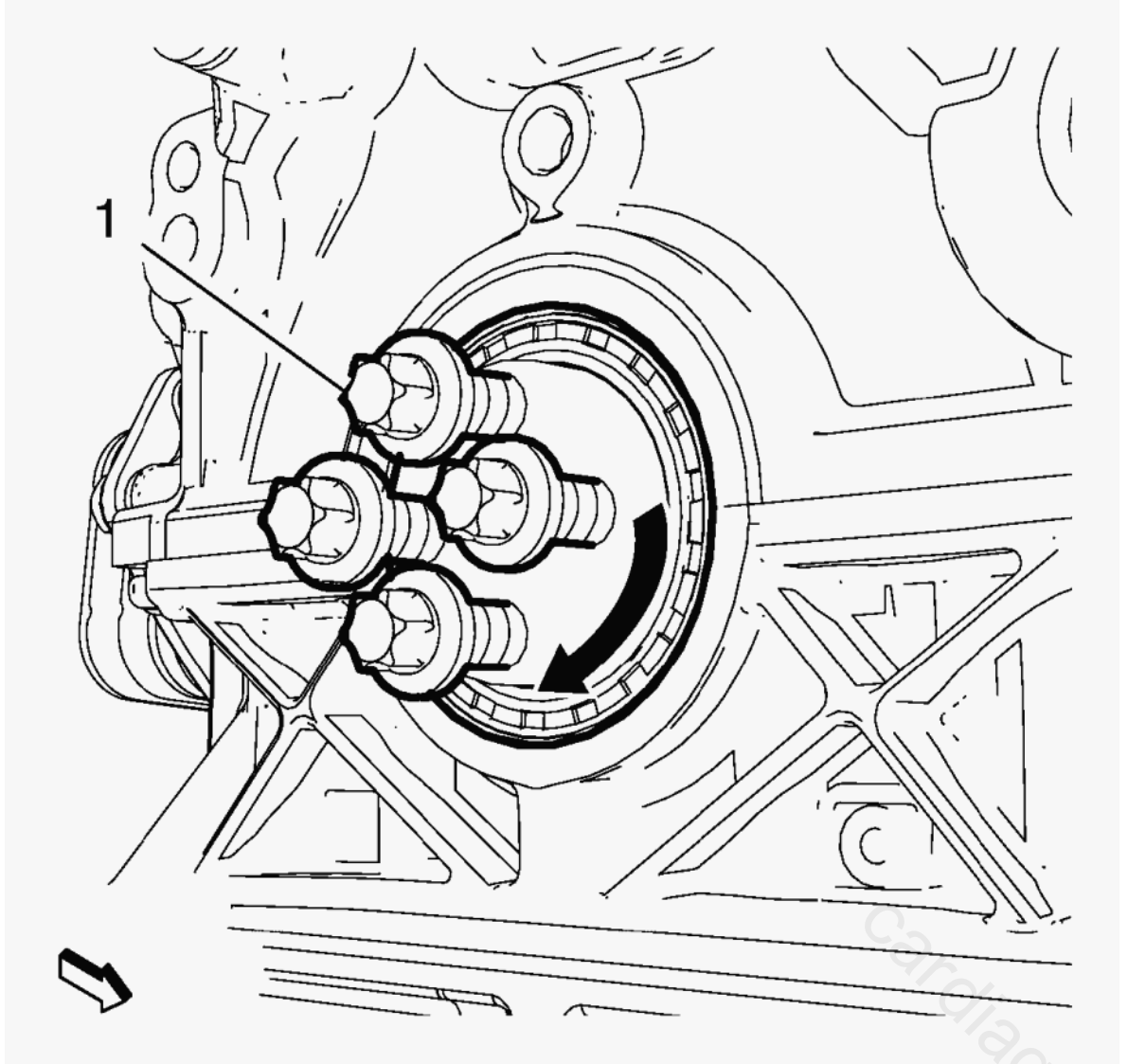


Fig. 260: Crankshaft Pulley Bolts

Courtesy of GENERAL MOTORS COMPANY

6. Remove the 4 crankshaft pulley bolts (1).

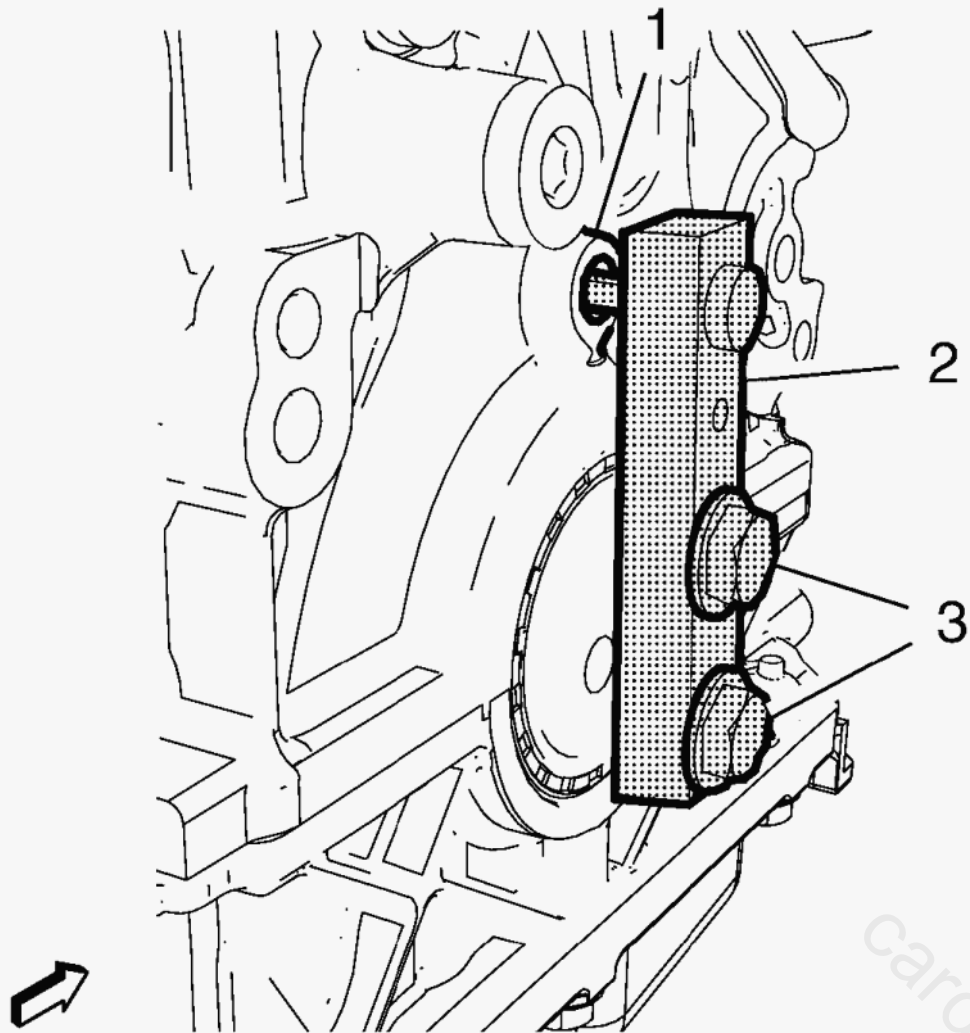


Fig. 261: Crankshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

7. Install **EN-51140** fixing tool (2).
8. Install the fixing pin into the engine block bore (1) and tighten the 2 bolts (3).
9. If the **EN-51140** fixing tool can not installed. Refer to [Camshaft Timing Chain Adjustment](#).
10. Lower the vehicle.

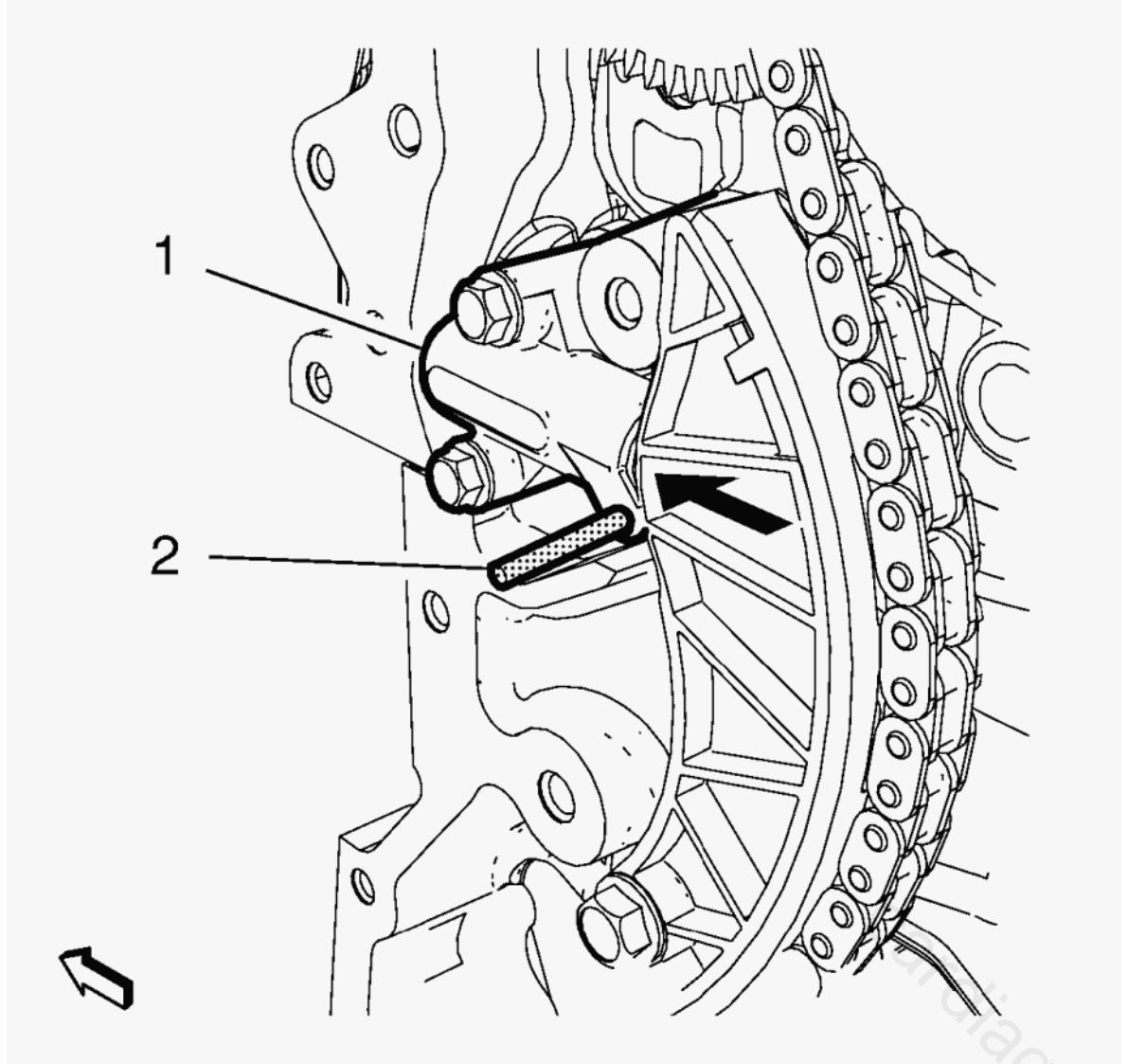


Fig. 262: Timing Chain Tensioner And Pin

Courtesy of GENERAL MOTORS COMPANY

11. Tension the timing chain tensioner (1) in arrow direction.
12. Install the EN-50513 pin (2).

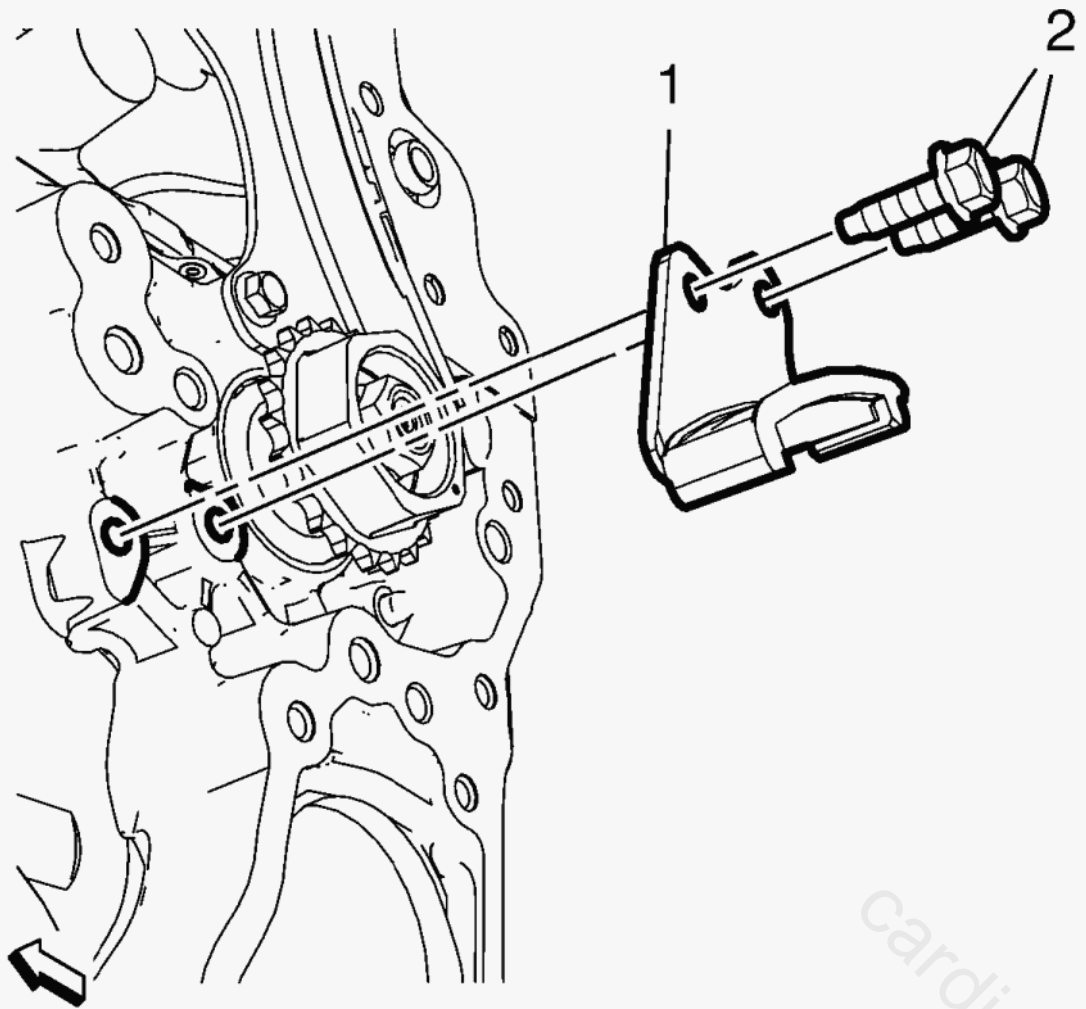


Fig. 263: Timing Chain Lower Guide And Bolts
Courtesy of GENERAL MOTORS COMPANY

13. Remove the 2 timing chain lower guide bolts (2).
14. Remove the timing chain lower guide (1).

Installation Procedure

NOTE: Before installing the timing chain lower guide, check the components of the timing chain system for damage and wear.

1. Check the components of the timing chain system for damage and wear:
 - Timing chain guides with plastic attachment
 - Timing chain tensioner and timing chain tensioner shoe with plastic attachment
 - Timing chain and all timing chain sprockets
 - Oil pump sprocket
 - Oil pump drive chain tensioner

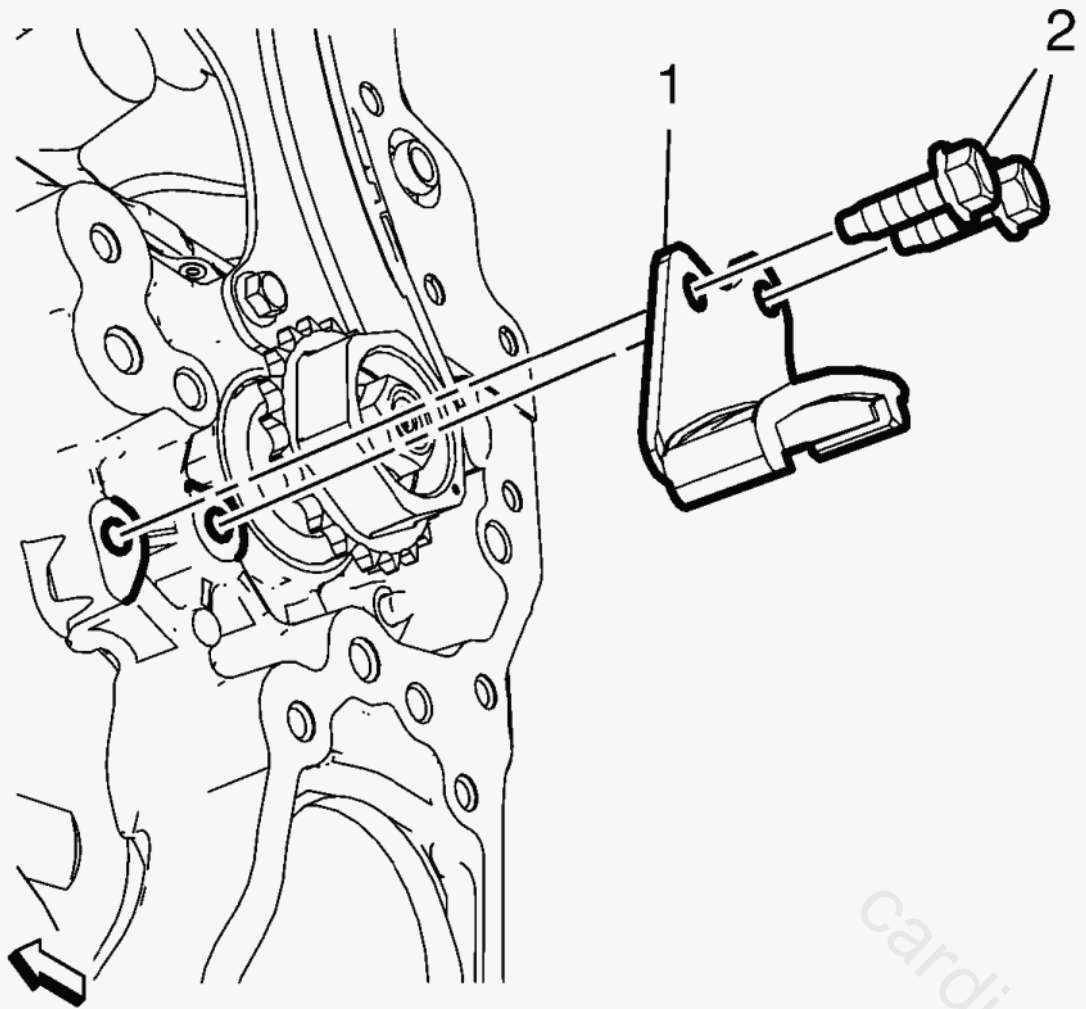


Fig. 264: Timing Chain Lower Guide And Bolts
Courtesy of GENERAL MOTORS COMPANY

2. Install the timing chain lower guide (1).

CAUTION: Refer to **Fastener Caution** .

3. Install the 2 timing chain lower guide bolts (2) and tighten to 10 N.m (89 lb in).

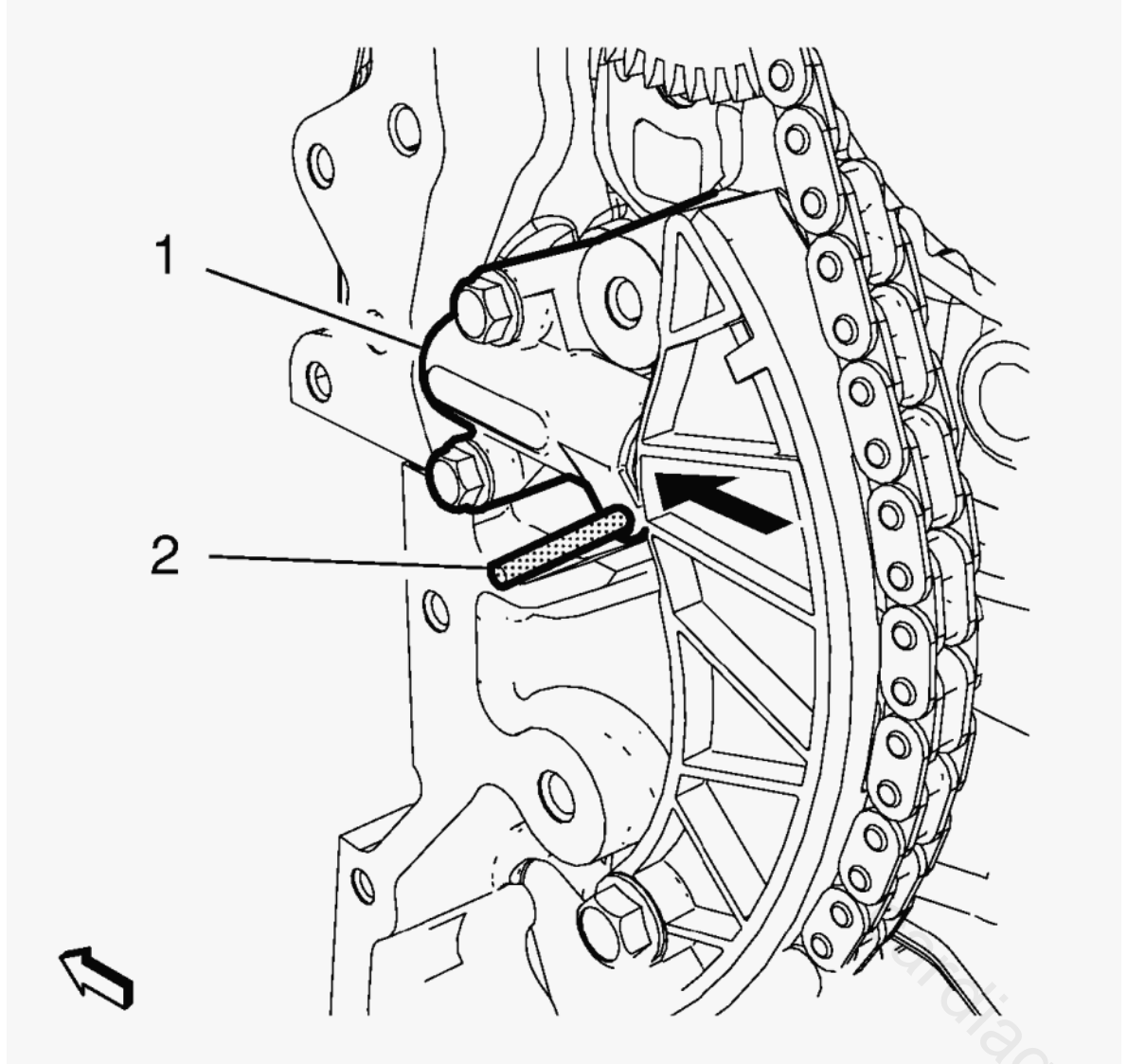


Fig. 265: Timing Chain Tensioner And Pin
Courtesy of GENERAL MOTORS COMPANY

4. Remove the EN-50513 pin (2).

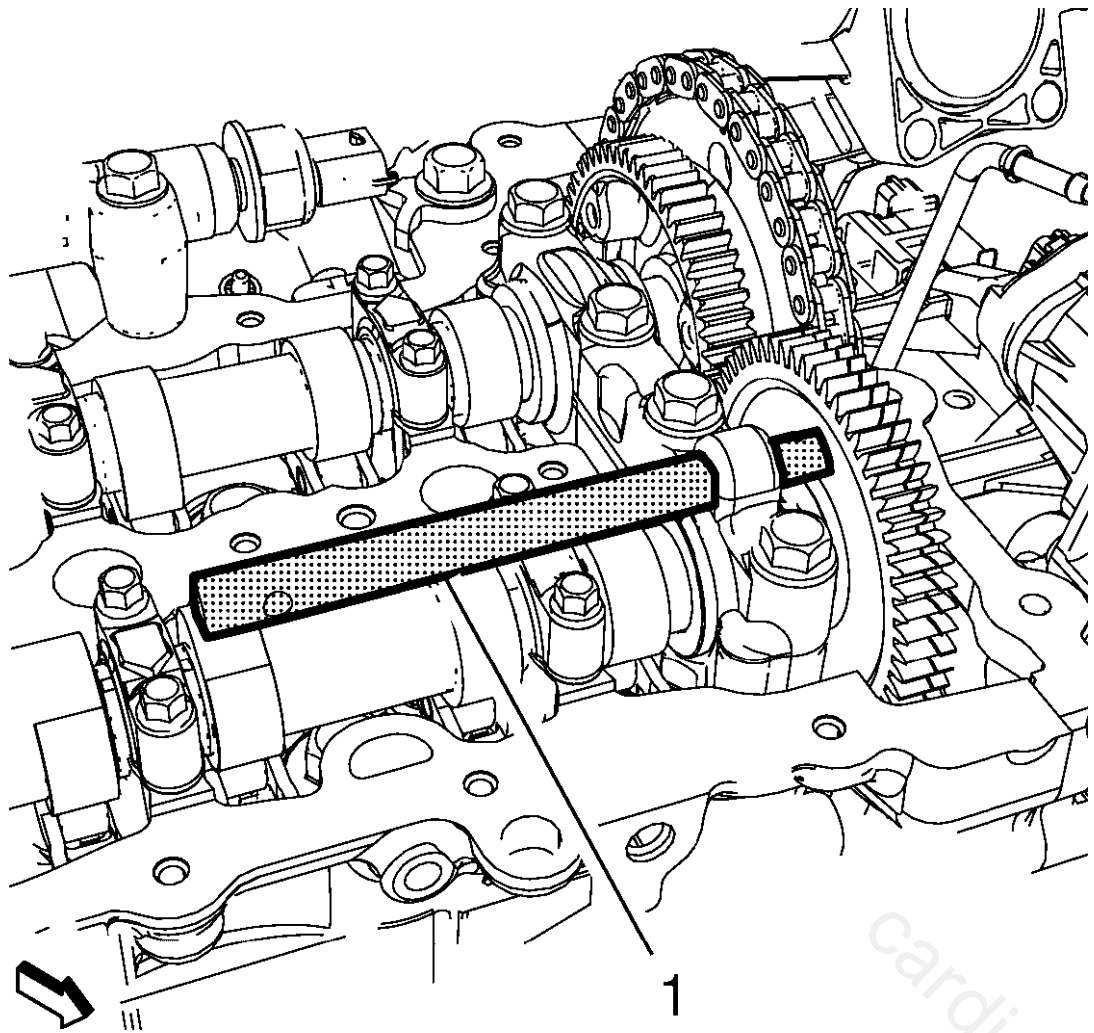


Fig. 266: Camshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

5. Remove the **EN-51143** fixing tool (1).
6. Raise the vehicle.

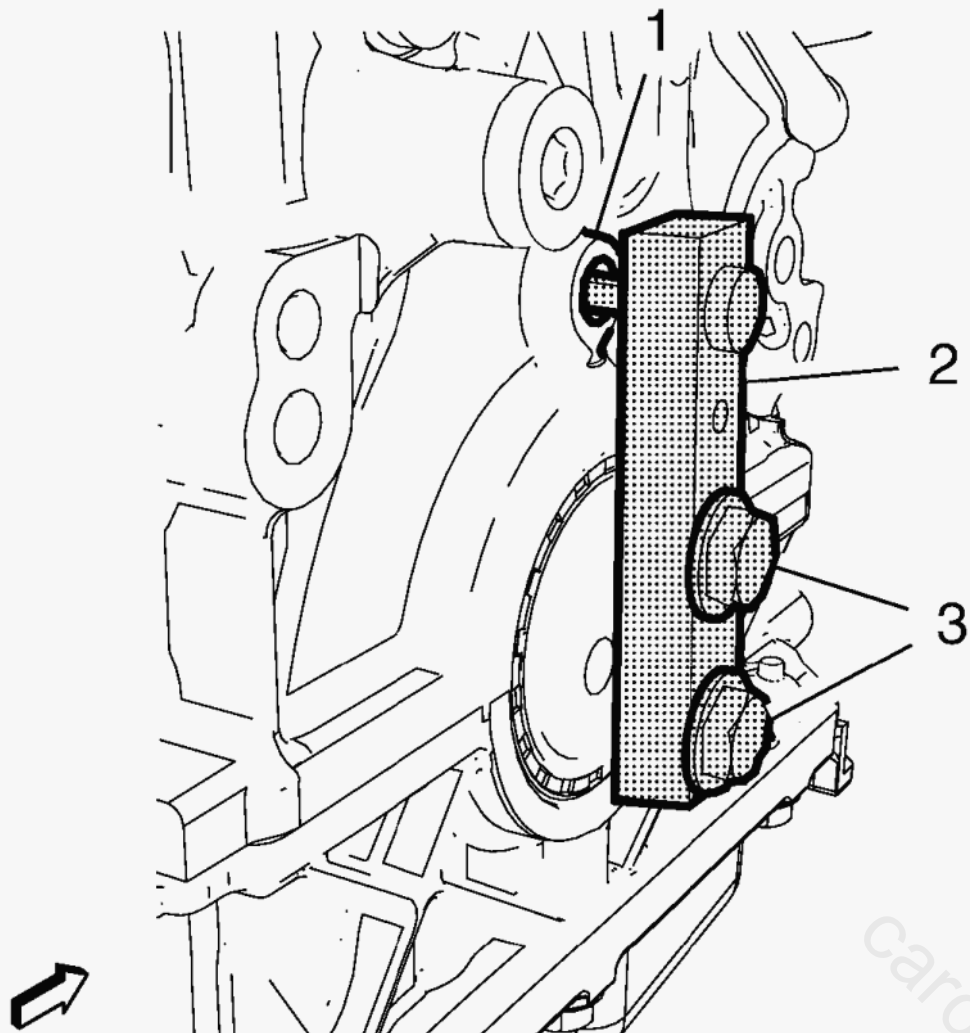


Fig. 267: Crankshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

7. Remove the 2 bolts (3).
8. Remove the **EN-51140** fixing tool (2).

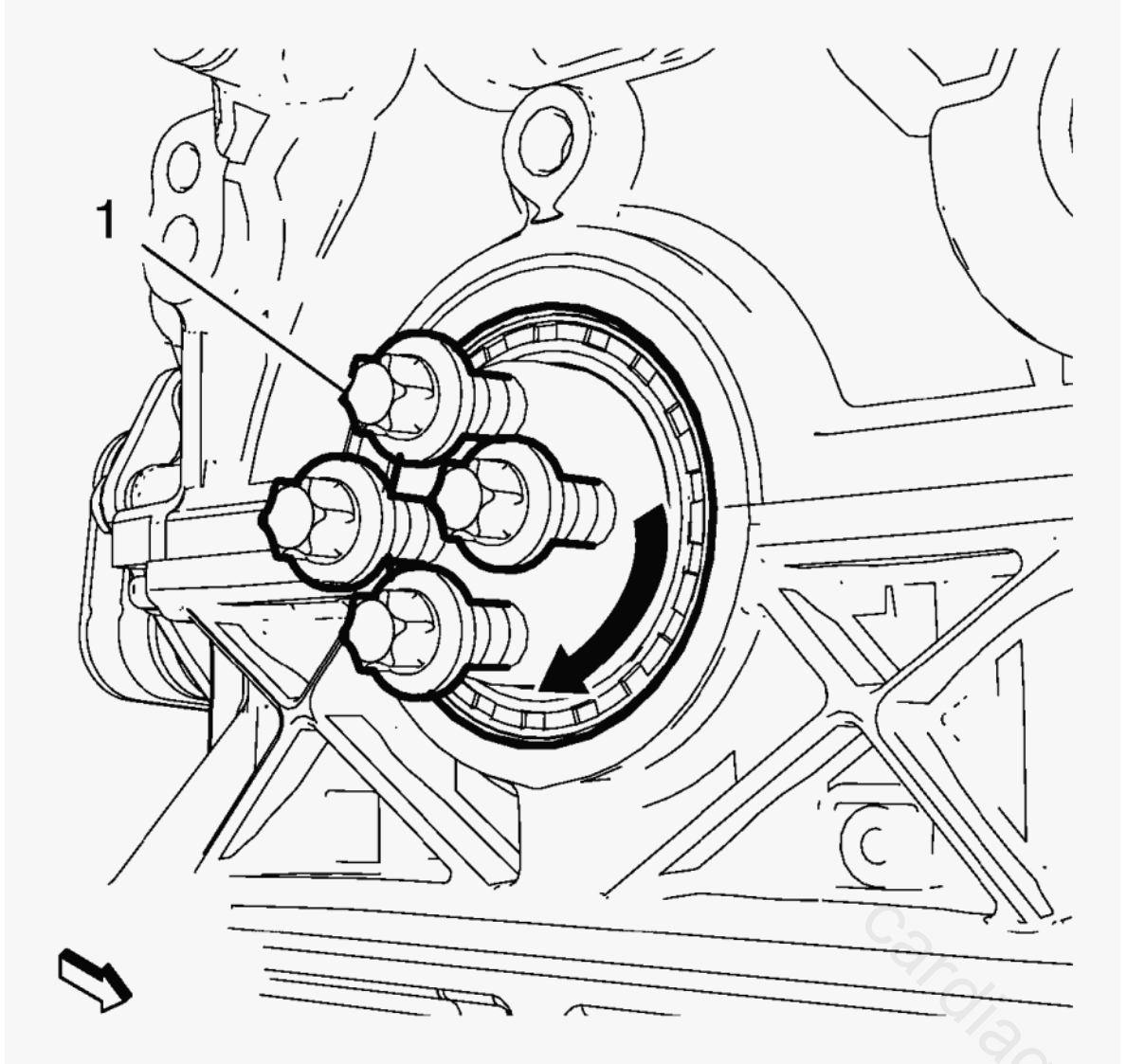


Fig. 268: Crankshaft Pulley Bolts

Courtesy of GENERAL MOTORS COMPANY

9. Install the 4 crankshaft pulley bolts (1).

Rotate the crankshaft 720 degrees in direction of arrow. Use a pry bar at the 4 crankshaft pulley bolts (1).

10. Remove the 4 crankshaft pulley bolts (1).
11. Check the camshaft timing. Refer to [Camshaft Timing Chain Inspection](#).
12. Install the crankshaft pulley. Refer to [Crankshaft Pulley Replacement](#).
13. Install the timing chain lower cover. Refer to [Timing Chain Lower Cover Replacement](#).

TIMING CHAIN TENSIONER REPLACEMENT

Special Tools

- **EN-50513** Fixing Pin
- **EN-51140** Crankshaft Fixing Tool
- **EN-51143** Camshaft Sprocket Fixing Tool

For equivalent regional tools, refer to [Special Tools](#).

Removal Procedure

1. Remove the timing chain upper cover. Refer to [Timing Chain Upper Cover Replacement](#)
2. Remove the crankshaft pulley. Refer to [Crankshaft Pulley Replacement](#).

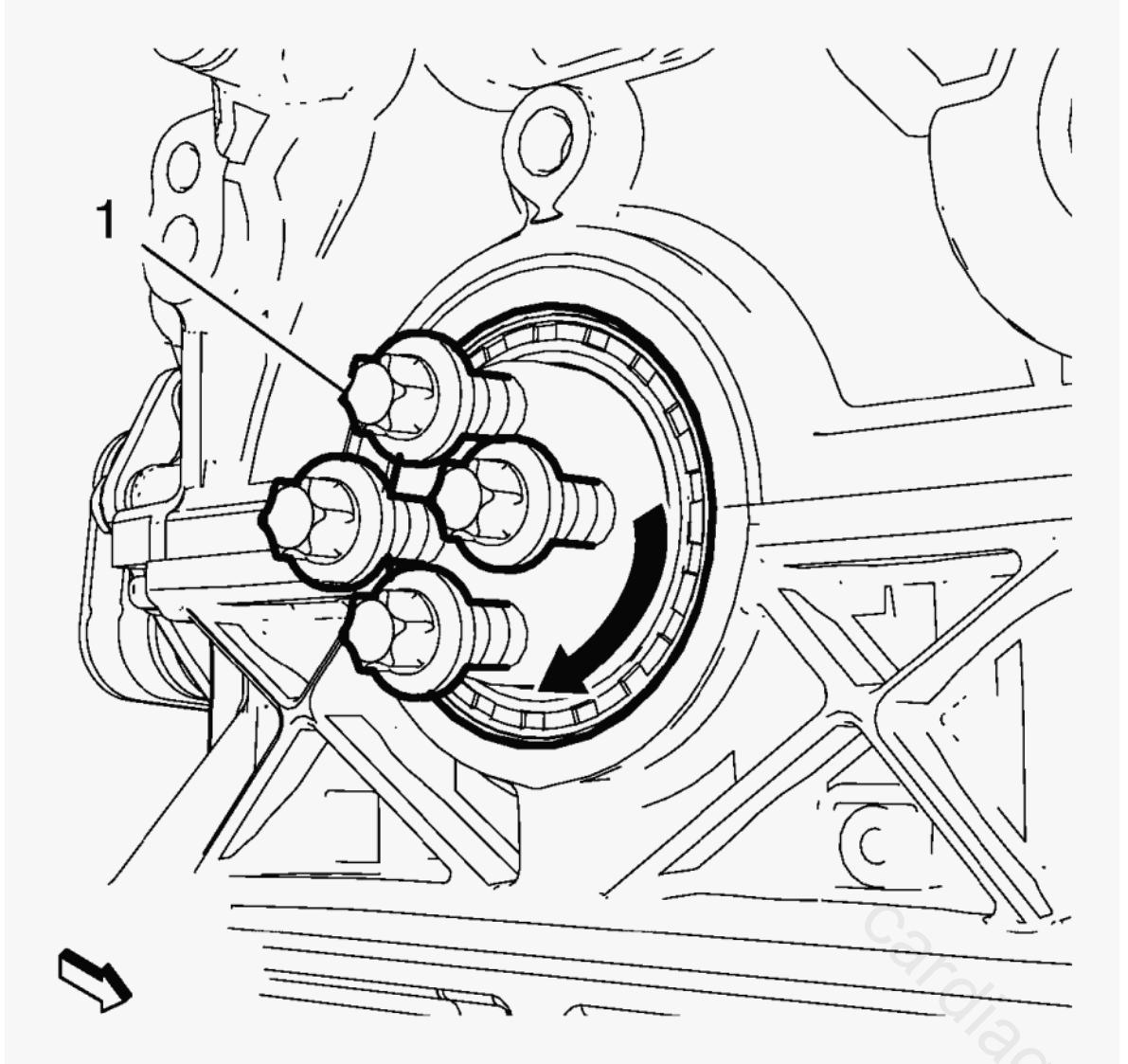


Fig. 269: Crankshaft Pulley Bolts

Courtesy of GENERAL MOTORS COMPANY

3. Install the 4 crankshaft pulley bolts (1).

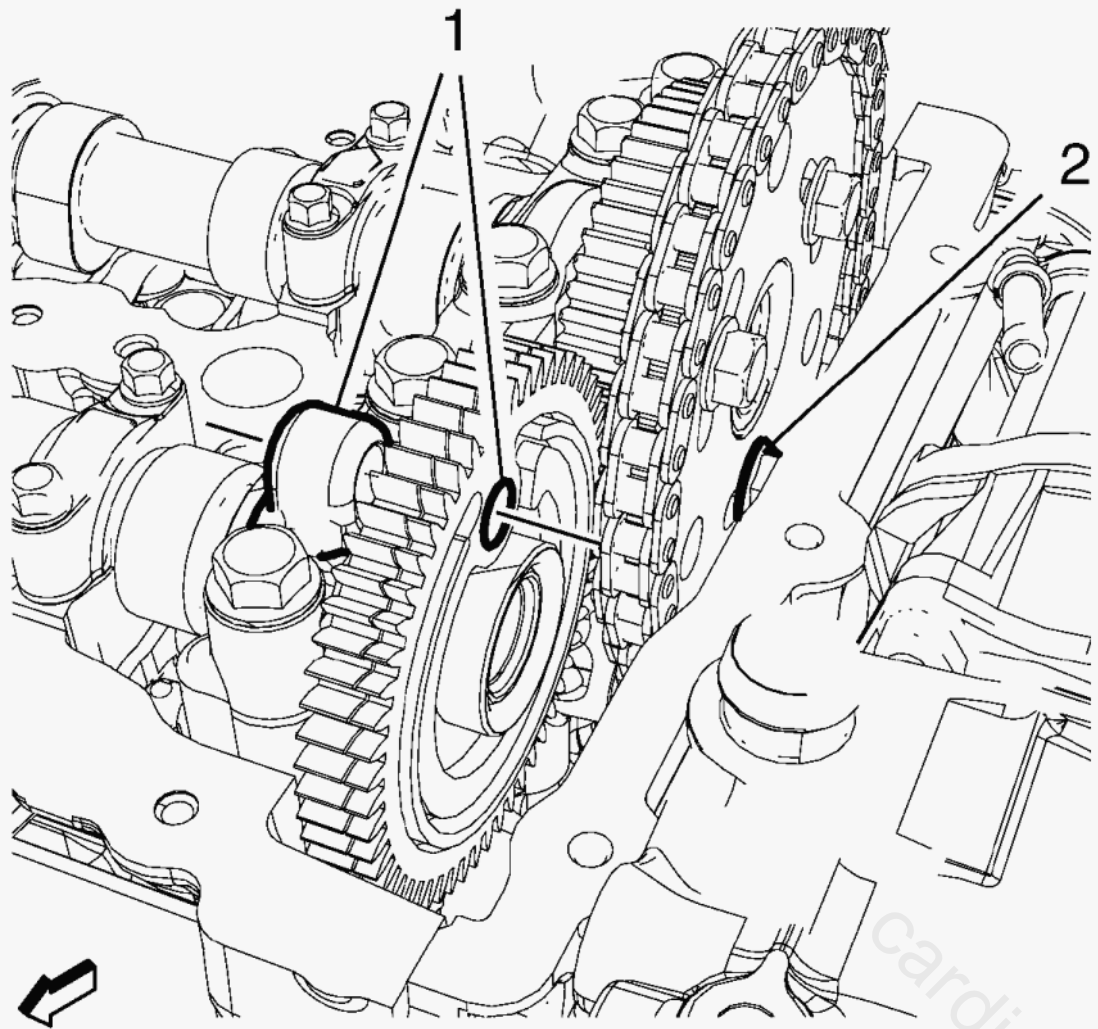


Fig. 270: Aligning Bores

Courtesy of GENERAL MOTORS COMPANY

NOTE: If the bores not aligned turn the crankshaft at the crankshaft pulley bolts.

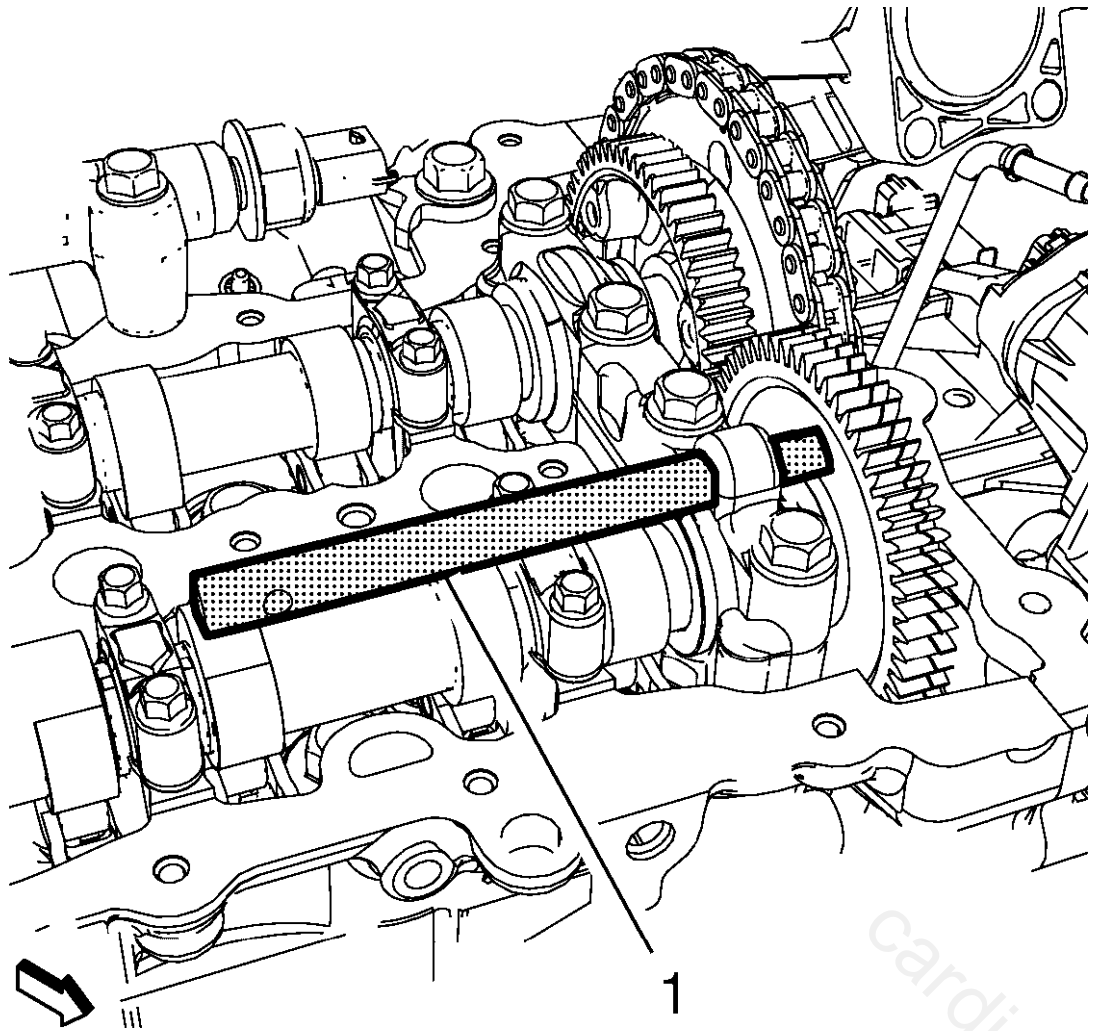


Fig. 271: Camshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

4. Check if the bores (1) are aligned.

Turn the exhaust camshaft at the hexagon so far if the **EN-51143** fixing tool (1) can be installed.

5. Raise and support the vehicle. Refer to [Lifting and Jacking the Vehicle](#)

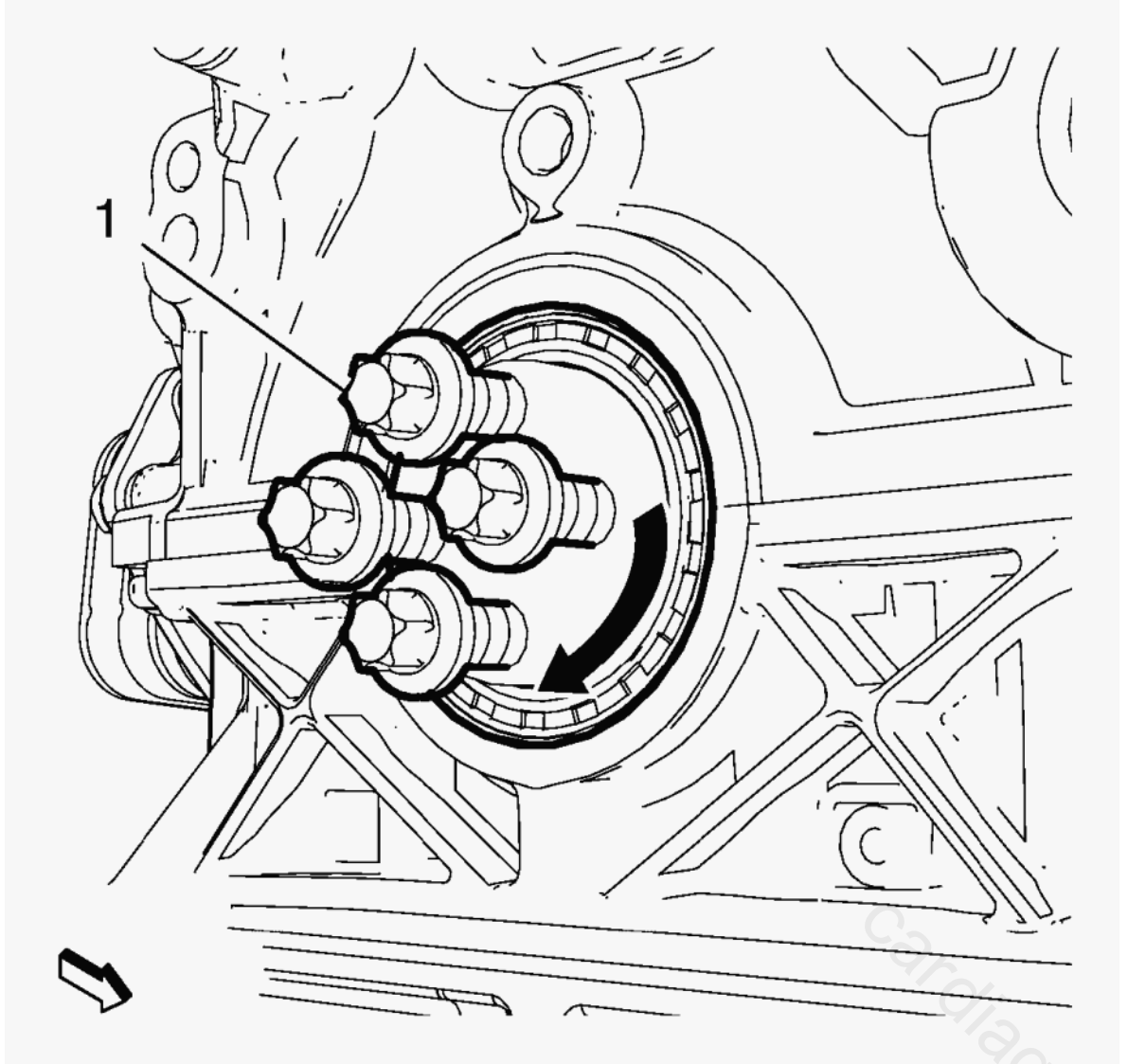


Fig. 272: Crankshaft Pulley Bolts

Courtesy of GENERAL MOTORS COMPANY

6. Remove the 4 crankshaft pulley bolts (1).

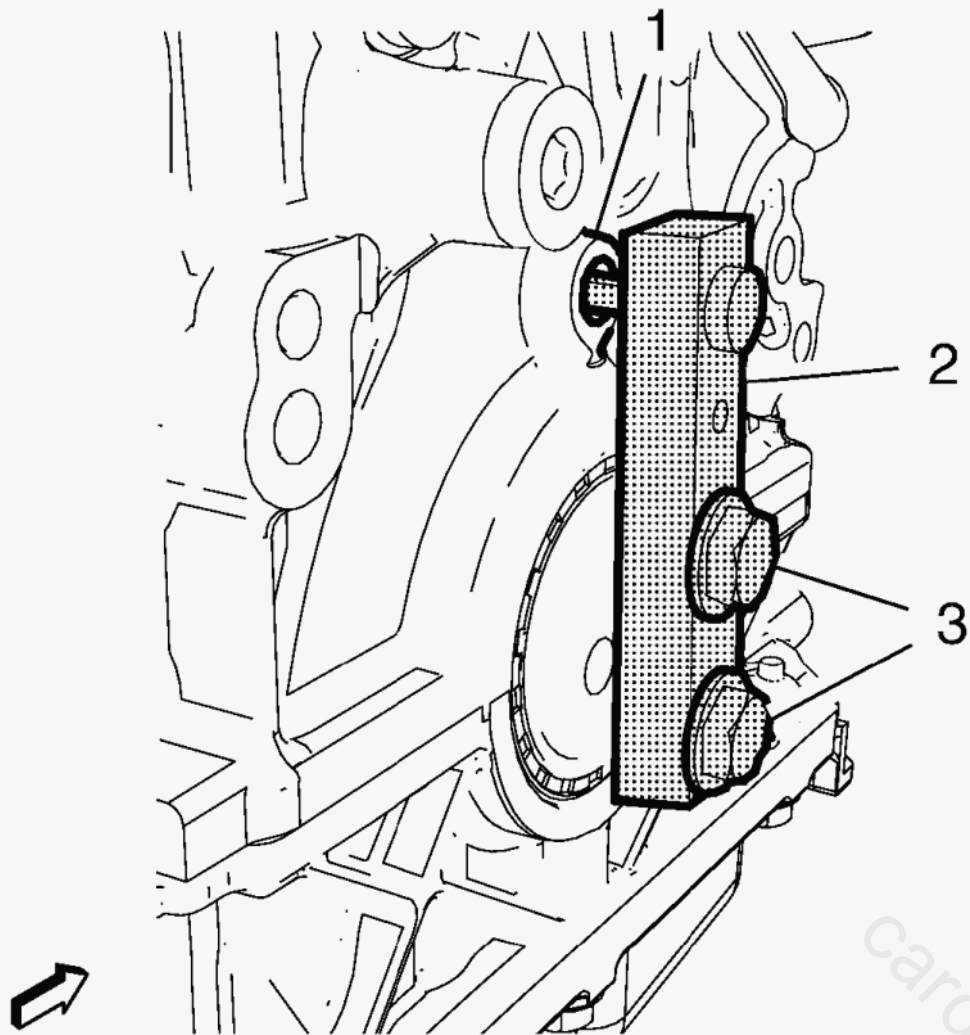


Fig. 273: Crankshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

7. Install **EN-51140** fixing tool (2).
8. Install the fixing pin into the engine block bore (1) and tighten the 2 bolts (3).
9. If the **EN-51140** fixing tool can not installed. Refer to [Camshaft Timing Chain Adjustment](#).
10. Lower the vehicle.

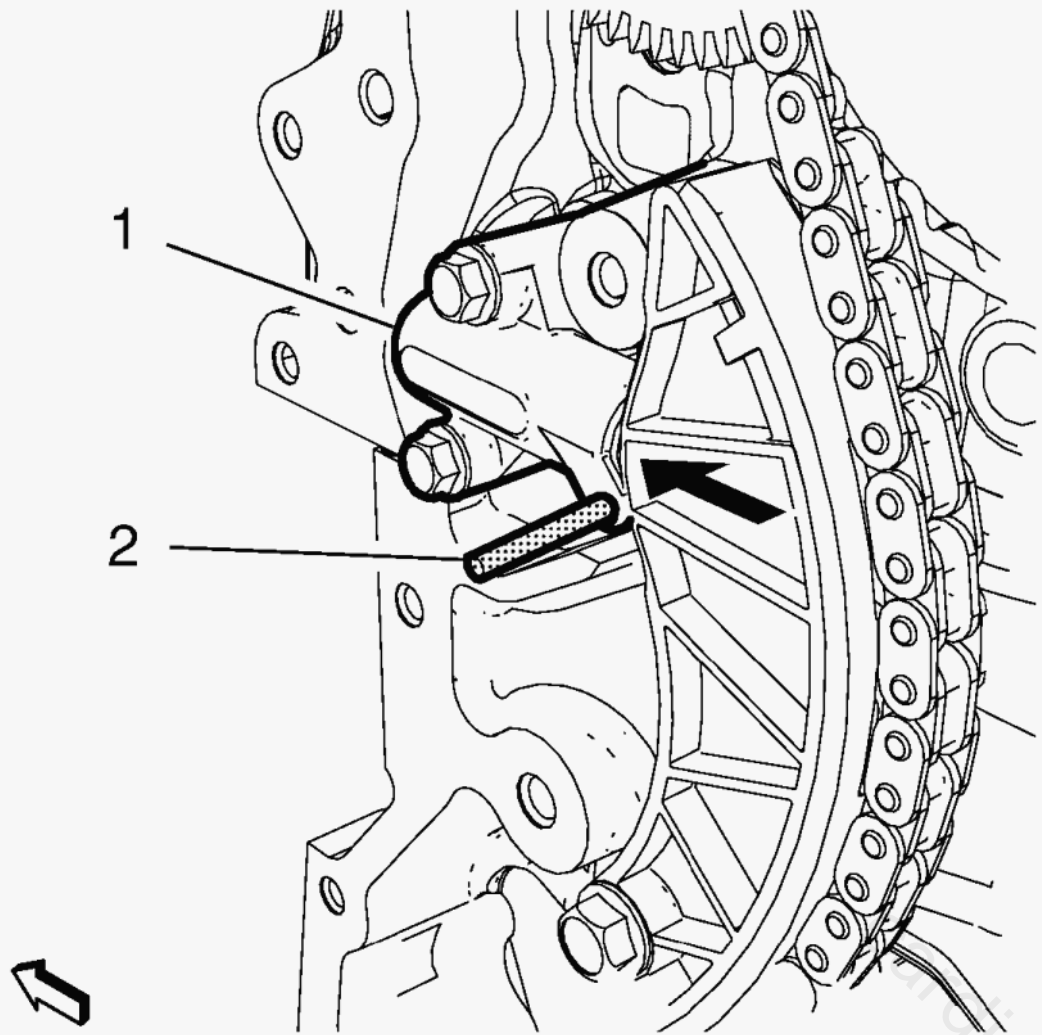


Fig. 274: Timing Chain Tensioner And Pin

Courtesy of GENERAL MOTORS COMPANY

11. Tension the timing chain tensioner (1) in arrow direction.
12. Install the EN-50513 pin (2).

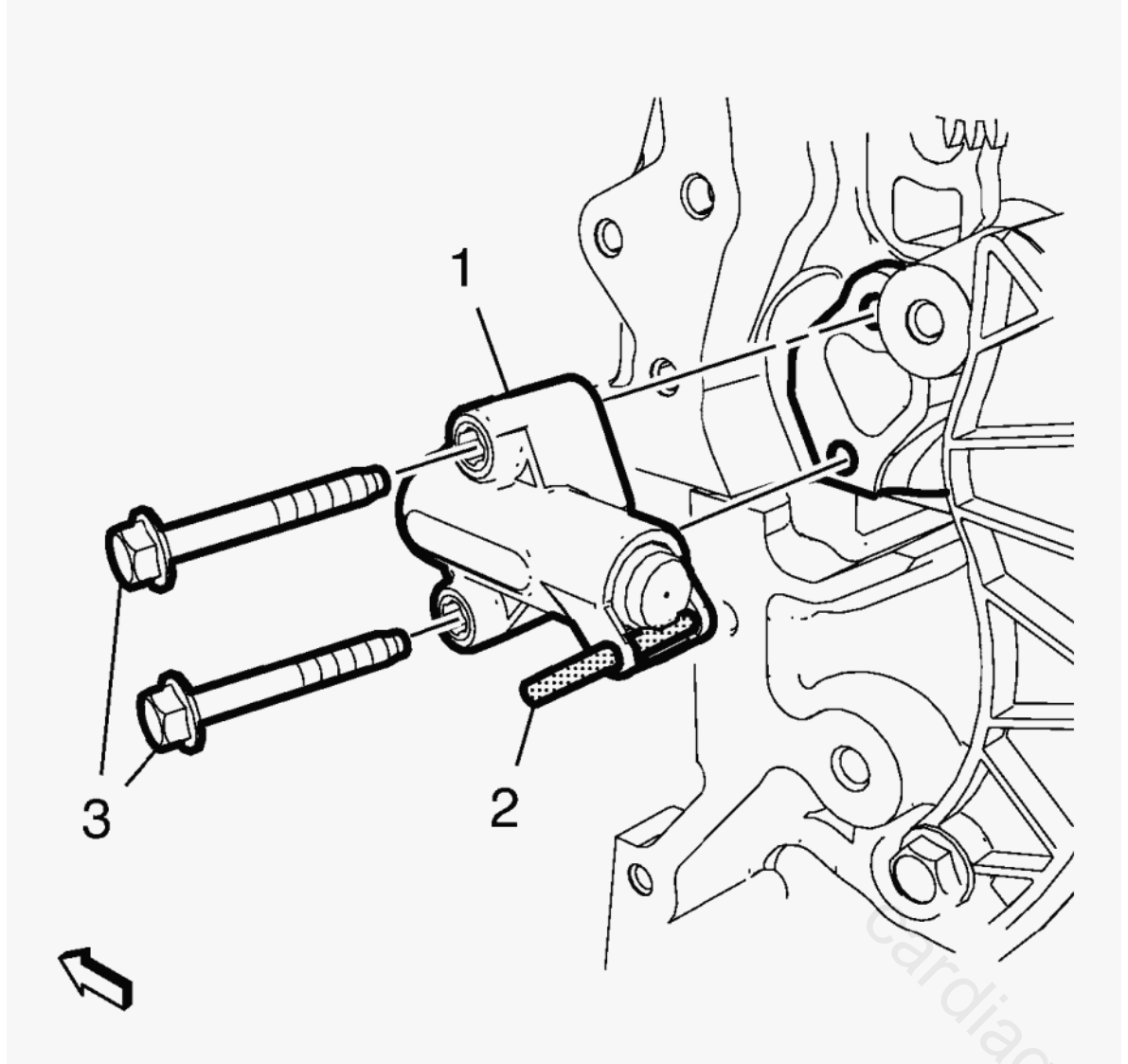


Fig. 275: Timing Chain Tensioner, Bolts And Pin
Courtesy of GENERAL MOTORS COMPANY

13. Remove the 2 timing chain tensioner bolts (3).

NOTE: If the timing chain tensioner will be reused, do not remove the EN-50513 pin (2).

14. Remove the timing chain tensioner (1).

Installation Procedure

NOTE: Before installing the timing chain tensioner, check the components of the timing chain system for damage and wear.

1. Check the components of the timing chain system for damage and wear:
 - Timing chain guides with plastic attachment
 - Timing chain tensioner and timing chain tensioner shoe with plastic attachment
 - Timing chain and all timing chain sprockets
 - Oil pump sprocket
 - Oil pump drive chain tensioner

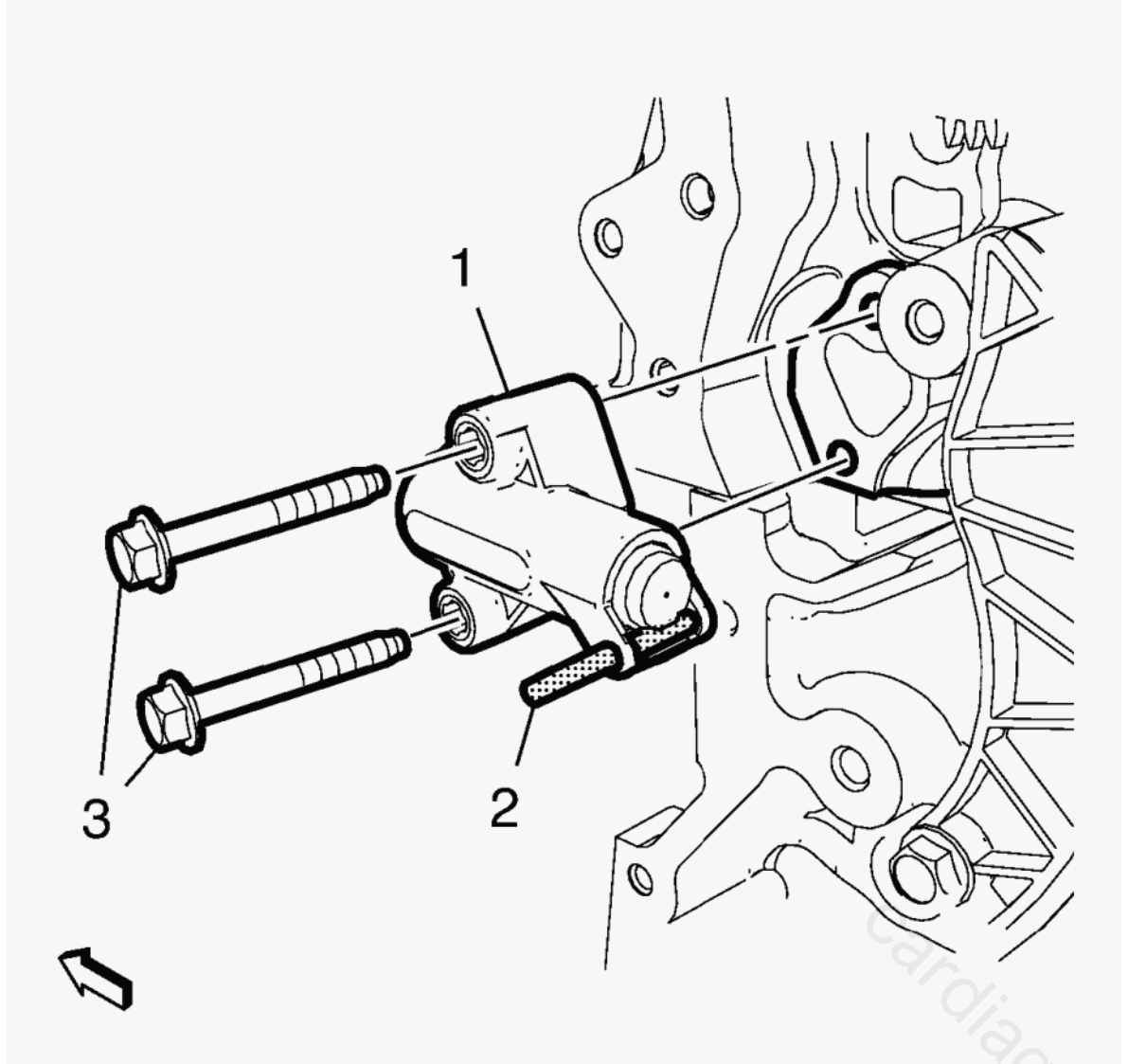


Fig. 276: Timing Chain Tensioner, Bolts And Pin
Courtesy of GENERAL MOTORS COMPANY

2. Install the timing chain tensioner (1).

CAUTION: Refer to **Fastener Caution** .

3. Install the 2 timing chain tensioner bolts (3) and tighten to 10 N.m (89 lb in).

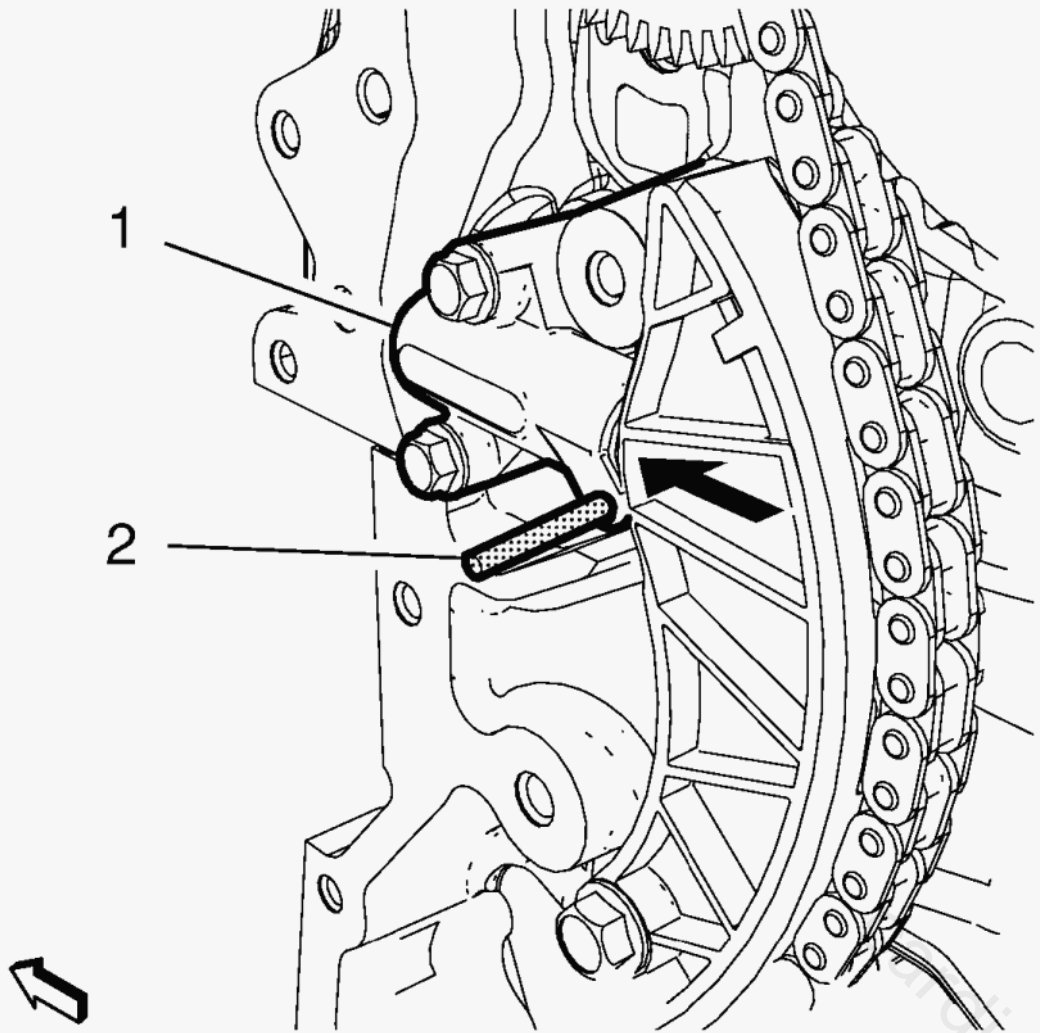


Fig. 277: Timing Chain Tensioner And Pin
Courtesy of GENERAL MOTORS COMPANY

4. Remove the EN-50513 pin (2).

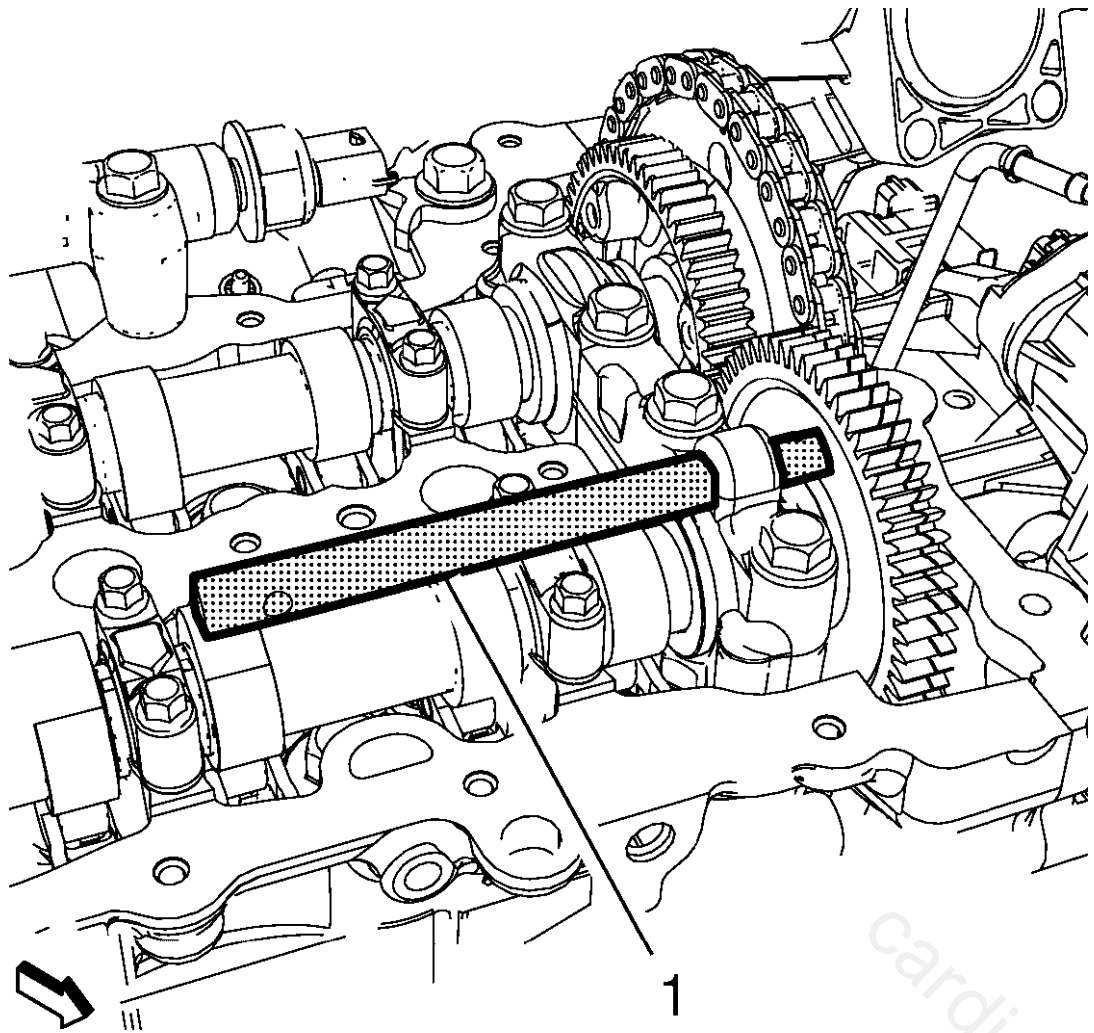


Fig. 278: Camshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

5. Remove the **EN-51143** fixing tool (1).
6. Raise the vehicle.

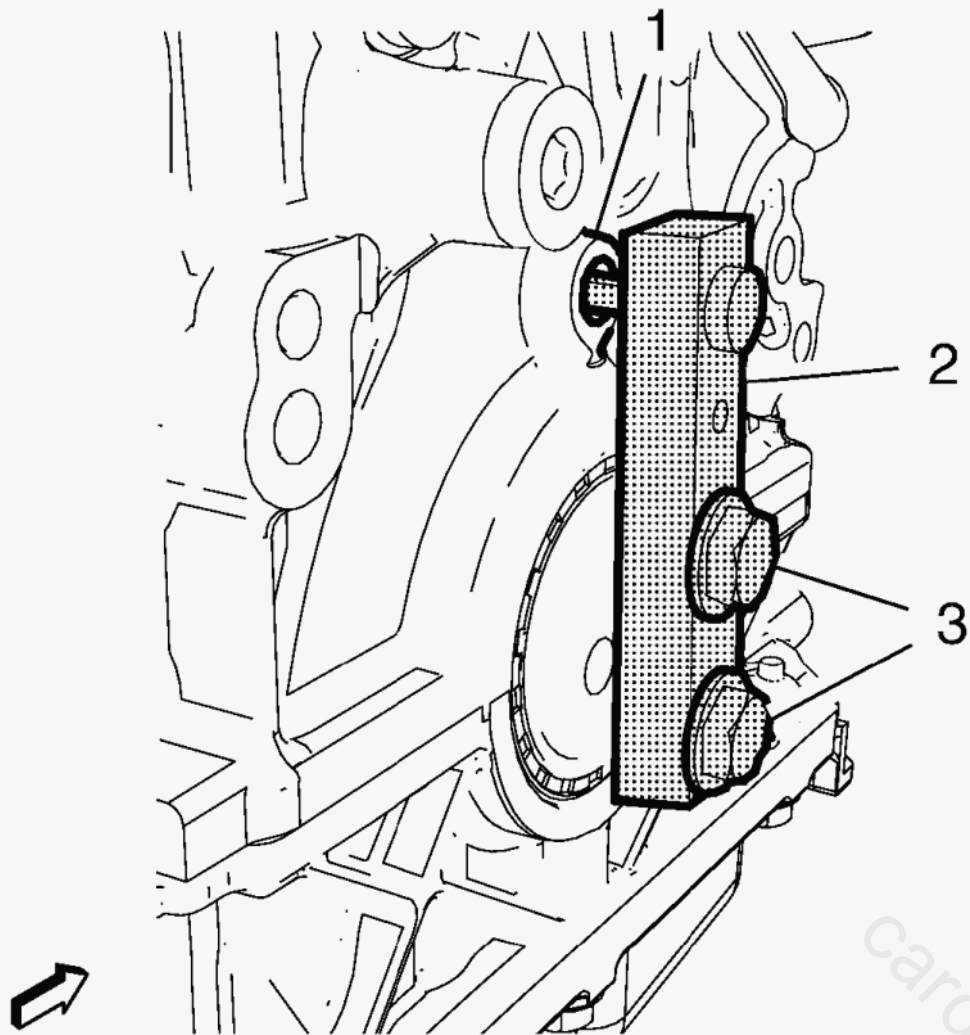


Fig. 279: Crankshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

7. Remove the 2 bolts (3).
8. Remove the **EN-51140** fixing tool (2).

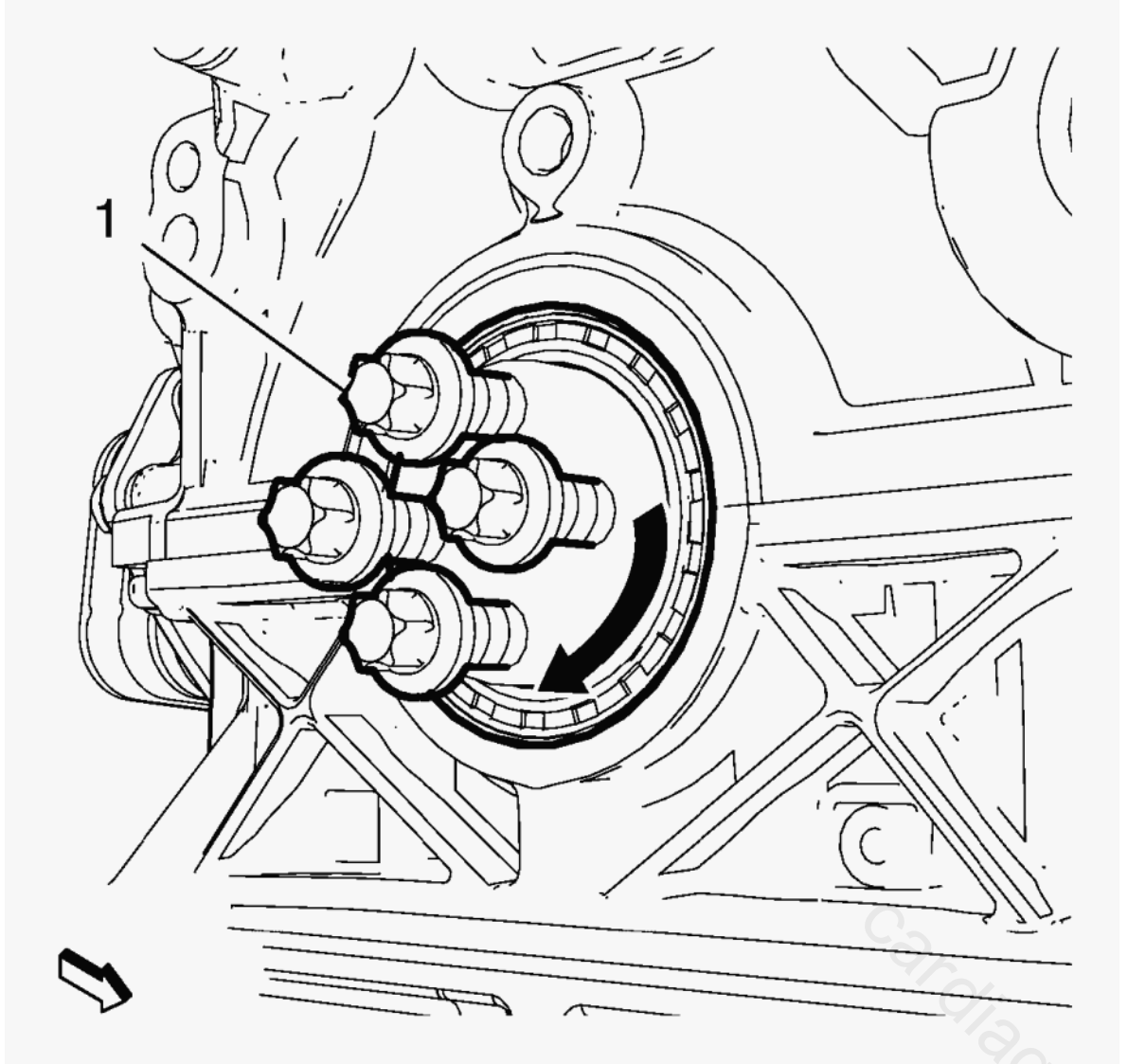


Fig. 280: Crankshaft Pulley Bolts

Courtesy of GENERAL MOTORS COMPANY

9. Install the 4 crankshaft pulley bolts (1).

Rotate the crankshaft 720 degrees in direction of arrow. Use a pry bar at the 4 crankshaft pulley bolts (1).

10. Remove the 4 crankshaft pulley bolts (1).
11. Check the camshaft timing. Refer to [Camshaft Timing Chain Inspection](#).
12. Install the crankshaft pulley. Refer to [Crankshaft Pulley Replacement](#).
13. Install the timing chain upper cover. Refer to [Timing Chain Upper Cover Replacement](#).

TIMING CHAIN TENSIONER SHOE REPLACEMENT

Special Tools

- EN-50513 Fixing Pin
- EN-51140 Crankshaft Fixing Tool
- EN-51143 Camshaft Sprocket Fixing Tool

For equivalent regional tools, refer to [Special Tools](#).

Removal Procedure

1. Remove the timing chain lower cover. Refer to [Timing Chain Lower Cover Replacement](#).
2. Remove the crankshaft pulley. Refer to [Crankshaft Pulley Replacement](#).

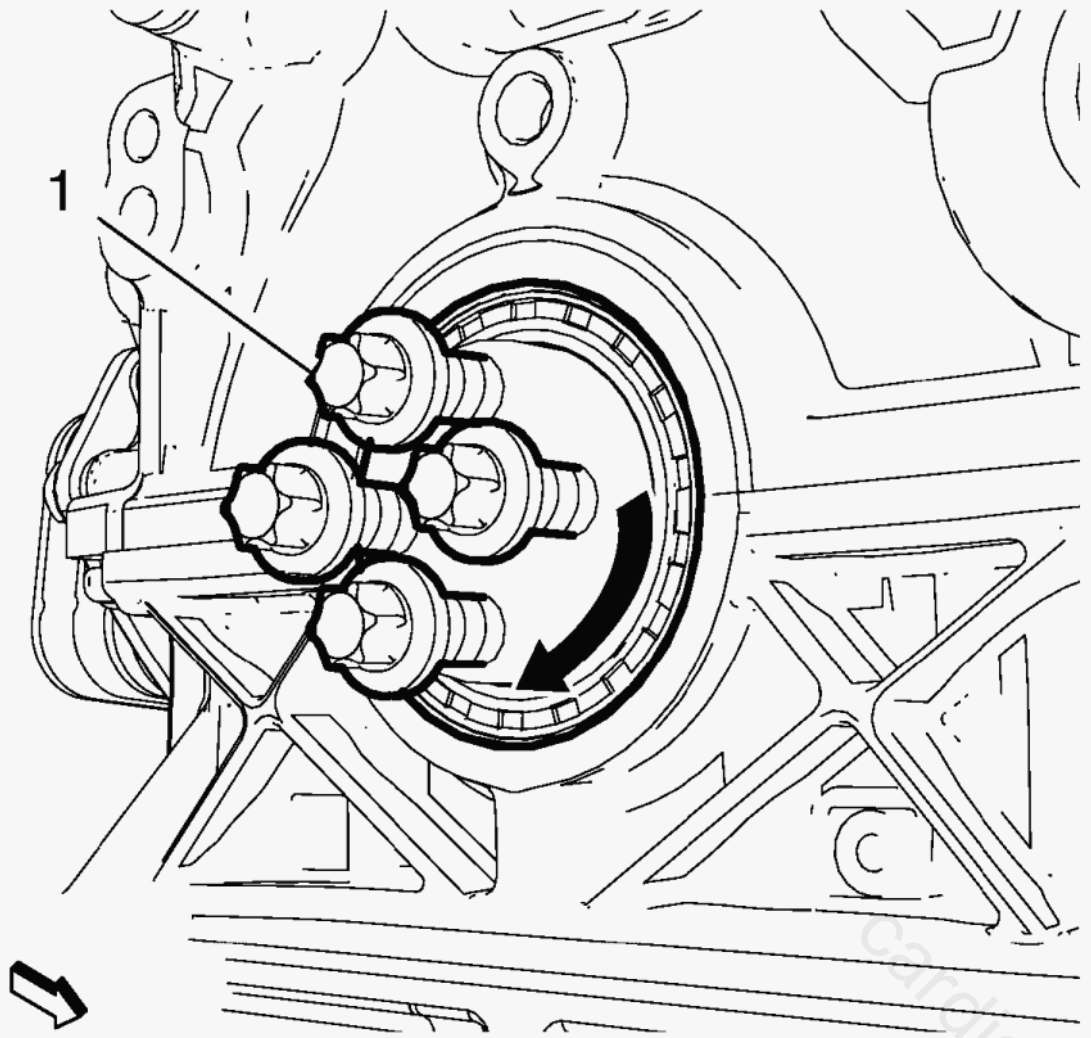


Fig. 281: Crankshaft Pulley Bolts

Courtesy of GENERAL MOTORS COMPANY

3. Install the 4 crankshaft pulley bolts (1).

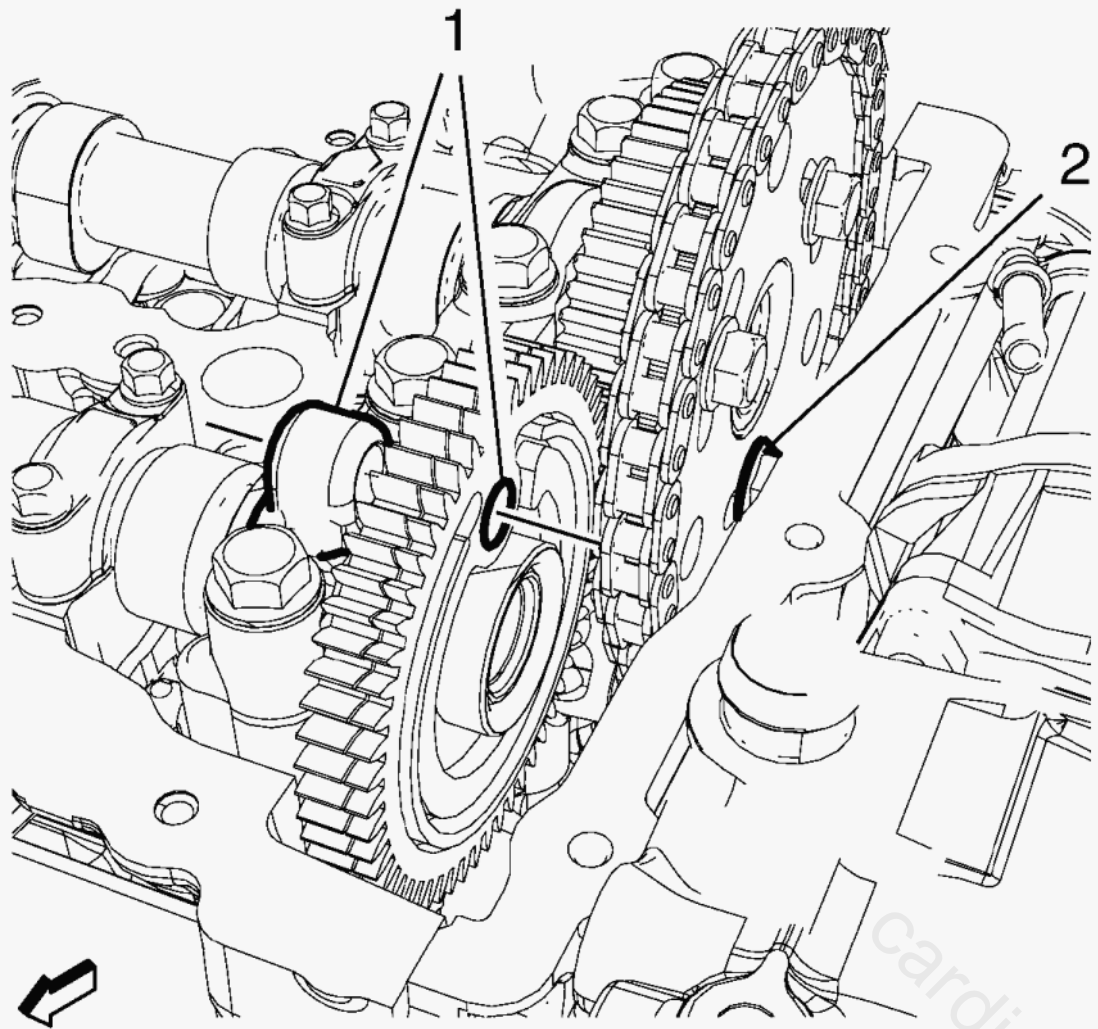


Fig. 282: Aligning Bores

Courtesy of GENERAL MOTORS COMPANY

NOTE: If the bores not aligned turn the crankshaft at the crankshaft pulley bolts.

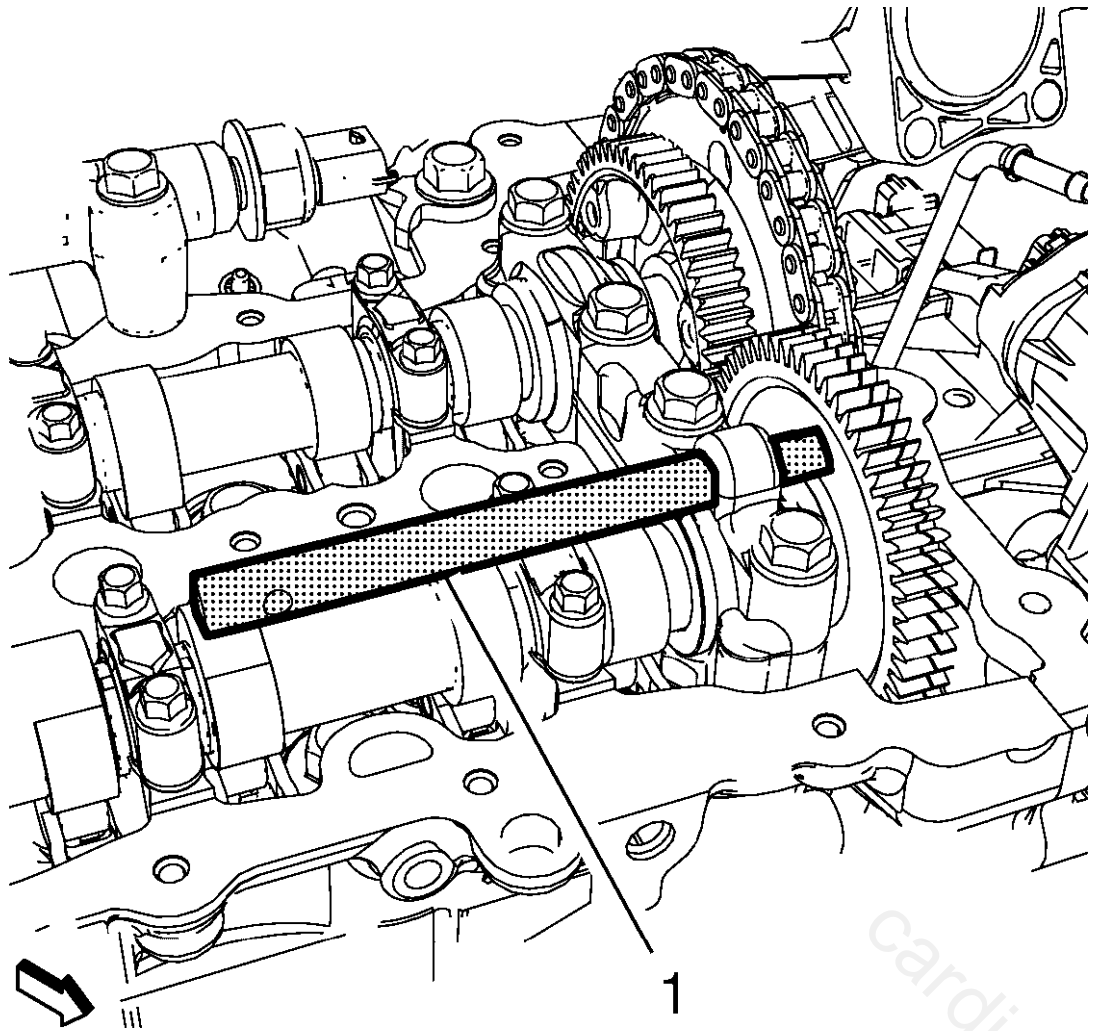


Fig. 283: Camshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

4. Check if the bores (1) are aligned.

Turn the exhaust camshaft at the hexagon so far if the **EN-51143** fixing tool (1) can be installed.

5. Raise and support the vehicle. Refer to [Lifting and Jacking the Vehicle](#)

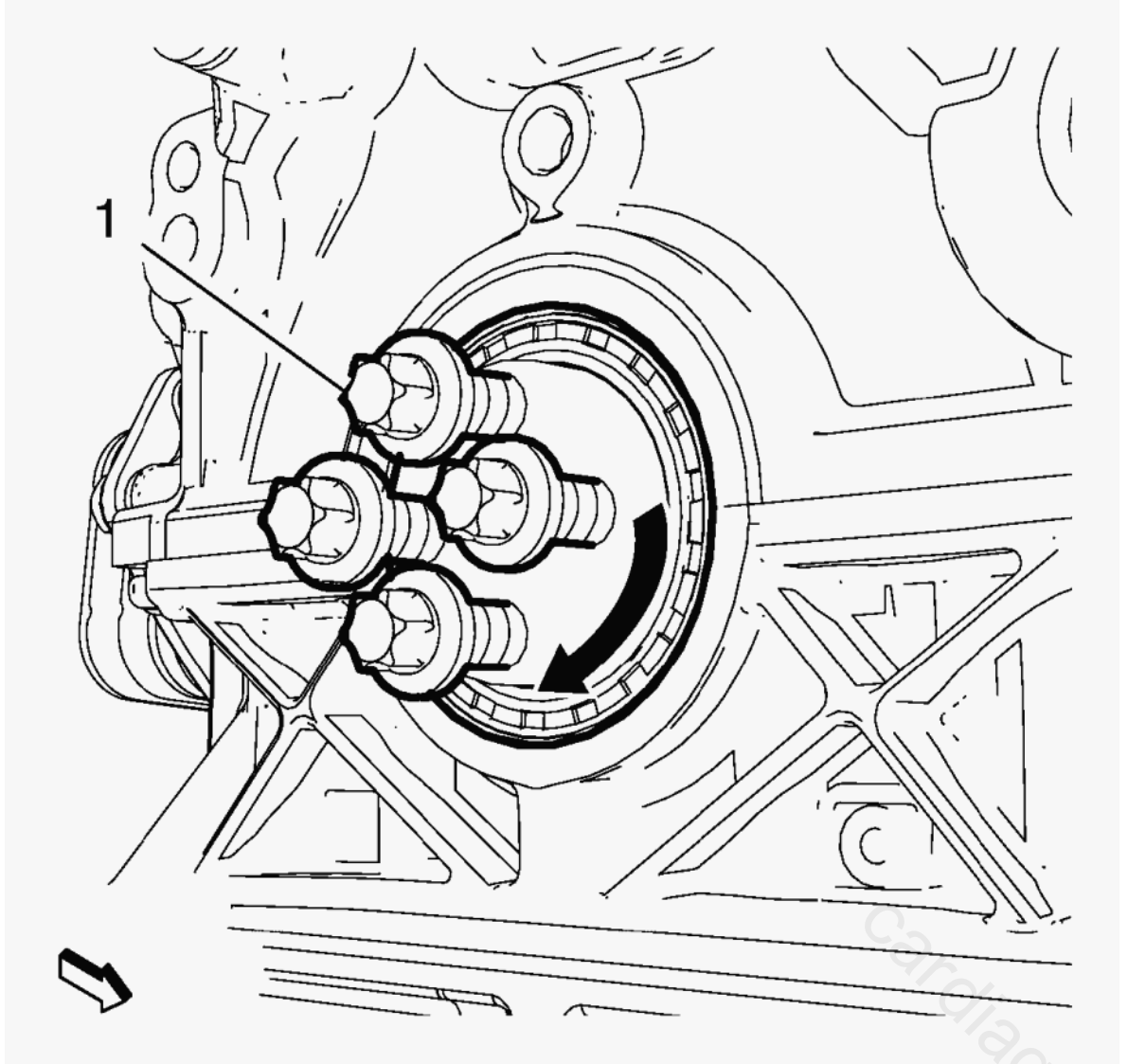


Fig. 284: Crankshaft Pulley Bolts

Courtesy of GENERAL MOTORS COMPANY

6. Remove the 4 crankshaft pulley bolts (1).

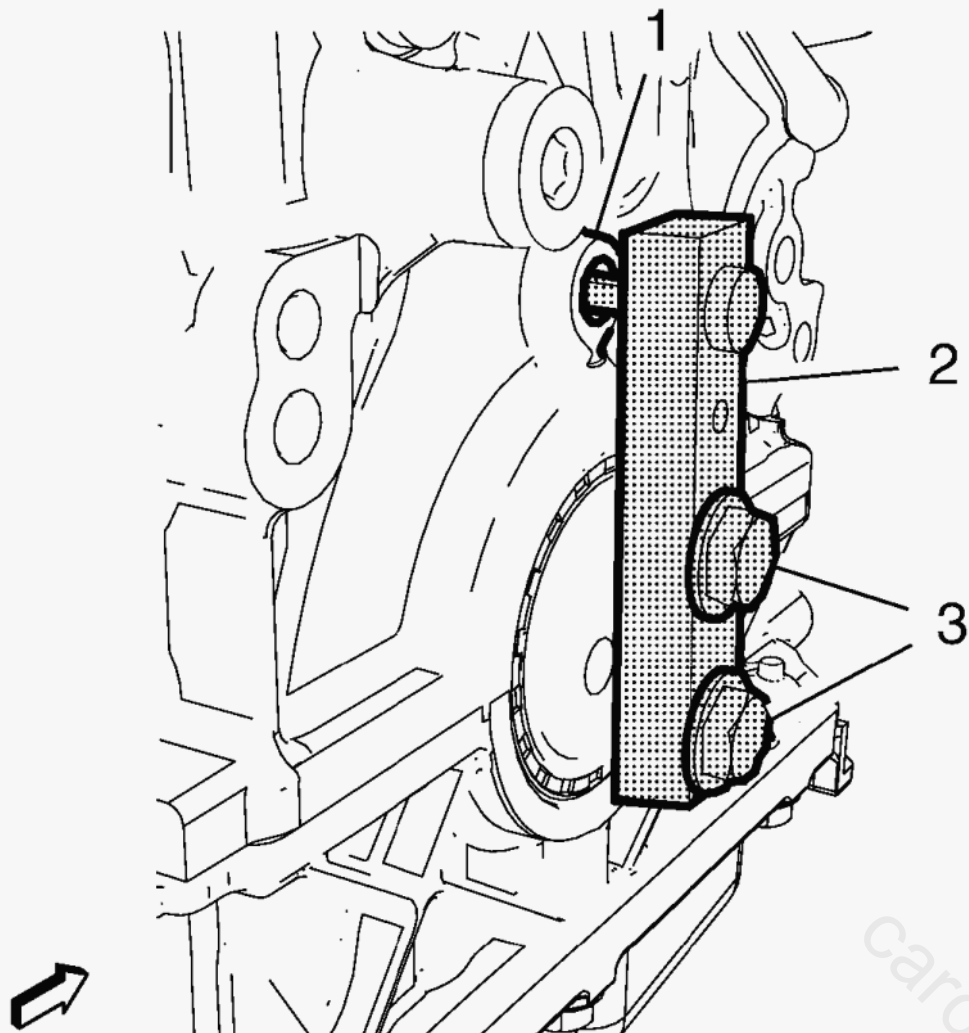


Fig. 285: Crankshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

7. Install **EN-51140** fixing tool (2).
8. Install the fixing pin into the engine block bore (1) and tighten the 2 bolts (3).
9. If the **EN-51140** fixing tool can not installed. Refer to [Camshaft Timing Chain Adjustment](#).
10. Lower the vehicle.

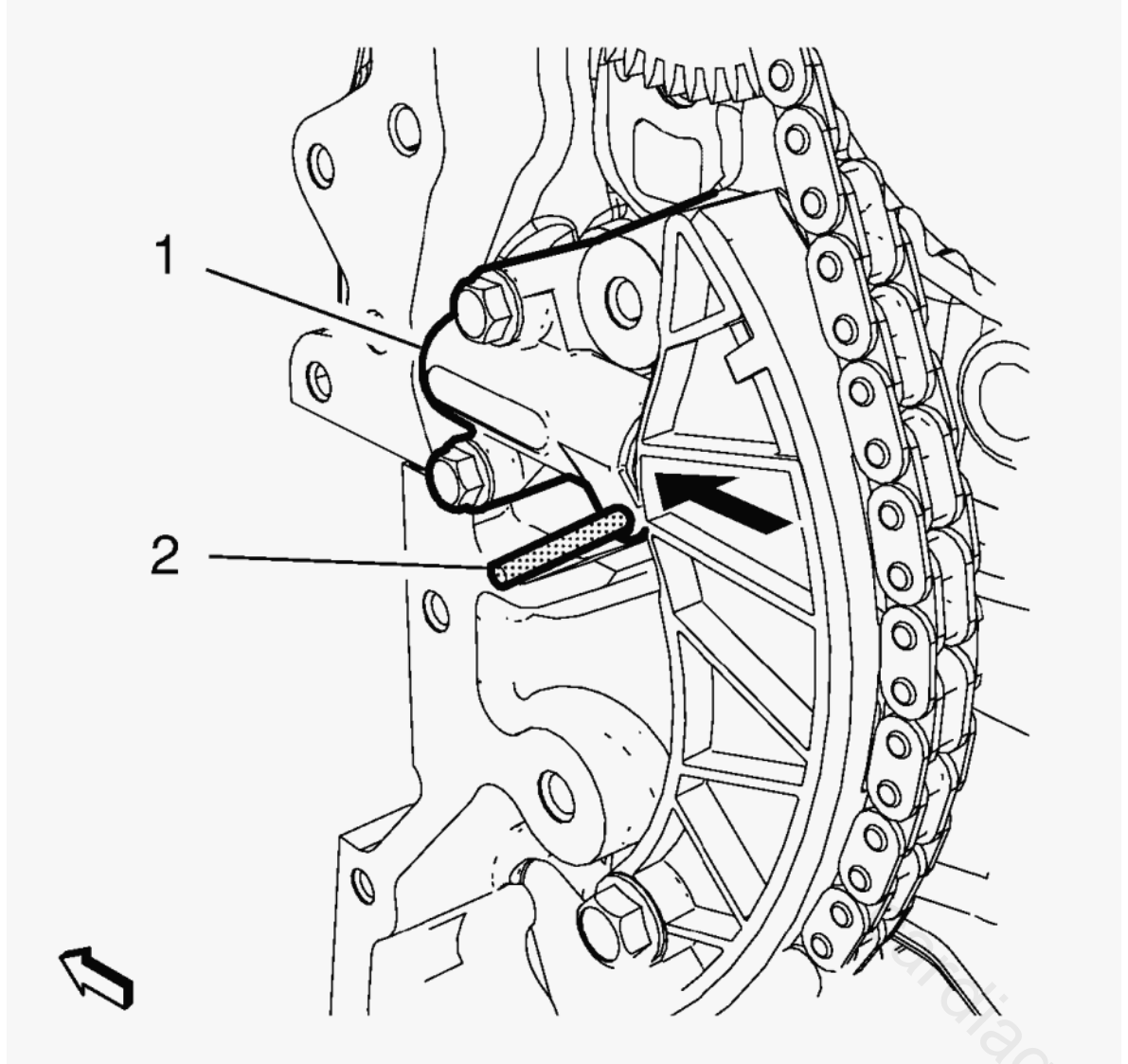


Fig. 286: Timing Chain Tensioner And Pin

Courtesy of GENERAL MOTORS COMPANY

11. Tension the timing chain tensioner (1) in arrow direction.
12. Install the EN-50513 pin (2).

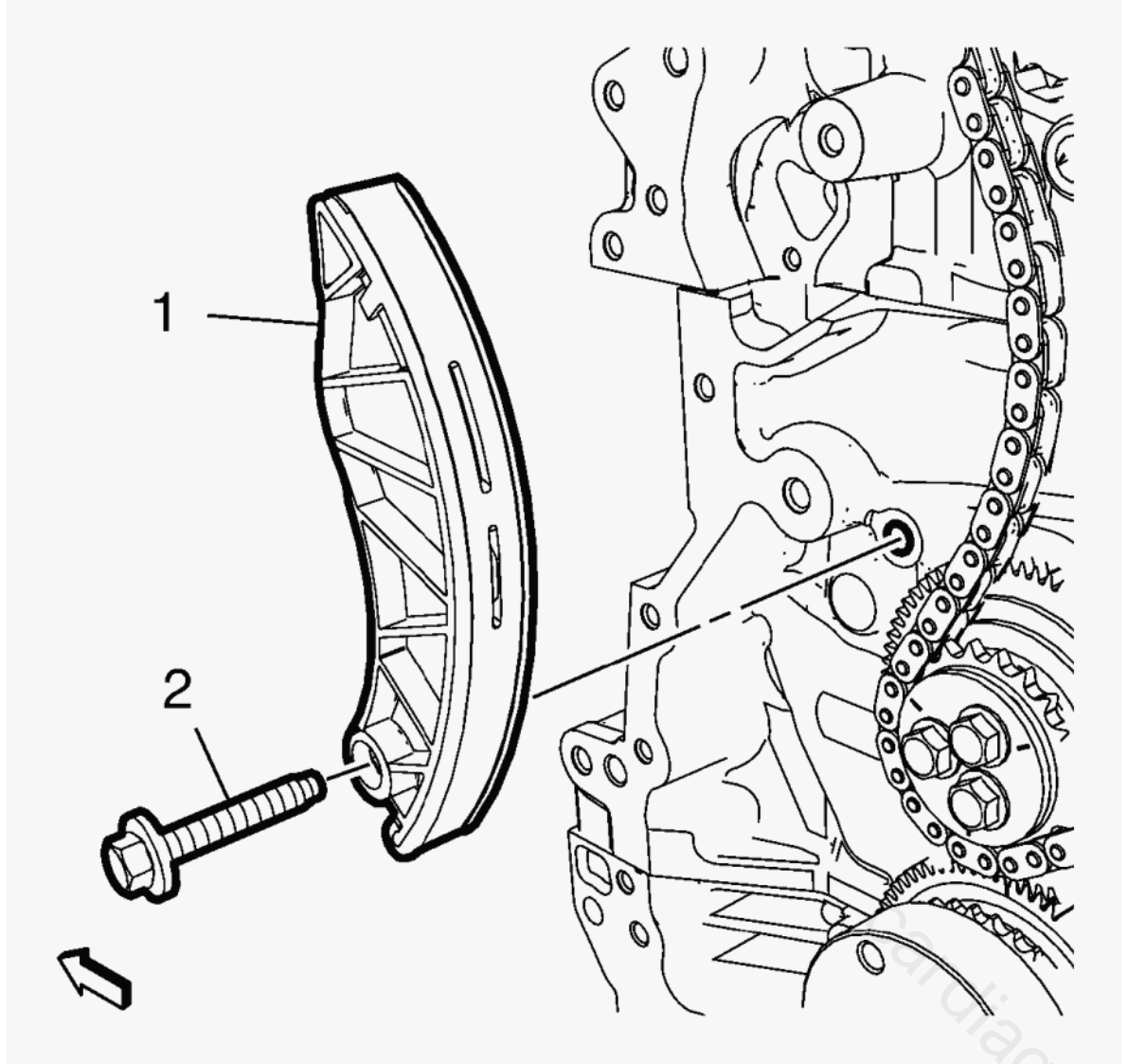


Fig. 287: Timing Chain Tensioner Shoe And Bolt
Courtesy of GENERAL MOTORS COMPANY

13. Remove the timing chain tensioner shoe bolt (2).
14. Remove the timing chain tensioner shoe (1).

Installation Procedure

NOTE: Before installing the timing chain tensioner shoe, check the components of the timing chain system for damage and wear.

1. Check the components of the timing chain system for damage and wear:
 - Timing chain guides with plastic attachment
 - Timing chain tensioner and timing chain tensioner shoe with plastic attachment
 - Timing chain and all timing chain sprockets
 - Oil pump sprocket
 - Oil pump drive chain tensioner

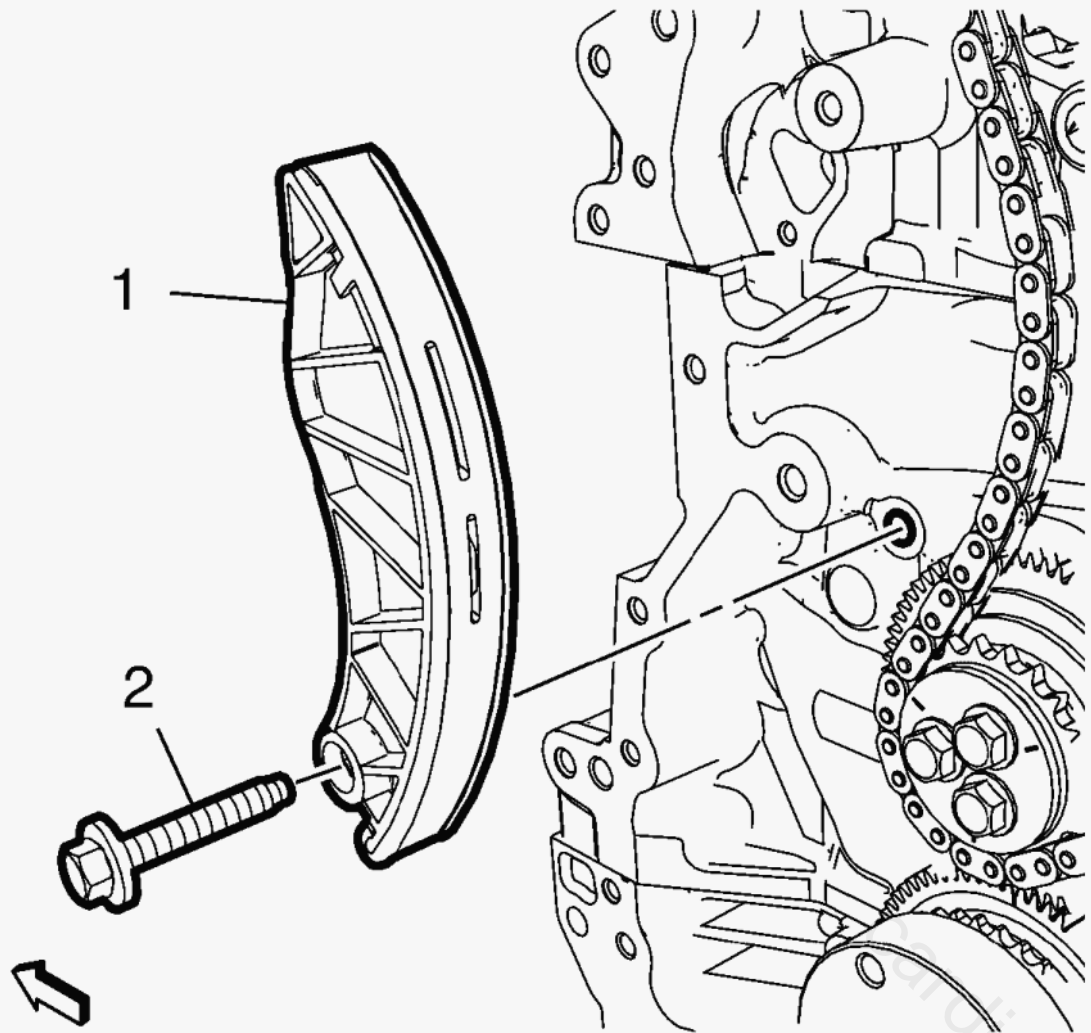


Fig. 288: Timing Chain Tensioner Shoe And Bolt
Courtesy of GENERAL MOTORS COMPANY

2. Install the timing chain tensioner shoe (1).

CAUTION: Refer to **Fastener Caution** .

3. Install the timing chain tensioner shoe bolt (2) and tighten to 25 N.m (18 lb ft).

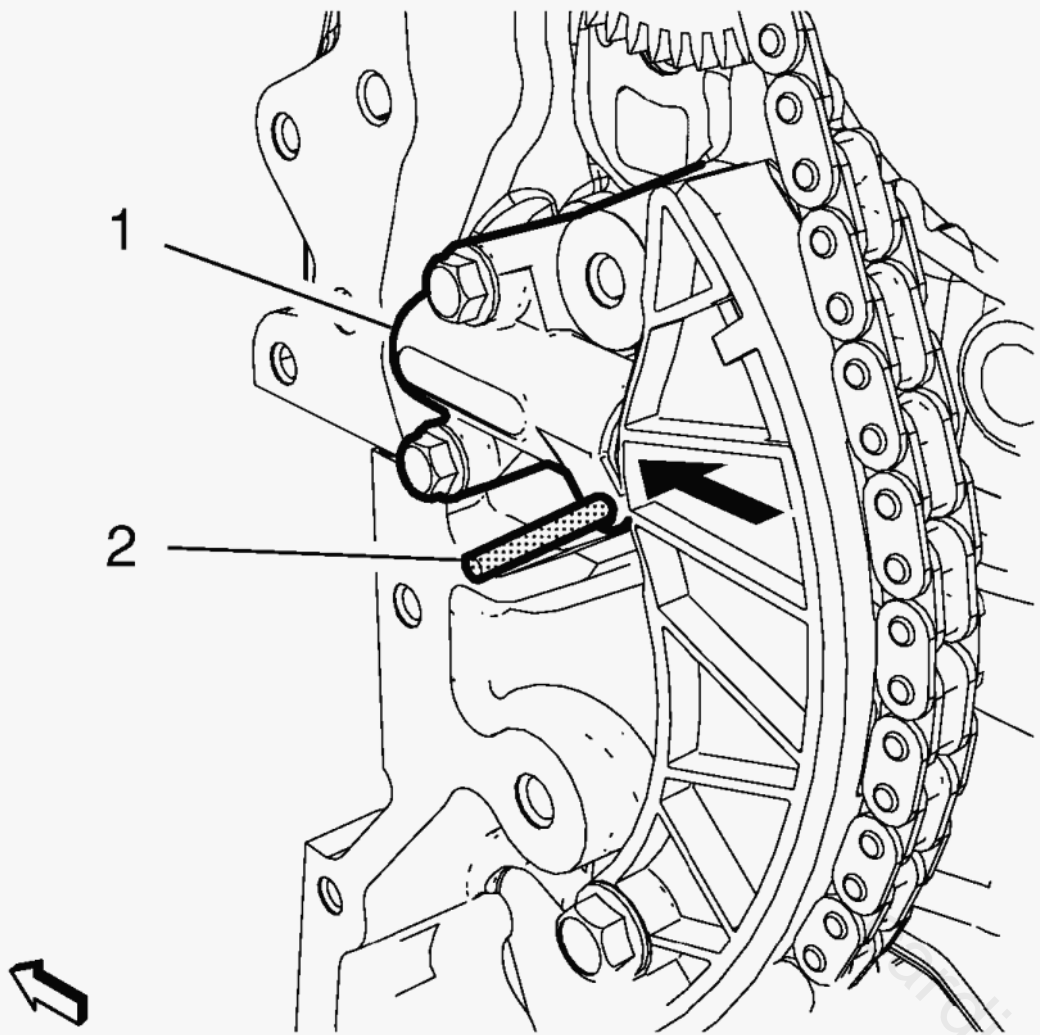


Fig. 289: Timing Chain Tensioner And Pin
Courtesy of GENERAL MOTORS COMPANY

4. Remove the EN-50513 pin (2).

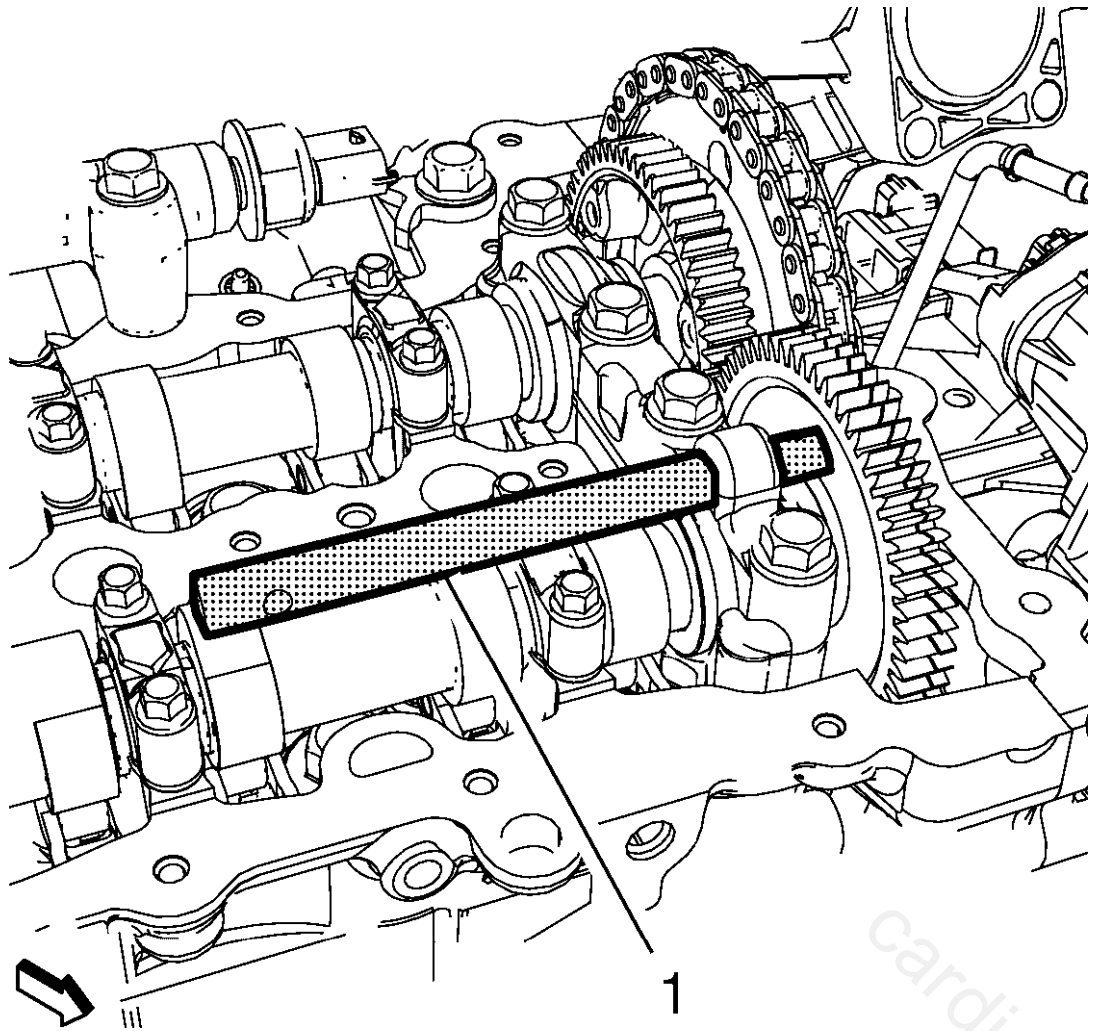


Fig. 290: Camshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

5. Remove the **EN-51143** fixing tool (1).
6. Raise the vehicle.

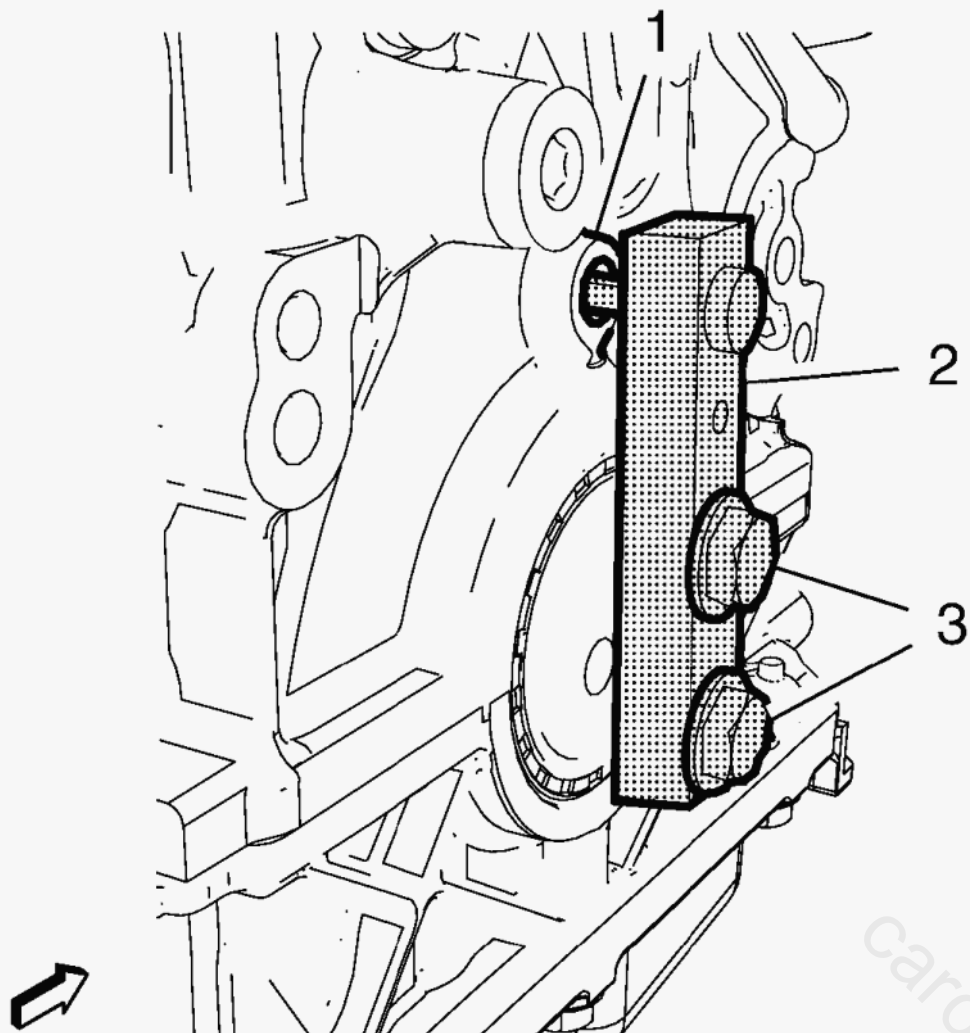


Fig. 291: Crankshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

7. Remove the 2 bolts (3).
8. Remove the **EN-51140** fixing tool (2).

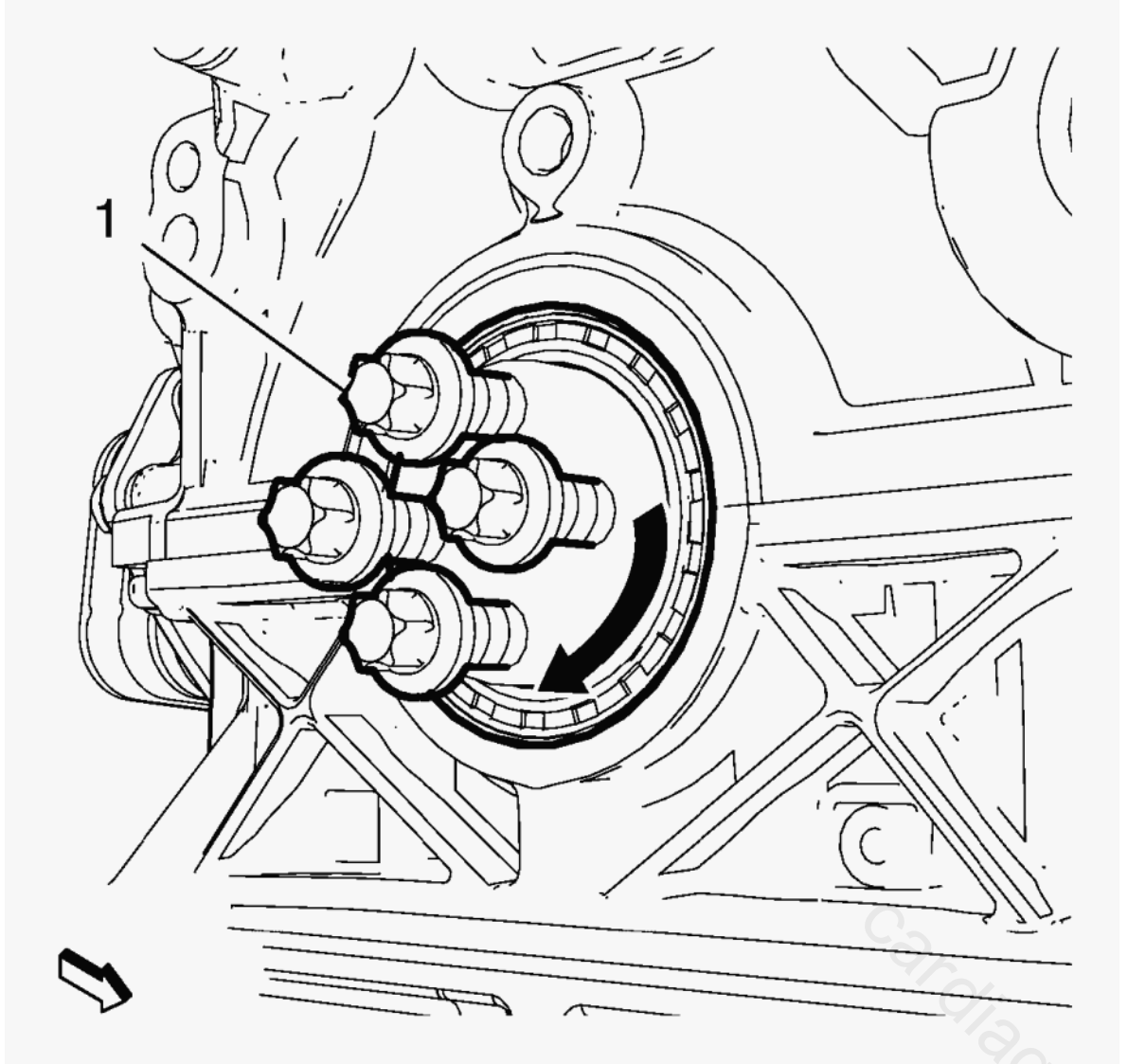


Fig. 292: Crankshaft Pulley Bolts

Courtesy of GENERAL MOTORS COMPANY

9. Install the 4 crankshaft pulley bolts (1).

Rotate the crankshaft 720 degrees in direction of arrow. Use a pry bar at the 4 crankshaft pulley bolts (1).

10. Remove the 4 crankshaft pulley bolts (1).
11. Check the camshaft timing. Refer to [Camshaft Timing Chain Inspection](#).
12. Install the crankshaft pulley. Refer to [Crankshaft Pulley Replacement](#).
13. Install the timing chain lower cover. Refer to [Timing Chain Lower Cover Replacement](#).

TIMING CHAIN UPPER COVER REPLACEMENT

Removal Procedure

1. Remove Power Brake Booster Inlet Hose Connector Fitting. Refer to [Power Brake Booster Inlet Hose Connector Fitting Replacement](#).
2. Remove Camshaft Housing. Refer to [Camshaft Housing Replacement](#).

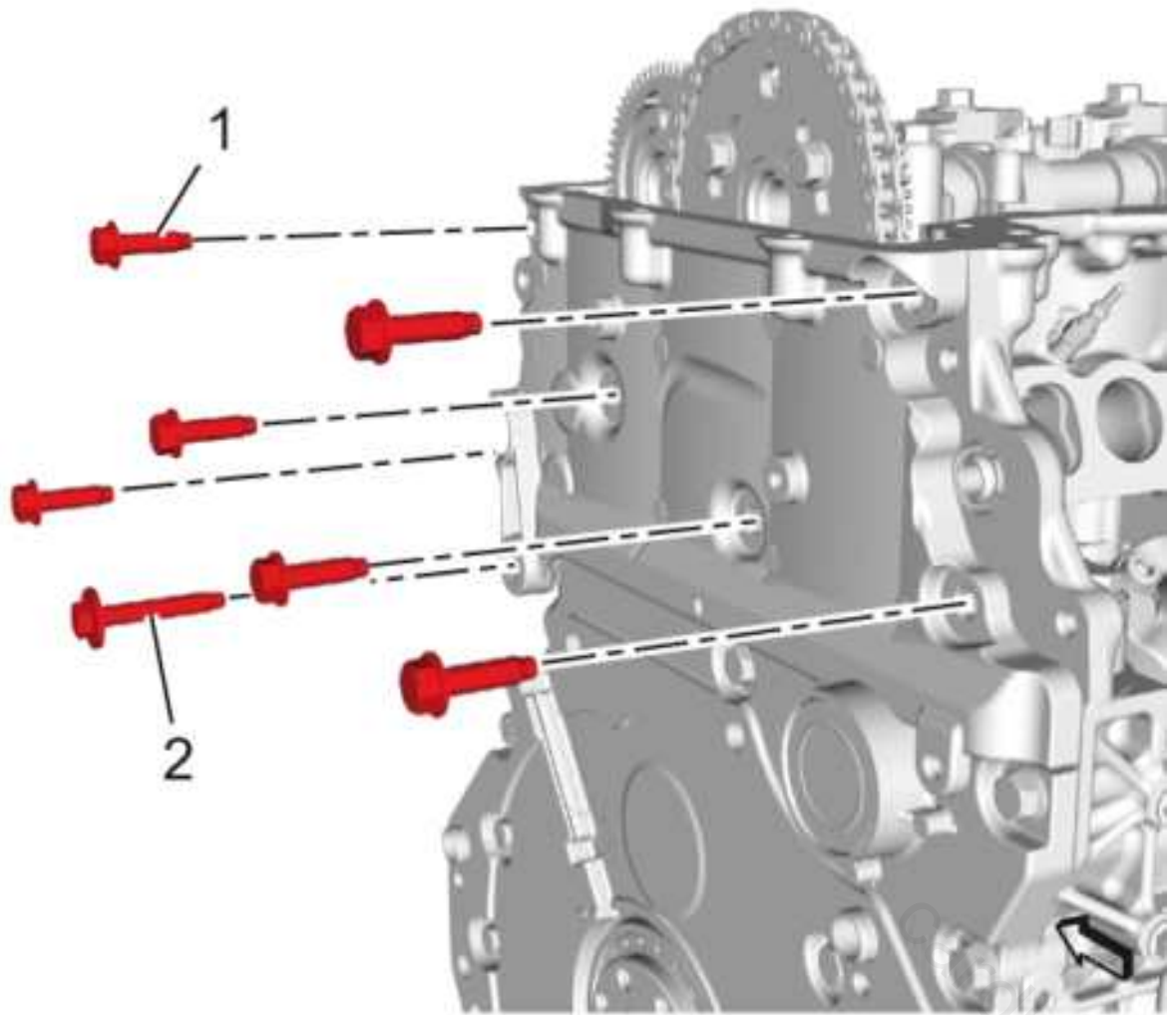


Fig. 293: Timing Chain Upper Cover Bolts And Sleeve Bolt
Courtesy of GENERAL MOTORS COMPANY

3. Remove the 6 timing chain upper cover bolts (1).
4. Remove the sleeve bolt (2).

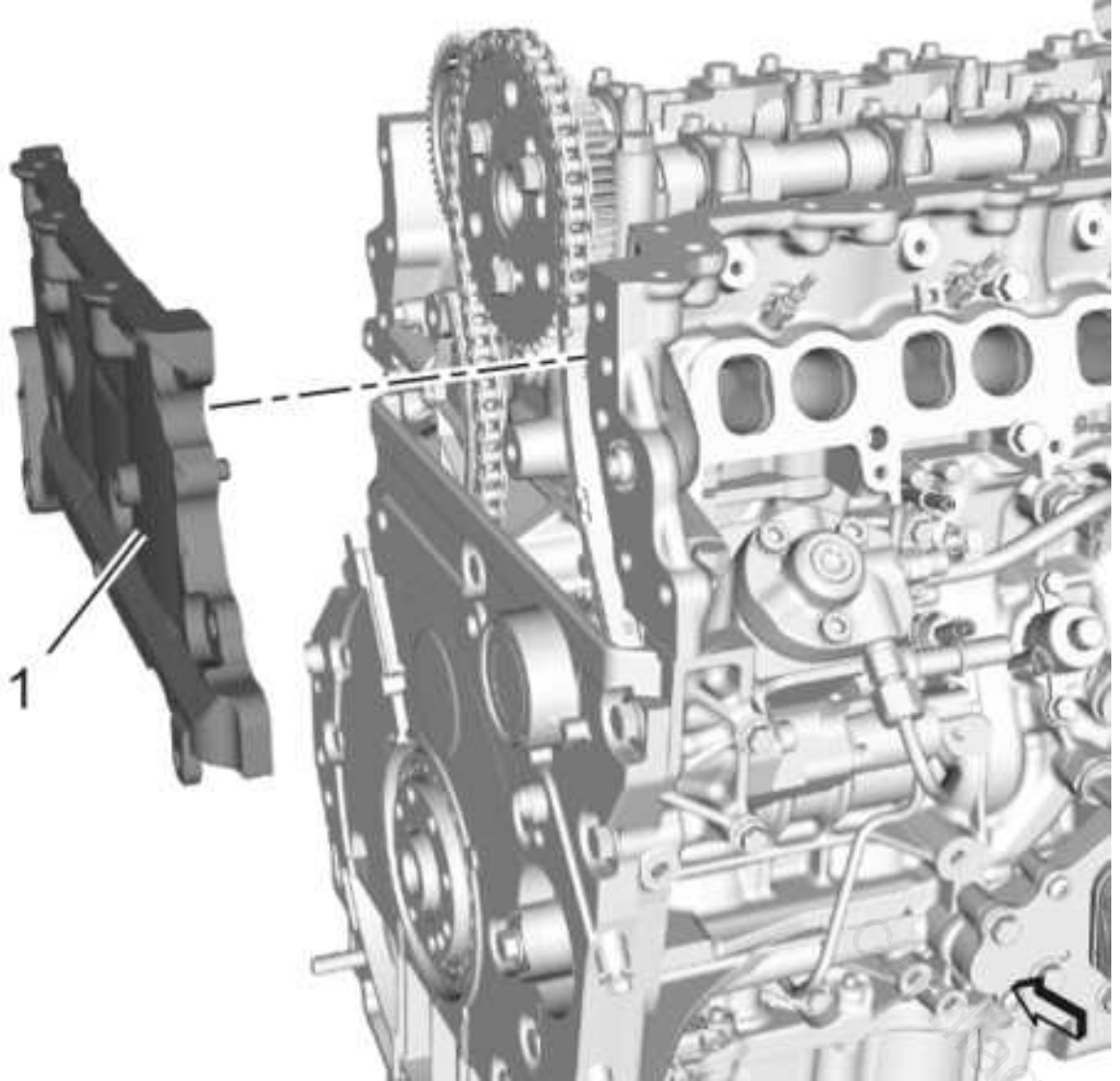


Fig. 295: Timing Chain Upper Cover

Courtesy of GENERAL MOTORS COMPANY

7. Remove Timing Chain Upper Cover (1)

Installation Procedure

NOTE: Before installing the timing chain upper cover, check the components of the timing chain system for damage and wear.

1. Check the components of the timing chain system for damage and wear:
 - Timing chain guides with plastic attachment
 - Timing chain tensioner and timing chain tensioner shoe with plastic attachment
 - Timing chain and all timing chain sprockets
 - Oil pump sprocket
 - Oil pump drive chain tensioner
2. Clean all sealing surfaces.

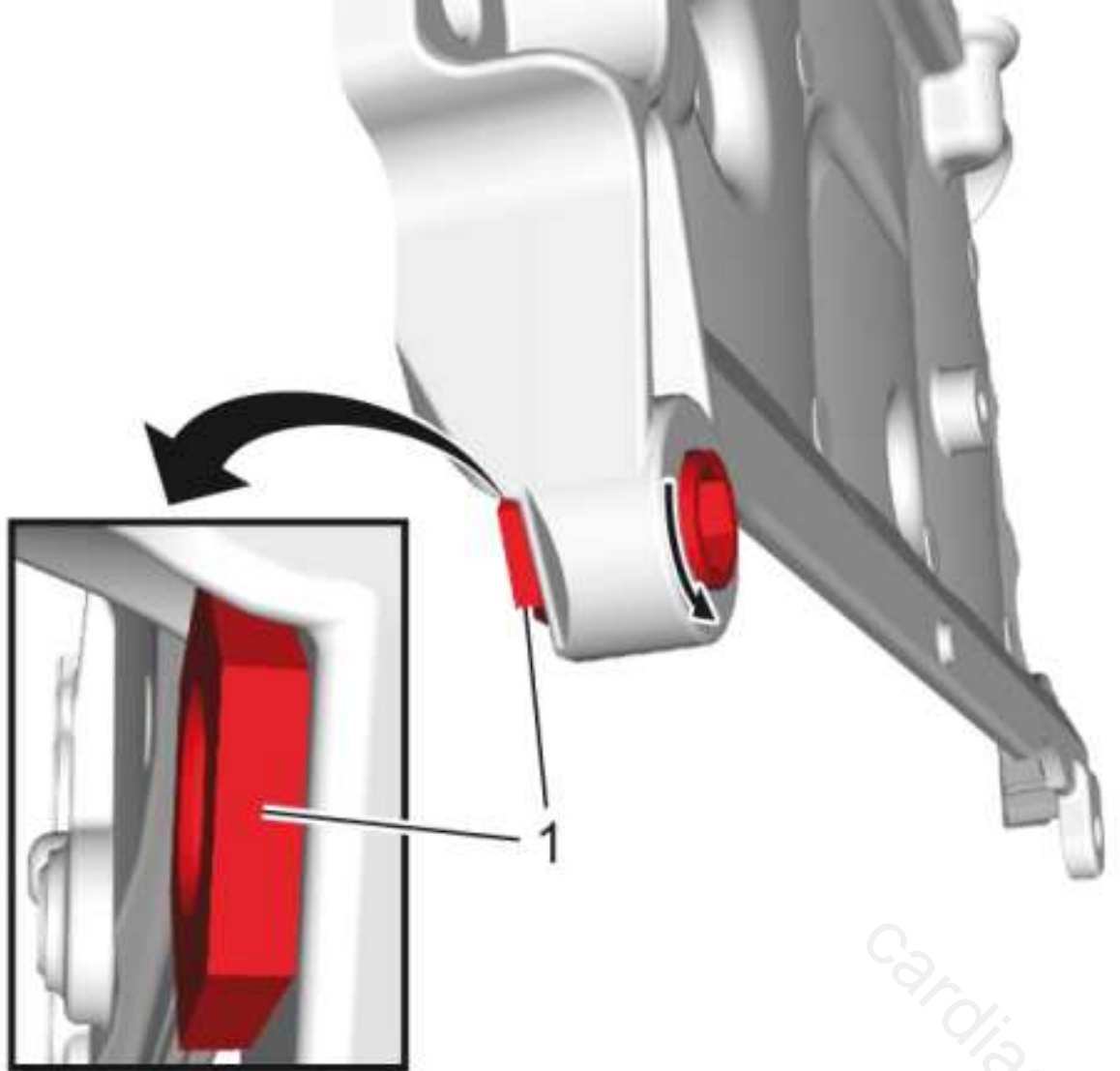


Fig. 296: Timing Chain Upper Cover Sleeve
Courtesy of GENERAL MOTORS COMPANY

3. Unscrew the timing chain upper cover sleeve (1) to the initial position in arrow direction.

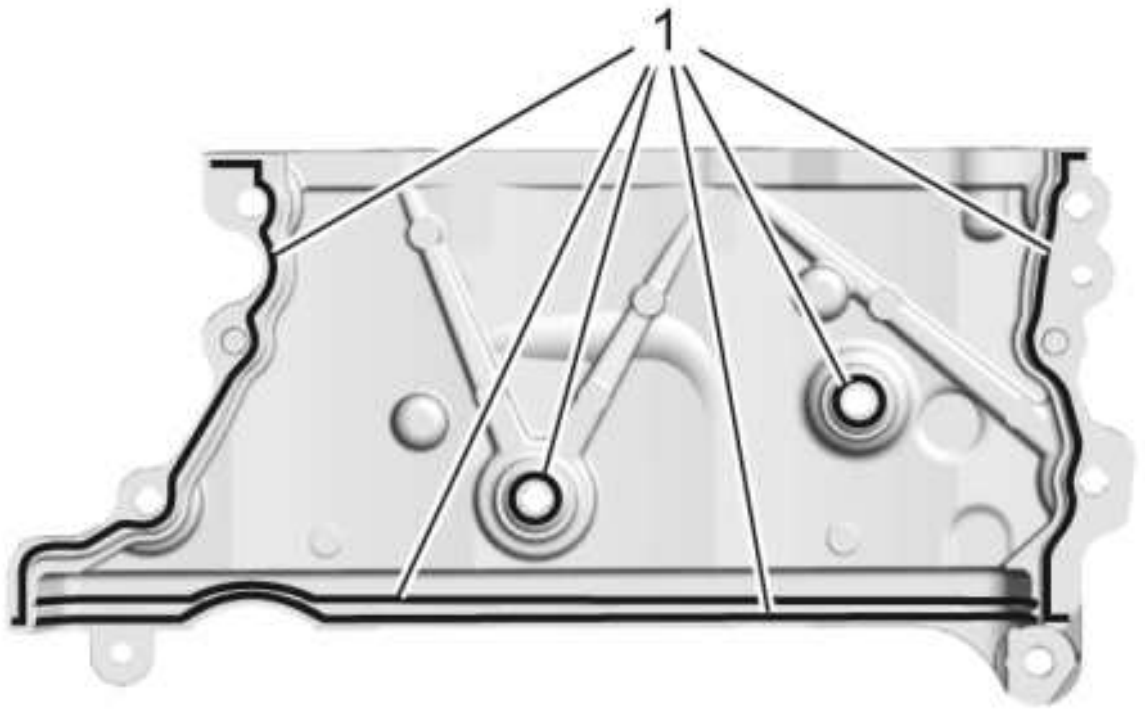


Fig. 297: Silicone Sealing Compound Application Area
Courtesy of GENERAL MOTORS COMPANY

NOTE: The complete installation procedure of the timing chain upper cover should be done in 20 minutes.

4. Apply silicone sealing compound (1) to the timing chain upper cover sealing surface. The thickness of the sealing bead should be 2.0 - 3.0 mm (0.079 - 0.118 in).

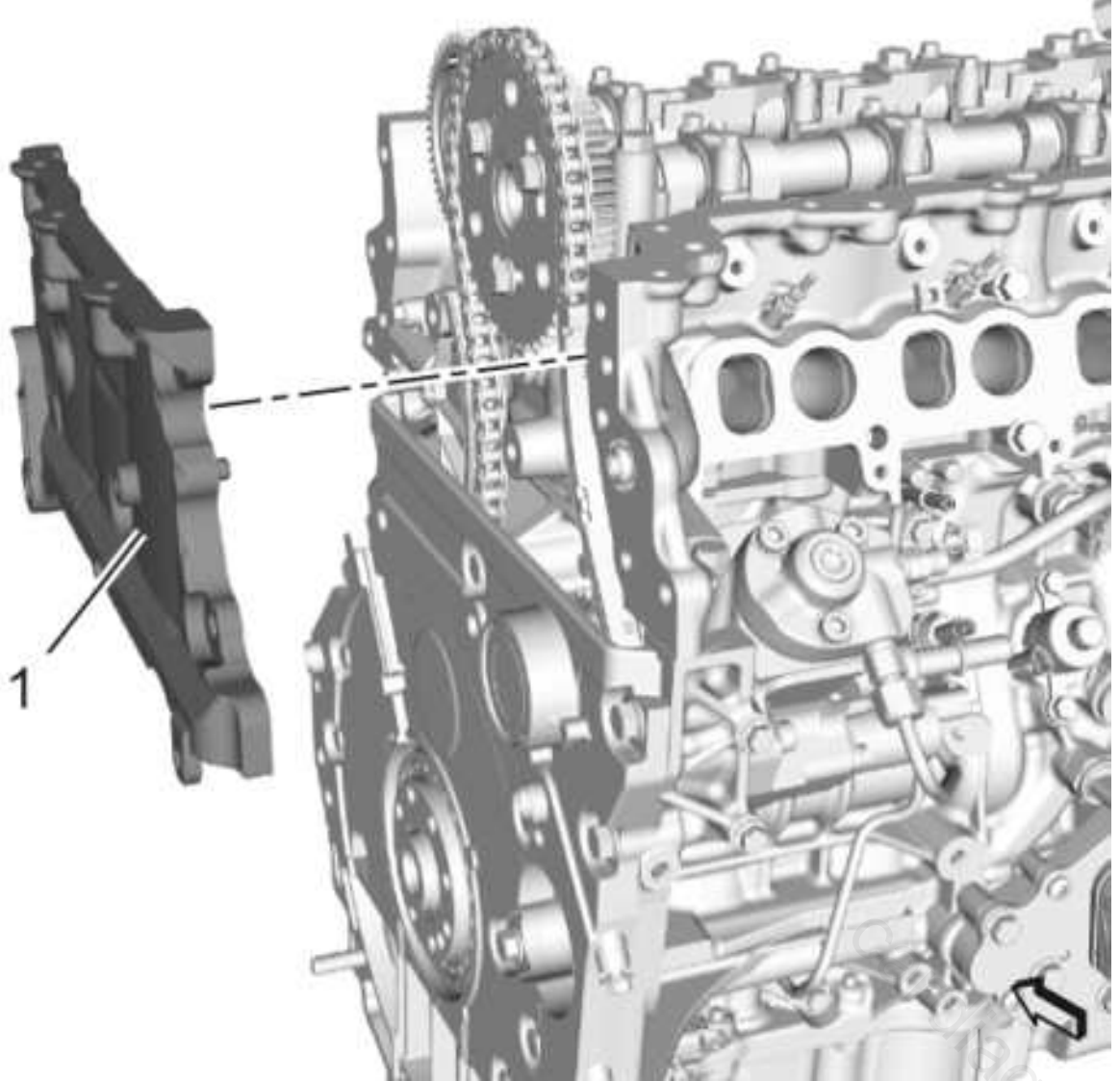


Fig. 298: Timing Chain Upper Cover
Courtesy of GENERAL MOTORS COMPANY

5. Install Timing Chain Upper Cover (1)

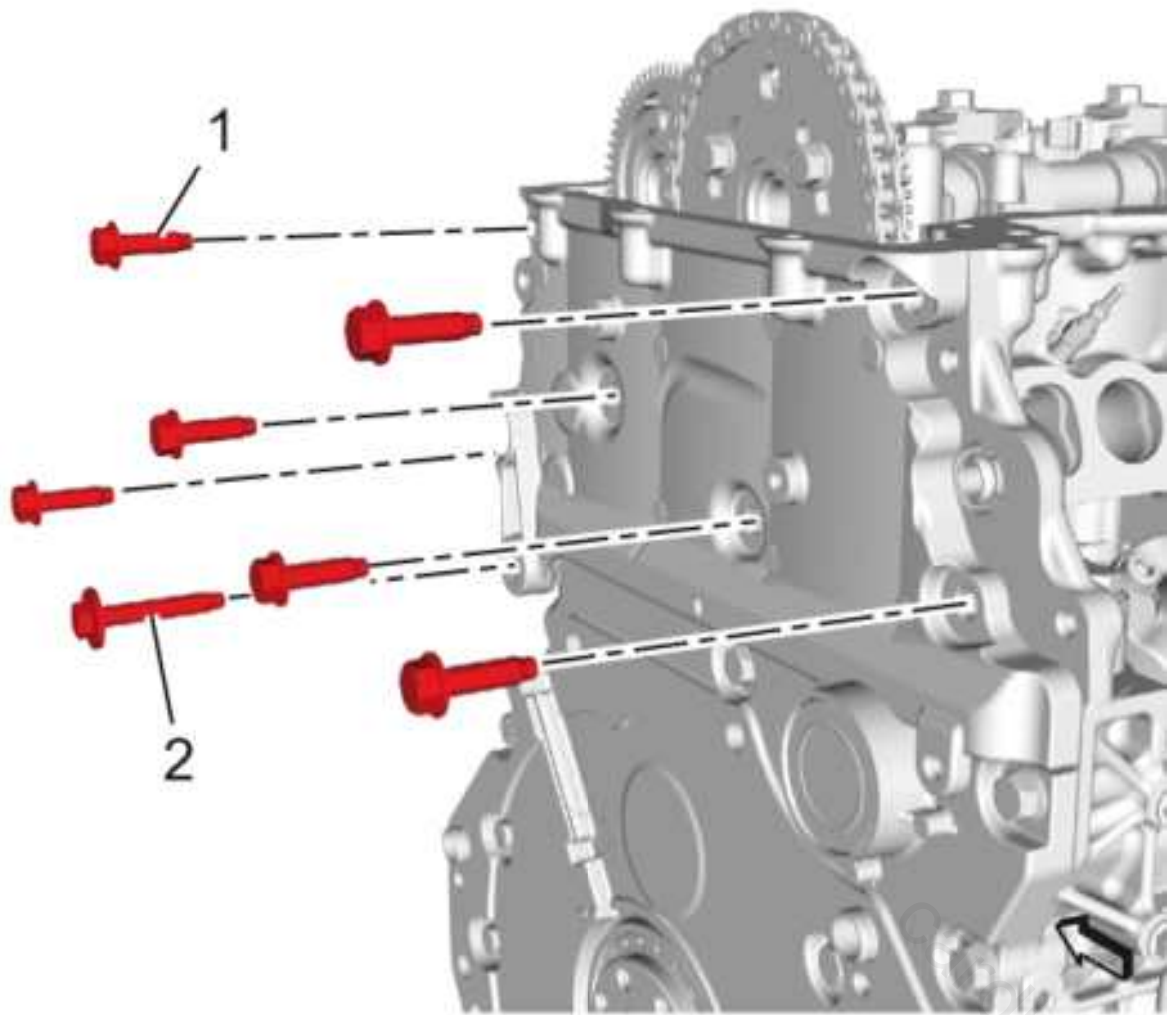


Fig. 299: Timing Chain Upper Cover Bolts And Sleeve Bolt
Courtesy of GENERAL MOTORS COMPANY

NOTE: Do not install the sleeve bolt (2).

6. Install the 6 timing chain upper cover bolts (1).

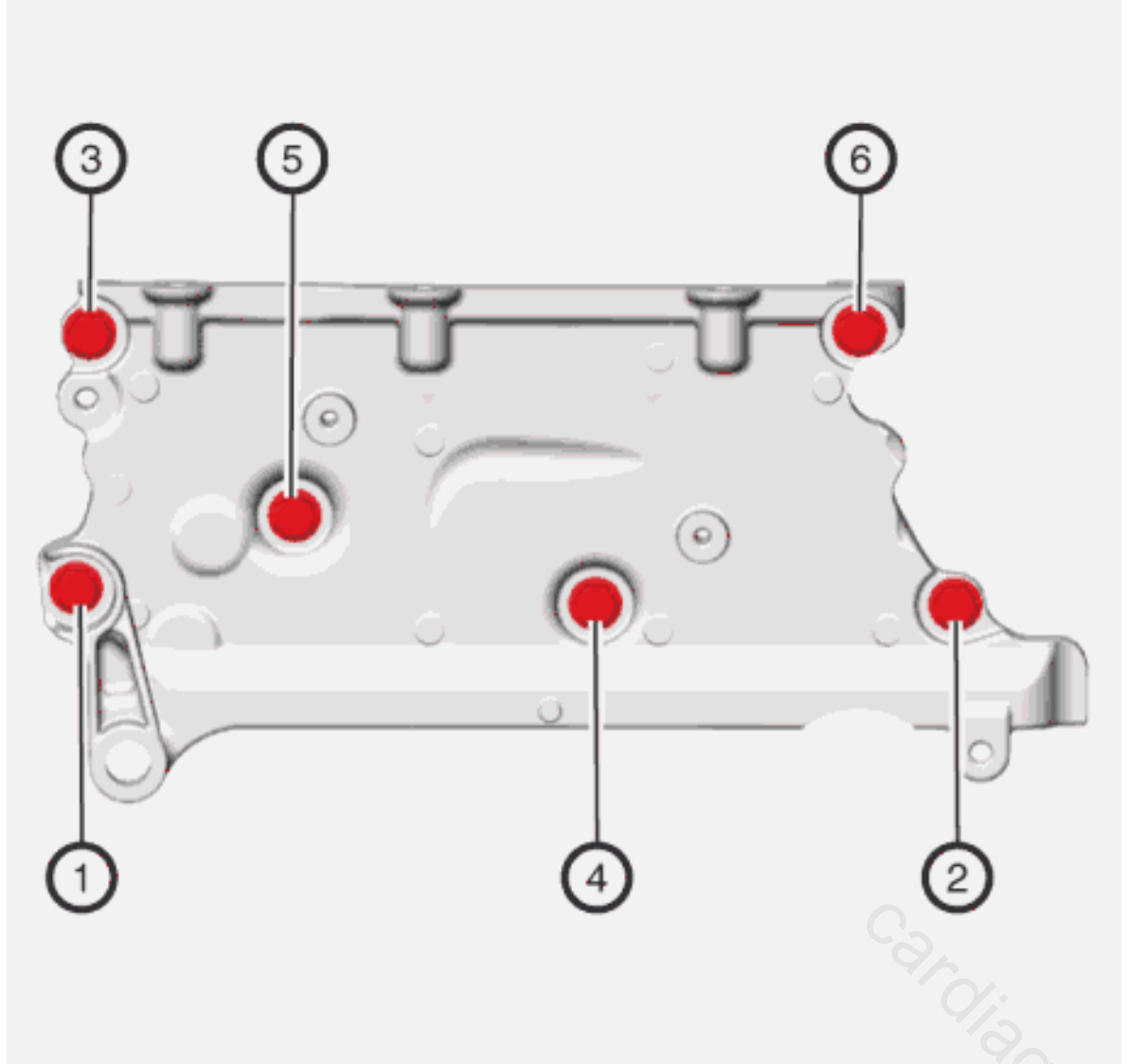


Fig. 300: Timing Chain Upper Cover Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to: [Fastener Caution](#) .

7. Tighten the 6 timing chain upper cover bolts in sequence as shown to 25 N.m (18 lb ft).

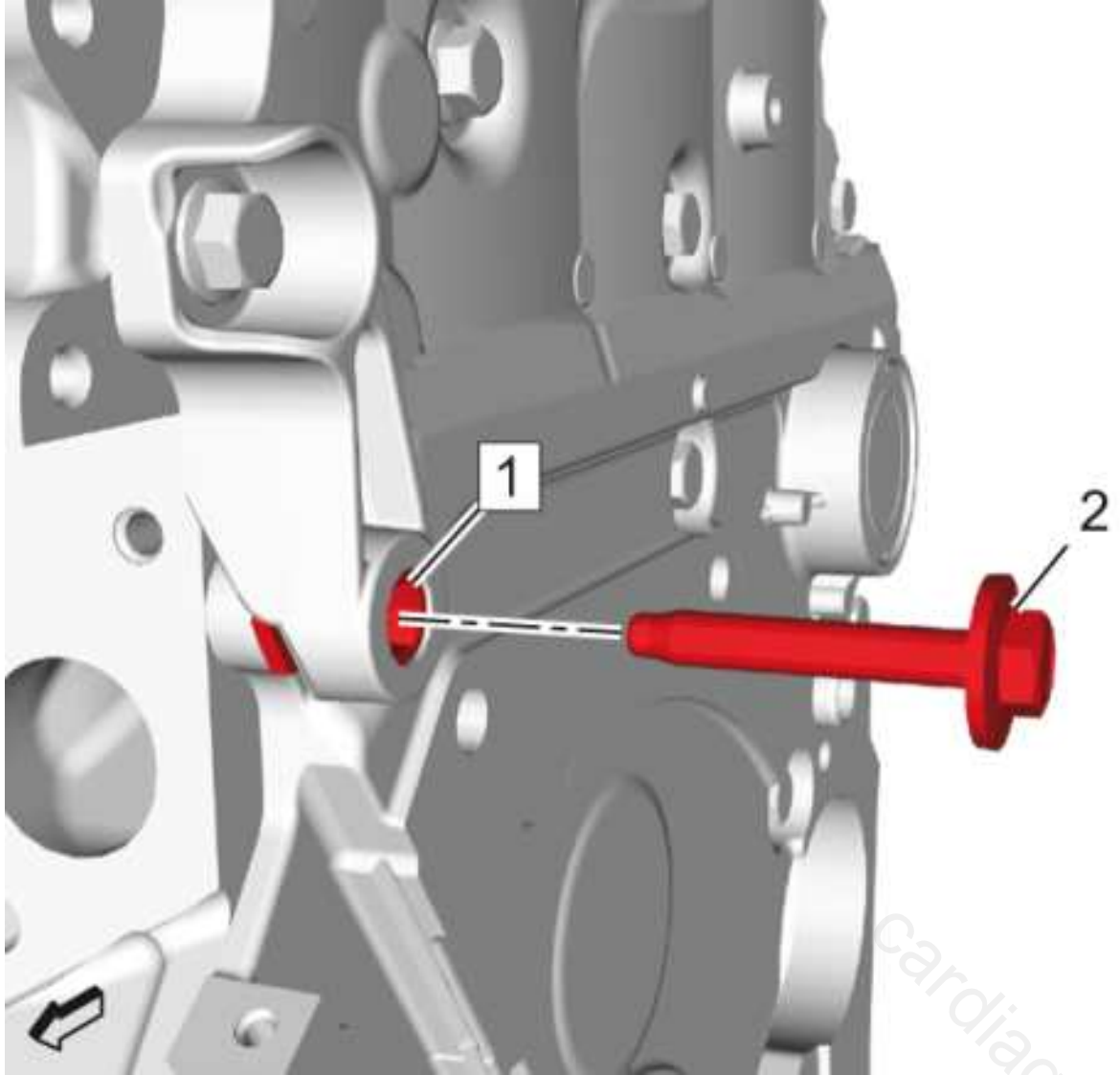


Fig. 301: Timing Chain Upper Cover Sleeve And Bolt
Courtesy of GENERAL MOTORS COMPANY

8. Tighten the timing chain upper cover sleeve (1) to 3.5 N.m (31 lb in).
9. Install the timing chain upper cover sleeve bolt (2) and tighten to 25 N.m (18 lb ft).
10. Install Camshaft Housing. Refer to [Camshaft Housing Replacement](#).
11. Install Power Brake Booster Inlet Hose Connector Fitting. Refer to [Power Brake Booster Inlet Hose Connector Fitting Replacement](#).

TIMING CHAIN UPPER GUIDE REPLACEMENT

Removal Procedure

1. Remove the camshaft timing chain. Refer to [Camshaft Timing Chain Replacement](#).

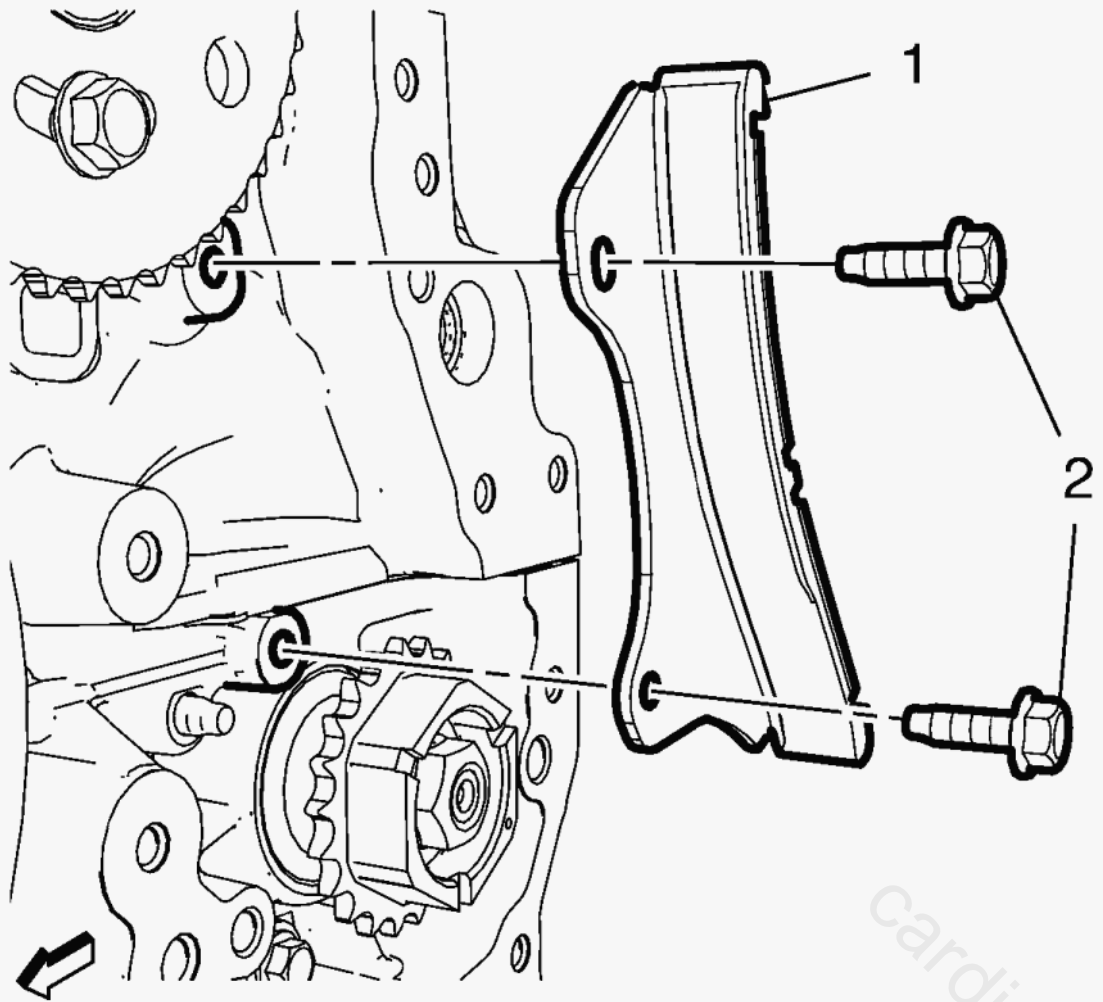


Fig. 302: Timing Chain Upper Guide And Bolts
Courtesy of GENERAL MOTORS COMPANY

2. Remove the upper timing chain upper guide bolt (2).
3. Remove the timing chain upper guide (1).

Installation Procedure

NOTE: Before installing the timing chain upper guide, check the components of the timing chain system for damage and wear.

1. Check the components of the timing chain system for damage and wear:
 - Timing chain guides with plastic attachment
 - Timing chain tensioner and timing chain tensioner shoe with plastic attachment
 - Timing chain and all timing chain sprockets
 - Oil pump sprocket
 - Oil pump drive chain tensioner

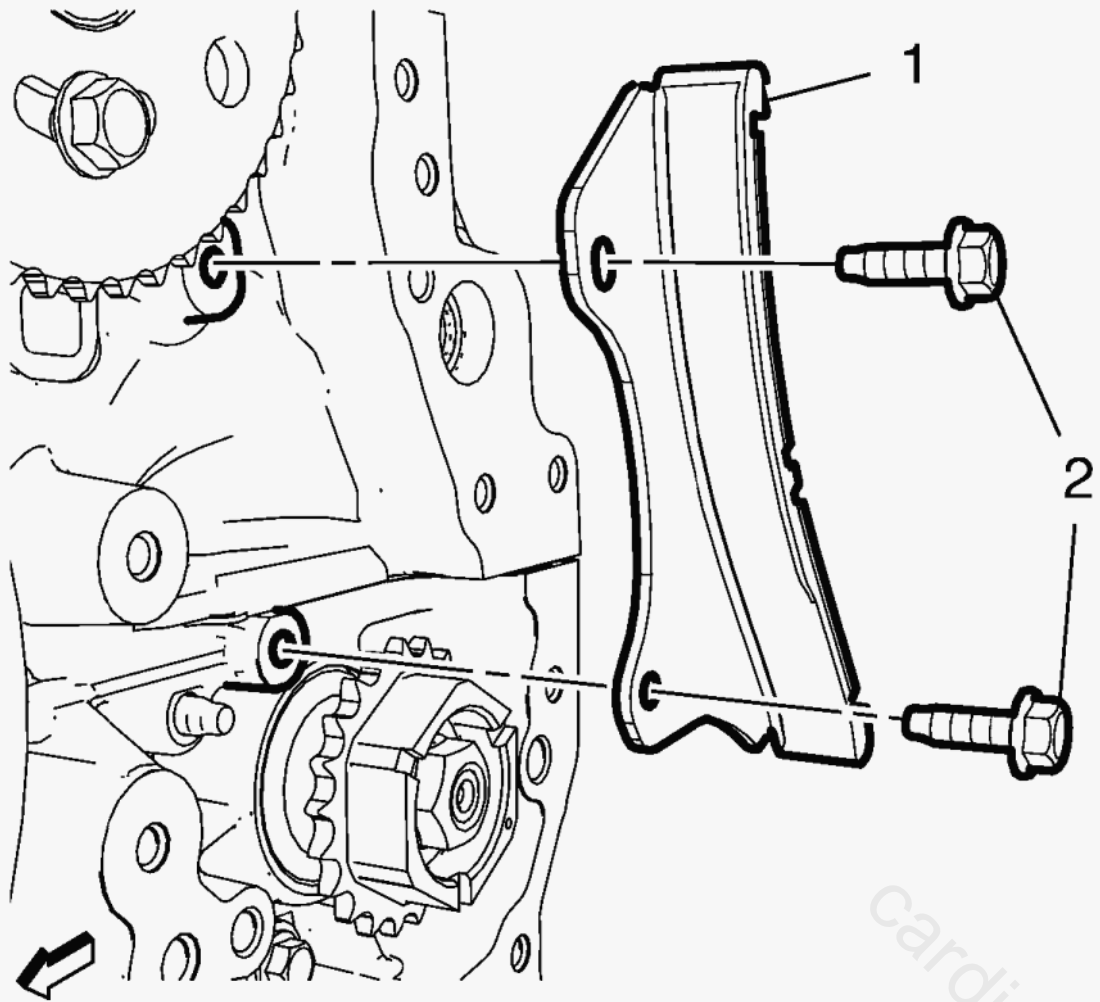


Fig. 303: Timing Chain Upper Guide And Bolts
Courtesy of GENERAL MOTORS COMPANY

2. Re-cut thread at cylinder head and engine block for the 2 timing chain upper guide bolts (2).
3. Install the timing chain upper guide (1).

NOTE: The tightening procedure of the upper timing chain upper guide bolts should be completed within 10 minutes

4. Apply thread lock agent to the upper timing chain upper guide bolt (2).

NOTE: Do not tighten the upper timing chain upper guide bolt before the camshaft timing chain is installed.

5. Install the upper timing chain upper guide bolt (2).
6. Install the camshaft timing chain. Refer to [Camshaft Timing Chain Replacement](#).

CRANKSHAFT PULLEY REPLACEMENT

Special Tools

- EN-956-1 Extension
- EN-45059 Angle Meter
- EN-49979 Crankshaft Holder
- EN-49979-100 Crankshaft Holder Pins

For equivalent regional tools, refer to [Special Tools](#).

Removal Procedure

1. Remove the drive belt. Refer to [Generator and Air Conditioning Compressor Belt Replacement](#).

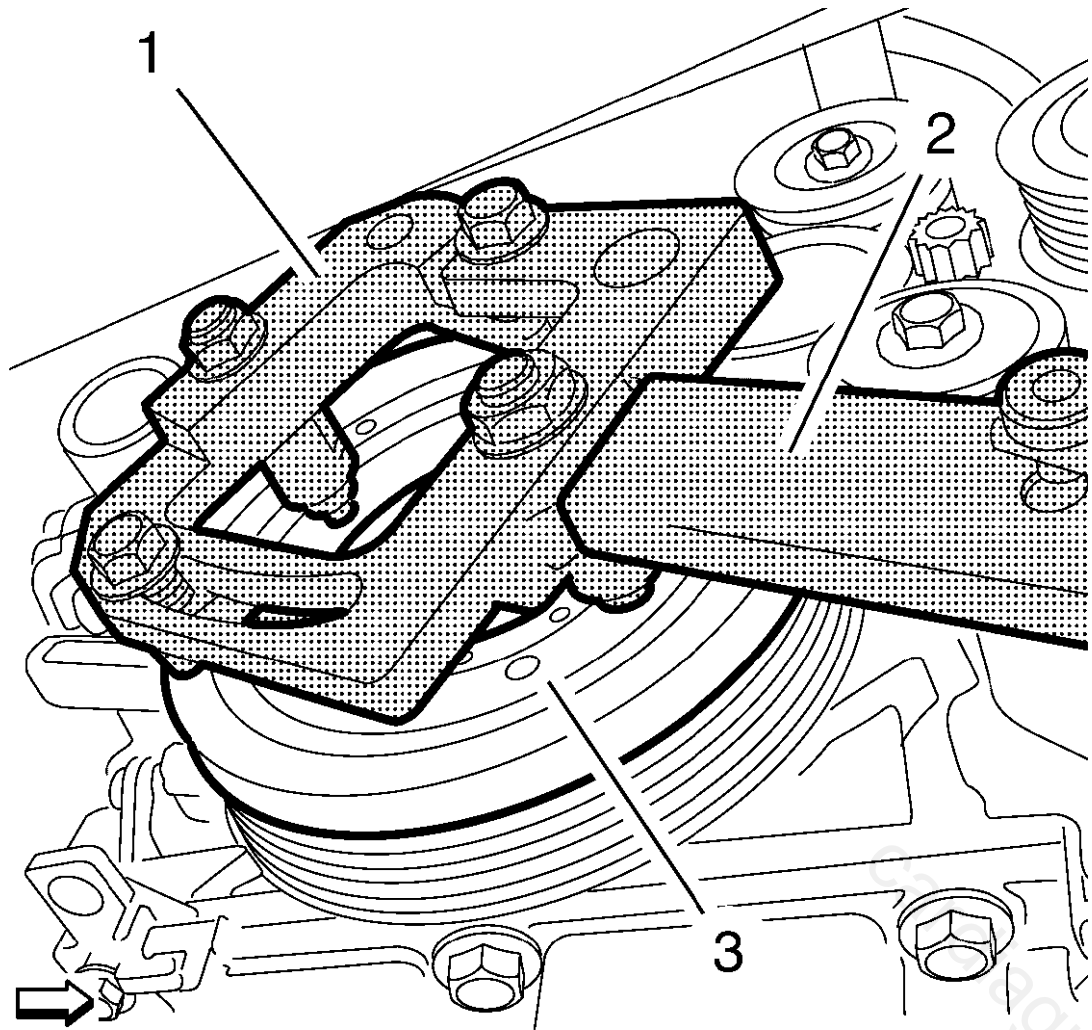


Fig. 304: Crankshaft Holder, Pins, Extension And Crankshaft Pulley.
Courtesy of GENERAL MOTORS COMPANY

NOTE: Install the EN-49979 holder along with the EN-49979-100 pins to the outer hole pattern.

2. Install the EN-49979 holder (1) in compound with the EN-49979-100 pins and the EN-956-1 extension (2) to counterhold the crankshaft pulley (3).

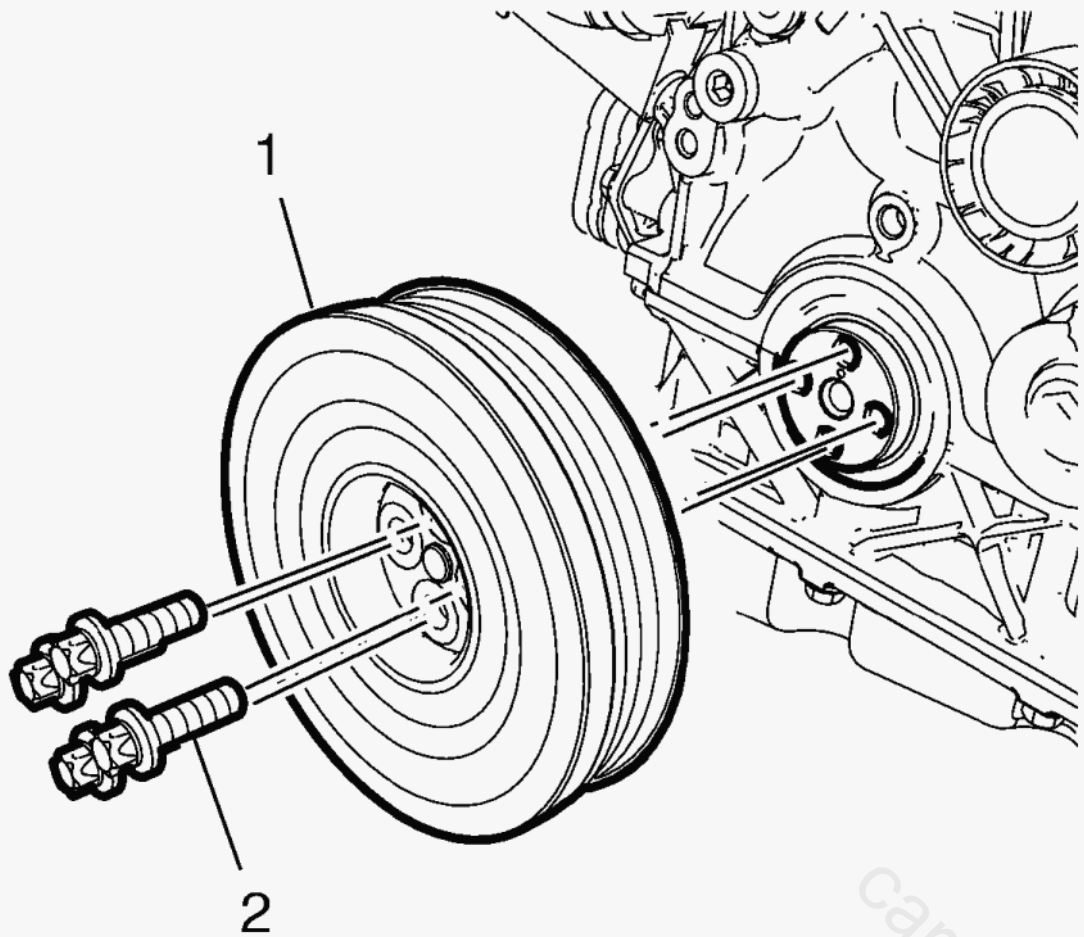


Fig. 305: Crankshaft Pulley And Bolts

Courtesy of GENERAL MOTORS COMPANY

3. Remove and DISCARD the 4 crankshaft pulley bolts (2).
4. Remove the crankshaft pulley (1).

Installation Procedure

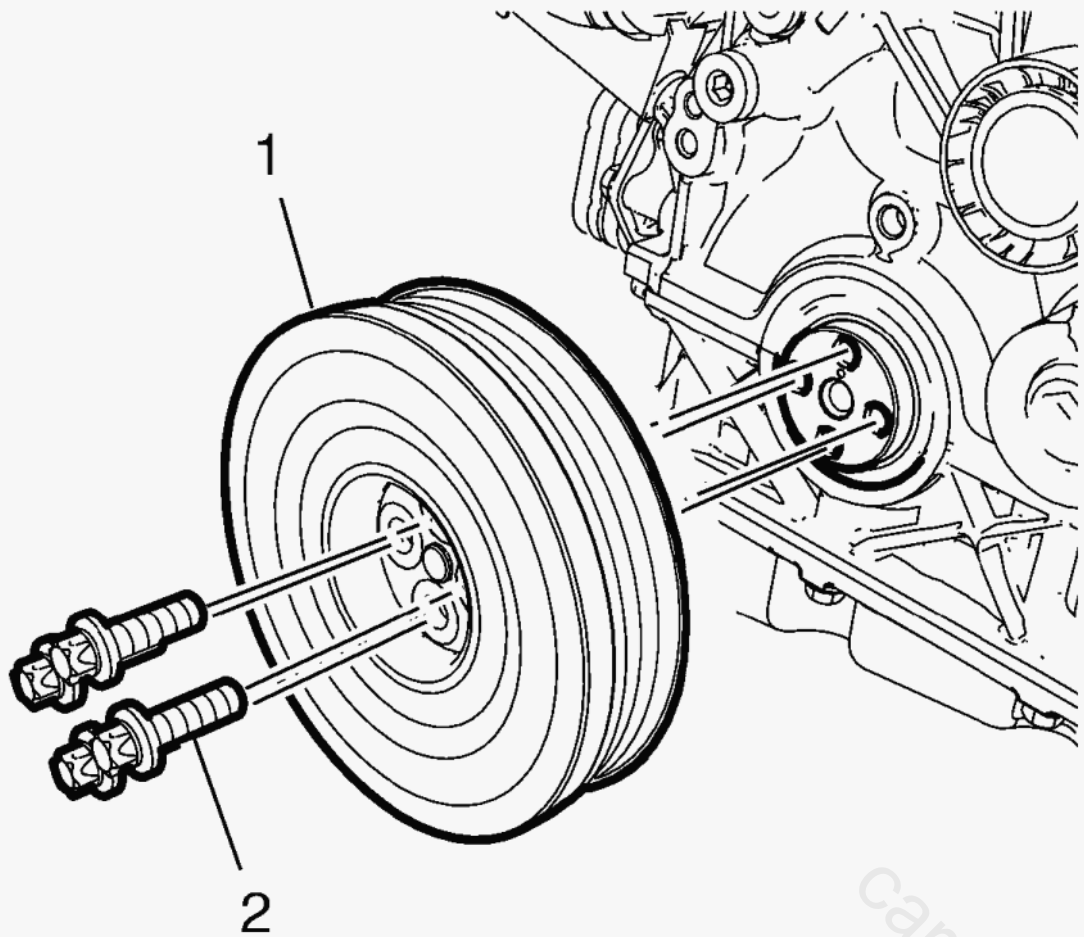


Fig. 306: Crankshaft Pulley And Bolts

Courtesy of GENERAL MOTORS COMPANY

1. Install the crankshaft pulley (1).
2. Pre-install the 4 NEW crankshaft pulley bolts (2).

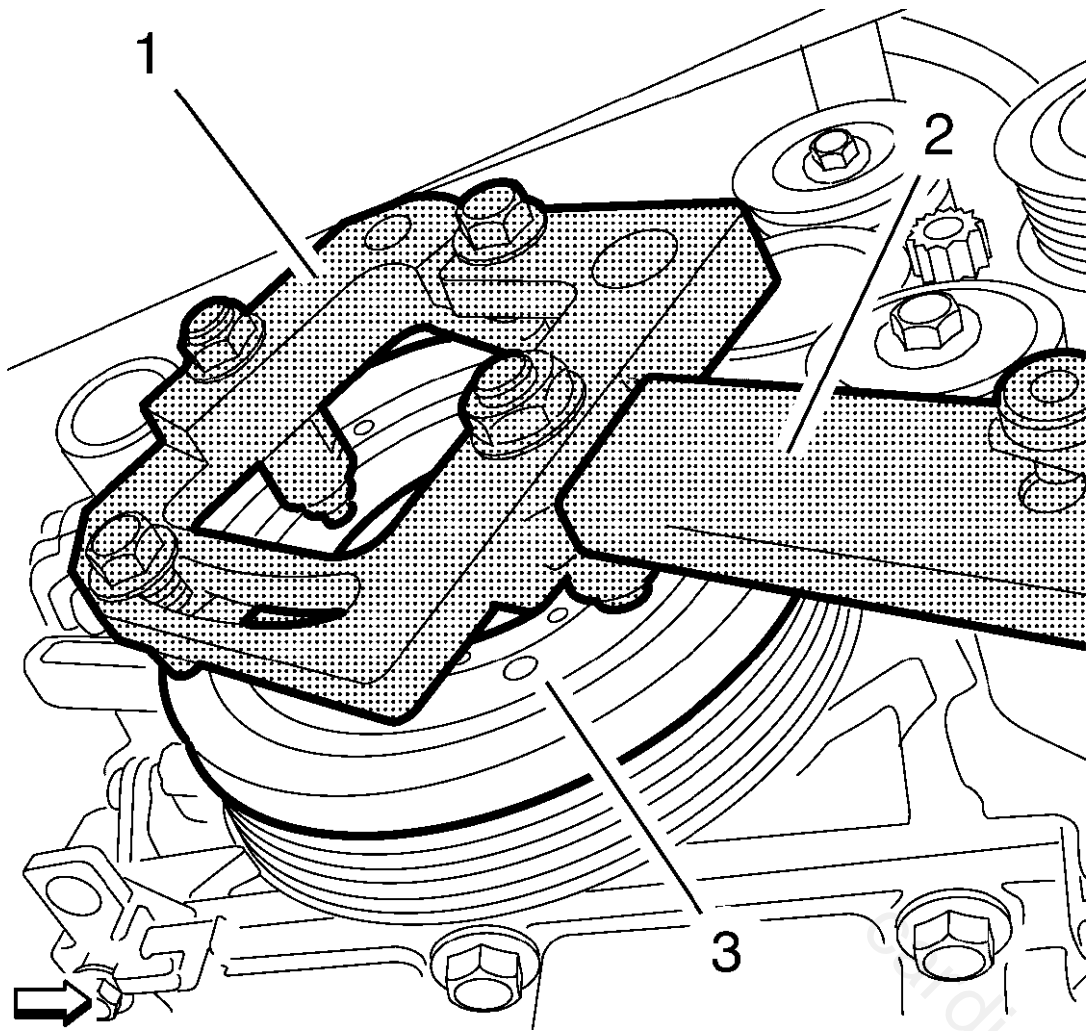


Fig. 307: Crankshaft Holder, Pins, Extension And Crankshaft Pulley.
Courtesy of GENERAL MOTORS COMPANY

NOTE: Install the EN-49979 holder with the EN-49979-100 pins to the outer hole pattern.

3. Install the EN-49979 holder (1) in compound with the EN-49979-100 pins and the EN-956-1 extension (2) to counterhold the crankshaft pulley (3).

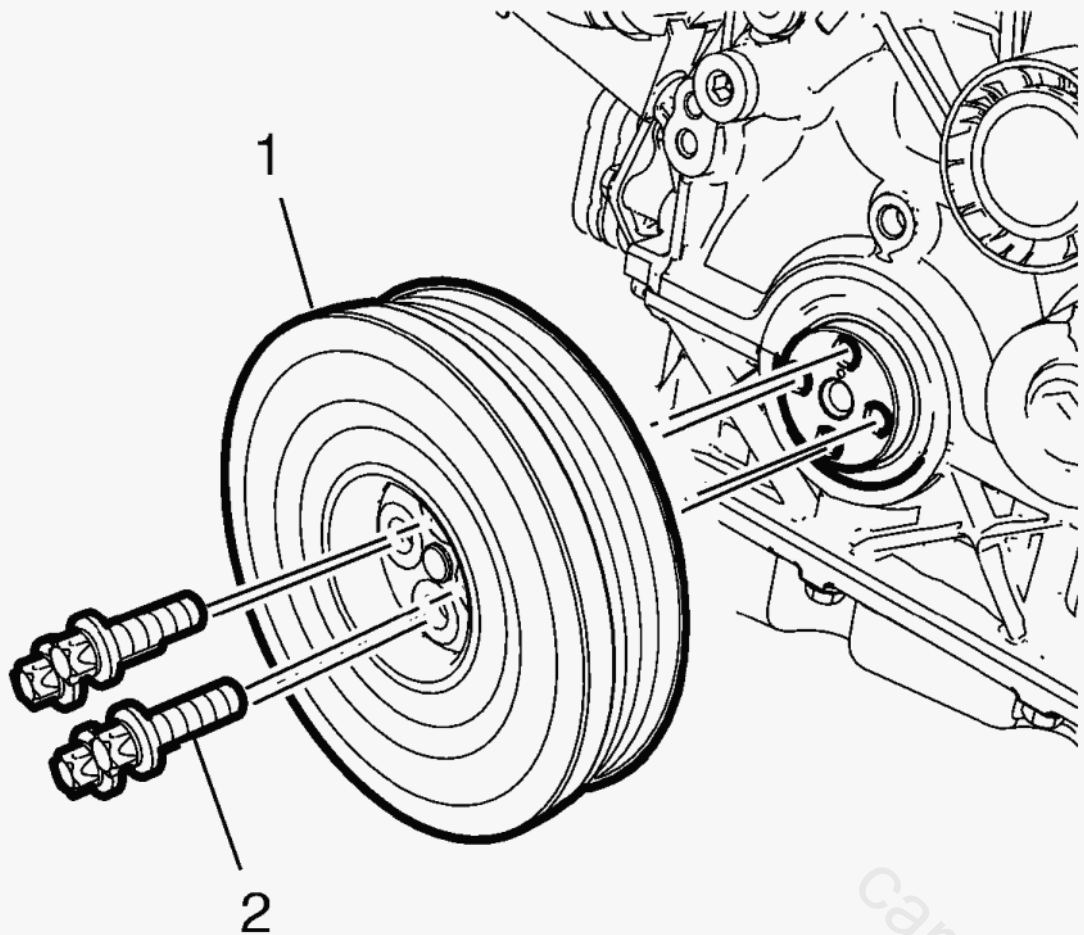


Fig. 308: Crankshaft Pulley And Bolts

Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to [Fastener Caution](#) .

4. Install the 4 crankshaft pulley bolts (2) and tighten in first pass to 50 N.m (37 lb ft).

CAUTION: Refer to [Torque-to-Yield Fastener Caution](#) .

5. Tighten the 4 crankshaft pulley bolts a final pass to an additional 45 degrees, use the **EN-45059** meter.
6. Install the drive belt. Refer to [Generator and Air Conditioning Compressor Belt Replacement](#).

CRANKSHAFT FRONT OIL SEAL REPLACEMENT

Special Tools

- **GE-328-B** Pin Remover
- **EN-6624** Remover
- **EN-51144** Crankshaft Seal Installer
- **EN-51144-100** Crankshaft Seal Installer

For equivalent regional tools, refer to [Special Tools](#).

Removal Procedure

1. Remove the crankshaft pulley. Refer to [Crankshaft Pulley Replacement](#).

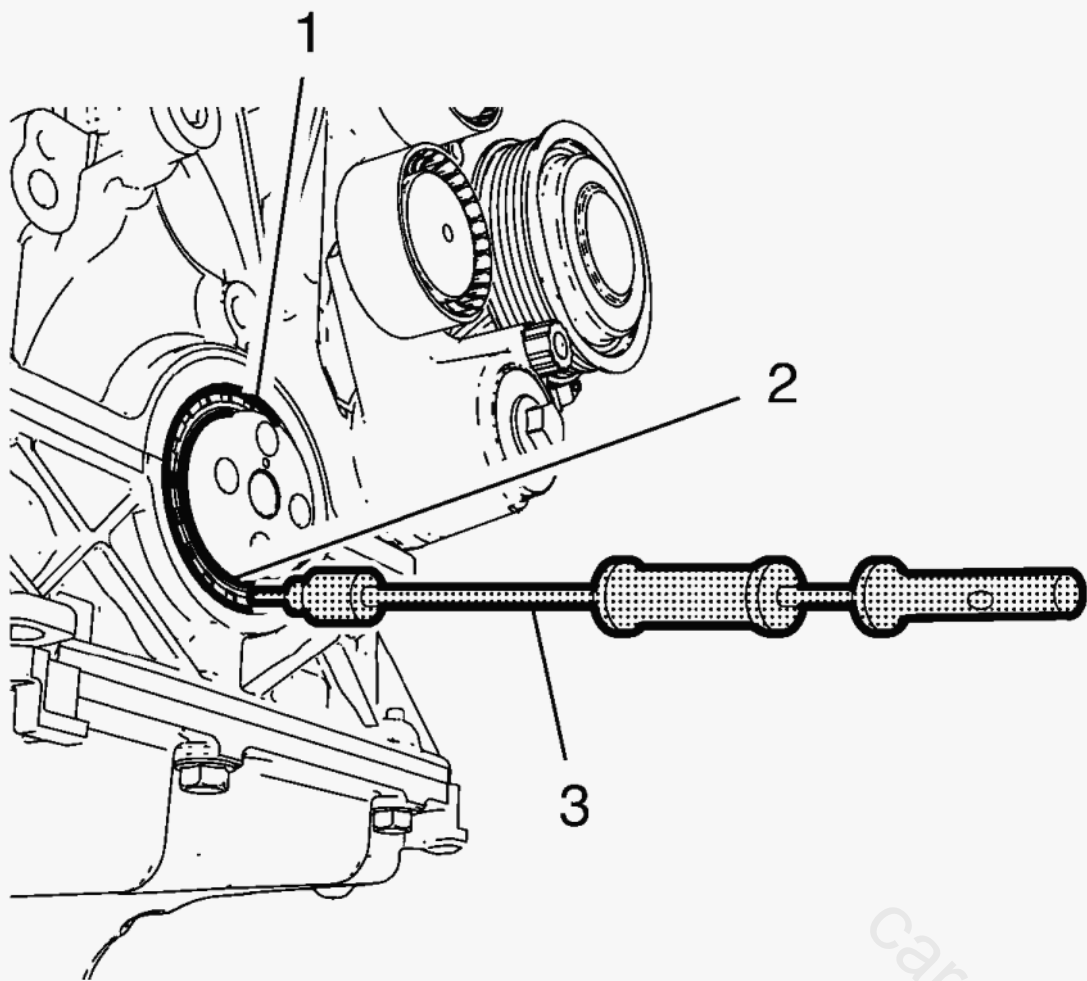


Fig. 309: Removers And Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS COMPANY

2. Punch a bore into the crankshaft seal, use a suitable tool.
3. Install the **EN-6624** remover (2) into the oil sealing ring (1).
4. Install the **GE-328-B** remover (3) to **EN-6624** remover (2).
5. Remove the crankshaft front oil seal, with the **GE-328-B** remover.

Installation Procedure

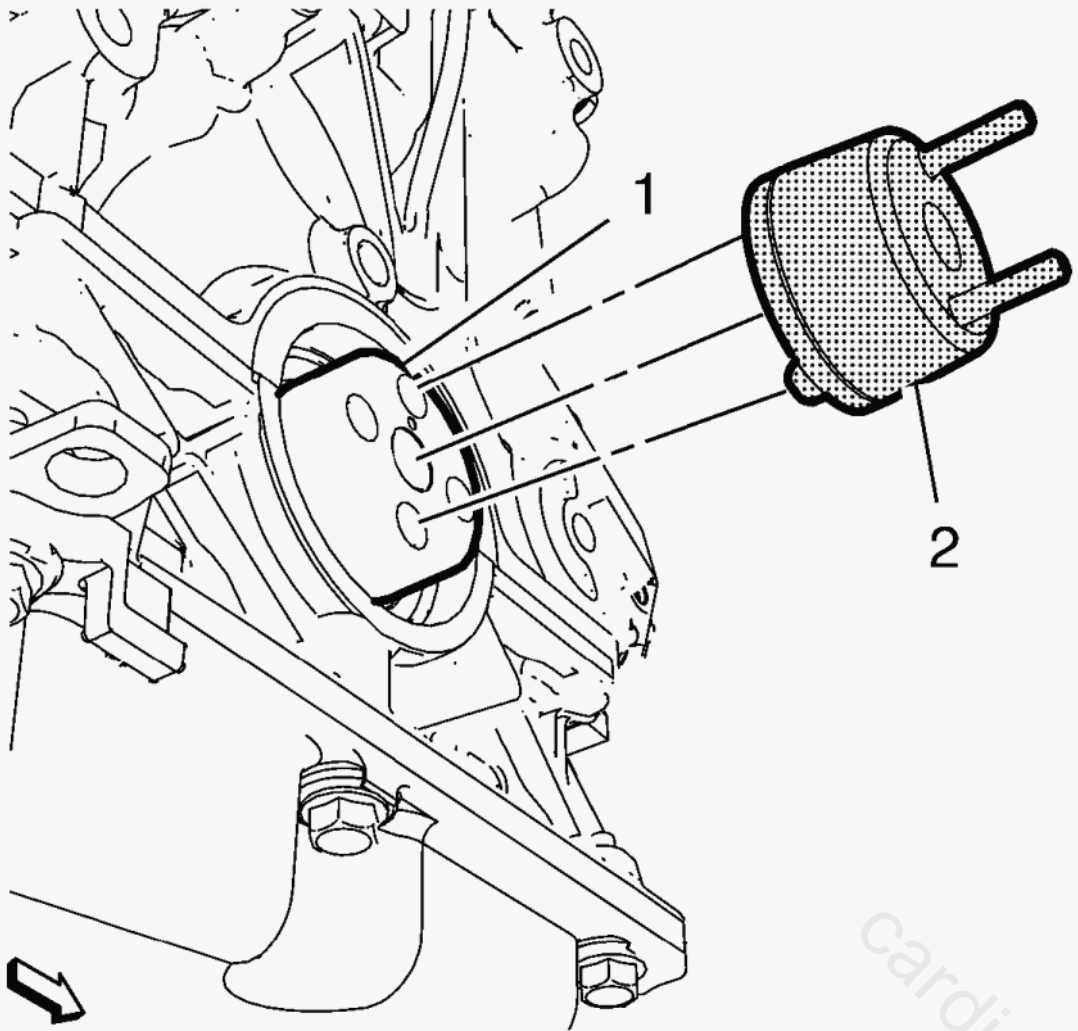


Fig. 310: Installer And Crankshaft

Courtesy of GENERAL MOTORS COMPANY

1. Install the EN-51144-1 installer (2) to the crankshaft (1).

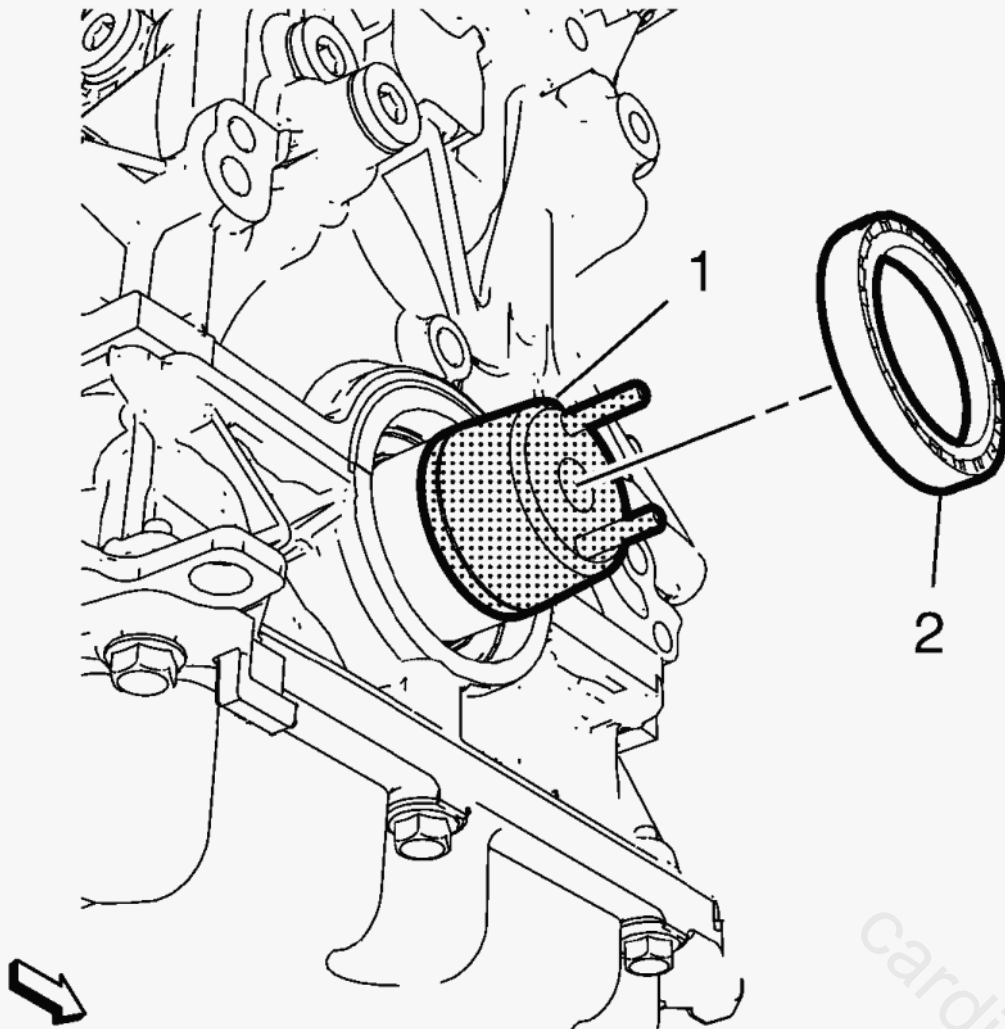


Fig. 311: Crankshaft Front Oil Seal And Installer
Courtesy of GENERAL MOTORS COMPANY

2. Install the NEW crankshaft front oil seal (2) to the **EN-51144-1** installer (1).

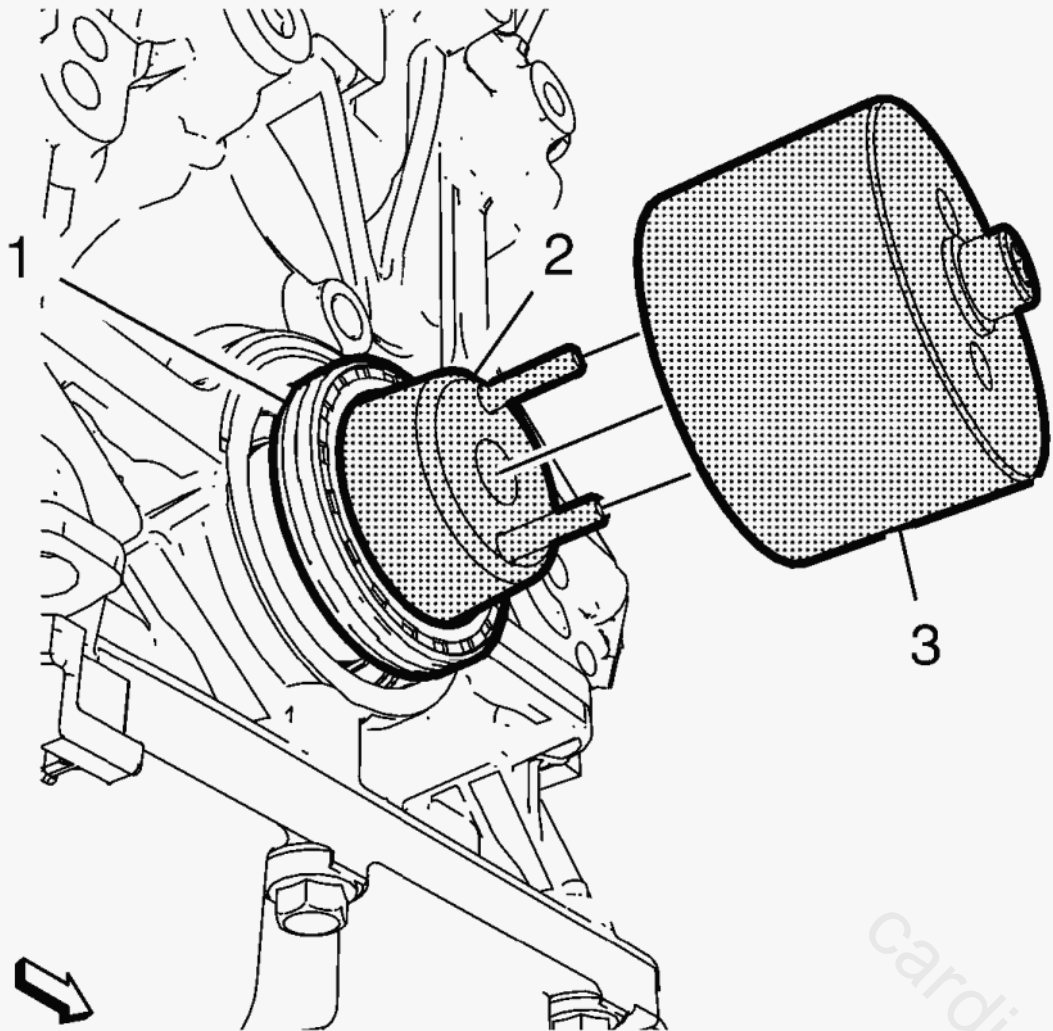


Fig. 312: Crankshaft Seal Installers

Courtesy of GENERAL MOTORS COMPANY

3. Install the **EN-51144-100** crankshaft seal installer (3) to the **EN-51144-1** installer (2).

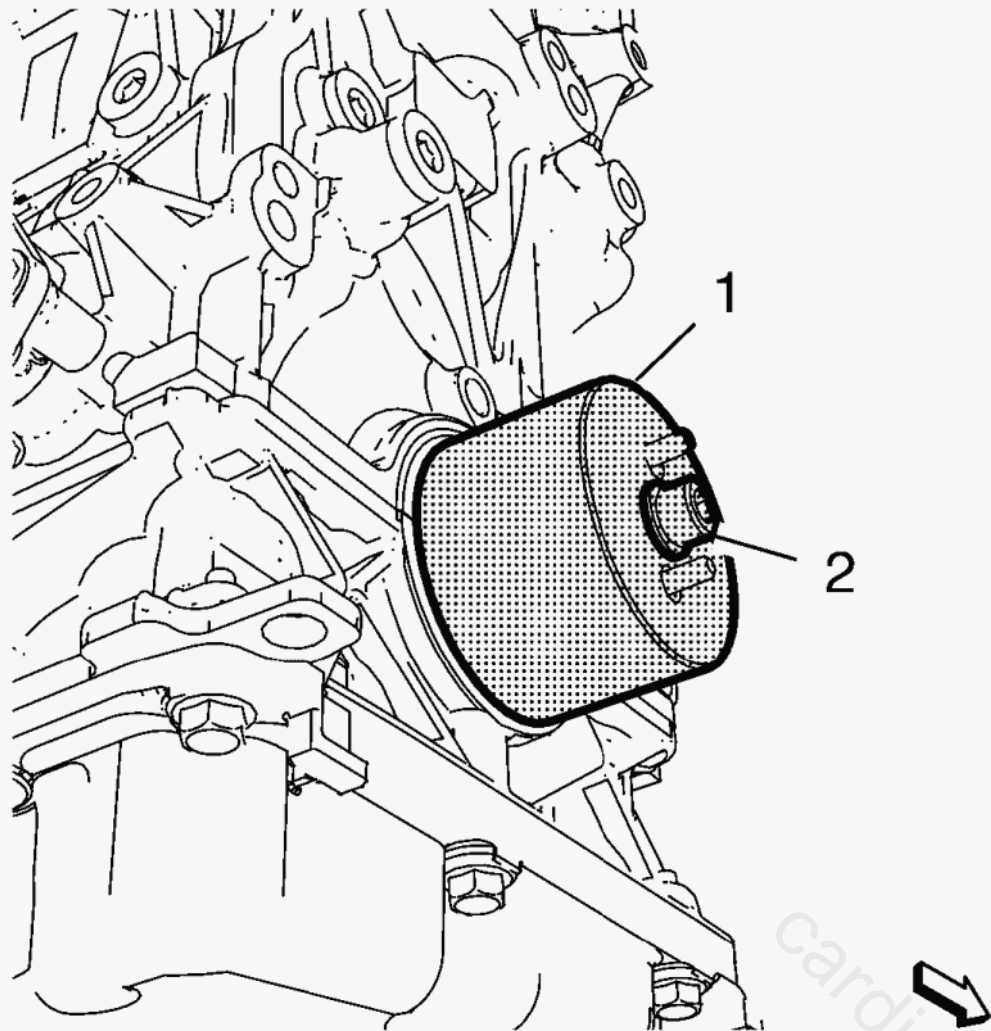


Fig. 313: Seating Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS COMPANY

4. Press the crankshaft front oil seal into the correct seat, by tighten the bolt (2) from **EN-51144** installer (1).
5. Thus they drive the crankshaft front oil seal as far purely until the **EN-51144** installer (1) on the stop is.
6. Remove the **EN-51144** installer.
7. Install the crankshaft pulley. Refer to [Crankshaft Pulley Replacement](#).
8. Check and correct the engine oil level.

CRANKSHAFT REAR OIL SEAL REPLACEMENT

Special Tools

- **DT-523-1** Handle
- **EN-6624** Remover
- **EN-51145** Crankshaft Seal Installer
- **GE-328-B** Pin Remover

For equivalent regional tools, refer to [Special Tools](#).

Removal Procedure

1. Remove the crankshaft position sensor reluctor ring. Refer to [Crankshaft Position Sensor Reluctor Ring Replacement](#).

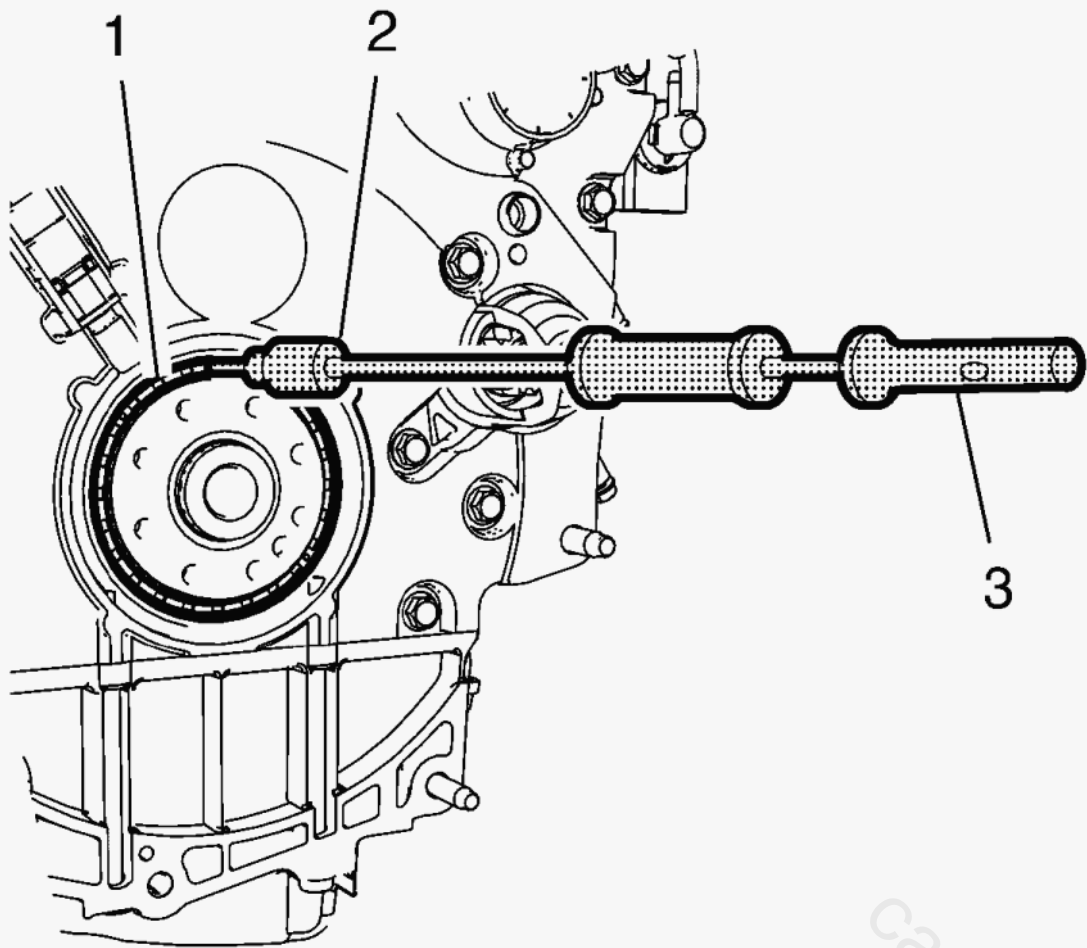


Fig. 314: Crankshaft Rear Oil Seal And Removers
Courtesy of GENERAL MOTORS COMPANY

2. Punch a bore into the crankshaft seal, use a suitable tool.
3. Install the **EN-6624** remover (2) into the oil sealing ring (1).
4. Install the **GE-328-B** remover (3) to the **EN-6624** remover (2).
5. Remove the crankshaft rear oil seal, with the **GE-328-B** remover.

Installation Procedure

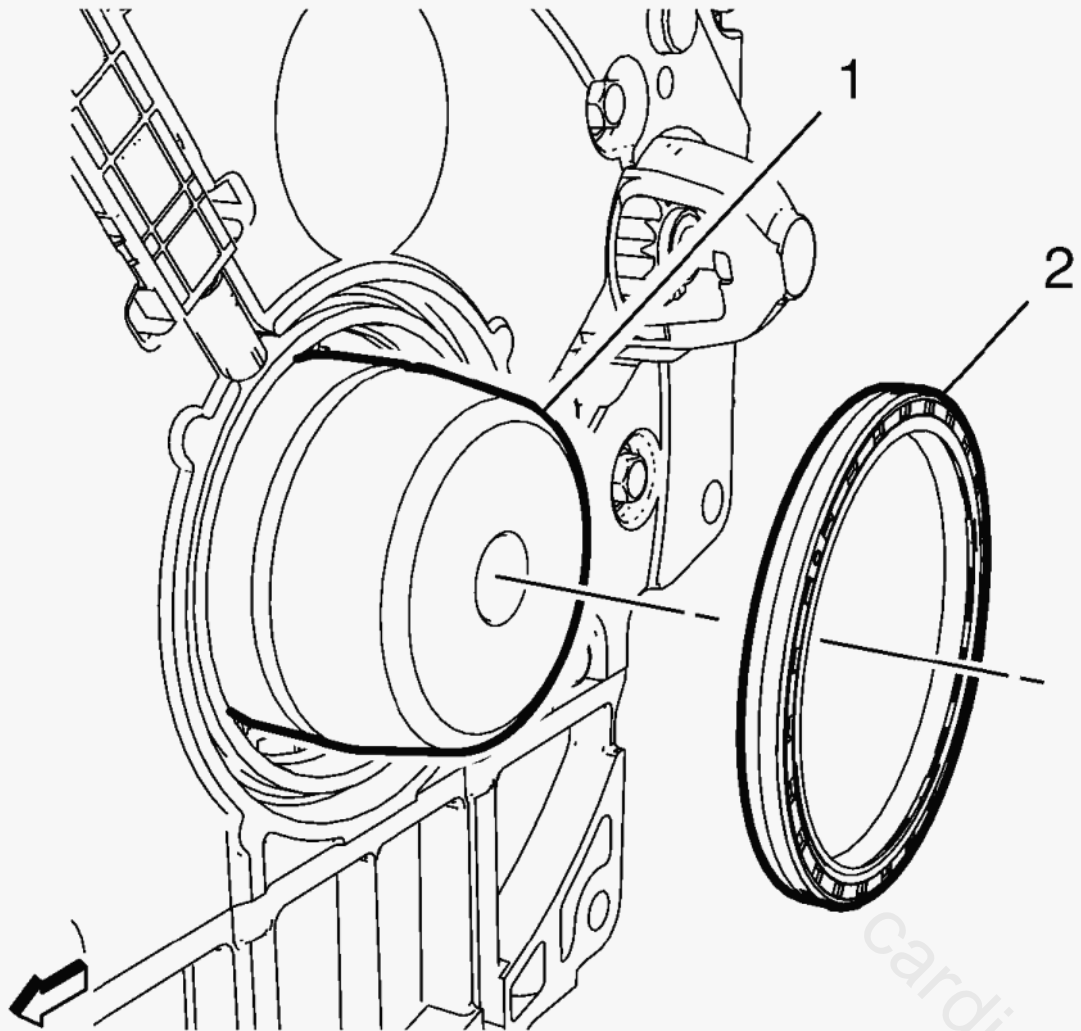


Fig. 315: Crankshaft Rear Oil Seal And Installer
Courtesy of GENERAL MOTORS COMPANY

1. Install the **EN-51145-1** installer (1) to the crankshaft.
2. Install the crankshaft rear oil seal (2) to the **EN-51145-1** installer (1).

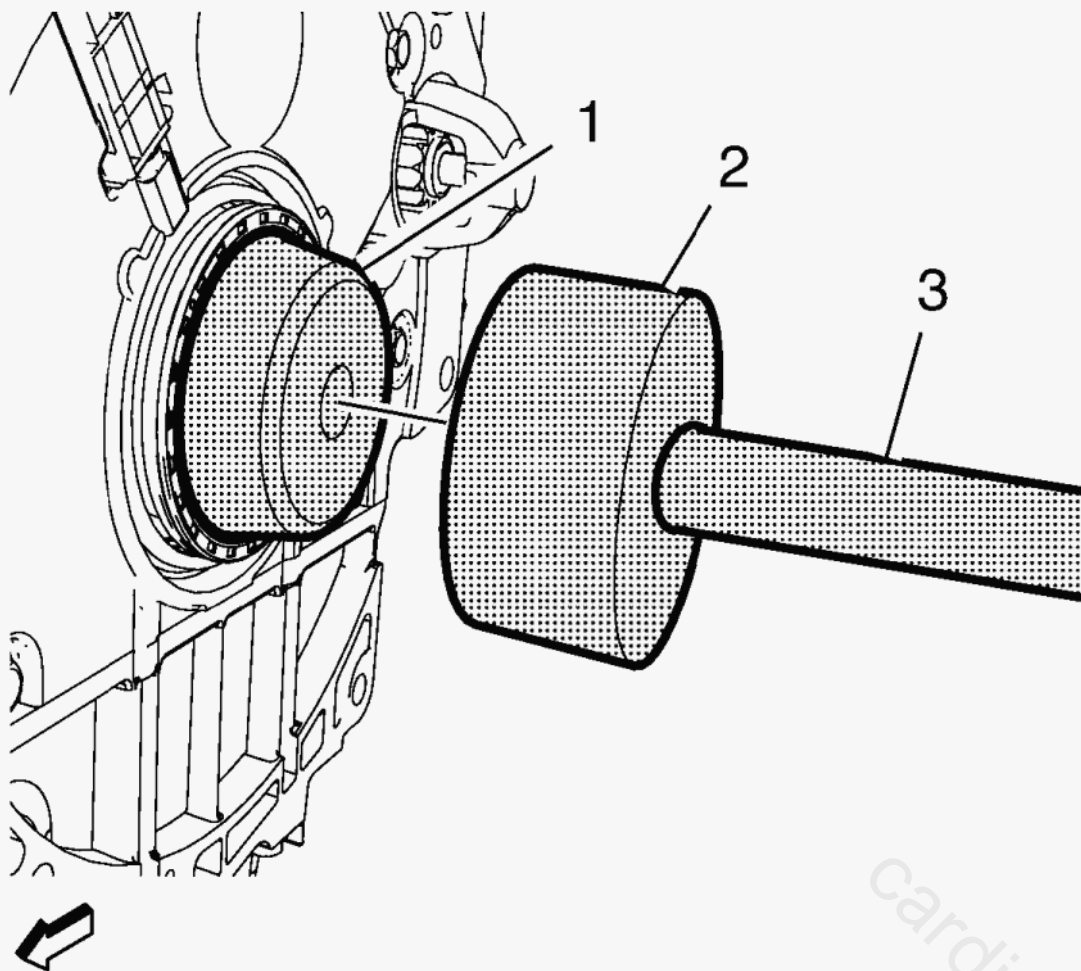


Fig. 316: Seating Crankshaft Rear Oil Seal

Courtesy of GENERAL MOTORS COMPANY

3. Pull in the crankshaft rear oil seal with the **EN-51145-2** installer (2) and the **DT-523-1** handle (3).
4. Remove the **EN-51145** installer.

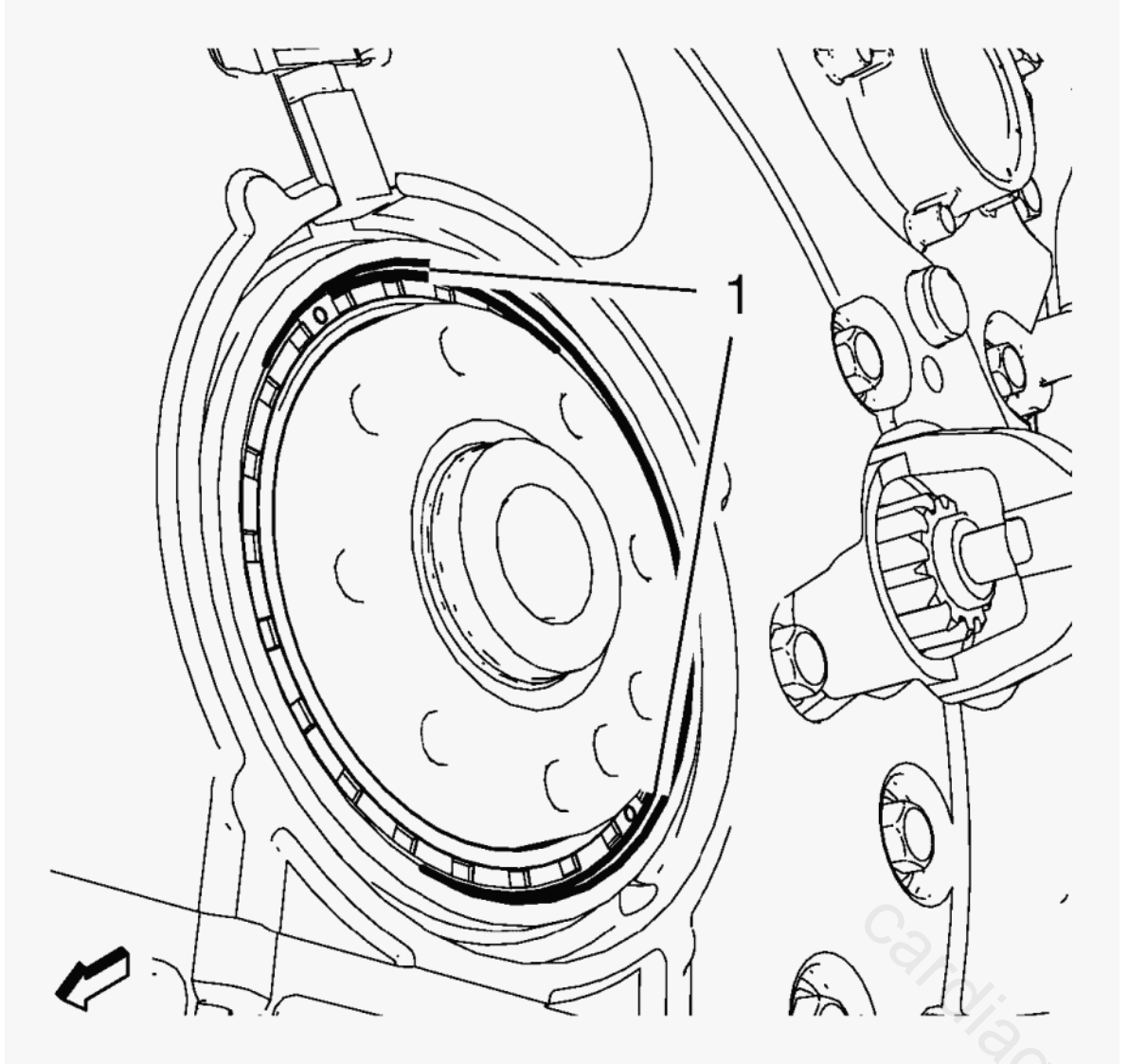


Fig. 317: Ensure Crankshaft Rear Oil Seal Is Properly Seated
 Courtesy of GENERAL MOTORS COMPANY

5. Check the proper seat (1) of the crankshaft rear oil seal.
6. Install the crankshaft position sensor reluctor ring. Refer to [Crankshaft Position Sensor Reluctor Ring Replacement](#).

CRANKSHAFT POSITION SENSOR RELUCTOR RING REPLACEMENT

Removal Procedure

1. Remove Automatic Transmission Flex Plate. Refer to [Automatic Transmission Flex Plate Replacement](#)

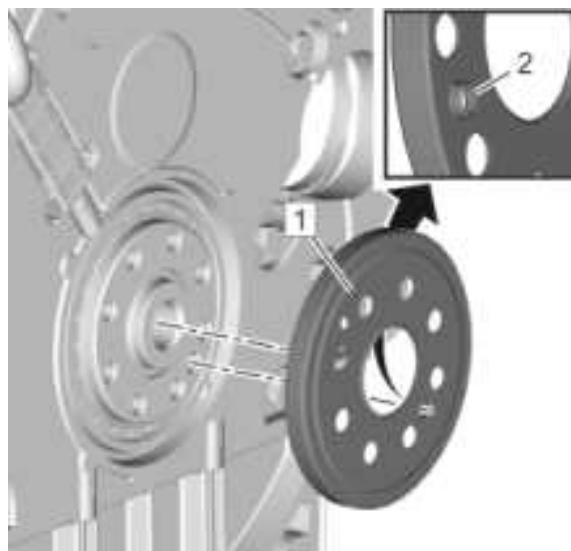


Fig. 318: Crankshaft Position Sensor Reluctor Ring And Pin
 Courtesy of GENERAL MOTORS COMPANY

2. Remove Crankshaft Position Sensor Reluctor Ring (1)

Installation Procedure

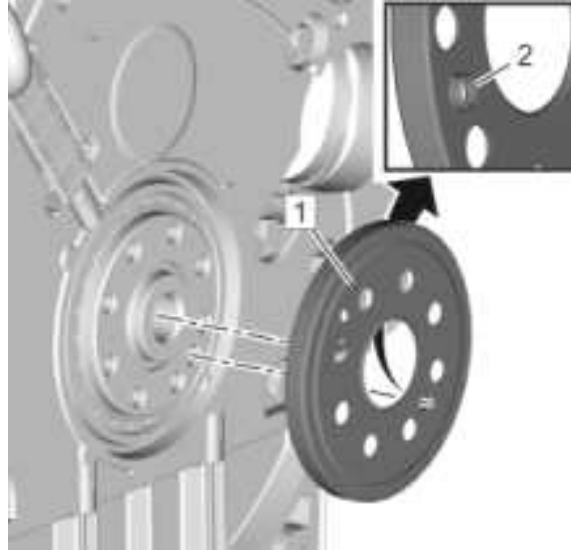


Fig. 319: Crankshaft Position Sensor Reluctor Ring And Pin
Courtesy of GENERAL MOTORS COMPANY

1. Install the crankshaft position sensor reluctor ring (1) by installing the pin (2) in the correct hole of the engine block.
2. Install Automatic Transmission Flex Plate. Refer to [Automatic Transmission Flex Plate Replacement](#)

CYLINDER HEAD REPLACEMENT

Special Tools

- EN-45059 Angle Meter
- EN-50509 Fixing Tool
- EN-50513 Fixing Pin
- EN-51140 Crankshaft Fixing Tool
- EN-51143 Camshaft Sprocket Fixing Tool
- GE-7872 Magnetic Base Dial Indicator

Equivalent regional tools: [Special Tools](#)

Removal Procedure

1. Remove the intake manifold. Refer to [Intake Manifold Replacement](#)
2. Remove the exhaust manifold. Refer to [Exhaust Manifold Replacement \(LH7\)](#)
3. Remove Camshaft Sprocket. Refer to [Camshaft Sprocket Replacement](#)
4. Remove Glow Plugs (Qty: 4). Refer to [Glow Plug Replacement](#)

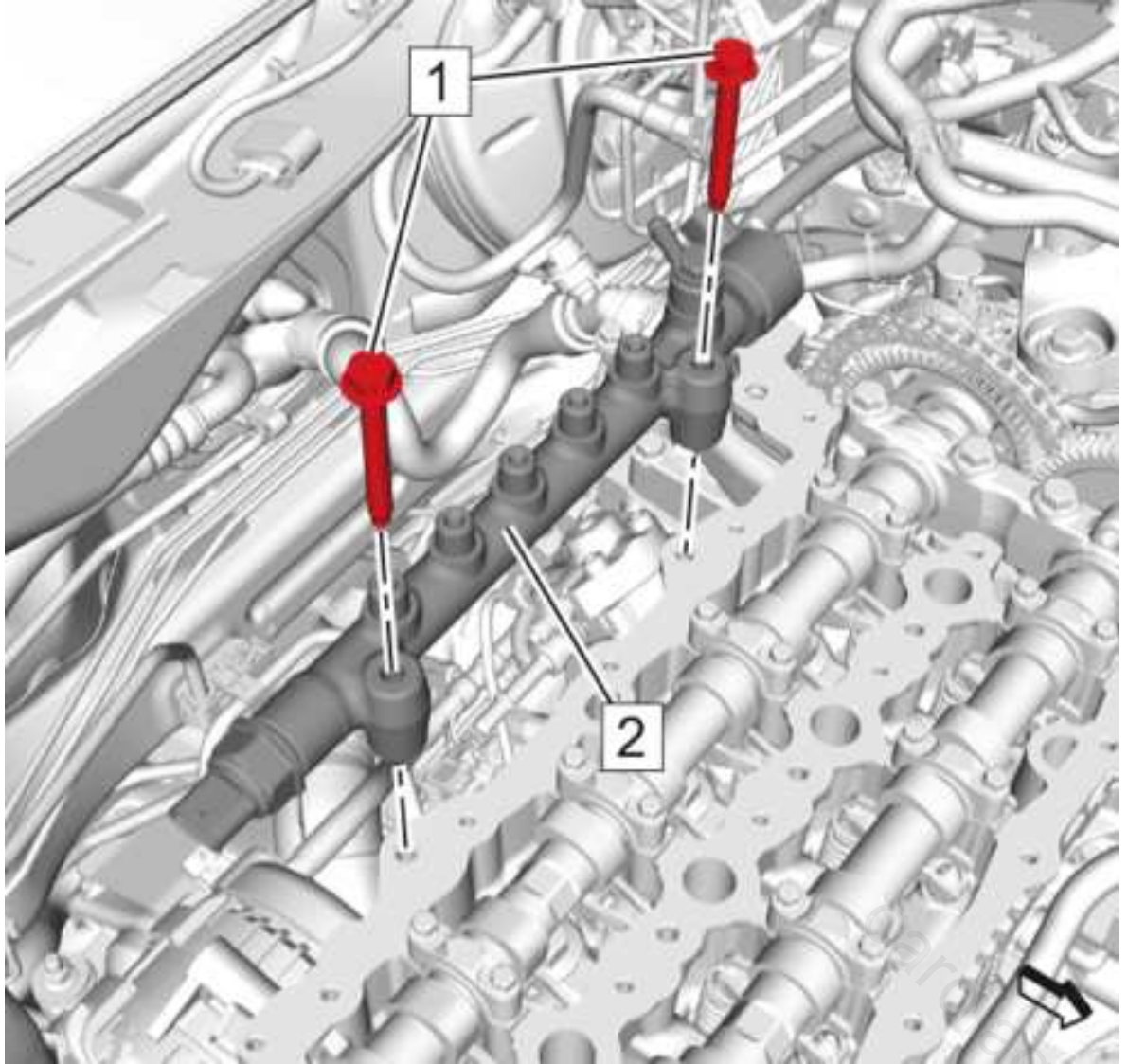


Fig. 320: Fuel Injection Fuel Rail And Bolts
Courtesy of GENERAL MOTORS COMPANY

5. Remove Fuel Injection Fuel Rail Bolts (1) (Qty: 2)
6. Remove Fuel Injection Fuel Rail (2)

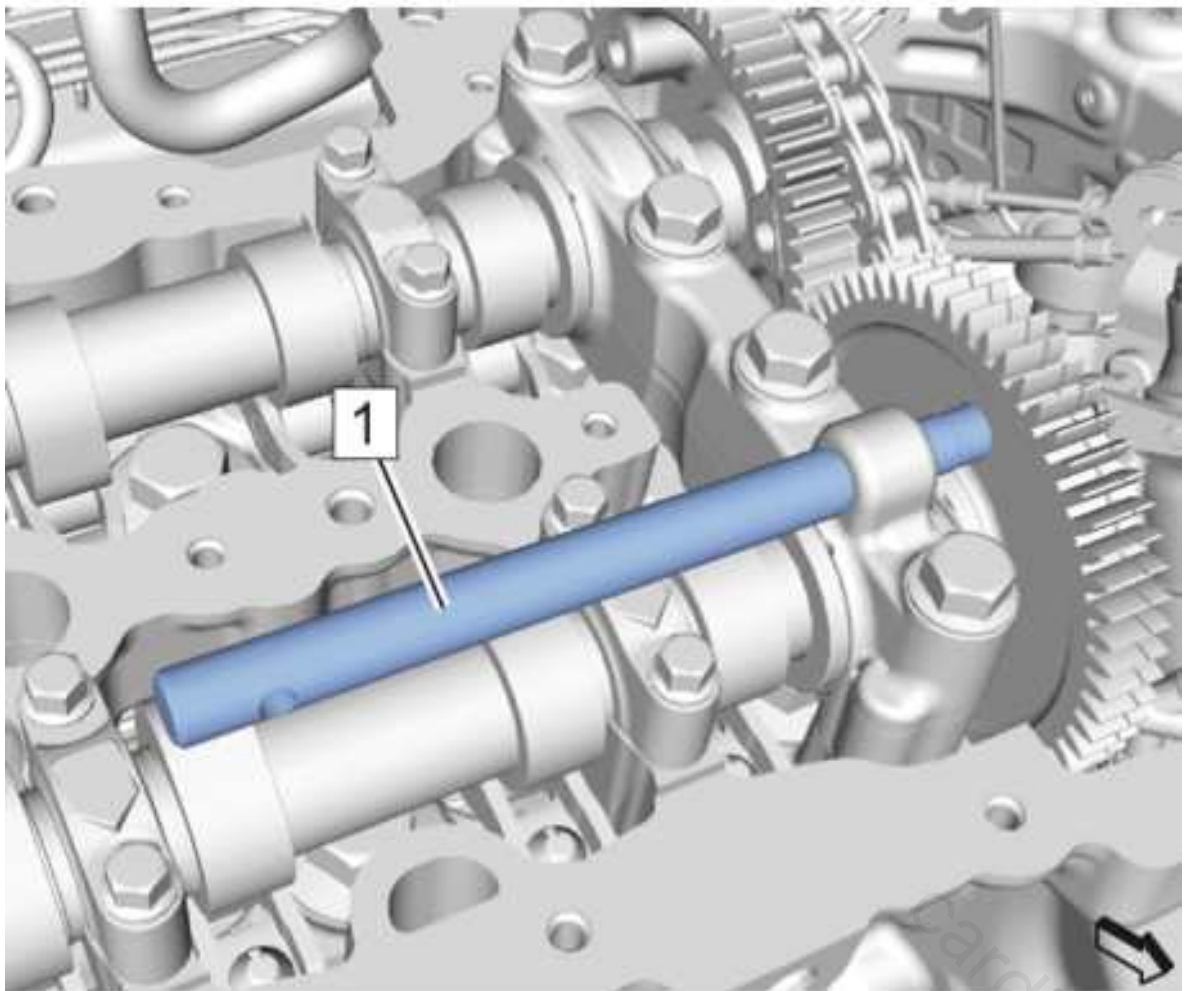


Fig. 321: Camshaft Sprocket Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

7. Remove the **EN-51143** fixing tool (1).

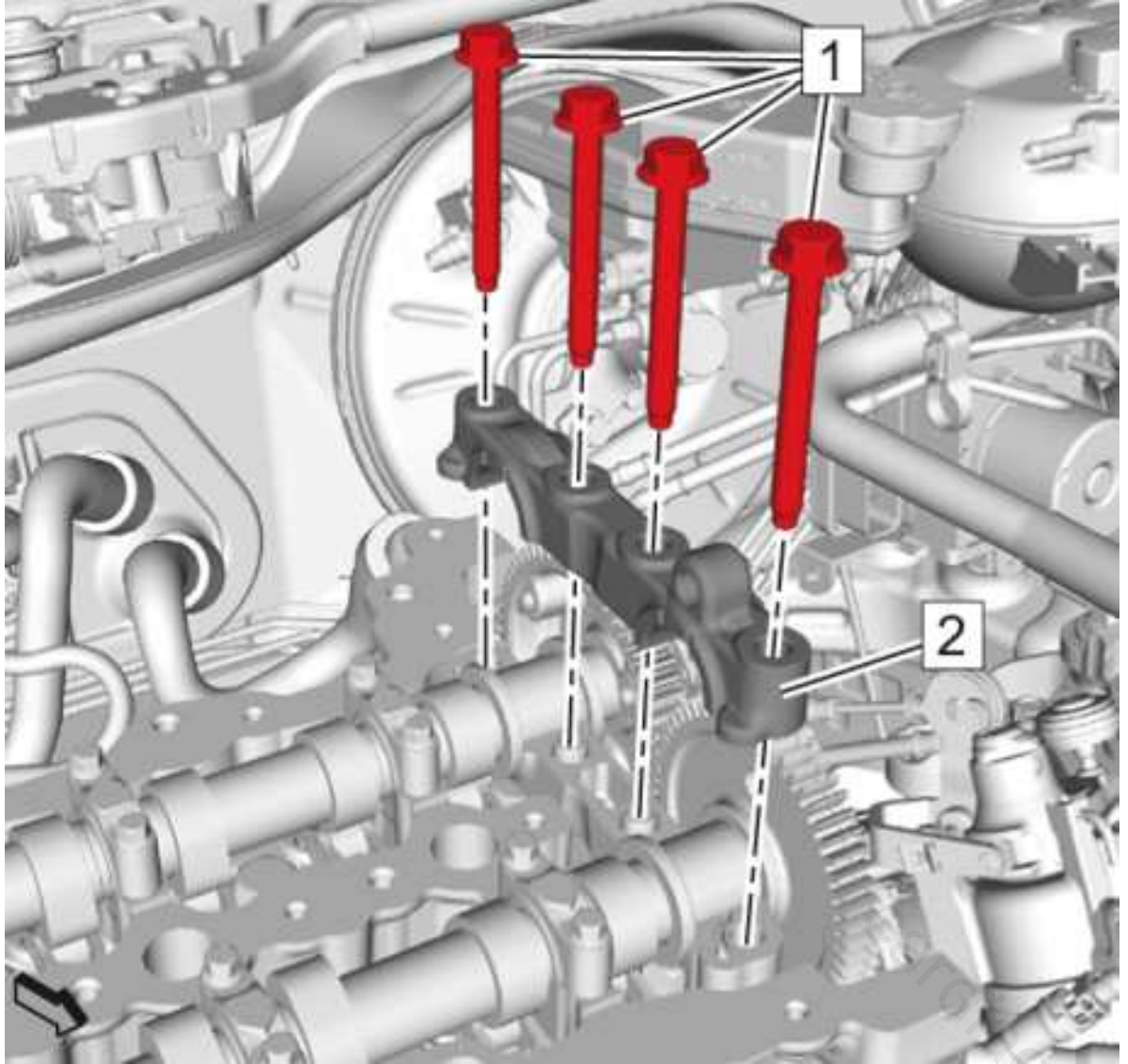


Fig. 322: Camshaft Bearing Rear Cap And Bolts
Courtesy of GENERAL MOTORS COMPANY

8. Remove the 4 camshaft bearing rear cap bolts (1).
9. Remove Camshaft Bearing Rear Cap (2)

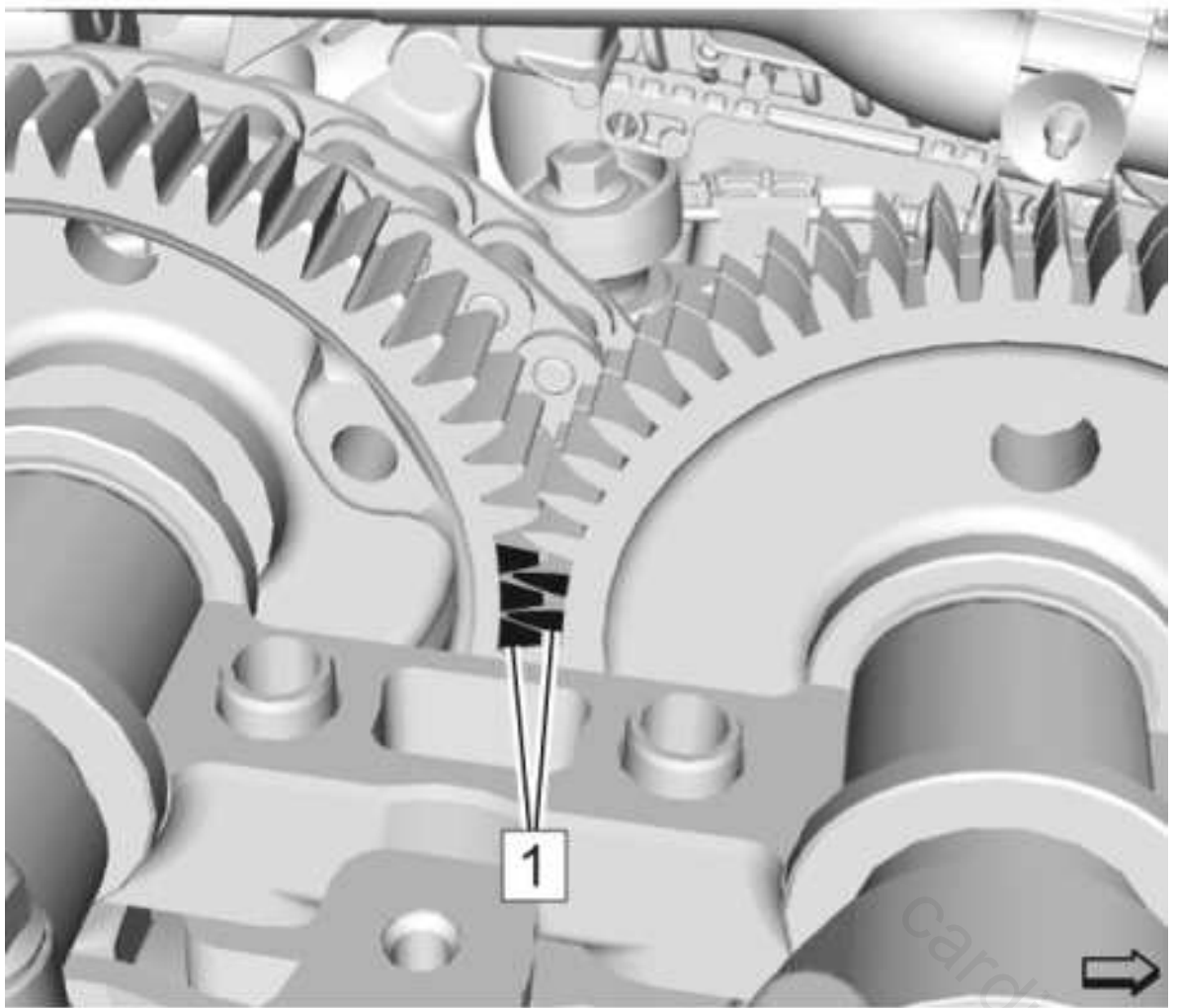


Fig. 323: Mark Exhaust Camshaft Sprocket And Intake Camshaft Sprocket With Paint Marks
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Marking the camshaft sprockets.**

10. Marking the exhaust camshaft sprocket and intake camshaft sprocket with paint marks (1).

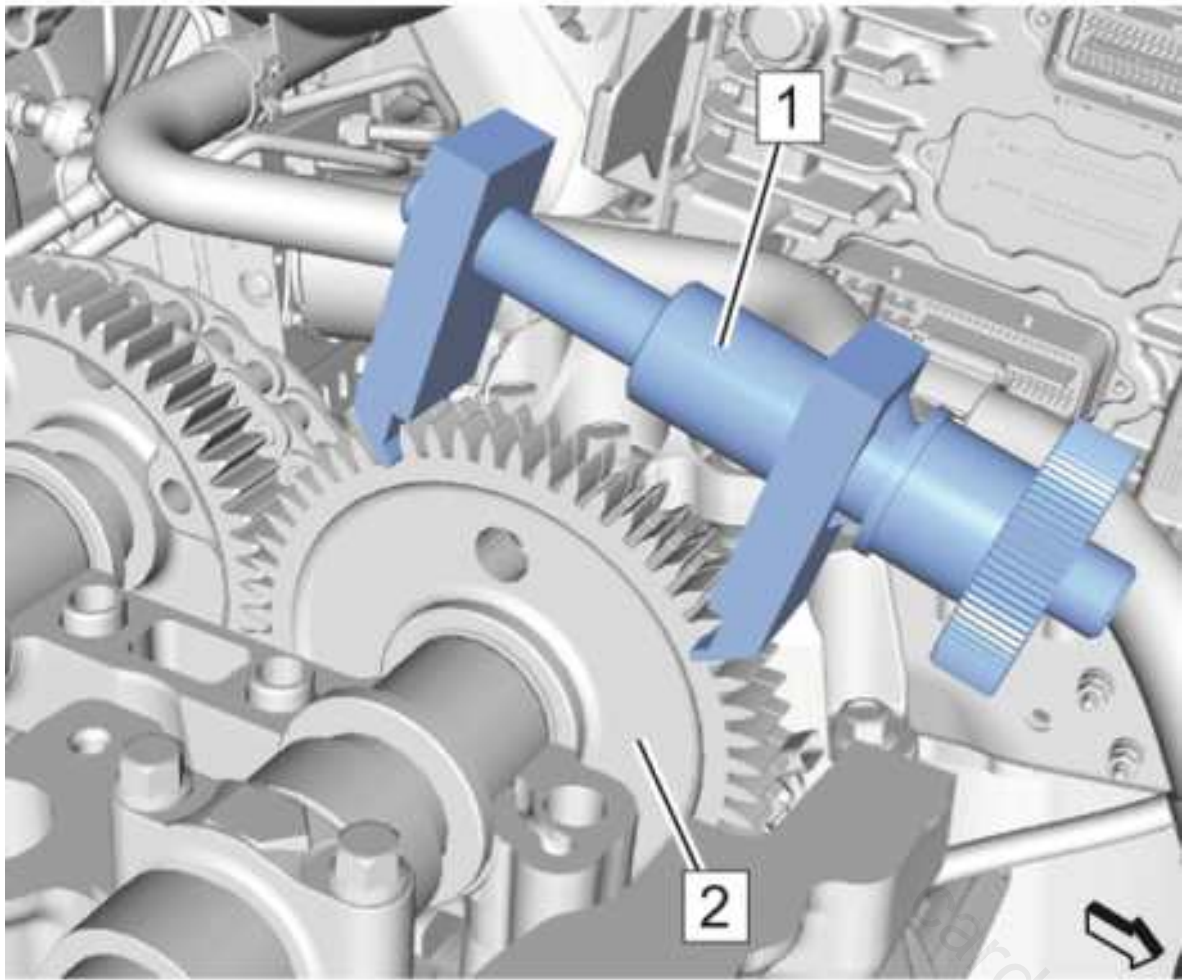


Fig. 324: Split Intake Camshaft Sprocket Fixing Tool
Courtesy of GENERAL MOTORS COMPANY

11. Install the EN-50509 fixing tool (1) to the exhaust camshaft sprocket (2).

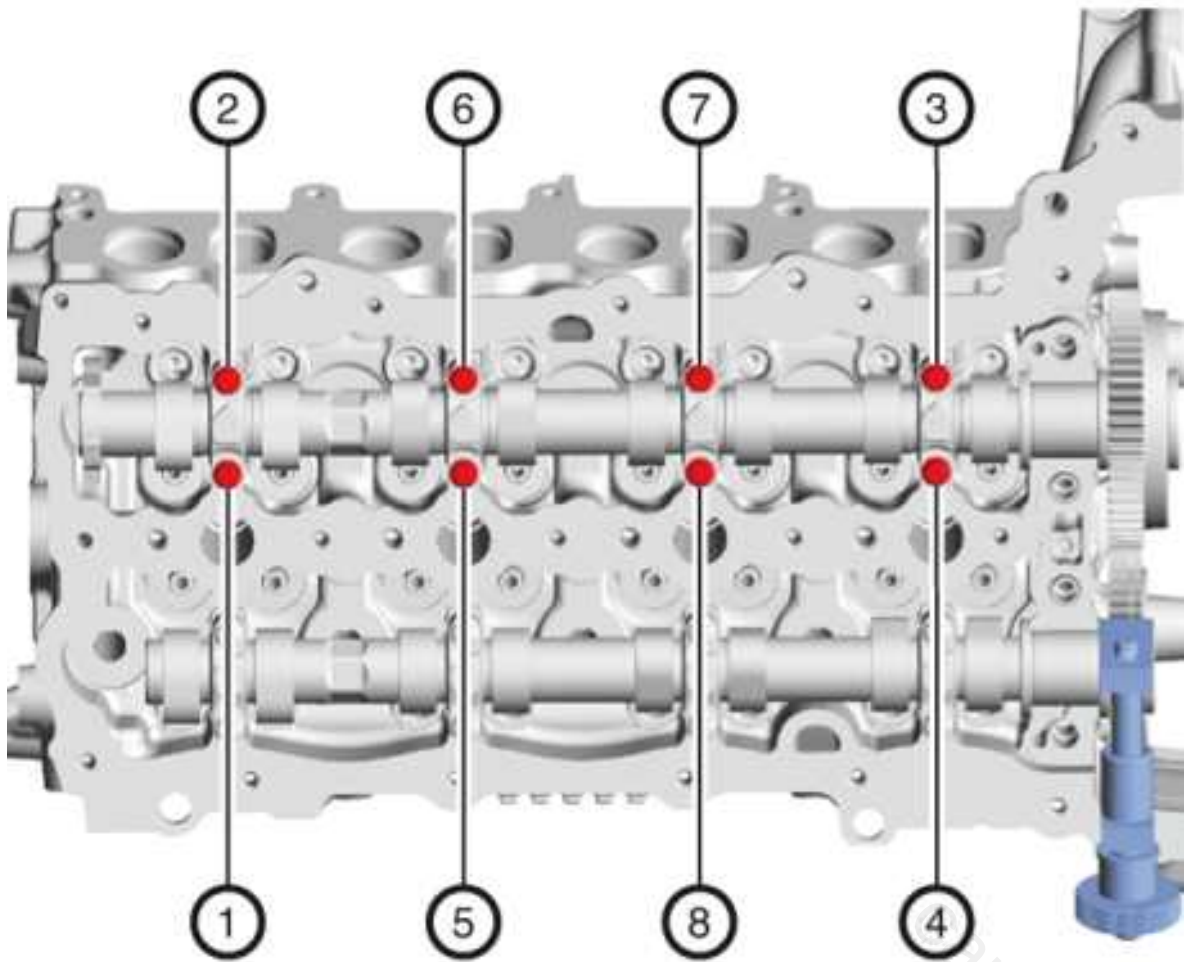


Fig. 325: Intake Camshaft Bearing Cap Bolt Loosening Sequence
Courtesy of GENERAL MOTORS COMPANY

12. Loosen the 8 intake camshaft bearing cap bolts in sequence as shown.

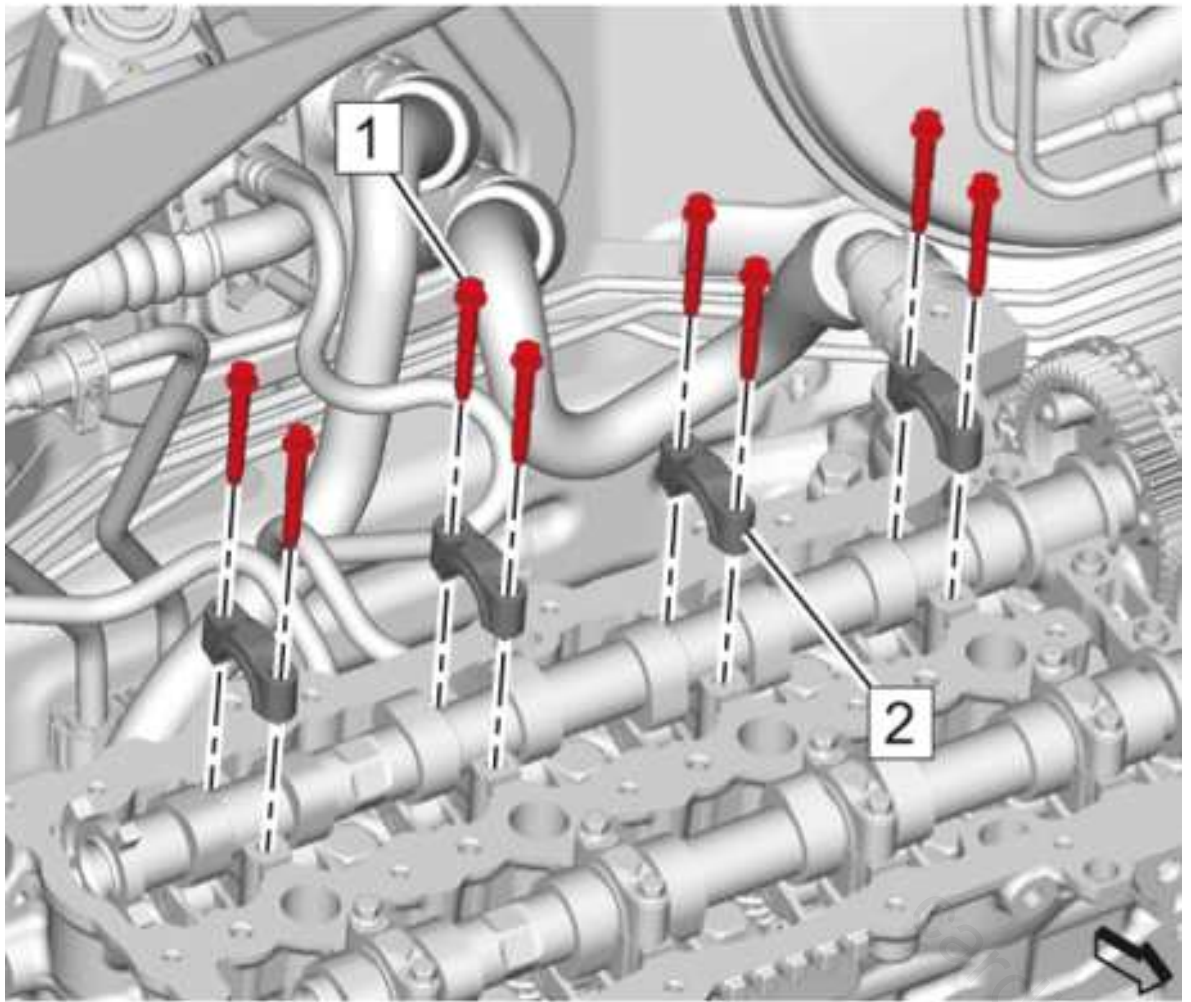


Fig. 326: Intake Camshaft Bearing Caps And Bolts
Courtesy of GENERAL MOTORS COMPANY

13. Remove the 8 intake camshaft bearing cap bolts (1).
14. Remove the 4 intake camshaft bearing caps (2) and lay aside in the order as they were removed.

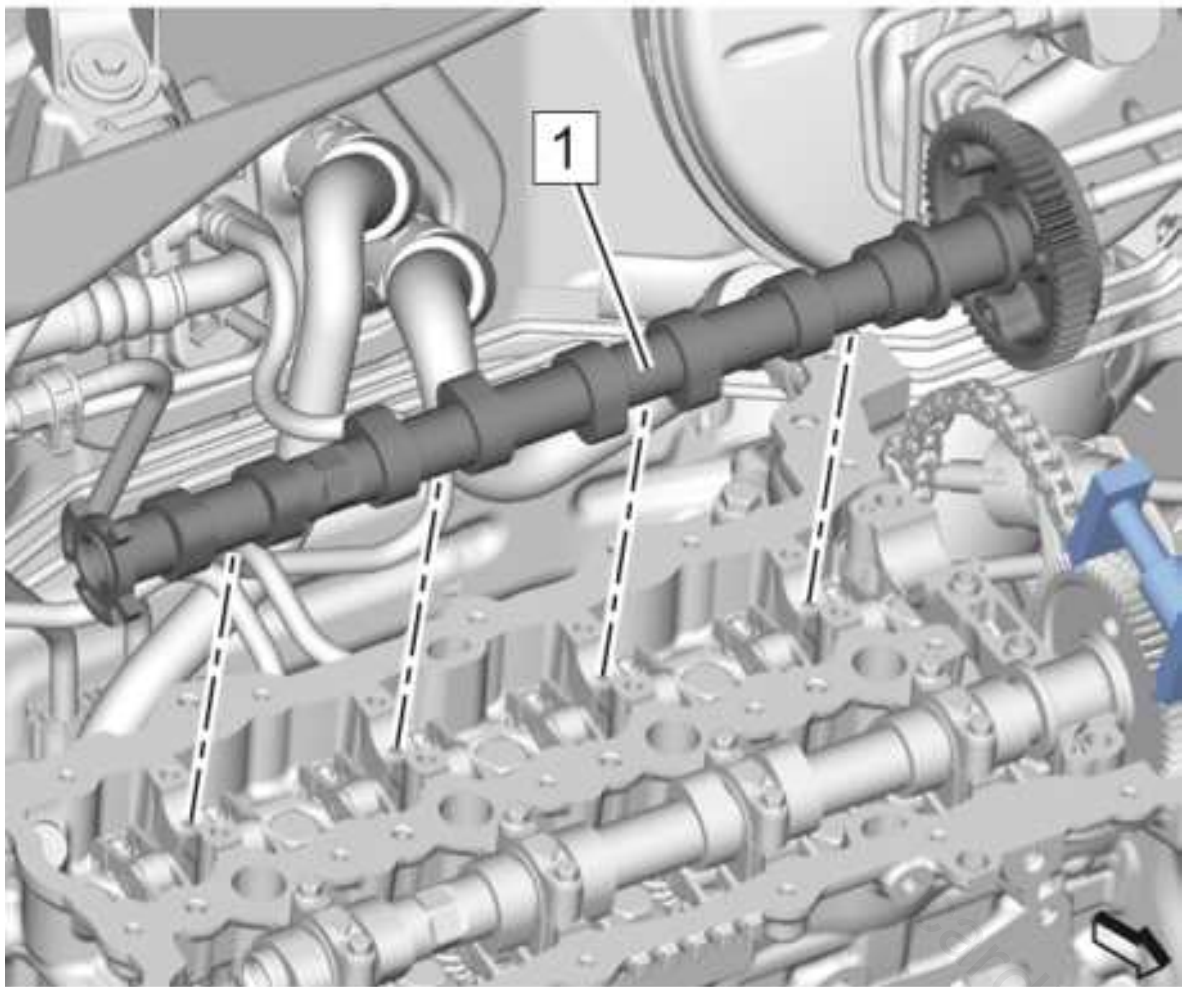


Fig. 327: Intake Camshaft

Courtesy of GENERAL MOTORS COMPANY

15. Remove Intake Camshaft (1)

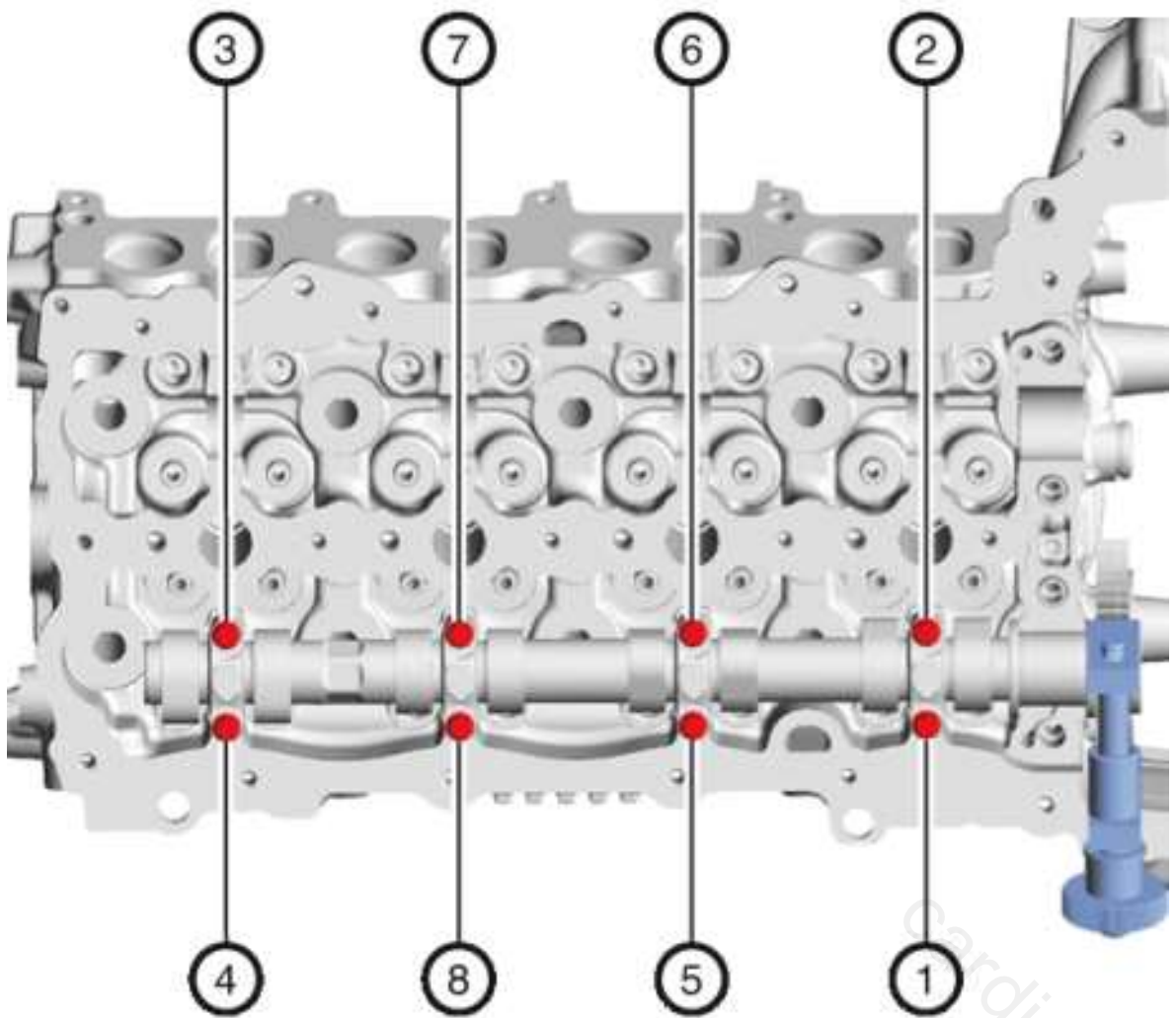


Fig. 328: Exhaust Camshaft Bearing Cap Bolt Loosening Sequence
Courtesy of GENERAL MOTORS COMPANY

16. Loosen the 8 exhaust camshaft bearing cap bolts in sequence as shown.

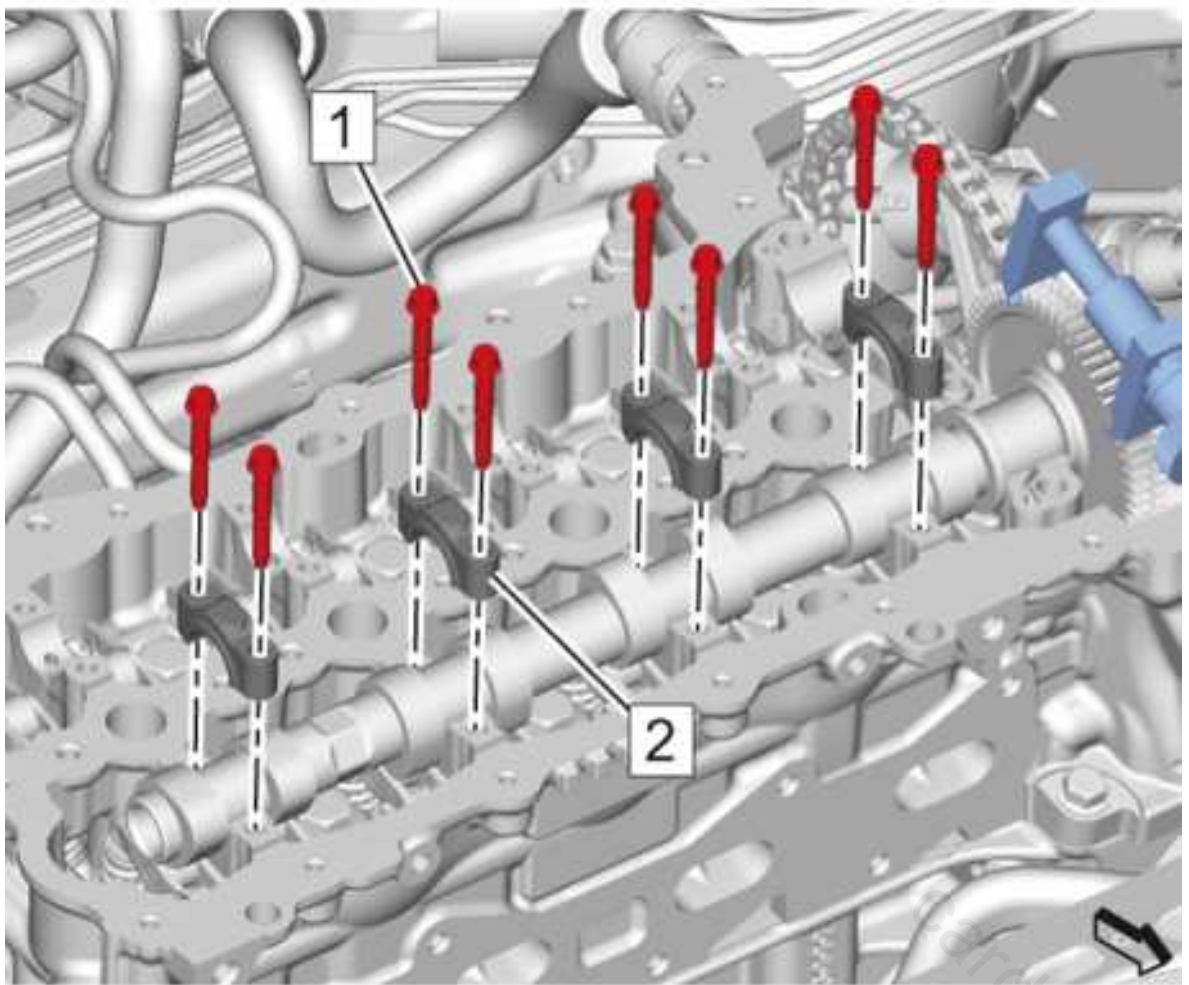


Fig. 329: Exhaust Camshaft Bearing Caps And Bolts
Courtesy of GENERAL MOTORS COMPANY

17. Remove the 8 exhaust camshaft bearing cap bolts (1).
18. Remove the 4 exhaust camshaft bearing caps (2) and lay aside in the order as they were removed.

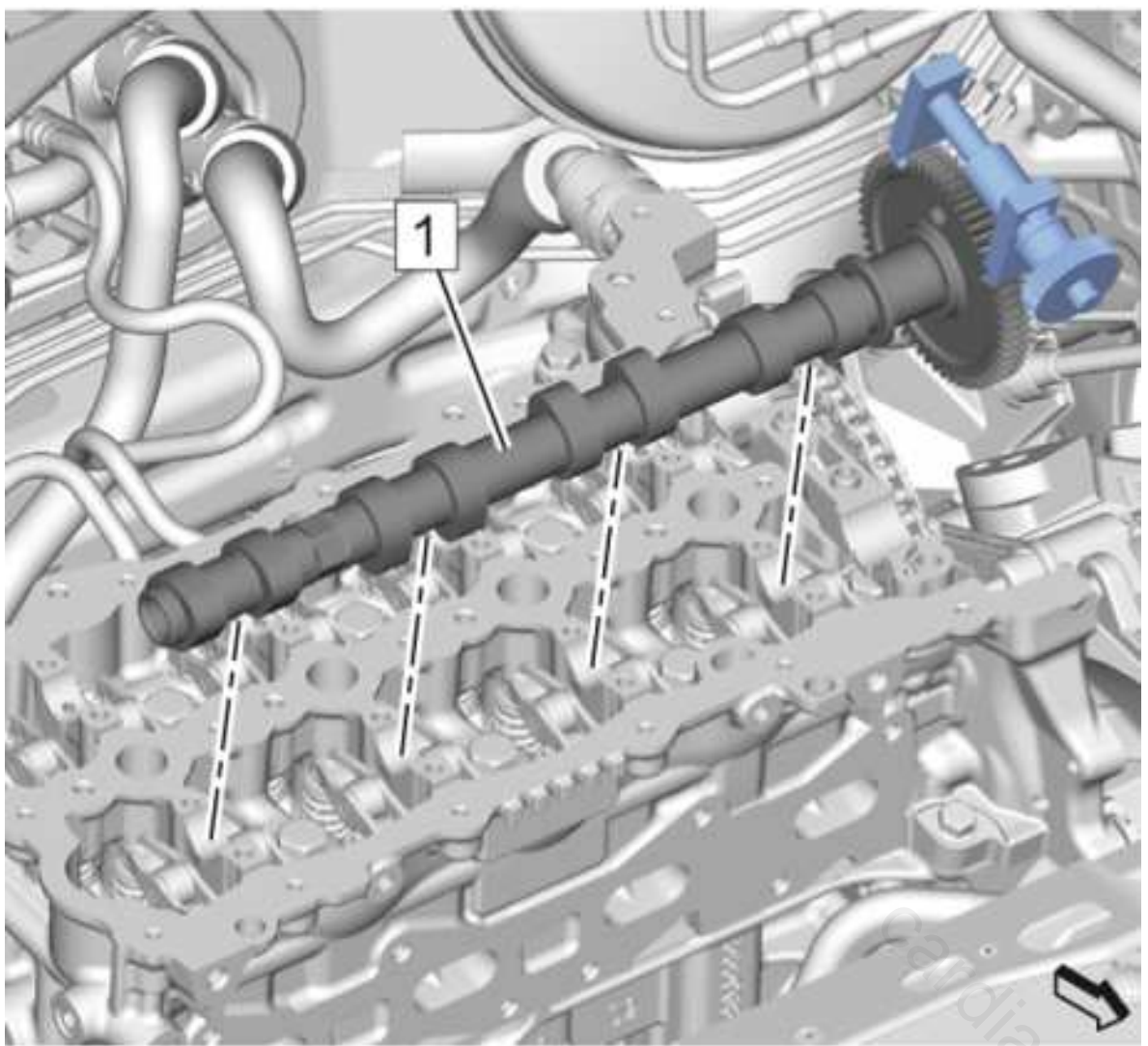


Fig. 330: Exhaust Camshaft With Bore Of Camshaft Sprocket Upwards
Courtesy of GENERAL MOTORS COMPANY

NOTE: Do not remove the EN-50509 fixing tool.

19. Remove Exhaust Camshaft (1)

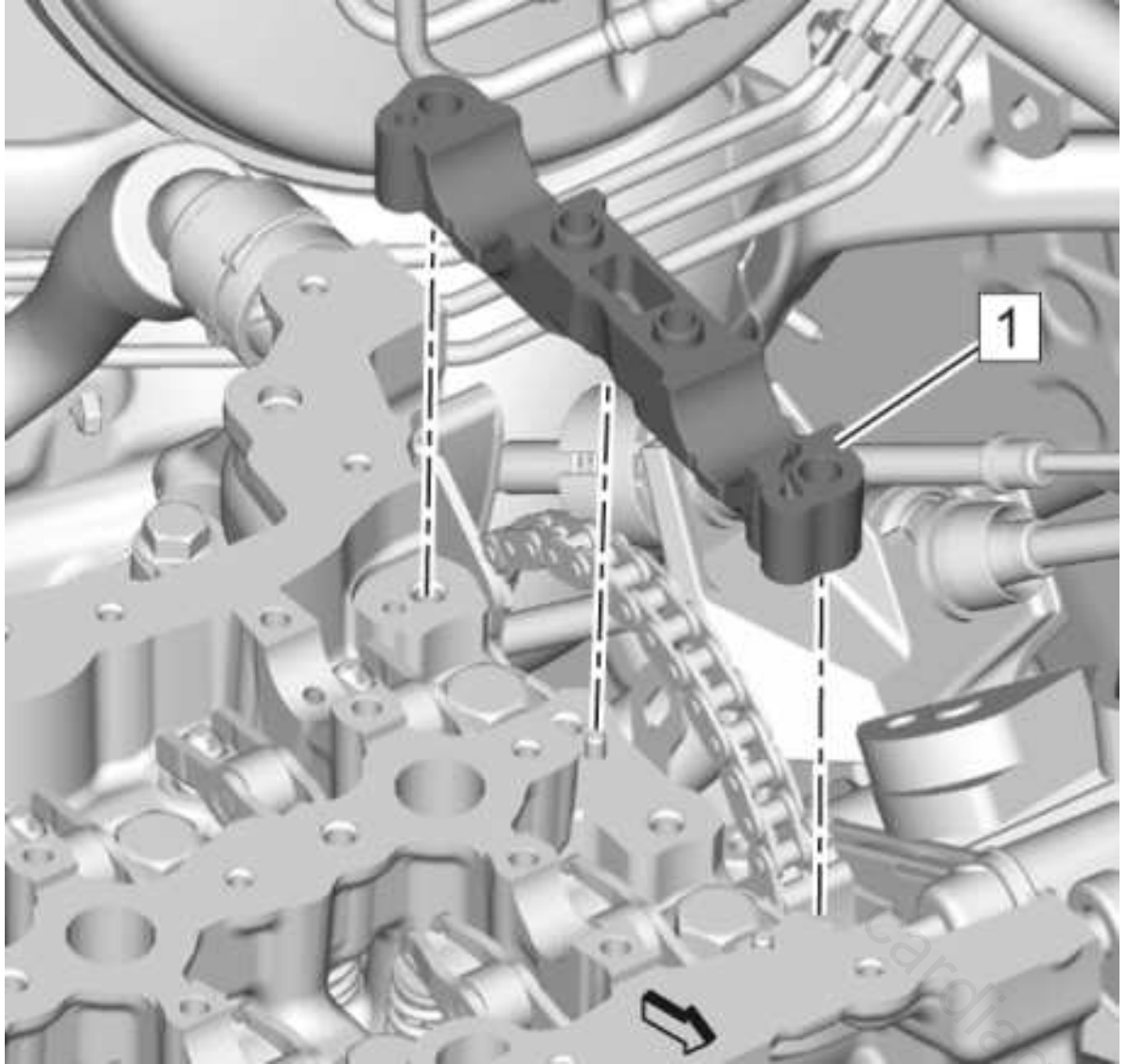


Fig. 331: Bearing Bracket

Courtesy of GENERAL MOTORS COMPANY

20. Remove the bearing bracket (1).

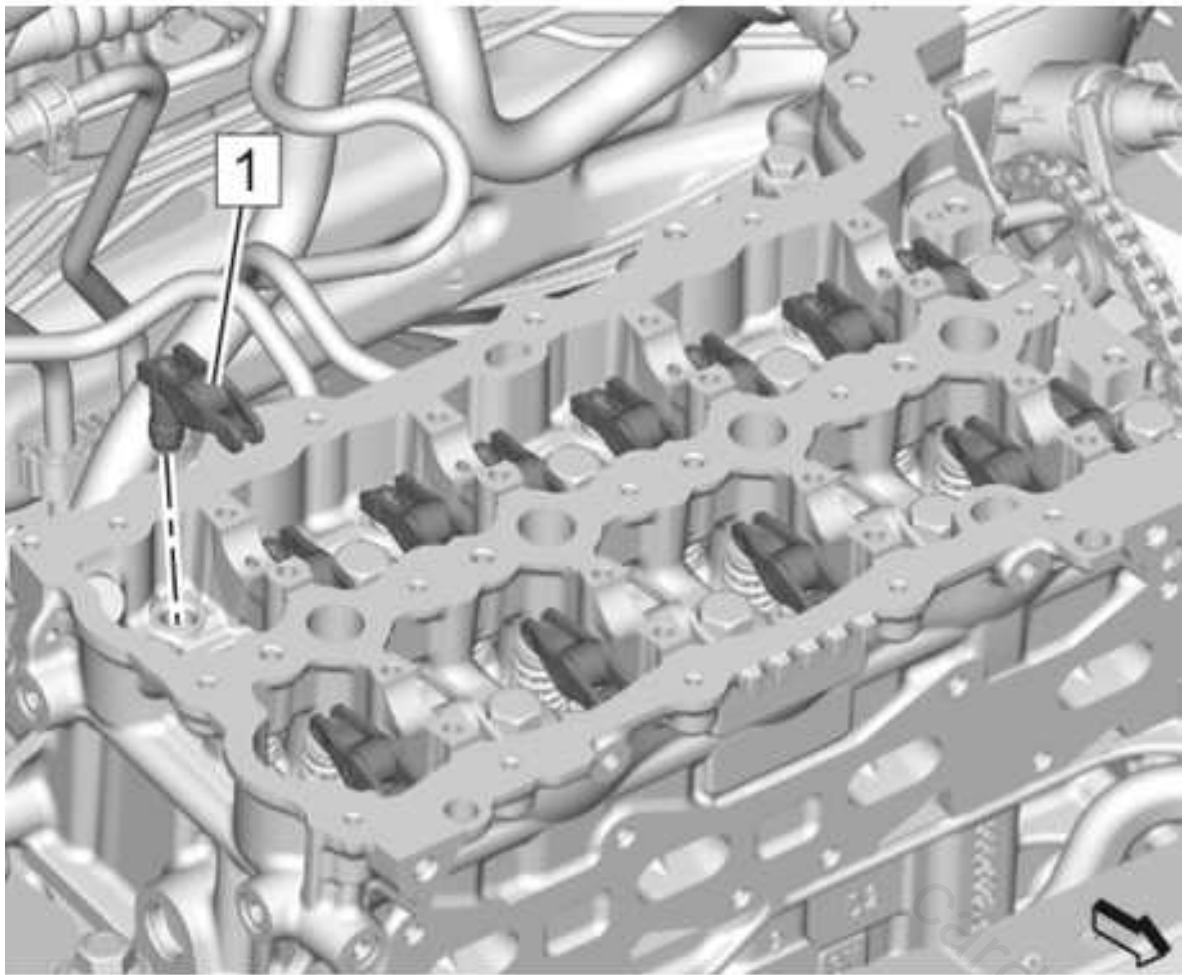


Fig. 332: Valve Lifter Roller Assemblies

Courtesy of GENERAL MOTORS COMPANY

21. Remove the 16 valve lifter with valve lifter roller (1) and lay aside in the order as they was removed.

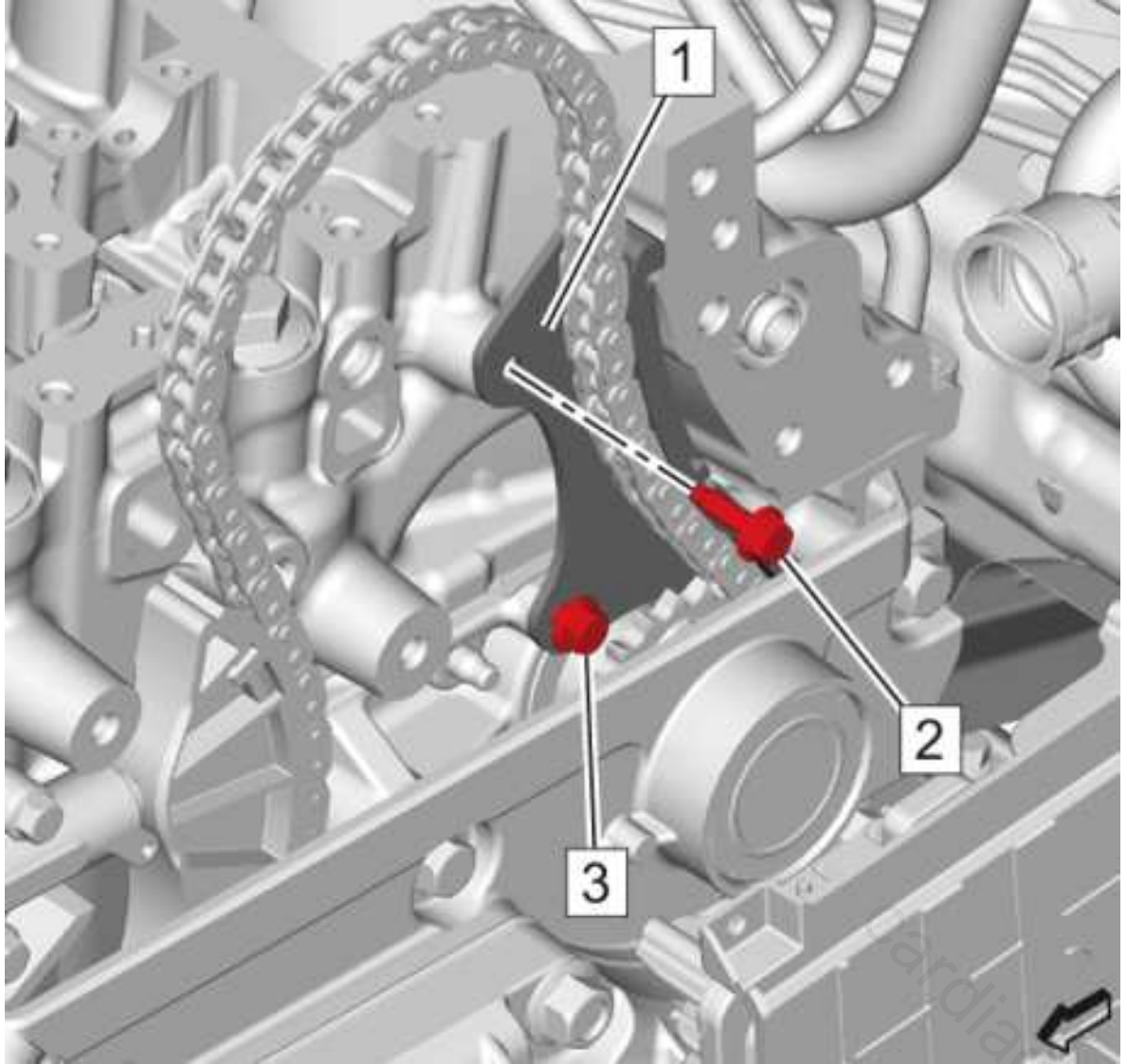


Fig. 333: Upper Timing Chain Upper Guide And Bolts
Courtesy of GENERAL MOTORS COMPANY

22. Remove the upper timing chain upper guide bolt (2).
23. Loosen the timing chain upper guide (1) by loosen the lower bolt (3).

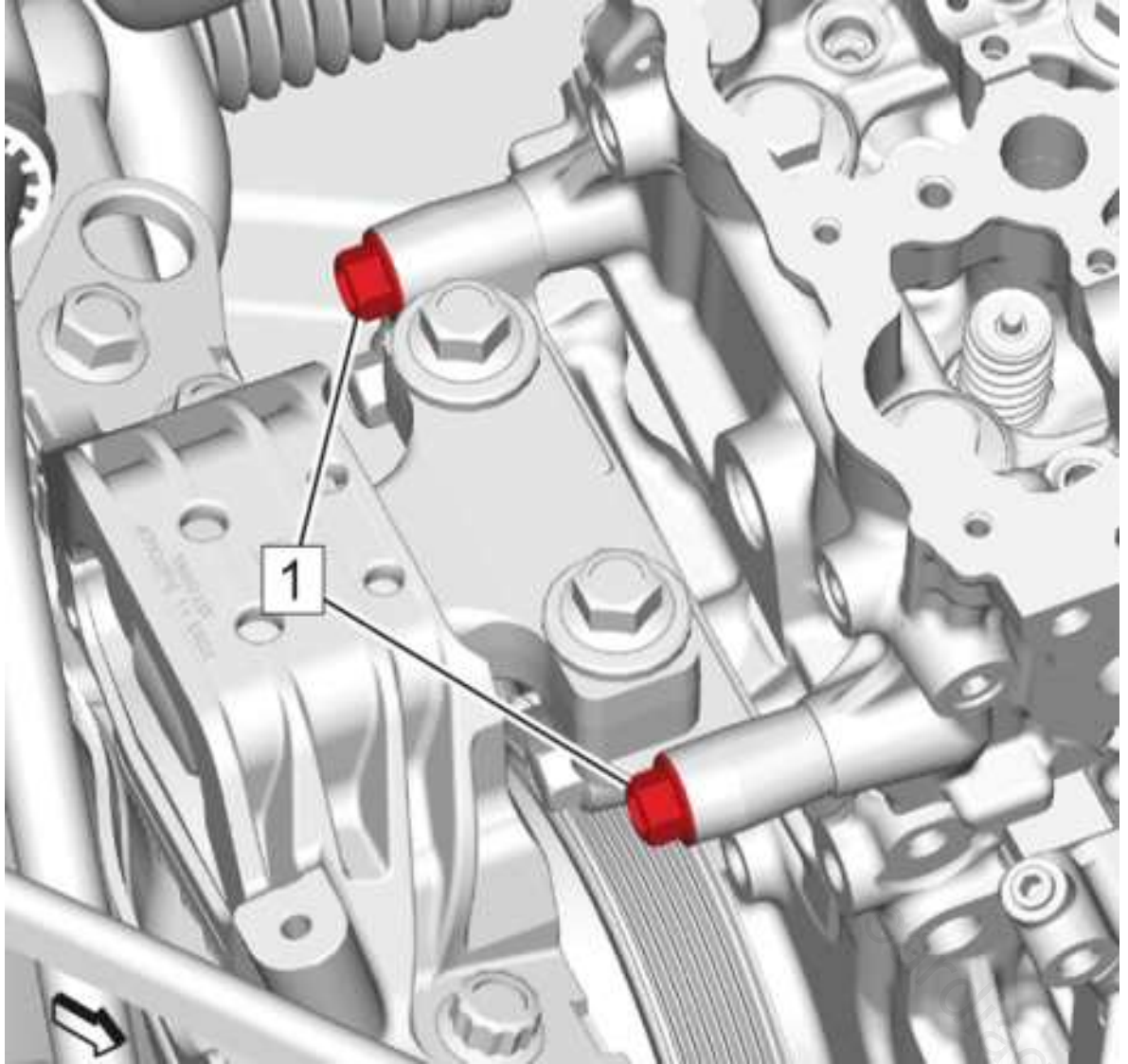


Fig. 334: Engine Mount Bracket Bolts

Courtesy of GENERAL MOTORS COMPANY

24. Remove Engine Mount Bracket Bolts (1) (Qty: 2)

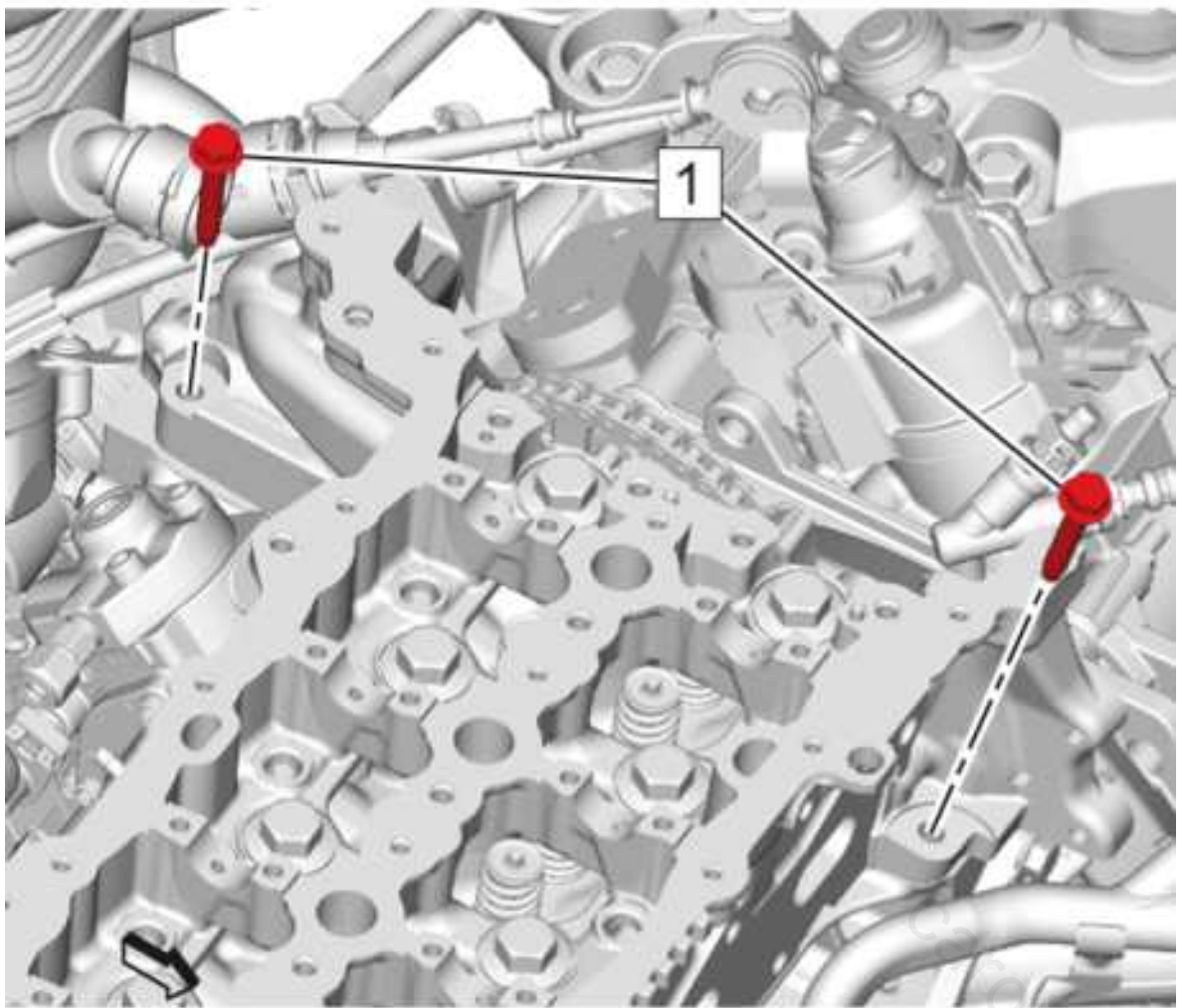


Fig. 335: Outer Cylinder Head Bolts

Courtesy of GENERAL MOTORS COMPANY

25. Remove and DISCARD the 2 outer cylinder head bolts (1).

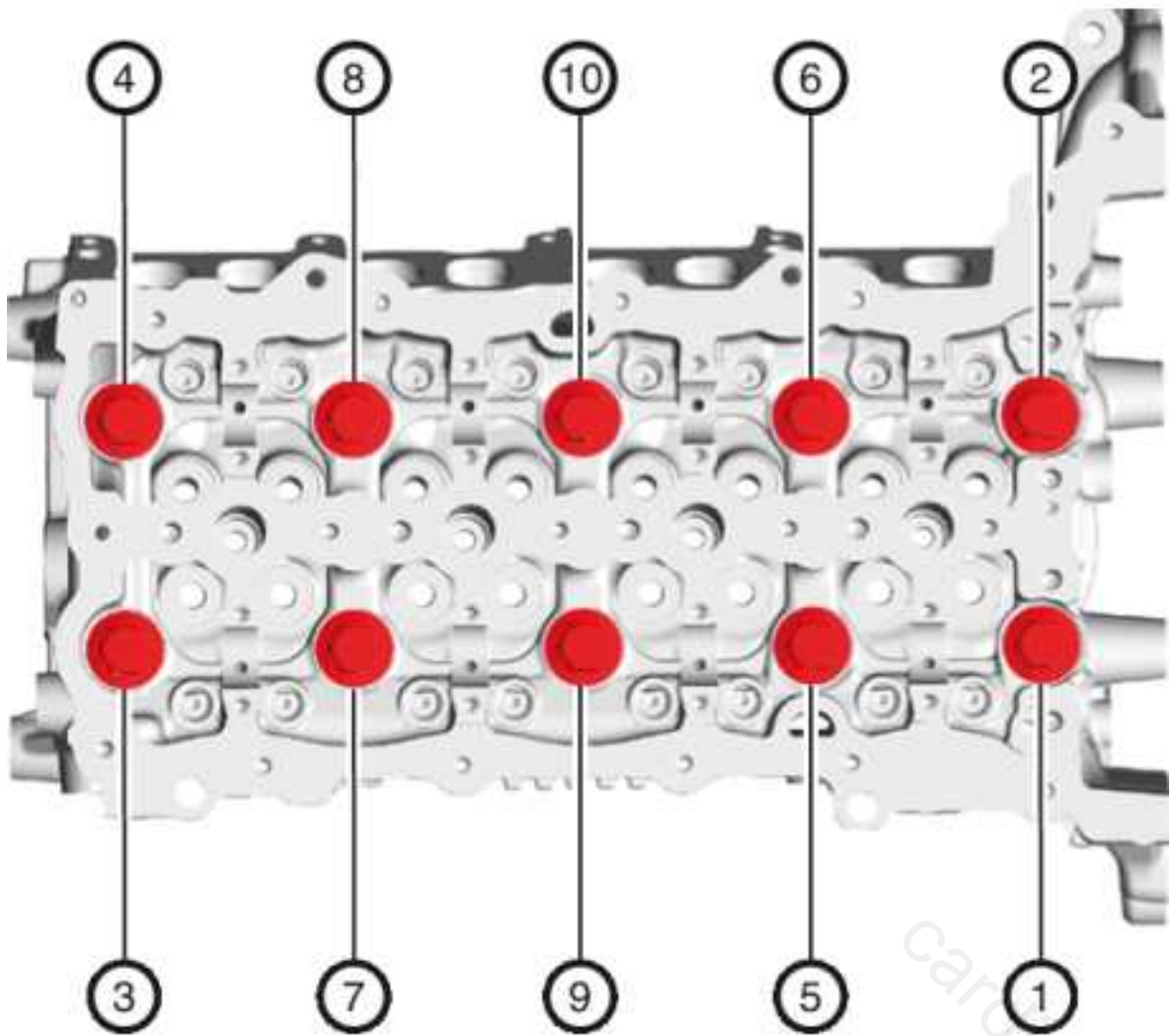


Fig. 336: Cylinder Head Bolt Loosening Sequence
Courtesy of GENERAL MOTORS COMPANY

26. Loosen the 10 cylinder head bolts in sequence as shown step by step.

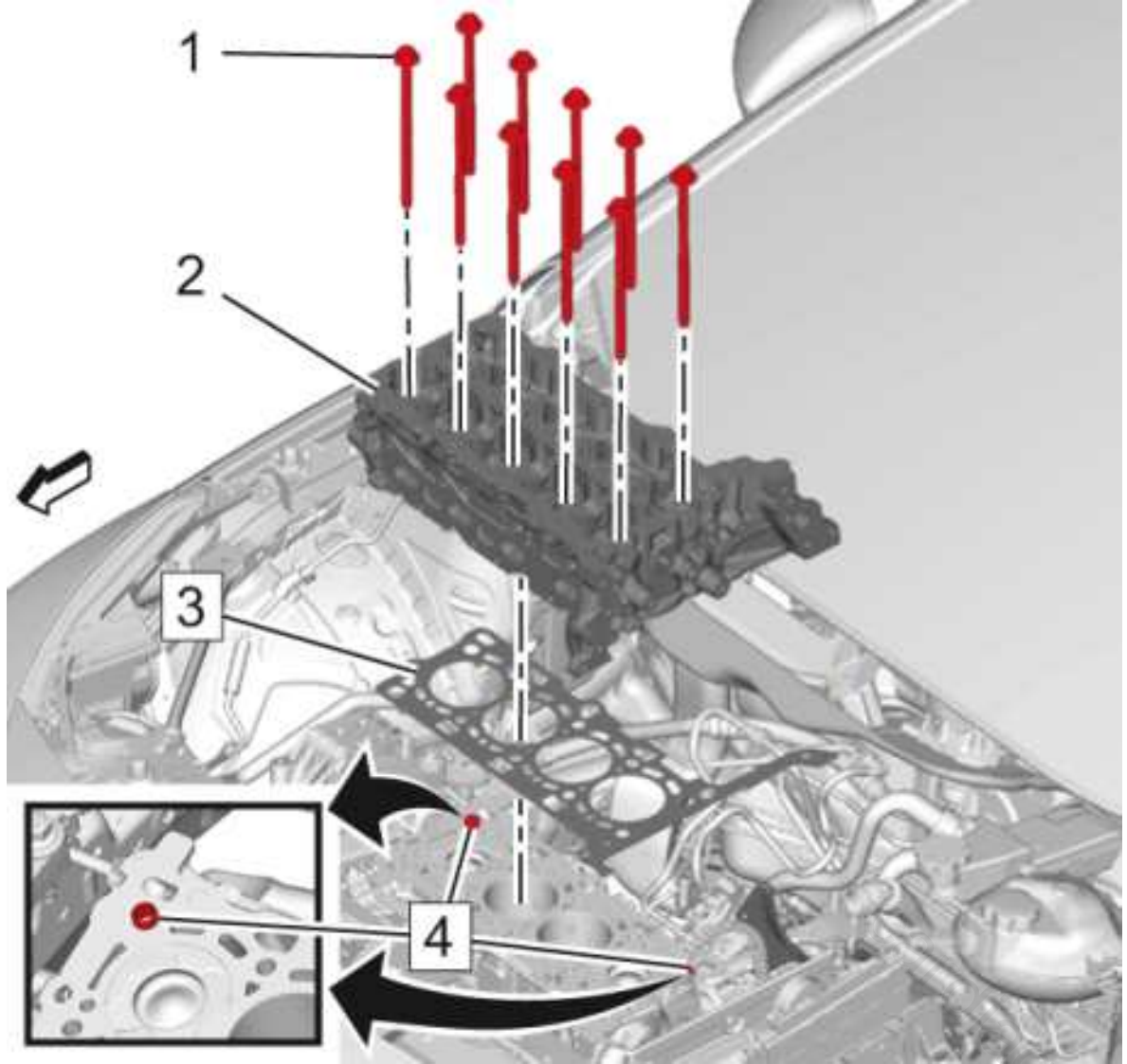


Fig. 337: Cylinder Head, Bolts, Gasket And Guide Sleeves
Courtesy of GENERAL MOTORS COMPANY

27. Remove and DISCARD Cylinder Head Bolts (1) (Qty: 10)

NOTE: Ensure the guide sleeves (4) are properly seated in the engine block.

28. Remove Cylinder Head (2)

29. Remove and DISCARD Cylinder Head Gasket (3)

30. Disassemble the cylinder head. Refer to [Cylinder Head Disassemble](#)

Installation Procedure

CAUTION: Clean all dirt, debris, and coolant from the engine block cylinder head bolt holes. Failure to remove all foreign material may result in damaged threads, improperly tightened fasteners or damage to components.

NOTE:

- Do not use the cylinder head bolts again. Install NEW cylinder head bolts during assembly.
- Do not use any type of sealant on the cylinder head gasket, unless specified.
- The cylinder head gaskets must be installed in the proper direction and position.

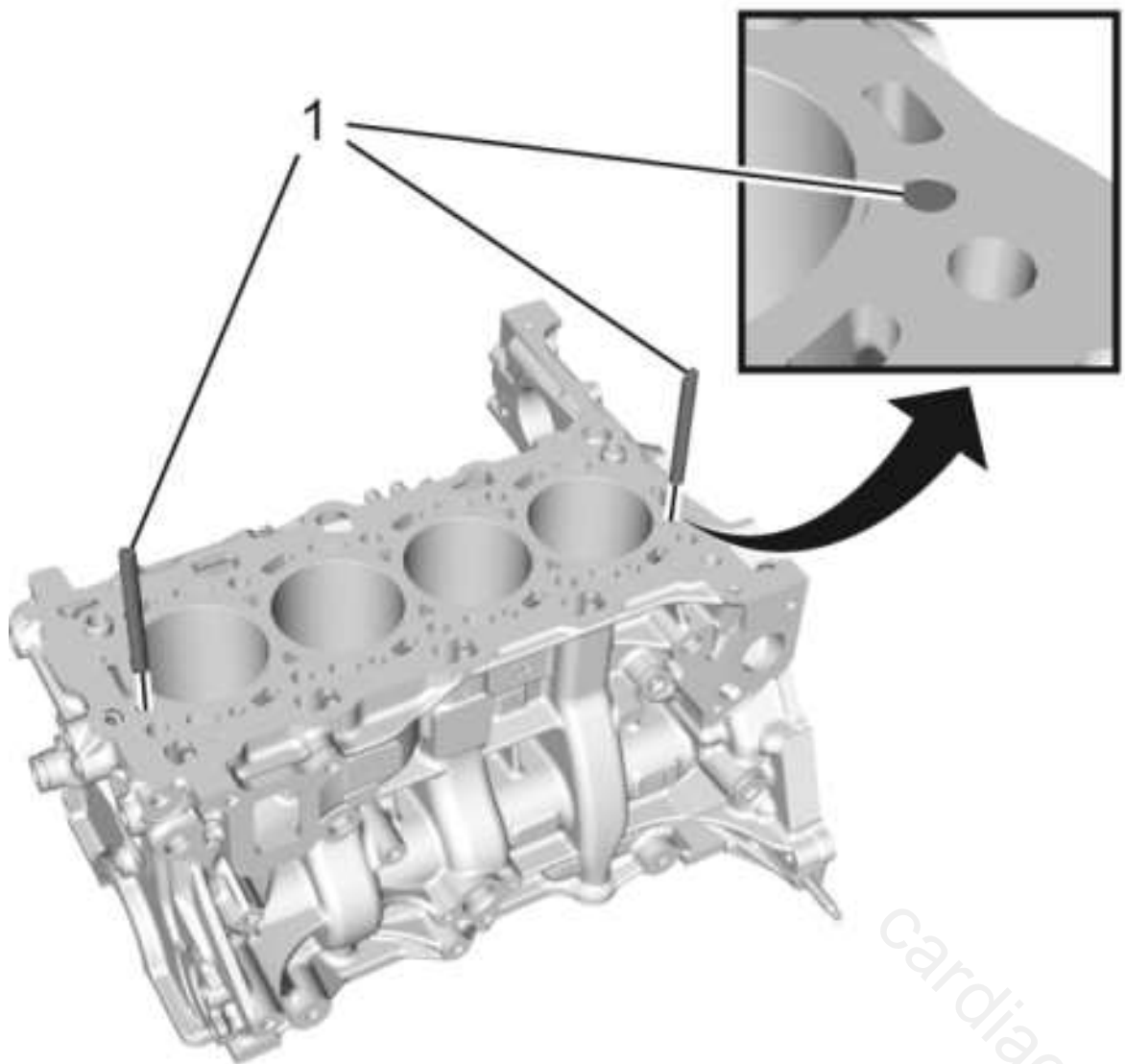


Fig. 338: Deflectors

Courtesy of GENERAL MOTORS COMPANY

1. Check that the 2 deflectors (1) are installed in the engine block and install 2 NEW deflectors if the deflectors are missing.

NOTE: Ensure that the cylinder head and the cylinder block sealing surfaces are clear of oil, grease and old gasket material.

2. Clean all sealing surfaces.
3. Inspect the flatness of the cylinder head and cylinder block sealing surfaces.
4. Assemble Cylinder Head. Refer to [Cylinder Head Assemble](#).

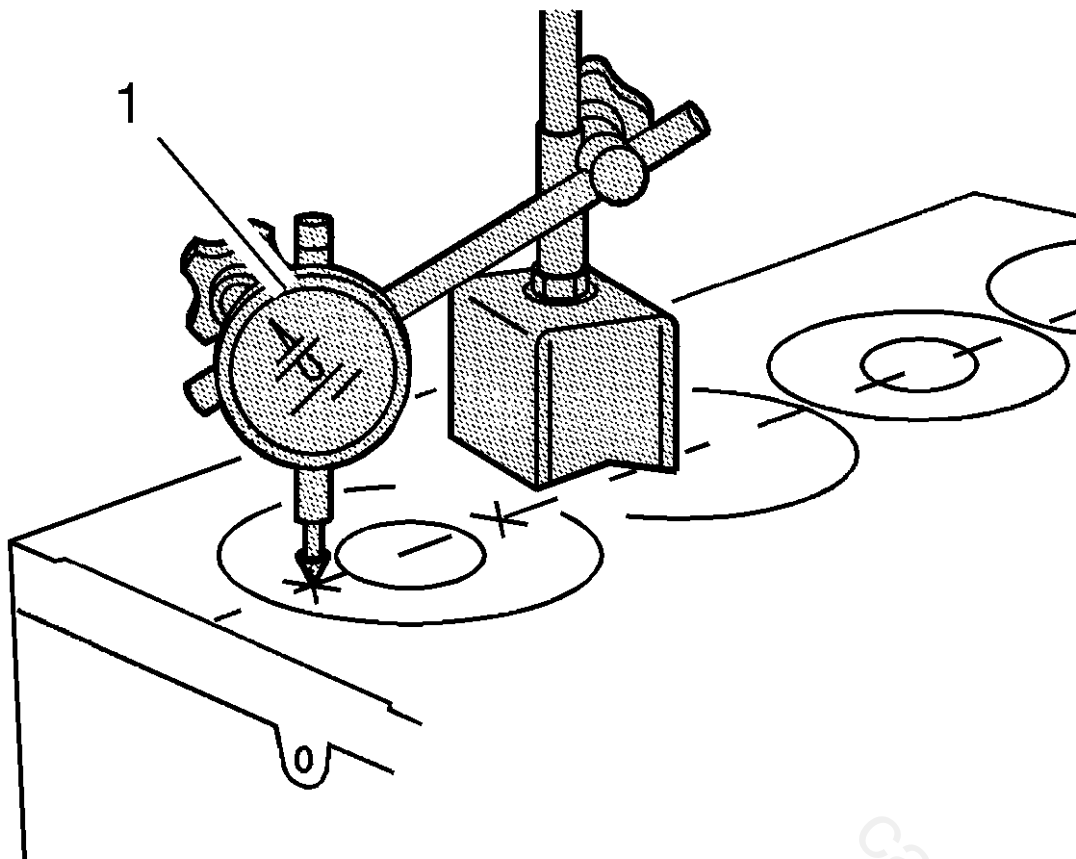


Fig. 339: Indicator

Courtesy of GENERAL MOTORS COMPANY

NOTE: For the measurement, the piston has to stay on TDC. Measure the piston projection dimensions at all pistons.

5. Install the **GE-7872** indicator (1).
6. Measure the piston projection of the cylinder 1 and the cylinder 4.

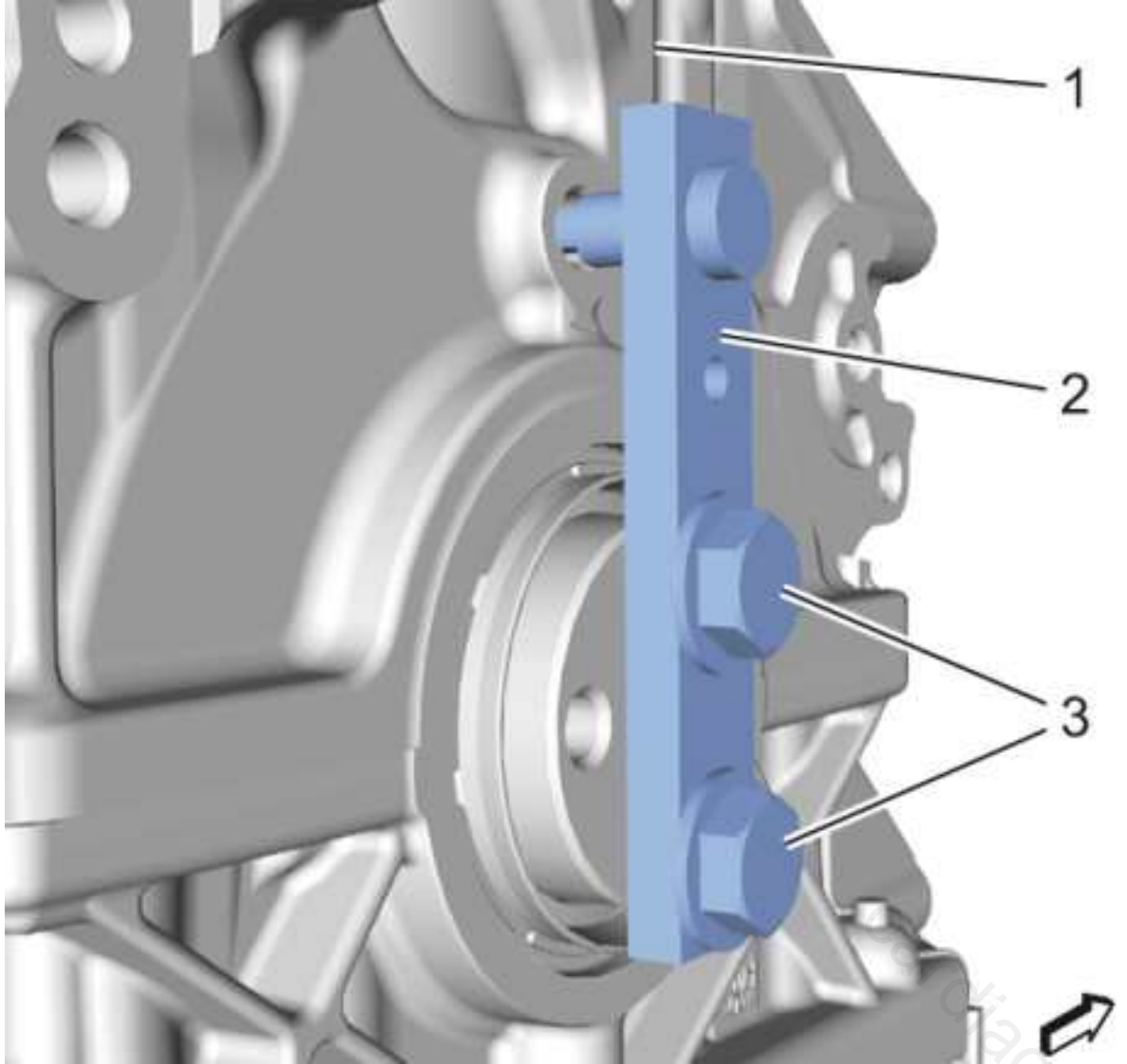


Fig. 340: Crankshaft Fixing Tool And Bolts
Courtesy of GENERAL MOTORS COMPANY

7. Remove Bolts (3) (Qty: 2)
8. Remove the **EN-51140** fixing tool (2).

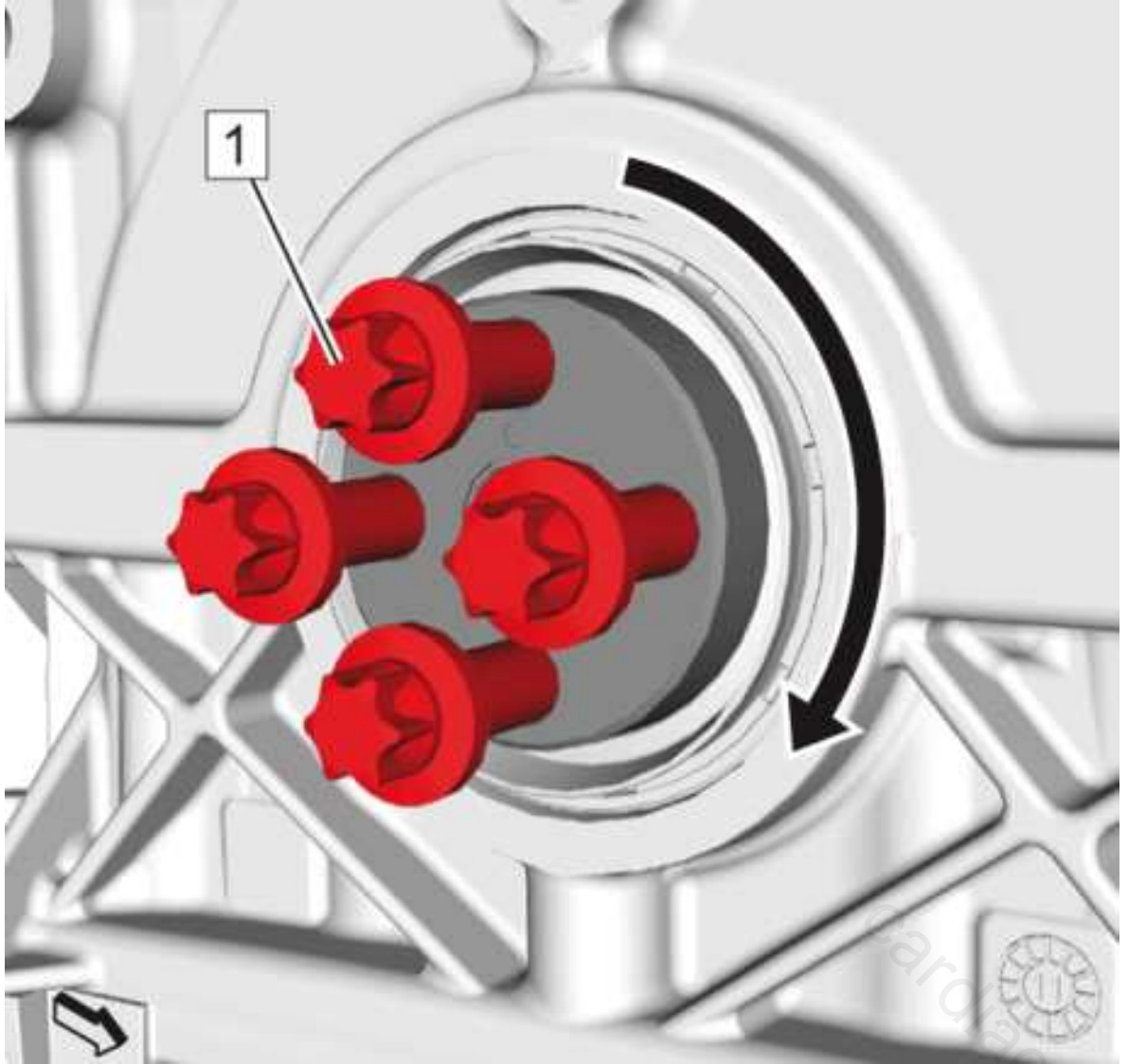


Fig. 341: Crankshaft Pulley Bolts

Courtesy of GENERAL MOTORS COMPANY

9. Install Crankshaft Pulley Bolts (1) (Qty: 4)

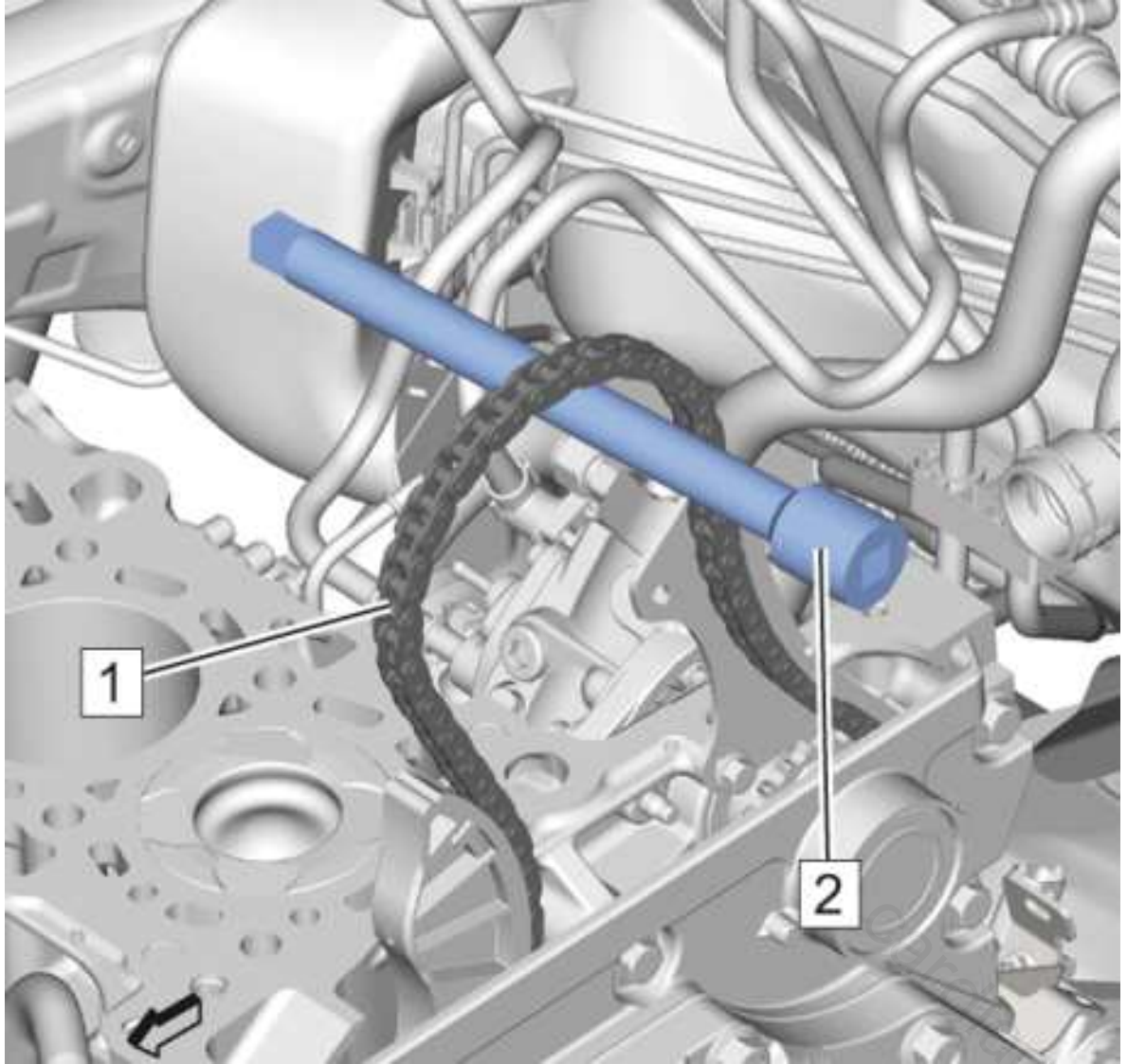


Fig. 342: Timing Chain And Suitable Tool

Courtesy of GENERAL MOTORS COMPANY

10. Hold the timing chain (1) up with a suitable tool like an extension (2).

NOTE: A second technician is required.

11. Rotate the crankshaft 180 degrees, use a pry bar at the 4 crankshaft pulley bolts.
12. Measure the piston projection of the cylinder 2 and the cylinder 3.
13. Rotate the crankshaft 180 degrees

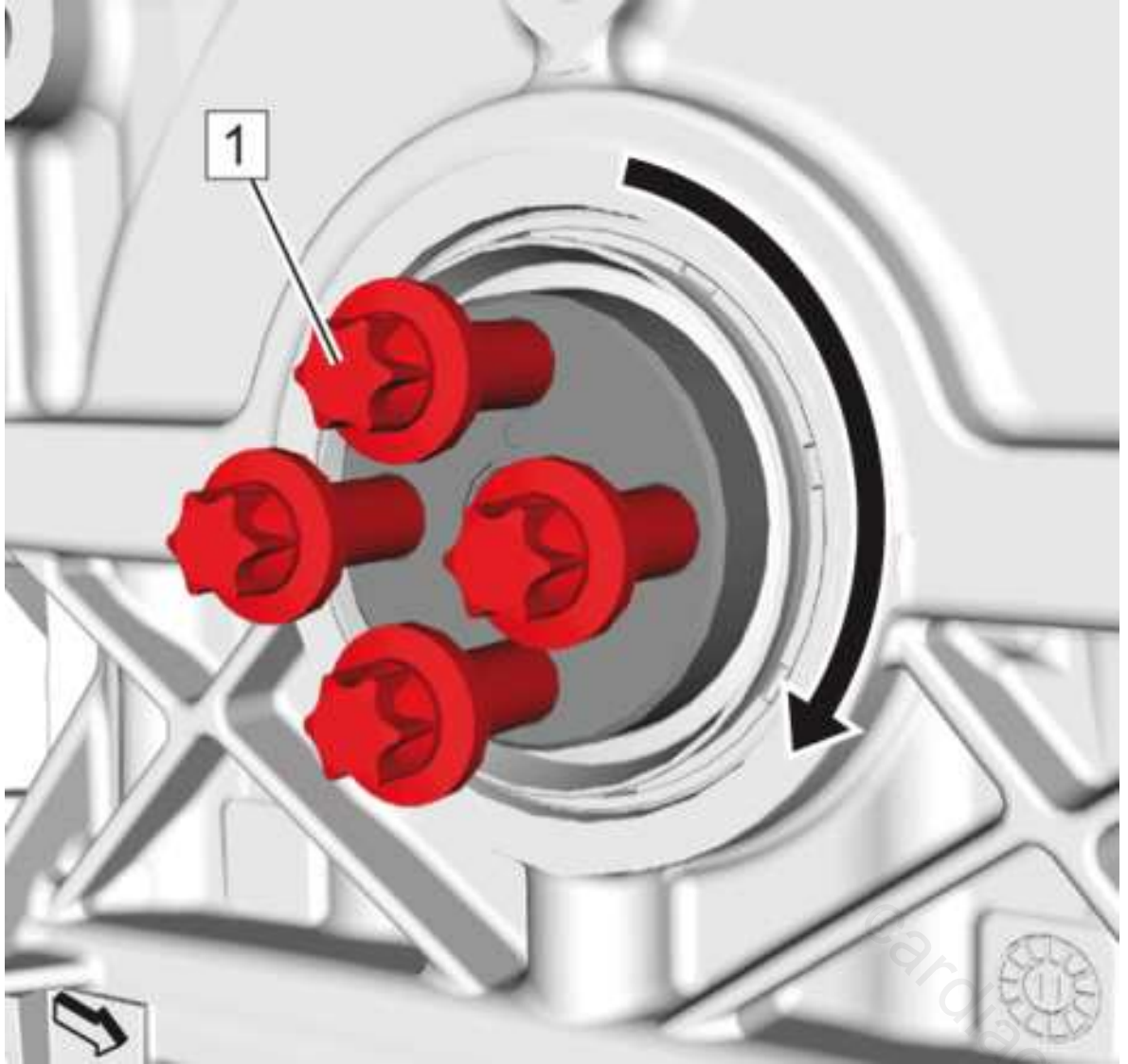


Fig. 343: Crankshaft Pulley Bolts

Courtesy of GENERAL MOTORS COMPANY

14. Remove Crankshaft Pulley Bolts (1) (Qty: 4)

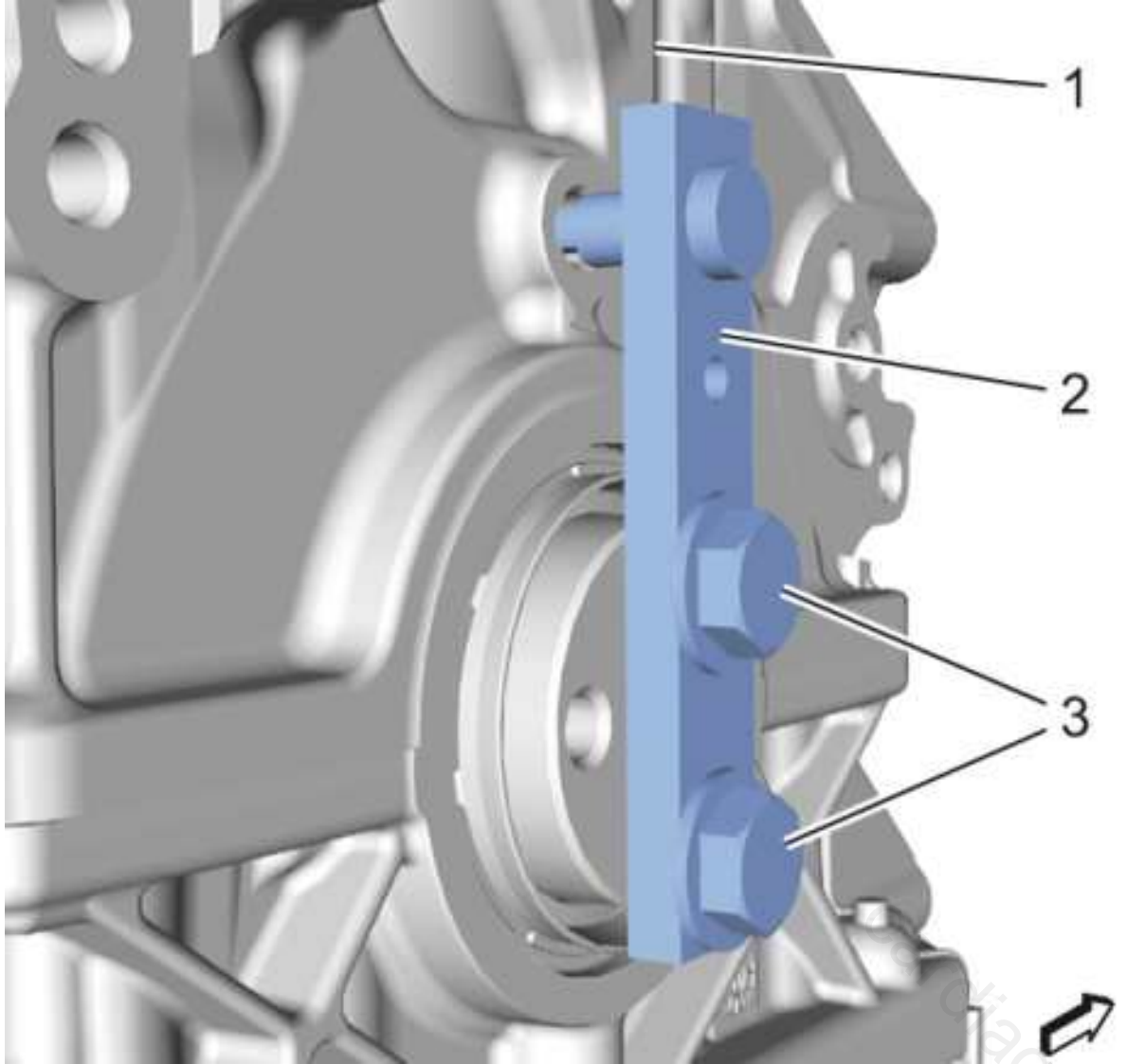


Fig. 344: Crankshaft Fixing Tool And Bolts
Courtesy of GENERAL MOTORS COMPANY

15. Install the **EN-51140** fixing tool (2).
16. Install the fixing pin into the engine block bore (1) and tighten the 2 bolts (3).

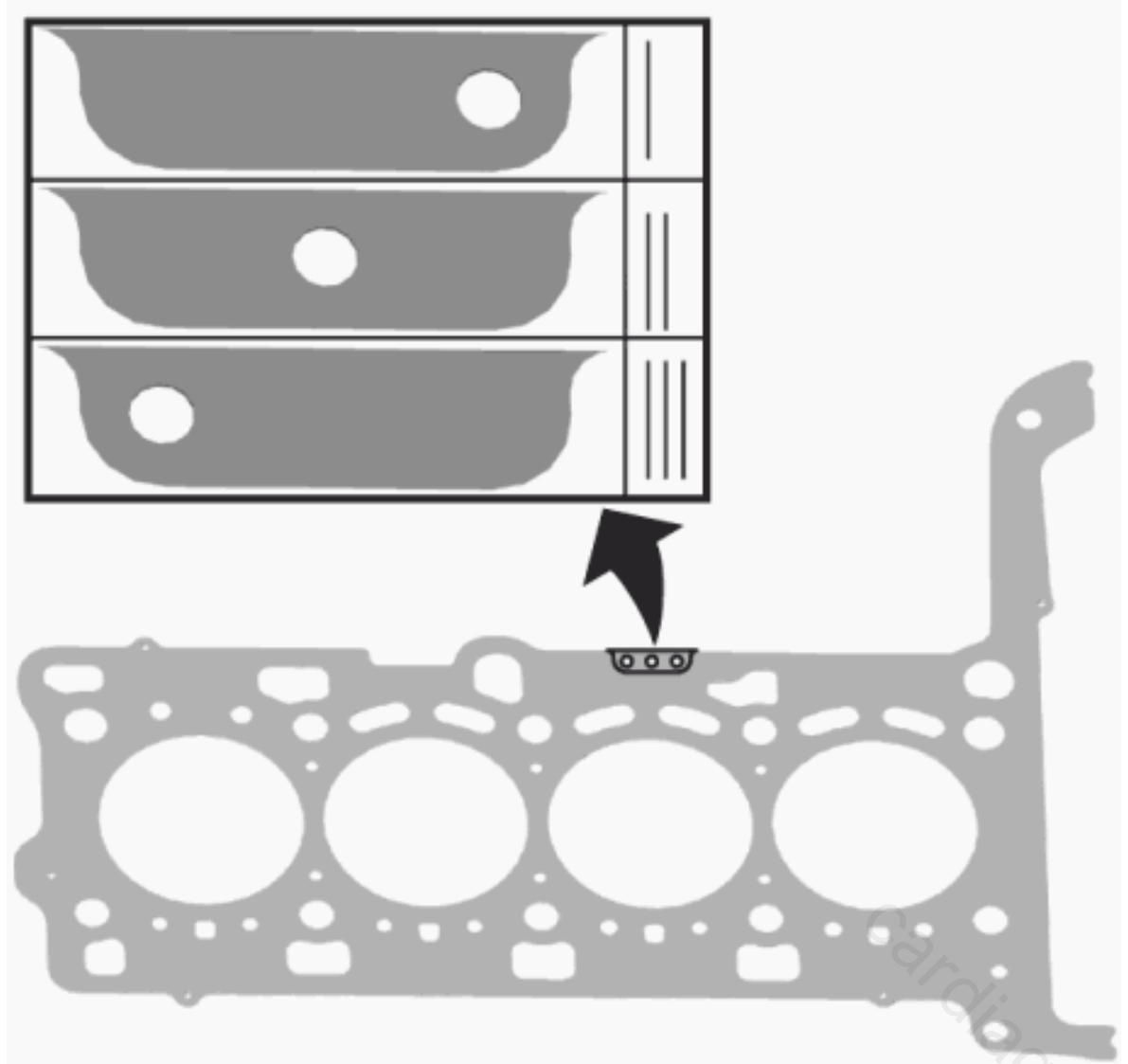


Fig. 345: Cylinder Head Gasket Identification Marks
 Courtesy of GENERAL MOTORS COMPANY

NOTE: The largest piston projection is decisive for the selection of the cylinder head gasket with the corresponding marking. The different between the three max. projection measurements must be no greater than 0.1 mm (0.0039 in).

17. Select the cylinder head gasket with the correct identification marks (1):
 1. Piston projection 0.440 - 0.535 mm (0.0173 - 0.0211 in), choose cylinder head gasket with identification mark on Position I, thickness 1.25 mm (0.049 in).
 2. Piston projection 0.535 - 0.630 mm (0.0211 - 0.0248 in), choose cylinder head gasket with identification mark on Position II, thickness 1.35 mm (0.053 in).
 3. Piston projection 0.630 - 0.725 mm (0.0248 - 0.0285 in), choose cylinder head gasket with identification mark on Position III, thickness 1.45 mm (0.057 in).

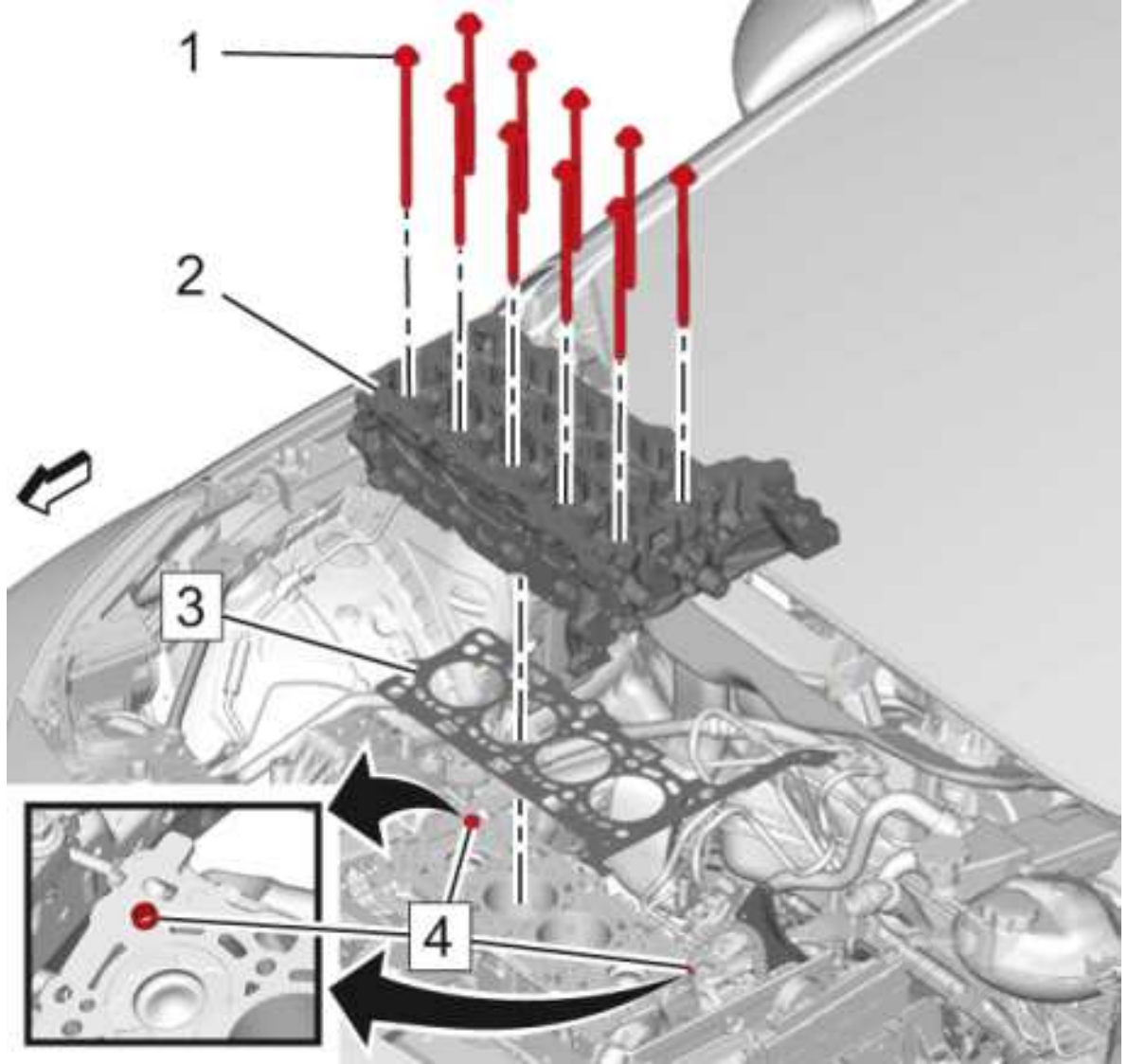


Fig. 346: Cylinder Head, Bolts, Gasket And Guide Sleeves
Courtesy of GENERAL MOTORS COMPANY

18. Install NEW Cylinder Head Gasket (3)
19. Install Cylinder Head (2)
20. Install NEW Cylinder Head Bolts (1) (Qty: 10) - Do NOT tighten.

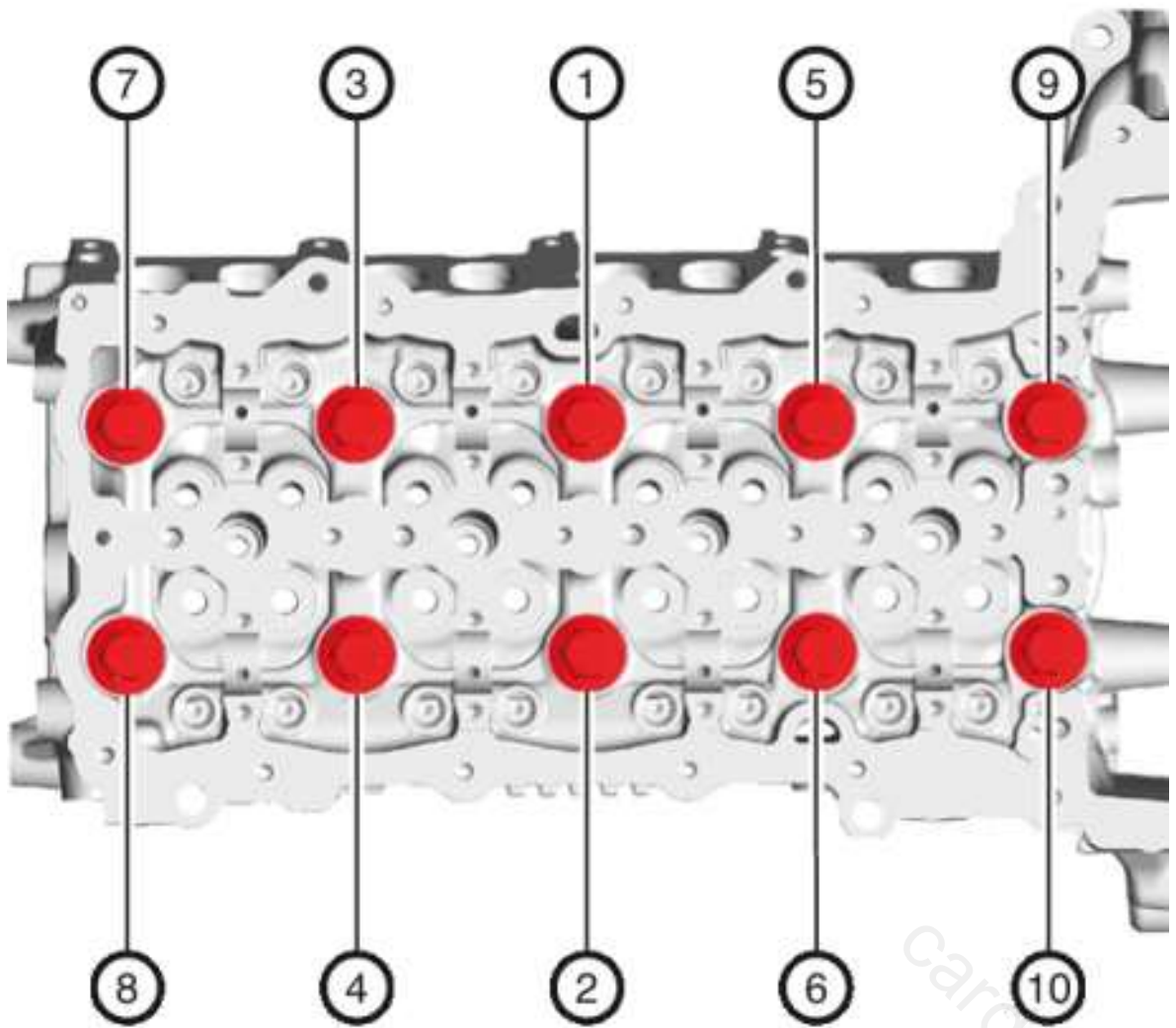


Fig. 347: Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

21. Tighten Cylinder Head Bolts in sequence

CAUTION: Refer to [Fastener Caution](#)

CAUTION: Refer to [Torque-to-Yield Fastener Caution](#)

1. First Pass: 50 N.m (37 lb ft)
2. Second Pass: 90 degrees - Use the special tool: **EN-45059** angle meter
3. Third Pass: 90 degrees - Use the special tool: **EN-45059** angle meter
4. Final Pass: 90 degrees - Use the special tool: **EN-45059** angle meter

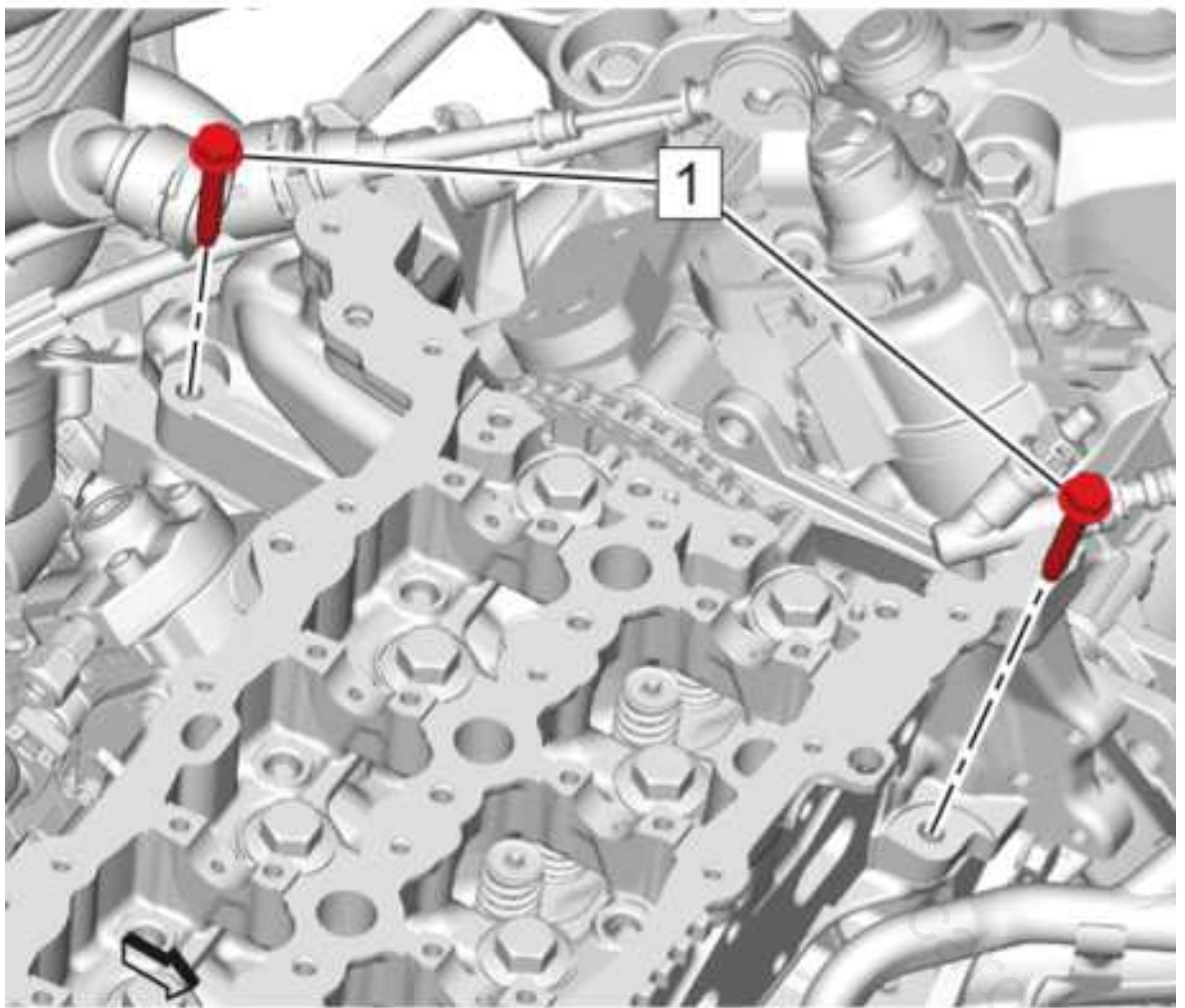


Fig. 348: Outer Cylinder Head Bolts

Courtesy of GENERAL MOTORS COMPANY

22. Install the NEW 2 cylinder head outer bolts (1) and tighten in 2 passes:

CAUTION: Refer to [Torque-to-Yield Fastener Caution](#)

1. First Pass: 20 N.m (15 lb ft)
2. Final Pass: 45 degrees - Use the special tool: **EN-45059** angle meter

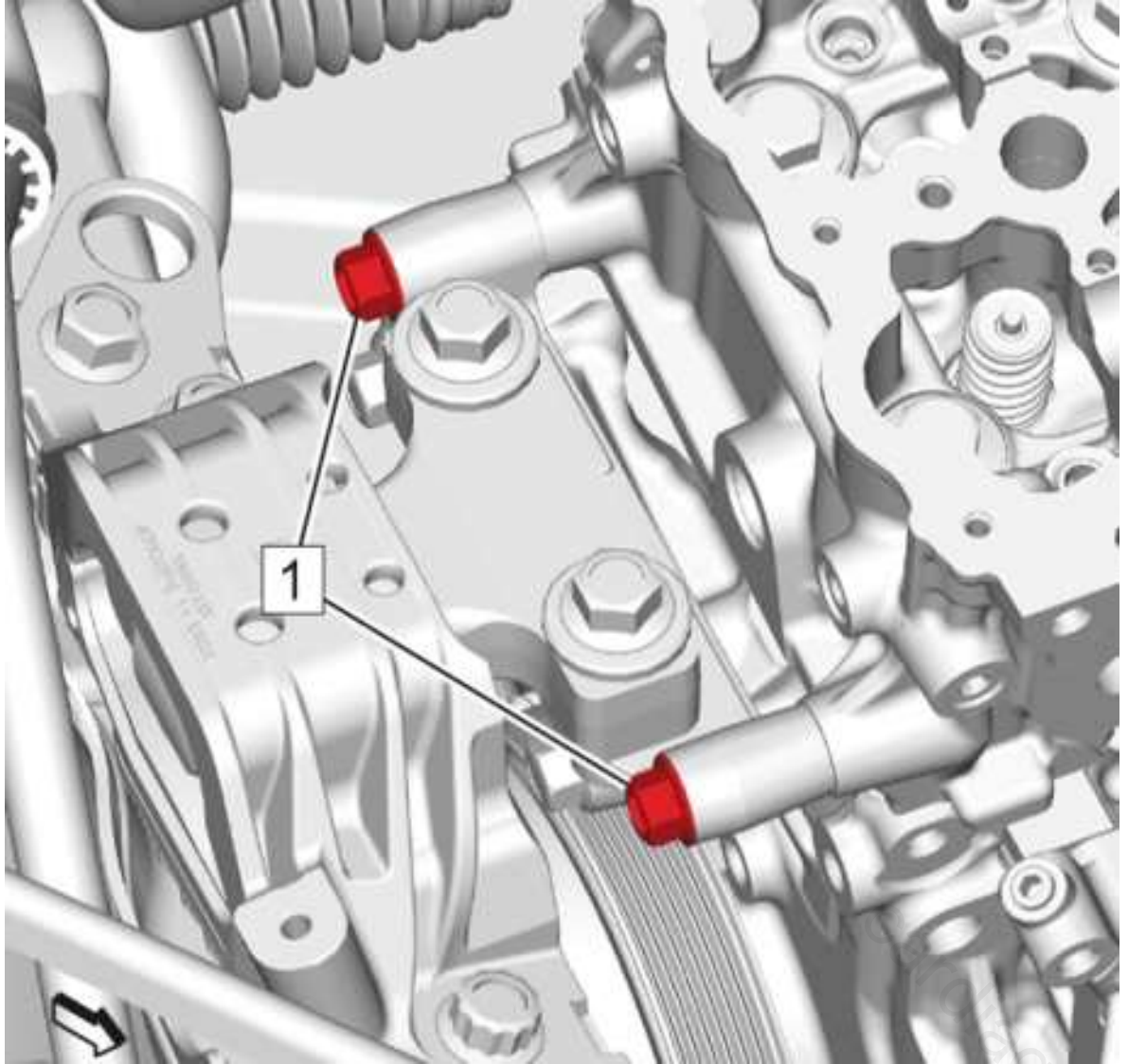


Fig. 349: Engine Mount Bracket Bolts

Courtesy of GENERAL MOTORS COMPANY

23. Install and tighten Engine Mount Bracket Bolts (1) (Qty: 2) to 62 N.m (46 lb ft)

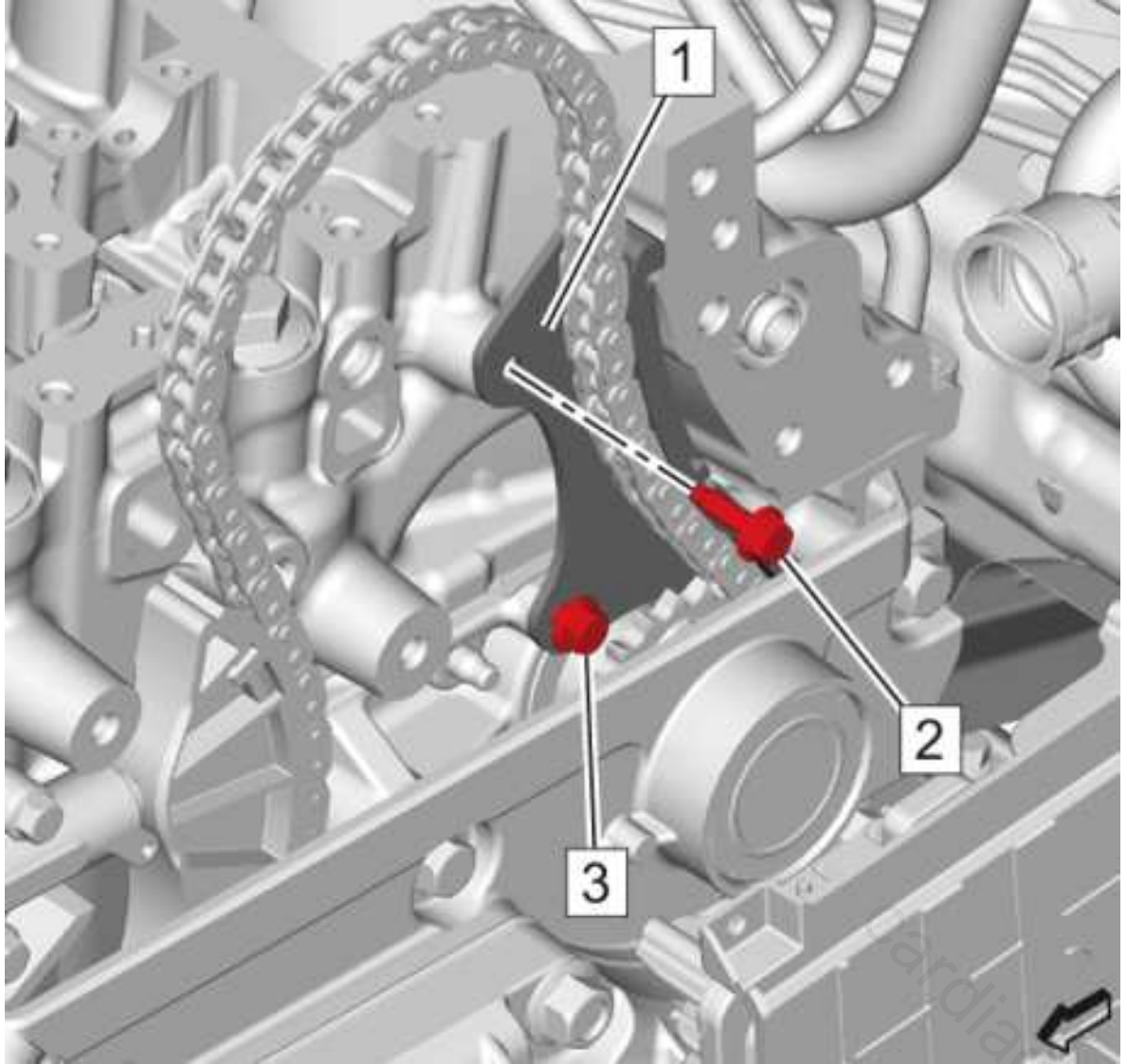


Fig. 350: Upper Timing Chain Upper Guide And Bolts
Courtesy of GENERAL MOTORS COMPANY

24. Re-cut thread at cylinder head for the upper timing chain upper guide bolt (2).

NOTE: **The tightening procedure of the timing chain upper guide bolts should be completed within 10 minutes.**

25. Apply thread lock agent to the upper timing chain upper guide bolt (2).

26. Install the upper timing chain upper guide bolt (2) and tighten to 11 N.m (97 lb in).

27. Remove the lower timing chain upper guide bolt (3).

28. Re-cut thread at engine block for the lower timing chain upper guide bolt (3).

29. Apply thread lock agent to the lower timing chain upper guide bolt.

30. Install and tighten the lower timing chain upper guide bolt (3) to 11 N.m (97 lb in).

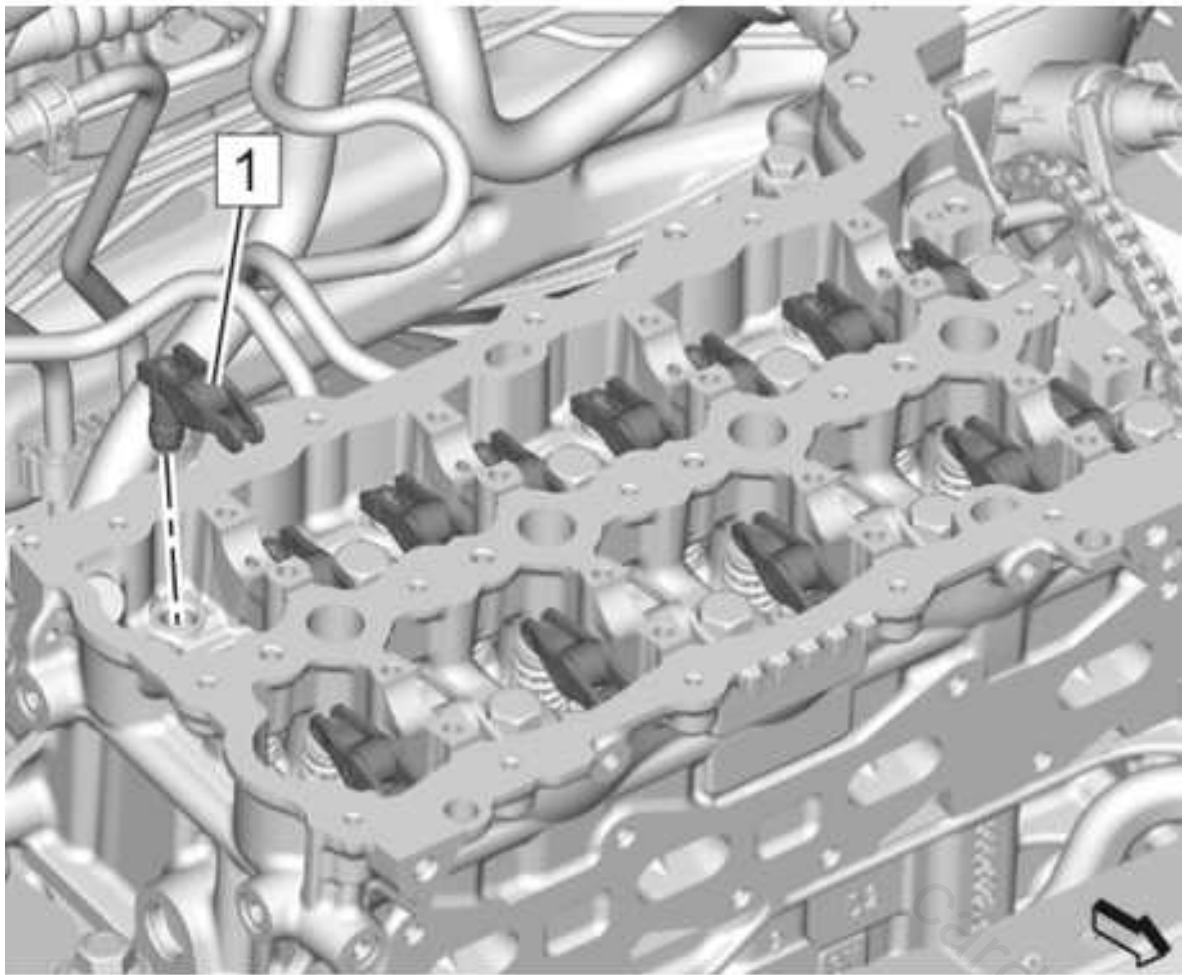


Fig. 351: Valve Lifter Roller Assemblies

Courtesy of GENERAL MOTORS COMPANY

31. Coat the 16 valve lifter with engine oil.
32. Install the 16 valve lifter with valve lifter roller (1) in the order as they were removed.

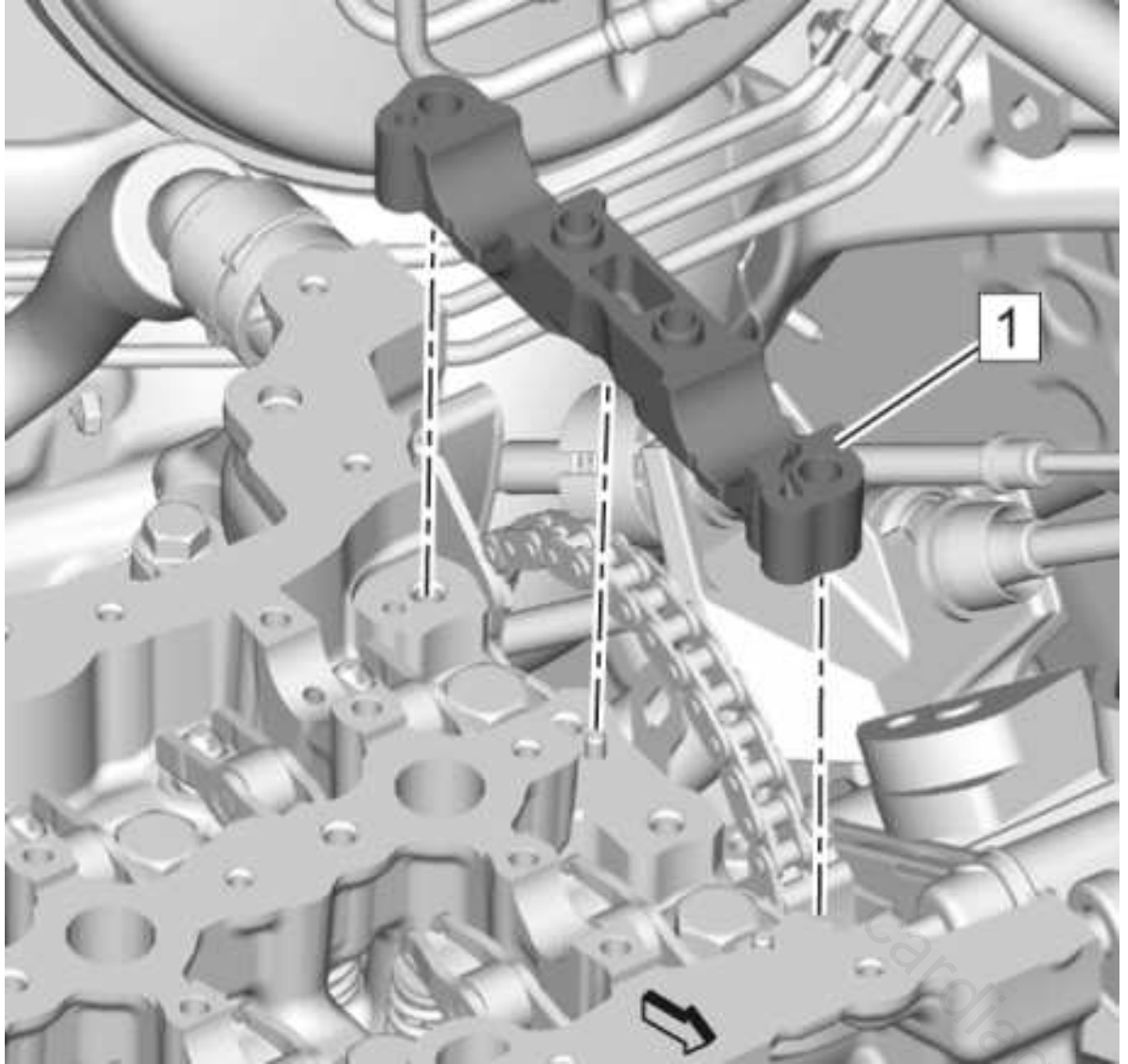


Fig. 352: Bearing Bracket

Courtesy of GENERAL MOTORS COMPANY

33. Install the bearing bracket (1).

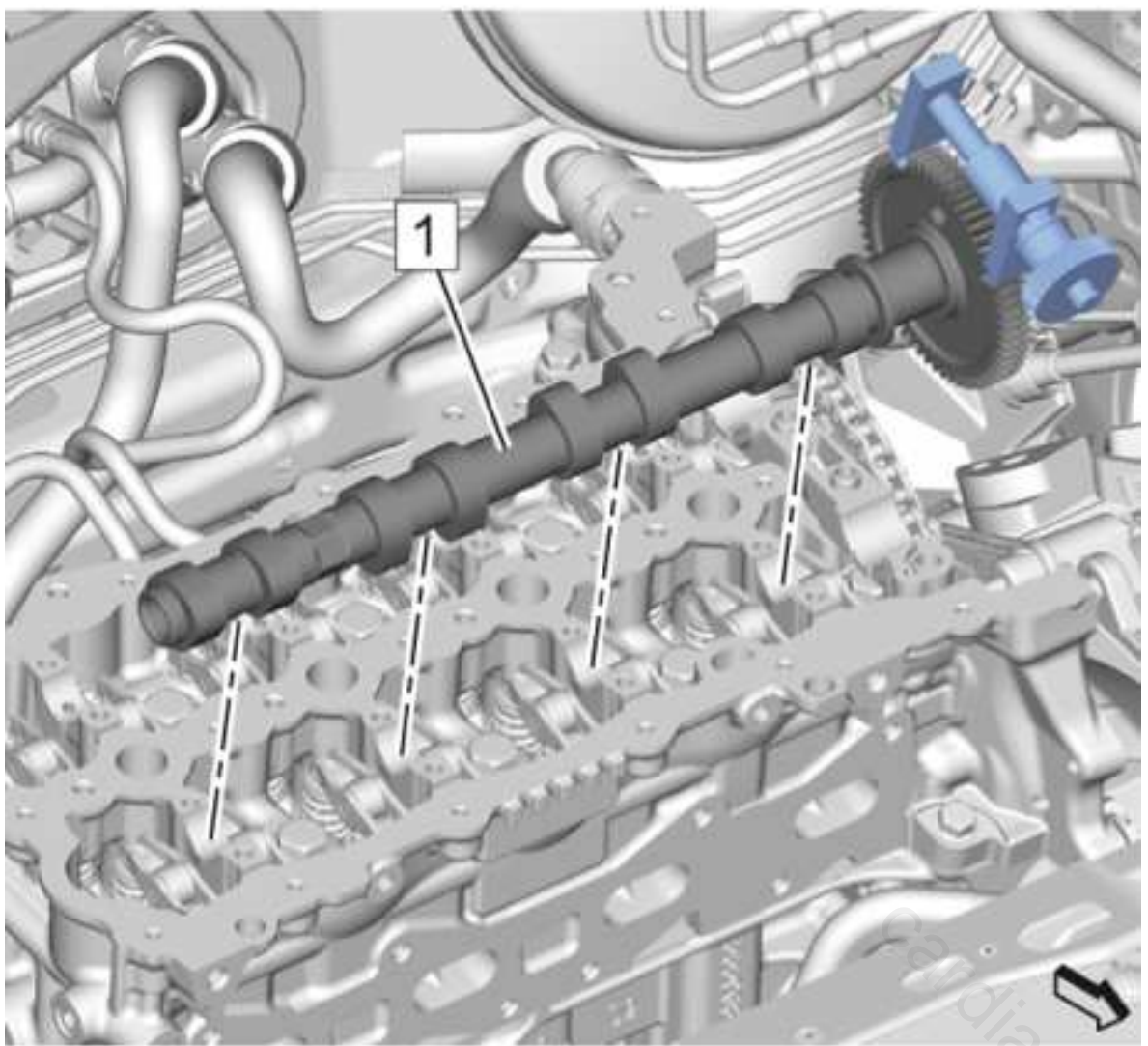


Fig. 353: Exhaust Camshaft With Bore Of Camshaft Sprocket Upwards
Courtesy of GENERAL MOTORS COMPANY

34. Coat all bearing surfaces with engine oil.
35. Install the exhaust camshaft (1), ensure the bore (2) of the camshaft sprocket shows upwards.

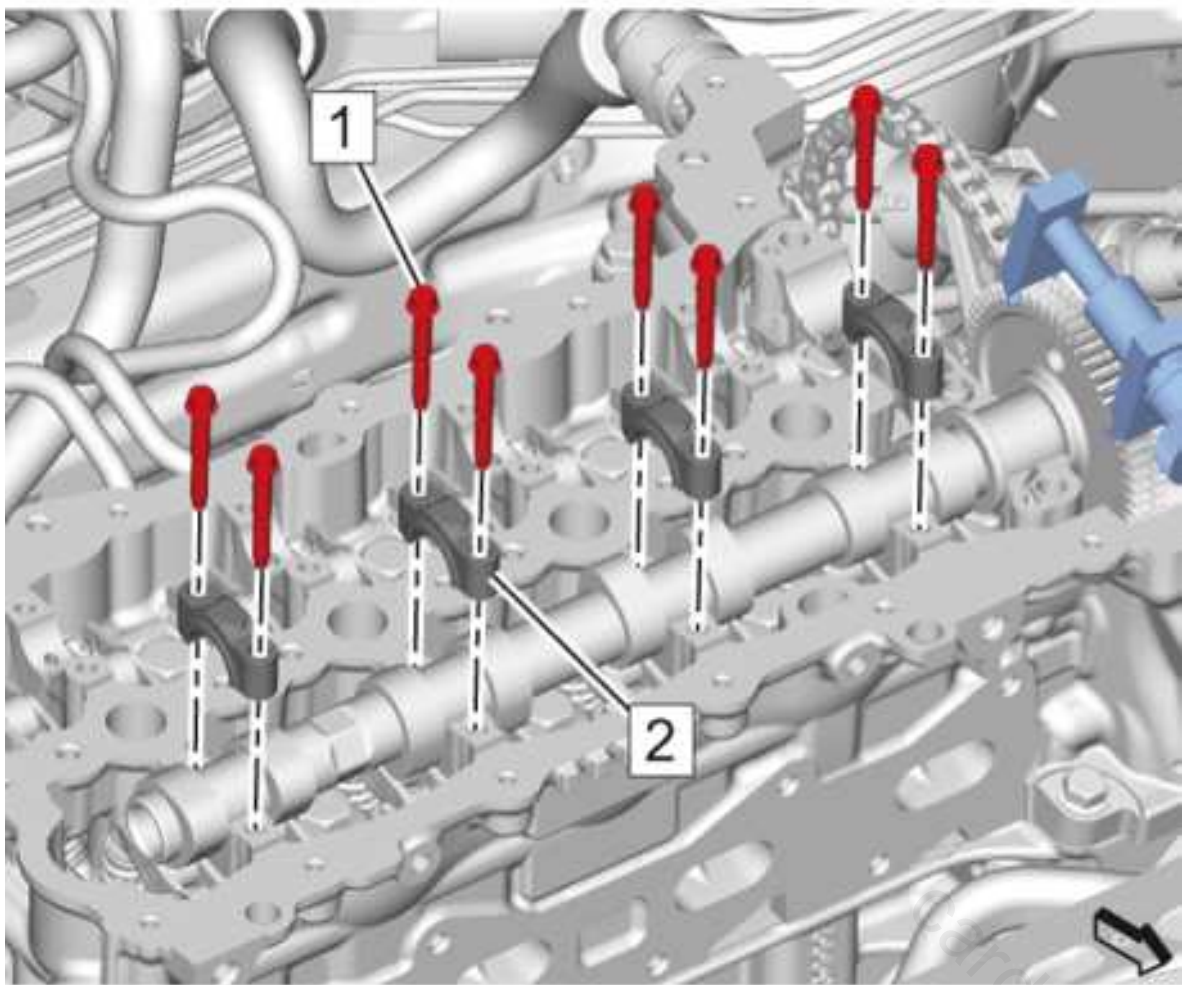


Fig. 354: Exhaust Camshaft Bearing Caps And Bolts

Courtesy of GENERAL MOTORS COMPANY

NOTE: Note the arrows as marks on the camshaft bearing caps, which shows on the outside of the cylinder head.

36. Install the exhaust camshaft bearing caps (2) in the order as they were removed.
37. Install the 8 exhaust camshaft bearing cap bolts (1).

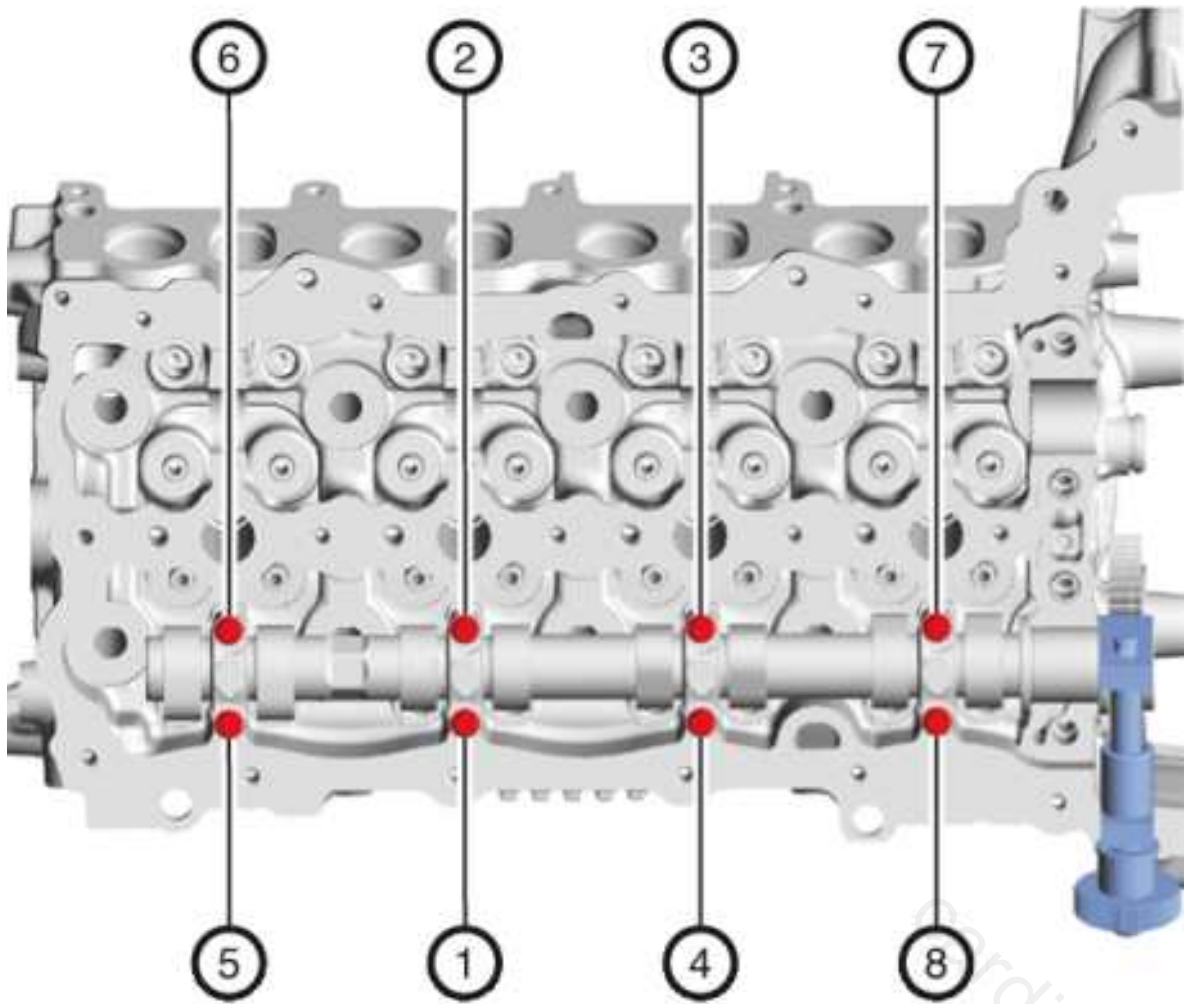


Fig. 355: Exhaust Camshaft Bearing Cap Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

38. Tighten the 8 exhaust camshaft bearing cap bolts in sequence as shown to 10 N.m (89 lb in).

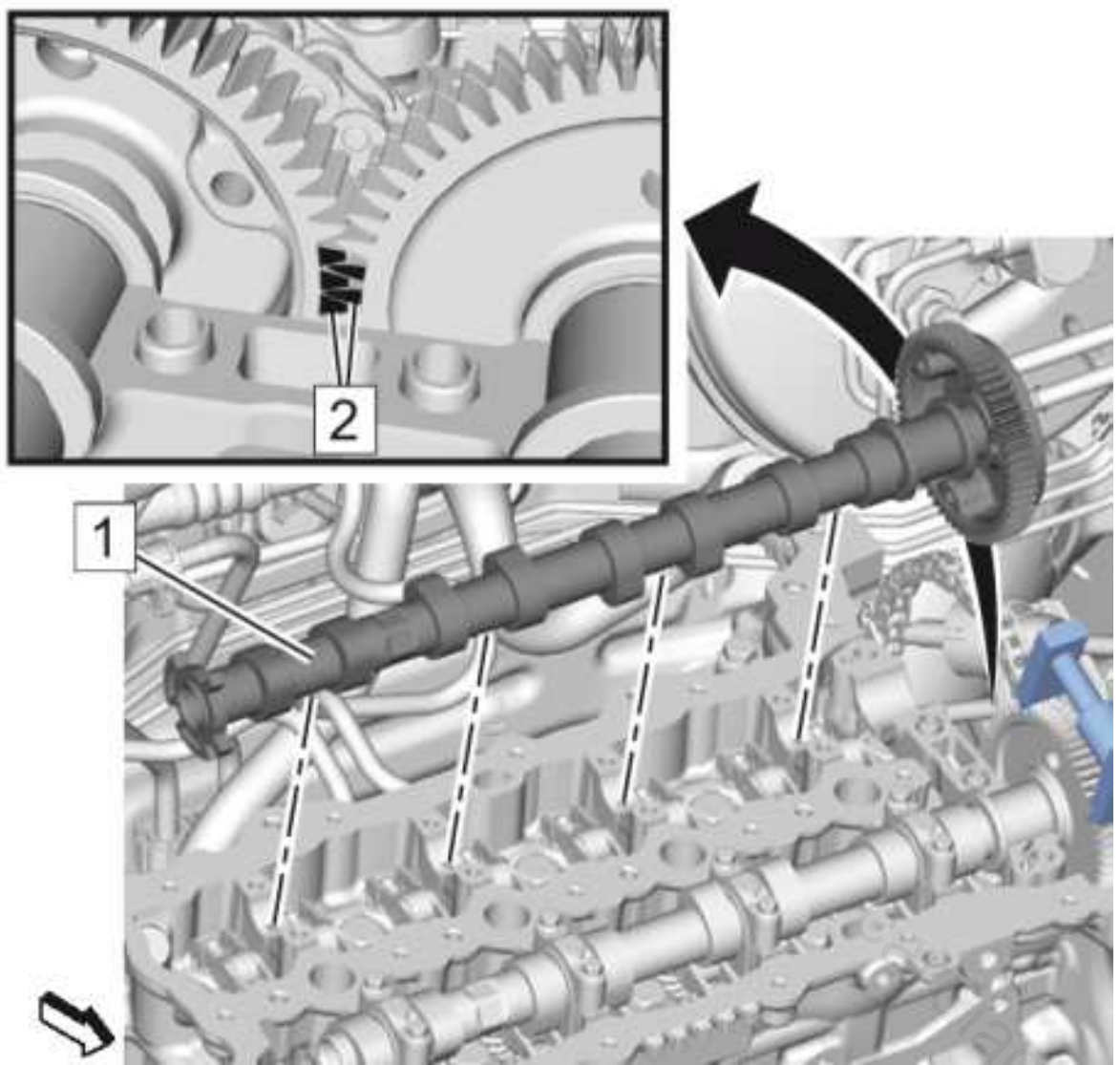


Fig. 356: Intake Camshaft With Camshaft Sprocket Marks Aligned
Courtesy of GENERAL MOTORS COMPANY

39. Coat all bearing surfaces with engine oil.

NOTE: Ensure the marks (2) of the camshaft sprocket are aligned.

40. Install Intake Camshaft (1)

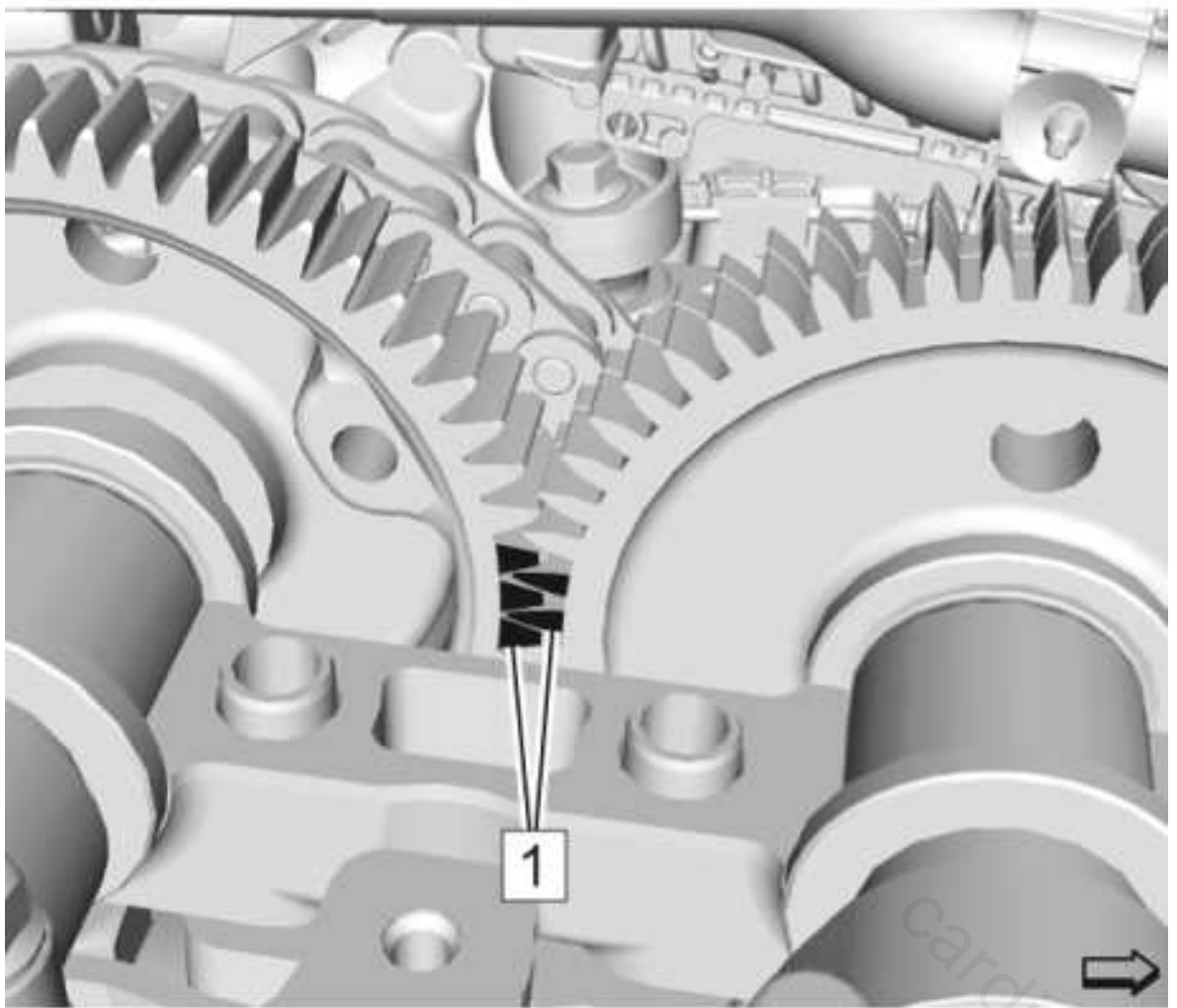


Fig. 357: Mark Exhaust Camshaft Sprocket And Intake Camshaft Sprocket With Paint Marks
Courtesy of GENERAL MOTORS COMPANY

41. Check the marks (1) of the camshaft sprockets whether they are aligned.

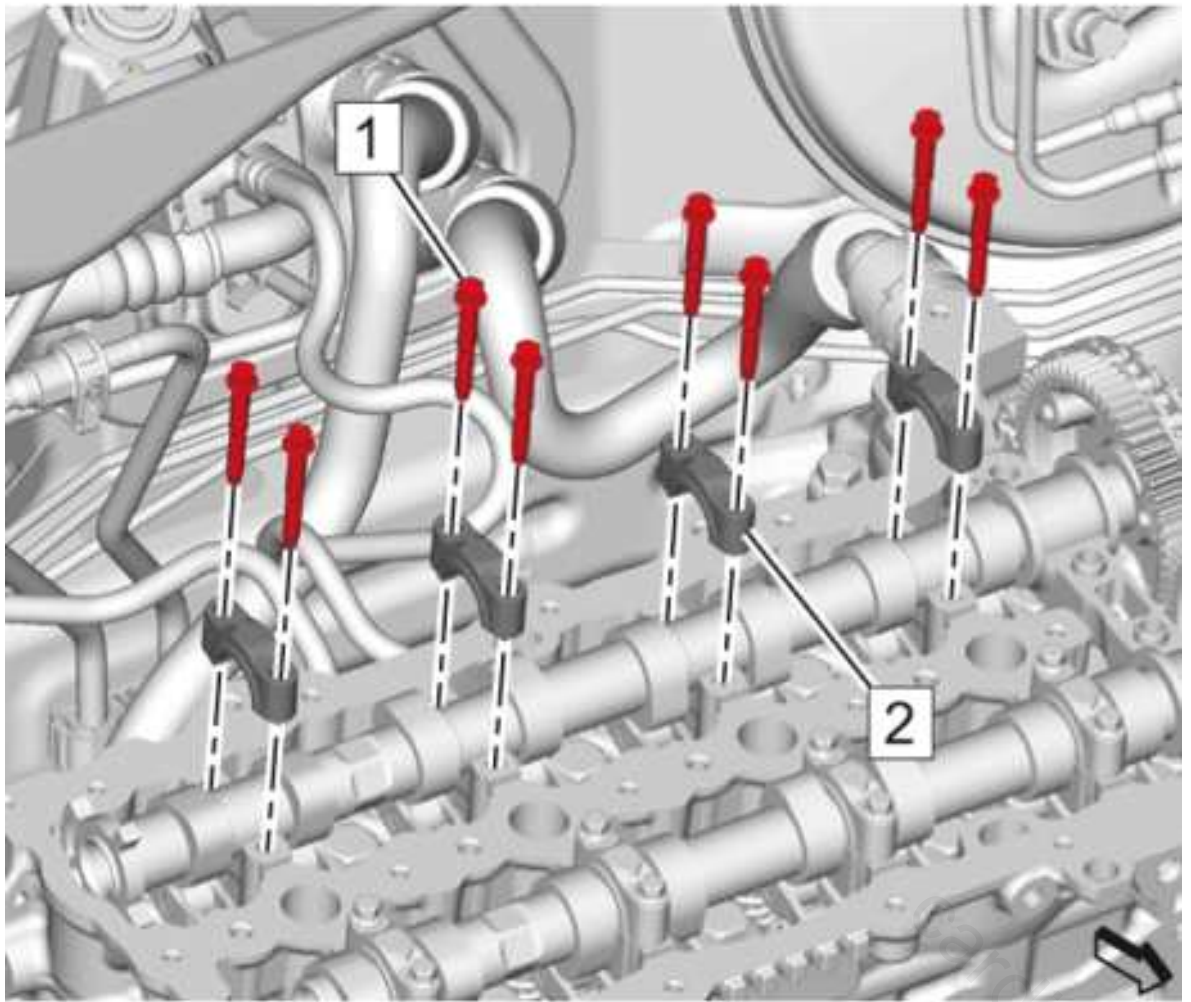


Fig. 358: Intake Camshaft Bearing Caps And Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: Note the arrows as marks on the camshaft bearing caps, which shows on the outside of the cylinder head.

42. Install the 4 intake camshaft bearing caps (2) in the order as they were removed.
43. Install the 8 intake camshaft bearing cap bolts (1).

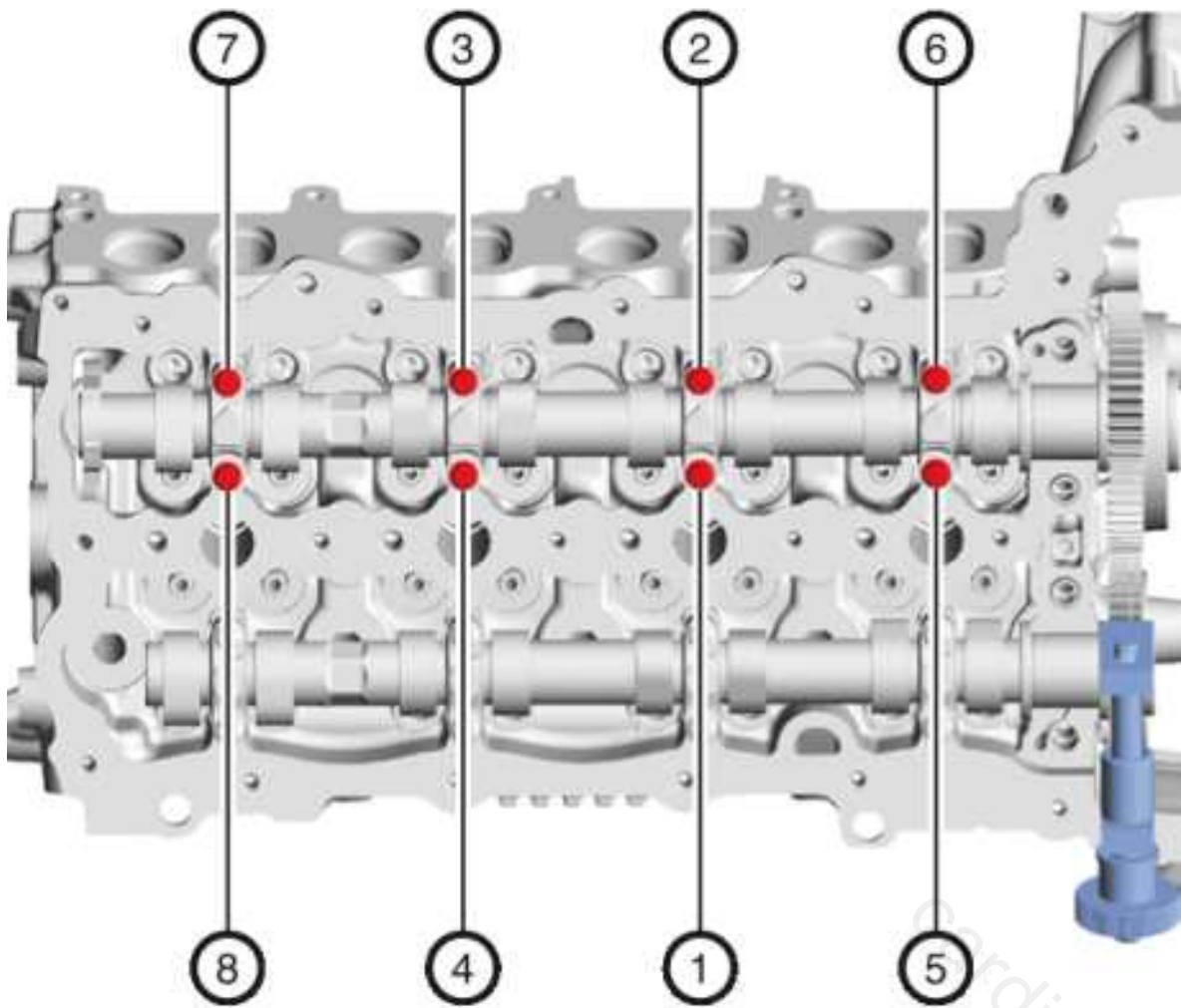


Fig. 359: Intake Camshaft Bearing Cap Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

44. Tighten the 8 intake camshaft bearing cap bolts in sequence as shown to 10 N.m (89 lb in).

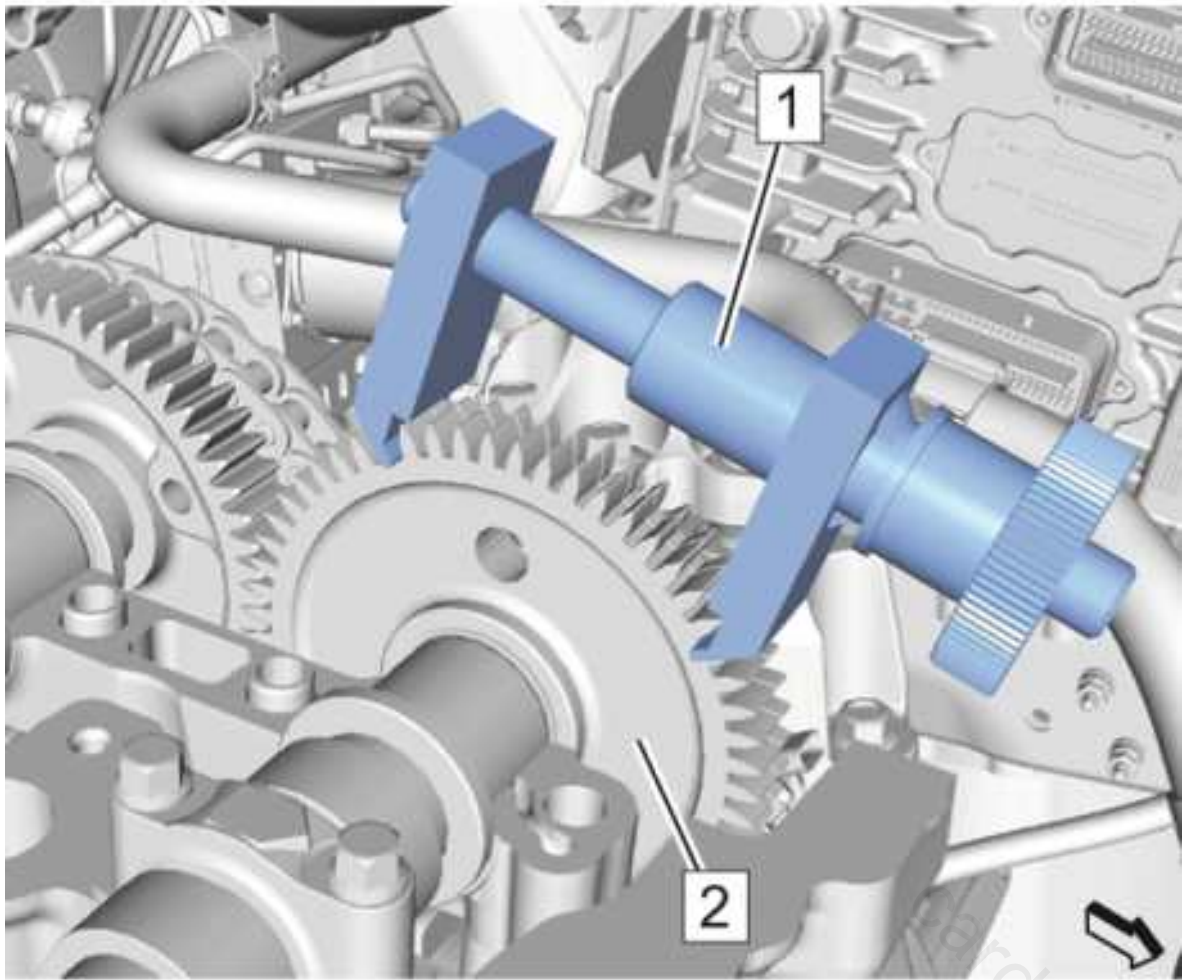


Fig. 360: Split Intake Camshaft Sprocket Fixing Tool
Courtesy of GENERAL MOTORS COMPANY

45. Remove the **EN-50509** fixing tool (1).

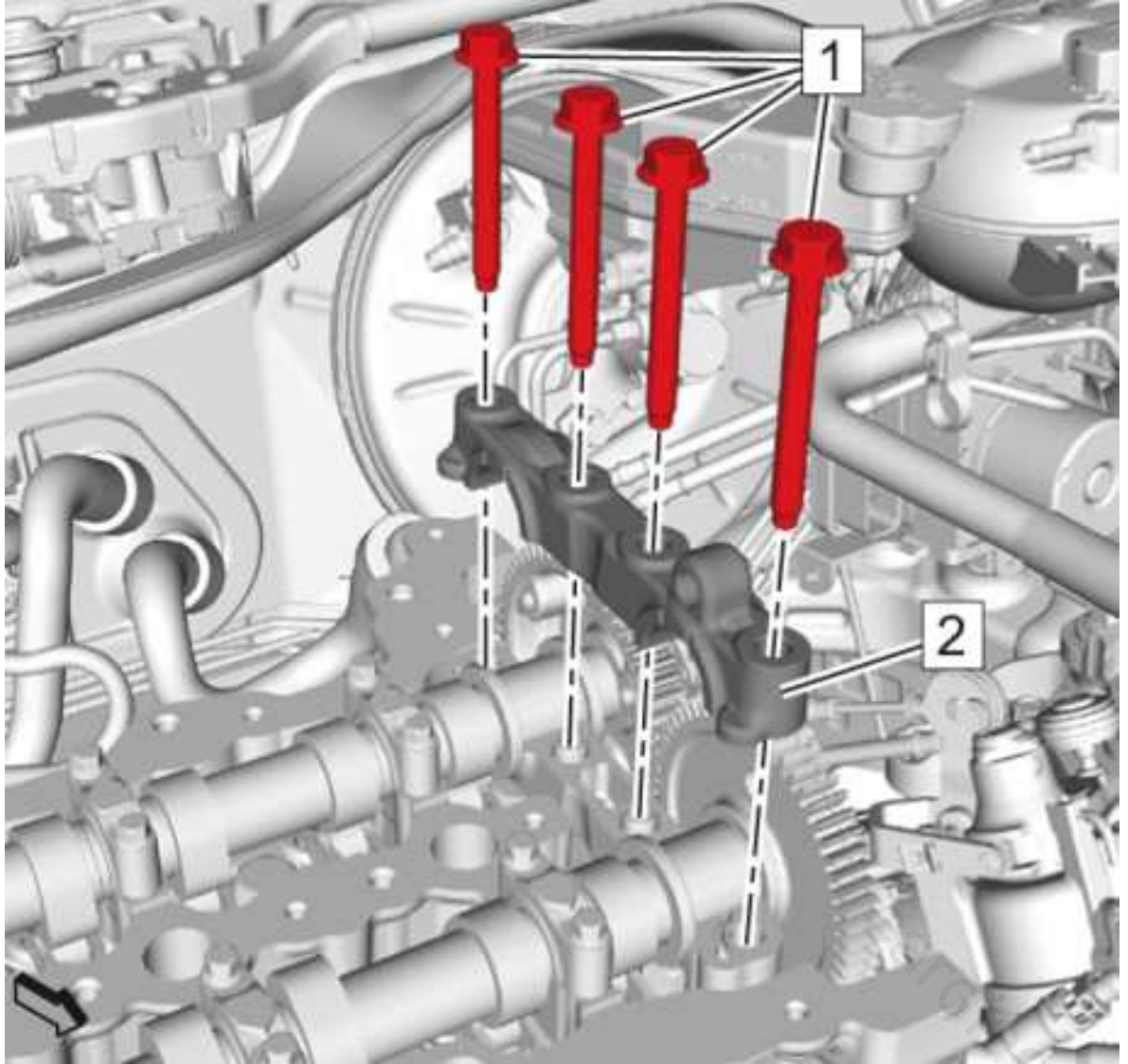


Fig. 361: Camshaft Bearing Rear Cap And Bolts
Courtesy of GENERAL MOTORS COMPANY

- 46. Coat all bearing surfaces with engine oil.
- 47. Install Camshaft Bearing Rear Cap (2)
- 48. Install the 4 camshaft bearing rear cap bolts (1).

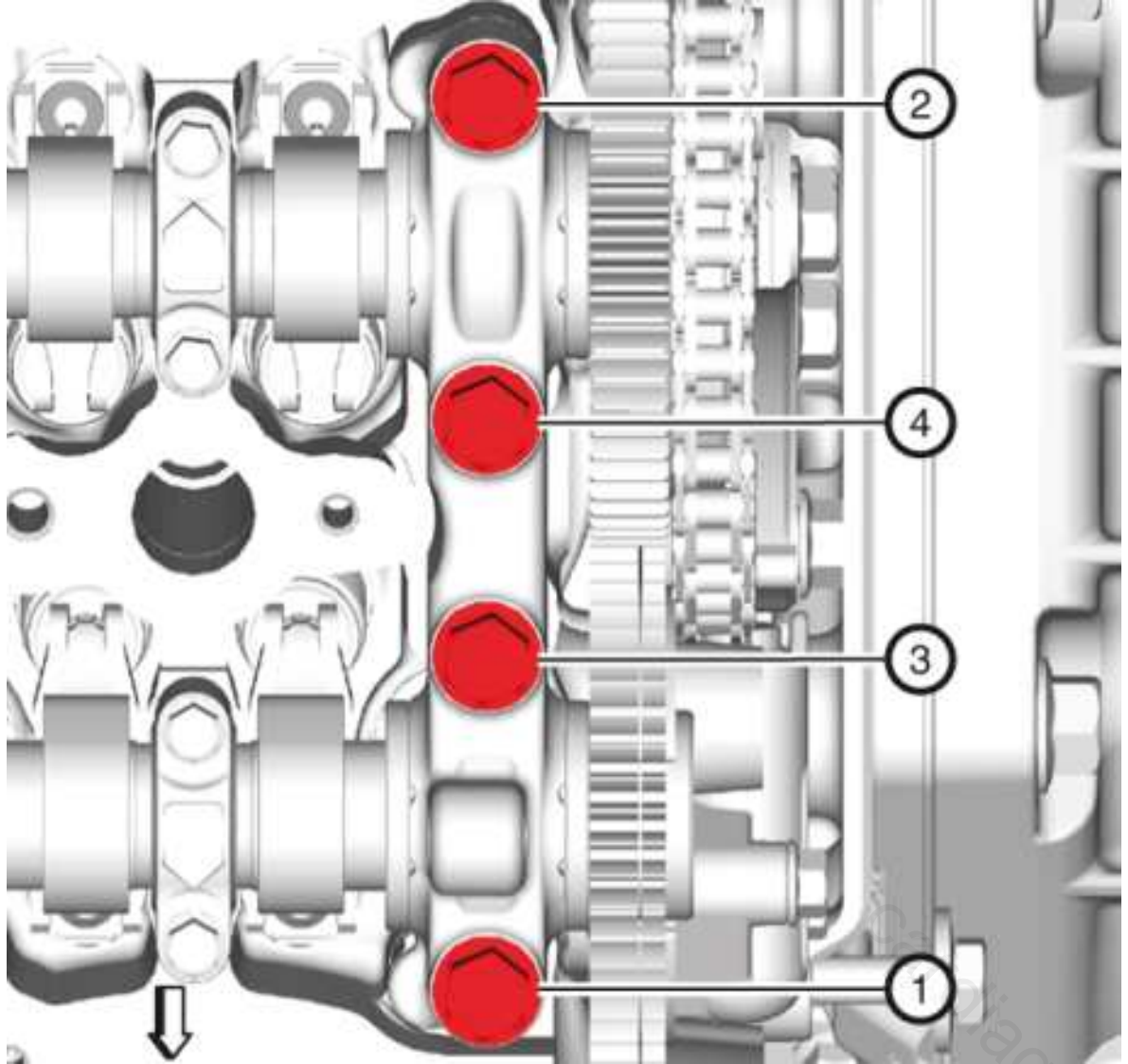


Fig. 362: Camshaft Rear Cap Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

49. Tighten the 4 camshaft rear cap bolts in sequence as shown to 25 N.m (18 lb ft).

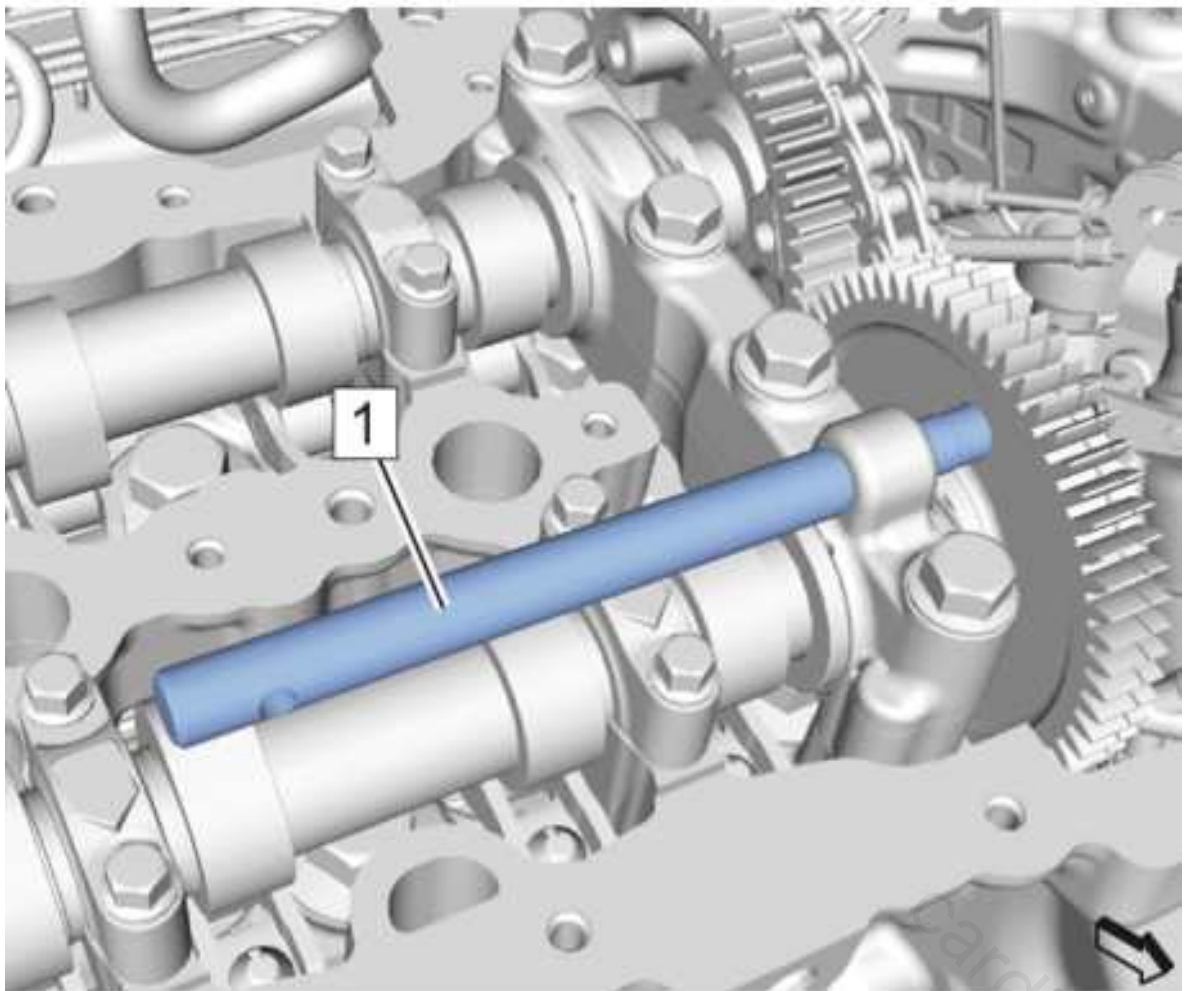


Fig. 363: Camshaft Sprocket Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

50. Install the EN-51143 fixing tool (1), by carefully turning the hexagon of the camshaft.

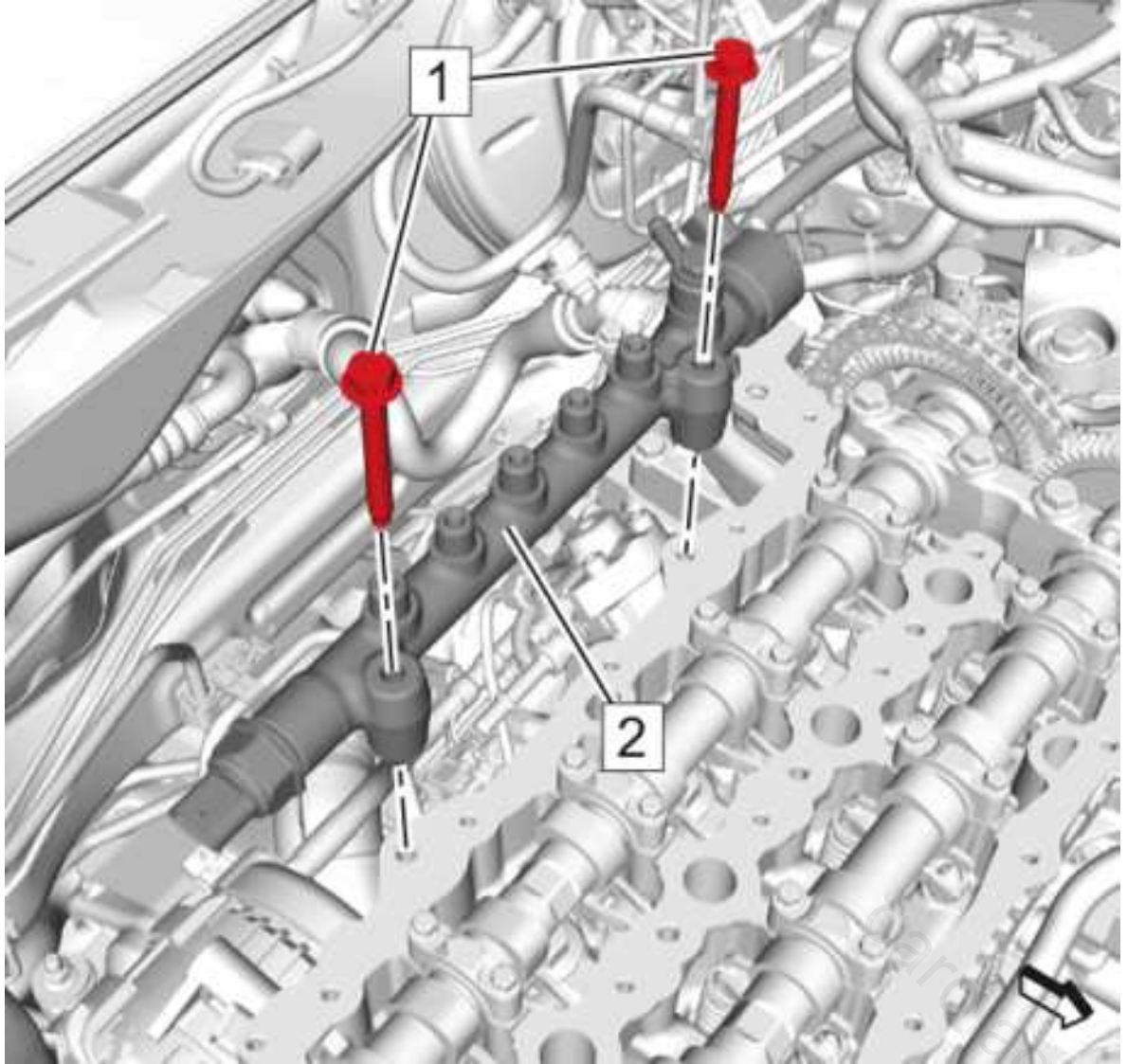


Fig. 364: Fuel Injection Fuel Rail And Bolts
Courtesy of GENERAL MOTORS COMPANY

51. Install Fuel Injection Fuel Rail (2)
52. Install and tighten Fuel Injection Fuel Rail Bolts (1) (Qty: 2) to 25 N.m (18 lb ft)
53. Install Glow Plugs (Qty: 4). Refer to [Glow Plug Replacement](#)
54. Install Camshaft Sprocket. Refer to [Camshaft Sprocket Replacement](#)
55. Install the exhaust manifold. Refer to [Exhaust Manifold Replacement \(LH7\)](#)
56. Install the intake manifold. Refer to [Intake Manifold Replacement](#)

AUTOMATIC TRANSMISSION FLEX PLATE REPLACEMENT

Special Tools

- EN-652 Holder Flex Plate
- EN-45059 Angle Meter

Equivalent regional tools: [Special Tools](#)

Removal Procedure

1. Remove Transmission. Refer to [Transmission Replacement \(Front Wheel Drive\)](#) [Transmission Replacement \(All Wheel Drive\)](#).



Fig. 365: Flex Plate Holder

Courtesy of GENERAL MOTORS COMPANY

2. Install the **EN-652** holder (1) in order to fix the flex plate.

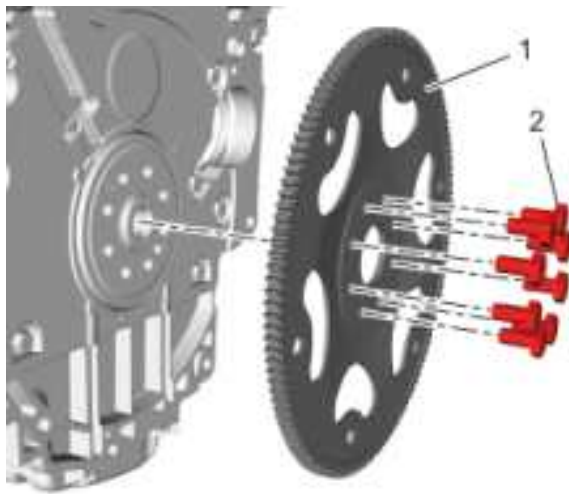


Fig. 366: Automatic Transmission Flex Plate And Bolts

Courtesy of GENERAL MOTORS COMPANY

3. Remove and DISCARD Automatic Transmission Flex Plate Bolts (2) (Qty: 8)
4. Remove the **EN-652** holder.
5. Remove Automatic Transmission Flex Plate (1)

Installation Procedure

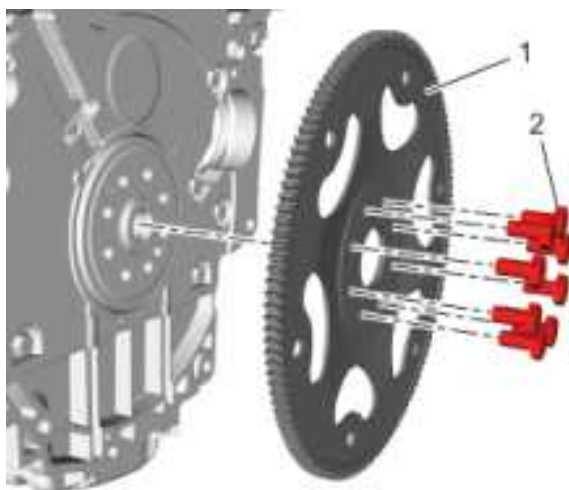


Fig. 367: Automatic Transmission Flex Plate And Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Install Automatic Transmission Flex Plate (1)

NOTE: Install **NEW** bolts.

2. Install Automatic Transmission Flex Plate Bolts (2) (Qty: 8)



Fig. 368: Flex Plate Holder
Courtesy of GENERAL MOTORS COMPANY

3. Install the **EN-652** holder (1) in the position shown.

CAUTION: Refer to [Fastener Caution](#)

CAUTION: Refer to [Torque-to-Yield Fastener Caution](#)

4. Tighten the flex plate bolts crosswise in the following order:

1. First Pass: 60 N.m (44 lb ft)
2. Final Pass: 45 degrees - **EN-45059** meter

5. Remove the **EN-652** holder.

6. Install Transmission. Refer to [Transmission Replacement \(Front Wheel Drive\)](#), [Transmission Replacement \(All Wheel Drive\)](#)

ENGINE OIL LEVEL INDICATOR SWITCH REPLACEMENT

Removal Procedure

1. Drain the engine oil. Refer to [Engine Oil and Oil Filter Replacement](#)

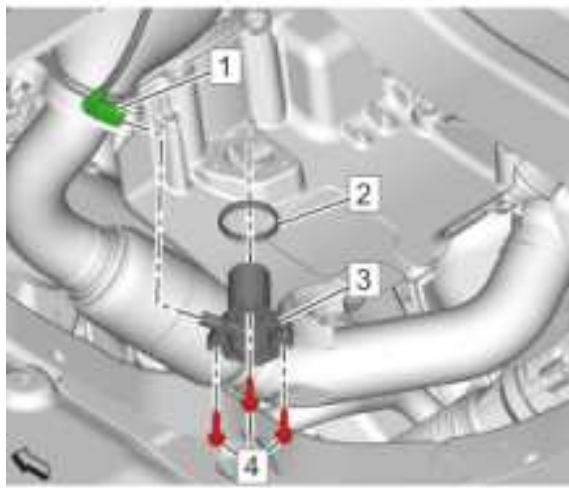


Fig. 369: Engine Oil Level Indicator Switch, Bolts, O-Ring Seal And Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

2. Disconnect the electrical connector. (1)
3. Remove Engine Oil Level Indicator Switch Bolt (4) (Qty: 3)
4. Remove Engine Oil Level Indicator Switch (3)
5. Remove and DISCARD Engine Oil Level Indicator Switch O-Ring Seal (2)

Installation Procedure

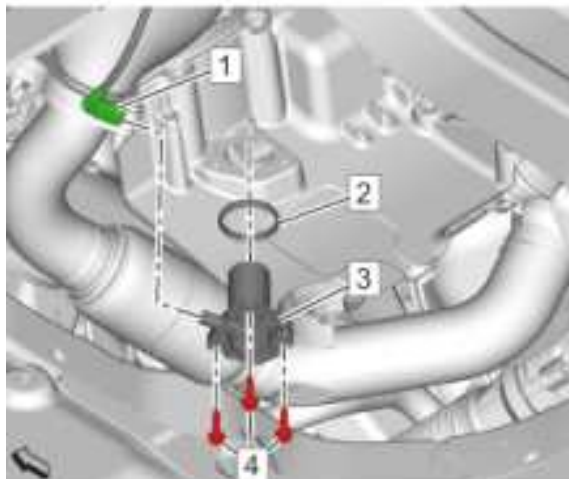


Fig. 370: Engine Oil Level Indicator Switch, Bolts, O-Ring Seal And Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

1. Install a NEW O-ring seal. (2)
2. Install Engine Oil Level Indicator Switch (3)

CAUTION: Refer to: [Fastener Caution](#)

3. Install and tighten Engine Oil Level Indicator Switch Bolts (4) (Qty: 3) to 10 N.m (89 lb in)
4. Connect the electrical connector. (1)
5. Fill the engine oil. Refer to [Engine Oil and Oil Filter Replacement](#)

ENGINE OIL PRESSURE SWITCH REPLACEMENT

Removal Procedure

1. Disconnect the negative battery cable. Refer to [Battery Negative Cable Disconnection and Connection \(KL9\)](#)
2. Raise and support the vehicle. Refer to [Lifting and Jacking the Vehicle](#)

3. Remove Exhaust Front Pipe. Refer to [Exhaust Front Pipe Replacement \(LH7\)](#).

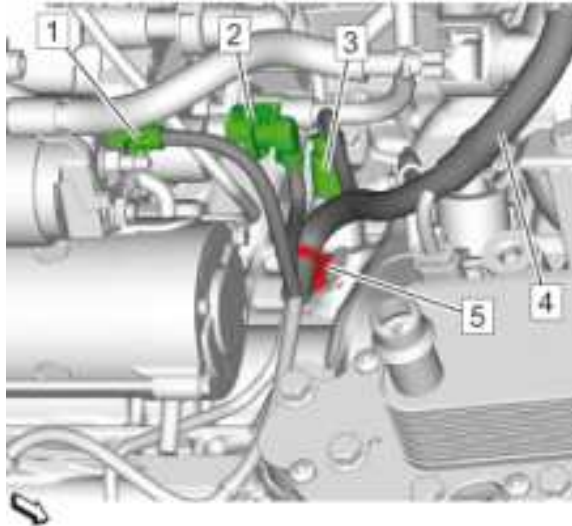


Fig. 371: Electrical Connectors, Wiring Harness And Clip
Courtesy of GENERAL MOTORS COMPANY

4. Disconnect the electrical connector:
 1. Starter (1)
 2. Fuel Injection Pump (2)
 3. Engine Oil Pressure Switch (3)
5. Unclip Wiring Harness Clip (5)
6. Hang the wiring harness (4) aside.

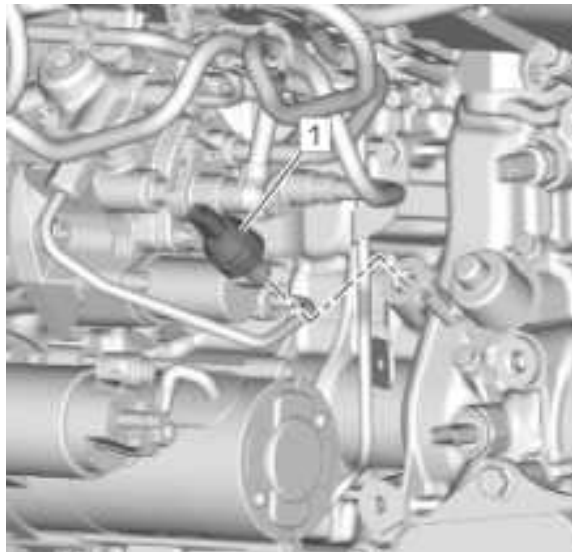


Fig. 372: Engine Oil Pressure Switch
Courtesy of GENERAL MOTORS COMPANY

7. Remove Engine Oil Pressure Switch (1)

Installation Procedure

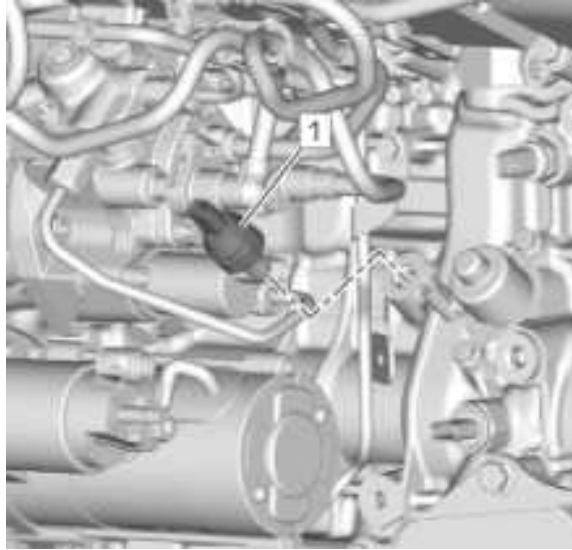


Fig. 373: Engine Oil Pressure Switch
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to: [Fastener Caution](#)

1. Install and tighten Engine Oil Pressure Switch (1) to 35 N.m (26 lb ft)

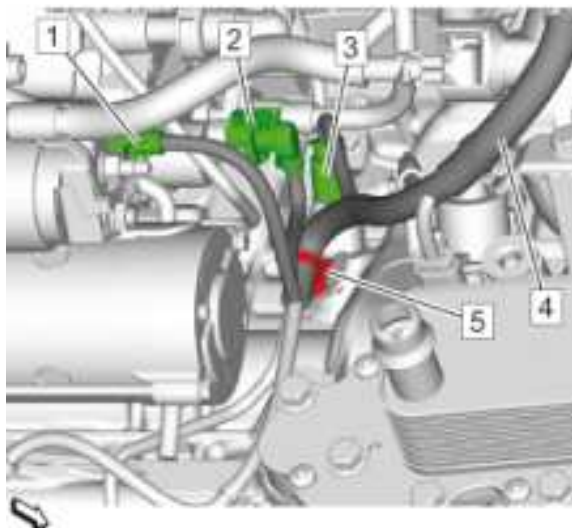


Fig. 374: Electrical Connectors, Wiring Harness And Clip
Courtesy of GENERAL MOTORS COMPANY

2. Install Wiring Harness Clip (5)
3. Connect the electrical connector:
 1. Starter (1)
 2. Fuel Injection Pump (2)
 3. Engine Oil Pressure Switch (3)
4. Install Exhaust Front Pipe. Refer to [Exhaust Front Pipe Replacement \(LH7\)](#)
5. Lower the vehicle.
6. Connect the negative battery cable. Refer to [Battery Negative Cable Disconnection and Connection \(KL9\)](#)

ENGINE OIL AND OIL FILTER REPLACEMENT

Removal Procedure

1. Disconnect the battery negative cable. Refer to [Battery Negative Cable Disconnection and Connection \(KL9\)](#)
2. Raise and support the vehicle. Refer to [Lifting and Jacking the Vehicle](#)
3. Place a drain pan under the vehicle.

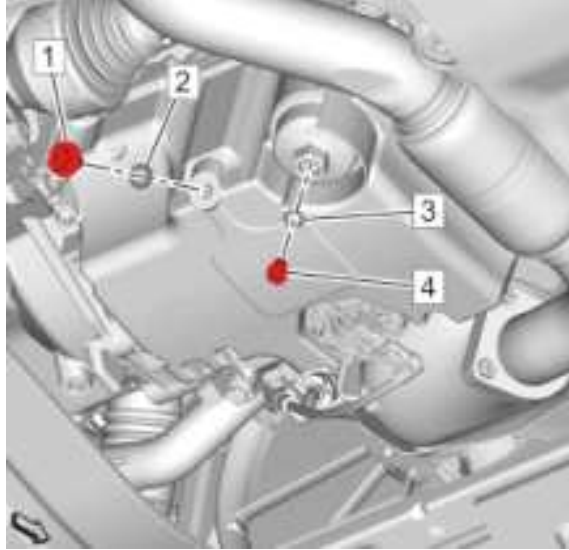


Fig. 375: Oil Pan Drain Plug, Bolt And Seals
Courtesy of GENERAL MOTORS COMPANY

4. Remove Oil Pan Drain Plug (1)
5. Remove and DISCARD Oil Pan Drain Plug Seal (2)
6. Remove Oil Filter Cap Plug (4)
7. Remove and DISCARD the O-ring seal. (3)
8. Drain the engine oil into a suitable container.

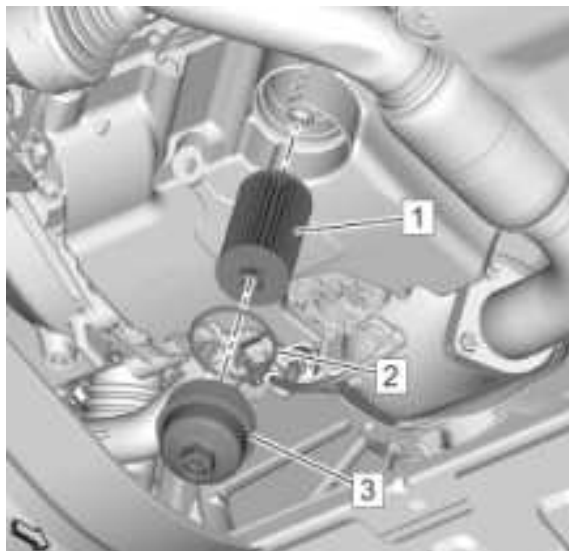


Fig. 376: Oil Filter Cap, O-Ring And Filter Insert
Courtesy of GENERAL MOTORS COMPANY

9. Remove the oil filter cap. (3)
10. Remove and DISCARD Oil Filter Cap O-Ring (2)

CAUTION: This engine uses a special high performance oil filter. Use of any other filter may lead to filter failure and/or severe engine damage.

11. Remove and properly dispose the oil filter insert (1).

Installation Procedure

1. Clean the oil filter housing of the oil pan and oil filter cap free from debris.

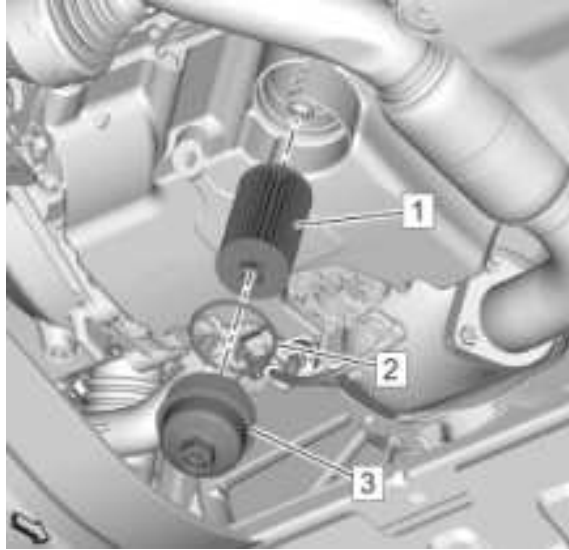


Fig. 377: Oil Filter Cap, O-Ring And Filter Insert
Courtesy of GENERAL MOTORS COMPANY

2. Install a NEW oil filter insert (1).

NOTE: Coat the o-ring with NEW clean engine oil.

3. Install NEW Oil Filter Cap O-Ring (2)

CAUTION: Refer to [Fastener Caution](#)

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

4. Install and tighten Oil Filter Cap (3) to 25 N.m (18 lb ft)

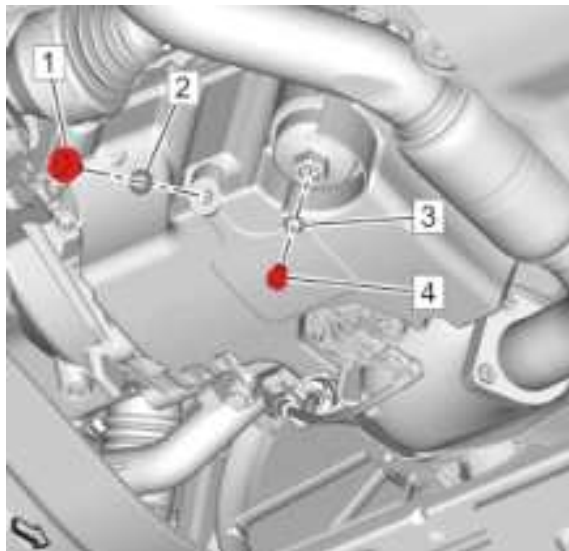


Fig. 378: Oil Pan Drain Plug, Bolt And Seals
Courtesy of GENERAL MOTORS COMPANY

5. Install a NEW O-ring seal. (3)
6. Install and tighten Oil Filter Cap Plug (4) to 10 N.m (89 lb in)
7. Install a NEW oil pan drain plug seal (2).
8. Install and tighten Oil Pan Drain Plug (1) to 25 N.m (18 lb ft)
9. Lower the vehicle.
10. Connect the battery negative cable. Refer to [Battery Negative Cable Disconnection and Connection \(KL9\)](#).
11. Fill in NEW engine oil. Refer to [Approximate Fluid Capacities, Adhesives, Fluids, Lubricants, and Sealers](#)
12. Start the engine and allow it to run until the oil pressure control indicator goes off.

13. Inspect the engine oil level.

14. Perform the engine oil life reset. Refer to [GM Oil Life System Resetting \(Without Scan Tool\)](#), [GM Oil Life System Resetting \(With Scan Tool\)](#).

OIL LEVEL INDICATOR REPLACEMENT

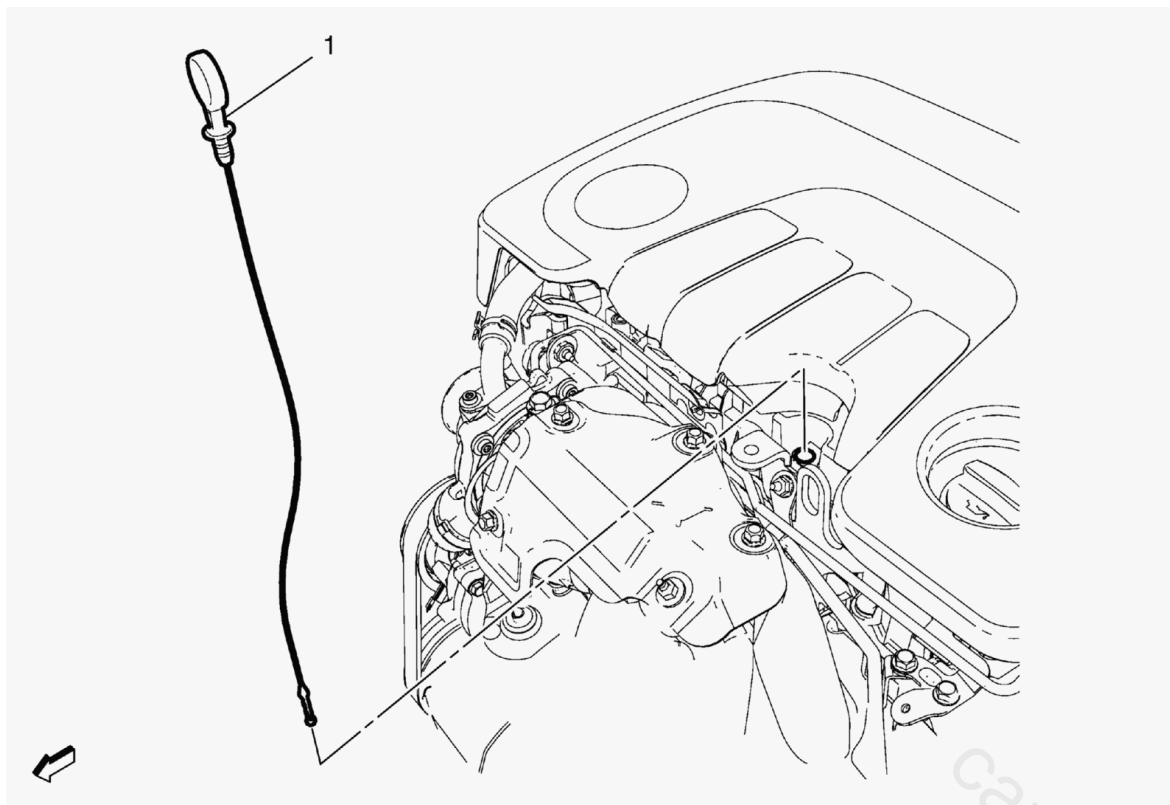


Fig. 379: Oil Level Indicator

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Oil Level Indicator

ENGINE OIL HEATER REPLACEMENT

Removal Procedure

1. Raise the vehicle. Refer to [Lifting and Jacking the Vehicle](#)

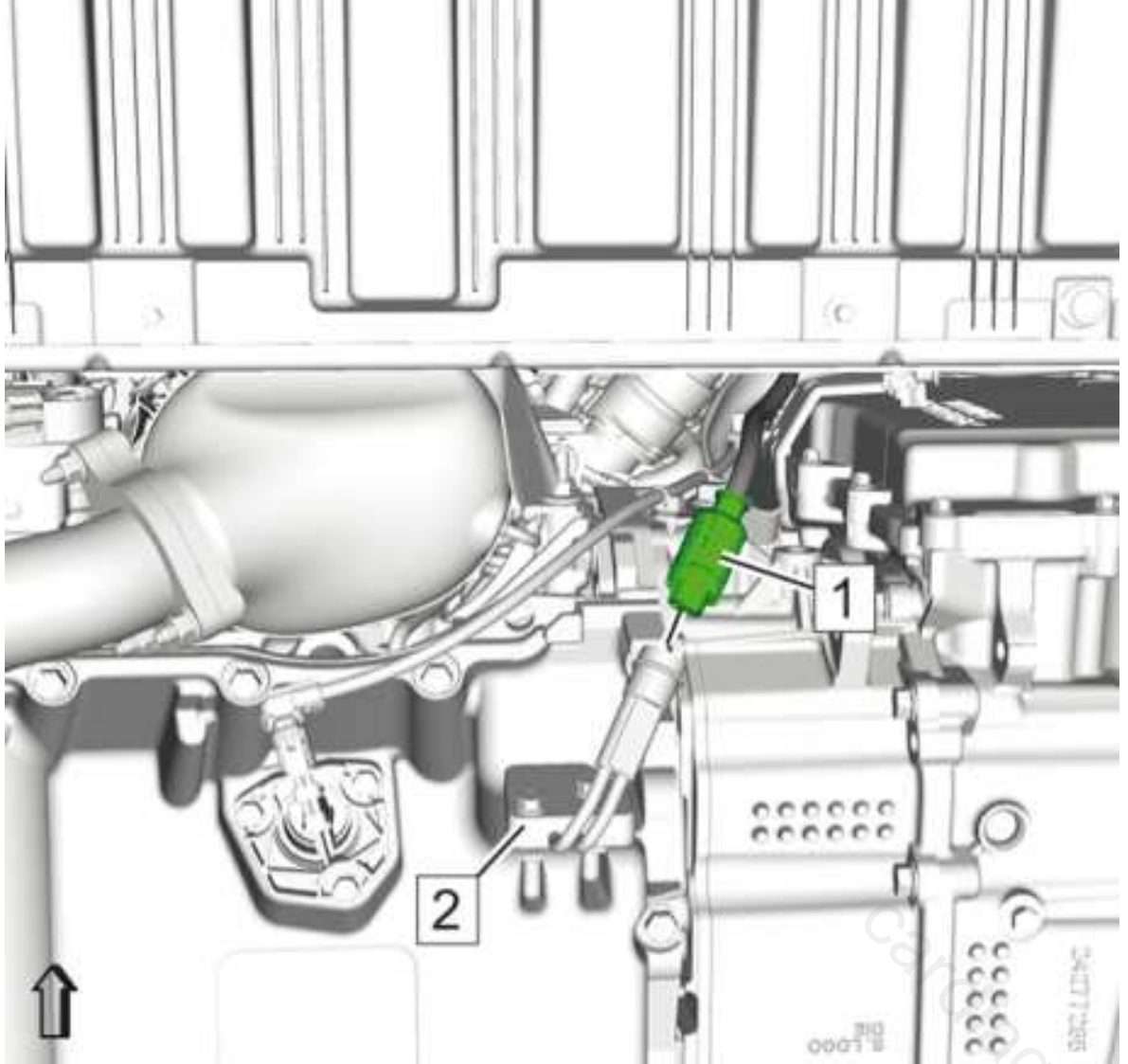


Fig. 380: Engine Oil Heater And Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

2. Disconnect the electrical connector (1) at the engine oil heater (2).

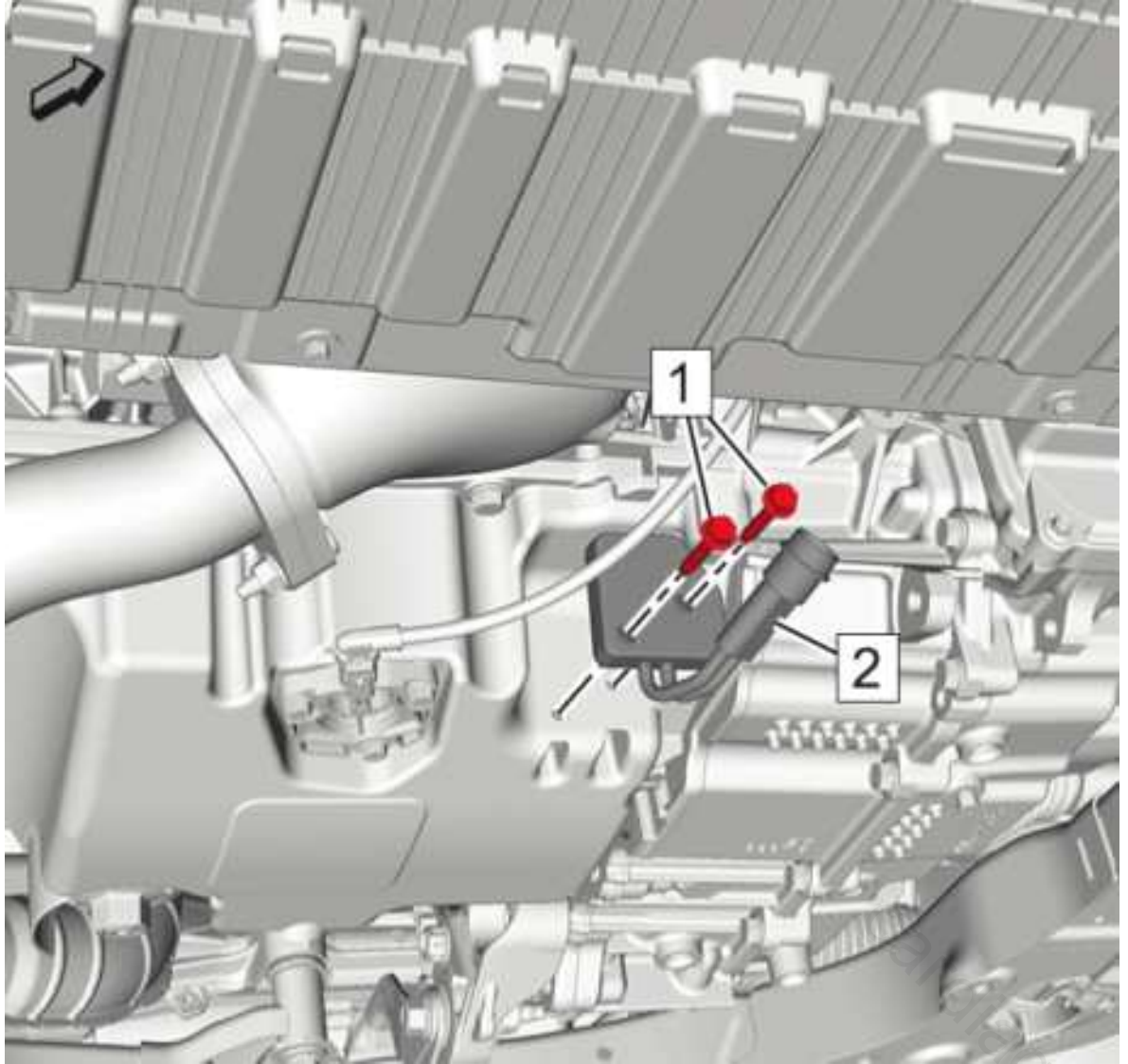


Fig. 381: Engine Oil Heater And Bolts

Courtesy of GENERAL MOTORS COMPANY

3. Remove the 2 engine oil heater bolts (1).
4. Remove the engine oil heater (2).

Installation Procedure

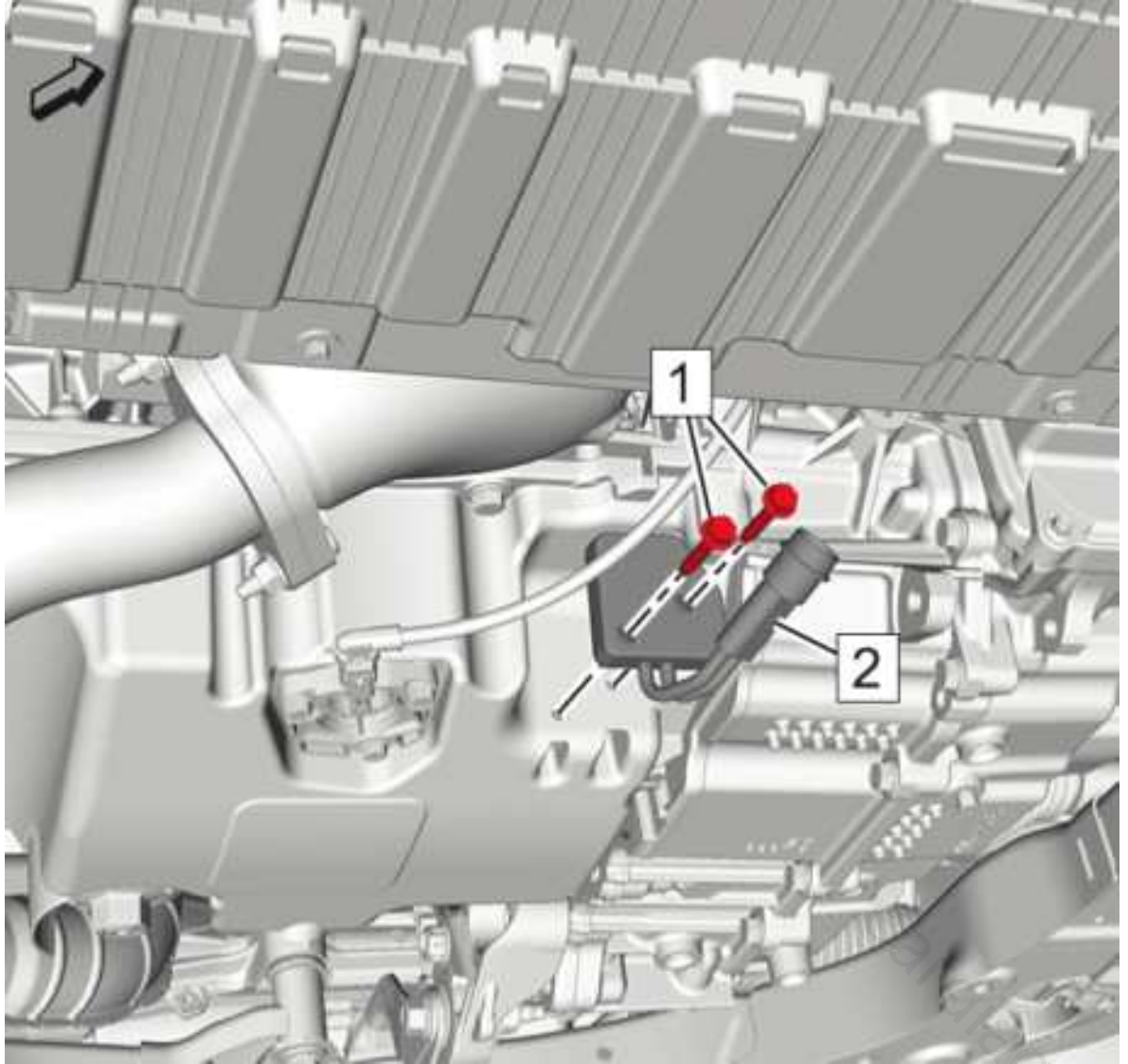


Fig. 382: Engine Oil Heater And Bolts

Courtesy of GENERAL MOTORS COMPANY

1. Install the engine oil heater (2).

CAUTION: Refer to **Fastener Caution**

2. Install the 2 engine oil heater bolts (1) and tighten to 9 N.m (80 lb in).

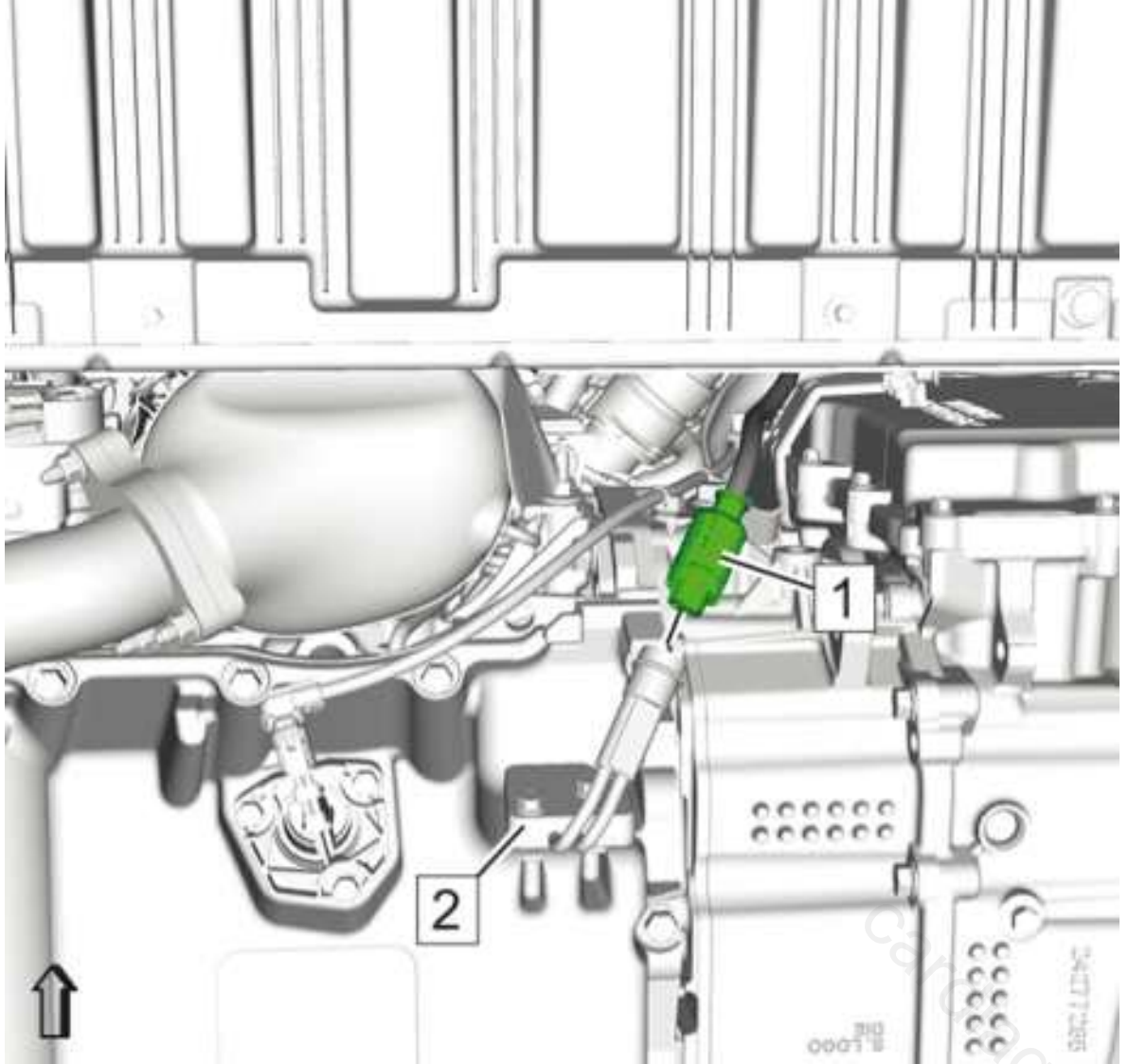


Fig. 383: Engine Oil Heater And Electrical Connector
 Courtesy of GENERAL MOTORS COMPANY

3. Connect the electrical connector (1) to the engine oil heater (2).
4. Lower the vehicle. Refer to [Lifting and Jacking the Vehicle](#)

OIL PAN REPLACEMENT

Removal Procedure

1. Remove the oil level indicator. Refer to [Oil Level Indicator Replacement](#)
2. Remove Exhaust Front Pipe. Refer to [Exhaust Front Pipe Replacement \(LH7\)](#)
3. Remove the engine oil heater. Refer to [Engine Oil Heater Replacement](#)
4. Place a drain pan under the vehicle.

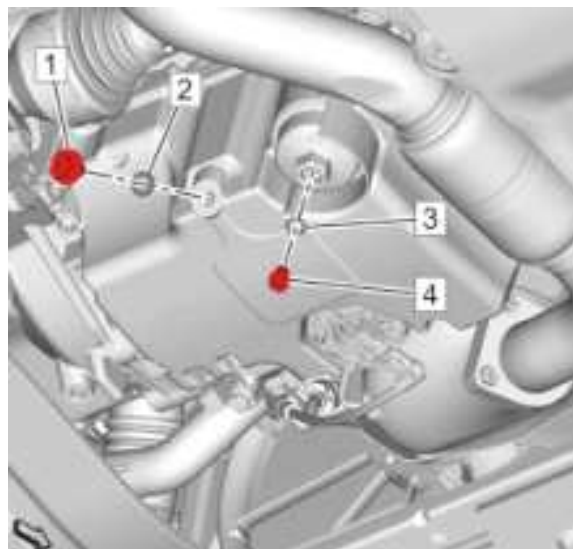


Fig. 384: Oil Pan Drain Plug, Bolt And Seals
Courtesy of GENERAL MOTORS COMPANY

5. Remove Oil Pan Drain Plug (1)
 6. Remove and DISCARD Oil Pan Drain Plug Seal (2)
 7. Remove the oil filter cap bolt (4).
 8. Remove and DISCARD Oil Filter Cap O-Ring (3)
 9. Drain the engine oil into a suitable container.
 10. If the oil pan will be reused:
 1. Install NEW Oil Filter Cap O-Ring (3)
- CAUTION:** Refer to [Fastener Caution](#)
2. Install the oil filter cap bolt (4) and tighten to 10 N.m (89 lb in)
 3. Install NEW Oil Pan Drain Plug Seal (2)
 4. Install and tighten Oil Pan Drain Plug (1) to 25 N.m (18 lb ft)

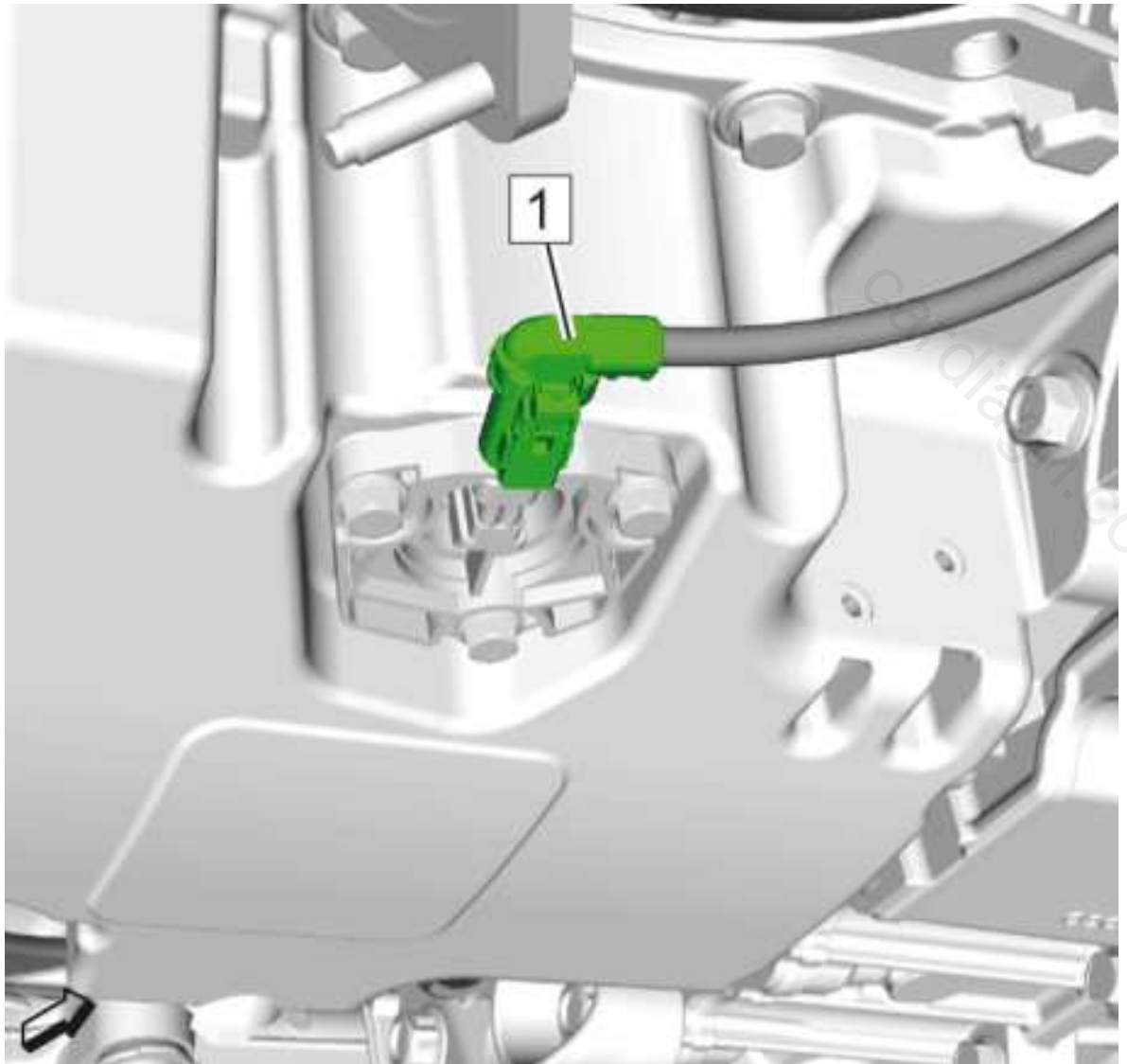


Fig. 385: Engine Oil Level Indicator Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

11. Disconnect Electrical Connector (1) @ Engine Oil Level Indicator

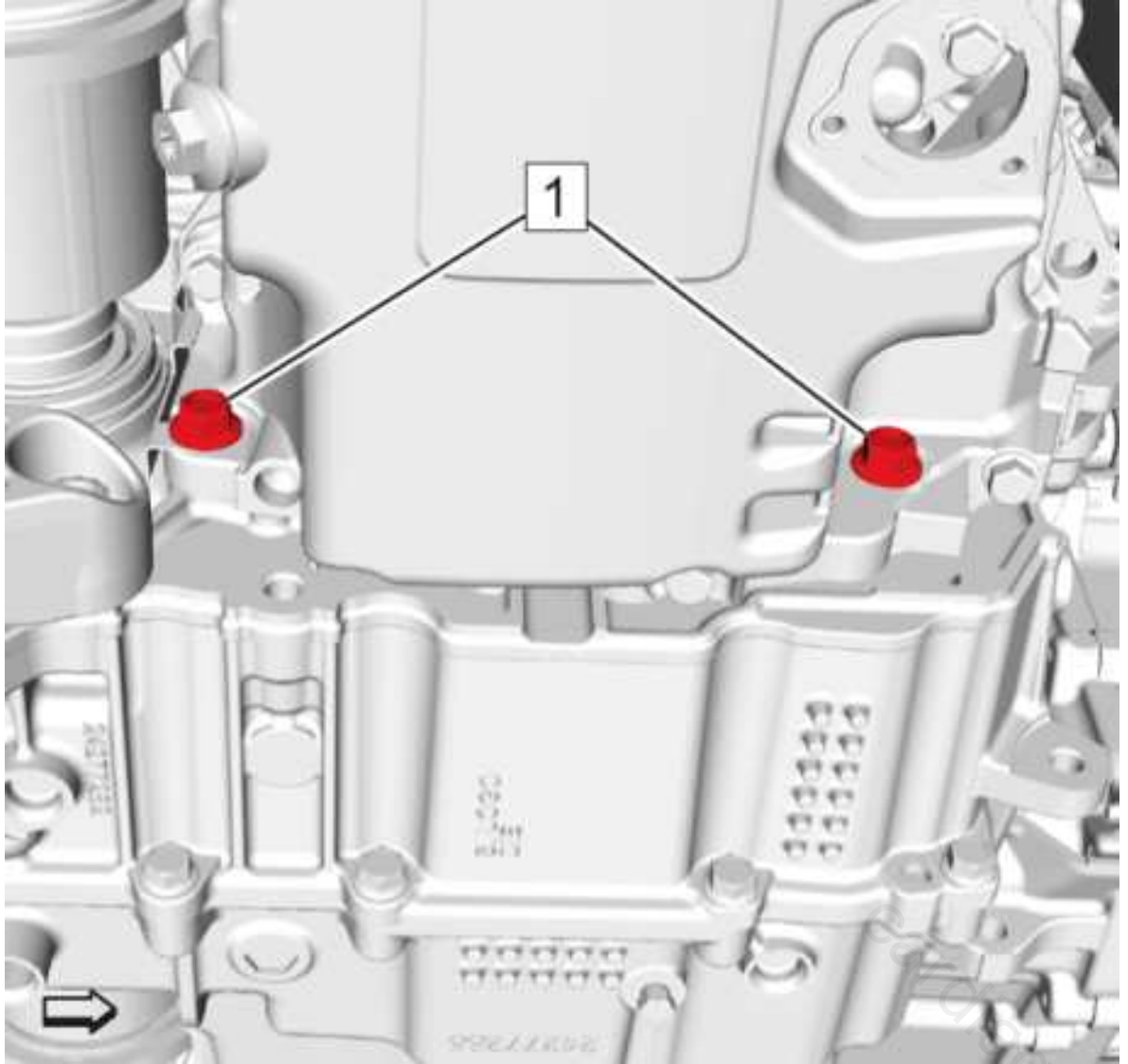


Fig. 386: Transmission Bolts

Courtesy of GENERAL MOTORS COMPANY

12. Remove Transmission Bolts (1) (Qty: 2)

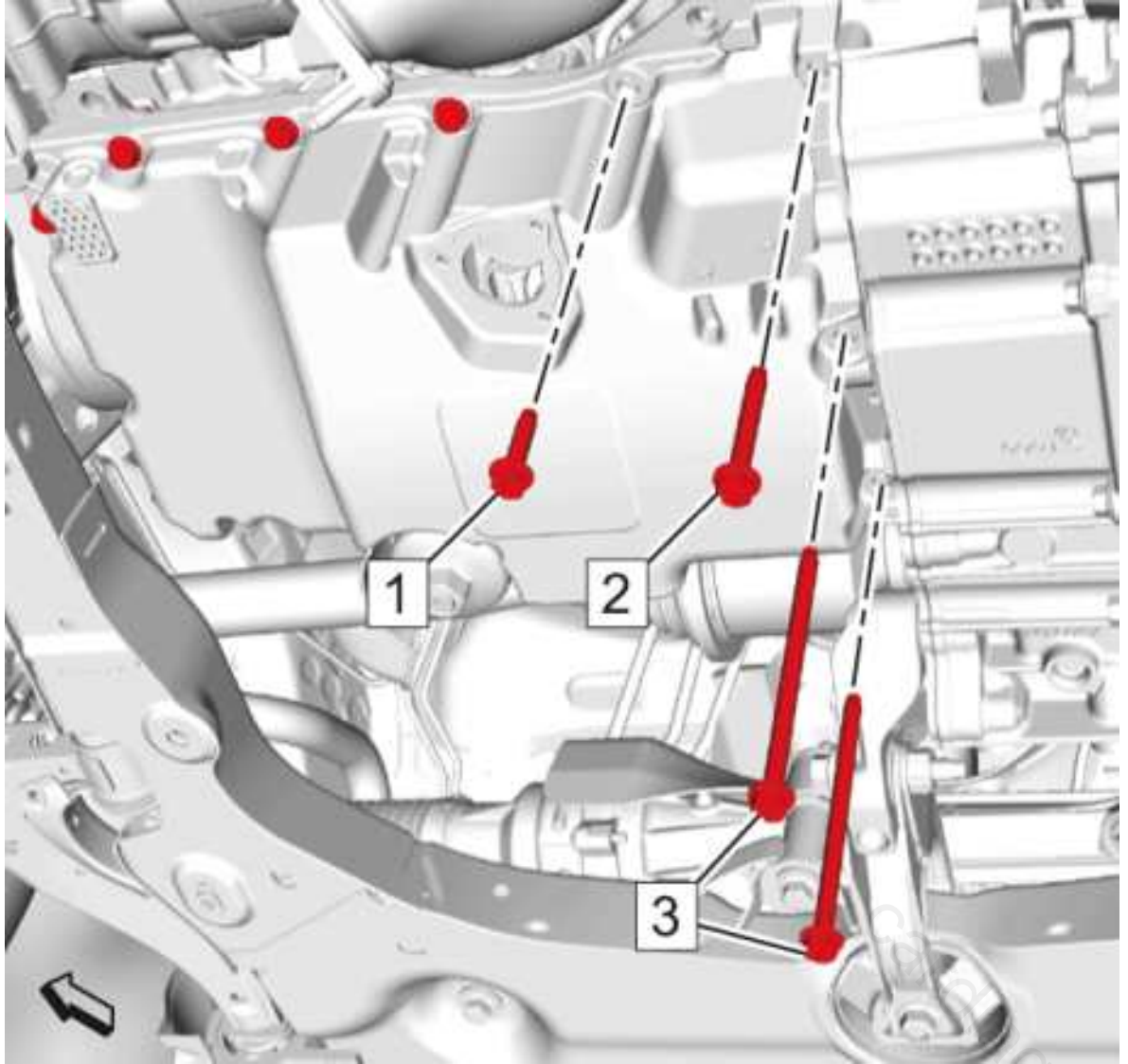


Fig. 387: Oil Pan Bolts

Courtesy of GENERAL MOTORS COMPANY

NOTE: Mark the position of the oil pan bolts because of different length.

13. Remove Oil Pan Bolts (1, 2, 3) (Qty: 15)

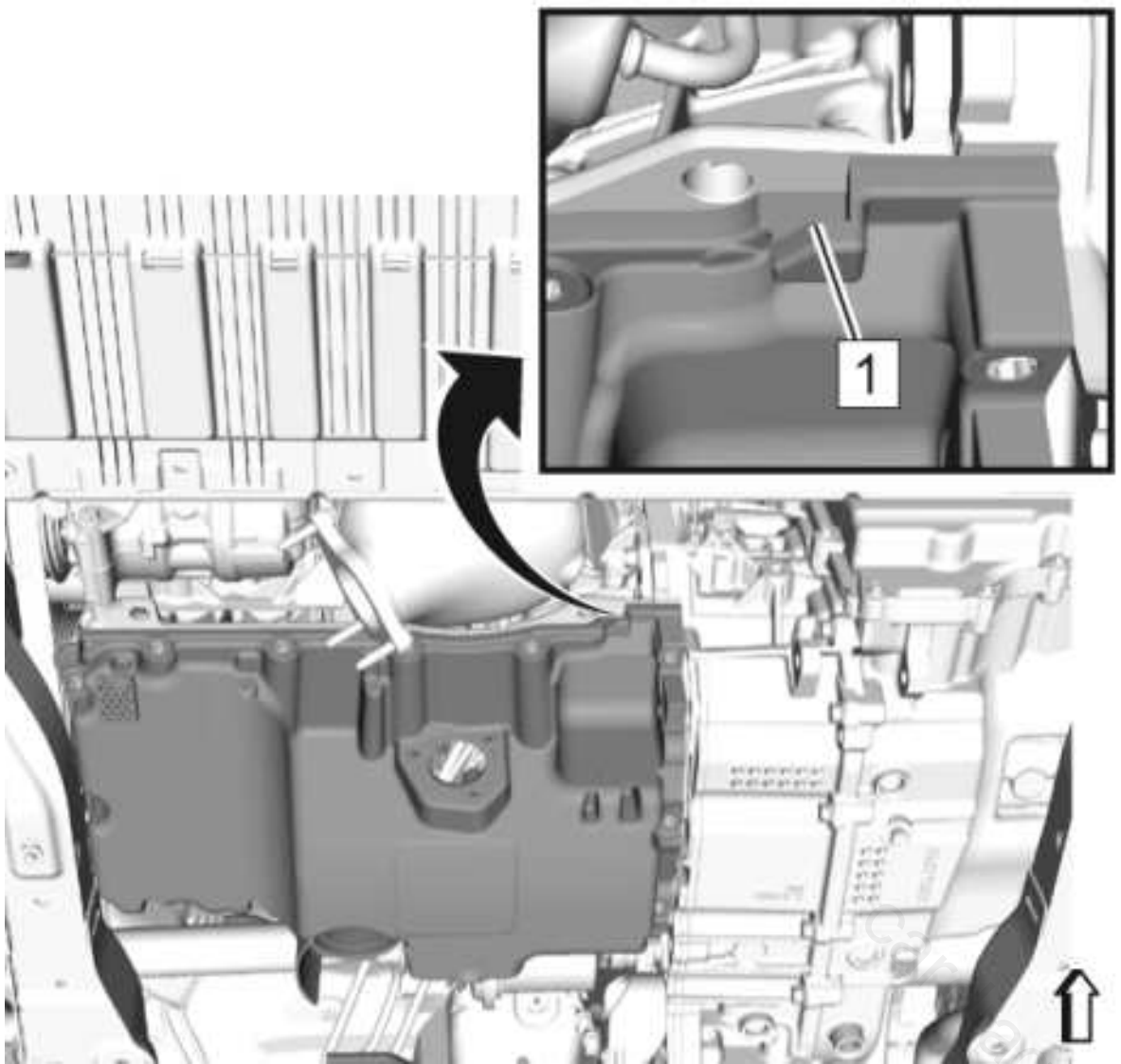


Fig. 388: Oil Pan Pry Point

Courtesy of GENERAL MOTORS COMPANY

14. Loosen the oil pan carefully from the lower cylinder block, use a suitable tool at the location as shown to pry (1).

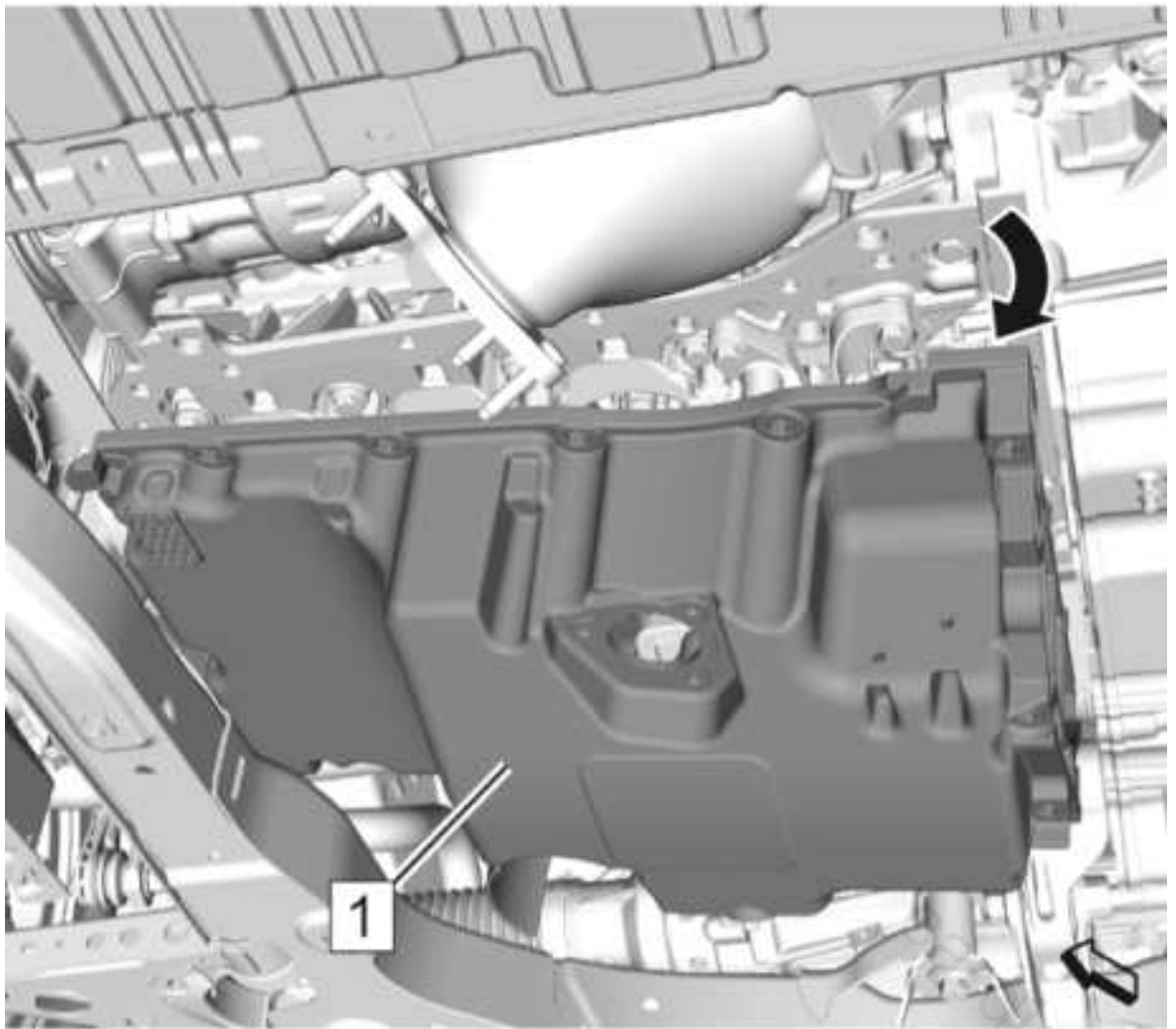


Fig. 389: Oil Pan

Courtesy of GENERAL MOTORS COMPANY

15. Remove Oil Pan (1)

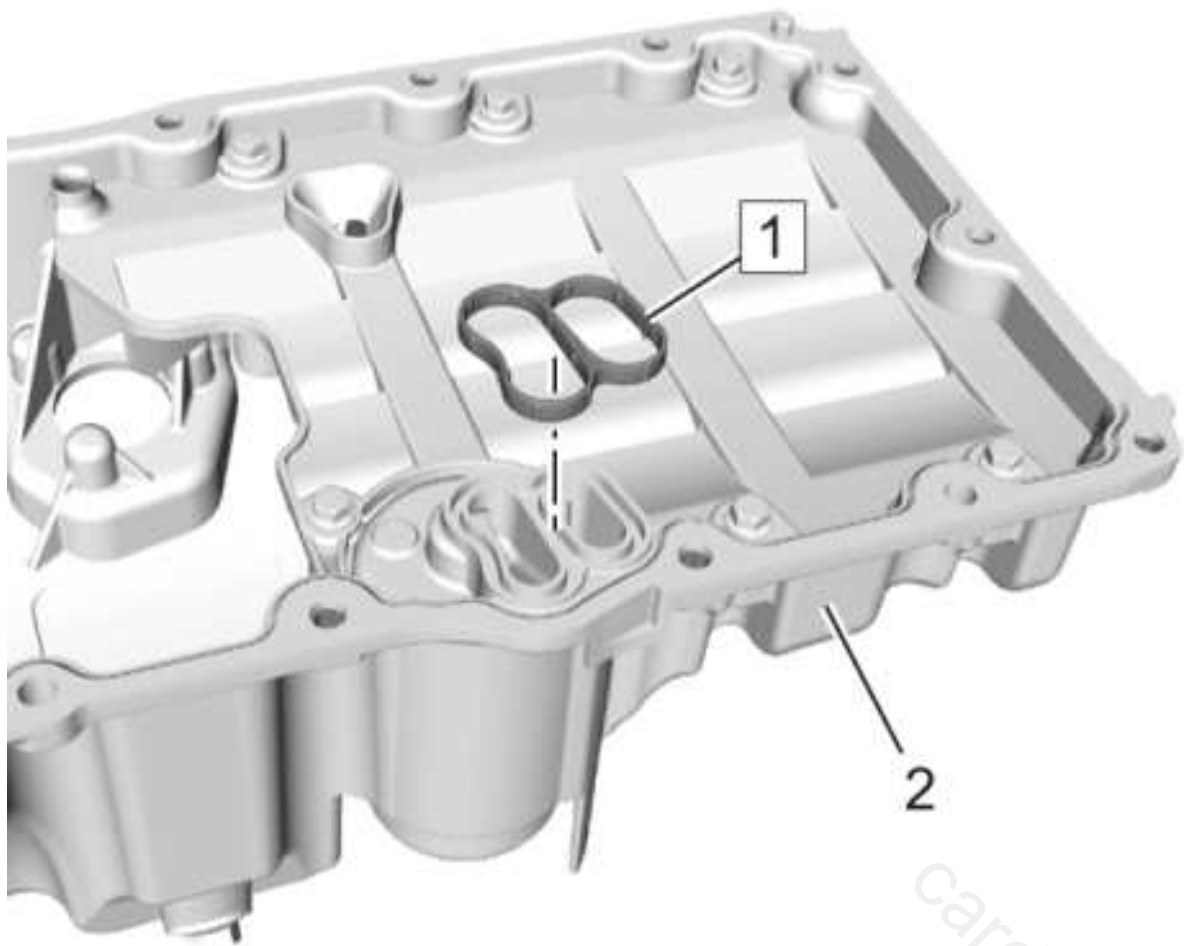


Fig. 390: Oil Filter Seal

Courtesy of GENERAL MOTORS COMPANY

16. Remove and DISCARD the oil filter seal (1)
17. Disassemble the oil pan. Refer to [Oil Pan Disassemble](#)

Installation Procedure

1. Clean all sealing surfaces.
2. Assemble the oil pan. Refer to [Oil Pan Assemble](#)

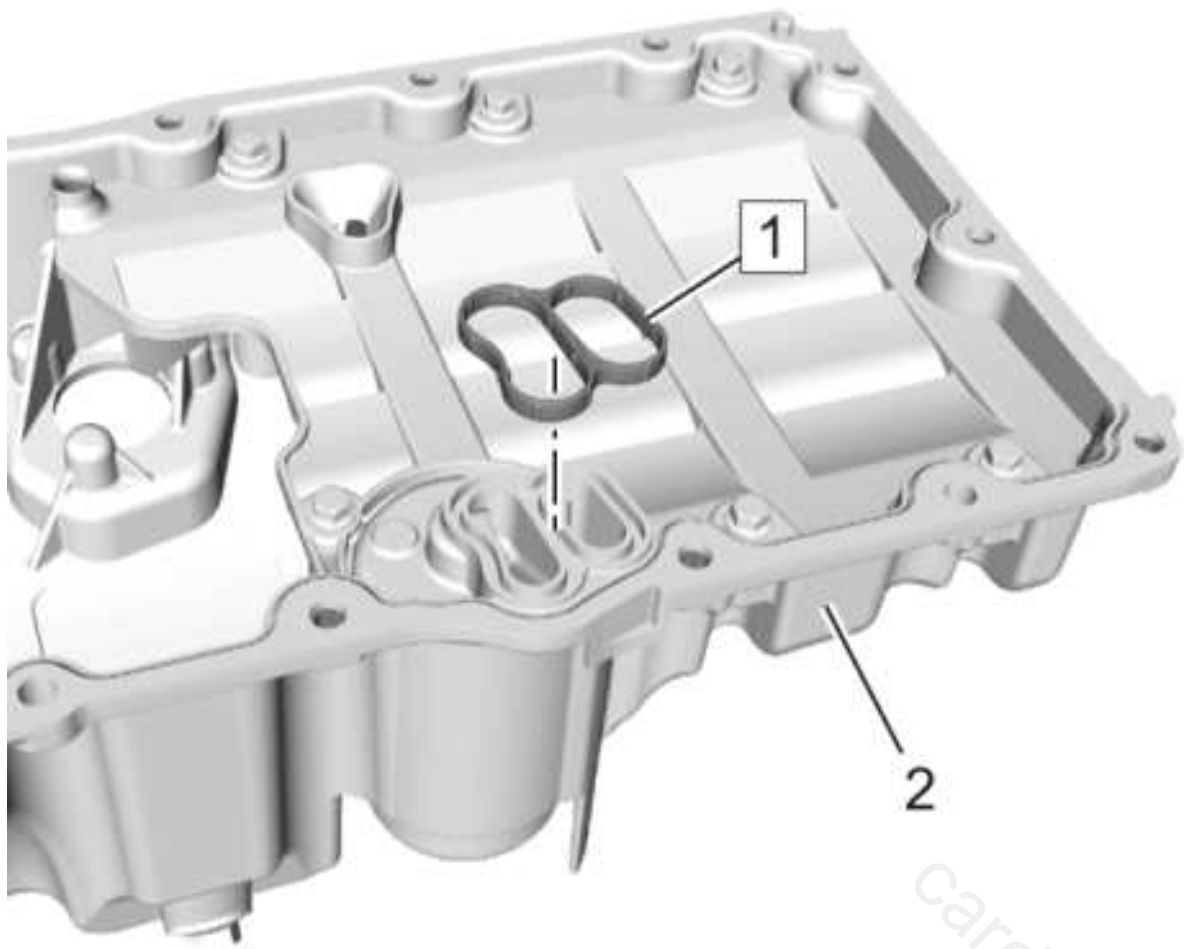


Fig. 391: Oil Filter Seal

Courtesy of GENERAL MOTORS COMPANY

3. Install a NEW oil filter seal (1)

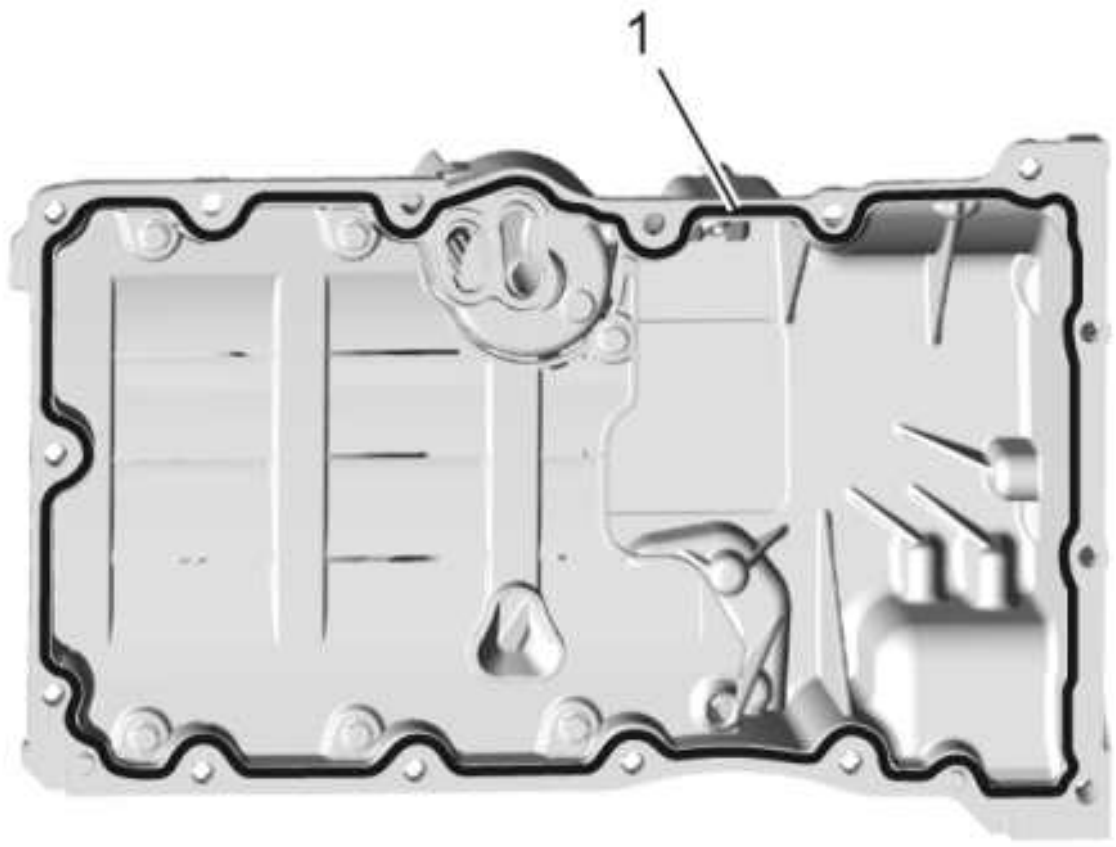


Fig. 392: Silicone Sealing Compound Application Area
Courtesy of GENERAL MOTORS COMPANY

NOTE: The complete installation procedure of the oil pan should be completed within 20 minutes.

4. Apply silicone sealing compound (1) to the oil pan surface. The thickness of the sealing bead (1) should be 3.0 - 4.0 mm (0.118 - 0.157 in).

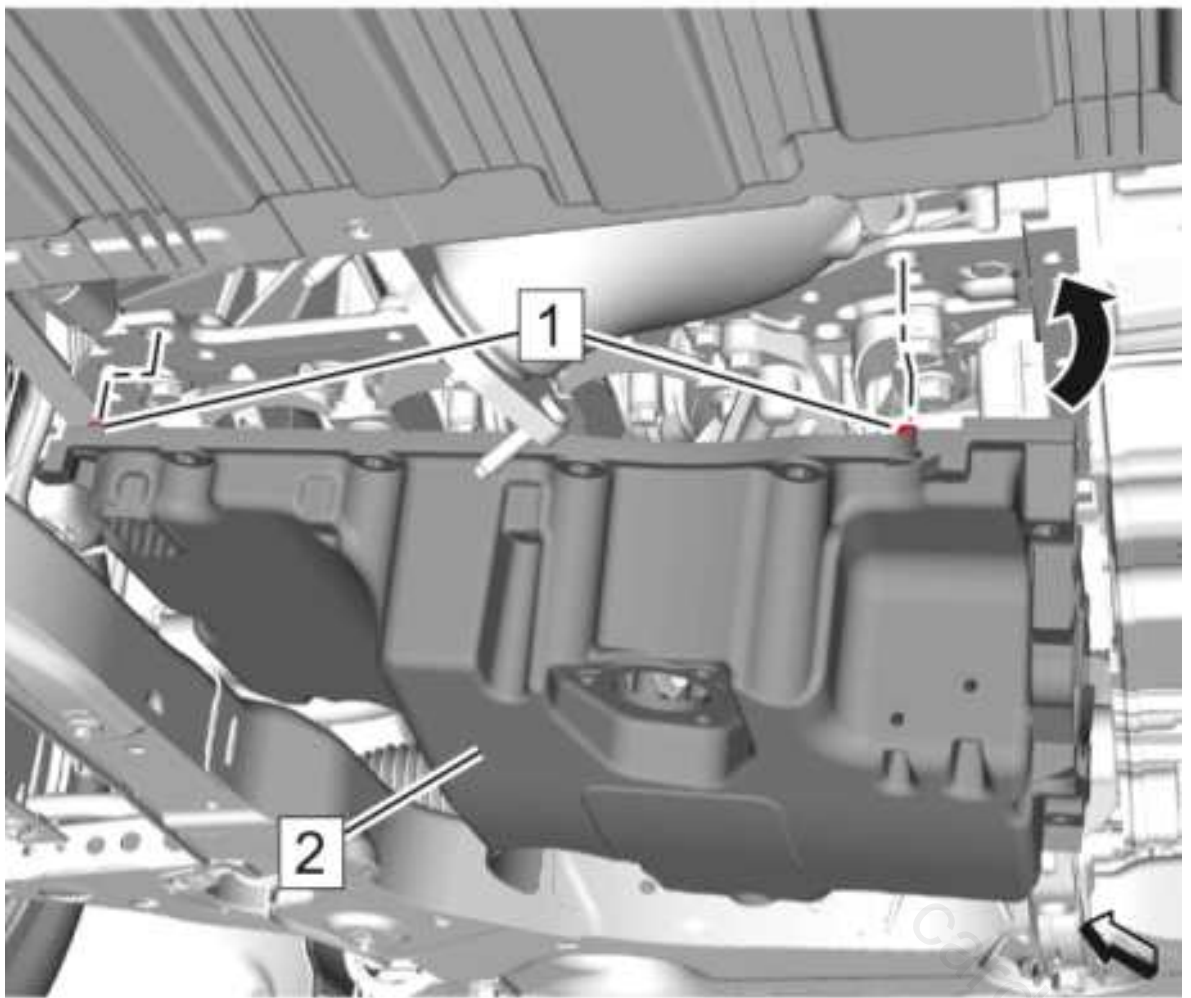


Fig. 393: Align Pins To Install Oil Pan

Courtesy of GENERAL MOTORS COMPANY

5. Install the oil pan (2) with the pins (1) in their holes.

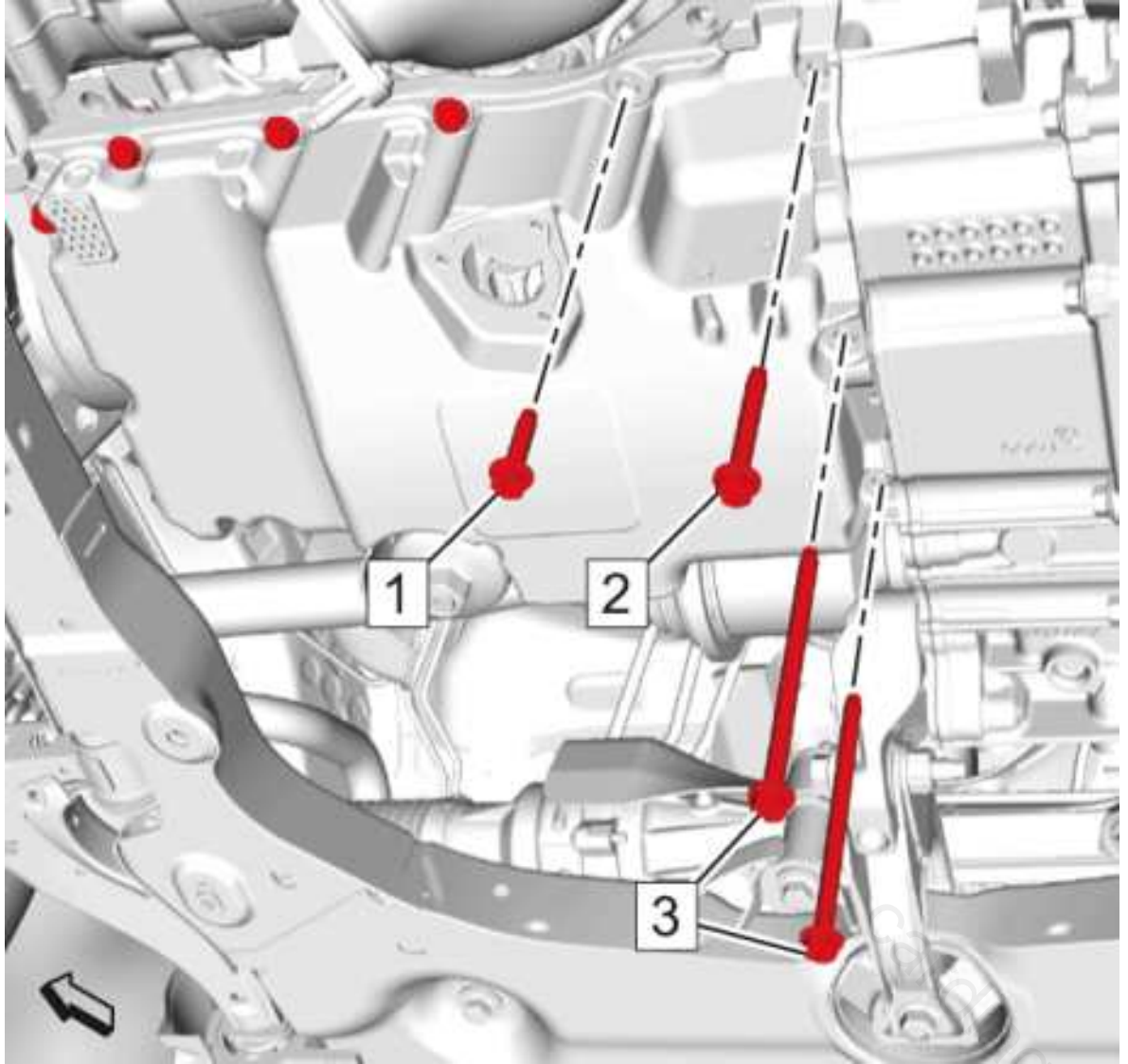


Fig. 394: Oil Pan Bolts

Courtesy of GENERAL MOTORS COMPANY

6. Loosely install the oil pan bolts. (1, 2, 3) (Qty: 15)

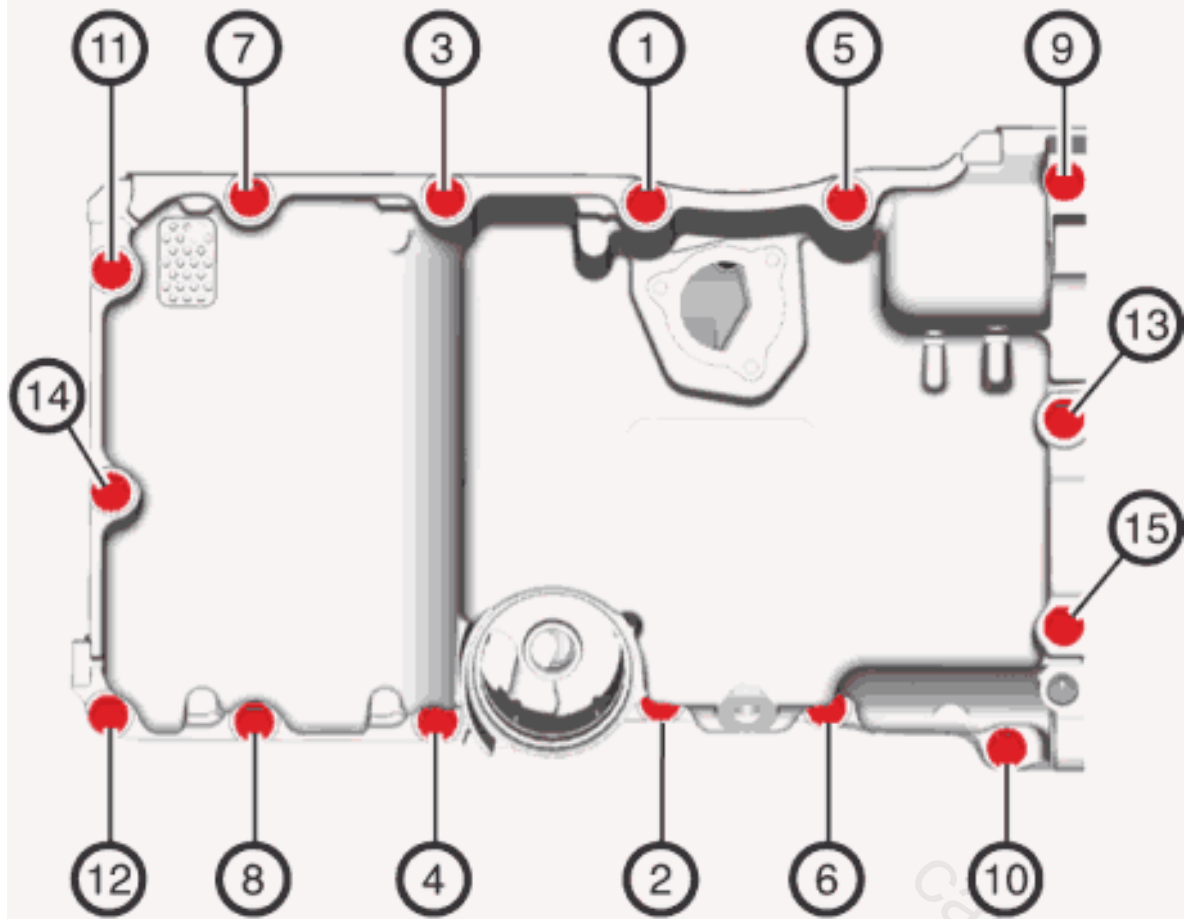


Fig. 395: Oil Pan Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution**

7. Tighten Oil Pan Bolts (Qty: 15) in sequence to 25 N.m (18 lb ft)

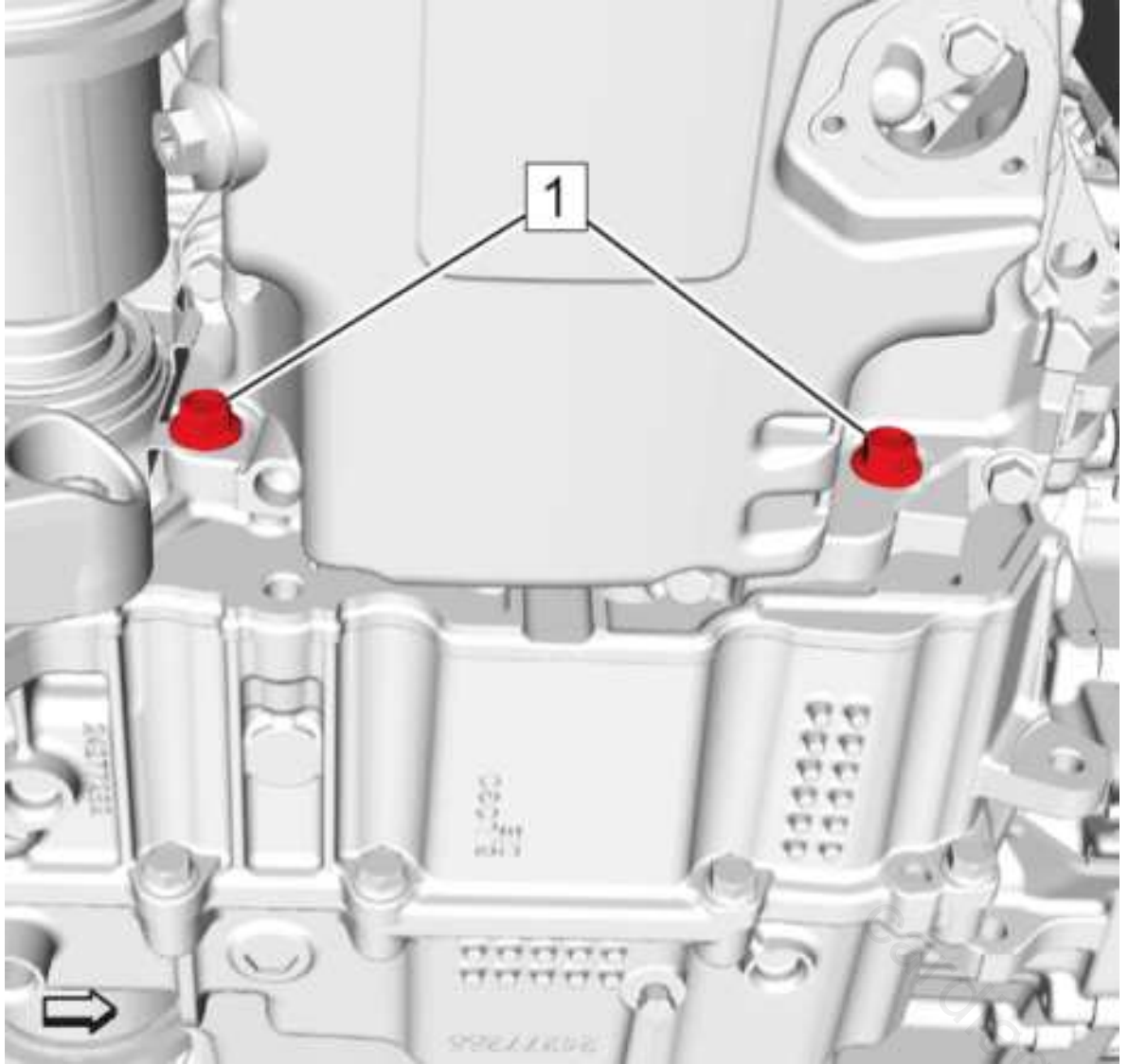


Fig. 396: Transmission Bolts

Courtesy of GENERAL MOTORS COMPANY

8. Install and tighten Transmission Bolts (1) (Qty: 2) to 58 N.m (43 lb ft).

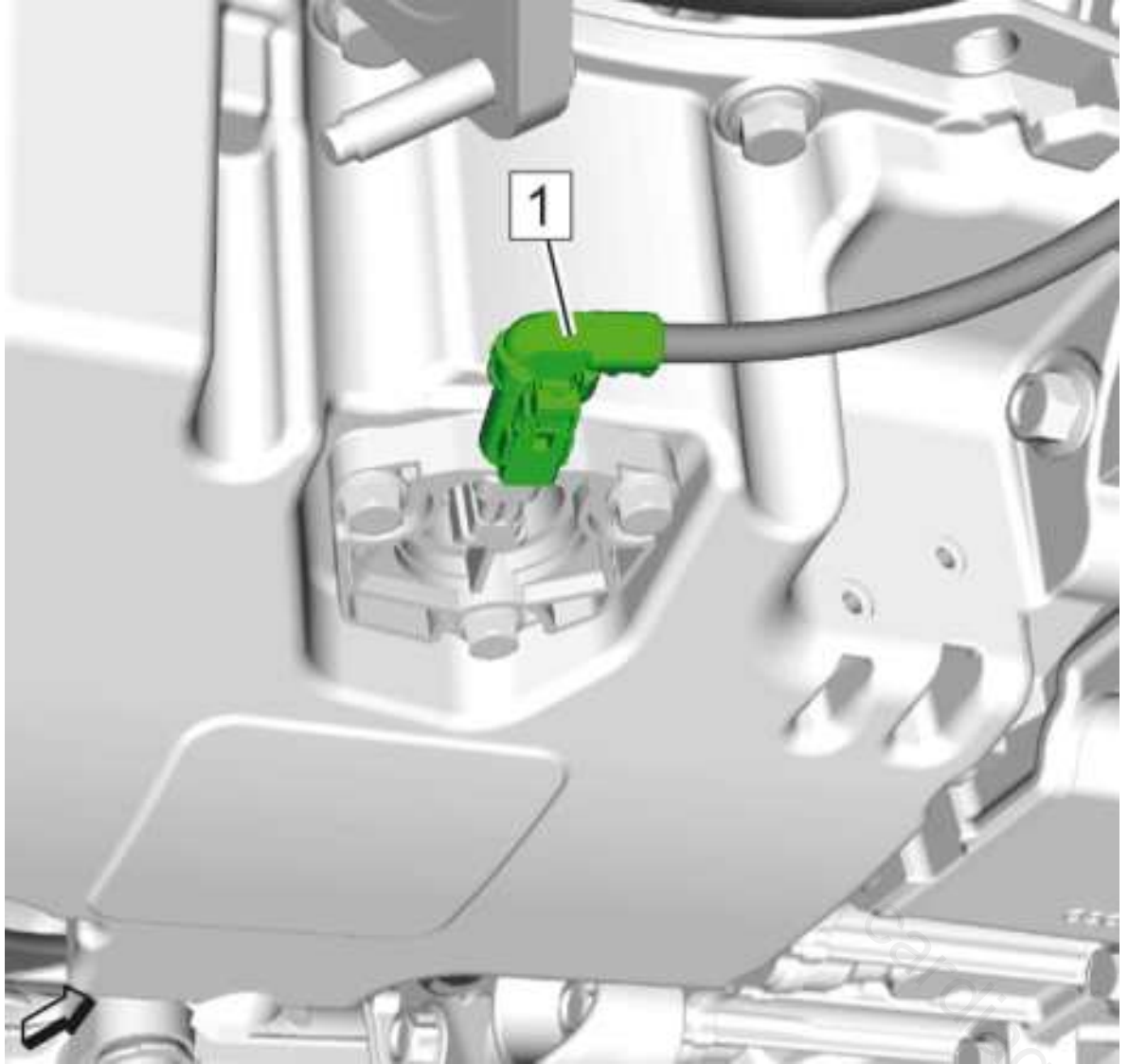


Fig. 397: Engine Oil Level Indicator Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

9. Connect Electrical Connector (1) @ Engine Oil Level Indicator
10. Install the engine oil heater. Refer to [Engine Oil Heater Replacement](#)
11. Install Exhaust Front Pipe. Refer to [Exhaust Front Pipe Replacement \(LH7\)](#) .
12. Install the oil level indicator. Refer to [Oil Level Indicator Replacement](#)
13. Fill and check the engine oil level. Refer to [Engine Oil and Oil Filter Replacement](#)

PISTON, CONNECTING ROD, AND BEARING REPLACEMENT

Special Tools

- **CH-904** Base Frame
- **CH-49290** Engine Support Tool
- **EN-45059** Angle Meter
- **EN-51140** Crankshaft Fixing Tool

Equivalent regional tools: [Special Tools](#).

Removal Procedure

1. Remove Cylinder Head. Refer to [Cylinder Head Replacement](#)

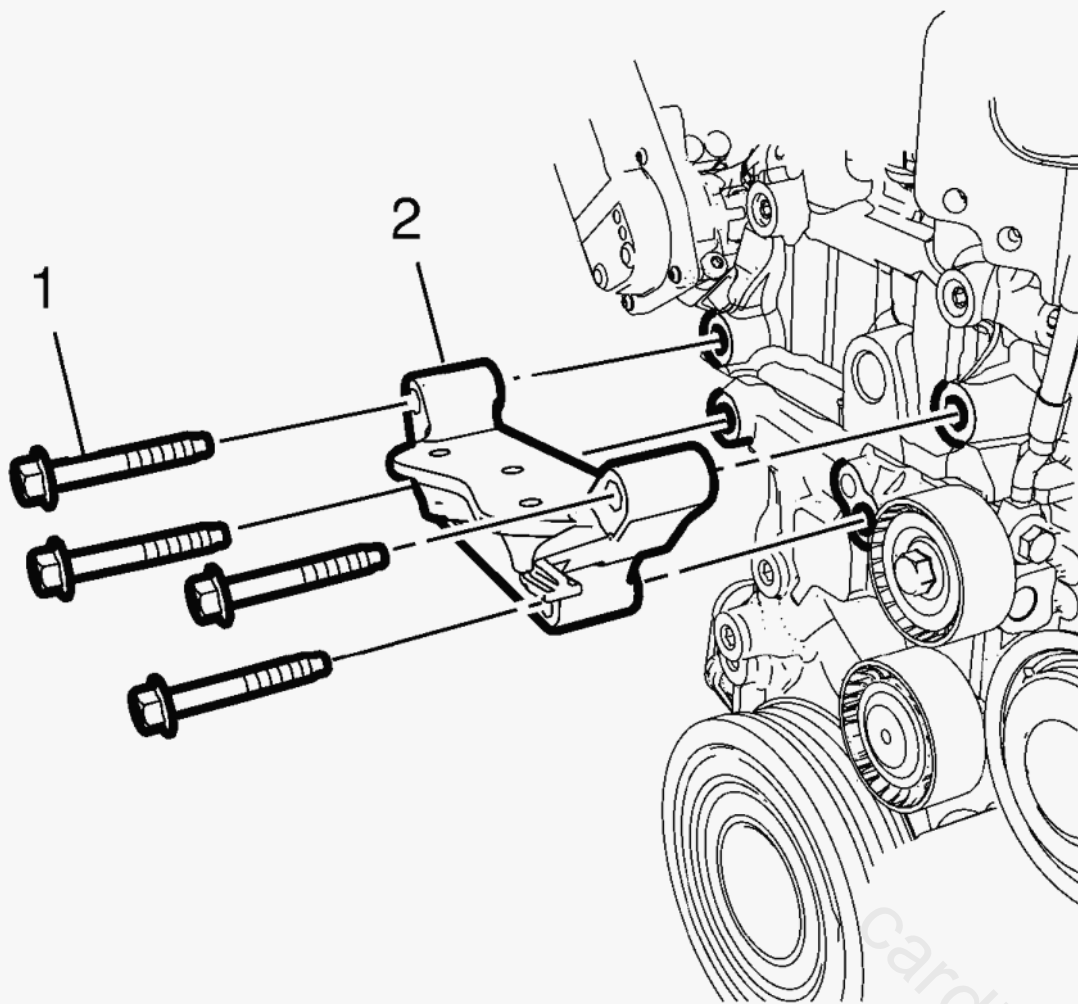


Fig. 398: Engine Mount Bracket And Bolts
Courtesy of GENERAL MOTORS COMPANY

2. Install Engine Mount Bracket (2)
3. Install the 2 lower engine mount bracket bolts (1) to the engine block and tighten to 58 N.m (43 lb ft).
4. Install Engine Mount. Refer to [Engine Mount Replacement](#)
5. Raise the vehicle. Refer to [Lifting and Jacking the Vehicle](#)

NOTE: The service information is supplied with the special tool and is also available online. Go to <https://gmtoolsandequipment.com>.

6. Lower the **CH-49290** support tool with the **CH-904** base frame and a jack.
7. Remove Oil and Power Brake Booster Pump. Refer to [Oil and Power Brake Booster Pump Replacement](#)

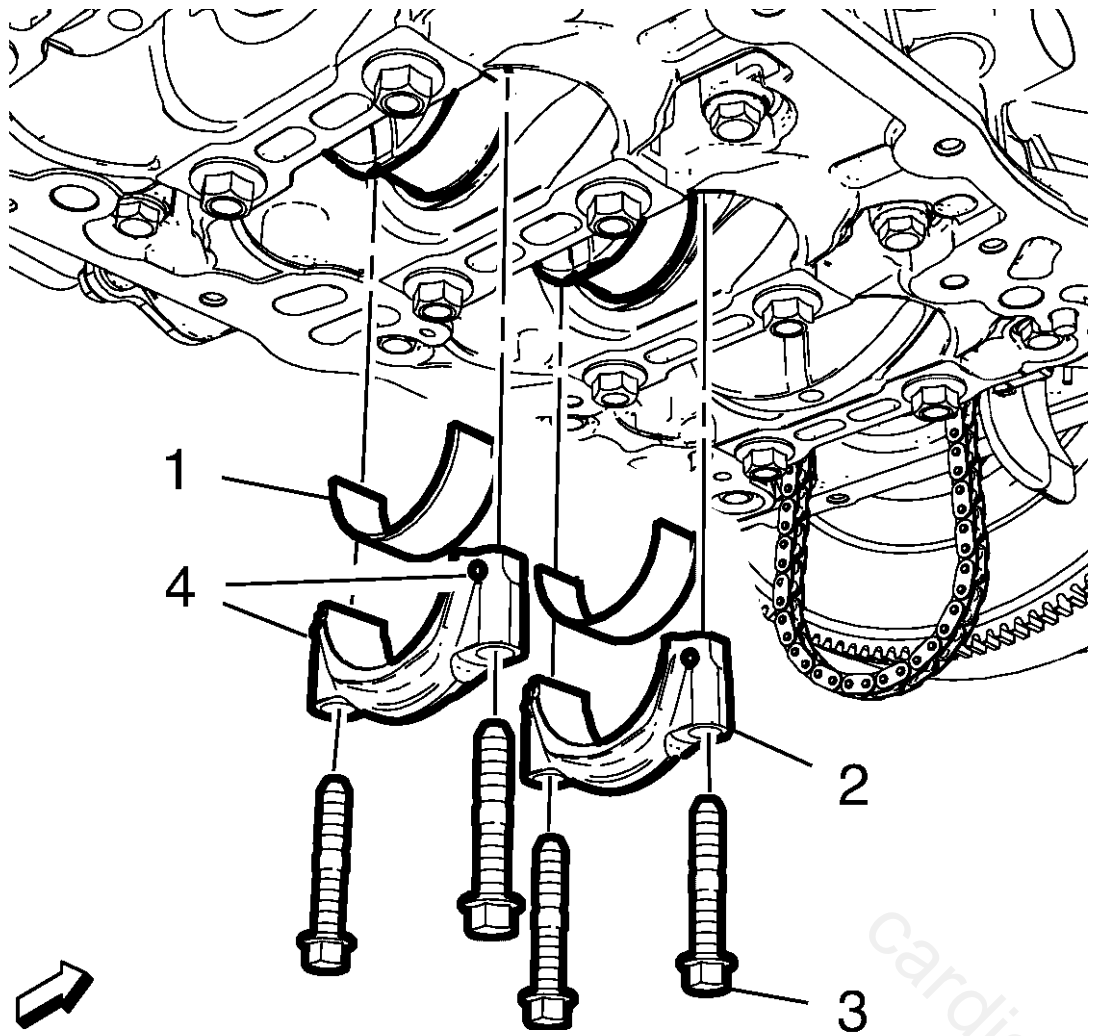


Fig. 399: Cylinder 2 And 3 Connecting Rod Caps, Bolts And Lower Bearings
Courtesy of GENERAL MOTORS COMPANY

8. Remove and DISCARD the 4 connecting rod bearing cap bolts (3) from the cylinder 2 and the cylinder 3.

NOTE: Lay aside in the order as they was removed.

NOTE: The shear surfaces of the connecting rod and the connecting rod bearing cap form a unique fit and must not be swapped or damaged. Do not lay down on the shear surfaces.

9. Remove the 2 connecting rod bearing caps (2) from the cylinder 2 and the cylinder 3.

NOTE: Lay aside in the order as they was removed.

10. Remove the 2 connecting rod lower bearings (1).
11. Lower the vehicle.

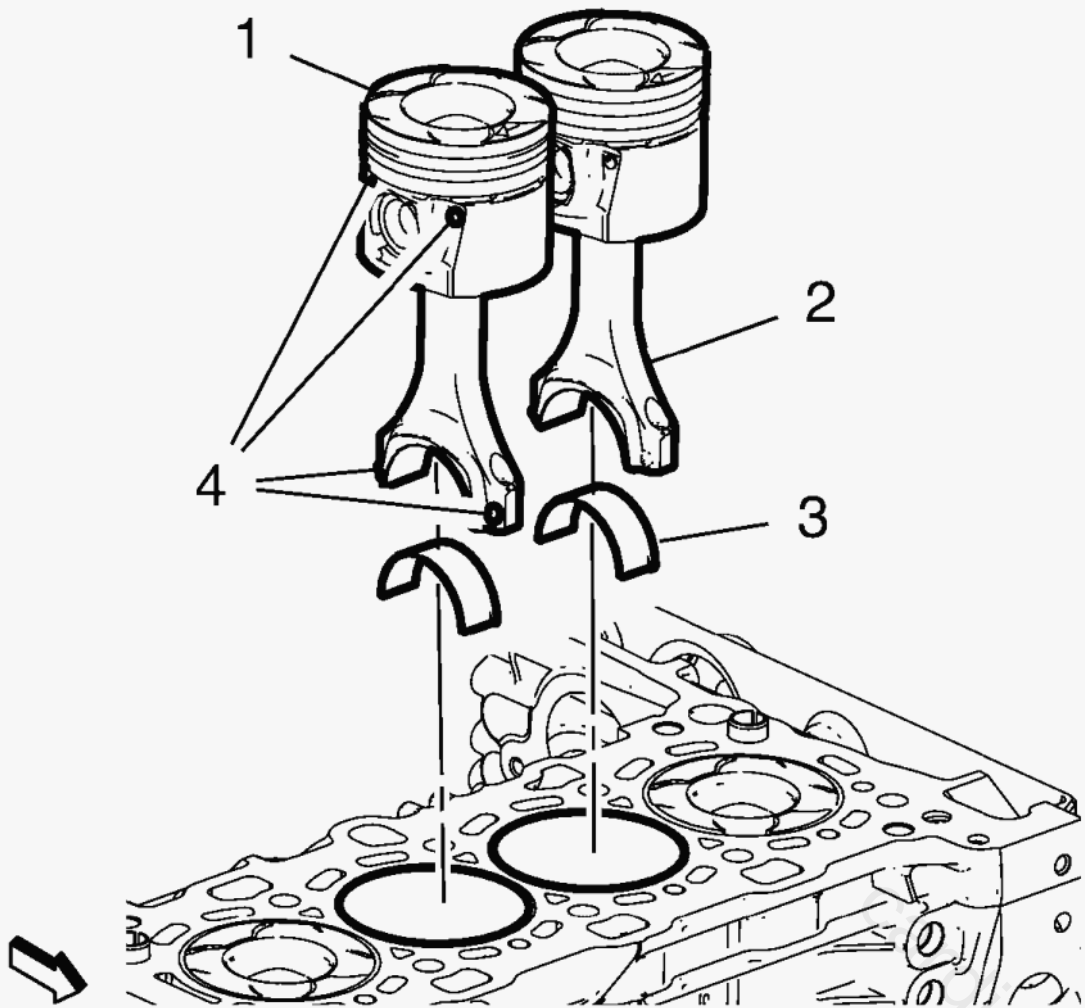


Fig. 400: Cylinder 2 And 3 Piston/Connecting Rod Assemblies And Upper Bearings
Courtesy of GENERAL MOTORS COMPANY

NOTE: Lay aside in the order as they was removed.

12. Push the 2 pistons (1) with the 2 connecting rods (2) out of the cylinder 2 and the cylinder 3 upwards.

NOTE: Lay aside in the order as they was removed.

13. Remove the 2 connecting rod upper bearings (3) from the 2 connecting rods (2).

14. Raise the vehicle.

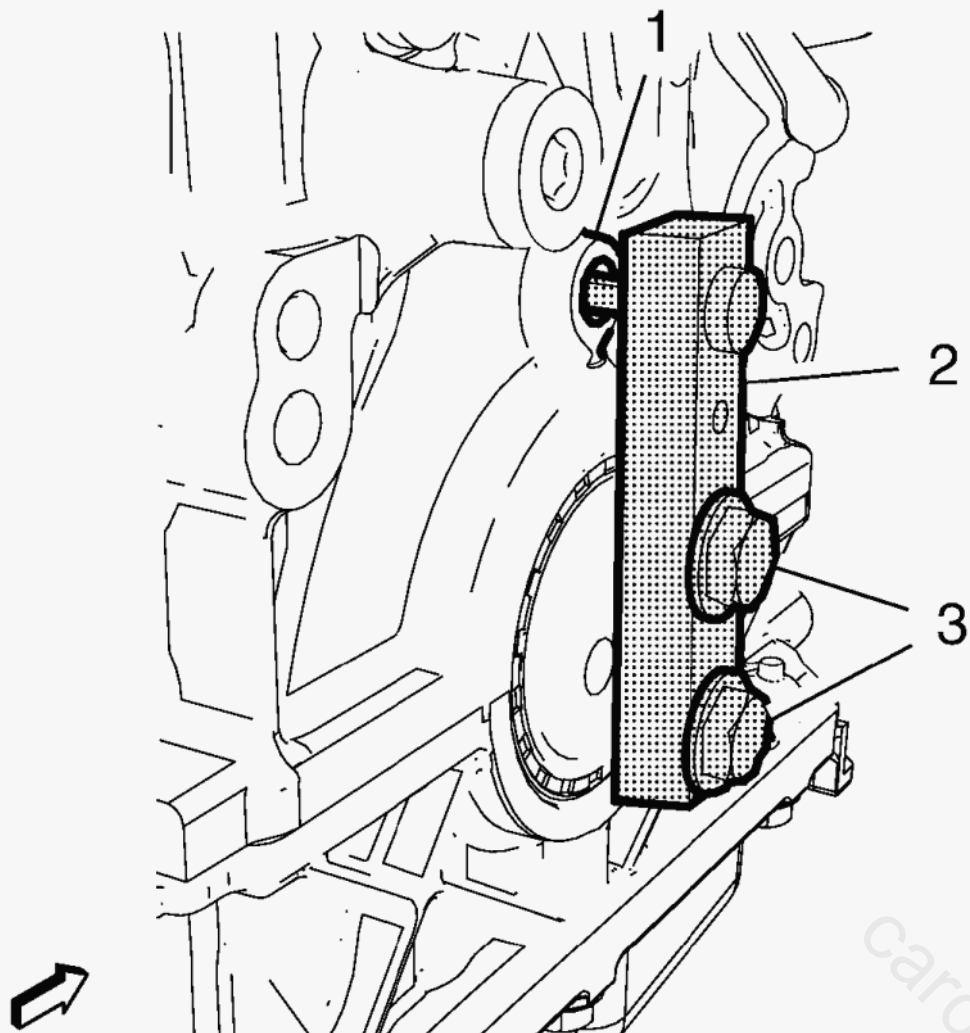


Fig. 401: Crankshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

15. Remove the 2 bolts (3).
16. Remove the **EN-51140** fixing tool (2).

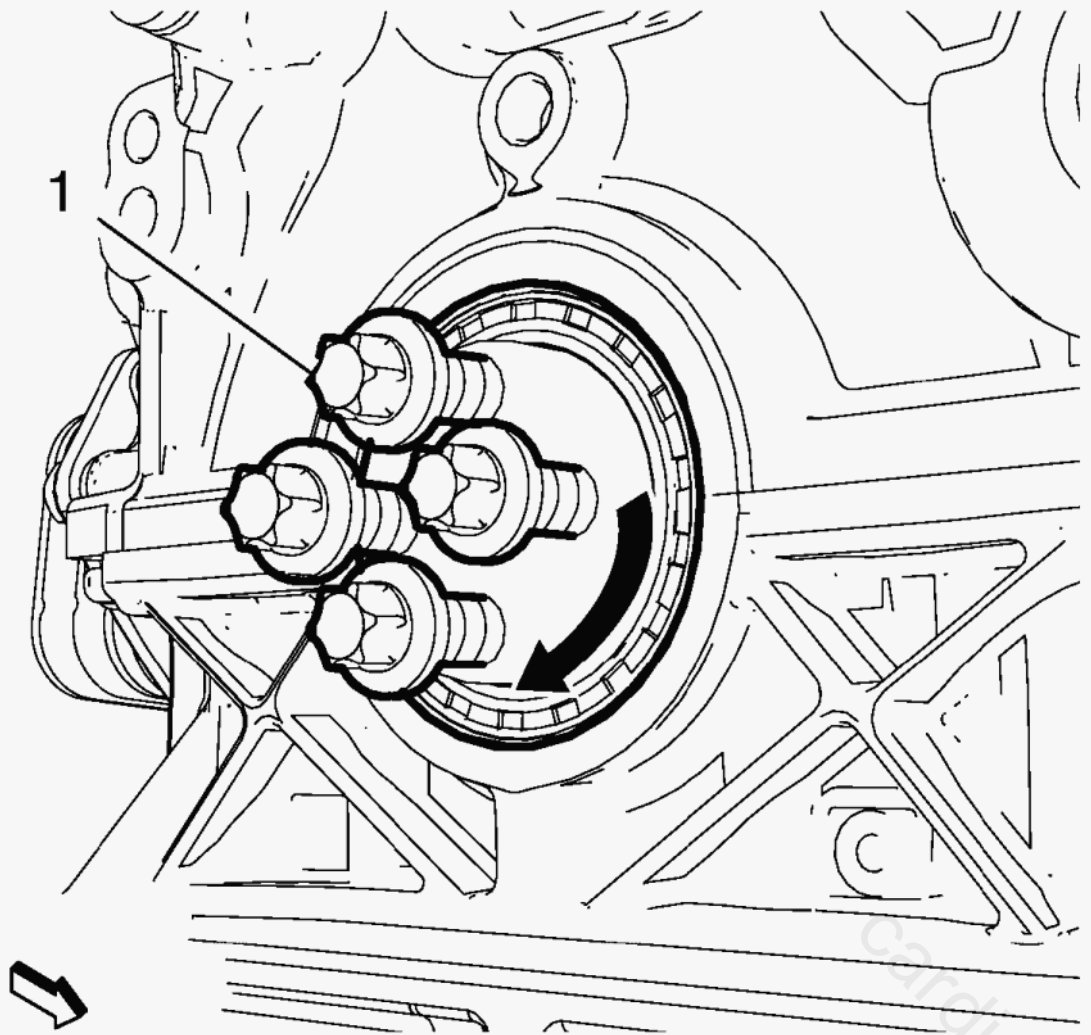


Fig. 402: Crankshaft Pulley Bolts

Courtesy of GENERAL MOTORS COMPANY

17. Install the 4 crankshaft pulley bolts (1).

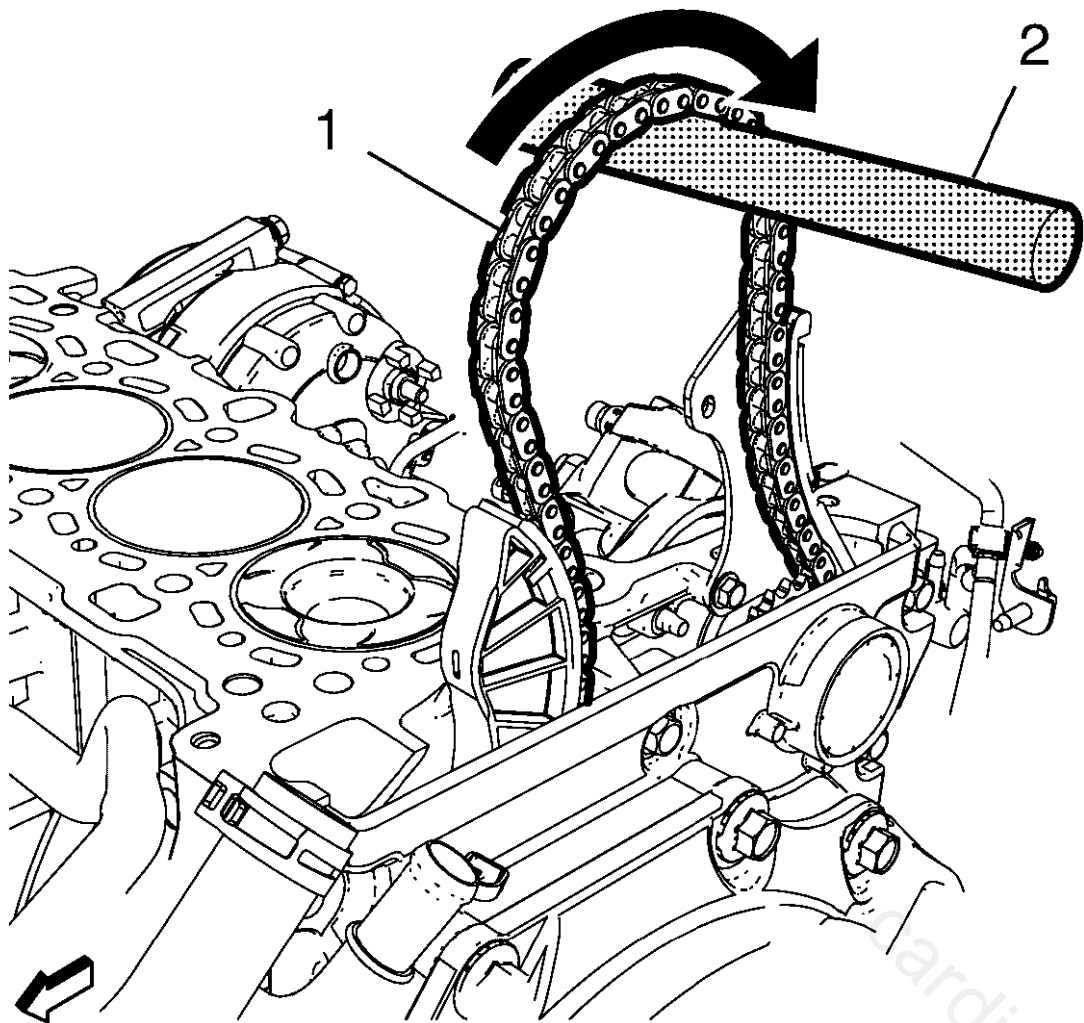


Fig. 403: Timing Chain And Suitable Tool

Courtesy of GENERAL MOTORS COMPANY

18. Hold the timing chain (1) up with a suitable tool like a extension (2).

NOTE: **A second technician is required.**

19. Set the cylinder 2 to TDC. Rotate the crankshaft 180 degrees, use a pry bar at the 4 crankshaft pulley bolts (1).

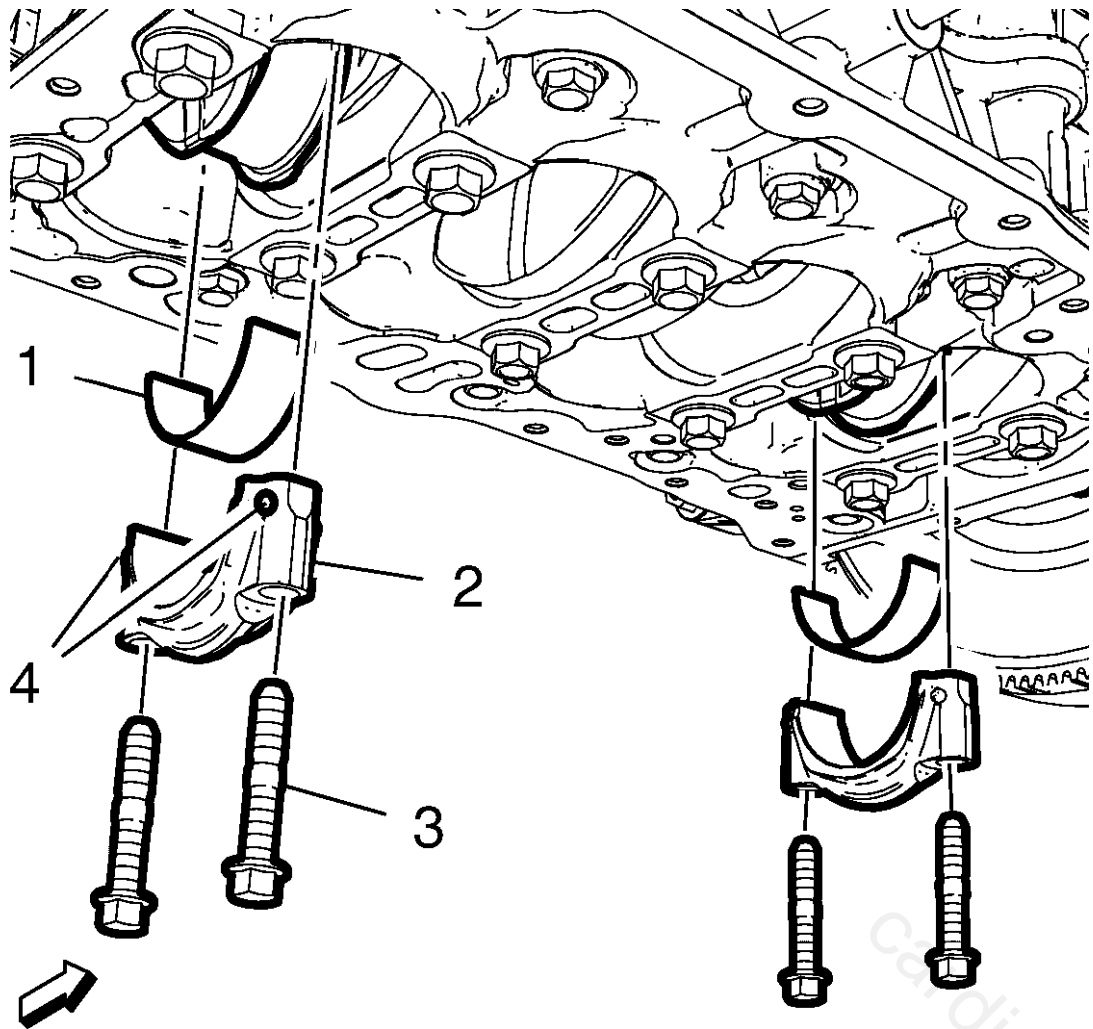


Fig. 404: Cylinder 1 And 4 Connecting Rod Caps, Bolts And Lower Bearings
Courtesy of GENERAL MOTORS COMPANY

20. Remove and DISCARD the 4 connecting rod bearing cap bolts (3) from the cylinder 1 and the cylinder 4.

NOTE: Lay aside in the order as they was removed.

NOTE: The shear surfaces of the connecting rod and the connecting rod bearing cap form a unique fit and must not be swapped or damaged. Do not lay down on the shear surfaces.

21. Remove the 2 connecting rod bearing caps (2) from the cylinder 1 and the cylinder 4.

NOTE: Lay aside in the order as they was removed.

22. Remove the 2 connecting rod lower bearings (1).

23. Lower the vehicle.

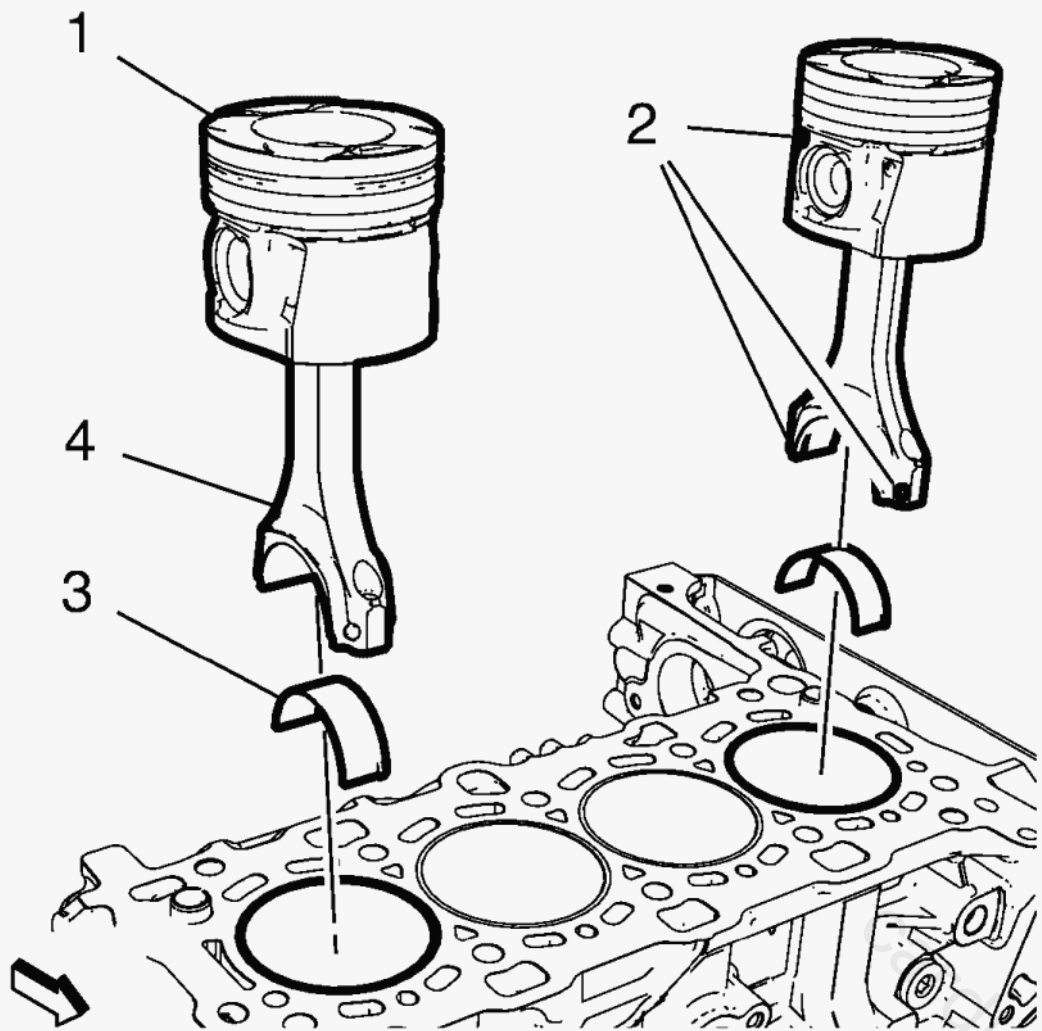


Fig. 405: Cylinder 1 And 4 Piston/Connecting Rod Assemblies And Upper Bearings
Courtesy of GENERAL MOTORS COMPANY

NOTE: Lay aside in the order as they was removed.

24. Push the 2 pistons (1) with the 2 connecting rods (4) out of the cylinder 1 and the cylinder 4 upwards.

NOTE: Lay aside in the order as they was removed.

25. Remove the 2 connecting rod upper bearings (3) from the 2 connecting rods (4).

26. Disassemble the piston and connecting rod. Refer to [Piston and Connecting Rod Disassemble](#).

Installation Procedure

1. Assemble the piston and connecting rod. Refer to [Piston and Connecting Rod Assemble](#).

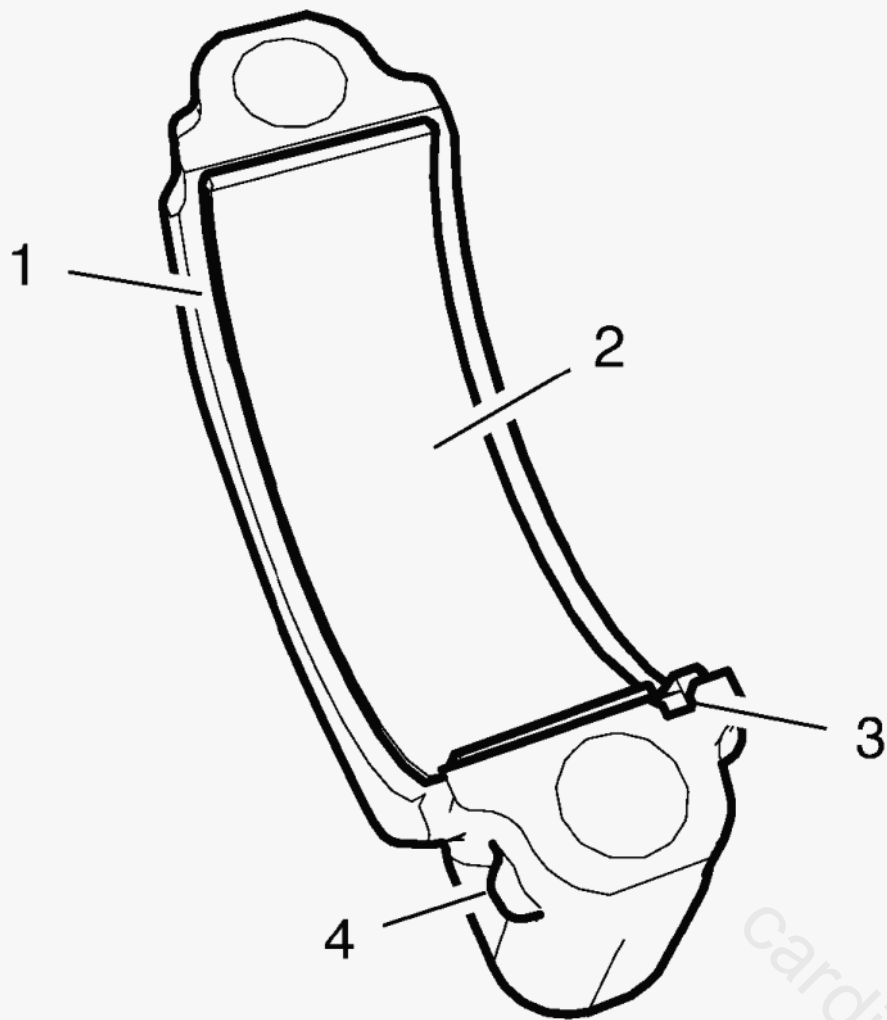


Fig. 406: Connecting Rod Bearings, Caps And Oil Notches
Courtesy of GENERAL MOTORS COMPANY

NOTE: Ensure the proper seat of the oil notches (3).

NOTE: If the old connecting rod bearings will be reused, install in their original position.

2. Install the 8 connecting rod bearings (2) to the connecting rod bearing cap (1) and the connecting rod.
3. Coat the 8 connecting rod bearings and cylinder bores with engine oil.

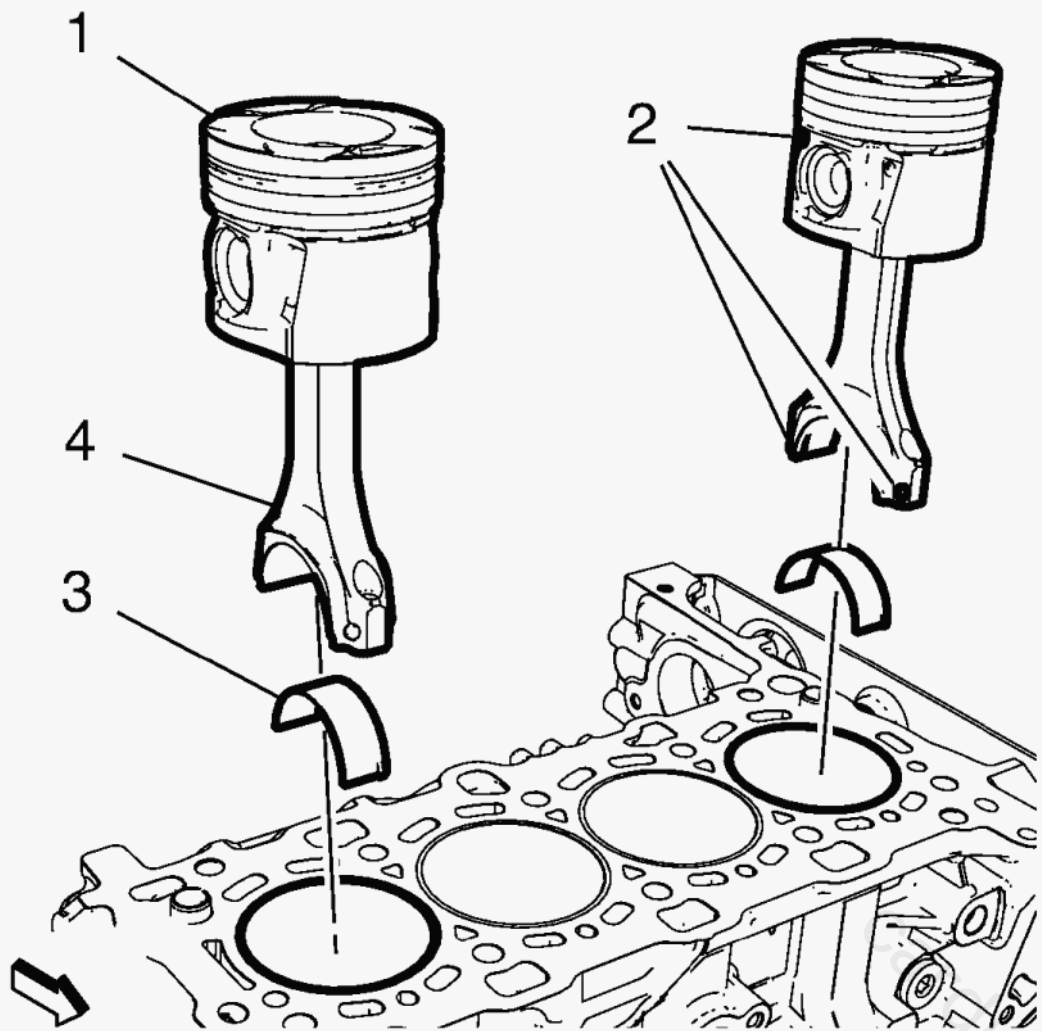


Fig. 407: Cylinder 1 And 4 Piston/Connecting Rod Assemblies And Upper Bearings
Courtesy of GENERAL MOTORS COMPANY

4. Install a piston ring compressor in order to compress the piston rings.

NOTE: The arrow on the top of the piston and the marks (2) of the piston and connecting rod, must point to front of the engine.

NOTE: If the old piston and connecting rod will be reused, install in their original position.

5. Install the 2 pistons (1) and the 2 connecting rods (4) with the connecting rod upper bearing (3) to the cylinder 1 and the cylinder 4.

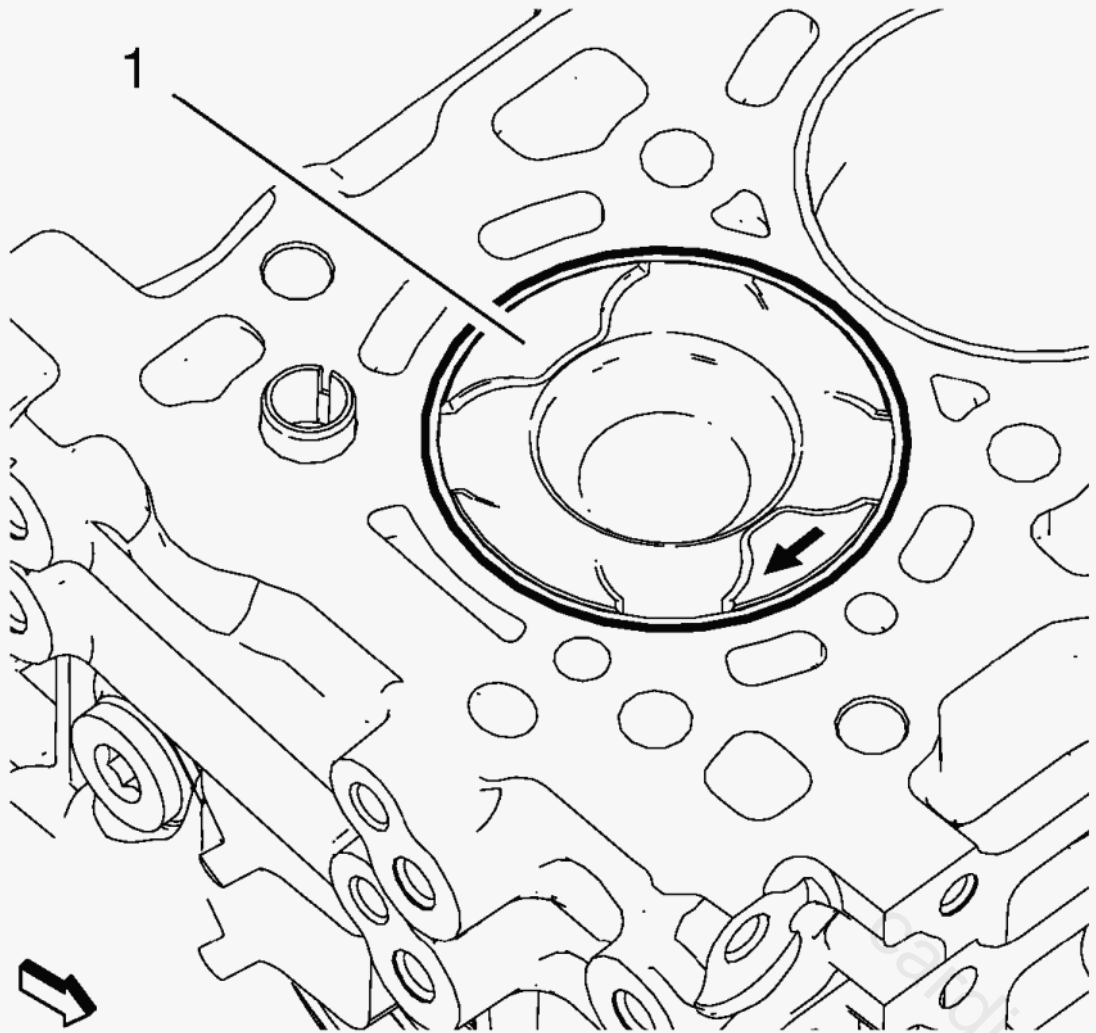


Fig. 408: Arrow On Top Of Pistons Must Point To Front Of Engine
Courtesy of GENERAL MOTORS COMPANY

6. The arrow on the top of the pistons (1) must point to front of the engine.
7. Raise the vehicle.

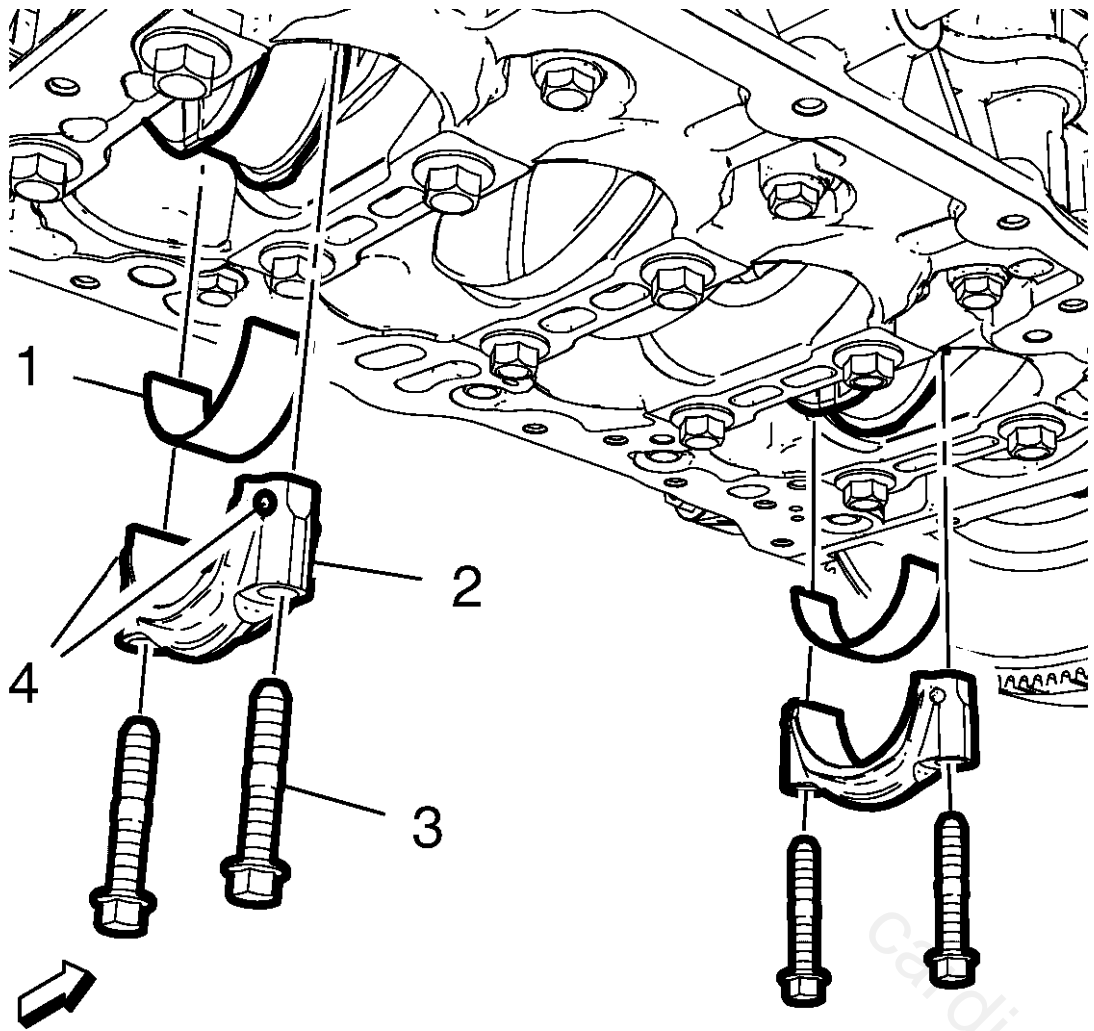


Fig. 409: Cylinder 1 And 4 Connecting Rod Caps, Bolts And Lower Bearings
Courtesy of GENERAL MOTORS COMPANY

NOTE: The marks (4) of the connecting rod bearing caps, must point to front of the engine.

NOTE: If the old connecting rod bearing caps will be reused, install in their original position.

8. Install the 2 connecting rod bearing caps (2) with the 2 connecting rod lower bearings (1) to the cylinder 1 and the cylinder 4.

CAUTION: Refer to [Fastener Caution](#)

CAUTION: Refer to [Torque-to-Yield Fastener Caution](#)

9. Install 4 NEW connecting bearing cap bolts (3) and tighten in two passes:
 1. First Pass: 25 N.m (18 lb ft).
 2. Final Pass: 110 degrees, using the **EN-45059** angle meter.

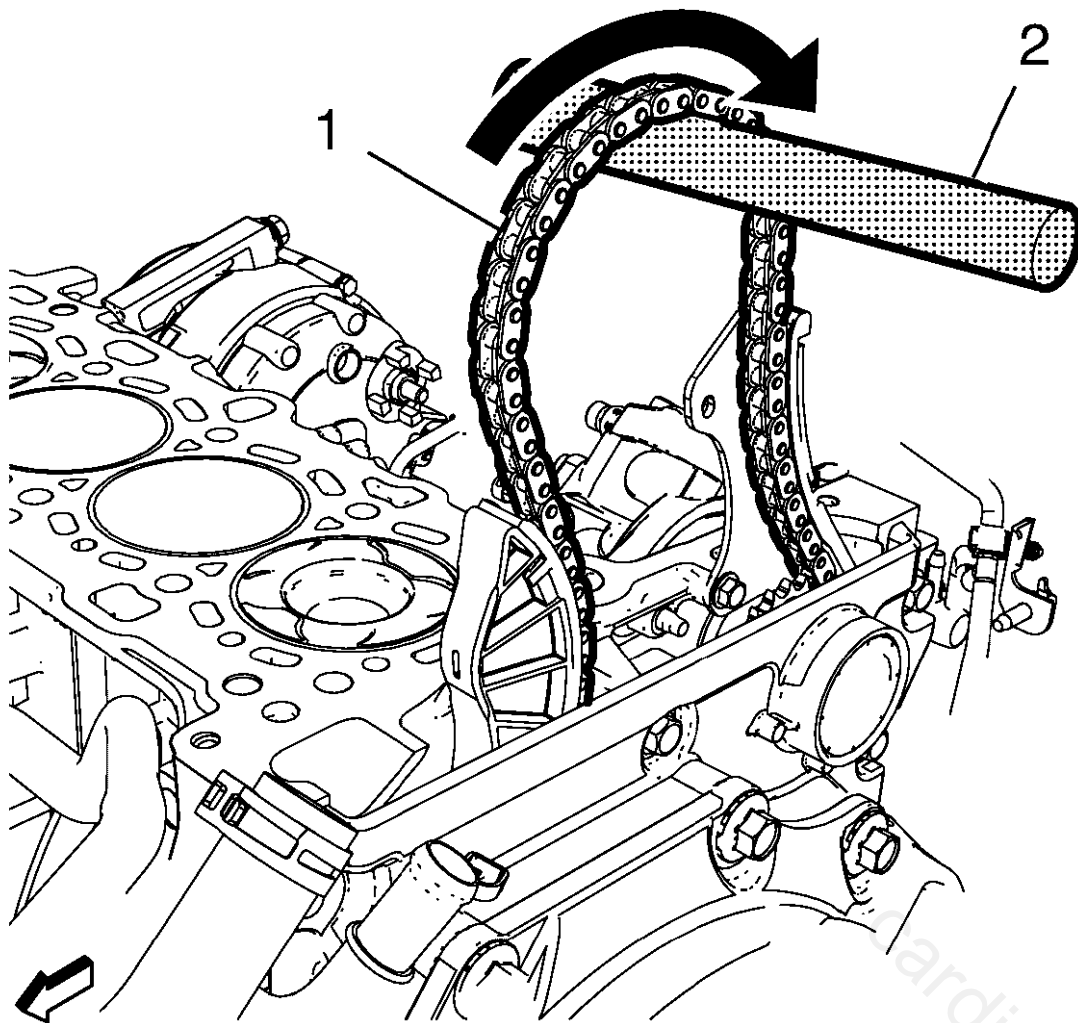


Fig. 410: Timing Chain And Suitable Tool

Courtesy of GENERAL MOTORS COMPANY

10. Hold the timing chain (1) up with a suitable tool like a extension (2).

NOTE: **A second technician is required.**

11. Set TDC of the cylinder 1. Rotate the crankshaft 180 degrees, use a pry bar at the 4 crankshaft pulley bolts (1).

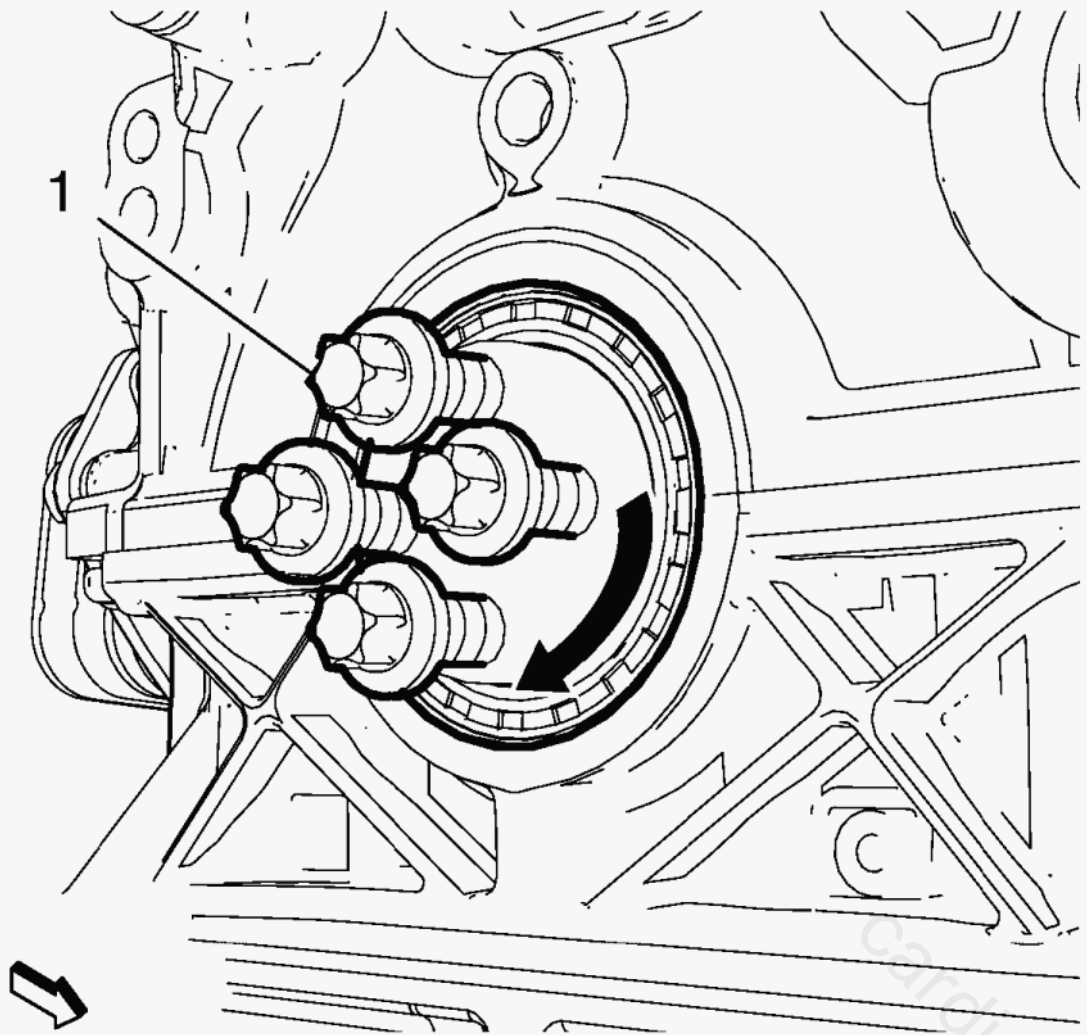


Fig. 411: Crankshaft Pulley Bolts

Courtesy of GENERAL MOTORS COMPANY

12. Remove the 4 crankshaft pulley bolts (1).

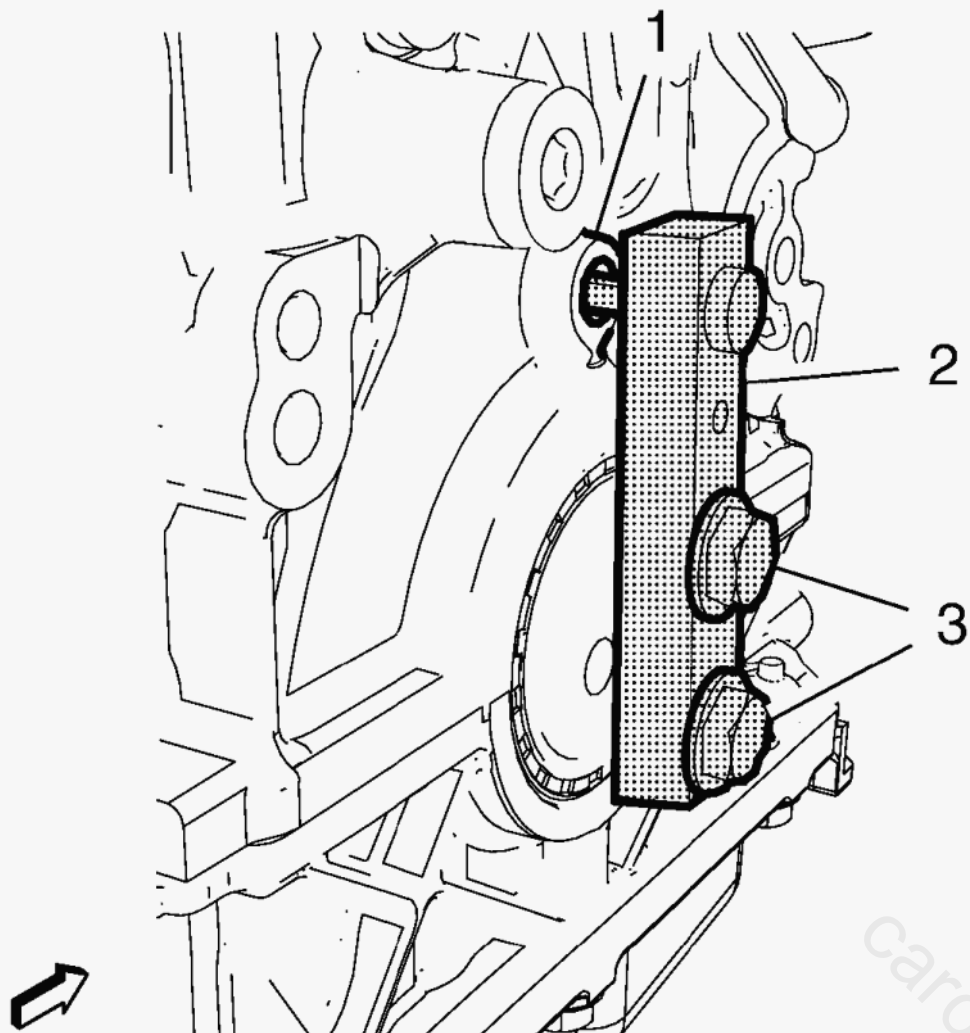


Fig. 412: Crankshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

13. Install **EN-51140** fixing tool (2).
14. Install the fixing pin into the engine block bore (1) and tighten the 2 bolts (3).
15. Lower the vehicle.

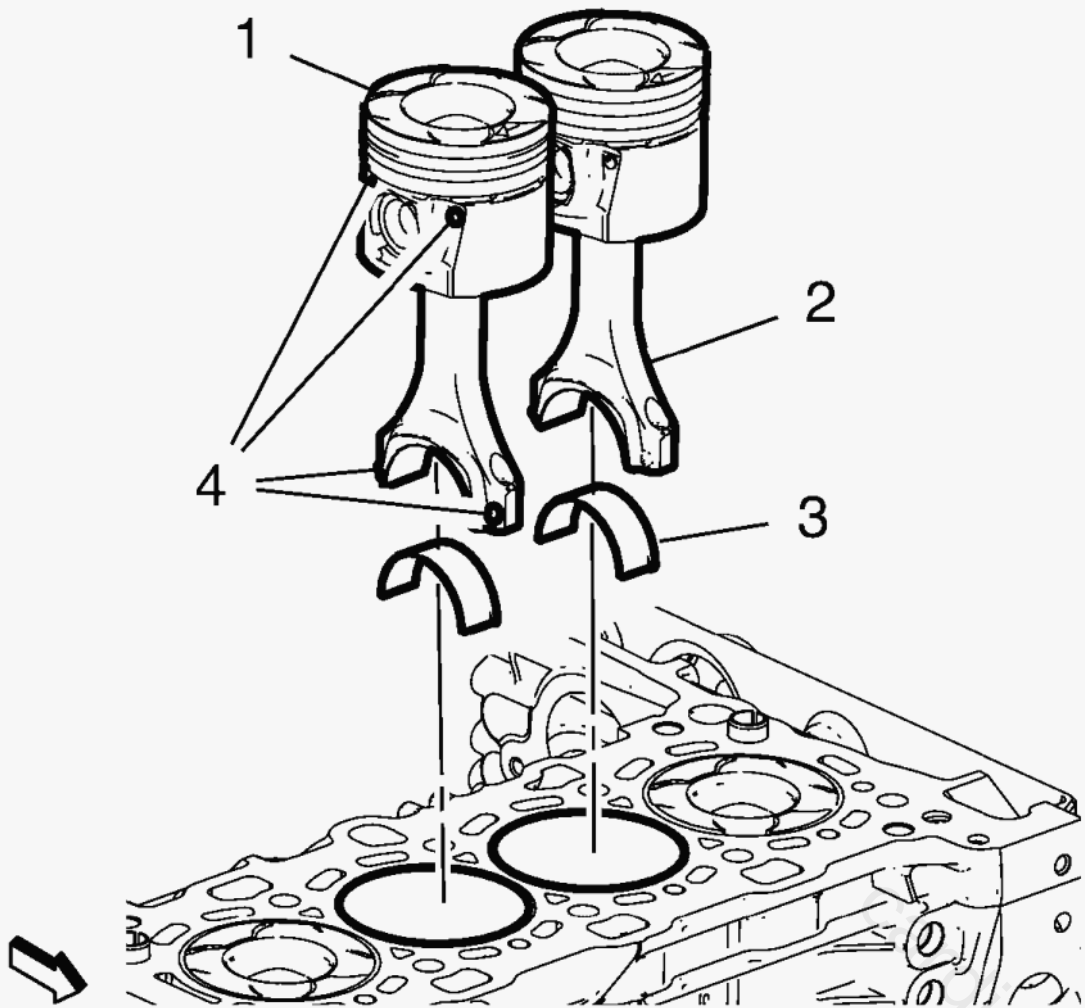


Fig. 413: Cylinder 2 And 3 Piston/Connecting Rod Assemblies And Upper Bearings
Courtesy of GENERAL MOTORS COMPANY

16. Install a piston ring compressor in order to compress the piston rings.

NOTE: The arrow on the top of the piston and the marks (4) of the piston and connecting rod, must point to front of the engine.

NOTE: If the old piston and connecting rod will be reused, install in their original position.

17. Install the 2 pistons (1) and the 2 connecting rods (2) with the connecting rod upper bearing (3) to the cylinder 2 and the cylinder 3.

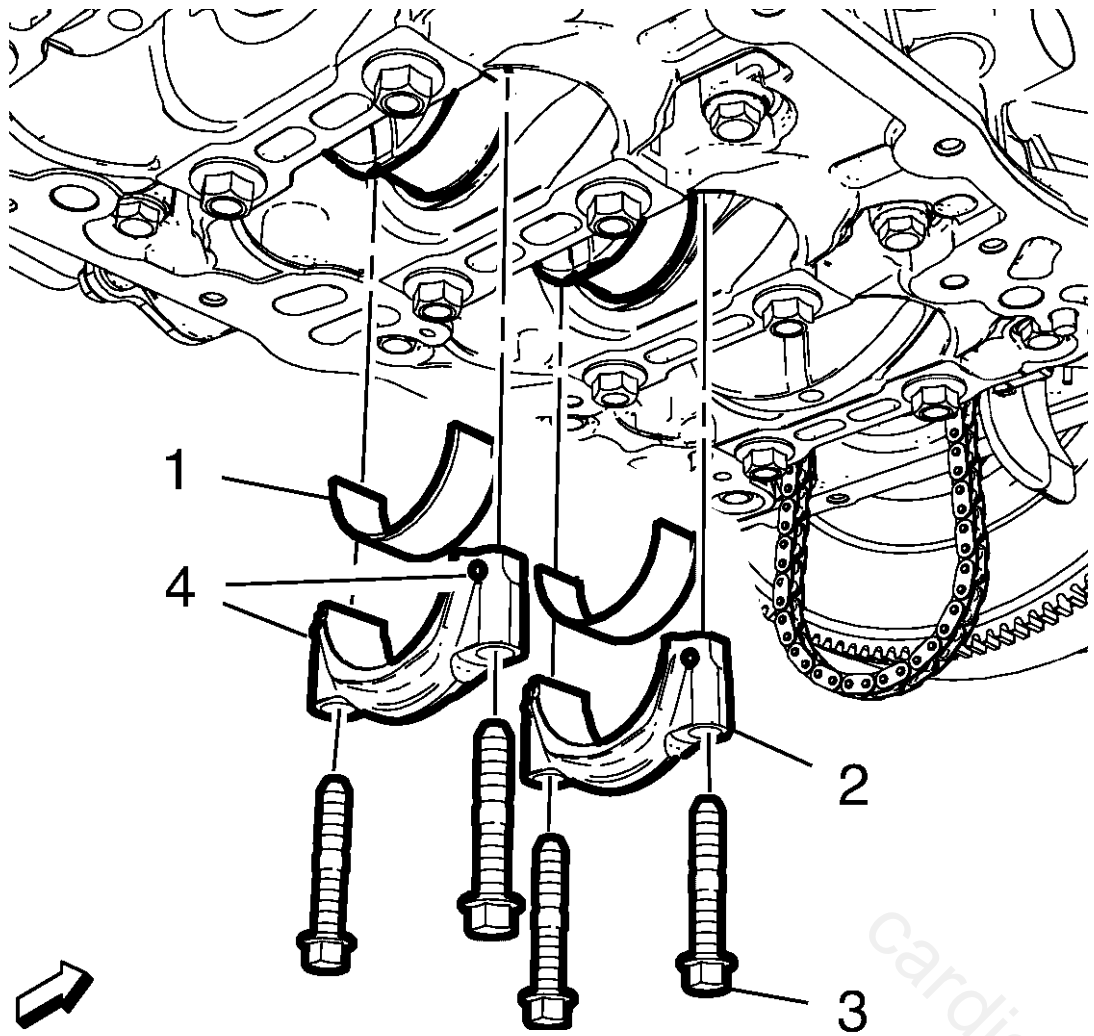


Fig. 414: Cylinder 2 And 3 Connecting Rod Caps, Bolts And Lower Bearings
Courtesy of GENERAL MOTORS COMPANY

NOTE: The marks (4) of the connecting rod bearing caps, must point to front of the engine.

NOTE: If the old connecting rod bearing caps will be reused, install in their original position.

18. Install the 2 connecting rod bearing caps (2) with the 2 connecting rod lower bearings (1) to the cylinder 2 and the cylinder 3.
19. Install 4 NEW connecting bearing cap bolts (3) and tighten in two passes:

CAUTION: Refer to **Fastener Caution**

1. First pass tighten to 25 N.m (18 lb ft).
2. Final pass to an additional 110 degrees, using the EN-45059 angle meter.
20. Install Oil and Power Brake Booster Pump. Refer to **Oil and Power Brake Booster Pump Replacement**

NOTE: The service information is supplied with the special tool and is also available online. Go to <https://gmtoolsandequipment.com>.

21. Install the CH-49290 support tool with the CH-904 base frame and a jack. According to the details provided in the installation manual.
22. Lower the vehicle.
23. Remove Engine Mount. Refer to **Engine Mount Replacement**

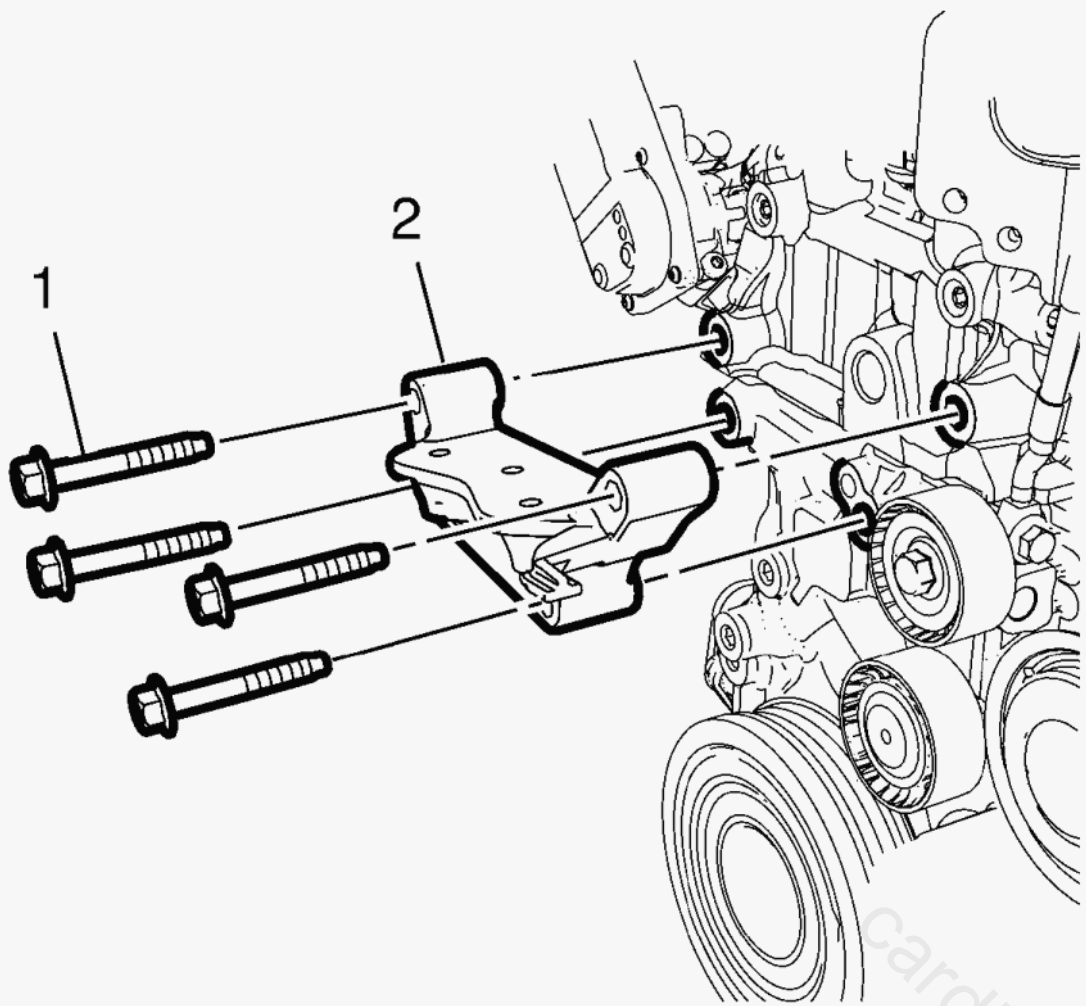


Fig. 415: Engine Mount Bracket And Bolts
Courtesy of GENERAL MOTORS COMPANY

24. Remove the 2 lower engine mount bracket bolts (1) from the engine block.
25. Remove Engine Mount Bracket (2)
26. Install Cylinder Head. Refer to [Cylinder Head Replacement](#)

OIL PUMP DRIVE CHAIN AND SPROCKET REPLACEMENT

Special Tools

- **EN-45059** Angle Meter
- **EN-50513** Fixing Pin
- **EN-51142** Oil Pump Sprocket Unit Holding Tool

Equivalent regional tools: [Special Tools](#).

Removal Procedure

1. Remove the timing chain lower cover. Refer to [Timing Chain Lower Cover Replacement](#).

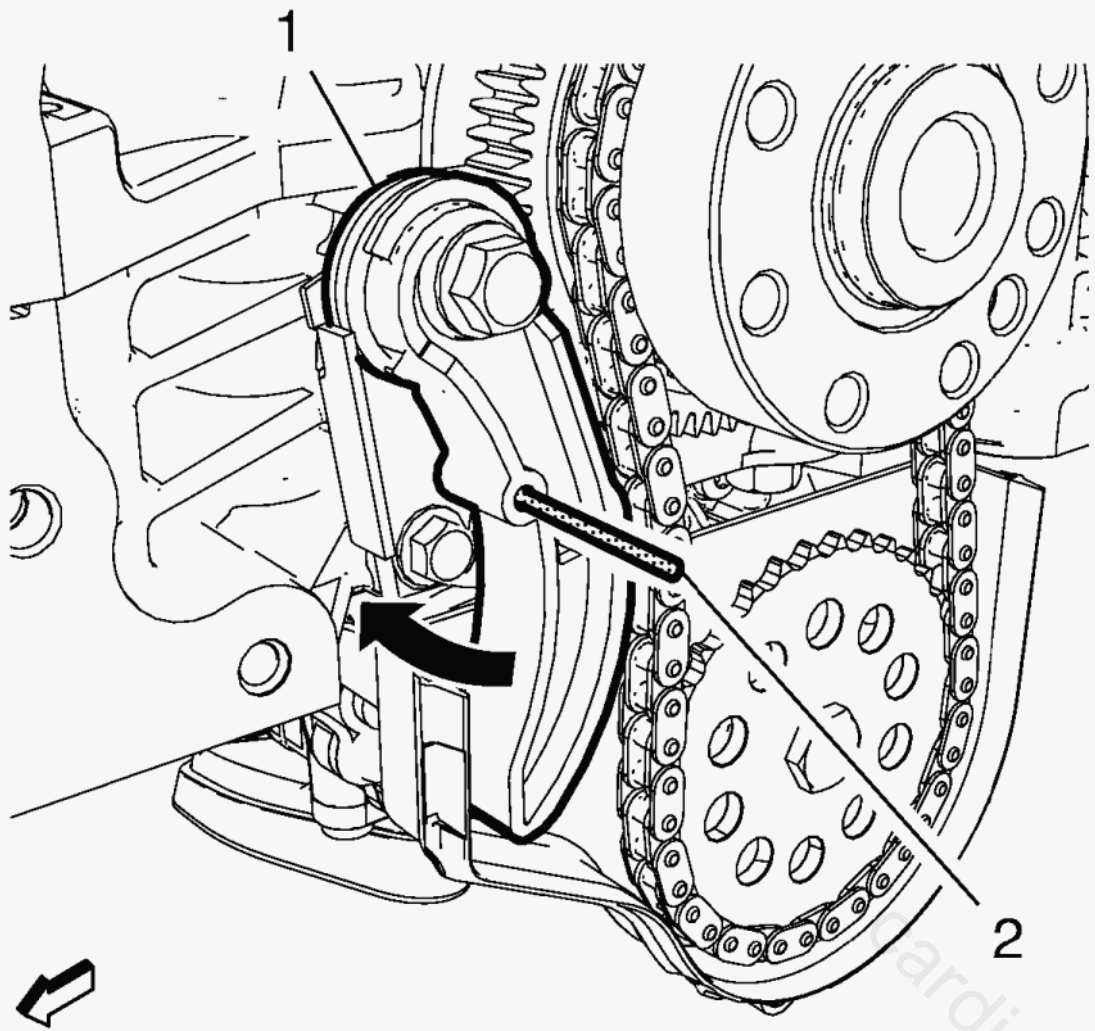


Fig. 416: Oil Pump Drive Chain Tensioner And Fixing Pin
Courtesy of GENERAL MOTORS COMPANY

2. Tension the oil pump drive chain tensioner (1) in arrow direction.
3. Install the **EN-50513** fixing pin (2).

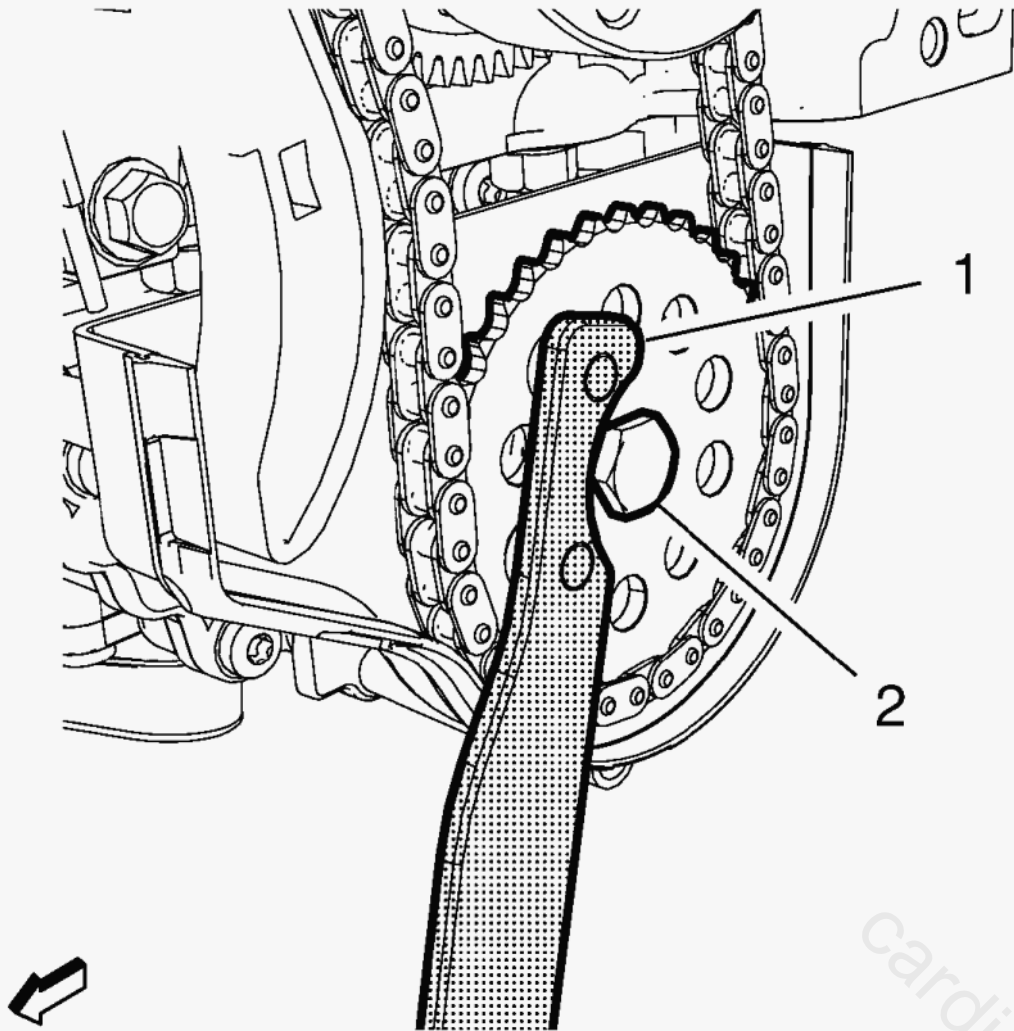


Fig. 417: Oil Pump Sprocket Bolt And Sprocket Holding Tool
Courtesy of GENERAL MOTORS COMPANY

4. Loosen the oil pump sprocket bolt (2), by counterhold with the **EN-51142** holding tool (1).

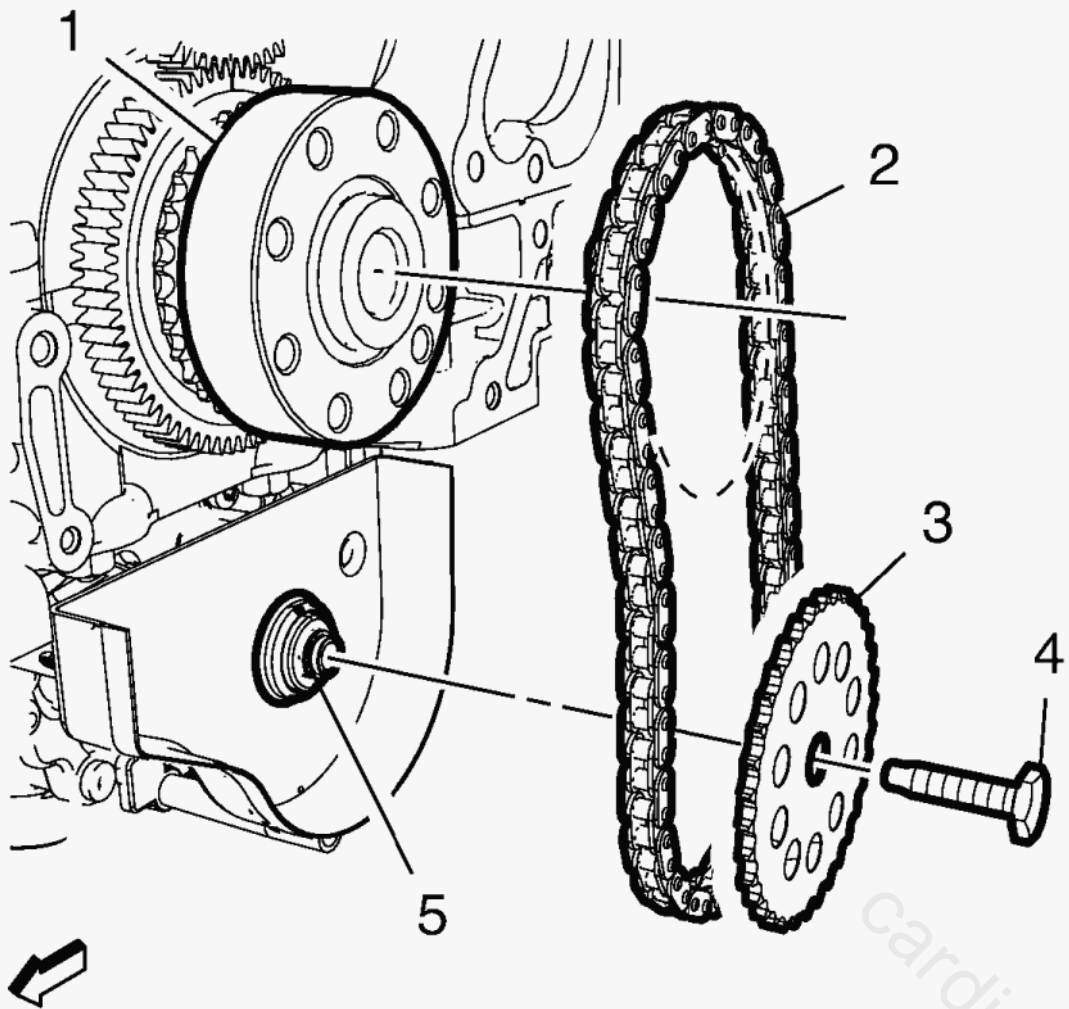


Fig. 418: Oil Pump Sprocket, Bolt, Shaft, Drive Chain And Drive Chain Sprocket
Courtesy of GENERAL MOTORS COMPANY

5. Remove and DISCARD the oil pump sprocket bolt (4).
6. Remove the oil pump sprocket (3) from the oil pump shaft (5).
7. Remove the oil pump drive chain (2) from the oil pump drive chain sprocket (1).

Installation Procedure

NOTE: Before installing the oil pump drive chain, check the components of the timing chain system for damage and wear.

1. Check the components of the timing chain system for damage and wear:
 - Timing chain guides with plastic attachment
 - Timing chain tensioner and timing chain tensioner shoe with plastic attachment
 - Timing chain and all timing chain sprockets
 - Oil pump sprocket
 - Oil pump drive chain tensioner

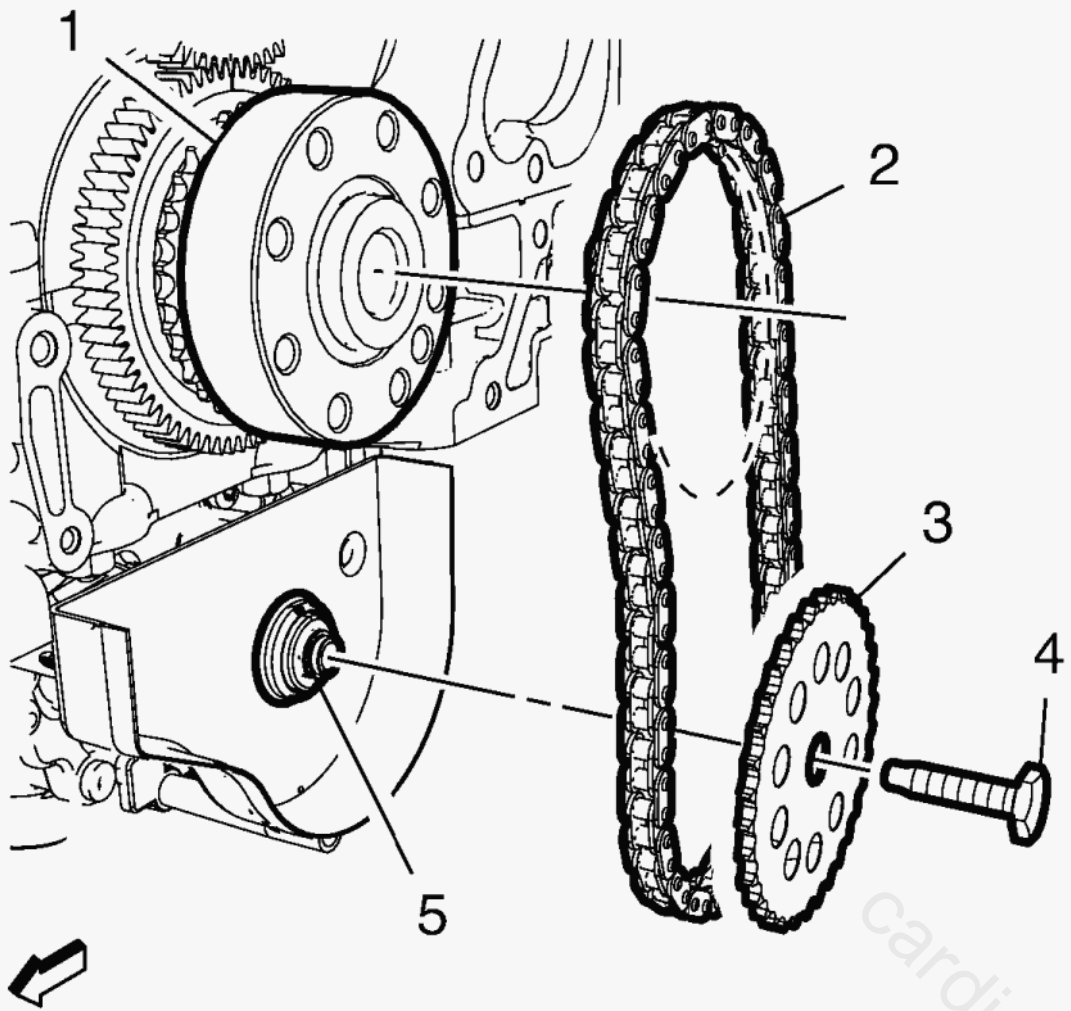


Fig. 419: Oil Pump Sprocket, Bolt, Shaft, Drive Chain And Drive Chain Sprocket
Courtesy of GENERAL MOTORS COMPANY

2. Install the oil pump drive chain (2) to the oil pump drive chain sprocket (1).
3. Install the oil pump sprocket (3) to the oil pump shaft (5).
4. Install a NEW oil pump sprocket bolt (4).

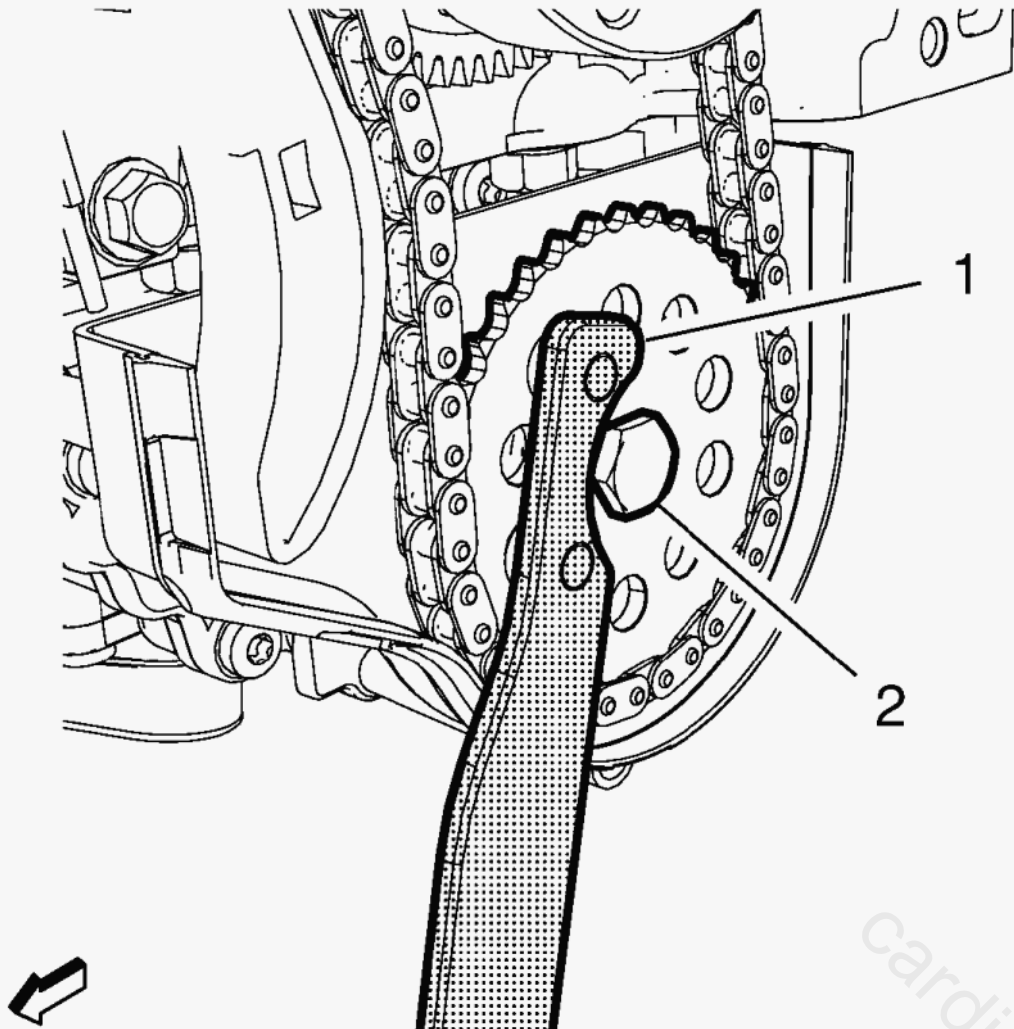


Fig. 420: Oil Pump Sprocket Bolt And Sprocket Holding Tool
 Courtesy of GENERAL MOTORS COMPANY

5. Hold the sprocket with the EN-51142 holding tool (1), and tighten the oil pump sprocket bolt (2) in 2 steps:

CAUTION: Refer to [Fastener Caution](#) .

CAUTION: Refer to [Torque-to-Yield Fastener Caution](#) .

1. Tighten in the first step to 25 N.m (18 lb ft).
 2. Tighten in the final step to an additional 60 degrees, using the EN-45059 angle meter.
6. Install the timing chain lower cover. Refer to [Timing Chain Lower Cover Replacement](#).

OIL PUMP DRIVE CHAIN TENSIONER REPLACEMENT

Special Tools

- EN-45059 Angle Meter
- EN-50513 Fixing Pin

For equivalent regional tools, refer to [Special Tools](#).

Removal Procedure

1. Remove the timing chain lower cover. Refer to [Timing Chain Lower Cover Replacement](#).

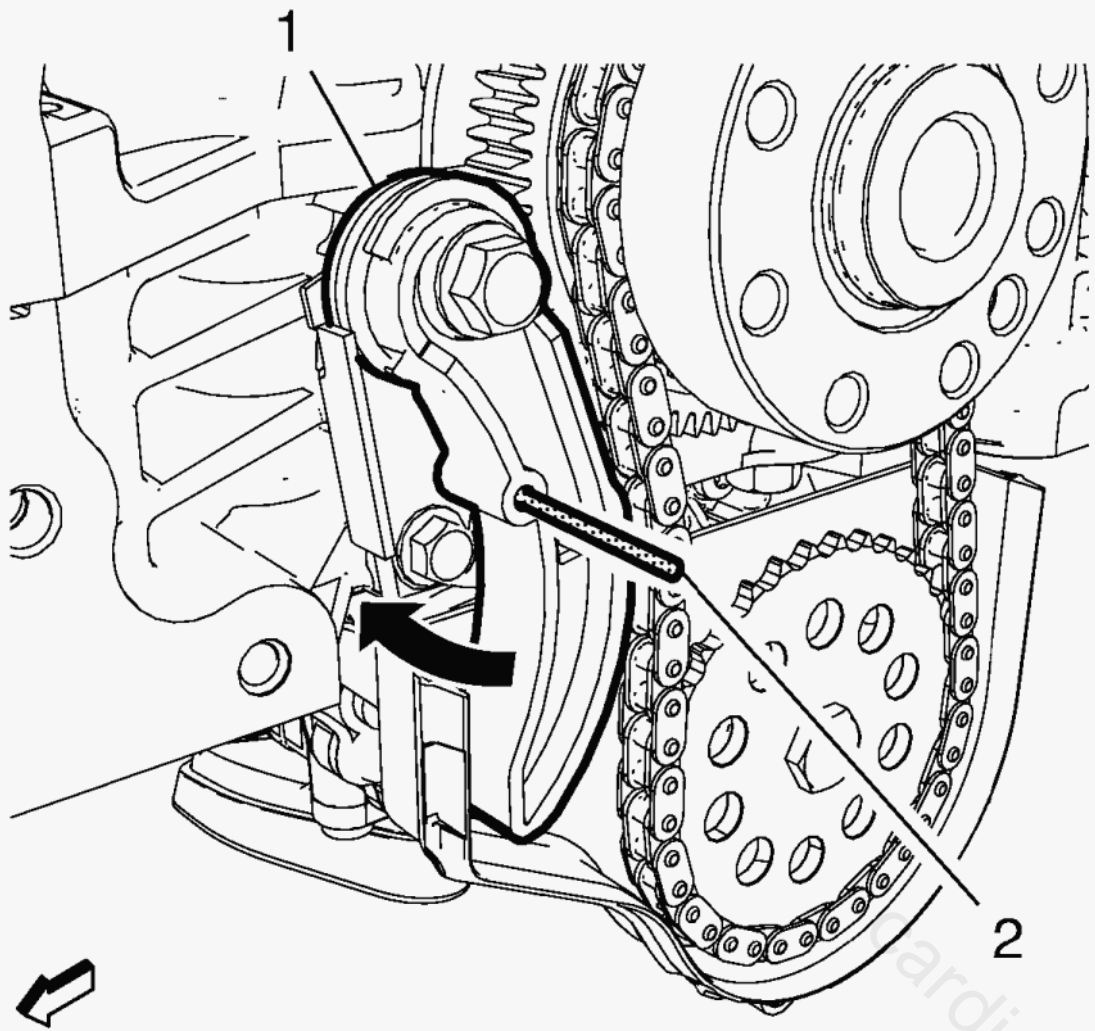


Fig. 421: Oil Pump Drive Chain Tensioner And Fixing Pin
Courtesy of GENERAL MOTORS COMPANY

2. Tension the oil pump drive chain tensioner (1) in arrow direction.
3. Install the **EN-50513** fixing pin (2).

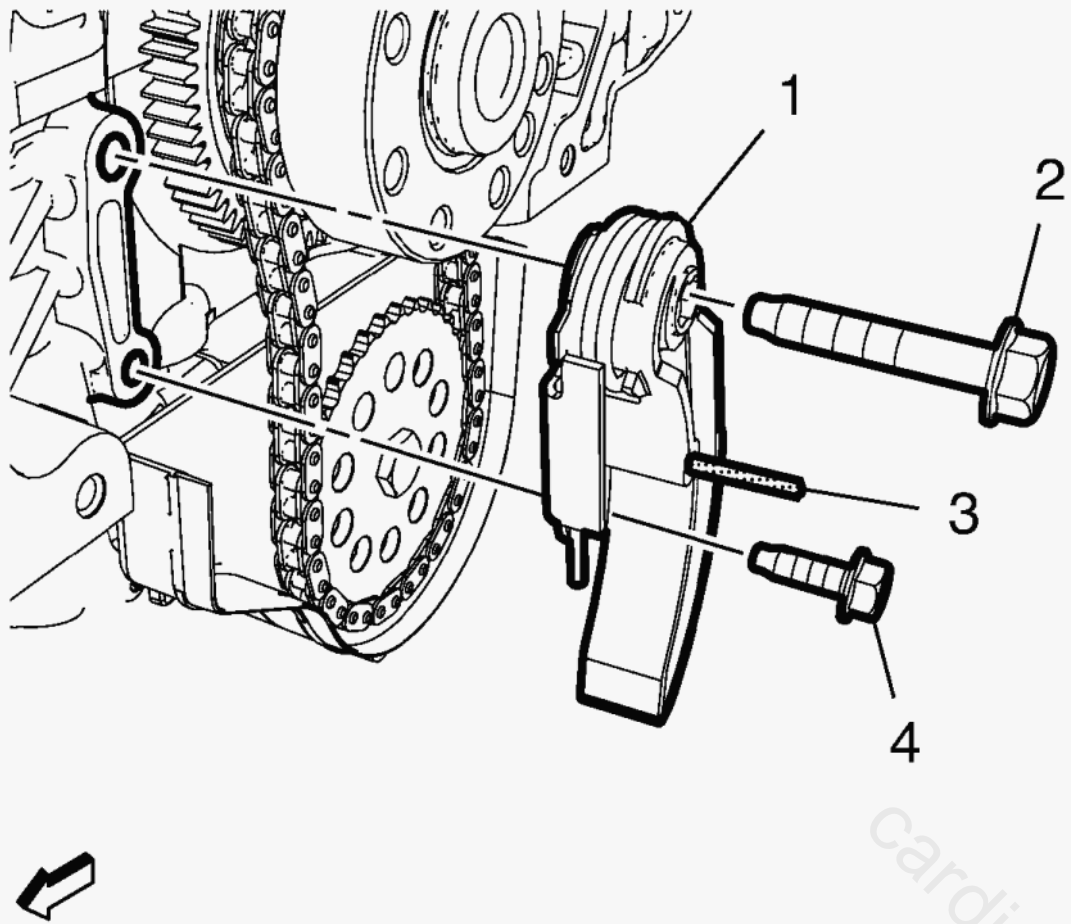


Fig. 422: Oil Pump Drive Chain Tensioner, Bolts And Fixing Pin
 Courtesy of GENERAL MOTORS COMPANY

4. Remove the oil pump drive chain tensioner bolt (4).
5. Remove the oil pump drive chain tensioner bolt (2).

NOTE: If the oil pump drive chain tensioner reused, do not remove the EN-50513 fixing pin (3).

6. Remove the oil pump drive chain tensioner (1).

Installation Procedure

NOTE: Before installing the oil pump drive chain tensioner, check the components of the timing chain system for damage and wear.

1. Check the components of the timing chain system for damage and wear:
 - Timing chain guides with plastic attachment
 - Timing chain tensioner and timing chain tensioner shoe with plastic attachment
 - Timing chain and all timing chain sprockets
 - Oil pump sprocket
 - Oil pump drive chain tensioner

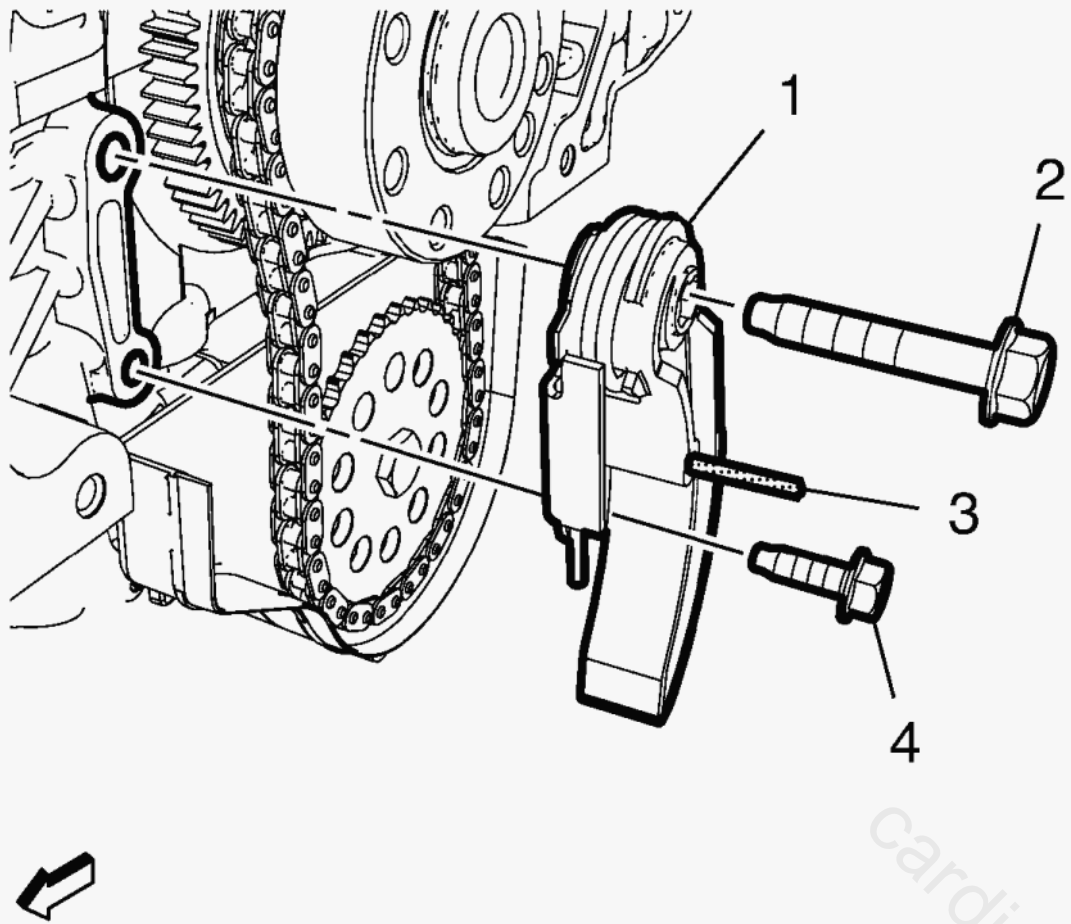


Fig. 423: Oil Pump Drive Chain Tensioner, Bolts And Fixing Pin
Courtesy of GENERAL MOTORS COMPANY

2. Install the oil pump drive chain tensioner (1).
3. Install the oil pump drive chain tensioner bolts (2, 4).

CAUTION: Refer to **Fastener Caution** .

4. Tighten the oil pump drive chain tensioner bolt (2) to 25 N.m (18 lb ft).
5. Tighten the oil pump drive chain tensioner bolt (4) to 10 N.m (89 lb in).

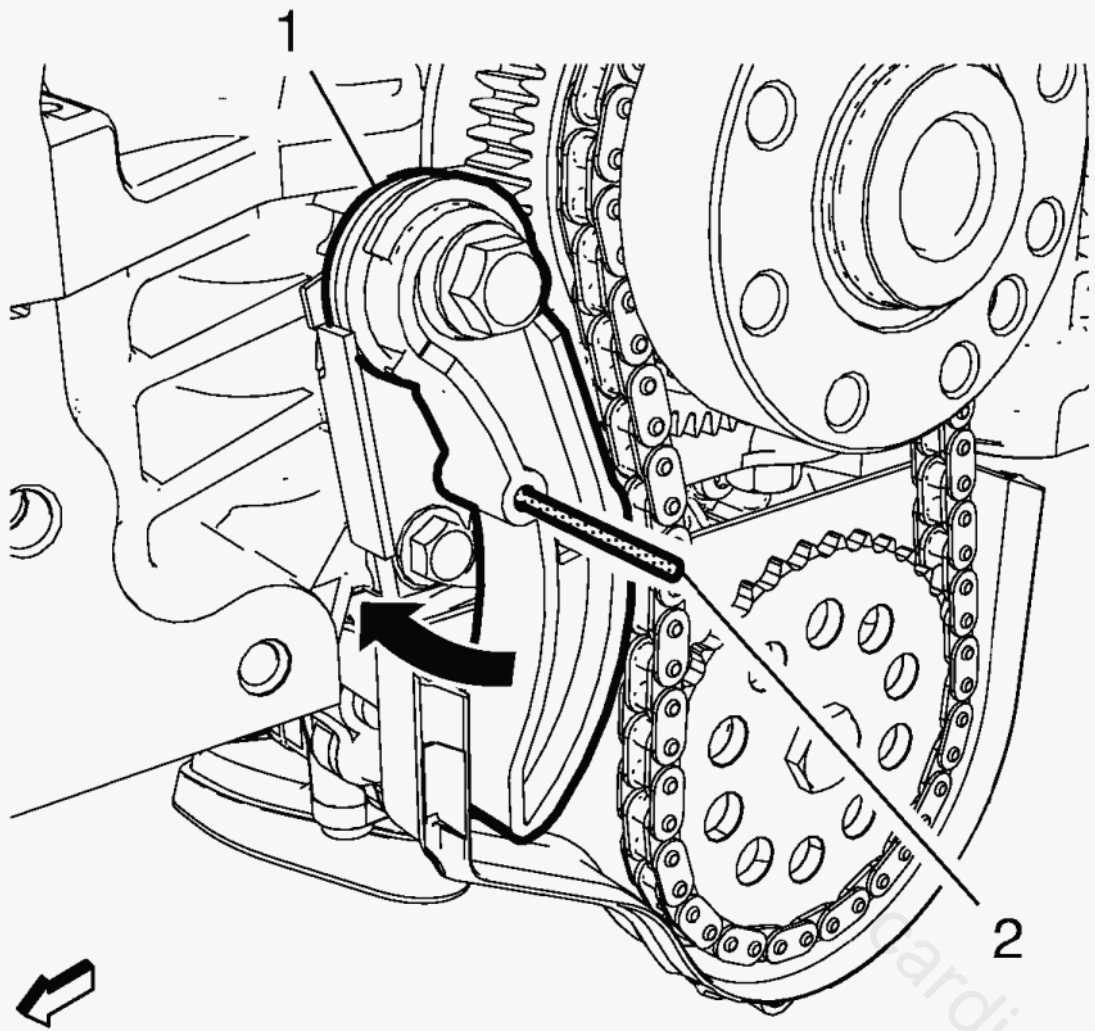


Fig. 424: Oil Pump Drive Chain Tensioner And Fixing Pin
Courtesy of GENERAL MOTORS COMPANY

6. Remove the EN-50513 fixing pin (2).
7. Install the timing chain lower cover. Refer to [Timing Chain Lower Cover Replacement](#).

OIL AND POWER BRAKE BOOSTER PUMP REPLACEMENT

Special Tools

EN-51142 Oil Pump Sprocket Unit Holding Tool

For equivalent regional tools, refer to [Special Tools](#).

Removal Procedure

1. Remove the automatic transmission flex plate. Refer to [Automatic Transmission Flex Plate Replacement](#).
2. Remove the oil pan. Refer to [Oil Pan Replacement](#).

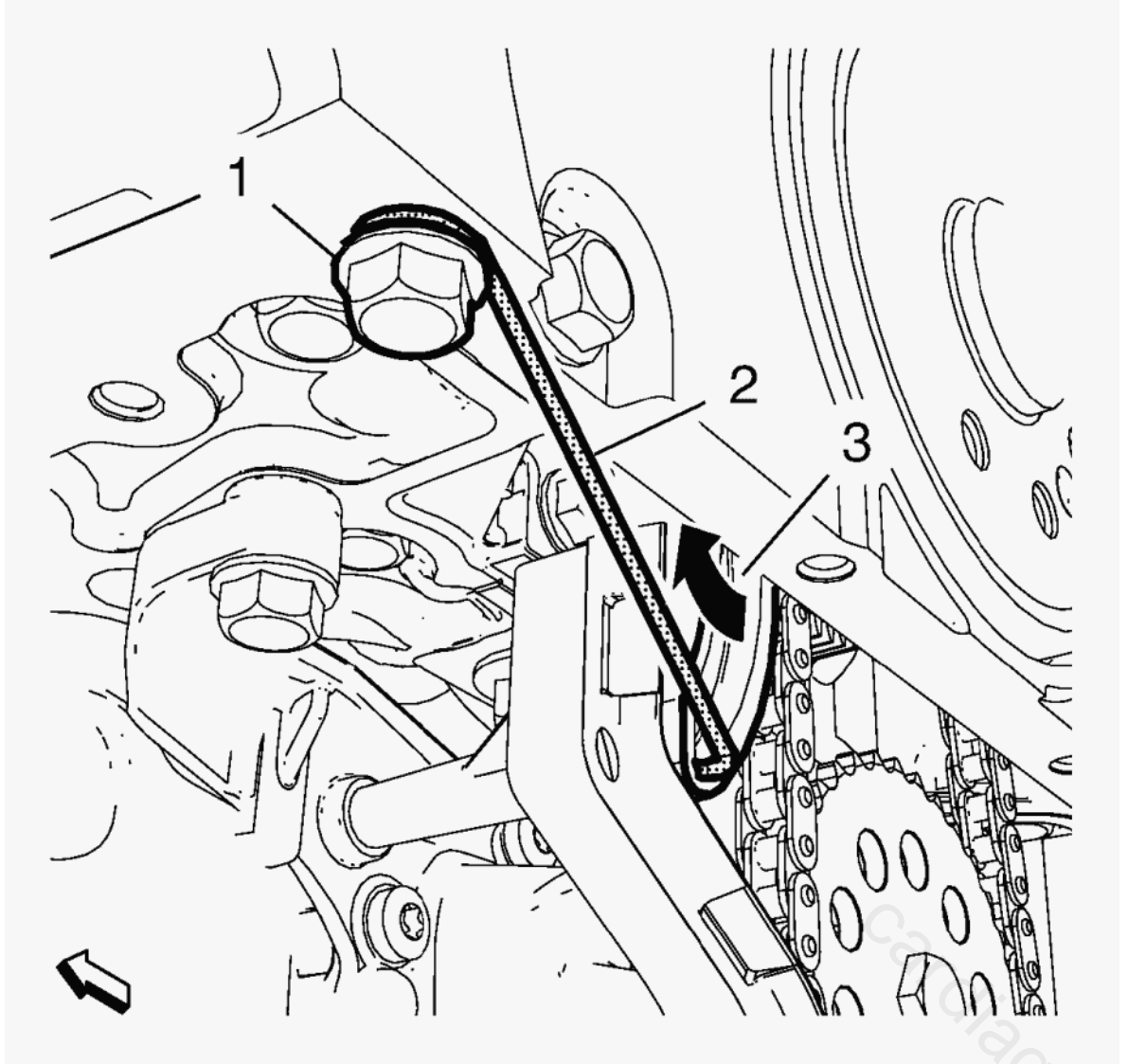


Fig. 425: Oil Pump Drive Chain Tensioner, Holding Tool And Oil Pan Bolt
Courtesy of GENERAL MOTORS COMPANY

3. Tension the oil pump drive chain tensioner (3) with the **EN-51142-2** holding tool (2) in arrow direction.
4. Install the oil pan bolt (1) to fix the **EN-51142-2** holding tool.

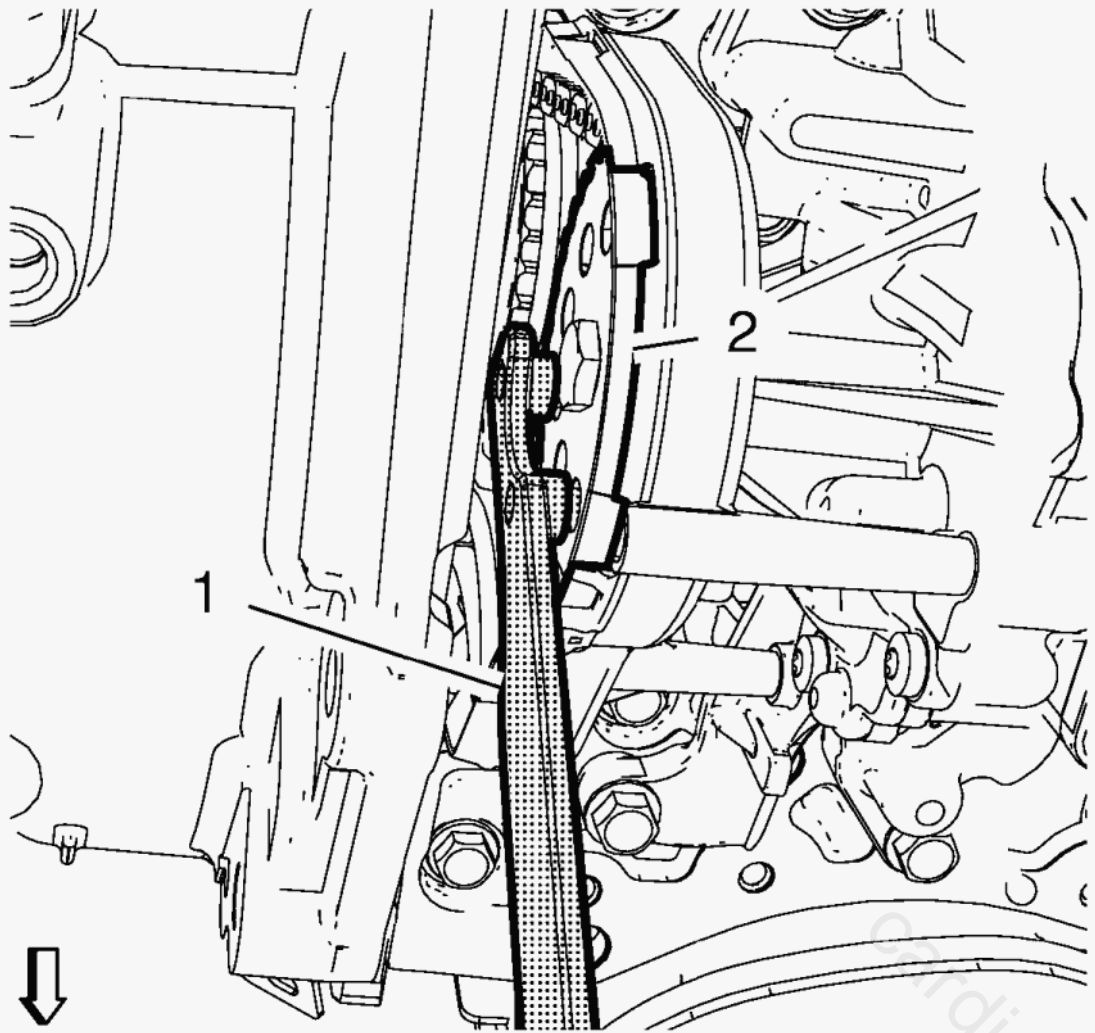


Fig. 426: Oil Pump Sprocket Bolt And Holding Tool
Courtesy of GENERAL MOTORS COMPANY

5. Install the **EN-51142-1** holding tool (1) to oil pump sprocket.
6. Loosen the oil pump sprocket bolt (2) by counterhold at the **EN-51142-1** holding tool.

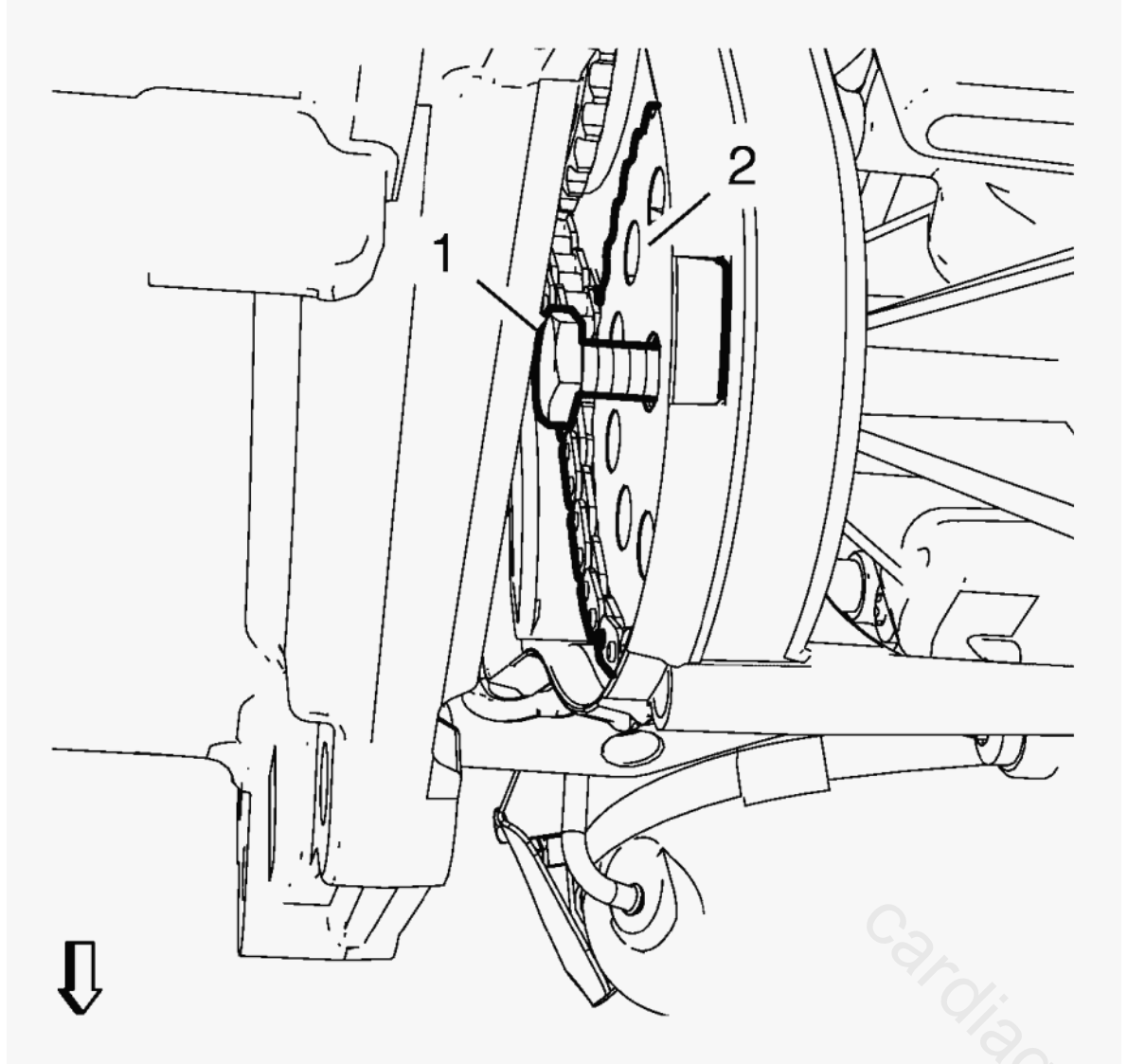


Fig. 427: Oil Pump Sprocket And Bolt

Courtesy of GENERAL MOTORS COMPANY

7. Unscrew the oil pump sprocket bolt (1) as far as possible.
8. Detach the oil pump sprocket (2) from the oil and power brake booster pump shaft, use a suitable tool.

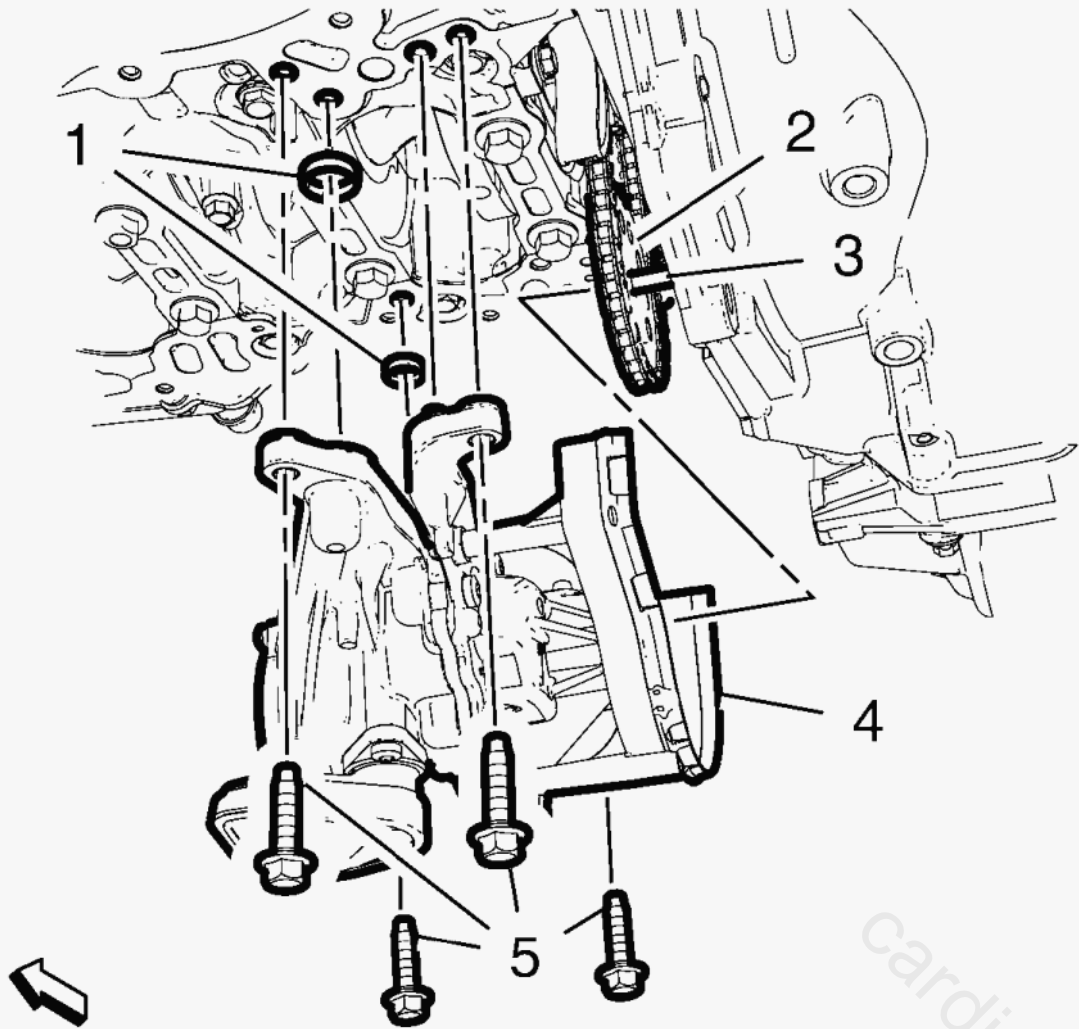


Fig. 428: Oil Pump Bolts, Sprocket, Sprocket Bolt, Oil/Power Brake Booster Pump And Gaskets
Courtesy of GENERAL MOTORS COMPANY

9. Remove the 4 oil pump bolts (5).
10. Remove the oil and power brake booster pump (4).
11. Remove and DISCARD the oil pump sprocket bolt (3) from the oil pump sprocket (2).
12. Remove the 2 oil and power brake booster pump gaskets (1).

Installation Procedure

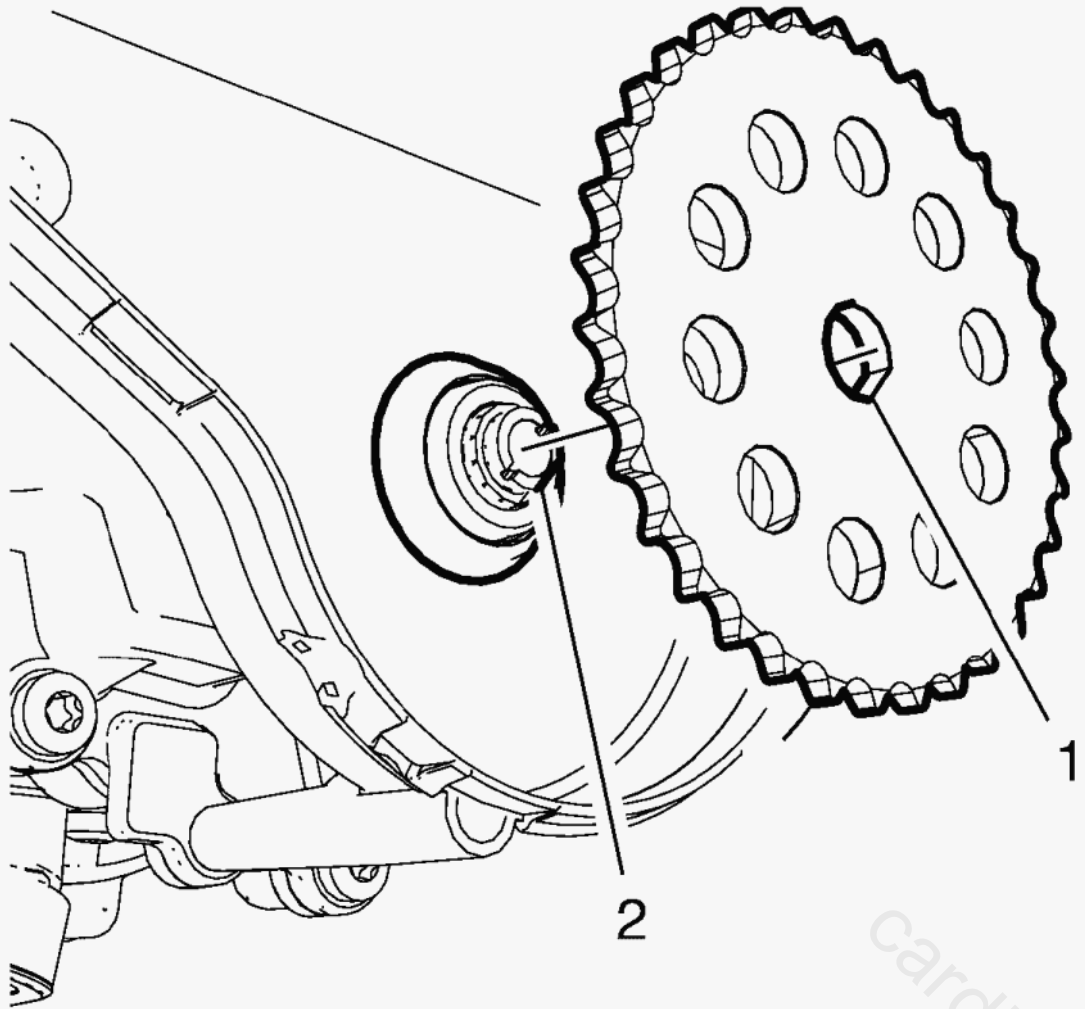


Fig. 429: Oil Pump Shaft Face And Oil Pump Sprocket Face Positioning
Courtesy of GENERAL MOTORS COMPANY

1. Check the position of the oil pump shaft face (2) to the oil pump sprocket face (1) before installing the oil and power brake booster pump.

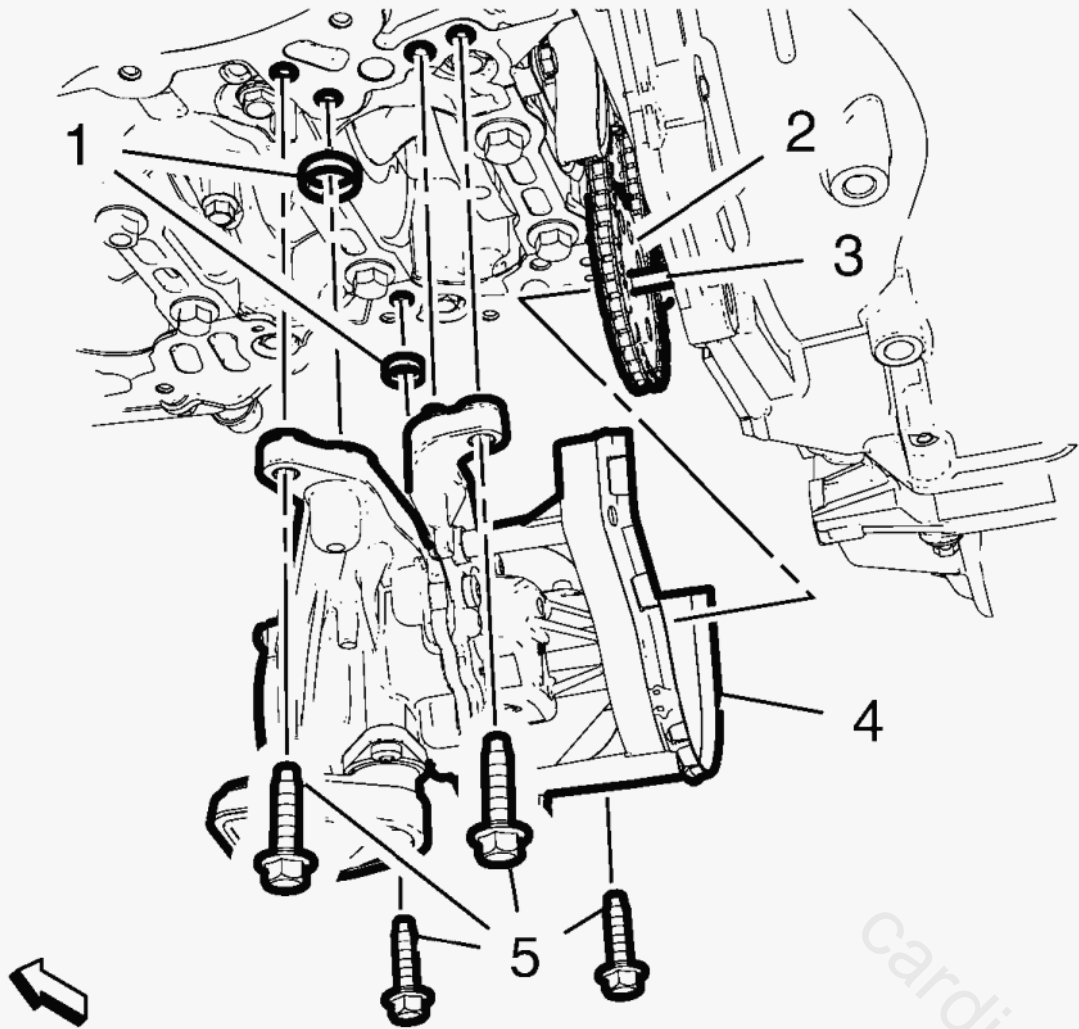


Fig. 430: Oil Pump Bolts, Sprocket, Sprocket Bolt, Oil/Power Brake Booster Pump And Gaskets
Courtesy of GENERAL MOTORS COMPANY

NOTE: The oil pump sprocket bolt can not be installed, if the oil and power brake booster pump is installed.

2. Install the NEW oil pump sprocket bolt (3) to the oil pump sprocket (2).
3. Install 2 oil and power brake booster pump gaskets (1).
4. Install the oil and power brake booster pump (4).

CAUTION: Refer to **Fastener Caution** .

5. Install the 4 oil pump bolts (5) and tighten to 25 N.m (18 lb ft).

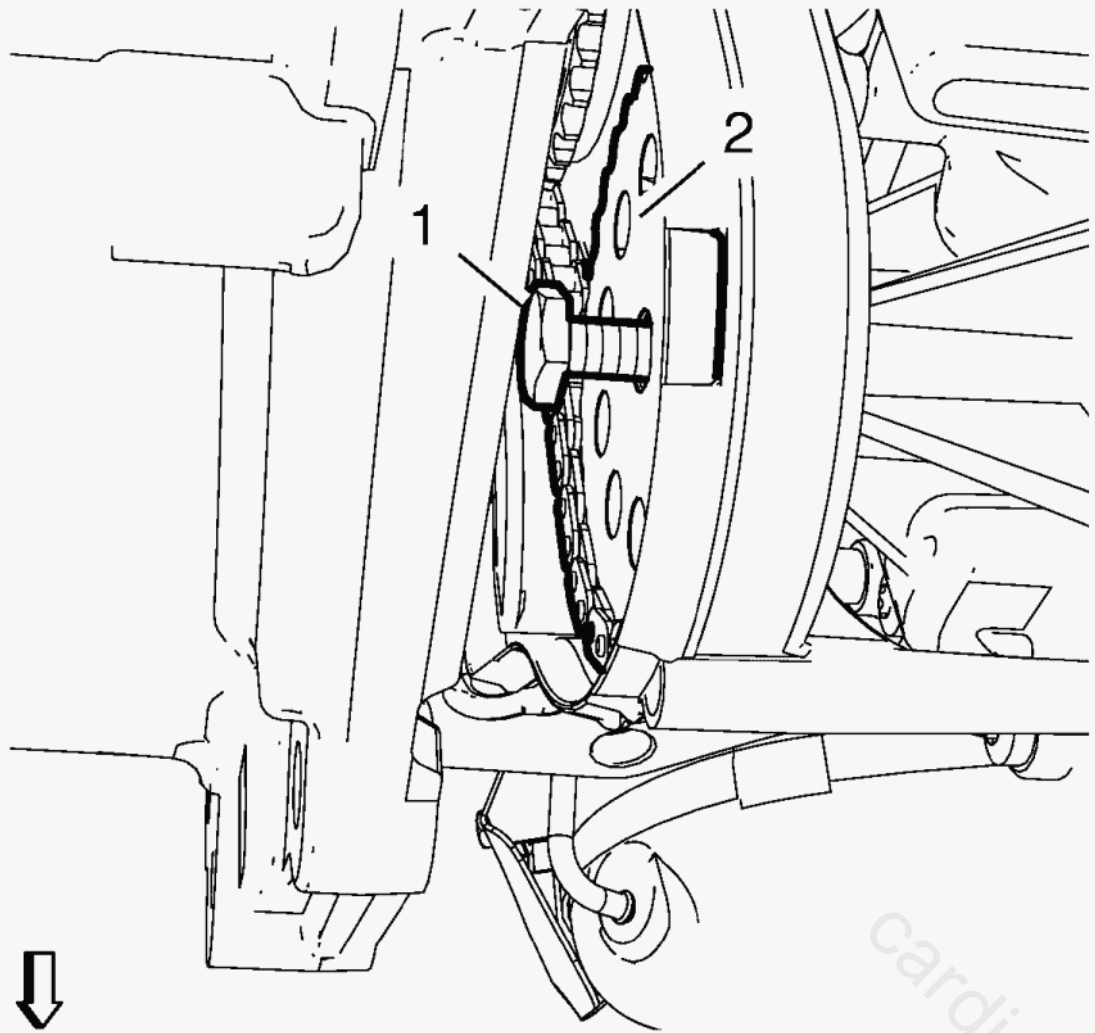


Fig. 431: Oil Pump Sprocket And Bolt

Courtesy of GENERAL MOTORS COMPANY

6. Attach the oil pump sprocket (2) to the oil and power brake booster pump shaft.
7. Screw in the NEW oil pump sprocket bolt (1).

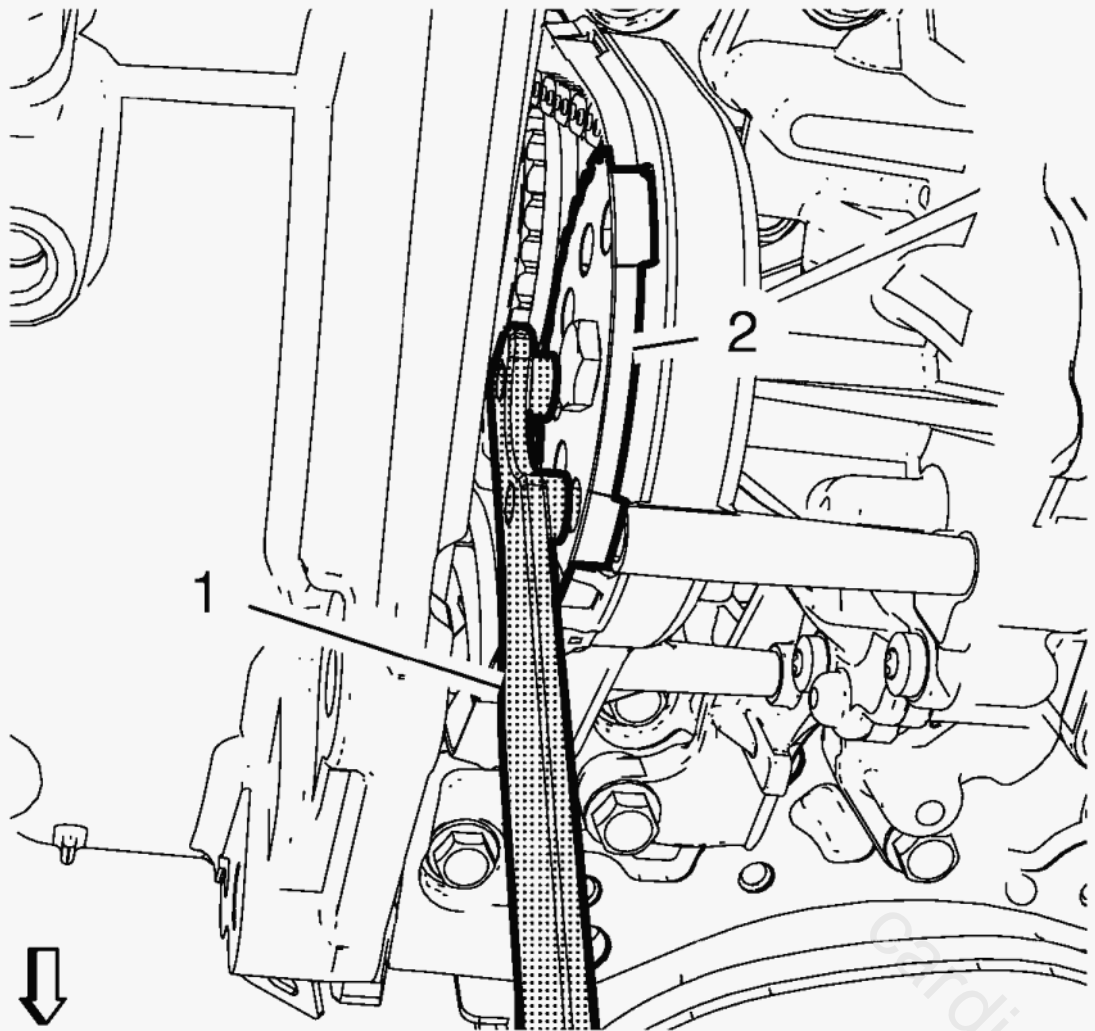


Fig. 432: Oil Pump Sprocket Bolt And Holding Tool
Courtesy of GENERAL MOTORS COMPANY

8. Install the **EN-51142-1** holding tool (1) to oil pump sprocket.
9. Tighten the NEW oil pump sprocket bolt (2) by counterhold at the **EN-51142-1** holding tool to:

CAUTION: Refer to **Torque-to-Yield Fastener Caution** .

1. Tighten in the bolts a first pass to 25 N.m (18 lb ft).
2. Tighten the bolts a final pass an additional to 60 degrees.

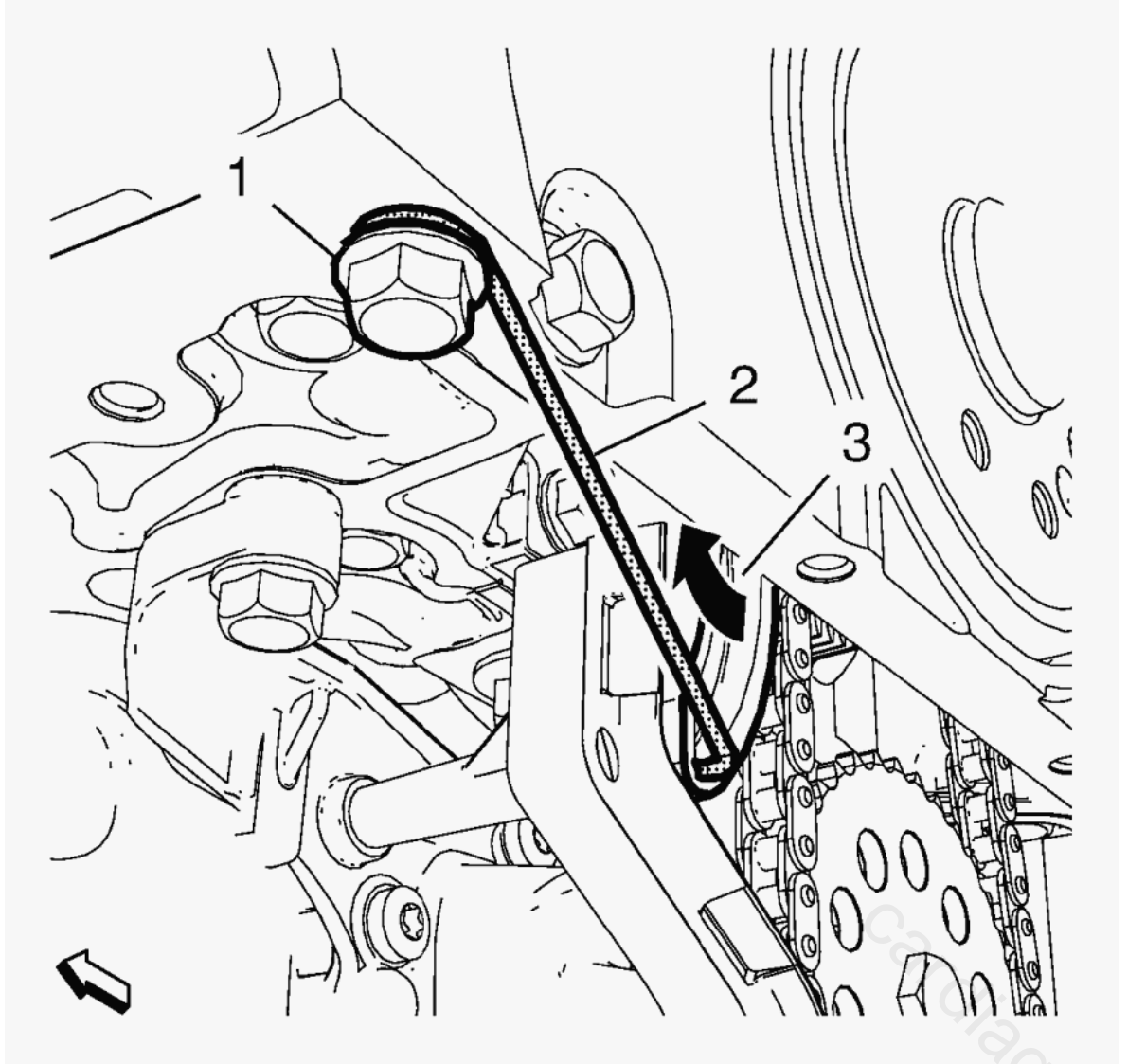


Fig. 433: Oil Pump Drive Chain Tensioner, Holding Tool And Oil Pan Bolt
Courtesy of GENERAL MOTORS COMPANY

10. Remove the oil pan bolt (1).
11. Remove the **EN-51142-2** holding tool (2).
12. Install the oil pan. Refer to **Oil Pan Replacement**.
13. Install the automatic transmission flex plate. Refer to **Automatic Transmission Flex Plate Replacement**.

INTAKE MANIFOLD COVER REPLACEMENT

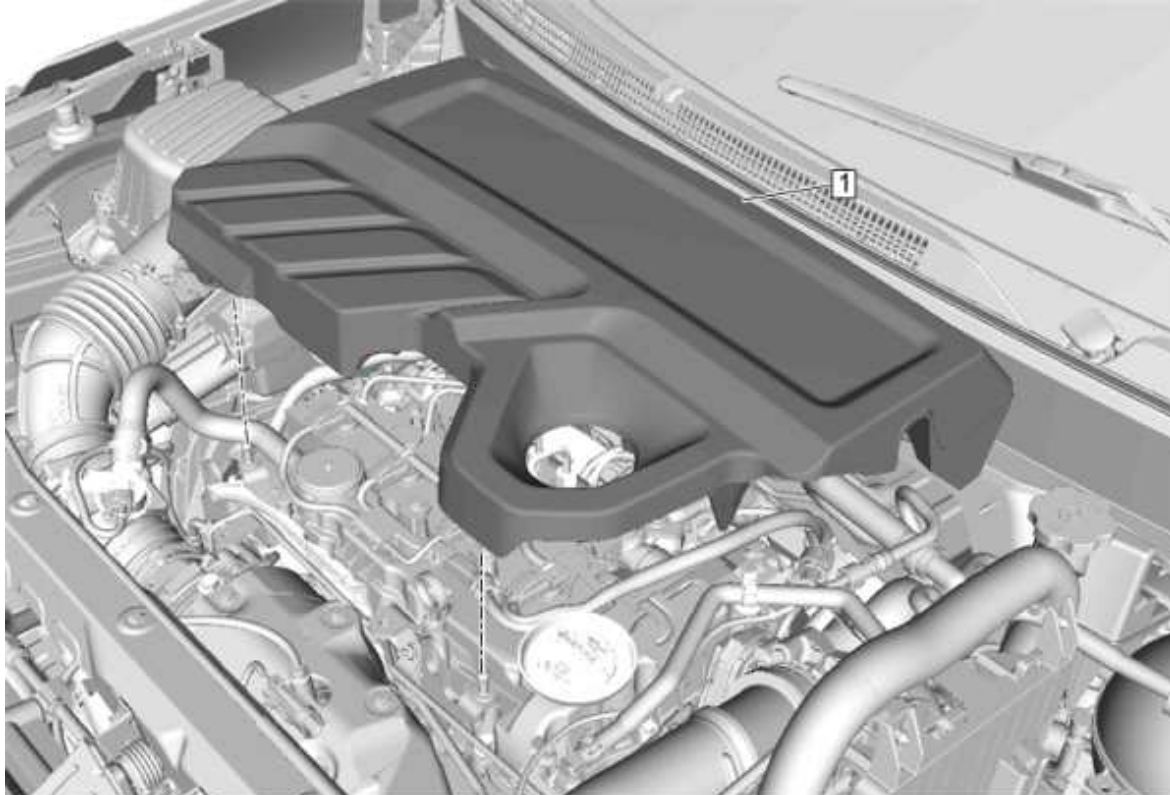


Fig. 434: Intake Manifold Cover

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Intake Manifold Cover Procedure Release the intake manifold cover retainers by pulling the cover upwards.

INTAKE MANIFOLD REPLACEMENT

Removal Procedure

1. Disconnect the battery negative cable. Refer to [Battery Negative Cable Disconnection and Connection \(KL9\)](#)
2. Remove Diesel Fuel Separator. Refer to [Diesel Fuel Separator Replacement](#)

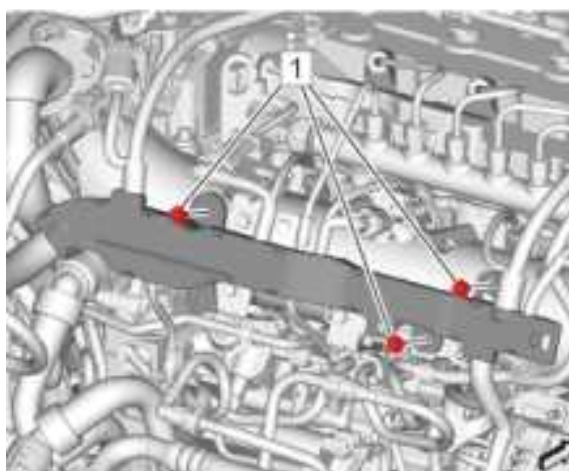


Fig. 435: Engine Wiring Harness Conduit Bolts

Courtesy of GENERAL MOTORS COMPANY

3. Remove Engine Wiring Harness Conduit Bolts (1) (Qty: 3)

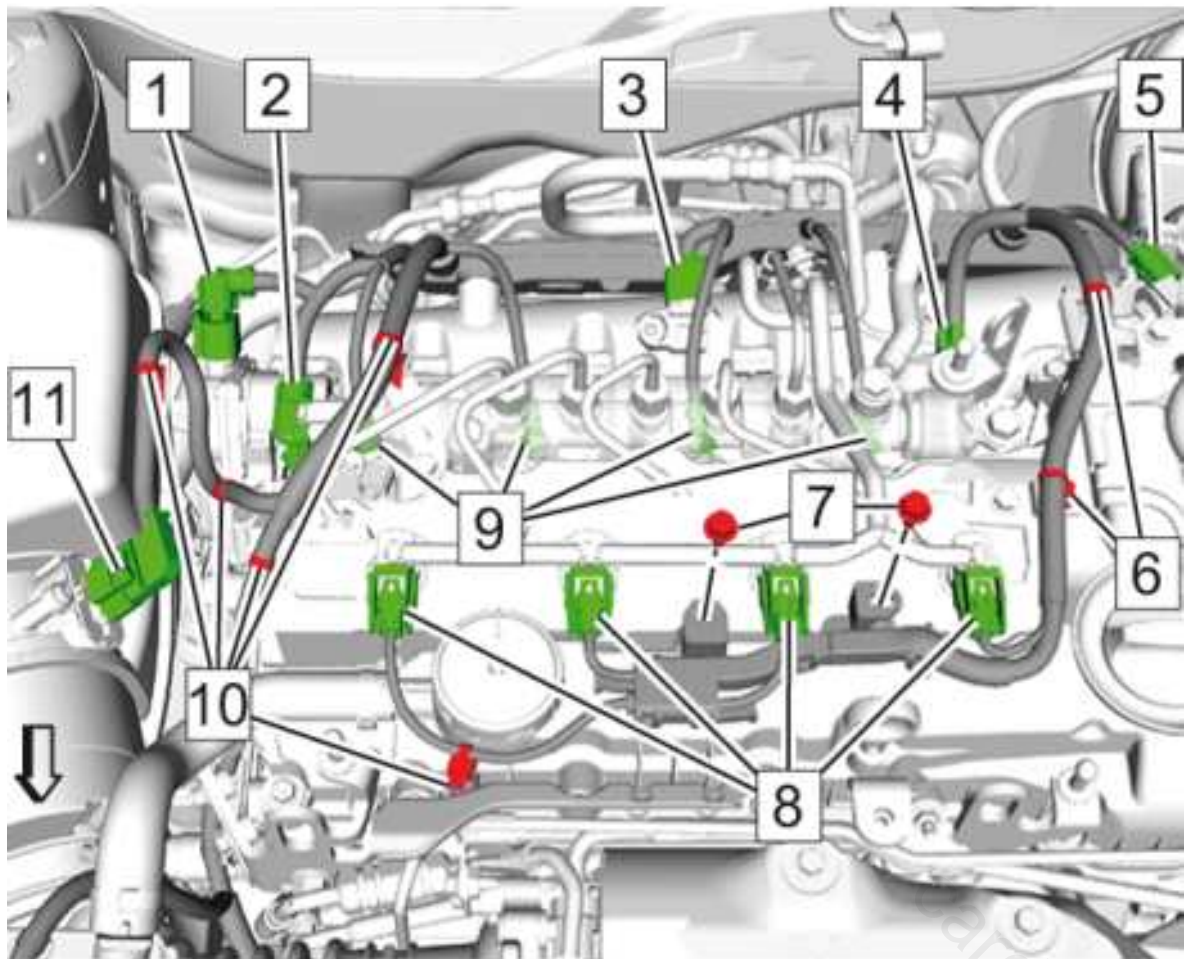


Fig. 436: Electrical Connectors, Bolts And Retainers
Courtesy of GENERAL MOTORS COMPANY

4. Disconnect the electrical connector:
 1. Intake Manifold Runner Control Valve Actuator (1)
 2. Fuel Rail Pressure Sensor (2)
 3. Intake Air Pressure and Temperature Sensor (3)
 4. Fuel Pressure Regulator (4)
 5. Exhaust Temperature Sensor - Position 1 (5)
 6. Fuel Injector (8) (Qty: 4)
 7. Mass Airflow Sensor (11)
 8. Camshaft Position Sensor (12)
5. Remove Engine Wiring Harness Conduit Bolts (7) (Qty: 2)
6. Unclip Engine Wiring Harness Retainers (6, 10) (Qty: 7)

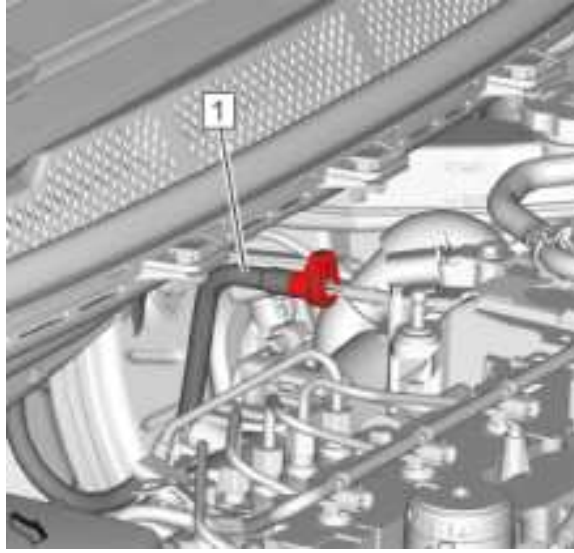


Fig. 437: Power Brake Booster Vacuum Pipe
Courtesy of GENERAL MOTORS COMPANY

7. Disconnect Power Brake Booster Vacuum Pipe (1). Refer to [Plastic Collar Quick Connect Fitting Service](#)

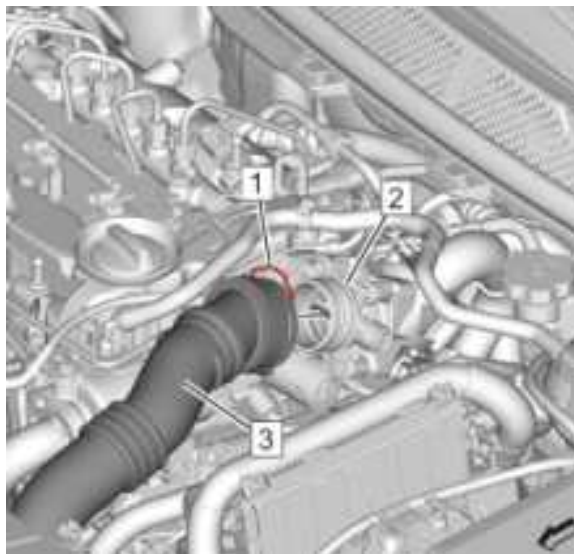


Fig. 438: Charge Air Cooler Outlet Air Hose, Retainer Spring And Throttle Body
Courtesy of GENERAL MOTORS COMPANY

8. Loosen Charge Air Cooler Outlet Air Hose Retainer Spring (1)
9. Disconnect Charge Air Cooler Outlet Air Hose (3) @ Throttle Body Assembly (2)

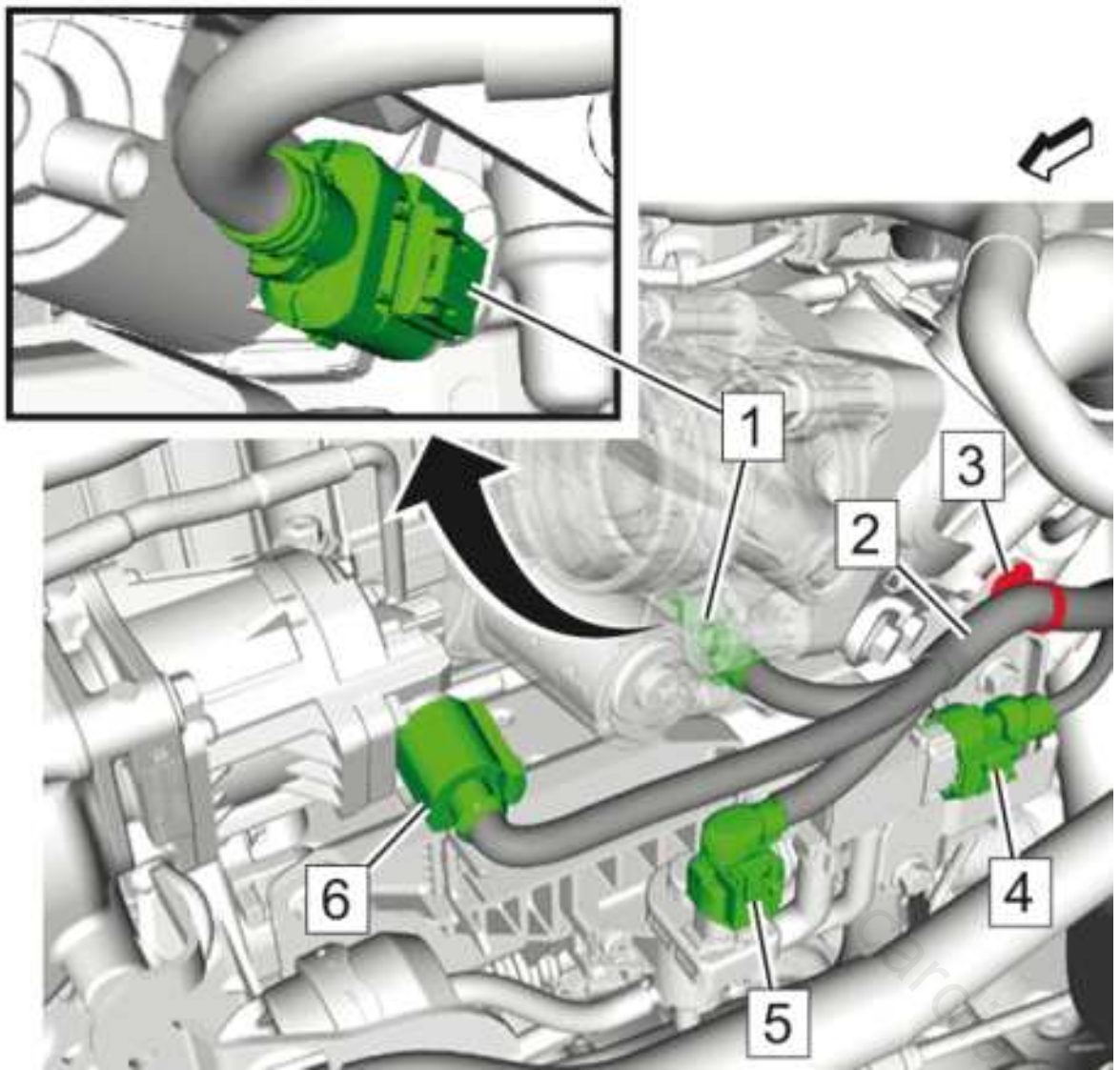


Fig. 439: Electrical Connectors, Engine Wiring Harness And Clip
Courtesy of GENERAL MOTORS COMPANY

10. Disconnect the electrical connector:
 1. Exhaust Gas Recirculation Valve (6)
 2. Exhaust Gas Recirculation Vacuum Regulator Solenoid Valve (5)
 3. Exhaust Pressure Differential Sensor (4)
 4. Throttle Body (1)
11. Unclip Engine Wiring Harness Clip (3)
12. Position aside Engine Wiring Harness (2)

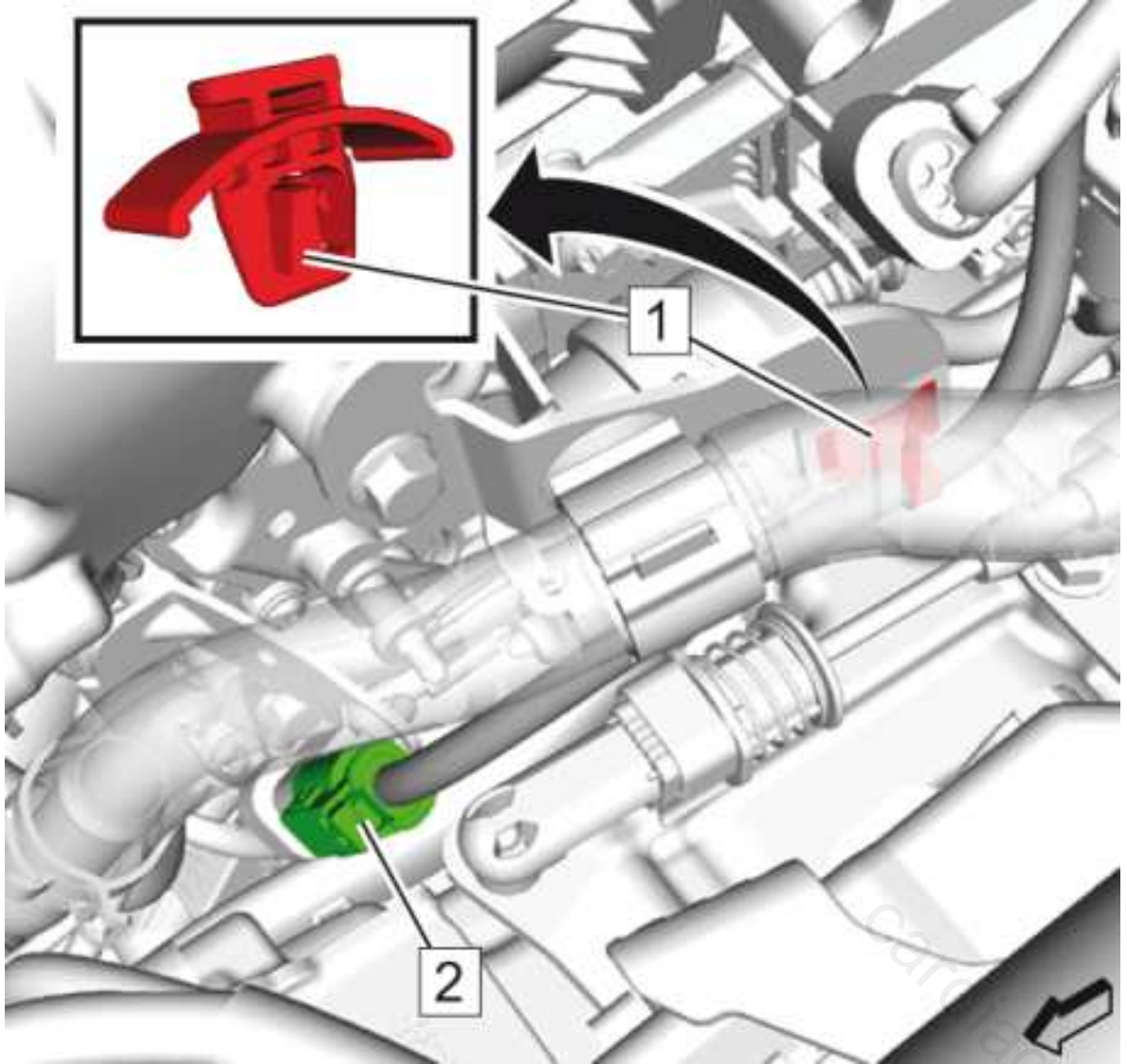


Fig. 440: Exhaust Temperature Sensor Electrical Connector And Retainer
Courtesy of GENERAL MOTORS COMPANY

13. Disconnect Exhaust Temperature Sensor Electrical Connector (2)
14. Unclip Engine Wiring Harness Retainer (1)

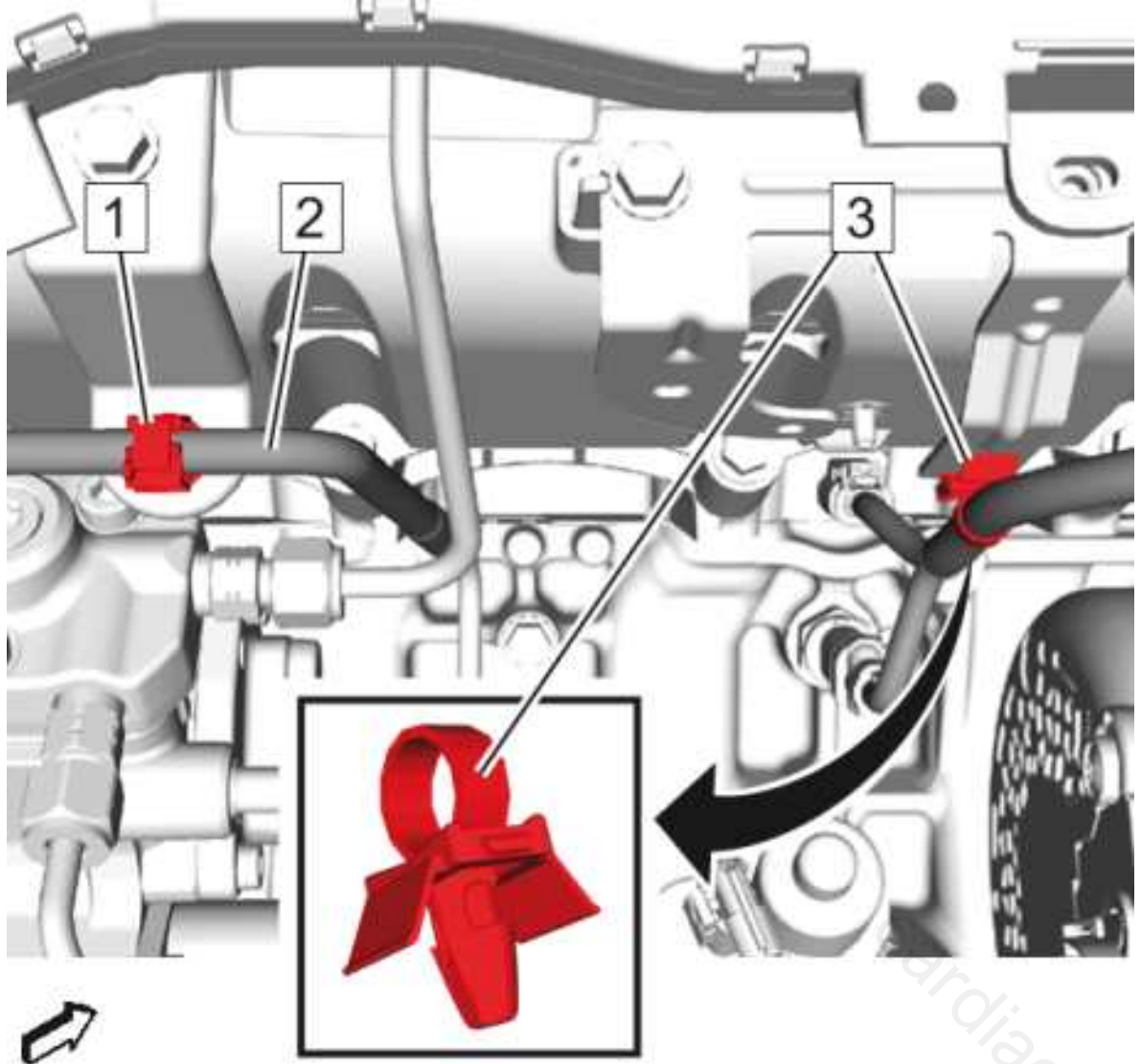


Fig. 441: Charge Air Bypass Valve Vacuum Hose, Retainer And Clip
Courtesy of GENERAL MOTORS COMPANY

15. Unclip the charge air bypass valve vacuum hose (2) from the retainer (1).
16. Unclip Engine Wiring Harness Clip (3)

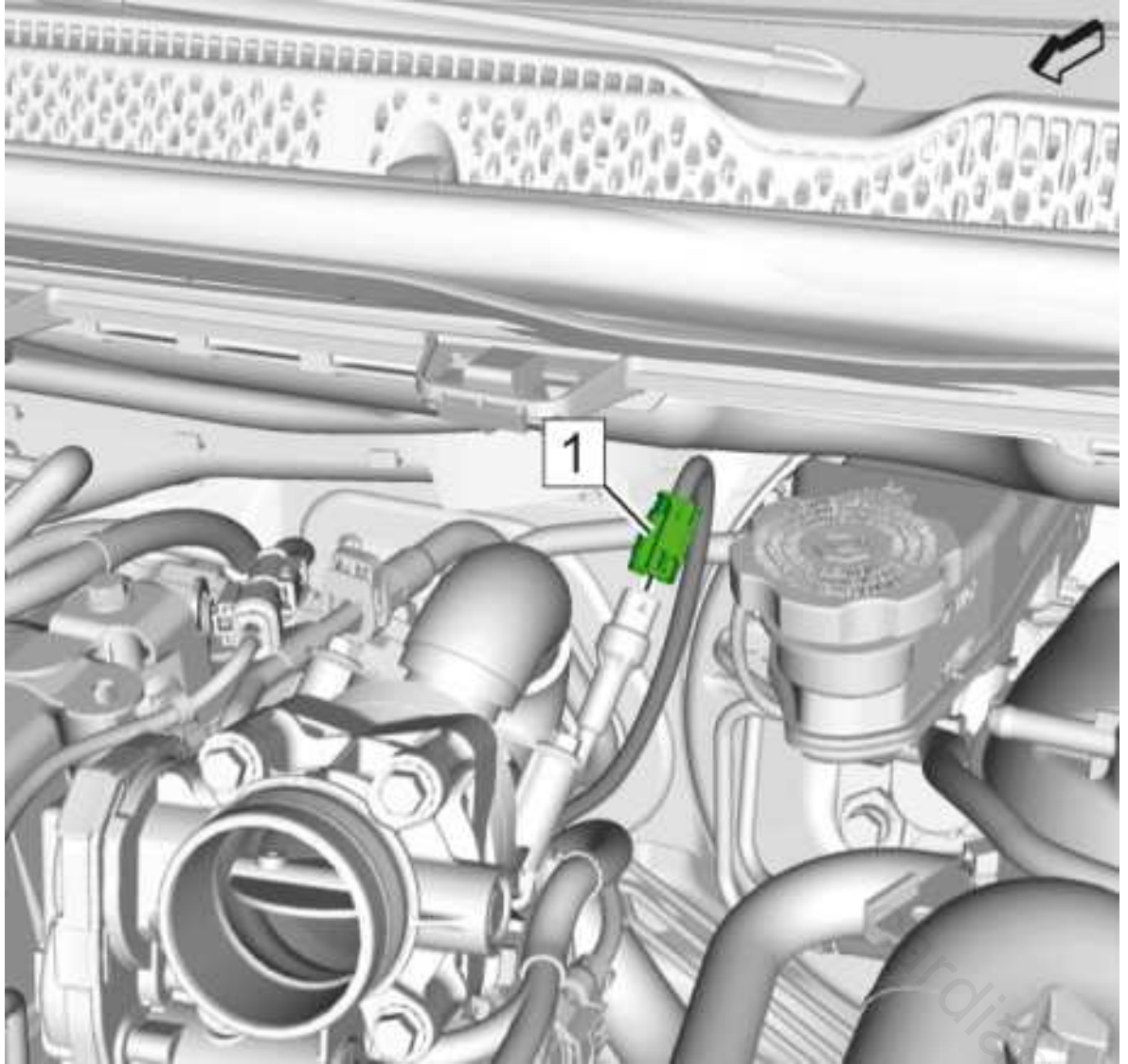


Fig. 442: Exhaust Gas Recirculation Cooler Temperature Sensor Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

17. Disconnect Exhaust Gas Recirculation Cooler Temperature Sensor Electrical Connector (1)

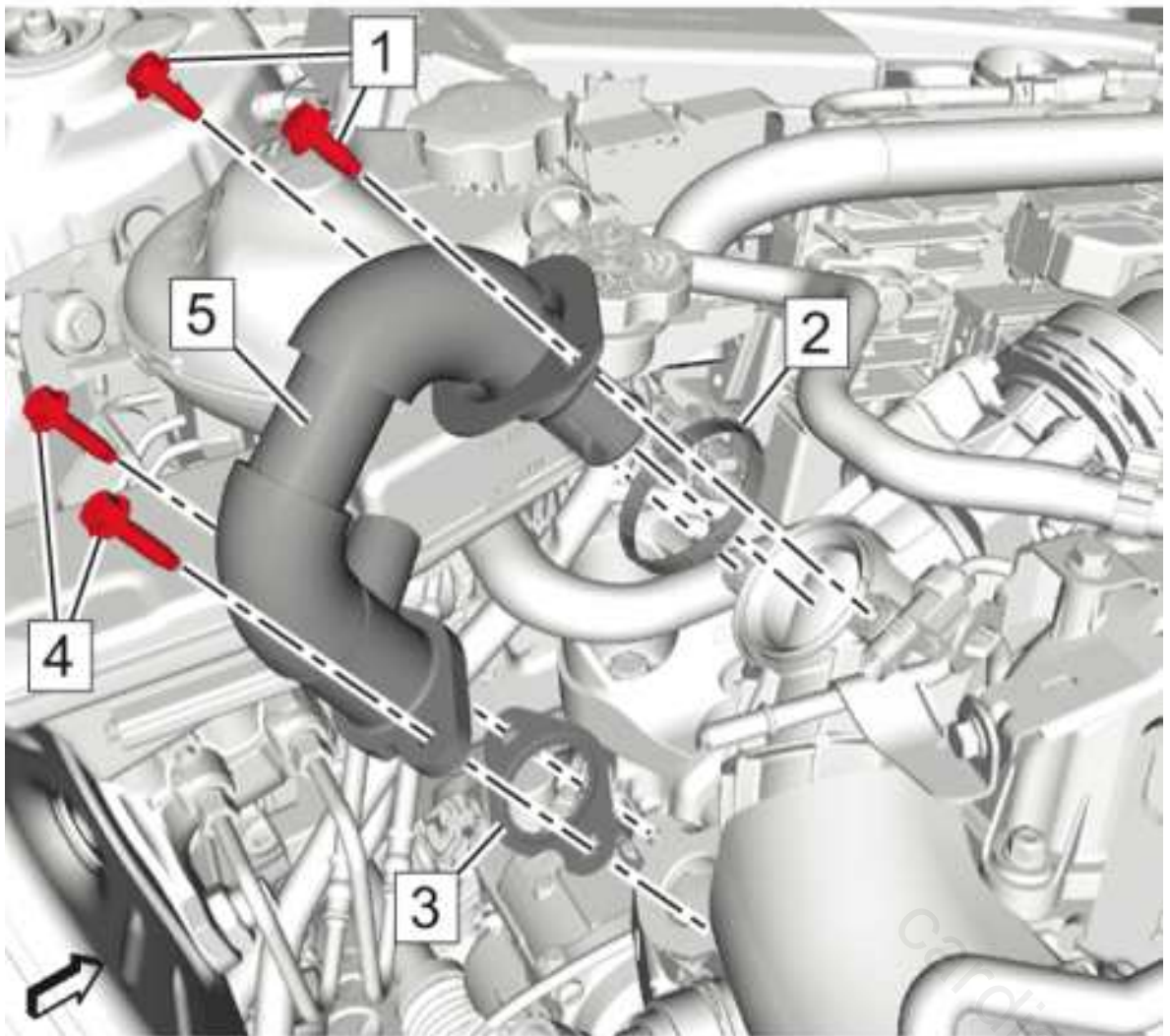


Fig. 443: Exhaust Gas Recirculation Cooler Outlet Pipe, Bolts And Gaskets
Courtesy of GENERAL MOTORS COMPANY

18. Remove Exhaust Gas Recirculation Cooler Outlet Pipe Bolts (1, 4) (Qty: 4)
19. Remove Exhaust Gas Recirculation Cooler Outlet Pipe (5)
20. Remove and DISCARD the gaskets. (2, 3) (Qty: 2)

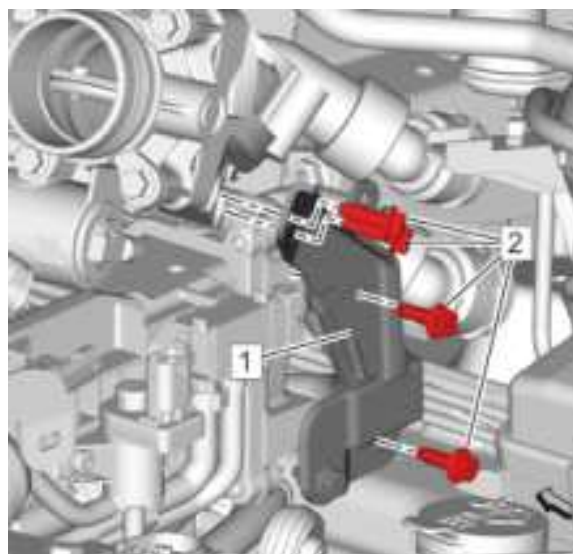


Fig. 444: Intake Manifold Brace And Bolts
Courtesy of GENERAL MOTORS COMPANY

21. Remove Intake Manifold Brace Bolts (2) (Qty: 4)
22. Remove Intake Manifold Brace (1)

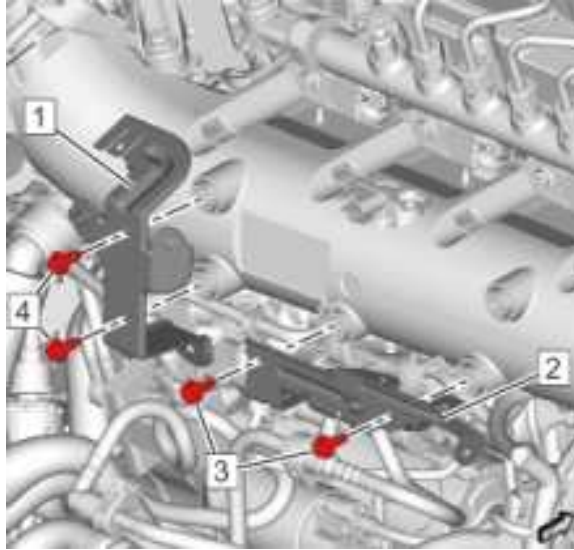


Fig. 445: Fuel Rail Fuel Pressure Sensor Wire Bracket, Fuel Return Pipe Bracket And Bolts
Courtesy of GENERAL MOTORS COMPANY

23. Remove Fuel Injection Fuel Rail Fuel Pressure Sensor Wire Bracket Bolts (4) (Qty: 2)
24. Remove Fuel Injection Fuel Rail Fuel Pressure Sensor Wire Bracket (1)
25. Remove Fuel Injection Fuel Return Pipe Bracket Bolts (3) (Qty: 2)
26. Remove Fuel Injection Fuel Return Pipe Bracket (2)

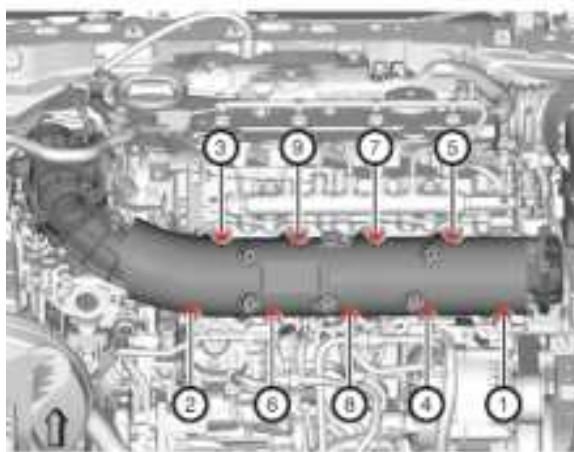


Fig. 446: Intake Manifold Bolt Loosening Sequence
Courtesy of GENERAL MOTORS COMPANY

27. Loosen the 9 intake manifold bolts in sequence as shown.

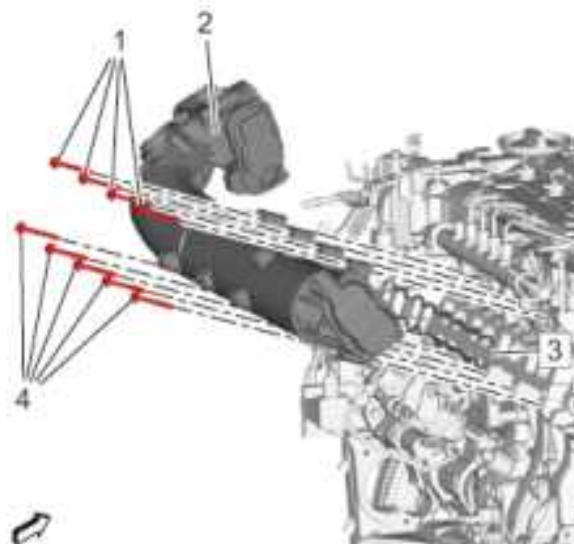


Fig. 447: Intake Manifold, Bolts And Gasket
Courtesy of GENERAL MOTORS COMPANY

28. Remove Intake Manifold Bolts (1, 4) (Qty: 9)
29. Remove Intake Manifold (2)
30. Remove and DISCARD Intake Manifold Gasket (3)
31. Disassemble the intake manifold. Refer to [Intake Manifold Disassemble](#)

Installation Procedure

1. Assemble the intake manifold. Refer to [Intake Manifold Assemble](#)

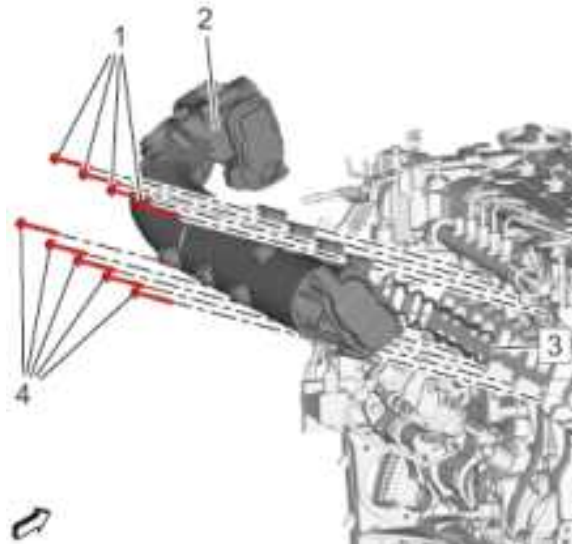


Fig. 448: Intake Manifold, Bolts And Gasket
Courtesy of GENERAL MOTORS COMPANY

2. Install a NEW intake manifold gasket. (3)
3. Install Intake Manifold (2)
4. Install Intake Manifold Bolts (1, 4) (Qty: 9)

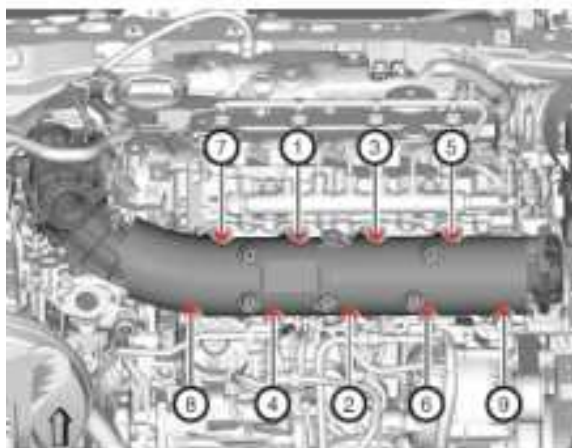


Fig. 449: Intake Manifold Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to [Fastener Caution](#)

5. Tighten Intake Manifold Bolts in sequence (Qty: 9) to 12 N.m (106 lb in)

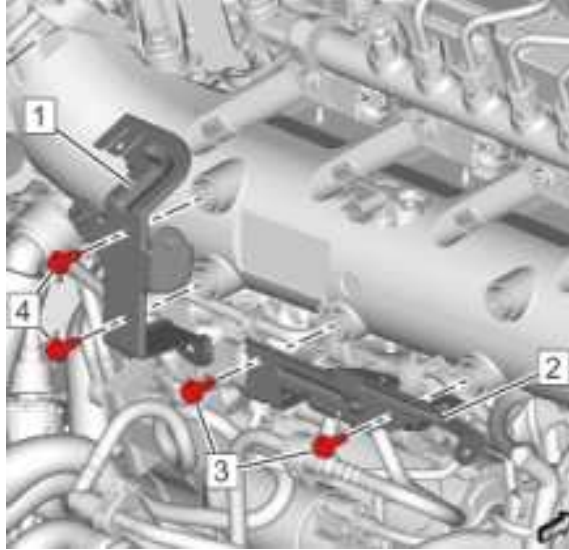


Fig. 450: Fuel Rail Fuel Pressure Sensor Wire Bracket, Fuel Return Pipe Bracket And Bolts
Courtesy of GENERAL MOTORS COMPANY

6. Install Fuel Injection Fuel Return Pipe Bracket (2)
7. Install and tighten Fuel Injection Fuel Return Pipe Bracket Bolts (3) (Qty: 2) to 9 N.m (80 lb in)
8. Install Fuel Injection Fuel Rail Fuel Pressure Sensor Wire Bracket (1)
9. Install and tighten Fuel Injection Fuel Rail Fuel Pressure Sensor Wire Bracket Bolts (4) (Qty: 2) to 9 N.m (80 lb in)

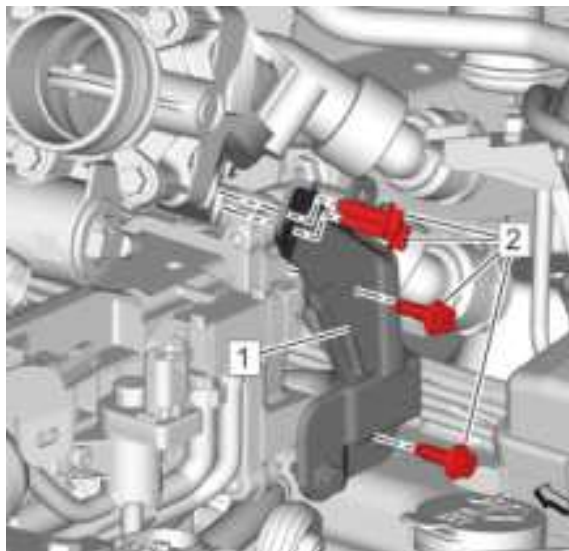


Fig. 451: Intake Manifold Brace And Bolts
Courtesy of GENERAL MOTORS COMPANY

10. Install Intake Manifold Brace (1)
11. Install and tighten Intake Manifold Brace Bolts (2) (Qty: 4) to 10 N.m (89 lb in)

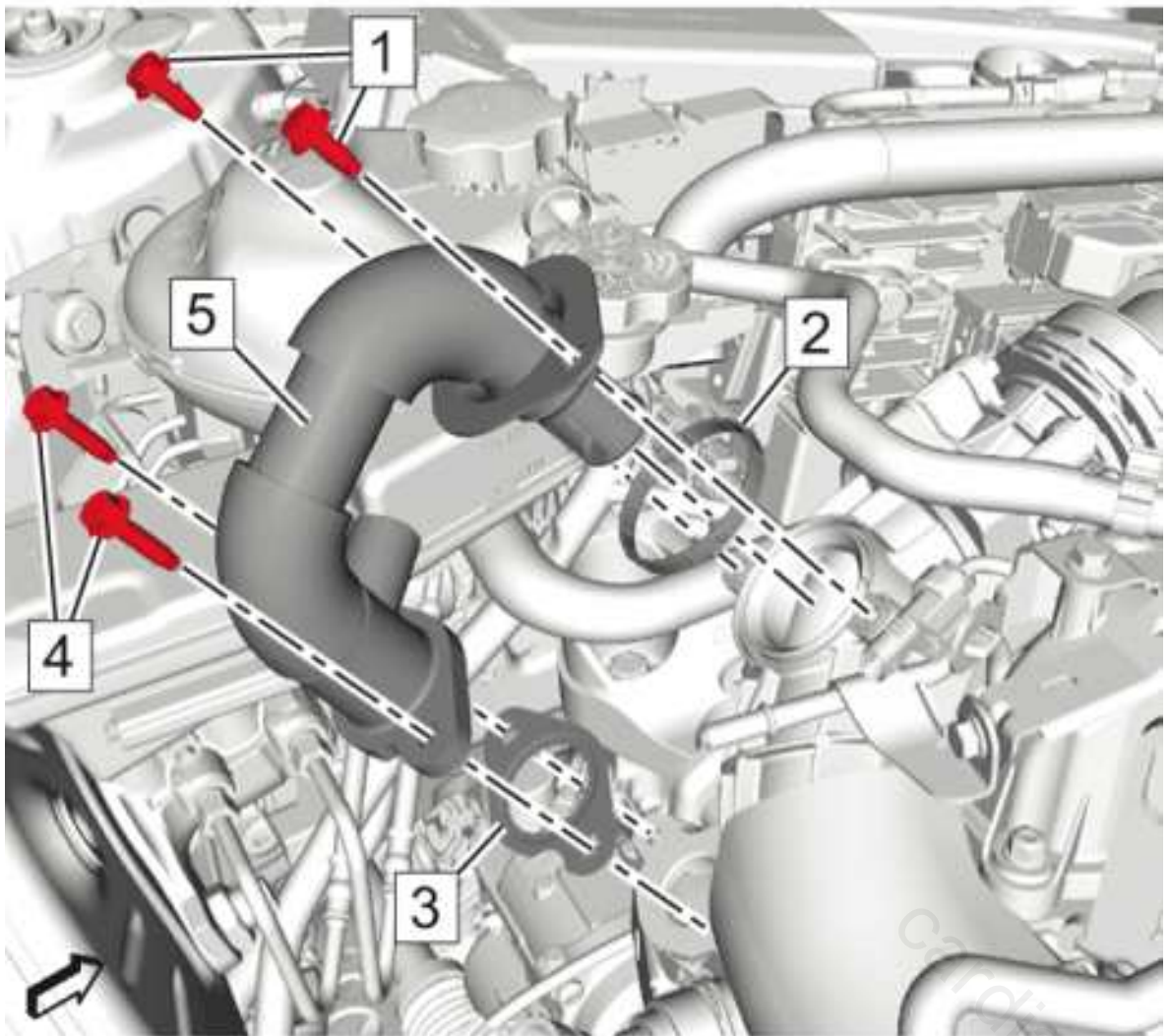


Fig. 452: Exhaust Gas Recirculation Cooler Outlet Pipe, Bolts And Gaskets
Courtesy of GENERAL MOTORS COMPANY

12. Install NEW gaskets. (2, 3) (Qty: 2)
13. Install Exhaust Gas Recirculation Cooler Outlet Pipe (5)
14. Install and tighten Exhaust Gas Recirculation Cooler Outlet Pipe Bolts (1, 4) (Qty: 4) to 10 N.m (89 lb in)

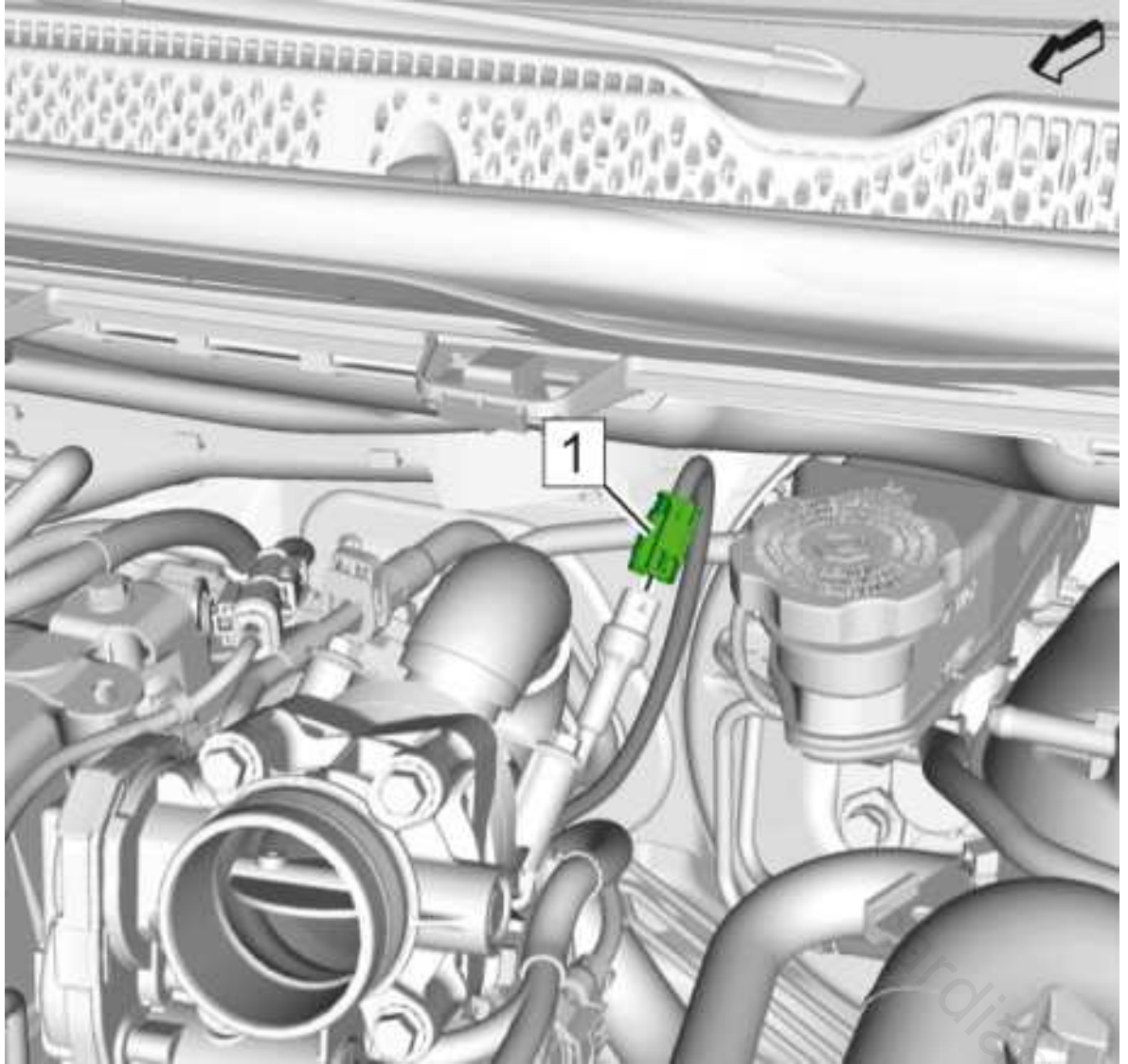


Fig. 453: Exhaust Gas Recirculation Cooler Temperature Sensor Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

15. Connect Exhaust Gas Recirculation Cooler Temperature Sensor Electrical Connector (1)

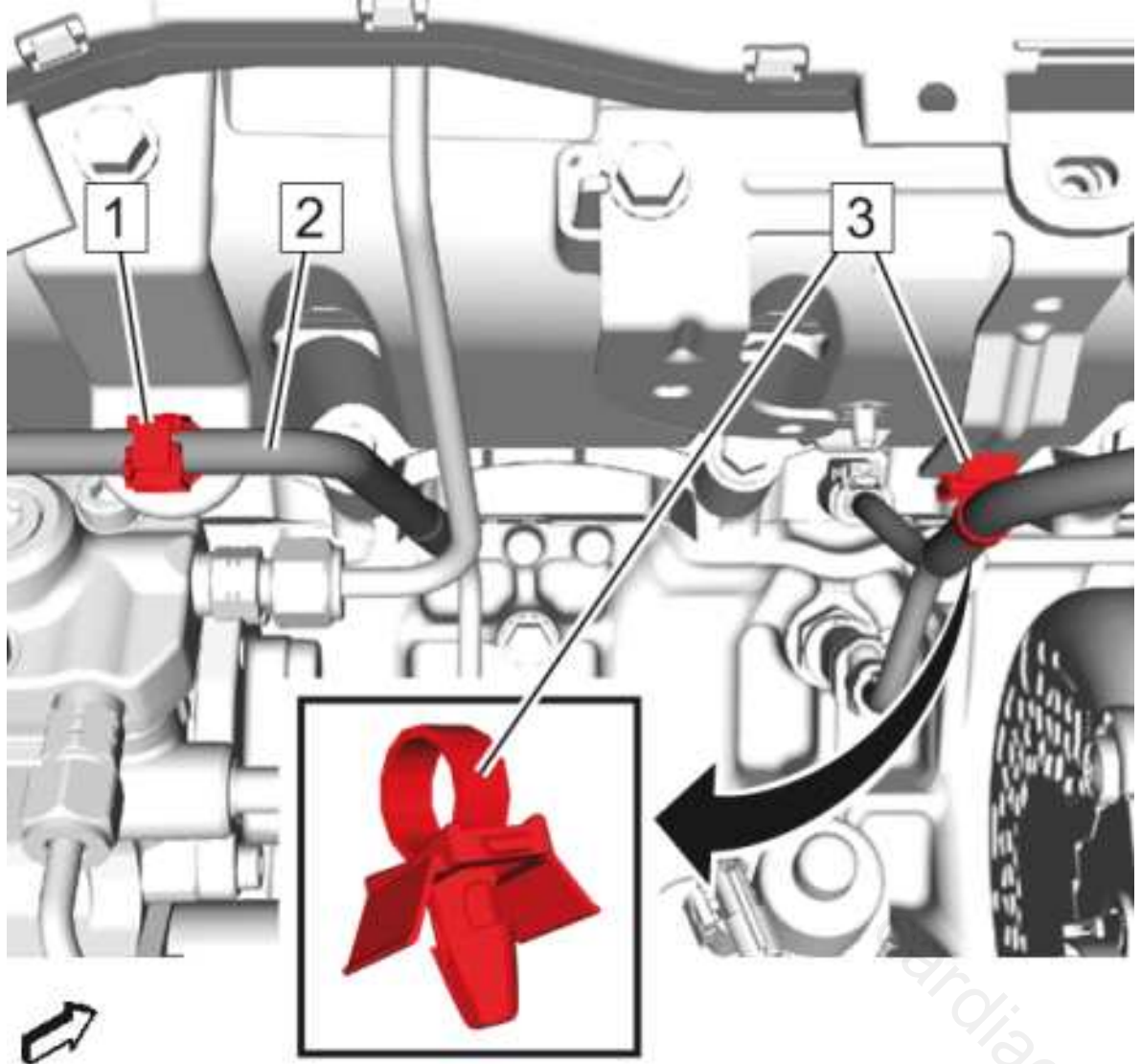


Fig. 454: Charge Air Bypass Valve Vacuum Hose, Retainer And Clip
Courtesy of GENERAL MOTORS COMPANY

16. Install Engine Wiring Harness Clip (3)
17. Install the charge air bypass valve vacuum hose (2) to the retainer (1).

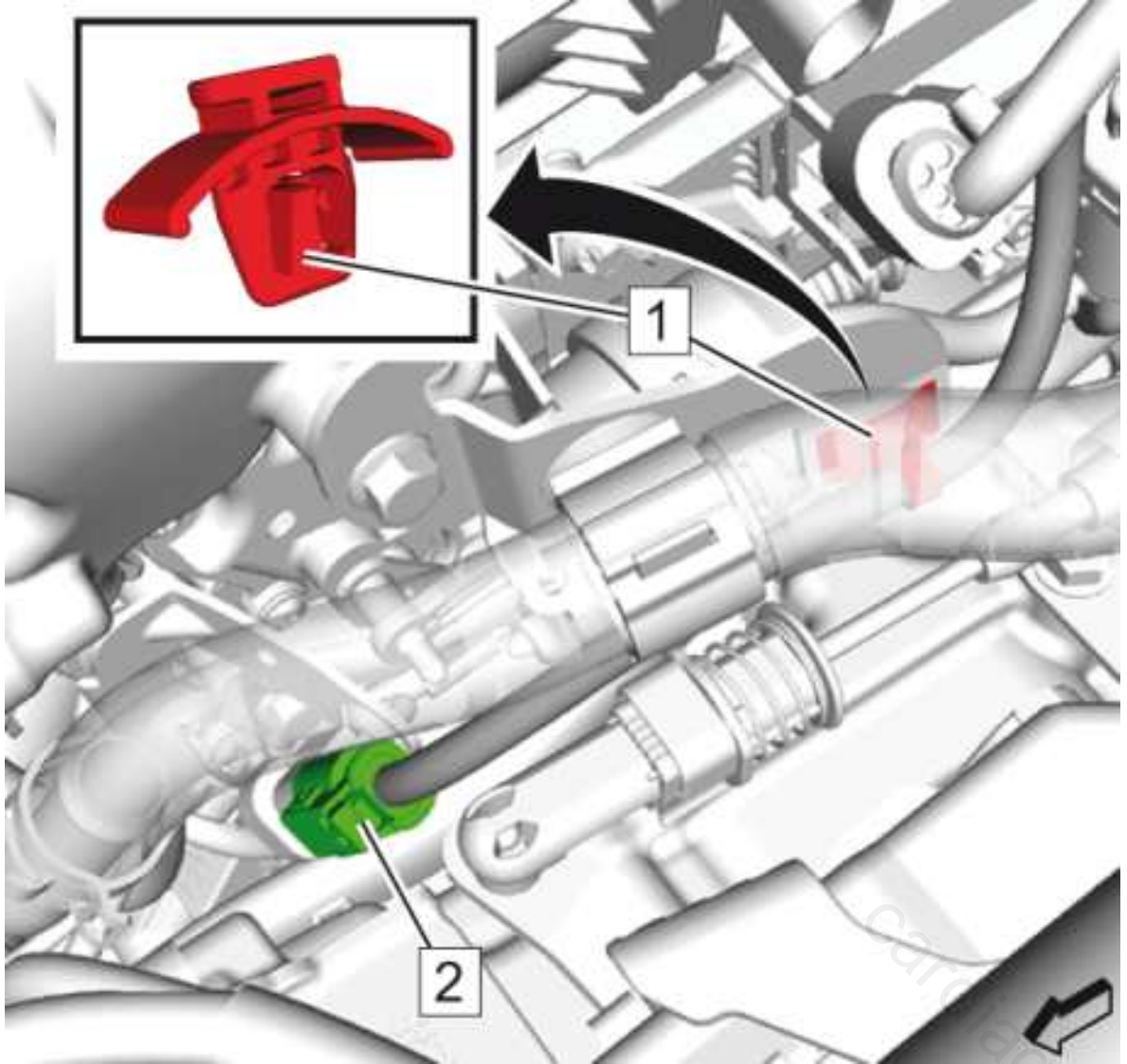


Fig. 455: Exhaust Temperature Sensor Electrical Connector And Retainer
Courtesy of GENERAL MOTORS COMPANY

18. Install Engine Wiring Harness Retainer (1)
19. Connect Exhaust Temperature Sensor Electrical Connector (2)

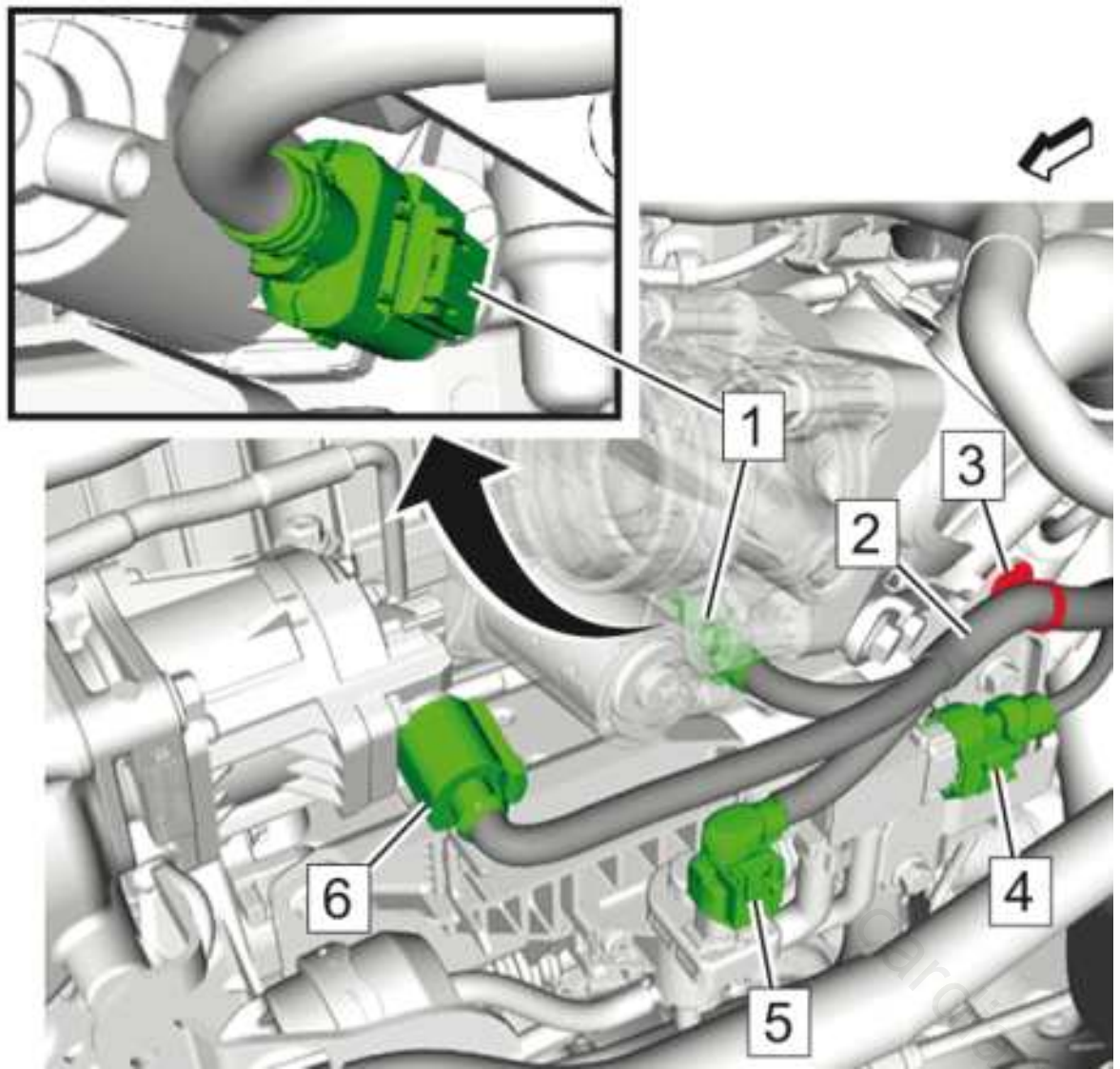


Fig. 456: Electrical Connectors, Engine Wiring Harness And Clip
 Courtesy of GENERAL MOTORS COMPANY

20. Reposition Engine Wiring Harness (2)
21. Connect the electrical connector:
 1. Exhaust Gas Recirculation Valve (6)
 2. Exhaust Gas Recirculation Vacuum Regulator Solenoid Valve (5)
 3. Exhaust Pressure Differential Sensor (4)
 4. Throttle Body (1)
22. Install Engine Wiring Harness Clip (3)

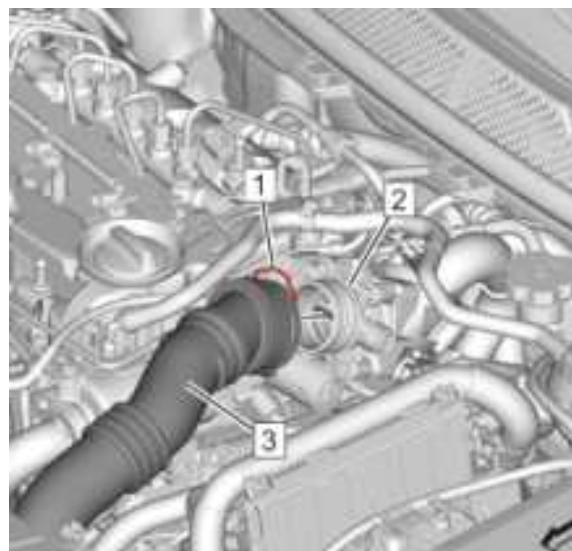


Fig. 457: Charge Air Cooler Outlet Air Hose, Retainer Spring And Throttle Body
 Courtesy of GENERAL MOTORS COMPANY

23. Connect Charge Air Cooler Outlet Air Hose (3) @ Throttle Body Assembly (2)
24. Lock Charge Air Cooler Outlet Air Hose Retainer Spring (1)

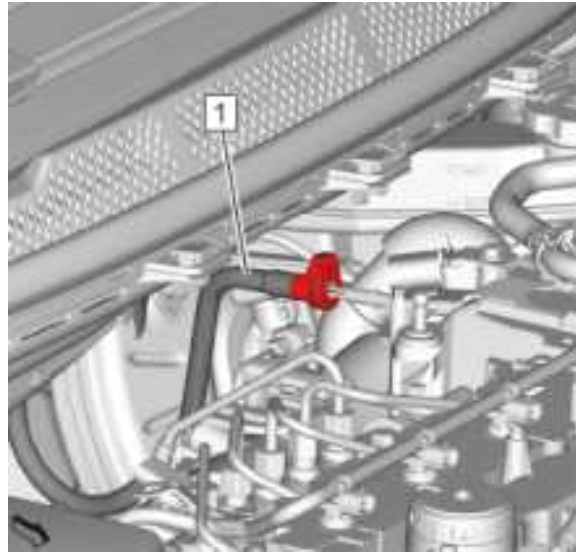


Fig. 458: Power Brake Booster Vacuum Pipe
Courtesy of GENERAL MOTORS COMPANY

25. Connect Power Brake Booster Vacuum Pipe (1). Refer to [Plastic Collar Quick Connect Fitting Service](#)

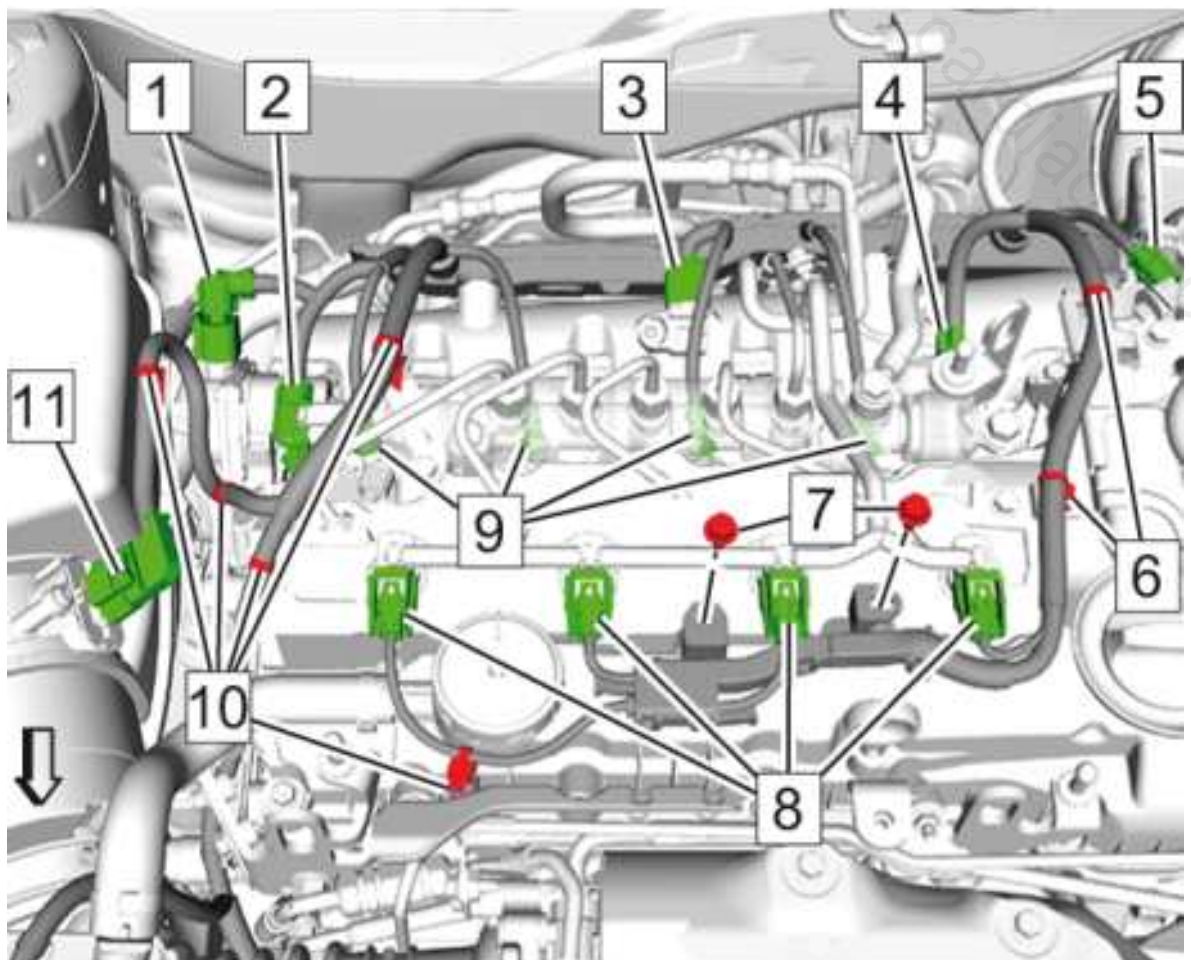


Fig. 459: Electrical Connectors, Bolts And Retainers
Courtesy of GENERAL MOTORS COMPANY

26. Connect the electrical connector:
1. Intake Manifold Runner Control Valve Actuator (1)
 2. Fuel Rail Pressure Sensor (2)

3. Intake Air Pressure and Temperature Sensor (3)
4. Fuel Pressure Regulator (4)
5. Exhaust Temperature Sensor - Position 1 (5)
6. Fuel Injector (8) (Qty: 4)
7. Mass Airflow Sensor (11)
8. Camshaft Position Sensor (12)
27. Install and tighten Engine Wiring Harness Conduit Bolts (7) (Qty: 2) to 9 N.m (80 lb in)
28. Install Engine Wiring Harness Retainers (6, 10) (Qty: 7)

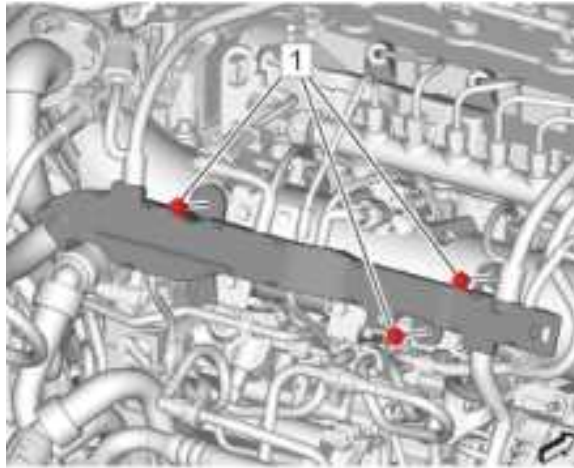


Fig. 460: Engine Wiring Harness Conduit Bolts
Courtesy of GENERAL MOTORS COMPANY

29. Install and tighten Engine Wiring Harness Conduit Bolts (1) (Qty: 3) to 9 N.m (80 lb in)
30. Install Diesel Fuel Separator. Refer to [Diesel Fuel Separator Replacement](#)
31. Connect the battery negative cable. Refer to [Battery Negative Cable Disconnection and Connection \(KL9\)](#)
32. Check the fuel system for leaks. Refer to [Fuel Leak Diagnosis](#)

INTAKE MANIFOLD BRACE REPLACEMENT

Removal Procedure

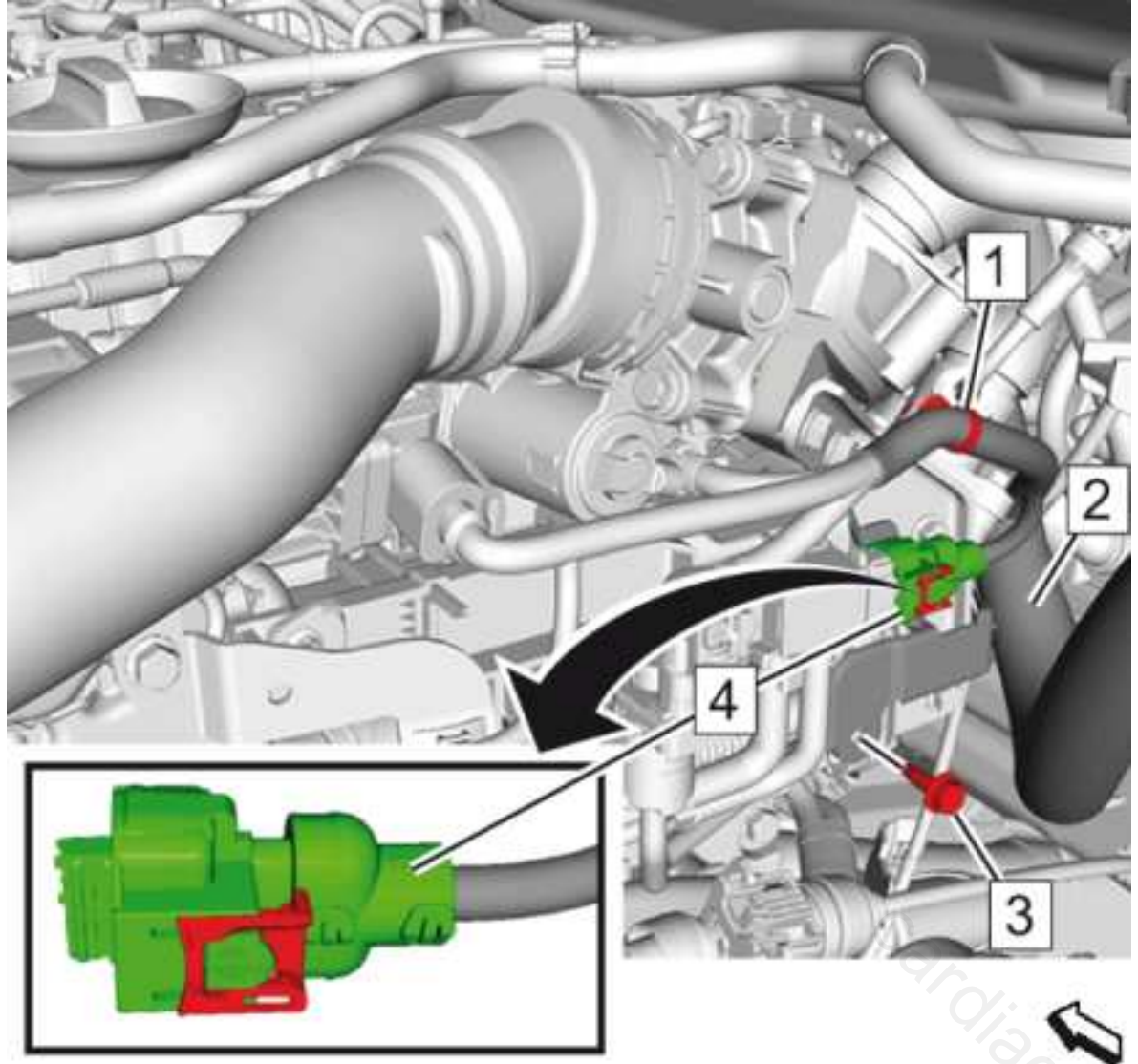


Fig. 461: Engine Wiring Harness, Bracket, Bolt, Retainer And Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

1. Unclip Wiring Harness Retainer (1)
2. Disconnect Electrical Connector (4)
3. Remove Engine Wiring Harness Bracket Bolt (3)
4. Position aside Engine Wiring Harness (2)

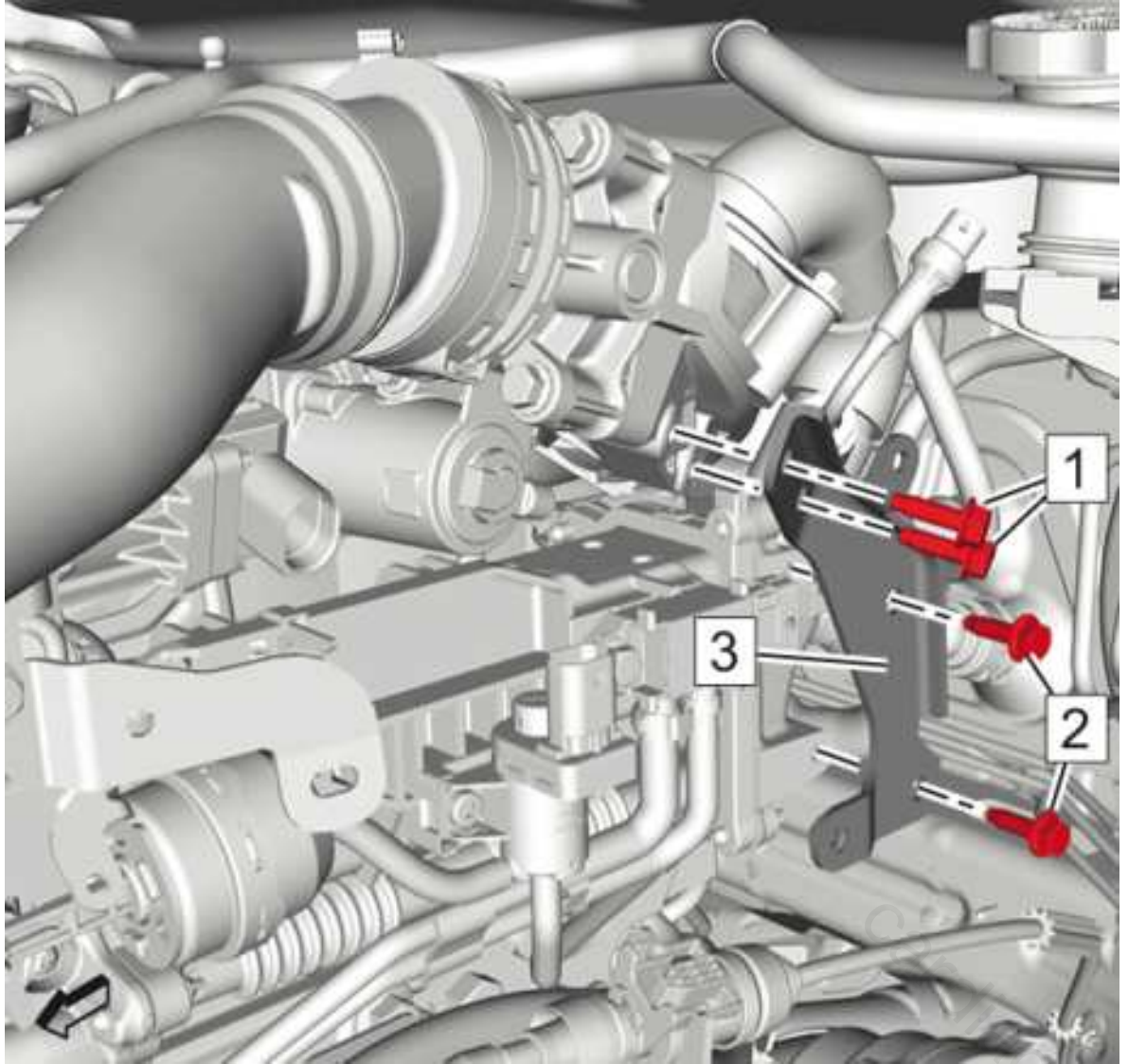


Fig. 462: Intake Manifold Brace And Bolts
Courtesy of GENERAL MOTORS COMPANY

5. Remove Intake Manifold Brace Bolts (1, 2) (Qty: 4)
6. Remove Intake Manifold Brace (3)

Installation Procedure

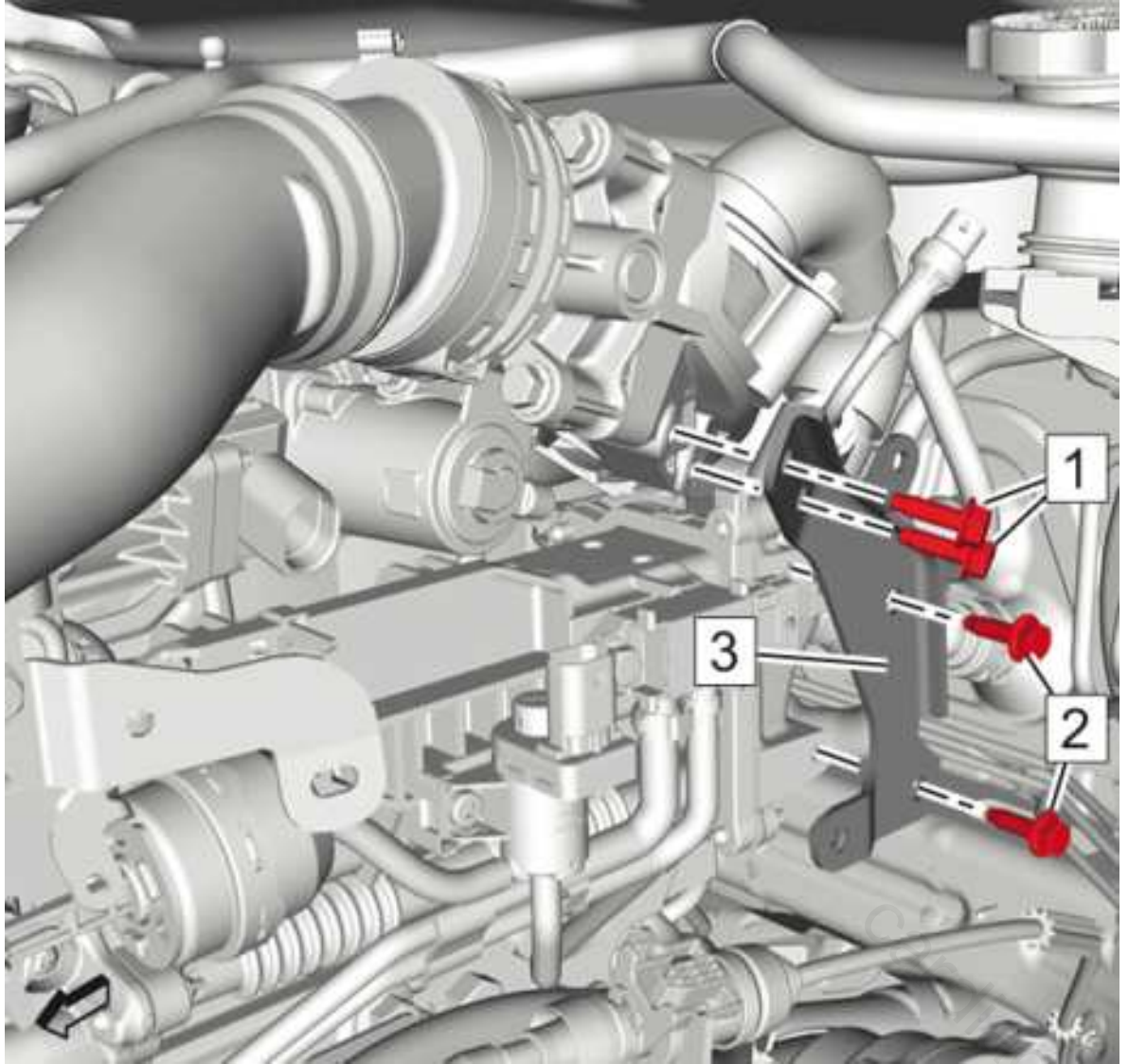


Fig. 463: Intake Manifold Brace And Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Install Intake Manifold Brace (3)

CAUTION: Refer to [Fastener Caution](#)

2. Install and tighten Intake Manifold Brace Bolts (1, 2) (Qty: 4) to 10 N.m (89 lb in)

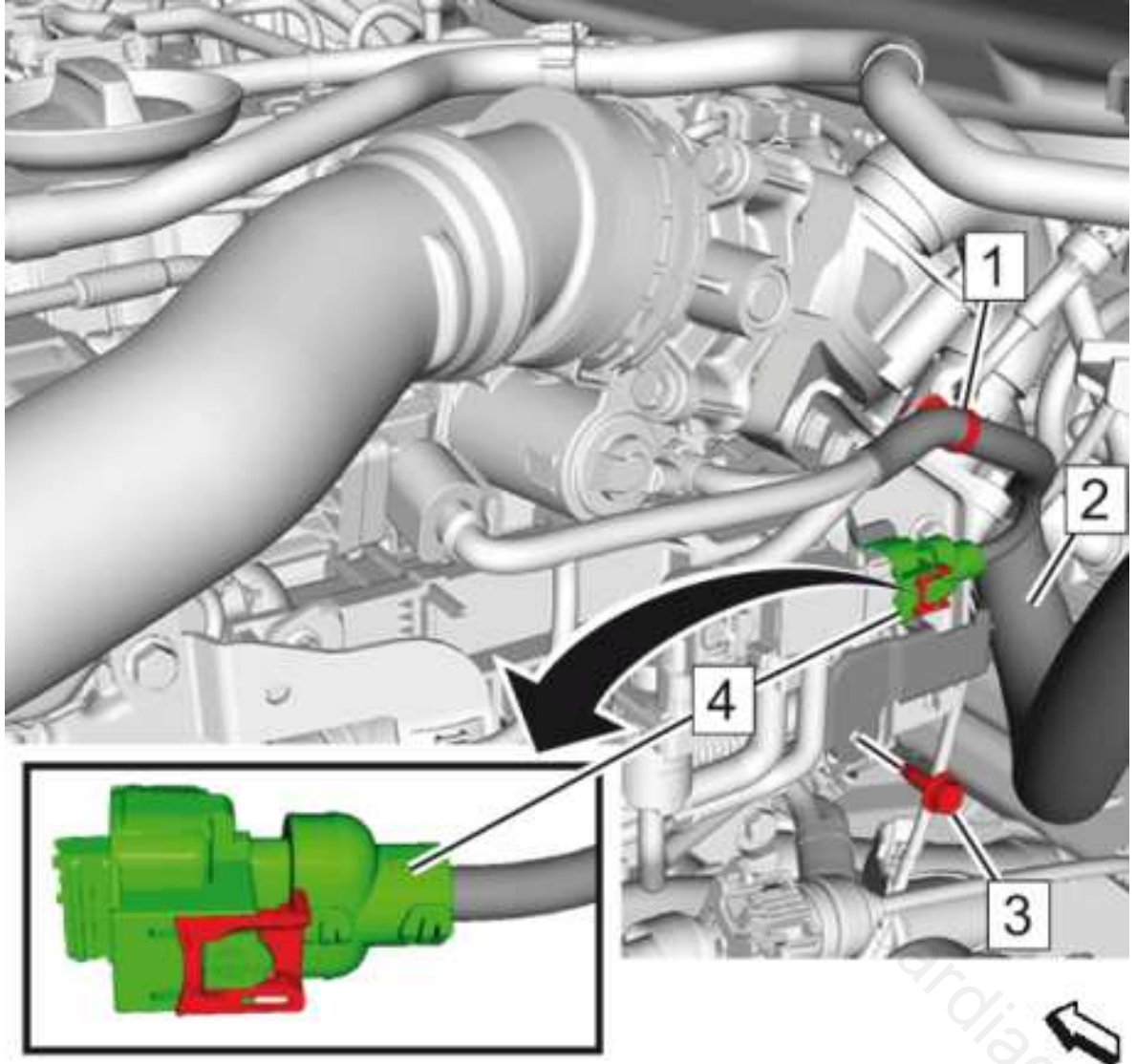


Fig. 464: Engine Wiring Harness, Bracket, Bolt, Retainer And Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

3. Reposition Engine Wiring Harness (2)
4. Install and tighten Engine Wiring Harness Bracket Bolt (3) to 10 N.m (89 lb in)
5. Install Wiring Harness Retainer (1)
6. Connect Electrical Connector (4)

TURBOCHARGER OIL FEED PIPE REPLACEMENT

Removal Procedure

1. Remove Intake Manifold Cover. Refer to [Intake Manifold Cover Replacement](#)
2. Remove the air cleaner outlet duct. Refer to [Air Cleaner Outlet Duct Replacement](#)

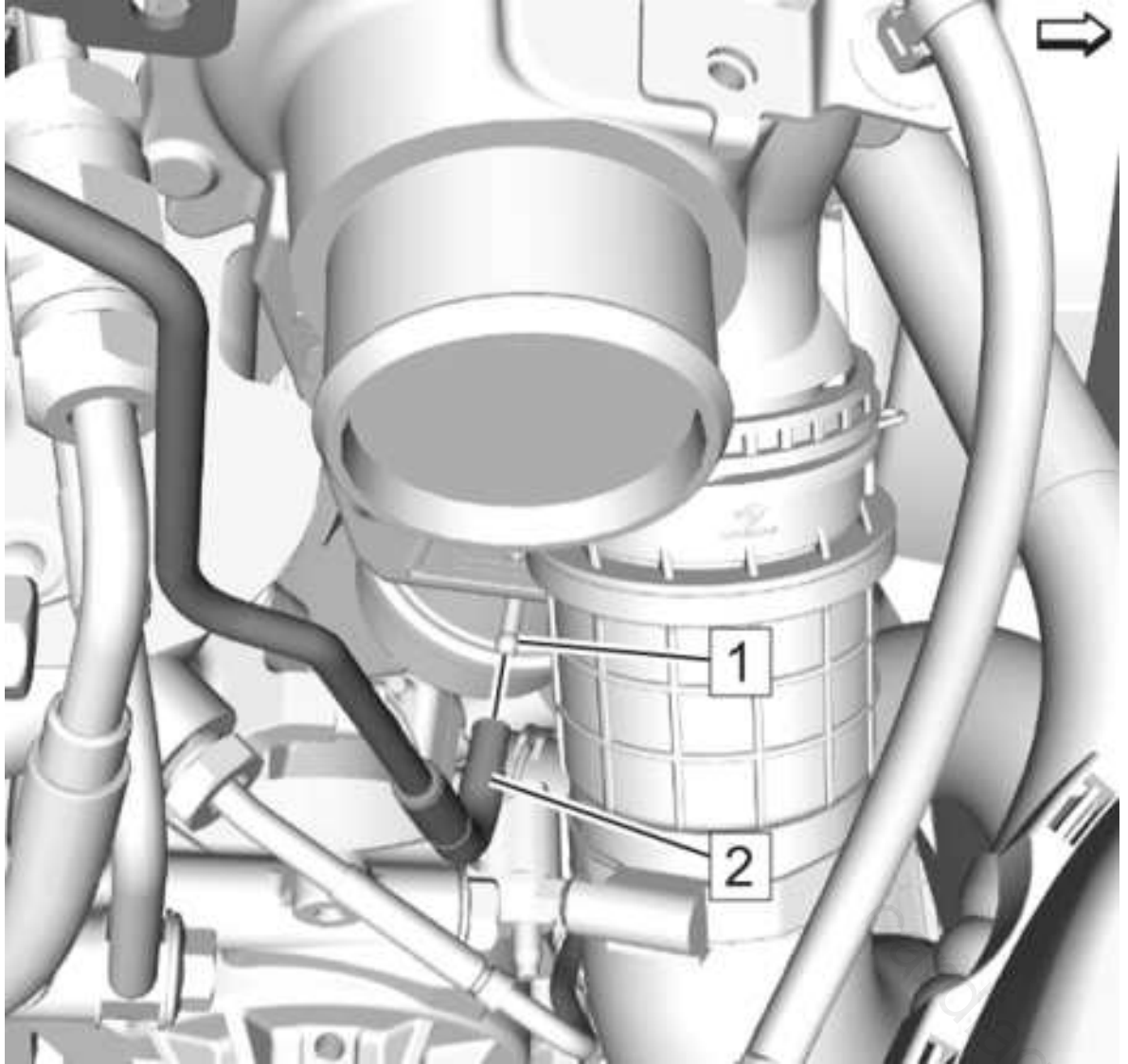


Fig. 465: Turbocharger Wastegate Actuator Pipe And Turbocharger
Courtesy of GENERAL MOTORS COMPANY

3. Remove Turbocharger Wastegate Actuator Pipe (2) @ Turbocharger (1)

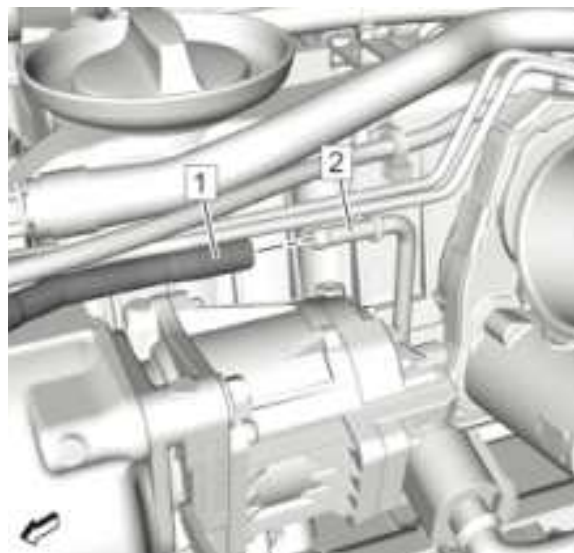


Fig. 466: Turbocharger Wastegate Actuator Pipe And Power Brake Booster Inlet Hose Connector Fitting
Courtesy of GENERAL MOTORS COMPANY

4. Remove Turbocharger Wastegate Actuator Pipe (1) @ Power Brake Booster Inlet Hose Connector Fitting (2)

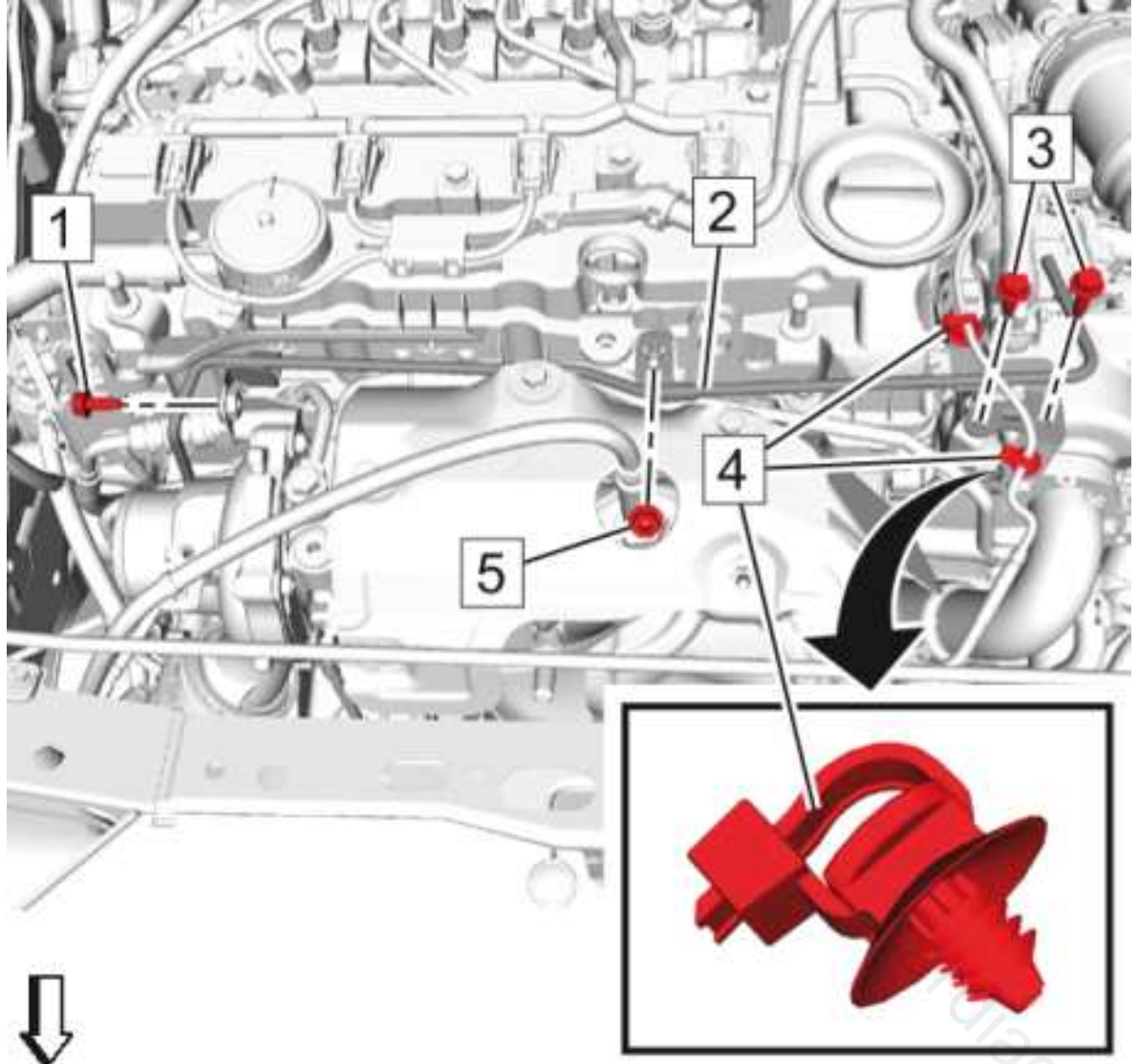


Fig. 467: Turbocharger Wastegate Actuator Pipe, Bolts, Nut And Clips
Courtesy of GENERAL MOTORS COMPANY

5. Remove Turbocharger Wastegate Actuator Pipe Bolts (1, 3) (Qty: 3)
6. Remove the turbocharger wastegate actuator pipe nut (5).
7. Unclip Wiring Harness Clips (4) (Qty: 2)
8. Remove Turbocharger Wastegate Actuator Pipe (2)

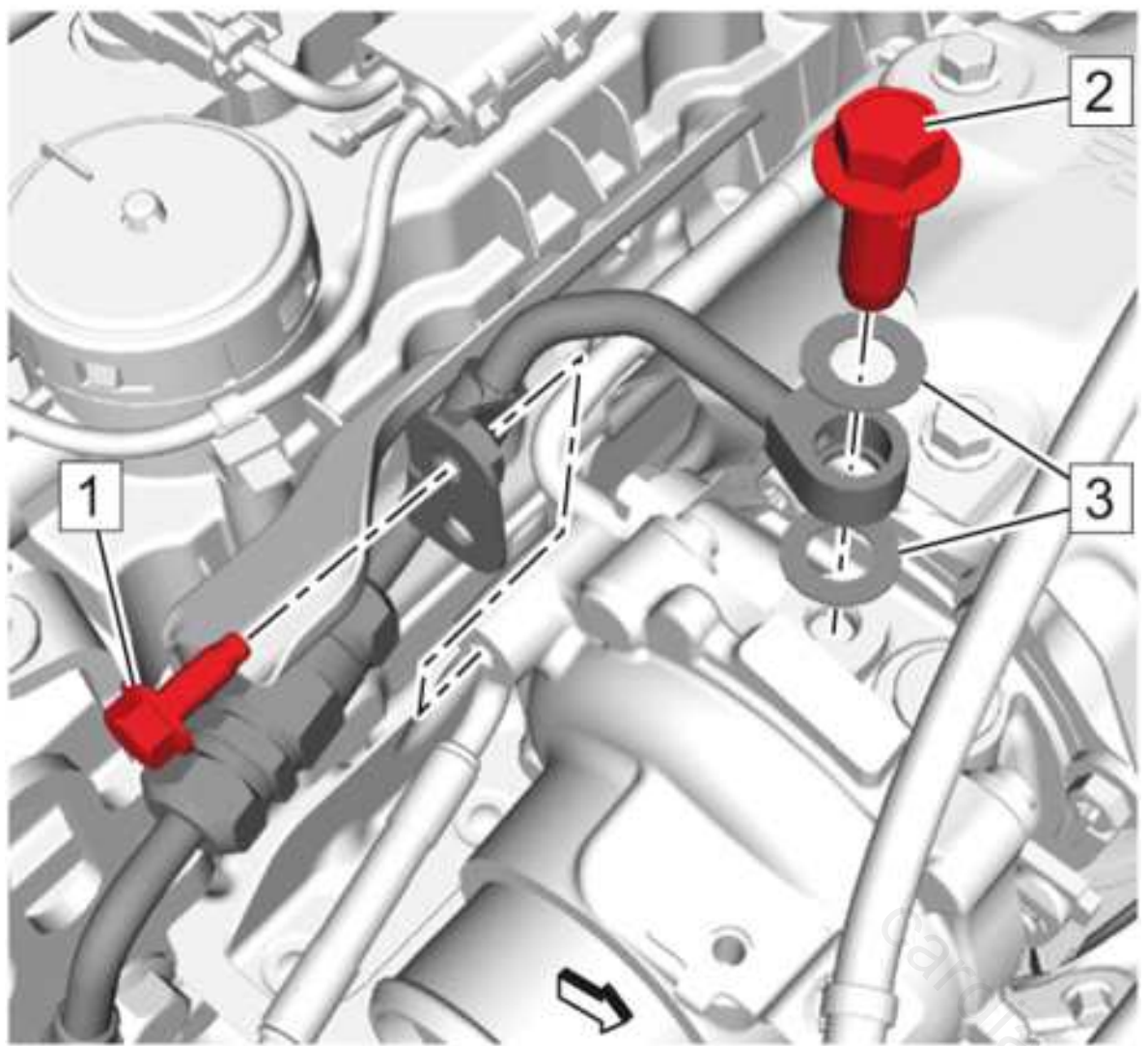


Fig. 468: Turbocharger Oil Feed Pipe Hollow Screw, Bracket Bolt And Gaskets
Courtesy of GENERAL MOTORS COMPANY

9. Remove Turbocharger Oil Feed Pipe Bracket Bolt (1)
10. Remove Turbocharger Oil Feed Pipe Hollow Screw (2)
11. Remove and DISCARD the gaskets. (3) (Qty: 2)

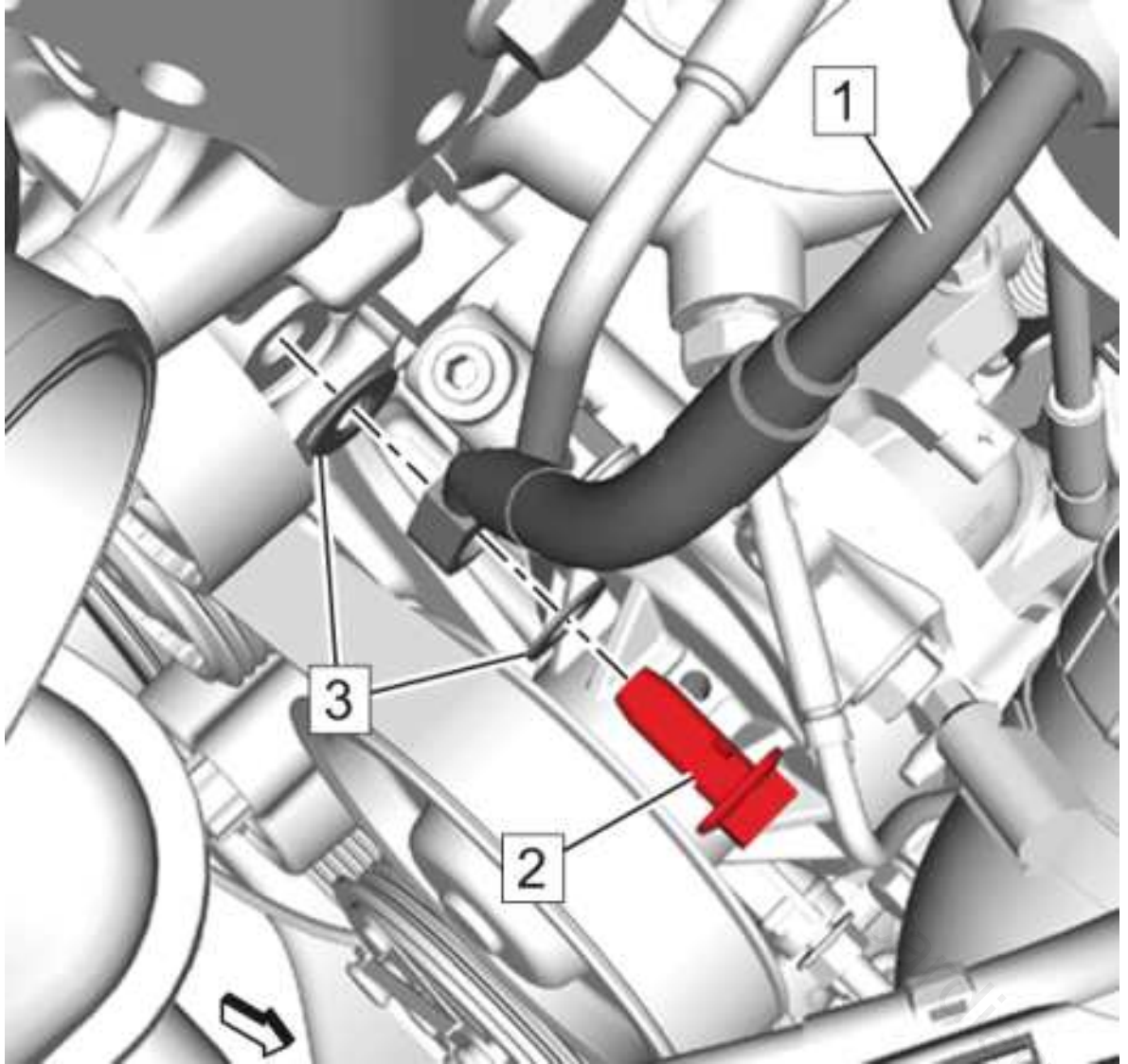


Fig. 469: Turbocharger Oil Feed Pipe, Hollow Screw And Gaskets
Courtesy of GENERAL MOTORS COMPANY

12. Remove Turbocharger Oil Feed Pipe Hollow Screw (2)
13. Remove and DISCARD the gaskets. (3) (Qty: 2)
14. Remove Turbocharger Oil Feed Pipe (1)

Installation Procedure

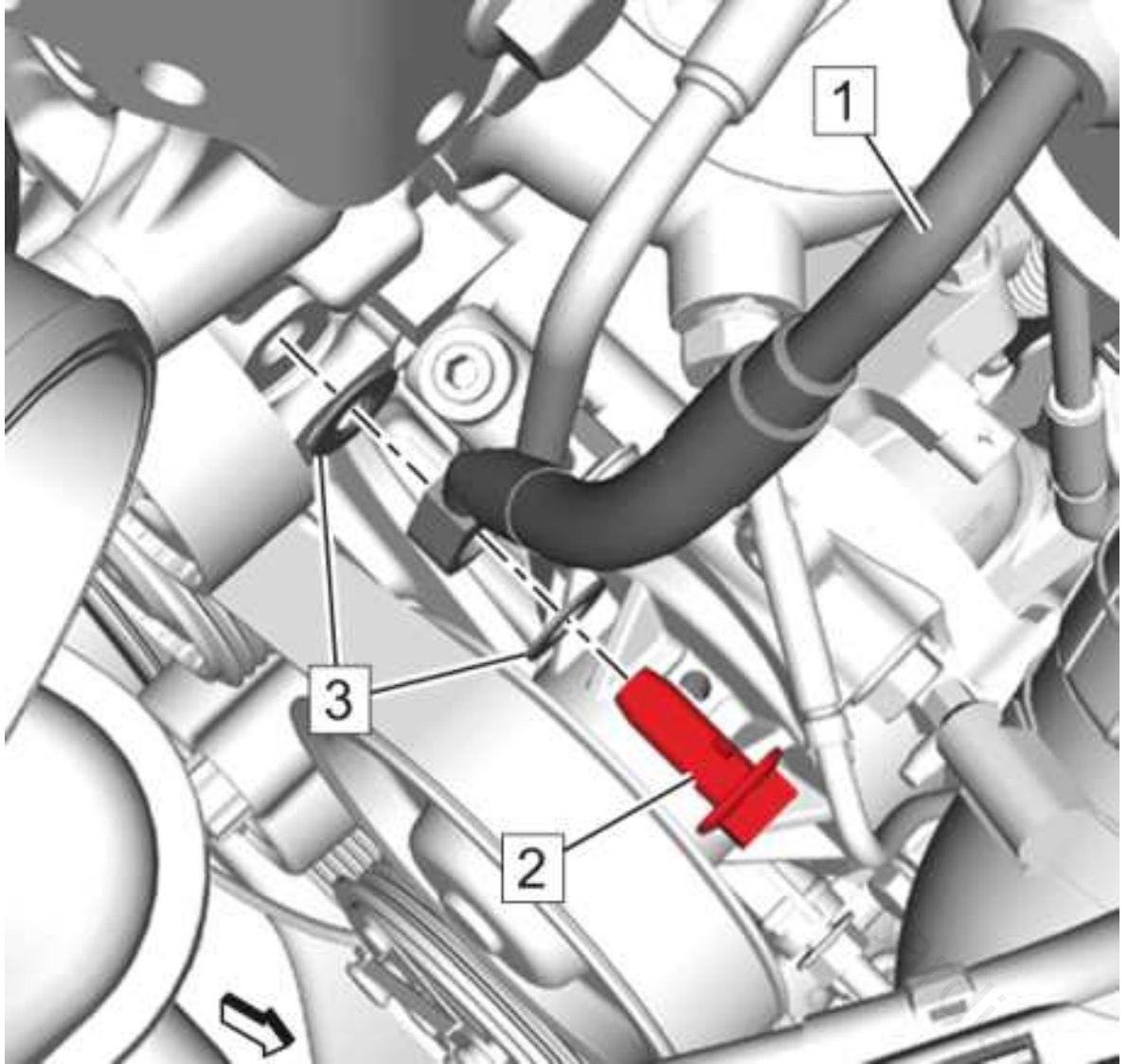


Fig. 470: Turbocharger Oil Feed Pipe, Hollow Screw And Gaskets
Courtesy of GENERAL MOTORS COMPANY

1. Install Turbocharger Oil Feed Pipe (1)
2. Install NEW gaskets. (3) (Qty: 2)
3. Install Turbocharger Oil Feed Pipe Hollow Screw (2) - Do NOT tighten.

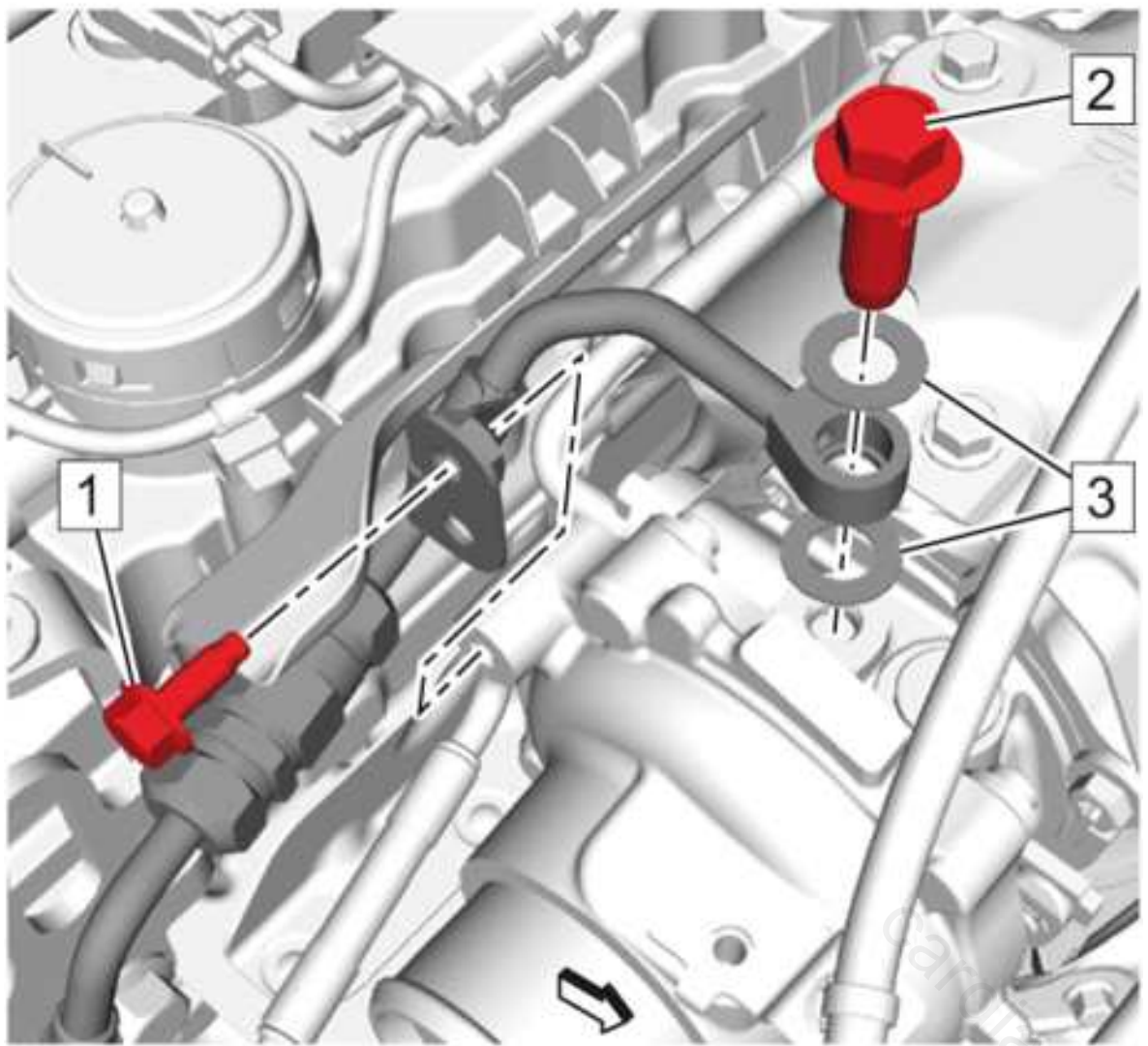


Fig. 471: Turbocharger Oil Feed Pipe Hollow Screw, Bracket Bolt And Gaskets
Courtesy of GENERAL MOTORS COMPANY

4. Install NEW gaskets. (3) (Qty: 2)

CAUTION: Refer to **Fastener Caution**

5. Install and tighten Turbocharger Oil Feed Pipe Hollow Screw (2) to 25 N.m (18 lb ft)

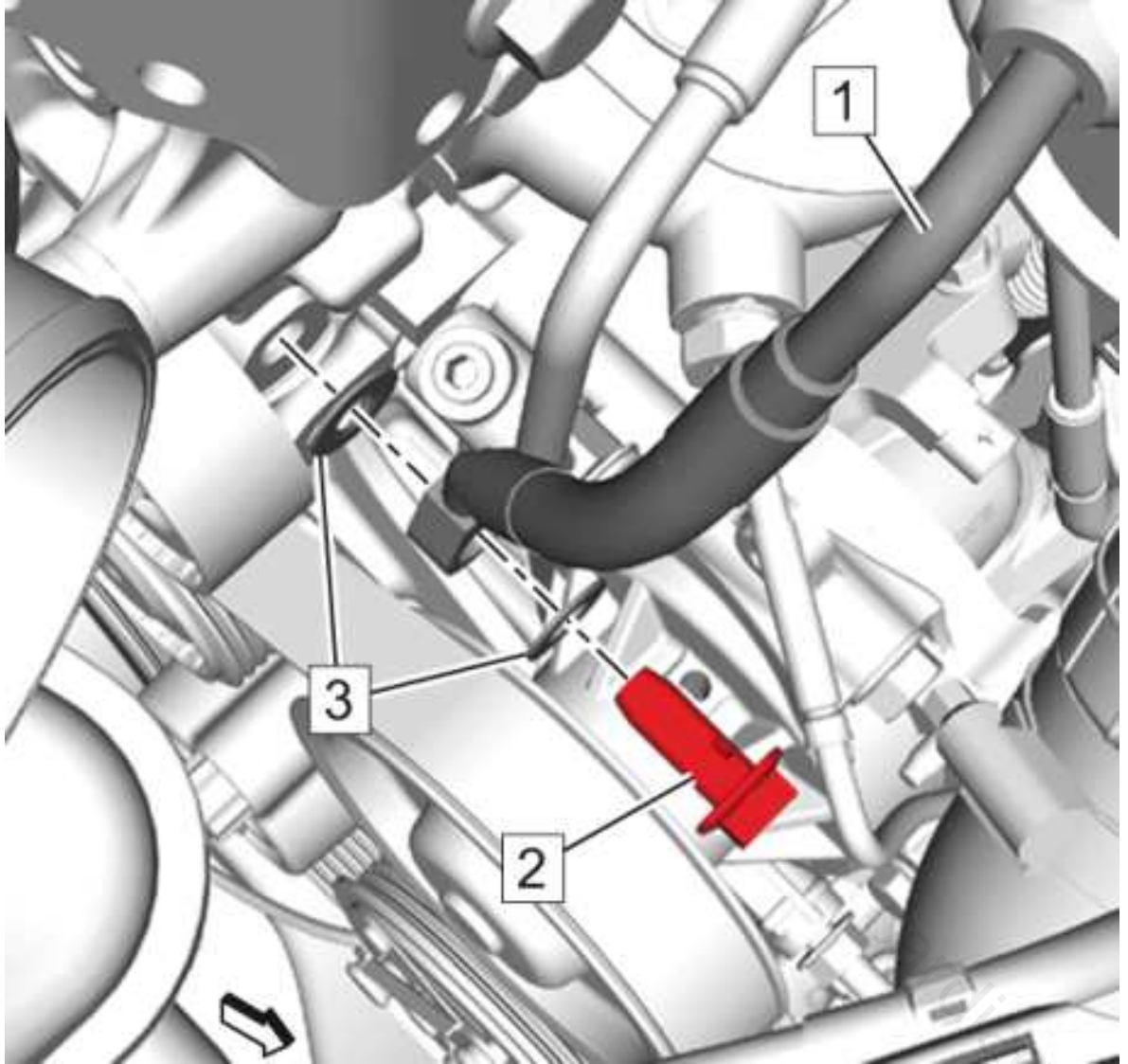


Fig. 472: Turbocharger Oil Feed Pipe, Hollow Screw And Gaskets
Courtesy of GENERAL MOTORS COMPANY

6. Tighten Turbocharger Oil Feed Pipe Hollow Screw (2) to 25 N.m (18 lb ft)

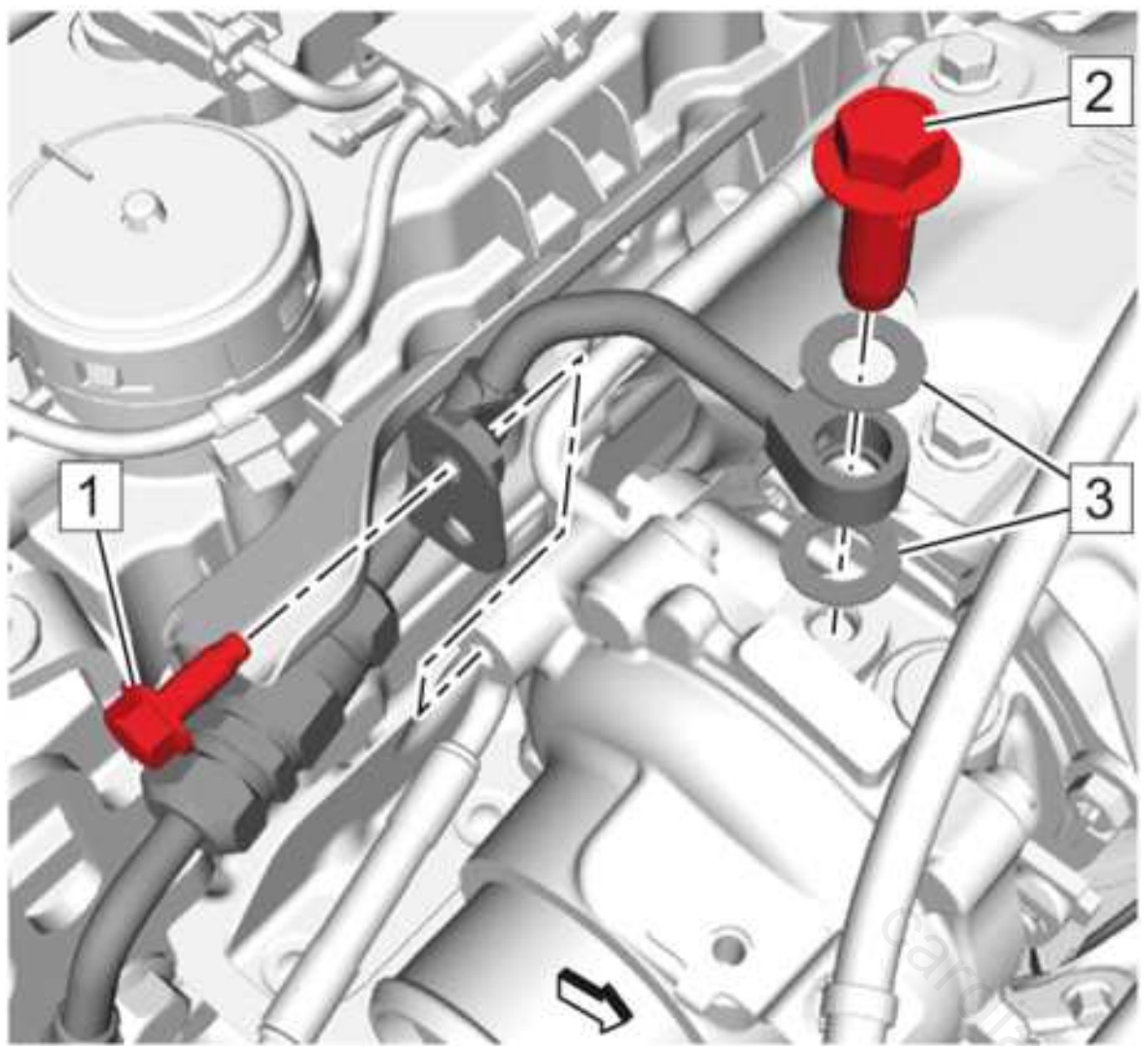


Fig. 473: Turbocharger Oil Feed Pipe Hollow Screw, Bracket Bolt And Gaskets
Courtesy of GENERAL MOTORS COMPANY

7. Install and tighten Turbocharger Oil Feed Pipe Bracket Bolt (1) to 10 N.m (89 lb in)

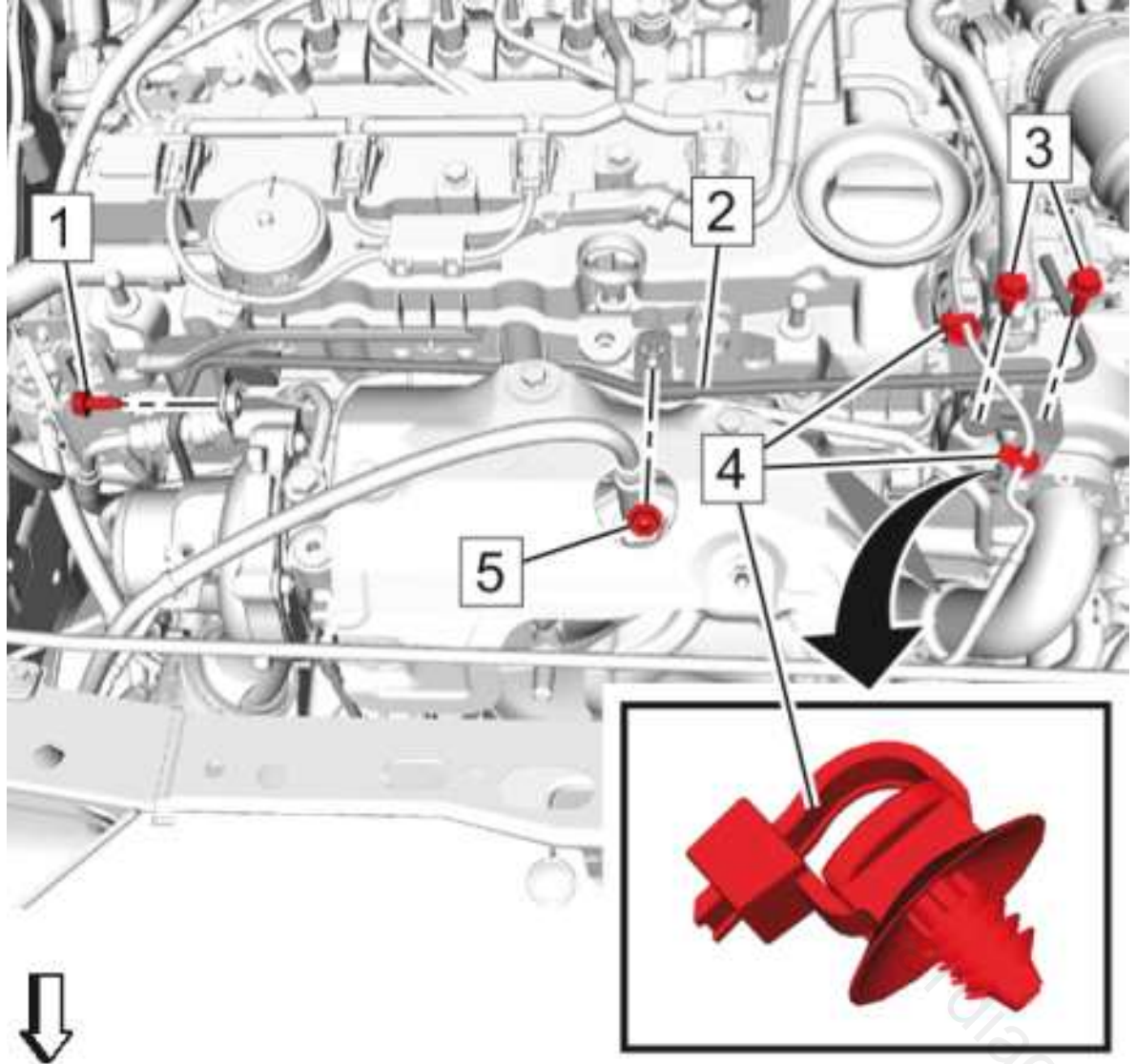


Fig. 474: Turbocharger Wastegate Actuator Pipe, Bolts, Nut And Clips
 Courtesy of GENERAL MOTORS COMPANY

8. Install Turbocharger Wastegate Actuator Pipe (2)
9. Install Wiring Harness Clips (4) (Qty: 2)
10. Install the turbocharger wastegate actuator pipe nut (5) and tighten to 10 N.m (89 lb in)
11. Install and tighten Turbocharger Wastegate Actuator Pipe Bolts (1, 3) (Qty: 3) to 10 N.m (89 lb in)

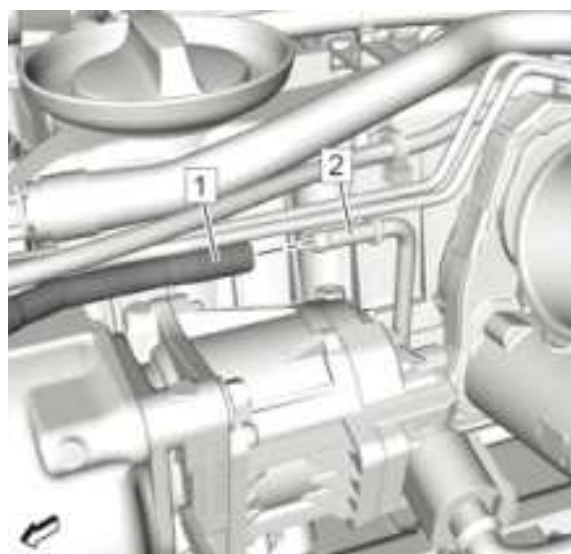


Fig. 475: Turbocharger Wastegate Actuator Pipe And Power Brake Booster Inlet Hose Connector Fitting
 Courtesy of GENERAL MOTORS COMPANY

12. Install Turbocharger Wastegate Actuator Pipe (1) @ Power Brake Booster Inlet Hose Connector Fitting (2)

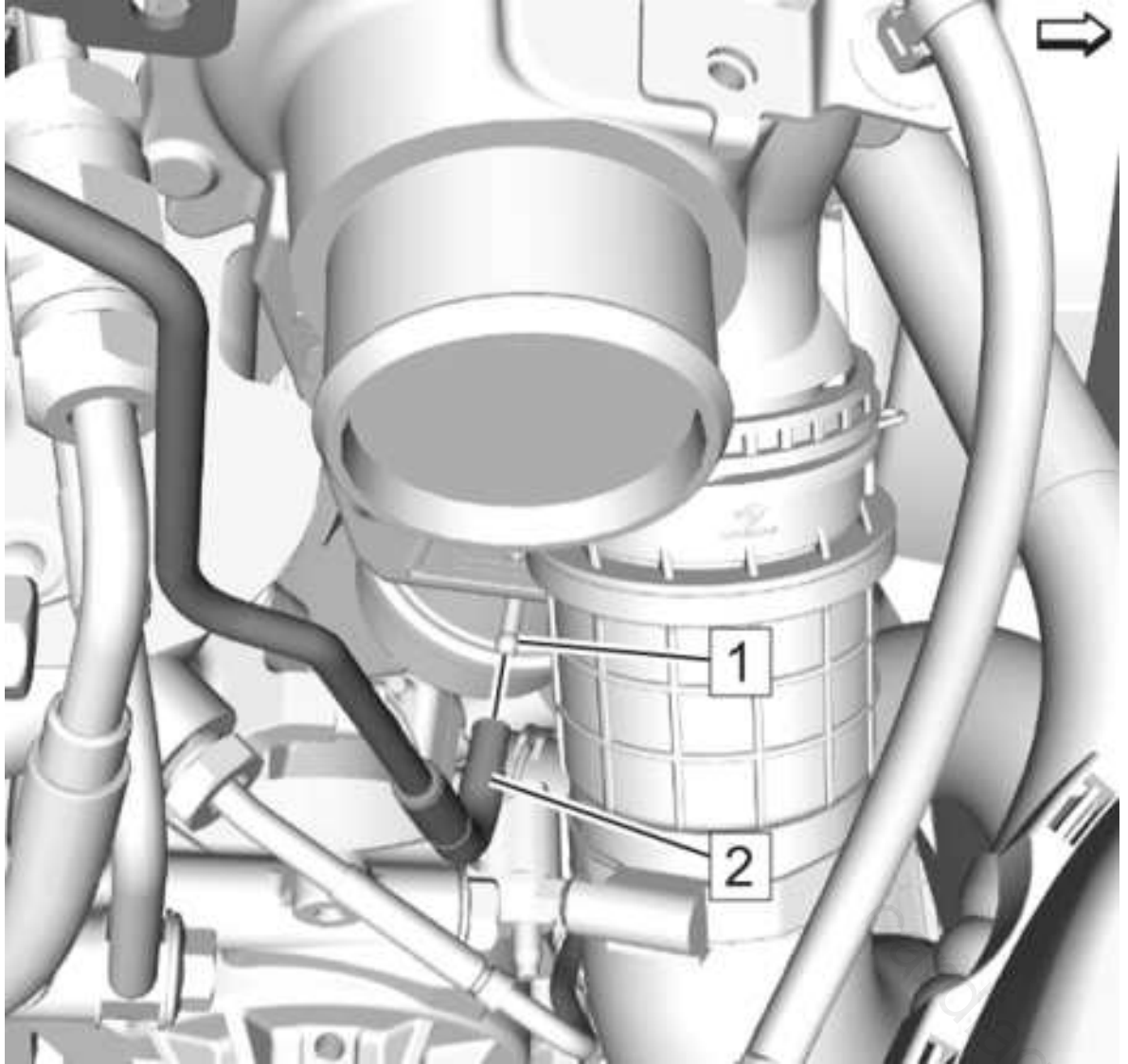


Fig. 476: Turbocharger Wastegate Actuator Pipe And Turbocharger
Courtesy of GENERAL MOTORS COMPANY

13. Install Turbocharger Wastegate Actuator Pipe (2) @ Turbocharger (1)
14. Install the air cleaner outlet duct. Refer to [Air Cleaner Outlet Duct Replacement](#)
15. Install Intake Manifold Cover. Refer to [Intake Manifold Cover Replacement](#)

TURBOCHARGER OIL RETURN PIPE REPLACEMENT

Removal Procedure

1. Remove Oxidation Catalytic Converter. Refer to [Oxidation Catalytic Converter Replacement \(LH7\)](#)

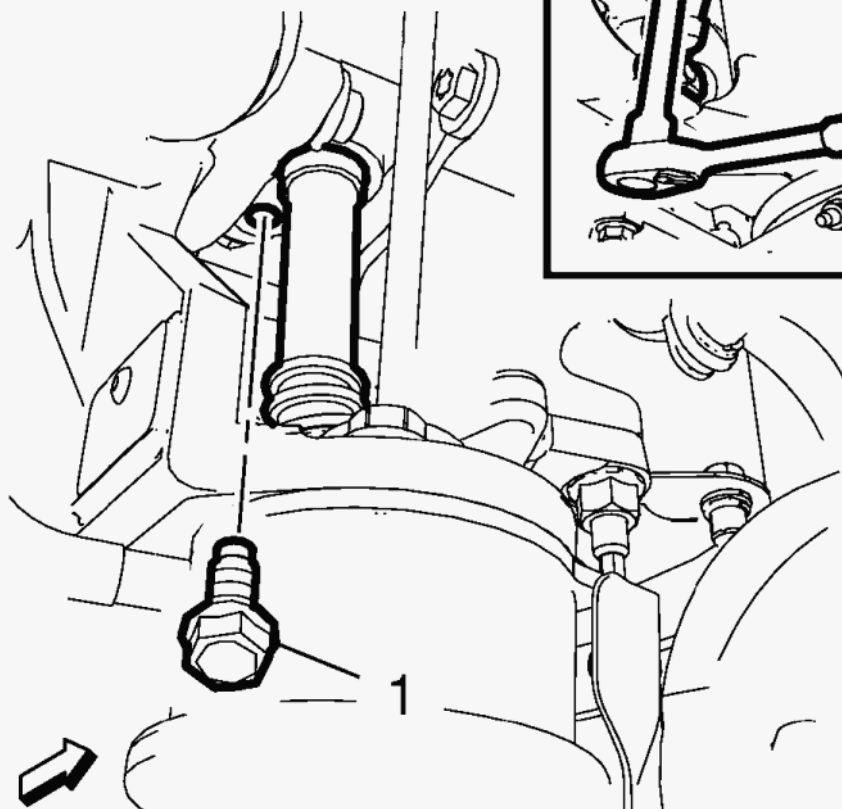


Fig. 477: Upper Turbocharger Oil Return Pipe Bolt
Courtesy of GENERAL MOTORS COMPANY

2. Remove the upper turbocharger oil return pipe bolt (1).

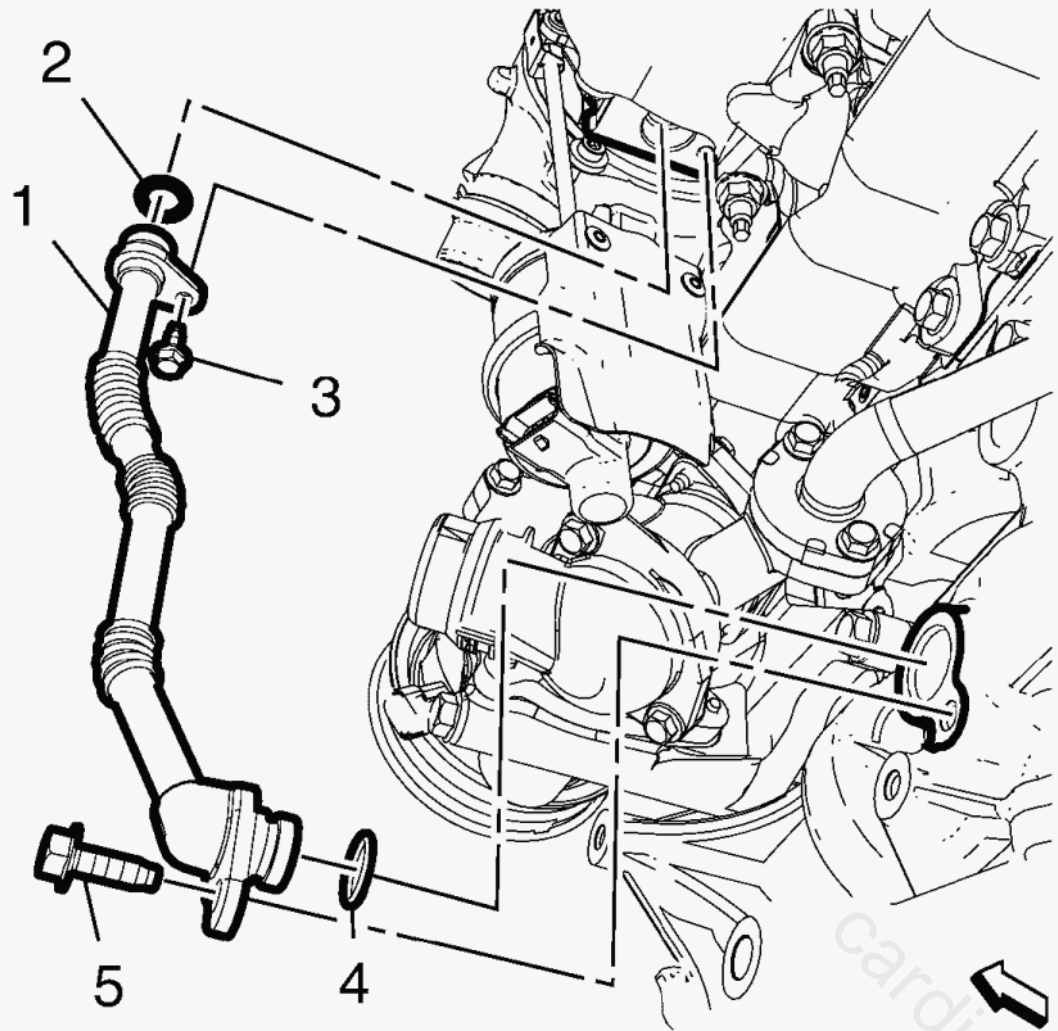


Fig. 478: Turbocharger Oil Return Pipe, Bolts And Gaskets
Courtesy of GENERAL MOTORS COMPANY

3. Remove Turbocharger Oil Return Pipe Bolt (5)
4. Remove Turbocharger Oil Return Pipe (1)
5. Remove and DISCARD Turbocharger Oil Return Pipe Gaskets (2, 4)

Installation Procedure

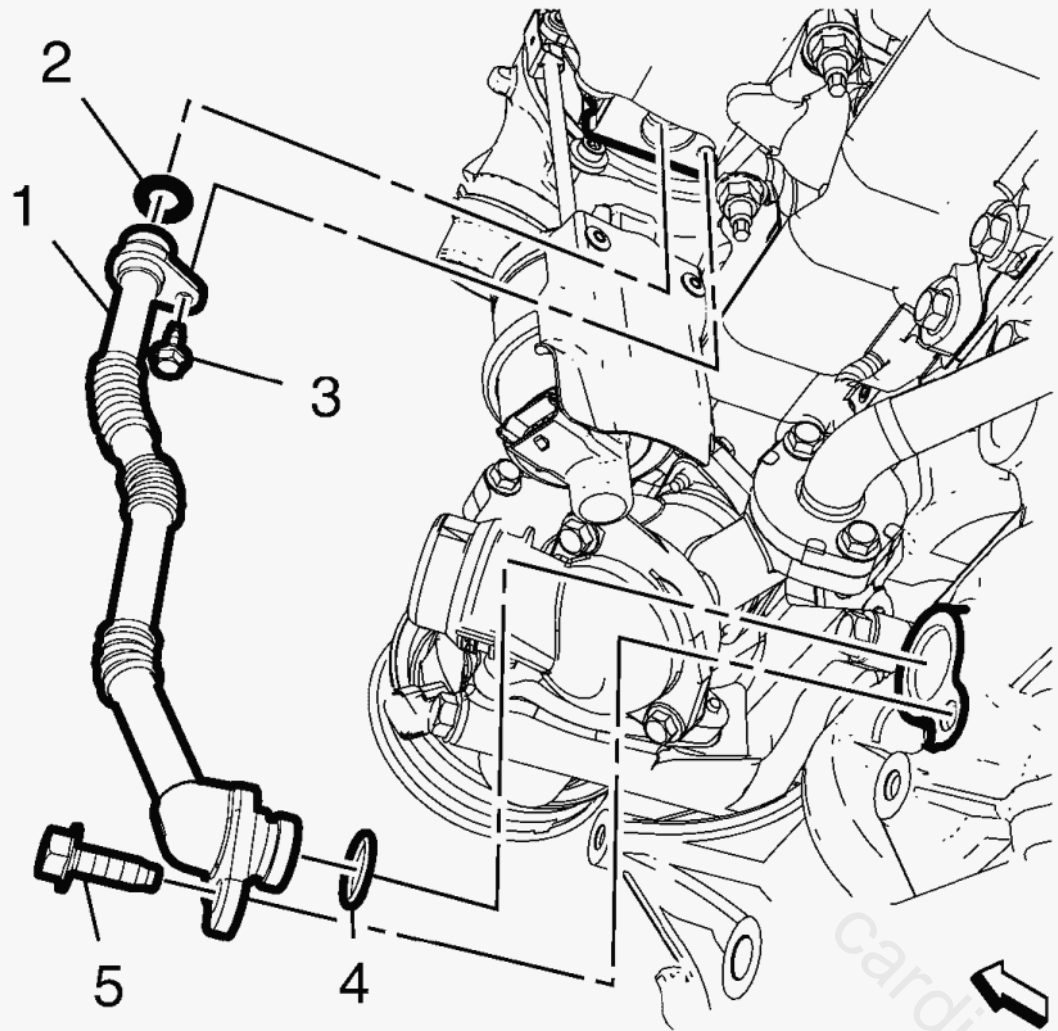


Fig. 479: Turbocharger Oil Return Pipe, Bolts And Gaskets
Courtesy of GENERAL MOTORS COMPANY

1. Install NEW Turbocharger Oil Return Pipe Gaskets (2, 4)

NOTE: The new turbocharger oil return pipe has a flexible pipe.

2. Install Turbocharger Oil Return Pipe (1)
3. Install, but do NOT tighten Turbocharger Oil Return Pipe Bolt (5)

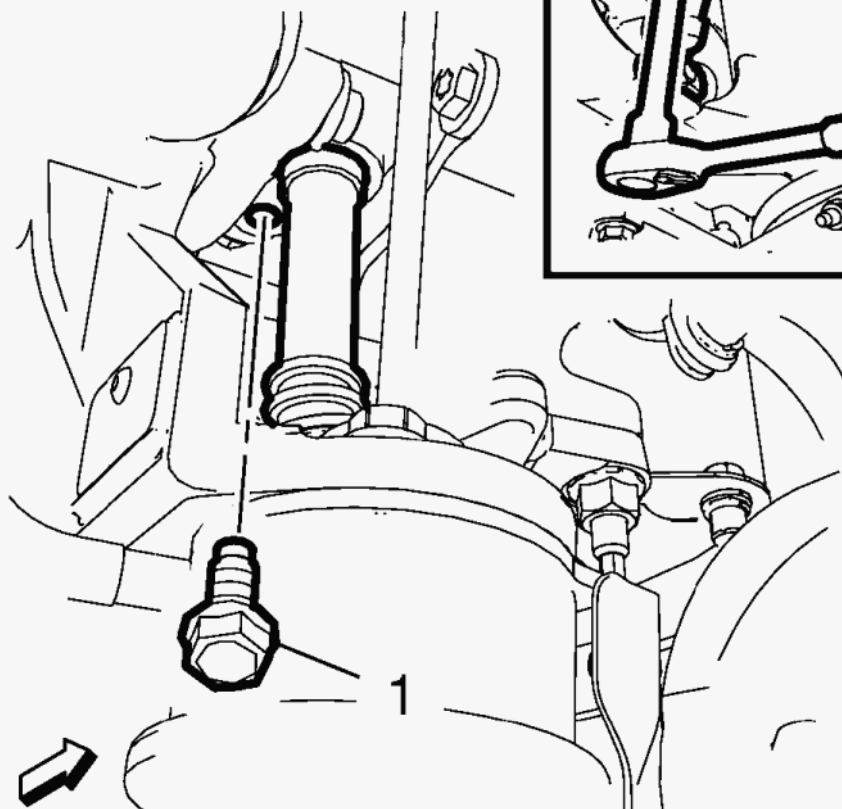


Fig. 480: Upper Turbocharger Oil Return Pipe Bolt
Courtesy of GENERAL MOTORS COMPANY

4. Install and tighten the upper turbocharger oil return pipe bolt (1) to 10 N.m (89 lb in).

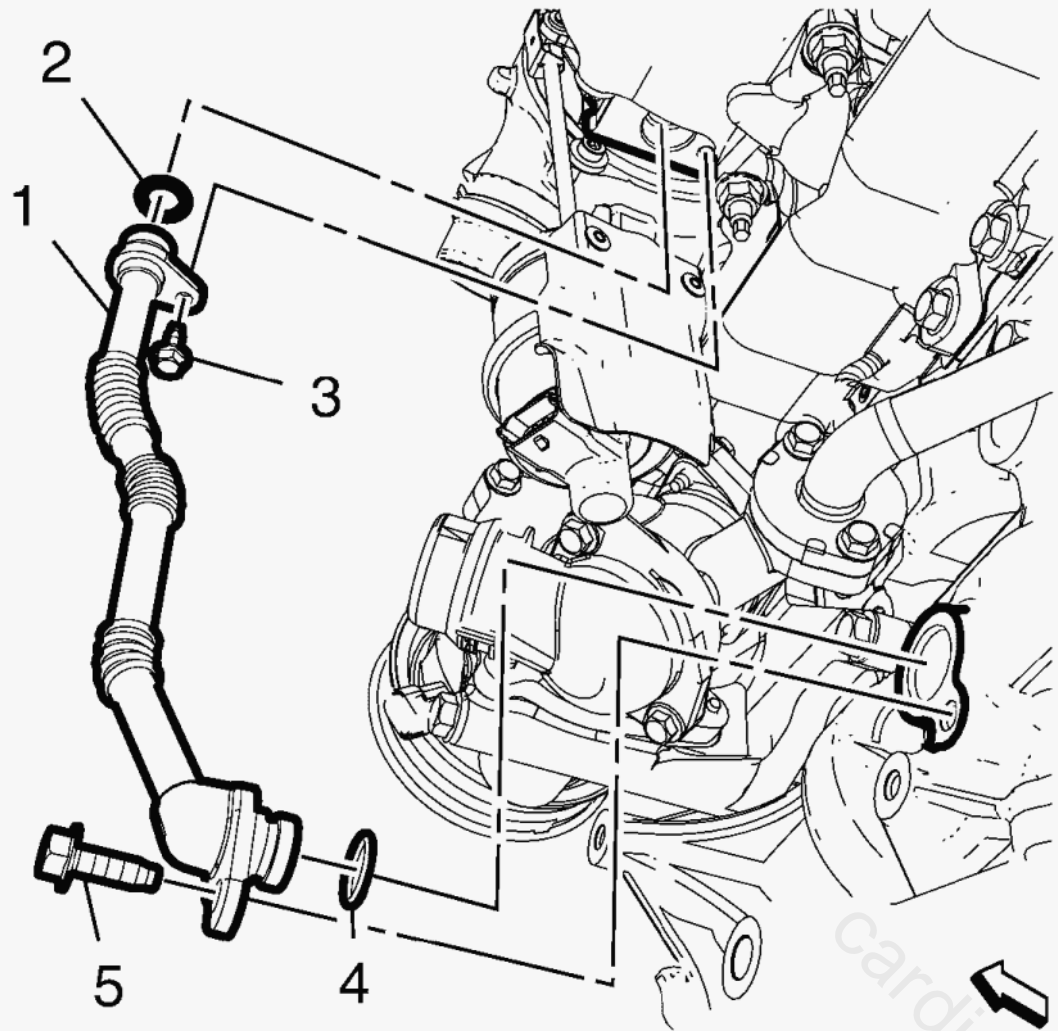


Fig. 481: Turbocharger Oil Return Pipe, Bolts And Gaskets
Courtesy of GENERAL MOTORS COMPANY

5. Tighten Turbocharger Oil Return Pipe Bolt (5) to 25 N.m (18 lb ft)
6. Install Oxidation Catalytic Converter. Refer to [Oxidation Catalytic Converter Replacement \(LH7\)](#)

TURBOCHARGER REPLACEMENT

Removal Procedure

1. Remove the air cleaner outlet duct. Refer to [Air Cleaner Outlet Duct Replacement](#)
2. Remove Oxidation Catalytic Converter. Refer to [Oxidation Catalytic Converter Replacement \(LH7\)](#)
3. Drain the cooling system. Refer to [Cooling System Draining and Filling \(GE 47716\)](#), [Cooling System Draining and Filling \(Static\)](#)
4. Remove Turbocharger Wastegate Actuator Pipe. Refer to [Turbocharger Wastegate Actuator Pipe Replacement](#)

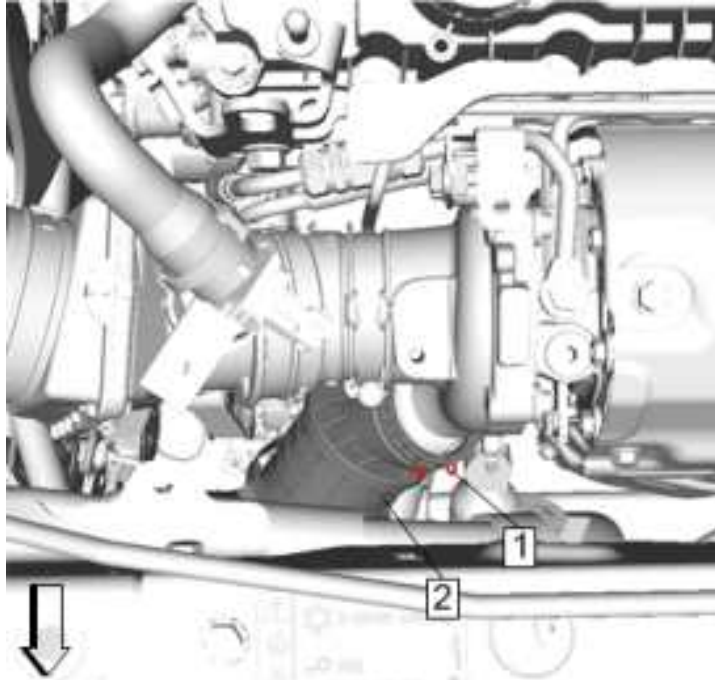


Fig. 482: Charge Air Cooler Inlet Air Tube And Retaining Clip
 Courtesy of GENERAL MOTORS COMPANY

5. Disconnect Charge Air Cooler Inlet Air Tube (2) @ Turbocharger. Refer to [Charge Air Cooler Inlet Air Tube Replacement](#)

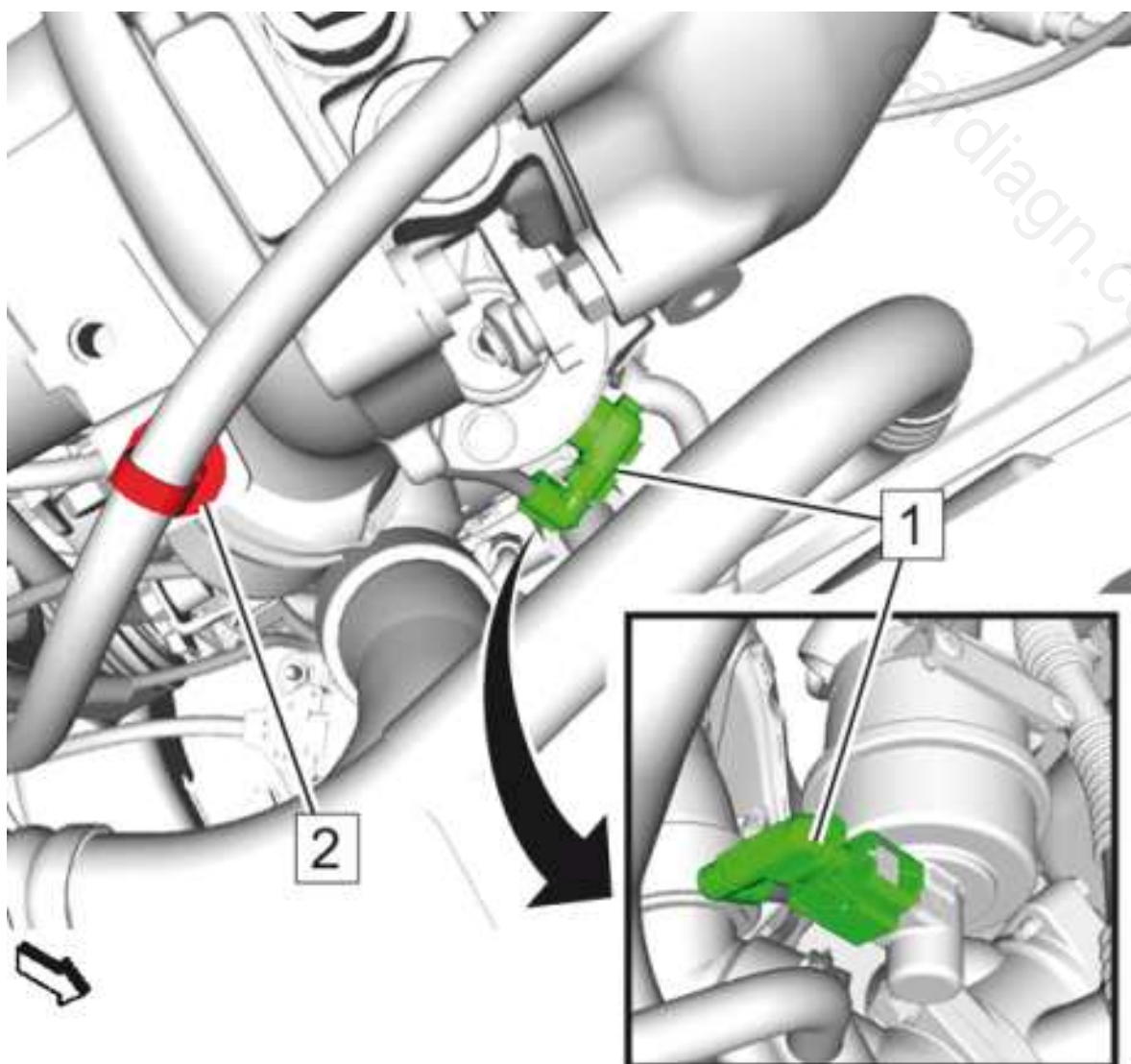


Fig. 483: Wiring Harness Retainer And Electrical Connector
 Courtesy of GENERAL MOTORS COMPANY

6. Remove Wiring Harness Retainer (2)

7. Disconnect the electrical connector. (1)

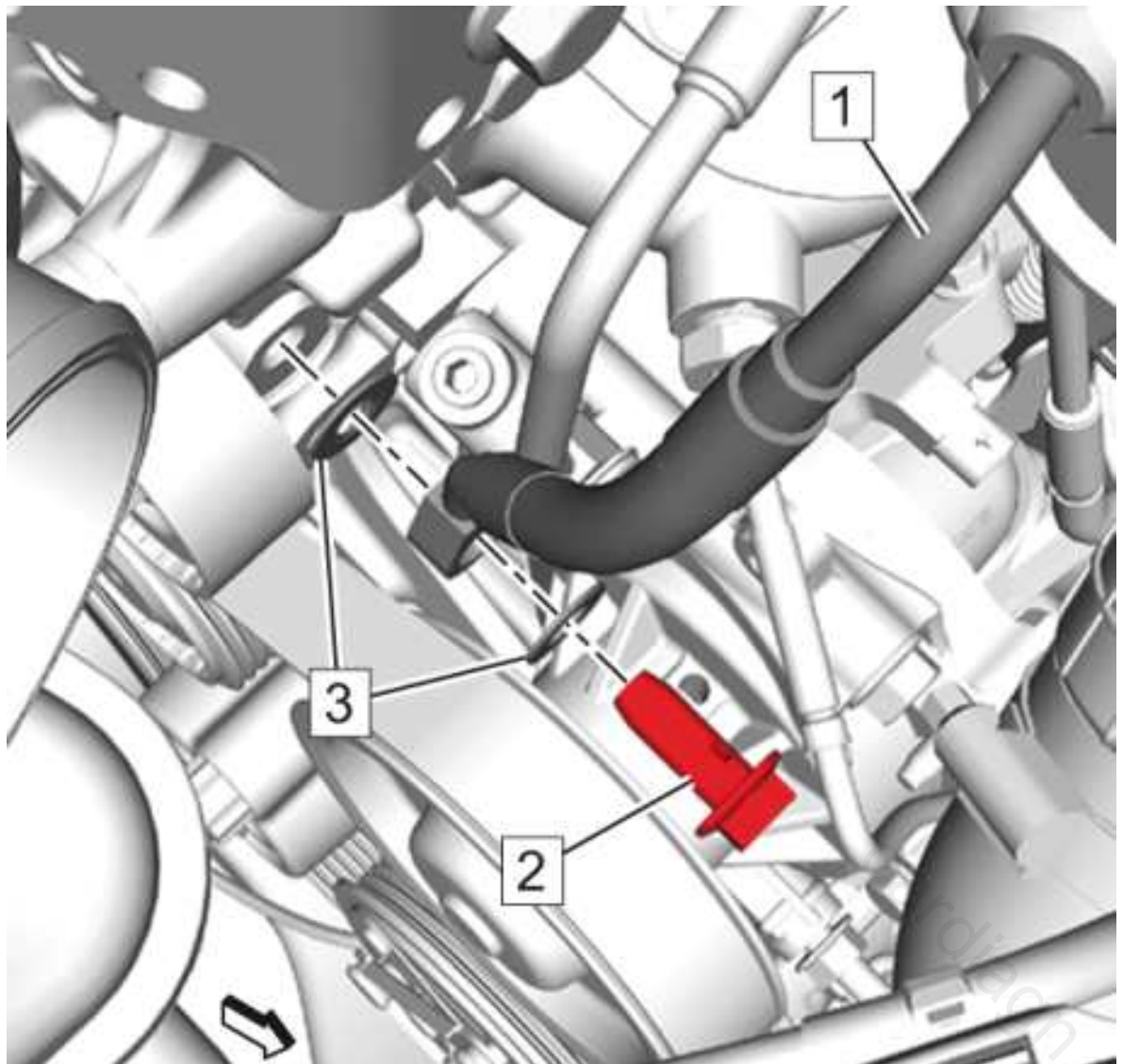


Fig. 484: Turbocharger Oil Feed Pipe, Hollow Screw And Gaskets
Courtesy of GENERAL MOTORS COMPANY

8. Remove Turbocharger Oil Feed Pipe Hollow Screw (2)
9. Remove and DISCARD the gaskets. (3) (Qty: 2)

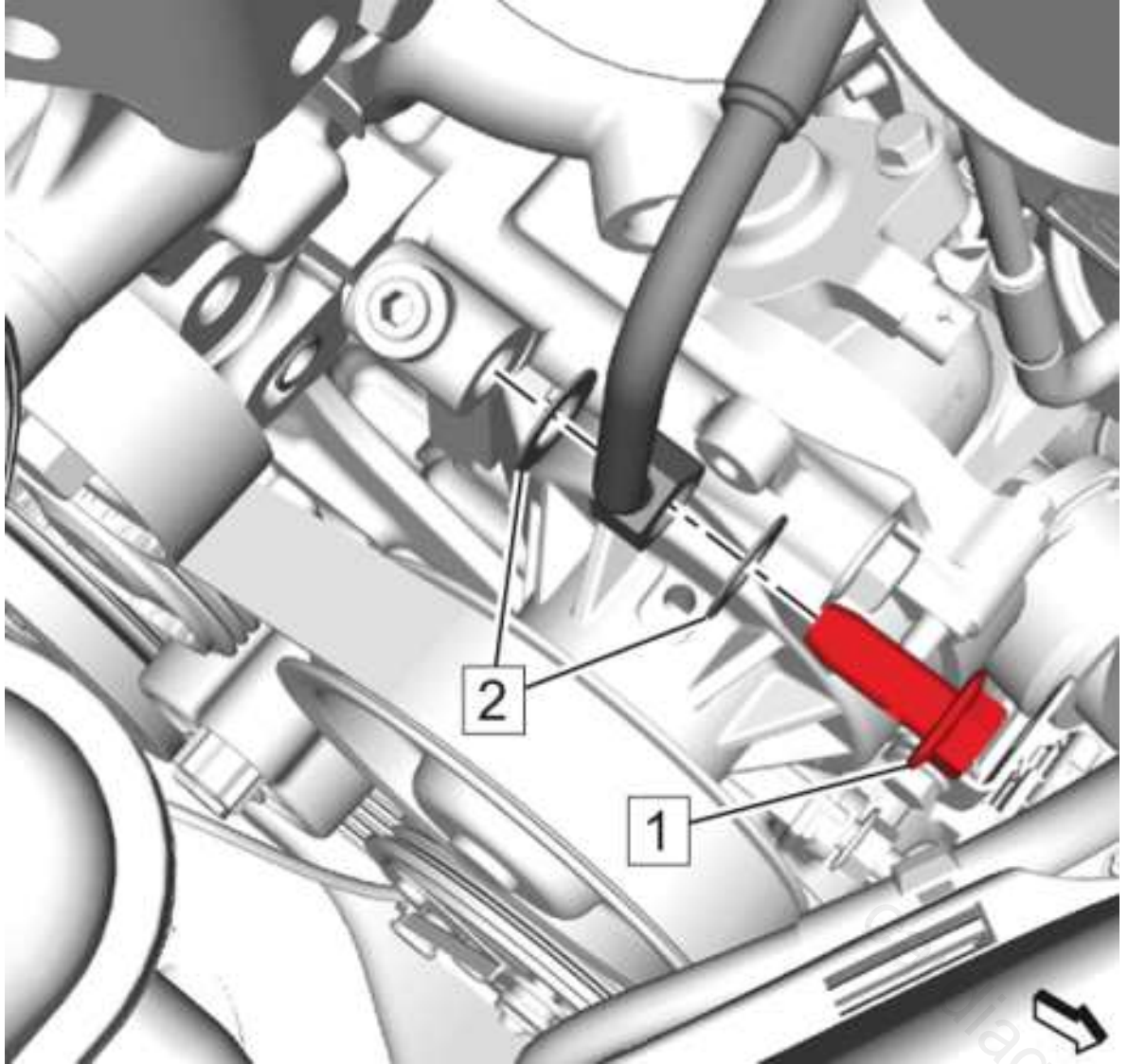


Fig. 485: Turbocharger Coolant Feed Pipe Hollow Screw And Gaskets
Courtesy of GENERAL MOTORS COMPANY

10. Remove Turbocharger Coolant Feed Pipe Hollow Screw (1)
11. Remove and DISCARD the gaskets. (2) (Qty: 2)

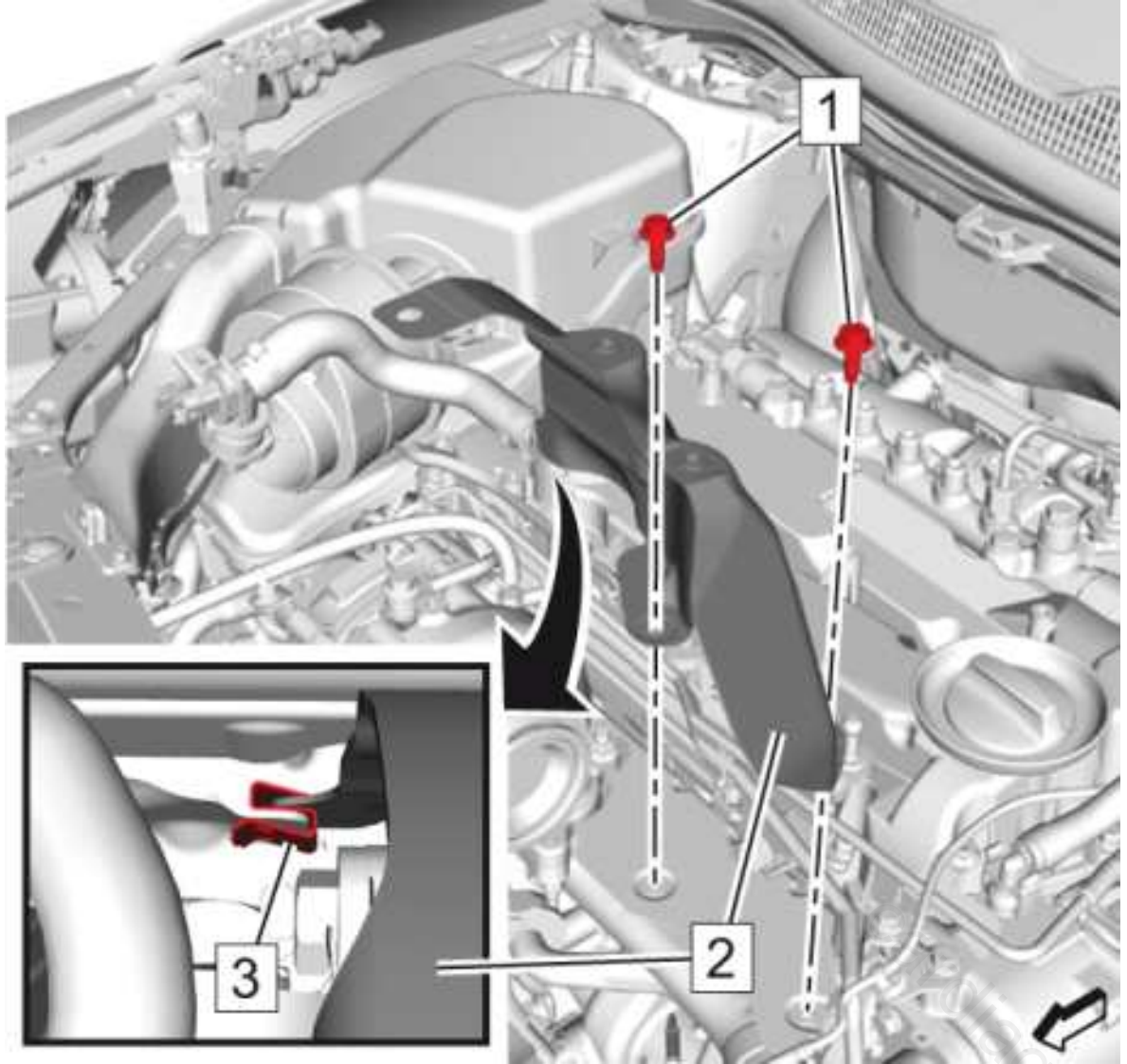


Fig. 486: Turbocharger Heat Shield, Bolts And Clamp
Courtesy of GENERAL MOTORS COMPANY

12. Remove Turbocharger Heat Shield Bolts (1) (Qty: 2)
13. Unclip Turbocharger Heat Shield (2) @ Clamp (3)
14. Remove Turbocharger Heat Shield (2)

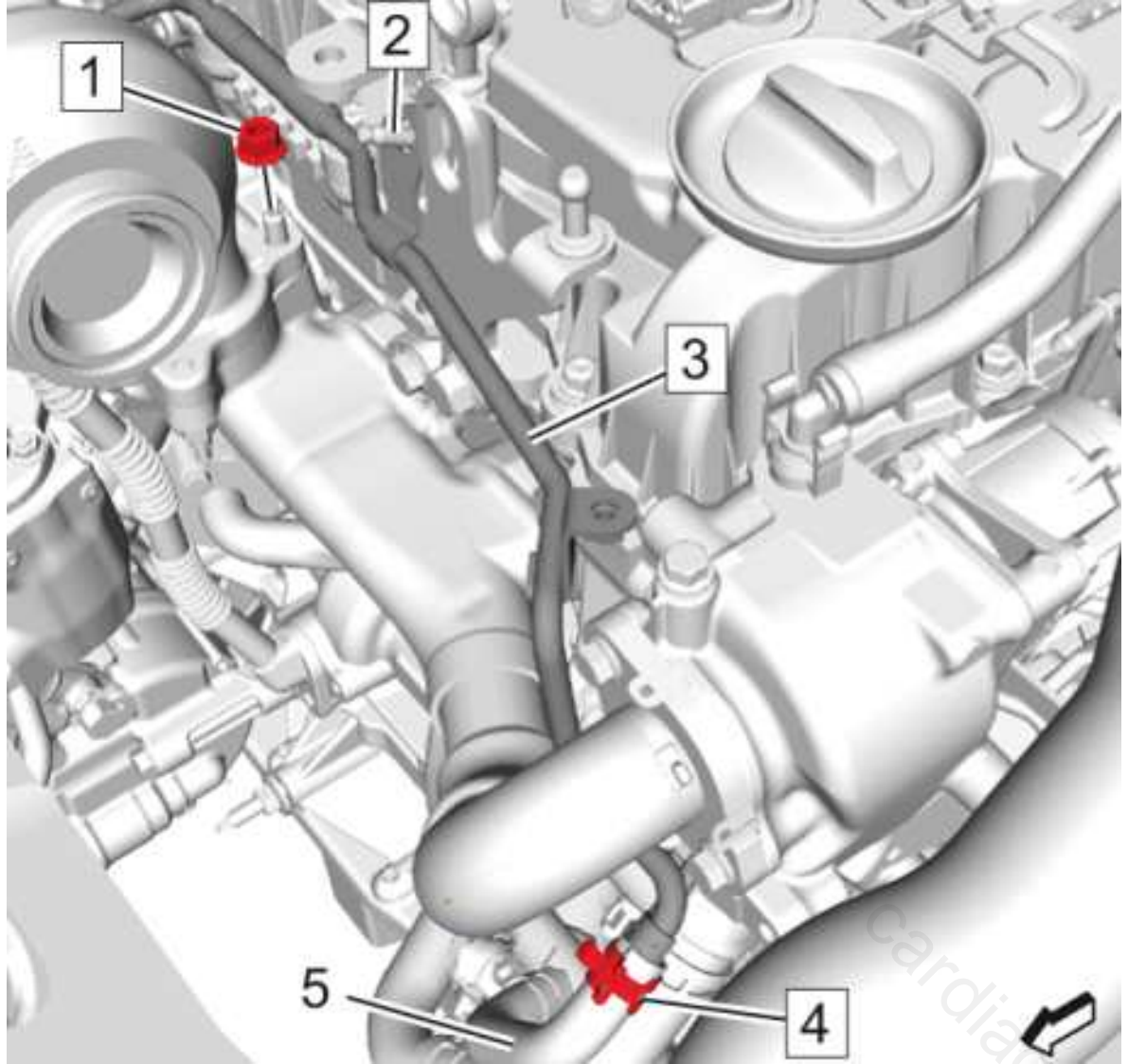


Fig. 487: Turbocharger Coolant Feed Hose, Feed Pipe, Clamp, Stud And Nut
Courtesy of GENERAL MOTORS COMPANY

15. Loosen Turbocharger Coolant Feed Hose Clamp (4)
16. Disconnect Turbocharger Coolant Feed Hose (5) @ Turbocharger Coolant Feed Pipe (3)
17. Remove Turbocharger Coolant Feed Pipe (3) @ Stud (2)
18. Remove Turbocharger Nut (1)
19. Raise and support the vehicle. Refer to [Lifting and Jacking the Vehicle](#)

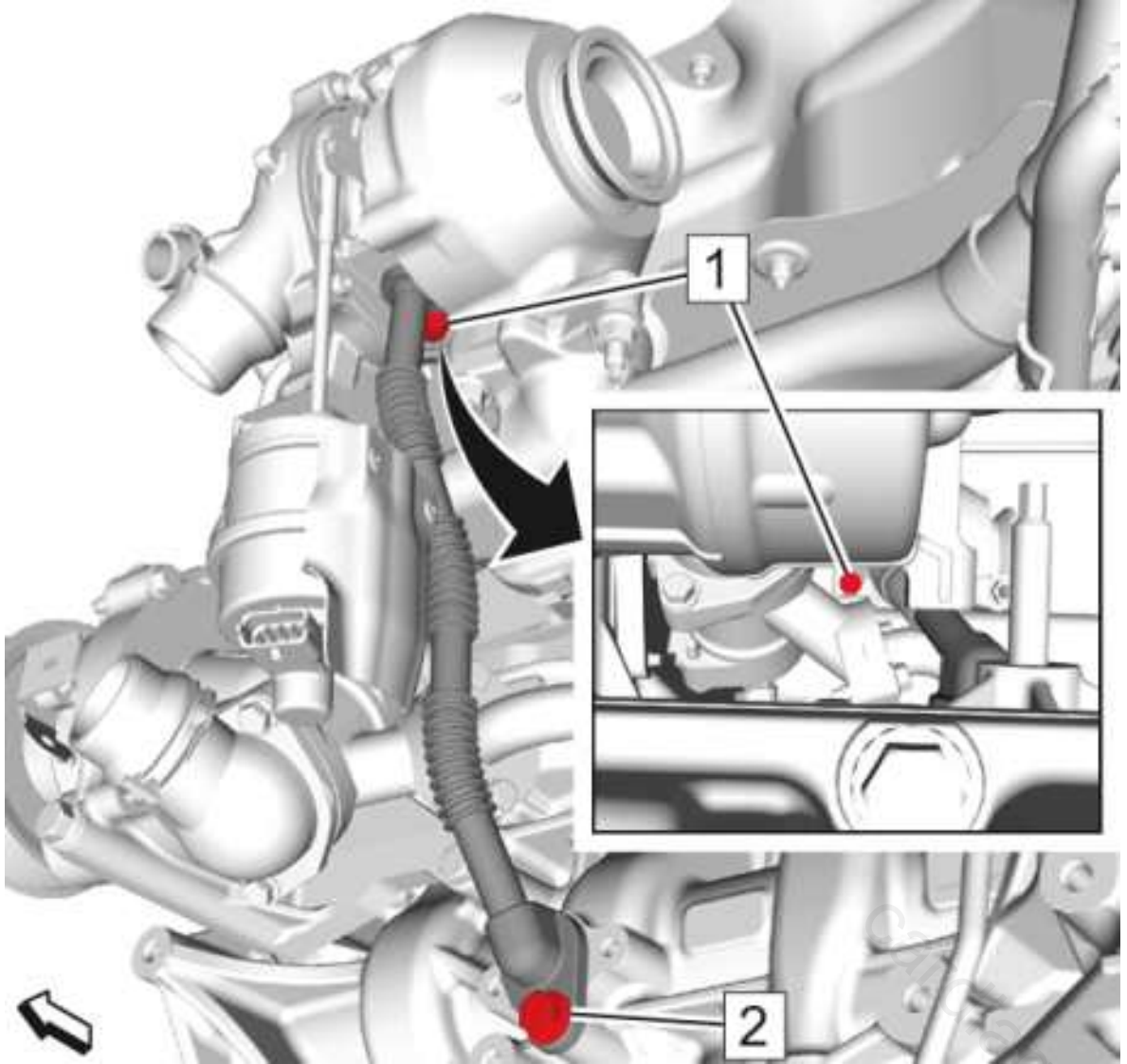


Fig. 488: Turbocharger Oil Return Pipe Bolts
Courtesy of GENERAL MOTORS COMPANY

20. Loosen Turbocharger Oil Return Pipe Bolt (2)
21. Remove Turbocharger Oil Return Pipe Bolt (1)

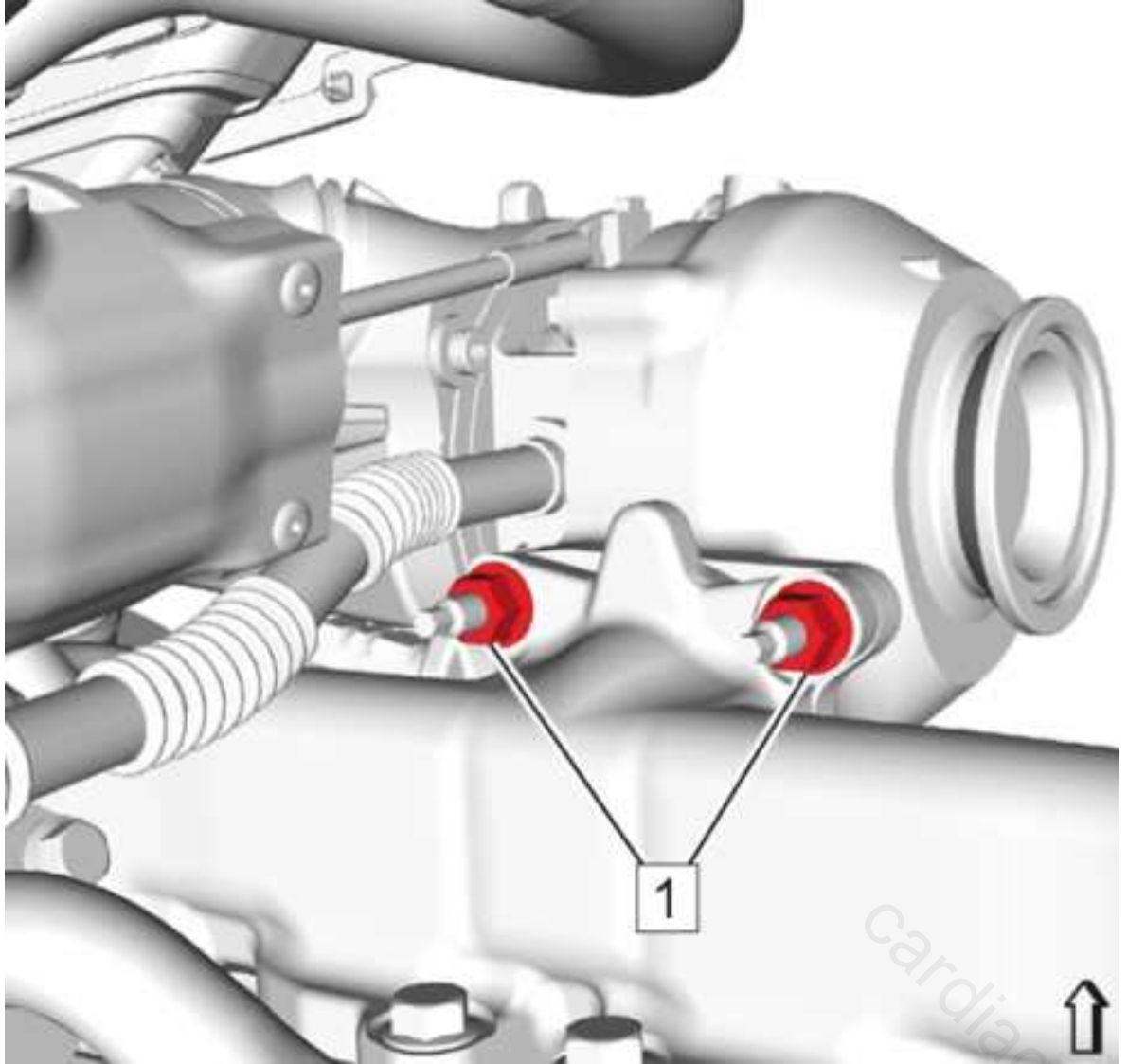


Fig. 489: Turbocharger Nuts

Courtesy of GENERAL MOTORS COMPANY

22. Remove Turbocharger Nuts (1) (Qty: 2)
23. Lower the vehicle.

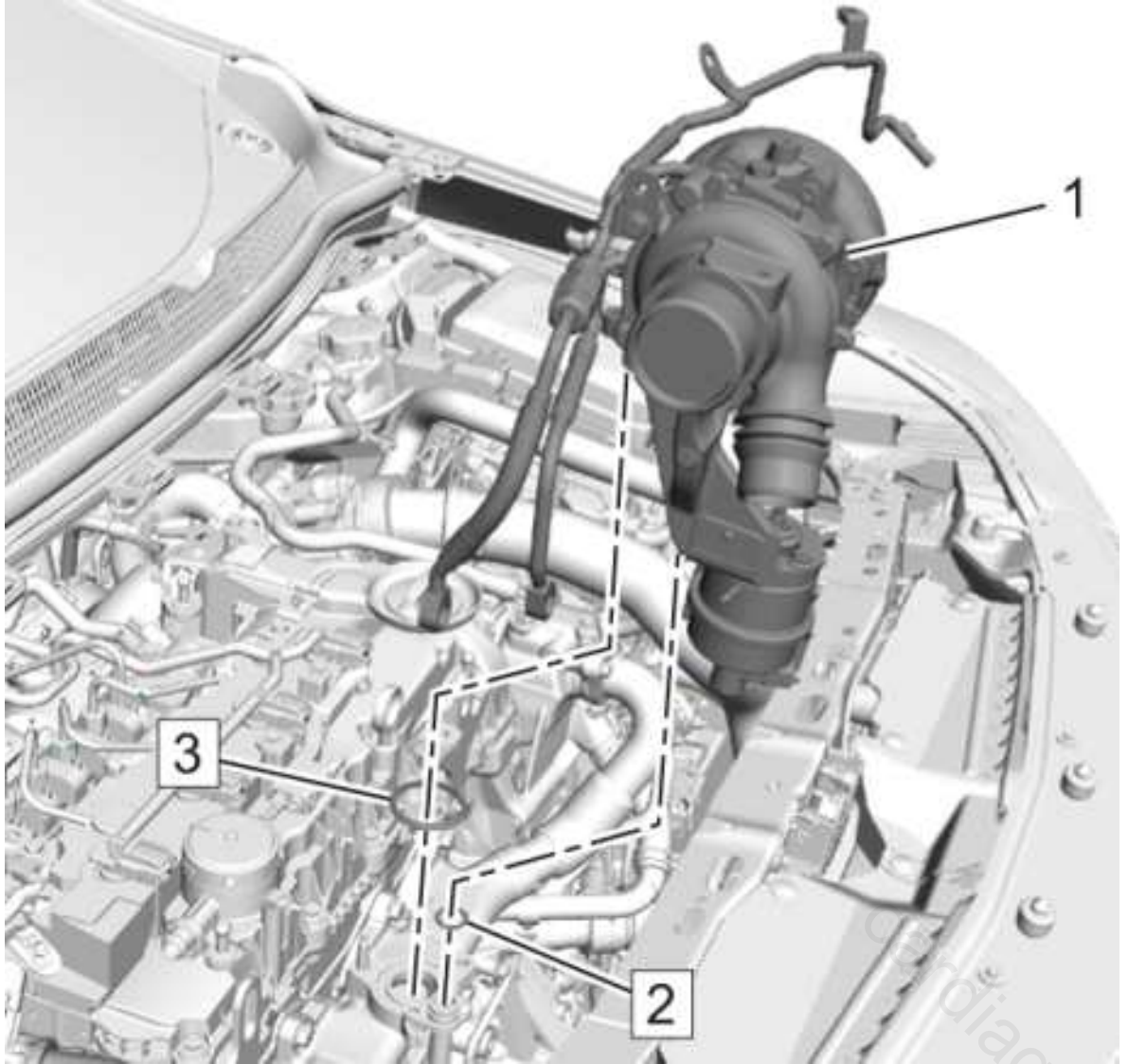


Fig. 490: Turbocharger Assembly And Gaskets
Courtesy of GENERAL MOTORS COMPANY

- 24. Remove Turbocharger Assembly (1)
- 25. Remove and DISCARD the gaskets. (2, 3) (Qty: 2)

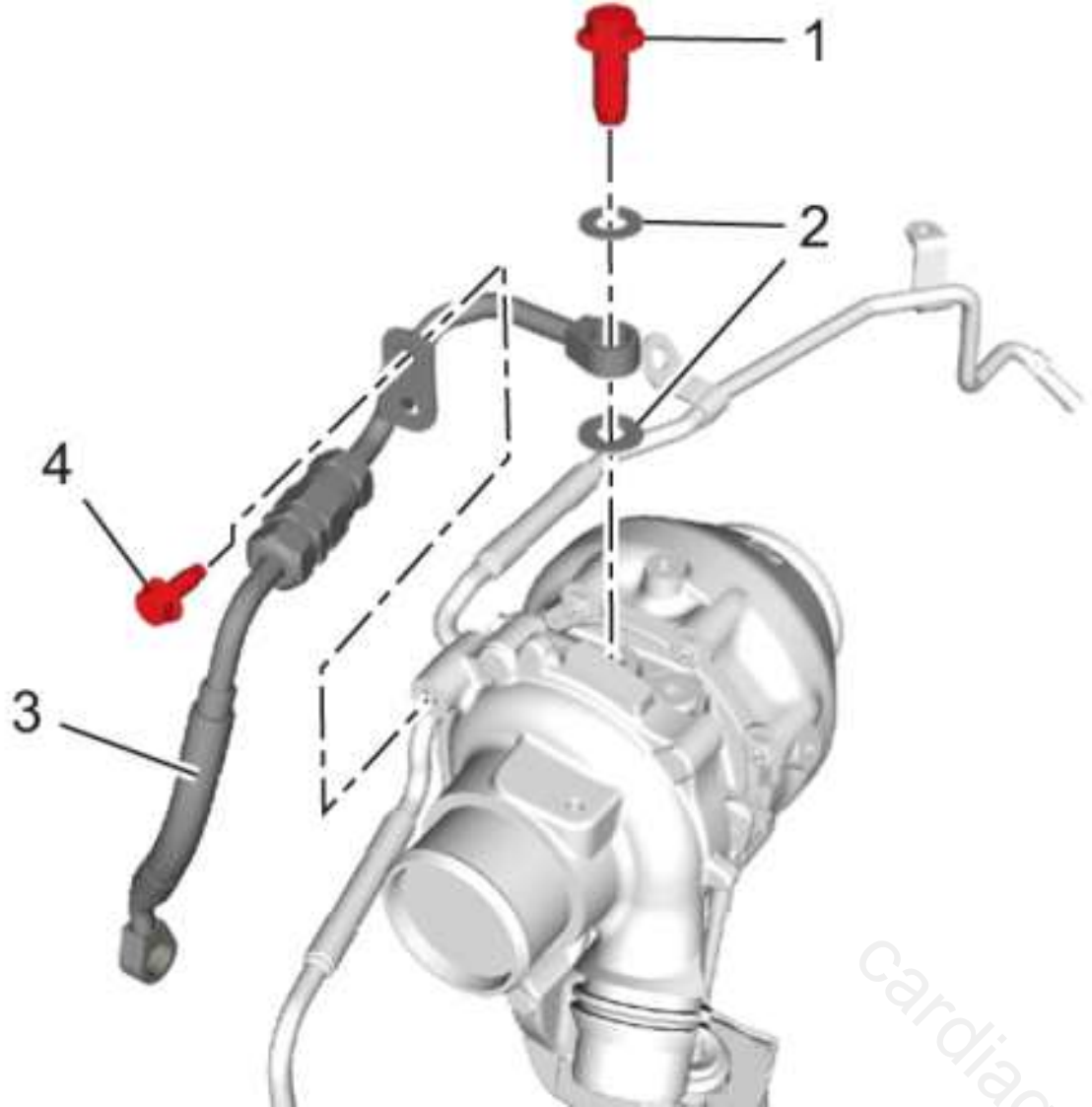


Fig. 491: Turbocharger Oil Feed Pipe, Hollow Screw, Bolt And Gaskets
Courtesy of GENERAL MOTORS COMPANY

26. Remove Turbocharger Oil Feed Pipe Hollow Screw (1)
27. Remove and DISCARD the gaskets. (2) (Qty: 2)
28. Remove Turbocharger Oil Feed Pipe Bolt (4)
29. Remove Turbocharger Oil Feed Pipe (3)

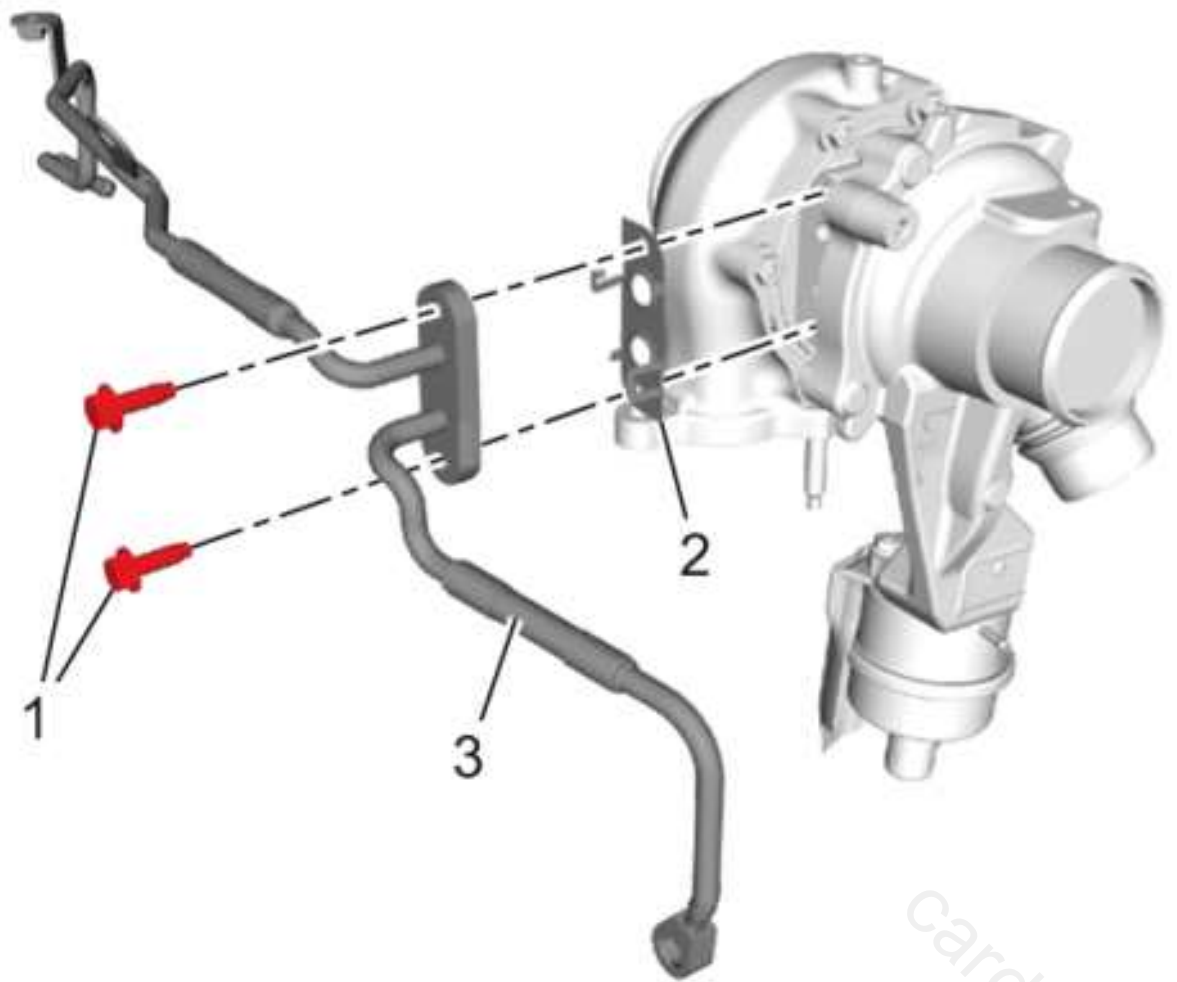


Fig. 492: Turbocharger Coolant Feed Pipe, Bolts And Gasket
Courtesy of GENERAL MOTORS COMPANY

- 30. Remove Turbocharger Coolant Feed Pipe Bolts (1) (Qty: 2)
- 31. Remove Turbocharger Coolant Feed Pipe (3)
- 32. Remove and DISCARD the gasket. (2)

Installation Procedure

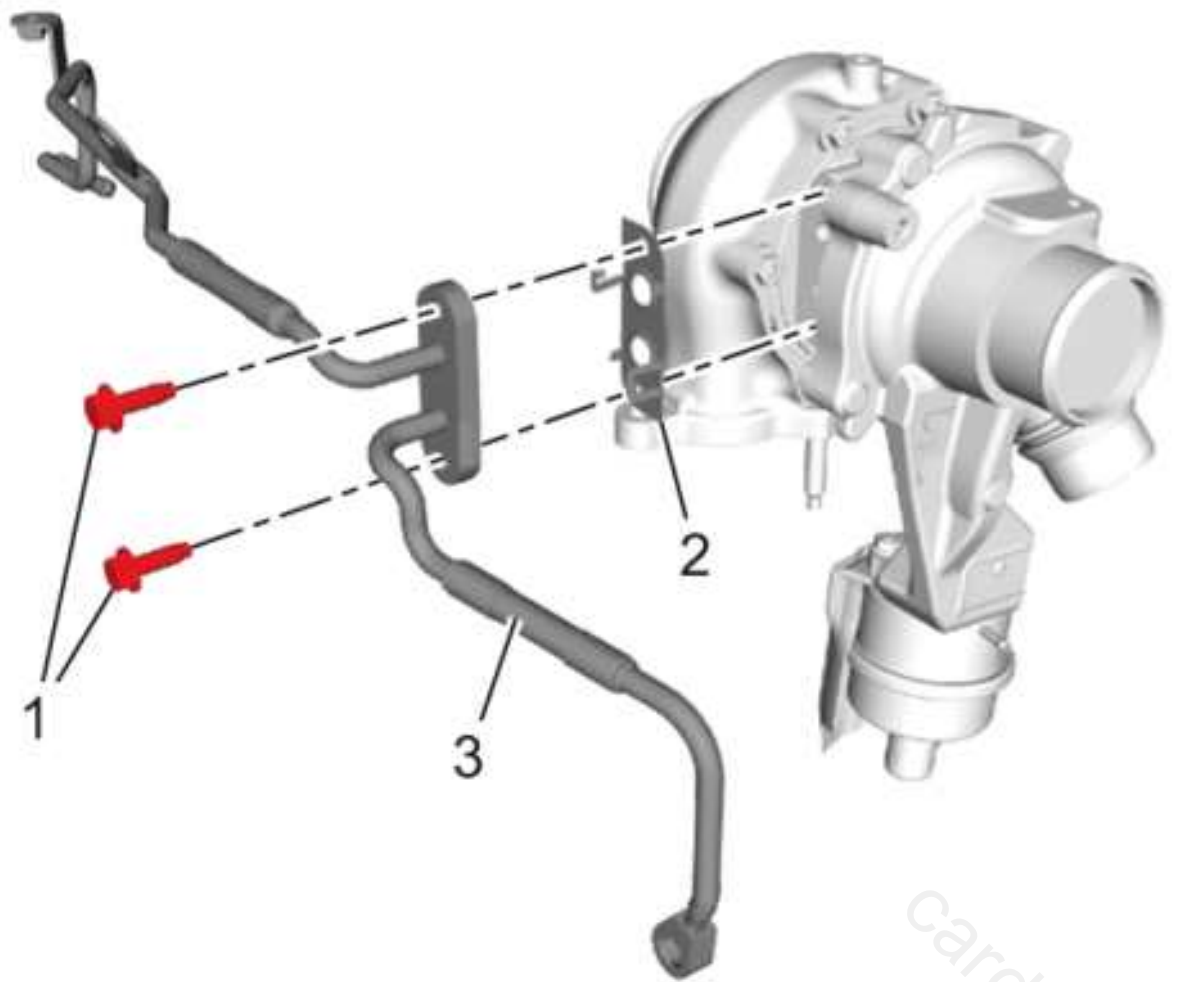


Fig. 493: Turbocharger Coolant Feed Pipe, Bolts And Gasket
Courtesy of GENERAL MOTORS COMPANY

1. Install a NEW gasket. (2)
2. Install Turbocharger Coolant Feed Pipe (3)

CAUTION: Refer to **Fastener Caution**

3. Install and tighten Turbocharger Coolant Feed Pipe Bolts (1) (Qty: 2) to 10 N.m (89 lb in)

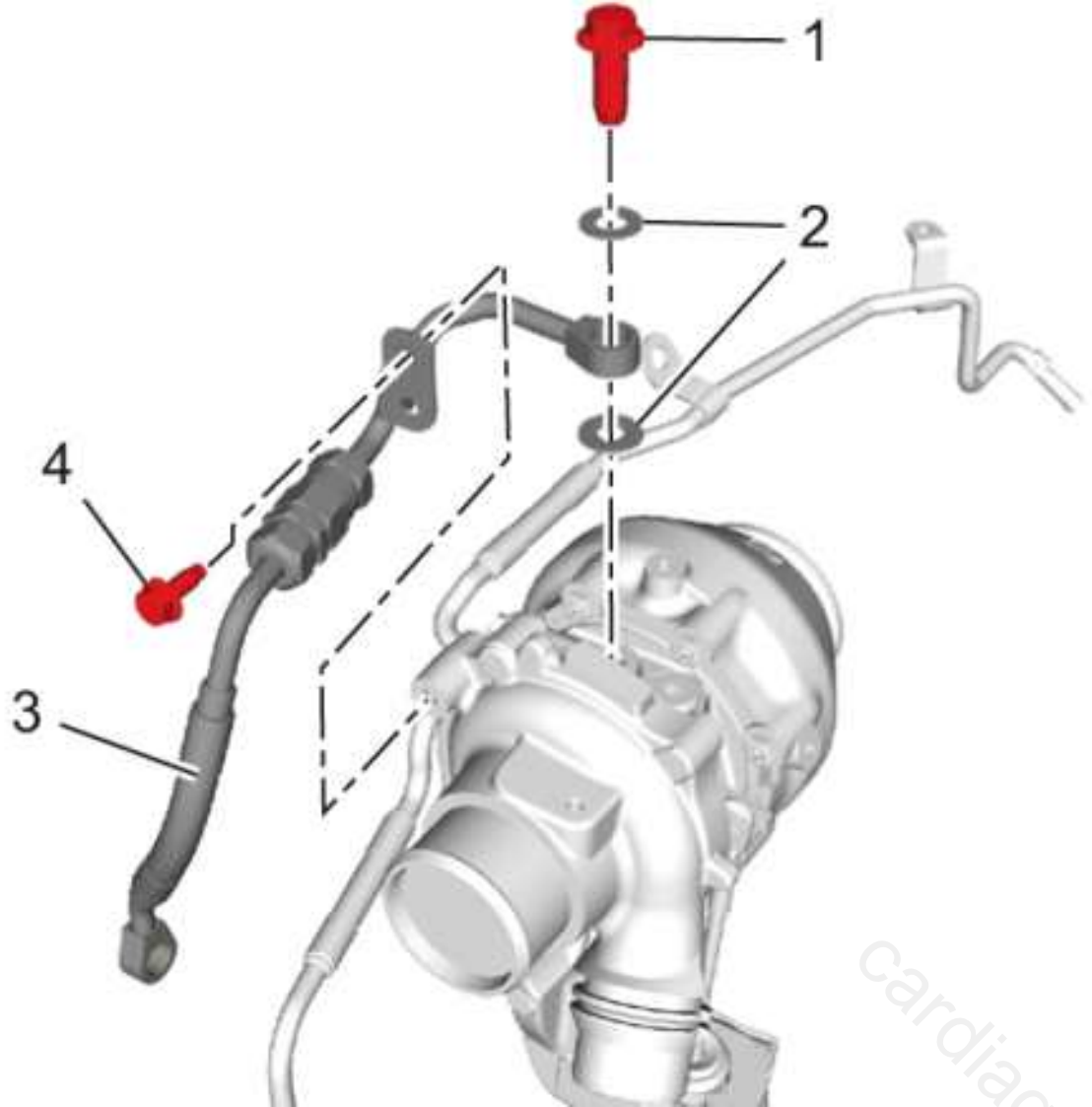


Fig. 494: Turbocharger Oil Feed Pipe, Hollow Screw, Bolt And Gaskets
Courtesy of GENERAL MOTORS COMPANY

4. Install Turbocharger Oil Feed Pipe (3)
5. Install NEW gaskets. (2) (Qty: 2)
6. Install and tighten Turbocharger Oil Feed Pipe Bolt (4) to 10 N.m (89 lb in)
7. Install and tighten Turbocharger Oil Feed Pipe Hollow Screw (1) to 25 N.m (18 lb ft)

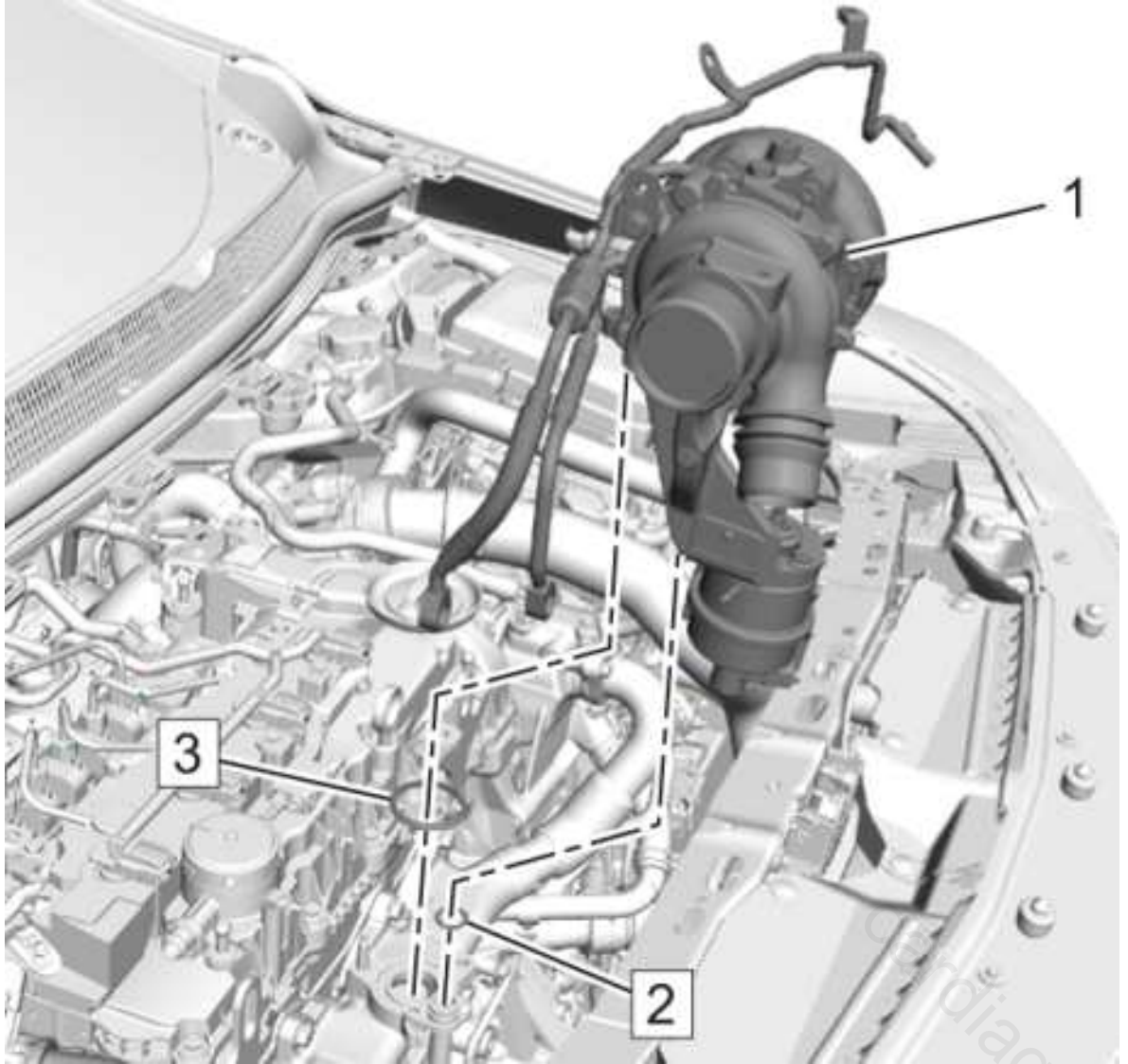


Fig. 495: Turbocharger Assembly And Gaskets
Courtesy of GENERAL MOTORS COMPANY

8. Install NEW gaskets. (2, 3) (Qty: 2)
9. Install Turbocharger Assembly (1)

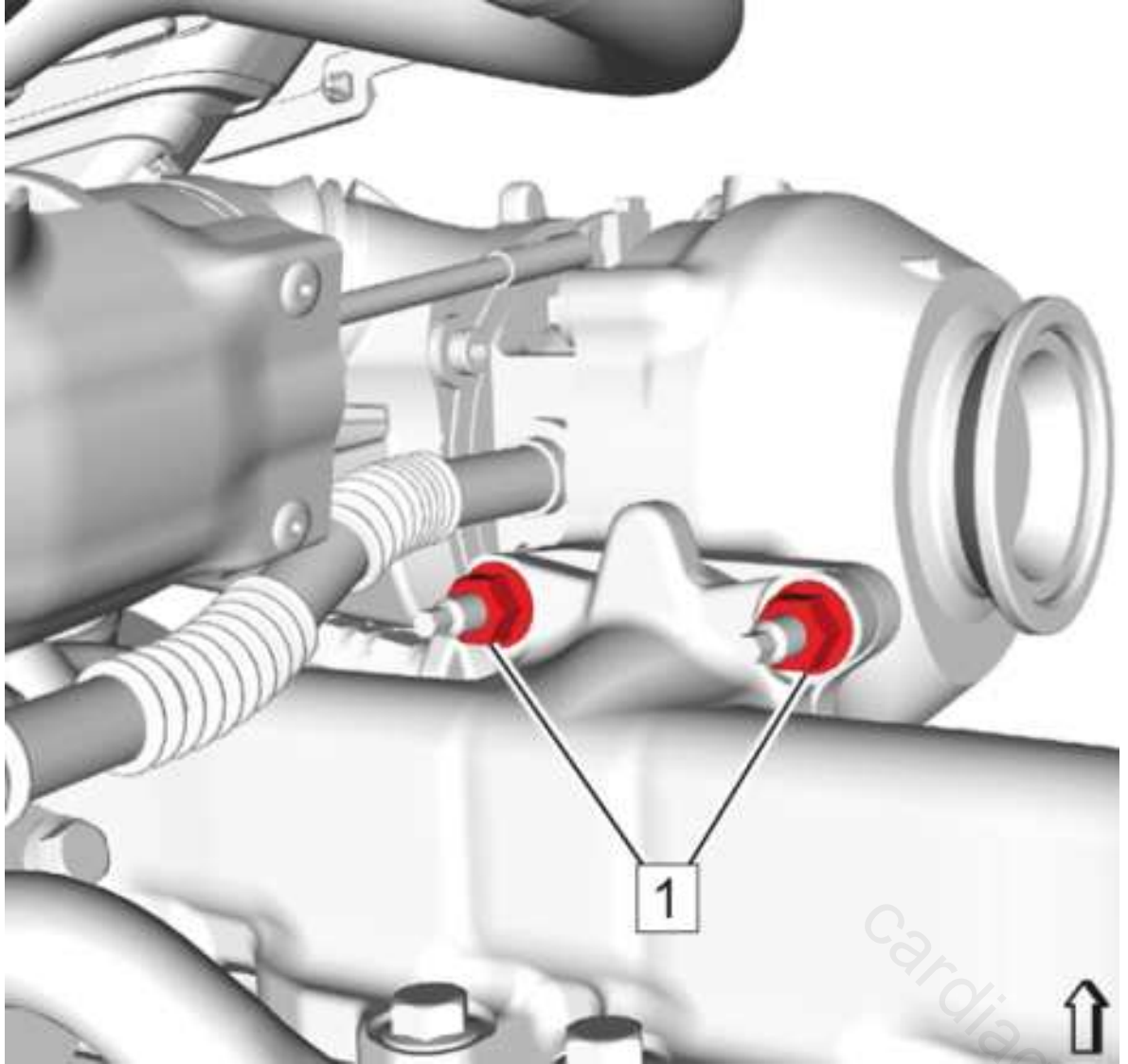


Fig. 496: Turbocharger Nuts

Courtesy of GENERAL MOTORS COMPANY

10. Install and tighten Turbocharger Nuts (1) (Qty: 2) to 30 N.m (22 lb ft)

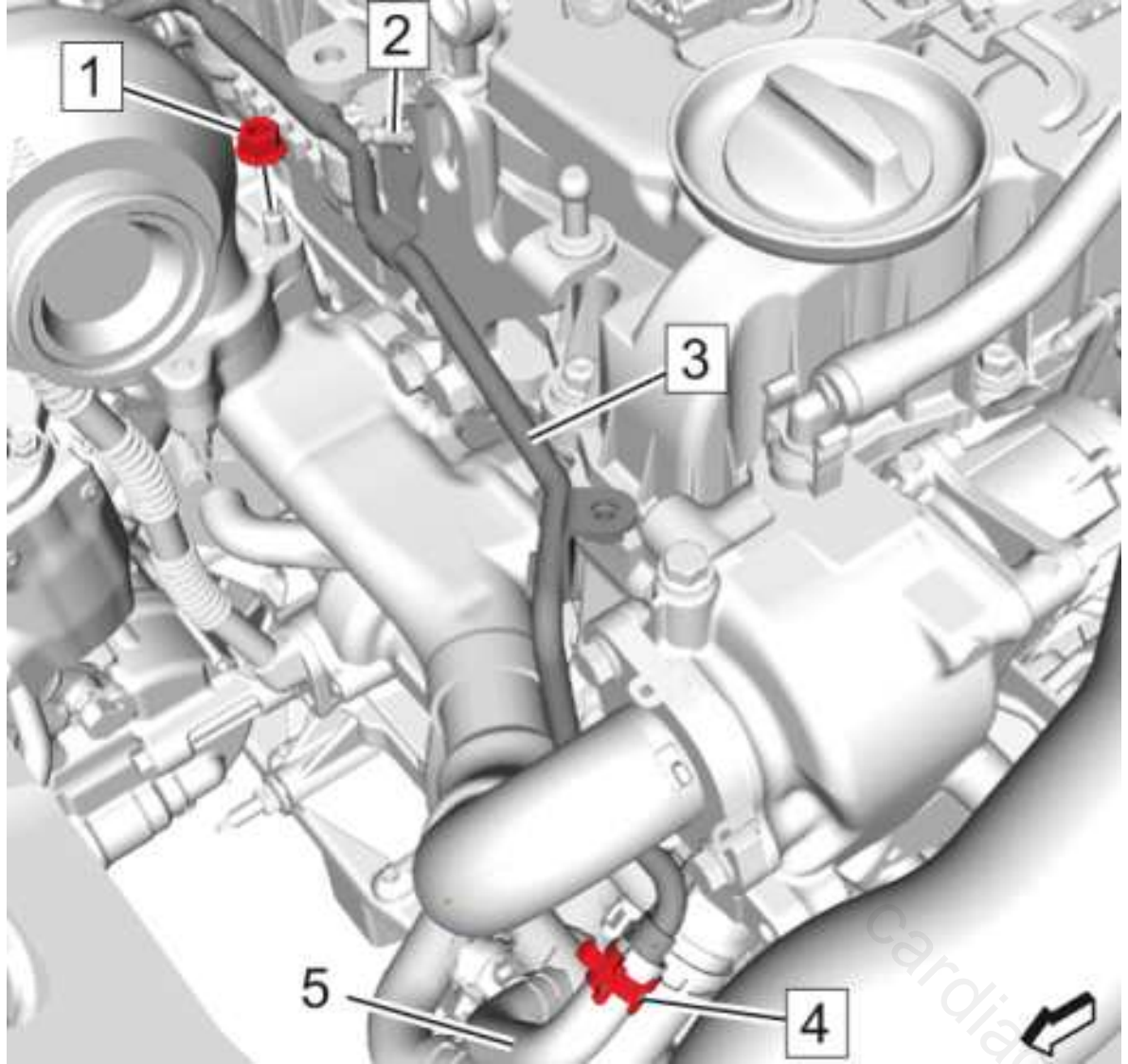


Fig. 497: Turbocharger Coolant Feed Hose, Feed Pipe, Clamp, Stud And Nut
Courtesy of GENERAL MOTORS COMPANY

11. Install and tighten Turbocharger Nut (1) to 30 N.m (22 lb ft)
12. Install Turbocharger Coolant Feed Pipe (3) @ Stud (2)
13. Connect Turbocharger Coolant Feed Hose (5) @ Turbocharger Coolant Feed Pipe (3)
14. Install Turbocharger Coolant Feed Hose Clamp (4)

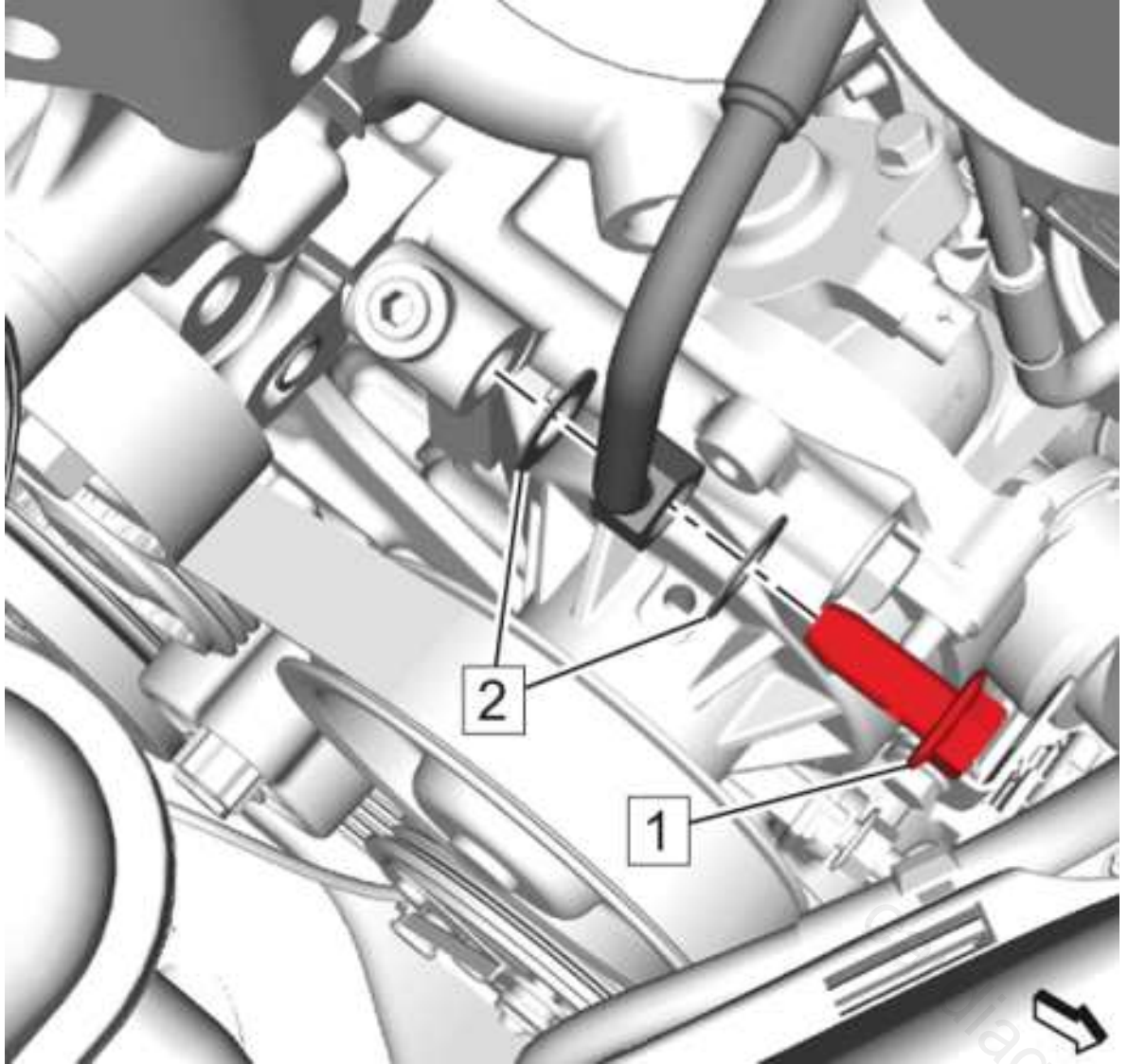


Fig. 498: Turbocharger Coolant Feed Pipe Hollow Screw And Gaskets
Courtesy of GENERAL MOTORS COMPANY

15. Install NEW gaskets. (2) (Qty: 2)
16. Install and tighten Turbocharger Coolant Feed Pipe Hollow Screw (1) to 25 N.m (18 lb ft)

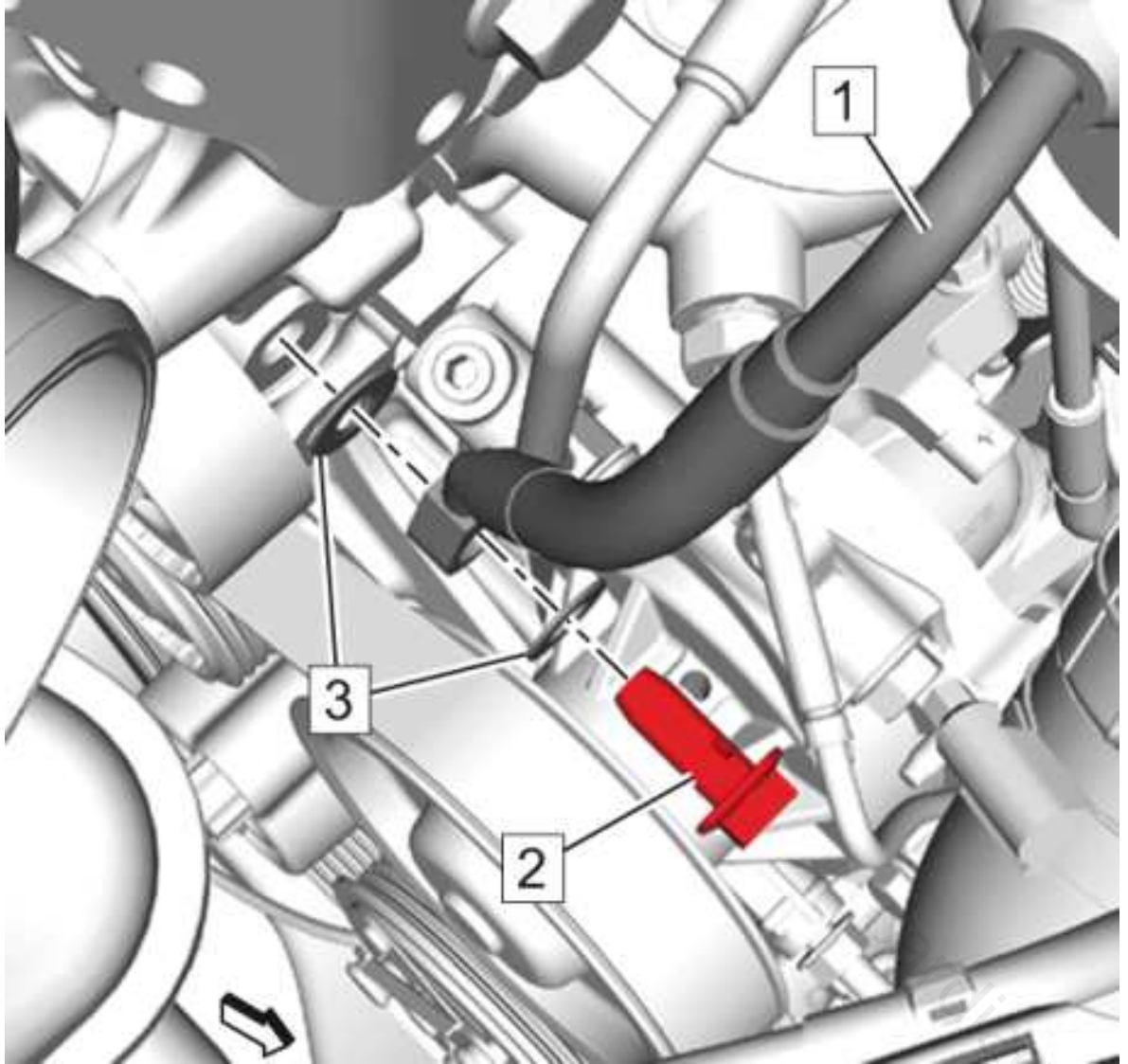


Fig. 499: Turbocharger Oil Feed Pipe, Hollow Screw And Gaskets
Courtesy of GENERAL MOTORS COMPANY

17. Install NEW gaskets. (3) (Qty: 2)
18. Install and tighten Turbocharger Oil Feed Pipe Hollow Screw (2) to 25 N.m (18 lb ft)

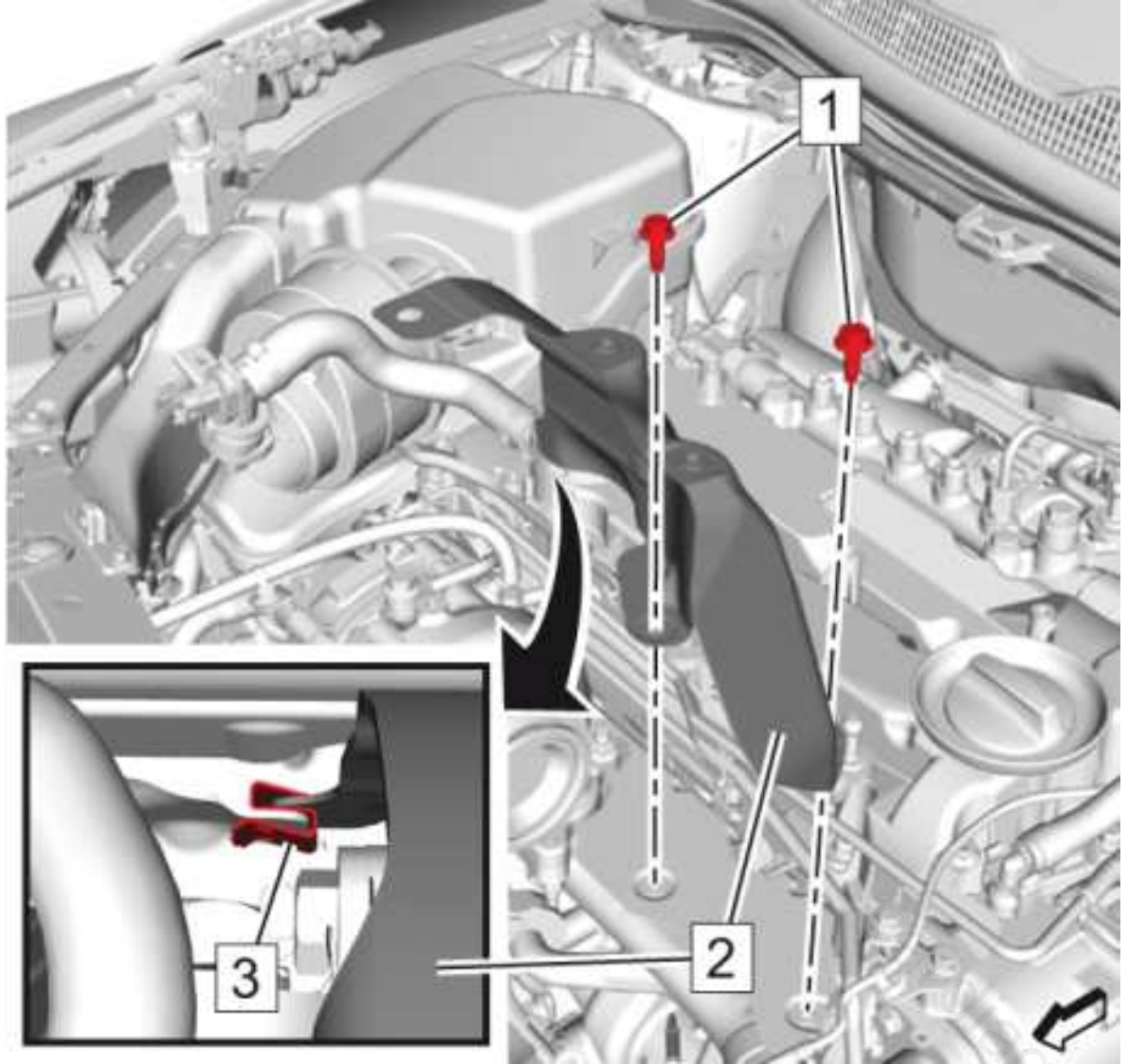


Fig. 500: Turbocharger Heat Shield, Bolts And Clamp
Courtesy of GENERAL MOTORS COMPANY

19. Install Turbocharger Heat Shield (2)
20. Install Turbocharger Heat Shield (2) @ Clamp (3)
21. Install and tighten Turbocharger Heat Shield Bolts (1) (Qty: 2) to 10 N.m (89 lb in)

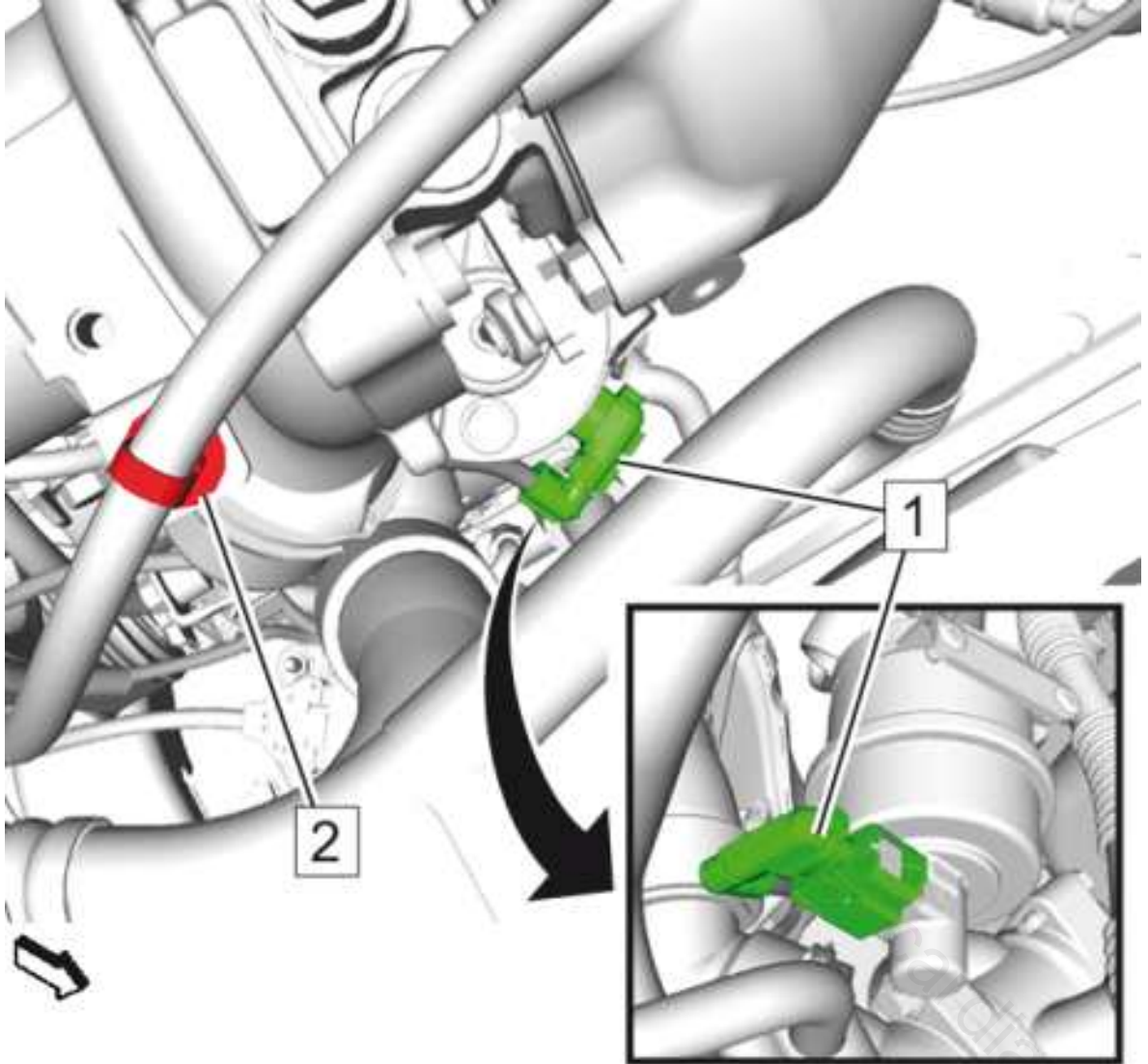


Fig. 501: Wiring Harness Retainer And Electrical Connector
 Courtesy of GENERAL MOTORS COMPANY

22. Connect the electrical connector. (1)
23. Install Wiring Harness Retainer (2)

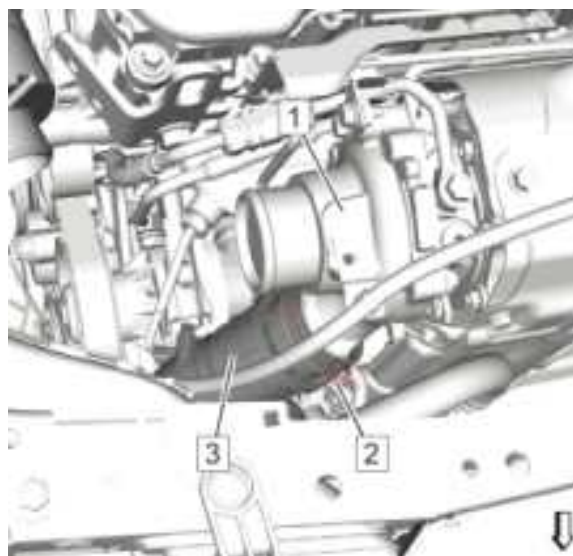


Fig. 502: Charge Air Cooler Inlet Air Hose, Retainer Spring And Turbocharger
 Courtesy of GENERAL MOTORS COMPANY

24. Install Charge Air Cooler Inlet Air Hose (3) @ Turbocharger (1)
25. Install Charge Air Cooler Inlet Air Hose Retainer Spring (2)
26. Raise the vehicle.

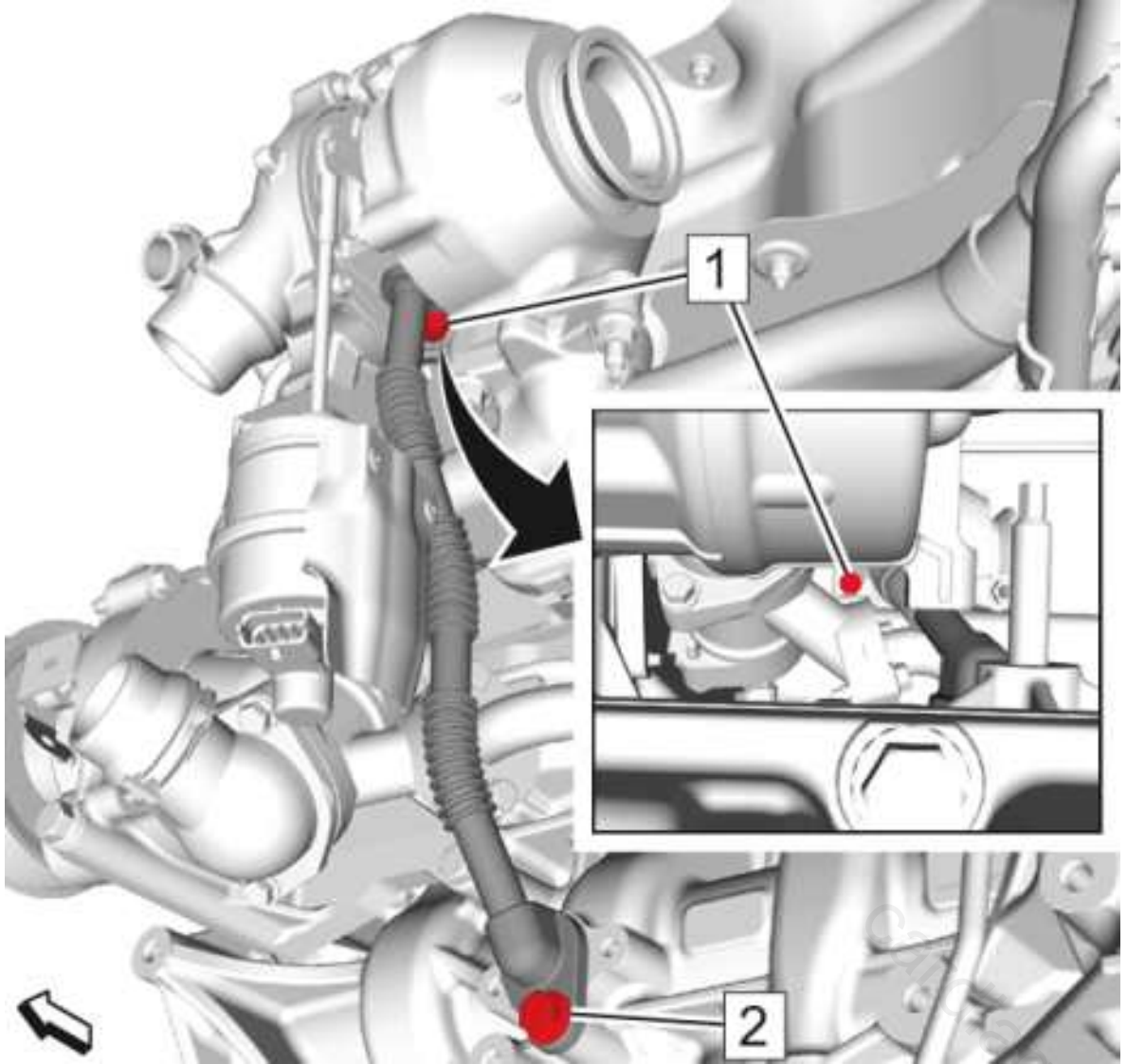


Fig. 503: Turbocharger Oil Return Pipe Bolts
Courtesy of GENERAL MOTORS COMPANY

27. Install and tighten Turbocharger Oil Return Pipe Bolt (1) to 10 N.m (89 lb in)
28. Tighten Turbocharger Oil Return Pipe Bolt (2) to 25 N.m (18 lb ft)
29. Install Turbocharger Wastegate Actuator Pipe. Refer to [Turbocharger Wastegate Actuator Pipe Replacement](#)
30. Fill the cooling system. Refer to [Cooling System Draining and Filling \(GE 47716\) Cooling System Draining and Filling \(Static\)](#)
31. Install Oxidation Catalytic Converter. Refer to [Oxidation Catalytic Converter Replacement \(LH7\)](#)
32. Install the air cleaner outlet duct. Refer to [Air Cleaner Outlet Duct Replacement](#)

VALVE LIFTER REPLACEMENT

Removal Procedure

1. Remove the intake and exhaust camshaft. Refer to [Camshaft Replacement](#).

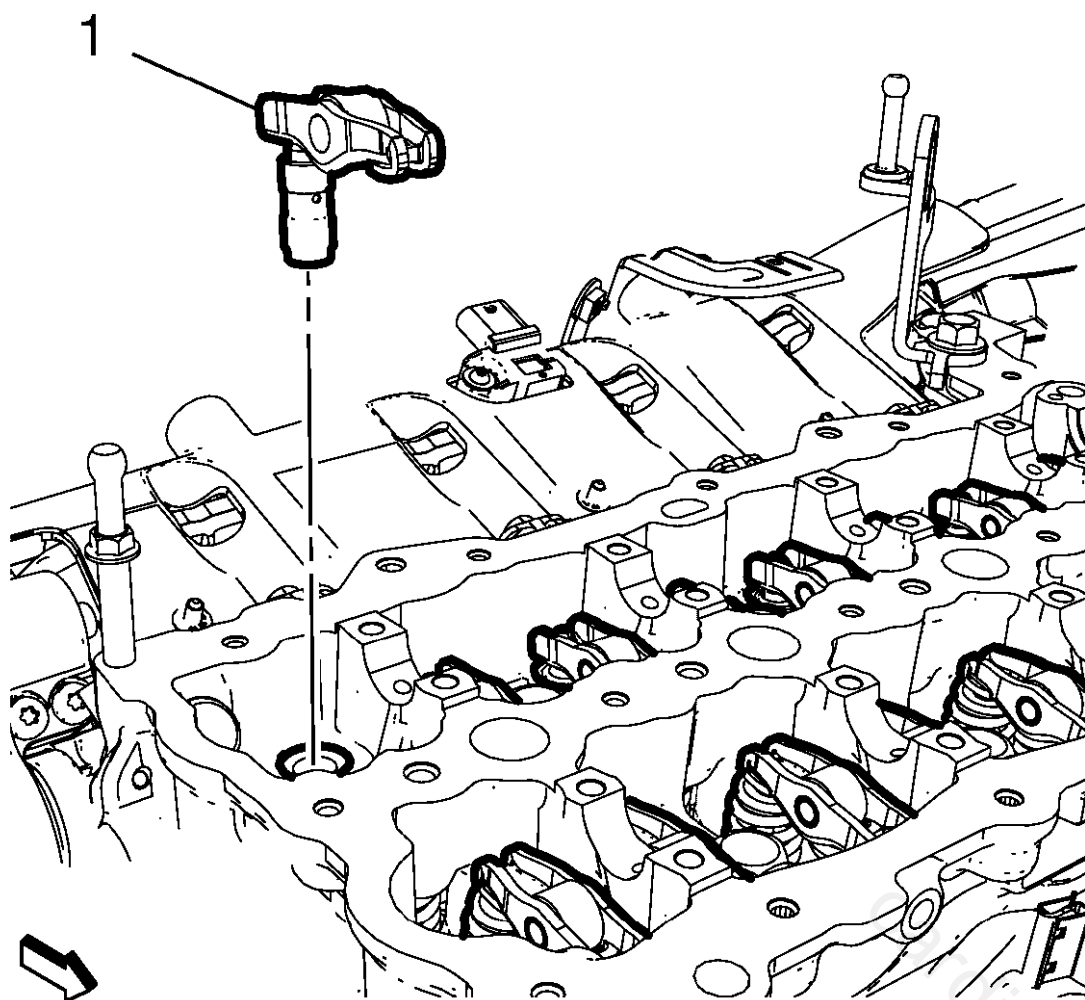


Fig. 504: Valve Lifter Roller Assemblies

Courtesy of GENERAL MOTORS COMPANY

2. Remove the 16 valve lifter with valve lifter roller (1) and lay aside in the order as they were removed.

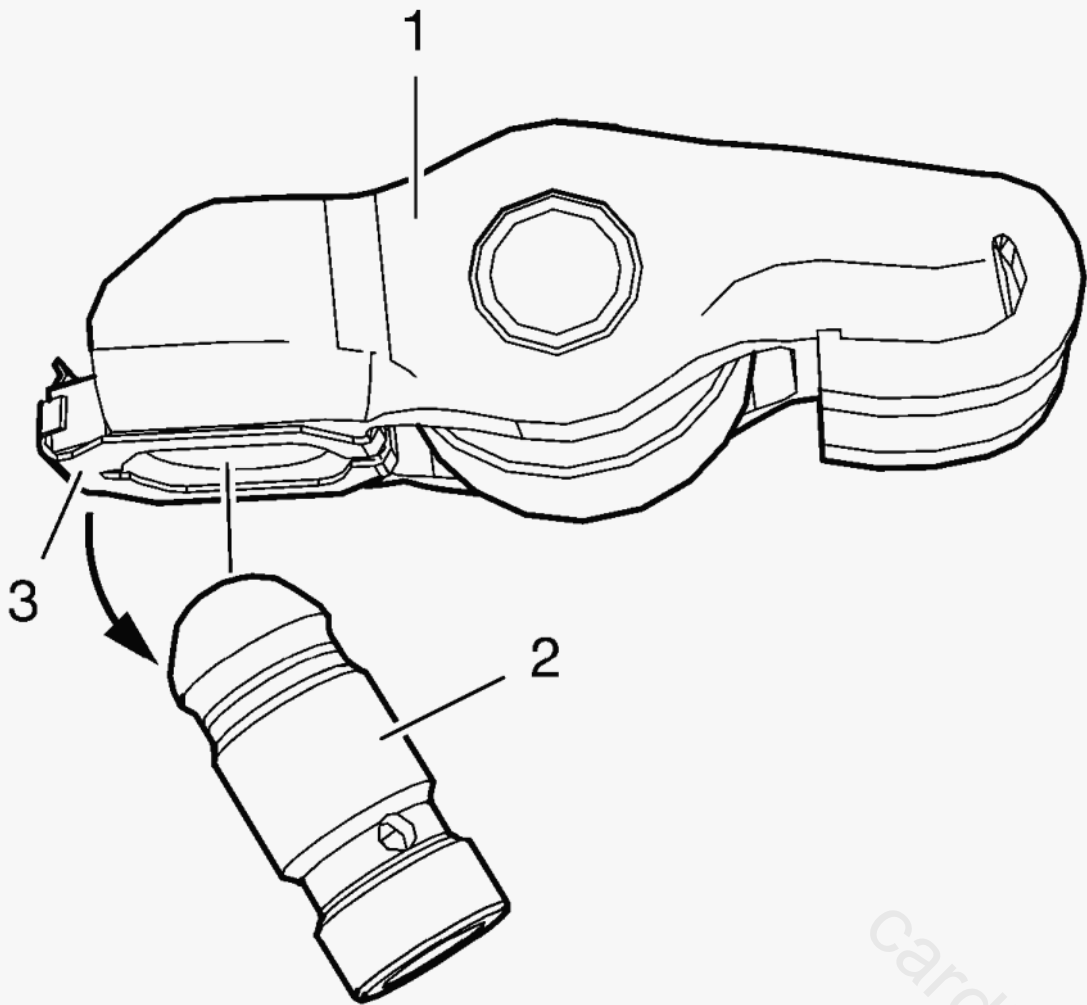


Fig. 505: Valve Rocker Arms And Valve Lifters
Courtesy of GENERAL MOTORS COMPANY

NOTE: Unclip the valve lifter from the valve lifter roller in direction as shown (arrow). Mind to the centering link on retainer spring (3).

3. Remove the 16 valve lifters (2) from the valve lifter rollers (1).

Installation Procedure

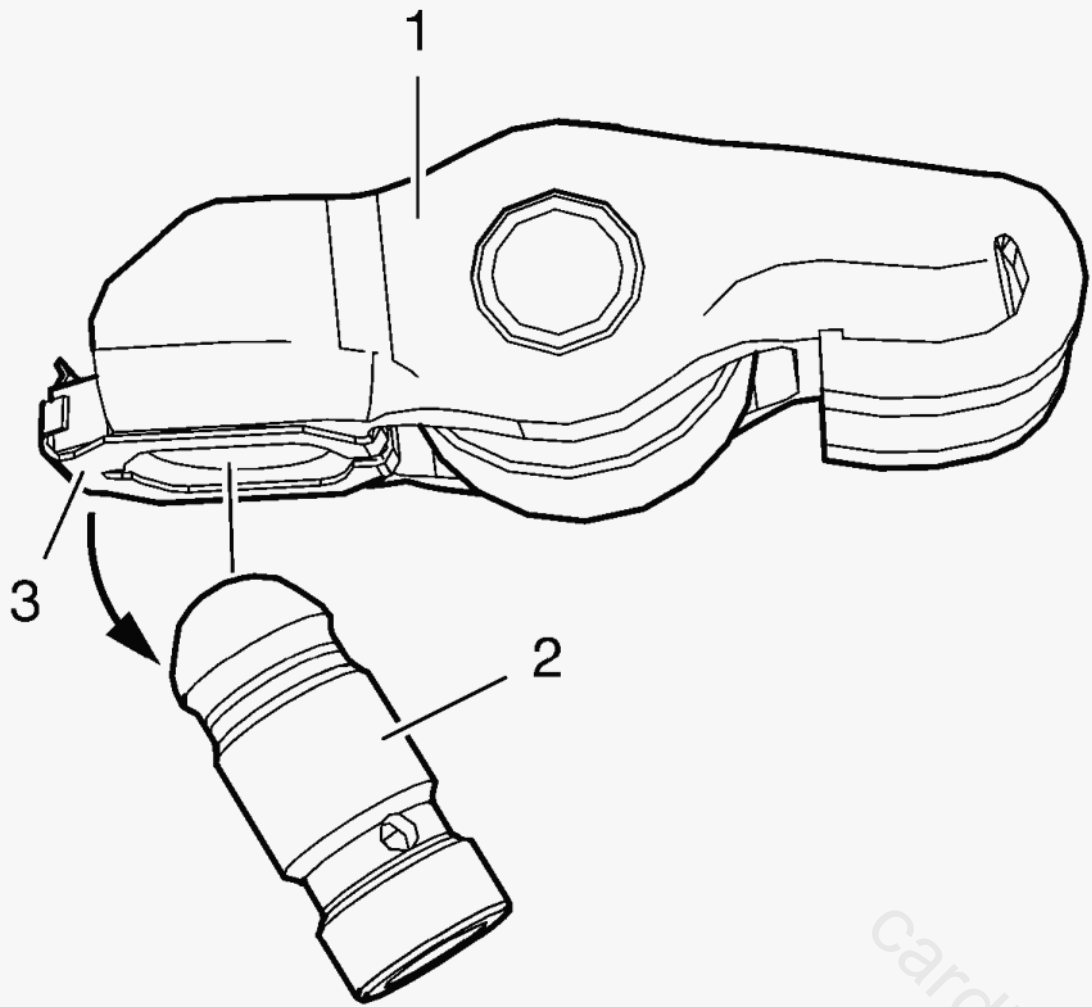


Fig. 506: Valve Rocker Arms And Valve Lifters
Courtesy of GENERAL MOTORS COMPANY

NOTE: Clip in the valve lifter to the valve lifter roller. Mind to the centering link on retainer spring (3).

1. Install the 16 valve lifters (2) to the valve lifter rollers (1).
2. Coat the 16 valve lifter with engine oil.

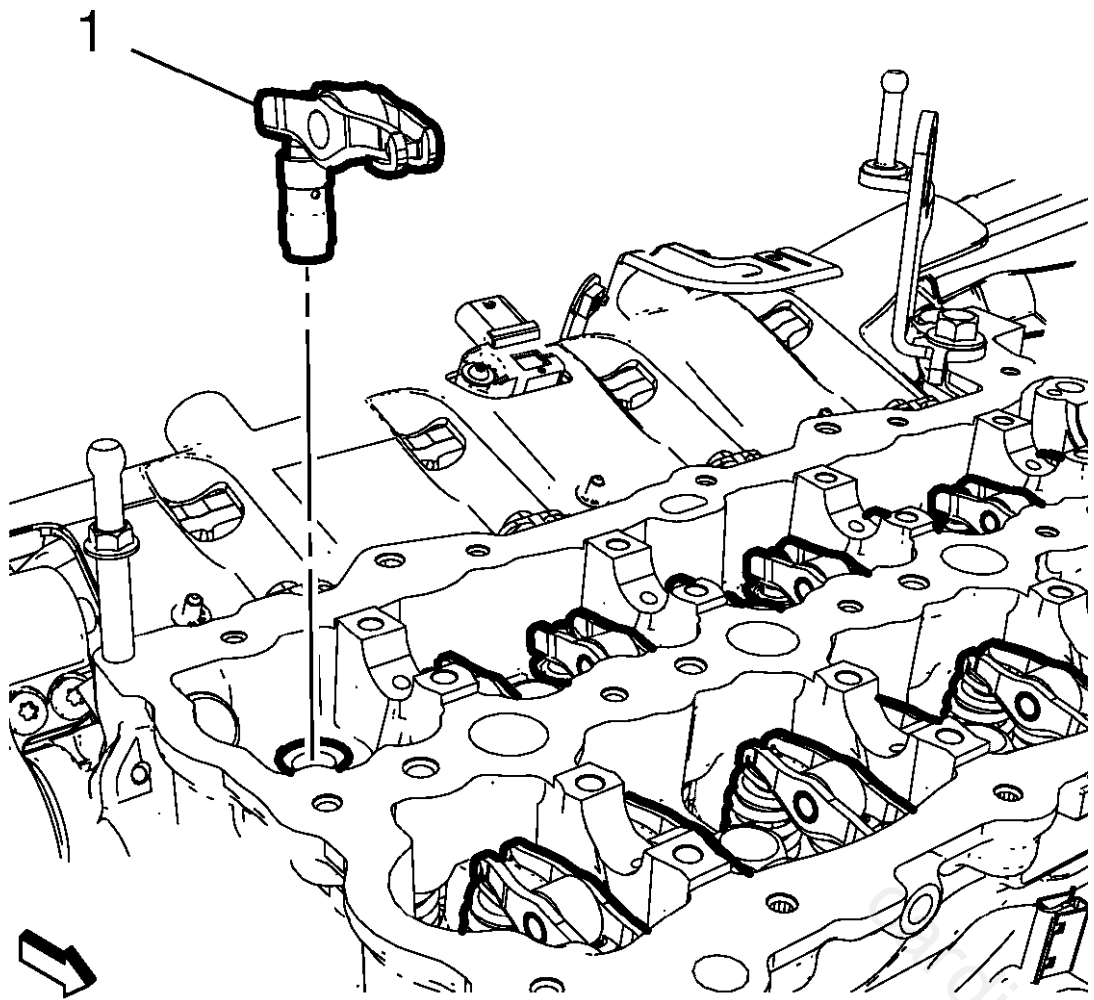


Fig. 507: Valve Lifter Roller Assemblies

Courtesy of GENERAL MOTORS COMPANY

NOTE: If the valve lifters or valve lifter rollers are reused, the valve lifter or valve lifter roller must be installed in their original position.

3. Install the 16 valve lifter with valve lifter roller (1) in the order as they was removed.
4. Install the intake and exhaust camshaft. Refer to [Camshaft Replacement](#).

ENGINE SUPPORT FIXTURE

Special Tools

EN-51007 Engine Support Fixture

Equivalent regional tools: [Special Tools](#)

[Assemble EN-51007 Engine Support Fixture](#)

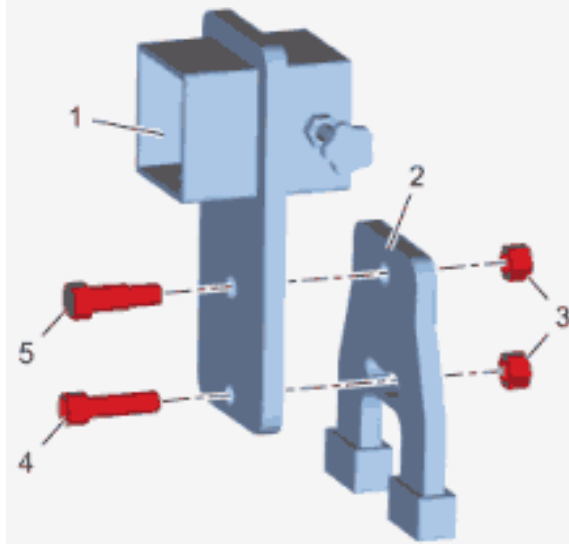


Fig. 508: Engine Support Fixture Components
 Courtesy of GENERAL MOTORS COMPANY

NOTE: Pre-assemble special tool assembly outside the vehicle.

1. Install the lower foot (2) to the upper foot (1).
2. Install the mounting bolt (5).
3. Install the adjustment screw (4) and tighten the 2 nuts (3).

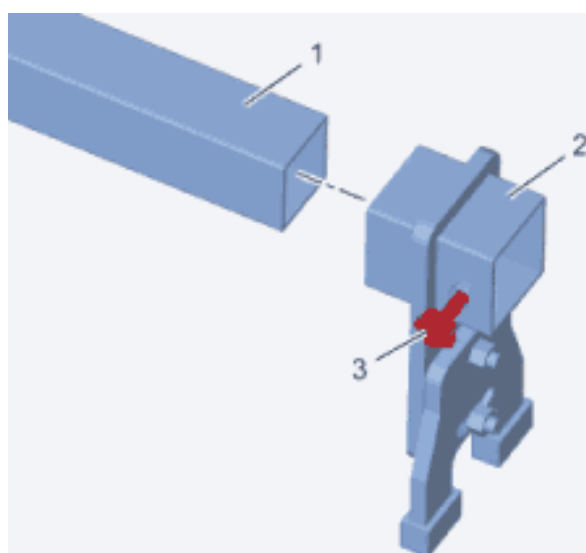


Fig. 509: Engine Support Fixture Components
 Courtesy of GENERAL MOTORS COMPANY

4. Install the 2 **EN-51007-7** adapters (2) to the **EN-51007-1** adapter (1).
5. Tighten the adjustment screw (3).

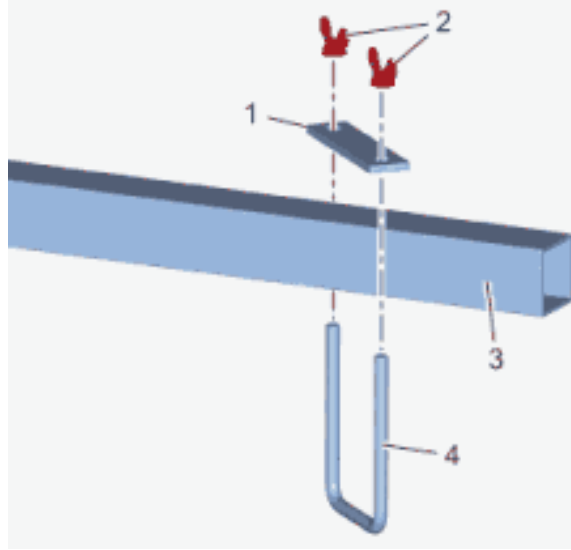


Fig. 510: Engine Support Fixture Components
Courtesy of GENERAL MOTORS COMPANY

6. Install the 2 **EN-51007-4** adapters to the **EN-51007-1** adapter by guiding the bail (4) into the board (1).
7. Install the 2 thumb nuts (2).

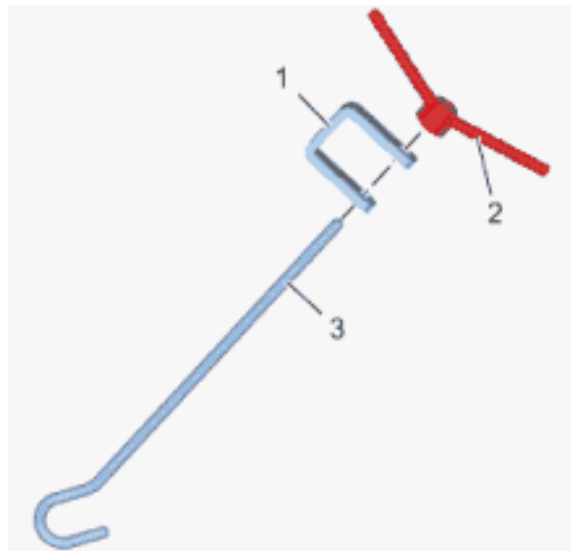


Fig. 511: Bushing, Lever And Hook
Courtesy of GENERAL MOTORS COMPANY

8. Install the bushing (1) to the hook (3).
9. Install the lever (2) to the hook (3).

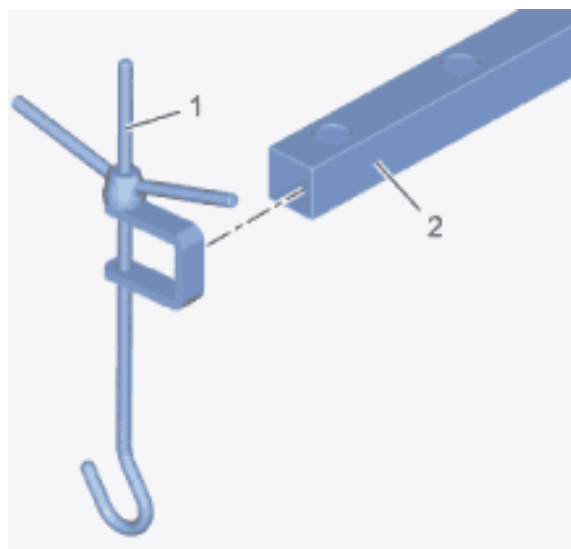


Fig. 512: Engine Support Fixture Adapters
Courtesy of GENERAL MOTORS COMPANY

10. Install the **EN-51007-6** adapters (1) to the **EN-51007-3** adapters (2).

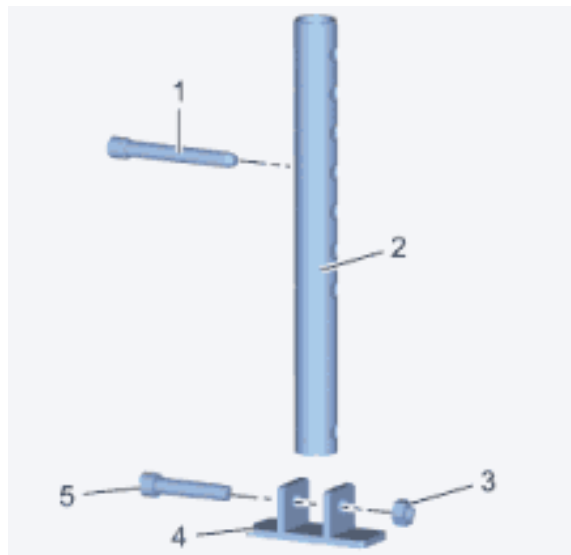


Fig. 513: Foot, Rod, Bolts And Nut

Courtesy of GENERAL MOTORS COMPANY

11. Install the foot (4) to the rod (2)
12. Install and tighten the bolt (5) and the nut (3).
13. Install the bolt (1).

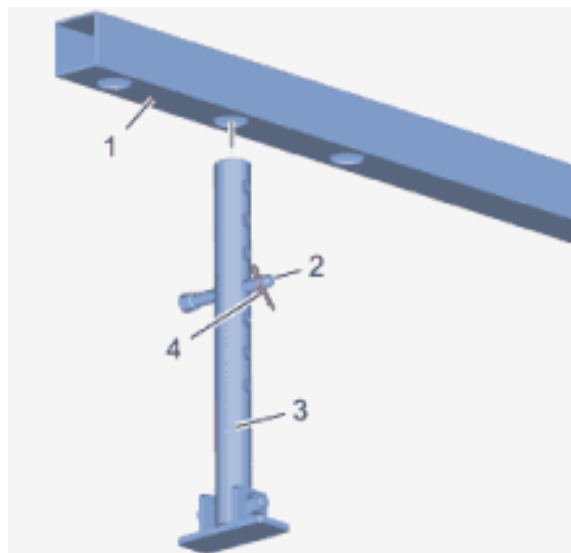


Fig. 514: Adapters, Bolt And Cotter Pin

Courtesy of GENERAL MOTORS COMPANY

NOTE: The feet should stay in the second hole of the rakes.

14. Install **EN-51007-5** adapter (3) to the **EN-51007-3** adapter (1).
15. Install the cotter pin (4) into the bolt (2).

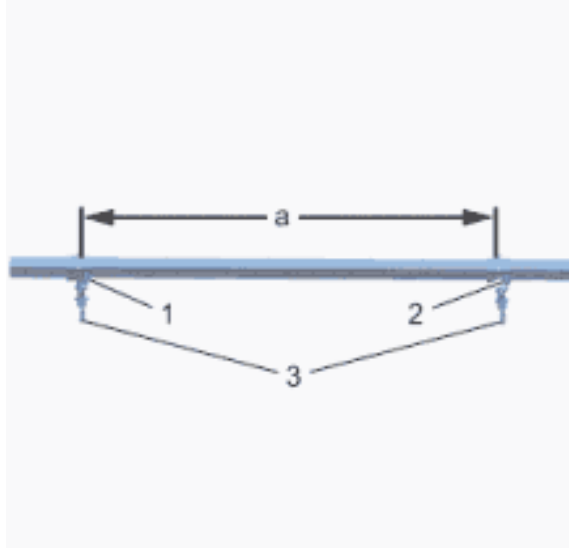


Fig. 515: Distance Between Feet And Adjustment Screws

Courtesy of GENERAL MOTORS COMPANY

NOTE: The distance (a) must be aligned to 1400 mm (55 in).

16. Check the distance between the 2 feet (3).
17. Tighten the 2 adjustment screws (1, 2).

Installation Procedure

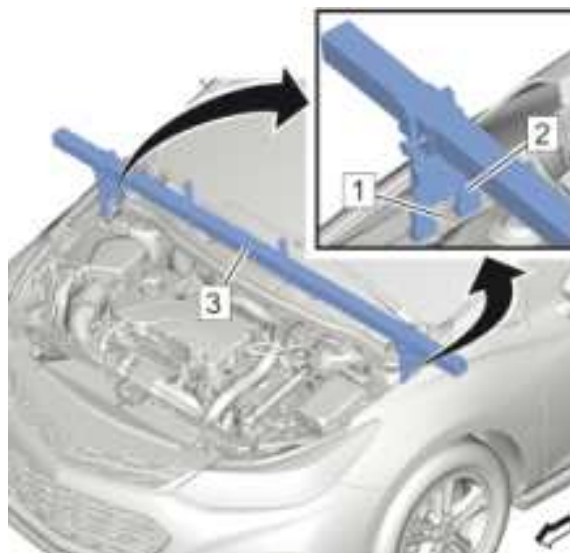


Fig. 516: Engine Support Fixture Adapters And Front Compartment Upper Side Rail

Courtesy of GENERAL MOTORS COMPANY

NOTE: A second technician is required.

1. Install the **EN-51007-1** adapter (3) with the **EN-51007-7** adapters (2) between the bulge (1) of the front compartment upper side rail.

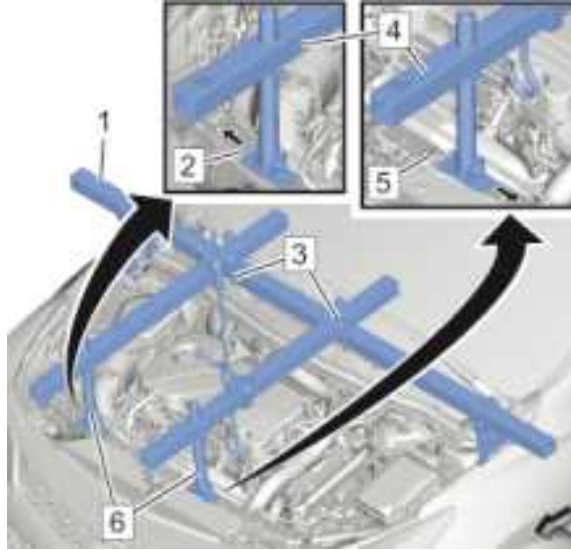


Fig. 517: Engine Support Fixture Adapters And Front End Upper Tie Bar
 Courtesy of GENERAL MOTORS COMPANY

NOTE: The 2 feet of the rakes should be placed as far as possible in the direction as shown.

2. Install the EN-51007-3 adapters (4) to the EN-51007-1 adapter (1) with the EN-51007-5 adapters (6) on the front end upper tie bar (2, 5).

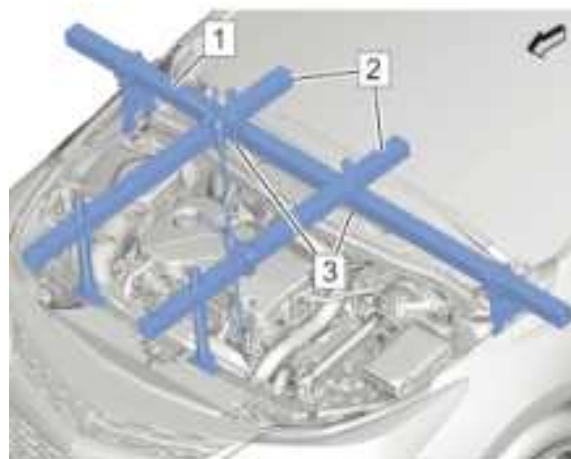


Fig. 518: Engine Support Fixture Adapters
 Courtesy of GENERAL MOTORS COMPANY

3. Tighten the EN-51007-3 adapters (2) to the EN-51007-1 adapter (1) by tighten it with the EN-51007-4 adapters (3).

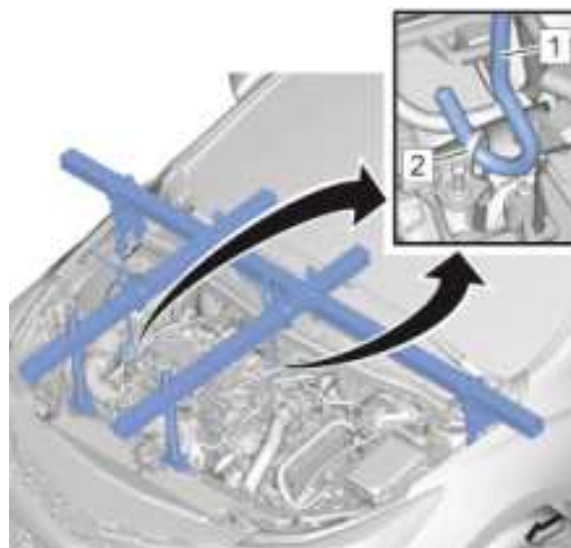


Fig. 519: Engine Support Fixture Adapters And Engine Lift Brackets
Courtesy of GENERAL MOTORS COMPANY

4. Install the 2 **EN-51007-6** adapters (1) into the 2 engine lift brackets (2).
5. When the tool assembly **EN-51007** support fixture is under load, adjust complete assemble and re-tighten ALL fasteners.

Removal Procedure

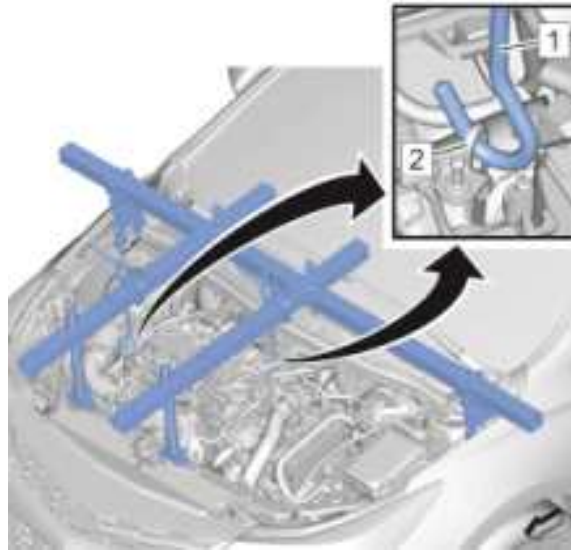


Fig. 520: Engine Support Fixture Adapters And Engine Lift Brackets
Courtesy of GENERAL MOTORS COMPANY

1. Remove the 2 **EN-51007-6** adapters (1) from the 2 engine lift brackets (2).

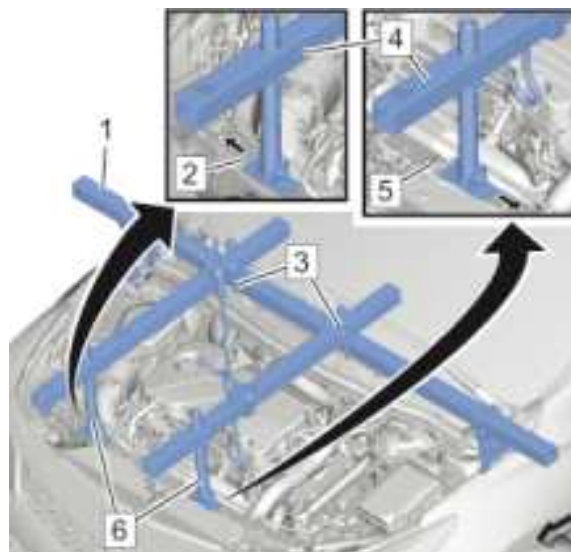


Fig. 521: Engine Support Fixture Adapters And Front End Upper Tie Bar
Courtesy of GENERAL MOTORS COMPANY

2. Loosen the 2 **EN-51007-4** adapters (3).

NOTE: A second technician is required.

3. Remove the 2 **EN-51007-3** adapters (4) with the **EN-51007-5** adapters (6) from the **EN-51007-1** adapter (1).

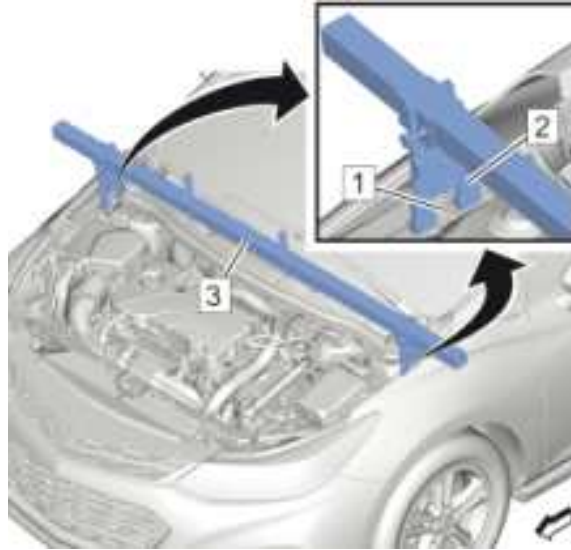


Fig. 522: Engine Support Fixture Adapters And Front Compartment Upper Side Rail
Courtesy of GENERAL MOTORS COMPANY

4. Remove the **EN-51007-1** adapter (3).
5. Clean the contact surfaces from the **EN-51007-5** adapters on the front end upper tie bar with solvent.

ENGINE REPLACEMENT

Special Tools

- **CH-51034** Guide Pins
- **EN-45059** Angle Meter

Equivalent regional tools: **Special Tools**

Removal Procedure

1. Recover the refrigerant. Refer to **Refrigerant Recovery and Recharging (R-134a)**. **Refrigerant Recovery and Recharging (R-1234yf)**
2. Drain the cooling system. Refer to **Cooling System Draining and Filling (GE 47716)**. **Cooling System Draining and Filling (Static)**
3. Disconnect the battery negative cable. Refer to **Battery Negative Cable Disconnection and Connection (KL9)**
4. Remove Battery Tray. Refer to **Battery Tray Replacement**

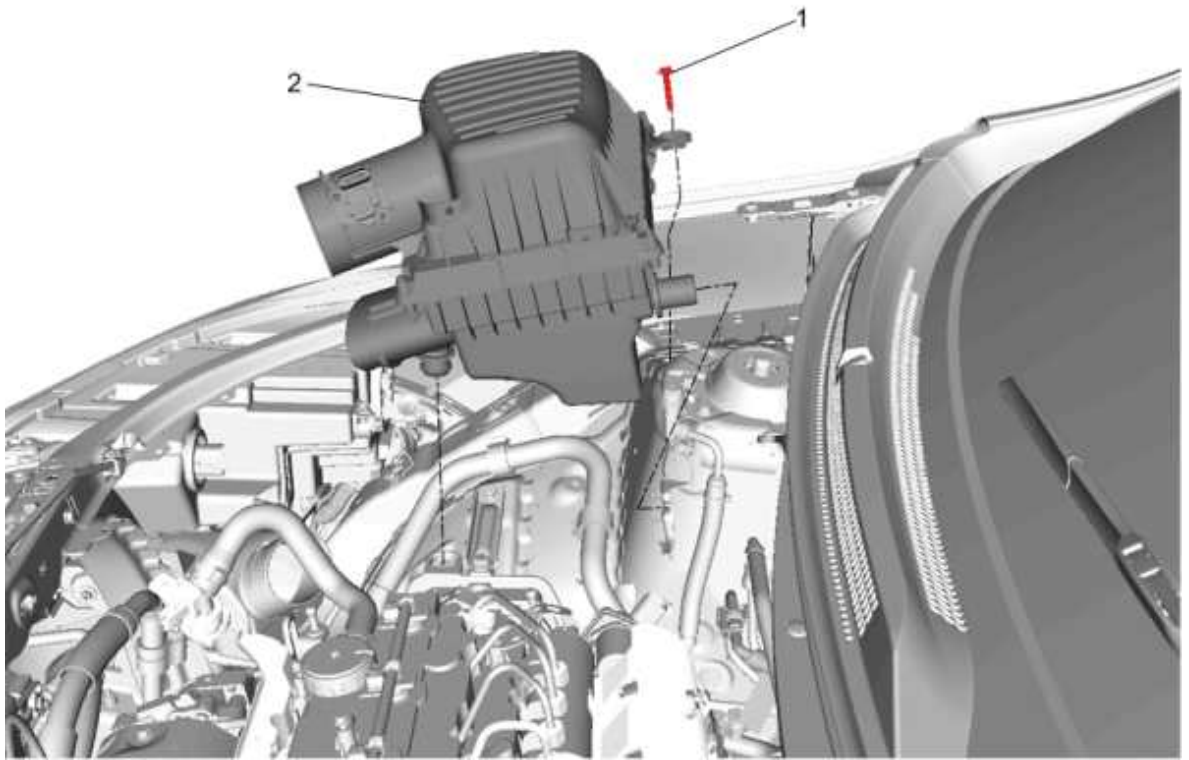


Fig. 523: Air Cleaner Assembly And Fastener
Courtesy of GENERAL MOTORS COMPANY

5. Remove the air cleaner assembly (2). Refer to [Air Cleaner Assembly Replacement](#)
6. Remove Engine Wiring Harness Junction Block. Refer to [Engine Wiring Harness Junction Block Replacement](#)
7. Remove the air cleaner outlet duct. Refer to [Air Cleaner Outlet Duct Replacement](#)
8. Remove Exhaust Front Pipe. Refer to [Exhaust Front Pipe Replacement \(LH7\)](#).

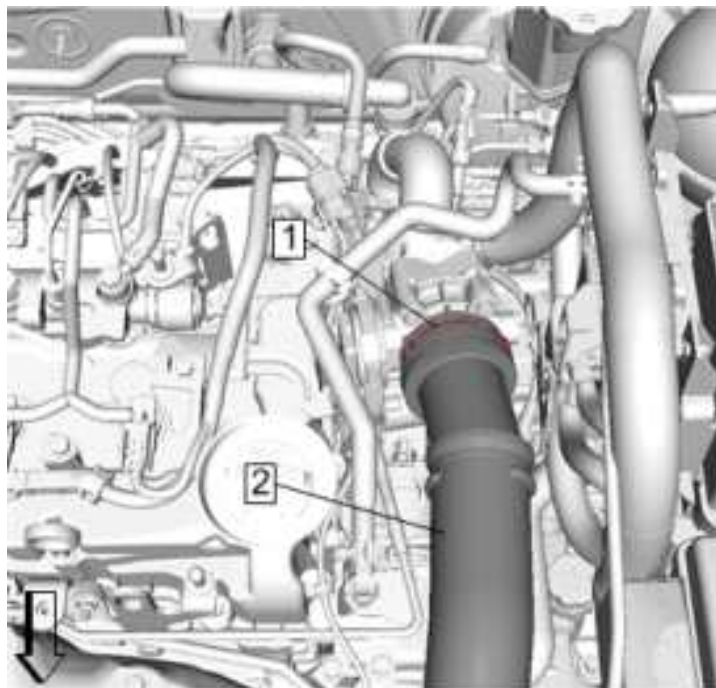


Fig. 524: Charge Air Cooler Outlet Air Tube And Retaining Clip
Courtesy of GENERAL MOTORS COMPANY

9. Remove Charge Air Cooler Outlet Air Tube (2). Refer to [Charge Air Cooler Outlet Air Tube Replacement](#)

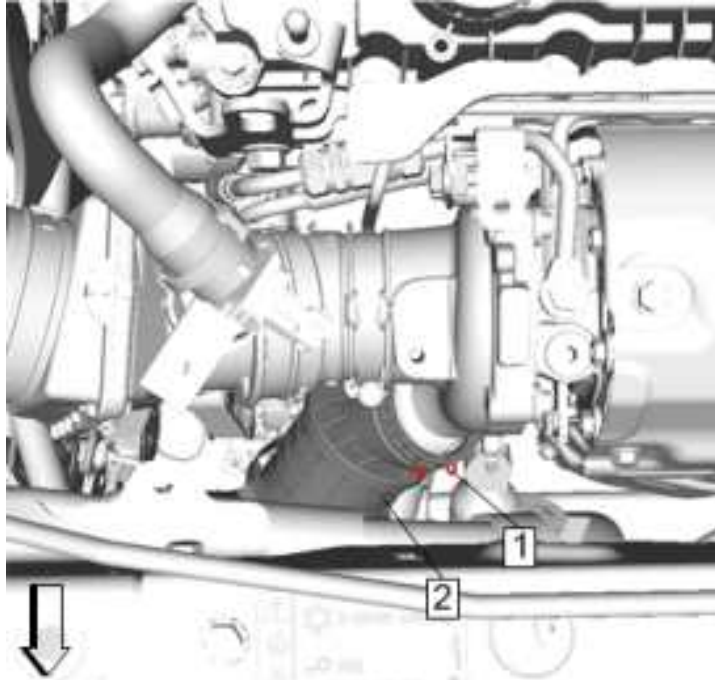


Fig. 525: Charge Air Cooler Inlet Air Tube And Retaining Clip
 Courtesy of GENERAL MOTORS COMPANY

10. Remove Charge Air Cooler Inlet Air Tube (2). Refer to [Charge Air Cooler Inlet Air Tube Replacement](#)

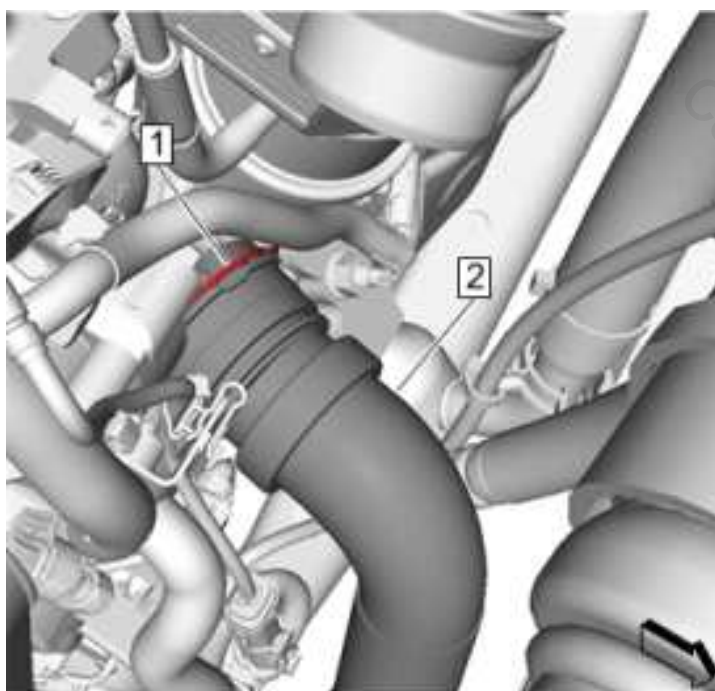


Fig. 526: Radiator Outlet Hose And Retaining Clip
 Courtesy of GENERAL MOTORS COMPANY

11. Disconnect Radiator Outlet Hose (2)@ Engine. Refer to [Radiator Outlet Hose Replacement \(LH7\)](#)

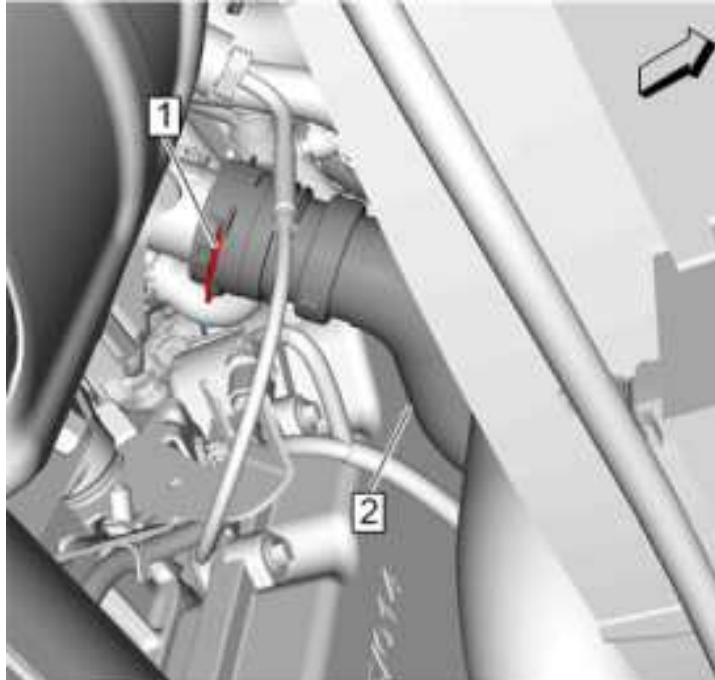


Fig. 527: Radiator Inlet Hose And Retaining Clip
 Courtesy of GENERAL MOTORS COMPANY

12. Disconnect Radiator Inlet Hose (2) @ Engine. Refer to [Radiator Inlet Hose Replacement \(LH7\)](#).

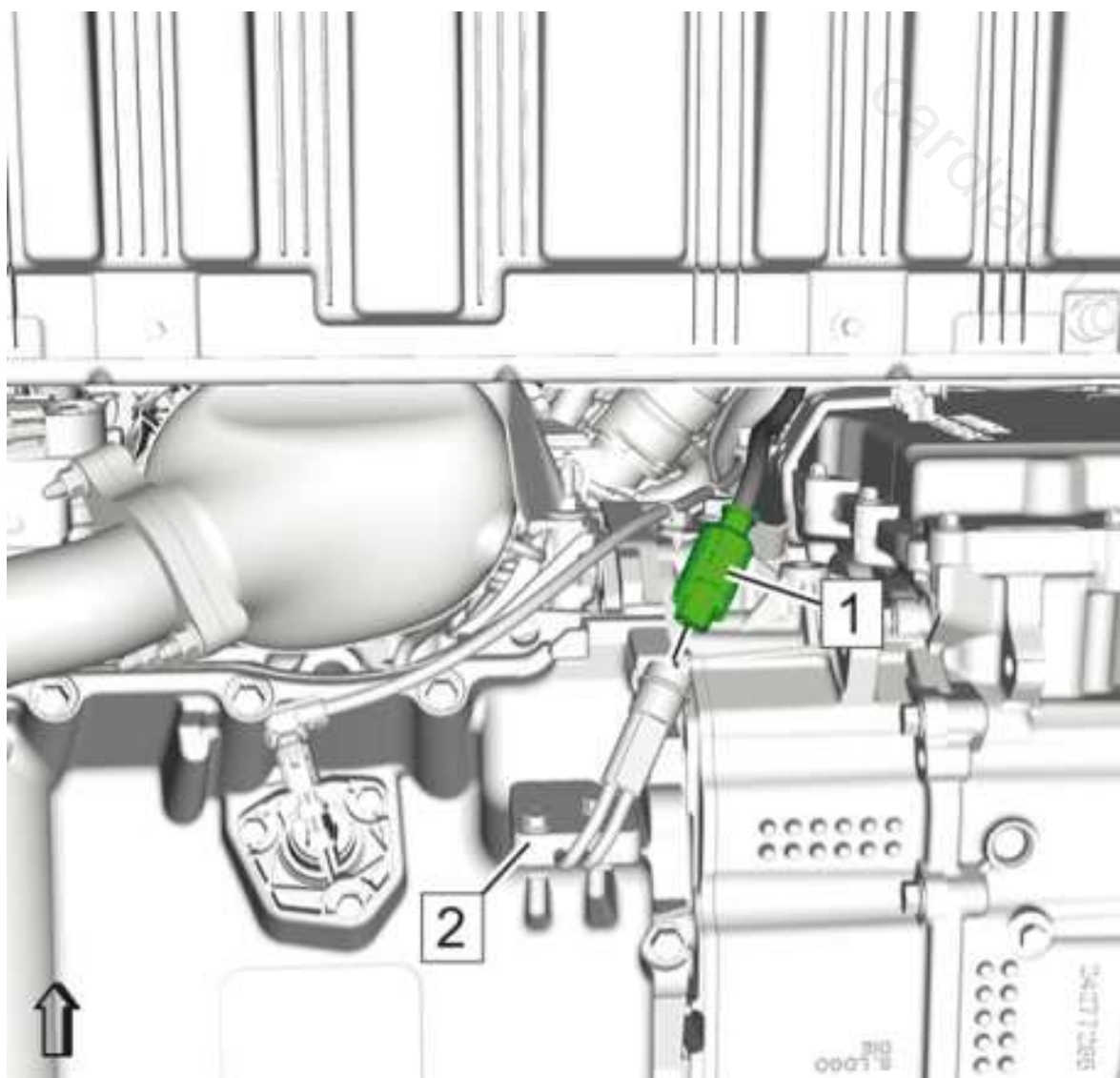


Fig. 528: Engine Oil Heater And Electrical Connector
 Courtesy of GENERAL MOTORS COMPANY

13. Disconnect the electrical connector (1) at the engine oil heater (2).

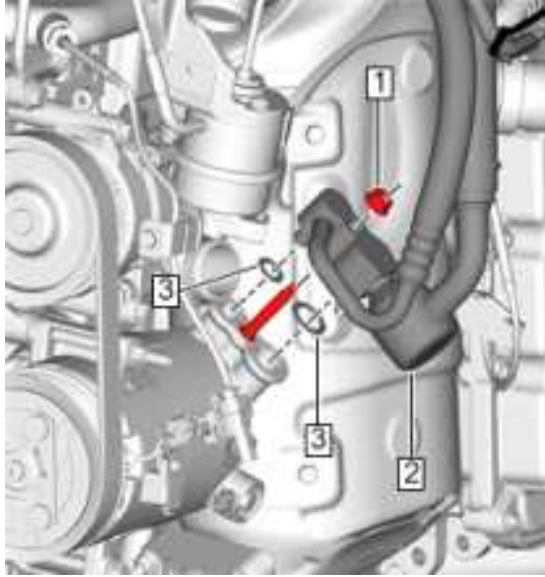


Fig. 529: A/C Evaporator Connector Hose/Tube And Compressor Hose, Seals And Retaining Nut
 Courtesy of GENERAL MOTORS COMPANY

14. Disconnect Air Conditioning Evaporator Connector Hose/Tube and Compressor Hose (2) @ Air Conditioning Compressor. Refer to [Air Conditioning Evaporator Connector Hose/Tube and Compressor Hose Replacement \(LH7\)](#)

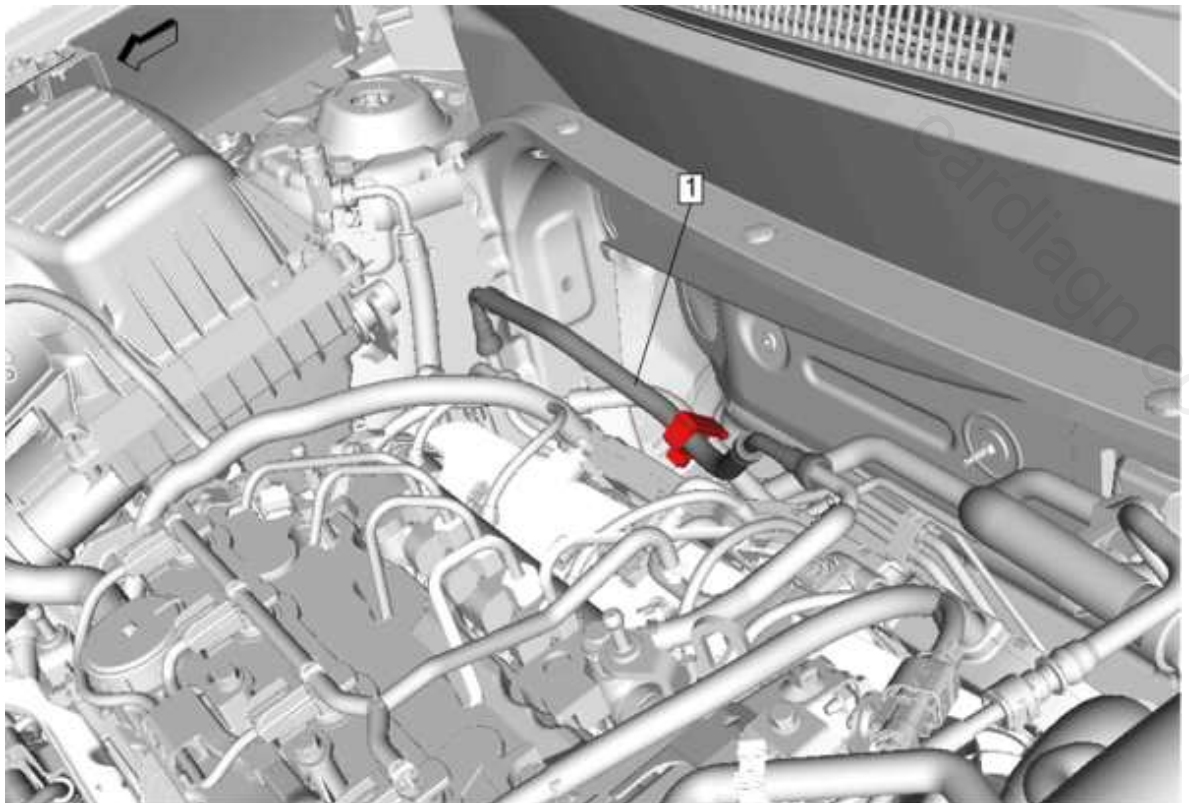


Fig. 530: Fuel Return Front Pipe
 Courtesy of GENERAL MOTORS COMPANY

15. Remove Fuel Return Front Pipe (1). Refer to [Fuel Return Front Pipe Replacement](#)

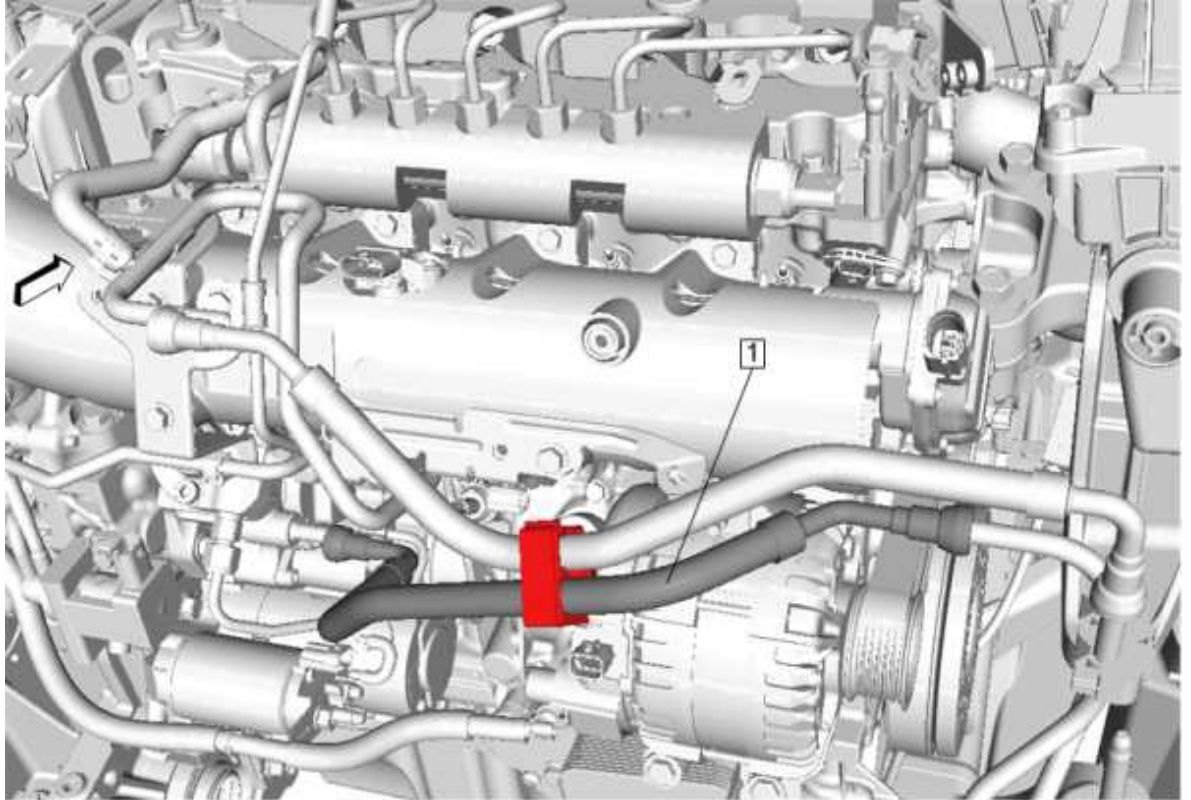


Fig. 531: Fuel Feed Front Pipe

Courtesy of GENERAL MOTORS COMPANY

16. Disconnect Fuel Feed Front Pipe (1) @ Fuel Feed Pipe. Refer to [Fuel Feed Front Pipe Replacement](#)

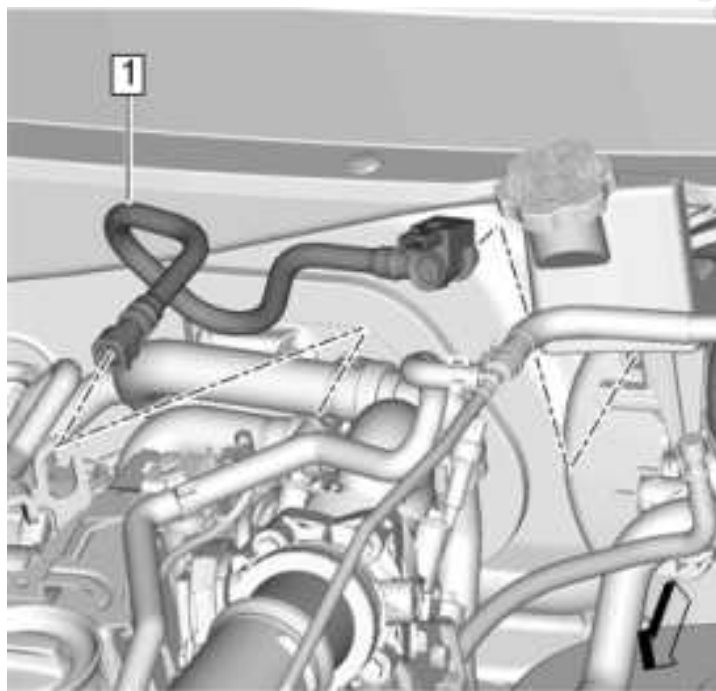


Fig. 532: Power Brake Booster Vacuum Pipe

Courtesy of GENERAL MOTORS COMPANY

17. Remove Power Brake Booster Vacuum Pipe (1). Refer to [Power Brake Booster Vacuum Pipe Replacement \(LH7\)](#)

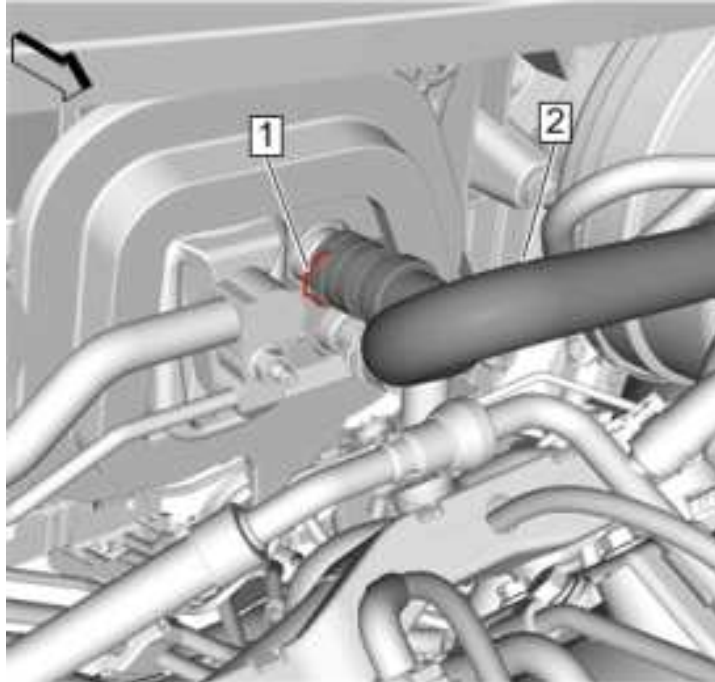


Fig. 533: Heater Inlet Hose And Retaining Clip
 Courtesy of GENERAL MOTORS COMPANY

18. Disconnect Heater Inlet Hose (2) @ Heater Core. Refer to [Heater Inlet Hose Replacement \(LH7 Terrain\)](#) [Heater Inlet Hose Replacement \(LH7 Equinox\)](#).

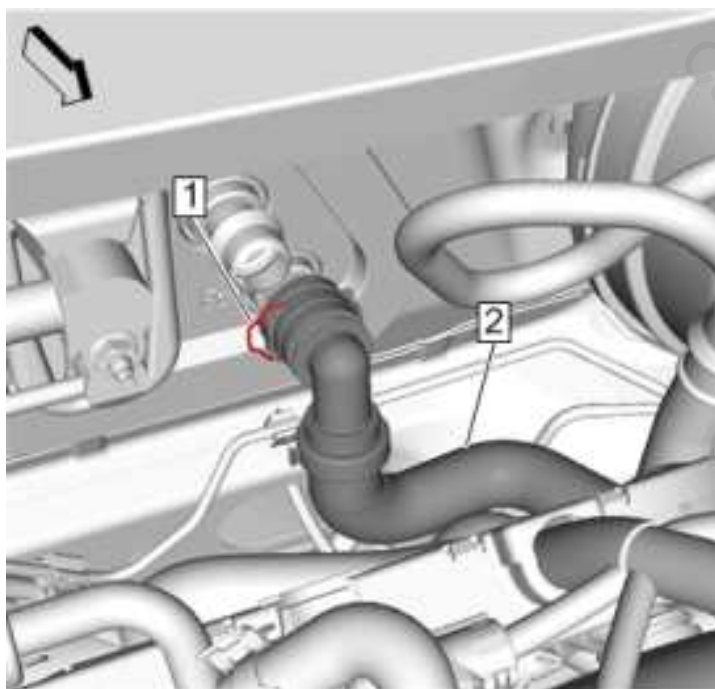


Fig. 534: Heater Outlet Hose And Retaining Clip
 Courtesy of GENERAL MOTORS COMPANY

19. Disconnect Heater Outlet Hose (2) @ Heater Core. Refer to [Heater Outlet Hose Replacement \(LH7\)](#).

CAUTION: Do not disconnect the nitrogen oxide sensor from the nitrogen oxide sensor control module. A separation of the two components may cause a defect on the nitrogen oxide sensor control module. Always replace the nitrogen oxide sensor along with the nitrogen oxide sensor control module as an assembly.

20. Remove Nitrogen Oxides Sensor - Position 1. Refer to [Nitrogen Oxides Sensor Replacement - Position 1](#)
21. Remove Power Transfer Unit Case. Refer to [Power Transfer Unit Case Replacement \(MHG Transmission with LH7 Engine\)](#).
22. Disconnect the steering intermediate shaft from the steering gear. Refer to [Intermediate Steering Shaft Replacement \(Equinox\)](#) [Intermediate Steering Shaft Replacement \(Terrain\)](#)

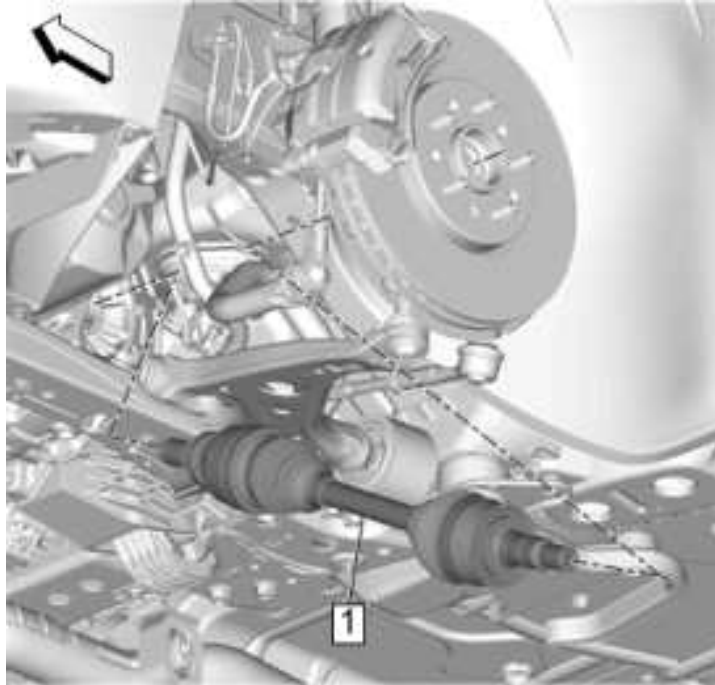


Fig. 535: Wheel Drive Shaft

Courtesy of GENERAL MOTORS COMPANY

23. Remove Front Wheel Drive Half Shaft-Left Side. Refer to [Front Wheel Drive Half Shaft Replacement - Left Side](#)
24. Remove Front Wheel Drive Half Shaft-Right Side. Refer to [Front Wheel Drive Half Shaft Replacement - Right Side \(AWD\)](#) [Front Wheel Drive Half Shaft Replacement - Right Side \(M3U, MHG, MNH, MNK with FWD\)](#)
25. Disconnect Stabilizer Shaft Link (Qty: 2) @ Stabilizer Shaft. Refer to [Stabilizer Shaft Link Replacement \(Equinox\)](#) [Stabilizer Shaft Link Replacement \(Terrain\)](#)

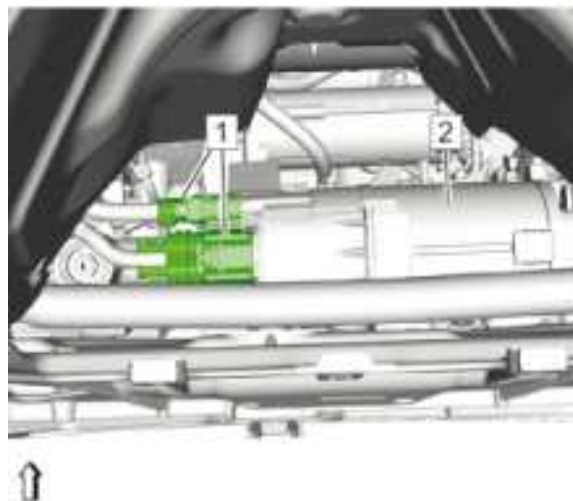


Fig. 536: Power Steering Assist Motor And Electrical Connectors

Courtesy of GENERAL MOTORS COMPANY

26. Disconnect Electrical Connectors (1) (Qty: 2) @ Power Steering Assist Motor (2)

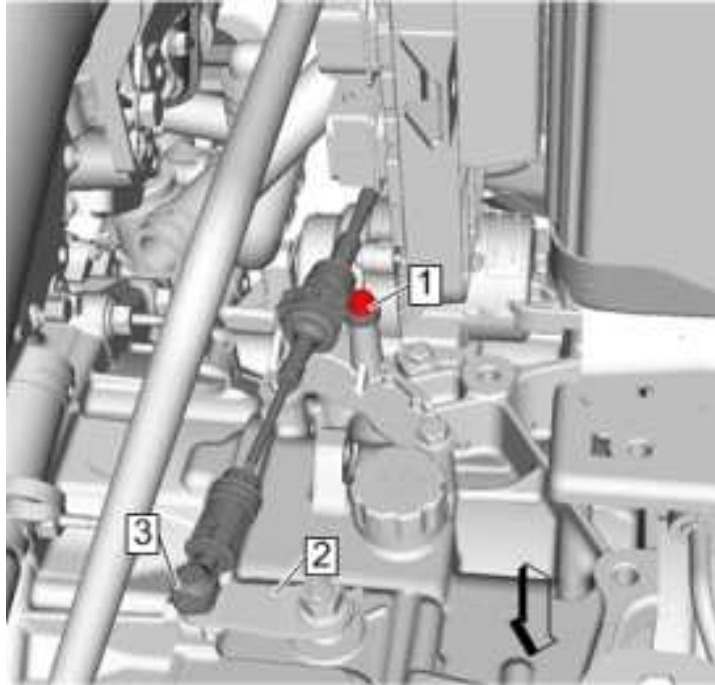


Fig. 537: Automatic Transmission Range Selector Lever Cable Terminal, Shift Lever And Clamp Bolt
Courtesy of GENERAL MOTORS COMPANY

27. Disconnect Automatic Transmission Range Selector Lever Cable Terminal (3) And Clamp Bolt (1) @ Transmission. Refer to [Automatic Transmission Range Selector Lever Cable Replacement](#)
28. Position aside Radiator Surge Tank. Refer to [Radiator Surge Tank Replacement \(LH7 FWD\)](#) [Radiator Surge Tank Replacement \(LH7 AWD\)](#).
29. Remove Transmission Fluid Cooler Inlet and Outlet Pipe @ Transmission. Refer to [Transmission Fluid Cooler Inlet and Outlet Pipe Replacement \(MNH, MHG\)](#).

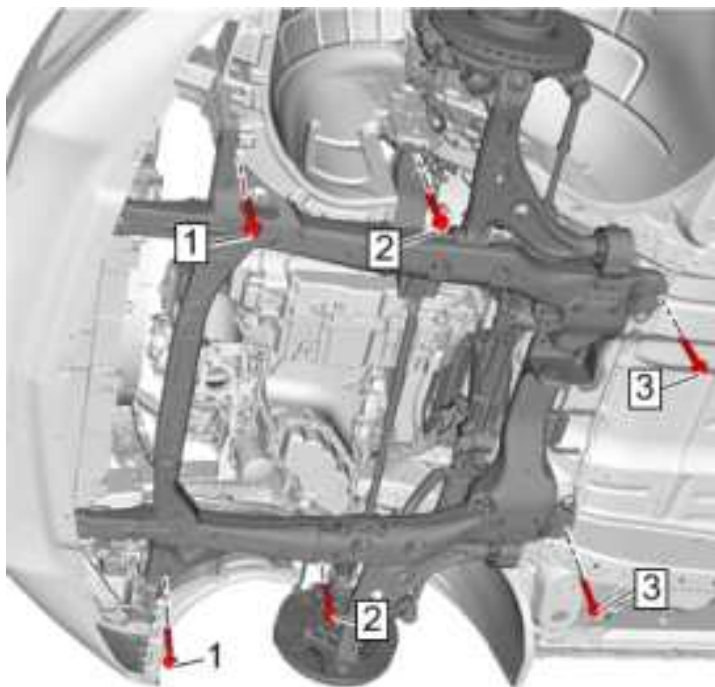


Fig. 538: Front Cradle Mounting Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: Use a suitable device to hold the cradle while removing the fasteners.

NOTE: Remove ONLY the body to frame bolts as the powertrain will be removed while still bolted to the frame.

30. Remove bolts necessary to remove the cradle (1) (2) and (3). Refer to [Drivetrain and Front Suspension Cradle Replacement \(Front Wheel Drive\)](#) [Drivetrain and Front Suspension Cradle Replacement \(All Wheel Drive\)](#).
31. Disconnect remaining electrical connections, hoses and reposition harnesses as needed.

32. Lower the vehicle.
33. Position an engine support table under the powertrain assembly.
34. Position blocks of wood below the oil pan and transmission to stabilize the powertrain on the support table.
35. With the table positioned, fully raise the table to contact with the powertrain assembly.

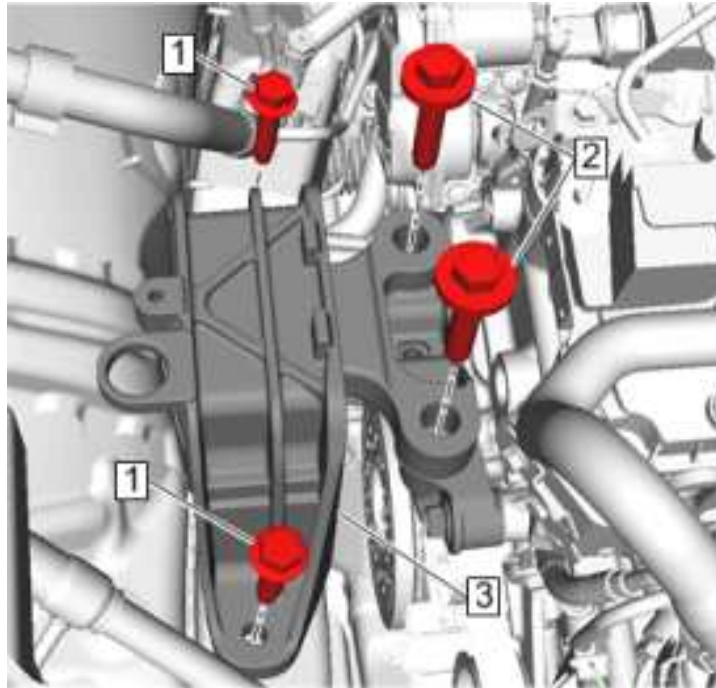


Fig. 539: Engine Mount And Bolts

Courtesy of GENERAL MOTORS COMPANY

36. Remove Engine Mount Bolts (2) (Qty: 2). Refer to [Engine Mount Replacement](#)

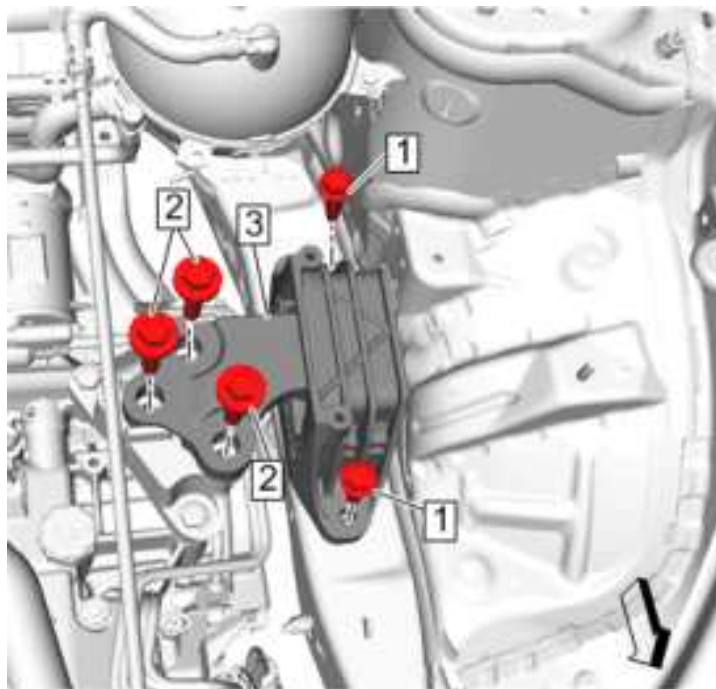


Fig. 540: Transmission Mount And Bolts

Courtesy of GENERAL MOTORS COMPANY

37. Remove Transmission Mount Bolts (2) (Qty: 3). Refer to [Transmission Mount Replacement - Left Side](#)

NOTE: A second technician is required.

NOTE: Ensure the powertrain assembly is free from wiring, hoses and other engine compartment components.

38. Carefully lower the engine table and raise the body on the hoist until the engine/transaxle and frame are separated from the vehicle.

39. Separate the engine from the transmission. Refer to [Transmission Replacement \(All Wheel Drive with Diesel Engine, Equinox\)](#). [Transmission Replacement \(Front Wheel Drive with Diesel Engine\)](#). [Transmission Replacement \(All Wheel Drive with Diesel Engine, Terrain\)](#).
40. Install the engine to a suitable engine stand.
41. If replacing the engine, transfer components as necessary.

Installation Procedure

1. Install the transmission to the engine. Refer to [Transmission Replacement \(All Wheel Drive with Diesel Engine, Equinox\)](#). [Transmission Replacement \(Front Wheel Drive with Diesel Engine\)](#). [Transmission Replacement \(All Wheel Drive with Diesel Engine, Terrain\)](#).
2. Position the powertrain and support table under the vehicle.

NOTE: A second technician is required.

3. Slowly and carefully lower the vehicle, ensure the powertrain assembly is free from wiring, hoses and other engine compartment components.

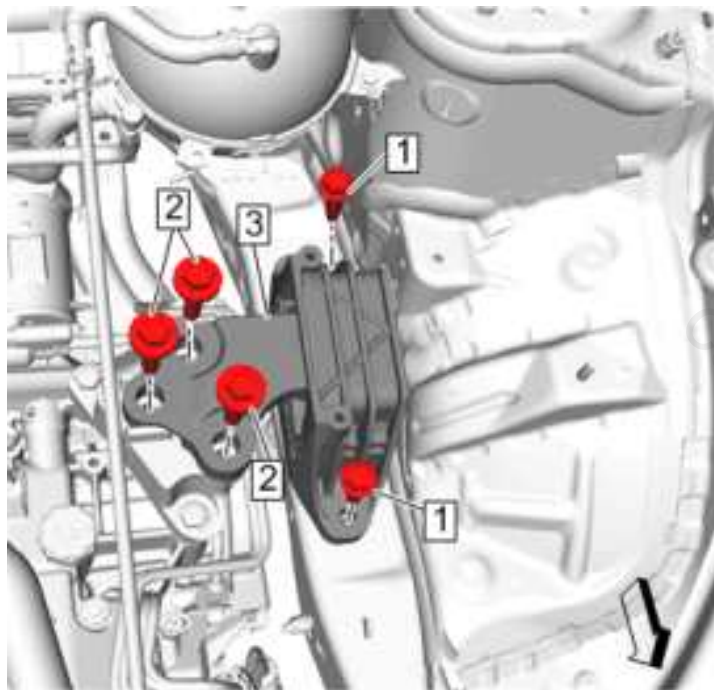
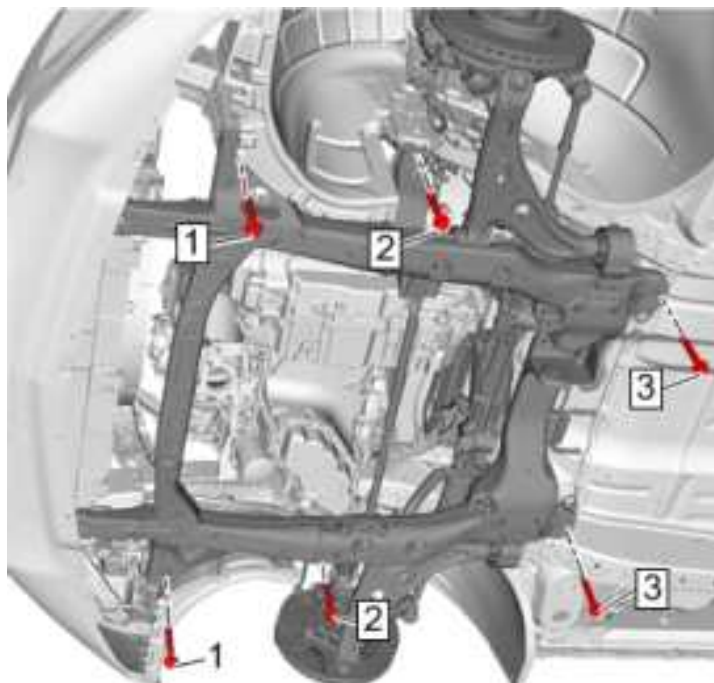


Fig. 541: Transmission Mount And Bolts

Courtesy of GENERAL MOTORS COMPANY

4. Install Transmission Mount Bolts (2) (Qty: 3). Refer to [Transmission Mount Replacement - Left Side](#)



NOTE: Use a suitable device to hold the cradle while installing the fasteners.

5. Install fasteners (1) (2) and (3). Refer to [Drivetrain and Front Suspension Cradle Replacement \(Front Wheel Drive\)](#), [Drivetrain and Front Suspension Cradle Replacement \(All Wheel Drive\)](#).
6. Connect electrical connections, hoses and reposition harnesses as needed.
7. Install Transmission Fluid Cooler Inlet and Outlet Pipe @ Transmission. Refer to [Transmission Fluid Cooler Inlet and Outlet Pipe Replacement \(MNH, MHG\)](#).
8. Install Radiator Surge Tank. Refer to [Radiator Surge Tank Replacement \(LH7 FWD\)](#), [Radiator Surge Tank Replacement \(LH7 AWD\)](#).

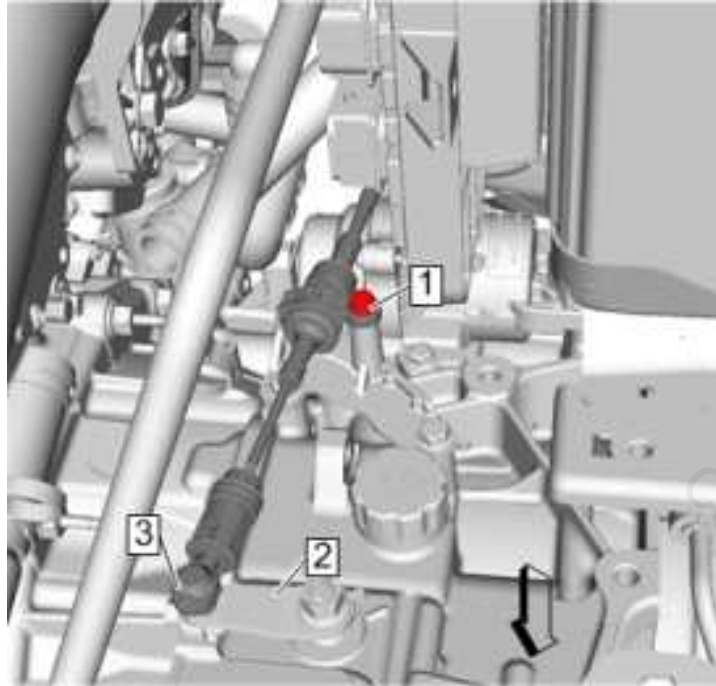


Fig. 543: Automatic Transmission Range Selector Lever Cable Terminal, Shift Lever And Clamp Bolt
Courtesy of GENERAL MOTORS COMPANY

9. Install Automatic Transmission Range Selector Lever Cable Terminal (3) And Clamp Bolt (1) @ Transmission. Refer to [Automatic Transmission Range Selector Lever Cable Replacement](#)

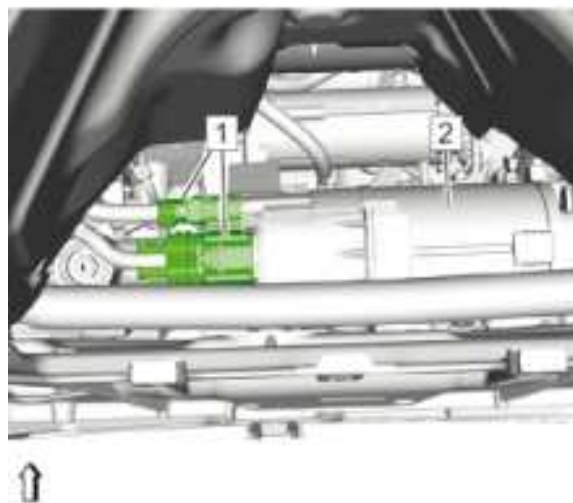


Fig. 544: Power Steering Assist Motor And Electrical Connectors
Courtesy of GENERAL MOTORS COMPANY

10. Connect Electrical Connectors (1) (Qty: 2) @ Power Steering Assist Motor (2)
11. Install Front Wheel Drive Half Shaft-Right Side. Refer to [Front Wheel Drive Half Shaft Replacement - Right Side \(AWD\)](#), [Front Wheel Drive Half Shaft Replacement - Right Side \(M3U, MHG, MNH, MNK with FWD\)](#).

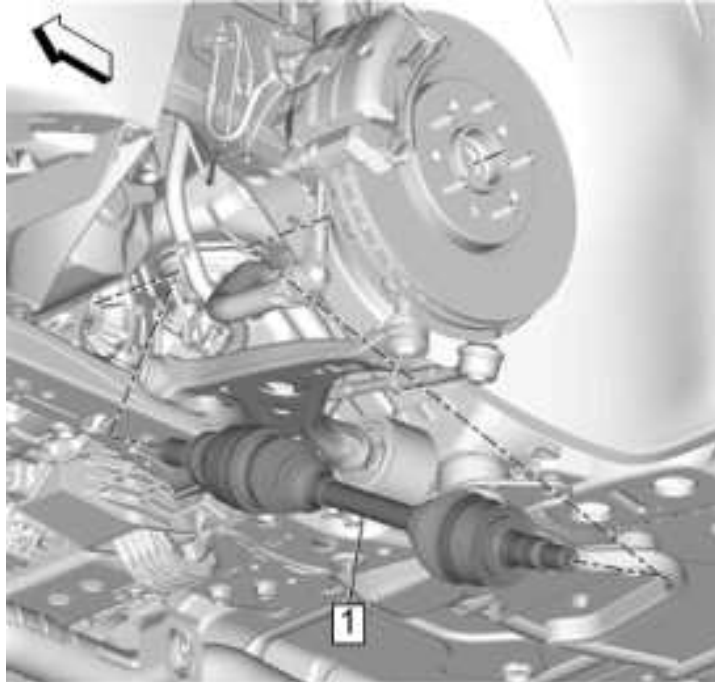


Fig. 545: Wheel Drive Shaft

Courtesy of GENERAL MOTORS COMPANY

12. Install Front Wheel Drive Half Shaft-Left Side (1). Refer to [Front Wheel Drive Half Shaft Replacement - Left Side](#)
13. Connect Stabilizer Shaft Link (Qty: 2) @ Stabilizer Shaft. Refer to [Stabilizer Shaft Link Replacement \(Equinox\)](#) [Stabilizer Shaft Link Replacement \(Terrain\)](#)
14. Connect the steering intermediate shaft to the steering gear. Refer to [Intermediate Steering Shaft Replacement \(Equinox\)](#) [Intermediate Steering Shaft Replacement \(Terrain\)](#)
15. Install Power Transfer Unit Case. Refer to [Power Transfer Unit Case Replacement \(MHG Transmission with LH7 Engine\)](#)

CAUTION: Do not disconnect the nitrogen oxide sensor from the nitrogen oxide sensor control module. A separation of the two components may cause a defect on the nitrogen oxide sensor control module. Always replace the nitrogen oxide sensor along with the nitrogen oxide sensor control module as an assembly.

16. Install Nitrogen Oxides Sensor - Position 1. Refer to [Nitrogen Oxides Sensor Replacement - Position 1](#)

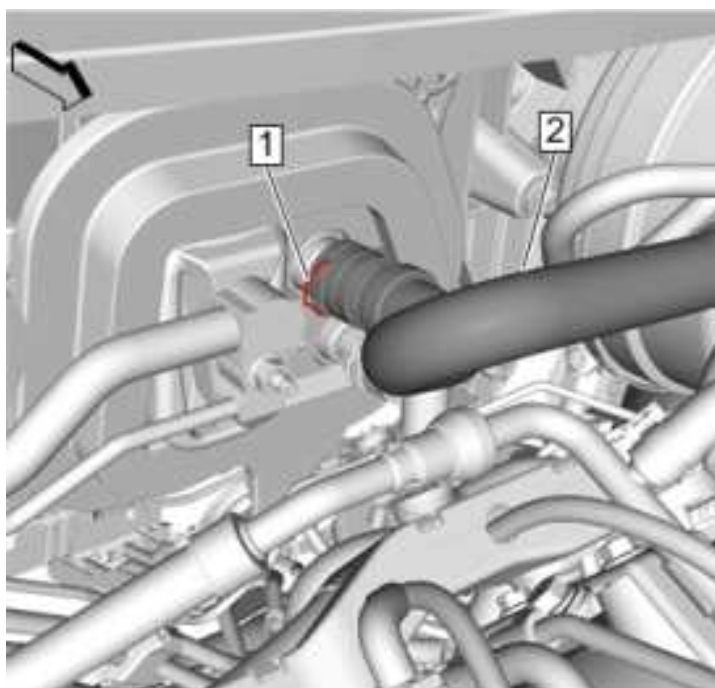


Fig. 546: Heater Inlet Hose And Retaining Clip

Courtesy of GENERAL MOTORS COMPANY

17. Connect Heater Inlet Hose (2) @ Heater Core. Refer to [Heater Inlet Hose Replacement \(LH7 Terrain\)](#).
[Heater Inlet Hose Replacement \(LH7 Equinox\)](#).

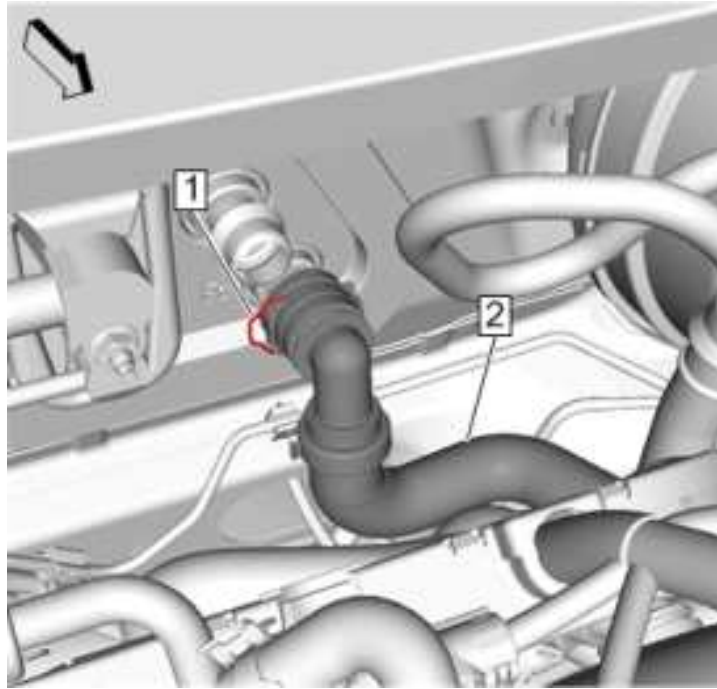


Fig. 547: Heater Outlet Hose And Retaining Clip
Courtesy of GENERAL MOTORS COMPANY

18. Connect Heater Outlet Hose (2) @ Heater Core. Refer to [Heater Outlet Hose Replacement \(LH7\)](#).

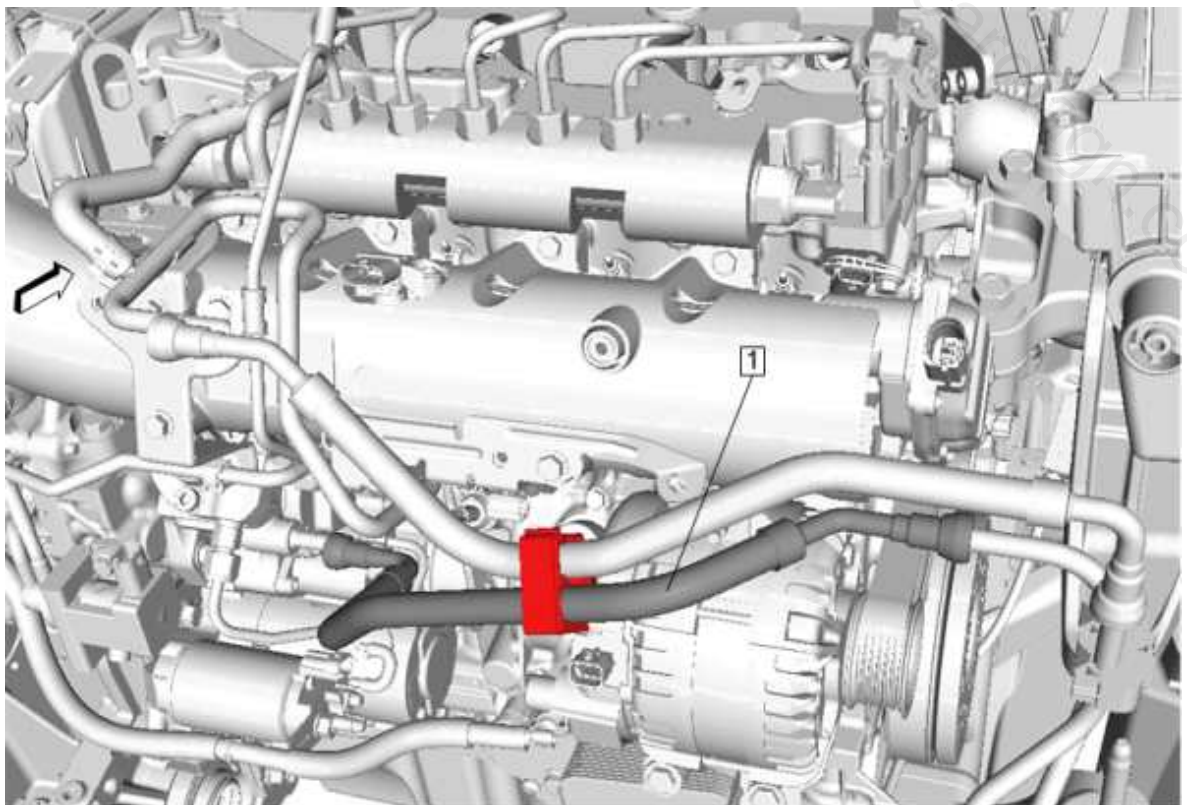


Fig. 548: Fuel Feed Front Pipe
Courtesy of GENERAL MOTORS COMPANY

19. Connect Fuel Feed Front Pipe (1) @ Fuel Feed Pipe. Refer to [Fuel Feed Front Pipe Replacement](#)

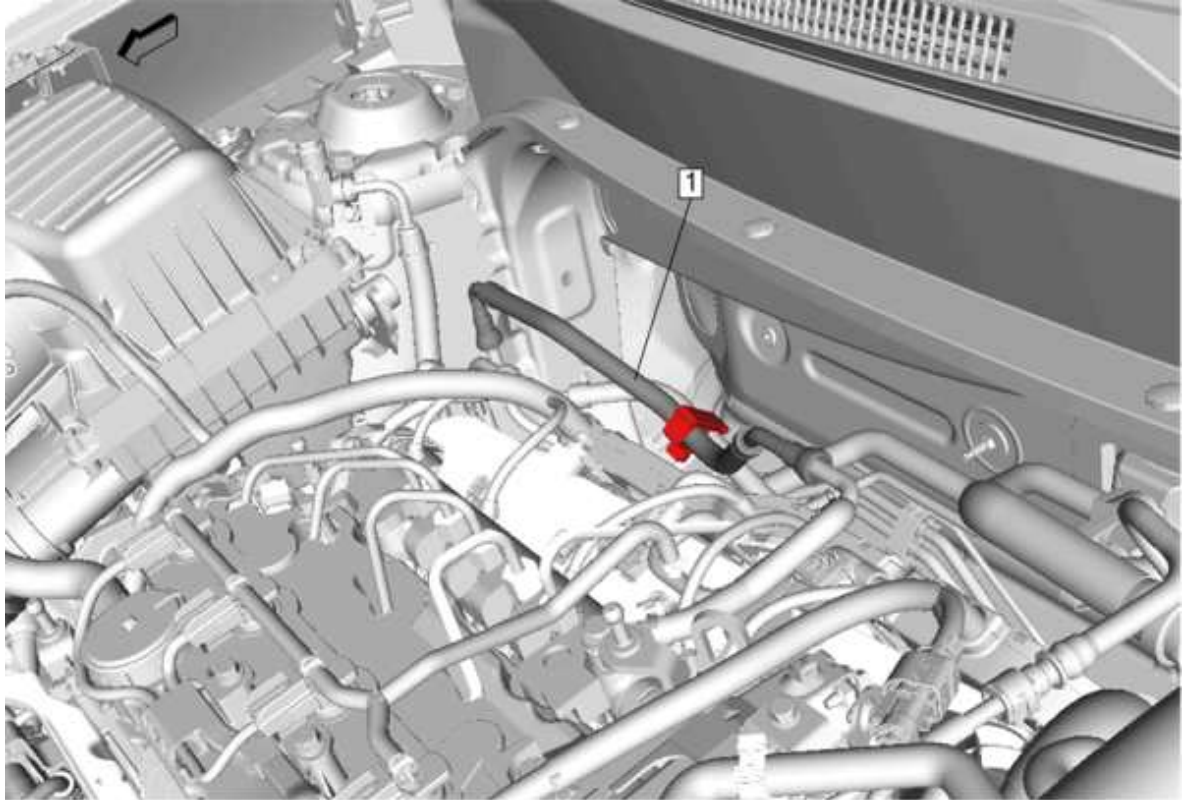


Fig. 549: Fuel Return Front Pipe

Courtesy of GENERAL MOTORS COMPANY

20. Install Fuel Return Front Pipe (1). Refer to [Fuel Return Front Pipe Replacement](#)

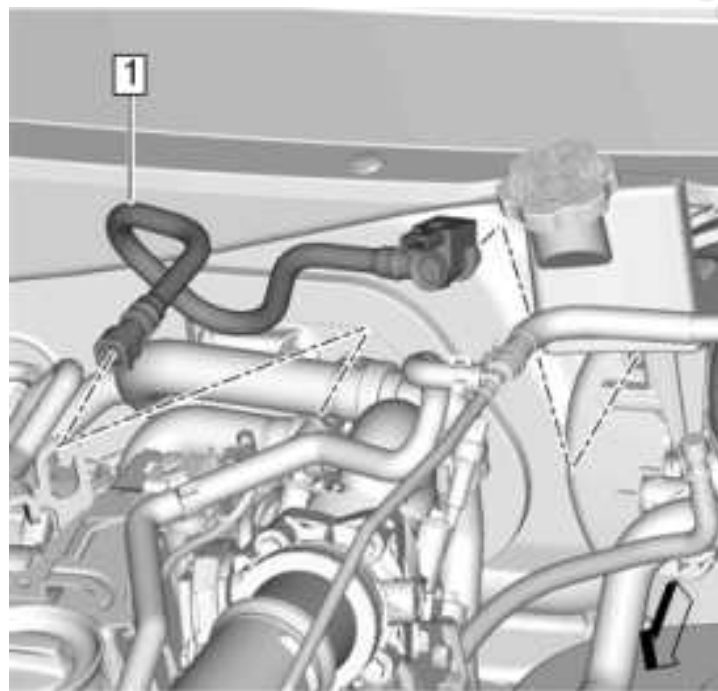


Fig. 550: Power Brake Booster Vacuum Pipe

Courtesy of GENERAL MOTORS COMPANY

21. Install Power Brake Booster Vacuum Pipe (1). Refer to [Power Brake Booster Vacuum Pipe Replacement \(LH7\)](#)

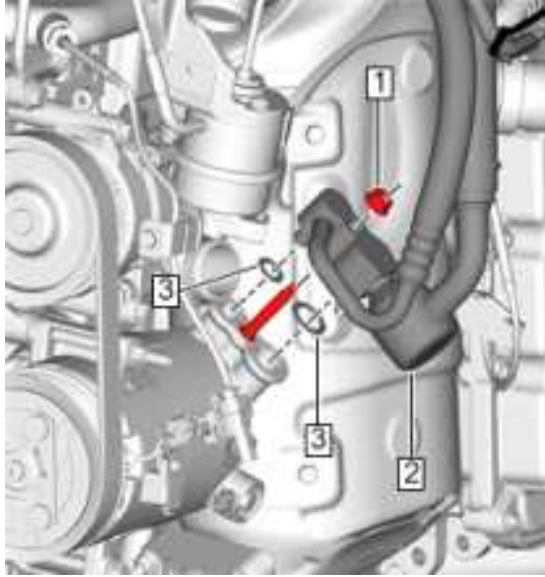


Fig. 551: A/C Evaporator Connector Hose/Tube And Compressor Hose, Seals And Retaining Nut
 Courtesy of GENERAL MOTORS COMPANY

22. Connect Air Conditioning Evaporator Connector Hose/Tube and Compressor Hose (2) @ Air Conditioning Compressor. Refer to [Air Conditioning Evaporator Connector Hose/Tube and Compressor Hose Replacement \(LH7\)](#).

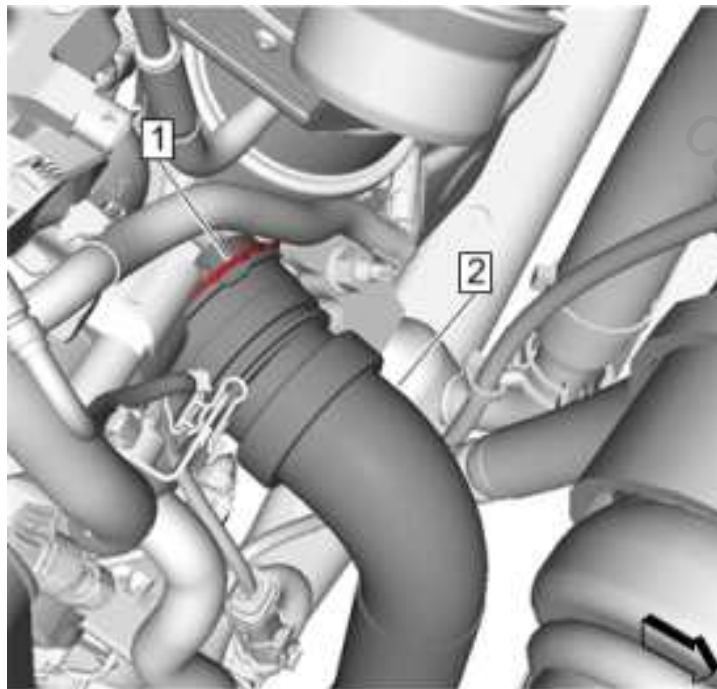


Fig. 552: Radiator Outlet Hose And Retaining Clip
 Courtesy of GENERAL MOTORS COMPANY

23. Connect Radiator Outlet Hose (2) @ Engine. Refer to [Radiator Outlet Hose Replacement \(LH7\)](#).

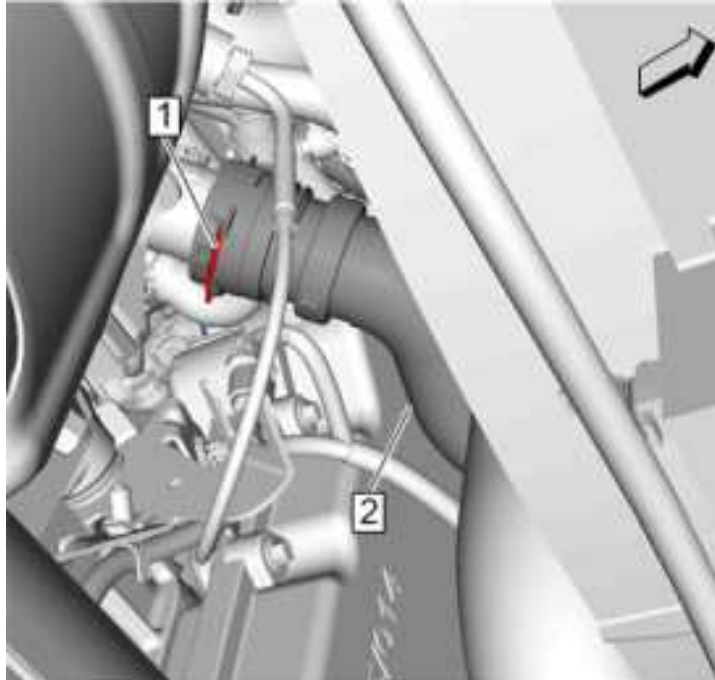


Fig. 553: Radiator Inlet Hose And Retaining Clip
 Courtesy of GENERAL MOTORS COMPANY

24. Connect Radiator Inlet Hose (2) @ Engine. Refer to [Radiator Inlet Hose Replacement \(LH7\)](#)

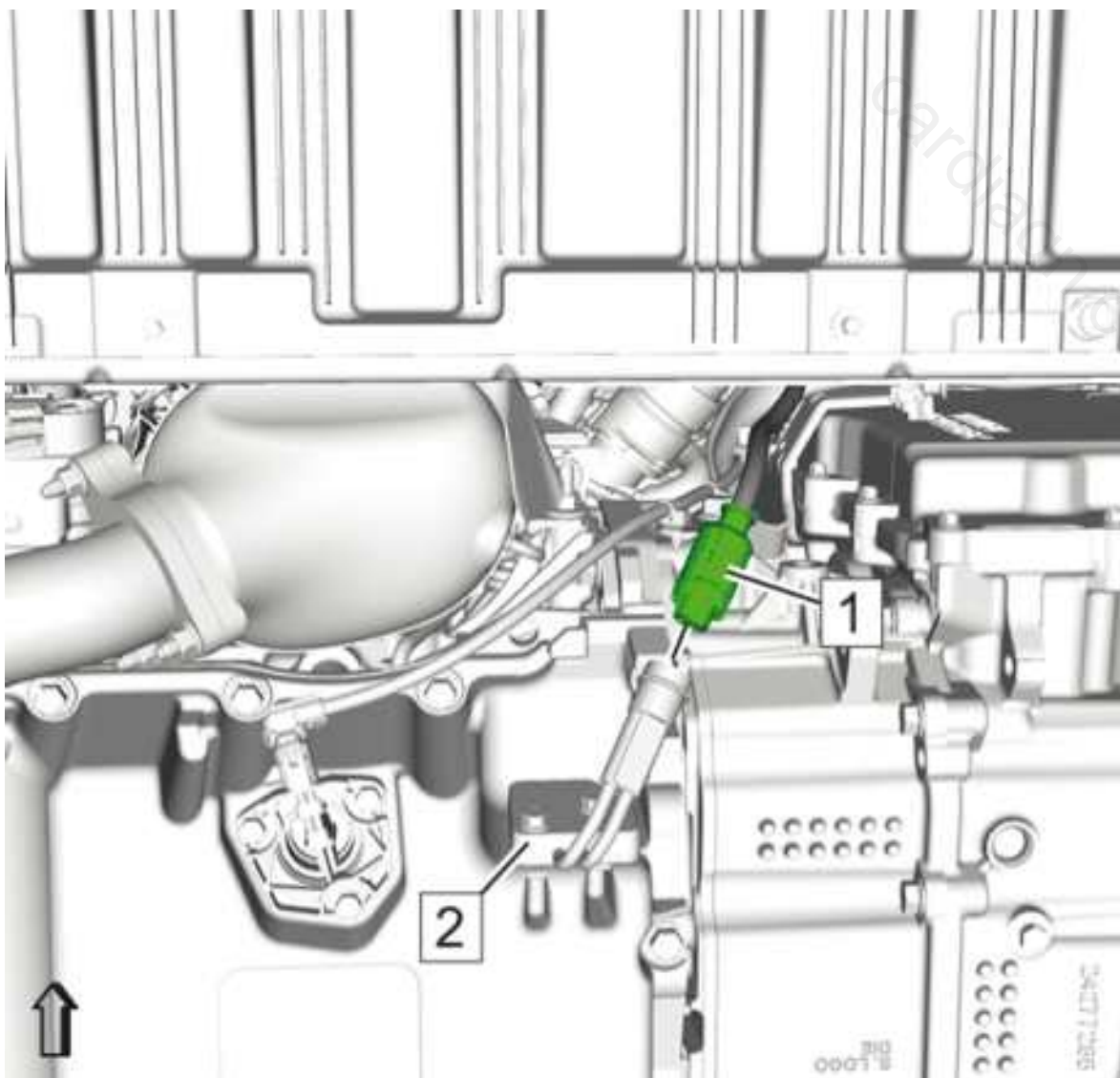


Fig. 554: Engine Oil Heater And Electrical Connector
 Courtesy of GENERAL MOTORS COMPANY

25. Connect the electrical connector (1) at the engine oil heater (2).

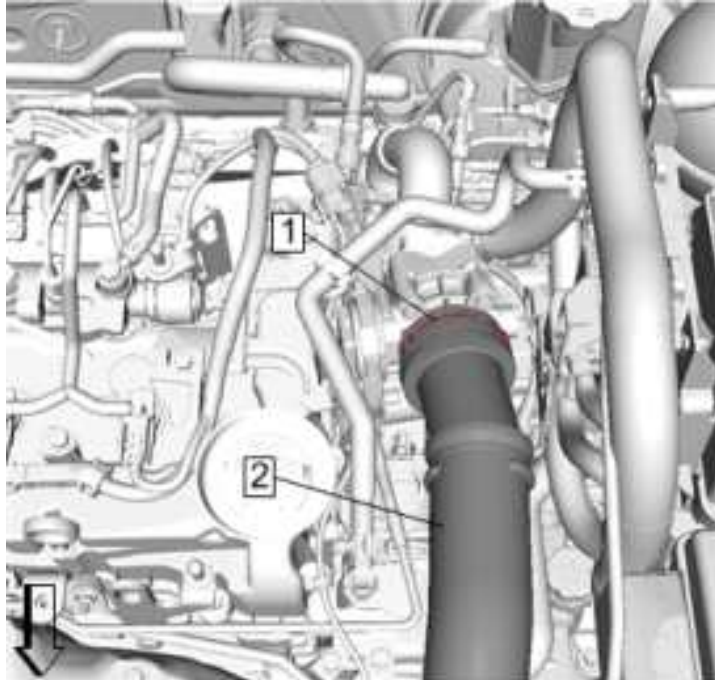


Fig. 555: Charge Air Cooler Outlet Air Tube And Retaining Clip
 Courtesy of GENERAL MOTORS COMPANY

26. Install Charge Air Cooler Outlet Air Tube (2). Refer to [Charge Air Cooler Outlet Air Tube Replacement](#)

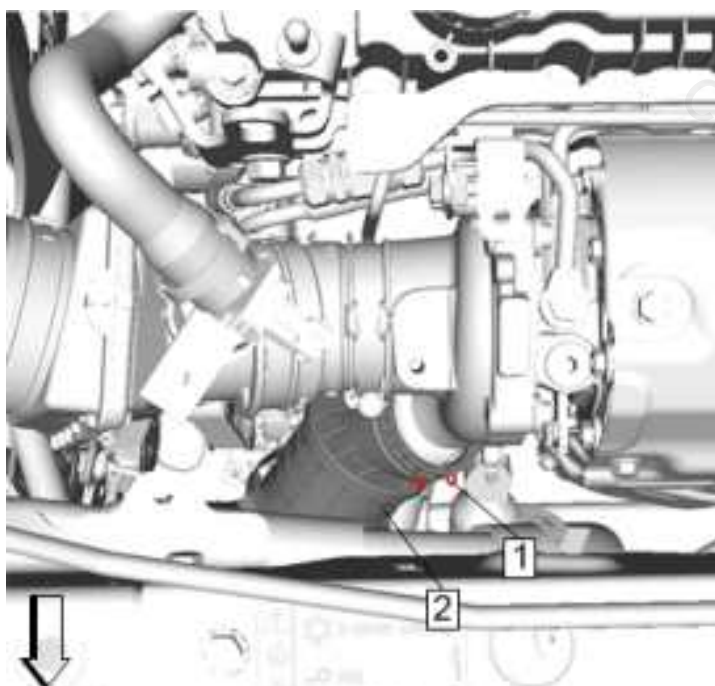


Fig. 556: Charge Air Cooler Inlet Air Tube And Retaining Clip
 Courtesy of GENERAL MOTORS COMPANY

27. Install Charge Air Cooler Inlet Air Tube (2). Refer to [Charge Air Cooler Inlet Air Tube Replacement](#)
 28. Install Exhaust Front Pipe. Refer to [Exhaust Front Pipe Replacement \(LH7\)](#)
 29. Install Battery Tray. Refer to [Battery Tray Replacement](#)
 30. Install Engine Wiring Harness Junction Block. Refer to [Engine Wiring Harness Junction Block Replacement](#)

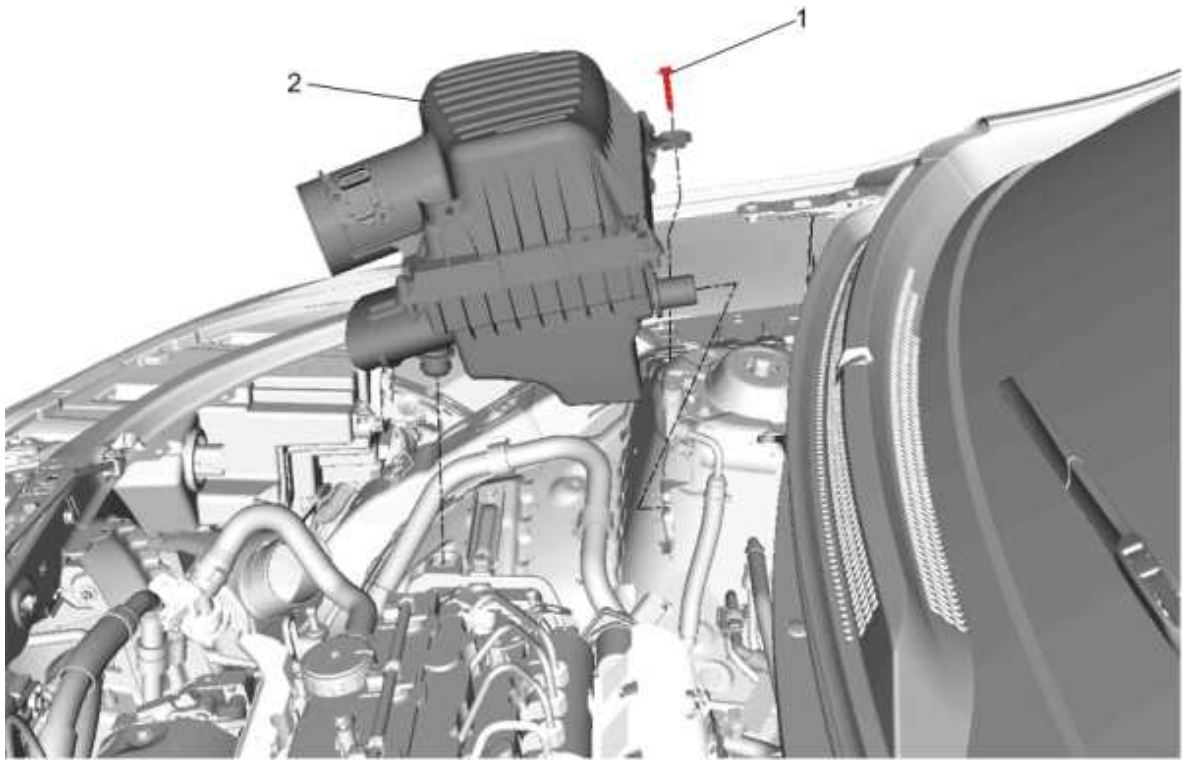


Fig. 557: Air Cleaner Assembly And Fastener
Courtesy of GENERAL MOTORS COMPANY

31. Install the air cleaner assembly (2). Refer to [Air Cleaner Assembly Replacement](#)
32. Install the air cleaner outlet duct. Refer to [Air Cleaner Outlet Duct Replacement](#)
33. Connect the battery negative cable. Refer to [Battery Negative Cable Disconnection and Connection \(KL9\)](#)
34. Fill the cooling system. Refer to [Cooling System Draining and Filling \(GE 47716\) Cooling System Draining and Filling \(Static\)](#)
35. Recharge the refrigerant. Refer to [Refrigerant Recovery and Recharging \(R-134a\) Refrigerant Recovery and Recharging \(R-1234yf\)](#)
36. Change the engine oil and filter. Refer to [Engine Oil and Oil Filter Replacement](#)
37. When the replacement is completed, use a scan tool to perform the appropriate reset functions. Refer to [Control Module References](#)

CAMSHAFT TIMING CHAIN ADJUSTMENT

Special Tools

- **EN-51140** Crankshaft Fixing Tool
- **EN-51143** Camshaft Sprocket Fixing Tool

Equivalent regional tools: [Special Tools](#)

Removal Procedure

1. Disconnect the battery negative cable. Refer to [Battery Negative Cable Disconnection and Connection \(KL9\)](#)
2. Remove Throttle Body Assembly. Refer to [Throttle Body Assembly Replacement](#)
3. Remove Camshaft Housing. Refer to [Camshaft Housing Replacement](#)
4. Remove Crankshaft Pulley. Refer to [Crankshaft Pulley Replacement](#)
5. Lower the vehicle. Refer to [Lifting and Jacking the Vehicle](#)

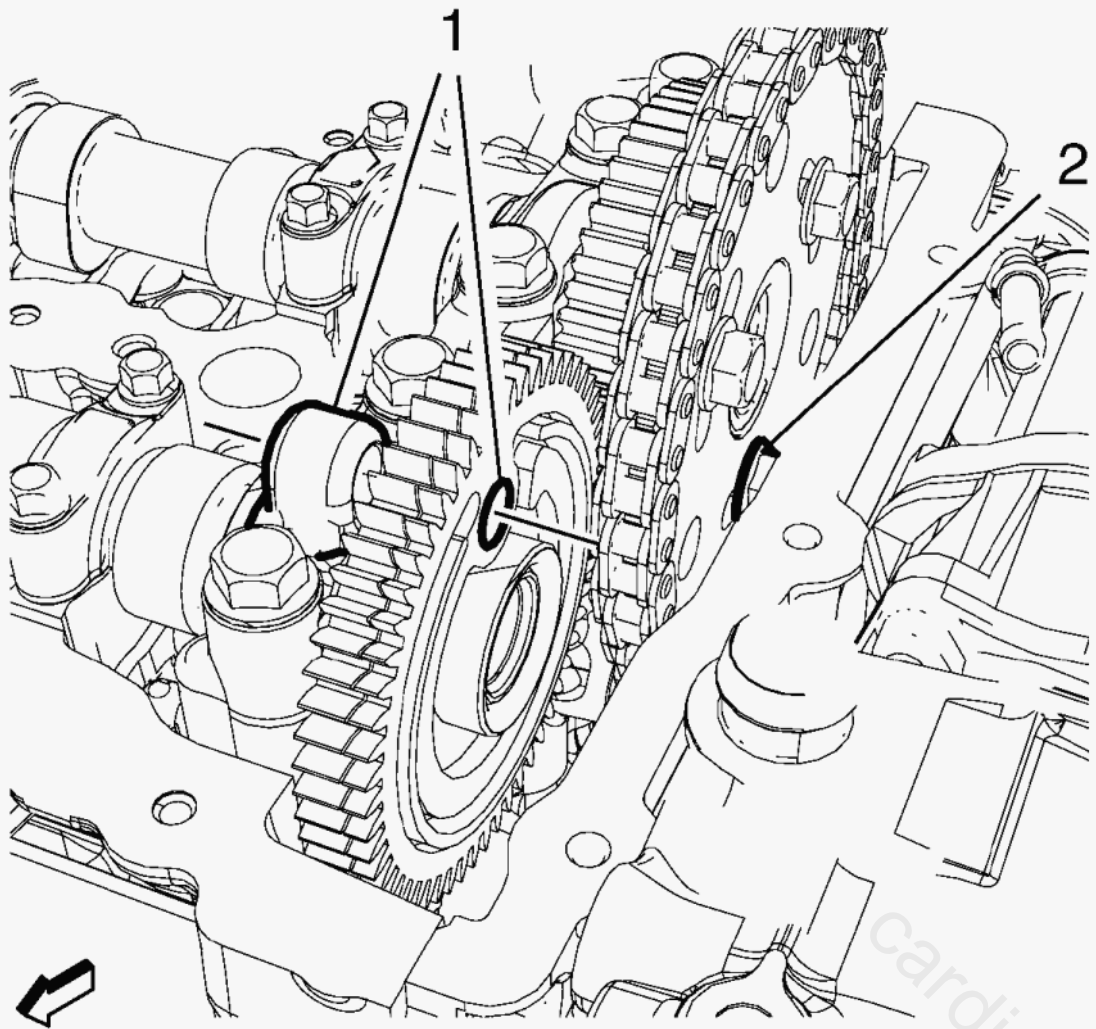


Fig. 558: Aligning Bores

Courtesy of GENERAL MOTORS COMPANY

NOTE: To locate the correct camshaft sprocket bolt (2) check the TDC position.

6. Check if the bores (1) are aligned.
7. Raise the vehicle.

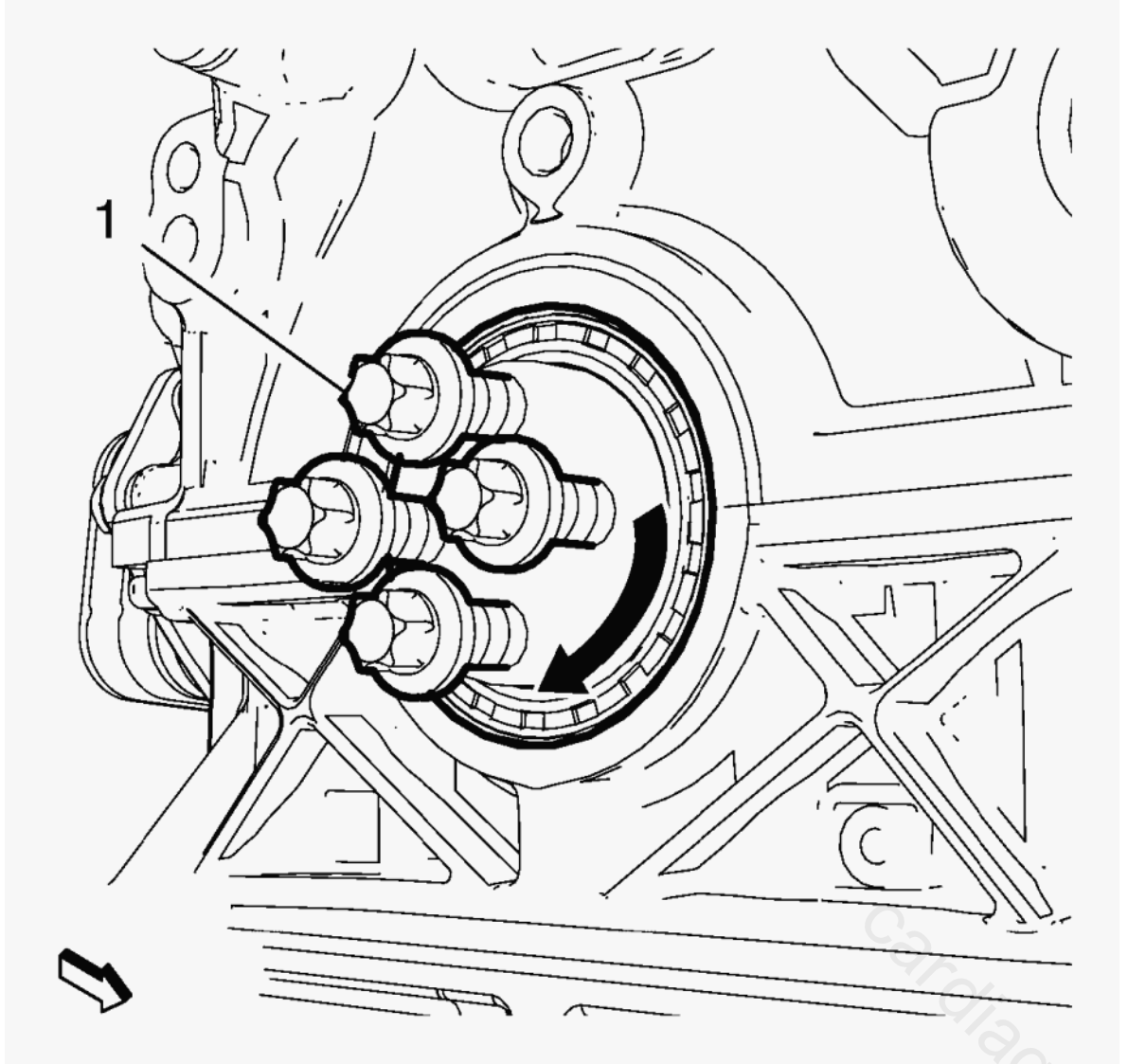


Fig. 559: Crankshaft Pulley Bolts

Courtesy of GENERAL MOTORS COMPANY

8. Install the 4 crankshaft pulley bolts (1).
9. Rotate the crankshaft 360 degrees in direction of arrow. Use a pry bar.
10. Lower the vehicle.

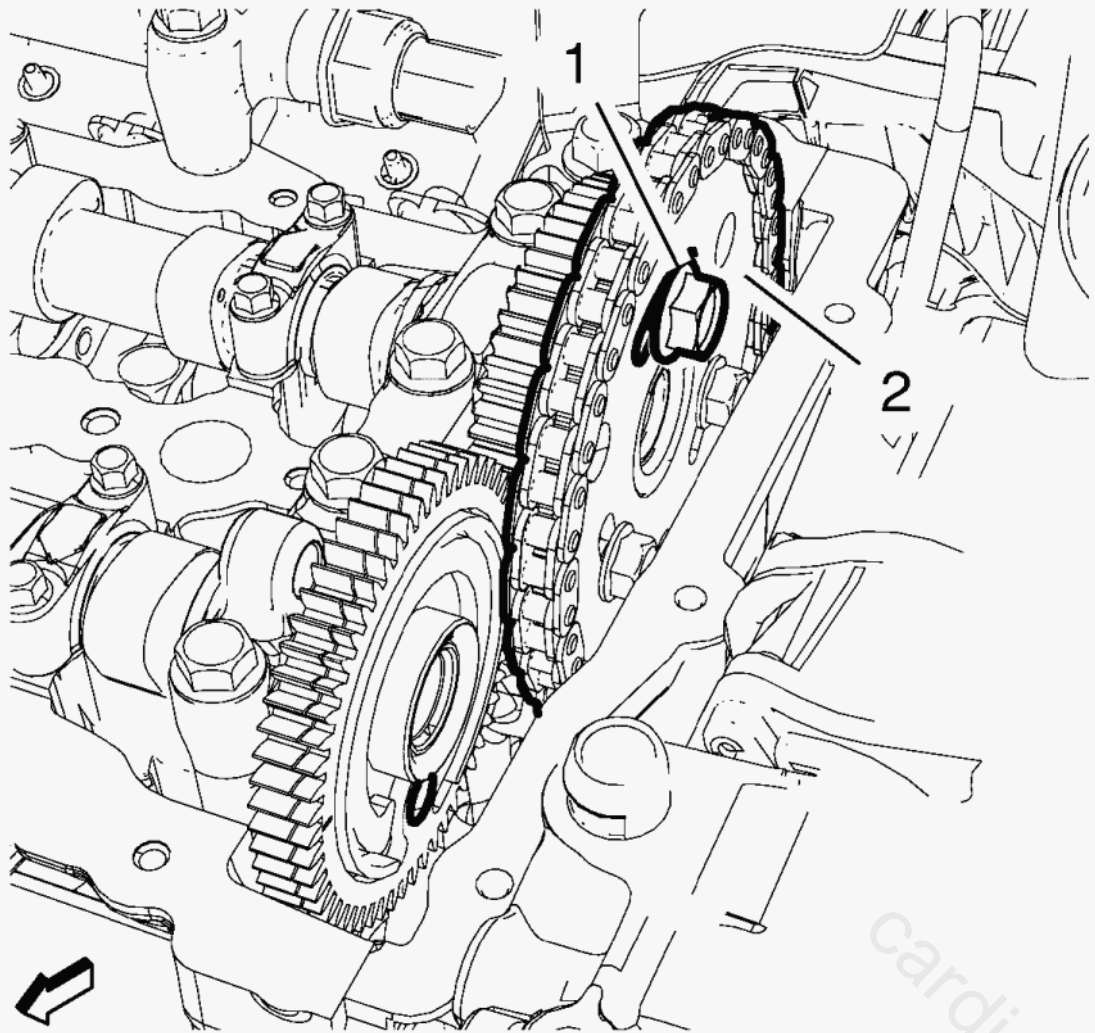


Fig. 560: Intake Camshaft Sprocket And Bolt
Courtesy of GENERAL MOTORS COMPANY

11. Loosen the camshaft sprocket bolt (1) from the intake camshaft sprocket (2). Counterhold with a wrench at the camshaft hexagon.
12. Raise the vehicle.

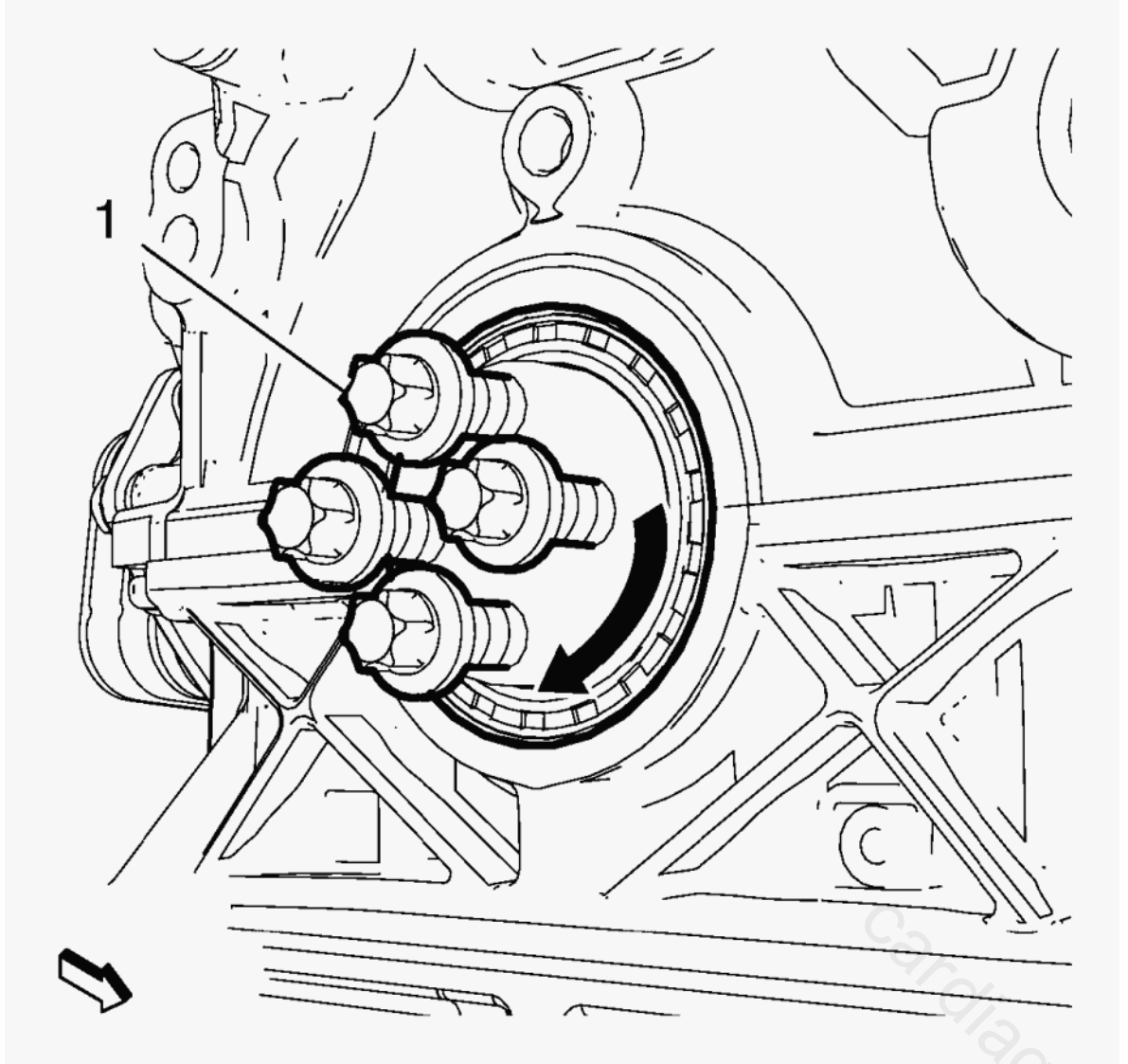


Fig. 561: Crankshaft Pulley Bolts

Courtesy of GENERAL MOTORS COMPANY

13. Rotate the crankshaft 360 degrees in direction of arrow. Use a pry bar at the 4 crankshaft pulley bolts (1).
14. Remove the 4 crankshaft pulley bolts (1).

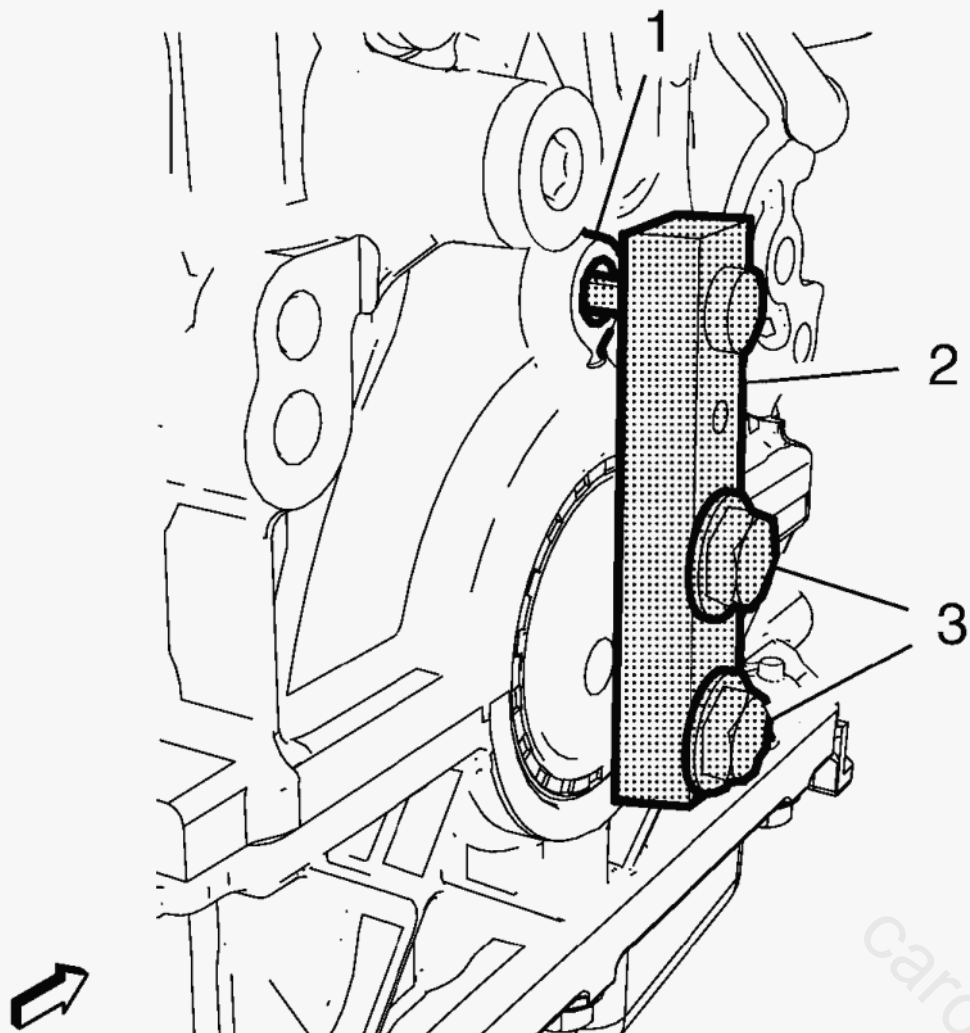


Fig. 562: Crankshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

15. Install **EN-51140** fixing tool (2).
16. Install the fixing pin into the engine block bore (1) and tighten the 2 bolts (3).
17. Lower the vehicle.

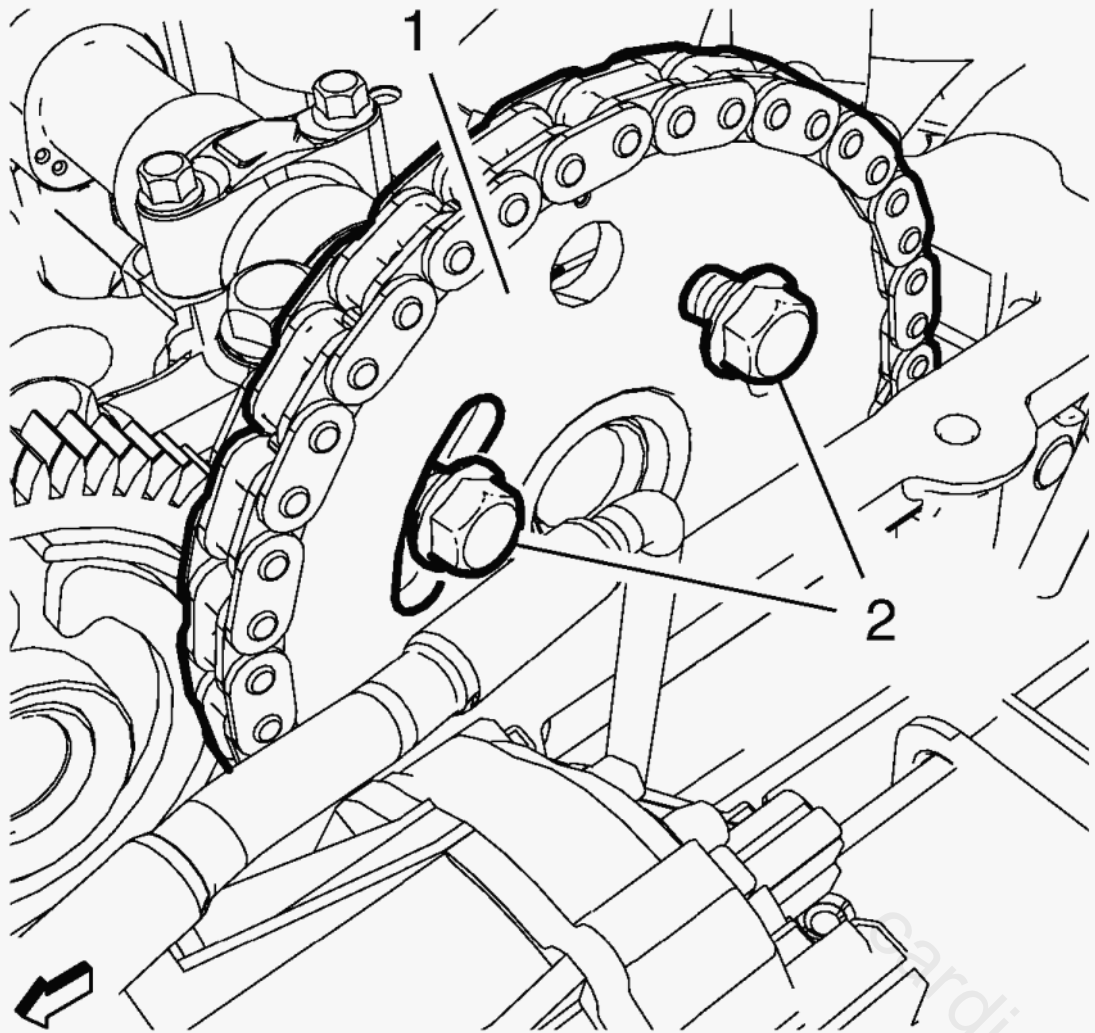


Fig. 563: Intake Camshaft Sprocket And Bolts
Courtesy of GENERAL MOTORS COMPANY

18. Loosen the 2 camshaft sprocket bolts (2) from the camshaft sprocket (1). Counterhold with a wrench at the camshaft hexagon.

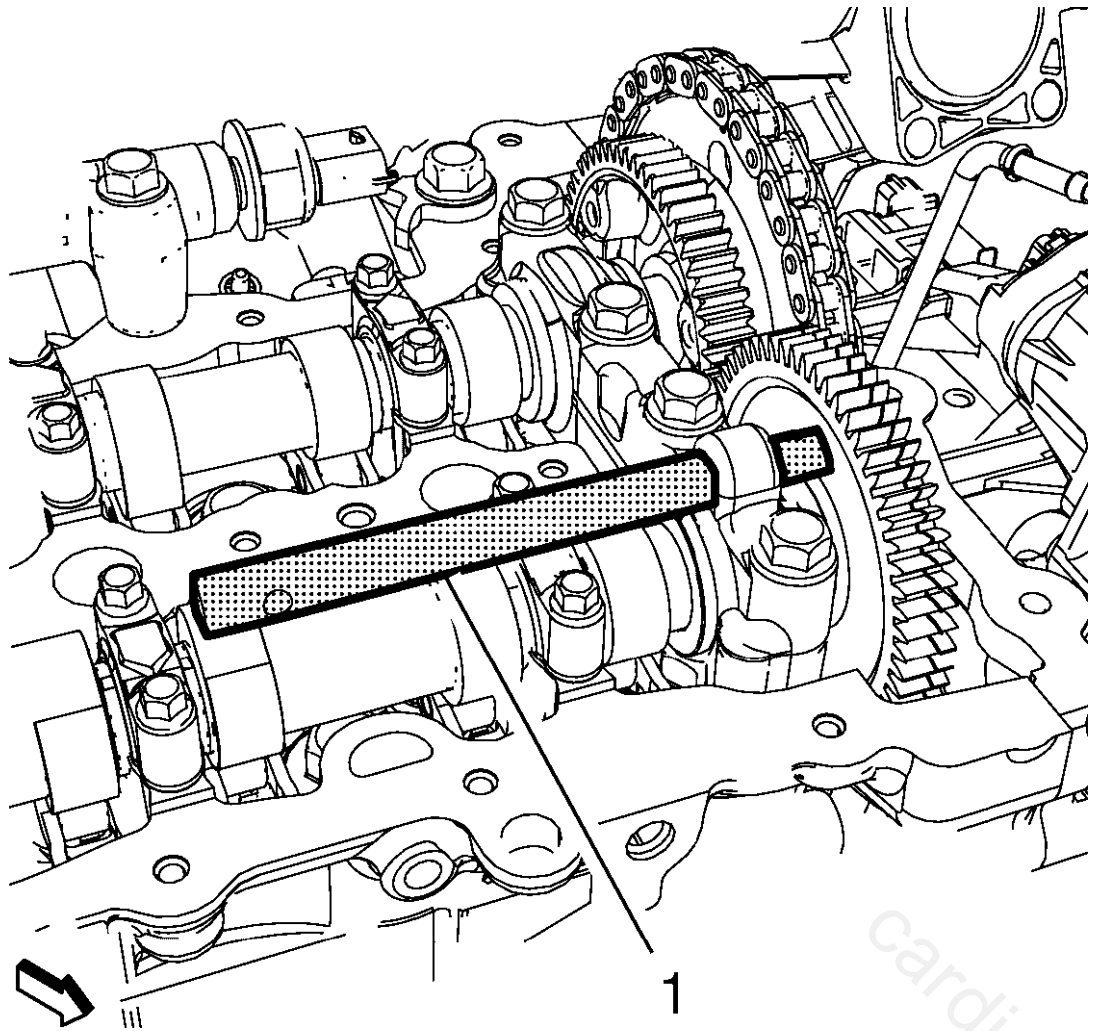


Fig. 564: Camshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

19. Turn the exhaust camshaft at the hexagon until the **EN-51143** fixing tool (1) can be installed.

Installation Procedure

NOTE: Before installation, check the components of the timing chain system for damage and wear.

1. Check the components of the timing chain system for damage and wear:
 - Timing chain guides with plastic attachment
 - Timing chain tensioner and timing chain tensioner shoe with plastic attachment
 - Timing chain and all timing chain sprockets
 - Oil pump sprocket
 - Oil pump drive chain tensioner

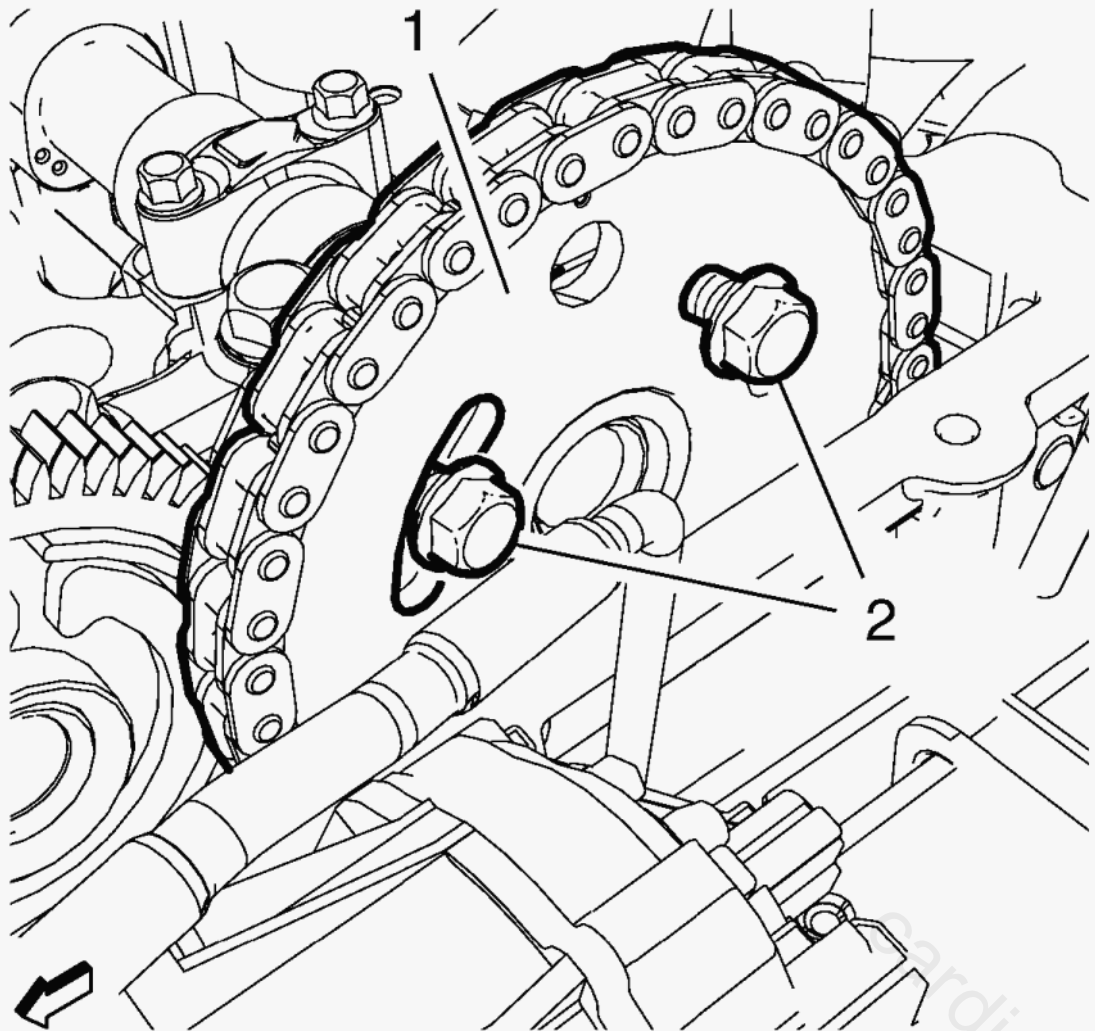


Fig. 565: Intake Camshaft Sprocket And Bolts
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution** .

2. Counterhold with a wrench at the camshaft hexagon, and tighten the 2 camshaft sprocket bolts (2) to 25 N.m (18 lb ft).

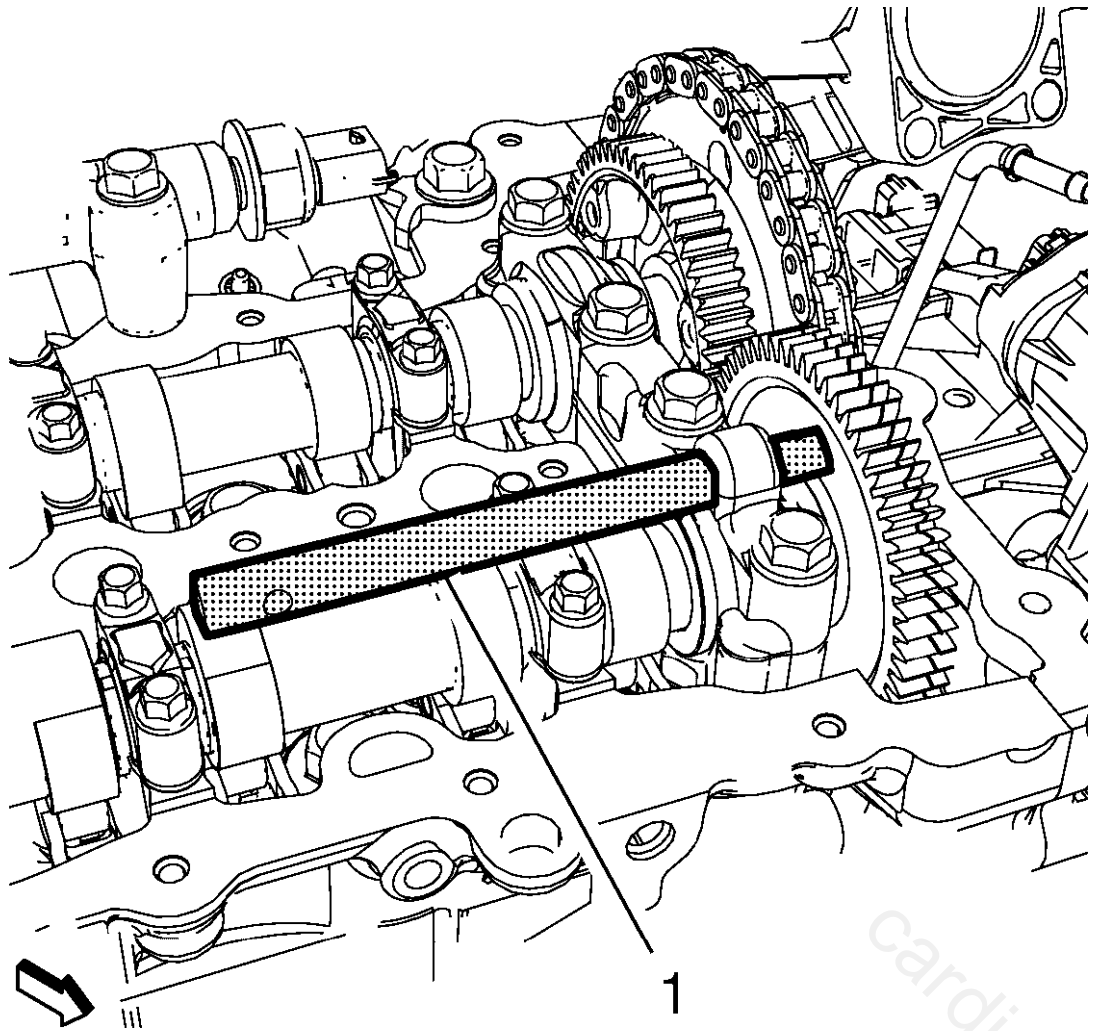


Fig. 566: Camshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

3. Remove the **EN-51143** fixing tool (1).
4. Raise the vehicle.

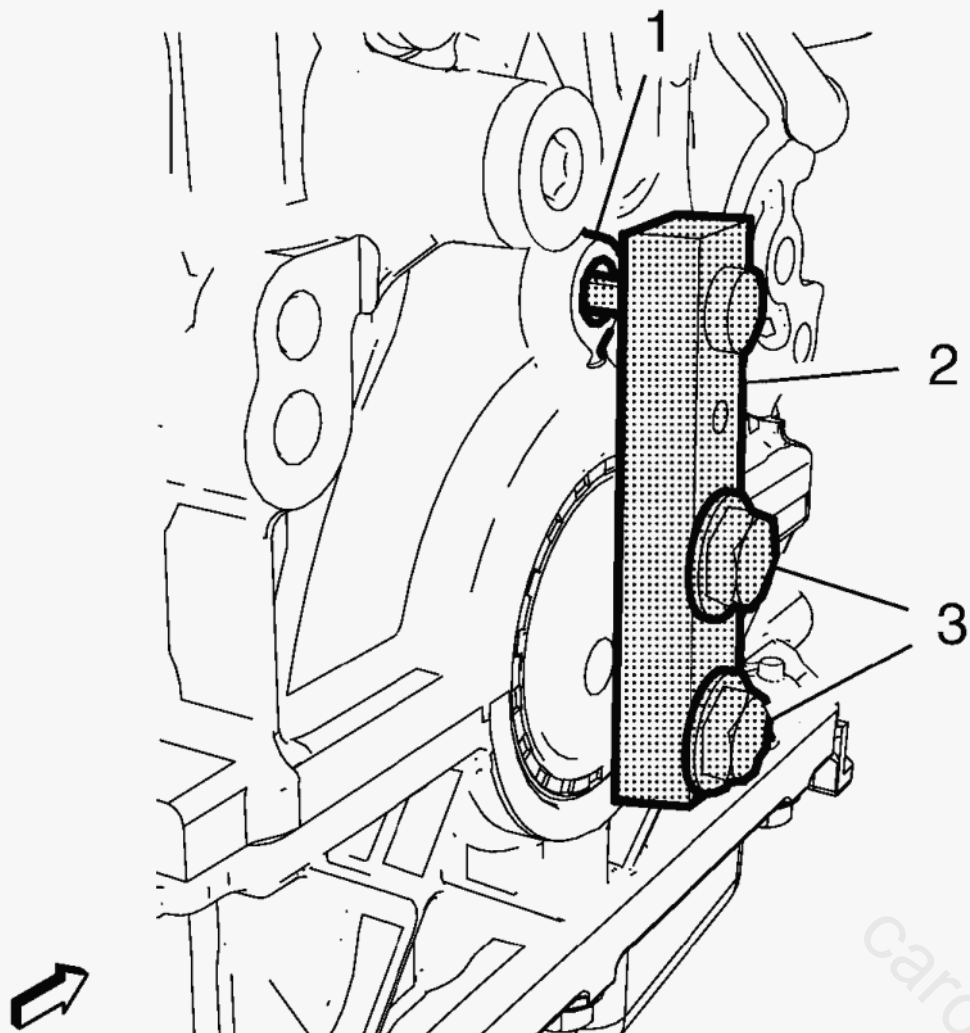


Fig. 567: Crankshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

5. Remove the 2 bolts (3).
6. Remove the **EN-51140** fixing tool (2).

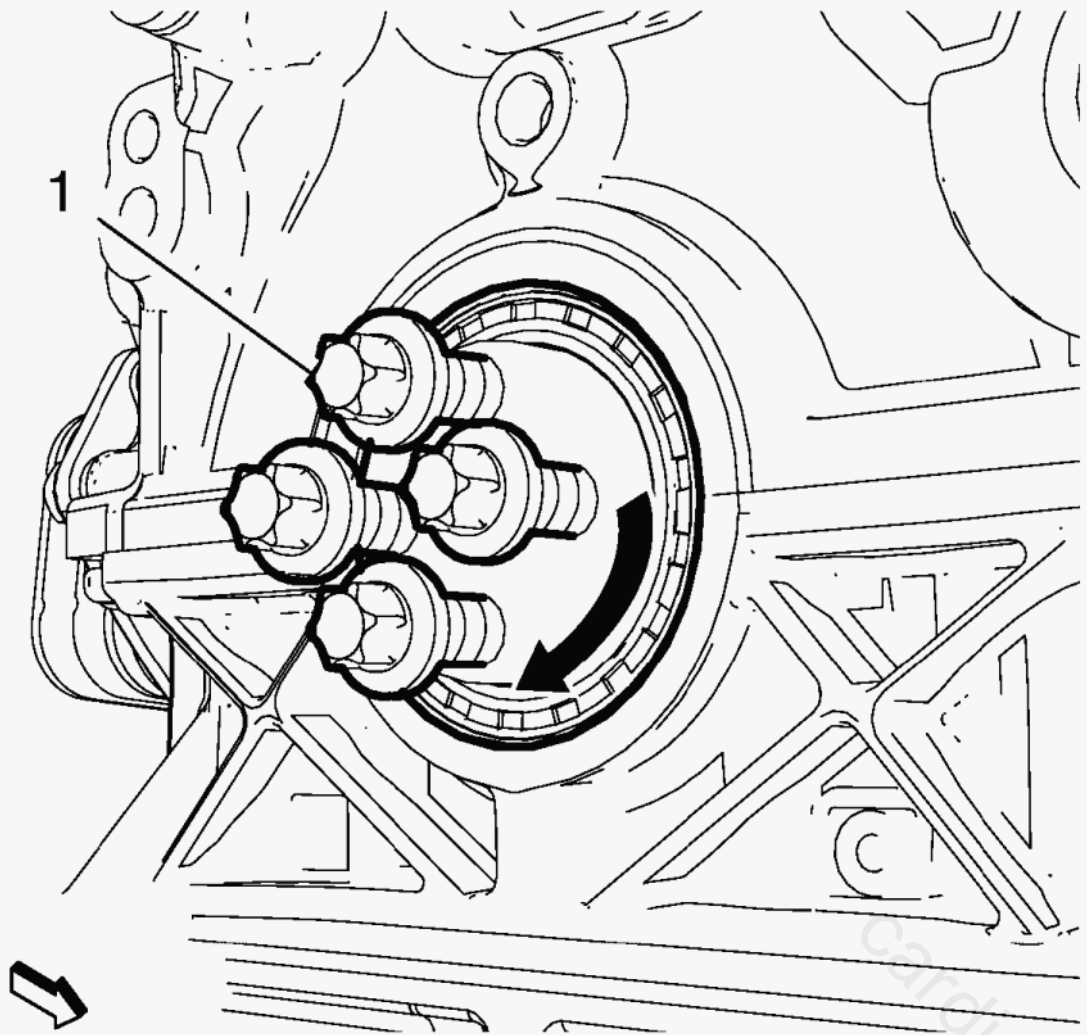


Fig. 568: Crankshaft Pulley Bolts

Courtesy of GENERAL MOTORS COMPANY

7. Install the 4 crankshaft pulley bolts (1) and rotate the crankshaft 360 degrees in direction of arrow. Use a pry bar at the 4 crankshaft pulley bolts (1).
8. Lower the vehicle.

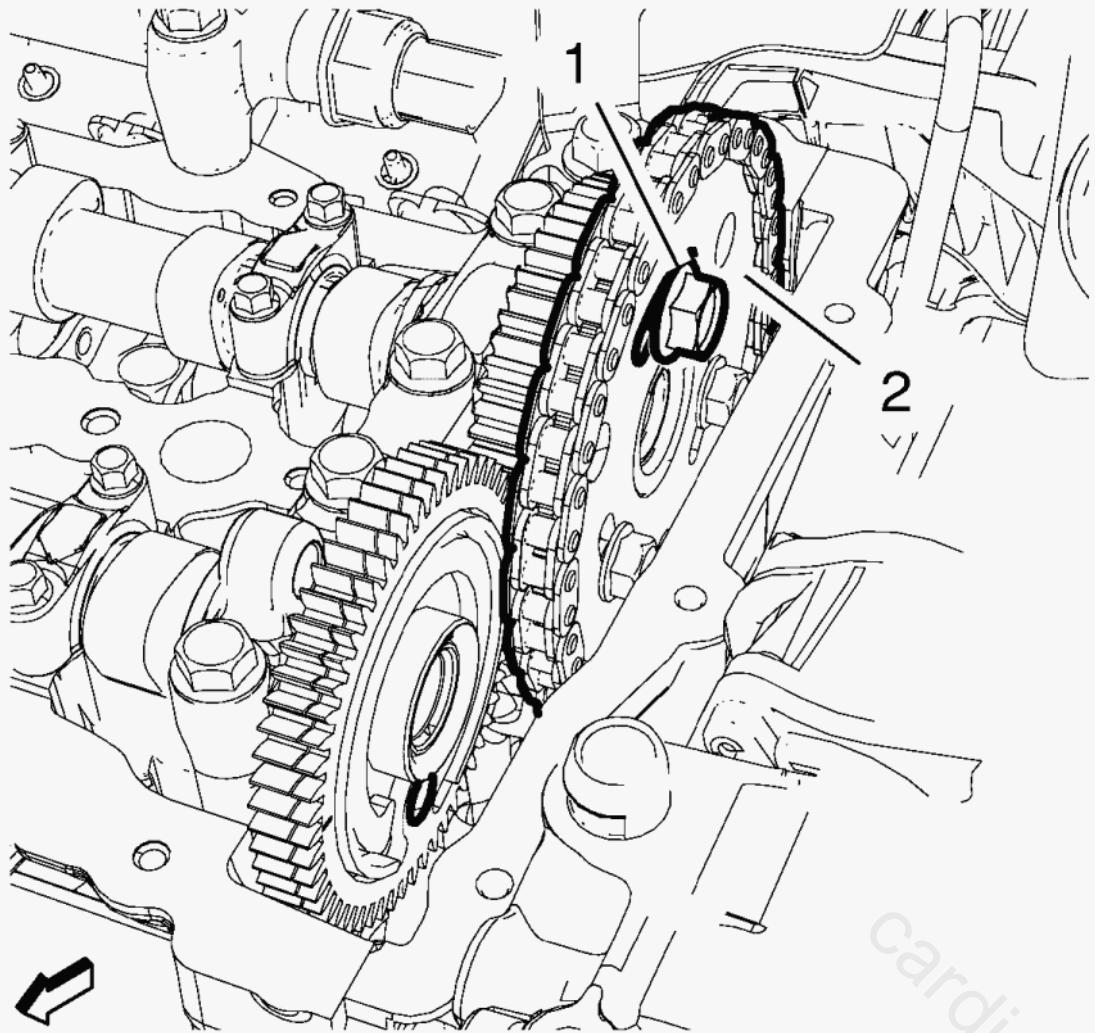


Fig. 569: Intake Camshaft Sprocket And Bolt
Courtesy of GENERAL MOTORS COMPANY

9. Counterhold with a wrench at the camshaft hexagon, and tighten the camshaft sprocket bolt (1) to 25 N.m (18 lb ft).

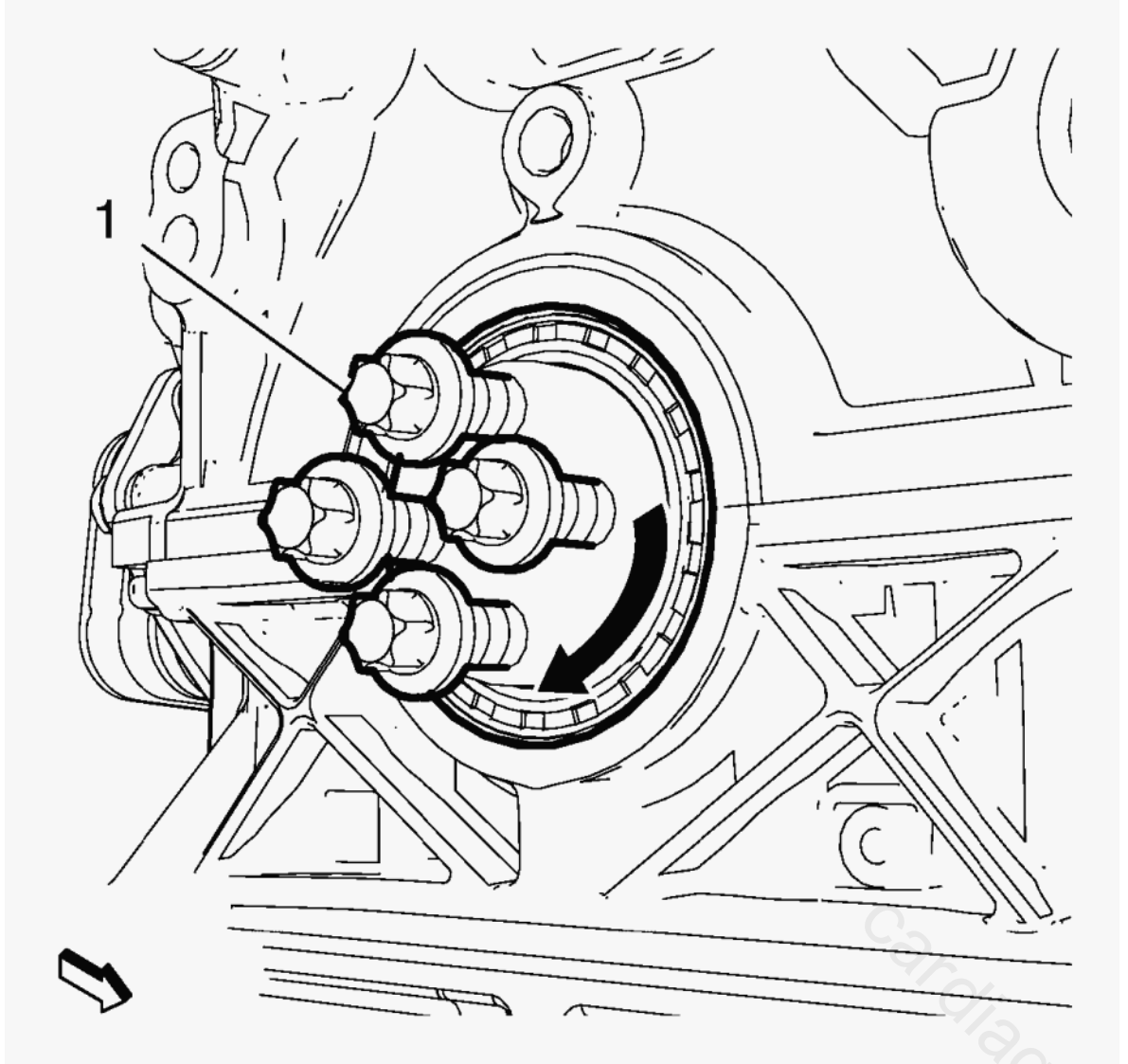


Fig. 570: Crankshaft Pulley Bolts

Courtesy of GENERAL MOTORS COMPANY

10. Rotate the crankshaft 360 degrees in direction of arrow. Use a pry bar at the 4 crankshaft pulley bolts (1).
11. Remove the 4 crankshaft pulley bolts (1).

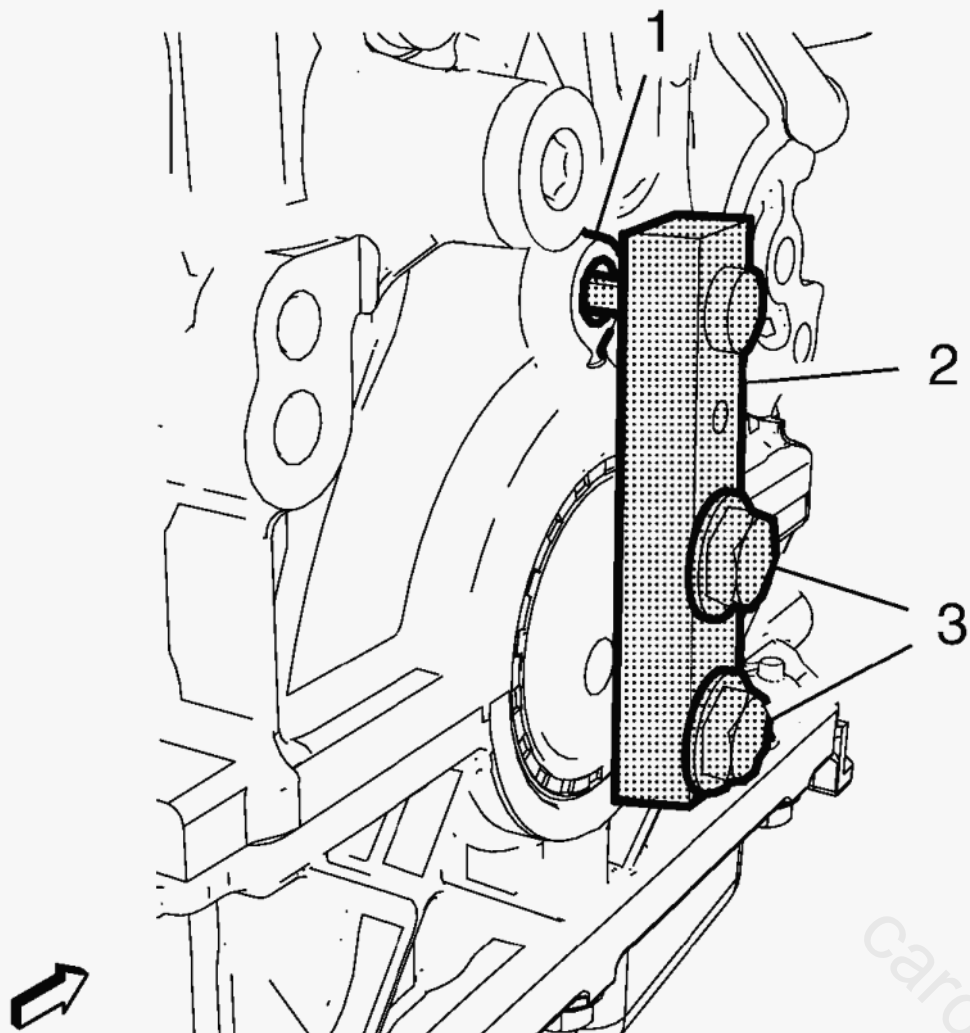


Fig. 571: Crankshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

12. Install **EN-51140** fixing tool (2).
13. Install the fixing pin into the engine block bore (1) and tighten the 2 bolts (3).
14. Lower the vehicle.

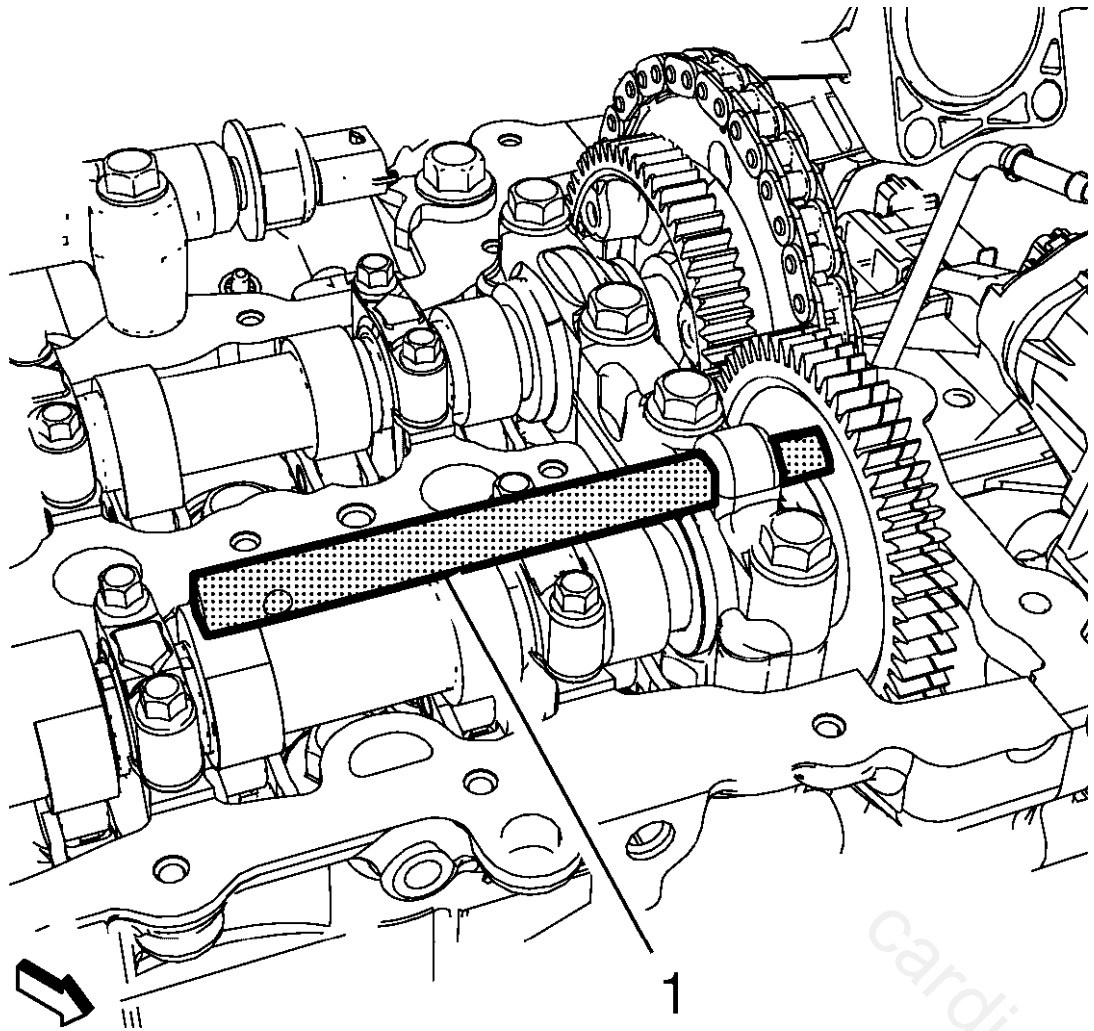


Fig. 572: Camshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

15. Install the **EN-51143** fixing tool (1).
16. Remove the **EN-51143** fixing tool (1).
17. Raise the vehicle.

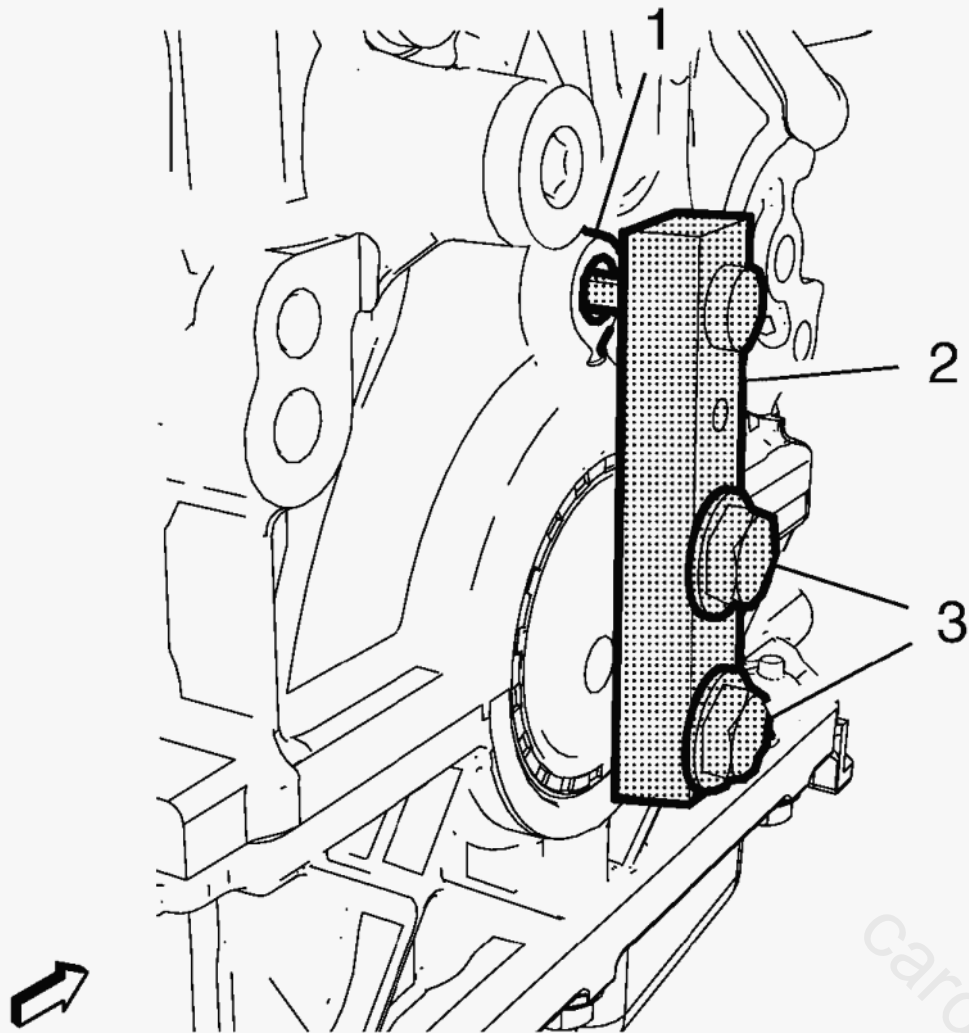


Fig. 573: Crankshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

18. Remove the 2 bolts (3).
19. Remove the **EN-51140** fixing tool (2).
20. Install Crankshaft Pulley. Refer to [Crankshaft Pulley Replacement](#)
21. Install Camshaft Housing. Refer to [Camshaft Housing Replacement](#)
22. Install Throttle Body Assembly. Refer to [Throttle Body Assembly Replacement](#)
23. Connect the battery negative cable. Refer to [Battery Negative Cable Disconnection and Connection \(KL9\)](#)

CAMSHAFT TIMING CHAIN INSPECTION

Special Tools

- **EN-51140** Crankshaft Fixing Tool
- **EN-51143** Camshaft Sprocket Fixing Tool

Equivalent regional tools: [Special Tools](#)

Removal Procedure

1. Disconnect the battery negative cable. Refer to [Battery Negative Cable Disconnection and Connection \(KL9\)](#)
2. Remove Camshaft Housing. Refer to [Camshaft Housing Replacement](#)
3. Remove Crankshaft Pulley. Refer to [Crankshaft Pulley Replacement](#)
4. Lower the vehicle. Refer to [Lifting and Jacking the Vehicle](#) .

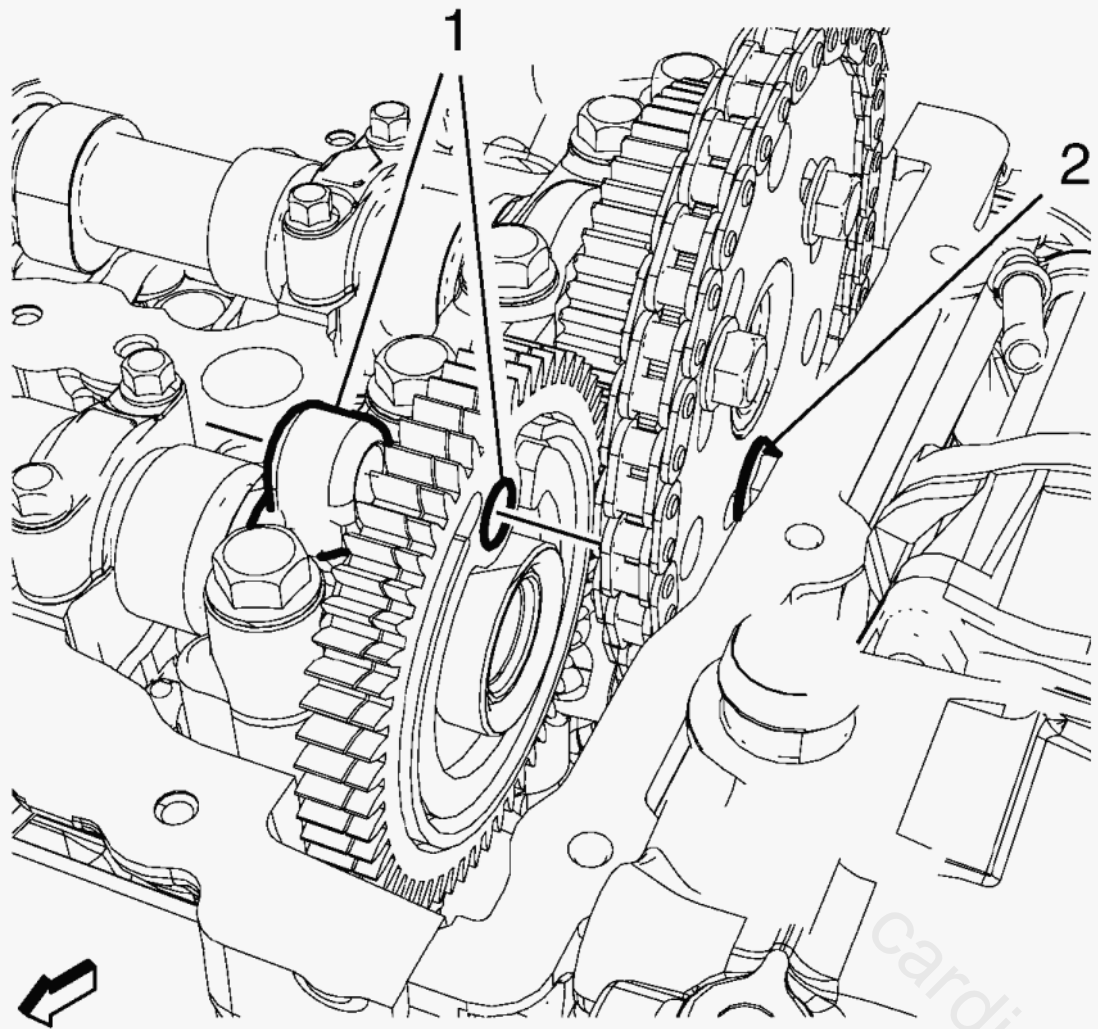


Fig. 574: Aligning Bores

Courtesy of GENERAL MOTORS COMPANY

NOTE: Check the TDC position of cylinder 1.

5. Check if the bores (1) are aligned.
6. Rotate the crankshaft, if the bores (1) are not aligned.

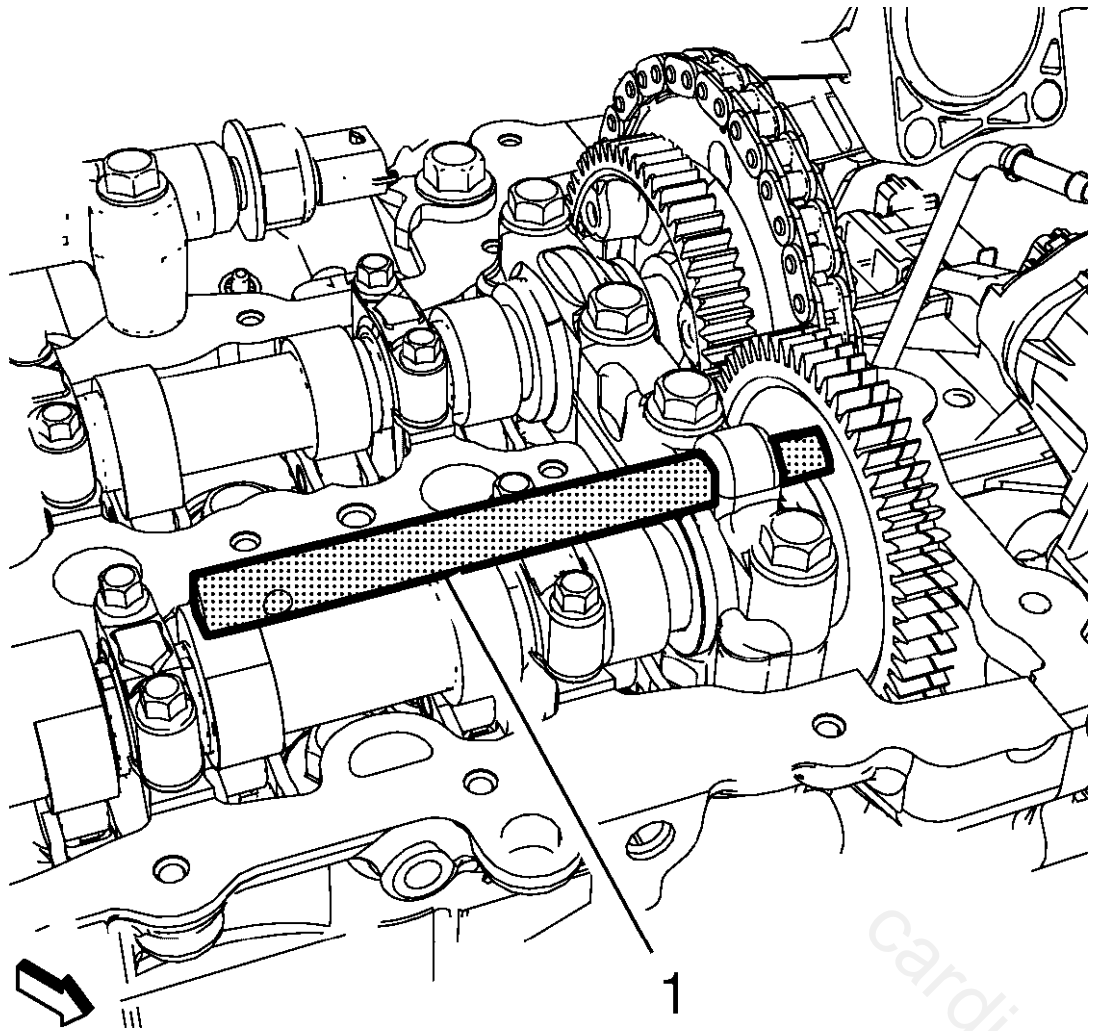


Fig. 575: Camshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

NOTE: Turn the exhaust camshaft at the hexagon until the EN-51143 fixing tool can be installed.

7. Install the EN-51143 fixing tool (1).
8. Raise the vehicle.

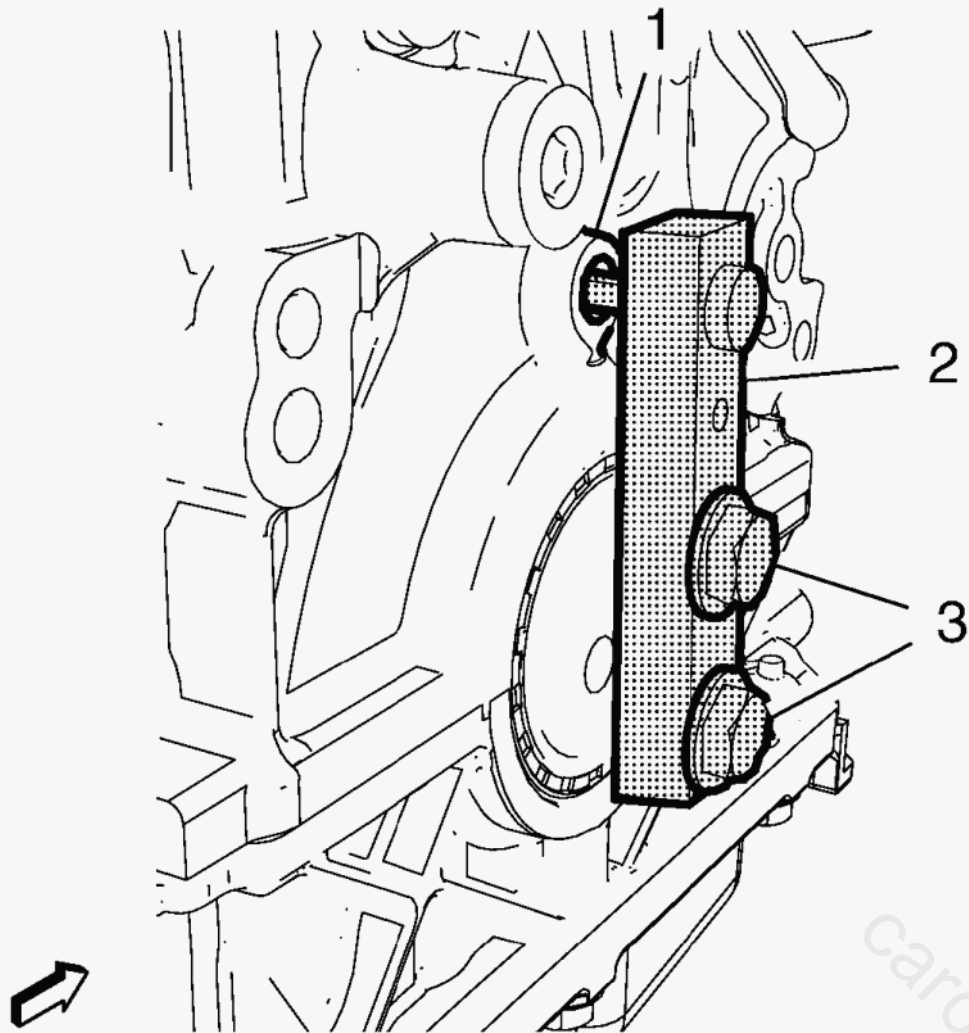


Fig. 576: Crankshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

9. Install EN-51140 fixing tool (2).
10. Install the fixing pin into the engine block bore (1) and tighten the 2 bolts (3).
11. If the fixing pin does not fit into the engine block bore, the camshaft timing must be adjusted. Refer to [Camshaft Timing Chain Adjustment](#).

Installation Procedure

NOTE: Before installation, check the components of the timing chain system for damage and wear.

1. Check the components of the timing chain system for damage and wear:
 - Timing chain guides with plastic attachment
 - Timing chain tensioner and timing chain tensioner shoe with plastic attachment
 - Timing chain and all timing chain sprockets
 - Oil pump sprocket
 - Oil pump drive chain tensioner

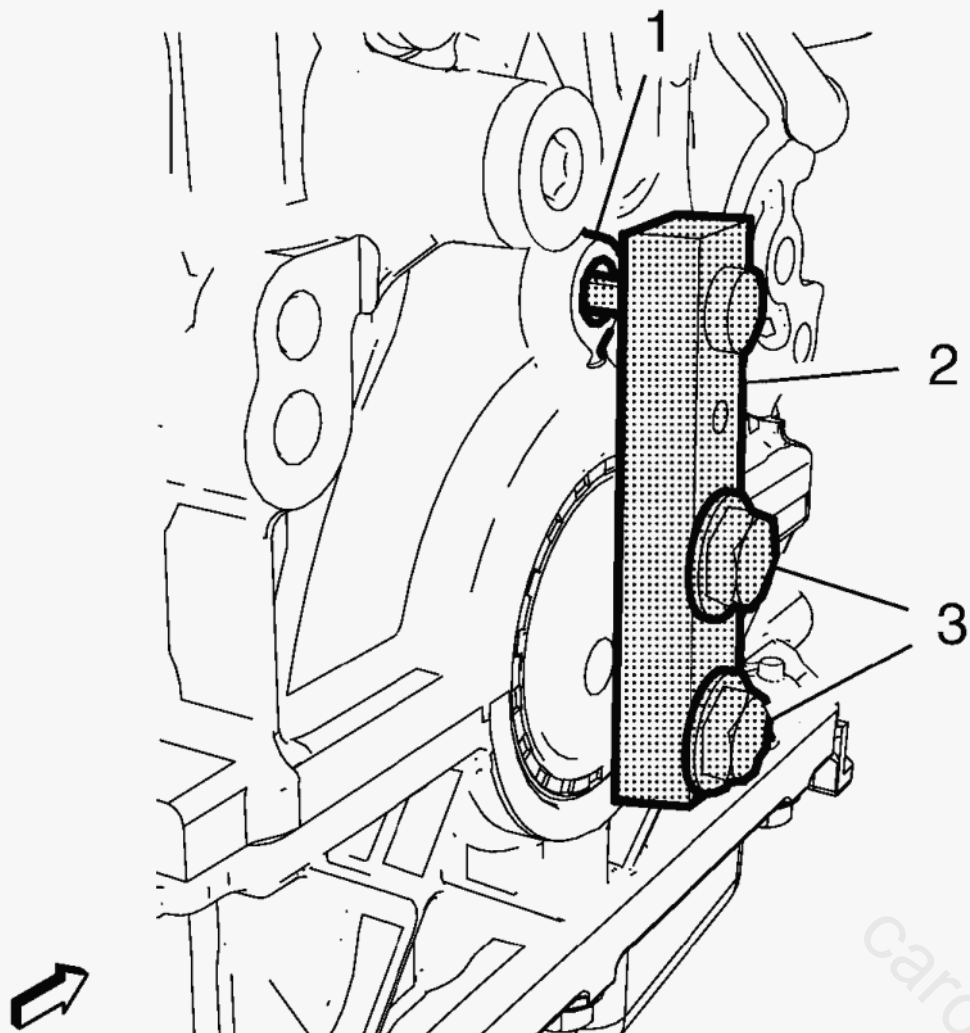


Fig. 577: Crankshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

2. Remove the 2 bolts (3).
3. Remove the **EN-51140** fixing tool (2).
4. Lower the vehicle.

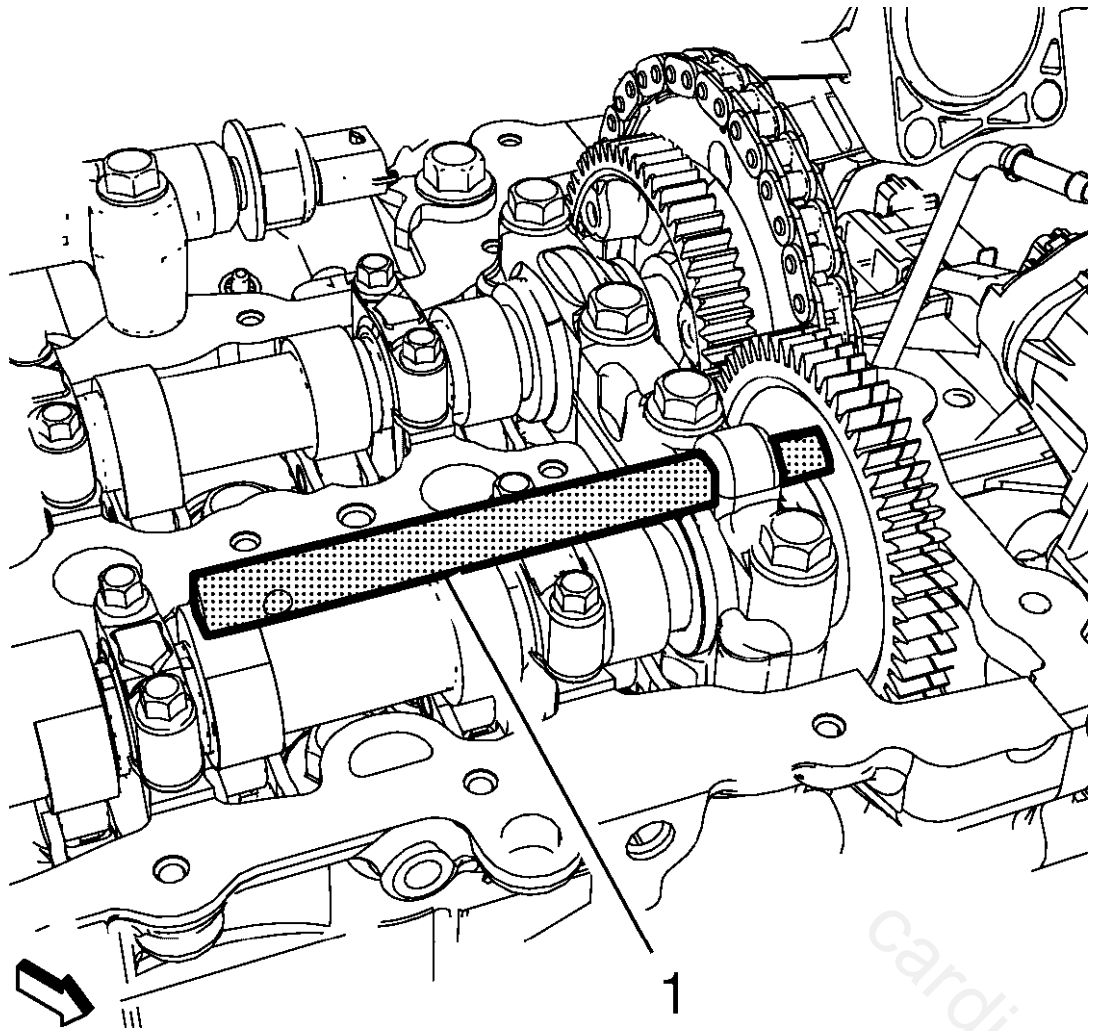


Fig. 578: Camshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

5. Remove the **EN-51143** fixing tool (1).
6. Raise the vehicle.
7. Install Crankshaft Pulley. Refer to [Crankshaft Pulley Replacement](#)
8. Install Camshaft Housing. Refer to [Camshaft Housing Replacement](#)
9. Connect the battery negative cable. Refer to [Battery Negative Cable Disconnection and Connection \(KL9\)](#).

REPAIR INSTRUCTIONS - OFF VEHICLE

ENGINE MOUNT BRACKET REMOVAL

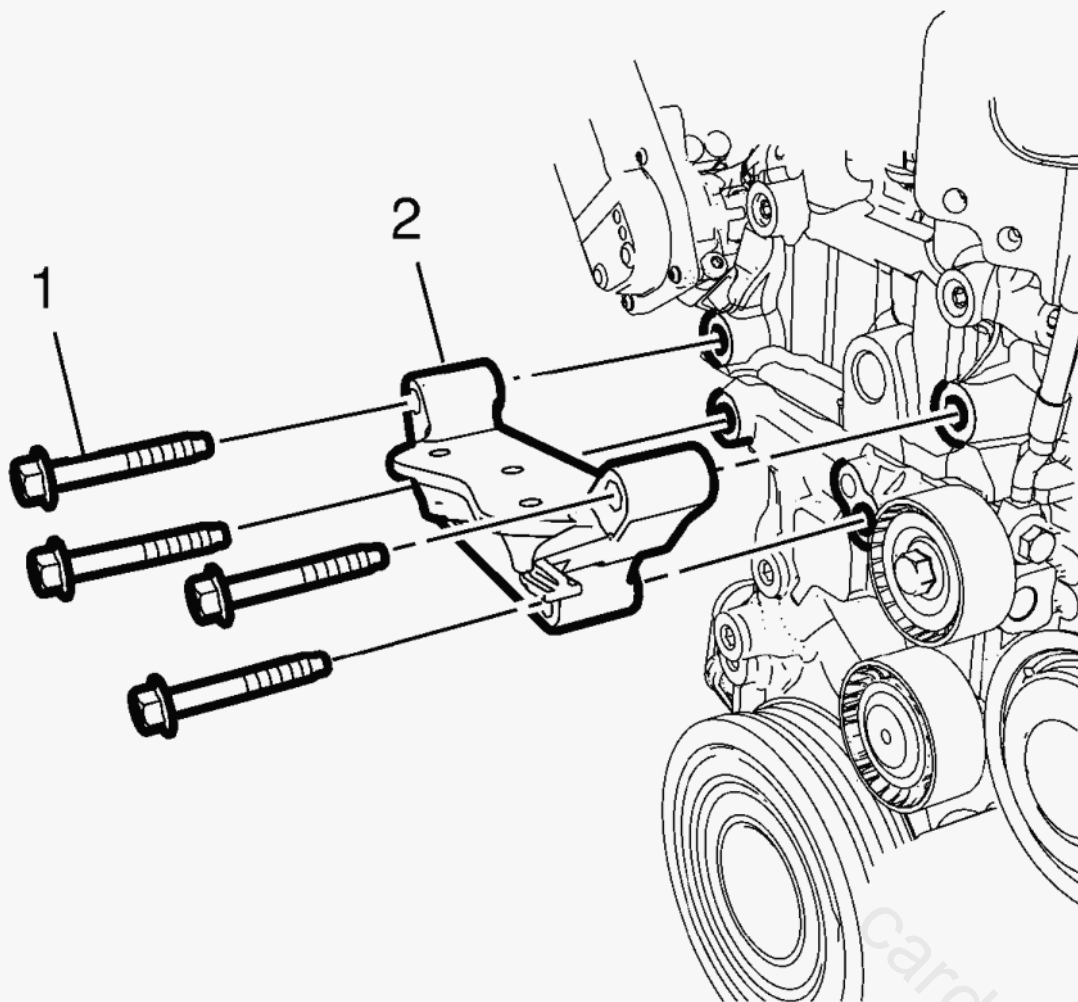


Fig. 579: Engine Mount Bracket And Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Remove the 4 engine mount bracket bolts (1).
2. Remove the engine mount bracket (2).

BELT IDLER PULLEY REMOVAL

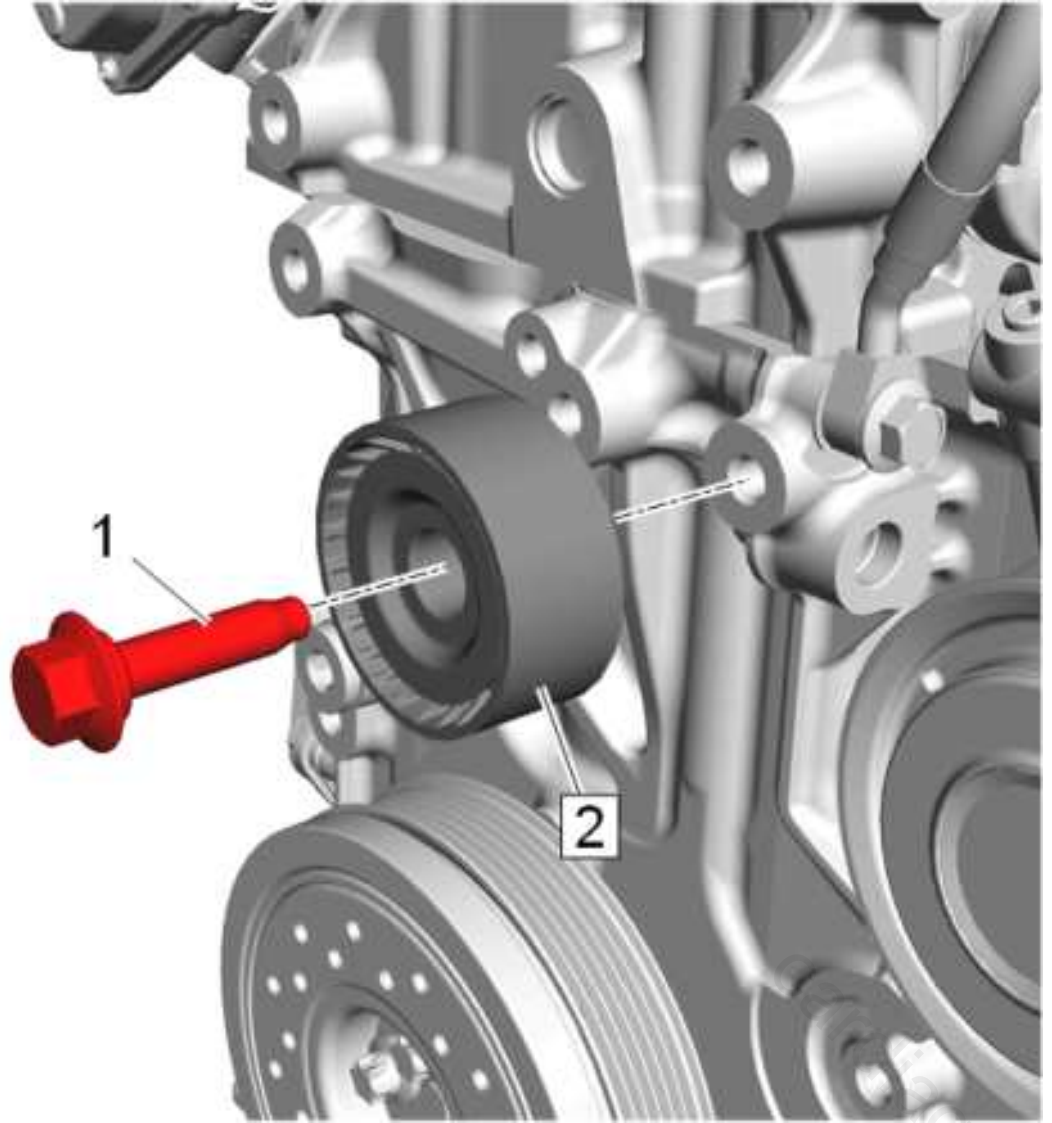


Fig. 580: Drive Belt Idler Pulley And Bolt
Courtesy of GENERAL MOTORS COMPANY

1. Remove the drive belt idler pulley bolt (1).
2. Remove the drive belt idler pulley (2).

DRIVE BELT TENSIONER REMOVAL

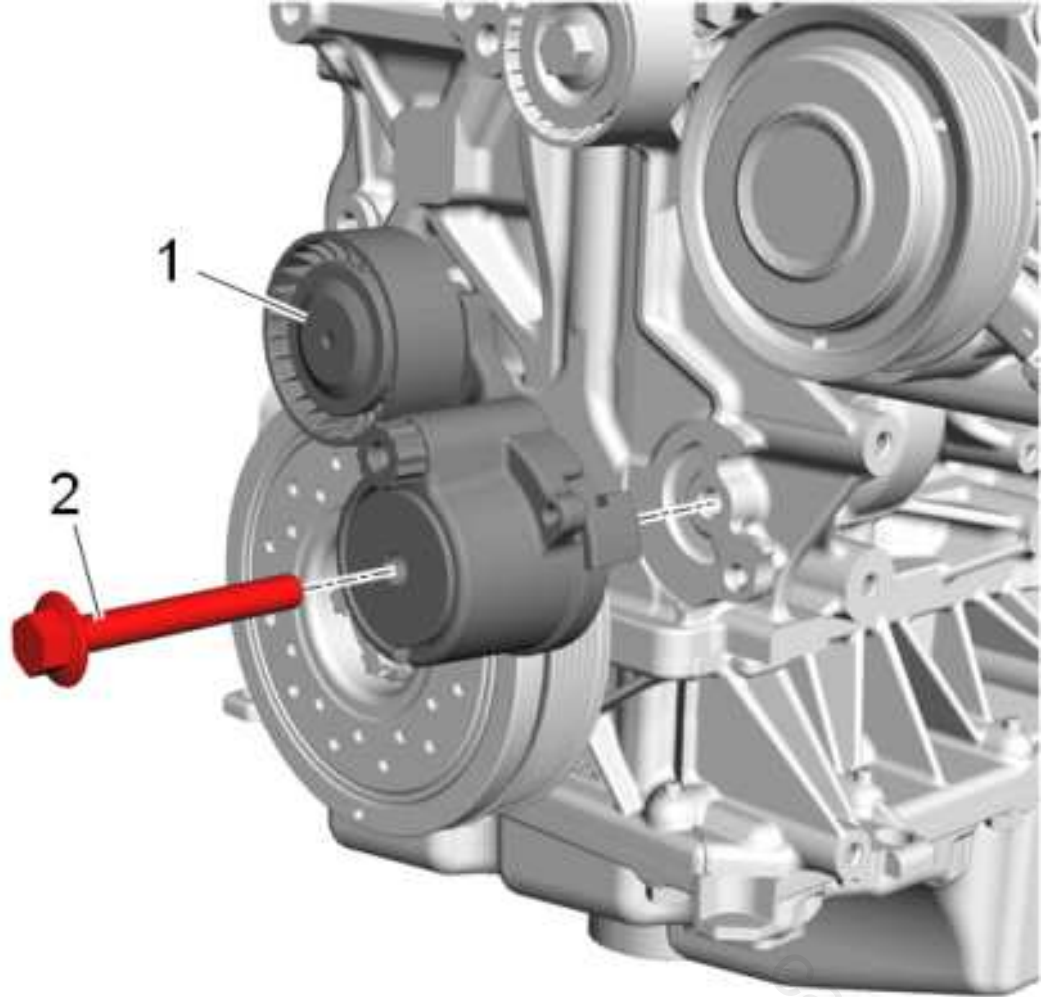


Fig. 581: Drive Belt Tensioner And Bolt
Courtesy of GENERAL MOTORS COMPANY

1. Remove the drive belt tensioner bolt (2).
2. Remove the drive belt tensioner (1).

CRANKSHAFT PULLEY REMOVAL

Special Tools

- **EN-956-1** Extension
- **EN-49979** Crankshaft Holder
- **EN-49979-100** Crankshaft Holder Pins

For equivalent regional tools, refer to [**Special Tools**](#).

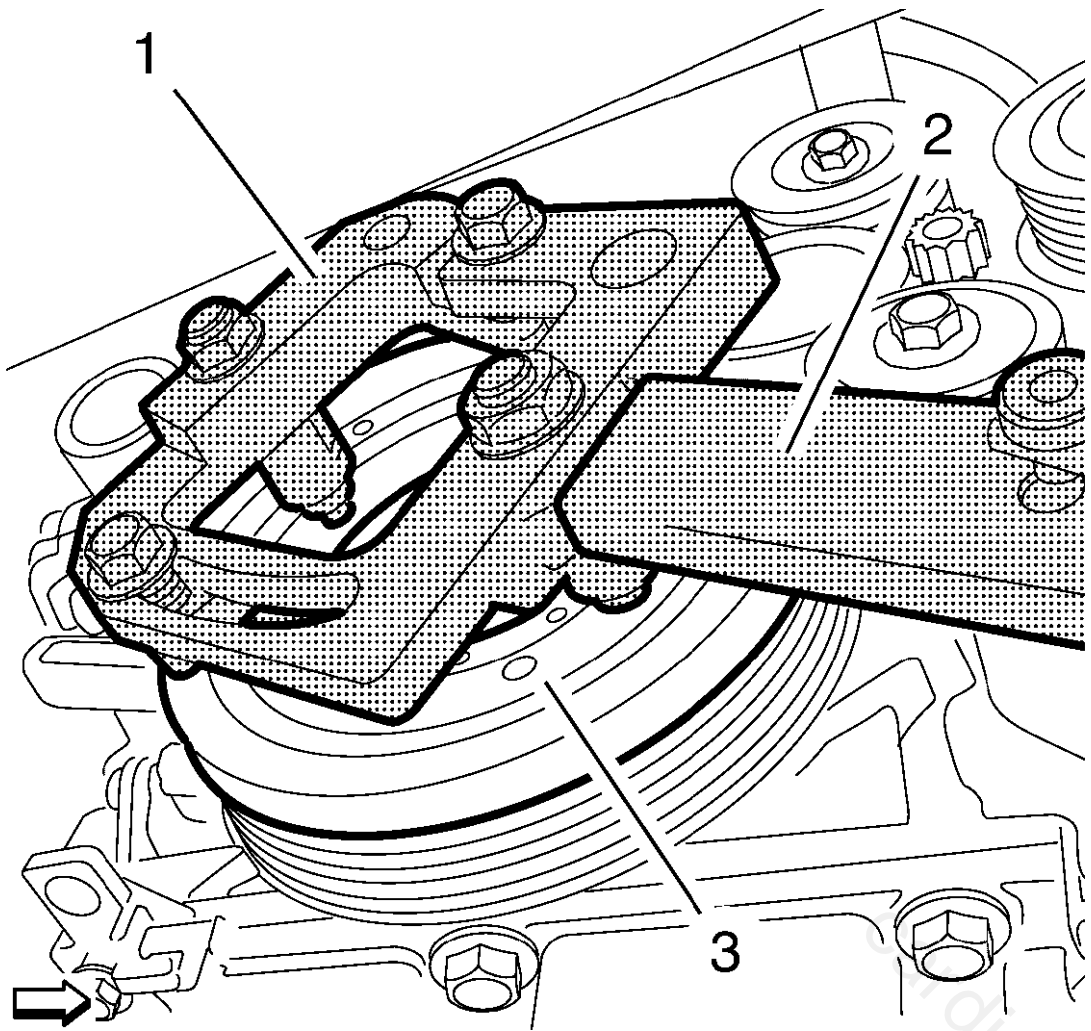


Fig. 582: Crankshaft Holder, Pins, Extension And Crankshaft Pulley.
Courtesy of GENERAL MOTORS COMPANY

1. Install the EN-49979 holder (1) in compound with the EN-49979-100 pins and the EN-956-1 extension (2) to counterhold the crankshaft pulley (3).

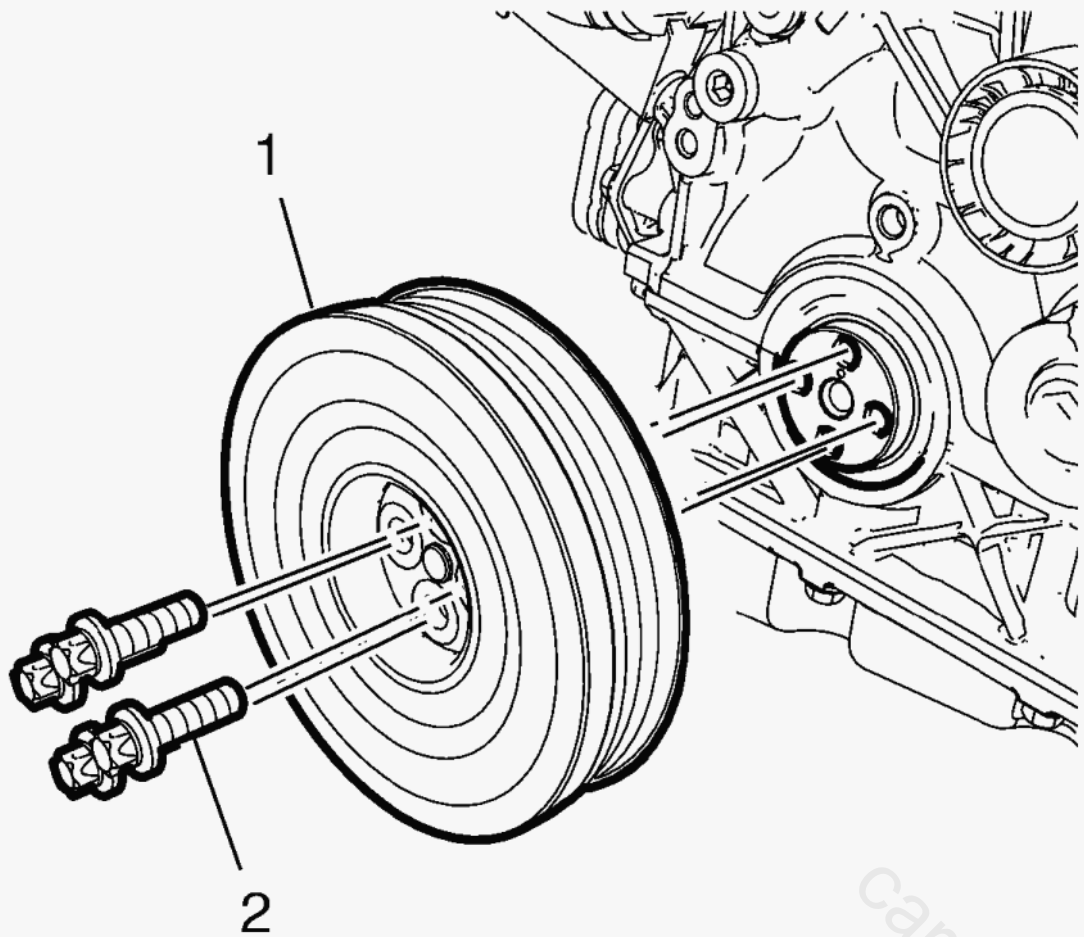


Fig. 583: Crankshaft Pulley And Bolts

Courtesy of GENERAL MOTORS COMPANY

2. Remove and DISCARD the 4 crankshaft pulley bolts (2).
3. Remove the crankshaft pulley (1).

TURBOCHARGER HEAT SHIELD REMOVAL

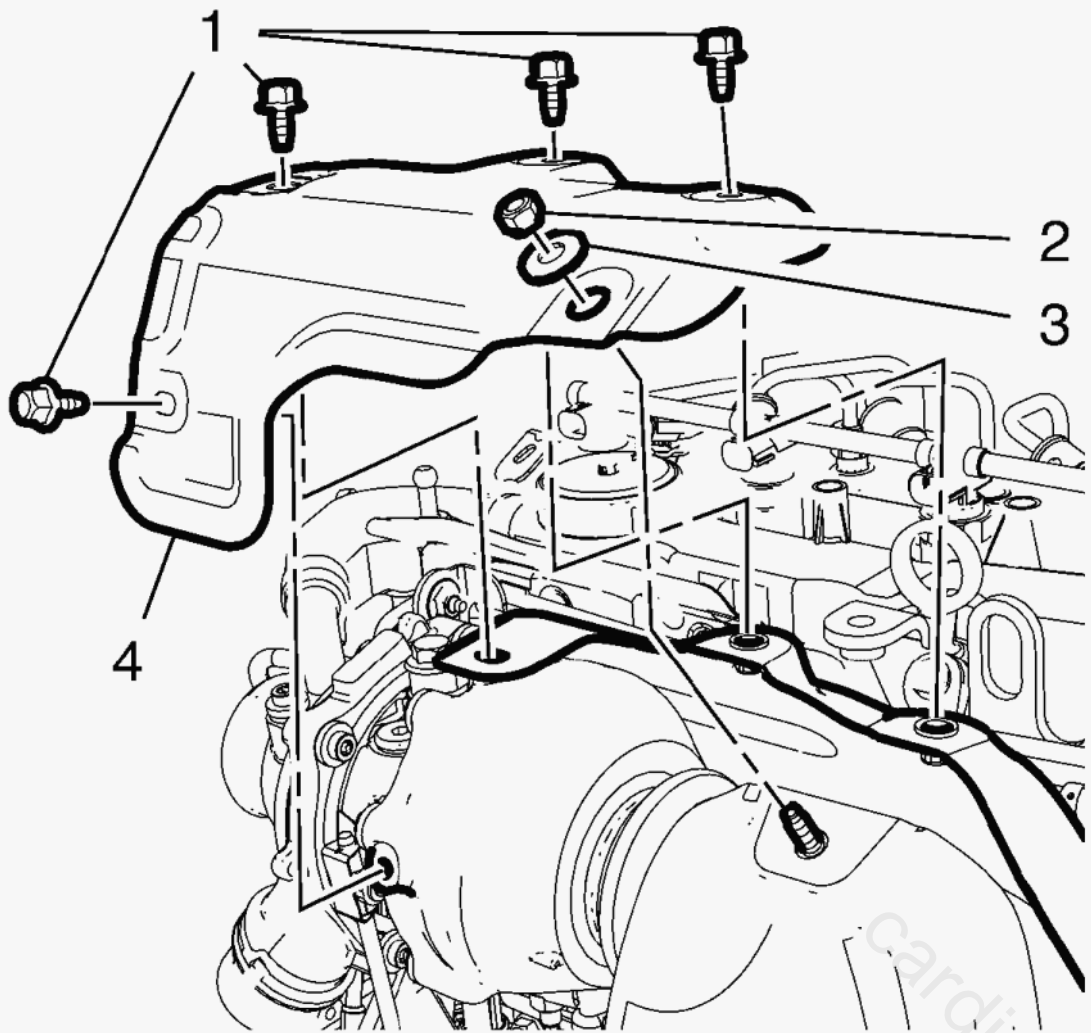


Fig. 584: Turbocharger Heat Shield, Bolts, Nut And Washer
Courtesy of GENERAL MOTORS COMPANY

1. Remove the 4 turbocharger heat shield bolts (1).
2. Remove the turbocharger heat shield nut (2).
3. Remove the turbocharger heat shield washer (3).
4. Remove the turbocharger heat shield (4).

CATALYTIC CONVERTER HEAT SHIELD REMOVAL

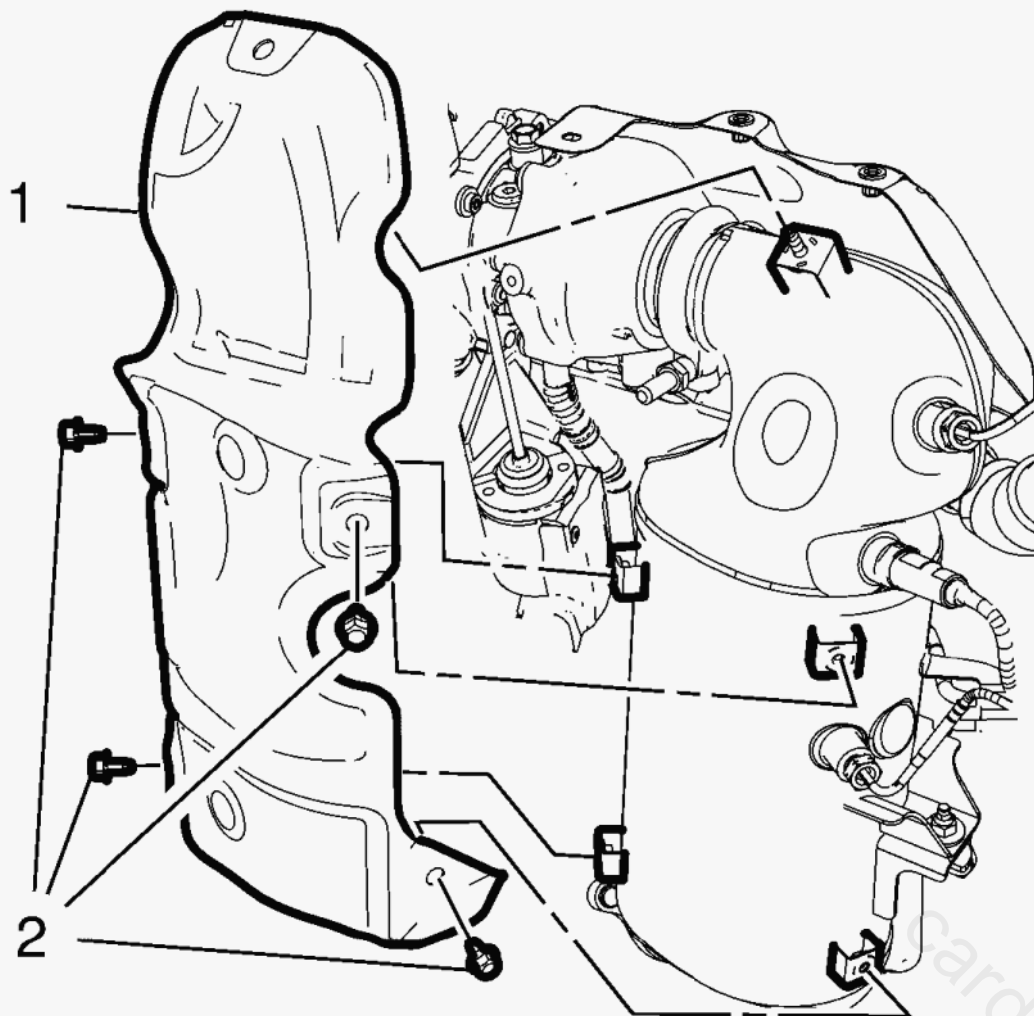


Fig. 585: Catalytic Converter Heat Shield And Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Remove the 4 catalytic converter heat shield bolts (2).
2. Remove the catalytic converter heat shield (1).

EXHAUST TEMPERATURE SENSOR REMOVAL - POSITION 1

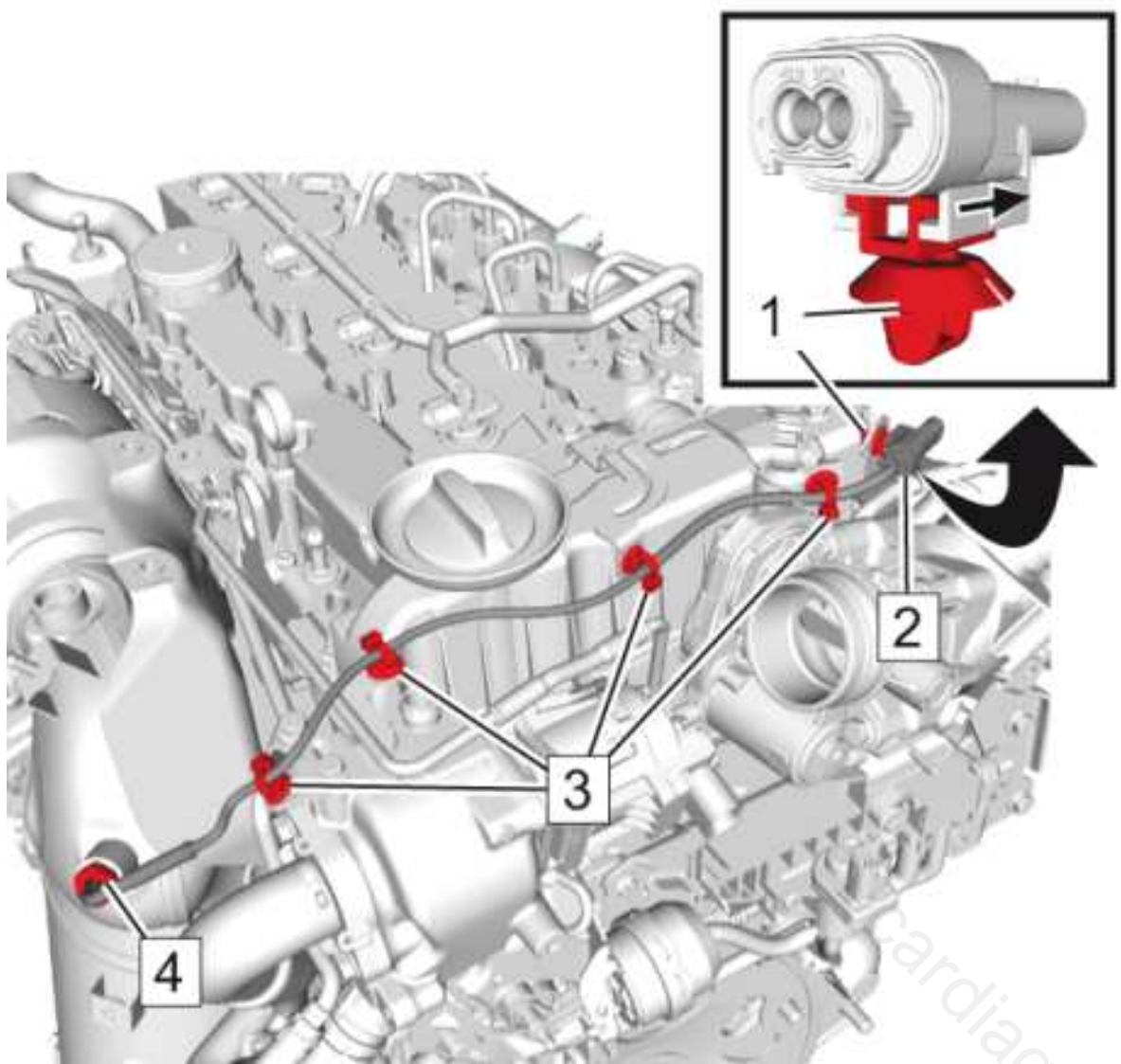


Fig. 586: Exhaust Temperature Sensor - Position 1, Electrical Connector And Retainers
 Courtesy of GENERAL MOTORS COMPANY

1. Unclip Electrical Connector (2) @ Retainer (1)
2. Remove Wiring Harness Retainers (3) (Qty: 4)
3. Remove Exhaust Temperature Sensor - Position 1 (4)

EXHAUST TEMPERATURE SENSOR REMOVAL - POSITION 2

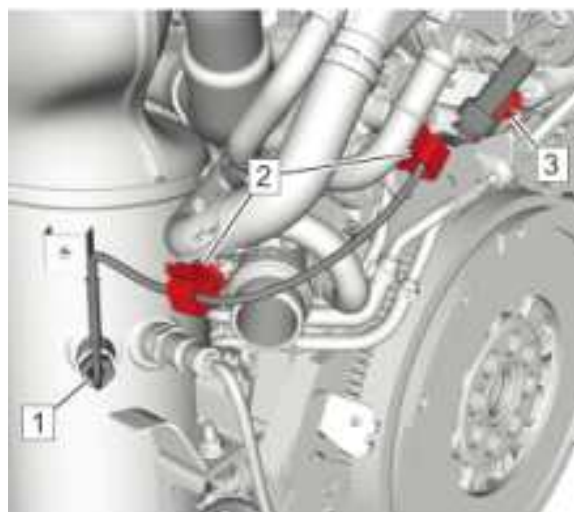


Fig. 587: Exhaust Temperature Sensor - Position 2 And Retainers
 Courtesy of GENERAL MOTORS COMPANY

1. Unclip Retainers (2, 3) (Qty: 3)
2. Remove the exhaust temperature sensor - position 2 (1) from the catalytic converter.

EXHAUST PRESSURE DIFFERENTIAL SENSOR PIPE REMOVAL

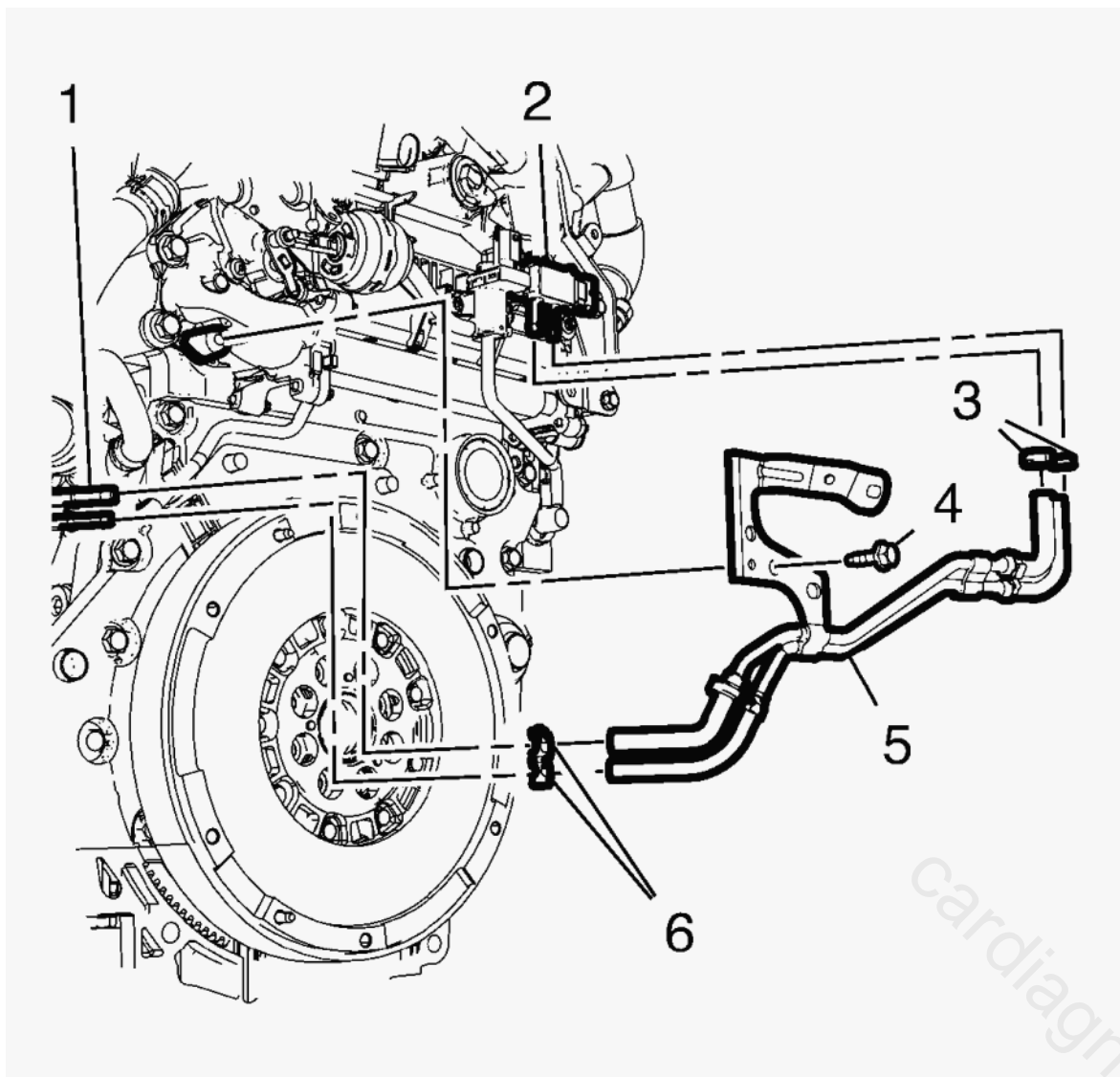
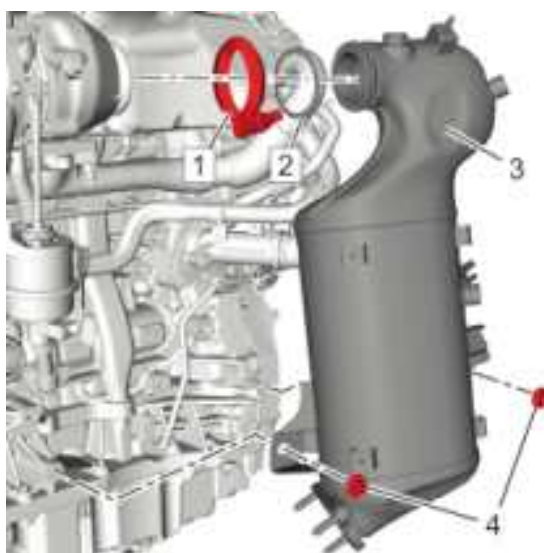


Fig. 588: Exhaust Pressure Differential Sensor Pipe And Components
Courtesy of GENERAL MOTORS COMPANY

1. Remove and DISCARD the 2 clamps (3).
2. Disconnect the 2 hoses from the exhaust pressure differential sensor (2).
3. Remove and DISCARD the 2 clamps (6).
4. Disconnect the 2 hoses from the catalytic converter connection pipes (1).
5. Remove the exhaust pressure differential sensor pipe bracket bolt (4).
6. Remove the exhaust pressure differential sensor pipe (5).

CATALYTIC CONVERTER REMOVAL



1. Remove Catalytic Converter Clamp (1)
2. Remove Catalytic Converter Bracket Nuts (4) (Qty: 2)
3. Remove Catalytic Converter (3)
4. Remove and DISCARD Gasket (2)

TURBOCHARGER WASTEGATE ACTUATOR PIPE REMOVAL

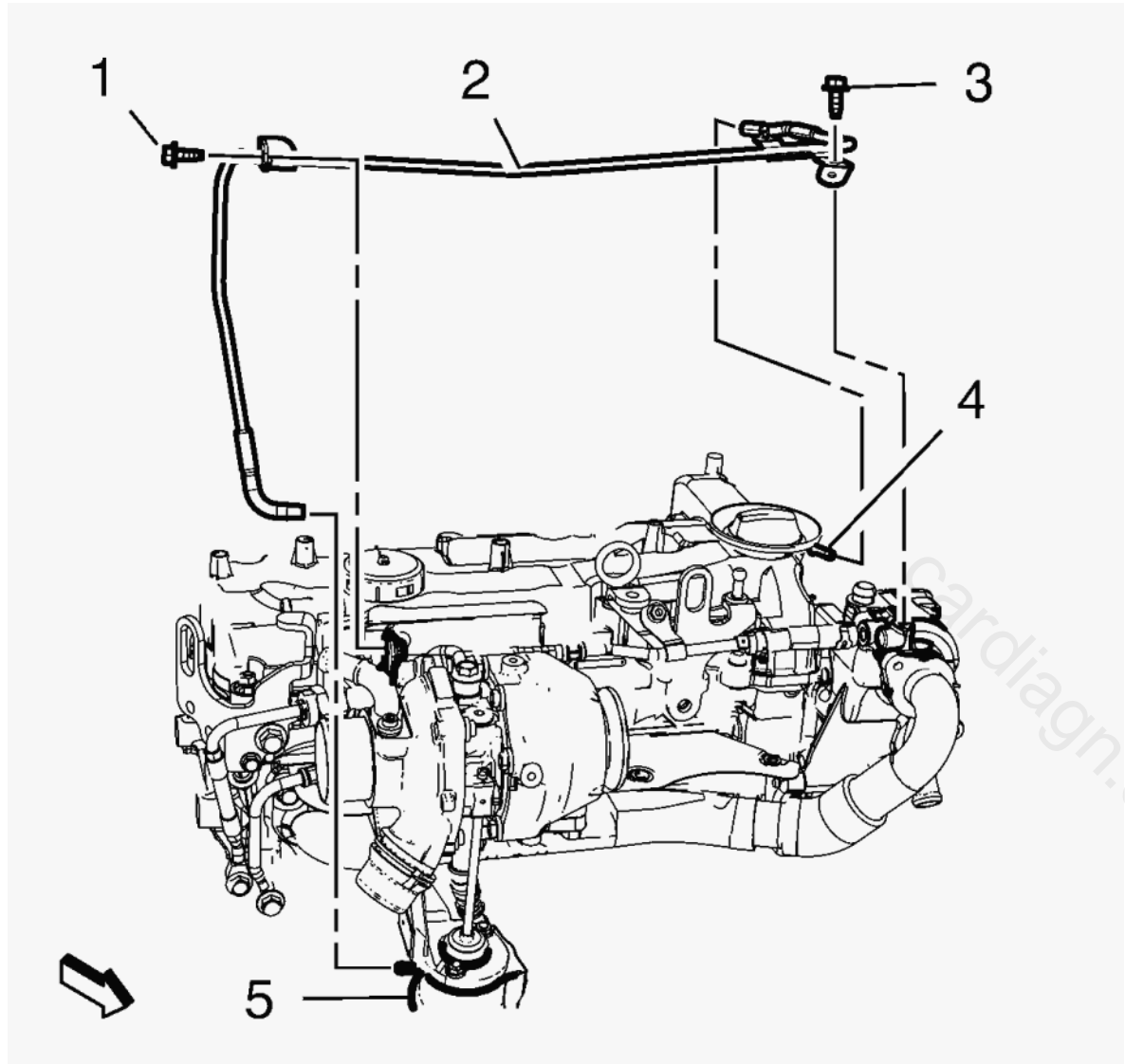


Fig. 590: Turbocharger Wastegate Actuator Pipe And Components
Courtesy of GENERAL MOTORS COMPANY

1. Remove the turbocharger wastegate actuator pipe bracket bolt (1).
2. Remove the turbocharger wastegate actuator pipe bracket bolt (3).
3. Disconnect the turbocharger wastegate actuator pipe (2) from the turbocharger wastegate actuator (5).
4. Disconnect the turbocharger wastegate actuator pipe (2) from the power brake booster vacuum pipe (4).
5. Remove the turbocharger wastegate actuator pipe (2).

TURBOCHARGER OIL FEED PIPE REMOVAL

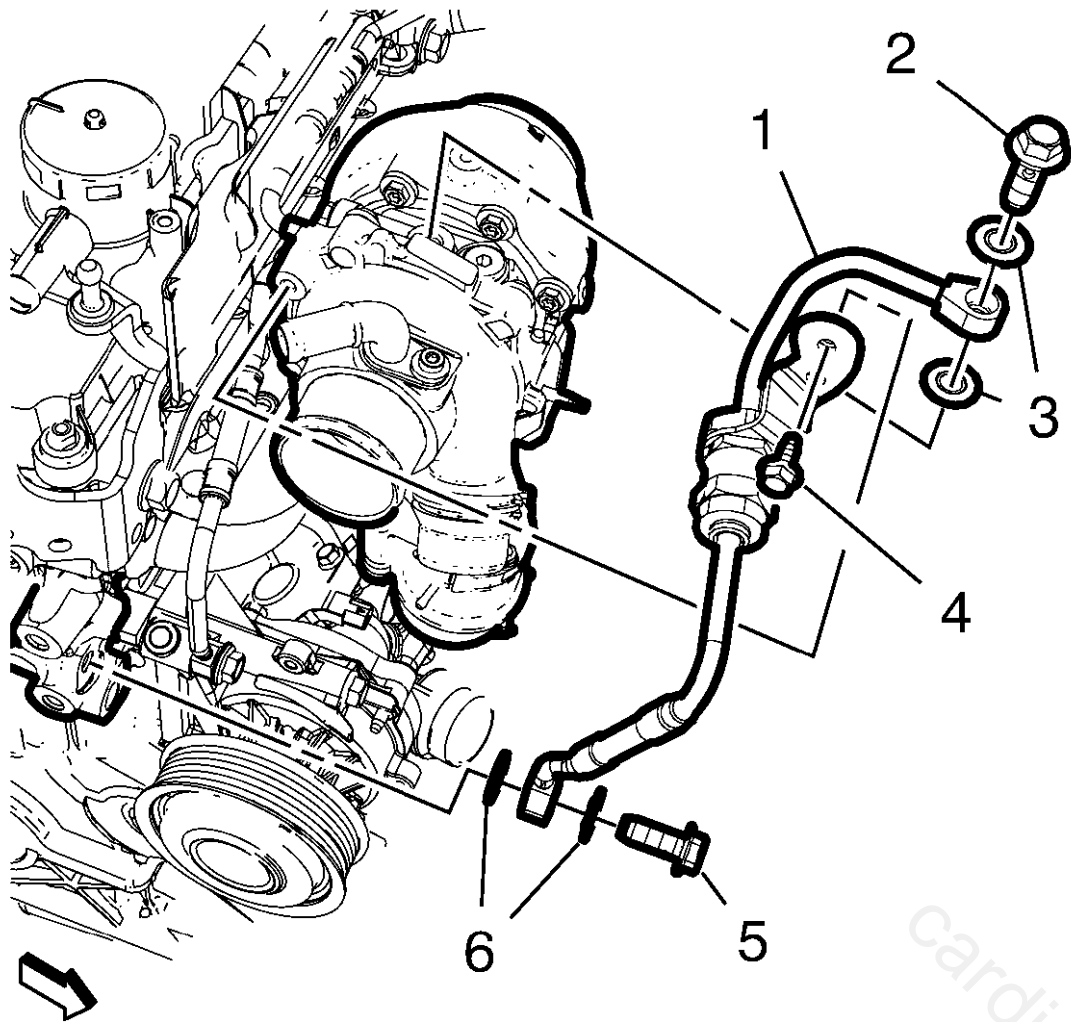


Fig. 591: Turbocharger Oil Feed Pipe And Components
Courtesy of GENERAL MOTORS COMPANY

1. Remove the 2 turbocharger oil feed pipe hollow bolts (2, 5).
2. Remove the 4 turbocharger oil feed pipe gaskets (3, 6).
3. Remove the turbocharger oil feed pipe bracket bolt (4).
4. Remove the turbocharger oil feed pipe (1).

TURBOCHARGER OIL RETURN PIPE REMOVAL

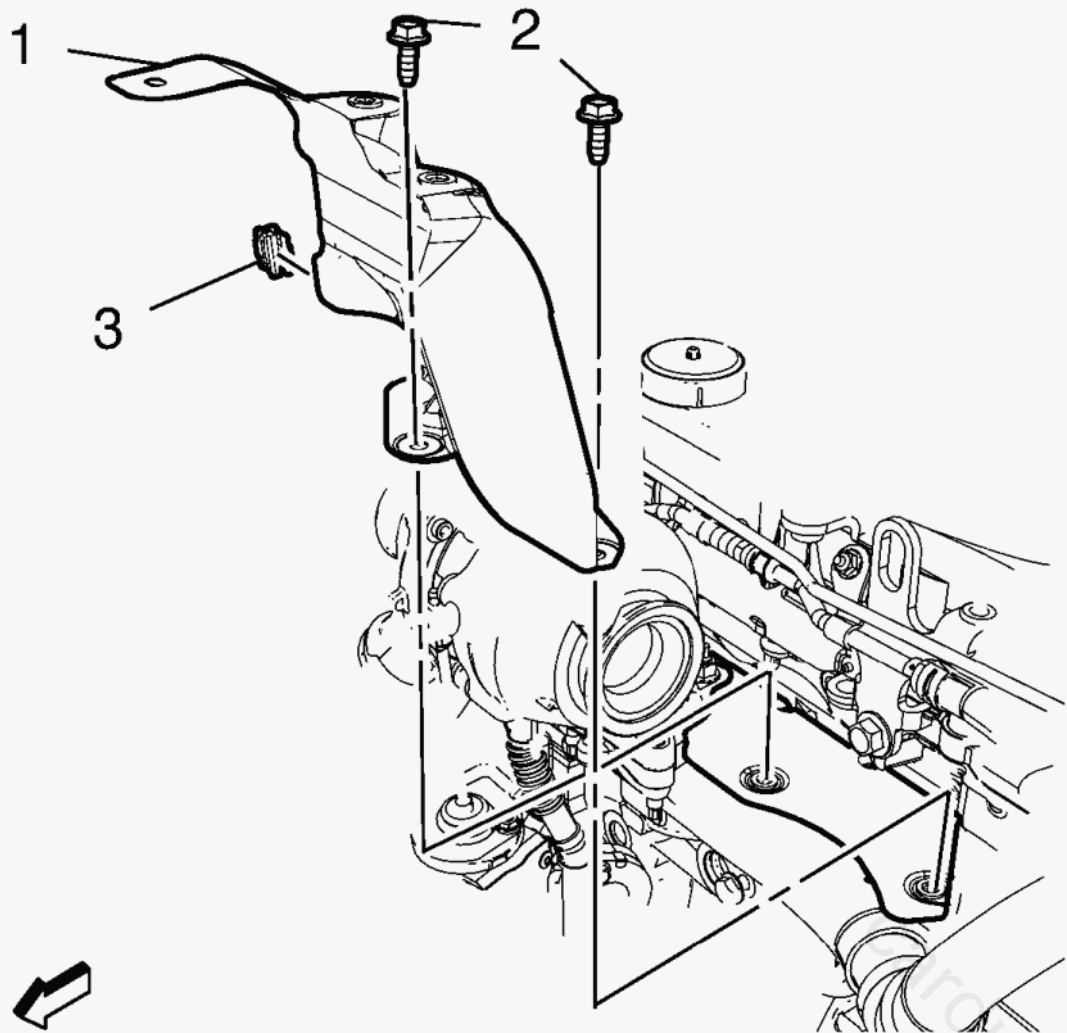


Fig. 592: Turbocharger Heat Shield, Bolts And Clip
Courtesy of GENERAL MOTORS COMPANY

1. Remove the 2 turbocharger heat shield bolts (2).
2. Unclip the turbocharger heat shield connection clip (3).
3. Remove the turbocharger heat shield (1).

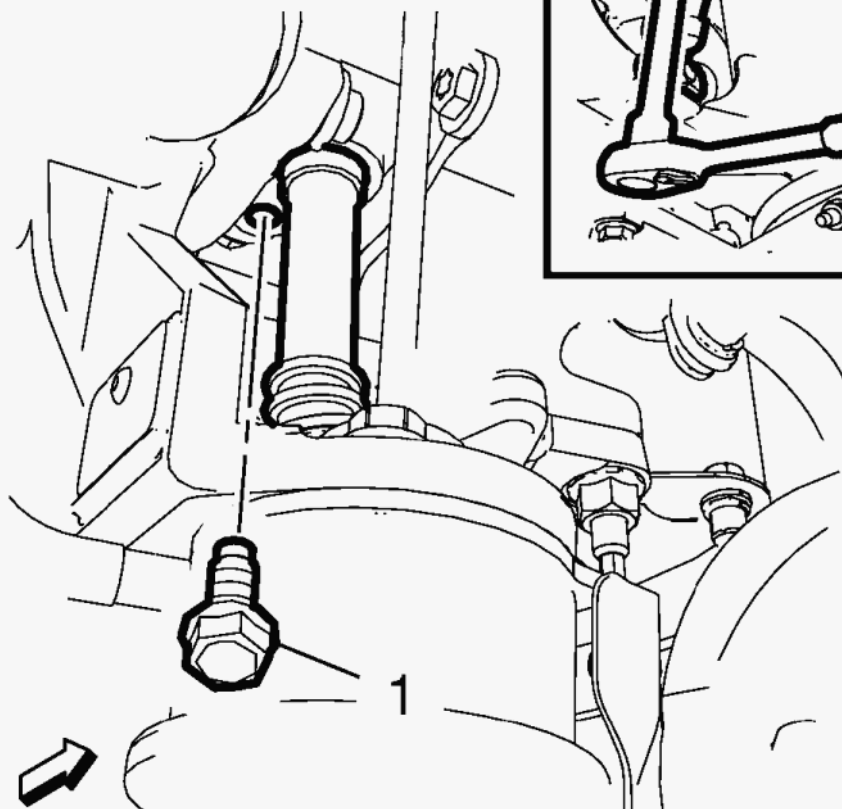


Fig. 593: Upper Turbocharger Oil Return Pipe Bolt
Courtesy of GENERAL MOTORS COMPANY

4. Remove the upper turbocharger oil return pipe bolt (1)

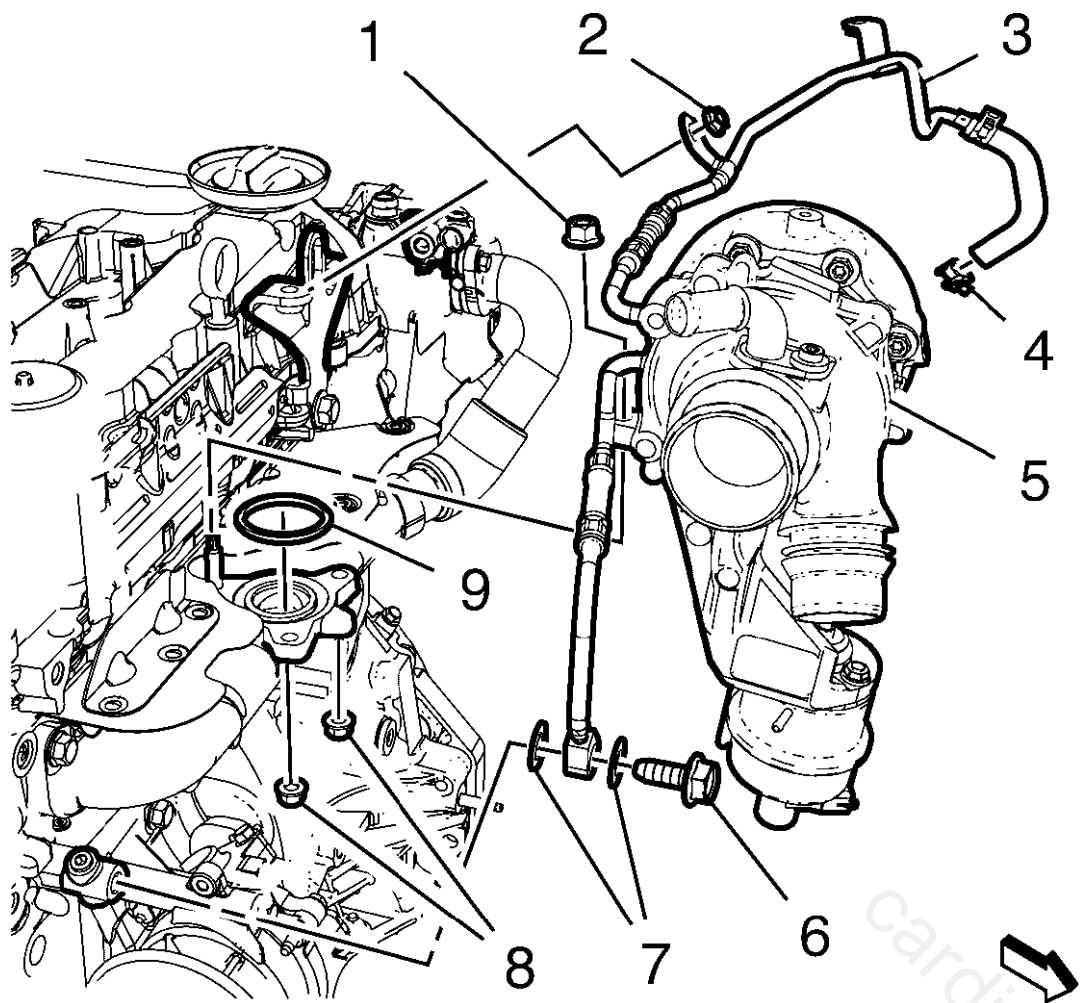


Fig. 594: Turbocharger And Components

Courtesy of GENERAL MOTORS COMPANY

5. Remove the clamp (4) from thermostat bypass pipe.
6. Remove the turbocharger coolant feed pipe bracket nut (2).
7. Remove the turbocharger coolant feed pipe hollow bolt (6).
8. Remove and DISCARD the 2 turbocharger coolant feed pipe gaskets (7).
9. Remove the 3 turbocharger nuts (1, 8).
10. Pull the turbocharger (5) slightly upwards and remove the turbocharger coolant feed pipe (3) from the thermostat bypass pipe.
11. Remove the turbocharger (5) from the exhaust manifold.
12. Remove and DISCARD the turbocharger gasket (9).

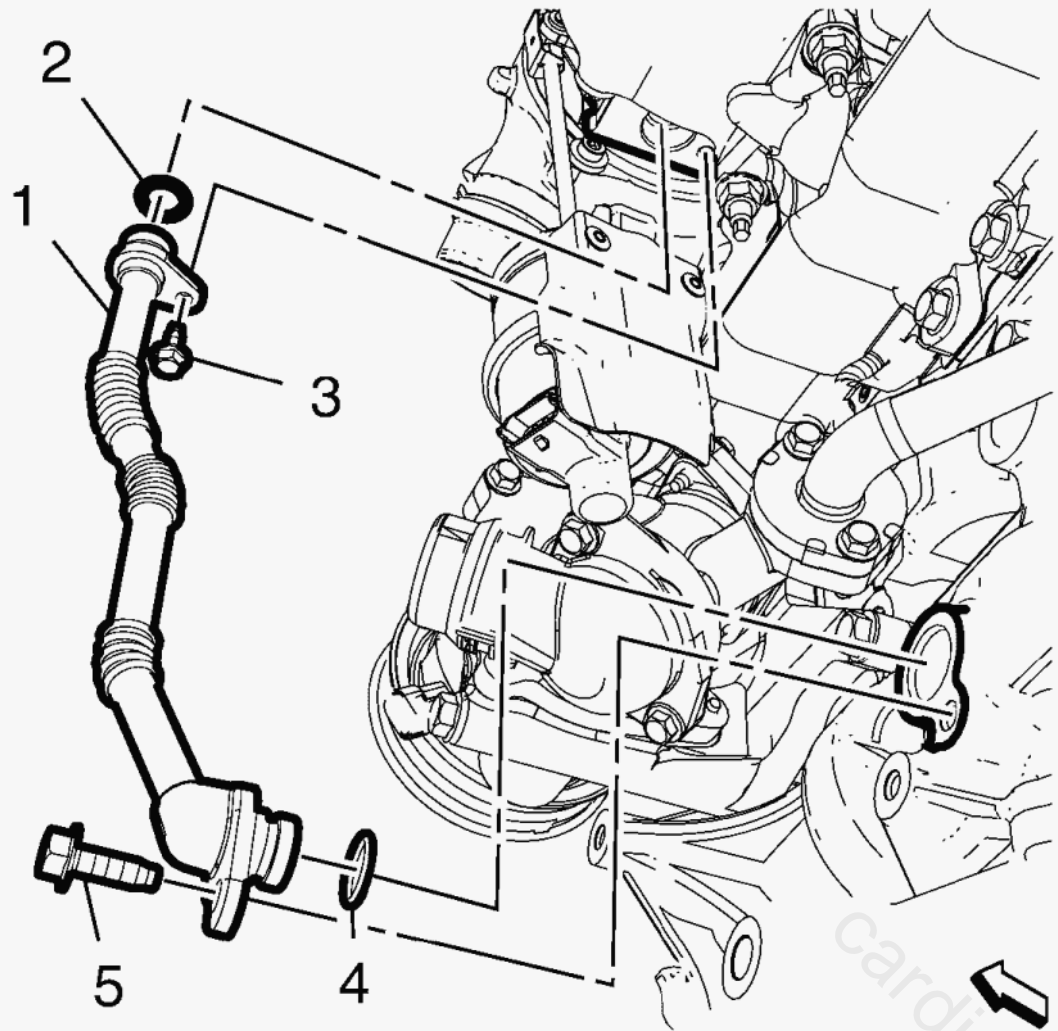


Fig. 595: Turbocharger Oil Return Pipe, Bolts And Gaskets
Courtesy of GENERAL MOTORS COMPANY

13. Remove the turbocharger oil return pipe bolt (5).
14. Remove the lower turbocharger oil return pipe joint out of the engine block.
15. Remove the turbocharger oil return pipe (1).
16. Remove and DISCARD the turbocharger oil return pipe seals (2, 4).

TURBOCHARGER REMOVAL

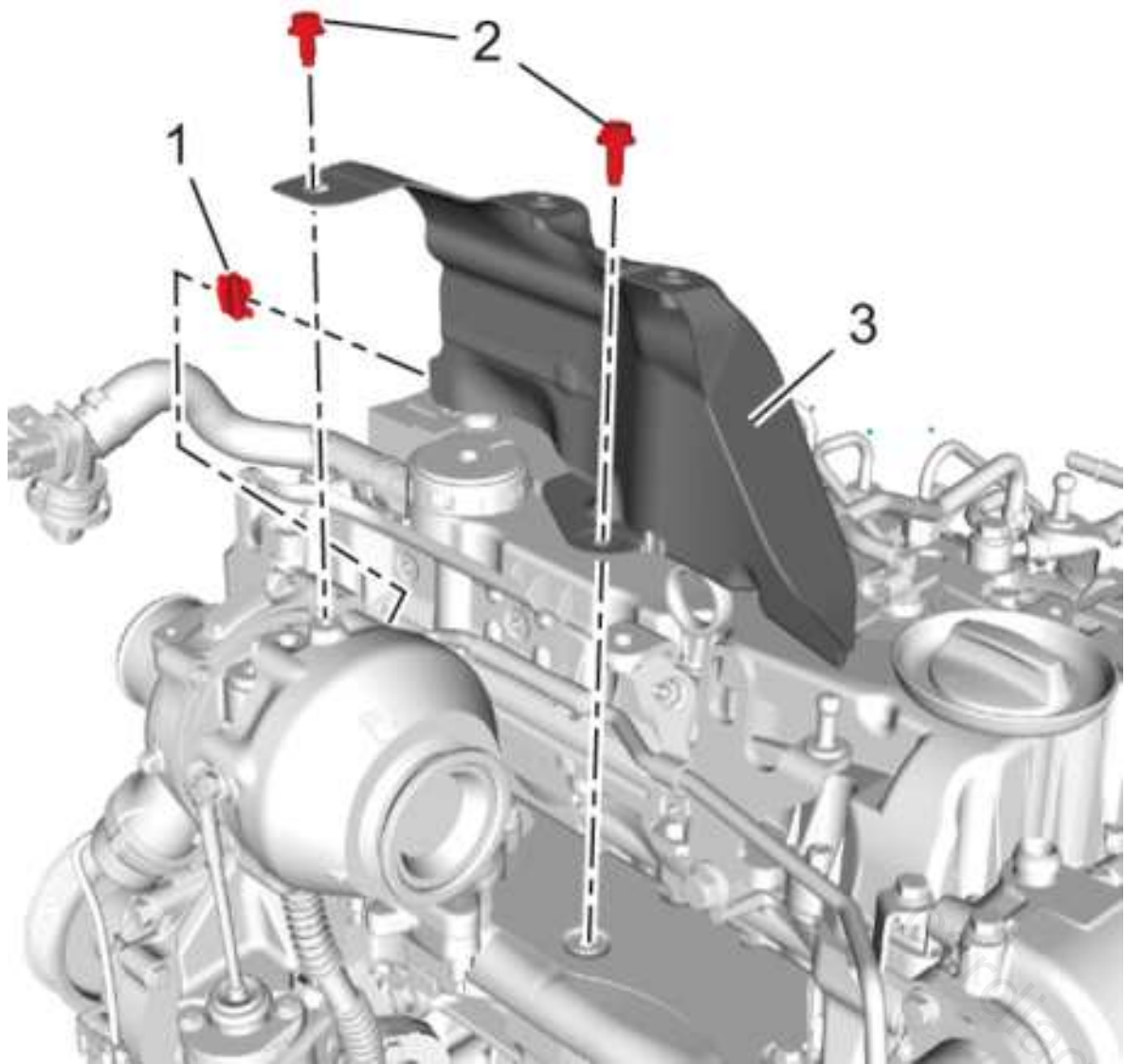


Fig. 596: Turbocharger Heat Shield, Bolts And Clamp
Courtesy of GENERAL MOTORS COMPANY

1. Remove Turbocharger Heat Shield Bolts (2) (Qty: 2)
2. Unclip Turbocharger Heat Shield (3) @ Clamp (1)
3. Remove Turbocharger Heat Shield (3)

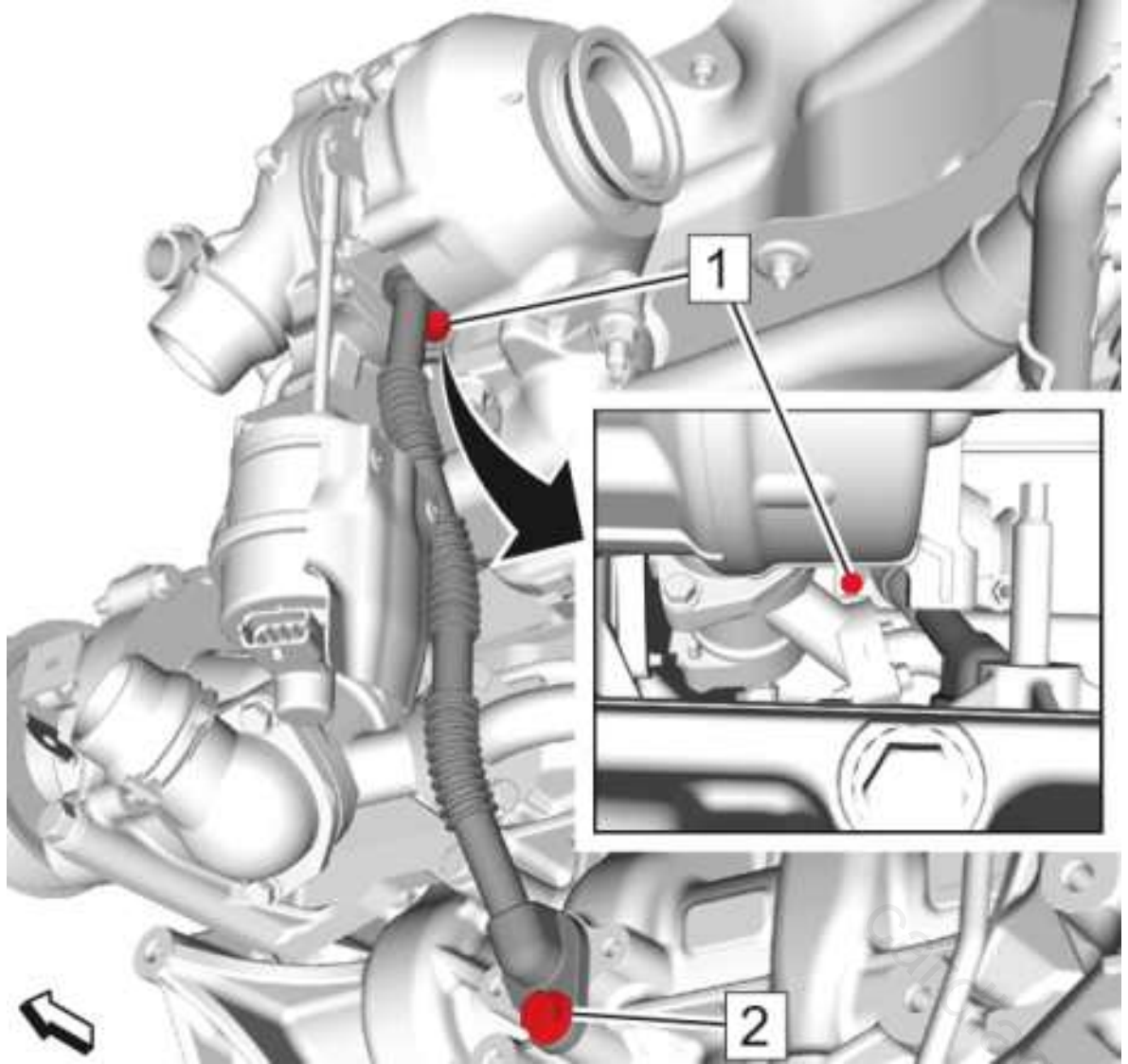


Fig. 597: Turbocharger Oil Return Pipe Bolts
Courtesy of GENERAL MOTORS COMPANY

4. Remove Turbocharger Oil Return Pipe Bolt (1)
5. Loosen Turbocharger Oil Return Pipe Bolt (2)

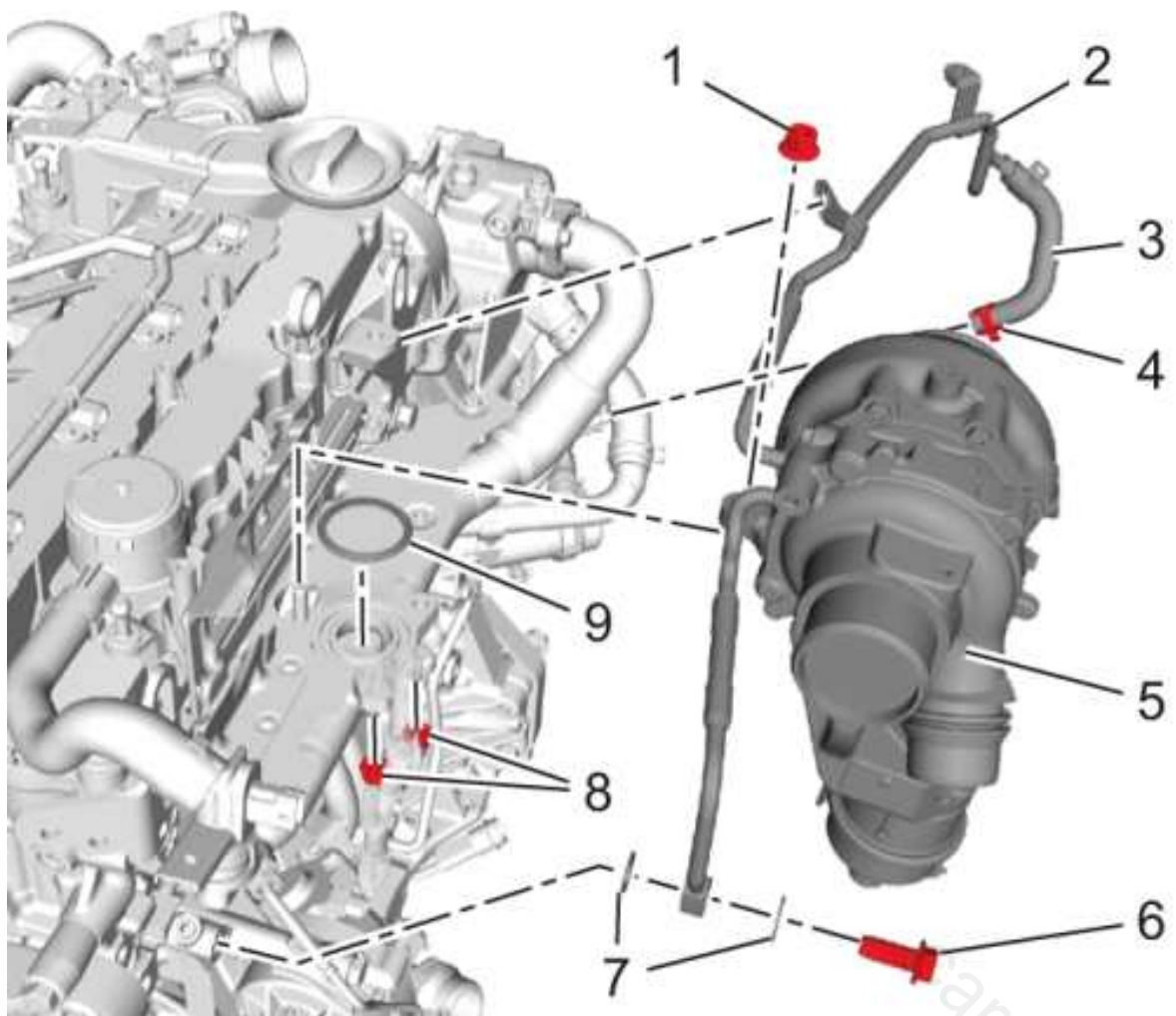


Fig. 598: Turbocharger And Components

Courtesy of GENERAL MOTORS COMPANY

6. Loosen Thermostat Bypass Hose Clamp (4)
7. Disconnect Thermostat Bypass Hose (3) @ Thermostat Bypass Pipe
8. Remove Turbocharger Coolant Feed Pipe Hollow Screw (6)
9. Remove and DISCARD Turbocharger Coolant Feed Pipe Gasket (7) (Qty: 2)
10. Remove Turbocharger Nuts (1, 8) (Qty: 3)
11. Pull the turbocharger (5) slightly upwards and remove the turbocharger oil return pipe from the turbocharger.
12. Remove Turbocharger (5) @ Exhaust Manifold
13. Remove and DISCARD Turbocharger Gasket (9)

EXHAUST GAS RECIRCULATION COOLER TEMPERATURE SENSOR REMOVAL - POSITION 1

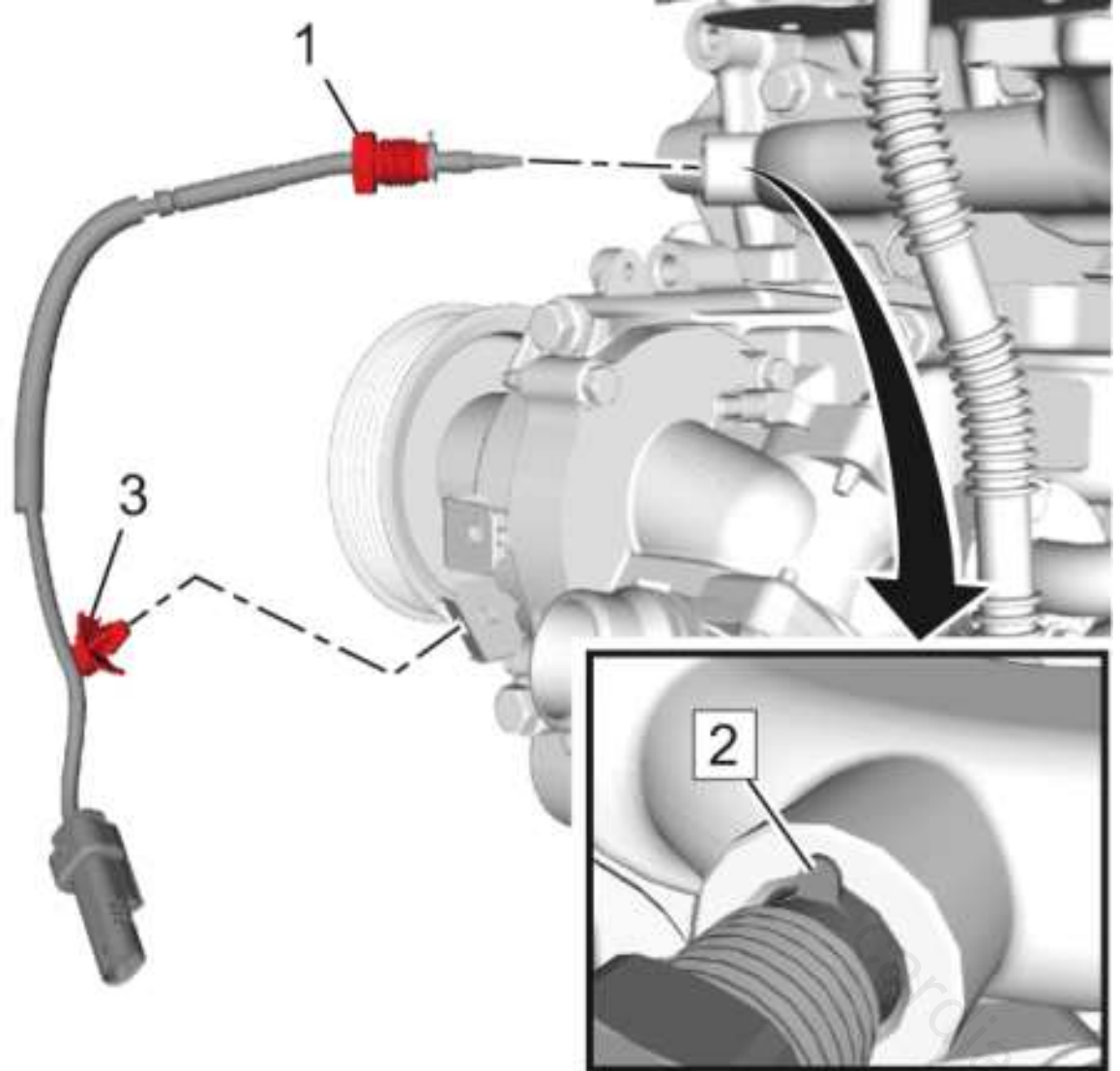


Fig. 599: Exhaust Gas Recirculation Cooler Temperature Sensor - Position 1 And Clip
Courtesy of GENERAL MOTORS COMPANY

1. Unclip Wiring Harness Clip (3)
2. Remove Exhaust Gas Recirculation Cooler Temperature Sensor-Position 1 (1)

EXHAUST MANIFOLD REMOVAL

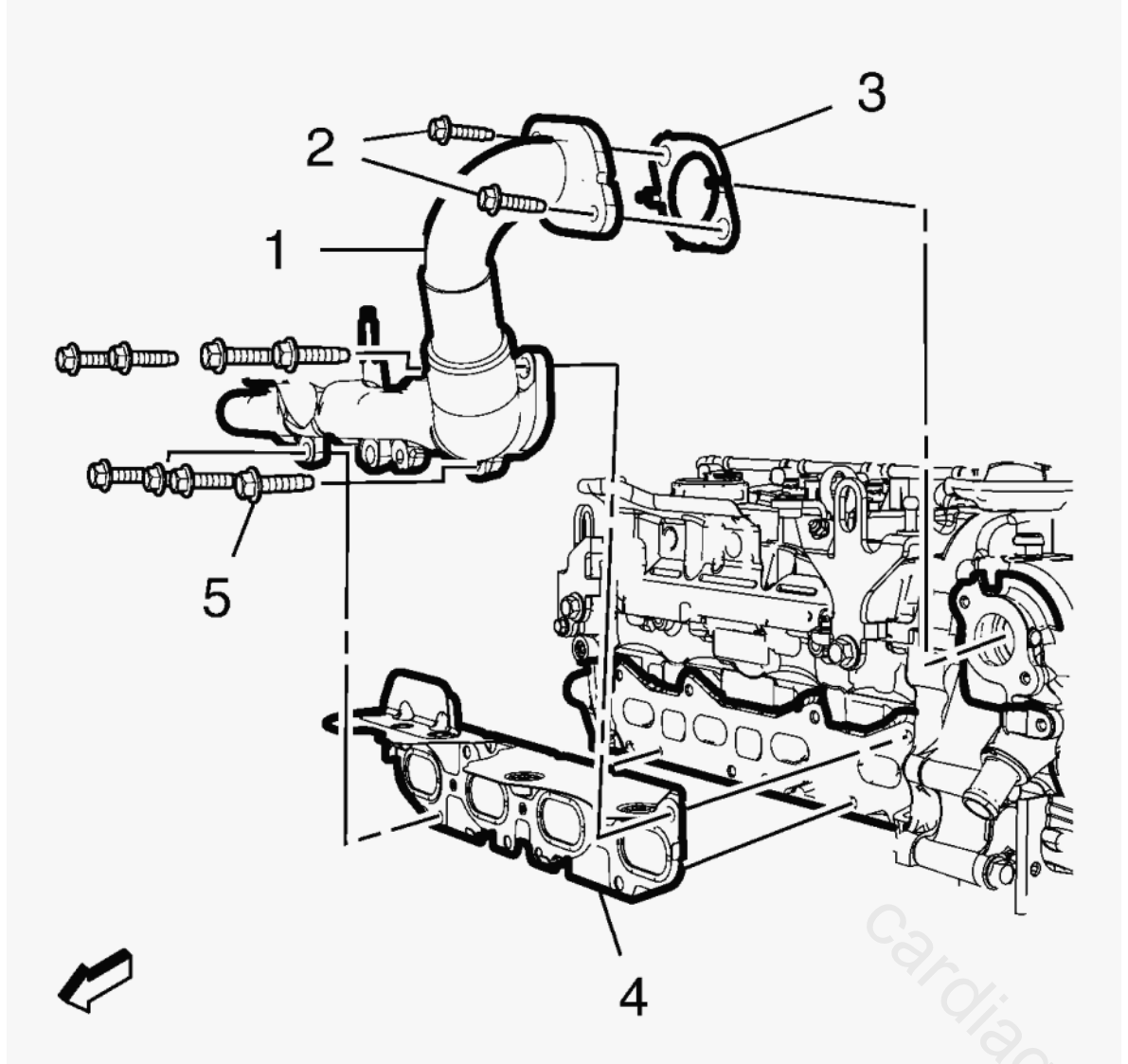


Fig. 600: Exhaust Manifold Components

Courtesy of GENERAL MOTORS COMPANY

1. Remove the 2 exhaust gas recirculation pipe bolts (2).
2. Remove and DISCARD the 8 exhaust manifold bolts (5).

NOTE: Do not bend the exhaust gas recirculation pipe.

3. Remove the exhaust manifold (1).
4. Remove and DISCARD the exhaust manifold gasket (4).
5. Remove and DISCARD the exhaust gas recirculation pipe gasket (3).

THERMOSTAT BYPASS PIPE REMOVAL



Fig. 601: Thermostat Bypass Pipe Components
Courtesy of GENERAL MOTORS COMPANY

1. Release Clamps (4) (Qty: 2)
2. Remove Thermostat Bypass Pipe Bolts (1) (Qty: 2)
3. Remove the 3 thermostat bypass pipe bracket bolts (5, 6).
4. Remove Thermostat Bypass Pipe (3)
5. Remove and DISCARD Gasket (2)

WATER PUMP REMOVAL

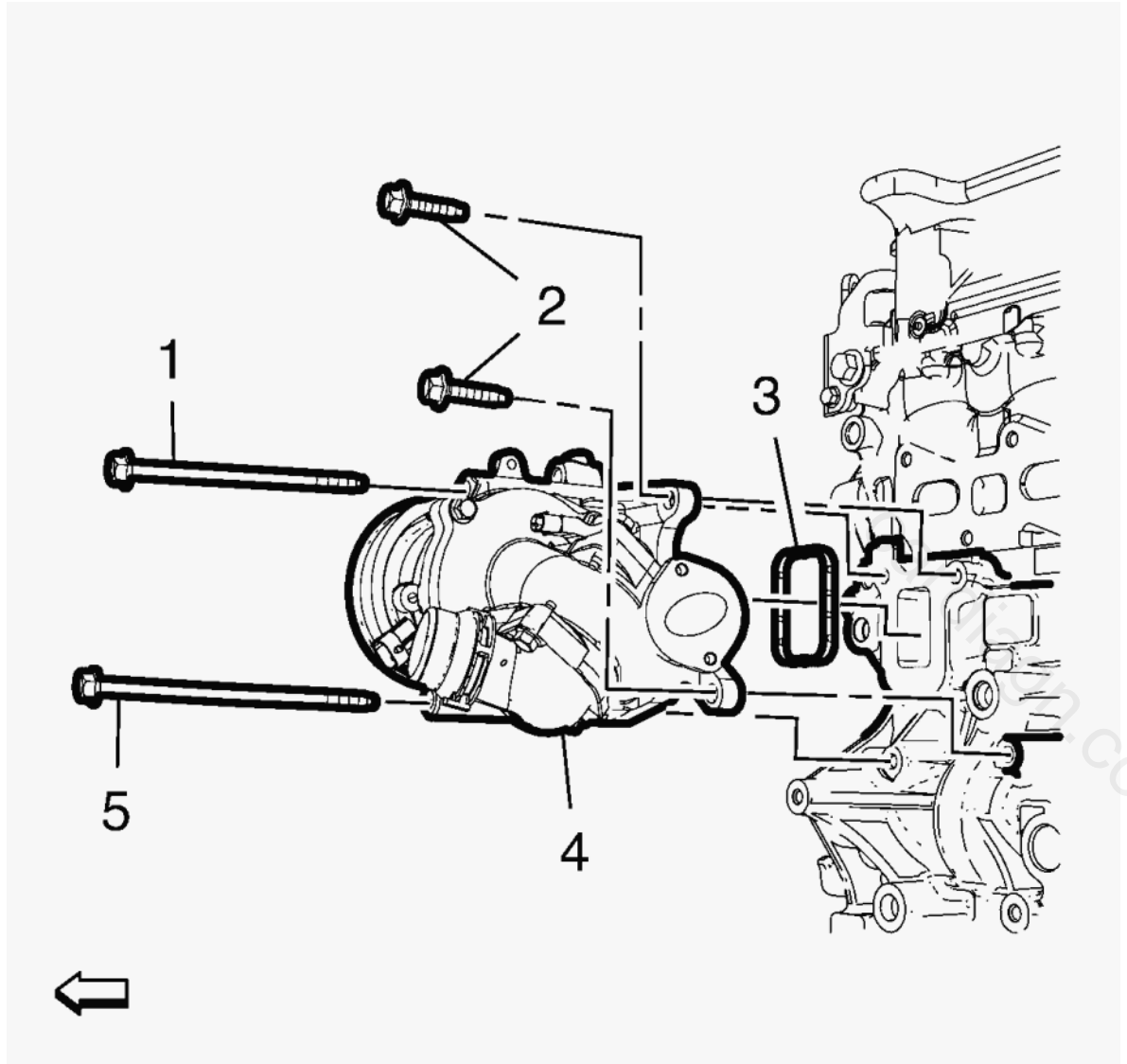


Fig. 602: Water Pump And Components
Courtesy of GENERAL MOTORS COMPANY

NOTE: Different bolt length.

1. Remove the 4 water pump bolts (1, 2, 5).
2. Remove the water pump (4).
3. Remove and DISCARD the water pump seal (3).

ENGINE COOLANT OUTLET PIPE REMOVAL

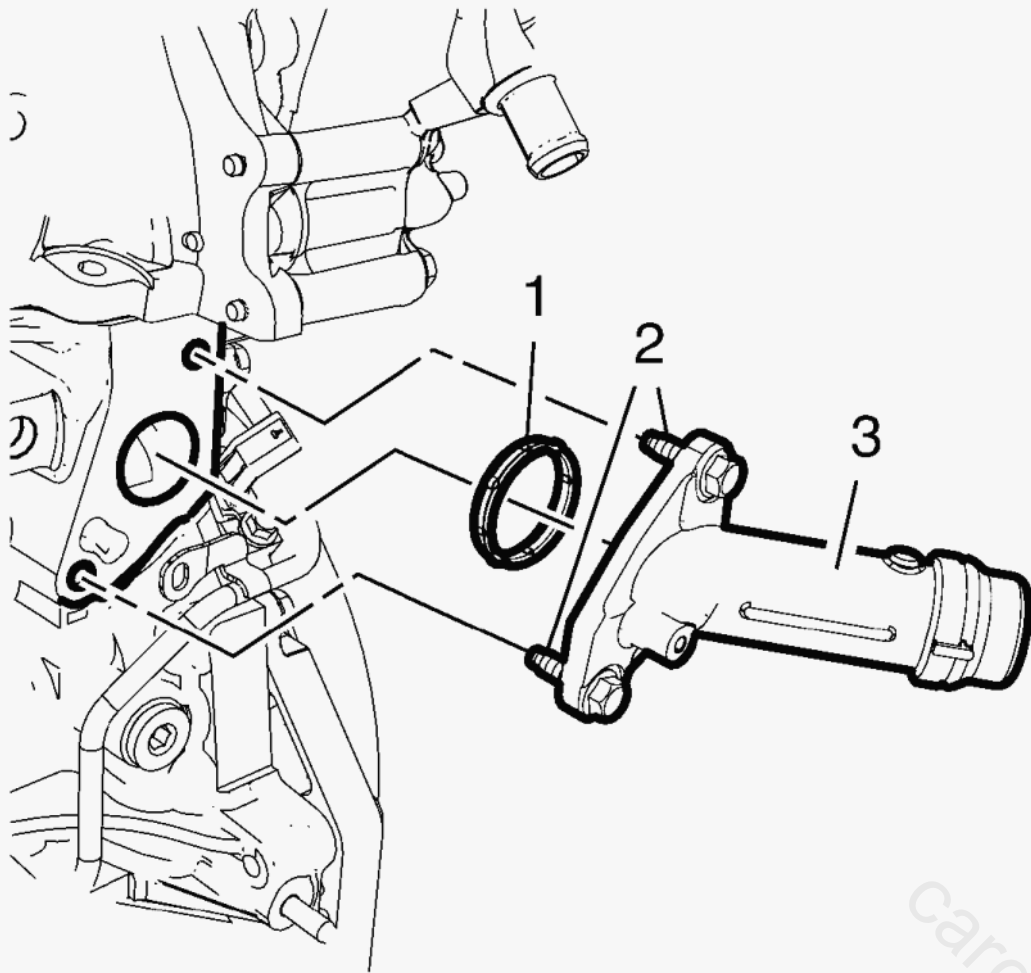
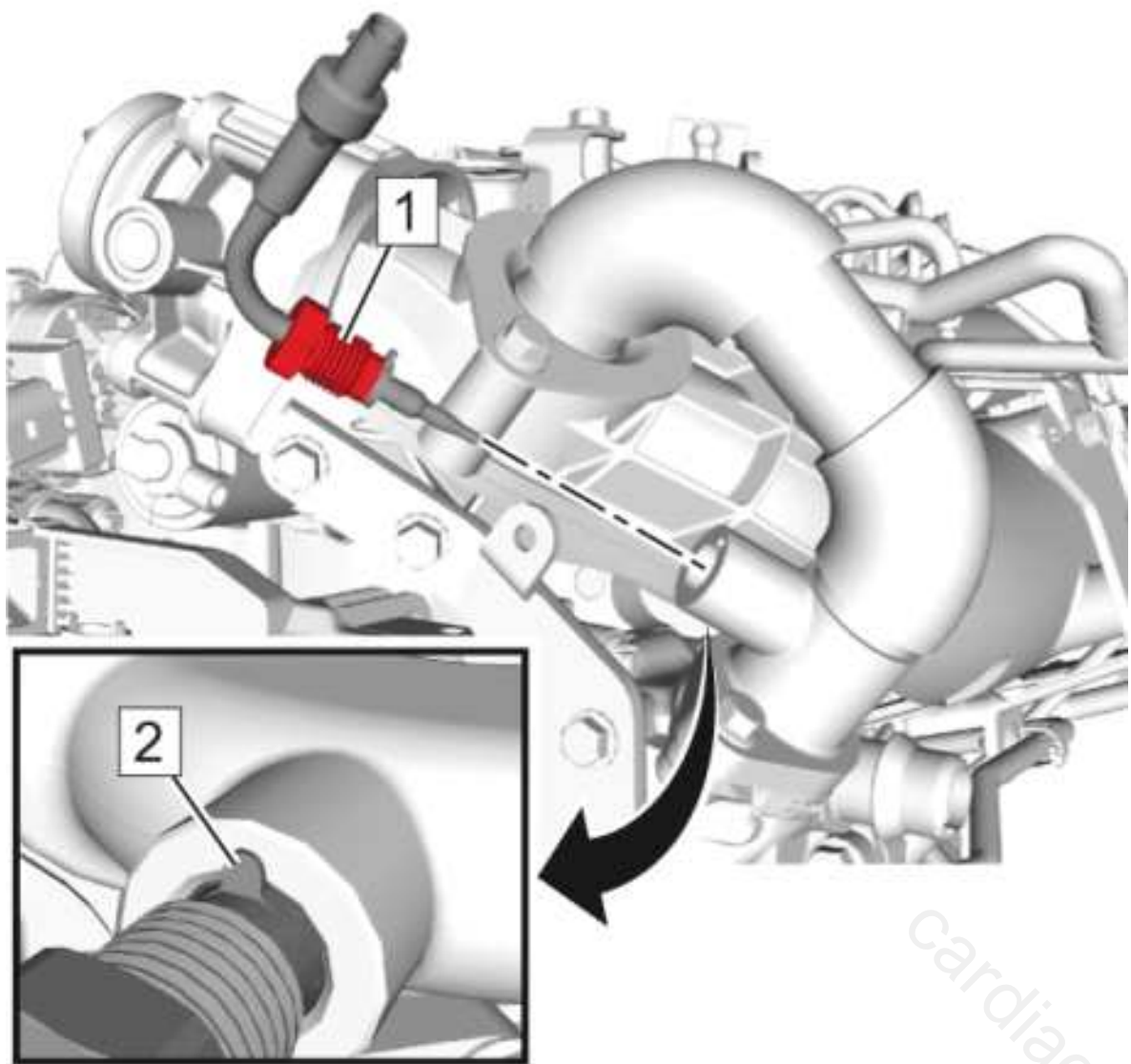


Fig. 603: Engine Coolant Outlet Pipe And Components
Courtesy of GENERAL MOTORS COMPANY

1. Remove the 2 engine coolant outlet pipe bolts (2).
2. Remove the engine coolant outlet pipe (3).
3. Remove and DISCARD the engine coolant outlet pipe seal (1).

EXHAUST GAS RECIRCULATION COOLER TEMPERATURE SENSOR REMOVAL - POSITION 2



cardiagn.com

Fig. 604: Exhaust Gas Recirculation Cooler Temperature Sensor - Position 2
Courtesy of GENERAL MOTORS COMPANY

Remove Exhaust Gas Recirculation Cooler Temperature Sensor - Position 2 (1)

EXHAUST GAS RECIRCULATION COOLER OUTLET PIPE REMOVAL

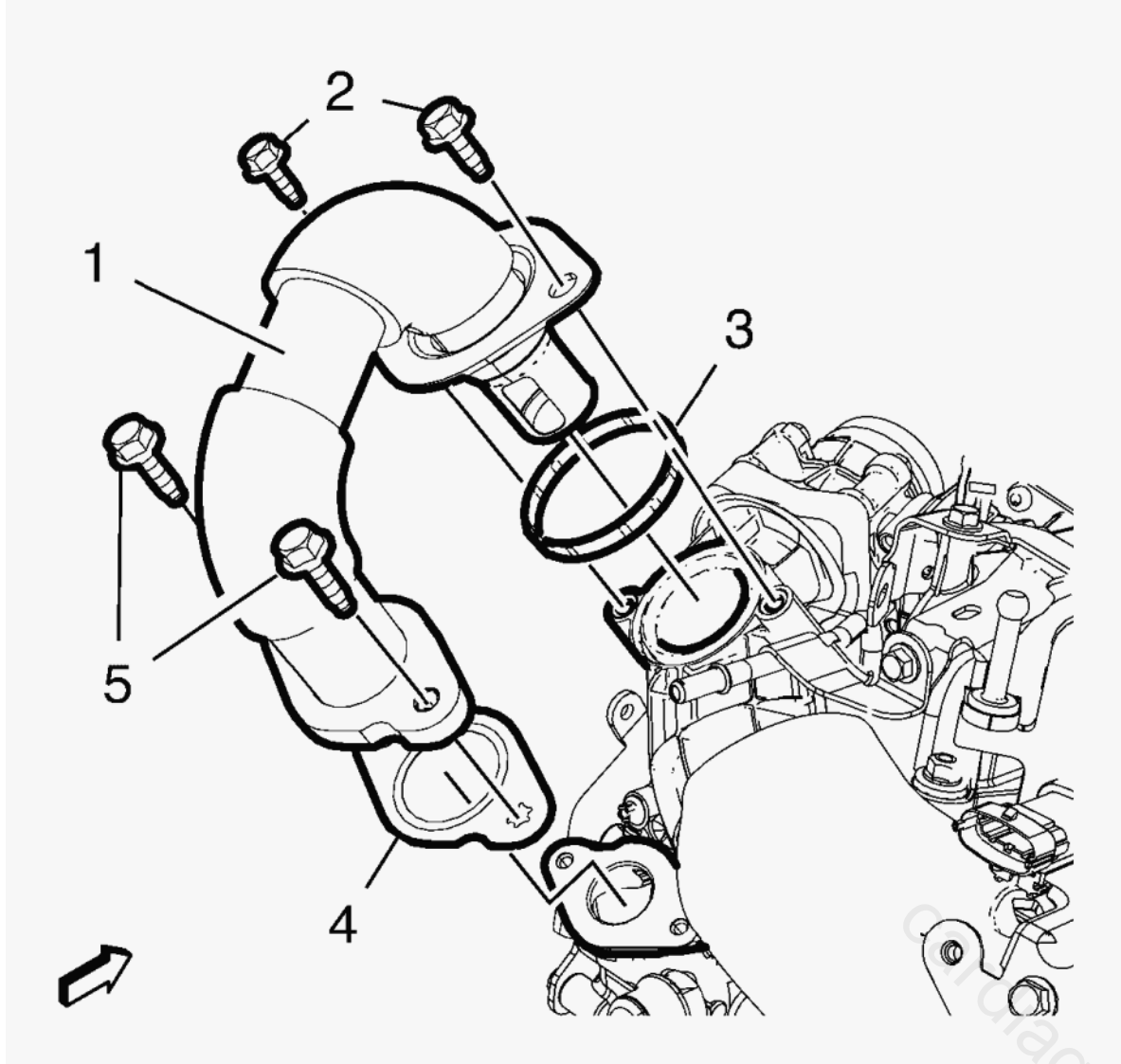


Fig. 605: Exhaust Gas Recirculation Cooler Outlet Pipe And Components
Courtesy of GENERAL MOTORS COMPANY

1. Remove the 4 exhaust gas recirculation cooler outlet pipe bolts (2, 5).
2. Remove the exhaust gas recirculation cooler outlet pipe (1).
3. Remove the exhaust gas recirculation cooler outlet pipe seal (3).
4. Remove and DISCARD the exhaust gas recirculation cooler outlet pipe gasket (4).

INTAKE MANIFOLD BRACE REMOVAL

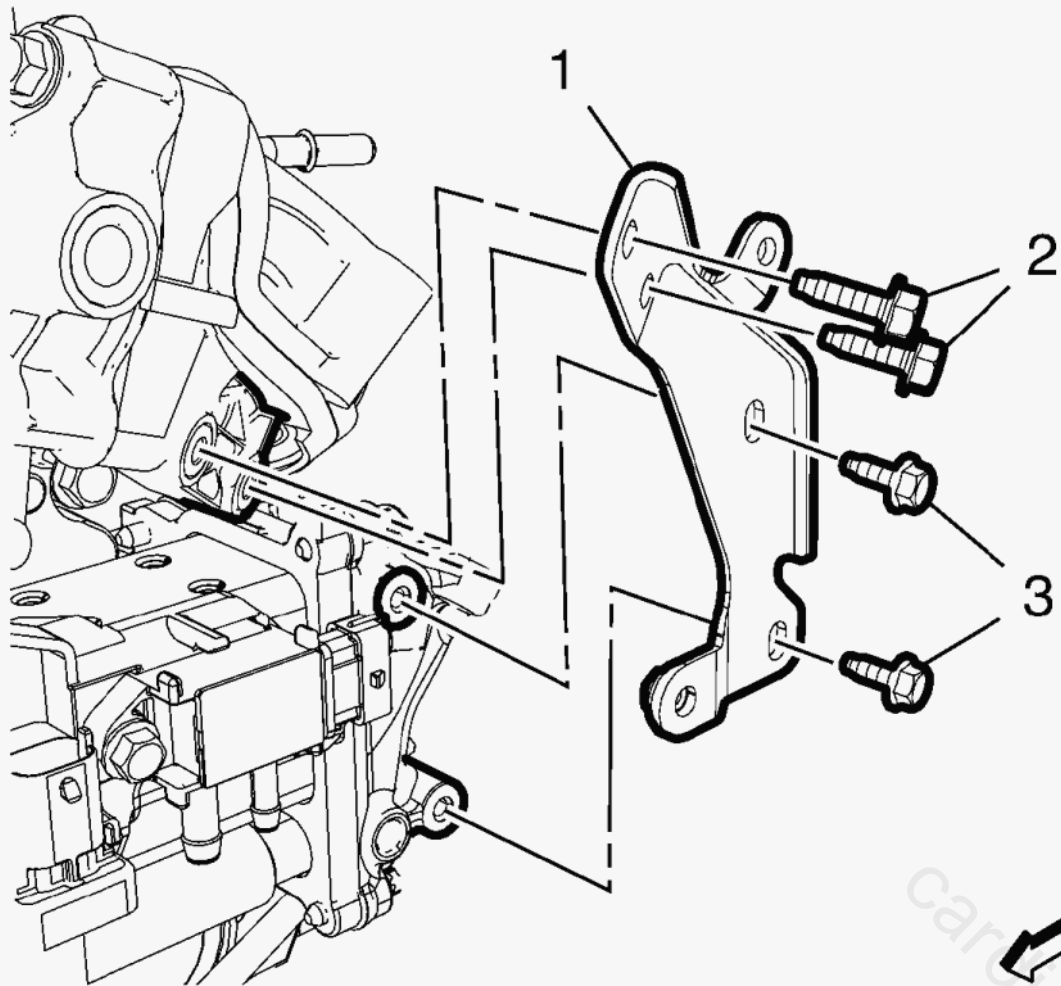


Fig. 606: Intake Manifold Brace And Bolts

Courtesy of GENERAL MOTORS COMPANY

1. Remove the 4 intake manifold brace bolts (2, 3).
2. Remove the intake manifold brace (1).

EXHAUST GAS RECIRCULATION COOLER HOUSING REMOVAL

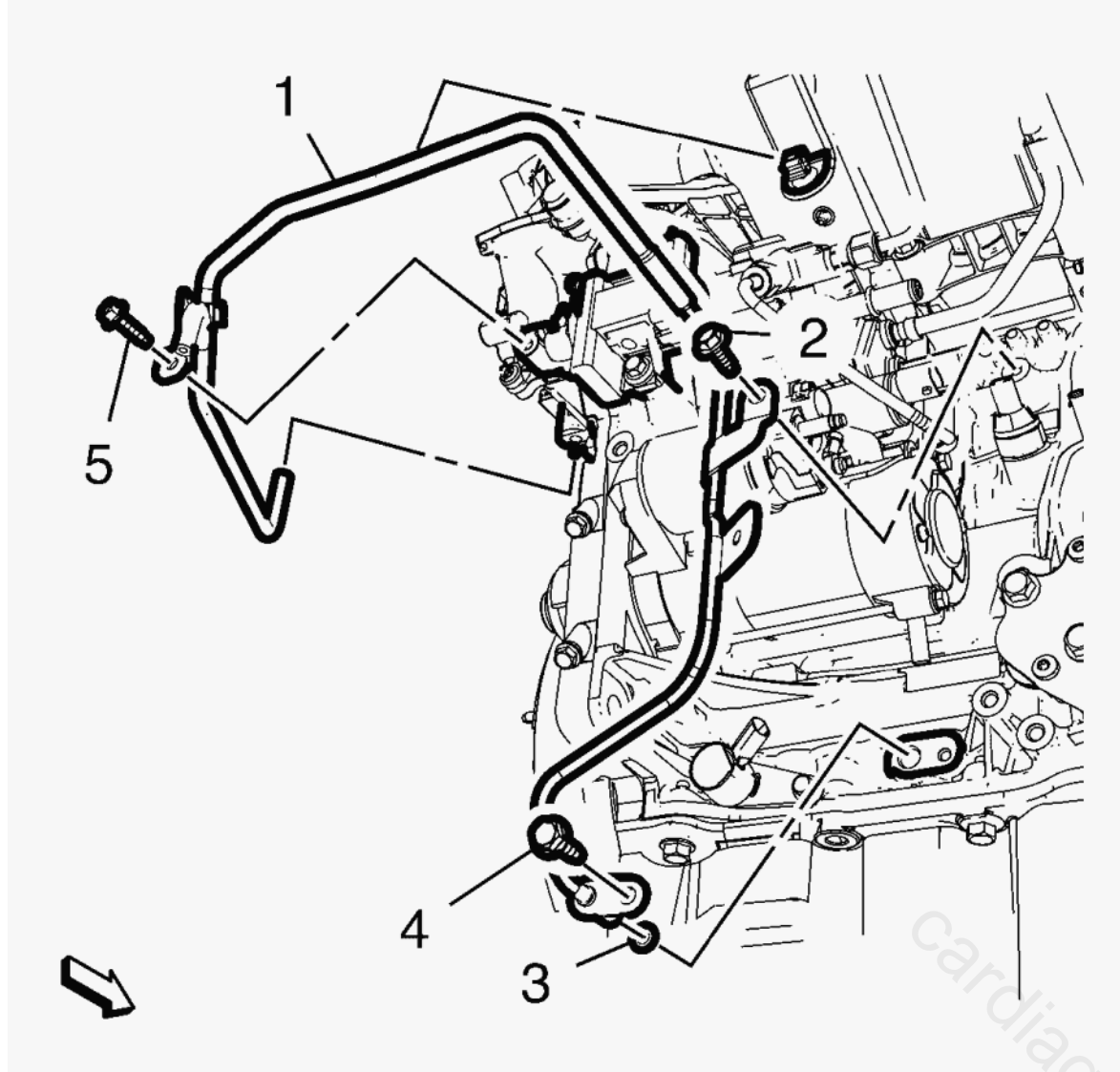


Fig. 607: Charge Air Bypass Regulator Solenoid Valve Vacuum Tube Components
Courtesy of GENERAL MOTORS COMPANY

1. Remove the 3 charge air bypass valve vacuum hose bracket bolts (2, 4, 5).
2. Disconnect the charge air bypass valve vacuum hose (1) from the exhaust gas recirculation vacuum regulator solenoid valve.
3. Unclip the charge air bypass valve vacuum hose retainer clip.
4. Remove the charge air bypass valve vacuum hose (1).
5. Remove the charge air bypass valve vacuum hose seal (3).

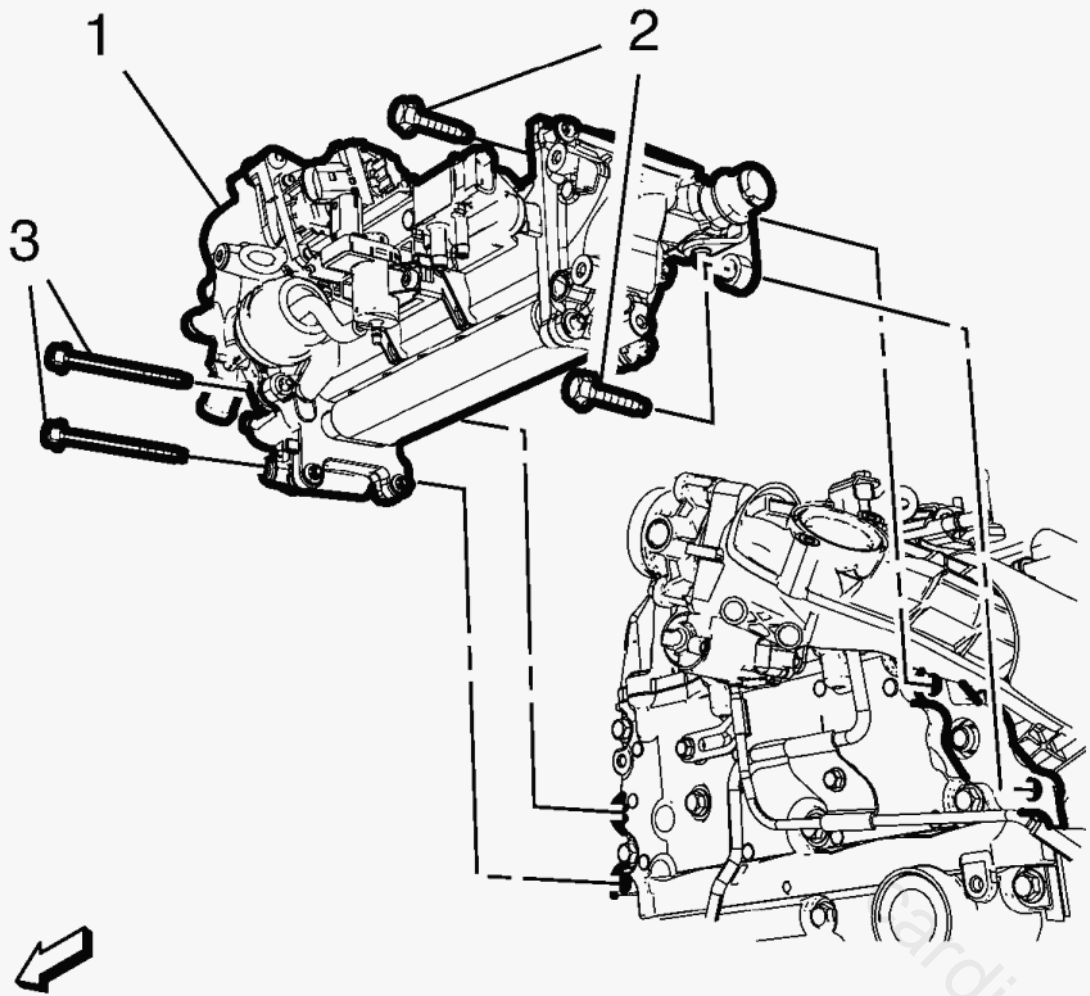


Fig. 608: Exhaust Gas Recirculation Cooler Housing And Bolts
Courtesy of GENERAL MOTORS COMPANY

6. Remove the 4 exhaust gas recirculation cooler housing bolts (2, 3).
7. Remove the exhaust gas recirculation cooler housing (1).
8. Remove the exhaust gas recirculation cooler housing gasket.

THROTTLE BODY ASSEMBLY REMOVAL

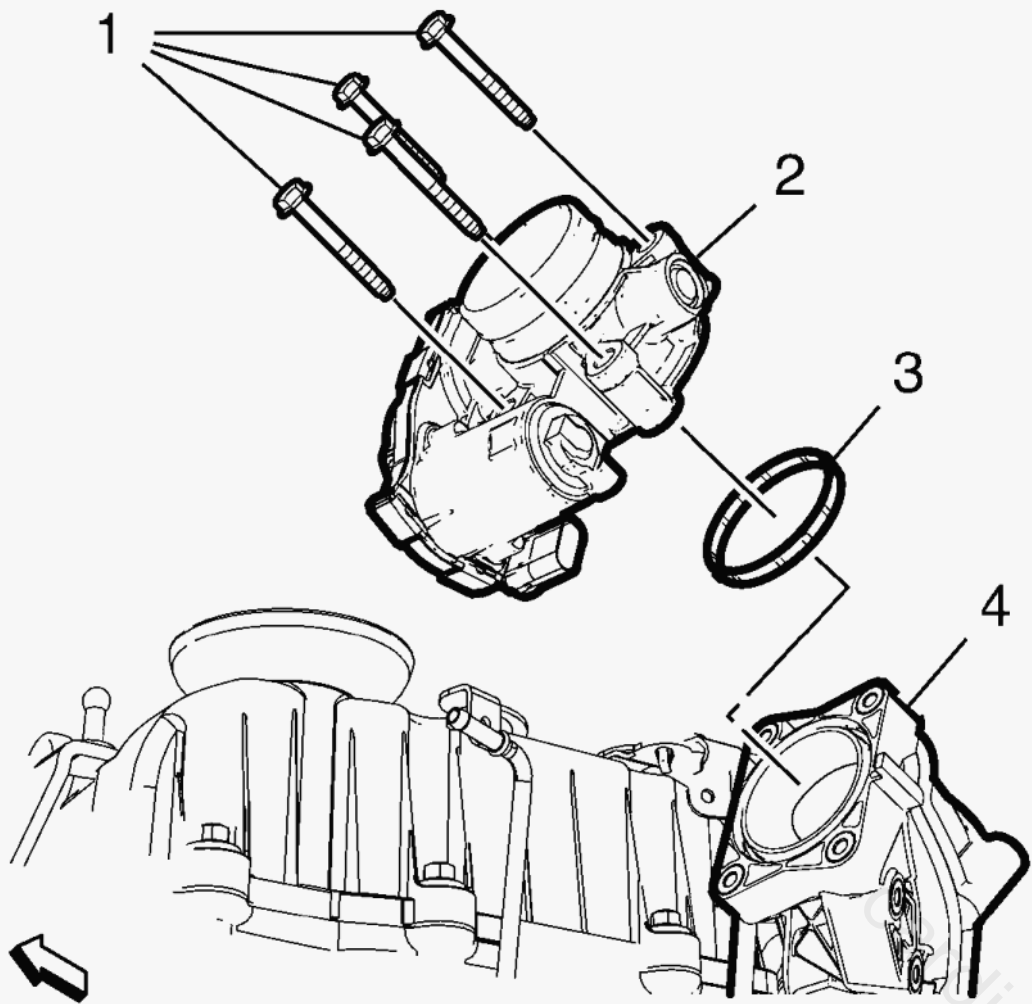


Fig. 609: Throttle Body Assembly, Bolts, Gasket And Intake Manifold
Courtesy of GENERAL MOTORS COMPANY

1. Remove the 4 throttle body assembly bolts (1).
2. Remove the throttle body assembly (2) from the intake manifold (4).
3. Remove the throttle body assembly gasket (3).

FUEL RETURN HOSE REMOVAL

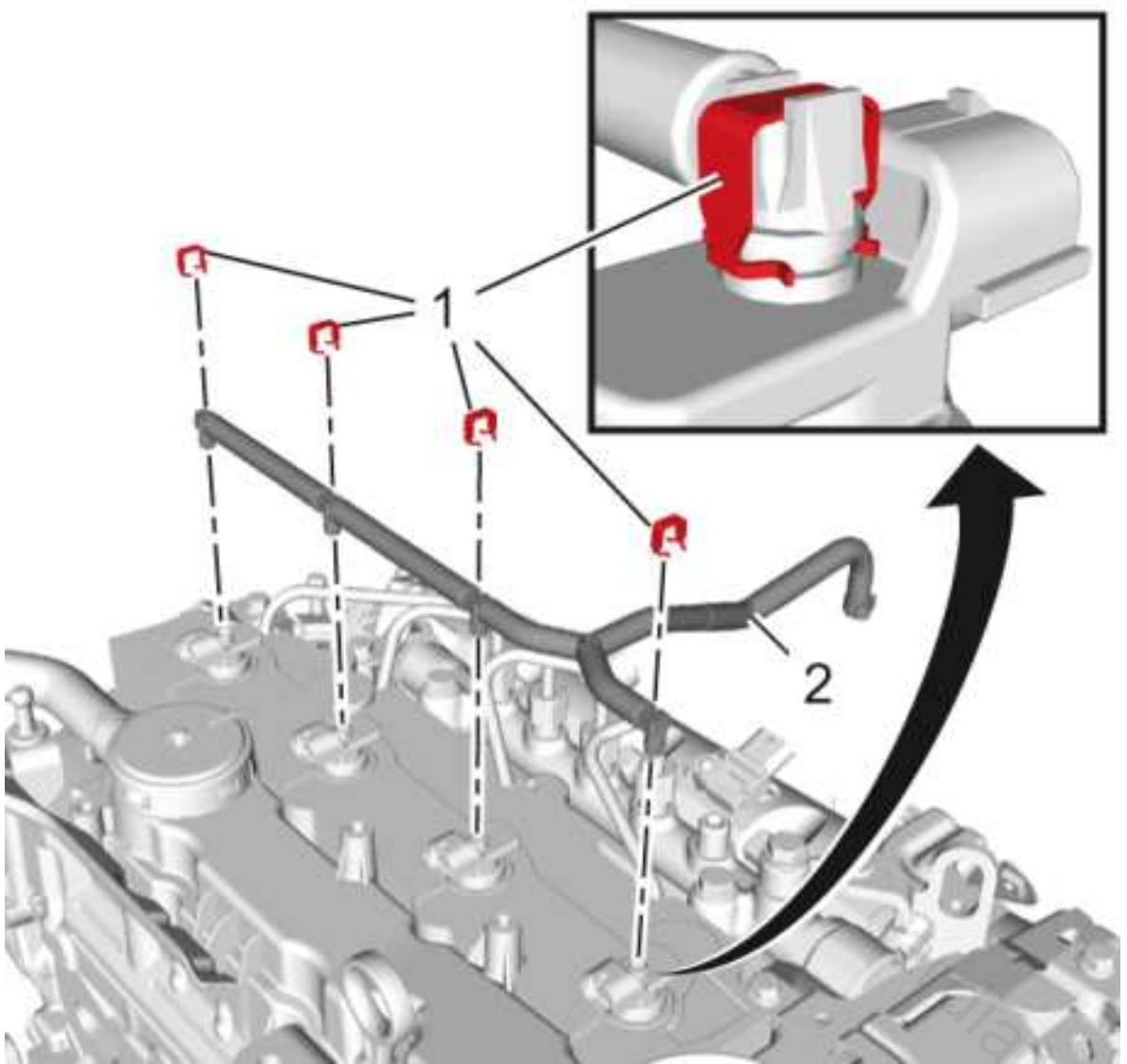


Fig. 610: Fuel Return Hose And Clamps

Courtesy of GENERAL MOTORS COMPANY

1. Remove and DISCARD Fuel Return Hose Clamps (1) (Qty: 4)
2. Unclip Fuel Return Hose (2) @ Fuel Injectors (Qty: 4)
3. Remove Fuel Return Hose (2)

FUEL INJECTION FUEL FEED PIPE REMOVAL - FUEL INJECTION PUMP TO FUEL RAIL

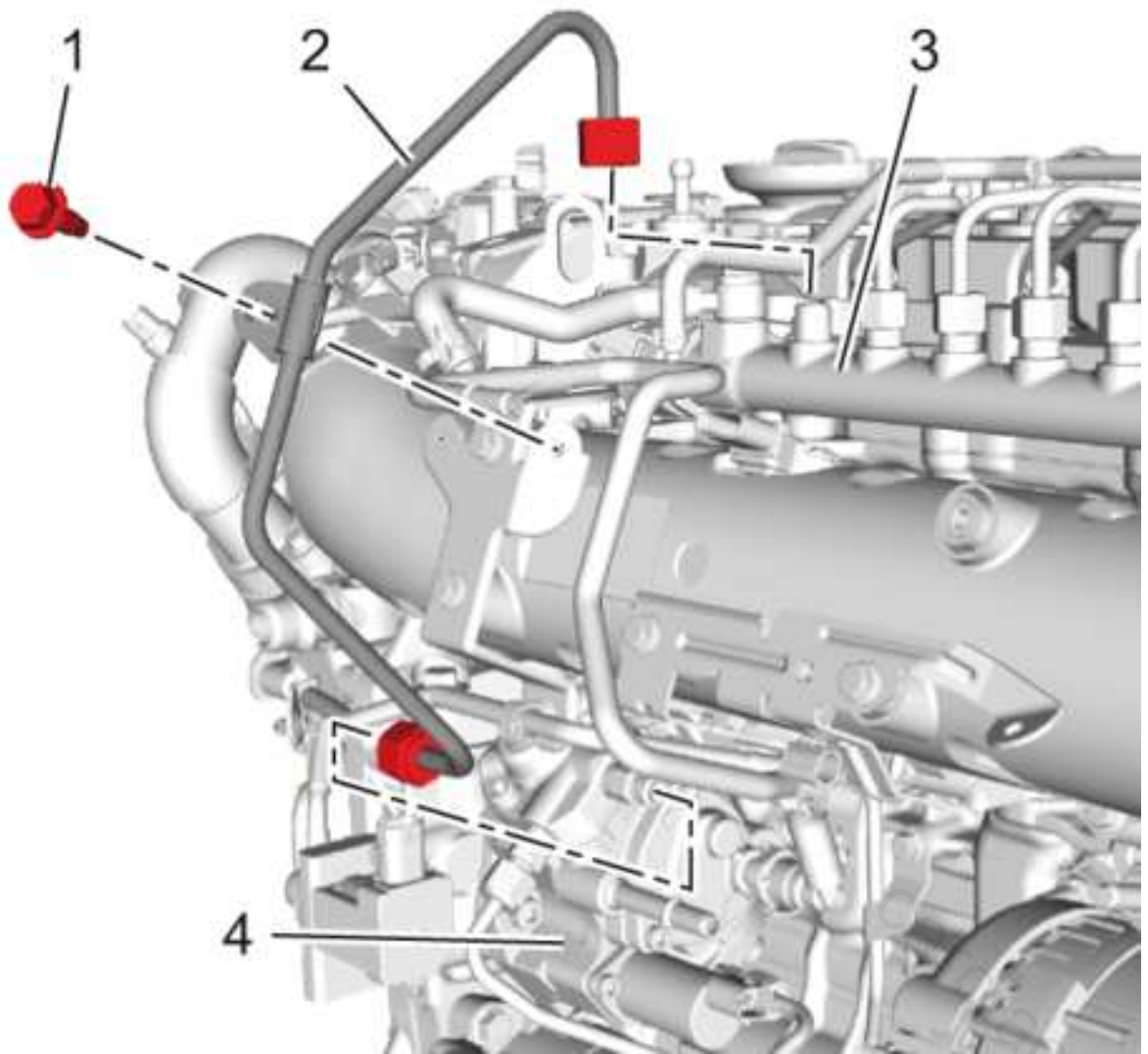


Fig. 611: Fuel Injection Fuel Feed Pipe And Components - Fuel Injection Pump to Fuel Rail
Courtesy of GENERAL MOTORS COMPANY

1. Remove Fuel Injection Fuel Feed Pipe Bracket Bolt (1)
2. Loosen Fuel Injection Fuel Feed Pipe (2) @ Fuel Rail (3)

NOTE: Counterhold at the fuel injection pump hexagon connector.

3. Loosen Fuel Injection Fuel Feed Pipe (2) @ Fuel Injection Pump (4)
4. Remove and DISCARD Fuel Injection Fuel Feed Pipe (2)

DIESEL FUEL SEPARATOR REMOVAL

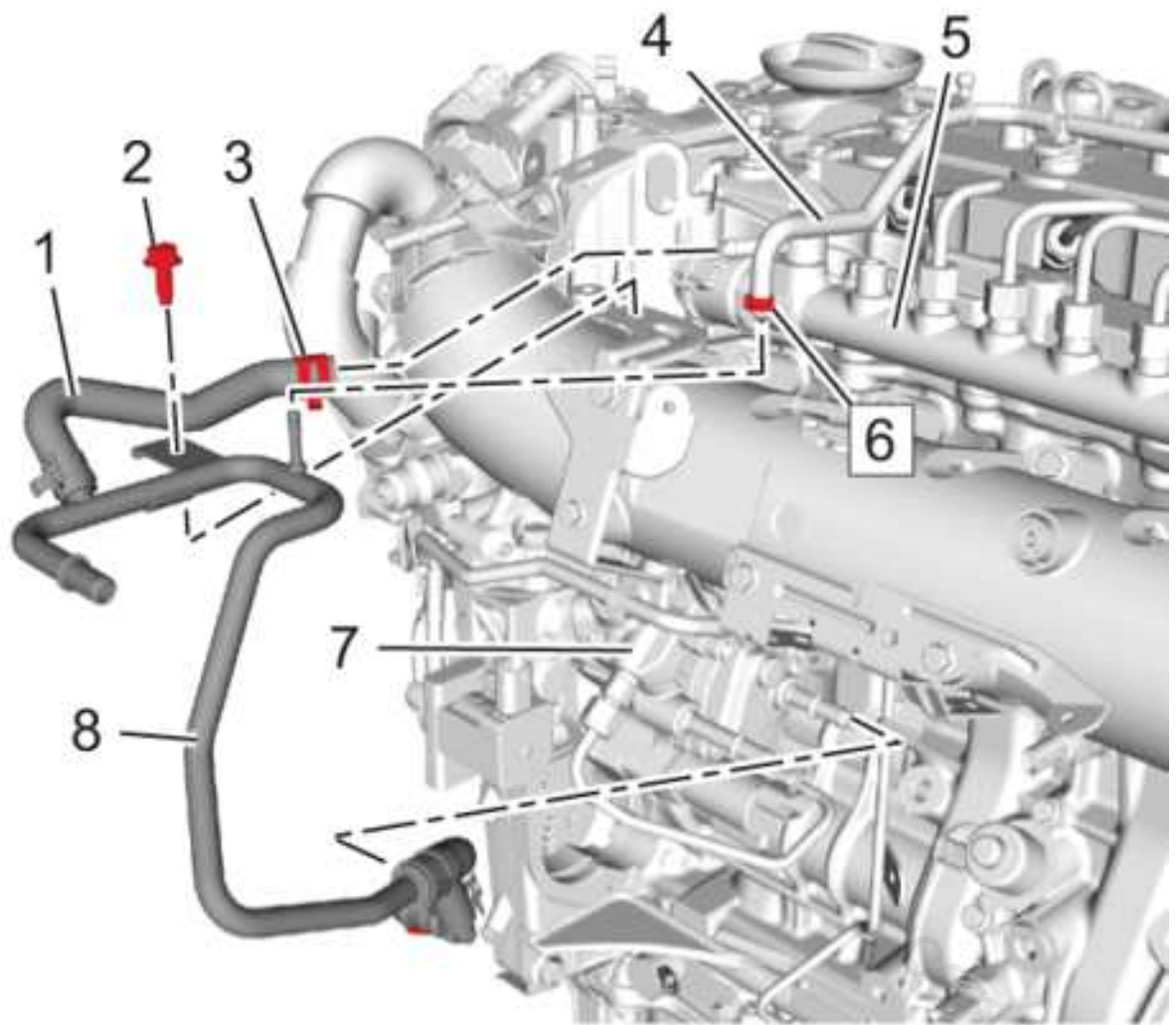


Fig. 612: Diesel Fuel Separator And Components
Courtesy of GENERAL MOTORS COMPANY

1. Loosen Diesel Fuel Separator Hose Clamp (3)
2. Disconnect Diesel Fuel Separator Hose (1) @ Fuel Rail (5)
3. Remove and DISCARD Clamp (6)
4. Disconnect Fuel Return Hose (4) @ Diesel Fuel Separator (8)
5. Remove Diesel Fuel Separator Bolt (2)
6. Disconnect Diesel Fuel Separator (8) @ Fuel Injection Pump (7). Refer to **Plastic Collar Quick Connect Fitting Service**

INTAKE MANIFOLD REMOVAL

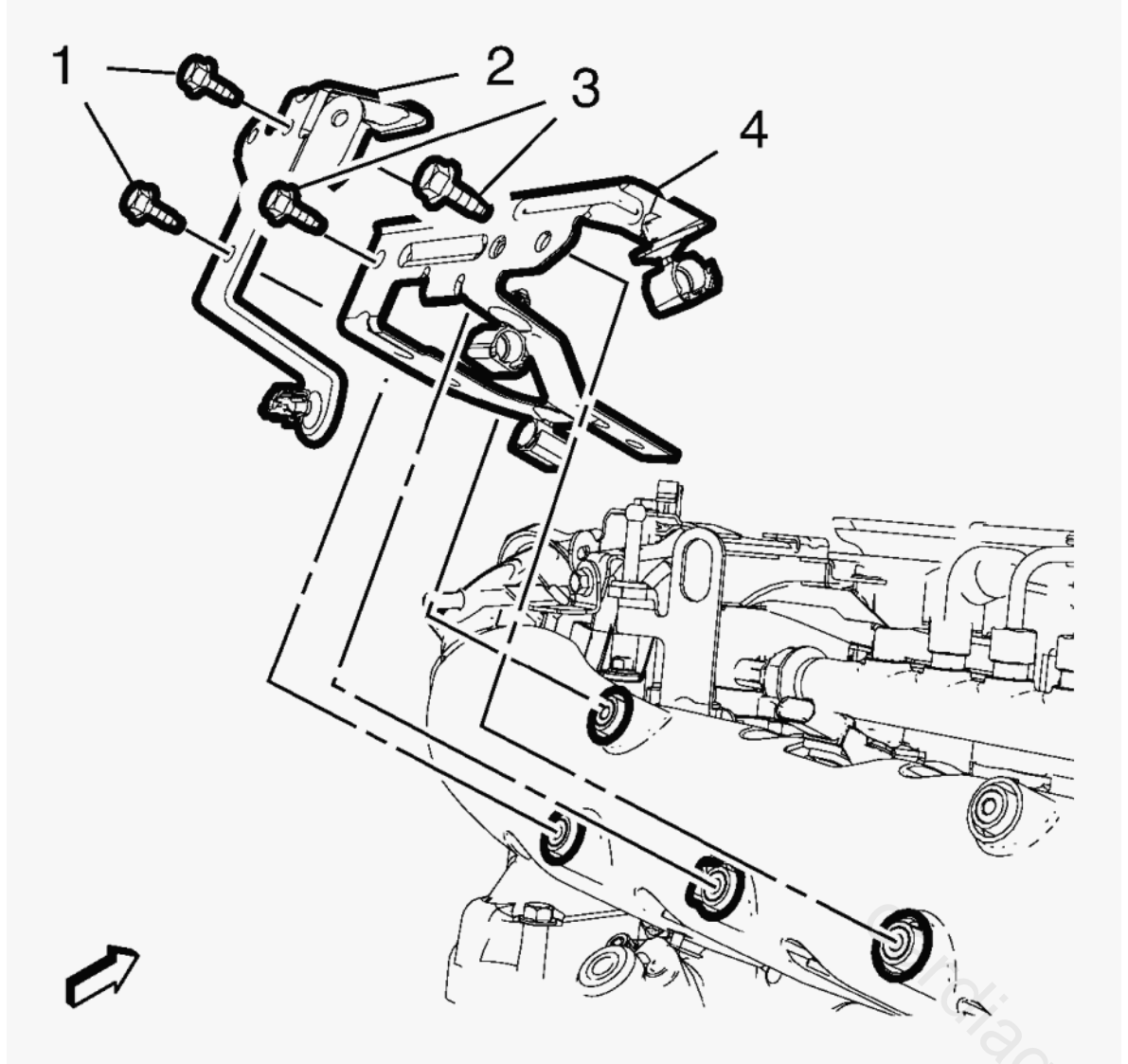


Fig. 613: Fuel Rail Fuel Pressure Sensor Wiring Harness Bracket, Fuel Rail Return Pipe Bracket And Bolts

Courtesy of GENERAL MOTORS COMPANY

1. Remove the 2 fuel rail fuel pressor sensor wiring harness bracket bolts (1).
2. Remove the fuel rail fuel pressor sensor wiring harness bracket (2).
3. Remove the 2 fuel rail return pipe bracket bolts (3).
4. Remove the fuel rail return pipe bracket (4).

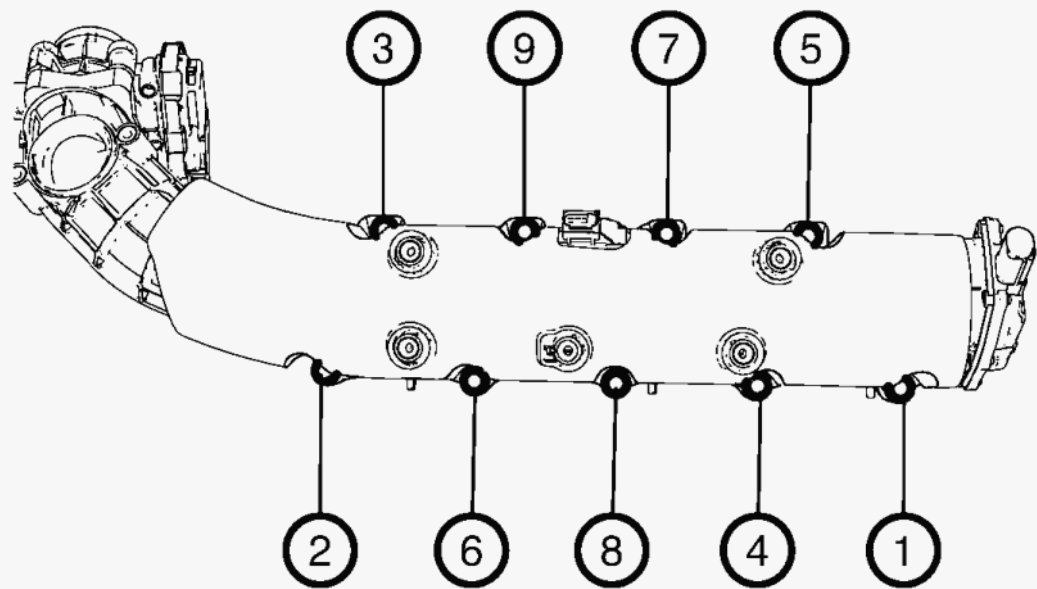


Fig. 614: Intake Manifold Bolt Loosening Sequence
Courtesy of GENERAL MOTORS COMPANY

5. Loosen 9 intake manifold bolts in the sequence as shown.

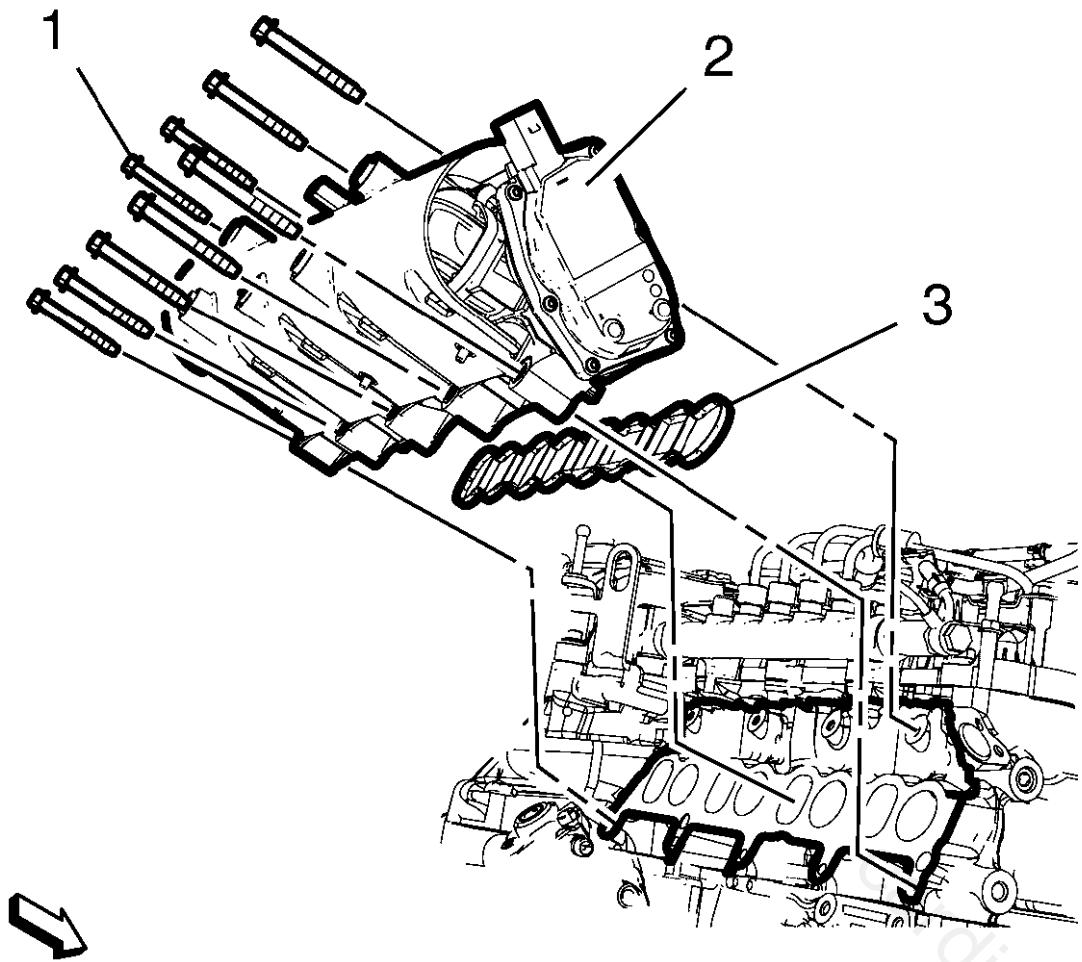


Fig. 615: Intake Manifold, Bolts And Gasket
Courtesy of GENERAL MOTORS COMPANY

6. Remove the 9 intake manifold bolts (1).
7. Remove the intake manifold (2).
8. Remove and DISCARD the intake manifold gasket (3).

CHARGE AIR BYPASS REGULATOR SOLENOID VALVE VACUUM TUBE REMOVAL

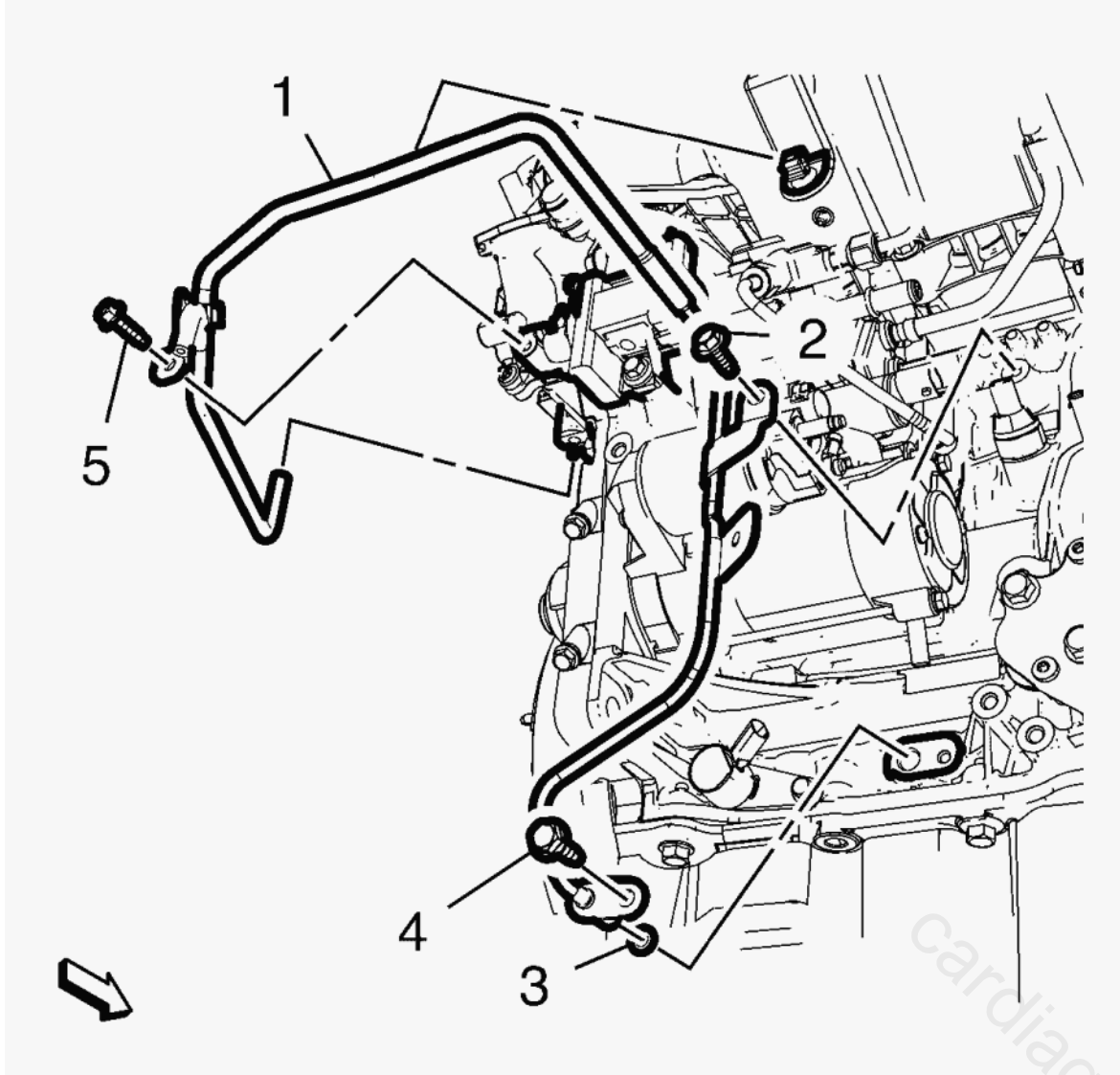


Fig. 616: Charge Air Bypass Regulator Solenoid Valve Vacuum Tube Components
Courtesy of GENERAL MOTORS COMPANY

1. Remove the 3 charge air bypass valve vacuum hose bracket bolts (2, 4, 5).
2. Disconnect the charge air bypass valve vacuum hose (1) from the exhaust gas recirculation vacuum regulator solenoid valve.
3. Unclip the charge air bypass valve vacuum hose retainer clip.
4. Remove the charge air bypass valve vacuum hose (1).
5. Remove the charge air bypass valve vacuum hose seal (3).

POWER BRAKE BOOSTER INLET HOSE CONNECTOR FITTING REMOVAL

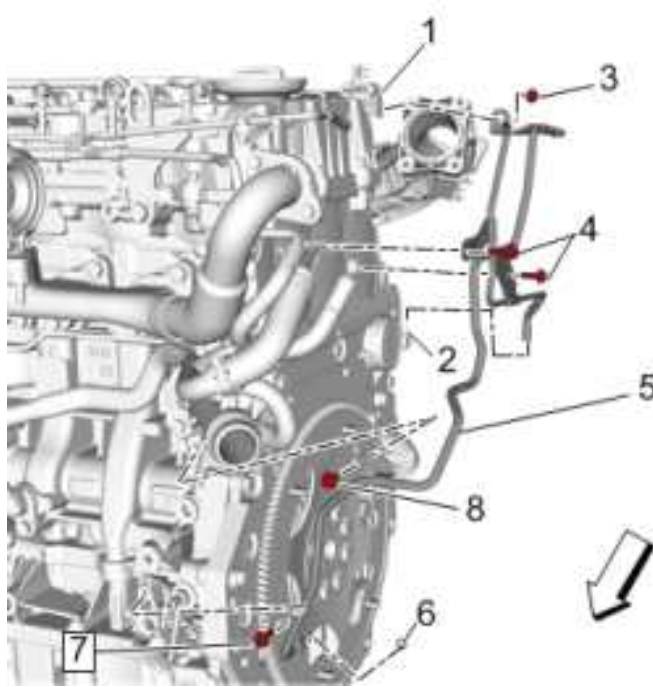


Fig. 617: Power Brake Booster Inlet Hose Connector Fitting And Components
Courtesy of GENERAL MOTORS COMPANY

1. Remove the power brake booster inlet hose connector fitting bracket bolt (3) from the exhaust temperature sensor wiring harness bracket (1).
2. Remove the 2 power brake booster inlet hose connector fitting bolts (4)
3. Remove the power brake booster inlet hose from the turbocharger wastegate actuator vacuum control solenoid valve (2).
4. Remove the power brake booster inlet hose connector fitting bolt (7) from the lower crankcase.
5. Remove the power brake booster inlet hose connector fitting (5).
6. Remove the power brake booster inlet hose connector fitting seal (6).

STARTER REMOVAL

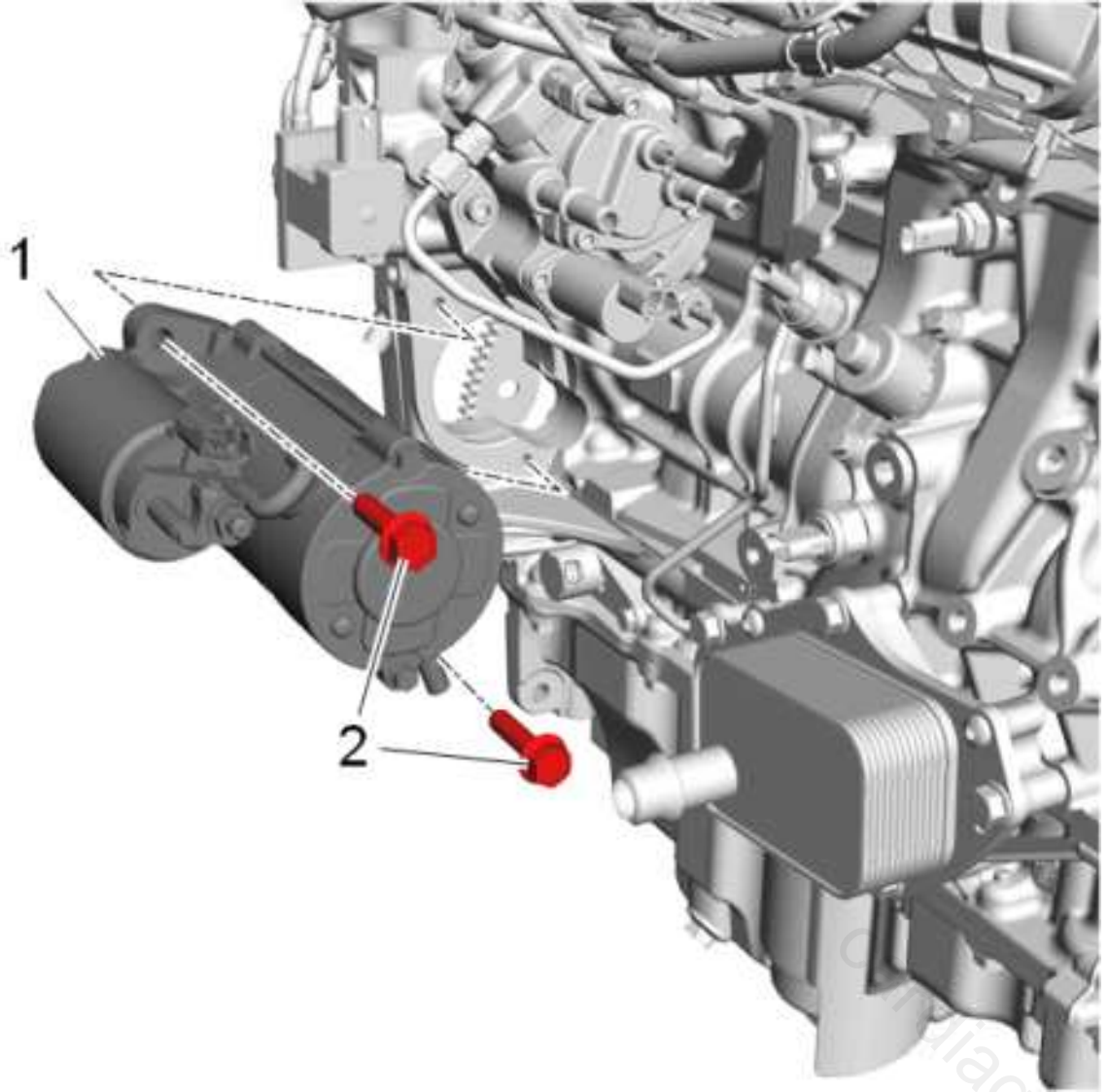


Fig. 618: Starter And Bolts

Courtesy of GENERAL MOTORS COMPANY

1. Remove the 2 starter bolts (2).
2. Remove the starter (1).

GENERATOR REMOVAL

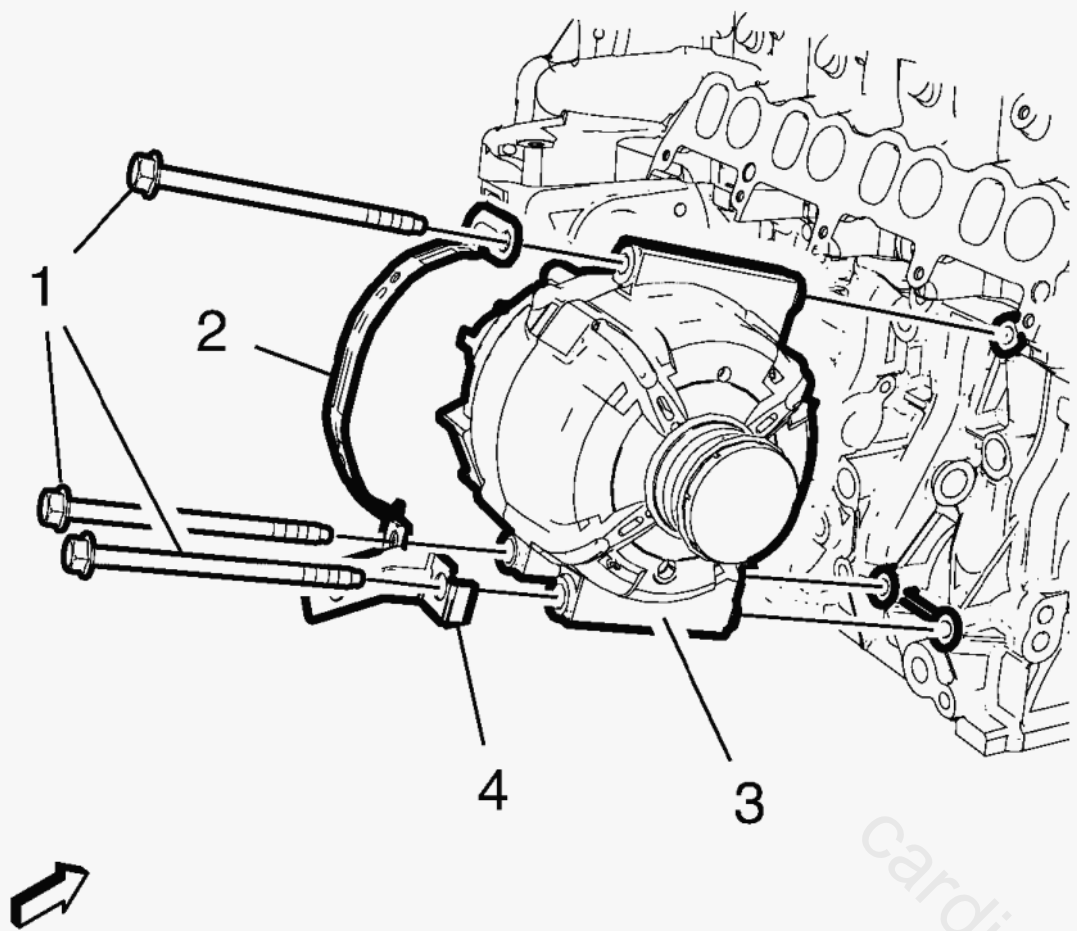


Fig. 619: Generator, Bolts And Wiring Brackets
Courtesy of GENERAL MOTORS COMPANY

1. Remove the 3 generator bolts (1).
2. Remove the wiring harness bracket (2).
3. Remove the nitrogen oxide sensor wire bracket (4).
4. Remove the generator (3).

ENGINE OIL COOLER REMOVAL

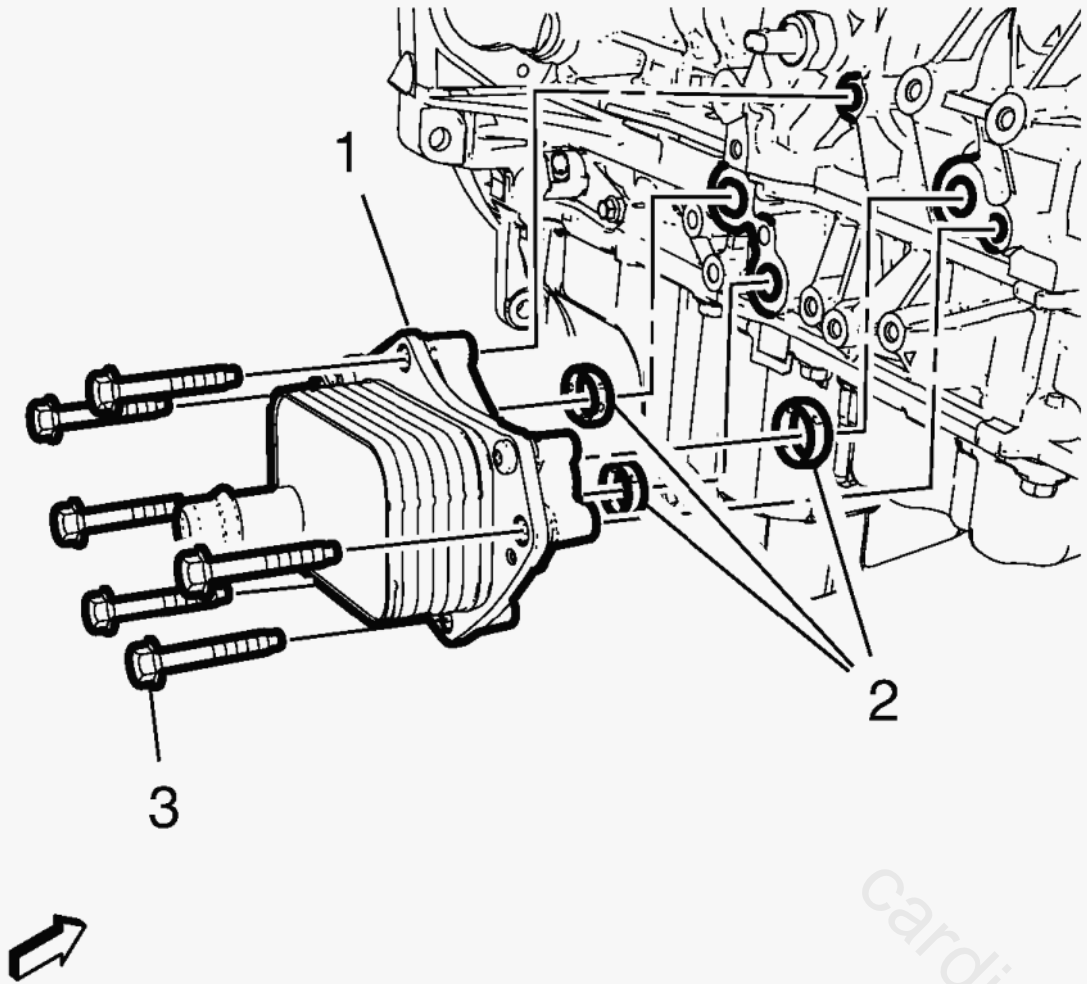


Fig. 620: Engine Oil Cooler, Bolts And Gaskets
Courtesy of GENERAL MOTORS COMPANY

1. Remove the 6 oil cooler bolts (3).
2. Remove and DISCARD the 3 oil cooler adapter gaskets (2).
3. Remove the oil cooler with oil cooler adapter (1).

FUEL INJECTION FUEL FEED PIPE REMOVAL - FUEL RAIL TO FUEL INJECTOR

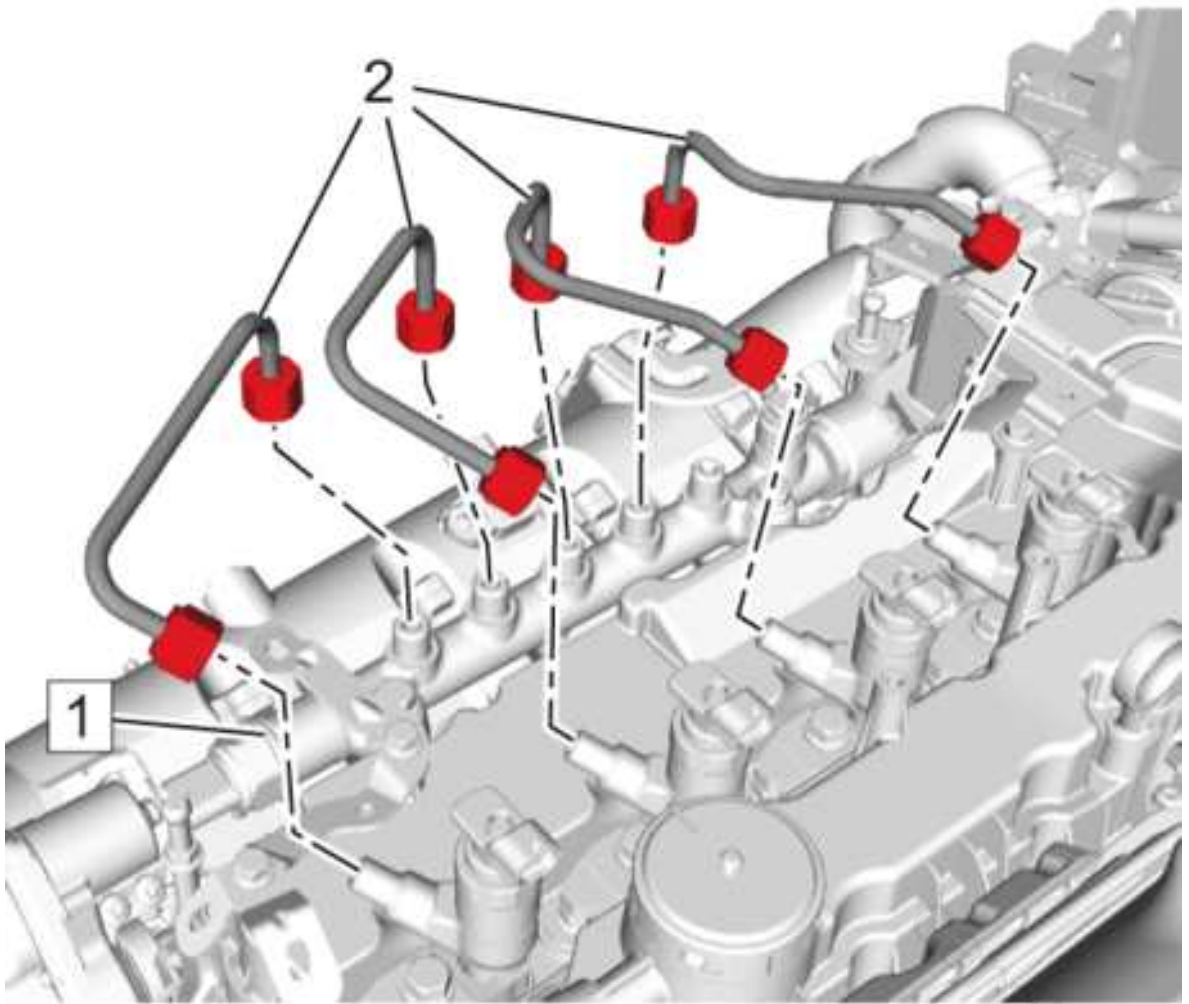


Fig. 621: Fuel Injection Fuel Feed Pipes And Fuel Rail
Courtesy of GENERAL MOTORS COMPANY

1. Loosen Fuel Injection Fuel Feed Pipes (2) (Qty: 4) @ Fuel Rail (1)
2. Loosen Fuel Injection Fuel Feed Pipes (2) (Qty: 4) @ Fuel Injector (3)
3. Remove and DISCARD Fuel Injection Fuel Feed Pipes (2) (Qty: 4)

FUEL PRESSURE SENSOR REMOVAL

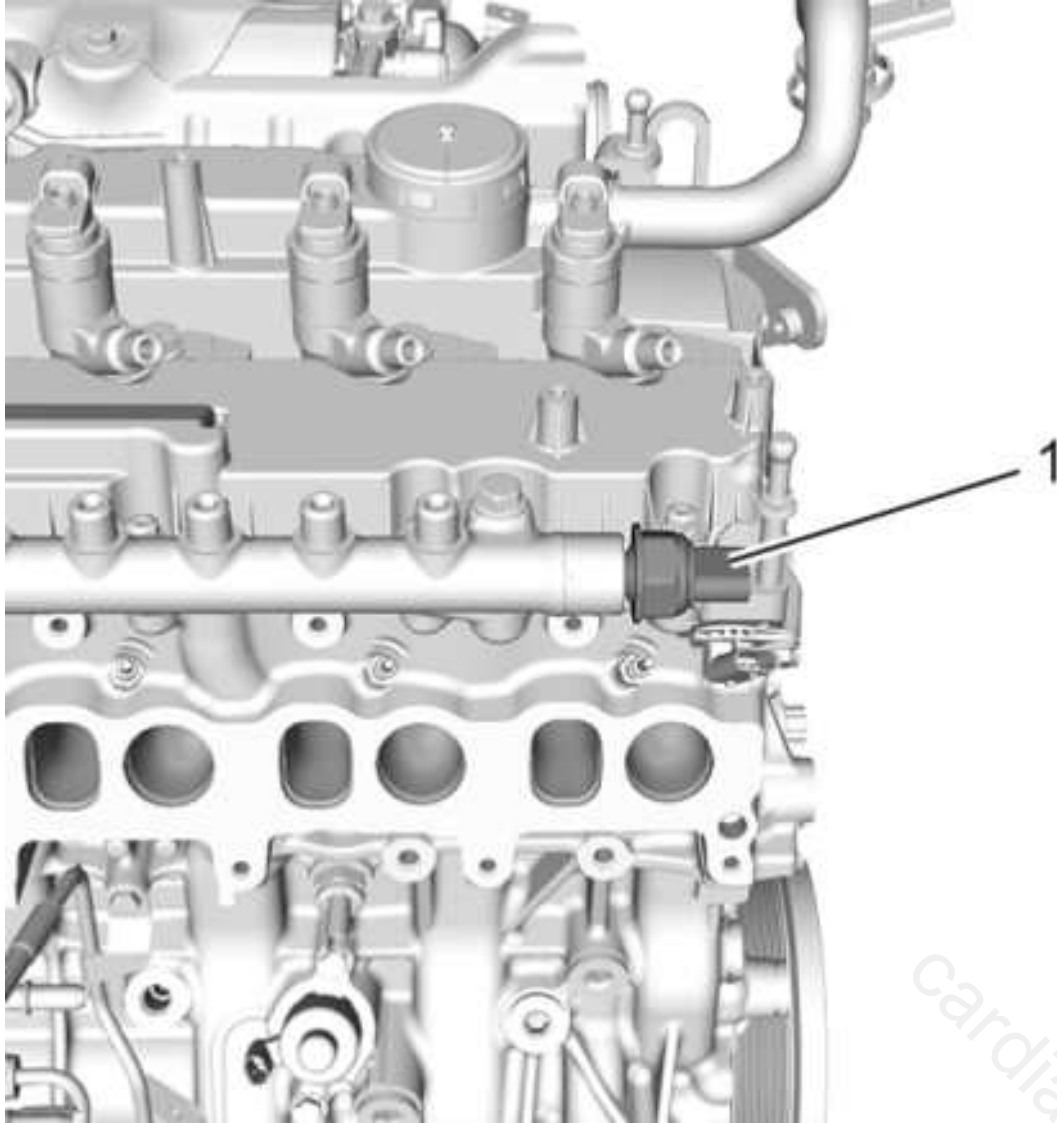


Fig. 622: Fuel Injection Fuel Rail Fuel Pressure Sensor
Courtesy of GENERAL MOTORS COMPANY

1. Remove and DISCARD Fuel Injection Fuel Rail Fuel Pressure Sensor (1)

FUEL RAIL REMOVAL

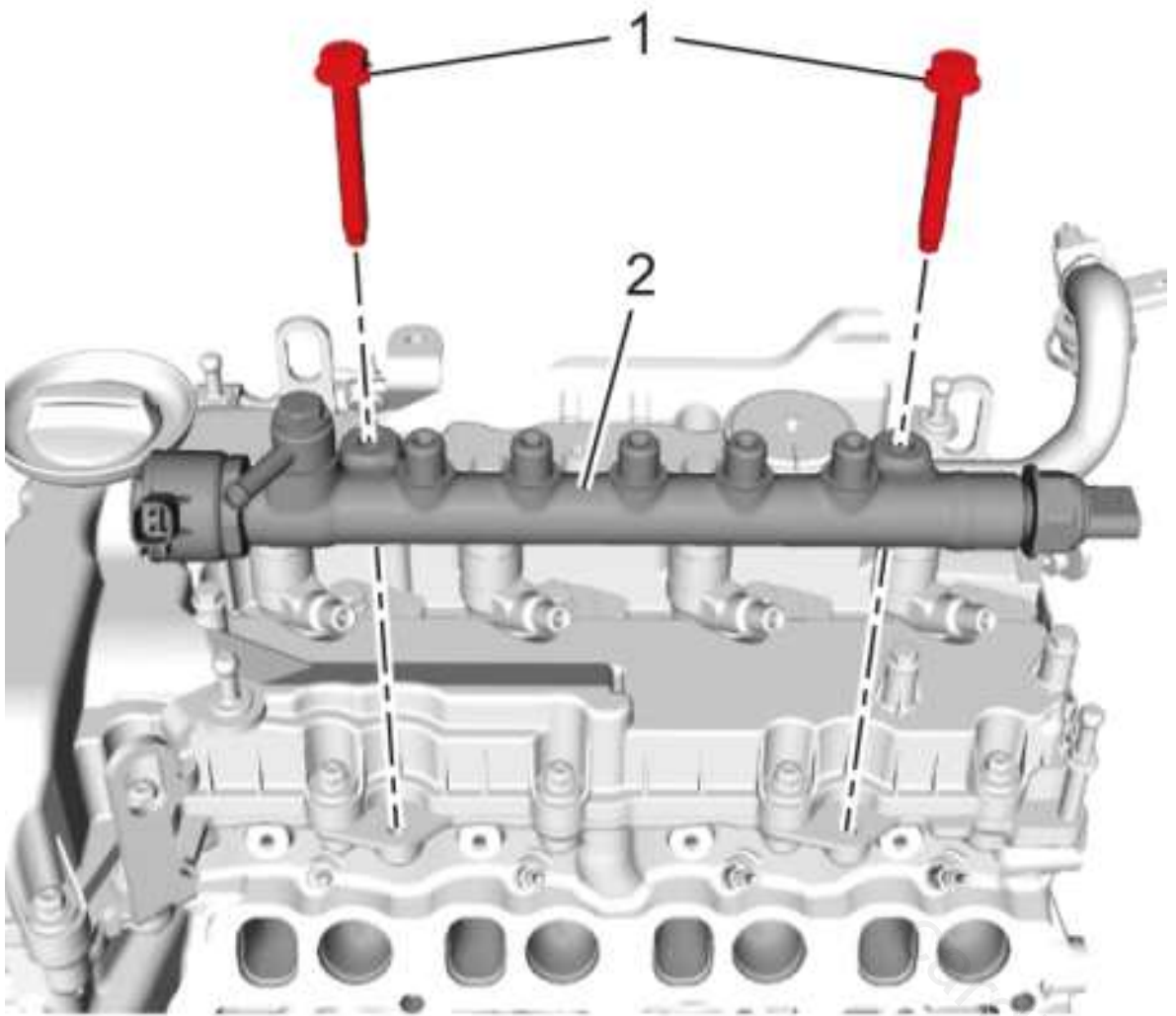


Fig. 623: Fuel Injection Fuel Rail And Bolts

Courtesy of GENERAL MOTORS COMPANY

1. Remove Fuel Injection Fuel Rail Bolts (1) (Qty: 2)
2. Remove Fuel Injection Fuel Rail (2)

FUEL INJECTOR REMOVAL

Special Tools

- EN-51146-1-3 Sliding Hammer
- EN-51187 Injector Remover

Equivalent regional tools: [Special Tools](#)

WARNING: Refer to [Diesel/Gasoline Vapors Warning](#)

WARNING: Always wear safety goggles when working with fuel in order to protect the eyes from fuel splash.

NOTE:

- Be very thorough in terms of cleanliness when working in the fuel system. Malfunctions can also occur due to very small dirt particles. Prevent dirt from entering the fuel system by cleaning the hoses and plugging the pipes and lines upon removal. Store the components so that contaminants cannot enter.
- In order to reuse the injectors, mark the injectors so that they can be installed to the same cylinder.

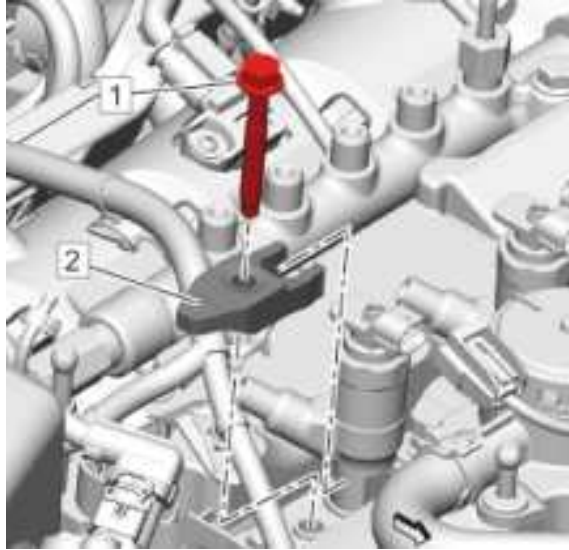


Fig. 624: Fuel Injector Brackets And Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Remove and DISCARD Fuel Injector Bracket Bolts (1) (Qty: 4)
2. Remove Fuel Injector Brackets (2) (Qty: 4)

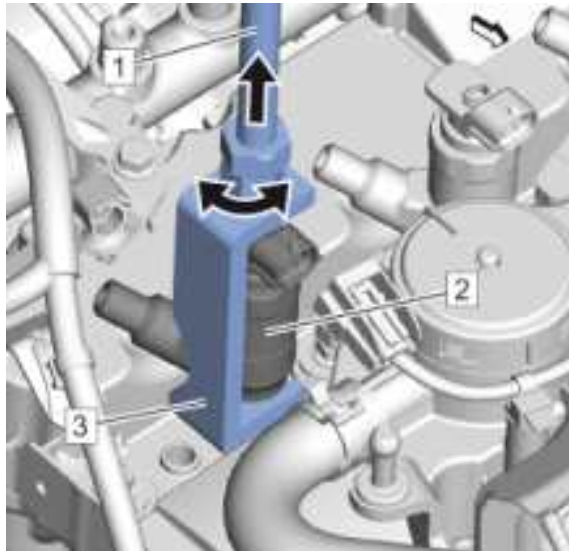


Fig. 625: Fuel Injector And Special Tools
Courtesy of GENERAL MOTORS COMPANY

NOTE: If the injector can not be removed by hand, use the EN-51187 remover and solve the Injector by turning at the hexagon.

3. Pull out the 4 fuel injectors (2) with the EN-51187 remover (3) along with the EN-51146-1-3 sliding hammer (1).

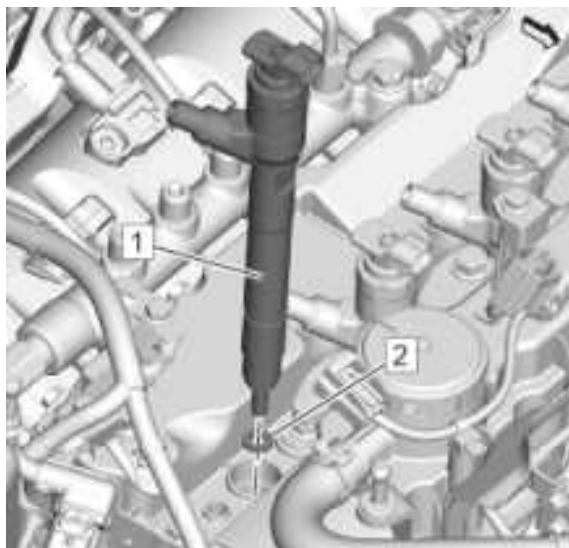


Fig. 626: Fuel Injectors And Washers
Courtesy of GENERAL MOTORS COMPANY

4. Remove Fuel Injectors (1) (Qty: 4)
5. Remove and DISCARD Fuel Injector Washers (2) (Qty: 4)
6. Protect the 4 fuel injector nozzles with suitable closure caps.

CAMSHAFT HOUSING REMOVAL

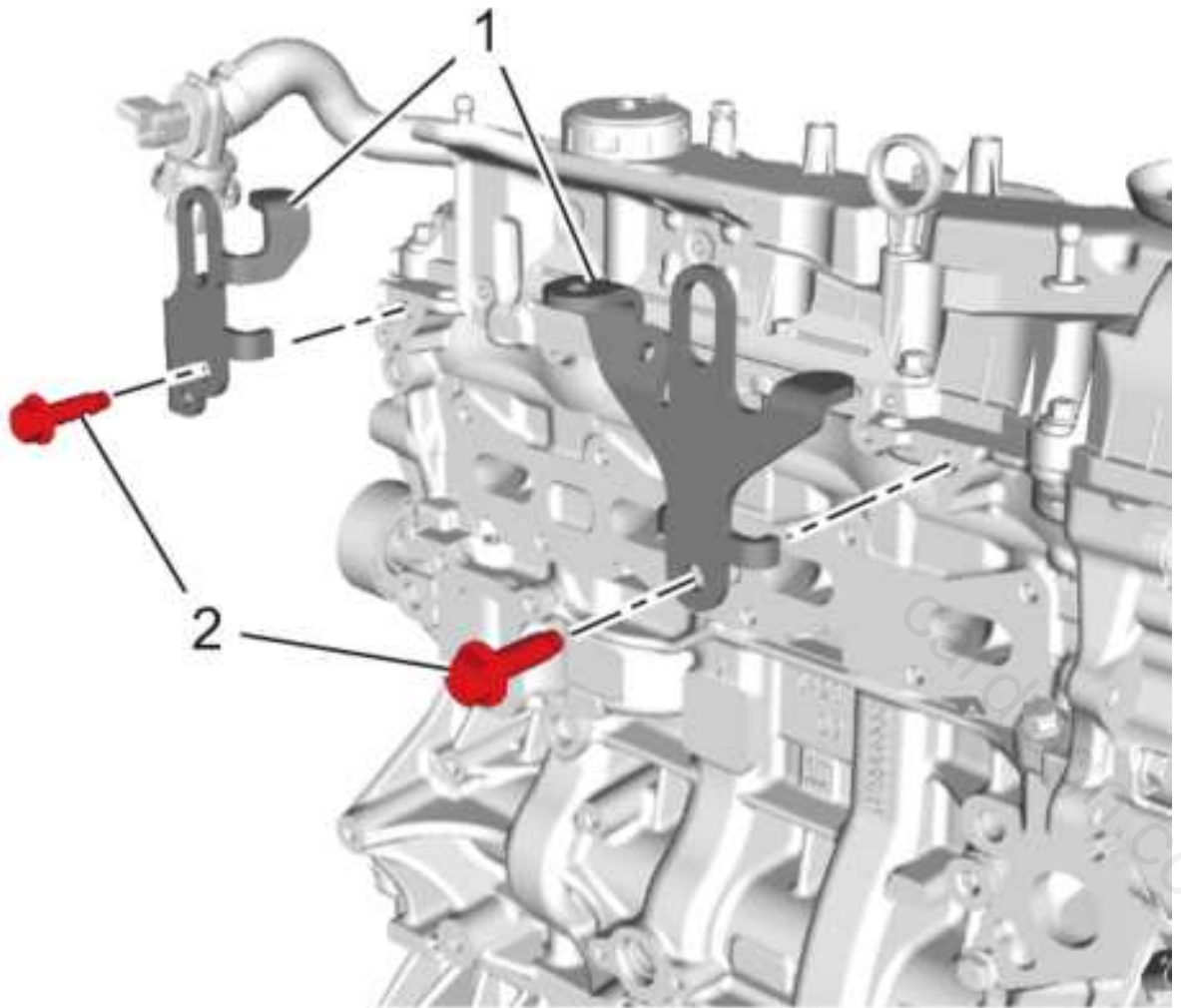


Fig. 627: Engine Lift Brackets And Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Remove Engine Lift Bracket Bolts (2) (Qty: 2)
2. Remove Engine Lift Brackets (1) (Qty: 2)

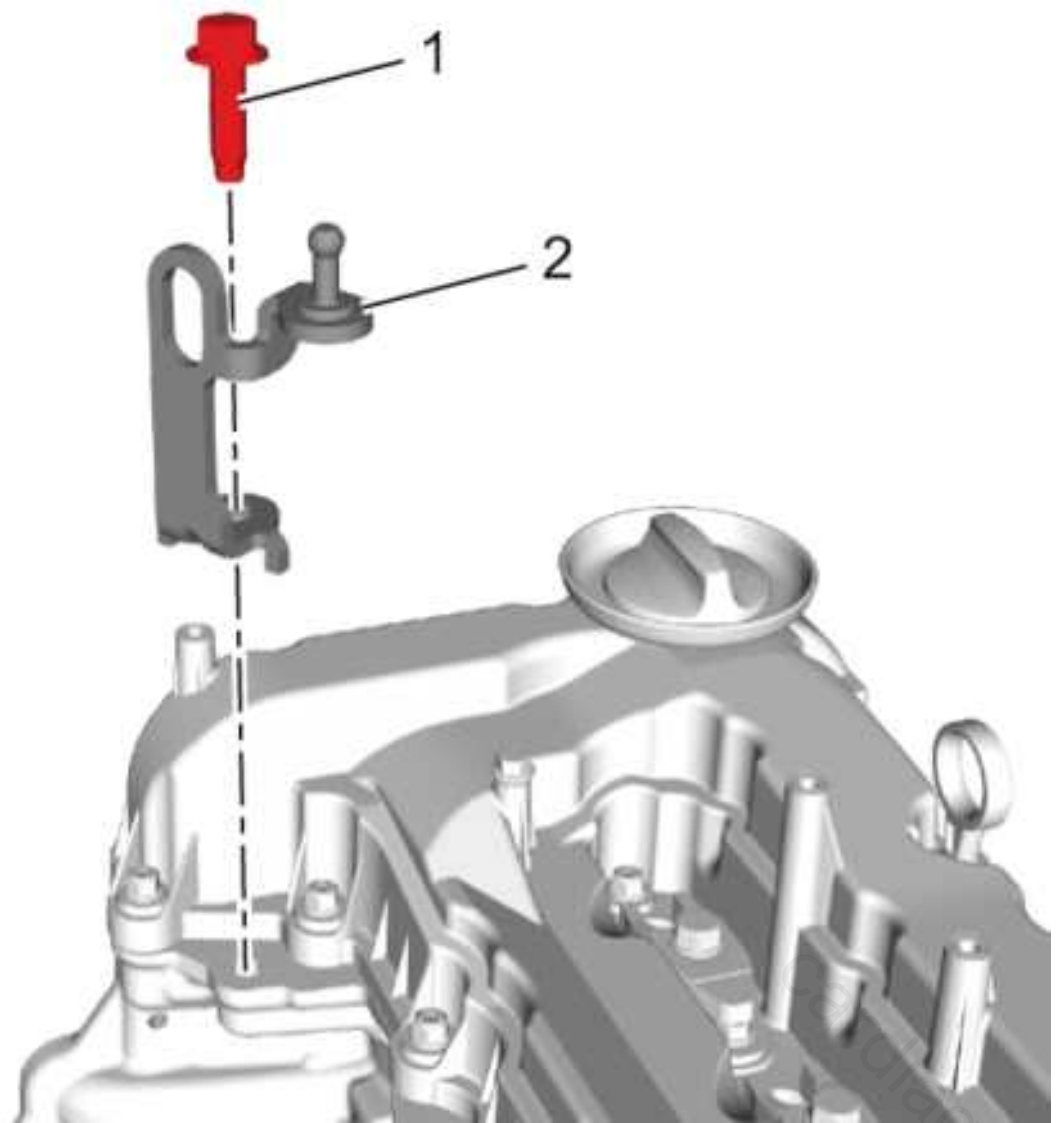


Fig. 628: Engine Lift Bracket And Bolt

Courtesy of GENERAL MOTORS COMPANY

3. Remove Engine Lift Bracket Bolt (1)
4. Remove Engine Lift Bracket (2)

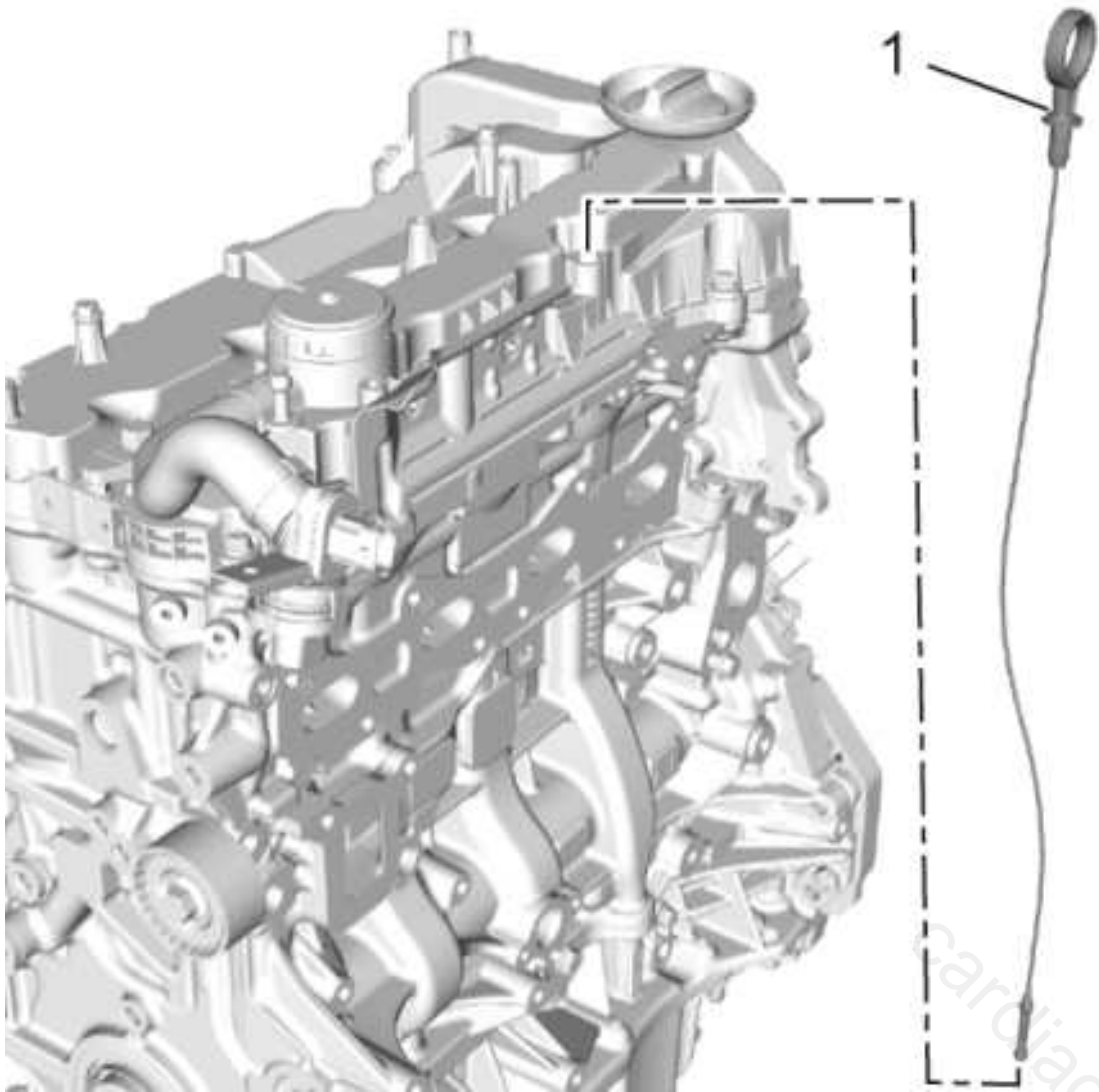


Fig. 629: Engine Oil Level Indicator

Courtesy of GENERAL MOTORS COMPANY

5. Remove Engine Oil Level Indicator (1)

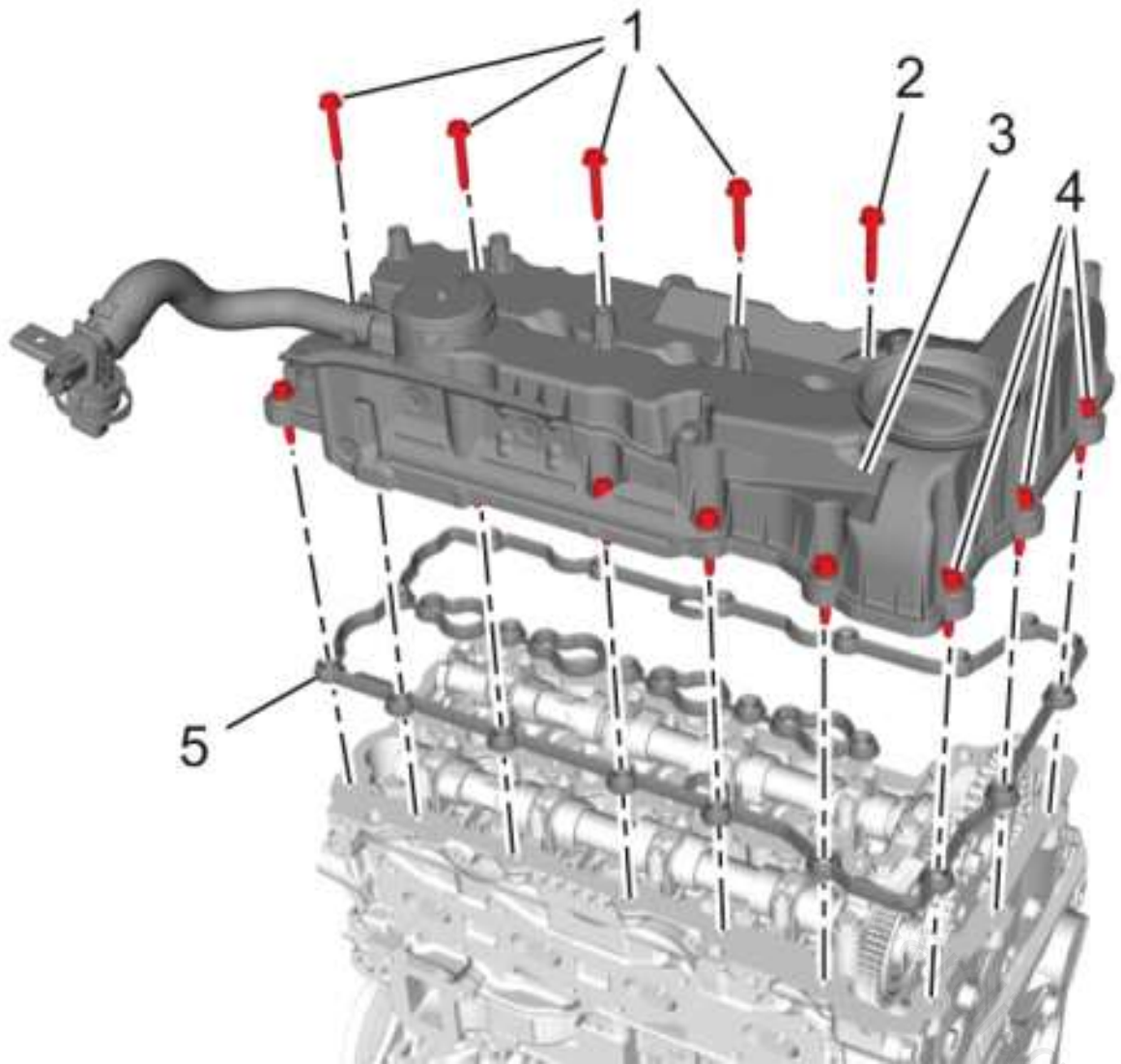


Fig. 630: Camshaft Housing, Bolts And Gasket
Courtesy of GENERAL MOTORS COMPANY

NOTE: Mind the different bolts.

6. Remove Camshaft Housing Bolt - Outer (4) (Qty: 15)
7. Remove Camshaft Housing Bolt - Inner (1, 2) (Qty: 5)
8. Remove Camshaft Housing (3)
9. Remove and DISCARD Camshaft Housing Gasket (5)

TIMING CHAIN UPPER COVER REMOVAL

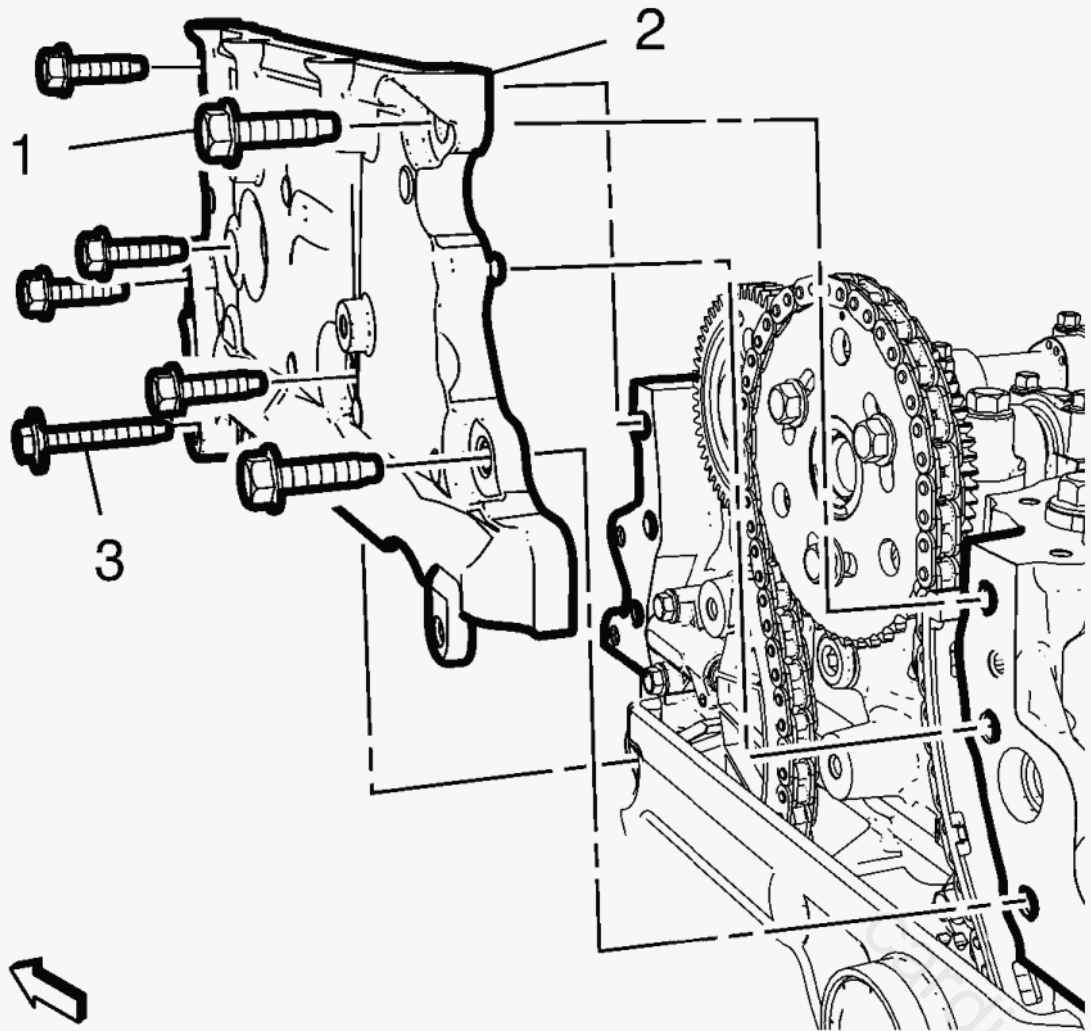


Fig. 631: Timing Chain Upper Cover And Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Remove the 6 timing chain upper cover bolts (1).
2. Remove the sleeve bolt (3).
3. Remove the timing chain upper cover (2), by loosen the timing chain upper cover from the cylinder head with a suitable tool.

CRANKSHAFT POSITION SENSOR REMOVAL

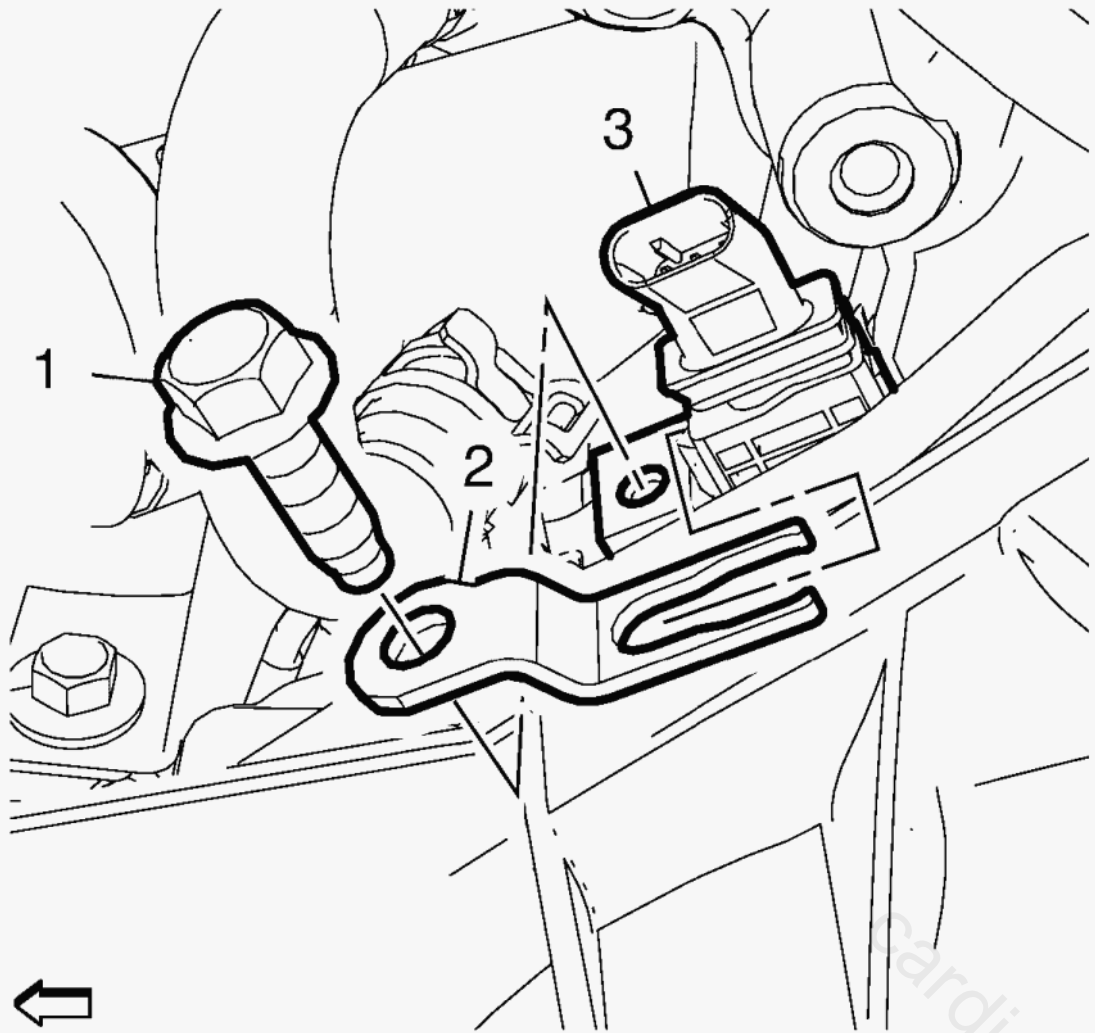


Fig. 632: Crankshaft Position Sensor, Bolt And Retainer Spring
Courtesy of GENERAL MOTORS COMPANY

1. Remove the crankshaft position sensor bolt (1).
2. Remove the crankshaft position sensor retainer spring (2) from the crankshaft position sensor (3)

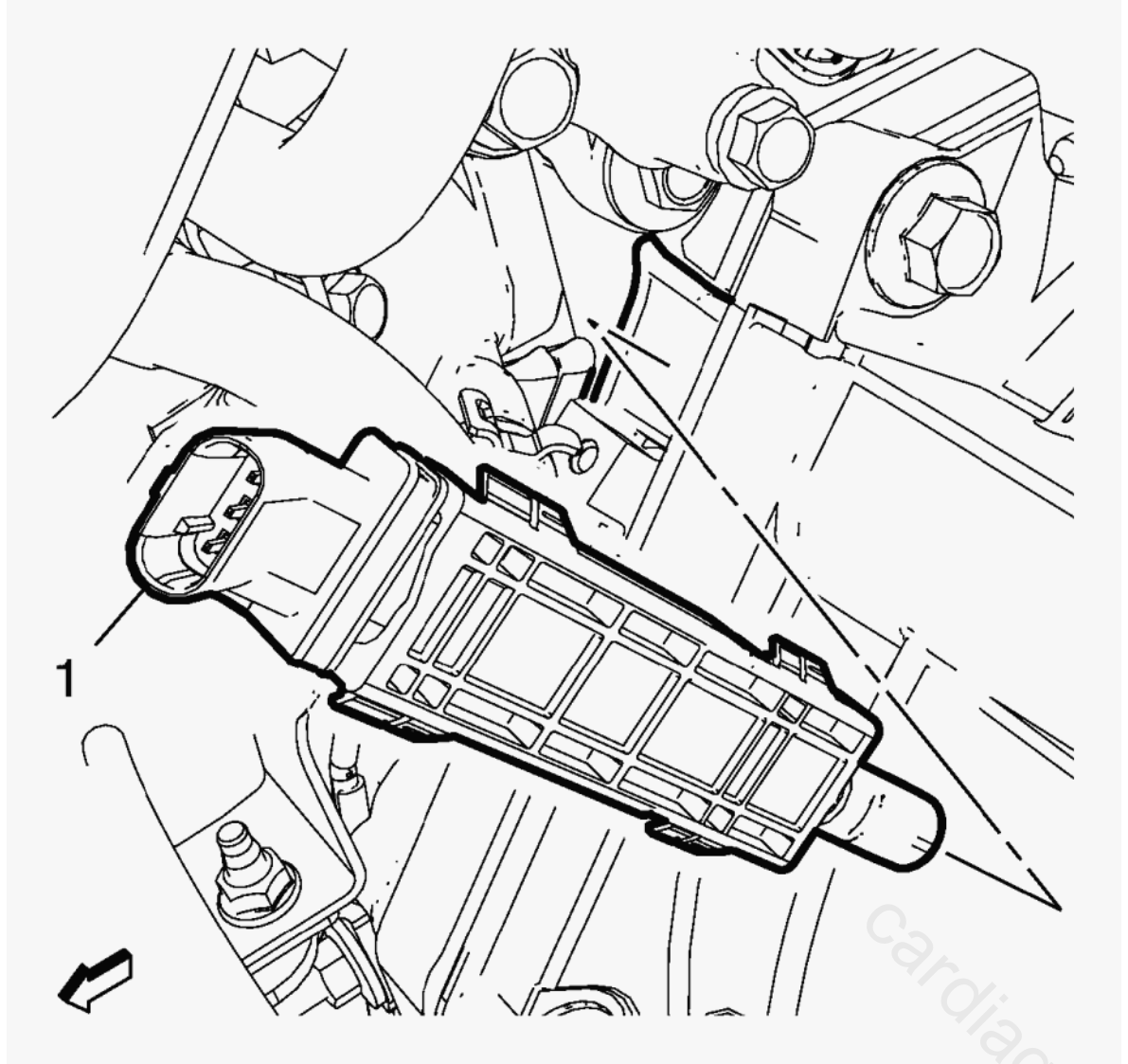


Fig. 633: Crankshaft Position Sensor

Courtesy of GENERAL MOTORS COMPANY

3. Remove the crankshaft position sensor (1).

CRANKSHAFT POSITION SENSOR RELUCTOR RING REMOVAL

Special Tools

EN-652 Flywheel Holder

Equivalent regional tools: [Special Tools](#)

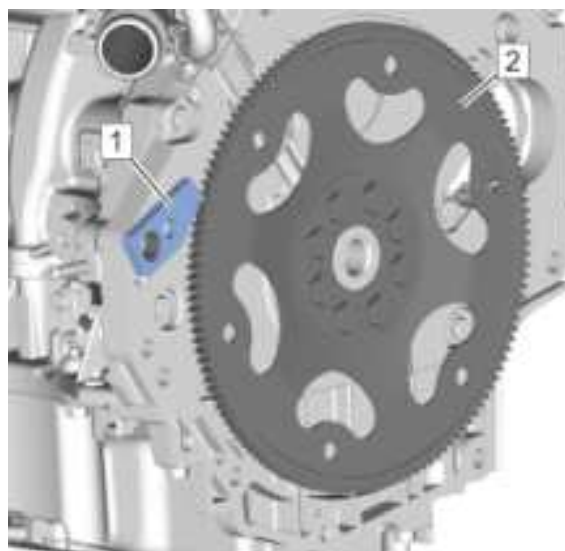


Fig. 634: Flex Plate Holder

Courtesy of GENERAL MOTORS COMPANY

1. Install the **EN-652** flywheel holder (1) in order to fix the automatic transmission flex plate (2).

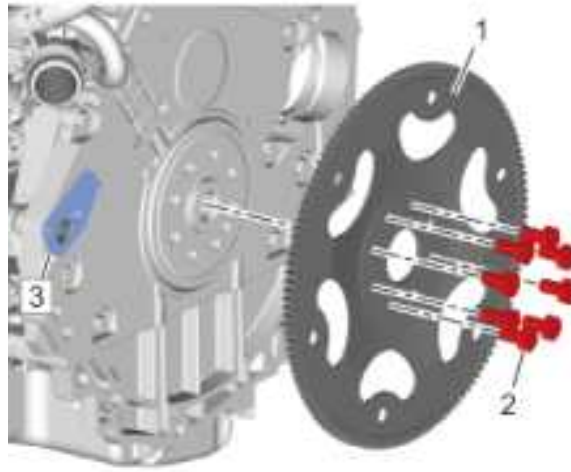


Fig. 635: Automatic Transmission Flex Plate And Bolts
Courtesy of GENERAL MOTORS COMPANY

2. Remove and DISCARD Automatic Transmission Flex Plate Bolts (2) (Qty: 8)
3. Remove the **EN-652** flywheel holder (3).
4. Remove Automatic Transmission Flex Plate (1)

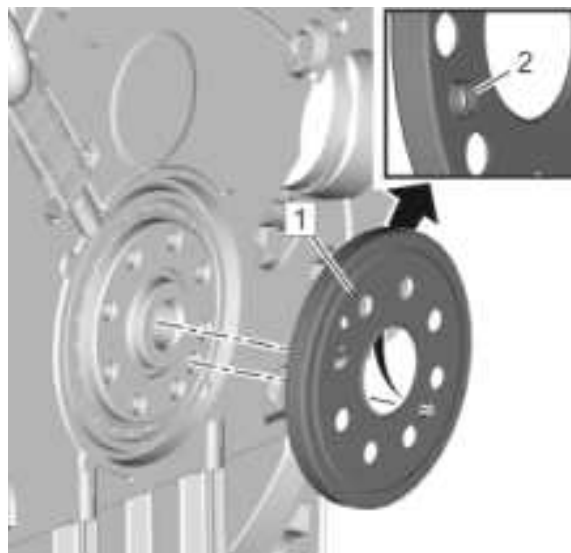


Fig. 636: Crankshaft Position Sensor Reluctor Ring And Pin
Courtesy of GENERAL MOTORS COMPANY

5. Remove Crankshaft Position Sensor Reluctor Ring (1)

CRANKSHAFT REAR OIL SEAL REMOVAL

Special Tools

- **GE-328-B** Pin Remover
- **EN-6624** Remover

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

Removal Procedure

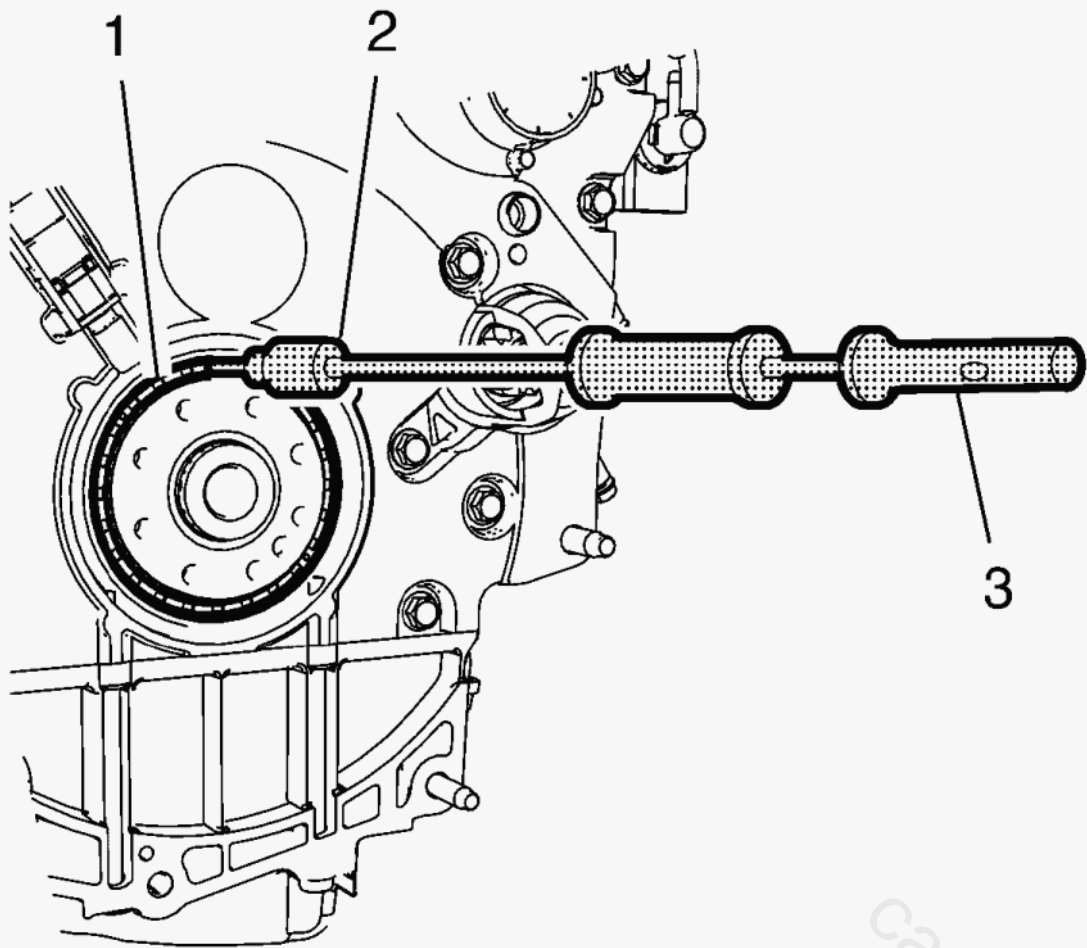


Fig. 637: Crankshaft Rear Oil Seal And Removers
Courtesy of GENERAL MOTORS COMPANY

1. Punch a bore into the crankshaft seal, use a suitable tool.
2. Install the **EN-6624** remover (2) into the oil sealing ring (1).
3. Install the **GE-328-B** remover (3) to the **EN-6624** remover (2).
4. Remove the crankshaft rear oil seal, with the **GE-328-B** remover.

AUTOMATIC TRANSMISSION FLEX PLATE REMOVAL

Special Tools

EN-652 Holder Flex Plate

Equivalent regional tools: **Special Tools**

Removal Procedure



Fig. 638: Flex Plate Holder

Courtesy of GENERAL MOTORS COMPANY

1. Install the **EN-652** holder (1) in order to fix the flex plate.

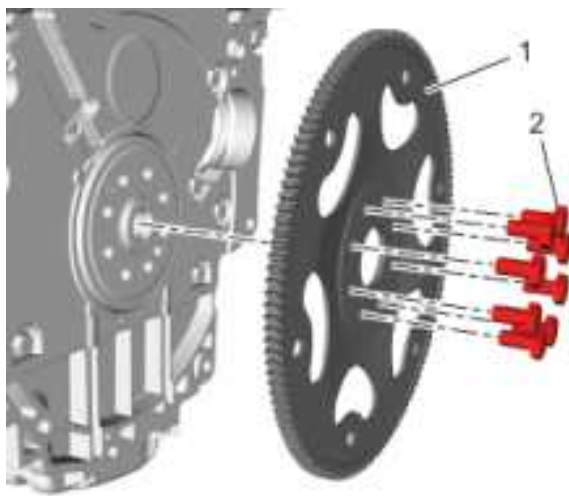


Fig. 639: Automatic Transmission Flex Plate And Bolts

Courtesy of GENERAL MOTORS COMPANY

2. Remove and DISCARD Automatic Transmission Flex Plate Bolts (2) (Qty: 8)
3. Remove the **EN-652** holder.
4. Remove Automatic Transmission Flex Plate (1)

ENGINE FLYWHEEL REMOVAL

Special Tools

EN-652 Flywheel Holder

For equivalent regional tools, refer to [**Special Tools**](#).

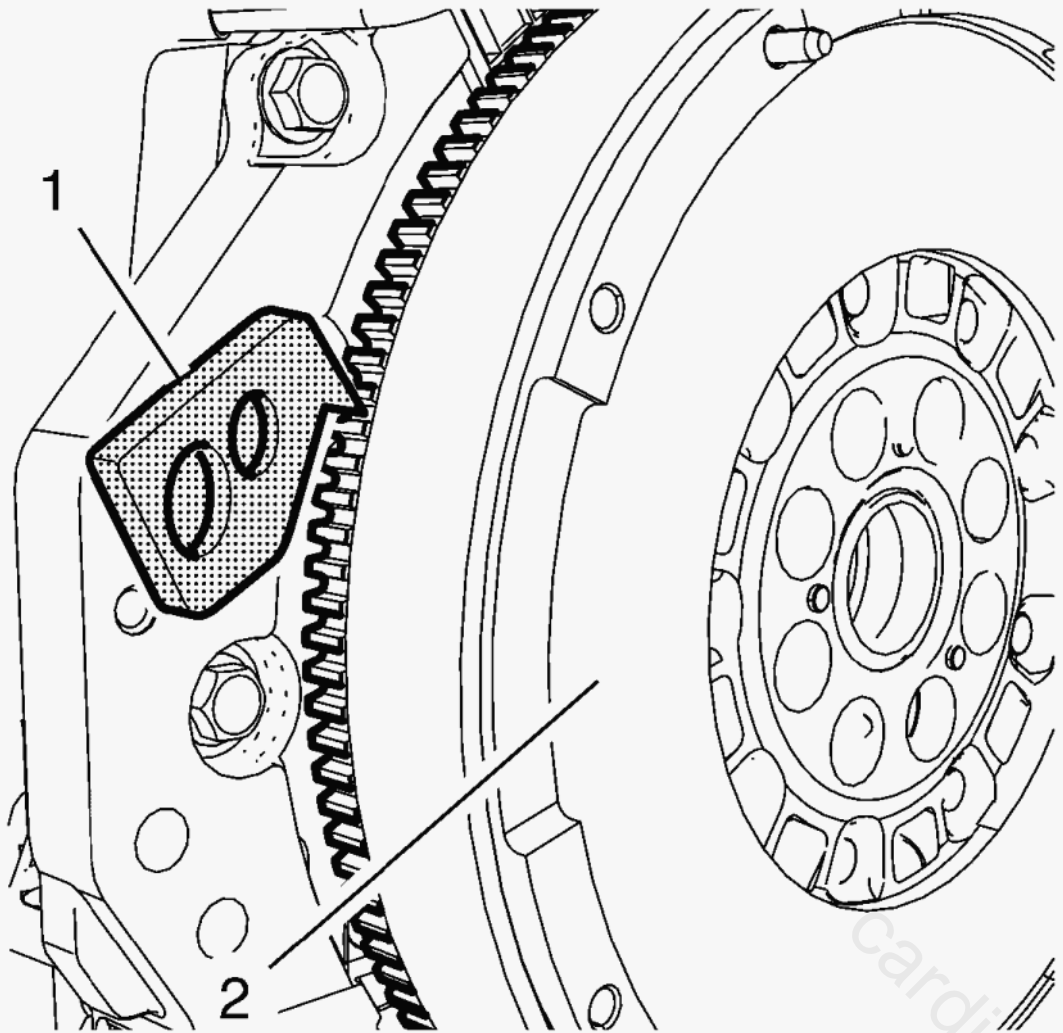


Fig. 640: Flywheel Holder

Courtesy of GENERAL MOTORS COMPANY

1. Install the **EN-652** holder (1) in order to fix the flywheel (2).

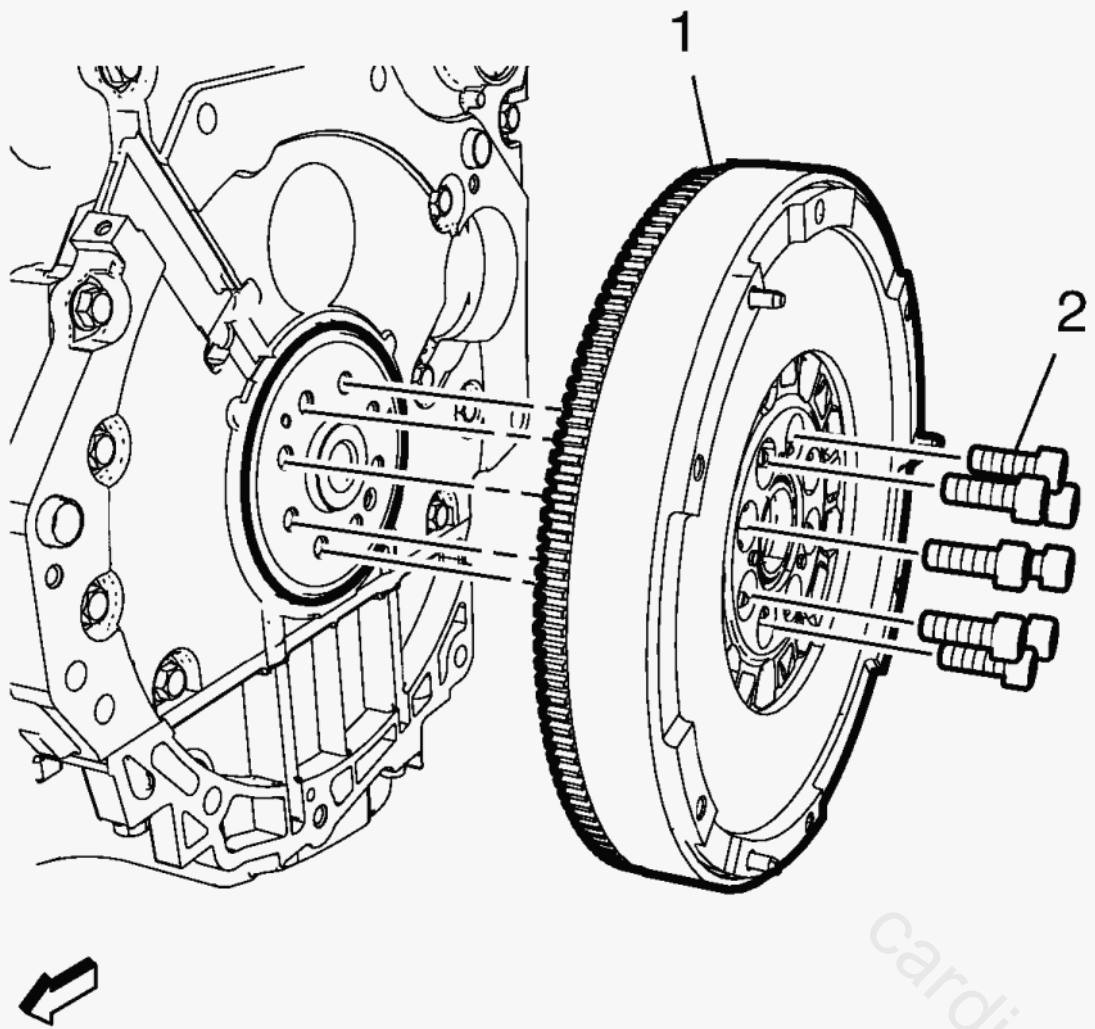


Fig. 641: Engine Flywheel And Bolts

Courtesy of GENERAL MOTORS COMPANY

2. Remove and DISCARD the 8 engine flywheel bolts (2).
3. Remove the EN-652 flywheel holder.
4. Remove the engine flywheel (1).

OIL PAN REMOVAL

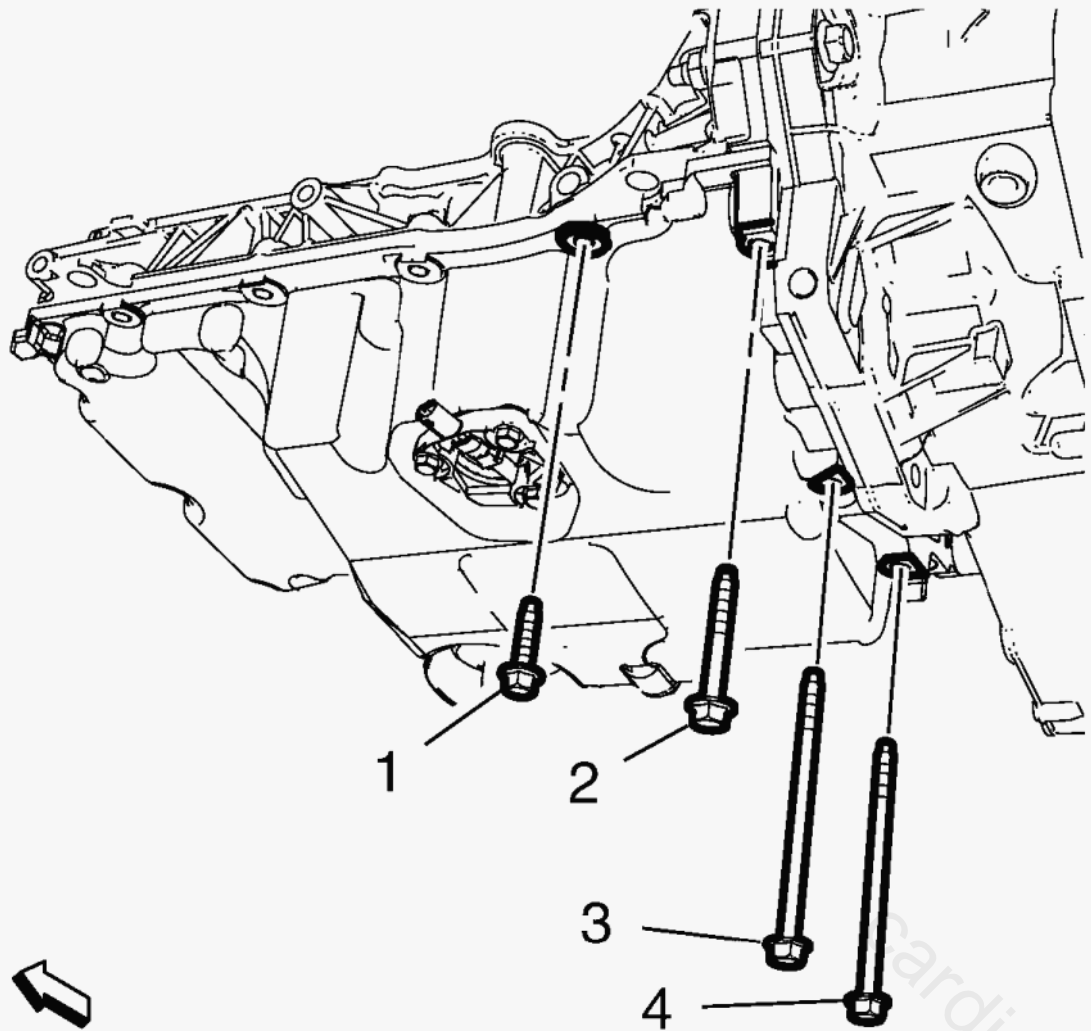


Fig. 642: Oil Pan Bolts

Courtesy of GENERAL MOTORS COMPANY

NOTE: Note the difference bolt lengths.

1. Remove the 2 oil pan bolts (3, 4).
2. Remove the oil pan bolt (2).
3. Remove the 12 oil pan bolts (1).

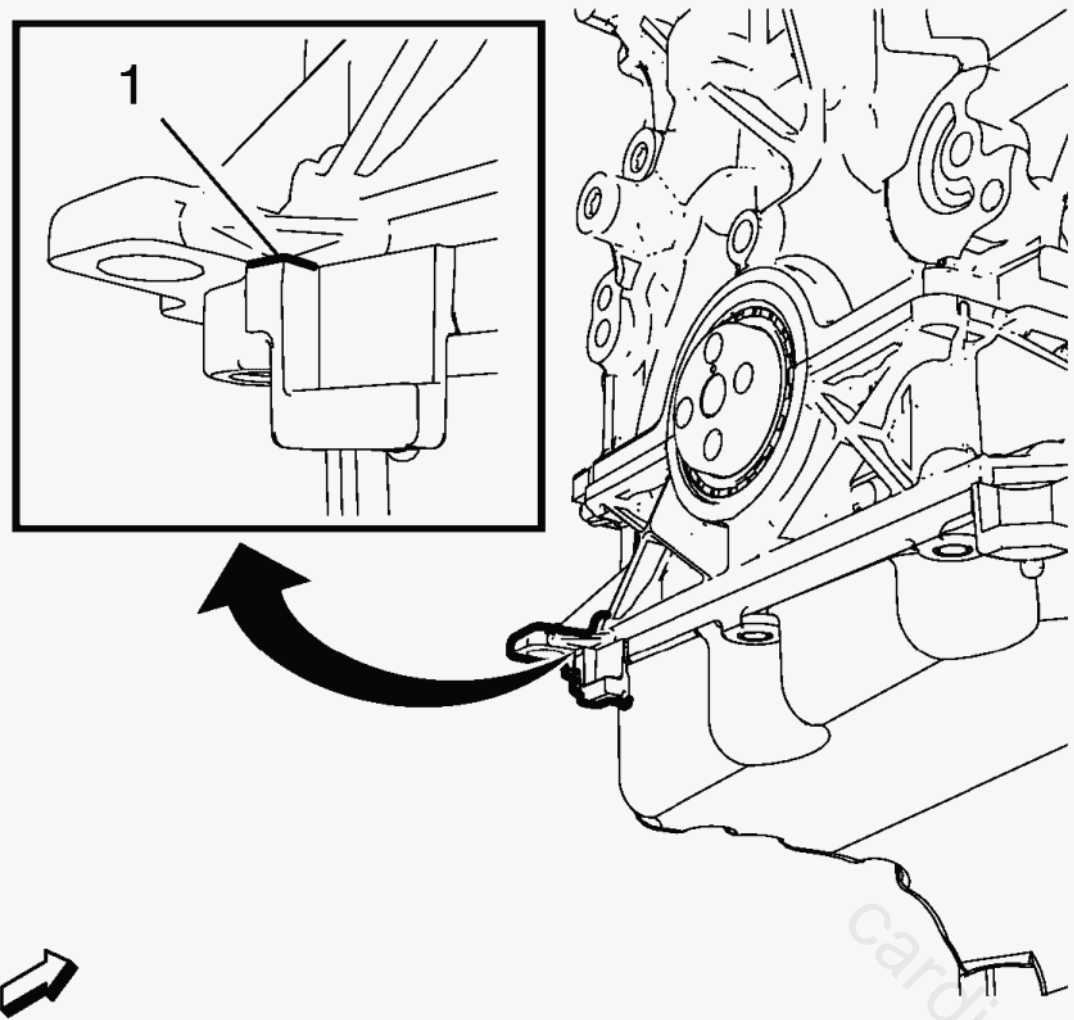


Fig. 643: Oil Pan And Pry Point

Courtesy of GENERAL MOTORS COMPANY

4. Loosen the oil pan carefully from the lower cylinder block, use a suitable tools at the location as shown to pry (1).
5. Remove the oil pan.

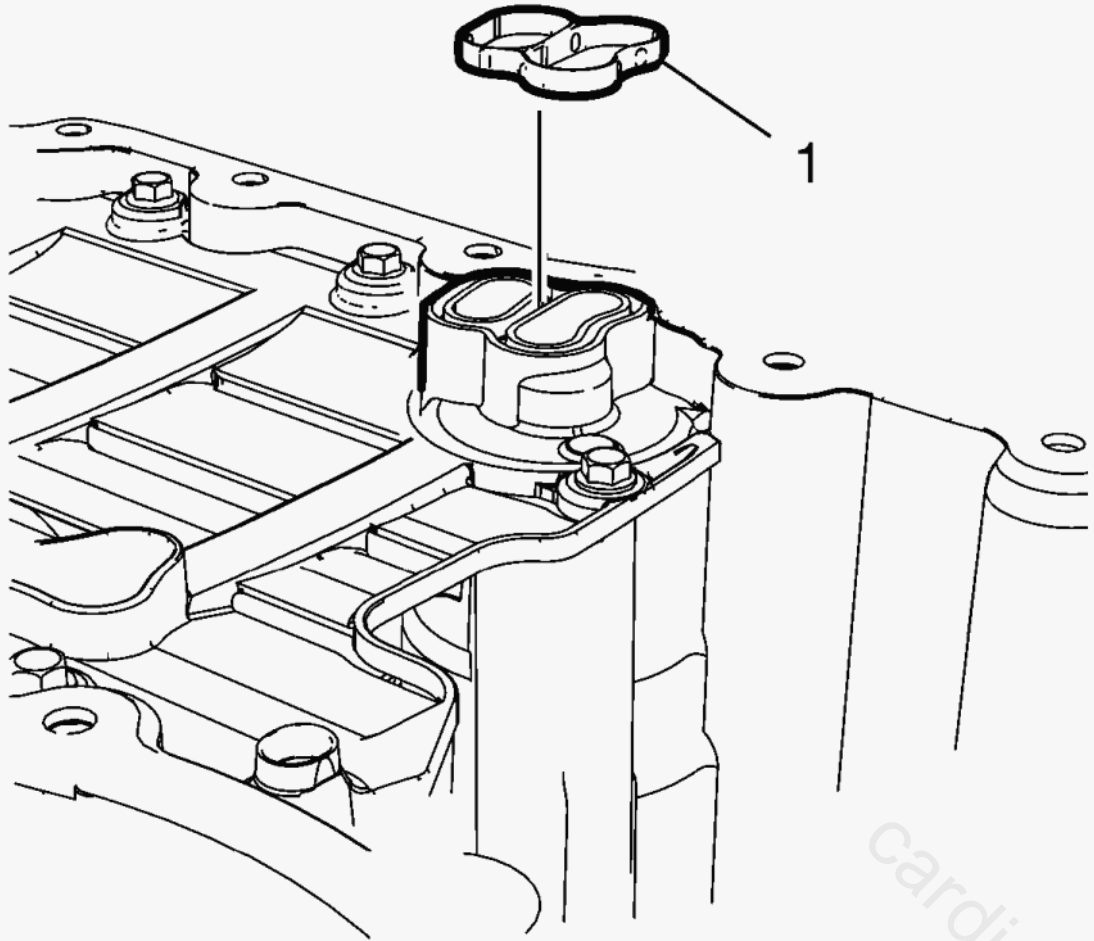


Fig. 644: Oil Filter Seal

Courtesy of GENERAL MOTORS COMPANY

6. Remove and DISCARD the oil filter seal (1).

TIMING CHAIN LOWER COVER REMOVAL

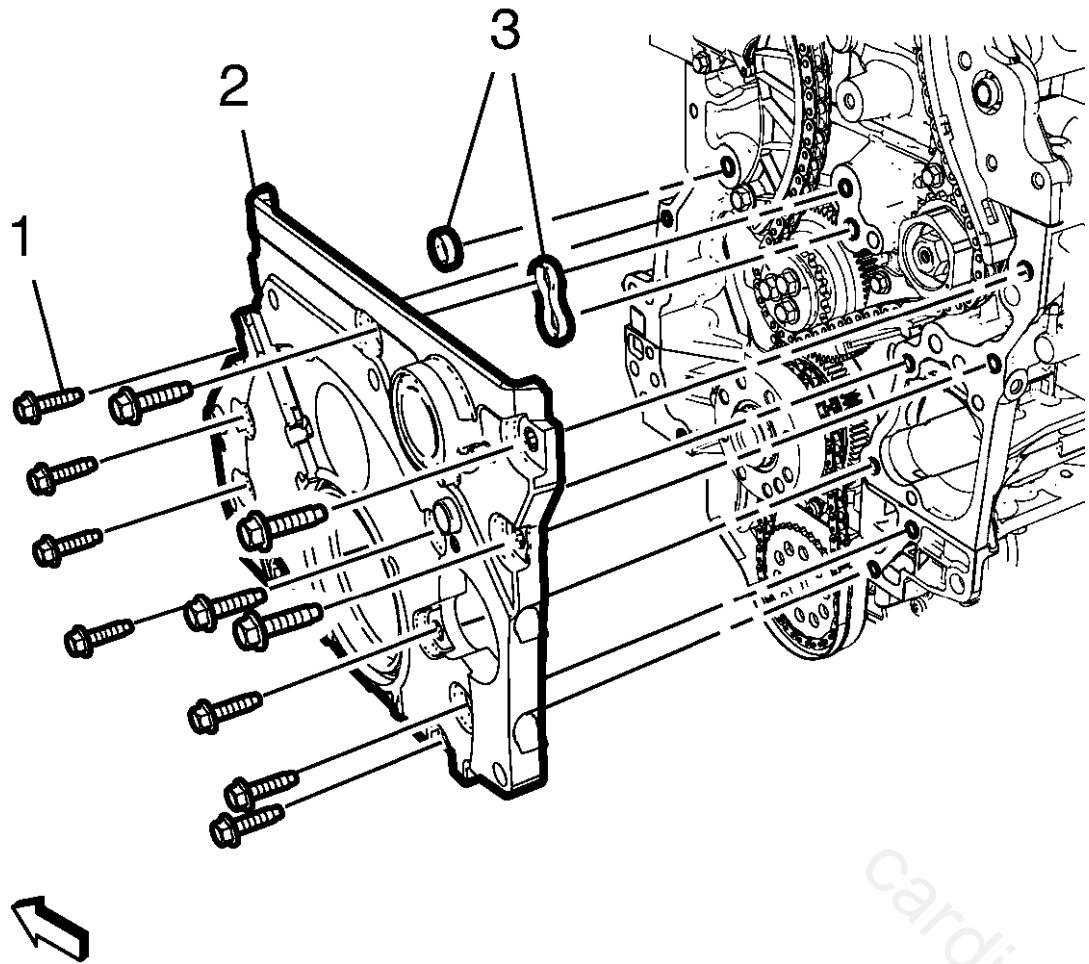


Fig. 645: Timing Chain Lower Cover, Bolts And Gaskets
Courtesy of GENERAL MOTORS COMPANY

1. Remove the 11 timing chain lower cover bolts (1).
2. Remove the timing chain lower cover (2), by loosen the timing chain upper cover from the cylinder block with a suitable tool.
3. Remove the 2 timing chain lower cover gaskets (3).
4. Remove the crankshaft rear oil seal, if the timing chain lower cover is reused.

OIL PUMP DRIVE CHAIN TENSIONER REMOVAL

Special Tools

EN-50513 Fixing Pin

For equivalent regional tools, refer to [Special Tools](#).

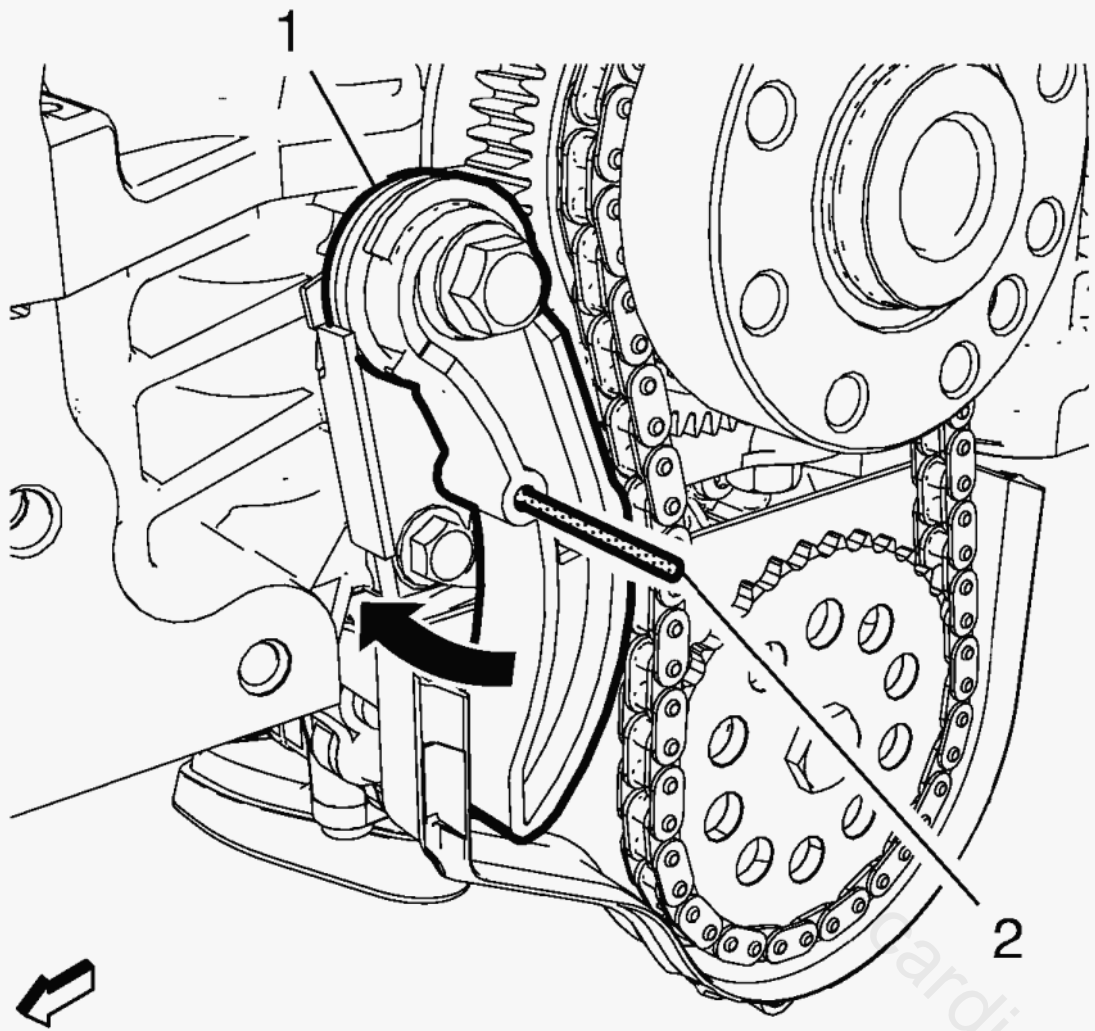


Fig. 646: Oil Pump Drive Chain Tensioner And Fixing Pin
Courtesy of GENERAL MOTORS COMPANY

1. Tension the oil pump drive chain tensioner (1) in arrow direction.
2. Install the **EN-50513** fixing pin (2).

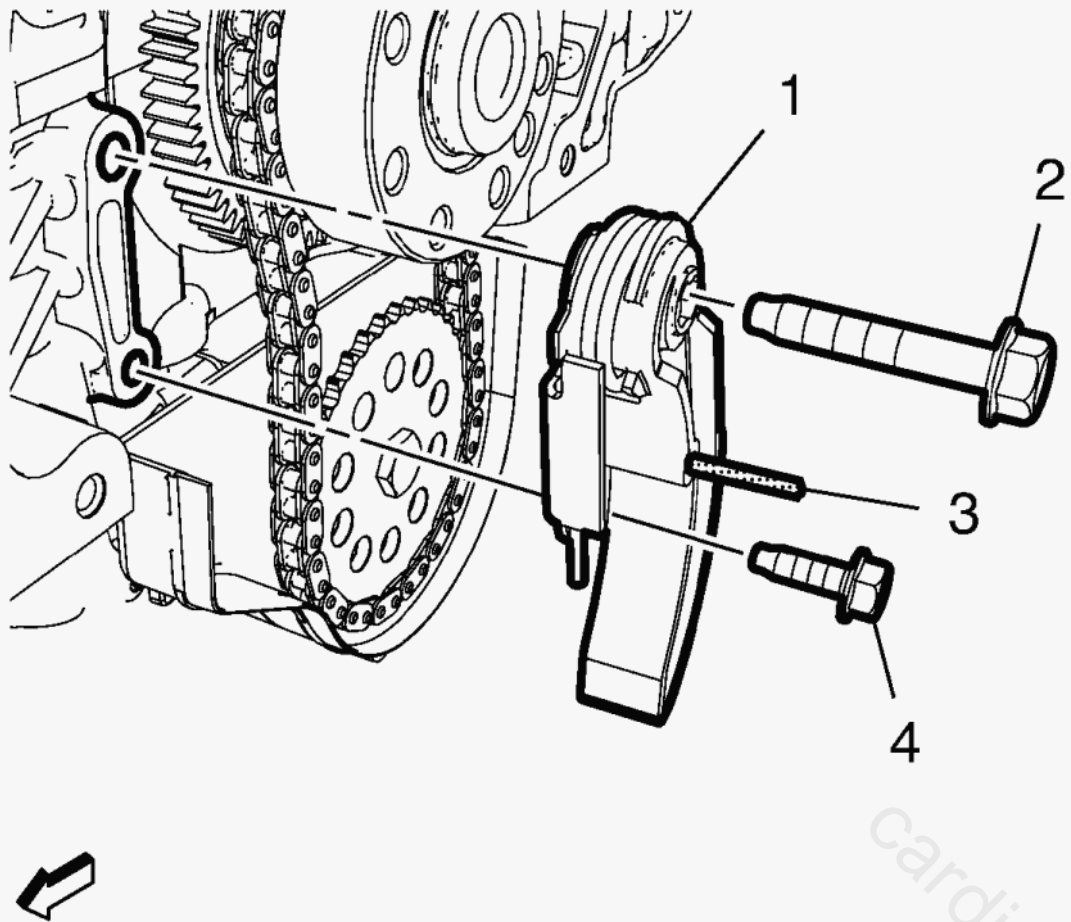


Fig. 647: Oil Pump Drive Chain Tensioner, Bolts And Fixing Pin
Courtesy of GENERAL MOTORS COMPANY

3. Remove the oil pump drive chain tensioner bolt (4).
4. Remove the oil pump drive chain tensioner bolt (2)

NOTE: If the oil pump drive chain tensioner is reused, do not remove the EN-50513 fixing pin (3).

5. Remove the oil pump drive chain tensioner (1).

OIL PUMP DRIVE CHAIN AND SPROCKET REMOVAL

Special Tools

EN-51142 Oil Pump Sprocket Unit Holding Tool

For equivalent regional tools, refer to [Special Tools](#).

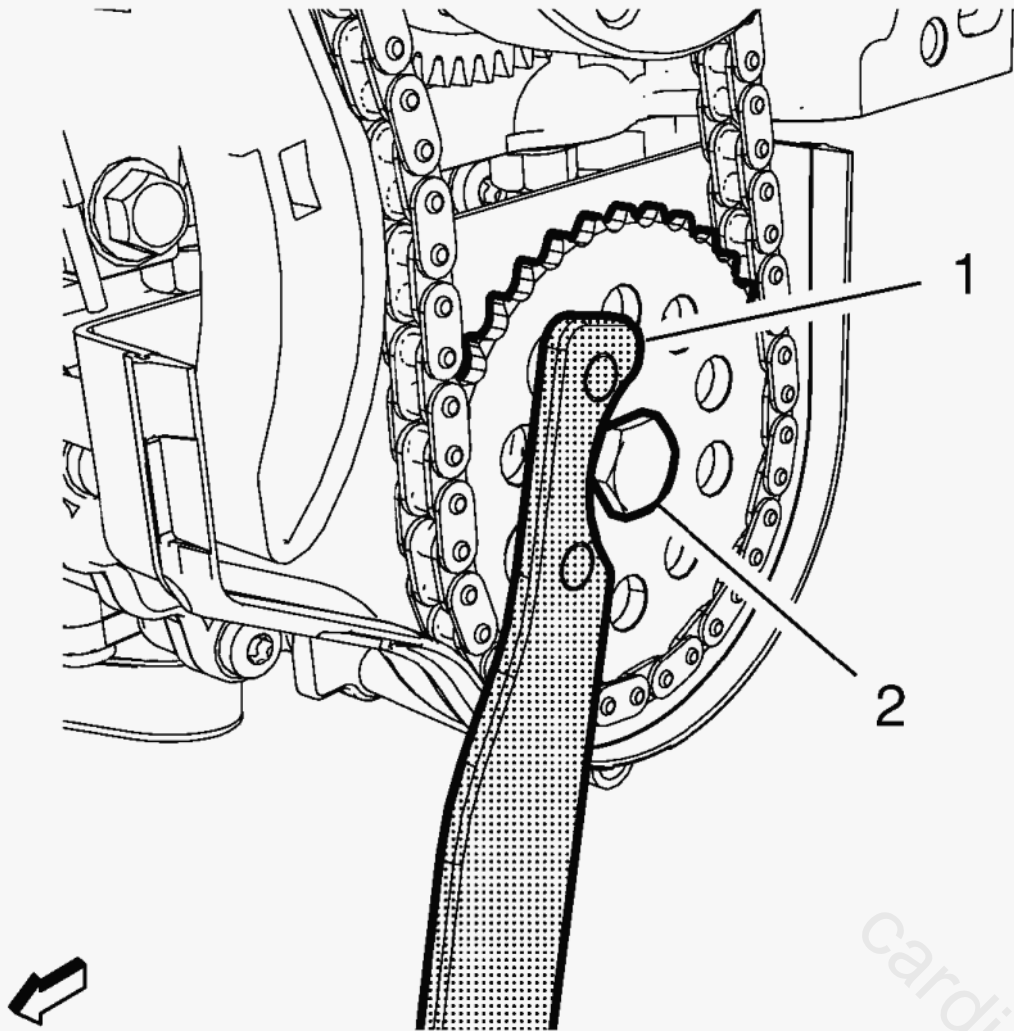


Fig. 648: Oil Pump Sprocket Bolt And Sprocket Holding Tool
Courtesy of GENERAL MOTORS COMPANY

1. Loosen the oil pump sprocket bolt (2), by counterhold with the **EN-51142** holding tool (1).

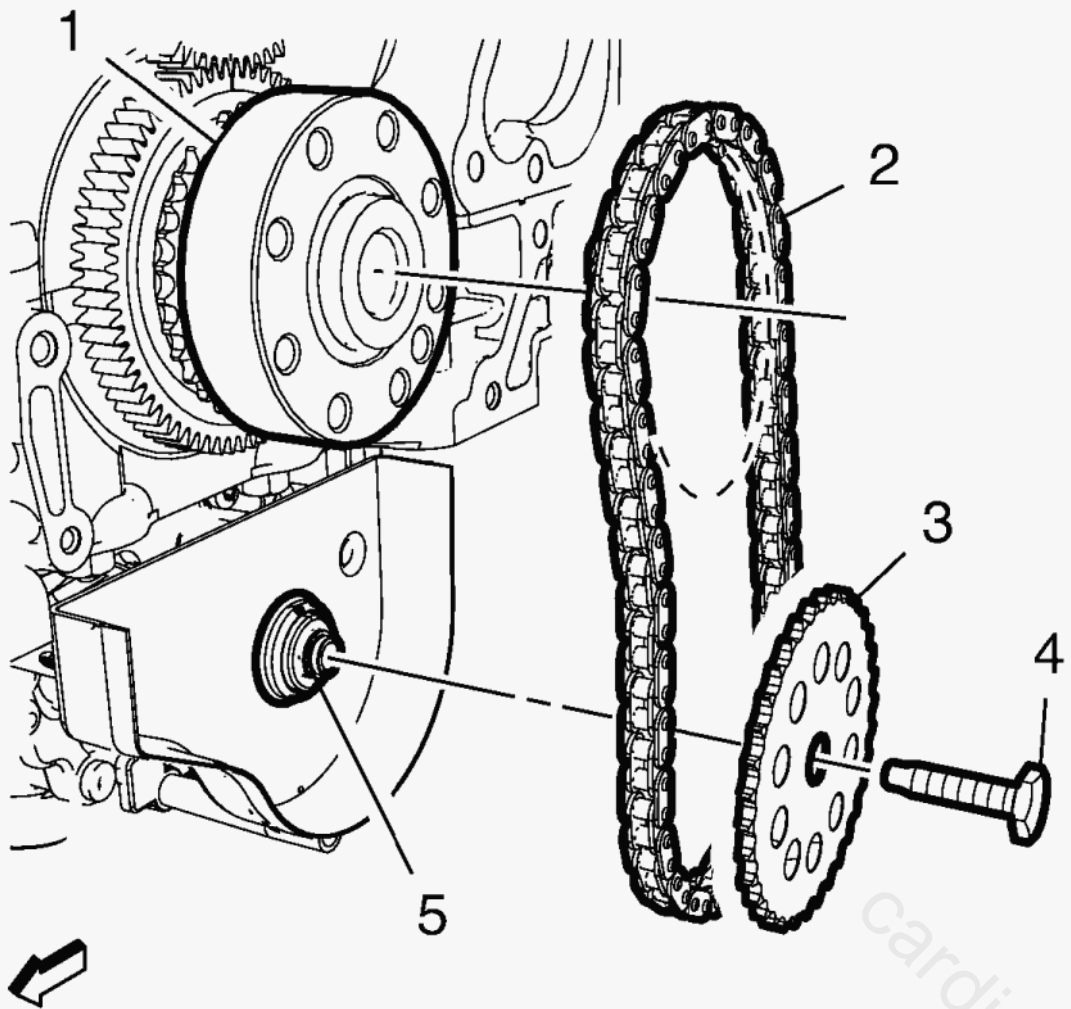


Fig. 649: Oil Pump Sprocket, Bolt, Shaft, Drive Chain And Drive Chain Sprocket
Courtesy of GENERAL MOTORS COMPANY

2. Remove and DISCARD the oil pump sprocket bolt (4).
3. Remove the oil pump sprocket (3) from the oil pump shaft (5).
4. Remove the oil pump drive chain (2) from the oil pump drive chain sprocket (1).

OIL AND POWER BRAKE BOOSTER PUMP REMOVAL

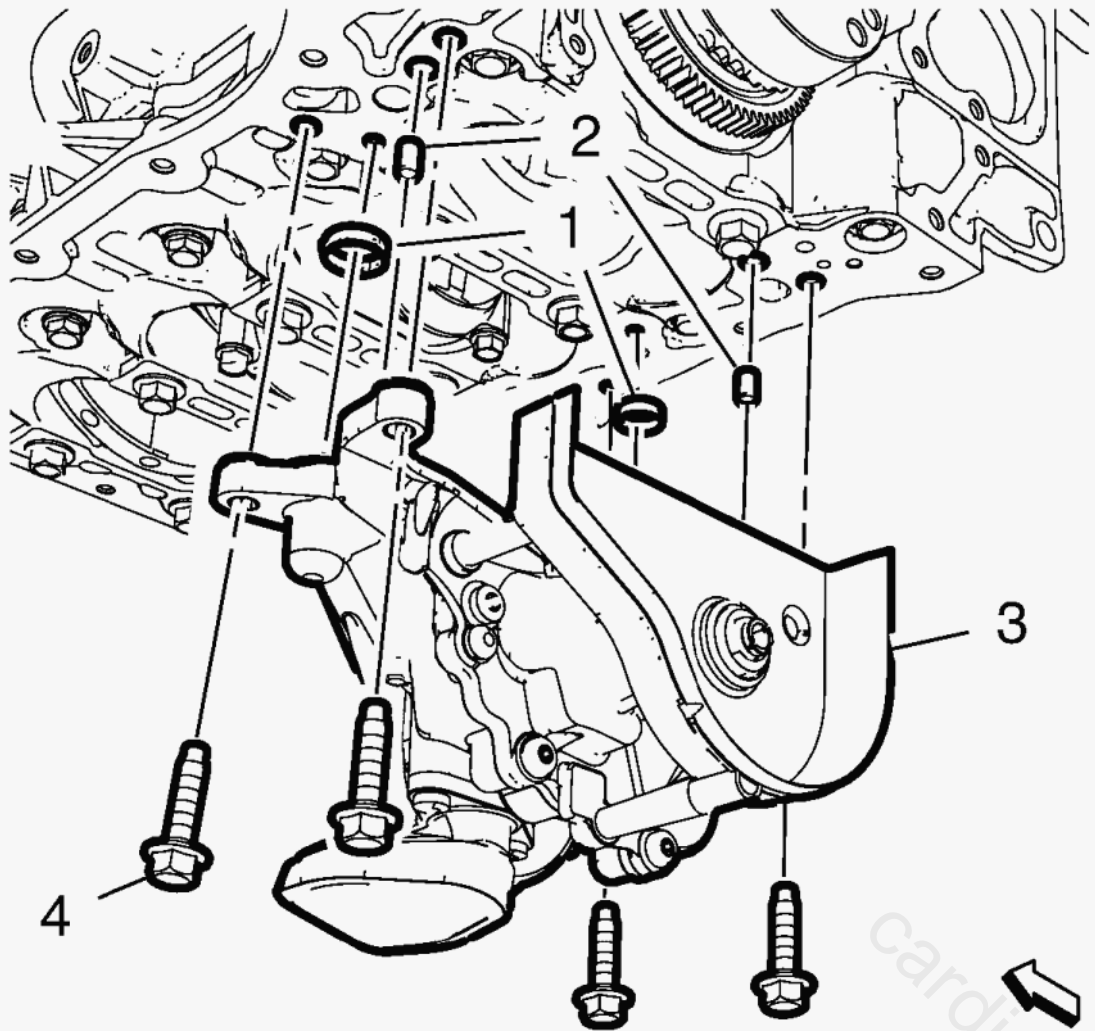


Fig. 650: Oil And Power Steering Pump, Bolts, Locating Pins And Gaskets
Courtesy of GENERAL MOTORS COMPANY

1. Remove the 4 oil pump bolts (4).
2. Remove the oil and power steering pump (3).
3. Remove the 2 oil and power steering pump gaskets (1).
4. Remove the 2 location pins (2).

CAMSHAFT TIMING CHAIN REMOVAL

Special Tools

- **EN-50513** Fixing Pin
- **EN-51140** Crankshaft Fixing Tool
- **EN-51143** Camshaft Sprocket Fixing Tool

For equivalent regional tools, refer to [Special Tools](#).

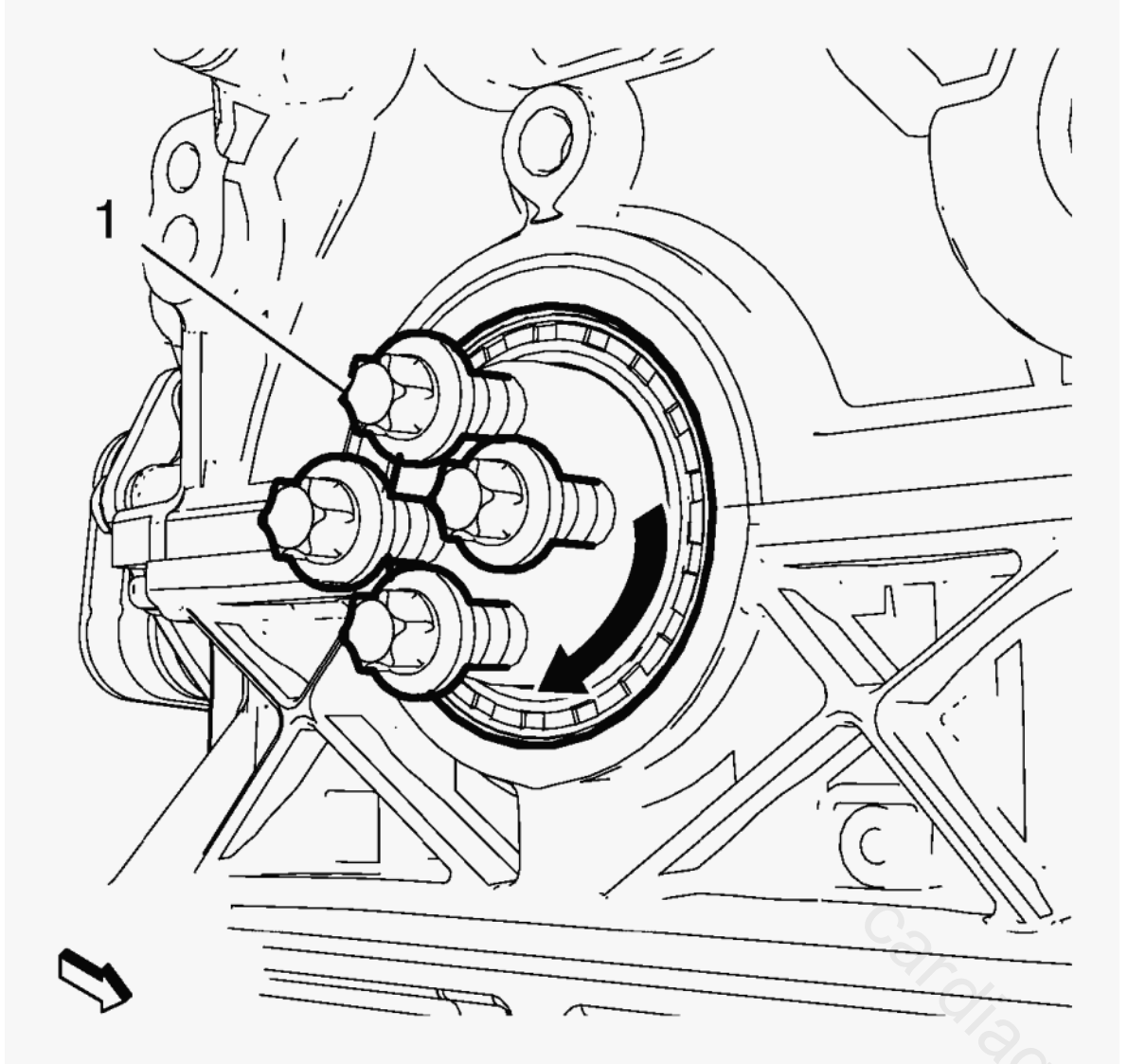


Fig. 651: Crankshaft Pulley Bolts

Courtesy of GENERAL MOTORS COMPANY

1. Install the 4 crankshaft pulley bolts (1).

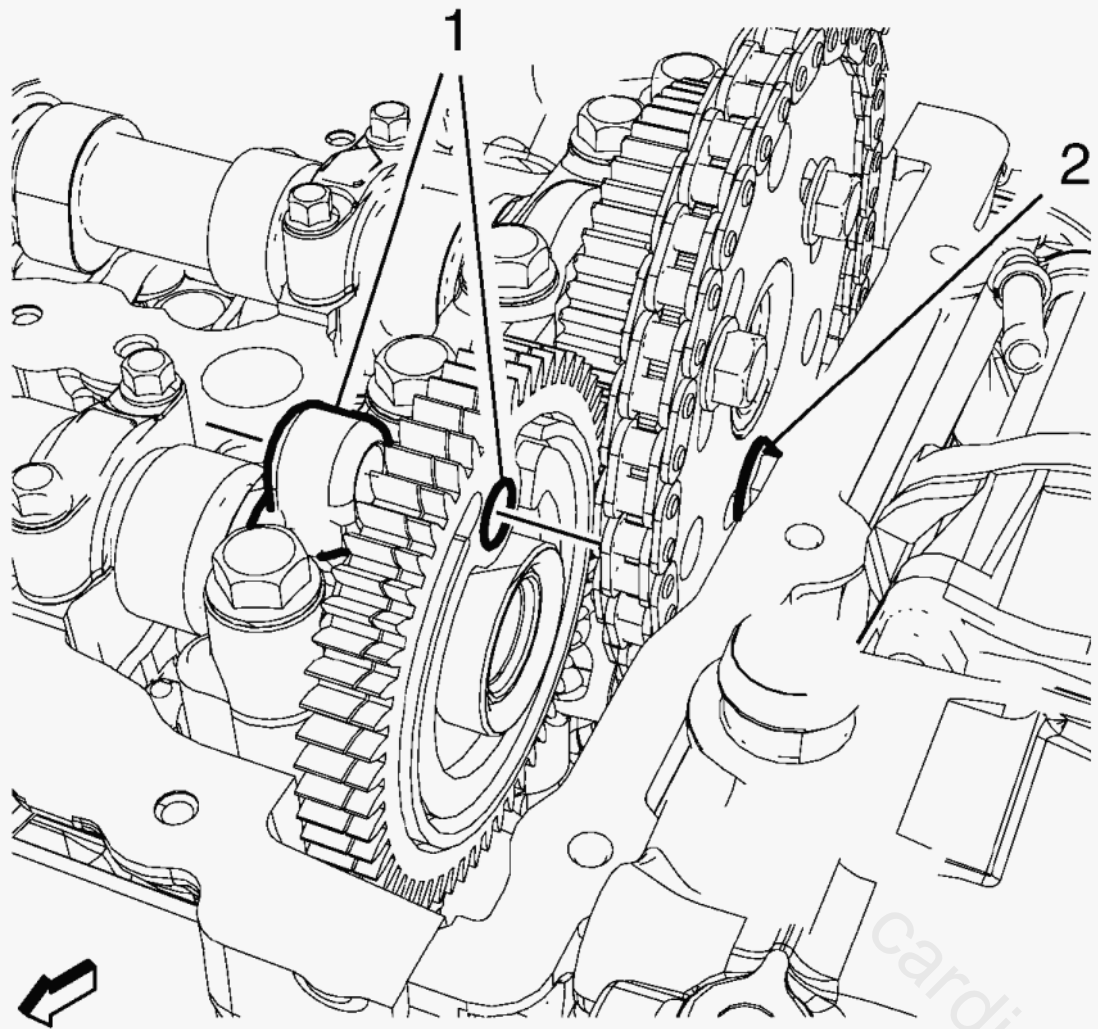


Fig. 652: Aligning Bores

Courtesy of GENERAL MOTORS COMPANY

NOTE: If the bores not aligned turn the crankshaft at the crankshaft pulley bolts.

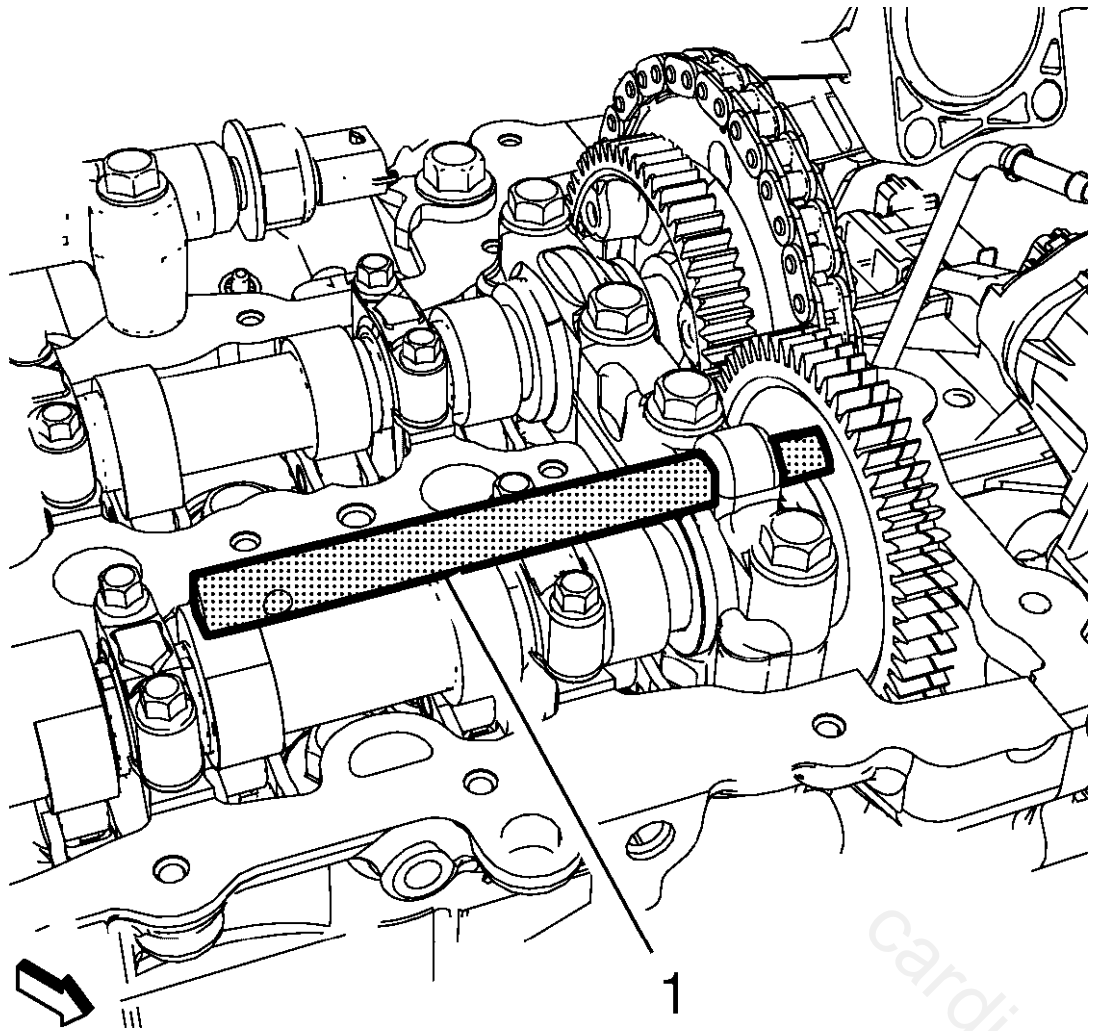


Fig. 653: Camshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

2. Check if the bores (1) are aligned.

Turn the exhaust camshaft at the hexagon so far if the **EN-51143** fixing tool (1) can be installed.

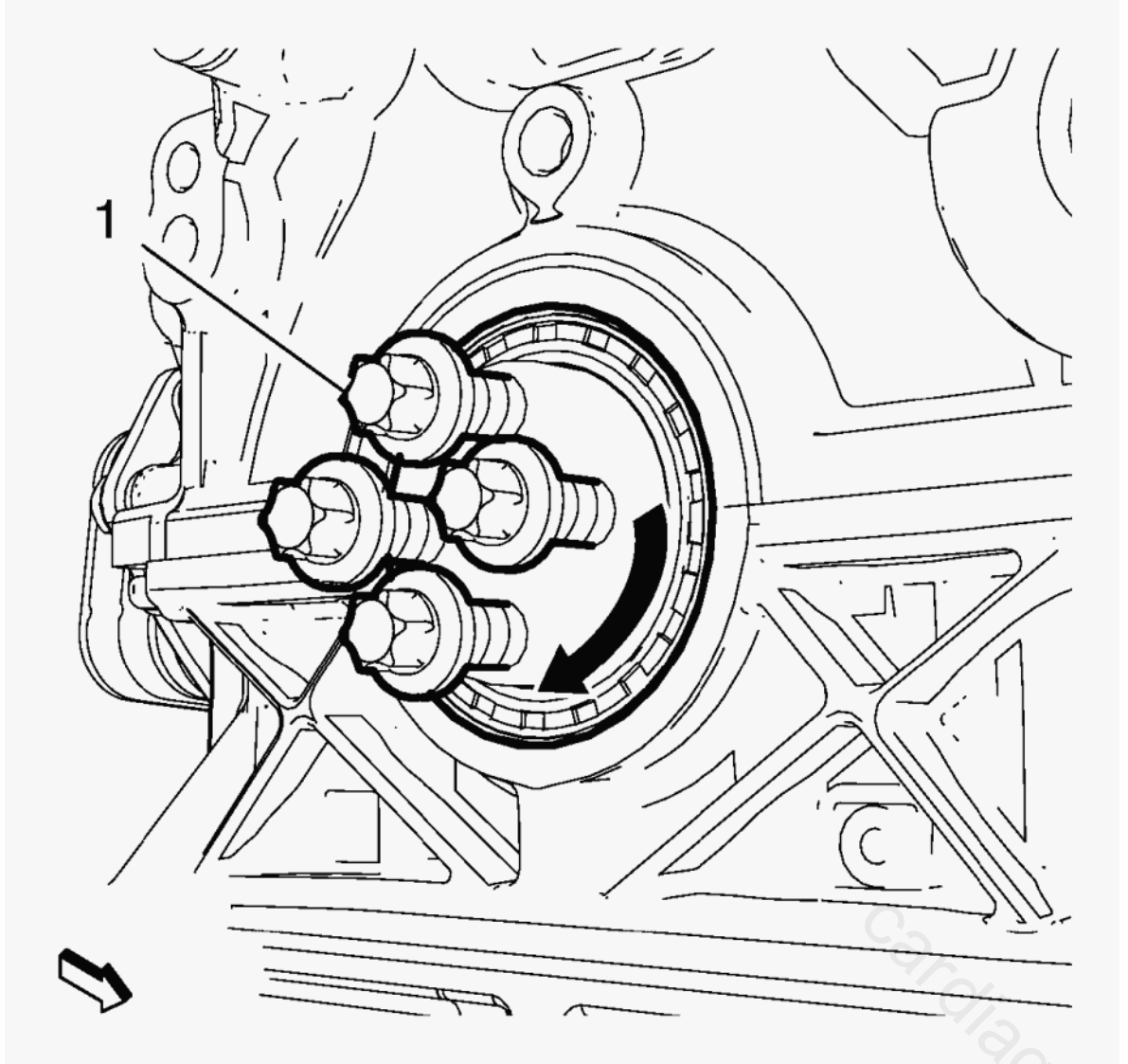


Fig. 654: Crankshaft Pulley Bolts

Courtesy of GENERAL MOTORS COMPANY

3. Remove the 4 crankshaft pulley bolts (1).

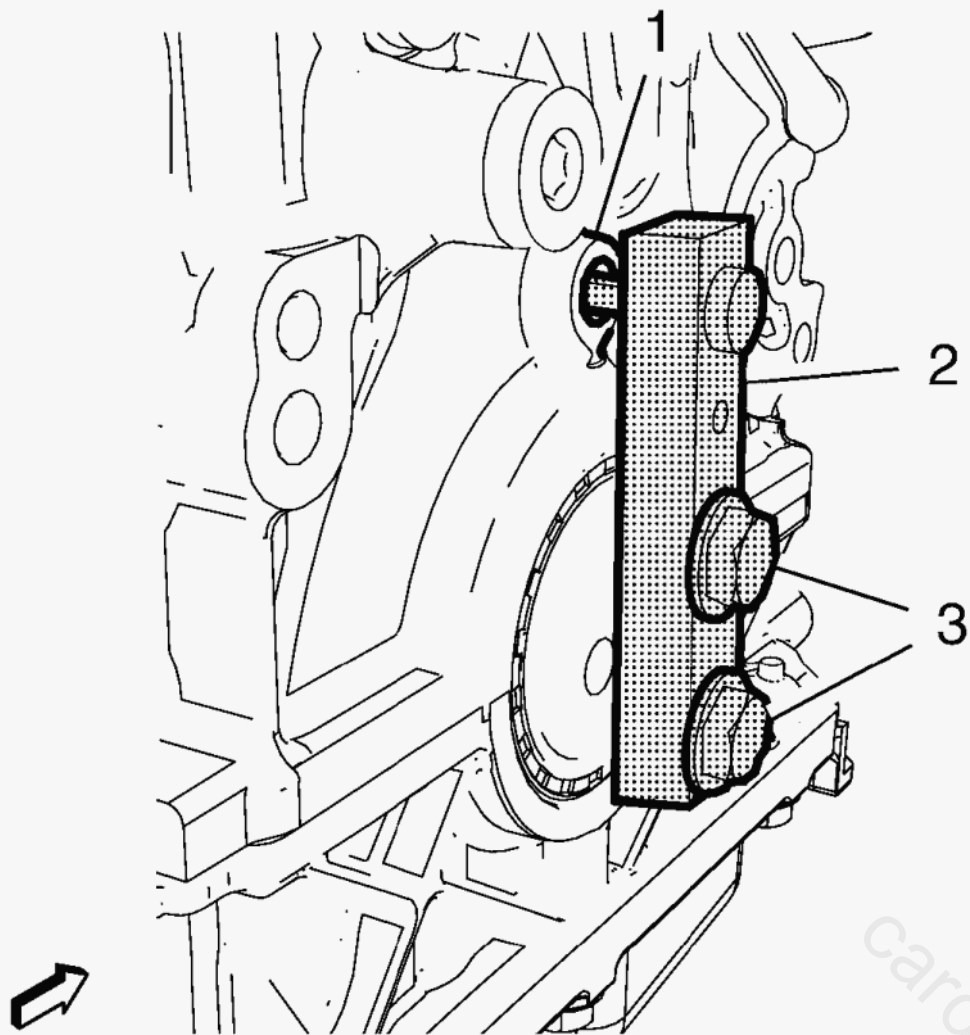


Fig. 655: Crankshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

4. Install the **EN-51140** fixing tool (2).
5. Install the fixing pin into the engine block bore (1) and tighten the 2 bolts (3).

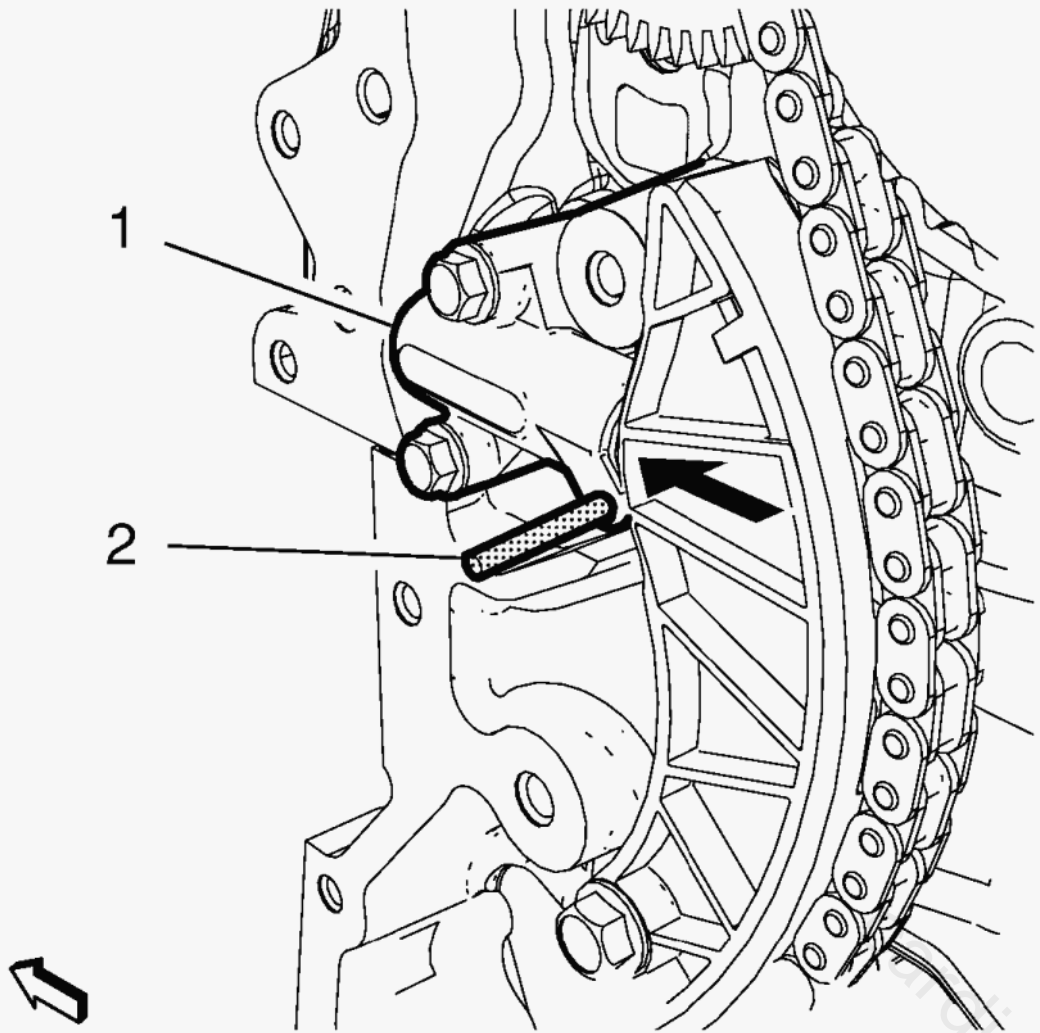


Fig. 656: Timing Chain Tensioner And Pin

Courtesy of GENERAL MOTORS COMPANY

6. Tension the timing chain tensioner (1) in arrow direction.
7. Install the EN-50513 pin (2).

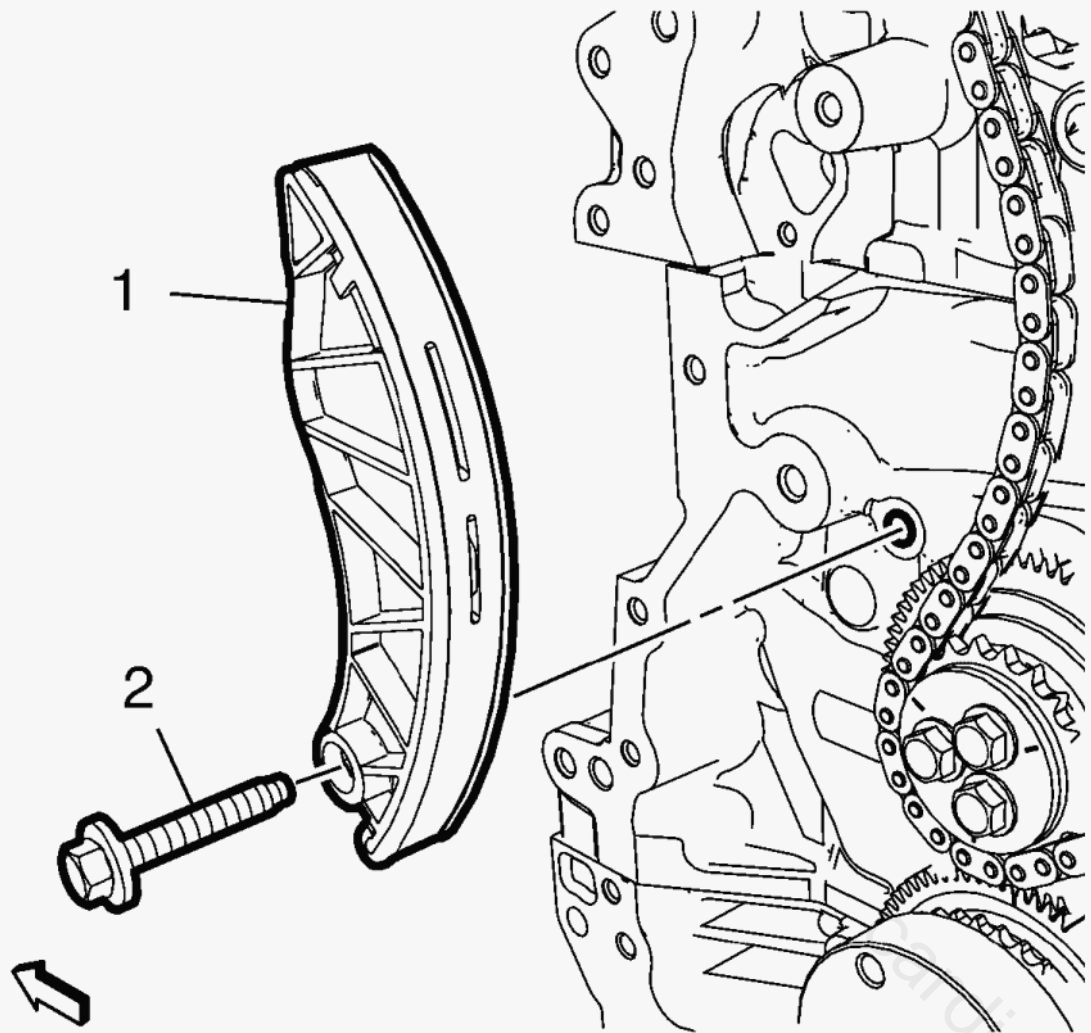


Fig. 657: Timing Chain Tensioner Shoe And Bolt
Courtesy of GENERAL MOTORS COMPANY

8. Remove the timing chain tensioner shoe bolt (2).
9. Remove the timing chain tensioner shoe (1).

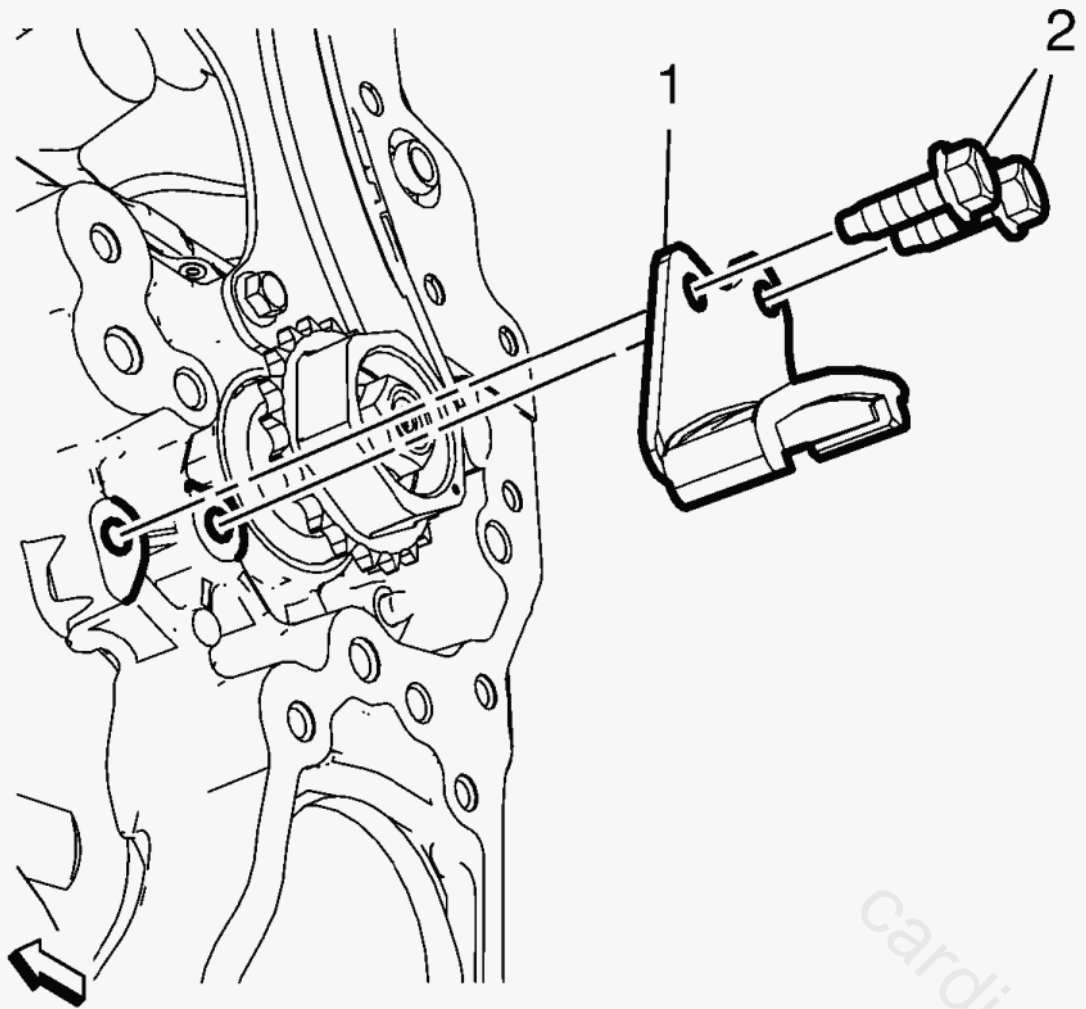


Fig. 658: Timing Chain Lower Guide And Bolts
Courtesy of GENERAL MOTORS COMPANY

10. Remove the 2 timing chain lower guide bolts (2).
11. Remove the timing chain lower guide (1).

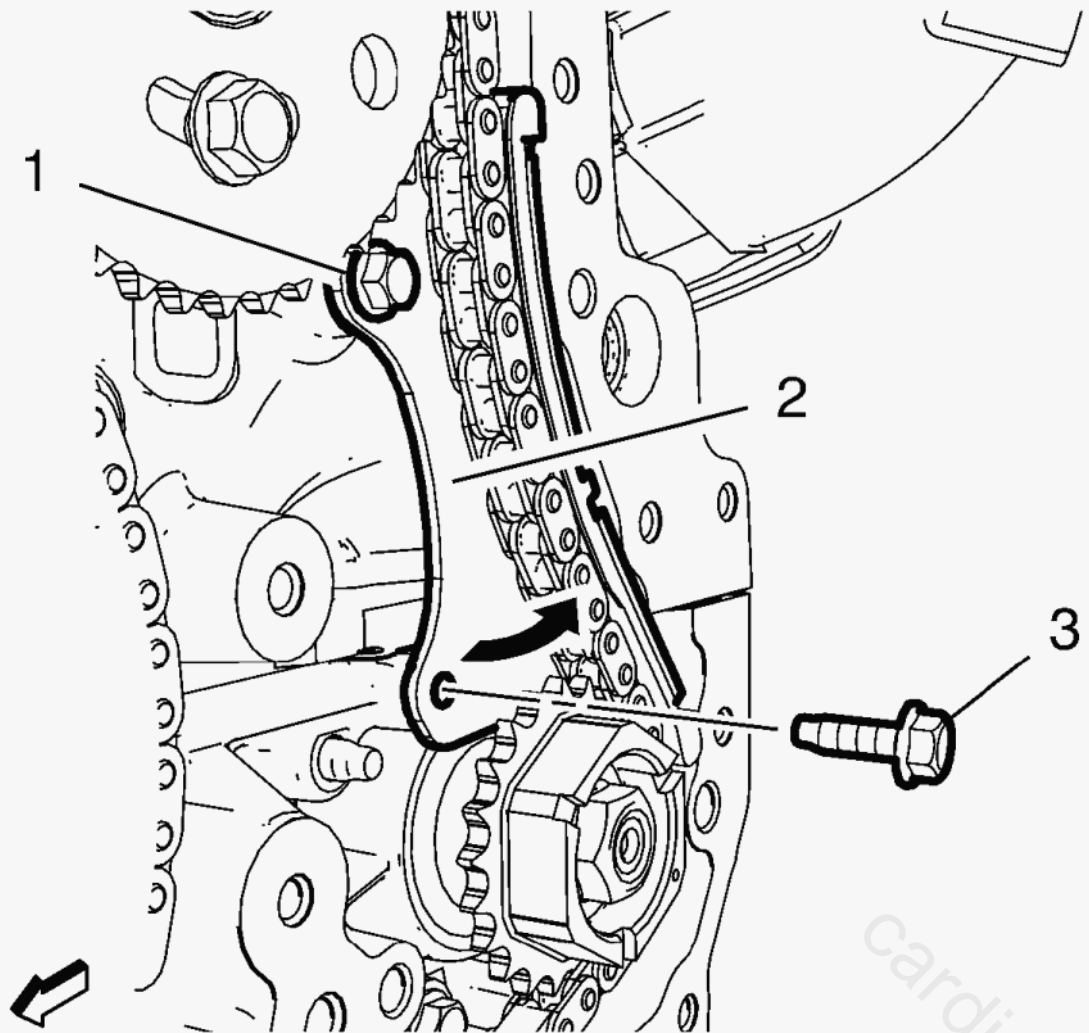


Fig. 659: Timing Chain Upper Guide And Bolts
Courtesy of GENERAL MOTORS COMPANY

12. Loosen the timing chain upper guide bolt (1).
13. Remove the timing chain upper guide bolt (3).
14. Move the timing chain upper guide (2) in the direction of arrow.

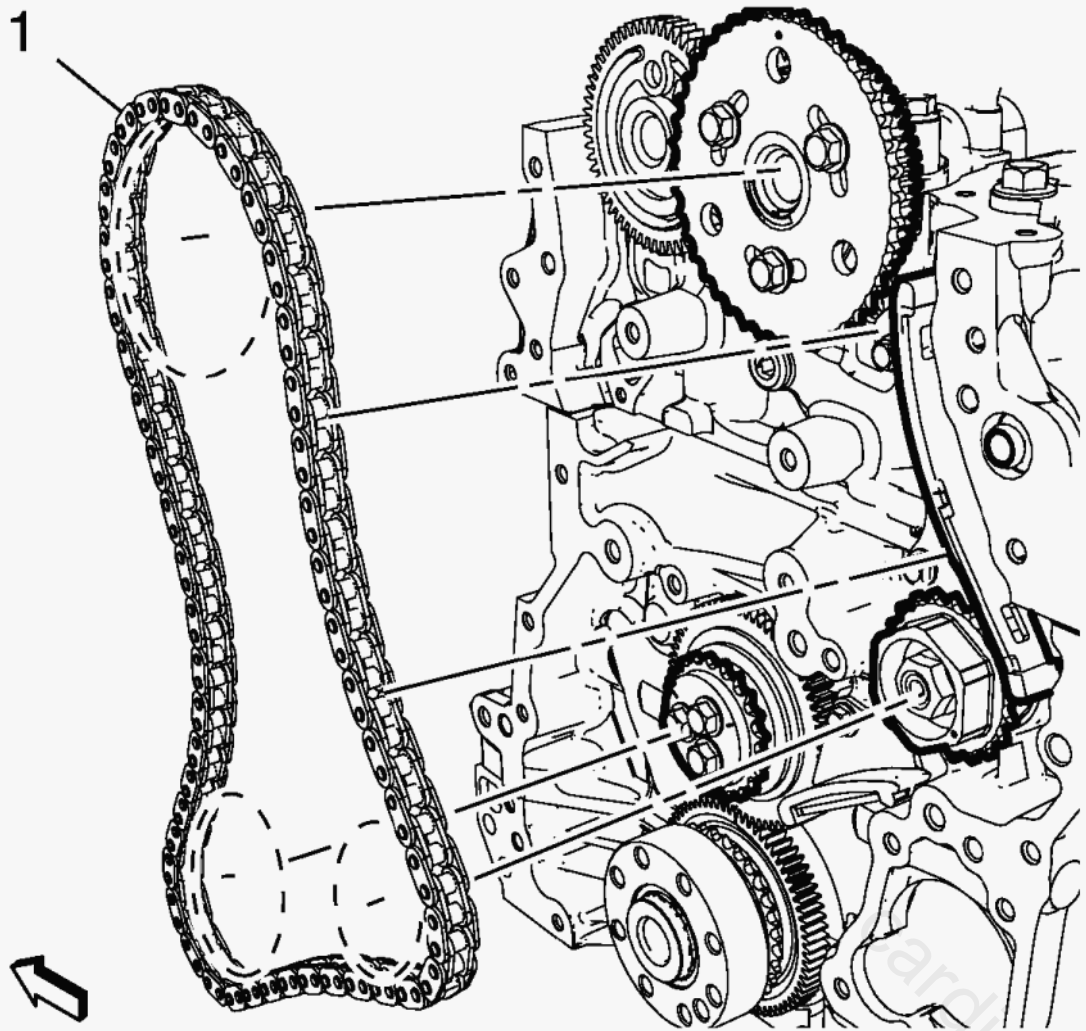


Fig. 660: Timing Chain

Courtesy of GENERAL MOTORS COMPANY

15. Remove the timing chain (1).

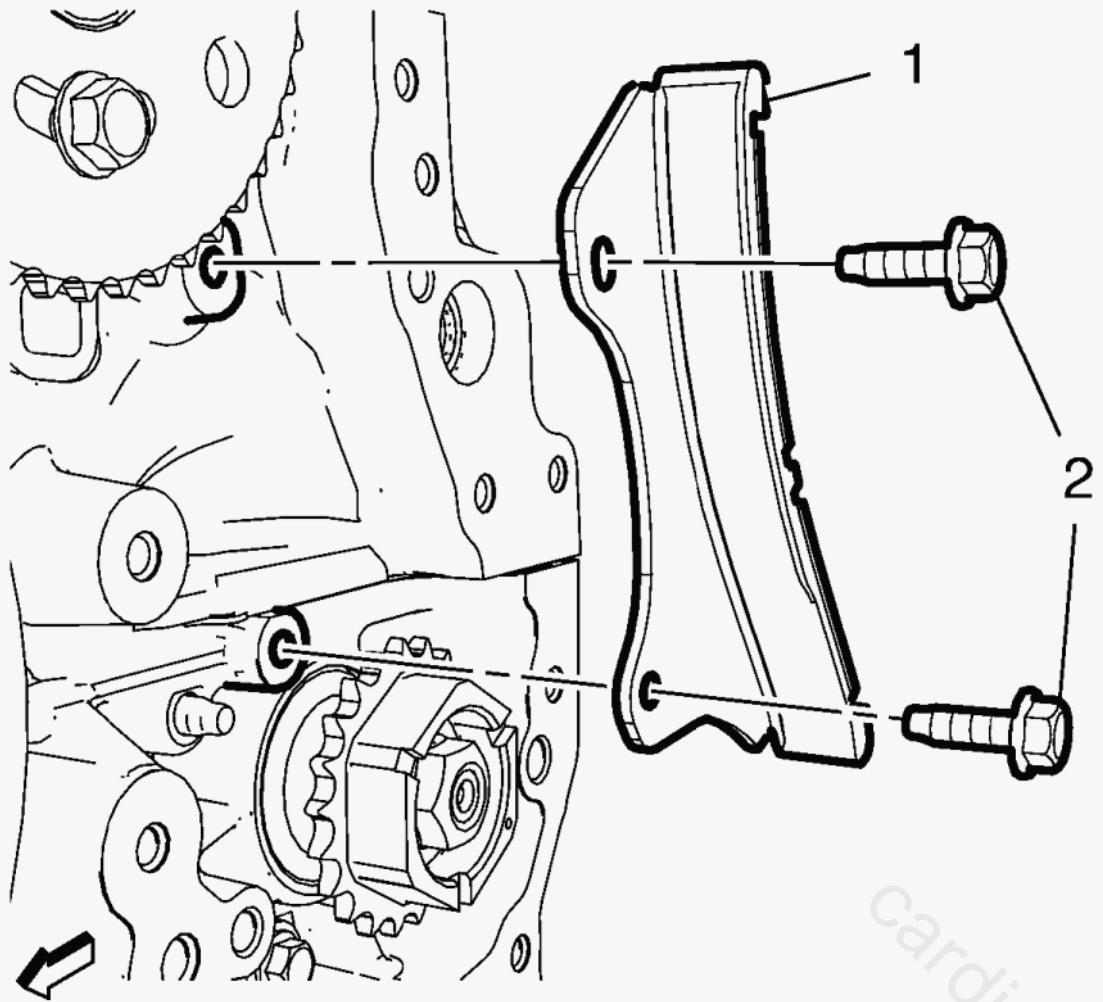


Fig. 661: Timing Chain Upper Guide And Bolts
Courtesy of GENERAL MOTORS COMPANY

16. Remove the upper timing chain upper guide bolt (2).
17. Remove the timing chain upper guide (1).

TIMING CHAIN TENSIONER REMOVAL

Special Tools

EN-50513 Fixing Pin

For equivalent regional tools, refer to [Special Tools](#).

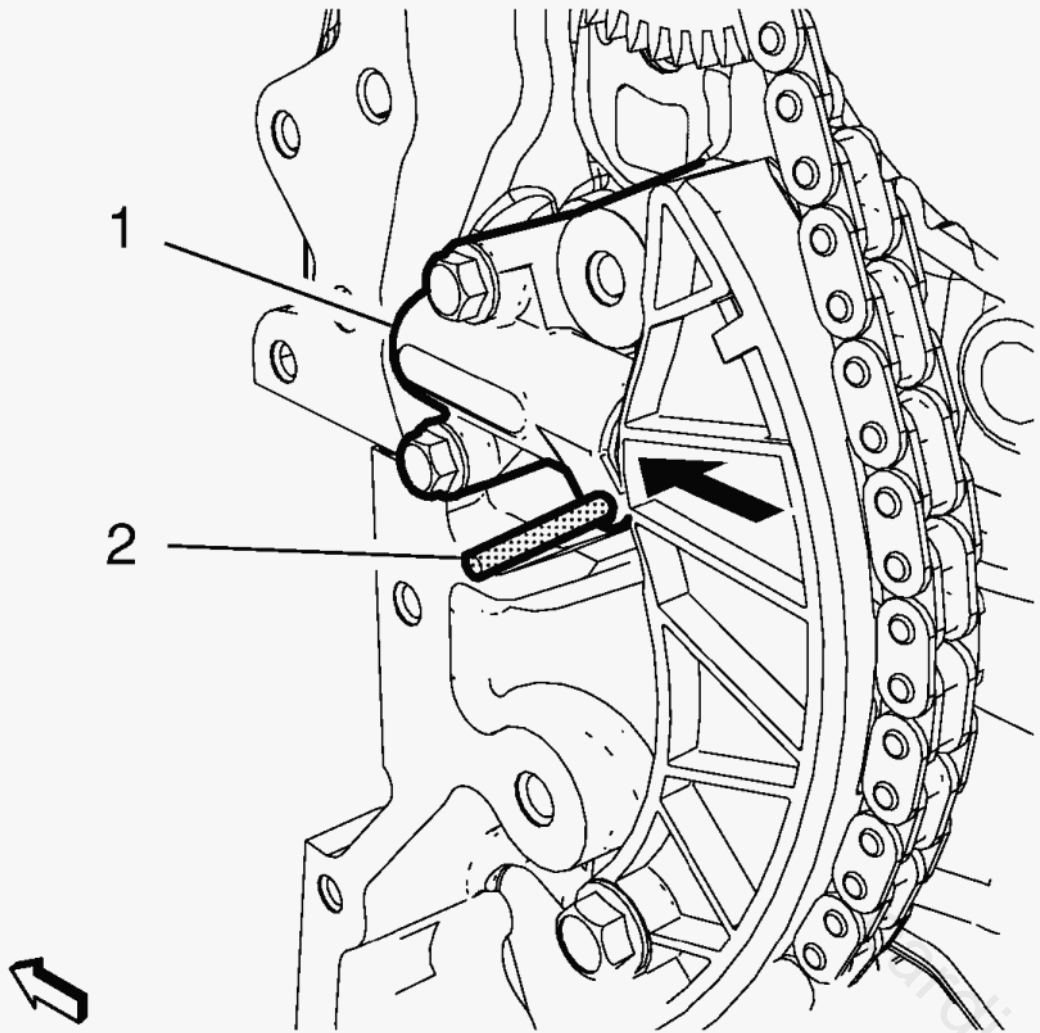


Fig. 662: Timing Chain Tensioner And Pin

Courtesy of GENERAL MOTORS COMPANY

1. Tension the timing chain tensioner (1) in arrow direction.
2. Install the EN-50513 pin (2).

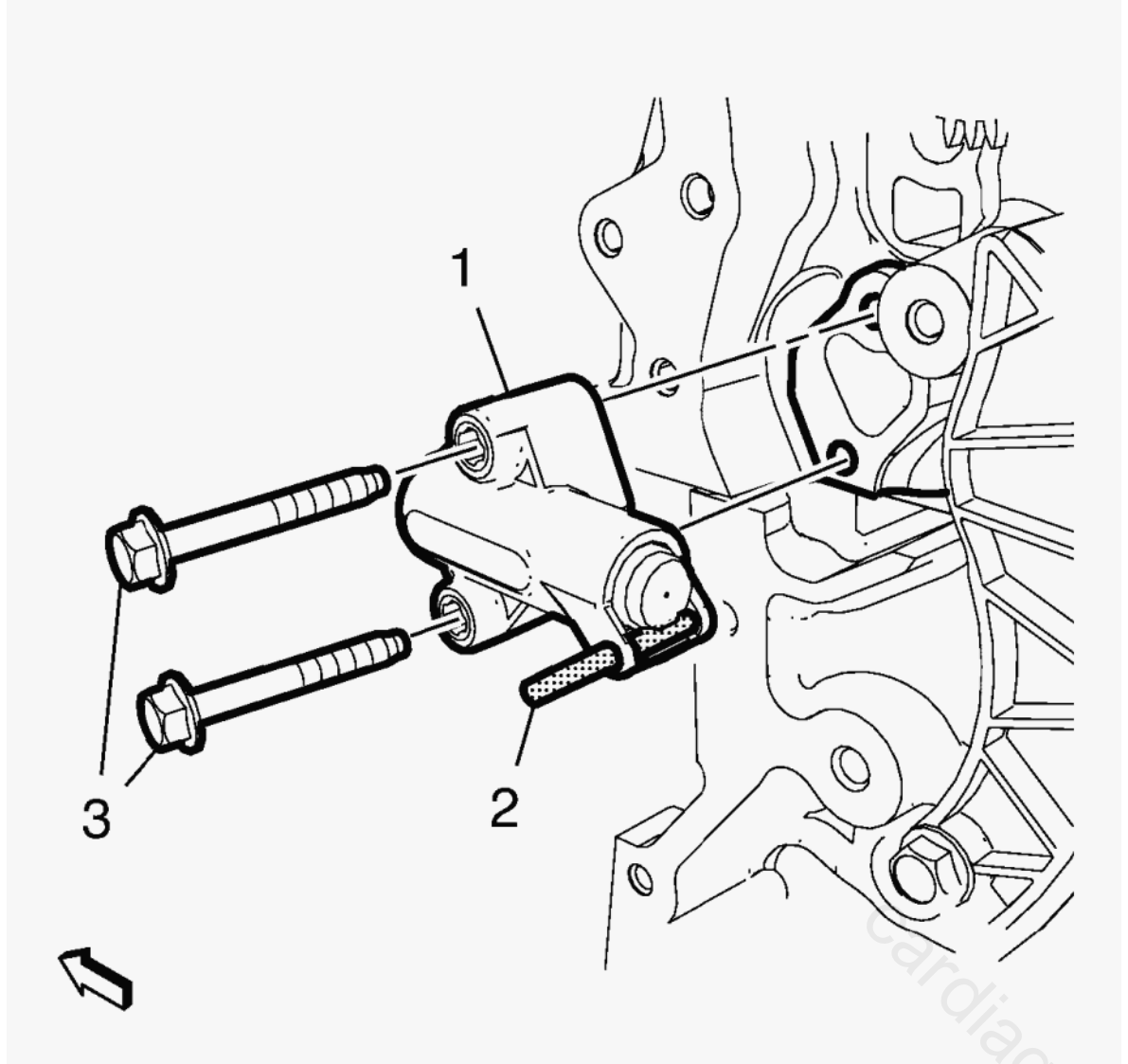


Fig. 663: Timing Chain Tensioner, Bolts And Pin
Courtesy of GENERAL MOTORS COMPANY

3. Remove the 2 timing chain tensioner bolts (3).

NOTE: If the timing chain tensioner reused, do not remove the EN-50513 pin (2).

4. Remove the timing chain tensioner (1).

TIMING CHAIN TENSIONER SHOE REMOVAL

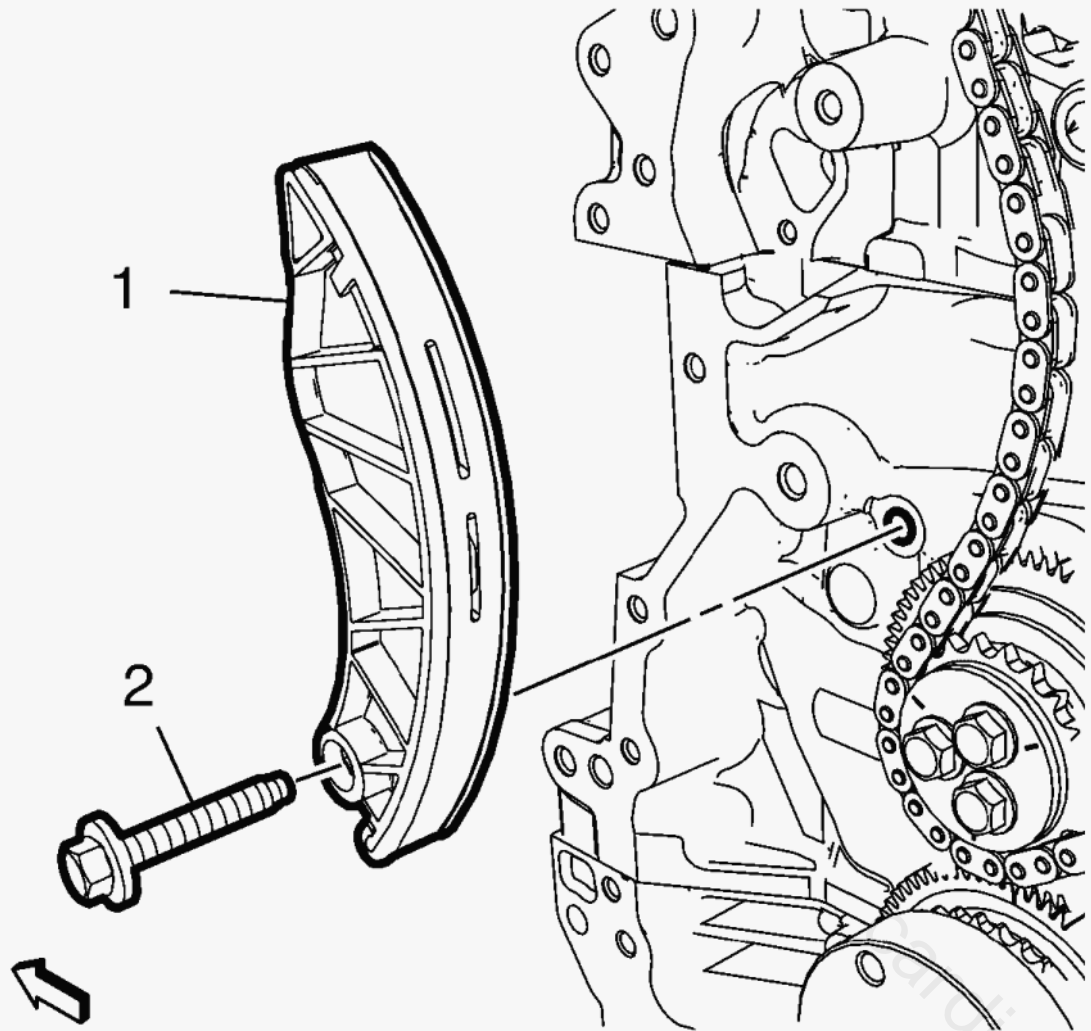


Fig. 664: Timing Chain Tensioner Shoe And Bolt
Courtesy of GENERAL MOTORS COMPANY

1. Remove the timing chain tensioner shoe bolt (2).
2. Remove the timing chain tensioner shoe (1).

TIMING CHAIN LOWER GUIDE REMOVAL

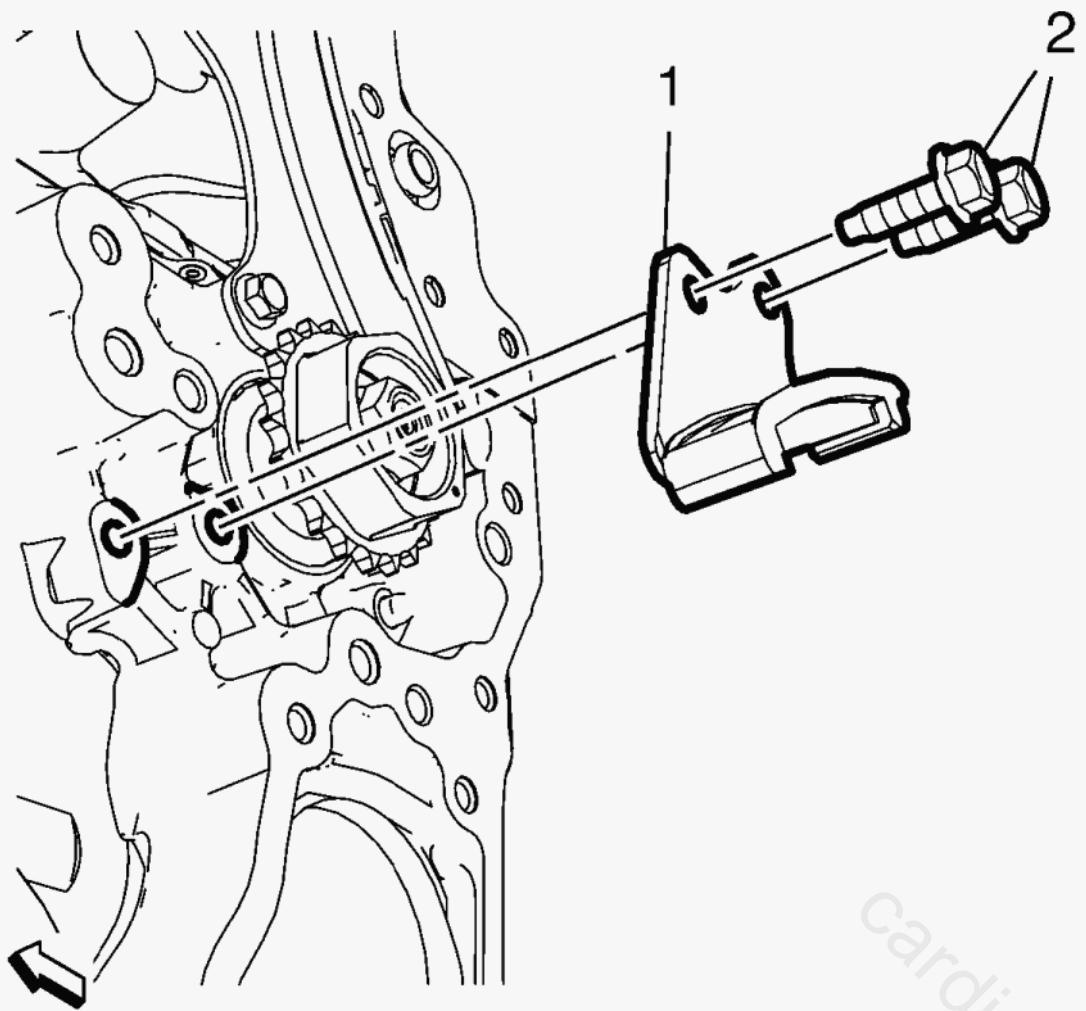


Fig. 665: Timing Chain Lower Guide And Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Remove the 2 timing chain lower guide bolts (2).
2. Remove the timing chain lower guide (1).

TIMING CHAIN UPPER GUIDE REMOVAL

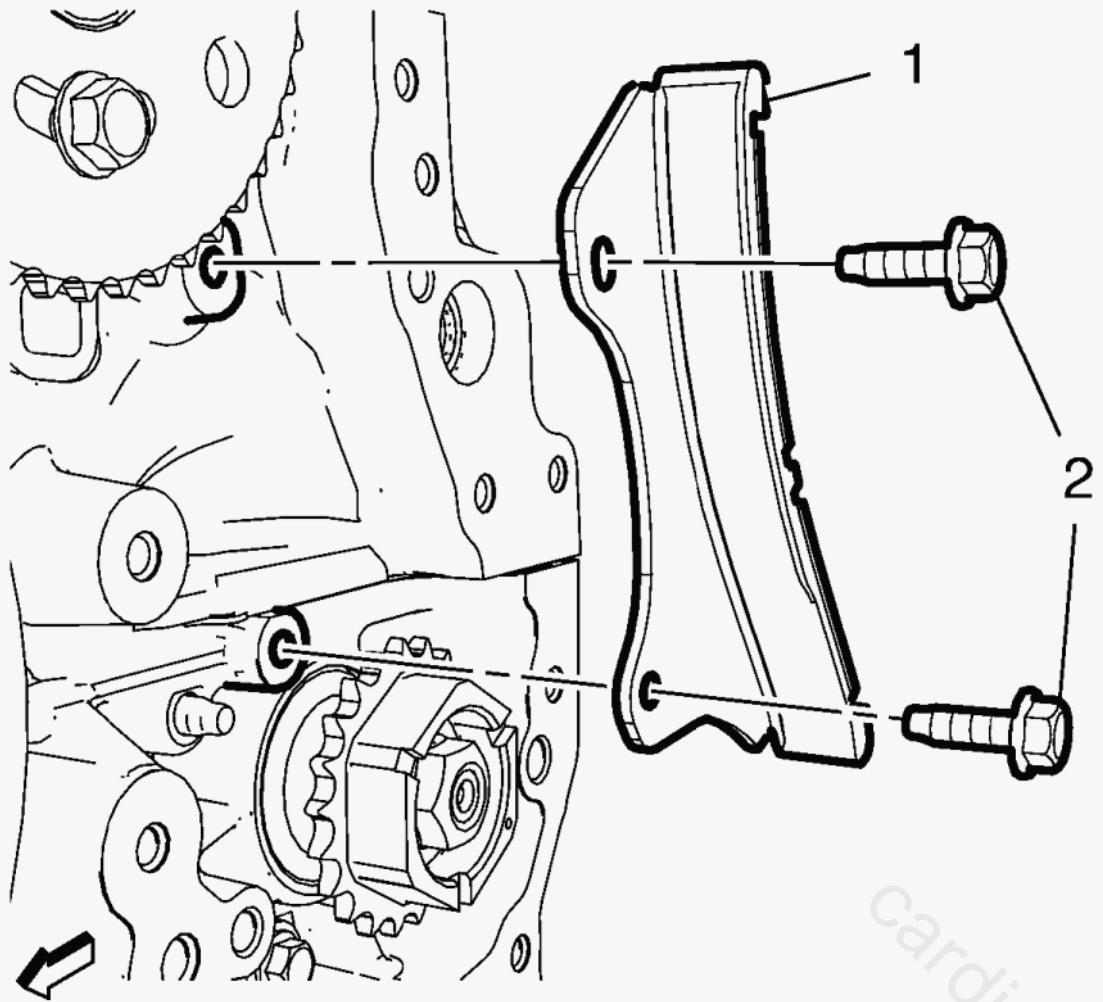


Fig. 666: Timing Chain Upper Guide And Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: The camshaft timing chain must be removed. The lower timing chain bolt has already removed by the camshaft timing chain removal.

1. Remove the upper timing chain upper guide bolt (2).
2. Remove the timing chain upper guide (1).

TIMING CHAIN IDLER SPROCKET REMOVAL

Special Tools

EN-51141 Intermediate Drive Gear Fixing Tool

For equivalent regional tools, refer to [Special Tools](#).

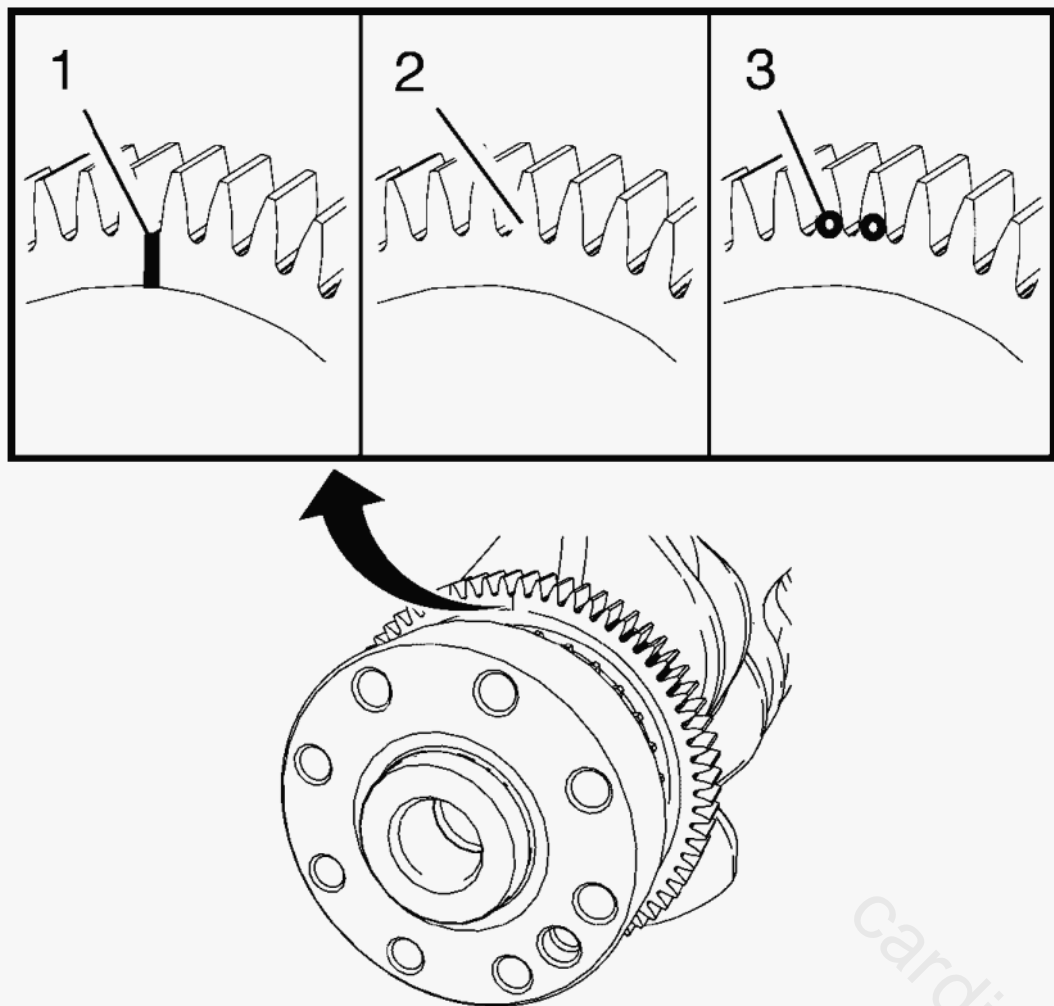


Fig. 667: Crankshaft Sprocket Marks

Courtesy of GENERAL MOTORS COMPANY

NOTE: Depending on the crankshaft, two different marks (1) and (3) or none (2) can be located on the crankshaft sprocket.

1. Mark the crankshaft sprocket align with the timing chain idler sprocket if there is no mark.

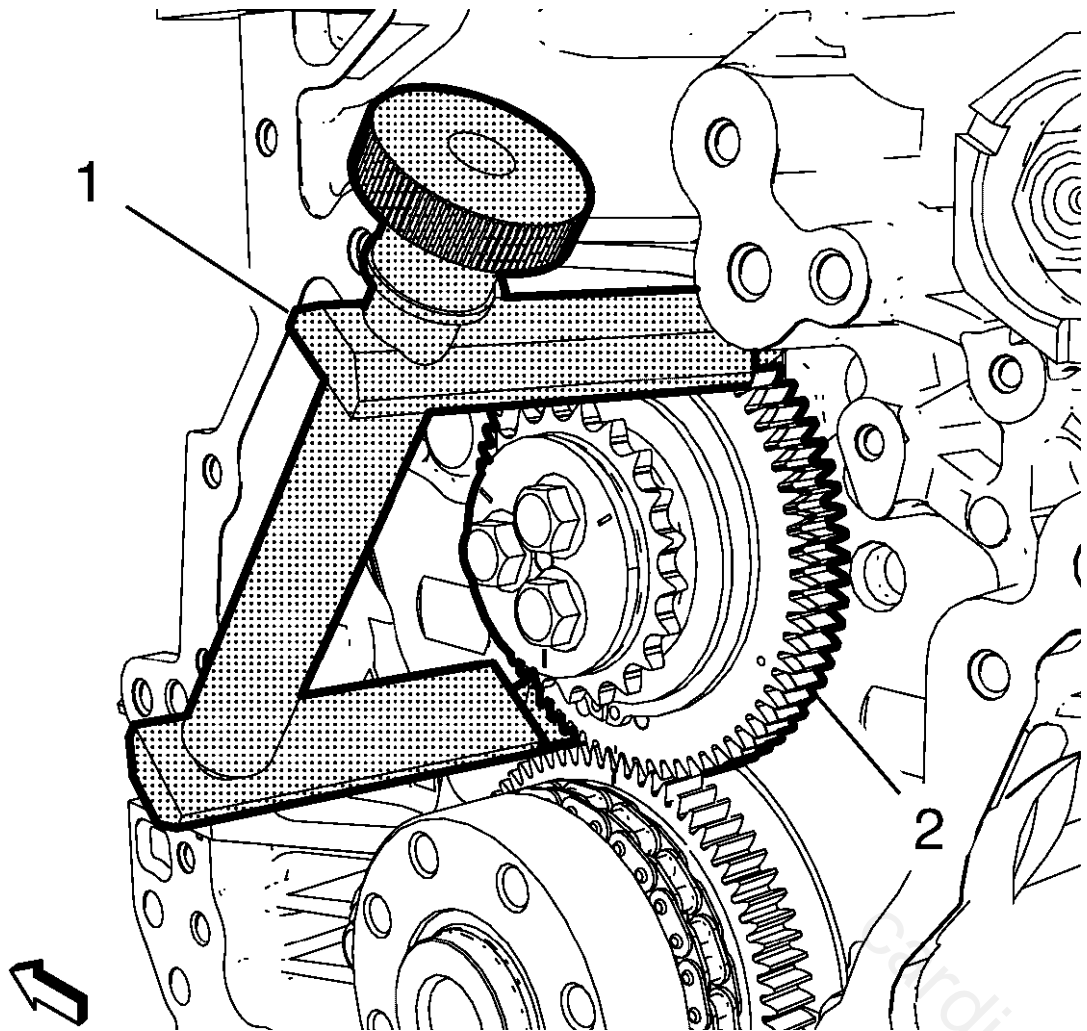


Fig. 668: Intermediate Drive Gear Fixing Tool And Timing Chain Idler Sprocket
Courtesy of GENERAL MOTORS COMPANY

2. Install the EN-51141 fixing tool (1) to the timing chain idler sprocket (2).

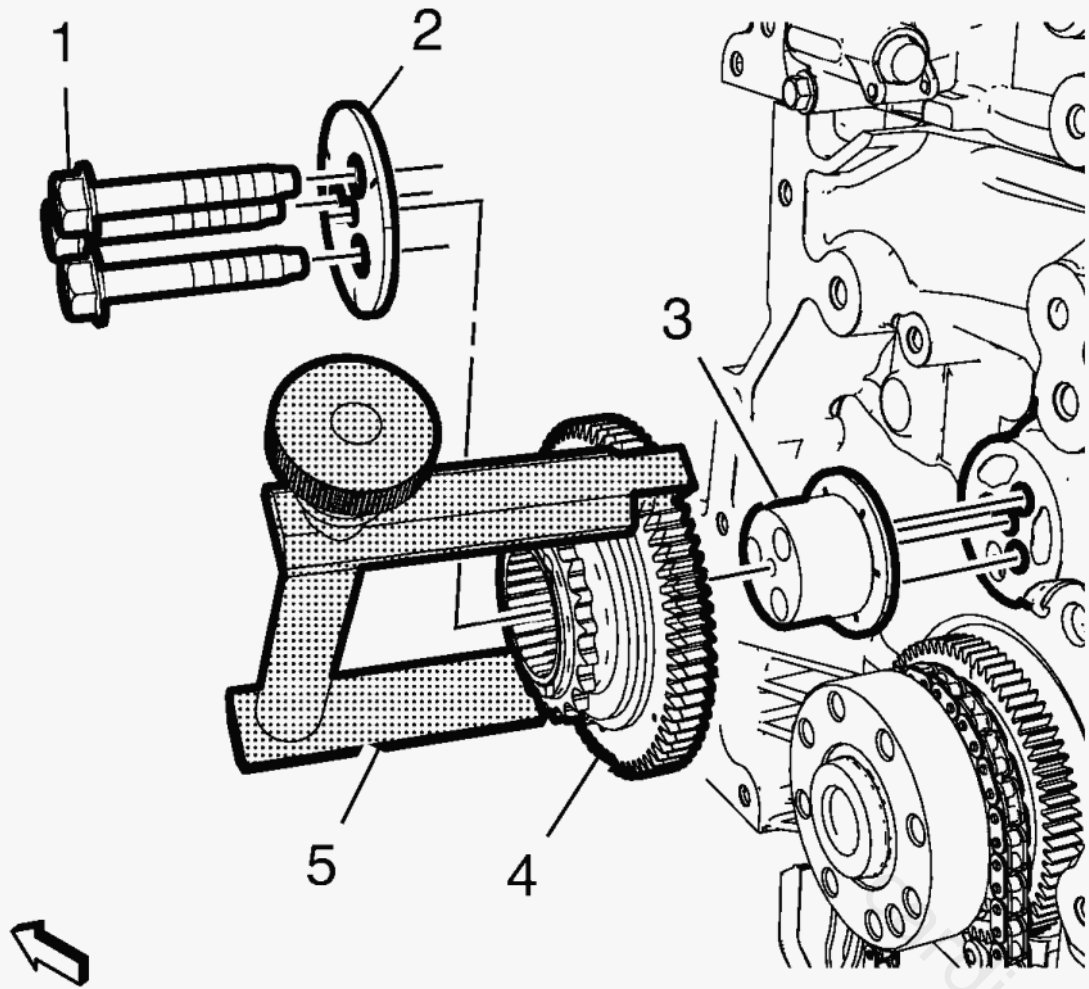


Fig. 669: Timing Chain Idler Sprocket, Bolts, Bearing Plate And Gear Shaft Distributor
 Courtesy of GENERAL MOTORS COMPANY

3. Remove the 3 timing chain idler sprocket bolts (1).
4. Remove the timing chain idler sprocket bearing plate (2).

NOTE: If the timing chain idler sprocket is reused, do not remove the EN-51141 fixing tool (5).

5. Remove the timing chain idler sprocket (4).
6. Remove the gear shaft distributor (3).

FUEL INJECTION PUMP DRIVEN SPROCKET REMOVAL

Special Tools

EN-50885-2 Locking Tool

For equivalent regional tools, refer to [Special Tools](#).

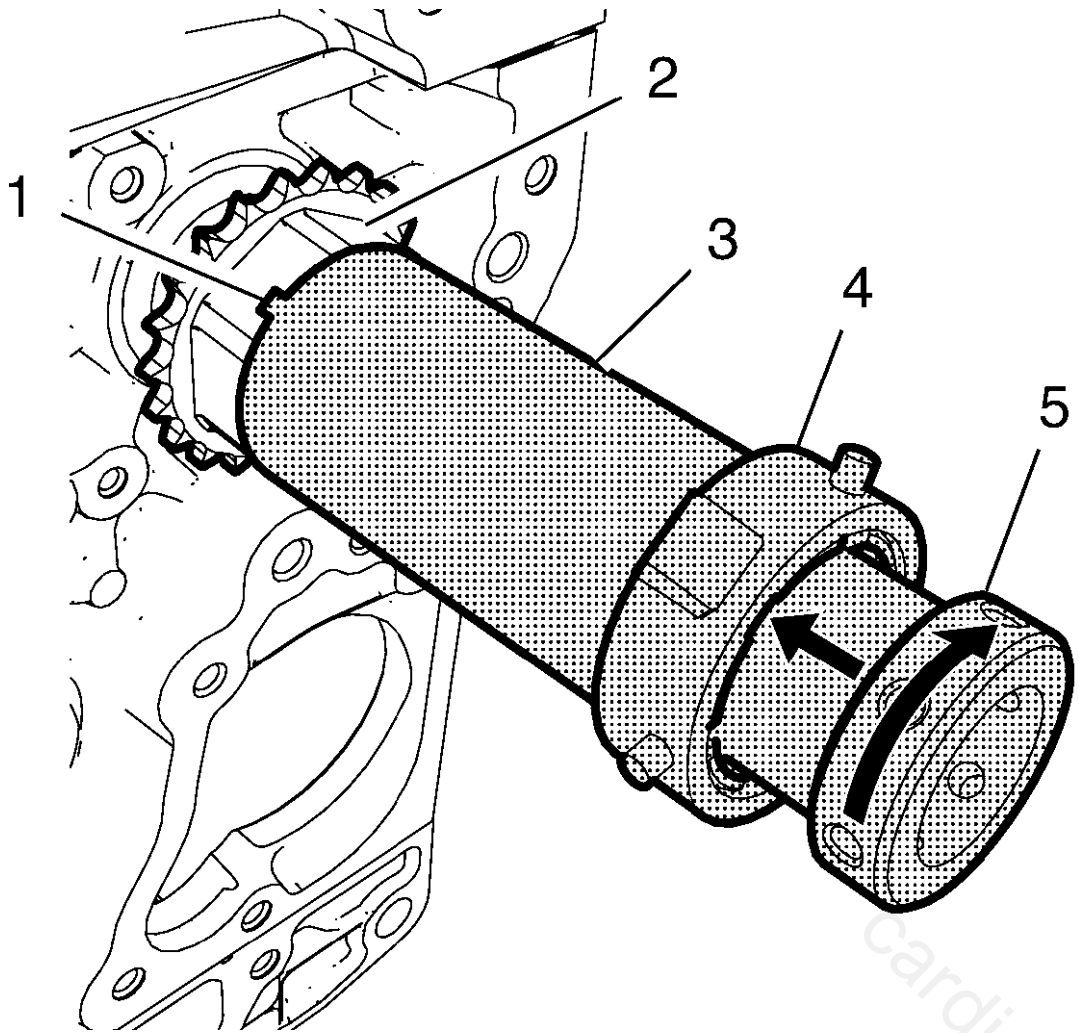


Fig. 670: Locking Tool Installed

Courtesy of GENERAL MOTORS COMPANY

1. Install the EN-50885-2 locking tool.
 1. Install the housing (3) to the fuel injection pump driven sprocket nut (2). Ensure that the 3 tappets (1) mesh with the 3 slots of the fuel injection pump driven sprocket nut.
 2. Position the ring (4) for a good handling.
 3. Screw in the fixing tool (5) into the fuel injection pump driven sprocket nut.

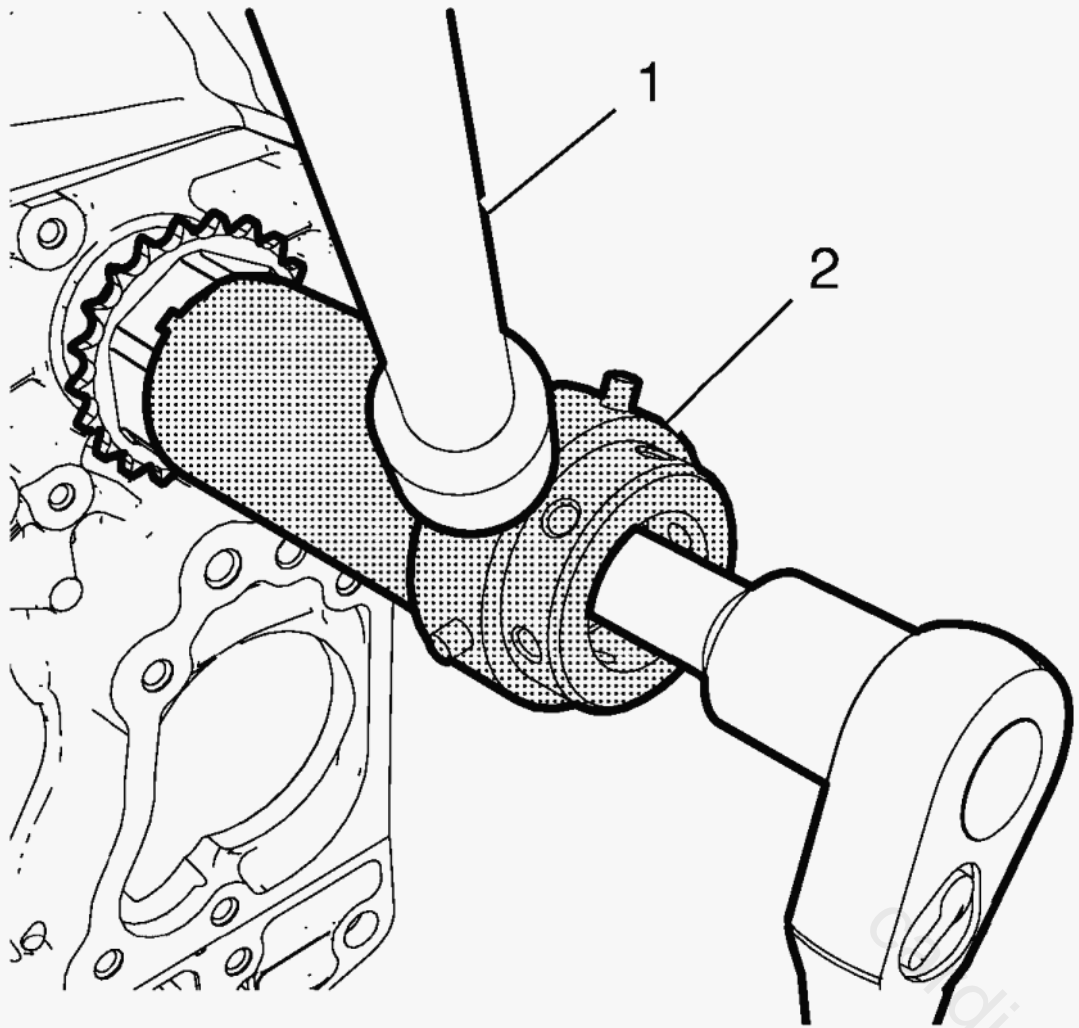


Fig. 671: Extension And Locking Tool

Courtesy of GENERAL MOTORS COMPANY

2. Install a 1/2" extension (1) to the EN-50885-2 locking tool (2) to counterhold.
3. Loosen the fuel injection pump driven sprocket nut.

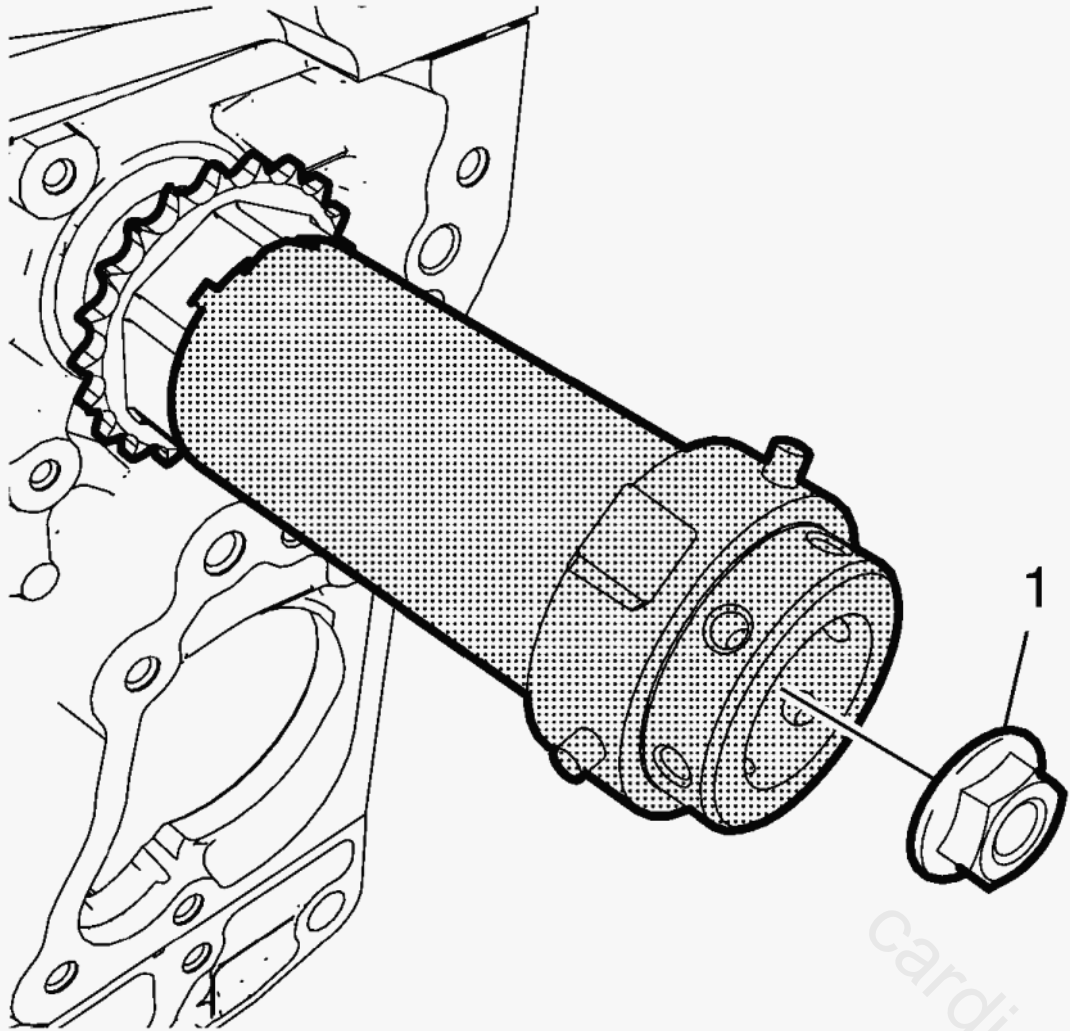


Fig. 672: Fuel Injection Pump Driven Sprocket Nut
Courtesy of GENERAL MOTORS COMPANY

4. Remove the fuel injection pump driven sprocket nut (1).

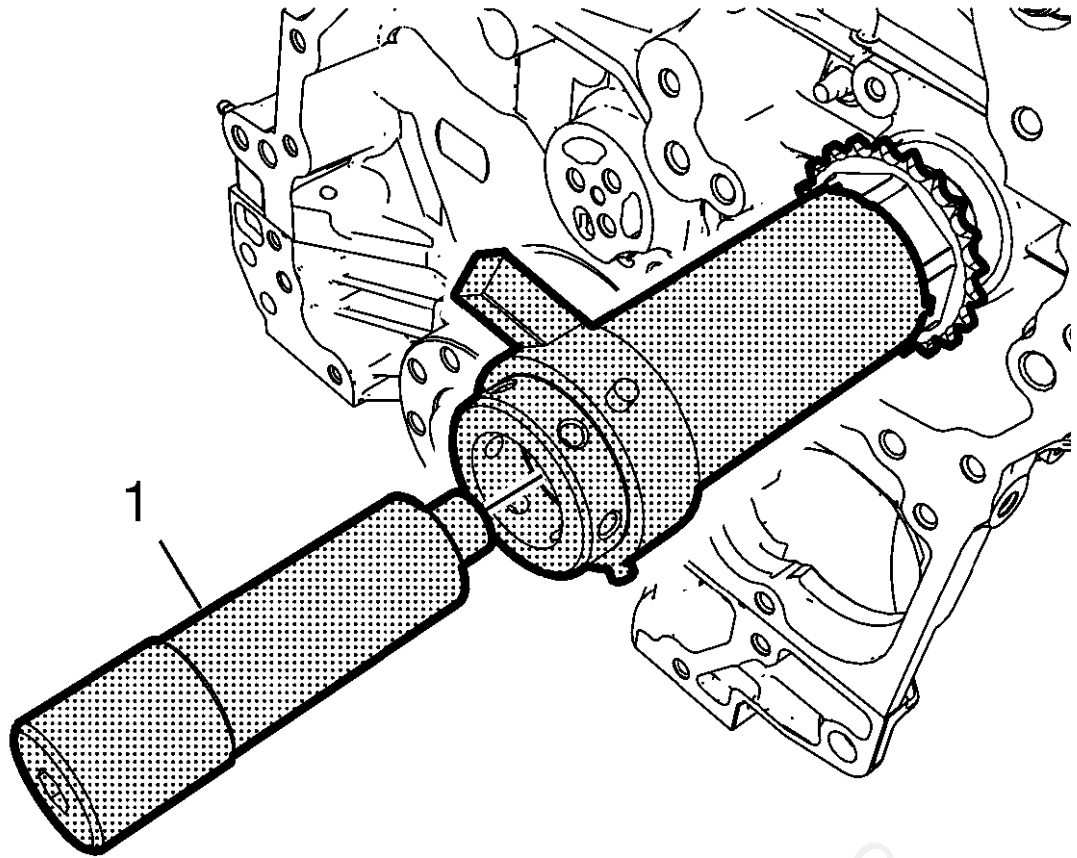


Fig. 673: Pressure Spindle And Locking Tool
Courtesy of GENERAL MOTORS COMPANY

5. Install the pressure spindle (1) to the EN-50885-2 locking tool (2).

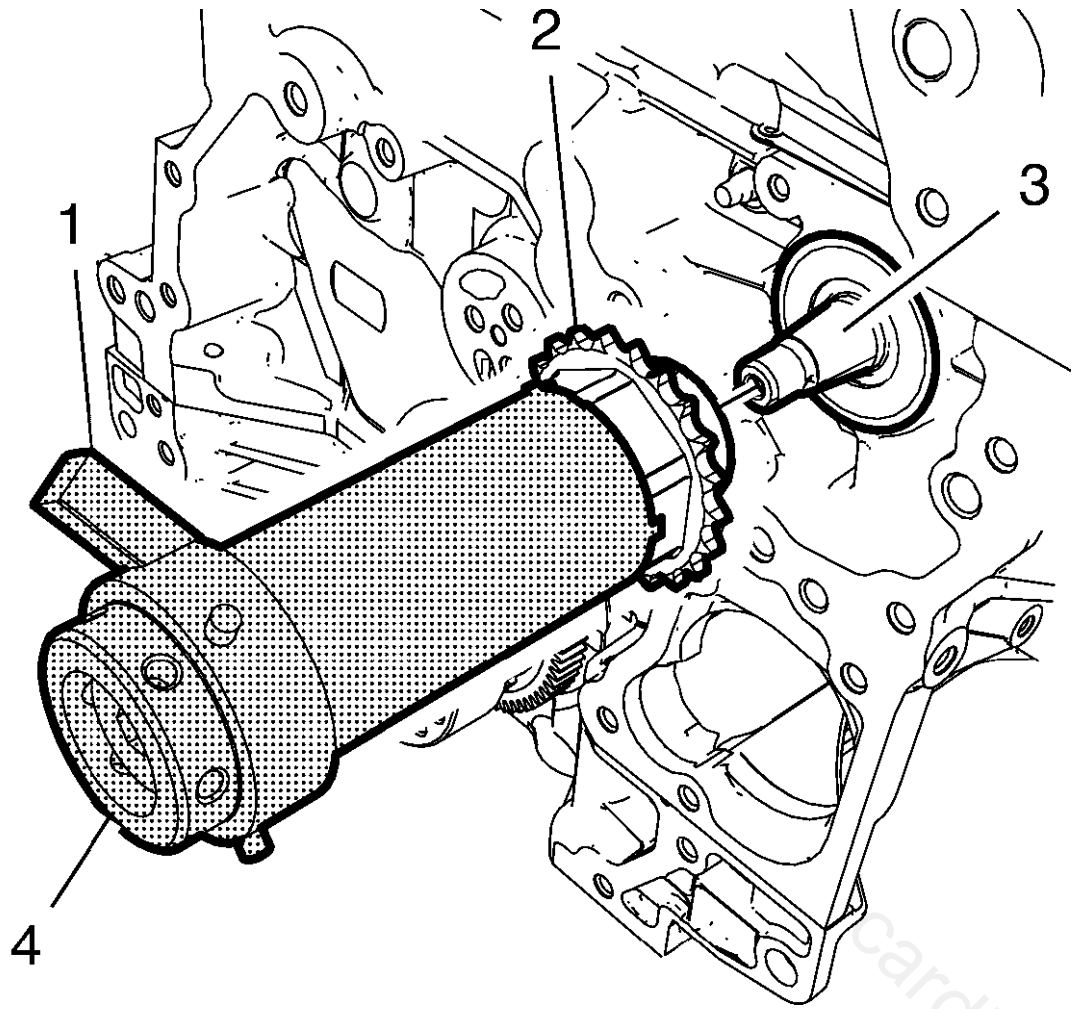


Fig. 674: Fuel Injection Pump Sprocket, Pressure Spindle And Locking Tool
Courtesy of GENERAL MOTORS COMPANY

6. Press out the fuel injection pump sprocket (2), by screw in the pressure spindle (4) into the **EN-50885-2** fixing tool (1).
7. Remove the fuel injection fuel pump driven sprocket.
8. Remove the **EN-50885-2** fixing tool from the fuel injection pump driven sprocket.

FUEL INJECTION PUMP REMOVAL

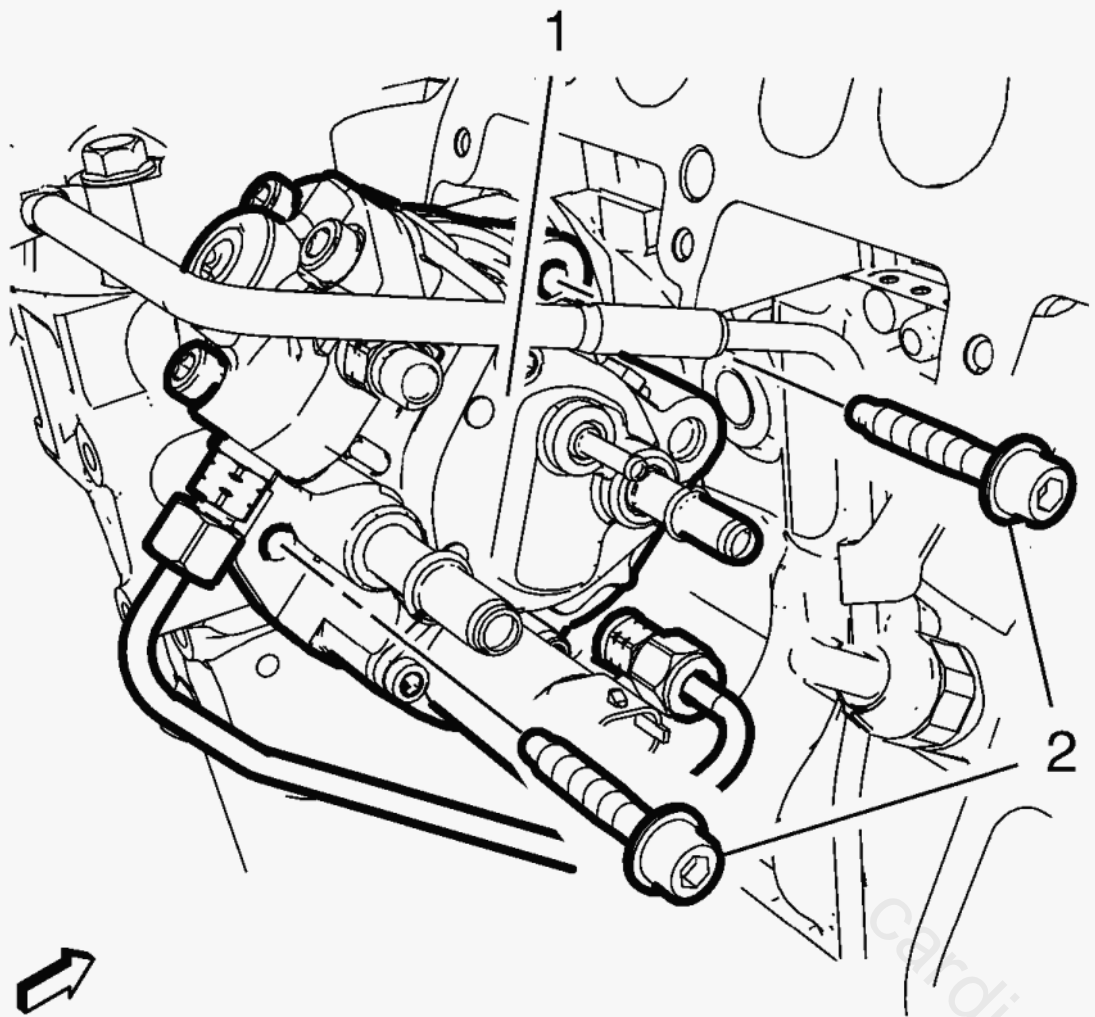


Fig. 675: Fuel Injection Fuel Pump And Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Remove the 2 fuel injection fuel pump bolts (2) from the fuel injection fuel pump (1).

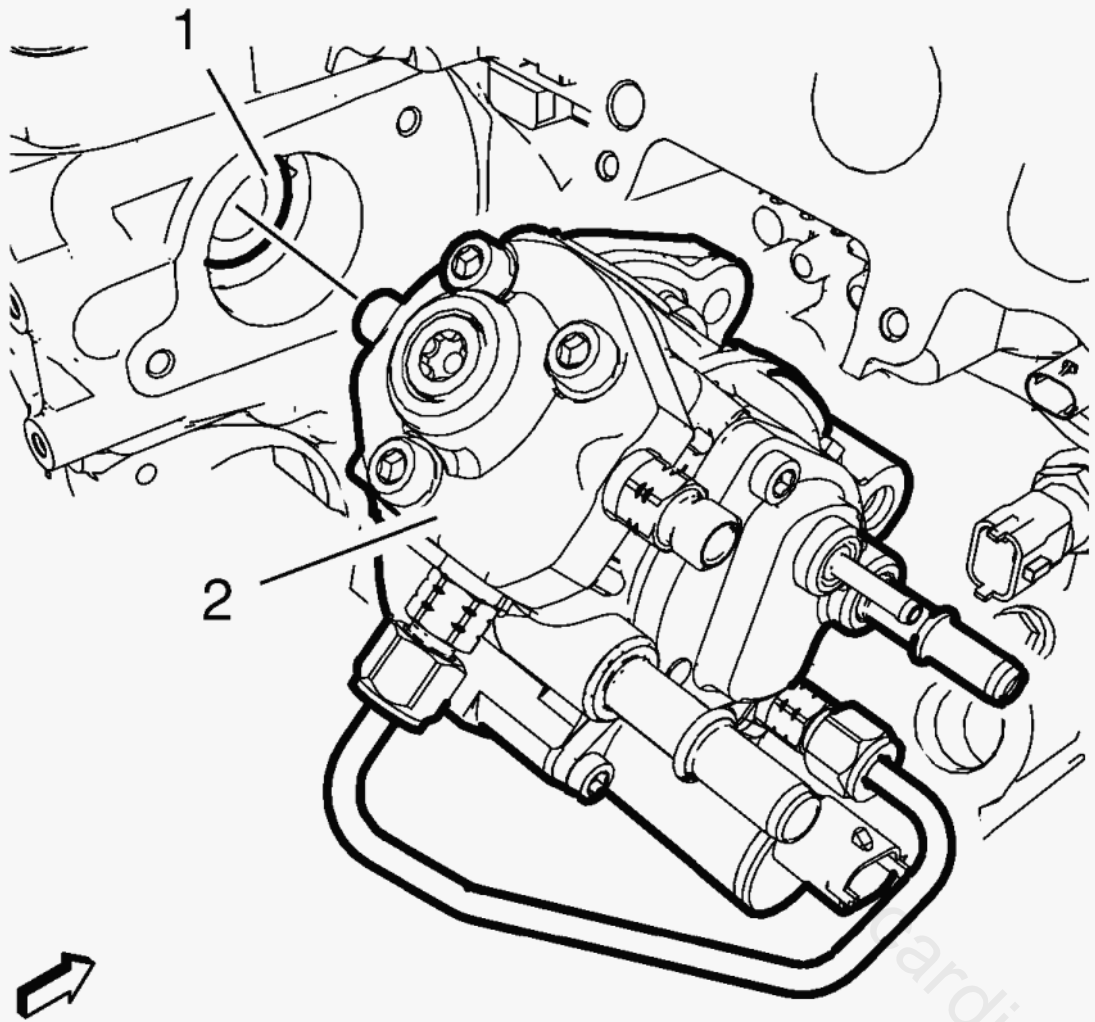


Fig. 676: Fuel Injection Fuel Pump

Courtesy of GENERAL MOTORS COMPANY

2. Remove the fuel injection pump (2).

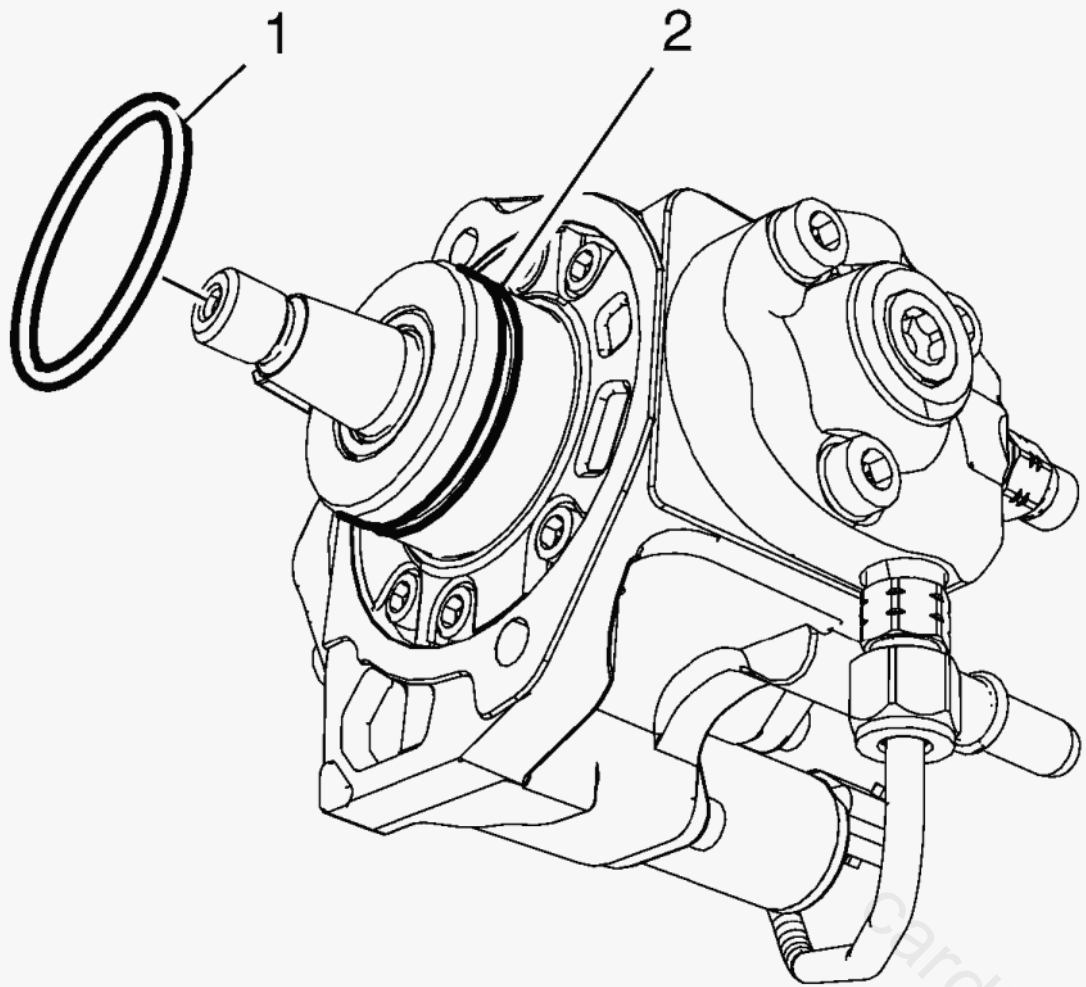


Fig. 677: Fuel Injection Pump Seal Ring And Fuel Injection Pump Sealing Groove
Courtesy of GENERAL MOTORS COMPANY

3. Remove and DISCARD the fuel injection pump seal ring (1) from the fuel injection pump sealing groove (2).

CAMSHAFT SPROCKET REMOVAL

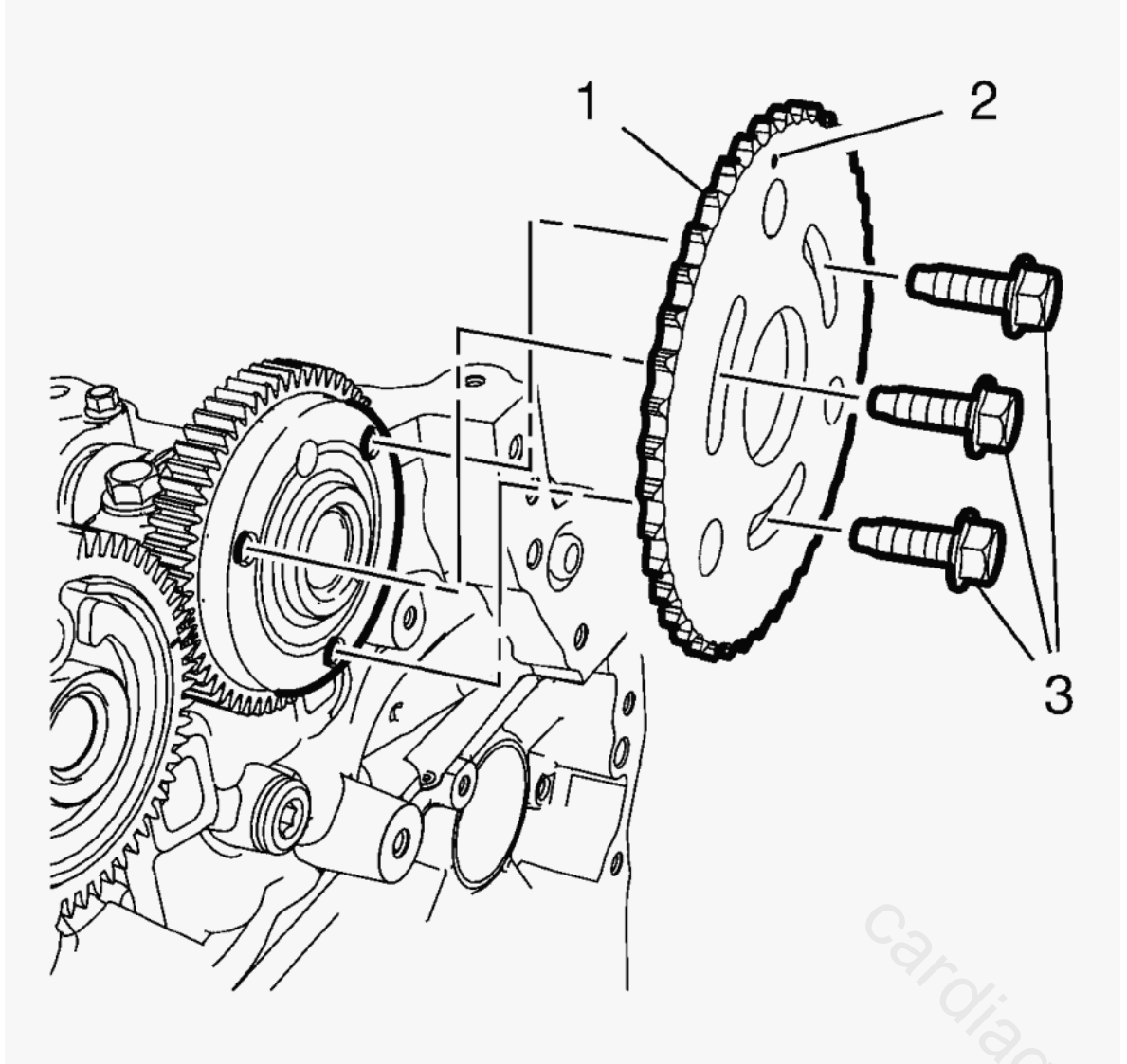


Fig. 678: Camshaft Sprocket And Bolts

Courtesy of GENERAL MOTORS COMPANY

1. Remove the 3 camshaft sprocket bolts (3), counterhold with a wrench at the camshaft hexagon.
2. Remove the camshaft sprocket (1) from the intake camshaft.

INTAKE CAMSHAFT REMOVAL

Special Tools

- **EN-50509** Split Intake Camshaft Sprocket Fixing Tool
- **EN-51143** Camshaft Sprocket Fixing Tool

For equivalent regional tools, refer to [**Special Tools**](#).

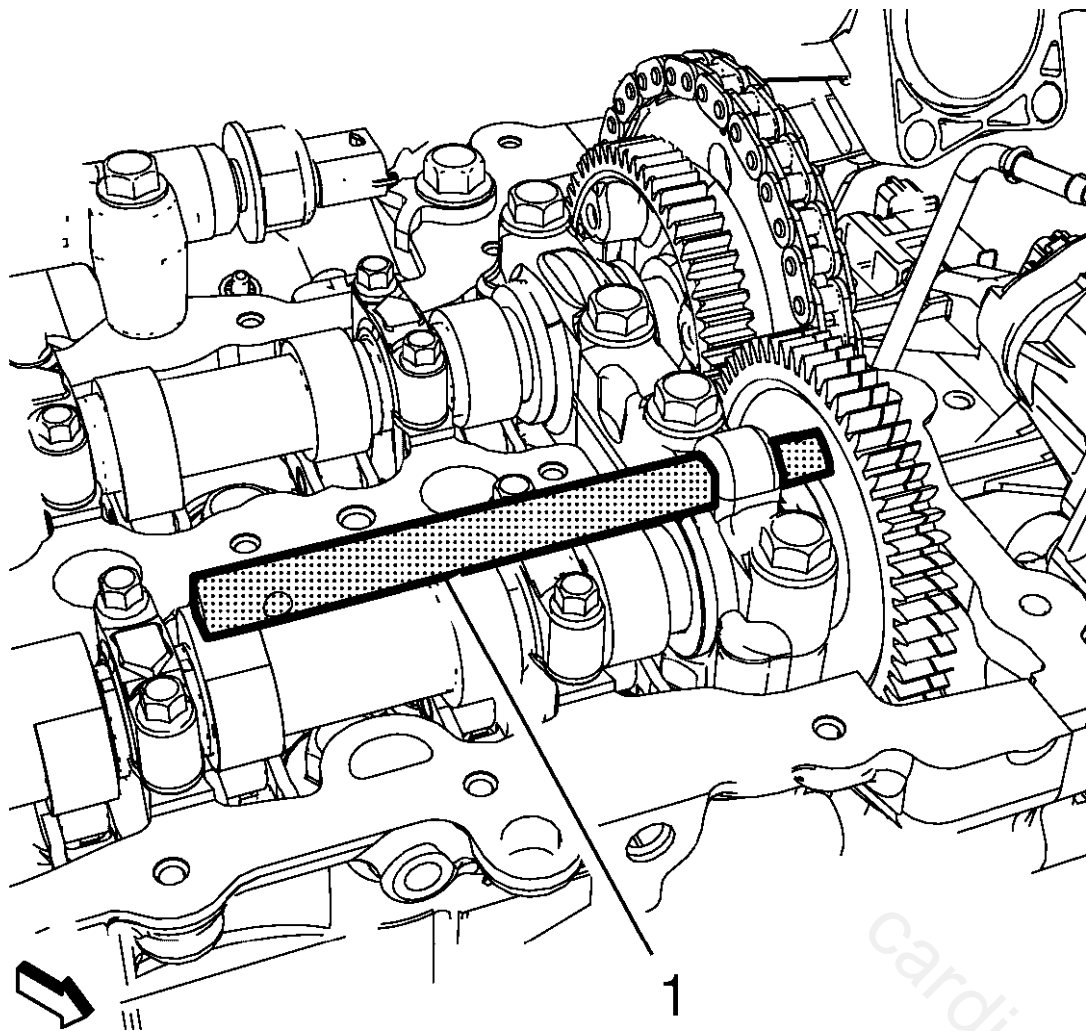


Fig. 679: Camshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

1. Remove the **EN-51143** fixing tool (1), by carefully turning the hexagon of the camshaft.

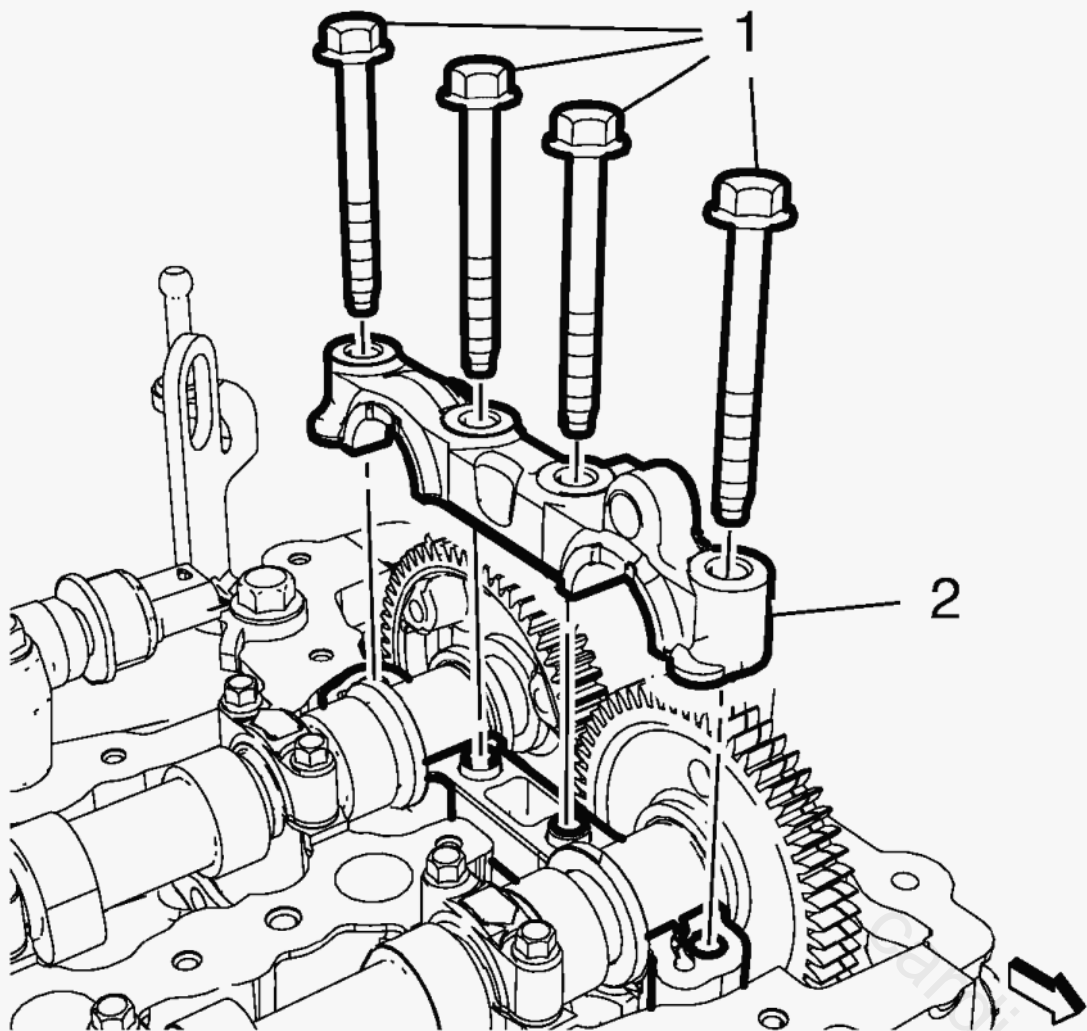


Fig. 680: Camshaft Bearing Rear Cap And Bolts
Courtesy of GENERAL MOTORS COMPANY

2. Remove the camshaft bearing rear cap bolts (1).
3. Remove the camshaft bearing rear cap (2).

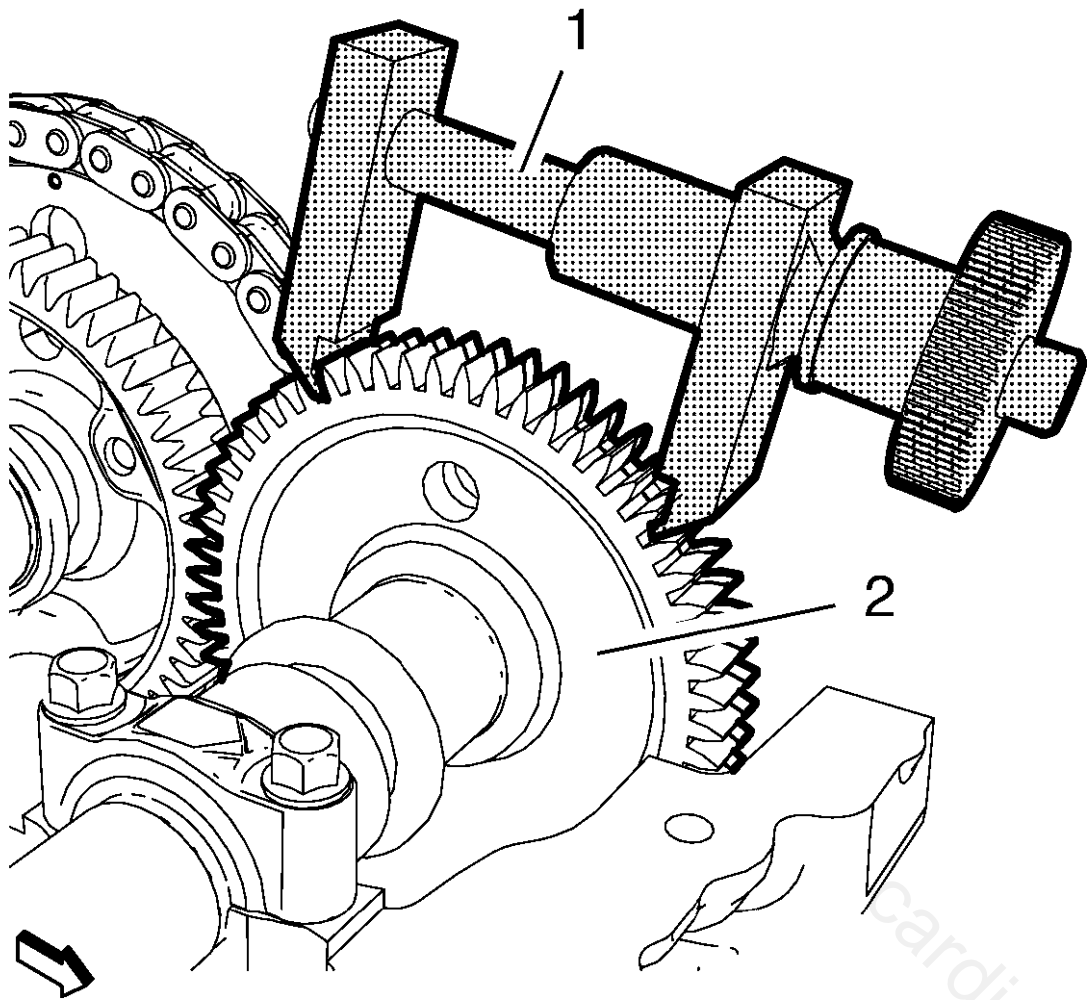


Fig. 681: Split Intake Camshaft Sprocket Fixing Tool
Courtesy of GENERAL MOTORS COMPANY

4. Install the EN-50509 fixing tool (1) to the exhaust camshaft sprocket (2).

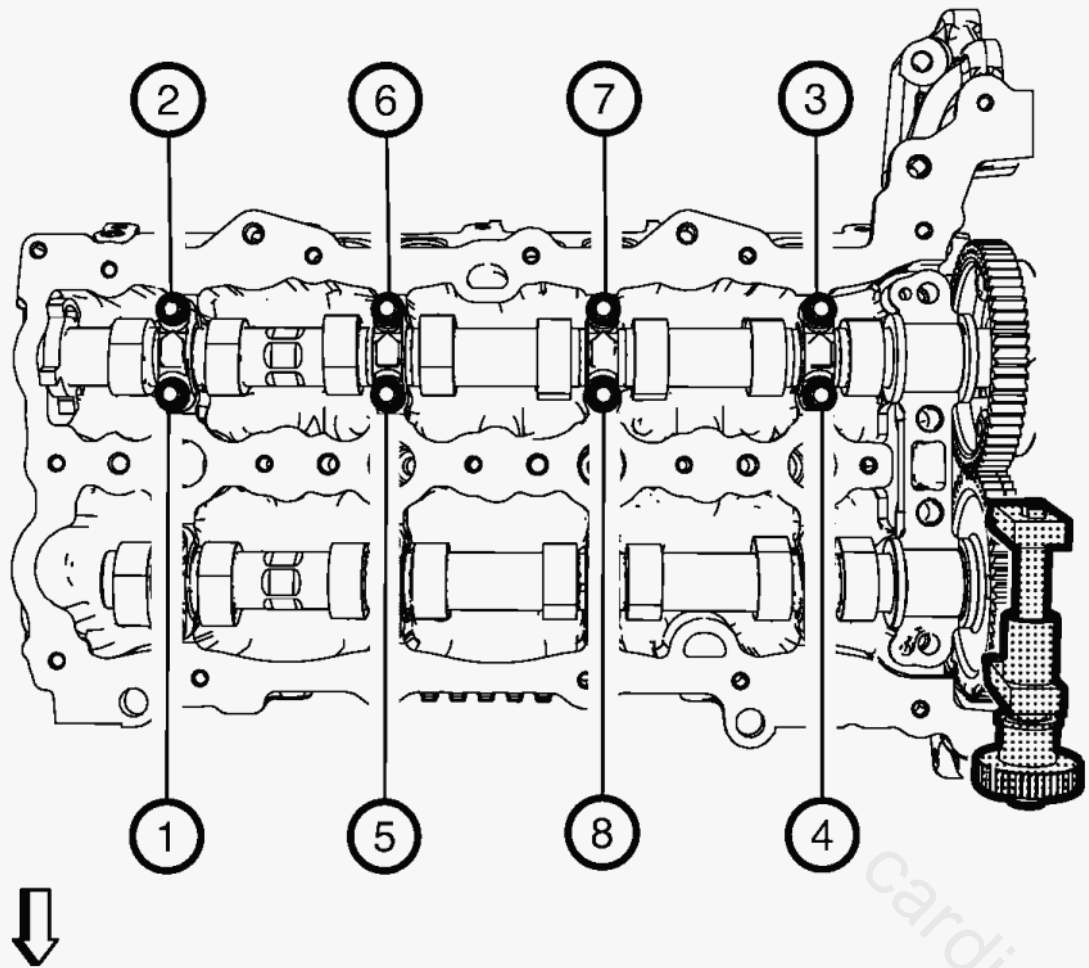


Fig. 682: Intake Camshaft Bearing Cap Bolt Loosening Sequence
Courtesy of GENERAL MOTORS COMPANY

5. Loosen the 8 intake camshaft bearing cap bolts in sequence as shown.

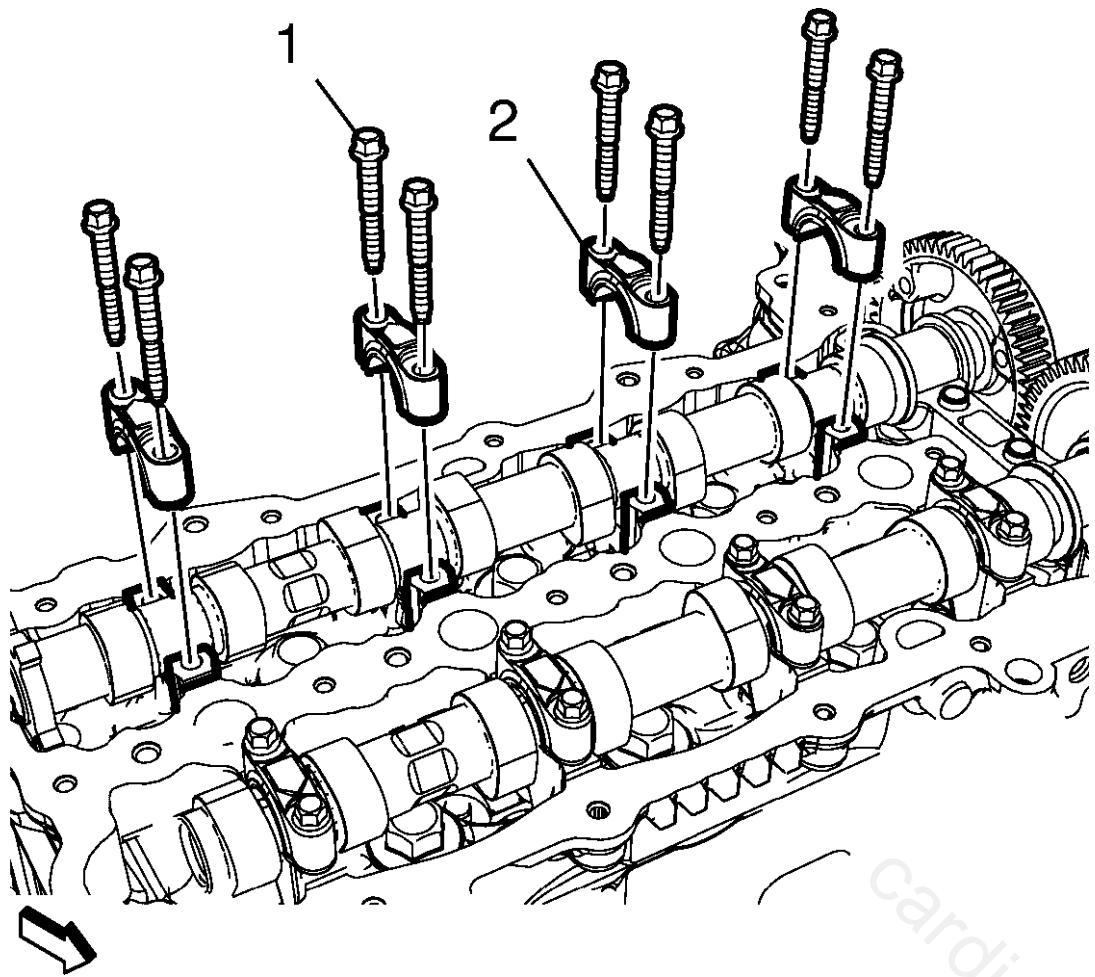


Fig. 683: Intake Camshaft Bearing Caps And Bolts
Courtesy of GENERAL MOTORS COMPANY

6. Remove the 8 intake camshaft bearing cap bolts (1).
7. Remove the 4 intake camshaft bearing caps (2) and lay aside in the order as they were removed.

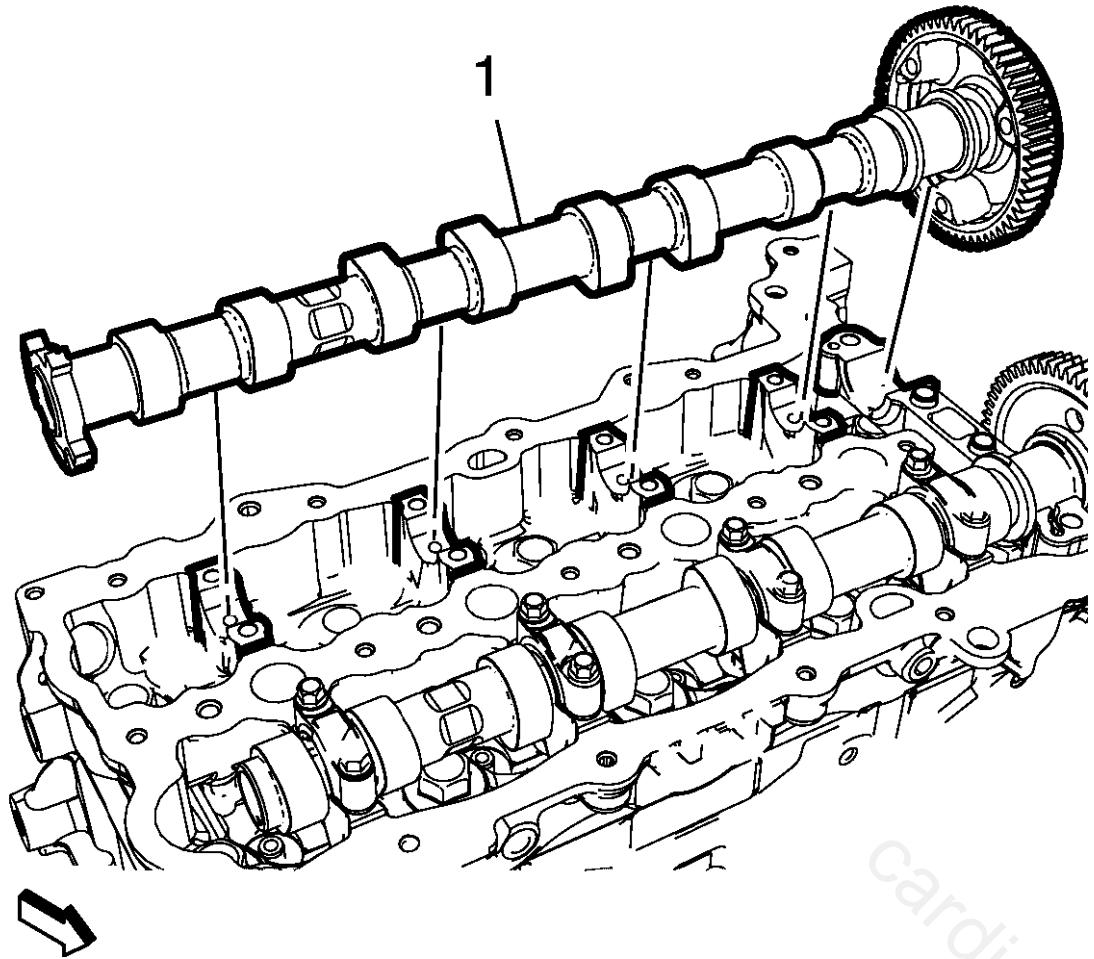


Fig. 684: Intake Camshaft

Courtesy of GENERAL MOTORS COMPANY

8. Remove the intake camshaft (1).

EXHAUST CAMSHAFT REMOVAL

Special Tools

- **EN-50509** Split Intake Camshaft Sprocket Fixing Tool
- **EN-51143** Camshaft Sprocket Fixing Tool

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

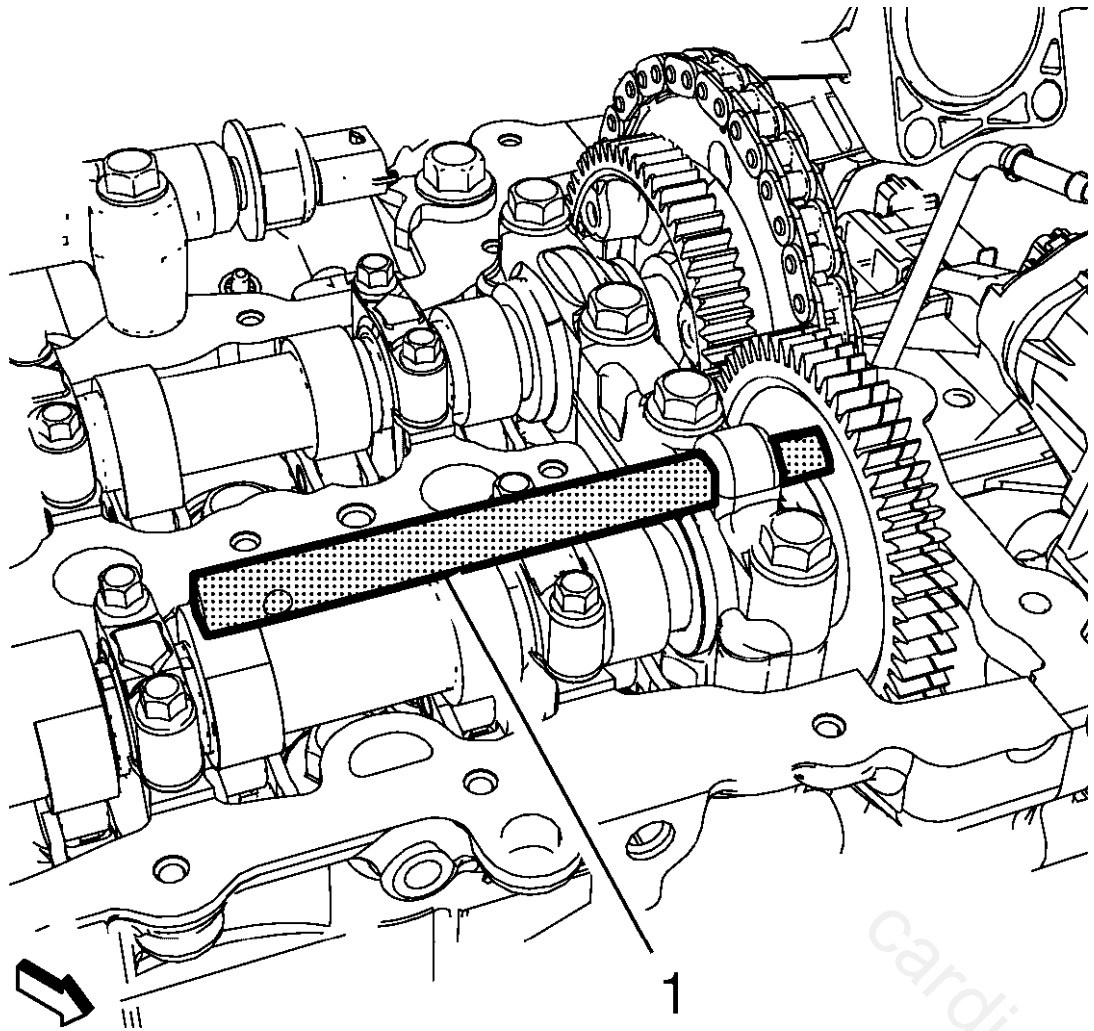


Fig. 685: Camshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

1. Remove the EN-51143 fixing tool (1).

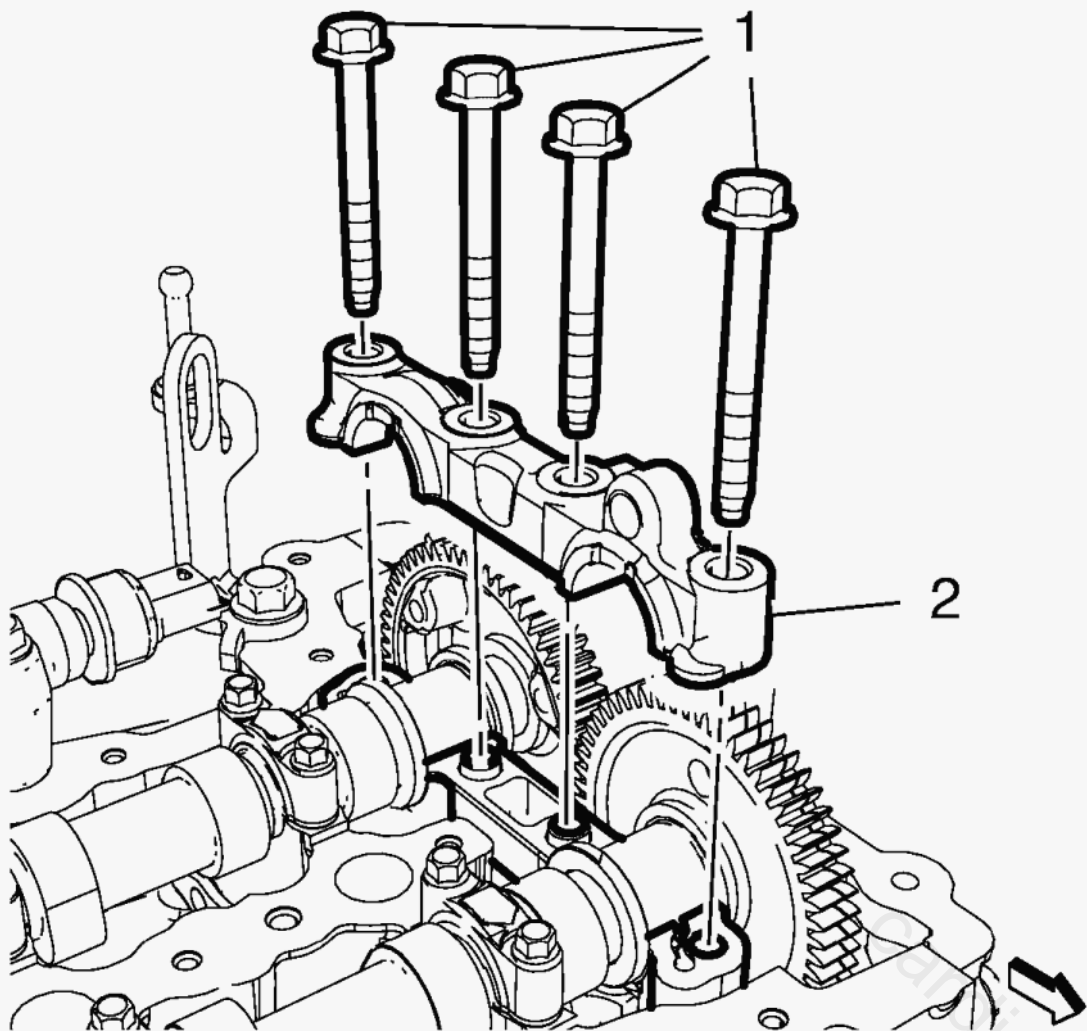


Fig. 686: Camshaft Bearing Rear Cap And Bolts
Courtesy of GENERAL MOTORS COMPANY

2. Remove the camshaft bearing rear cap bolts (1).
3. Remove the camshaft bearing rear cap (2).

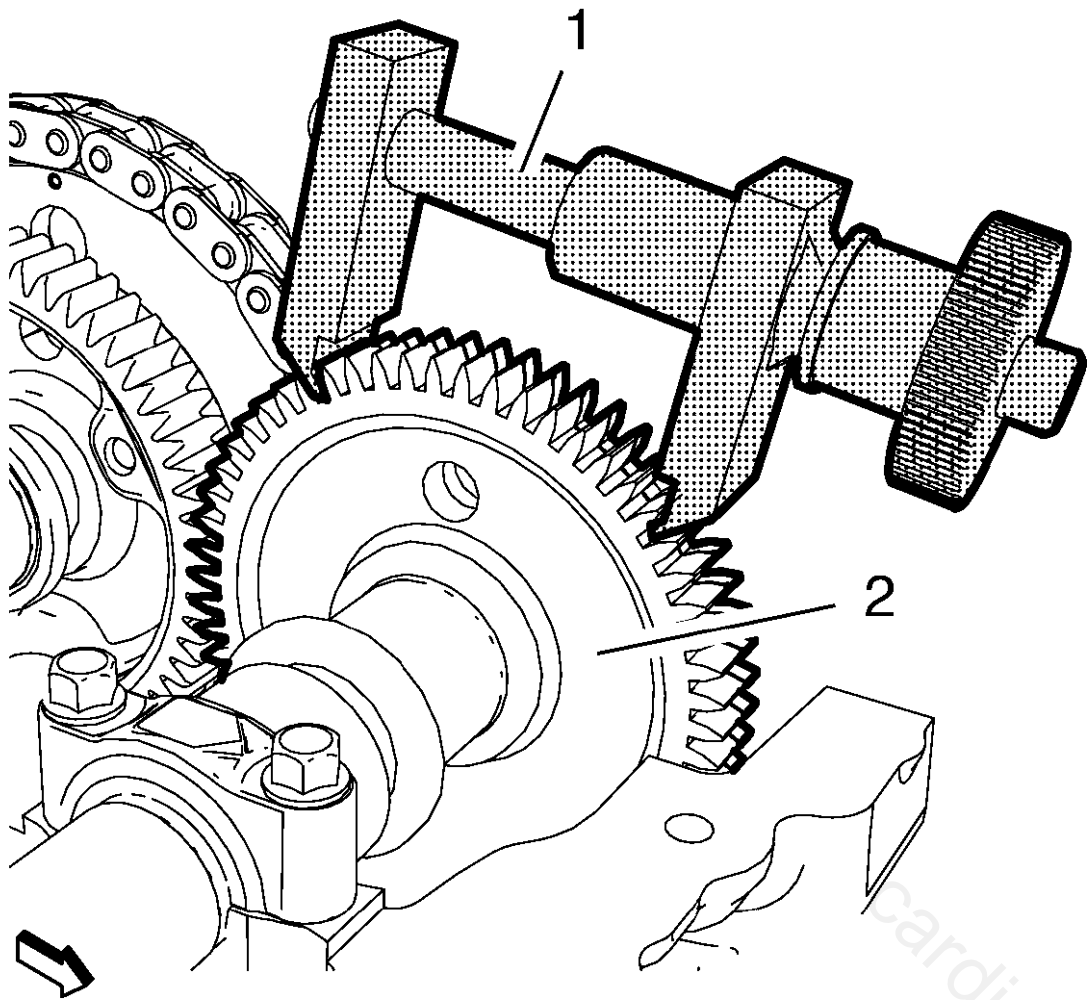


Fig. 687: Split Intake Camshaft Sprocket Fixing Tool
Courtesy of GENERAL MOTORS COMPANY

4. Install the EN-50509 fixing tool (1) to the exhaust camshaft sprocket (2).

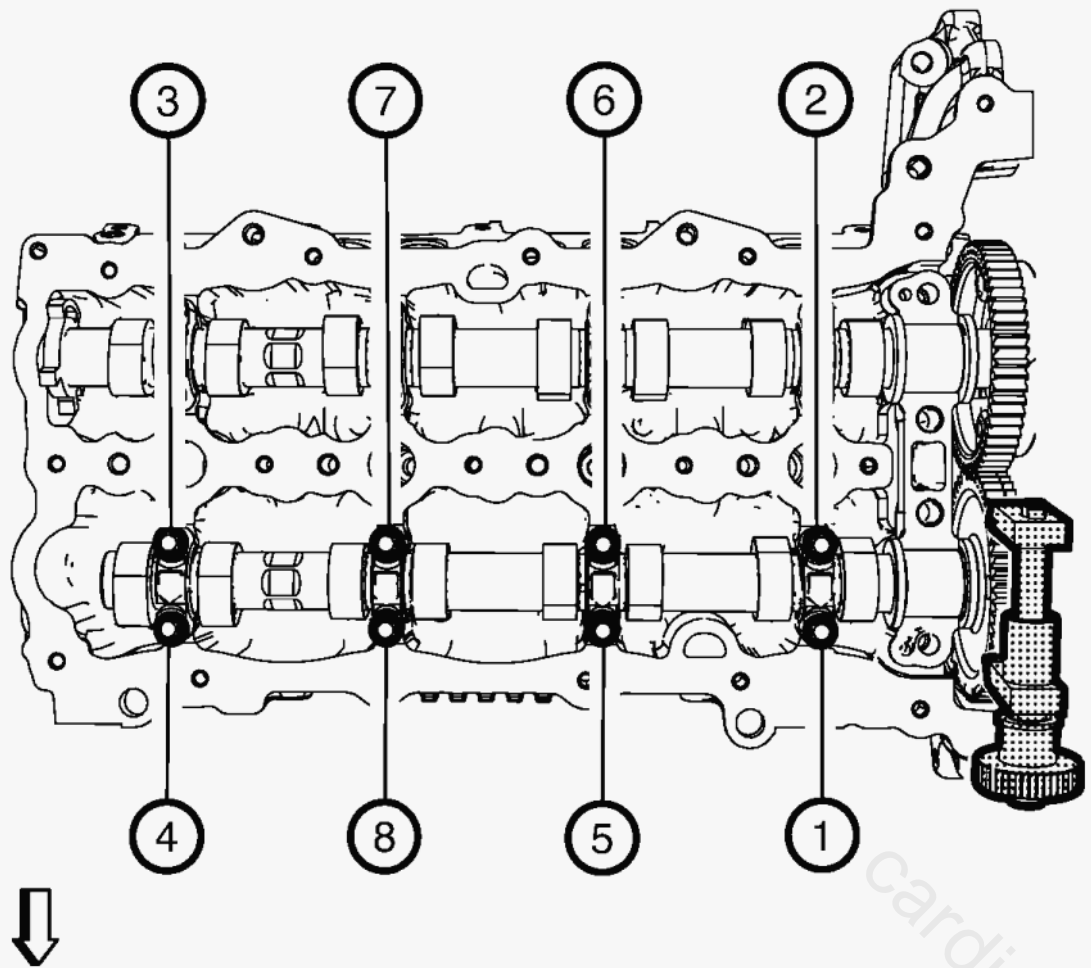


Fig. 688: Exhaust Camshaft Bearing Cap Bolt Loosening Sequence
Courtesy of GENERAL MOTORS COMPANY

5. Loosen the 8 exhaust camshaft bearing cap bolts in sequence as shown.

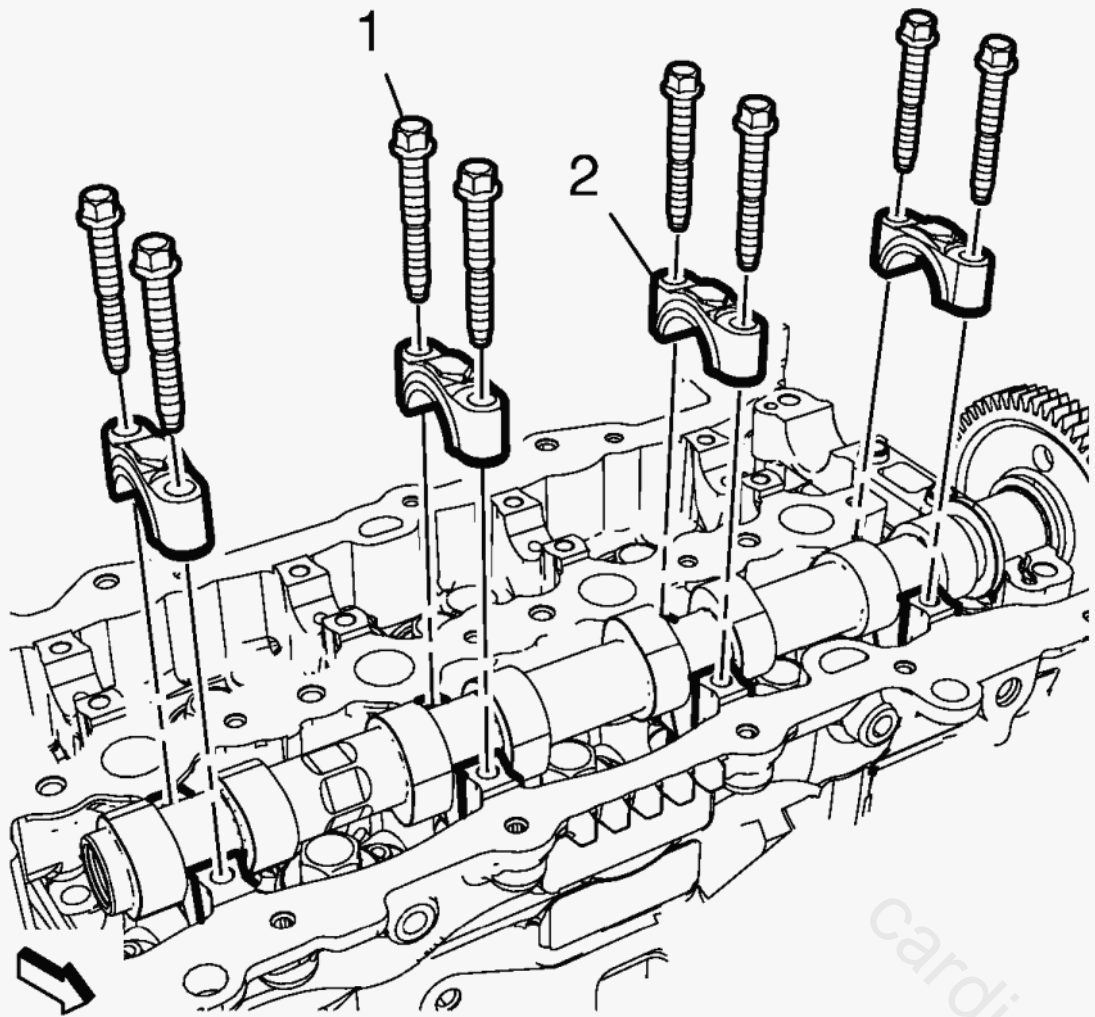


Fig. 689: Exhaust Camshaft Bearing Caps And Bolts
Courtesy of GENERAL MOTORS COMPANY

6. Remove the 8 exhaust camshaft bearing cap bolts (1).
7. Remove the 4 exhaust camshaft bearing caps (2) and lay aside in the order as they was removed.

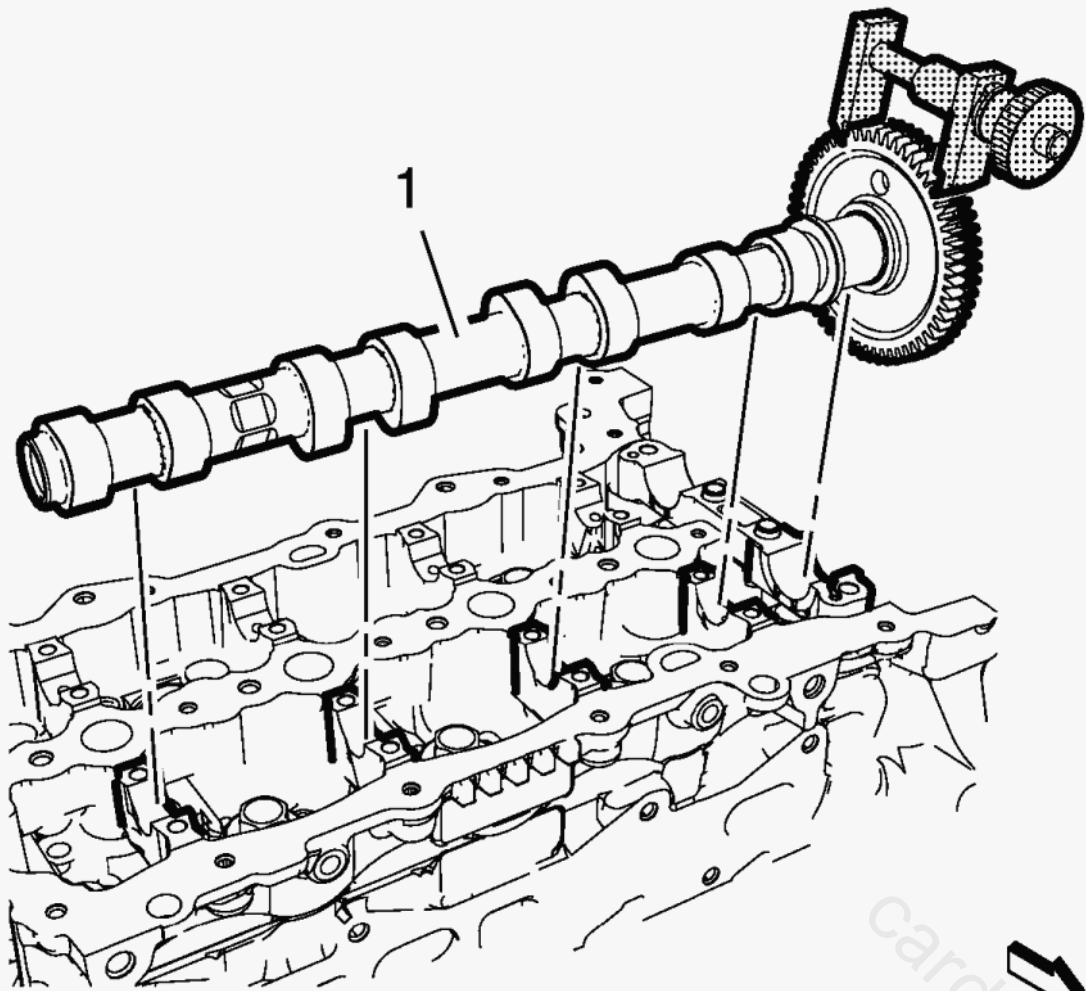


Fig. 690: Exhaust Camshaft

Courtesy of GENERAL MOTORS COMPANY

NOTE: If the exhaust camshaft are reinstall, do not remove the EN-50509 fixing tool.

8. Remove the exhaust camshaft (1).

VALVE LIFTER REMOVAL

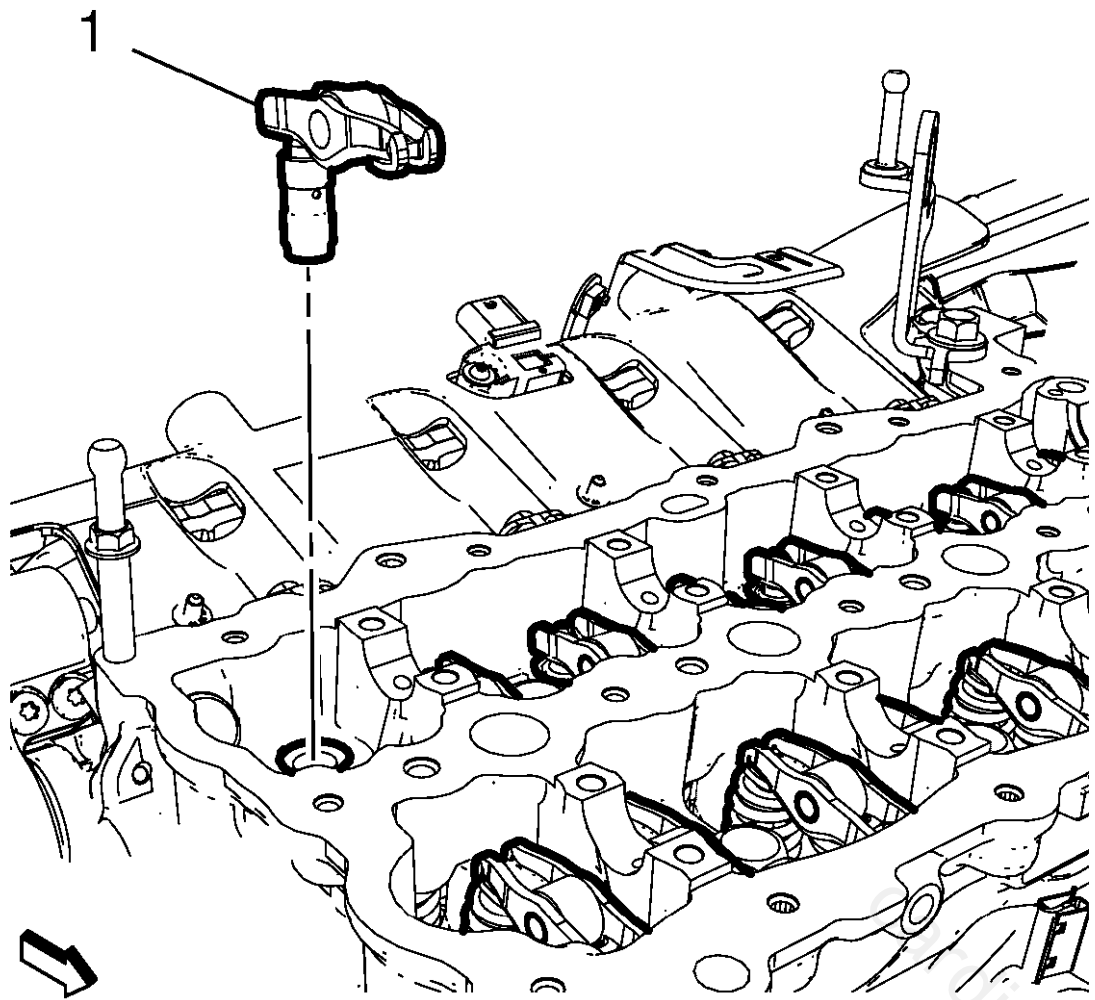


Fig. 691: Valve Lifter Roller Assemblies

Courtesy of GENERAL MOTORS COMPANY

1. Remove the 16 valve lifters with valve lifter roller (1) and lay aside in the order as they was removed.

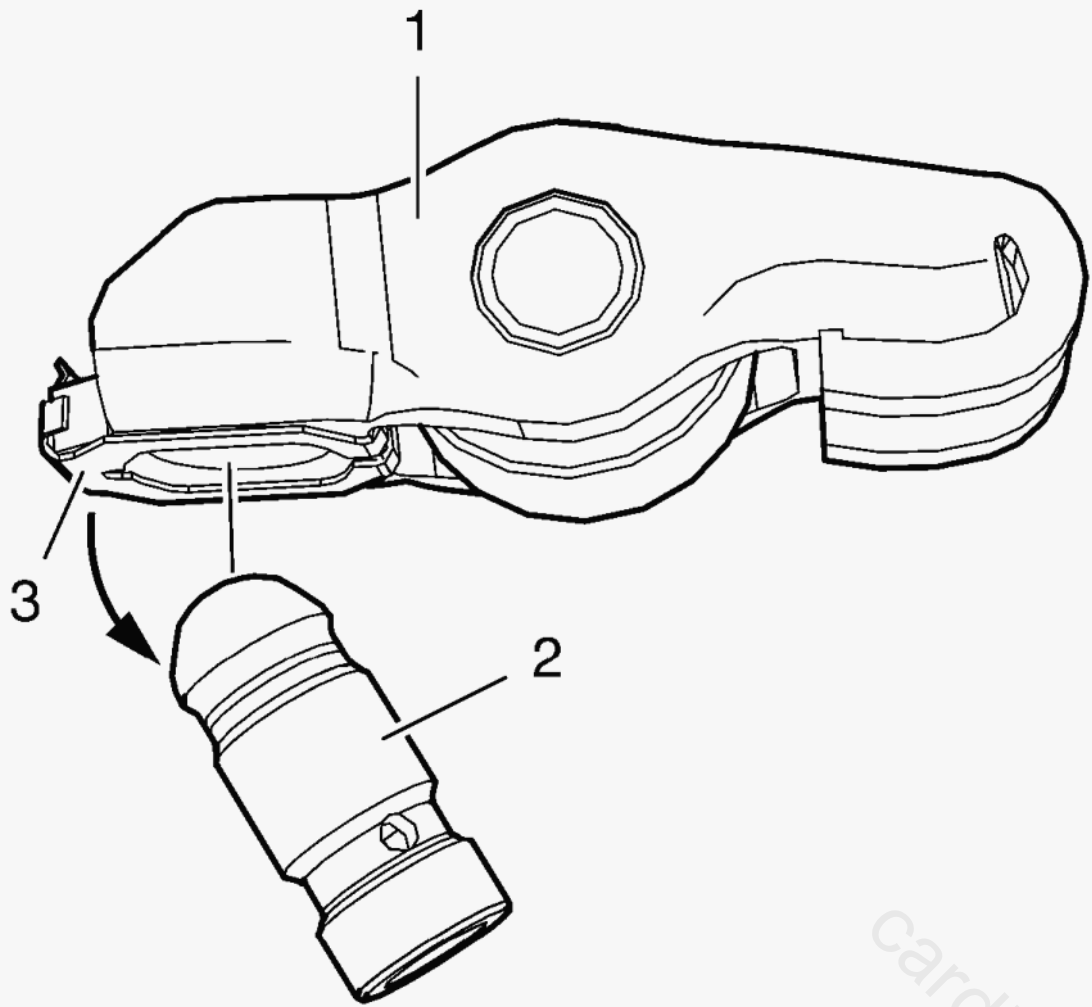


Fig. 692: Valve Rocker Arms And Valve Lifters
Courtesy of GENERAL MOTORS COMPANY

2. Unclip the valve lifter from the valve lifter roller in direction as shown (arrow). Mind to the centering link on retainer spring (3).
3. Remove the 16 valve lifters (2) from the valve lifter roller (1).

CAMSHAFT POSITION SENSOR REMOVAL

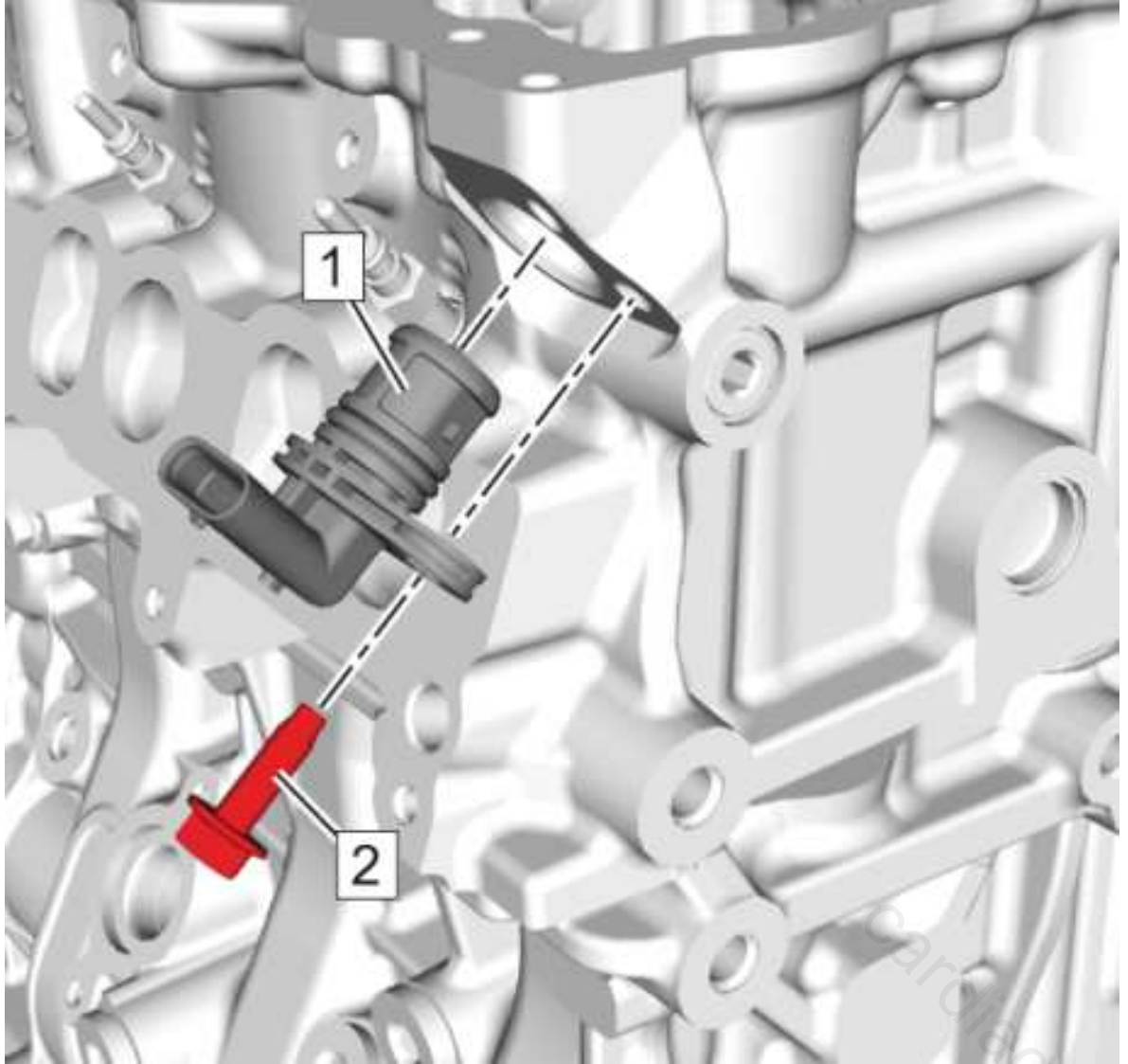


Fig. 693: Camshaft Position Sensor And Bolt
Courtesy of GENERAL MOTORS COMPANY

1. Remove Camshaft Position Sensor Bolt (2)
2. Remove Camshaft Position Sensor (1)

GLOW PLUG REMOVAL

Special Tools

EN-6104 Glow Plug Socket

Equivalent regional tools: [Special Tools](#)

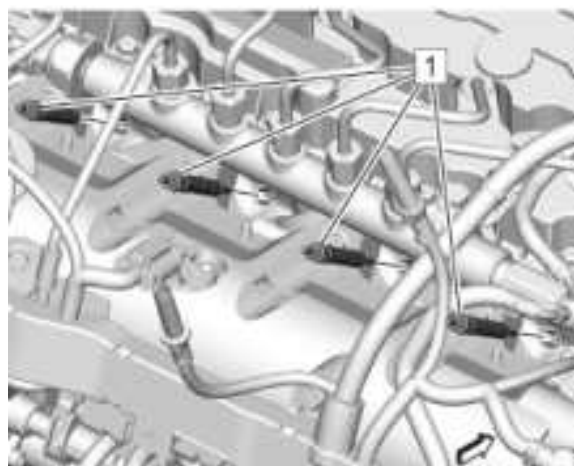


Fig. 694: Glow Plugs

Courtesy of GENERAL MOTORS COMPANY

1. Remove the 4 glow plugs (1), using the **EN-6104** socket.

CYLINDER HEAD REMOVAL

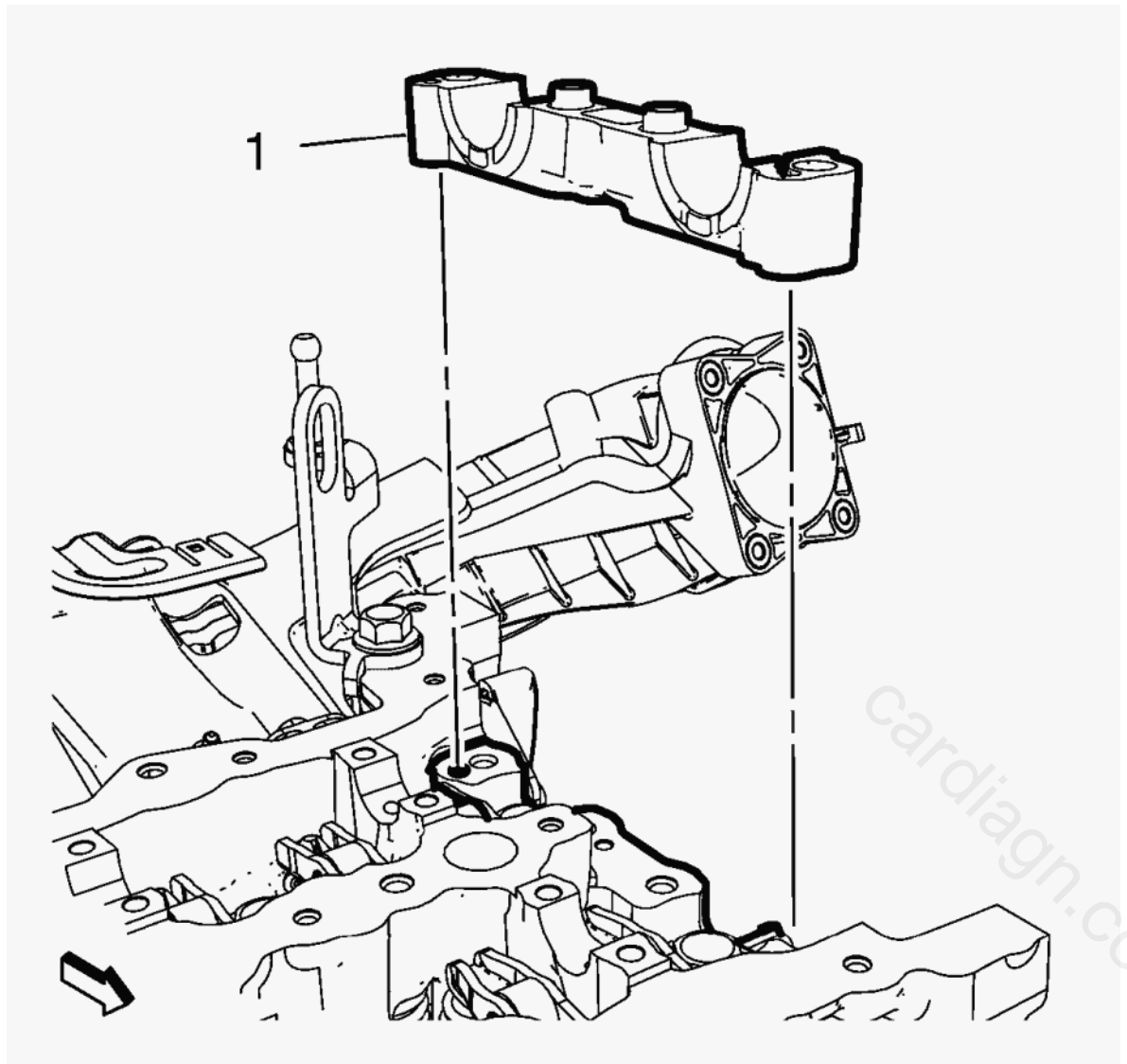


Fig. 695: Bearing Bracket

Courtesy of GENERAL MOTORS COMPANY

1. Remove the bearing bracket (1).

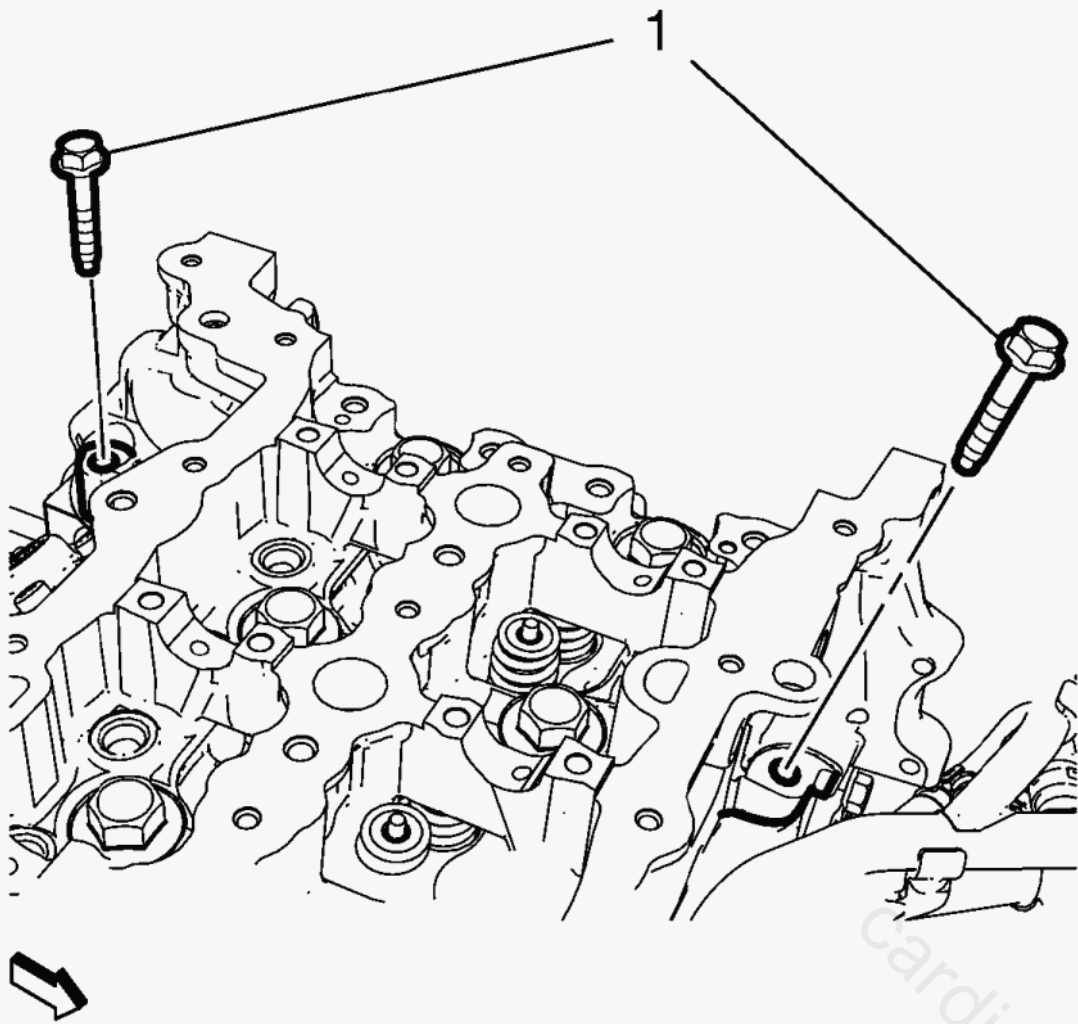


Fig. 696: Outer Cylinder Head Bolts

Courtesy of GENERAL MOTORS COMPANY

2. Remove and DISCARD the 2 outer cylinder head bolts (1).

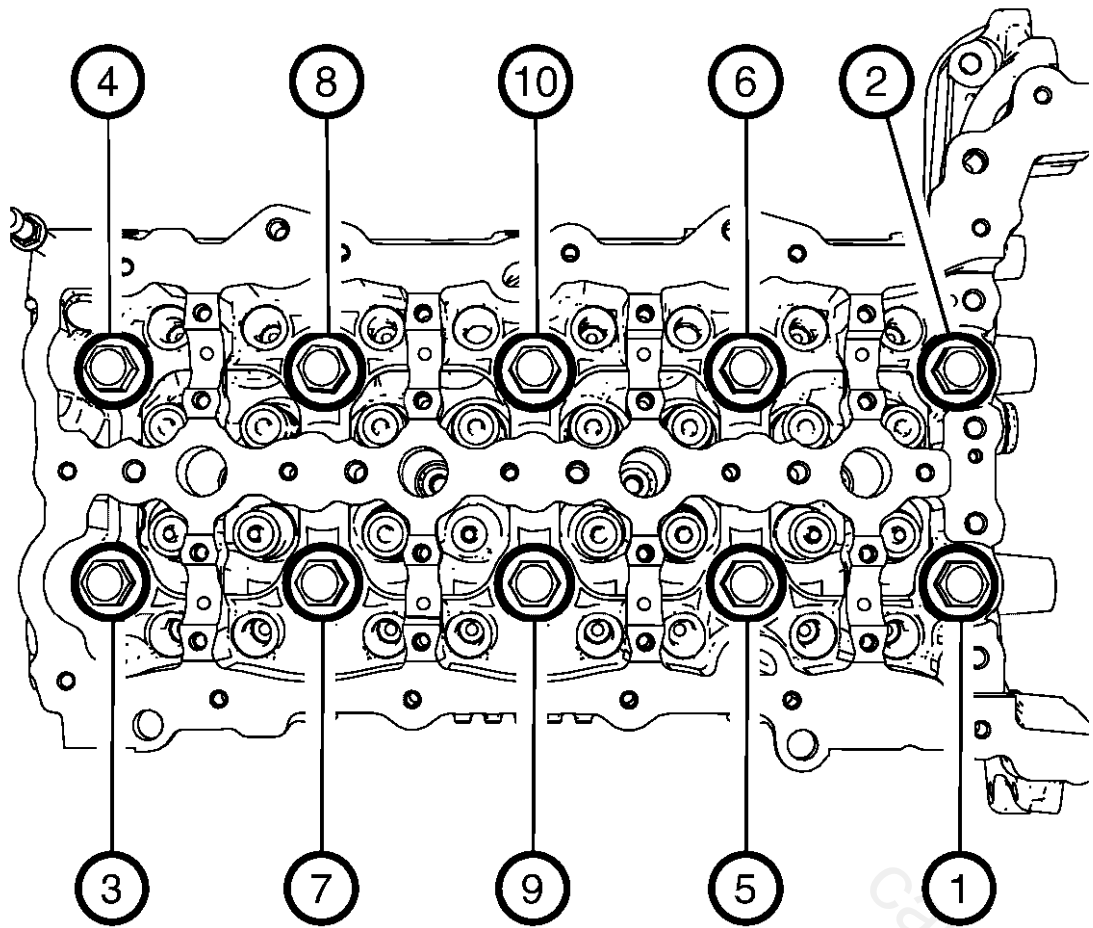


Fig. 697: Cylinder Head Bolt Loosening Sequence
Courtesy of GENERAL MOTORS COMPANY

3. Loosen the 10 cylinder head bolts in sequence as shown.

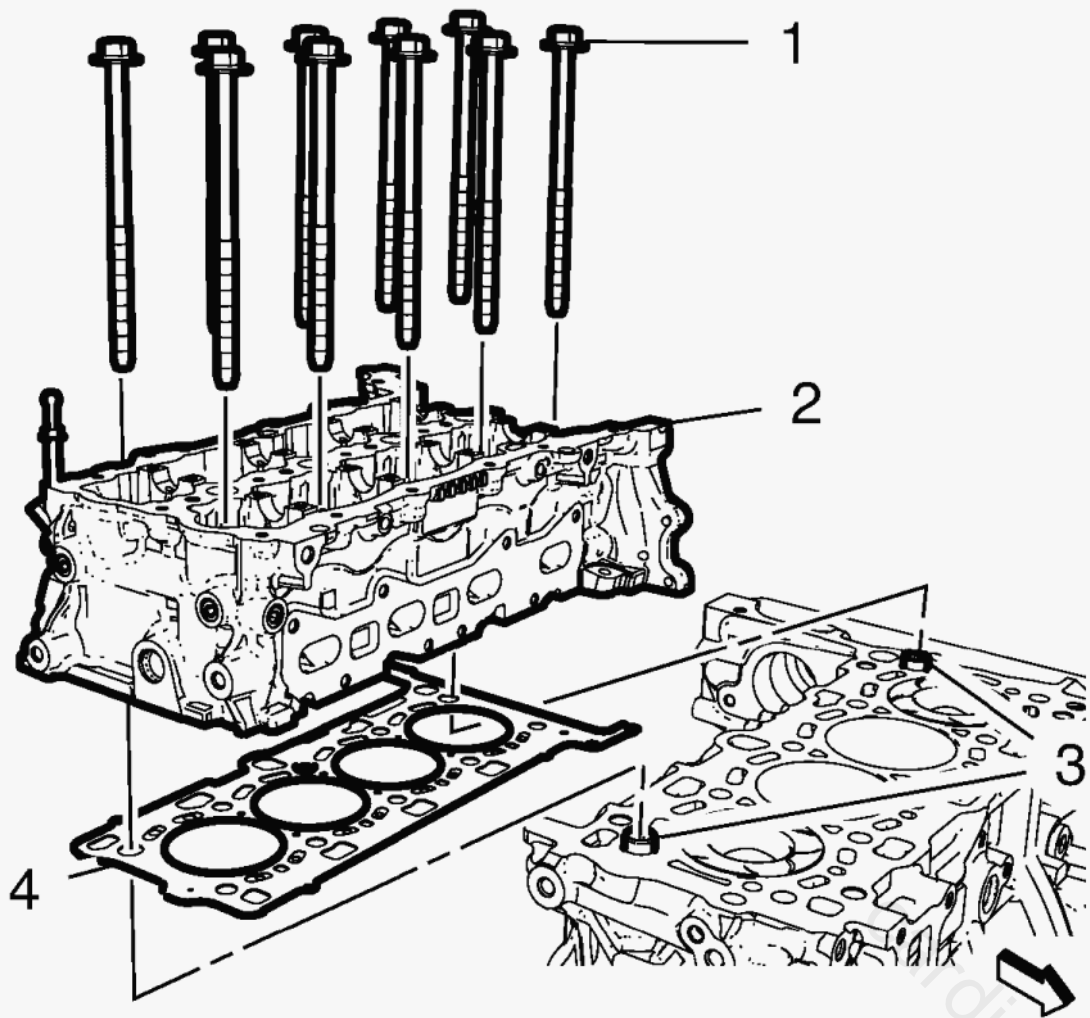


Fig. 698: Cylinder Head, Bolts And Gasket
Courtesy of GENERAL MOTORS COMPANY

4. Remove and DISCARD the 10 cylinder head bolts (1).

NOTE: Ensure the guide sleeves (3) are properly seated in the engine block.

5. Remove the cylinder head (2).

6. Remove and DISCARD the cylinder head gasket (4).

PISTON, CONNECTING ROD, AND BEARING REMOVAL

Special Tools

EN-51140 Crankshaft Fixing Tool

For equivalent regional tools, refer to [Special Tools](#).

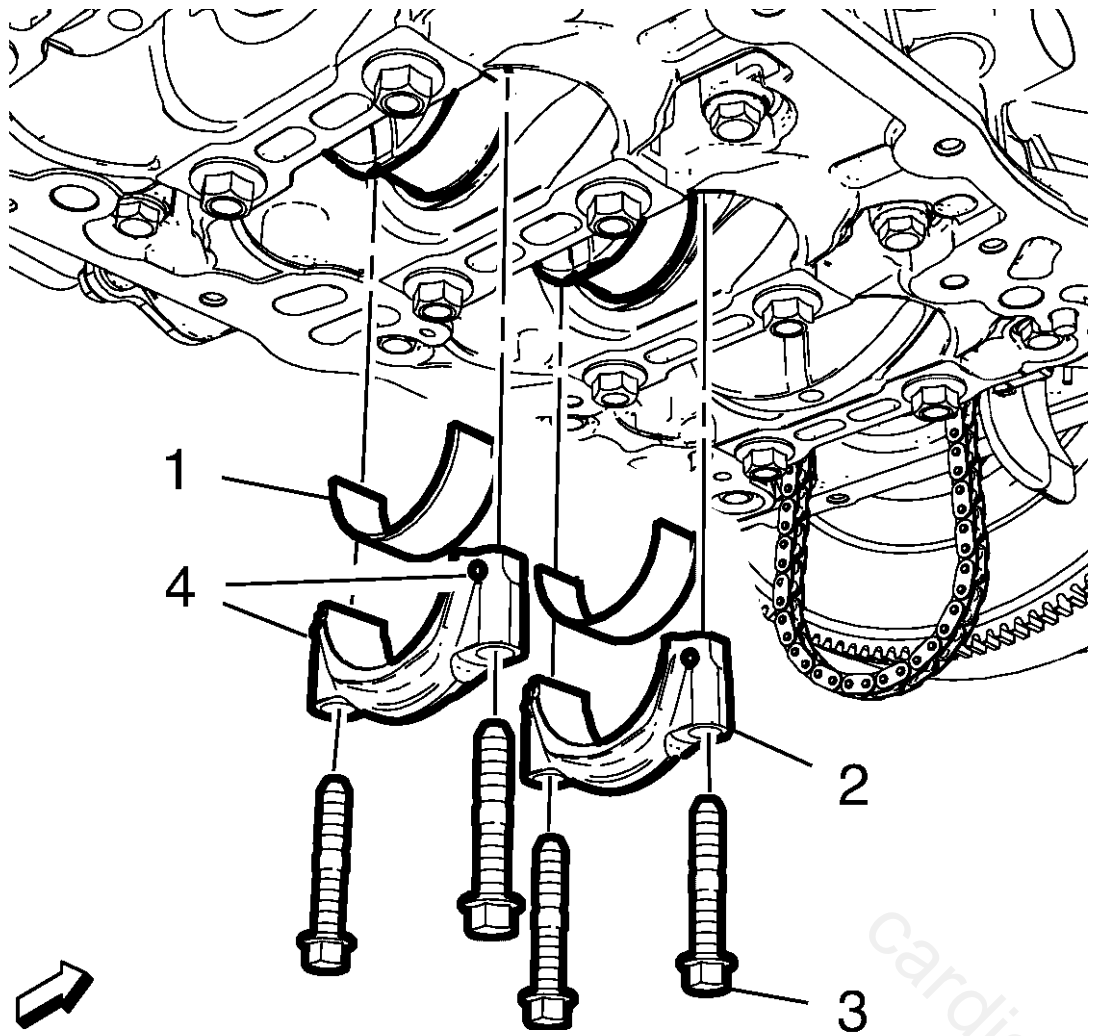


Fig. 699: Cylinder 2 And 3 Connecting Rod Caps, Bolts And Lower Bearings
Courtesy of GENERAL MOTORS COMPANY

1. Remove and DISCARD the 4 connecting rod bearing cap bolts (3) from the cylinder 2 and the cylinder 3.

NOTE: Lay aside in the order as they was removed.

NOTE: The shear surfaces of the connecting rod and the connecting rod bearing cap form a unique fit and must not be swapped or damaged. Do not lay down on the shear surfaces.

2. Remove the 2 connecting rod bearing caps (2) from the cylinder 2 and the cylinder 3.

NOTE: Lay aside in the order as they was removed.

3. Remove the 2 connecting rod lower bearings (1).

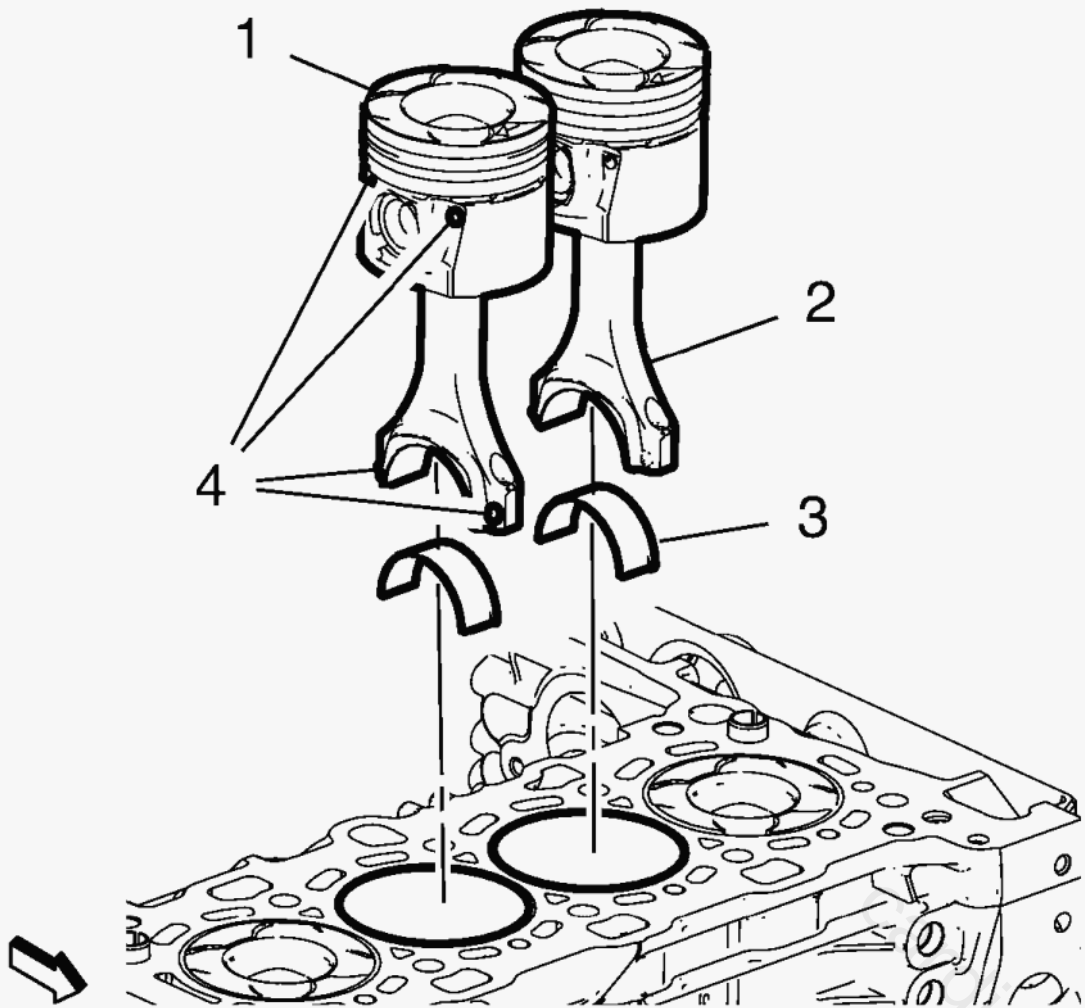


Fig. 700: Cylinder 2 And 3 Piston/Connecting Rod Assemblies And Upper Bearings
Courtesy of GENERAL MOTORS COMPANY

NOTE: Lay aside in the order as they was removed.

4. Push the 2 pistons (1) with the 2 connecting rods (2) out of the cylinder 2 and the cylinder 3 upwards.

NOTE: Lay aside in the order as they was removed.

5. Remove the 2 connecting rod upper bearings (3) from the 2 connecting rods (2).

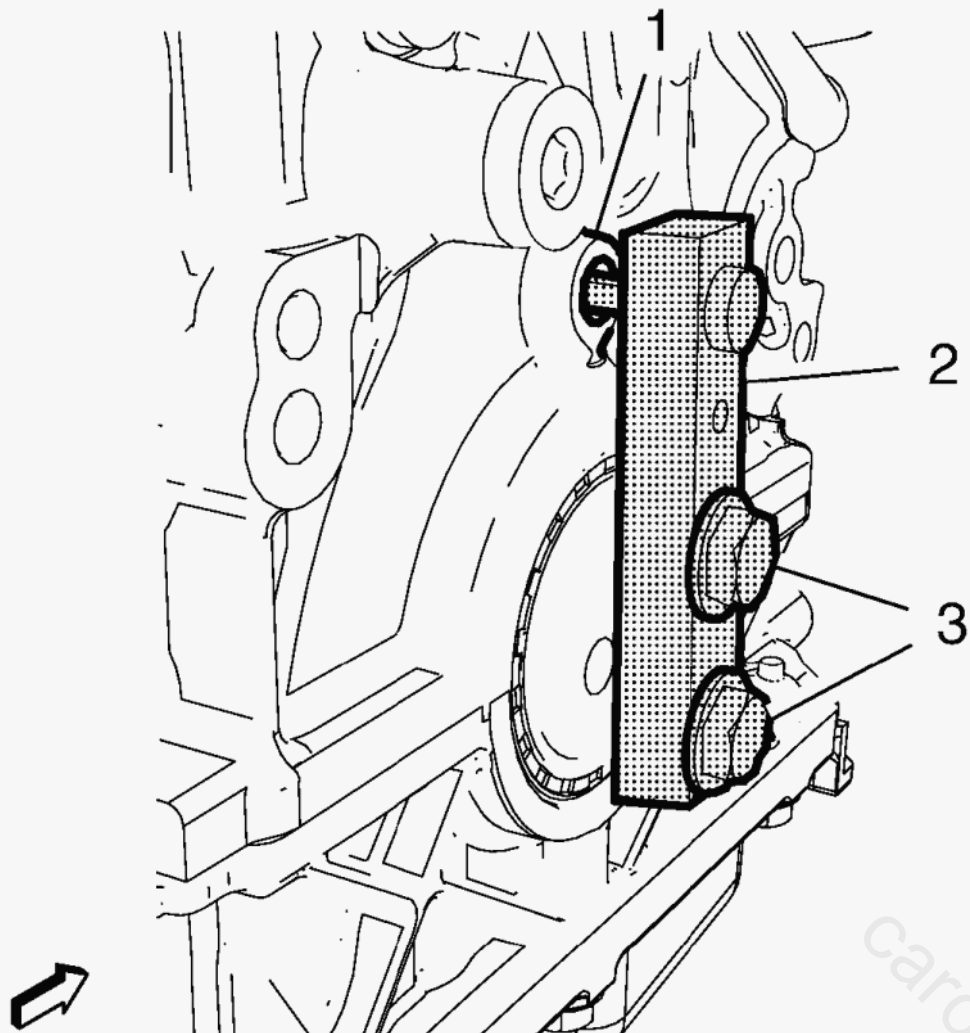


Fig. 701: Crankshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

6. Remove the 2 bolts (3).
7. Remove the **EN-51140** fixing tool (2).

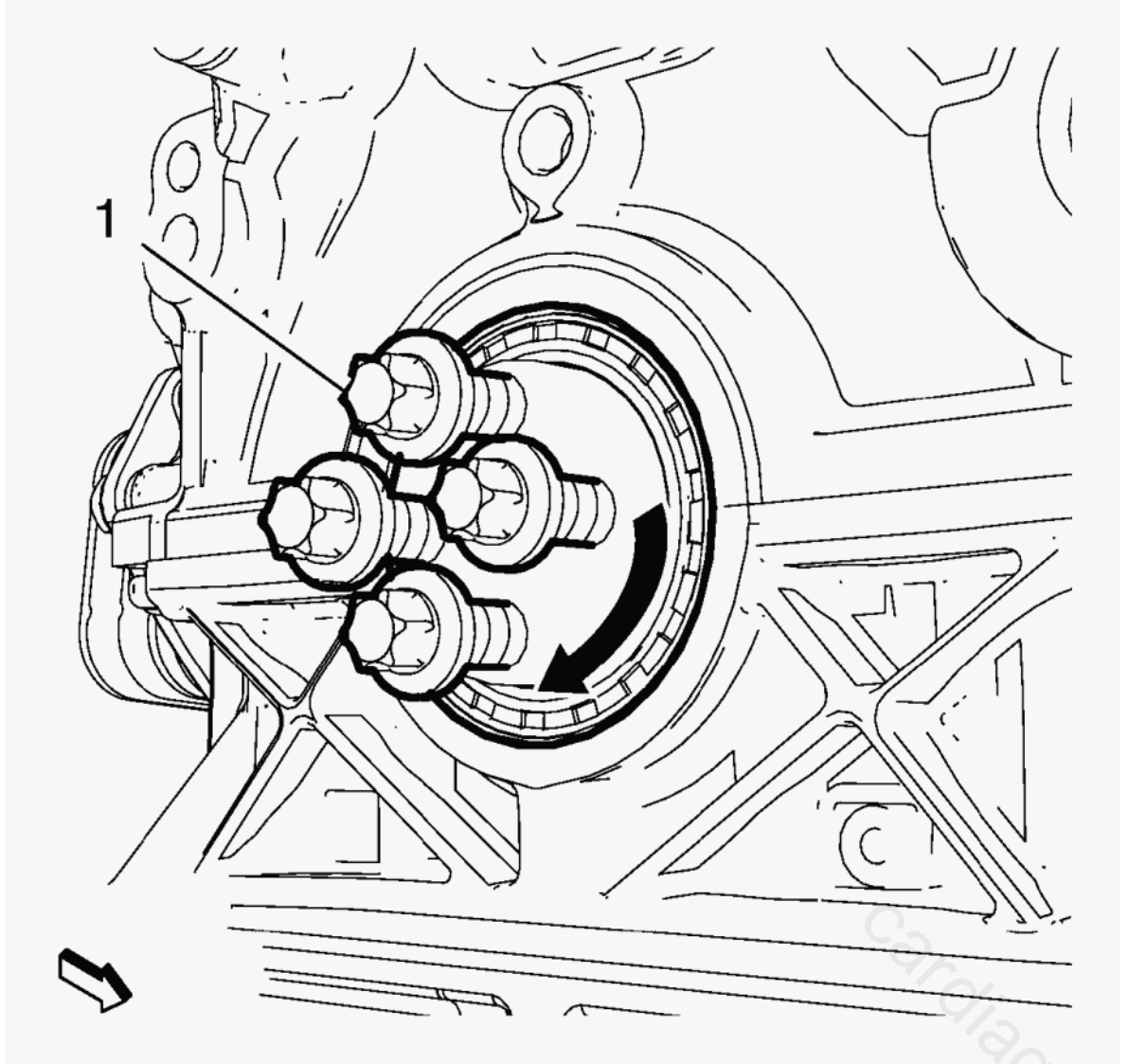


Fig. 702: Crankshaft Pulley Bolts

Courtesy of GENERAL MOTORS COMPANY

8. Install the 4 crankshaft pulley bolts (1).
9. Set the cylinder 2 to TDC. Rotate the crankshaft 180 degrees, use a pry bar at the 4 crankshaft pulley bolts (1).

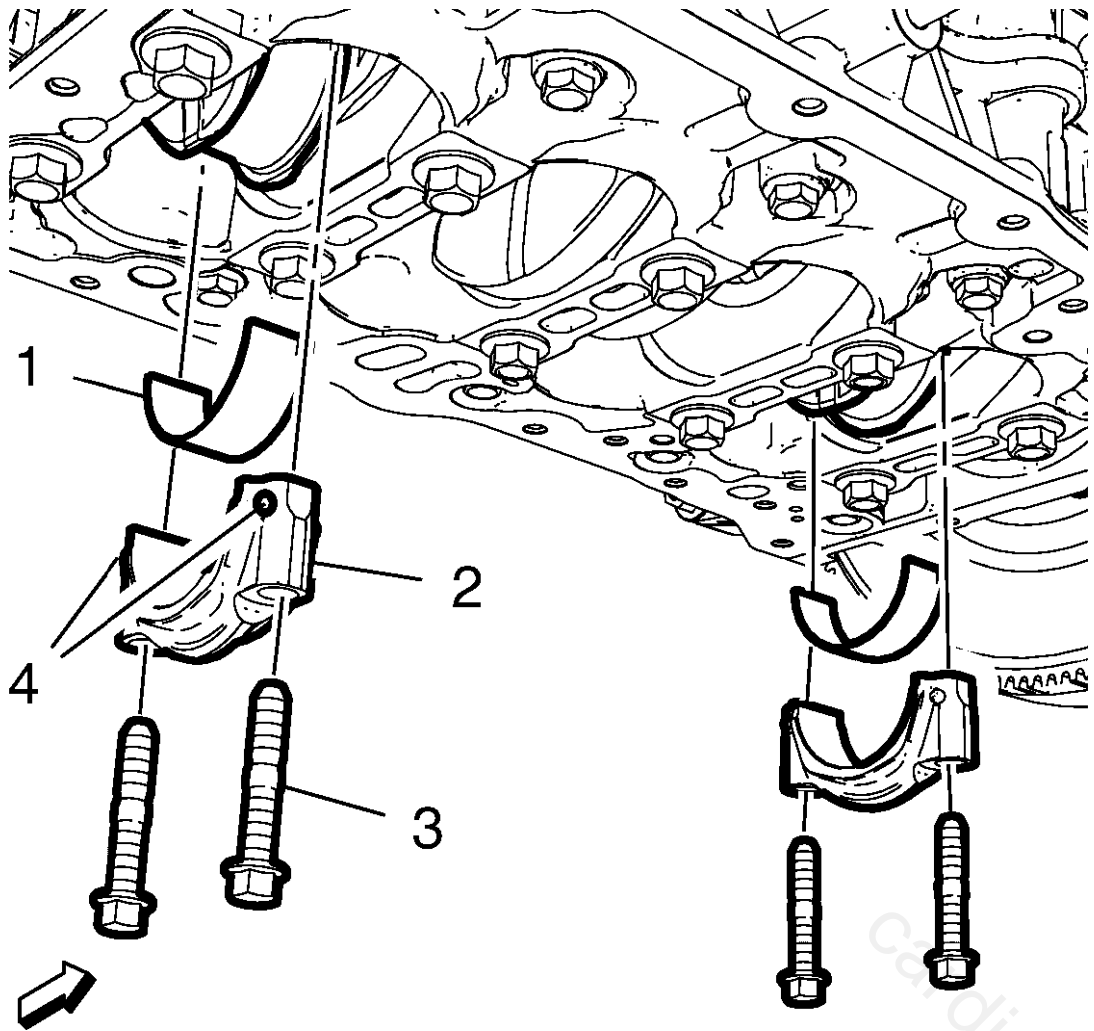


Fig. 703: Cylinder 1 And 4 Connecting Rod Caps, Bolts And Lower Bearings
Courtesy of GENERAL MOTORS COMPANY

10. Remove and DISCARD the 4 connecting rod bearing cap bolts (3) from the cylinder 1 and the cylinder 4.

NOTE: Lay aside in the order as they was removed.

NOTE: The shear surfaces of the connecting rod and the connecting rod bearing cap form a unique fit and must not be swapped or damaged. Do not lay down on the shear surfaces.

11. Remove the 2 connecting rod bearing caps (2) from the cylinder 1 and the cylinder 4.

NOTE: Lay aside in the order as they was removed.

12. Remove the 2 connecting rod lower bearings (1).

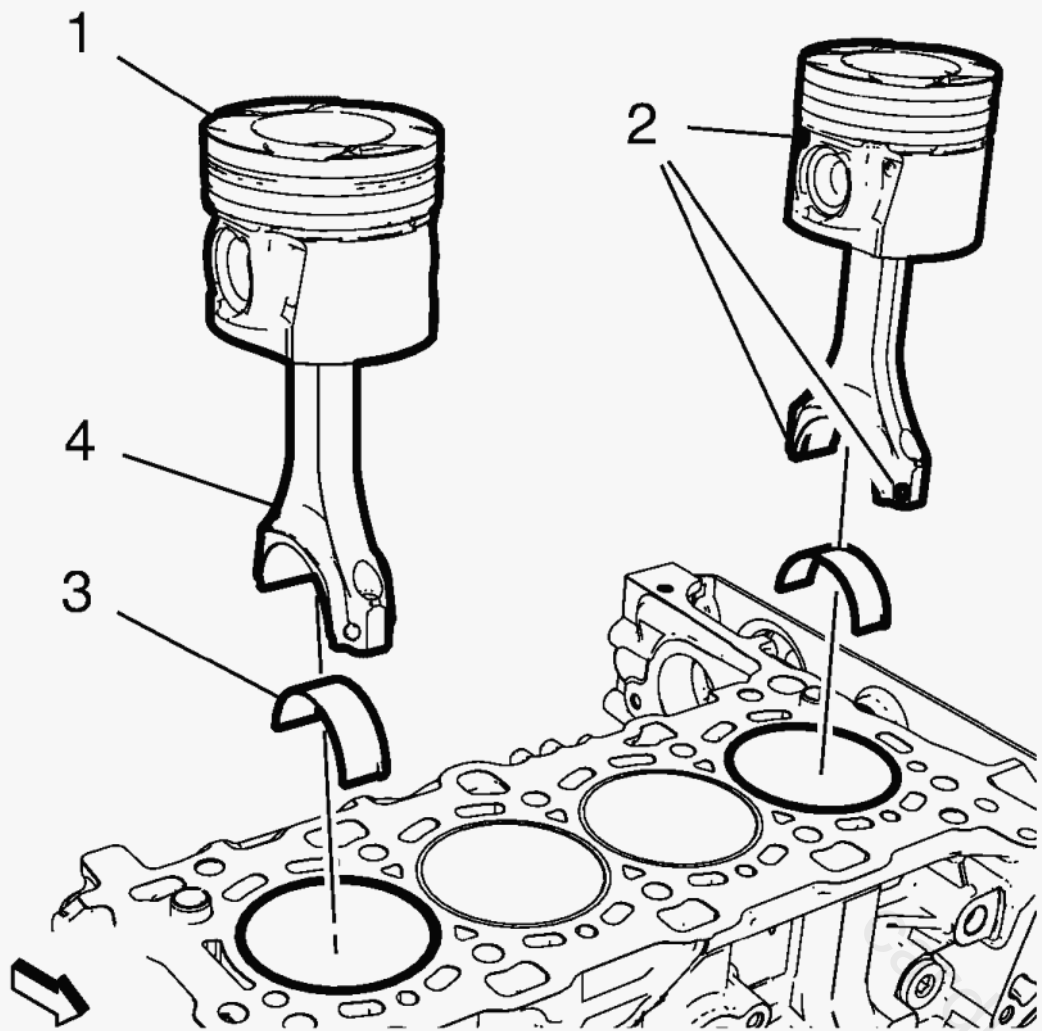


Fig. 704: Cylinder 1 And 4 Piston/Connecting Rod Assemblies And Upper Bearings
Courtesy of GENERAL MOTORS COMPANY

NOTE: Lay aside in the order as they was removed.

13. Push the 2 pistons (1) with the 2 connecting rods (4) out of the cylinder 1 and the cylinder 4 upwards.

NOTE: Lay aside in the order as they was removed.

14. Remove the 2 connecting rod upper bearings (3) from the 2 connecting rods (4).

CRANKSHAFT FRONT OIL SEAL REMOVAL

Special Tools

- EN-6624 Remover
- GE-328-B Pin Remover

For equivalent regional tools, refer to [Special Tools](#).

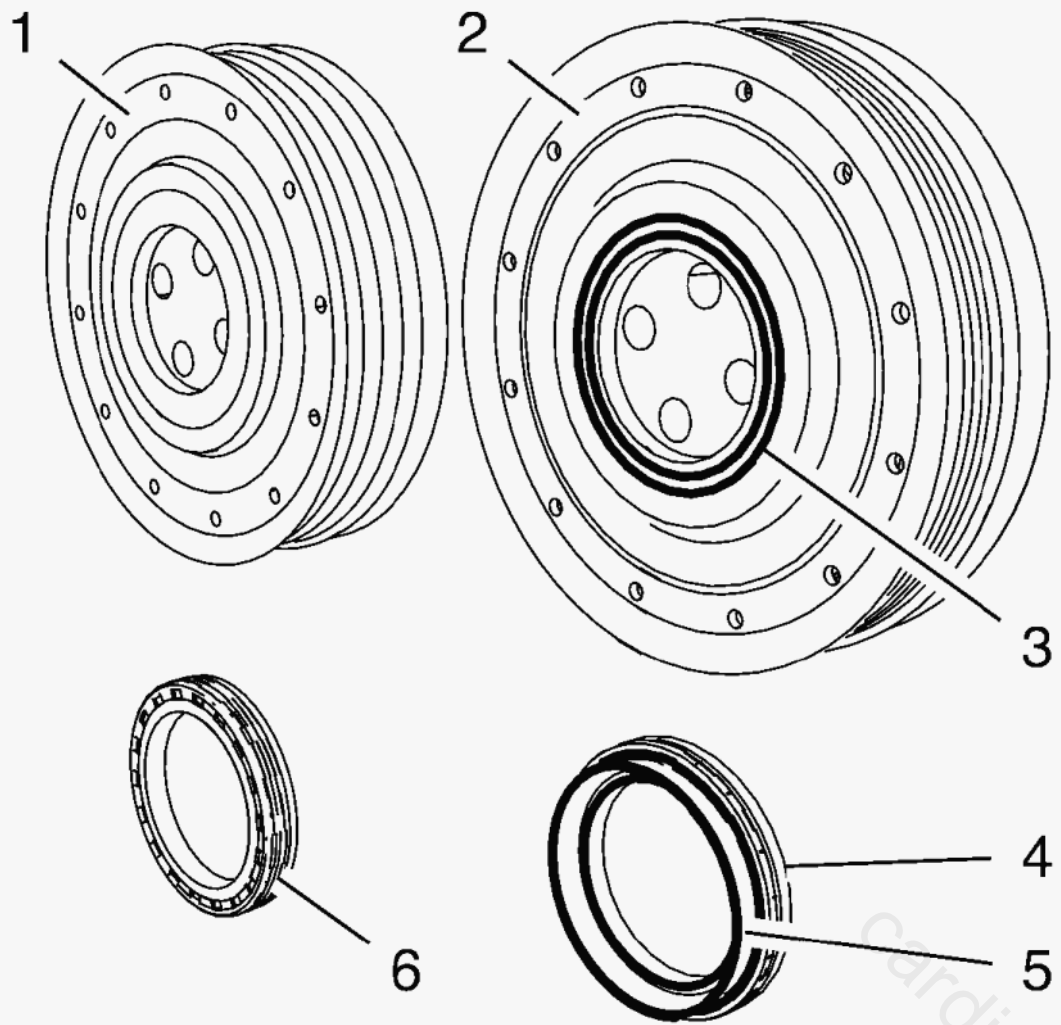


Fig. 705: Crankshaft Pulley And Crankshaft Front Oil Seal Variations
Courtesy of GENERAL MOTORS COMPANY

NOTE: To ensure installation of the correct version of the crankshaft pulley and crankshaft front oil seal, use the following procedure.

1. Check the installed version of the crankshaft pulley (1, 2) and the crankshaft front oil seal (4, 6).

If the crankshaft pulley version (1) without groove (3) is installed, the crankshaft pulley must be replaced.

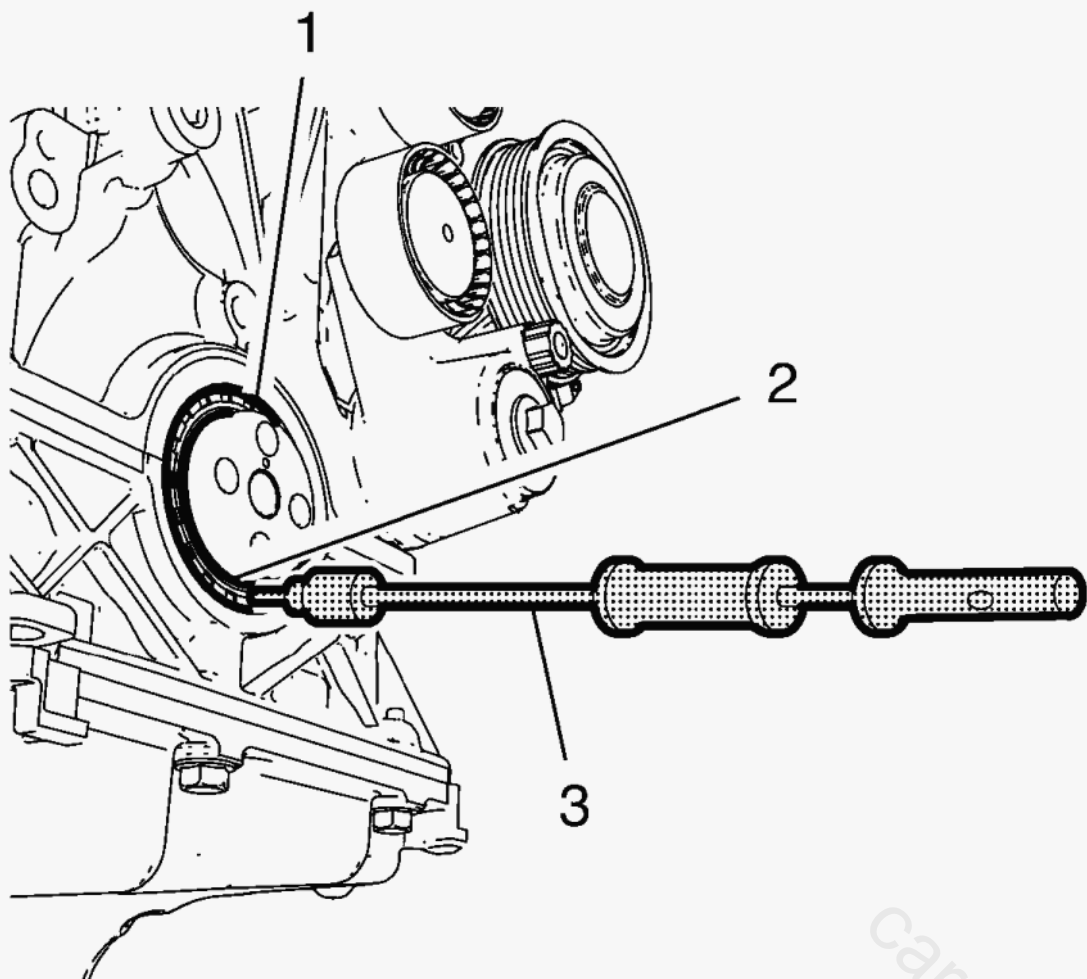


Fig. 706: Removers And Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS COMPANY

2. Punch a bore into the crankshaft seal, use a suitable tool.
3. Install the **EN-6624** remover (2) into the oil sealing ring (1).
4. Install the **GE-328-B** remover (3) to **EN-6624** remover (2).
5. Remove the crankshaft front oil seal with the **GE-328-B** remover.

CRANKSHAFT AND BEARING REMOVAL

Special Tools

EN-571-B Dial Gauge

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

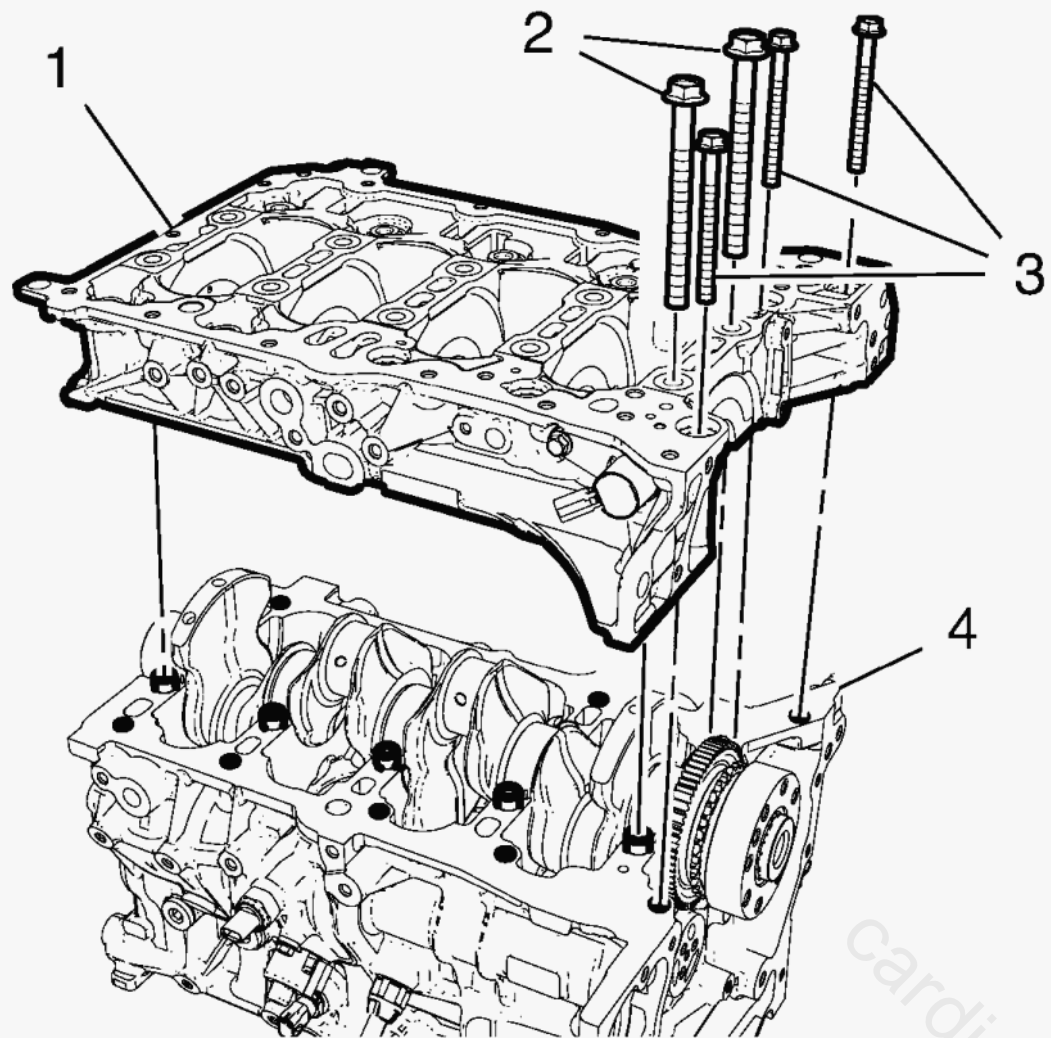


Fig. 707: Lower Crankcase And Bolts

Courtesy of GENERAL MOTORS COMPANY

1. Remove the 11 lower crankcase bolts M8 (3).
2. Remove and DISCARD the 10 main bearing bolts M10 (2).

NOTE: Carefully detach the lower crankcase from the engine block, using a suitable tool.

3. Remove the lower crankcase (1).

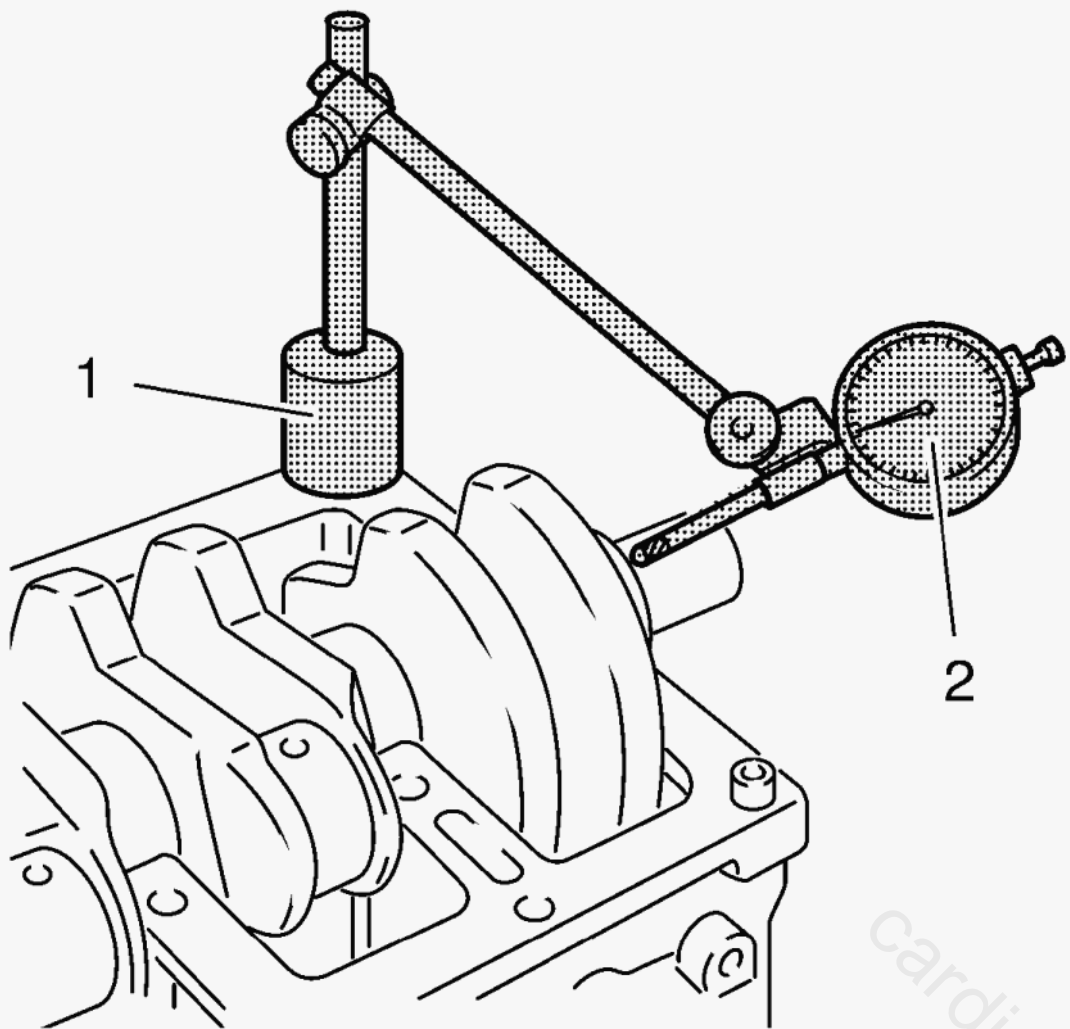


Fig. 708: Measuring Crankshaft Axial Play

Courtesy of GENERAL MOTORS COMPANY

NOTE: The check is conducted with the crankshaft bearings installed in the cylinder block and the flywheel/automatic transmission flex plate is removed. The crankshaft is only loosely fitted in the cylinder block.

4. Install the EN-571-B dial gauge (2) with the bracket (1) to the timing side of the engine block.

NOTE: If the value for the crankshaft axial play does not correspond with the permissible axial play, regrind the crankcase seat and use suitable oversize thrust bearings. For oversize thrust bearings, refer to [Engine Mechanical Specifications](#).

5. Measure the crankshaft axial play. For permissible axial play, refer to [Engine Mechanical Specifications](#).

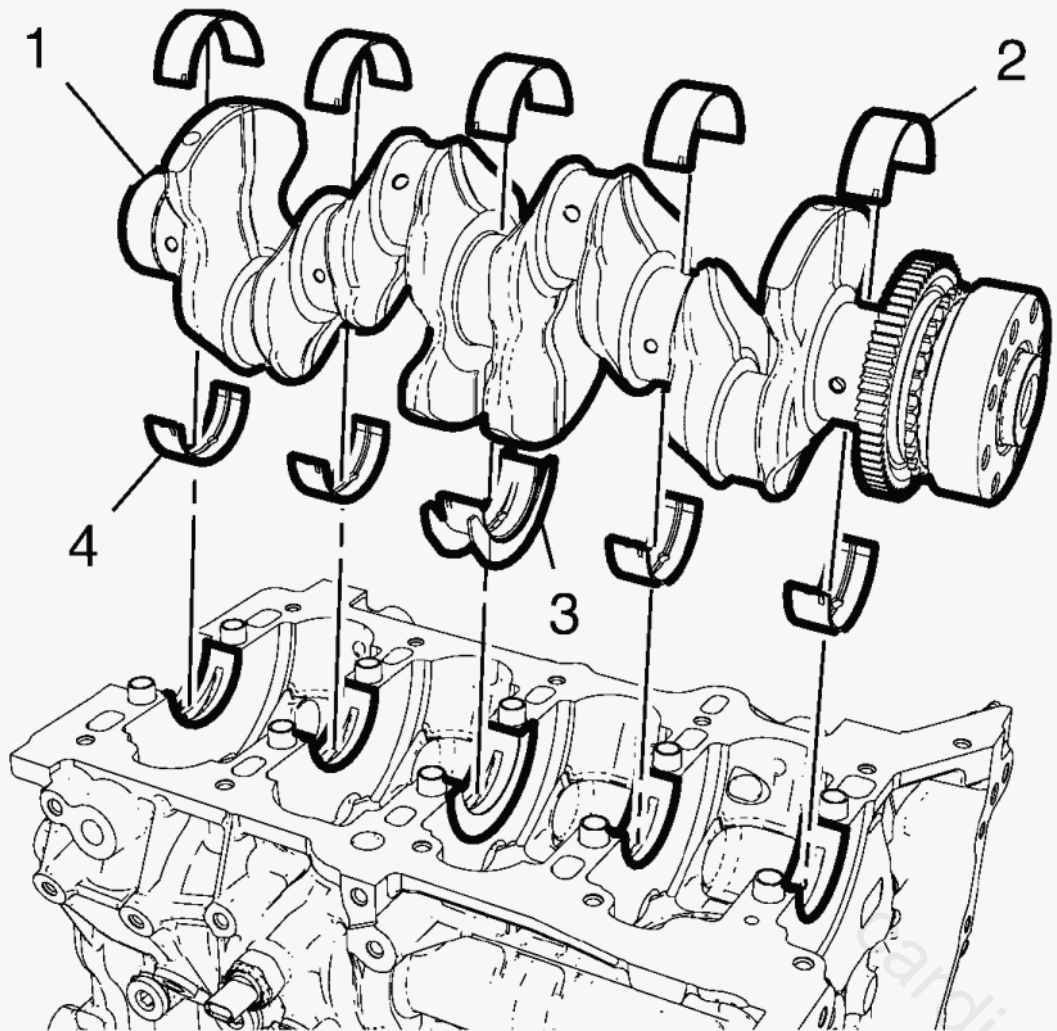


Fig. 709: Crankshaft And Bearings

Courtesy of GENERAL MOTORS COMPANY

NOTE: Mark the installation position of the crankshaft main bearing. Lay aside in order removed.

6. Remove the 5 crankshaft lower main bearings (2) from the crankcase.
7. Remove the crankshaft (1).

NOTE: Mark the installation position of the crankshaft main bearing. Set aside in order removed.

NOTE: The middle crankshaft main bearing contains the thrust bearing (3).

8. Remove the 5 crankshaft upper main bearings (3, 4).
9. Check the crankshaft and bearings. Refer to [Crankshaft and Bearing Cleaning and Inspection](#).

WATER PUMP DISASSEMBLE

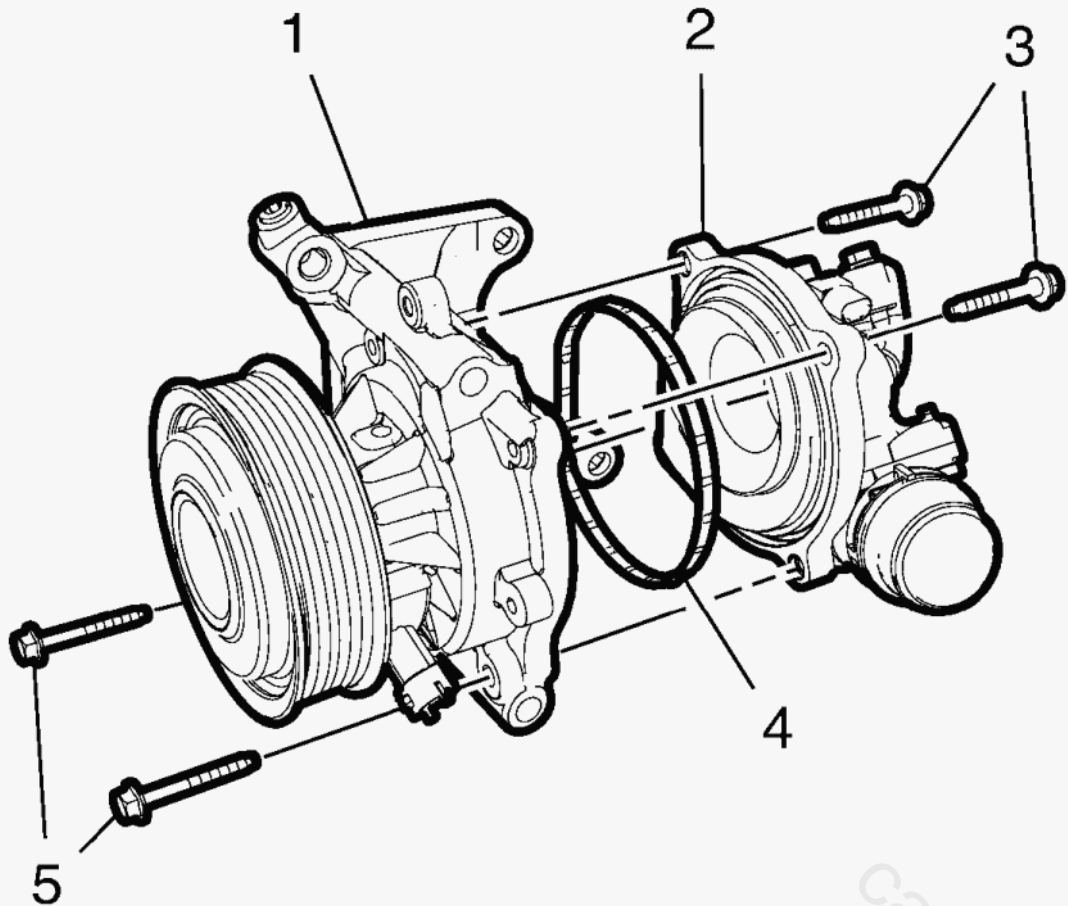


Fig. 710: Water Pump, Bolts And Seal

Courtesy of GENERAL MOTORS COMPANY

1. Remove the 4 water pump bolts (3, 5).
2. Remove the thermostat housing (2) from the water pump (1).
3. Remove and DISCARD the water pump seal (4).

WATER PUMP CLEANING AND INSPECTION

Cleaning Procedure

CAUTION: Do not immerse the water pump in solvent. The solvent may enter the water pump's permanently lubricated bearings and cause premature bearing failure.

1. Remove the old gasket material from the water pump sealing surfaces.
2. Clean all excess dirt and debris from the water pump housing.

Inspection Procedure

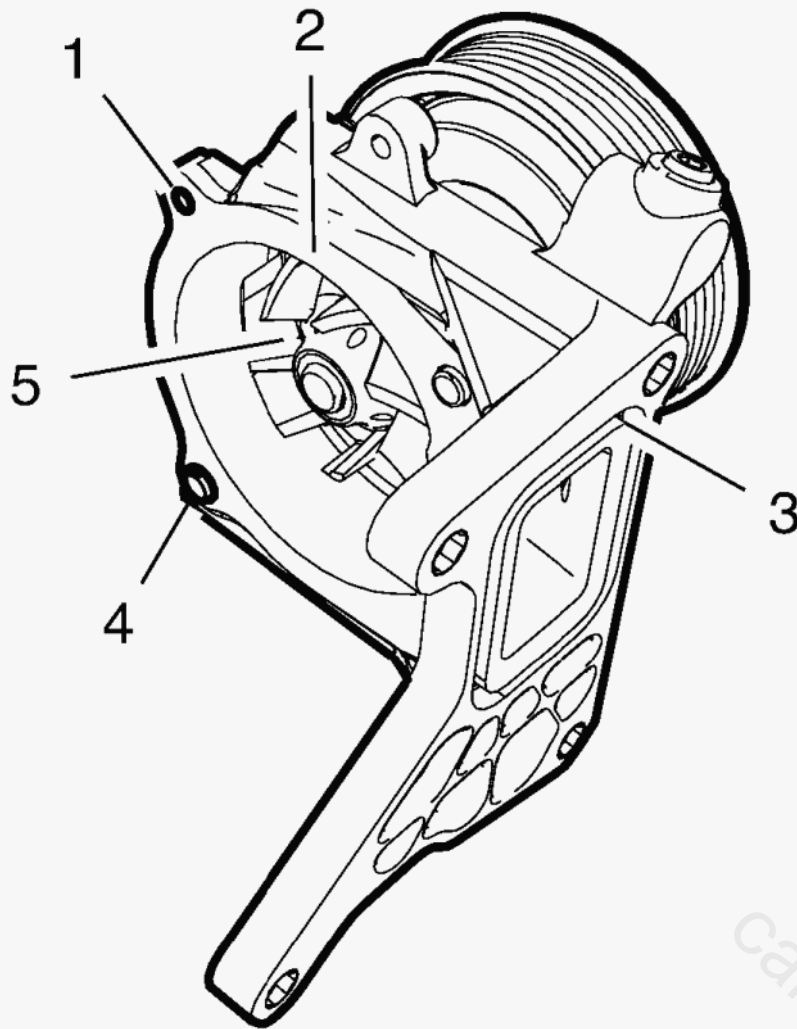


Fig. 711: Water Pump Inspection Points

Courtesy of GENERAL MOTORS COMPANY

NOTE: The water pump hub and impeller should turn straight and smoothly. If the hub wobbles, is noisy, or feels rough when rotated, replace the water pump.

1. Rotate the water pump hub (5).
2. Inspect the exterior of the water pump for the following:
 - Damage to the water pump bolt holes (1)
 - Damage to the water pump gasket sealing surface (2, 3)
 - Damage or deformations of the location pin (4)
 - Damage, corrosion or restrictions
3. Repair or replace the water pump as necessary.

WATER PUMP ASSEMBLE

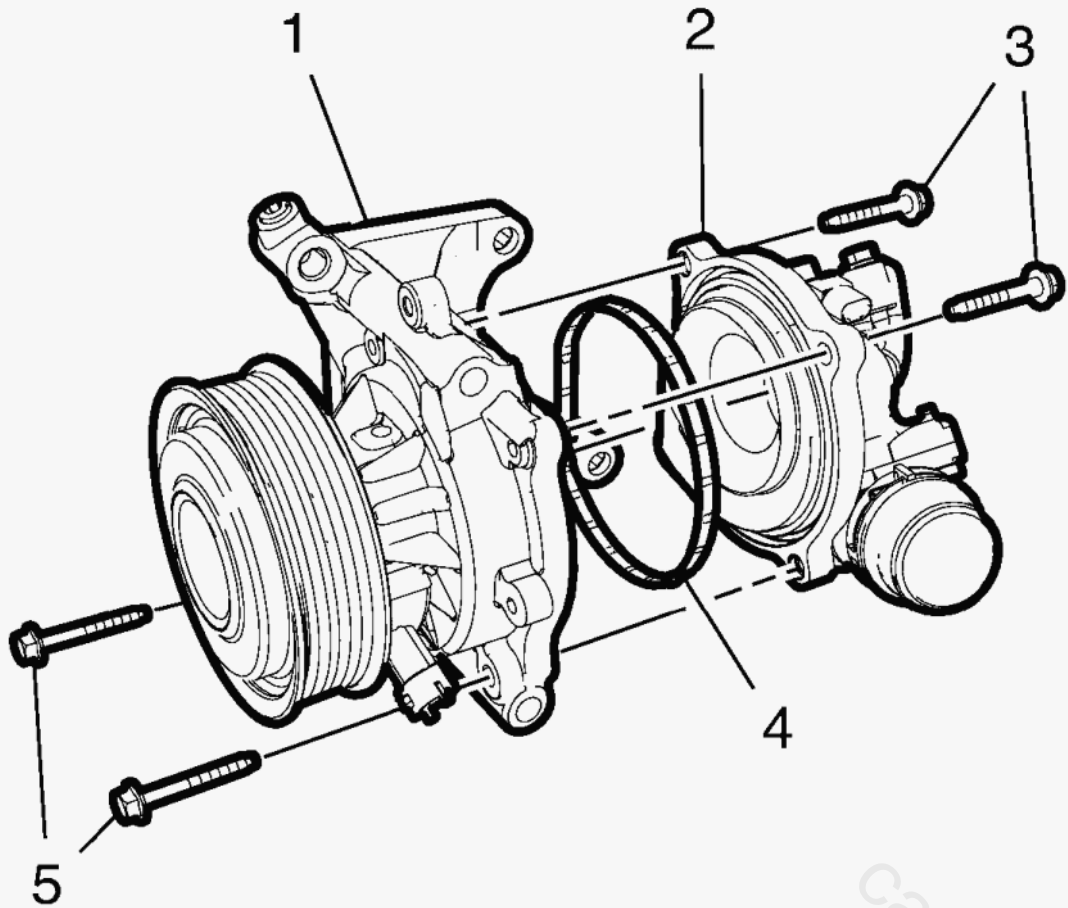


Fig. 712: Water Pump, Bolts And Seal

Courtesy of GENERAL MOTORS COMPANY

1. Clean the sealing surfaces of the water pump (1) and the thermostat housing (2).
2. Install a NEW water pump seal (4).
3. Install the thermostat housing (2) to the water pump (1).

CAUTION: Refer to Fastener Caution .

4. Install the 4 water pump bolts (3, 5) and tighten to 10 N.m (89 lb in).

EXHAUST GAS RECIRCULATION COOLER HOUSING DISASSEMBLE

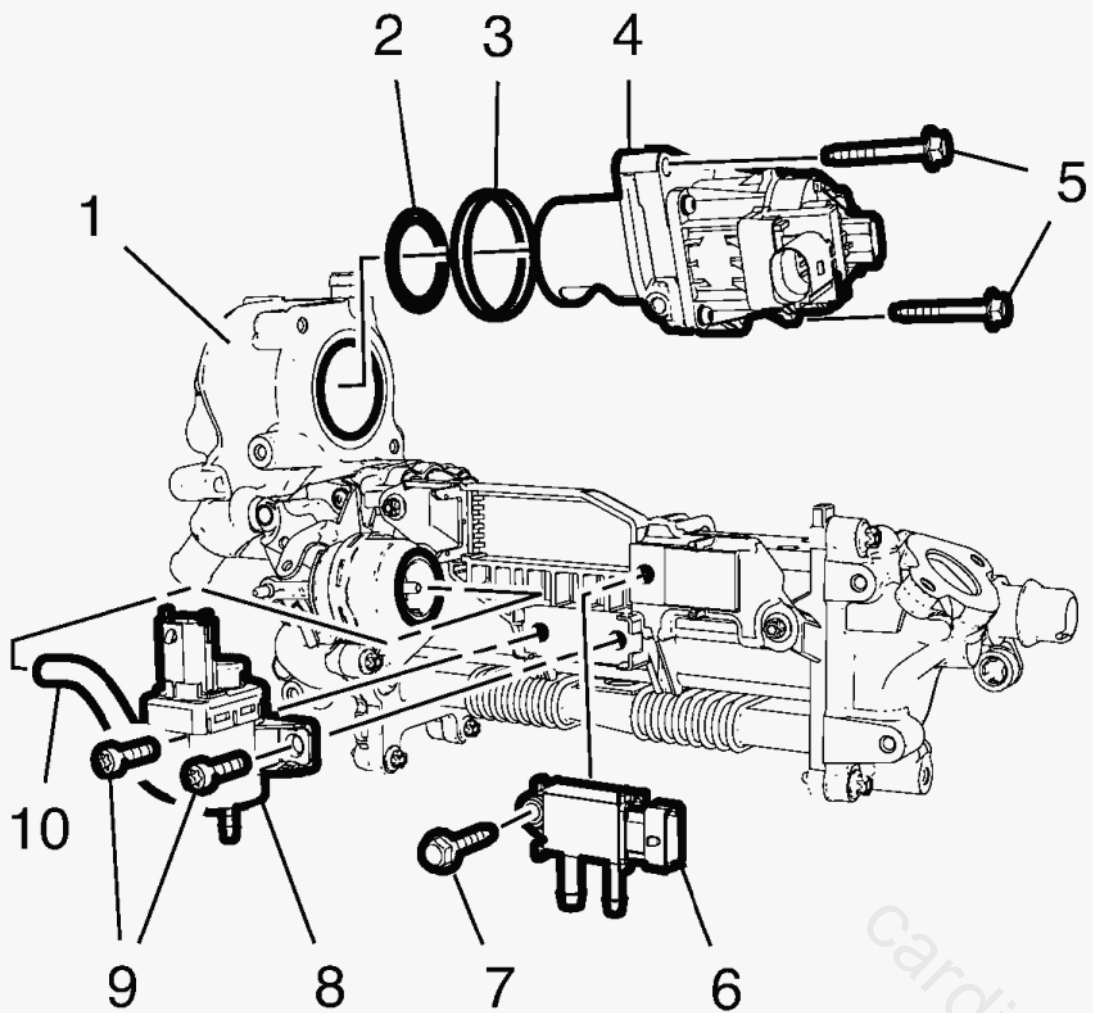


Fig. 713: Exhaust Gas Recirculation Cooler Housing And Components
Courtesy of GENERAL MOTORS COMPANY

1. Remove the 2 exhaust gas recirculation valve bolts (5).
2. Remove the exhaust gas recirculation valve (4) from the exhaust gas recirculation valve cooler (1).
3. Remove and DISCARD the exhaust gas recirculation valve gasket (3).
4. Remove and DISCARD the exhaust gas recirculation valve seat gasket (2).
5. Remove the exhaust pressure differential sensor bolt (7).
6. Remove the exhaust pressure differential sensor (6).
7. Remove the exhaust gas recirculation vacuum regulator hose (10).
8. Remove the 2 exhaust gas recirculation vacuum regulator solenoid valve bolts (9).
9. Remove the exhaust gas recirculation vacuum regulator solenoid valve (8).

EXHAUST GAS RECIRCULATION COOLER HOUSING ASSEMBLE

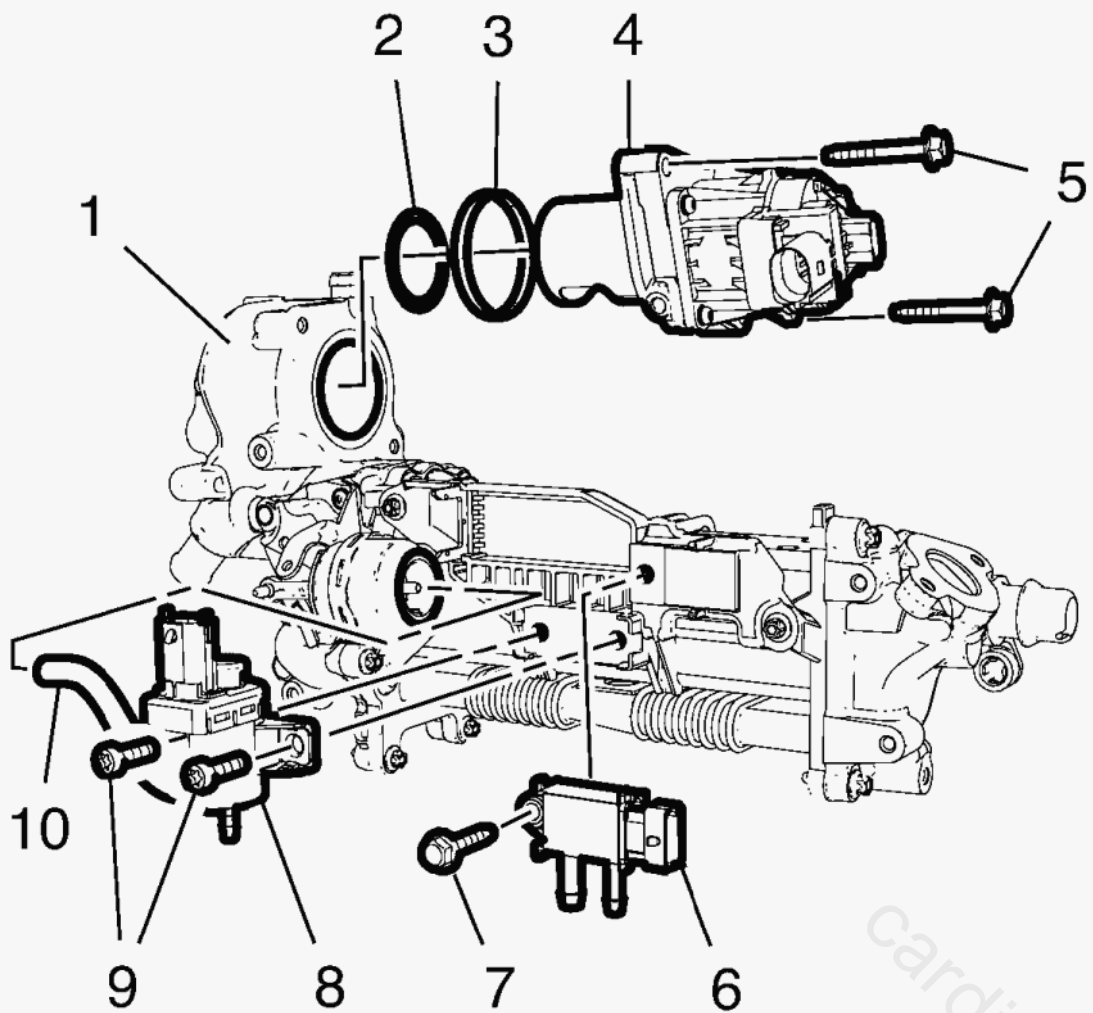


Fig. 714: Exhaust Gas Recirculation Cooler Housing And Components
 Courtesy of GENERAL MOTORS COMPANY

1. Install the exhaust gas recirculation vacuum regulator solenoid valve (8).

CAUTION: Refer to **Fastener Caution** .

2. Install the 2 exhaust gas recirculation vacuum regulator solenoid valve bolts (9) and tighten to 7 N.m (62 lb in).
3. Install the exhaust gas recirculation vacuum regulator hose (10).
4. Install the exhaust pressure differential sensor (6).
5. Install the exhaust pressure differential sensor bolt (7) and tighten to 9 N.m (80 lb in).
6. Install a NEW exhaust gas recirculation valve seat gasket (2).
7. Install a NEW exhaust gas recirculation valve gasket (3).
8. Install the exhaust gas recirculation valve (4) to the exhaust gas recirculation valve cooler (1).
9. Install the 2 exhaust gas recirculation valve bolts (5) and tighten to 10 N.m (89 lb in).

INTAKE MANIFOLD DISASSEMBLE

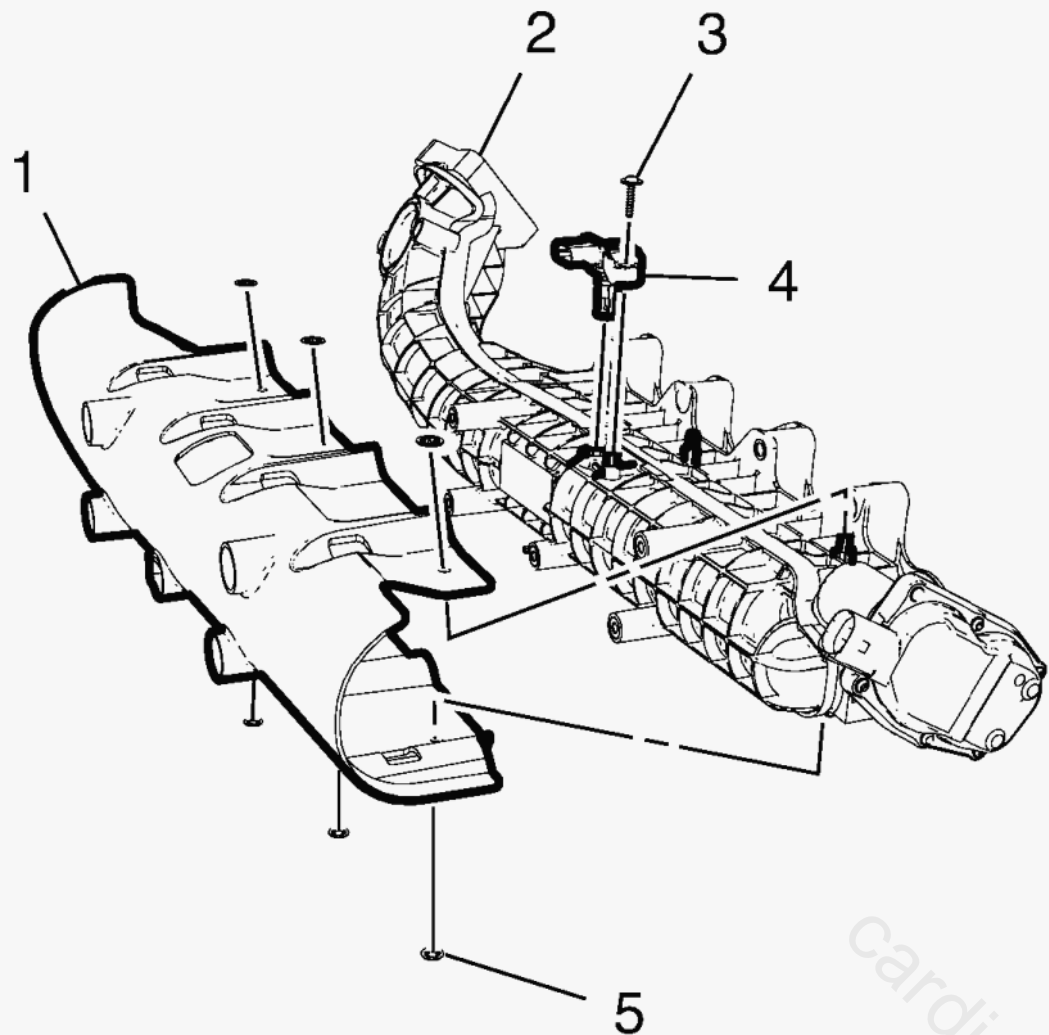


Fig. 715: Intake Manifold And Components
Courtesy of GENERAL MOTORS COMPANY

1. Remove Throttle Body Assembly @ Intake Manifold (2). Refer to [Throttle Body Assembly Replacement](#)
2. Remove the intake air pressure and temperature sensor bolt (3).
3. Remove the intake air pressure and temperature sensor (4).
4. Remove the 6 intake manifold cover washers (5).
5. Remove the intake manifold cover (1) from the intake manifold (2).

INTAKE MANIFOLD CLEANING AND INSPECTION

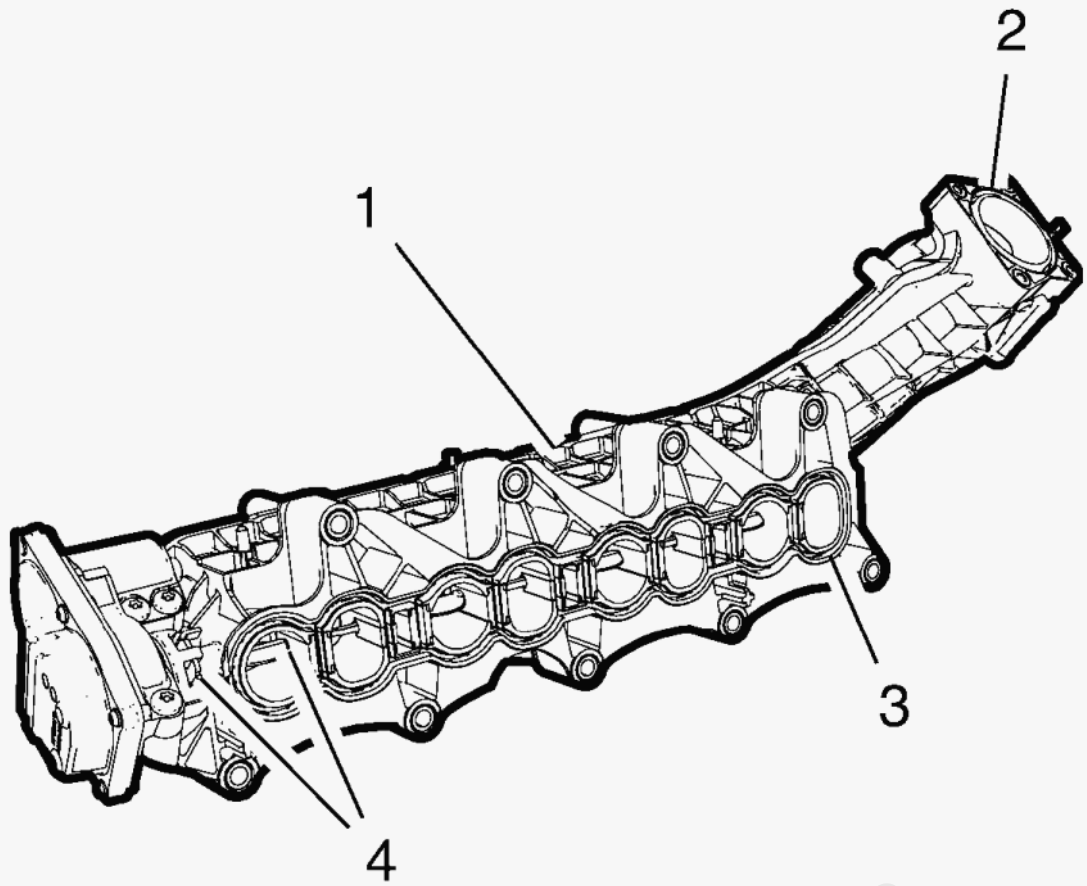


Fig. 716: Intake Manifold Inspection Points
Courtesy of GENERAL MOTORS COMPANY

1. Inspect the intake manifold (1) for damage.
2. Inspect the intake manifold for cracks near metallic inserts.
3. Inspect the crankcase ventilation passages in the intake manifold face for blockage.
4. Inspect the intake manifold runner (4) for proper operation.

WARNING: Wear safety glasses in order to avoid eye damage.

5. Clean the crankcase ventilation passages with compressed air if necessary. Use a maximum of 172 kPa (25 psi) of air pressure.
6. Clean the intake manifold runner with compressed air if necessary. Use a maximum of 172 kPa (25 psi) of air pressure.
7. Clean the throttle body sealing surface (2).
8. Clean the intake manifold to cylinder head sealing surface (3).
9. Replace the intake manifold as necessary.

INTAKE MANIFOLD ASSEMBLE

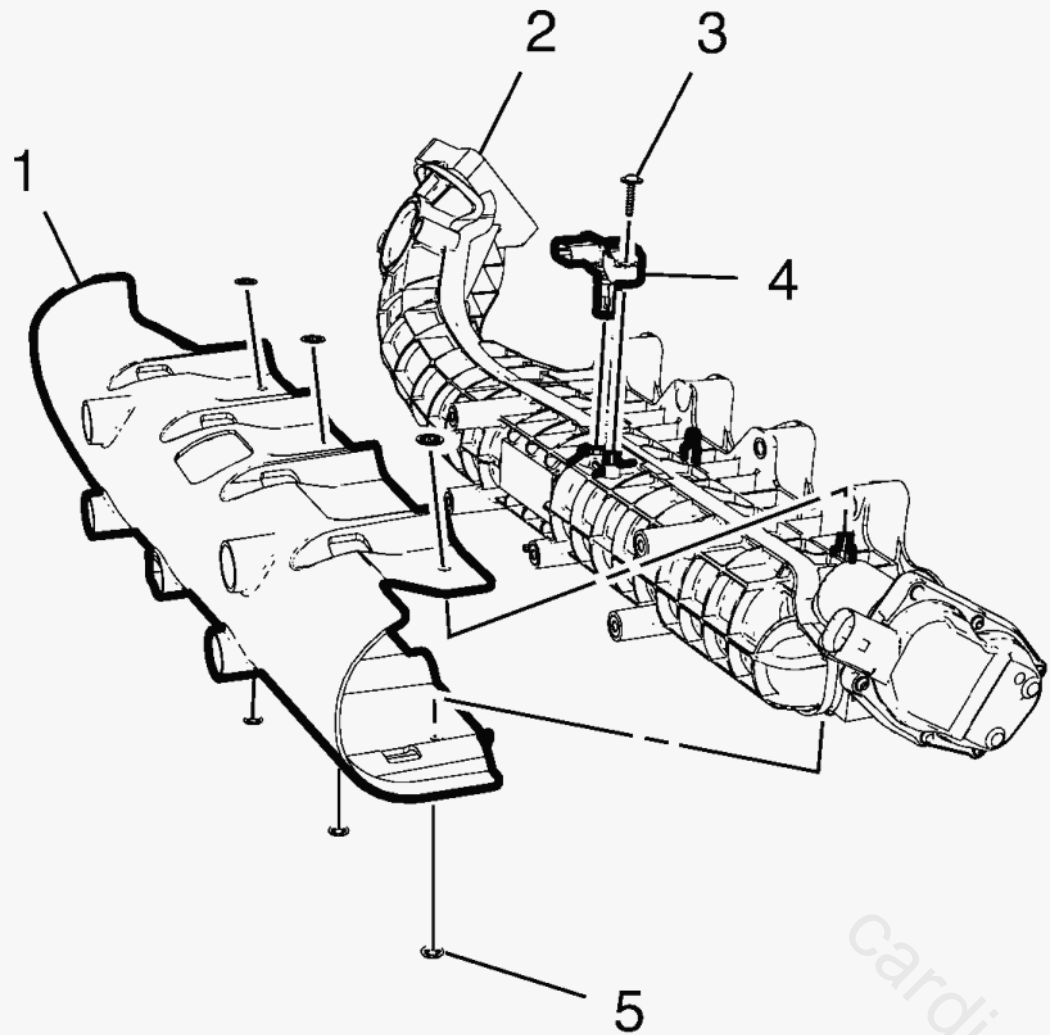


Fig. 717: Intake Manifold And Components
Courtesy of GENERAL MOTORS COMPANY

1. Install the intake manifold cover (1) to the intake manifold.
2. Install 6 intake manifold washers (5).
3. Install the intake air pressure and temperature sensor (4).

CAUTION: Refer to [Fastener Caution](#) .

4. Install the intake air pressure and temperature sensor bolt (3) and tighten to 1.6 N.m (14 lb in).
5. Install Throttle Body Assembly @ Intake Manifold (2). Refer to [Throttle Body Assembly Replacement](#)

OIL PAN DISASSEMBLE

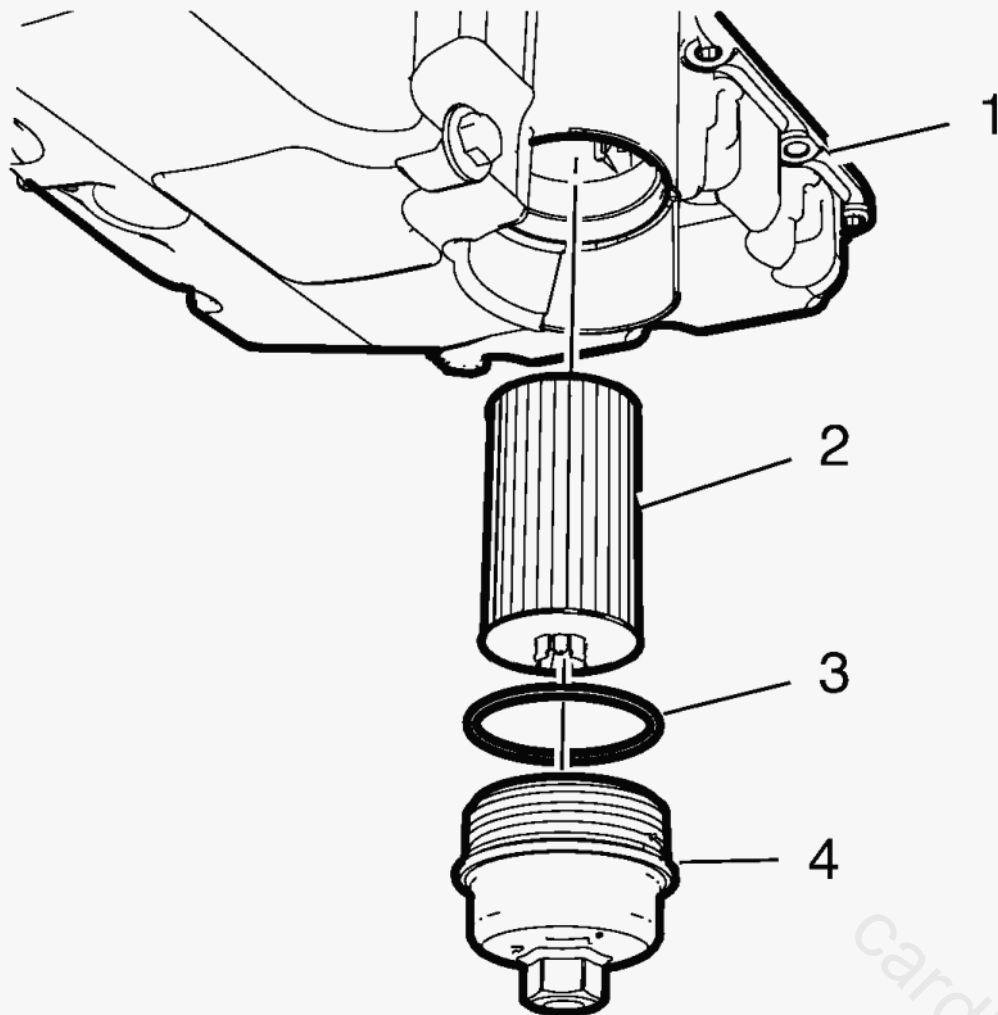


Fig. 718: Oil Filter And Components

Courtesy of GENERAL MOTORS COMPANY

1. Remove the oil filter cap (4) from the oil pan (1).
2. Remove and DISCARD the oil filter cap seal (3)

CAUTION: This engine uses a special high performance oil filter. Use of any other filter may lead to filter failure and/or severe engine damage.

3. Remove and properly dispose the oil filter insert (2).

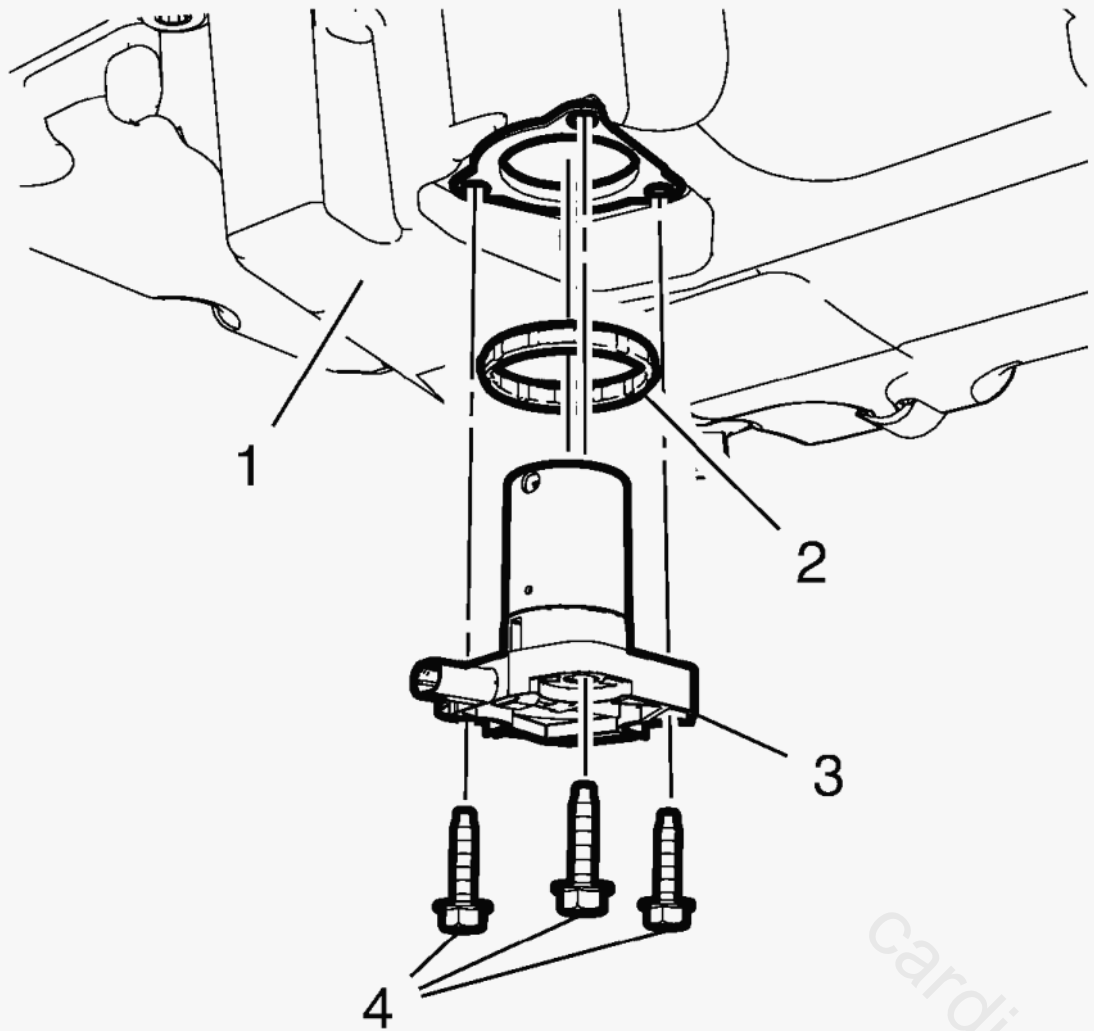


Fig. 719: Oil Level Indicator Switch Components
Courtesy of GENERAL MOTORS COMPANY

4. Remove the 3 oil level indicator switch bolts (4).
5. Remove the oil level indicator switch (3) from the oil pan (1).
6. Remove and DISCARD the oil level indicator switch gasket (2).

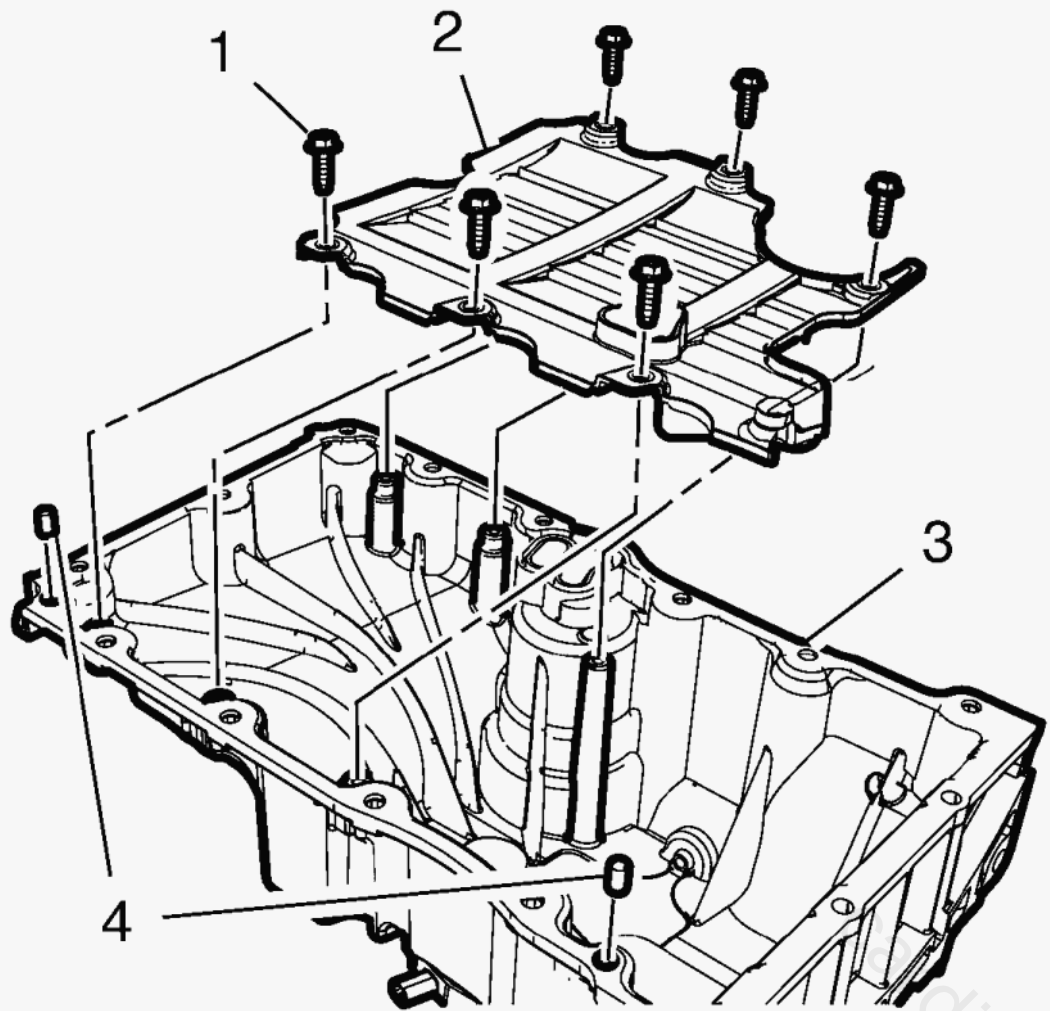


Fig. 720: Oil Pan, Baffle, Pins And Bolts

Courtesy of GENERAL MOTORS COMPANY

7. Remove the 2 location pins (4) from the oil pan (3).
8. Remove the 6 oil pan baffle bolts (1).
9. Remove the oil pan baffle (2).

OIL PAN CLEANING AND INSPECTION

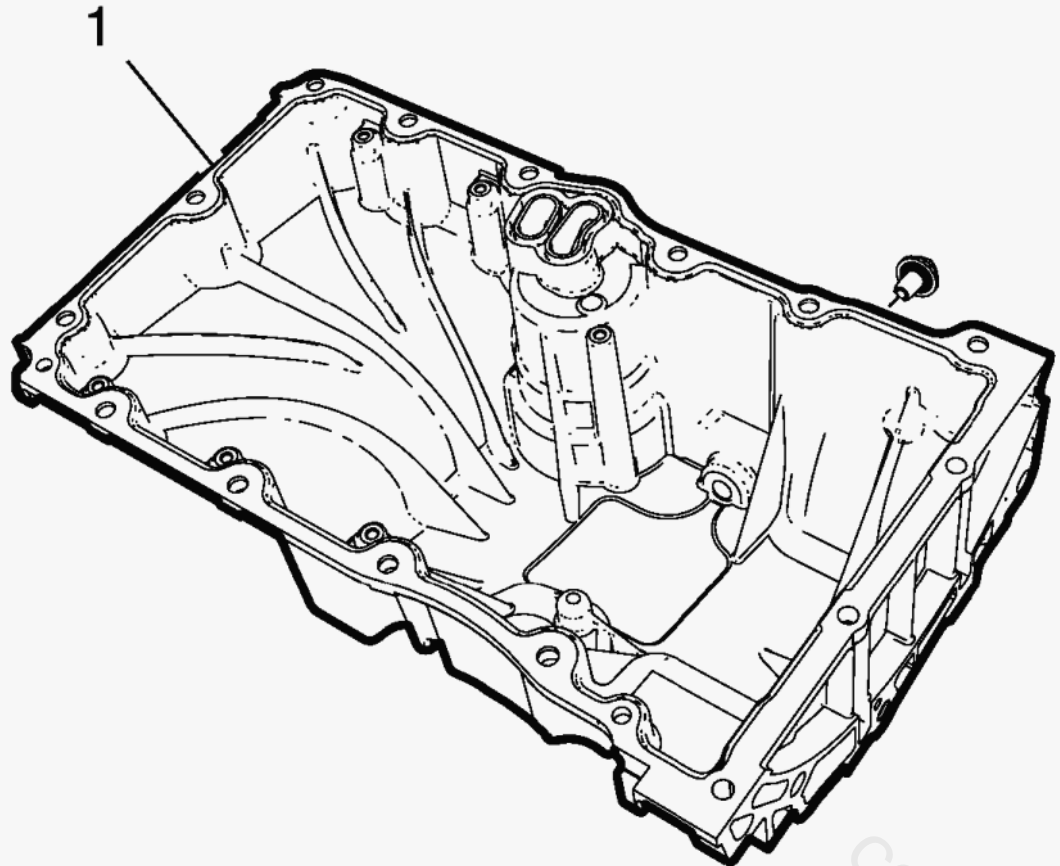


Fig. 721: Oil Pan

Courtesy of GENERAL MOTORS COMPANY

1. Clean the oil pan mating surface
2. Clean the oil pan (1). 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.
6. Repair or replace the oil pan as necessary.

OIL PAN ASSEMBLE

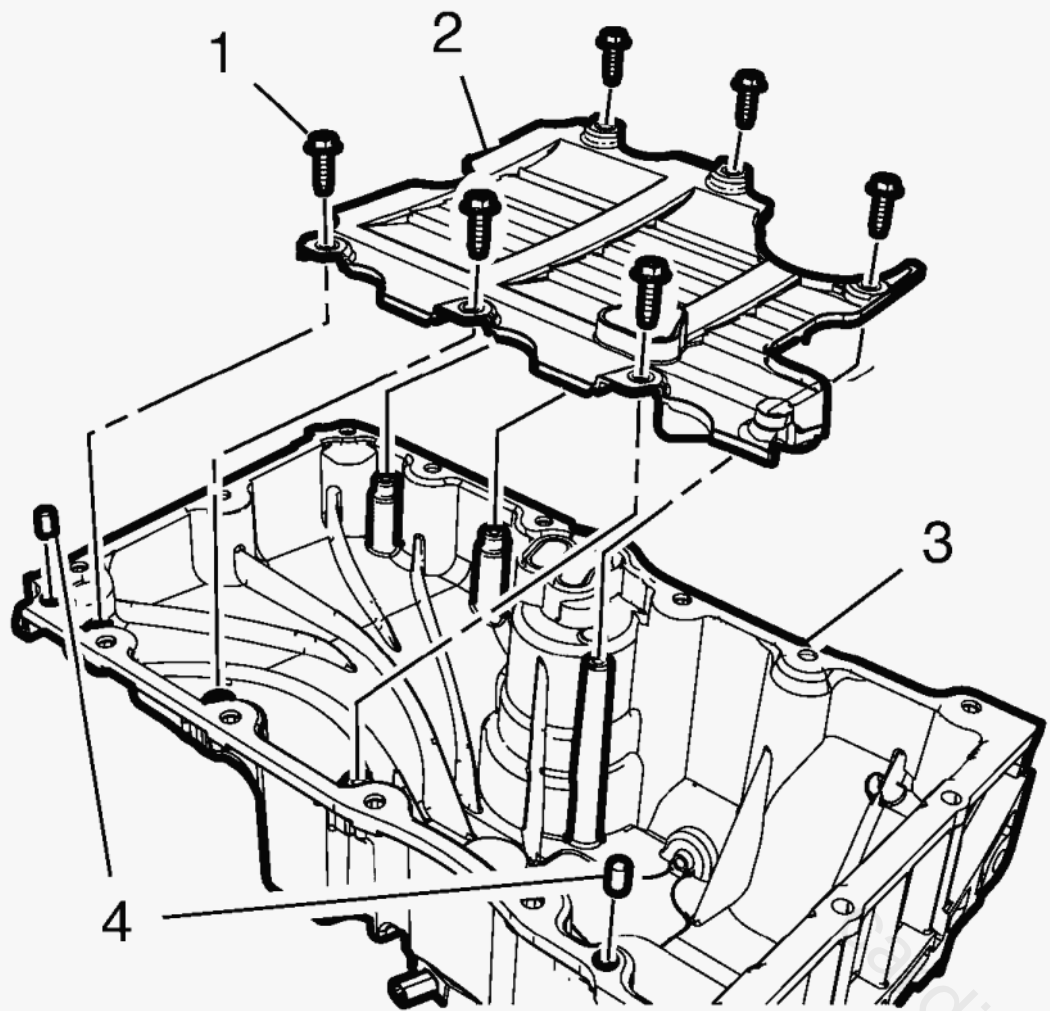


Fig. 722: Oil Pan, Baffle, Pins And Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Install the oil pan baffle (2) to the oil pan (3).

CAUTION: Refer to **Fastener Caution** .

2. Install the 6 oil pan baffle bolts (1) and tighten to 10 N.m (89 lb in).
3. Install the 2 location pins (4).

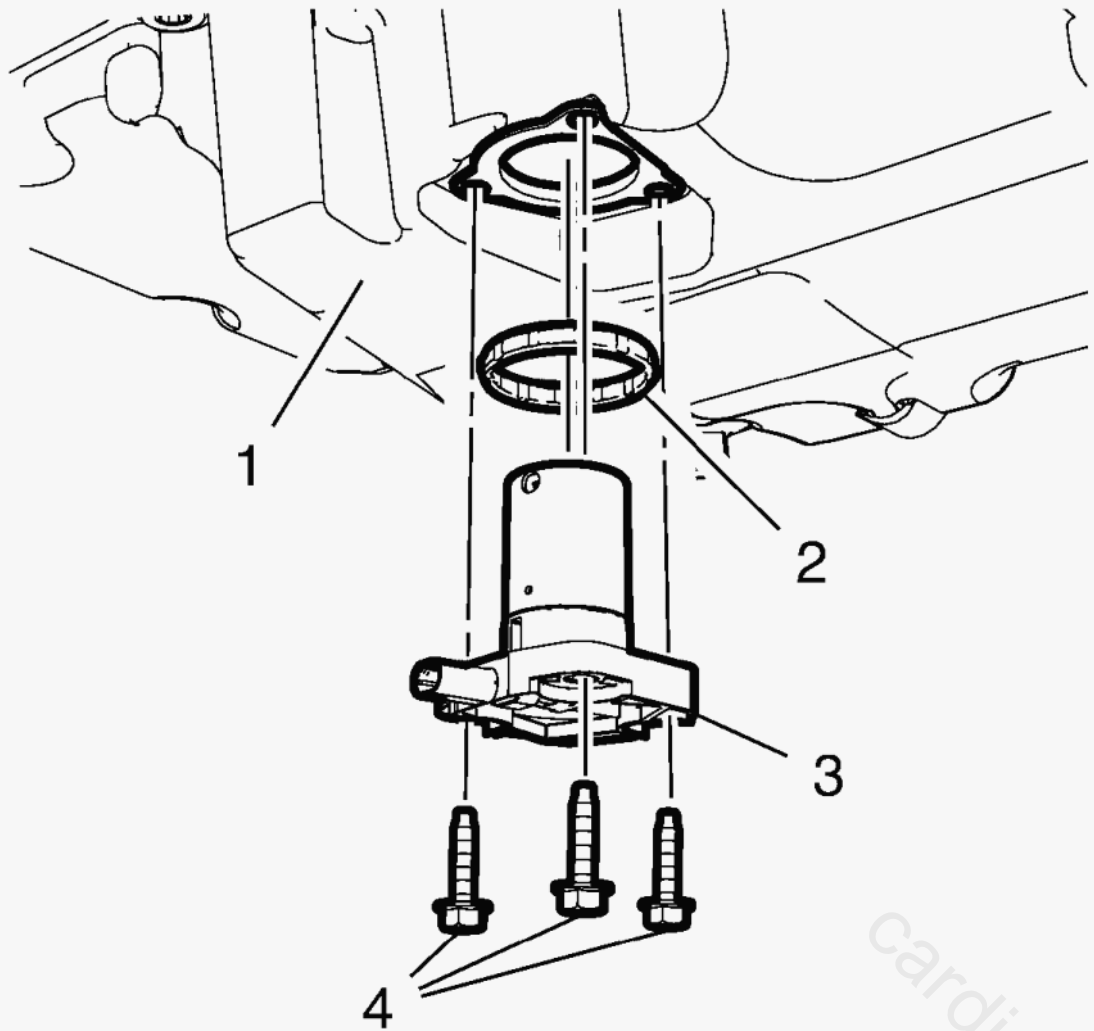


Fig. 723: Oil Level Indicator Switch Components
Courtesy of GENERAL MOTORS COMPANY

4. Install a NEW oil level indicator switch gasket (2).
5. Install the oil level indicator switch (3) to the oil pan (1).
6. Install the 3 oil level indicator switch bolts (4) and tighten to 10 N.m (89 lb in).
7. Clean the oil filter housing of the oil pan and oil filter cap until it is completely free of debris.

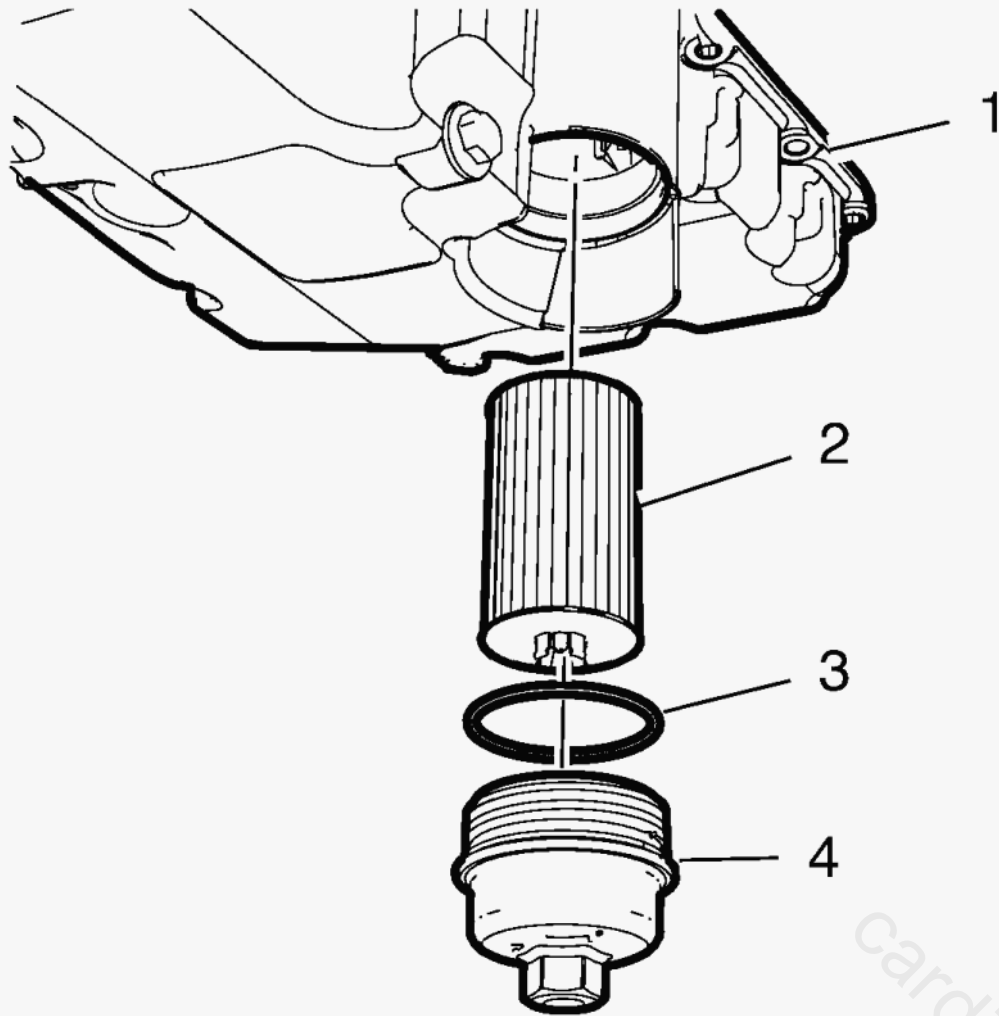


Fig. 724: Oil Filter And Components

Courtesy of GENERAL MOTORS COMPANY

8. Install a NEW oil filter insert (2).
9. Coat the seal ring with NEW clean engine oil.
10. Install a NEW oil filter cap seal (3).

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

11. Install the oil filter cap (4) to the oil pan (1) and tighten to 25 N.m (18 lb ft).

CAMSHAFT HOUSING DISASSEMBLE

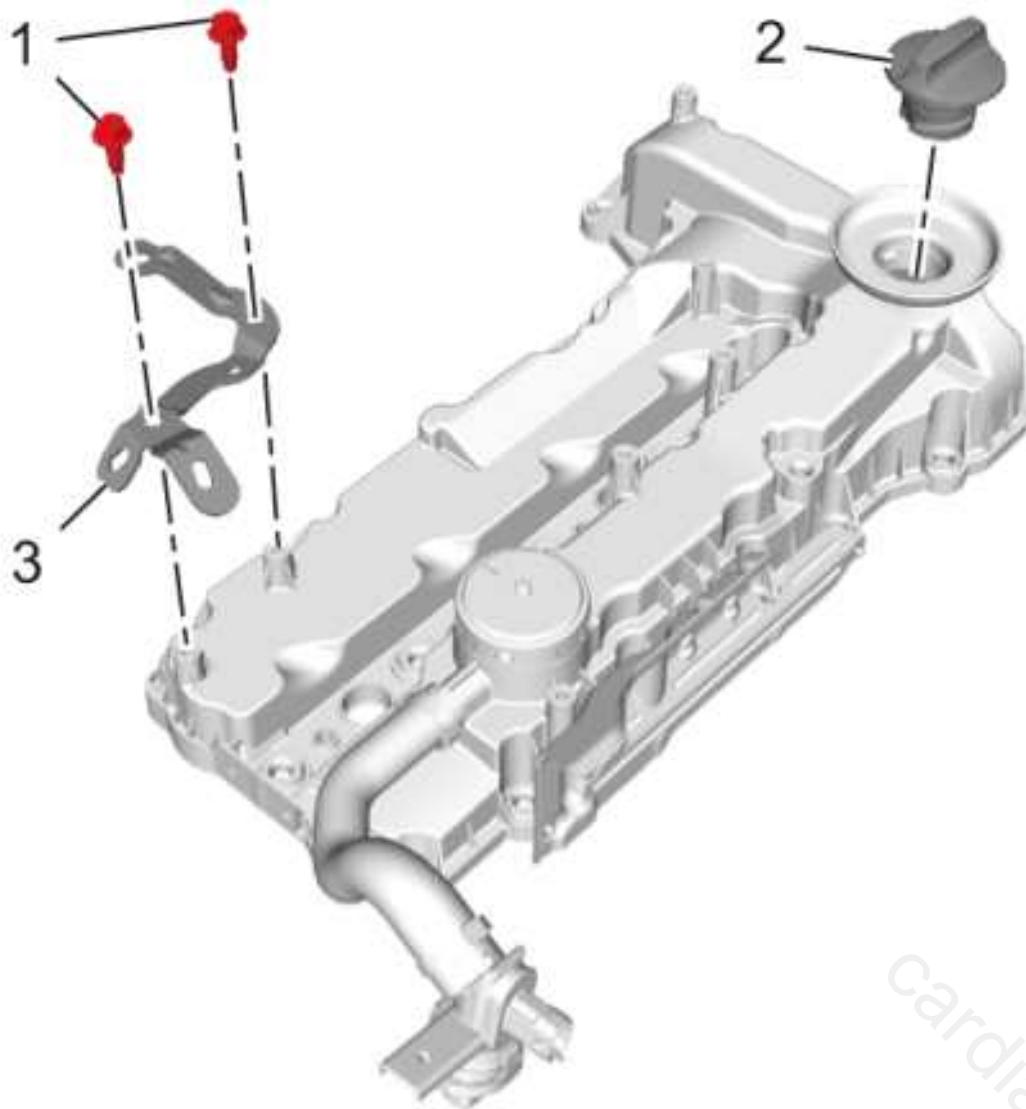


Fig. 725: Wiring Harness Bracket, Bolts And Oil Filler Cap
Courtesy of GENERAL MOTORS COMPANY

1. Remove Wiring Harness Bracket Bolts (1) (Qty: 2)
2. Remove Wiring Harness Bracket (3)
3. Remove Oil Filler Cap (2)

CAMSHAFT AND HOUSING CLEANING AND INSPECTION

Cleaning Procedure

1. Clean the camshaft covers in solvent.

WARNING: Refer to Safety Glasses and Compressed Air Warning .

2. Dry the camshaft covers with compressed air.

Inspection Procedure

1. Inspect each camshaft cover for the dents or damage to the exterior. A dented or damaged camshaft cover may:
 - Leak engine oil
 - Affect crankcase ventilation
 - Interfere with the camshafts
 - Interfere with the ignition coil sealing
 - Allow water or condensation to enter the engine

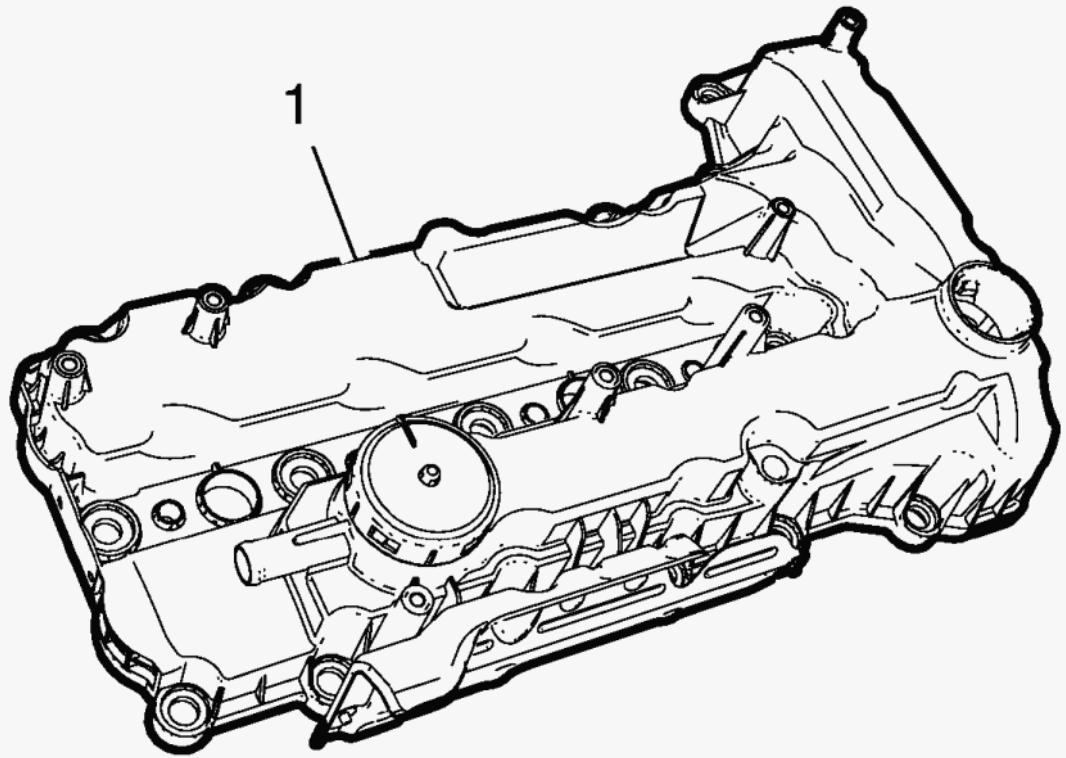


Fig. 726: Camshaft Cover Exterior

Courtesy of GENERAL MOTORS COMPANY

2. Inspect the exterior of the camshaft cover (1) for the following conditions:
 - Damage to the camshaft cover bolt holes
 - Damage to the camshaft cover injector bracket bolt holes

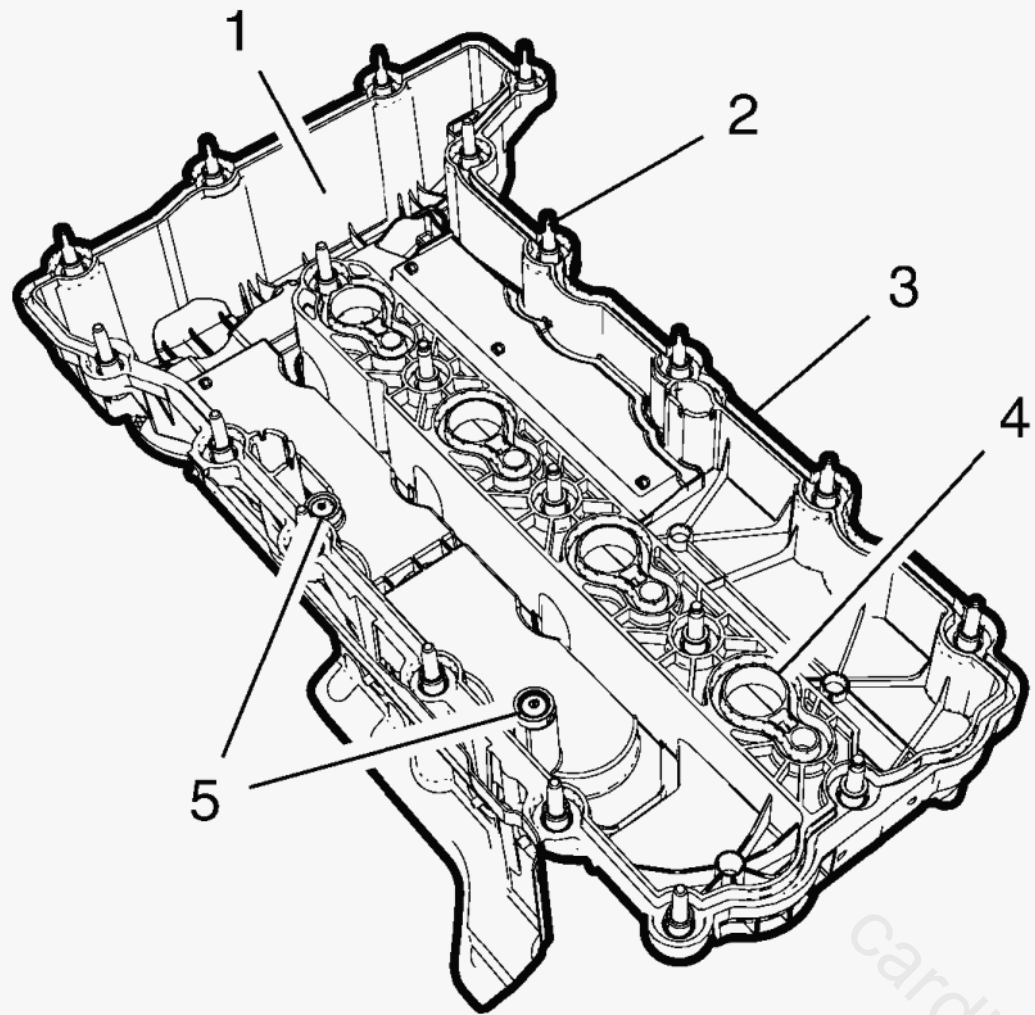


Fig. 727: Camshaft Cover Interior Inspection Points
Courtesy of GENERAL MOTORS COMPANY

3. Inspect the interior of the camshaft cover (1) for the following conditions:
 - Inspect the camshaft cover for cracks, casting imperfections or damage
 - Inspect the camshaft cover sealing (3) and the fuel injector sealing (4) for cracks or damage
 - Inspect the camshaft cover bolts (2) for flawless thread
 - Inspect the positive crankcase oil separator valves (5) for cracks or damages

CAMSHAFT HOUSING ASSEMBLE

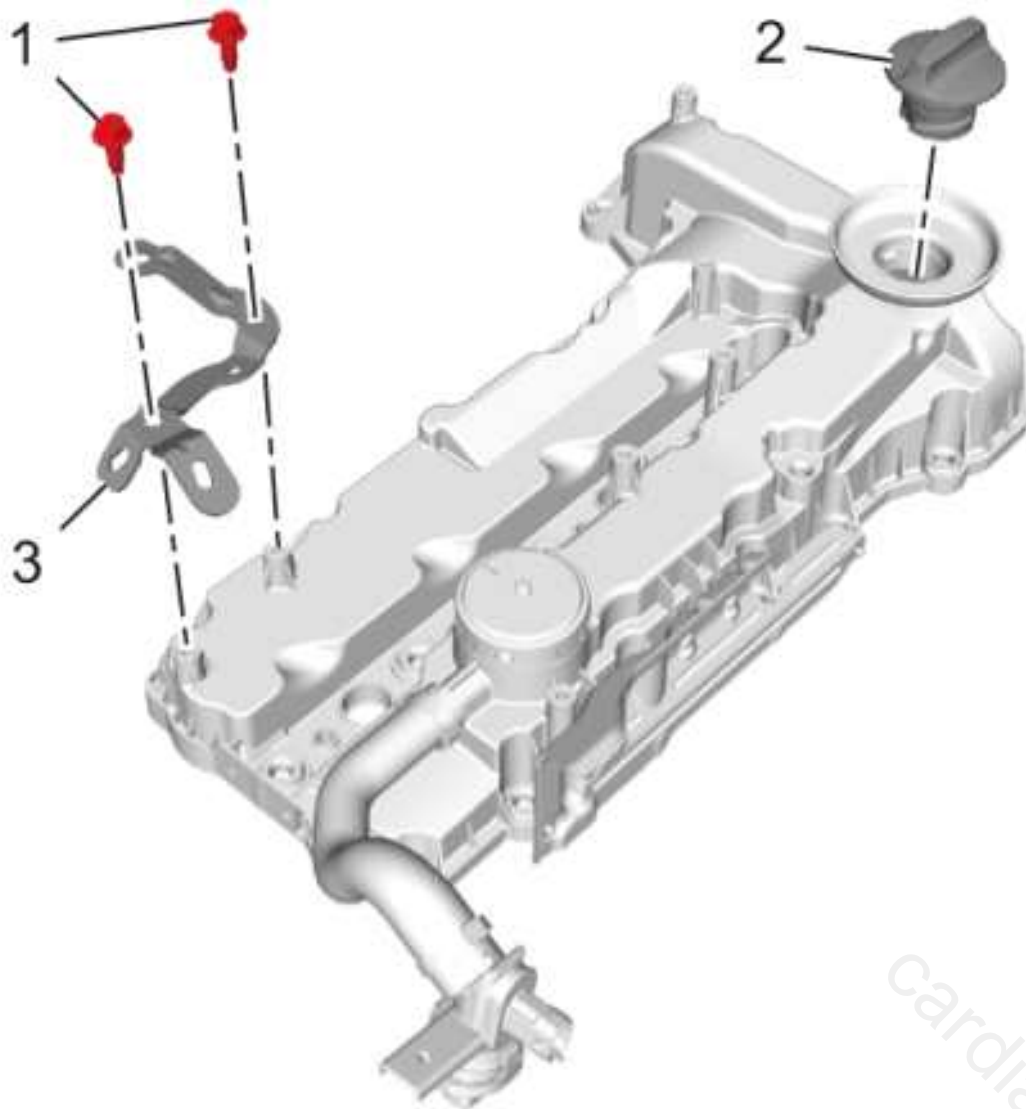


Fig. 728: Wiring Harness Bracket, Bolts And Oil Filler Cap
Courtesy of GENERAL MOTORS COMPANY

1. Install Oil Filler Cap (2)
2. Install Wiring Harness Bracket (3)

CAUTION: Refer to **Fastener Caution**

3. Install and tighten Wiring Harness Bracket Bolts (1) (Qty: 2) to 9 N.m (80 lb in)

PISTON AND CONNECTING ROD DISASSEMBLE

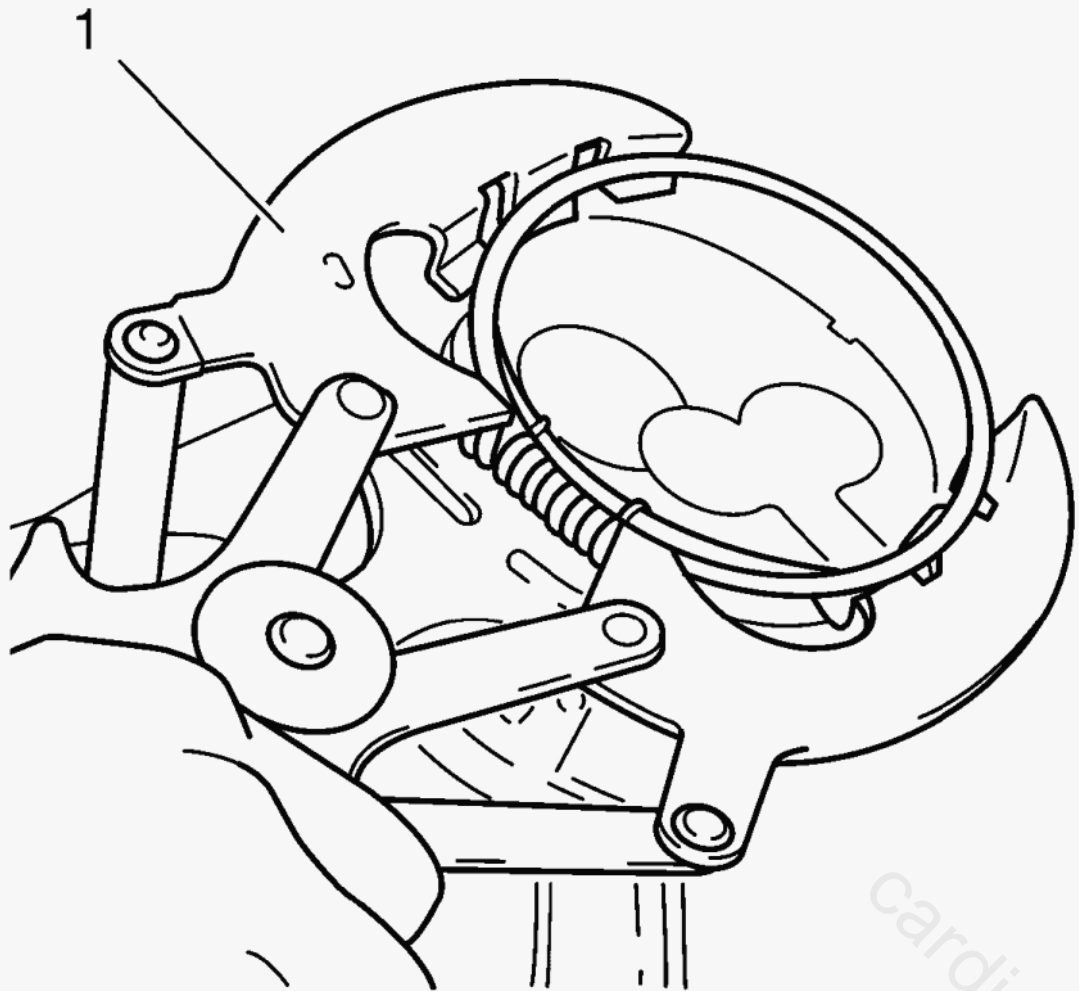


Fig. 729: Using Piston Ring Pliers

Courtesy of GENERAL MOTORS COMPANY

1. Remove the piston rings. Use a piston ring plier (1).

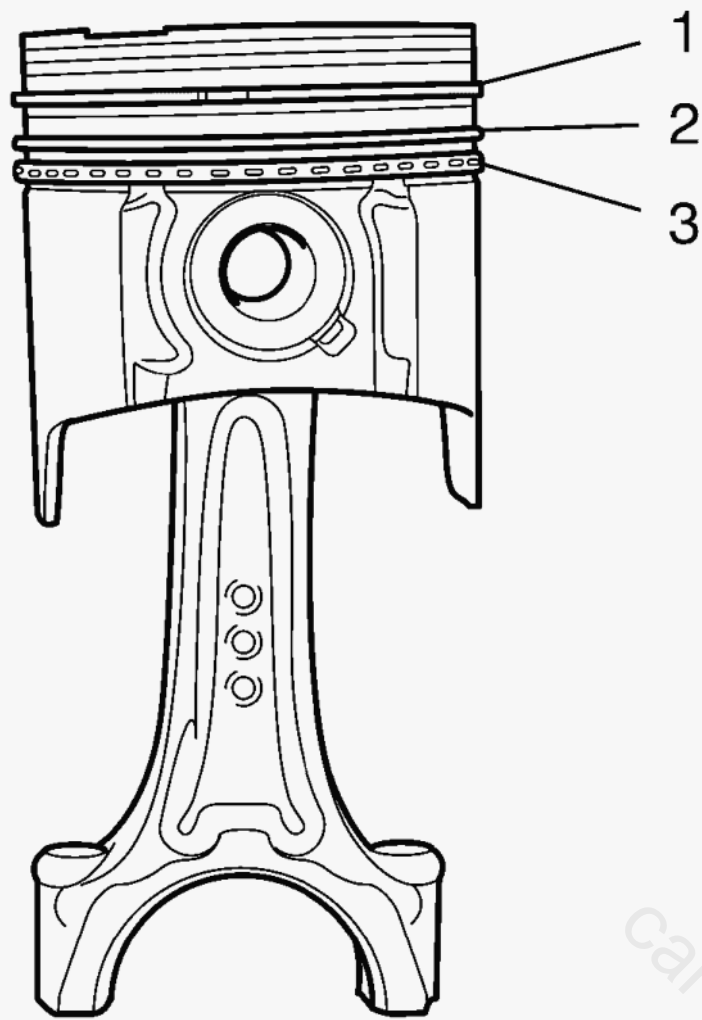


Fig. 730: Piston Rings

Courtesy of GENERAL MOTORS COMPANY

2. The piston rings are ordered as followed:

- Upper compression ring (1)
- Lower compression ring (2)
- Oil ring (3)

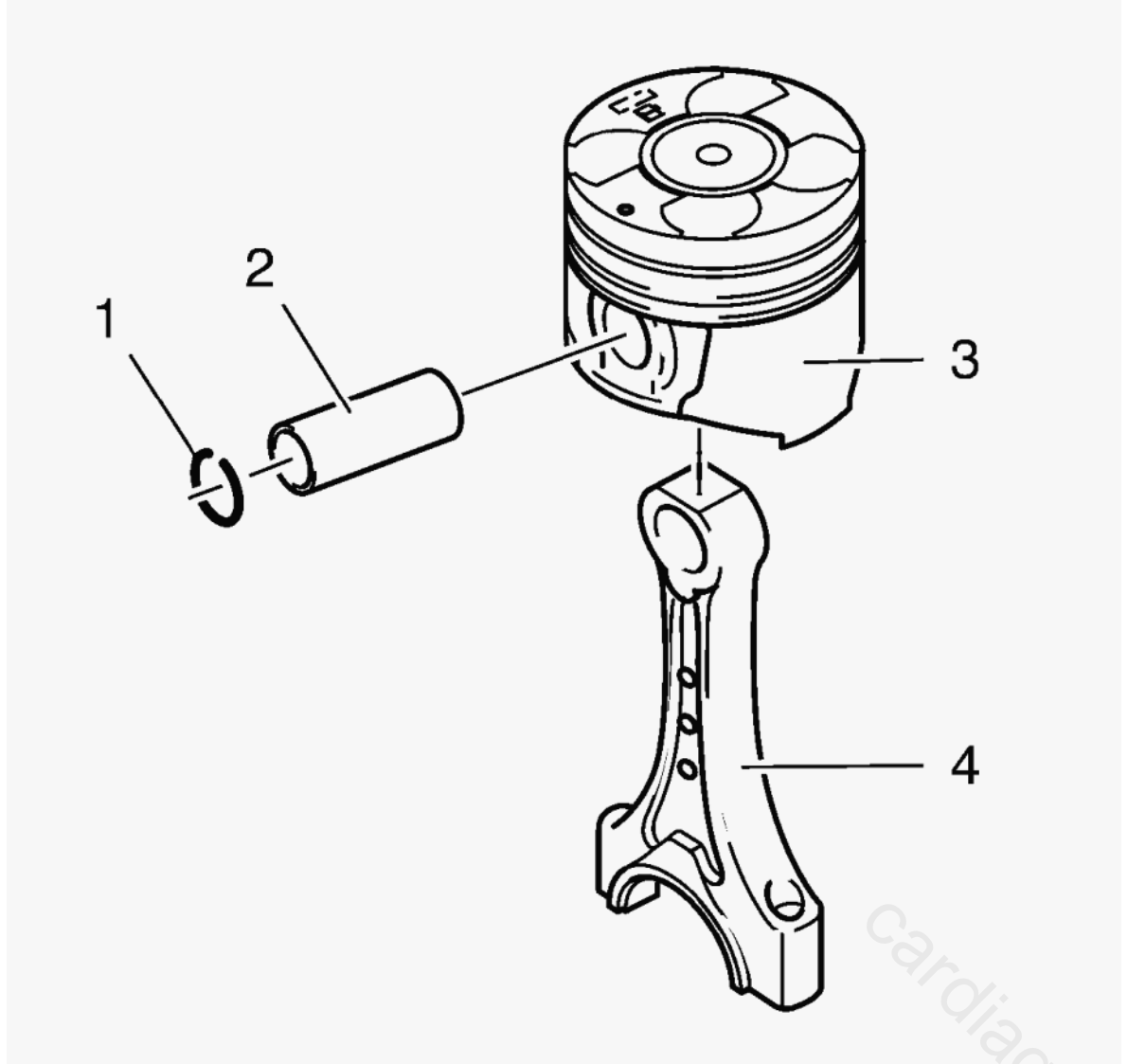


Fig. 731: Connecting Rod, Piston, Piston Pin And Retainer
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Clamp the connecting rod.**

3. Remove the 2 piston pin retainer (1).
4. Remove the piston pin (2).
5. Remove the piston (3) from the connecting rod (4).

PISTON, CONNECTING ROD, AND BEARING CLEANING AND INSPECTION

Special Tools

EN-45059 Angle Meter

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

Visual Inspection And Cleaning Procedure

Connecting Rod

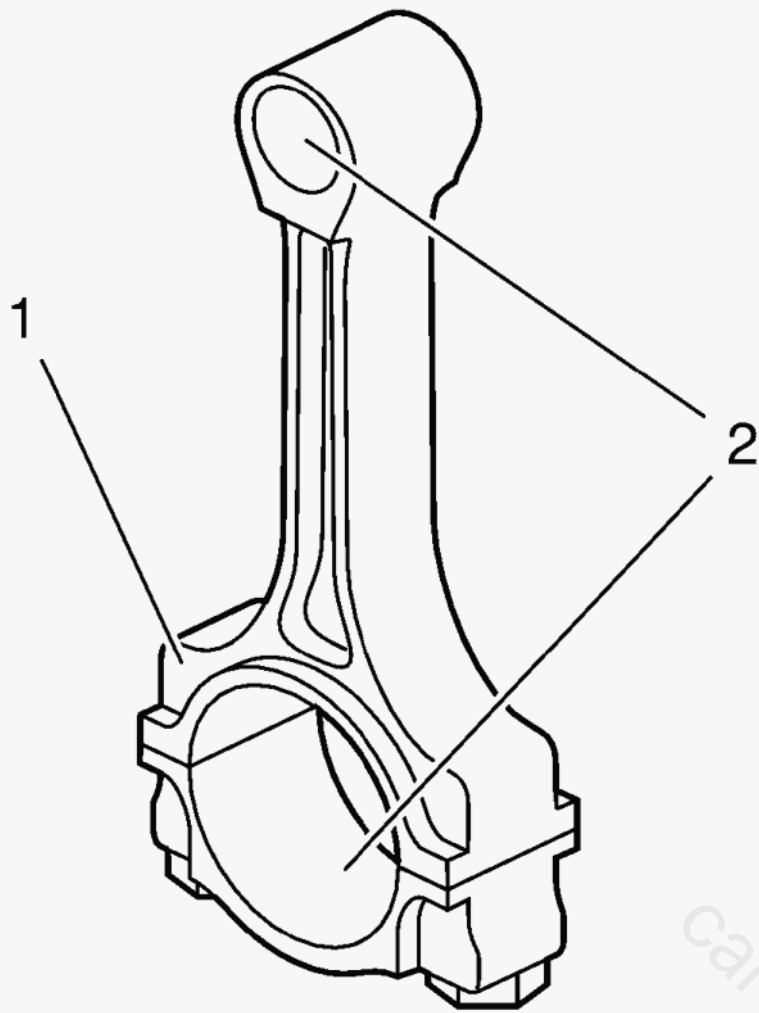


Fig. 732: Connecting Rods

Courtesy of GENERAL MOTORS COMPANY

WARNING: Refer to [Safety Glasses Warning](#) .

1. Clean the connecting rods (1) in solvent and dry with compressed air.
2. Inspect the connecting rod for the following:
 - Signs of being twisted, bent, nicked or cracked
 - Scratches or abrasion on the connecting rod bearing seating surfaces
3. If the connecting rod bores (2) 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.

Piston

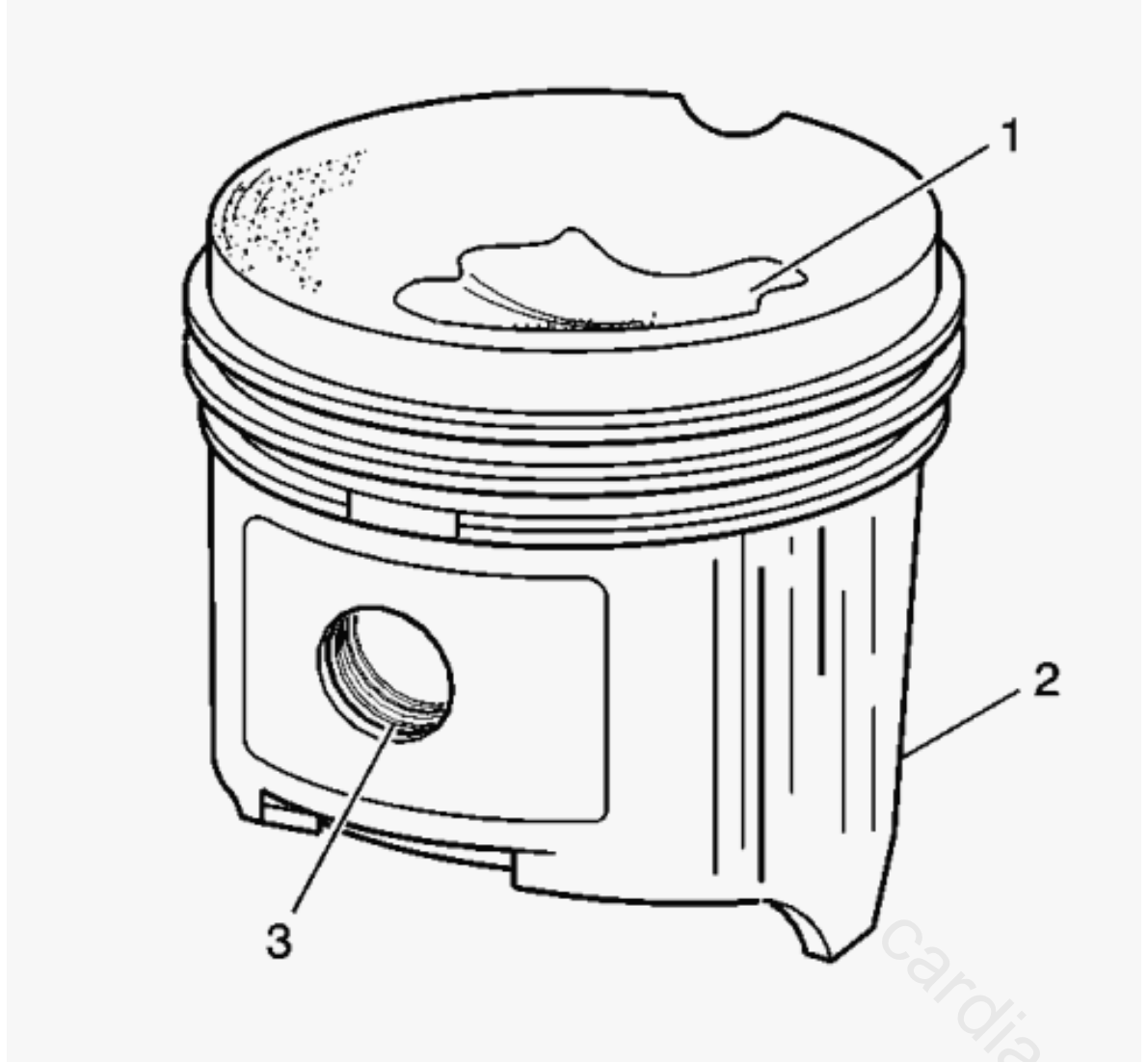


Fig. 733: Identifying Piston Damage Inspection Areas
Courtesy of GENERAL MOTORS COMPANY

1. Clean the piston with a cleaning solvent. DO NOT wire brush any parts of the piston.
2. Clean the piston ring grooves.
3. Inspect the piston on the following:
 - Cracked ring lands, skirts or pin bosses
 - Ring grooves for nicks
 - Eroded areas on the top of the piston (1)
 - Scuffed or damaged skirts (2)
 - Worn piston pin bores (3)
4. If there is any excessive wear, replace the piston.
5. Measure the clearance between piston pin and piston bore. Use the following procedure:

Piston And Connecting Rod Measurement Procedure

Piston Pin To Connecting Rod Bore And Piston Bore Clearance

1. Measure clearance between piston pin and connecting rod bore. Use the following procedure:
 1. Measure the piston pin outside diameter.
 2. Measure the connecting rod bore diameter.
 3. Subtract the piston pin outside diameter from the connecting rod diameter to calculate the clearance.
 4. Refer to the **Engine Mechanical Specifications** for the correct value of the clearance piston pin in connecting rod.
2. If there is excessive clearance, replace the piston pin.
3. If there is still excessive clearance, replace the connecting rod.
4. Measure clearance between piston pin and piston bore. Use the following procedure:

1. Measure the piston pin outside diameter.
2. Measure the piston bore diameter.
3. Subtract the piston pin outside diameter from the piston bore diameter to calculate the clearance.
4. Refer to [Engine Mechanical Specifications](#) for the correct value of the clearance piston pin in piston.
5. If there is excessive clearance, replace the piston pin.
6. If there is still excessive clearance, replace the piston.

Piston Ring Clearance

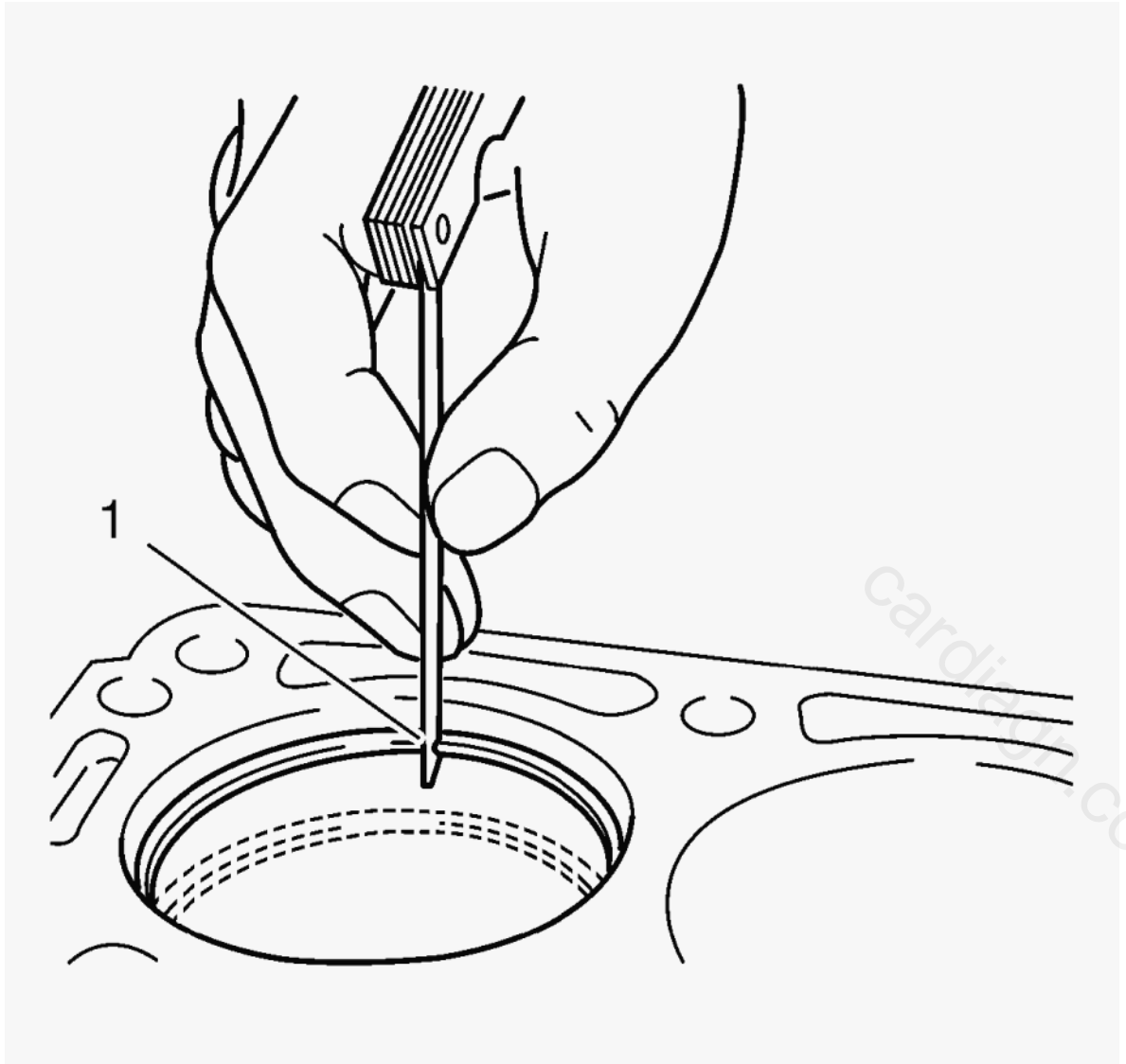


Fig. 734: Measuring Piston Ring End Clearance

Courtesy of GENERAL MOTORS COMPANY

1. Install the piston rings to the cylinder as shown (1) and measure the piston ring end gap. Compare the measurements with those provided below:
 - The upper compression ring end gap. Refer to [Engine Mechanical Specifications](#) for the correct value of the clearance.
 - The lower compression ring end gap. Refer to [Engine Mechanical Specifications](#) for the correct value of the clearance.
 - The oil scraper ring end gap. Refer to [Engine Mechanical Specifications](#) for the correct value of the clearance.
2. If the clearance is greater than the provided specifications, the piston rings must be replaced.

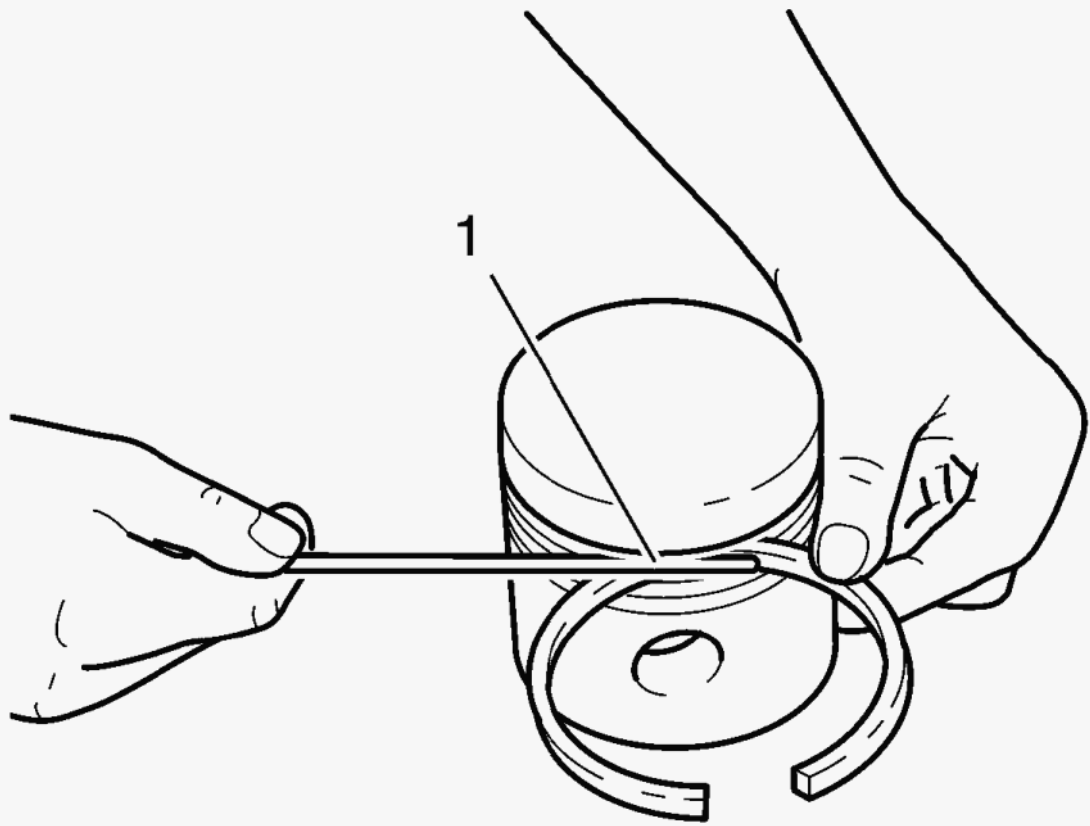


Fig. 735: Measuring Piston Ring Side Clearance
Courtesy of GENERAL MOTORS COMPANY

3. Measure the piston ring axial clearance as shown (1). Compare the measurements with those provided below:
 - The upper compression ring end gap. Refer to [Engine Mechanical Specifications](#) for the correct value of the clearance.
 - The lower compression ring end gap. Refer to [Engine Mechanical Specifications](#) for the correct value of the clearance.
 - The oil scraper ring end gap. Refer to [Engine Mechanical Specifications](#) for the correct value of the clearance.
4. If the clearance is greater than the provided specifications, replace the piston rings.
5. If the clearance is still too great, replace the pistons.

Piston to Engine Block Cylinder Bore Clearance

1. Measure the engine cylinder bore. Refer to [Engine Block Cleaning and Inspection](#).

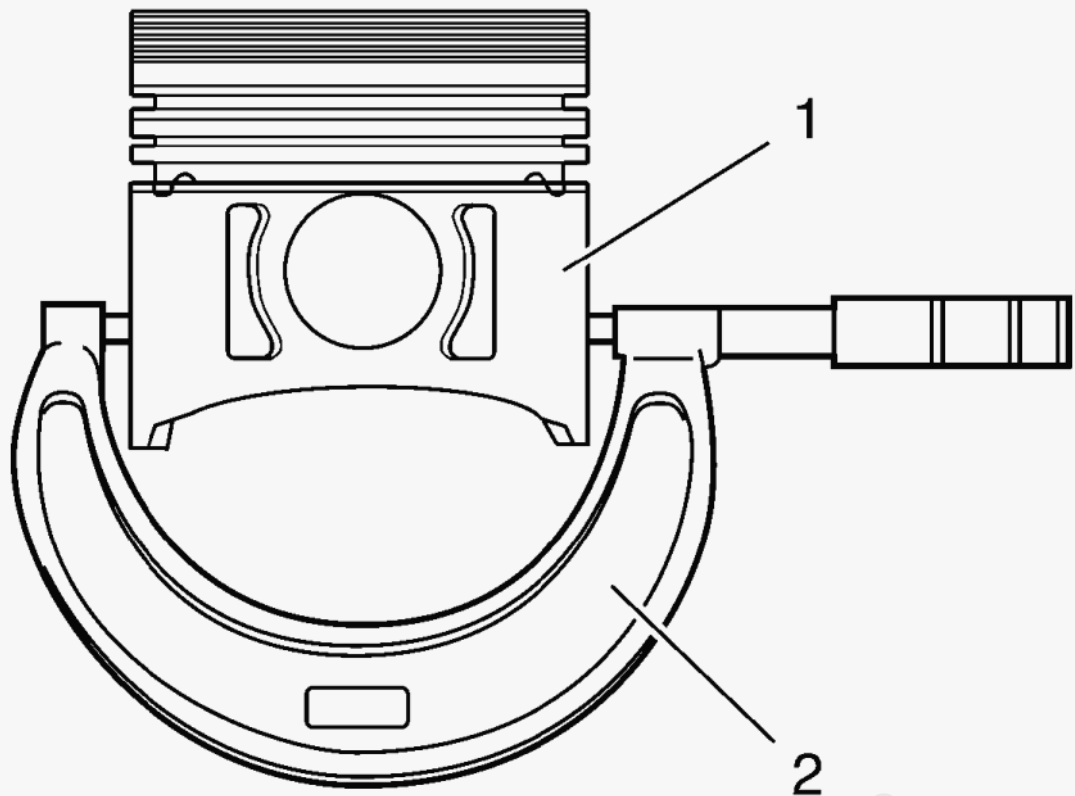


Fig. 736: Outside Micrometer And Piston

Courtesy of GENERAL MOTORS COMPANY

2. Measure the piston (1) 10 mm (0.3937 in) from the bottom of the skirt, with a micrometer (2) or caliper at a right angle to the piston.
3. Subtract the piston diameter from the cylinder bore diameter in order to calculate the piston-to-bore clearance.
4. Refer to [Engine Mechanical Specifications](#) for the correct value of the clearance piston-to-bore.
5. If the clearance obtained through measurement is greater than these specifications and the cylinder bores are within specification, replace the piston.

Connecting Rod Bearing Clearance (with Micrometer Gauge Internal Measuring Device)

1. Install the connecting bearings and the connecting rod bearing caps.
2. Tighten the connecting rod bearing cap bolts in the following sequence:

CAUTION: Refer to [Fastener Caution](#) .

NOTE: The old bolts can be reused for the measuring procedure.

1. Tighten the connecting rod bearing cap bolts a first pass to 25 N.m (18 lb ft).

CAUTION: Refer to [Torque-to-Yield Fastener Caution](#) .

2. Tighten the bolts a final pass an additional to 110 degrees using the **EN-45059** meter.

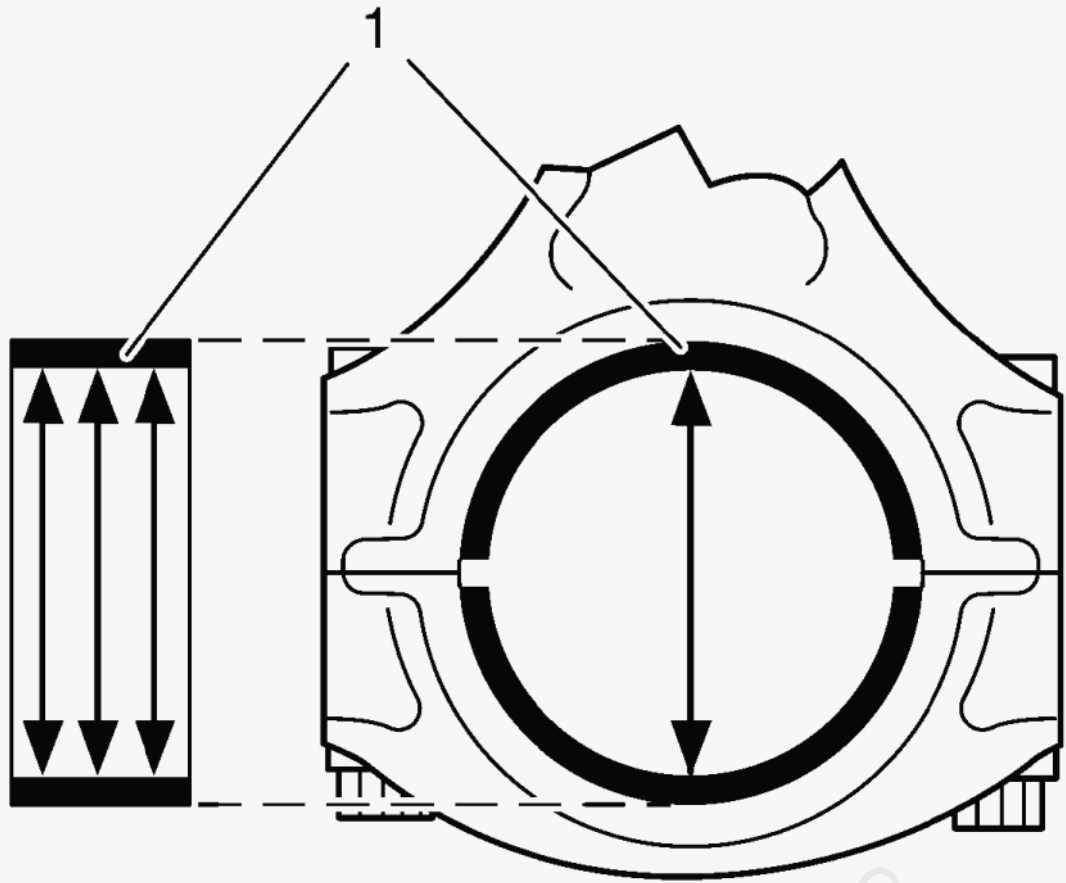


Fig. 737: Measuring Connecting Rod Bearing Diameters
Courtesy of GENERAL MOTORS COMPANY

3. Measure the connecting rod bearing diameters at 3 points as shown (1). Use an internal measuring device.
4. Calculate the average connecting rod inner diameter.

Formula: $1. \text{ result} + 2. \text{ result} + 3. \text{ result} / 3$

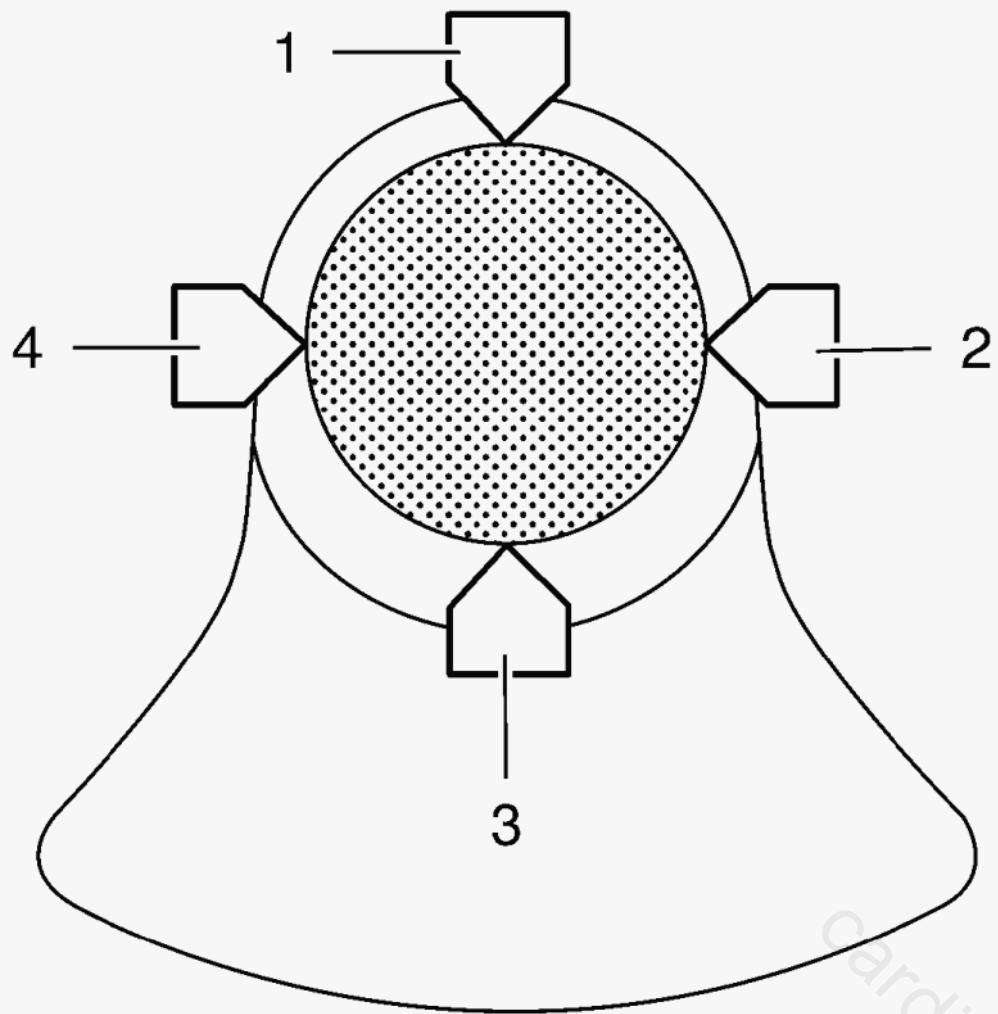


Fig. 738: Connecting Rod Journal Diameter Points
Courtesy of GENERAL MOTORS COMPANY

5. Measure the connecting rod journal diameter at 2 points between (1) and (3) and between (2) and (4). Use a micrometer gauge.
6. Calculate the average connecting rod journal diameter.

Formula: $1. \text{ result} + 2. \text{ result} / 2.$

7. Subtract the average connecting rod journal diameter from the average connecting rod bearing diameter in order to determine the connecting rod bearing clearance.
8. Refer to [Engine Mechanical Specifications](#) for the correct value of the connecting rod bearing clearance.

PISTON AND CONNECTING ROD ASSEMBLE

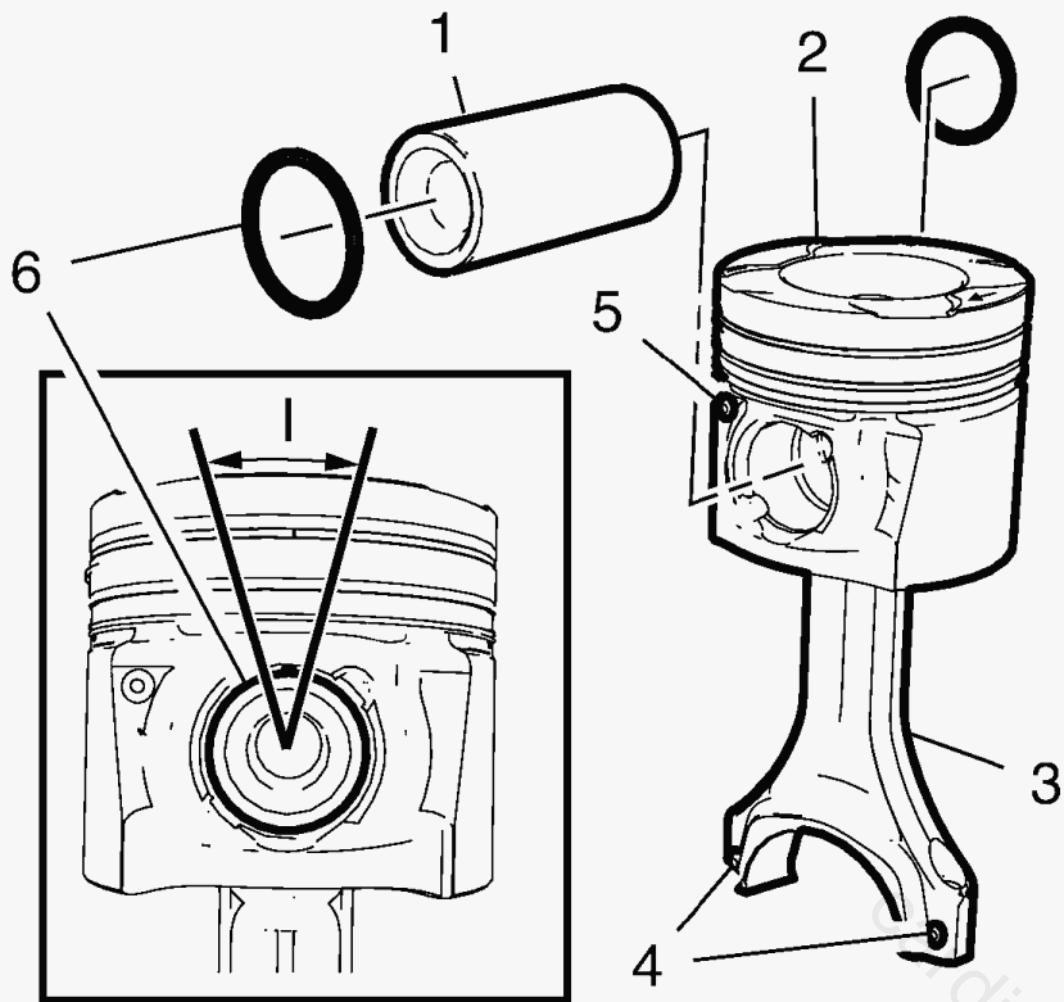


Fig. 739: Connecting Rod, Piston, Piston Pin, Retainer And Marks
 Courtesy of GENERAL MOTORS COMPANY

NOTE: Lubricate the piston pin and the piston bore with engine oil.

1. Install the connecting rod (3) to the piston (2).

NOTE: The marks (4) on the connecting rod must show in direction to the mark (5) from the piston and the arrow on the top of the piston.

2. Install the piston pin (1).

NOTE: The 2 piston pin retainer (6) must be positioned in region of measurement maximum 30° as shown in the extensional graphic position (I).

3. Install the 2 piston pin retainer (6).

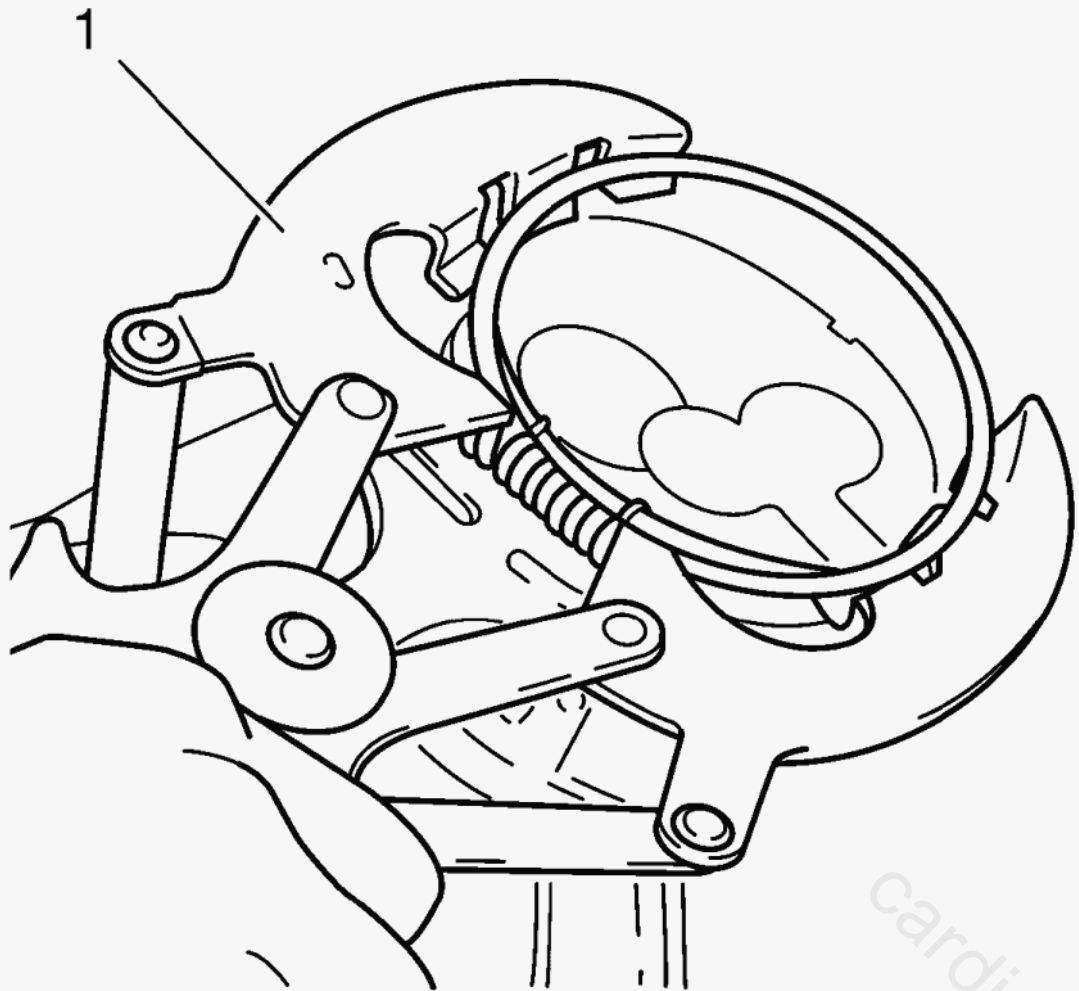


Fig. 740: Using Piston Ring Pliers

Courtesy of GENERAL MOTORS COMPANY

4. Install the piston rings. Use a piston ring plier (1).

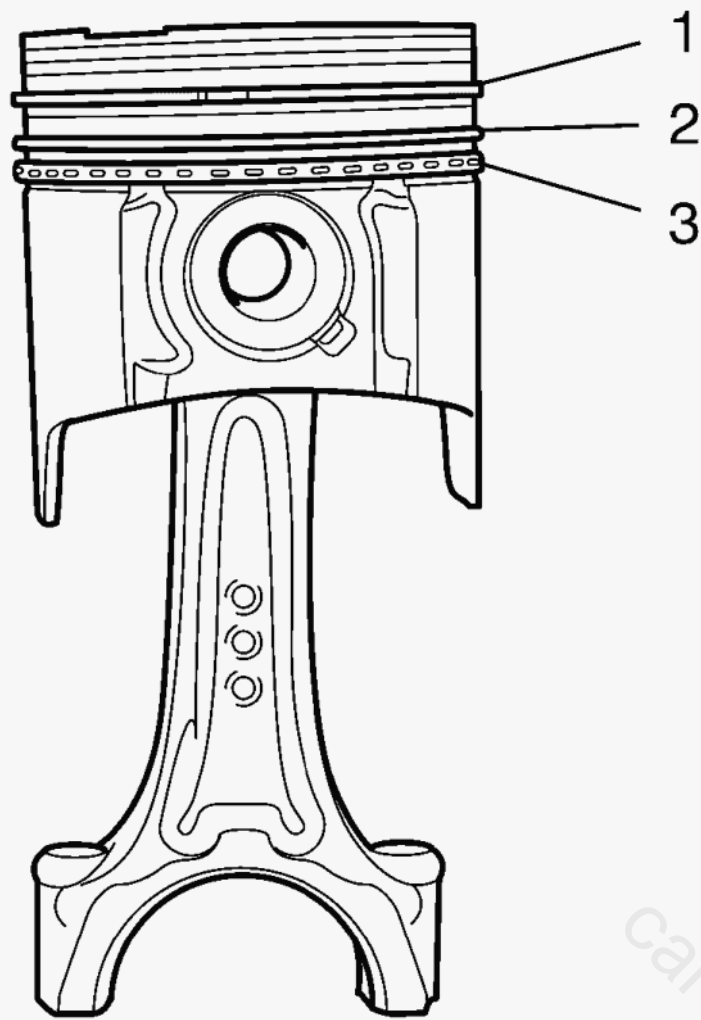


Fig. 741: Piston Rings

Courtesy of GENERAL MOTORS COMPANY

5. The piston rings must be ordered as followed:
 - Upper compression ring (1)
 - Lower compression ring (2)
 - Oil ring (3)
6. The piston ring joints must be displaced 120 degrees to each other.

CRANKSHAFT AND BEARING CLEANING AND INSPECTION

Special Tools

EN-45059 Angle Meter

Equivalent regional tools: **Special Tools**.

Cleaning Procedure

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

WARNING: Refer to **Safety Glasses and Compressed Air Warning** .

3. Dry the crankshaft with compressed air.

Visual Inspection

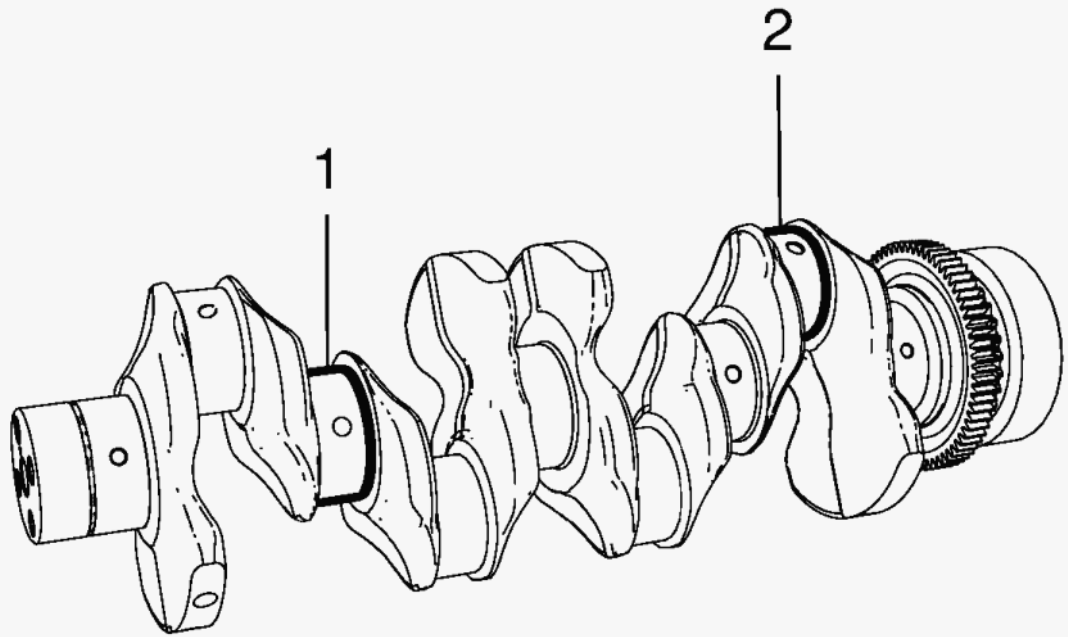


Fig. 742: Inspecting Crankshaft Bearing Journals And Connecting Rod Bearing Journals
Courtesy of GENERAL MOTORS COMPANY

1. Inspect the 5 crankshaft bearing journals (1) and 4 connecting rod bearing journals (2) for wear:
 - grooves or scoring
 - scratches
 - pitting or imbedded bearing material

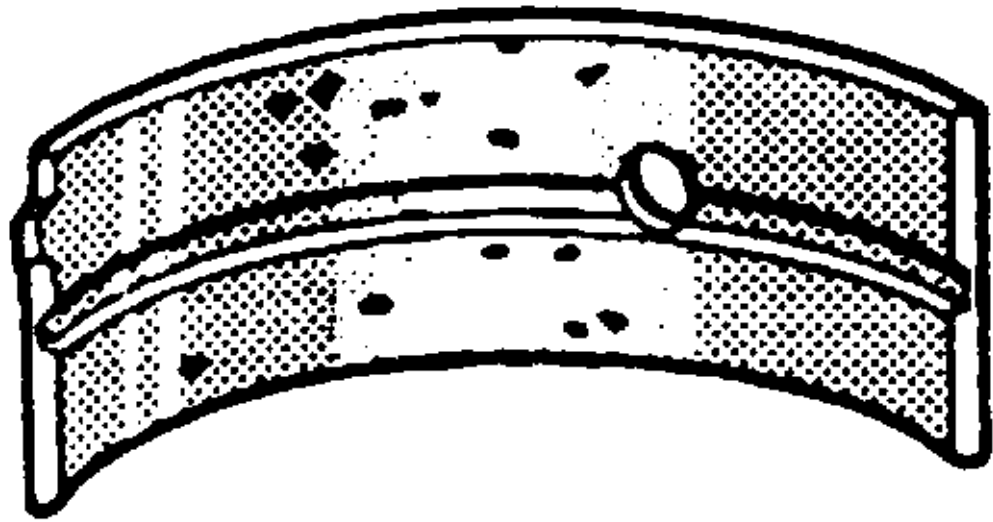


Fig. 743: Identifying Crankshaft Bearing Craters Or Pockets
Courtesy of GENERAL MOTORS COMPANY

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

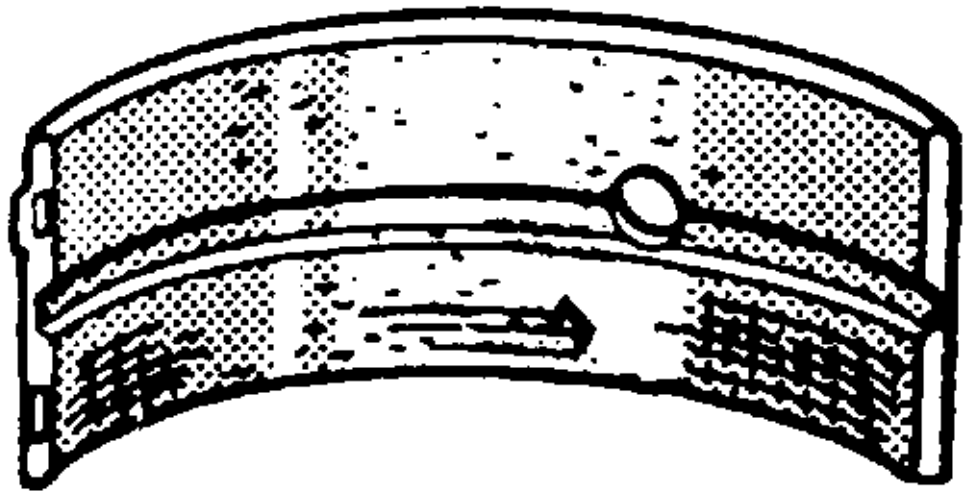


Fig. 744: Identifying Connecting Rod Bearing Scoring Or Discoloration
Courtesy of GENERAL MOTORS COMPANY

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

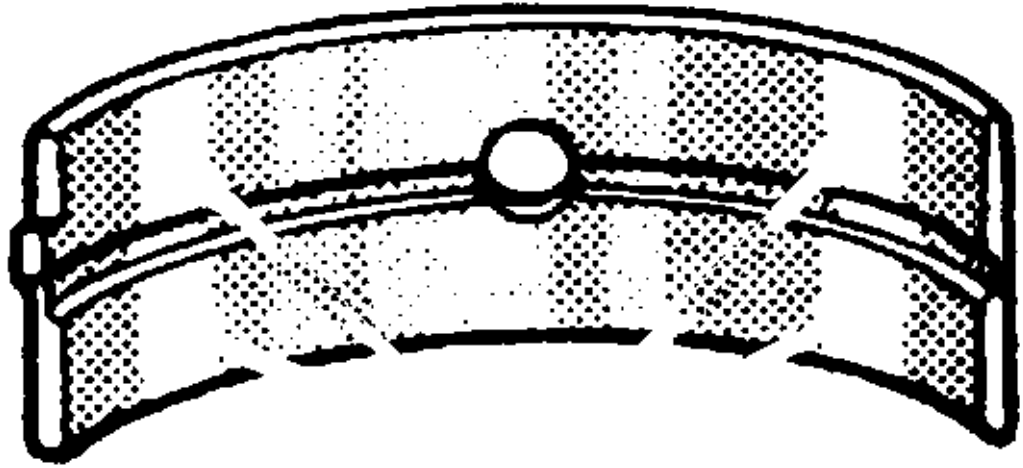


Fig. 745: View Of Crankshaft Bearing Improper Seating

Courtesy of GENERAL MOTORS COMPANY

NOTE: 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.

5. Inspect the crankshaft bearings for improper seating indicated by bright, polished sections of the bearing.

Check Crankshaft Bearing Clearance (with Micrometer Gage Internal Measuring Device)

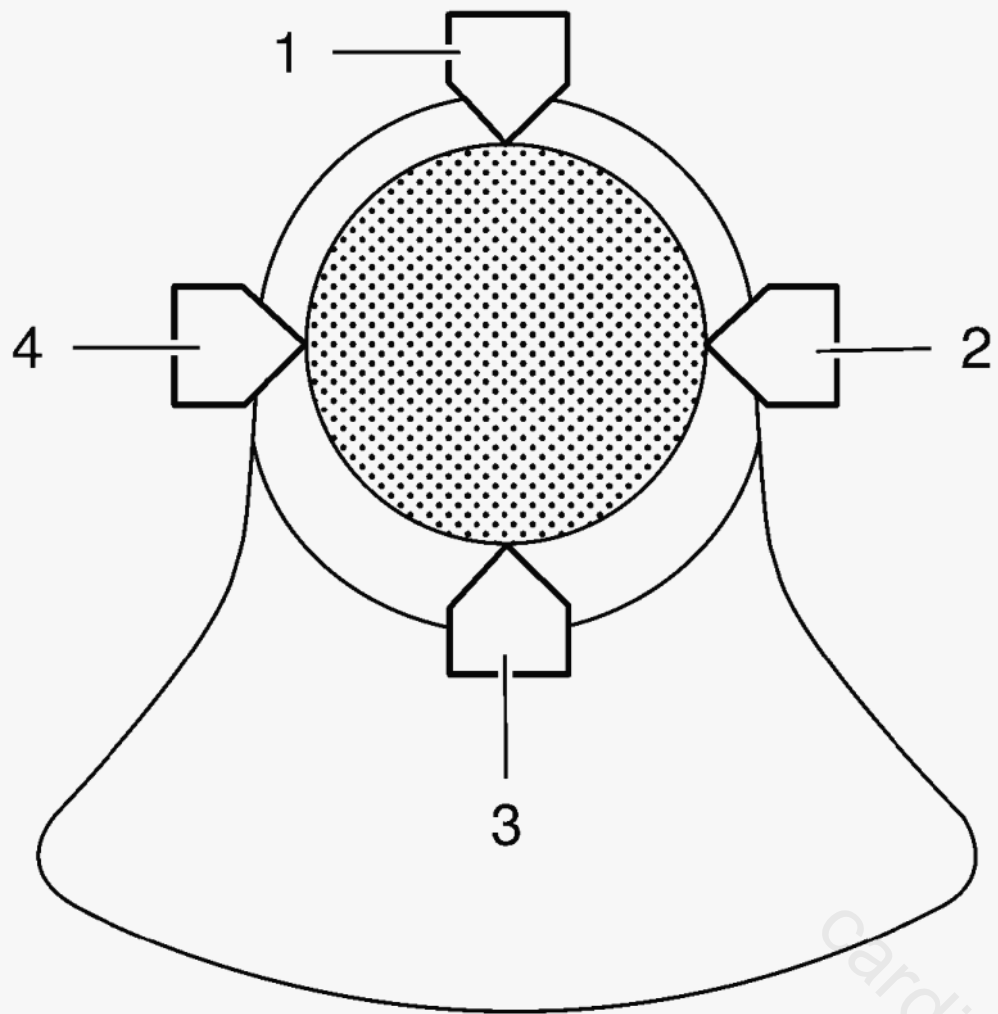


Fig. 746: Connecting Rod Journal Diameter Points
 Courtesy of GENERAL MOTORS COMPANY

1. Measurement the crankshaft bearing journal diameter with a micrometer gauge at the measuring points (1, 3) and (2, 4).
2. Calculate the average crankshaft bearing journal diameter. Formula: $\frac{1. \text{ result} + 2. \text{ result}}{2}$.

Refer to [Engine Mechanical Specifications](#) for the recommended limits.

NOTE: Different classes of bearing shells can be used for a crankshaft bearing to reduce bearing clearance. The stronger of the two bearing shells must be inserted in the crankcase.

3. Crankshaft bearing clearance is calculated by using:
 - Crankshaft bearing bore diameter, refer to [Engine Block Cleaning and Inspection](#).
 - Crankshaft bearing journal diameter
 - Crankshaft bearing shell thickness
4. Determine the crankshaft bearing clearance.

Calculation formula: average crankshaft bearing bore diameter minus average crankshaft bearing journal diameter minus crankshaft bearing shell thickness from lower crankcase minus crankshaft bearing shell thickness from engine block.

Refer to [Engine Mechanical Specifications](#) for the recommended limits.

Check Crankshaft Bearing Clearance (with Plastigage)

1. Clean all sealant surfaces from lower crankcase and engine block.

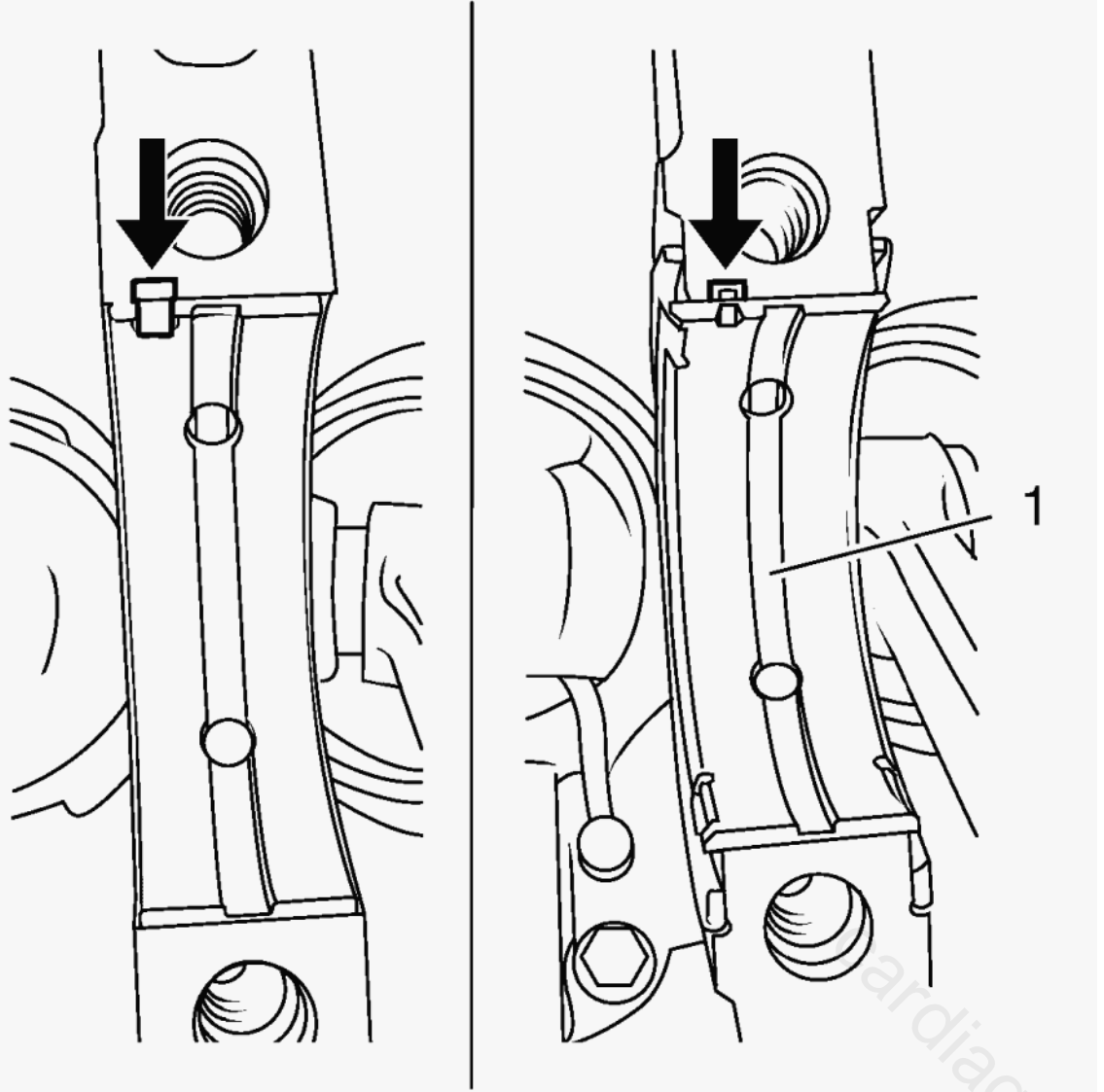


Fig. 747: Crankshaft Thrust Bearing

Courtesy of GENERAL MOTORS COMPANY

NOTE: Ensure that guide lugs (arrows) are properly seated. Note position of thrust bearing (1) at middle crankshaft bearing.

If the old crankshaft bearing shells was reused, set it in as removed.

2. Install the 5 upper crankshaft bearings to the engine block.

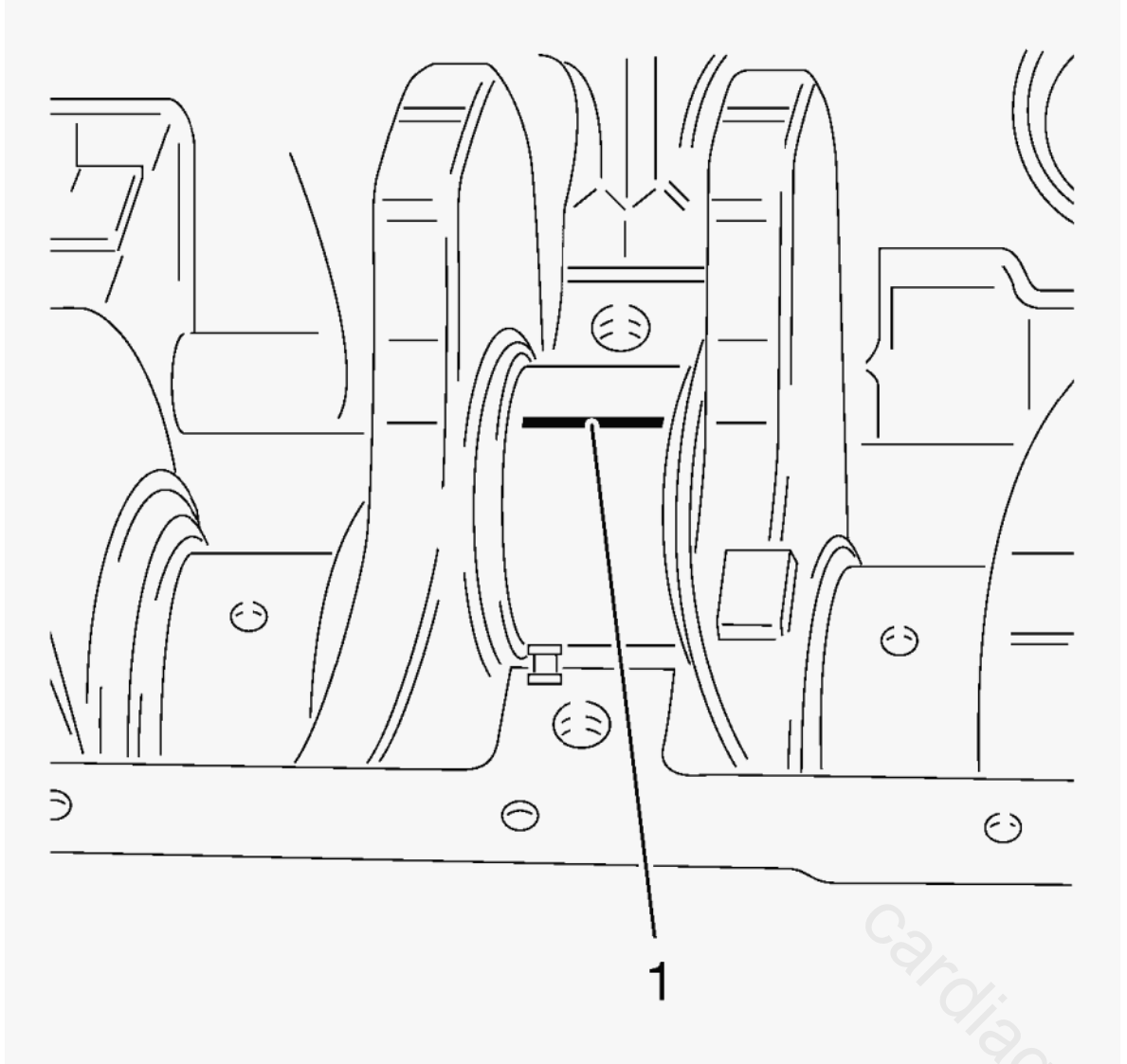


Fig. 748: Plastigage

Courtesy of GENERAL MOTORS COMPANY

NOTE: Do not rotate the crankshaft.

3. Lay on 5 times plastigage (flexible plastic thread) axially over the entire width of the crankshaft bearing journal (1).

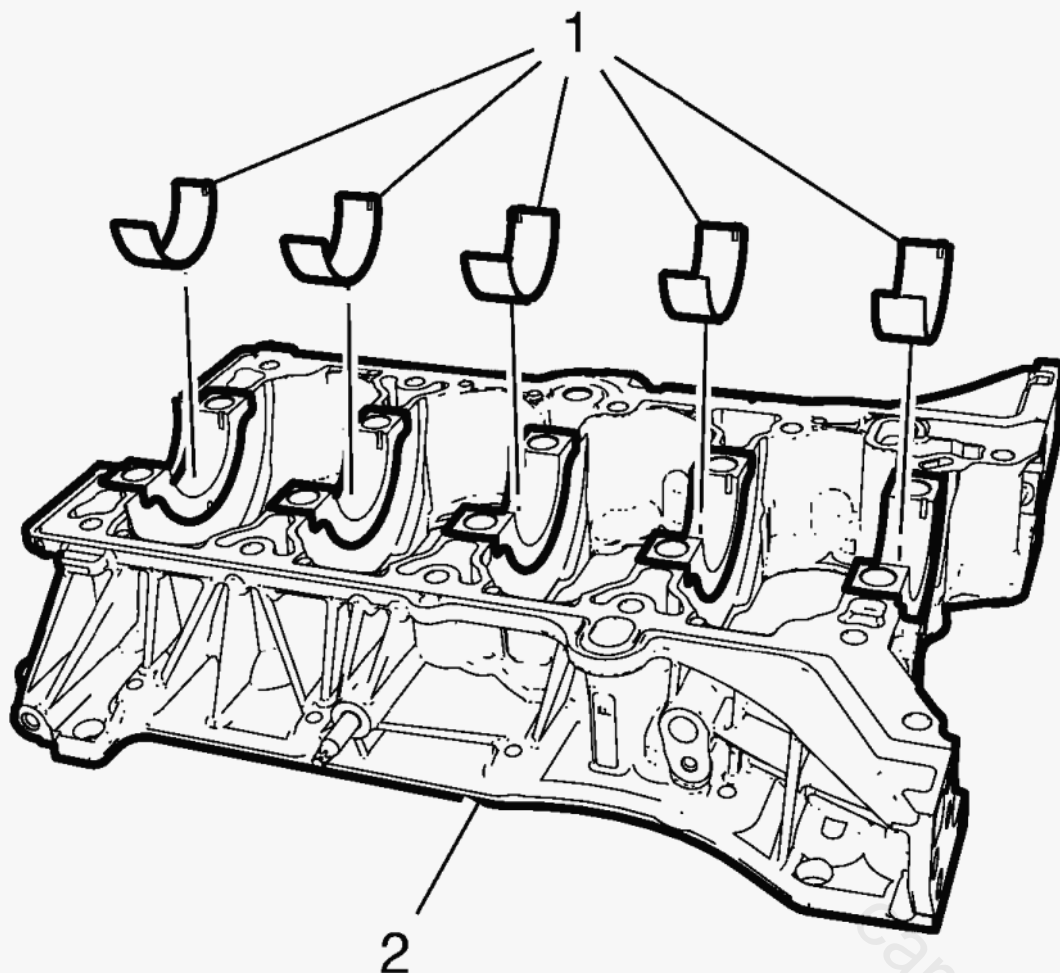


Fig. 749: Lower Crankshaft Bearings And Crankcase
Courtesy of GENERAL MOTORS COMPANY

NOTE: Ensure that guide lugs are properly seated. If the old crankshaft bearings are reused, set it in as removed.

4. Install the 5 lower crankshaft bearings (1) into the crankcase (2).

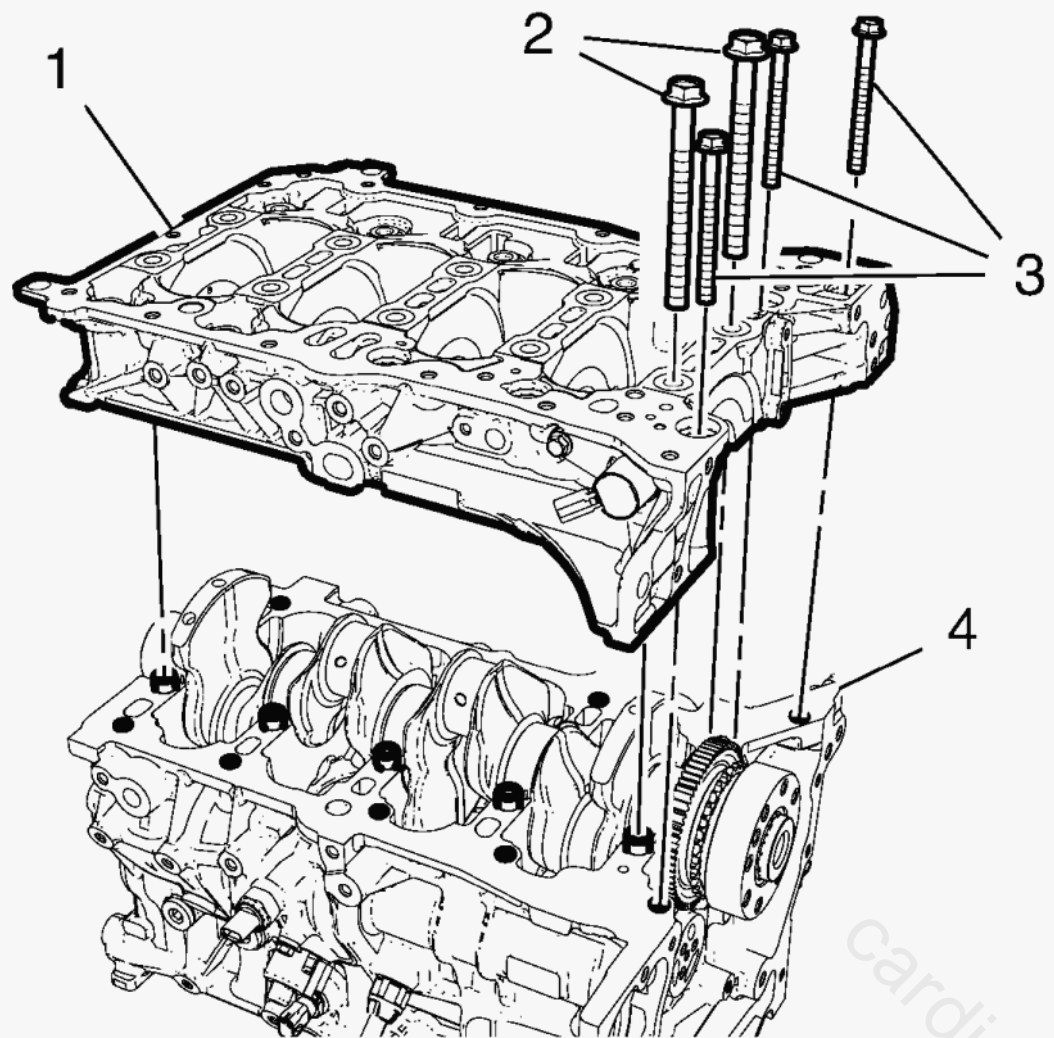


Fig. 750: Lower Crankcase And Bolts

Courtesy of GENERAL MOTORS COMPANY

5. Install the crankshaft to the engine block (4).
6. Install the lower crankcase (1).
7. Loosely install 10 main bearing bolts M10 (2).
8. Loosely install the 11 lower crankcase bolts M8 (3).

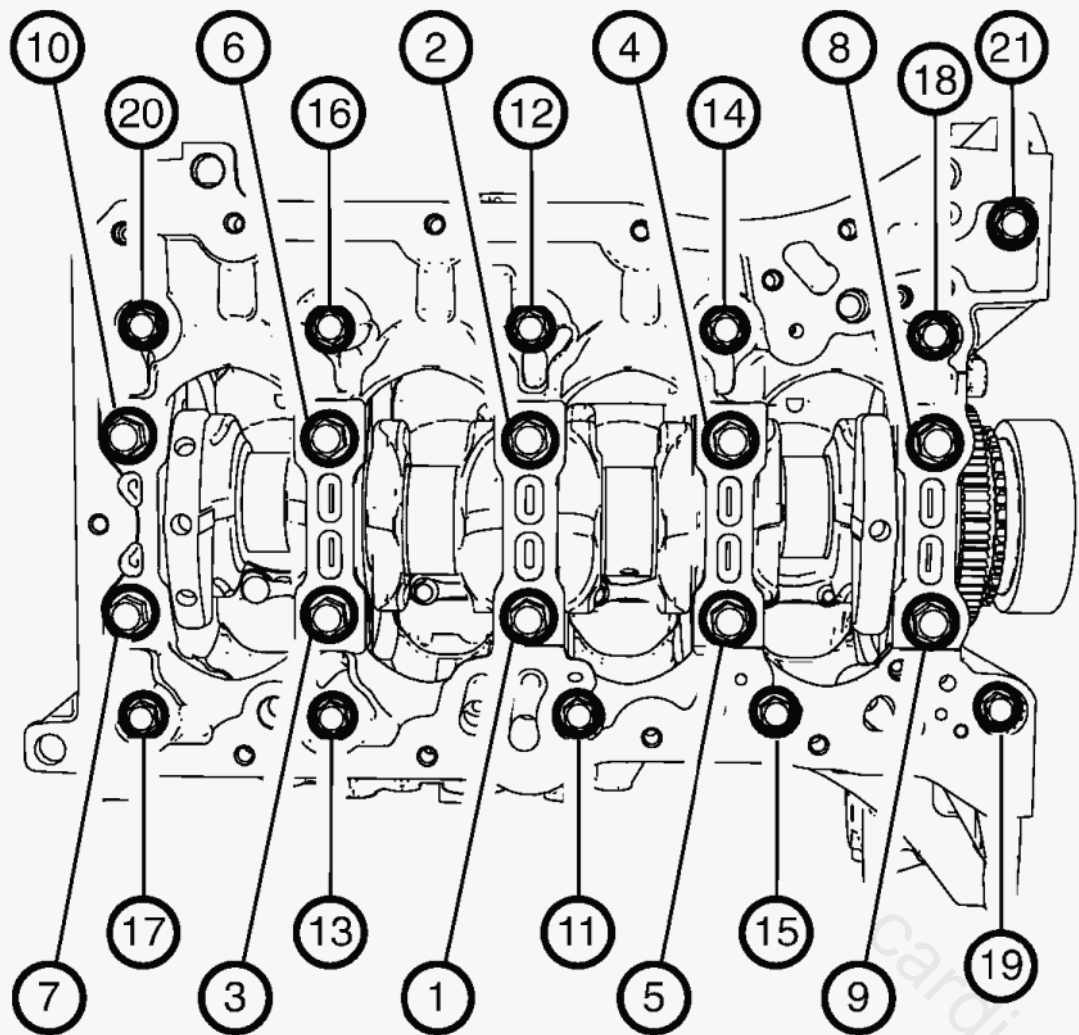


Fig. 751: Main Bearing And Lower Crankcase Bolt Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to [Fastener Caution](#) .

CAUTION: Refer to [Torque-to-Yield Fastener Caution](#) .

9. Tighten the 10 main bearing bolts.
 1. Tighten the bolts (1-10) a first pass in sequence shown to 50 N.m (37 lb ft).
 2. Tighten the bolts (1-10) a second pass in sequence shown an additional to 90 degrees, using the **EN-45059** meter.
 3. Tighten the bolts (1-10) a final pass in sequence shown an additional to 90 degrees, using the **EN-45059** meter.
10. Tighten the 11 lower crankcase bolts (11-21) in sequence shown to 34 N.m (25 lb ft).

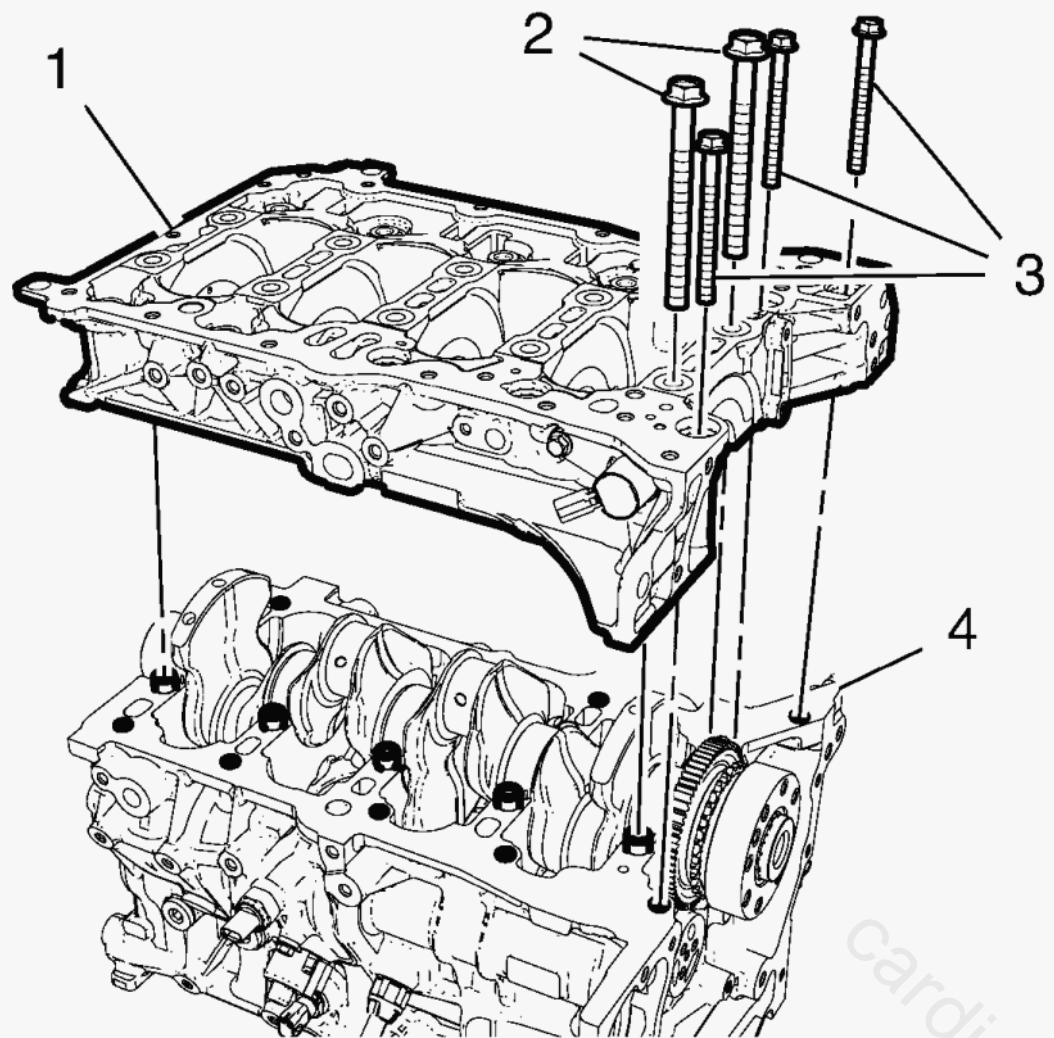


Fig. 752: Lower Crankcase And Bolts

Courtesy of GENERAL MOTORS COMPANY

11. Remove the 11 lower crankcase bolts M8 (3).
12. Remove 10 main bearing bolts M10 (2).
13. Remove the lower crankcase (1) from the engine block (4).

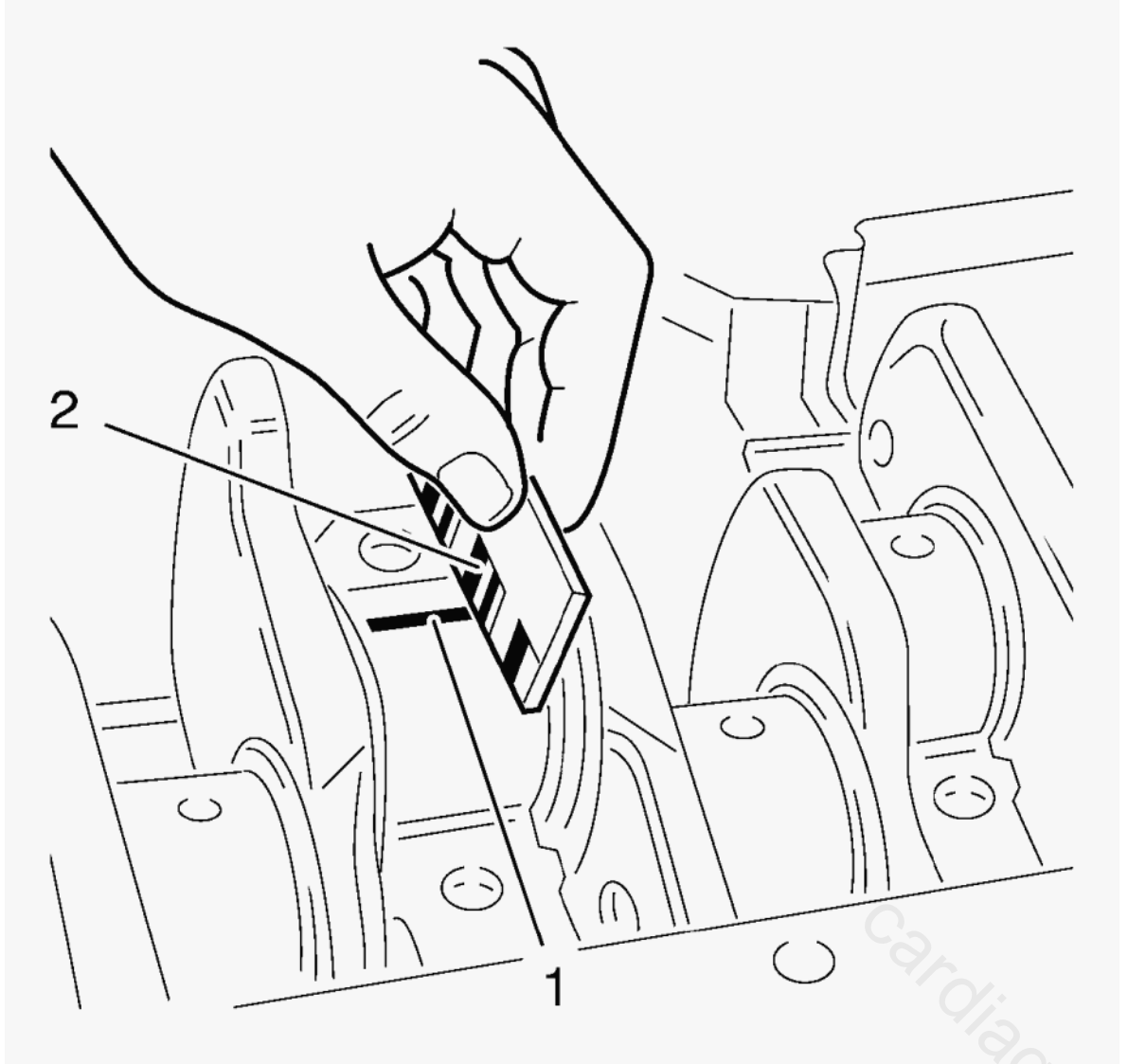


Fig. 753: Measuring Plastigage

Courtesy of GENERAL MOTORS COMPANY

NOTE: When reading the value, do not confuse millimeters and inches on the measuring scale.

14. Measure the crankshaft bearing play.

- Compare the width of the flattened plastic thread (1) to the measuring scale (2).
- For the permissible crankshaft bearing clearance, refer to [Engine Mechanical Specifications](#).

CYLINDER HEAD DISASSEMBLE

Special Tools

- EN-8062 Valve Spring Compressor
- EN-8062-5 Adapter
- EN-43963 Adapter
- EN-46116 Pliers/Remover

For equivalent regional tools, refer to [Special Tools](#).

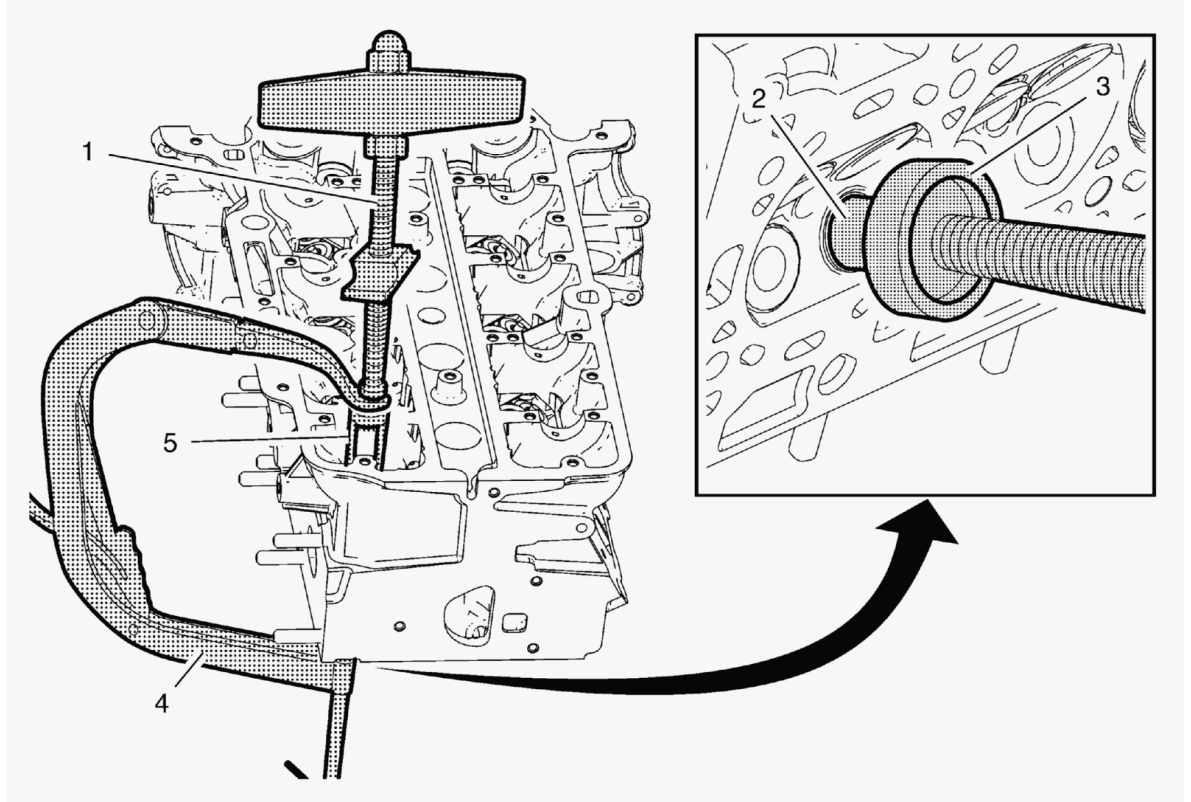
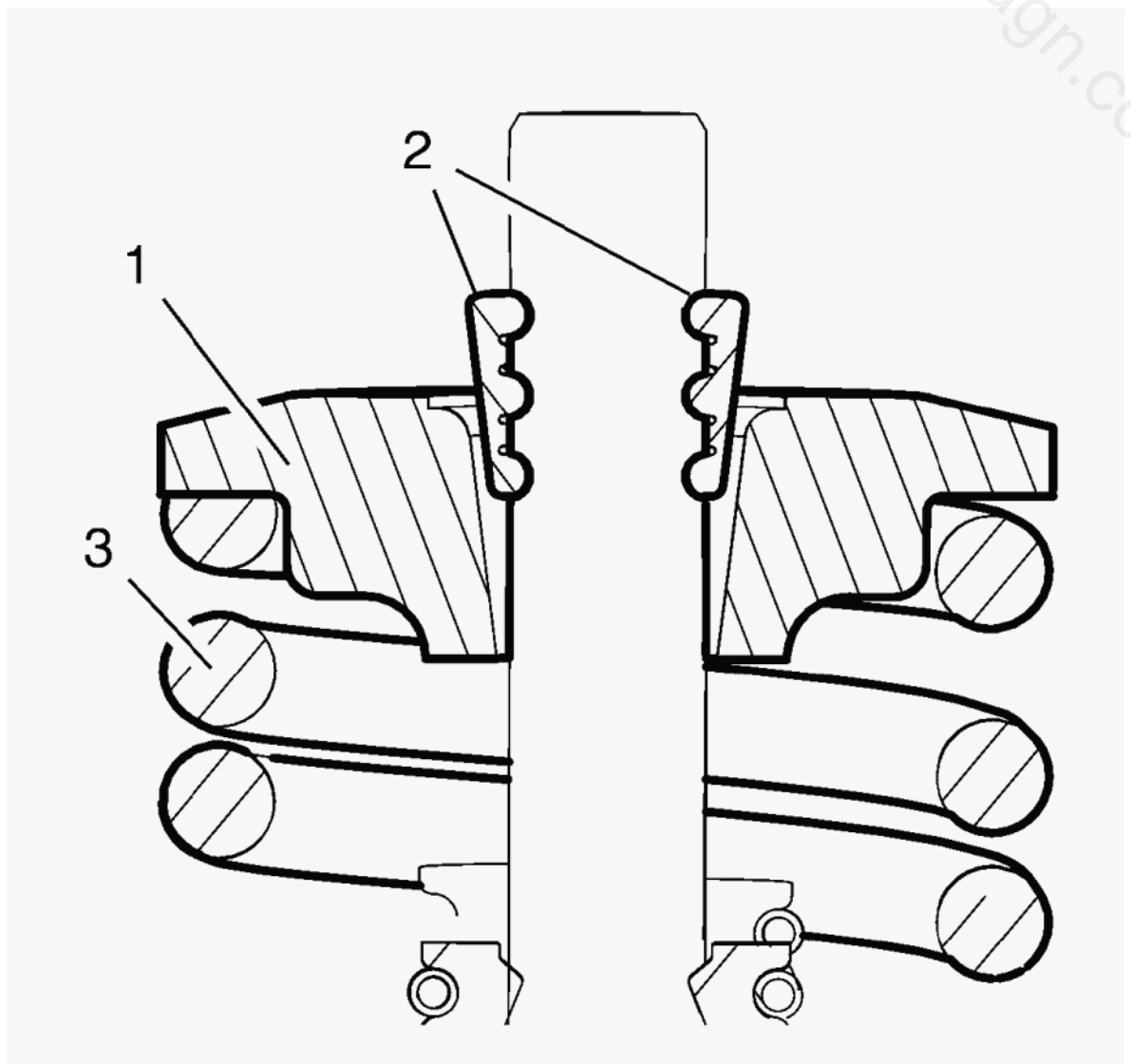


Fig. 754: Valve Spring Compressor And Adapter Assembly.

Courtesy of GENERAL MOTORS COMPANY

1. Install the **EN-8062-5** adapter (3) to the **EN-8062** compressor (4).
2. Install the compressor assembly to the cylinder head, so that the **EN-43963** adapter (5) of the **EN-8062** compressor (1) contacts the valve spring retainer properly and the **EN-8062-5** adapter (3) contacts the valve disc (2). Prefix the **EN-8062** compressor (4).



WARNING: Valve springs can be tightly compressed. Use care when removing the retainers and plugs. Personal injury could result.

3. Apply pressure to the EN-8062 compressor to push down the valve spring retainer (1) and compress the valve spring (3) until the valve keys (2) are free from tension. Carefully remove the valve keys.

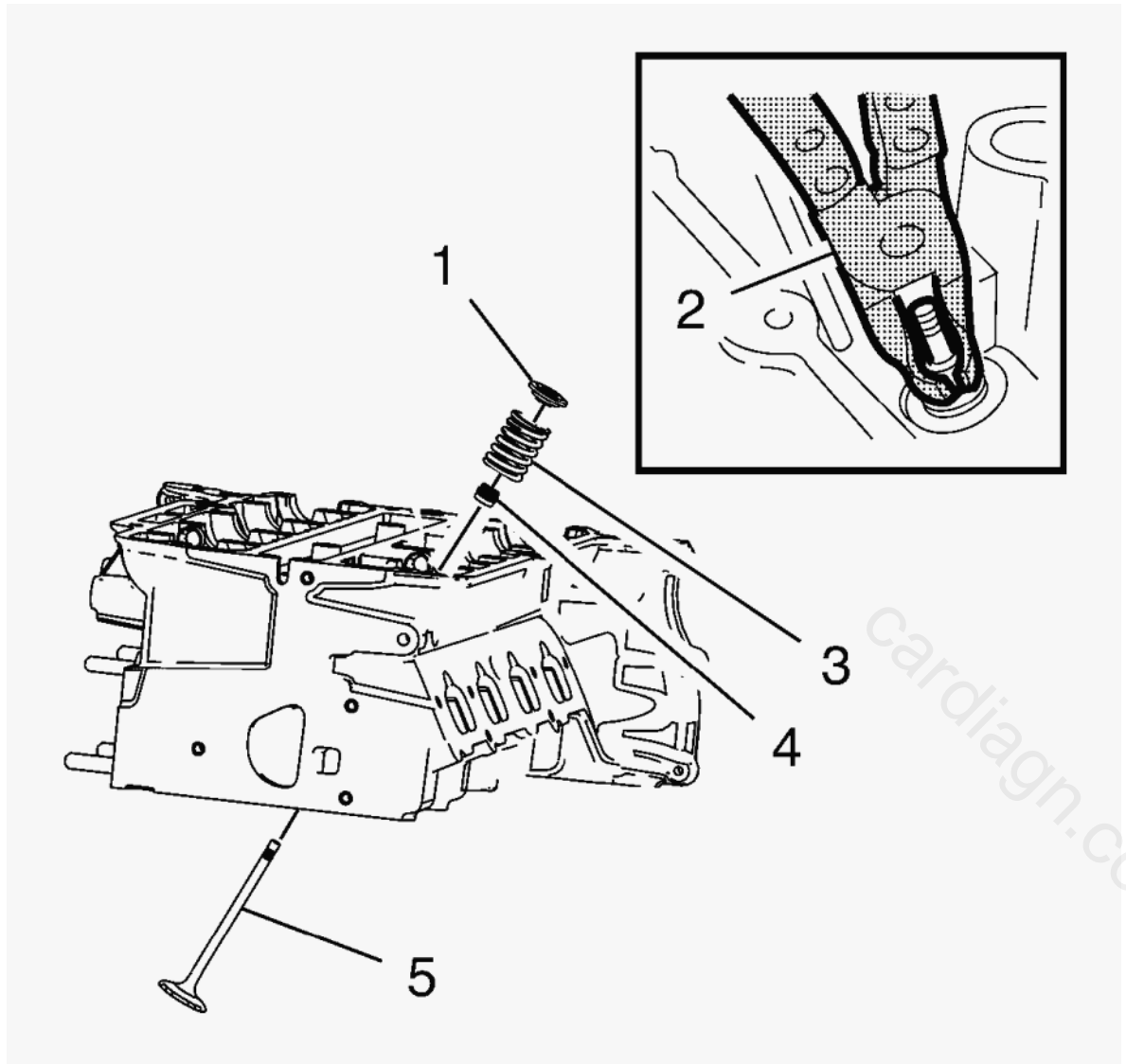


Fig. 756: Spring Compressor
Courtesy of GENERAL MOTORS COMPANY

4. Slowly and carefully loosen the EN-8062 compressor until the valve spring is entirely expanded.
5. Remove the compressor assembly from the cylinder head.
6. Remove the valve spring retainer (1) and the valve spring (3).
7. Remove and DISCARD the valve stem oil seal (4), using the EN-46116 pliers (2).
8. Remove the valve (5).

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

9. Repeat the procedure with the remaining valves.
10. In case of re-using the cylinder head, refer to [Cylinder Head Cleaning and Inspection](#).

CYLINDER HEAD CLEANING AND INSPECTION

Special Tools

GE-7872 Magnetic Base Dial Indicator

For equivalent regional tools, refer to [Special Tools](#).

Cleaning Procedure

1. Remove any old thread sealant, gasket material or sealant.
2. Clean all cylinder head surfaces with non-corrosive cleaning solvent.

WARNING: Refer to [Safety Glasses Warning](#) .

3. Blow out all the oil galleries using compressed air.
4. Remove any carbon deposits from the combustion chamber.

Visual Inspection

1. Inspect the cylinder head camshaft bearing surfaces for the following conditions:
 - Excessive scoring or pitting
 - Discoloration from overheating
 - Deformation from excessive wear
 - If the camshaft bearing journals appear to be scored or damaged, you must replace the cylinder head. DO NOT machine the camshaft bearing journals.
2. If any of the above conditions exist on the camshaft bearing surfaces, replace the cylinder head.
3. Inspect the cylinder head for the following:
 - Cracks, damage or pitting in the combustion chambers.
 - Debris in the oil galleries - Continue to clean the galleries until all debris is removed.
 - Coolant leaks or damage to the deck face sealing surface - If coolant leaks are present, measure the surface war page as described under cylinder head measurement - deck flatness inspection.
 - Damage to any gasket surfaces.
 - Burnt or eroded areas in the combustion chamber.
 - Cracks in the exhaust ports and combustion chambers.
 - External cracks in the water passages.
 - Restrictions in the intake or exhaust passages.
 - Restrictions in the cooling system passages.
 - Rusted, damaged or leaking core plugs.
4. If the cylinder head is cracked or damaged, it must be replaced. No welding or patching of the cylinder head is allowed.

Valve Inspection And Measurement

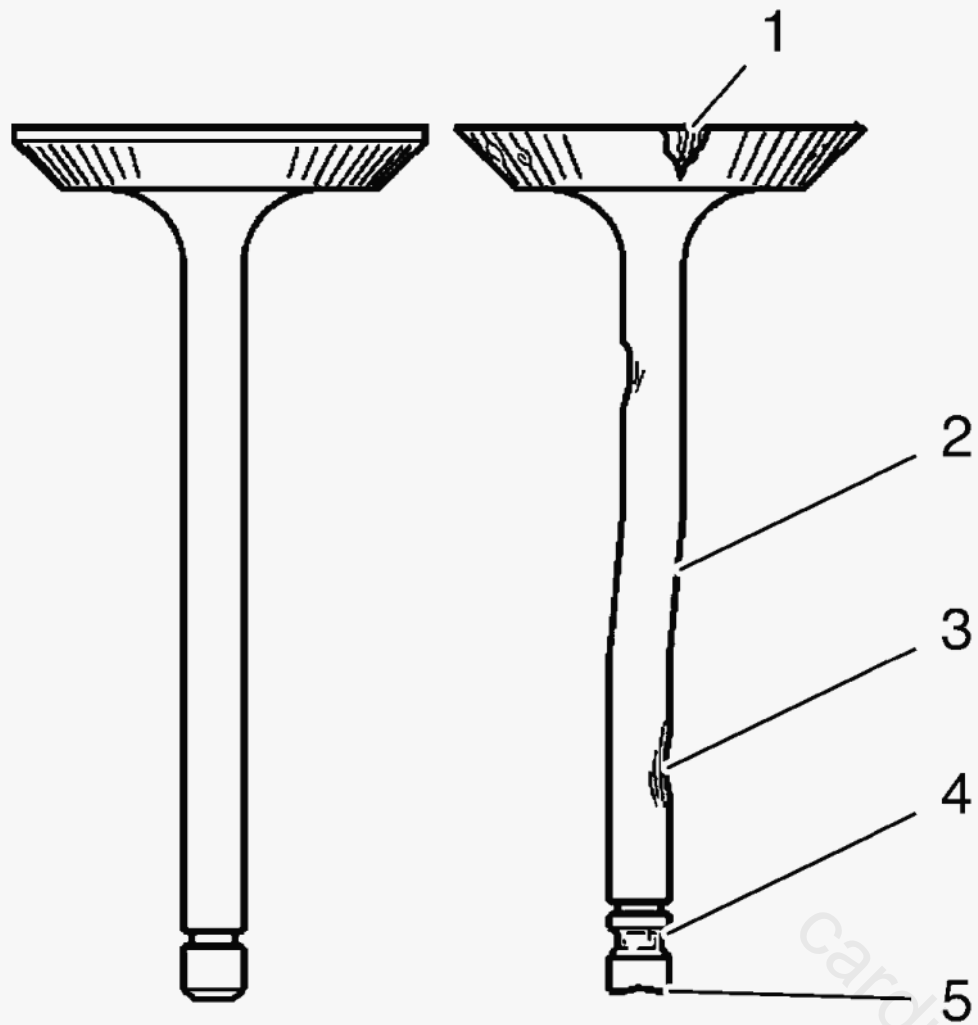


Fig. 757: Valve Inspection And Measurement
Courtesy of GENERAL MOTORS COMPANY

1. Clean the valves of carbon and oil. Carbon can be removed with a wire brush.
2. Inspect the valves for the following conditions:
 1. Inspect the valve faces for burning and cracking (1). If pieces are broken, replace the valve and inspect the corresponding piston and cylinder head area for damage.
 2. Inspect the valve for straightness and distortion (2). Distorted valve must be replaced.
 3. Inspect the valve stem for wear (3).
 4. Inspect the valve key grooves for chipping and wear (4) and (5). Replace the valve if chipped or worn.

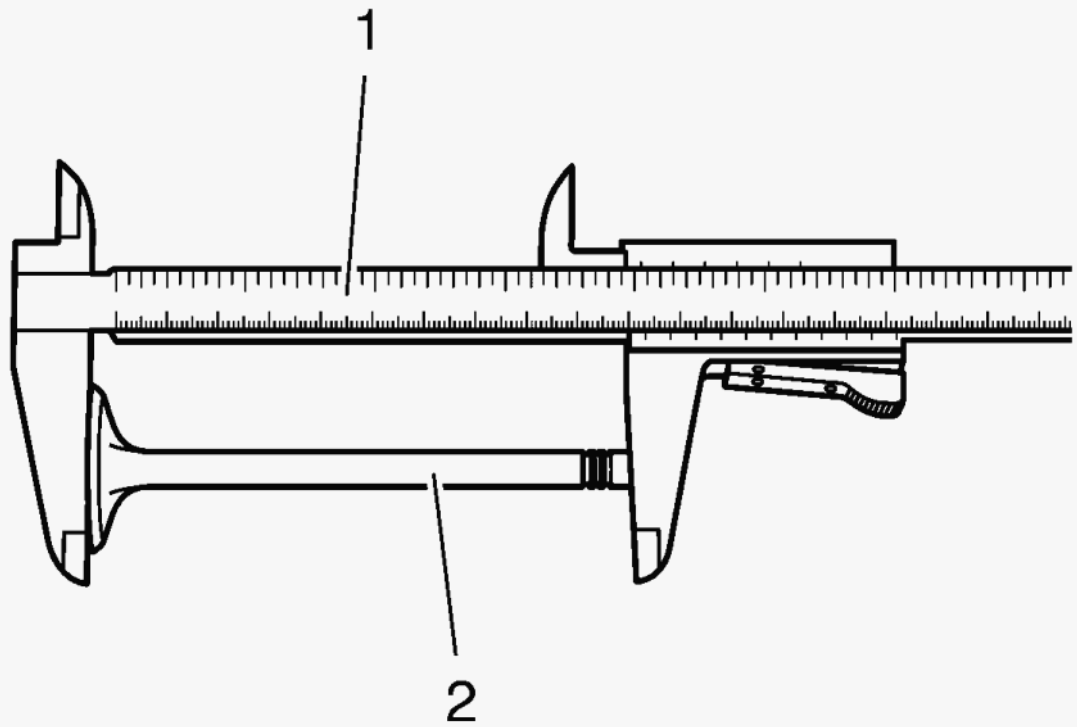


Fig. 758: Measuring Valve Length Using Slide Gauge
Courtesy of GENERAL MOTORS COMPANY

3. Measure the valve length (2). Use a slide gauge (1). Refer to [Engine Mechanical Specifications](#) to find the permitted values.

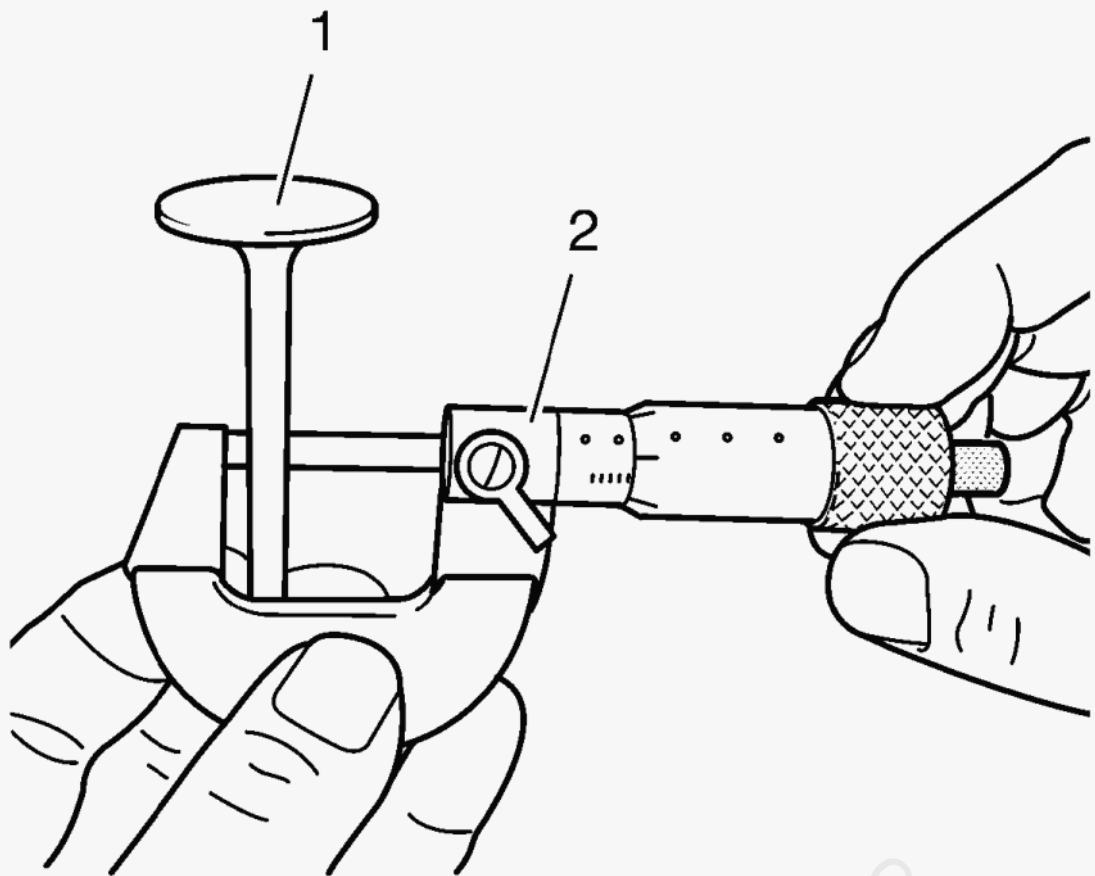


Fig. 759: Measuring Valve Stem Diameter Using Micrometer Gauge
Courtesy of GENERAL MOTORS COMPANY

4. Measure the valve stem diameter. Use a micrometer gauge (2). Refer to [Engine Mechanical Specifications](#) to find the permitted values. Note the measurement results.

Cylinder Head Measurement

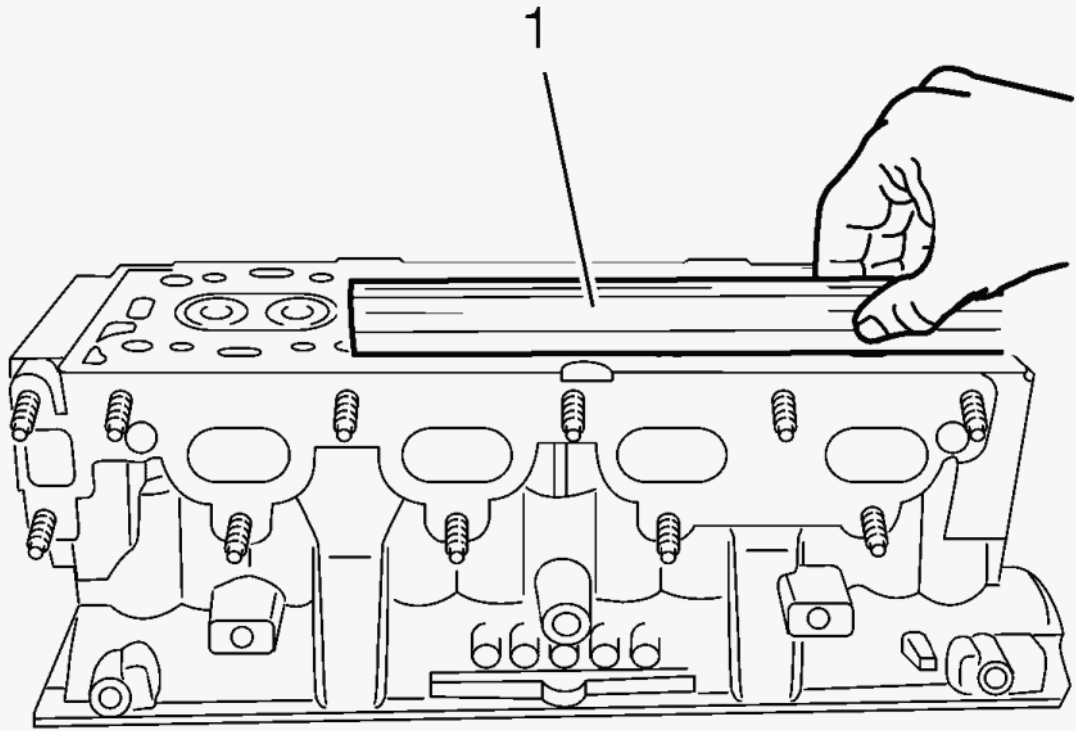


Fig. 760: Using Straightedge To Inspect Cylinder Head Sealing Surface For Flatness
Courtesy of GENERAL MOTORS COMPANY

1. Inspect the cylinder head sealing surface for flatness. Use a straightedge (1).
2. Turn the cylinder head upside down.

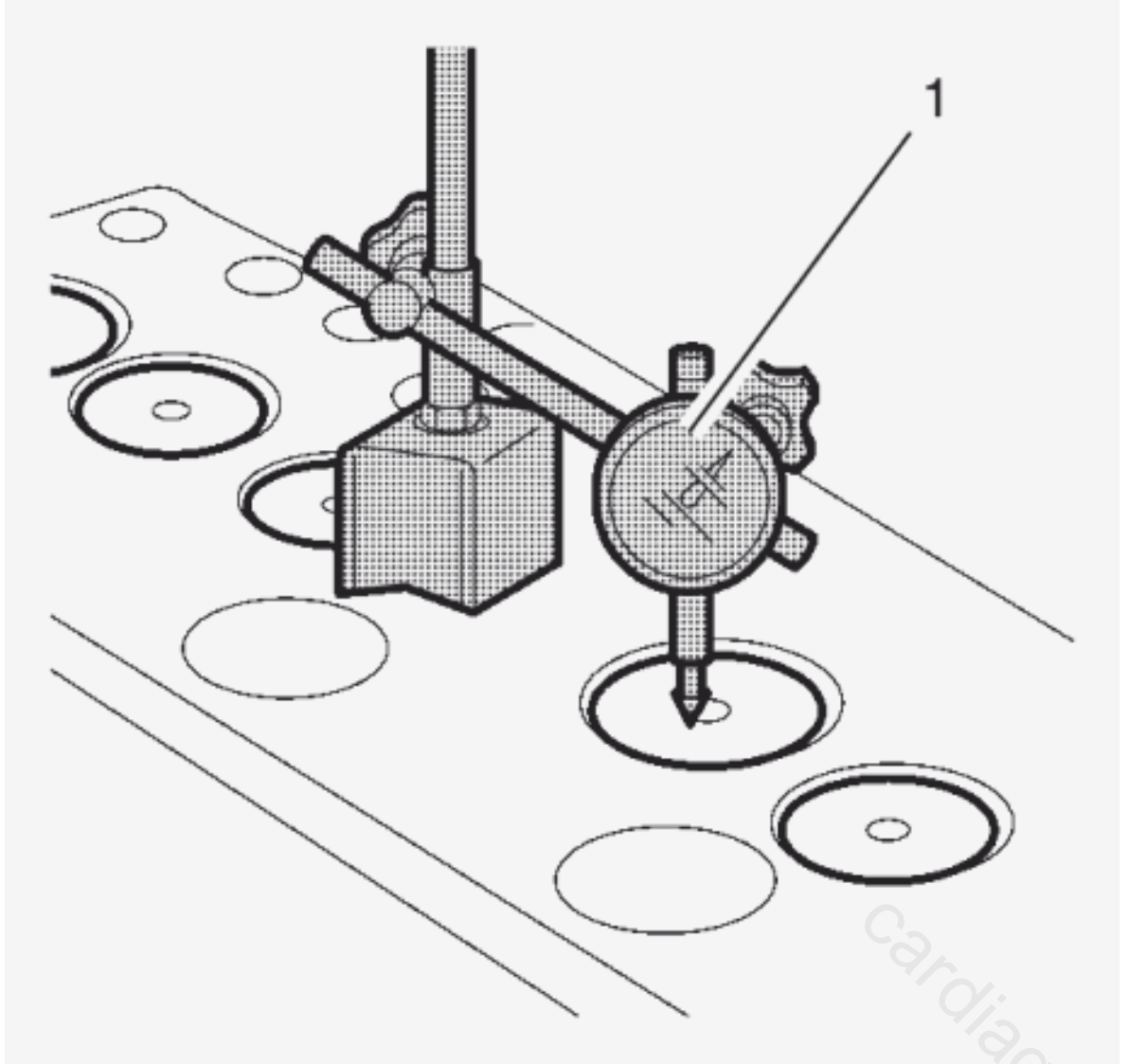


Fig. 761: Using Dial Indicator To Measure Valve Assembly Height
Courtesy of GENERAL MOTORS COMPANY

3. Loosely install one valve to the cylinder head.
4. Place the **GE-7872** indicator (1) to the cylinder head sealing surface and measure the valve assembly height. Refer to [Engine Mechanical Specifications](#) to find the permitted values.

CYLINDER HEAD ASSEMBLE

Special Tools

- **EN-958** Valve Stem Seal Installer
- **EN-8062** Valve Spring Compressor
- **EN-8062-5** Adapter
- **EN-43963** Adapter

For equivalent regional tools, refer to [Special Tools](#).

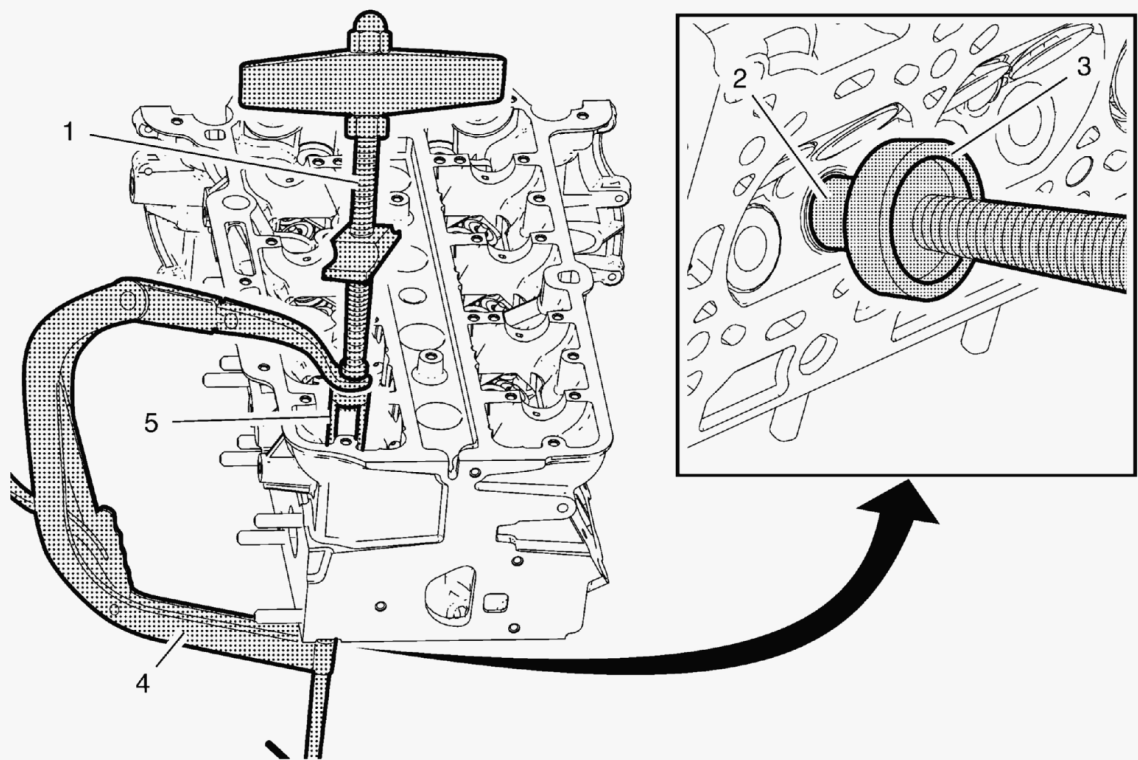
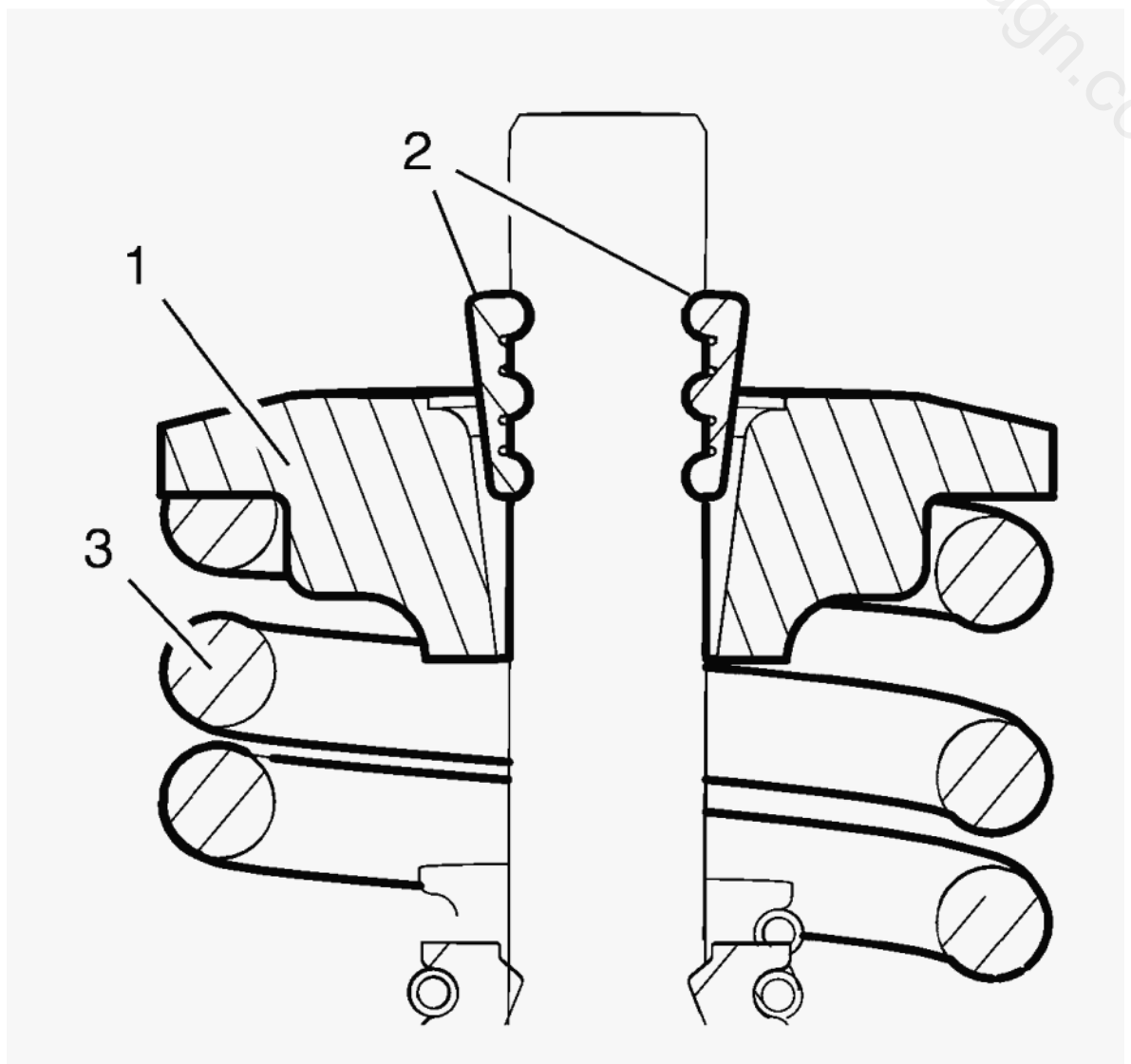


Fig. 763: Valve Spring Compressor And Adapter Assembly.

Courtesy of GENERAL MOTORS COMPANY

5. Install the **EN-8062-5** adapter (3) to the **EN-8062** compressor (4).
6. Install the compressor assembly to the cylinder head, so that the **EN-43963** adapter (5) of the **EN-8062** compressor (1) contacts the valve spring retainer properly and the **EN-8062-5** adapter (3) contacts the valve disc (2). Prefix the **EN-8062** compressor (4).



CAUTION: The valve stem keys must correctly seat in the valve spring cap. Engine damage may occur by not installing properly.

7. Apply pressure to the **EN-8062** compressor to push down the valve spring retainer (1) and compress the valve spring (3) until the valve keys (2) can be inserted. Carefully insert the valve keys then, so that they are properly installed to the valve stem grooves.
8. Carefully release the tension from the **EN-8062** compressor.
9. Inspect the valve keys and valve spring retainers for proper seat.
10. Remove the compressor assembly from the cylinder head.
11. Repeat the procedure with the remaining valves.

ENGINE BLOCK DISASSEMBLE

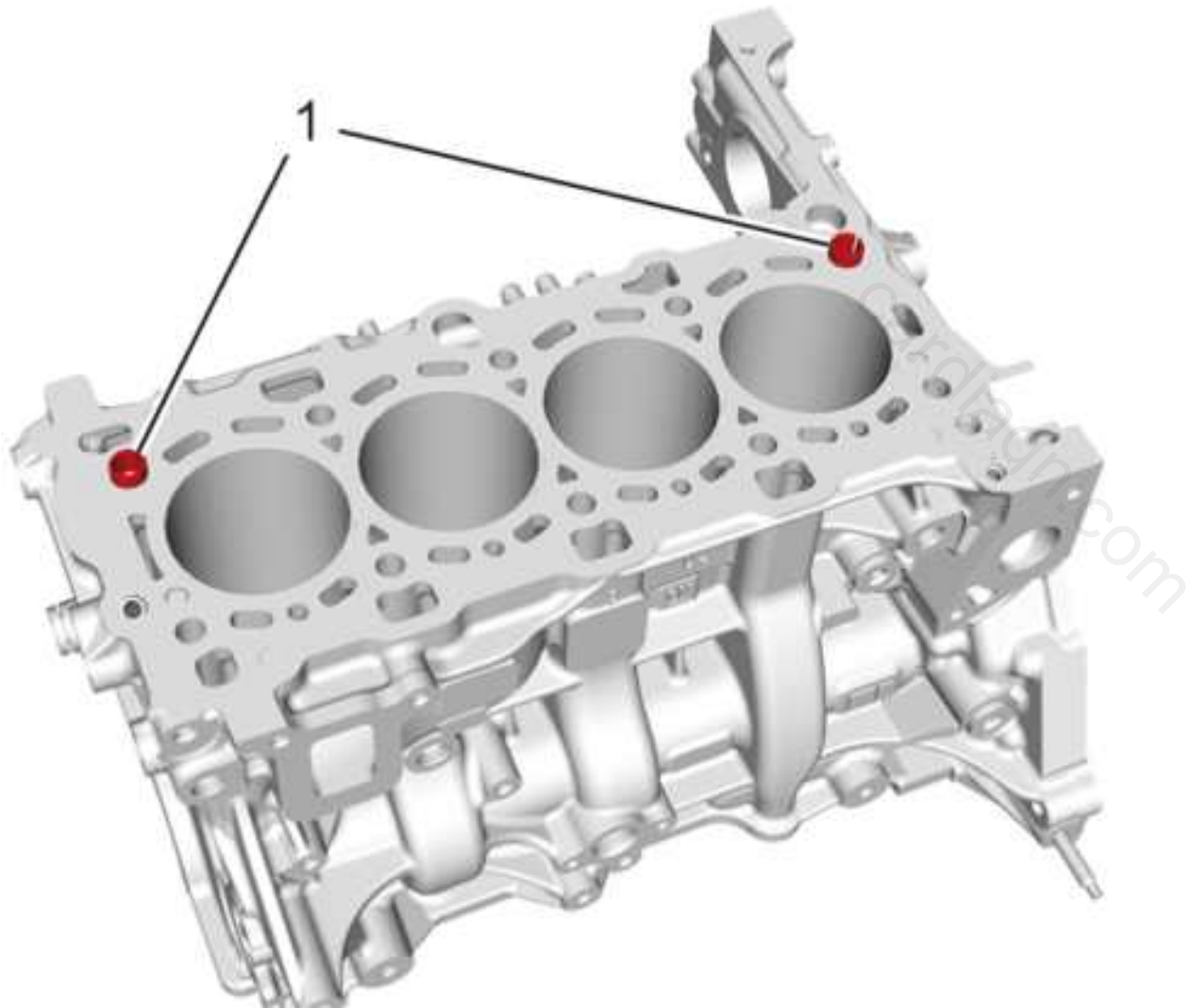


Fig. 765: Cylinder Head Guide Sleeves
Courtesy of GENERAL MOTORS COMPANY

1. Remove the 2 cylinder head guide sleeves (1).

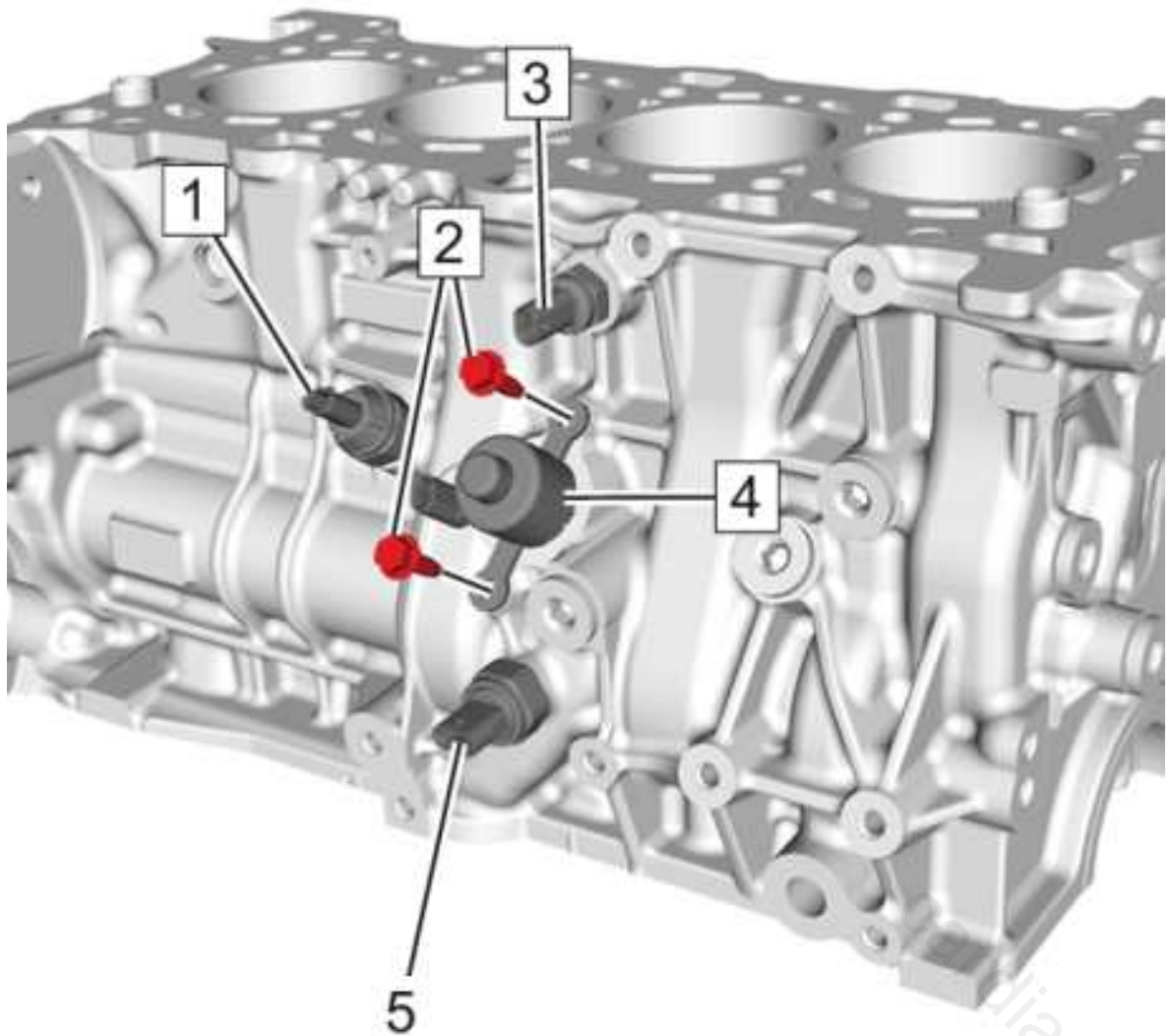


Fig. 766: Engine Oil Pressure Switch, Engine Oil Pressure Sensor, Engine Coolant Temperature Sensor, Piston Oil Nozzle Oil Control Solenoid Valve And Bolts

Courtesy of GENERAL MOTORS COMPANY

2. Remove Engine Oil Pressure Switch (1)
3. Remove Engine Coolant Temperature Sensor (3)
4. Remove the 2 piston oil nozzle oil control solenoid valve bolts (2).
5. Remove the piston oil nozzle oil control solenoid valve (4).
6. Remove Engine Oil Pressure Sensor (5)

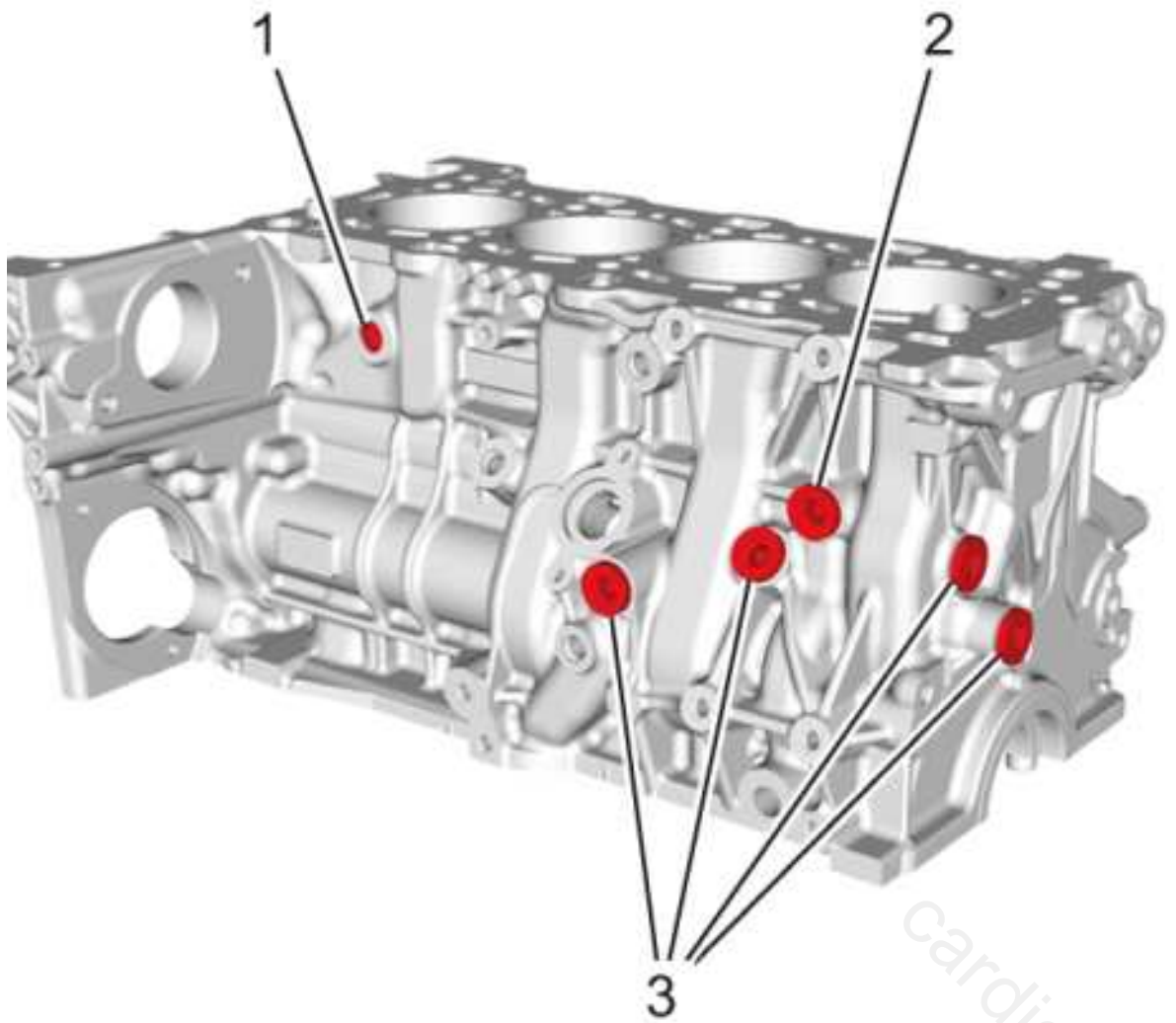


Fig. 767: Engine Block Plugs

Courtesy of GENERAL MOTORS COMPANY

7. Remove and DISCARD Engine Block Core Hole Plug (1)
8. Remove Engine Block Coolant Drain Hole Plug (2)
9. Remove Engine Block Oil Gallery Plugs (3) (Qty: 4)

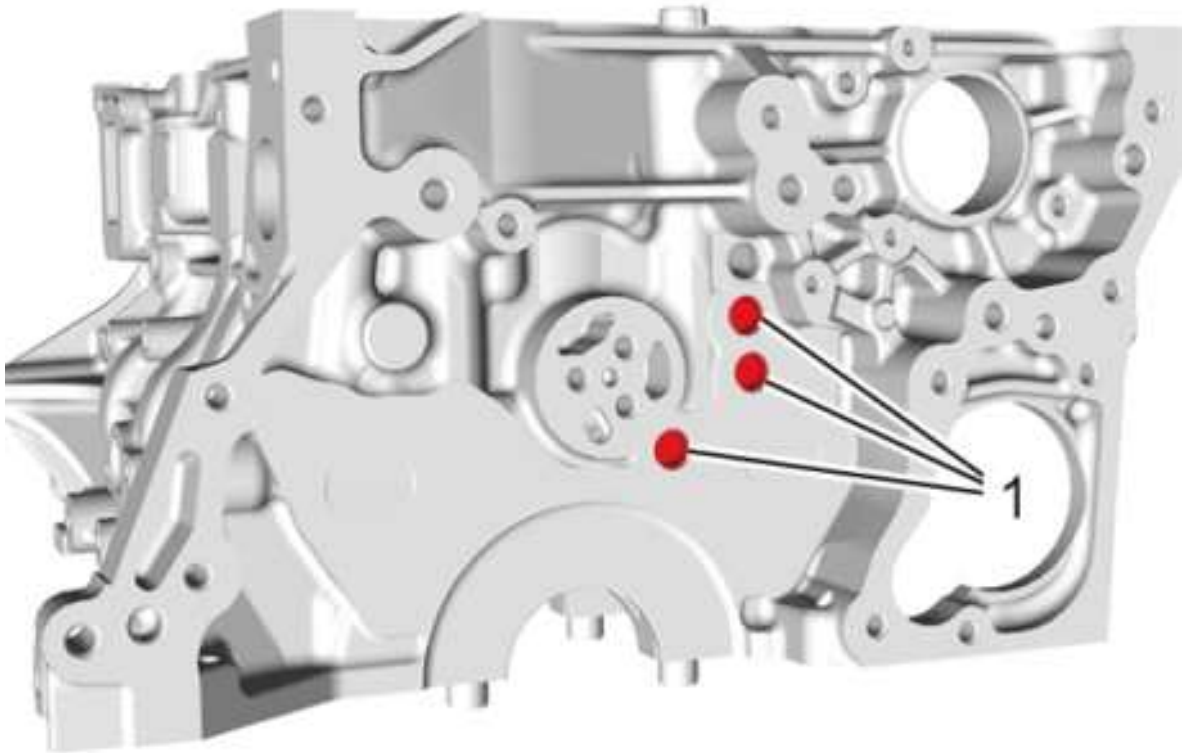


Fig. 768: Engine Block Core Hole Plugs

Courtesy of GENERAL MOTORS COMPANY

10. Remove and DISCARD Engine Block Core Hole Plugs (1) (Qty: 3)

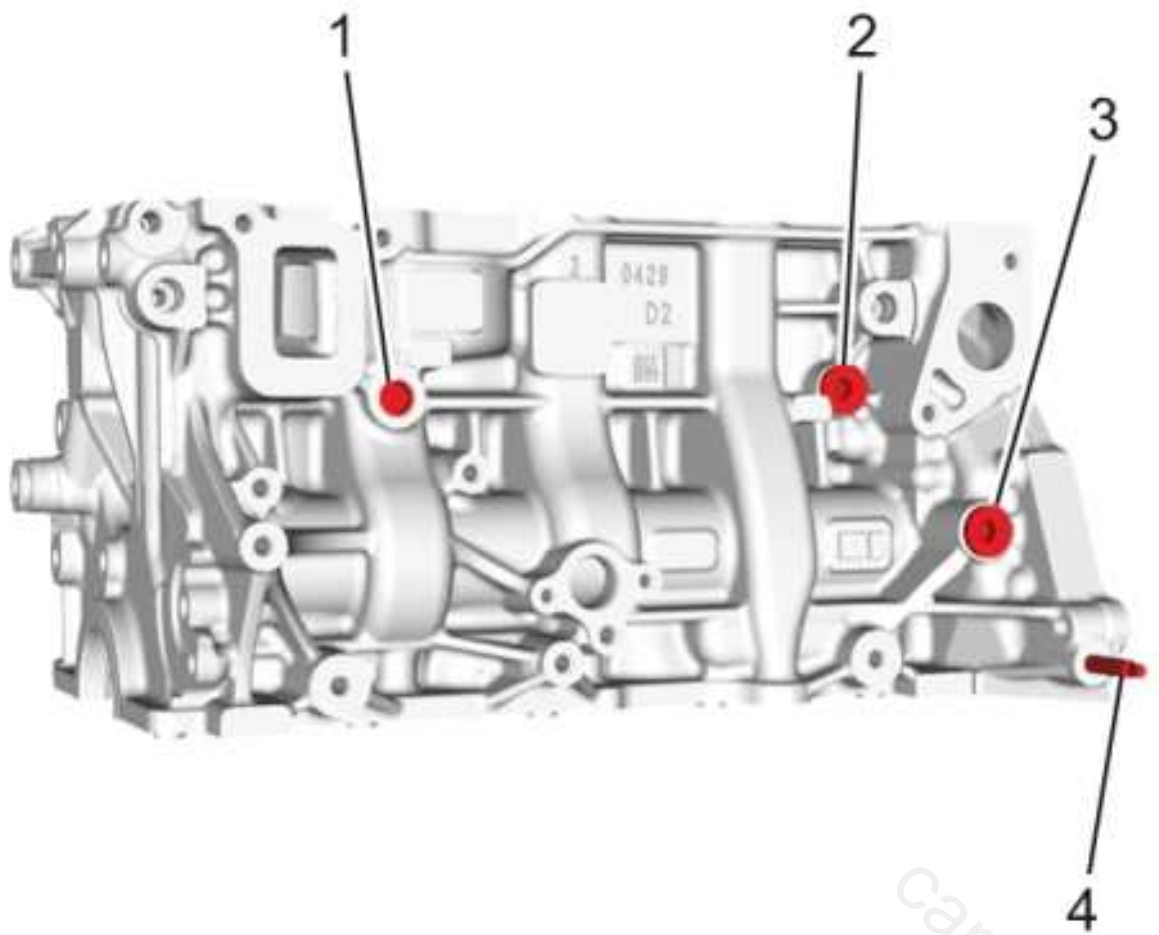


Fig. 769: Catalytic Converter Stud And Engine Block Plugs
Courtesy of GENERAL MOTORS COMPANY

11. Remove Catalytic Converter Stud (4)
12. Remove and DISCARD Engine Block Core Hole Plug (1)
13. Remove Engine Block Coolant Drain Hole Plug (2)
14. Remove Engine Block Oil Gallery Plug (3)

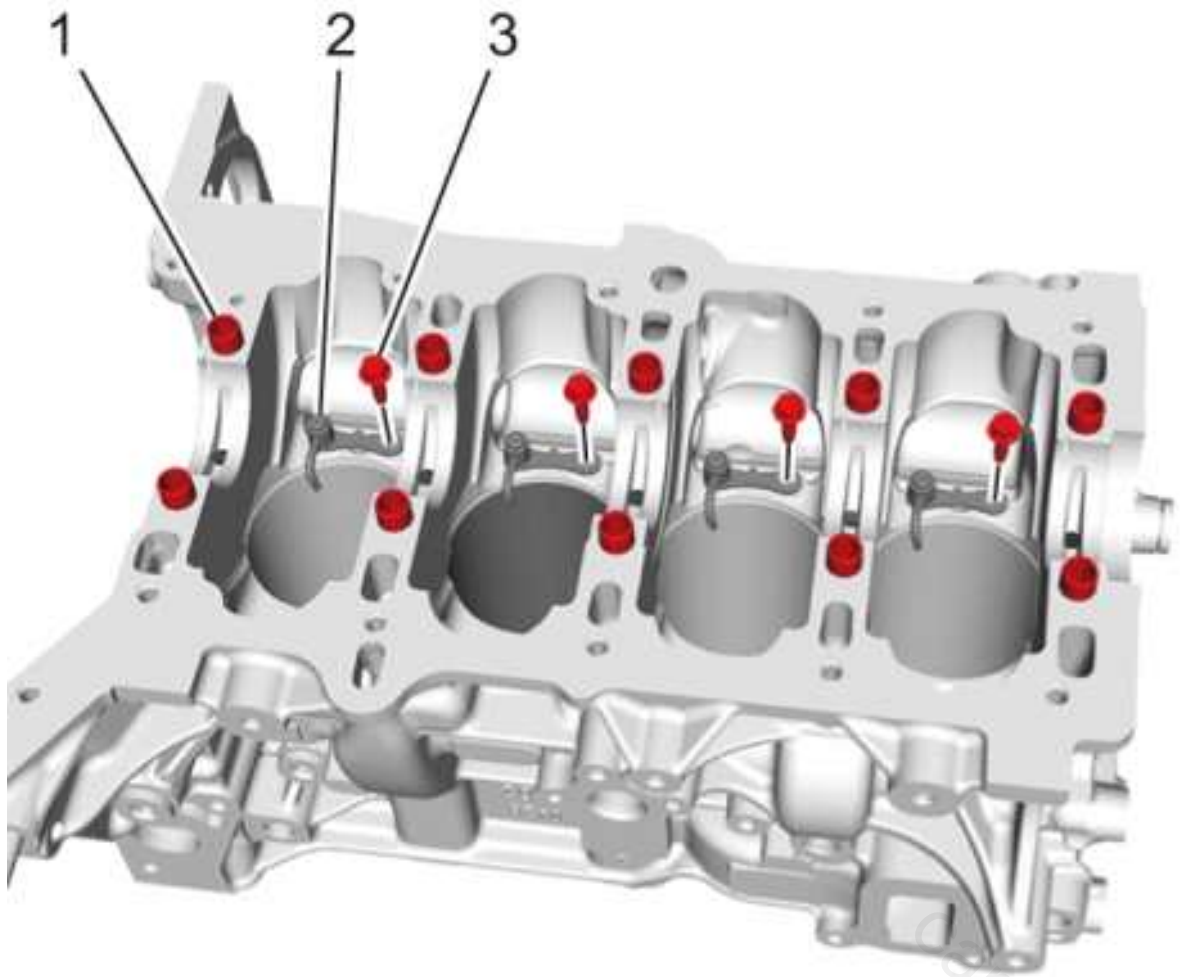


Fig. 770: Piston Oil Nozzles, Bolts And Lower Crankcase Guide Sleeves
Courtesy of GENERAL MOTORS COMPANY

15. Remove Piston Oil Nozzle Bolts (3) (Qty: 4)
16. Piston Oil Nozzles (2) (Qty: 4)
17. Remove the 10 lower crankcase guide sleeves (1).

ENGINE BLOCK CLEANING AND INSPECTION

Special Tools

- **EN-8087** Gauge
- **EN-45059** Angle Meter

For equivalent regional tools, refer to [Special Tools](#).

Cleaning Procedure

1. Remove any old thread sealant, gasket material or sealant.
2. Clean all the following areas with solvent:
 - Sealing surfaces
 - Cooling passages
 - Oil passages
 - Bearing journals
3. Clean all threaded and through holes with solvent.

WARNING: Refer to [Safety Glasses and Compressed Air Warning](#) .

4. Dry the engine block with compressed air.

Visual Inspection

1. Inspect the crankshaft bearings journals for damage or spun bearings. The crankshaft bearing journals are not repairable, if the crankshaft bearing journals are damaged the engine block assembly must be replaced.
2. Inspect all sealing and mating surfaces for damage, repair or replace the engine block assembly if necessary.
3. Inspect all threaded and through holes for damage or excessive debris.
4. Inspect all bolts for damage, if damaged replace with NEW bolts only.
5. Inspect the cylinder walls for cracks or damage. The cylinder sleeves are not serviced separately, if the cylinders are damaged the cylinder block assembly must be replaced.
6. Inspect the engine block for cracks. Do not repair any cracks. If cracks are found, the cylinder block assembly must be replaced.

Measuring Procedure

Engine Block Flatness Inspection

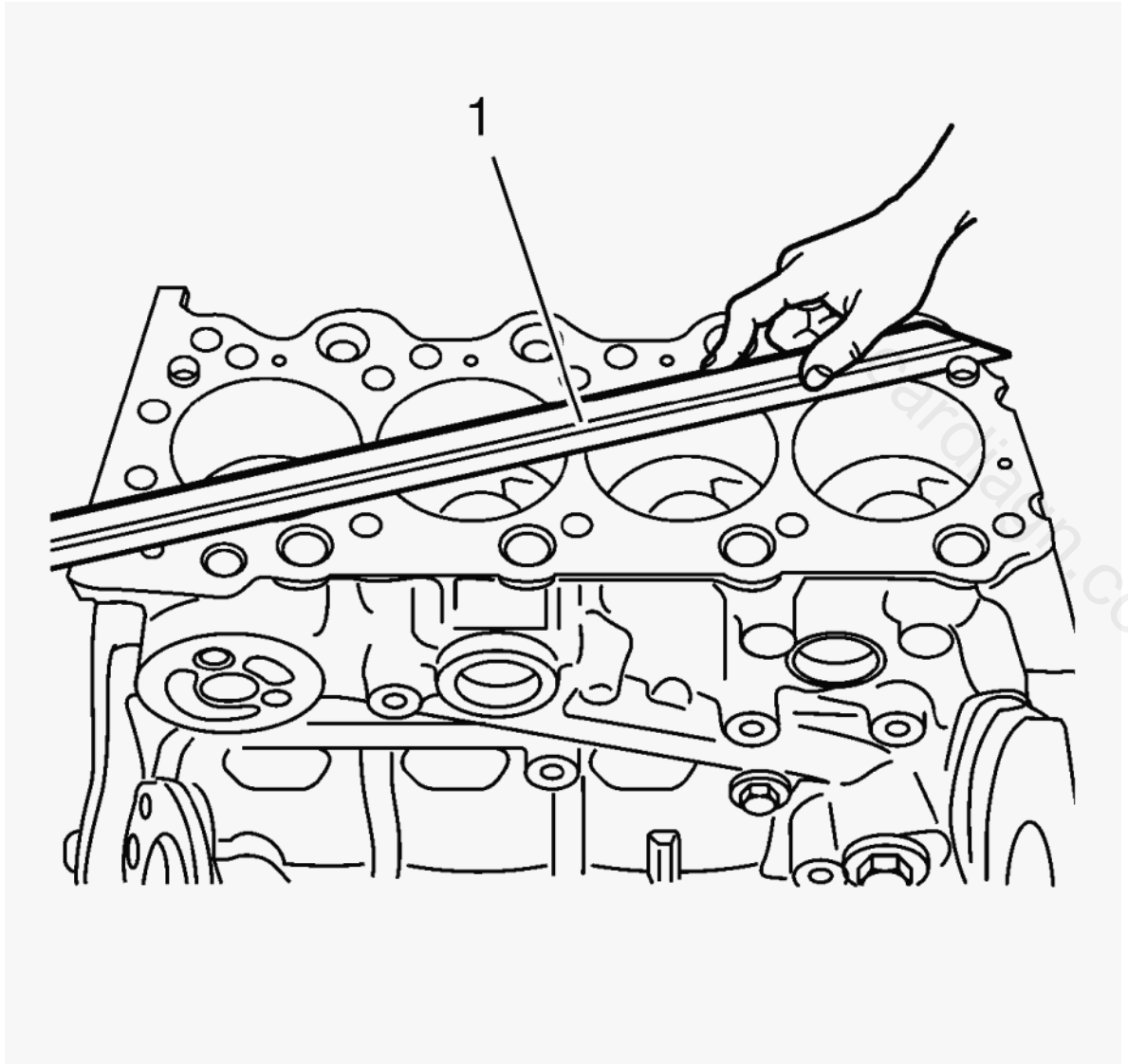


Fig. 771: Inspecting Engine Block For Distortion Using Straight Edge
Courtesy of GENERAL MOTORS COMPANY

1. Inspect the engine block as shown for distortion. Use a straightedge (1).

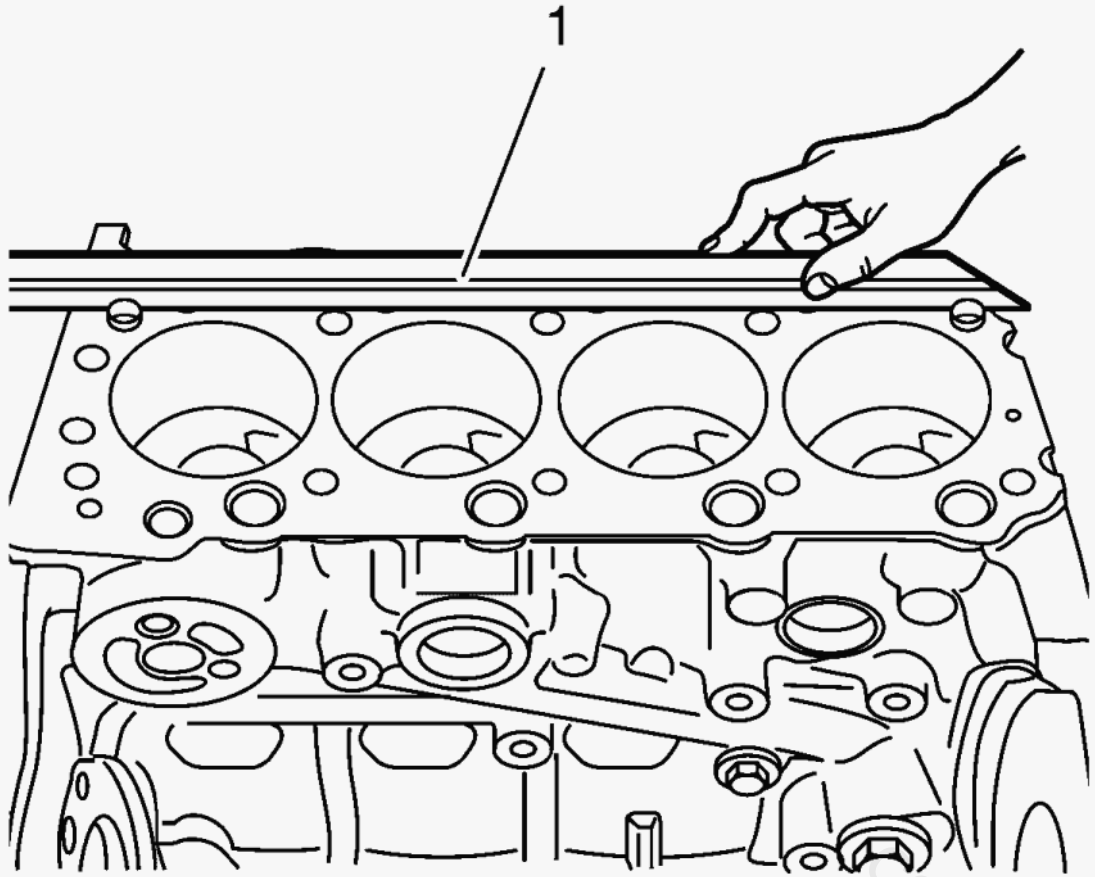


Fig. 772: Inspecting Engine Block For Deflection Using Straight Edge
Courtesy of GENERAL MOTORS COMPANY

2. Inspect the engine block as shown for deflection. Use a straightedge (1).

Cylinder Sleeve Diameter Inspection

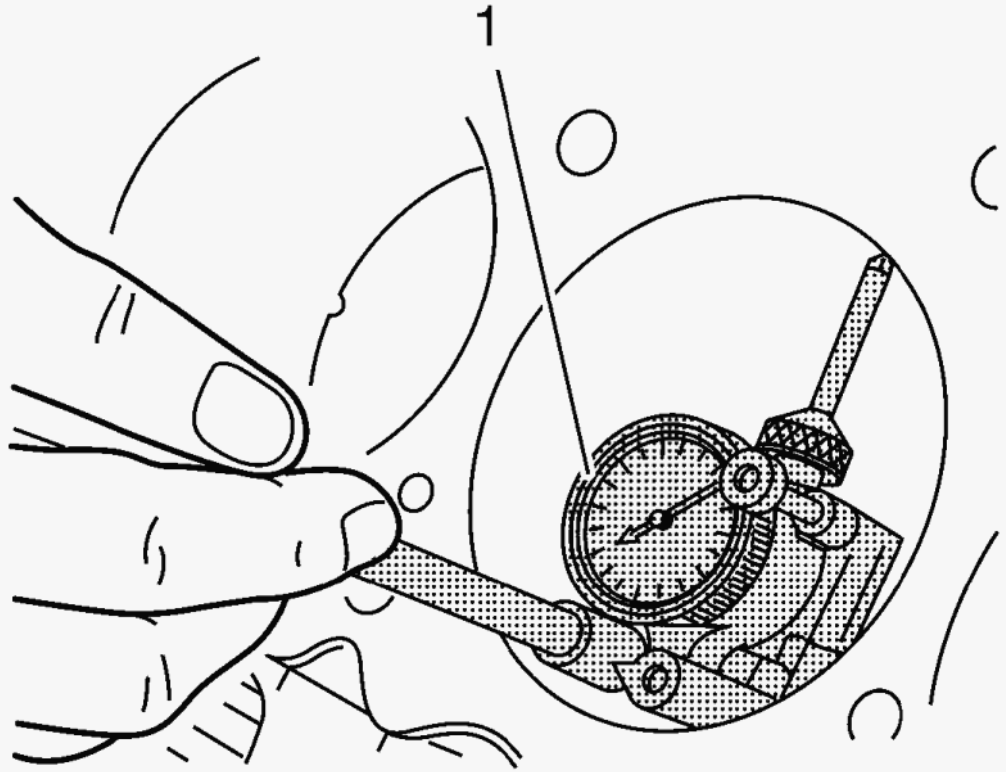


Fig. 773: Inspecting Cylinder Bore

Courtesy of GENERAL MOTORS COMPANY

NOTE: If the cylinder sleeve measurements are not within the recommended limits, ream the cylinder bores with the recommended oversize. Refer to [Engine Mechanical Specifications](#).

1. Inspect the cylinder bores using the EN-8087 gauge (1). Inspect for the following items:

- Wear of cylinder sleeve
- Cylinder sleeve diameter
- Tapering of cylinder sleeve
- Oval status of cylinder sleeve

Refer to [Engine Mechanical Specifications](#) for the recommended limits.

Bearing Bore Diameter In Cylinder Block Inspection

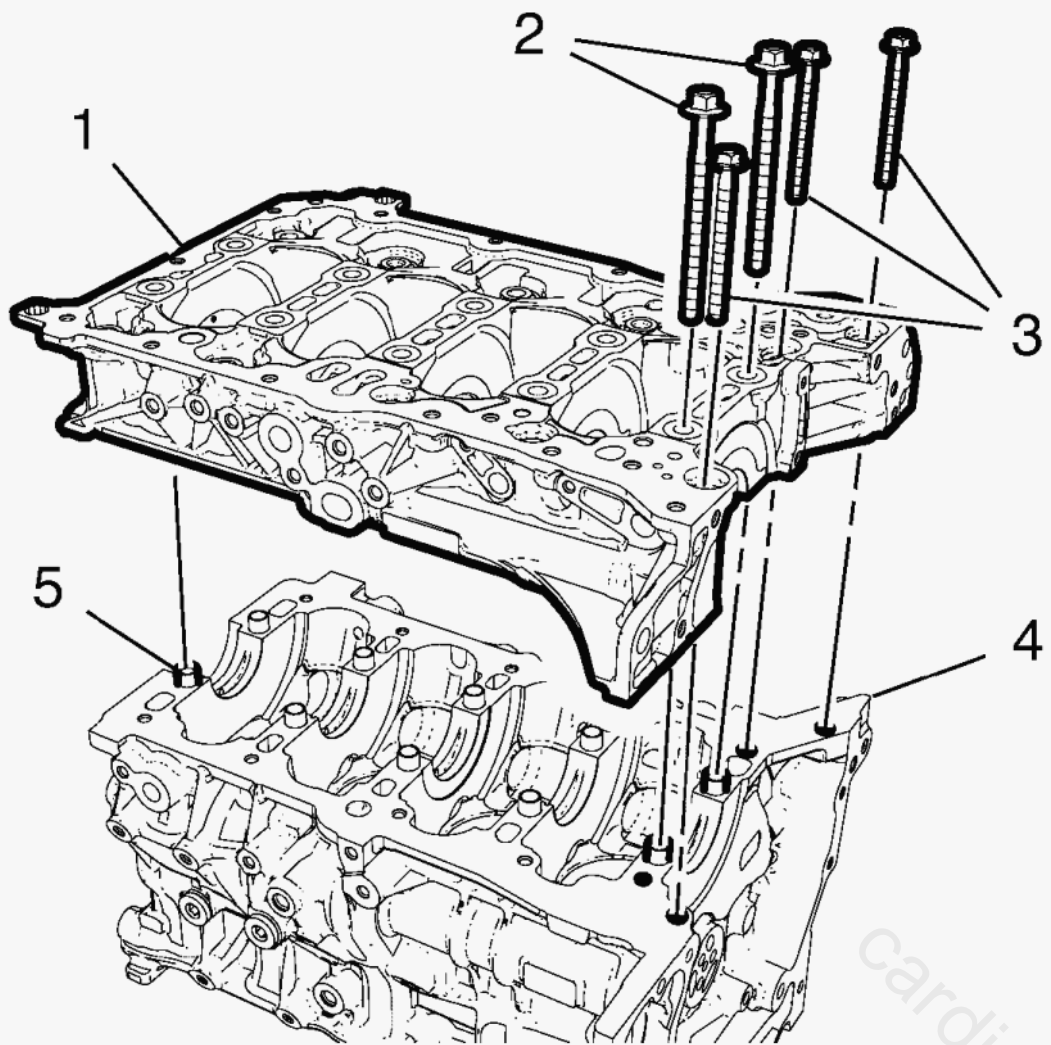


Fig. 774: Crankshaft, Lower Crankcase, Locating Pins And Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Install the 10 lower crankcase locating pin, if they was removed.
2. Install the crankshaft to the engine block (4).
3. Install the lower crankcase (1).
4. Loosely install the 10 main bearing bolts M10 (2).
5. Loosely install the 11 lower crankcase bolts M8 (3).

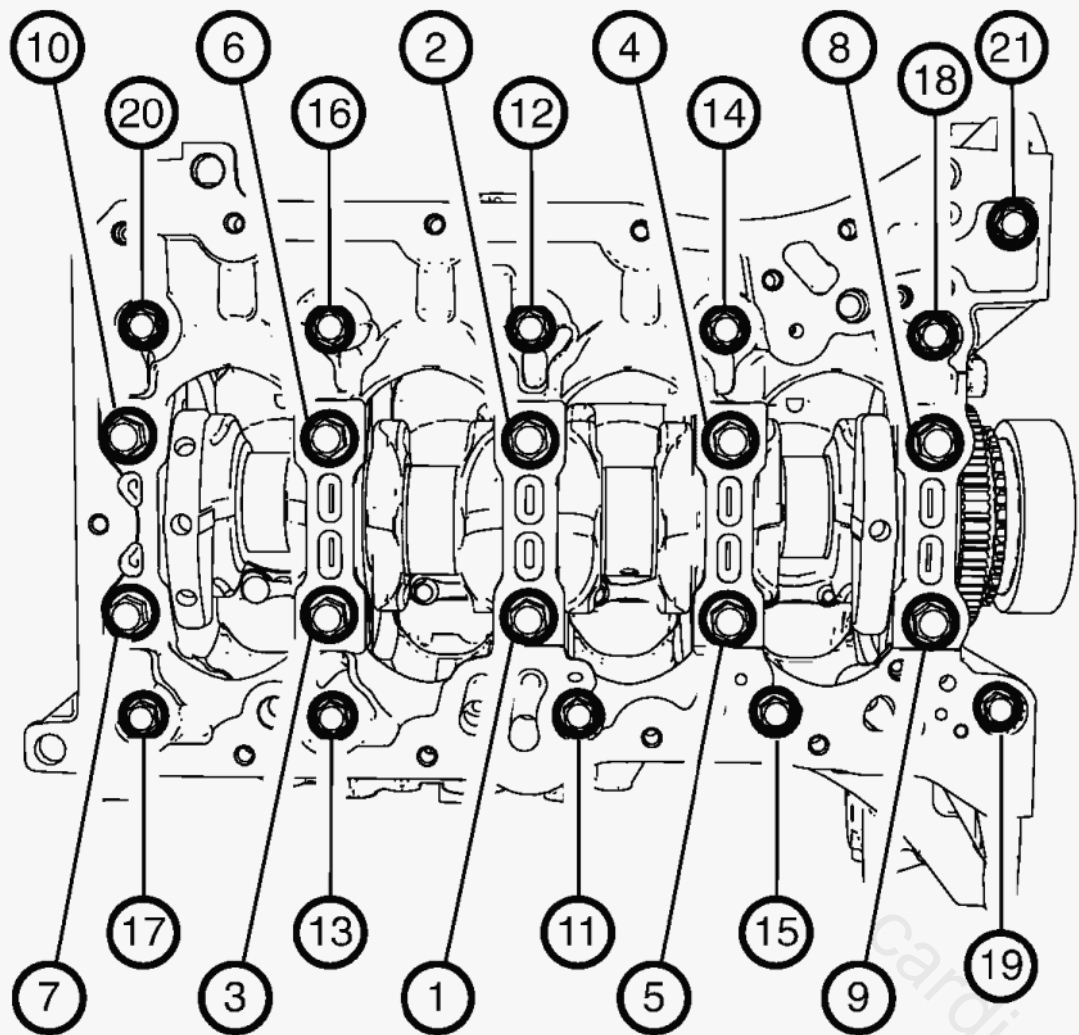


Fig. 775: Main Bearing And Lower Crankcase Bolt Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to [Fastener Caution](#) .

CAUTION: Refer to [Torque-to-Yield Fastener Caution](#) .

6. Tighten the 10 main bearing bolts.
 1. Tighten the bolts (1-10) a first pass in sequence shown to 50 N.m (37 lb ft).
 2. Tighten the bolts (1-10) a second pass in sequence shown an additional to 90 degrees, using the **EN-45059** meter.
 3. Tighten the bolts (1-10) a final pass in sequence shown an additional to 90 degrees, using the **EN-45059** meter.
7. Tighten the 11 lower crankcase bolts (11-21) in sequence shown to 34 N.m (25 lb ft).

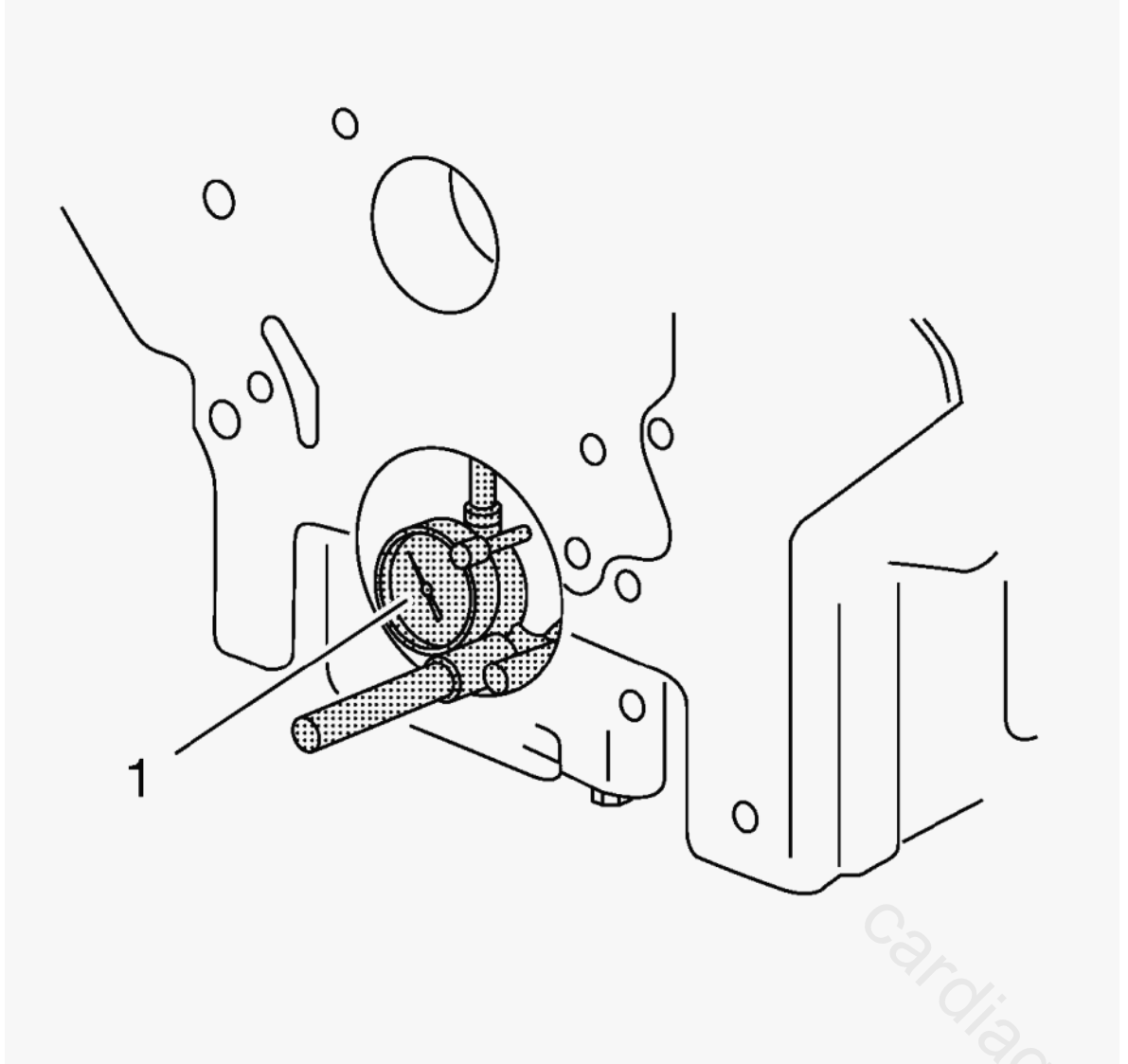


Fig. 776: Measuring Bearing Bore Concentricity And Alignment Using Gauge Tool
Courtesy of GENERAL MOTORS COMPANY

8. Inspect the bearing bore diameter in cylinder block using the **EN-8087** gauge (1). Refer to **Engine Mechanical Specifications** for the recommended limits.

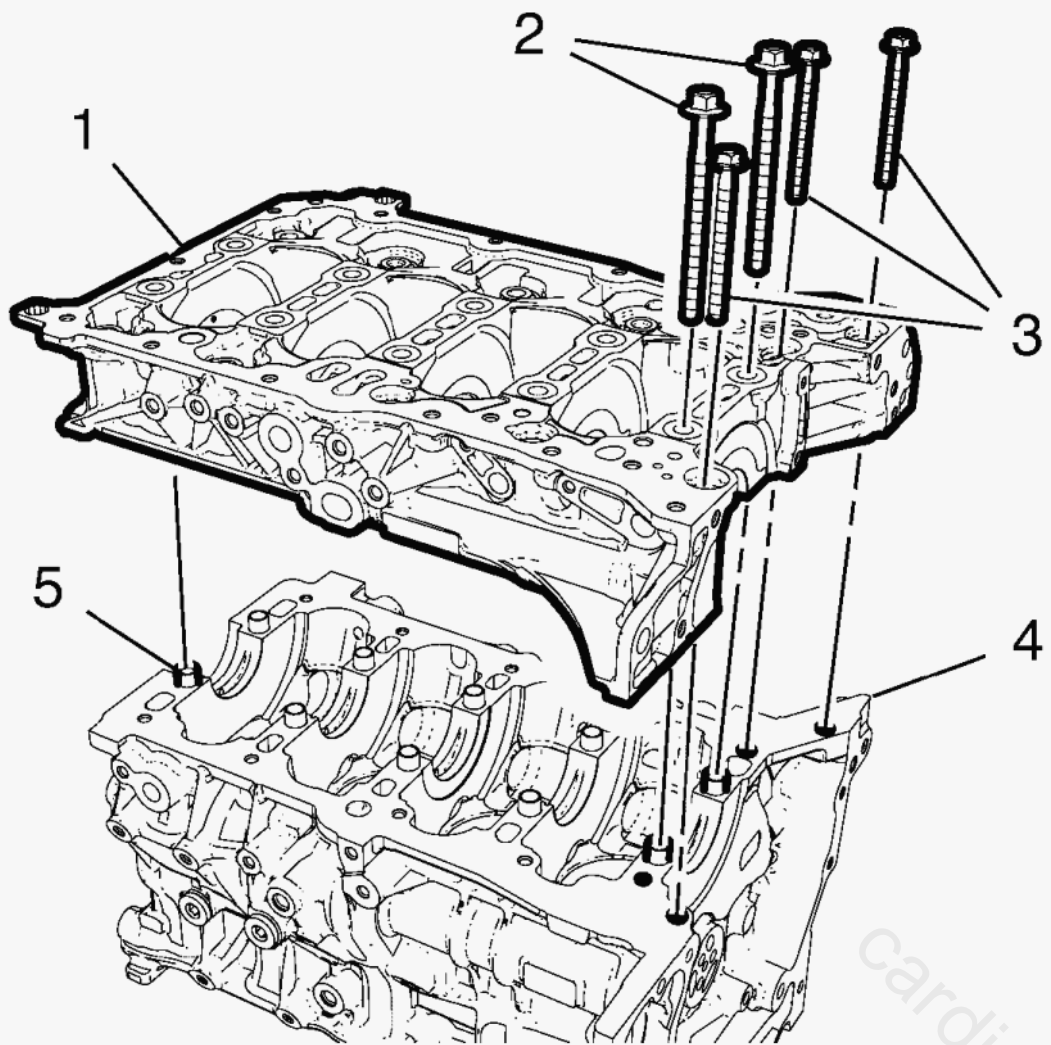


Fig. 777: Crankshaft, Lower Crankcase, Locating Pins And Bolts
Courtesy of GENERAL MOTORS COMPANY

9. Remove the 11 lower crankcase bolts (3).
10. Remove the 10 main bearing bolts (2).
11. Remove the lower crankcase (1) from the engine block (4).
12. Remove the 10 lower crankcase locating pin (5), if they was removed.

ENGINE BLOCK ASSEMBLE

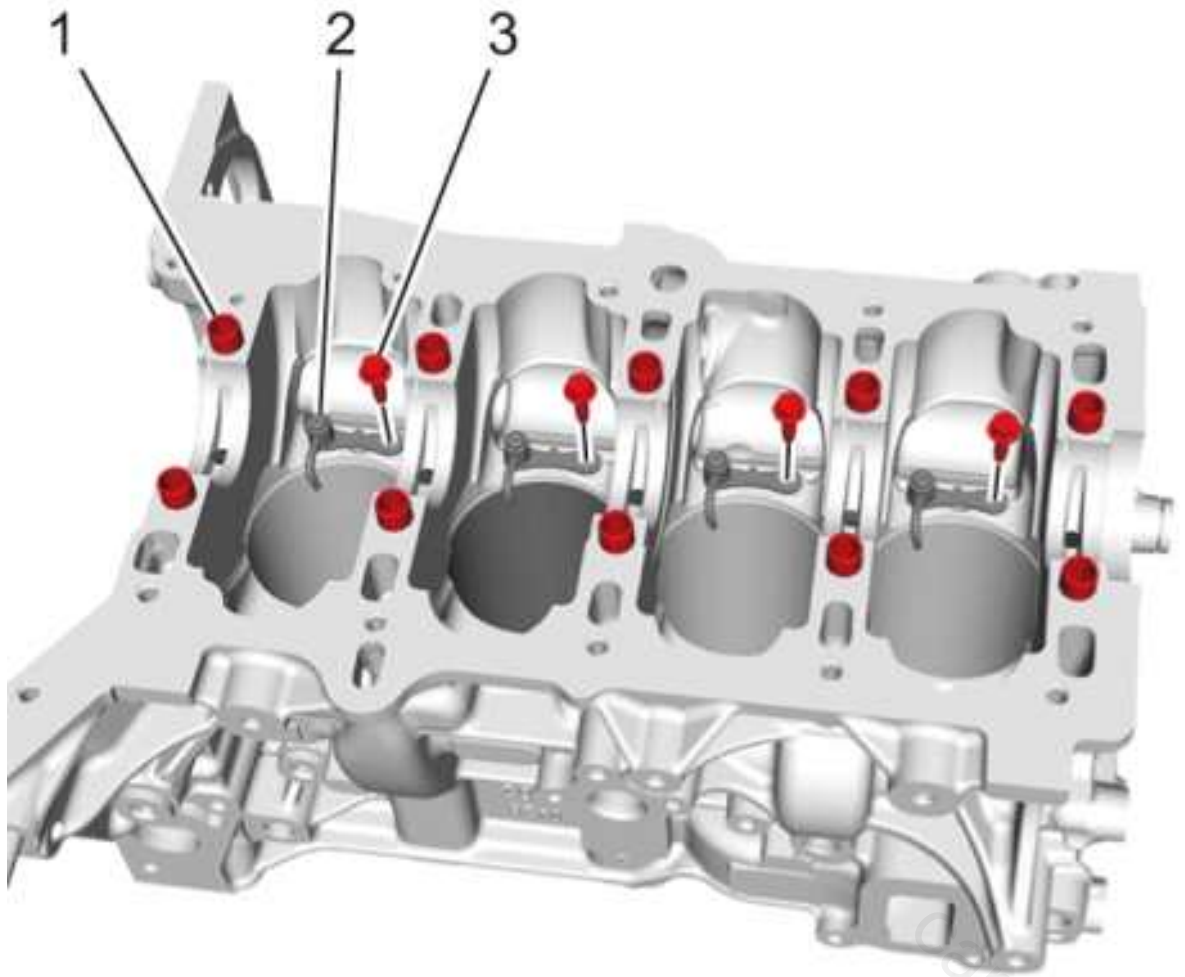


Fig. 778: Piston Oil Nozzles, Bolts And Lower Crankcase Guide Sleeves
Courtesy of GENERAL MOTORS COMPANY

1. Install the 10 lower crankcase guide sleeves (1).

CAUTION: Refer to [Fastener Caution](#)

2. Install Piston Oil Nozzles (2) (Qty: 4)
3. Install and tighten Piston Oil Nozzle Bolts (3) (Qty: 4) to 10 N.m (89 lb in)

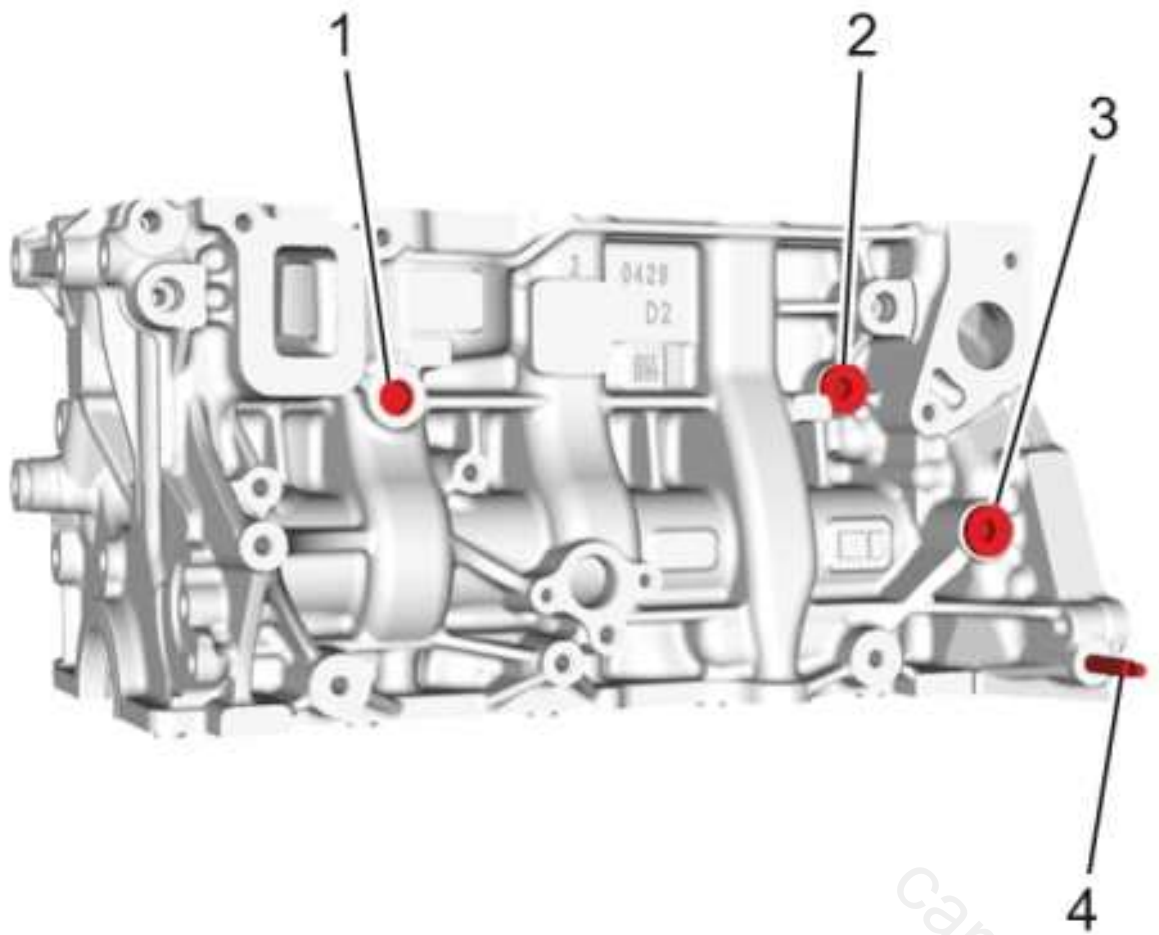


Fig. 779: Catalytic Converter Stud And Engine Block Plugs
Courtesy of GENERAL MOTORS COMPANY

4. Install and tighten Engine Block Coolant Drain Hole Plug (2) to 65 N.m (48 lb ft)
5. Install and tighten Engine Block Oil Gallery Plug (3) to 65 N.m (48 lb ft)
6. Install NEW Engine Block Core Hole Plug (1)
7. Install and tighten Catalytic Converter Stud (4) to 9 N.m (80 lb in)

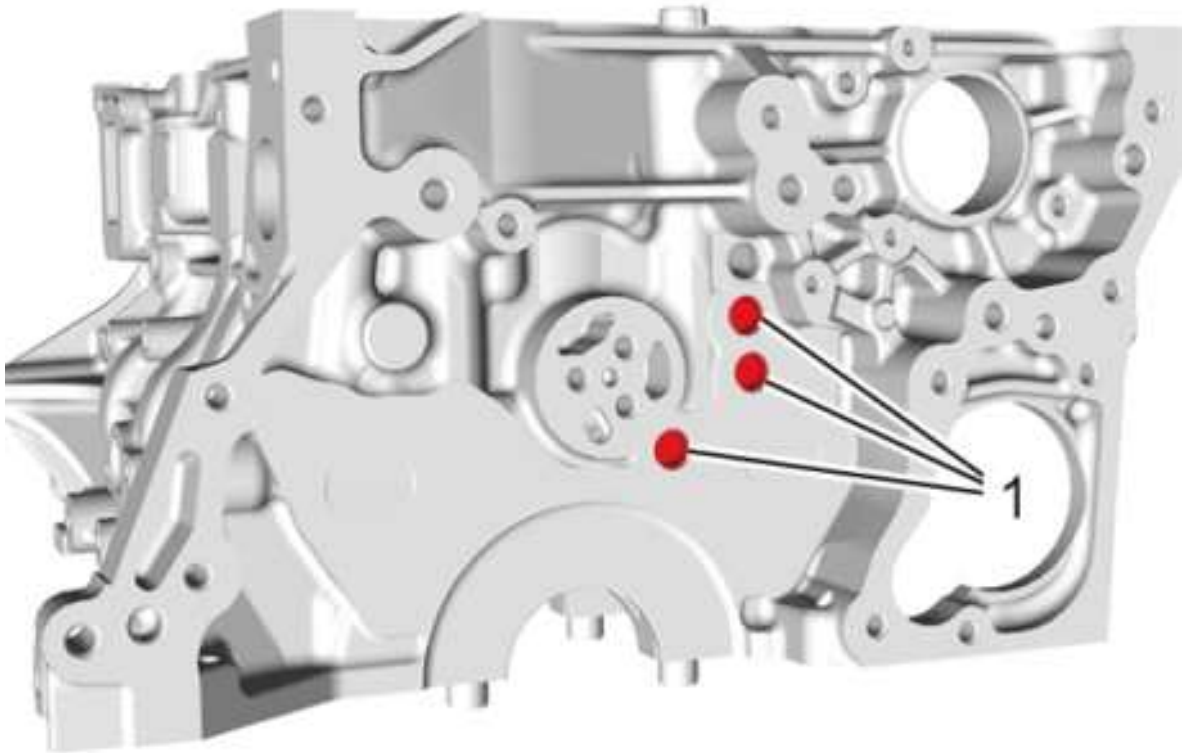


Fig. 780: Engine Block Core Hole Plugs

Courtesy of GENERAL MOTORS COMPANY

8. Install NEW Engine Block Core Hole Plugs (1) (Qty: 3)

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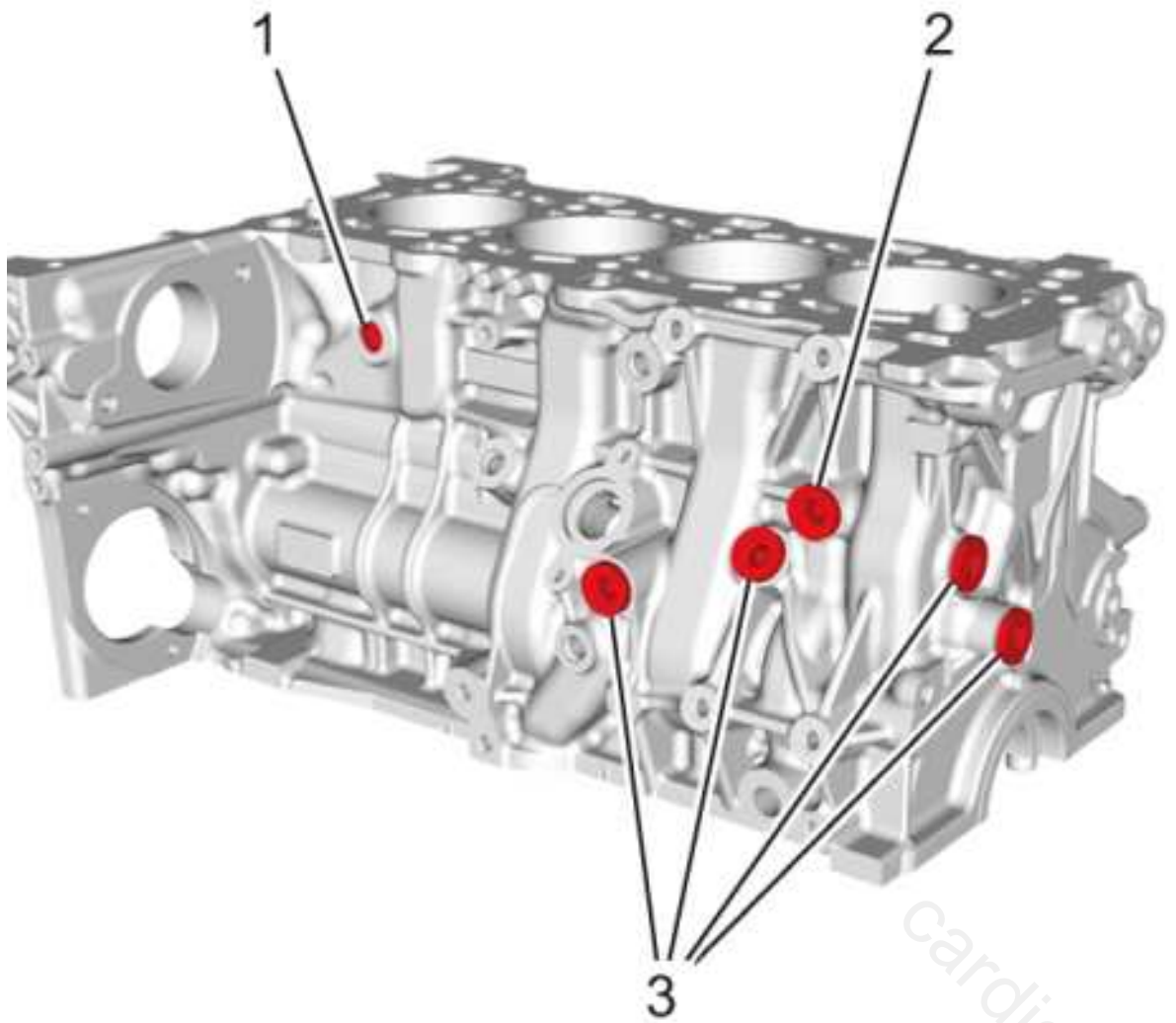


Fig. 781: Engine Block Plugs

Courtesy of GENERAL MOTORS COMPANY

9. Install and tighten Engine Block Coolant Drain Hole Plug (2) to 65 N.m (48 lb ft)
10. Install and tighten Engine Block Oil Gallery Plugs (3) (Qty: 4) to 65 N.m (48 lb ft)
11. Install NEW Engine Block Core Hole Plug (1)

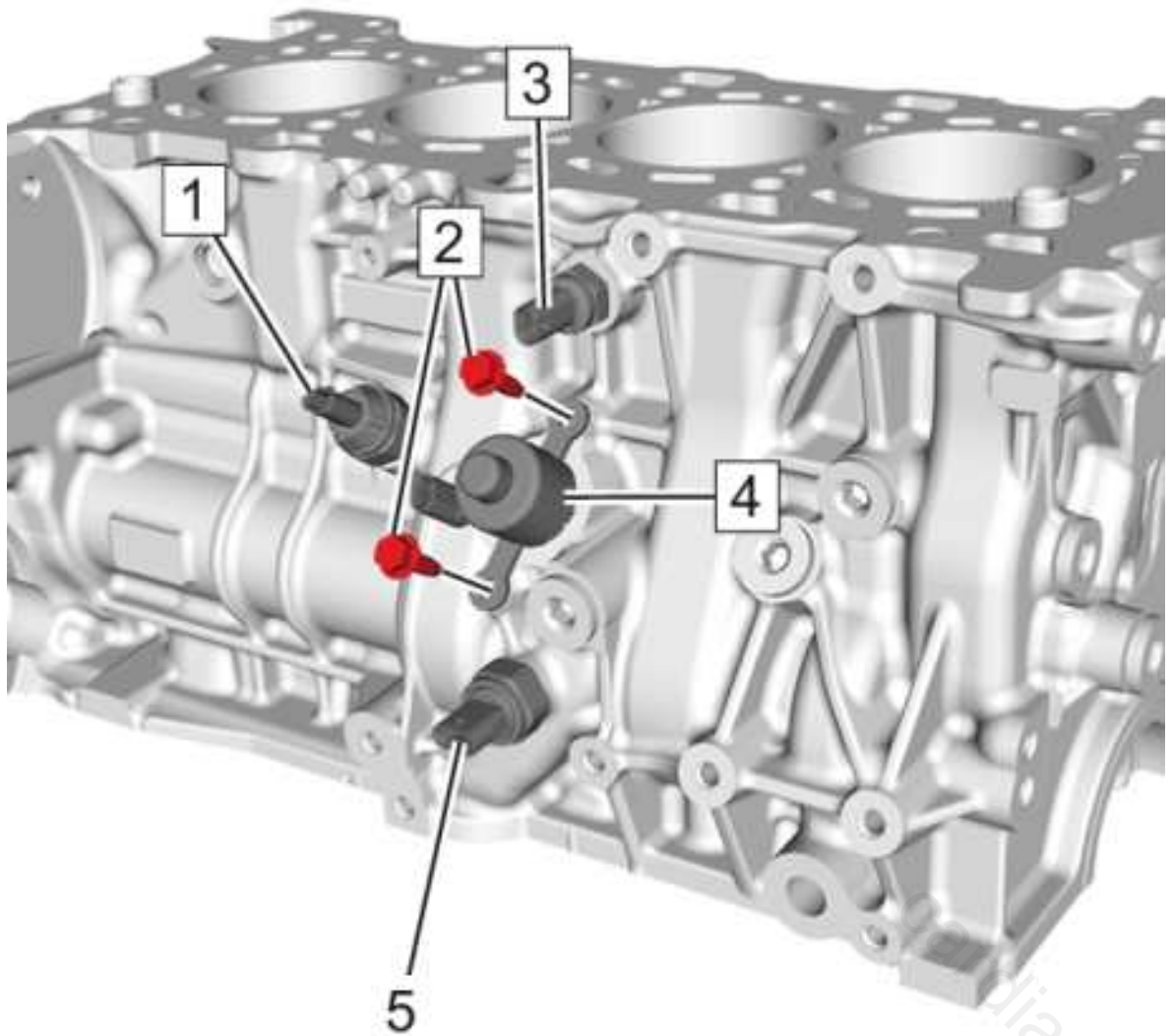


Fig. 782: Engine Oil Pressure Switch, Engine Oil Pressure Sensor, Engine Coolant Temperature Sensor, Piston Oil Nozzle Oil Control Solenoid Valve And Bolts

Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to [Component Fastener Tightening Caution](#)

12. Install and tighten Engine Oil Pressure Sensor (5) to 35 N.m (26 lb ft)
13. Install the piston oil nozzle oil control solenoid valve (4).
14. Install the 2 piston oil nozzle oil control solenoid valve bolts (2) and tighten to 10 N.m (89 lb in).
15. Install and tighten Engine Coolant Temperature Sensor (3) to 33 N.m (24 lb ft)
16. Install and tighten Engine Oil Pressure Switch (1) to 35 N.m (26 lb ft)

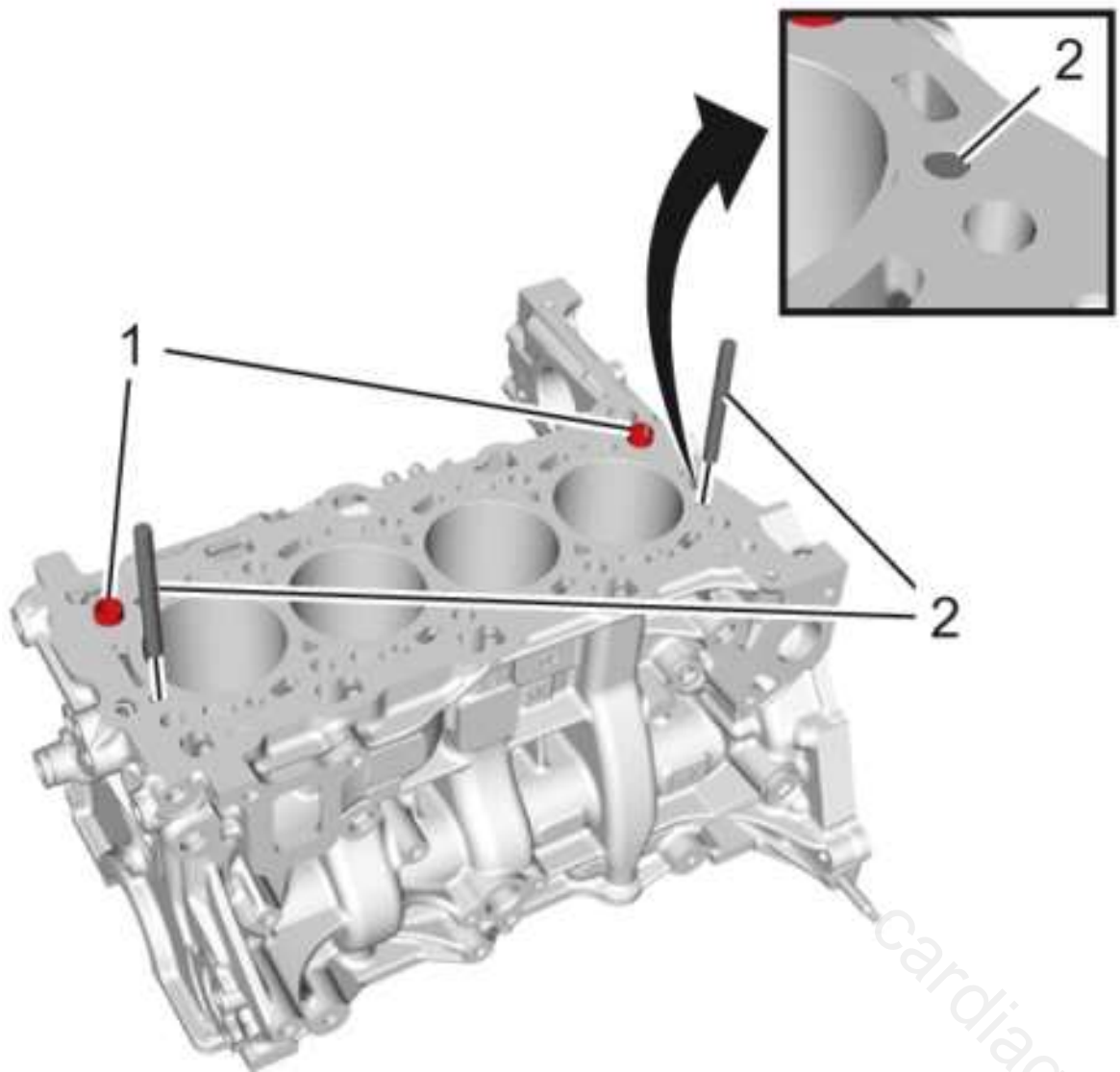


Fig. 783: Cylinder Head Guide Sleeves And Deflectors
Courtesy of GENERAL MOTORS COMPANY

17. Install the 2 cylinder head guide sleeves (1).
18. Check that the 2 deflectors (2) are installed in the engine block and install 2 NEW deflectors if the deflectors are missing.

CRANKSHAFT AND BEARING INSTALLATION

Special Tools

EN-45059 Angle Meter

For equivalent regional tools, refer to [Special Tools](#).

1. Clean all sealant surfaces from lower crankcase and engine block.

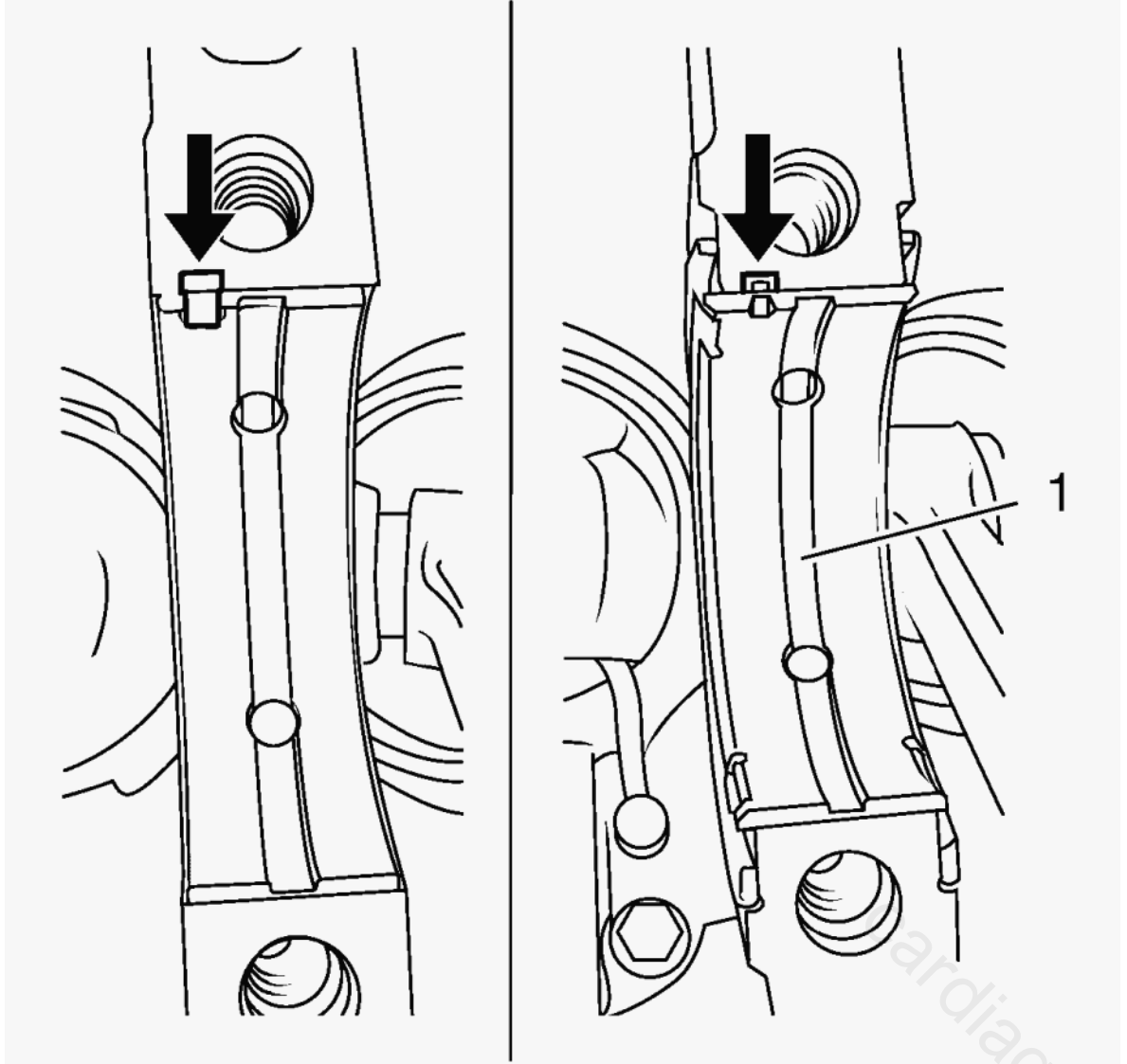


Fig. 784: Crankshaft Thrust Bearing

Courtesy of GENERAL MOTORS COMPANY

NOTE: Ensure that guide lugs (arrows) are properly seated. Note position of thrust bearing (1) at middle crankshaft bearing.

If the old crankshaft bearing shells was reused, set it in as removed.

2. Install the 5 upper crankshaft bearings to the engine block.
3. Coat the crankshaft bearings with engine oil.

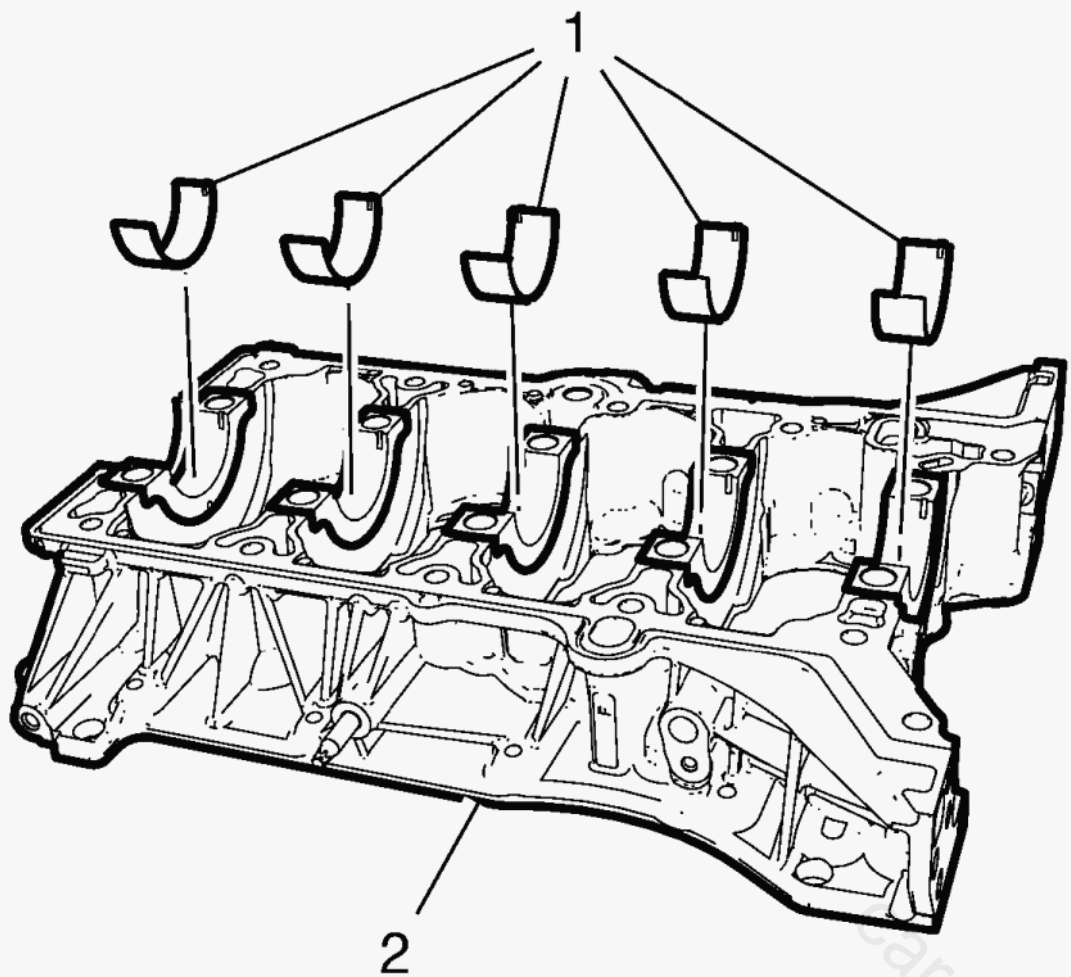


Fig. 785: Lower Crankshaft Bearings And Crankcase
Courtesy of GENERAL MOTORS COMPANY

NOTE: Ensure that guide lugs are properly seated. If the old crankshaft bearings are reused, set it in as removed.

4. Install the 5 lower crankshaft bearings (1) into the crankcase (2).
5. Coat the crankshaft bearings with engine oil.

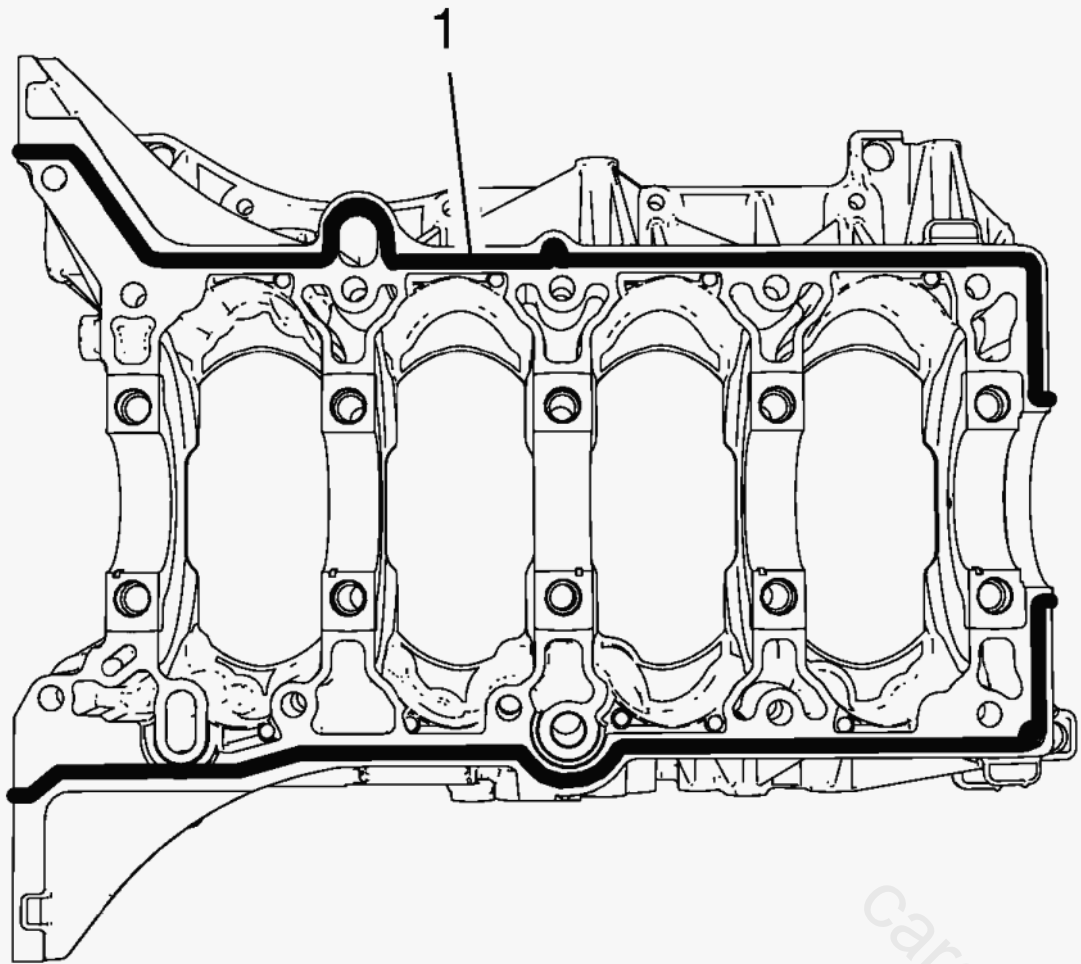


Fig. 786: Silicone Sealing Compound Lower Crankcase Application Area
Courtesy of GENERAL MOTORS COMPANY

NOTE: The complete installation procedure of the lower crankcase should be done in 20 minutes.

6. Apply silicone sealing compound to the lower crankcase. The thickness of the sealing bead (1) should be 2.0 - 3.0 mm (0.0787 - 0.1181 in).

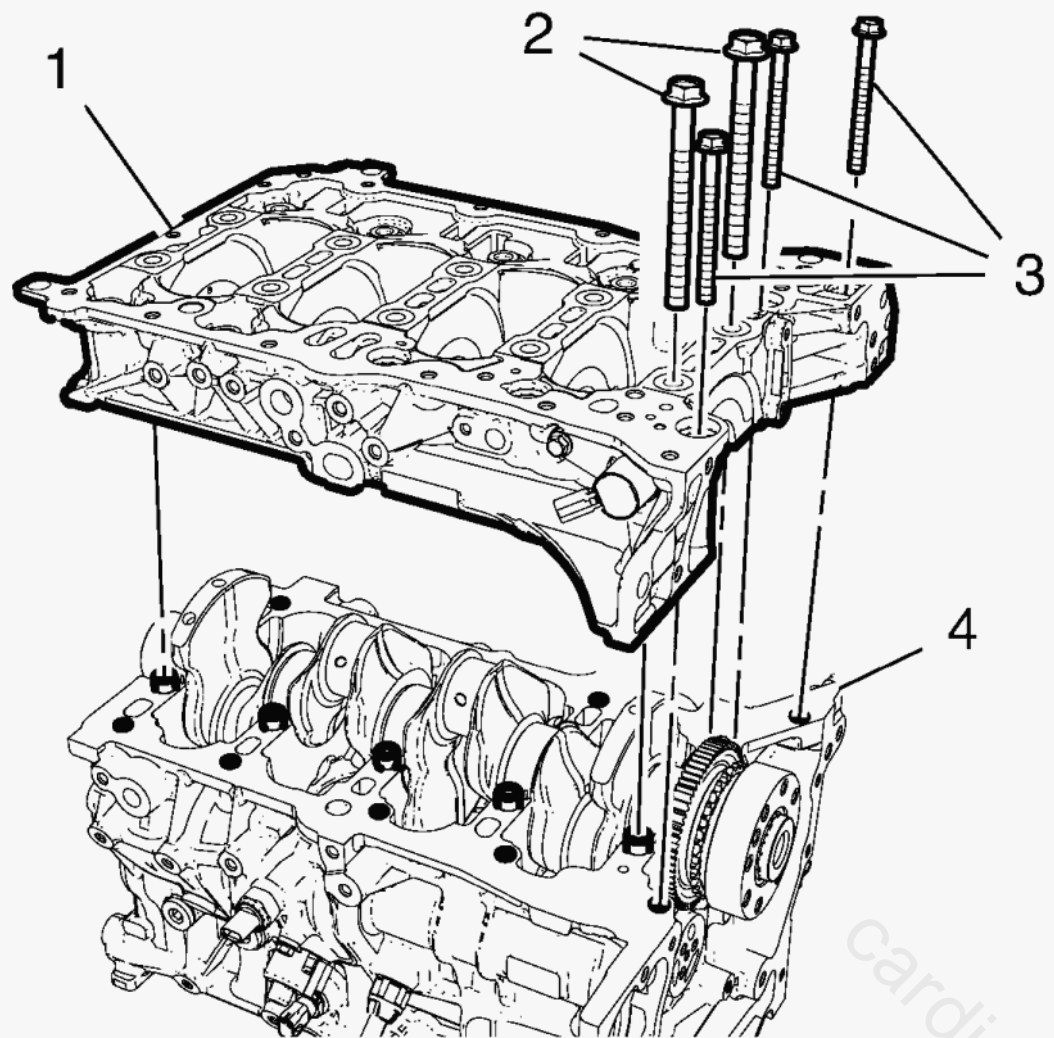


Fig. 787: Lower Crankcase And Bolts

Courtesy of GENERAL MOTORS COMPANY

7. Install the crankshaft to the engine block (4).
8. Install the lower crankcase (1).
9. Loosely install 10 NEW main bearing bolts M10 (2).
10. Loosely install the 11 lower crankcase bolts M8 (3).

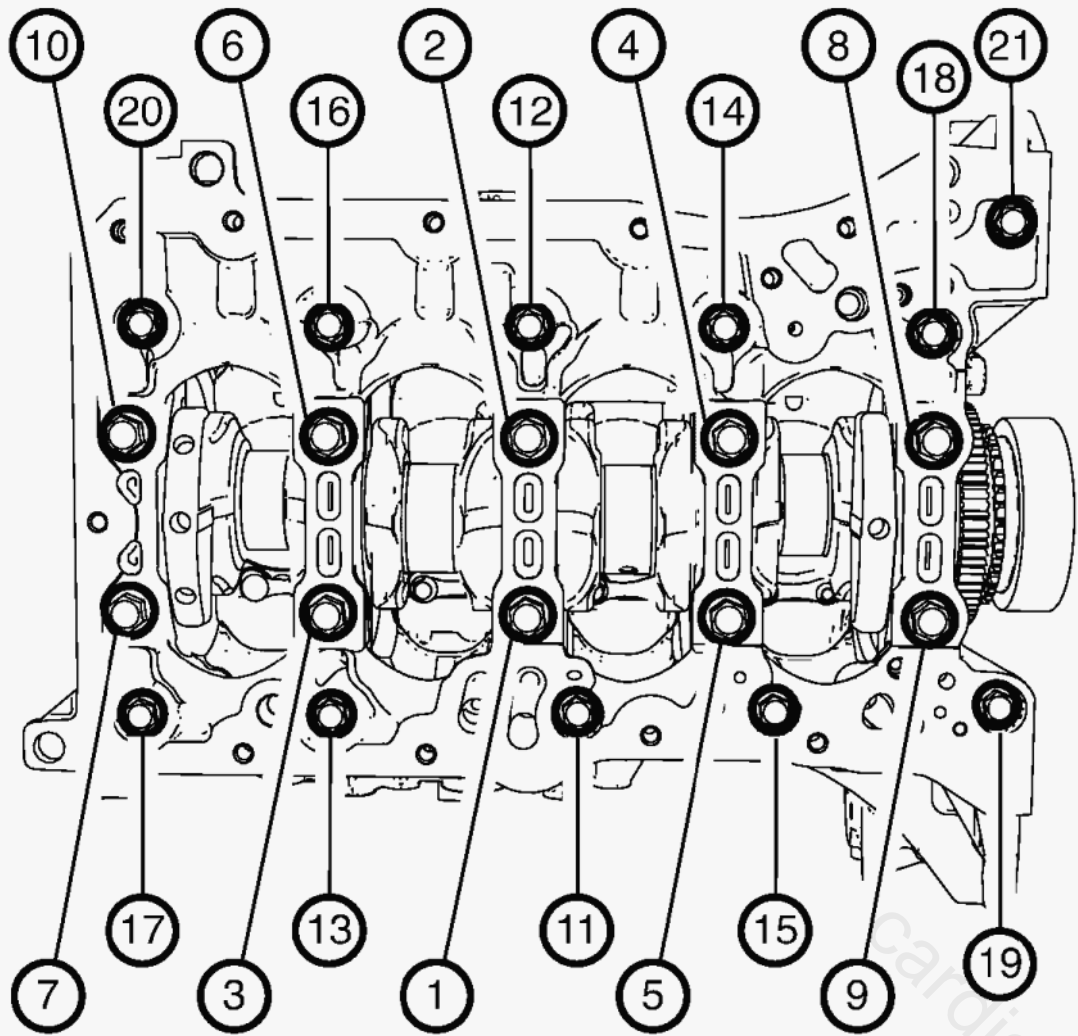


Fig. 788: Main Bearing And Lower Crankcase Bolt Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to [Fastener Caution](#) .

CAUTION: Refer to [Torque-to-Yield Fastener Caution](#) .

11. Tighten the 10 main bearing bolts.
 1. Tighten the bolts (1-10) a first pass in sequence shown to 50 N.m (37 lb ft).
 2. Tighten the bolts (1-10) a second pass in sequence shown an additional 90 degrees, using the **EN-45059** meter.
 3. Tighten the bolts (1-10) a final pass in sequence shown an additional 90 degrees, using the **EN-45059** meter.
12. Tighten the 11 lower crankcase bolts (11-21) in sequence shown to 34 N.m (25 lb ft).

CRANKSHAFT FRONT OIL SEAL INSTALLATION

Special Tools

- **EN-51144** Crankshaft Seal Installer
- **EN-51144 - 100** Crankshaft Seal Installer

For equivalent regional tools, refer to [Special Tools](#).

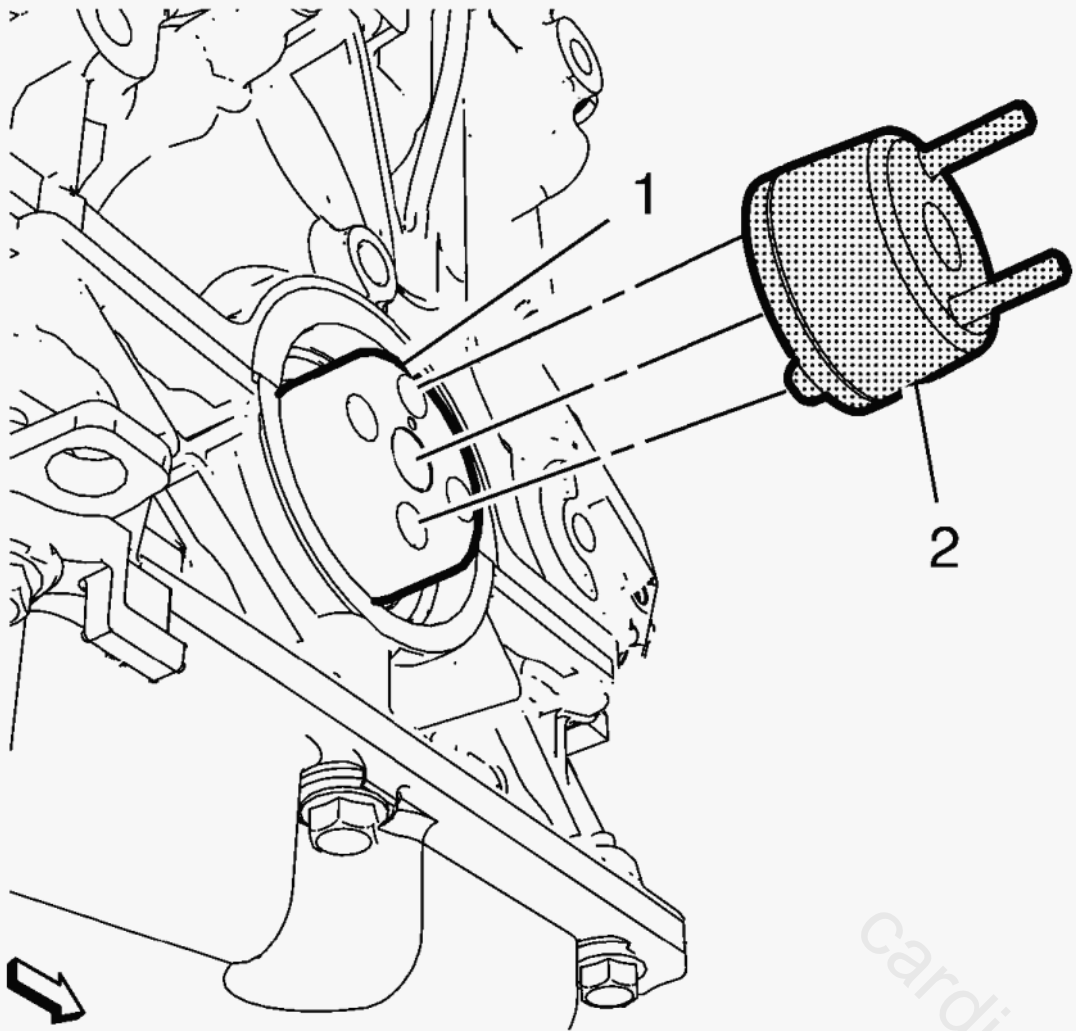


Fig. 789: Installer And Crankshaft

Courtesy of GENERAL MOTORS COMPANY

1. Install **EN-51144-1** installer (2) to crankshaft (1).

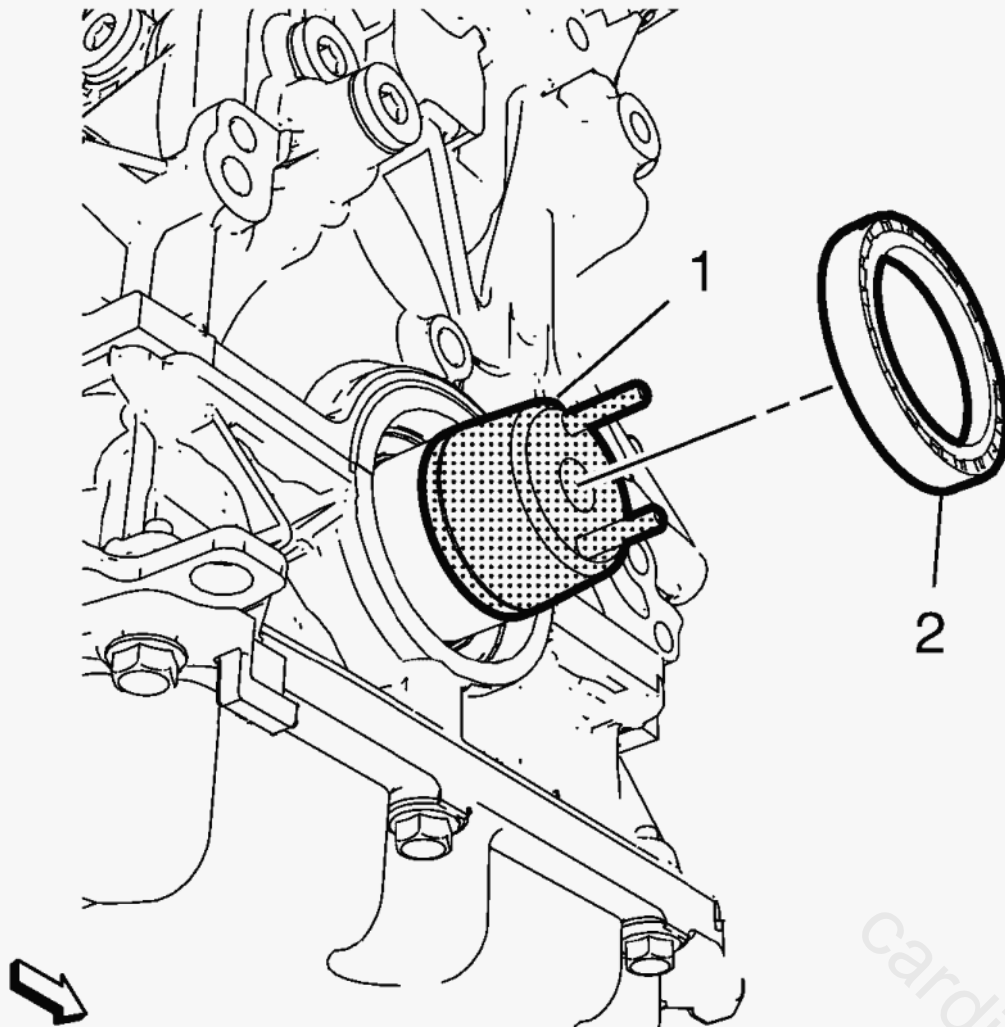


Fig. 790: Crankshaft Front Oil Seal And Installer
Courtesy of GENERAL MOTORS COMPANY

2. Install the NEW crankshaft front oil seal (2) to EN-51144-1 installer (1).

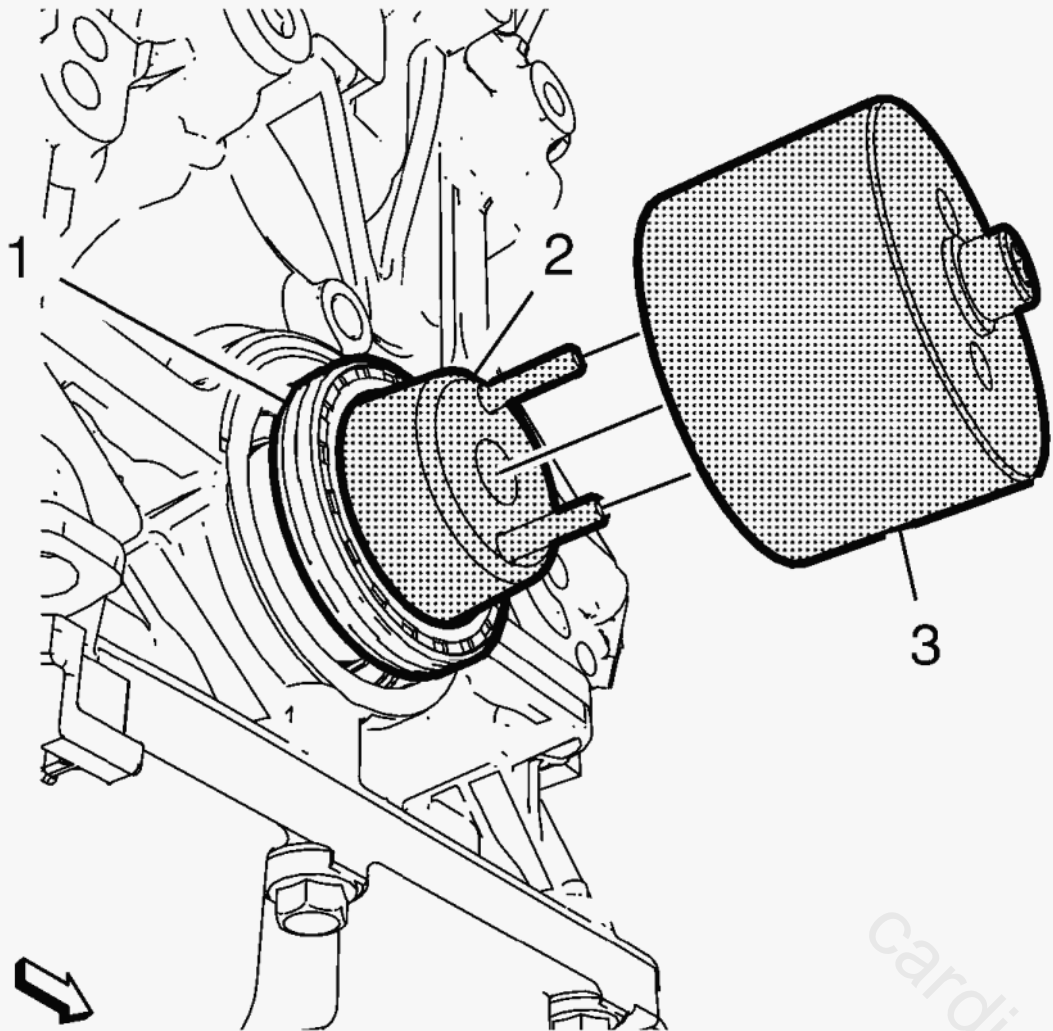


Fig. 791: Crankshaft Seal Installers

Courtesy of GENERAL MOTORS COMPANY

3. Install **EN-51144-100** crankshaft seal installer (3) to the **EN-51144-1** installer (2).

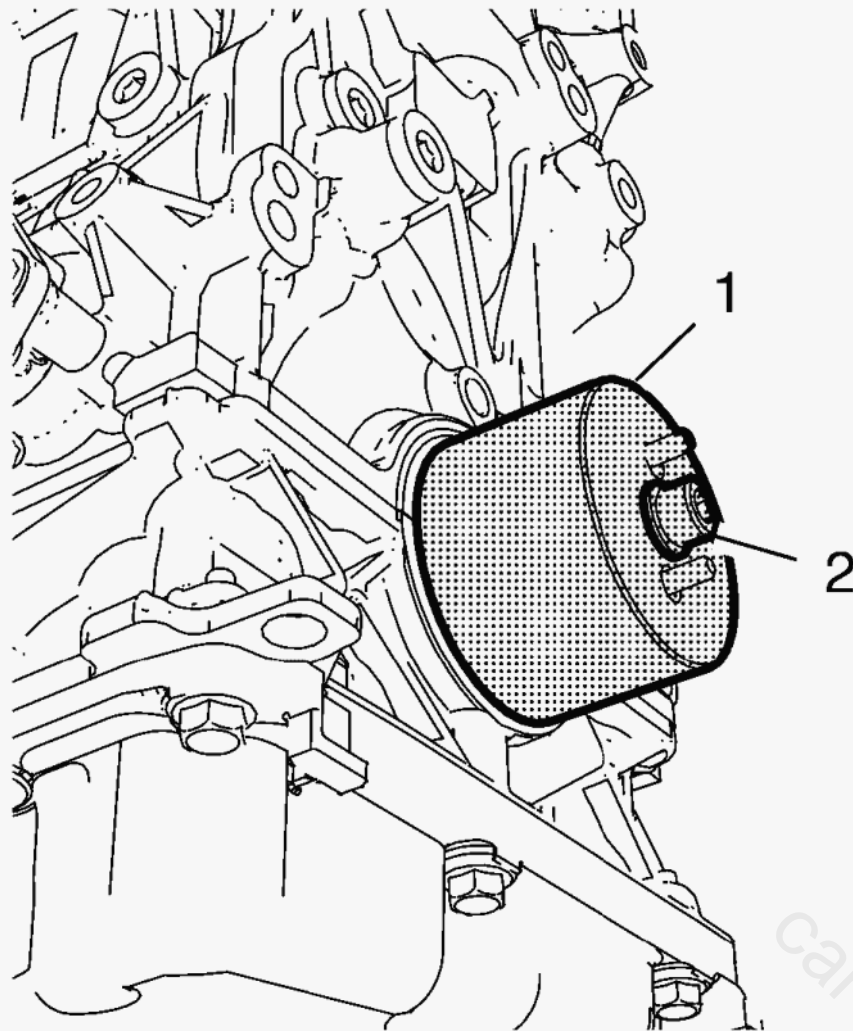


Fig. 792: Seating Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS COMPANY

4. Press the crankshaft front oil seal into the correct seat, by tighten the bolt (2) of the **EN-51144** installer (1).
5. Press the crankshaft front oil seal as far purely until the **EN-51144** installer is on the stop.
6. Remove the **EN-51144** installer.

PISTON, CONNECTING ROD, AND BEARING INSTALLATION

Special Tools

- **EN-45059** Angle Meter
- **EN-51140** Crankshaft Fixing Tool

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

1. Coat the 8 connecting rod bearings and cylinder bores with engine oil.

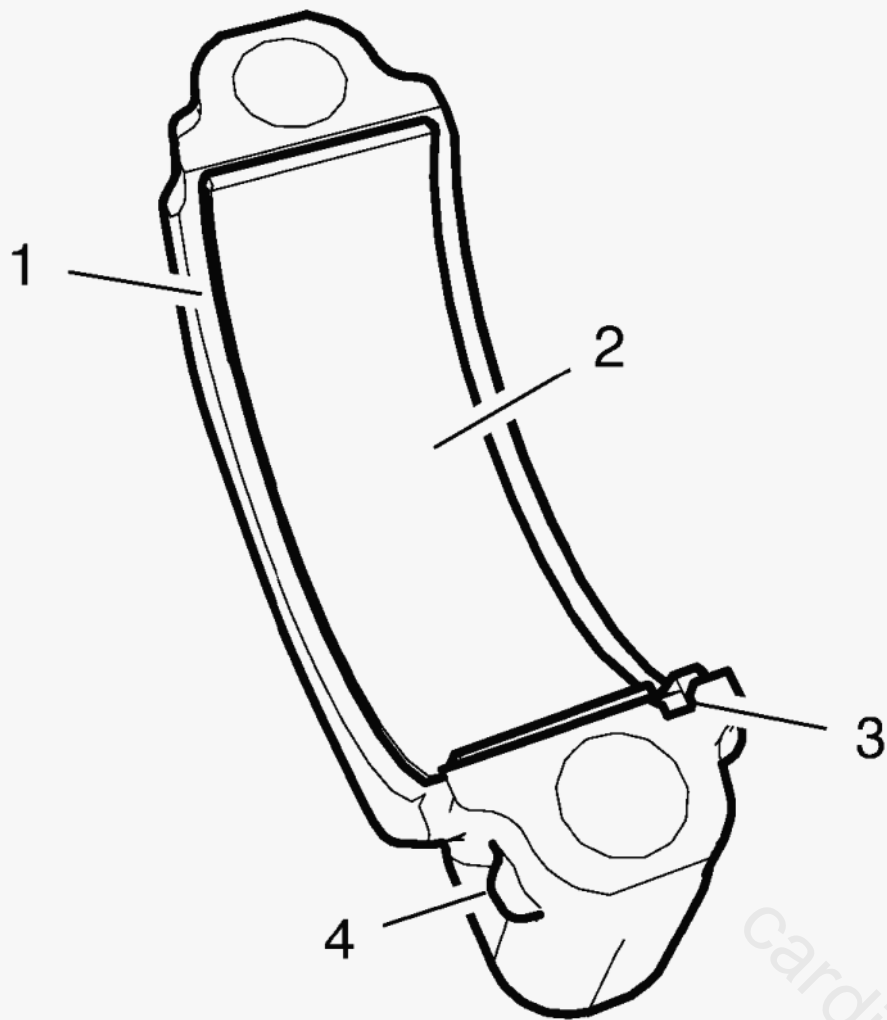


Fig. 793: Connecting Rod Bearings, Caps And Oil Notches
Courtesy of GENERAL MOTORS COMPANY

NOTE: Ensure the proper seat of the oil notches (3).

NOTE: If the old connecting rod bearings will be reused, install in their original position.

2. Install the 8 connecting rod bearings (2) to the connecting rod bearing cap (1) and the connecting rod.

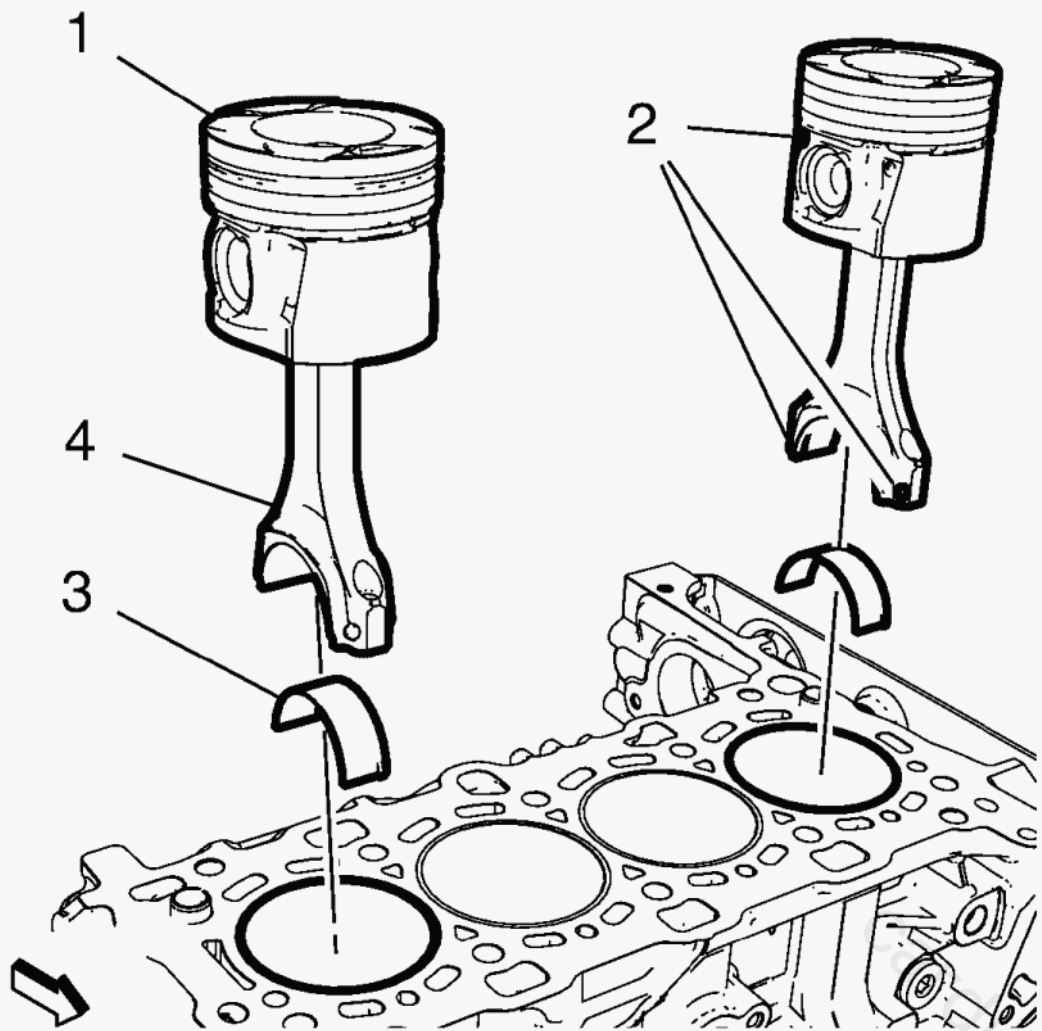


Fig. 794: Cylinder 1 And 4 Piston/Connecting Rod Assemblies And Upper Bearings
Courtesy of GENERAL MOTORS COMPANY

3. Install a piston ring compressor in order to compress the piston rings.

NOTE: The arrow on the top of the piston and the marks (2) of the piston and connecting rod, must point to front of the engine.

NOTE: If the old piston and connecting rod will be reused, install in their original position.

4. Install the 2 pistons (1) and the 2 connecting rods (4) with the connecting rod upper bearing (3) to the cylinder 1 and the cylinder 4.

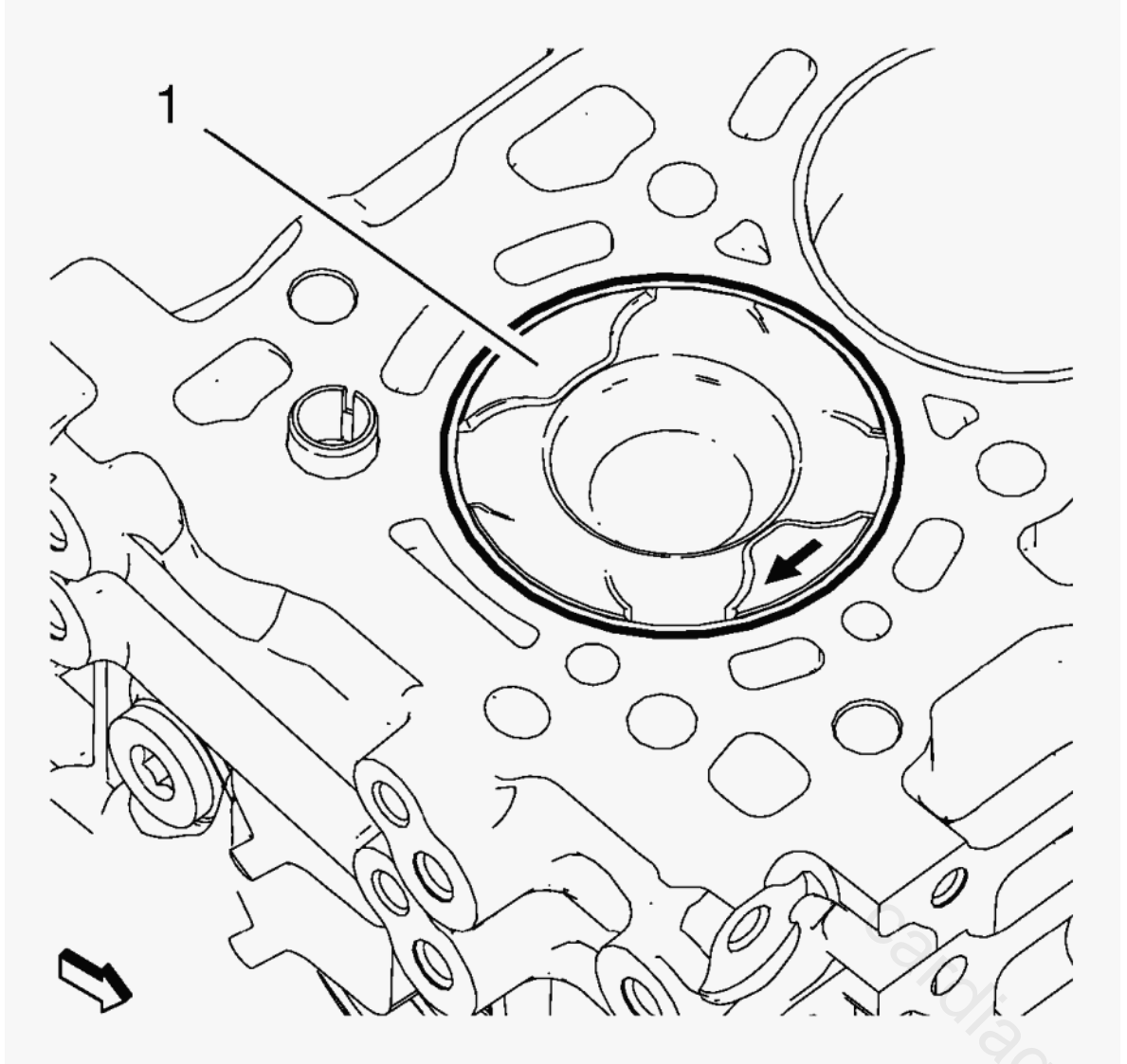


Fig. 795: Arrow On Top Of Pistons Must Point To Front Of Engine
Courtesy of GENERAL MOTORS COMPANY

5. The arrow on the top of the pistons (1) must point to front of the engine.

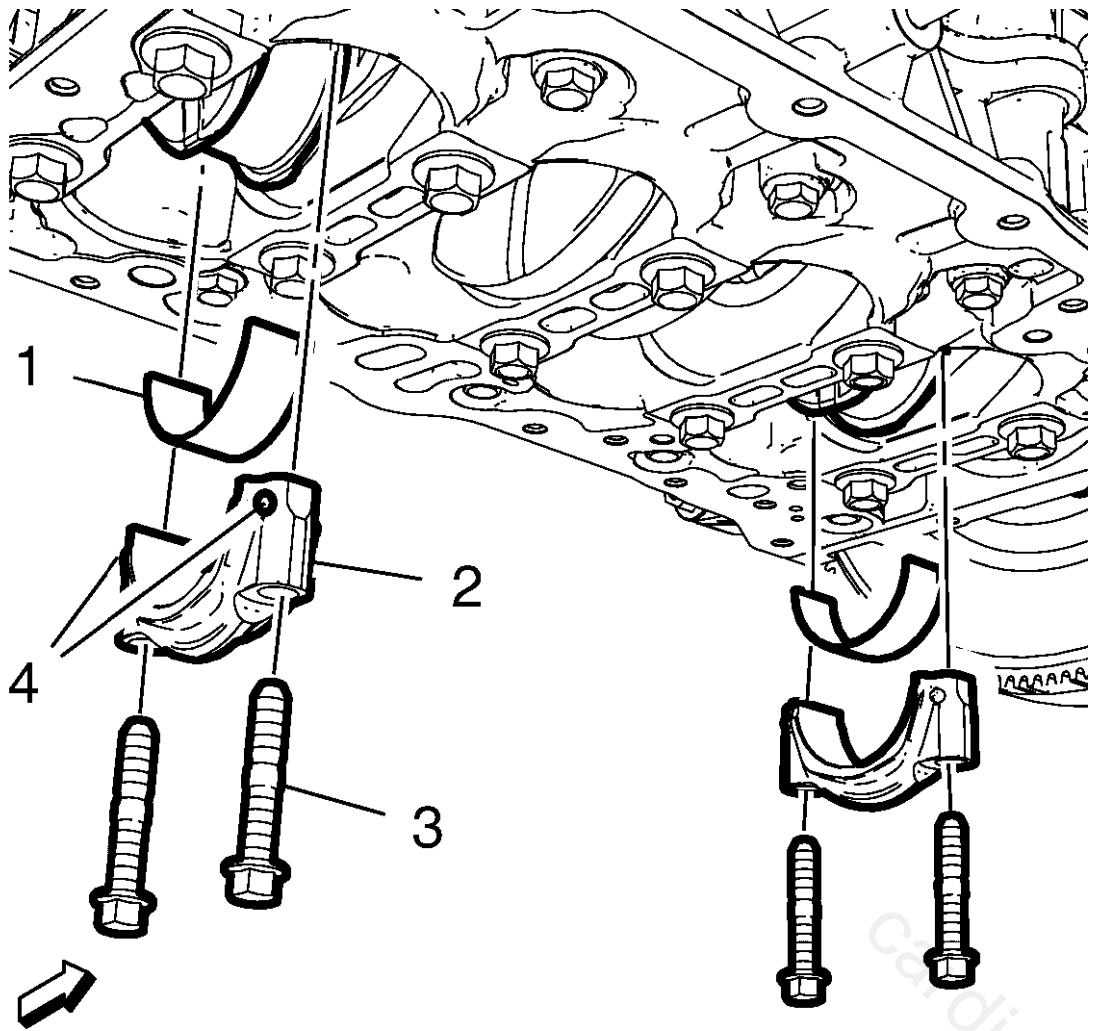


Fig. 796: Cylinder 1 And 4 Connecting Rod Caps, Bolts And Lower Bearings
 Courtesy of GENERAL MOTORS COMPANY

NOTE: The marks (4) of the connecting rod bearing caps, must point to front of the engine.

NOTE: If the old connecting rod bearing caps will be reused, install in their original position.

6. Install the 2 connecting rod bearing caps (2) with the 2 connecting rod lower bearings (1) to the cylinder 1 and the cylinder 4.

CAUTION: Refer to [Fastener Caution](#) .

CAUTION: Refer to [Torque-to-Yield Fastener Caution](#) .

7. Install 4 NEW connecting bearing cap bolts (3) and tighten in two passes:
 1. First pass tighten to 25 N.m (18 lb ft).
 2. Final pass an additional to 110 degrees, using the **EN-45059** angle meter.
8. Set TDC of the cylinder 1. Rotate the crankshaft 180 degrees, use a pry bar at the 4 crankshaft pulley bolts (1).

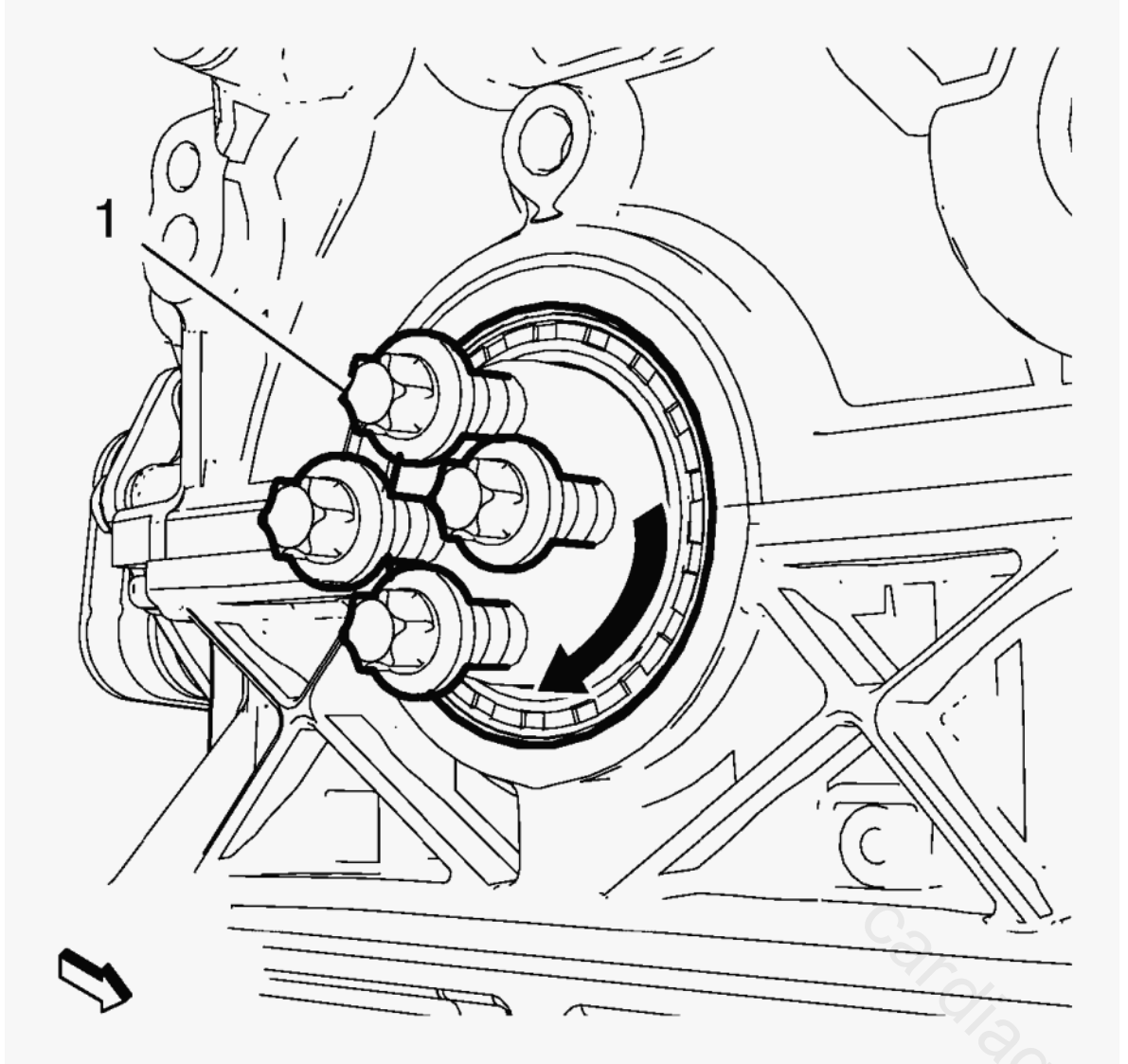


Fig. 797: Crankshaft Pulley Bolts

Courtesy of GENERAL MOTORS COMPANY

9. Remove the 4 crankshaft pulley bolts (1).

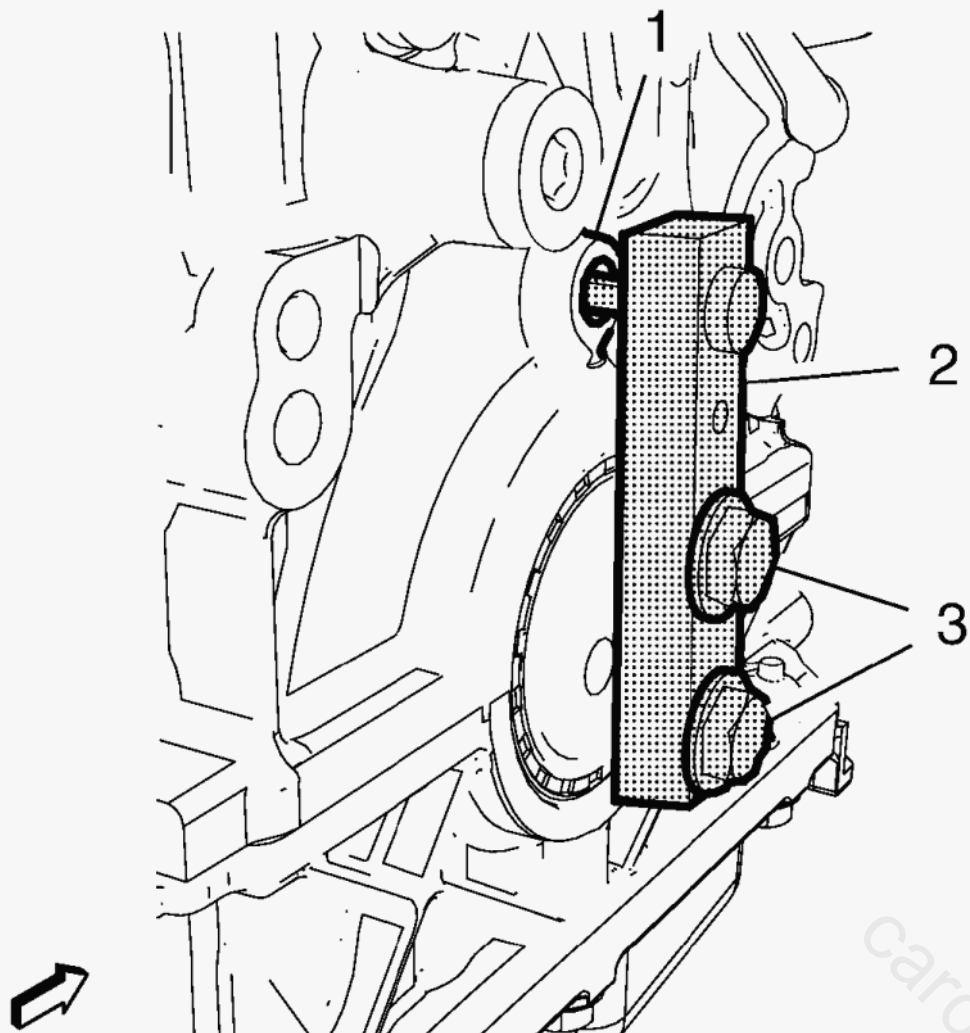


Fig. 798: Crankshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

10. Install **EN-51140** fixing tool (2).
11. Install the fixing pin into the engine block bore (1) and tighten the 2 bolts (3).

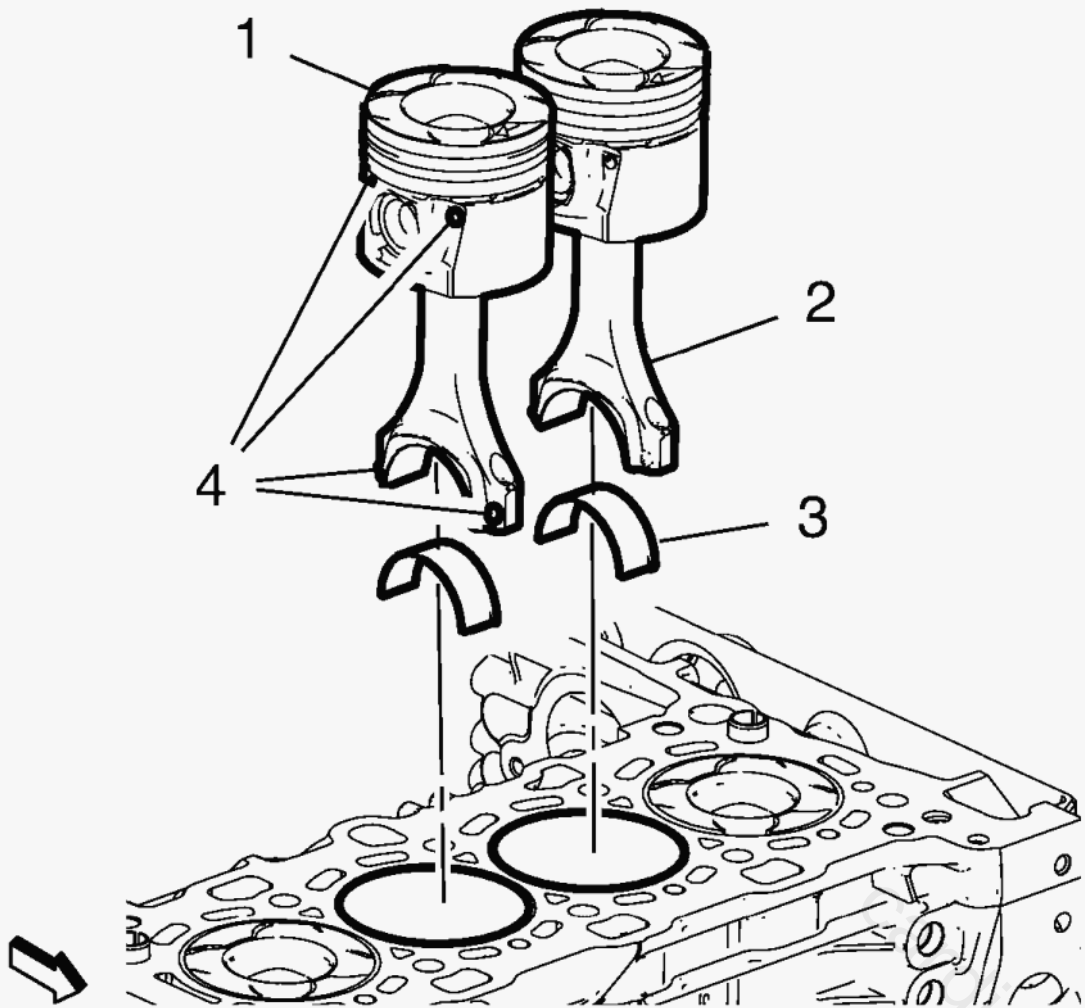


Fig. 799: Cylinder 2 And 3 Piston/Connecting Rod Assemblies And Upper Bearings
Courtesy of GENERAL MOTORS COMPANY

12. Install a piston ring compressor in order to compress the piston rings.

NOTE: The arrow on the top of the piston and the marks (4) of the piston and connecting rod, must point to front of the engine.

NOTE: If the old piston and connecting rod will be reused, install in their original position.

13. Install the 2 pistons (1) and the 2 connecting rods (2) with the connecting rod upper bearing (3) to the cylinder 2 and the cylinder 3.

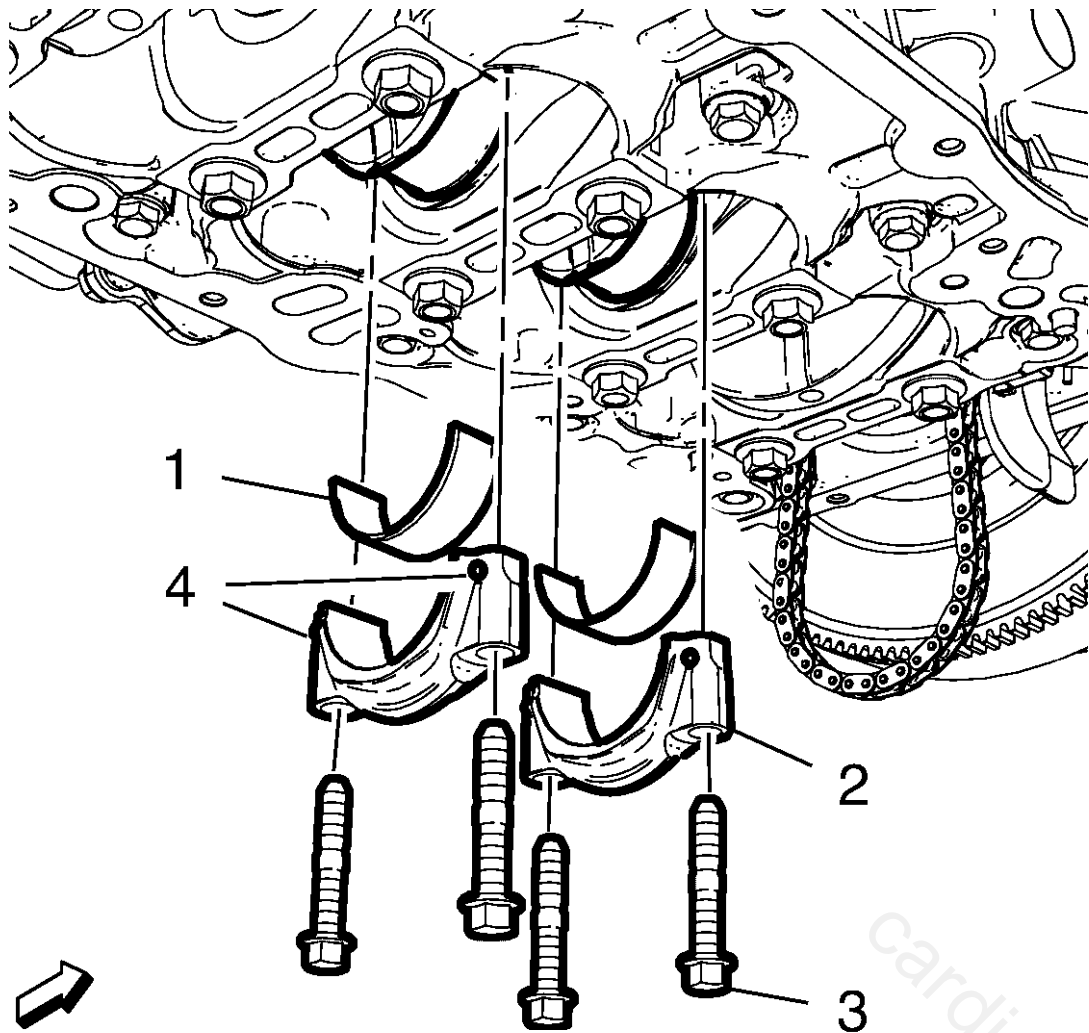


Fig. 800: Cylinder 2 And 3 Connecting Rod Caps, Bolts And Lower Bearings
 Courtesy of GENERAL MOTORS COMPANY

NOTE: The marks (4) of the connecting rod bearing caps, must point to front of the engine.

NOTE: If the old connecting rod bearing caps will be reused, install in their original position.

14. Install the 2 connecting rod bearing caps (2) with the 2 connecting rod lower bearings (1) to the cylinder 2 and the cylinder 3.

CAUTION: Refer to [Torque-to-Yield Fastener Caution](#) .

15. Install 4 NEW connecting bearing cap bolts (3) and tighten in two passes:
 1. First pass tighten to 25 N.m (18 lb ft).
 2. Final pass an additional to 110 degrees, using the **EN-45059** angle meter.

CYLINDER HEAD INSTALLATION

Special Tools

- **EN-45059** Angle Meter
- **EN-51140** Crankshaft Fixing Tool
- **GE-7872** Magnetic Base Dial Indicator

Equivalent regional tools: [Special Tools](#)

CAUTION: Clean all dirt, debris, and coolant from the engine block cylinder head bolt holes.

Failure to remove all foreign material may result in damaged threads, improperly tightened fasteners or damage to components.

NOTE:

- Do not use the cylinder head bolts again. Install NEW cylinder head bolts during assembly.
- Do not use any type of sealant on the cylinder head gasket, unless specified.
- The cylinder head gaskets must be installed in the proper direction and position.

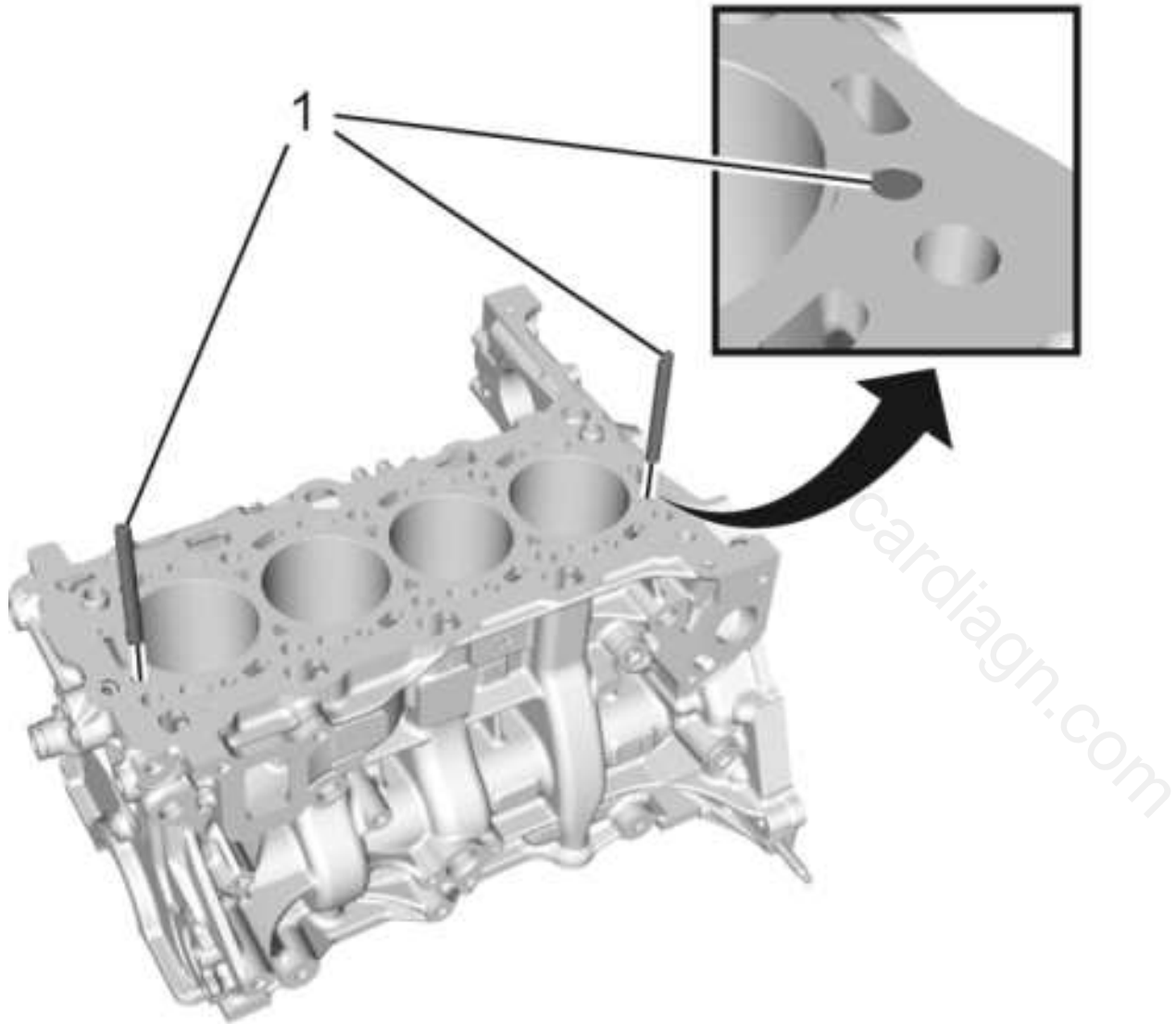


Fig. 801: Deflectors

Courtesy of GENERAL MOTORS COMPANY

1. Check that the 2 deflectors (1) are installed in the engine block and install 2 NEW deflectors if the deflectors are missing.

NOTE:

Ensure that the cylinder head and the cylinder block sealing surfaces are clear of oil, grease and old gasket material.

2. Clean all sealing surfaces.
3. Inspect the flatness of the cylinder head and cylinder block sealing surfaces.
4. Set the TDC of cylinder 1.

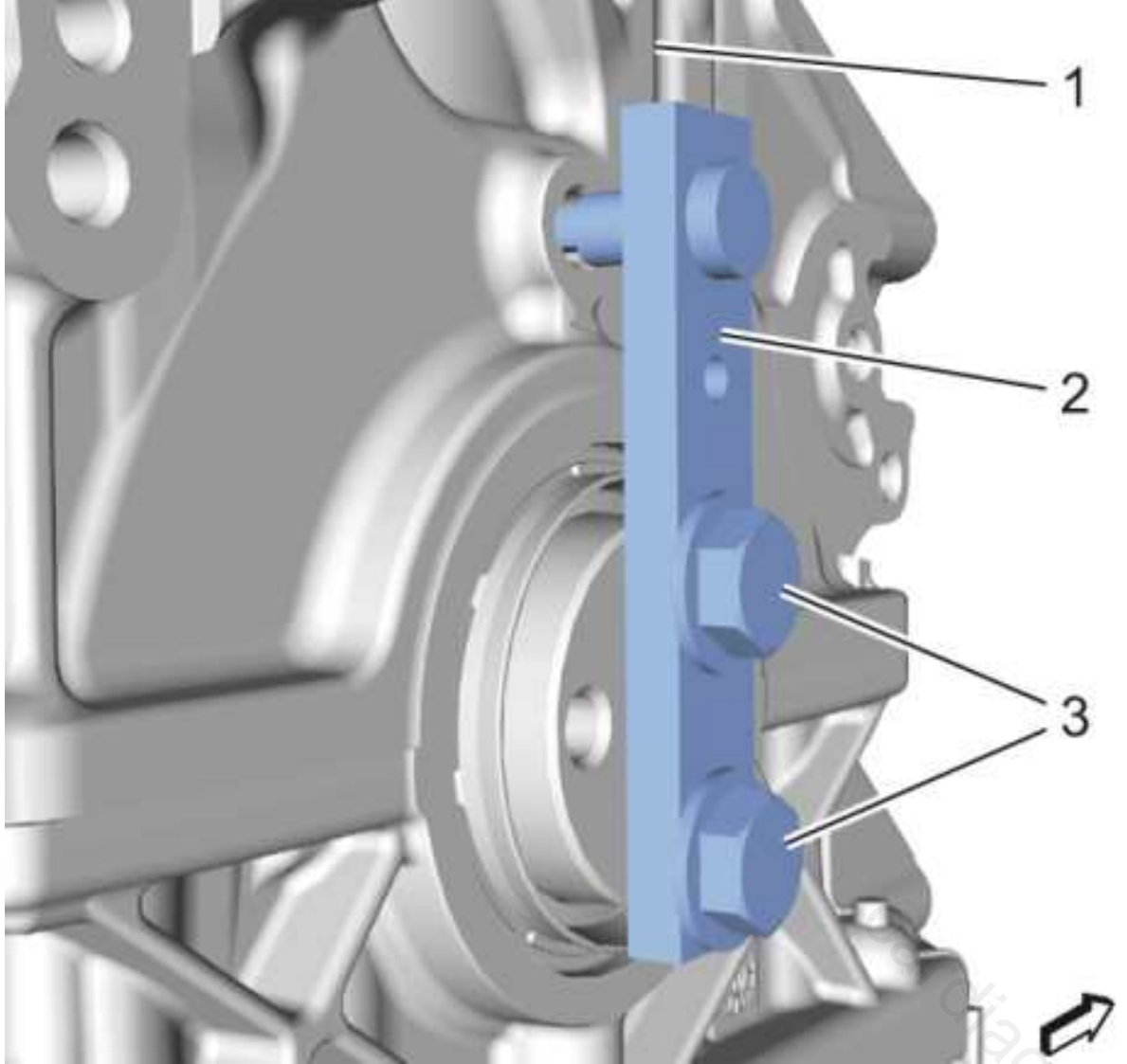


Fig. 802: Crankshaft Fixing Tool And Bolts
Courtesy of GENERAL MOTORS COMPANY

5. Install the **EN-51140** fixing tool (2).
6. Install the fixing pin into the engine block bore (1) and tighten the 2 bolts (3).

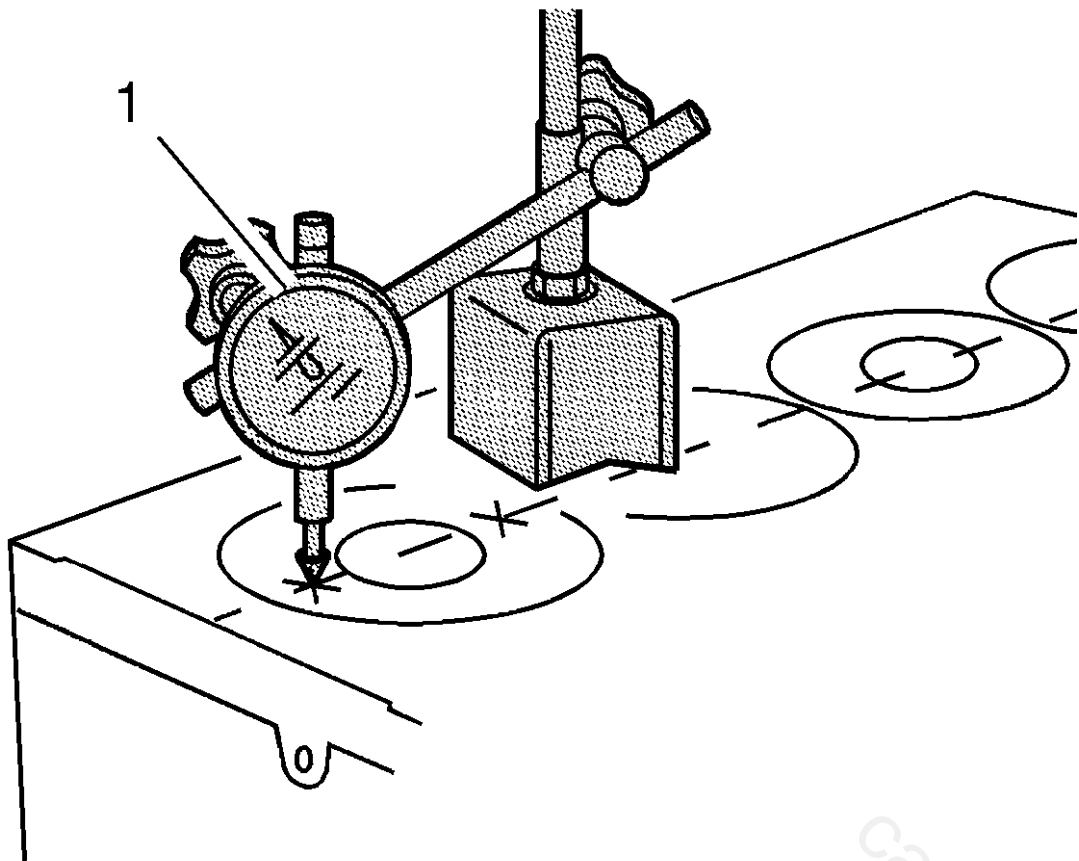


Fig. 803: Indicator

Courtesy of GENERAL MOTORS COMPANY

NOTE: For the measurement, the piston has to stay on TDC. Measure the piston projection dimensions at all pistons.

7. Install the GE-7872 indicator (1).
8. Measure the piston projection of the cylinder 1 and the cylinder 4.

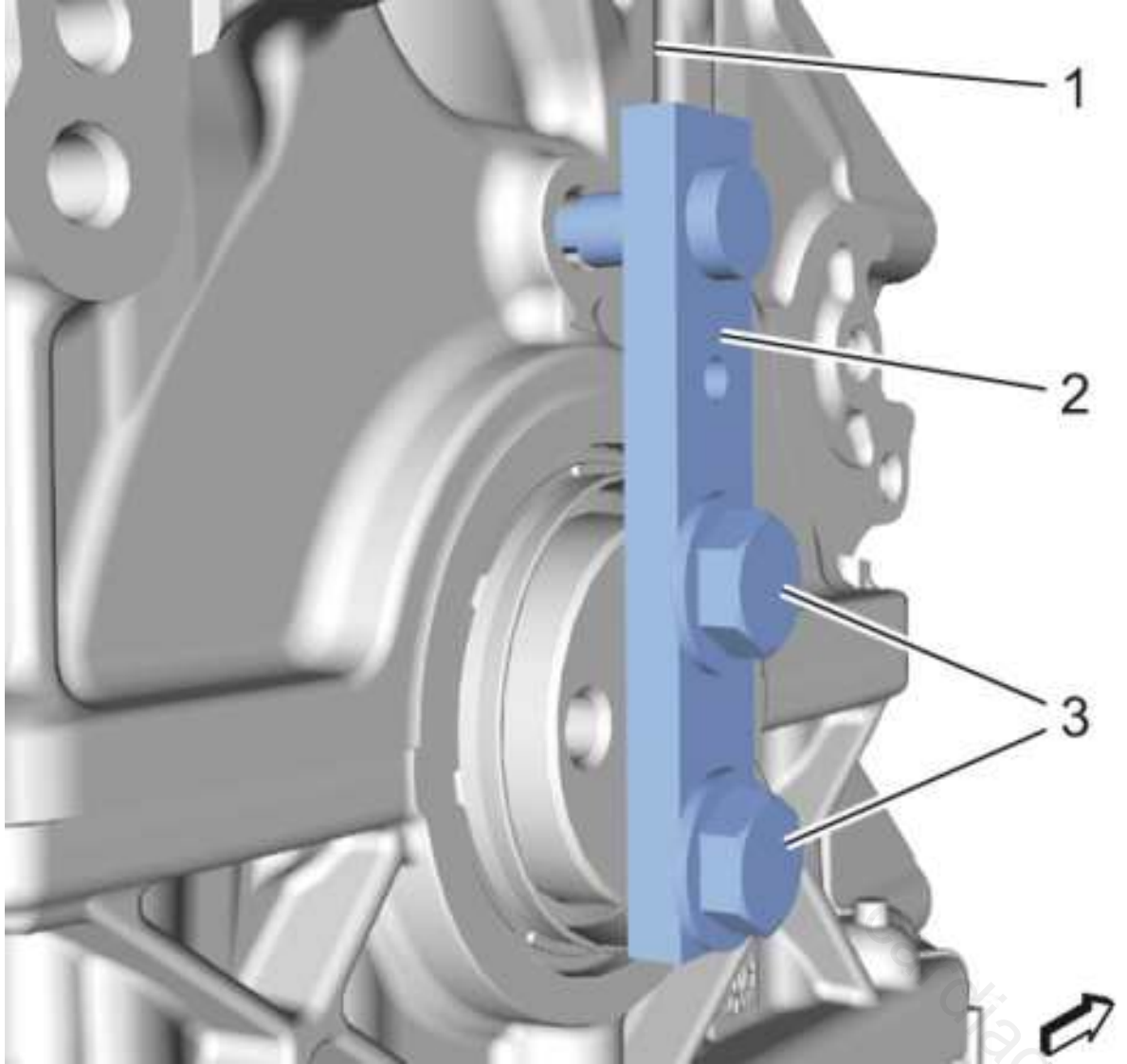


Fig. 804: Crankshaft Fixing Tool And Bolts
Courtesy of GENERAL MOTORS COMPANY

9. Remove Bolts (3) (Qty: 2)
10. Remove the **EN-51140** fixing tool (2).

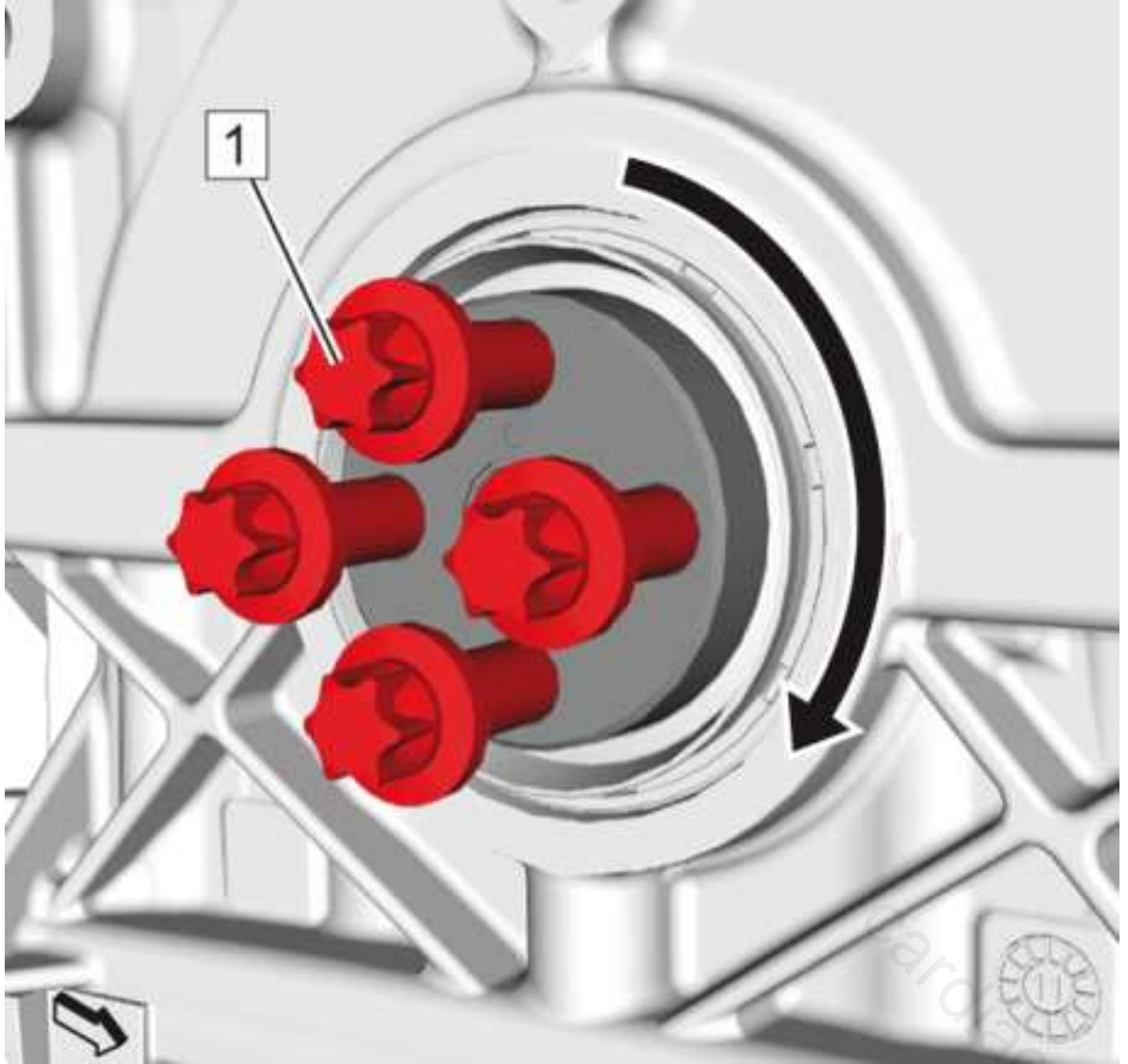


Fig. 805: Crankshaft Pulley Bolts

Courtesy of GENERAL MOTORS COMPANY

11. Install Crankshaft Pulley Bolts (1) (Qty: 4)
12. Rotate the crankshaft 360 degrees, use a pry bar at the 4 crankshaft pulley bolts (1).
13. Remove Crankshaft Pulley Bolts (1) (Qty: 4)

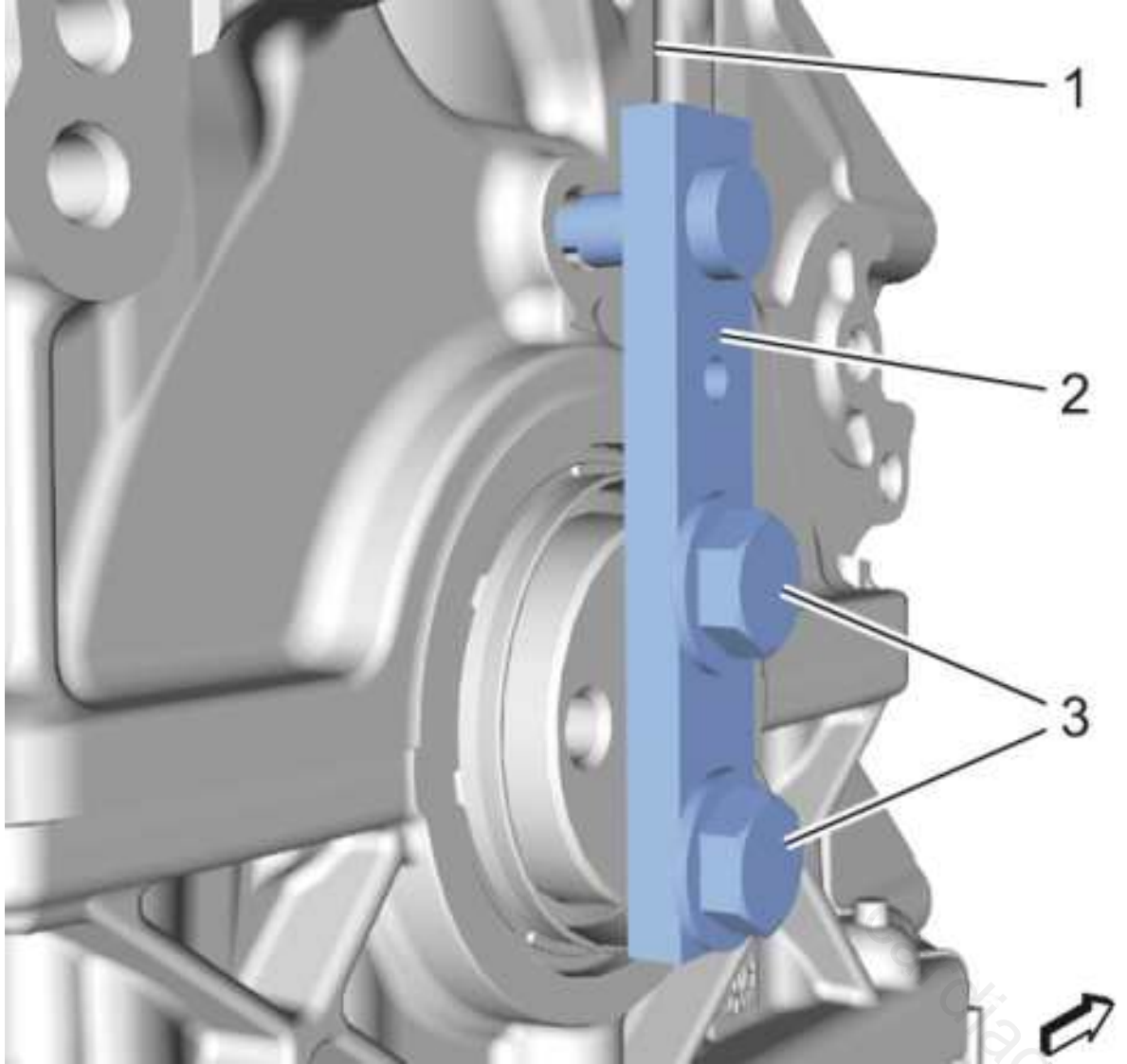


Fig. 806: Crankshaft Fixing Tool And Bolts
Courtesy of GENERAL MOTORS COMPANY

14. Install the **EN-51140** fixing tool (2).
15. Install the fixing pin into the engine block bore (1) and tighten the 2 bolts (3).
16. Measure the piston projection of the cylinder 2 and the cylinder 3.

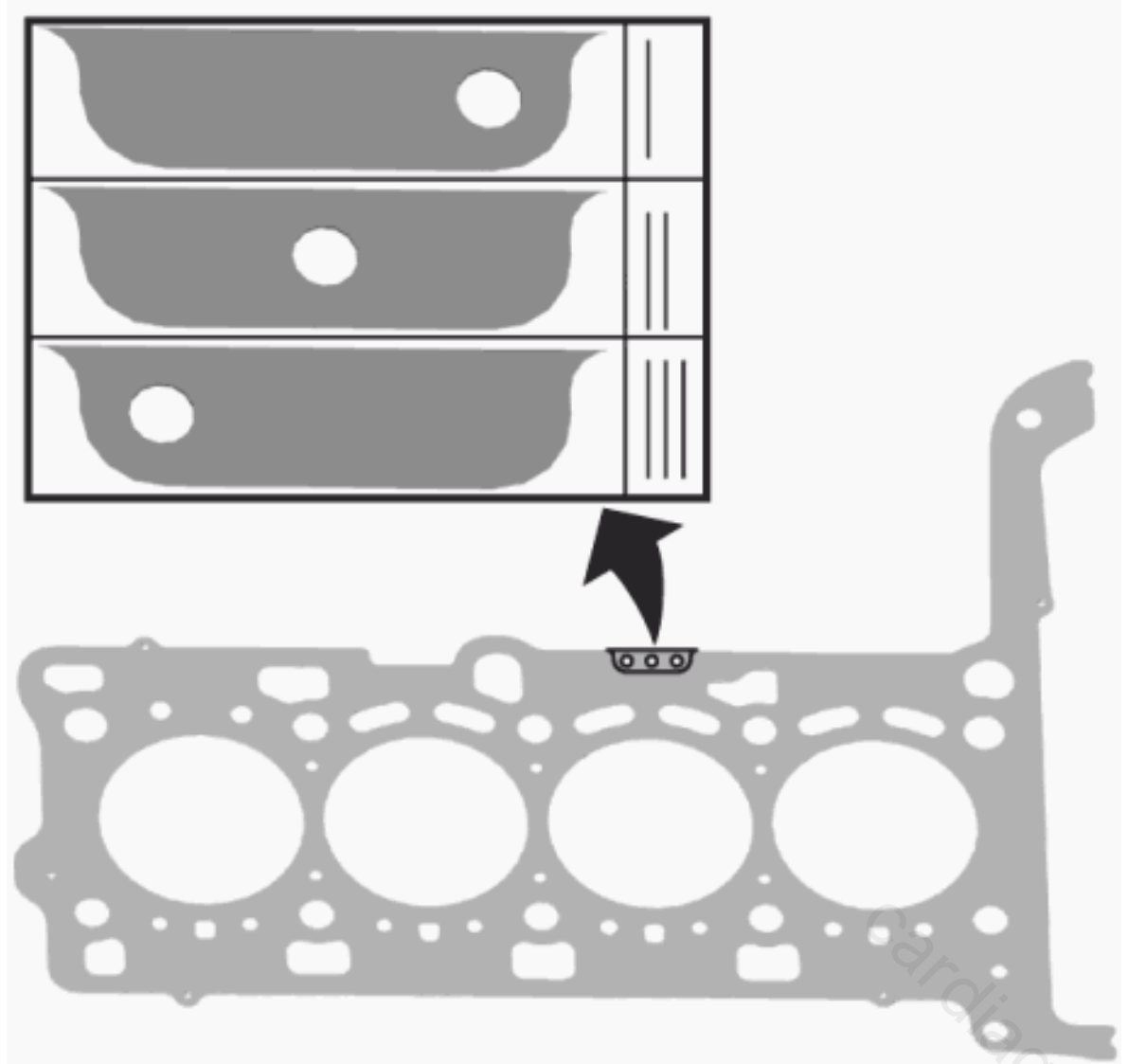


Fig. 807: Cylinder Head Gasket Identification Marks
 Courtesy of GENERAL MOTORS COMPANY

NOTE: The largest piston projection is decisive for the selection of the cylinder head gasket with the corresponding marking. The different between the three max. projection measurements must be no greater than 0.1 mm (0.0039 in).

17. Select the cylinder head gasket with the correct identification marks (1):
 1. Piston projection 0.440 - 0.535 mm (0.0173 - 0.0211 in), choose cylinder head gasket with identification mark on Position I, thickness 1.25 mm (0.049 in).
 2. Piston projection 0.535 - 0.630 mm (0.0211 - 0.0248 in), choose cylinder head gasket with identification mark on Position II, thickness 1.35 mm (0.053 in).
 3. Piston projection 0.630 - 0.725 mm (0.0248 - 0.0285 in), choose cylinder head gasket with identification mark on Position III, thickness 1.45 mm (0.057 in).

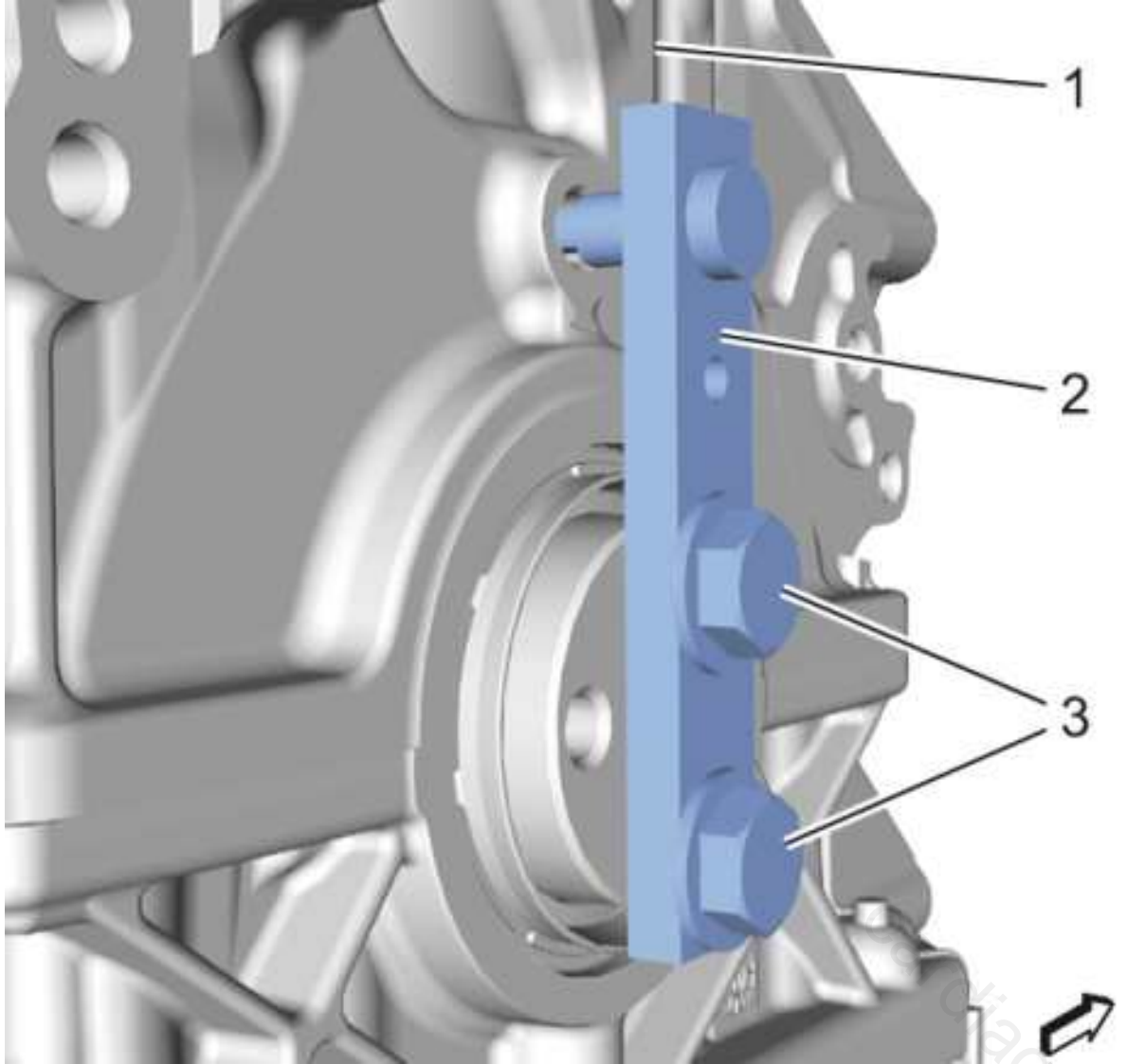


Fig. 808: Crankshaft Fixing Tool And Bolts
Courtesy of GENERAL MOTORS COMPANY

18. Remove Bolts (3) (Qty: 2)
19. Remove the **EN-51140** fixing tool (2).

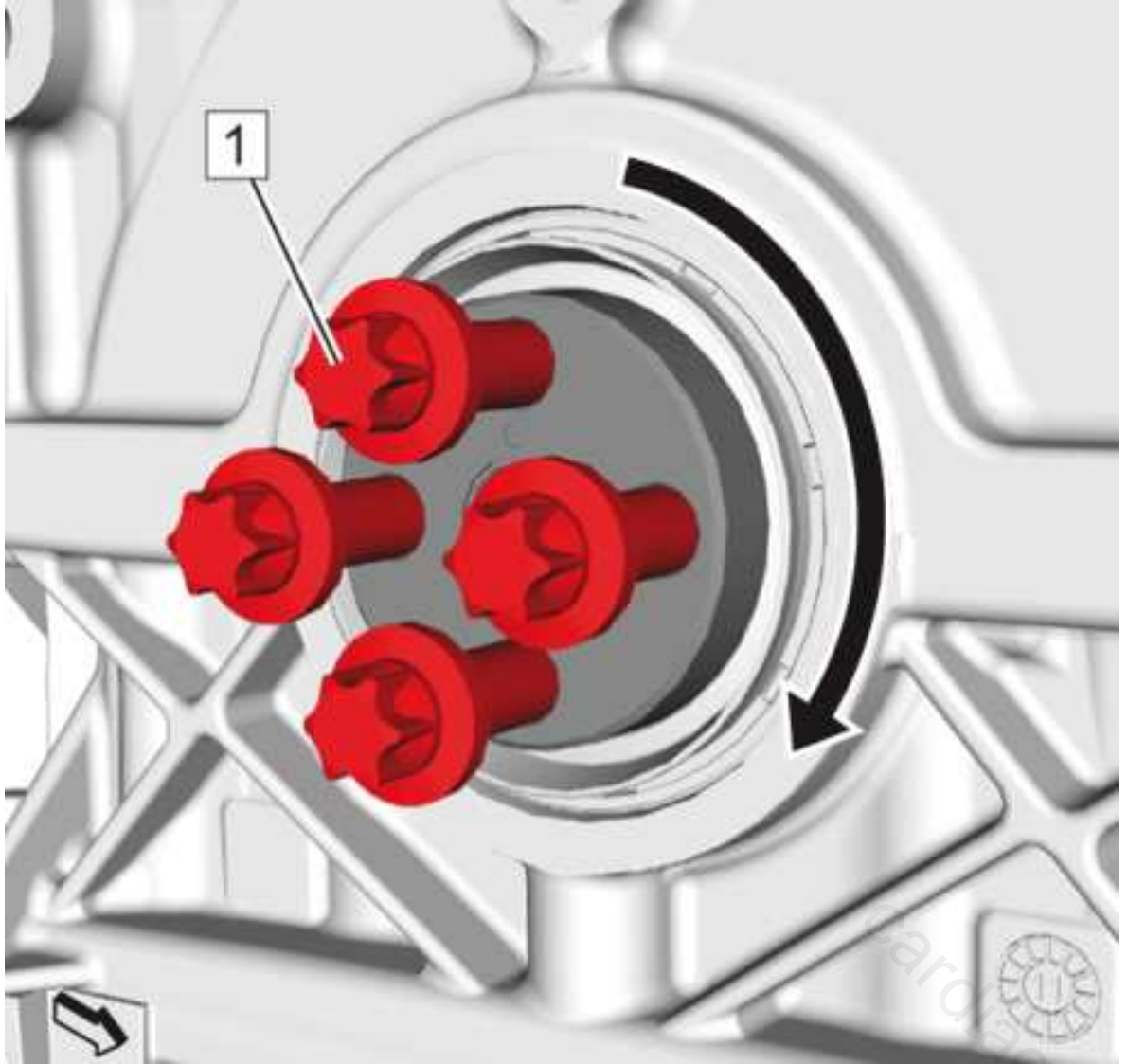


Fig. 809: Crankshaft Pulley Bolts

Courtesy of GENERAL MOTORS COMPANY

20. Install Crankshaft Pulley Bolts (1) (Qty: 4)
21. Rotate the crankshaft 360 degrees, use a pry bar at the 4 crankshaft pulley bolts (1).
22. Remove Crankshaft Pulley Bolts (1) (Qty: 4)

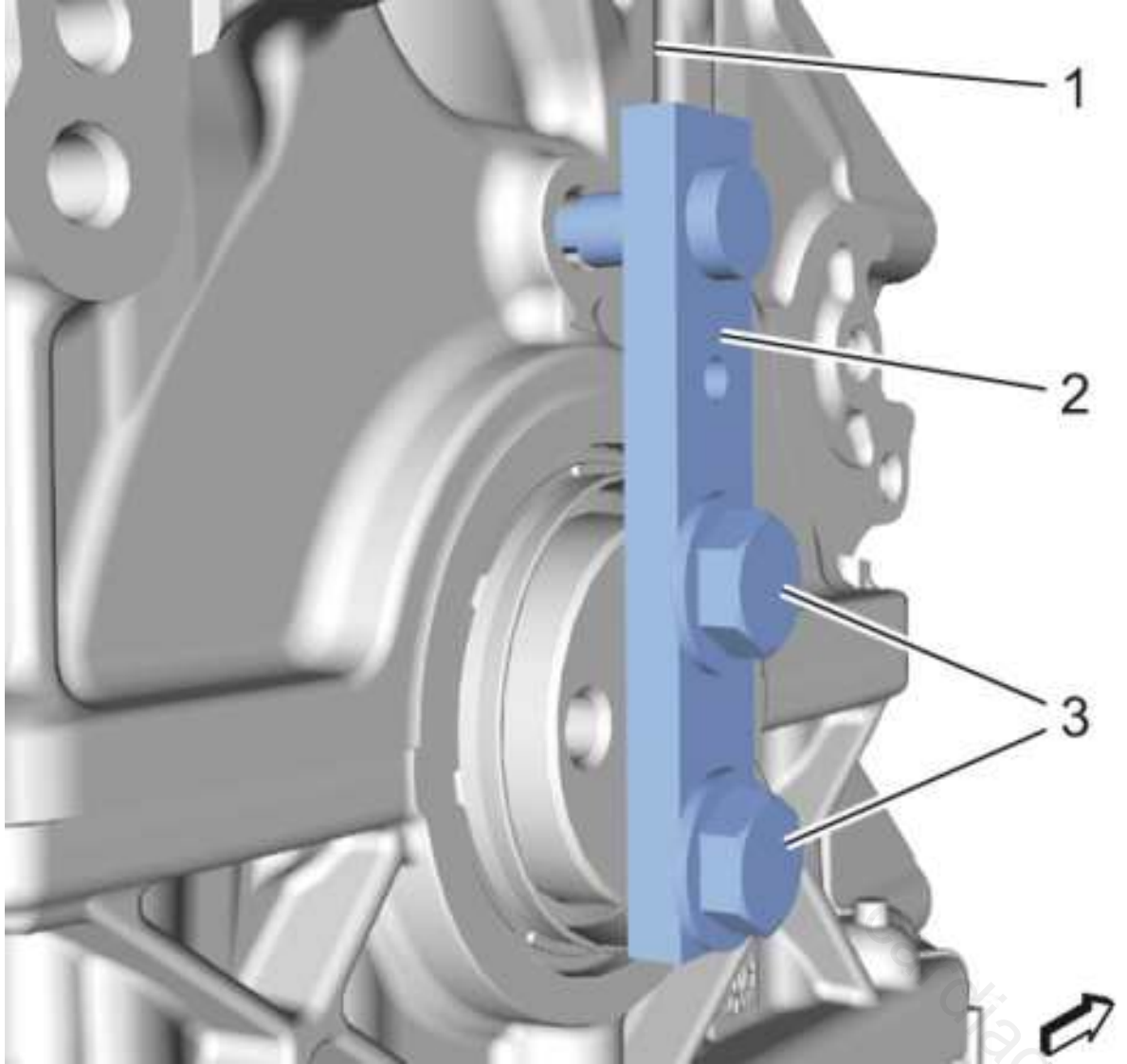


Fig. 810: Crankshaft Fixing Tool And Bolts

Courtesy of GENERAL MOTORS COMPANY

23. Install the **EN-51140** fixing tool (2) to fix the TDC of cylinder 1.
24. Install the fixing pin into the engine block bore (1) and tighten the 2 bolts (3).

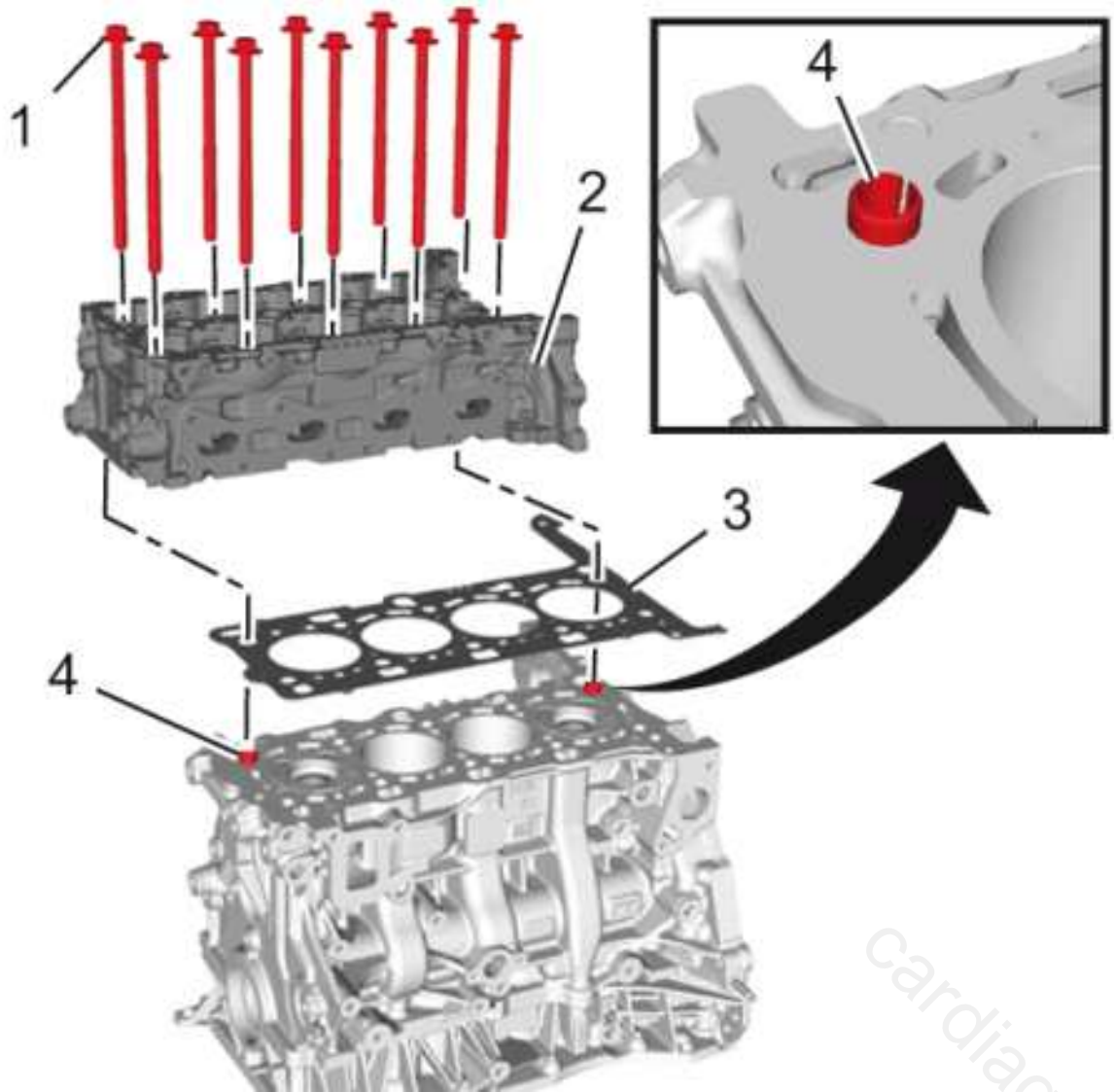


Fig. 811: Cylinder Head, Guide Sleeves, Gasket And Bolts
Courtesy of GENERAL MOTORS COMPANY

25. Install NEW Cylinder Head Gasket (3)

NOTE: Ensure the guide sleeves (4) are properly seated in the engine block.

26. Install Cylinder Head (2)

27. Install NEW Cylinder Head Bolts (1) (Qty: 10) - Do NOT tighten.

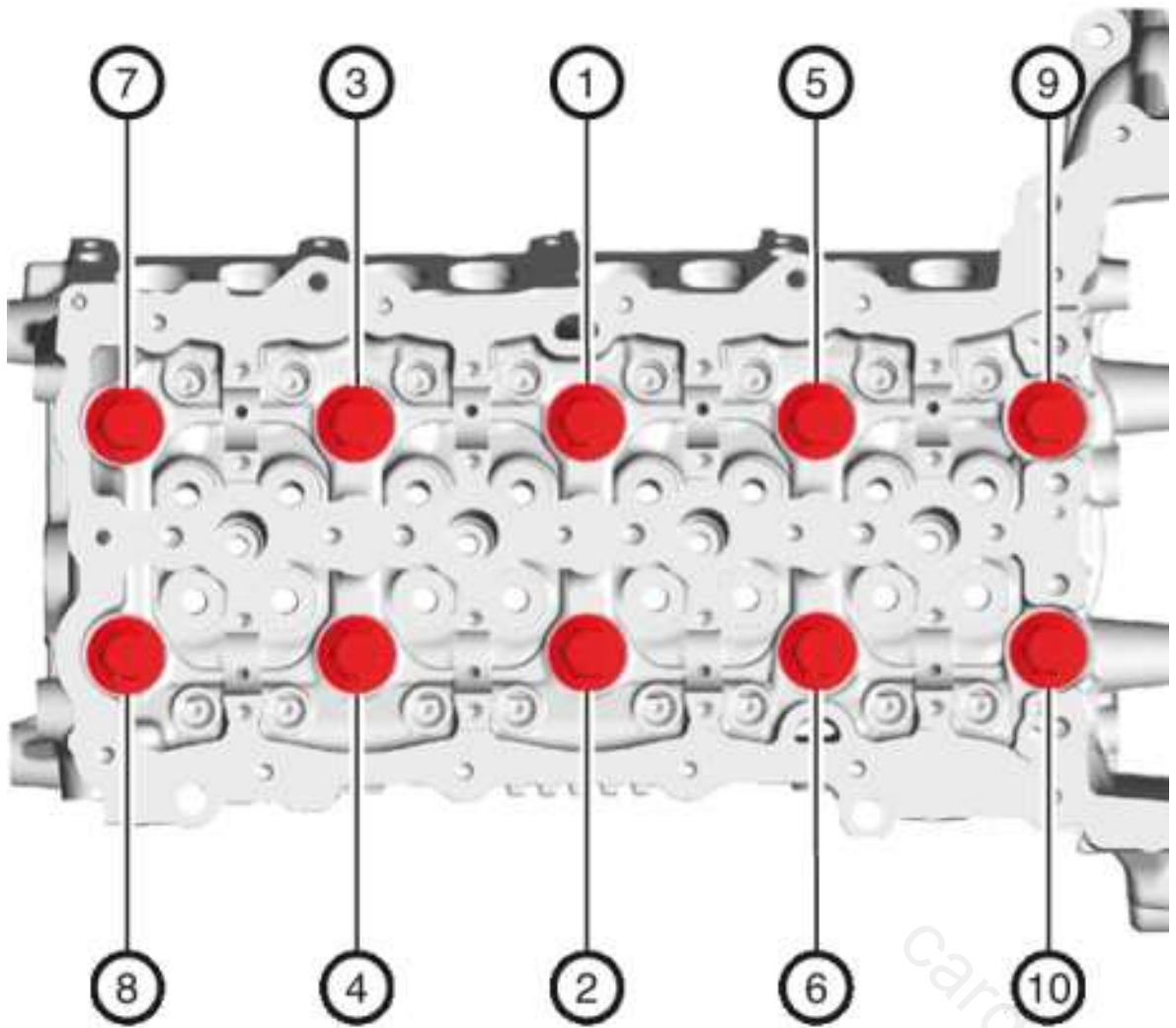


Fig. 812: Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

28. Tighten Cylinder Head Bolts in sequence

CAUTION: Refer to [Fastener Caution](#)

CAUTION: Refer to [Torque-to-Yield Fastener Caution](#)

1. First Pass: 50 N.m (37 lb ft)
2. Second Pass: 90 degrees - Use the special tool: **EN-45059** angle meter
3. Third Pass: 90 degrees - Use the special tool: **EN-45059** angle meter
4. Final Pass: 90 degrees - Use the special tool: **EN-45059** angle meter

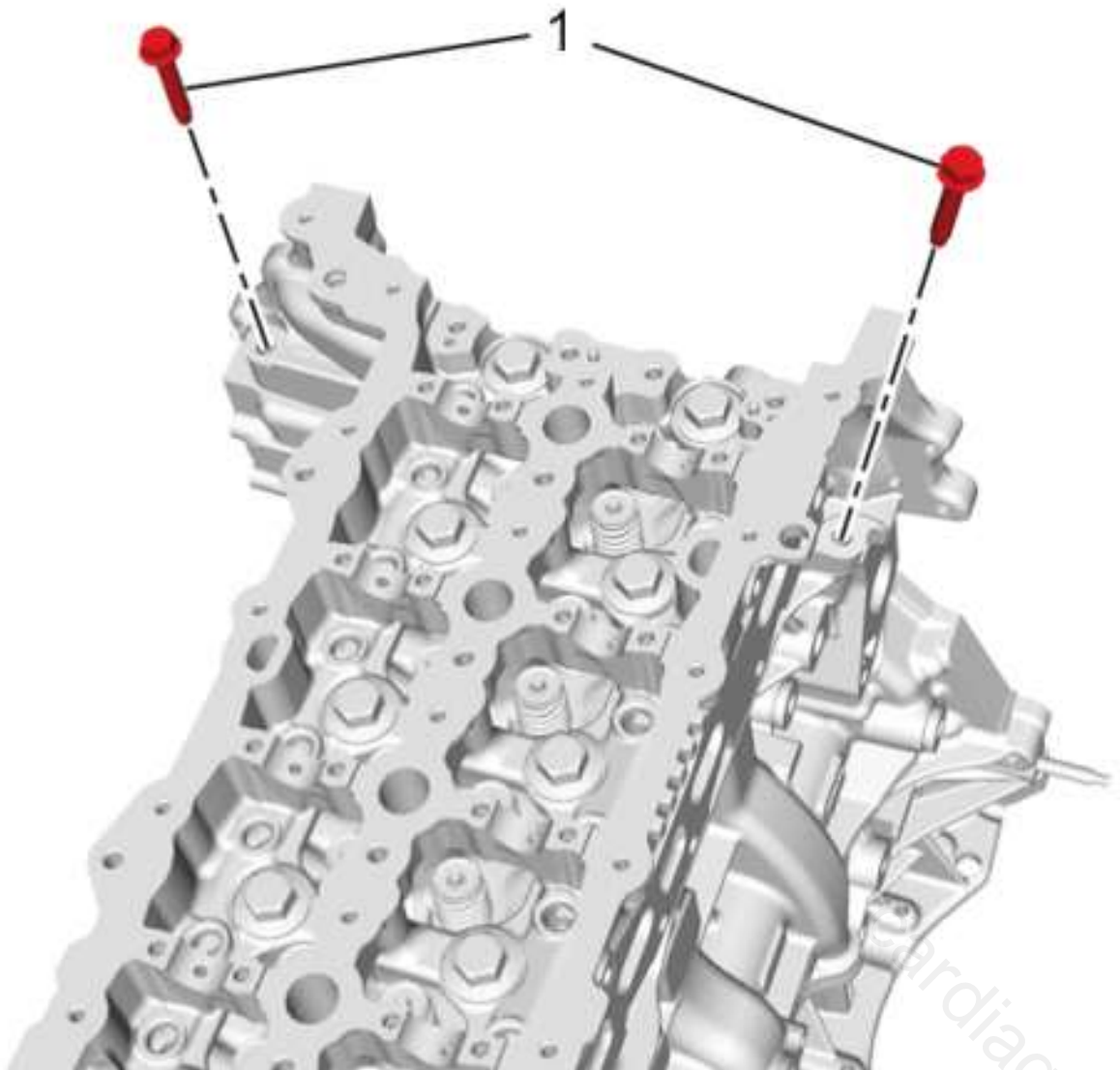


Fig. 813: Cylinder Head Outer Bolts

Courtesy of GENERAL MOTORS COMPANY

29. Install the NEW 2 cylinder head outer bolts (1) and tighten in 2 passes:

CAUTION: Refer to [Torque-to-Yield Fastener Caution](#)

1. First Pass: 20 N.m (15 lb ft)
2. Final Pass: 45 degrees - Use the special tool: **EN-45059** angle meter

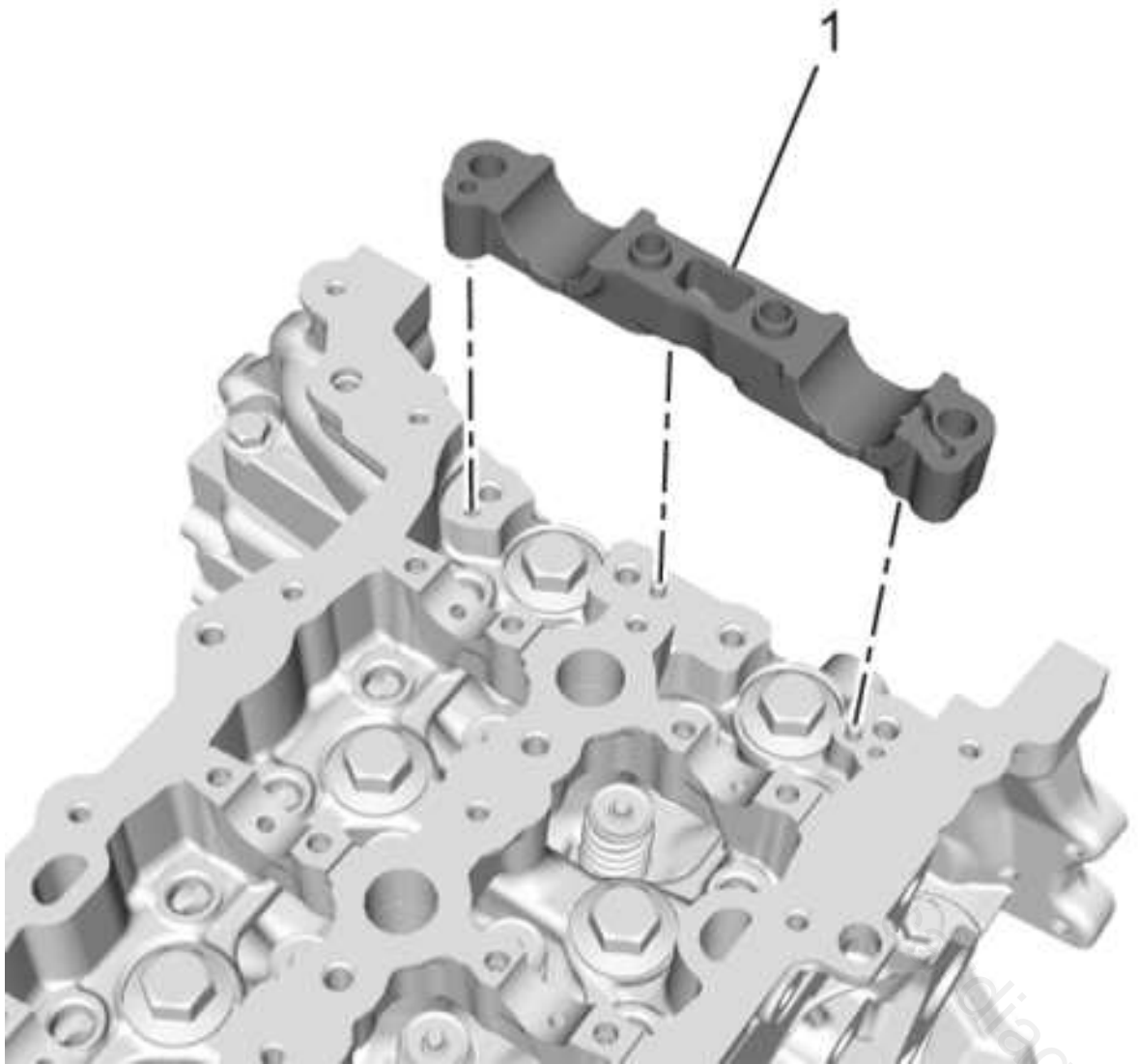


Fig. 814: Bearing Bracket

Courtesy of GENERAL MOTORS COMPANY

30. Install the bearing bracket (1).

CAMSHAFT POSITION SENSOR INSTALLATION

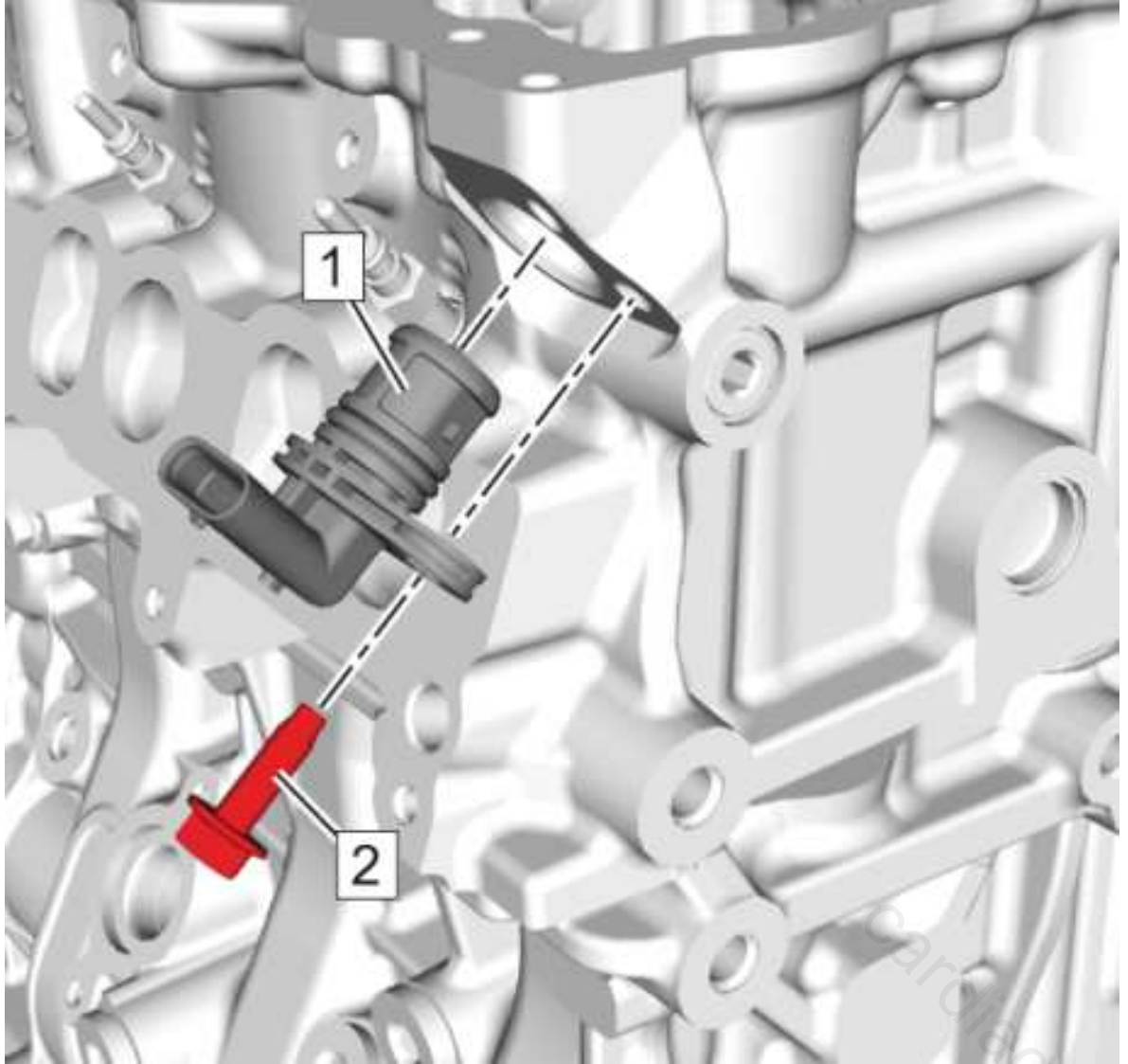


Fig. 815: Camshaft Position Sensor And Bolt
Courtesy of GENERAL MOTORS COMPANY

1. Install Camshaft Position Sensor (1)

CAUTION: Refer to [Fastener Caution](#)

2. Install and tighten Camshaft Position Sensor Bolt (2) to 10 N.m (89 lb in)

GLOW PLUG INSTALLATION

Special Tools

EN-6104 Glow Plug Socket

Equivalent regional tools : [Special Tools](#)

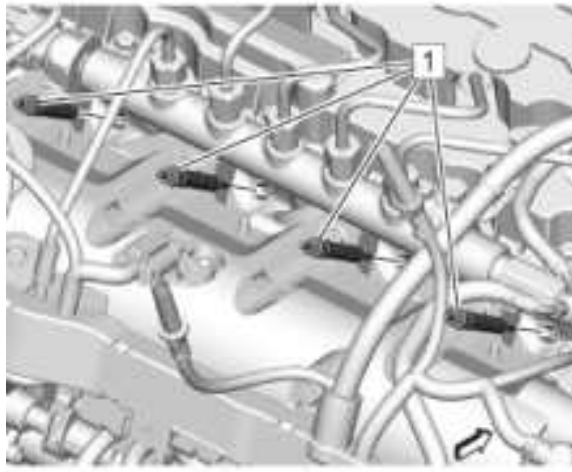


Fig. 816: Glow Plugs

Courtesy of GENERAL MOTORS COMPANY

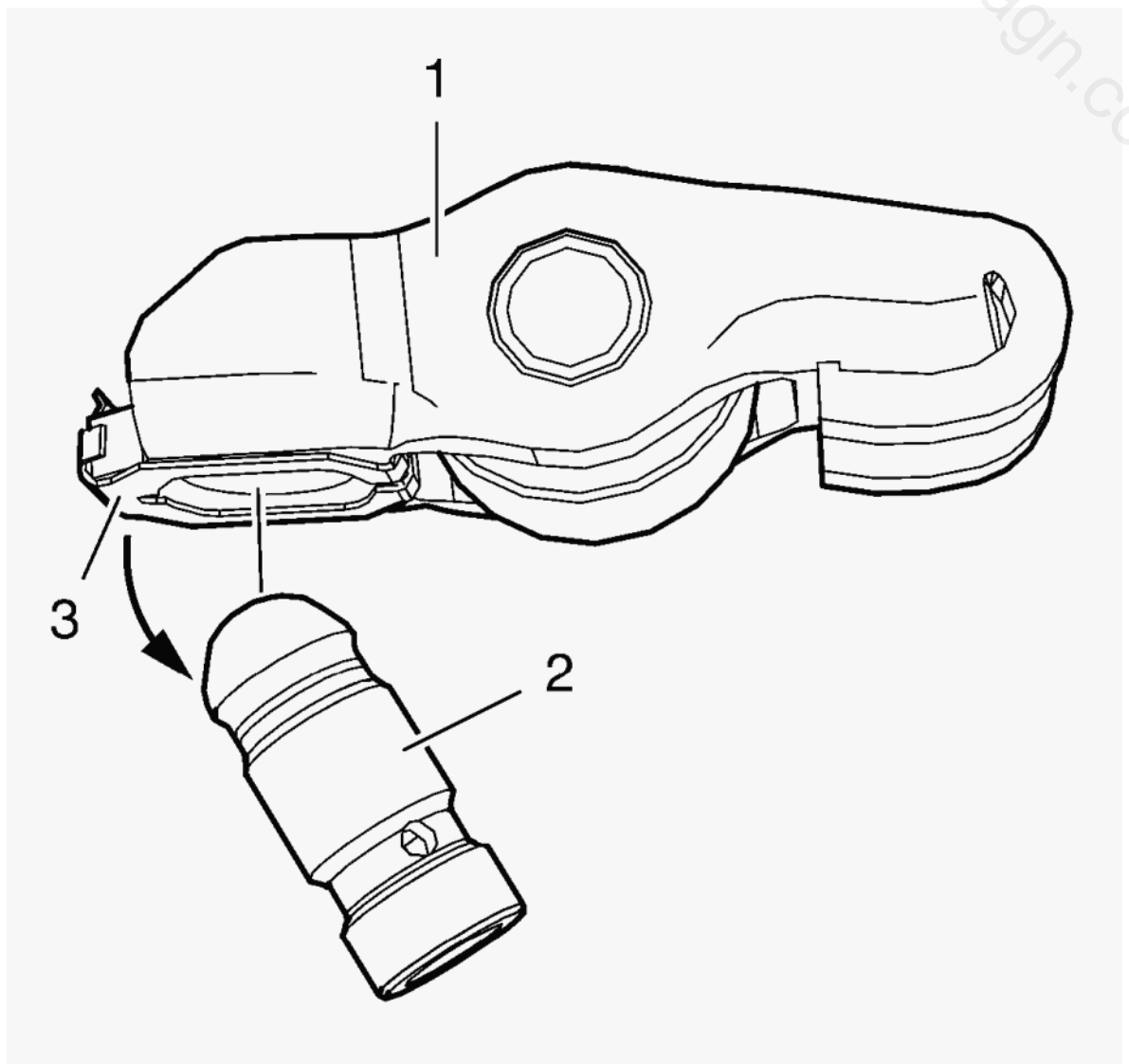
CAUTION: Refer to [Fastener Caution](#)

NOTE: To aid in hand starting glow plugs into their bores, a hose or tube with an inner diameter of 4 mm (0.2 in) can be used as an extension when installed on the end of the glow plug.

1. Install the 4 glow plugs (1) and tighten to 16.5 N.m (12 lb ft), using the **EN-6104** socket.

VALVE LIFTER INSTALLATION

1. Coat the 16 valve lifters with engine oil.



NOTE: Clip in the valve lifter to the valve lifter roller. Mind to the centering link on retainer spring (3).

2. Install the 16 valve lifters (2) to the valve lifter roller (1).

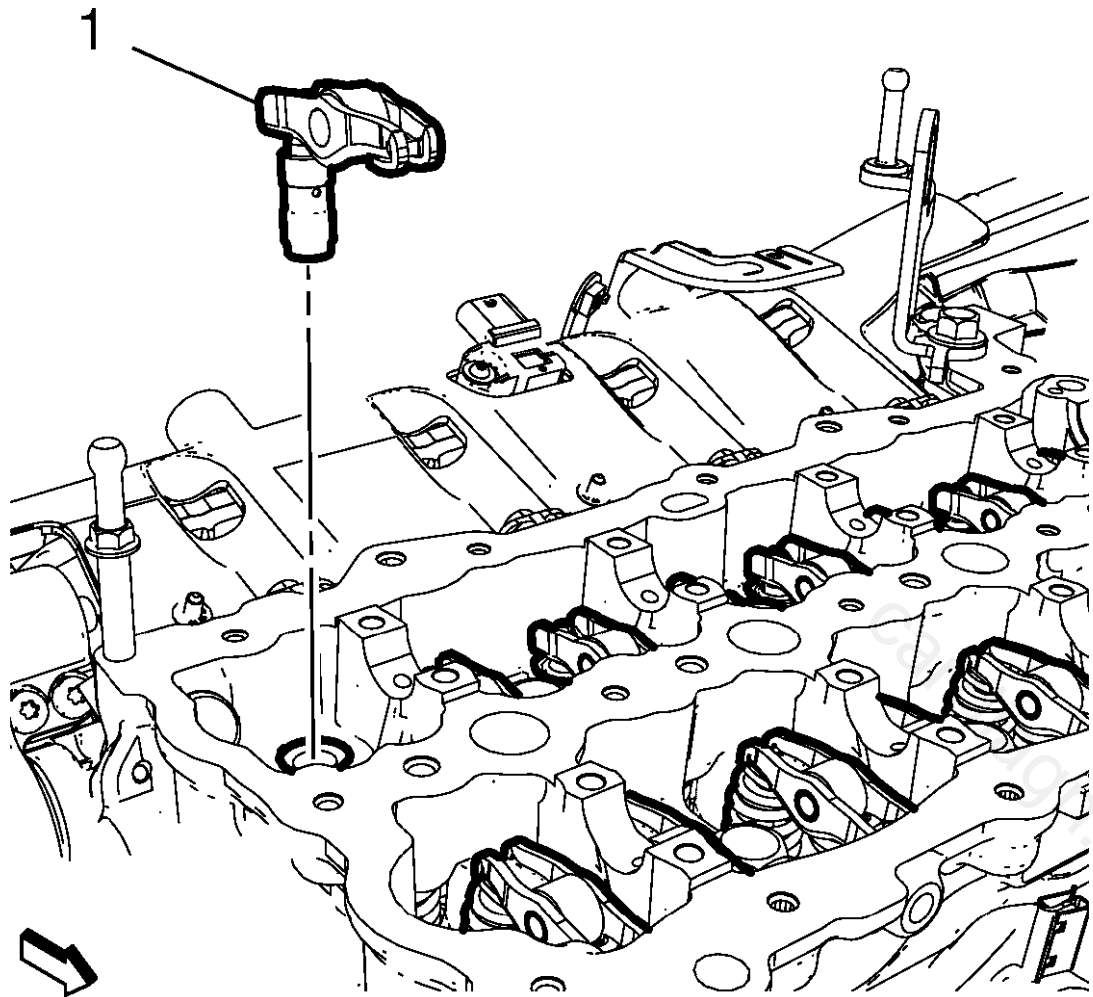


Fig. 818: Valve Lifter Roller Assemblies
Courtesy of GENERAL MOTORS COMPANY

NOTE: If the valve lifters or valve lifter rollers are reused, the valve lifter or valve lifter roller must be installed in their original position.

3. Install the 16 valve lifter with valve lifter roller (1) in the order as they were removed.

EXHAUST CAMSHAFT INSTALLATION

Special Tools

- EN-50509 Split Intake Camshaft Sprocket Fixing Tool
- EN-51143 Camshaft Sprocket Fixing Tool

For equivalent regional tools, refer to [Special Tools](#).

NOTE: Before installing the exhaust camshaft, check the components of the timing chain system for damage and wear.

1. Check the components of the timing chain system for damage and wear:
 - Timing chain guides with plastic attachment

- Timing chain tensioner and timing chain tensioner shoe with plastic attachment
- Timing chain and all timing chain sprockets
- Oil pump sprocket
- Oil pump drive chain tensioner

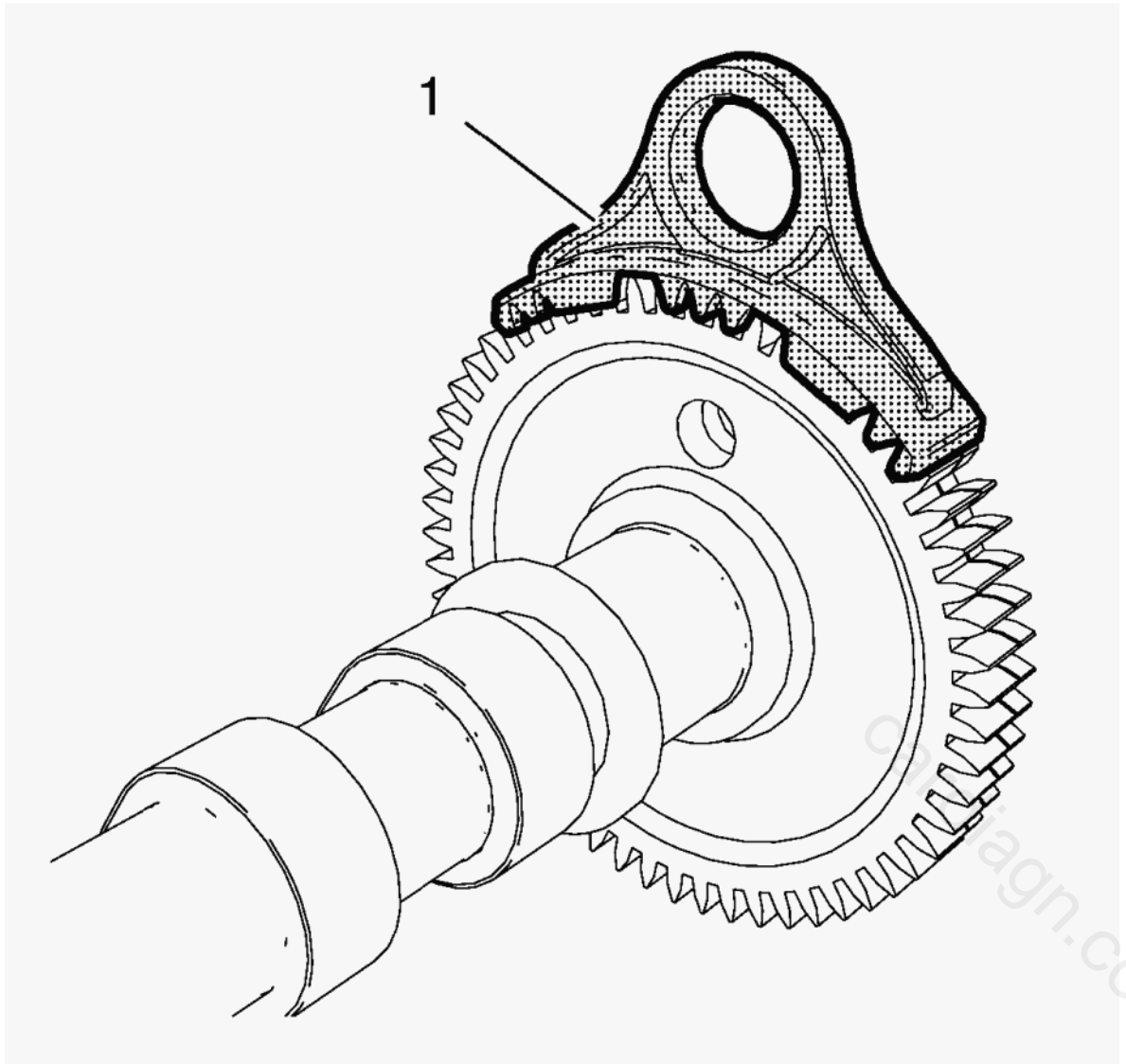


Fig. 819: Transport Lock

Courtesy of GENERAL MOTORS COMPANY

2. For Install a NEW exhaust camshaft do not remove the transport lock (1), before the exhaust camshaft and intake camshaft are installed.

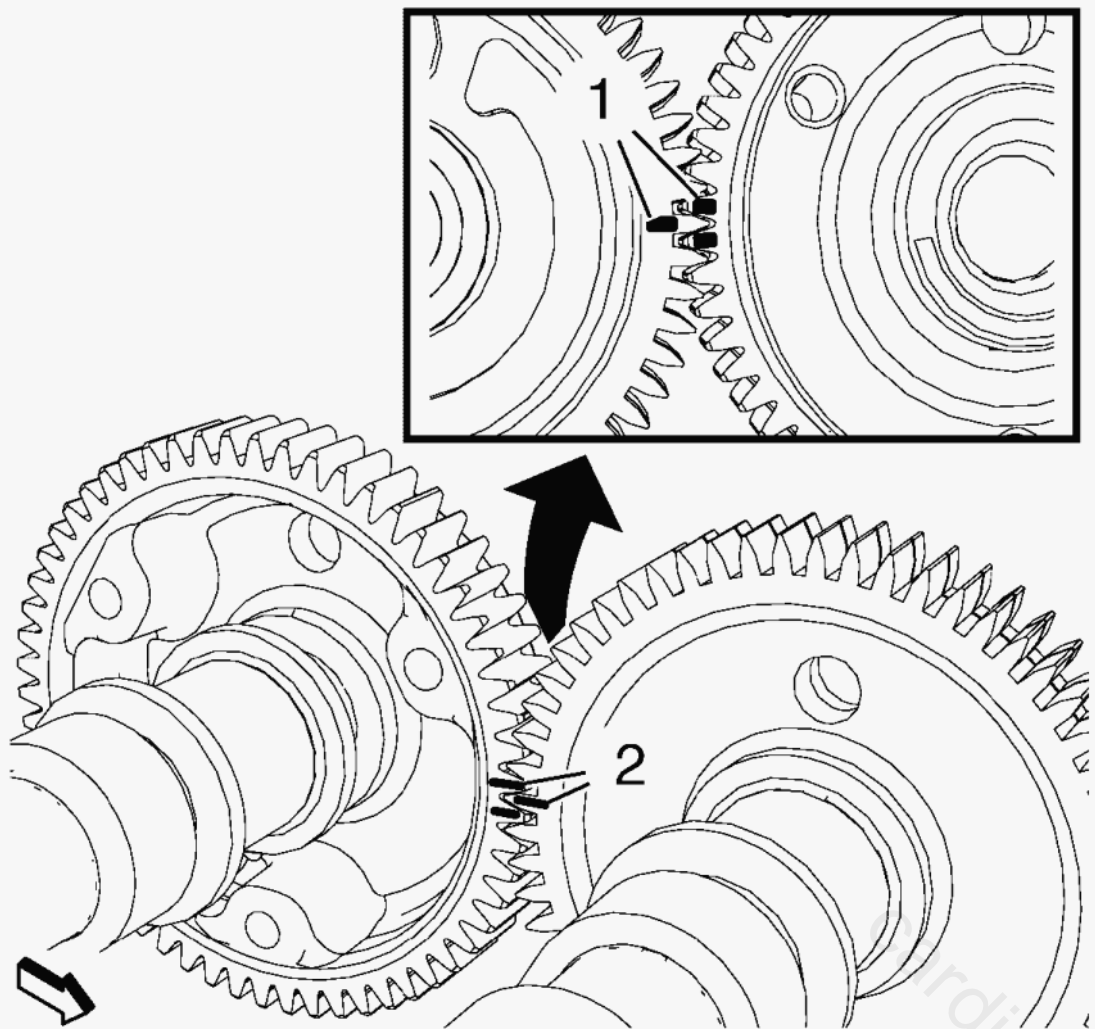


Fig. 820: Marking Camshaft Sprockets With Paint Marks By Transmitting Front Marks
Courtesy of GENERAL MOTORS COMPANY

NOTE: Transmit the front marks (1) on the back of the camshaft sprockets.

3. Marking the exhaust camshaft sprocket and intake camshaft sprocket with paint marks (2), by transmit the front marks (1).

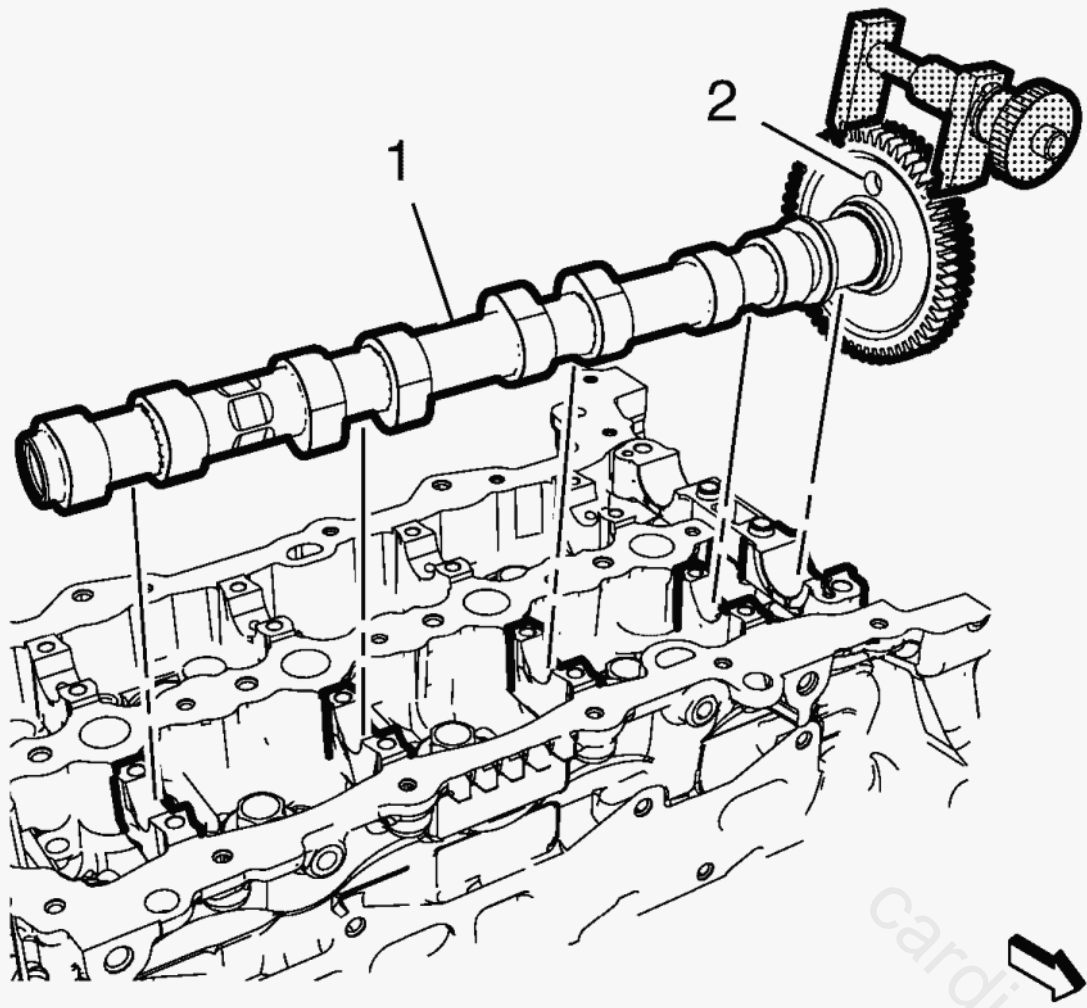


Fig. 821: Exhaust Camshaft With Bore Of Camshaft Sprocket Upwards
Courtesy of GENERAL MOTORS COMPANY

4. Coat all bearing surfaces with engine oil.
5. Install the exhaust camshaft (1), ensure the bore (2) of the camshaft sprocket shows upwards.

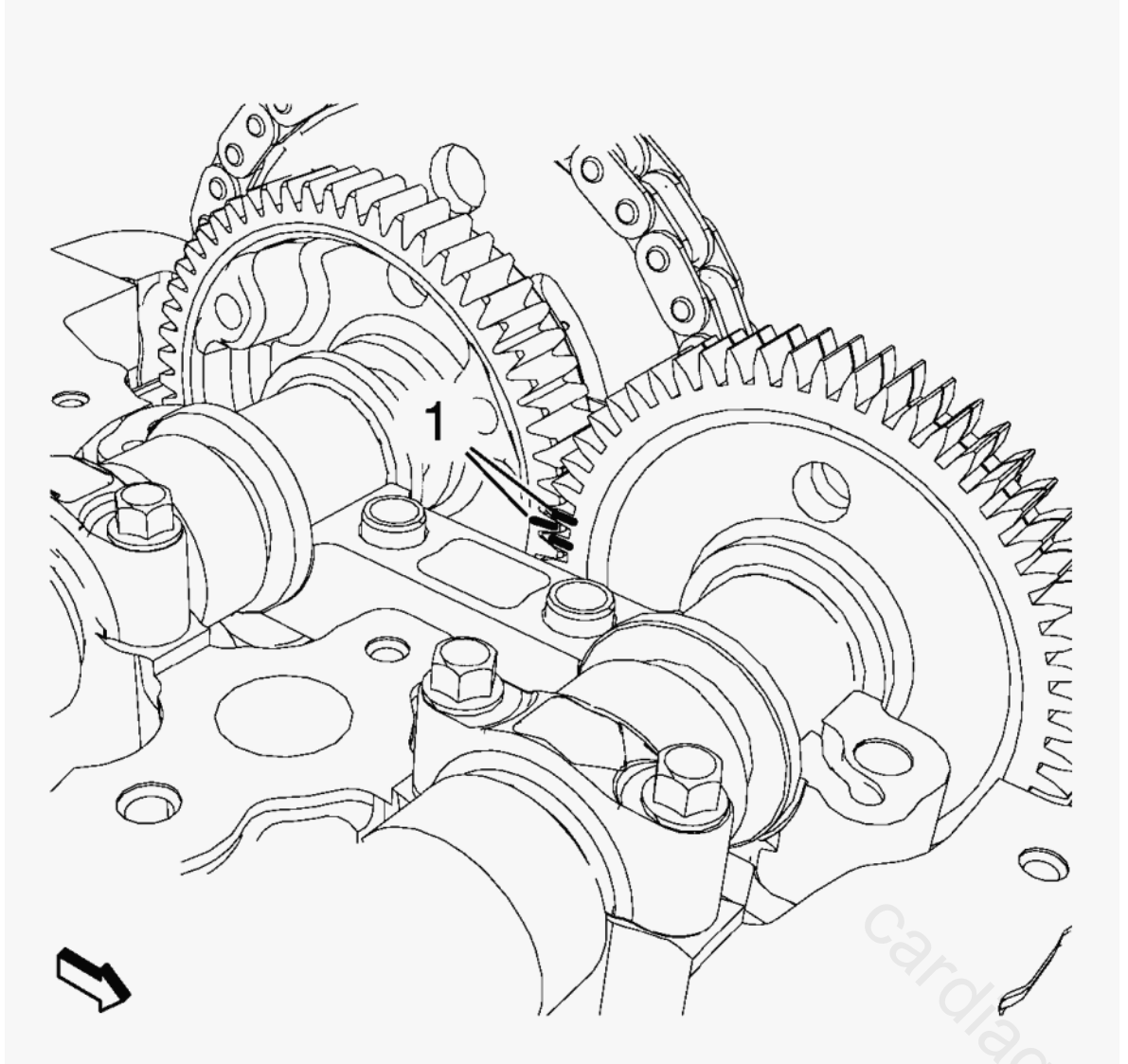


Fig. 822: Marking Exhaust Camshaft Sprocket And Intake Camshaft Sprocket With Paint Marks
Courtesy of GENERAL MOTORS COMPANY

6. Check the marks (1) of the camshaft sprockets whether they are aligned.

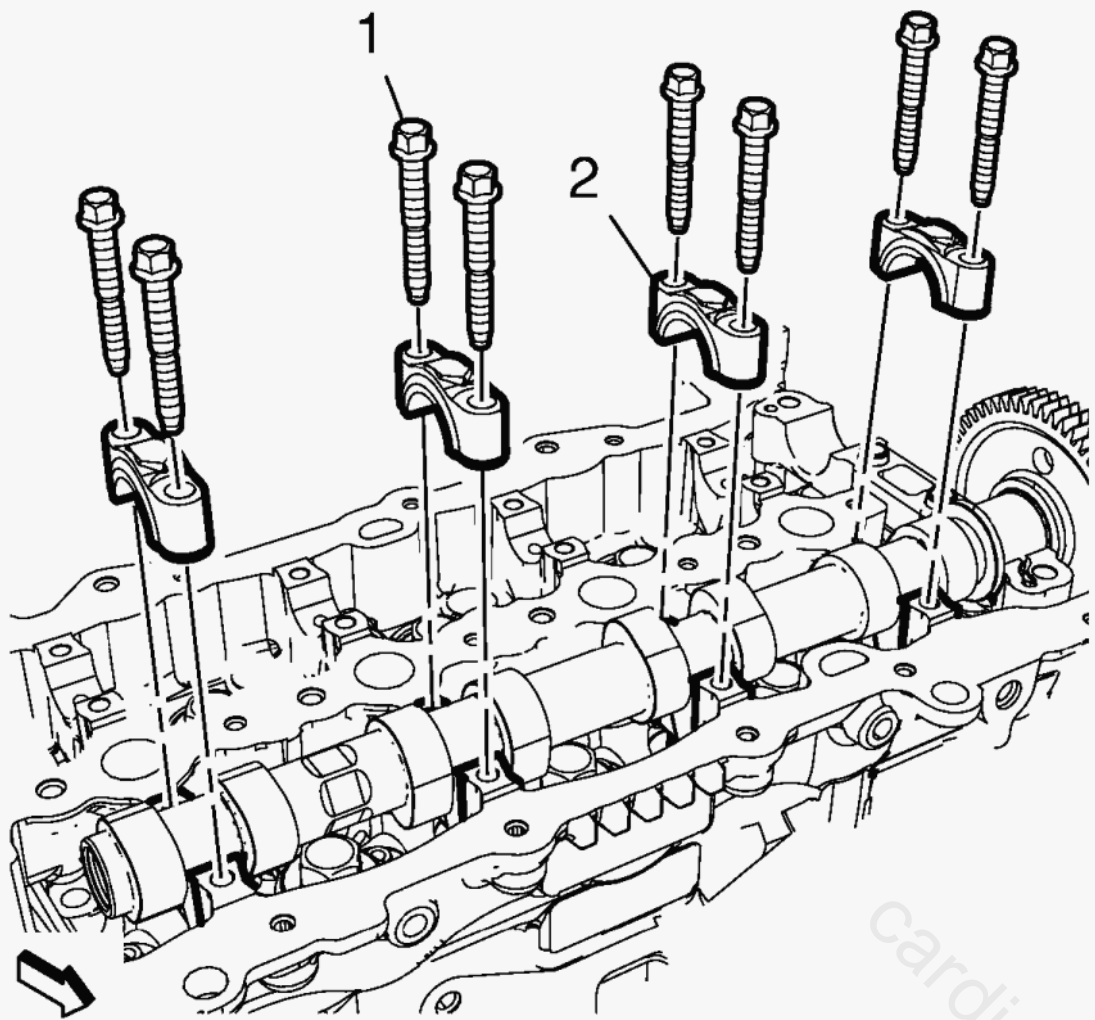


Fig. 823: Exhaust Camshaft Bearing Caps And Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: Note the arrows as marks on the camshaft bearing caps, which shows on the outside of the cylinder head.

7. Install the exhaust camshaft bearing caps (2) in the order as they was removed.
8. Install the exhaust camshaft bearing cap bolts (1).

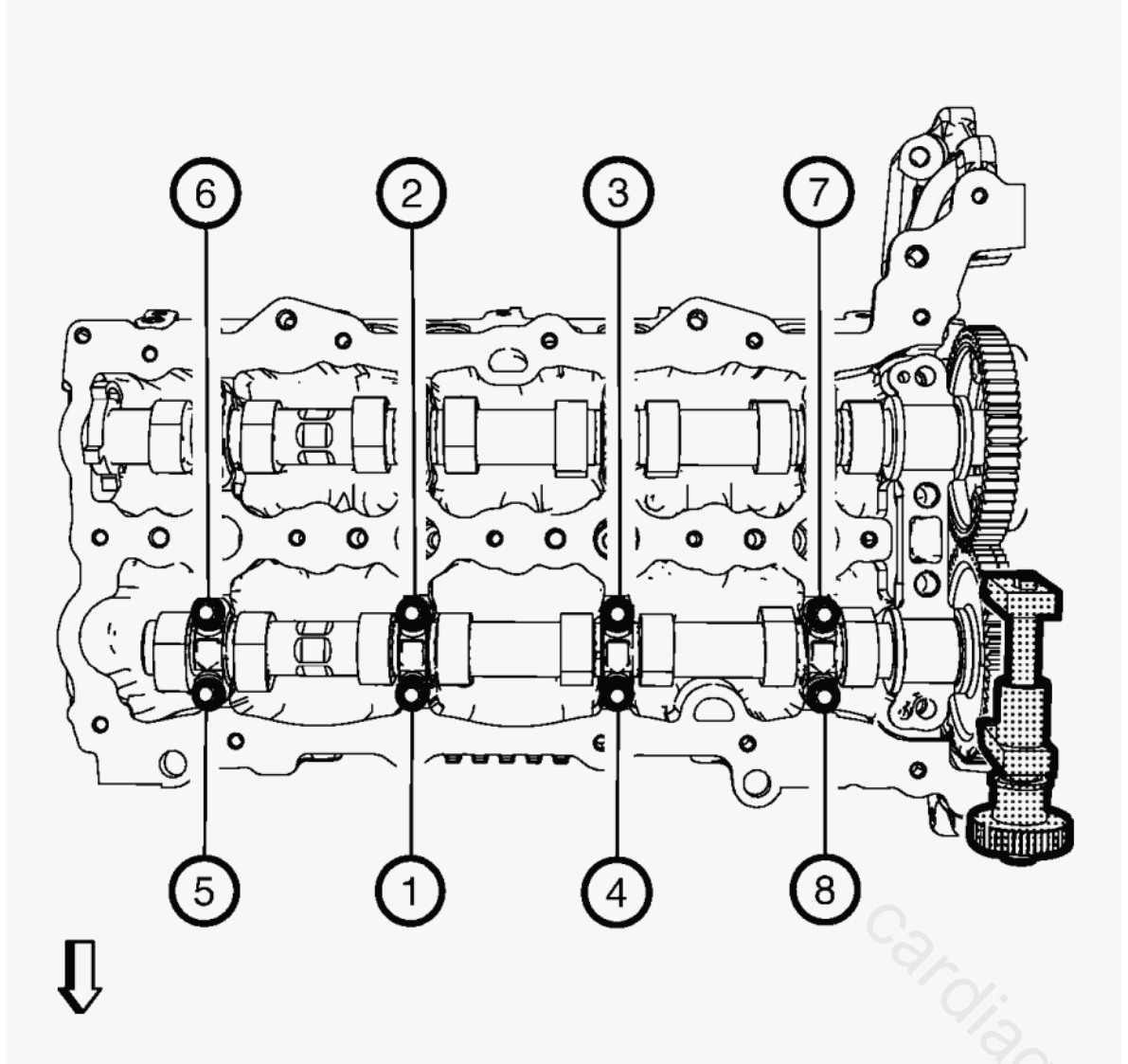


Fig. 824: Exhaust Camshaft Bearing Cap Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution** .

9. Tighten the 8 exhaust camshaft bearing cap bolts in sequence as shown to 10 N.m (89 lb in).

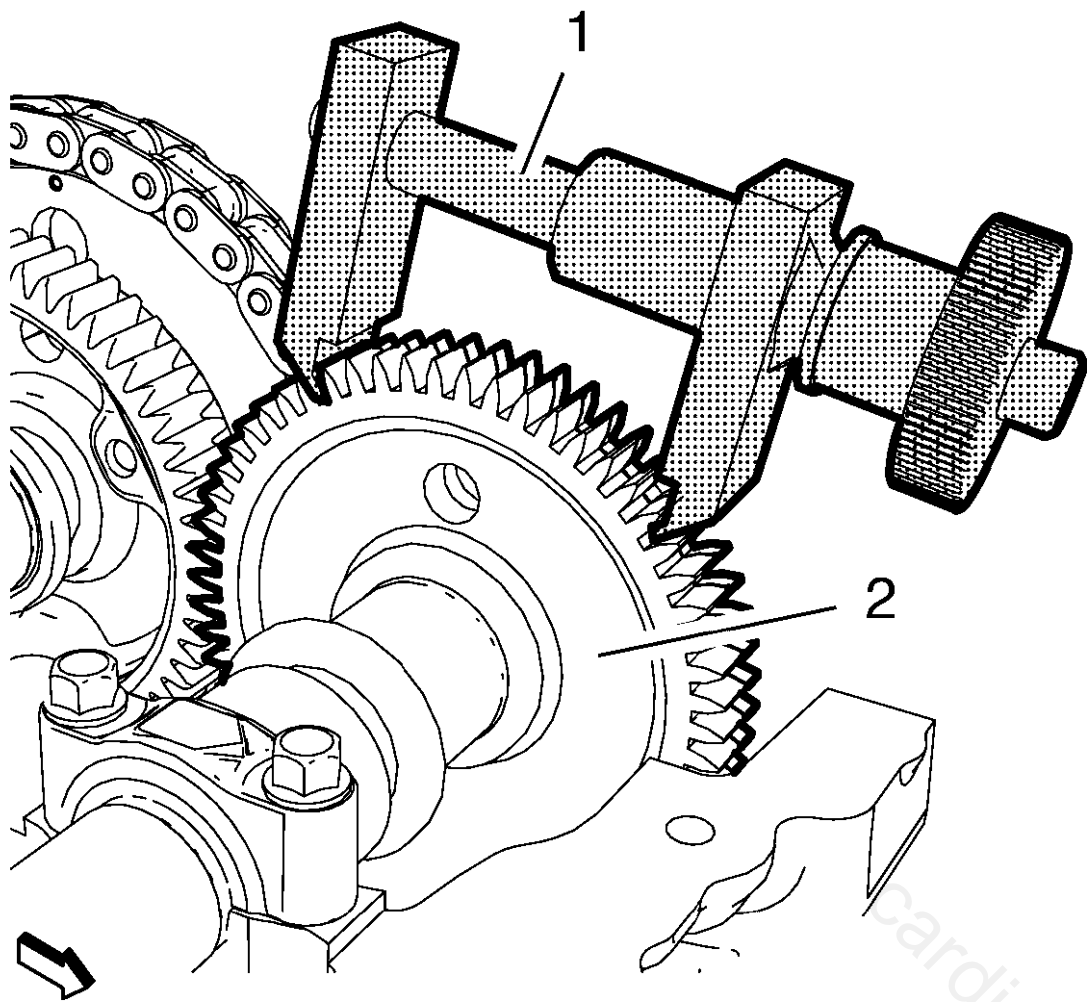


Fig. 825: Split Intake Camshaft Sprocket Fixing Tool
Courtesy of GENERAL MOTORS COMPANY

10. Remove the **EN-50509** fixing tool (1) or the transport lock from the exhaust camshaft sprocket (2).

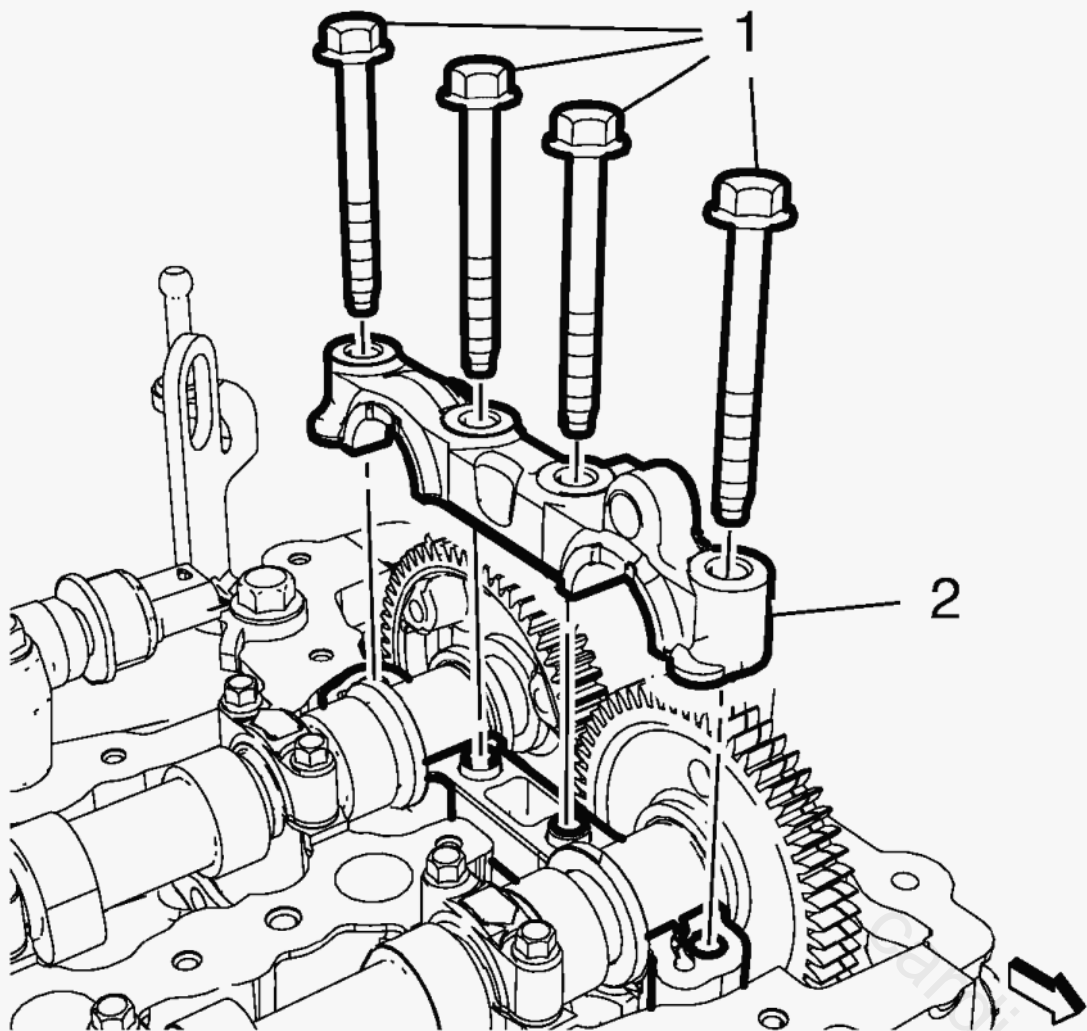


Fig. 826: Camshaft Bearing Rear Cap And Bolts
Courtesy of GENERAL MOTORS COMPANY

11. Coat all bearing surfaces with engine oil.
12. Install the camshaft bearing rear cap (2).
13. Install the 4 camshaft bearing rear cap bolts (1).

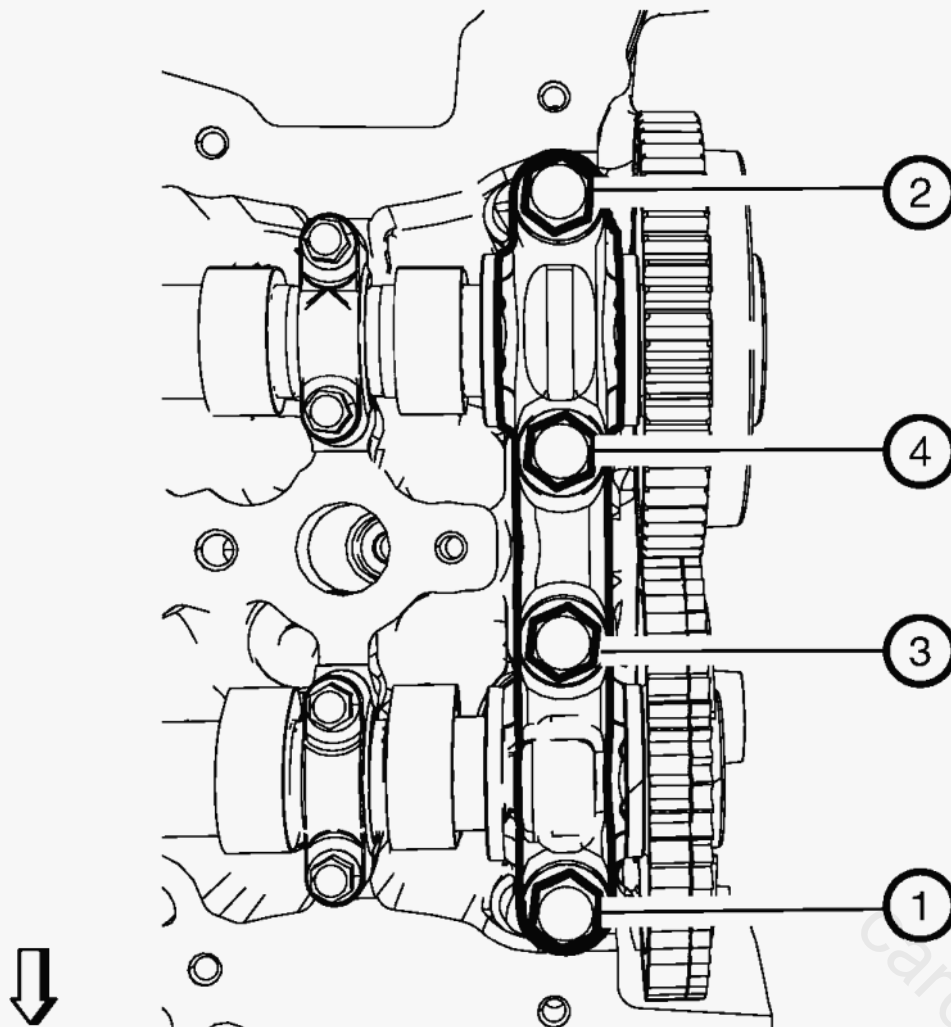


Fig. 827: Camshaft Rear Cap Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

14. Tighten the 4 camshaft rear cap bolts in sequence as shown to 25 N.m (18 lb ft).

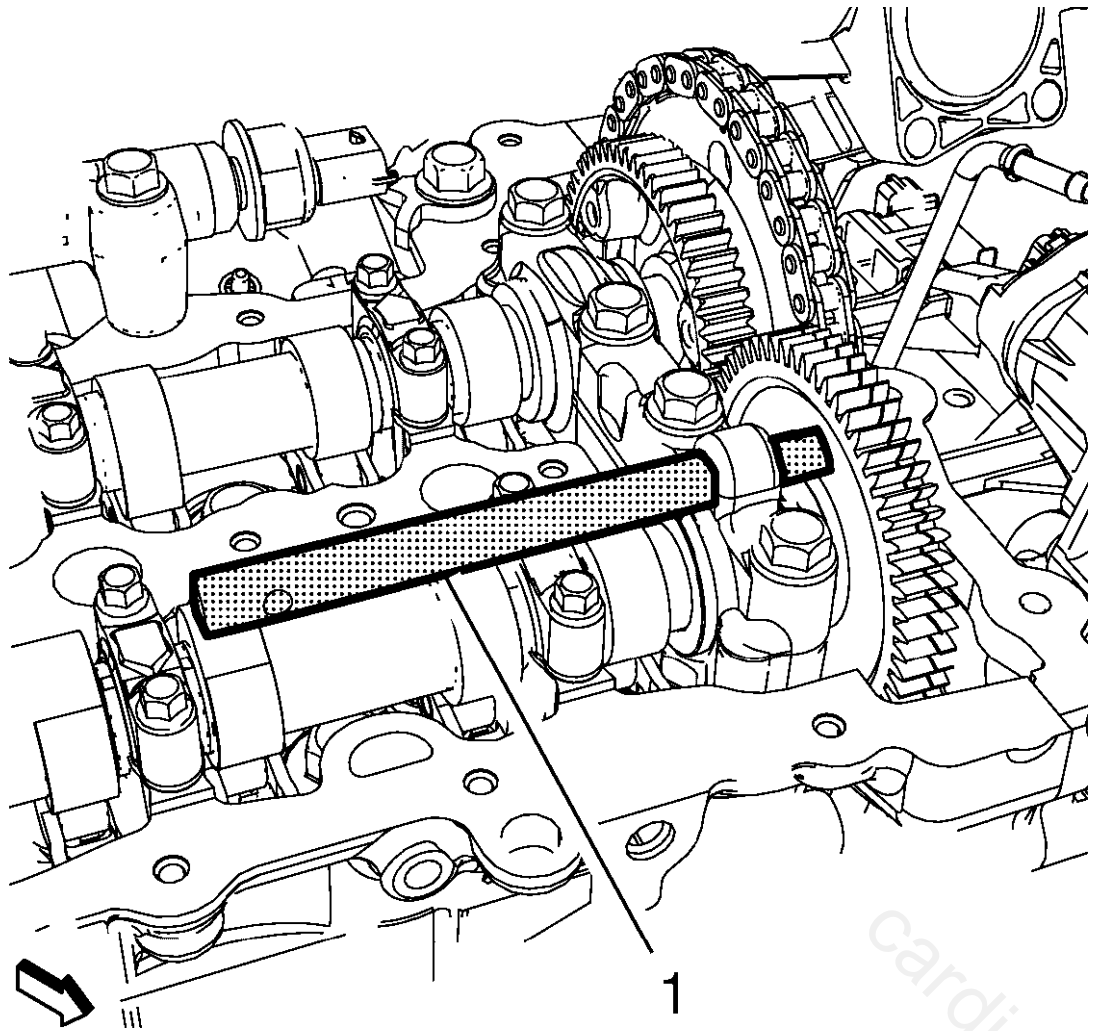


Fig. 828: Camshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

15. Install the EN-51143 fixing tool (1), by carefully turning the hexagon of the camshaft.

INTAKE CAMSHAFT INSTALLATION

Special Tools

- EN-50509 Split Intake Camshaft Sprocket Fixing Tool
- EN-51143 Camshaft Sprocket Fixing Tool

For equivalent regional tools, refer to [Special Tools](#).

NOTE: Before installing the intake camshaft, check the components of the timing chain system for damage and wear.

1. Check the components of the timing chain system for damage and wear:
 - Timing chain guides with plastic attachment
 - Timing chain tensioner and timing chain tensioner shoe with plastic attachment
 - Timing chain and all timing chain sprockets
 - Oil pump sprocket
 - Oil pump drive chain tensioner

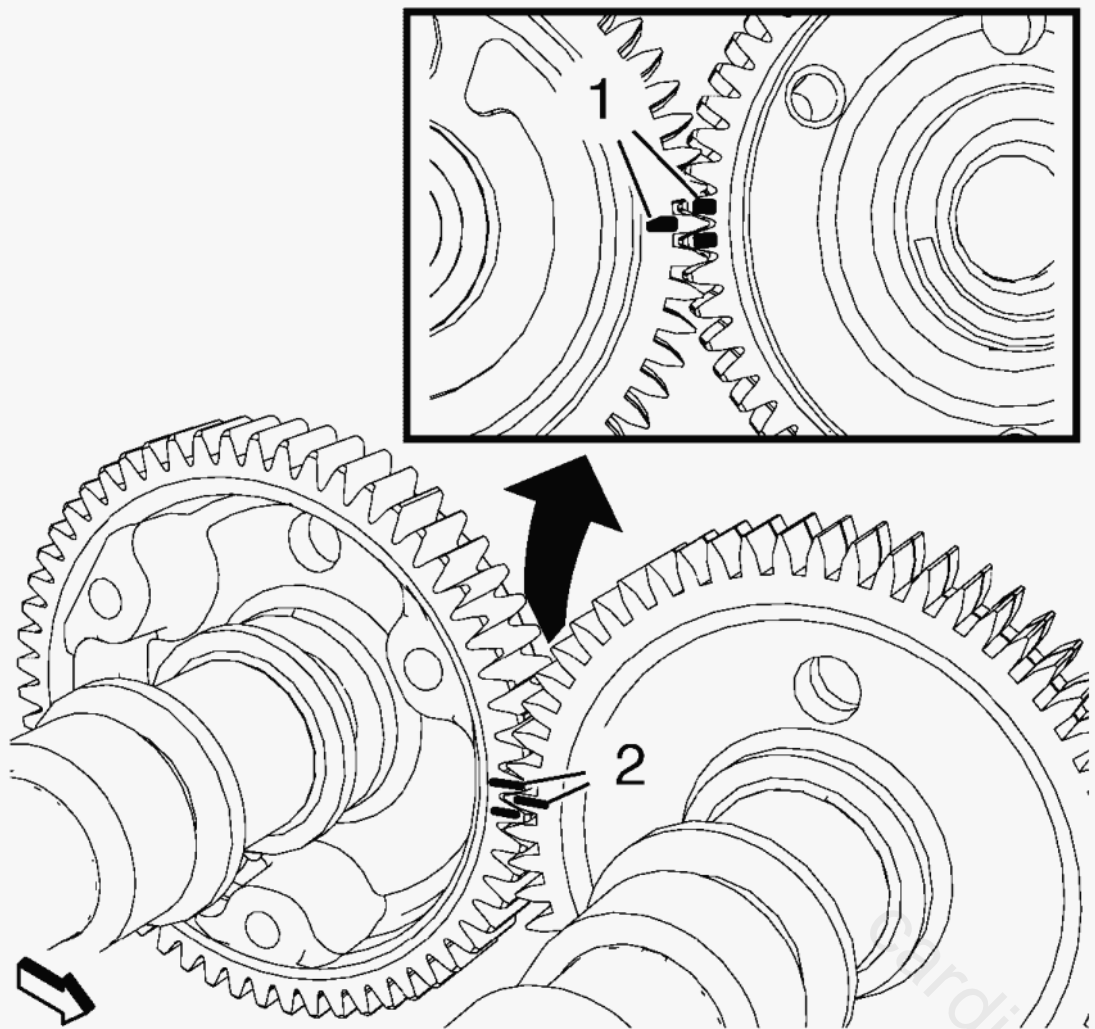


Fig. 829: Marking Camshaft Sprockets With Paint Marks By Transmitting Front Marks
Courtesy of GENERAL MOTORS COMPANY

NOTE: Transmit the front marks (1) on the back of the camshaft sprockets.

2. Marking the exhaust camshaft sprocket and intake camshaft sprocket with paint marks (2), by transmit the front marks (1).

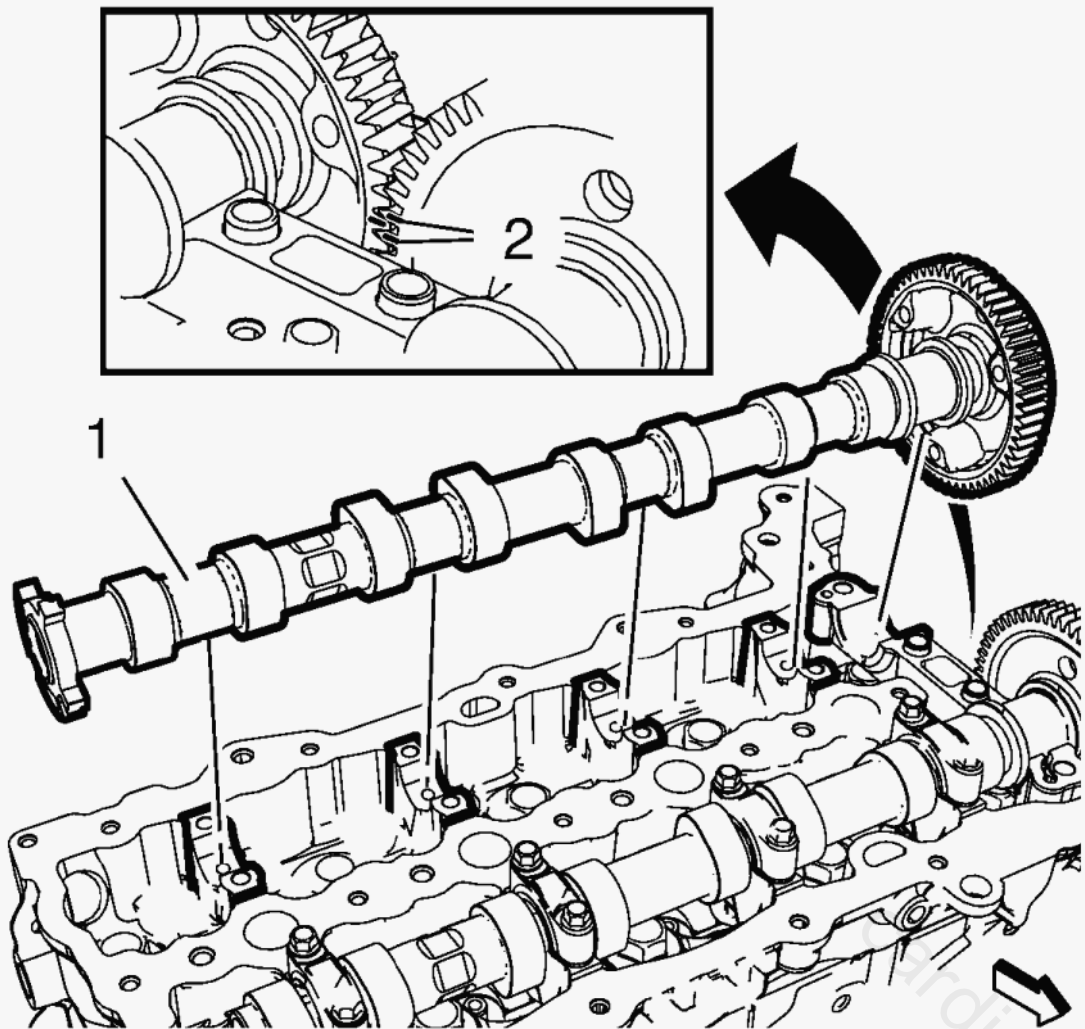


Fig. 830: Intake Camshaft With Camshaft Sprocket Marks Aligned
Courtesy of GENERAL MOTORS COMPANY

3. Coat all bearing surfaces with engine oil.

NOTE: Ensure the marks (2) of the camshaft sprocket are aligned.

4. Install the intake camshaft (1).

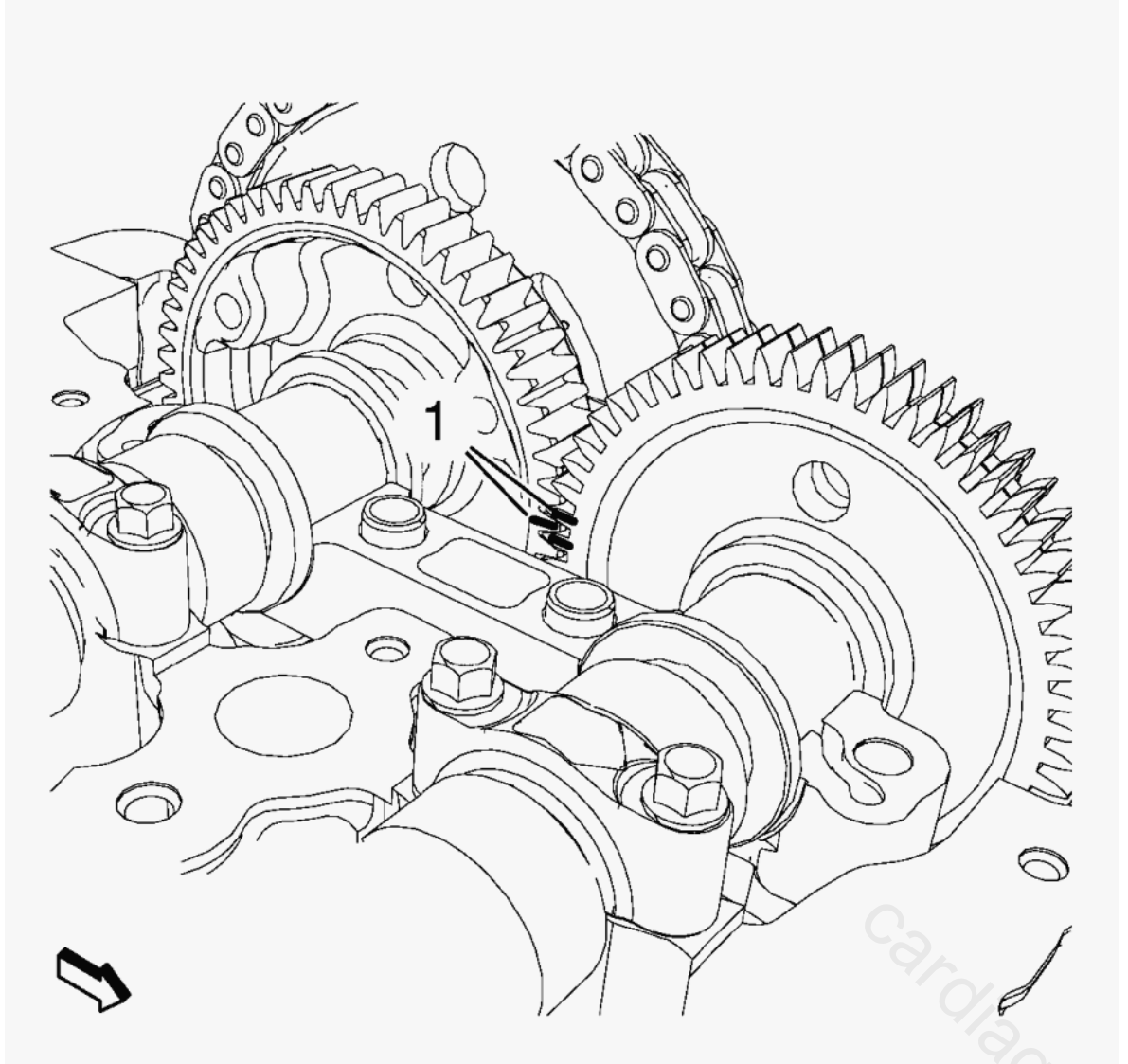


Fig. 831: Marking Exhaust Camshaft Sprocket And Intake Camshaft Sprocket With Paint Marks
Courtesy of GENERAL MOTORS COMPANY

5. Check the marks (1) of the camshaft sprockets whether they are aligned.

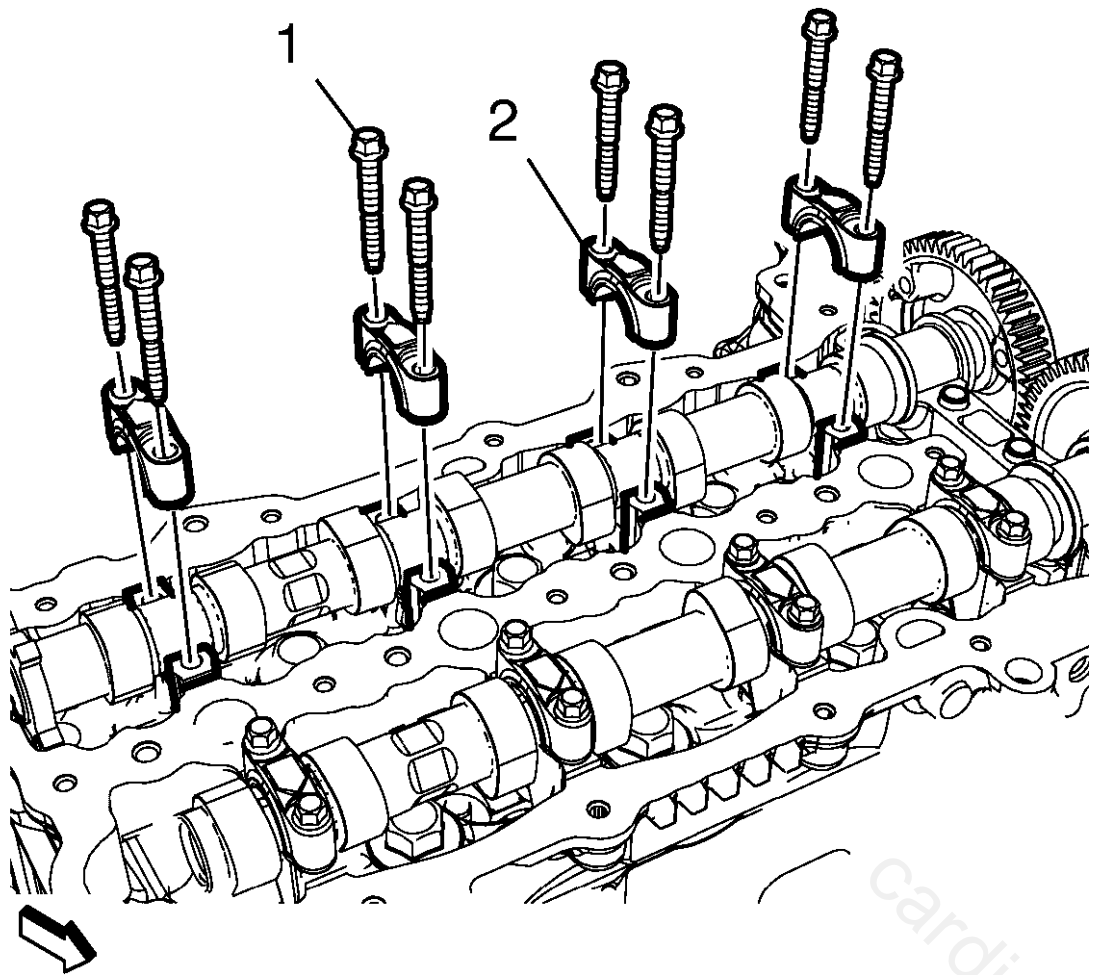


Fig. 832: Intake Camshaft Bearing Caps And Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: Note the arrows as marks on the camshaft bearing caps, which shows on the outside of the cylinder head.

6. Install the intake camshaft bearing caps (2) in the order as they was removed.
7. Install the intake camshaft bearing cap bolts (1).

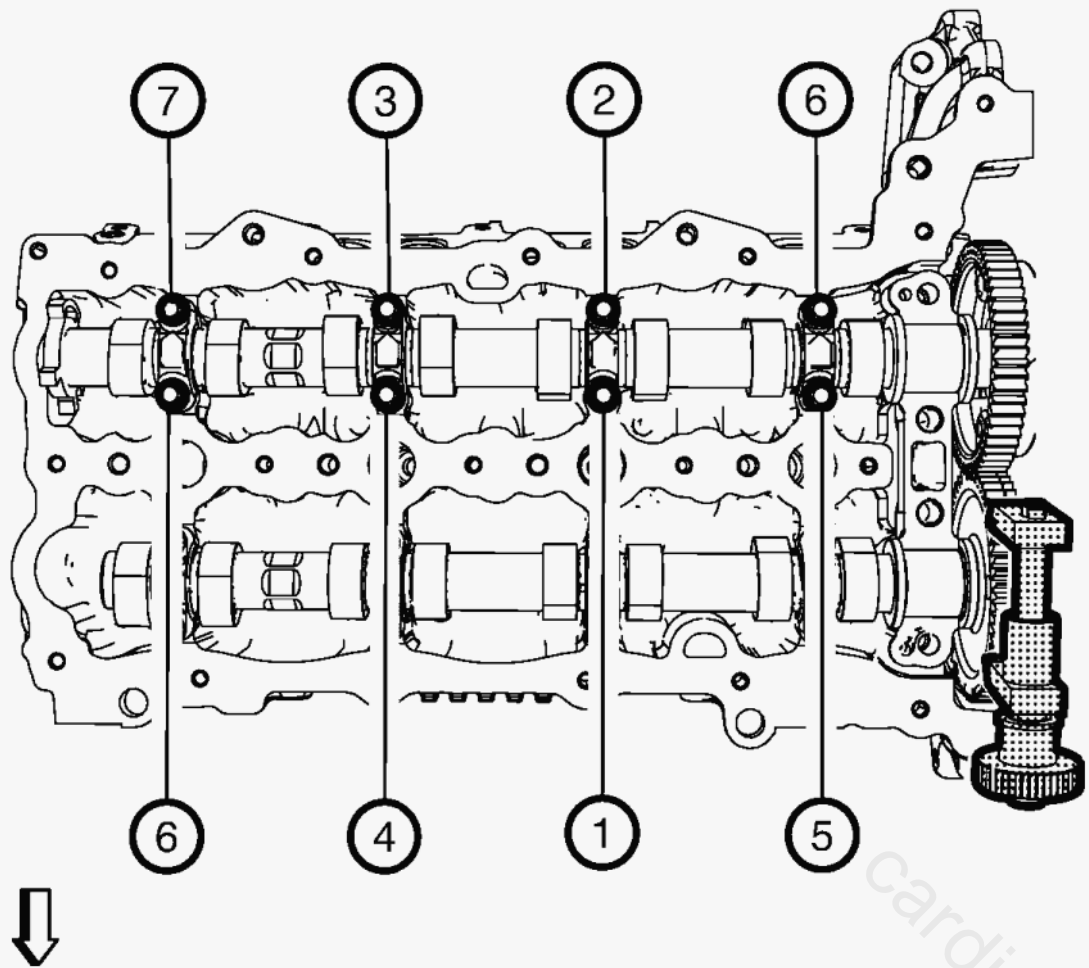


Fig. 833: Intake Camshaft Bearing Cap Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution** .

8. Tighten the 8 intake camshaft bearing cap bolts in sequence as shown to 10 N.m (89 lb in).

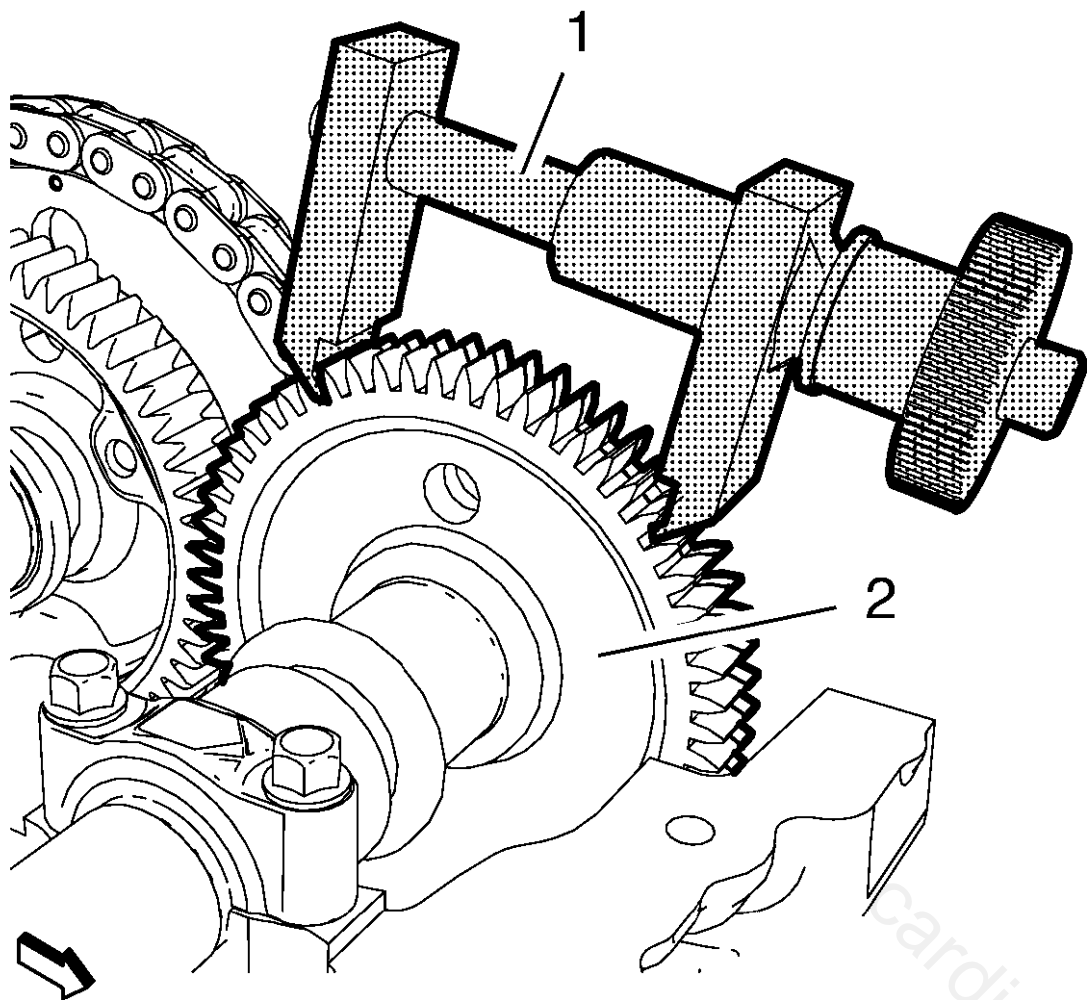


Fig. 834: Split Intake Camshaft Sprocket Fixing Tool
Courtesy of GENERAL MOTORS COMPANY

9. Remove the **EN-50509** fixing tool (1) or the transport lock from the exhaust camshaft sprocket (2).

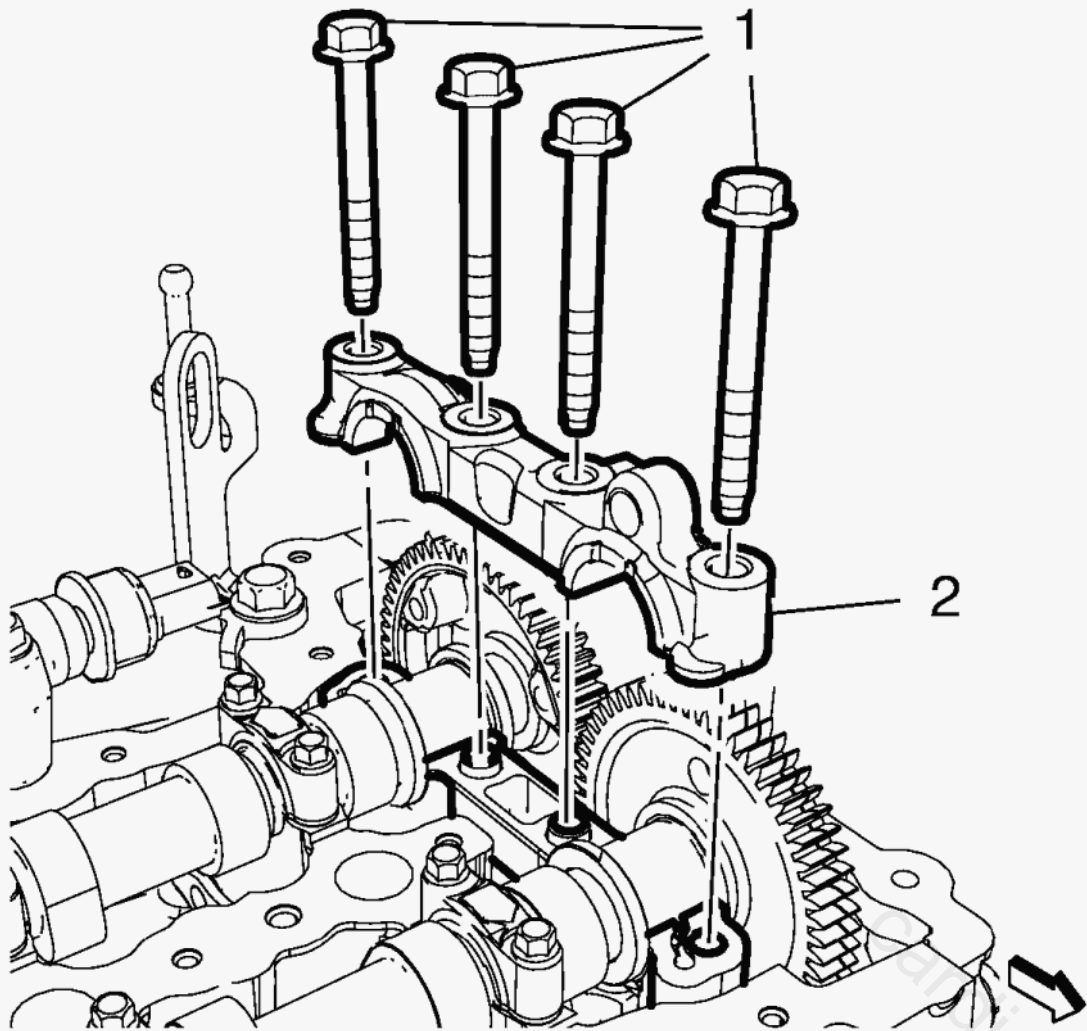


Fig. 835: Camshaft Bearing Rear Cap And Bolts
Courtesy of GENERAL MOTORS COMPANY

10. Coat all bearing surfaces with engine oil.
11. Install the camshaft bearing rear cap (2).
12. Install the 4 camshaft bearing rear cap bolts (1).

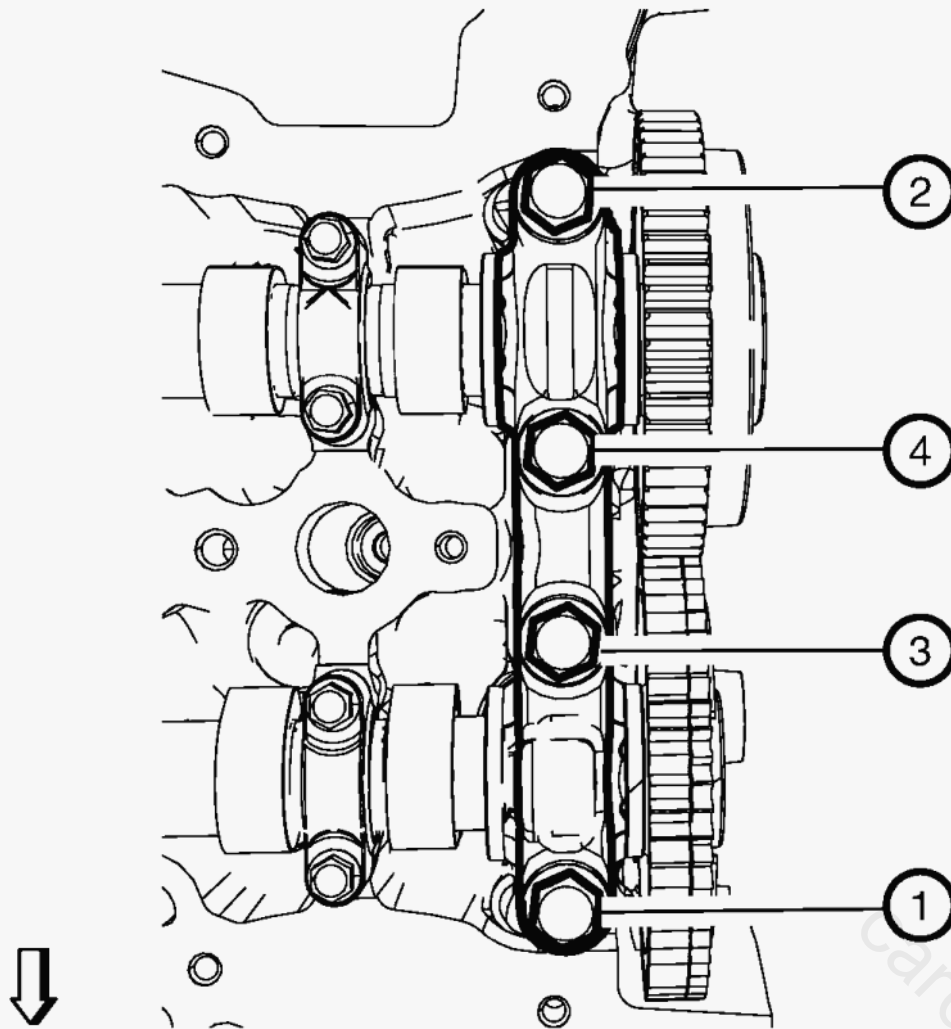


Fig. 836: Camshaft Rear Cap Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

13. Tighten the 4 camshaft rear cap bolts in sequence as shown to 25 N.m (18 lb ft).

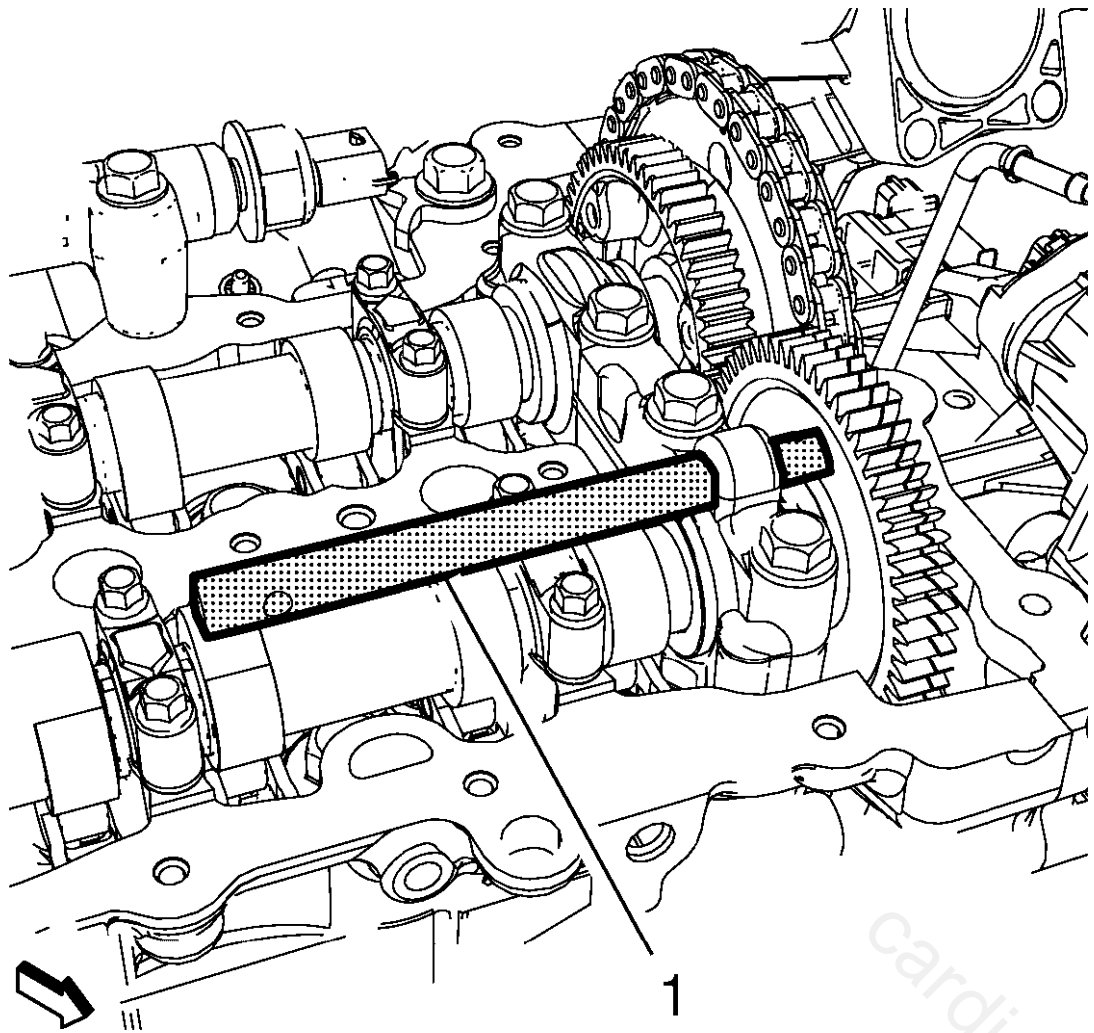


Fig. 837: Camshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

14. Install the EN-51143 fixing tool (1), by carefully turning the hexagon of the camshaft.

CAMSHAFT SPROCKET INSTALLATION

NOTE: Before installing the camshaft sprocket, check the components of the timing chain system for damage and wear.

1. Check the components of the timing chain system for damage and wear:
 - Timing chain guides with plastic attachment
 - Timing chain tensioner and timing chain tensioner shoe with plastic attachment
 - Timing chain and all timing chain sprockets
 - Oil pump sprocket
 - Oil pump drive chain tensioner

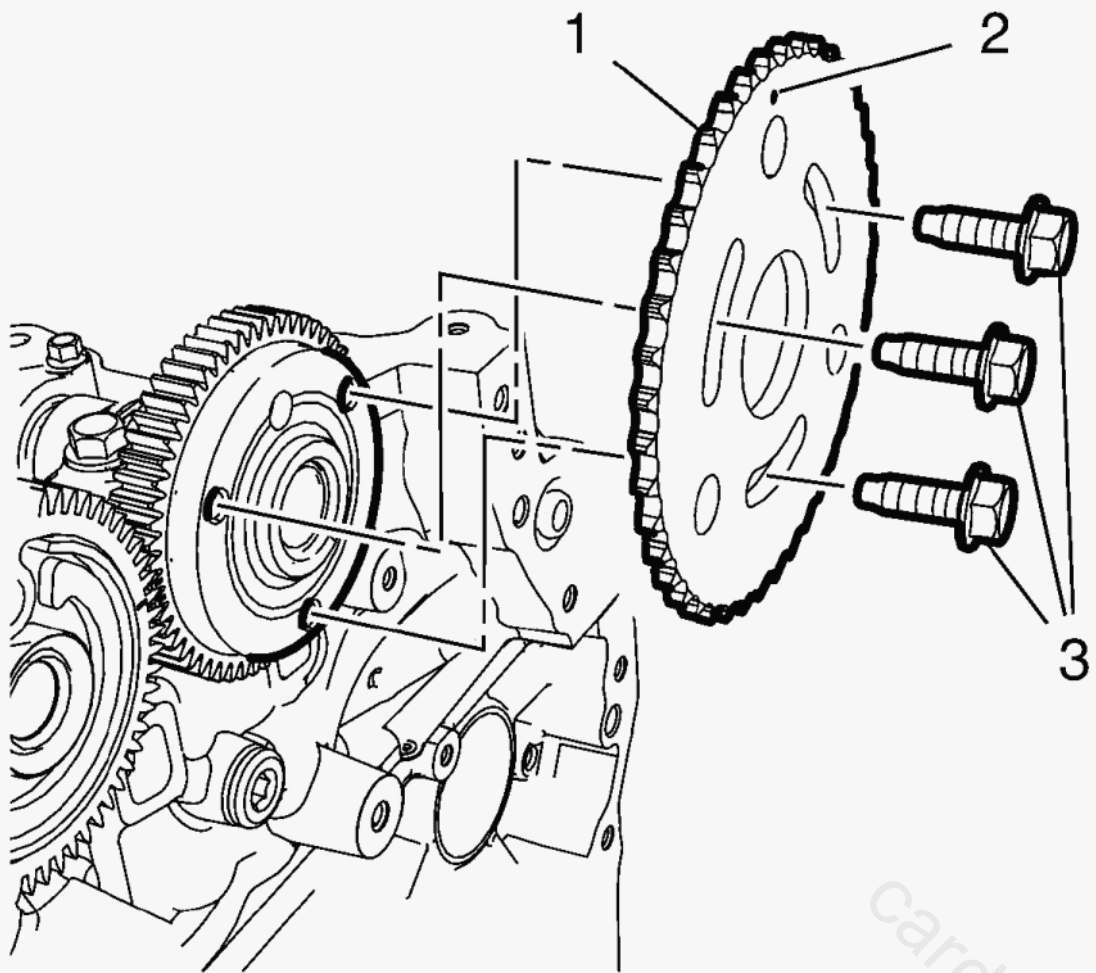


Fig. 838: Camshaft Sprocket And Bolts

Courtesy of GENERAL MOTORS COMPANY

2. Position the camshaft sprocket mark (2) at a 12 o'clock position and install the camshaft sprocket (1) to the intake camshaft.

CAUTION: Refer to **Fastener Caution** .

3. Install the 3 camshaft sprocket bolts (3) and tighten to 25 N.m (18 lb ft), counterhold with a wrench at the camshaft hexagon.

FUEL INJECTION PUMP INSTALLATION

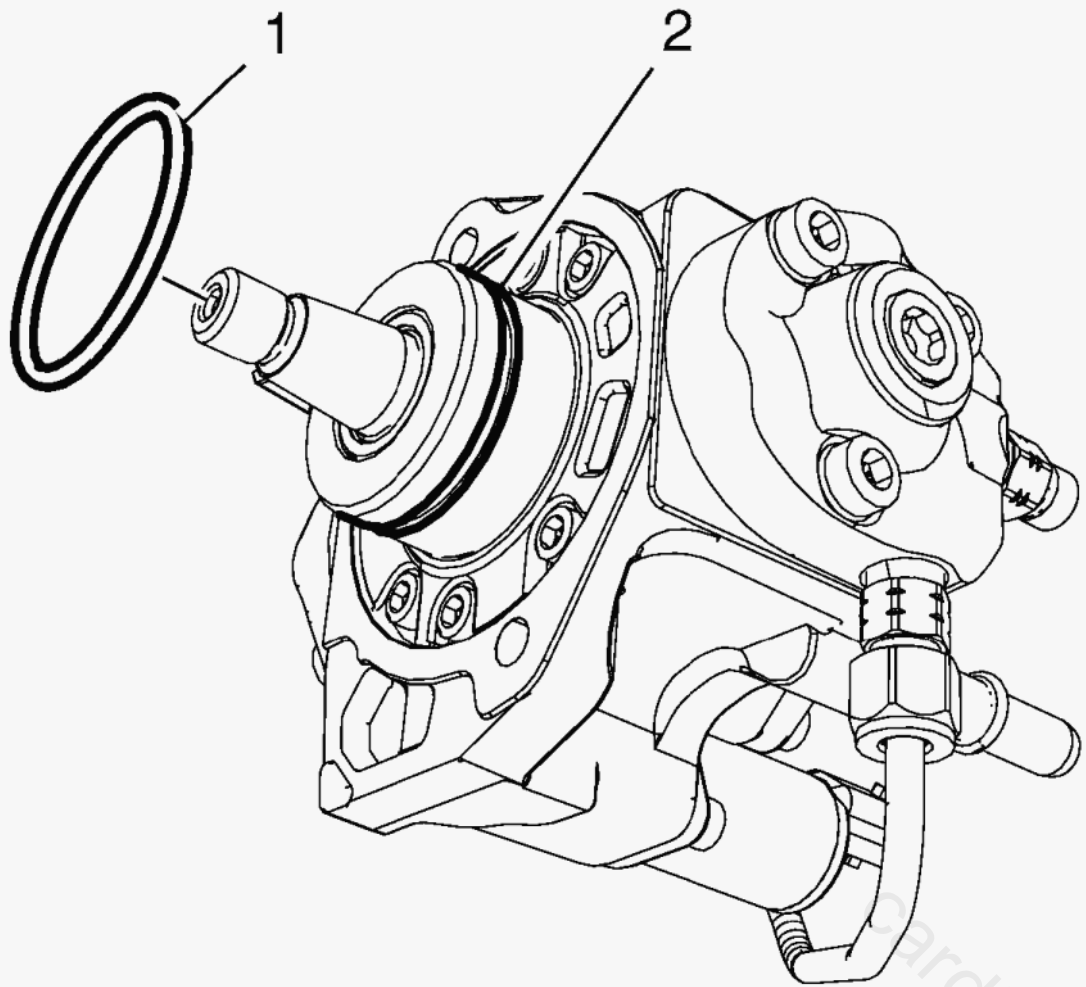


Fig. 839: Fuel Injection Pump Seal Ring And Fuel Injection Pump Sealing Groove
Courtesy of GENERAL MOTORS COMPANY

1. Install a NEW fuel injection pump seal ring (1) to the fuel injection pump sealing groove (2).

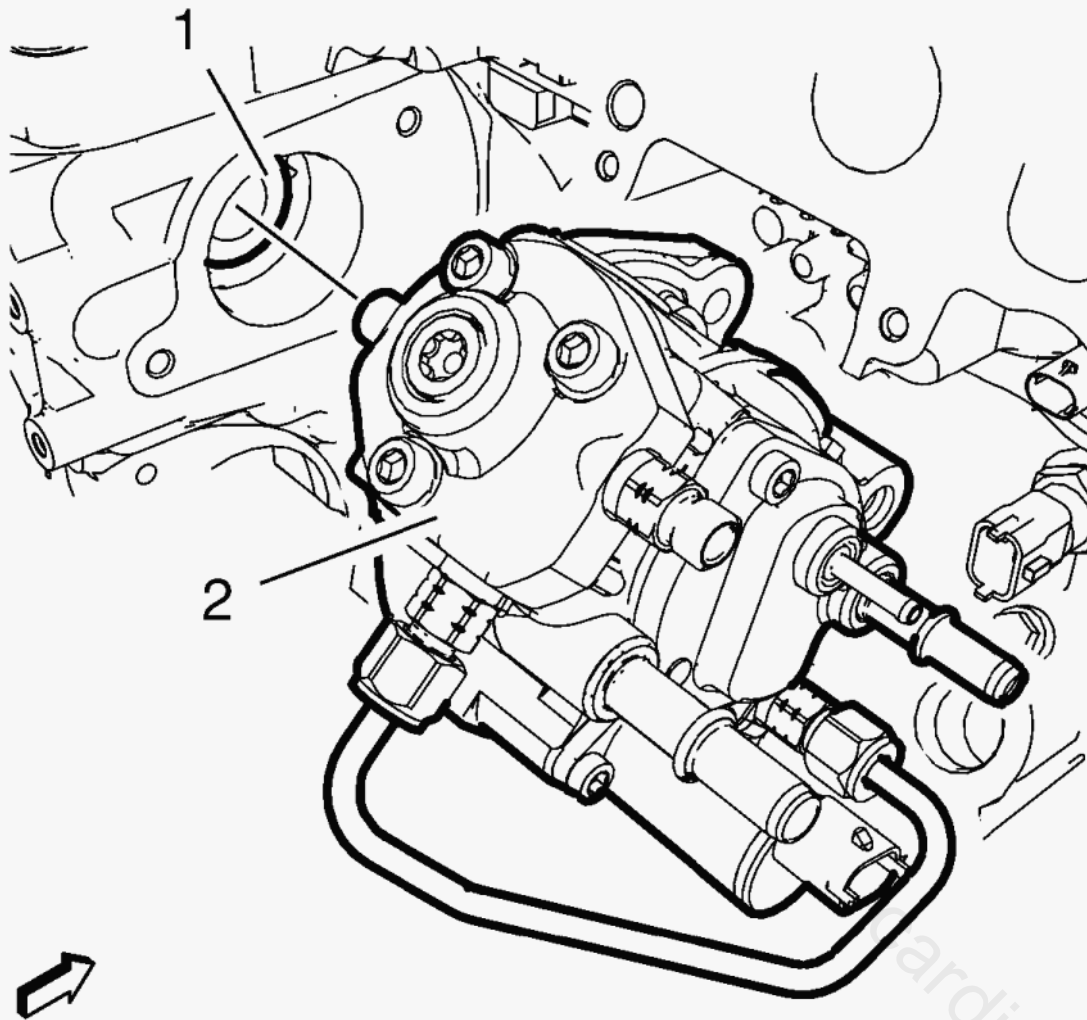


Fig. 840: Fuel Injection Fuel Pump

Courtesy of GENERAL MOTORS COMPANY

2. Install the fuel injection pump (2).

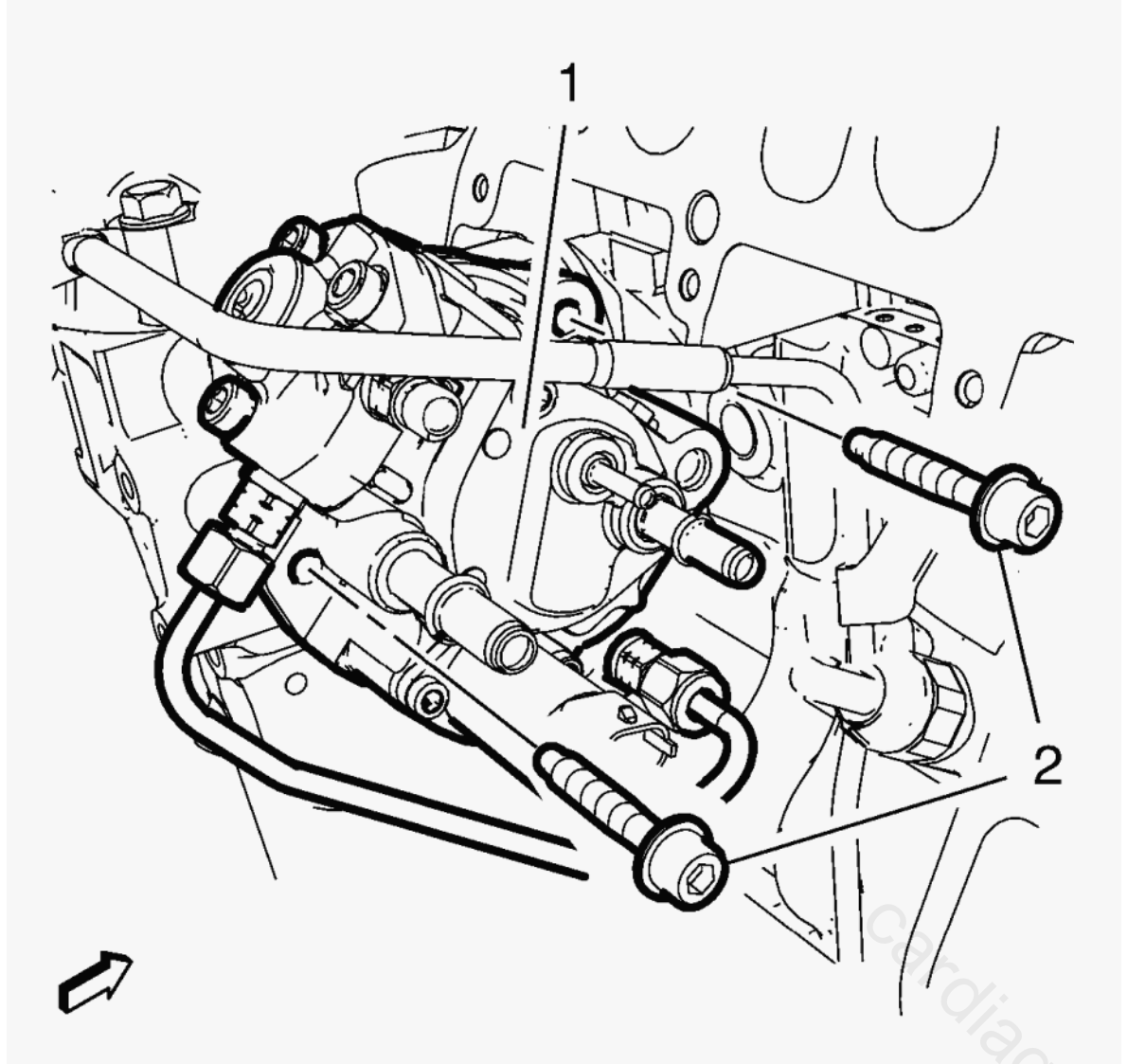


Fig. 841: Fuel Injection Fuel Pump And Bolts
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to [Fastener Caution](#) .

3. Install the 2 fuel injection fuel pump bolts (2) to the fuel injection fuel pump (1) and tighten to 25 N.m (18 lb ft).

FUEL INJECTION PUMP DRIVEN SPROCKET INSTALLATION

Special Tools

EN-50885-2 Locking Tool

For equivalent regional tools, refer to [Special Tools](#).

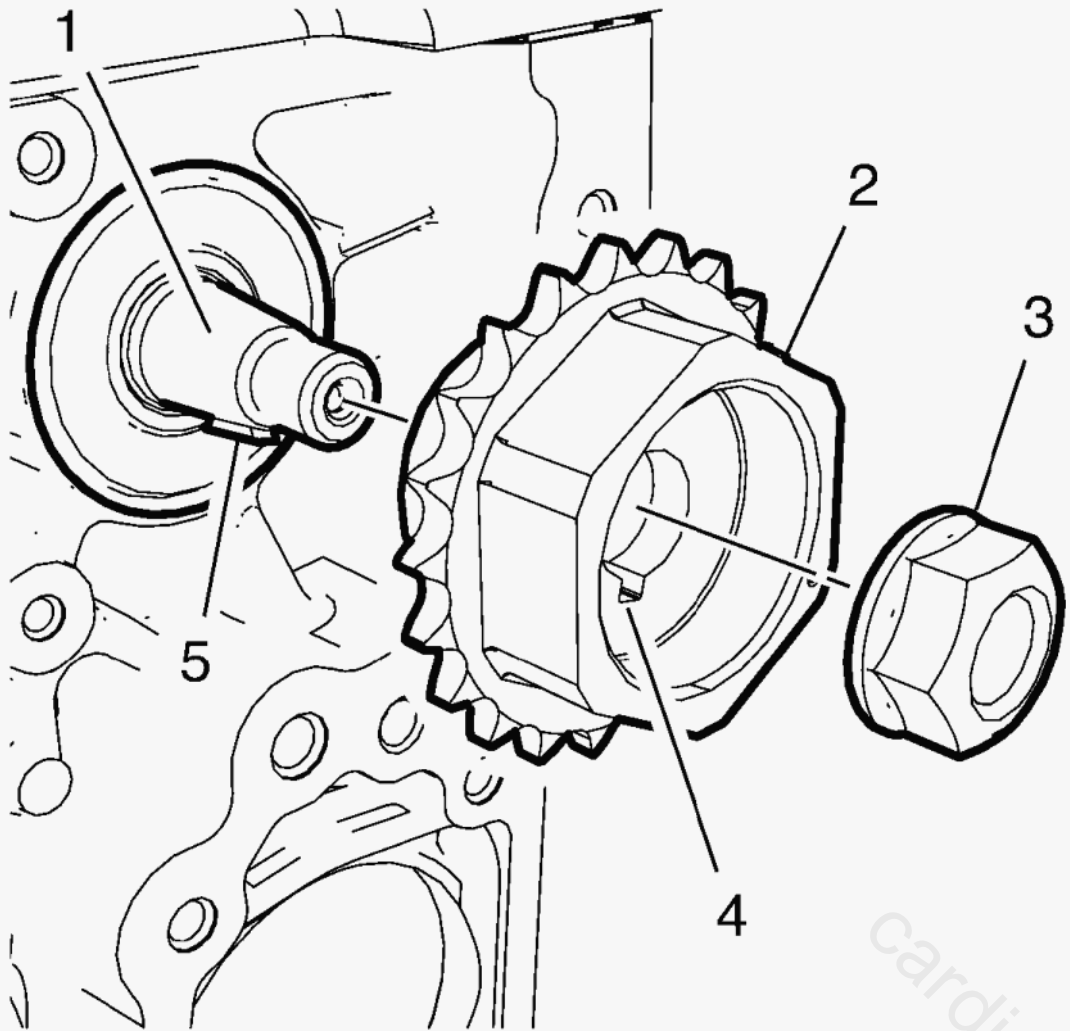


Fig. 842: Fuel Injection Pump, Driven Sprocket, Pump Shaft Wedge, Sprocket Groove And Nut
Courtesy of GENERAL MOTORS COMPANY

1. Install the fuel injection pump driven sprocket (2) to the fuel injection pump (1). Ensure the fuel injection pump shaft wedge (5) and the fuel injection pump driven sprocket groove (4) are aligned.
2. Pre-install the fuel injection pump driven sprocket nut (3).

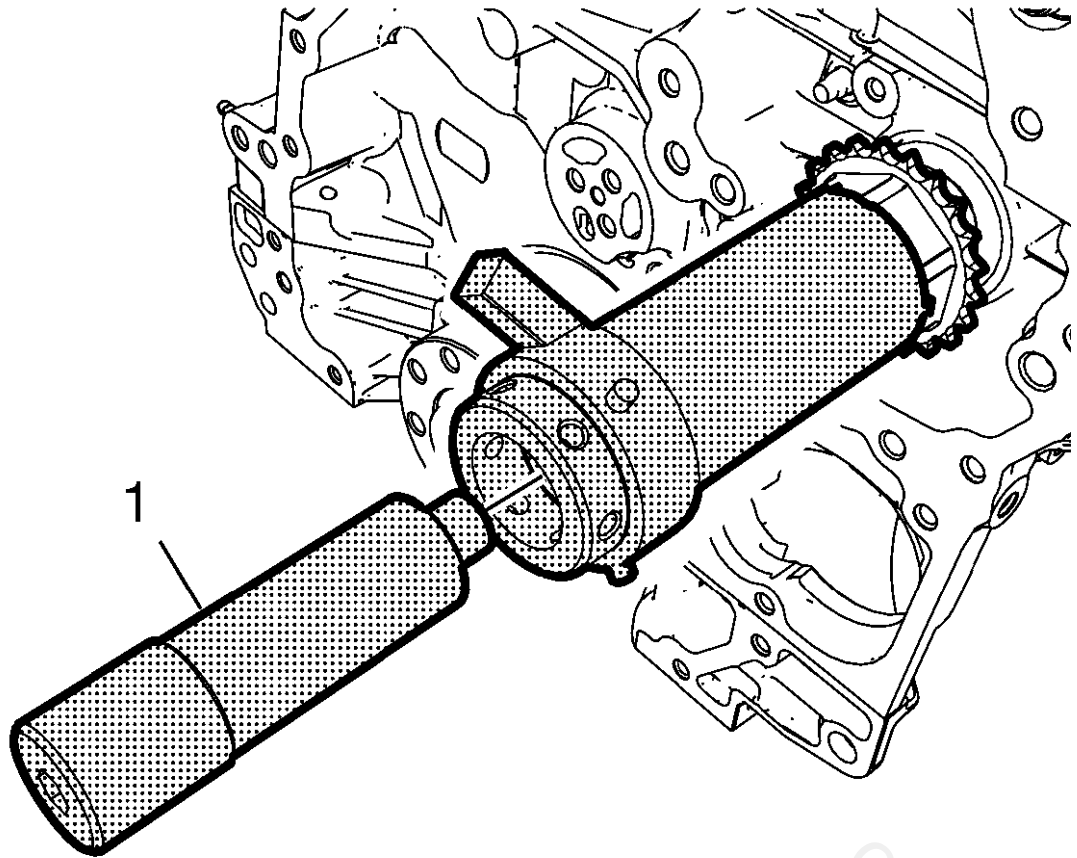


Fig. 843: Pressure Spindle And Locking Tool
Courtesy of GENERAL MOTORS COMPANY

3. Remove the pressure spindle (1) from the EN-50885-2 locking tool (2).

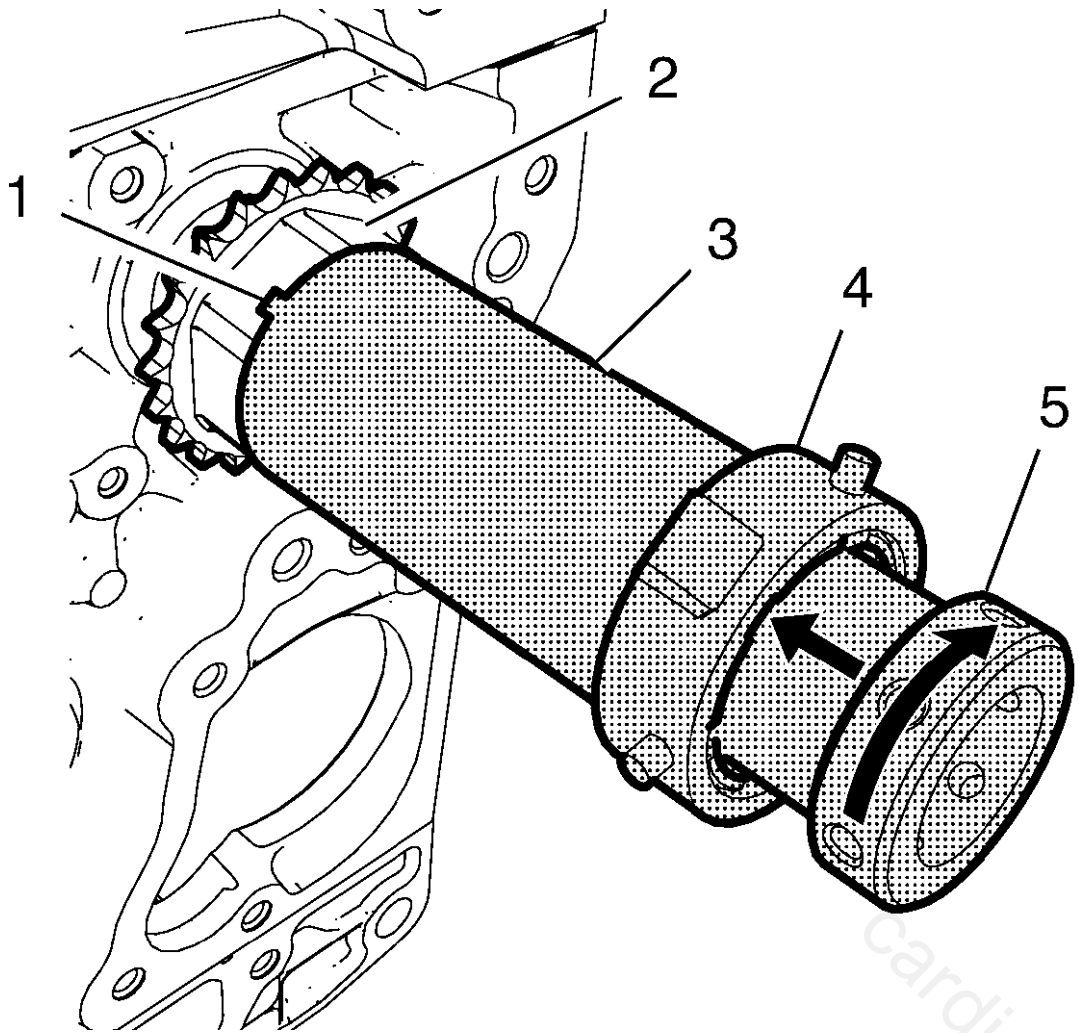


Fig. 844: Locking Tool Installed

Courtesy of GENERAL MOTORS COMPANY

4. Install the EN-50885-2 locking tool.
 1. Install the housing (3) to the fuel injection pump driven sprocket nut (2). Ensure that the 3 tappets (1) mesh with the 3 slots of the fuel injection pump driven sprocket nut.
 2. Position the ring (4) for a good handling.
 3. Screw in the fixing tool (5) into the fuel injection pump driven sprocket nut.

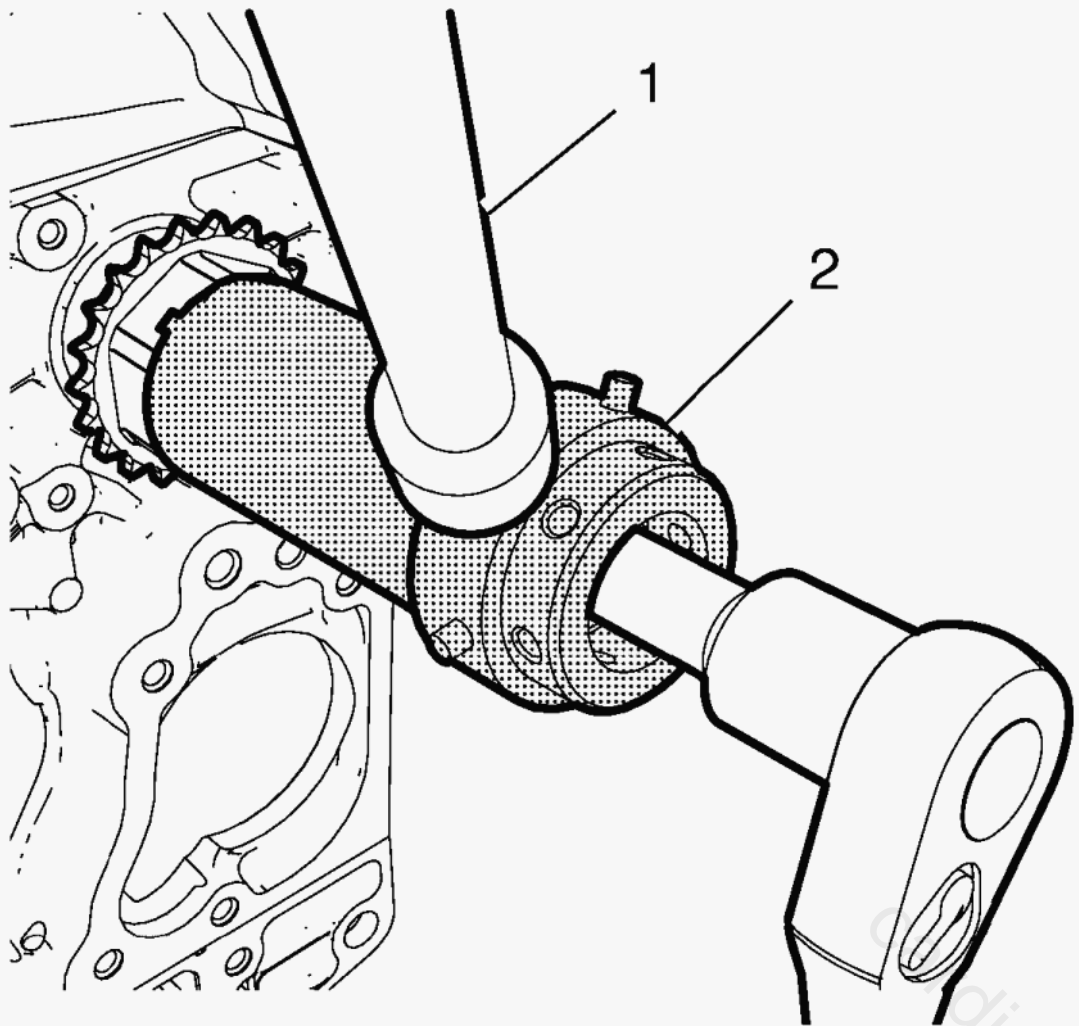


Fig. 845: Extension And Locking Tool

Courtesy of GENERAL MOTORS COMPANY

5. Install a 1/2" extension (1) to the EN-50885-2 locking tool (2) to counterhold.

CAUTION: Refer to **Fastener Caution** .

6. Tighten the fuel injection pump driven sprocket nut to 64 N.m (47 lb ft).
7. Remove the EN-50885-2 locking tool.

TIMING CHAIN IDLER SPROCKET INSTALLATION

Special Tools

EN-51141 Intermediate Drive Gear Fixing Tool

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

NOTE: Before installing the timing chain idler sprocket, check the components of the timing chain system for damage and wear.

1. Check the components of the timing chain system for damage and wear:
 - Timing chain guides with plastic attachment
 - Timing chain tensioner and timing chain tensioner shoe with plastic attachment
 - Timing chain and all timing chain sprockets
 - Oil pump sprocket
 - Oil pump drive chain tensioner

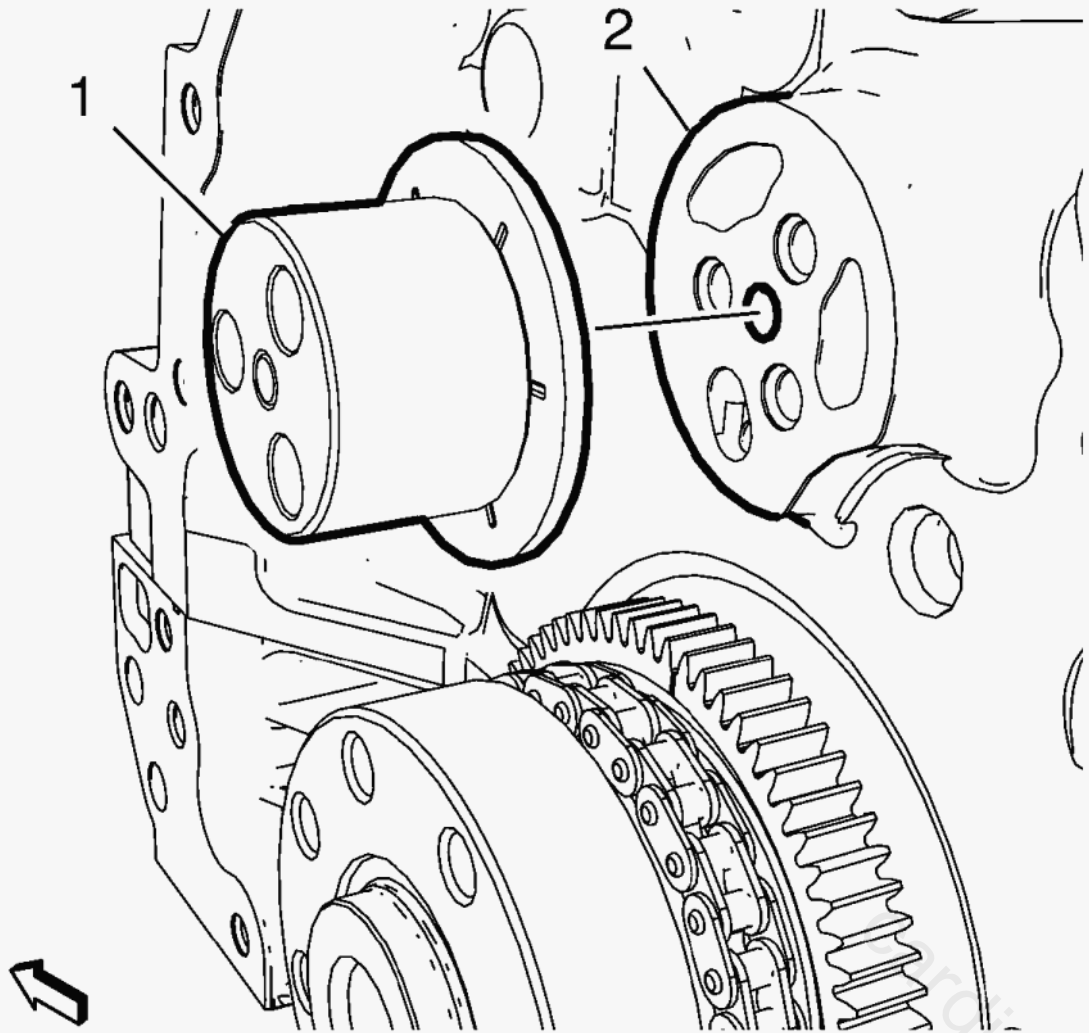


Fig. 846: Gear Shaft Distributor And Engine Block
Courtesy of GENERAL MOTORS COMPANY

2. Install the gear shaft distributor (1) to the engine block (2).

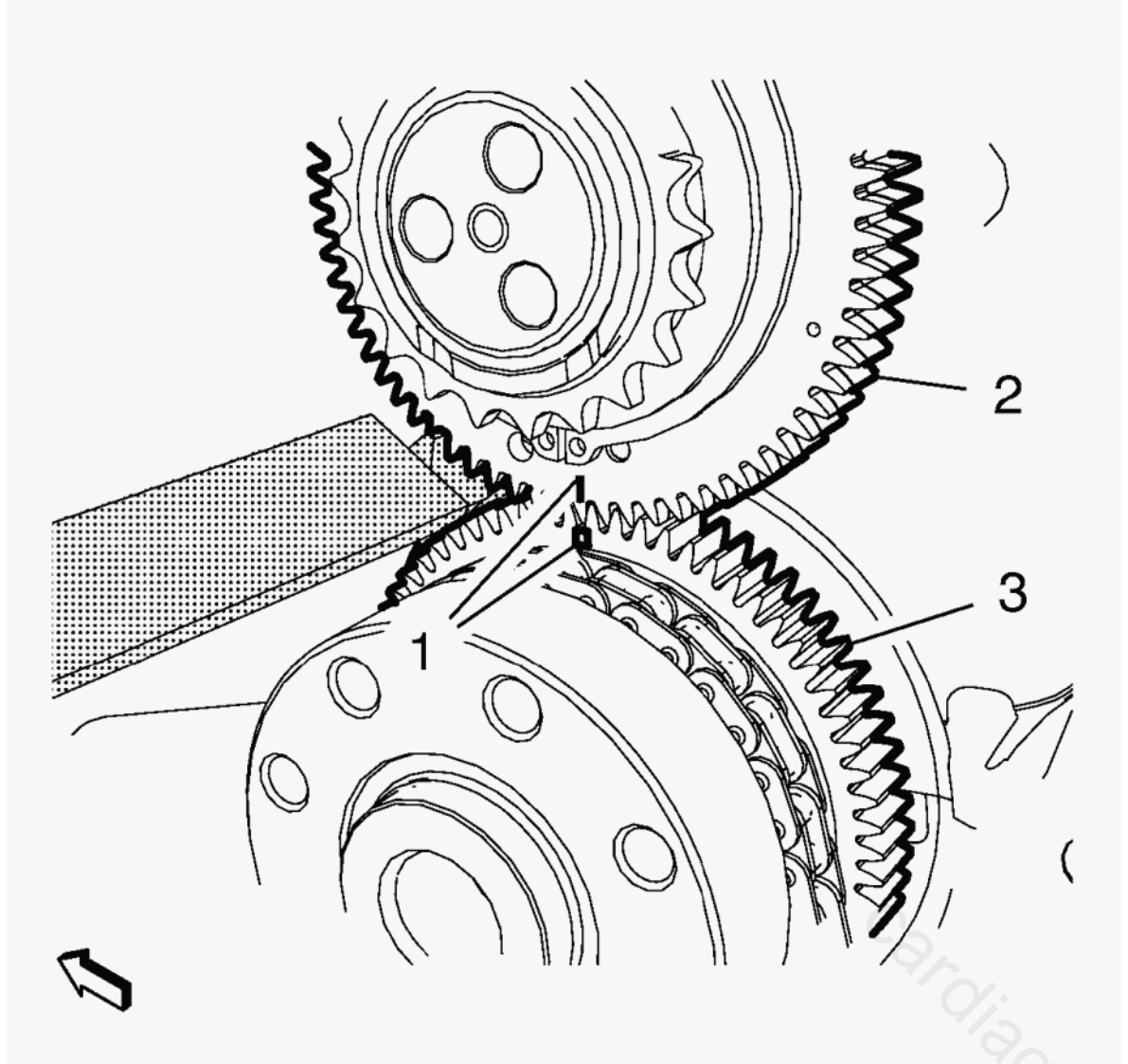


Fig. 847: Timing Chain Idler Sprocket, Alignment Marks And Crankshaft Sprocket
Courtesy of GENERAL MOTORS COMPANY

3. Install the timing chain idler sprocket (2), by align the marks (1) with the timing chain idler sprocket and the crankshaft sprocket (3).

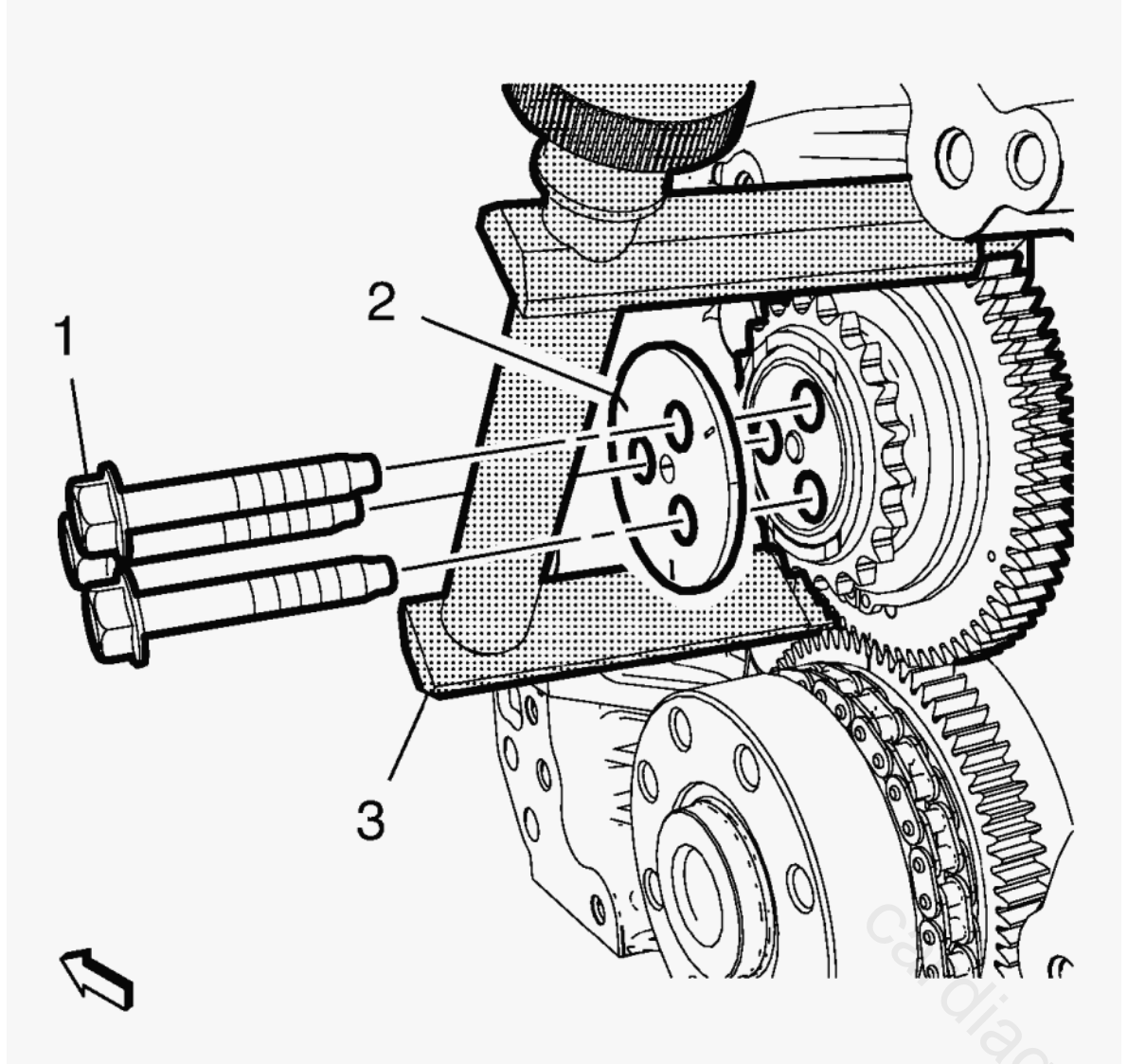


Fig. 848: Timing Chain Idler Sprocket Bearing Plate, Sprocket Bolts And Fixing Tool
Courtesy of GENERAL MOTORS COMPANY

4. Install the timing chain idler sprocket bearing plate (2).

CAUTION: Refer to **Fastener Caution** .

5. Install the 3 timing chain idler sprocket bolts (1) and tighten to 25 N.m (18 lb ft).
6. Remove the **EN-51141** fixing tool (3).

TIMING CHAIN UPPER GUIDE INSTALLATION

NOTE: Before installing the timing chain upper guide, check the components of the timing chain system for damage and wear.

1. Check the components of the timing chain system for damage and wear:
 - Timing chain guides with plastic attachment
 - Timing chain tensioner and timing chain tensioner shoe with plastic attachment
 - Timing chain and all timing chain sprockets
 - Oil pump sprocket
 - Oil pump drive chain tensioner

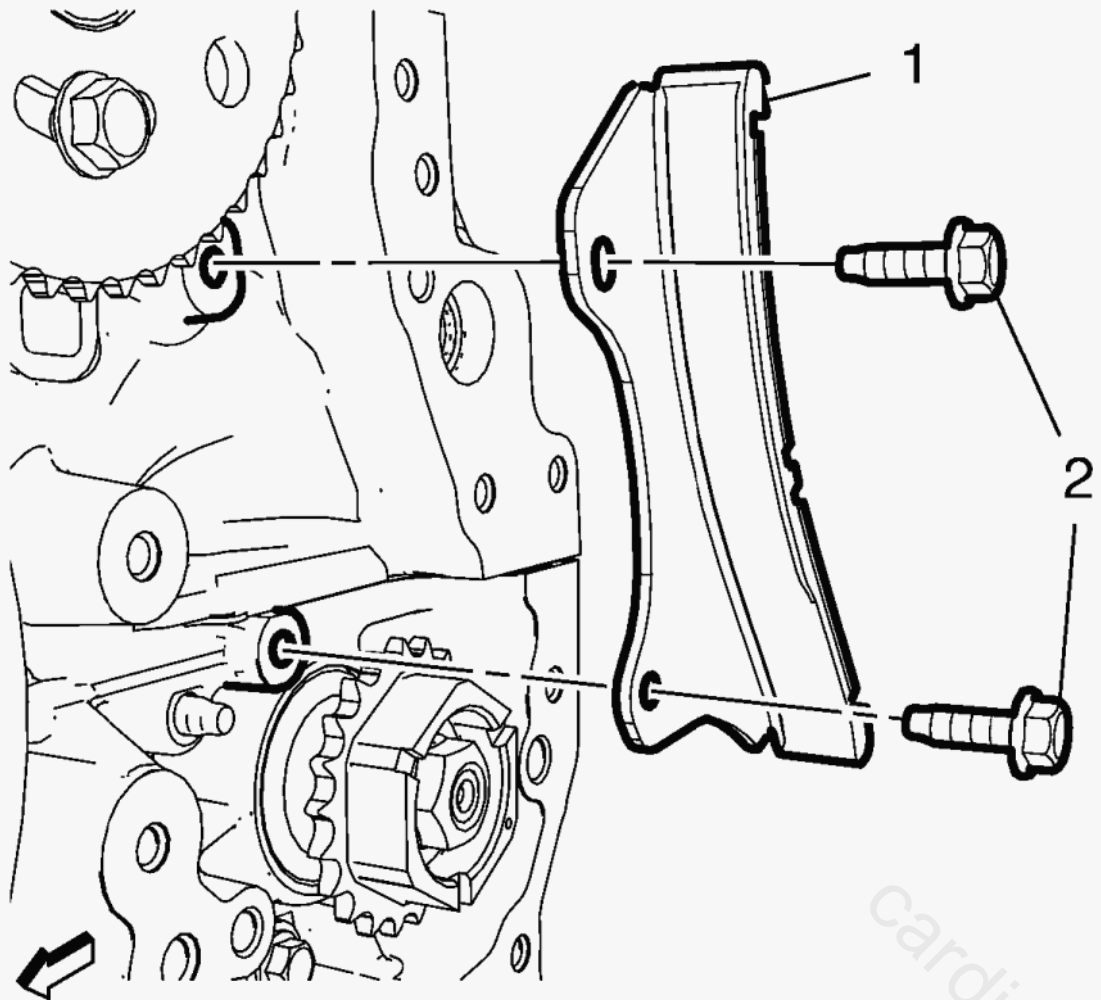


Fig. 849: Timing Chain Upper Guide And Bolts
Courtesy of GENERAL MOTORS COMPANY

2. Re-cut thread at cylinder head and engine block for the 2 timing chain upper guide bolts (2).
3. Install the timing chain upper guide (1).

NOTE: The tightening procedure of the upper timing chain upper guide bolts should be completed within 10 minutes

4. Apply thread lock agent to the upper timing chain upper guide bolt (2).

NOTE: Do not tighten the upper timing chain upper guide bolt before the camshaft timing chain is installed.

5. Install the upper timing chain upper guide bolt (2).

TIMING CHAIN LOWER GUIDE INSTALLATION

NOTE: Before installing the timing chain lower guide, check the components of the timing chain system for damage and wear.

1. Check the components of the timing chain system for damage and wear:
 - Timing chain guides with plastic attachment
 - Timing chain tensioner and timing chain tensioner shoe with plastic attachment
 - Timing chain and all timing chain sprockets
 - Oil pump sprocket
 - Oil pump drive chain tensioner

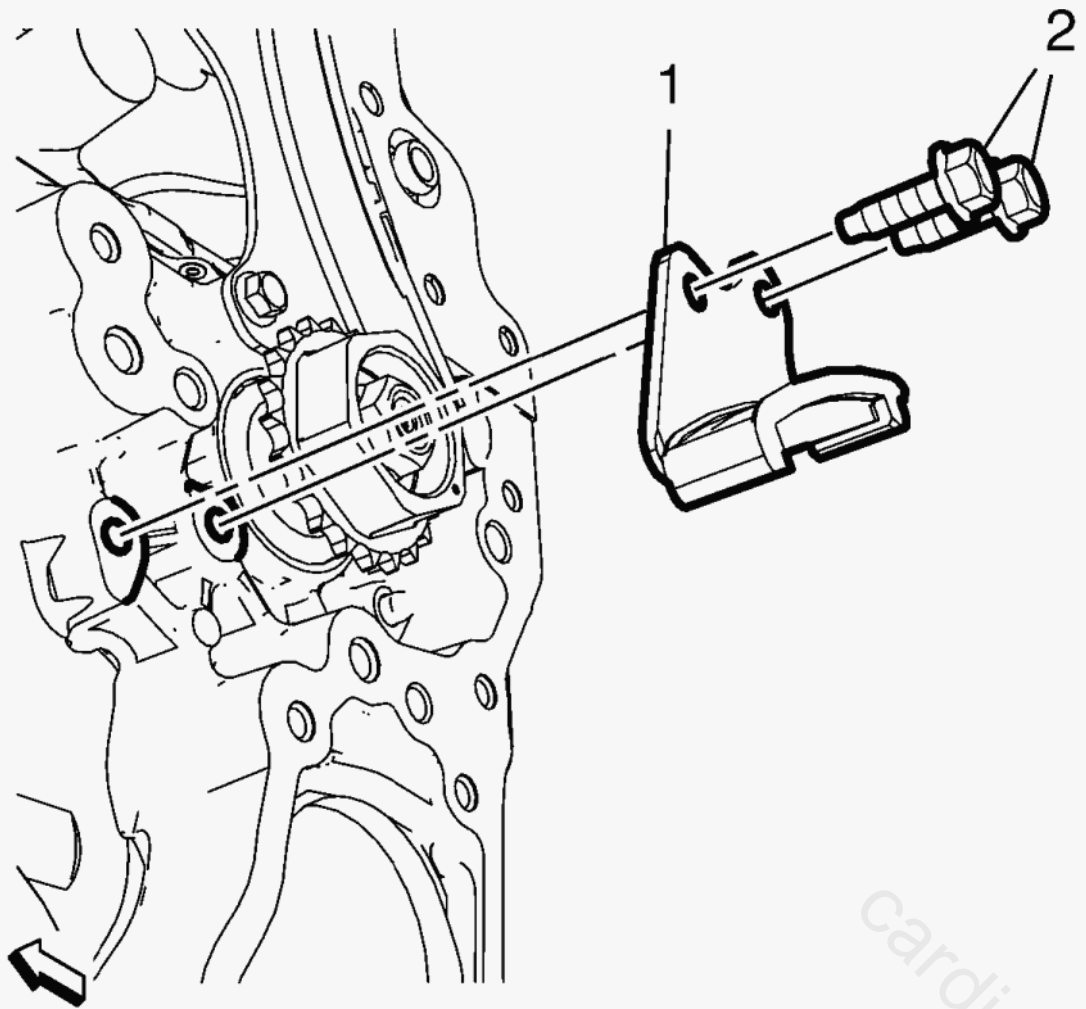


Fig. 850: Timing Chain Lower Guide And Bolts
Courtesy of GENERAL MOTORS COMPANY

2. Install the timing chain lower guide (1).

CAUTION: Refer to **Fastener Caution** .

3. Install the 2 timing chain lower guide bolts (2) and tighten to 10 N.m (89 lb in).

TIMING CHAIN TENSIONER SHOE INSTALLATION

NOTE: Before installing the timing chain tensioner shoe, check the components of the timing chain system for damage and wear.

1. Check the components of the timing chain system for damage and wear:
 - Timing chain guides with plastic attachment
 - Timing chain tensioner and timing chain tensioner shoe with plastic attachment
 - Timing chain and all timing chain sprockets
 - Oil pump sprocket
 - Oil pump drive chain tensioner

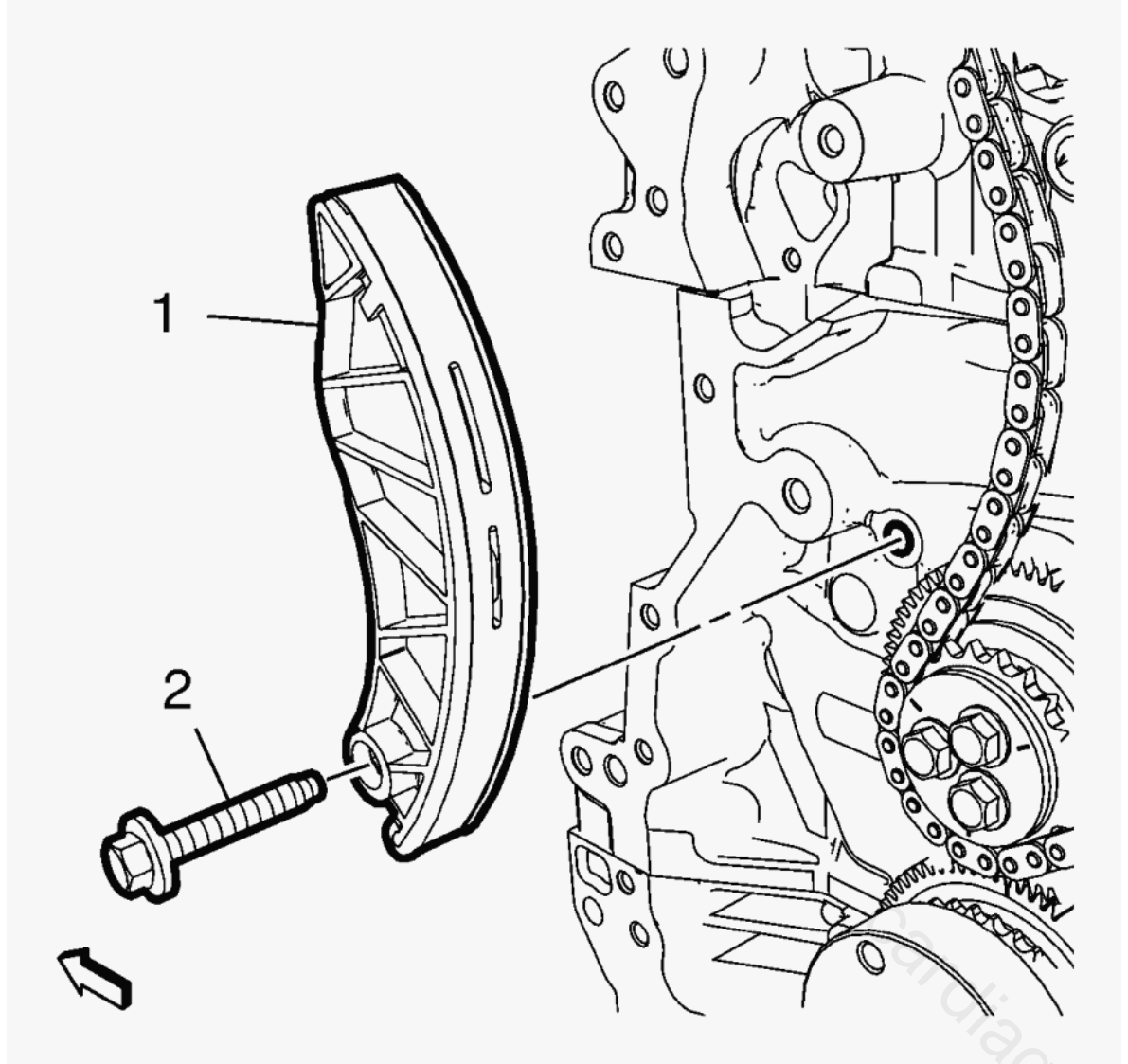


Fig. 851: Timing Chain Tensioner Shoe And Bolt
Courtesy of GENERAL MOTORS COMPANY

2. Install the timing chain tensioner shoe (1).

CAUTION: Refer to [Fastener Caution](#) .

3. Install the timing chain tensioner shoe bolt (2) and tighten to 25 N.m (18 lb ft).

TIMING CHAIN TENSIONER INSTALLATION

Special Tools

EN-50513 Fixing Pin

For equivalent regional tools, refer to [Special Tools](#).

NOTE: Before installing the timing chain tensioner, check the components of the timing chain system for damage and wear.

1. Check the components of the timing chain system for damage and wear:
 - Timing chain guides with plastic attachment
 - Timing chain tensioner and timing chain tensioner shoe with plastic attachment
 - Timing chain and all timing chain sprockets
 - Oil pump sprocket
 - Oil pump drive chain tensioner

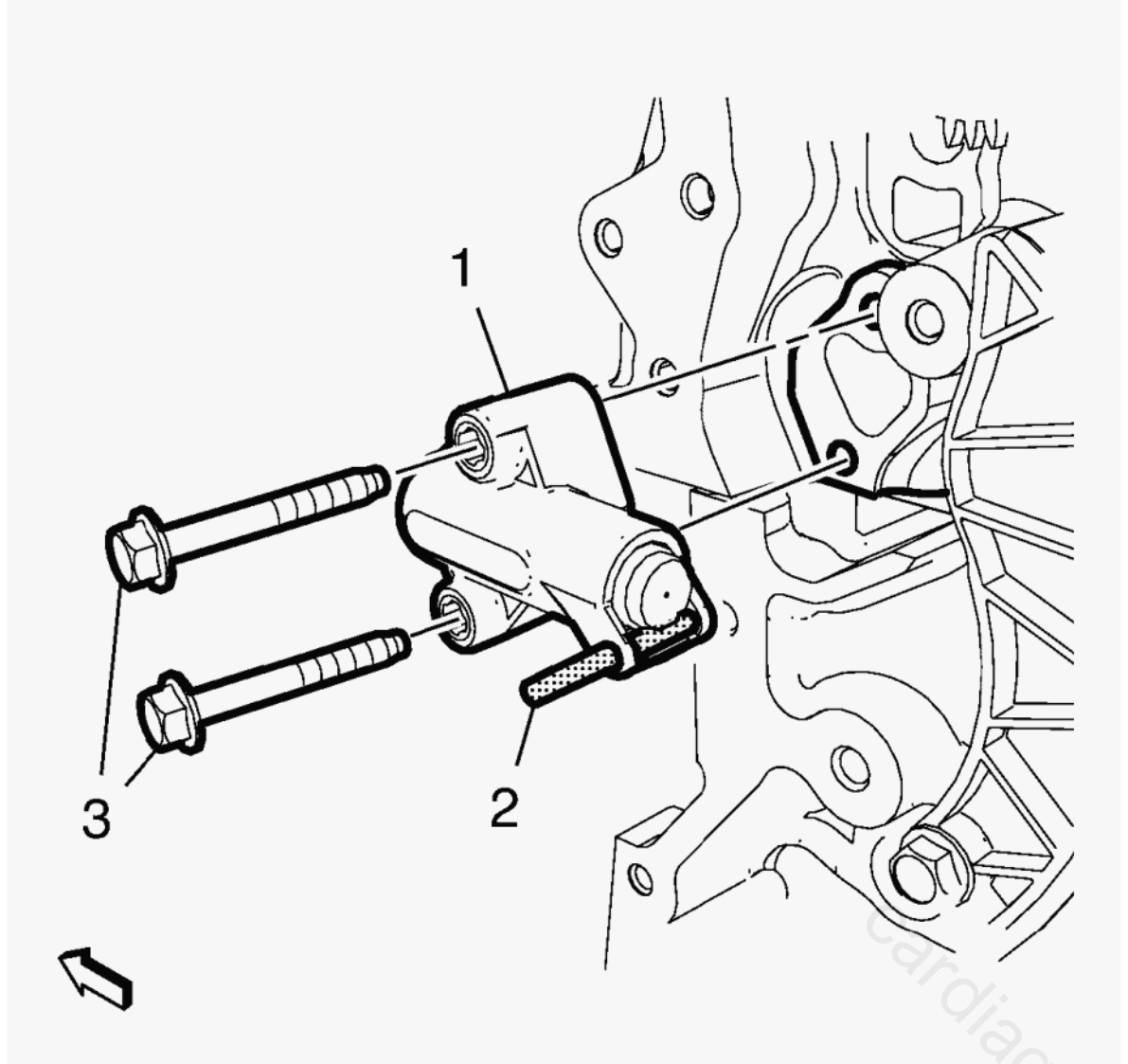


Fig. 852: Timing Chain Tensioner, Bolts And Pin
Courtesy of GENERAL MOTORS COMPANY

2. Install the timing chain tensioner (1).

CAUTION: Refer to **Fastener Caution** .

3. Install the 2 timing chain tensioner bolts (3) and tighten to 10 N.m (89 lb in).

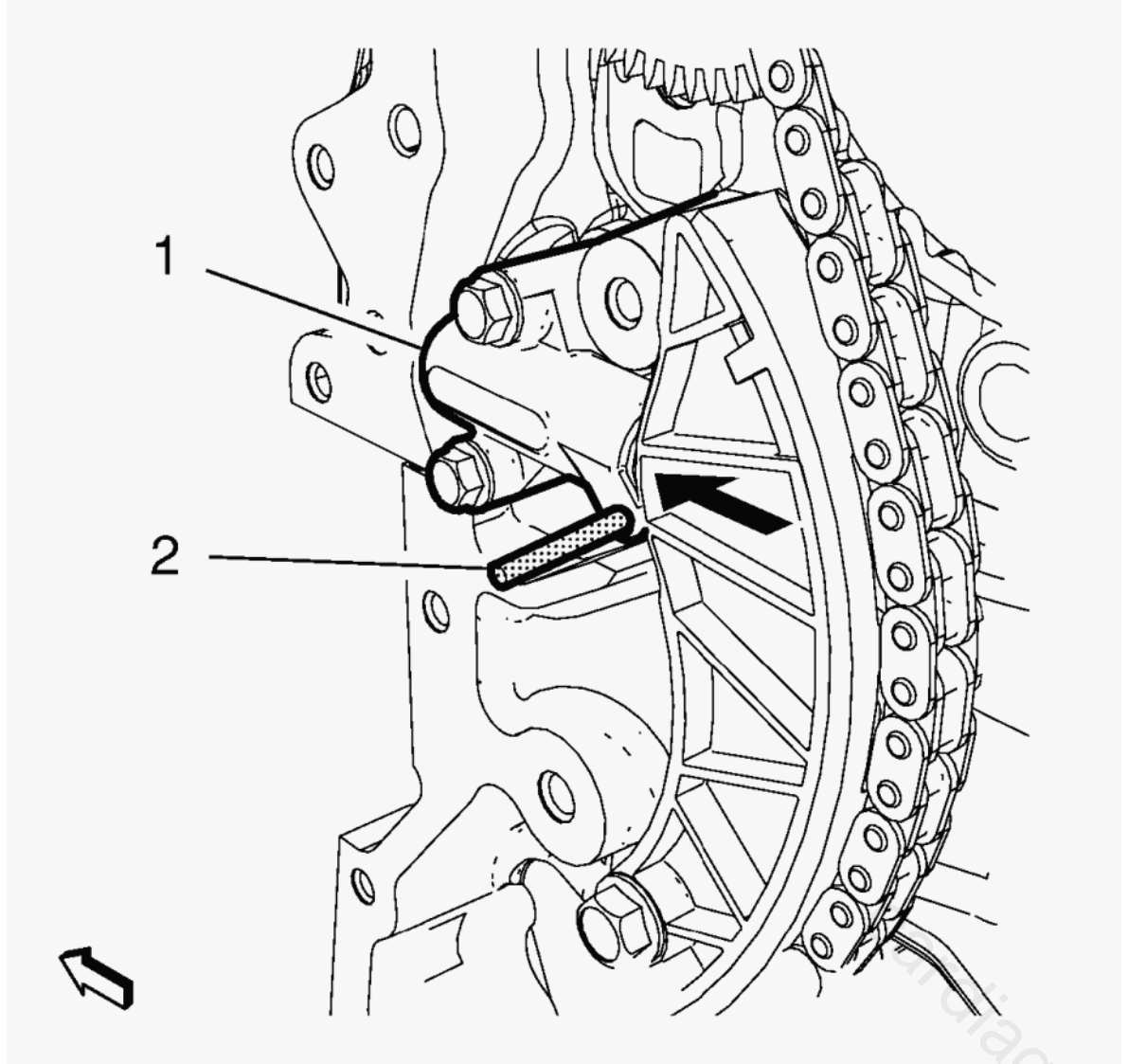


Fig. 853: Timing Chain Tensioner And Pin
Courtesy of GENERAL MOTORS COMPANY

4. Remove the EN-50513 pin (2).

CAMSHAFT TIMING CHAIN INSTALLATION

Special Tools

- EN-50513 Fixing Pin
- EN-51140 Crankshaft Fixing Tool
- EN-51143 Camshaft Sprocket Fixing Tool

For equivalent regional tools, refer to [**Special Tools**](#).

NOTE: Before installing the camshaft timing chain, check the components of the timing chain system for damage and wear.

1. Check the components of the timing chain system for damage and wear:
 - Timing chain guides with plastic attachment
 - Timing chain tensioner and timing chain tensioner shoe with plastic attachment
 - Timing chain and all timing chain sprockets
 - Oil pump sprocket
 - Oil pump drive chain tensioner

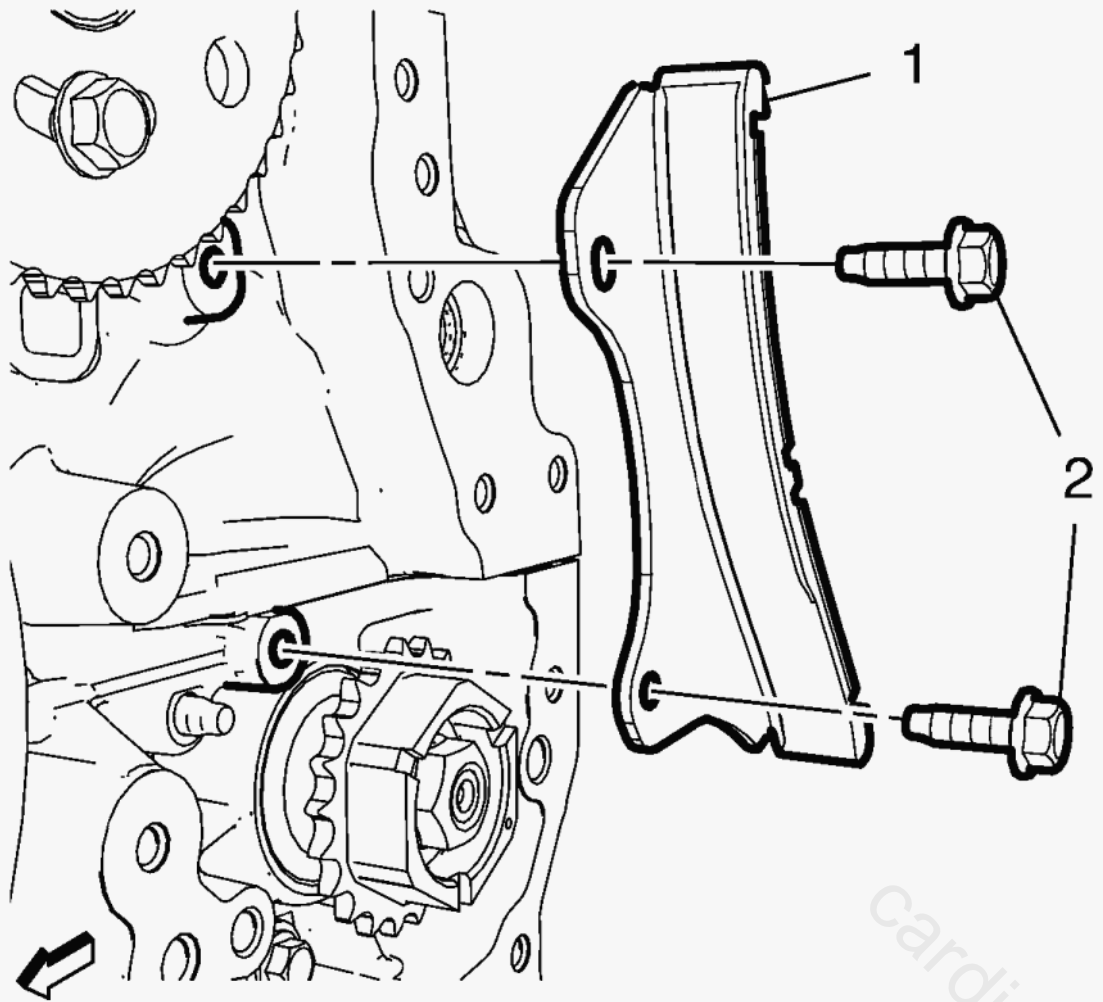


Fig. 854: Timing Chain Upper Guide And Bolts
Courtesy of GENERAL MOTORS COMPANY

2. Re-cut thread at cylinder head and engine block for the 2 timing chain upper guide bolts (2).
3. Install the timing chain upper guide (1).

NOTE: The tightening procedure of the upper timing chain upper guide bolts should be completed within 10 minutes

4. Apply thread lock agent to the upper timing chain upper guide bolt (2).

NOTE: Do not tighten the upper timing chain upper guide bolt before the camshaft timing chain is installed.

5. Install the upper timing chain upper guide bolt (2).

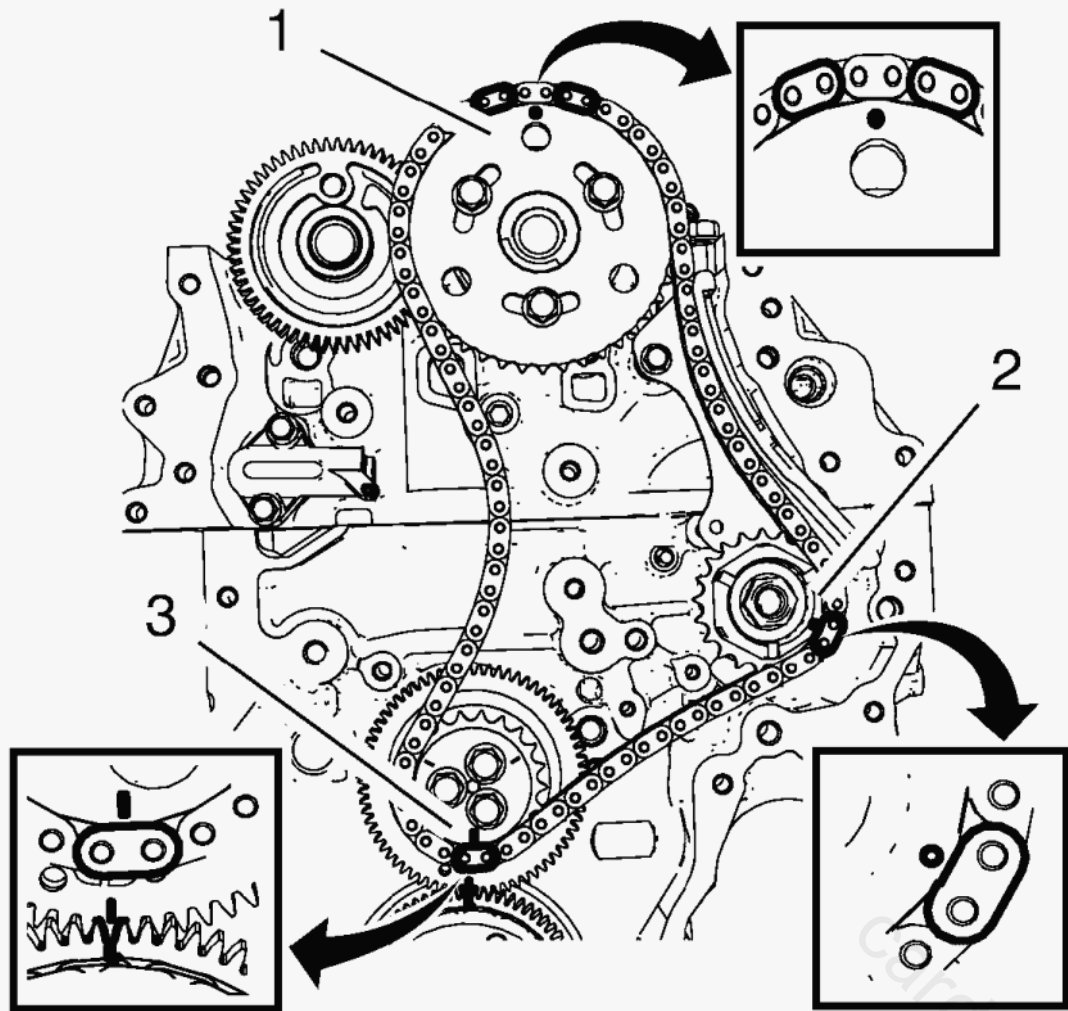


Fig. 855: Aligning Timing Chain Marked Chain Links
Courtesy of GENERAL MOTORS COMPANY

6. Install the timing chain with the marked chain links as shown and follow the installation sequence:
1. Install the timing chain in the first step to the fuel injection pump sprocket (2).
 2. Install the timing chain in the second step to the camshaft sprocket (1).
 3. Install the timing chain in the final step to the timing chain idler sprocket (3).

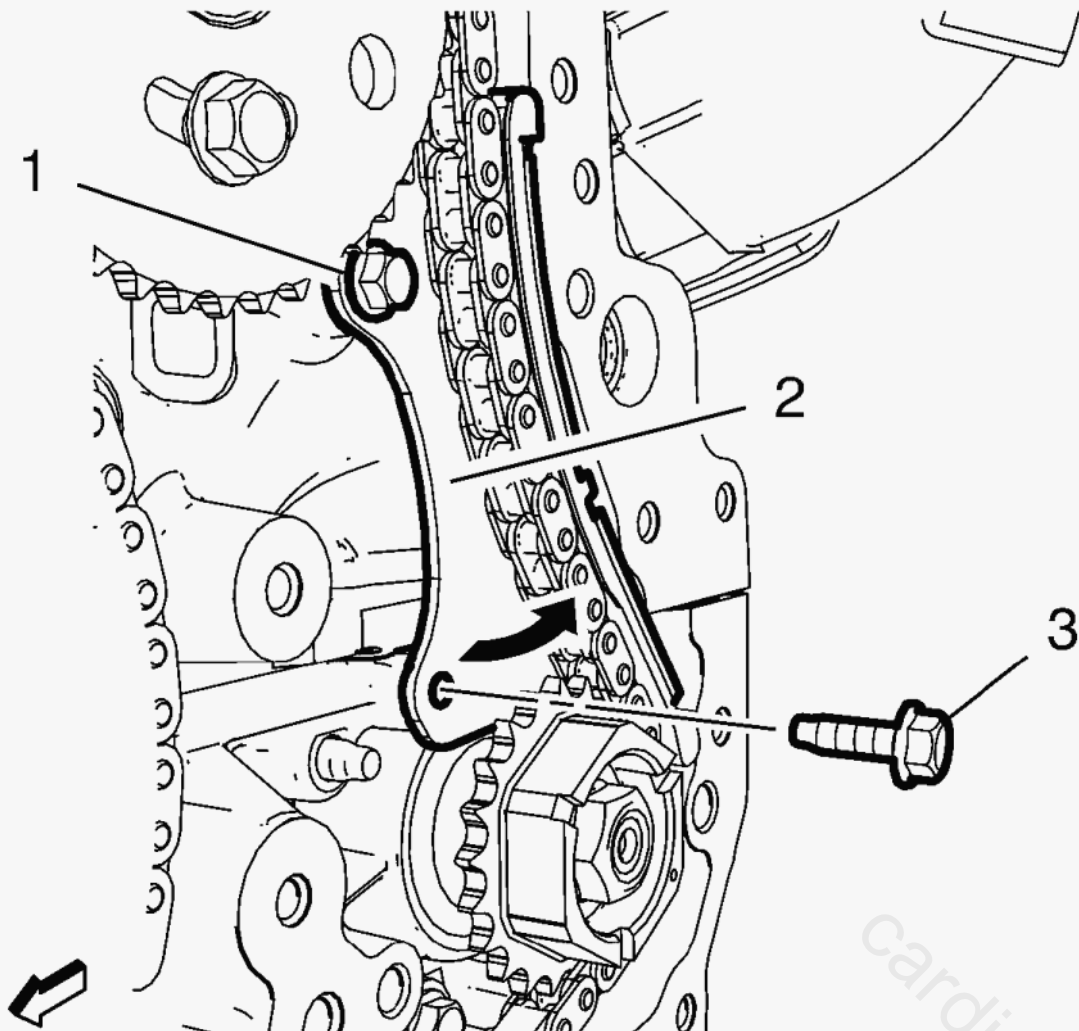


Fig. 856: Timing Chain Upper Guide And Bolts
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution** .

7. Apply thread lock agent to the lower timing chain upper guide bolt (3).
8. Install the timing chain upper guide bolt (3) and tighten to 11 N.m (97 lb in).
9. Tighten the timing chain upper guide bolt (1) to 11 N.m (97 lb in).

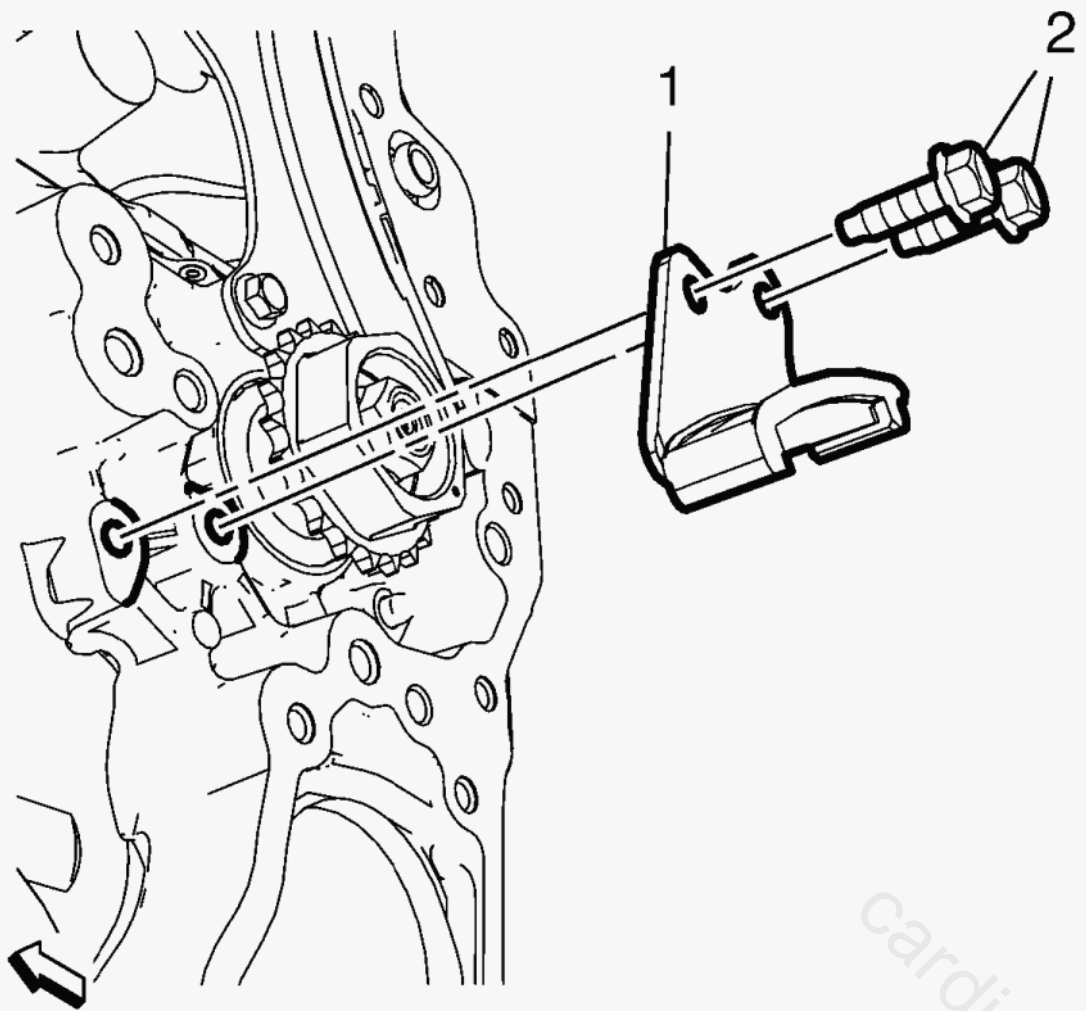


Fig. 857: Timing Chain Lower Guide And Bolts
Courtesy of GENERAL MOTORS COMPANY

10. Install the timing chain lower guide (1).
11. Install the 2 timing chain lower guide bolts (2) and tighten to 10 N.m (89 lb in).

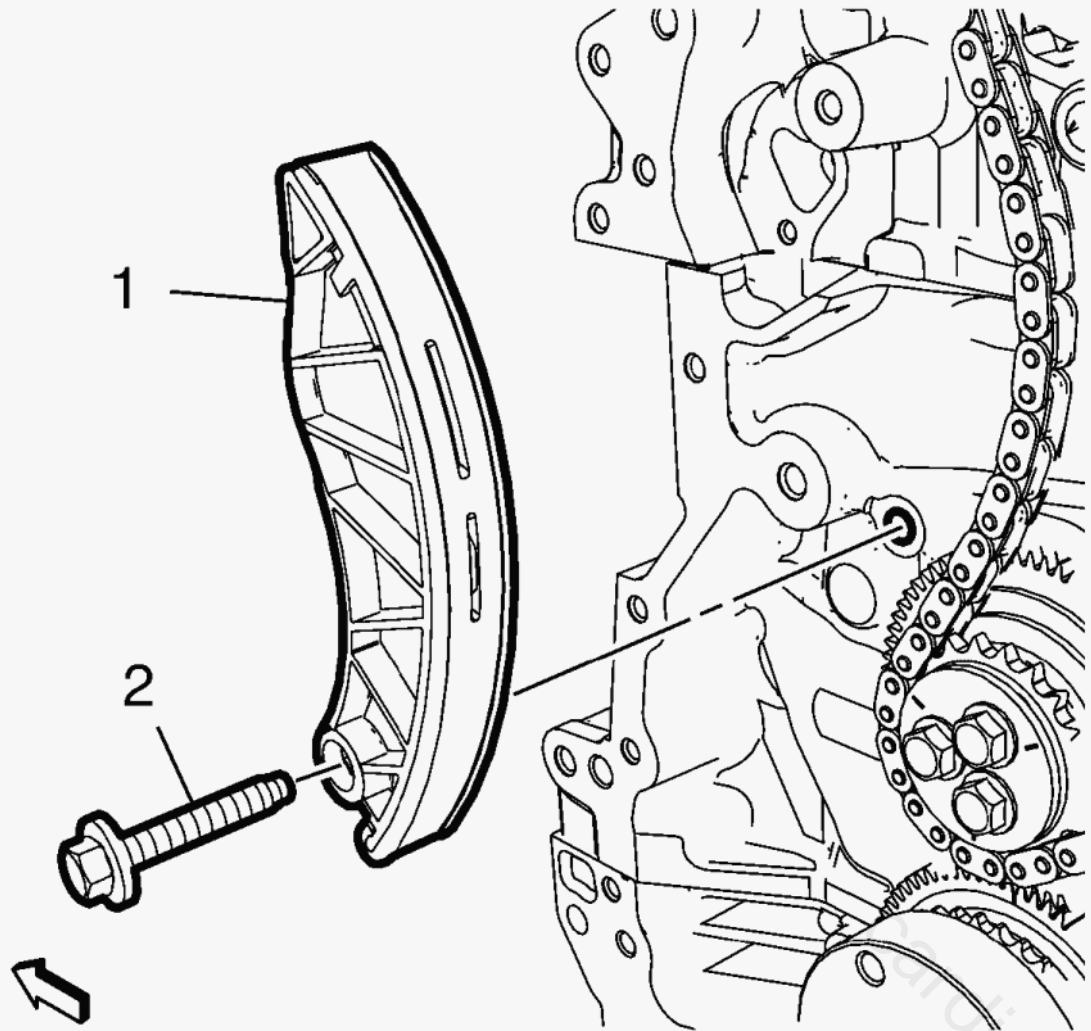


Fig. 858: Timing Chain Tensioner Shoe And Bolt
Courtesy of GENERAL MOTORS COMPANY

12. Install the timing chain tensioner shoe (1).
13. Install the timing chain tensioner shoe bolt (2) and tighten to 25 N.m (18 lb ft).

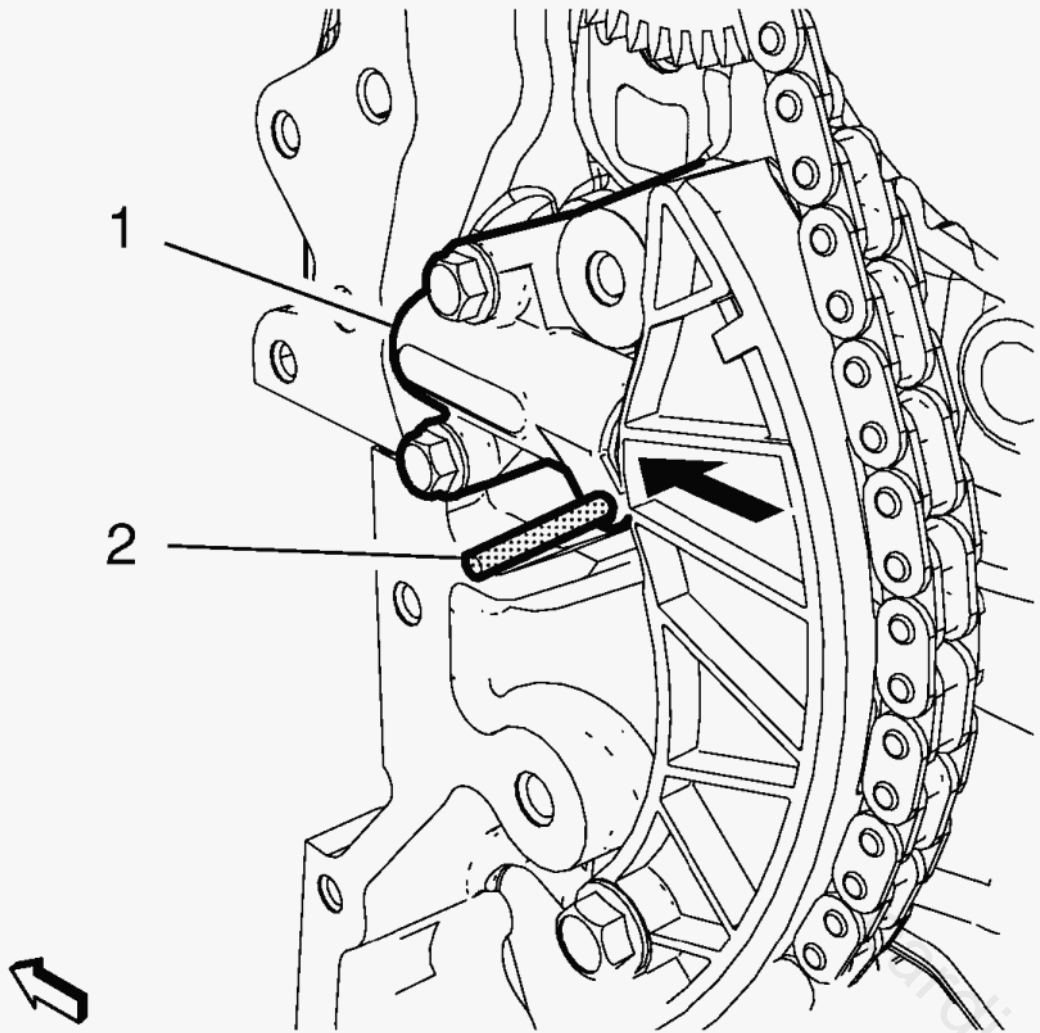


Fig. 859: Timing Chain Tensioner And Pin

Courtesy of GENERAL MOTORS COMPANY

14. Remove the EN-50513 pin (2).

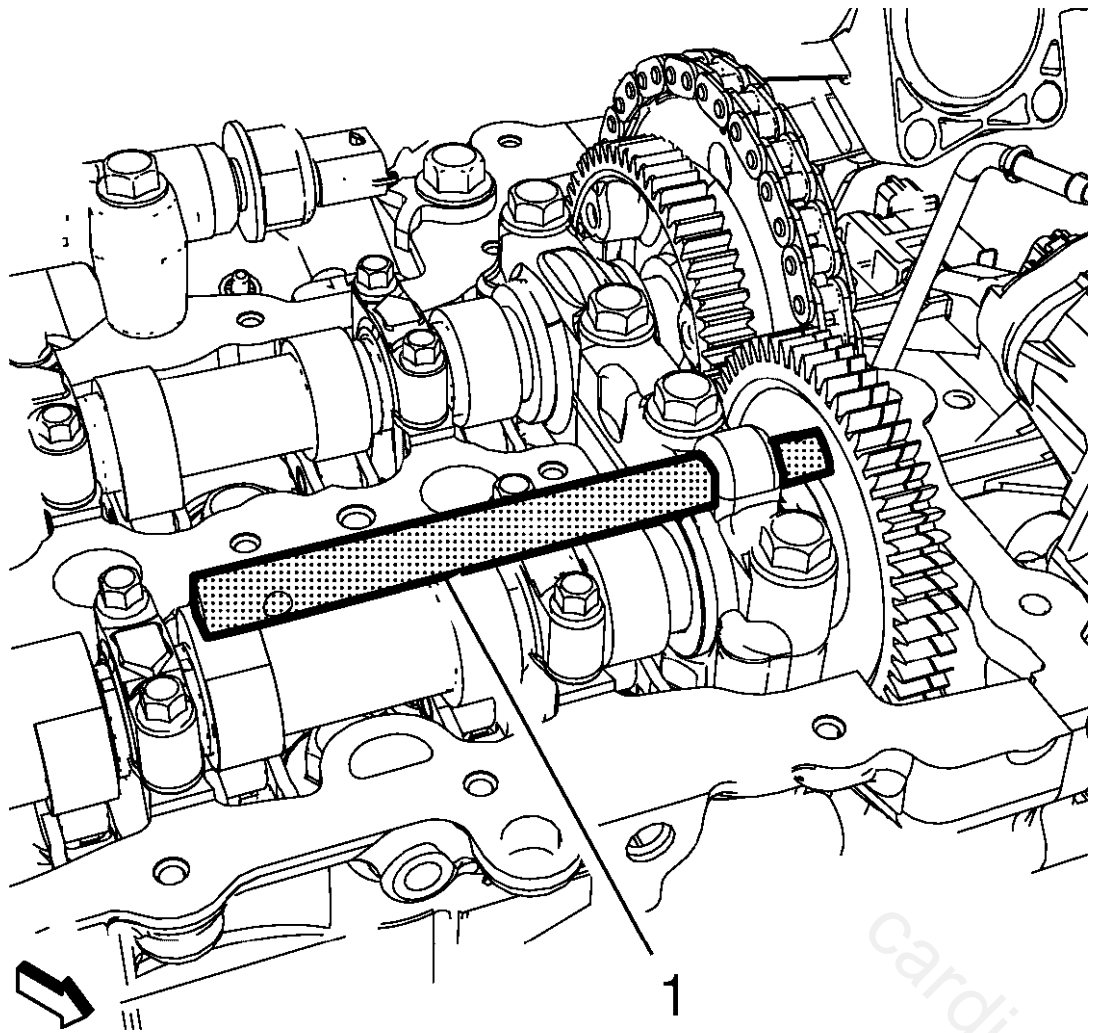


Fig. 860: Camshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

15. Remove the EN-51143 fixing tool (1).

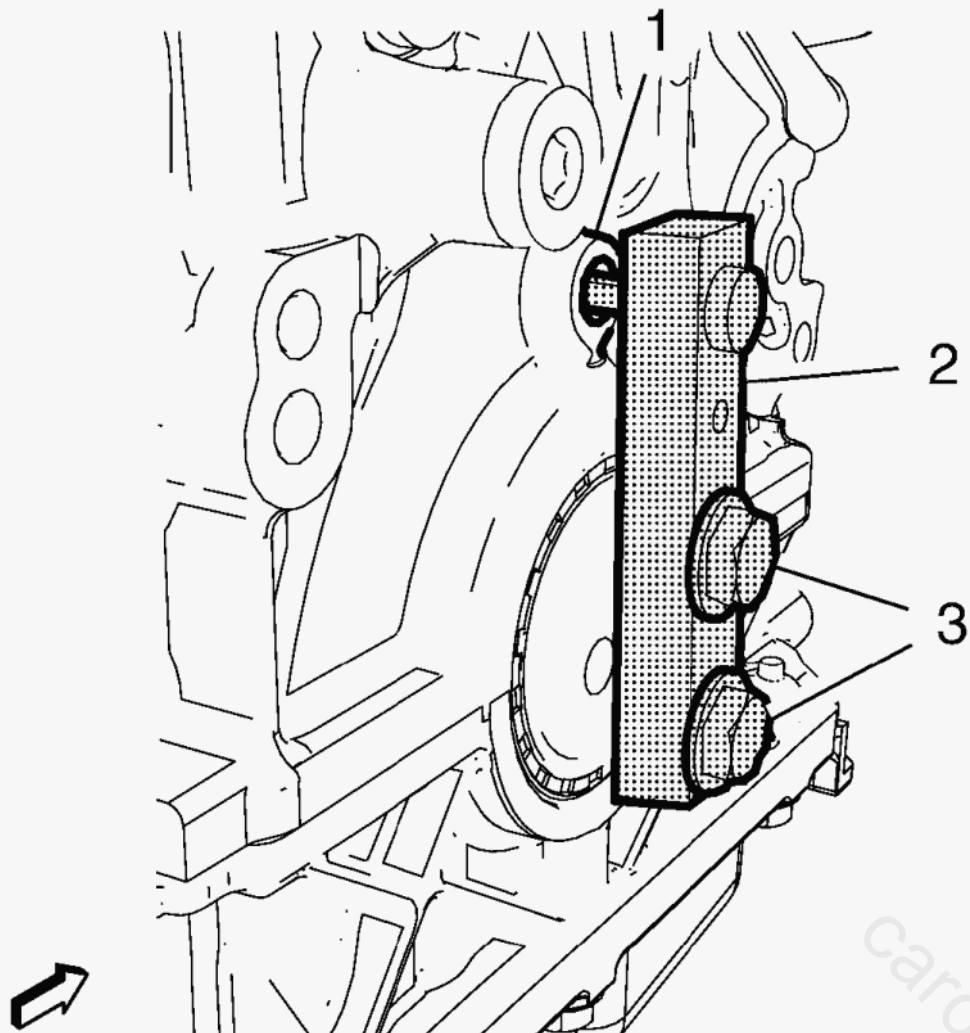


Fig. 861: Crankshaft Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

16. Remove the 2 bolts (3).
17. Remove the **EN-51140** fixing tool (2).

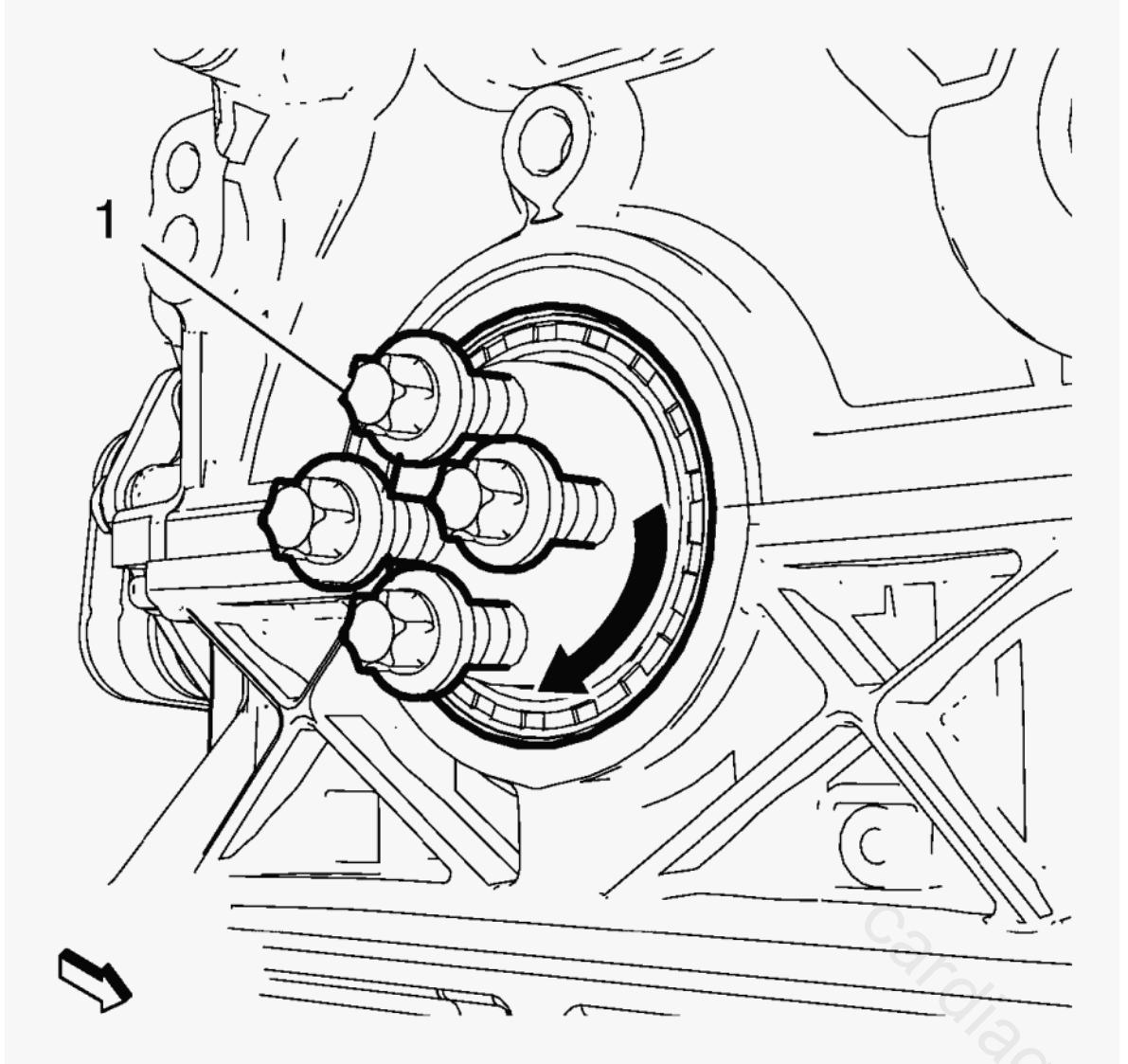


Fig. 862: Crankshaft Pulley Bolts

Courtesy of GENERAL MOTORS COMPANY

18. Install the 4 crankshaft pulley bolts (1).

Rotate the crankshaft 720 degrees in direction of arrow. Use a pry bar at the 4 crankshaft pulley bolts (1).

19. Remove the 4 crankshaft pulley bolts (1).
20. Check the camshaft timing. Refer to [Camshaft Timing Chain Inspection](#).

OIL AND POWER BRAKE BOOSTER PUMP INSTALLATION

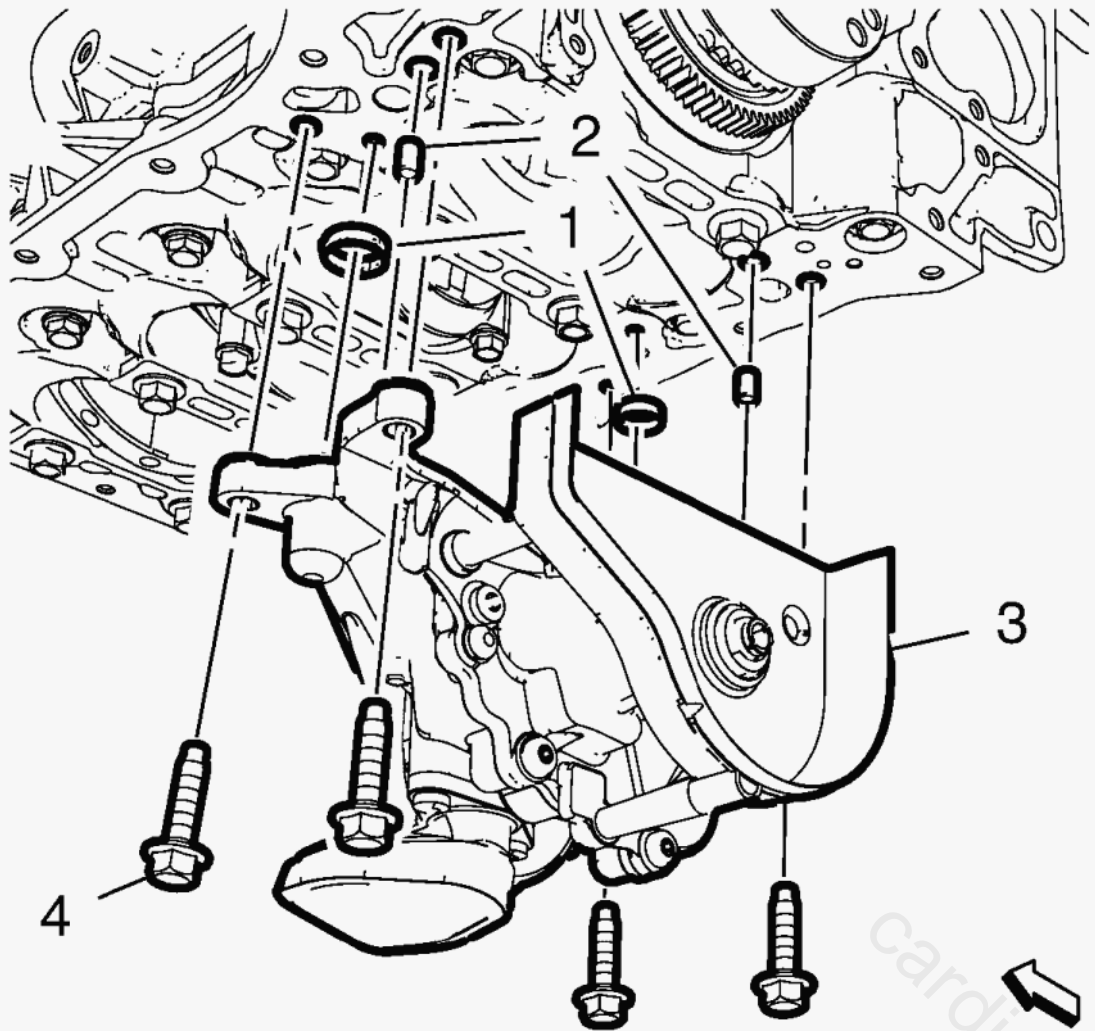


Fig. 863: Oil And Power Steering Pump, Bolts, Locating Pins And Gaskets
 Courtesy of GENERAL MOTORS COMPANY

1. Install the 2 location pins (2).
2. Install 2 NEW oil and power steering pump gaskets (1).
3. Install the oil and power steering pump (3).

CAUTION: Refer to [Fastener Caution](#) .

4. Install the 4 oil pump bolts (4) and tighten to 25 N.m (18 lb ft).

OIL PUMP DRIVE CHAIN AND SPROCKET INSTALLATION

Special Tools

- EN-45059 Angle Meter
- EN-51142 Oil Pump Sprocket Unit Holding Tool

For equivalent regional tools, refer to [Special Tools](#).

NOTE: Before installing the oil pump drive chain, check the components of the timing chain system for damage and wear.

1. Check the components of the timing chain system for damage and wear:
 - Timing chain guides with plastic attachment
 - Timing chain tensioner and timing chain tensioner shoe with plastic attachment
 - Timing chain and all timing chain sprockets
 - Oil pump sprocket
 - Oil pump drive chain tensioner

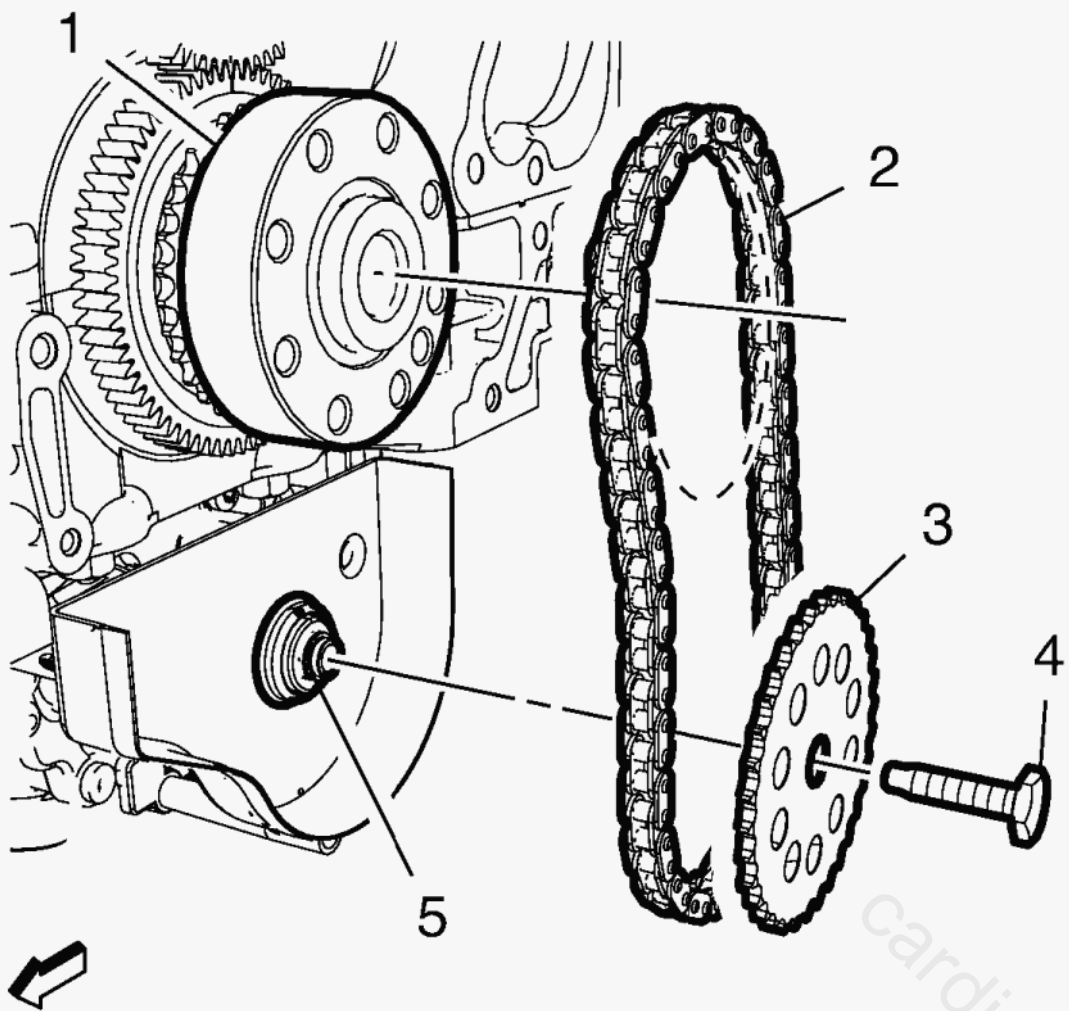


Fig. 864: Oil Pump Sprocket, Bolt, Shaft, Drive Chain And Drive Chain Sprocket
Courtesy of GENERAL MOTORS COMPANY

2. Install the oil pump drive chain (2) to the oil pump drive chain sprocket (1).
3. Install the oil pump sprocket (3) to the oil pump shaft (5).
4. Install a NEW oil pump sprocket bolt (4).

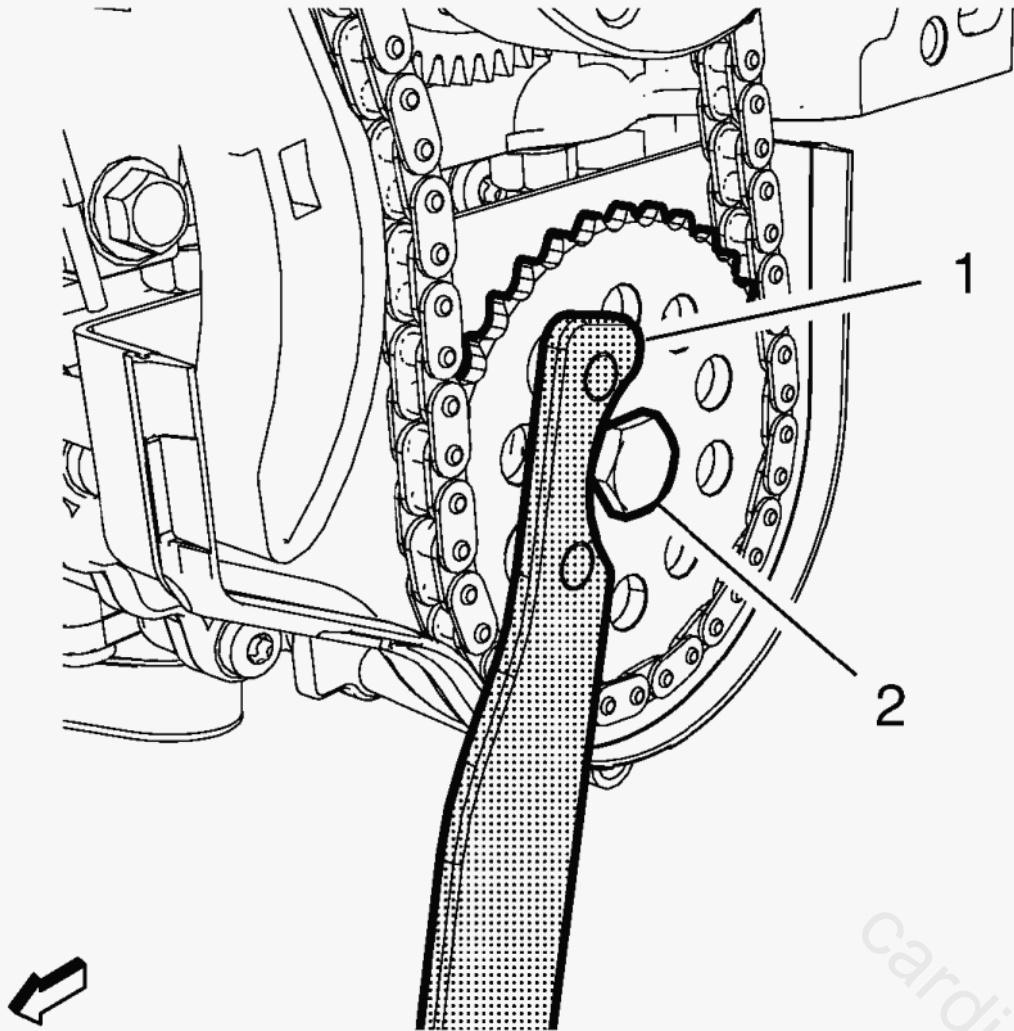


Fig. 865: Oil Pump Sprocket Bolt And Sprocket Holding Tool
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to [Fastener Caution](#) .

CAUTION: Refer to [Torque-to-Yield Fastener Caution](#) .

5. Tighten the NEW oil pump sprocket bolt (2), by counterhold with the EN-51142 holding tool (1) in 2 passes:
 1. Tighten a first pass to 25 N.m (18 lb ft)
 2. Tighten a final pass an additional to 60 degrees, use the EN-45059 angle meter.

OIL PUMP DRIVE CHAIN TENSIONER INSTALLATION

Special Tools

EN-50513 Fixing Pin

For equivalent regional tools, refer to [Special Tools](#).

NOTE: Before installing the oil pump drive chain tensioner, check the components of the timing chain system for damage and wear.

1. Check the components of the timing chain system for damage and wear:
 - Timing chain guides with plastic attachment
 - Timing chain tensioner and timing chain tensioner shoe with plastic attachment
 - Timing chain and all timing chain sprockets
 - Oil pump sprocket
 - Oil pump drive chain tensioner

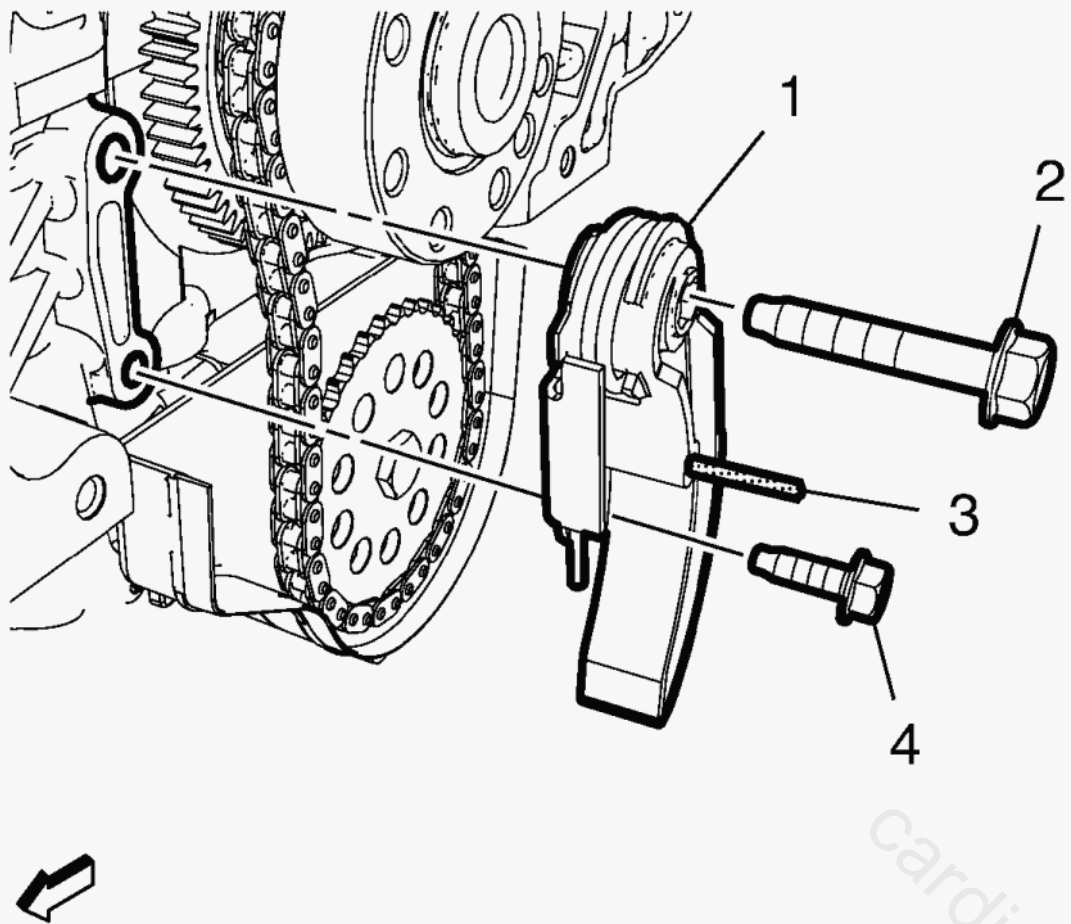


Fig. 866: Oil Pump Drive Chain Tensioner, Bolts And Fixing Pin
Courtesy of GENERAL MOTORS COMPANY

2. Install the oil pump drive chain tensioner (1).
3. Install the oil pump drive chain tensioner bolts (2, 4).

CAUTION: Refer to **Fastener Caution** .

4. Tighten the oil pump drive chain tensioner bolt (2) to 25 N.m (18 lb ft).
5. Tighten the oil pump drive chain tensioner bolt (4) to 10 N.m (89 lb in).

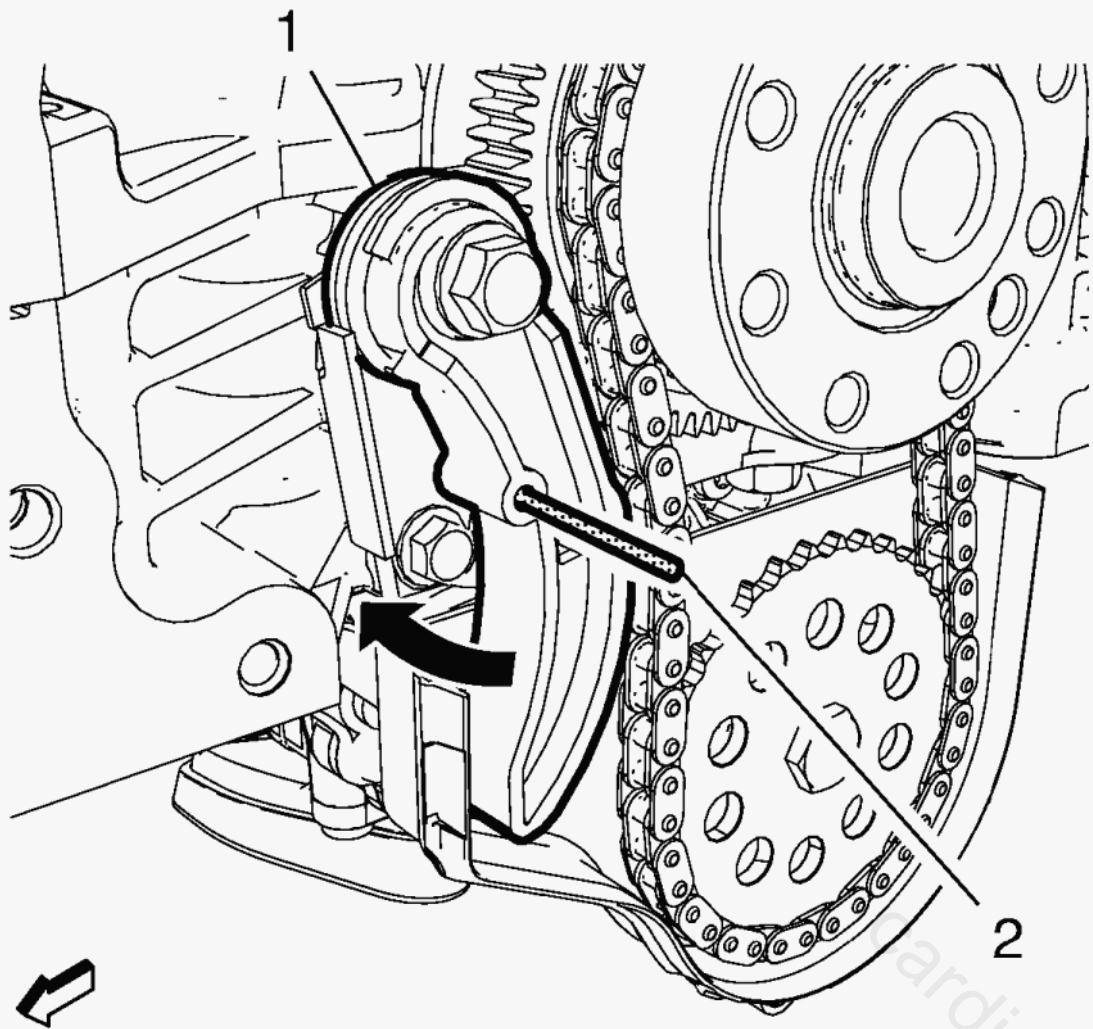


Fig. 867: Oil Pump Drive Chain Tensioner And Fixing Pin
 Courtesy of GENERAL MOTORS COMPANY

6. Remove the EN-50513 fixing pin (2).

TIMING CHAIN LOWER COVER INSTALLATION

Special Tools

- DT-523-1 Handle
- EN-51145 Crankshaft Rear Oil Seal Installer

For equivalent regional tools, refer to [Special Tools](#).

NOTE: Before installing the timing chain lower cover, check the components of the timing chain system for damage and wear.

1. Check the components of the timing chain system for damage and wear:
 - Timing chain guides with plastic attachment
 - Timing chain tensioner and timing chain tensioner shoe with plastic attachment
 - Timing chain and all timing chain sprockets
 - Oil pump sprocket
 - Oil pump drive chain tensioner
2. Clean the sealant surfaces.

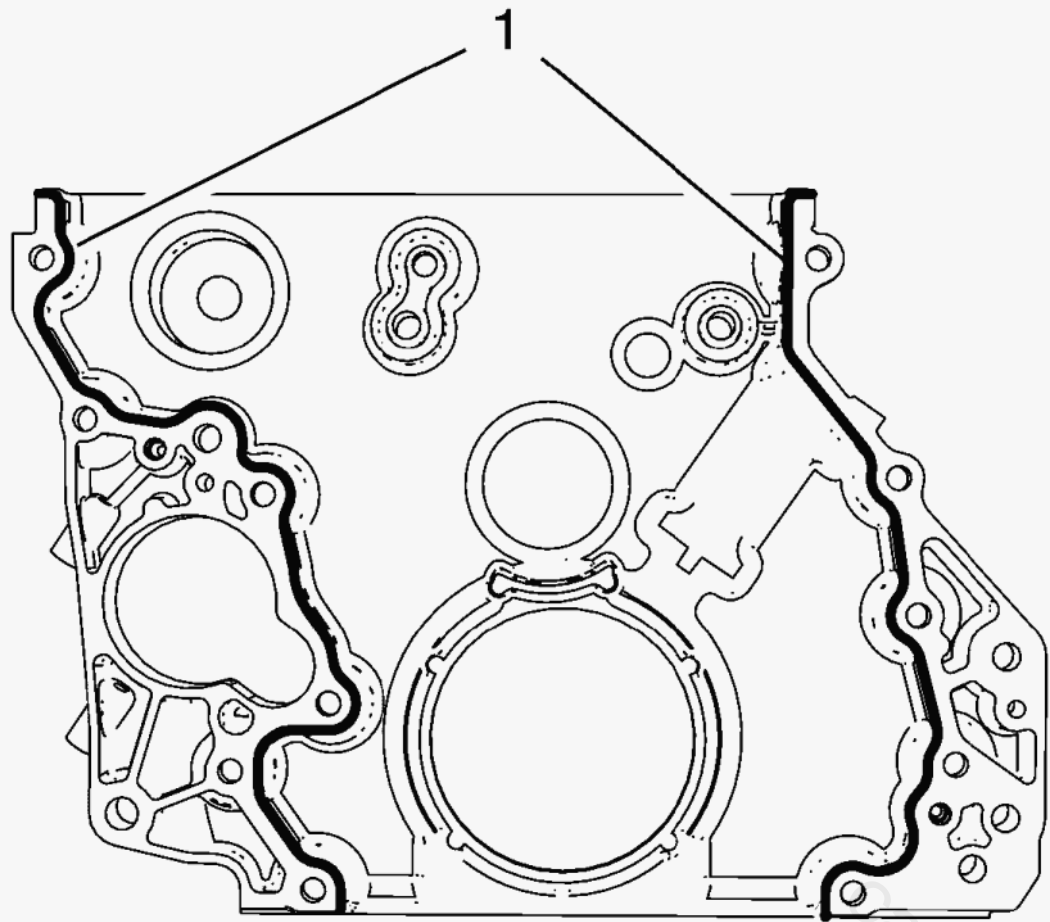


Fig. 868: Silicone Sealing Compound Application Area
Courtesy of GENERAL MOTORS COMPANY

NOTE: The complete installation procedure of the timing chain lower cover should be done in 20 minutes.

3. Apply silicone sealing compound (1) to the timing chain lower cover sealing surface. The thickness of the sealing bead should be 2.0 - 3.0 mm (0.079 - 0.118 in).

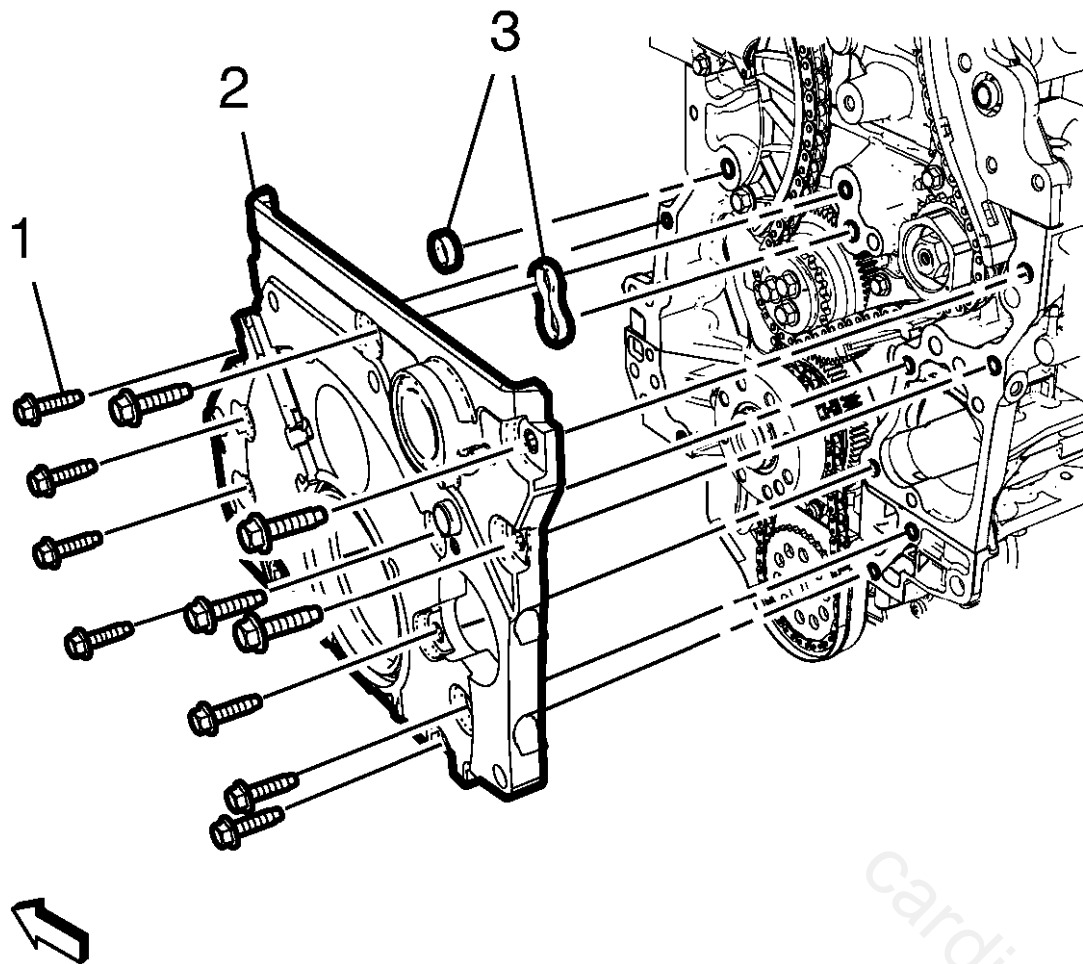


Fig. 869: Timing Chain Lower Cover, Bolts And Gaskets
Courtesy of GENERAL MOTORS COMPANY

4. Install the 2 NEW timing chain lower cover gaskets (3).
5. Install the timing chain lower cover (2)
6. Install the 11 timing chain lower cover bolts (1).

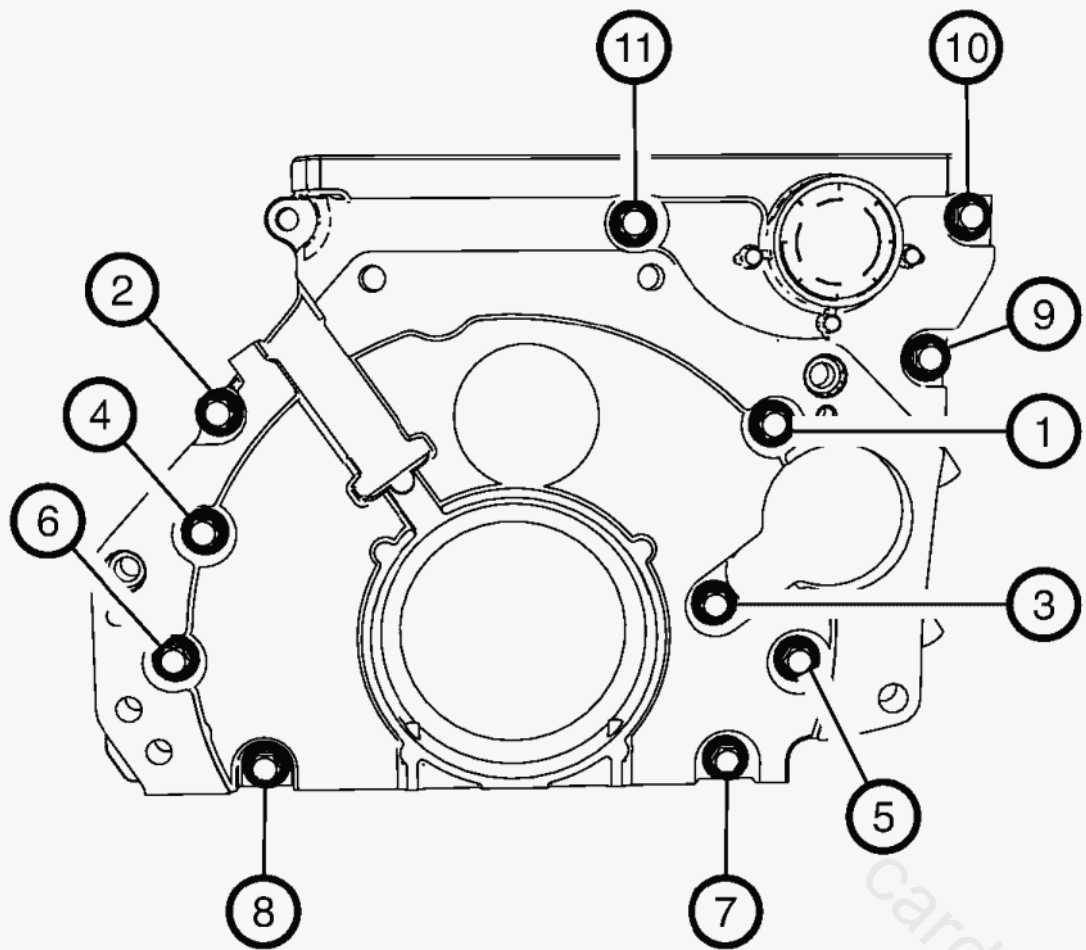


Fig. 870: Timing Chain Lower Cover Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution** .

7. Tighten the 11 timing chain lower cover bolts in sequence as shown to 25 N.m (18 lb ft).

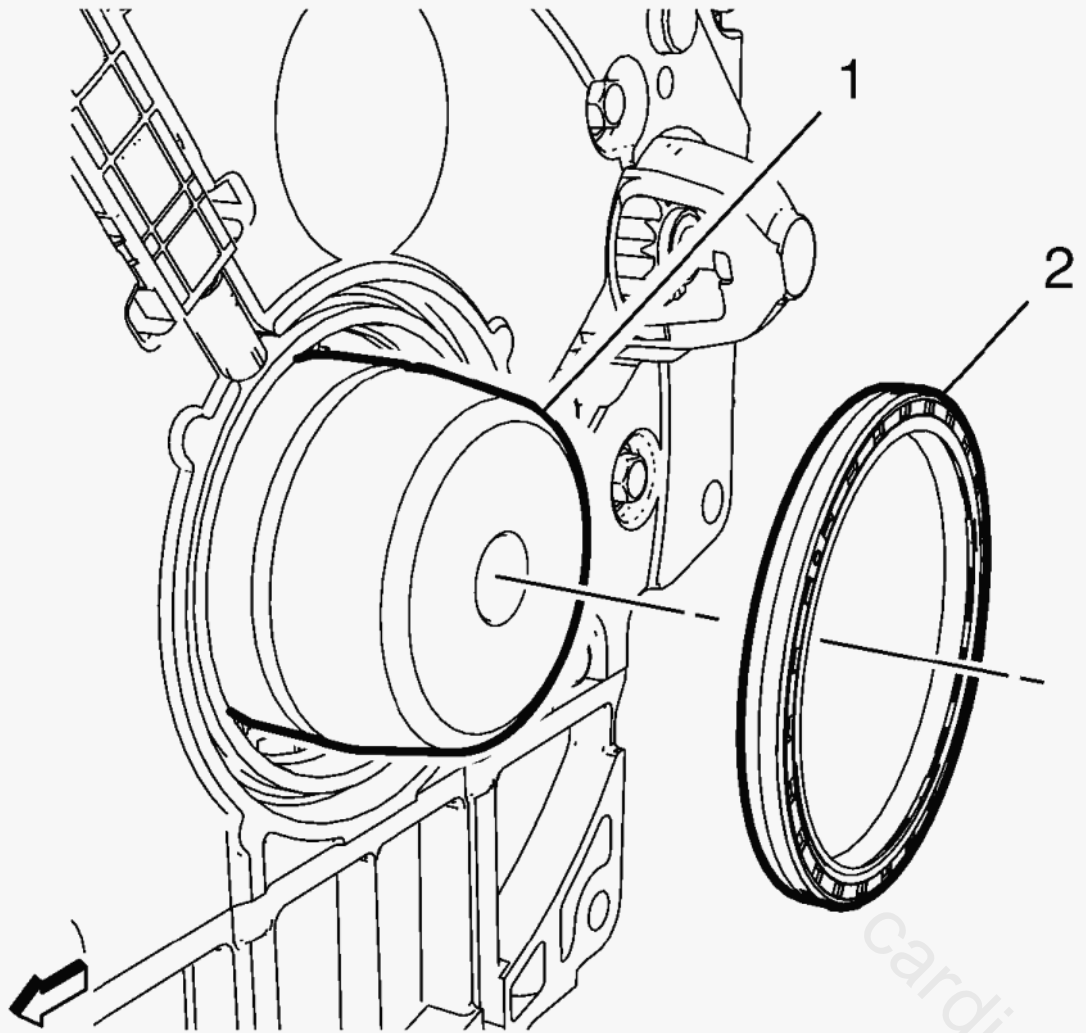


Fig. 871: Crankshaft Rear Oil Seal And Installer
Courtesy of GENERAL MOTORS COMPANY

8. Install the **EN-51145-1** installer (1) to the crankshaft.
9. Install a NEW crankshaft rear oil seal (2) to the **EN-51145-1** installer (1).

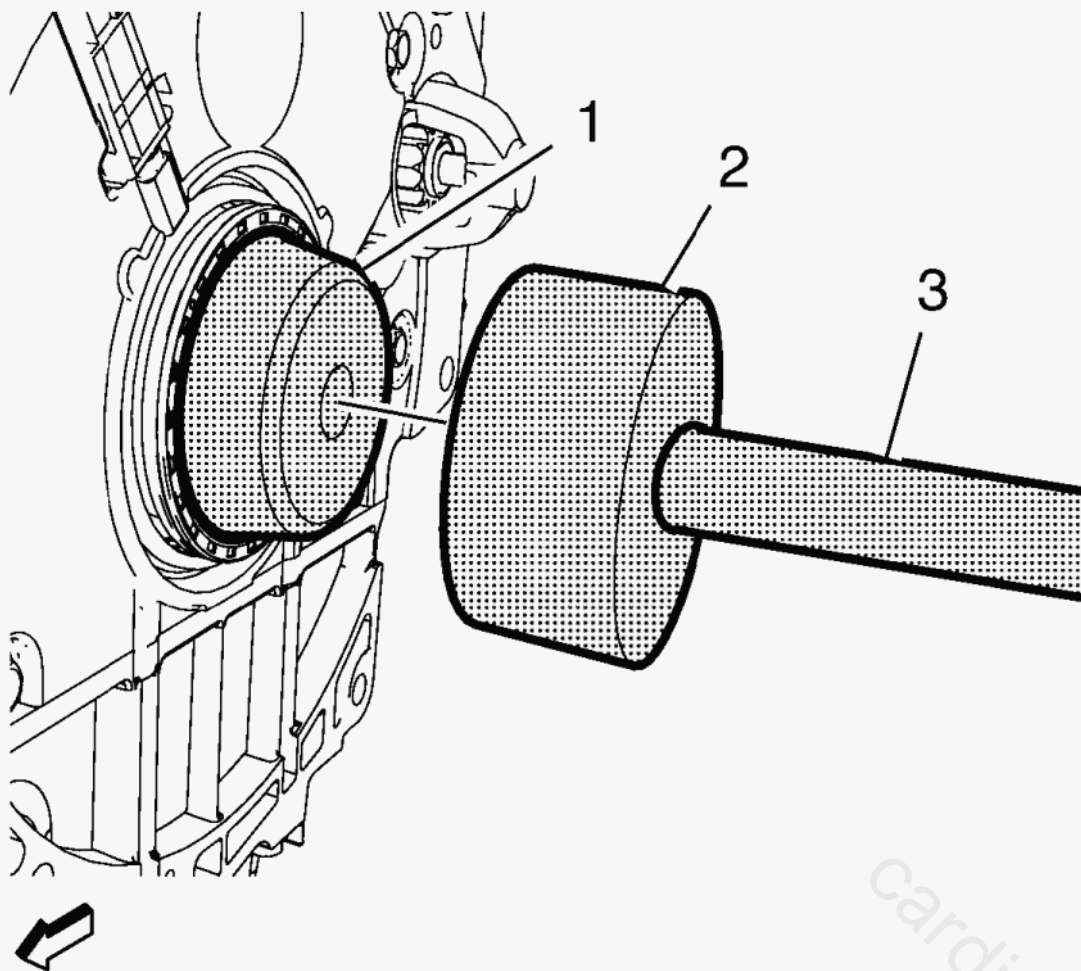


Fig. 872: Seating Crankshaft Rear Oil Seal

Courtesy of GENERAL MOTORS COMPANY

10. Pull in the crankshaft rear oil seal (1) with the **EN-51145-2** installer (2) and the **DT-523-1** handle (3).
11. Remove the **EN-51145** installer.

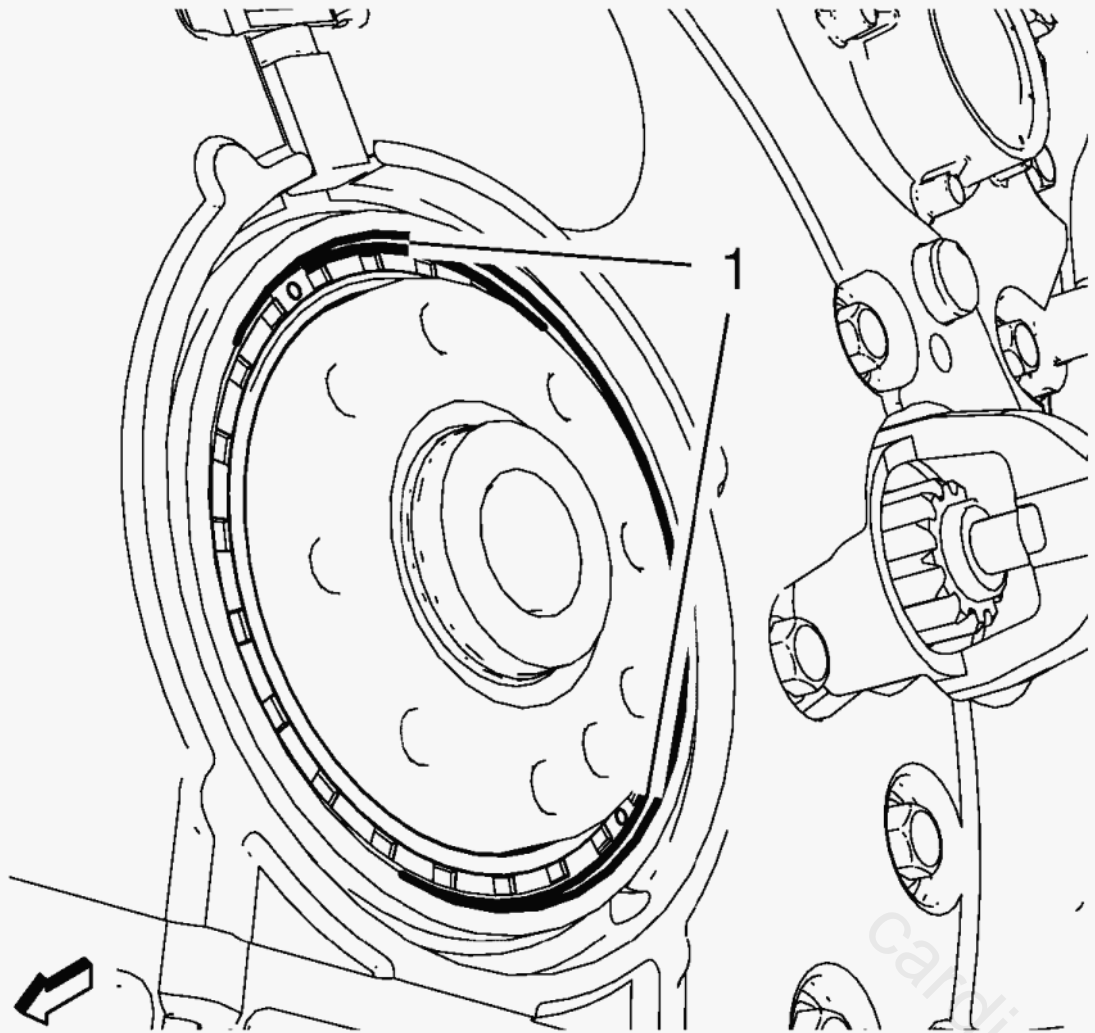


Fig. 873: Ensure Crankshaft Rear Oil Seal Is Properly Seated
Courtesy of GENERAL MOTORS COMPANY

12. Check the proper seat (1) of the crankshaft rear oil seal.

OIL PAN INSTALLATION

1. Clean the sealing surfaces.

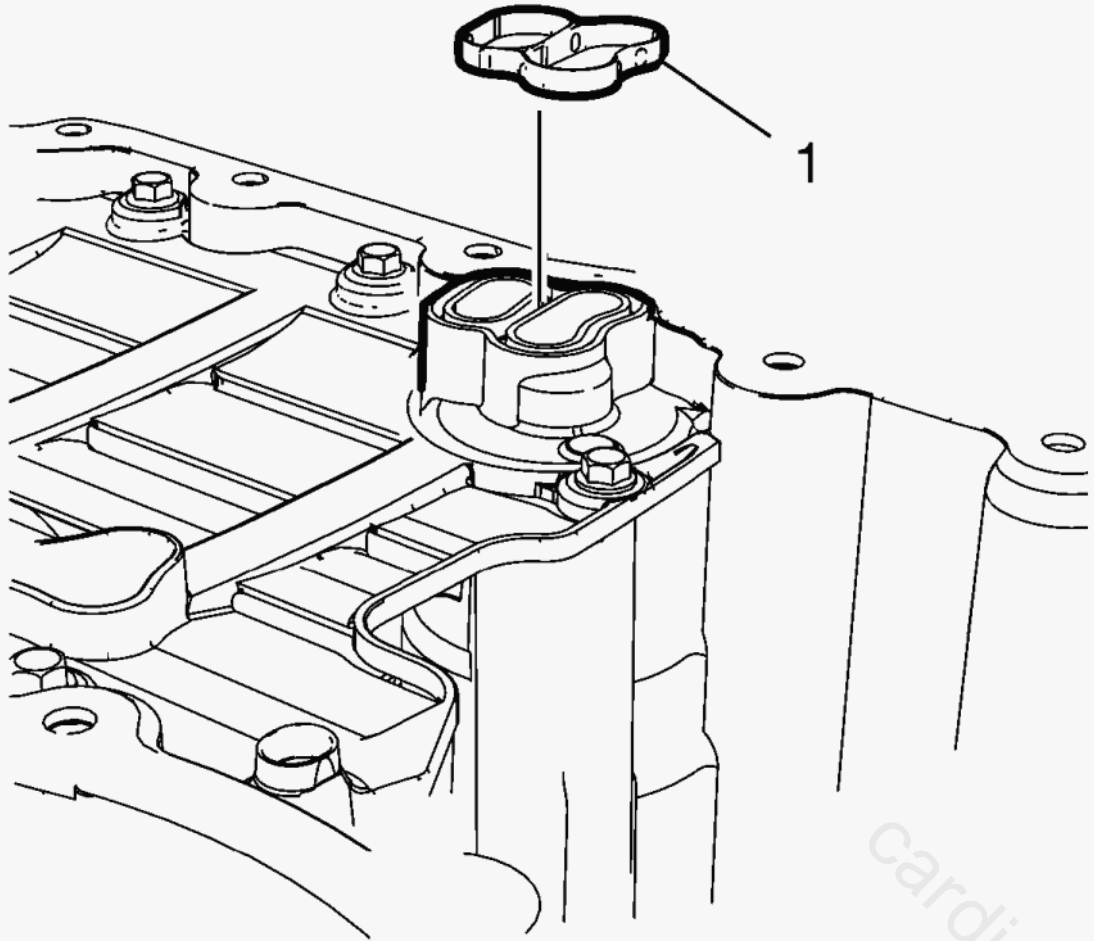


Fig. 874: Oil Filter Seal

Courtesy of GENERAL MOTORS COMPANY

2. Install a NEW oil filter seal (1)

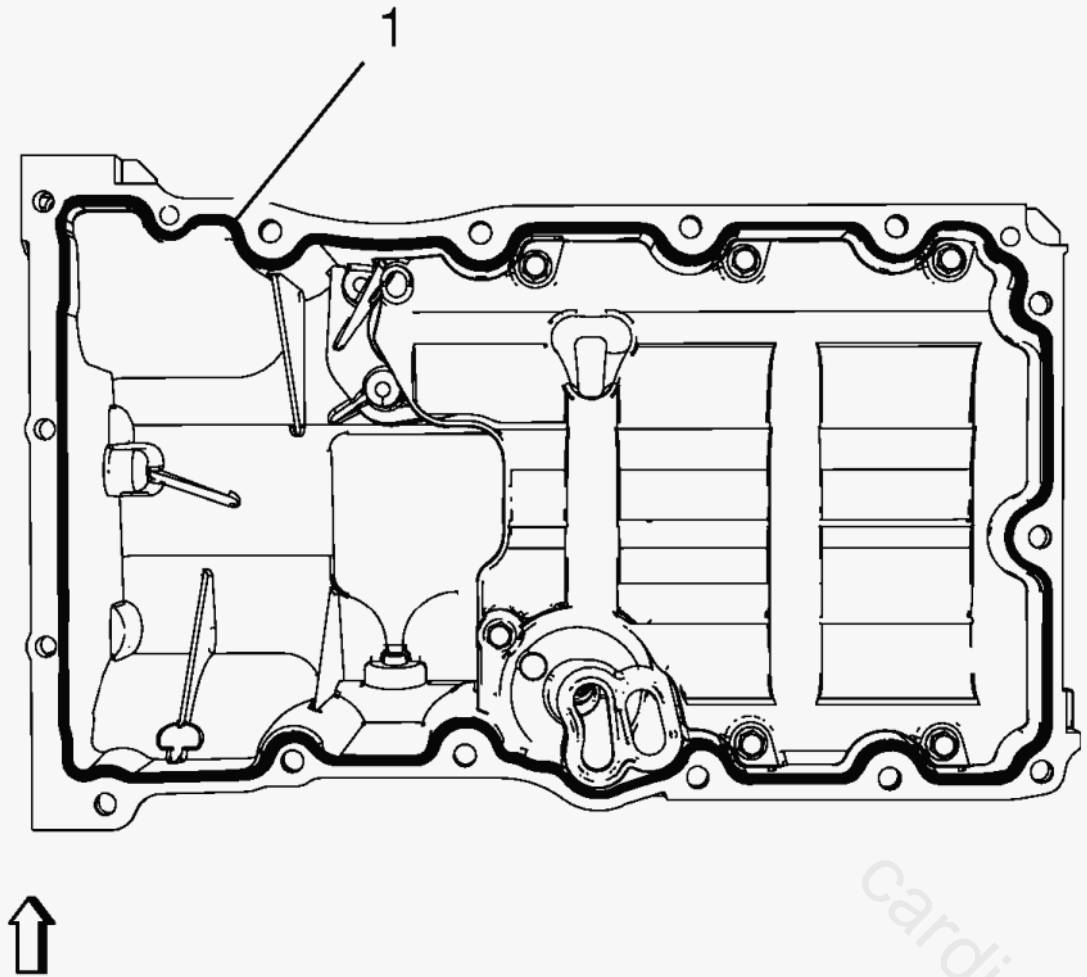


Fig. 875: Silicone Sealing Compound Application Area
Courtesy of GENERAL MOTORS COMPANY

NOTE: The complete installation procedure of the oil pan should be done in 20 minutes.

3. Apply silicone sealing compound (1) to the oil pan surface. The thickness of the sealing bead (1) should be 3.0 - 4.0 mm (0.118 - 0.157 in).

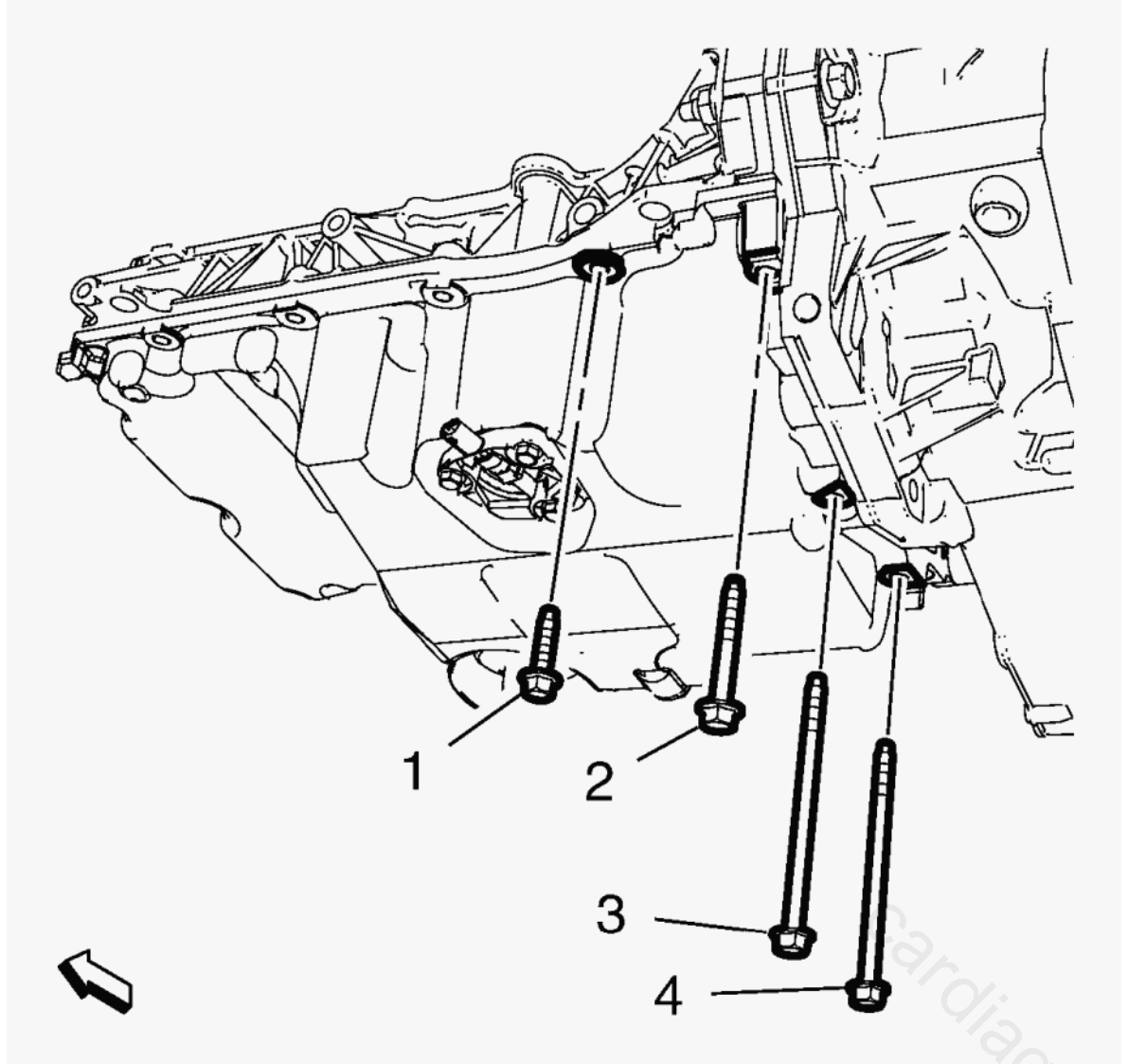


Fig. 876: Oil Pan Bolts

Courtesy of GENERAL MOTORS COMPANY

4. Install the oil pan.
5. Hand tighten the 12 oil pan bolts (1).
6. Hand tighten the oil pan bolt (2).
7. Hand tighten the 2 oil pan bolts (3, 4).

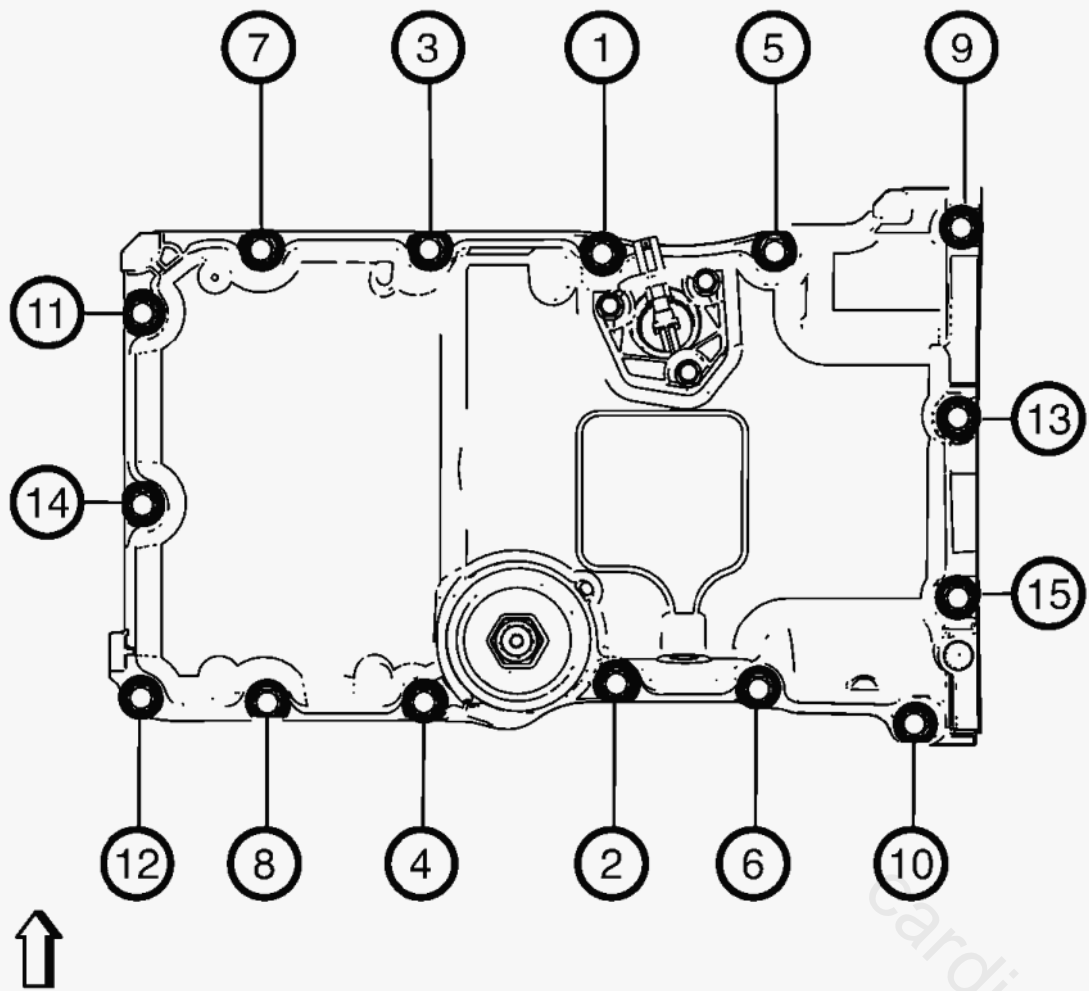


Fig. 877: Oil Pan Bolt Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to [Fastener Caution](#) .

8. Tighten the 15 oil pan bolts in sequence as shown to 25 N.m (18 lb ft).

CRANKSHAFT POSITION SENSOR RELUCTOR RING INSTALLATION

Special Tools

- **EN-652** Flywheel Holder
- **EN-45059** Angle Meter

Equivalent regional tools: [Special Tools](#)

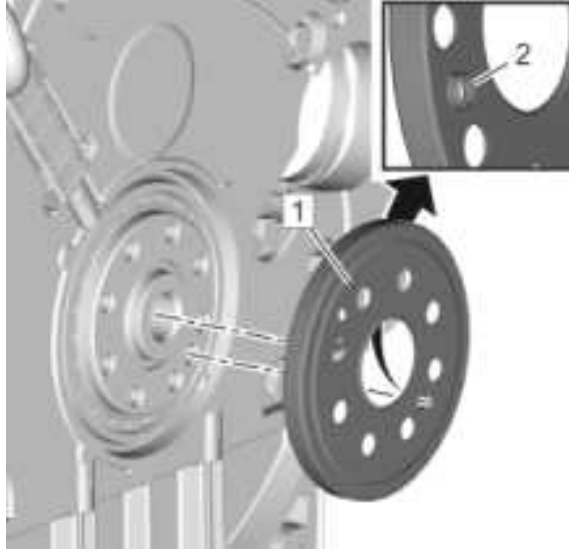


Fig. 878: Crankshaft Position Sensor Reluctor Ring And Pin
Courtesy of GENERAL MOTORS COMPANY

1. Install the crankshaft position sensor reluctor ring (1) by install the pin (2) in the correct hole of the engine block.

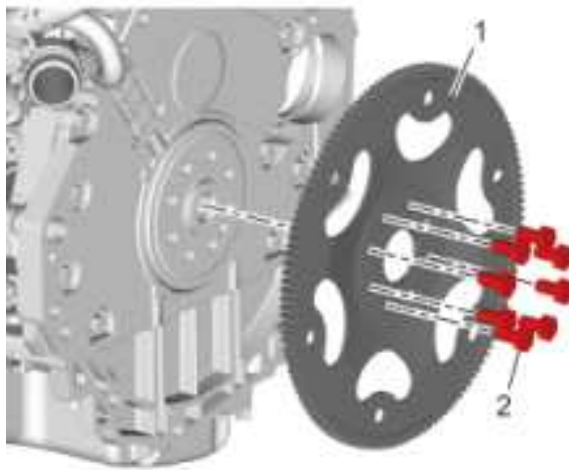
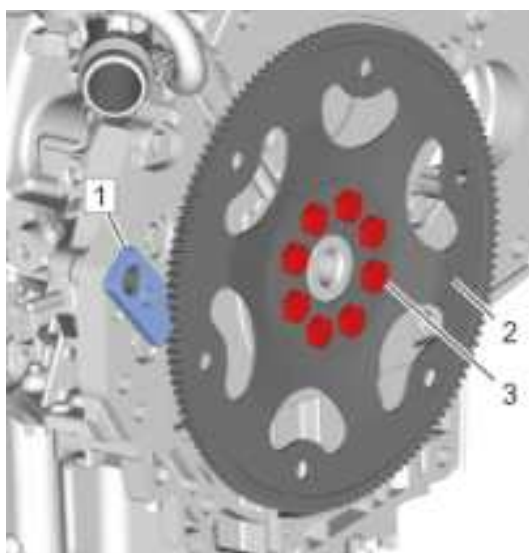


Fig. 879: Automatic Transmission Flex Plate And Bolts
Courtesy of GENERAL MOTORS COMPANY

2. Install Automatic Transmission Flex Plate (1)
3. Install the 8 NEW automatic transmission flex plate bolts.

Install NEW Automatic Transmission Flex Plate Bolts (2).



4. Install the **EN-652** flywheel holder (1) in order to fix the automatic transmission flex plate (2).

CAUTION: Refer to **Fastener Caution**

CAUTION: Refer to **Torque-to-Yield Fastener Caution**

5. Tighten the 8 automatic transmission flex plate bolts (3) crosswise to the following order:

First Pass: 60 N.m (44 lb ft).

Final Pass: 45 degrees, use the **EN-45059** meter.

6. Remove the **EN-652** flywheel holder.

CRANKSHAFT REAR OIL SEAL INSTALLATION

Special Tools

- **EN-51145** Crankshaft Seal Installer
- **DT-523-1** Handle

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

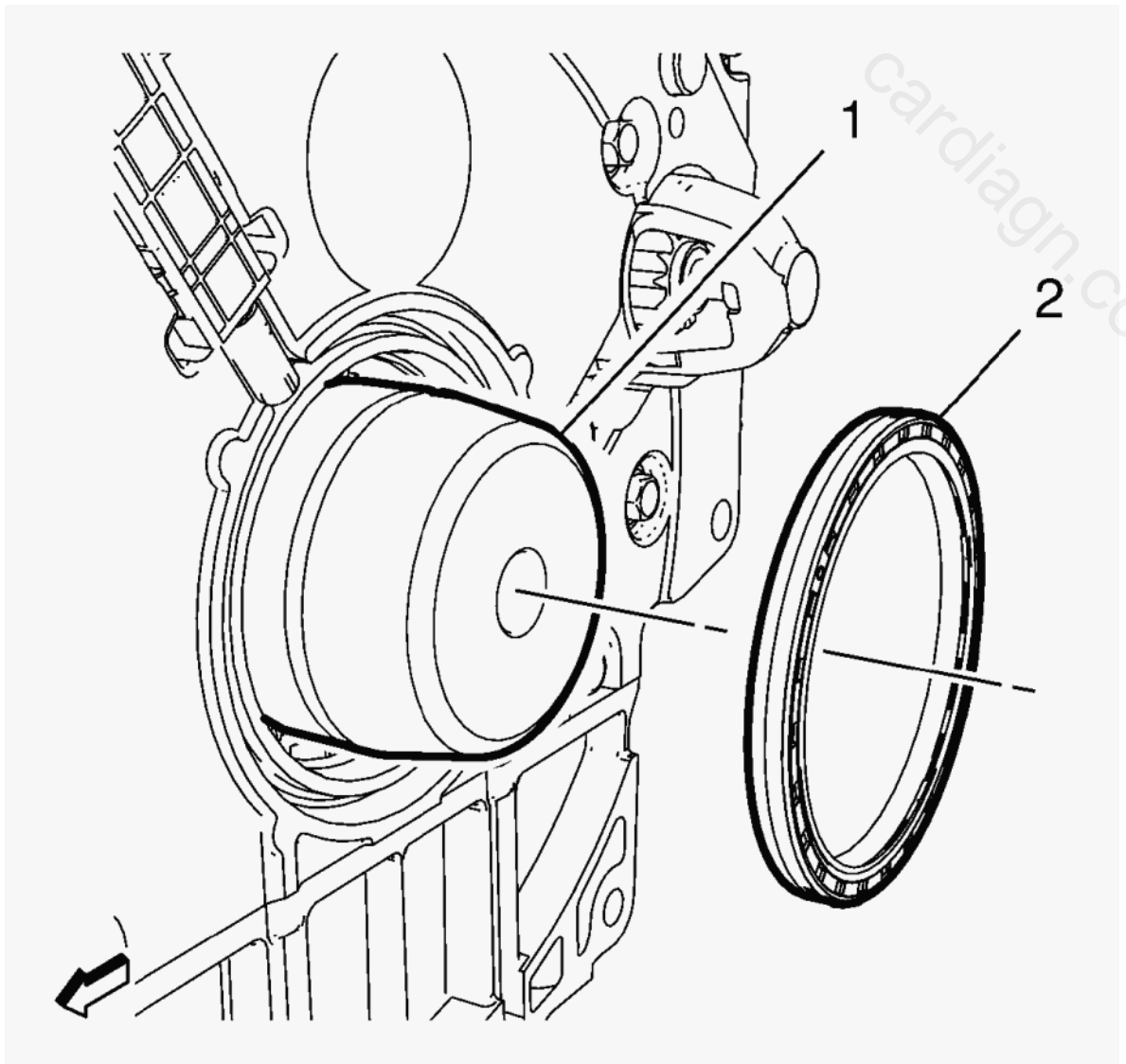


Fig. 881: Crankshaft Rear Oil Seal And Installer

Courtesy of GENERAL MOTORS COMPANY

1. Install the **EN-51145-1** installer (1) to the crankshaft.
2. Install the crankshaft rear oil seal (2) to the **EN-51145-1** installer (1).

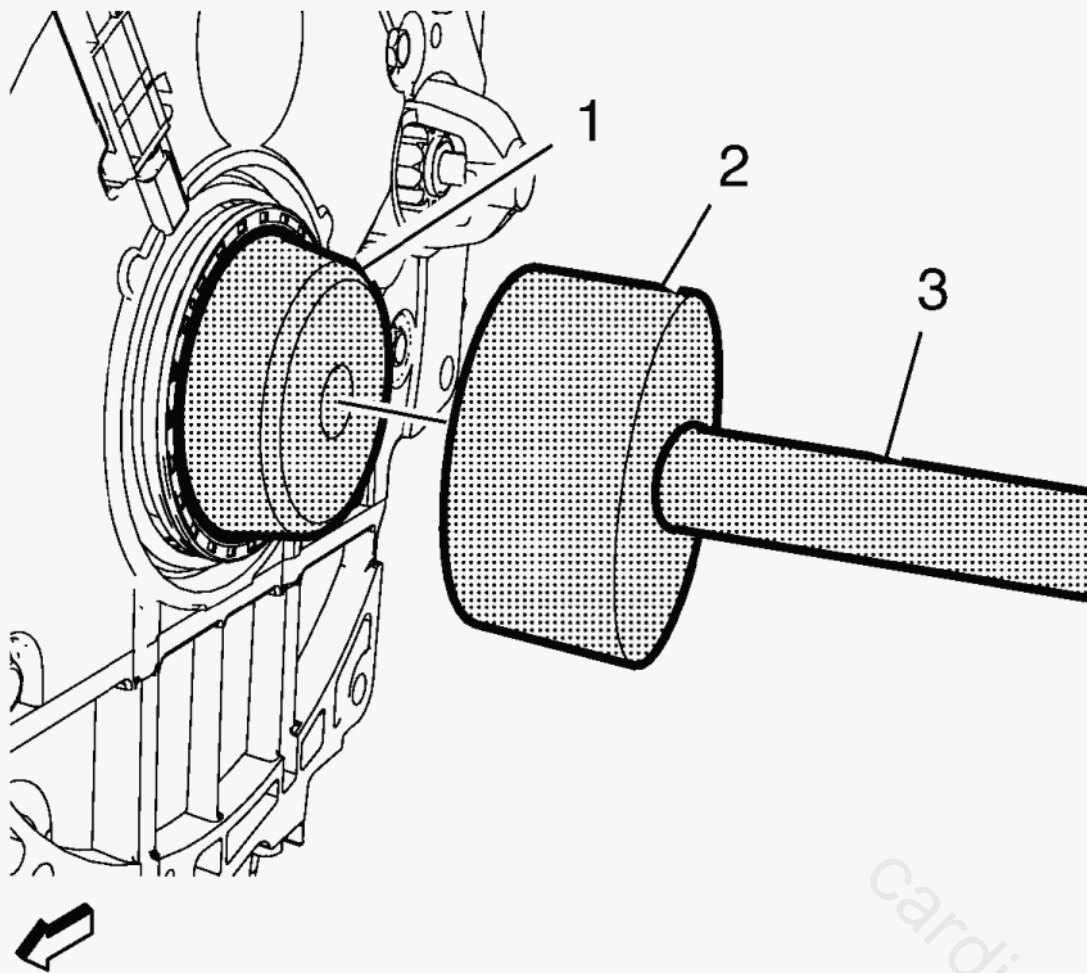


Fig. 882: Seating Crankshaft Rear Oil Seal

Courtesy of GENERAL MOTORS COMPANY

3. Pull in the crankshaft rear oil seal (1) with the **EN-51145-2** installer (2) and the **DT-523-1** handle (3).
4. Remove **EN-51145** installer.

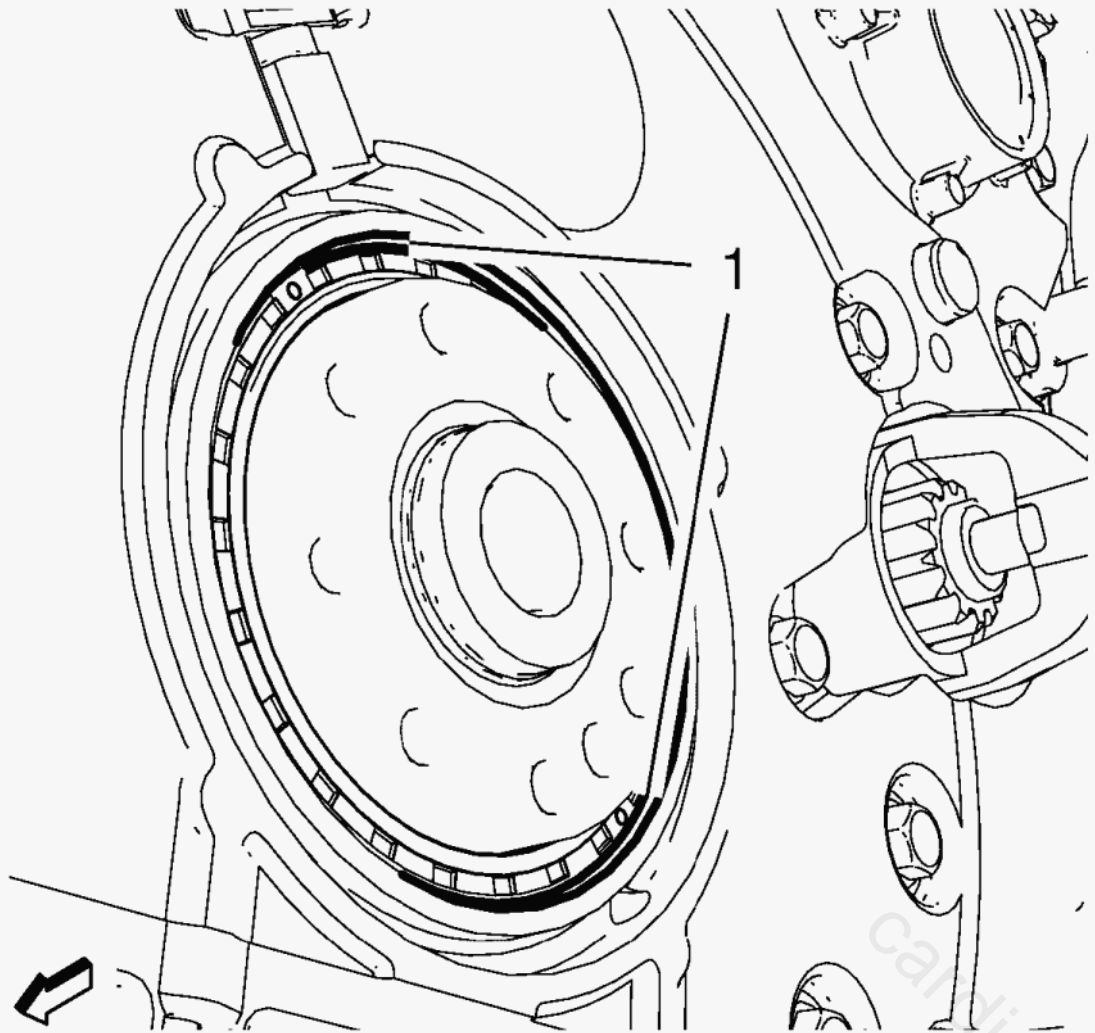


Fig. 883: Ensure Crankshaft Rear Oil Seal Is Properly Seated
Courtesy of GENERAL MOTORS COMPANY

5. Check the proper seat (1) of the crankshaft rear oil seal.

ENGINE FLYWHEEL INSTALLATION

Special Tools

- **EN-652** Flywheel Holder
- **EN-45059** Angle Meter

Equivalent regional tools: **Special Tools**.

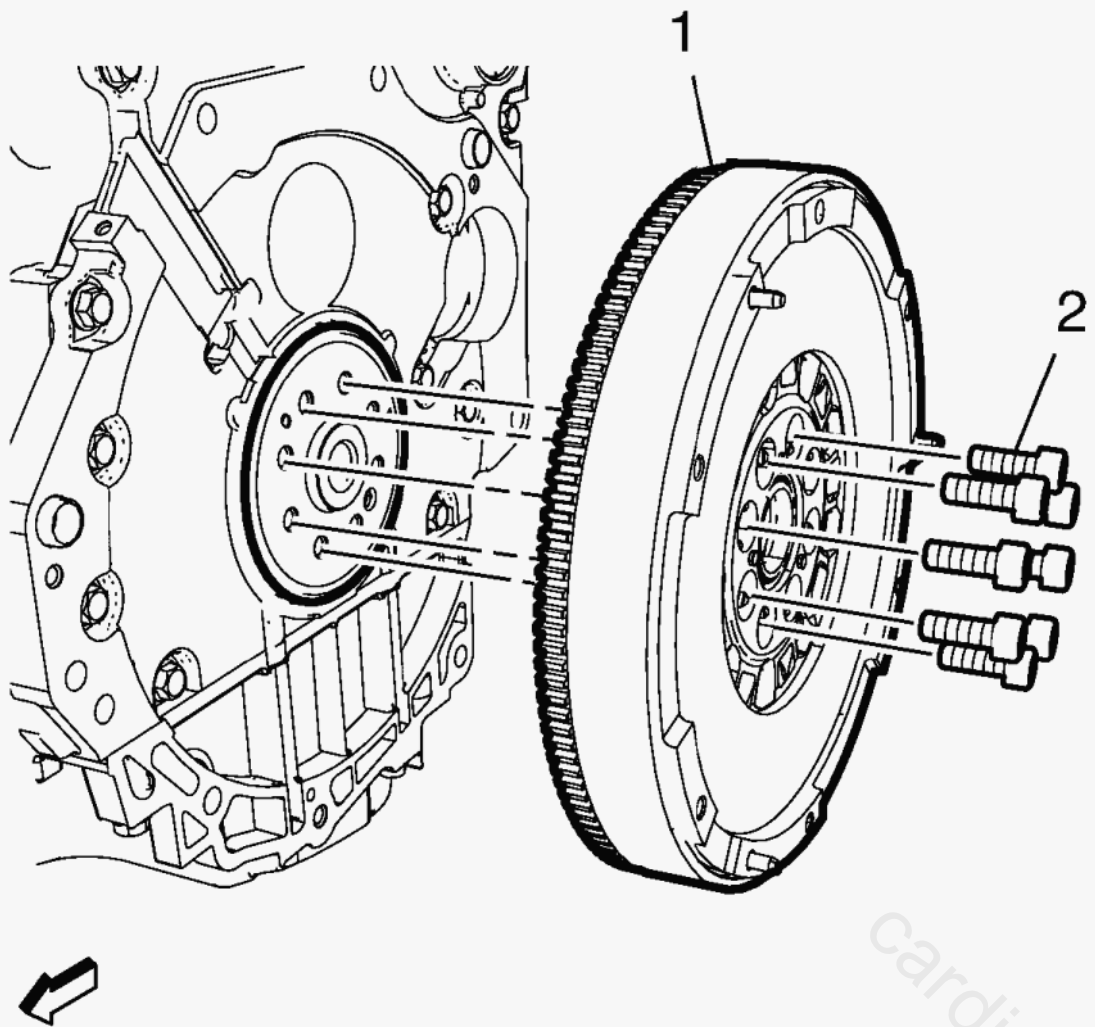


Fig. 884: Engine Flywheel And Bolts

Courtesy of GENERAL MOTORS COMPANY

1. Install the engine flywheel (1).
2. Install the EN-652 flywheel holder in order to fix the flywheel (1).

CAUTION: Refer to [Fastener Caution](#) .

CAUTION: Refer to [Torque-to-Yield Fastener Caution](#) .

3. Install the 8 NEW engine flywheel bolts (2) and tighten in the following order:

Tighten the bolts a first pass to 60 N.m (44 lb ft).

Tighten the bolts a final pass an additional to 45 degrees, use the **EN-45059** meter.

4. Remove the **EN-652** holder.

AUTOMATIC TRANSMISSION FLEX PLATE INSTALLATION

Special Tools

- **EN-652** Holder Flex Plate
- **EN-45059** Angle Meter

Equivalent regional tools: [Special Tools](#)

Installation Procedure

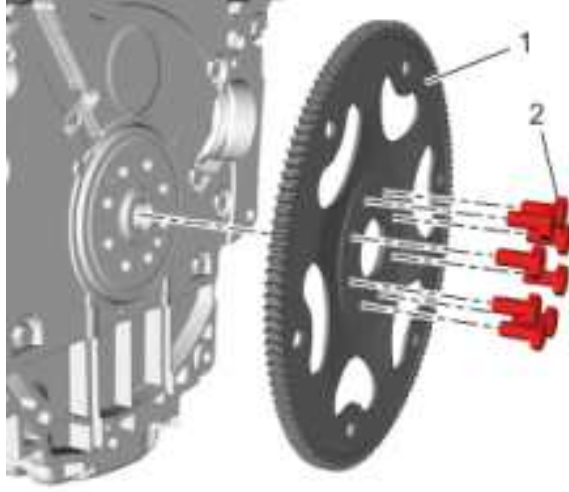


Fig. 885: Automatic Transmission Flex Plate And Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Install Automatic Transmission Flex Plate (1)

NOTE: **Install NEW bolts.**

2. Install Automatic Transmission Flex Plate Bolts (2) (Qty: 8)



Fig. 886: Flex Plate Holder
Courtesy of GENERAL MOTORS COMPANY

3. Install the EN-652 holder (1) in order to fix the flex plate.
4. Tighten the flex plate bolts crosswise in the following order:

CAUTION: Refer to **Fastener Caution**

CAUTION: Refer to **Torque-to-Yield Fastener Caution**

1. First Pass: 60 N.m (44 lb ft)
2. Final Pass: 45 degrees - **EN-45059** meter
5. Remove the **EN-652** holder.

CRANKSHAFT POSITION SENSOR INSTALLATION

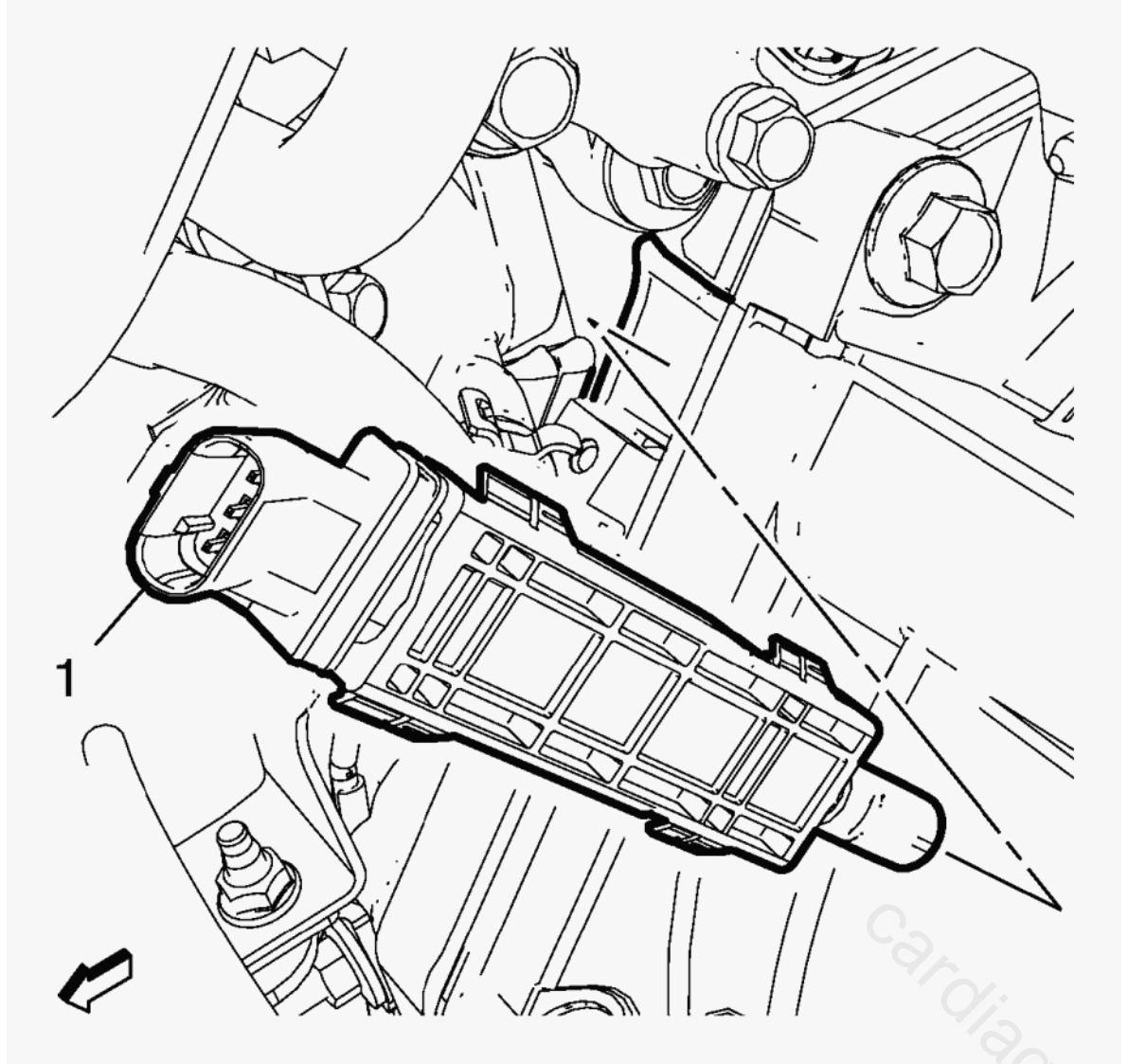


Fig. 887: Crankshaft Position Sensor

Courtesy of GENERAL MOTORS COMPANY

1. Install the crankshaft position sensor (1).

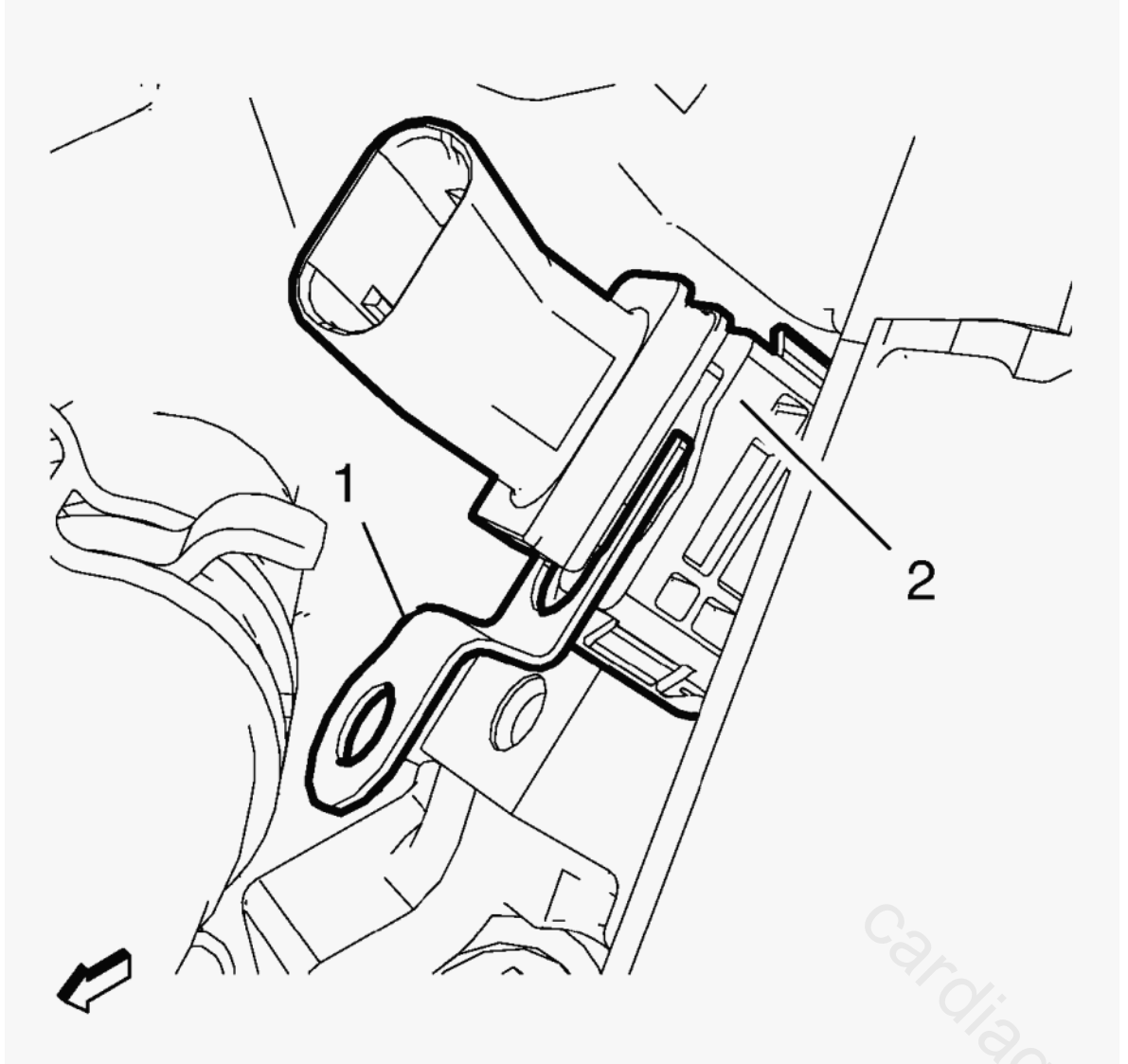


Fig. 888: Crankshaft Position Sensor Retainer Spring Into Correct Channel
Courtesy of GENERAL MOTORS COMPANY

NOTE: Slightly lift the crankshaft position sensor to install the retainer spring.

2. Install the crankshaft position sensor retainer spring (1) into the correct channel (2) of the crankshaft position sensor.

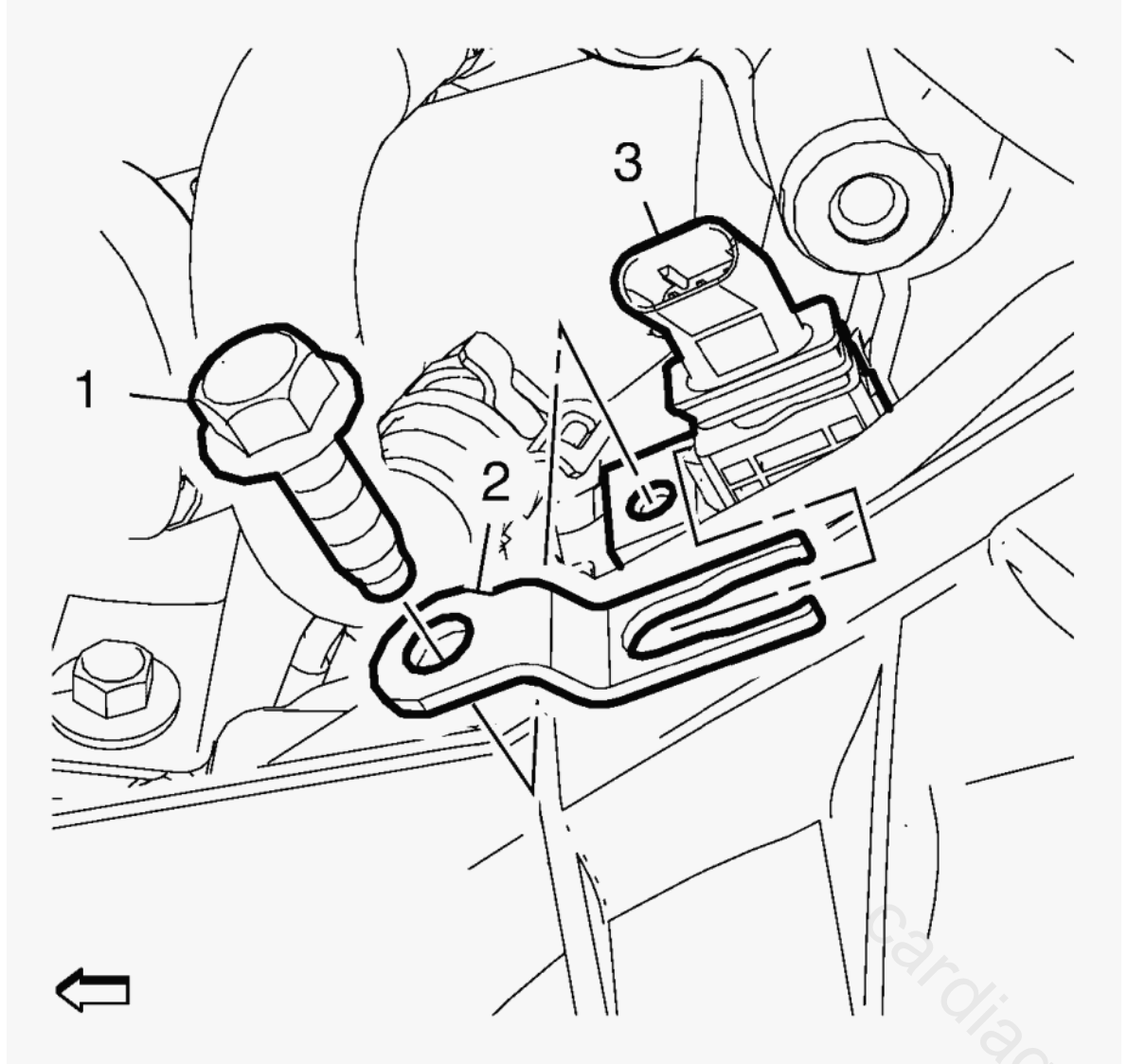


Fig. 889: Crankshaft Position Sensor, Bolt And Retainer Spring
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution** .

3. Install the crankshaft position sensor bolt (1) and tighten to 10 N.m (89 lb in).

TIMING CHAIN UPPER COVER INSTALLATION

NOTE: Before installing the timing chain upper cover, check the components of the timing chain system for damage and wear.

1. Check the components of the timing chain system for damage and wear:
 - Timing chain guides with plastic attachment
 - Timing chain tensioner and timing chain tensioner shoe with plastic attachment
 - Timing chain and all timing chain sprockets
 - Oil pump sprocket
 - Oil pump drive chain tensioner
2. Clean the sealant surfaces.

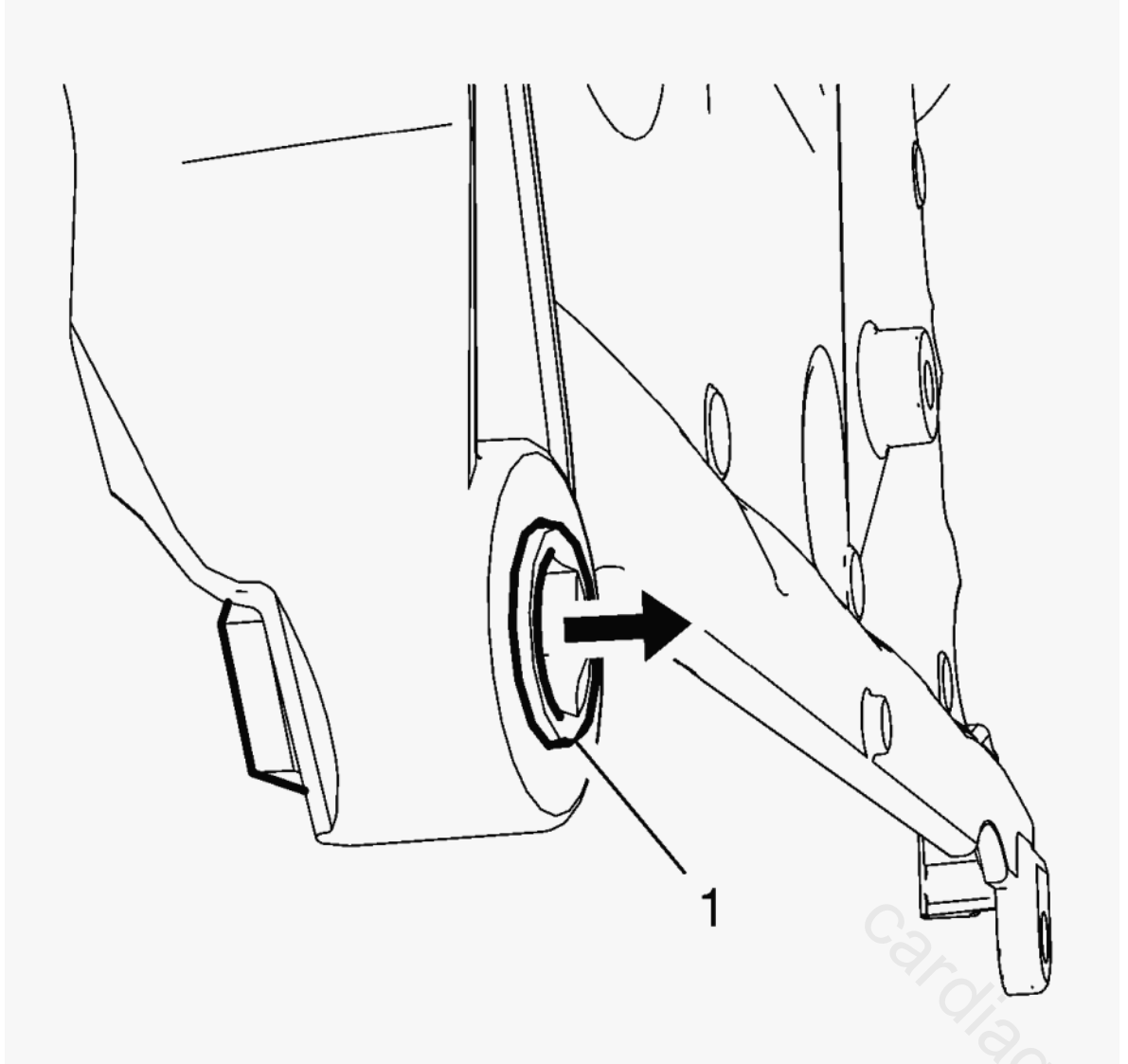


Fig. 890: Timing Chain Upper Cover Sleeve
Courtesy of GENERAL MOTORS COMPANY

3. Unscrew the timing chain upper cover sleeve (1) to the initial position in arrow direction.

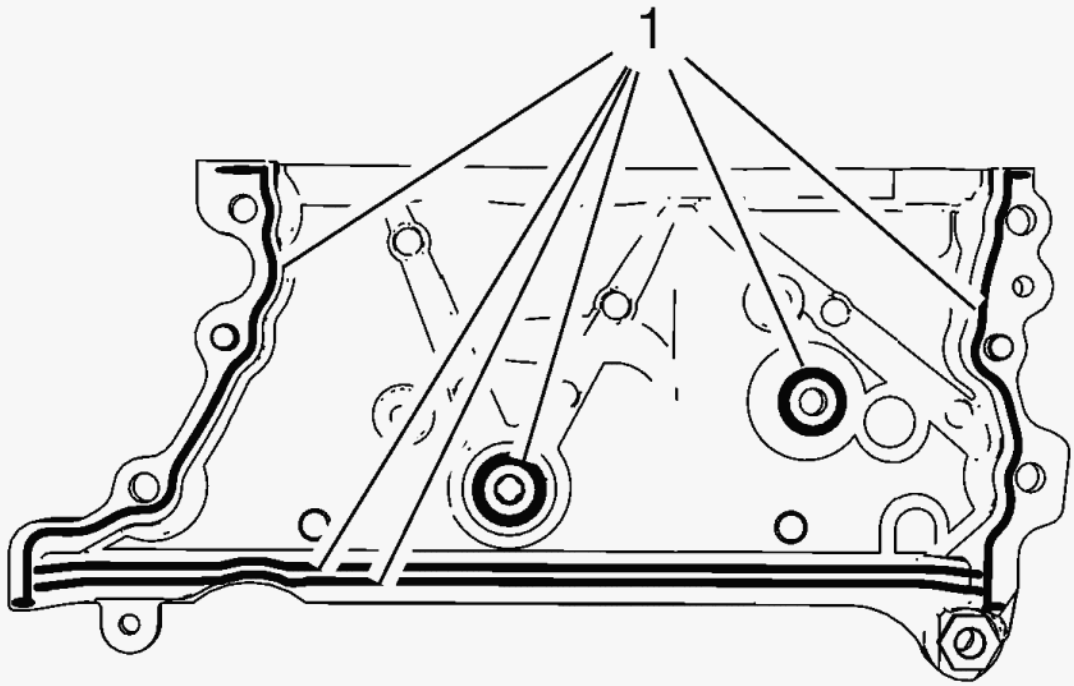


Fig. 891: Silicone Sealing Compound Application Area
Courtesy of GENERAL MOTORS COMPANY

NOTE: The complete installation procedure of the timing chain upper cover should be done in 20 minutes.

4. Apply silicone sealing compound (1) to the timing chain upper cover sealing surface. The thickness of the sealing bead should be 2.0 - 3.0 mm (0.079 - 0.118 in).

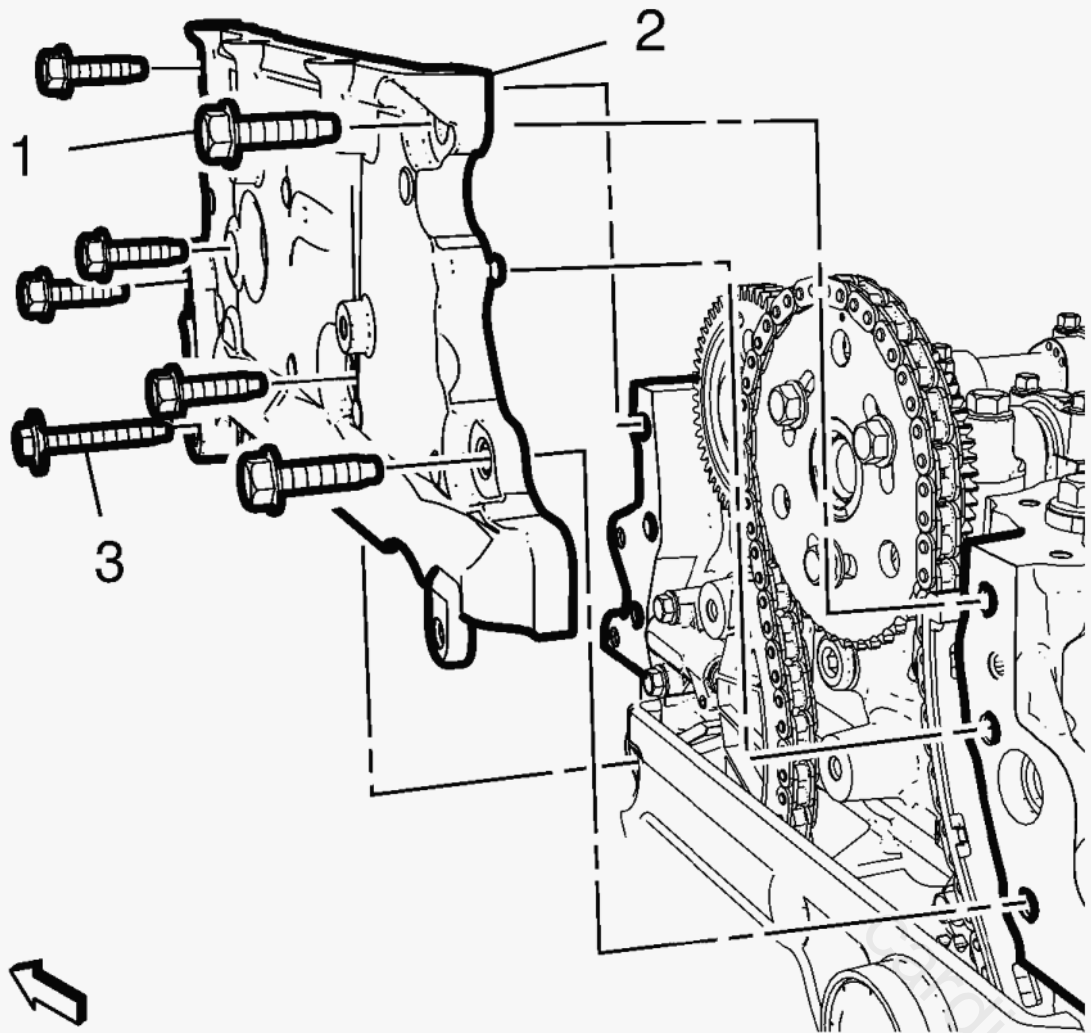


Fig. 892: Timing Chain Upper Cover And Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: Do not install the sleeve bolt (3).

5. Install the 6 timing chain upper cover bolts (1).

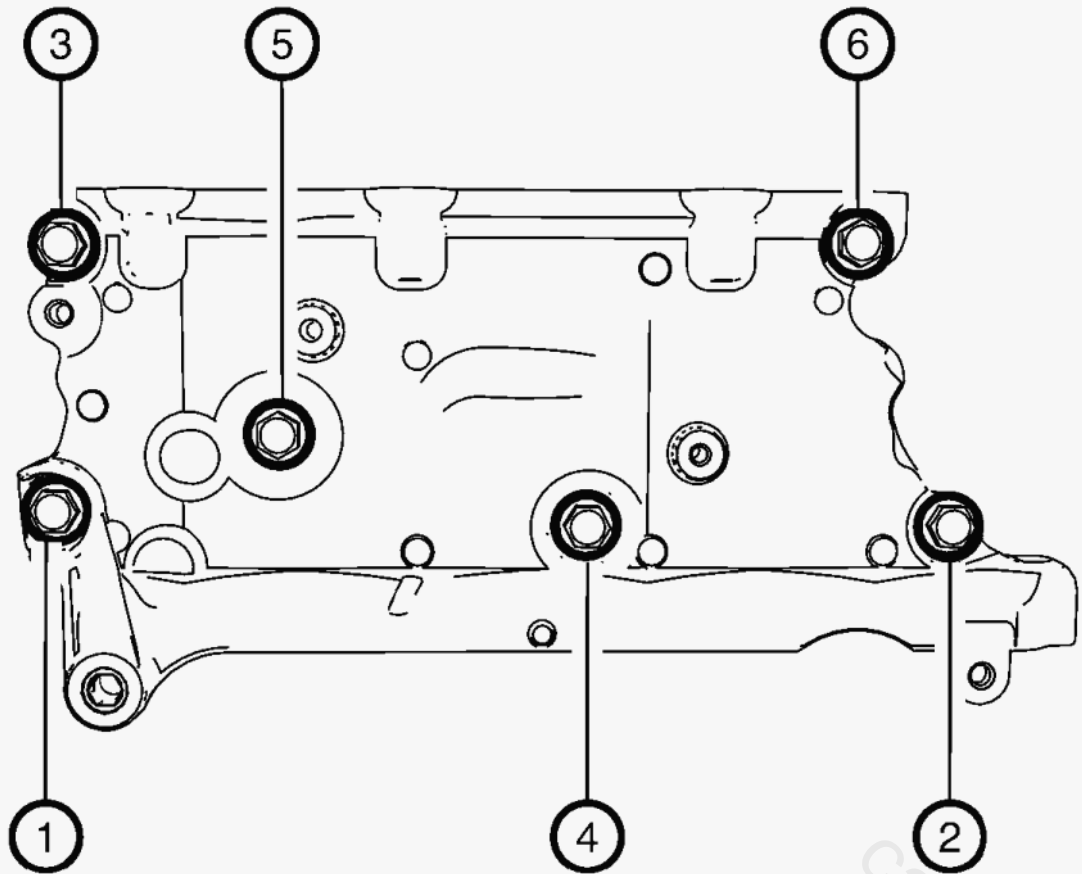


Fig. 893: Timing Chain Upper Cover Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution** .

6. Tighten the 6 chain upper cover bolts in sequence as shown to 25 N.m (18 lb ft).

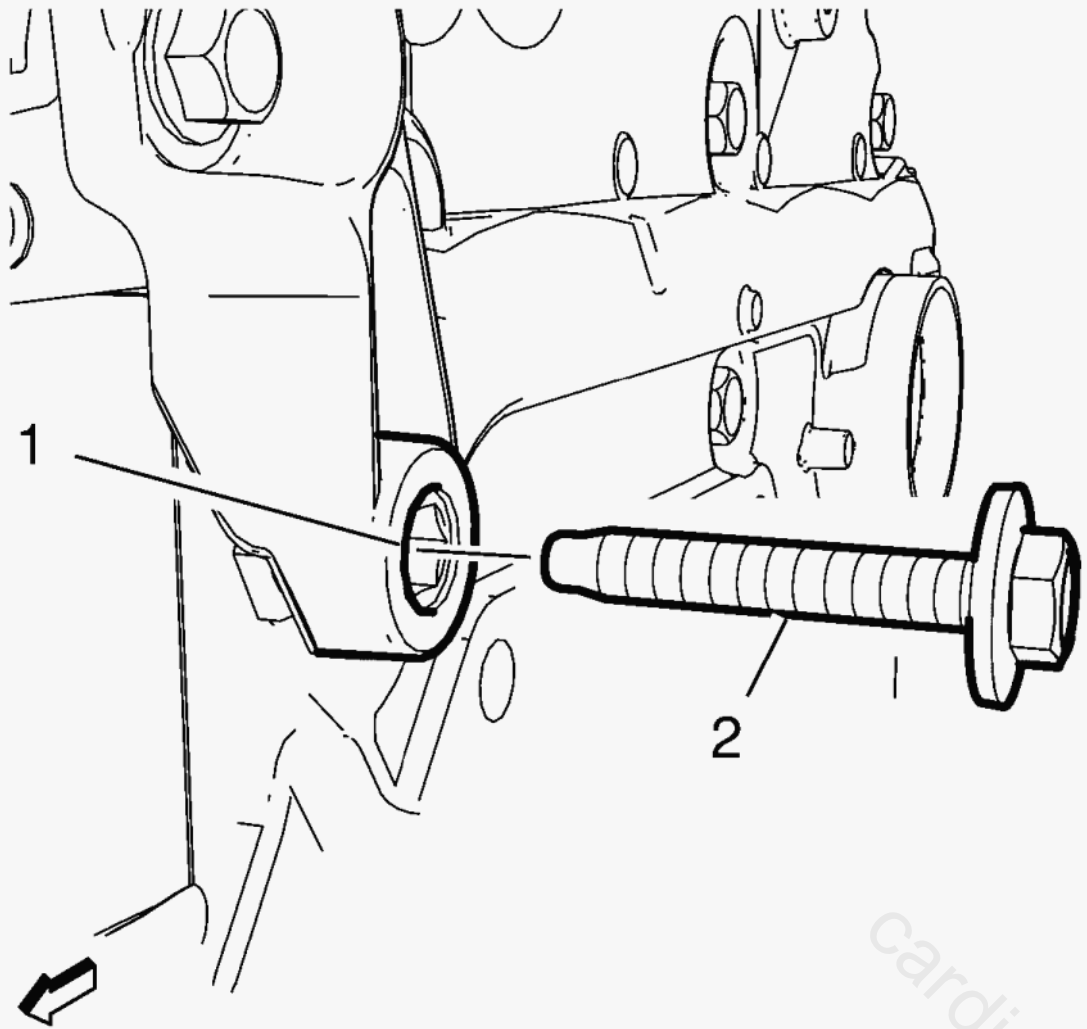


Fig. 894: Timing Chain Upper Cover Sleeve And Bolt
 Courtesy of GENERAL MOTORS COMPANY

7. Tighten the timing chain upper cover sleeve (1) to 3.5 N.m (31 lb in).
8. Install the timing chain upper cover sleeve bolt (2) and tighten to 25 N.m (18 lb ft).

CAMSHAFT HOUSING INSTALLATION

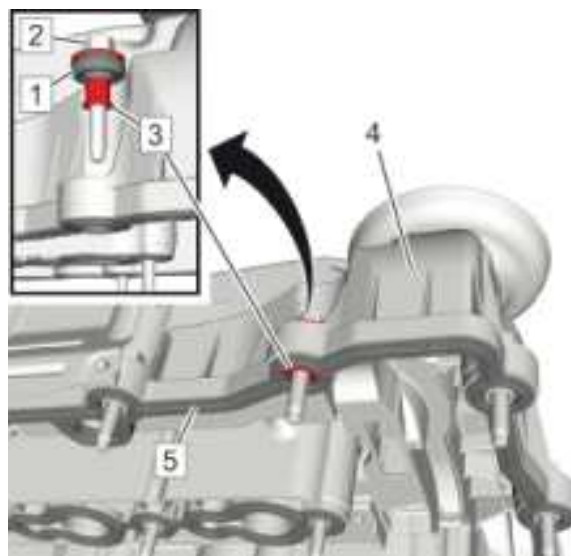


Fig. 895: Camshaft Housing, Gasket, Bolts, Bushings And Insulators
 Courtesy of GENERAL MOTORS COMPANY

1. Install NEW Camshaft Housing Gasket (5) @ Camshaft Housing (4)
2. Install Camshaft Housing Bolts (2) (Qty: 20) @ Camshaft Housing (4)

3. Inspect the correct seat of the camshaft housing bolt bushings (3) and the camshaft housing cover insulators (1).

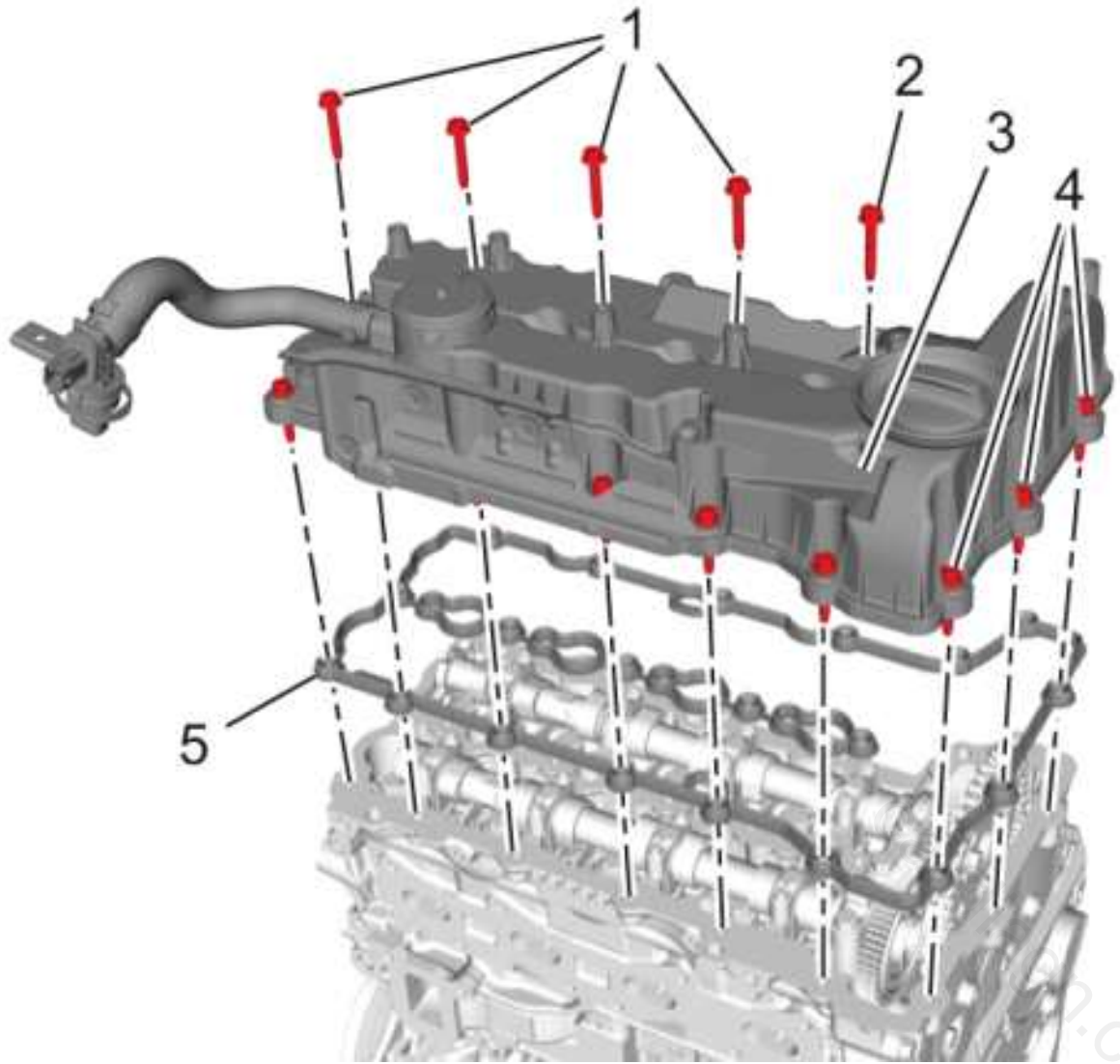


Fig. 896: Camshaft Housing, Bolts And Gasket
Courtesy of GENERAL MOTORS COMPANY

NOTE: Mind the different bolts.

4. Install the camshaft housing cover (3) along with the camshaft housing gasket (5) and the 20 camshaft housing bolts (1, 2, 4).
5. Hand tighten Camshaft Housing Bolts (1, 2, 4) (Qty: 20)

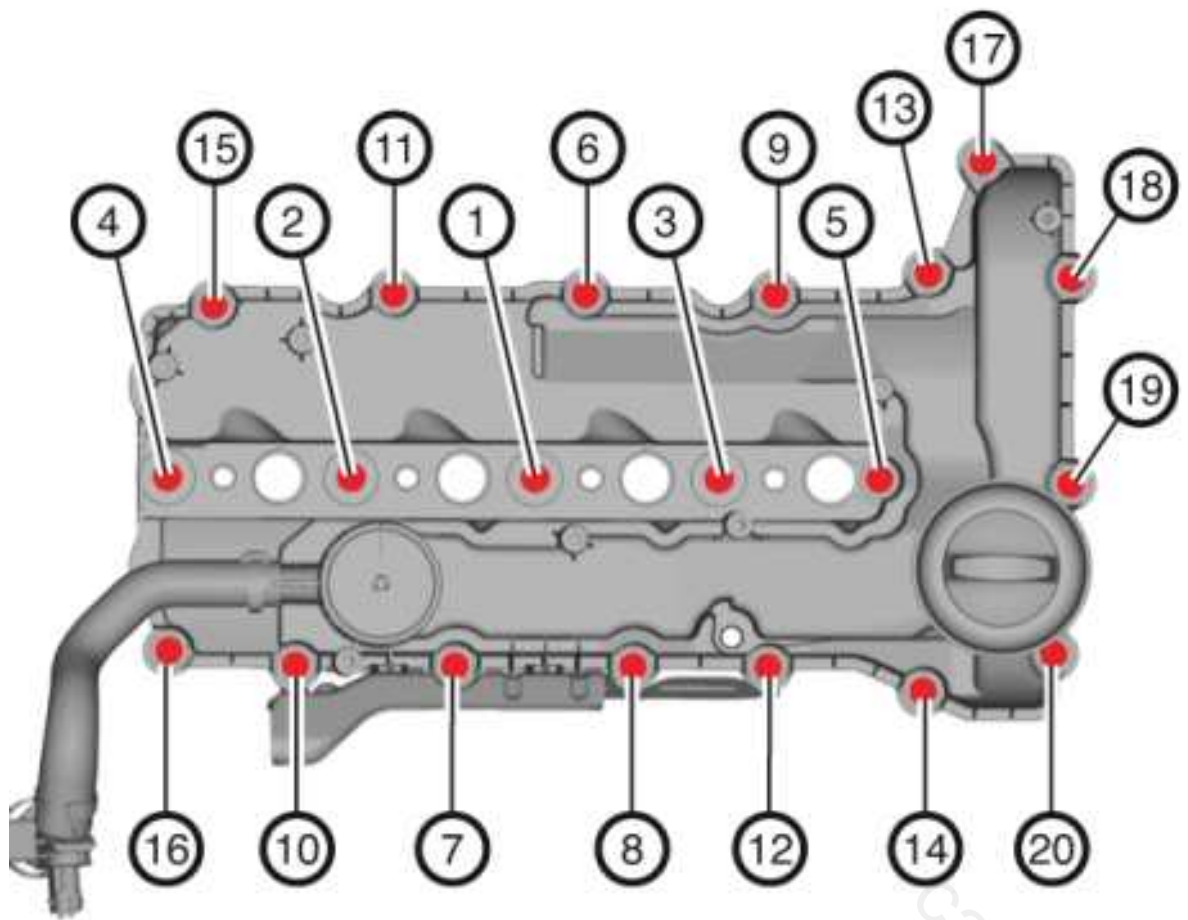


Fig. 897: Camshaft Housing Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution**

6. Tighten Camshaft Housing Bolts (Qty: 20) in sequence to 10 N.m (89 lb in)

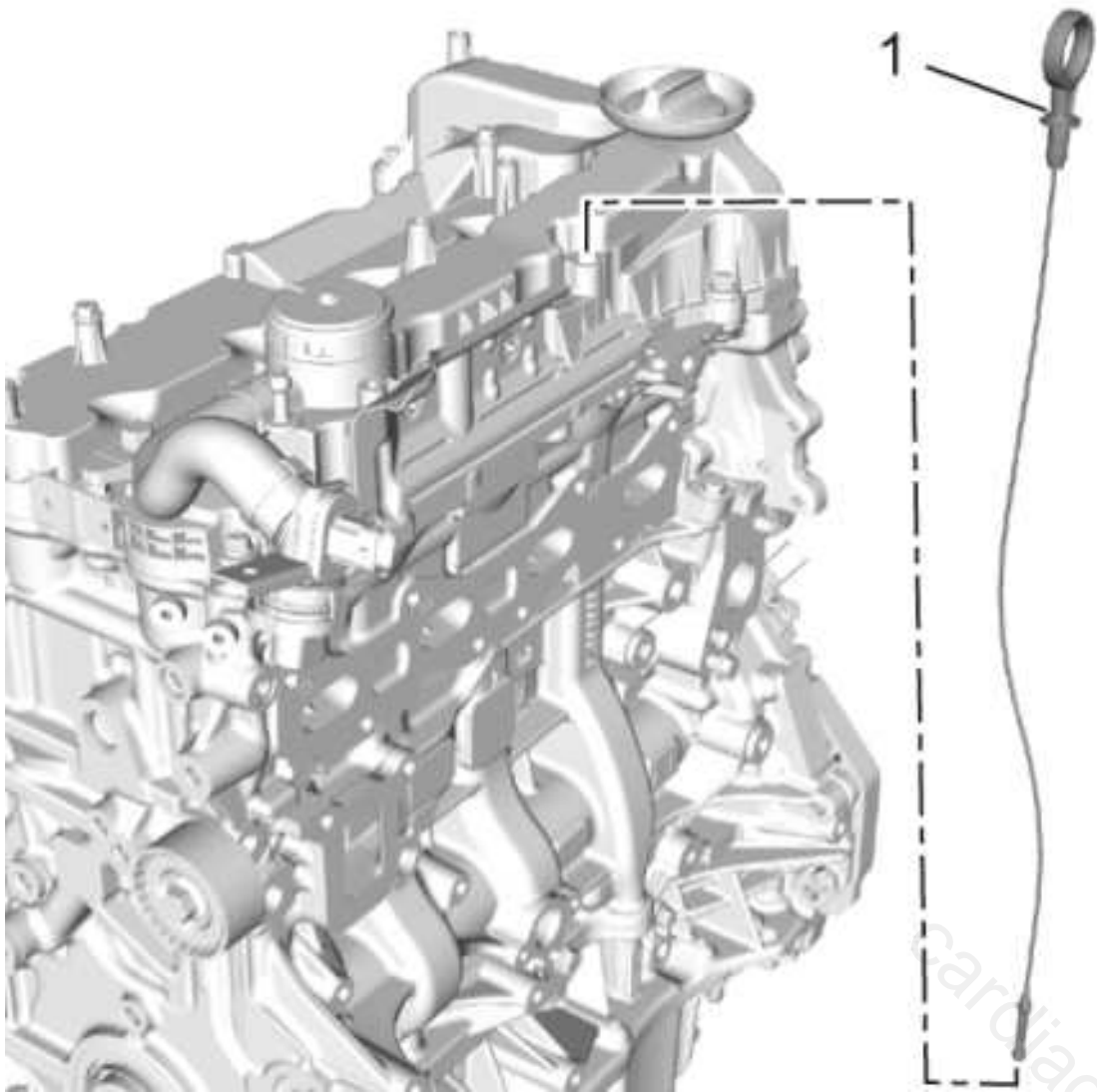


Fig. 898: Engine Oil Level Indicator

Courtesy of GENERAL MOTORS COMPANY

7. Install Engine Oil Level Indicator (1)

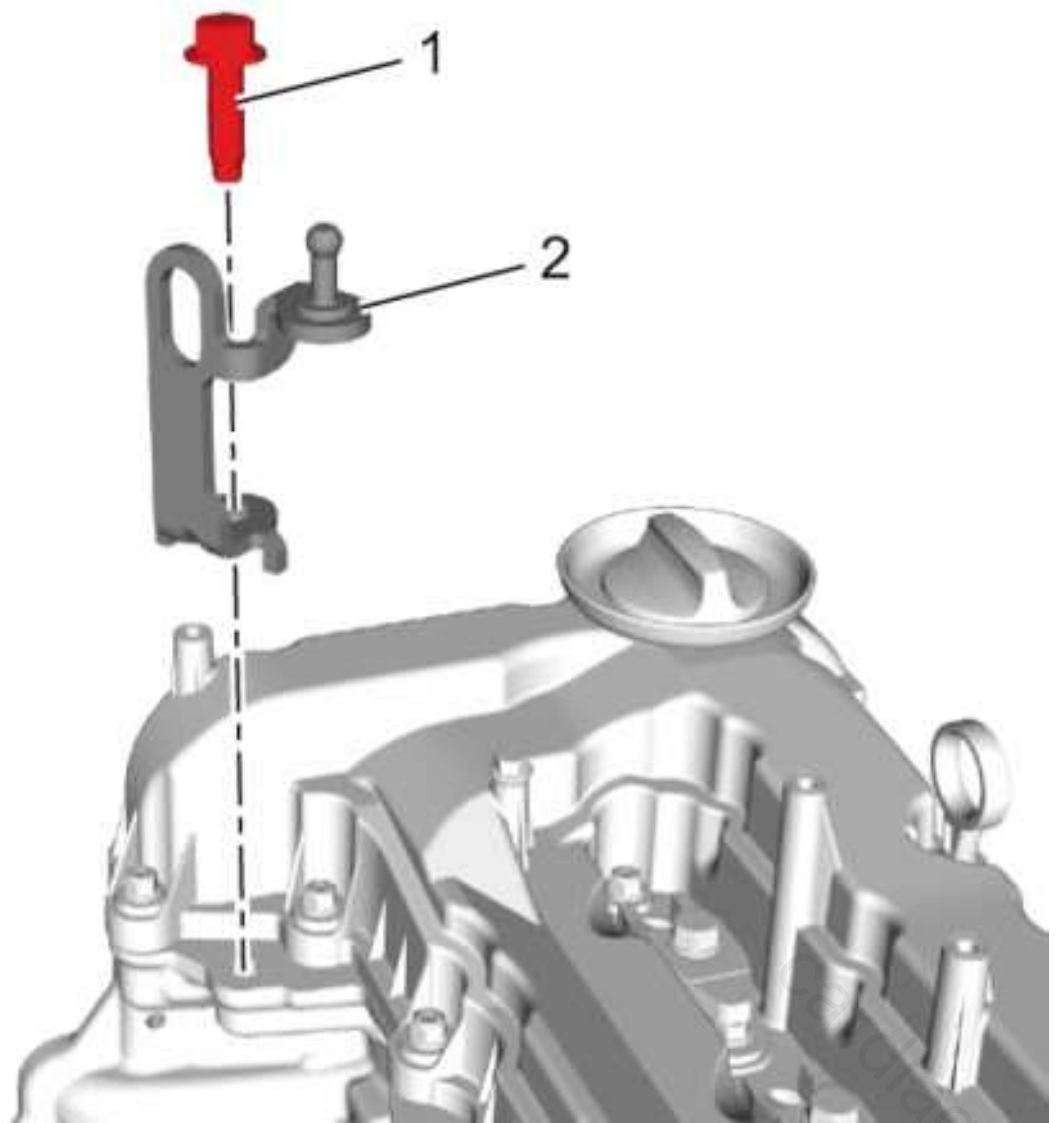


Fig. 899: Engine Lift Bracket And Bolt
Courtesy of GENERAL MOTORS COMPANY

8. Install Engine Lift Bracket (2)
9. Install and tighten Engine Lift Bracket Bolt (1) to 58 N.m (43 lb ft)

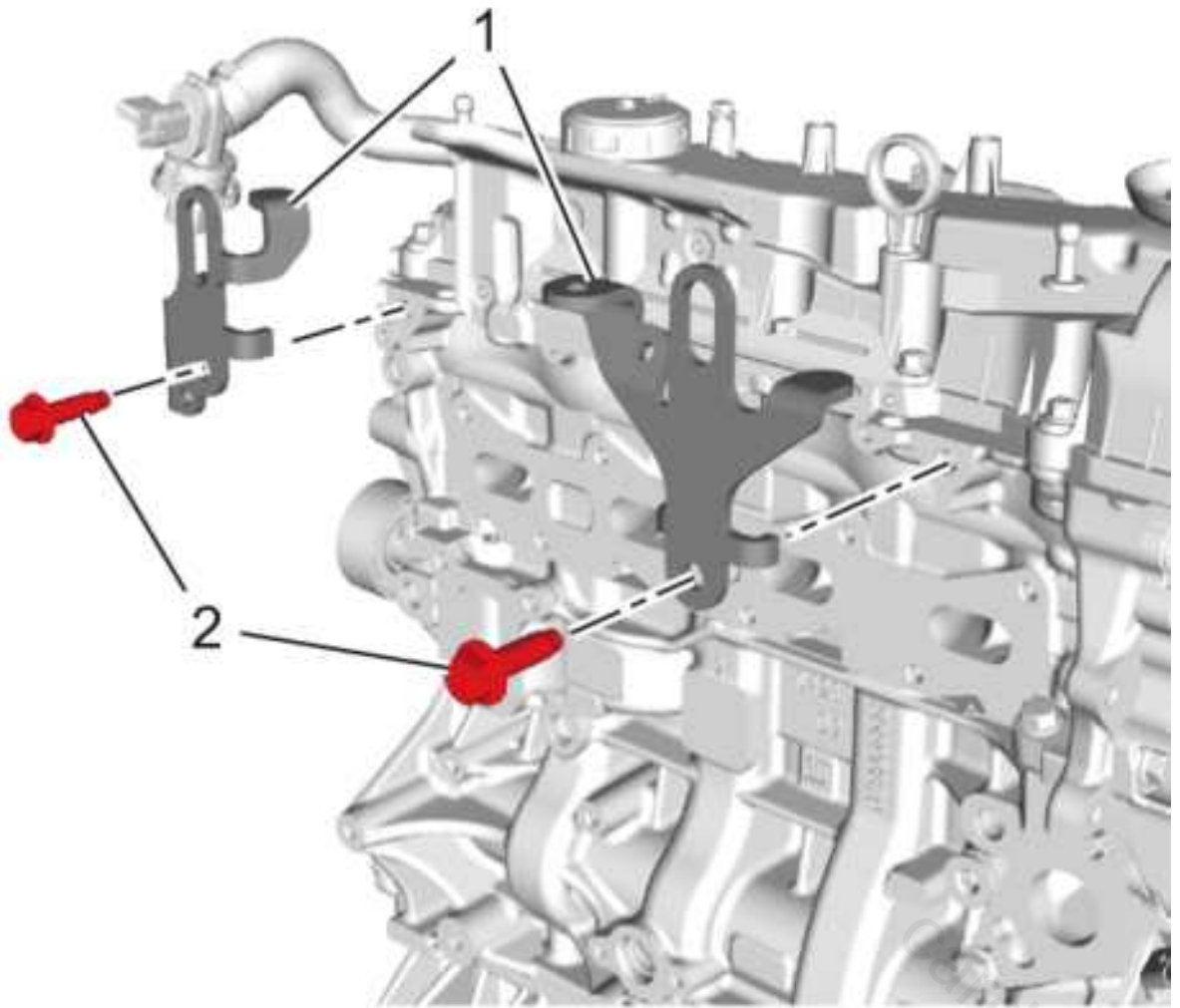


Fig. 900: Engine Lift Brackets And Bolts
 Courtesy of GENERAL MOTORS COMPANY

10. Install Engine Lift Brackets (1) (Qty: 2)
11. Install and tighten Engine Lift Bracket Bolts (2) (Qty: 2) to 58 N.m (43 lb ft)

FUEL INJECTOR INSTALLATION

Special Tools

EN-45059-A Angle Meter

Equivalent regional tools: [Special Tools](#)



CAUTION: Refer to [EN-47632 Cleaning Tool Rotation Caution](#)

1. Clean the 4 injector sealing surfaces in the cylinder head with a suitable cleaning tool (1) in the following procedure:
 1. First take the brush side to loosen the dirt.
 2. Accordingly take the sponge side to remove the dirt.

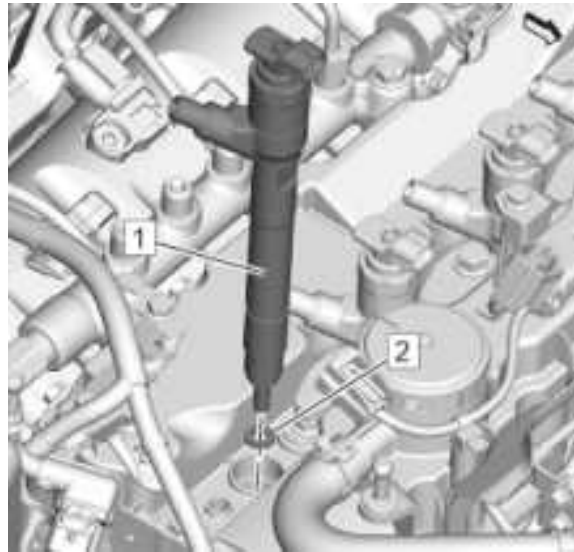


Fig. 902: Fuel Injectors And Washers
Courtesy of GENERAL MOTORS COMPANY

2. Remove the closure caps from the 4 fuel injector nozzles.
3. Install NEW Fuel Injector Washers (2) (Qty: 4)
4. Install Fuel Injectors (1) (Qty: 4)



Fig. 903: Fuel Injector Brackets And Bolts
Courtesy of GENERAL MOTORS COMPANY

5. Install Fuel Injector Brackets (2) (Qty: 4)
6. Install NEW Fuel Injector Bracket Bolts (1) (Qty: 4)

CAUTION: Refer to [Fastener Caution](#)

7. Tighten Fuel Injector Bracket Bolts (1) (Qty: 4) in sequence
 1. First Pass: 10 N.m (89 lb in)
 2. Final Pass: 60 degrees, use the **EN-45059-A** meter

FUEL RAIL INSTALLATION

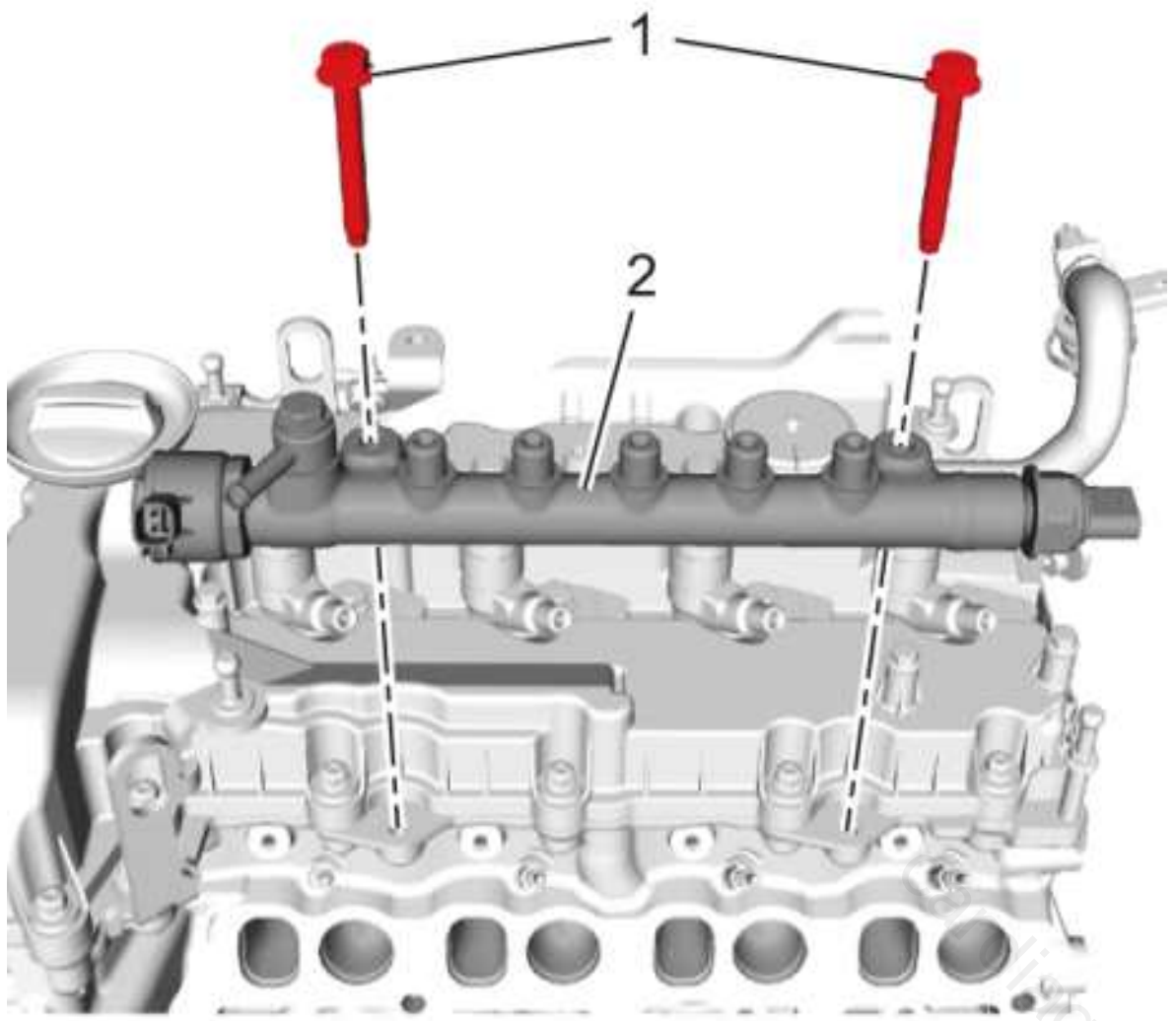


Fig. 904: Fuel Injection Fuel Rail And Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Install Fuel Injection Fuel Rail (2)

CAUTION: Refer to [Fastener Caution](#)

2. Install and tighten Fuel Injection Fuel Rail Bolts (1) (Qty: 2) to 25 N.m (18 lb ft)

FUEL PRESSURE SENSOR INSTALLATION

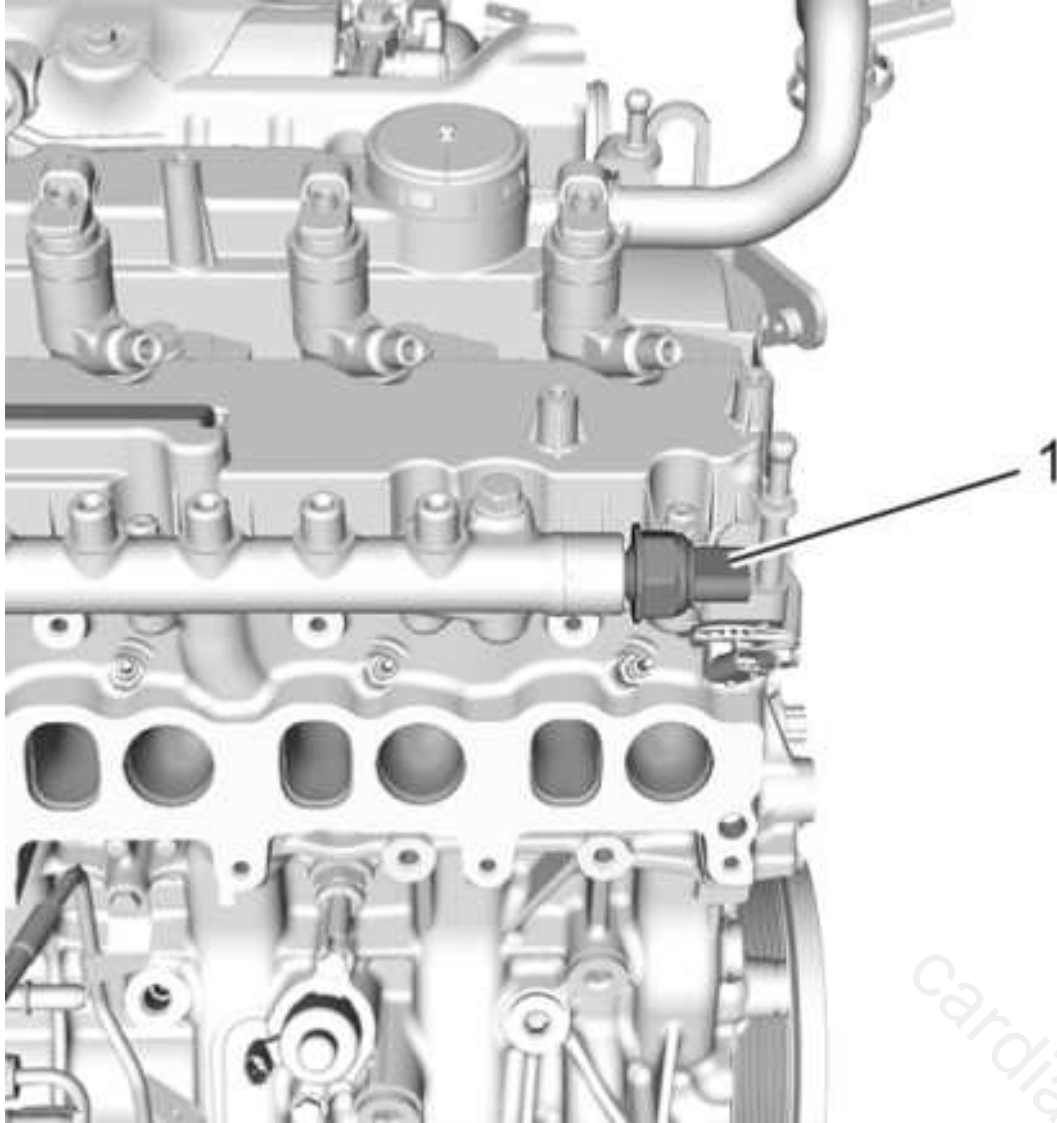


Fig. 905: Fuel Injection Fuel Rail Fuel Pressure Sensor
Courtesy of GENERAL MOTORS COMPANY

1. Install NEW Fuel Injection Fuel Rail Fuel Pressure Sensor (1) - Hand tighten

CAUTION: Refer to [Component Fastener Tightening Caution](#)

2. Tighten Fuel Injection Fuel Rail Fuel Pressure Sensor (1) to 35 N.m (26 lb ft)

FUEL INJECTION FUEL FEED PIPE INSTALLATION - FUEL RAIL TO FUEL INJECTOR

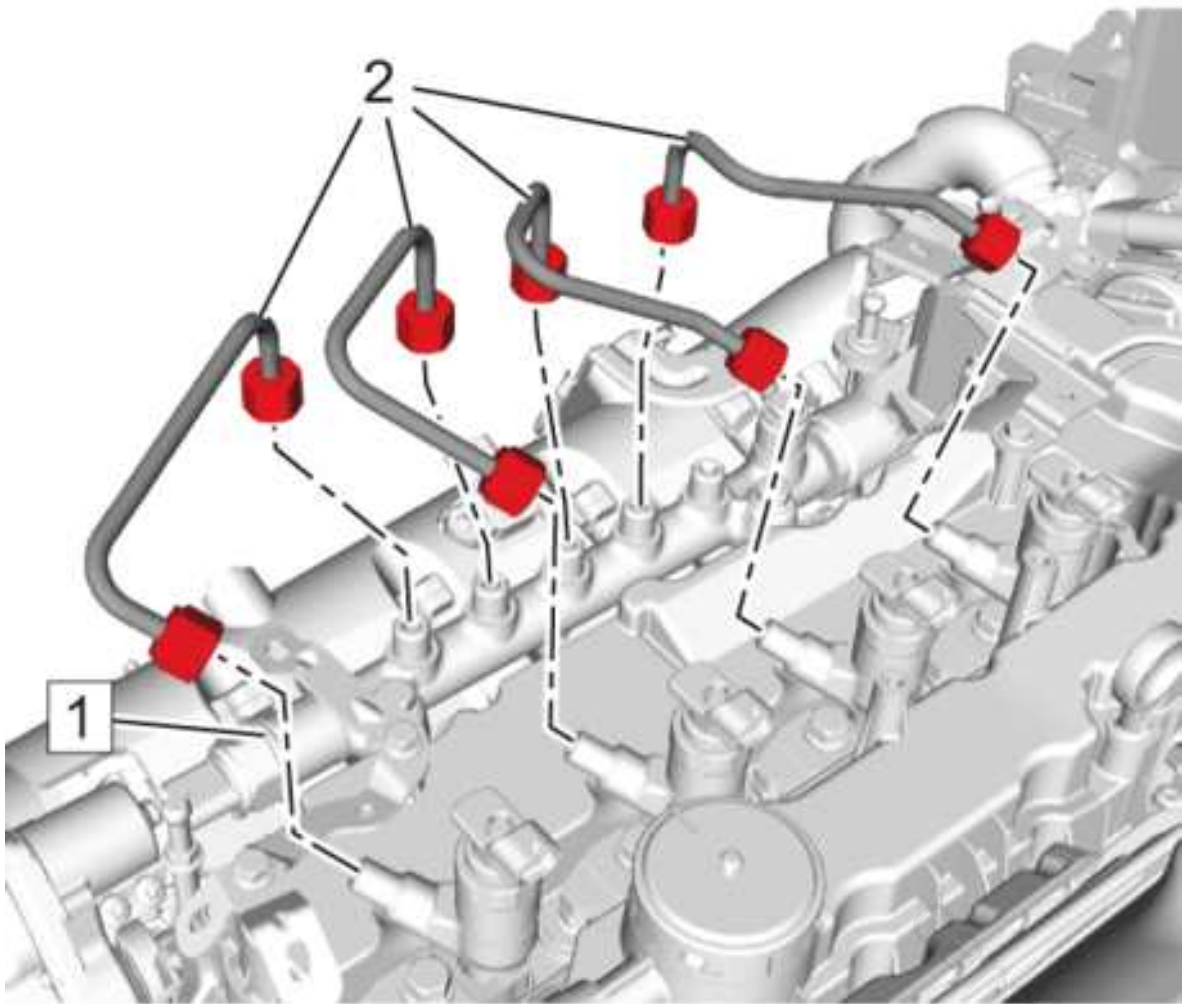


Fig. 906: Fuel Injection Fuel Feed Pipes And Fuel Rail
Courtesy of GENERAL MOTORS COMPANY

1. Install NEW Fuel Injection Fuel Feed Pipes (2) (Qty: 4)
2. Install Fuel Injection Fuel Feed Pipes (2) (Qty: 4) @ Fuel Injector (3)
3. Install Fuel Injection Fuel Feed Pipes (2) (Qty: 4) @ Fuel Rail (1)

CAUTION: Refer to **Fastener Caution**

4. Tighten Fuel Injection Fuel Feed Pipes (2) (Qty: 4) @ Fuel Injector (3) to 28 N.m (21 lb ft)
5. Tighten Fuel Injection Fuel Feed Pipes (2) (Qty: 4) @ Fuel Rail (1) to 28 N.m (21 lb ft)

ENGINE OIL COOLER INSTALLATION

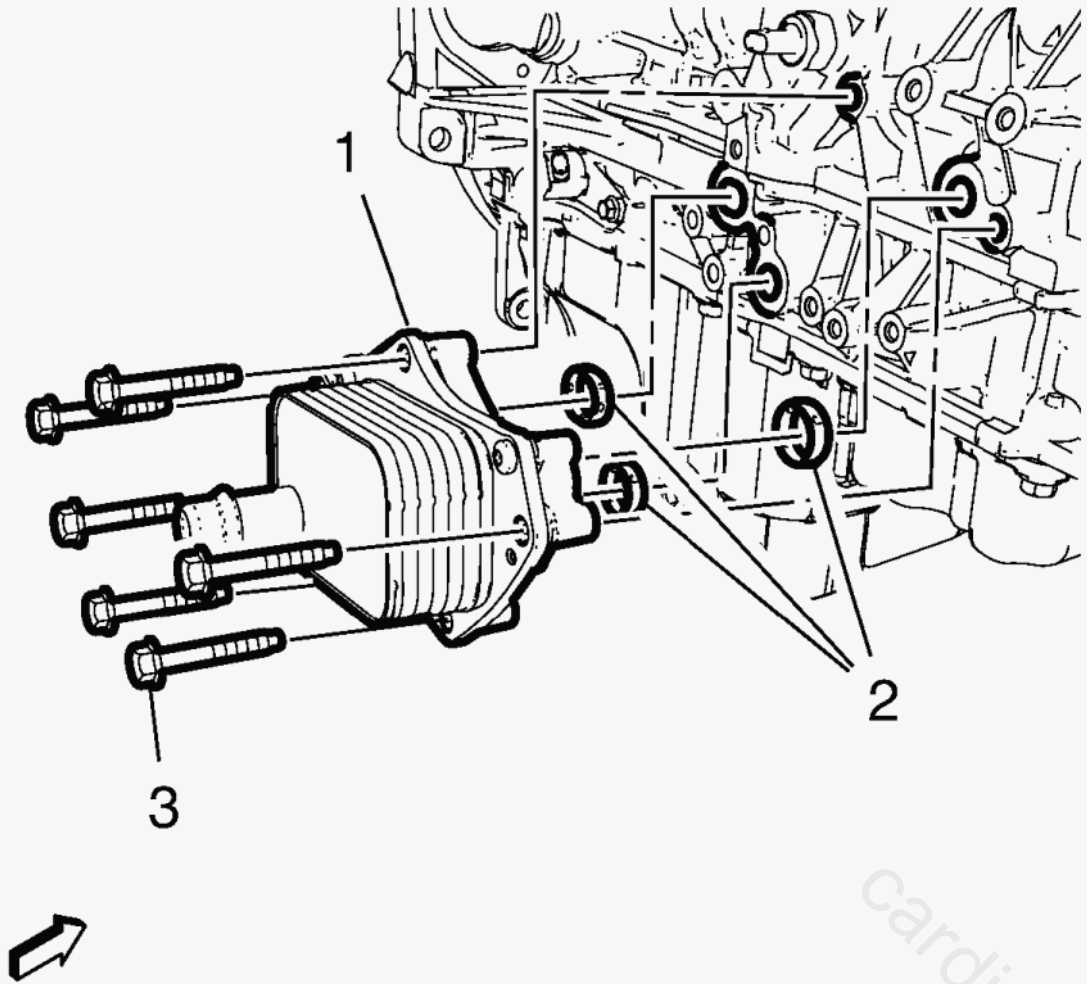


Fig. 907: Engine Oil Cooler, Bolts And Gaskets
Courtesy of GENERAL MOTORS COMPANY

1. Install the NEW 3 oil cooler adapter gaskets (2).
2. Install the oil cooler with oil cooler adapter (1).

CAUTION: Refer to **Fastener Caution** .

3. Install the 6 oil cooler bolts (3) and tighten to 25 N.m (18 lb ft).

GENERATOR INSTALLATION

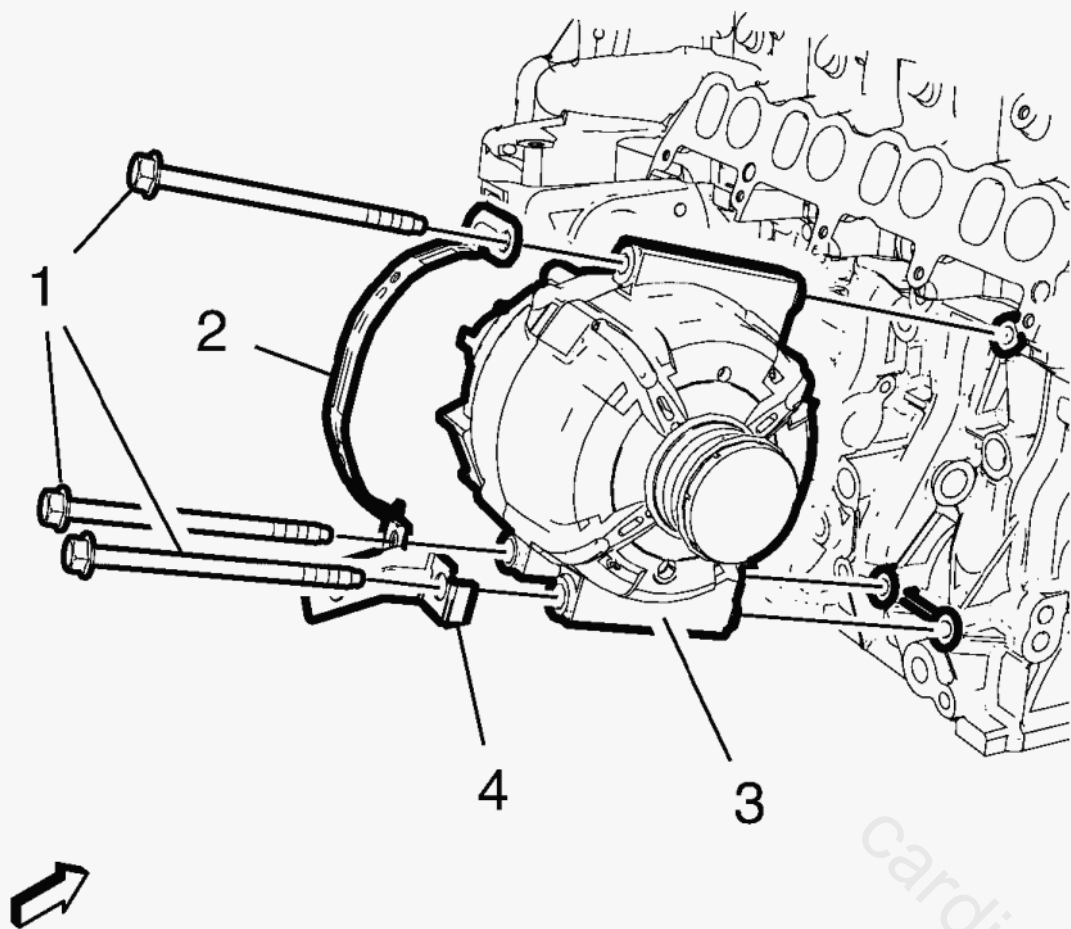


Fig. 908: Generator, Bolts And Wiring Brackets
Courtesy of GENERAL MOTORS COMPANY

1. Install the generator (3).
2. Install the wiring harness bracket (2).
3. Install the nitrogen oxide sensor wire bracket (4).

CAUTION: Refer to **Fastener Caution** .

4. Install the 3 generator bolts (1) and tighten to 22 N.m (16 lb ft).

STARTER INSTALLATION

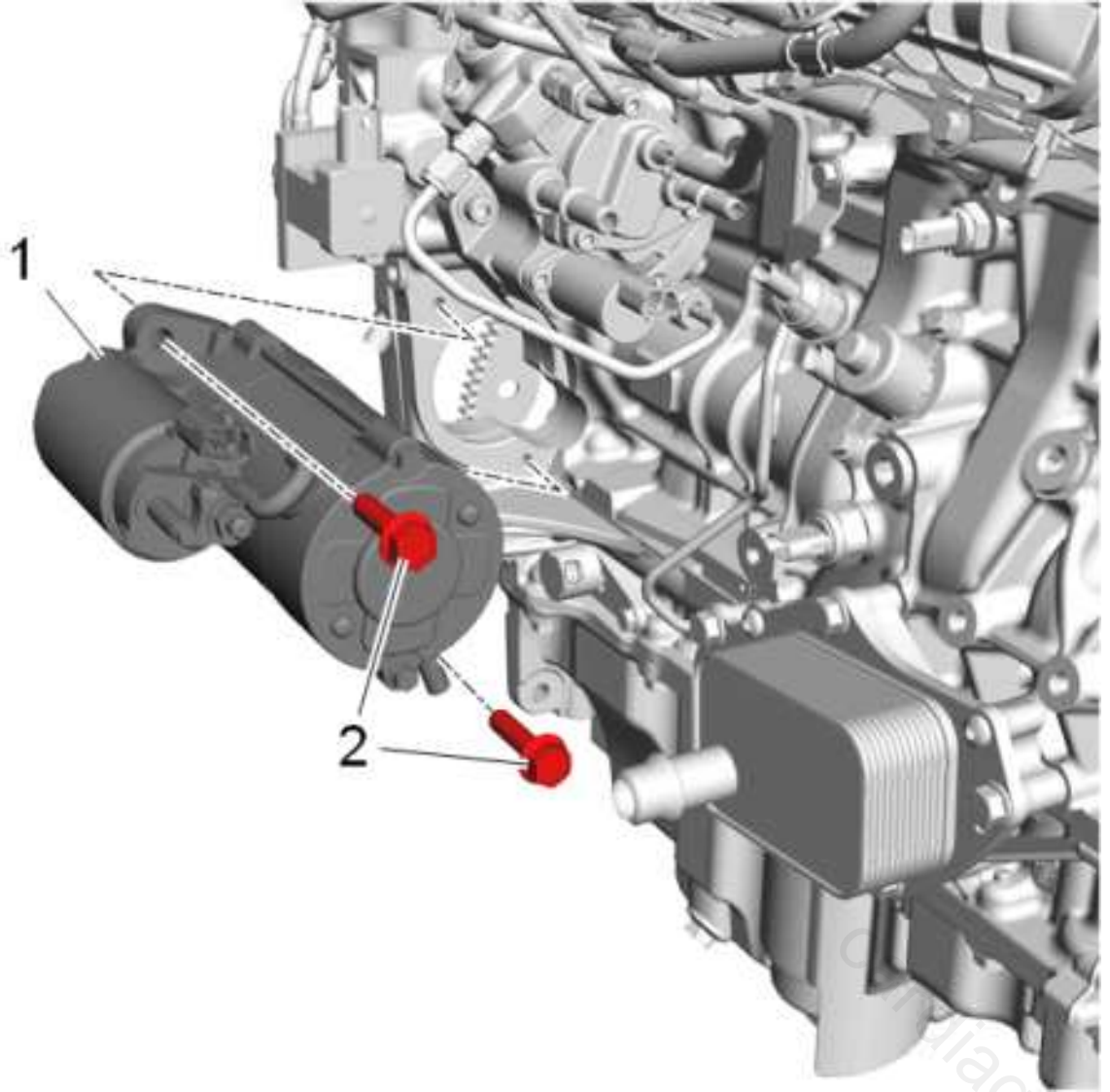


Fig. 909: Starter And Bolts

Courtesy of GENERAL MOTORS COMPANY

1. Install the starter (1).

CAUTION: Refer to [Fastener Caution](#) .

2. Install the 2 starter bolts (2) and tighten to 22 N.m (16 lb ft).

POWER BRAKE BOOSTER INLET HOSE CONNECTOR FITTING INSTALLATION

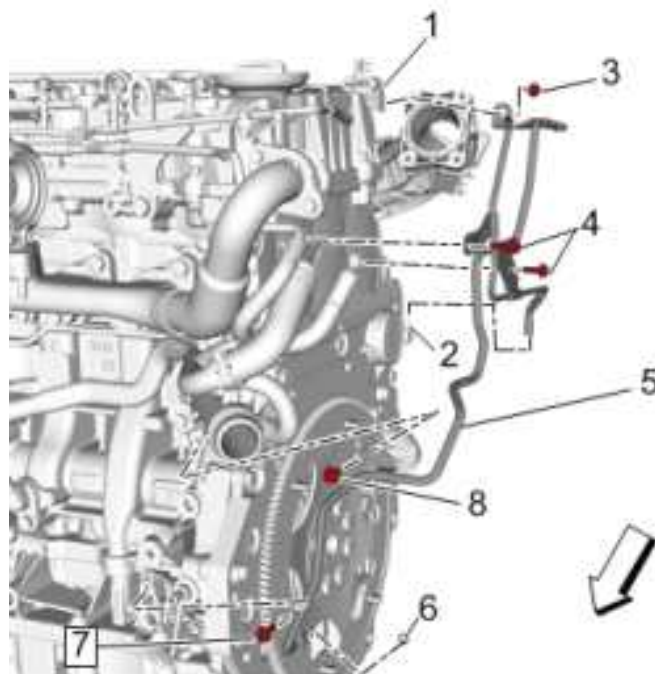


Fig. 910: Power Brake Booster Inlet Hose Connector Fitting And Components
Courtesy of GENERAL MOTORS COMPANY

1. Install the power brake booster inlet hose connector fitting seal (6).
2. Install the power brake booster inlet hose connector fitting (5).

CAUTION: Refer to **Fastener Caution** .

3. Install the power brake booster inlet hose connector fitting bolt (7) to lower crankcase and tighten to 10 N.m (89 lb in).
4. Install the 2 power brake booster inlet hose connector fitting bolts (4) and tighten to 10 N.m (89 lb in).
5. Install the power brake booster inlet hose to turbocharger wastegate actuator vacuum control solenoid valve (2).
6. Install the power brake booster inlet hose connector fitting bracket bolt (3) to the exhaust temperature sensor wiring harness bracket (1) and tighten to 10 N.m (89 lb in).

CHARGE AIR BYPASS REGULATOR SOLENOID VALVE VACUUM TUBE INSTALLATION

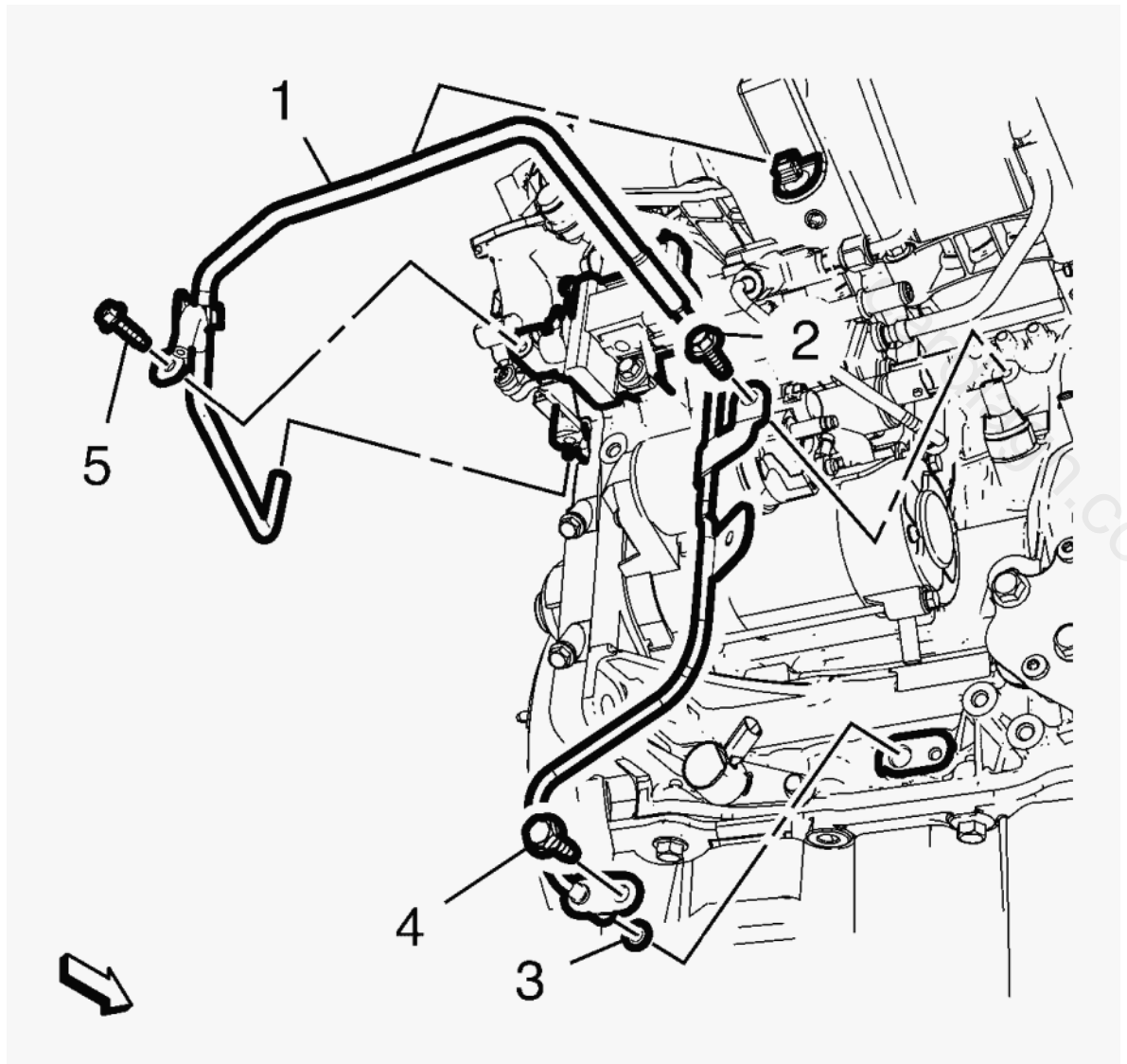


Fig. 911: Charge Air Bypass Regulator Solenoid Valve Vacuum Tube Components
Courtesy of GENERAL MOTORS COMPANY

1. Install a new charge bypass valve vacuum hose seal (3).
2. Install the charge bypass valve vacuum hose (1).
3. Clip the charge bypass valve vacuum hose (1) into the retainer clip.
4. Connect the charge bypass valve vacuum hose (1) to the exhaust gas recirculation vacuum regulator solenoid valve.

CAUTION: Refer to **Fastener Caution** .

5. Install the 2 charger bypass valve vacuum hose bracket bolts (2, 5) and tighten to 10 N.m (89 lb in).
6. Install the charger bypass valve vacuum hose bracket bolt (4) and tighten to 10 N.m (89 lb in).

INTAKE MANIFOLD INSTALLATION

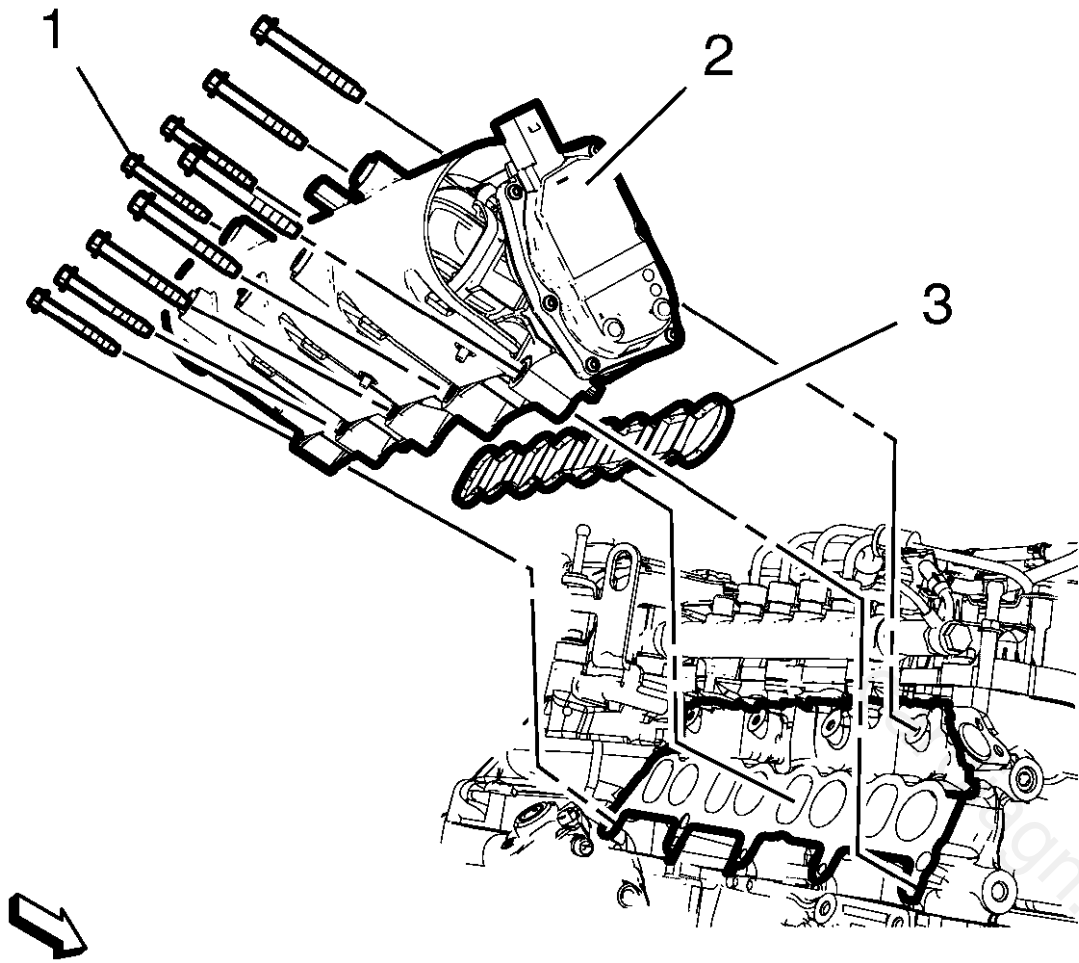


Fig. 912: Intake Manifold, Bolts And Gasket
Courtesy of GENERAL MOTORS COMPANY

1. Install a NEW intake manifold gasket (3).
2. Install the intake manifold (2).
3. Loosely install the 9 intake manifold bolts (1).

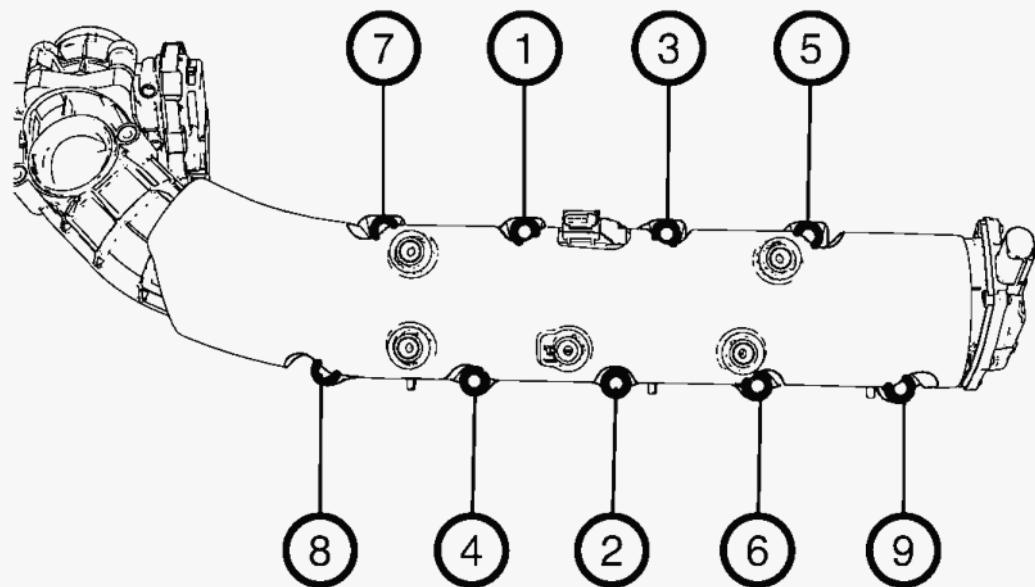


Fig. 913: Intake Manifold Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution** .

4. Tighten the 9 Intake manifold bolts in sequence as shown to 12 N.m (106 lb in).

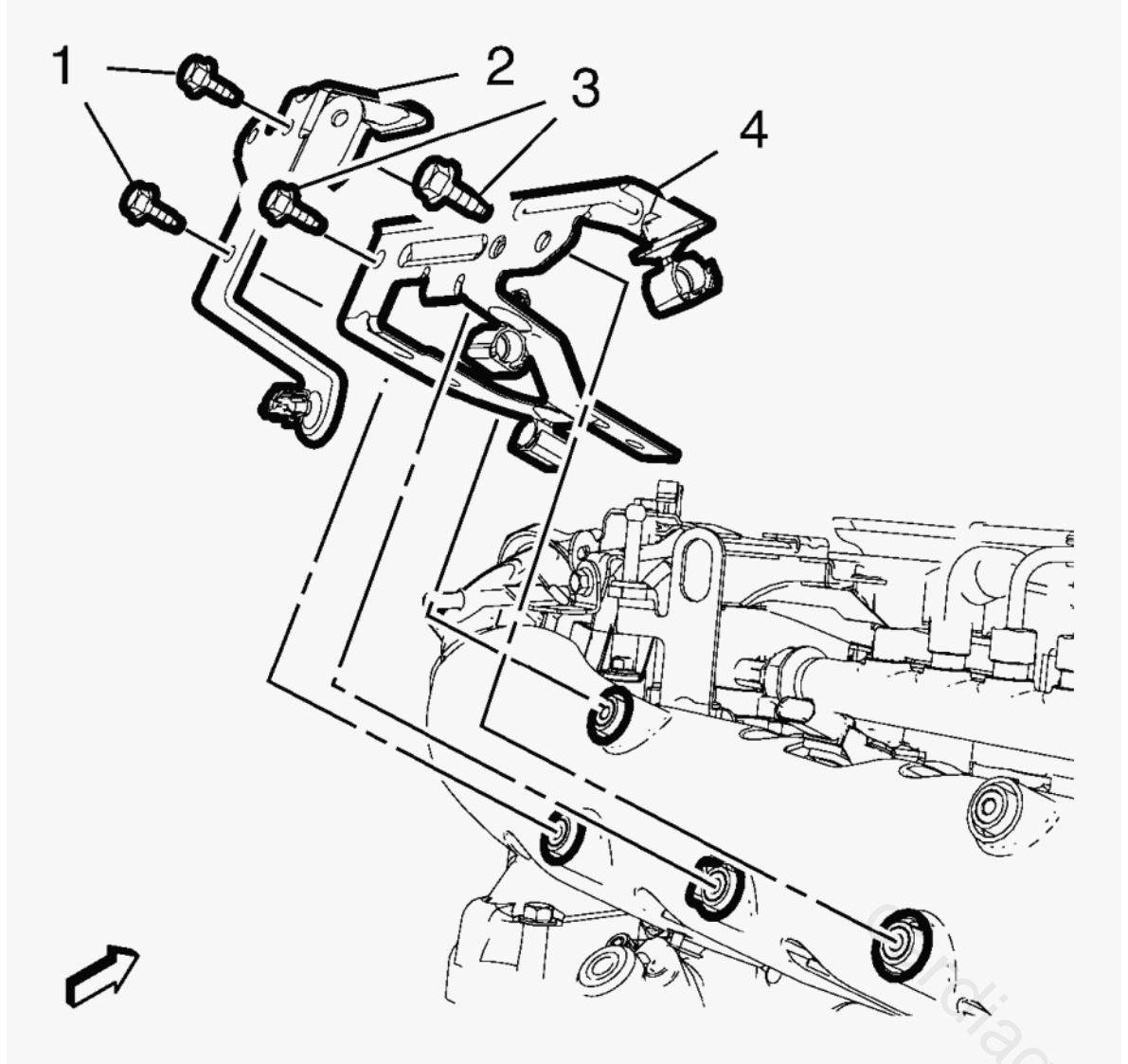


Fig. 914: Fuel Rail Fuel Pressure Sensor Wiring Harness Bracket, Fuel Rail Return Pipe Bracket And Bolts

Courtesy of GENERAL MOTORS COMPANY

5. Install the fuel rail return pipe bracket (4).
6. Install the 2 fuel rail return pipe bracket bolts (3) and tighten to 9 N.m (80 lb in).
7. Install the fuel rail fuel pressor sensor wiring harness bracket (2).
8. Install the 2 fuel rail fuel pressor sensor wiring harness bracket bolts (1) and tighten to 9 N.m (80 lb in).

DIESEL FUEL SEPARATOR INSTALLATION

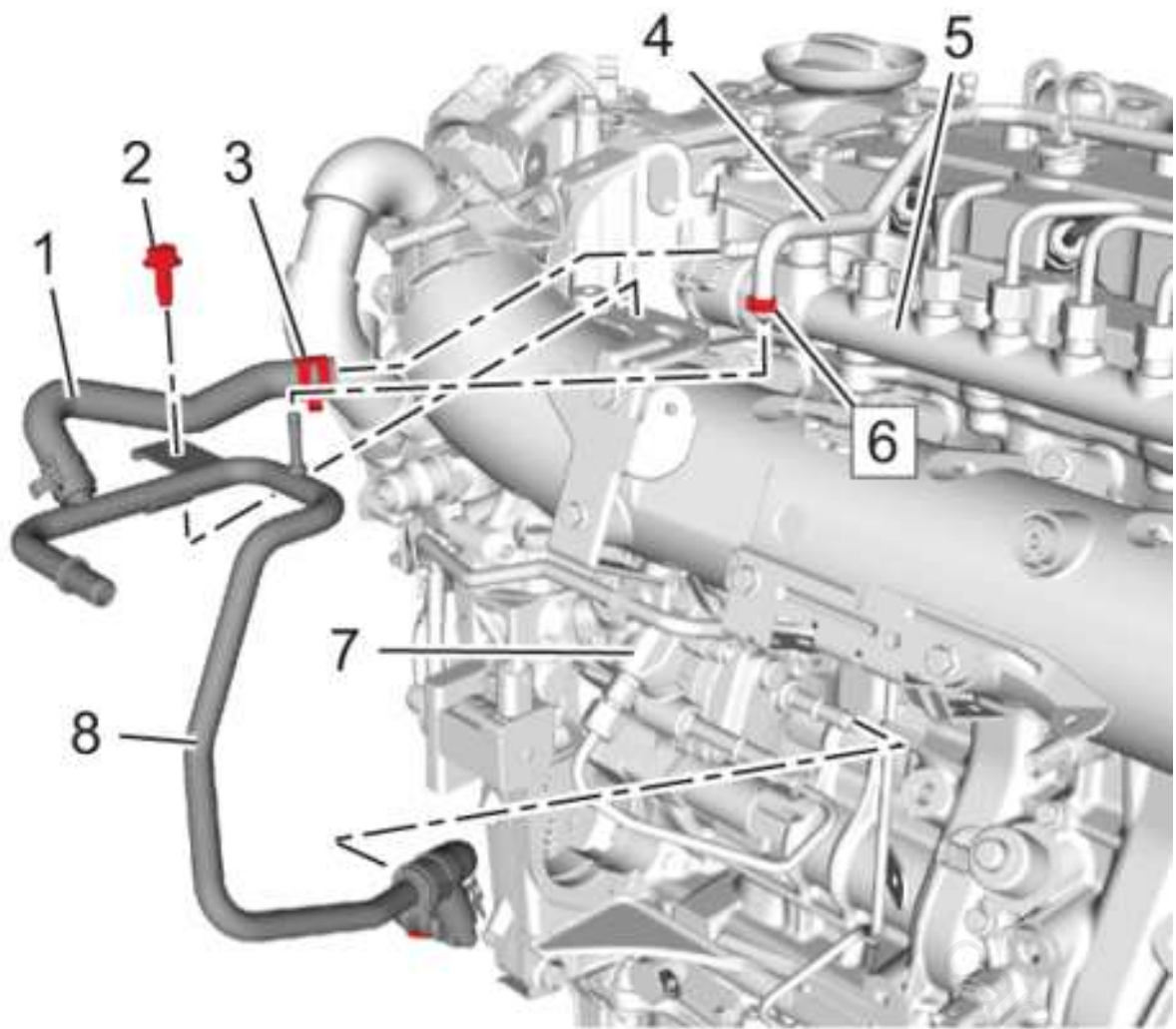


Fig. 915: Diesel Fuel Separator And Components
Courtesy of GENERAL MOTORS COMPANY

1. Connect Diesel Fuel Separator (8) @ Fuel Injection Pump (7). Refer to [Plastic Collar Quick Connect Fitting Service](#)
2. Connect Diesel Fuel Separator Hose (1) @ Fuel Rail (5)
3. Install Diesel Fuel Separator Hose Clamp (3)

CAUTION: Refer to [Fastener Caution](#)

4. Install and tighten Diesel Fuel Separator Bolt (2) to 10 N.m (89 lb in)
5. Connect Fuel Return Hose (4) @ Diesel Fuel Separator (8)
6. Install NEW Clamp (6)

FUEL INJECTION FUEL FEED PIPE INSTALLATION - FUEL INJECTION PUMP TO FUEL RAIL

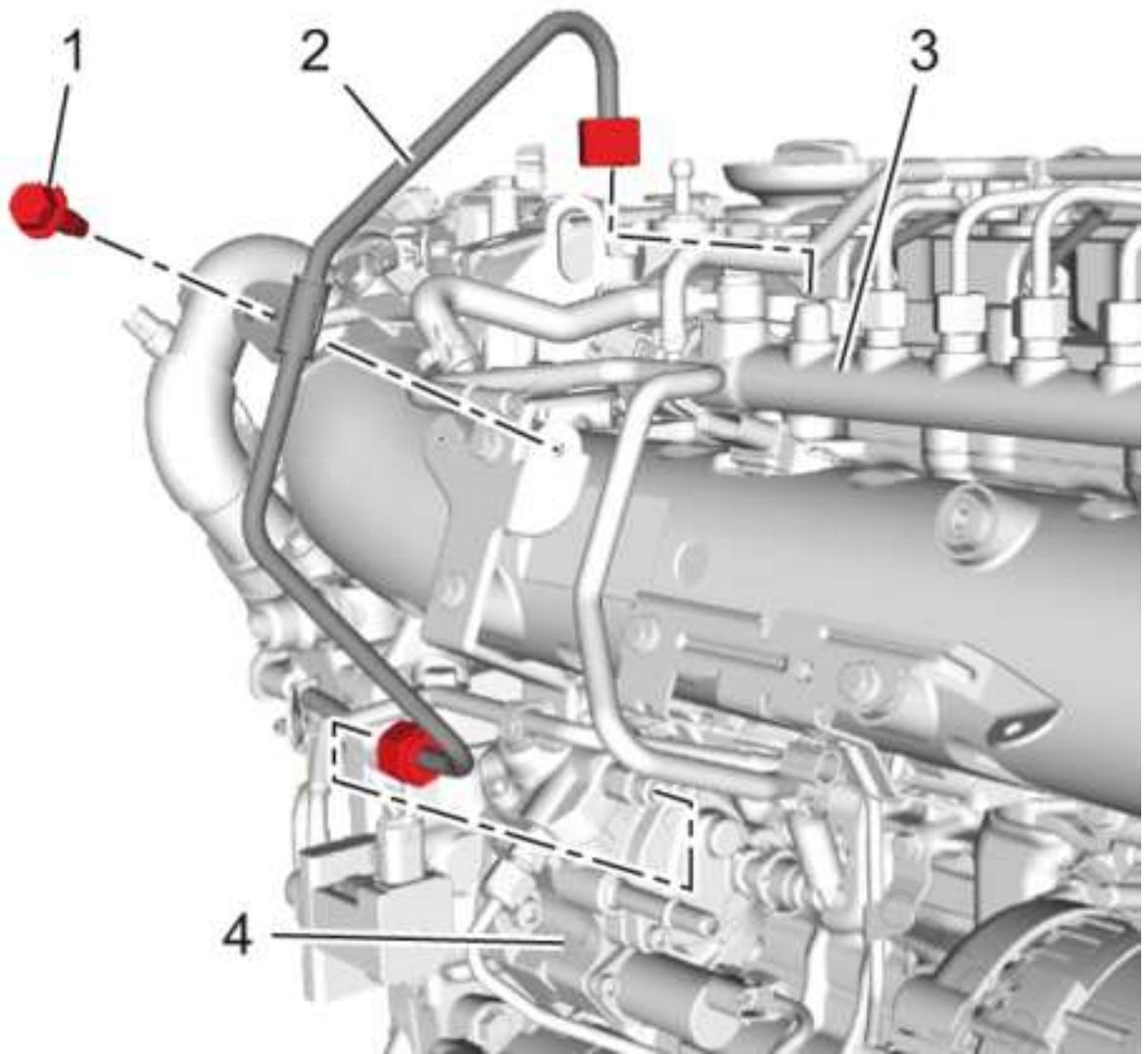


Fig. 916: Fuel Injection Fuel Feed Pipe And Components - Fuel Injection Pump to Fuel Rail
Courtesy of GENERAL MOTORS COMPANY

1. Install NEW Fuel Injection Fuel Feed Pipe (2)

NOTE: Counterhold at the fuel injection pump hexagon connector.

2. Install Fuel Injection Fuel Feed Pipe (2) @ Fuel Injection Pump (4)
3. Install Fuel Injection Fuel Feed Pipe (2) @ Fuel Rail (3)

NOTE: Counterhold at the fuel injection pump hexagon connector.

CAUTION: Refer to **Fastener Caution**

4. Tighten Fuel Injection Fuel Feed Pipe (2) @ Fuel Injection Pump (4) to 28 N.m (21 lb ft)
5. Tighten Fuel Injection Fuel Feed Pipe (2) @ Fuel Rail (3) to 28 N.m (21 lb ft)
6. Install and tighten Fuel Injection Fuel Feed Pipe Bracket Bolt (1) to 9 N.m (80 lb in)

FUEL RETURN HOSE INSTALLATION

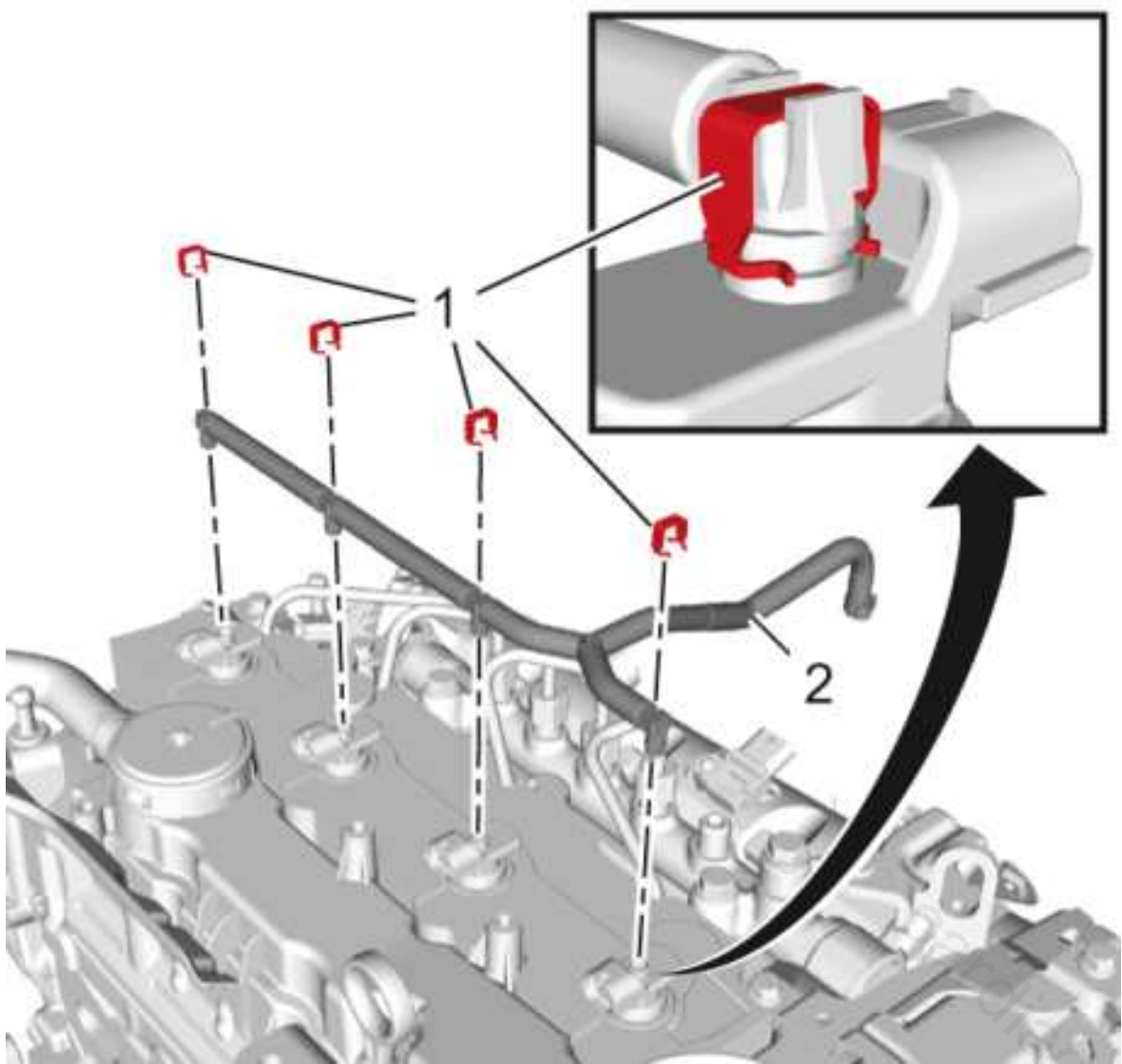


Fig. 917: Fuel Return Hose And Clamps

Courtesy of GENERAL MOTORS COMPANY

1. Install Fuel Return Hose (2) @ Fuel Injector
2. Install NEW Fuel Return Hose Clamps (1) (Qty: 4)

THROTTLE BODY ASSEMBLY INSTALLATION

1. Clean the sealing surfaces of the throttle body assembly and the intake manifold.

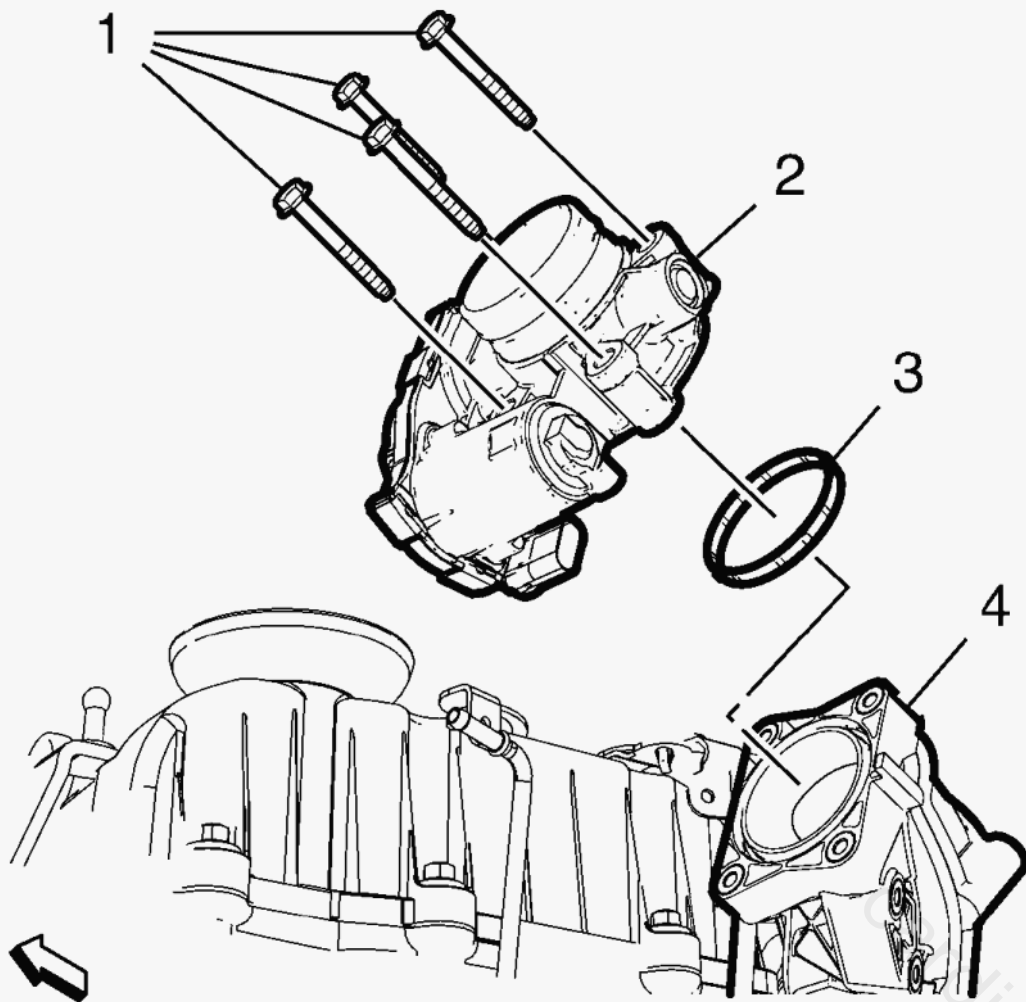


Fig. 918: Throttle Body Assembly, Bolts, Gasket And Intake Manifold
Courtesy of GENERAL MOTORS COMPANY

2. Install a new throttle body assembly gasket (3) into the intake manifold (4).
3. Install the throttle body assembly (2).

CAUTION: Refer to **Fastener Caution** .

4. Install the 4 throttle body assembly bolts (1) and tighten to 10 N.m (89 lb in).

EXHAUST GAS RECIRCULATION COOLER HOUSING INSTALLATION

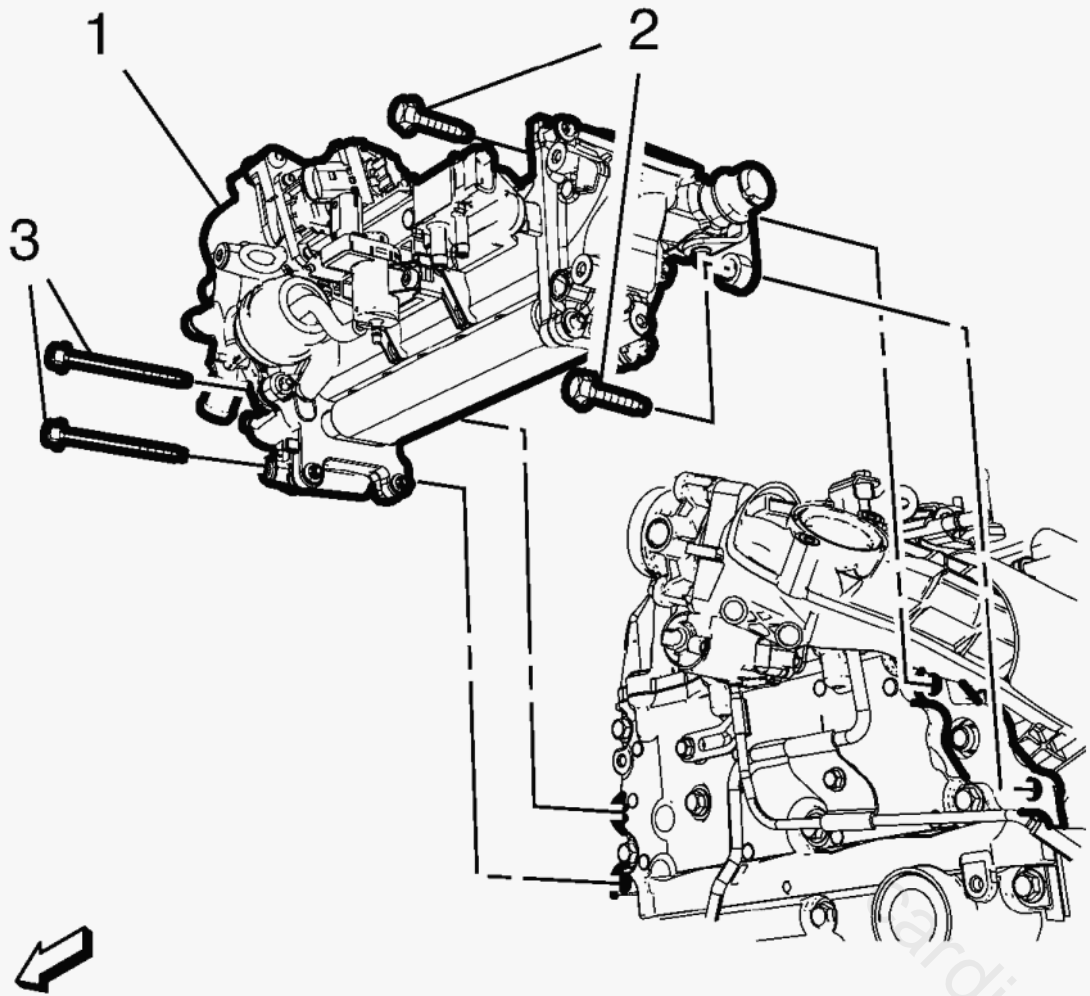


Fig. 919: Exhaust Gas Recirculation Cooler Housing And Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Install the NEW exhaust gas recirculation cooler housing gasket.
2. Install the exhaust gas recirculation cooler housing (1).

CAUTION: Refer to **Fastener Caution** .

NOTE: Different bolt length.

3. Install the 2 exhaust gas recirculation cooler bolts (2) and tighten to 25 N.m (18 lb ft).
4. Install the 2 exhaust gas recirculation cooler bolts (3) and tighten to 25 N.m (18 lb ft).

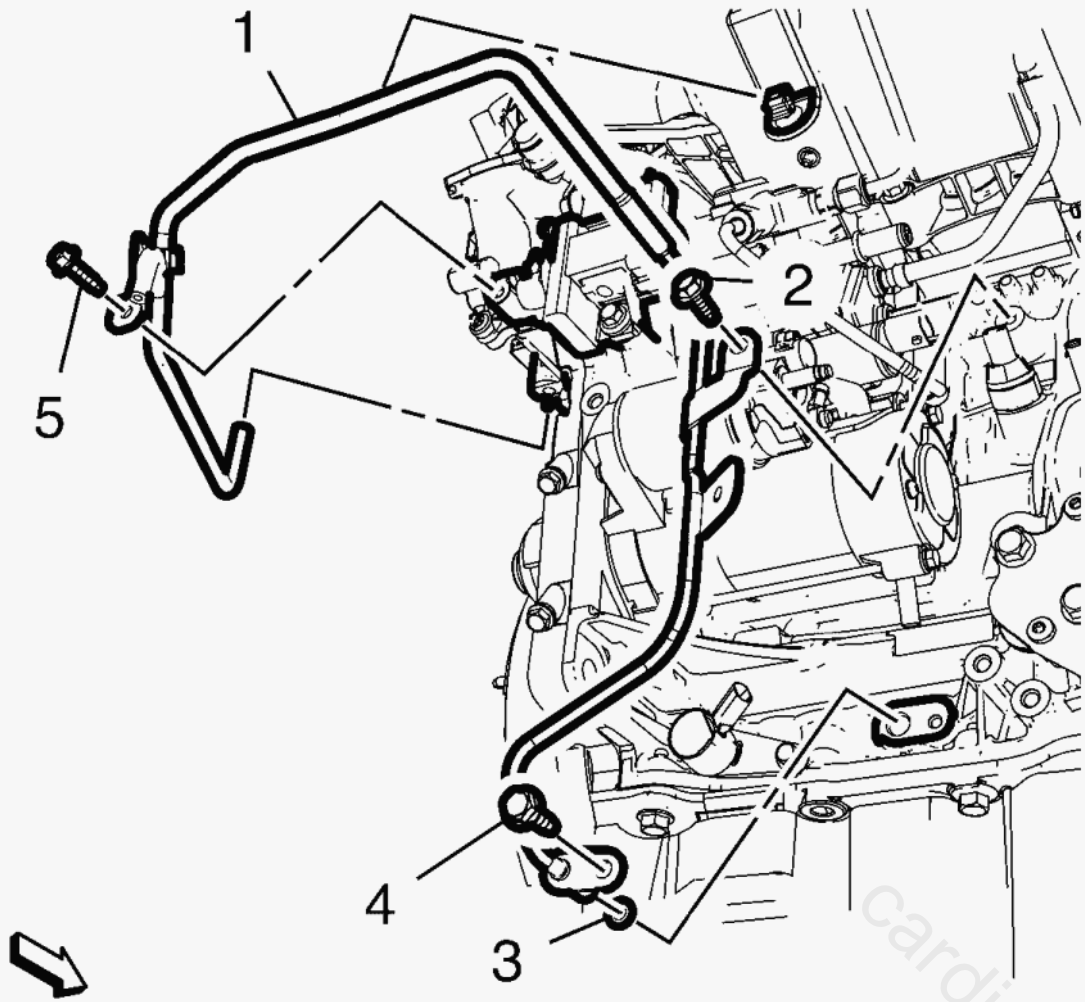


Fig. 920: Charge Air Bypass Regulator Solenoid Valve Vacuum Tube Components
Courtesy of GENERAL MOTORS COMPANY

5. Install a NEW charge bypass valve vacuum hose seal (3).
6. Install the charge bypass valve vacuum hose (1).
7. Clip the charge bypass valve vacuum hose (1) into the retainer clip.
8. Connect the charge bypass valve vacuum hose (1) to the exhaust gas recirculation vacuum regulator solenoid valve.

NOTE: Different bolt length.

9. Install the 2 charger bypass valve vacuum hose bracket bolts (2, 5) and tighten to 10 N.m (89 lb in).
10. Install the charger bypass valve vacuum hose bracket bolt (4) and tighten to 10 N.m (89 lb in).

INTAKE MANIFOLD BRACE INSTALLATION

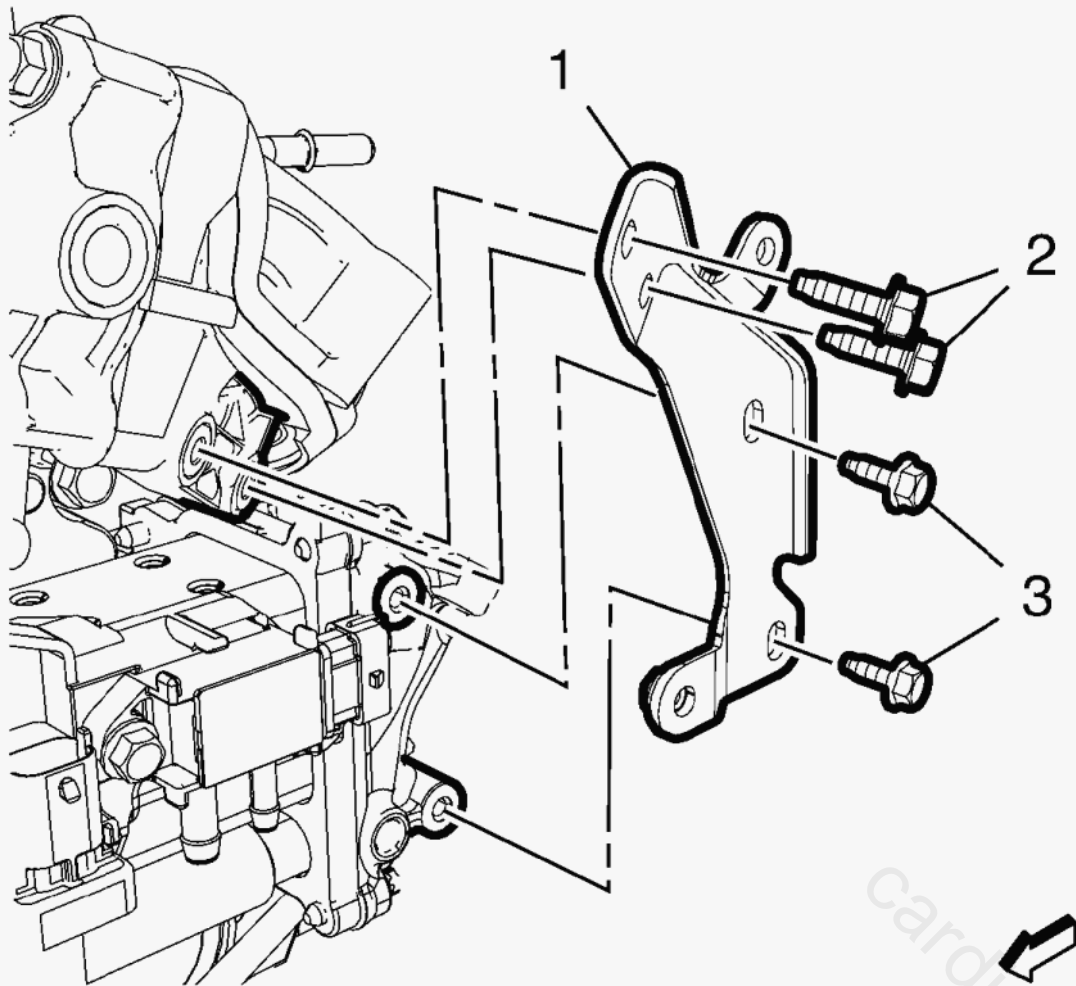


Fig. 921: Intake Manifold Brace And Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Install the intake manifold brace (1).

CAUTION: Refer to **Fastener Caution** .

2. Install the 4 intake manifold brace bolts (2, 3) and tighten to 10 N.m (89 lb in).

EXHAUST GAS RECIRCULATION COOLER OUTLET PIPE INSTALLATION

1. Clean the sealing surfaces of the intake manifold, the exhaust gas recirculation cooler housing and the exhaust gas recirculation cooler outlet pipe.

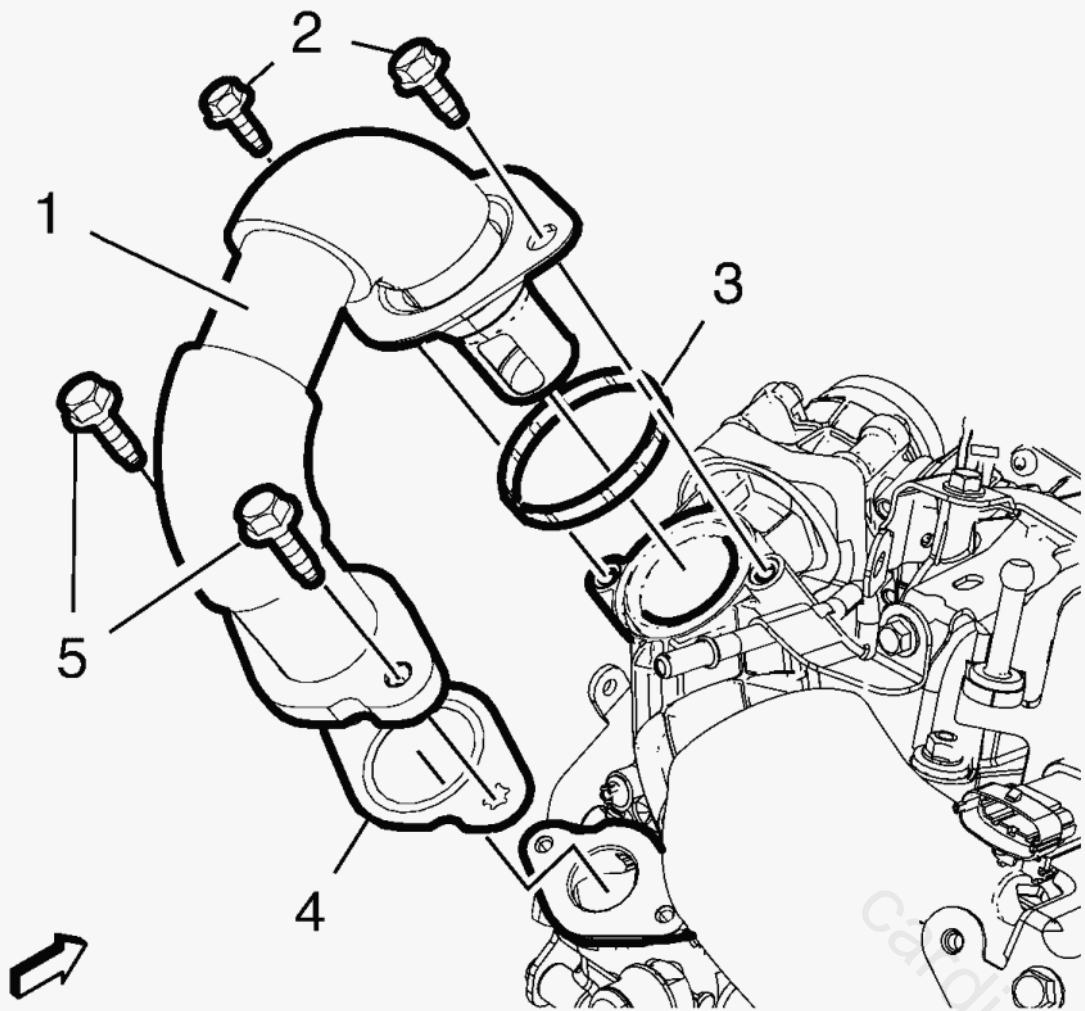


Fig. 922: Exhaust Gas Recirculation Cooler Outlet Pipe And Components
Courtesy of GENERAL MOTORS COMPANY

2. Install a NEW exhaust gas recirculation cooler outlet pipe seal (3) into the intake manifold.
3. Install a NEW exhaust gas recirculation cooler pipe gasket (4).
4. Install the exhaust gas recirculation cooler pipe (1).

CAUTION: Refer to [Fastener Caution](#) .

NOTE: Different bolt lengths.

5. Install the 2 exhaust gas recirculation cooler outlet pipe bolts (2) and tighten to 10 N.m (89 lb in).
6. Install the 2 exhaust gas recirculation cooler outlet pipe bolts (5) and tighten to 10 N.m (89 lb in).

EXHAUST GAS RECIRCULATION COOLER TEMPERATURE SENSOR INSTALLATION - POSITION 2

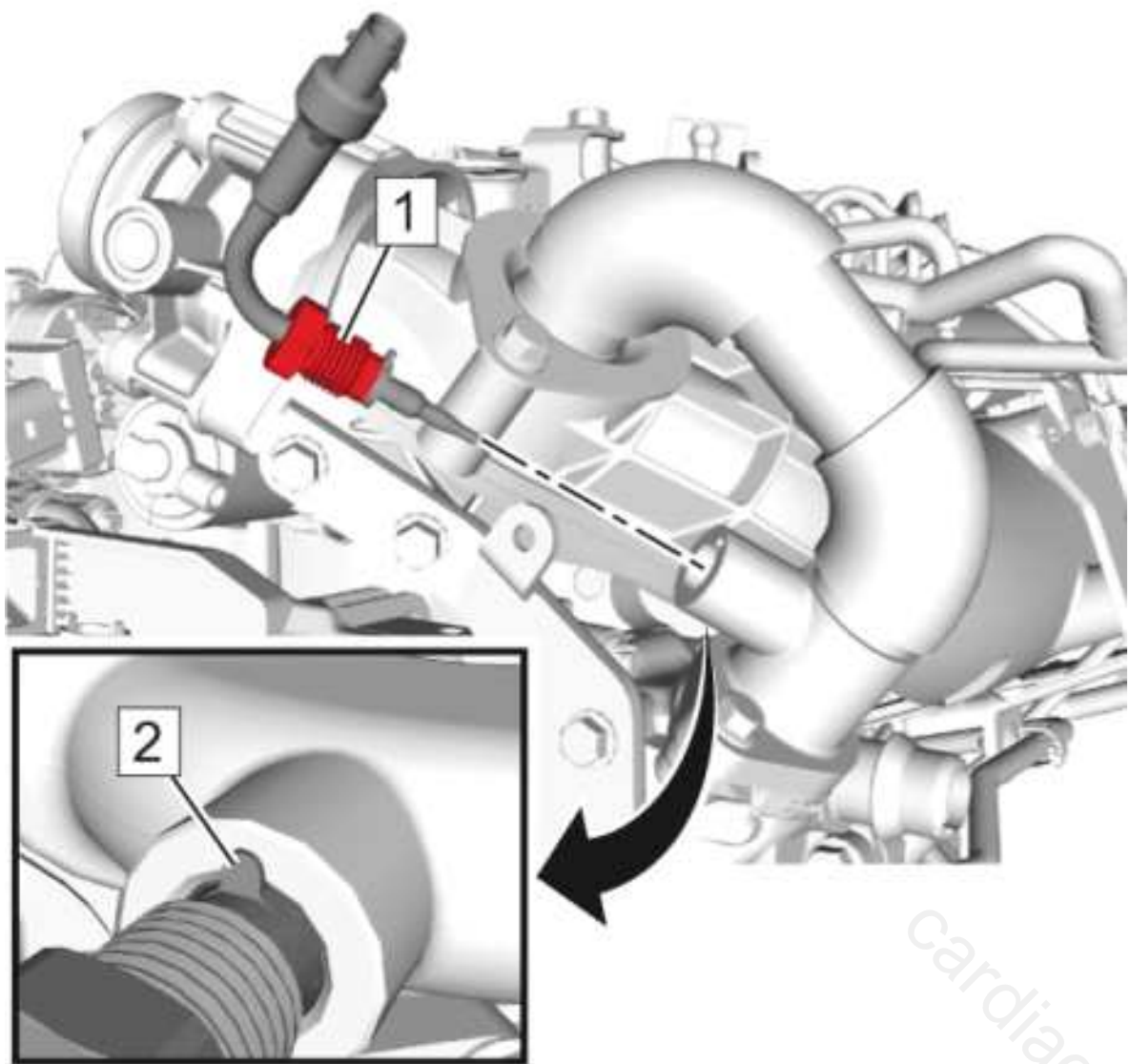


Fig. 923: Exhaust Gas Recirculation Cooler Temperature Sensor - Position 2
Courtesy of GENERAL MOTORS COMPANY

NOTE: The guide lug (2) must fit the groove.

CAUTION: Refer to [Fastener Caution](#)

Install and tighten Exhaust Gas Recirculation Cooler Temperature Sensor - Position 2 (1) to 45 N.m (33 lb ft)

ENGINE COOLANT OUTLET PIPE INSTALLATION

1. Clean the sealing surfaces of the engine block and the engine cooler outlet pipe.

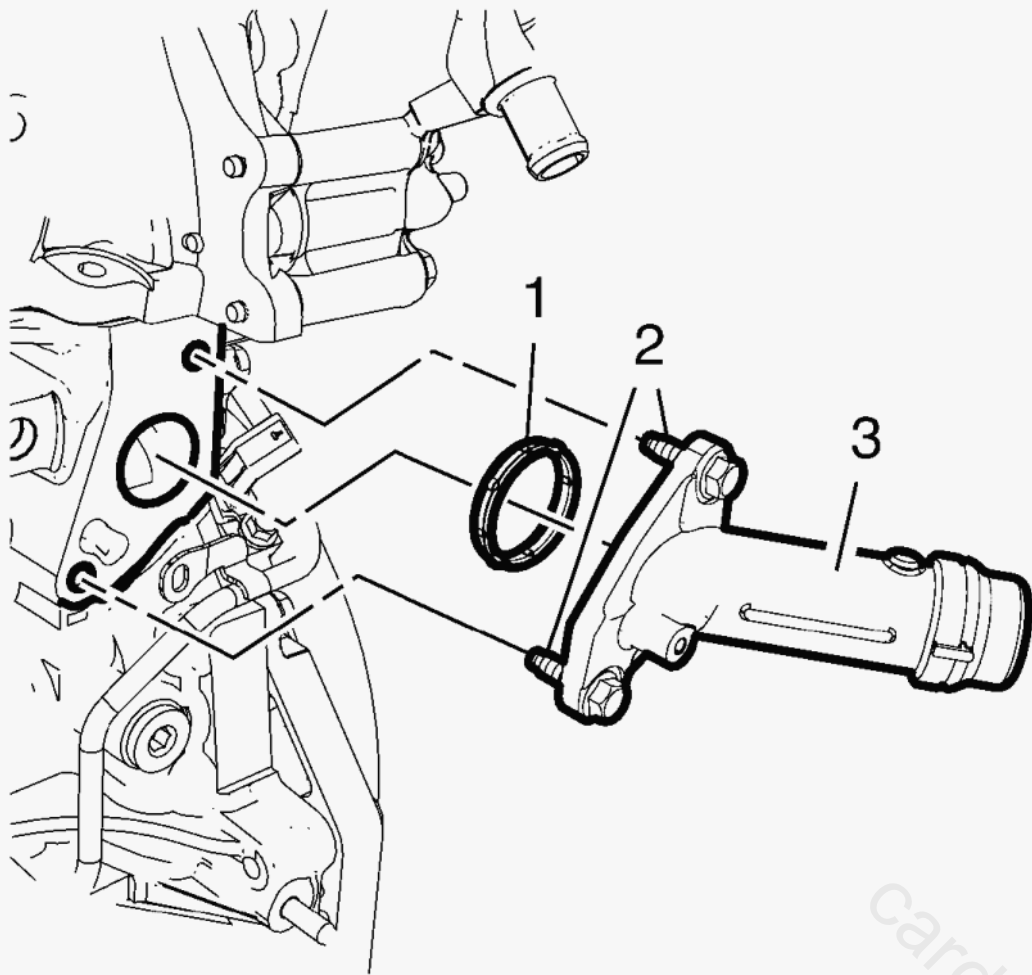


Fig. 924: Engine Coolant Outlet Pipe And Components
Courtesy of GENERAL MOTORS COMPANY

2. Install a NEW engine cooler outlet pipe seal (1).
3. Install the engine cooler outlet pipe (3).

CAUTION: Refer to **Fastener Caution** .

4. Install the 2 engine cooler outlet pipe bolts (2) and tighten to 25 N.m (18 lb ft).

WATER PUMP INSTALLATION

1. Clean the sealing surfaces of the water pump and the engine block.

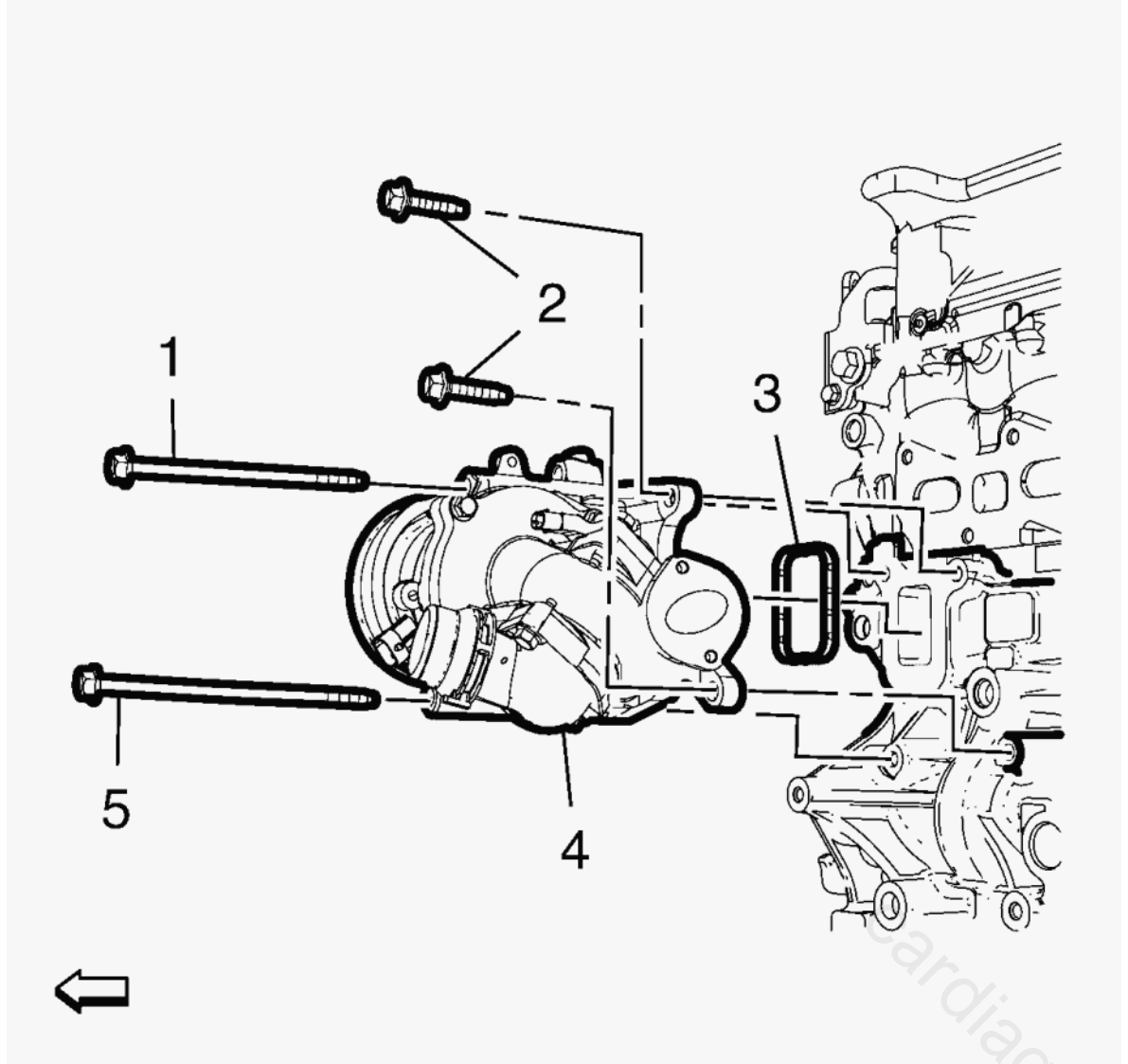


Fig. 925: Water Pump And Components

Courtesy of GENERAL MOTORS COMPANY

2. Install a NEW water pump seal (3) into the water pump housing (4).
3. Install the water pump (4).

CAUTION: Refer to **Fastener Caution** .

NOTE: Mind the different bolt lengths.

4. Install the 4 water pump bolts (1, 2, 5) and tighten to 25 N.m (18 lb ft).

THERMOSTAT BYPASS PIPE INSTALLATION

1. Clean all sealing surfaces.



Fig. 926: Thermostat Bypass Pipe Components
Courtesy of GENERAL MOTORS COMPANY

2. Insert a NEW gasket. (2)
3. Install Thermostat Bypass Pipe (3)

CAUTION: Refer to **Fastener Caution**

4. Install the 3 thermostat bypass pipe bracket bolts (5, 6) and tighten to 10 N.m (89 lb in).
5. Install and tighten Thermostat Bypass Pipe Bolts (1) (Qty: 2) to 10 N.m (89 lb in)
6. Install Clamps (4) (Qty: 2)

EXHAUST MANIFOLD INSTALLATION

1. Re-cut the thread at cylinder head for the 8 exhaust manifold bolts.

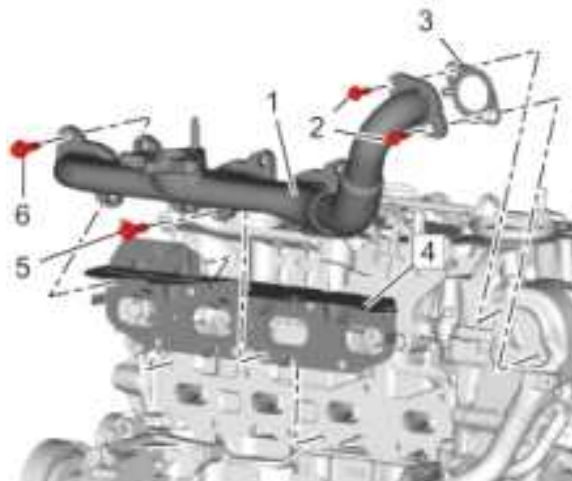


Fig. 927: Exhaust Manifold And Components
Courtesy of GENERAL MOTORS COMPANY

2. Install NEW Exhaust Gas Recirculation Pipe Gasket (3)
3. Install a NEW exhaust manifold gasket. (4)

NOTE: Do not grab the exhaust manifold during assembly procedure at the EGR pipe as this is a sensitive part.

4. Install Exhaust Manifold (1)

NOTE: Service may offer bolts without micro-encapsulated thread locking adhesive. If this is the case, apply thread locking adhesive to the bolt. Do NOT reuse old

bolts.

5. Loosely install NEW Exhaust Manifold Bolts (5, 6) (Qty: 2) - Use NEW bolts.
6. Loosely install NEW Exhaust Gas Recirculation Pipe Bolts (2) (Qty: 2) - Use NEW bolts.

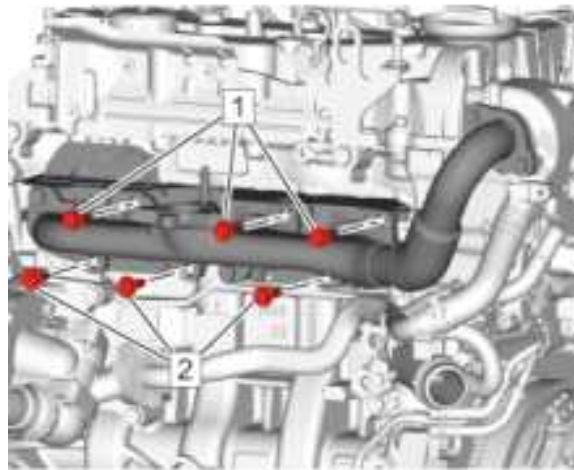


Fig. 928: Exhaust Manifold Bolts

Courtesy of GENERAL MOTORS COMPANY

7. Loosely install NEW Exhaust Manifold Bolts (1, 2) (Qty: 6) - Use NEW bolts.

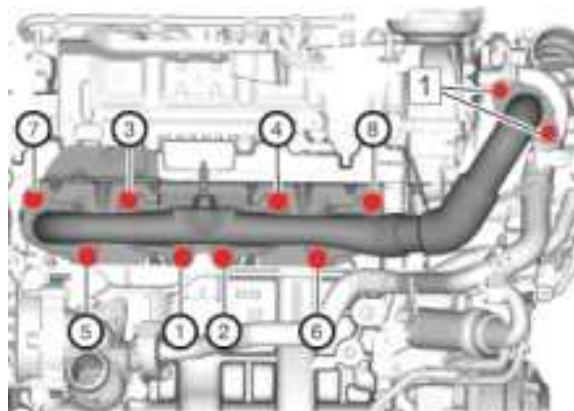


Fig. 929: Exhaust Manifold Bolt Tightening Sequence

Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution**

NOTE: The complete tightening procedure should be completed within 10 minutes.

8. Tighten Exhaust Manifold Bolts (Qty: 6) in sequence
 1. First Pass: 27 N.m (20 lb ft)
 2. Second Pass: 27 N.m (20 lb ft)
 3. Final Pass: 27 N.m (20 lb ft)
9. Tighten Exhaust Gas Recirculation Pipe Bolts (1) (Qty: 2) to 10 N.m (89 lb in)

EXHAUST GAS RECIRCULATION COOLER TEMPERATURE SENSOR INSTALLATION - POSITION

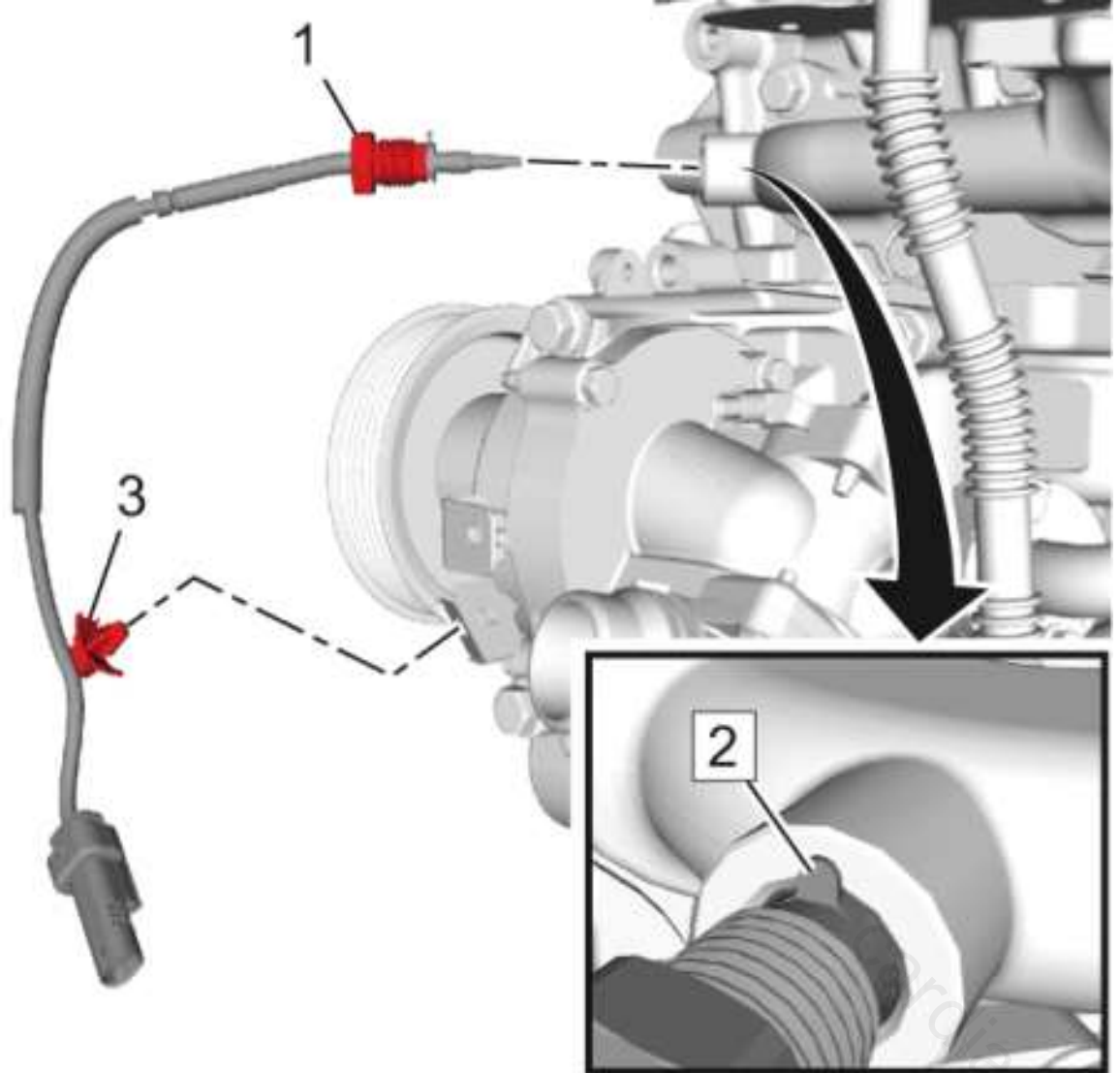


Fig. 930: Exhaust Gas Recirculation Cooler Temperature Sensor - Position 1 And Clip
Courtesy of GENERAL MOTORS COMPANY

NOTE: The guide lug (2) must fit the groove.

CAUTION: Refer to **Fastener Caution**

1. Install and tighten Exhaust Gas Recirculation Cooler Temperature Sensor-Position 1 (1) to 45 N.m (33 lb ft)
2. Install Wiring Harness Clip (3)

TURBOCHARGER INSTALLATION

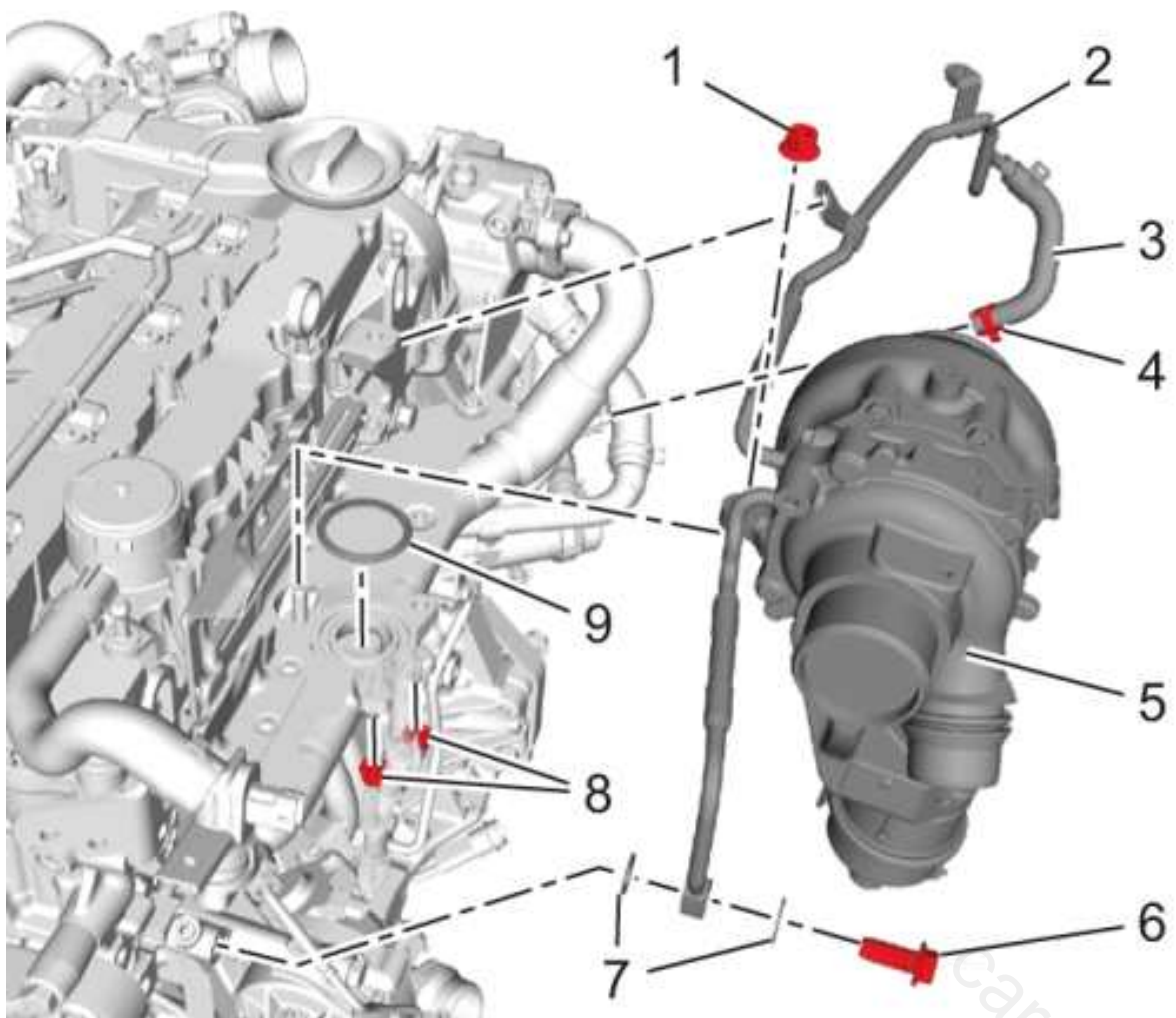


Fig. 931: Turbocharger And Components

Courtesy of GENERAL MOTORS COMPANY

1. Install NEW Turbocharger Gasket (9)
2. Position the turbocharger to the turbocharger oil return pipe.
3. Install Turbocharger (5) @ Exhaust Manifold

CAUTION: Refer to **Fastener Caution**

4. Install and tighten Turbocharger Nuts (1, 8) (Qty: 3) to 30 N.m (22 lb ft)
5. Install NEW Turbocharger Coolant Feed Pipe Gaskets (7) (Qty: 2)
6. Install and tighten Turbocharger Coolant Feed Pipe Hollow Screw (6) to 25 N.m (18 lb ft)
7. Connect Thermostat Bypass Hose (3) @ Thermostat Bypass Pipe
8. Install Thermostat Bypass Hose Clamp (4)

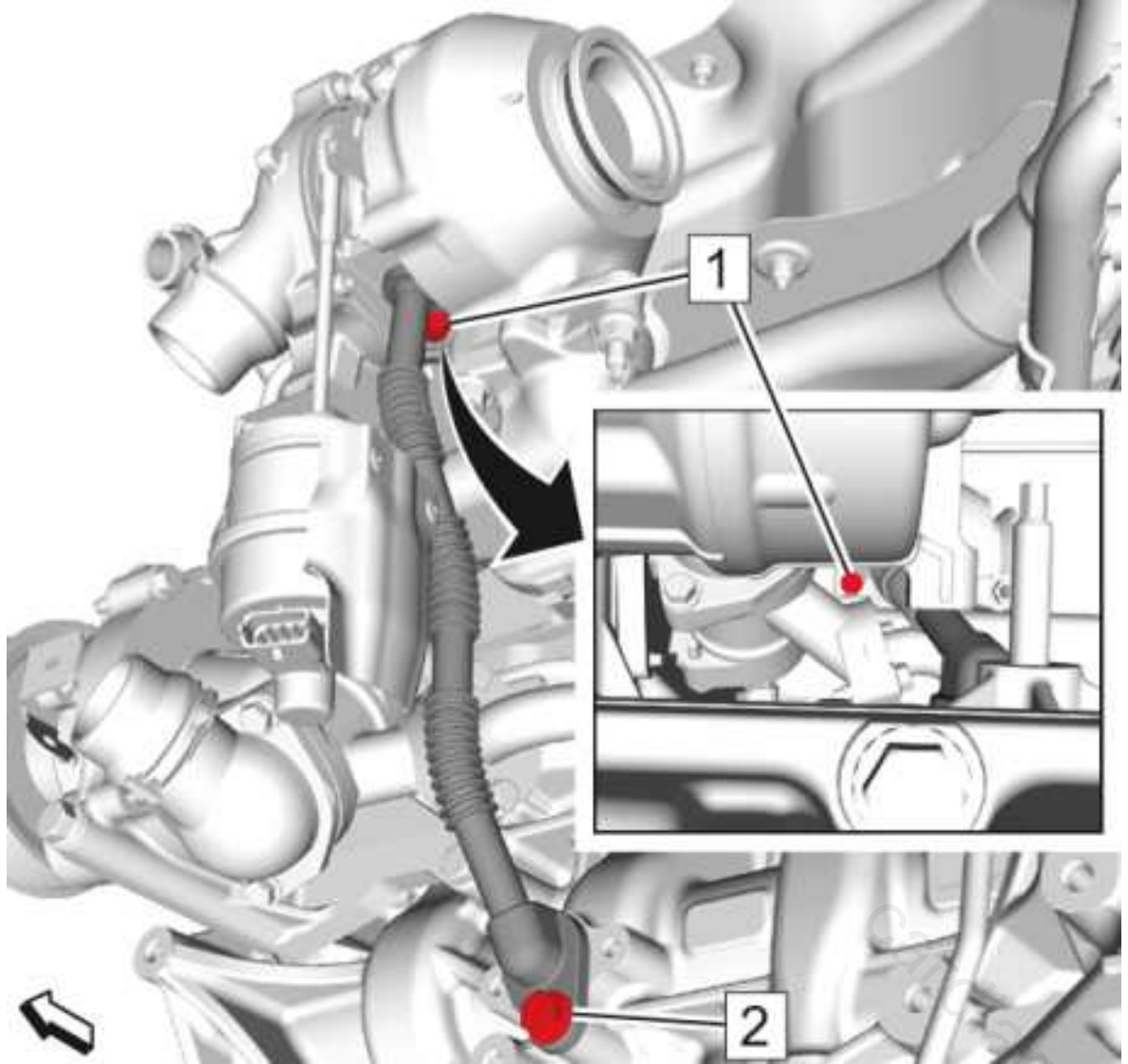


Fig. 932: Turbocharger Oil Return Pipe Bolts
Courtesy of GENERAL MOTORS COMPANY

9. Install and tighten Turbocharger Oil Return Pipe Bolt (1) to 10 N.m (89 lb in)
10. Tighten Turbocharger Oil Return Pipe Bolt (2) to 25 N.m (18 lb ft)

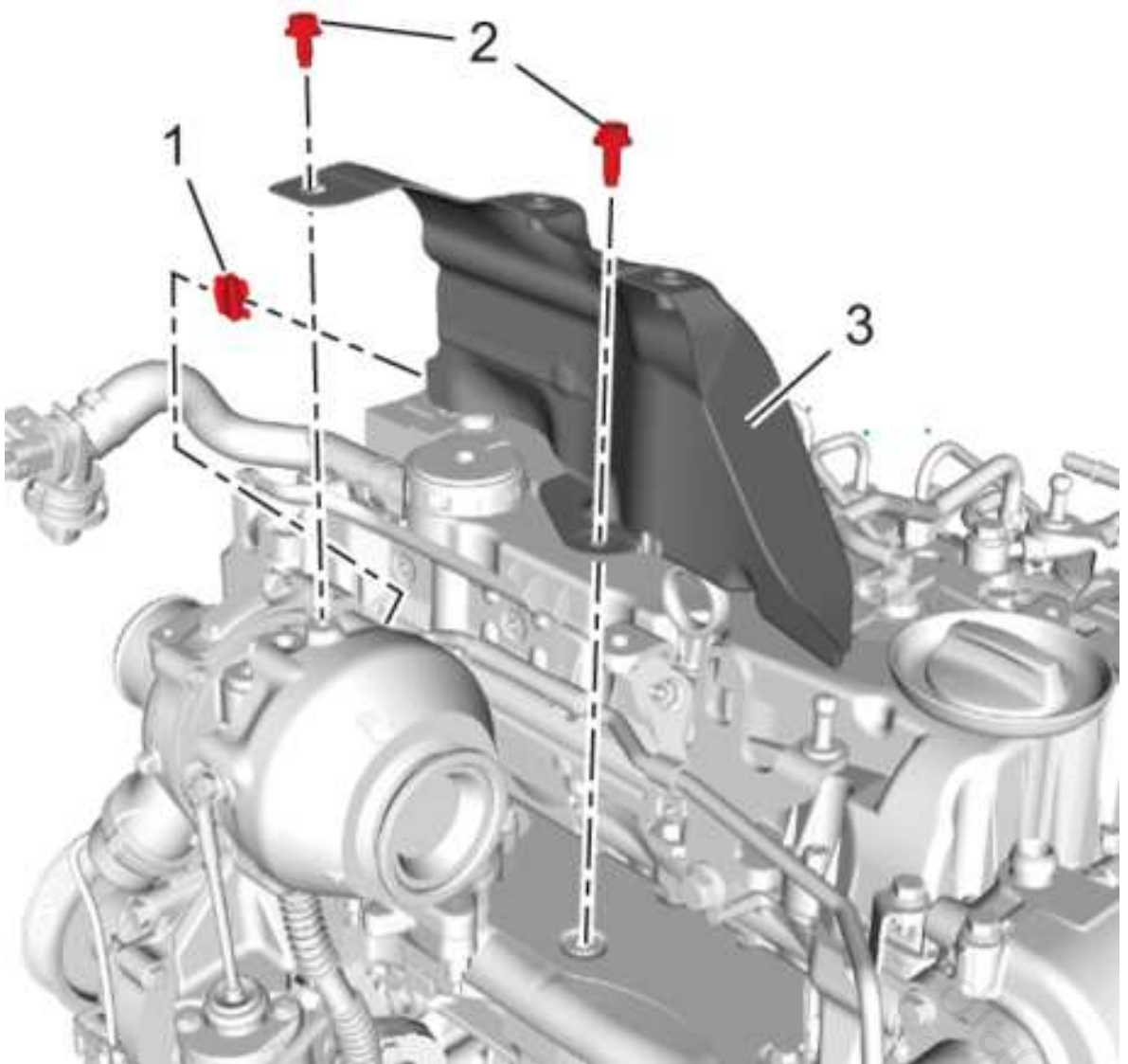


Fig. 933: Turbocharger Heat Shield, Bolts And Clamp
Courtesy of GENERAL MOTORS COMPANY

11. Install Turbocharger Heat Shield (3)
12. Install Turbocharger Heat Shield (3) @ Clamp (1)
13. Install and tighten Turbocharger Heat Shield Bolts (2) (Qty: 2) to 10 N.m (89 lb in)

TURBOCHARGER OIL RETURN PIPE INSTALLATION

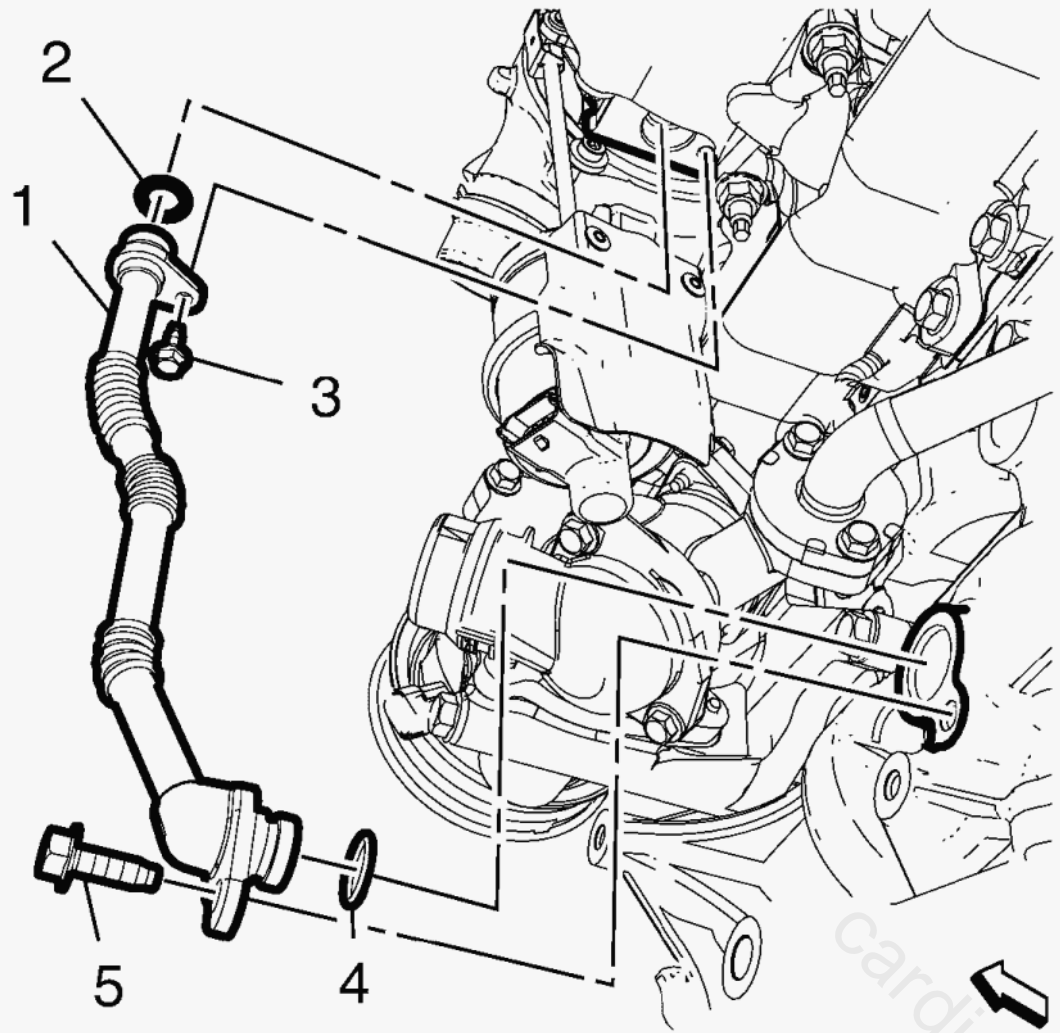


Fig. 934: Turbocharger Oil Return Pipe, Bolts And Gaskets
Courtesy of GENERAL MOTORS COMPANY

1. Install 2 NEW turbocharger oil return pipe seals (2, 4).
2. Install the turbocharger oil return pipe (1) to the lower crankcase.
3. Install the turbocharger oil return bolt (5) and handtighten.

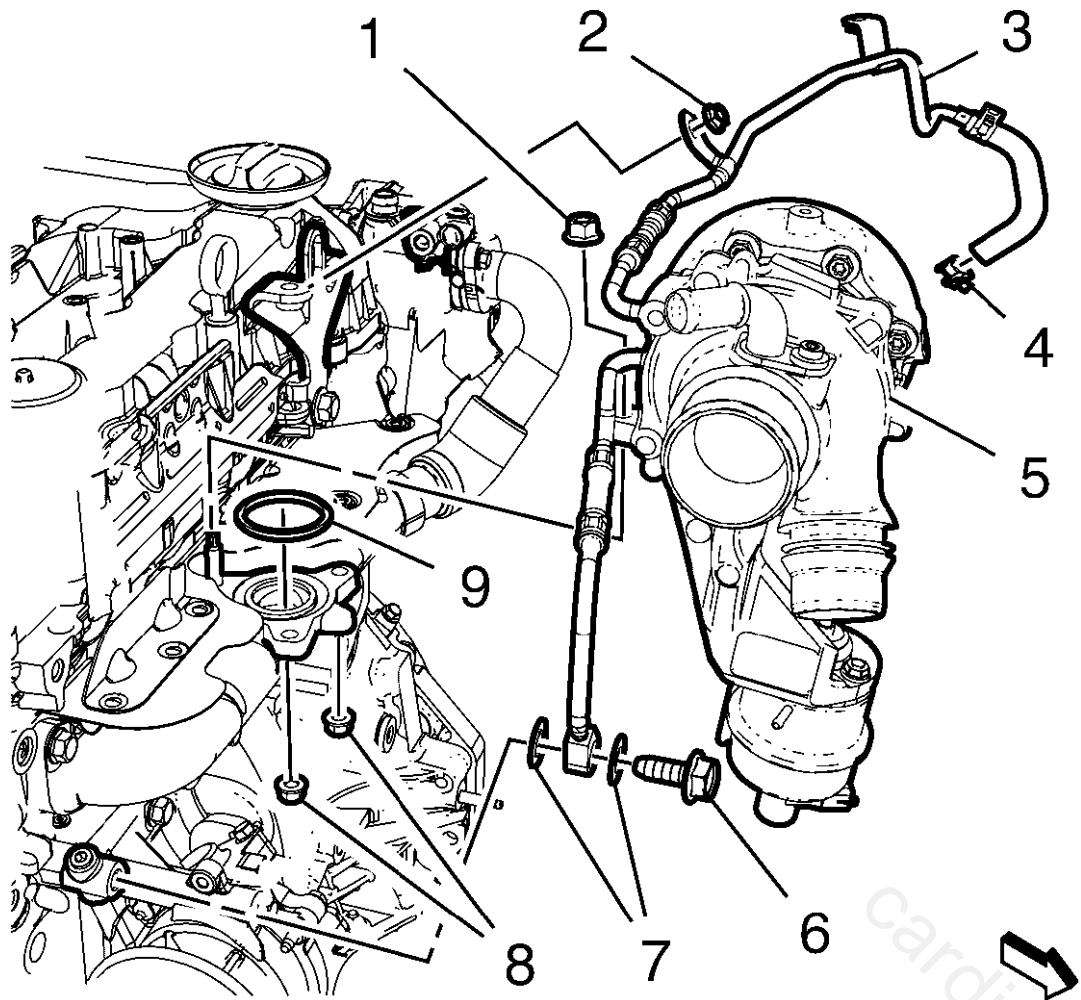


Fig. 935: Turbocharger And Components

Courtesy of GENERAL MOTORS COMPANY

4. Install the NEW turbocharger gasket (9).
5. Position the turbocharger to the turbocharger oil return pipe.
6. Install the turbocharger (5) to the exhaust manifold.

CAUTION: Refer to **Fastener Caution** .

7. Install the 3 turbocharger nuts (1, 8) and tighten to 30 N.m (22 lb ft).
8. Connect the turbocharger coolant feed pipe (3) to the thermostat bypass pipe.
9. Install the clamp (4).
10. Install the 2 turbocharger coolant feed pipe gaskets (7).
11. Install the turbocharger coolant feed pipe hollow bolt (6) and tighten to 25 N.m (18 lb ft).
12. Install the turbocharger coolant feed pipe bracket nut (2) and tighten to 10 N.m (89 lb in).

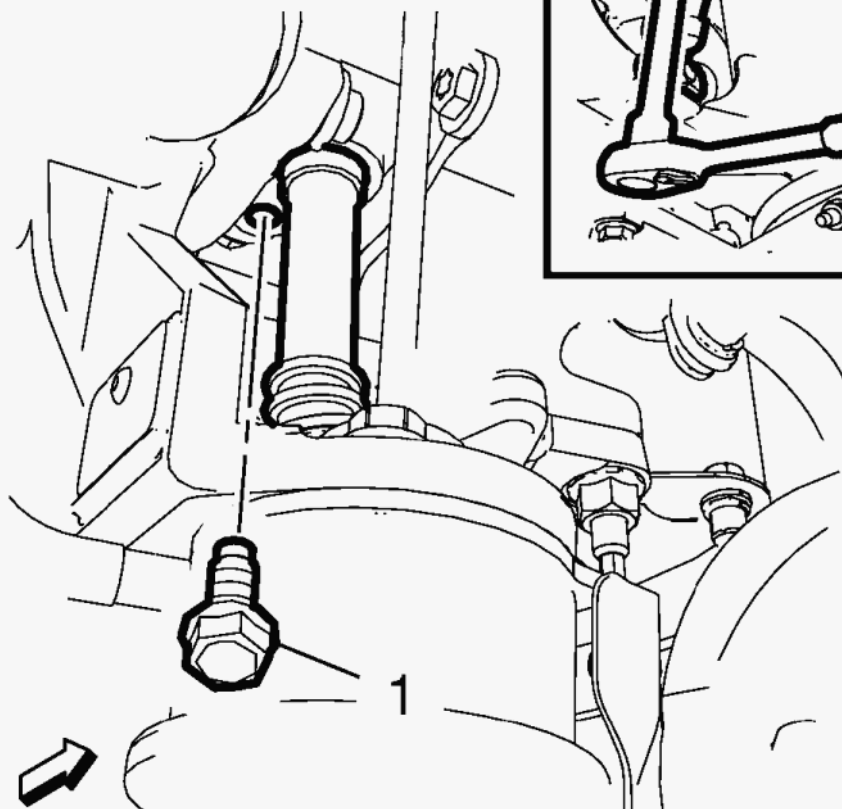


Fig. 936: Upper Turbocharger Oil Return Pipe Bolt
Courtesy of GENERAL MOTORS COMPANY

13. Tighten the upper turbocharger oil return pipe bolt (1) to 10 N.m (89 lb in).

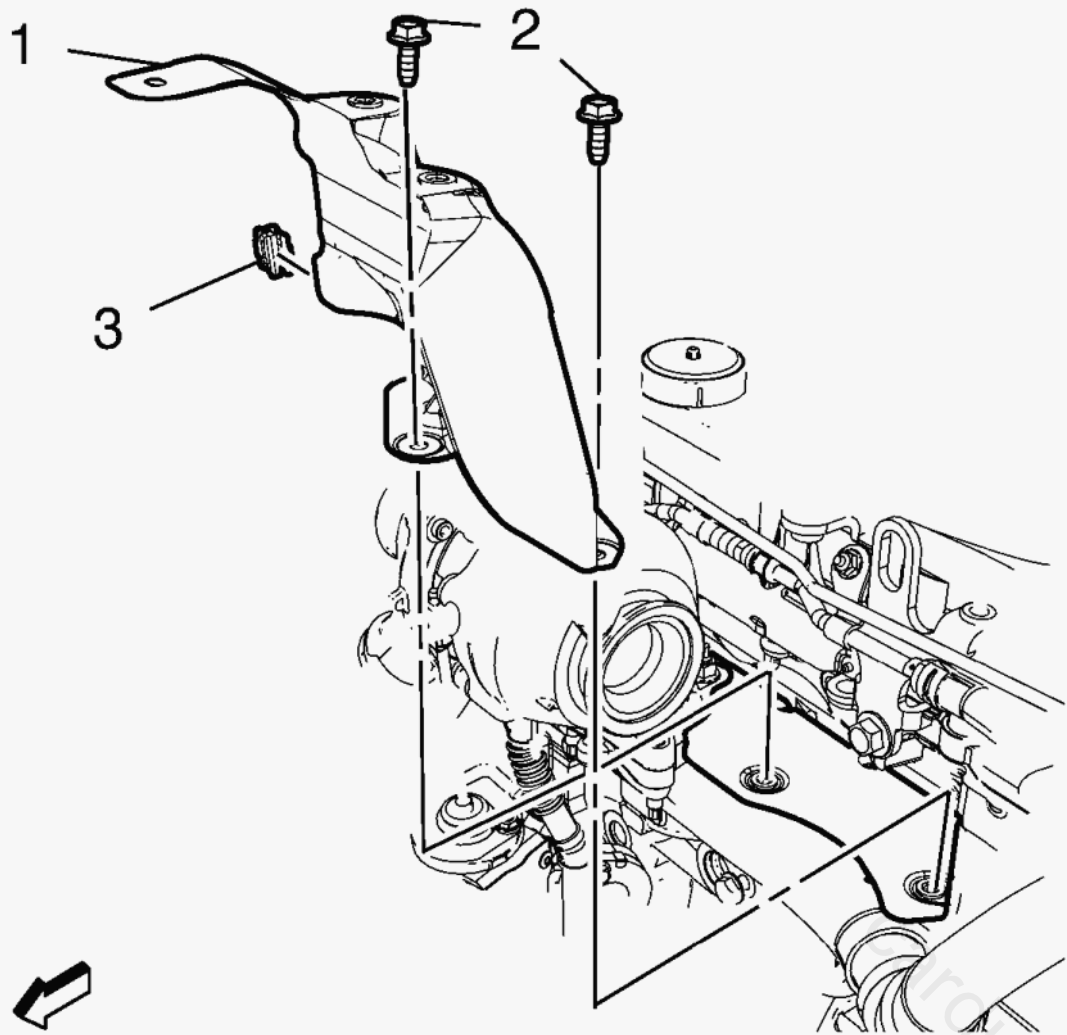


Fig. 937: Turbocharger Heat Shield, Bolts And Clip
Courtesy of GENERAL MOTORS COMPANY

14. Install the turbocharger heat shield (1).
15. Install the turbocharger heat shield connection clamp (3).
16. Install the turbocharger heat shield bolts (2) and tighten to 9 N.m (80 lb in).

TURBOCHARGER OIL FEED PIPE INSTALLATION

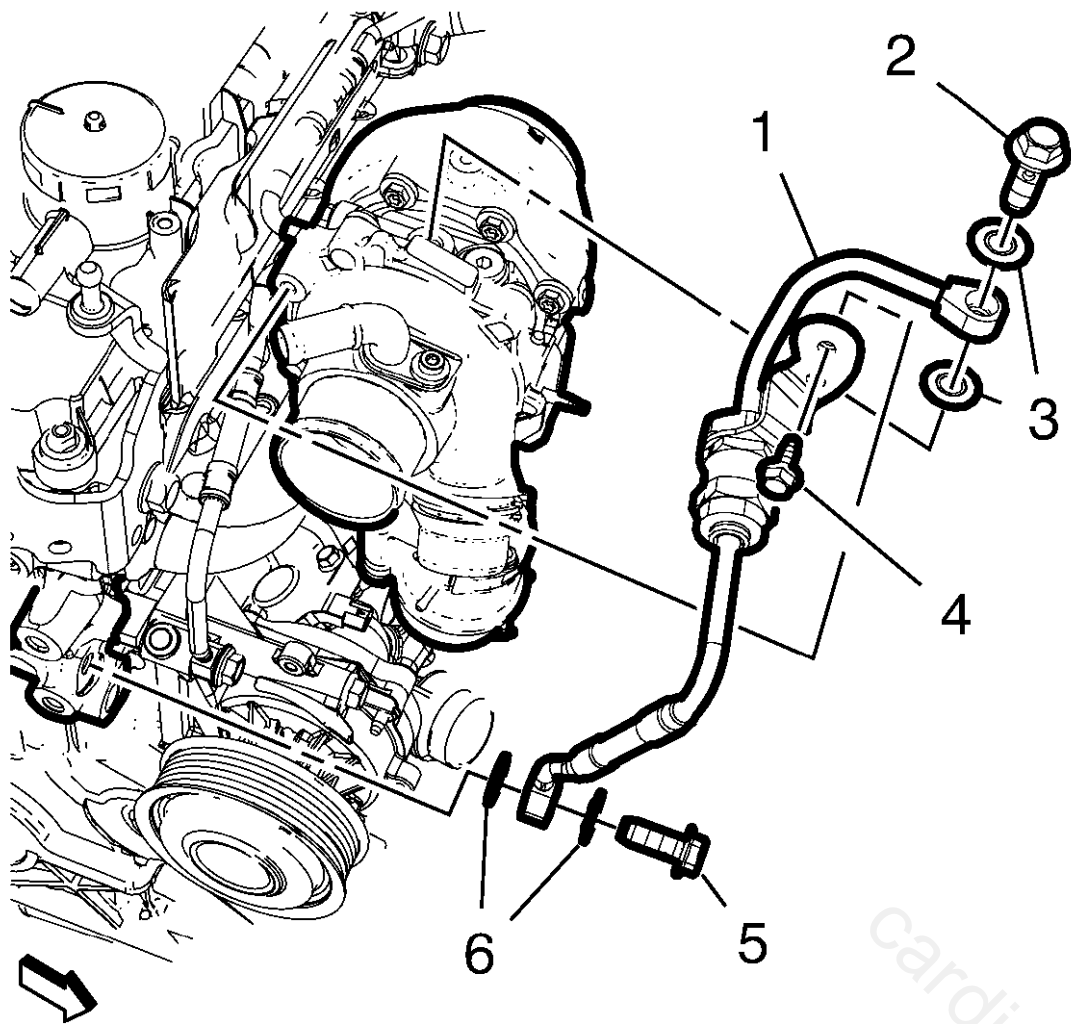


Fig. 938: Turbocharger Oil Feed Pipe And Components
Courtesy of GENERAL MOTORS COMPANY

1. Install the turbocharger oil feed pipe (1).
2. Install the turbocharger oil feed pipe bracket bolt (4) but do not tighten yet.
3. Install the 2 NEW turbocharger oil feed pipe gaskets (6).

CAUTION: Refer to **Fastener Caution** .

4. Install the turbocharger oil feed hollow bolt (5) and tighten to 25 N.m (18 lb ft).
5. Install the 2 NEW turbocharger oil feed pipe gaskets (3).
6. Install the turbocharger oil feed pipe hollow bolt (2) and tighten to 25 N.m (18 lb ft).
7. Tighten the turbocharger oil feed pipe bracket bolt (4) to 10 N.m (89 lb in).

TURBOCHARGER WASTEGATE ACTUATOR PIPE INSTALLATION

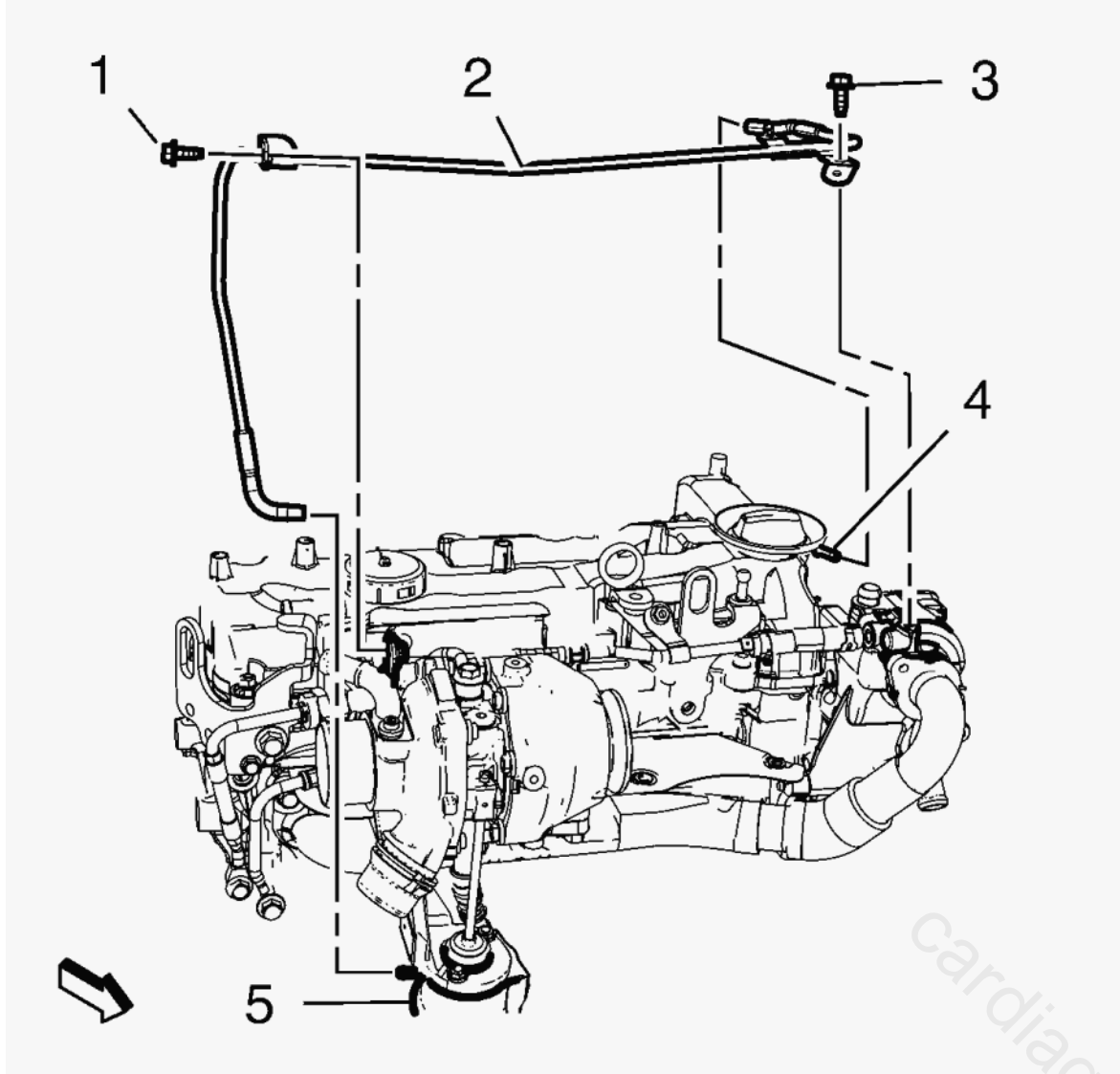


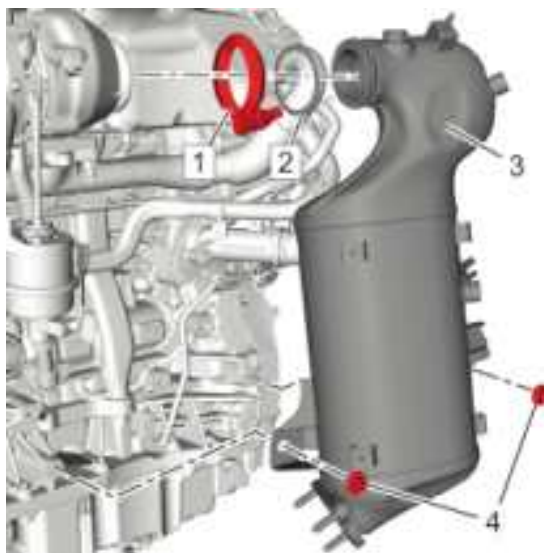
Fig. 939: Turbocharger Wastegate Actuator Pipe And Components
 Courtesy of GENERAL MOTORS COMPANY

1. Install the turbocharger wastegate actuator pipe (2).
2. Connect the turbocharger wastegate actuator pipe (2) to the power brake booster vacuum pipe (4).
3. Connect the turbocharger wastegate actuator pipe (2) to the turbocharger wastegate actuator (5).

CAUTION: Refer to **Fastener Caution** .

4. Install the turbocharger wastegate actuator pipe bracket bolt (3) and tighten to 10 N.m (89 lb in).
5. Install the turbocharger wastegate actuator pipe bracket bolt (1) and tighten to 10 N.m (89 lb in).

CATALYTIC CONVERTER INSTALLATION



1. Install a NEW gasket. (2)
2. Install Catalytic Converter Clamp (1)
3. Install Catalytic Converter (3)

CAUTION: Refer to **Fastener Caution**

NOTE: Only tighten the catalytic converter clamp bolt that a rotation of the catalytic converter is possible.

4. Tighten Catalytic Converter Clamp (1) to 6 N.m (53 lb in)
5. Install and tighten Catalytic Converter Bracket Nuts (4) (Qty: 2) to 22 N.m (17 lb ft)
6. Tighten Catalytic Converter Clamp (1) to 25 N.m (18 lb ft)

EXHAUST PRESSURE DIFFERENTIAL SENSOR PIPE INSTALLATION

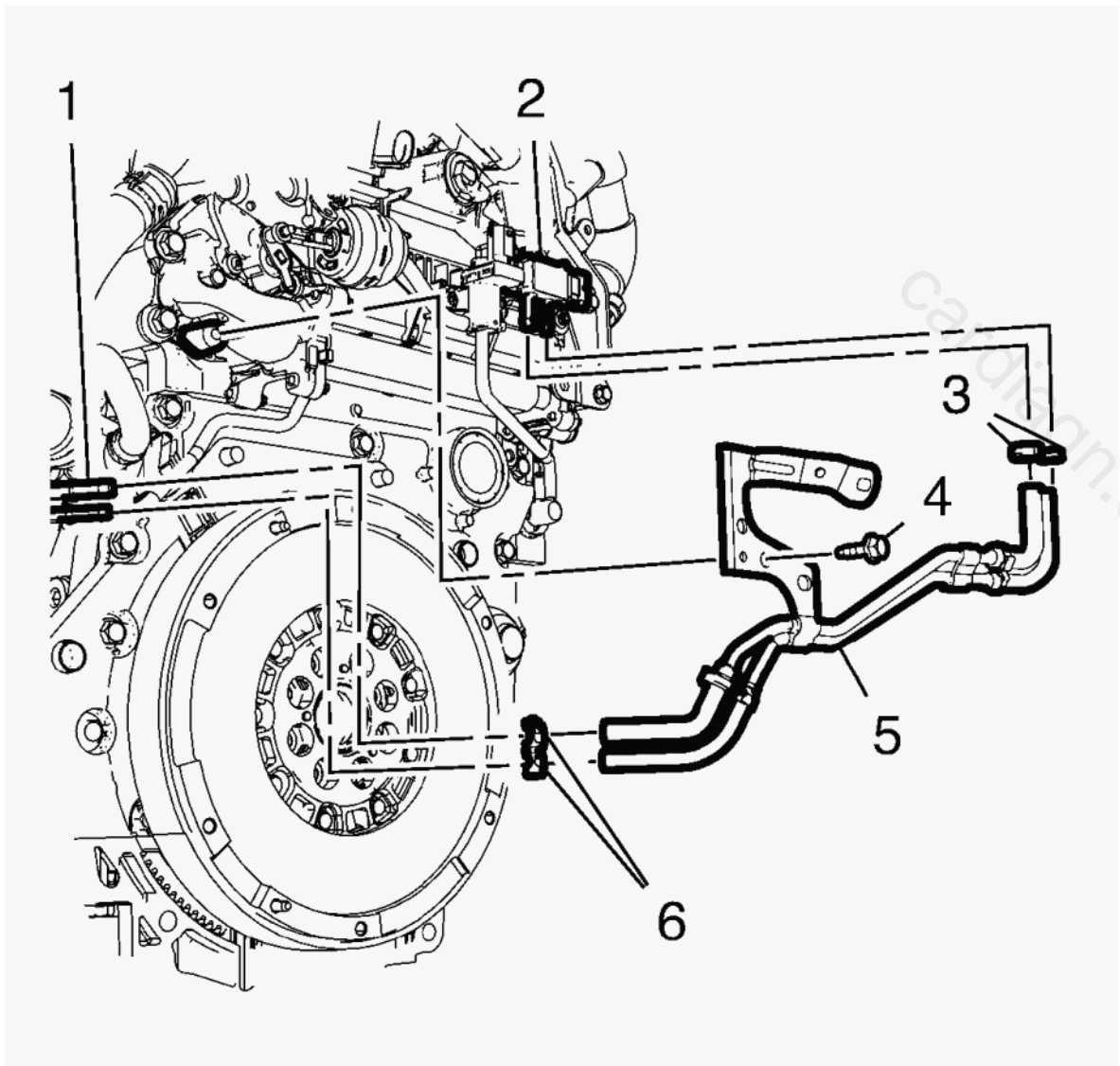


Fig. 941: Exhaust Pressure Differential Sensor Pipe And Components
Courtesy of GENERAL MOTORS COMPANY

1. Install the exhaust pressure differential sensor pipe (5).

CAUTION: Refer to **Fastener Caution** .

2. Install the exhaust pressure differential sensor pipe bracket bolt (4) and tighten to 9 N.m (80 lb in).
3. Install 2 NEW clamps (6) to the hoses.
4. Connect the hoses to the catalytic converter connection pipes (1) and fasten the clamps (6).
5. Install 2 NEW clamps (3) to the hoses.

6. Connect the hoses to the exhaust pressure differential sensor (2) and fasten the clamps (3).

EXHAUST TEMPERATURE SENSOR INSTALLATION - POSITION 2

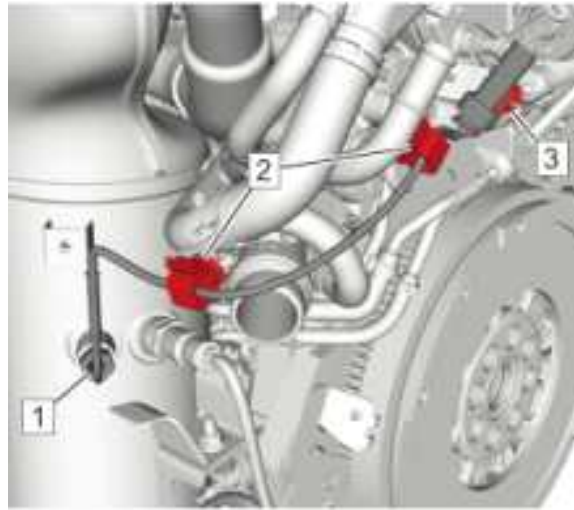


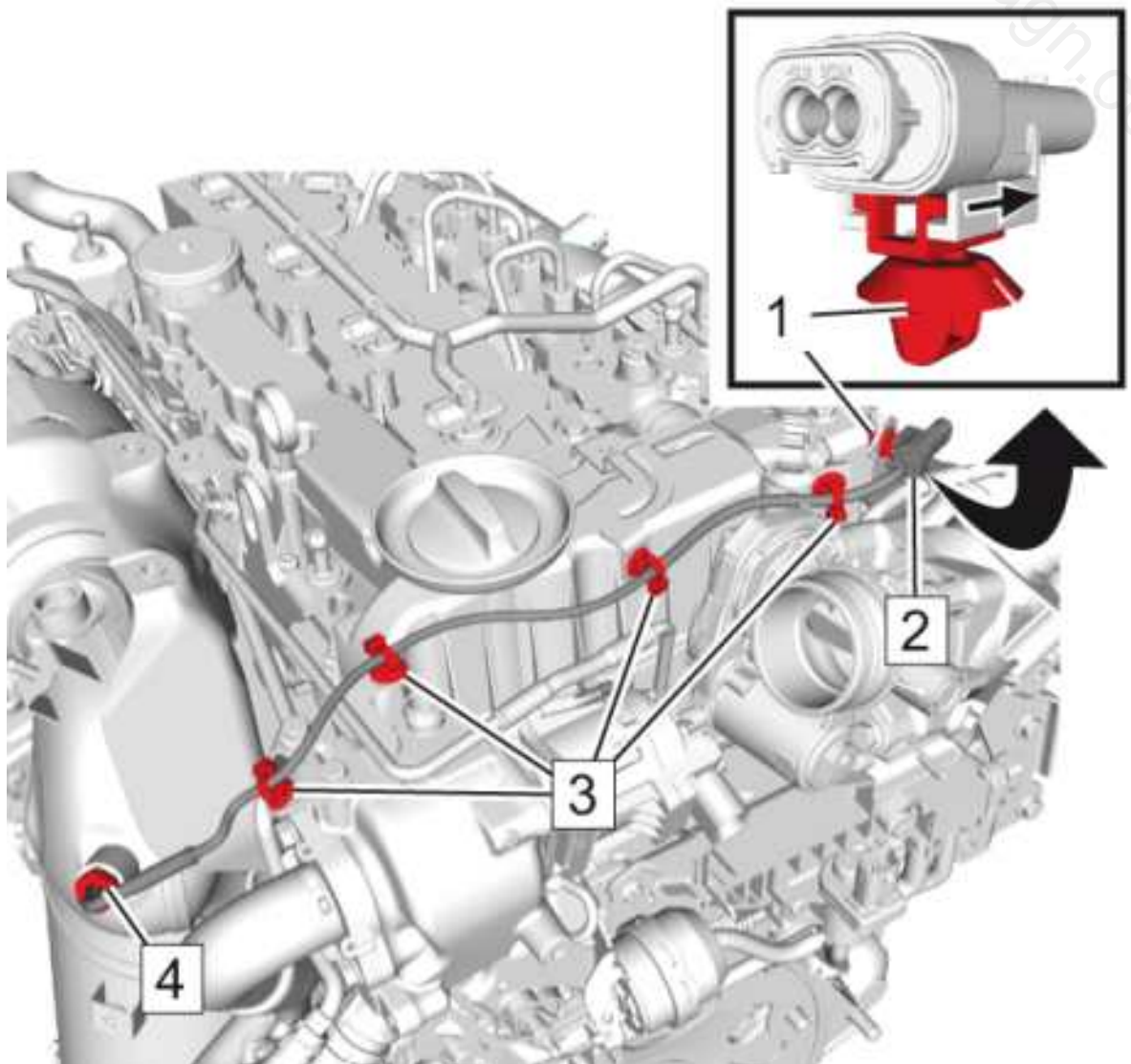
Fig. 942: Exhaust Temperature Sensor - Position 2 And Retainers

Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution** .

1. Install the exhaust temperature sensor - position 2 (1) to the catalytic converter and tighten to 45 N.m (33 lb ft).
2. Install Retainers (2, 3) (Qty: 3)

EXHAUST TEMPERATURE SENSOR INSTALLATION - POSITION 1



CAUTION: Refer to **Fastener Caution** .

1. Install and tighten Exhaust Temperature Sensor - Position 1 (4) to 45 N.m (33 lb ft)
2. Install Wiring Harness Retainers (3) (Qty: 4)
3. Install Electrical Connector (2) @ Retainer (1)

CATALYTIC CONVERTER HEAT SHIELD INSTALLATION

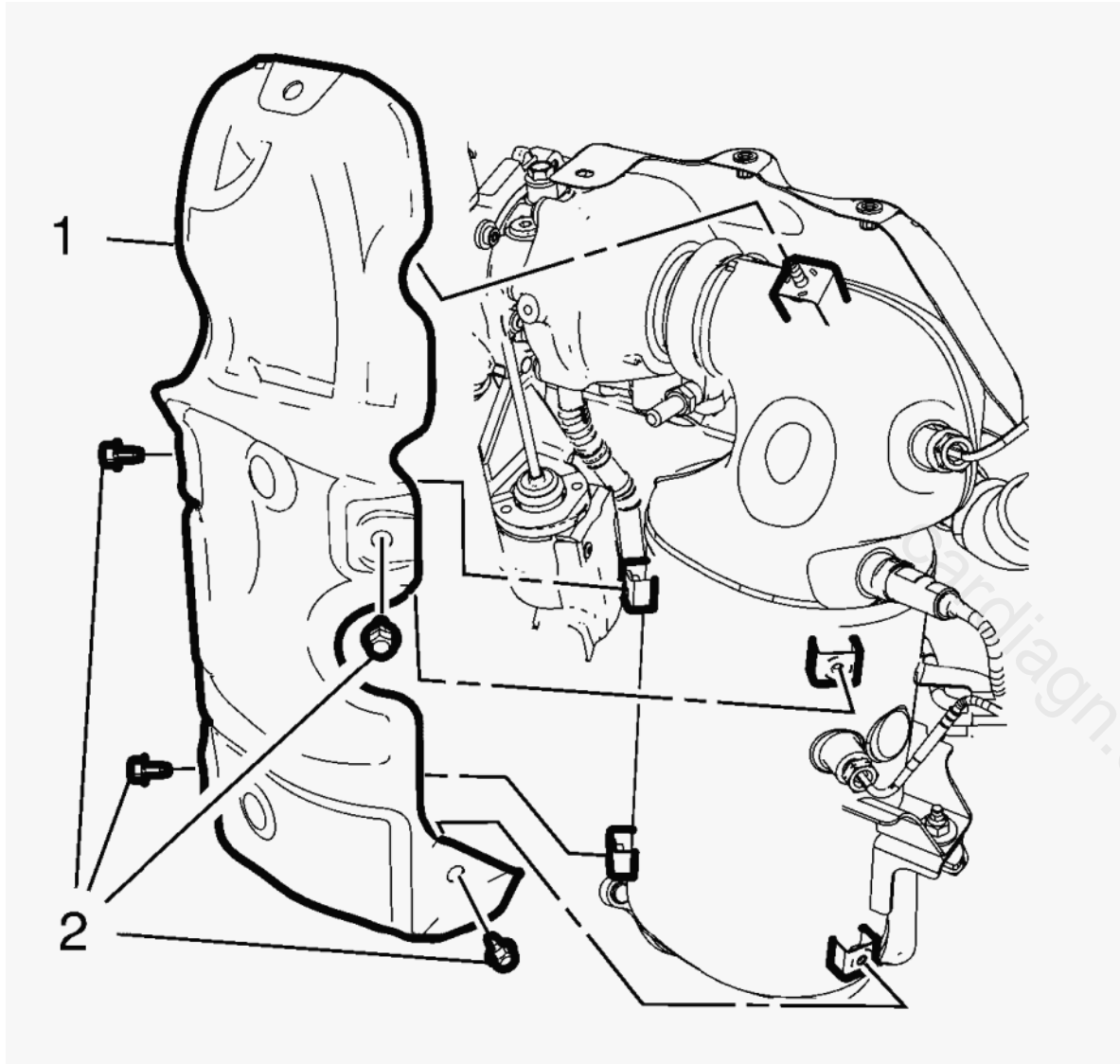


Fig. 944: Catalytic Converter Heat Shield And Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Install the catalytic converter heat shield (1).

CAUTION: Refer to **Fastener Caution** .

2. Install the 4 catalytic converter heat shield bolts (2) and tighten to 9 N.m (80 lb in).

TURBOCHARGER HEAT SHIELD INSTALLATION

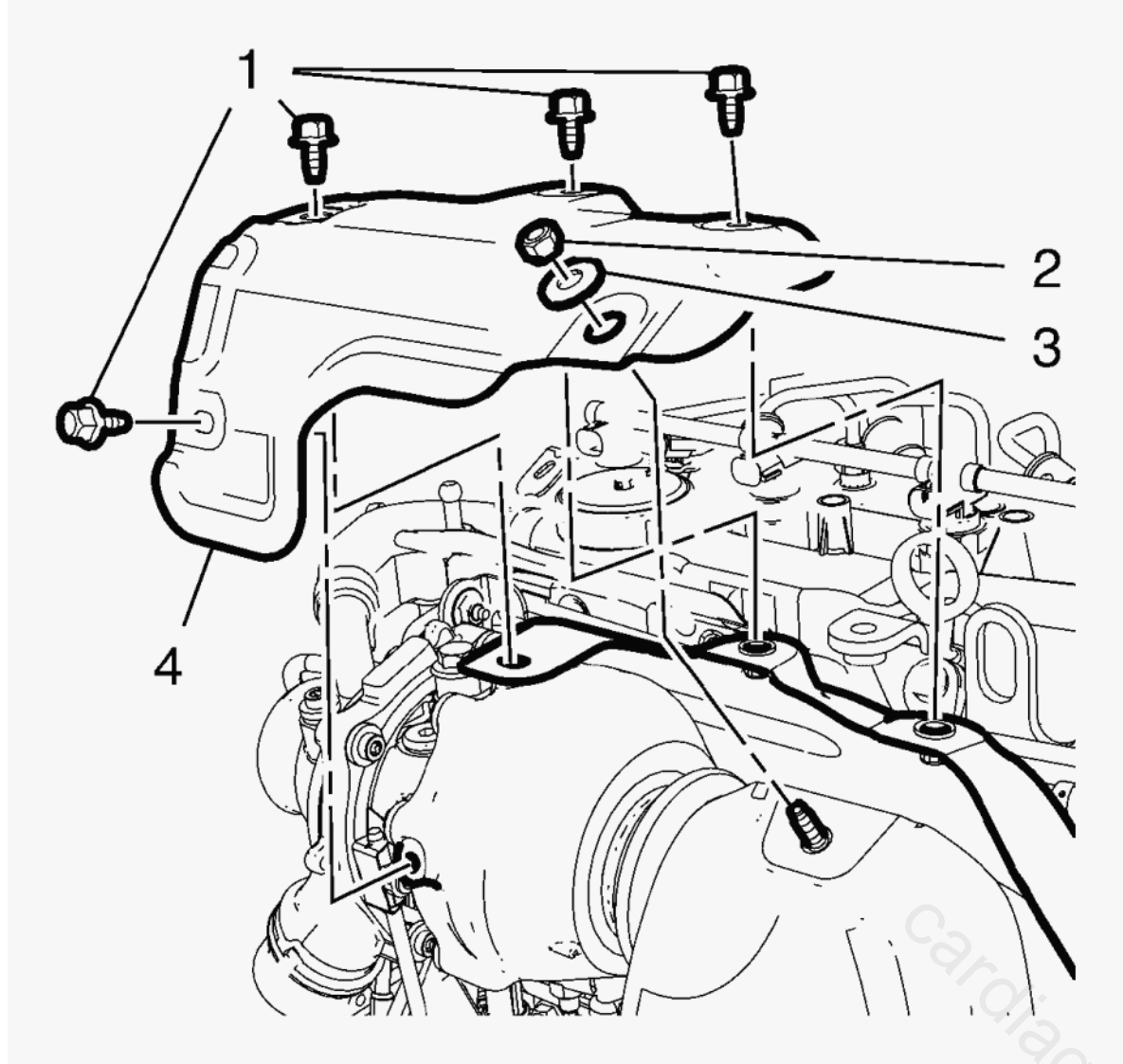


Fig. 945: Turbocharger Heat Shield, Bolts, Nut And Washer
Courtesy of GENERAL MOTORS COMPANY

1. Install the turbocharger heat shield (4).
2. Install the turbocharger heat shield washer (3).

CAUTION: Refer to **Fastener Caution** .

3. Install the 4 turbocharger heat shield bolts (1) and tighten to 9 N.m (80 lb in).
4. Install the turbocharger heat shield nut (2) and tighten to 9 N.m (80 lb in).

CRANKSHAFT PULLEY INSTALLATION

Special Tools

- EN-956-1 Extension
- EN-45059 Angle Meter
- EN-49979 Crankshaft Holder
- EN-49979-100 Crankshaft Holder Pins

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

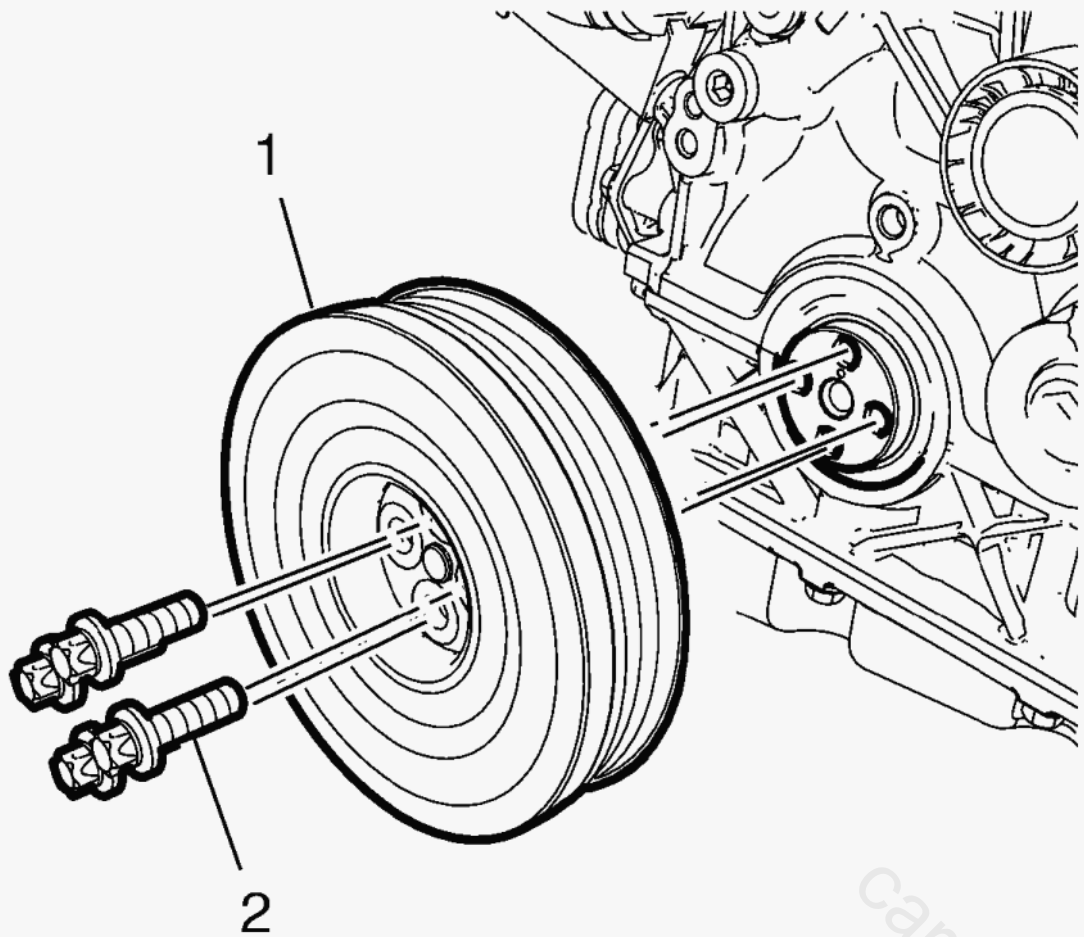


Fig. 946: Crankshaft Pulley And Bolts

Courtesy of GENERAL MOTORS COMPANY

1. Install the crankshaft pulley (1).
2. Pre-install the 4 NEW crankshaft pulley bolts (2).

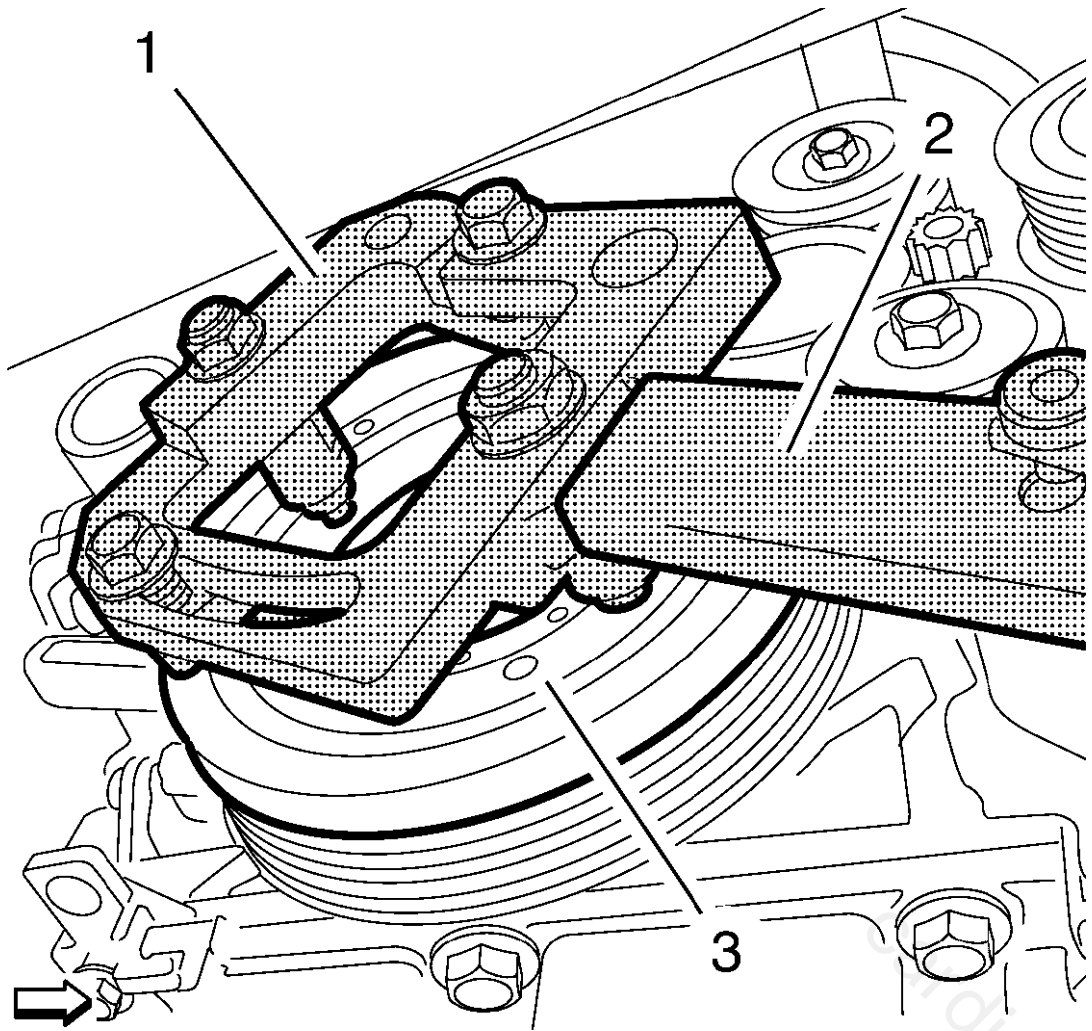


Fig. 947: Crankshaft Holder, Pins, Extension And Crankshaft Pulley.
Courtesy of GENERAL MOTORS COMPANY

3. Install the EN-49979 holder (1) in compound with the EN-49979-100 pins and the EN-956-1 extension (2) to counterhold the crankshaft pulley (3).

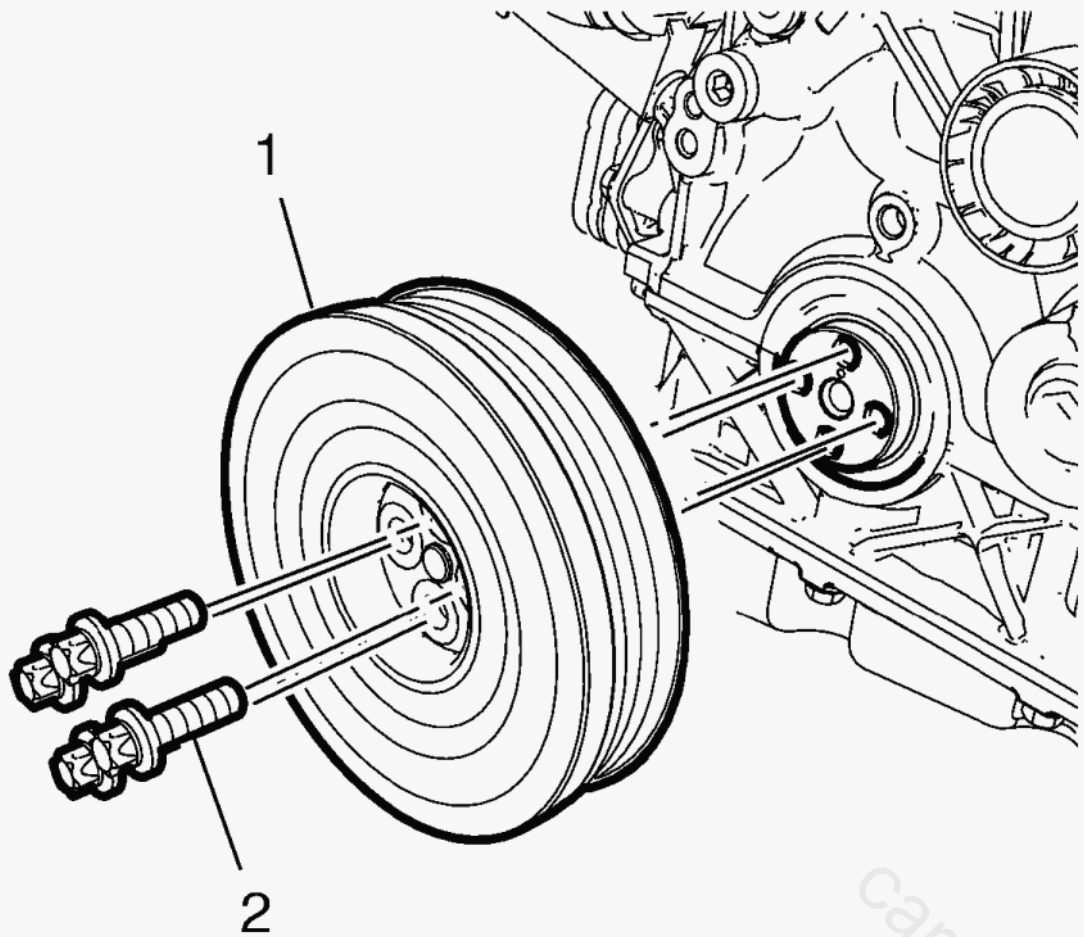


Fig. 948: Crankshaft Pulley And Bolts

Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to [Fastener Caution](#) .

CAUTION: Refer to [Torque-to-Yield Fastener Caution](#) .

4. Install the 4 crankshaft pulley bolts (2) and tighten in first pass to 50 N.m (37 lb ft).
5. Tighten in final pass to 45 degrees, use the **EN-45059** meter.

DRIVE BELT TENSIONER INSTALLATION

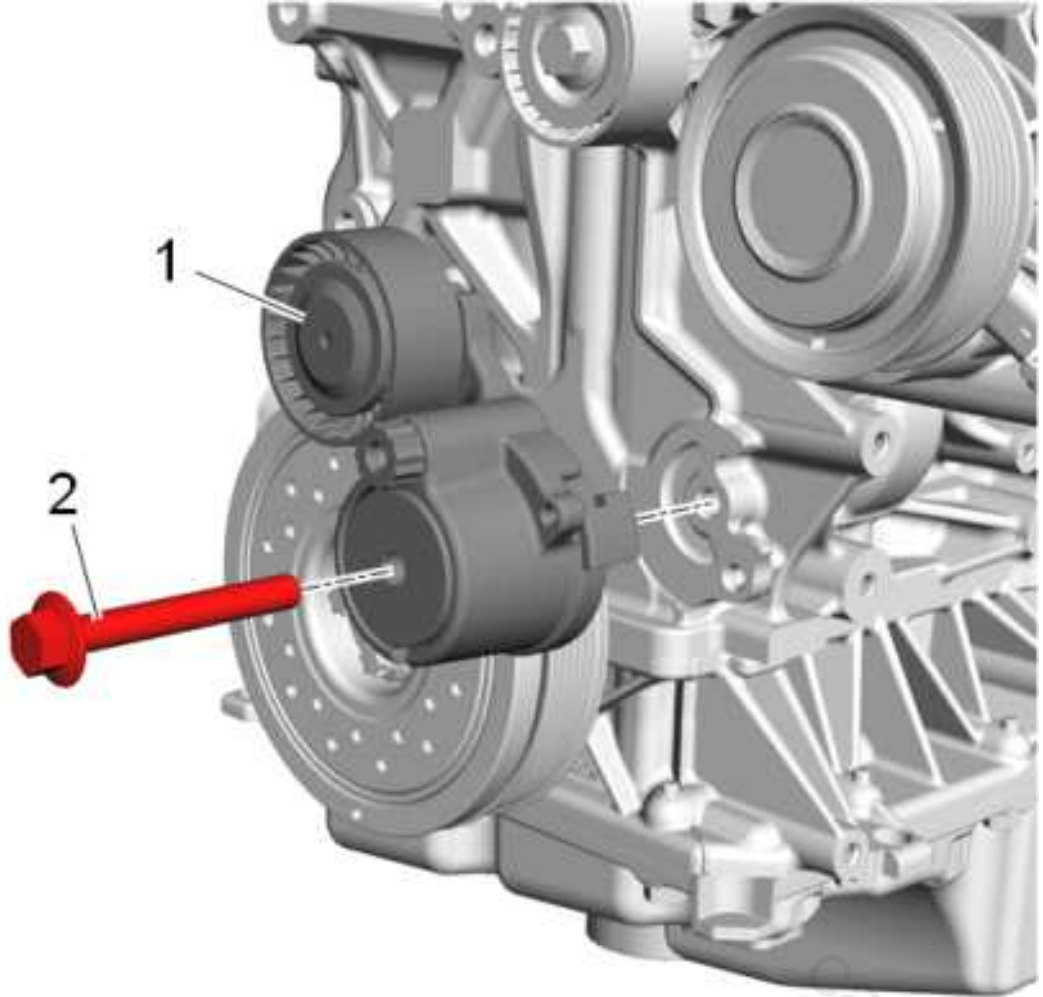


Fig. 949: Drive Belt Tensioner And Bolt

Courtesy of GENERAL MOTORS COMPANY

1. Install Drive Belt Tensioner (1)

CAUTION: Refer to [Fastener Caution](#)

2. Install and tighten Drive Belt Tensioner Bolt (2) to 58 N.m (43 lb ft)

BELT IDLER PULLEY INSTALLATION

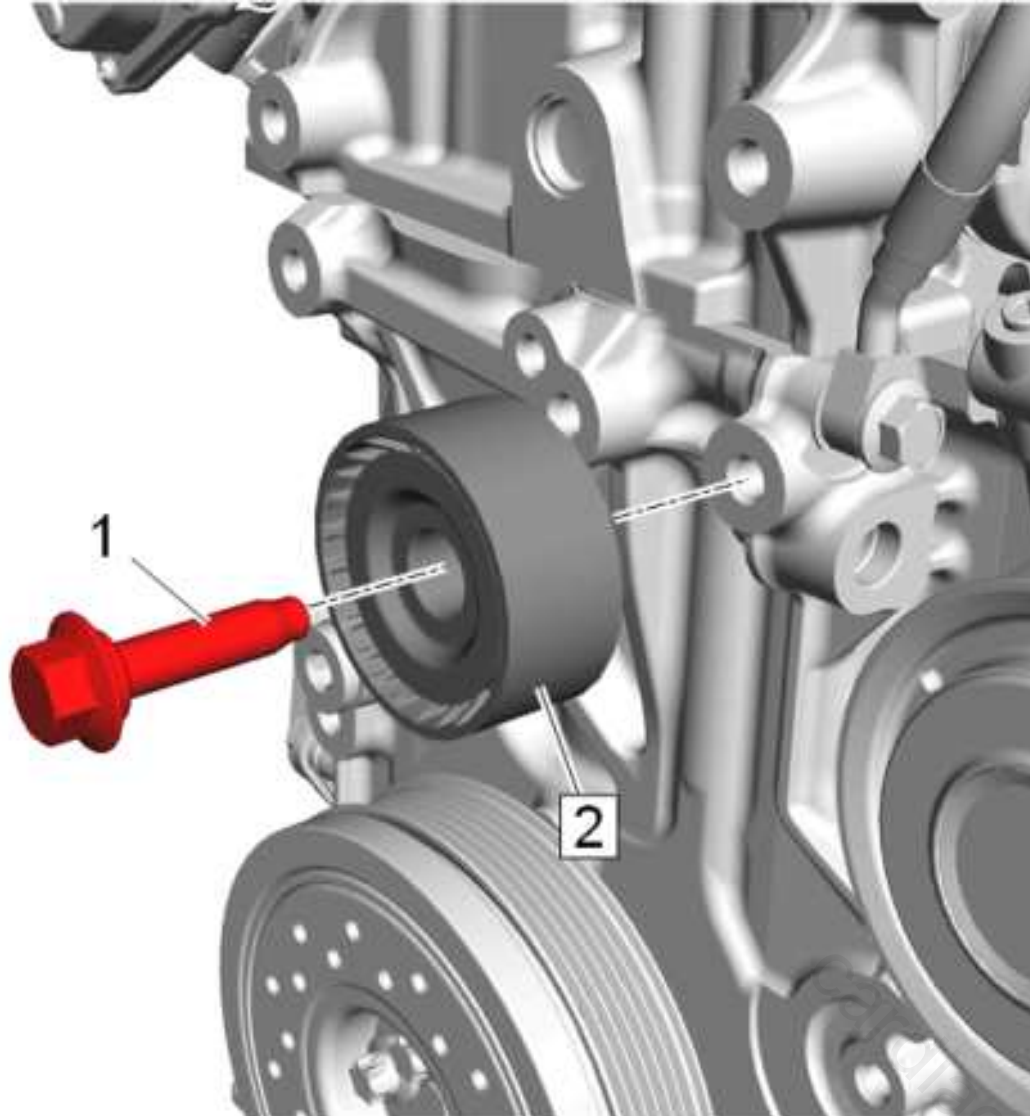


Fig. 950: Drive Belt Idler Pulley And Bolt
Courtesy of GENERAL MOTORS COMPANY

1. Install the drive belt idler pulley (2).

CAUTION: Refer to [Fastener Caution](#) .

2. Install the drive belt idler pulley bolt (1) and tighten to 58 N.m (43 lb ft).

ENGINE MOUNT BRACKET INSTALLATION

Special Tools

EN-45059 Angle Meter

Equivalent regional tools: [Special Tools](#)

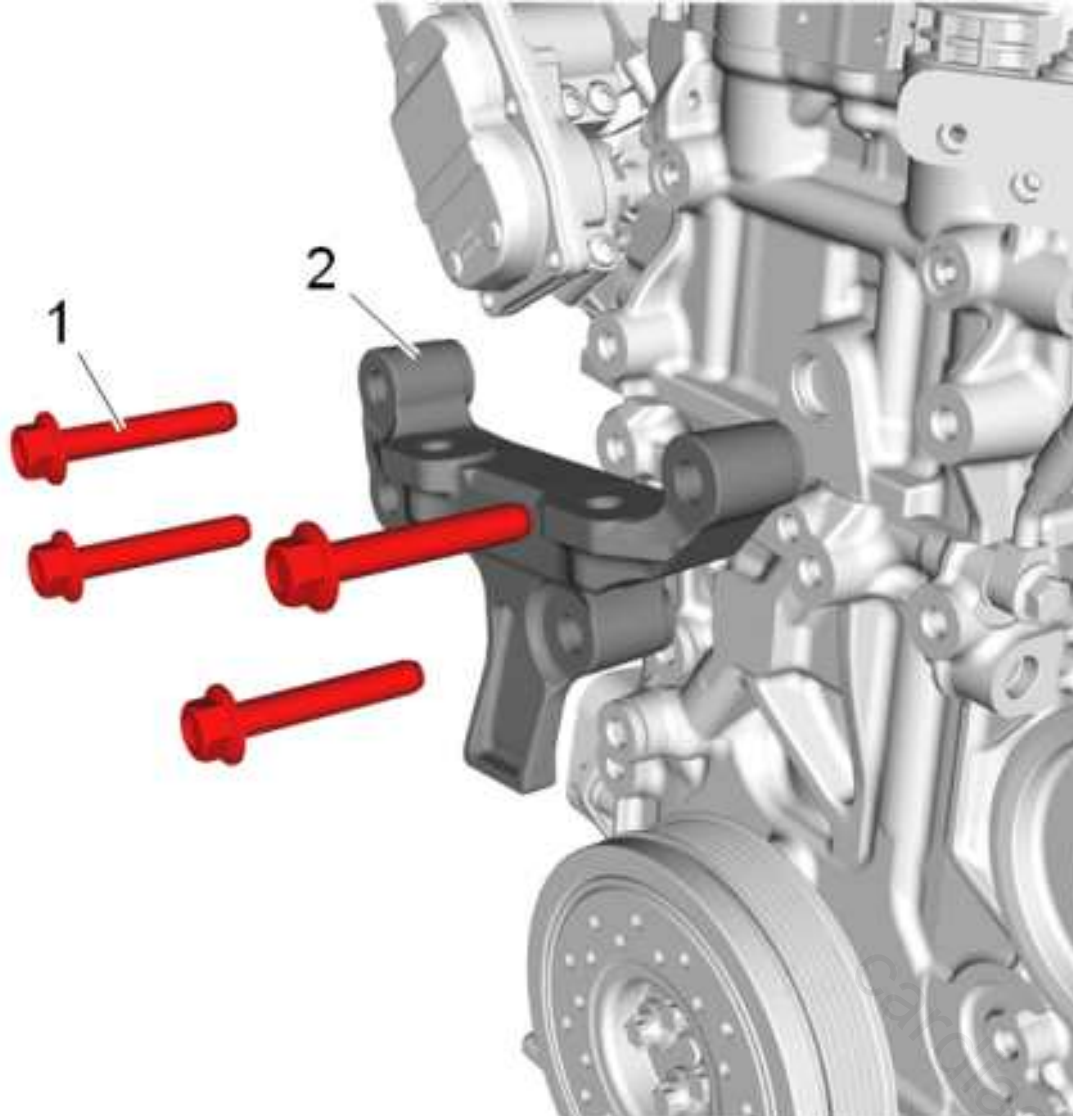


Fig. 951: Engine Mount Bracket And Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Install Engine Mount Bracket (2)

CAUTION: Refer to [Fastener Caution](#)

2. Install NEW Engine Mount Bracket Bolts (1) (Qty: 4) - Hand tighten

CAUTION: Refer to [Torque-to-Yield Fastener Caution](#)

3. Tighten Engine Mount Bracket Bolts (1) (Qty: 4) in sequence
 1. First Pass: 58 N.m (43 lb ft)
 2. Final Pass: 60-75 degrees - Use the special tool: **EN-45059** Angle Meter

DESCRIPTION AND OPERATION

DRIVE BELT SYSTEM DESCRIPTION

The drive belt system consists of the following components:

- The drive belt
- The drive belt tensioner
- The drive belt idler pulley
- The crankshaft pulley
- The accessory drive components
 - The generator
 - The A/C compressor, if equipped

- The water pump

The drive belt is thin so that it can bend backward and has several ribs to match the grooves in the pulleys. The drive belts are made of different types of rubber (chloroprene or EPDM) and have different layers or plies 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.

LUBRICATION DESCRIPTION

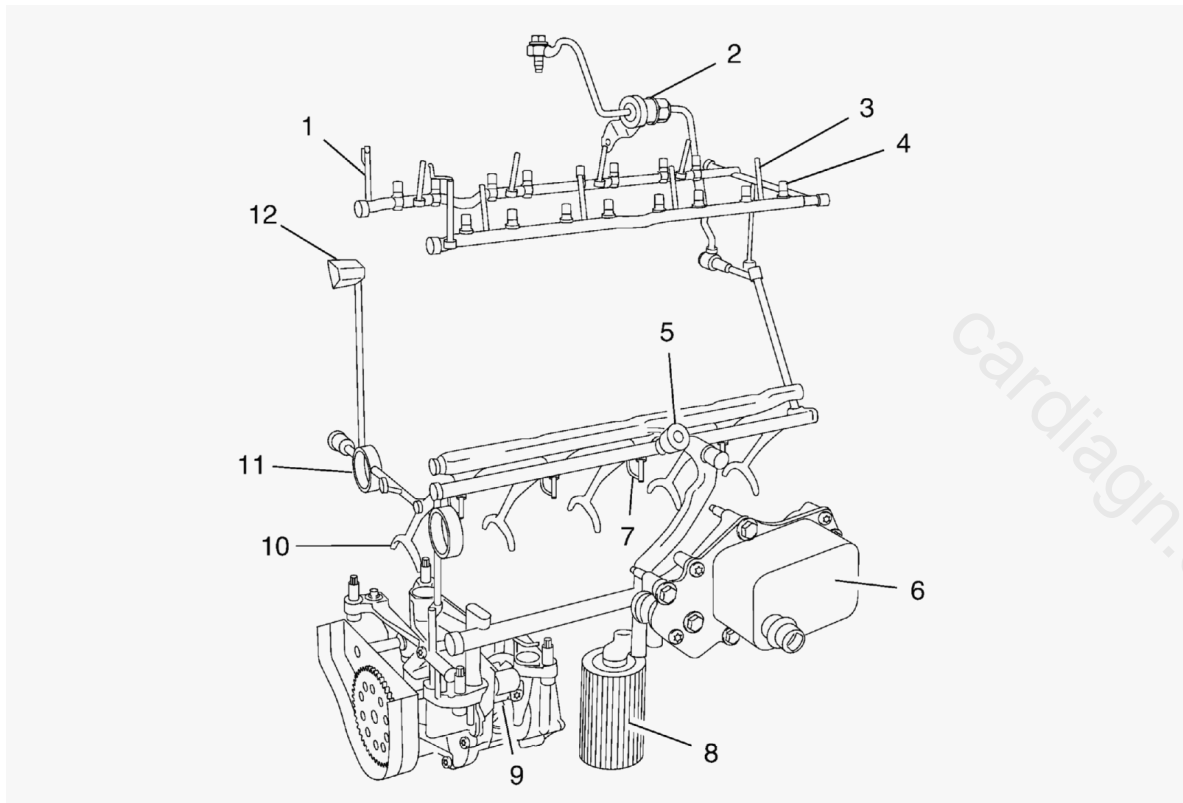


Fig. 952: Engine Lubrication System
Courtesy of GENERAL MOTORS COMPANY

Oil is applied under pressure to the crankshaft bearings (10), connecting rod bearings, balancer bearings (11) (if equipped), piston cooling nozzles (7), camshaft bearings (3), camshaft rear bearings (1) and hydraulic lash adjusters (4). In addition the variable oil pump (9) and hydraulic chain tensioner (12) are supplied with pressurized oil. Oil is sucked from the oil pan through the fixed screen into the variable vane type oil pump. The pump is driven by the oil pump chain and the crankshaft. The piston oil nozzle oil control solenoid valve (5) is fixed at the engine block. The piston oil nozzle oil control solenoid valve close or open the oil passes into the engine oil gallery to the piston oil nozzles (7). The oil cooler (6) is before the oil filter (8), to improve the cleanliness. The pressurized oil from the pump passes through the oil filter. The oil filter is located in the oil pan.

The turbocharger is supplied with oil over the turbocharger oil feed pipe (2), which is installed at the engine block. The turbocharger oil feed pipe including a dedicated filter to reduce the risk of turbo damage. The oil is cleaned by passing the filter from the outer to the inner side of the filter. Then the oil flows into the main oil gallery. The connecting rod bearings are supplied by 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. In the cylinder head the oil is distributed to the chain tensioner, oil pump flow control valve (5) and into the camshaft feed oil gallery. From there the hydraulic valve lifters and camshaft bearings are supplied with oil.

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.

CAUTION: Engine damage may result if an abrasive paper, pad, or motorized wire brush is used to clean any engine gasket surfaces.

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.

WARNING: Unless directed otherwise, the ignition must be OFF with the key removed, and all electrical loads must be OFF before servicing any electrical component. Disconnect the negative battery cable to prevent an electrical spark should a tool or equipment come in contact with an exposed electrical terminal. Failure to follow these precautions may result in personal injury and/or damage to the vehicle or its components.

For Vehicles equipped with OnStar® (UE1) with Back Up Battery:

The Back Up Battery is a redundant power supply to allow limited OnStar® functionality in the event of a main vehicle battery power disruption to the VCIM (OnStar® module). Do not disconnect the main vehicle battery or remove the OnStar® fuse with the ignition key in any position other than OFF. Retained accessory power should be allowed to time out or be disabled (simply opening the driver door should disable retained accessory power) before disconnecting power. Disconnecting power to the OnStar® module in any way while the ignition is On or with retained accessory power activated may cause activation of the OnStar® Back-Up Battery system and will discharge and permanently damage the back-up battery. Once the Back-Up Battery is activated it will stay on until it has completely discharged. The back-up battery is not rechargeable and once activated the back-up battery must be replaced.

Disconnect the negative battery cables before you perform any major work on the engine. For more information on the disconnection of the battery, refer to [Battery Negative Cable Disconnection and Connection \(KL9\)](#).

SEPARATING PARTS

NOTE:

- 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 tappets
- 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

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 a suitable tool.
- Care must be used to avoid gouging or scraping the sealing surfaces.
- Do not use any other method or technique to remove sealant or gasket material from a part.
- Do not use abrasive pads, sand paper, or power tools to clean the gasket surfaces.
 - These methods of cleaning can cause damage to the component sealing surfaces.
 - Abrasive pads also produce a fine grit that the oil filter cannot remove from the oil.
 - This grit is abrasive and has been known to cause internal engine damage.

Assembling Components

- When assembling components, use only the sealant specified or equivalent in the service procedure.
- Sealing surfaces should be clean and free of debris or oil.
- Specific components such as crankshaft oil seals or valve stem oil seals may require lubrication during assembly.
- Components requiring lubrication will be identified in the service procedure.
- When applying sealant to a component, apply the amount specified in the service procedure.
- Do not allow the sealant to enter into any blind threaded holes, as it may prevent the bolt from clamping properly or cause component damage when tightened.
- Tighten bolts to specifications. Do not overtighten.

USE OF ROOM TEMPERATURE VULCANIZING (RTV) AND ANAEROBIC SEALANT

Pipe Joint Compound

NOTE: Three types of sealer are commonly used in engines. These are RTV sealer, anaerobic gasket eliminator sealer, and pipe joint compound. The correct sealer and amount must be used in the proper location to prevent oil leaks. **DO NOT interchange the 3 types of sealers. Use only the specific sealer or the equivalent as recommended in the service procedure.**

- Pipe joint compound is a pliable sealer that does not completely harden. This type sealer is used where 2 non-rigid parts, such as the oil pan and the engine block, are assembled together.
- Do not use pipe joint compound in areas where extreme temperatures are expected. These areas include: exhaust manifold, head gasket, or other surfaces where gasket eliminator is specified.
- Follow all safety recommendations and directions that are on the container.

To remove the sealant or the gasket material, refer to [Replacing Engine Gaskets](#).

- Apply the pipe joint compound to a clean surface. Use a bead size or quantity as specified in the procedure. Run the bead to the inside of any bolt holes. Do not allow the sealer to enter any blind threaded holes, as it may prevent the bolt from clamping properly or cause component damage when the bolt is tightened.
- Apply a continuous bead of pipe joint compound to one sealing surface. Sealing surfaces to be resealed must be clean and dry.
- Tighten the bolts to specifications. Do not overtighten the bolts.

ENGINE COMPONENT DESCRIPTION

Camshaft

Two camshafts are used, one for all intake valves, the other for all exhaust valves. The camshafts are cast iron. The camshafts are driven by a cam to cam gear. The exhaust camshaft have a split gear.

Crankshaft

The crankshaft is a steel crankshaft with 4 counterweights. It is supported in 5 main journals with main bearings which have oil clearance for lubricating. The 3rd bearing of the 5 main bearing is the thrust bearing where the crankshaft has properly axial end play. A crankshaft balancer is used to control torsional vibration.

Cylinder Block

The cylinder block is a light weight aluminum block and the cap inserts are a nodular cast iron. The block has 5 crankshaft bearings with the thrust bearing located on the third bearing from the front of the engine.

Cylinder Head

This cylinder head is double over head camshaft (DOHC) type and has 2 camshafts that open 4 valves per cylinder with the finger followers with roller type and the valve bridges. Because of the cam follower of the hydraulic type, it does not need to adjust of valve clearance. The cylinder head is made of cast aluminum alloy for better strength in hardness with light weight. The combustion chamber of plate type of the cylinder head is designed for increasing of squish and swirl efficiency and then this is maximized to diesel combustion efficiency.

Exhaust Manifold

The exhaust manifold is located to the cylinder head and send the turbocharger the exhaust gas out of the combustion chamber. It is designed to endure on high pressure and high temperature.

Intake Manifold

The intake manifold is air flow passage to the cylinder combustion chamber through the throttle body and has an effect on engine torque, power, noise, driveability, emission, fuel economy and performance. It is made of plastic for better strength in hardness with light.

Oil Pan

The oil pan includes the oil suction pipe, this pipe is connected with the oil pump. The oil pan is attached at the lower crankcase.

Oil Pump

The oil pump is a variable displacement oil pump with a integrated power brake booster vacuum pump. The oil pump draws engine oil from the oil pan and feeds it under pressure to the various parts of the engine. An oil strainer is mounted before the inlet of the oil pump to remove impurities which could clog or damage the oil pump or other engine components. When the crankshaft rotates, the oil pump driven gear rotates. This causes the space between the gears to constantly open and narrow, pulling oil in from the oil pan when the space opens and pumping the oil out to the engine as it narrows. At high engine speeds, the oil pump supplies a much higher amount of oil than required for lubrication of the engine. The oil pressure regulator prevents too much oil from entering the engine lubrication passages.

Positive Crankcase Ventilation System

The positive crankcase ventilation (PCV) valve carries the blow-by gas to the turbocharger inlet of the intake system. According to the engine conditions, driving conditions and the pressure of turbocharger, it is different from the amount of blow-by gas. So, the PCV valve controls the amount of blow-by gas.

Solenoid Injector Fuel Injection System

The fuel injection occurs by a common rail system of the third generation. The fuel pressure goes up to 2000 bar (29008 psi). The solenoid injector fuel injection system is piloted by a closed loop combustion control.

Timing Chain

The Timing chain are installed at the transmission side. A timing chain is used for camshaft drive and a oil pump chain is used for the oil pump drive. There are tensioner to control the tension of camshaft timing chain and a tensioner to control the oil pump chain.

Valve Lash Adjusters

The valve train uses a roller finger follower acted on by a hydraulic lash adjuster. The roller finger follower reduces friction and noise.

Valves

There are 2 intake and 2 exhaust valves per cylinder with "minilash" hydraulic adjusters with roller fingers.

Variable Turbine Geometry Turbocharger

The turbocharger is the device that supplies hot, compressed air, that is from the turbine/impeller created from the passing exhaust gas or ram air, to the engine to increase the power. Quick compressed air from this turbocharger expands with high temperature and causes decreasing of charging efficiency into the cylinder because density of oxygen gets lower. However charging efficiency into the cylinder increases as compressed hot air is cooled and density of air gets higher through the charge air cooler. It brings also higher fuel efficiency as well as lower CO₂ emissions. Charge air cooler which is installed on top of radiator in front of car makes compressed hot air cool by airflow through the radiator grill. With the variable turbine geometry turbocharger the boost pressure is optimized in all engine conditions.

TOOLS AND EQUIPMENT

Special tools are listed and illustrated throughout this section with a complete listing at the end of the section. These tools, or their equivalents, are specially designed to quickly and safely accomplish the operations for which they are intended. The use of these special tools will also minimize possible damage to engine components. Some precision measuring tools are required for inspection of certain critical components. Torque wrenches and a torque angle meter are necessary for the proper tightening of various fasteners.

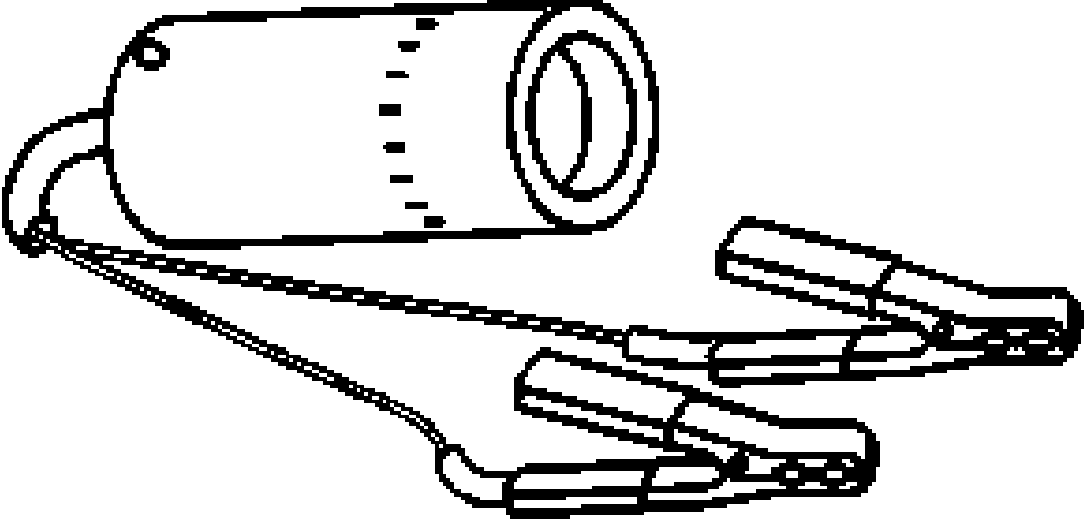
To properly service the engine assembly, the following items should be readily available:

- Approved eye protection and safety gloves
- A clean, well lit, work area
- A suitable parts cleaning tank
- A compressed air supply
- Trays or storage containers to keep parts and fasteners organized
- An adequate set of hand tools
- Approved engine repair stand
- An approved engine lifting device that will adequately support the weight of the components

SPECIAL TOOLS AND EQUIPMENT

SPECIAL TOOLS

Illustration	Tool Number/Description

Illustration	Tool Number/Description
	BO-42220 J-42220 Universal Leak Detection Lamp

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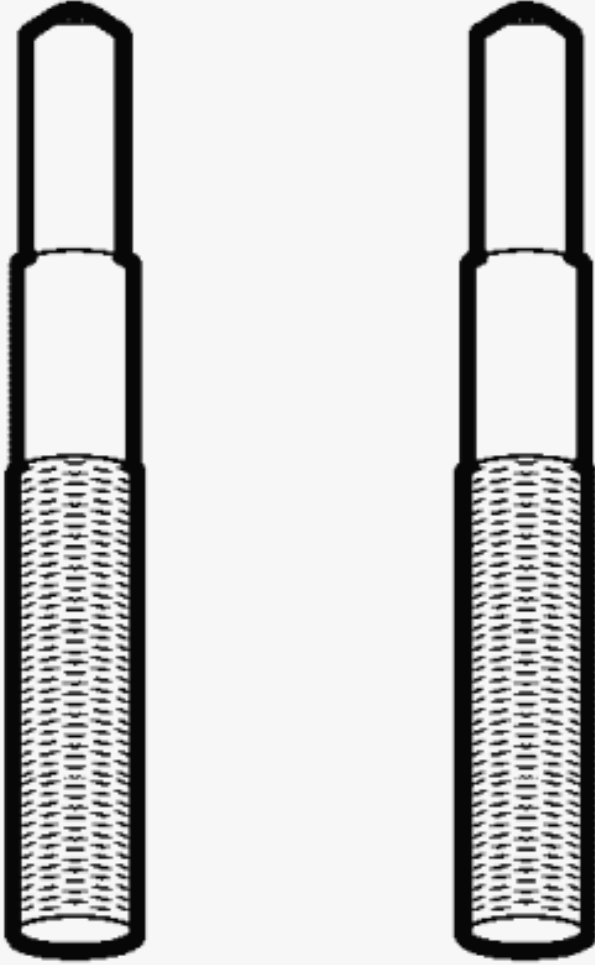
Illustration	Tool Number/Description
	CH-51034 Guide Pins cardiagn.com

Illustration	Tool Number/Description
	DT-523-1 KM-523-1 Handle
	GE-7872 J-7872 Magnetic Base Dial Indicator

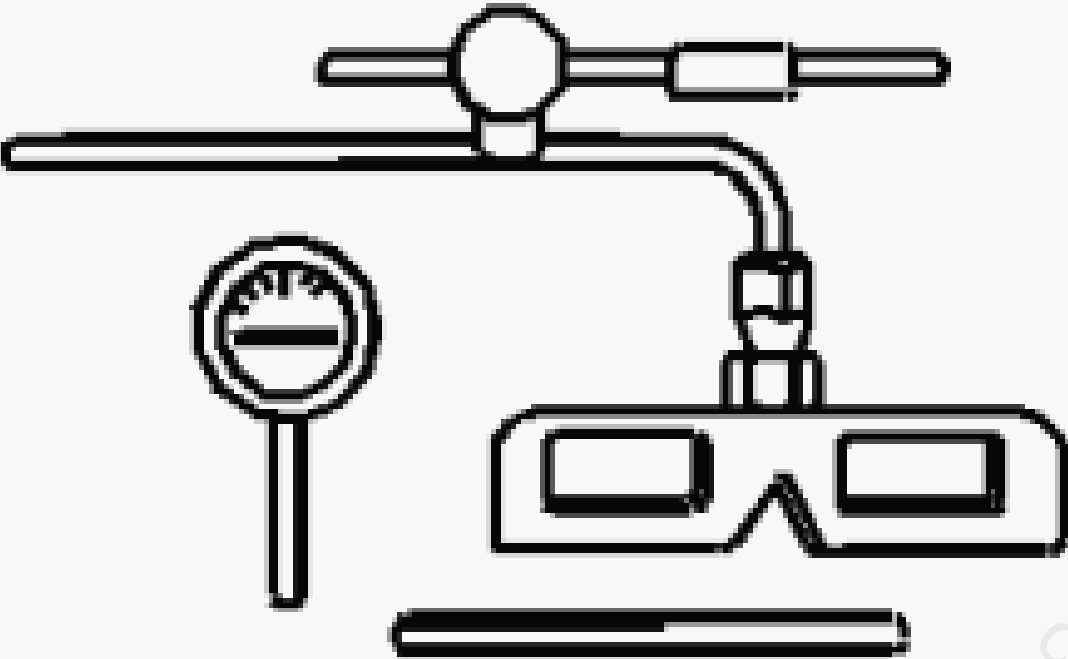
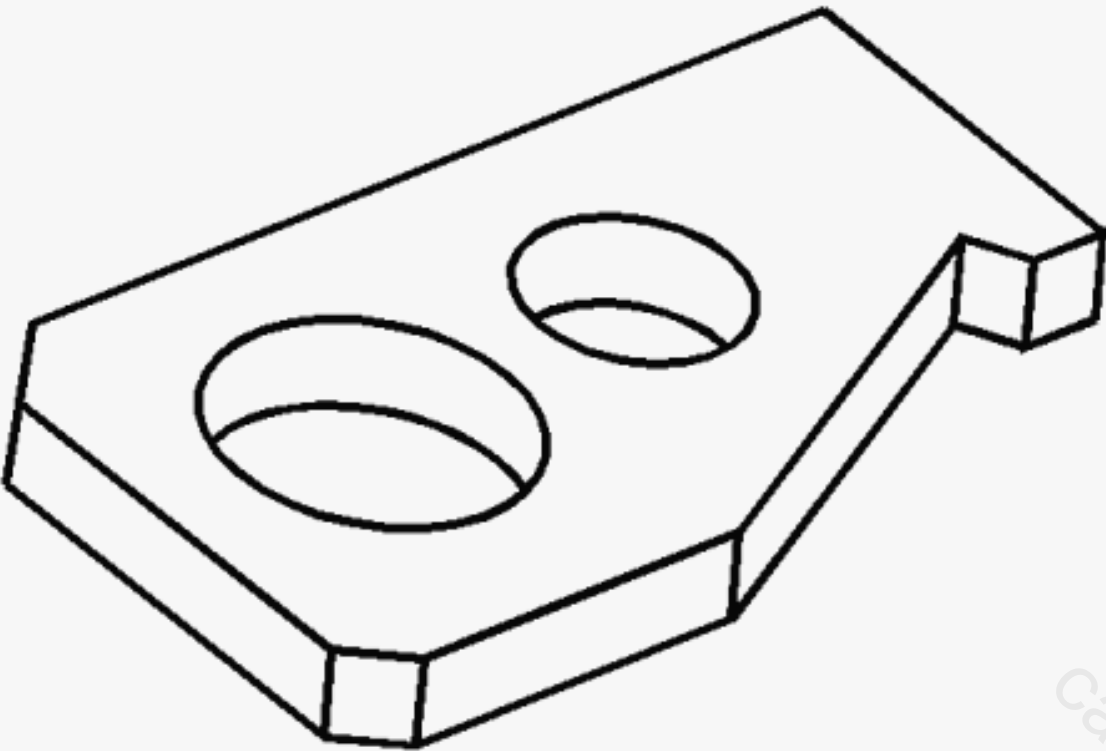
Illustration	Tool Number/Description
 The illustration shows a medical device, likely a ventilator or a similar respiratory machine. It consists of a horizontal tube on the left, a vertical tube with a circular gauge (possibly a pressure or flow gauge) in the middle, and a rectangular control unit on the right with two rectangular displays. A long, thin tube is connected to the control unit. The entire device is shown in a simplified line-drawing style.	cardiagn.com

Illustration	Tool Number/Description
	EN-652 KM-652 Flywheel Holder

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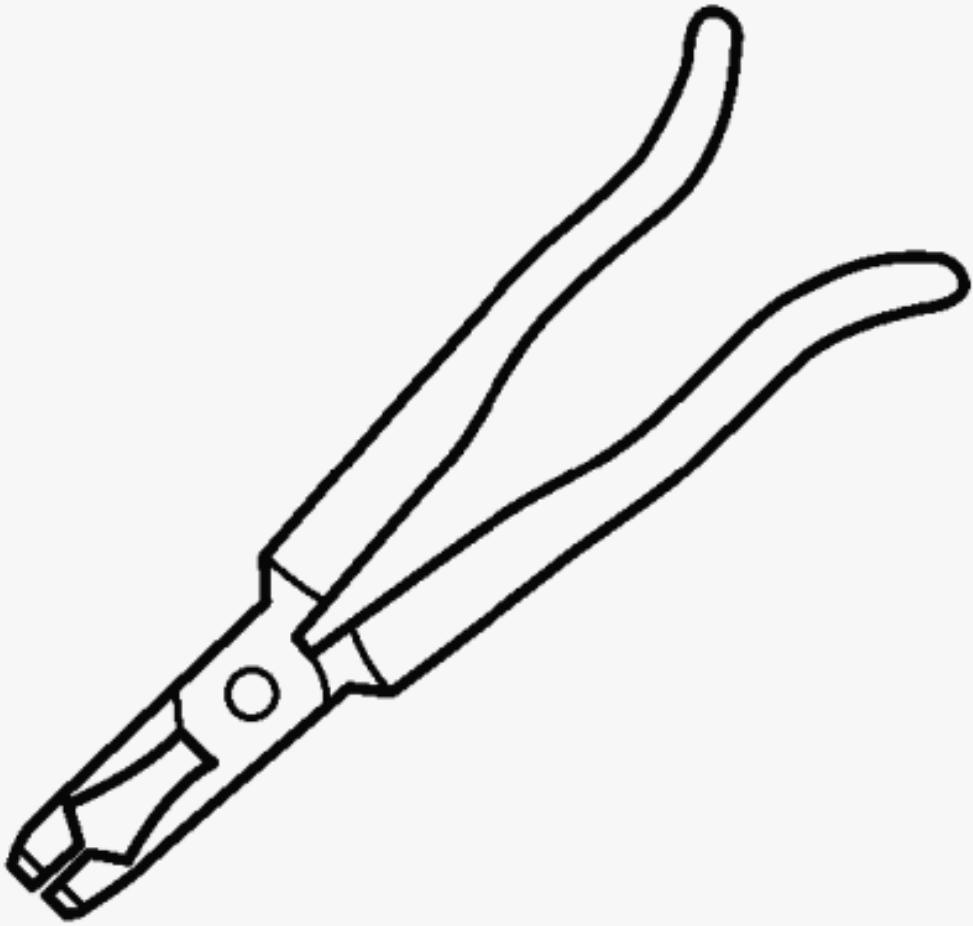
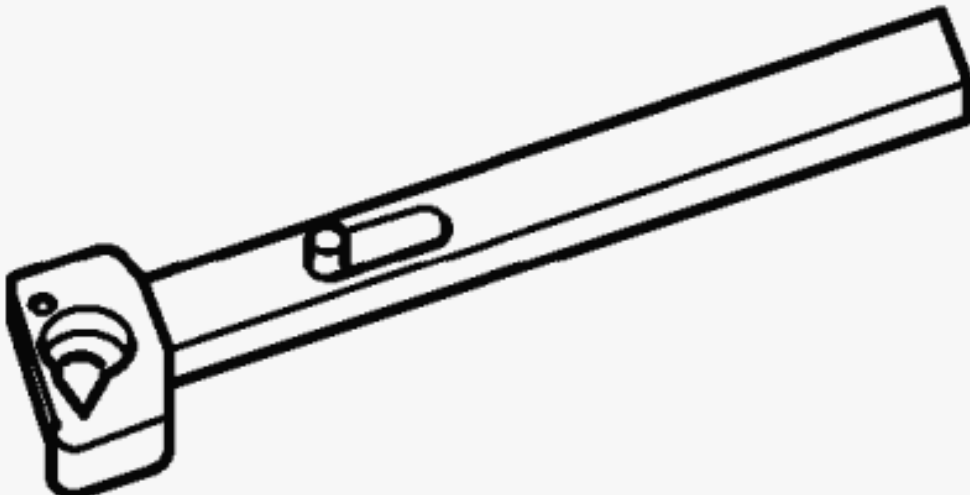
Illustration	Tool Number/Description
 cardiagn.com	EN-840 KM-840 EN-46116 83 94 157 Pliers Remover

Illustration	Tool Number/Description
	EN-956-1 KM-956-1 Extension

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Illustration	Tool Number/Description
	EN-958 KM-958 Valve Stem Seal Installer

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Illustration	Tool Number/Description
	EN-6104 Glow Plug Remover/Installer

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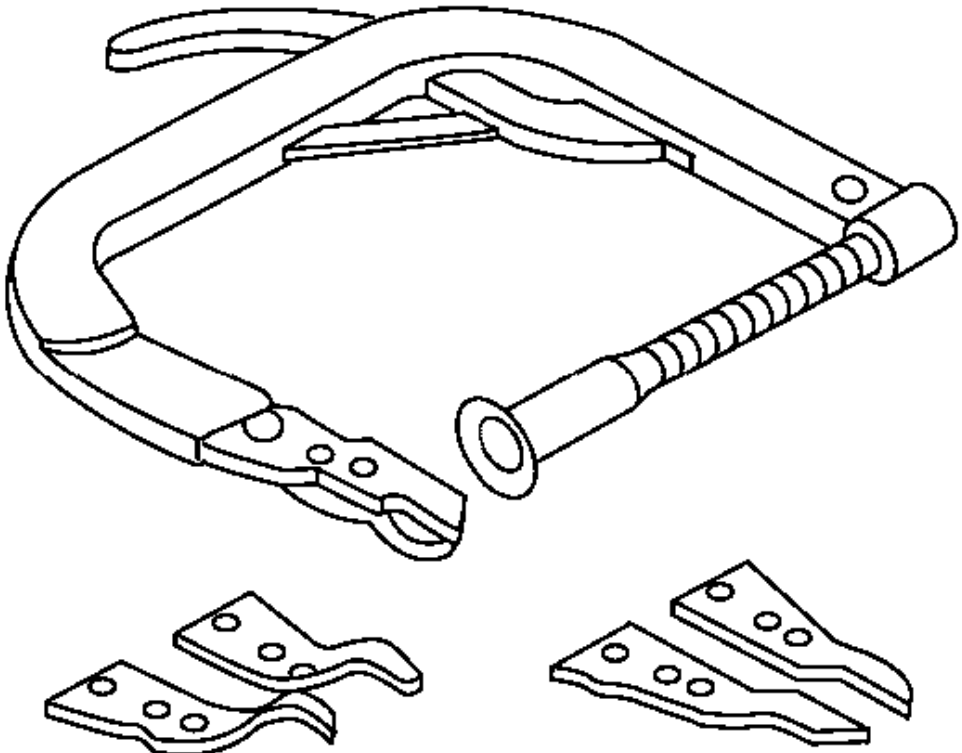
Illustration	Tool Number/Description
	EN-8062 J8062 Valve Spring Compressor
	EN-43963 J-43963 Valve Spring Compressor Adapter

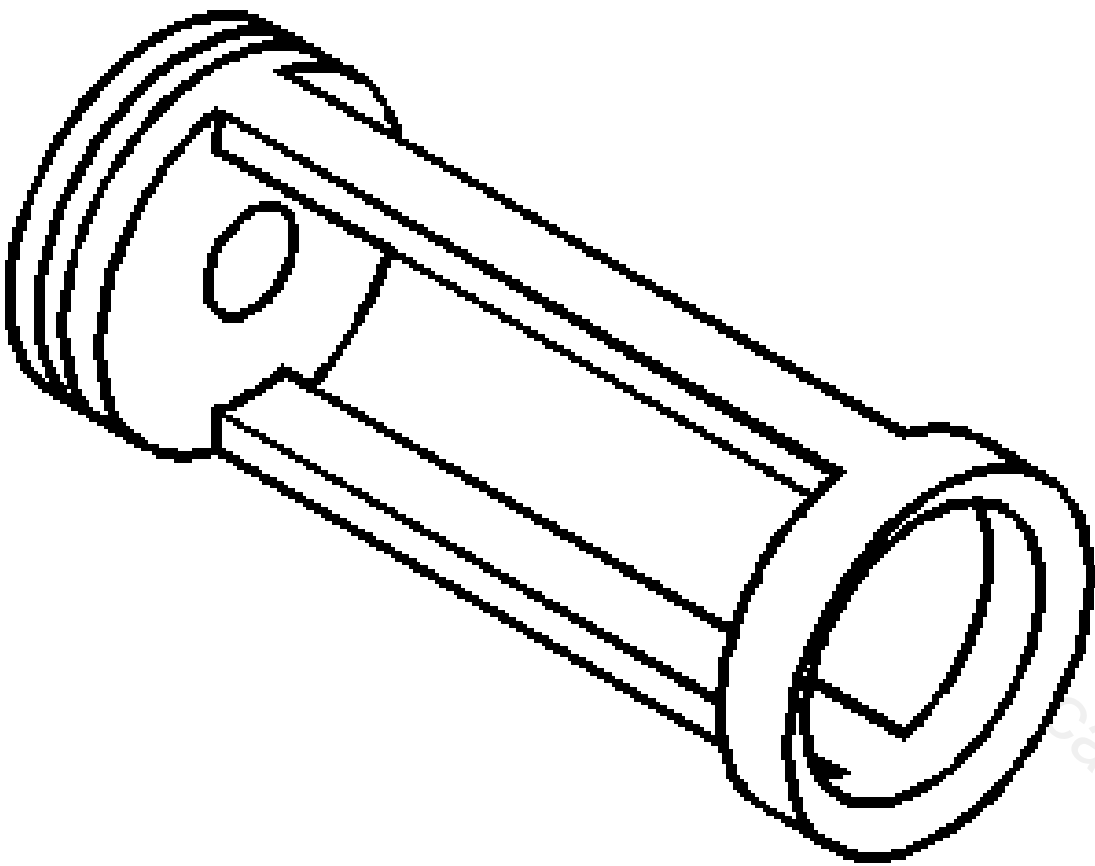
Illustration	Tool Number/Description
 A line drawing of a medical instrument, likely a catheter or probe, with a cylindrical body and a flared, multi-lobed tip. The drawing is oriented diagonally.	

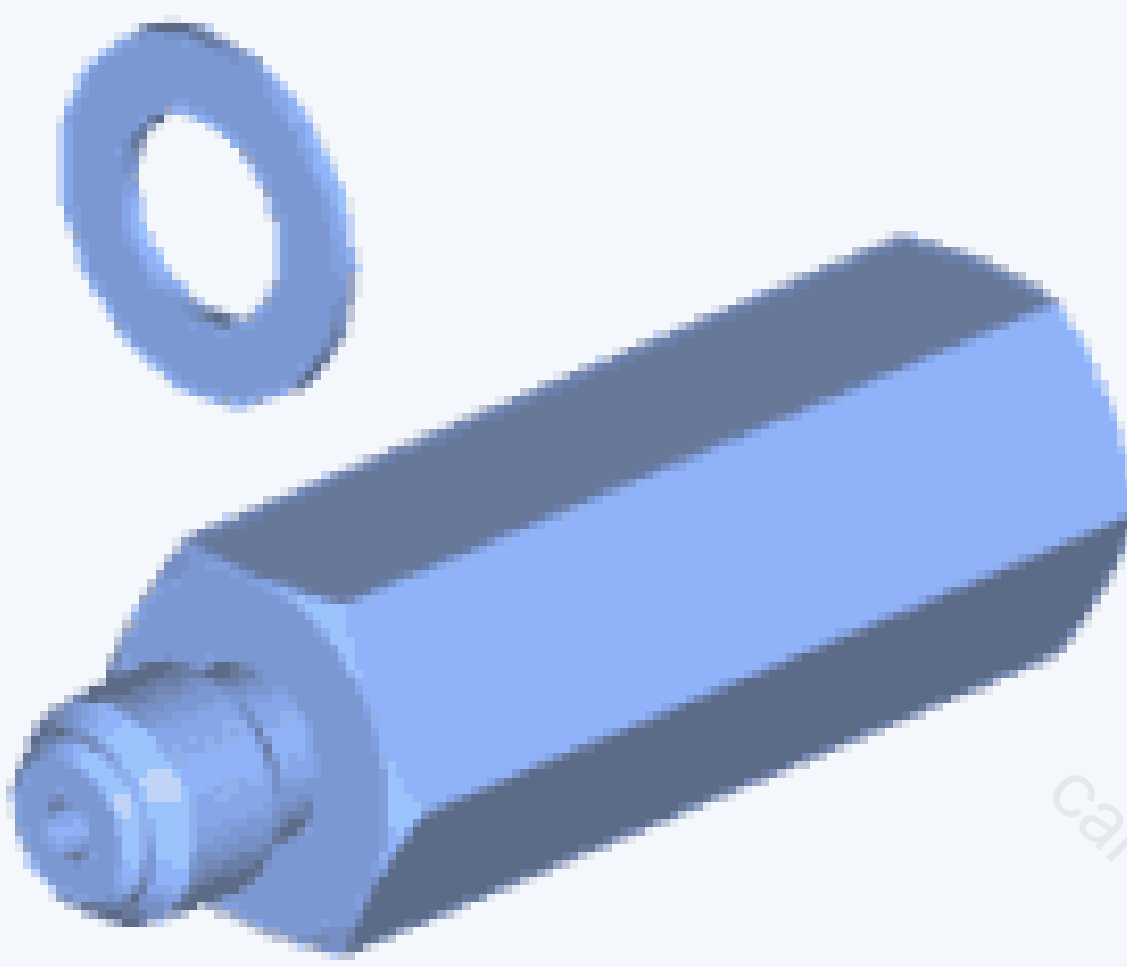
Illustration	Tool Number/Description
 The illustration shows a blue cylindrical tool, identified as an oil pressure gage adapter. It has a threaded end on the left and a smooth cylindrical body. A separate blue O-ring seal is shown above the tool. The background is light blue with a subtle gradient. A watermark 'cardiagn.com' is visible diagonally across the bottom right of the illustration area.	EN-21867-850 J-21867-850 EN-6106 Oil Pressure Gage Adapter

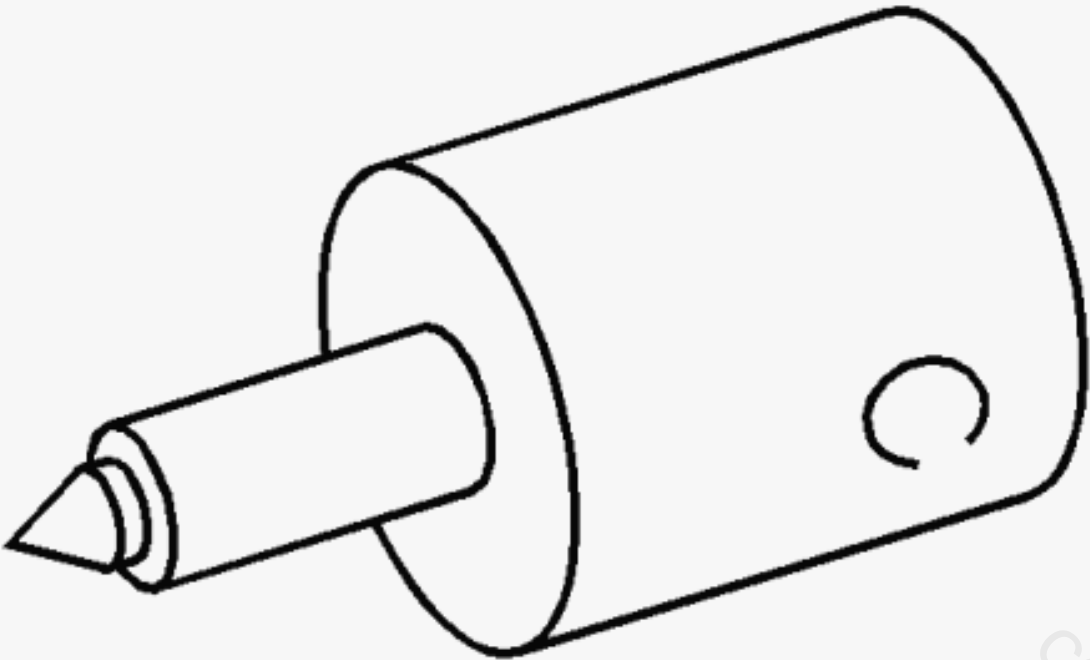
Illustration	Tool Number/Description
	EN-6624 KM-6624 J-36825-A Seal Remover
	EN-8087 J-8087 Cylinder Bore Gauge

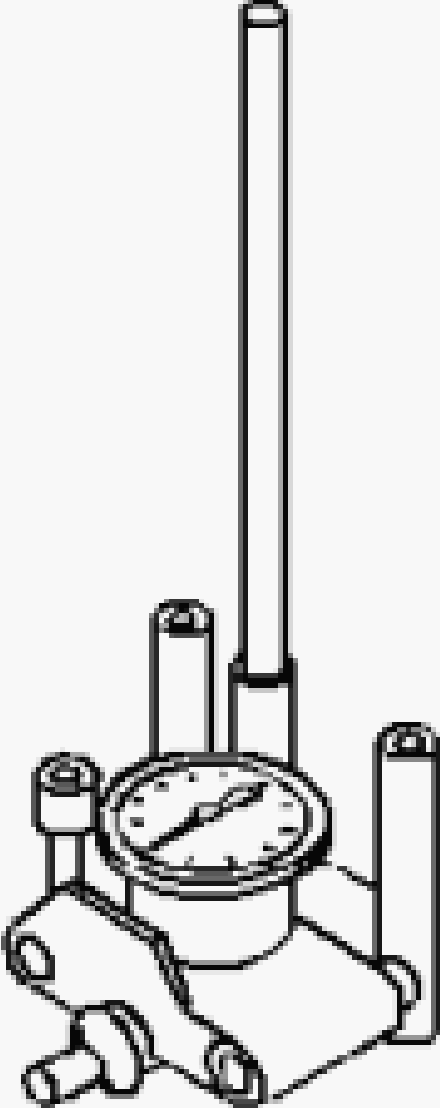
Illustration	Tool Number/Description
	

Illustration	Tool Number/Description
	EN-26999 J-26999 Compression Gauge cardiagn.com

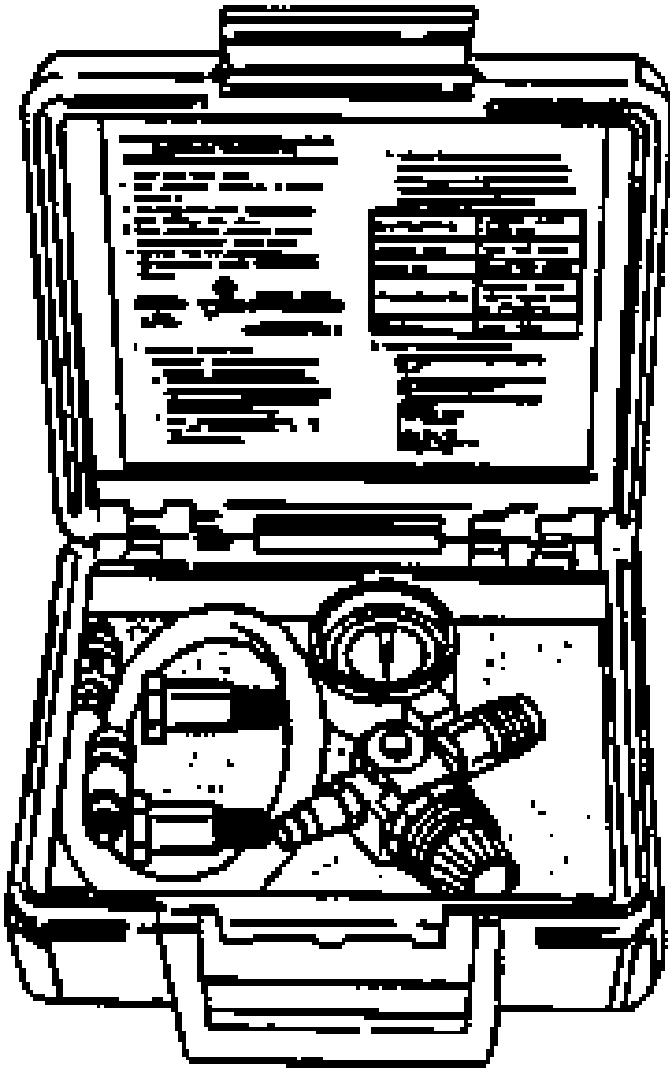
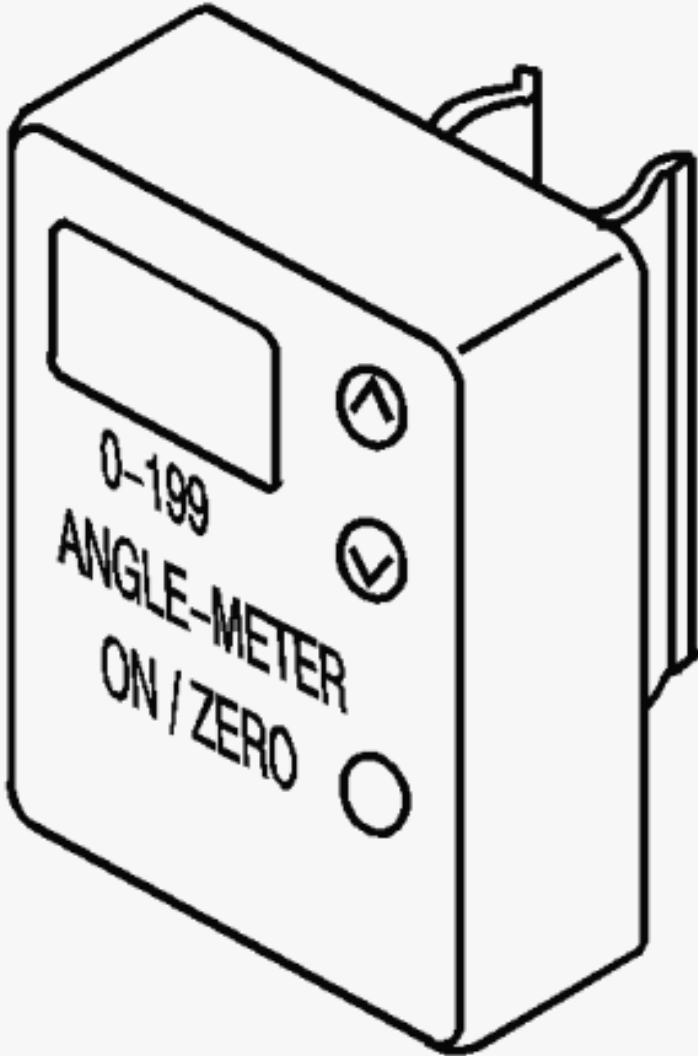
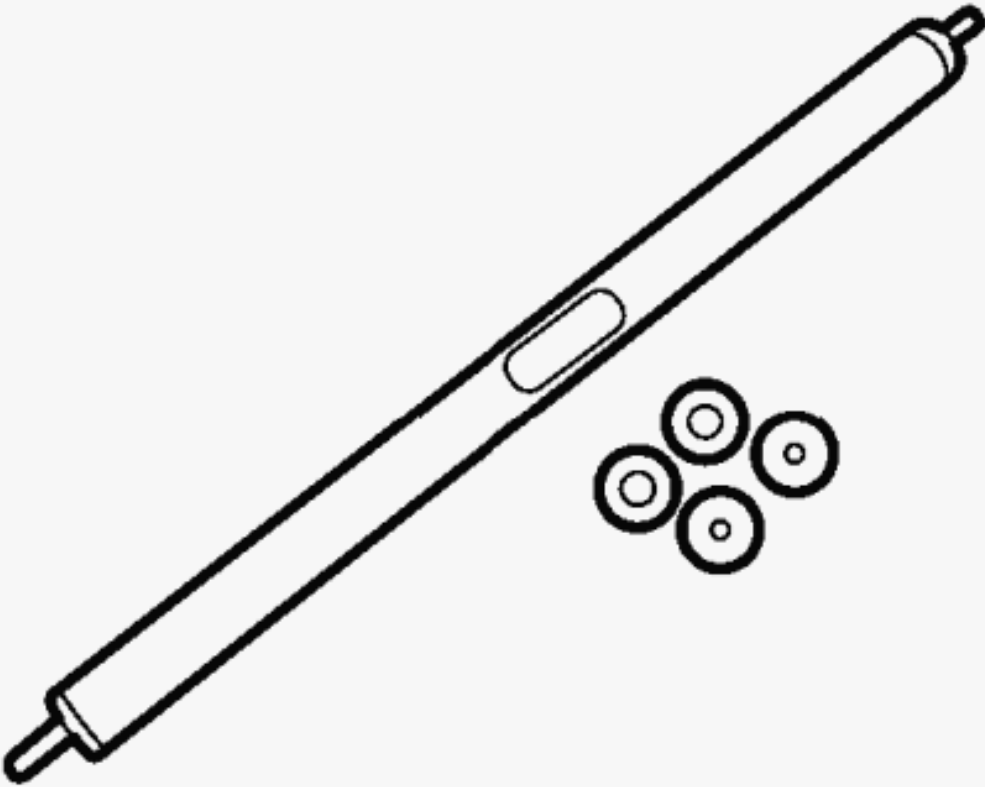
Illustration	Tool Number/Description
	EN-35667-A J-35667-A Cylinder Leakdown Tester cardiagn.com

Illustration	Tool Number/Description
	EN-45059-A J-45059-A Angle Meter

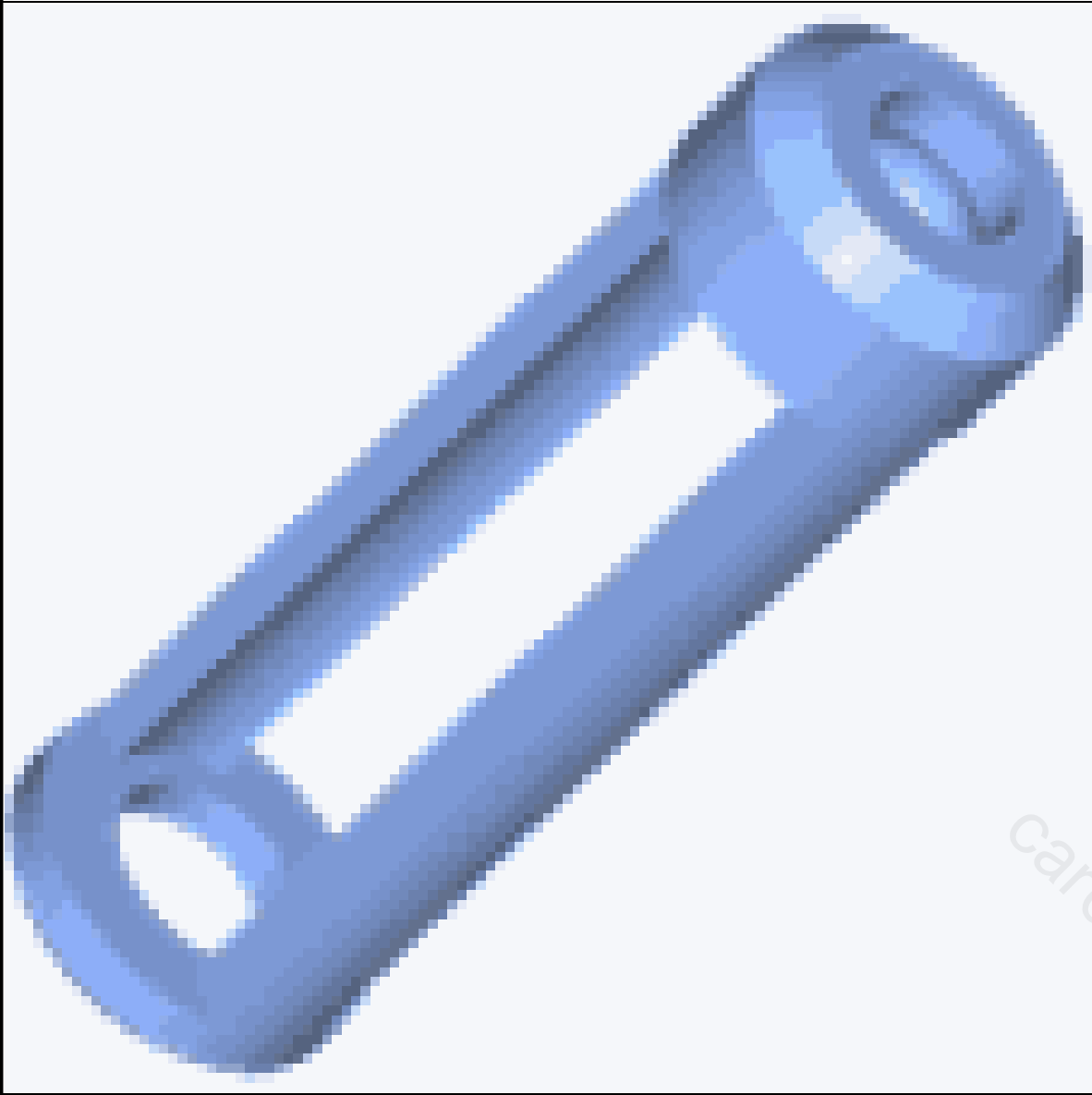
cardiagn.com

Illustration	Tool Number/Description
	EN-46116 Valve Stem Seal Remover

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Illustration	Tool Number/Description
	EN-47632 Injector Cleaning Tool

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Illustration	Tool Number/Description
	EN-49075 Valve Spring Compressor Adapter

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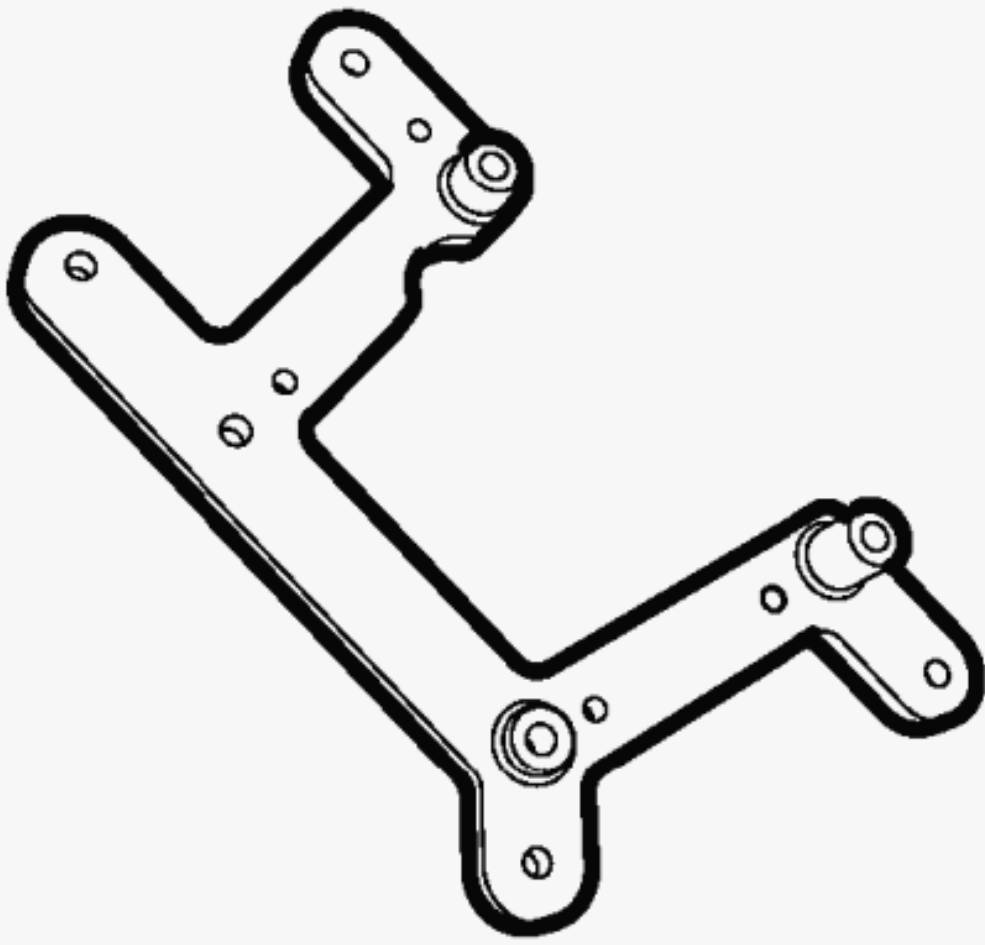
Illustration	Tool Number/Description
 The illustration shows a mechanical bracket or adapter plate. It has a central vertical section with two horizontal arms extending outwards. Each arm has a mounting point at its end, consisting of a circular hole with a flange. There are also smaller holes along the arms. The entire part is shown in a perspective view.	EN-49271-200 Adapter Engine Stand



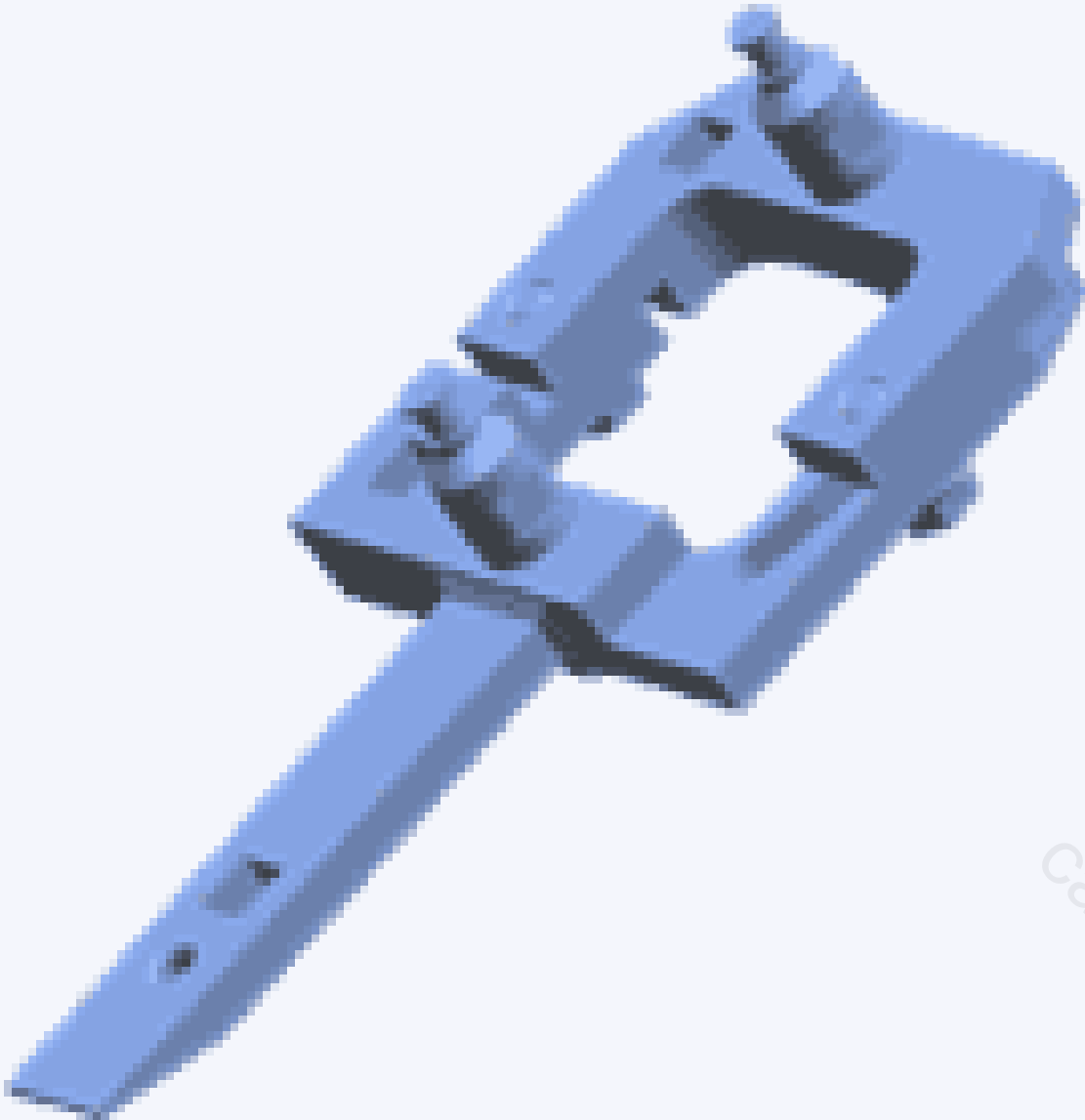
Illustration	Tool Number/Description
	EN-49979 Retainer Shock Mount Crankshaft along with EN- 49979-100

Illustration	Tool Number/Description
 The image shows two identical blue, cylindrical medical devices, identified as decoupler holders. They are positioned diagonally, one above the other. Each device has a wider, flanged base with a central opening and a narrower, threaded section at the top. The material appears to be a smooth, matte blue plastic or metal. The background is plain white.	EN-49979-100 Decoupler Holder Pins along with EN- 49979 cardiagn.com

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Illustration	Tool Number/Description
	EN-50513 EN-52234 Locking pin cardiagn.com

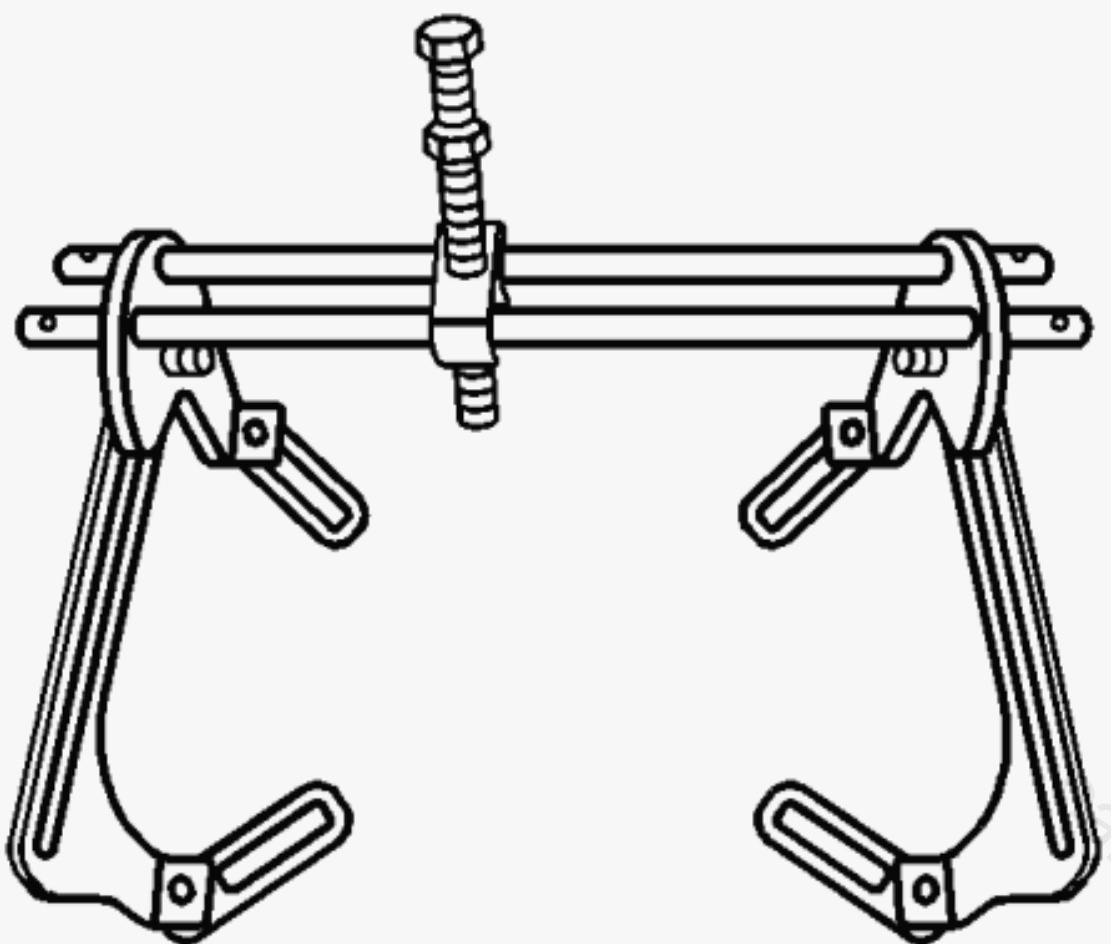
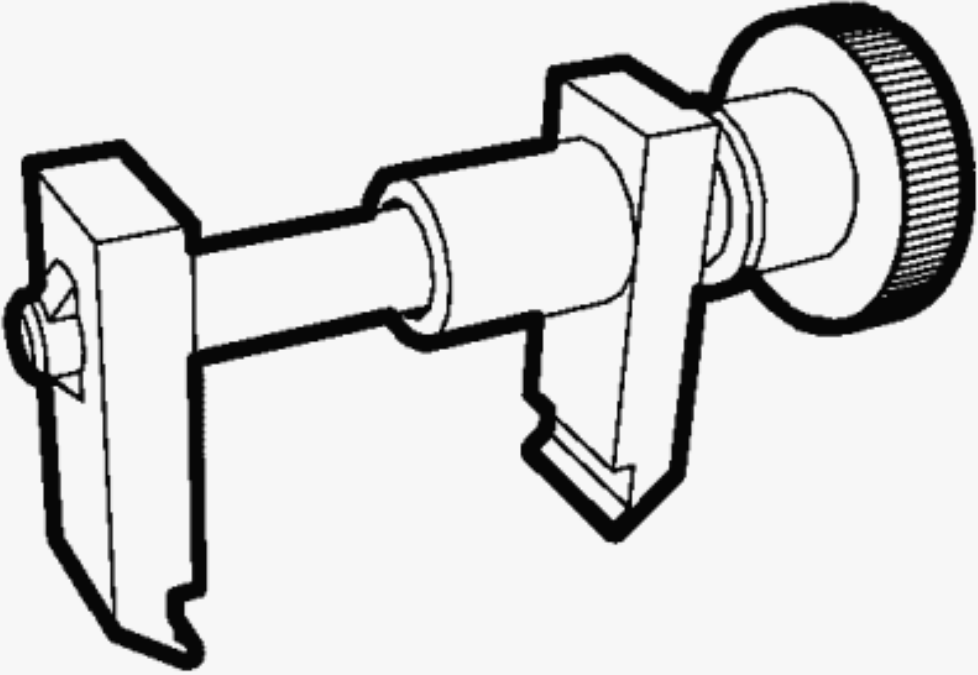
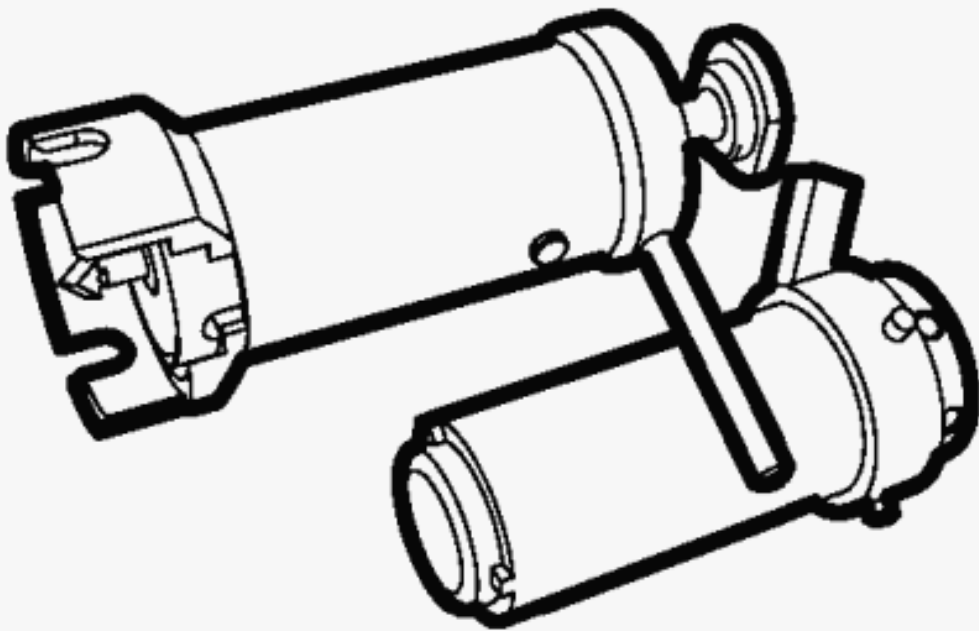
Illustration	Tool Number/Description
	EN-50173 Universal Valve Spring Compressor

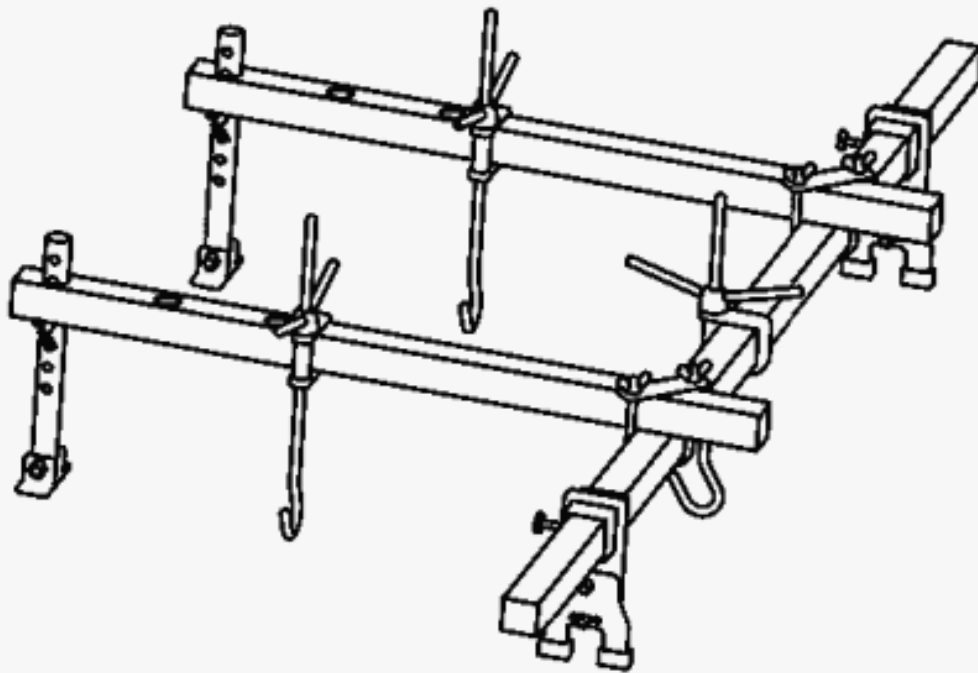
Illustration	Tool Number/Description
	EN-50509 Fixing Tool

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Illustration	Tool Number/Description
	EN-50885 High Pressure Pump Locking Tool cardiagn.com

Illustration

Tool Number/Description



EN-51007
J-28467-B
Engine Support
Fixture

cardiagn.com

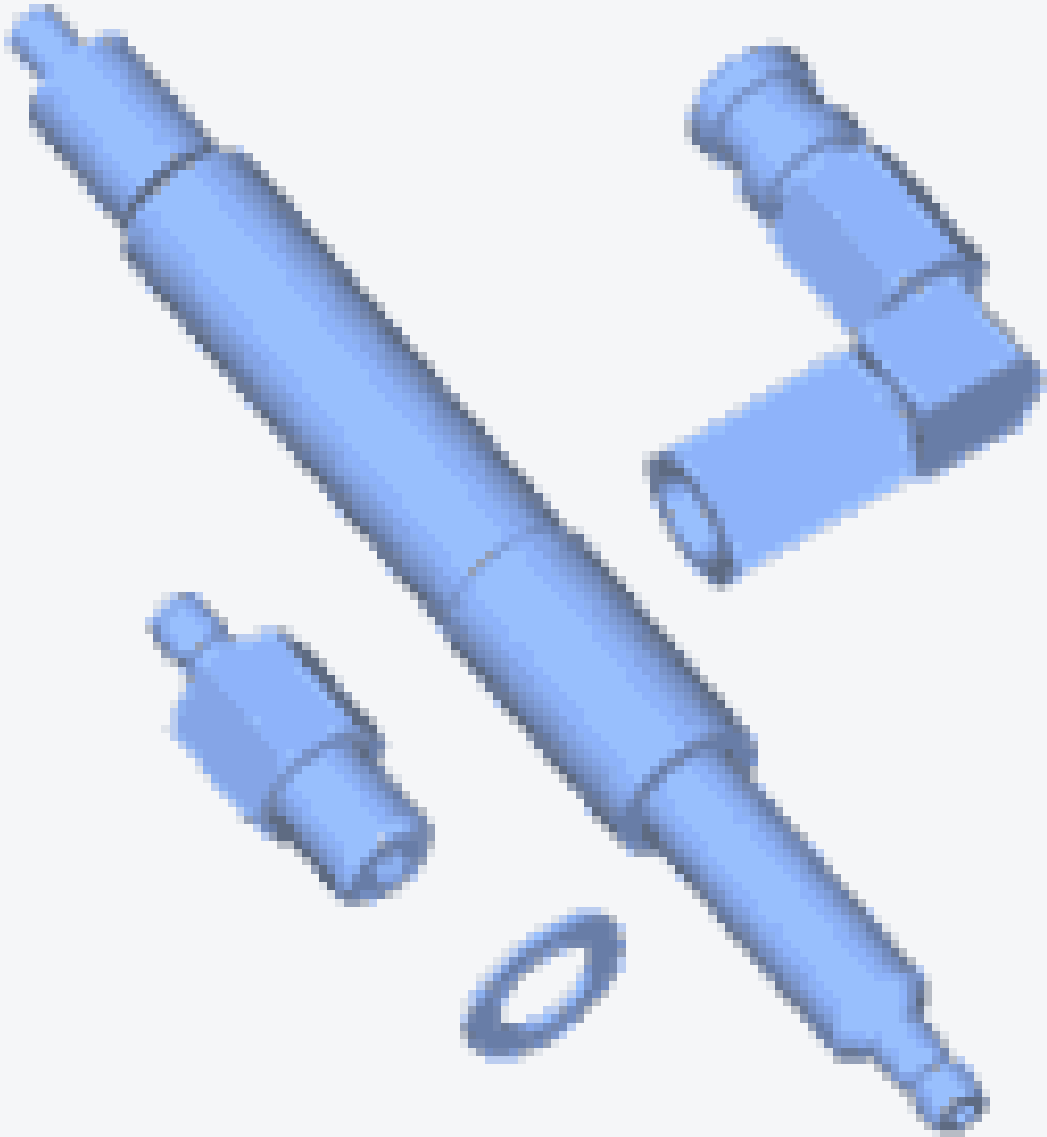
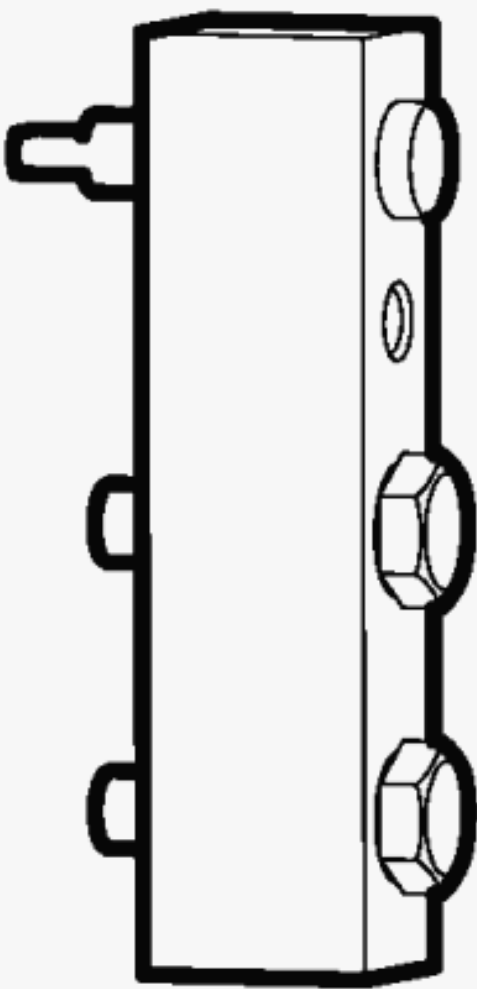
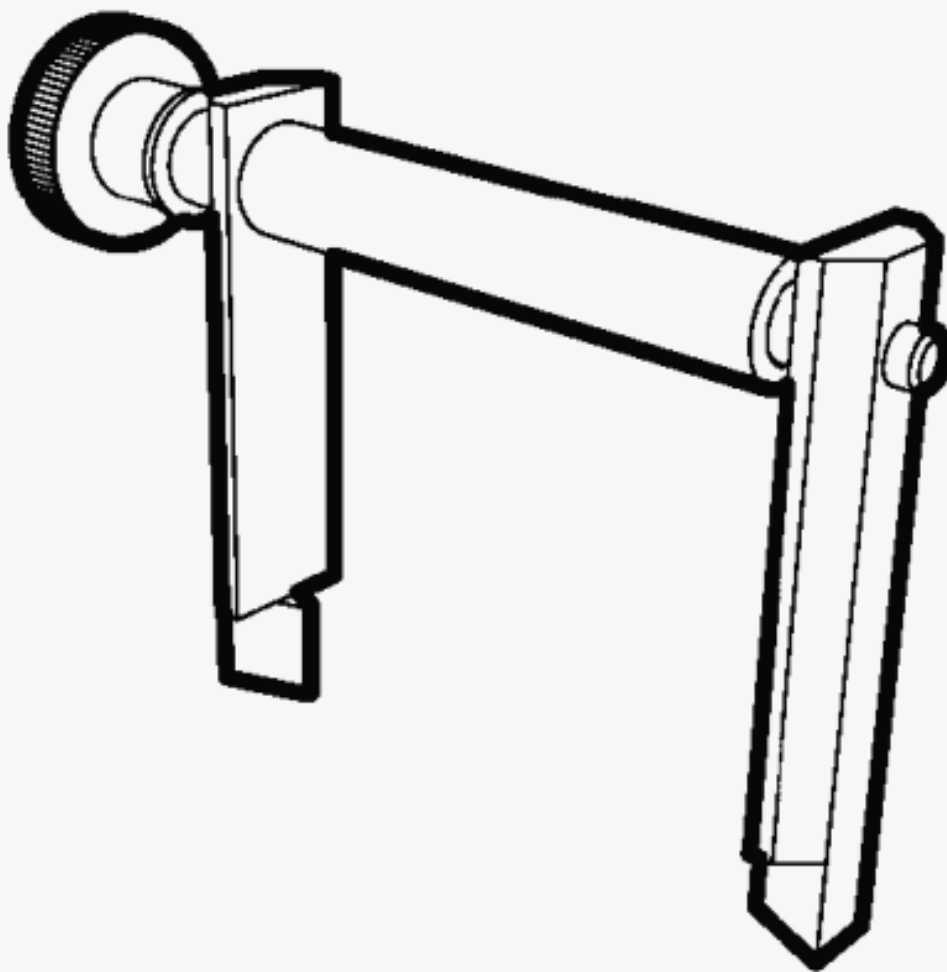
Illustration	Tool Number/Description
	EN-51110 Compression Tester Adapter

Illustration	Tool Number/Description
	EN-51140 Crankshaft Fixing Tool

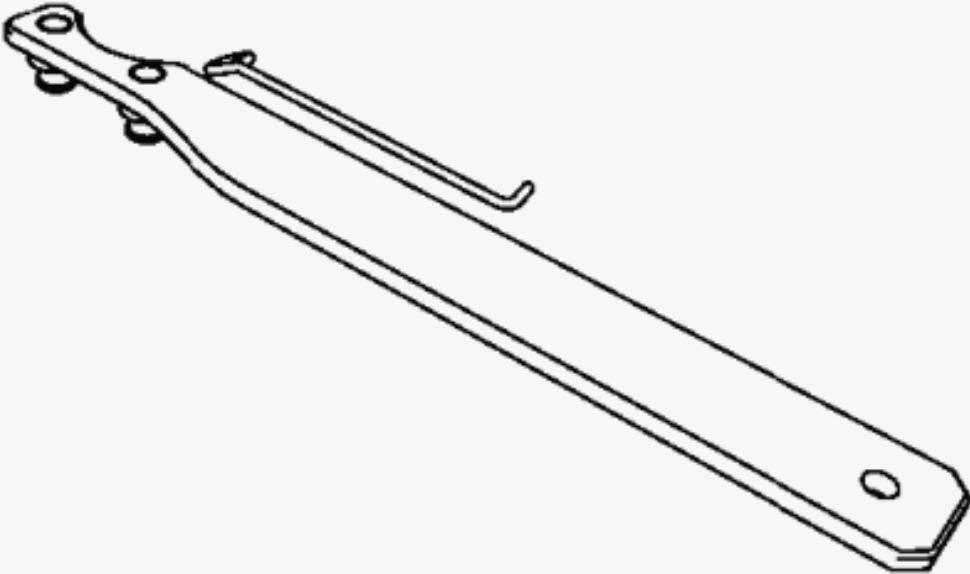
Illustration

Tool
Number/Description



EN-51141
Intermediate Drive
Gear Fixing Tool

cardiagn.com

Illustration	Tool Number/Description
	EN-51142 Oil Pump Sprocket Unit Holding Tool

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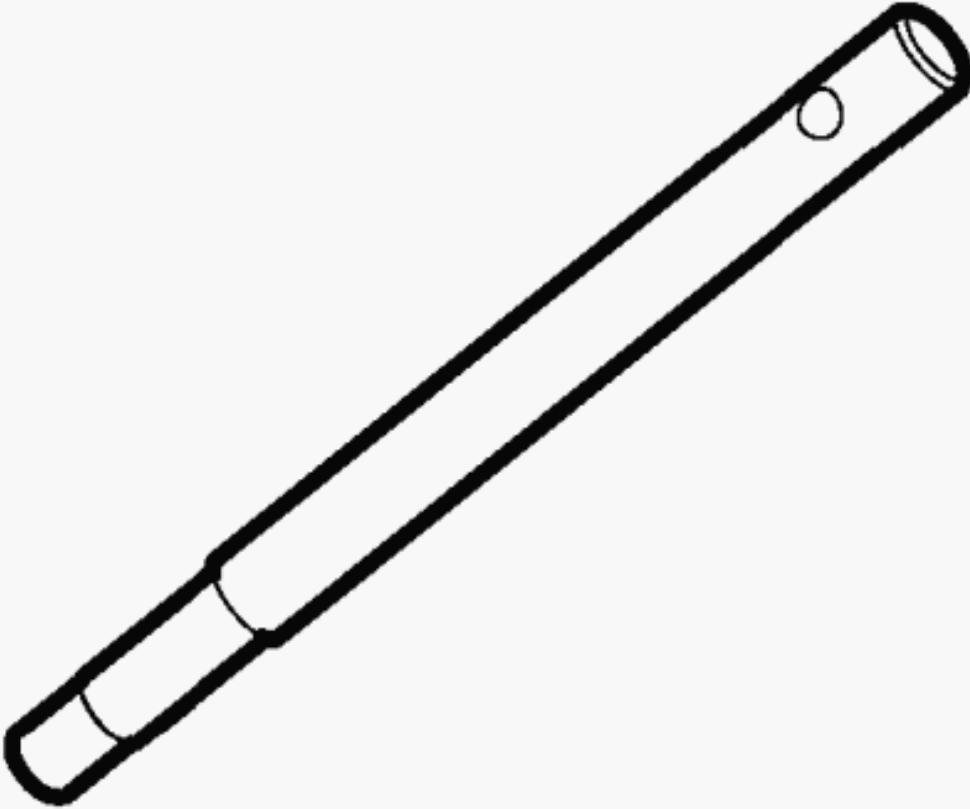
Illustration	Tool Number/Description
	EN-51143 Camshaft Fixing Tool

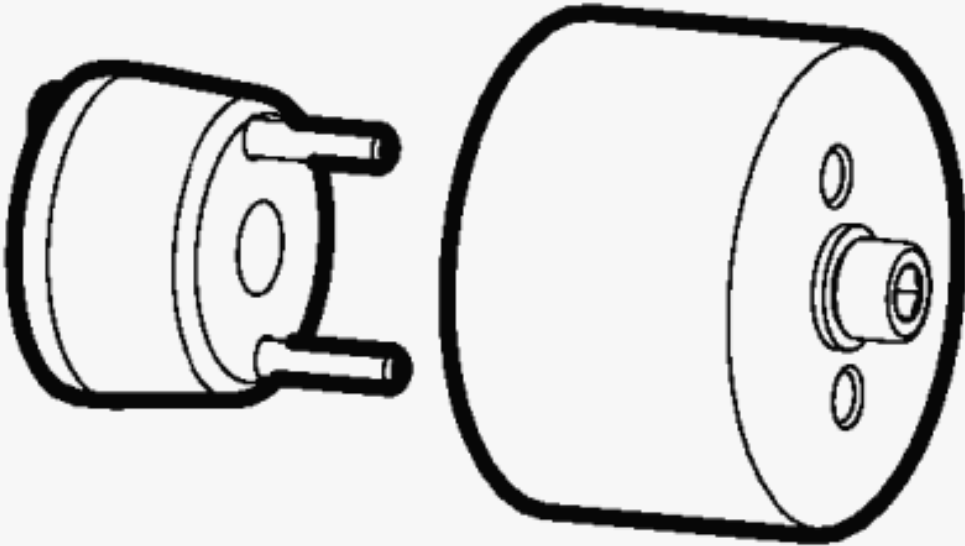
Illustration	Tool Number/Description
	EN-51144 Crankshaft Seal Installer

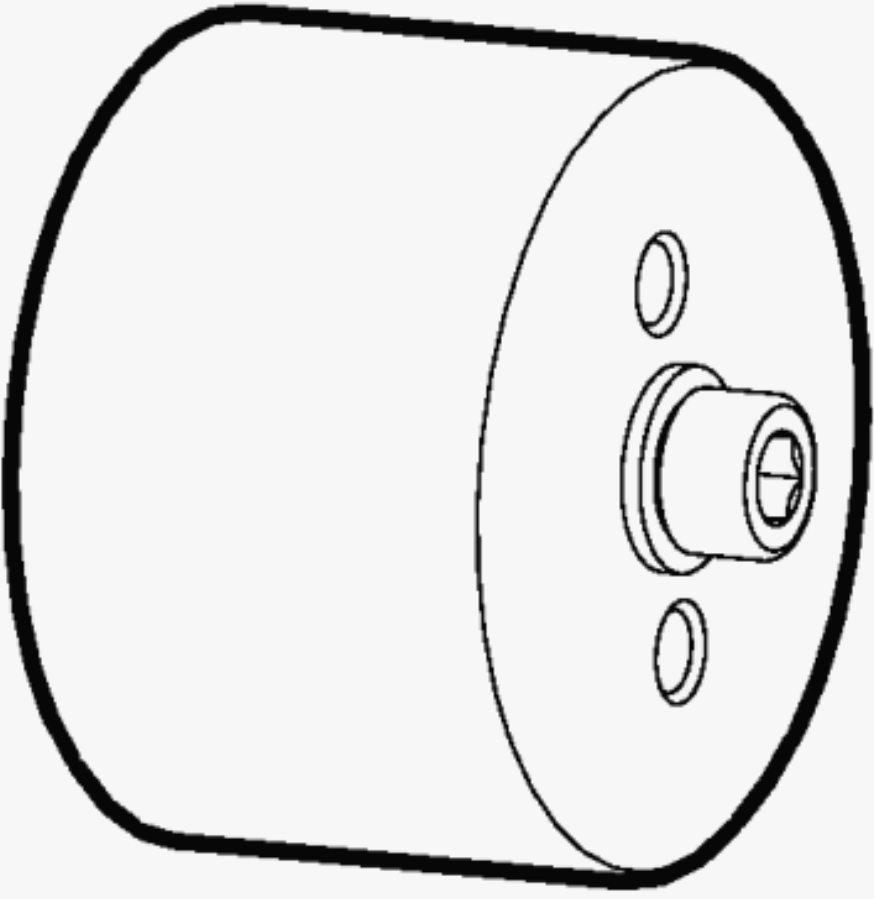
Illustration	Tool Number/Description
	EN-51144-100 Crankshaft Seal Installer cardiagn.com

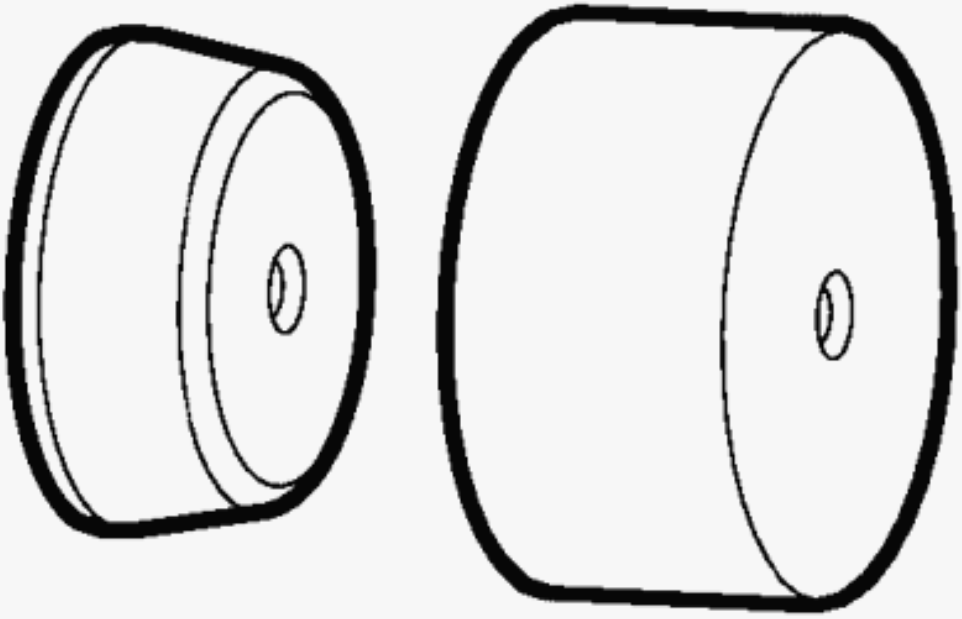
Illustration	Tool Number/Description
 The illustration shows two cylindrical tools, likely crankshaft seal installers. The tool on the left is smaller, while the one on the right is larger. Both have a central hole and a slightly flared outer edge. A diagonal watermark 'cardiagn.com' is visible across the bottom right of the illustration area.	EN-51145 Crankshaft Seal Installer

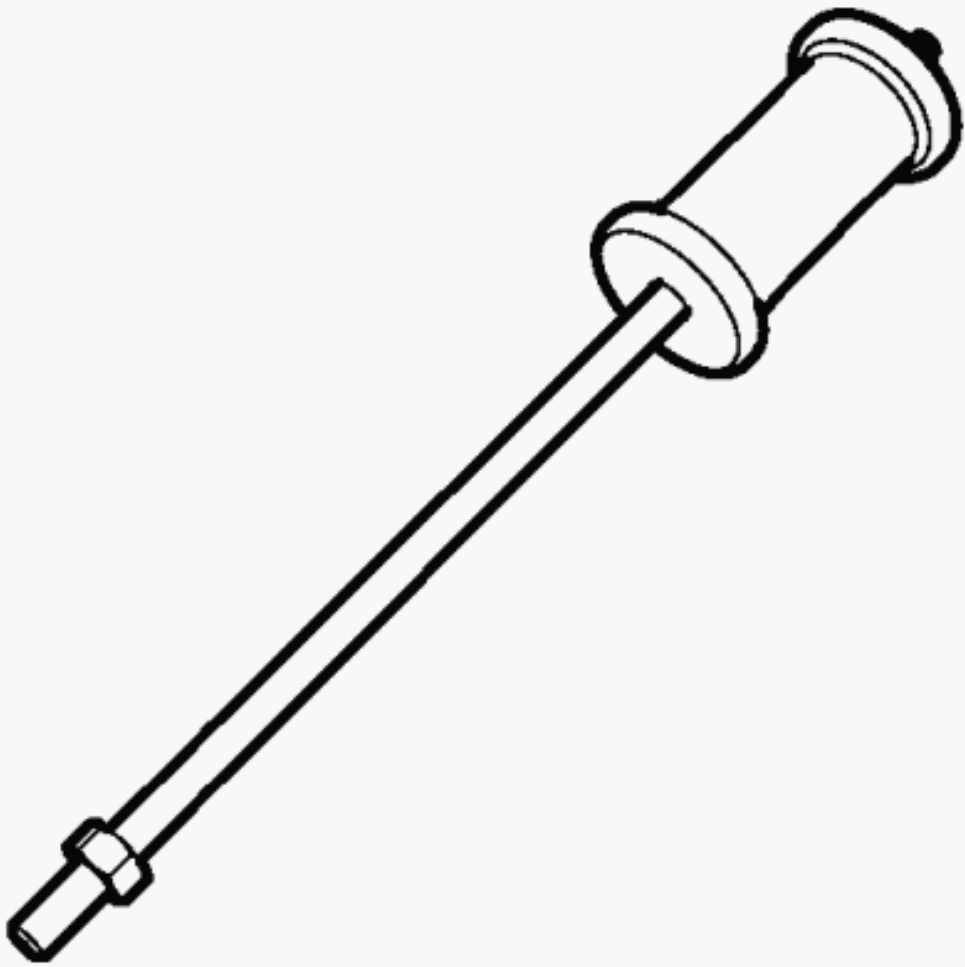
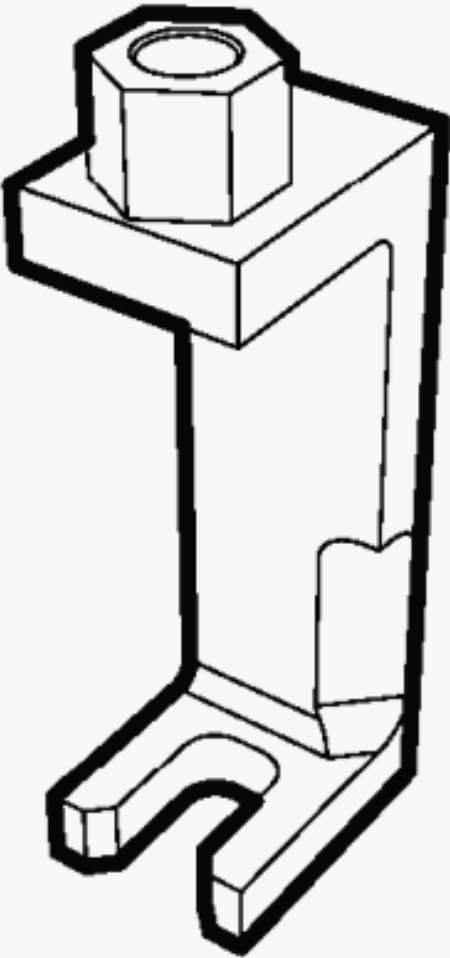
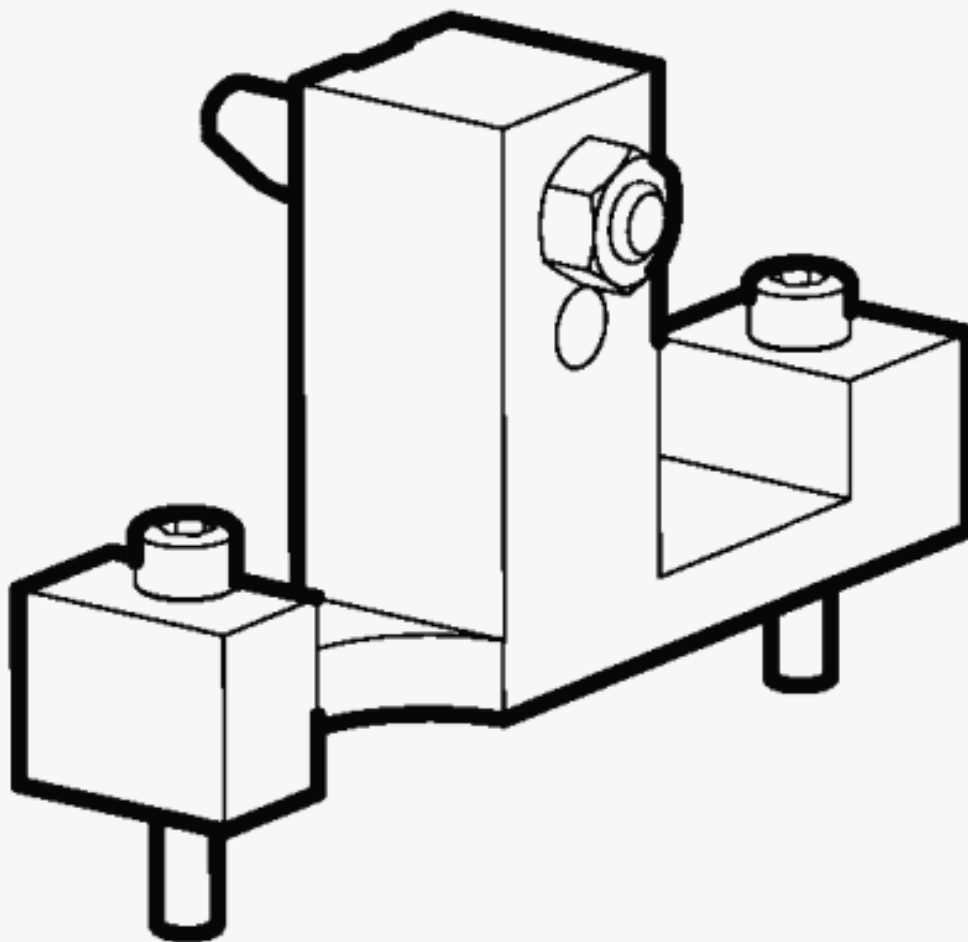
Illustration	Tool Number/Description
	EN-51146-1-3 Sliding Hammer cardiagn.com

Illustration	Tool Number/Description
	EN-51187 Injector Remover cardiagn.com

Illustration

Tool
Number/Description

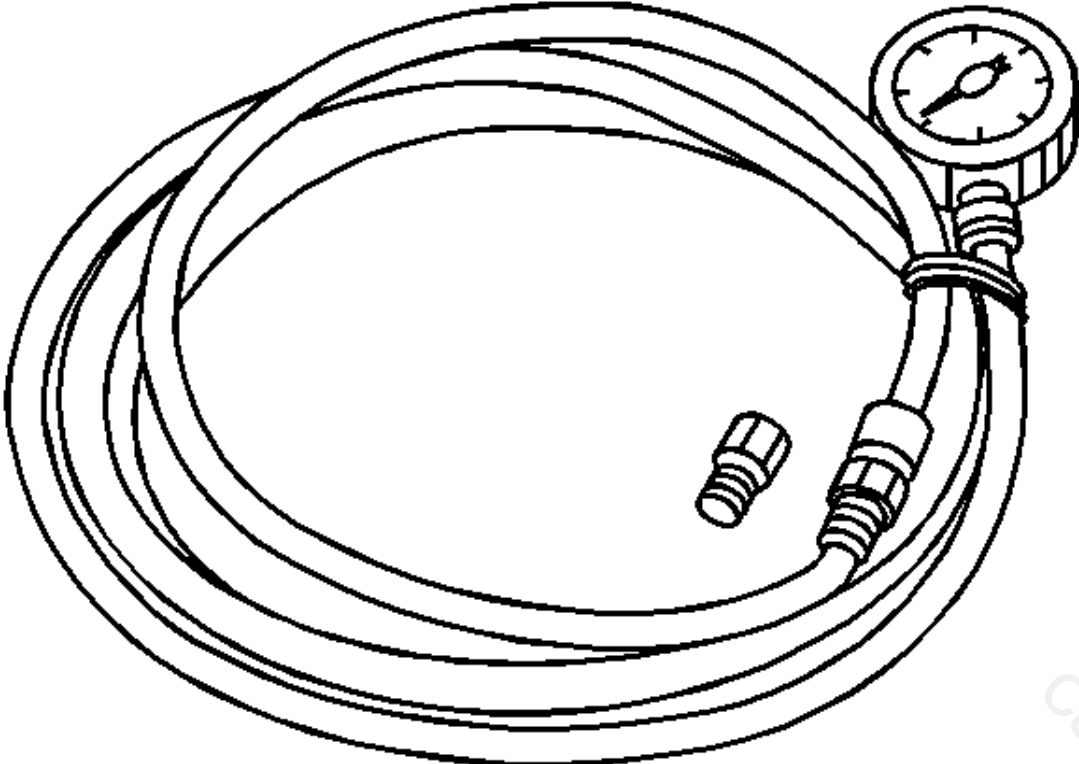


EN-51188
Camshaft Sprocket
Support

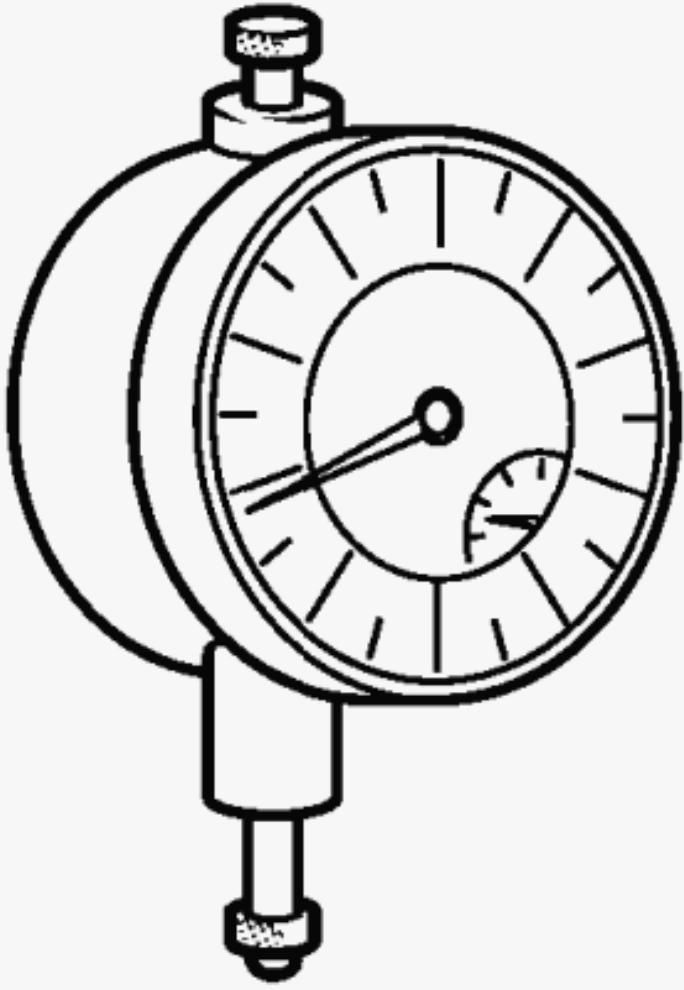
Illustration	Tool Number/Description
	EN-51878 Compression and Cylinder Leakdown Adapter Kit

Illustration	Tool Number/Description
	GE-328-B KM-328-B J-6215-1B Sliding Hammer

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Illustration	Tool Number/Description
	GE-498-B KM-498-B CH-48027 J-21867-A 83 92 516 or 87 91 600 Oil Pressure Gauge

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Illustration	Tool Number/Description
	GE-571-B MKM-571-B J-8001 Dial Gauge cardiagn.com