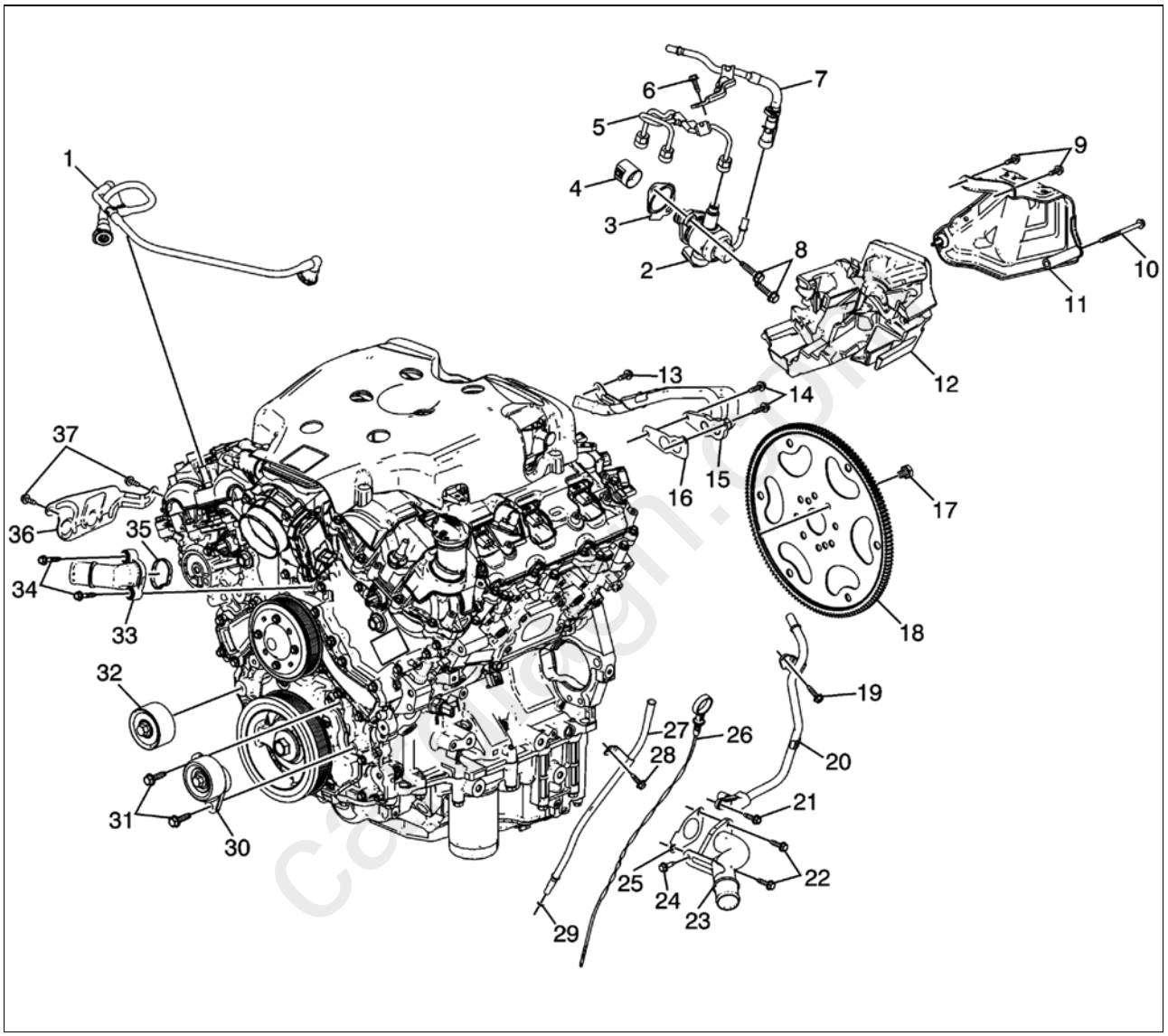
Service Manual: ENGINE MECHANICAL - 3.6L (LGX) -
COMPONENT LOCATOR

COMPONENT LOCATOR > DISASSEMBLED VIEWS > ENGINE COMPONENT ASSEMBLIES

Fig 1: Engine Component Assemblies



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Positive Crankcase Ventilation Tube Connector (PCV)
2	Fuel Pump
3	Fuel Pump Bracket Gasket
4	Valve Lifter Follower

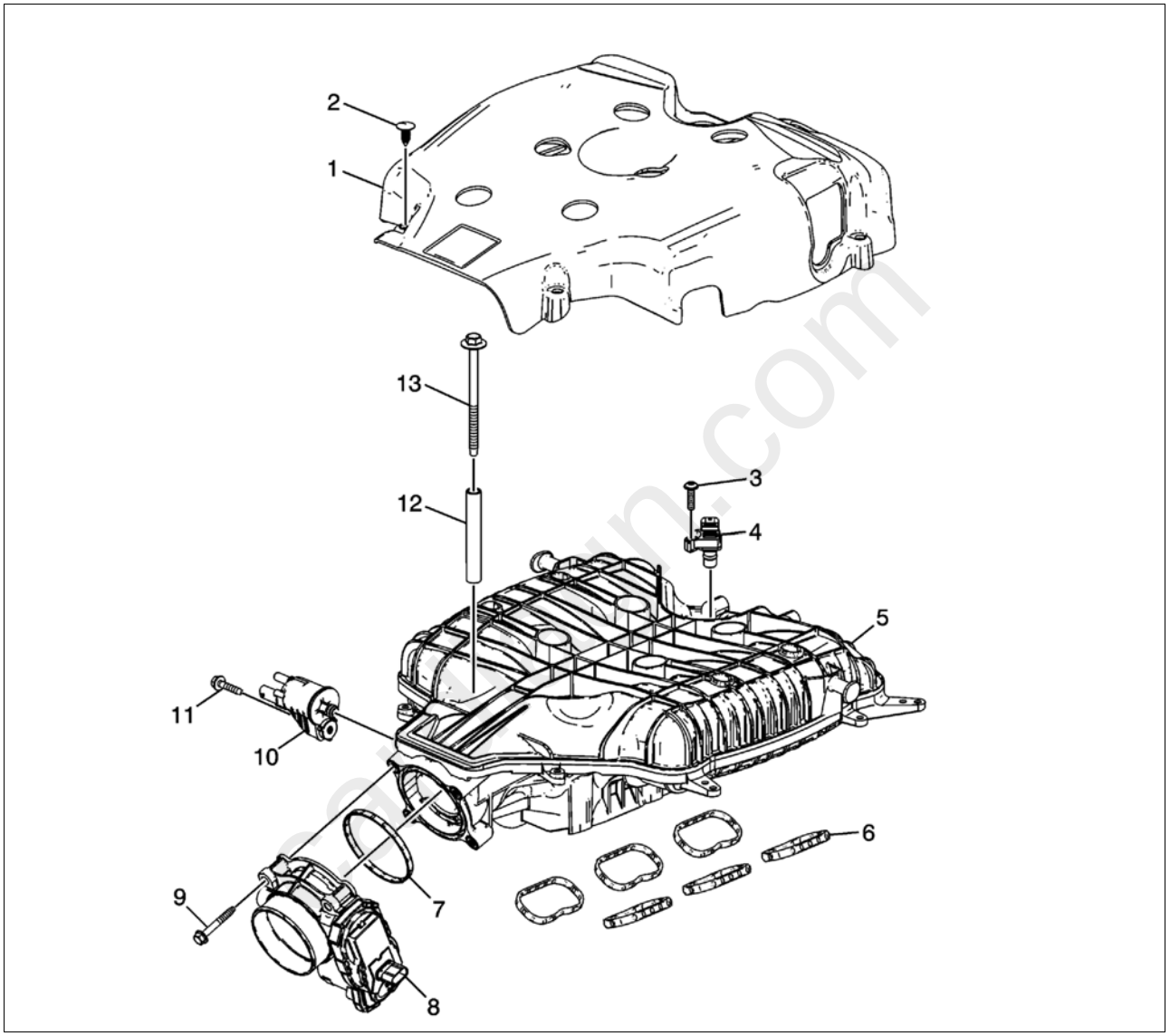
5	Fuel Pump O-Ring
6	Fuel Feed Intermediate Pipe
7	Fuel Feed Pipe Bolt
8	Fuel Feed Pipe
9	Fuel Pump Bolt (Qty: 2)
10	Fuel Pipe Shield Bolt (Qty: 2)
11	Fuel Pipe Shield Bolt
12	Fuel Pipe Shield
13	Engine Rear Noise Shield
14	Heater Inlet and Outlet Pipe Bolt
15	Heater Inlet and Outlet Pipe Bolt
16	Heater Inlet and Outlet Pipe
17	Heater Inlet and Outlet Pipe Gasket
18	Automatic Transmission Flex Plate Bolt (Qty: 8)
19	Automatic Transmission Flex Plate
20	Vacuum Pump Pipe Bolt
21	Vacuum Pump Pipe
22	Vacuum Pump Pipe Bolt
23	Water Pump Inlet Pipe Bolt (Qty: 2)
24	Water Pump Inlet Pipe
25	Water Pump Inlet Pipe Bolt
26	Water Inlet Seal
27	Oil Level Indicator
28	Oil Level Indicator Tube
29	Oil Level Indicator Tube Bolt
30	Oil Level Indicator Tube Seal
31	Drive Belt Tensioner
32	Drive Belt Tensioner Bolt (Qty: 2)
33	Belt Idler Pulley
34	Water Outlet Bolt (Qty: 2)
35	Water Outlet Pipe
36	Water Outlet Pipe Seal
37	Knock Sensor Heat Shield

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38	Knock Sensor Heat Shield Bolt (Qty: 2)

COMPONENT LOCATOR > DISASSEMBLED VIEWS > INTAKE MANIFOLD AND COMPONENTS

Fig 1: Intake Manifold and Components



Courtesy of GENERAL MOTORS COMPANY

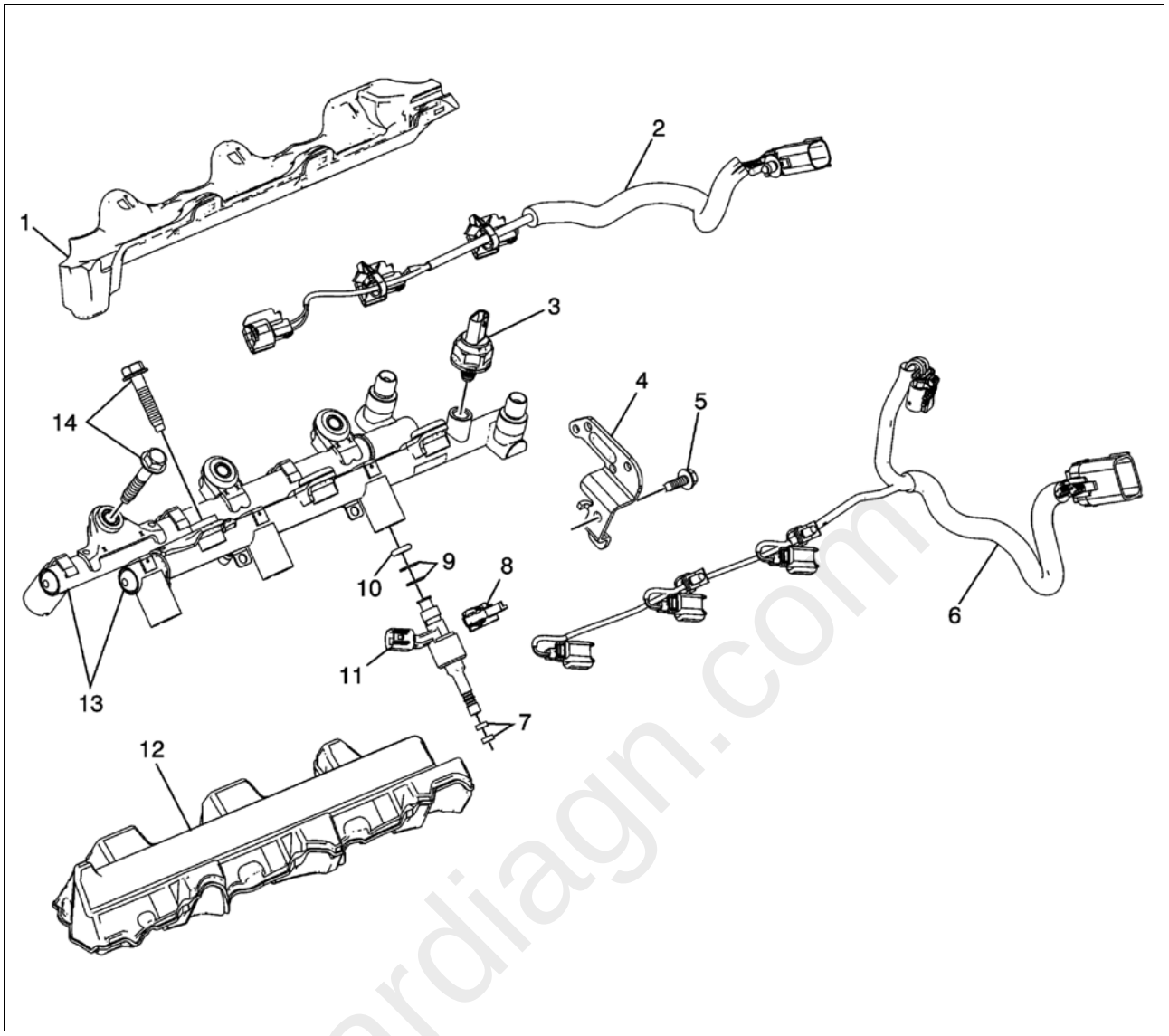
Callout	Component Name
1	Intake Manifold Insulator
2	Intake Manifold Insulator Retainer
3	Manifold Absolute Pressure Sensor Bolt
4	Manifold Absolute Pressure Sensor

5	Intake Manifold
6	Intake Manifold Seal
7	Throttle Body Gasket
8	Throttle Body
9	Throttle Body Bolt (Qty: 4)
10	Evaporative Emission Canister
11	Evaporative Emission Canister Purge Solenoid Valve Bolt
12	Intake Manifold Insulator
13	Intake Manifold Bolt (Qty: 8)

COMPONENT LOCATOR > DISASSEMBLED VIEWS > FUEL RAIL ASSEMBLY

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Fig 1: Fuel Rail Assembly



Courtesy of GENERAL MOTORS COMPANY

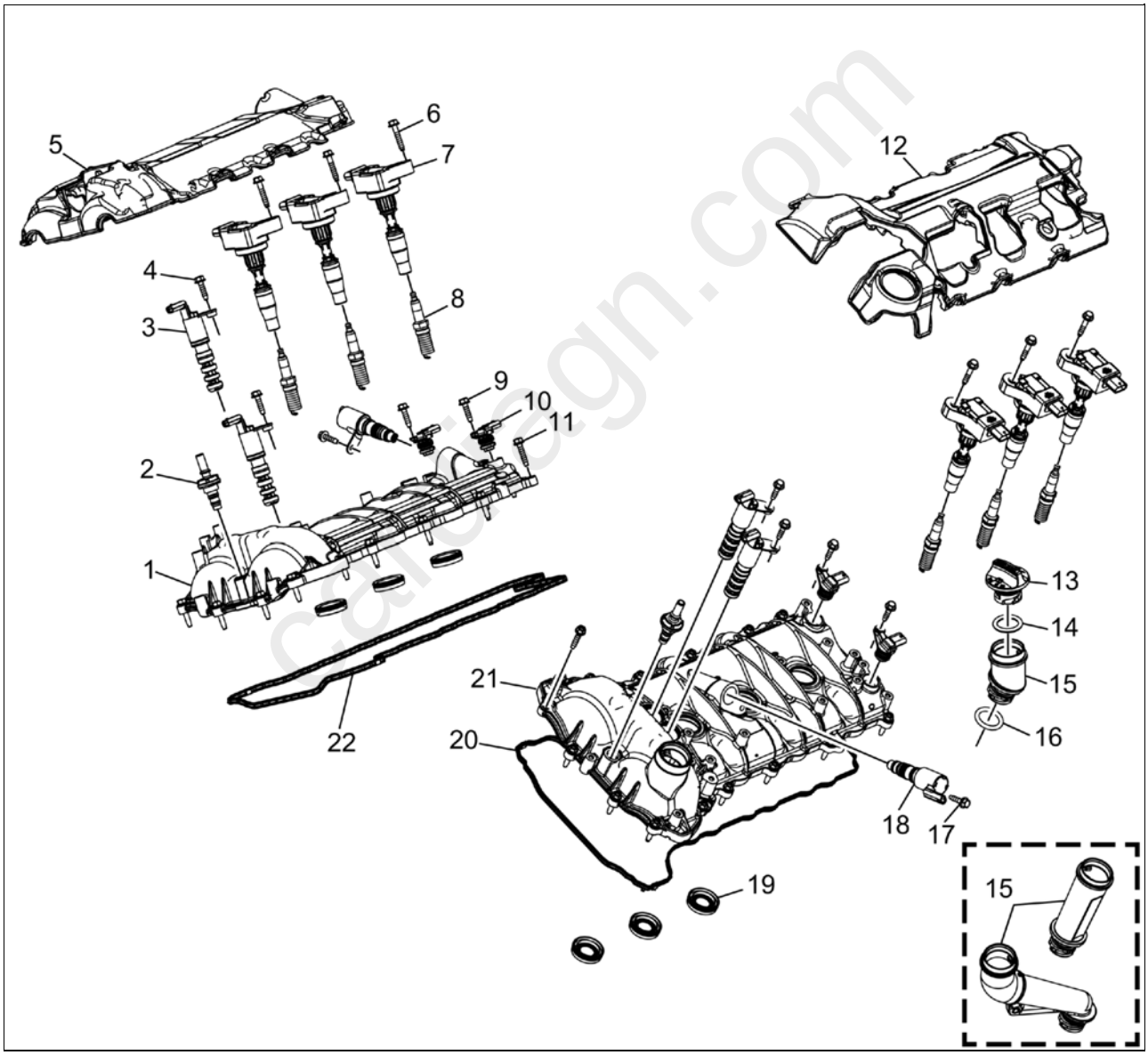
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Callout	Component Name
1	Fuel Injection Fuel Rail Noise Shield
2	Fuel Injector Wiring Harness
3	Fuel Injection Fuel Rail Fuel Pressure Sensor
4	Fuel Injector Wiring Harness Bracket
5	Fuel Injector Wiring Harness Bracket Bolt (Qty: 2)
6	Fuel Injector Wiring Harness
7	Fuel Injector Nozzle Housing Seal
8	Fuel Injector Retainer
9	Fuel Injector Spacer

10	Fuel Injection Fuel Rail Seal - (O-ring)
11	Direct Fuel Injector
12	Fuel Injection Fuel Rail Noise Shield
13	Direct Fuel Injection Fuel Rail
14	Fuel Injection Fuel Rail Bolt (Qty: 6)

COMPONENT LOCATOR > DISASSEMBLED VIEWS > CAMSHAFT COVER AND COMPONENTS

Fig 1: Camshaft Cover and Components



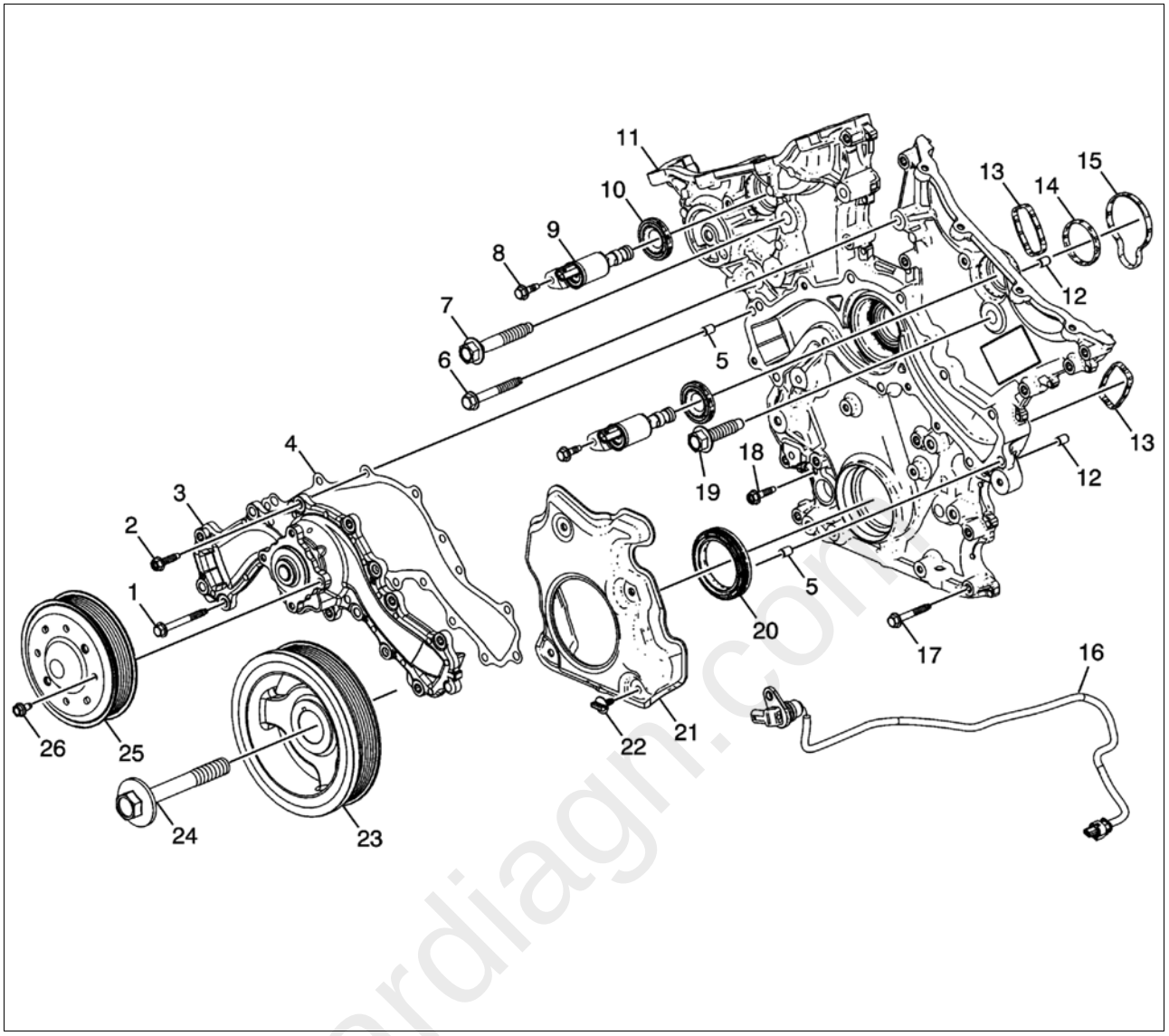
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Camshaft Cover - Right
2	Positive Crankcase Ventilation Valve
3	Camshaft Position Actuator Solenoid Valve
4	Camshaft Position Actuator Solenoid Valve Bolt (Qty: 4)
5	Camshaft Housing Cover Insulator - Right
6	Ignition Coil Bolt (Qty: 6)
7	Ignition Coil
8	Spark Plug (Qty: 6)
9	Camshaft Position Sensor Bolt (Qty: 4)
10	Camshaft Position Sensor (Qty: 4)
11	Camshaft Cover Bolt (Qty: 36)
12	Camshaft Housing Cover Insulator - Left
13	Oil Filler Cap (Model Dependant)
14	Oil Filler Cap Seal (Model Dependant)
15	Oil Filler Cap Tube (Model Dependant)
16	Oil Filler Cap Tube Seal (Model Dependant)
17	Valve Rocker Arm Oil Control Valve Bolt (Qty: 2)
18	Valve Rocker Arm Oil Control Valve
19	Spark Plug Shield Seal
20	Camshaft Cover Seal - Left
21	Camshaft Cover - Left
22	Camshaft Cover Seal - Right

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COMPONENT LOCATOR > DISASSEMBLED VIEWS > ENGINE FRONT COVER

Fig 1: Engine Front Cover



Courtesy of GENERAL MOTORS COMPANY

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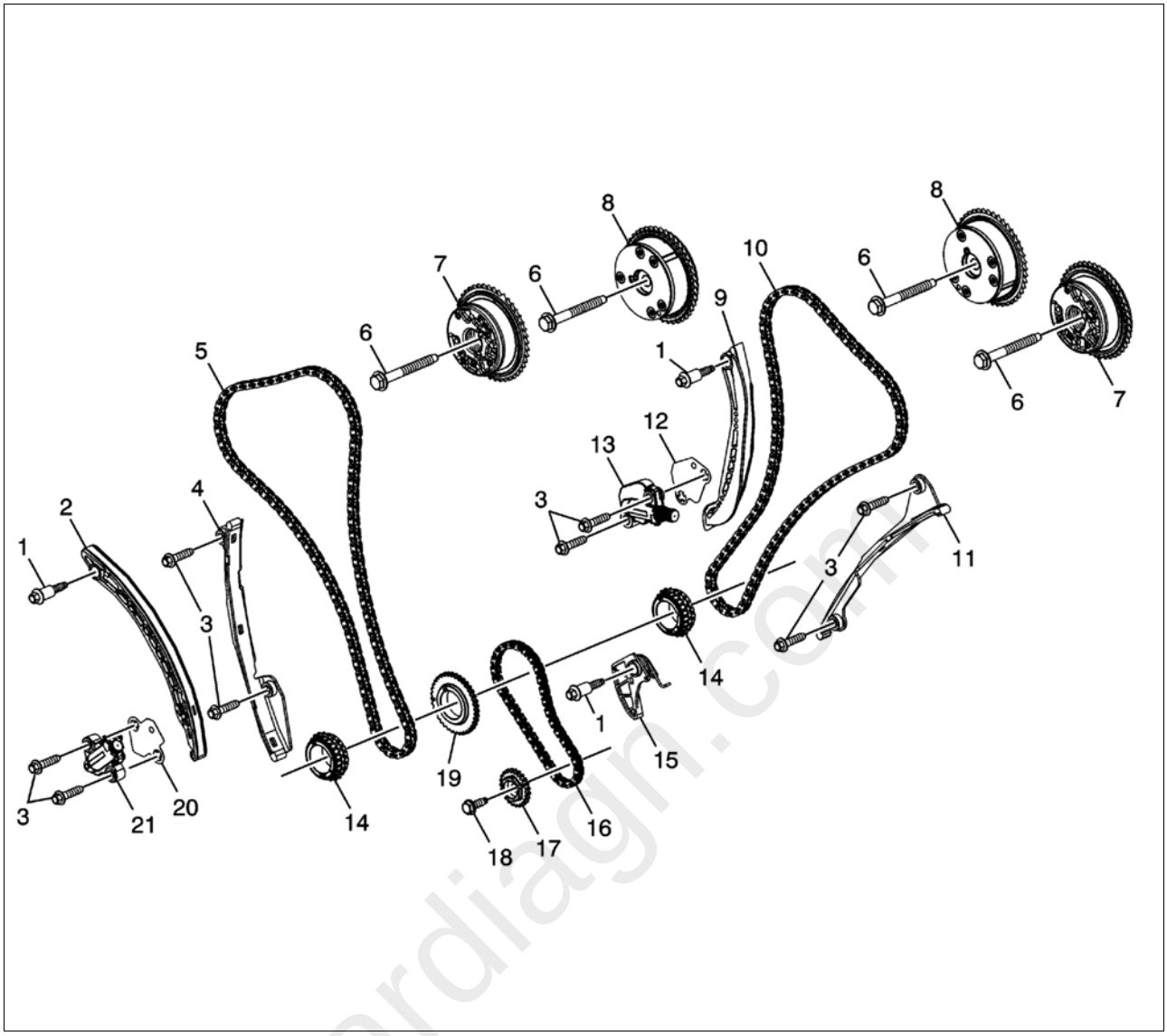
Callout	Component Name
1	Water Pump Bolt (Qty: 5) M6 x 20
2	Water Pump Bolt (Qty: 9) M6 x 60
3	Water Pump Housing
4	Water Pump Gasket
5	Water Pump Locating Pin (Qty: 2)
6	Engine Front Cover Bolt (Qty: 2) M8 x 66
7	Engine Front Cover Bolt M12 x 75
8	Camshaft Position Actuator Control Valve Bolt (Qty: 2)
9	Camshaft Position Actuator Control Valve (Qty: 2)

10	Camshaft Position Actuator Control Valve Seal (Qty: 2)
11	Engine Front Cover
12	Engine Front Cover Locating Pin (Qty: 2)
13	Water Pump Seal (Qty: 2)
14	Water Pump Seal
15	Water Pump Seal
16	Oil Pump Flow Control Solenoid Valve Wire
17	Engine Front Cover Bolt (Qty: 16) M8 x 45
18	Harness Connector Bolt
19	Engine Front Cover Bolt M12 x 50
20	Crankshaft Front Oil Seal
21	Engine Front Cover Insulator
22	Engine Front Cover Retainer (Qty: 4)
23	Crankshaft Balancer
24	Crankshaft Balancer Bolt
25	Water Pump Pulley
26	Water Pump Pulley Bolt (Qty: 4)

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COMPONENT LOCATOR > DISASSEMBLED VIEWS > CAMSHAFT TIMING COMPONENTS

Fig 1: Camshaft Timing Components



Courtesy of GENERAL MOTORS COMPANY

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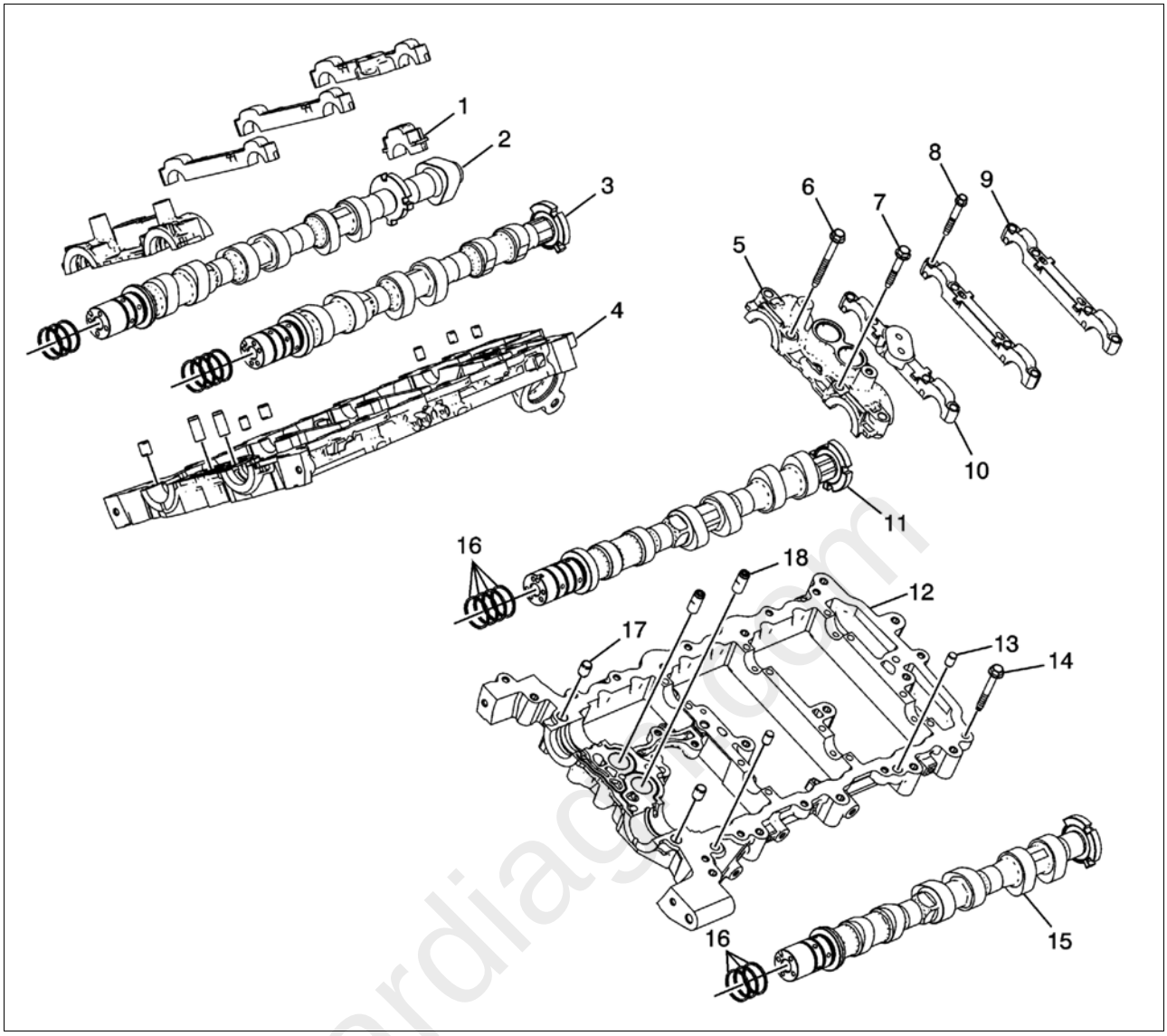
Callout	Component Name
1	Timing Chain Guide Bolt (Qty: 2)
2	Timing Chain Guide - Right
3	Timing Chain Tensioner Bolt (Qty: 8)
4	Timing Chain Guide - Right
5	Timing Chain - Right
6	Camshaft Position Actuator Bolt (Qty: 4)
7	Camshaft Position Actuator - Exhaust
8	Camshaft Position Actuator - Intake
9	Timing Chain Guide - Left

10	Timing Chain - Left
11	Timing Chain Guide - Left
12	Timing Chain Tensioner Gasket
13	Timing Chain Tensioner - Left
14	Timing Chain Crankshaft Sprocket
15	Timing Chain Tensioner
16	Oil Pump Timing Chain
17	Oil Pump Sprocket
18	Oil Pump Drive Bolt
19	Crankshaft Sprocket
20	Timing Chain Tensioner Gasket
21	Timing Chain Tensioner - Right

COMPONENT LOCATOR > DISASSEMBLED VIEWS > CAMSHAFT CARRIER COMPONENTS

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Fig 1: Camshaft Carrier Components



Courtesy of GENERAL MOTORS COMPANY

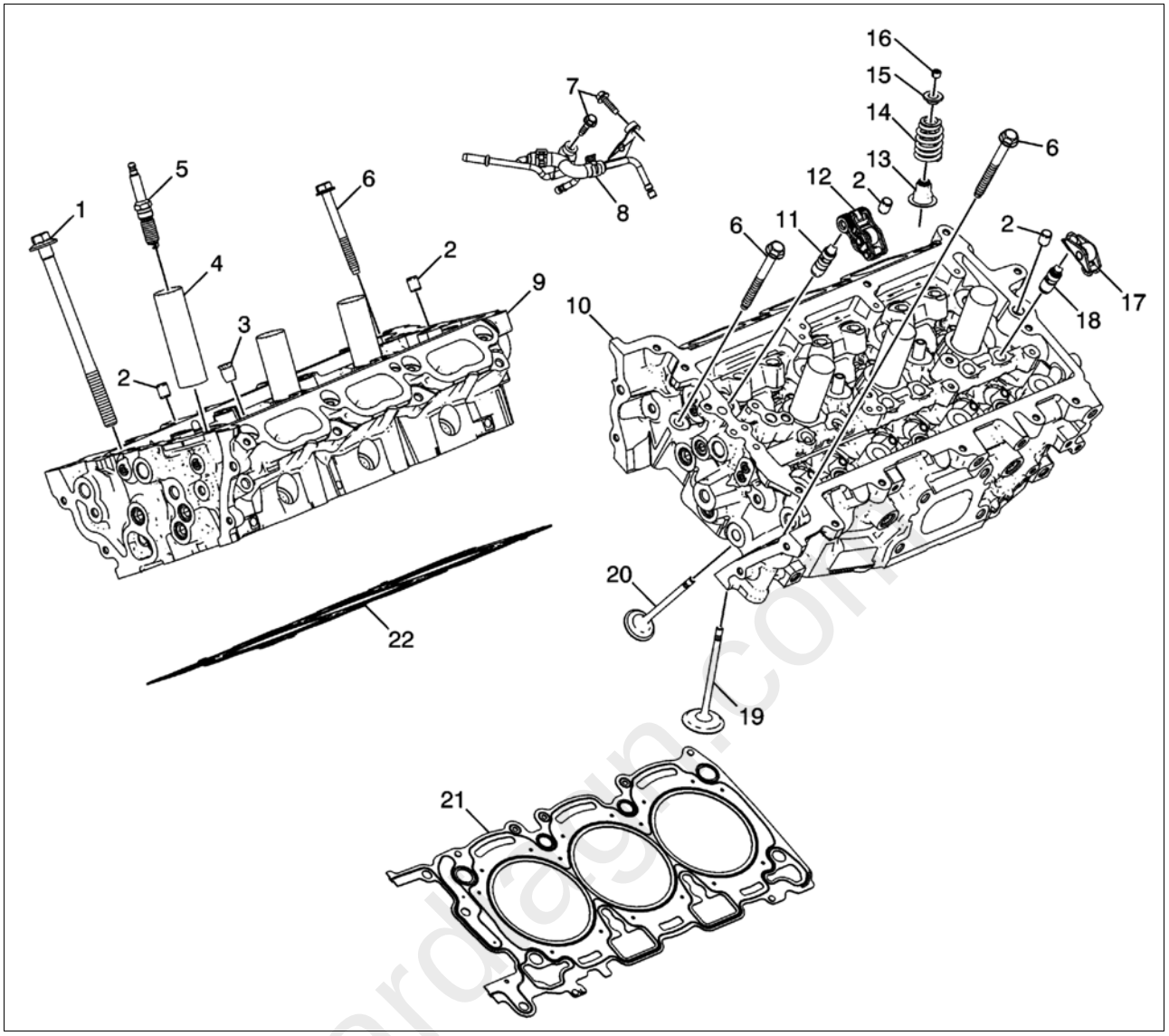
Callout	Component Name
1	Camshaft Bearing Cap - Intermediate
2	Exhaust Camshaft - Right
3	Intake Camshaft - Right
4	Camshaft Carrier - Right
5	Camshaft Bearing Cap
6	Camshaft Bearing Cap Bolt (Qty: 8)
7	Camshaft Bearing Cap Bolt (Qty: 8)
8	Camshaft Bearing Cap Bolt (Qty: 26)
9	Camshaft Bearing Cap

10	Camshaft Bearing Cap
11	Intake Camshaft - Left
12	Camshaft Carrier - Left
13	Dowel Pin
14	Camshaft Carrier Bolt
15	Exhaust Camshaft - Left
16	Camshaft Oil Seal Ring
17	Dowel Pin
18	Engine Oil Manifold Check Valve

COMPONENT LOCATOR > DISASSEMBLED VIEWS > CYLINDER HEAD ASSEMBLIES

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Fig 1: Cylinder Head Assemblies



Courtesy of GENERAL MOTORS COMPANY

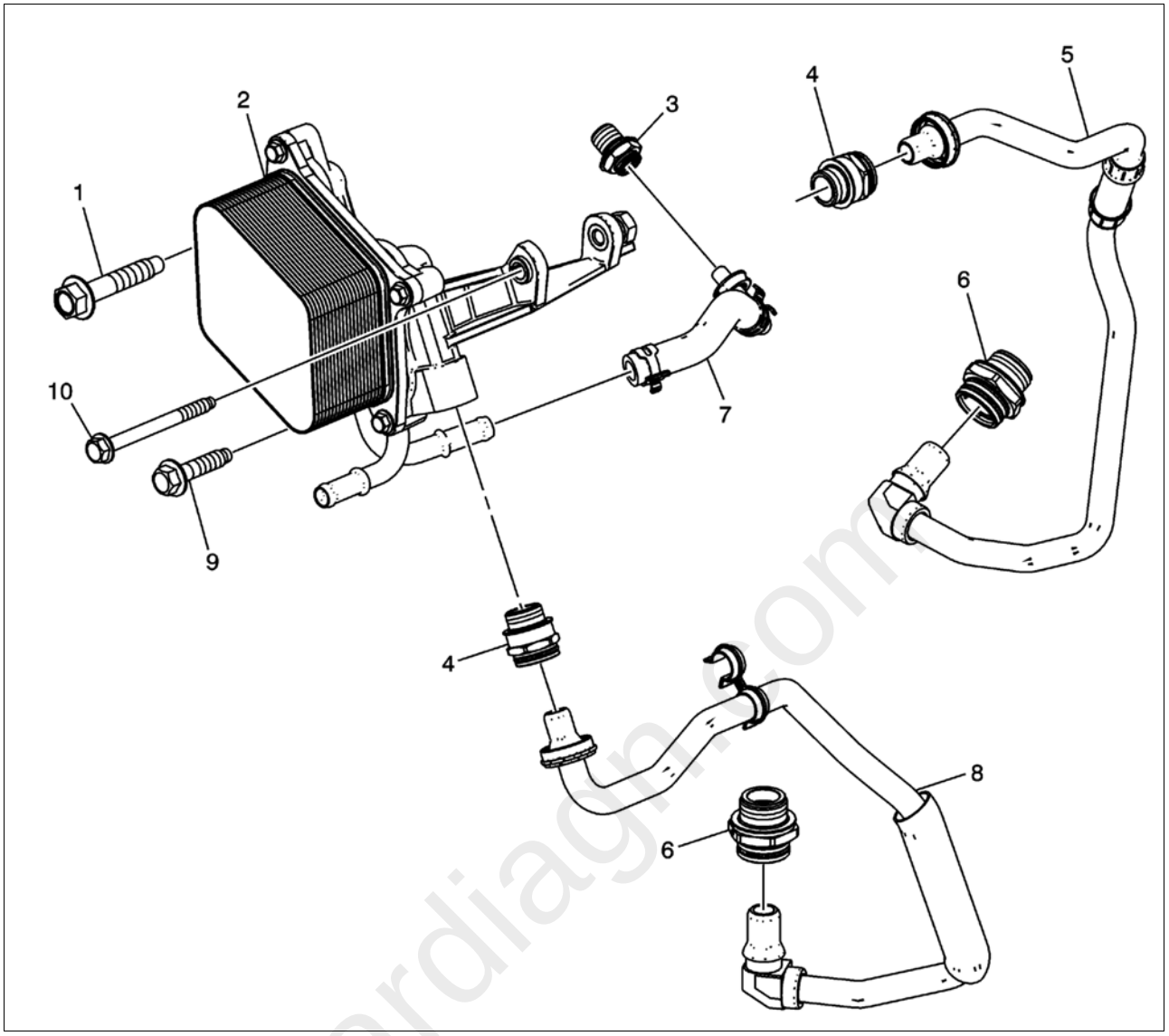
Callout	Component Name
1	Cylinder Head Bolt (Qty: 16)
2	Dowel Pin
3	Cylinder Head Oil Gallery Plug
4	Spark Plug Wire Sleeve
5	Spark Plug
6	Cylinder Head Bolt (Qty: 3)
7	Engine Coolant Air Bleed Pipe Bolt (Qty: 2)
8	Engine Coolant Air Bleed Pipe
9	Cylinder Head - Left

10	Cylinder Head - Right
11	Dual Feed Hydraulic Valve Adjustor
12	Valve Rocker Switching Arm
13	Valve Stem Oil Seal
14	Valve Spring
15	Valve Spring Cap
16	Valve Stem Key
17	Valve Rocker Arm
18	Hydraulic Valve Lash Adjuster
19	Intake Valve
20	Exhaust Valve
21	Cylinder Head Gasket - Right
22	Cylinder Head Gasket - Left

COMPONENT LOCATOR > DISASSEMBLED VIEWS > ENGINE OIL COOLER ADAPTER ASSEMBLY

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Fig 1: Engine Oil Cooler Adapter Assembly



Courtesy of GENERAL MOTORS COMPANY

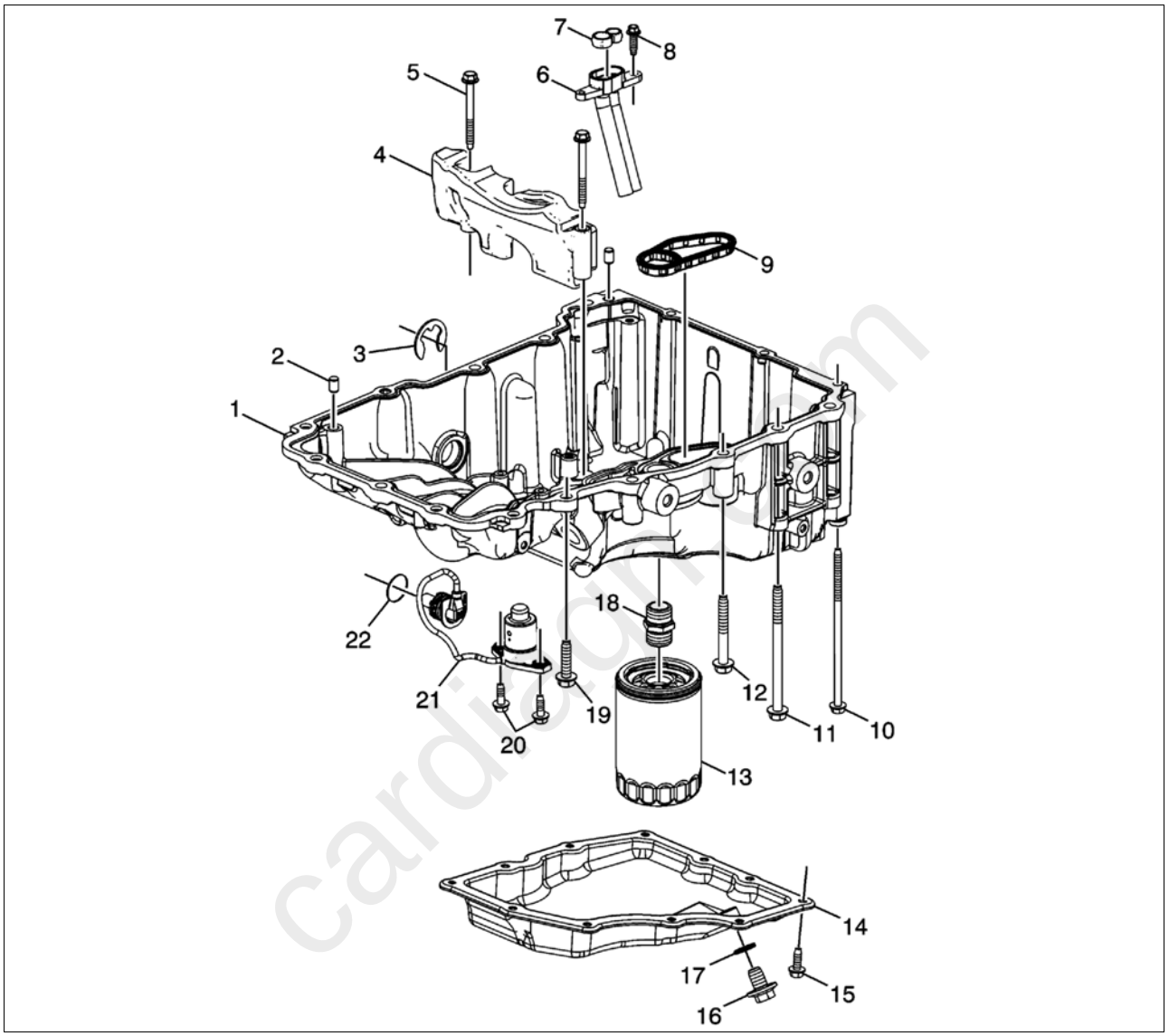
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Callout	Component Name
1	Engine Oil Cooler Adapter Bolt M12 x 65.90
2	Engine Oil Cooler Adapter Assembly
3	Engine Oil Cooler Fitting
4	Engine Oil Cooler Fitting (Qty: 2)
5	Engine Oil Cooler Pipe
6	Engine Oil Cooler Fitting (Qty: 2)
7	Engine Oil Cooler Inlet Pipe
8	Engine Oil Cooler Pipe
9	Engine Oil Cooler Adapter Bolt M10 x 45.75

10	Engine Oil Cooler Adapter Bolt M8 x 90.8

COMPONENT LOCATOR > DISASSEMBLED VIEWS > OIL PAN ASSEMBLY

Fig 1: Oil Pan Assembly



Courtesy of GENERAL MOTORS COMPANY

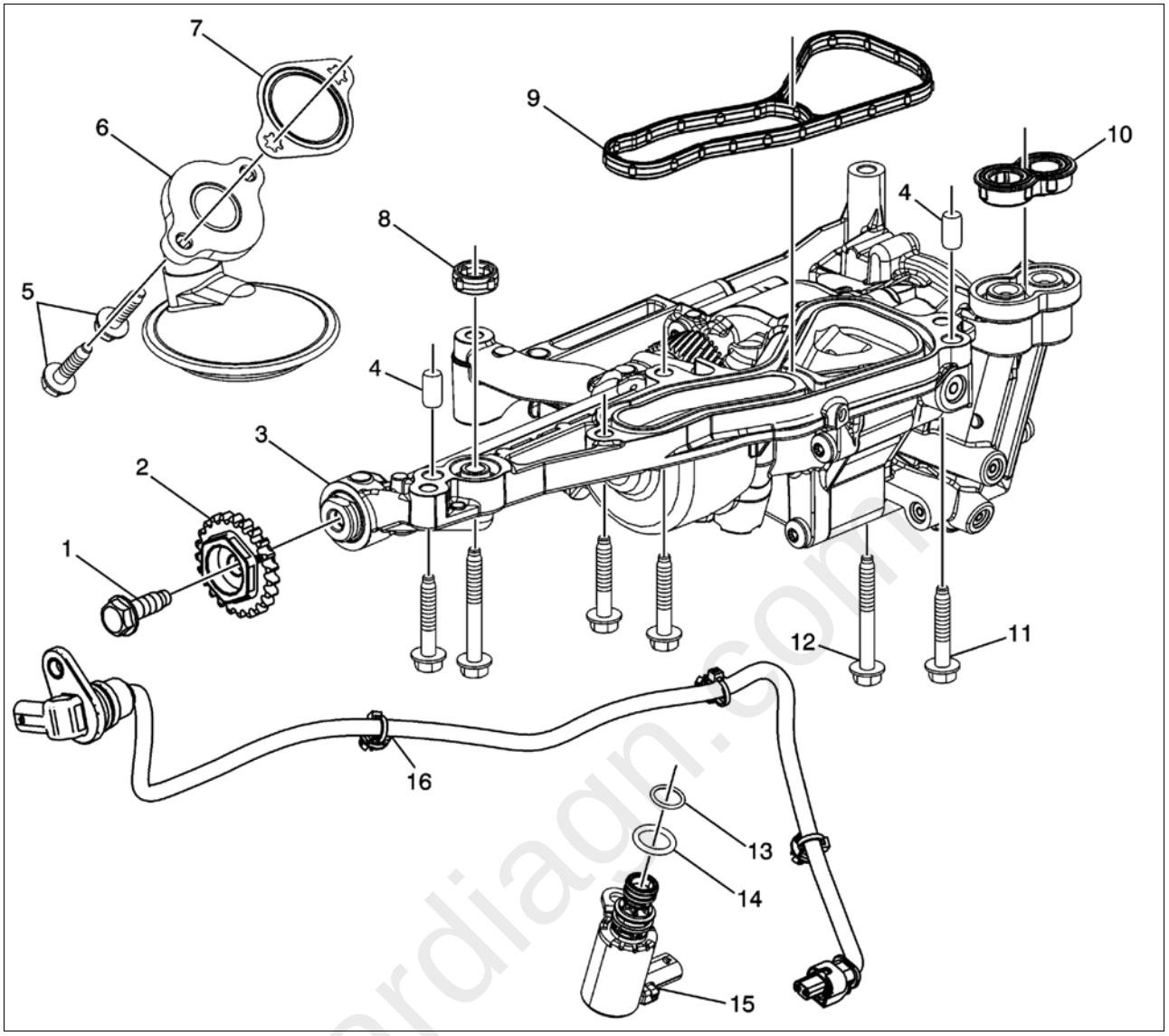
Callout	Component Name
1	Oil Pan
2	Dowel Pin (Qty: 2)
3	Engine Oil Level Switch Clip
4	Oil Pan Baffle
5	Oil Pan Baffle Bolt (Qty: 2)

6	Positive Crankcase Ventilation Oil Separator Drain
7	Positive Crankcase Ventilation Oil Separator Drain Seal
8	Positive Crankcase Ventilation Oil Separator Drain Bolt
9	Oil Pan High Pressure Port Seal
10	Oil Pan Bolt (Qty: 3)
11	Oil Pan Bolt (Qty: 6)
12	Oil Pan Bolt (Qty: 6)
13	Oil Filter
14	Lower Oil Pan
15	Lower Oil Pan Bolt (Qty: 13)
16	Oil Pan Drain Plug
17	Oil Pan Drain Plug Seal
18	Oil Filter Adapter Fitting
19	Oil Pan Bolt (Qty: 7)
20	Engine Oil Level Indicator Switch Bolt (Qty: 2)
21	Engine Oil Level Indicator Switch
22	Engine Oil Level Indicator Switch O-Ring Seal

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COMPONENT LOCATOR > DISASSEMBLED VIEWS > OIL PUMP ASSEMBLY

Fig 1: Oil Pump Assembly



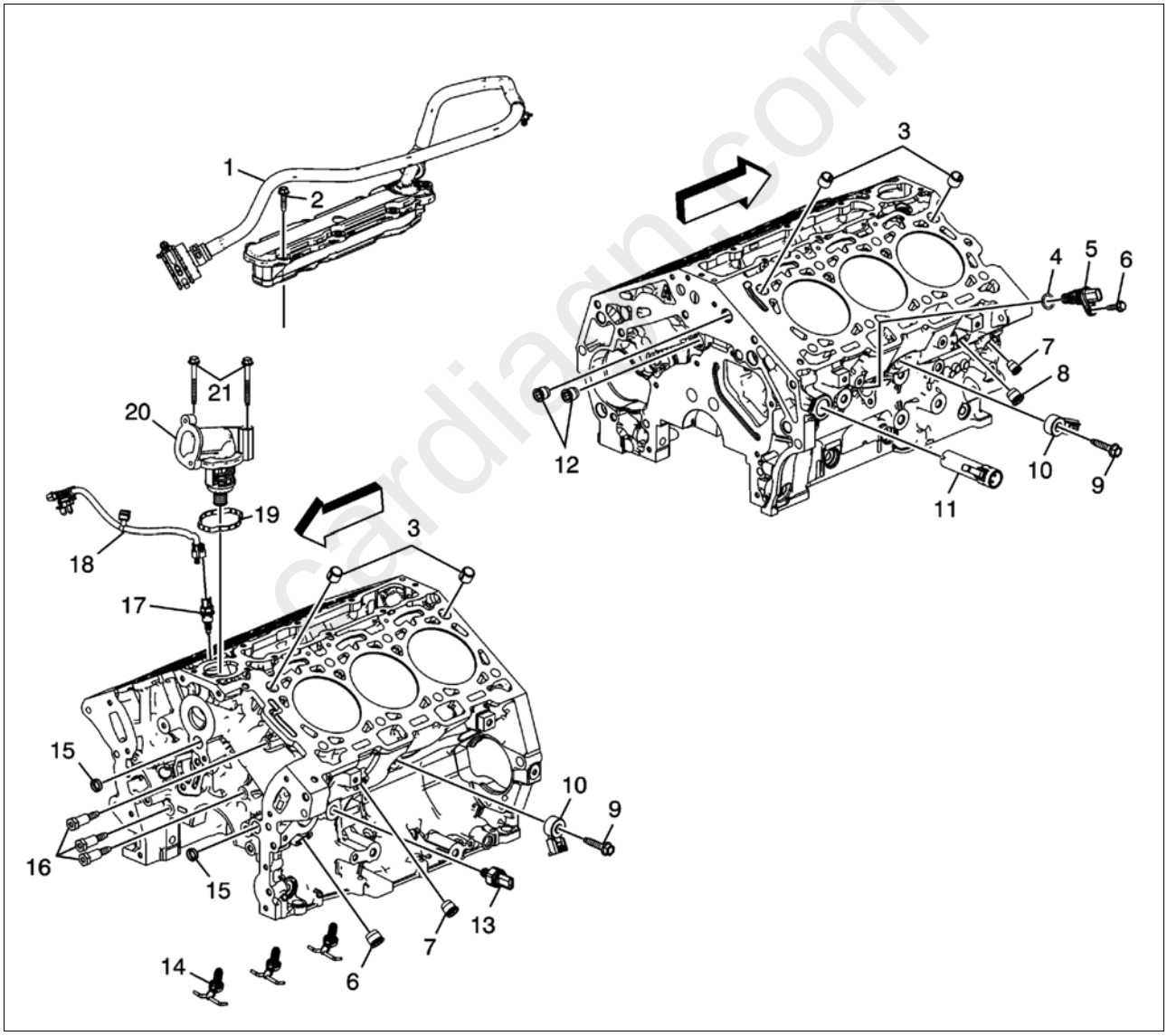
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Oil Pump Sprocket Bolt
2	Oil Pump Sprocket
3	Oil Pump
4	Dowel Pin - Not Serviceable
5	Oil Pump Suction Pipe Bolt (Qty: 2)
6	Oil Pump Suction Pipe
7	Oil Pump Suction Pipe Gasket
8	Oil Pump Housing Passage Seal
9	Oil Pump Housing Passage Seal

10	Vacuum Pump Seal
11	Oil Pump Bolt (Qty: 2)
12	Oil Pump Bolt (Qty: 4)
13	Oil Pump Flow Control Valve Seal O-Ring
14	Oil Pump Flow Control Valve Seal
15	Oil Pump Flow Control Valve
16	Oil Pump Flow Control Solenoid Valve Wiring

COMPONENT LOCATOR > DISASSEMBLED VIEWS > ENGINE BLOCK COMPONENTS

Fig 1: Engine Block Components



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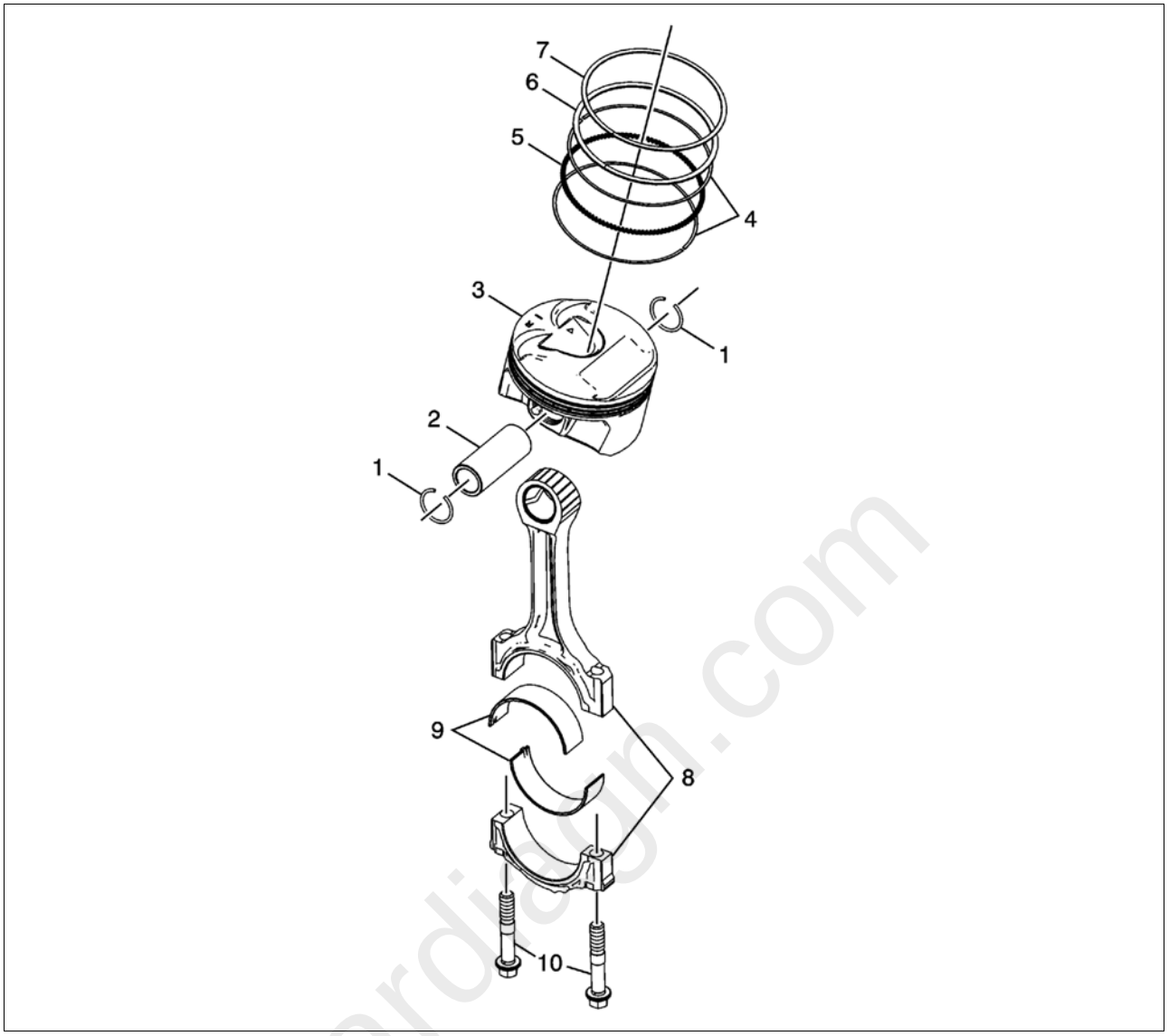
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Positive Crankcase Ventilation Oil Separator
2	Positive Crankcase Ventilation Oil Separator Bolt (Qty: 6)
3	Cylinder Head Locating Pin
4	Crankshaft Position Sensor Seal
5	Crankshaft Position Sensor
6	Crankshaft Position Sensor Bolt
7	Engine Block Core Hole Plug M16 x 16.25
8	Engine Block Core Hole Plug M18 x 16.25
9	Knock Sensor Bolt (Qty: 2)
10	Knock Sensor
11	Engine Coolant Heater
12	Engine Block Oil Gallery Plug M16 x 16.25
13	Engine Oil Pressure Sensor
14	Piston Oil Nozzle (Qty: 3)
15	Engine Block Oil Gallery Plug 14 mm
16	Engine Front Cover Stud (Qty: 3)
17	Engine Coolant Temperature Sensor
18	Engine Coolant Temperature Sensor Wire
19	Engine Coolant Thermostat Seal
20	Engine Coolant Thermostat Housing
21	Engine Coolant Thermostat Housing Bolt (Qty: 2)

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COMPONENT LOCATOR > DISASSEMBLED VIEWS > PISTON, RINGS, BEARINGS AND CONNECTING ROD ASSEMBLY

Fig 1: Piston, Rings, Bearings and Connecting Rod Assembly



Courtesy of GENERAL MOTORS COMPANY

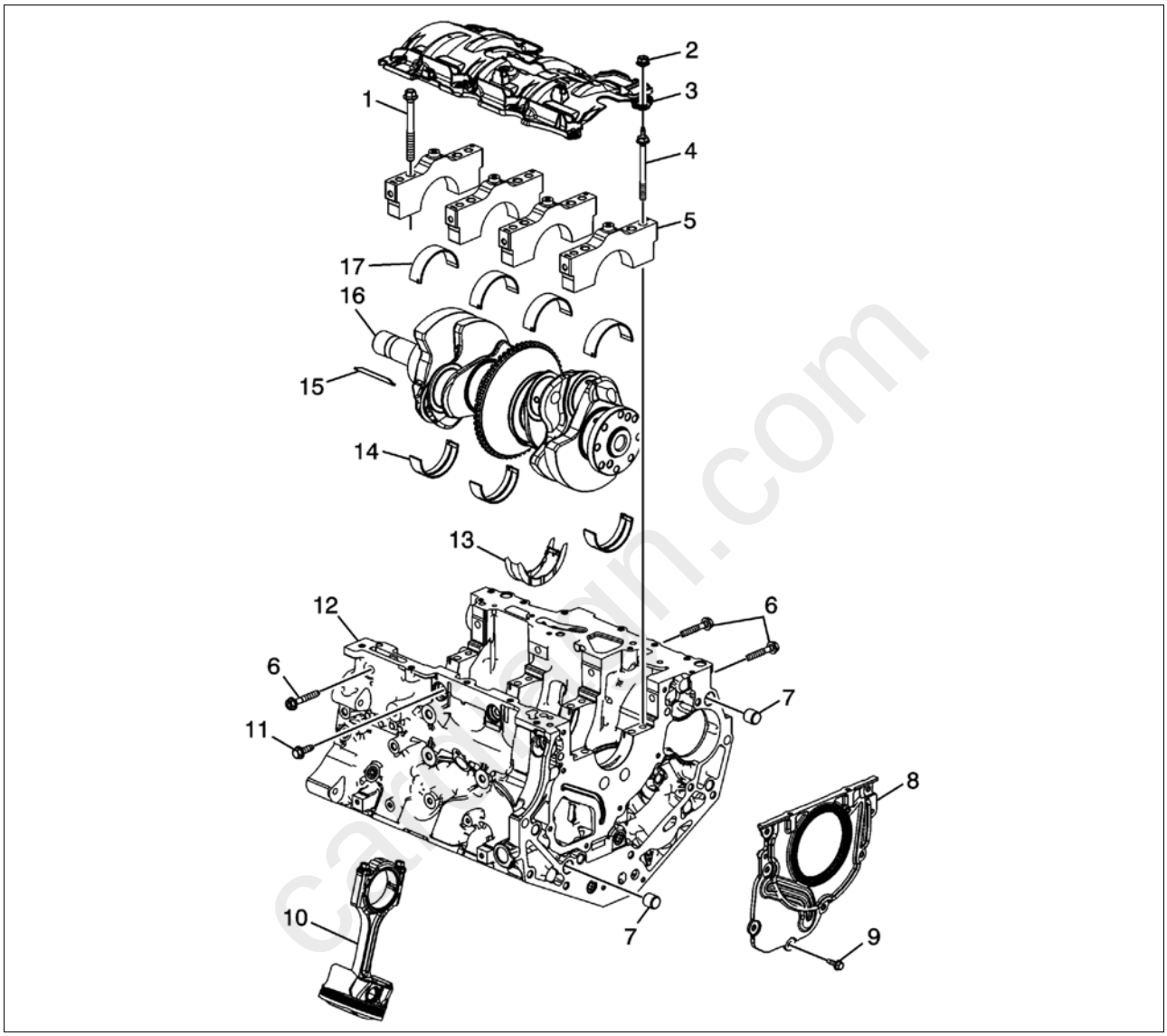
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Callout	Component Name
1	Piston Pin Retainer
2	Piston Pin
3	Piston
4	Piston Oil Ring Rail
5	Piston Oil Ring Rail Spacer
6	Piston Compression Ring - Lower
7	Piston Compression Ring - Upper
8	Connecting Rod
9	Connecting Rod Bearing

10	Connecting Rod Bolt (Qty: 2)

COMPONENT LOCATOR > DISASSEMBLED VIEWS > ENGINE BLOCK ASSEMBLY

Fig 1: Engine Block Assembly



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Crankshaft Bearing Cap Bolt (Qty: 8)
2	Crankshaft Oil Deflector Nut (Qty: 8)
3	Crankshaft Oil Deflector
4	Crankshaft Bearing Cap Bolt (Qty: 8)
5	Crankshaft Bearing Cap

6	Crankshaft Bearing Cap Bolt (Qty: 3)
7	Crankshaft Rear Oil Seal Housing Locating Pin
8	Crankshaft Rear Oil Seal Housing
9	Crankshaft Rear Oil Seal Housing Bolt (Qty: 8)
10	Piston and Connecting Rod Assembly
11	Crankshaft Bearing Cap Bolt
12	Engine Block
13	Crankshaft Thrust Upper Bearing
14	Crankshaft Upper Bearing
15	Crankshaft Balancer Key
16	Crankshaft
17	Crankshaft Lower Bearing

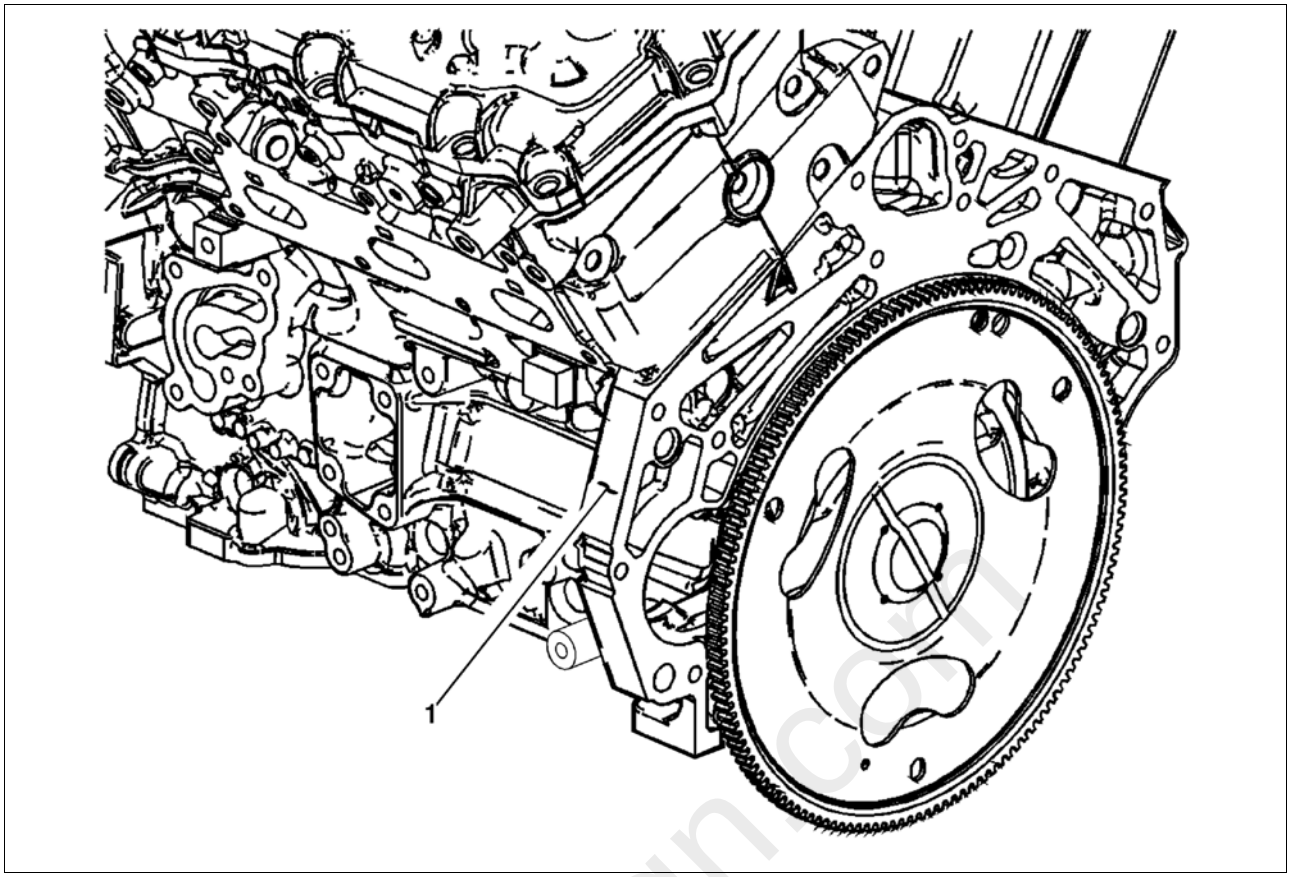
COMPONENT LOCATOR > ENGINE IDENTIFICATION > VEHICLE IDENTIFICATION NUMBER

The Vehicle Identification Number (VIN) Derivative is located in two places on the engine and is a nine digit number stamped or laser etched onto the block at the vehicle assembly plant. If reading the identification number the following information can be obtained:

- The first digit identifies the vehicle division.
- The second digit is the model year.
- The third digit identifies the assembly plant.
- The fourth through ninth digits are the last six digits of the Vehicle Identification Number (VIN).

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Fig 1: Engine VIN - Left Rear Side

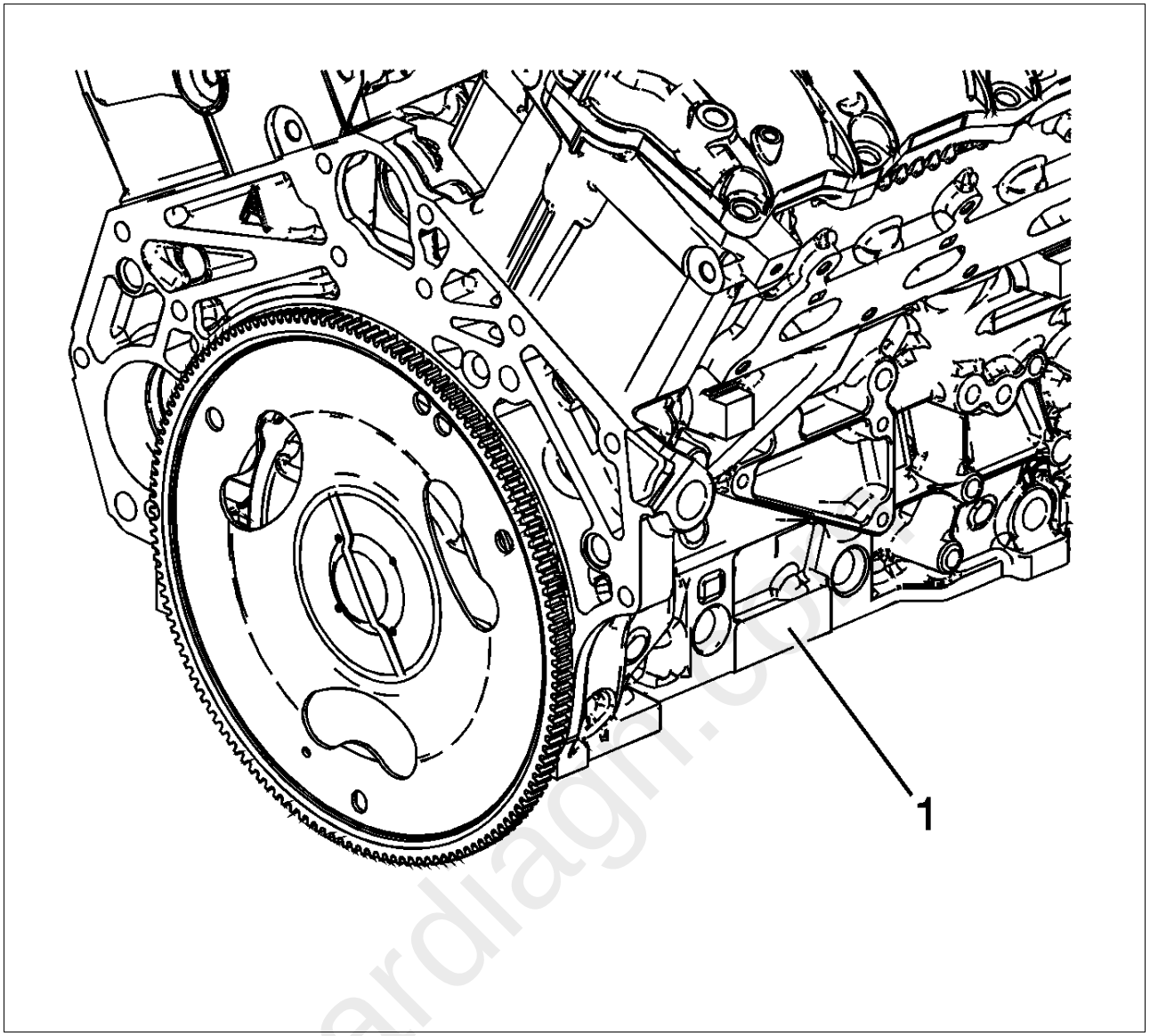


Courtesy of GENERAL MOTORS COMPANY

The engine block is marked with the VIN on a pad area on the left rear side (1).

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Fig 2: Vehicle Identification Number (VIN) - Center Lower Right Side



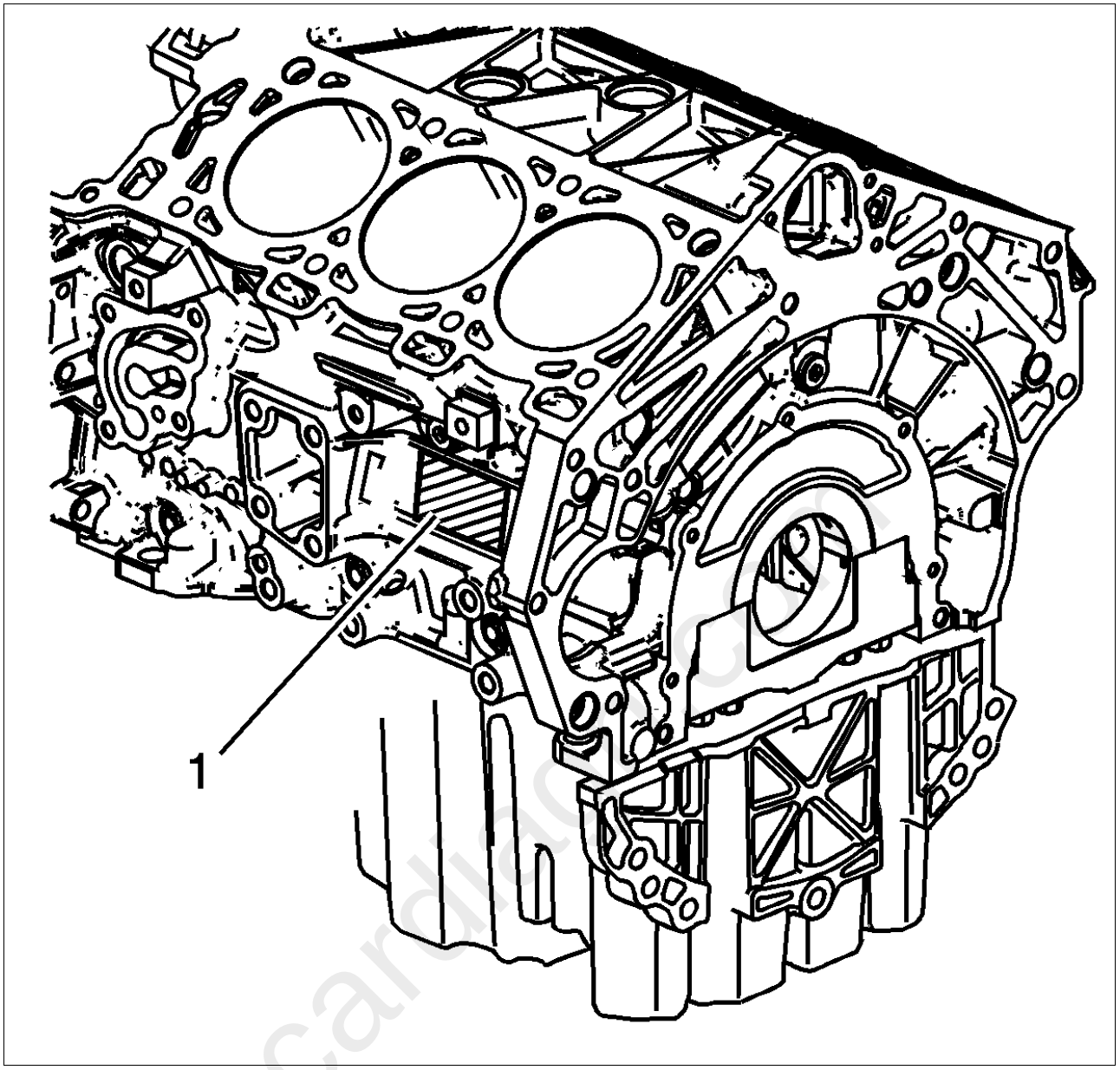
Courtesy of GENERAL MOTORS COMPANY

The engine block is marked with the VIN on a pad area on the center lower right side (1).

COMPONENT LOCATOR > ENGINE IDENTIFICATION > ENGINE TRACEABILITY LABEL

The engine traceability label is located in two places on the engine and consists of the broadcast code, bar code and sequence number. This label is used in engine and vehicle assembly plants and is not intended to be permanent. If it is missing refer back to the engine block VIN pad for the permanent ID.

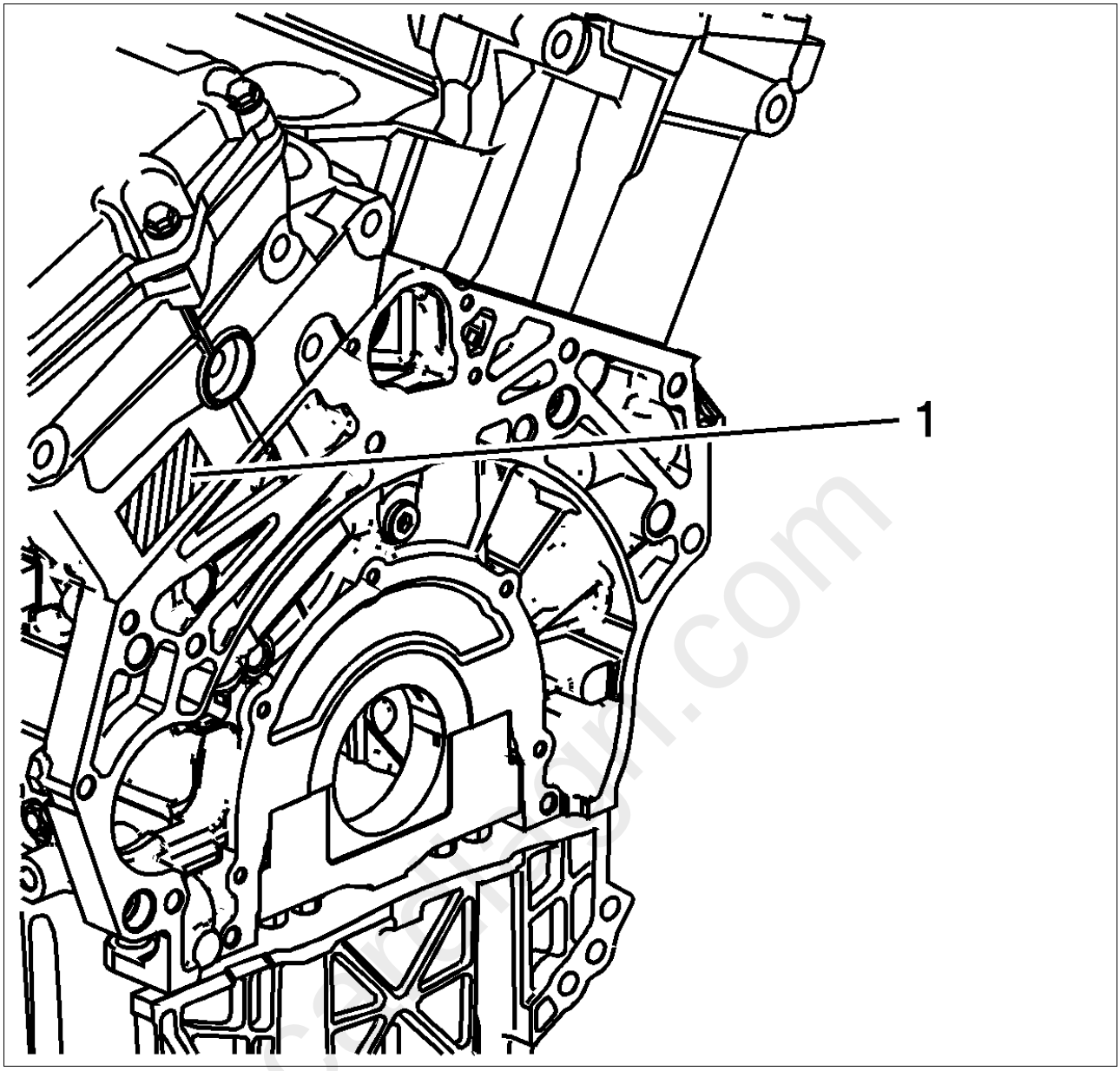
Fig 1: Left Rear Engine Traceability Label



Courtesy of GENERAL MOTORS COMPANY

One engine traceability label (1) is located on the left rear side of the engine block. This label is used in engine and vehicle assembly plants and is not intended to be permanent. If it is missing refer back to the engine block VIN pad for the permanent ID.

Fig 2: Engine Traceability Label On Left Cylinder Head



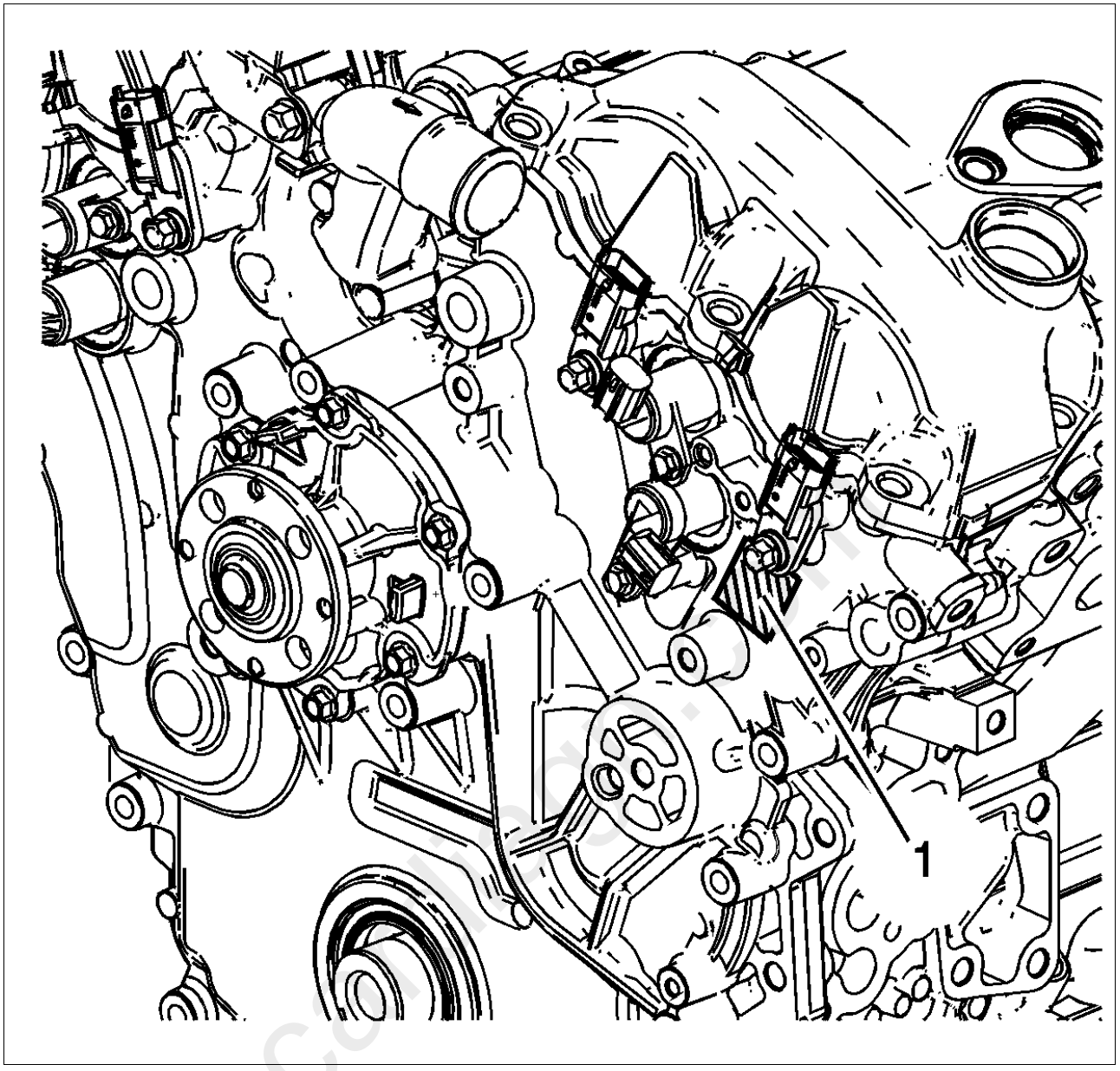
Courtesy of GENERAL MOTORS COMPANY

Another engine traceability label (1) is located on the rear of the left cylinder head. This label is used in engine and vehicle assembly plants and is not intended to be permanent. If it is missing refer back to the engine block VIN pad for the permanent ID.

COMPONENT LOCATOR > ENGINE IDENTIFICATION > ENGINE VERIFICATION LABEL

The engine verification label is located in two places on the engine and consists of the broadcast code and bar code. This label is used in engine and vehicle assembly plants and is not intended to be permanent. If it is missing refer back to the engine block VIN pad for the permanent ID.

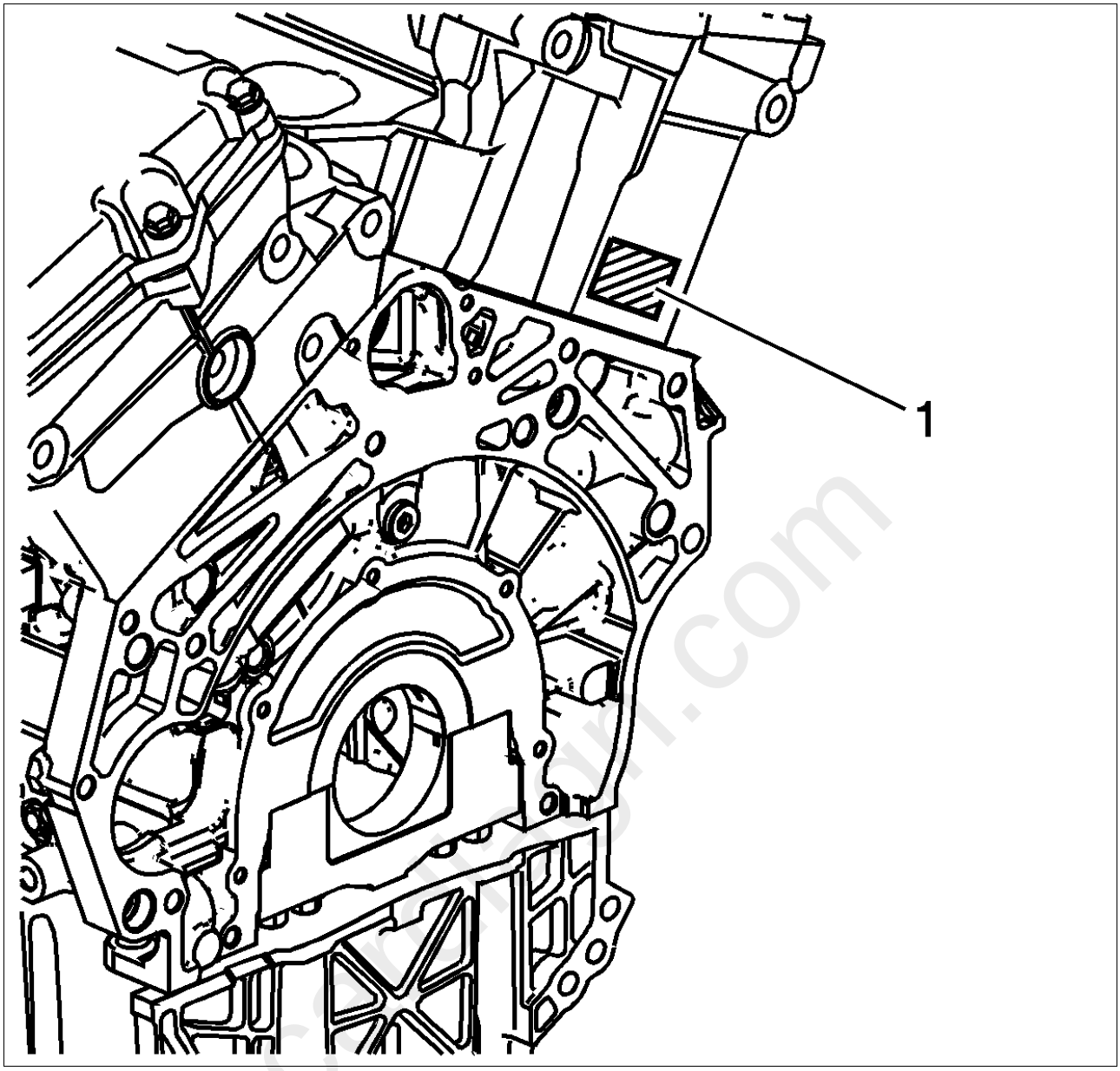
Fig 1: Left Engine Verification Label



Courtesy of GENERAL MOTORS COMPANY

One engine verification label (1) is located on the left side of the engine front cover below the exhaust camshaft position sensor. This label is used in engine and vehicle assembly plants and is not intended to be permanent. If it is missing refer back to the engine block VIN pad for the permanent ID.

Fig 2: Engine Verification Label On Rear Of Right Cylinder Head



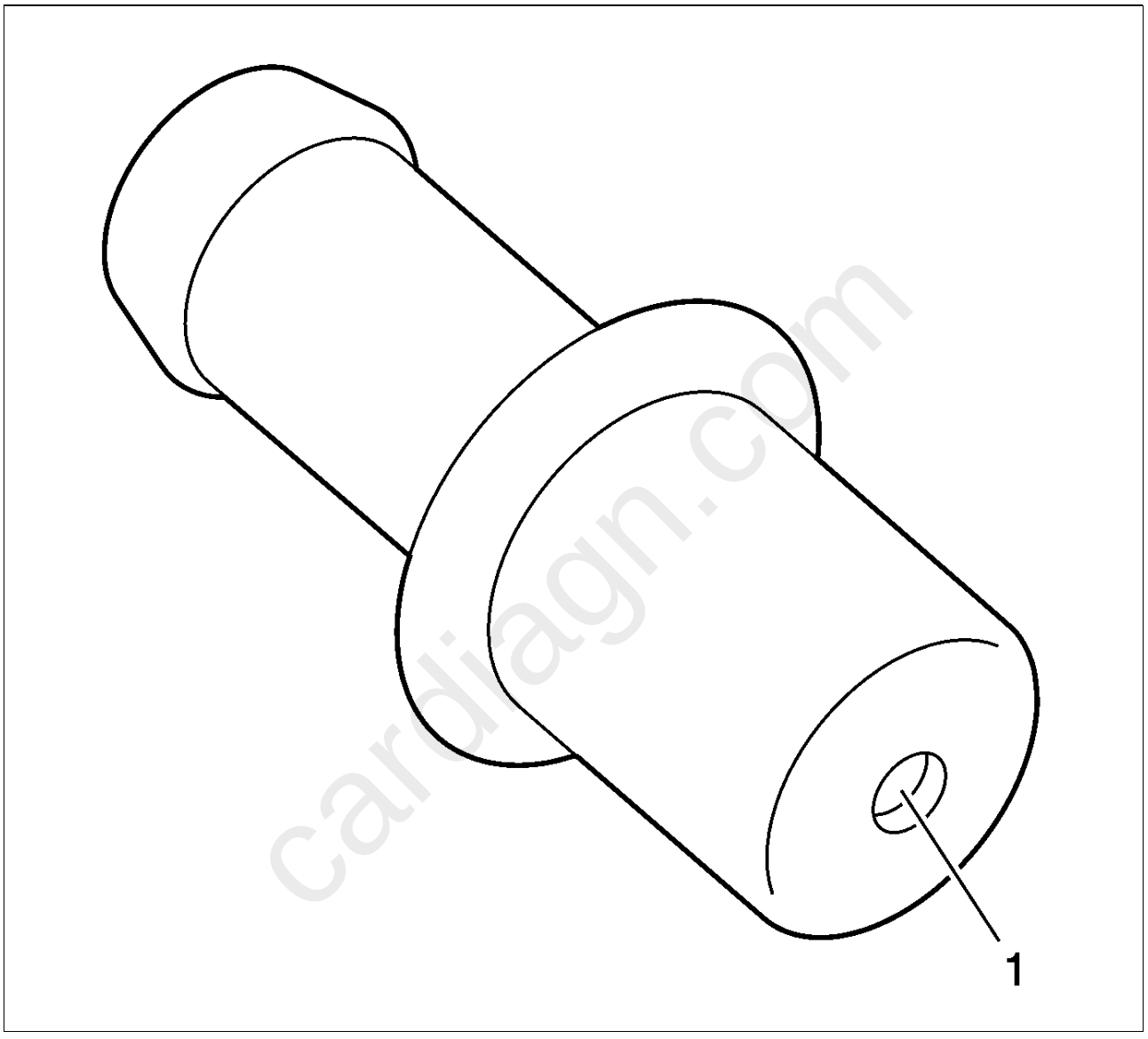
Courtesy of GENERAL MOTORS COMPANY

Another engine verification label (1) is located on the rear of the right cylinder head. This label is used in engine and vehicle assembly plants and is not intended to be permanent. If it is missing refer back to the engine block VIN pad for the permanent ID.

Service Manual: ENGINE MECHANICAL - 3.6L (LGX) -
DESCRIPTION AND OPERATION

DESCRIPTION AND OPERATION > CRANKCASE VENTILATION SYSTEM DESCRIPTION

Fig 1: PCV Orificed Tube



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Courtesy of GENERAL MOTORS COMPANY

A crankcase ventilation system is used to consume crankcase vapors created during the combustion process instead of venting them to the atmosphere.

Fresh air is supplied through a filter to the crankcase, the crankcase mixes the fresh air with the blow-by gases and then passed through a positive crankcase ventilation (PCV) orificed tube into the intake manifold.

The PCV orificed tube restricts the flow rate of the blow-by gases using an orifice (1) located at the end of the tube. If abnormal operating conditions arise, the system is designed to allow excessive amounts

of blow-by gases to back flow through the crankcase vent tube into the throttle body in order to be consumed by normal combustion.

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 balancer pulley
- The accessory drive component mounting brackets
- The accessory drive components
    - The power steering pump, if belt driven
    - The generator
    - The A/C compressor, if equipped
    - The engine cooling fan, if belt driven
    - The water pump, if belt driven
    - The vacuum pump, if equipped
    - The air compressor, if equipped

The drive belt system may use 1 belt or 2 belts. The drive belt is thin so that it can bend backwards and has several ribs to match the grooves in the pulleys. The drive belts are made of different types of rubbers, chloroprene or EPDM, and have different layers or 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.

DESCRIPTION AND OPERATION > ENGINE COMPONENT DESCRIPTION

The High Feature V6 (VIN Code Identifier "S") RPO LGX is a 3.6 Liter VVT (Variable Valve Timing)

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engine with direct injection. The direct injection system places the high pressure injectors in the cylinder heads. This engine incorporates 2 intake and 2 exhaust valves per cylinder, and uses a dual overhead cam design with individual intake and exhaust camshafts. A camshaft position actuator is mounted on each camshaft. The cylinders are arranged in 2 banks of 3 with a 60 degree included angle. The right bank of cylinders are number 1-3-5 and the left bank of cylinders are 2-4-6, viewed from the flywheel end of the engine. The engine firing order is 1-2-3-4-5-6.

DESCRIPTION AND OPERATION > ENGINE COMPONENT DESCRIPTION > ACTIVE FUEL MANAGEMENT SYSTEM (AFM)

The AFM consists of the camshafts, valves, the switching roller finger followers (SRFF), also known as the valve switching rocker arm, the dual feed hydraulic lash adjusters and the oil control valve (OCV) which is also known as the valve rocker arm oil control valve.

Depending on engine RPM, the ECM sends a signal to the OCV commanding it either ON or OFF.

With the AFM system ON, the OCV directs oil to the dual feed hydraulic lash adjuster unlatching the switching roller finger followers creating zero lift and not allowing the valves to open on cylinders two and five. AFM is active at this time.

With the AFM system off, the OCV is not active and no oil is directed to the dual feed hydraulic lash adjuster. The switching roller finger followers operate as a normal rocker arm and all valves open 11.5 mm of lift at 90° BTDC. AFM is inactive at this time.

DESCRIPTION AND OPERATION > ENGINE COMPONENT DESCRIPTION > CAMSHAFT DRIVE SYSTEM

The camshaft drive system consists of two timing drive chains driven by the crankshaft which drives the respective cylinder head's intake and exhaust camshaft position actuators. Cushioned actuator chain sprockets have been added contributing to quieter engine operation.

The timing drive chains use moveable timing drive chain guides and a hydraulic-actuated tensioner. The tensioner minimizes timing drive chain noise and provides accurate valve action by keeping slack out of the timing drive chains and continuously adjusting for timing drive chain wear. The tensioner incorporates a plunger that adjusts out with wear allowing only a minimal amount of backlash. All tensioners are sealed to the head or block using a rubber coated steel gasket. The gasket traps an adequate oil reserve to ensure quiet start-up.

DESCRIPTION AND OPERATION > ENGINE COMPONENT DESCRIPTION > CAMSHAFT POSITION ACTUATOR SYSTEM

The engine incorporates a camshaft position actuator for each intake and exhaust camshaft. Camshaft phasing changes valve timing as engine operating conditions vary. Dual camshaft phasing allows the further optimization of performance, fuel economy and emissions without compromising overall engine response and drivability. Variable valve timing also contributes to a reduction in exhaust emissions. It optimizes exhaust and inlet valve overlap and eliminates the need for an exhaust gas recirculation (EGR) system.

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The camshaft position actuator is a hydraulic vane-type actuator that changes the camshaft lobe timing relative to the camshaft drive sprocket. Engine oil is directed by a camshaft position actuator oil control valve to the appropriate passages in the camshaft position actuator. Oil acting on the vane in the camshaft position actuator rotates the camshaft relative to the sprocket. At idle, both camshafts are at the default or "home" position. At this position, the exhaust camshaft is fully advanced and the intake is fully retarded to minimize valve overlap for smooth idle. In addition, this engine has intermediate park technology, which incorporates an intermediate-lock intake variable valve timing cam phaser, allowing the cams to be parked at the most favorable position for cold starting. Under other engine operating conditions, the camshaft position actuator is controlled by the engine control module (ECM) to deliver optimal intake and exhaust valve timing for performance, drivability and fuel economy. The camshaft position actuator incorporates an integral trigger wheel, which is sensed by the camshaft position sensor mounted in the front cover, to accurately determine the position of each camshaft. The exhaust camshaft position actuator has a different internal configuration than the intake camshaft position actuator since the exhaust camshaft position actuator phases in the opposite direction relative to the inlet camshaft position actuator.

The camshaft position actuator oil control valve (OCV) directs oil from the oil feed in the head to the appropriate camshaft position actuator oil passages. There is one OCV for each camshaft position actuator. The OCV is sealed and mounted to the front cover. The ported end of the OCV is inserted into the cylinder head with a sliding fit. A filter screen protects each OCV oil port from any contamination in the oil supply.

DESCRIPTION AND OPERATION > ENGINE COMPONENT DESCRIPTION > CONNECTING RODS AND PISTONS

The connecting rods are sinter-forged with a high copper content and have press-in-place piston pin bushings. The connecting rods and rod cap are aligned by dowel pins retained in the cap. The cast aluminum pistons incorporate a polymer-coated skirt to reduce friction. The pistons are unique to the LGX both for compression ratio and combustion efficiency. The piston uses two low tension compression rings and one multi-piece oil control ring.

DESCRIPTION AND OPERATION > ENGINE COMPONENT DESCRIPTION > COOLING SYSTEM

This engine has a targeted cooling system which sends coolant simultaneously to each water jacket in the heads and block. This new, parallel-flow design maximizes heat extraction in the area of the upper deck, intake and exhaust valve bridges in the heads and integrated exhaust manifold with a minimal amount of coolant. The result is more even and consistent cooling, which enhances performance, and faster engine warm up, which improves cold-start efficiency and reduces emissions.

DESCRIPTION AND OPERATION > ENGINE COMPONENT DESCRIPTION > CRANKCASE

The cylinder block is constructed of aluminum alloy by precision sand-casting with cast in place iron cylinder liners. Each nodular main bearing cap incorporates 6 bolts bolting the cap into the engine block. Along with 2 outer and 2 inner bolts, 2 side bolts are used in the deep skirt block. To prevent aeration, oil

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return from the valve train and cylinder heads is channeled away from the rotating and reciprocating components through oil drain back passages incorporated into the cylinder heads and engine block. Pressure-actuated piston oil cooling jets are mounted between opposing cylinders. Twin knock sensors are located in the valley of the block between the cylinder heads. The knock sensors have an acoustic foam noise barrier that surrounds them in the valley.

DESCRIPTION AND OPERATION > ENGINE COMPONENT DESCRIPTION > CRANKSHAFT

The crankshaft is a hardened, forged steel design with 4 main bearings. Crankshaft thrust is controlled by the upper portion of the number 3 main bearing. The crankshaft position reluctor wheel is pressed onto the rear of the crankshaft in front of the rear main journal. A micro encapsulated adhesive is used on the reluctor wheel to aid retention. This crankshaft is internally balanced.

DESCRIPTION AND OPERATION > ENGINE COMPONENT DESCRIPTION > CYLINDER HEADS

The cylinder heads are a two piece design consisting of a head and a camshaft carrier which are cast aluminum with powdered metal valve seat inserts and valve guides. The two piece design allows for the Active Fuel Management (AFM) System. The cylinder heads also feature integrated exhaust manifolds; the exhaust manifolds are incorporated into the head casting. Two intake valves and two exhaust valves are actuated by roller finger followers pivoting on a stationary hydraulic lash adjuster (SHLA). In the LGX engine, the valves and seats are constructed with specialized materials and coatings, and the exhaust valves are sodium filled for robustness. The cylinder heads also feature a "high-tumble" port design, and are sealed with LGX specific head gaskets. The head gaskets are also specific to the LH and RH sides.

Separate exhaust and intake camshafts are supported by bearings machined into the camshaft carrier. The front camshaft bearing cap is used as a thrust control surface for each camshaft. Each spark plug is shielded by a tube that is pressed into the cylinder head. Each spark plug ignition coil is also mounted through the spark plug tube. The LGX engine uses specific spark plugs and a different spark plug gap from other HFV6 engines. The engine coolant temperature (ECT) sensor is mounted in the thermostat housing near the flywheel end of the engine. With direct injection, the high pressure injectors are located in machined bores below the intake ports. A stainless steel, high pressure fuel rail is attached to the intake side of the head. The LGX engine has unique higher-flow injectors and fuel pump. The cylinder head has a larger bore for the new larger diameter fuel pump follower that operates the higher-flow pump. The fuel injectors are retained to the fuel rail in a new "twist-lock" retention scheme that does not require special tools for service.

DESCRIPTION AND OPERATION > ENGINE COMPONENT DESCRIPTION > OILING SYSTEM

The LGX engine contains a dual-pressure control and variable-displacement vane pump that enhances efficiency by optimizing oil pressure as a function of engine speed. The oil pump is located beneath the cylinder block inside the oil pan, contributing to the engines smoother and quieter operation. The oiling system components differ depending on the engine being in a transverse or longitudinal orientation. The LGX has unique oil pans depending on orientation, with the pans being separated into an upper

(traditional aluminum) and lower (stamped steel) pan. This configuration helps with noise and mass concerns. It also affords some serviceability improvements through not needing to remove the entire upper pan for some service procedures; the procedures can be performed through removing the lower pan. The LGX oil pans contain oil level switches as do nearly all HFV6 applications. The oil level switch is normally open and closes at oil levels above minimum requirements.

DESCRIPTION AND OPERATION > ENGINE COMPONENT DESCRIPTION > RIGHT AND LEFT BANK DESIGNATION

Right hand (RH) and left hand (LH) designation through the engine mechanical section are viewed from the rear, flywheel side, of the engine or from inside the vehicle. These banks are also referred to as Bank 1 (RH) and Bank 2 (LH).

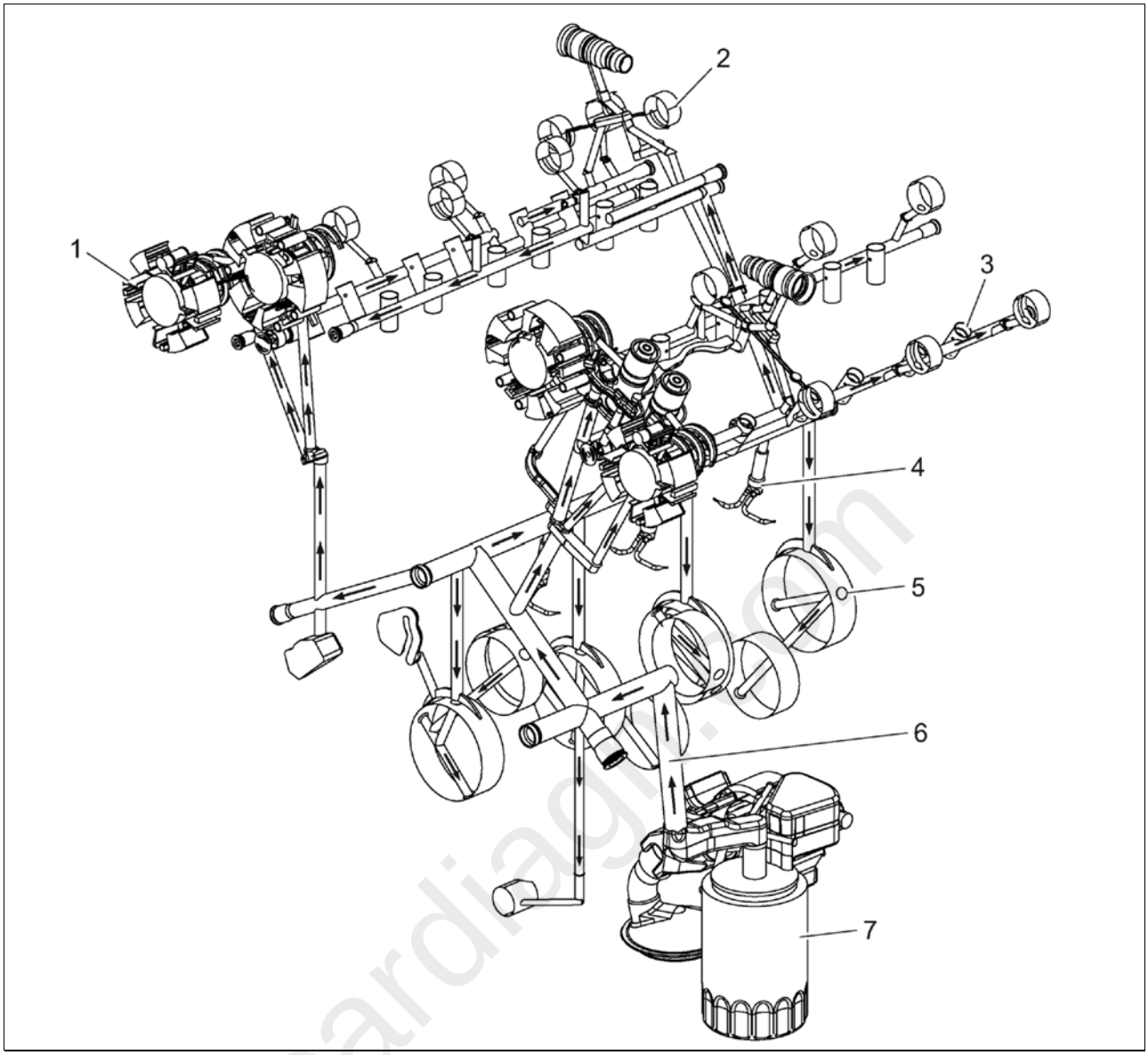
DESCRIPTION AND OPERATION > ENGINE COMPONENT DESCRIPTION > VACUUM PUMP

The HFV6 Gen 2 LGX engine utilizes a mechanical vacuum pump to provide a vacuum source for the braking system. The vacuum pump is integrated into the oil pump assembly located in the oil pan. Both vacuum pump and oil pump are part of a common assembly, referred to as a tandem pump. Neither pump is serviceable individually. If either the oil pump or vacuum pump are defective, replace the entire tandem pump assembly.

DESCRIPTION AND OPERATION > LUBRICATION DESCRIPTION > LUBRICATION DESCRIPTION

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Fig 1: Lubrication Description



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Phaser
2	Cam Bearing
3	Lifter Bore
4	Oil Squirter
5	Main Bearing
6	Pump Out
7	Filter

Engine lubrication is supplied by a variable displacement two-stage vane-type oil pump assembly. An oil

control solenoid valve, controlled by the engine control module (ECM) and mounted to the oil pump, will vary engine oil pressure according to engine needs based on speed and load. Oil pressure may change quickly as the engine speed or load varies. Oil pressure may also vary with outside temperature and oil viscosity. This is considered normal. The oil pump is mounted to the engine block oil pan rail and main bearing caps and is driven by a dedicated timing chain. The pump rotor and vanes rotate and draw oil from the oil pan sump through a pick-up screen and pipe. The oil is pressurized as it passes through the pump and is sent to the oil cooler if equipped for oil conditioning.

Pressurized oil is directed through the oil pan to the full flow oil filter (7) where harmful contaminants are removed. A bypass valve is incorporated into the oil filter, which permits oil flow in the event the filter becomes restricted. Oil exits the oil filter and is then directed to the main oil gallery. Oil from the main oil gallery is directed to the crankshaft bearings (5), piston oil nozzle (4) used for piston cooling under certain conditions, and the cylinder heads via drilled passages.

Oil that has entered the cylinder heads is used to actuate the camshaft position phasors (1), pressurize the hydraulic lash adjusters (3), lubricate the cam bearings (2) and valve train, and actuate cylinder deactivation and reactivation though ECM control of the active fuel management (AFM) oil control valves located on the camshaft covers. With active fuel management activated, the ECM commands the two AFM solenoids to open, directing oil through the camshaft cover and cylinder head oil galleries to deactivate the intake and exhaust valve for cylinders 2 and 5.

Oil returning to the pan is directed by the crankshaft oil deflector. The oil pressure sensor is located at the left front of the engine.

DESCRIPTION AND OPERATION > CLEANLINESS AND CARE

An automobile engine is a combination of many of the following surfaces:

- Machined
- Honed
- Polished
- Lapped

The tolerances of these surfaces are measured in the ten-thousandths of an inch. When you service any internal engine part, cleanliness and care are important. Apply a liberal coating of engine oil to the friction areas during assembly in order to protect and lubricate the surfaces on initial operation. Throughout this section, practice proper cleaning and protection procedures to the machined surfaces and to the friction areas.

> ⚠ *CAUTION:*
>
> *Engine damage may result if an abrasive paper, pad, or motorized wire brush is used to clean any engine gasket surfaces.*

Whenever you remove the valve train components, keep the components in order. Follow this procedure in order to install the components in the same locations and with the same mating surfaces as when removed.

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WARNING:

Refer to Battery Disconnect Warning .

Disconnect the negative battery cables before you perform any major work on the engine.

DESCRIPTION AND OPERATION > SEPARATING PARTS

In addition to the room temperature vulcanizing (RTV) sealant's sealing capabilities, the RTV sealants may form an adhesive bond between the components. This may make the components difficult to remove or to separate. Pry points have been provided in the components that utilize RTV as the sealing system. Pry points are positioned so they can be used without damaging other vital engine components.

DESCRIPTION AND OPERATION > REPLACING ENGINE GASKETS > SPECIAL TOOLS

EN-28410 Gasket Remover

For equivalent regional tools, refer to Special Tools .

DESCRIPTION AND OPERATION > REPLACING ENGINE GASKETS > GASKET REUSE AND APPLYING SEALANT

- 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 specified in the service procedure.

DESCRIPTION AND OPERATION > REPLACING ENGINE GASKETS > SEPARATING COMPONENTS

- Use incorporated pry points to separate components using an RTV sealing system.
- Do not try to separate RTV sealed components by prying against other engine components.
- Pry points are positioned so no other vital engine components are damaged when they are used.

DESCRIPTION AND OPERATION > REPLACING ENGINE GASKETS > CLEANING GASKET SURFACES

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- Use care to avoid gouging or scraping the sealing surfaces.
- Use a plastic or wood scraper in order to remove all the sealant from the components.

  Do not use any other method or technique to remove the sealant or the 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 engine oil.

      This fine grit is an abrasive and can cause internal engine damage.

DESCRIPTION AND OPERATION > REPLACING ENGINE GASKETS > ASSEMBLING COMPONENTS

- Assemble components using only the sealant, or equivalent, that is specified in the service procedure.
- Sealing surfaces must 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.
- Apply only the amount of sealant specified in the service procedure to a component.
- Do not allow the sealant to enter into any blind threaded holes, as the sealant may prevent the fastener from clamping properly or cause component damage when tightened.

> *NOTE:*
>
> *Do not overtighten the fasteners.*

- Tighten the fasteners to the proper specifications.

DESCRIPTION AND OPERATION > USE OF ROOM TEMPERATURE VULCANIZING (RTV) AND ANAEROBIC SEALANT > CLEANING MATING PART SURFACES FOR RTV JOINTS

RTV sealant depends greatly on adhesion to the mating parts in order to form and maintain a robust sealed joint. As with any adhesion system, proper surface preparation of the bonded parts is extremely important to ensure good adhesion over the life of the product.

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⚠ *CAUTION:*

When cleaning the sealing surfaces of engine components, DO NOT use bristle discs, abrasive pads, wire wheels or surface conditioning discs. These types of devices should not be used because they produce a very fine grit that is abrasive and known to cause internal engine damage. The bristle discs and pads are embedded with abrasive material and wear down as they clean, continually exposing fresh abrasive to the surface of the component.

Abrasive pads, wire wheels and bristle discs can remove enough metal to affect the engine front cover, cylinder head, engine block, oil pan rail, and intake manifold runner surface flatness, which can then result in engine coolant leaks, engine oil leaks and air leaks. It takes about 15 seconds to remove 0.203 mm (0.008 in) of metal with an abrasive pad.

Abrasive pads, wire wheels and bristle discs used with high speed grinders produce airborne debris that can travel throughout the shop contaminating other work being performed outside of the immediate work area.

When cleaning engine gasket sealing surfaces and/or cleaning parts from an engine that are to be reused, surface conditioning discs, typically constructed of woven fiber or molded bristles that contain abrasives, such as a high amount of aluminum oxide, should NOT be used. The use of such surface conditioning discs dislodges aluminum oxide from the disk and metal component particles, which can lead to premature engine bearing failure. The presence of aluminum oxide in engine oil has been shown to cause premature engine bearing failure. In some cases, this failure occurs in as little as 1, 600 km (1, 000 mi) or less after the repair has been made.

Surface conditioning discs may grind the component material and embed it into the disc. This can result when more aggressive grinding of the gasket surface takes place.

General Motors strongly recommends using a plastic razor blade, plastic gasket scraper, a wood scraper or a non-metallic scraper to remove all sealer/gasket material on the surface of engine components that are to be reused. Do not use any other method or technique to remove the sealant or the gasket material from a part.

- Do not gouge or scratch any engine sealing surface during the cleaning process.
- It is not necessary to remove every speck of the old sealer.

To remove the old RTV sealant from the sealing surface, spray GM Low VOC Cleaner or an equivalent, on the mating surfaces and allow it to soak to loosen the old gasket material. Use care to avoid getting GM Low VOC Cleaner in any area other than the mating surface to be cleaned.

Use a plastic razor blade, that mounts in a scraper device or a hand held plastic razor blade, to remove old RTV sealant from a sealing surface. Use a new blade for each corresponding engine component surface. Hold the blade as parallel to the flat surface as possible.

To properly clean the sealing surfaces prior to reassembly, spray GM Low VOC Cleaner on a folded lint free shop cloth. Wipe the mating surfaces on the engine and front cover and rotate the shop cloth until there are no more visible signs of contamination on the cloth.

After the final cleaning of the parts, allow up to 5 minutes for the components to dry before applying new RTV sealant.

NOTE:

After the final cleaning with GM Low VOC Cleaner and before reassembly, DO NOT touch the cleaned surfaces with your hand. Oils from your skin WILL CONTAMINATE the surface and prevent proper bonding of the new RTV sealant.

DESCRIPTION AND OPERATION > USE OF ROOM TEMPERATURE VULCANIZING (RTV) AND ANAEROBIC SEALANT > TYPICAL APPLICATIONS

This procedure is intended for use in the following operations:

- Building of engines in a manual low volume build process where the use of assembly lubricants and other typical conditions exist which may contaminate the component sealing surfaces in an RTV joint.
- Cleaning of surfaces contaminated with oil or other substance during the assembly operation as a special case event.

In the typical situation, both the part being assembled, and the assembly to which it is to be sealed will be cleaned. An example is an oil pan assembled to a block/front cover/rear cover assembly using an RTV seal applied to the pan or the block. Both the pan and the block assembly should be cleaned prior to RTV application.

Any loose gaskets that are part of the RTV joint should not be cleaned unless it is known that they have been contaminated during the build process. Examples of loose gaskets are intake side and end seals which contact RTV used to seal a T-joint.

Assemblies supplied to GM with gaskets in place should not be cleaned unless they are known to be contaminated during the build process. Examples are rocker/cam covers with press in place gaskets using RTV at corners or T-joints.

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DESCRIPTION AND OPERATION > USE OF ROOM TEMPERATURE VULCANIZING (RTV) AND ANAEROBIC SEALANT > MATERIALS NEEDED

Use clean dry lint free cloths to wipe surface with approved solvent based cleaner. Examples are:

- GM Good Wrench Service Low VOC Brake Parts Cleaner
- AC Delco Non-Chlorinated Brake Parts Cleaner
- Loctite ODC -Free Cleaner & Degreaser

Procedure:

1. Identify the surfaces to which the RTV will come into contact in the assembled joint.
2. Using an approved solvent based cleaner, thoroughly soak an appropriate portion of a clean, dry cloth. Immediately wipe the surfaces with the cloth to remove any residue of oil, soap, etc.

3. Repeat step 2 using a clean portion of the cloth as many times as required until the cleanliness of the cloth after wiping the surface becomes constant in appearance. There is typically some discoloration of the cloth after wiping however a clean surface should produce the same level of discoloration with successive wiping with a clean cloth and solvent.
4. If crevices exist in the joint such that wiping the surface would not be sufficient to clean the crevice, the approved solvent based cleaner should be directly sprayed on the joint to ensure wetting of the surfaces and removal of the contaminant. DO NOT spray rubber components directly. Care must be used to avoid getting solvent in areas other than necessary to clean the joint. Then continue with step 3.
5. Allow the surfaces to dry for a minimum of 1 minute or longer if necessary for the solvent to evaporate from the surface.
6. Do not touch the cleaned surface with anything prior to RTV application.
7. The surface is now prepared for RTV application.

DESCRIPTION AND OPERATION > USE OF ROOM TEMPERATURE VULCANIZING (RTV) AND ANAEROBIC SEALANT > SEALANT TYPES

NOTE:

The correct sealant and amount of sealant must be used in the proper location to prevent oil leaks, coolant leaks, or the loosening of the fasteners. DO NOT interchange the sealants. Use only the sealant, or equivalent, as specified in the service procedure.

The following two major types of sealant are commonly used in engines:

- Room Temperature Vulcanizing (RTV)
- Anaerobic sealant, which include the following:
    - Gasket Eliminator
    - Pipe Sealant
    - Threadlock

Room Temperature Vulcanizing (RTV) Sealer

This type of sealant is used where two components, such as the intake manifold and the engine block, are assembled together.

Use the following information when using RTV sealant:

- Do not use RTV sealant in areas where extreme temperatures are expected. These areas include:
    - The exhaust manifold
    - The head gasket

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    - Any other surfaces where a different type of sealant is specified in the service procedure

- Do not use RTV sealant unless the ambient air temperature is at least 18°C (65°F) degrees or higher.
- Always follow all the safety recommendations and the directions that are on the RTV sealant container.
- Use a plastic or wood scraper in order to remove all the RTV sealant from the components.

> ⚠ *CAUTION:*
>
> *Do not allow the RTV sealant to enter any blind threaded hole. RTV sealant that is allowed to enter a blind threaded hole can cause hydraulic lock of the fastener when the fastener is tightened. Hydraulic lock of a fastener can lead to damage to the fastener and/or the components. Hydraulic lock of a fastener can also prevent the proper clamping loads to be obtained when the fastener is tightened. Improper clamping loads can prevent proper sealing of the components allowing leakage to occur. Preventing proper fastener tightening can allow the components to loosen or separate leading to extensive engine damage.*

> 📌 *NOTE:*
>
> *The bead size is critical and is easier to maintain consistency and application with a RTV dispensing tool. This also helps to eliminate waste.*

- The surfaces to be sealed must be clean and dry.
- Use a RTV sealant bead size as specified in the service procedure.
- Apply the RTV sealant bead to the inside of any bolt holes areas.

> 📌 *NOTE:*
>
> *Do not wait for the RTV sealant to skin over.*

- Assemble the components while the RTV sealant is still wet to the touch, within 10 minutes.

> 📌 *NOTE:*
>
> *Do not overtighten the fasteners.*

- Tighten the fasteners in sequence, if specified, and to the proper torque specifications.

Anaerobic Type Gasket Eliminator Sealant

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Anaerobic type gasket eliminator sealant cures in the absence of air. This type of sealant is used where two rigid parts, such as castings, are assembled together. When two rigid parts are disassembled and no sealant or gasket is readily noticeable, then the two parts were probably assembled using an anaerobic type gasket eliminator sealant.

Use the following information when using gasket eliminator sealant:

- Always follow all the safety recommendations and directions that are on the gasket eliminator sealant container.
- Apply a continuous bead of gasket eliminator sealant to one flange.
- The surfaces to be sealed must be clean and dry.

> ⚠ *CAUTION:*
>
> *Do not allow the sealant to enter a blind hole. The sealant may prevent the fastener from achieving proper clamp load, cause component damage when the fastener is tightened, or lead to component failure.*

- Do not allow the gasket eliminator sealed joint to cure more than 5 minutes before torquing to specification. This will result in an incorrect clamp load of assembled components.
- Do not overtighten the fasteners.
    - Apply the gasket eliminator sealant evenly to get a uniform thickness of the gasket eliminator sealant on the sealing surface.
    - Tighten the fasteners in sequence, if specified, and to the proper torque specifications.
    - After properly tightening the fasteners, remove the excess gasket eliminator sealant from the outside of the joint.

Anaerobic Type Threadlock Sealant

Anaerobic type threadlock sealant cures in the absence of air. This type of sealant is used for threadlocking and sealing of bolts, fittings, nuts, and studs. This type of sealant cures only when confined between two close fitting metal surfaces.

Use the following information when using threadlock sealant:

- Always follow all safety recommendations and directions that are on the threadlock sealant container.
- The threaded surfaces to be sealed must be clean and dry.
- Apply the threadlock sealant as specified on the threadlock sealant container.

> *NOTE:*
>
> - *Do not allow the threadlock sealant to cure more than 5 minutes before torquing to specification. This will result in an incorrect clamp load of assembled components.*

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- *Do not overtighten the fasteners.*

- Tighten the fasteners in sequence, if specified, and to the proper torque specifications.

Anaerobic Type Pipe Sealant

Anaerobic type pipe sealant cures in the absence of air and remains pliable when cured. This type of sealant is used where two parts are assembled together and require a leak proof joint.

Use the following information when using pipe sealant:

- Do not use pipe sealant in areas where extreme temperatures are expected. These areas include:
    - The exhaust manifold
    - The head gasket
    - Surfaces where a different sealant is specified
- Always follow all the safety recommendations and the directions that are on the pipe sealant container.
- The surfaces to be sealed must be clean and dry.
- Use a pipe sealant bead of the size or quantity as specified in the service procedure.

> ⚠ *CAUTION:*
>
> *Do not allow the sealant to enter a blind hole. The sealant may prevent the fastener from achieving proper clamp load, cause component damage when the fastener is tightened, or lead to component failure.*

- Apply the pipe sealant bead to the inside of any bolt hole areas.
- Apply a continuous bead of pipe sealant to one sealing surface.

> *NOTE:*
>
> *Do not overtighten the fasteners.*

- Tighten the fasteners in sequence, if specified, and to the proper torque specifications.

DESCRIPTION AND OPERATION > 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 designed to quickly and safely accomplish the operations for which they are intended. The use of these special tools 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

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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 component cleaning tank
    - A compressed air supply
    - Trays or storage containers to keep components and fasteners organized
    - An adequate set of hand tools
    - Approved engine repair stand
    - An approved engine lifting device that adequately supports the weight of the components

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Service Manual: ENGINE MECHANICAL - 3.6L (LGX) -
DIAGNOSTIC INFORMATION AND PROCEDURES

DIAGNOSTIC INFORMATION AND PROCEDURES > SYMPTOMS - ENGINE MECHANICAL > STRATEGY BASED DIAGNOSTICS

1. Perform a 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 , Drive Belt System Description , and Lubrication Description .

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

DIAGNOSTIC INFORMATION AND PROCEDURES > SYMPTOMS - ENGINE MECHANICAL > VISUAL/PHYSICAL INSPECTION

- Inspect for aftermarket devices which could affect the operation of the engine. Refer to Checking Aftermarket Accessories .
- 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.

DIAGNOSTIC INFORMATION AND PROCEDURES > SYMPTOMS - ENGINE MECHANICAL > INTERMITTENT

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

DIAGNOSTIC INFORMATION AND PROCEDURES > SYMPTOMS - ENGINE MECHANICAL > SYMPTOM LIST

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

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- 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

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DIAGNOSTIC INFORMATION AND PROCEDURES > DTC P06DA-P06DC: ENGINE OIL PRESSURE CONTROL SOLENOID VALVE > DIAGNOSTIC INSTRUCTIONS

- Perform the Diagnostic System Check - Vehicle prior to using this diagnostic procedure.
- Review Strategy Based Diagnosis for an overview of the diagnostic approach.
- Diagnostic Procedure Instructions provides an overview of each diagnostic category.

DIAGNOSTIC INFORMATION AND PROCEDURES > DTC P06DA-P06DC: ENGINE OIL PRESSURE CONTROL SOLENOID VALVE > DTC DESCRIPTORS

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

DIAGNOSTIC INFORMATION AND PROCEDURES > DTC P06DA-P06DC: ENGINE OIL PRESSURE CONTROL SOLENOID VALVE > CIRCUIT/SYSTEM DESCRIPTION

The engine oil pressure control solenoid is a two port solenoid valve used to control engine oil pressure inside the mechanical engine oil pump. The ECM controls the commanded states of the engine oil pressure control solenoid with the following ECM input's.

- Engine Speed
- Engine Oil Temperature (calculated from the Engine Coolant Temperature Sensor)
- Engine Oil Pressure
- Engine Run Time

With the engine oil pressure control solenoid commanded Off, engine oil pressure is higher. When commanded On engine oil pressure is lower. The purpose of this diagnostic is to isolate either a stuck on or stuck off engine oil pressure control solenoid.

DIAGNOSTIC INFORMATION AND PROCEDURES > DTC P06DA-P06DC: ENGINE OIL PRESSURE CONTROL SOLENOID VALVE > CONDITIONS FOR RUNNING THE DTC

- The system voltage is greater than 11 V.
- DTC P06DA, P06DB or P06DC runs continuously when the above conditions are met.

DIAGNOSTIC INFORMATION AND PROCEDURES > DTC P06DA-P06DC: ENGINE OIL PRESSURE CONTROL SOLENOID VALVE > CONDITIONS FOR SETTING THE DTC

The ECM detects that the commanded state of the driver and the actual state of the control circuit do not match for a minimum of 0.25 s.

DIAGNOSTIC INFORMATION AND PROCEDURES > DTC P06DA-P06DC: ENGINE OIL PRESSURE CONTROL SOLENOID VALVE > ACTION TAKEN WHEN THE DTC SETS

- DTC P06DA, P06DB and P06DC are Type B DTCs.
- ECM commands the engine oil pressure control solenoid valve OFF.
- ECM commands Reduced Engine Power.

DIAGNOSTIC INFORMATION AND PROCEDURES > DTC P06DA-P06DC: ENGINE OIL PRESSURE CONTROL SOLENOID VALVE > CONDITIONS FOR CLEARING THE MIL/DTC

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- DTC P06DA, P06DB and P06DC are Type B DTCs.

DIAGNOSTIC INFORMATION AND PROCEDURES > DTC P06DA-P06DC: ENGINE OIL PRESSURE CONTROL SOLENOID VALVE > REFERENCE INFORMATION

Schematic Reference

Engine Mechanical Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

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 for scan tool information

DIAGNOSTIC INFORMATION AND PROCEDURES > DTC P06DA-P06DC: ENGINE OIL PRESSURE CONTROL SOLENOID VALVE > CIRCUIT/SYSTEM VERIFICATION

1. Ignition ON.
2. Verify the parameters listed below do not display Malfunction when commanding the Engine Oil Pressure Control Solenoid Valve ON and OFF with a scan tool.
    1. Engine Oil Pressure Control Solenoid Valve Control Circuit Low Voltage Test Status
    2. Engine Oil Pressure Control Solenoid Valve Control Circuit Open Test Status
    3. Engine Oil Pressure Control Solenoid Valve Control Circuit High Voltage Test Status
        1. **If Malfunction is displayed**

            Refer to Circuit/System Testing.

        1. **If Malfunction is not displayed**
3. 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.

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4. Verify the DTC does not set.
    1. **If any DTC sets**

       Refer to Circuit/System Testing.

    1. **If the DTC does not set**
5. All OK.

DIAGNOSTIC INFORMATION AND PROCEDURES > DTC P06DA-P06DC: ENGINE OIL PRESSURE CONTROL SOLENOID VALVE > CIRCUIT/SYSTEM TESTING

1. Ignition OFF, disconnect the oil pressure control solenoid jumper harness X162 located at engine front lower right. Refer to Master Electrical Component List .
2. Ignition ON.
3. Verify that a test lamp illuminates between the ignition circuit terminal 1 and ground.
    1. **If the test lamp does not illuminate and the circuit fuse is good**

       NOTE:

       An internal short in any component supplied by the fuse may cause the fuse to open and set a DTC when the component is activated.

        1. Ignition OFF.
        2. Test for less than 2 Ω in the ignition circuit end to end.
            1. If 2 Ω or greater, repair the open/high resistance in the circuit.
            2. If less than 2 Ω verify the fuse is not open and there is voltage at the fuse.
    1. **If the test lamp does not illuminate and the circuit fuse is open**
        1. Ignition OFF.
        2. Test for infinite resistance between the ignition circuit and ground
            1. If less than infinite resistance, repair the short to ground in the circuit.
            2. If infinite resistance, test all the components connected to fuse and replace as necessary.
    1. **If the test lamp illuminates**
4. Verify that a test lamp does not illuminate between the ignition circuit terminal 1 and the control circuit terminal 2.
    1. **If the test lamp illuminates**

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1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
2. Test for infinite resistance between the control circuit and ground.
    1. If less than infinite resistance, repair the short to ground on the circuit.
    2. If infinite resistance, replace the K20 Engine Control Module.

1. **If the test lamp does not illuminate**

5. Command the Q44 Engine Oil Pressure Control Solenoid Valve ON with a scan tool.
6. Verify the scan tool Engine Oil Pressure Control Solenoid Valve Control Circuit High Voltage Test Status parameter displays OK.
    1. **If OK is not displayed**
        1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
        2. Test for less than 1 V between the control circuit and ground.
            1. If 1 V or greater, repair the short to voltage on the circuit.
            2. If less than 1 V, replace the K20 Engine Control Module.

    1. **If OK is displayed**

7. Install a 3 A fused jumper wire between the control circuit terminal 2 and the ignition circuit terminal 1.
8. Verify the scan tool Engine Oil Pressure Control Solenoid Valve Circuit High Voltage Test Status parameter is displaying Malfunction when commanding the Engine Oil Pressure Control Solenoid Valve ON and OFF with a scan tool.
    1. **If Malfunction is not displayed**
        1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module.
        2. Test for less than 2 Ω in the control circuit end to end.
            1. If 2 Ω or greater, repair the open/high resistance in the circuit.
            2. If less than 2 Ω replace the K20 Engine Control Module.

    1. **If Malfunction is displayed**

9. Test or replace the Q44 Engine Oil Pressure Control Solenoid Valve.

DIAGNOSTIC INFORMATION AND PROCEDURES > DTC P06DA-P06DC: ENGINE OIL PRESSURE CONTROL SOLENOID VALVE > COMPONENT TESTING

Static Test

1. Ignition OFF, disconnect the harness connector at the Q44 Engine Oil Pressure Control

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Solenoid Valve.

2. Test for 10-30 Ω between the control terminal 2 and the ignition voltage terminal 1.
    1. **If not between 10-30 Ω**

       Replace the Q44 Engine Oil Pressure Control Solenoid Valve.

    1. **If between 10-30 Ω**
3. Test for infinite resistance between each terminal and the Q44 Engine Oil Pressure Control Solenoid Valve housing.
    1. **If not OL**

       Replace the Q44 Engine Oil Pressure Control Solenoid Valve.

    1. **If OL**
4. All OK.

DIAGNOSTIC INFORMATION AND PROCEDURES > DTC P06DA-P06DC: ENGINE OIL PRESSURE CONTROL SOLENOID VALVE > REPAIR INSTRUCTIONS

Perform the Diagnostic Repair Verification after completing the repair.

- Oil Pump Flow Control Valve Replacement Engine Oil Pressure Control Solenoid Valve Replacement.
- Engine Control Module Replacement for engine control module replacement, programming, and setup.

DIAGNOSTIC INFORMATION AND PROCEDURES > DTC P06DD OR P06DE: ENGINE OIL PRESSURE CONTROL SOLENOID VALVE STUCK > DIAGNOSTIC INSTRUCTIONS

- Perform the Diagnostic System Check - Vehicle prior to using this diagnostic procedure.
- Review Strategy Based Diagnosis for an overview of the diagnostic approach.
- Diagnostic Procedure Instructions provides an overview of each diagnostic category.

DIAGNOSTIC INFORMATION AND PROCEDURES > DTC P06DD OR P06DE: ENGINE OIL PRESSURE CONTROL SOLENOID VALVE STUCK > DTC DESCRIPTORS

DTC P06DD

Engine Oil Pressure Control Solenoid Valve Stuck Off

DTC P06DE

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DIAGNOSTIC INFORMATION AND PROCEDURES > DTC P06DD OR P06DE: ENGINE OIL PRESSURE CONTROL SOLENOID VALVE STUCK > CIRCUIT/SYSTEM DESCRIPTION

The engine oil pressure control solenoid is a two port solenoid valve used to control engine oil pressure inside the mechanical engine oil pump. The ECM controls the commanded states of the engine oil pressure control solenoid with the following ECM input's.

- Engine Speed
- Engine Oil Temperature (calculated from the Engine Coolant Temperature Sensor)
- Engine Oil Pressure
- Engine Run Time

With the engine oil pressure control solenoid commanded Off, engine oil pressure is higher. When commanded On engine oil pressure is lower. The purpose of this diagnostic is to isolate either a stuck on or stuck off engine oil pressure control solenoid.

DIAGNOSTIC INFORMATION AND PROCEDURES > DTC P06DD OR P06DE: ENGINE OIL PRESSURE CONTROL SOLENOID VALVE STUCK > CONDITIONS FOR RUNNING THE DTC

P06DD

- DTC P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0117, P0118, P0119, P0128, P0335, P0336, P0521, P0522, P0523, P06DA, P06DB, P06DC, P06DD, P06DE, P111E, P2227, P2228, P2229 or P2230 is not set.
- Engine speed within range of 1, 500 RPM to 2, 500 RPM.

P06DE

- DTC P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0117, P0118, P0119, P0128, P0335, P0336, P0521, P0522, P0523, P06DA, P06DB, P06DC, P06DD, P06DE, P111E, P2227, P2228, P2229 or P2230 is not set.
- Engine running for greater than 20 s.
- Engine speed is within range of 1500 RPM to 2500 RPM.
- Engine oil pressure control solenoid in low pressure for greater than 1.5 s.

DIAGNOSTIC INFORMATION AND PROCEDURES > DTC P06DD OR P06DE: ENGINE OIL PRESSURE CONTROL SOLENOID VALVE STUCK > CONDITIONS FOR SETTING

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THE DTC

P06DD or P06DE

Engine oil pressure is above or below a calibrated amount during the time the solenoid is changing from ON to OFF states.

DIAGNOSTIC INFORMATION AND PROCEDURES > DTC P06DD OR P06DE: ENGINE OIL PRESSURE CONTROL SOLENOID VALVE STUCK > ACTION TAKEN WHEN THE DTC SETS

P06DD

DTC P06DD is a Type B DTC.

P06DE

DTC P06DE is a Type B DTC.

DIAGNOSTIC INFORMATION AND PROCEDURES > DTC P06DD OR P06DE: ENGINE OIL PRESSURE CONTROL SOLENOID VALVE STUCK > CONDITIONS FOR CLEARING THE DTC

P06DD

DTC P06DD is a Type B DTC.

P06DE

DTC P06DE is a Type B DTC.

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DIAGNOSTIC INFORMATION AND PROCEDURES > DTC P06DD OR P06DE: ENGINE OIL PRESSURE CONTROL SOLENOID VALVE STUCK > REFERENCE INFORMATION

Schematic Reference

Engine Mechanical Schematics

Connector End View Reference

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- Wiring Repairs

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

DIAGNOSTIC INFORMATION AND PROCEDURES > DTC P06DD OR P06DE: ENGINE OIL PRESSURE CONTROL SOLENOID VALVE STUCK > CIRCUIT/SYSTEM VERIFICATION

1. Verify no other DTCs are set.
    1. **If other DTCs are set**

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

    1. **If no other DTCs are set**
2. Verify correct engine oil level and condition. Refer to Engine Mechanical Specifications .
3. Engine Running, verify the scan tool Engine Oil Pressure parameter changes when commanding the Engine Oil Pressure Control Solenoid On and Off.
    1. **If the parameter does not change**

       Replace the Q44 Engine Oil Pressure Control Solenoid.

    1. **If the parameter changes**
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.
5. Verify the DTC does not set.
    1. **If the DTC sets**

       Refer to Oil Pressure Diagnosis and Testing .

    1. **If the DTC does not set**
6. All OK.

DIAGNOSTIC INFORMATION AND PROCEDURES > DTC P06DD OR P06DE: ENGINE OIL PRESSURE CONTROL SOLENOID VALVE STUCK > REPAIR INSTRUCTIONS

Perform the Diagnostic Repair Verification after completing the repair.

Oil Pump Flow Control Valve Replacement Oil Pump Flow Control Solenoid Valve Replacement

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DIAGNOSTIC INFORMATION AND PROCEDURES > BASE ENGINE MISFIRE WITHOUT INTERNAL ENGINE NOISES

Cause	Correction
Abnormalities, severe cracking, bumps, or missing areas, in the accessory drive belt Abnormalities in the accessory drive system and/or components may cause engine RPM variations and lead to a misfire DTC. A misfire code may be present without an actual misfire condition.	Replace the drive belt. Refer to Drive Belt Replacement .
Worn, damaged, or mis-aligned accessory drive components or excessive pulley runout and may lead to a misfire DTC. A misfire code may be present without an actual misfire condition.	Inspect the components, repair or replace as required.
Loose or improperly installed engine flywheel or crankshaft balancer A misfire code may be present without an actual misfire condition.	Repair or replace the flywheel and/or balancer as required. Refer to Automatic Transmission Flex Plate Replacement , or Crankshaft Balancer Replacement .
Restricted exhaust system A severe restriction in the exhaust flow can cause significant loss of engine performance and may set a DTC. Possible causes of restrictions include collapsed or dented pipes or plugged mufflers and/or catalytic converters.	Repair or replace as required.
Improperly installed or damaged vacuum hoses	Repair or replace as required.
Improper sealing between the intake manifold and cylinder heads, intake manifold and plenum duct, plenum duct and water crossover, water crossover and throttle body and/or pressure relief valve and intake manifold.	Replace the intake manifold, plenum duct, gaskets, cylinder heads, throttle body and/or pressure relief valve as required.
Improperly installed or damaged MAP sensor and/or seal The sealing grommet of the MAP sensor should not be torn or damaged.	Repair or replace the MAP sensor as required.
Improperly installed or damaged EVAP purge solenoid and/or O-ring seal	Repair or replace the EVAP purge solenoid as required.
Worn or loose followers, valve rocker arms The follower, valve rocker arm, roller bearing should be intact and in the proper position.	Replace the followers, valve rocker arms, as required.
Stuck valves Carbon buildup on the valve stem can cause the	Repair or replace as required.

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valve not to close properly.	
Excessively worn or mis-aligned timing chain or chains	Replace the timing chain or chains and sprockets as required.
Worn camshaft lobes	Replace the camshaft or camshafts and SHLAs (valve lifters).
Excessive oil pressure A lubrication system with excessive oil pressure may lead to excessive valve lifter pump-up and loss of compression.	• Perform an oil pressure test. Refer to Oil Pressure Diagnosis and Testing . • Repair or replace the oil pump as required.
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages. Refer to Diagnostic Starting Point - Vehicle . Coolant consumption may or may not cause the engine to overheat.	• Inspect for spark plugs saturated by coolant. Refer to Spark Plug Inspection for the 3.6L engine. • Inspect the cylinder heads, engine block, and/or head gaskets. • Repair or replace as required.
Worn Piston Rings Oil consumption may or may not cause the engine to misfire.	• Inspect the spark plugs for oil deposits. Refer to Spark Plug Inspection for the 3.6L engine. • Inspect the cylinders for a loss of compression. Refer to Engine Compression Test . • Perform cylinder leak down and compression testing to identify the cause. • Repair or replace as required.
A damaged crankshaft reluctor wheel A damaged crankshaft reluctor wheel can result in different symptoms depending on the severity and location of the damage. • Systems with SEVERE reluctor ring damage may exhibit periodic loss of crankshaft position, stop delivering a signal, and then re-sync the crankshaft position. • Systems with SLIGHT reluctor ring damage may exhibit no loss of crankshaft position and no misfire may occur. However, a P0300 DTC may be set.	Replace the crankshaft as required.

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DIAGNOSTIC INFORMATION AND PROCEDURES > BASE ENGINE MISFIRE WITH ABNORMAL INTERNAL LOWER ENGINE NOISES

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

DIAGNOSTIC INFORMATION AND PROCEDURES > BASE ENGINE MISFIRE WITH ABNORMAL VALVE TRAIN NOISE

Cause	Correction
Worn or loose followers, valve rocker arms The follower, valve rocker arm, roller bearing should be intact and in the proper position.	Replace the followers, valve rocker arms, as required.

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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 or chains	Replace the timing chain or chains and sprockets as required.
Worn camshaft lobes	Replace the camshaft or camshafts and SHLAs (valve lifters).
Sticking SHLAs (lifters)	Replace the SHLAs as required.

DIAGNOSTIC INFORMATION AND PROCEDURES > BASE ENGINE MISFIRE WITH COOLANT CONSUMPTION

Cause	Correction
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages. Refer to Diagnostic Starting Point - Vehicle . Coolant consumption may or may not cause the engine to overheat.	• Inspect for spark plugs saturated by coolant. Refer to Spark Plug Inspection for the 3.6L engine. • Perform a cylinder leak down test. • Inspect the cylinder heads and engine block for damage to the coolant passages and/or a faulty head gasket. • Repair or replace as required.

DIAGNOSTIC INFORMATION AND PROCEDURES > BASE ENGINE MISFIRE WITH EXCESSIVE OIL CONSUMPTION

Cause	Correction
Worn valves, valve guides and/or valve stem oil seals	1. Inspect the spark plugs for oil deposits. Refer to Spark Plug Inspection . 2. Repair or replace as required.
Worn piston rings Oil consumption may or may not cause the engine to misfire.	1. Inspect the spark plugs for oil deposits. Refer to Spark Plug Inspection . 2. Inspect the cylinders for a loss of compression. Refer to Engine Compression Test .

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	3. Perform cylinder leak down and compression testing to determine the cause. 4. Repair or replace as required.

DIAGNOSTIC INFORMATION AND PROCEDURES > ENGINE NOISE ON START-UP, BUT ONLY LASTING A FEW SECONDS

Cause	Correction
Incorrect oil filter without anti-drainback feature	Install the correct oil filter.
Incorrect oil viscosity	Drain the engine oil and replace with the correct viscosity oil.
High stationary hydraulic lash adjuster (SHLA), valve lifter, leak down rate	Replace the SHLAs, valve lifters, as required.
Worn crankshaft thrust bearing	• Inspect the thrust bearing and crankshaft. • Repair or replace as required.
Damaged or faulty oil filter by-pass valve	• Inspect the oil filter by-pass valve for proper operation. • Repair or replace as required.
Malfunctioning camshaft position actuators - improper oil viscosity or contamination.	Isolate the noise to a specific camshaft position actuator. Disconnect the electrical connector on the camshaft position actuator solenoid valves and start the vehicle. If noise is gone, repeat procedure to limit to an individual actuator. Refer to Camshaft Position Actuator Replacement - Bank 1 , or Camshaft Position Actuator Replacement - Bank 2 .

DIAGNOSTIC INFORMATION AND PROCEDURES > 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.

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Loose and/or worn follower, valve rocker arm	1. Inspect the follower, valve rocker arm. 2. Repair or replace as required.
Improper lubrication to the followers, valve rocker arms	Inspect the following components, and repair or replace as required: • The follower, valve rocker arm • The SHLA, valve lifter • The oil filter bypass valve • The oil pump and pump screen • The cylinder head oil galleries • The engine block oil galleries
Broken valve spring	Replace the valve spring.
Worn or dirty stationary hydraulic lash adjusters (SHLAs), valve lifters	Replace the SHLAs, valve lifters.
Stretched or broken timing chain or chains and/or damaged sprocket teeth	Replace the timing chain or chains and sprockets.
Worn timing chain tensioner or tensioners	Replace the timing chain tensioner or tensioners as required.
Worn timing chain shoe or shoes	Replace the timing chain shoe or shoes as required.
Worn timing chain guide or guides	Replace the timing chain guide or guides as required.
Worn engine camshaft lobes	1. Inspect the engine camshaft lobes. 2. Replace the camshaft or camshafts and SHLAs, 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

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DIAGNOSTIC INFORMATION AND PROCEDURES > LOWER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

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

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DIAGNOSTIC INFORMATION AND PROCEDURES > ENGINE NOISE UNDER LOAD

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

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DIAGNOSTIC INFORMATION AND PROCEDURES > ENGINE WILL NOT CRANK - CRANKSHAFT WILL NOT ROTATE

Cause	Correction
Seized accessory drive system component	1. Remove the accessory drive belt or belts.

	2. Rotate the crankshaft by hand at the crankshaft balancer or the engine flywheel location. 3. Repair or replace as required.
Hydraulically locked cylinder • Coolant/antifreeze in cylinder • Oil in cylinder • Fuel in cylinder	1. Remove the spark plugs and check for fluid. 2. Inspect for broken head gasket or gaskets. 3. Inspect for cracked engine block or cylinder head. 4. Inspect for a sticking fuel injector. 5. Repair or replace as required.
Seized automatic transmission torque converter	1. Remove the torque converter bolts. 2. Rotate the crankshaft by hand at the crankshaft balancer or the engine flywheel location. 3. Repair or replace as required.
Material in cylinder • Broken valve • Piston material • Foreign material	1. Inspect the cylinder for damaged components and/or foreign materials. 2. Repair or replace as required.
Seized crankshaft or connecting rod bearings	1. Inspect the crankshaft and the connecting rod bearings. 2. Repair as required.
Bent or broken connecting rod	1. Inspect the connecting rods. 2. Repair as required.
Broken crankshaft	1. Inspect the crankshaft. 2. Repair as required.

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Seized or broken camshaft	1. Inspect the camshaft or camshafts. 2. Inspect the cylinder head camshaft journals for damage. 3. Repair as required.
Seized or broken balance shaft	1. Inspect the balance shaft. 2. Inspect the block for damaged balance shaft bearings. 3. Repair as required.
Seized or broken camshaft timing components	1. Inspect the following sprockets: 1. The crankshaft sprocket 2. The exhaust sprockets 3. The intake sprockets 2. Inspect the following chains: 1. The primary camshaft drive chain 2. The secondary camshaft drive chains 3. Inspect the following guides: 1. The lower primary camshaft drive chain guide 2. The upper primary camshaft drive chain guides 4. Inspect the secondary camshaft drive chain shoe. 5. Inspect the following tensioners: 1. The primary camshaft drive chain tensioner 2. The secondary camshaft drive chain tensioners 6. Repair as required.
Seized or broken valve train components	1. Inspect the followers, rocker arms.

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	2. Inspect the lifters. 3. Inspect the valves. 4. Inspect the valve springs. 5. Repair as required.

DIAGNOSTIC INFORMATION AND PROCEDURES > COOLANT IN COMBUSTION CHAMBER

Cause	Correction
DEFINITION: Excessive white smoke and/or coolant type odor coming from the exhaust pipe may indicate coolant in the combustion chamber. Low coolant levels, an inoperative cooling fan, or a faulty thermostat may lead to an "overtemperature" condition which may cause engine component damage. *NOTE:* *While not always conclusive, use of hydrocarbon block test kits may reveal hydrocarbons indicating combustion chamber gases in the cooling system. It is important to follow the kit instructions. This is not a substitute for the service information. Combustion leak tests are available from a wide variety of aftermarket suppliers.* 1. A slower than normal cranking speed may indicate coolant entering the combustion chamber. Refer to Engine Will Not Crank - Crankshaft Will Not Rotate . 2. Remove the spark plugs and inspect for spark plugs saturated by coolant or coolant in the cylinder bore. 3. Inspect by performing a Cylinder Leakage Test . During this test, excessive air bubbles within the coolant may indicate a faulty gasket or damaged component. 4. Inspect by performing a cylinder compression test. Two cylinders "side-by-side" on the engine block, with low compression, may indicate a failed cylinder head gasket. Refer to Engine Compression Test .	
Cracked intake manifold or failed gasket	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 - Left Side , or Cylinder Head Replacement - Right Side .
Warped cylinder head	Machine the cylinder head to the proper flatness, if applicable and replace the cylinder head gasket. Refer to Cylinder Head Cleaning and Inspection .
Cracked cylinder head	Replace the cylinder head and gasket.

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Cracked cylinder liner or engine block	Replace the components as required.
Cylinder head or engine block porosity	Replace the components as required.

DIAGNOSTIC INFORMATION AND PROCEDURES > 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 Leakage Test . During this test, excessive air bubbles within the cooling system may indicate a faulty gasket or damaged component. 3. Inspect by performing a cylinder compression test. Two cylinders "side-by-side" on the engine block with low compression may indicate a failed cylinder head gasket. Refer to Engine Compression Test .	
Faulty external engine oil cooler	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 - Left Side , or Cylinder Head Replacement - Right Side .
Warped cylinder head	Machine the cylinder head to proper flatness, if applicable, and replace the cylinder head gasket. Refer to Cylinder Head Cleaning and Inspection .
Cracked cylinder head	Replace the cylinder head and gasket.
Cracked cylinder liner or engine block	Replace the components as required.
Cylinder head, block, or manifold porosity	Replace the components as required.

DIAGNOSTIC INFORMATION AND PROCEDURES > ENGINE COMPRESSION TEST

Special Tools

EN-51749 Spark Plug Port Adapter

For equivalent regional tools, refer to Special Tools .

A compression pressure test of the engine cylinders determines the condition of the piston rings, the valves and the head gaskets.

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1. Run the engine until it reaches normal operating temperature. The battery must be at or near full charge. You may wish to connect a battery charger for the duration of the test to maintain an adequate battery level.
2. Turn the engine OFF.
3. Remove the intake manifold cover.
4. Remove the ignition coils and spark plugs from all cylinders. Refer to Ignition Coil Replacement - Bank 1 , and Ignition Coil Replacement - Bank 2 .
5. Connect the GDS2 to the vehicle and select "Compression Test". Enabling the Compression Test will disable the fuel pump, fuel injectors, and spark. The throttle body is opened to a Wide Open Throttle (WOT) position. The GDS2 will also automatically control the cranking procedure for many applications. If cranking control is not available use a remote start switch in place of the Starter Relay to control cranking.
6. Measure the engine compression, using the following procedure:
    1. Thread the **EN-51749** adapter into the spark plug hole.
    2. Thread the compression gauge into the **EN-51749** adapter.
    3. Enable cranking via the GDS2 or remote start switch. Record the reading after the cranking cycle completes.
    4. When the compression measurement is normal, the compression builds up quickly and evenly to the specified compression on each cylinder.
    5. Repeat the compression test for each cylinder.
7. Compare the compression readings from all of the cylinders.
    1. The lowest reading should not be less than 70 percent of the highest reading.
    2. No cylinder reading should be less than 690 kPa (100 psi).
8. The following are indicators of potential problems:
    1. When low compression is caused by the piston rings, compression is low on the first stroke and tends to build up on the following strokes, but does not reach normal. Compression improves considerably with the addition of oil to the cylinder. Use approximately 3 squirts of oil from a plunger-type oiler into the cylinder and replace the gauge and measure again.
    2. When low compression is caused by the valves, the measurement is low on the first stroke and does not build up even with the addition of oil.
    3. Leaking head gaskets will provide the same results as worn valves but engine coolant may be identified in the crankcase. In addition, a leaking head gasket will give low readings on paired cylinders.
9. Disconnect GDS2 diagnostic tool or remote start switch.
10. Install the spark plugs. Refer to Spark Plug Replacement .
11. Install the ignition coils and spark plugs from all cylinders. Refer to Ignition Coil Replacement -

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Bank 1 , and Ignition Coil Replacement - Bank 2 .

12. Install the intake manifold cover.

DIAGNOSTIC INFORMATION AND PROCEDURES > CYLINDER LEAKAGE TEST

Special Tools

- **EN-35667-A** Cylinder Head Leakdown Tester
- **EN-39313** Spark Plug Port Adapter

For equivalent regional tools, refer to Special Tools .

NOTE:

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

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

WARNING:

Refer to Battery Disconnect Warning .

1. Disconnect the battery ground negative cable.
2. Remove the spark plugs. Refer to Spark Plug Replacement .

CAUTION:

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Only turn the engine in a CLOCKWISE direction as viewed from the crankshaft balancer. Counterclockwise rotation may result in the timing chain jumping a tooth, causing poor running, DTCs, or severe engine damage.

3. Rotate the crankshaft to place the piston in the cylinder being tested at top dead center (TDC) of the compression stroke.
4. Thread the **EN-39313** adapter into the spark plug hole.
5. Install the **EN-35667-A** tester or equivalent.

NOTE:

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

6. Apply shop air pressure to the **EN-35667-A** tester and adjust according to the manufacturers instructions.
7. Record the cylinder leakage value. Cylinder leakage that exceeds 25 percent is considered excessive and may require component service. In excessive leakage situations, inspect for the following conditions:
    1. Air leakage sounds at the throttle body or air inlet hose that may indicate a worn or burnt intake valve or a broken valve spring
    2. Air leakage sounds at the exhaust system tailpipe that may indicate a worn or burnt exhaust valve or a broken valve spring
    3. Air leakage sounds from the crankcase, oil level indicator tube, or oil fill tube that may indicate worn piston rings, a damaged piston, a worn or scored cylinder bore, a damaged engine block or a damaged cylinder head
    4. Air bubbles in the cooling system may indicate a damaged cylinder head or a damaged cylinder head gasket.
8. Perform the leakage test on the remaining cylinders and record the values.

DIAGNOSTIC INFORMATION AND PROCEDURES > OIL CONSUMPTION DIAGNOSIS

Checks	Causes
DEFINITION: Excessive oil consumption (not due to leaks) is the use of 0.946 L (1 qt) or more of engine oil within 3200 km (2, 000 mi). The causes of excessive oil consumption may include the following conditions:	
Preliminary	• External oil leaks - Refer to Oil Leak Diagnosis . • Incorrect oil level or improper reading of the oil level indicator

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	With the vehicle on a level surface, run the engine for a few minutes, allow adequate drain down time (2-3 minutes) and check for the correct engine oil level. • Improper oil viscosity Refer to the vehicle owners manual and use the recommended SAE grade and viscosity for the prevailing temperatures. • Continuous high speed driving and/or severe usage • Crankcase ventilation system restrictions or malfunctioning components • Worn valve guides and/or valve stems • Worn, missing or improperly installed valve stem oil seals • Piston rings broken, worn, not seated properly Allow adequate time for the rings to seat. Replace worn piston rings as necessary. • Piston and rings improperly installed or miss-fitted to the cylinder bore

DIAGNOSTIC INFORMATION AND PROCEDURES > OIL PRESSURE DIAGNOSIS AND TESTING

Special Tools

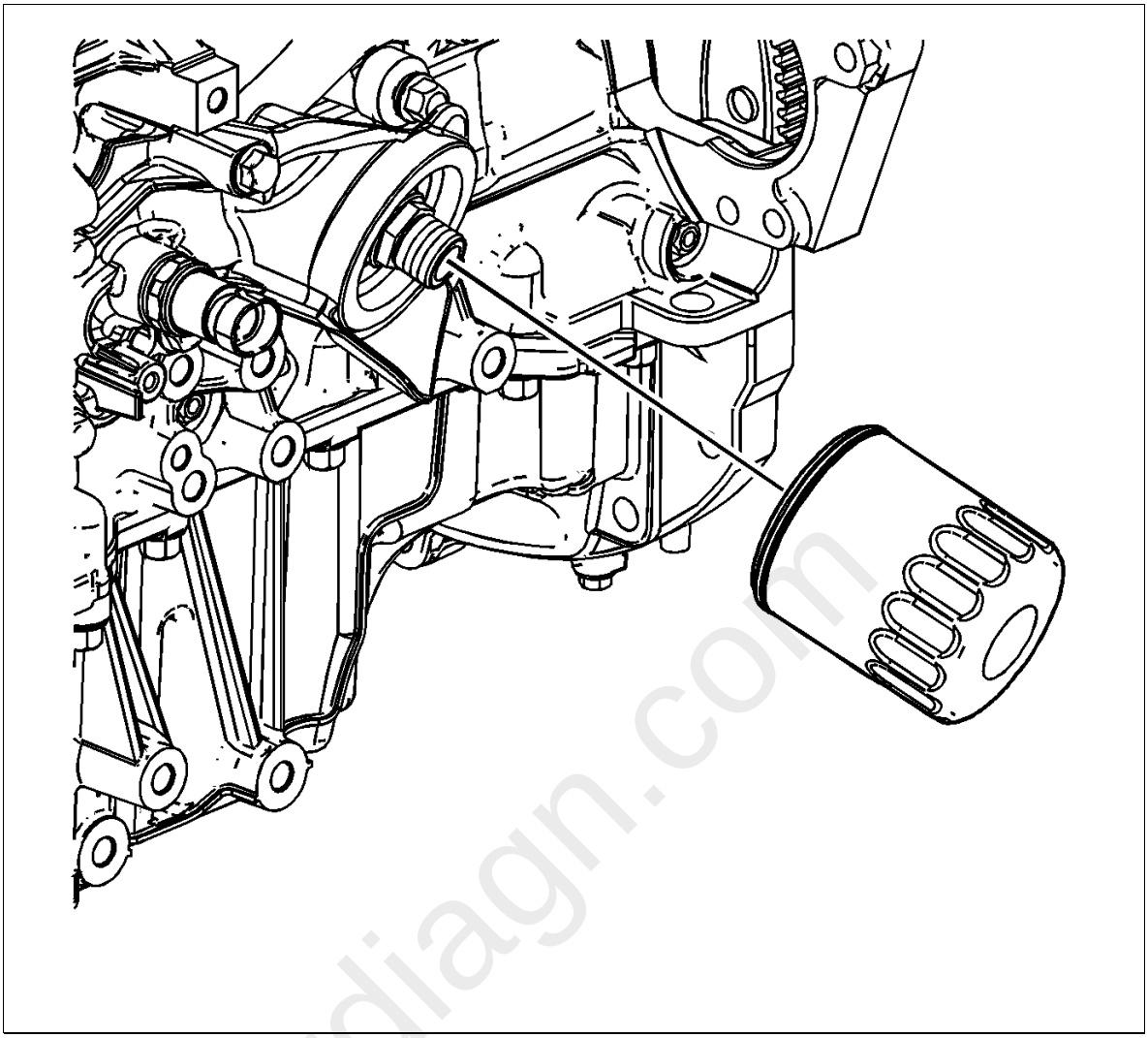
- **EN-47971** Oil Pressure Gauge Adapter
- **CH-48027** Pressure Gauge

For equivalent regional tools, refer to Special Tools .

1. With the vehicle on a level surface, run the vehicle for a few minutes, allow adequate drain down time, 2-3 minutes, and measure the oil level.
2. If required, add the recommended grade engine oil and fill the crankcase until the oil level measures full on the oil level indicator.
3. Run the engine briefly, 10-15 seconds, and verify low or no oil pressure on the vehicle gauge or light.
4. Listen for a noisy valve train or a knocking noise.
5. Inspect for the following conditions:
    1. Oil diluted by water or glycol antifreeze
    2. Foamy oil

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Fig 1: Oil Filter

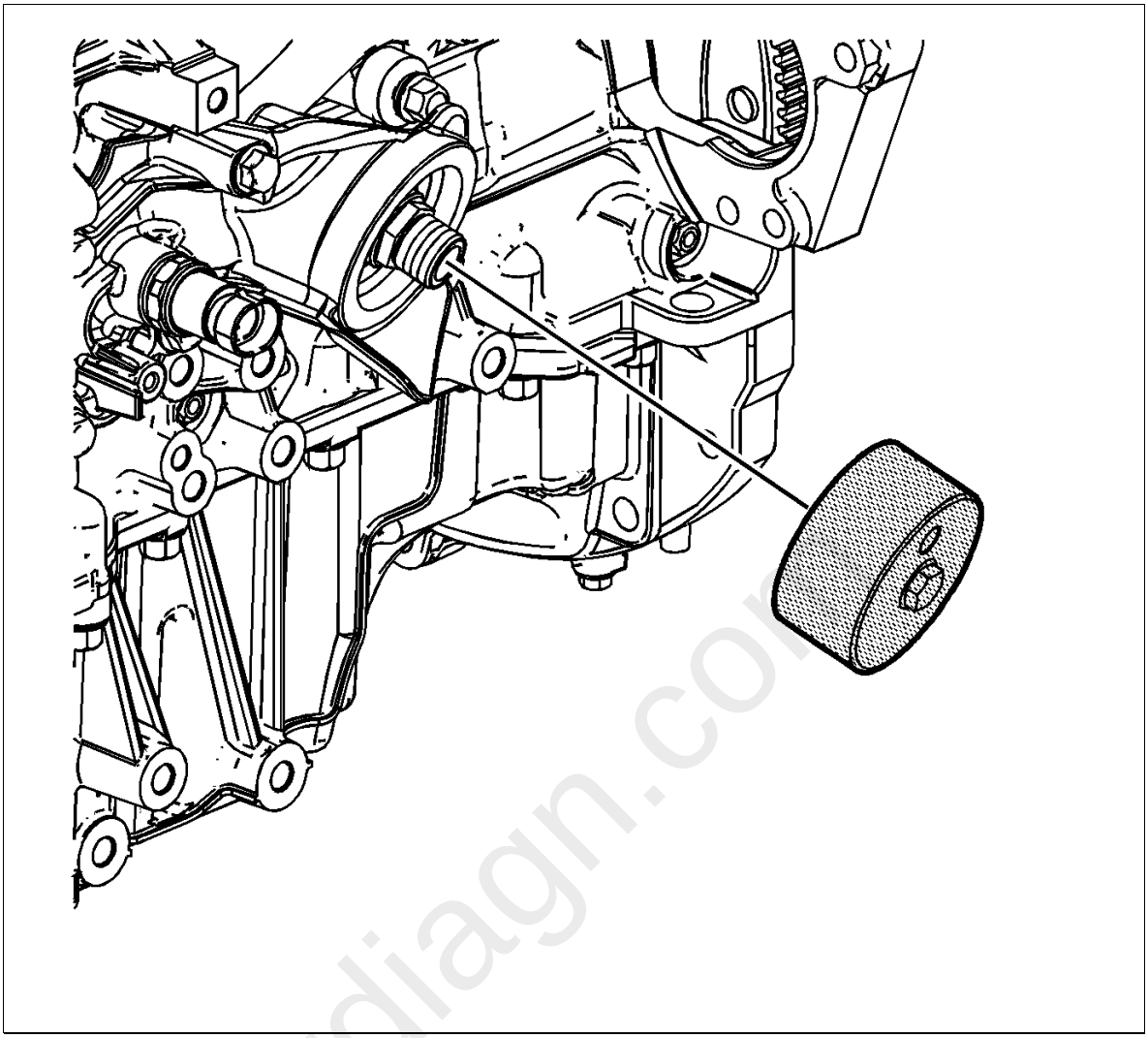


Courtesy of GENERAL MOTORS COMPANY

6. Remove the oil filter.

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Fig 2: Oil Pressure Gauge Adapter



Courtesy of GENERAL MOTORS COMPANY

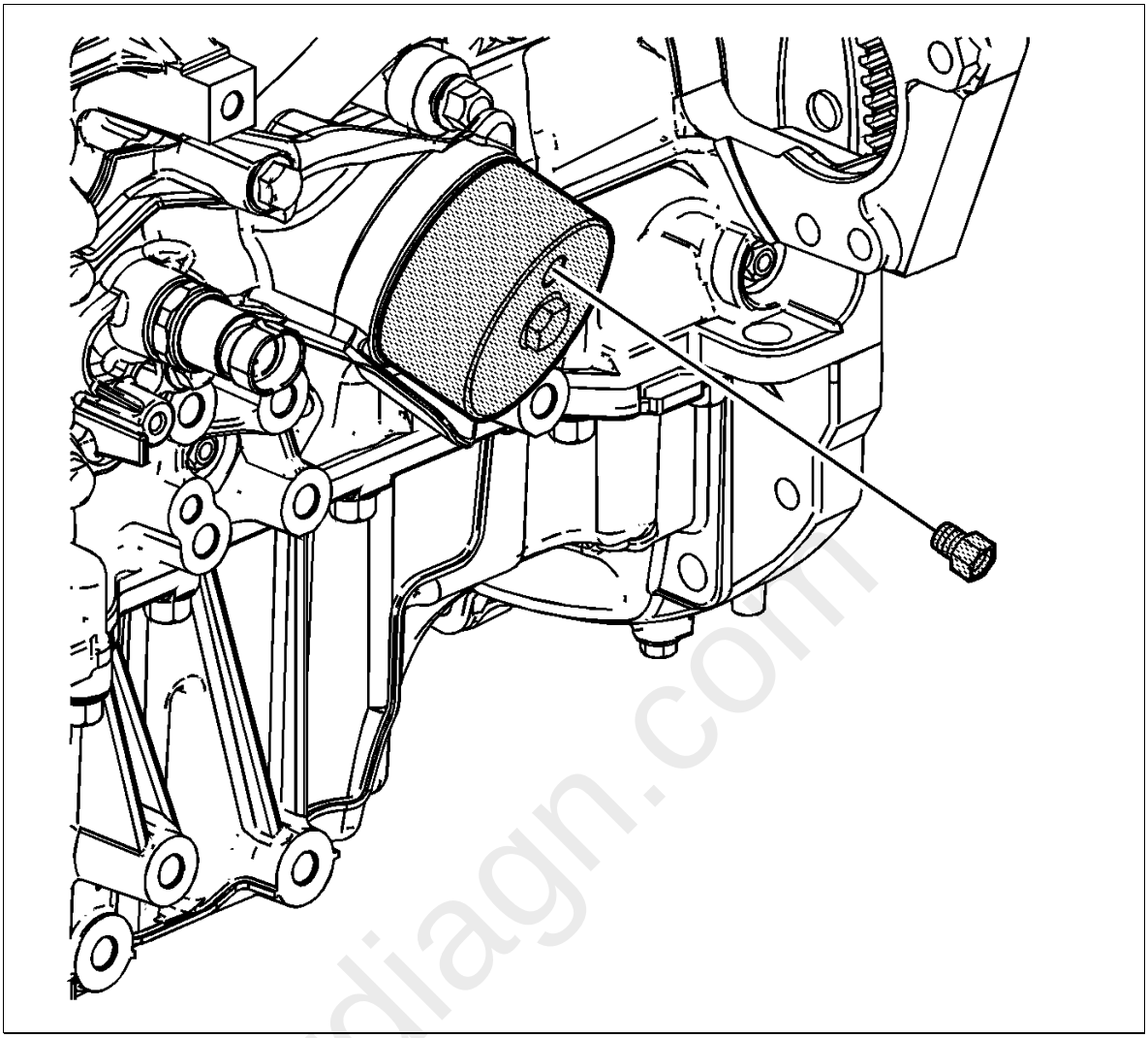
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⚠ *CAUTION:*

Special new tool EN 47971 must be used. Due to the special size and thread pitch of the oil filter adapter fitting ensure the proper tool is used or component damage will result.

7. Install the **EN-47971** adapter onto the oil filter adapter.

Fig 3: Oil Pressure Gauge Adaptor

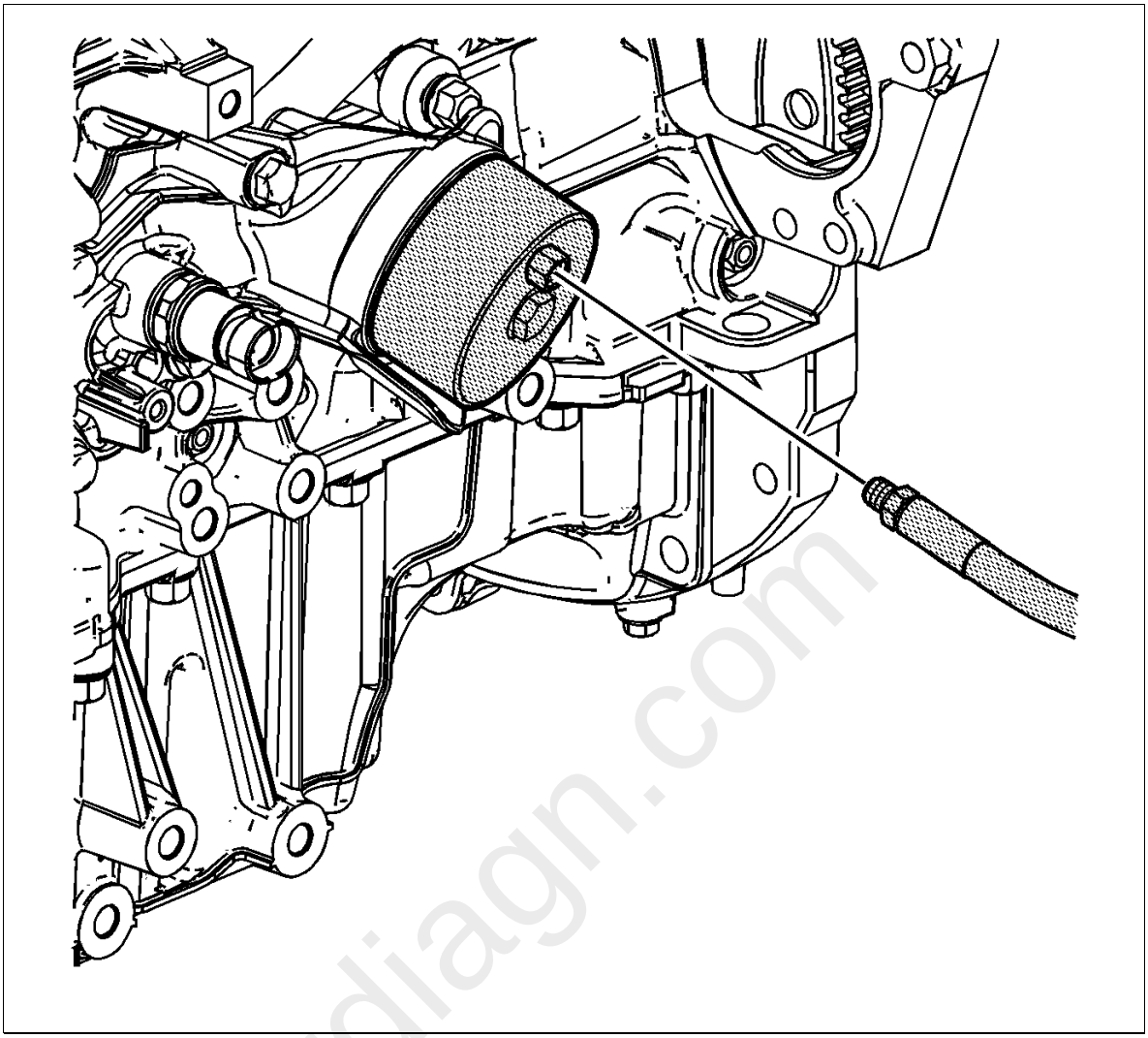


Courtesy of GENERAL MOTORS COMPANY

8. Install the 1/8 NPT fitting from the **CH-48027** gauge into the port on the **EN-47971** adapter.

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Fig 4: Special Tool & Flexible Hose



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9. Install the **CH-48027** gauge flexible hose to the **EN-47971** adapter.
10. Run the engine and measure the engine oil pressure.
11. Compare the readings to Engine Mechanical Specifications .
12. If the engine oil pressure is below specifications, inspect the engine for 1 or more of the following conditions:
    1. Oil pump worn or dirty. Refer to Oil Pump Replacement , Oil Pump Disassemble , and Oil Pump Cleaning and Inspection .
    2. Oil pump-to-engine block bolts loose. Refer to Oil Pump Replacement .
    3. Oil pump screen loose, plugged, or damaged. Refer to Oil Pump Suction Pipe and Screen Assembly Replacement , and Oil Pump Suction Pipe and Screen Cleaning and Inspection .
    4. Oil pump screen O-ring seal missing or damaged. Refer to Oil Pump Suction Pipe and Screen Assembly Replacement , and Oil Pump Suction Pipe and Screen Cleaning and

Inspection .

5. Oil pump pressure relief valve malfunction. Refer to Oil Pump Replacement .
6. Engine bearing clearance excessive. Refer to Crankshaft and Bearing Cleaning and Inspection , Crankshaft and Bearing Installation , and Piston, Connecting Rod, and Bearing Installation .
7. Cracked, porous, or restricted oil galleries.
8. Oil gallery plugs missing or incorrectly installed. Refer to Engine Block Assemble , and Cylinder Head Assemble .
9. Valve lifters broken. Repair, as necessary. Refer to Valve Lifter Replacement - Left Side , and/or Valve Lifter Replacement - Right Side , and Valve Lifter Cleaning and Inspection .

> ⚠ *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.*

13. If the oil pressure reading on the **CH-48027** gauge, or equivalent, is within specifications, inspect for the following conditions:
    1. Plugged or incorrect oil filter and/or malfunctioning oil bypass valve. Refer to Engine Oil and Oil Filter Replacement .
    2. Malfunctioning oil pressure gauge or sensor. Repair, as necessary. Refer to Engine Oil Pressure Sensor and/or Switch Replacement .

DIAGNOSTIC INFORMATION AND PROCEDURES > OIL LEAK DIAGNOSIS

Checks	Action
CAUTION: *It is important to correctly identify the source of an oil leak. A power steering fluid leak or spillage can travel across the valley area of the engine and run out the weep hole, which is located at the back of the block. Failure to correctly identify the source of an oil leak can lead to the incorrect or unnecessary replacement of components.* 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.	
Locating and identifying the leak	To determine if the leaking fluid is engine oil, transmission fluid, power steering fluid, brake fluid, or some other fluid, use the visual inspection method.

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Visual Inspection Method	1. Bring the vehicle to normal operating temperature. 2. Park the vehicle over a large sheet of paper, or other clean surface. 3. Wait several minutes, then check for drippings. 4. Identify the type of fluid, and the approximate location of the leak. 5. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 6. Check for leaks at sealing surfaces, fittings, or from cracked or damaged components. 7. If you cannot locate the leak, do the following: 1. Completely clean the entire engine and surrounding components. 2. Operate the vehicle for several miles at normal operation temperature and at varying speeds. 3. Park the vehicle over a large sheet of paper, or other clean surface. 4. Wait several minutes, then check for drippings. 5. Identify the type of fluid, and the approximate location of the leak. 6. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 7. See possible causes for leaks. 8. If you still cannot locate the leak, use the powder method or the black light and dye method.
Powder Method	1. Completely clean the entire engine and surrounding components. 2. Apply an aerosol-type powder (baby powder, foot powder, etc.) to the suspected area. 3. Operate the vehicle for several miles at normal operation 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. 5. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas.

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	6. See possible causes for leaks.
Black Light and Dye Method	1. A dye and light kit is available for finding leaks. Use the **GE 28428-E** High-Intensity Black Light Kit or equivalent. Refer to the manufacturer's instructions when using the tool. 2. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 3. See possible causes for leaks.
Possible Causes for Leaks	Check for the following conditions: • Higher than recommended fluid levels • Higher than recommended fluid pressures • Plugged or malfunctioning fluid filters or pressure bypass valves • Plugged or malfunctioning engine ventilation system • Improperly tightened or damaged fasteners • Cracked or porous components • Improper sealants or gaskets where required • Improper sealant or gasket installation • Damaged or worn gaskets or seals • Damaged or worn sealing surfaces

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DIAGNOSTIC INFORMATION AND PROCEDURES > CRANKCASE VENTILATION SYSTEM INSPECTION/DIAGNOSIS > CRANKCASE VENTILATION (CV) SYSTEM INSPECTION

- Test for vacuum at the vacuum hose where it connects to the crankcase ventilation housing. There should be manifold vacuum present at the hose. If there is no vacuum, inspect for a plugged hose, leaking hose or a plugged vent adapter.
- Plug the end of the vacuum hose while the engine is running. Inspect the hose for any areas that collapse when the end of the hose is blocked. Replace the hose if it collapses when blocked.
- If oil has accumulated in the intake air duct, inspect for the following conditions:
    - Plugged vacuum orifice in the crankcase ventilation housing
    - Plugged or restricted crankcase ventilation housing
    - Excessive crankcase pressure or blow-by, refer to Oil Consumption Diagnosis .

- Additional items to inspect:
    - Plugged or leaking fresh air vent hose assembly or vent adapter
    - Plugged or restricted passages in the throttle body
    - Missing or damaged O-ring seals on the vent adapter
    - Inspect the cam covers, the oil pan gasket, and other sealing areas for leaks

DIAGNOSTIC INFORMATION AND PROCEDURES > CRANKCASE VENTILATION SYSTEM INSPECTION/DIAGNOSIS > RESULTS OF INCORRECT OPERATION

A plugged crankcase ventilation housing or hose may contribute to the following conditions:

- A rough idle
- Stalling or a slow idle speed
- Oil leaks
- Oil accumulation in the intake air duct
- Sludge in the engine

A leaking housing or hose may contribute to the following conditions:

- A rough idle
- Stalling
- Unstable idle speed

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DIAGNOSTIC INFORMATION AND PROCEDURES > 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.

DIAGNOSTIC INFORMATION AND PROCEDURES > DRIVE BELT CHIRPING, SQUEAL, AND WHINE DIAGNOSIS > 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

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

17

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

19

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

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

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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**

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

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DIAGNOSTIC INFORMATION AND PROCEDURES > 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.

DIAGNOSTIC INFORMATION AND PROCEDURES > DRIVE BELT RUMBLING AND VIBRATION DIAGNOSIS > 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 plys of the belt separating and may be seen at the edge of the belt our felt as a lump in the belt.

5

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

9

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

11

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

12

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

Step	Action	Yes	No
	CAUTION: *Refer to Belt Dressing Caution .*		
DEFINITION: The following items are indications of drive belt rumbling: • A low pitch tapping, knocking, or thumping noise heard at or just above idle. • Heard once per revolution of the drive belt or a pulley.			

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- 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 or Go to Vibration Analysis - Engine	Go to **Step 4**
4	Inspect the drive belts for wear, damage, separation, sections of missing ribs, and debris build-up. Did you find any of these conditions?	Go to **Step 7**	Go to **Step 5**
5	Inspect for severe pilling of more than 1/3 of the drive belt pulley grooves. Did you find severe pilling?	Go to **Step 6**	Go to **Step 7**
6	1. Clean the drive belt pulleys using a suitable wire brush. 2. Reinstall the drive belts. Refer to Drive Belt Replacement . Did you correct the condition?	Go to **Step 8**	Go to **Step 7**
7	Install a new drive belt. Refer to Drive Belt Replacement .	Go to **Step 8**	Go to **Step 9**

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	Did you complete the replacement?		
8	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 9**
9	Inspect for improper, loose or missing fasteners. Did you find any of these conditions?	Go to **Step 10**	Go to **Step 11**
10	1. Tighten any loose fasteners. Refer to Fastener Specifications . 2. Replace improper or missing fasteners. Did you complete the repair?	Go to **Step 13**	Go to **Step 11**
11	Inspect for a bent water pump shaft. Refer to Water Pump Replacement (LGX) . Did you find and correct the condition?	Go to **Step 13**	Go to **Step 12**
12	Inspect for bent or cracked brackets. Did you find and correct the condition?	Go to **Step 13**	Go to Diagnostic Aids
13	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 3**

DIAGNOSTIC INFORMATION AND PROCEDURES > 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.

DIAGNOSTIC INFORMATION AND PROCEDURES > DRIVE BELT FALLS OFF AND EXCESSIVE WEAR DIAGNOSIS > TEST DESCRIPTION

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

2

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

4

Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley, or the pulley bent inward or outward from a previous repair. Test for a misaligned pulley using a straight edge in the pulley grooves across 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 two wide or two narrow will cause wear on the drive belt. The drive belt ribs should match all of the grooves on all of the pulleys.

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

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CAUTION:

Refer to Belt Dressing Caution .

DEFINITION: The drive belt falls off the pulleys or may not ride correctly on the pulleys.DEFINITION: Wear at the outside ribs of the drive belt due to an incorrectly installed drive belt.

1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to **Step 2**	Go to Symptoms - Engine Mechanical
2	If diagnosing excessive wear, proceed to step 13. If diagnosing a drive belt that falls off, inspect for a damaged drive belt. Did you find the condition?	Go to **Step 3**	Go to **Step 4**
3	Install a new drive belt. Refer to Drive Belt Replacement . Does the drive belt continue to fall off?	Go to **Step 4**	System OK
4	Inspect for misalignment of the pulleys. Did you find and repair the condition?	Go to **Step 12**	Go to **Step 5**
5	Inspect for a bent or dented pulley. Did you find and repair the condition?	Go to **Step 12**	Go to **Step 6**
6	Inspect for a bent or a cracked bracket. Did you find and repair the condition?	Go to **Step 12**	Go to **Step 7**
7	Inspect for improper, loose or missing fasteners. Did you find loose or missing fasteners?	Go to **Step 8**	Go to **Step 9**
8	*CAUTION:* *Refer to Fastener Caution .* 1. Tighten any loose fasteners. Refer to Fastener 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

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11	Inspect for failed drive belt idler and drive belt tensioner pulley bearings. Did you find and repair the condition?	Go to **Step 12**	Go to Diagnostic Aids
12	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 2**
13	Inspect the drive belt for the proper installation. Refer to Drive Belt Replacement . Did you find this condition?	Go to **Step 16**	Go to **Step 14**
14	Inspect for the proper drive belt. Did you find this condition?	Go to **Step 16**	Go to **Step 15**
15	Inspect for the drive belt rubbing against a bracket, hose, or wiring harness. Did you find and repair the condition?	Go to **Step 17**	Go to Diagnostic Aids
16	Replace the drive belt. Refer to Drive Belt Replacement . Did you complete the replacement?	Go to **Step 17**	-
17	Operate the system in order to verify the repair. Did you correct the condition?	System OK	-

DIAGNOSTIC INFORMATION AND PROCEDURES > DRIVE BELT TENSIONER DIAGNOSIS

Step	Action	Yes	No
1	Remove the drive belt and 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. Is the repair complete?	System OK	-

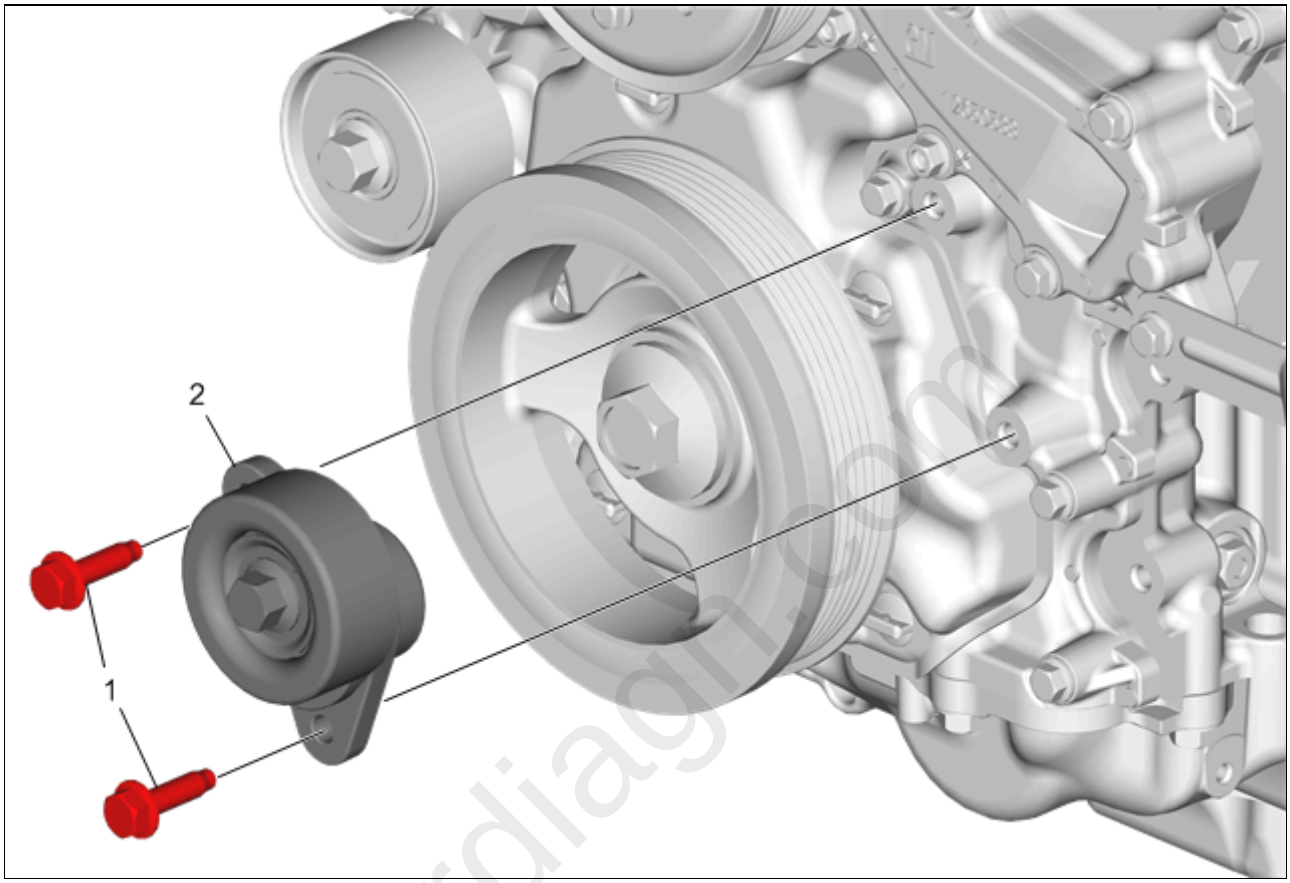
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Service Manual: ENGINE MECHANICAL - 3.6L (LGX) -
REPAIR INSTRUCTIONS - OFF VEHICLE

REPAIR INSTRUCTIONS - OFF VEHICLE > DRIVE BELT TENSIONER REMOVAL

Fig 1: Drive Belt Tensioner (LGX)

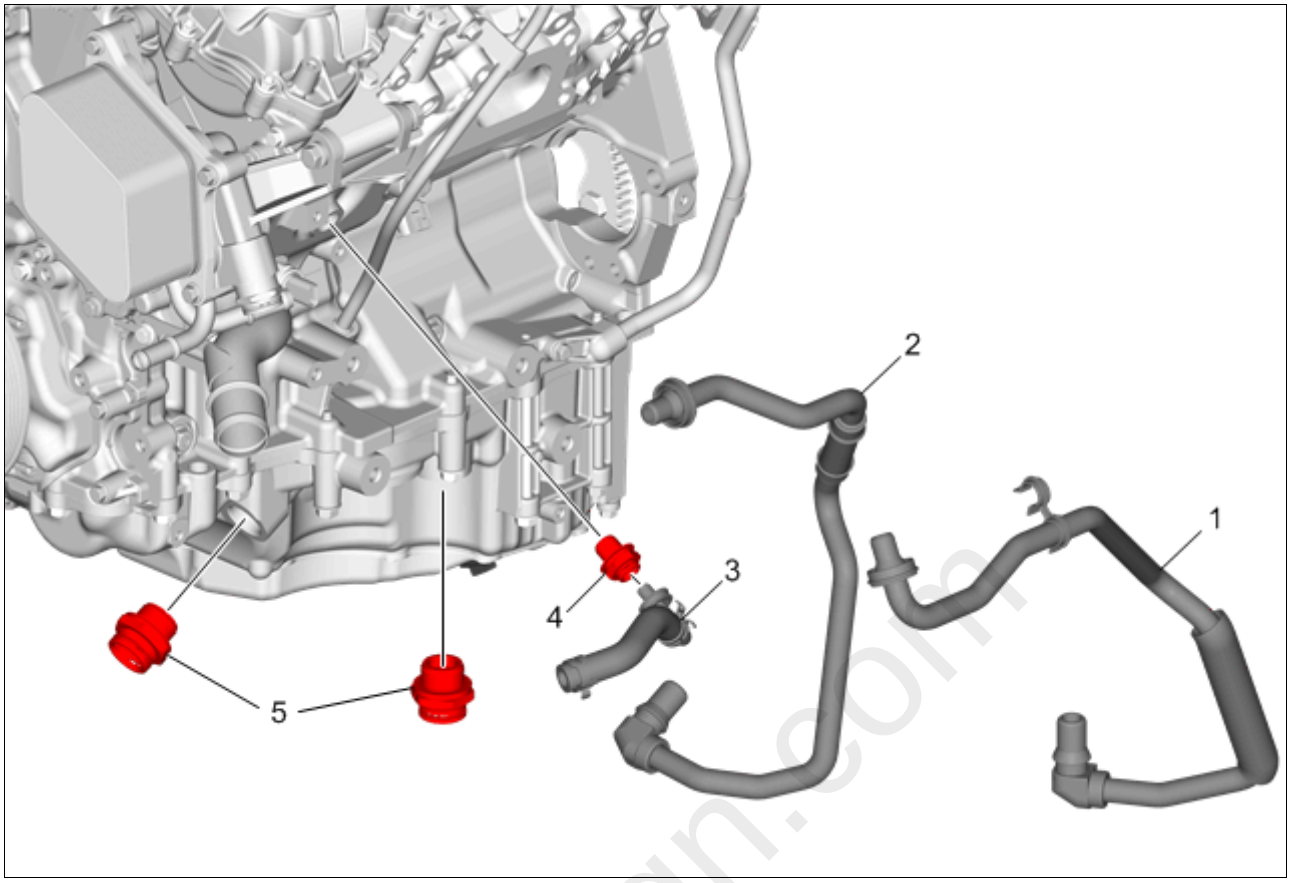


Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Drive Belt Tensioner Bolt (Qty: 2)
2	Drive Belt Tensioner

REPAIR INSTRUCTIONS - OFF VEHICLE > ENGINE OIL COOLER ADAPTER REMOVAL > ENGINE OIL COOLER PIPES AND FITTINGS REMOVAL

Fig 1: Engine Oil Cooler Pipes and Fittings



Courtesy of GENERAL MOTORS COMPANY

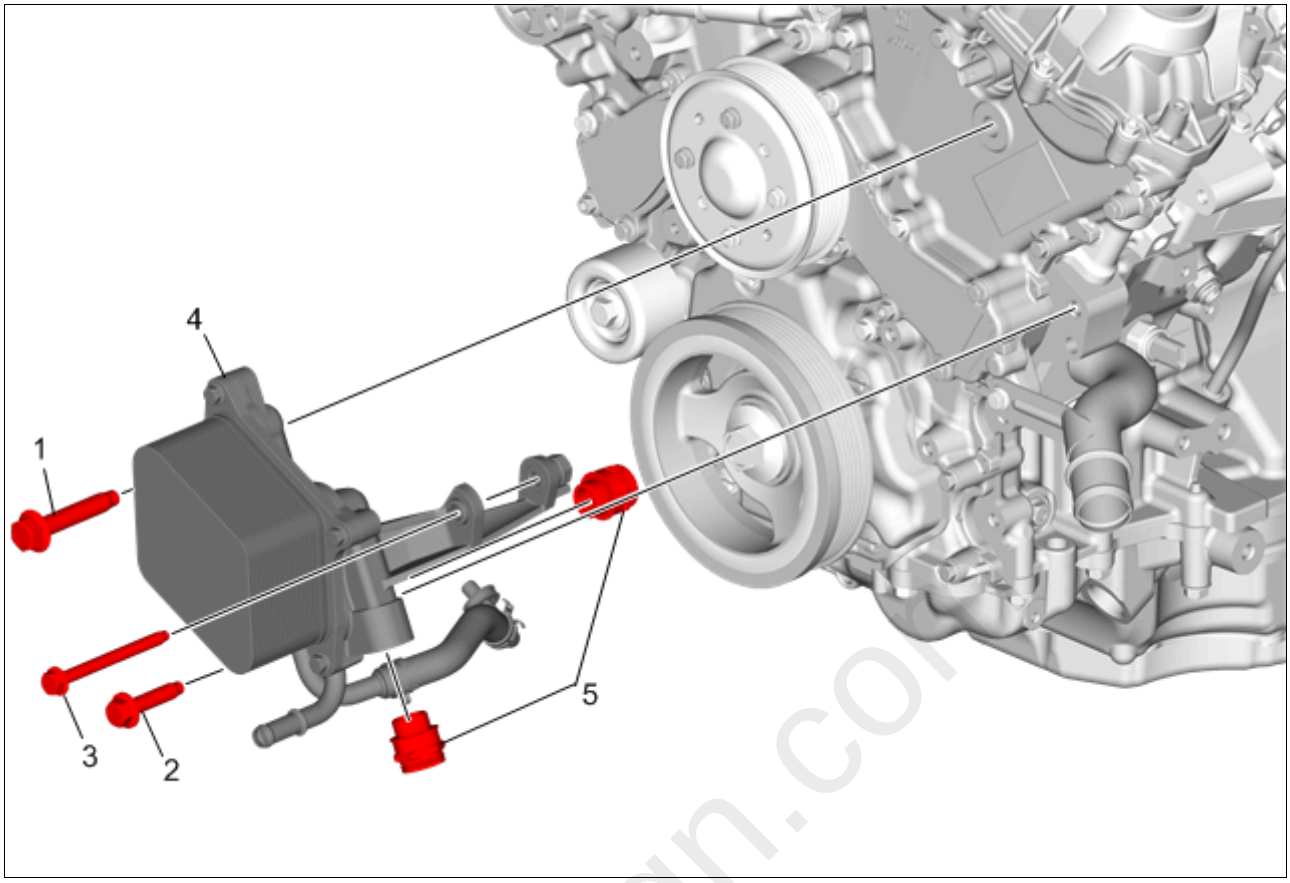
Engine Oil Cooler Pipes and Fittings Removal

Callout	Component Name
1	Engine Oil Cooler Pipe
2	Engine Oil Cooler Pipe
3	Engine Oil Cooler Inlet Pipe
4	Engine Oil Cooler Fitting
5	Engine Oil Cooler Fitting

REPAIR INSTRUCTIONS - OFF VEHICLE > ENGINE OIL COOLER ADAPTER REMOVAL > ENGINE OIL COOLER ADAPTER REMOVAL

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Fig 1: Engine Oil Cooler Adapter



Courtesy of GENERAL MOTORS COMPANY

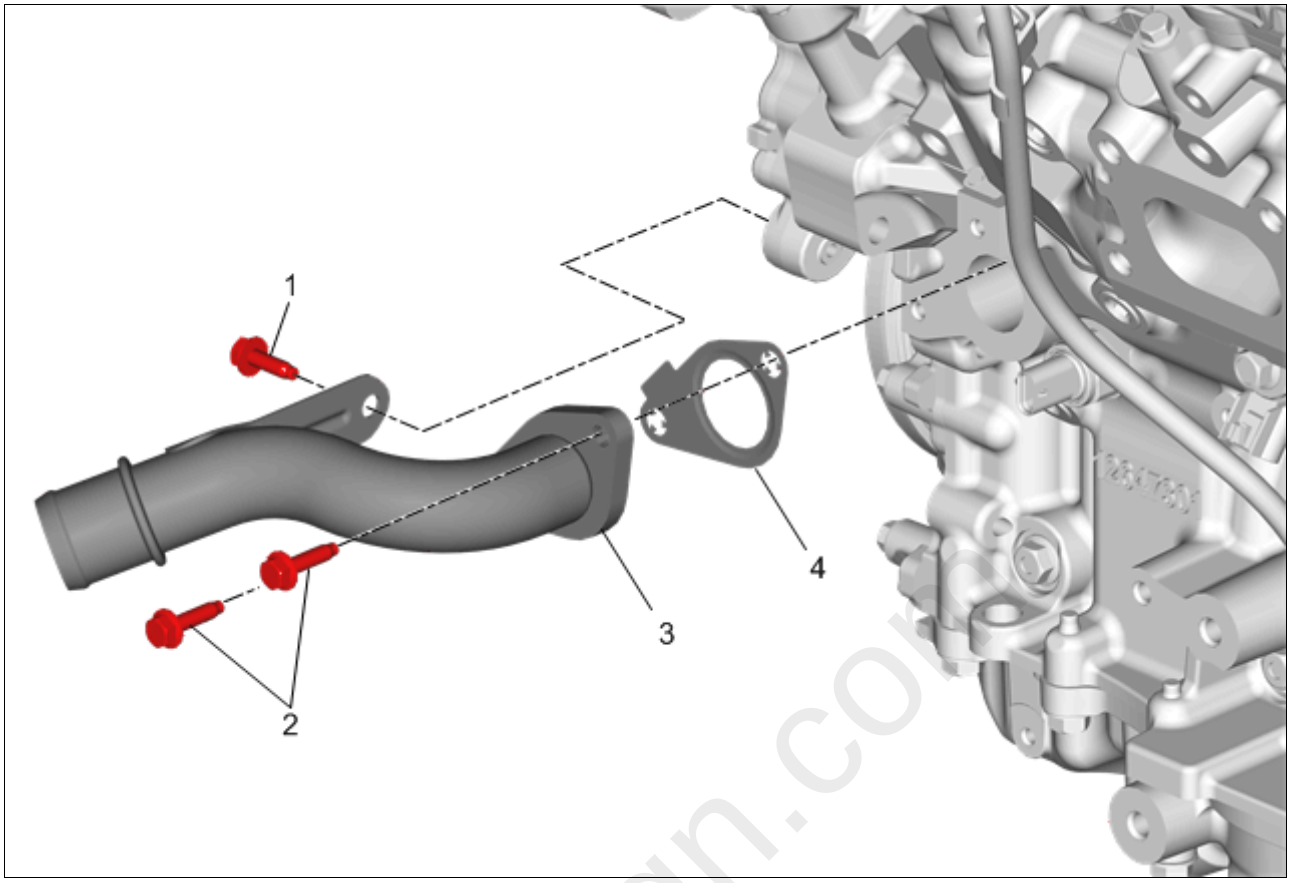
Engine Oil Cooler Adapter Removal

Callout	Component Name
1	Engine Oil Cooler Adapter Bolt M12 x 65.90
2	Engine Oil Cooler Adapter Bolt M10 x 45.75
3	Engine Oil Cooler Adapter Bolt M8 x 90.8
4	Engine Oil Cooler Adapter Assembly
5	Engine Oil Cooler Fitting (Qty: 2)

REPAIR INSTRUCTIONS - OFF VEHICLE > WATER PUMP INLET PIPE REMOVAL

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Fig 1: Water Pump Inlet Pipe

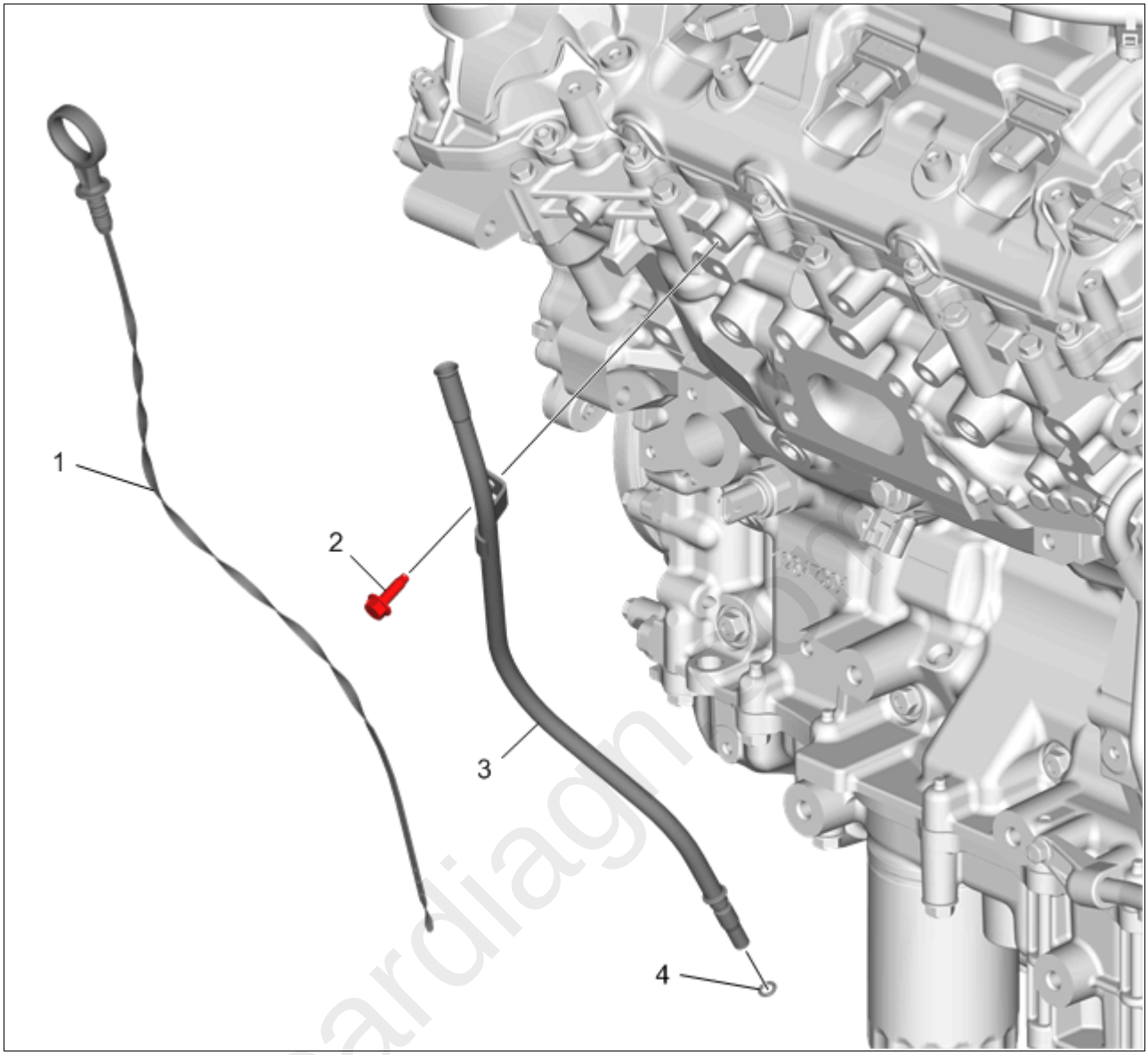


Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Water Pump Inlet Pipe Bolt
2	Water Pump Inlet Pipe Bolt (Qty: 2)
3	Water Pump Inlet Pipe
4	Water Inlet Seal *NOTE:* *Remove and DISCARD the seal.*

REPAIR INSTRUCTIONS - OFF VEHICLE > OIL LEVEL INDICATOR AND TUBE REMOVAL

Fig 1: Oil Level Indicator and Tube (LGX)

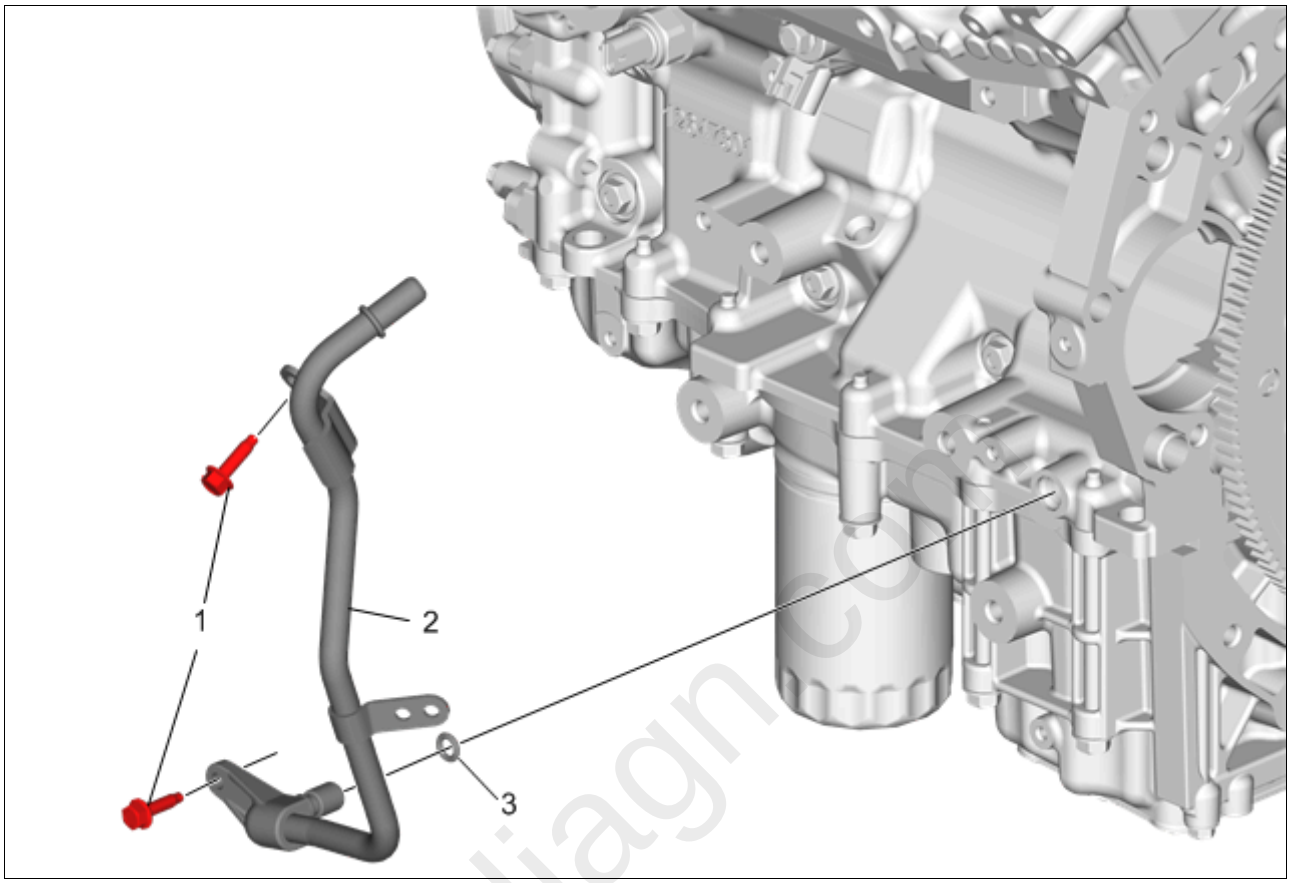


Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Engine Oil Level Indicator
2	Oil Level Indicator Tube Bolt
3	Oil Level Indicator Tube
4	Oil Level Indicator Tube Seal *NOTE:* *Remove and DISCARD the seal.*

REPAIR INSTRUCTIONS - OFF VEHICLE > VACUUM PUMP PIPE REMOVAL

Fig 1: Vacuum Pump Pipe

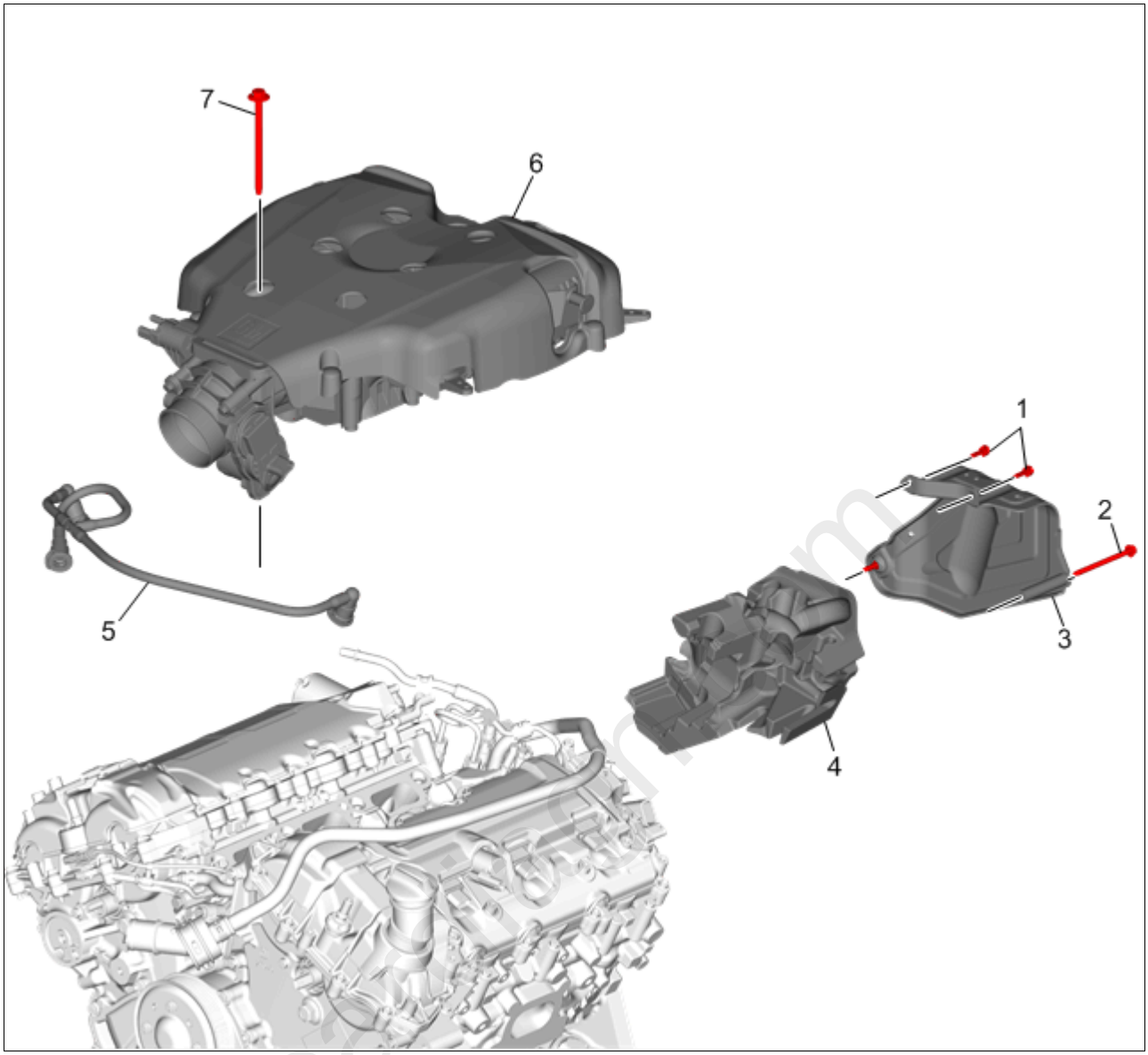


Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Vacuum Pump Pipe Bolt (Qty: 2)
2	Vacuum Pump Pipe
3	Vacuum Pump Pipe Seal

REPAIR INSTRUCTIONS - OFF VEHICLE > INTAKE MANIFOLD REMOVAL

Fig 1: Intake Manifold (LGX)



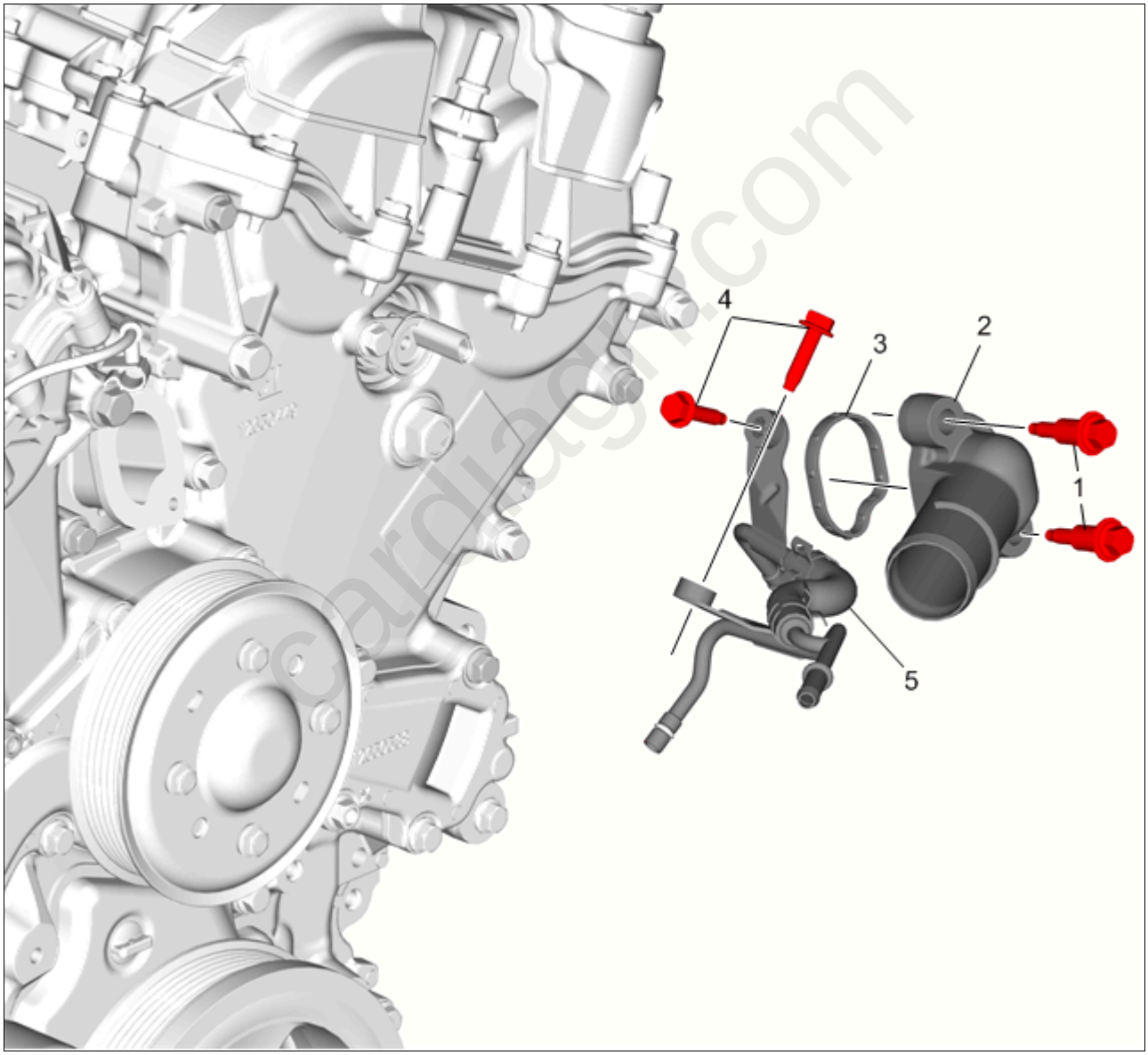
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Fuel Pipe Shield Bolt (Qty: 2)
2	Fuel Pipe Shield Bolt
3	Fuel Pipe Shield
4	Engine Rear Noise Shield *WARNING:* *The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire*

	resulting in catastrophic engine damage, and possible injury or death.
5	Positive Crankcase Ventilation Tube Connector
6	Intake Manifold Bolt (Qty: 8)
7	Intake Manifold

REPAIR INSTRUCTIONS - OFF VEHICLE > WATER OUTLET REMOVAL

Fig 1: Water Outlet (LGX)



Courtesy of GENERAL MOTORS COMPANY

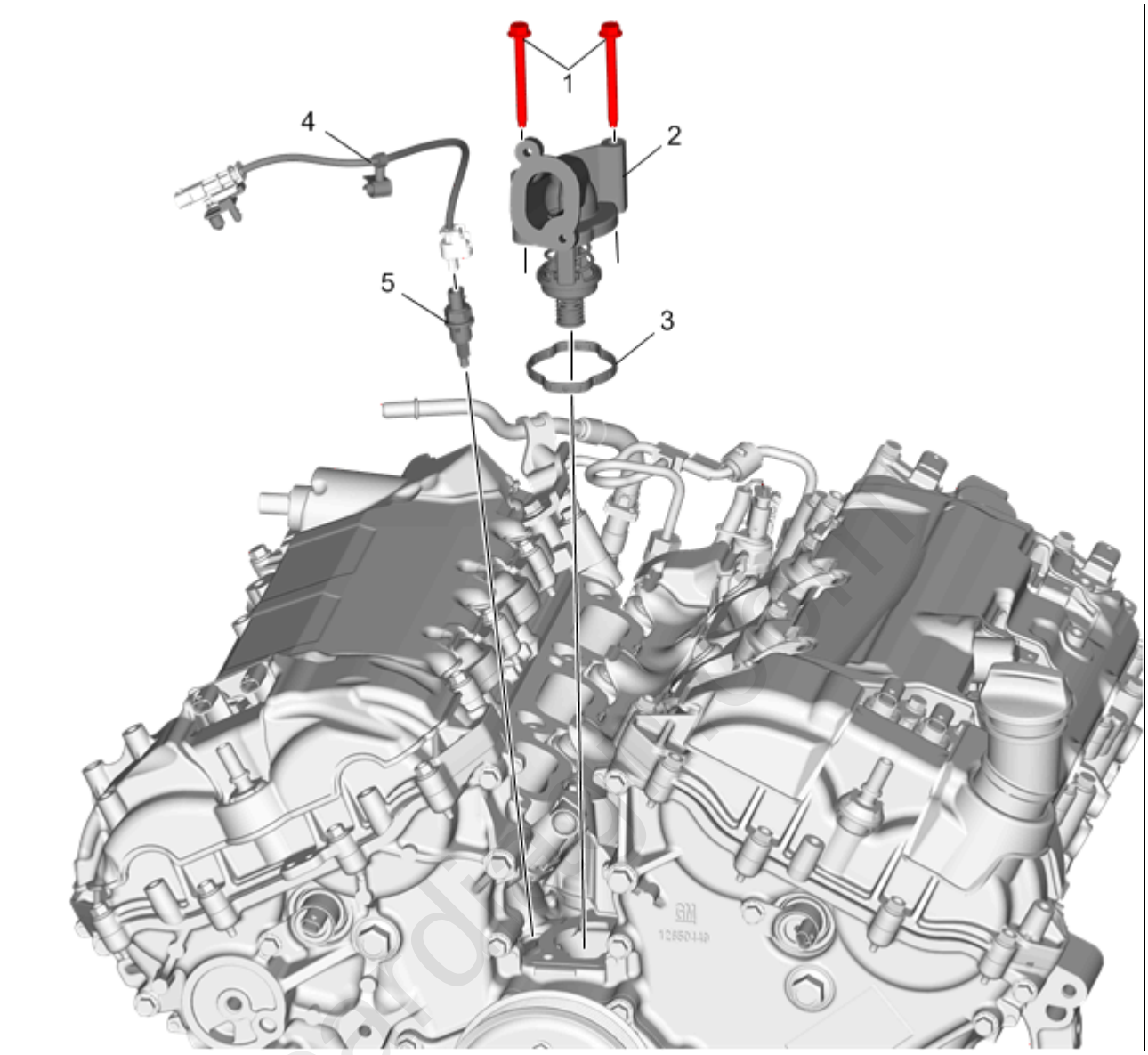
Callout	Component Name

1	Water Outlet Bolt (Qty: 2)
2	Water Outlet
3	Water Outlet Seal *NOTE:* *Discard seal, it is not reusable.*
4	Engine Coolant Air Bleed Pipe Bolt
5	Engine Coolant Air Bleed Pipe (Qty: 2)

REPAIR INSTRUCTIONS - OFF VEHICLE > ENGINE COOLANT THERMOSTAT HOUSING REMOVAL

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Fig 1: Engine Coolant Thermostat Housing (LGX)



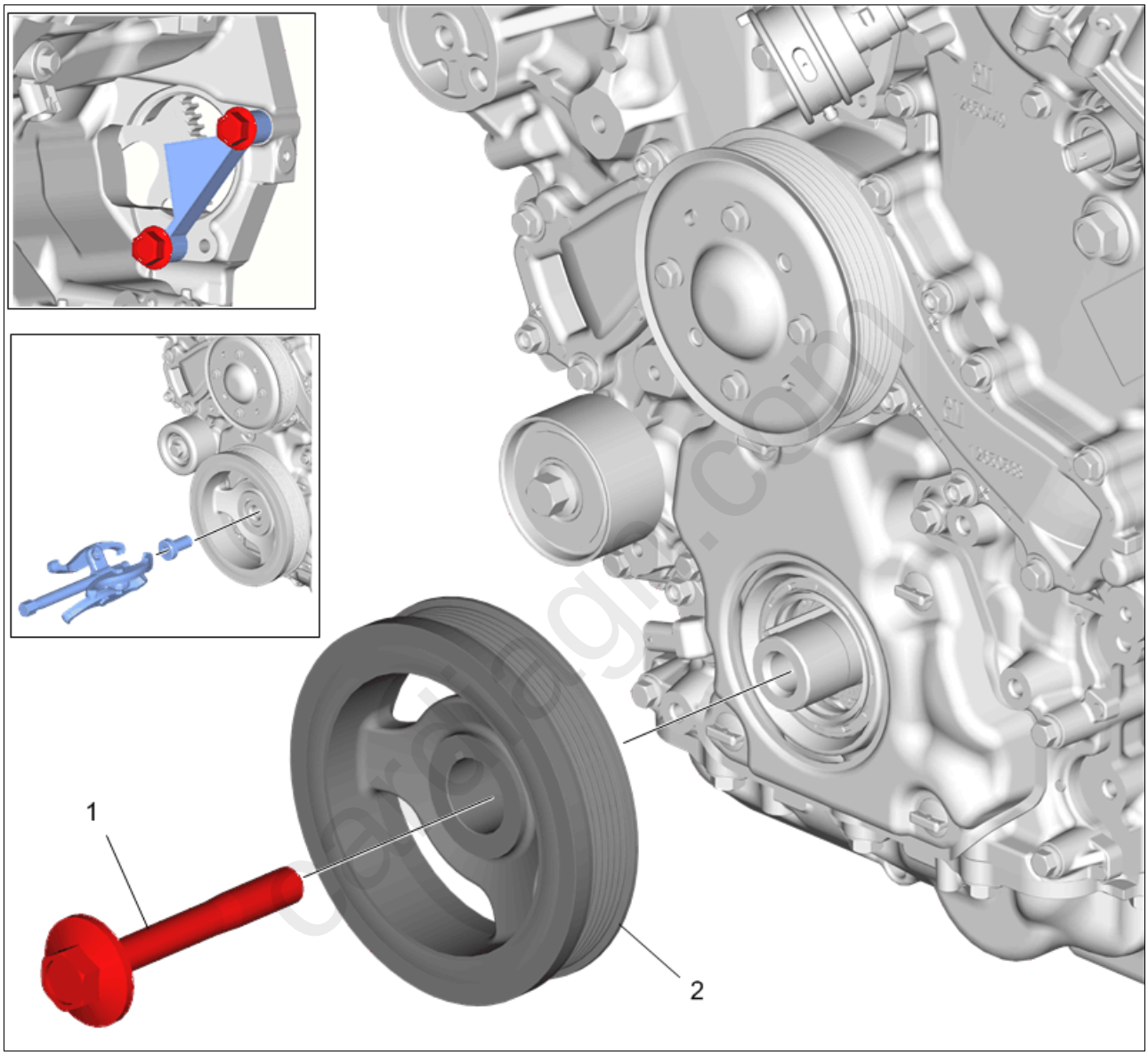
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Engine Coolant Thermostat Housing Bolt (Qty: 2)
2	Engine Coolant Thermostat Housing
3	Engine Coolant Thermostat Gasket *NOTE:* *Remove and DISCARD the gasket.*
4	Engine Coolant Temperature Sensor Wire

5	Engine Coolant Temperature Sensor

REPAIR INSTRUCTIONS - OFF VEHICLE > CRANKSHAFT BALANCER REMOVAL

Fig 1: Crankshaft Balancer (LGX)



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name

Procedure

1. Install the **EN-46106** Flywheel Holding Tool through the starter mounting hole.
2. Remove and discard the crankshaft balancer bolt.

3. Install the **EN-44226-5** Crankshaft Button in the nose of the crankshaft.
4. Install the **EN-41816** Crankshaft Balancer Remover in order to remove the crankshaft balancer.
5. Tighten the center bolt of the **EN-41816** Crankshaft Balancer Remover in order to pull the crankshaft balancer off of the crankshaft.
6. Remove the **EN-41816** Crankshaft Balancer Remover remover from the crankshaft balancer.
7. Remove the **EN-46106** Flywheel Holding Tool through the starter mounting hole.

Special Tools

- **EN-44226-5** Crankshaft Button
- **EN-41816** Crankshaft Balancer Remover
- **EN-46106** Flywheel Holding Tool

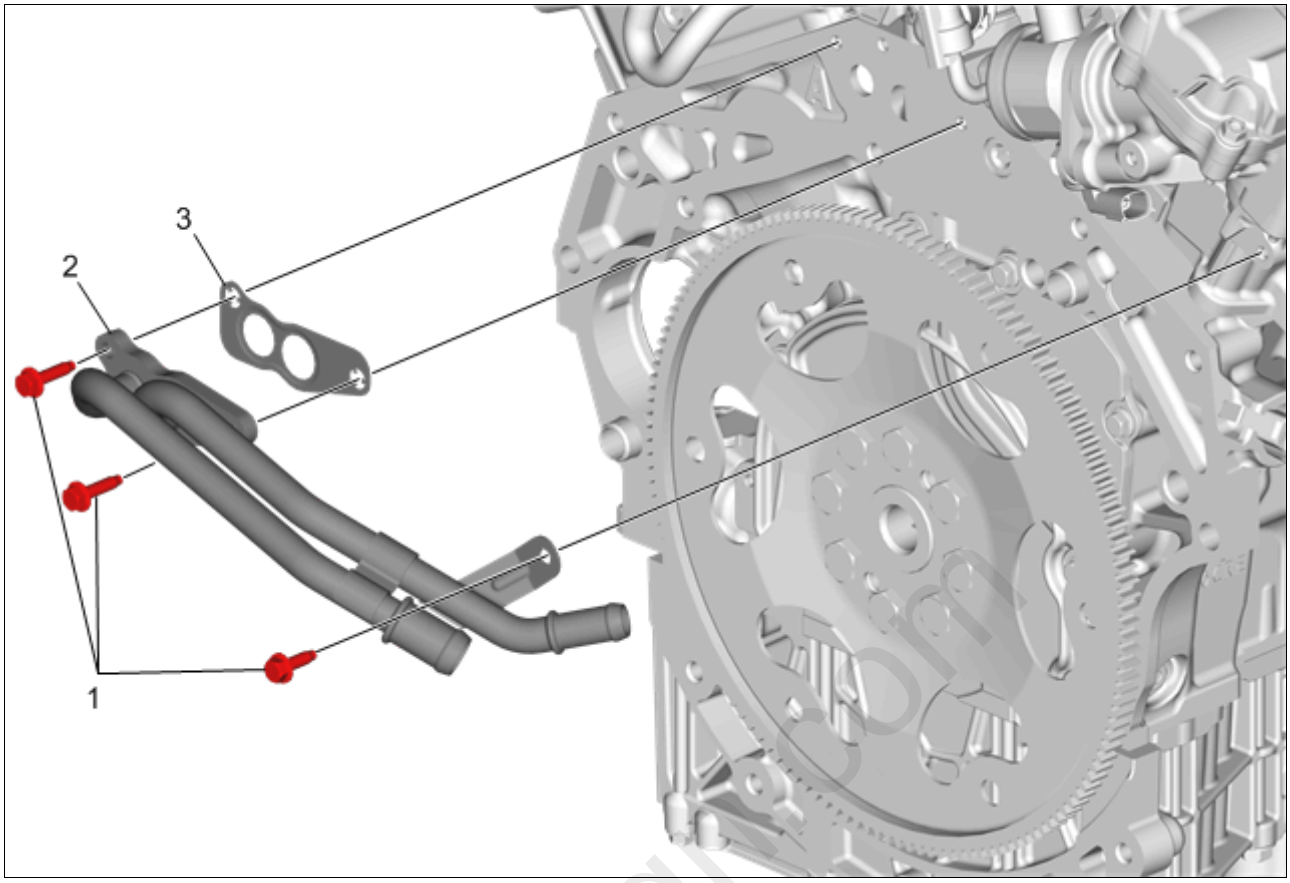
For equivalent regional tools, refer to Special Tools .

1	Crankshaft Balancer Bolt *NOTE:* *Remove and DISCARD the bolt.*
2	Crankshaft Balancer

REPAIR INSTRUCTIONS - OFF VEHICLE > HEATER INLET AND OUTLET PIPE REMOVAL

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Fig 1: Heater Inlet and Outlet Pipe



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Heater Inlet and Outlet Pipe Bolt (Qty: 3)
2	Heater Inlet and Outlet Pipe
3	Heater Inlet and Outlet Pipe Gasket *NOTE:* *Remove and DISCARD the gasket.*

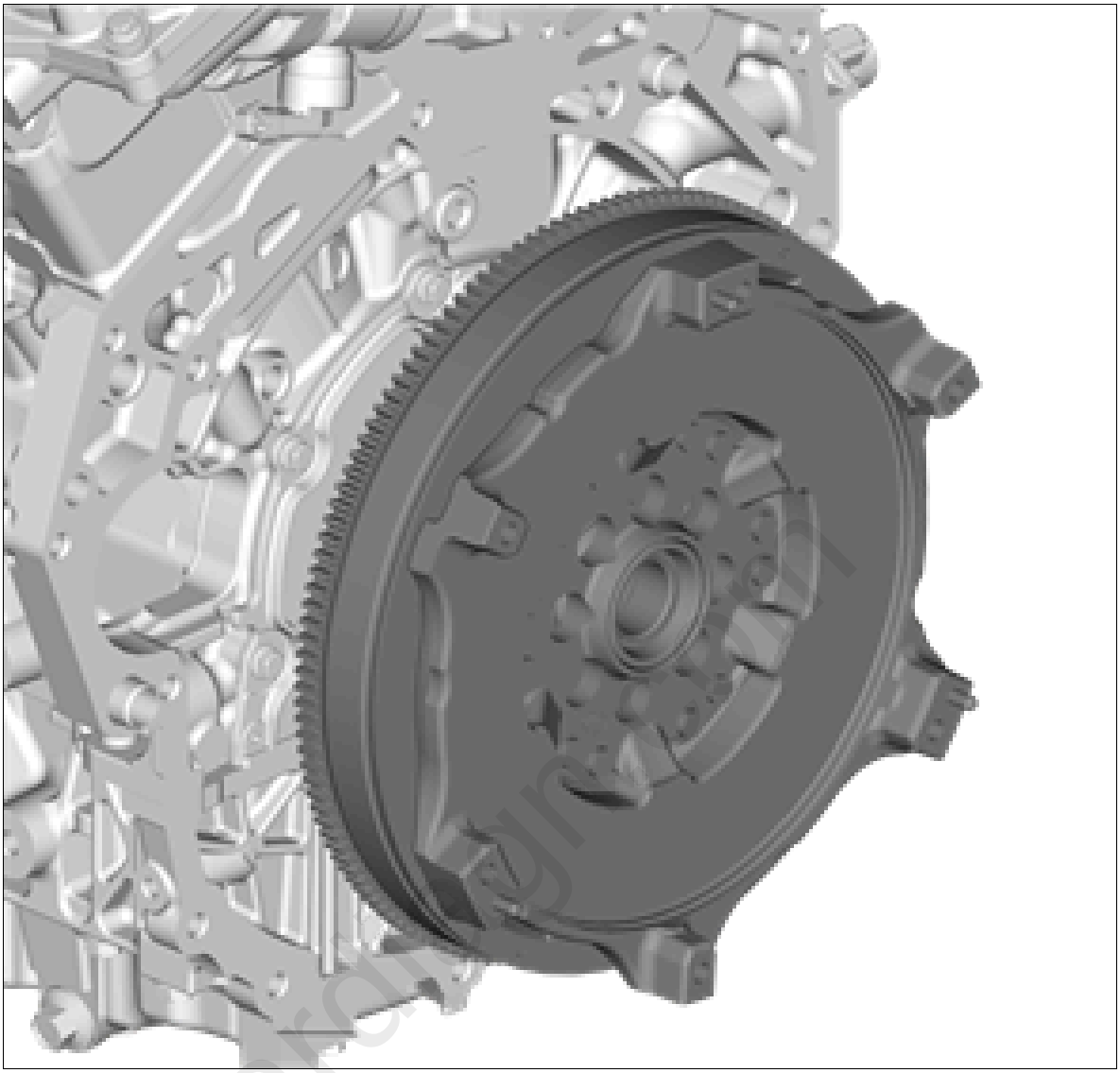
REPAIR INSTRUCTIONS - OFF VEHICLE > ENGINE FLYWHEEL REMOVAL

Special Tools

EN-46106 Flywheel Holding Tool

For equivalent regional tools, refer to Special Tools .

Fig 1: Engine Flywheel



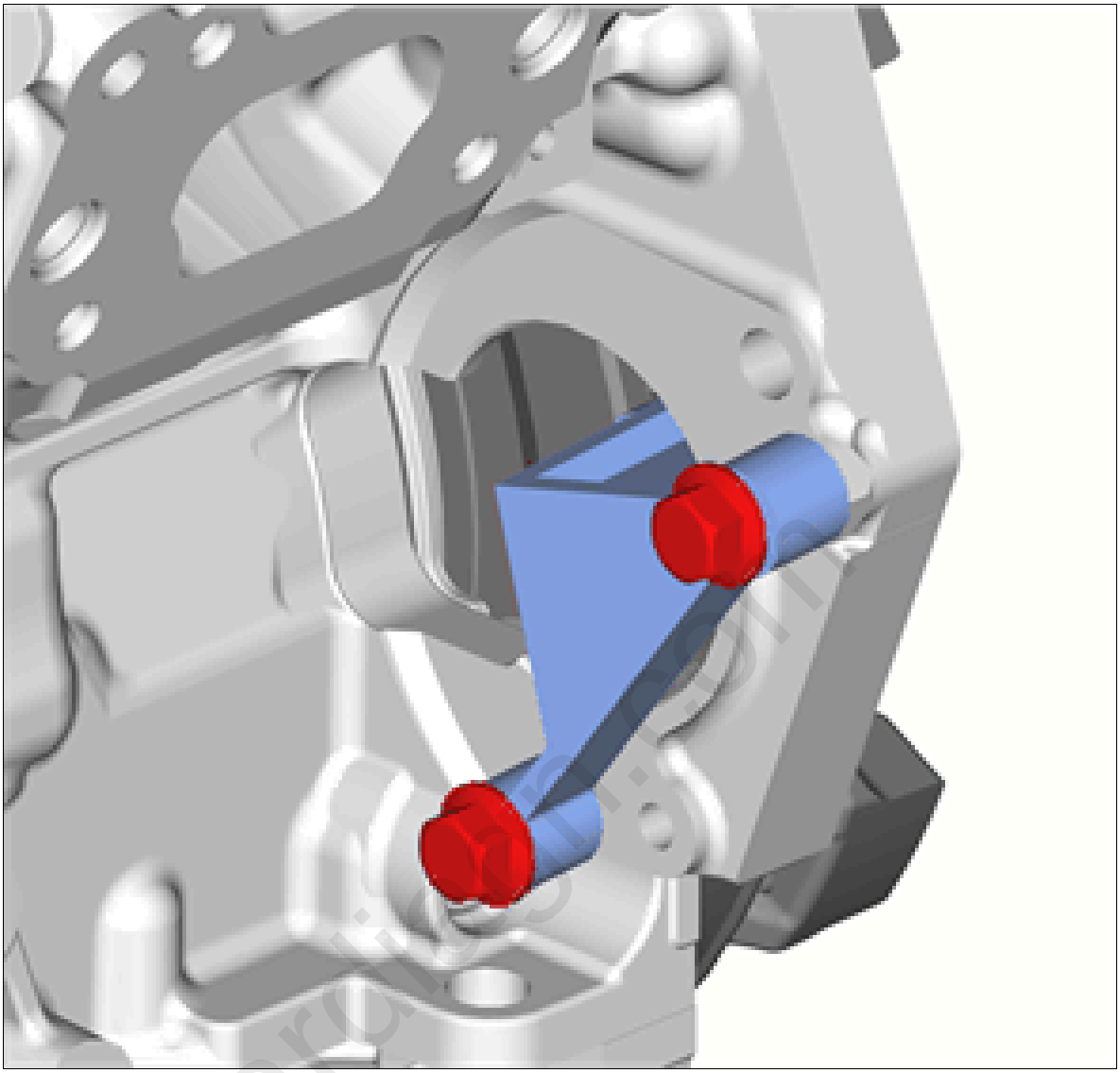
Courtesy of GENERAL MOTORS COMPANY

NOTE:

Note the position and direction of the engine flywheel before removal. The flywheel does not use a locating pin for alignment. Mark or scribe the end of the crankshaft and the flywheel before component removal. The existing manual transmission engine flywheel must be installed to the original position and direction.

1. Mark or scribe the end of the crankshaft and the manual transmission flywheel.

Fig 2: Flywheel Holding Tool



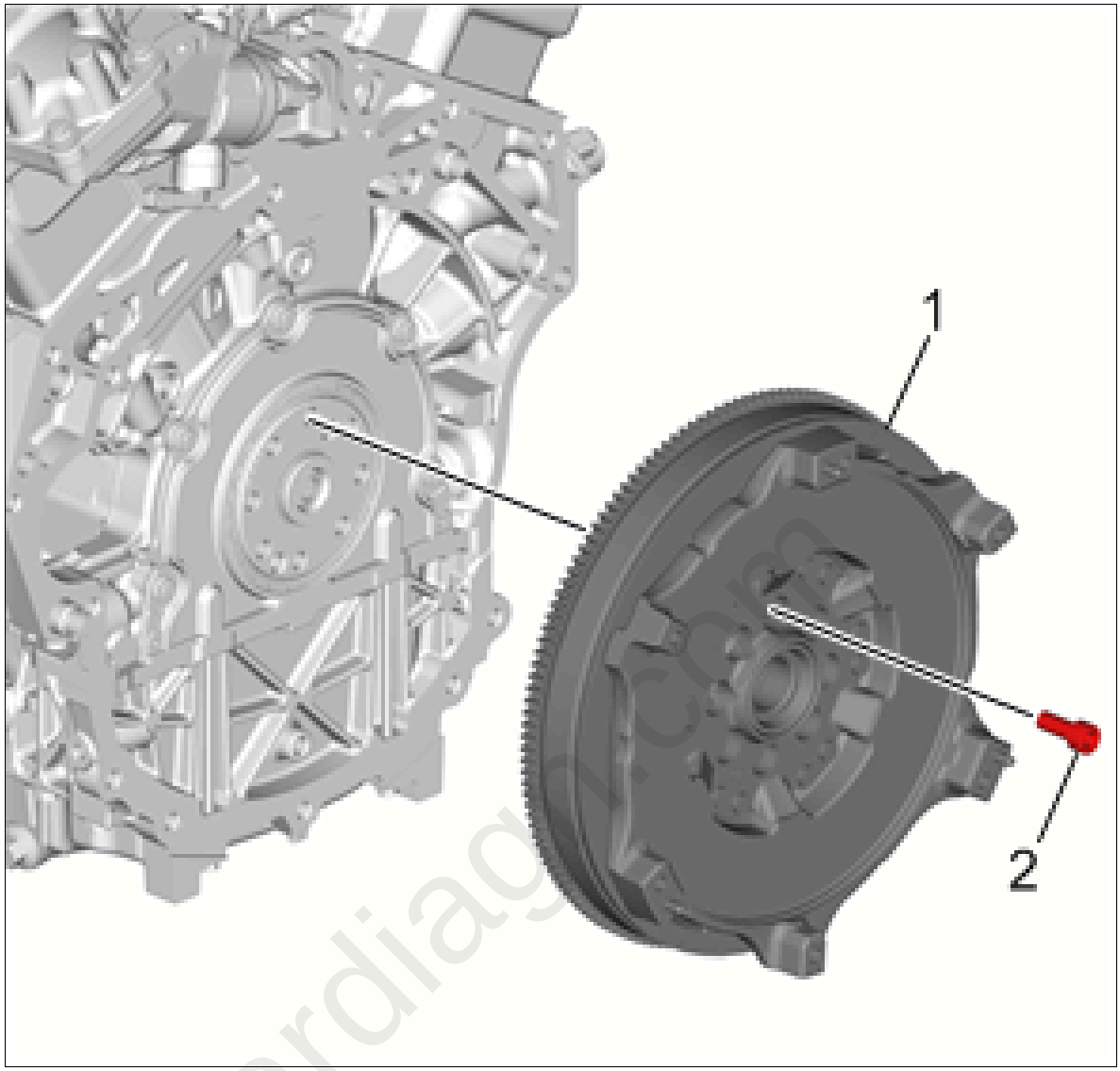
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> ⚠ *CAUTION:*
>
> *Refer to Fastener Caution .*

2. Install the **EN-46106** and bolts.

Fig 3: Flywheel Removed



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NOTE:

Do NOT reuse the flywheel bolts.

3. Remove and discard the flywheel bolts (2).
4. Remove the manual transmission flywheel (1).
5. Note the location of the manual transmission flywheel balance weights, if applicable.
6. Remove the **EN-46106** .

REPAIR INSTRUCTIONS - OFF VEHICLE > AUTOMATIC TRANSMISSION FLEX PLATE

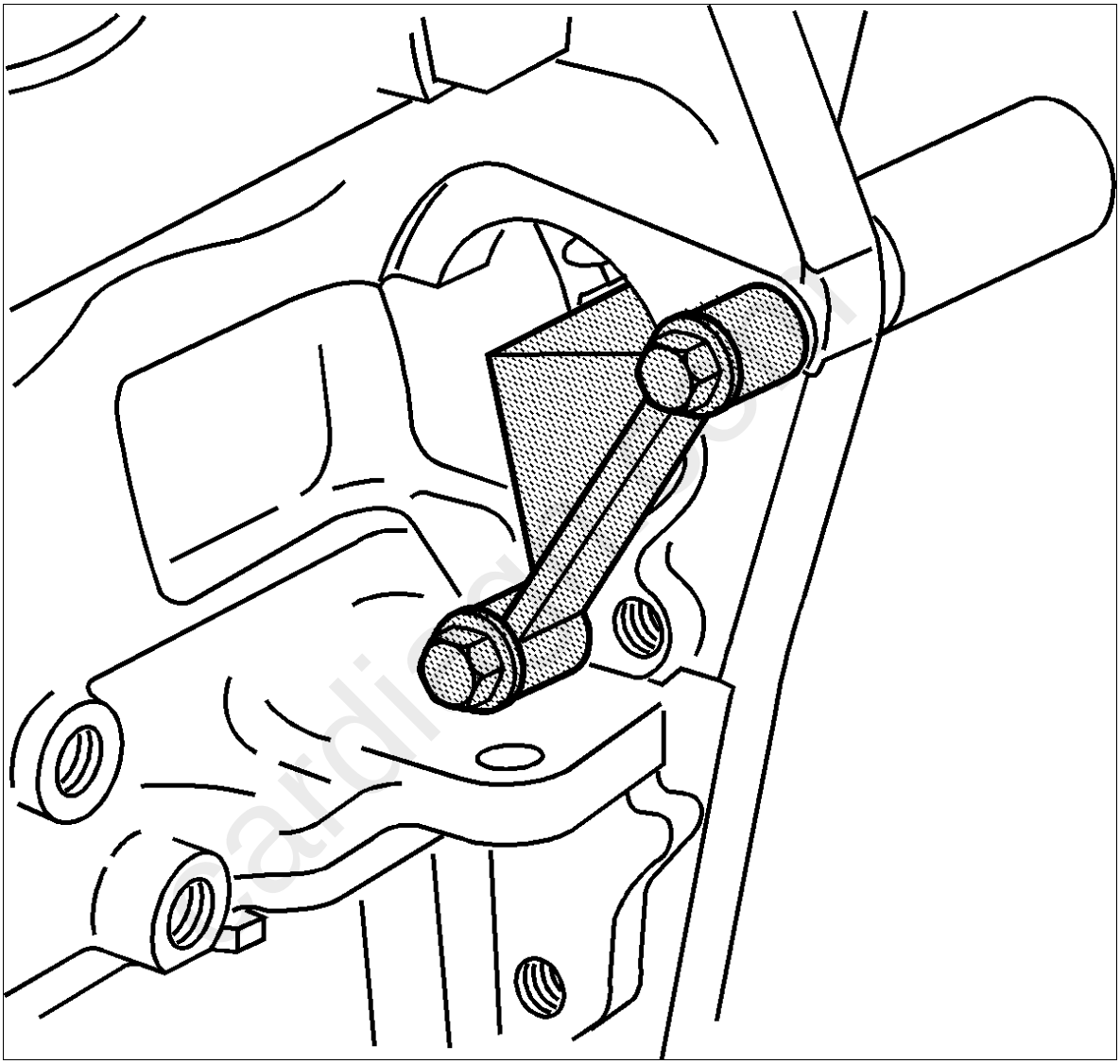
REMOVAL

Special Tools

EN 46106 Flywheel Holding Tool

For equivalent regional tools, refer to Special Tools .

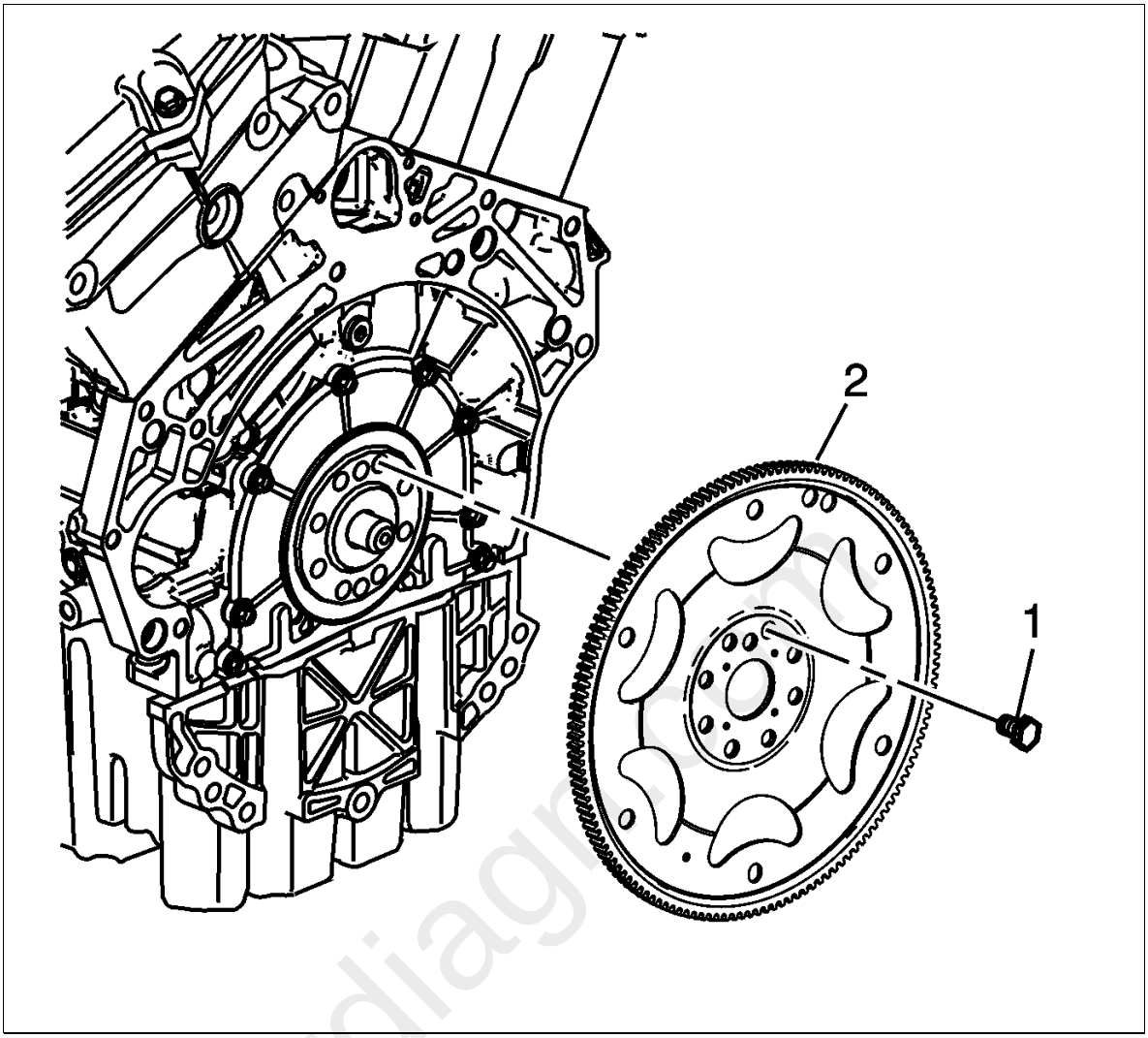
Fig 1: Flywheel Holding Fixture



Courtesy of GENERAL MOTORS COMPANY

1. Install the **EN 46106** tool through the starter mounting hole.

Fig 2: Engine Flywheel Bolts

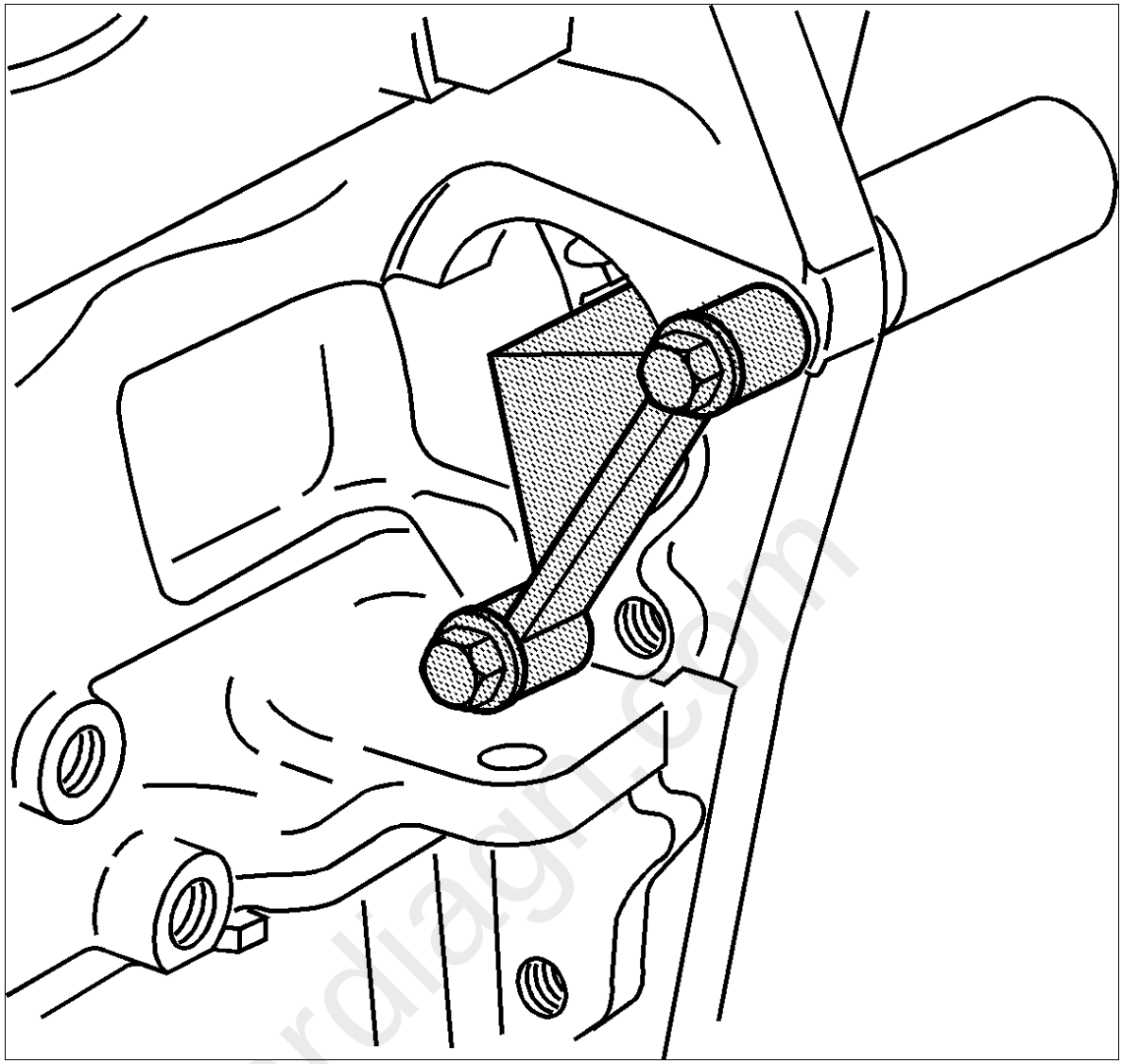


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2. Remove the flex plate bolts (1) and discard.
3. Remove the flex plate (2) from the crankshaft.

Fig 3: Flywheel Holding Fixture

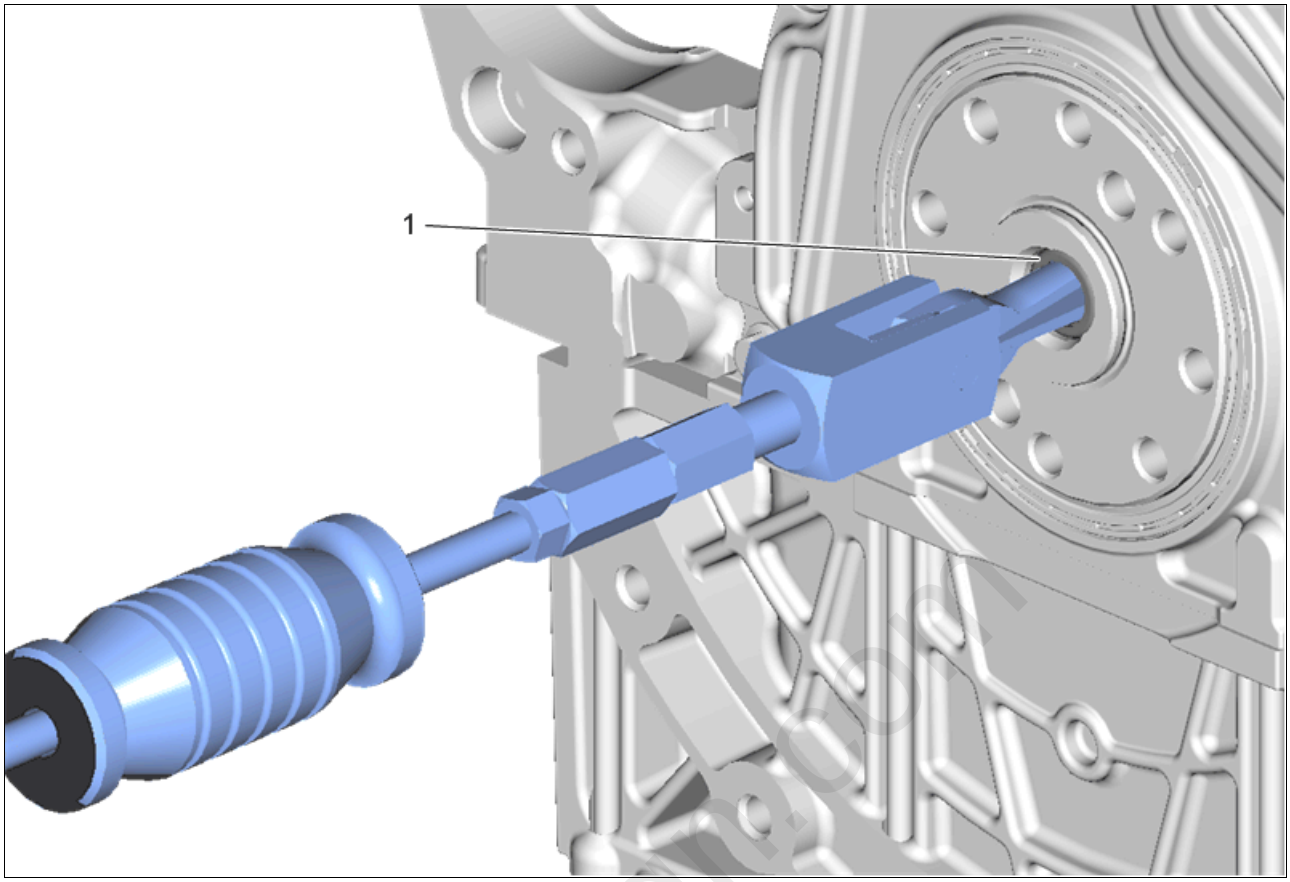


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4. Remove the **EN 46106** tool.

REPAIR INSTRUCTIONS - OFF VEHICLE > CLUTCH PILOT BEARING REMOVAL

Fig 1: Clutch Pilot Bearing



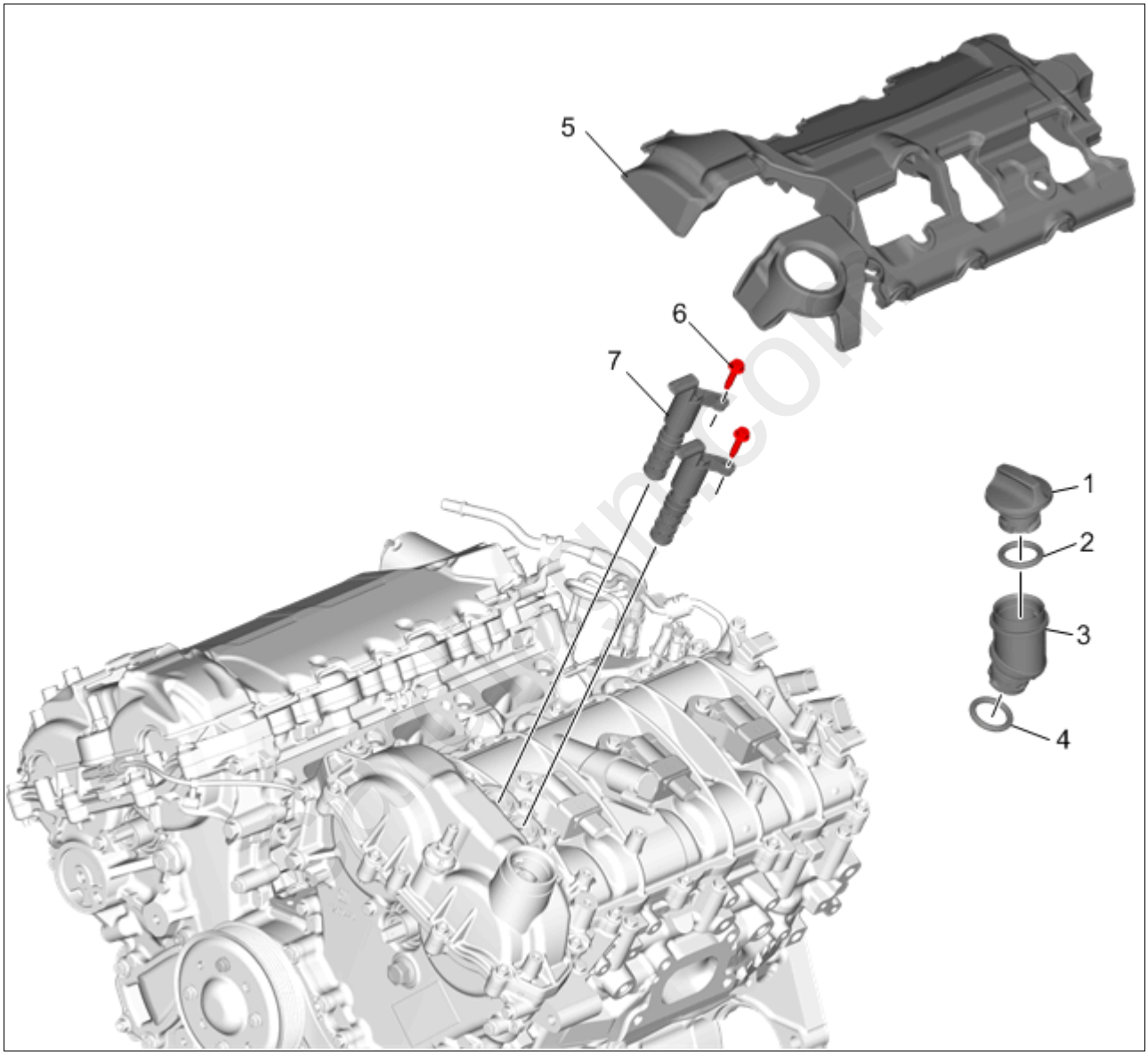
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Clutch Pilot Bearing Procedure 1. Install » **GE-23907** 2. Remove » Clutch Pilot Bearing 3. Remove » **GE-23907** **Special Tools** **GE-23907** Slide Hammer with Bearing Adapter *NOTE:* *DISCARD the clutch pilot bearing.* For equivalent regional tools, refer to Special Tools .

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REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT COVER REMOVAL - LEFT SIDE > OIL FILLER CAP AND TUBE, CAMSHAFT HOUSING COVER INSULATOR, AND CAMSHAFT POSITION ACTUATOR SOLENOID VALVE REMOVAL

Fig 1: Oil Filler Cap and Tube, Camshaft Housing Cover Insulator, and Camshaft Position Actuator Solenoid Valve



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Oil Filler Cap and Tube, Camshaft Housing Cover Insulator, and Camshaft Position Actuator Solenoid Valve Removal

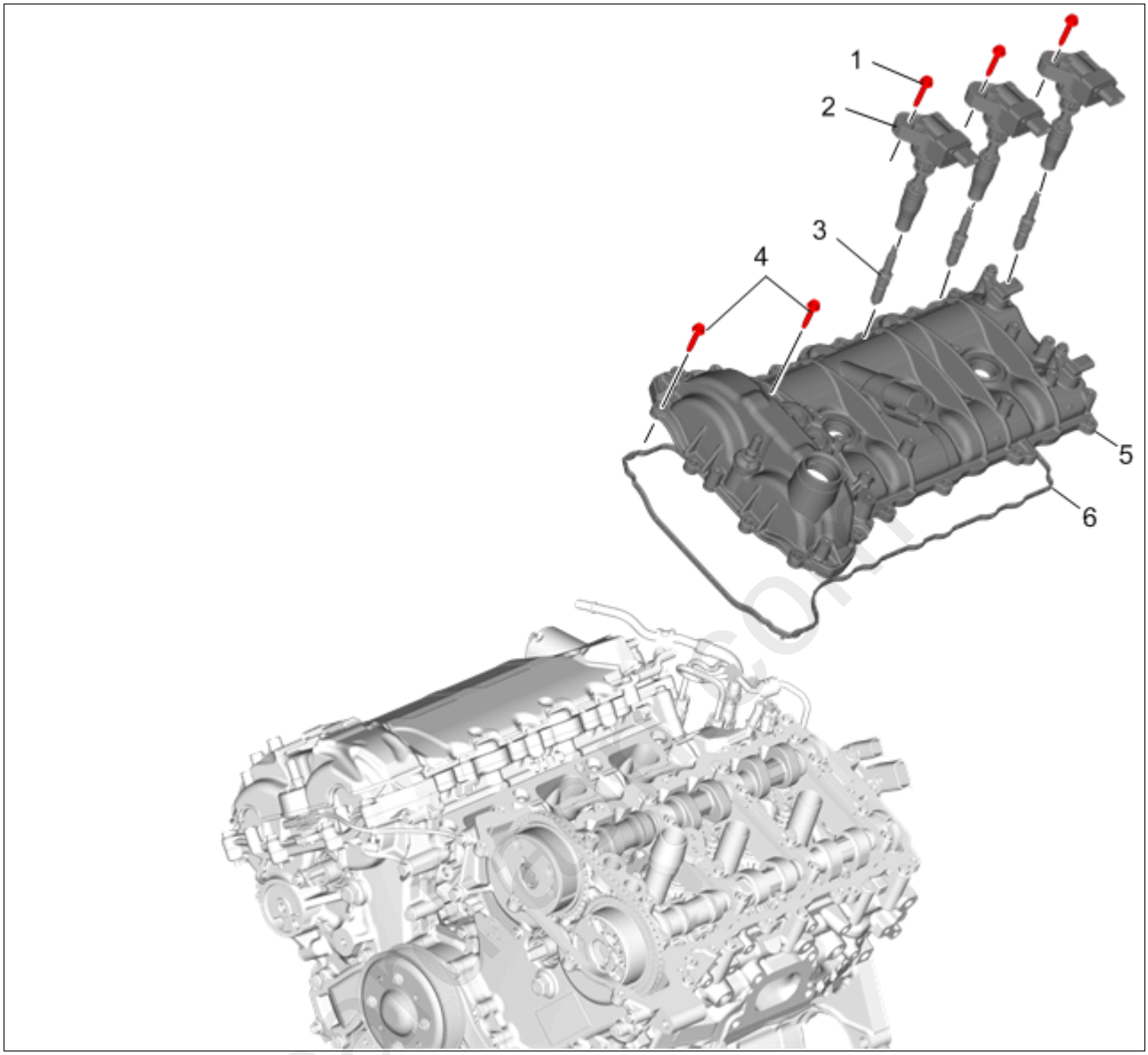
Callout	Component Name
1	Oil Filler Cap

2	Oil Filler Cap Seal *NOTE:* *Remove and DISCARD the seal.*
3	Oil Filler Cap Tube - Model Dependent
4	Oil Filler Cap Tube Seal *NOTE:* *Remove and DISCARD the seal.*
5	Camshaft Housing Cover InsulatorLeft Side Left Side
6	Camshaft Position Actuator Solenoid Valve Bolt (Qty: 2)
7	Camshaft Position Actuator Solenoid Valve (Qty: 2)

REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT COVER REMOVAL - LEFT SIDE > IGNITION COIL, SPARK PLUGS, CAMSHAFT COVER, AND SEAL REMOVAL

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Fig 1: Ignition Coil, Spark Plugs, Camshaft Cover, and Seal



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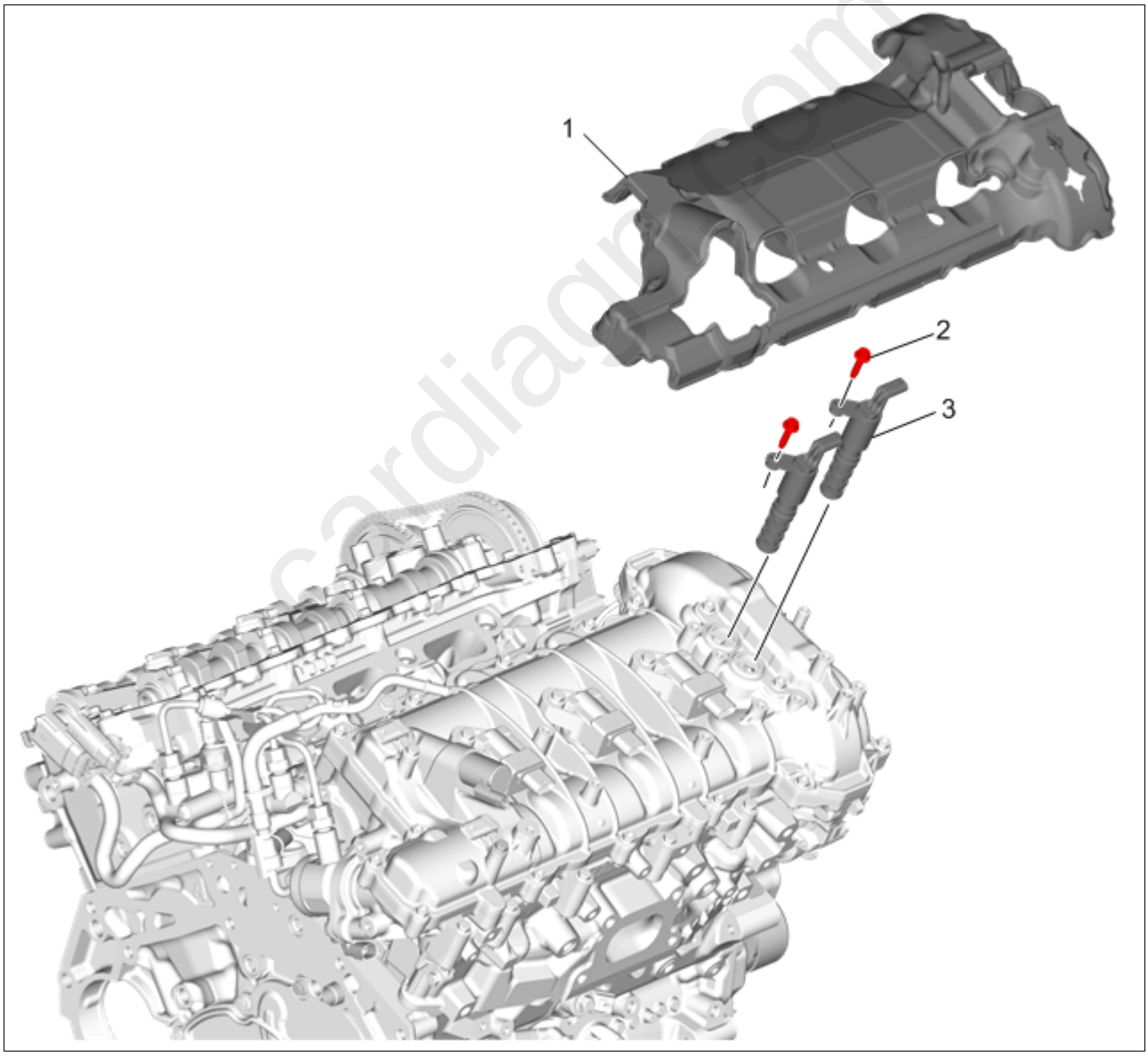
Ignition Coil, Spark Plugs, Camshaft Cover, and Seal Removal

Callout	Component Name
1	Ignition Coil Bolt (Qty: 3)
2	Ignition Coil (Qty: 3)
3	Spark Plug (Qty: 3)
4	Camshaft Cover Bolt (Qty: 18)
5	Camshaft CoverLeft Side

6	Camshaft Cover Seal Left Side *NOTE:* *Remove and DISCARD the seal.*

REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT COVER REMOVAL - RIGHT SIDE > CAMSHAFT HOUSING COVER INSULATOR AND CAMSHAFT POSITION ACTUATOR SOLENOID VALVE REMOVAL

Fig 1: Camshaft Housing Cover Insulator and Camshaft Position Actuator Solenoid Valve



Courtesy of GENERAL MOTORS COMPANY

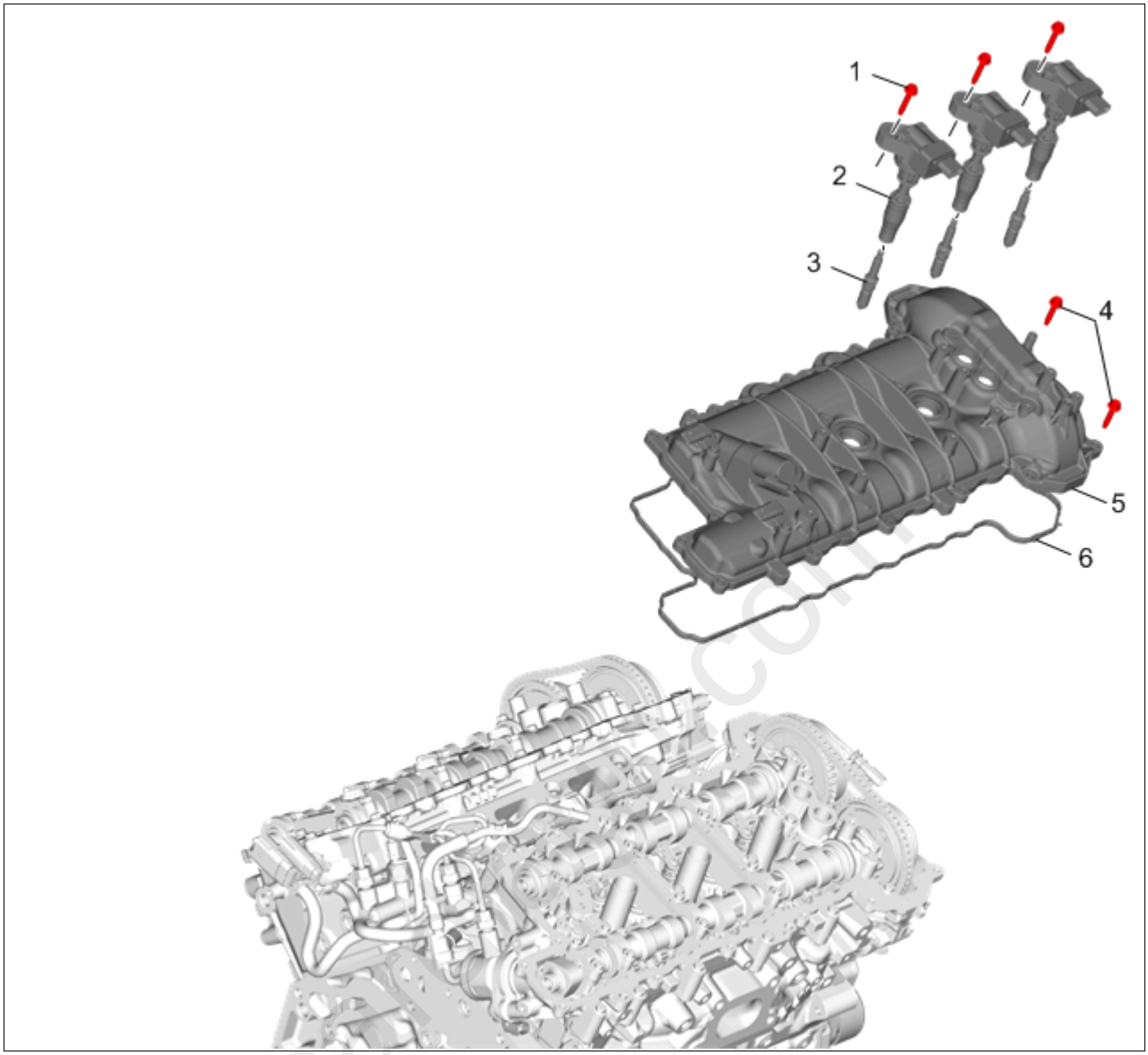
Camshaft Housing Cover Insulator and Camshaft Position Actuator Solenoid Valve Removal

Callout	Component Name
1	Camshaft Housing Cover InsulatorRight Side *WARNING:* *The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage, and possible injury or death.*
2	Camshaft Position Actuator Solenoid Valve Bolt (Qty: 2)
3	Camshaft Position Actuator Solenoid Valve (Qty: 2)

REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT COVER REMOVAL - RIGHT SIDE > IGNITION COIL, SPARK PLUGS, CAMSHAFT COVER, AND SEAL REMOVAL

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Fig 1: Ignition Coil, Spark Plugs, Camshaft Cover, and Seal



Courtesy of GENERAL MOTORS COMPANY

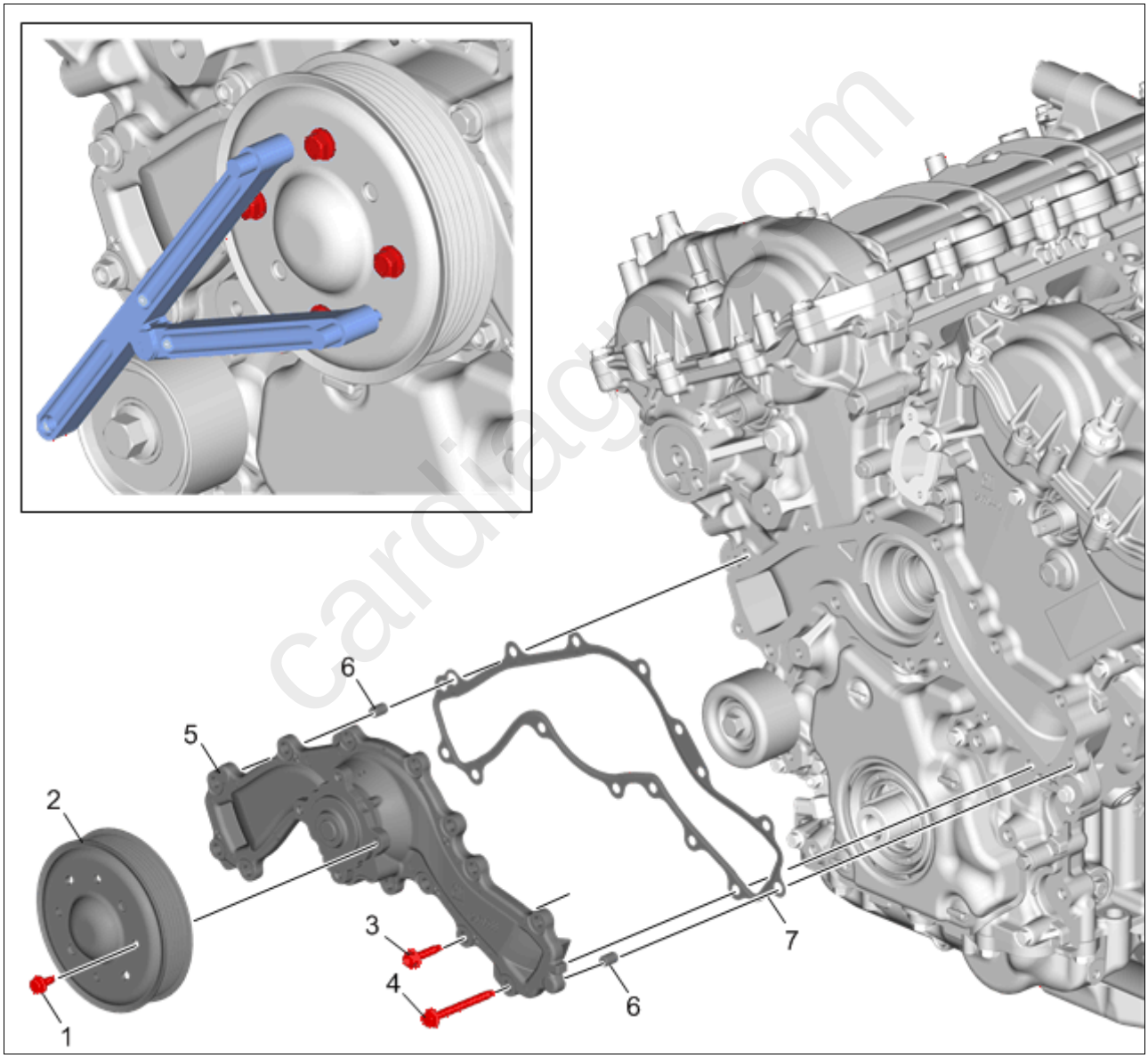
Ignition Coil, Spark Plugs, Camshaft Cover, and Seal Removal

Callout	Component Name
1	Ignition Coil Bolt (Qty: 3)
2	Ignition Coil (Qty: 3)
3	Spark Plug (Qty: 3)
4	Camshaft Cover Bolt (Qty: 18)
5	Camshaft CoverRight Side

6	Camshaft Cover Seal Right Side *NOTE:* *Remove and DISCARD the seal.*

REPAIR INSTRUCTIONS - OFF VEHICLE > WATER PUMP REMOVAL

Fig 1: Water Pump (LGX)



Courtesy of GENERAL MOTORS COMPANY

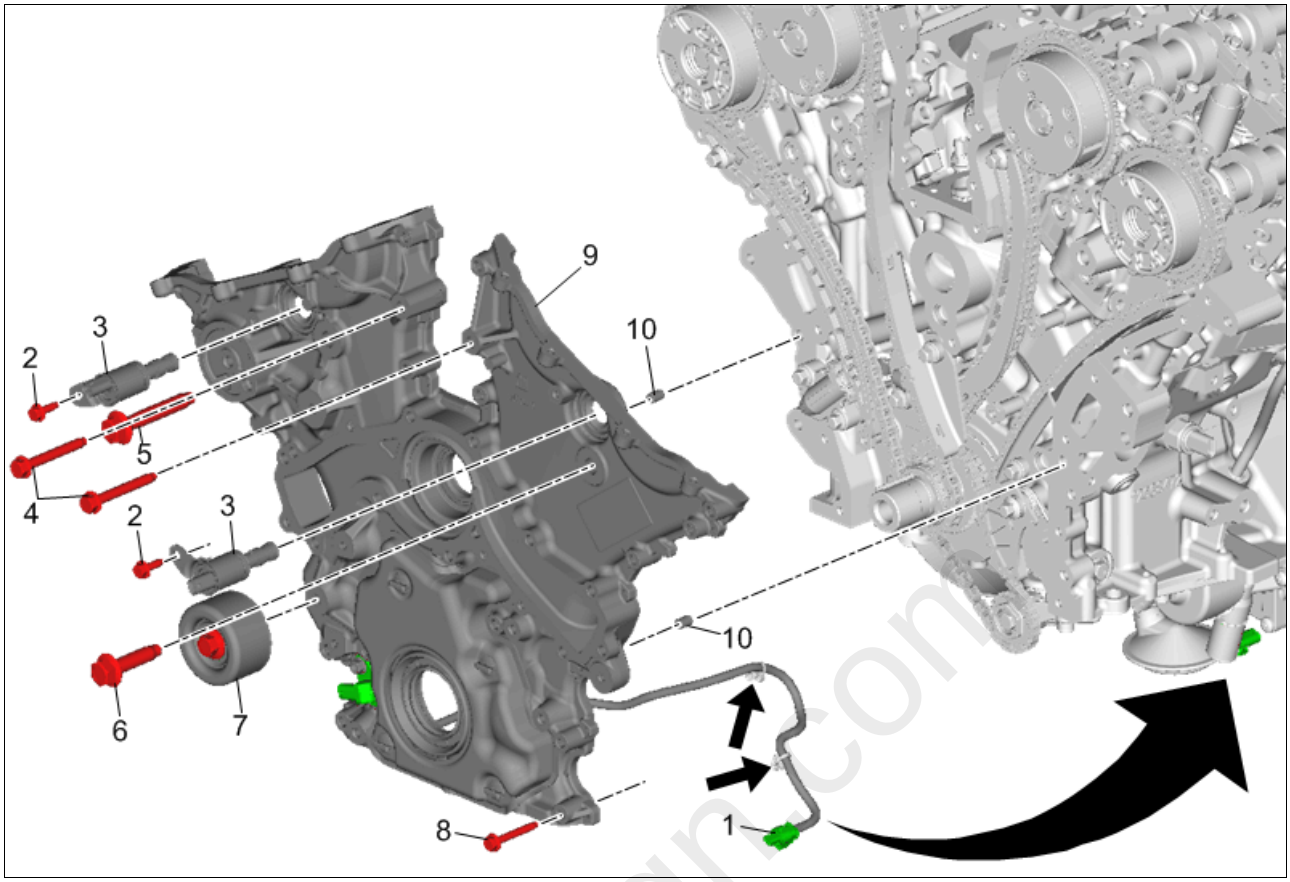
Callout	Component Name

1	Water Pump Pulley Bolt (Qty: 4)
2	Water Pump Pulley Procedure 1. Install the **EN-46104** Water Pump Pulley Holding Tool onto the water pump pulley mounting holes. 2. Remove the water pump pulley bolts. 3. Remove the **EN-46104** Water Pump Pulley Holding Tool from the water pump pulley. **Special Tools** **EN-46104** Water Pump Pulley Holding Tool For equivalent regional tools, refer to Special Tools .
3	Water Pump Bolt (Qty: 5) *NOTE:* *Remove and DISCARD the bolt.*
4	Engine Front Cover Bolt (Qty: 9) *NOTE:* *Remove and DISCARD the bolt.*
5	Water Pump
6	Water Pump Locating Pin (Qty: 2)
7	Water Pump Gasket *NOTE:* *Remove and DISCARD the gasket.*

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REPAIR INSTRUCTIONS - OFF VEHICLE > ENGINE FRONT COVER REMOVAL

Fig 1: Engine Front Cover (LGX)



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure If the oil pan needs removed it is easier to do before the front cover removal.Refer to:Oil Pan Removal . Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant	
1	Oil Pump Flow Control ValveElectrical Connector *NOTE:* *The retaining clips attached to the oil pump flow control solenoid wire are used for initial production only and should be removed and discarded.*
2	Camshaft Position Actuator Control Valve Bolt (Qty: 2)
3	Camshaft Position Actuator Control Valve (Qty: 2) *CAUTION:*

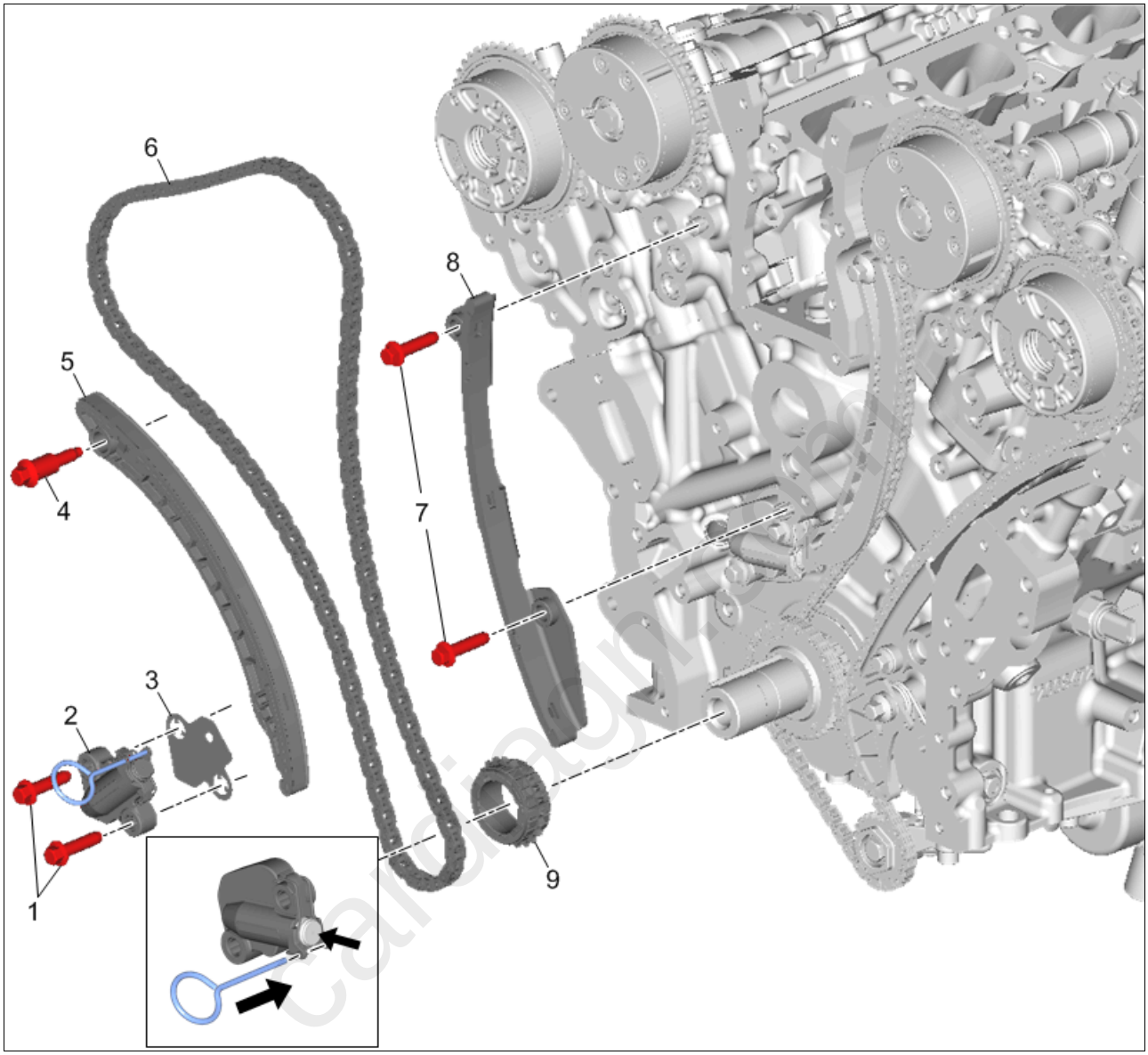
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	The camshaft position actuator valves must be removed from the front cover prior to front cover removal or damage to the valves may occur.
4	Engine Front Cover Bolt (Qty: 2)
5	Engine Front Cover Bolt *NOTE:* *Part of engine mount on Front Wheel Drive version.*
6	Engine Front Cover Bolt *NOTE:* *Part of engine mount on Front Wheel Drive version.*
7	Belt Idler Pulley
8	Engine Front Cover Bolt (Qty: 16)
9	Engine Front Cover *CAUTION:* *Do not use the jackscrew hole without first removing all engine front cover bolts. Failure to remove all engine front cover bolts before using the jackscrew hole could result in damage to components.* *CAUTION:* *Do not pry between the engine front cover and the camshaft position sensors or the camshaft position actuators in order to separate the RTV. Use the pry points and a bolt in the jackscrew hole in order to remove the engine front cover. Damage to the camshaft position sensors or the camshaft position actuators may occur if the camshaft position sensors or the camshaft position actuators are used to pry against in order to remove the engine front cover.*
10	Engine Front Cover Locating Pin (Qty: 2)

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REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT TIMING CHAIN COMPONENTS REMOVAL > RIGHT TIMING CHAIN COMPONENTS REMOVAL

Fig 1: Right Timing Chain Components



Courtesy of GENERAL MOTORS COMPANY

Right Timing Chain Components Removal

Callout	Component Name
Preliminary Procedure 1. Rotate the engine clockwise until the right hand bank camshaft flats with laser etched markings are straight up in relation to the cylinder head. The crankshaft key way will be at approximately the 3 o'clock position.	

WARNING:

The timing chain tensioner plunger is under high tension and must be retained by using the tensioner retraction pin during removal or installation of the timing chain tensioner. Failure to retain the timing chain tensioner plunger may cause it to be ejected with intense force and cause personal injury.

2. Reset the timing chain tensioner plunger using your thumb and **EN-52234** or a 1/8" drill bit to retain the plunger.
3. Compress the plunger into the body and lock the right timing chain tensioner by inserting **EN-52234** or 1/8" drill bit into the access hole in the side of the right timing chain tensioner body.
4. Slowly release pressure on the right timing chain tensioner. The right timing chain tensioner should remain compressed.

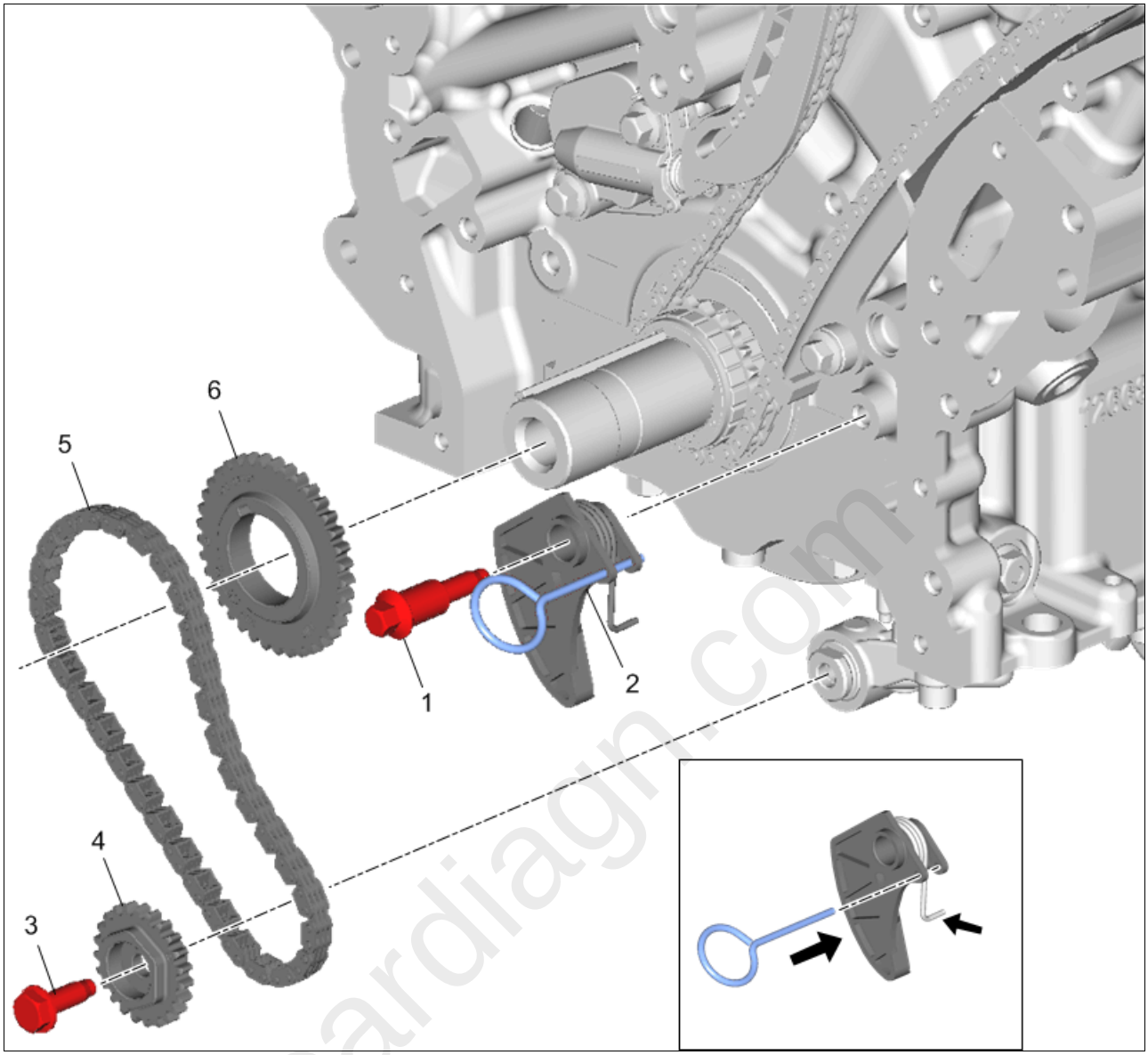
Special Tools EN-52234 Timing Chain Tensioner Retaining PinsFor equivalent regional tools, refer to Special Tools .

1	Timing Chain Tensioner Bolt (Qty: 2)
2	Timing Chain Tensioner - Right Side
3	Timing Chain Tensioner Gasket *NOTE:* *Remove and DISCARD the gasket.*
4	Timing Chain Guide Bolt
5	Timing Chain Guide - Right Side
6	Timing Chain - Right Side
7	Timing Chain Guide Bolt (Qty: 2)
8	Timing Chain Guide - Right Side
9	Crankshaft Sprocket

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REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT TIMING CHAIN COMPONENTS REMOVAL > OIL PUMP TIMING CHAIN COMPONENTS REMOVAL

Fig 1: Oil Pump Timing Chain Components



Courtesy of GENERAL MOTORS COMPANY

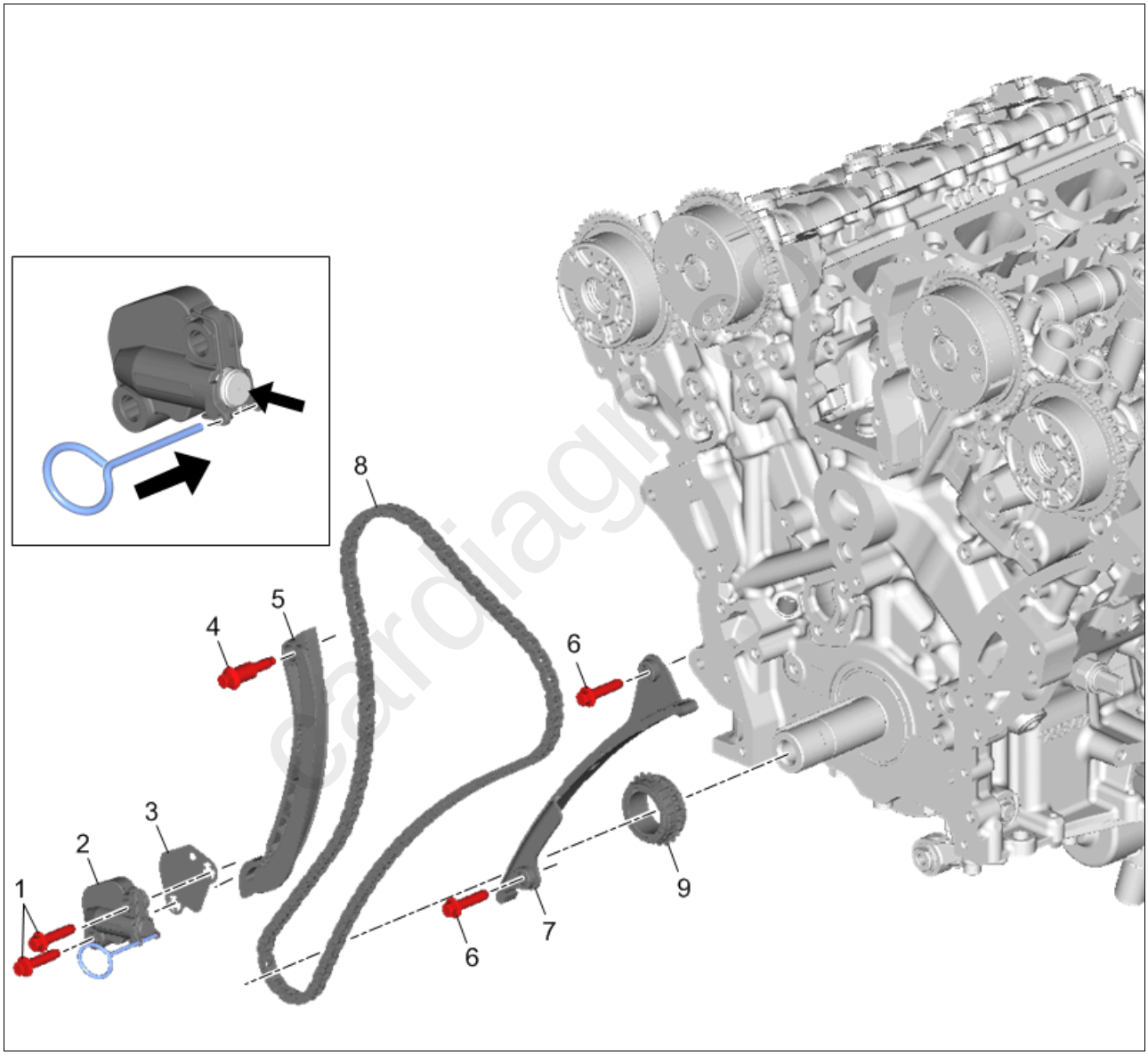
Oil Pump Timing Chain Components Removal

Callout	Component Name
1	Timing Chain Tensioner Bolt
2	Timing Chain Tensioner **Procedure** Collapse the oil pump timing tensioner by hand and install **EN-52234** or a 1/8" drill bit to hold it in place. **Special Tools** **EN-52234** Timing Chain Tensioner Retaining Pins For equivalent regional tools, refer to Special Tools .
3	Oil Pump Drive Bolt

4	Oil Pump Sprocket
5	Oil Pump Timing Chain
6	Crankshaft Sprocket

REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT TIMING CHAIN COMPONENTS REMOVAL > LEFT TIMING CHAIN COMPONENTS REMOVAL

Fig 1: Left Timing Chain Components



Courtesy of GENERAL MOTORS COMPANY

Left Timing Chain Components Removal

Callout	Component Name

Preliminary Procedure

1. Rotate the engine counter clockwise until the left hand bank camshaft flats with laser etched markings are straight up in relation to the cylinder head. The crankshaft key way will be at approximately the 11 o'clock position.

   WARNING:

   The timing chain tensioner plunger is under high tension and must be retained by using the tensioner retraction pin during removal or installation of the timing chain tensioner. Failure to retain the timing chain tensioner plunger may cause it to be ejected with intense force and cause personal injury.

2. Reset the timing chain tensioner plunger using your thumb and **EN-52234** or a 1/8" drill bit to retain the plunger.
3. Compress the plunger into the body and lock the right timing chain tensioner by inserting **EN-52234** or 1/8" drill bit into the access hole in the side of the right timing chain tensioner body.
4. Slowly release pressure on the right timing chain tensioner. The right timing chain tensioner should remain compressed.

Special Tools EN-52234 Timing Chain Tensioner Retaining PinsFor equivalent regional tools, refer to Special Tools .

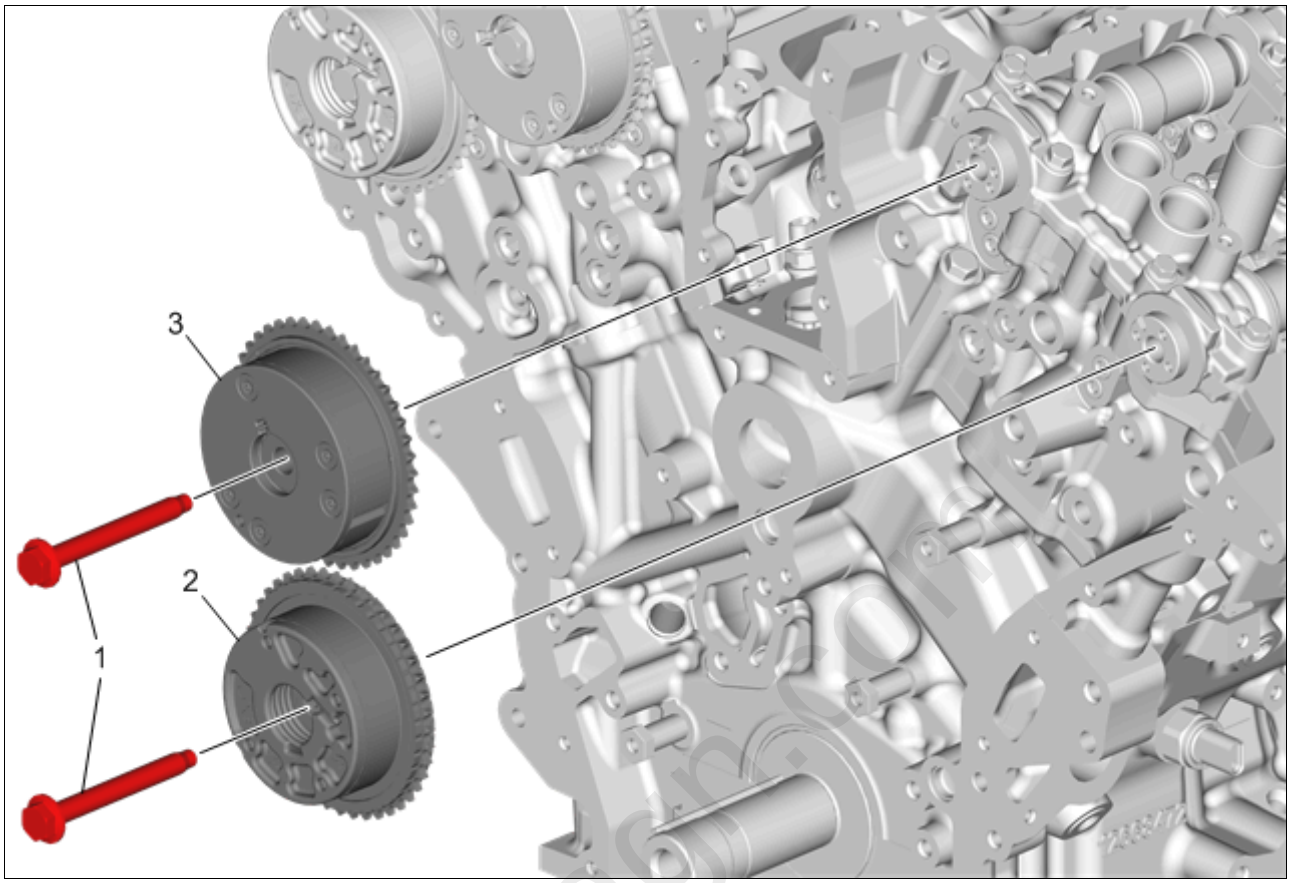
1	Timing Chain Tensioner Bolt (Qty: 2)
2	Timing Chain Tensioner - Left Side
3	Timing Chain Tensioner Gasket *NOTE:* *Remove and DISCARD the gasket.*
4	Timing Chain Guide Bolt (Qty: 2)
5	Timing Chain Guide - Left Side
6	Timing Chain Guide Bolt (Qty: 2)
7	Timing Chain Guide - Left Side
8	Timing Chain - Left Side
9	Crankshaft Sprocket

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REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT POSITION ACTUATOR

REMOVAL - BANK 2

Fig 1: Camshaft Position Actuator - Bank 2



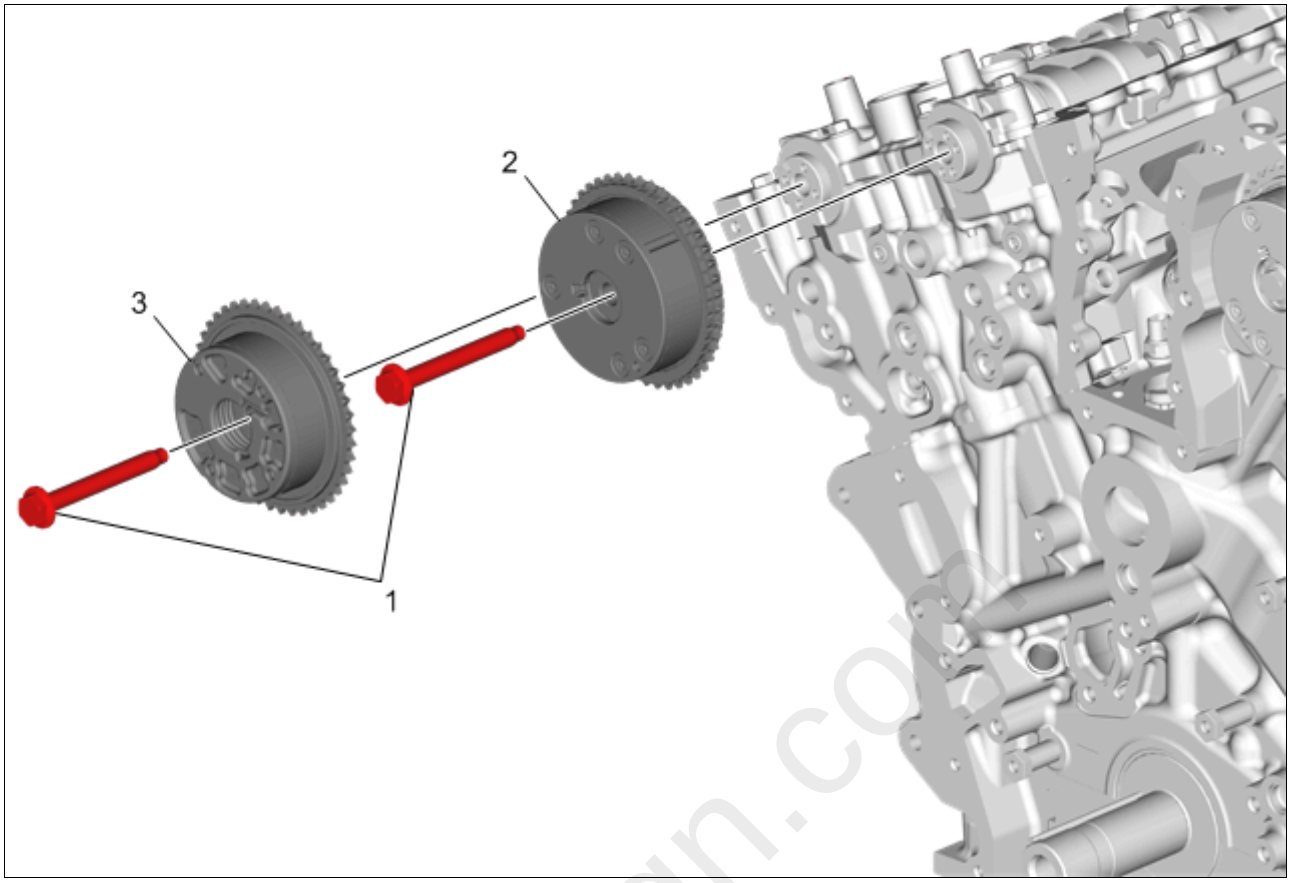
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Camshaft Position Actuator Bolt (Qty: 2)
2	Exhaust Camshaft Position Actuator Bank 2
3	Intake Camshaft Position Actuator Bank 2

REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT POSITION ACTUATOR

REMOVAL - BANK 1

Fig 1: Camshaft Position Actuator - Bank 1



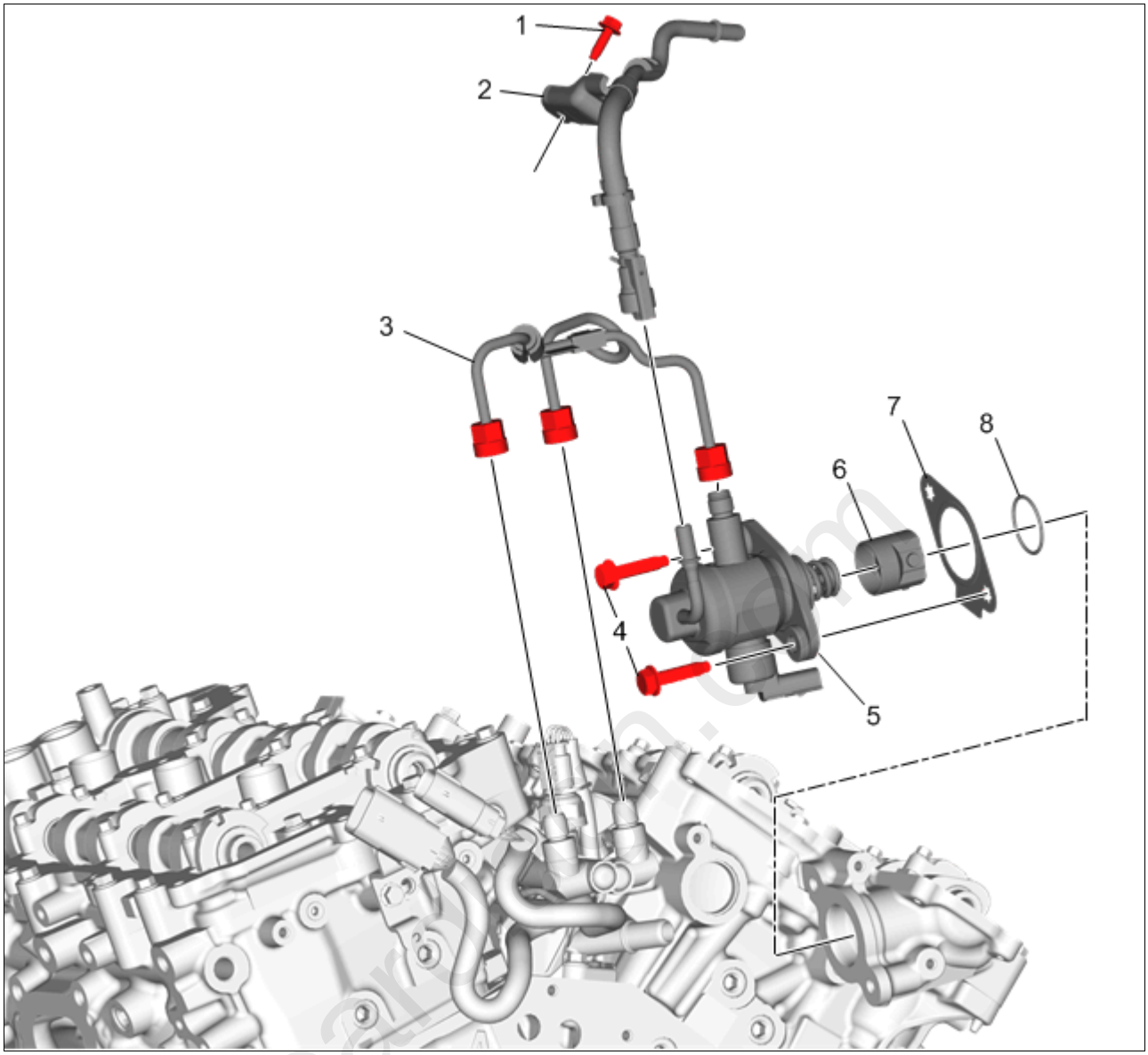
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Camshaft Position Actuator Bolt (Qty: 2)
2	Intake Camshaft Position Active Counter Bank 1
3	Exhaust Camshaft Position Actuator Bank 1

REPAIR INSTRUCTIONS - OFF VEHICLE > FUEL PUMP REMOVAL

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Fig 1: Fuel Pump (LGX)



Courtesy of GENERAL MOTORS COMPANY

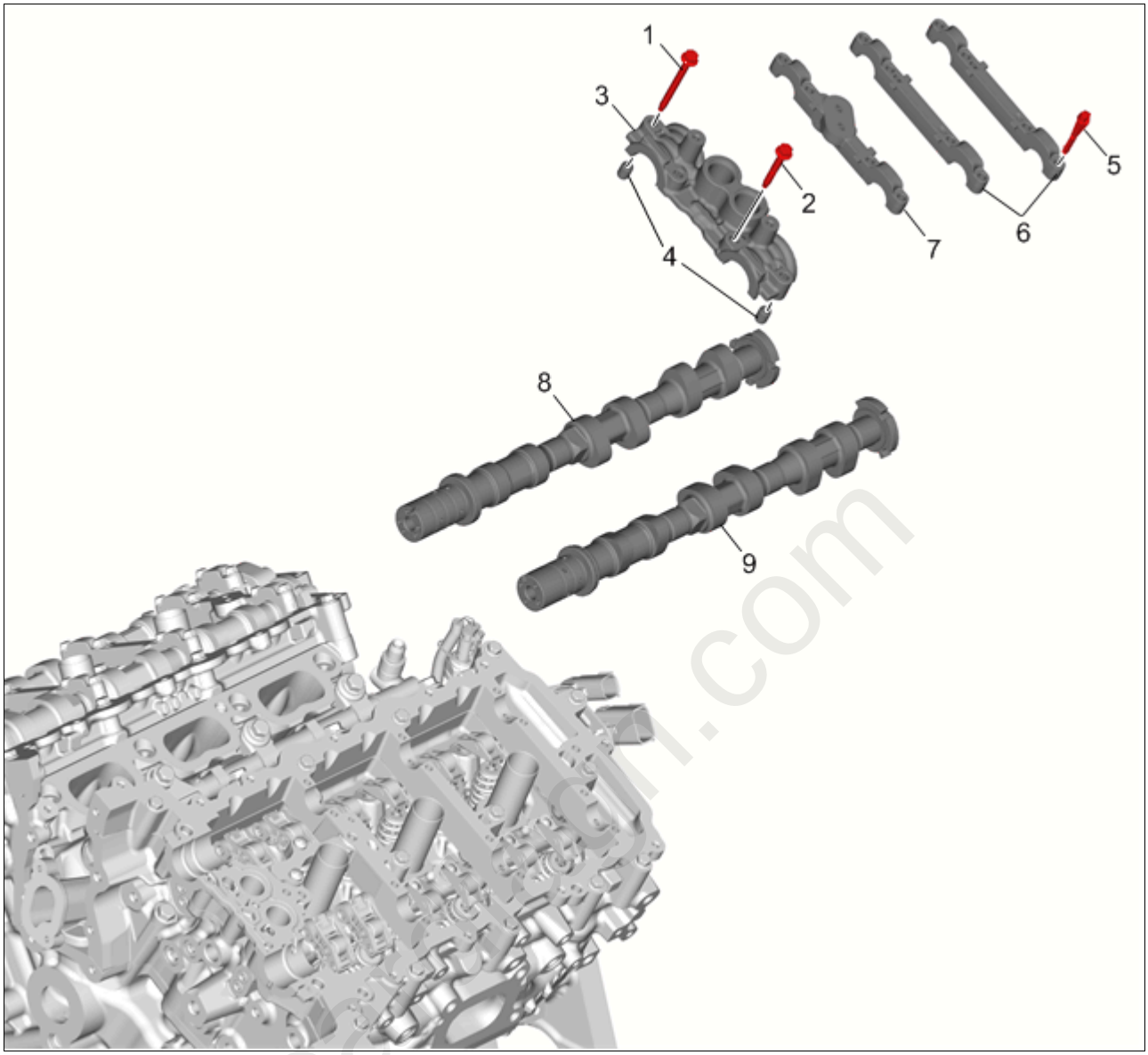
Callout	Component Name
1	Fuel Feed Pipe Bolt *NOTE:* *This is a camshaft cover bolt.*
2	Fuel Feed Pipe
3	Fuel Feed Intermediate Pipe

	NOTE: *Remove and DISCARD the pipe.*
4	Fuel Pump Bolt (Qty: 2) *CAUTION:* *Alternately loosen the fuel pump bolts one turn at a time until the pump is fully disengaged from fuel pump lifter follower. Trying to remove the pump bolts without even side-to-side loosening may result in pump plunger damage* *NOTE:* *Remove and DISCARD the bolt.*
5	Fuel Pump
6	Valve Lifter Follower
7	Fuel Pump Bracket Gasket *NOTE:* *If a high pressure pump is replaced on an engine which originally had a pump WITH a gasket, it must be rebuilt WITH a pump kit that includes the gasket; if a high pressure pump is replaced on an engine which originally had a pump WITHOUT a gasket, it must be rebuilt WITHOUT a gasket.*
8	Fuel Pump O-Ring *NOTE:* *Remove and DISCARD the O-ring seal.*

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REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT REMOVAL - LEFT SIDE

Fig 1: Camshaft - Left Side (LGX)



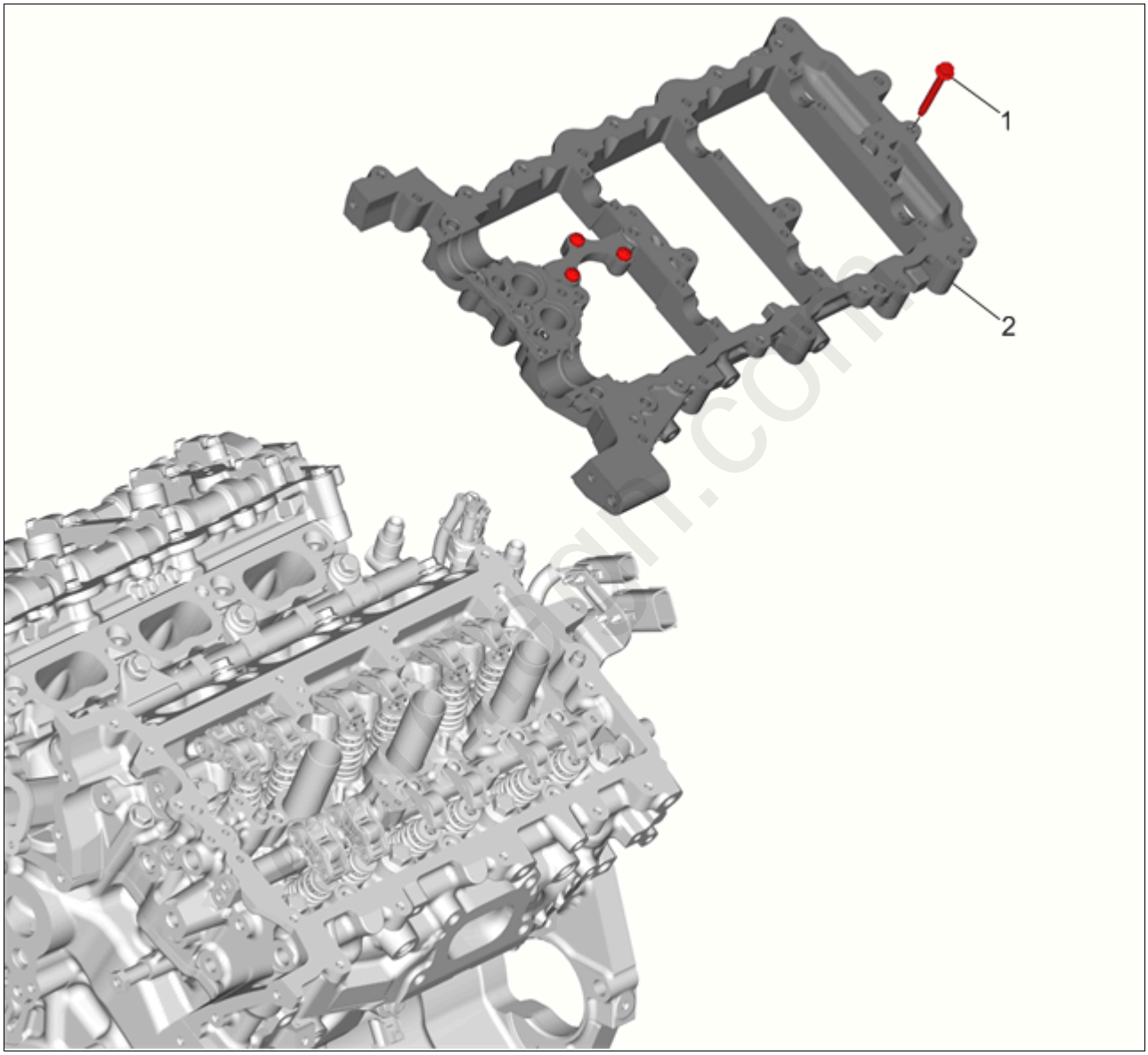
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Camshaft Carrier Bolt (Qty: 4)
2	Camshaft Bearing Cap Bolt (Qty: 4)
3	Camshaft Bearing Cap
4	Dowel Pin
5	Camshaft Bearing Cap Bolt (Qty: 12)
6	Camshaft Bearing Cap
7	Camshaft Bearing Cap
8	Intake Camshaft

9	Exhaust Camshaft

REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT CARRIER REMOVAL - LEFT SIDE

Fig 1: Camshaft Carrier - Left Side



Courtesy of GENERAL MOTORS COMPANY

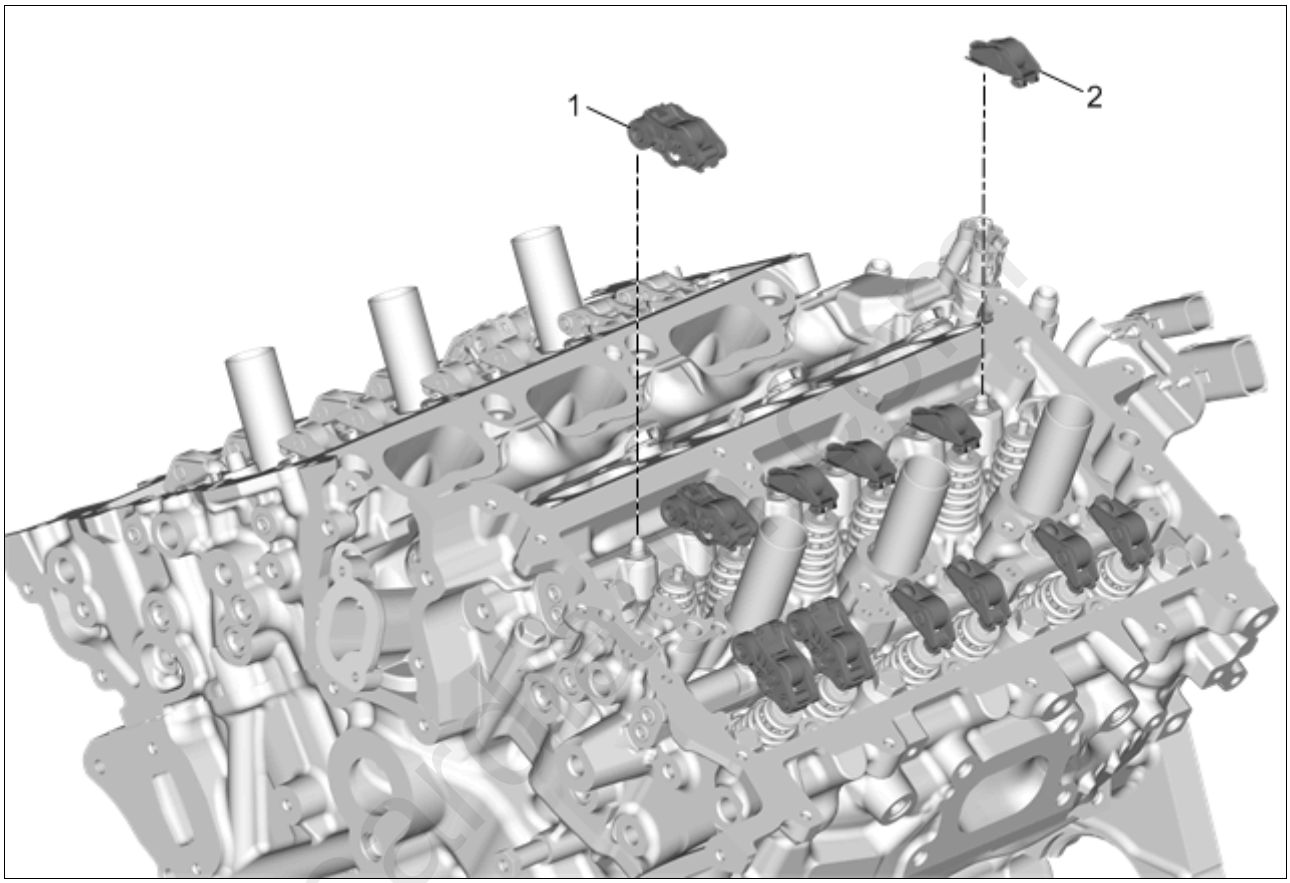
Callout	Component Name
1	Camshaft Carrier Bolt (Qty: 13)
2	Camshaft Carrier - Left

REPAIR INSTRUCTIONS - OFF VEHICLE > FUEL RAIL REMOVAL

Refer to Cylinder Head Disassemble .

REPAIR INSTRUCTIONS - OFF VEHICLE > VALVE ROCKER ARM REMOVAL - LEFT SIDE

Fig 1: Valve Rocker Arm - Left Side (LGX)



Courtesy of GENERAL MOTORS COMPANY

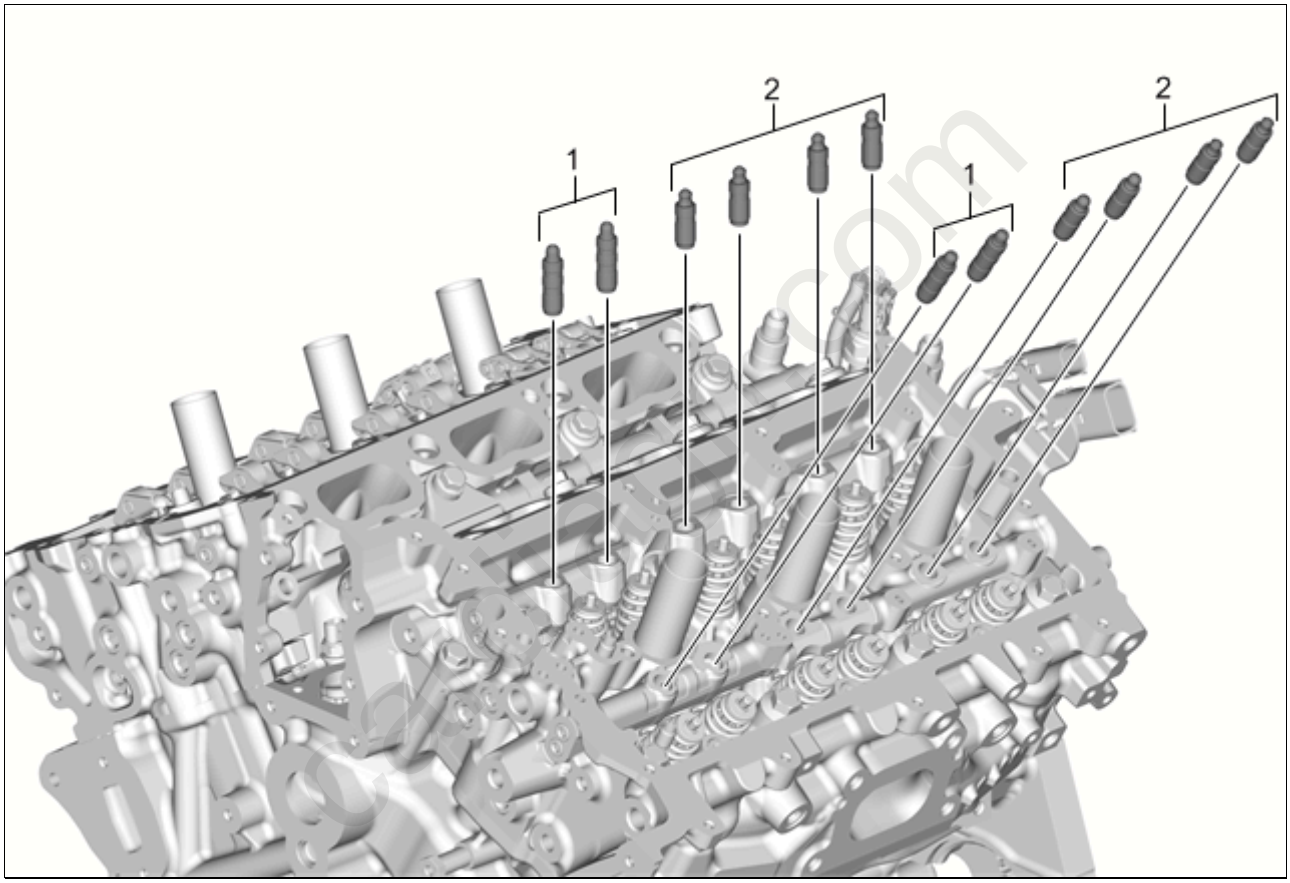
Callout	Component Name
1	Valve Rocker Switching Arm (Qty: 4) *NOTE:* *If the rocker arms are to be reused, keep in order so they can be reinstalled in the same position.*
2	Valve Rocker Arm (Qty: 8)

NOTE:

If the rocker arms are to be reused, keep in order so they can be reinstalled in the same position.

REPAIR INSTRUCTIONS - OFF VEHICLE > VALVE LIFTER REMOVAL - LEFT SIDE

Fig 1: Valve Lifter - Left Side (LGX)



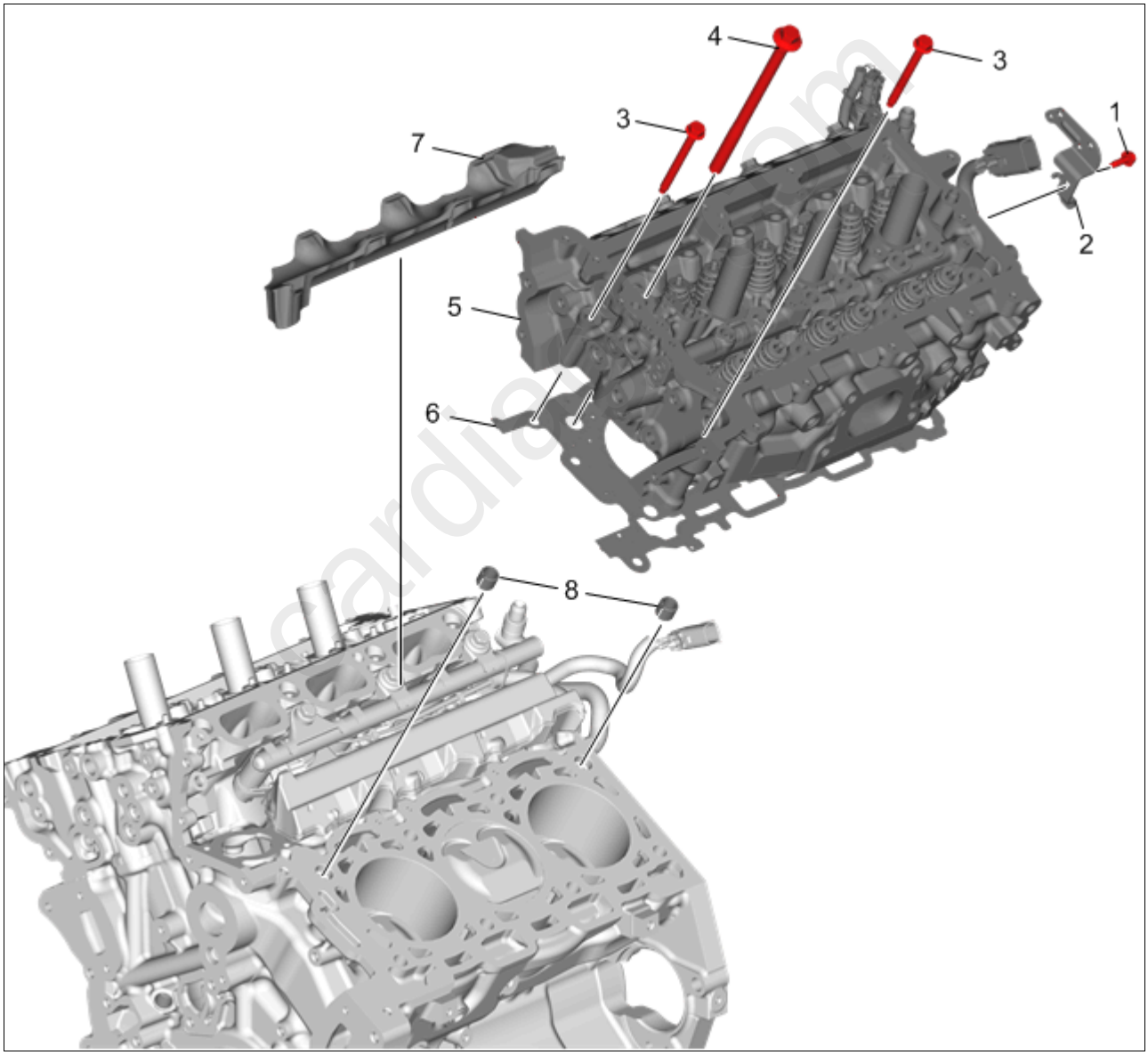
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Dual Feed Hydraulic Valve Adjustor (Qty: 4) *NOTE:* *If the lifters are to be reused, keep in order so they can be reinstalled in the same position.*

2	Hydraulic Valve Lash Adjuster (Qty: 8) *NOTE:* *If the lifters are to be reused, keep in order so they can be reinstalled in the same position.*

REPAIR INSTRUCTIONS - OFF VEHICLE > CYLINDER HEAD REMOVAL - LEFT SIDE

Fig 1: Cylinder Head - Left Side (LGX)



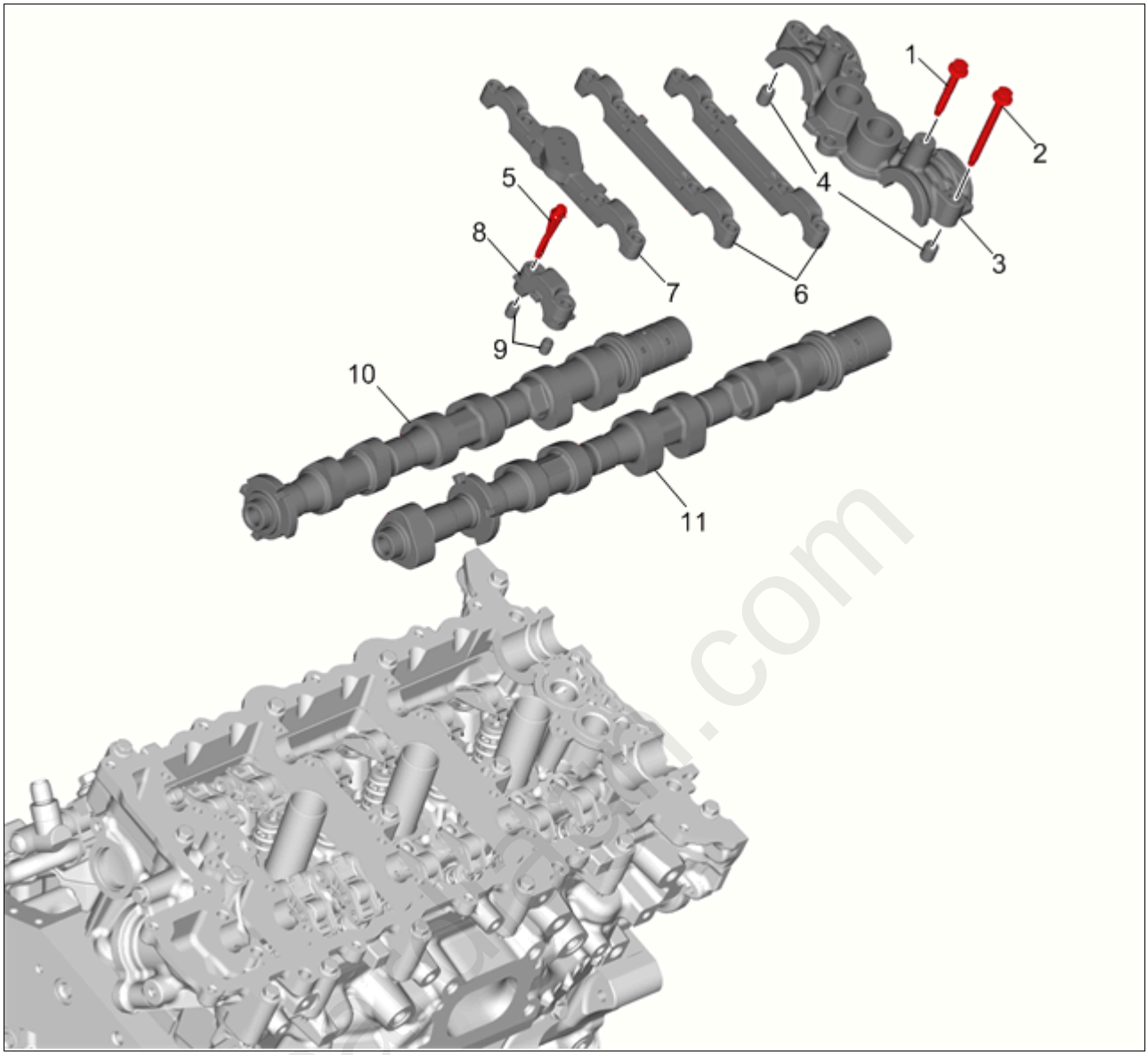
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Fuel Injector Wiring Harness Bracket Bolt
2	Fuel Injector Wiring Harness Bracket
3	Cylinder Head Bolt (Qty: 3)
4	Cylinder Head Bolt (Qty: 8)
5	Cylinder Head
6	Cylinder Head Gasket
7	Fuel Injection Fuel Rail Noise Shield *WARNING:* *The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage, and possible injury or death.*
8	Cylinder Head Locating Pin

REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT REMOVAL - RIGHT SIDE

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Fig 1: Camshaft - Right Side (LGX)



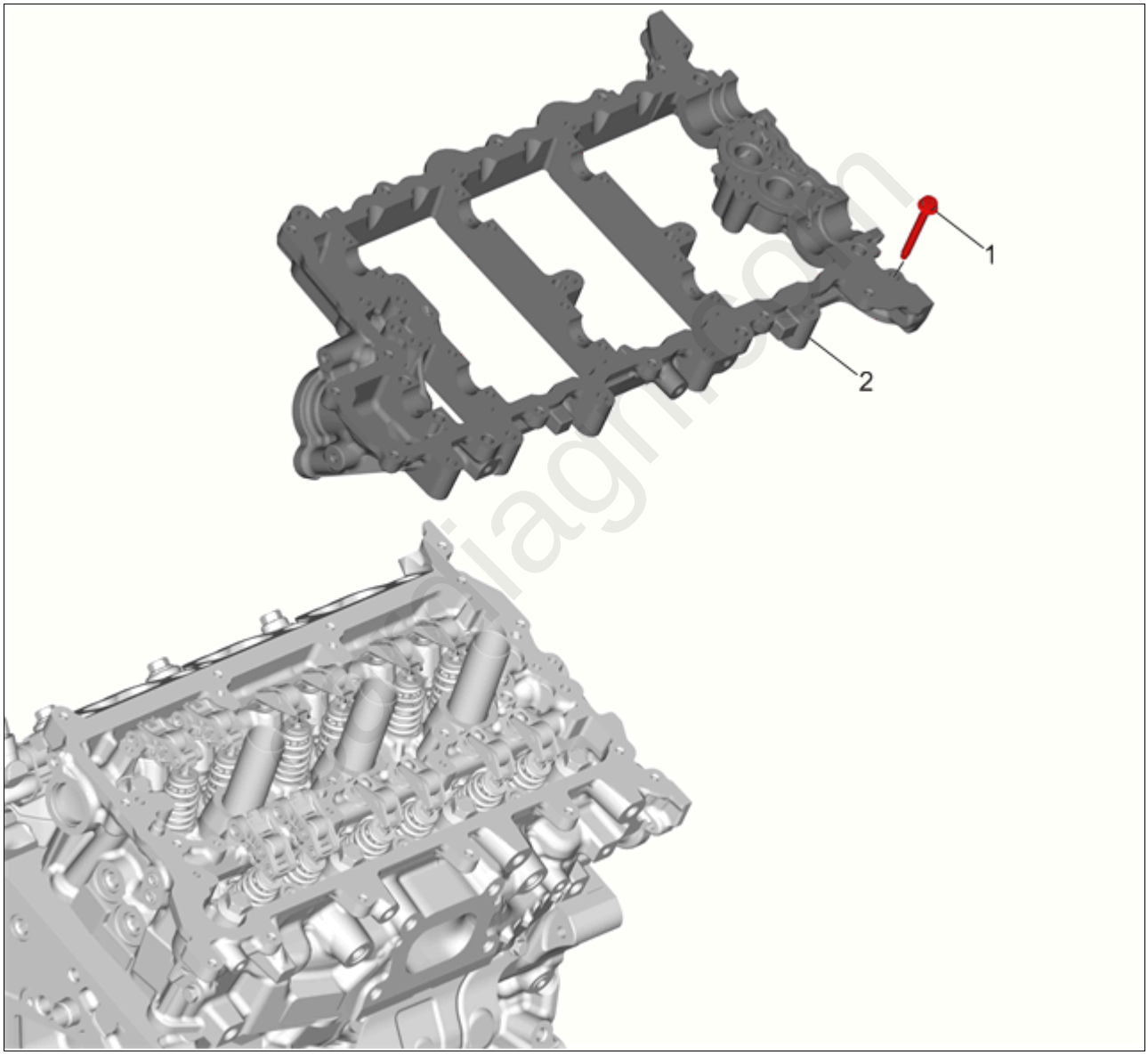
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Camshaft Bearing Cap Bolt (Qty: 4)
2	Camshaft Bearing Cap Bolt (Qty: 4)
3	Camshaft Bearing Cap
4	Dowel Pin
5	Camshaft Bearing Cap Bolt (Qty: 14)
6	Camshaft Bearing Cap
7	Camshaft Bearing Cap
8	Camshaft Bearing Cap - Intermediate

9	Dowel Pin
10	Intake Camshaft
11	Exhaust Camshaft

REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT CARRIER REMOVAL - RIGHT SIDE

Fig 1: Camshaft Carrier - Right Side



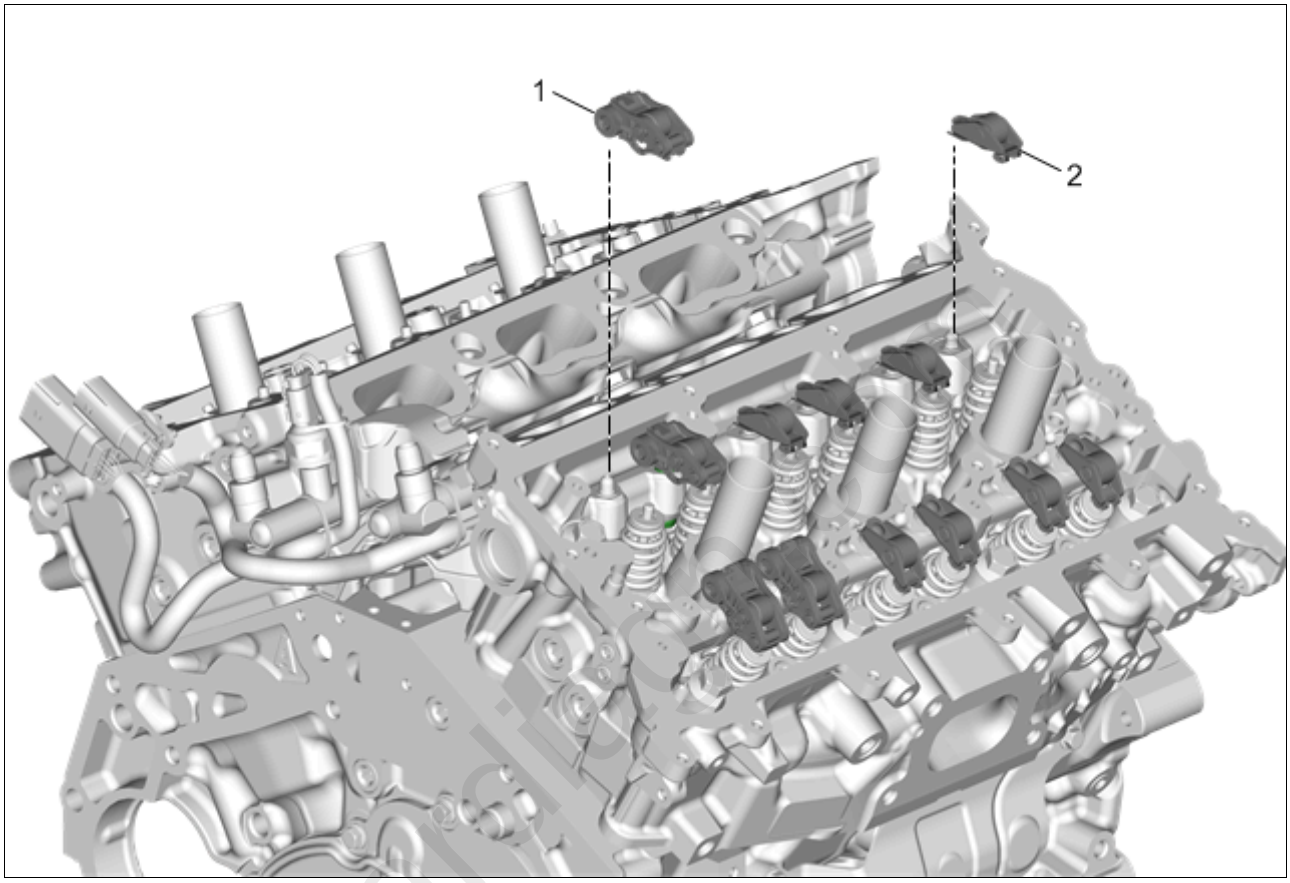
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Camshaft Carrier Bolt (Qty: 14)

2	Camshaft Carrier - Right

REPAIR INSTRUCTIONS - OFF VEHICLE > VALVE ROCKER ARM REMOVAL - RIGHT SIDE

Fig 1: Valve Rocker Arm - Right Side (LGX)



Courtesy of GENERAL MOTORS COMPANY

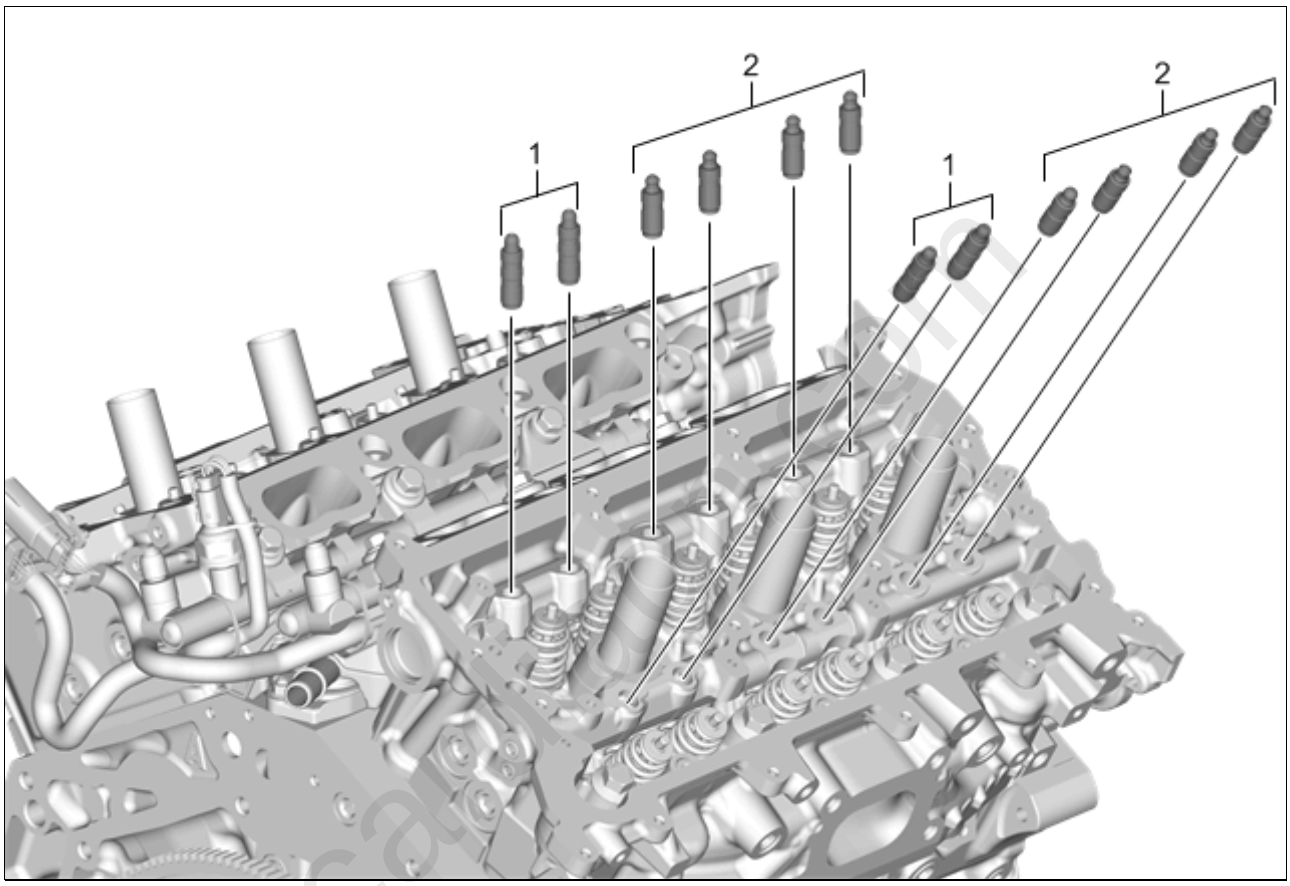
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Callout	Component Name
1	Valve Rocker Switching Arm (Qty: 4) *NOTE:* *If the rocker arms are to be reused, keep in order so they can be reinstalled in the same position.*
2	Valve Rocker Arm (Qty: 8) *NOTE:*

	If the rocker arms are to be reused, keep in order so they can be reinstalled in the same position.

REPAIR INSTRUCTIONS - OFF VEHICLE > VALVE LIFTER REMOVAL - RIGHT SIDE

Fig 1: Valve Lifter - Right Side (LGX)



Courtesy of GENERAL MOTORS COMPANY

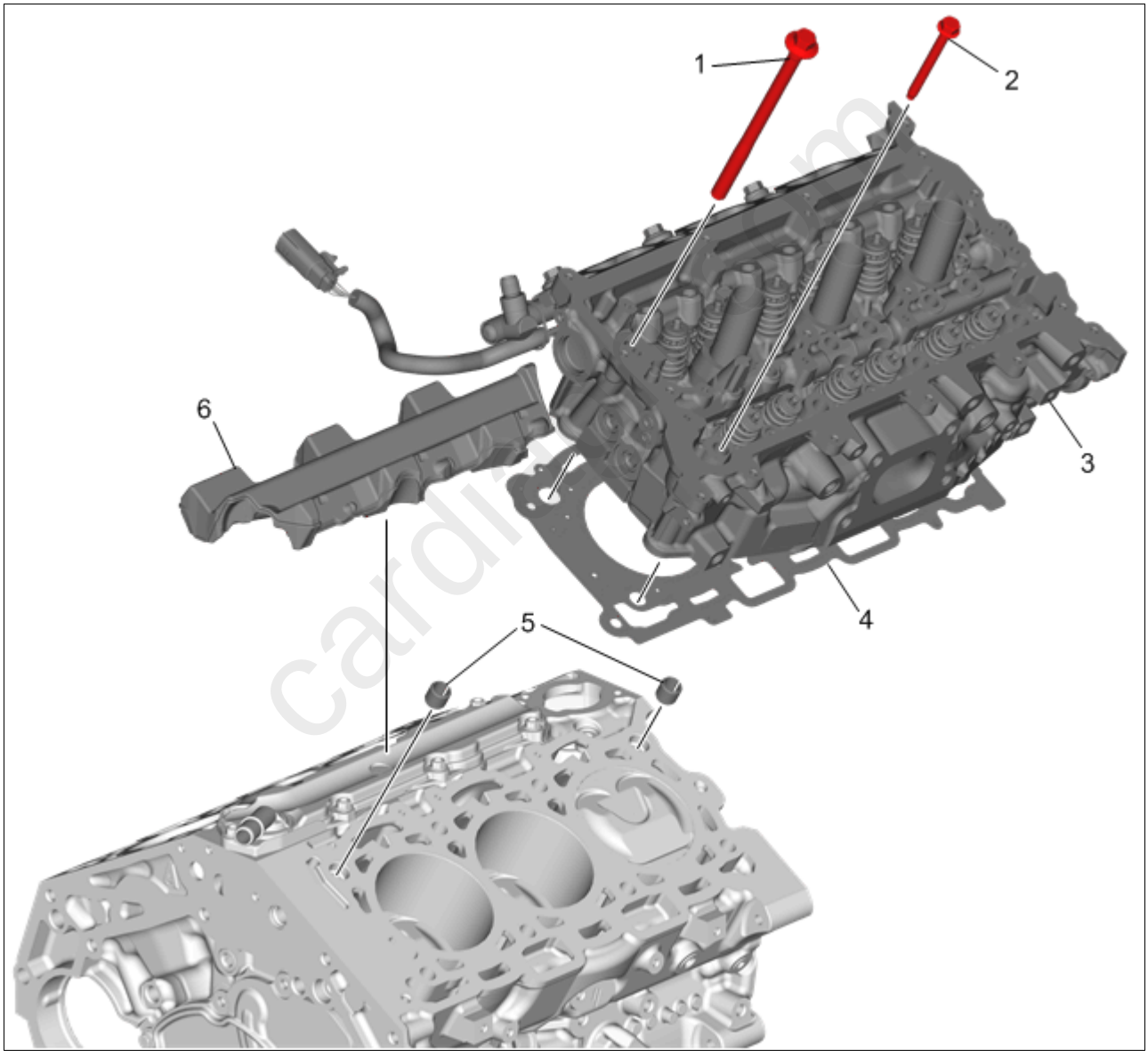
Callout	Component Name
1	Dual Feed Hydraulic Valve Adjustor (Qty: 4) *NOTE:* *If the lifters are to be reused, keep in order so they can be reinstalled in the same position.*
2	Hydraulic Valve Lash Adjuster (Qty: 8)

NOTE:

If the lifters are to be reused, keep in order so they can be reinstalled in the same position.

REPAIR INSTRUCTIONS - OFF VEHICLE > CYLINDER HEAD REMOVAL - RIGHT SIDE

Fig 1: Cylinder Head Removal - Right Side (LGX)



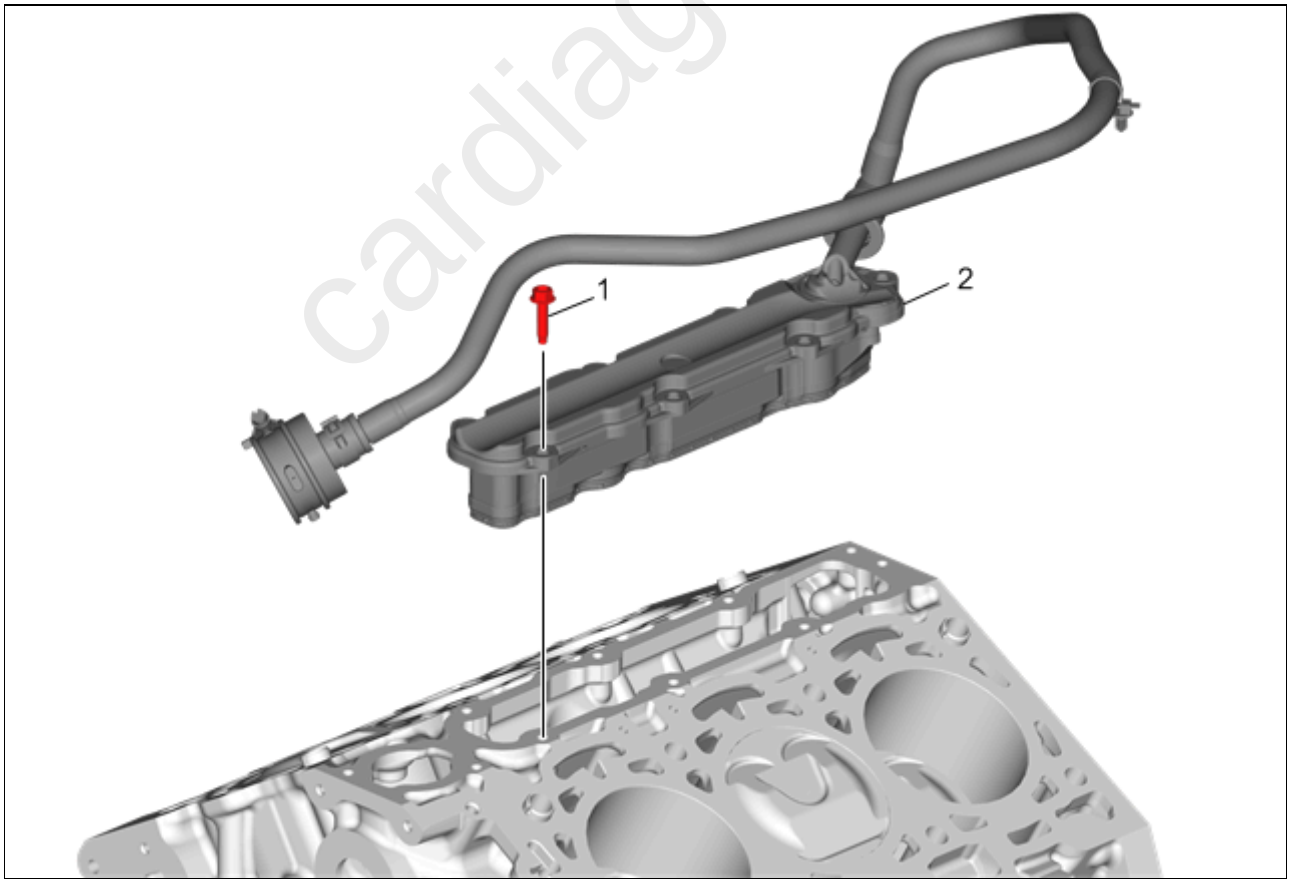
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name

1	Cylinder Head Bolt (Qty: 8)
2	Cylinder Head Bolt
3	Cylinder Head
4	Cylinder Head Gasket
5	Cylinder Head Locating Pin (Qty: 2)
6	Fuel Injection Fuel Rail Noise Shield *WARNING:* *The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage, and possible injury or death.*

REPAIR INSTRUCTIONS - OFF VEHICLE > POSITIVE CRANKCASE VENTILATION OIL SEPARATOR REMOVAL

Fig 1: Positive Crankcase Ventilation Oil Separator



Courtesy of GENERAL MOTORS COMPANY

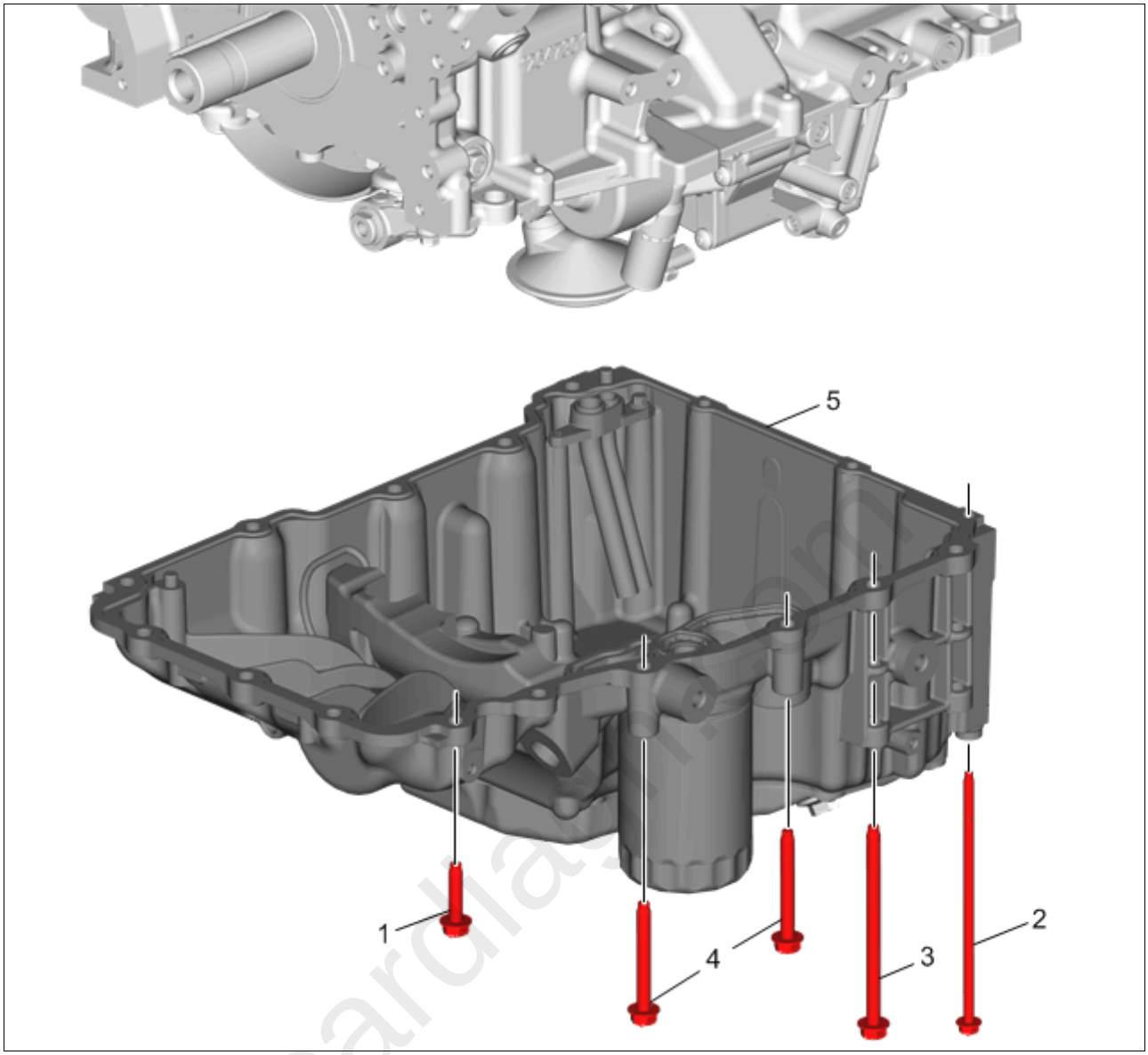
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Callout	Component Name
1	Positive Crankcase Ventilation Oil Separator Bolt (Qty: 7)
2	Positive Crankcase Ventilation Oil Separator *NOTE:* *These components have tamper-proof connections and cannot be disassembled.*

REPAIR INSTRUCTIONS - OFF VEHICLE > OIL PAN REMOVAL

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Fig 1: Oil Pan (LGX RWD)



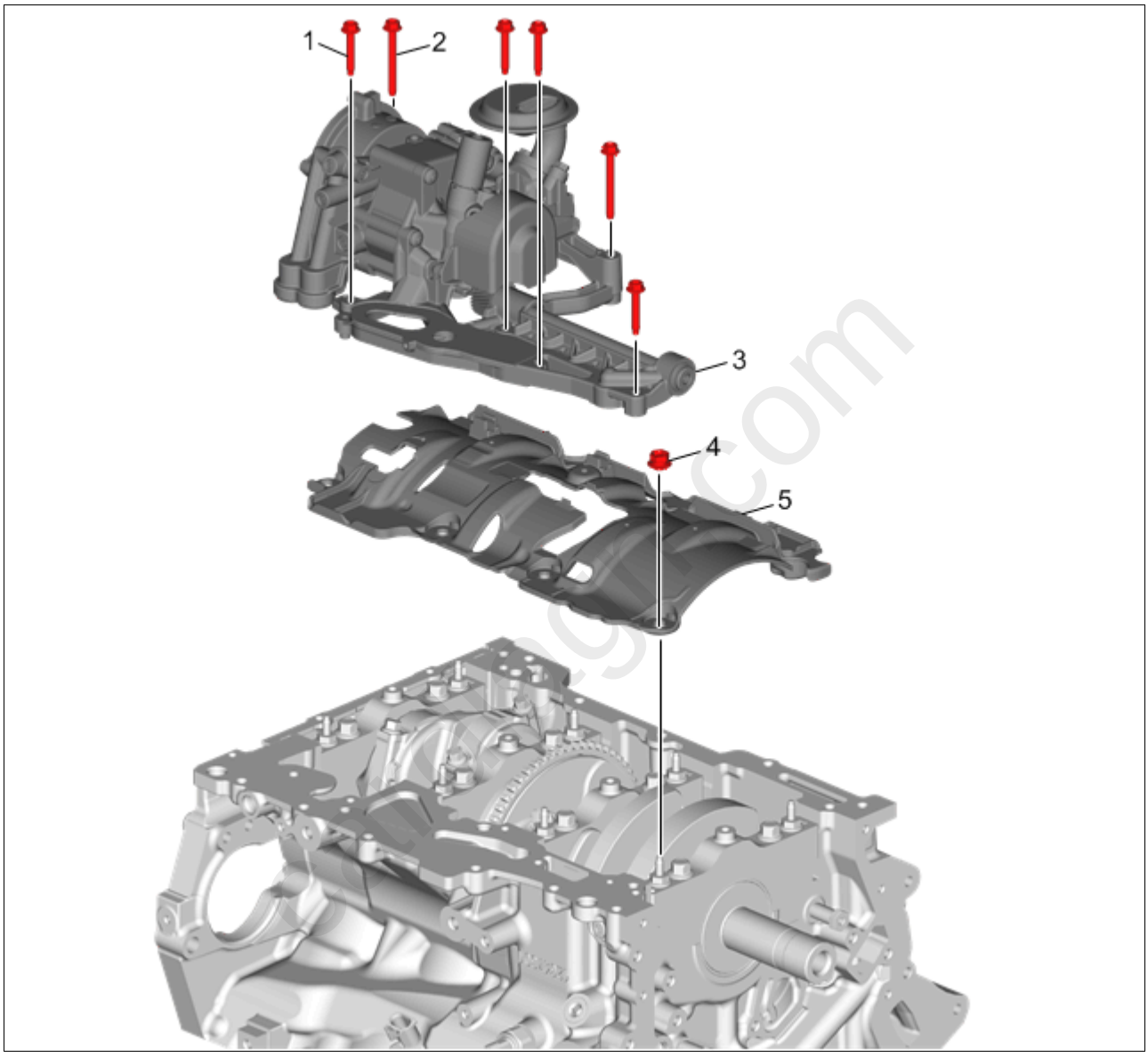
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Oil Pan Bolt (Qty: 7)
2	Oil Pan Bolt (Qty: 3) *NOTE:* *Remove and DISCARD the bolts.*
3	Oil Pan Bolt (Qty: 2)
4	Oil Pan Bolt (Qty: 5)

5	Oil Pan

REPAIR INSTRUCTIONS - OFF VEHICLE > OIL PUMP REMOVAL

Fig 1: Oil Pump (LGX)



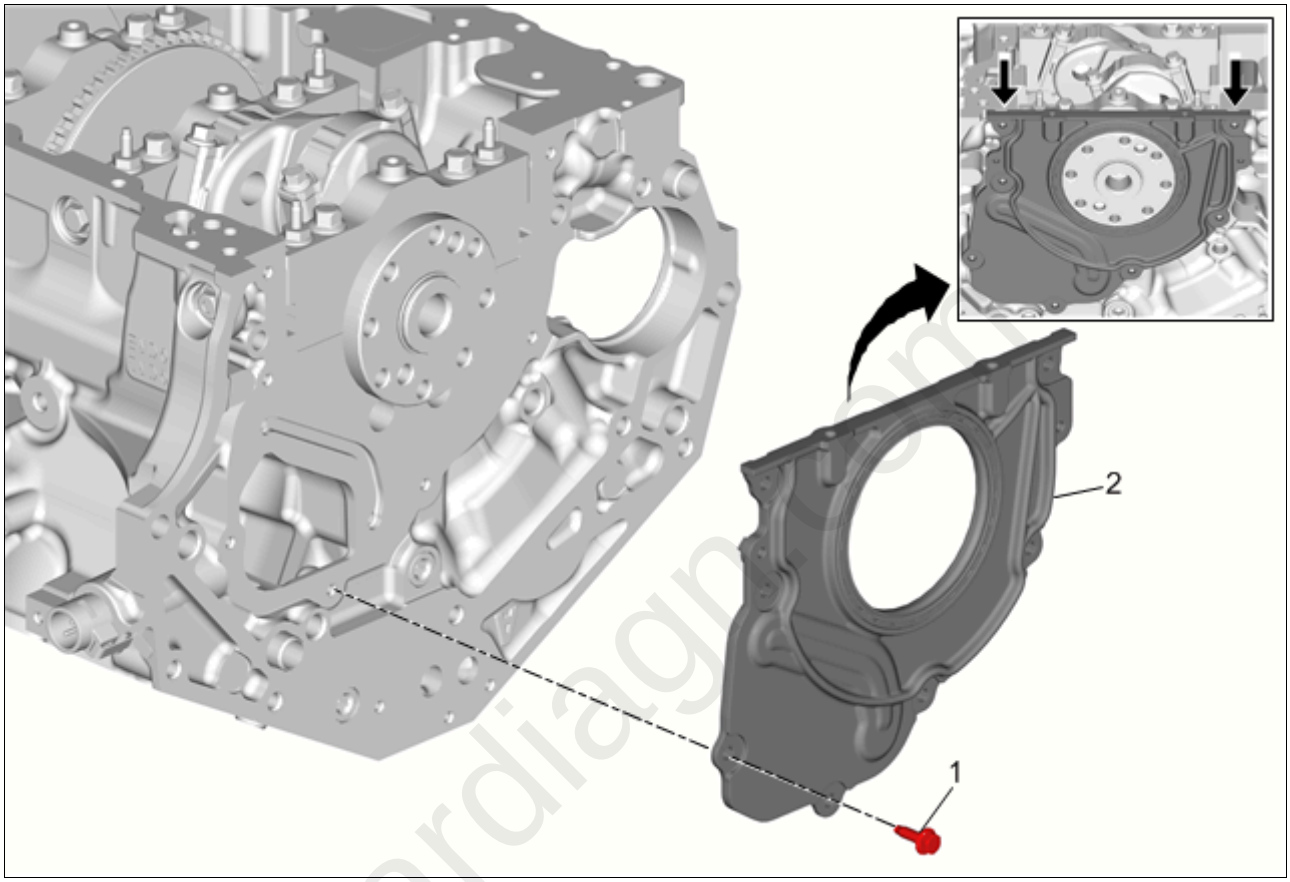
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Oil Pump Bolt (Qty: 4) M6 x 35.65
2	Oil Pump Bolt (Qty: 2) M6 x 53.65
3	Oil Pump
4	Crankshaft Oil Deflector Nut (Qty: 8)

5	Crankshaft Oil Deflector

REPAIR INSTRUCTIONS - OFF VEHICLE > CRANKSHAFT REAR OIL SEAL AND HOUSING REMOVAL

Fig 1: Crankshaft Rear Oil Seal and Housing (LGX)



Courtesy of GENERAL MOTORS COMPANY

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Callout	Component Name
1	Crankshaft Rear Oil Seal Housing Bolt (Qty: 7)
2	Crankshaft Rear Oil Seal Housing Procedure 1. Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant 2. Use Pry points located at the edge of the crankshaft rear oil seal housing to separate the RTV sealant. *NOTE:*

Remove and DISCARD the crankshaft rear oil seal housing.

REPAIR INSTRUCTIONS - OFF VEHICLE > PISTON, CONNECTING ROD, AND BEARING REMOVAL

Special Tools

EN 46121 Connecting Rod Guide Pin Set

For equivalent regional tools, refer to Special Tools .

NOTE:

An arrow/dot showing proper piston orientation is located on the top of the piston.

NOTE:

If the connecting rod bearings have been used in a running engine, you must replace them with NEW connecting rod bearings for reassembly.

1. Before removing the connecting rods, check the connecting rod side clearance using the following procedure:
    1. Tap the connecting rod to one end of the crankshaft journal with a dead-blow or wooden hammer.
    2. Using feeler gauges, measure the clearance between the crankshaft counterweight and the connecting rod.
    3. The connecting rod side clearance should not exceed specifications. Refer to Engine Mechanical Specifications .
    4. If the end play exceeds the specified limits, measure the width of the crankpin end of the connecting rod. Refer to Piston, Connecting Rod, and Bearing Cleaning and Inspection .
    5. If the connecting rod width is significantly smaller than specified and severe wear is present on the side of the connecting rod, replace the connecting rod.
    6. If the connecting rod width is within specification and excessive scoring is present on the crankshaft journals, replace the crankshaft.
2. Using a marker, number each piston face. Draw an arrow along the centerline of the piston pointing toward the front of the engine.

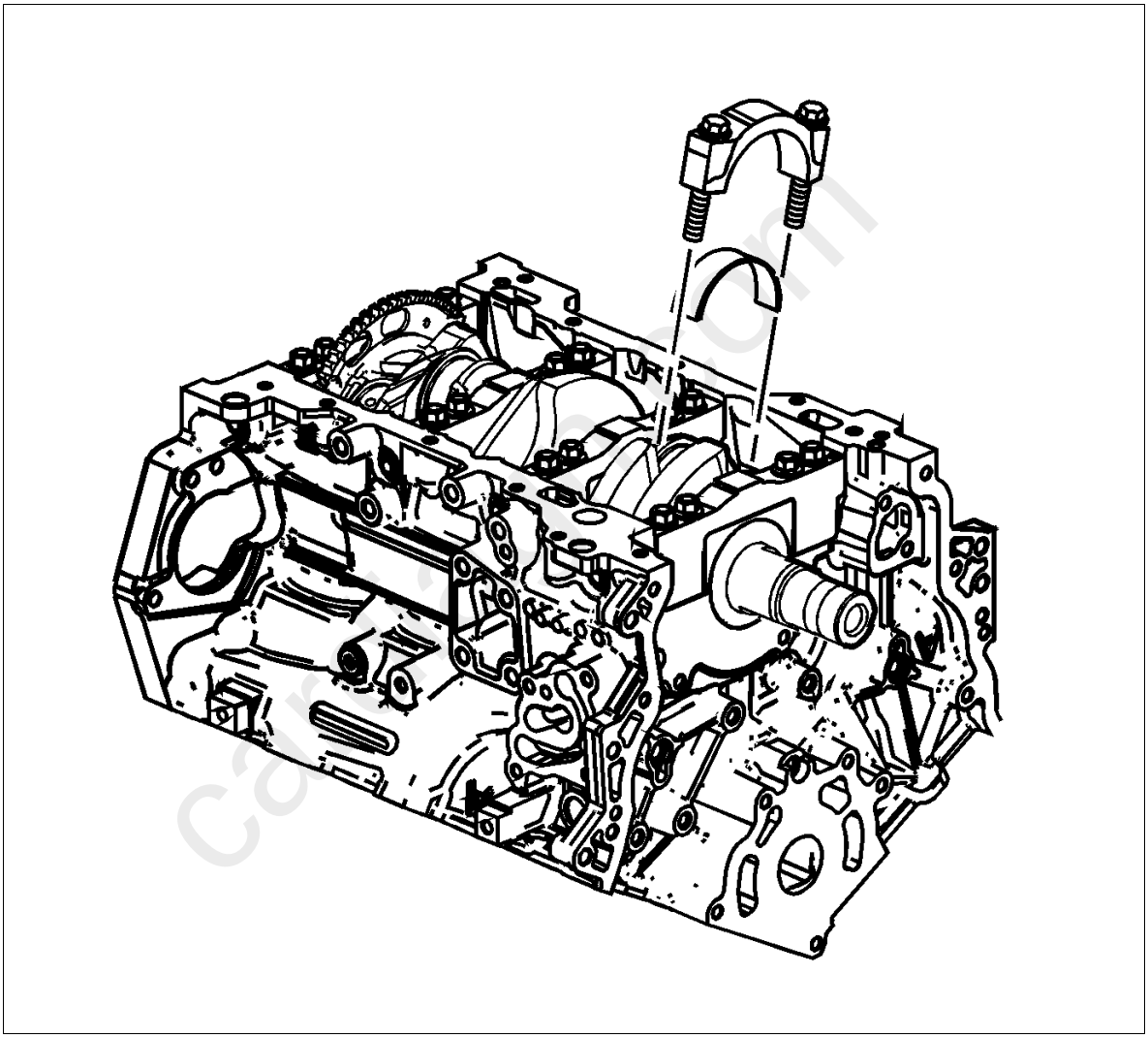
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⚠ *CAUTION:*

Do not use a stamp, punch or any other method that may distort or stress the connecting rod or connecting rod cap. Extensive engine damage may result from a connecting rod that is distorted or stressed.

3. Mark the cylinder number on the connecting rod and the connecting rod cap with a scribe, paint stick or permanent marker.

Fig 1: Connecting Rod Bearing & Cap



Courtesy of GENERAL MOTORS COMPANY

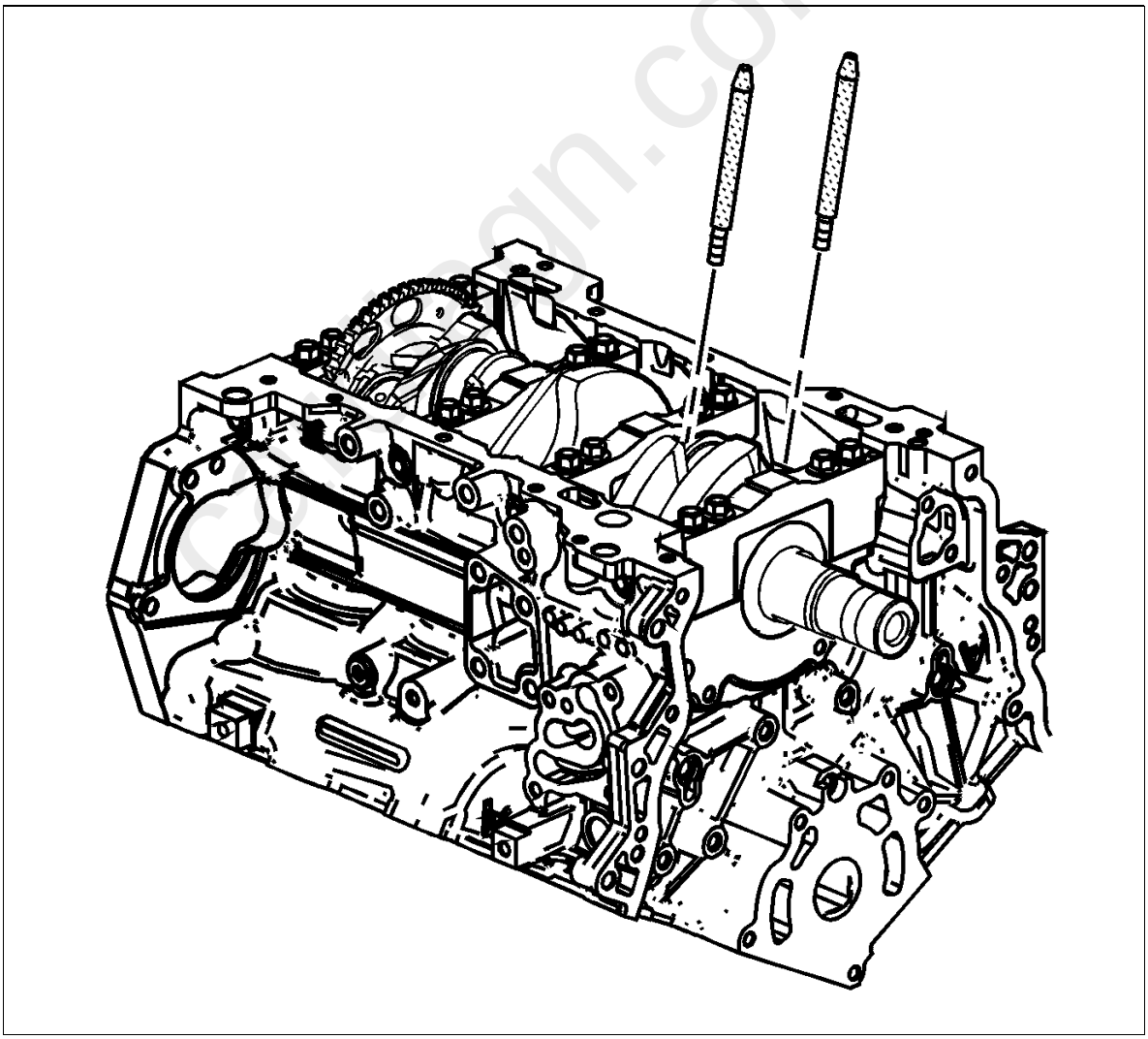
> ⚠ *CAUTION:*
>
> *Powdered metal connecting rods have rod bolts which yield when torqued. If the rod bolts are loosened or removed the rod bolts must be replaced. Rod bolts that are not replaced will not torque to the correct clamp load and can lead to serious engine damage.*

4. Remove the connecting rod bolts.

> *NOTE:*
>
> *The connecting rod caps must remain with the original connecting rod.*

5. Remove the connecting rod cap.

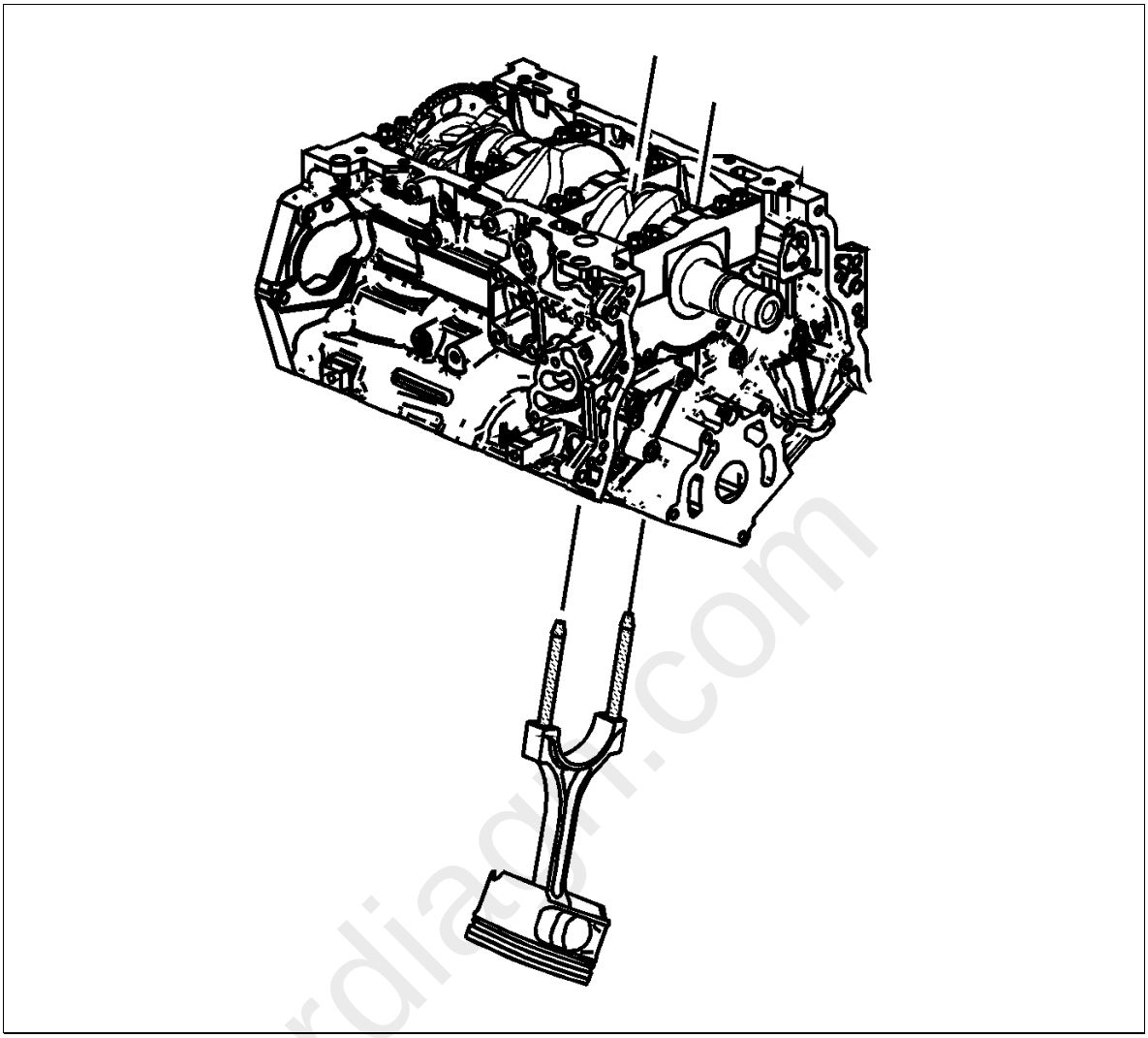
Fig 2: Crankshaft Protector Pins Installed in Connecting Rod Bolt Holes



Courtesy of GENERAL MOTORS COMPANY

6. Install the **EN 46121** set into the connecting rod bolt holes.

Fig 3: Connecting Rod & Piston Assembly

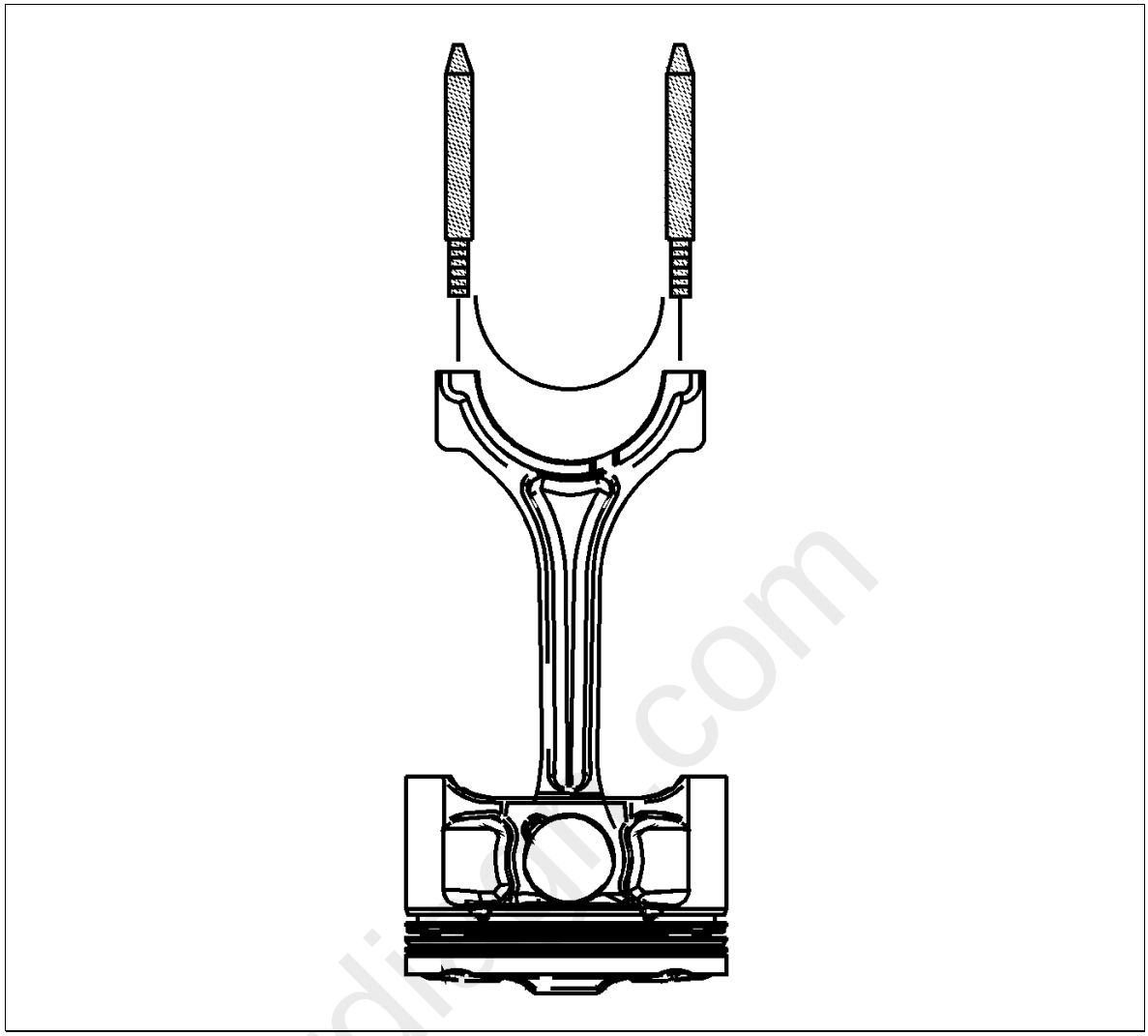


Courtesy of GENERAL MOTORS COMPANY

7. Using the **EN 46121** set, push the connecting rod and piston assembly through the top of the cylinder. DO NOT scratch the crankshaft journal or cylinder wall and DO NOT damage the oil jets when removing the connecting rod and piston assembly.

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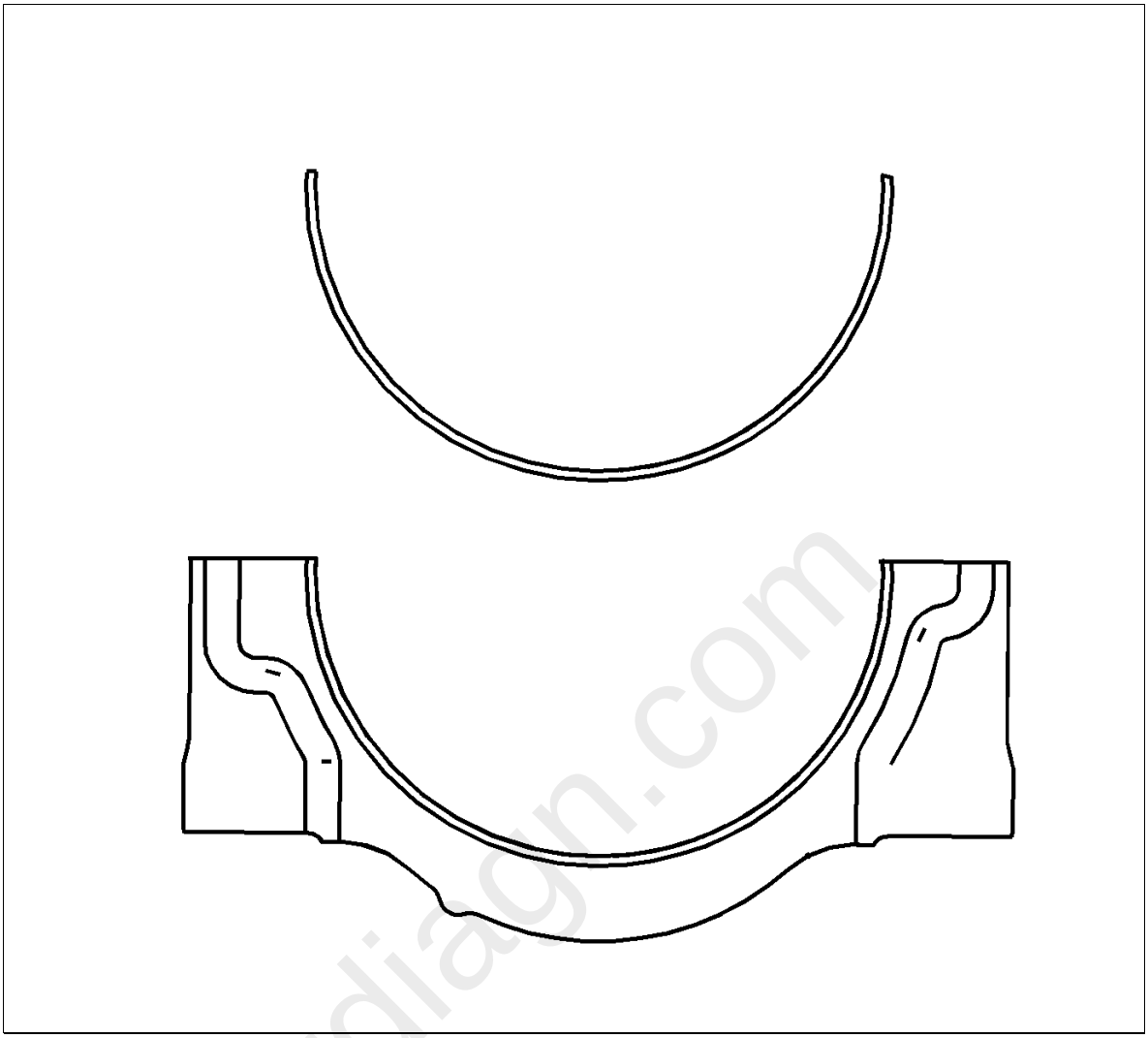
Fig 4: Crankshaft Protector Pins Installed in Connecting Rod Bolt Holes



Courtesy of GENERAL MOTORS COMPANY

8. Remove the **EN 46121** set from the connecting rod bolt holes.
9. Remove the upper connecting rod bearing from the connecting rod.

Fig 5: Lower Connecting Rod Cap & Bearing

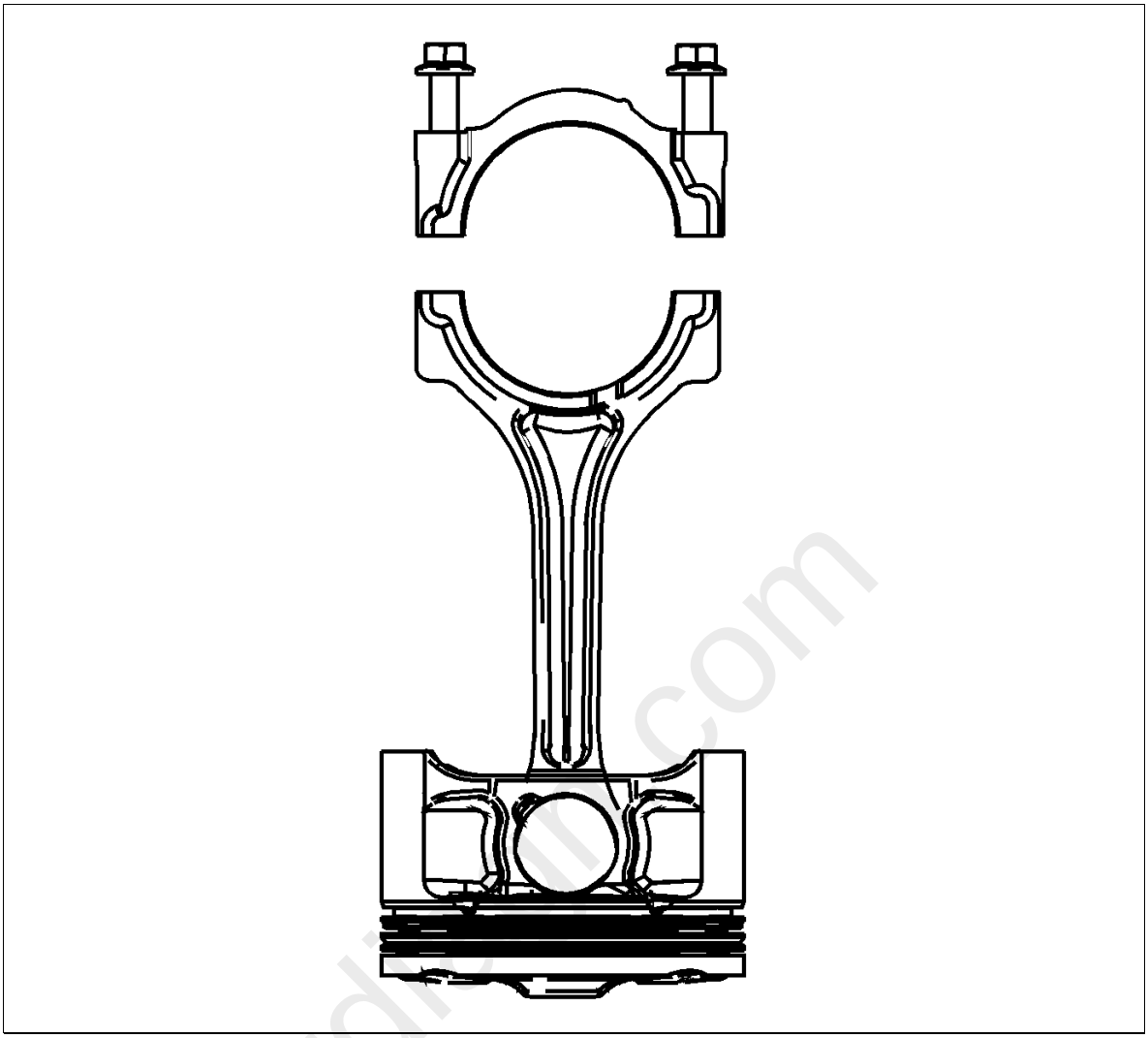


Courtesy of GENERAL MOTORS COMPANY

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10. Remove the lower connecting rod bearing from the connecting rod cap.

Fig 6: Connecting Rod Cap To Connecting Rod (Matched Sets)



Courtesy of GENERAL MOTORS COMPANY

11. Reattach the connecting rod cap to the connecting rod to prevent damage to their mating surfaces. The cap and rod are a matched set and must be kept together.

REPAIR INSTRUCTIONS - OFF VEHICLE > CRANKSHAFT AND BEARING REMOVAL

Special Tools

- **EN J 6125-1B** Slide Hammer Adapter
- **EN 49102** Crankshaft Bearing Cap Remover

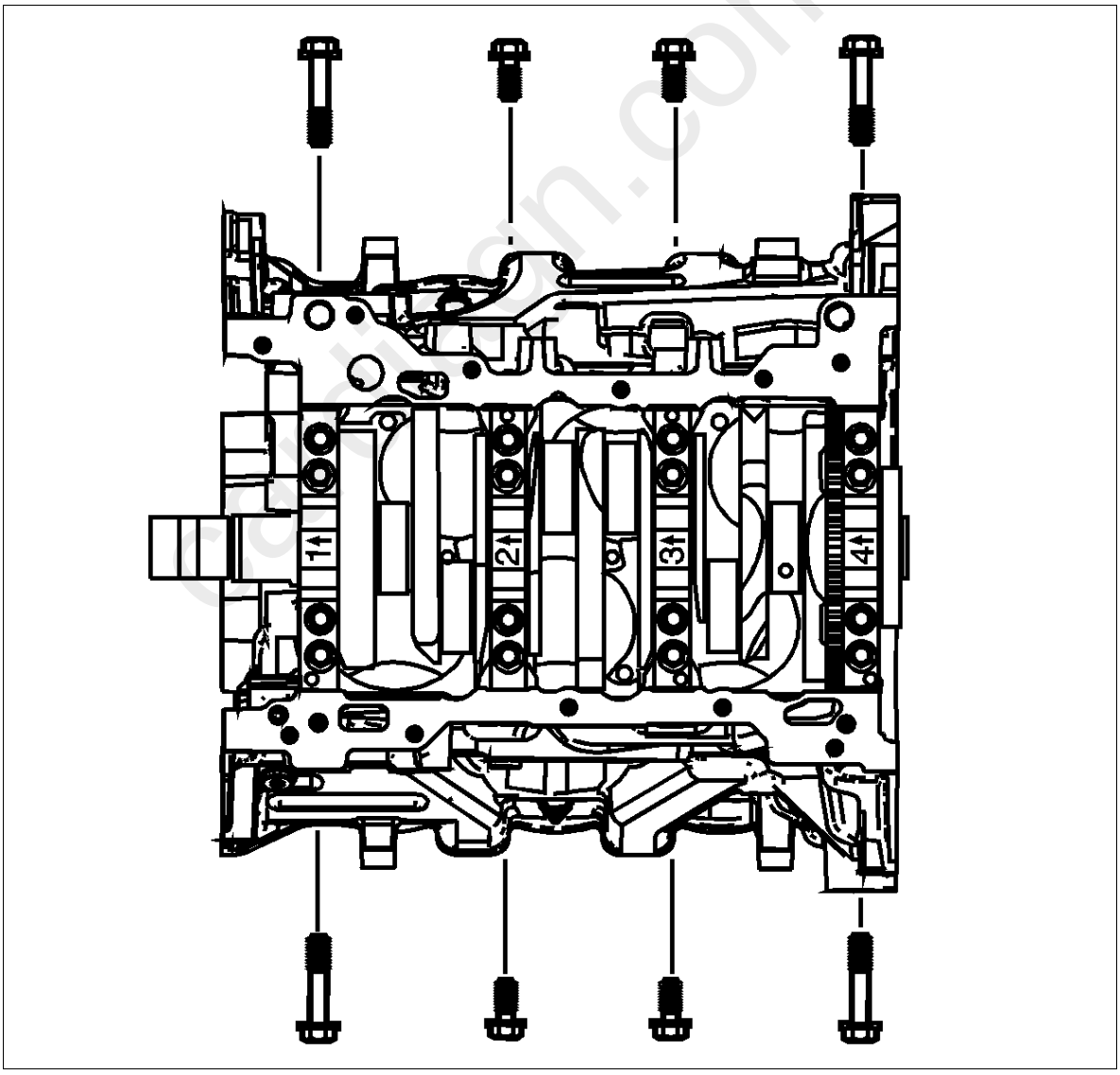
For equivalent regional tools, refer to Special Tools .

REPAIR INSTRUCTIONS - OFF VEHICLE > CRANKSHAFT AND BEARING REMOVAL > CRANKSHAFT END PLAY MEASUREMENT

1. Place a dial indicator at the crankshaft nose.
2. Gently force the crankshaft to the extreme front and rear positions with a pry tool while monitoring the movement of the dial indicator.
3. The crankshaft end play should not exceed specifications. Refer to Engine Mechanical Specifications .
4. If the specifications are exceeded inspect the thrust bearing thrust OD and the crankshaft thrust wall for wear and/or excessive runout. Refer to Engine Mechanical Specifications .
5. Replace the thrust bearing or crankshaft as necessary.

REPAIR INSTRUCTIONS - OFF VEHICLE > CRANKSHAFT AND BEARING REMOVAL > CRANKSHAFT REMOVAL

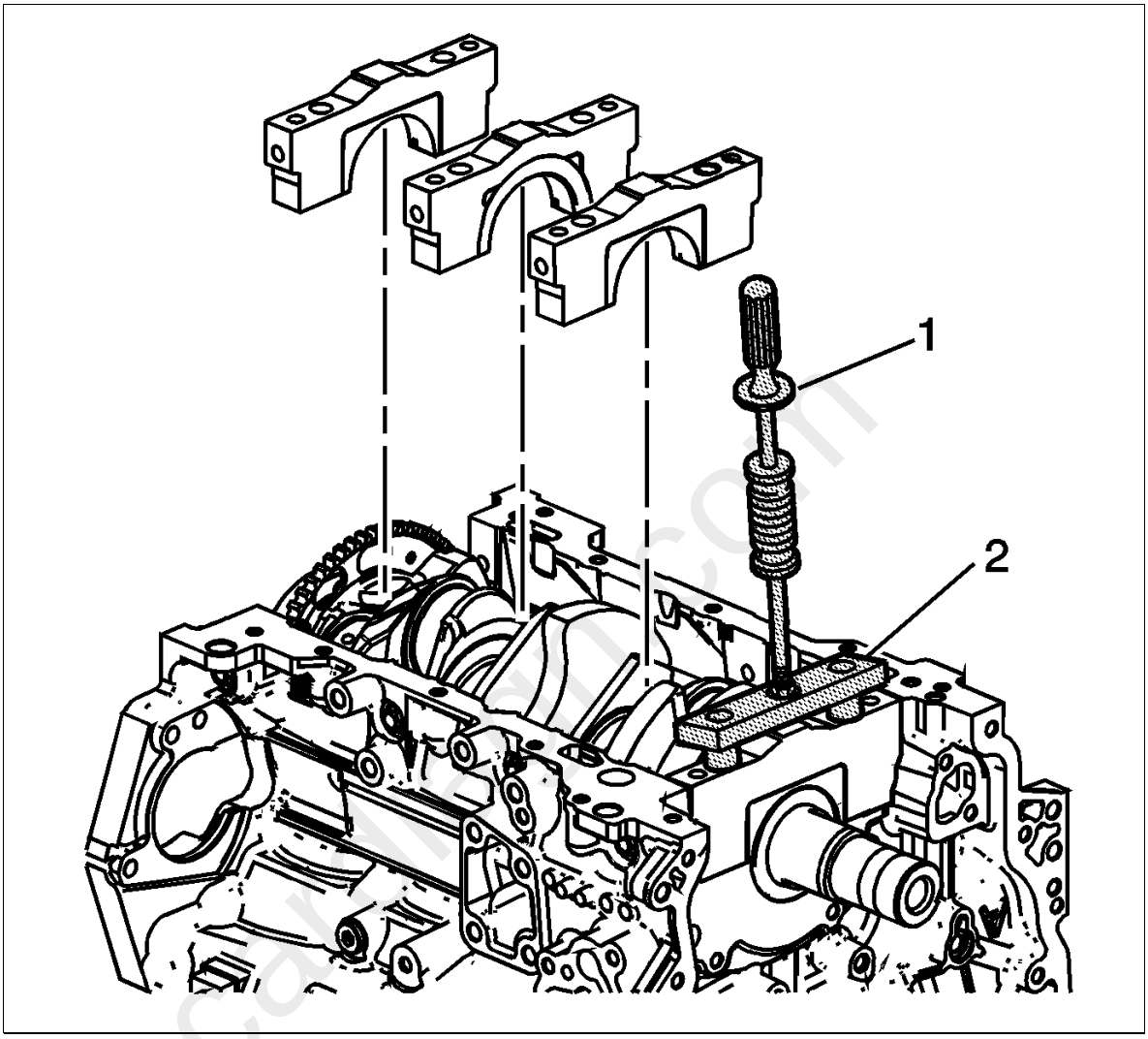
Fig 1: Crankshaft Main Bearing Cap Side Bolts



Courtesy of GENERAL MOTORS COMPANY

1. Remove the crankshaft bearing cap side bolts.
2. Remove the crankshaft bearing cap outer bolts.
3. Remove the crankshaft bearing cap inner bolts.

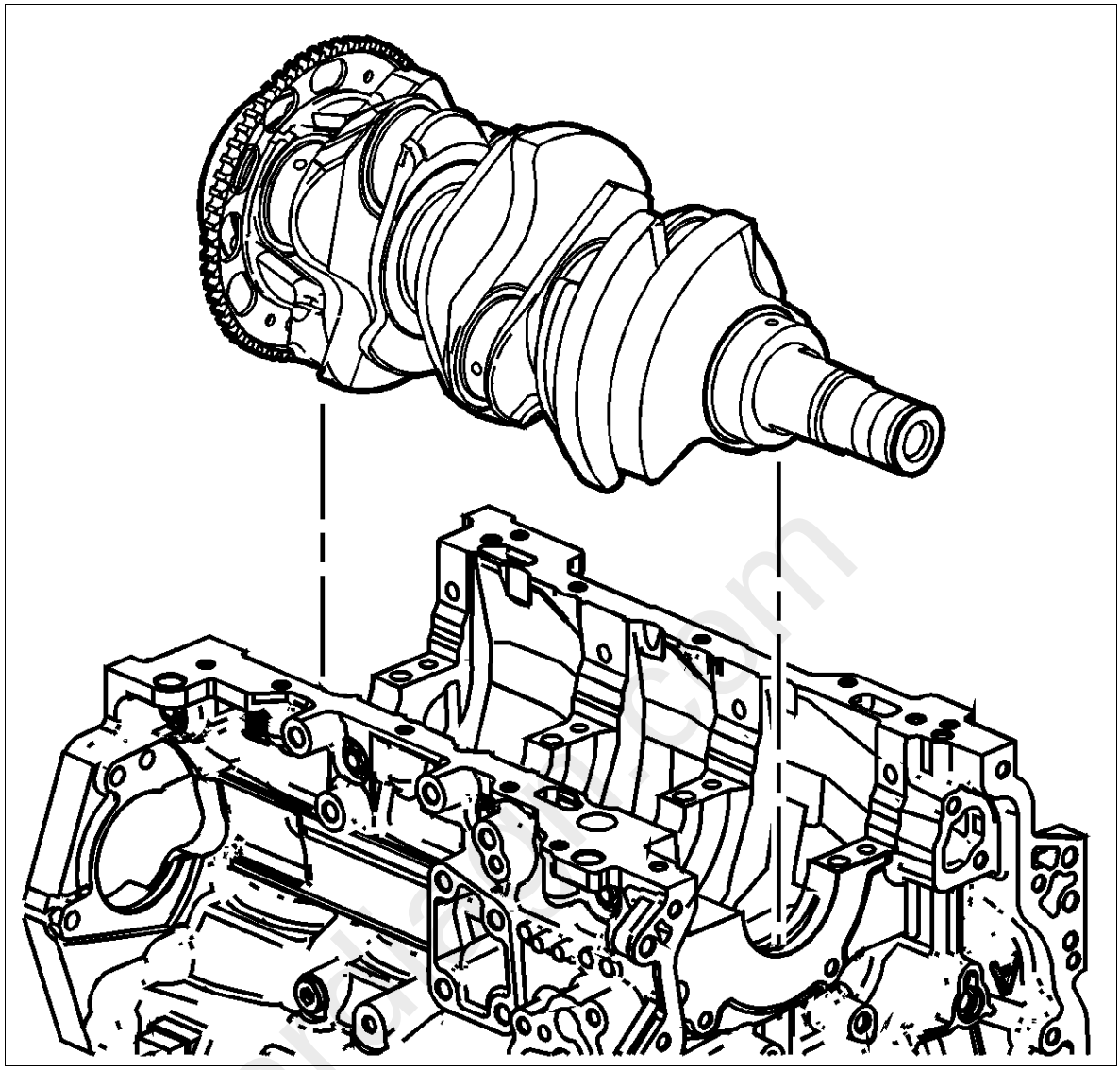
Fig 2: Crankshaft Main Bearing Caps



Courtesy of GENERAL MOTORS COMPANY

4. Remove the crankshaft bearing caps using the **EN J 6125-1B** adapter (1) and **EN 49102** remover (2).

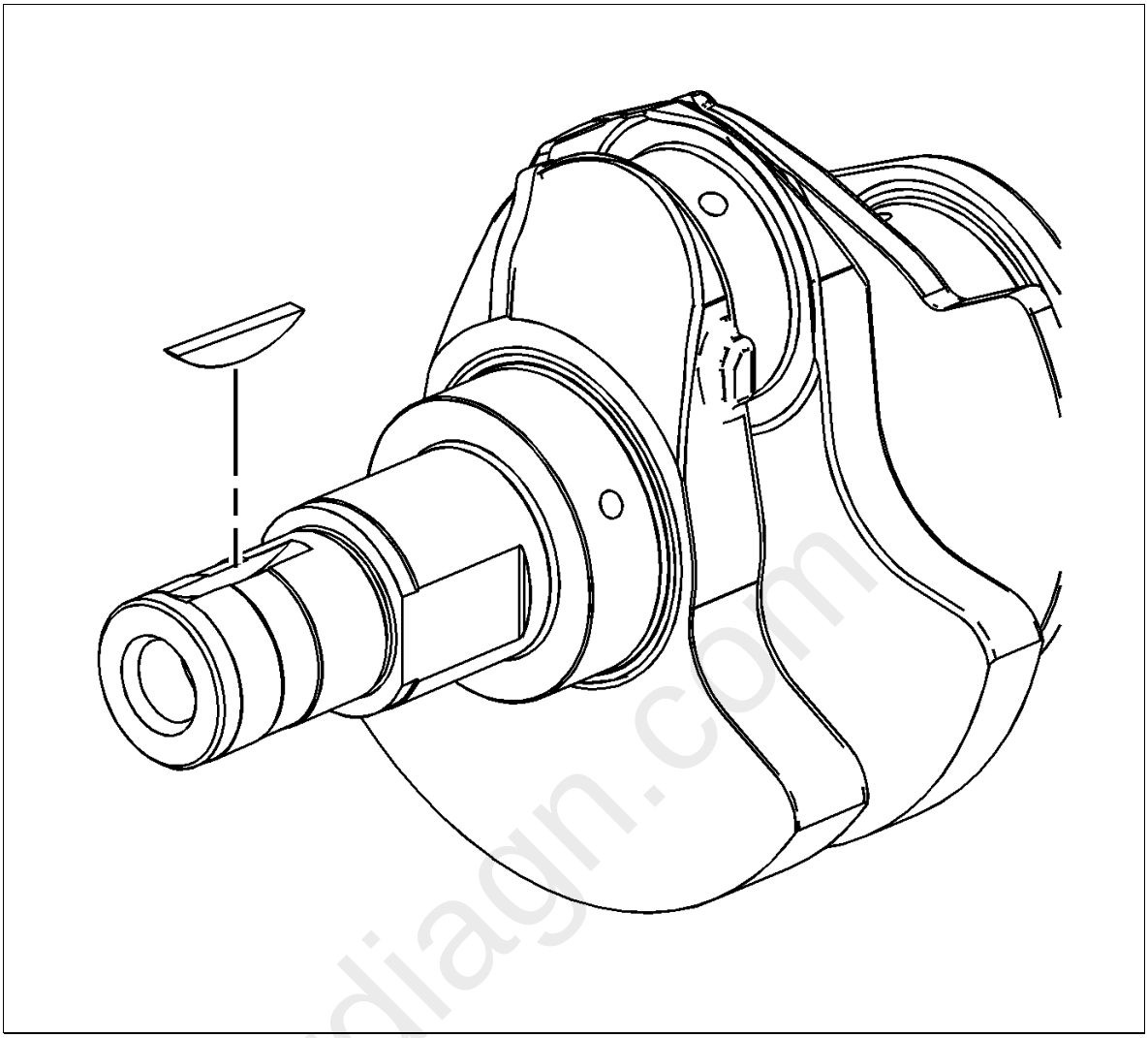
Fig 3: Crankshaft



Courtesy of GENERAL MOTORS COMPANY

5. Using two hands, lift the crankshaft straight up from the engine block.
6. Place the crankshaft in a secure place.

Fig 4: Crankshaft Sprocket Drive Pin



Courtesy of GENERAL MOTORS COMPANY

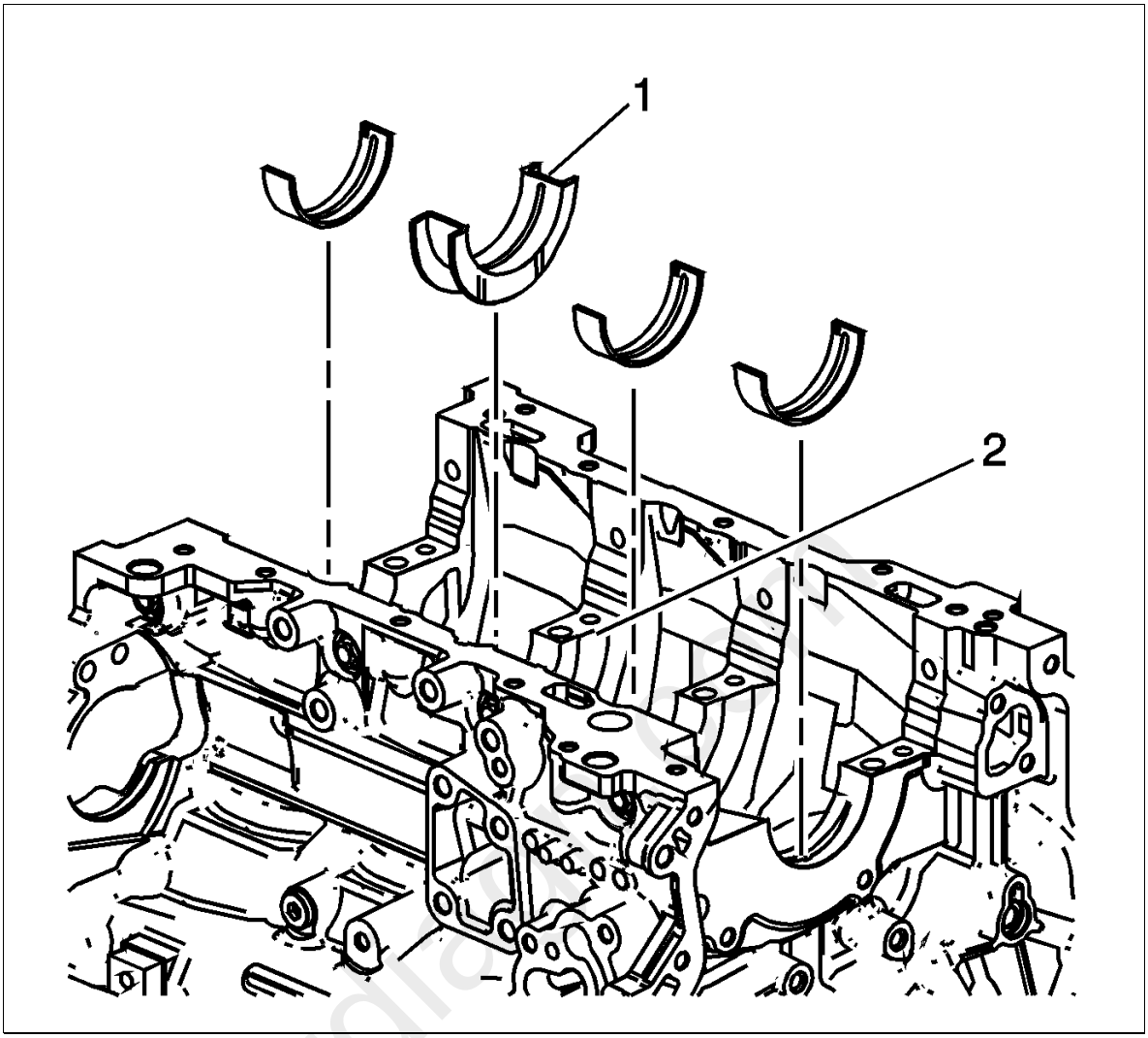
7. Remove the crankshaft key from the nose of the crankshaft, if damaged.

REPAIR INSTRUCTIONS - OFF VEHICLE > CRANKSHAFT AND BEARING REMOVAL > CRANKSHAFT BEARING REMOVAL

1. Prepare a piece of cardboard or equivalent, numbered 1-4 for bearing identification. Main bearing journals are numbered from the front of the engine.

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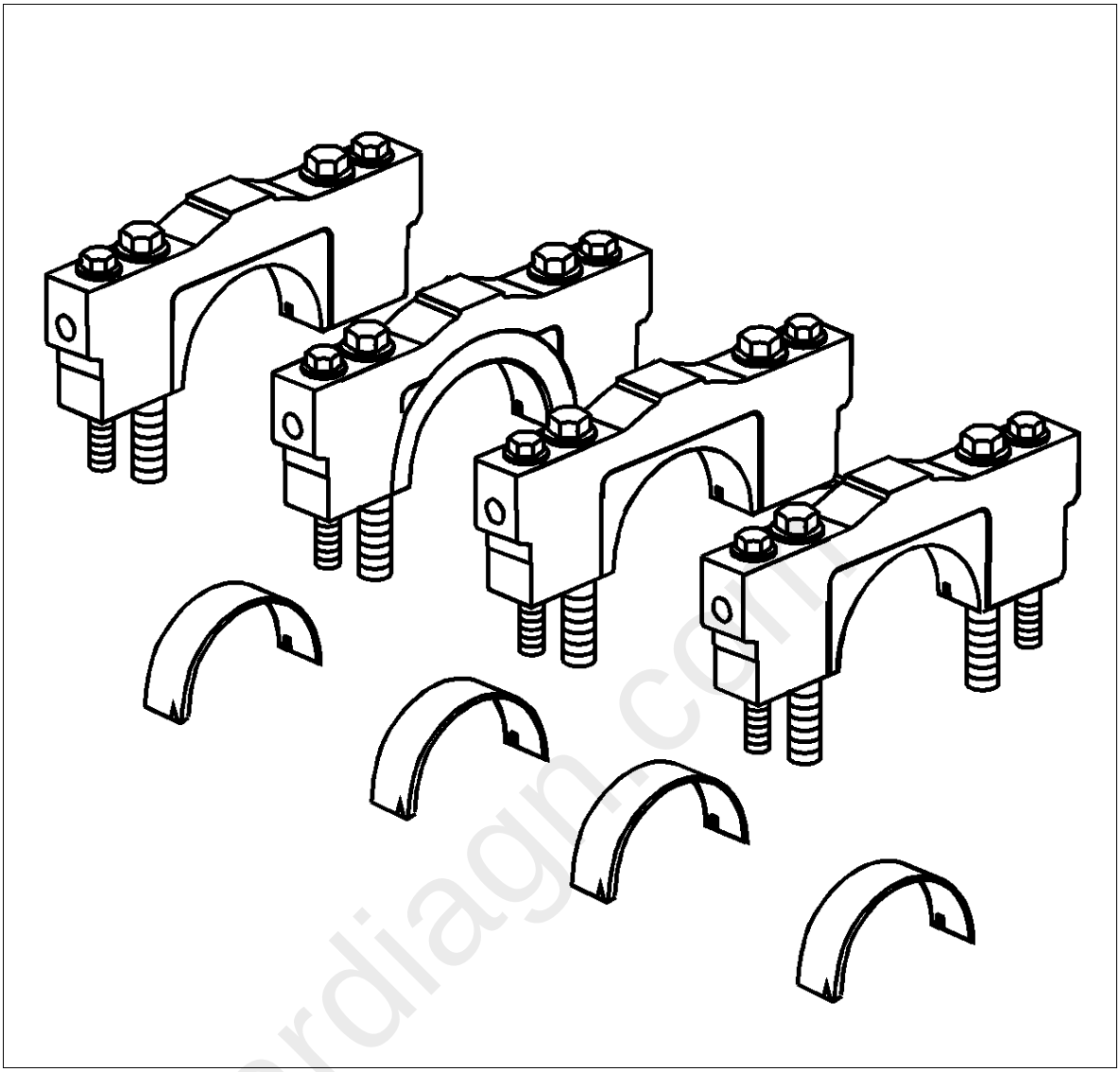
Fig 1: Thrust Bearing In Number 3 Journal



Courtesy of GENERAL MOTORS COMPANY

2. Remove the crankshaft upper bearing halves from the cylinder block. Note the position of the thrust bearing (1) at the number 3 journal (2).
3. Place the crankshaft upper bearing halves on the cardboard in the correct positions. Note that the number 3 bearing is the thrust bearing.

Fig 2: Crankshaft Bearing Caps & Lower Bearing Halves



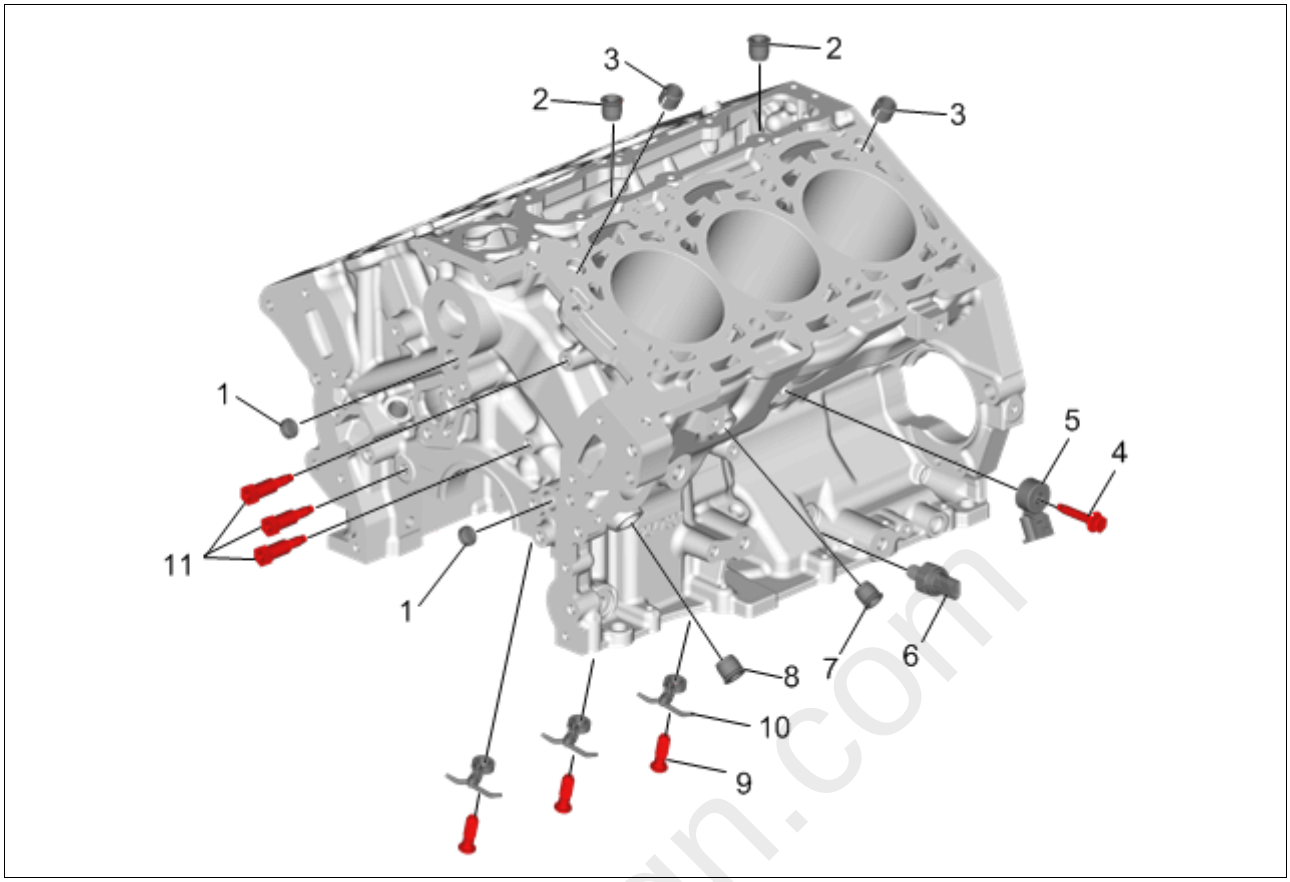
Courtesy of GENERAL MOTORS COMPANY

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4. Remove the crankshaft lower bearing halves from the crankshaft bearing caps.
5. Place the crankshaft lower bearing halves in the correct positions on the cardboard.

REPAIR INSTRUCTIONS - OFF VEHICLE > ENGINE BLOCK DISASSEMBLE > ENGINE BLOCK - LEFT - FRONT

Fig 1: Engine Block - Left - Front



Courtesy of GENERAL MOTORS COMPANY

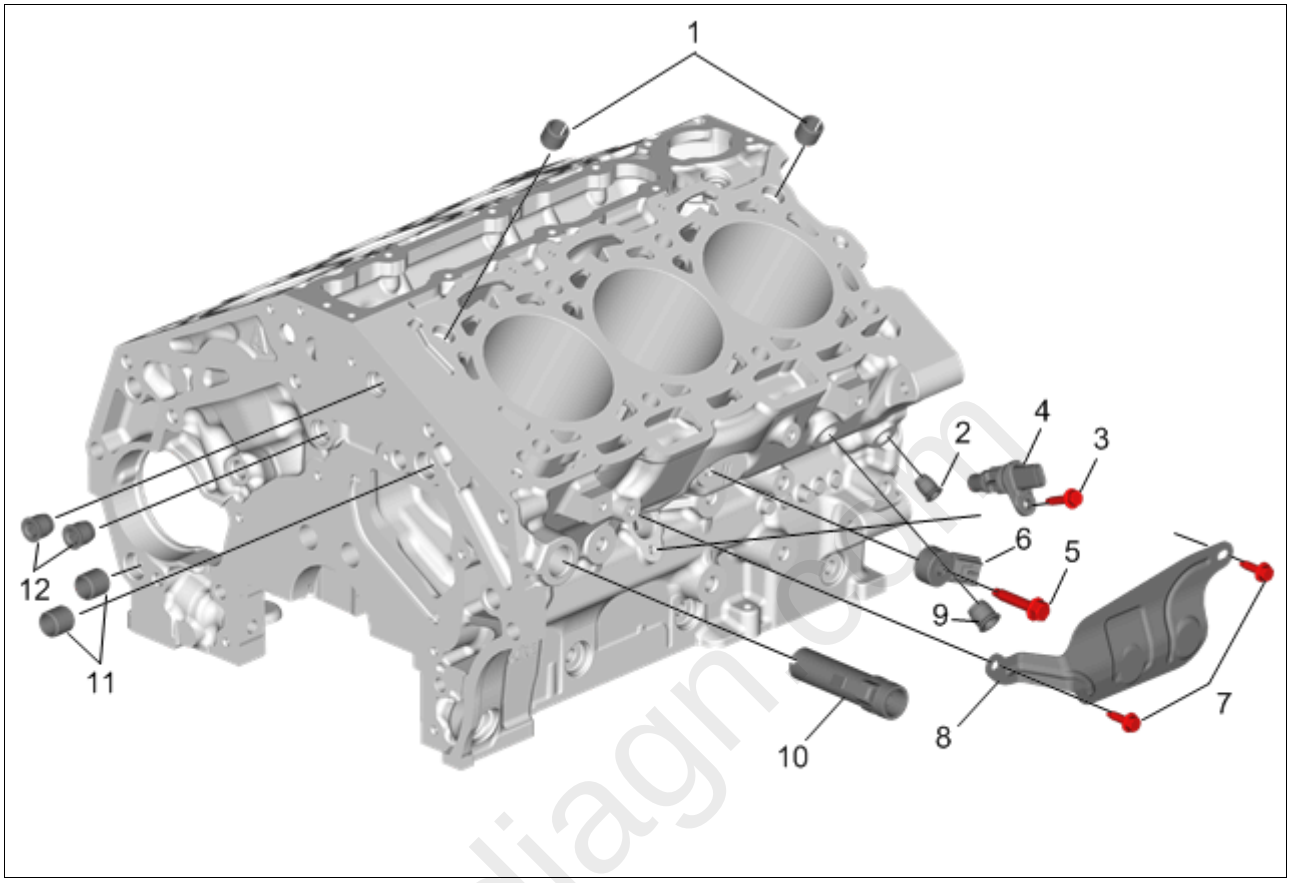
Engine Block - Left - Front

Callout	Component Name
1	Engine Block Oil Gallery Plug Cap (Qty: 2)
2	Engine Block Oil Gallery Plug (Qty: 2)
3	Cylinder Head Locating Pin (Qty: 2)
4	Knock Sensor Bolt
5	Knock Sensor
6	Engine Oil Pressure Sensor
7	Engine Block Core Hole Plug
8	Engine Block Oil Gallery Plug M16
9	Piston Oil Nozzle Bolt (Qty: 3)
10	Piston Oil Nozzle (Qty: 3)
11	Engine Front Cover Stud (Qty: 3)

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REPAIR INSTRUCTIONS - OFF VEHICLE > ENGINE BLOCK DISASSEMBLE > ENGINE BLOCK - RIGHT - REAR

Fig 1: Engine Block - Right - Rear



Courtesy of GENERAL MOTORS COMPANY

Engine Block - Right - Rear

Callout	Component Name
1	Cylinder Head Locating Pin (Qty: 2)
2	Engine Block Core Hole Plug
3	Crankshaft Position Sensor Bolt
4	Crankshaft Position Sensor
5	Knock Sensor Bolt
6	Knock Sensor
7	Knock Sensor Heat Shield Bolt (Qty: 2)
8	Knock Sensor Heat Shield
9	Engine Block Oil Gallery Plug M16

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10	Engine Coolant Temperature Sensor
11	Crankshaft Rear Oil Seal Housing Locating Pin (Qty: 2)
12	Engine Block Oil Gallery Plug (Qty: 2)

REPAIR INSTRUCTIONS - OFF VEHICLE > ENGINE BLOCK CLEANING AND INSPECTION

Special Tools

- **EN-8087** Cylinder Bore Gauge
- **EN-28410** Gasket Remover

For equivalent regional tools, refer to Special Tools .

REPAIR INSTRUCTIONS - OFF VEHICLE > ENGINE BLOCK CLEANING AND INSPECTION > CLEANING PROCEDURE

1. Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant
2. Remove any old thread sealant, gasket material or sealant using **EN-28410** Gasket Remover.
3. Clean all the following areas with solvent:
    1. Sealing surfaces
    2. Cooling passages
    3. Oil passages
    4. Bearing journals
4. Clean all threaded and through holes with solvent.

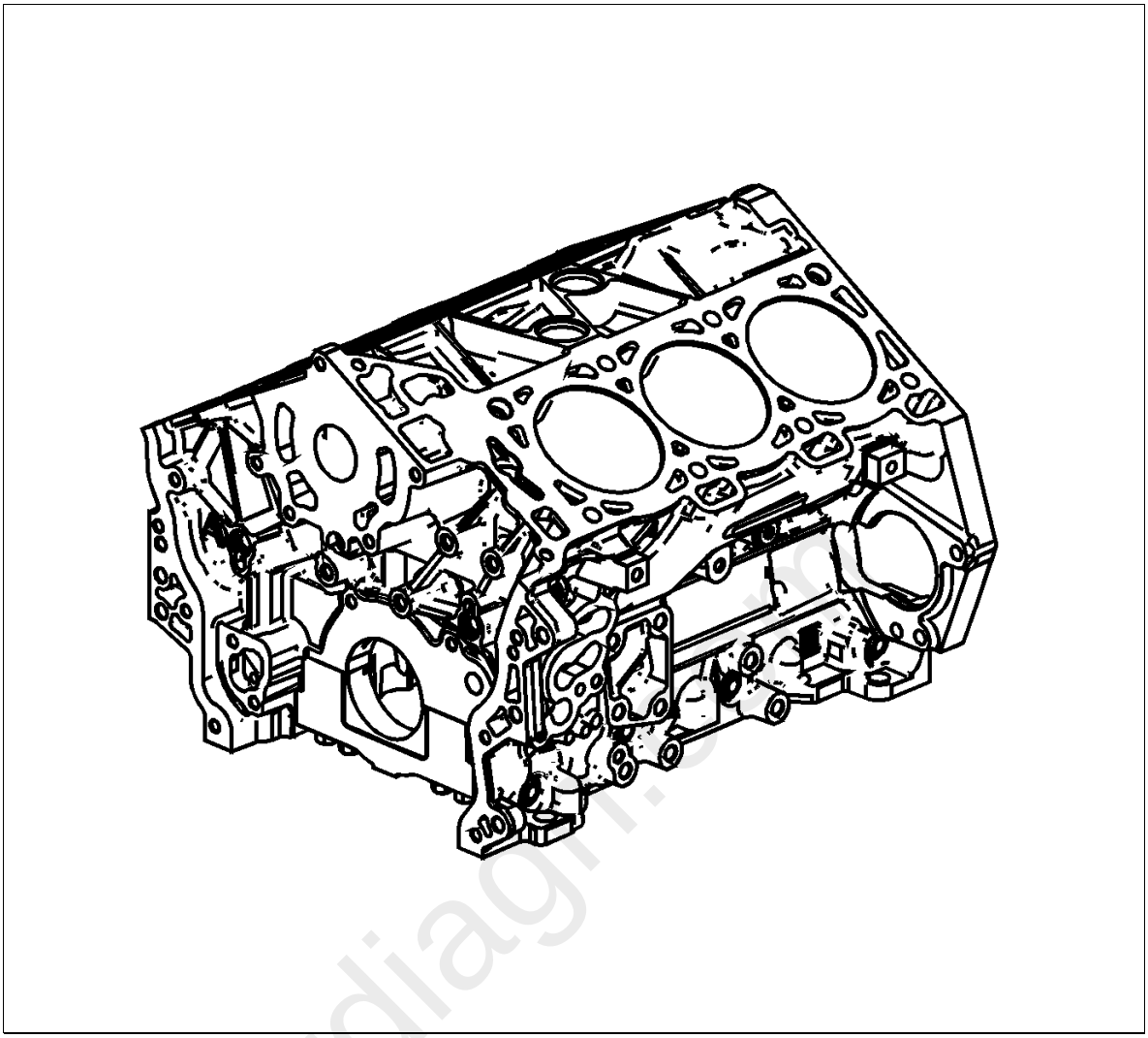
> *WARNING:*
>
> *Refer to Safety Glasses Warning .*

5. Dry the engine block with compressed air.

REPAIR INSTRUCTIONS - OFF VEHICLE > ENGINE BLOCK CLEANING AND INSPECTION > VISUAL INSPECTION

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Fig 1: Engine Block



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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 cylinder block assembly must be replaced.

2. Inspect the primary camshaft drive chain tensioner mounting surface on the engine block for burrs or any defects that would degrade the sealing of the NEW primary camshaft drive chain tensioner gasket.

3. Inspect all sealing and mating surfaces for damage, repair or replace the cylinder block assembly if necessary.

4. Inspect all threaded and through holes for damage or excessive debris.

5. Inspect all bolts for damage, if damaged replace with NEW bolts only.

6. Check the cylinder condition. Some light vertical marks may be visible on the cylinder wall. In these areas, check that the honing marks are still visible in this marked area. If they are, the cylinder surface has not been compromised and the engine block can be used.

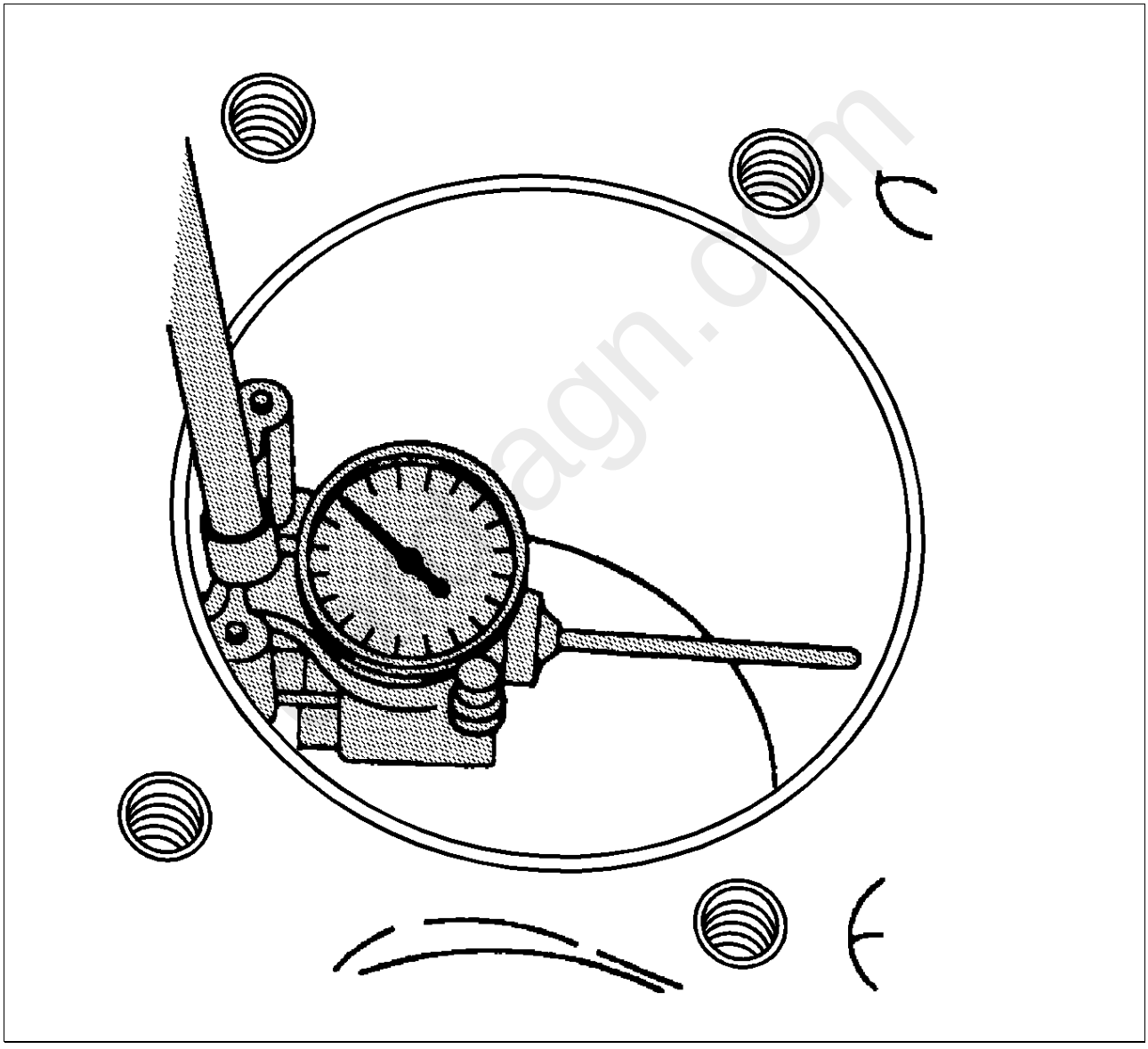
7. Inspect the cylinder walls for cracks or damage. The cylinder sleeves are not serviced

separately, if the cylinders are damaged the cylinder block assembly must be replaced.

8. Inspect the engine block for cracks. Do not repair any cracks. If cracks are found, the cylinder block assembly must be replaced.
9. Repair any damaged threaded holes. Refer to Thread Repair Specifications , and Thread Repair .

REPAIR INSTRUCTIONS - OFF VEHICLE > ENGINE BLOCK CLEANING AND INSPECTION > MEASURING CYLINDER BORE DIAMETER

Fig 1: Cylinder Bore



Courtesy of GENERAL MOTORS COMPANY

Measure the cylinder bore diameter 37 mm (1.457 in) from the deck face using the **EN-8087** gauge.

Compare your results with the Engine Mechanical Specifications . If the cylinder diameter exceeds the

specifications, the cylinder block may be oversized to 0.25 mm (0.010 in). There is only one size of oversized pistons and rings available for service.

REPAIR INSTRUCTIONS - OFF VEHICLE > ENGINE BLOCK CLEANING AND INSPECTION > MEASURING CYLINDER BORE TAPER

1. Measure the cylinder bore along the thrust surfaces, perpendicular to the crankshaft centerline, at 10 mm (0.397 in) below the deck surface and record your measurement.
2. Measure the cylinder bore along the thrust surfaces, perpendicular to the crankshaft centerline, at 100 mm (3.976 in) below the deck surface and record your measurement.
3. Calculate the difference between the 2 measurements. The result will be the cylinder taper.
4. Compare your results with the Engine Mechanical Specifications . If the cylinders exceed the specifications, the cylinder block may be oversized to 0.25 mm (0.010 in). There is only one size of oversized pistons and rings available for service.

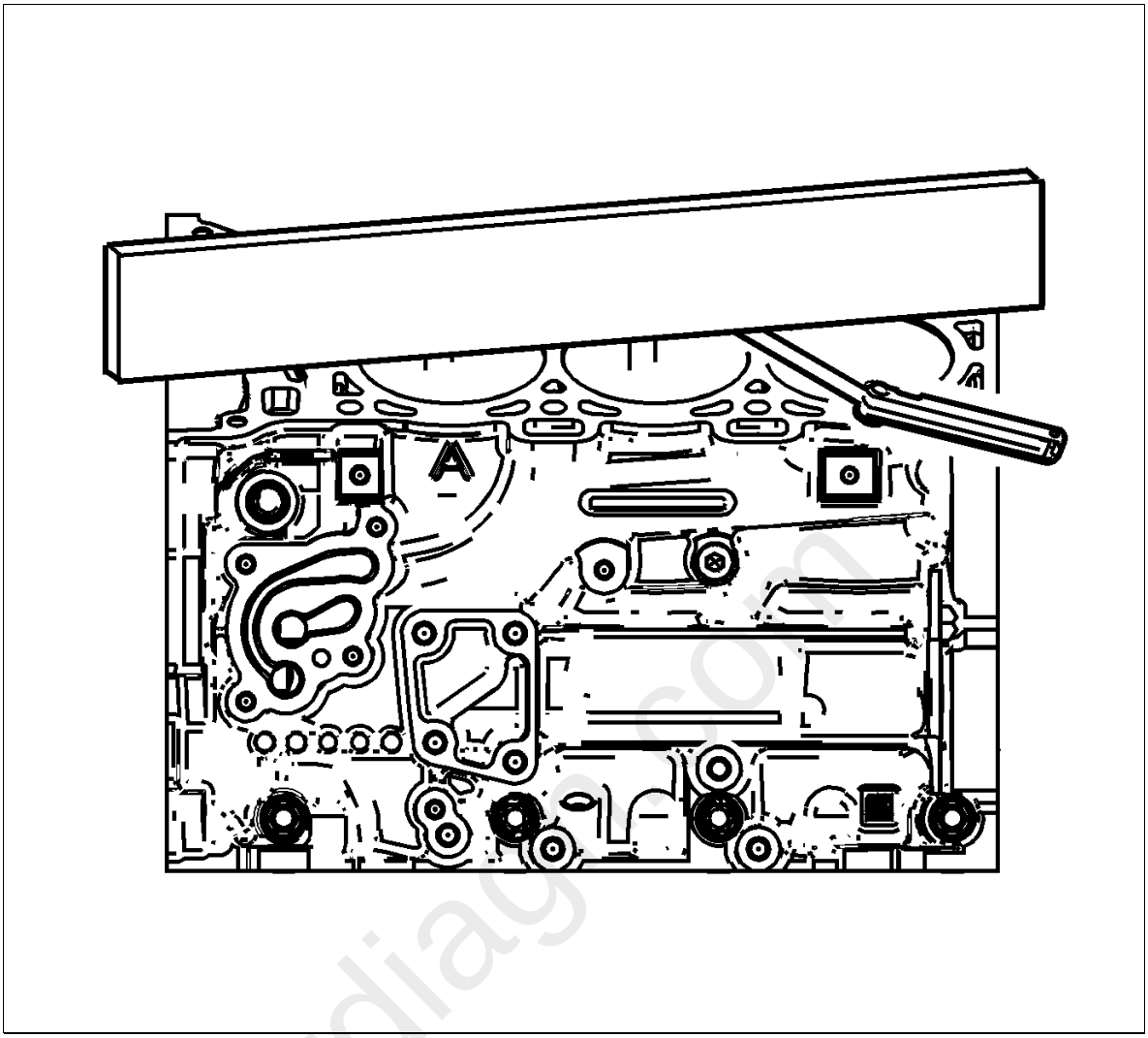
REPAIR INSTRUCTIONS - OFF VEHICLE > ENGINE BLOCK CLEANING AND INSPECTION > MEASURING CYLINDER BORE OUT-OF-ROUND

1. Measure both the thrust and non-thrust cylinder diameter at 10 mm (0.397 in) below the deck. Record your measurements.
2. Calculate the difference between the 2 measurements. The result will indicate out-of-round at the upper end of the cylinder.
3. Measure both the thrust and non-thrust cylinder diameter at 100 mm (3.976 in) below the deck surface. Record your measurements.
4. Calculate the difference between the 2 measurements. The result will indicate out-of-round at the lower end of the cylinder.
5. Compare your results with the Engine Mechanical Specifications . If the cylinders exceed these specifications, the cylinder block may be oversized to 0.25 mm (0.010 in). There is only one size of oversized pistons and rings available for service.

REPAIR INSTRUCTIONS - OFF VEHICLE > ENGINE BLOCK CLEANING AND INSPECTION > DECK FLATNESS INSPECTION

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Fig 1: Deck Flatness



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1. Ensure the engine block decks are clean and free of gasket material.
2. Inspect the surface for any imperfections or scratches that could inhibit proper cylinder head gasket sealing.
3. Place a straight-edge diagonally across the cylinder block deck face surface.
4. Measure the clearance between the straight-edge and the cylinder block deck face using a feeler gauge at 4 points along the straight-edge.
5. If the warpage is less than 0.05 mm (0.002 in), the cylinder block deck surface does not require resurfacing.
6. If the warpage is between 0.05-0.20 mm (0.002-0.008 in) or any imperfections or scratches that could inhibit proper cylinder head gasket sealing are present, the cylinder block deck surface requires resurfacing.
7. If resurfacing is required the maximum amount that can be removed is 0.25 mm (0.010 in).
8. If the cylinder block deck surface requires more than 0.25 mm (0.010 in) material removal the

block must be replaced.

REPAIR INSTRUCTIONS - OFF VEHICLE > CRANKSHAFT AND BEARING CLEANING AND INSPECTION > CLEANING PROCEDURE

1. Clean the following components in solvent:
    1. Crankshaft bearings
    2. Connecting rod bearings
    3. Crankshaft journals
    4. Crankpin journals
    5. Crankshaft oil passages
    6. Crankshaft threaded holes

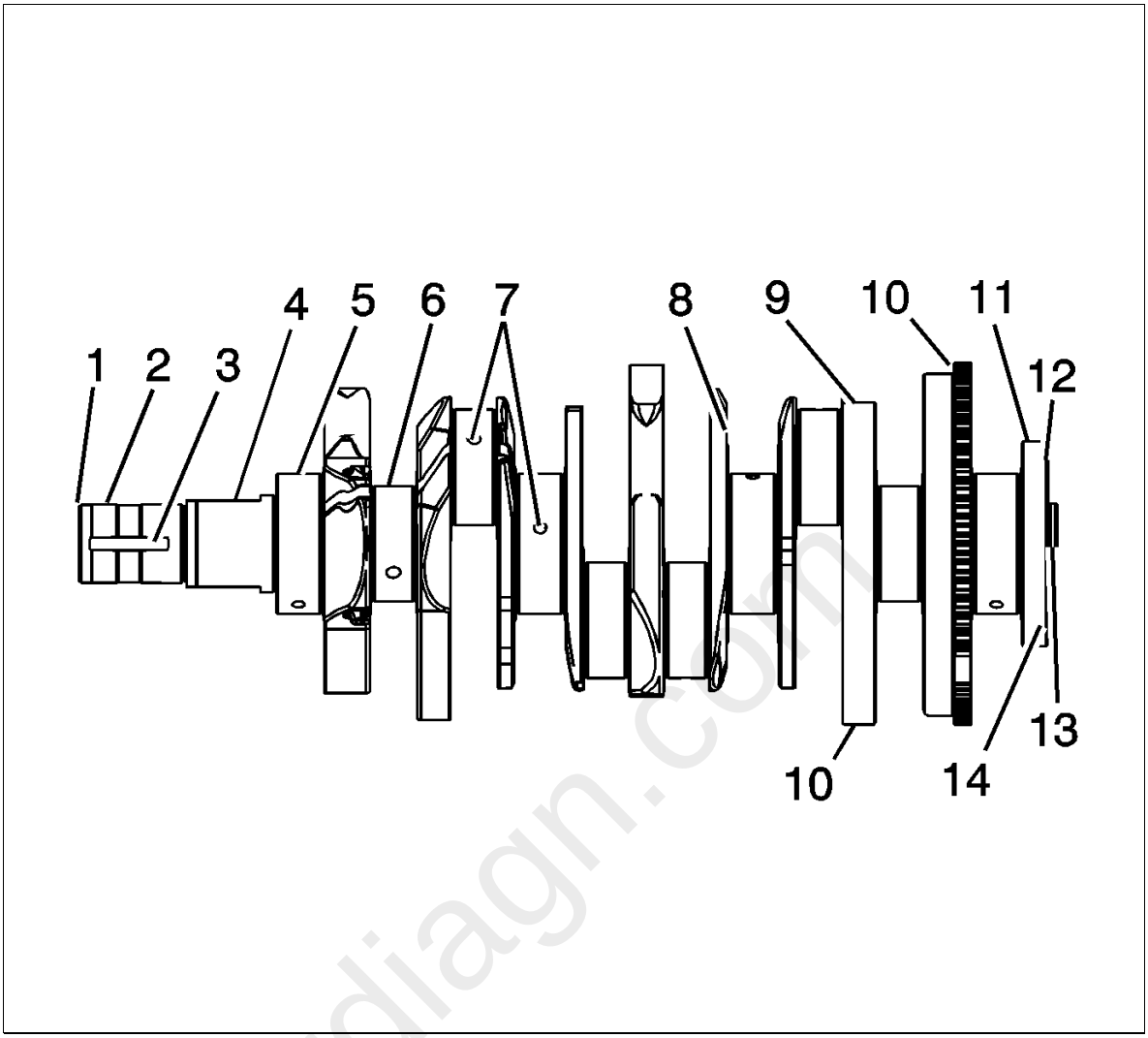
> *WARNING:*
>
> *Refer to Safety Glasses Warning*

2. Dry the following components with compressed air:
    1. Crankshaft bearings
    2. Connecting rod bearings
    3. Crankshaft journals
    4. Crankpin journals
    5. Crankshaft oil passages
    6. Crankshaft threaded holes

REPAIR INSTRUCTIONS - OFF VEHICLE > CRANKSHAFT AND BEARING CLEANING AND INSPECTION > VISUAL INSPECTION

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Fig 1: Crankshaft Inspection Areas



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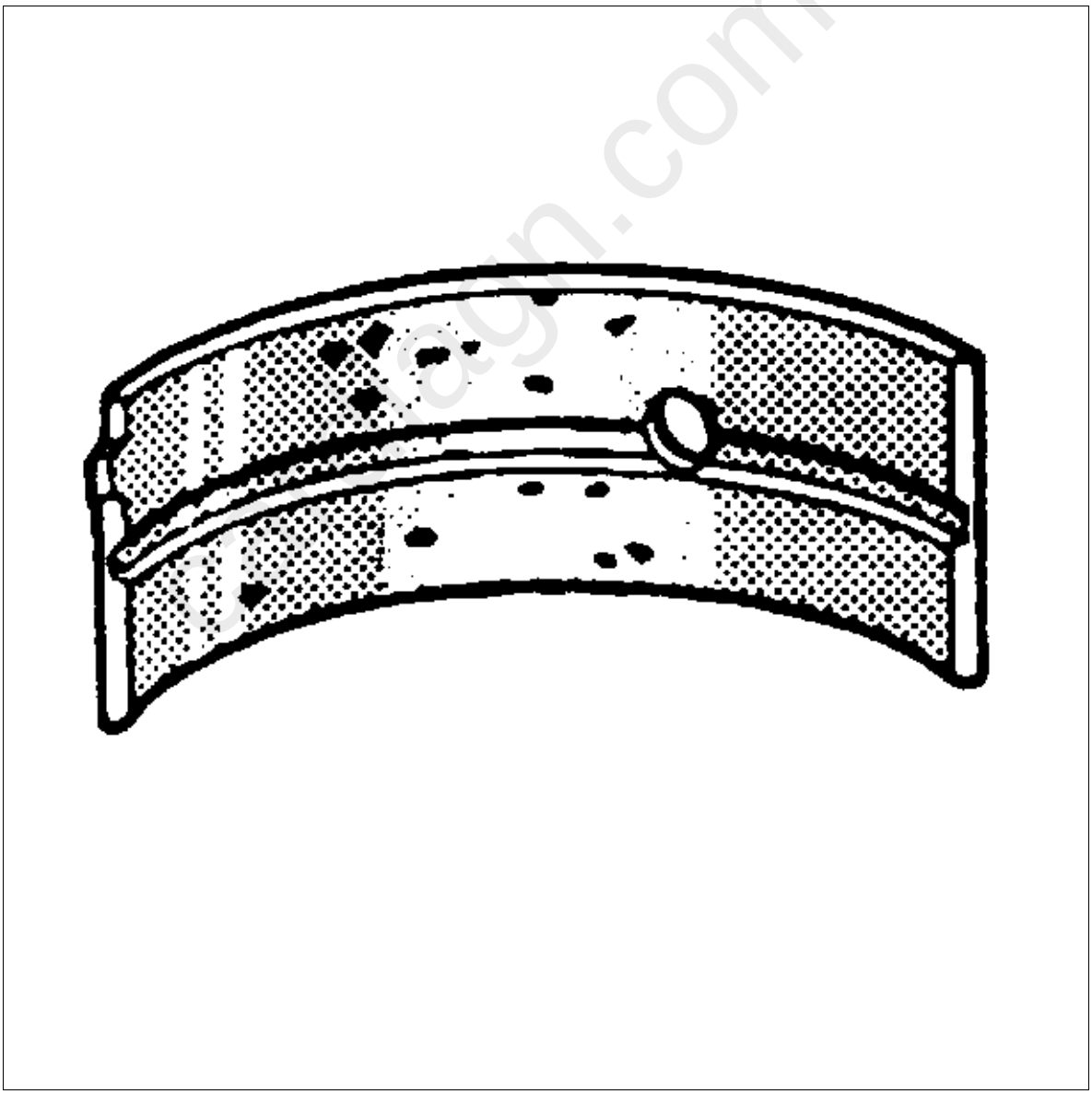
1. Perform the following visual inspections:
    1. Inspect the crankshaft balancer bolt hole (1) for thread damage.
    2. Inspect the crankshaft balancer mounting area (2) for damage.
    3. Inspect the crankshaft keyway (3) for damage.
    4. Inspect the oil pump drive flats (4) for damage.
    5. Inspect the crankshaft main journals (5) for damage.
    6. Inspect the crankshaft connecting rod journals (6) for damage.
    7. Inspect the crankshaft oil passages (7) for obstructions.
    8. Inspect the crankshaft main bearing thrust wall surfaces (8) for damage.
    9. Inspect the crankshaft counterweights (9) for damage.

10. Inspect the crankshaft reluctor ring teeth (10) for damage.
11. Inspect the crankshaft rear main oil seal surface (11) for damage.
12. Inspect the crankshaft engine flywheel mounting surface (12) for damage.
13. Inspect the crankshaft pilot hole (13) for damage.
14. Inspect the crankshaft engine flywheel bolt holes (14) for thread damage.

2. Repair or replace the crankshaft as necessary.

REPAIR INSTRUCTIONS - OFF VEHICLE > CRANKSHAFT AND BEARING CLEANING AND INSPECTION > CRANKSHAFT BEARING INSPECTION

Fig 1: Crankshaft Bearing Craters Or Pockets



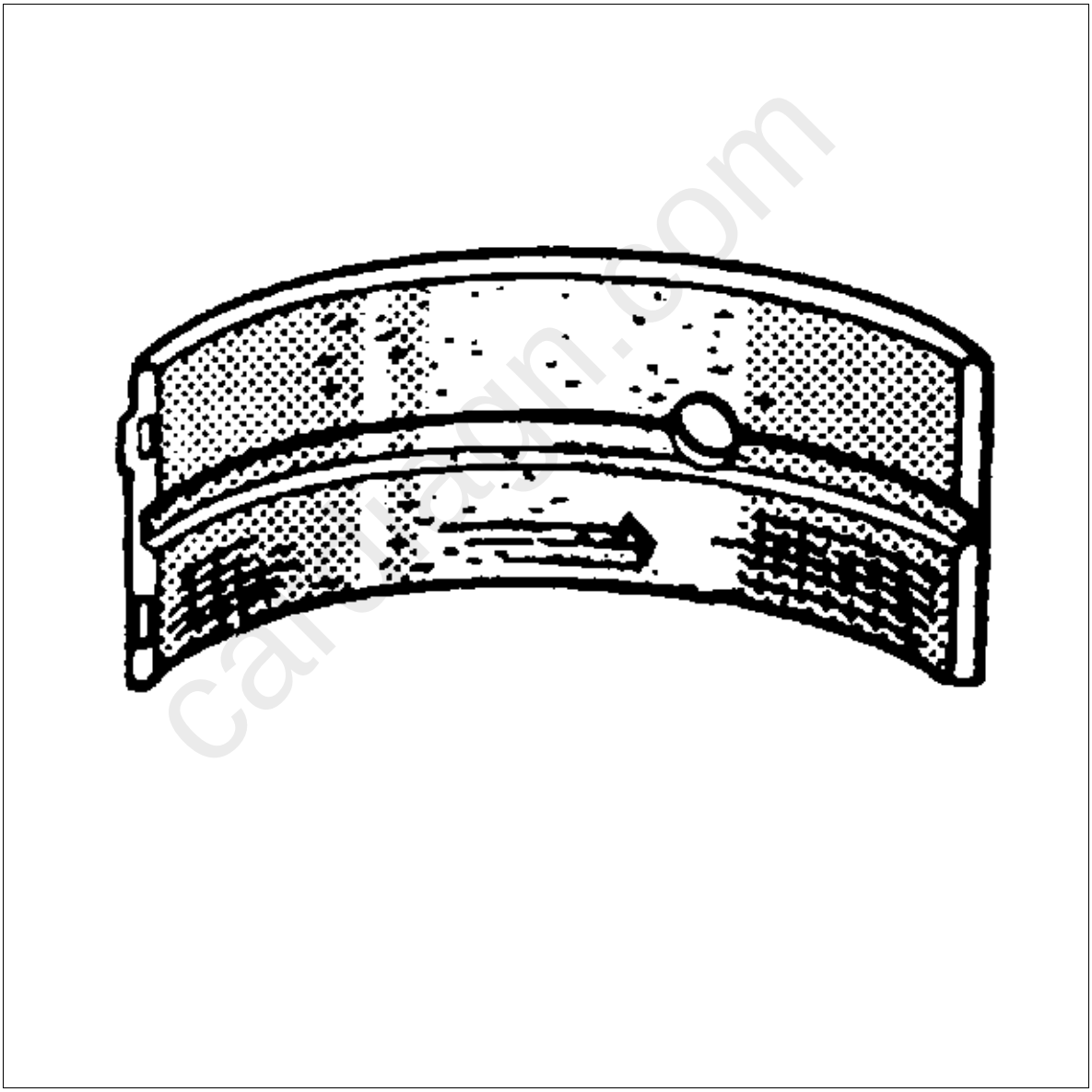
Courtesy of GENERAL MOTORS COMPANY

NOTE:

1. *All connecting rod and main journal bearings that have been used in a running engine must be replaced. Never re-use the crankshaft or connecting rod bearings.*
2. *The following bearing wear conditions should be used to diagnose engine operating conditions or root cause of a condition.*

1. Inspect for fatigue indicated by craters or pockets. Flattened sections on the bearing halves also indicate fatigue.

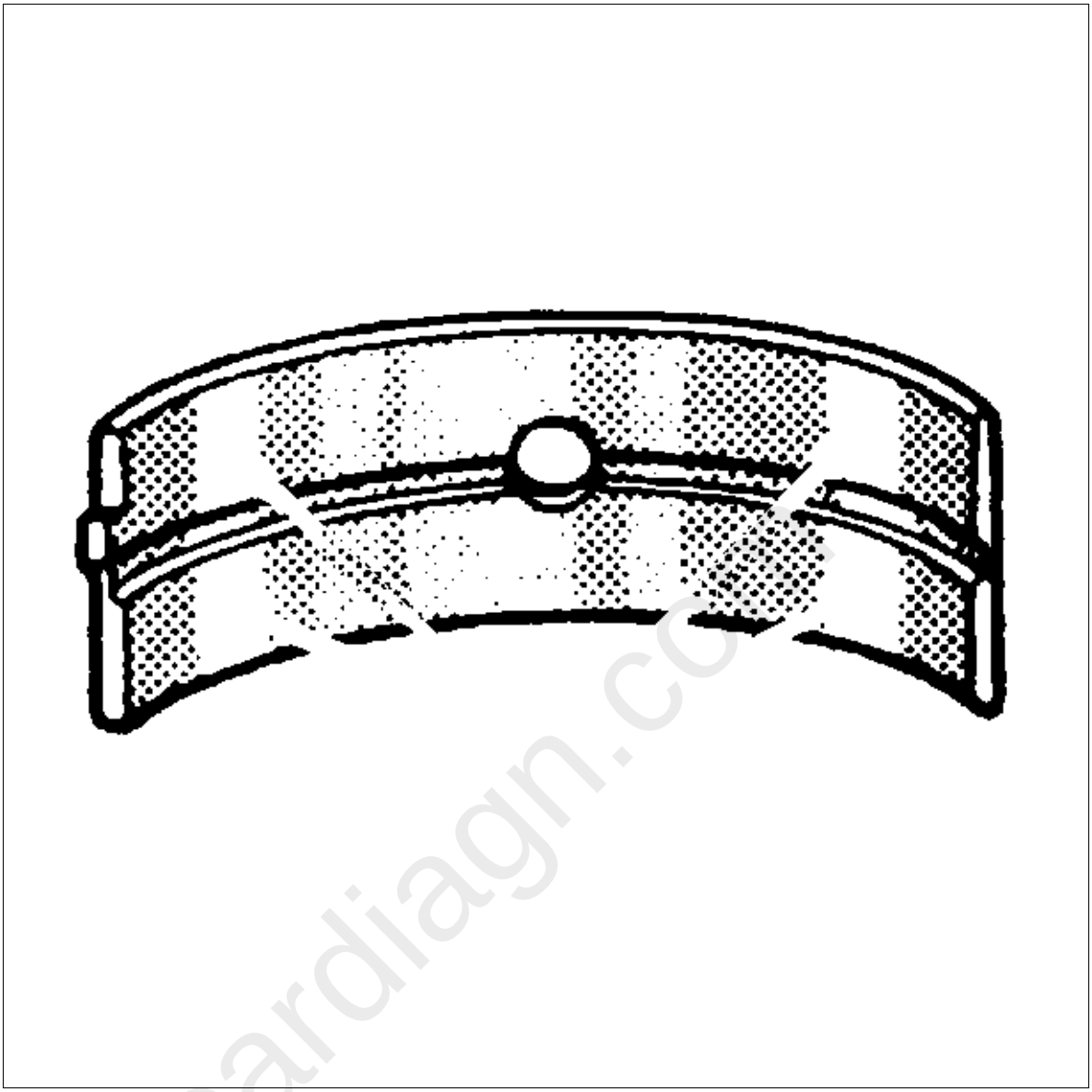
   Fig 2: Connecting Rod Bearing Scoring Or Discoloration



Courtesy of GENERAL MOTORS COMPANY

2. Inspect for excessive scoring or discoloration on both front and back of the bearing halves.
3. Inspect the main bearings for dirt embedded into the bearing material.

Fig 3: Crankshaft Bearing Improper Seating



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4. Inspect for improper seating indicated by bright, polished sections.

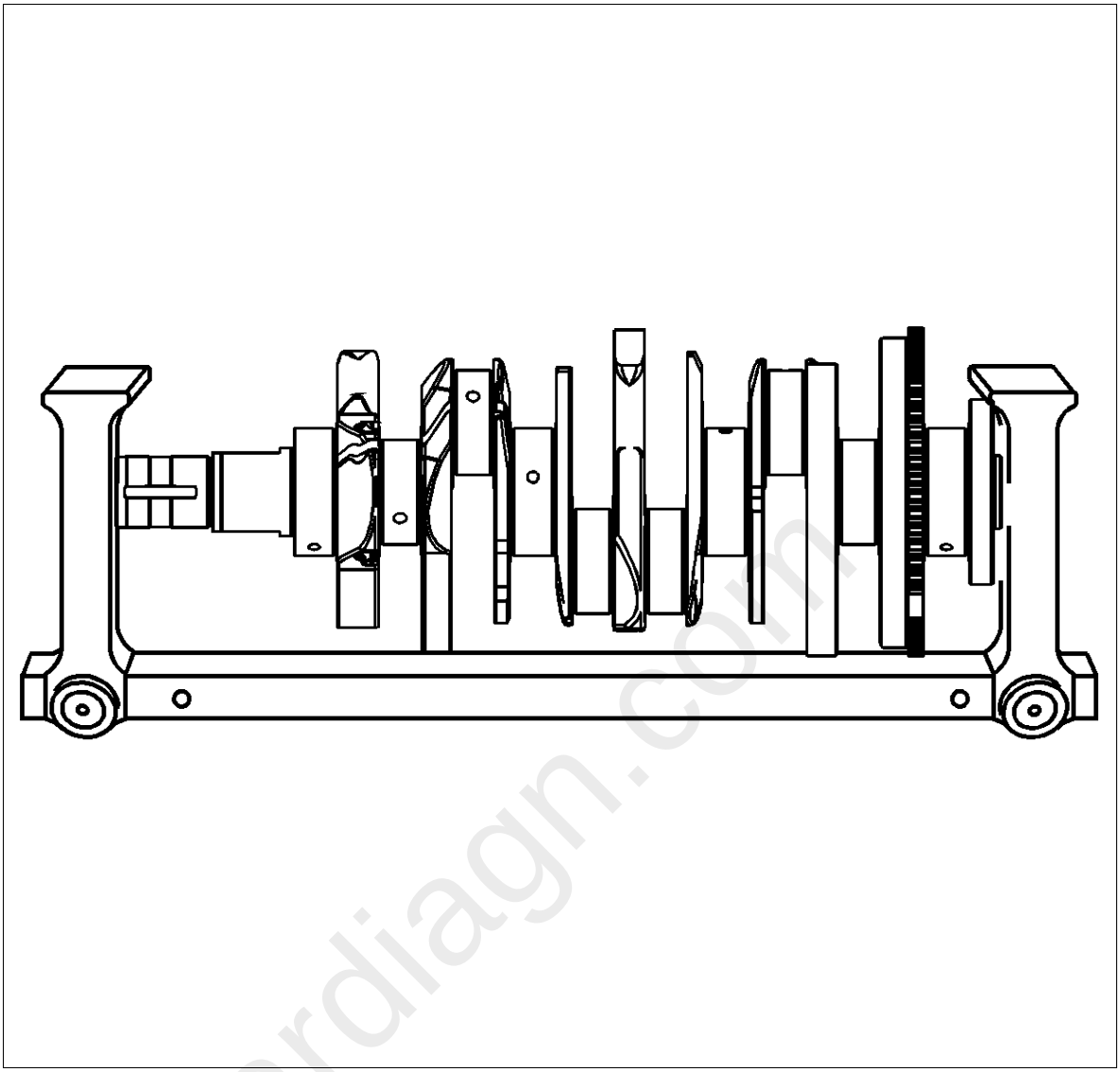
REPAIR INSTRUCTIONS - OFF VEHICLE > CRANKSHAFT AND BEARING CLEANING AND INSPECTION > CRANKSHAFT MEASUREMENT

Special Tools

J 7872 Magnetic Base Dial Indicator

For equivalent regional tools, refer to Special Tools .

Fig 1: Crankshaft & Support

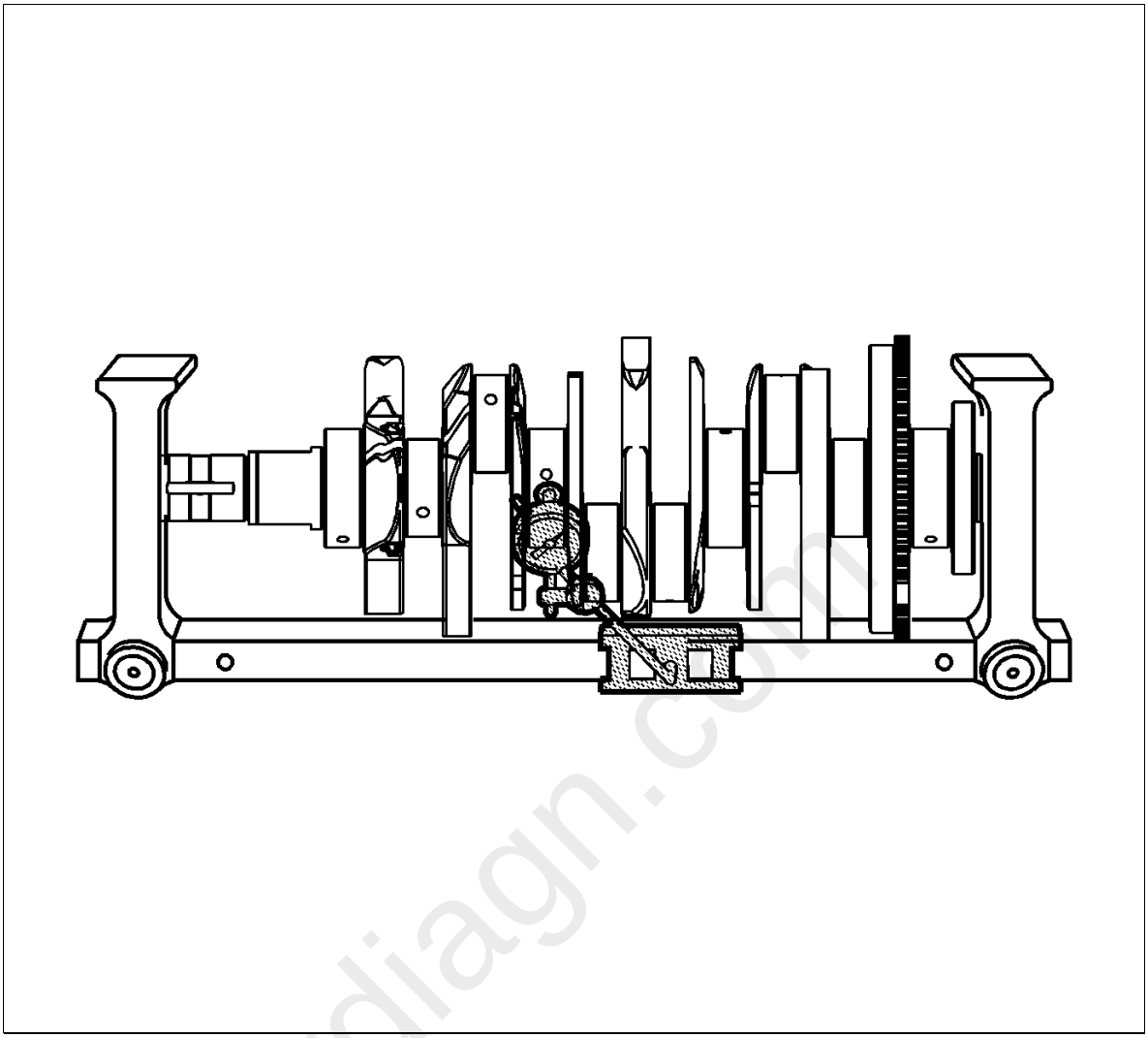


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1. Using a suitable fixture, support the crankshaft.

Fig 2: Crankshaft Runout

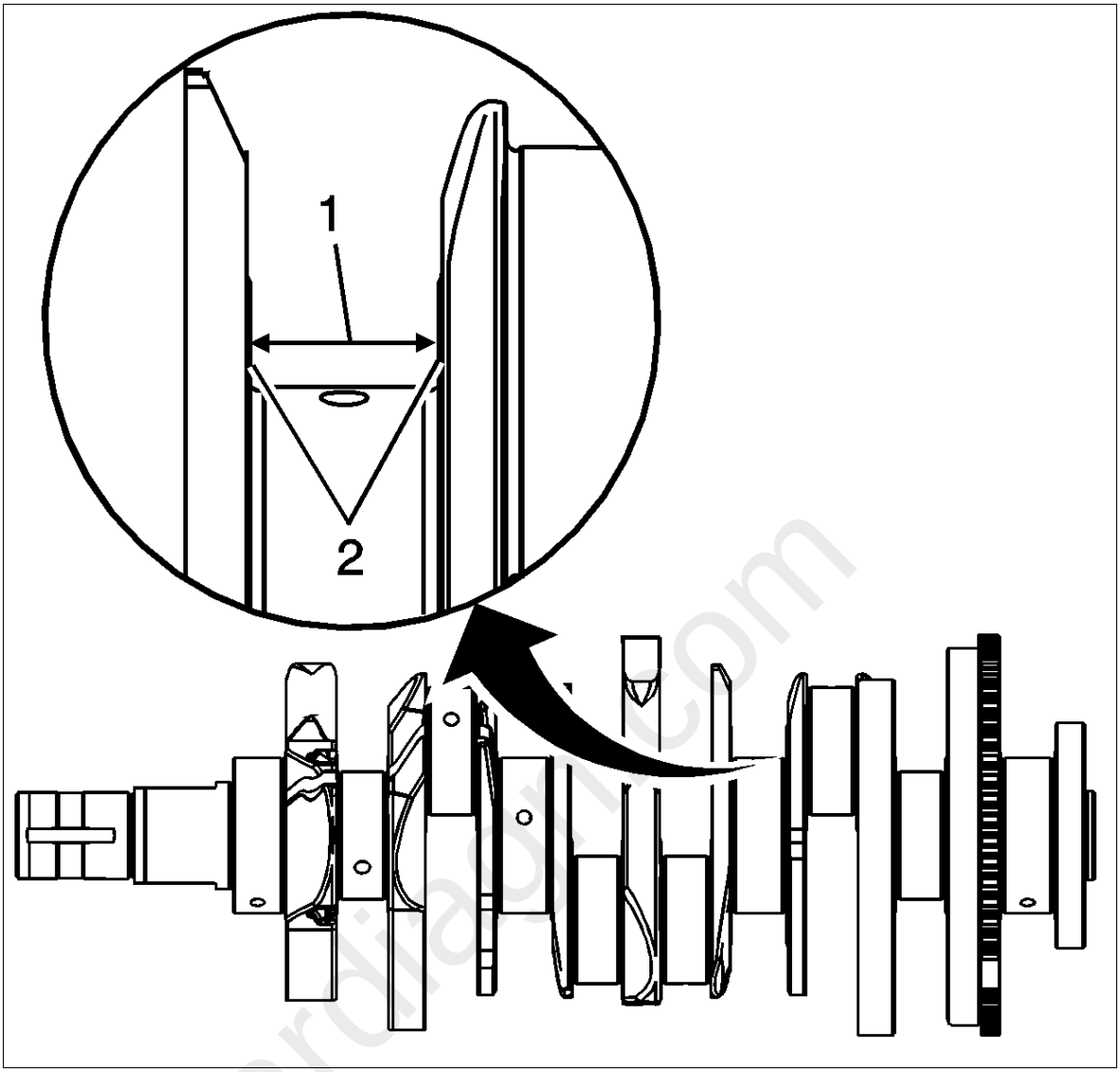


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2. Install the **J 7872** indicator.
3. Measure the crankshaft runout using the **J 7872** indicator. Refer to Engine Mechanical Specifications .

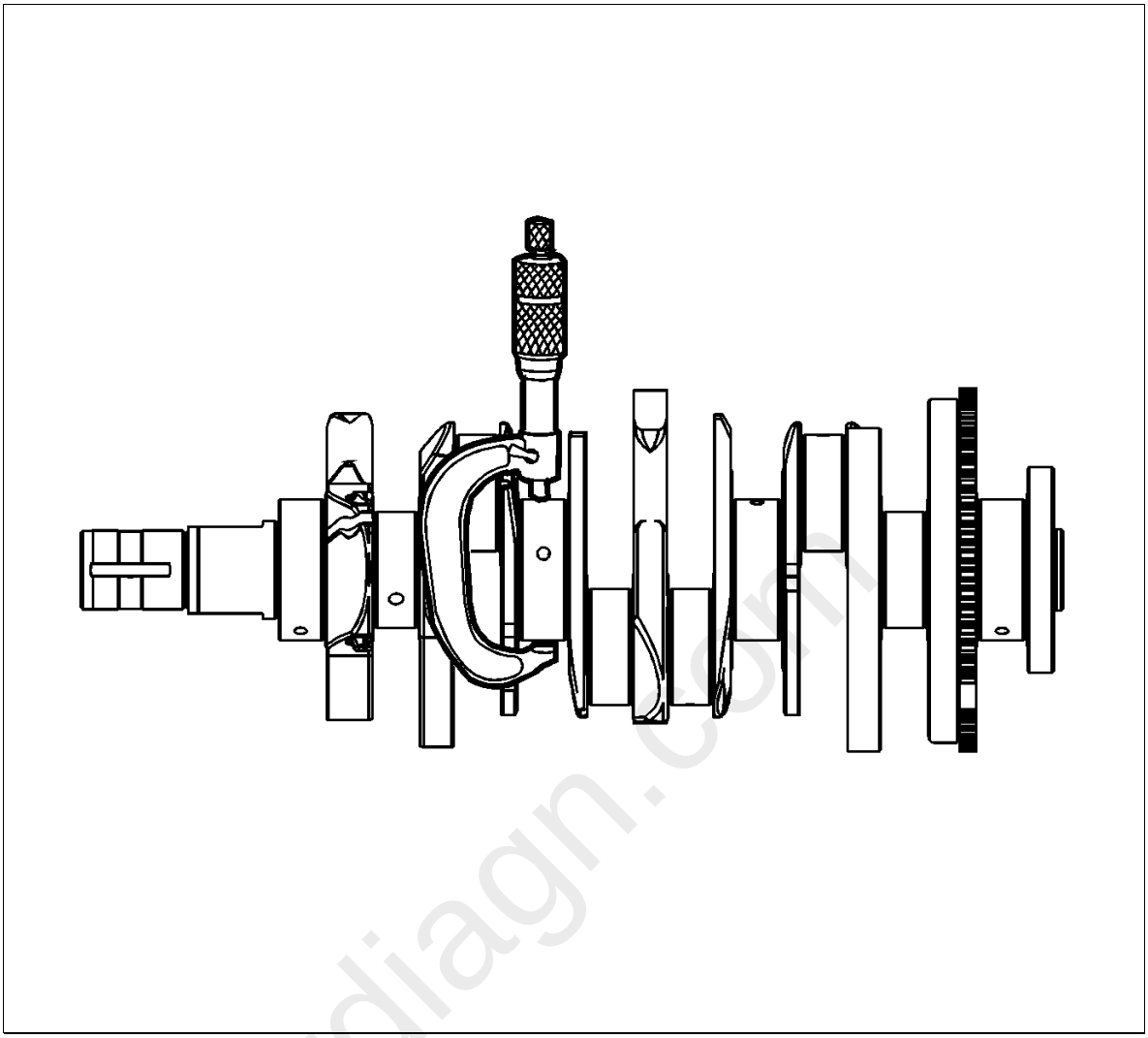
Fig 3: Crankshaft Thrust Wall Width & Surface



Courtesy of GENERAL MOTORS COMPANY

4. Measure the crankshaft thrust wall width (1) for wear using an inside micrometer. Refer to Engine Mechanical Specifications .
5. Measure the crankshaft thrust wall surface (2) for runout using the **J 7872** indicator. Refer to Engine Mechanical Specifications .
6. If the crankshaft journals are damaged or worn beyond specifications, the crankshaft may be ground 0.25 mm (0.010 in). There is only 1 size of oversized main bearings available for service.

Fig 4: Outside Micrometer To Inspect Crankshaft Main Journals

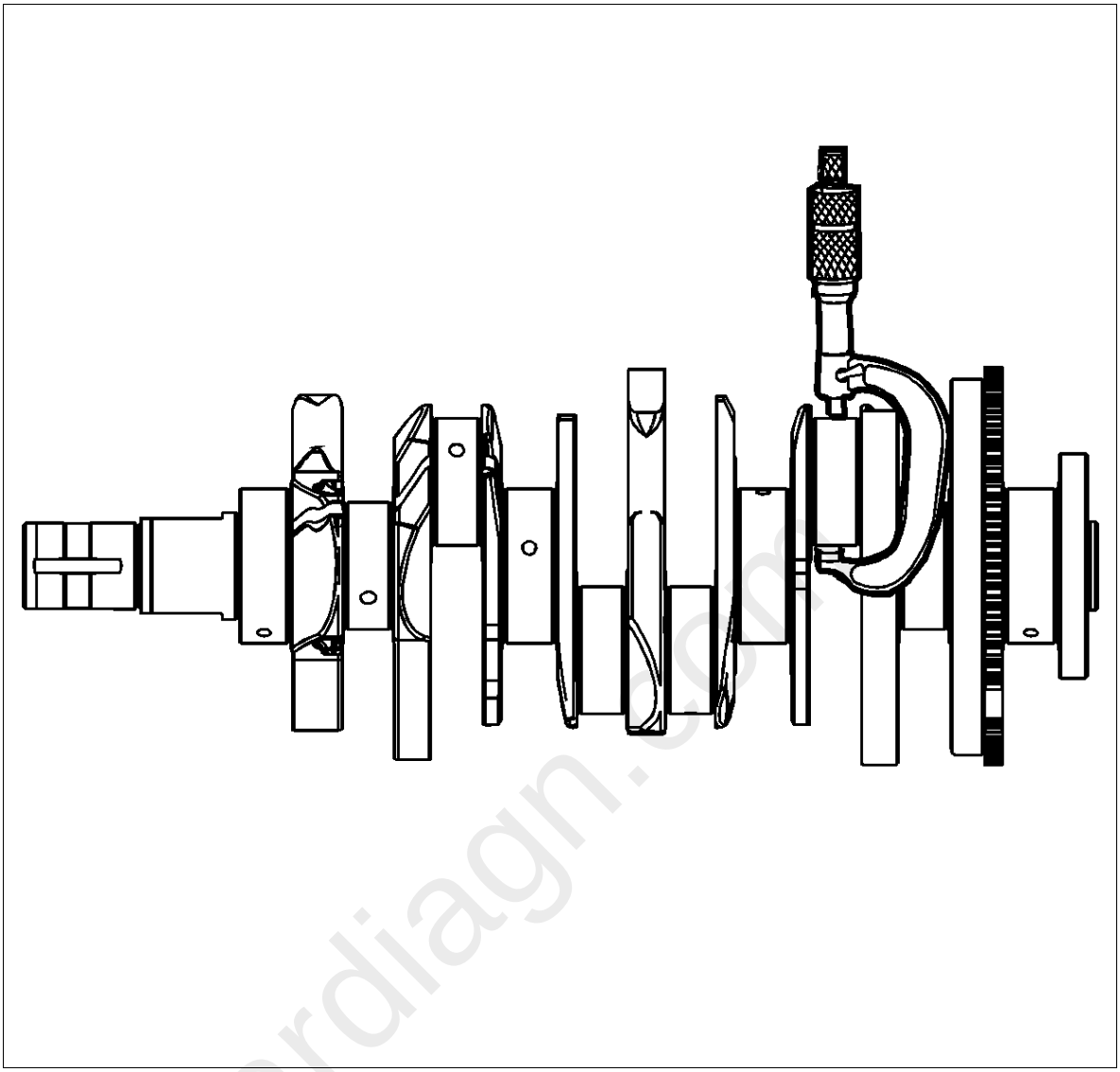


Courtesy of GENERAL MOTORS COMPANY

7. Inspect the crankshaft main journals for undersize, using an outside micrometer.

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Fig 5: Micrometer & Crankshaft Journals

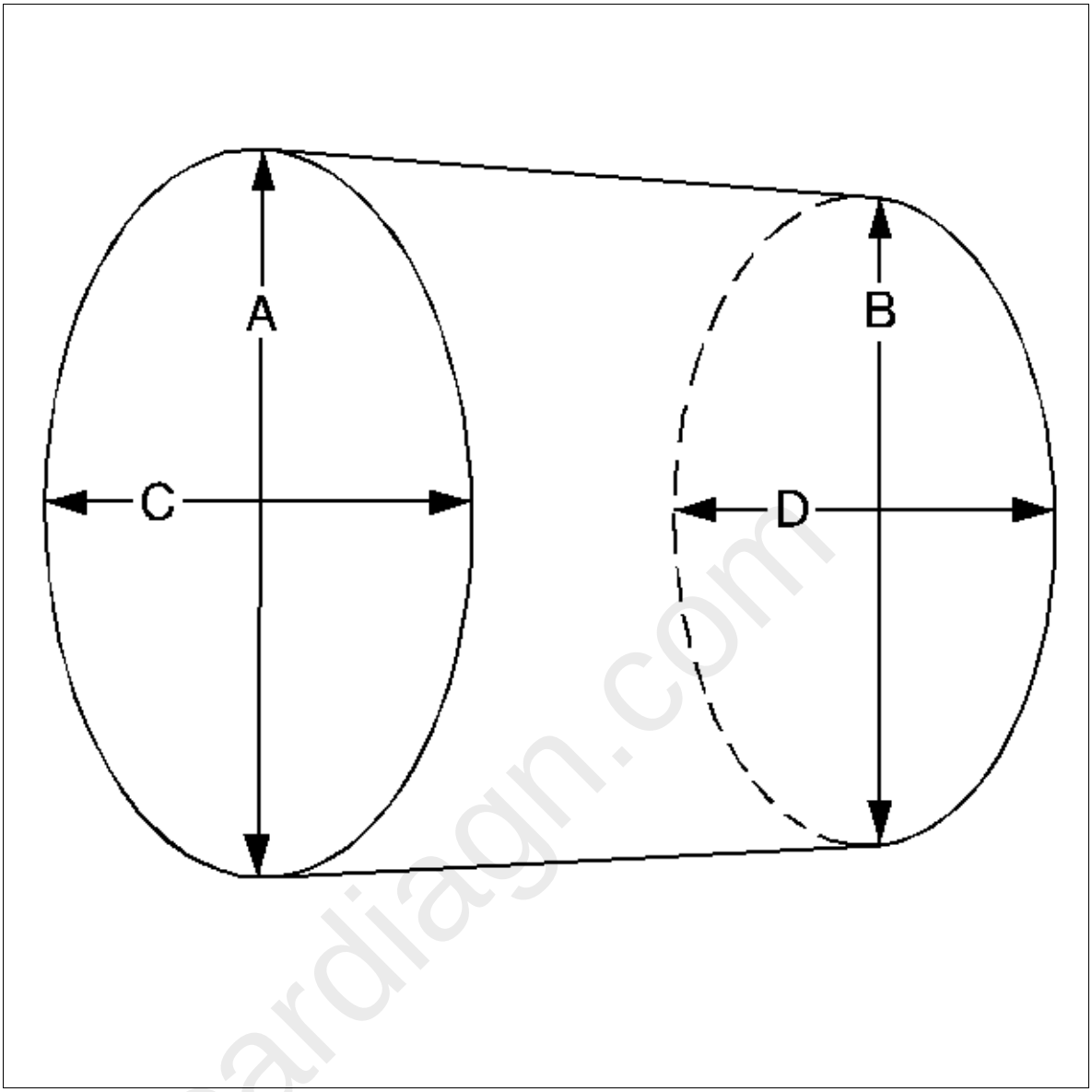


Courtesy of GENERAL MOTORS COMPANY

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8. Inspect the crankpins for undersize using an outside micrometer.
9. Compare your measurements with those listed in the Engine Mechanical Specifications . If the crankpin journals are worn beyond the specifications, the crankshaft may be ground 0.25 mm (0.010 in). There is only 1 size of oversized connecting rod bearings available for service.

Fig 6: Out-Of-Round Measurements



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10. Measure the main bearing and crankpin journals for out-of-round using the following procedure:
    1. Using an outside micrometer, measure the journal at the extreme front and rear locations on the journal. Call these points A and B.
    2. Measure the journal in 2 new locations exactly 90 degrees from the first points. Call these points C and D.
    3. Subtract A from C and B from D. The differences will indicate journal out-of-round.
    4. The out-of-round should not exceed 0.004 mm (0.00016 in) maximum.
    5. If the journals are worn beyond the specifications, the crankshaft may be ground 0.25 mm (0.010 in). There is only 1 size of oversized crankshaft and connecting rod bearings available for service.

11. Measure the main bearing and crankpin journals for taper using the following procedure:
    1. Using an outside micrometer, measure the journal at the extreme front (A) and rear (B) of the journal parallel to the crankshaft centerline.
    2. Subtract the smallest from the largest measurement. The result will be the journal taper.
    3. If the main bearing journal taper exceeds 0.004 mm (0.00016 in), replace the crankshaft.
    4. If the journals are worn beyond the specifications, the crankshaft may be ground 0.25 mm (0.010 in). There is only 1 size of oversized crankshaft and connecting rod bearings available for service.

REPAIR INSTRUCTIONS - OFF VEHICLE > AUTOMATIC TRANSMISSION FLEX PLATE CLEANING AND INSPECTION > CLEANING PROCEDURE

1. Clean the flex plate in solvent.

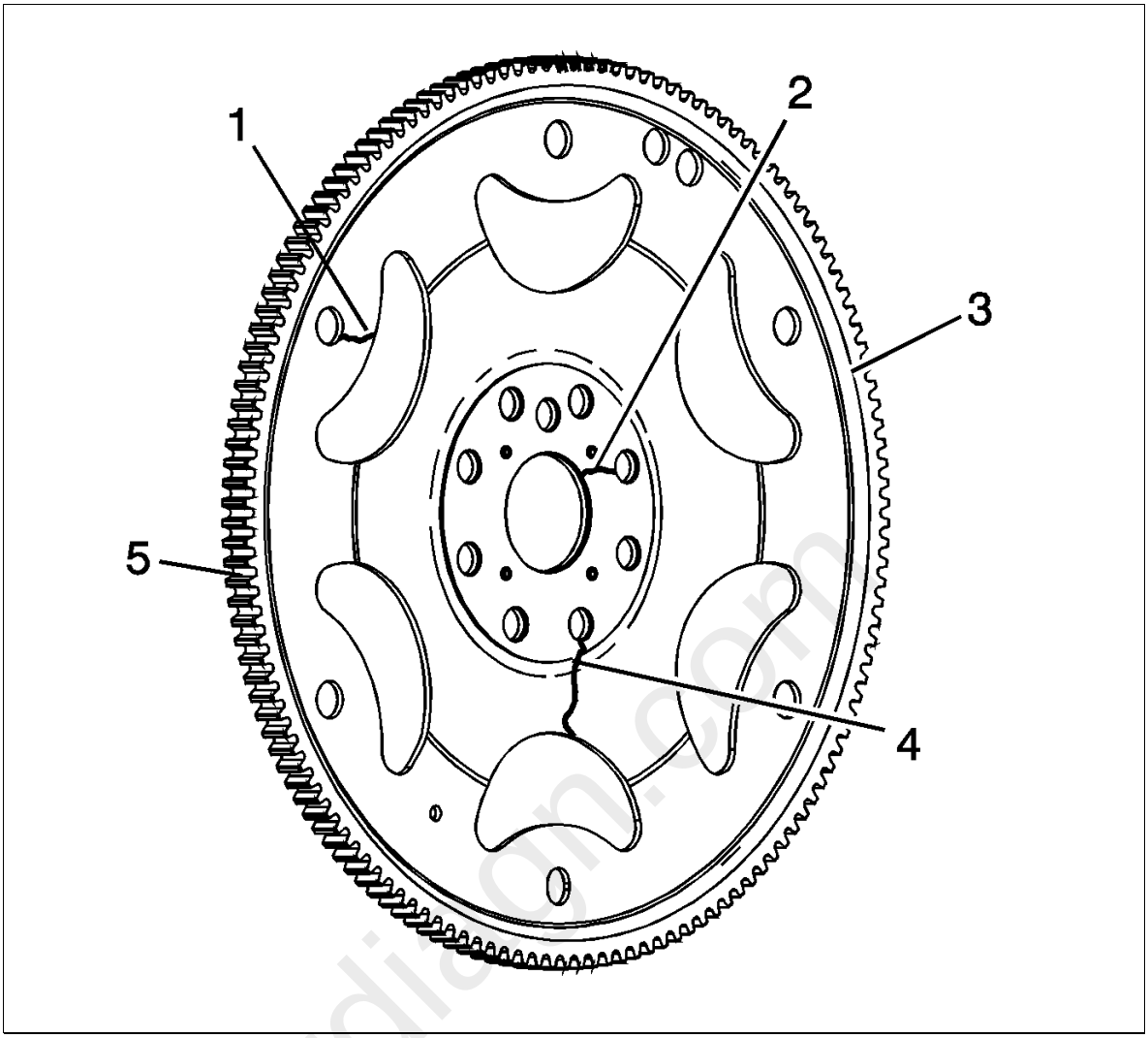
> *WARNING:*
>
> *Refer to Safety Glasses Warning .*

2. Dry the flex plate with compressed air.

REPAIR INSTRUCTIONS - OFF VEHICLE > AUTOMATIC TRANSMISSION FLEX PLATE CLEANING AND INSPECTION > INSPECTION PROCEDURE

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Fig 1: Engine Flywheel Inspection Areas



Courtesy of GENERAL MOTORS COMPANY

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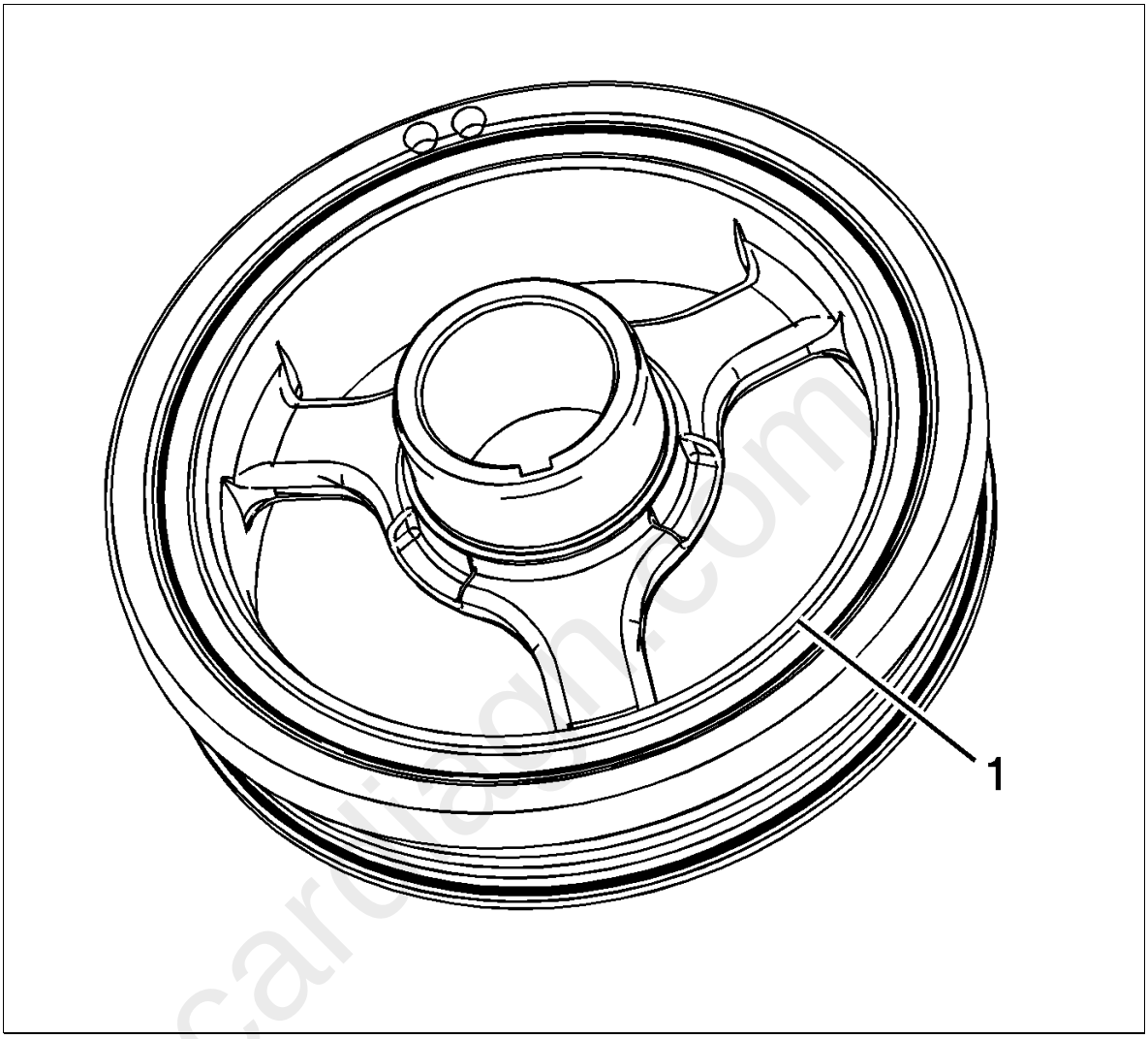
1. Inspect the flex plate for the following conditions:
    1. Stress cracks around the flex plate-to-torque converter mounting bolt hole locations (1) and/or flex plate-to-crankshaft (2, 4)

    > *NOTE:*
    >
    > *Do not attempt to repair the welded areas that retain the ring gear to the flex plate. Install a NEW flex plate.*

    2. Cracks at welded areas that retain the ring gear onto the flex plate (3)
    3. Damaged or missing ring gear teeth (5)
2. Replace the flex plate as necessary.

REPAIR INSTRUCTIONS - OFF VEHICLE > CRANKSHAFT BALANCER CLEANING AND INSPECTION > CLEANING PROCEDURE

Fig 1: Crankshaft Balancer



Courtesy of GENERAL MOTORS COMPANY

1. Clean the crankshaft balancer in solvent that is compatible with the rubber (1).

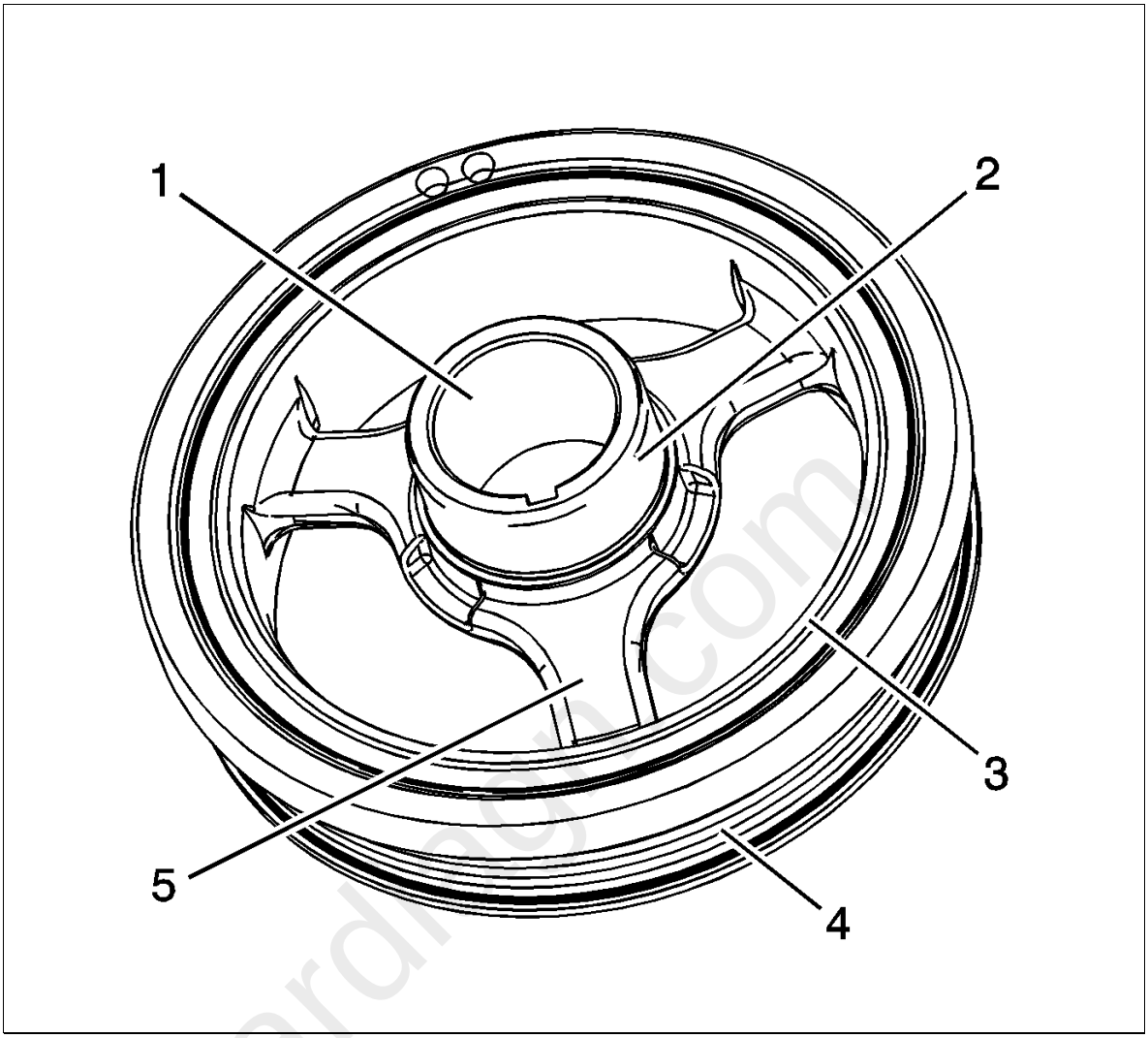
> *WARNING:*
>
> *Refer to Safety Glasses Warning .*

2. Dry the crankshaft balancer with compressed air.

REPAIR INSTRUCTIONS - OFF VEHICLE > CRANKSHAFT BALANCER CLEANING

AND INSPECTION > INSPECTION PROCEDURE

Fig 1: Crankshaft Balancer Inspection Areas



Courtesy of GENERAL MOTORS COMPANY

1. Inspect the crankshaft balancer for the following:
    1. Worn or damaged hub-to-crankshaft surface (1)
    2. Worn, grooved or damaged hub seal surface (2)

        A crankshaft balancer hub seal surface with excessive scoring, grooves, rust or other damage must be replaced.

    3. Worn, chunking or deteriorated rubber between the hub and pulley (3)
    4. Damaged drive belt ribs (4)
    5. Damaged webs (5)
2. Repair or replace the crankshaft balancer as necessary.

REPAIR INSTRUCTIONS - OFF VEHICLE > ENGINE FLYWHEEL CLEANING AND INSPECTION > CLEANING PROCEDURE

> *NOTE:*
>
> *In order to maintain the proper component balance, contact surface taper and heat transfer, manual transmission flywheels are NOT to be machined.*

1. Clean the engine flywheel in solvent.

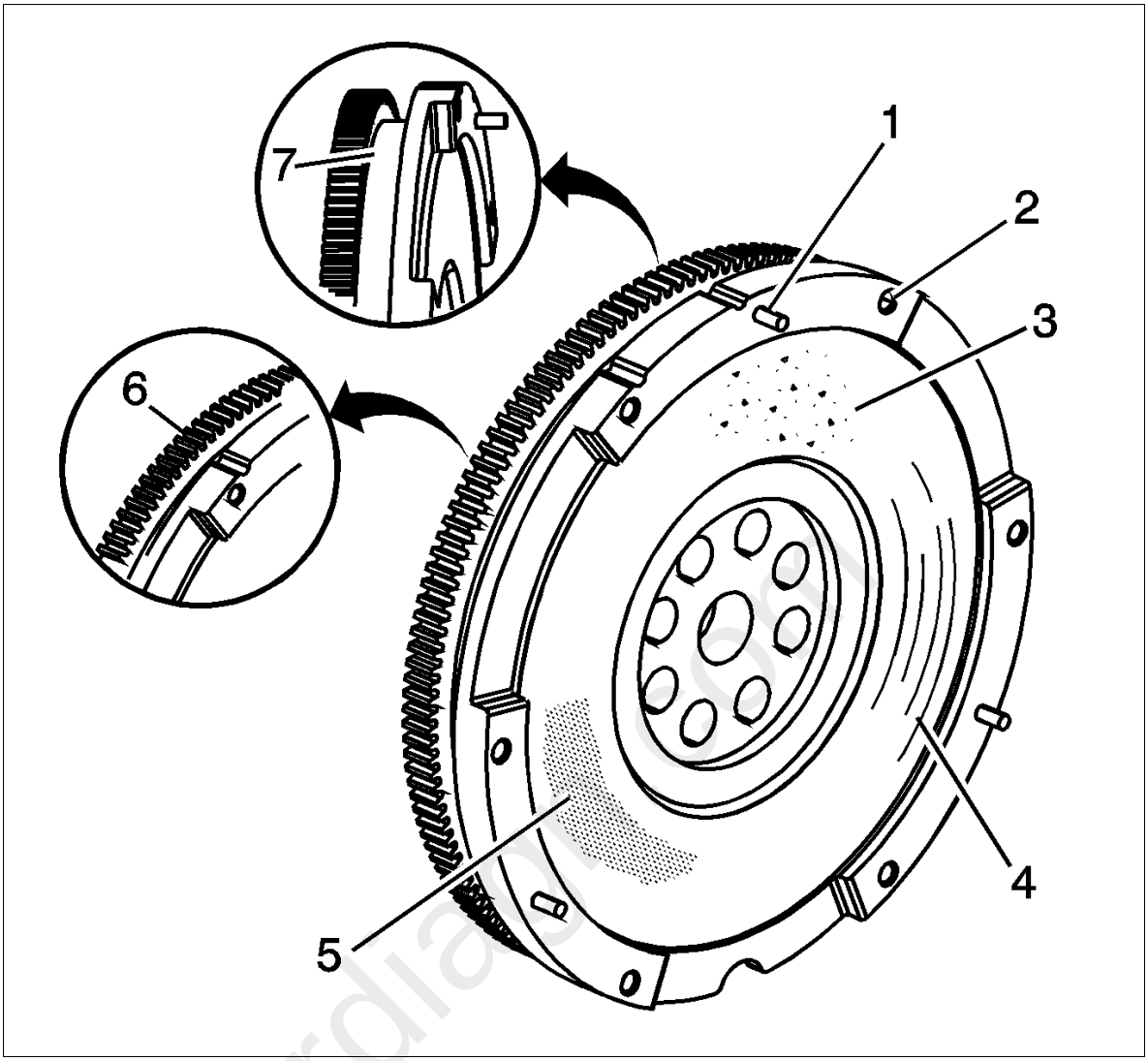
> *WARNING:*
>
> *Refer to Safety Glasses Warning .*

2. Dry the engine flywheel with compressed air.

REPAIR INSTRUCTIONS - OFF VEHICLE > ENGINE FLYWHEEL CLEANING AND INSPECTION > INSPECTION PROCEDURE

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Fig 1: Engine Flywheel Inspection Locations



Courtesy of GENERAL MOTORS COMPANY

1. Inspect the manual transmission engine flywheel for the following conditions:
    1. Missing and/or damaged alignment pins (1)
    2. Damaged threaded holes (2)
    3. Pitted surface (3)
    4. Scoring or grooves (4)
    5. Rust or other surface damaged (5)
    6. Damaged ring gear teeth (6)
    7. Loose or improperly positioned ring gear

        The ring gear has an interference fit onto the engine flywheel and should be positioned completely against the flange of the engine flywheel (7).
2. Replace the engine flywheel as necessary.

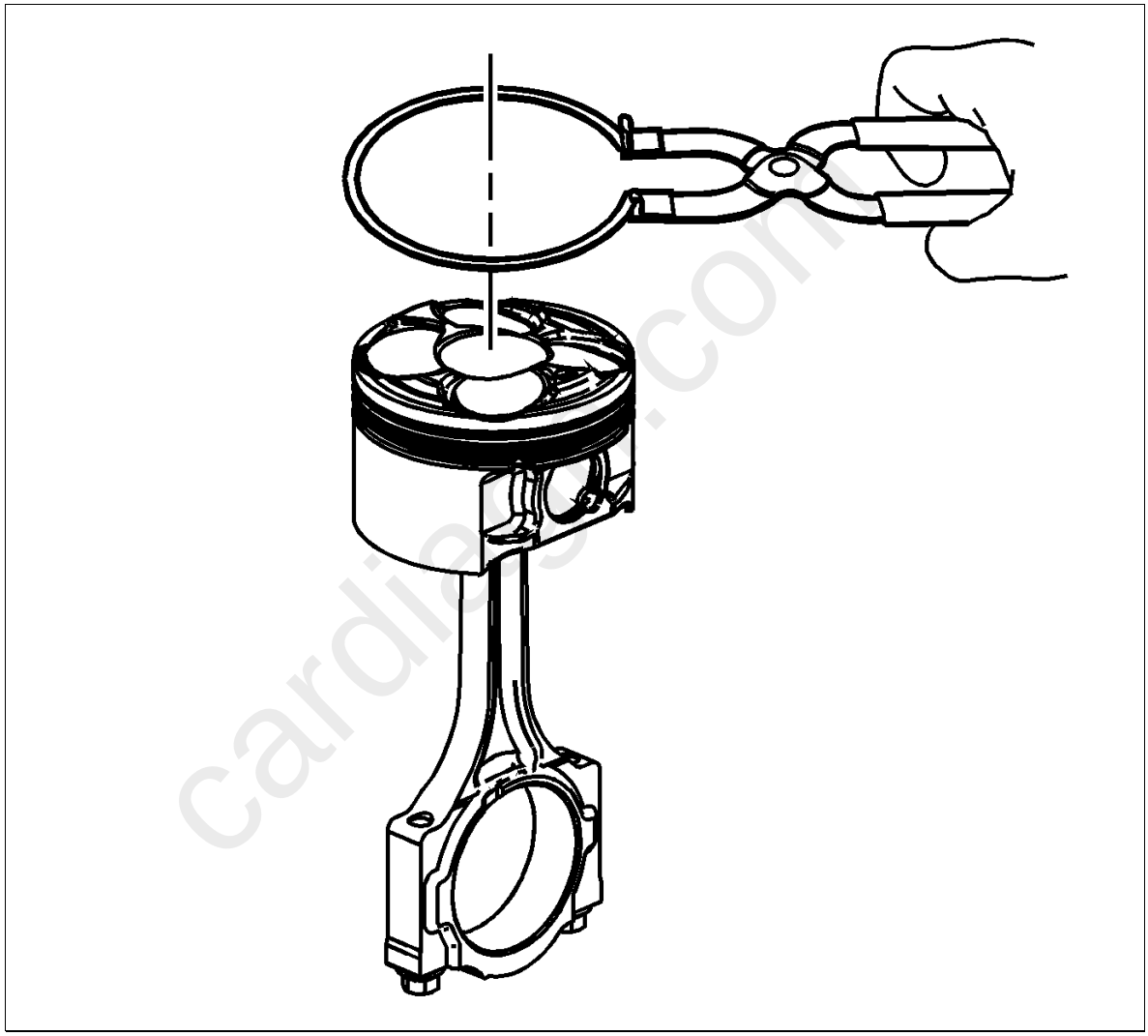
REPAIR INSTRUCTIONS - OFF VEHICLE > PISTON AND CONNECTING ROD DISASSEMBLE

Special Tools

EN-46745 Piston Pin Clip Remover/Installer

For equivalent regional tools, refer to Special Tools .

Fig 1: Piston Rings



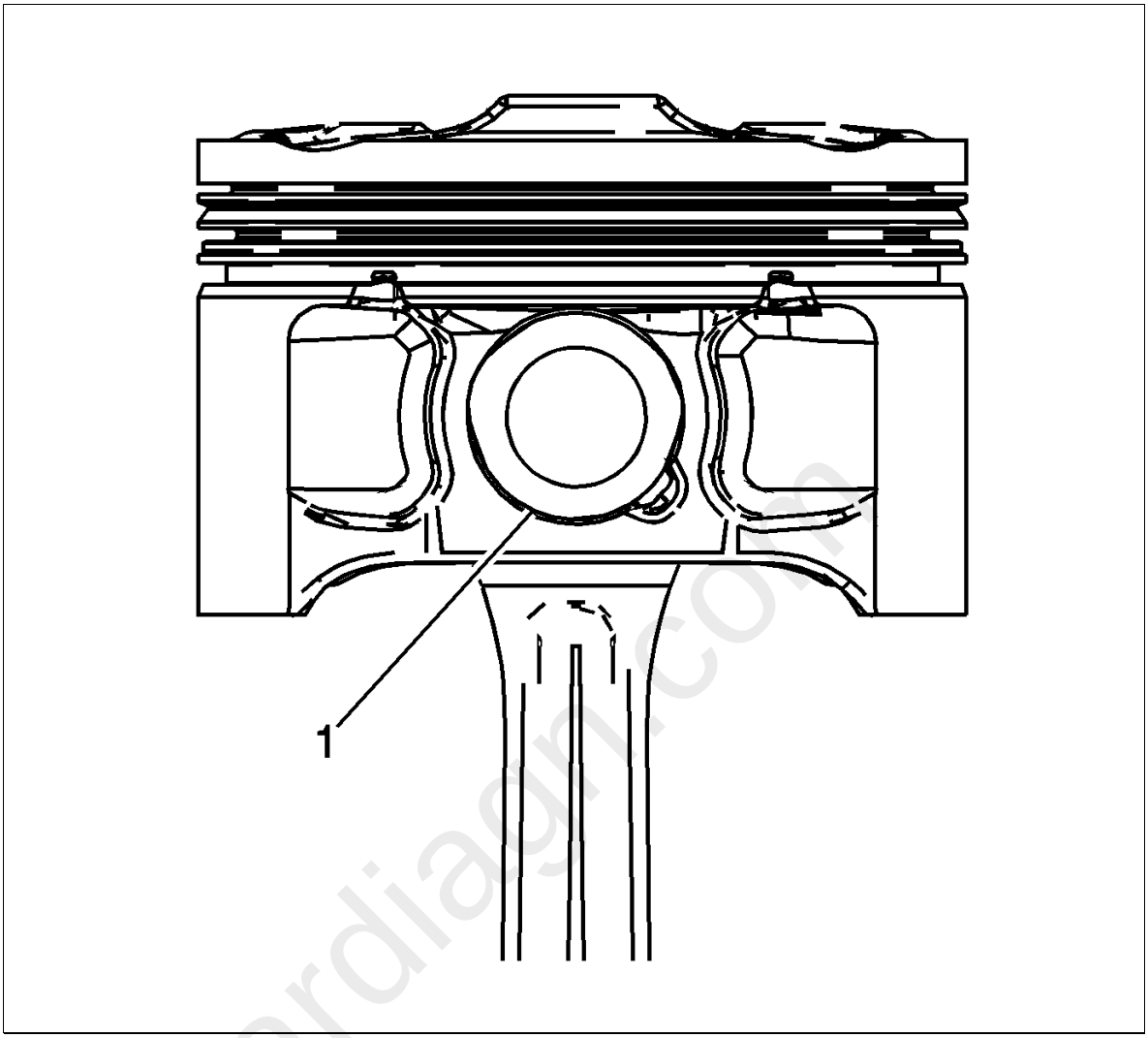
Courtesy of GENERAL MOTORS COMPANY

⚠ *CAUTION:*

You must use a piston ring expander to remove and install the piston rings. Only expand the rings far enough to fit over the piston lands. If the rings are overexpanded, the top ring will shatter and the others will distort.

1. Remove the piston rings using a piston ring expander. Place each ring in a clean shop towel for storage.

   Fig 2: Piston Pin Retainer



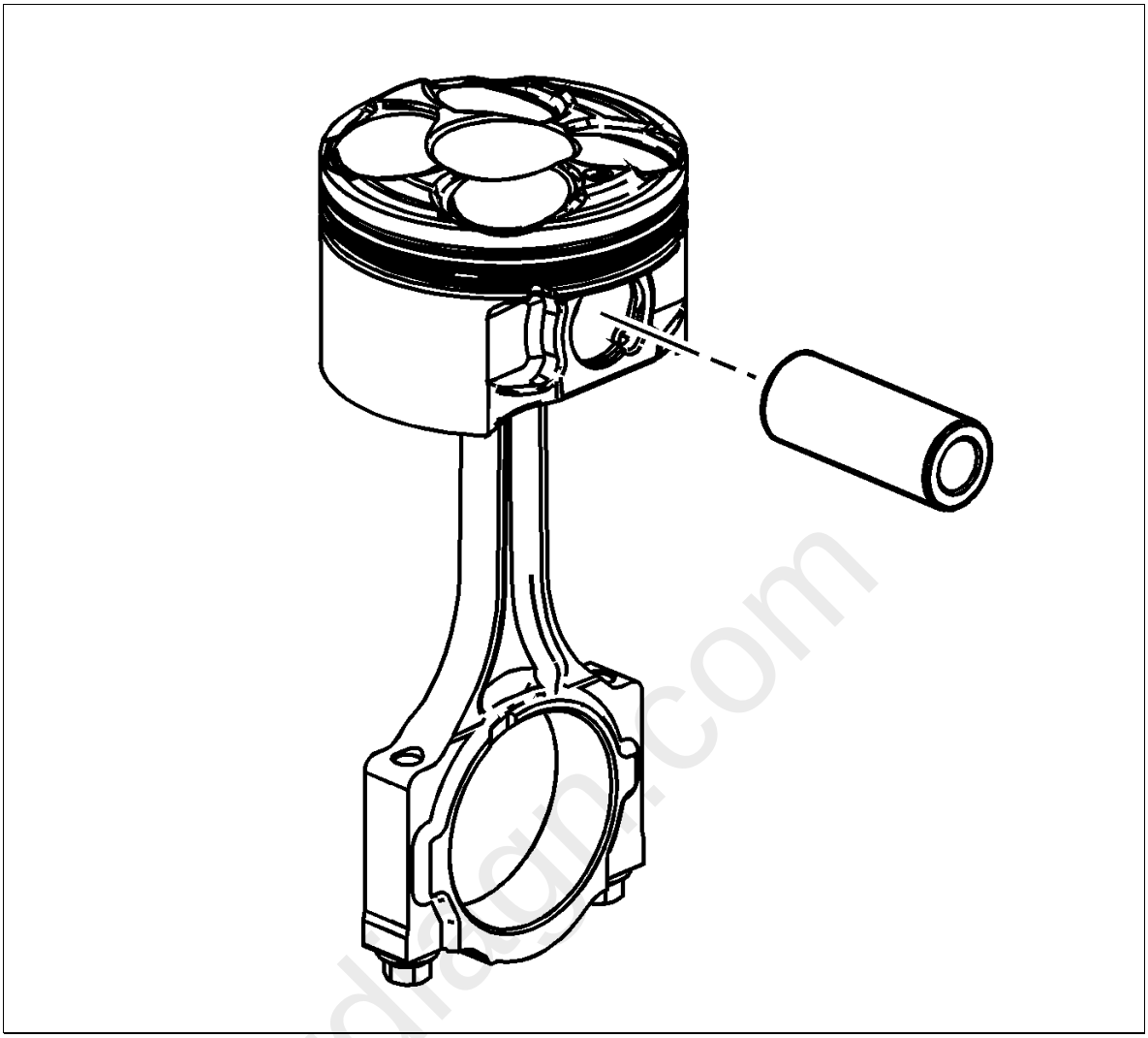
Courtesy of GENERAL MOTORS COMPANY

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> *NOTE:*
>
> 1. *The connecting rod is non-directional and may be assembled/reassembled to the piston in either direction.*
> 2. *DO NOT reuse the piston pin retainers.*

2. Using the **EN-46745** remover/installer, remove the piston pin retainers by using the removal access notch (1) in the side of the piston. Discard the piston pin retainers.

Fig 3: Piston Pin



Courtesy of GENERAL MOTORS COMPANY

3. Slide the piston pin out of the piston. The piston will disconnect from the connecting rod.

REPAIR INSTRUCTIONS - OFF VEHICLE > PISTON, CONNECTING ROD, AND BEARING CLEANING AND INSPECTION > CLEANING PROCEDURE

NOTE:

DO NOT wire brush any part of the piston.

1. Clean the piston skirts and the pins with a cleaning solvent.
2. Clean the piston ring grooves with a groove cleaner. Ensure that the oil ring holes and slots are clean.

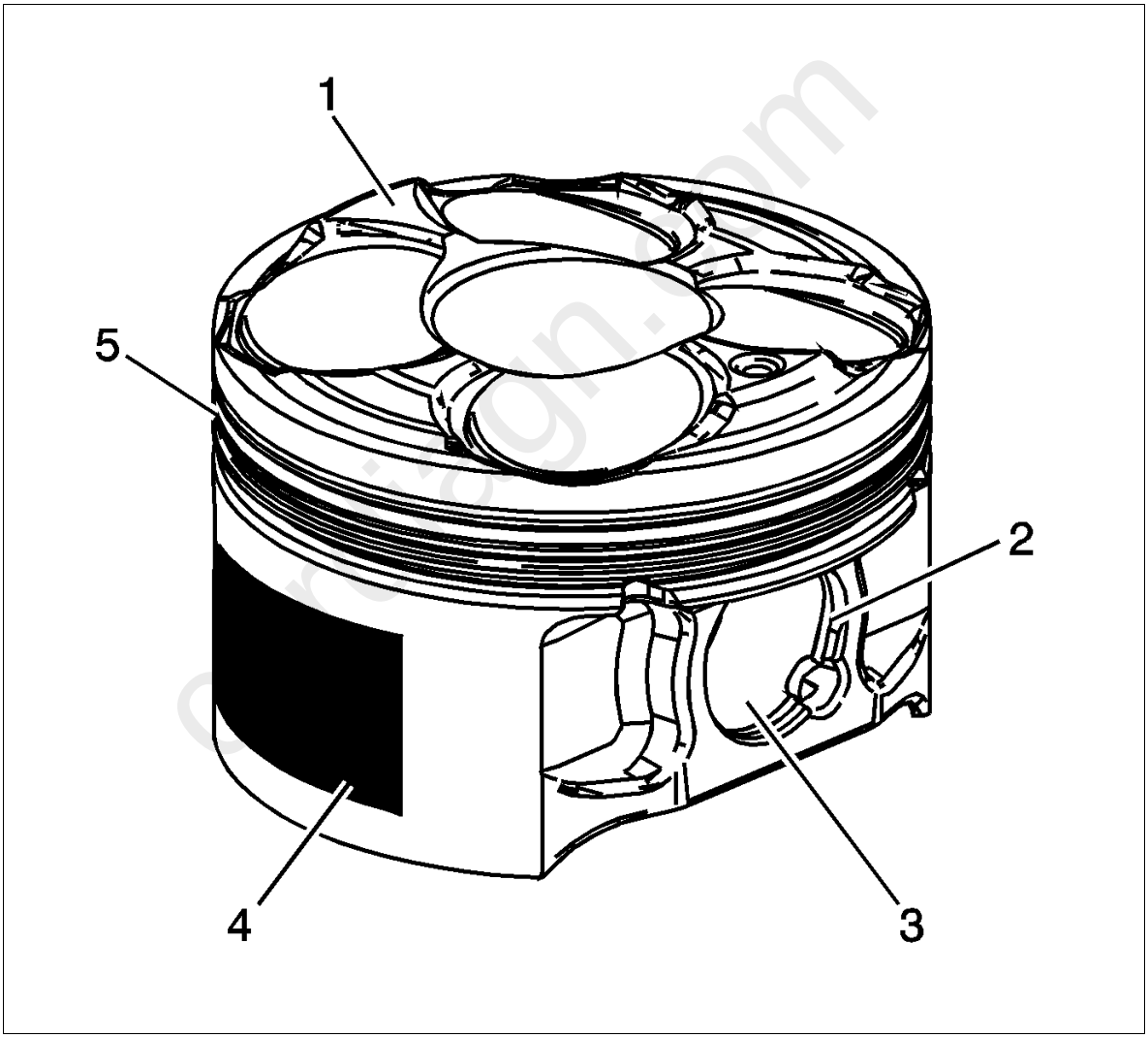
WARNING:

Refer to Safety Glasses Warning .

3. Dry the piston with compressed air.

REPAIR INSTRUCTIONS - OFF VEHICLE > PISTON, CONNECTING ROD, AND BEARING CLEANING AND INSPECTION > PISTON INSPECTION PROCEDURE

Fig 1: Piston Inspection Locations



Courtesy of GENERAL MOTORS COMPANY

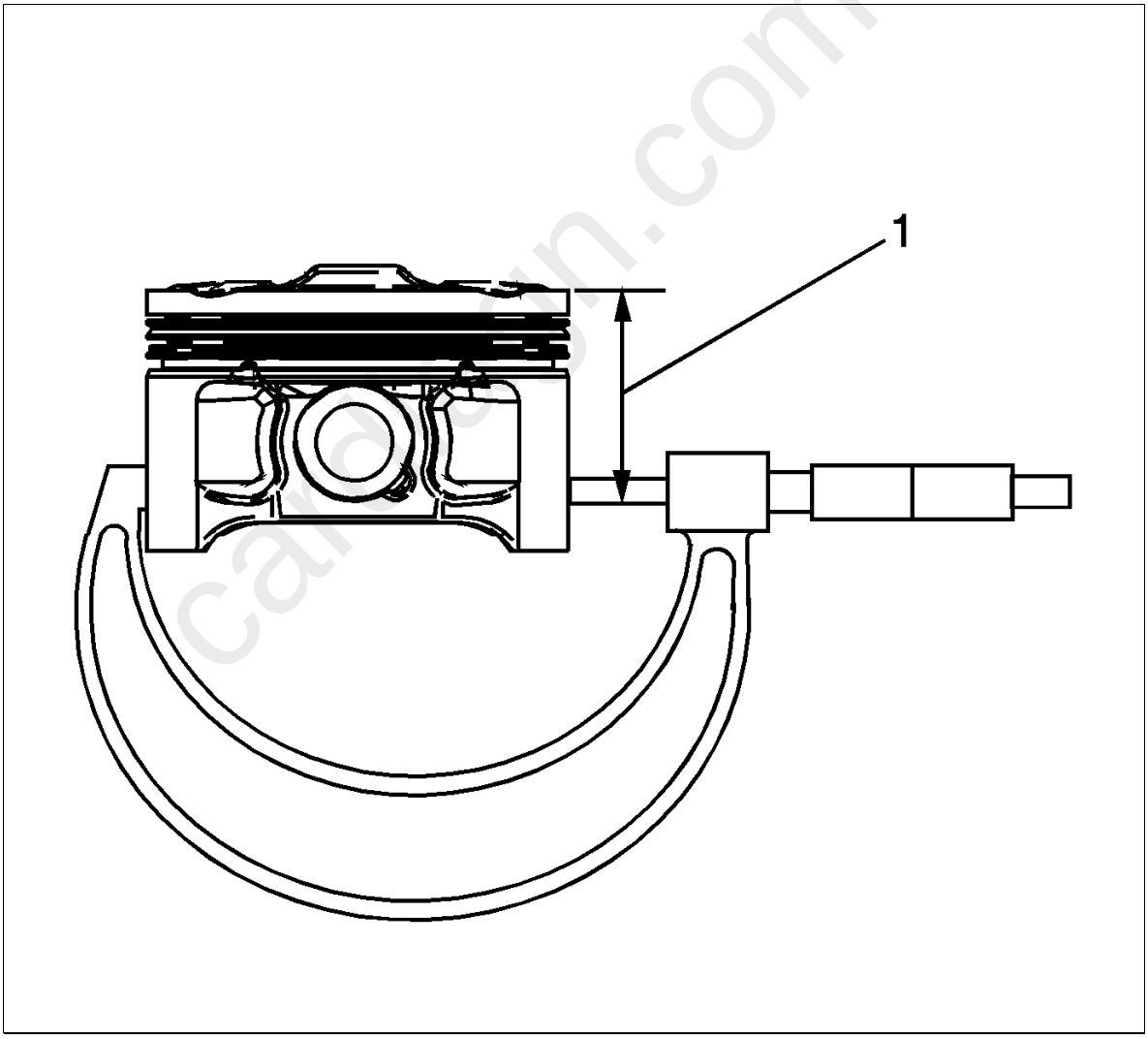
1. Inspect the pistons for the following conditions:
    1. Cracked ring lands, skirts or pin bosses
    2. Ring grooves for nicks, burrs that may cause binding (5)

3. Warped or worn ring lands (5)
4. Piston pin retainer grooves for burrs (2)
5. Eroded areas at the top of the piston (1)
6. Scuffed or damaged skirt coating (4)
7. Worn piston pin bores or worn piston pins (3)

2. Replace pistons that show any signs of damage or excessive wear.

REPAIR INSTRUCTIONS - OFF VEHICLE > PISTON, CONNECTING ROD, AND BEARING CLEANING AND INSPECTION > PISTON MEASUREMENT PROCEDURE

Fig 1: Piston Width

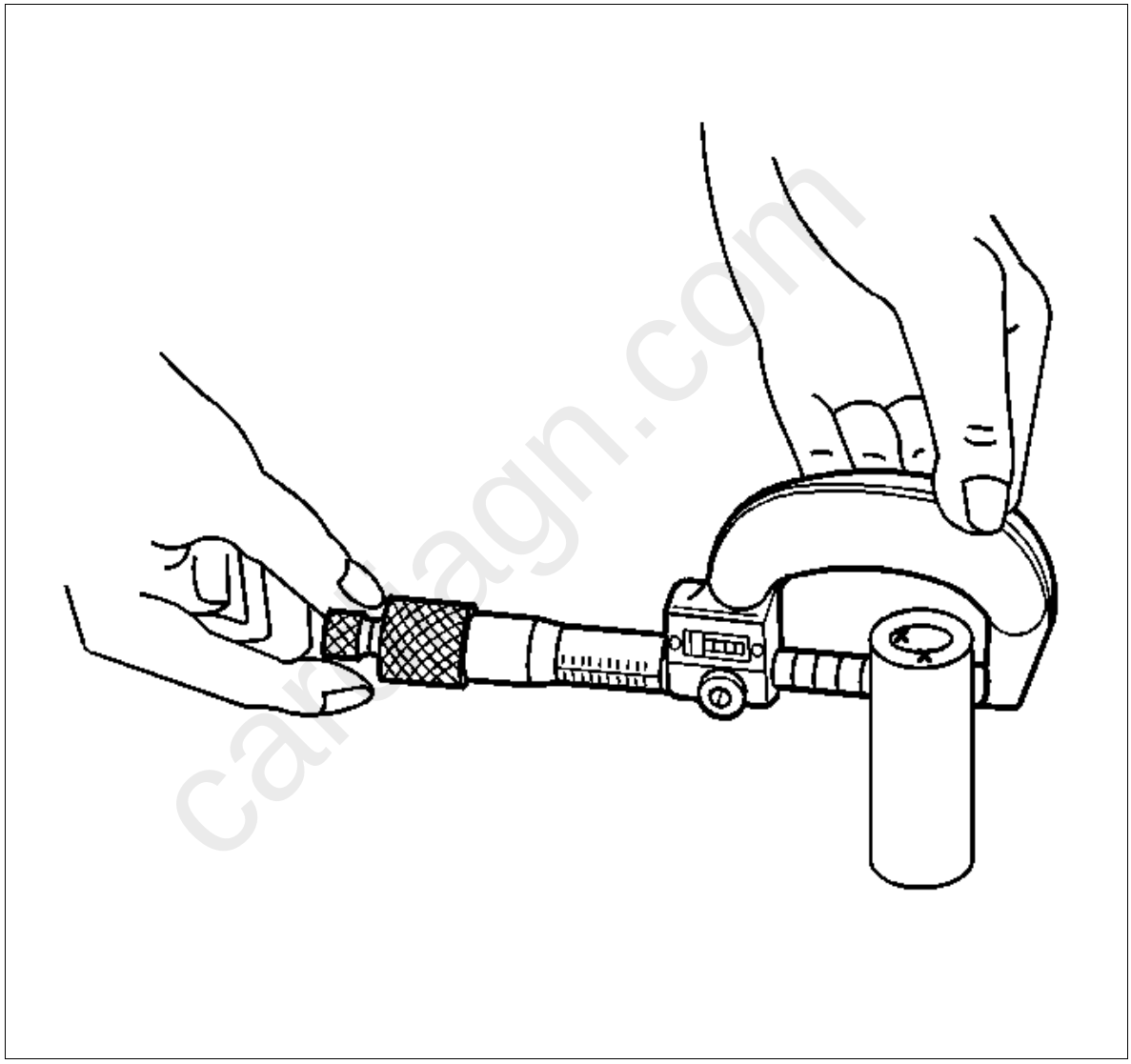


Courtesy of GENERAL MOTORS COMPANY

1. Measure piston width using the following procedure:

1. Using an outside micrometer, measure the width of the piston at 30 mm (1.181 in) below the crown, top, (1) at the thrust surfaces of the piston, perpendicular to the piston pin centerline.
2. Compare the measurement of the piston to its original cylinder by subtracting the piston width from the cylinder diameter.
3. Check your measurements with the Engine Mechanical Specifications .
4. If the clearance obtained through measurement is greater than the provided specifications and the cylinder bores are within specification, replace the piston.

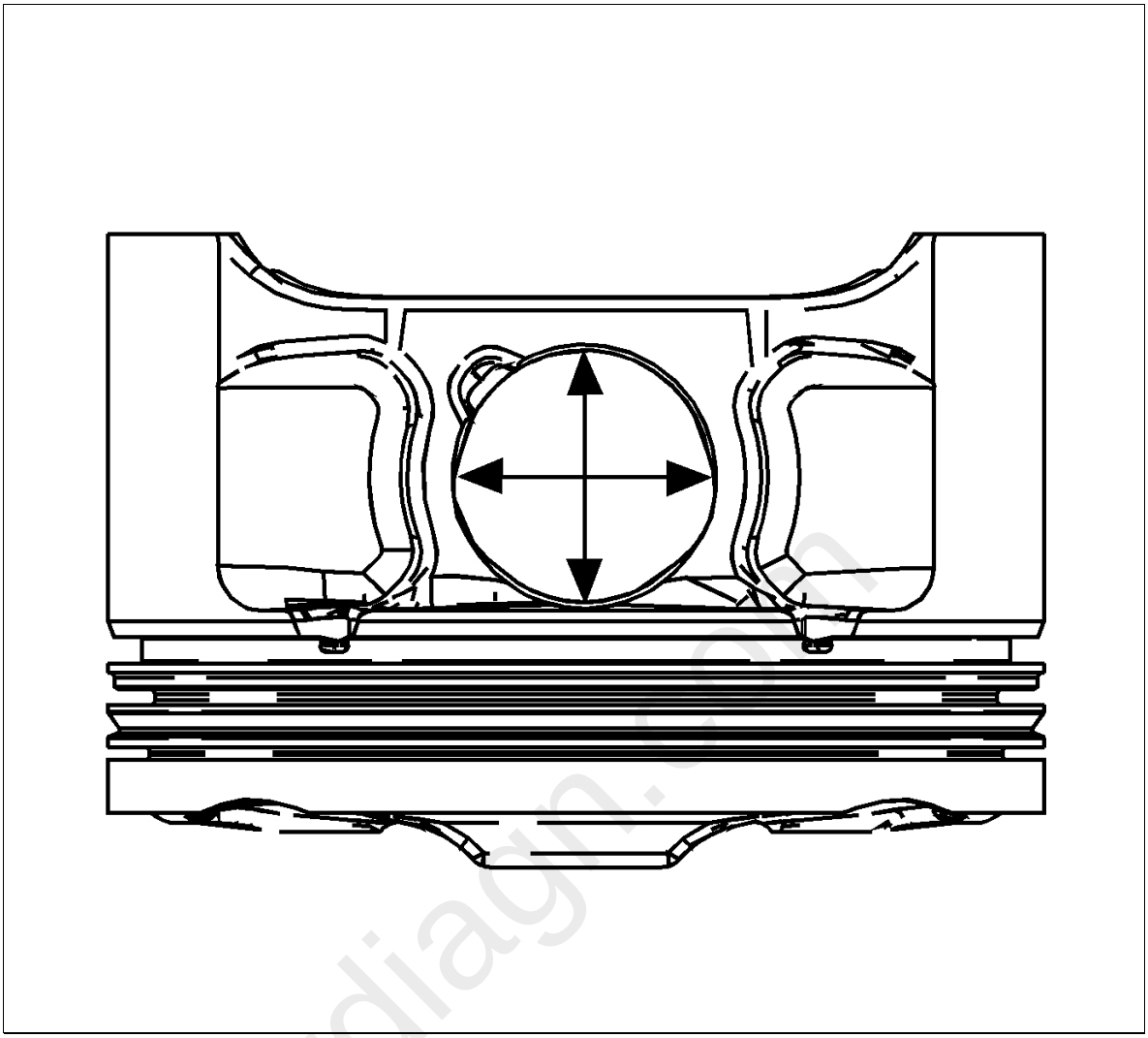
Fig 2: Piston Pin Diameter



Courtesy of GENERAL MOTORS COMPANY

2. Measure the piston pin bore to piston pin clearances using the following procedure:
    1. Piston pin bores and pins must be free of varnish or scuffing.
    2. Use an outside micrometer to measure the piston pin in the piston contact areas.

Fig 3: Piston Pin Bore



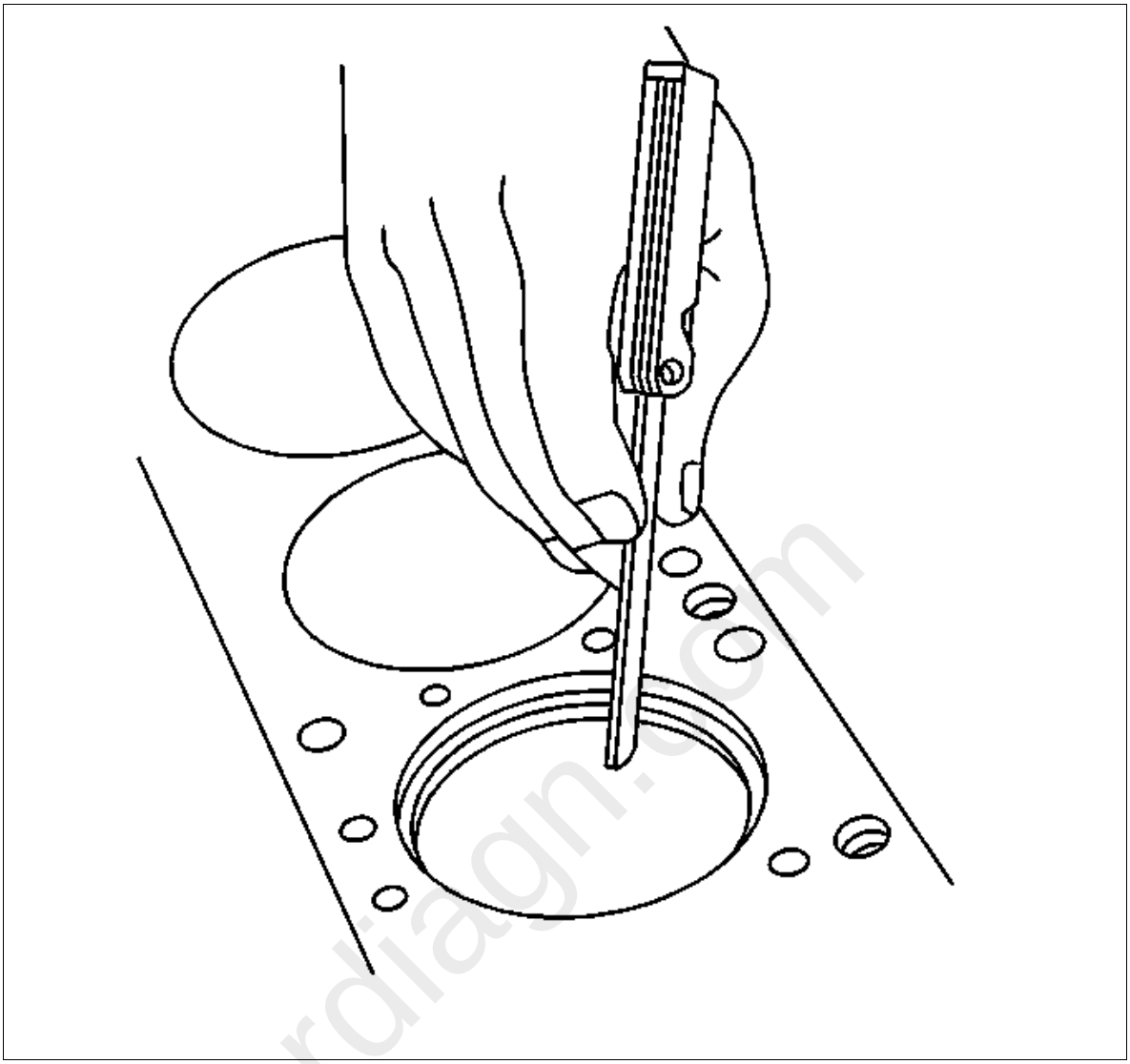
Courtesy of GENERAL MOTORS COMPANY

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3. Using an inside micrometer, measure the piston pin bore. Compare your result with the piston pin diameter and piston pin to piston pin bore clearance listed in the Engine Mechanical Specifications .
4. If the clearance is excessive, determine which piece is out of specification and replace as necessary.
5. You must replace the piston if any of its dimensions are out of specification.
6. If the new piston does not meet clearance specifications, the cylinder block may need to be oversized to 0.25 mm (0.010 in). There is only one size of oversized pistons and rings available for service.

REPAIR INSTRUCTIONS - OFF VEHICLE > PISTON, CONNECTING ROD, AND BEARING CLEANING AND INSPECTION > PISTON RING MEASUREMENT PROCEDURE

Fig 1: Piston Ring End Gap

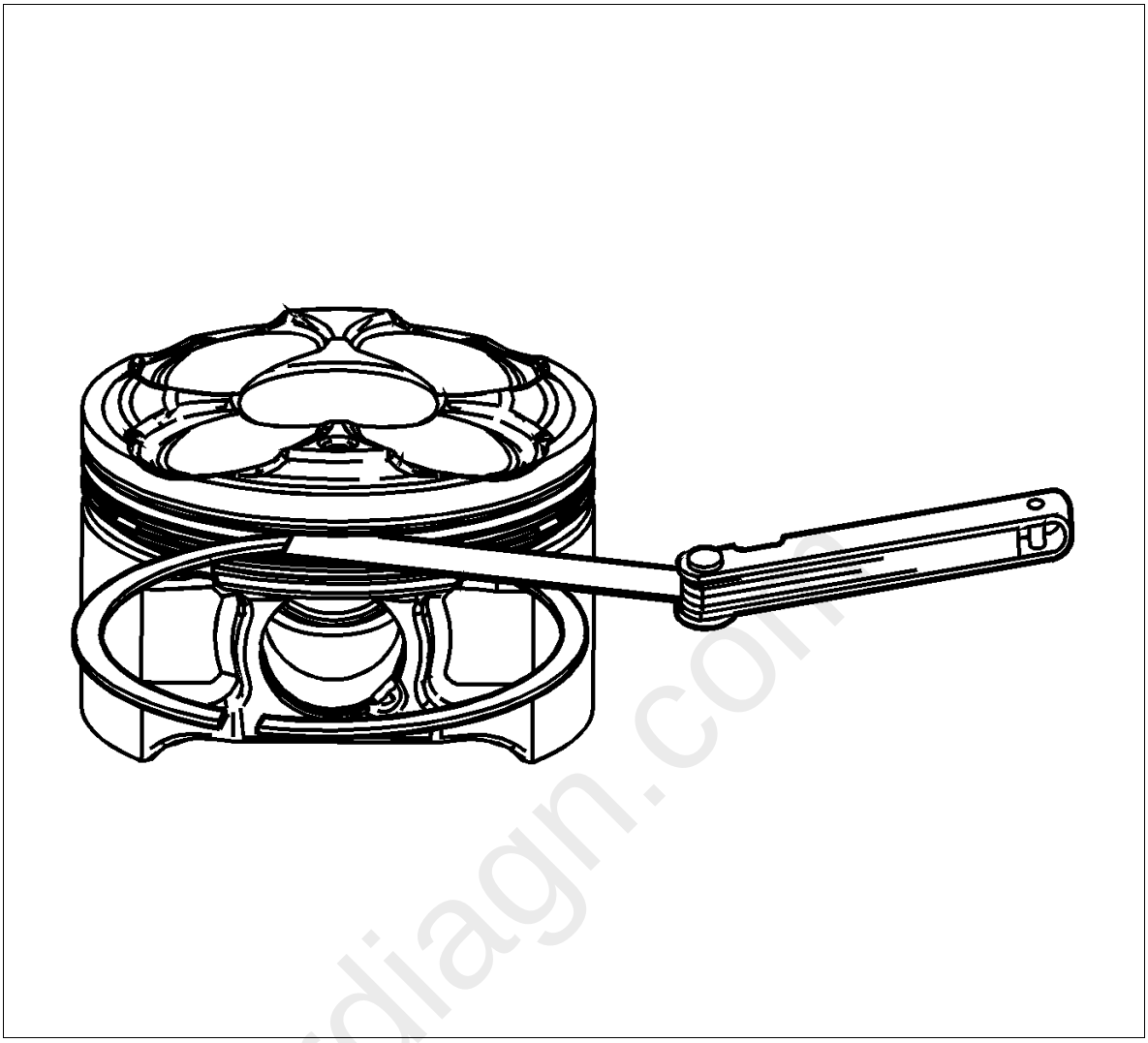


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1. Measure the piston ring end gap using the following procedure:
    1. Place the piston ring in the area of the bore where the piston ring will travel approximately 25 mm (1 in) down from the deck surface. Ensure that the ring is square with the cylinder bore by positioning the ring with the piston head.
    2. Measure the end gap of the piston ring with feeler gauges. Refer to Engine Mechanical Specifications .
    3. If the clearance exceeds the provided specifications, the piston rings must be replaced.
    4. Repeat the procedure for all the piston rings.

Fig 2: Piston Ring Side Clearance



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2. Measure the piston ring side clearance using the following procedure:

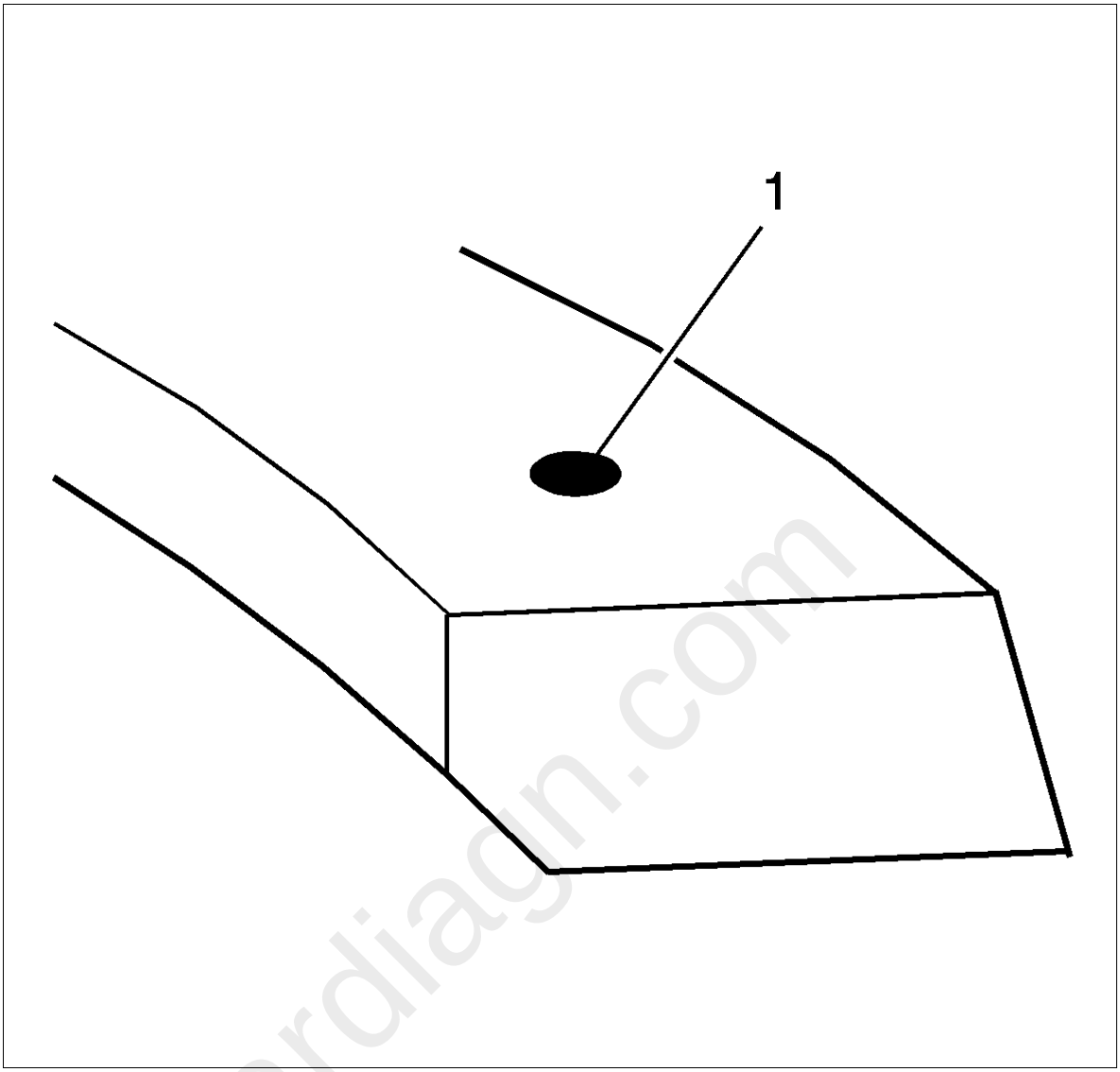
    1. Roll the piston ring entirely around the piston ring groove. If any binding is caused by the ring groove, dress the groove with a fine file. If any binding is caused by a distorted piston ring, replace the ring.

    2. With the piston ring on the piston, use feeler gauges to check clearance at multiple locations.

    3. Compare the measurements with piston ring side clearance listed in the Engine Mechanical Specifications .

    4. If the clearance is greater than specifications, replace the piston rings.

Fig 3: Lower Compression Piston Ring Mark



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3. There is a locating dimple (1) on the compression rings near the end for identification. Install the compression rings with the dimple facing up.
4. If the new ring does not reduce the clearance to the proper specification, install a new piston.
5. If the new piston does not meet clearance specifications, the cylinder block may need to be oversized to 0.25 mm (0.010 in). There is only 1 size of oversized pistons and rings available for service.

REPAIR INSTRUCTIONS - OFF VEHICLE > PISTON, CONNECTING ROD, AND BEARING CLEANING AND INSPECTION > CONNECTING ROD CLEANING PROCEDURE

1. Clean the connecting rods in solvent.

WARNING:

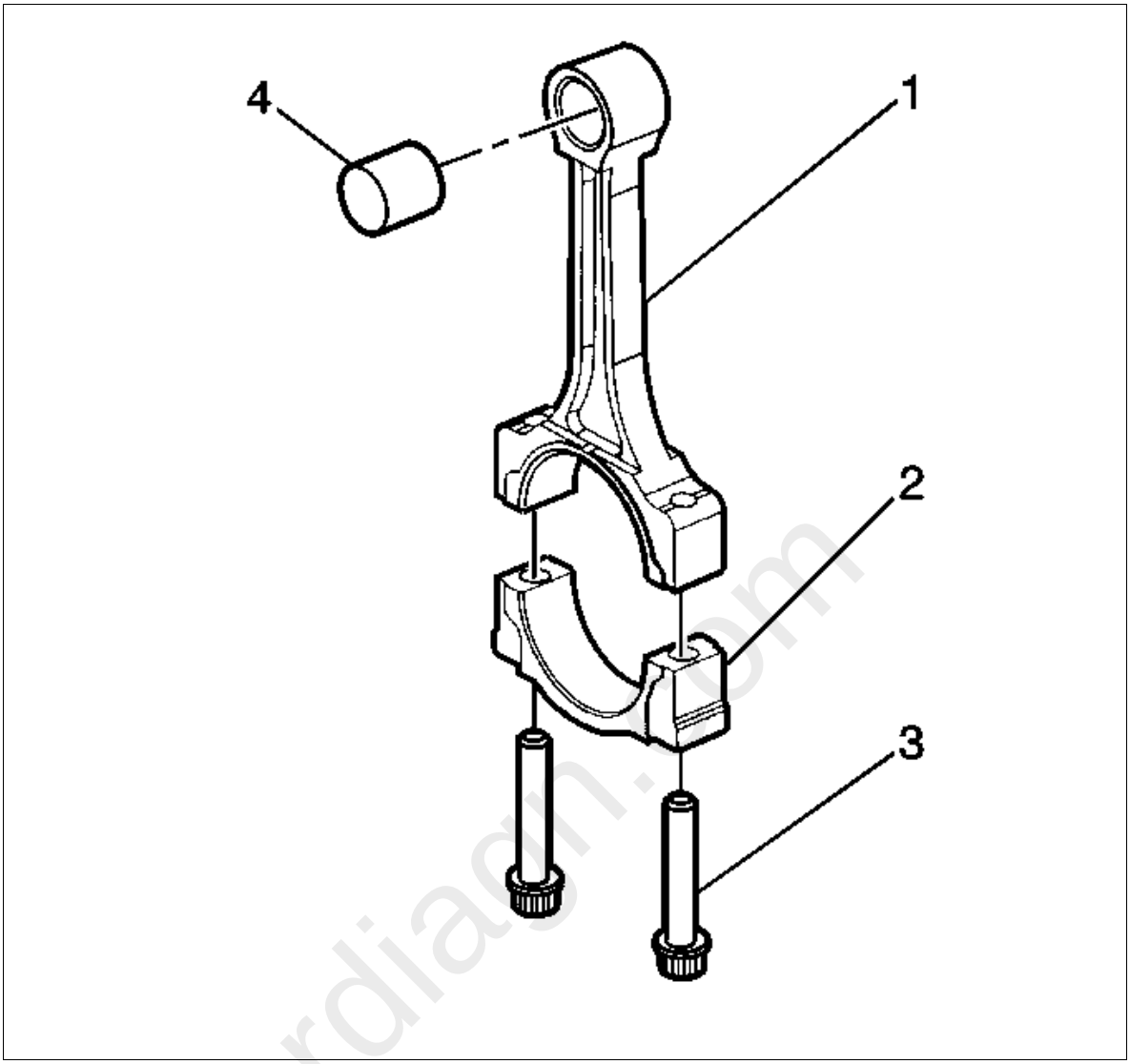
Refer to Safety Glasses Warning .

2. Dry the connecting rod using compressed air.
3. Remove the connecting rod cap and clean the threads.
4. Remove the connecting rod bearing and discard. Never reuse a connecting rod bearing used in a running engine.

REPAIR INSTRUCTIONS - OFF VEHICLE > PISTON, CONNECTING ROD, AND BEARING CLEANING AND INSPECTION > CONNECTING ROD VISUAL INSPECTION PROCEDURE

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Fig 1: Connecting Rod Components



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1. Inspect the piston pin bushing (4) for scoring or damage.
2. Inspect the connecting rod beam (1) for twisting or bending.
3. Inspect the rod cap (2) for any nicks or damage caused by possible interference.
4. Inspect for scratches or abrasion on the rod bearing seating surface.

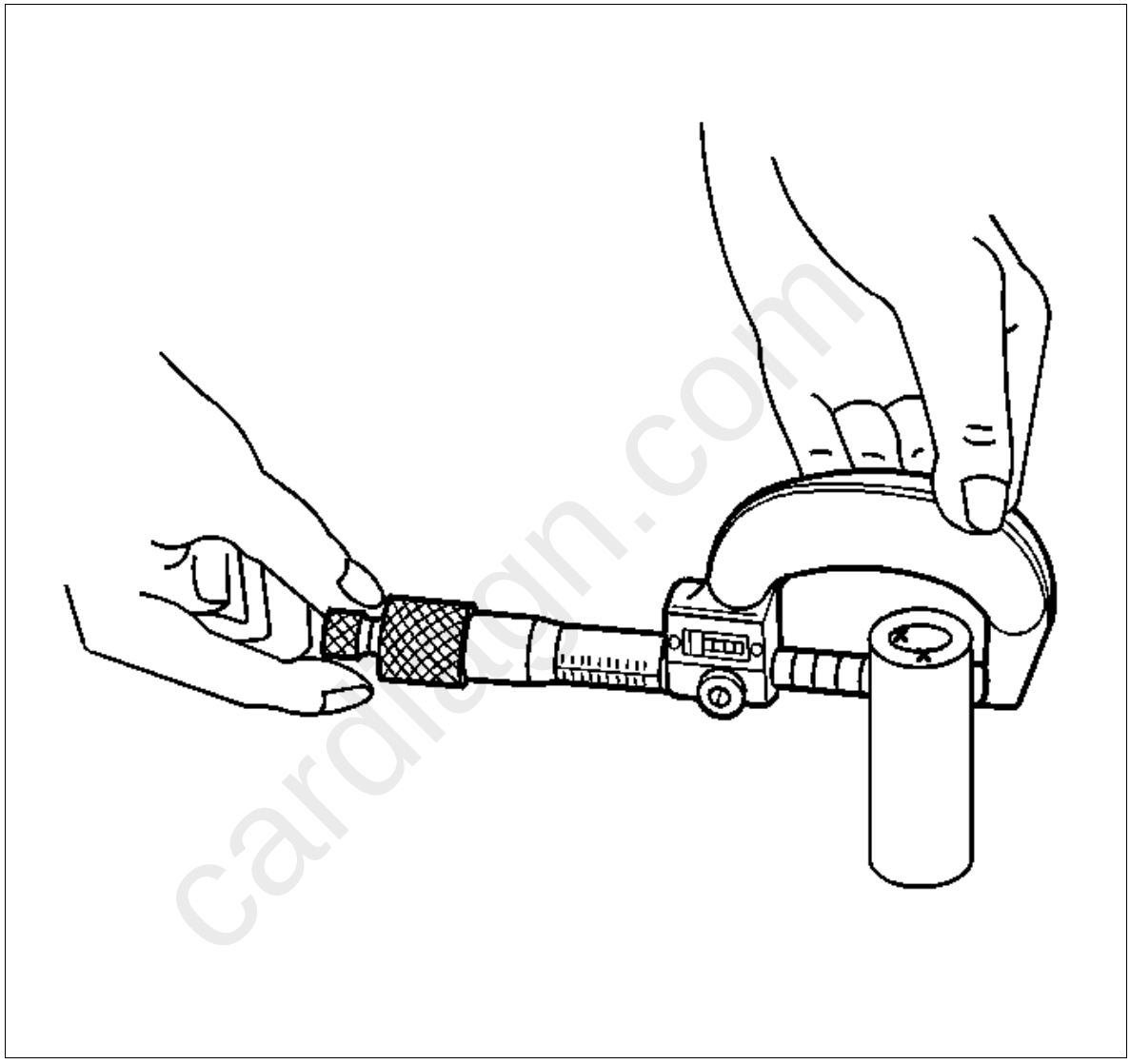
> *NOTE:*
>
> *DO NOT scrape the rod or rod cap.*

5. If the connecting rod bores contain minor scratches or abrasions, clean the bores in a circular direction with a light emery paper.

REPAIR INSTRUCTIONS - OFF VEHICLE > PISTON, CONNECTING ROD, AND BEARING CLEANING AND INSPECTION > CONNECTING ROD MEASUREMENT PROCEDURE

Piston Pin End

Fig 1: Piston Pin Diameter

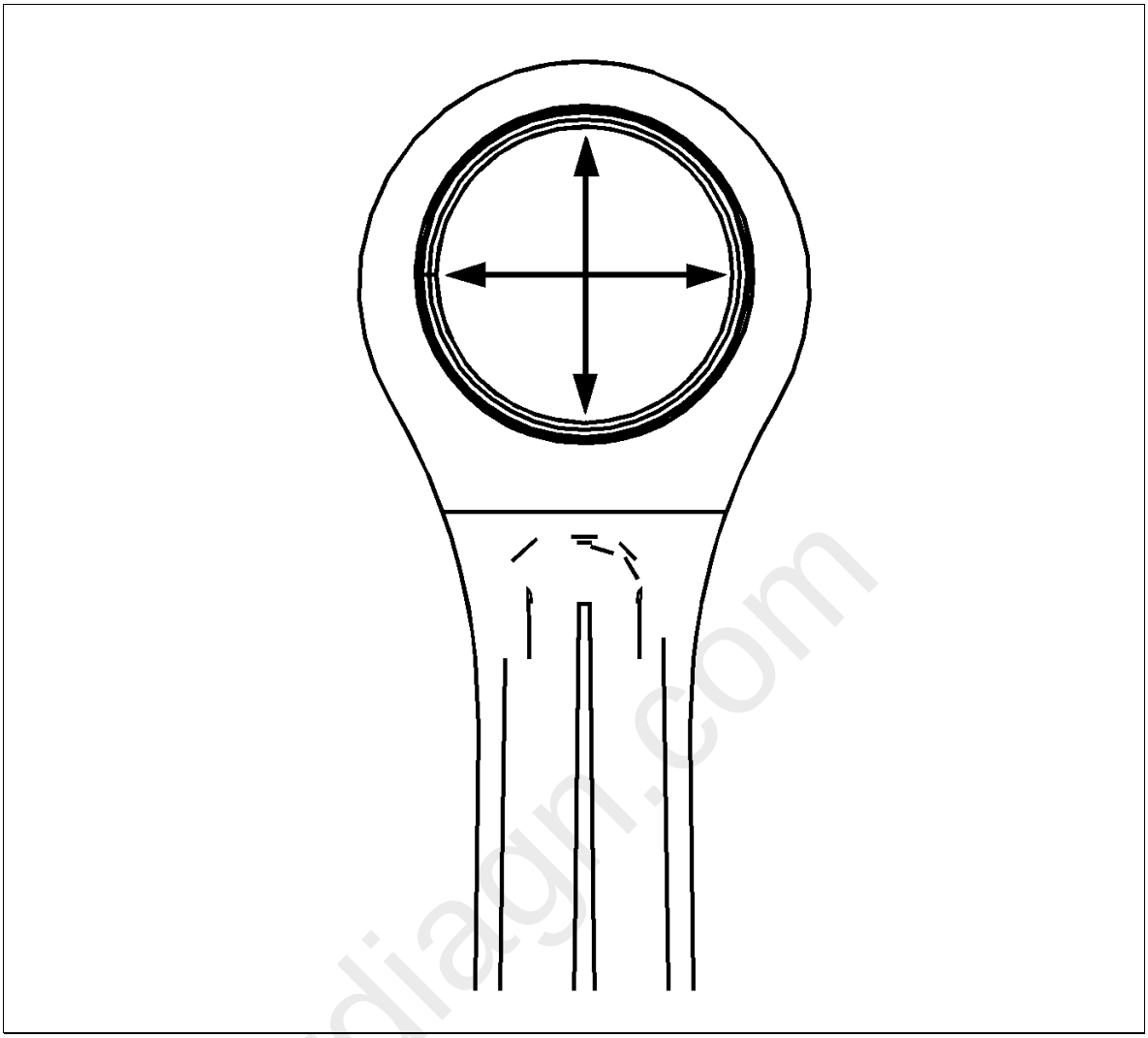


Courtesy of GENERAL MOTORS COMPANY

> *NOTE:*
>
> *Measurements of all components should be taken with the components at normal room temperature.*

1. Using an outside micrometer, take 2 measurements of the piston pin in the area of the connecting rod contact.

Fig 2: Connecting Rod Piston Pin Bore Dimensions



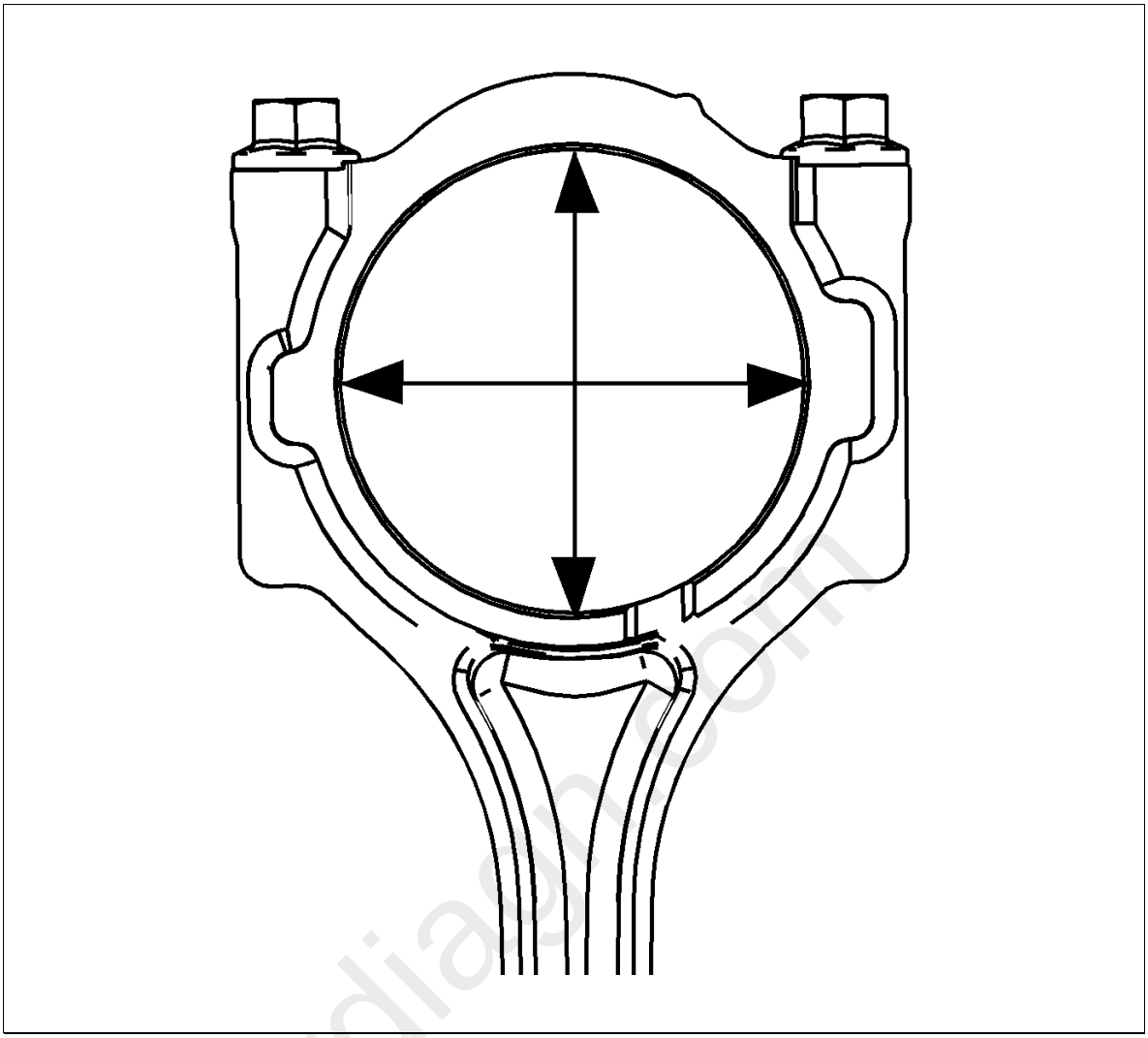
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2. Using an inside micrometer, measure the connecting rod piston pin bore.
3. Subtract the piston pin diameter from the piston pin bore.
4. Compare the clearance measurements with the Engine Mechanical Specifications .
5. If the clearance is excessive, replace the piston pin. If a new pin does not resolve the clearance problem, replace the connecting rod.

Connecting Rod Crankshaft Bearing End

Fig 3: Connecting Rod Crankshaft Bearing Bore



Courtesy of GENERAL MOTORS COMPANY

NOTE:

Measurements of all components should be taken with the components at normal room temperature.

1. Using an inside micrometer, measure the connecting rod crankshaft bearing bore.
2. Compare the bore measurements with the Engine Mechanical Specifications .
3. Replace the connecting rod if the bore is out of specifications. DO NOT recondition the connecting rod.

REPAIR INSTRUCTIONS - OFF VEHICLE > PISTON AND CONNECTING ROD ASSEMBLE

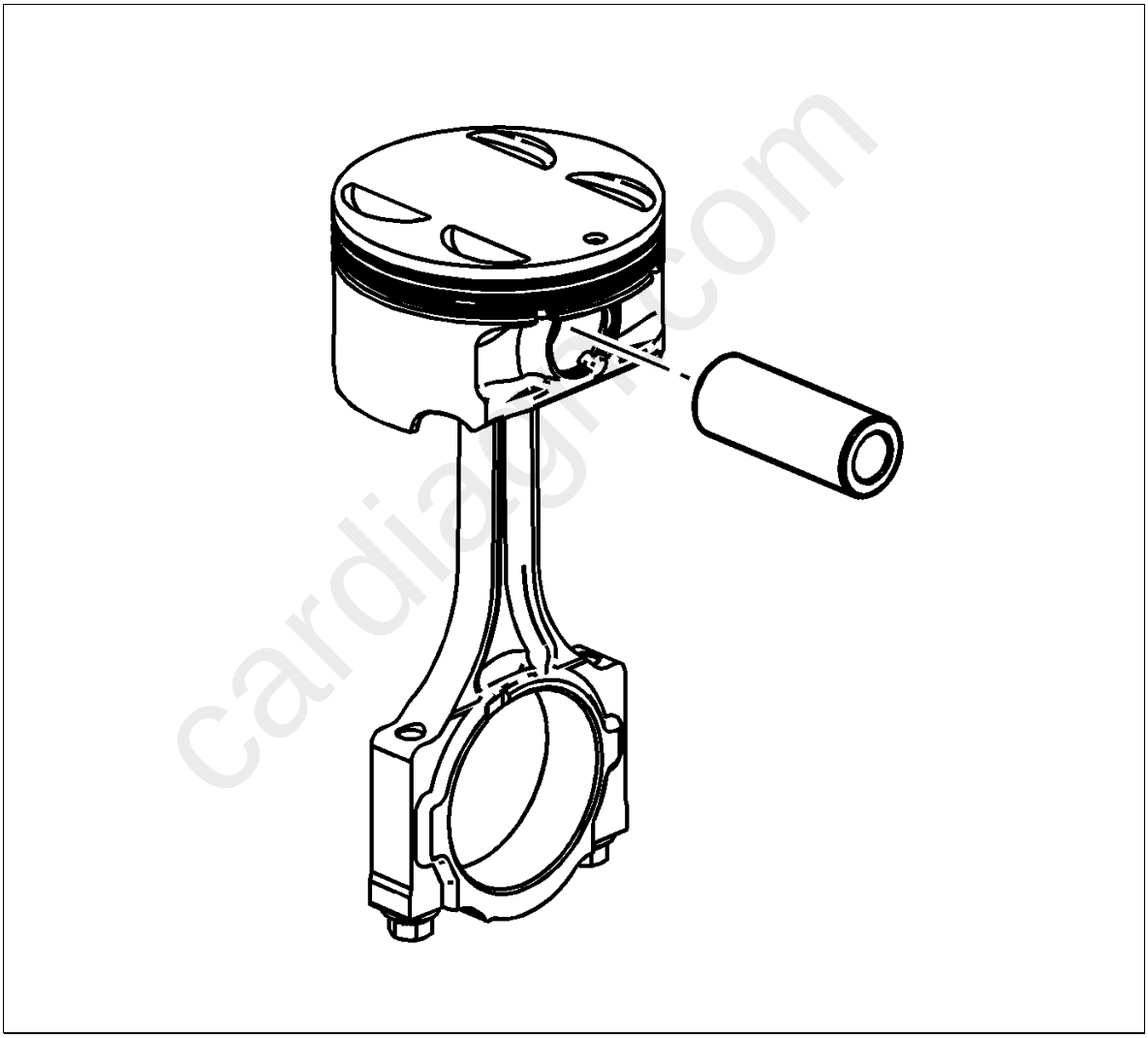
Special Tools

- **EN-46121** Connecting Rod Guide Pin Set
- **EN-46745** Piston Pin Clip Remover/Installer

For equivalent regional tools, refer to Special Tools

REPAIR INSTRUCTIONS - OFF VEHICLE > PISTON AND CONNECTING ROD ASSEMBLE > PISTON AND PISTON PIN INSTALLATION PROCEDURE

Fig 1: Piston Pin



Courtesy of GENERAL MOTORS COMPANY

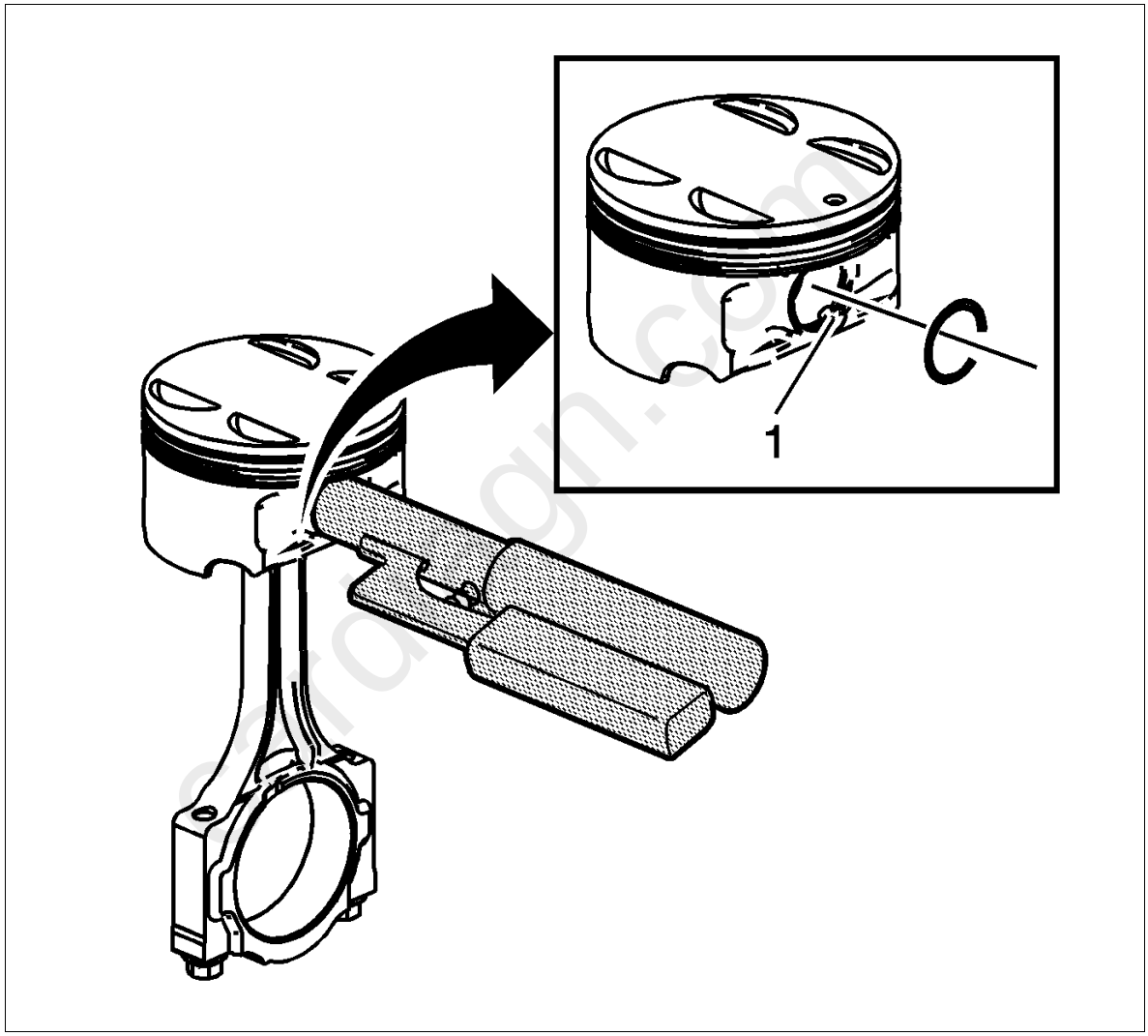
NOTE:

1. *The piston is directional and must be installed in the engine block in the proper direction. The dot on the top of the piston must face the front of the engine.*

2. The piston is model dependent and may not appear exactly as shown.

1. Lubricate the piston pin bores in the piston and the connecting rod with GM prelube lubricant. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended lubricant.
2. Assemble the piston and piston pin to the connecting rod. Properly orient the piston when reusing a marked connecting rod.
3. Align the piston pin bore with the connecting rod pin bore.
4. Slide the piston pin into the piston and the connecting rod.

Fig 2: Piston Pin Retainers Removal Access Notch



Courtesy of GENERAL MOTORS COMPANY

NOTE:

New piston pin retainers must be used. Never reuse the piston pin retainers.

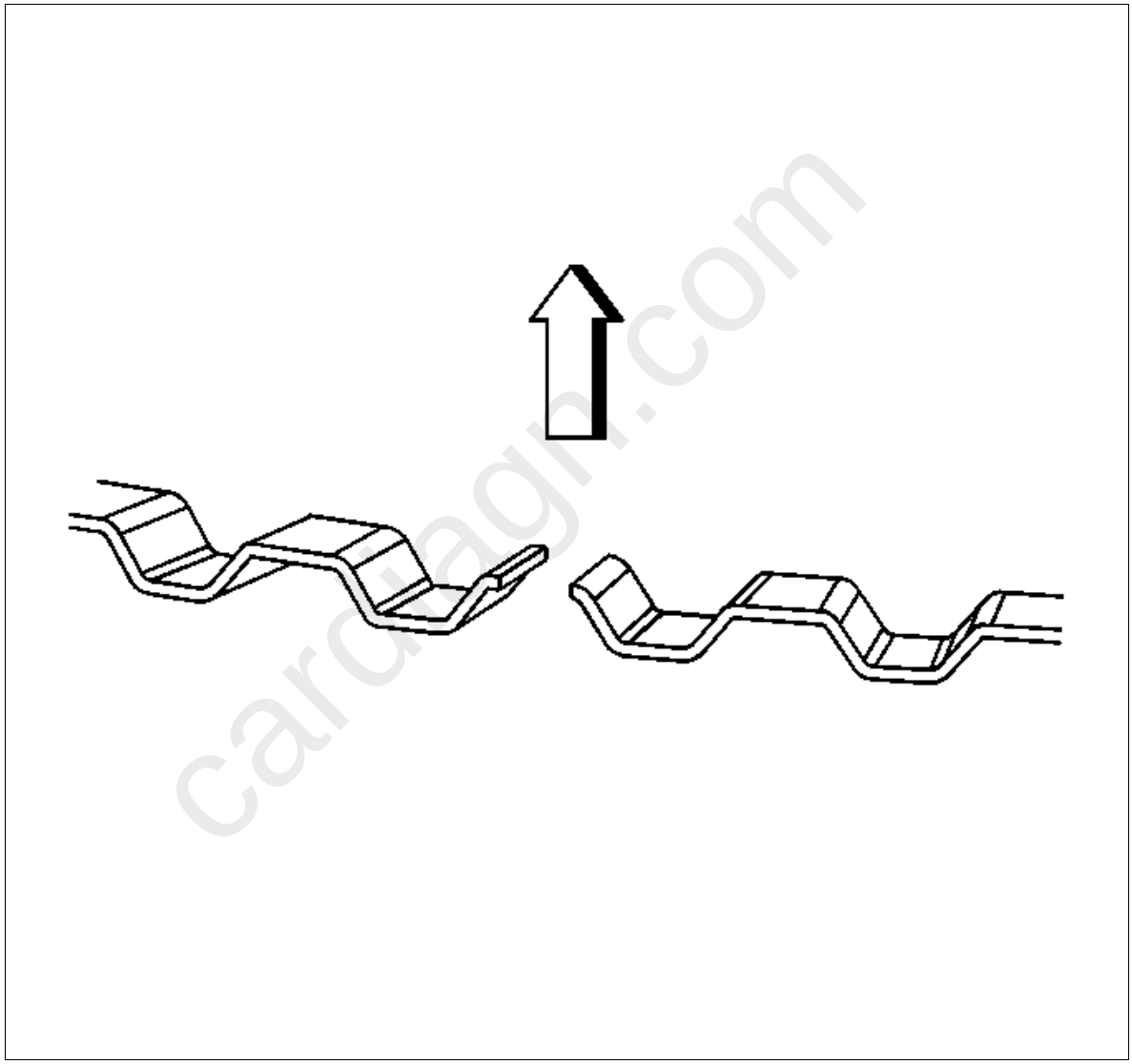
5. Install NEW piston pin retainers using the **EN-46745** remover/installer. Align the **EN-46745**

remover/installer to the notch (1) in the piston.

6. Ensure that the piston pin retainers are fully seated in their grooves.
7. Repeat these procedures for the remaining pistons.

REPAIR INSTRUCTIONS - OFF VEHICLE > PISTON AND CONNECTING ROD ASSEMBLE > PISTON RING INSTALLATION PROCEDURE

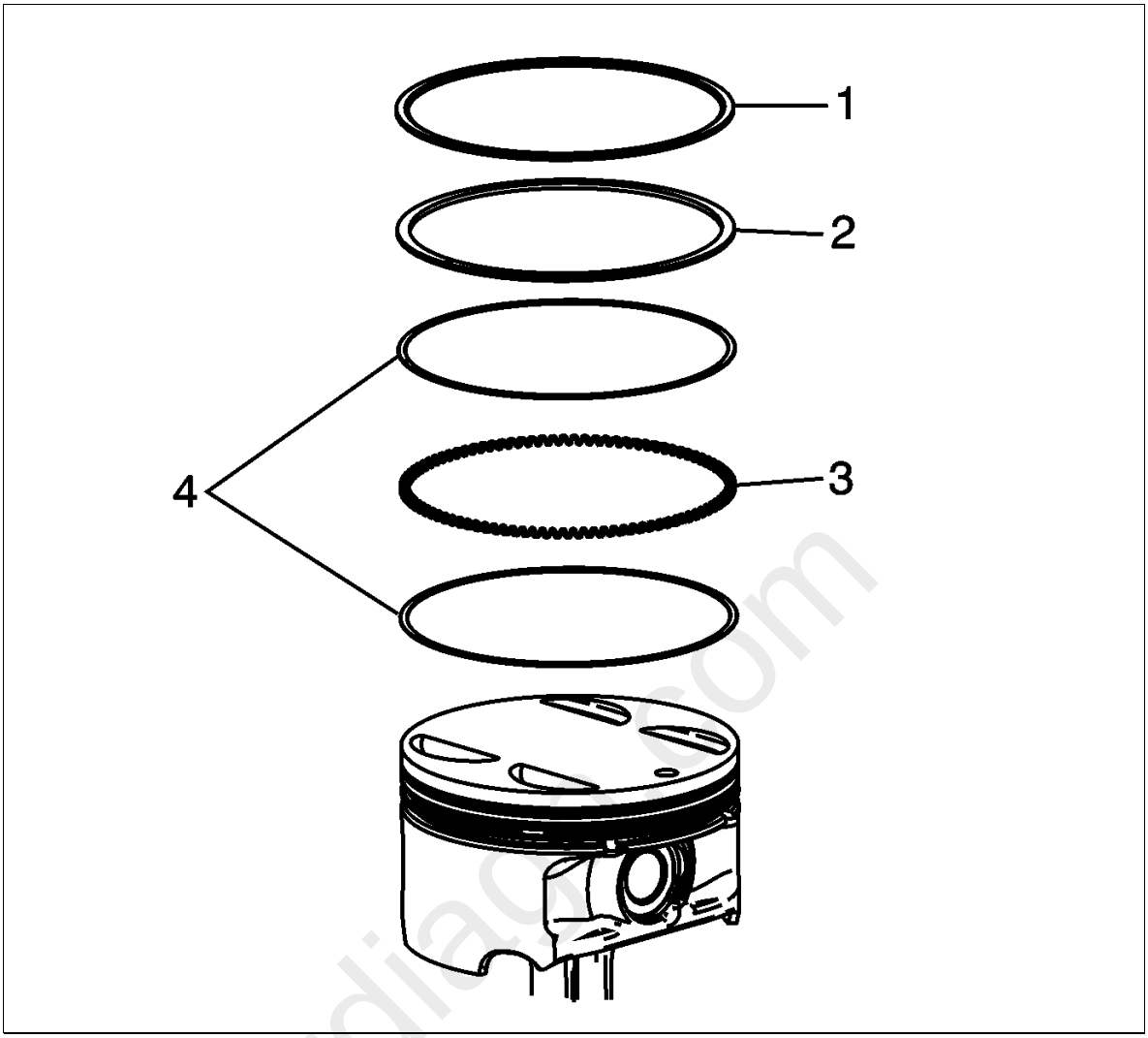
Fig 1: Oil Control Ring Expander



Courtesy of GENERAL MOTORS COMPANY

1. Properly orient the oil control ring expander as shown before installation. The ends of the expander must be facing toward the top of the piston.

Fig 2: Piston Rings



Courtesy of GENERAL MOTORS COMPANY

2. Using a piston ring expander, install the oil control ring assembly using the following procedure:
    1. Install the expander ring (3).
    2. Install the 2 oil scraper rings (4). Expand the rings only enough to clear the piston diameter. Overexpanding the piston rings will distort or crack the rings.

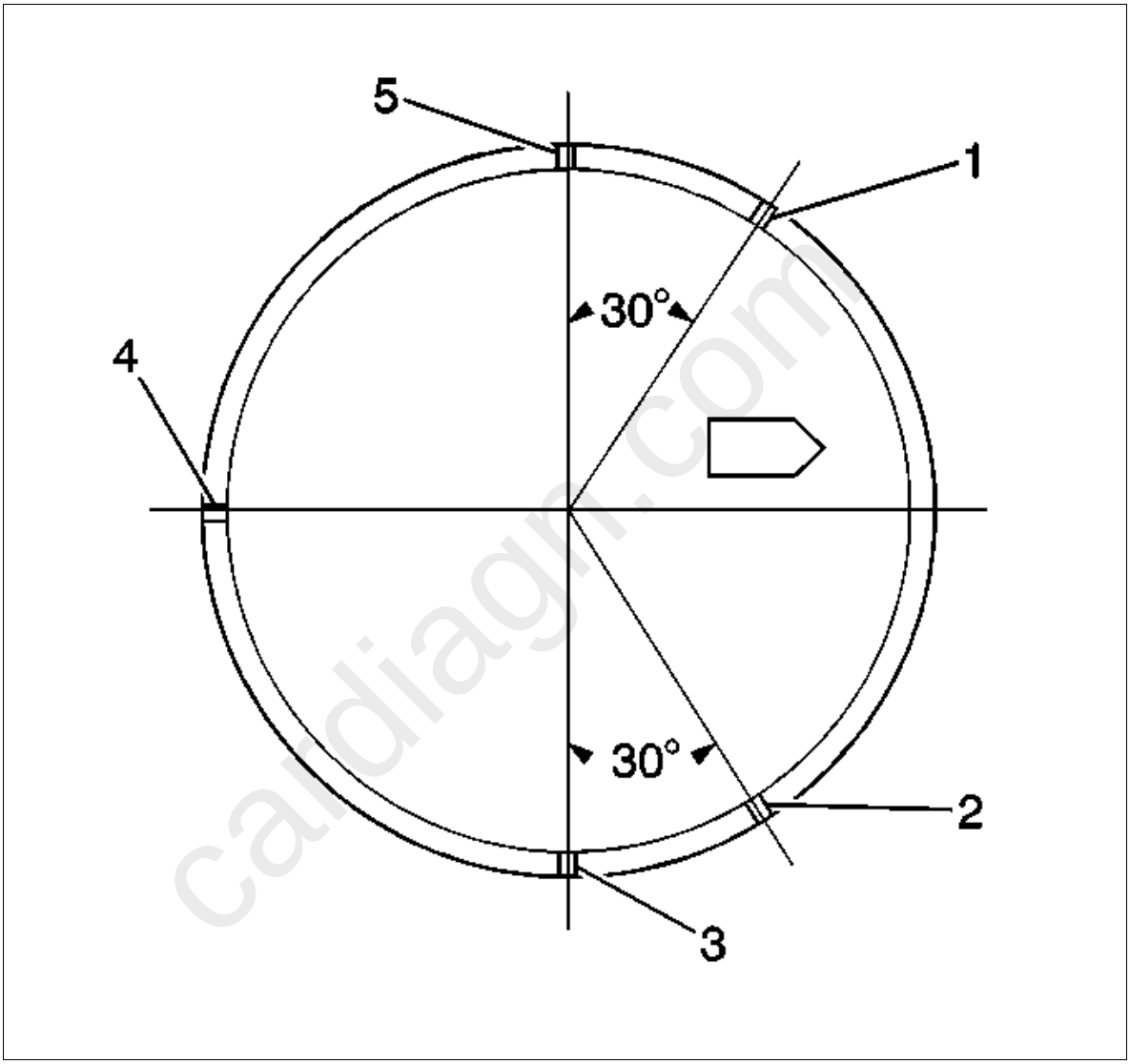
> *NOTE:*
>
> *The lower compression piston ring (2) is thicker and will not fit in the upper compression rings (1) position.*

> *NOTE:*
>
> *For the LY7, the upper compression ring is symmetrical and may be installed either side up. For all other RPO's, the mark on the piston ring should face the top of the*

piston.

3. Install the lower compression piston ring (2) onto the piston with the mark facing the top of the piston.
4. Install the upper compression piston ring (1) onto the piston with the mark facing the top of the piston, if required.

Fig 3: Ring Gap Positions



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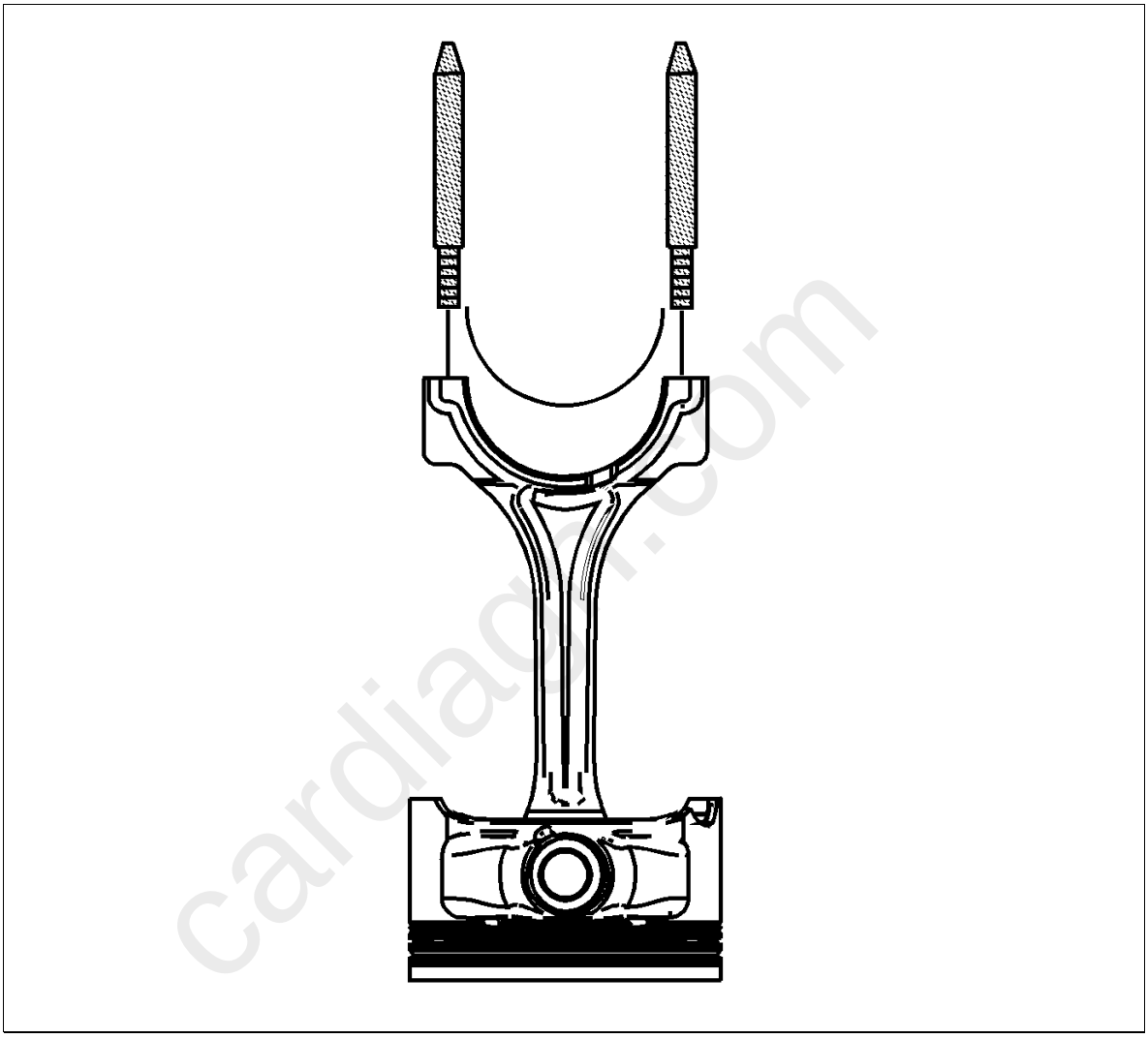
Courtesy of GENERAL MOTORS COMPANY

5. Once the rings are installed, set the ring gaps for the oil control, second and top ring as follows. Use the piston location arrow for reference.
    1. Lower oil control ring - position 1
    2. Upper oil control ring - position 2
    3. Top Ring - position 3
    4. Oil control ring expander - position 4

5. Second ring - position 5

REPAIR INSTRUCTIONS - OFF VEHICLE > PISTON AND CONNECTING ROD ASSEMBLE > CONNECTING ROD BEARING INSTALLATION PROCEDURE

Fig 1: Piston/Connecting Rod Installation Tool



Courtesy of GENERAL MOTORS COMPANY

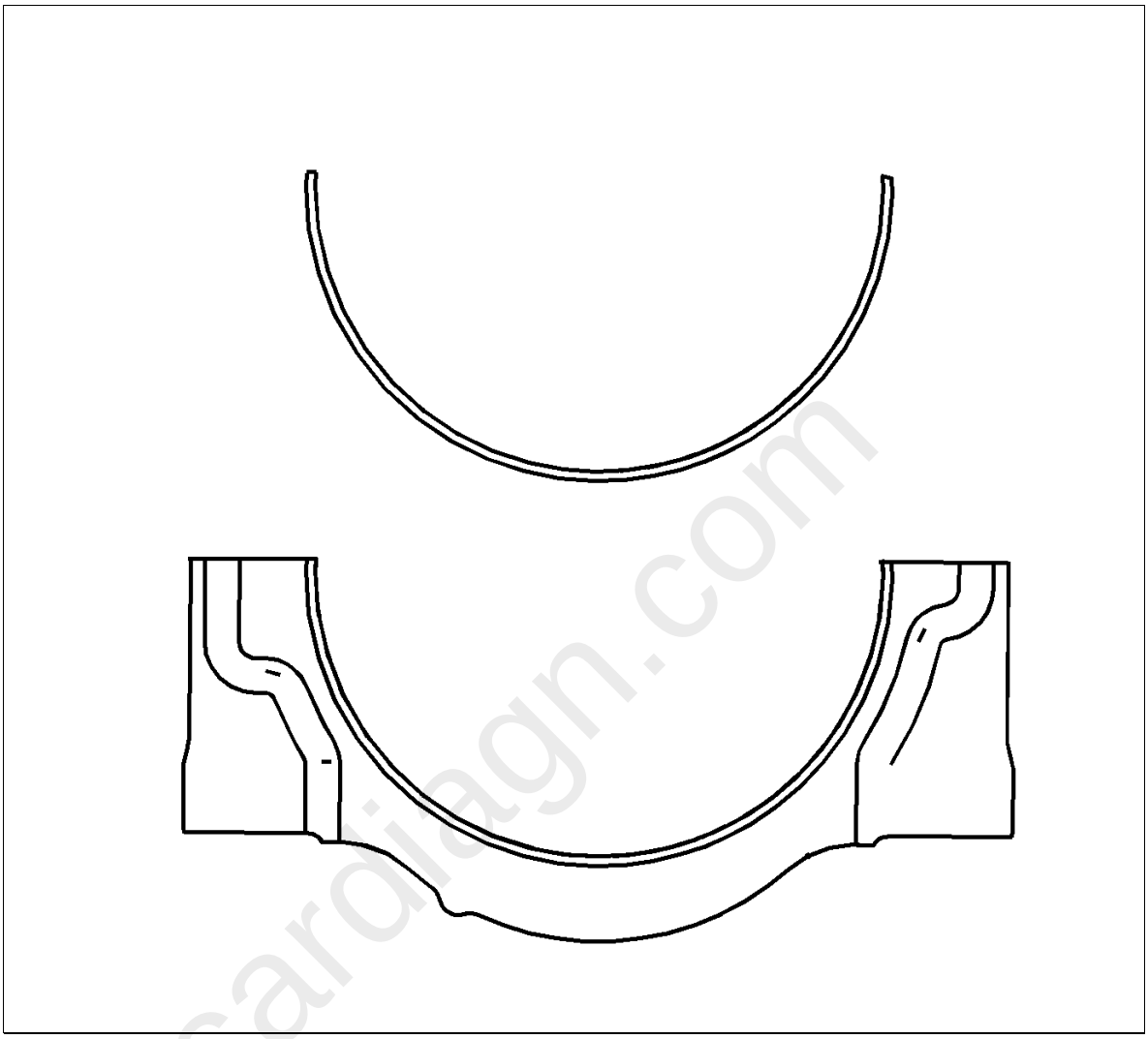
NOTE:

If the connecting rod bearings have been used in a running engine, you must replace them with NEW connecting rod bearings for reassembly.

1. Clean the connecting rod and the connecting rod cap bearing bore with a lint-free cloth.
2. Clean all the oil from behind the connecting rod bearing halves.

3. Install NEW upper connecting rod bearings into position. Roll the bearing into position so that the lock tang engages the alignment slot. The bearing must fit flush in the connecting rod.
4. Install the **EN-46121** set into the connecting rod bolt holes.

Fig 2: Lower Connecting Rod Cap & Bearing



Courtesy of GENERAL MOTORS COMPANY

5. Install NEW lower connecting rod bearings into position in the connecting rod cap. Roll the bearing into position so that the lock tang engages the alignment slot. The bearings must fit flush with the connecting rod cap.

REPAIR INSTRUCTIONS - OFF VEHICLE > CYLINDER HEAD DISASSEMBLE

Special Tools

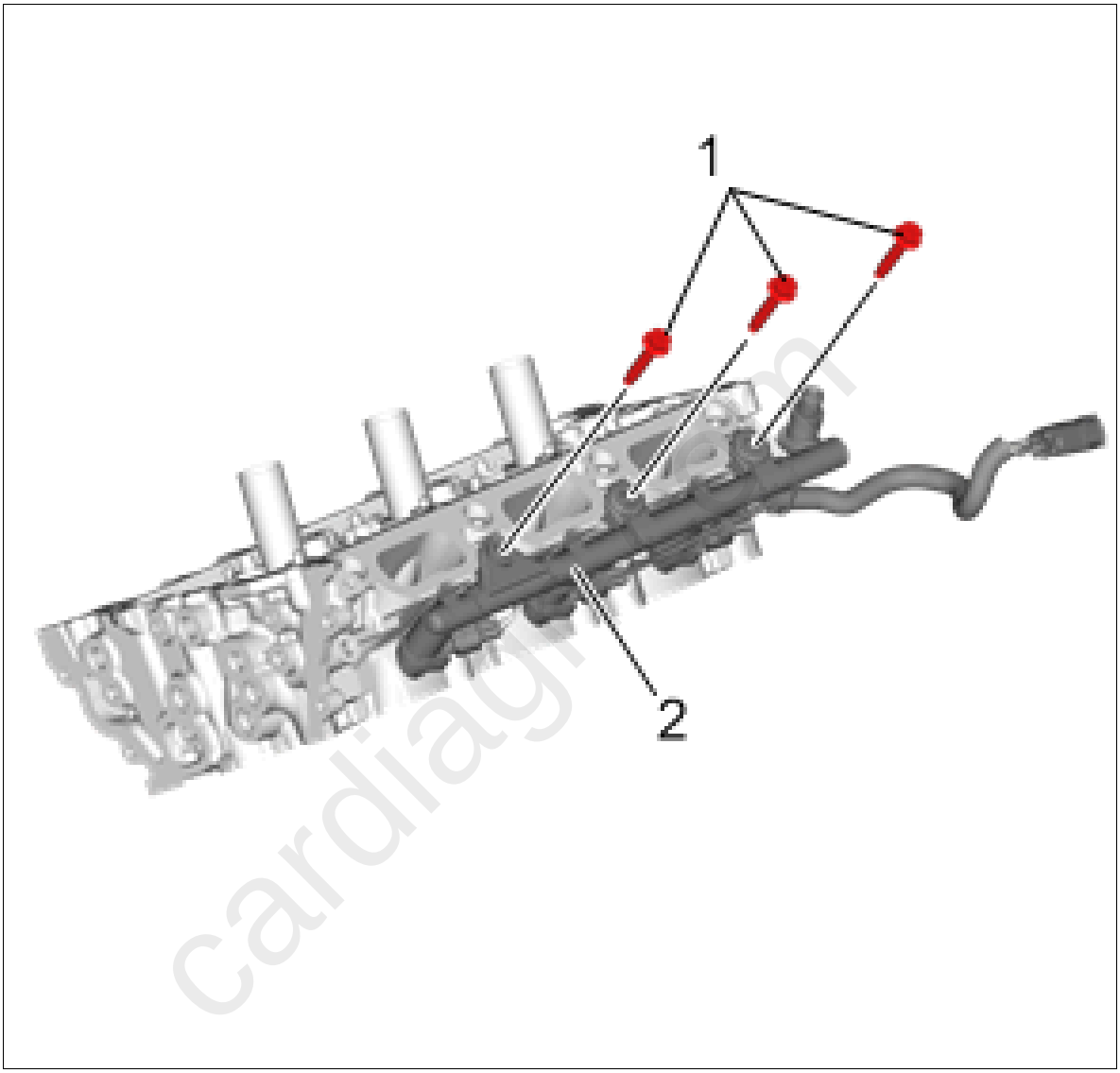
- **EN-8062** Valve Spring Compressor - Head Off
- **EN-46116** Valve Stem Seal Remover/Installer
- **EN-46117** Valve Stem Key Remover/Installer

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- **EN-46119** Off-Vehicle Valve Spring Compressor Adapter
- **EN-49248** Injector Rail Assembly Remover

For equivalent regional tools, refer to Special Tools .

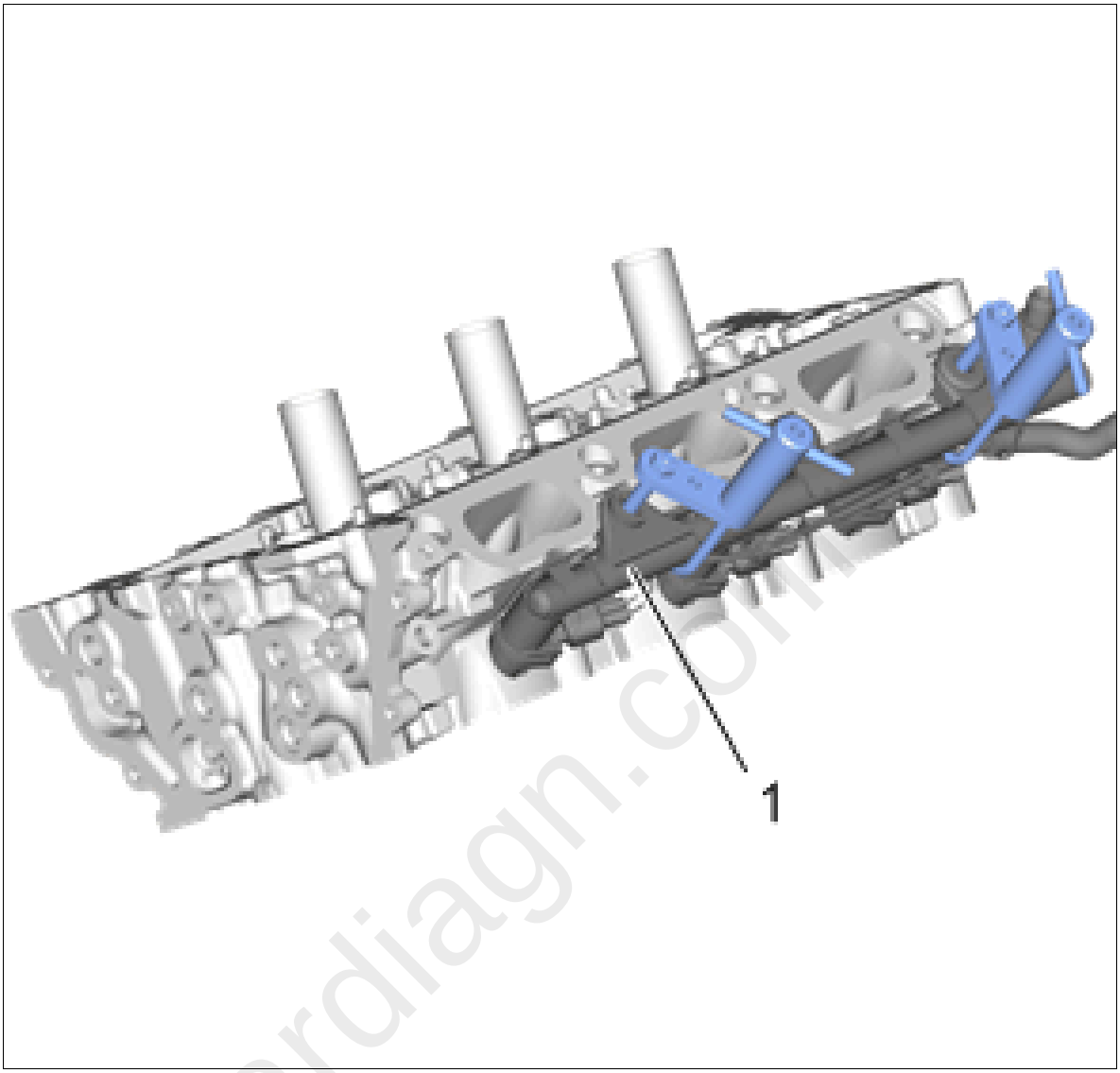
Fig 1: Fuel Rail Bolts



Courtesy of GENERAL MOTORS COMPANY

1. Remove the fuel rail bolts (1) from the fuel rail (2).

Fig 2: Fuel Rail And Injectors



Courtesy of GENERAL MOTORS COMPANY

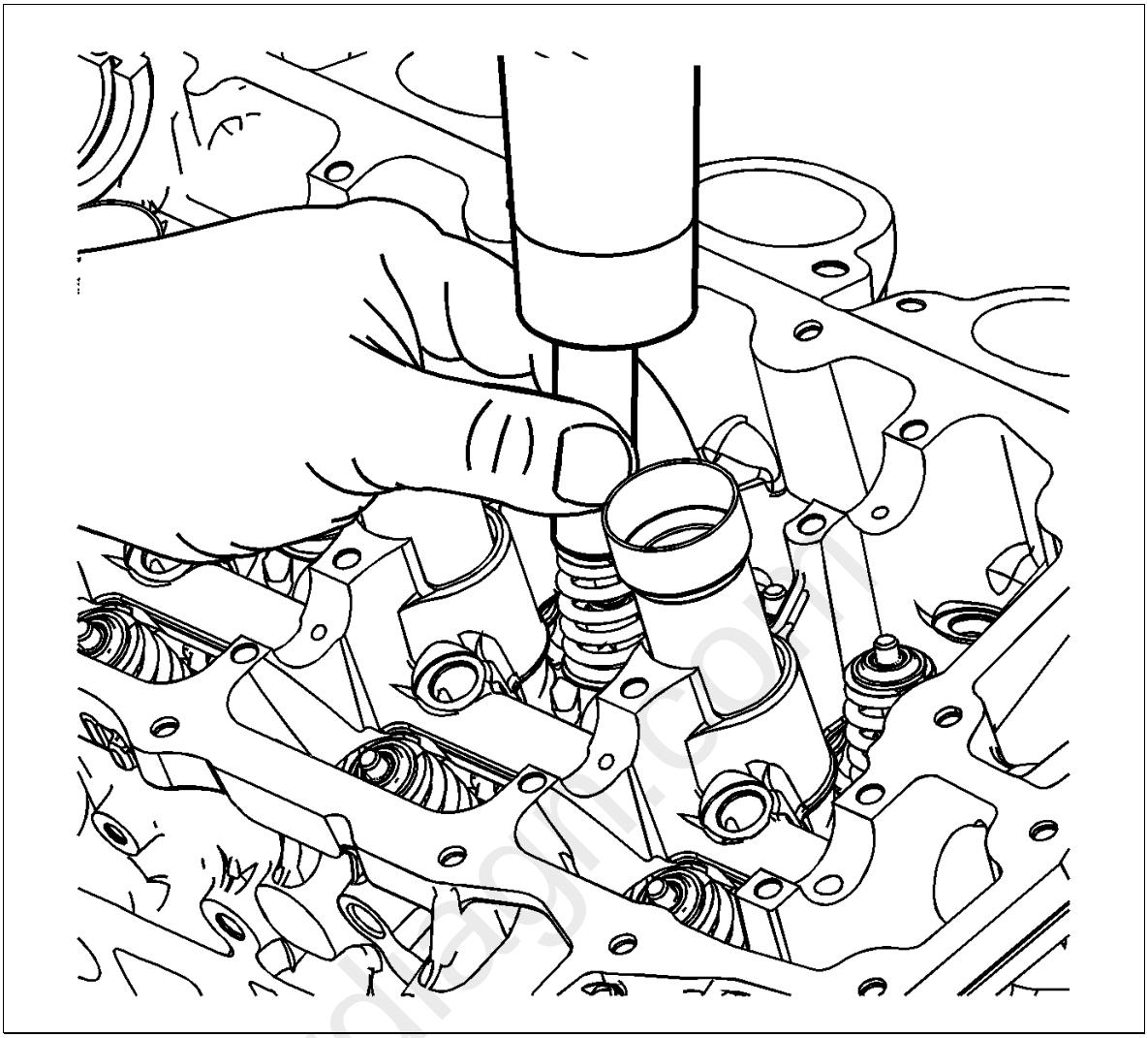
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⚠ *CAUTION:*

1. *Remove the fuel rail assembly carefully in order to prevent damage to the injector electrical connector terminals and the injector spray tips. Support the fuel rail after the fuel rail is removed in order to avoid damaging the fuel rail components.*
2. *Cap the fittings and plug the holes when servicing the fuel system in order to prevent dirt and other contaminants from entering open pipes and passages.*

2. Remove the fuel rail and injectors (1) as an assembly using the **EN-49248** remover.

Fig 3: Valve Keepers



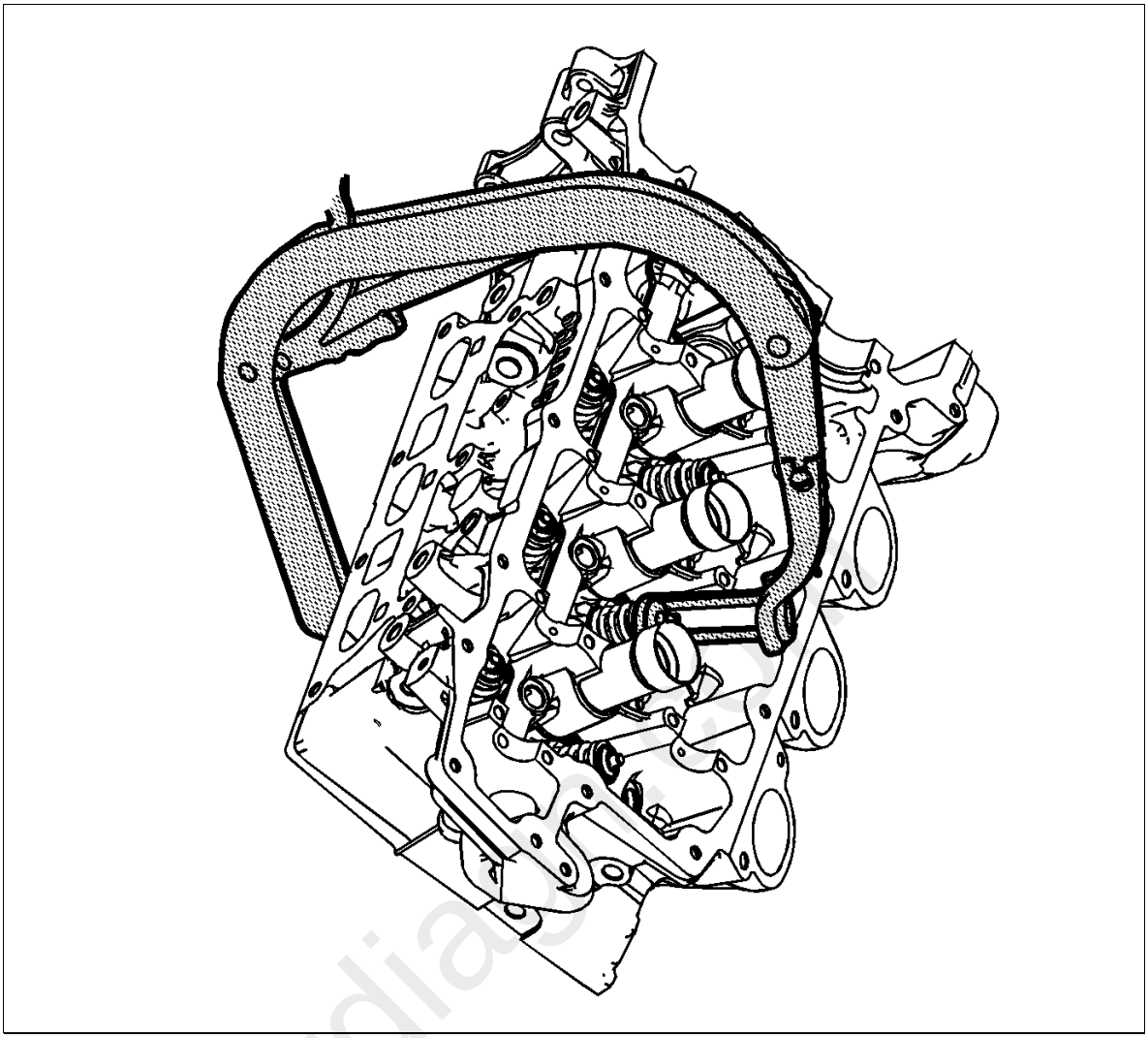
Courtesy of GENERAL MOTORS COMPANY

NOTE:

Ensure valve heads will not contact anything during the following step in order to avoid bending or damage.

3. Using an appropriately sized deep socket and a plastic hammer, lightly tap on the valve spring retainer to loosen the valve keepers.

Fig 4: Valve Spring



Courtesy of GENERAL MOTORS COMPANY

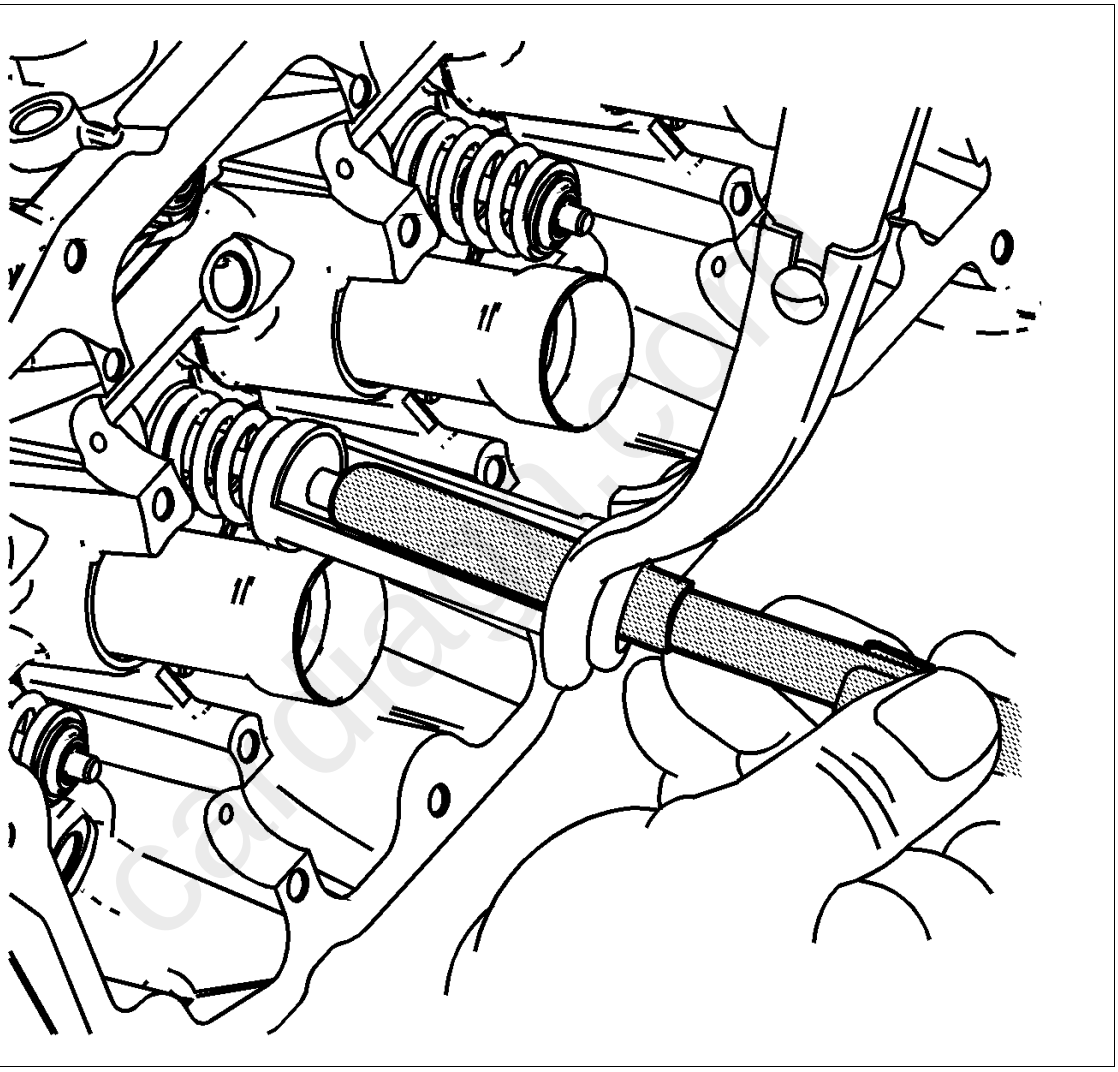
WARNING:

Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.

> ⚠ *CAUTION:*
>
> *Do not compress the valve springs to less than 24.0 mm (0.943 in). Contact between the valve spring retainer and the valve stem oil seal can cause potential valve stem oil seal damage.*

4. Compress the valve spring using the **EN-8062** compressor and the **EN-46119** adapter.

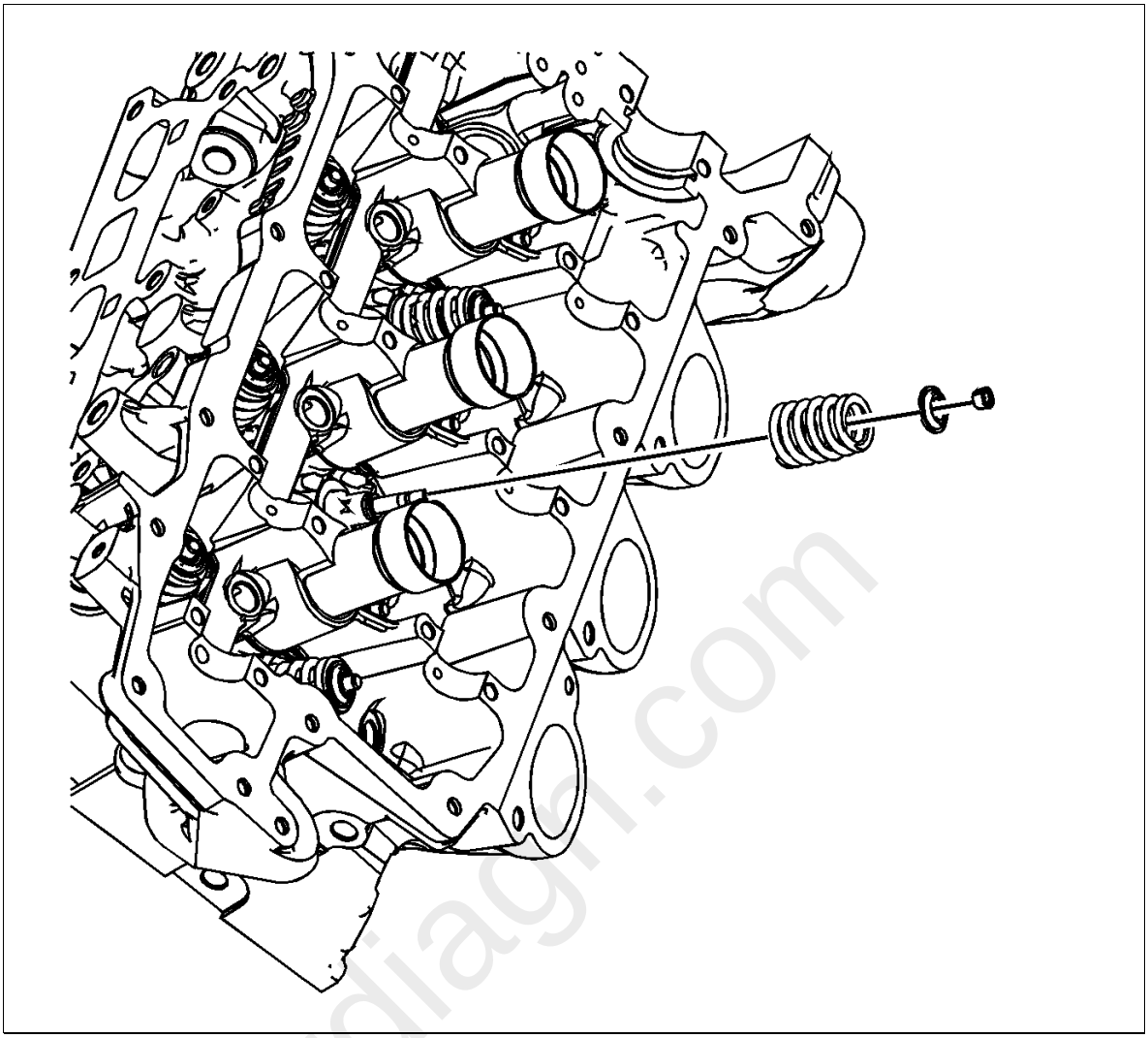
Fig 5: Valve Keepers



Courtesy of GENERAL MOTORS COMPANY

5. Use the magnet of the **EN-46117** remover/installer in order to remove the valve keepers.
6. Remove the valve spring compressor and the adapter.

Fig 6: Valve Spring & Retainer

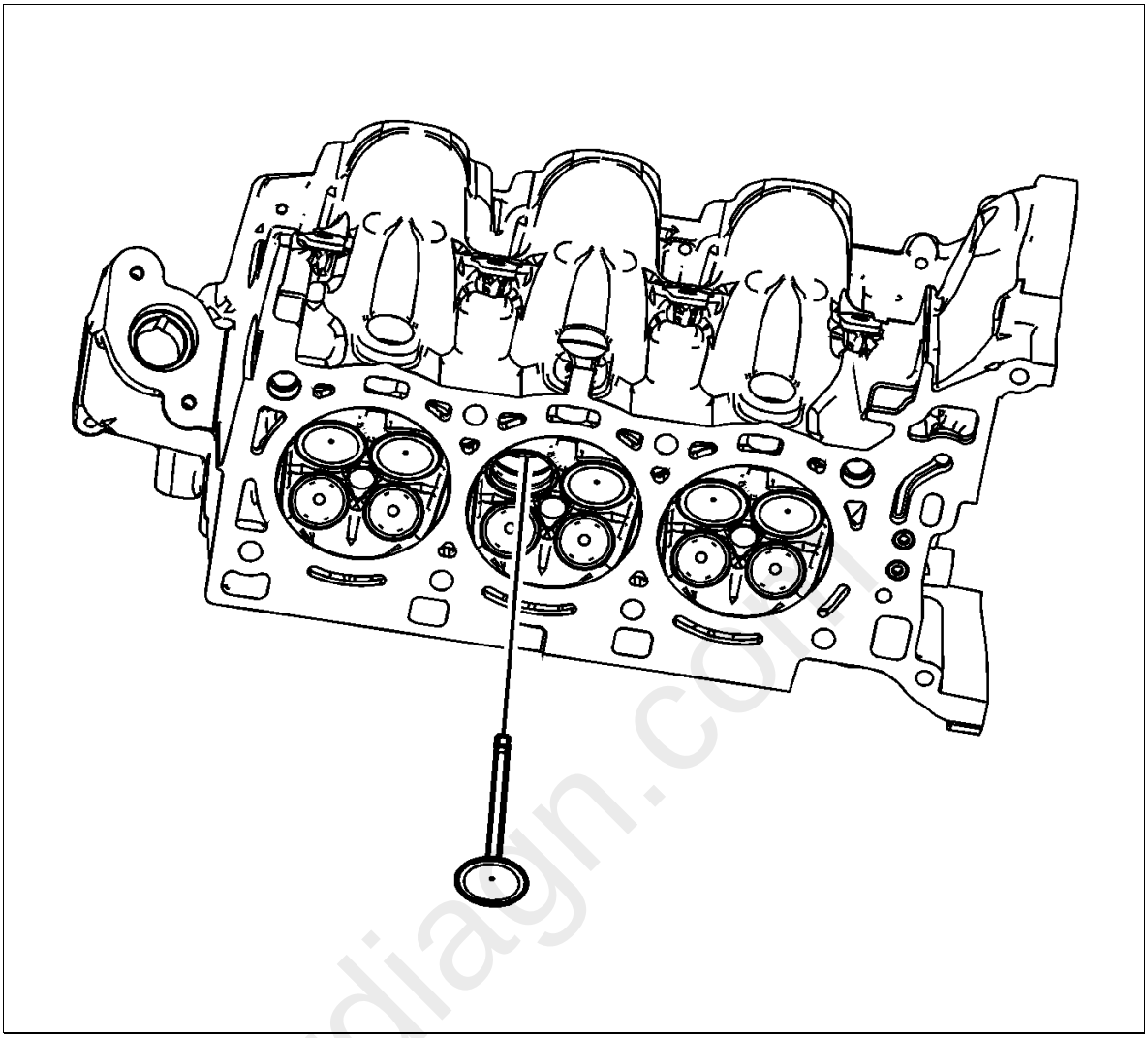


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7. Remove the valve spring retainer.
8. Remove the valve spring.

Fig 7: Oil Seal and Valve Guide

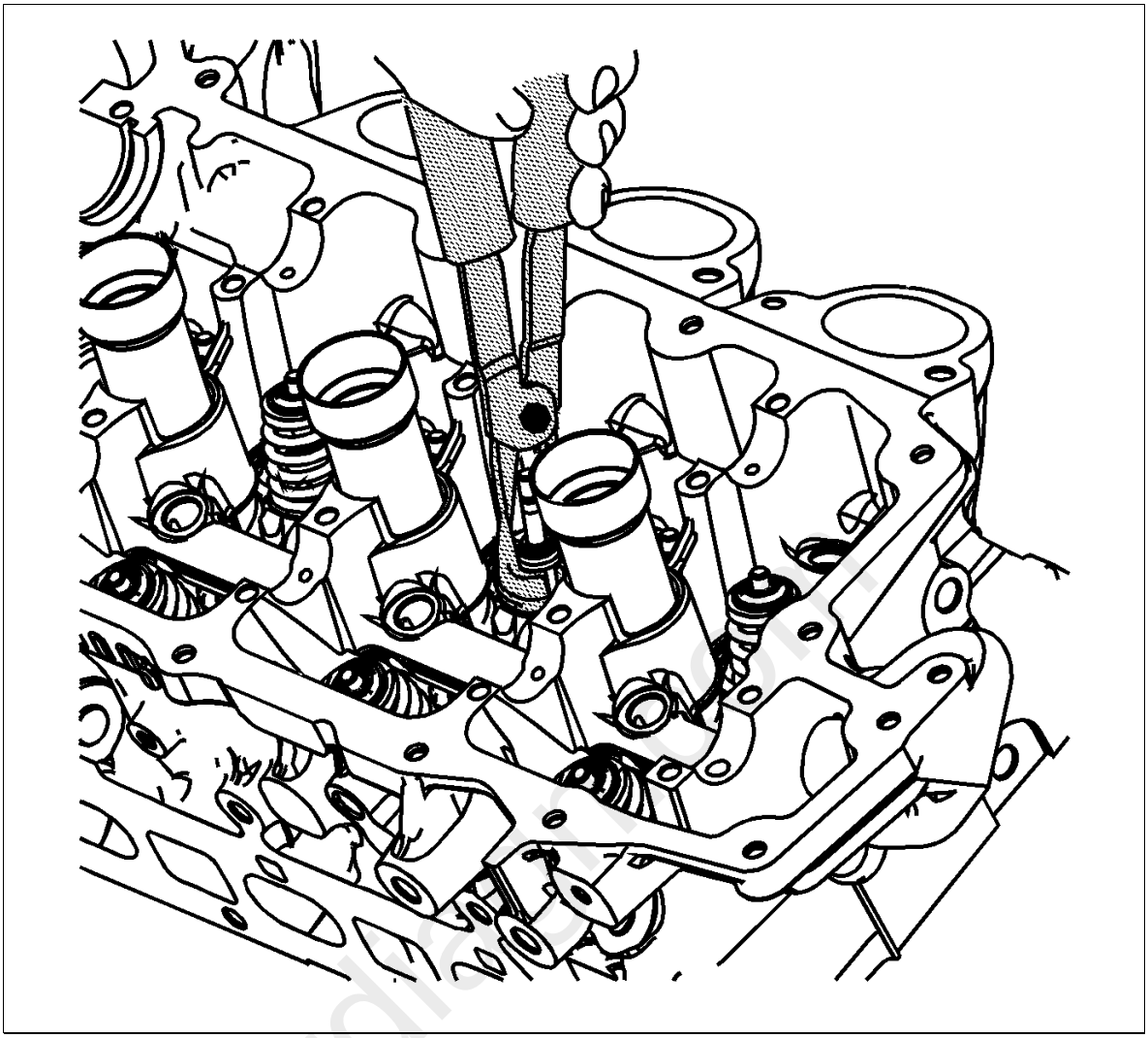


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9. Remove the valve.

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Fig 8: Valve Stem Oil Seals



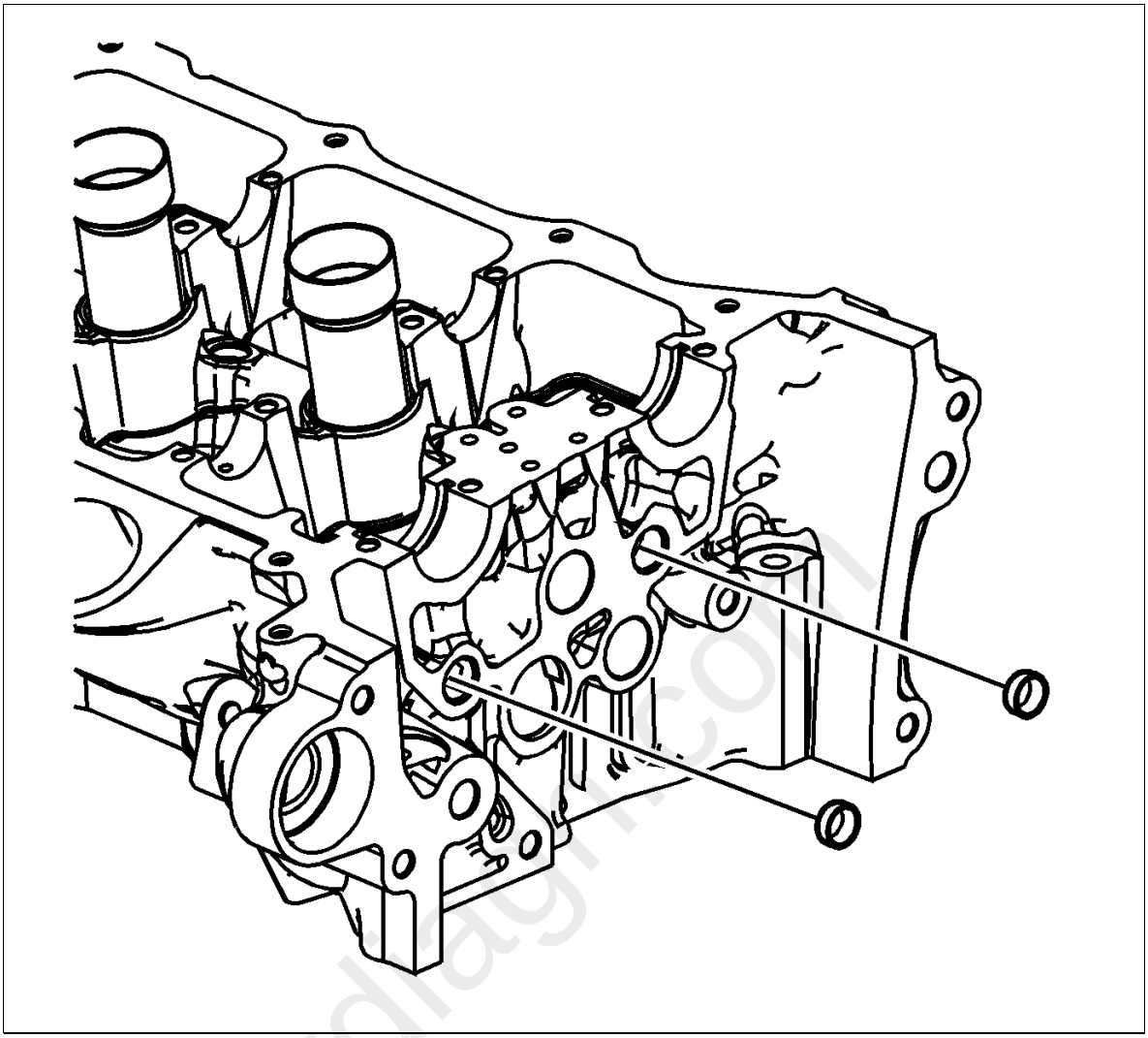
Courtesy of GENERAL MOTORS COMPANY

NOTE:

NEVER reuse a valve stem oil seal.

10. Remove the valve stem oil seal using the **EN-46116** remover/installer and discard.
11. Repeat these procedures for the remaining valves.

Fig 9: Cylinder Head Oil Gallery Expansion Plugs



Courtesy of GENERAL MOTORS COMPANY

12. Remove the cylinder head oil gallery expansion plugs.

REPAIR INSTRUCTIONS - OFF VEHICLE > CYLINDER HEAD CLEANING AND INSPECTION

Special Tools

- **GE-8001** Dial Indicator Set
- **GE-8358** Carbon Removal Brush
- **EN-28410** Gasket Remover
- **EN-42096** Valve Guide Reamer
- **EN-47909** Injector Bore and Sleeve Cleaning Kit

For equivalent regional tools, refer to Special Tools .

REPAIR INSTRUCTIONS - OFF VEHICLE > CYLINDER HEAD CLEANING AND INSPECTION > CLEANING PROCEDURE

1. Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant
2. Remove any old thread sealant, gasket material or sealant using **EN-28410** remover.
3. Clean all cylinder head surfaces with non-corrosive solvent.

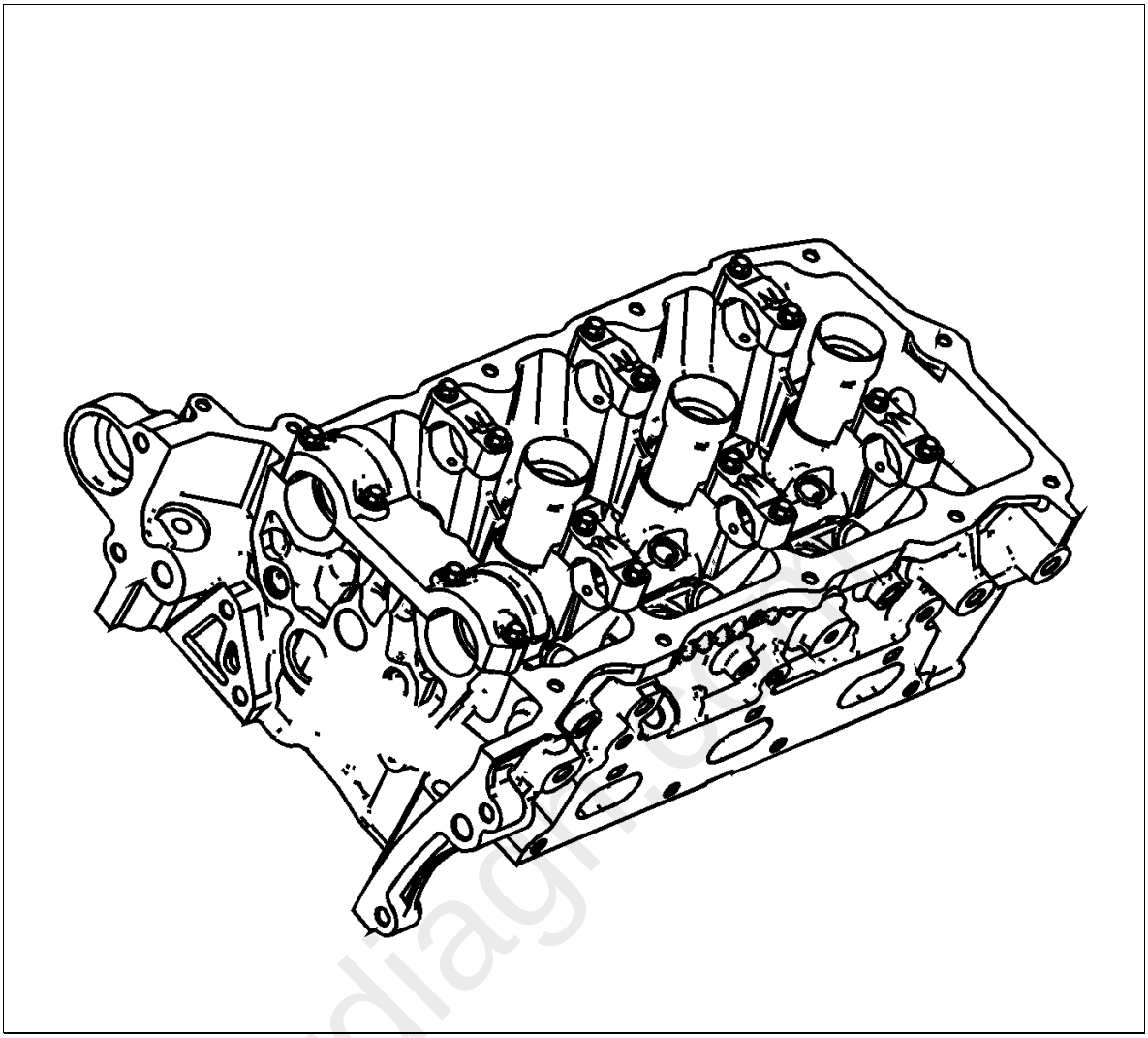
> *WARNING:*
>
> *Refer to Safety Glasses Warning .*

4. Blow out all the oil galleries using compressed air.
5. Remove any carbon deposits from the combustion chambers using the **GE-8358** brush.
6. Clean any debris or build-up from the lifter pockets.

REPAIR INSTRUCTIONS - OFF VEHICLE > CYLINDER HEAD CLEANING AND INSPECTION > VISUAL INSPECTION

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Fig 1: Cylinder Head



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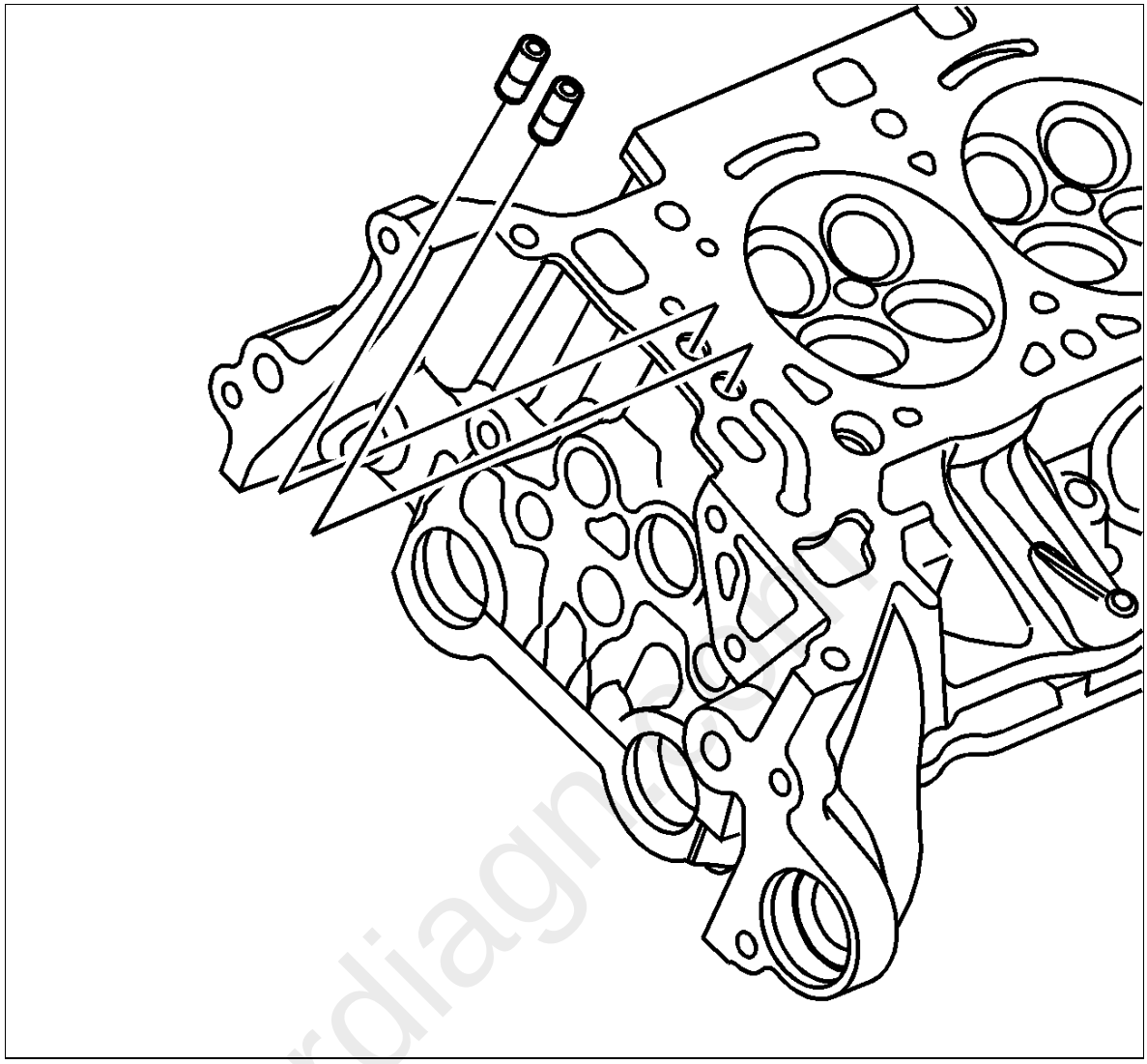
1. Inspect the cylinder head camshaft bearing surfaces for the following conditions:
    1. Excessive scoring or pitting
    2. Discoloration from overheating
    3. Deformation from excessive wear
    4. If the camshaft bearing journals appear to be scored or damaged, you must replace the cylinder head. 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:
    1. Cracks, damage or pitting in the combustion chambers
    2. Debris in the oil galleries - Continue to clean the galleries until all debris is removed.

3. Coolant leaks or damage to the deck face sealing surface - If coolant leaks are present, measure the surface warpage as described under Cylinder Head Measurement - Deck Flatness Inspection.
4. Burrs or any defects that would degrade the sealing of the NEW secondary camshaft drive chain tensioner gasket
5. Damage to any gasket surfaces
6. Damage to any threaded bolt holes
7. Burnt or eroded areas in the combustion chamber
8. Cracks in the exhaust ports and combustion chambers
9. External cracks in the water passages
10. Restrictions in the intake or exhaust passages
11. Restrictions in the cooling system passages
12. 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 recommended.

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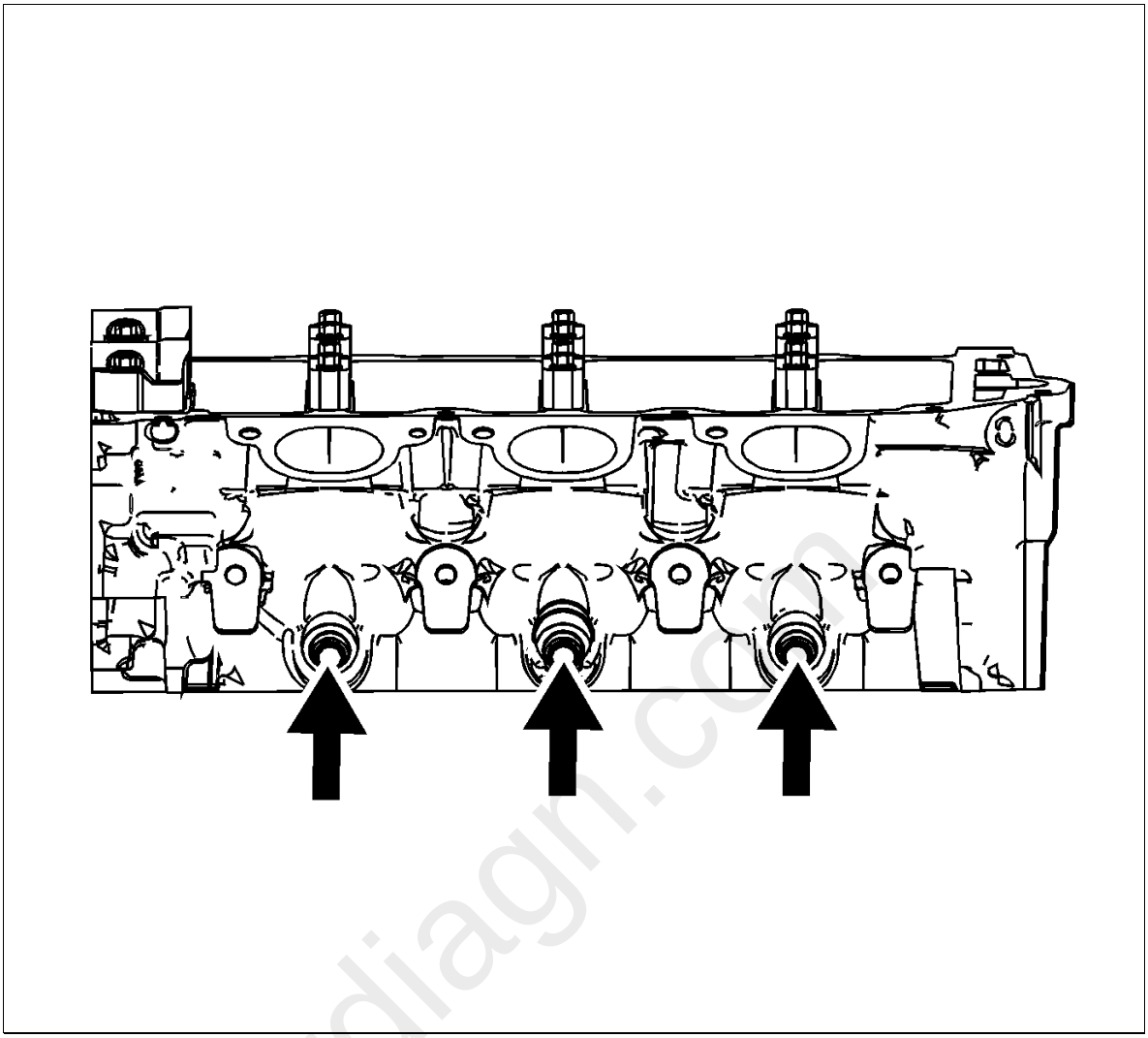
Fig 2: Camshaft Position Actuator Oil Feed Check Valve



Courtesy of GENERAL MOTORS COMPANY

5. Inspect the camshaft position actuator oil feed check valves. Damaged, restricted or clogged check valves must be replaced. Refer to Cylinder Head Disassemble .

Fig 3: Fuel Rail injector Bores



Courtesy of GENERAL MOTORS COMPANY

6. Inspect the fuel rail injector bores and clean with **EN-47909** kit, if required.

REPAIR INSTRUCTIONS - OFF VEHICLE > CYLINDER HEAD CLEANING AND INSPECTION > CYLINDER HEAD MEASUREMENT

Camshaft Journal Clearance

1. Install the camshaft bearing cap in the cylinder head without the camshaft.

> ⚠ *CAUTION:*
>
> *Refer to Fastener Caution .*

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

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3. Measure the camshaft bearings using an inside micrometer.
4. Subtract the camshaft journal diameter from the camshaft bearing diameter. This will provide the running clearance. If the running clearance exceeds specifications and the camshaft journals are within specification, replace the cylinder head.

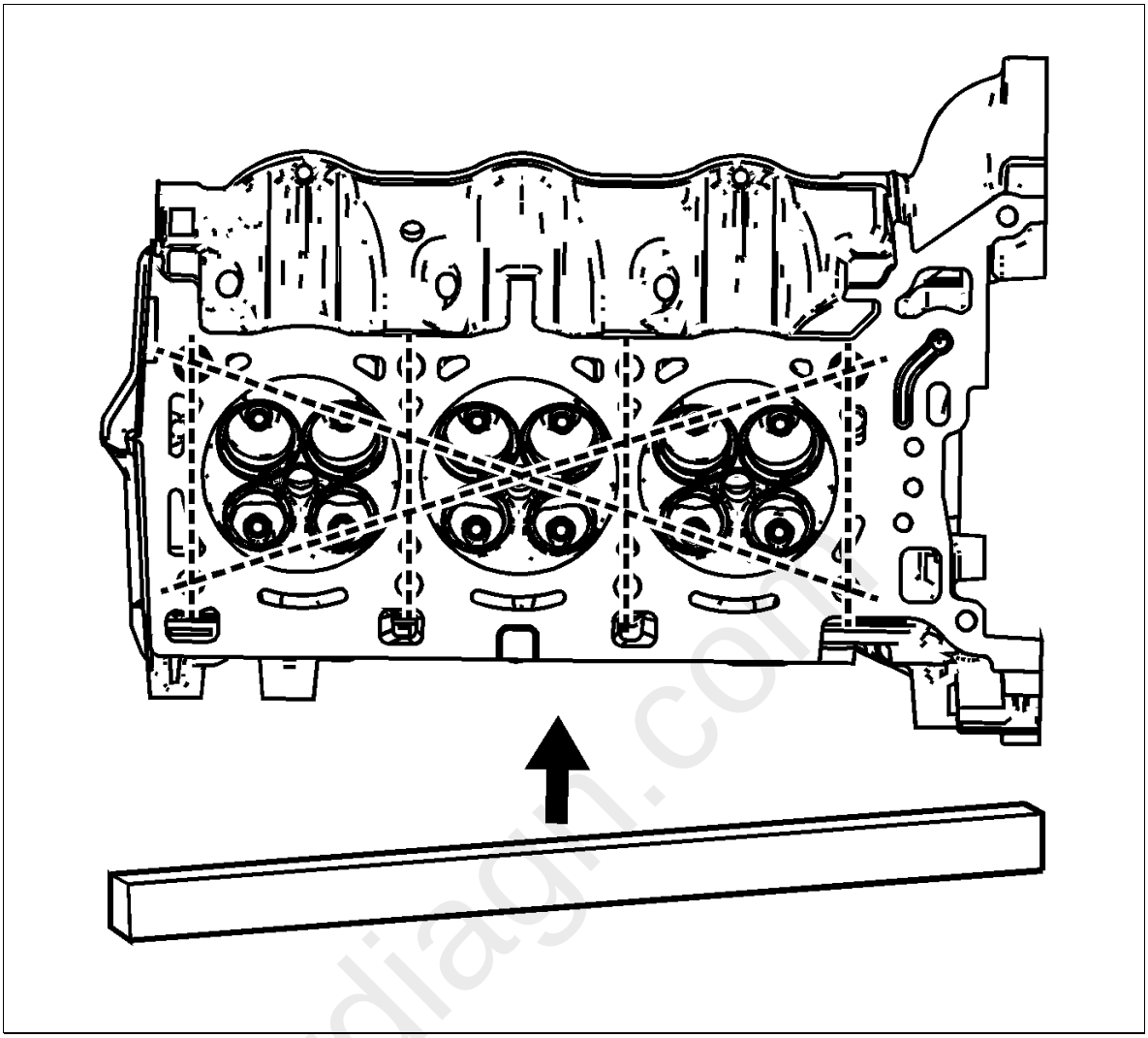
Camshaft Journal Alignment

1. Ensure the camshafts are serviceable.
2. Inspect the cylinder head camshaft bearing surfaces for any imperfections or scratches that could inhibit proper camshaft clearances. Repair minor imperfections or scratches.
3. Install the camshafts in the cylinder head.
4. Install the camshaft bearing caps.
5. Install the camshaft cap bolts and tighten to 10 N.m (89 lb in).
6. Ensure the camshafts spin freely in the cylinder head. If the camshaft does not run freely, replace the cylinder head.

Deck Flatness Inspection

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Fig 1: Deck Flatness



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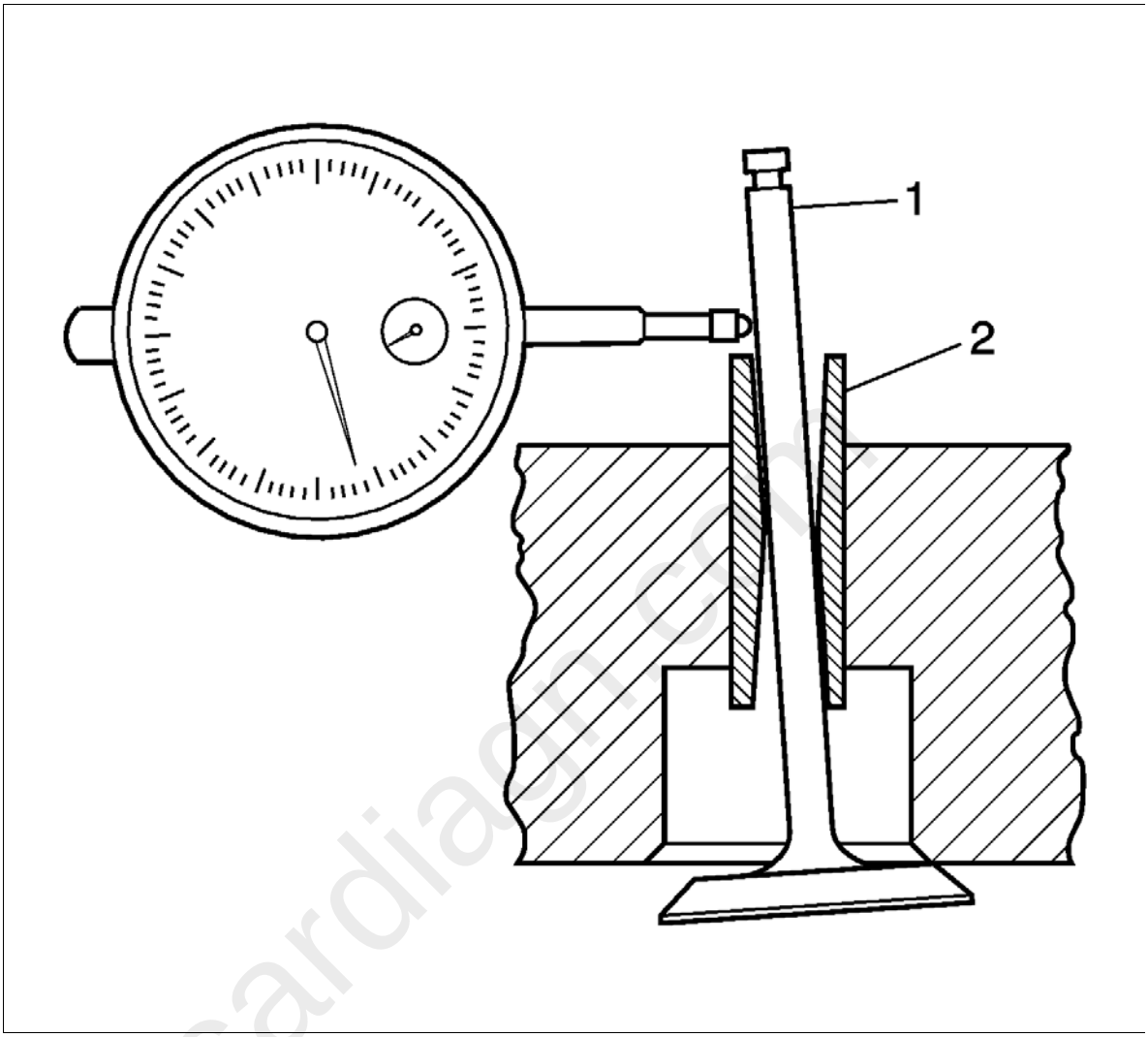
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1. Ensure the cylinder head decks are clean and free of gasket material.
2. Inspect the surface for any imperfections or scratches that could inhibit proper cylinder head gasket sealing.
3. Place a straight-edge diagonally across the cylinder head deck face surface.
4. Measure the clearance between the straight-edge and the cylinder head deck face using a feeler gauge at 4 points along the straight-edge.
5. If the warpage is less than 0.05 mm (0.002 in), the cylinder head deck surface does not require resurfacing.
6. If the warpage is between 0.05-0.20 mm (0.002-0.008 in) or any imperfections or scratches that could inhibit proper cylinder head gasket sealing are present, the cylinder head deck surface requires resurfacing.
7. If resurfacing is required the maximum amount that can be removed is 0.25 mm (0.010 in).
8. If the cylinder head deck surface requires more than 0.25 mm (0.010 in) material removal the

head must be replaced.

Valve Guide Measurement

Fig 2: Valve Stem To Guide Clearance



Courtesy of GENERAL MOTORS COMPANY

1. Measure the valve stem (1)-to-guide (2) clearance. Excessive valve stem-to-guide clearance may cause an excessive oil consumption and may also cause a valve to break. Insufficient clearance will result in noisy and sticky functioning of the valve and will disturb the engine assembly smoothness.
2. Clamp the **GE-8001** set to the cylinder head at the camshaft cover rail.
3. Locate the dial indicator so that the movement of the valve stem from side to side, crossways to the cylinder head, will cause a direct movement of the indicator stem. The dial indicator stem must contact the side of the valve stem just above the valve guide.
4. Drop the valve head about 0.064 mm (0.0025 in) off the valve seat.
5. Use light pressure when moving the valve stem from side to side in order to obtain a clearance reading. Refer to Engine Mechanical Specifications for proper clearance.

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1. If the clearance for the valve is greater than specifications and a new standard diameter valve stem will not bring the clearance within specifications, the valve guide may be oversized by 0.075 mm (0.003 in) using the **EN-42096** reamer. There is 1 size of oversized valve stem available for service.
2. Valve guide wear at the bottom 10 mm (0.390 in) of the valve guide is not significant to normal operation.
3. If oversizing the guide does not bring the clearance within specifications, replace the cylinder head.

REPAIR INSTRUCTIONS - OFF VEHICLE > VALVE SPRING INSPECTION AND MEASUREMENT

Special Tools

EN 22738-B Valve Spring Tester

For equivalent regional tools, refer to Special Tools .

REPAIR INSTRUCTIONS - OFF VEHICLE > VALVE SPRING INSPECTION AND MEASUREMENT > INSPECTION PROCEDURE

1. Clean the valve springs in solvent.

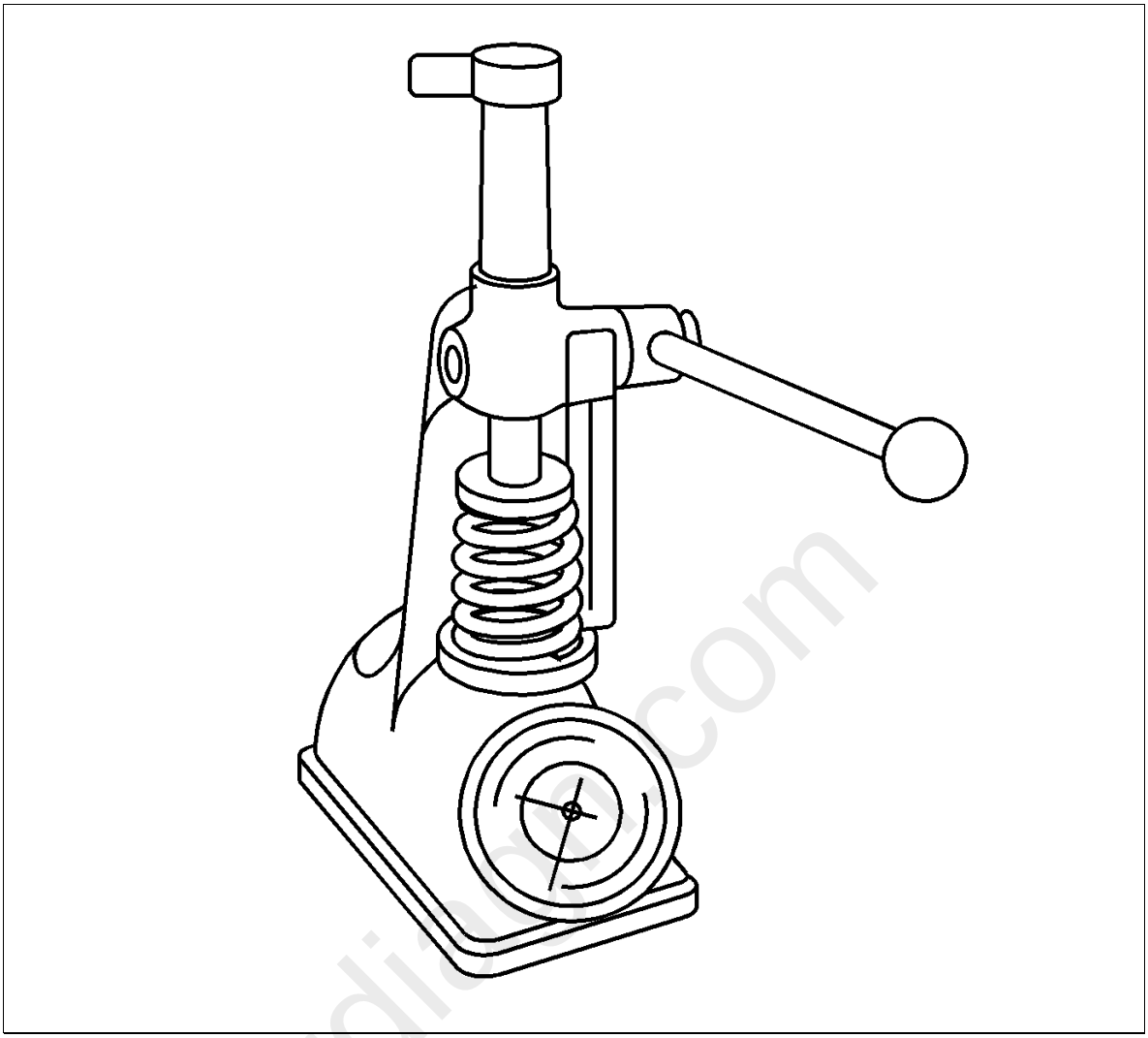
> *WARNING:*
>
> *Refer to Safety Glasses Warning .*

2. Dry the valve springs with compressed air.
3. Inspect the valve springs for broken coils or coil ends.

REPAIR INSTRUCTIONS - OFF VEHICLE > VALVE SPRING INSPECTION AND MEASUREMENT > MEASUREMENT PROCEDURE

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Fig 1: Valve Spring Tension



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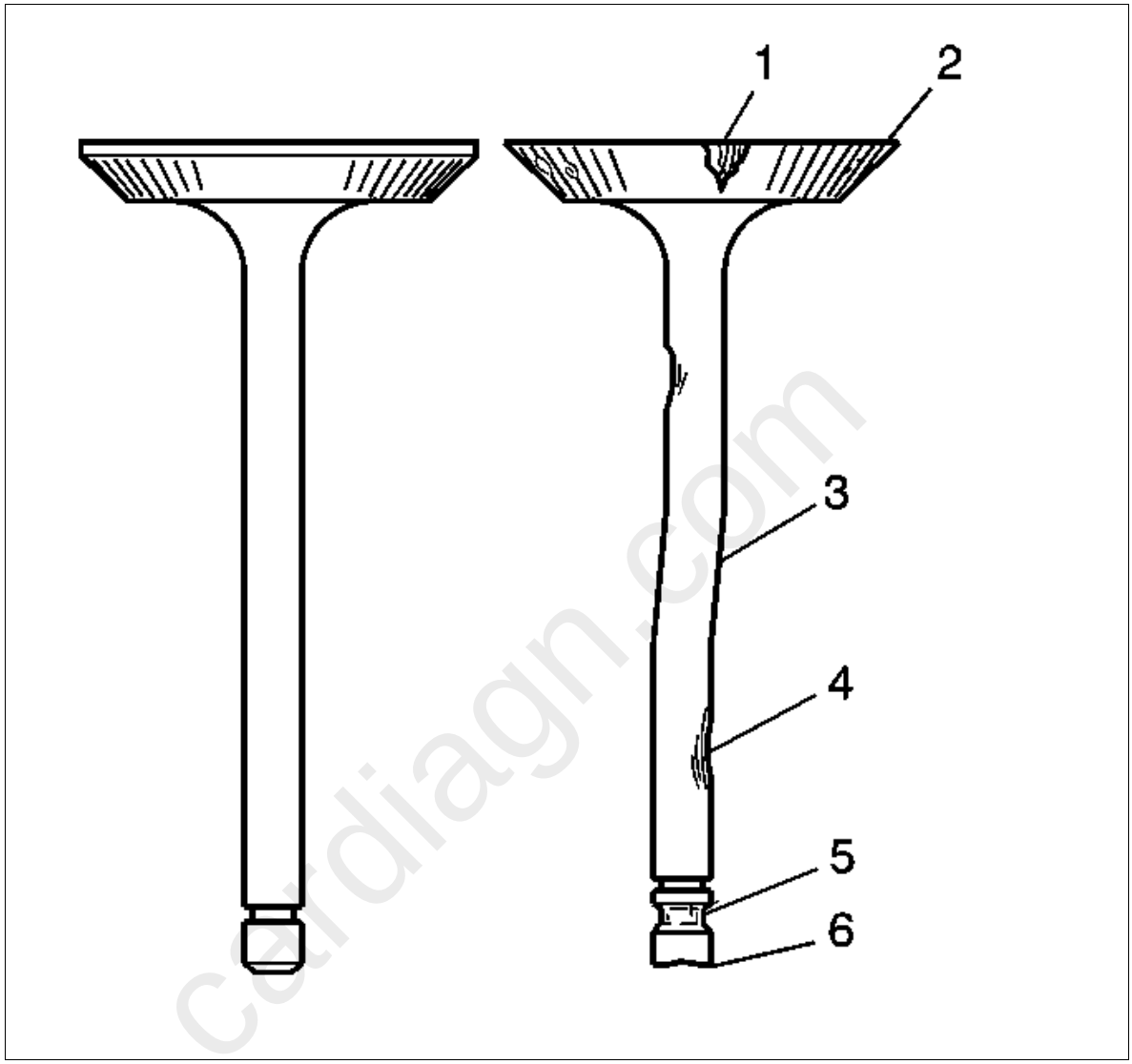
1. Measure the valve spring tension using the **EN 22738-B** tester. Refer to Engine Mechanical Specifications .
2. If low valve spring load is found, replace the valve springs. DO NOT use shims to increase spring load. The use of shims can cause the valve spring to bottom out before the camshaft lobe is at peak lift.

REPAIR INSTRUCTIONS - OFF VEHICLE > VALVE AND SEAT GRINDING > VALVE CLEANING PROCEDURE

1. Use soft bristle wire brush to clean any carbon build-up from the valve head. DO NOT use a wire brush on any part of the valve stem. The valve stem is chrome plated to provide enhanced wear characteristics. Wire brushing the stem could remove the chrome plating.
2. Thoroughly clean the valve with solvent and wipe dry.

REPAIR INSTRUCTIONS - OFF VEHICLE > VALVE AND SEAT GRINDING > VALVE VISUAL INSPECTION PROCEDURE

Fig 1: Inspection Points For Valves Damage



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Courtesy of GENERAL MOTORS COMPANY

1. Inspect the valve for damage from the head to tip for the following conditions:
    1. Pitting in the valve seat area (1)
    2. Lack of valve margin (2)
    3. Bending in the valve stem (3)
    4. Pitting or excessive wear in the stem (4)
    5. Worn valve key grooves (5)
    6. Worn valve tip (6)

2. Replace the valve if any of these conditions exist.

REPAIR INSTRUCTIONS - OFF VEHICLE > VALVE AND SEAT GRINDING > VALVE MEASUREMENT OVERVIEW

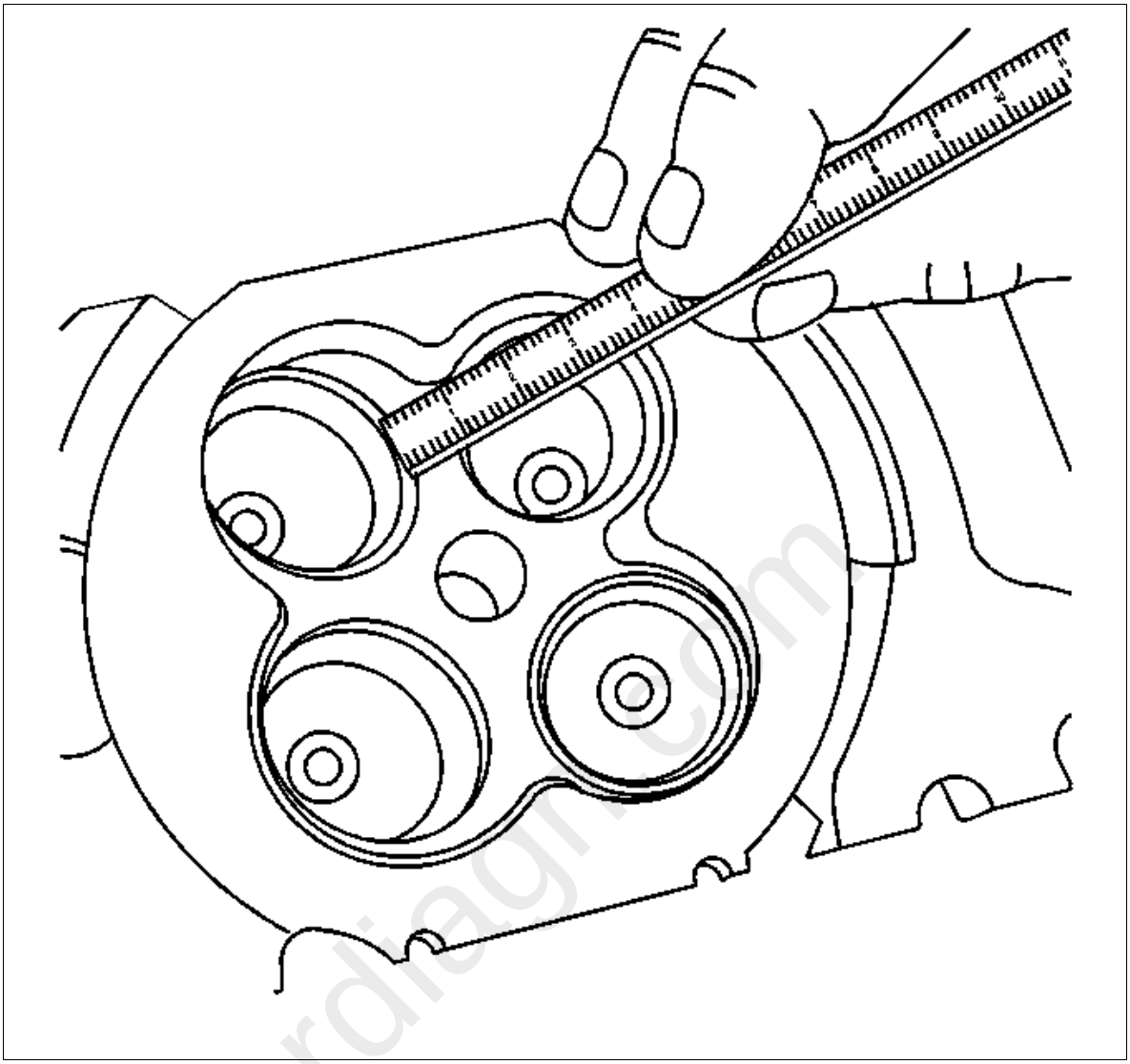
> *NOTE:*
>
> *The following measurement and reconditioning procedures must be followed to ensure proper engine performance.*

1. Proper valve service is critical to engine performance. Therefore, all detailed measurement procedures must be followed to identify components that are out of specification.
2. If the measurement procedures reveal that the valve seat must be reconditioned, it is critical to perform the measurement procedures after reconditioning. Valves for E85-compatible engines CANNOT be reconditioned. Any grinding, lapping, wire-brushing or other similar procedure will damage or destroy the coating that gives the valve the E-85 compatible features. If an E85-compatible valve is out of specification in any area, replace it.

REPAIR INSTRUCTIONS - OFF VEHICLE > VALVE AND SEAT GRINDING > VALVE SEAT WIDTH MEASUREMENT PROCEDURE

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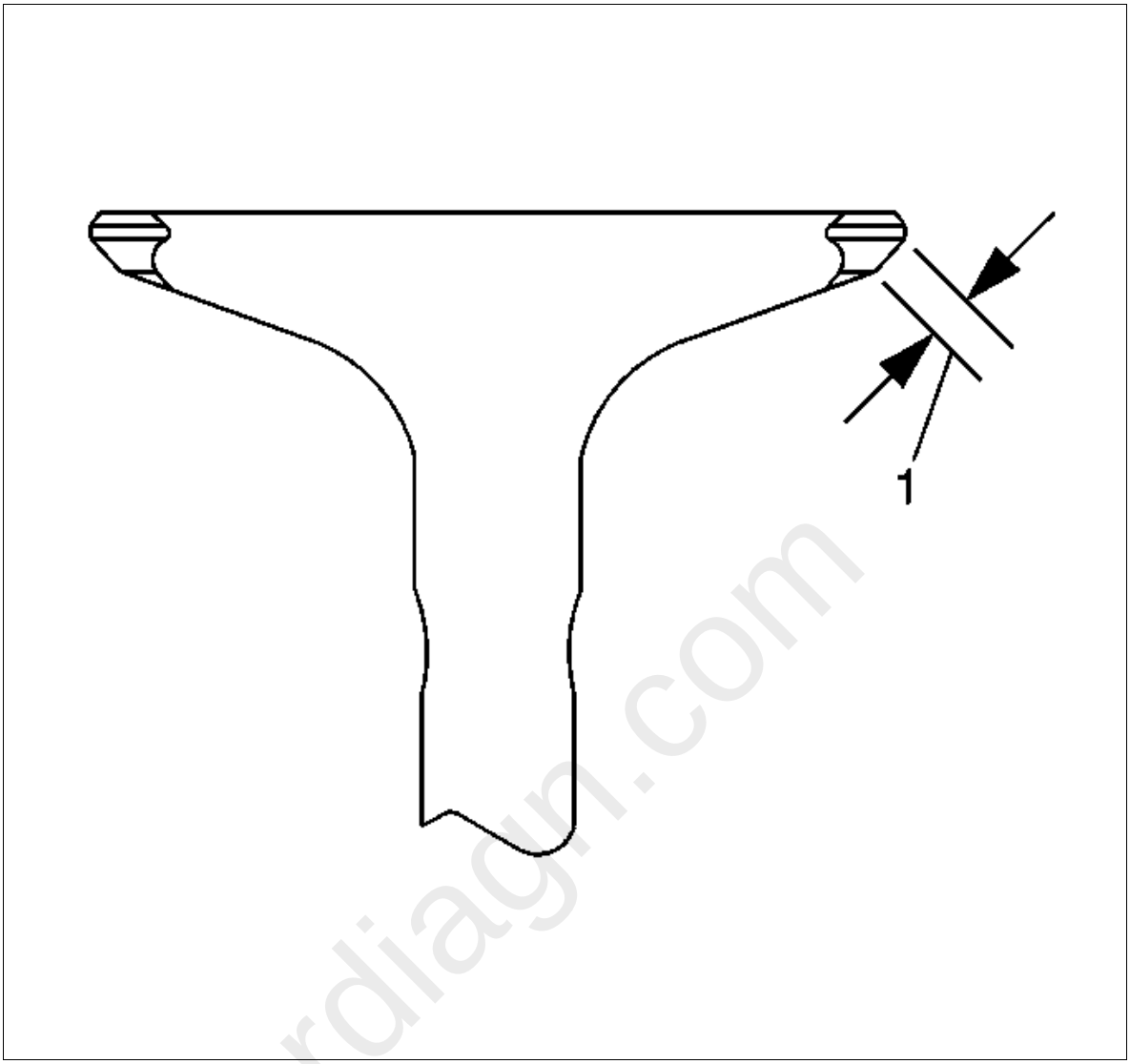
Fig 1: Valve Seat Width



Courtesy of GENERAL MOTORS COMPANY

1. Measure the valve seat width in the cylinder head using a proper scale.

Fig 2: Seat Width On Valve Face



Courtesy of GENERAL MOTORS COMPANY

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2. Measure the seat width on the valve face (1) using a proper scale.

> *NOTE:*
>
> *The seat contact area must be at least 0.5 mm (0.020 in) from the outer diameter (margin) of the valve. If the contact area is too close to the margins, the valve must be replaced.*

3. Compare your measurements with the specifications listed in Engine Mechanical Specifications .
4. If the seat widths are acceptable, check the valve seat roundness using the Valve Seat Roundness Measurement Procedure.
5. If the seat width is not acceptable, you must replace the valve. Proper valve seat width is

critical to providing the correct amount of valve heat dissipation.

REPAIR INSTRUCTIONS - OFF VEHICLE > VALVE AND SEAT GRINDING > VALVE SEAT ROUNDNESS MEASUREMENT PROCEDURE

1. Measure the valve seat roundness using a dial indicator attached to a tapered pilot installed in the guide. The pilot should have a slight bind when installed in the guide.

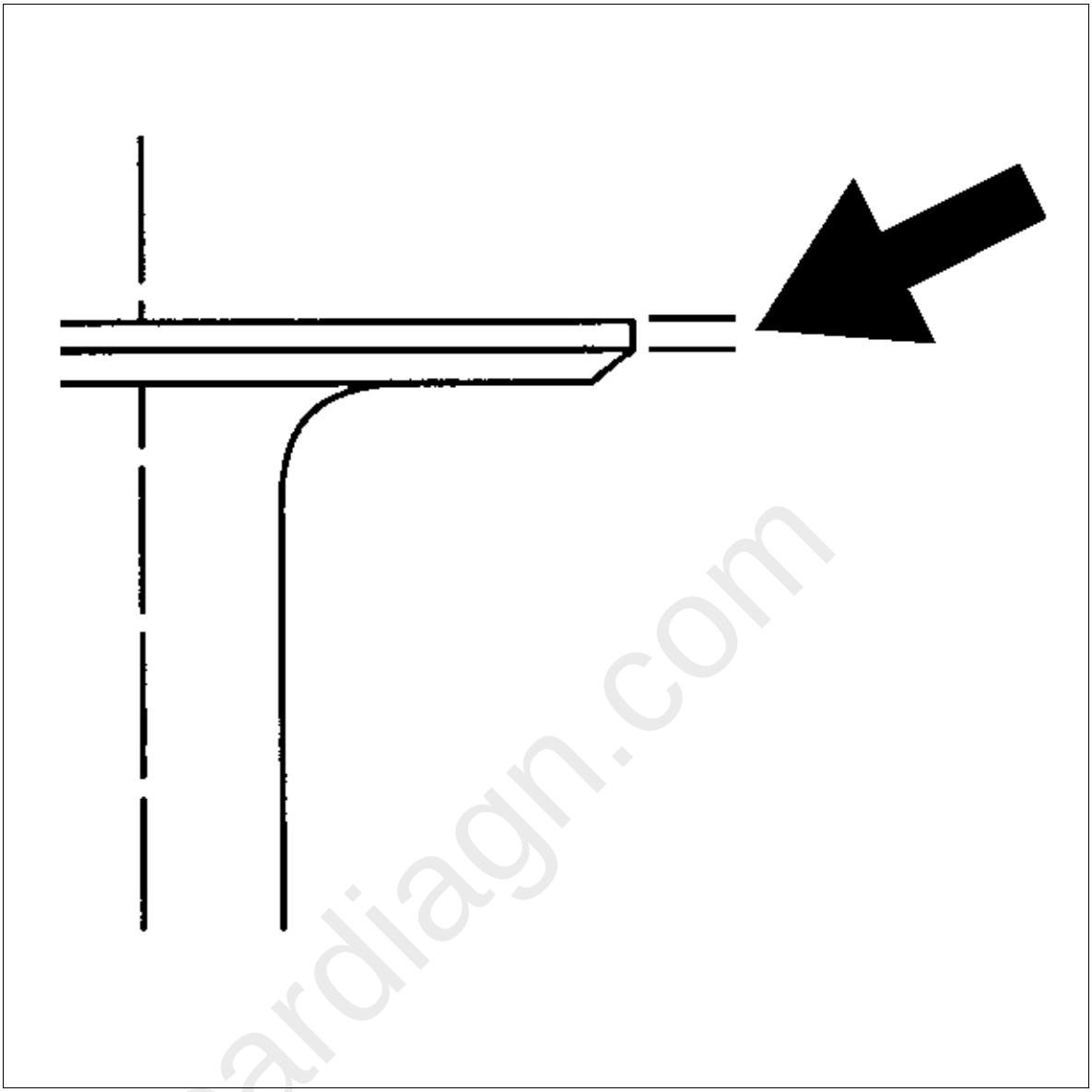
> ⚠ *CAUTION:*
>
> *The correct size pilot must be used. Do not use adjustable diameter pilots. Adjustable pilots may damage the valve guides.*

2. Compare your measurements with the specifications listed in Engine Mechanical Specifications .
3. If the valve seat exceeds the roundness specification, you must replace the valve.
4. If new valves are being used, the valve seat roundness must be within 0.05 mm (0.002 in).

REPAIR INSTRUCTIONS - OFF VEHICLE > VALVE AND SEAT GRINDING > VALVE MARGIN MEASUREMENT PROCEDURE

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Fig 1: Valve Margin Measurement



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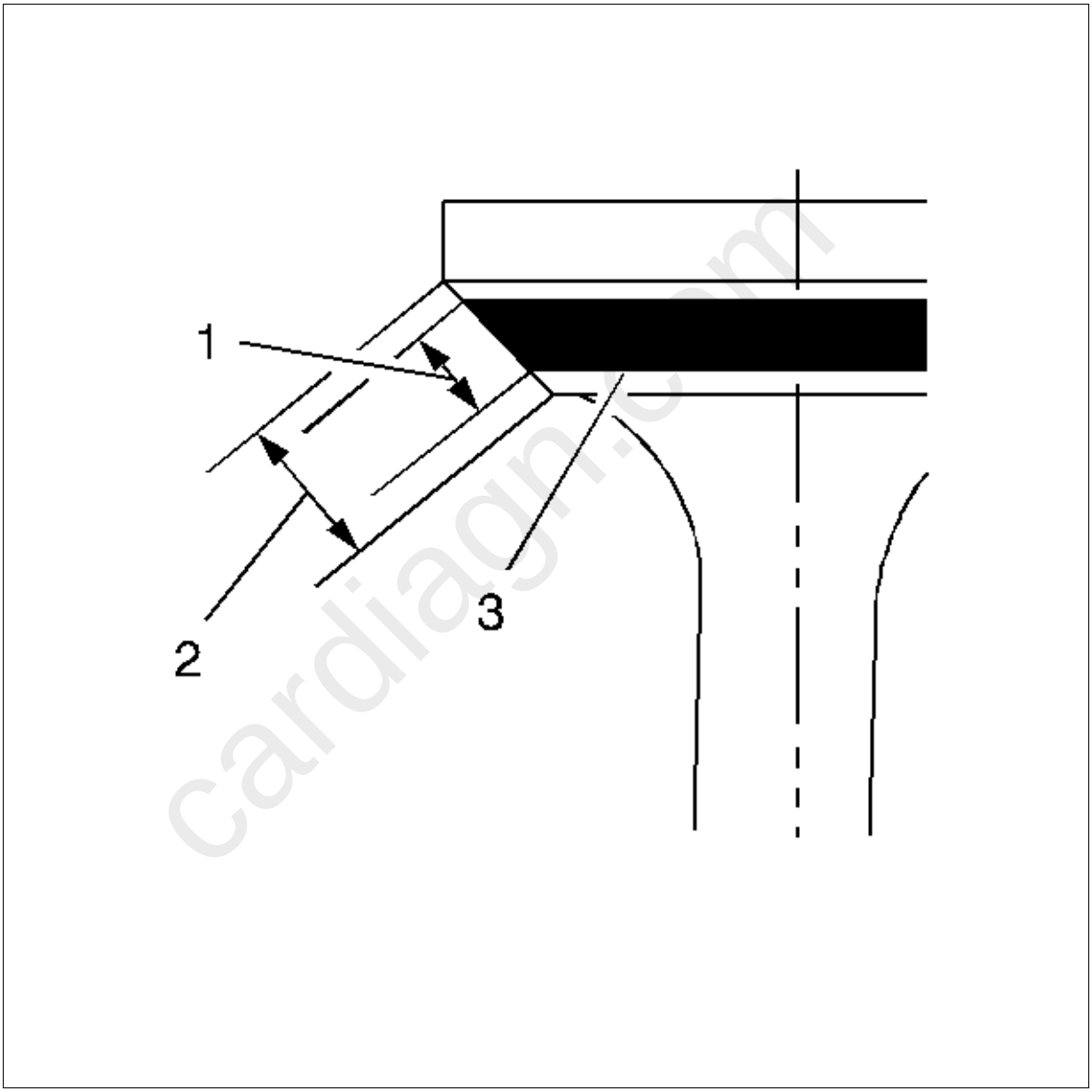
1. Measure the valve margin using an appropriate scale.
2. Reference the specifications in this section for minimum valve margin and compare them to your measurements.
3. If the valve margins are beyond specification, replace the valves.
4. If the valve margins are within specification, test the valve for seat concentricity using the Valve-to-Seat Concentricity Measurement Procedure.

REPAIR INSTRUCTIONS - OFF VEHICLE > VALVE AND SEAT GRINDING > VALVE-TO-SEAT CONCENTRICITY MEASUREMENT PROCEDURE

NOTE:

1. *Checking the valve-to-seat concentricity determines whether the valve and seat are sealing properly.*
2. *You must measure the valve face and the valve seat to ensure proper valve sealing.*

Fig 1: Valve Contact Face Measurements



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1. Coat the valve face lightly with blue dye (3).
2. Install the valve in the cylinder head.
3. Turn the valve against the seat with enough pressure to wear off the dye.

4. Remove the valve from the cylinder head.
5. Inspect the valve face.
    1. If the valve face is concentric, providing a proper seal-with the valve stem, a continuous mark will be made around the entire face (1).

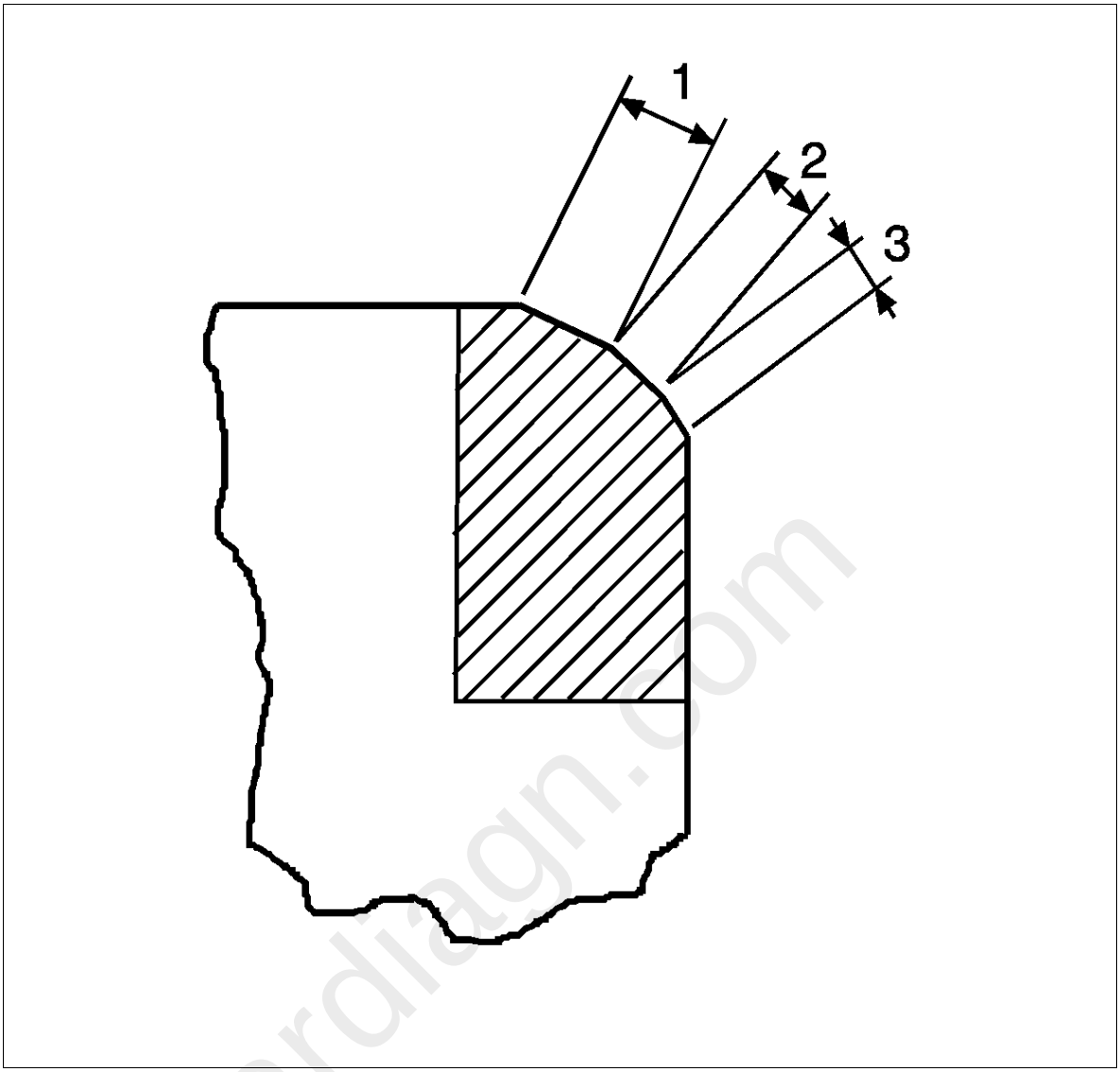
> *NOTE:*
>
> *The wear mark MUST be at least 0.5 mm (0.020 in) from the outer diameter, the margin, of the valve. If the wear mark is too close to the margin, the seat must be reconditioned to move the contact area away from the margin.*

    2. If the face is not concentric with the stem, the mark will NOT be continuous around the valve face. The valve should be replaced and the seat must be reconditioned using the Valve and Seat Reconditioning Procedure.

REPAIR INSTRUCTIONS - OFF VEHICLE > VALVE AND SEAT GRINDING > VALVE AND SEAT RECONDITIONING PROCEDURE

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Fig 1: Valve Seat Proper Angles



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NOTE:

1. *If the valve seat width, roundness or concentricity is beyond specifications, you must grind the seats in order to ensure proper heat dissipation and prevent the buildup of carbon on the seats.*
2. *A NEW valve must be used with any reconditioned seat.*

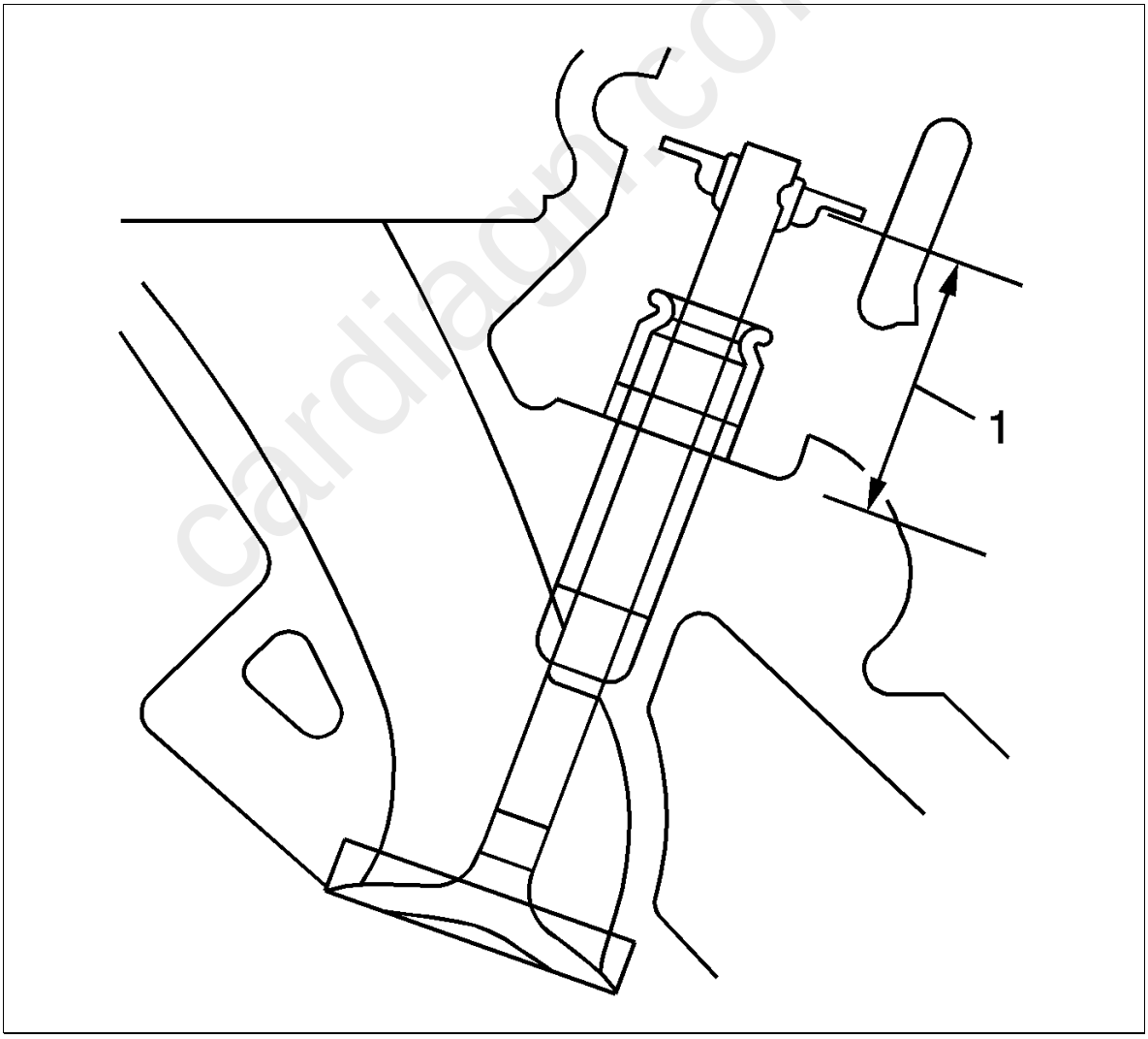
1. Grind the valve seats (2) to the proper angle specification listed in Engine Mechanical Specifications .
2. Using the proper angle specification listed in Engine Mechanical Specifications , grind, relieve, the valve seats (1) to correctly position the valve seating surface (2) to the valve.
3. Using the proper angle specification listed in Engine Mechanical Specifications , grind, undercut, the valve seats (3) to narrow the valve seat widths to the specifications listed in

Engine Mechanical Specifications .

4. When grinding the seats, grind off as little material as possible. Cutting valve seat results in lowering the valve spring pressure.
5. Install the valve in the cylinder head. Do not lap the valves under any condition, whether the valves are new or used.
6. After obtaining the proper valve seat width in the cylinder head, you must re-measure the valve stem height using the Valve Stem Height Measurement Procedure.
7. If the valve stem height is acceptable, test the seats for concentricity using the Valve-to-Seat Concentricity Measurement Procedure.

REPAIR INSTRUCTIONS - OFF VEHICLE > VALVE AND SEAT GRINDING > VALVE STEM HEIGHT MEASUREMENT PROCEDURE

Fig 1: Valve Stem Height



Courtesy of GENERAL MOTORS COMPANY

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> *NOTE:*
>
> *To determine the valve stem height measurement, measure from the valve spring seat to the valve spring retainer.*

1. Install the valve into the valve guide.
2. Ensure the valve is seated to the cylinder head valve seat.
3. Install the valve stem oil seal.
4. Install the valve spring retainer and valve stem locks.
5. Measure the distance (1) between the cylinder head to the bottom of the valve spring retainer. Refer to Engine Mechanical Specifications .
6. If the maximum height specification is exceeded, a new valve should be installed and the valve stem height re-measured.

> *CAUTION:*
>
> *DO NOT grind the valve stem tip. The tip of the valve is hardened and grinding the tip will eliminate the hardened surface causing premature wear and possible engine damage.*

> *CAUTION:*
>
> *DO NOT use shims in order to adjust valve stem height. The use of shims will cause the valve spring to bottom out before the camshaft lobe is at peak lift and engine damage could result.*

7. If the valve stem height still exceeds the maximum height specification, the cylinder head must be replaced.

REPAIR INSTRUCTIONS - OFF VEHICLE > FUEL RAIL AND INJECTORS CLEANING AND INSPECTION

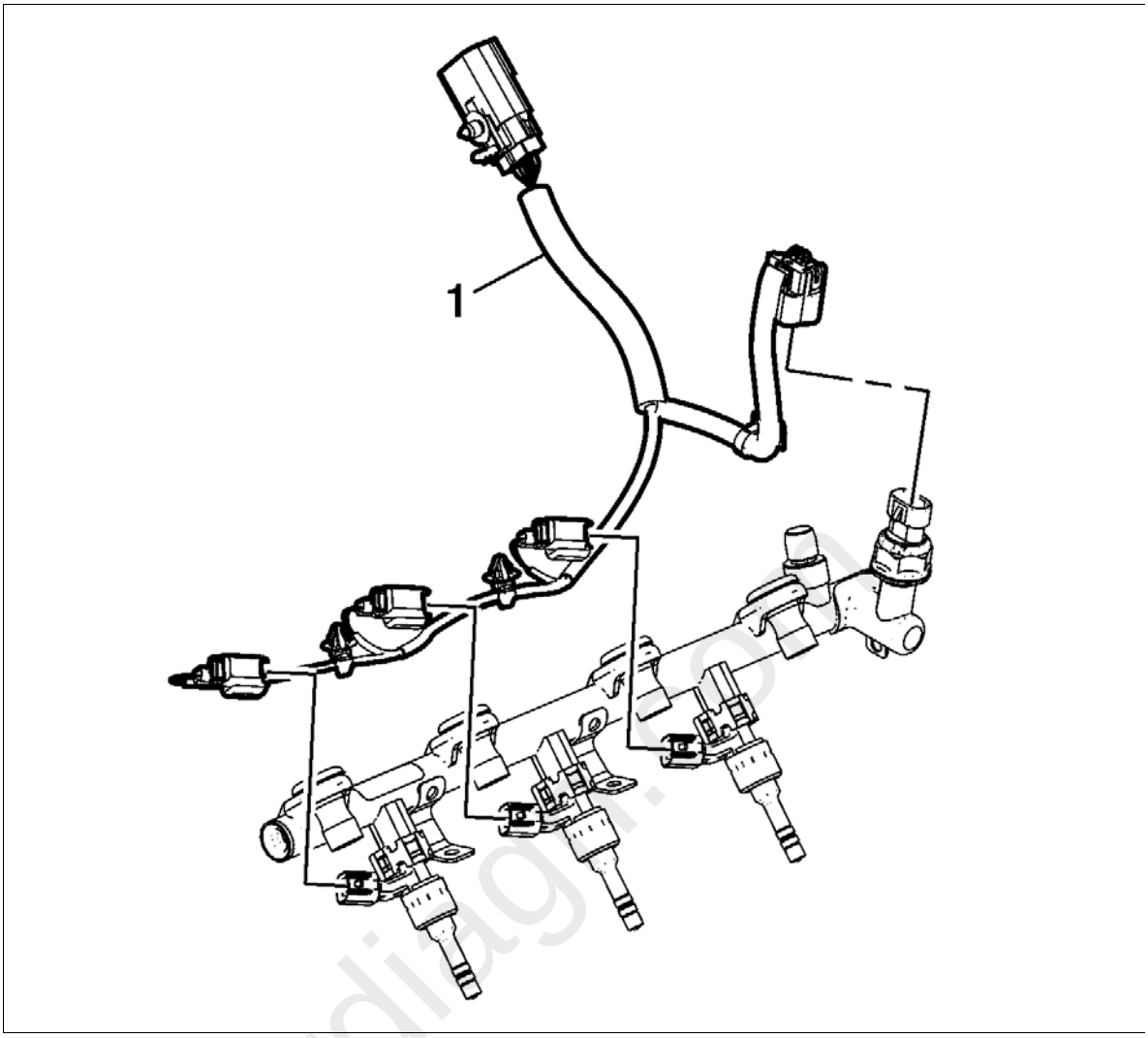
Special Tools

- **EN 49245** Injector Seal Installer Kit

For equivalent regional tools, refer to Special Tools .

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Fig 1: Fuel Rail Wiring Harness

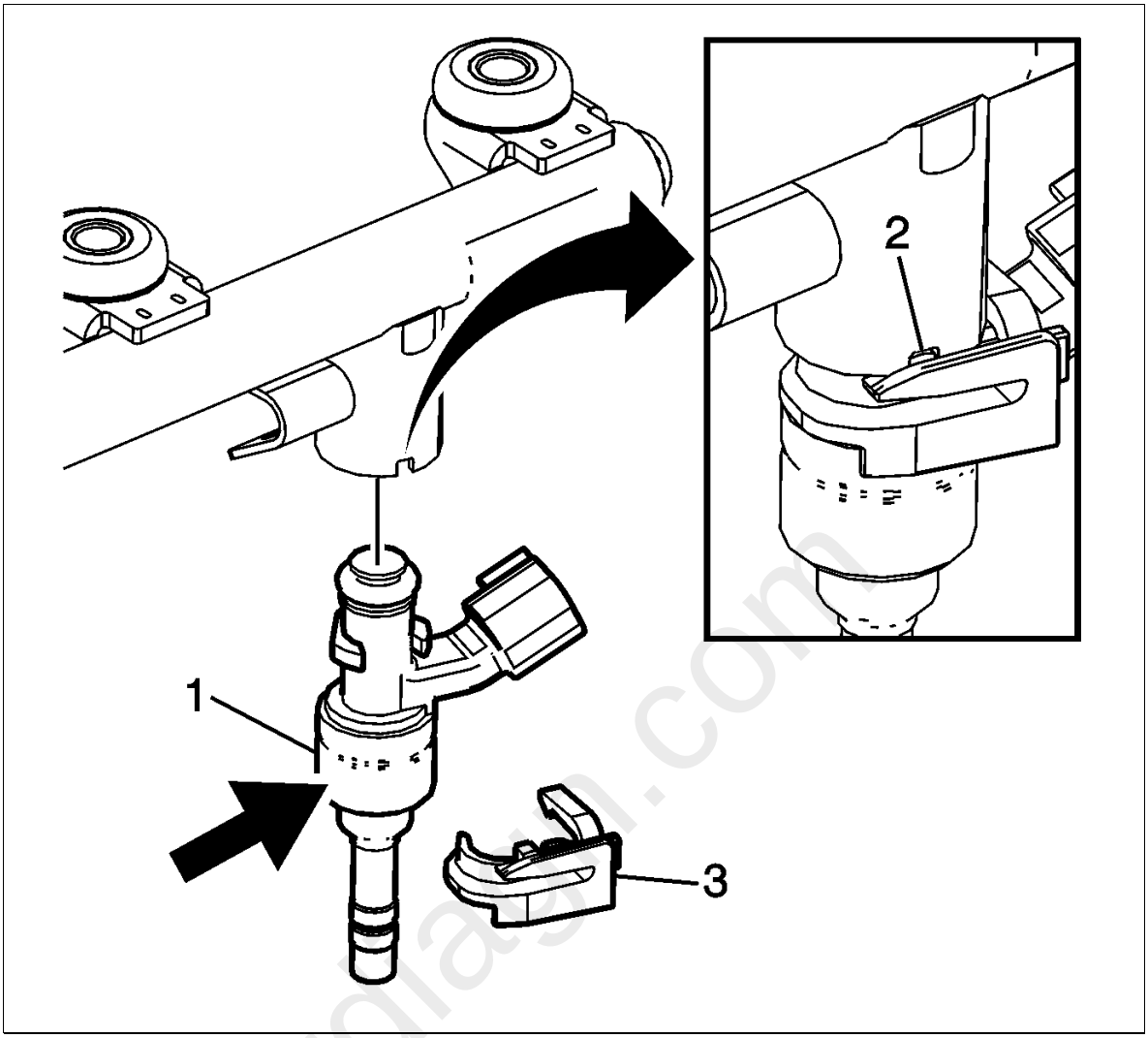


Courtesy of GENERAL MOTORS COMPANY

1. Disconnect and remove the fuel rail wiring harness (1).

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Fig 2: Fuel Injector

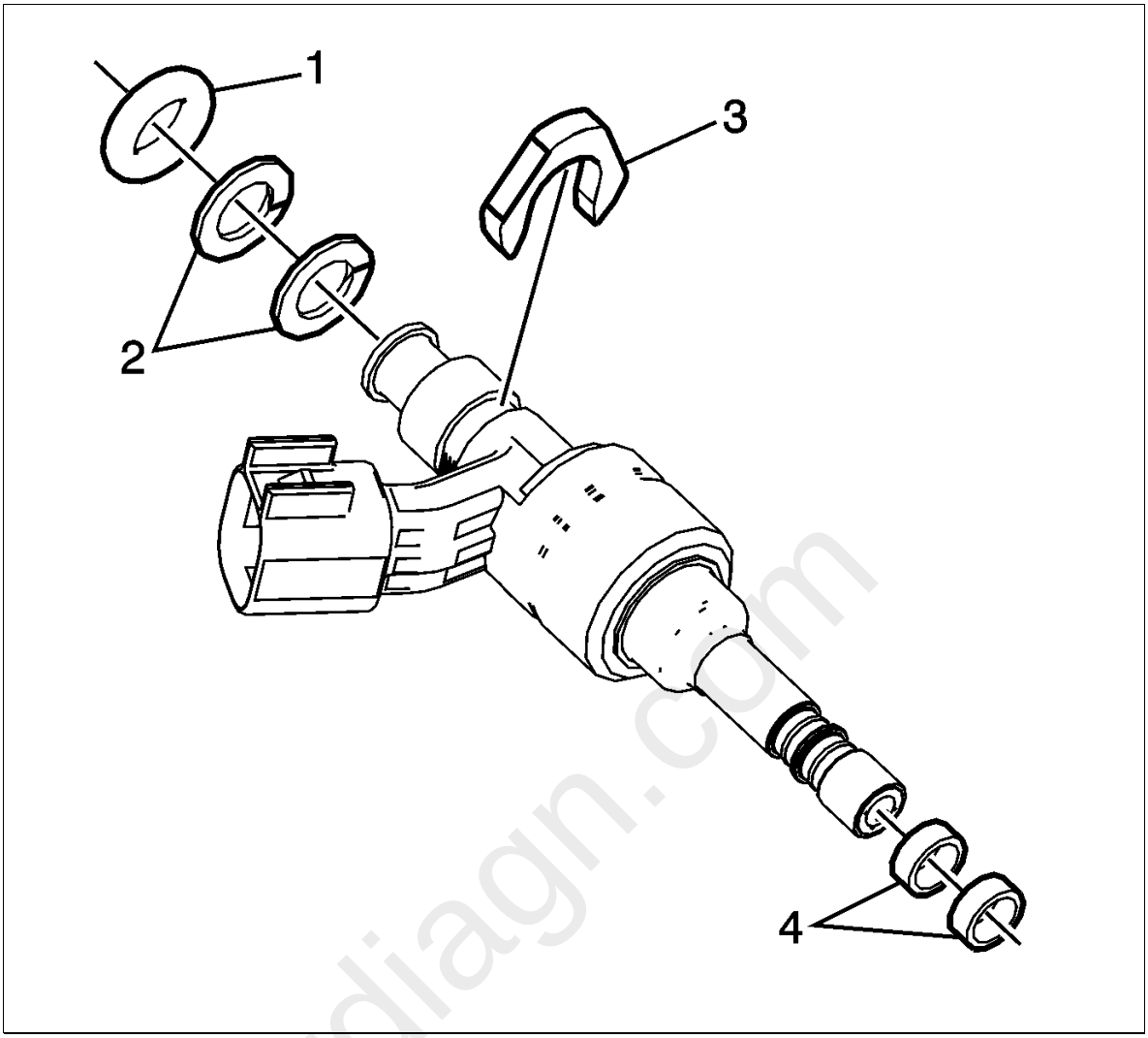


Courtesy of GENERAL MOTORS COMPANY

2. Taking care not to touch or apply force to the injector tip or electrical connector, remove the fuel injector (1) by pressing down on the retainer lever to release the tab (2) and simultaneously rotating the injector 45 degrees and pulling straight out from the fuel rail.

3. Remove the retainer (3) from the fuel injector and discard.

Fig 3: Fuel Injector Components



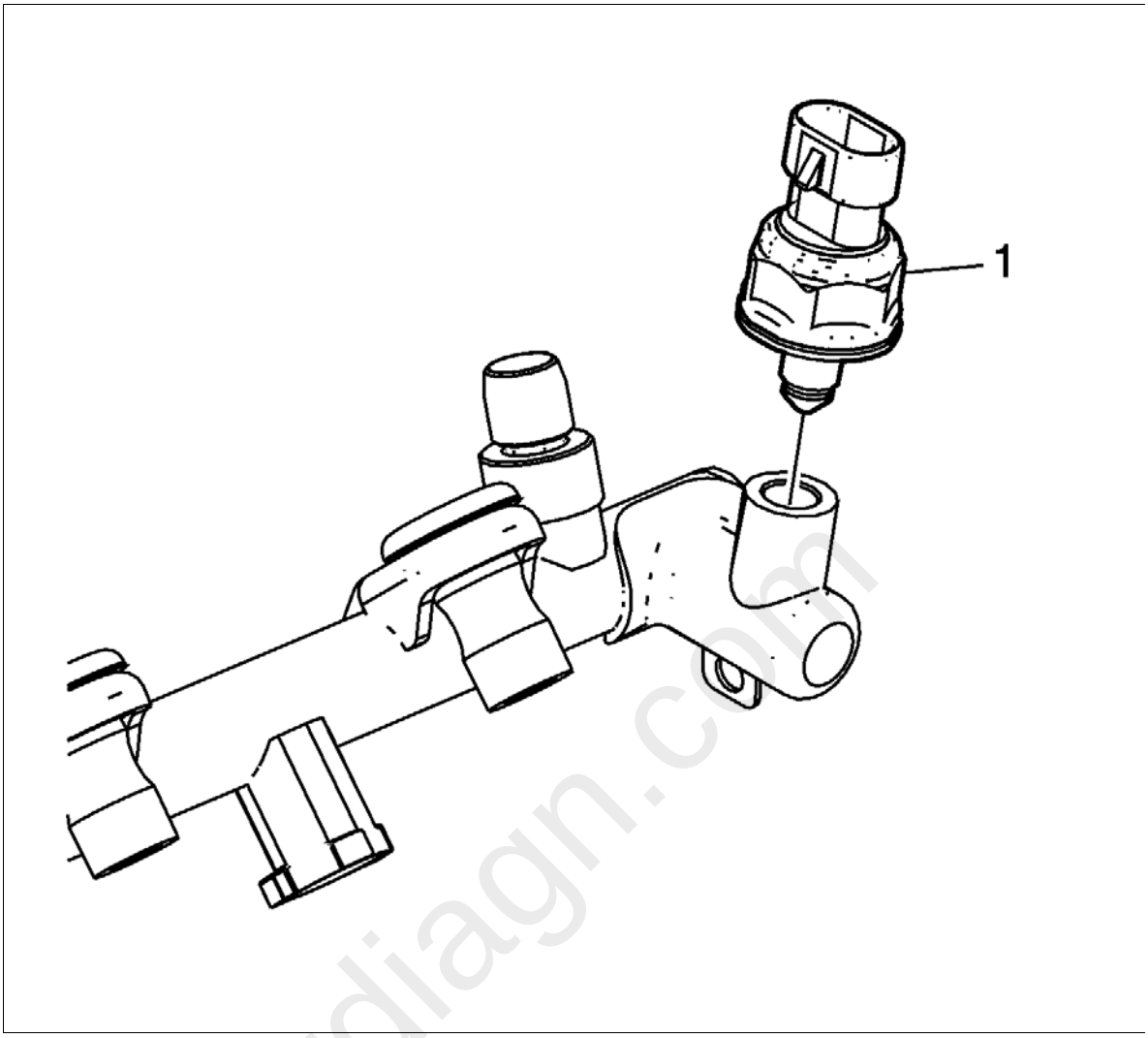
Courtesy of GENERAL MOTORS COMPANY

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4. Using pliers, remove the fuel injector bushing (3) straight out from injector body. Discard bushing (3). Remove and discard the fuel injector O-ring (1) and plastic spacers (2).

5. Remove and discard the fuel injector seals (4).

Fig 4: Fuel Pressure Sensor



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NOTE:

Applying force to the plastic housing of the sensor will destroy the sensor. To tighten or loosen, only apply force to the attached hexagon.

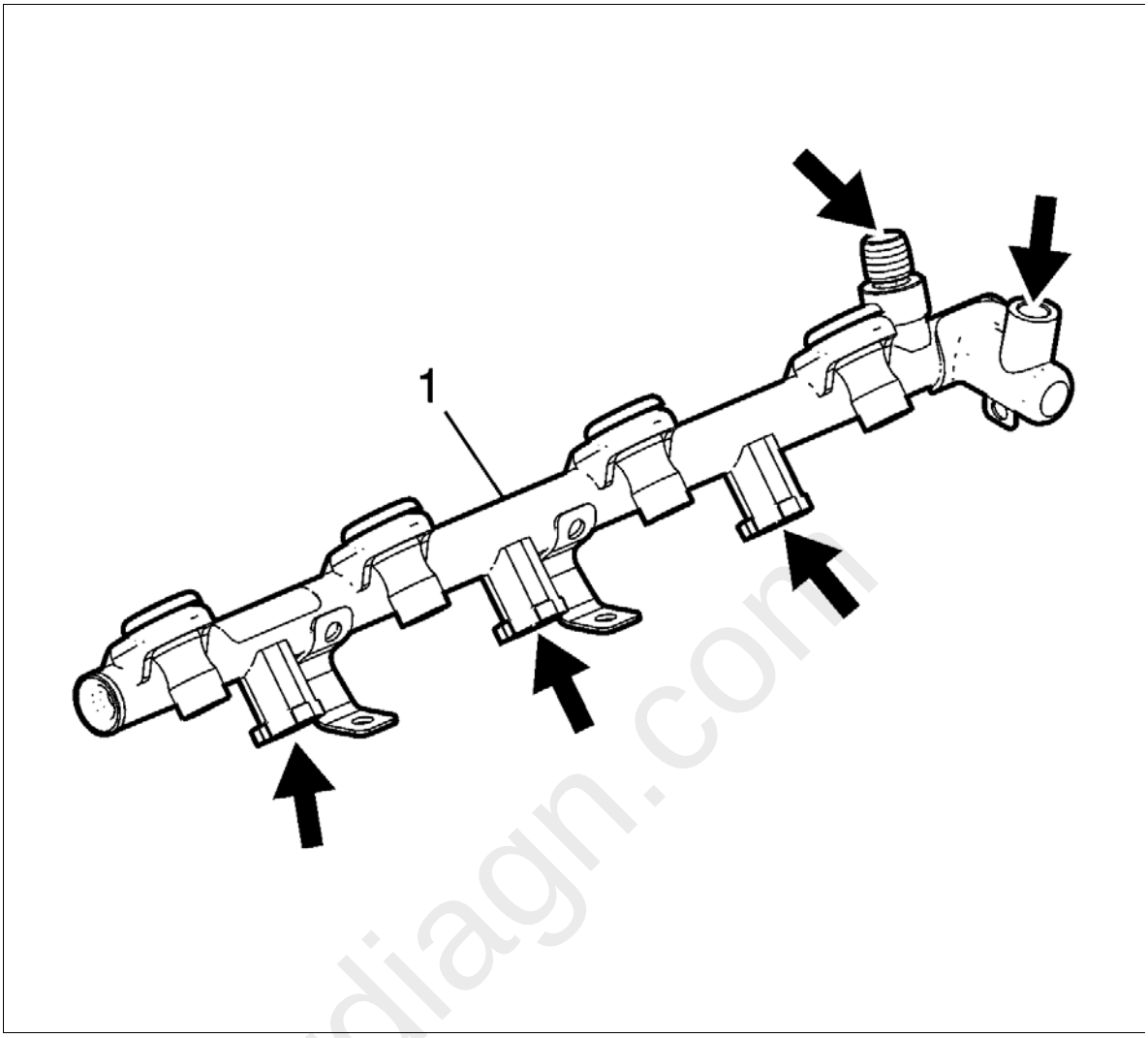
6. Remove the fuel pressure sensor (1).

NOTE:

Do not soak or submerge the fuel rail or injectors in solvent.

7. Clean the exterior of the fuel rail and injectors with solvent.

Fig 5: Fuel Rail Inspection Areas

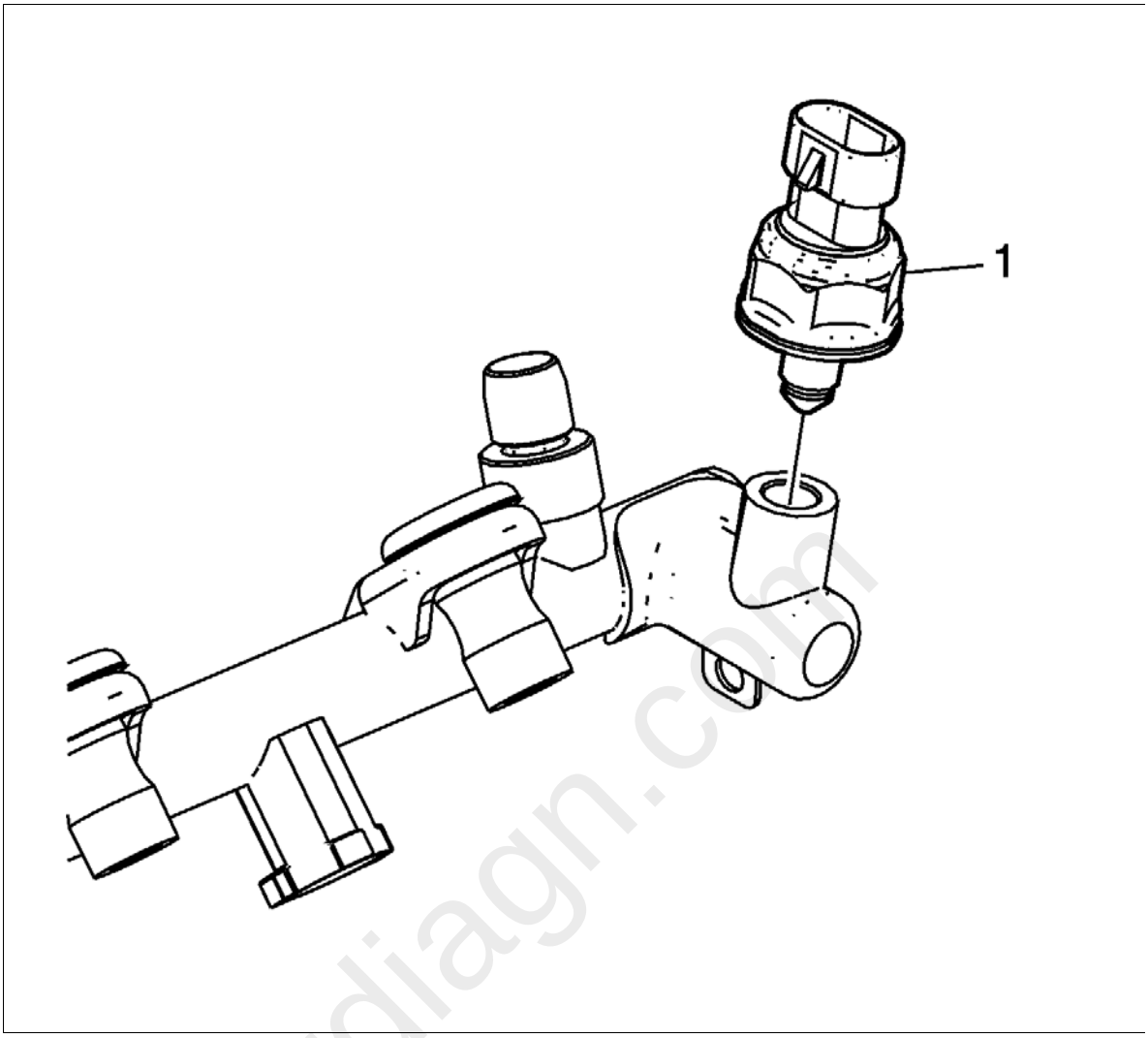


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8. Inspect the fuel rail (1) and components for the following conditions:
    1. Damage, debris or restrictions to the fuel rail
    2. Damage, debris or restrictions to the fuel ports in the fuel rail
    3. Damage to the mounting area for the fuel rail
    4. Damage to the fuel rail mounting bolts or mounting bolt grommets/isolators
    5. Damage to the threads on the fuel rail feed fitting
    6. Damage to the threads in the fuel pressure sensor bore
    7. Damage to the fuel pressure sensor connector, threads, or sealing face

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Fig 6: Fuel Pressure Sensor



Courtesy of GENERAL MOTORS COMPANY

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NOTE:

Applying force to the plastic housing of the sensor will destroy the sensor. To tighten or loosen, only apply force to the attached hexagon.

9. Install the fuel pressure sensor (1).

NOTE:

Ensure that the fuel rail threads have been cleaned of any excess fuel or the fuel pressure sensor will NOT seal properly.

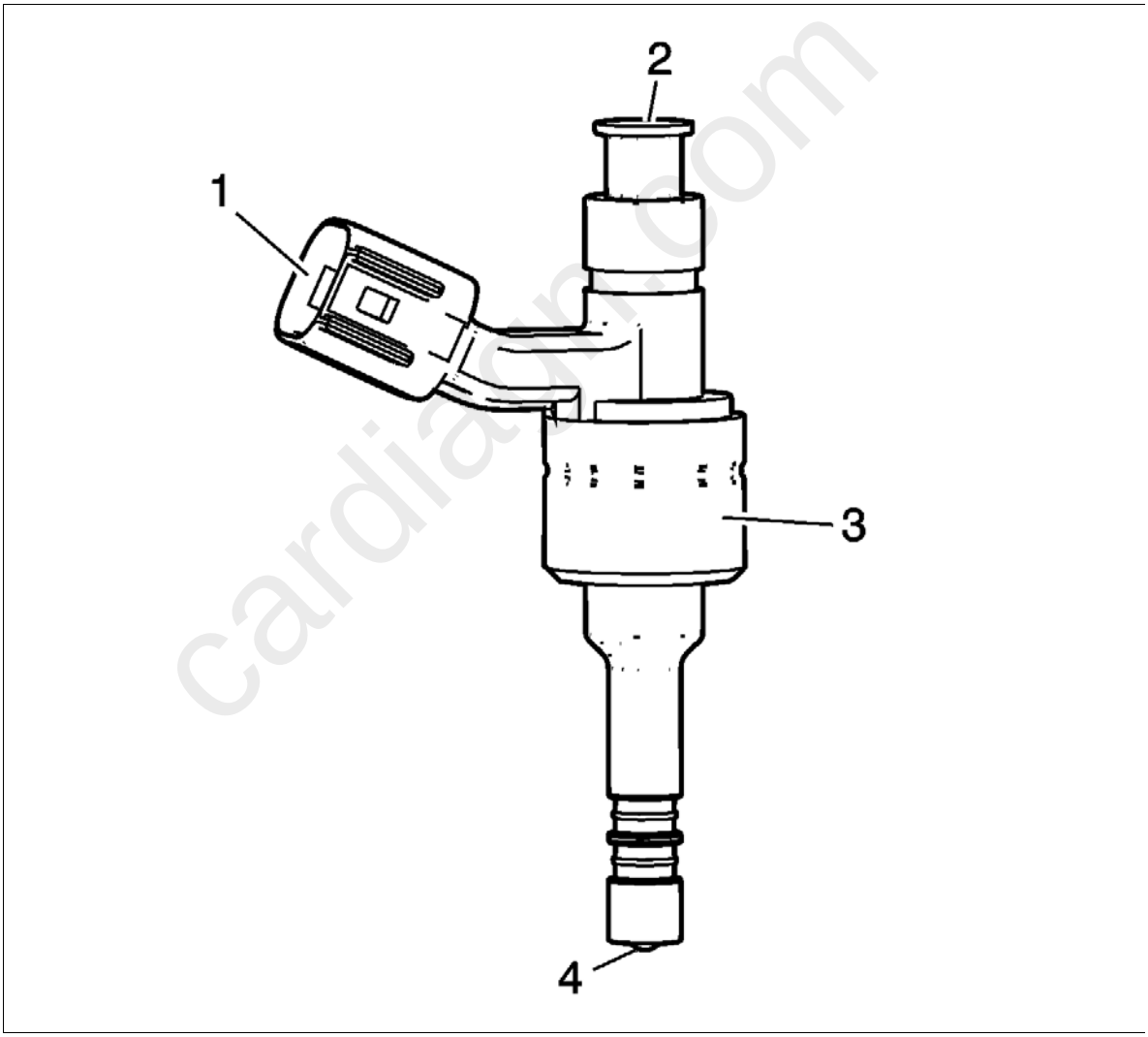
1. Lubricate the threads and the sealing area in the fuel rail with silicon free engine oil. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended lubricant.

2. Lubricate the threads and the sealing area on the fuel pressure sensor with silicon free engine oil. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended lubricant.
3. Install the fuel pressure sensor hand tight.
4. Remove the fuel pressure sensor and re-lubricate.

> ⚠ *CAUTION:*
>
> *Refer to Fastener Caution .*

5. Install the fuel pressure sensor and tighten to 33 N.m (25 lb ft).

Fig 7: Fuel Injector Components



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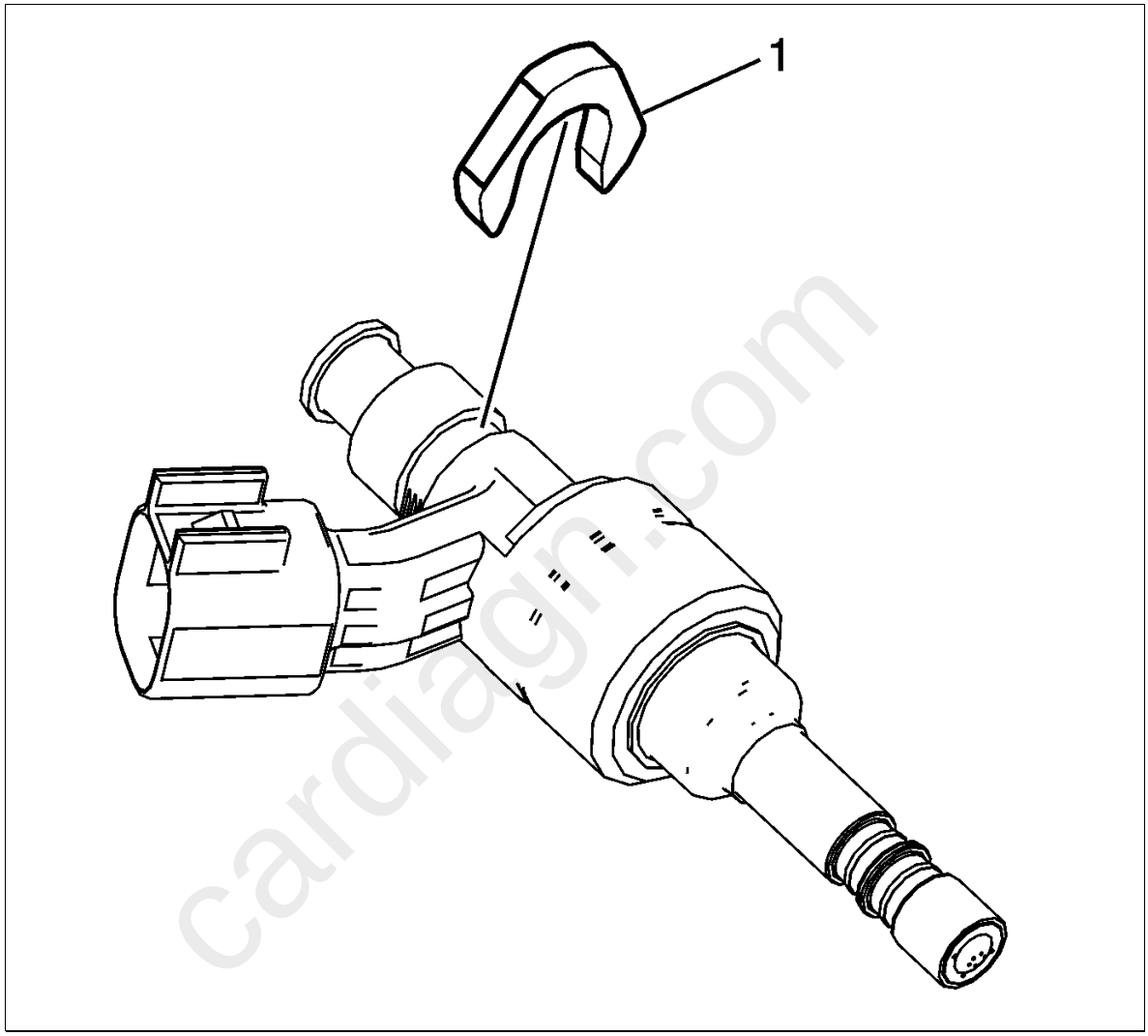
Courtesy of GENERAL MOTORS COMPANY

10. Inspect the fuel injectors for the following conditions:
    1. Damage to the fuel injector connector (1)

2. Damage to the fuel inlet cone (2)
3. Damage to the fuel injector body (3)
4. Damage to the fuel injector tip (4)

11. Replace the fuel rail or injector if any damage is found. Do not attempt to repair a fuel rail or injector.

Fig 8: Fuel Injector Bushing



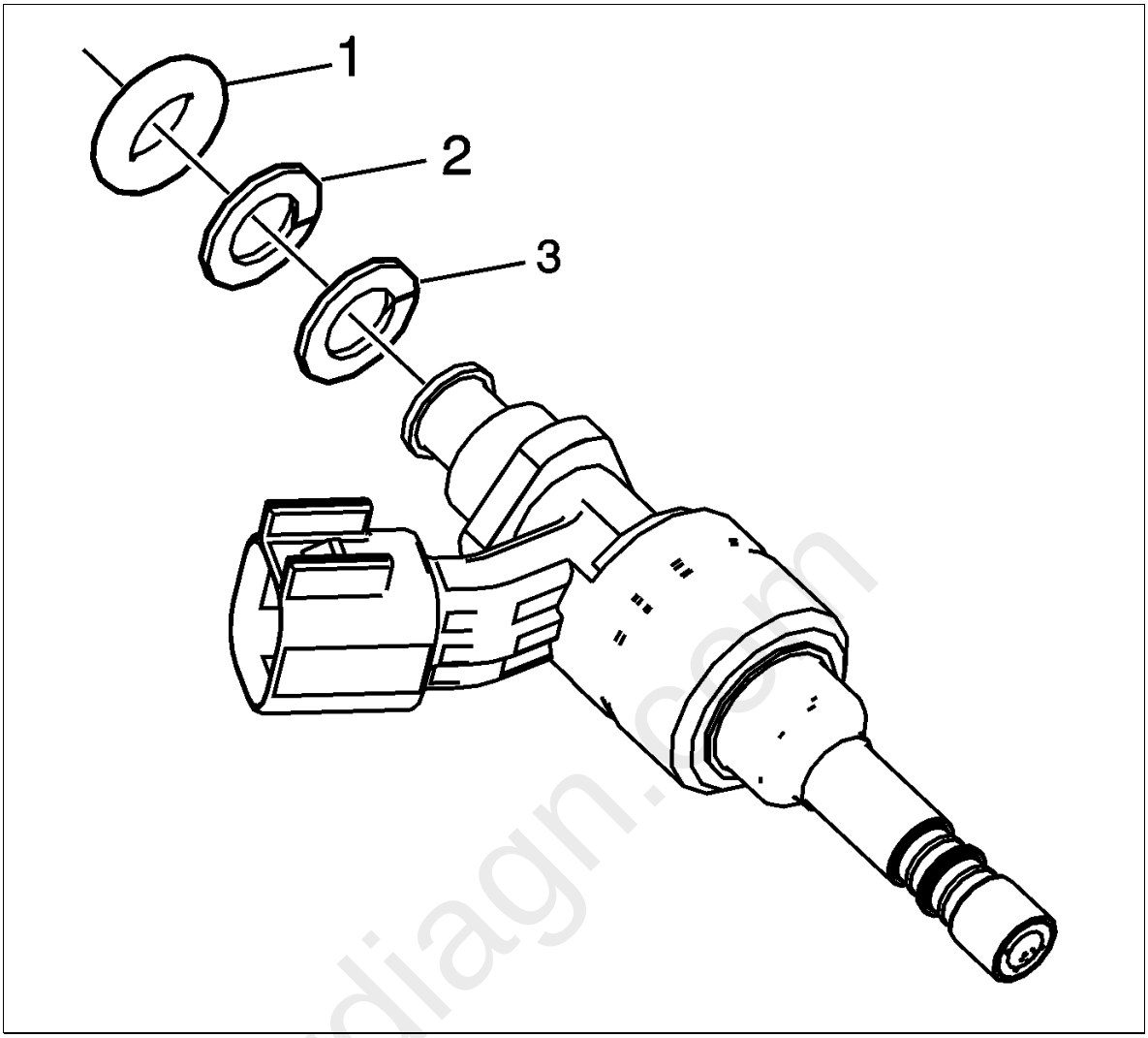
Courtesy of GENERAL MOTORS COMPANY

NOTE:

The fuel injector bushing (1) is to be installed BEFORE O-ring or backup rings are installed.

12. Install NEW fuel injector bushing (1) onto injector body. Bushing should seat with a distinct "snap" sound and feel. Ensure bushing is fully seated.

Fig 9: Injector And Components

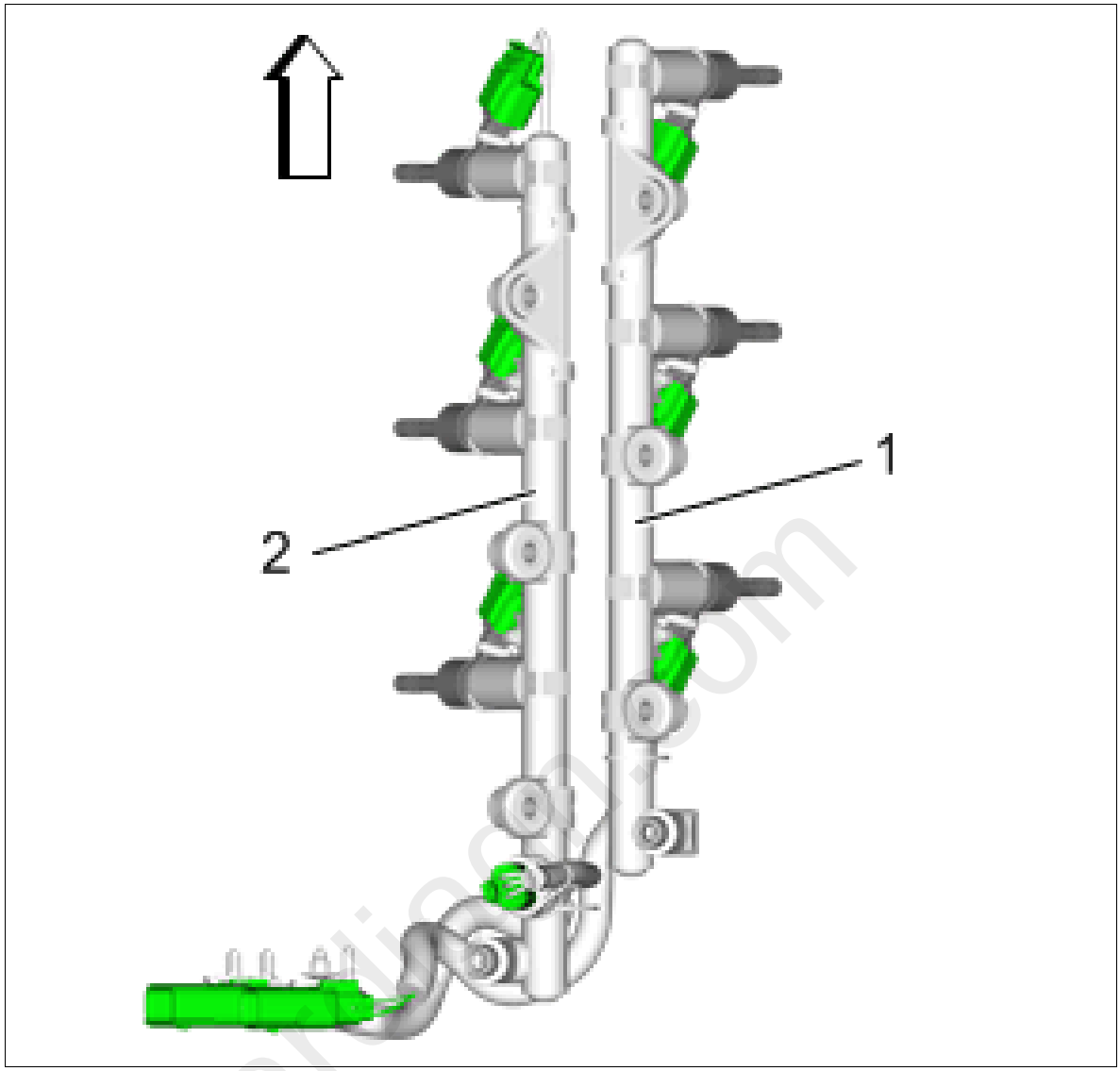


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13. Install the NEW white plastic spacer (3) on the fuel injector first.
14. Install the brown plastic spacer (2) second.
15. Lubricate the NEW O-ring (1) with one drop of clean engine oil.

Fig 10: Fuel Injector Wiring Harness Connectors



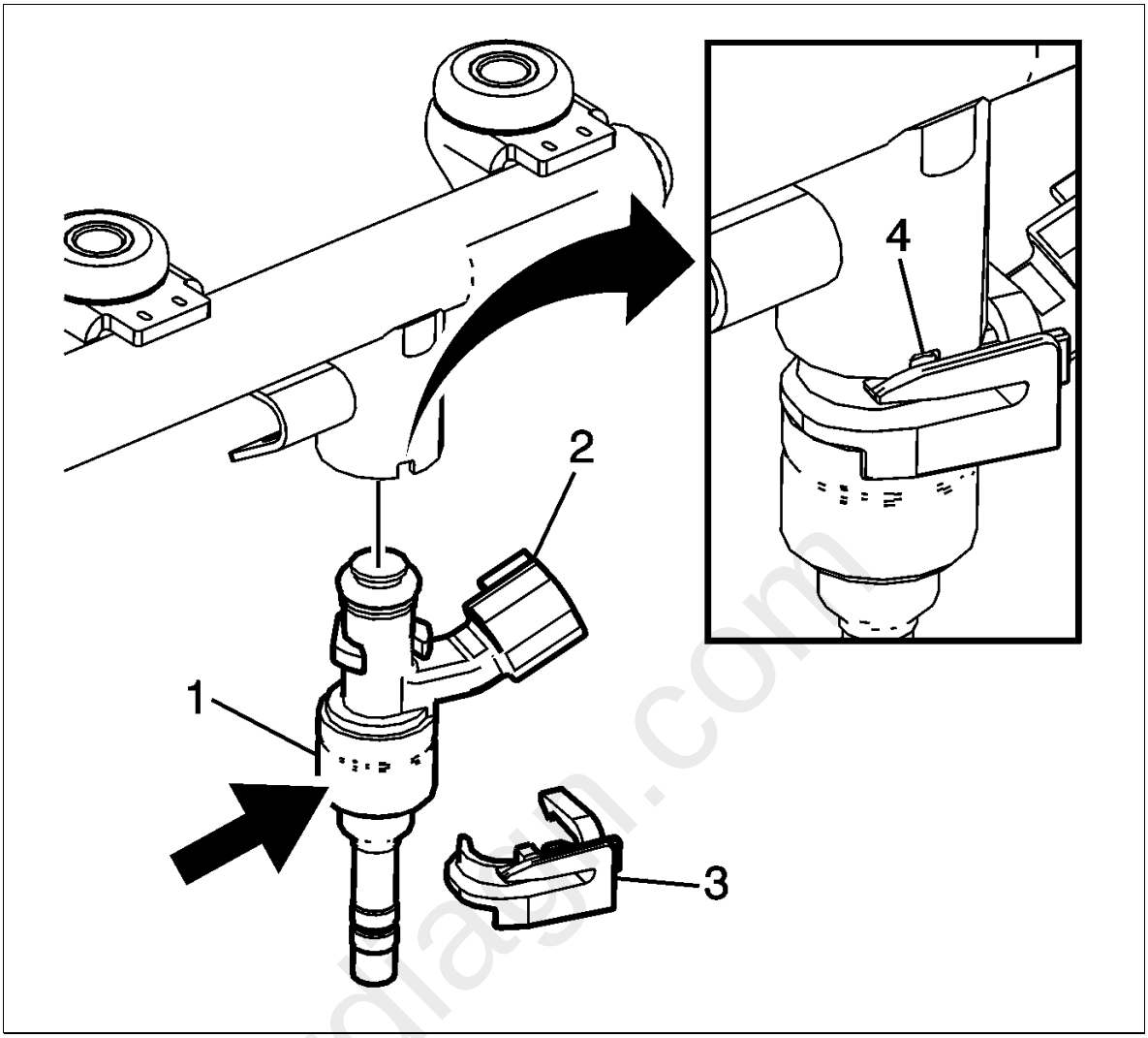
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> ⚠ *CAUTION:*
>
> *Ensure the fuel injectors are installed in the correct orientation. Improper orientation of the fuel injectors may result in engine misfire and possible engine damage.*

16. The right side (bank 1) fuel injector wiring harness connectors (1) should point to the rear of the engine. The left side (bank 2) fuel injector wiring harness connectors (2) should point to the front of the engine.

Fig 11: Injector Retainer

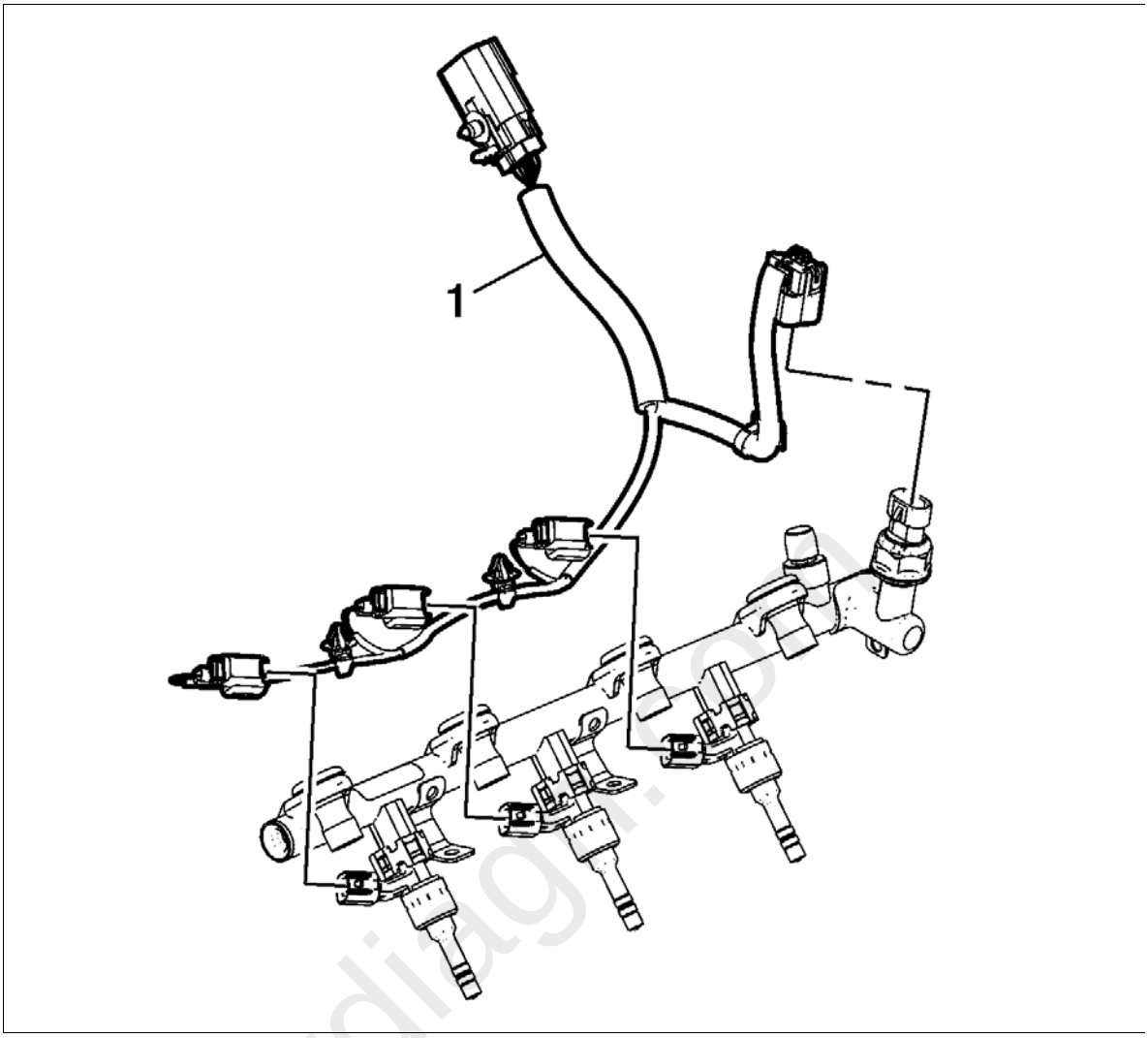


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17. Install NEW retainer (3) onto the fuel injector.
18. Holding the largest diameter/body of the injector only, indicated by arrow in graphic, insert the injector assembly (1) into the fuel rail. Ensure correct orientation of the electrical connector (2).
19. Rotate the fuel injector approximately 45 degrees until the tab on the retainer (4) locks into the notch on the fuel rail.
20. Repeat for remaining injectors until all are installed and retained in fuel rail.

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Fig 12: Fuel Rail Wiring Harness

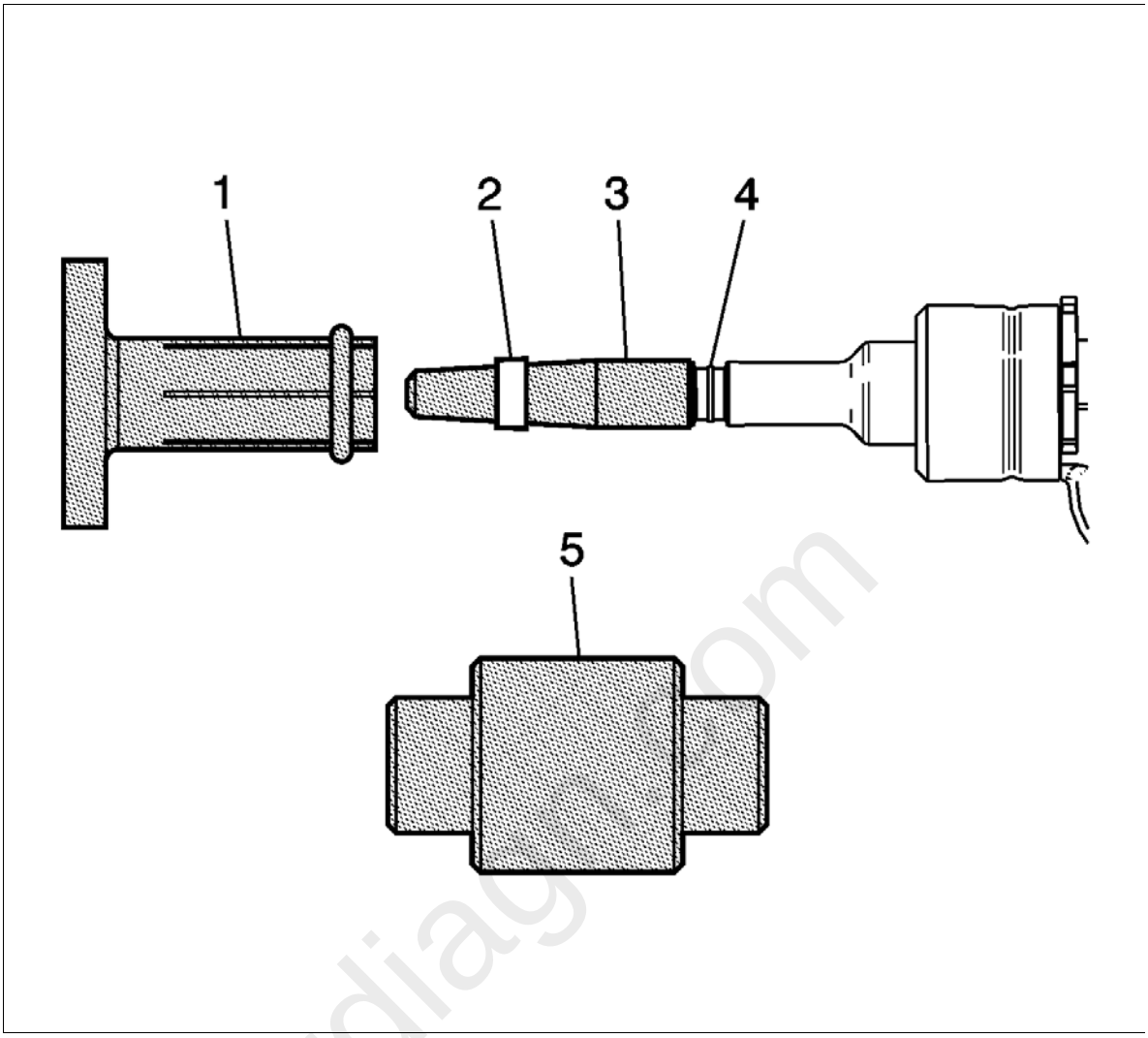


Courtesy of GENERAL MOTORS COMPANY

21. Install the fuel rail wiring harness (1).

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Fig 13: Fuel Injector Tip & Seals



Courtesy of GENERAL MOTORS COMPANY

NOTE:

Do not use any type of lubricant when installing the NEW seals (2) on the fuel injector tip.

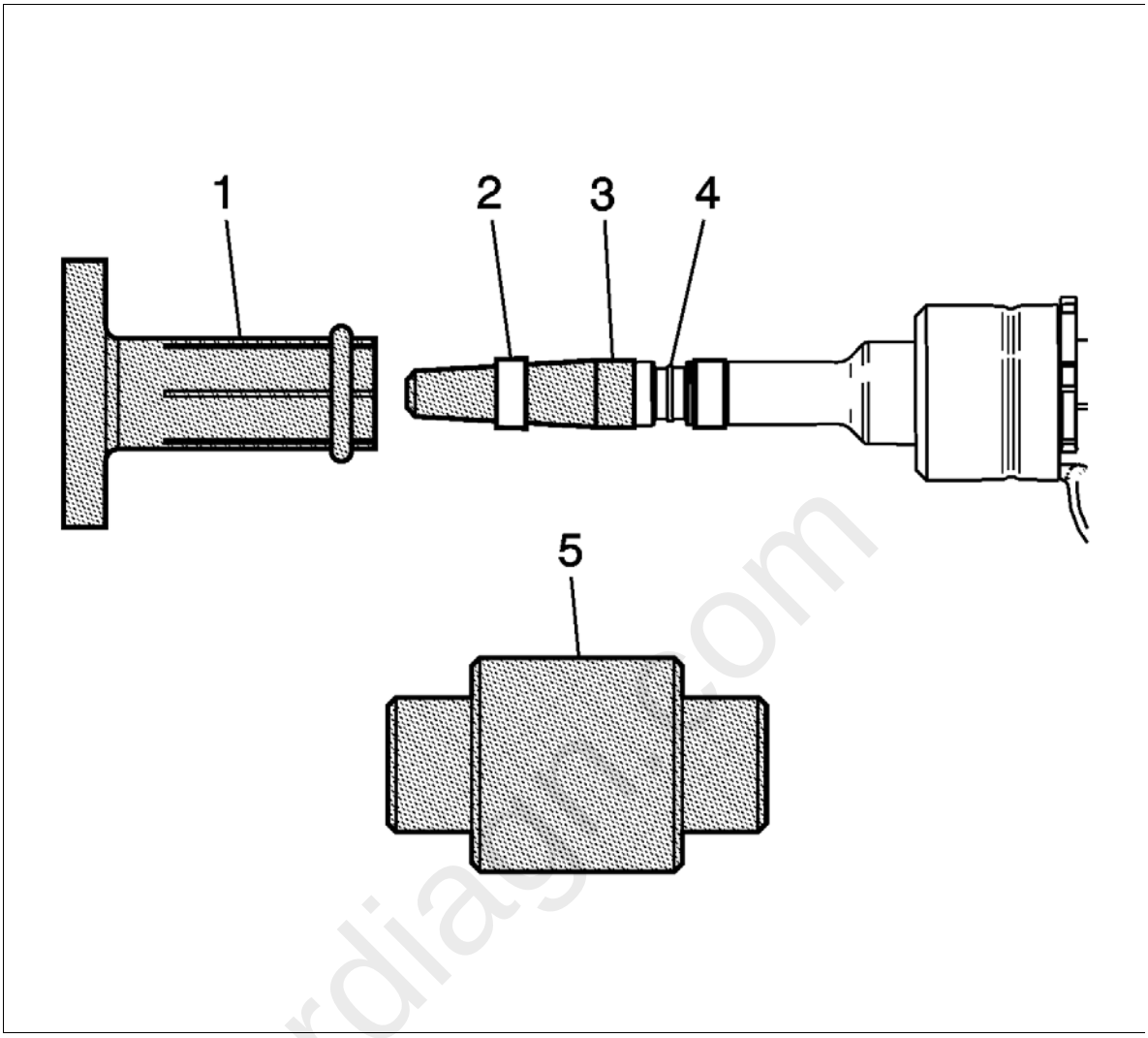
22. Install **EN 49245-1** long protector (3) onto the fuel injector tip, covering the first recessed area closest to the tip. Place a NEW seal (2) on **EN-49245-1** long protector.
23. Using **EN-49245-3** pusher (1), install the seal into the second recessed area (4) of the fuel injector.

NOTE:

*The **EN-49245-4** sizer is two sided, and either direction will size the seal correctly.*

24. Compress the seal with your fingers, then resize the seal using the **EN-49245-4** sizer (5).

Fig 14: Fuel Injector Tip & Seals



Courtesy of GENERAL MOTORS COMPANY

NOTE:

Do not use any type of lubricant when installing the NEW seals (2) on the fuel injector tip.

25. Install **EN-49245-2** short protector (3) onto the fuel injector tip. Place a NEW seal (2) on **EN-49245-2** short protector.

26. Using **EN-49245-3** pusher (1), install the seal into the first recessed area (4) of the fuel injector.

NOTE:

*The **EN-49245-4** sizer is two sided, and either direction will size the seal correctly.*

27. Compress the seal with your fingers, then resize the seal using the **EN-49245-4** sizer (5).

REPAIR INSTRUCTIONS - OFF VEHICLE > CYLINDER HEAD ASSEMBLE

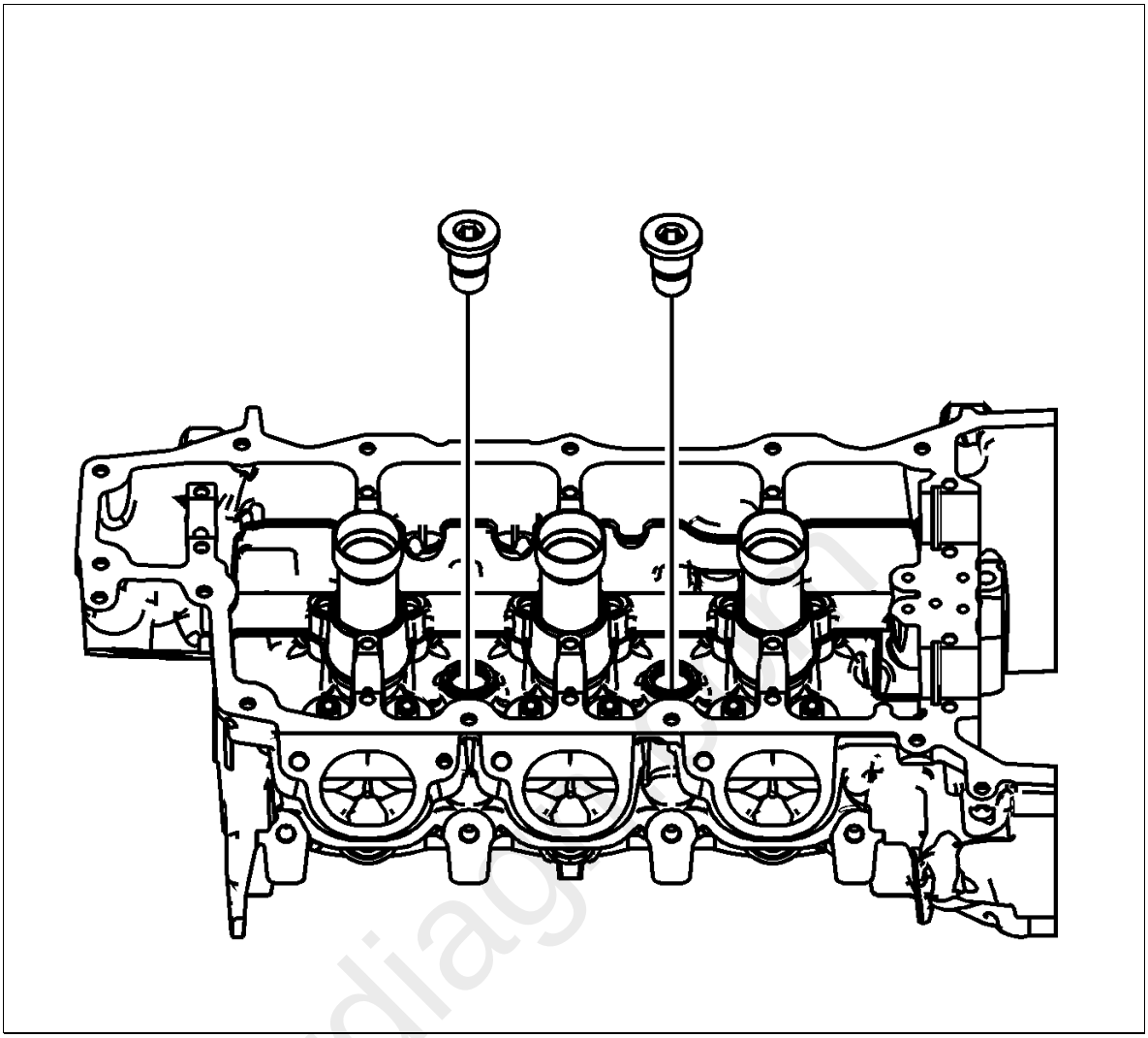
Special Tools

- **EN-8062** Valve Spring Compressor - Head Off
- **EN-46116** Valve Stem Seal Remover/Installer
- **EN-46117** Valve Stem Key Remover/Installer
- **EN-46119** Off-Vehicle Valve Spring Compressor Adapter

For equivalent regional tools, refer to Special Tools .

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Fig 1: Cylinder Head Coolant Threaded Plugs



Courtesy of GENERAL MOTORS COMPANY

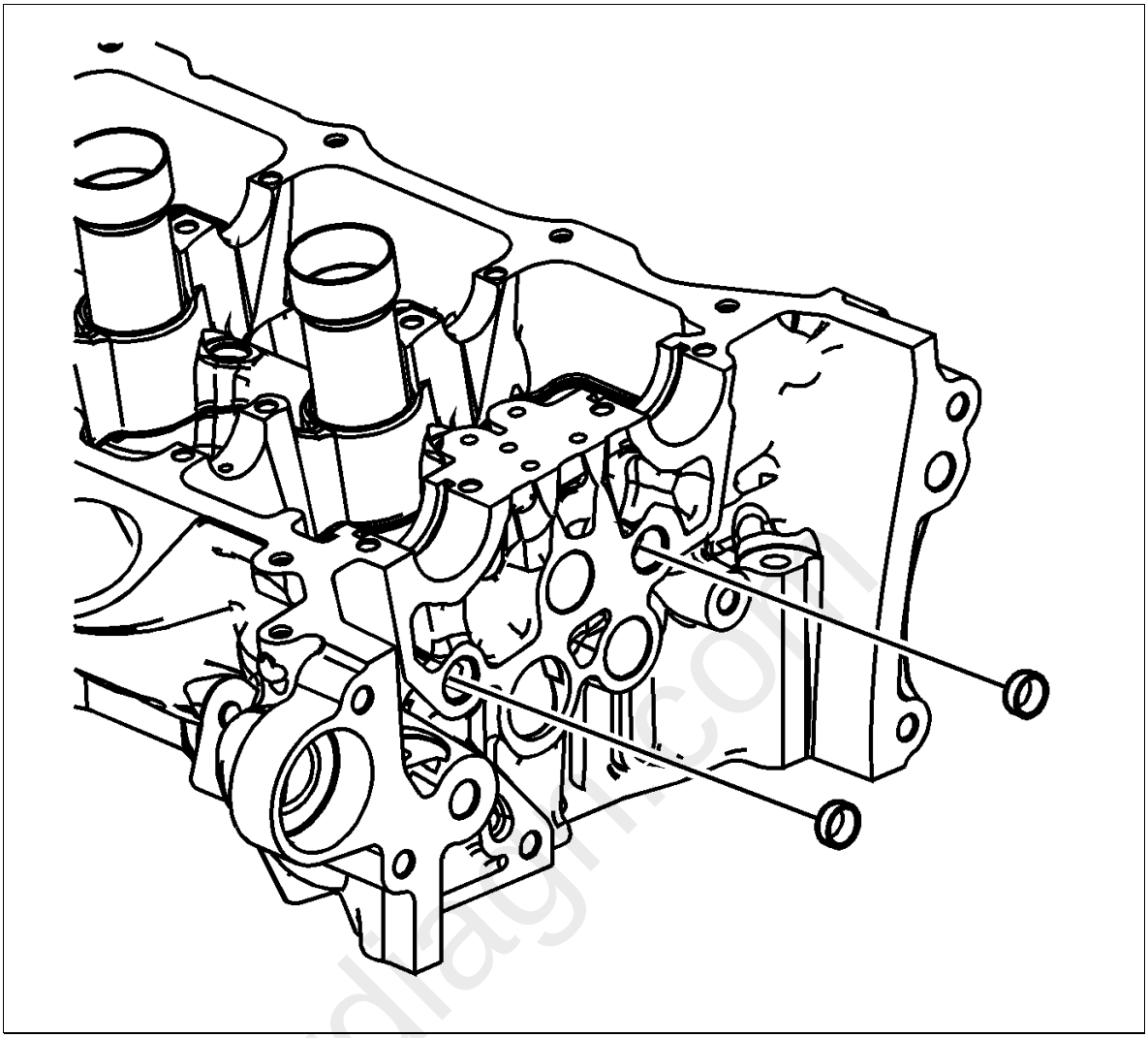
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⚠ *CAUTION:*

Refer to Fastener Caution .

1. Install the cylinder head coolant threaded plugs and tighten to 75 N.m (55 lb ft).

Fig 2: Cylinder Head Oil Gallery Expansion Plugs

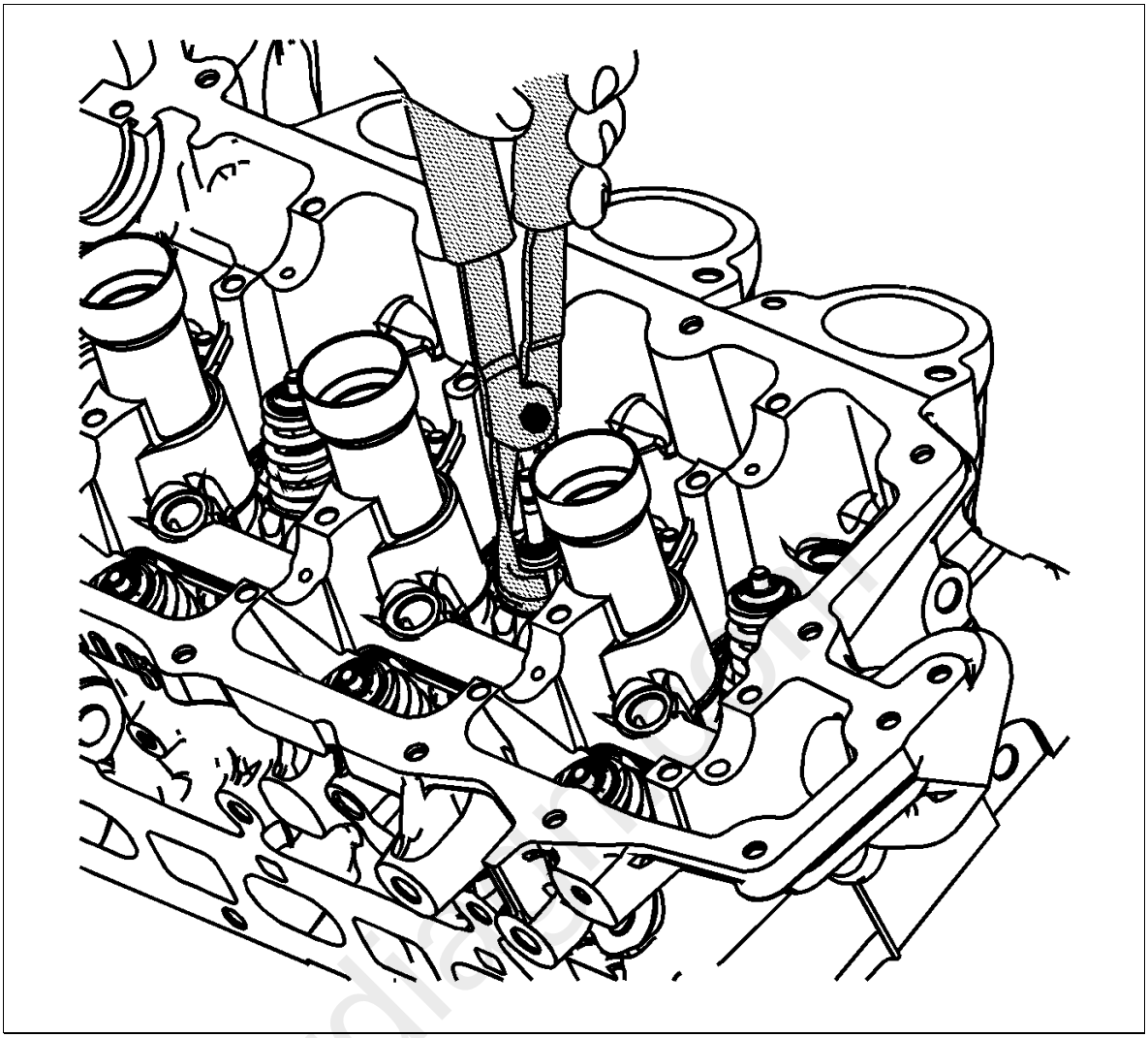


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2. Install the NEW cylinder head oil gallery expansion plugs.

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Fig 3: Valve Stem Oil Seals



Courtesy of GENERAL MOTORS COMPANY

3. Place the valve stem oil seals onto the guides.

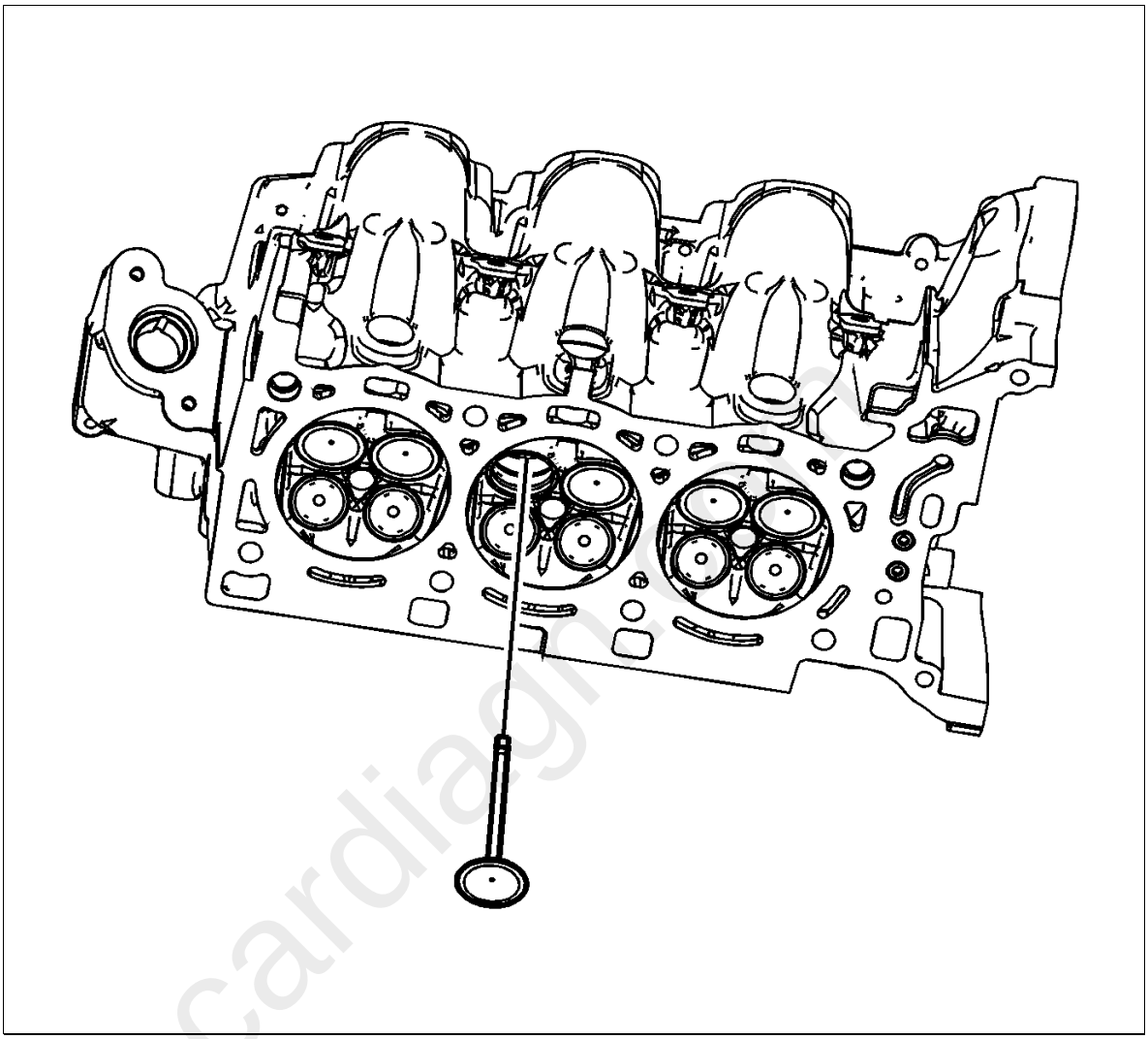
> *NOTE:*
>
> *NEVER reuse a valve stem oil seal. Always use new seals when assembling the cylinder head.*

4. Mount a new valve stem oil seal using the **EN-46116** remover/installer.

> *NOTE:*
>
> *Force should only be applied to the valve spring contact area of the new valve stem oil seal during installation.*

5. Push and twist the valve stem oil seal into position on the valve guide until the seal positively locks on the guide using the **EN-46116** remover/installer.
6. Lubricate the valve stem and valve guide ID with clean engine oil. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended lubricant.

Fig 4: Oil Seal and Valve Guide

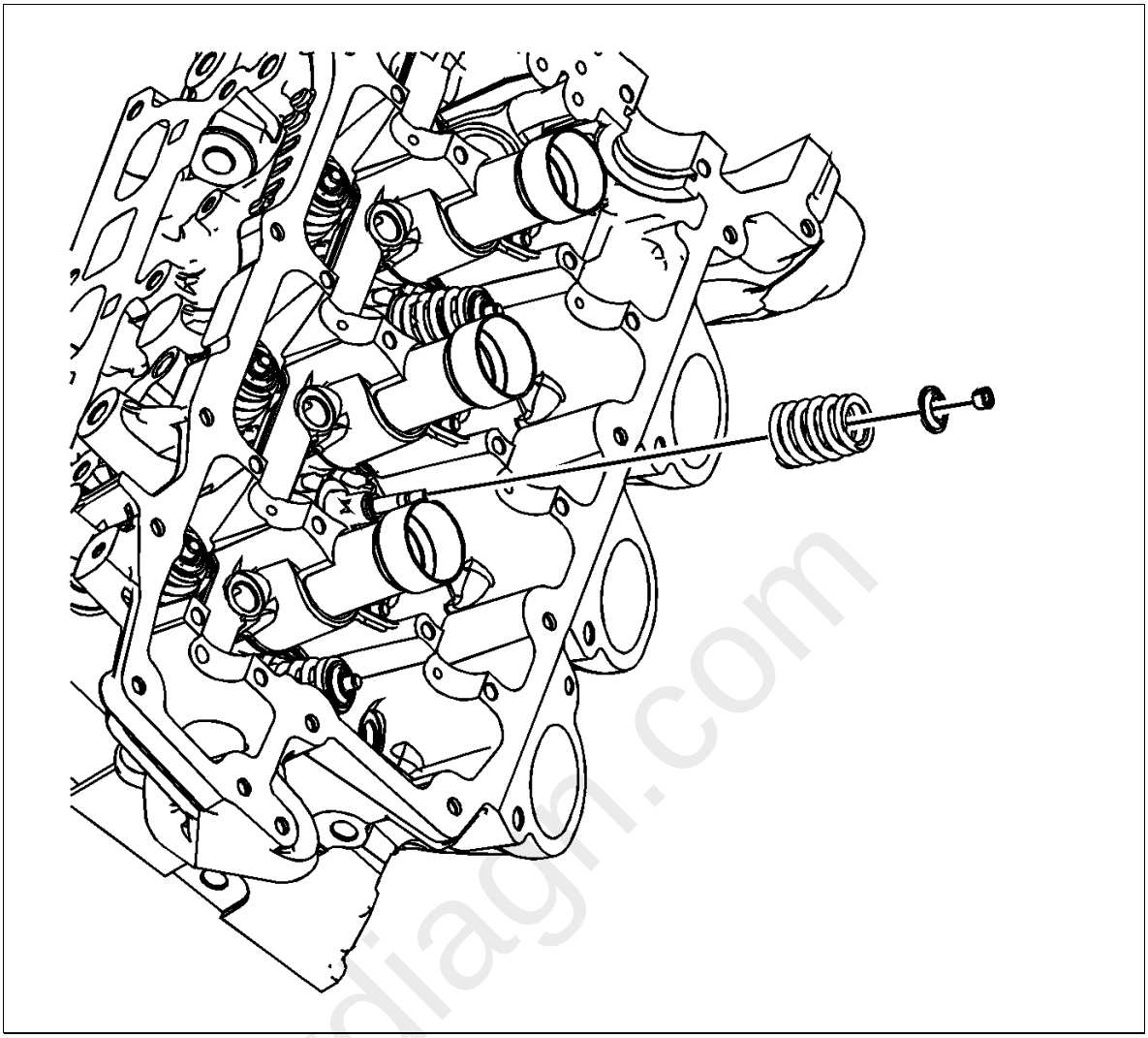


Courtesy of GENERAL MOTORS COMPANY

> *NOTE:*
>
> *The valve stem oil seal must not come loose from the valve guide when the valve is installed.*

7. Insert the valve into the valve guide until it bottoms on the valve seat.

Fig 5: Valve Spring & Retainer

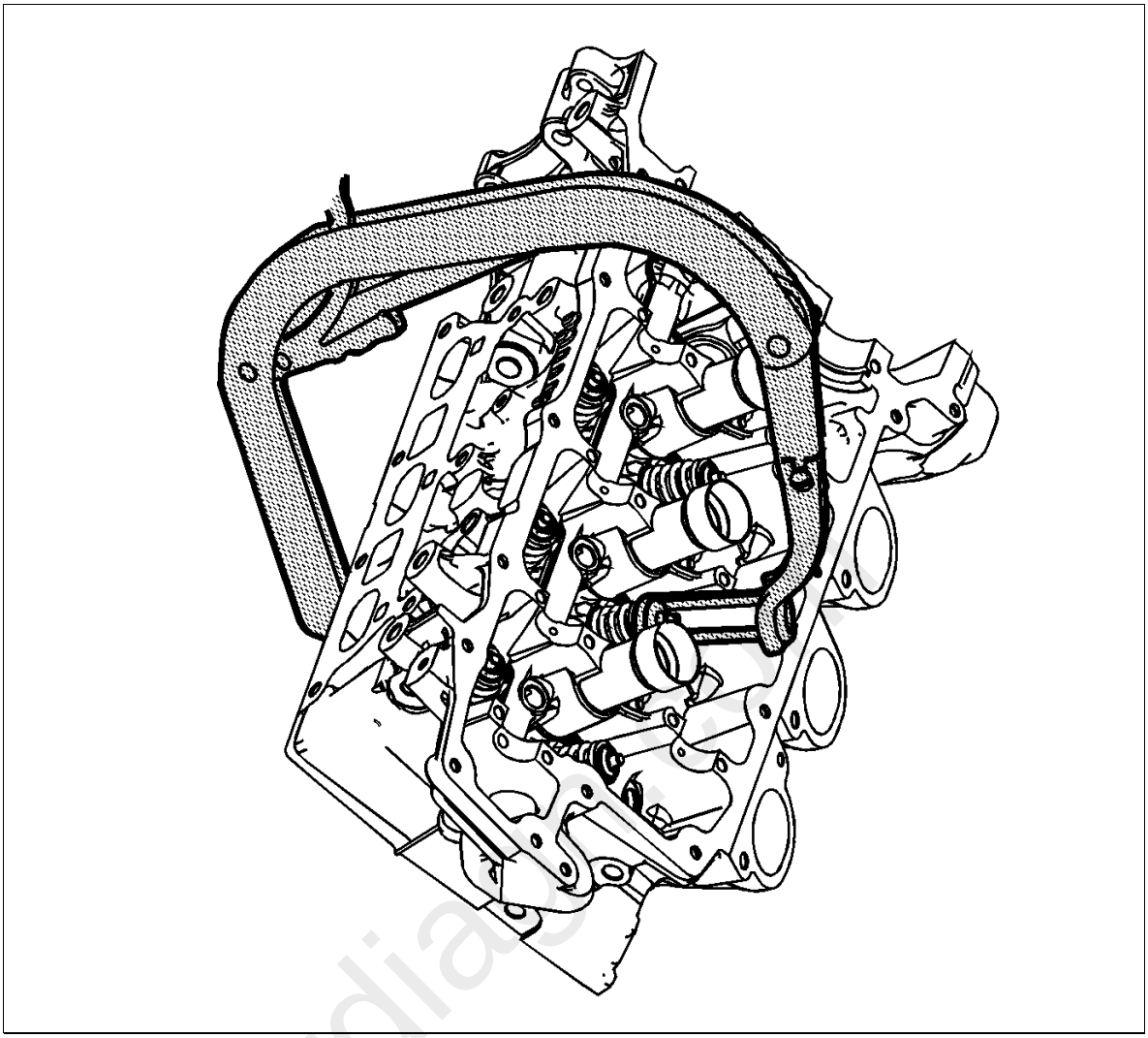


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8. Position the valve spring on the spring seat.
9. Place the valve spring retainer onto the valve spring.

Fig 6: Valve Spring



Courtesy of GENERAL MOTORS COMPANY

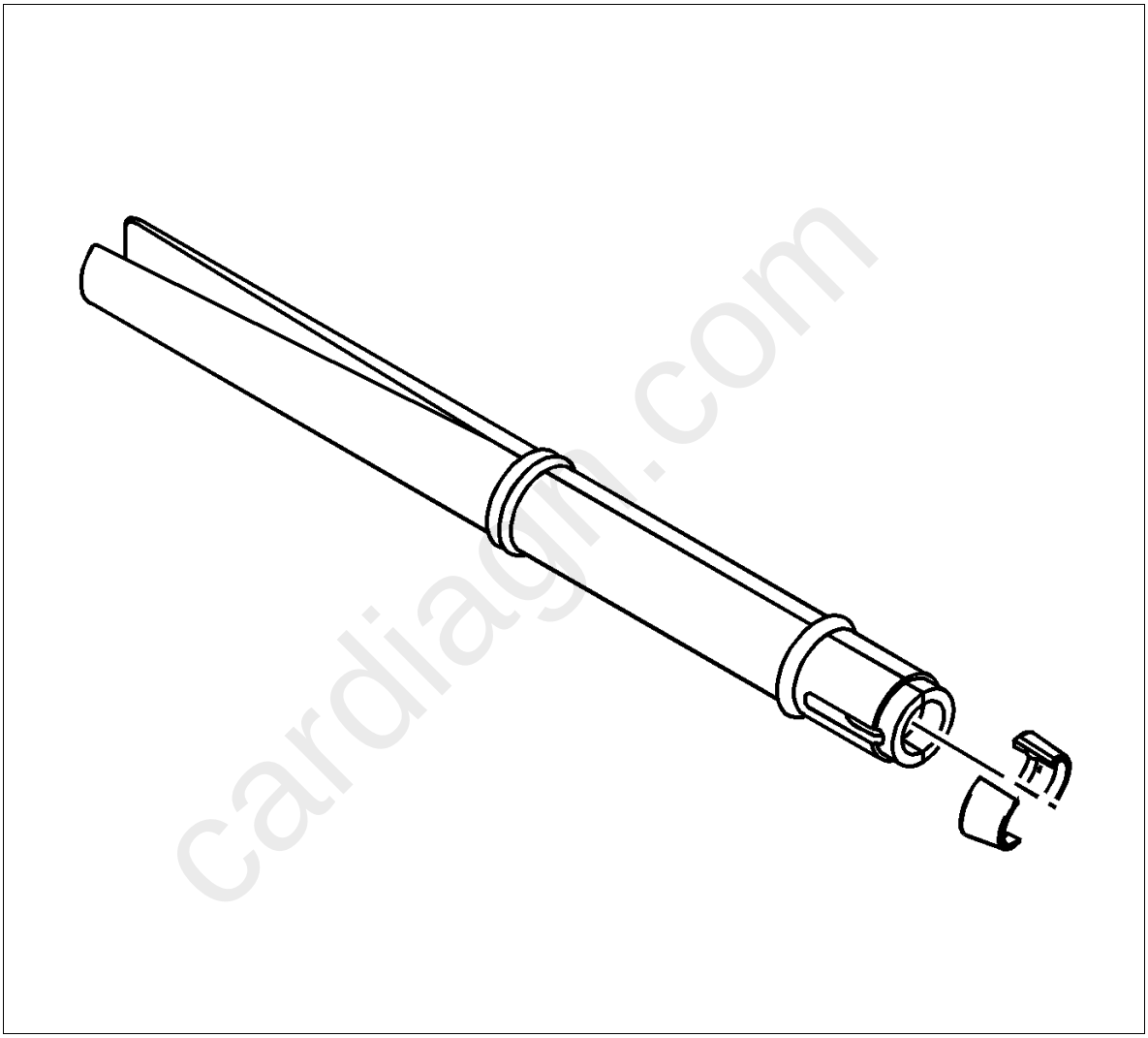
WARNING:

Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.

> ⚠ *CAUTION:*
>
> *Do not compress the valve springs to less than 24.0 mm (0.943 in). Contact between the valve spring retainer and the valve stem oil seal can cause potential valve stem oil seal damage.*

10. Compress the valve spring using the **EN-8062** compressor and the **EN-46119** adapter.

Fig 7: Valve Keepers



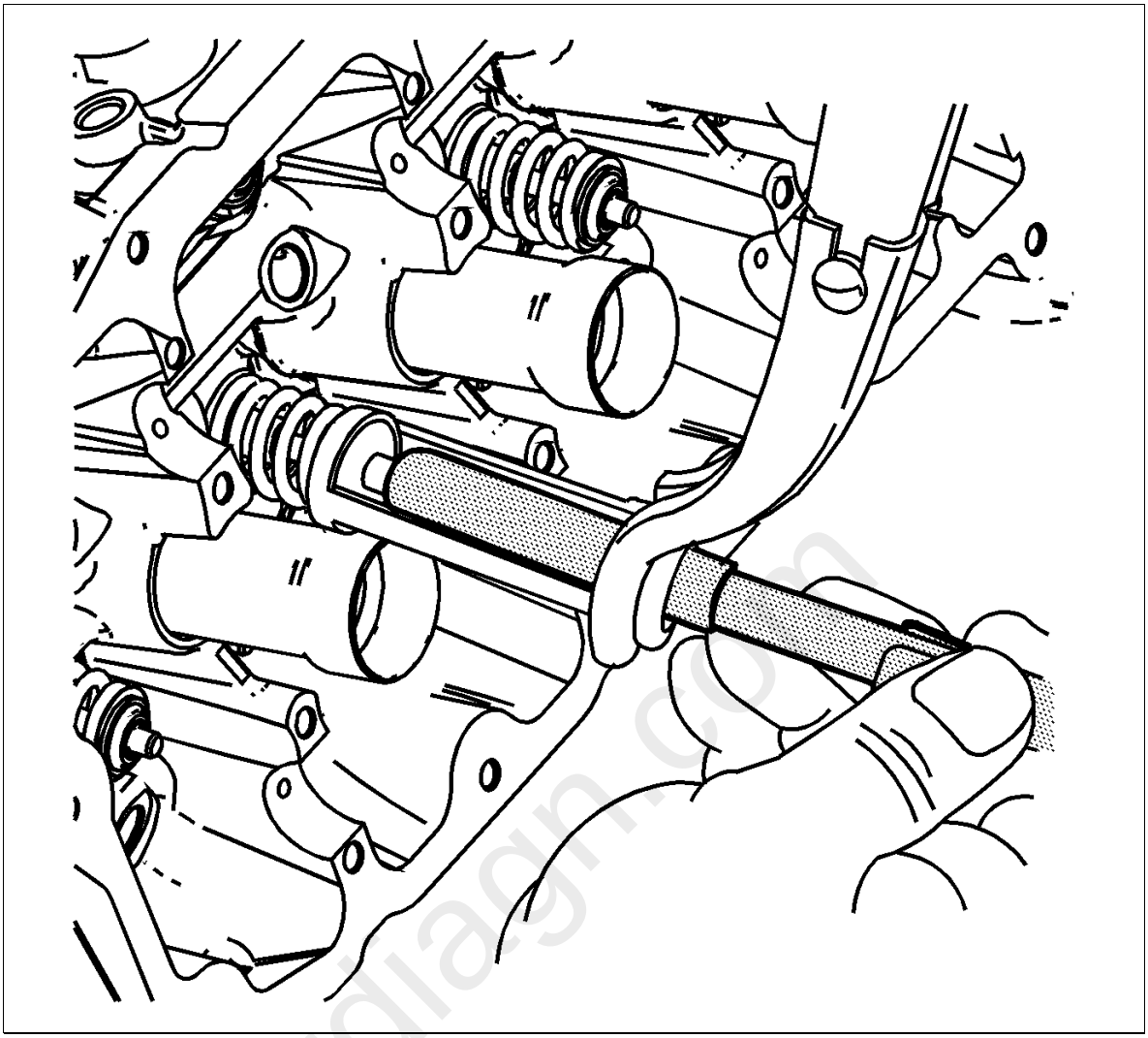
Courtesy of GENERAL MOTORS COMPANY

> *NOTE:*
>
> *Ensure proper directional placement of valve keepers in the **EN-46117** remover/installer. The valve keepers must be installed with the tapered end towards the valve stem seal.*

11. With the spring compressed, install the valve keepers into the **EN-46117** remover/installer.

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Fig 8: Valve Spring Compressor & Adapter

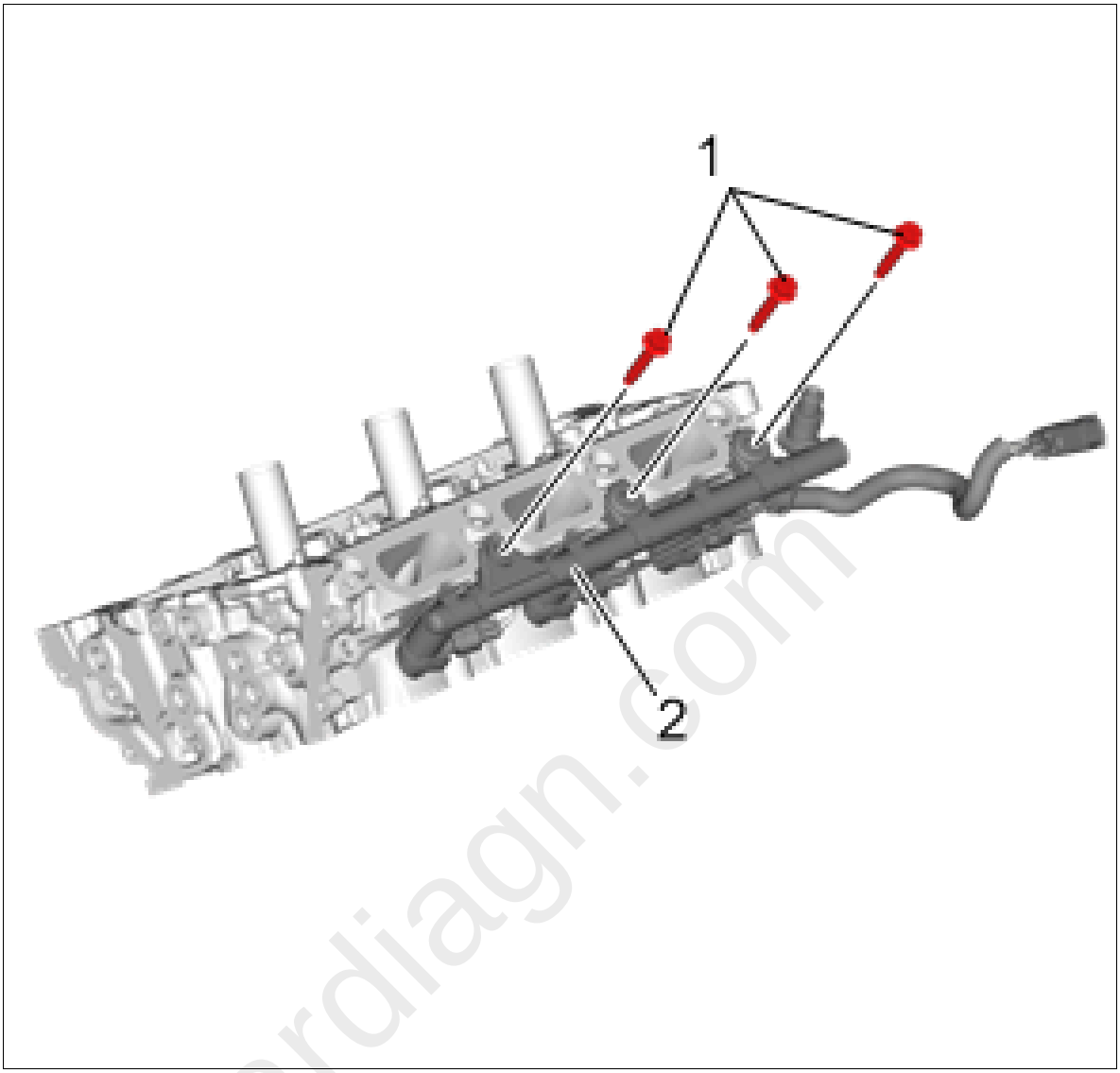


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12. Place the keepers into position by pushing the tool downward. While holding the tool lightly together in the area between the O-rings, using the thumb and forefinger, release tension on the **EN-46119** adapter and the **EN-8062** compressor. This will slowly push the **EN-46117** remover/installer off the valve stem, leaving the keepers in place.

13. Verify that the valve keepers are installed by placing a rag over the valve tip and tapping with a dead-blow hammer.

Fig 9: Fuel Rail Bolts



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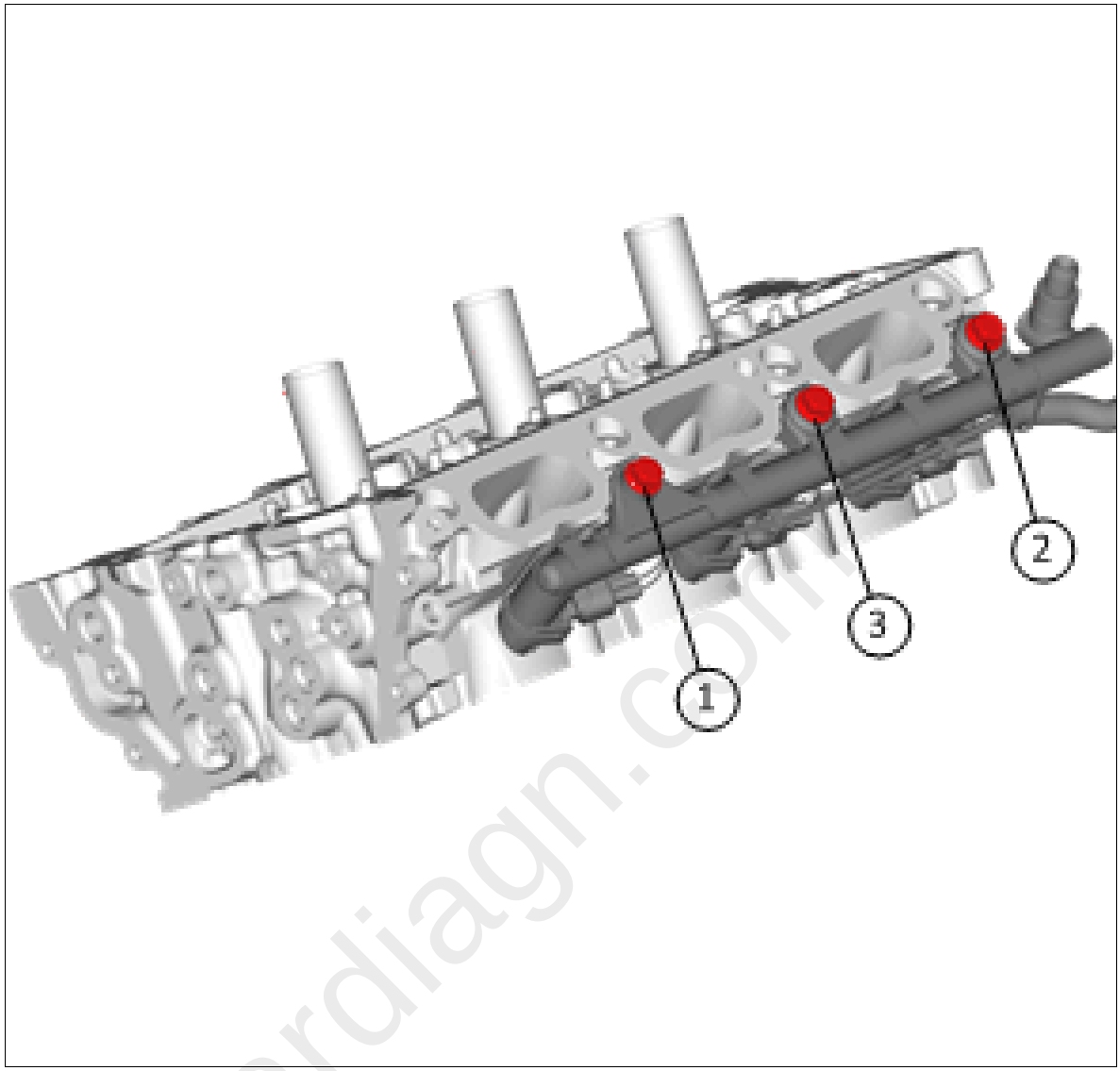
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NOTE:

If the fuel rail was removed from the cylinder head, the fuel injector tip seals must be replaced. Refer to Fuel Rail and Injectors Cleaning and Inspection .

14. Install the fuel rail with injectors (2) into the cylinder head evenly.
15. Install and hand tighten the three fuel rail bolts (1) to seat the injectors in the injector bores.

Fig 10: Fuel Rail Bolt Tightening Sequence



Courtesy of GENERAL MOTORS COMPANY

16. Tighten the fuel rail bolts in the sequence shown to 25 N.m (18 lb ft).

REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT CLEANING AND INSPECTION

Special Tools

GE 7872 Magnetic Base Dial Indicator

For equivalent regional tools, refer to Special Tools .

REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT CLEANING AND INSPECTION > CLEANING PROCEDURE

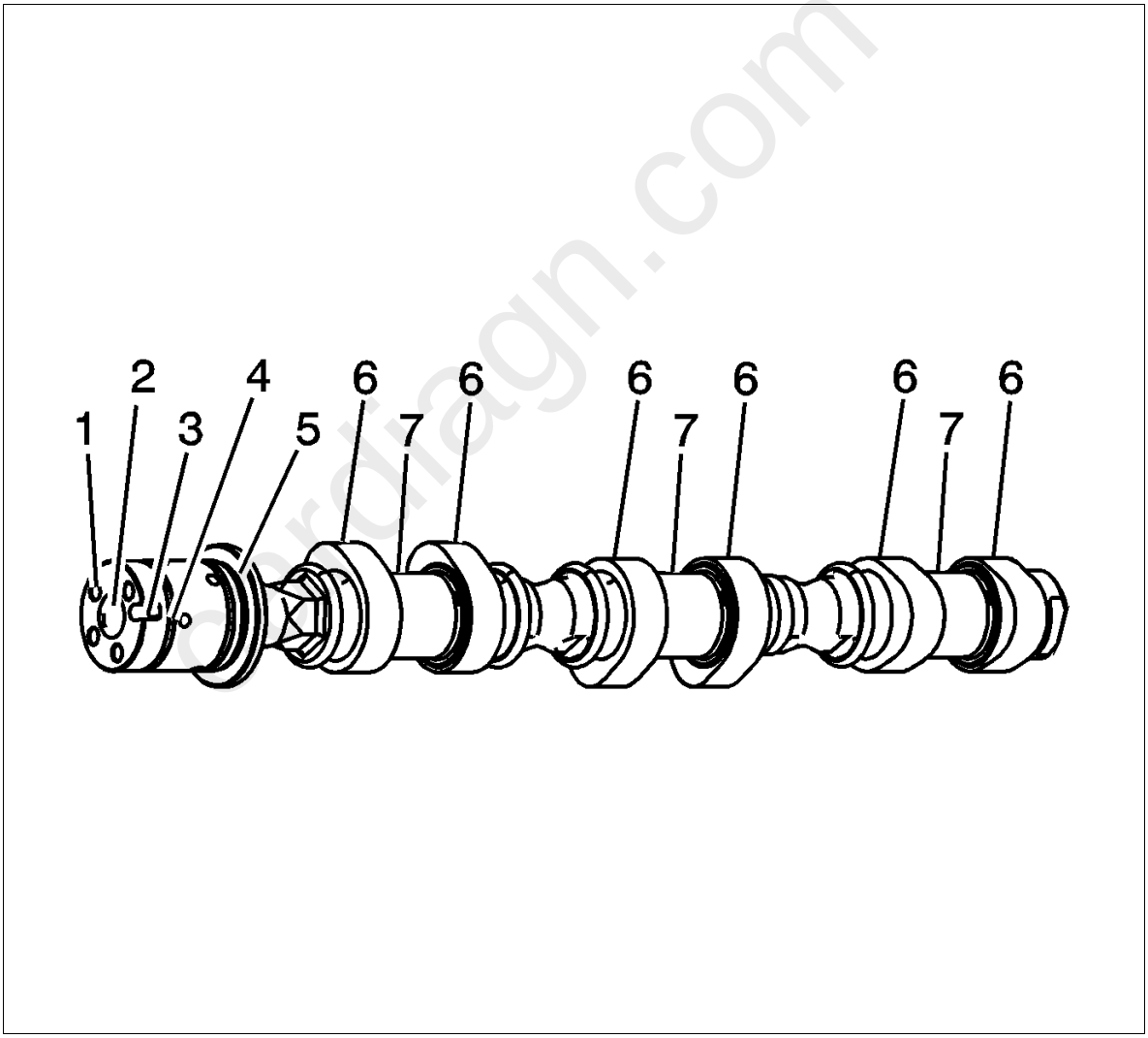
1. Clean the camshaft in solvent.

> *WARNING:*
>
> *Refer to Safety Glasses Warning .*

2. Dry the camshaft with compressed air.

REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT CLEANING AND INSPECTION > VISUAL INSPECTION

Fig 1: Camshaft Inspection Areas



Courtesy of GENERAL MOTORS COMPANY

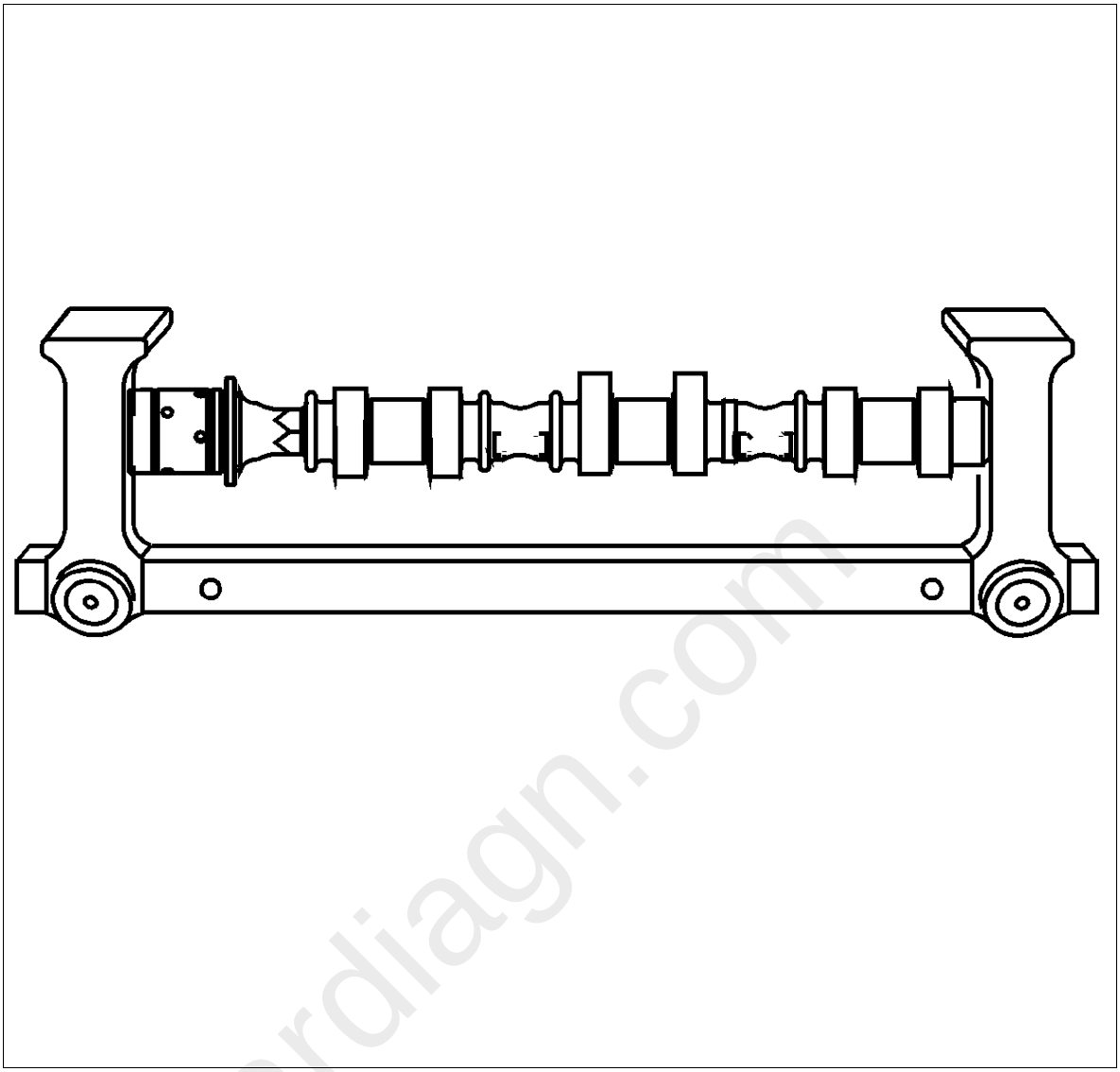
1. Inspect the camshaft oil feed holes (1) to the camshaft position actuator for dirt, debris or blockage.

2. Inspect the threaded hole (2) for damage.
3. Inspect the camshaft position actuator locating notch (3) for damage or wear.
4. Inspect the camshaft sealing grooves (4) for damage.
5. Inspect the camshaft thrust surface (5) for damage.
6. Inspect the camshaft lobes (6) and journals (7) for the following conditions:
    1. Excessive scoring or pitting
    2. Discoloration from overheating
    3. Deformation from excessive wear, especially the camshaft lobes
7. If any of the above conditions exist on the camshaft, replace the camshaft.

REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT CLEANING AND INSPECTION > CAMSHAFT MEASUREMENT

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Fig 1: Camshaft In Fixture

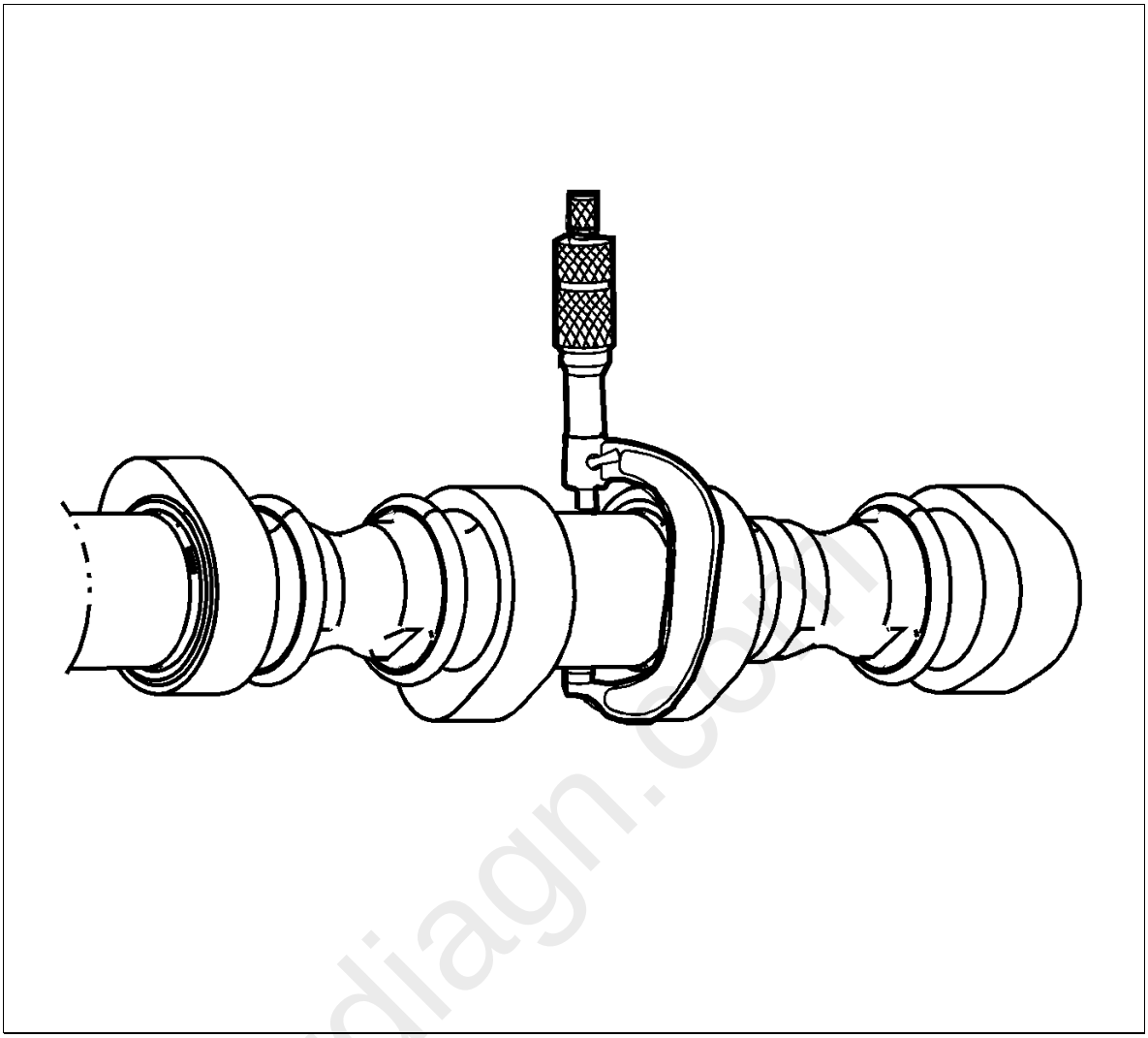


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1. With the camshaft in a suitable fixture, measure the camshaft for wear.

Fig 2: Camshaft Journals

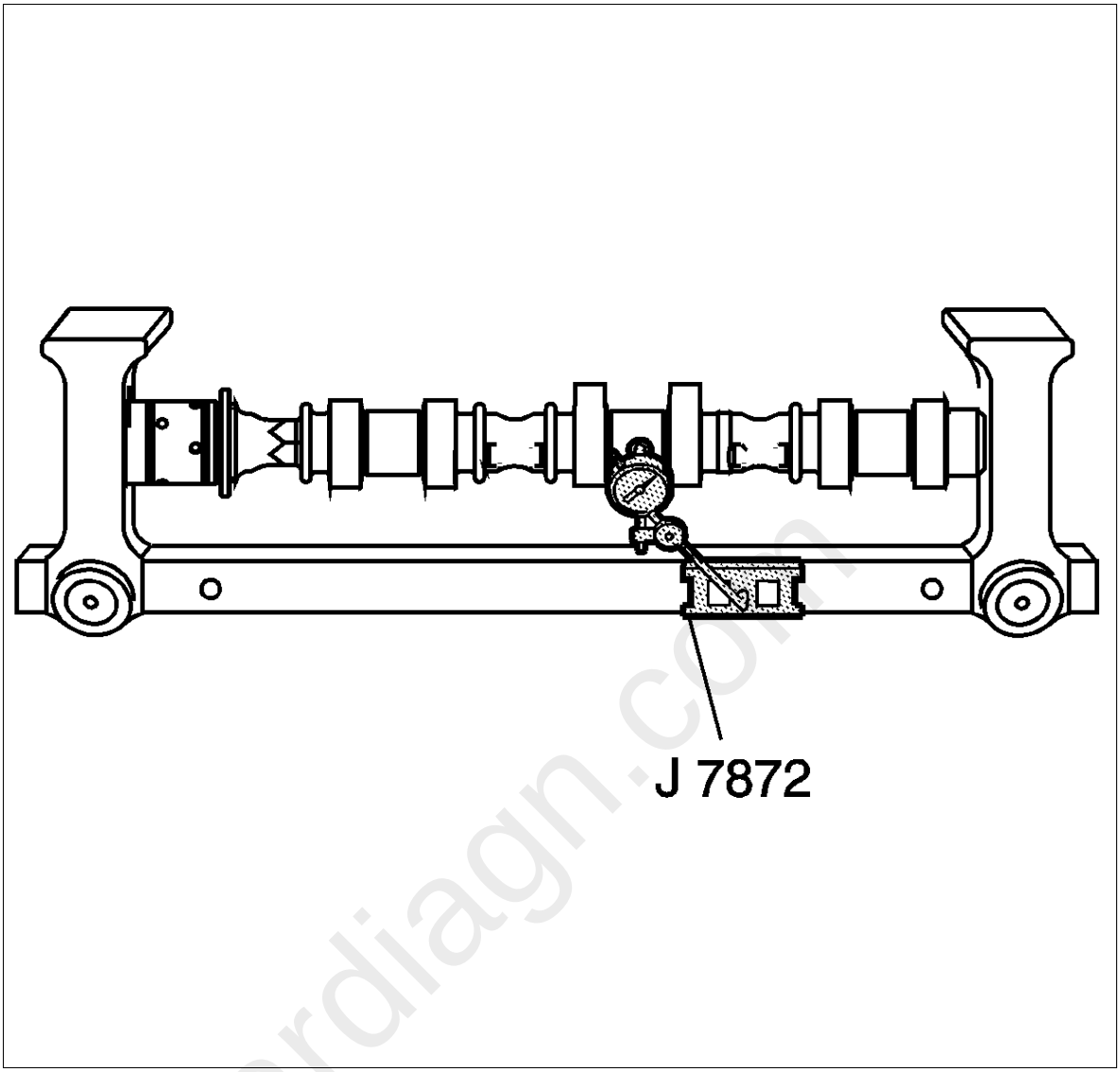


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2. Measure the camshaft journals for diameter and out-of-round using an outside micrometer. Refer to Engine Mechanical Specifications .
    1. If the diameter is smaller than specifications, replace the camshaft.
    2. If the out-of-round exceeds specifications, replace the camshaft.

Fig 3: Camshaft Runout

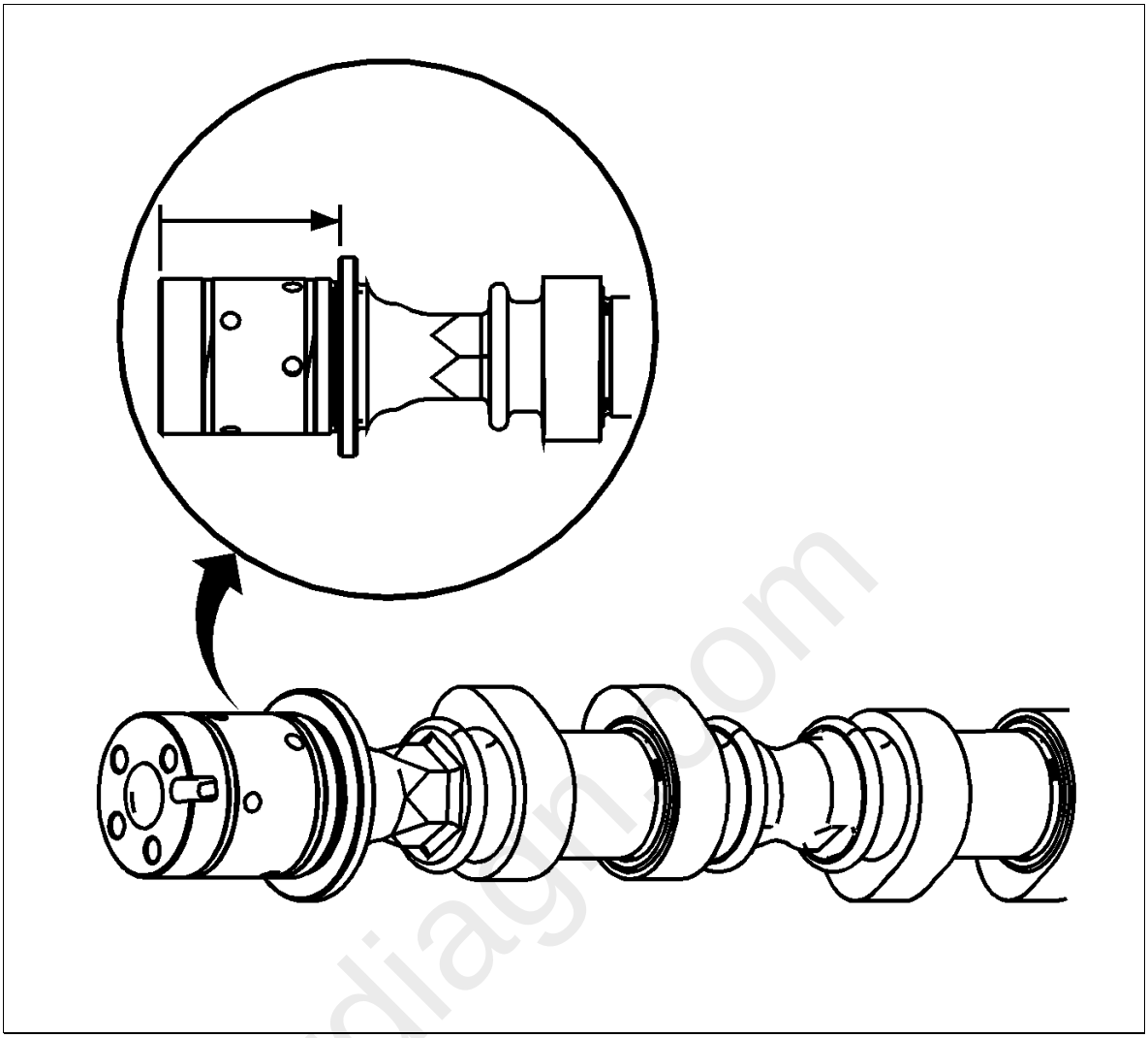


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3. Measure the camshaft runout using the **GE 7872** indicator. Refer to Engine Mechanical Specifications .

Fig 4: Camshaft Thrust Width

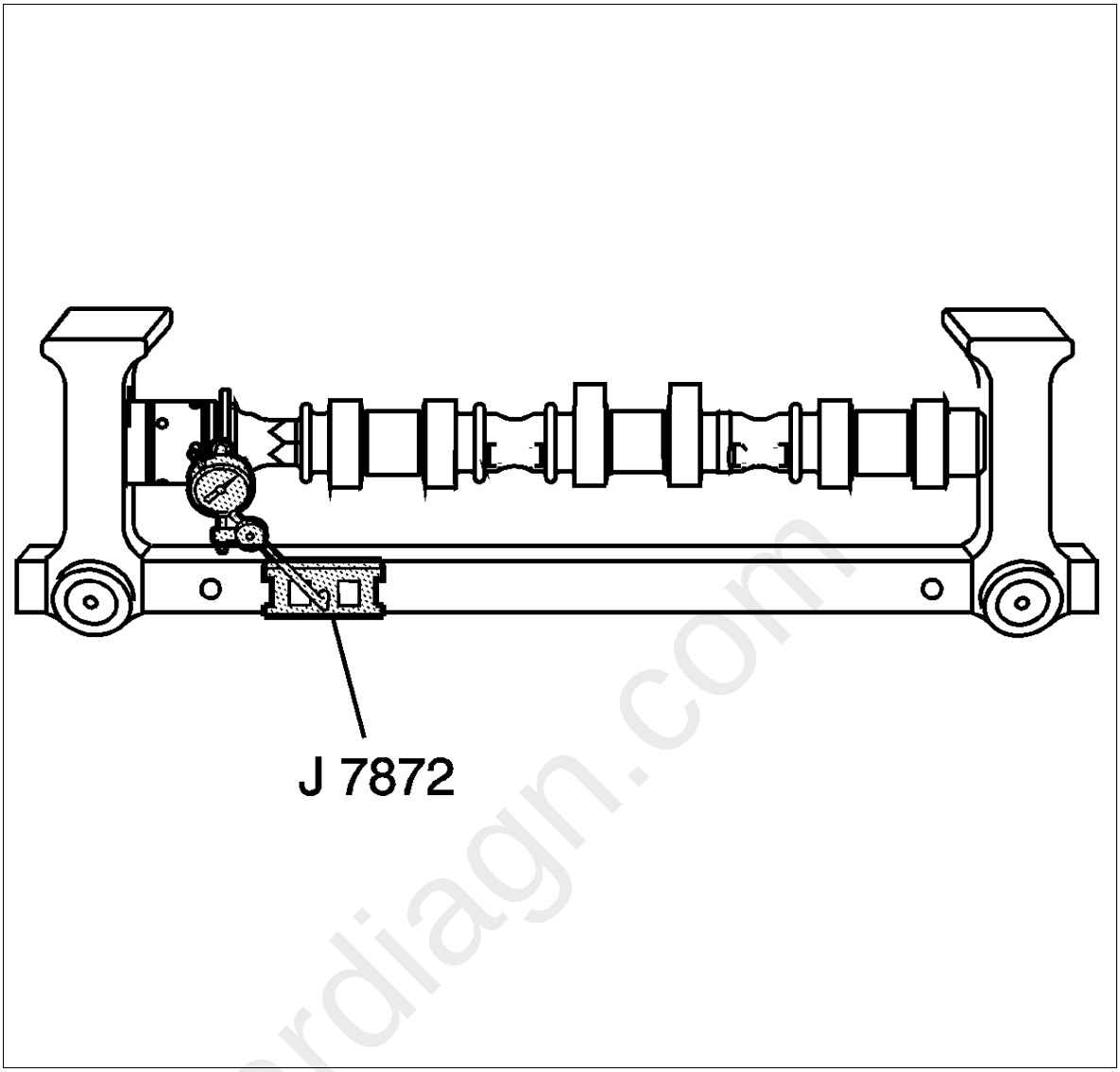


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4. Measure the camshaft thrust width for wear using a depth micrometer. Refer to Engine Mechanical Specifications .

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Fig 5: Camshaft

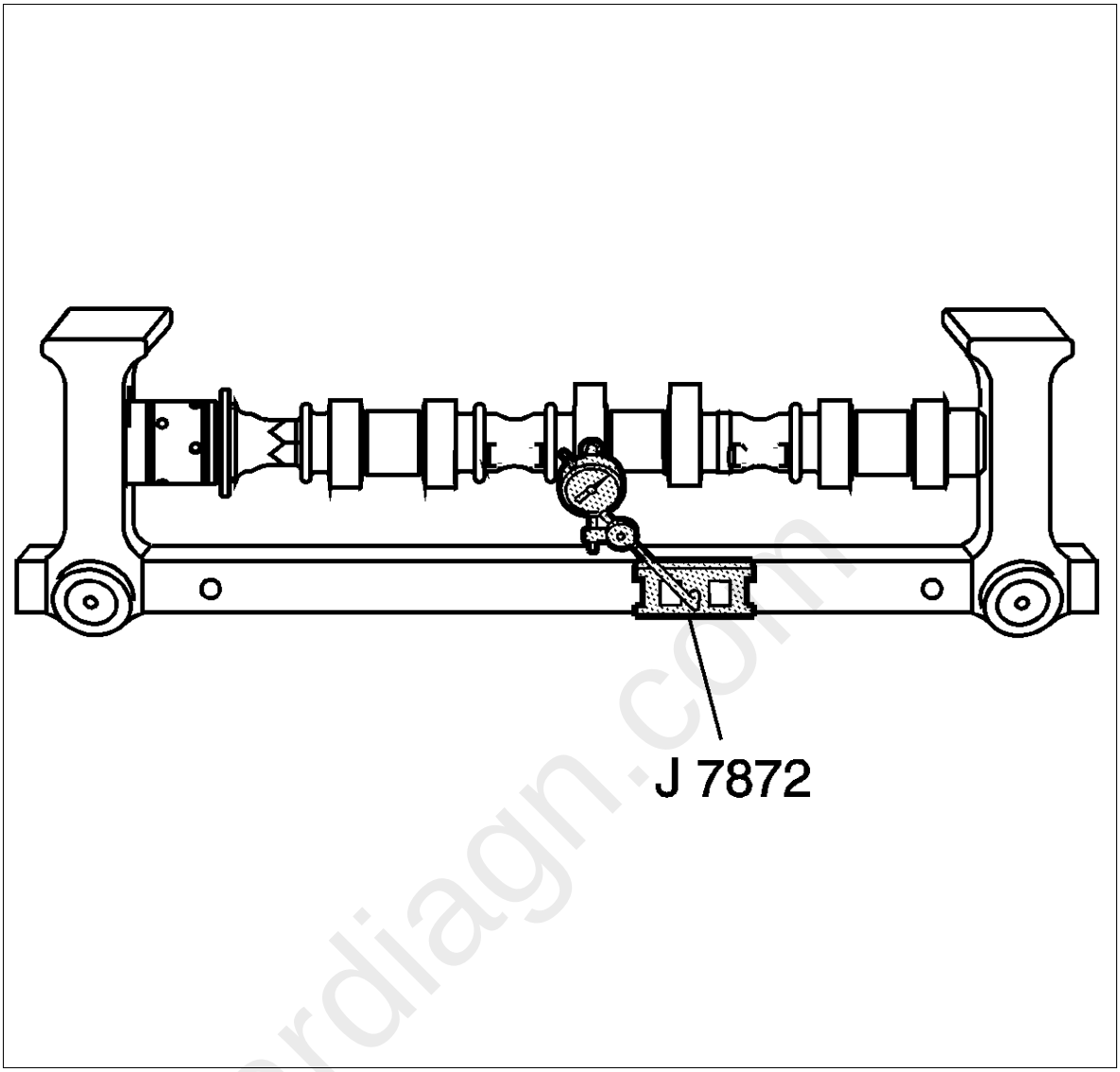


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5. Measure the camshaft thrust wall surface for runout using **GE 7872** indicator. Refer to Engine Mechanical Specifications .
6. If the camshaft is damaged or worn beyond specifications, replace the camshaft. No machining of the camshaft is allowed.

Fig 6: Camshaft Lobes For Wear

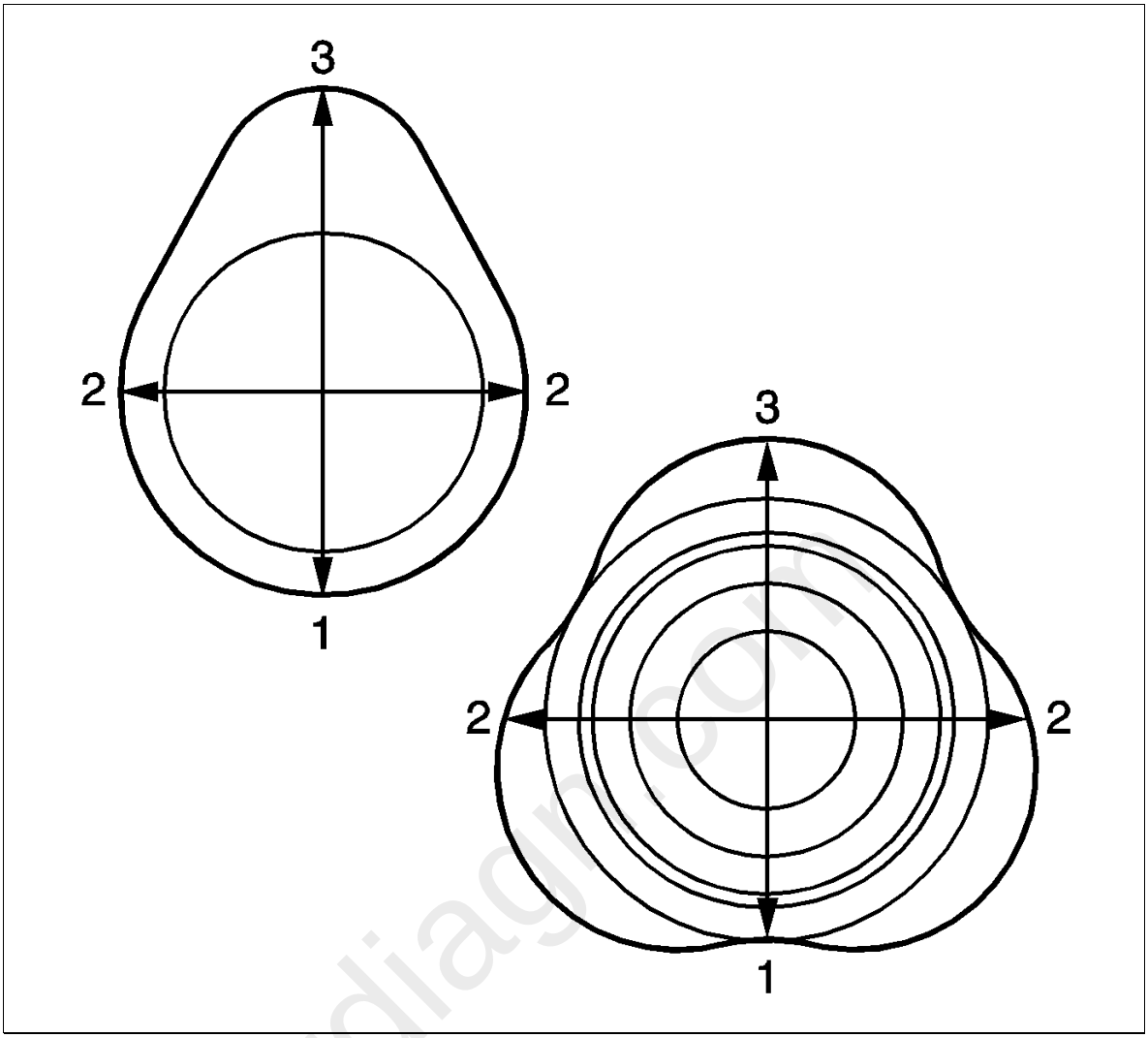


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7. Measure the camshaft lobes for wear using the **GE 7872** indicator.

Fig 7: Lobe Diagram

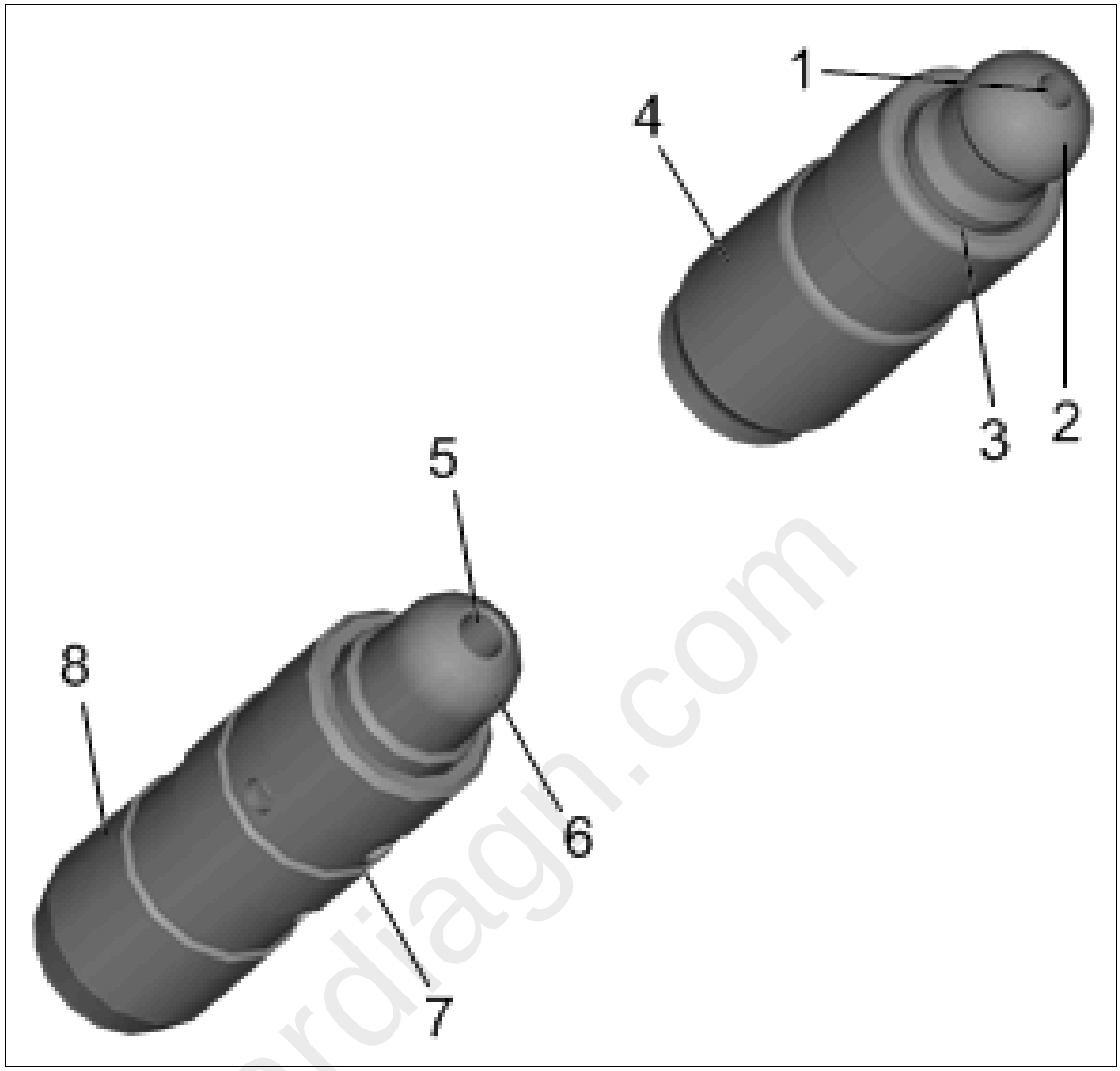


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8. Place the **GE 7872** indicator with the indicator tip on the base circle (1) of the camshaft lobe.
    1. Place the **GE 7872** indicator at zero.
    2. Rotate the camshaft until the indicator tip is at the highest point (3) on the lobe. This reading is the lift of the camshaft lobe. Refer to Engine Mechanical Specifications .
    3. If the indicated measurement is significantly lower than these specifications, replace the camshaft or engine performance will be reduced.

REPAIR INSTRUCTIONS - OFF VEHICLE > VALVE LIFTER CLEANING AND INSPECTION

Fig 1: Valve Lifter Inspection Points



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> ⚠ *CAUTION:*
>
> *Refer to Valve Lifter Priming Caution .*

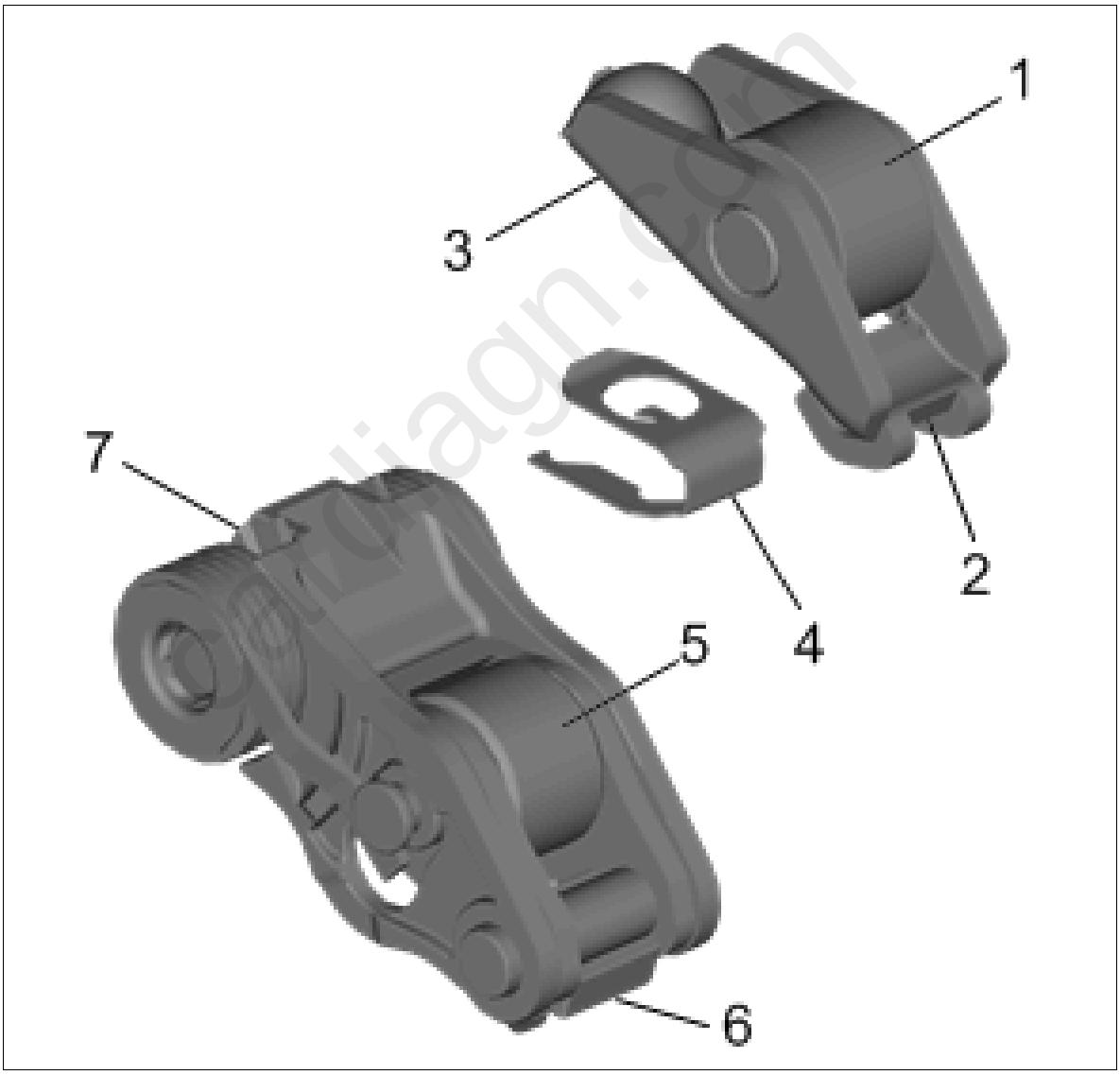
1. Inspect the hydraulic lash adjuster (HLA) in the following areas:
    1. A plugged oil passage (1)
    2. A scored or worn camshaft follower pivot area (2)
    3. A damaged or broken retainer (3), some applications
    4. A severely scuffed or worn HLA body (4)
2. Inspect the duel feed hydraulic lash adjuster (DFHLA) in the following areas:

1. A plugged oil passage (5)
2. A scored or worn camshaft follower pivot area (6)
3. A damaged or broken retainer (7), some applications
4. A severely scuffed or worn DFHLA body (8)

3. Replace the HLA or DFHLAs as necessary.

REPAIR INSTRUCTIONS - OFF VEHICLE > VALVE ROCKER ARM CLEANING AND INSPECTION

Fig 1: Valve Rocker Arm Roller



Courtesy of GENERAL MOTORS COMPANY

1. Inspect the valve rocker arm roller (1) for the following:

    1. Flat spots
    2. Excessive scoring and pitting
    3. Ensure the roller spins freely
2. Inspect the valve rocker arm tip area (2).
3. Inspect the valve rocker arm hydraulic lash adjuster (HLA) pivot area (3).
4. Inspect the valve rocker arm retaining clip (4).
5. Inspect the valve rocker switching arm roller (5) for the following:
    1. Flat spots
    2. Excessive scoring and pitting
    3. Ensure the roller spins freely
6. Inspect the valve rocker switching arm tip area (6).
7. Inspect the valve rocker switching arm duel feed hydraulic lash adjuster (DFHLA) pivot area (7).
8. Replace the valve rocker switching arm or followers as necessary.

REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT TIMING DRIVE COMPONENTS CLEANING AND INSPECTION > CLEANING PROCEDURE

1. Clean all the following components with solvent:
    1. Crankshaft sprocket
    2. Timing drive chains
    3. Right timing drive chain guides
    4. Right timing drive chain tensioner
    5. Left timing drive chain guides
    6. Left timing drive chain tensioners
    7. Timing component fastening bolts
2. Clean each camshaft position actuator's exterior with solvent.

> *WARNING:*
>
> *Refer to Safety Glasses Warning .*

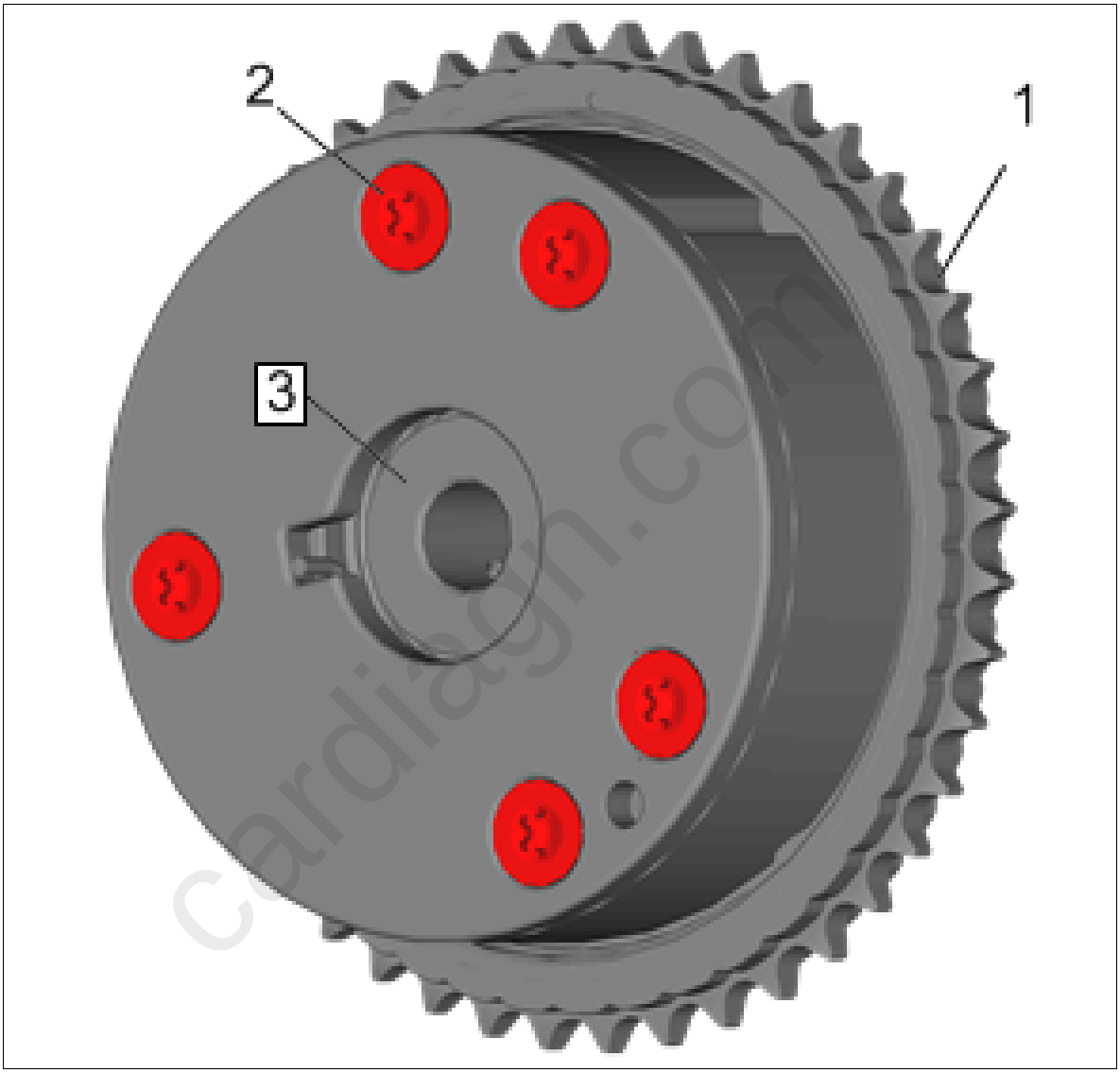
3. Dry the timing components with compressed air.

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REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT TIMING DRIVE COMPONENTS CLEANING AND INSPECTION > VISUAL INSPECTION

Camshaft Position Actuator

Fig 1: Camshaft Position Actuator Inspection Points

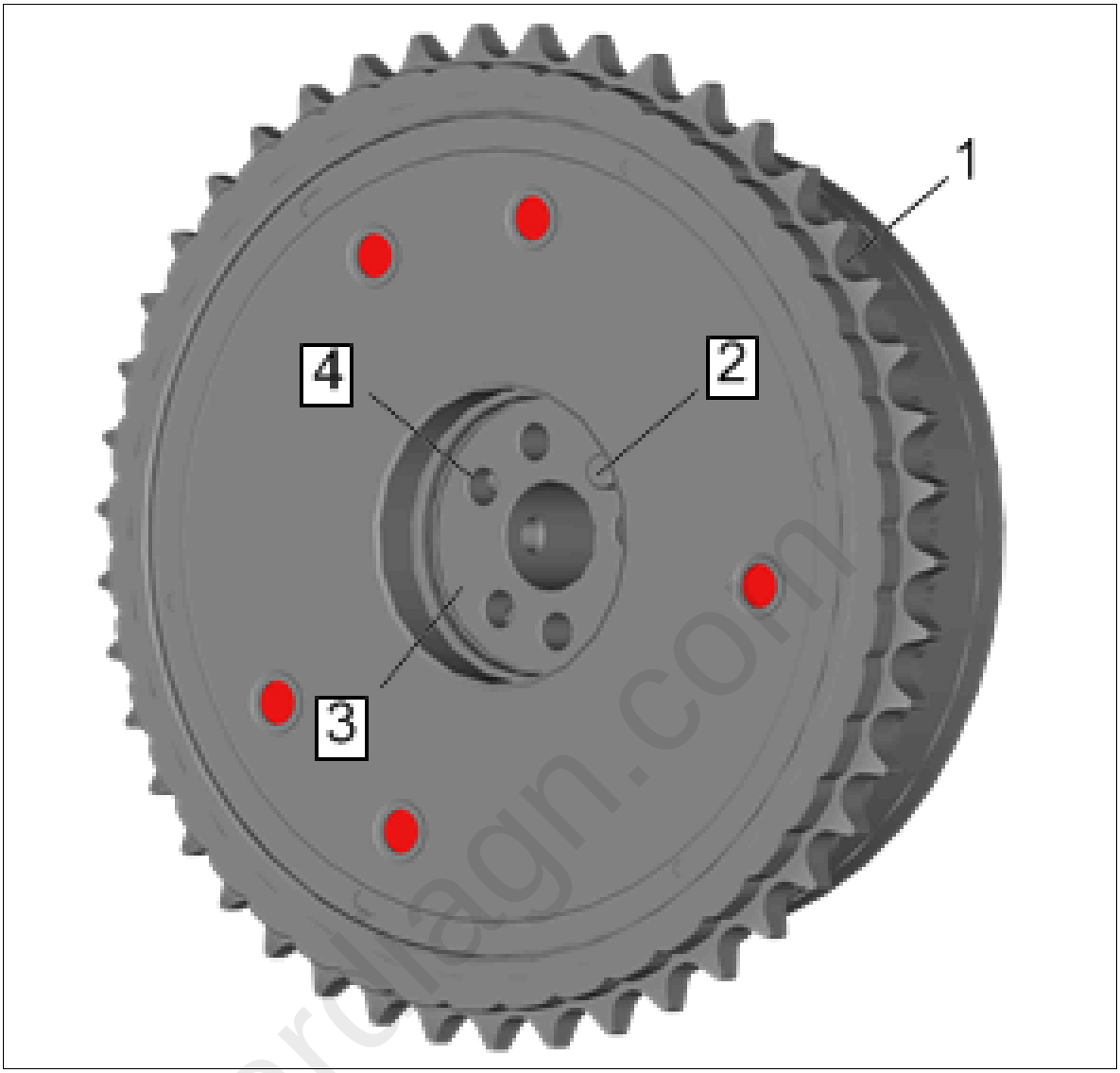


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1. Inspect the front of the right exhaust camshaft position actuators for the following:
    1. Sprocket damage (1)
    2. Loose or missing housing bolts (2)
    3. Camshaft position actuator bolt seating/sealing inner hub flange damage (3)

Fig 2: Camshaft Position Actuator Inspection Points

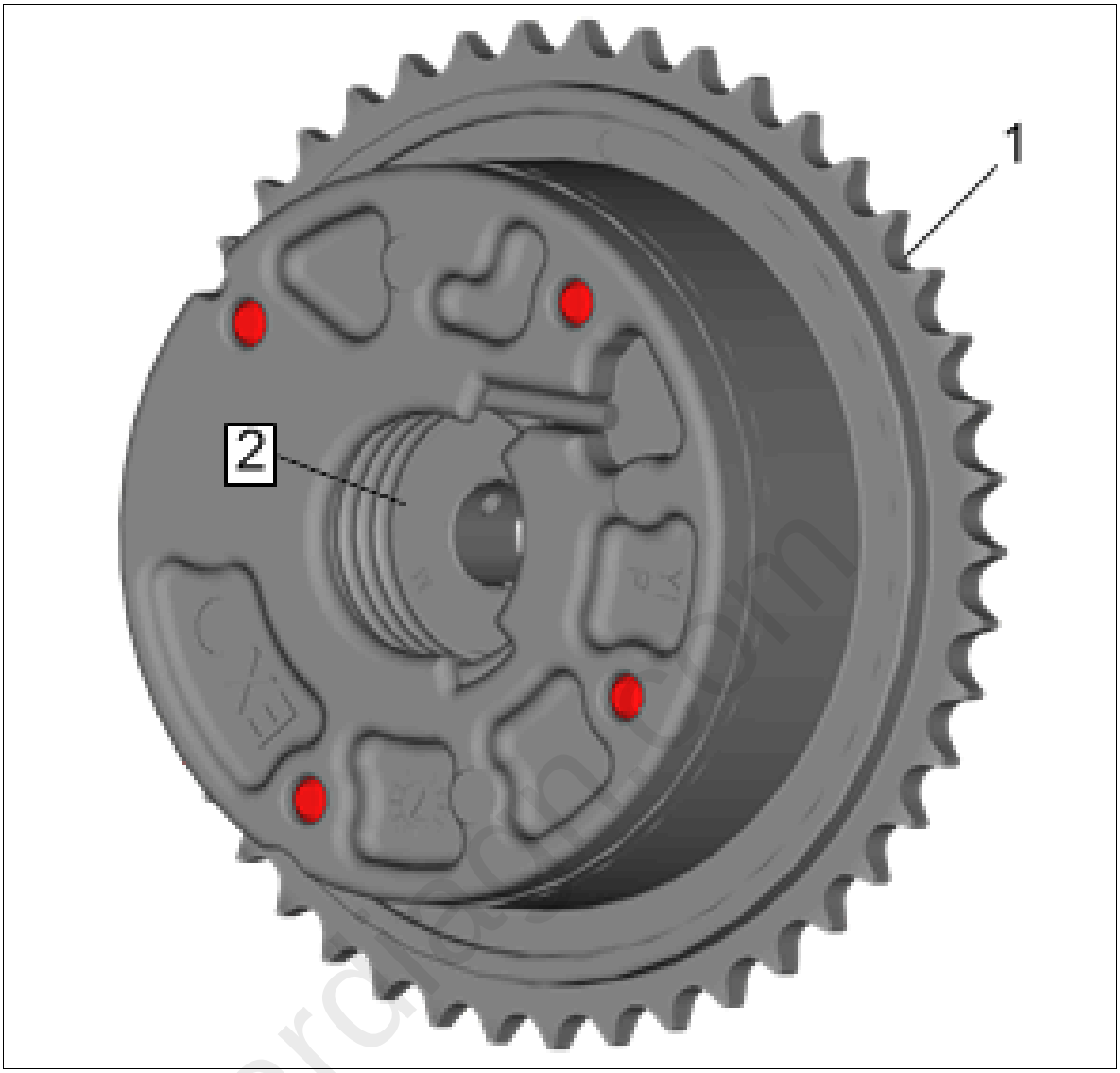


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2. Inspect the back of the right exhaust camshaft position actuators for the following:
    1. Sprocket damage (1)
    2. Camshaft locating pin damage (2)
    3. Camshaft seating/sealing inner hub flange damage (3)
    4. Blockage to the oil passages (4)

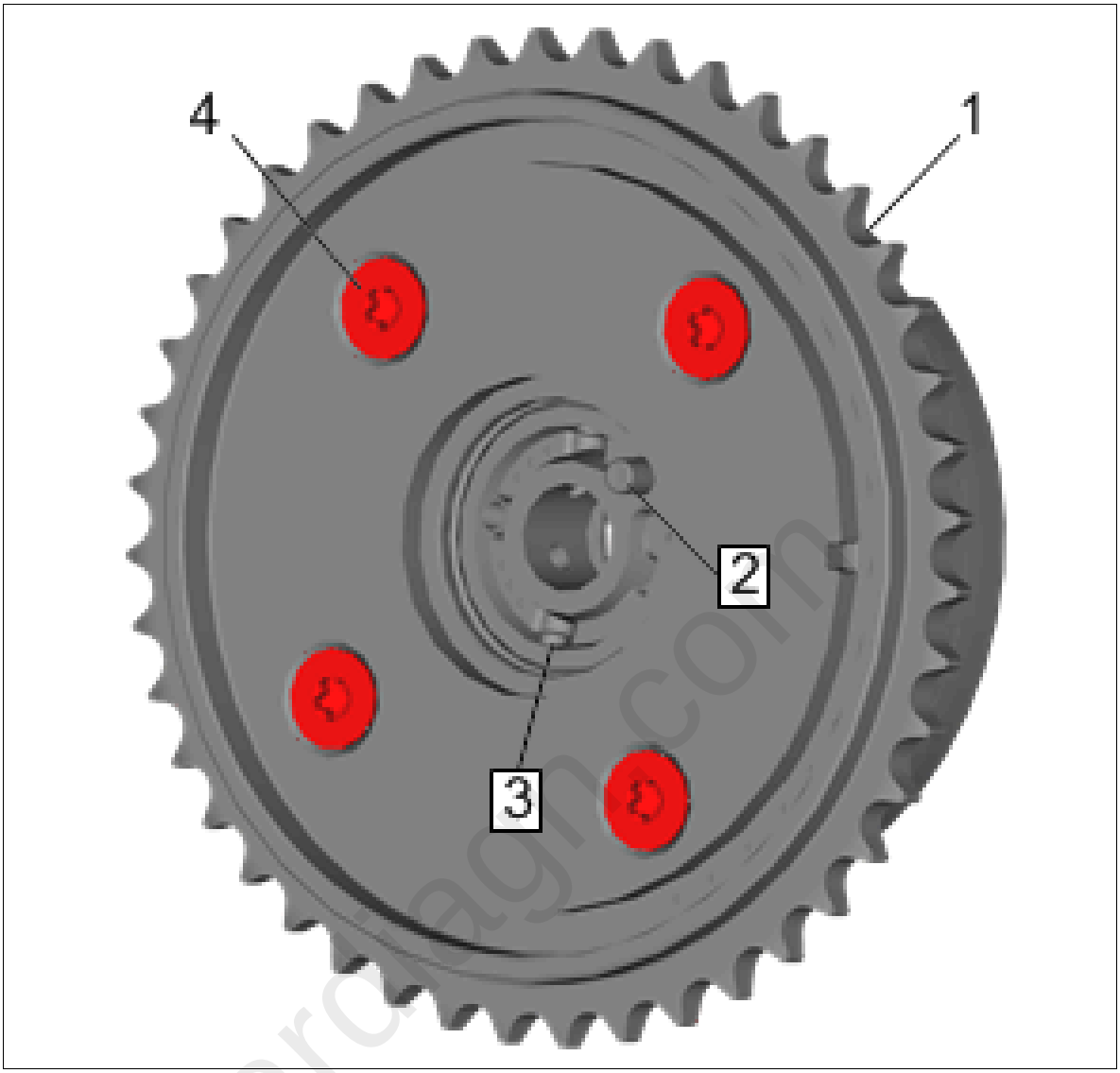
Fig 3: Camshaft Position Actuator Inspection Points



Courtesy of GENERAL MOTORS COMPANY

3. Inspect the front of the right intake camshaft position actuators for the following:
    1. Sprocket damage (1)
    2. Camshaft position actuator oil control valve bolt seating/sealing inner hub flange damage (2)

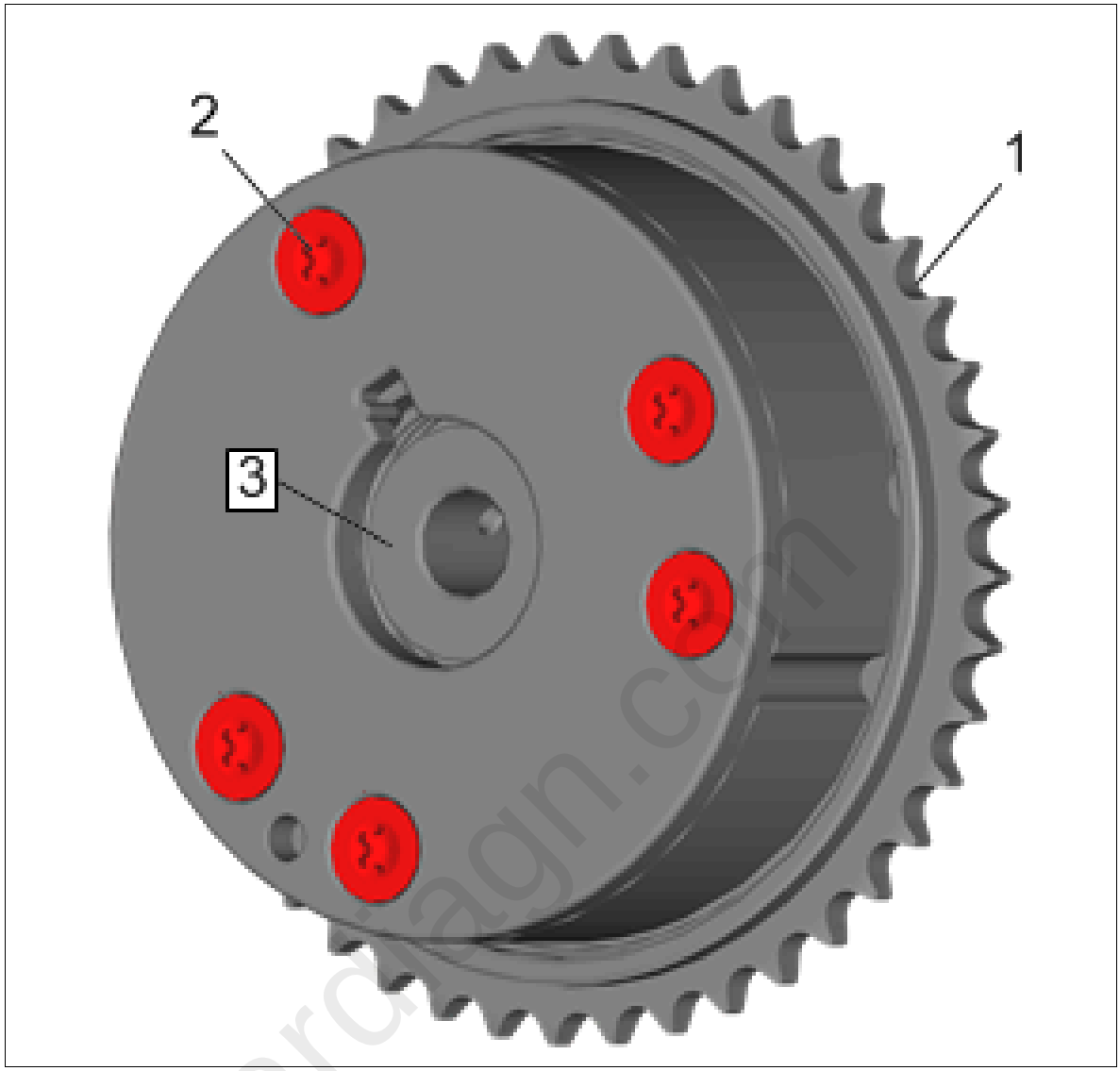
Fig 4: Camshaft Position Actuator Inspection Points



Courtesy of GENERAL MOTORS COMPANY

4. Inspect the back of the right intake camshaft position actuators for the following:
    1. Sprocket damage (1)
    2. Camshaft locating pin damage (2)
    3. Blockage to the oil passages (3)
    4. Loose or missing housing bolts (4)

Fig 5: Camshaft Position Actuator Inspection Points

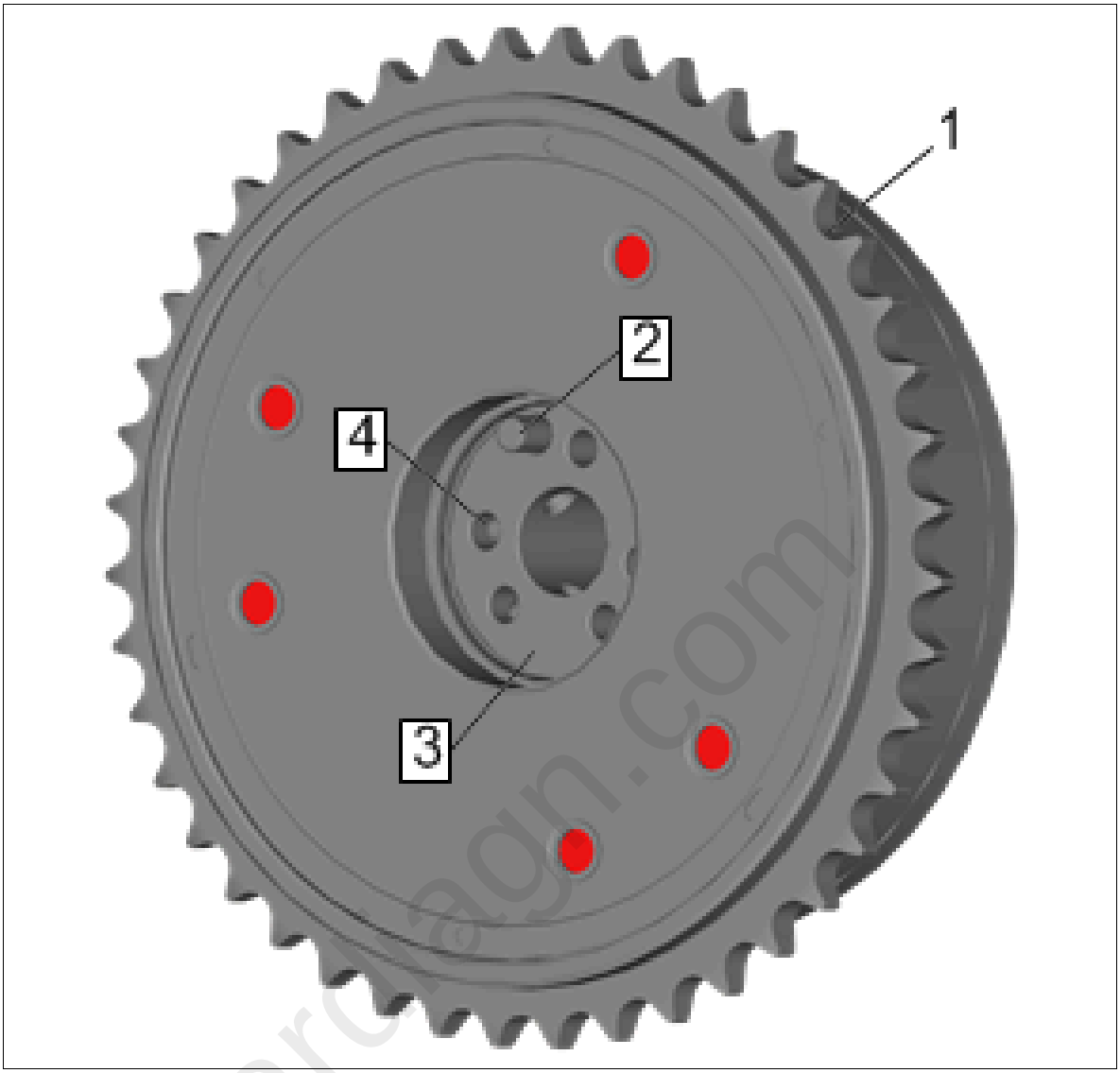


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5. Inspect the front of the left exhaust camshaft position actuators for the following:
    1. Sprocket damage (1)
    2. Loose or missing housing bolts (2)
    3. Camshaft position actuator bolt seating/sealing inner hub flange damage (3)

Fig 6: Camshaft Position Actuator Inspection Points

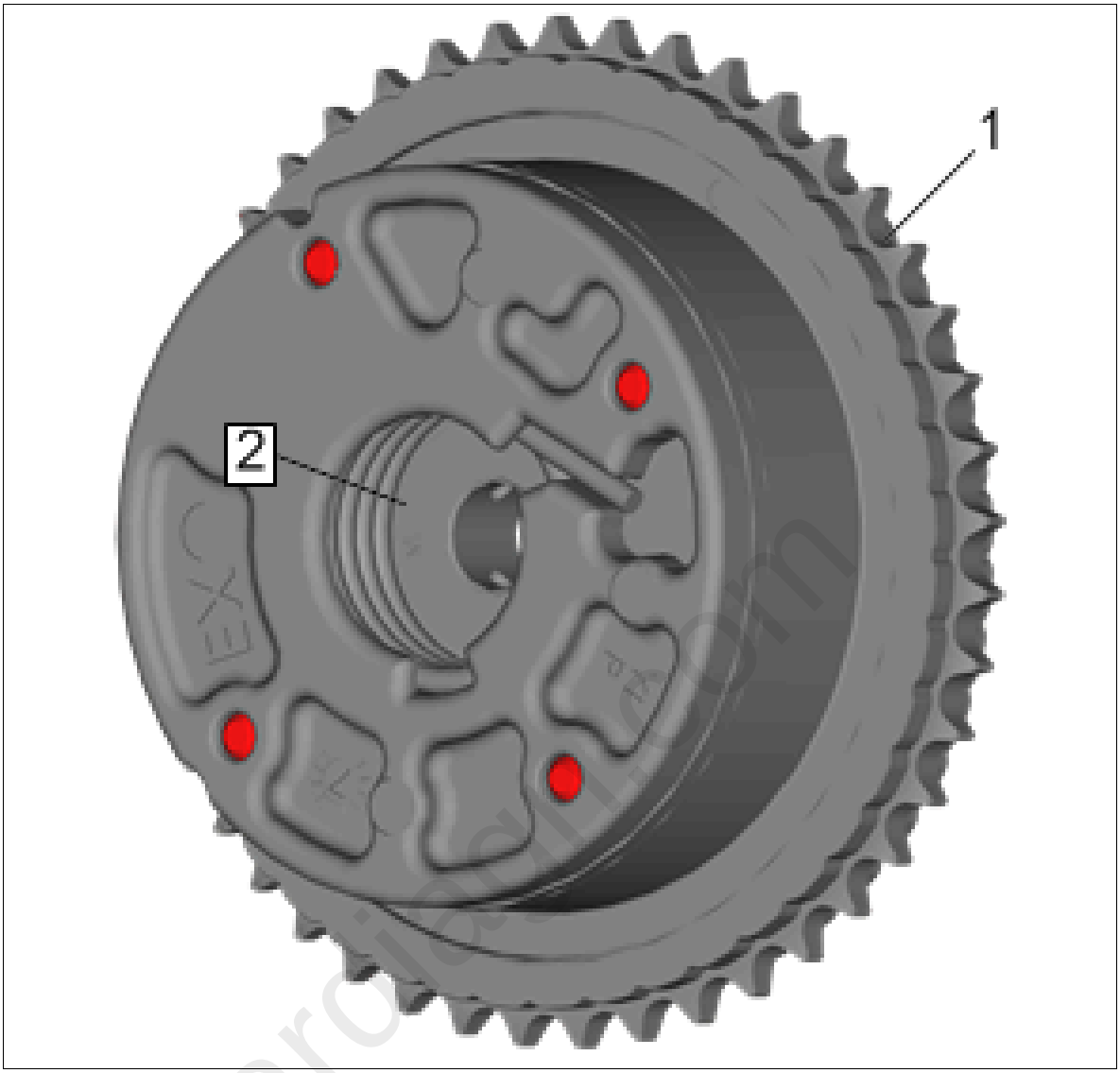


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6. Inspect the back of the left exhaust camshaft position actuators for the following:
    1. Sprocket damage (1)
    2. Camshaft locating pin damage (2)
    3. Camshaft seating/sealing inner hub flange damage (3)
    4. Blockage to the oil passages (4)

Fig 7: Camshaft Position Actuator Inspection Points

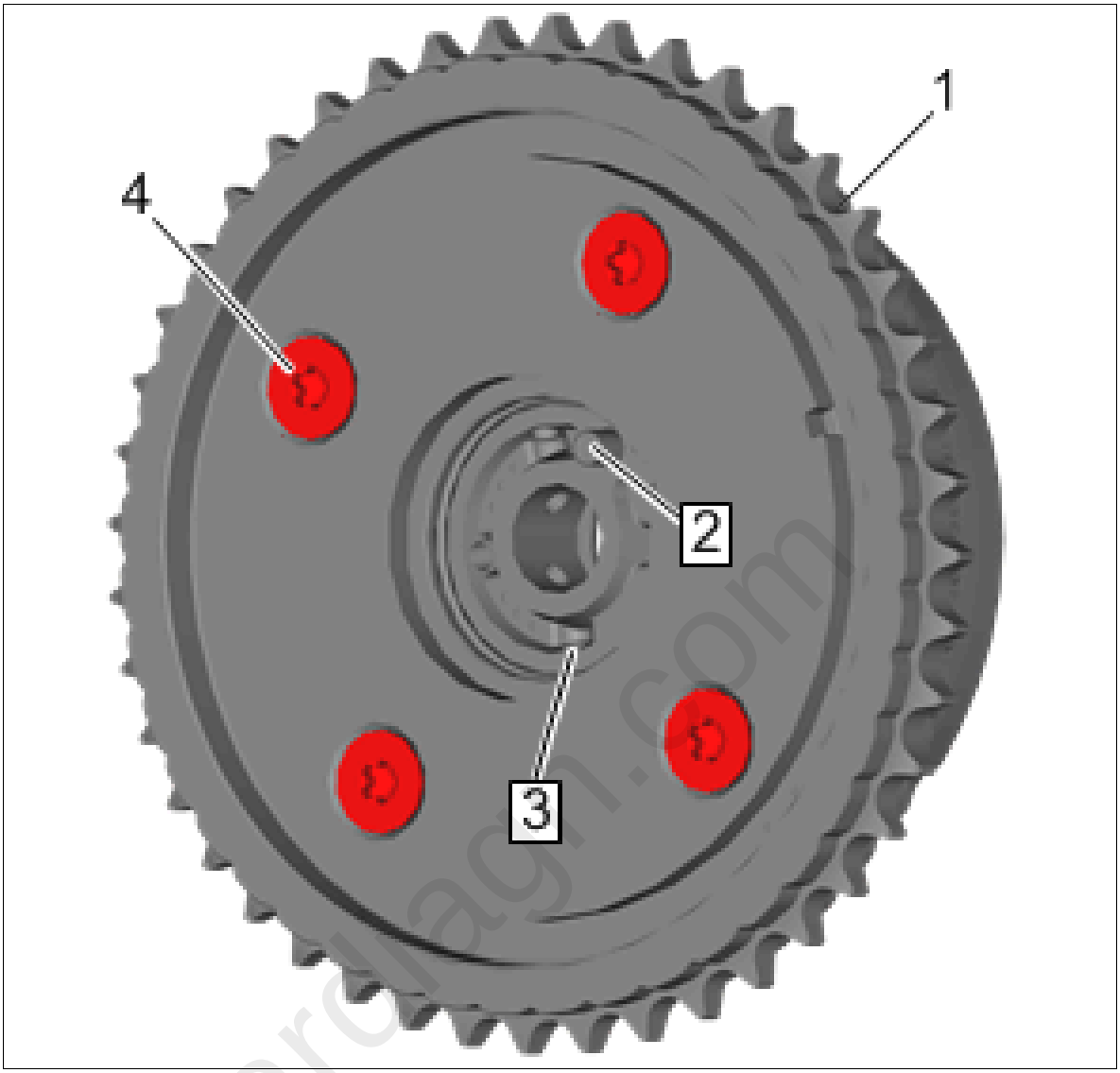


Courtesy of GENERAL MOTORS COMPANY

carolesuzon

7. Inspect the front of the left intake camshaft position actuators for the following:
    1. Sprocket damage (1)
    2. Camshaft position actuator oil control valve bolt seating/sealing inner hub flange damage (2)

Fig 8: Camshaft Position Actuator Inspection Points

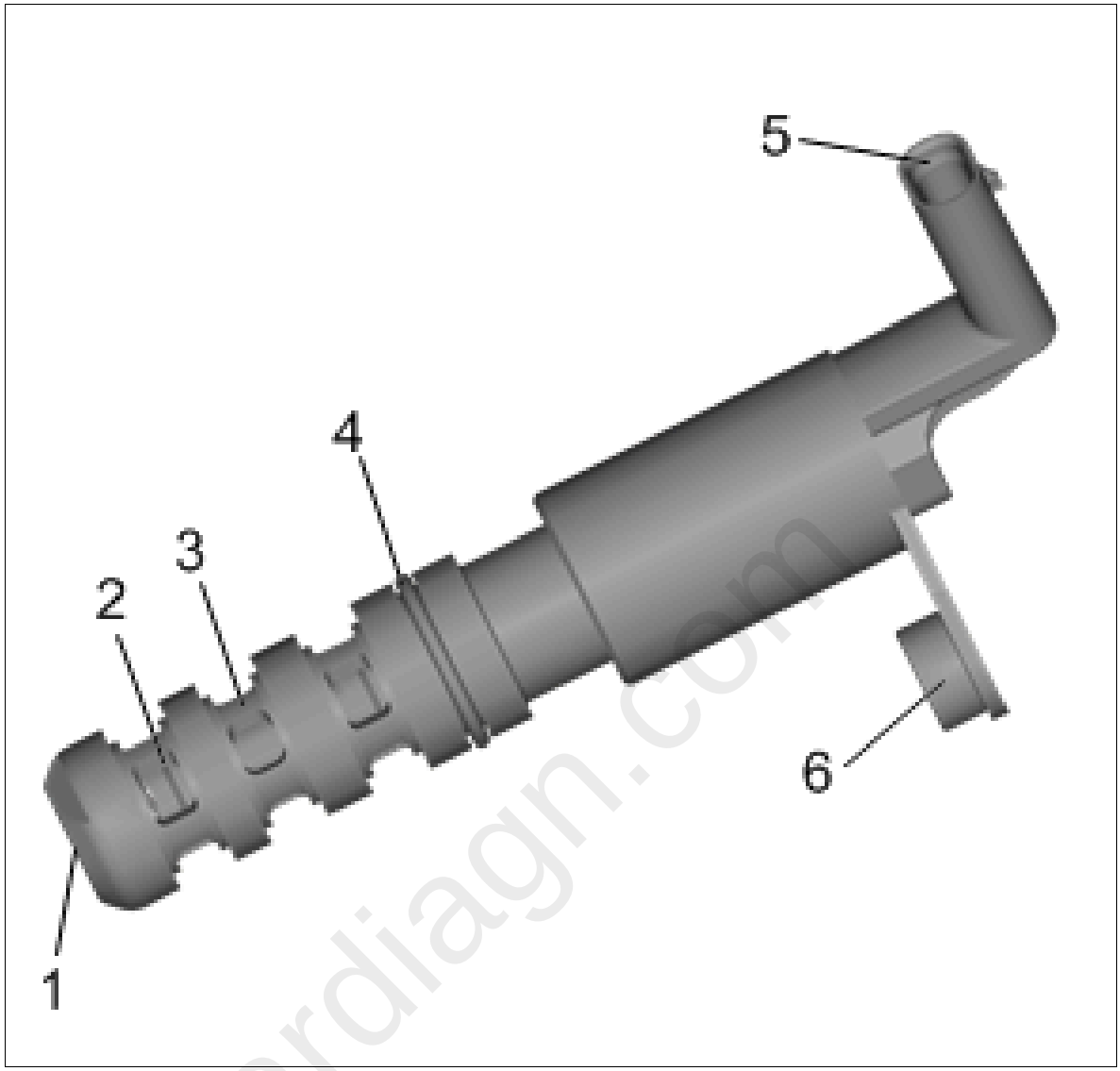


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8. Inspect the back of the left intake camshaft position actuators for the following:
    1. Sprocket damage (1)
    2. Camshaft locating pin damage (2)
    3. Blockage to the oil passages (3)
    4. Loose or missing housing bolts (4)
9. Replace a damaged camshaft position actuator.

Camshaft Position Actuator Solenoid Valve

Fig 9: Camshaft Position Actuator Solenoid Inspection Points

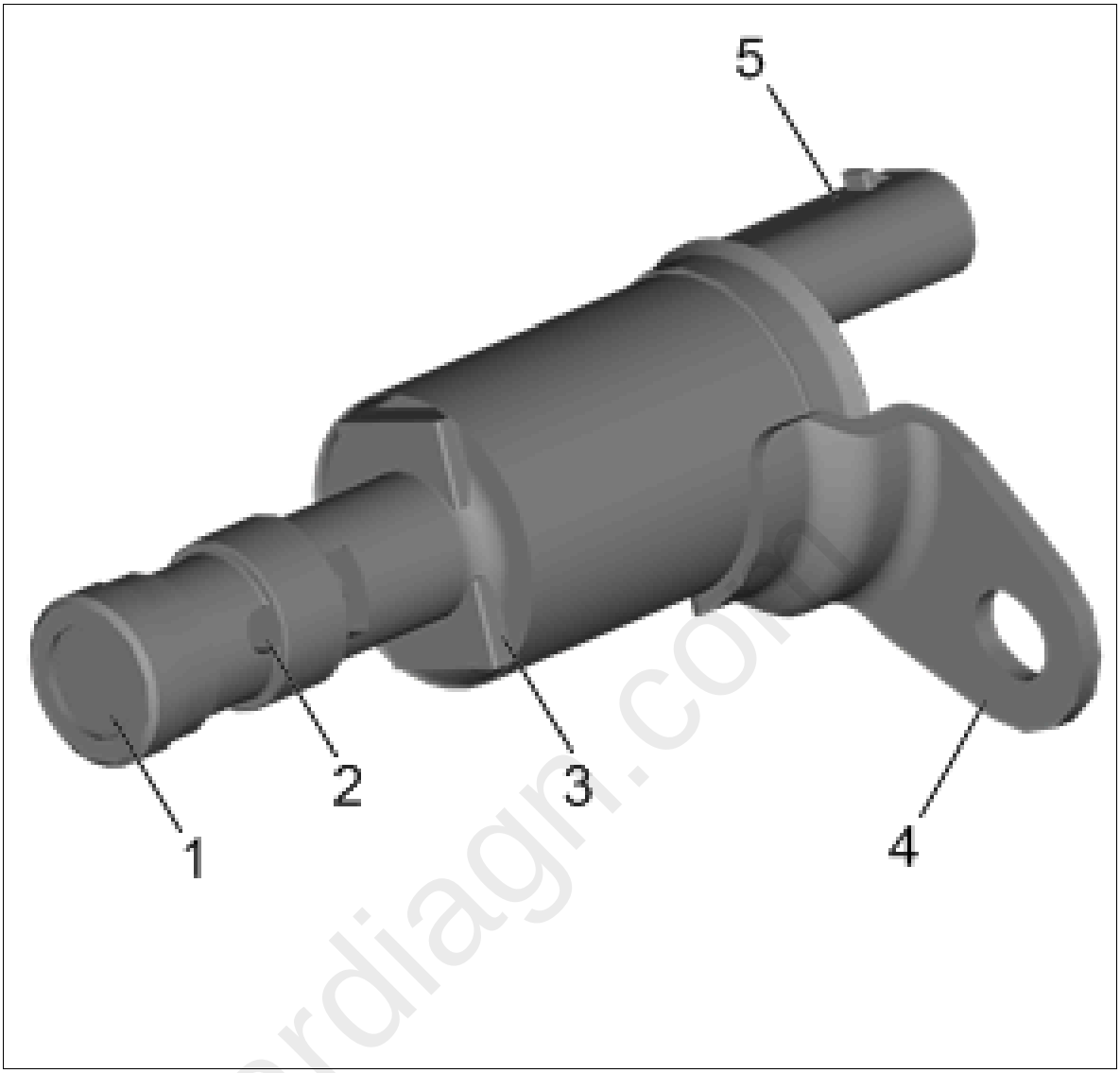


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1. Inspect the camshaft position actuator solenoid valves for the following:
    1. Blockage to the oil passage (1)
    2. Missing or damaged oil screen clip (2)
    3. Blockage or damage to the oil screen (3)
    4. Damage to the sealing surface for the camshaft position actuator solenoid valve solenoid oil seal (4)
    5. Damage to the wiring harness connection and/or terminals (5)
    6. Damage to the bracket (6)

Fig 10: Camshaft Position Actuator Solenoid Inspection Points



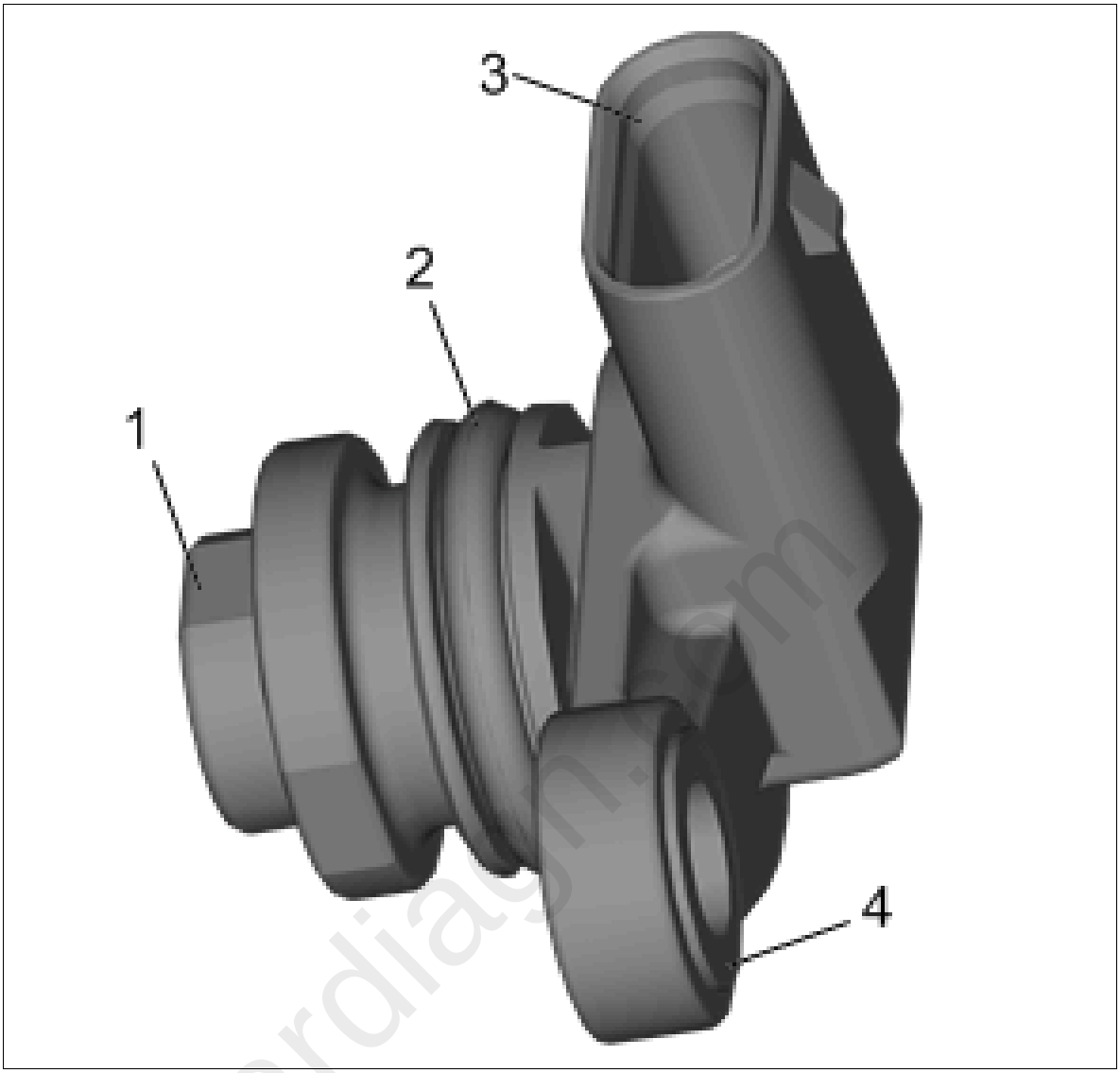
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2. Inspect the camshaft position actuator solenoid valves for the following:
    1. Blockage to the oil passage (1)
    2. Missing or damaged oil screen clip (2)
    3. Blockage or damage to the oil screen (3)
    4. Damage to the bracket (4)
    5. Damage to the wiring harness connection and/or terminals (5)
3. Replace a damaged camshaft position actuator solenoid valve.

Camshaft Position Sensor

Fig 11: Camshaft Position Sensor Inspection Points



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1. Inspect the camshaft position sensor for the following:
    1. Damage to the camshaft position sensor (1)
    2. Damage to the sealing surface for the camshaft position sensor (2)
    3. Damage to the wiring harness connection and/or terminals (3)
    4. Damage to the bracket (4)
2. Replace a damaged camshaft position sensor.

Crankshaft Sprocket

Fig 12: Crankshaft Sprocket Inspection Points



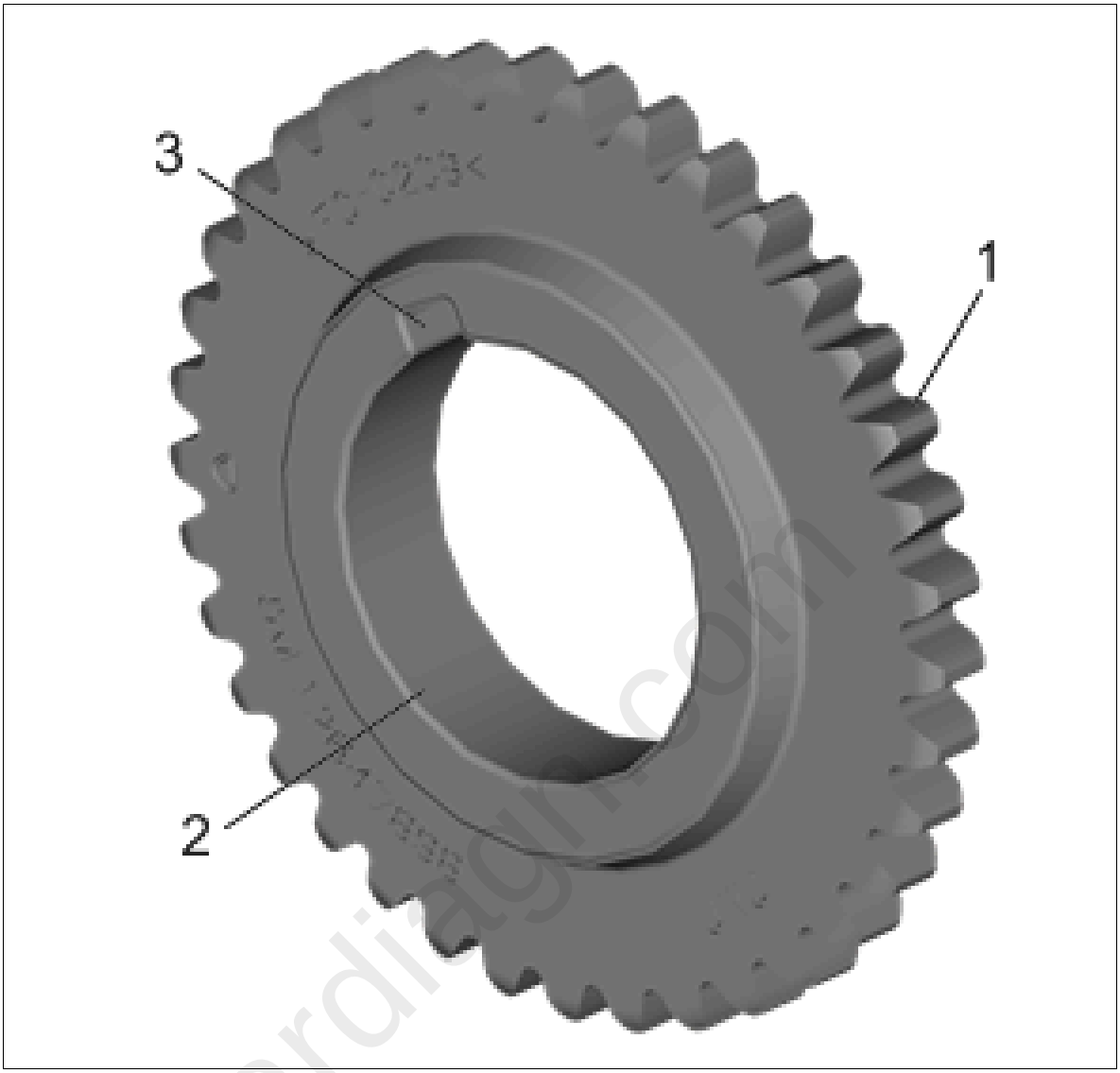
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1. Inspect the crankshaft sprocket for the following:
    1. Sprocket damage (1)
    2. Bore damage (2)
    3. Keyway damage (3)
2. Replace a damaged crankshaft sprocket.

Crankshaft Sprocket

Fig 13: Crankshaft Sprocket Inspection Points



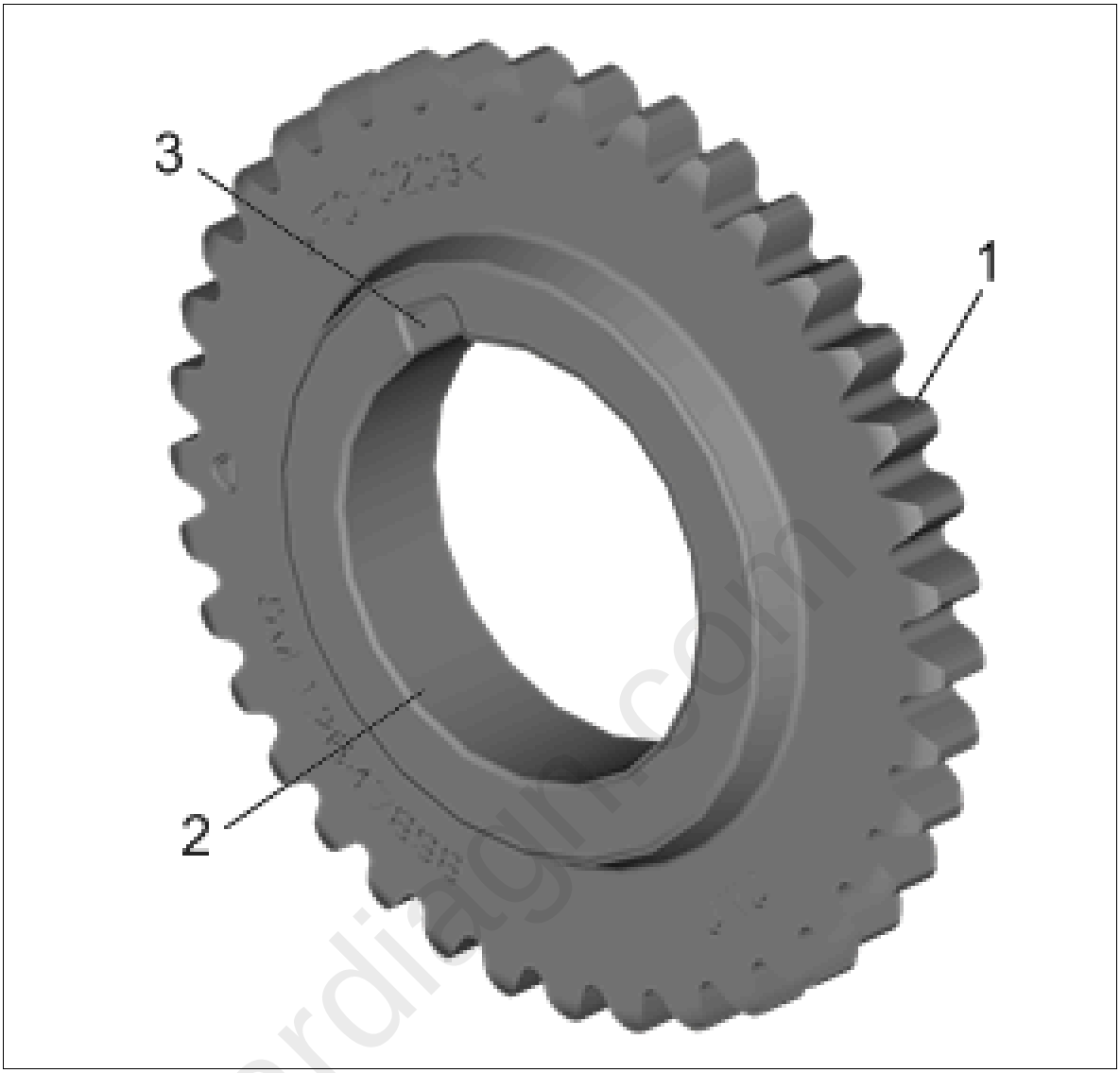
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1. Inspect the crankshaft sprocket for the following:
    1. Sprocket damage (1)
    2. Bore damage (2)
    3. Keyway damage (3)
2. Replace a damaged crankshaft sprocket.

Oil Pump Sprocket

Fig 14: Crankshaft Sprocket Inspection Points



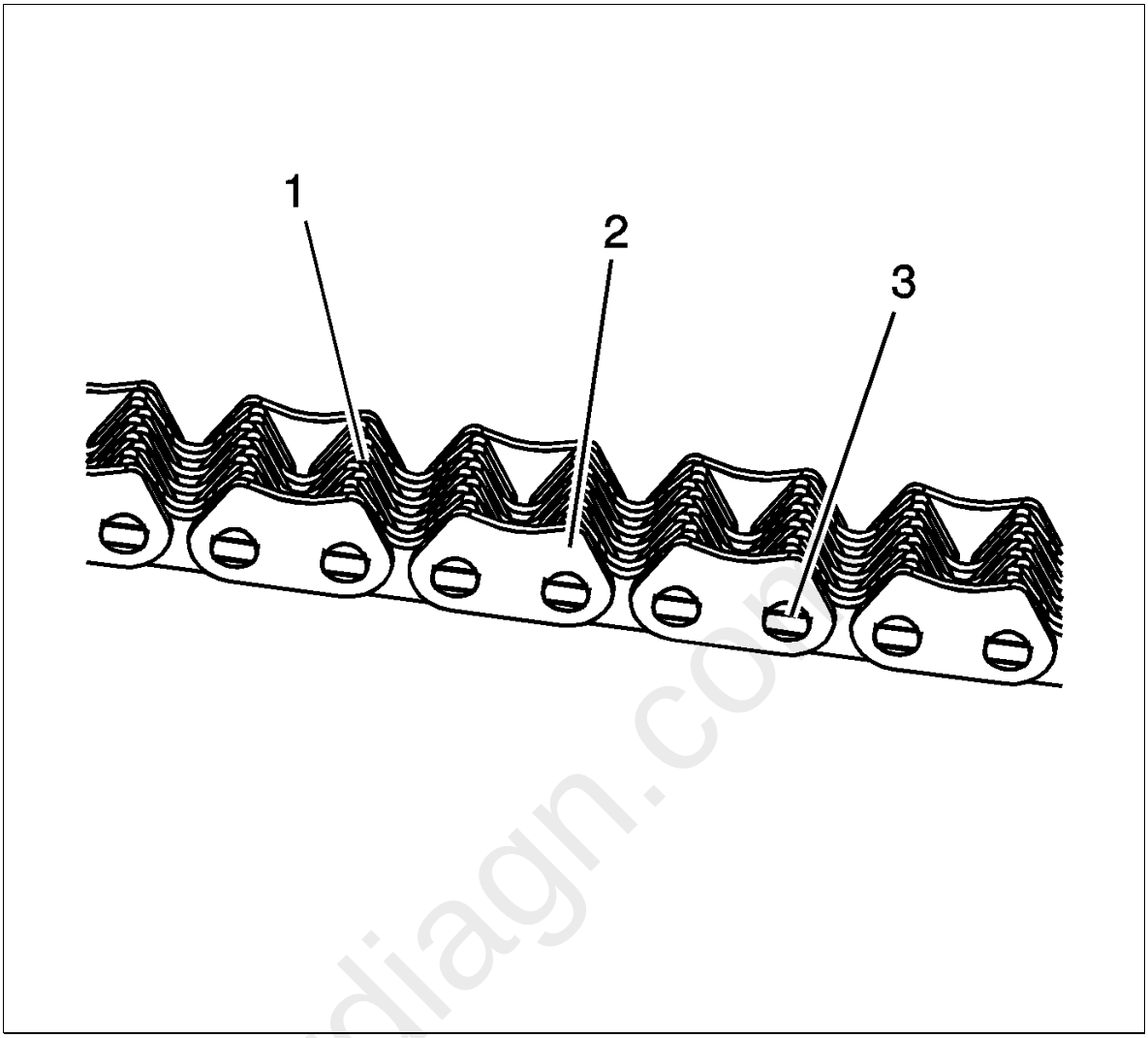
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1. Inspect the crankshaft sprocket for the following:
    1. Sprocket damage (1)
    2. Bore damage (2)
    3. Bore damage (3)
    4. Keyway damage (4)
2. Replace a damaged crankshaft sprocket.

Timing Chains with Inverted Tooth (IT) Chain

Fig 15: Primary & Secondary Timing Chain Inspection Locations



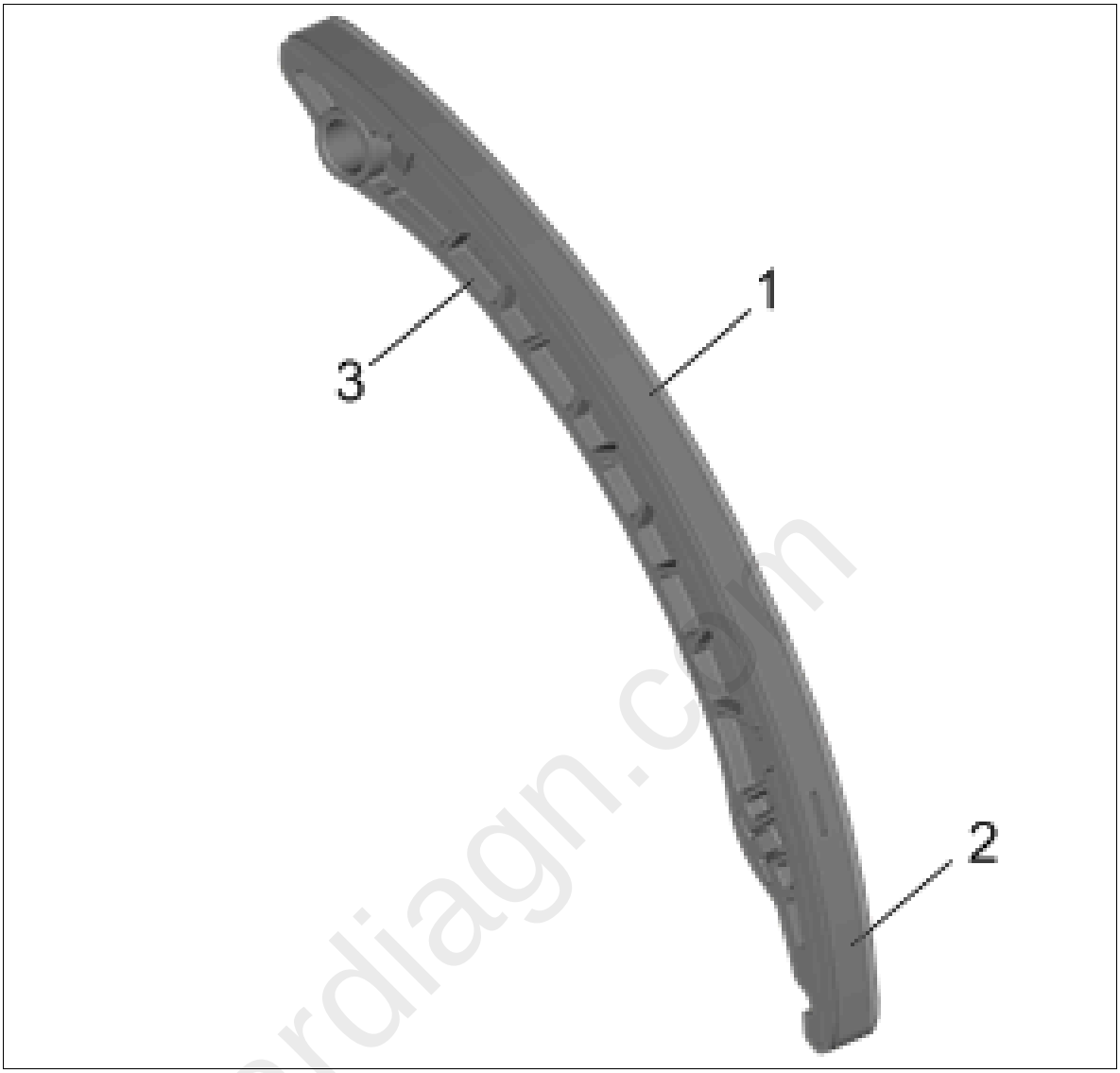
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1. Inspect the timing chain for the following:
    1. Binding or worn links (1)
    2. Loose links (2)
    3. Loose pins (3)
2. Replace a damaged timing chain.

Timing Chain Guide

Fig 16: Timing Chain Guide Inspection Points



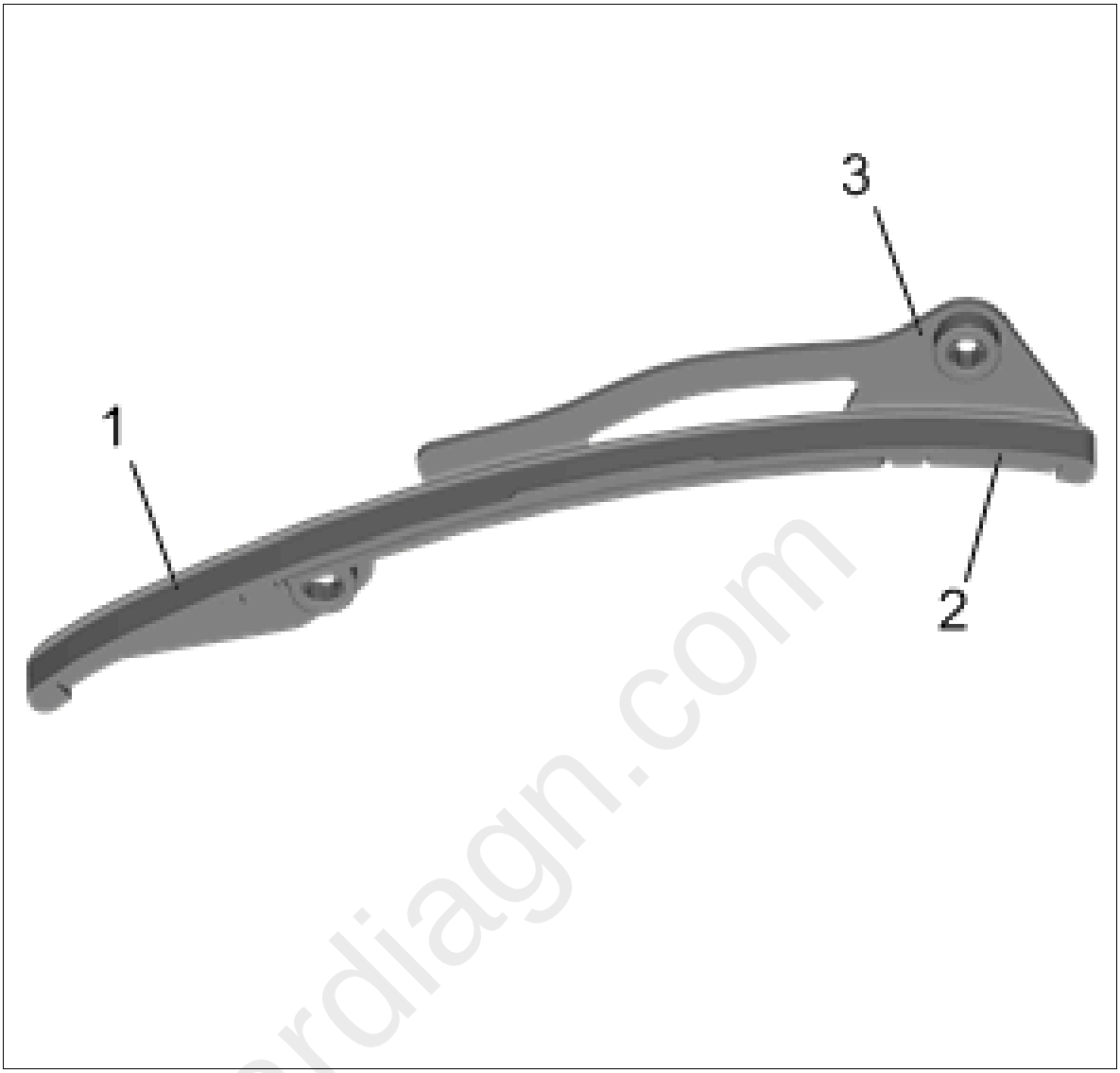
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1. Inspect the timing chain guide for the following:
    1. Worn guide surface (1)
    2. Cracked or broken guide surface (2)
    3. Cracked or damaged guide base (3)
2. Replace a damaged primary timing chain upper guide.

Timing Chain Guide

Fig 17: Timing Chain Guide Inspection Points



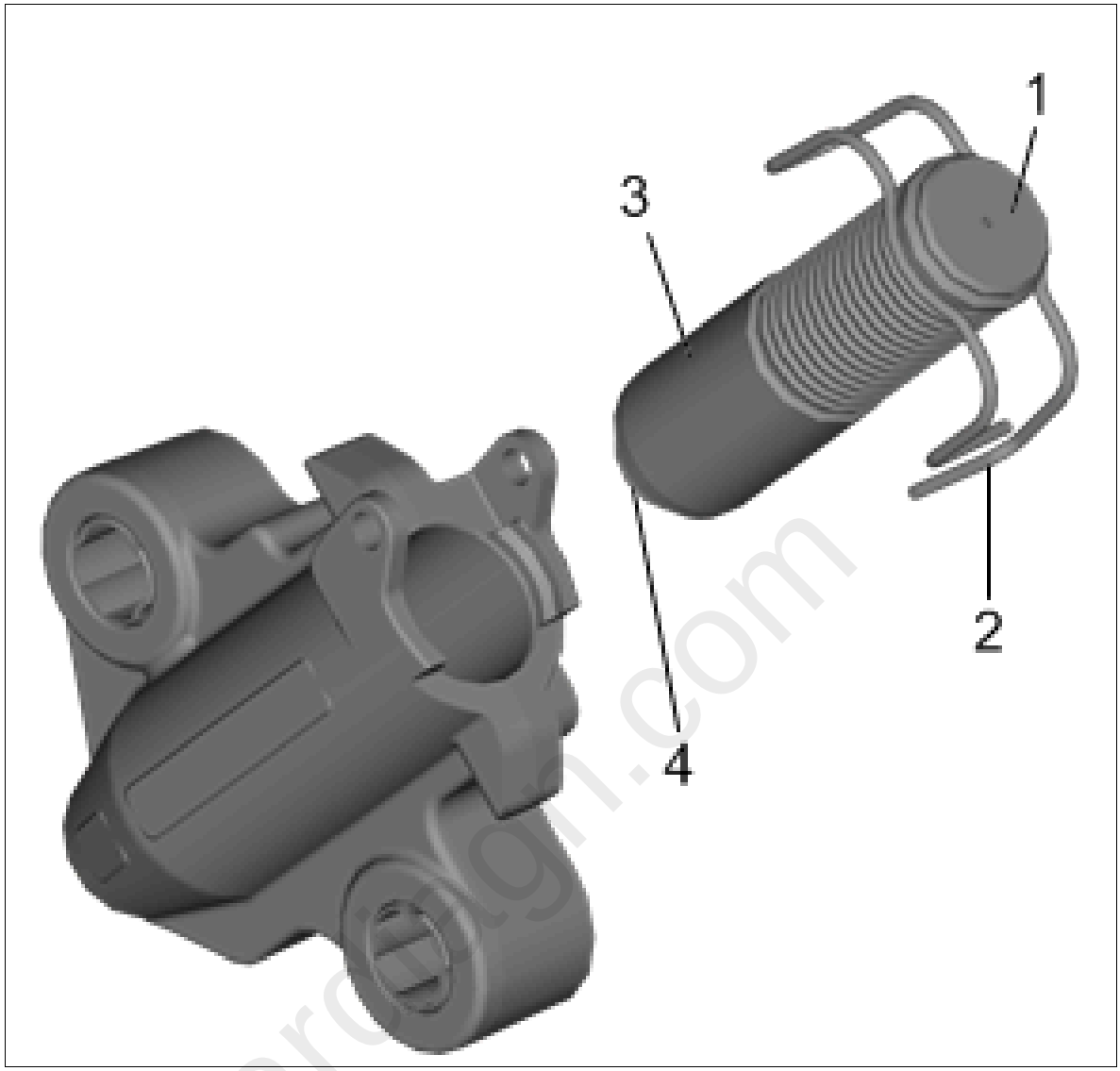
Courtesy of GENERAL MOTORS COMPANY

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1. Inspect the timing chain guide for the following:
    1. Worn guide surface (1)
    2. Cracked or broken guide surface (2)
    3. Cracked or damaged guide base (3)
2. Replace a damaged primary timing chain upper guide.

Timing Chain Tensioner

Fig 18: Timing Chain Tensioner



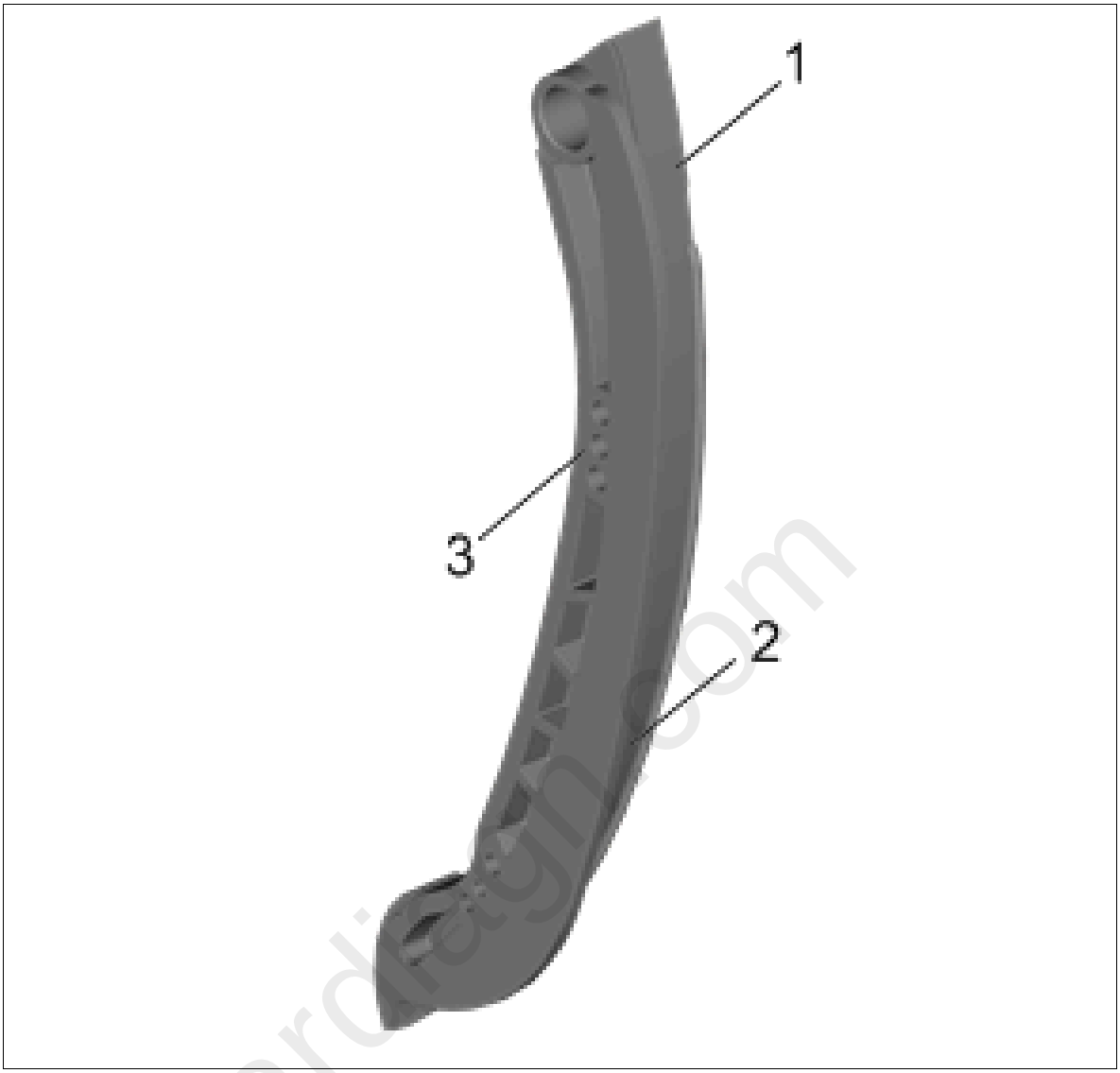
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1. Inspect the timing chain tensioner for worn timing chain tensioner surface (1).
2. Inspect the timing chain tensioner for worn timing chain tensioner spring (2).
3. Inspect the timing chain tensioner for locked or binding timing chain tensioner. Reset the plunger (4) and ensure the plunger moves freely (3) in and out of the body of the tensioner. Refer to Camshaft Timing Chain Components Installation .
4. Replace a damaged primary timing chain tensioner.

Timing Chain Guide

Fig 19: Timing Chain Guide Inspection Points



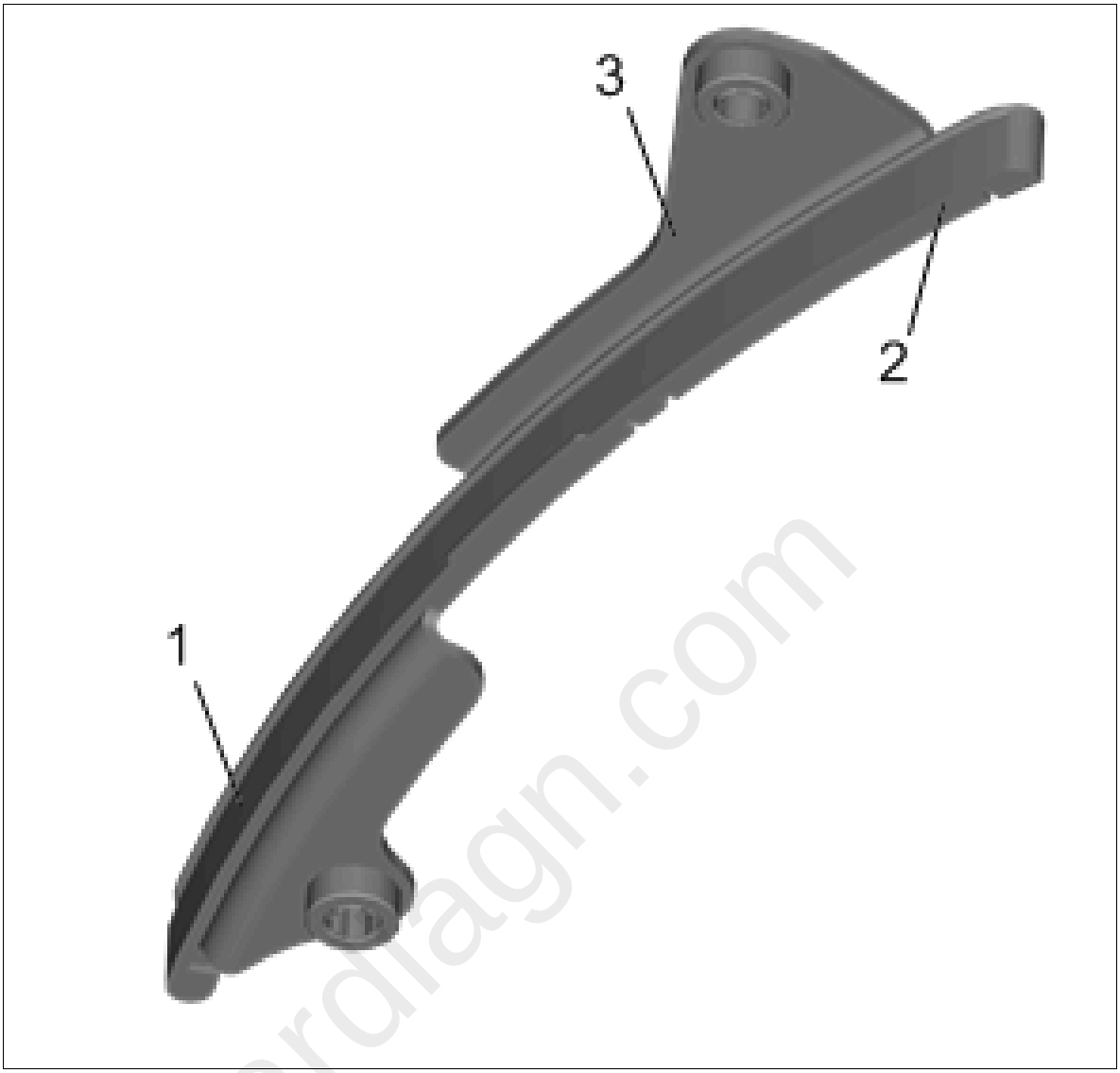
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1. Inspect the timing chain guide for the following:
    1. Worn guide surface (1)
    2. Cracked or broken guide surface (2)
    3. Cracked or damaged guide base (3)
2. Replace a damaged primary timing chain upper guide.

Timing Chain Guide

Fig 20: Timing Chain Guide Inspection Points



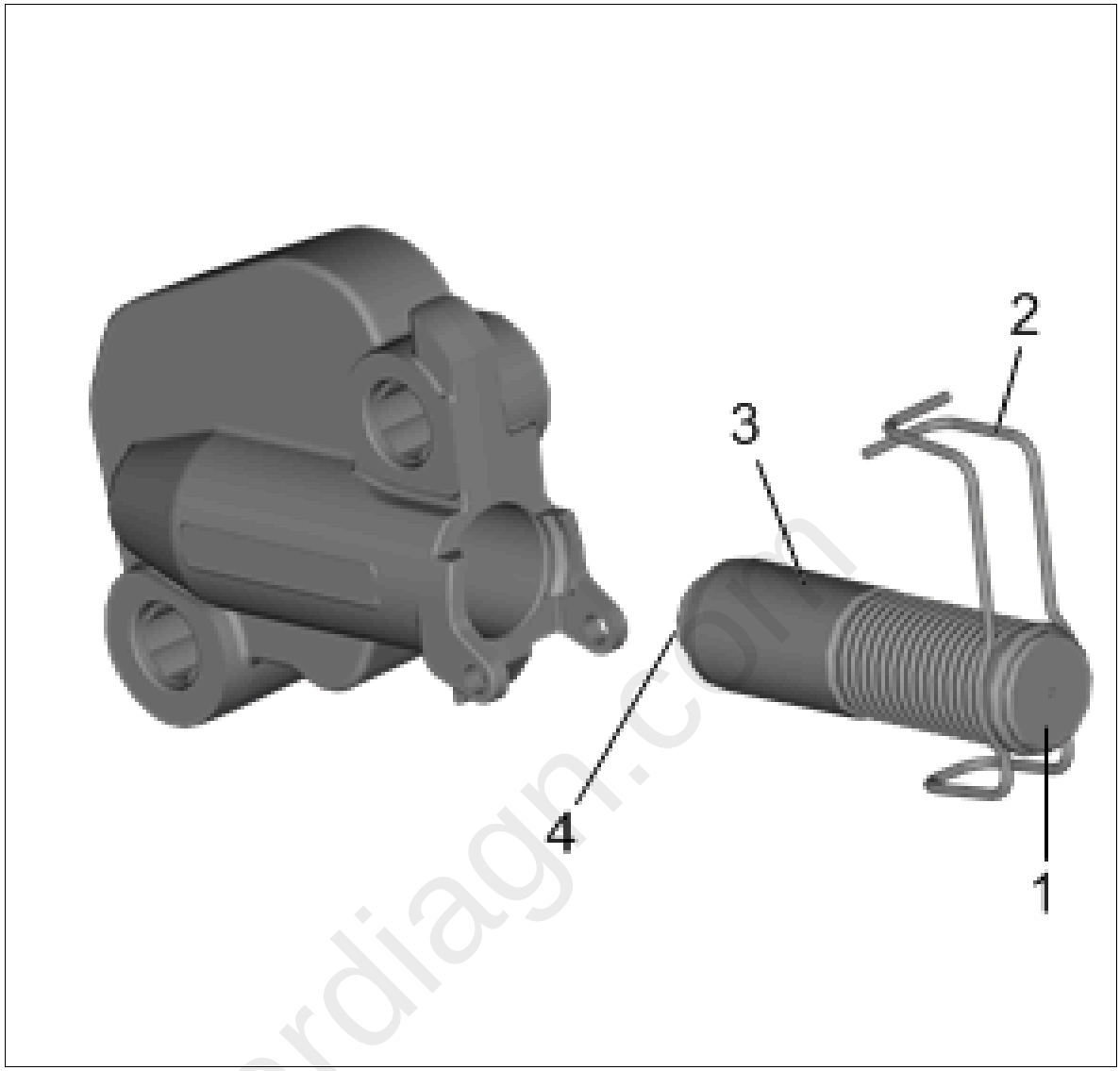
Courtesy of GENERAL MOTORS COMPANY

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1. Inspect the timing chain guide for the following:
    1. Worn guide surface (1)
    2. Cracked or broken guide surface (2)
    3. Cracked or damaged guide base (3)
2. Replace a damaged primary timing chain upper guide.

Timing Chain Tensioner

Fig 21: Timing Chain Tensioner Inspection Points



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1. Inspect the timing chain tensioner for worn timing chain tensioner surface (1).
2. Inspect the timing chain tensioner for worn timing chain tensioner spring (2).
3. Inspect the timing chain tensioner for locked or binding timing chain tensioner. Reset the plunger (4) and ensure the plunger moves freely (3) in and out of the body of the tensioner. Refer to Camshaft Timing Chain Components Installation .
4. Replace a damaged primary timing chain tensioner.

Timing Chain Tensioner

Fig 22: Timing Chain Tensioner Inspection Points



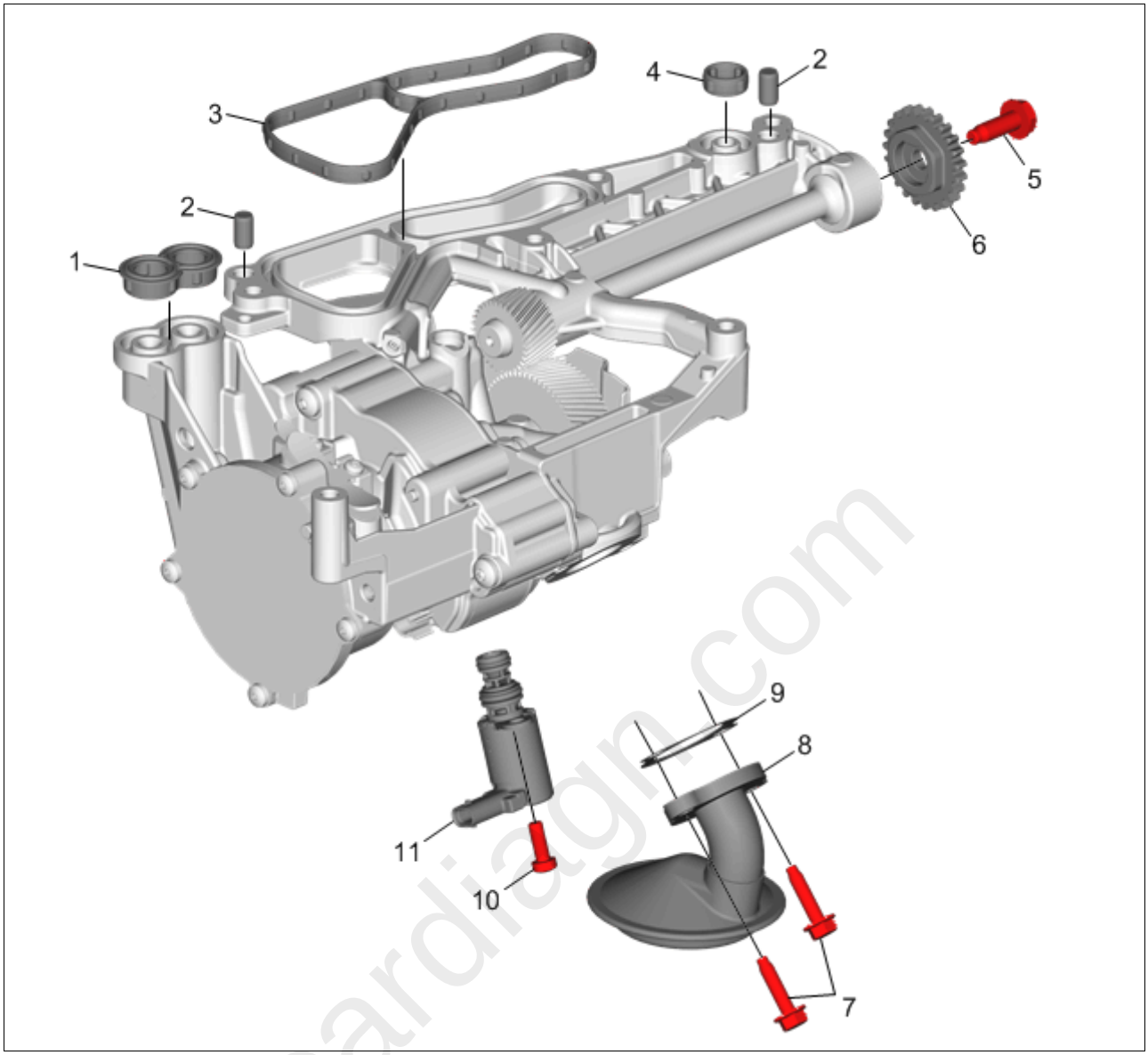
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1. Inspect the timing chain tensioner for worn timing chain tensioner surface (1).
2. Cracked or broken tensioner surface (2)
3. Inspect the timing chain tensioner for worn timing chain tensioner spring (3).
4. Replace a damaged primary timing chain tensioner.

REPAIR INSTRUCTIONS - OFF VEHICLE > OIL PUMP DISASSEMBLE

Fig 1: Oil Pump Disassemble (LGX)



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Vacuum Pump Seal *NOTE:* *Remove and DISCARD the seal.*
2	Dowel Pin *NOTE:*

	This is press fit and not serviceable.
3	Oil Pump Housing Passage Seal *NOTE:* *Remove and DISCARD the seal.*
4	Oil Pump Housing Passage Seal *NOTE:* *Remove and DISCARD the seal.*
5	Oil Pump Drive Bolt
6	Oil Pump Sprocket
7	Oil Pump Suction Pipe Bolt
8	Oil Pump Suction Pipe
9	Oil Pump Suction Pipe Gasket *NOTE:* *Remove and DISCARD the gasket.*
10	Oil Pump Flow Control Valve Bolt
11	Oil Pump Flow Control Valve *CAUTION:* *After removing the oil pump flow control valve, ensure the entire valve has been removed and there is no debris left in the oil pump bore. Failure to ensure the oil pump bore is free from debris may result in engine damage.*

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REPAIR INSTRUCTIONS - OFF VEHICLE > OIL PUMP CLEANING AND INSPECTION >

CLEANING PROCEDURE

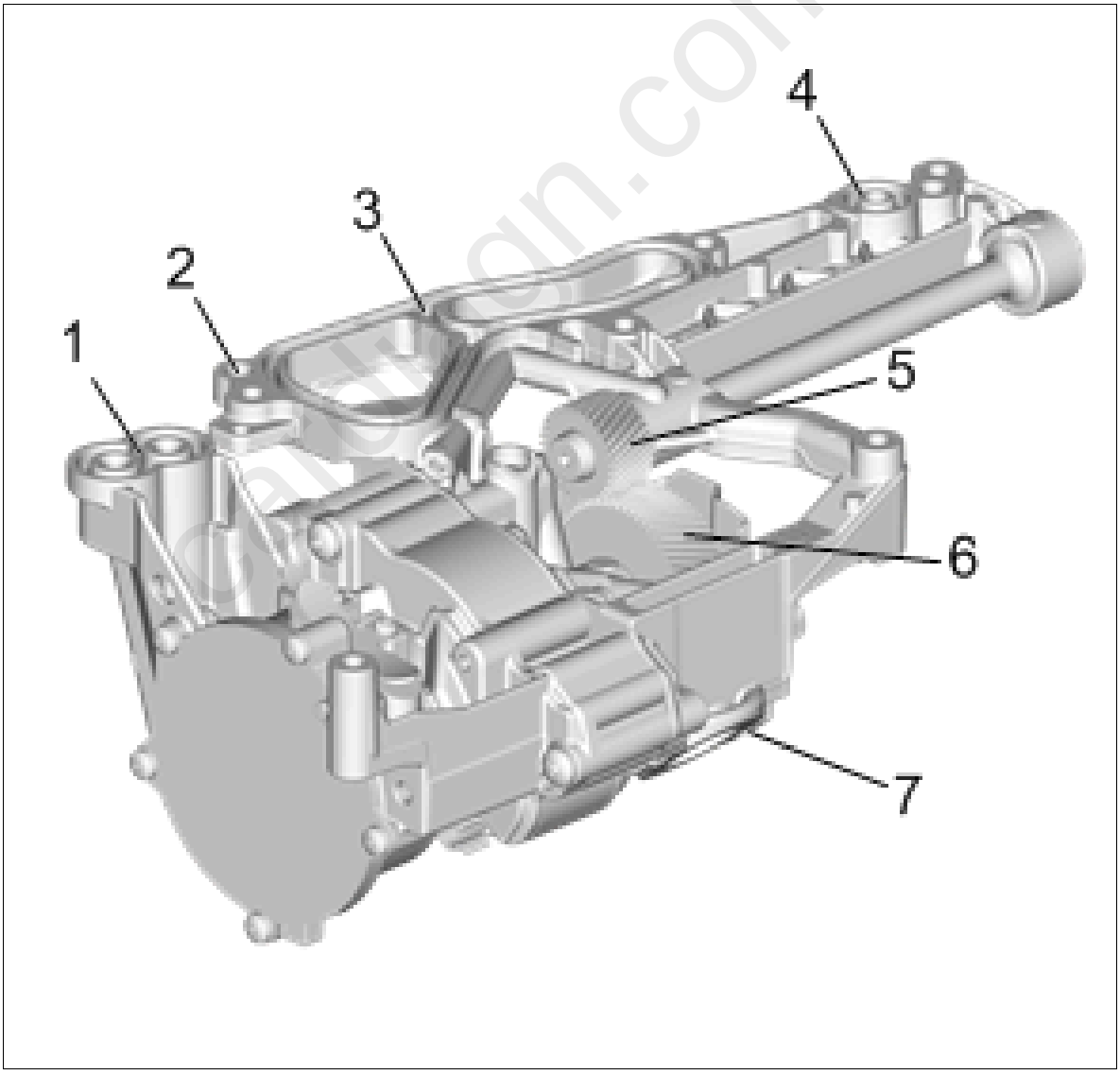
1. Clean the oil pump components with non-corrosive solvent.

> *WARNING:*
>
> *Refer to Safety Glasses Warning .*

2. Dry the oil pump components with compressed air.

REPAIR INSTRUCTIONS - OFF VEHICLE > OIL PUMP CLEANING AND INSPECTION > INSPECTION PROCEDURE

Fig 1: Oil Pump Inspection Points



Courtesy of GENERAL MOTORS COMPANY

NOTE:

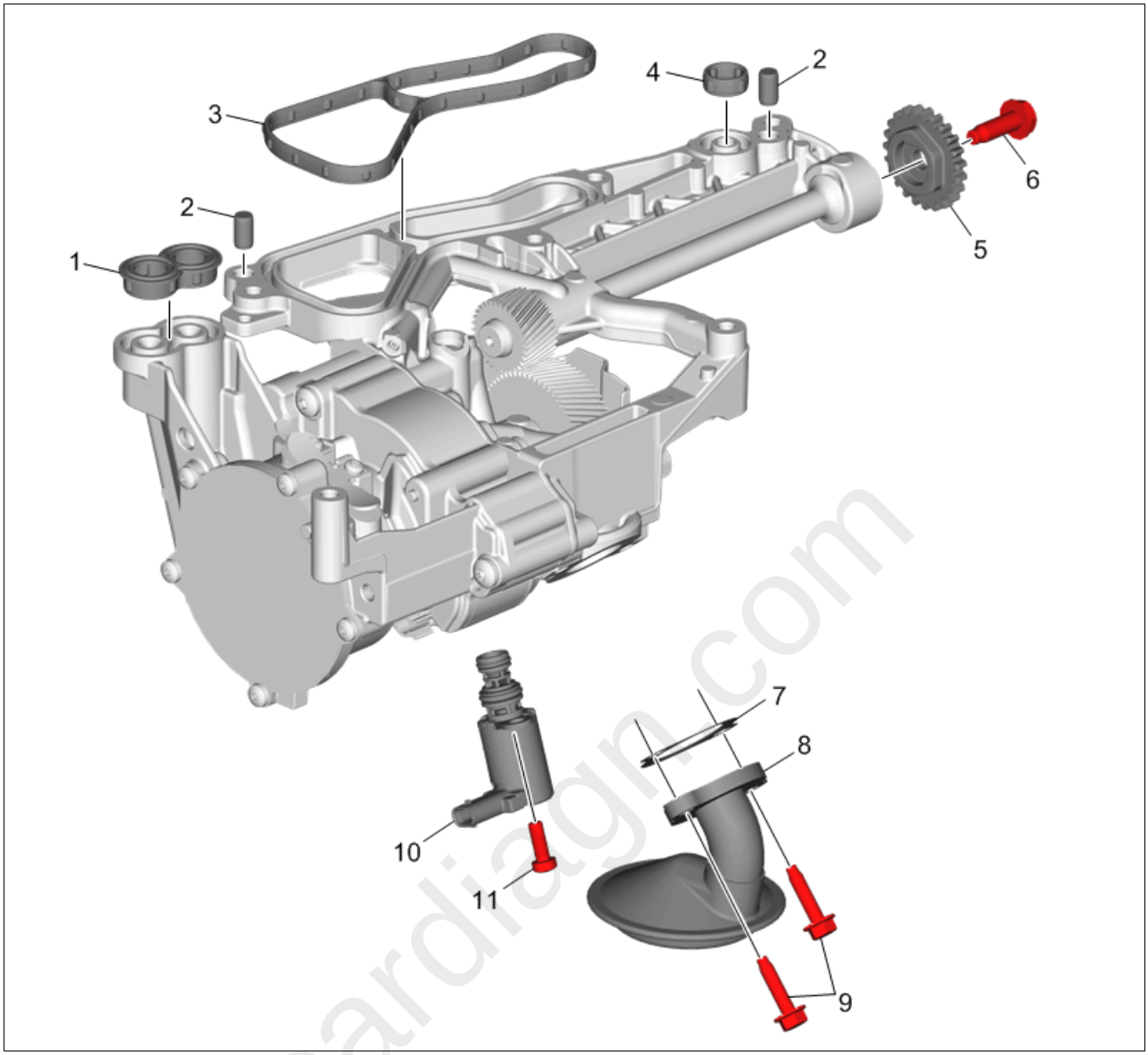
There are no serviceable components within the oil pump. Disassemble the pump only to diagnose an oiling concern. A disassembled oil pump must not be reused. A disassembled oil pump must be replaced.

1. Inspect the oil pump housing for the following:
    1. Damage to the vacuum pump seal surface (1)
    2. Damage to the oil pump mounting bosses (2)
    3. Damage to the oil pump housing seal surface (3)
    4. Damage to the oil pump housing seal surface (4)
    5. Damage to the gear (5)
    6. Damage to the gear (6)
    7. Damage to the mounting surface for the suction pipe (7)

REPAIR INSTRUCTIONS - OFF VEHICLE > OIL PUMP ASSEMBLE

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Fig 1: Oil Pump Assemble (LGX)



Courtesy of GENERAL MOTORS COMPANY

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Callout	Component Name
1	Vacuum Pump Seal *NOTE:* *Install a NEW seal.*
2	Dowel Pin *NOTE:*

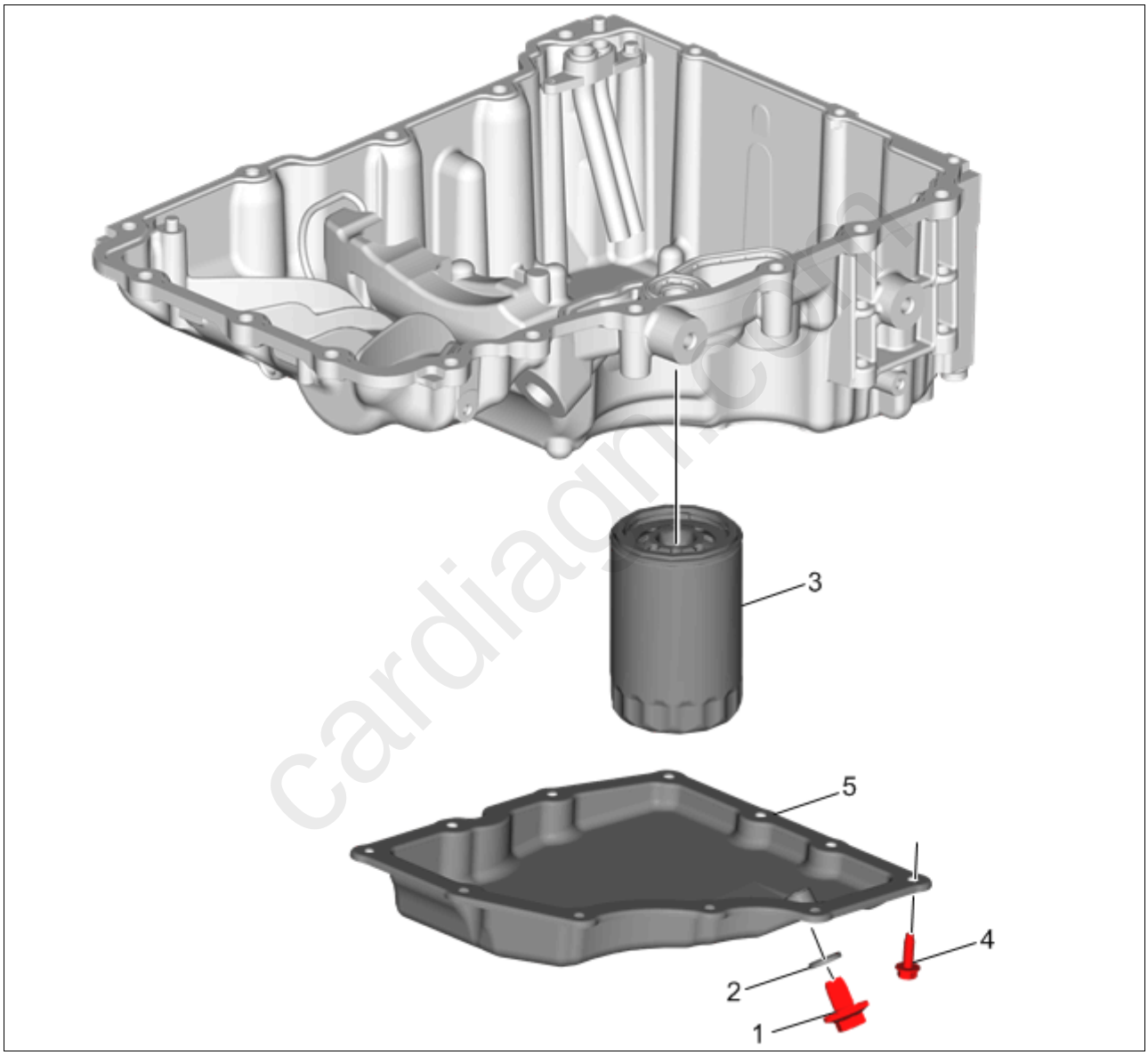
	This is press fit and not serviceable.
3	Oil Pump Housing Passage Seal *NOTE:* *Install a NEW seal.*
4	Oil Pump Housing Passage Seal *NOTE:* *Install a NEW seal.*
5	Oil Pump Sprocket
6	Oil Pump Drive Bolt *CAUTION:* *Refer to Fastener Caution .* **Tighten** First Pass : 15 N.m (11 lb ft) Final Pass: 110 degrees
7	Oil Pump Suction Pipe Gasket *NOTE:* *Install a NEW gasket.*
8	Oil Pump Suction Pipe
9	Oil Pump Suction Pipe Bolt **Tighten** 10 N.m (89 lb in)
10	Oil Pump Flow Control Valve

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11	Oil Pump Flow Control Valve Boltwith Insulator **Tighten** 5 N.m (44 lb in)

REPAIR INSTRUCTIONS - OFF VEHICLE > OIL PAN DISASSEMBLE > LOWER OIL PAN, DRAIN PLUG AND OIL FILTER DISASSEMBLE

Fig 1: Lower Oil Pan, Drain Plug and Oil Filter Disassemble



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Courtesy of GENERAL MOTORS COMPANY

Lower Oil Pan, Drain Plug and Oil Filter Disassemble

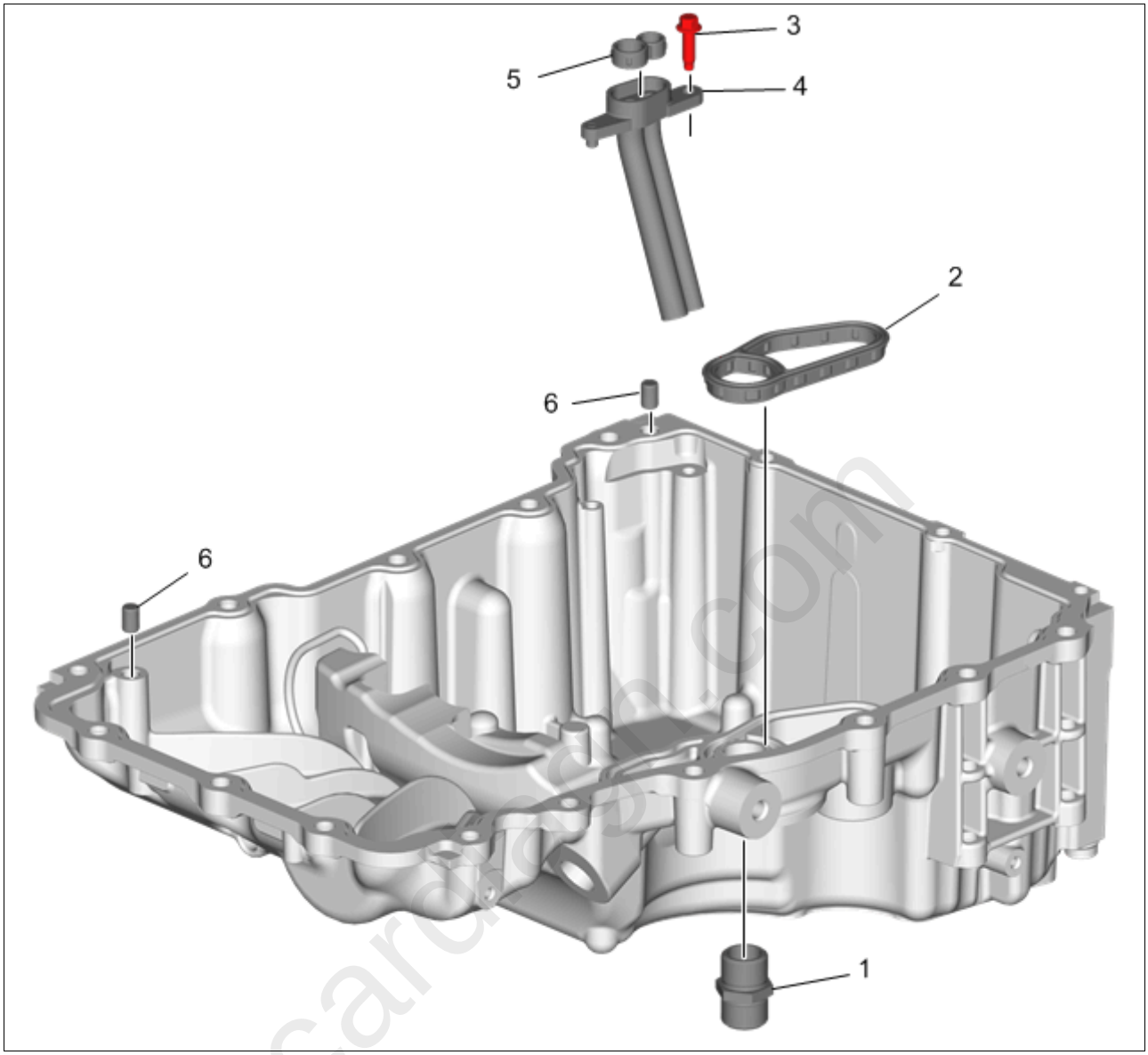
Callout	Component Name
1	Oil Pan Drain Plug

2	Oil Pan Drain Plug Seal *NOTE:* *Remove and DISCARD the seal.*
3	Oil Filter
4	Lower Oil Pan Bolt (Qty: 11)
5	Lower Oil Pan

REPAIR INSTRUCTIONS - OFF VEHICLE > OIL PAN DISASSEMBLE > OIL FILTER ADAPTER FITTING, OIL PAN HIGH PRESSURE SEAL, POSITIVE CRANKCASE VENTILATION OIL SEPARATOR DRAIN, AND DOWEL PINS DISASSEMBLE

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Fig 1: Oil Filter Adapter Fitting, Oil Pan High Pressure Seal, Positive Crankcase Ventilation Oil Separator Drain, and Dowel Pins Disassemble



Courtesy of GENERAL MOTORS COMPANY

Oil Filter Adapter Fitting, Oil Pan High Pressure Seal, Positive Crankcase Ventilation Oil Separator Drain, and Dowel Pins Disassemble

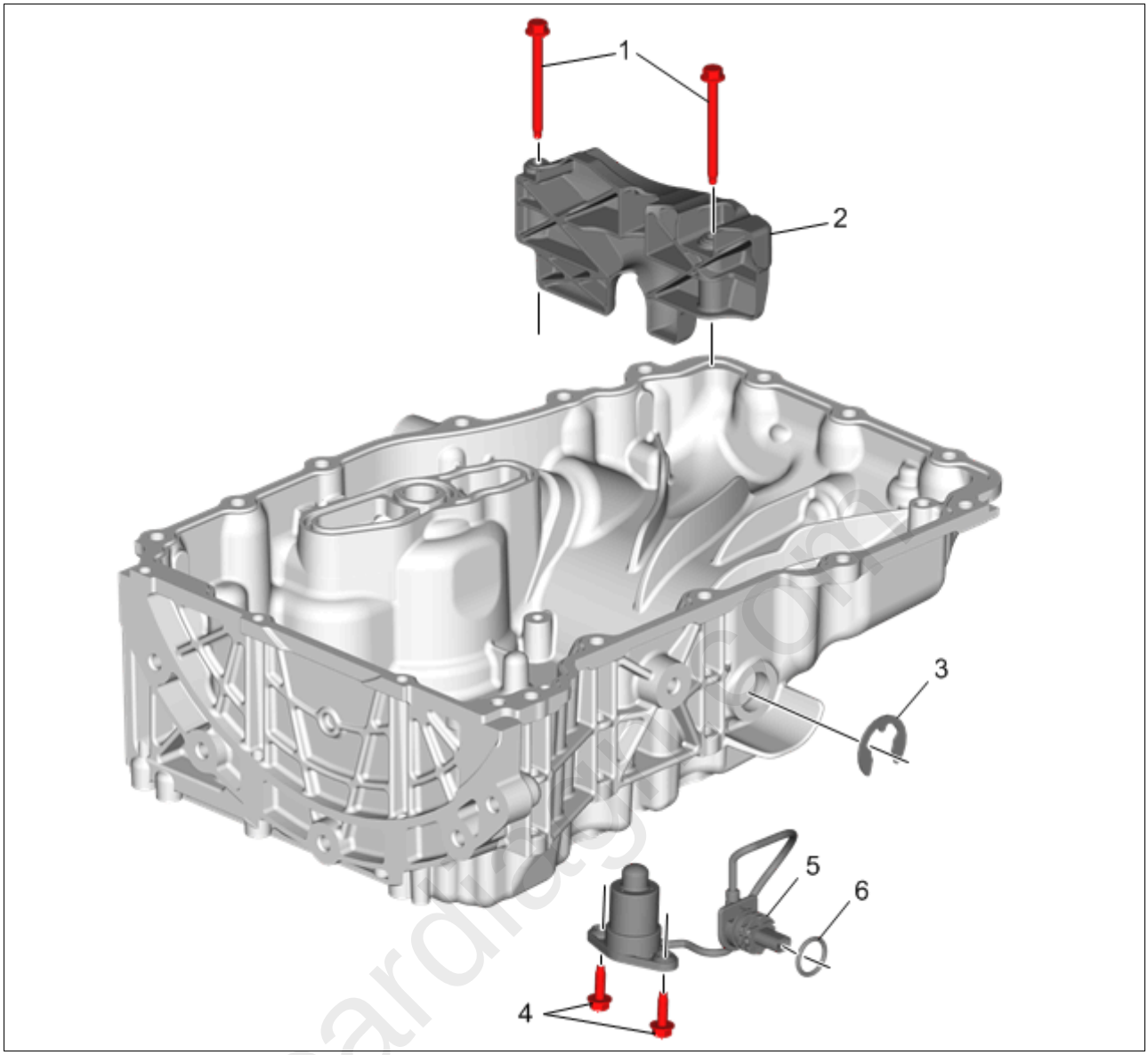
Callout	Component Name
1	Oil Filter Adapter Fitting
2	Oil Pan High Pressure Port Seal

	NOTE: *Remove and DISCARD the seal.*
3	Positive Crankcase Ventilation Oil Separator Bolt
4	Positive Crankcase Ventilation Oil Separator
5	Positive Crankcase Ventilation Oil Separator Seal *NOTE:* *Remove and DISCARD the seal.*
6	Dowel Pin (Qty: 2)

REPAIR INSTRUCTIONS - OFF VEHICLE > OIL PAN DISASSEMBLE > OIL PAN BAFFLE AND ENGINE OIL LEVEL INDICATOR SWITCH DISASSEMBLE

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Fig 1: Oil Pan Baffle and Engine Oil Level Indicator Switch Disassemble



Courtesy of GENERAL MOTORS COMPANY

Oil Pan Baffle and Engine Oil Level Indicator Switch Disassemble

Callout	Component Name
1	Oil Pan Baffle Bolt (Qty: 2)
2	Oil Pan Baffle
3	Engine Oil Level Switch Clip
4	Engine Oil Level Indicator Switch Bolt (Qty: 2)
5	Engine Oil Level Indicator Switch

6	Engine Oil Level Indicator Switch O-Ring Seal *NOTE:* *Remove and DISCARD the seal.*

REPAIR INSTRUCTIONS - OFF VEHICLE > OIL PAN CLEANING AND INSPECTION

Special Tools

EN-28410 Gasket Remover

For equivalent regional tools, refer to Special Tools

REPAIR INSTRUCTIONS - OFF VEHICLE > OIL PAN CLEANING AND INSPECTION > CLEANING PROCEDURE

1. Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant
2. Remove any old thread sealant, gasket material or sealant using **EN-28410** remover.
3. Clean the oil pan and oil pan components in solvent.
4. Clean out debris from the bolt holes.

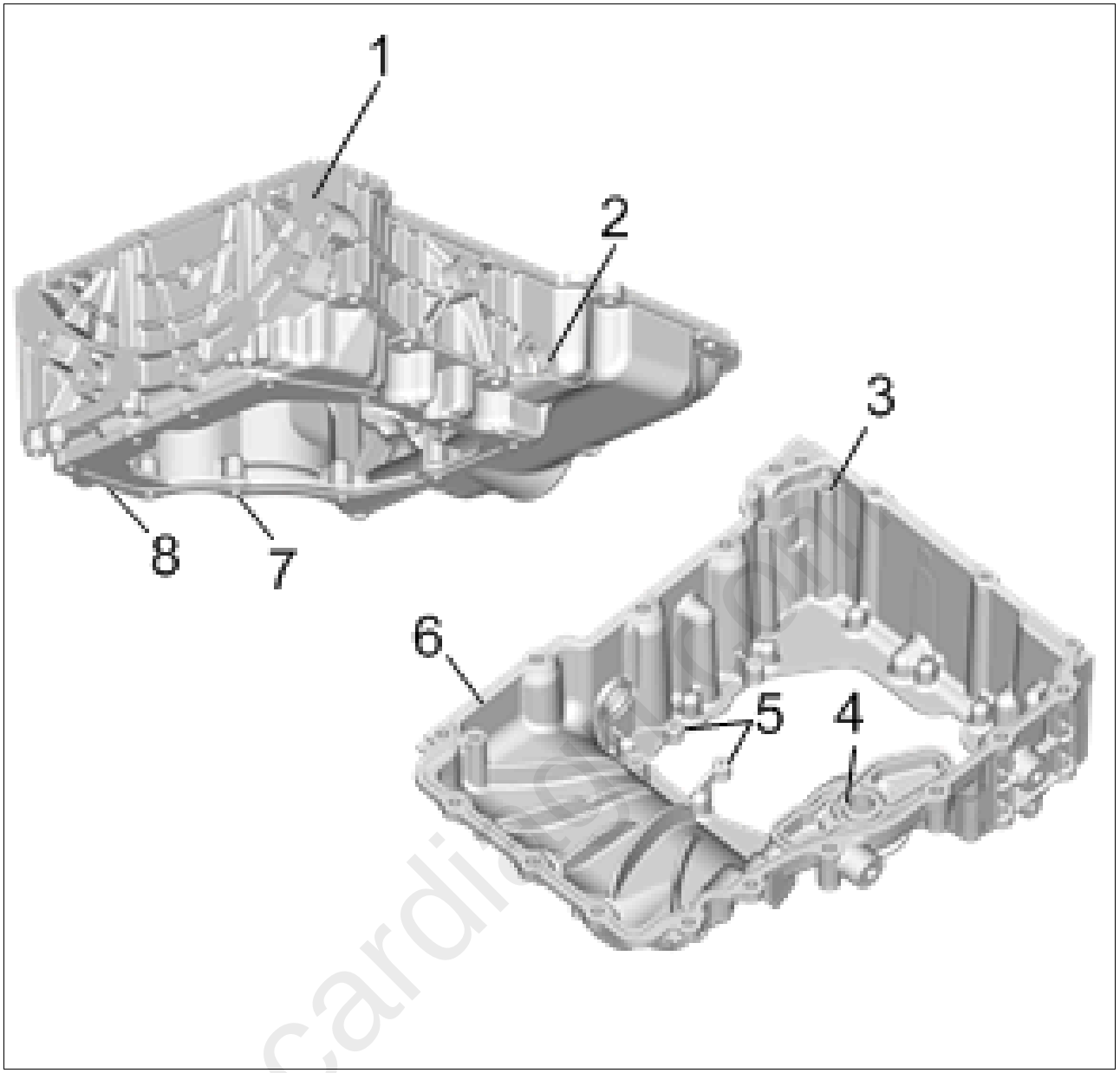
   WARNING:

   Refer to Safety Glasses Warning .
5. Dry the oil pan and oil pan components with compressed air.

REPAIR INSTRUCTIONS - OFF VEHICLE > OIL PAN CLEANING AND INSPECTION > INSPECTION PROCEDURE OIL PAN

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Fig 1: Oil Pan Inspection Points



Courtesy of GENERAL MOTORS COMPANY

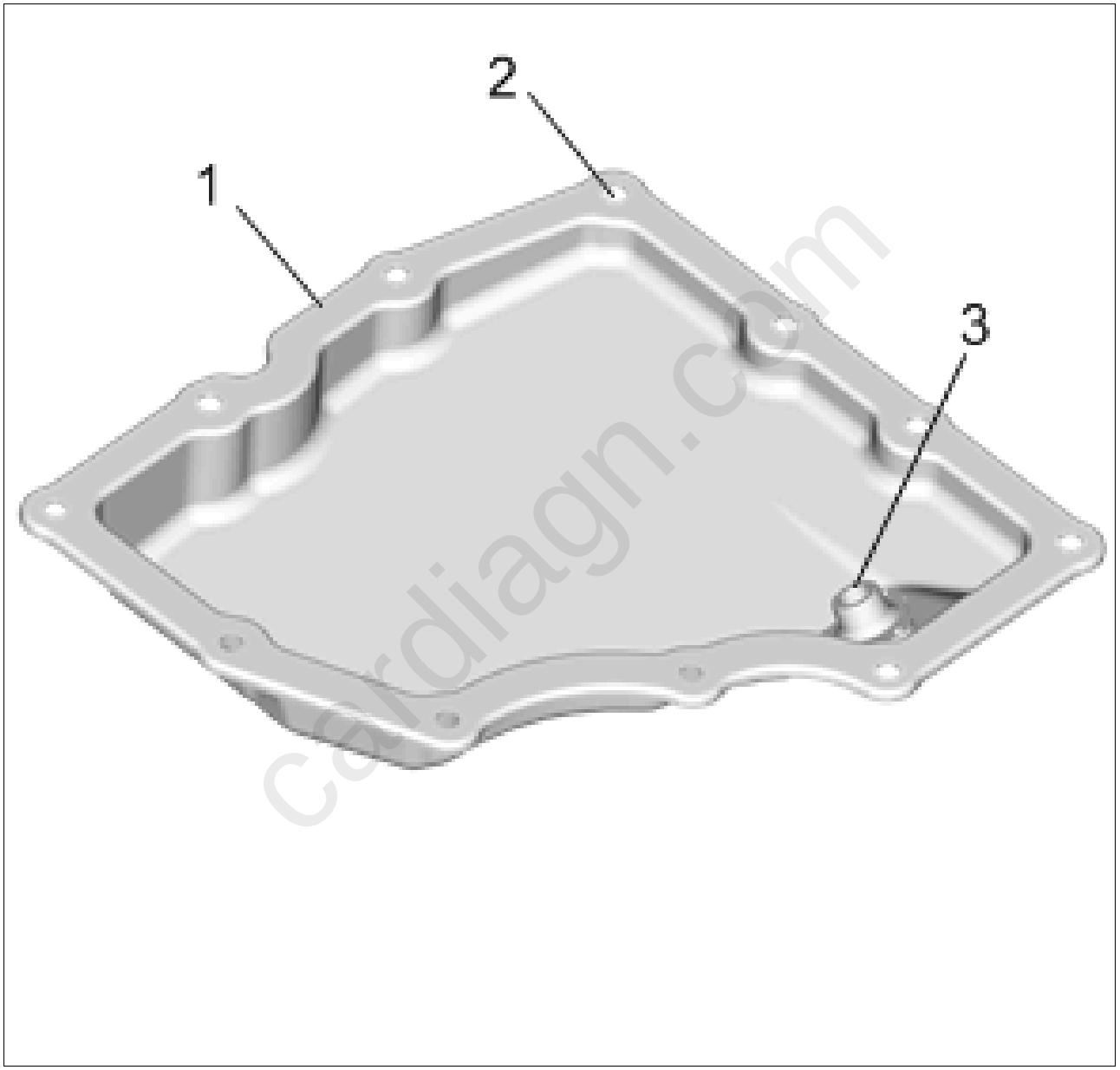
1. Inspect the oil pan for the following conditions:
    1. Damage to the brace mounting bosses (1)
    2. Damage to the engine oil level switch hole (2)
    3. Damage to the positive crankcase ventilation separator drain bolt hole (3)
    4. Damage to the high pressure part seal area (4)
    5. Damage to the engine oil level switch mounting holes (5)
    6. Gouges or damage to the oil pan sealing surfaces (6)
    7. Damage to the lower oil pan mounting holes (7)

8. Gouges or damage to the lower oil pan sealing surfaces (8)

2. Repair or replace the oil pan and/or oil pan components as necessary.

REPAIR INSTRUCTIONS - OFF VEHICLE > OIL PAN CLEANING AND INSPECTION > INSPECTION PROCEDURE LOWER OIL PAN

Fig 1: Lower Oil Pan Inspection Points



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Courtesy of GENERAL MOTORS COMPANY

1. Inspect the oil pan for the following conditions:

    1. Gouges or damage to the lower oil pan sealing surfaces (1)

    2. Damage to the lower oil pan mounting holes (2)

3. Damage to the drain plug or drain plug hole (3)

2. Repair or replace the lower oil pan and/or oil pan components as necessary.

REPAIR INSTRUCTIONS - OFF VEHICLE > OIL PUMP SUCTION PIPE AND SCREEN CLEANING AND INSPECTION > CLEANING PROCEDURE

1. Clean the oil pump pipe and screen with solvent.

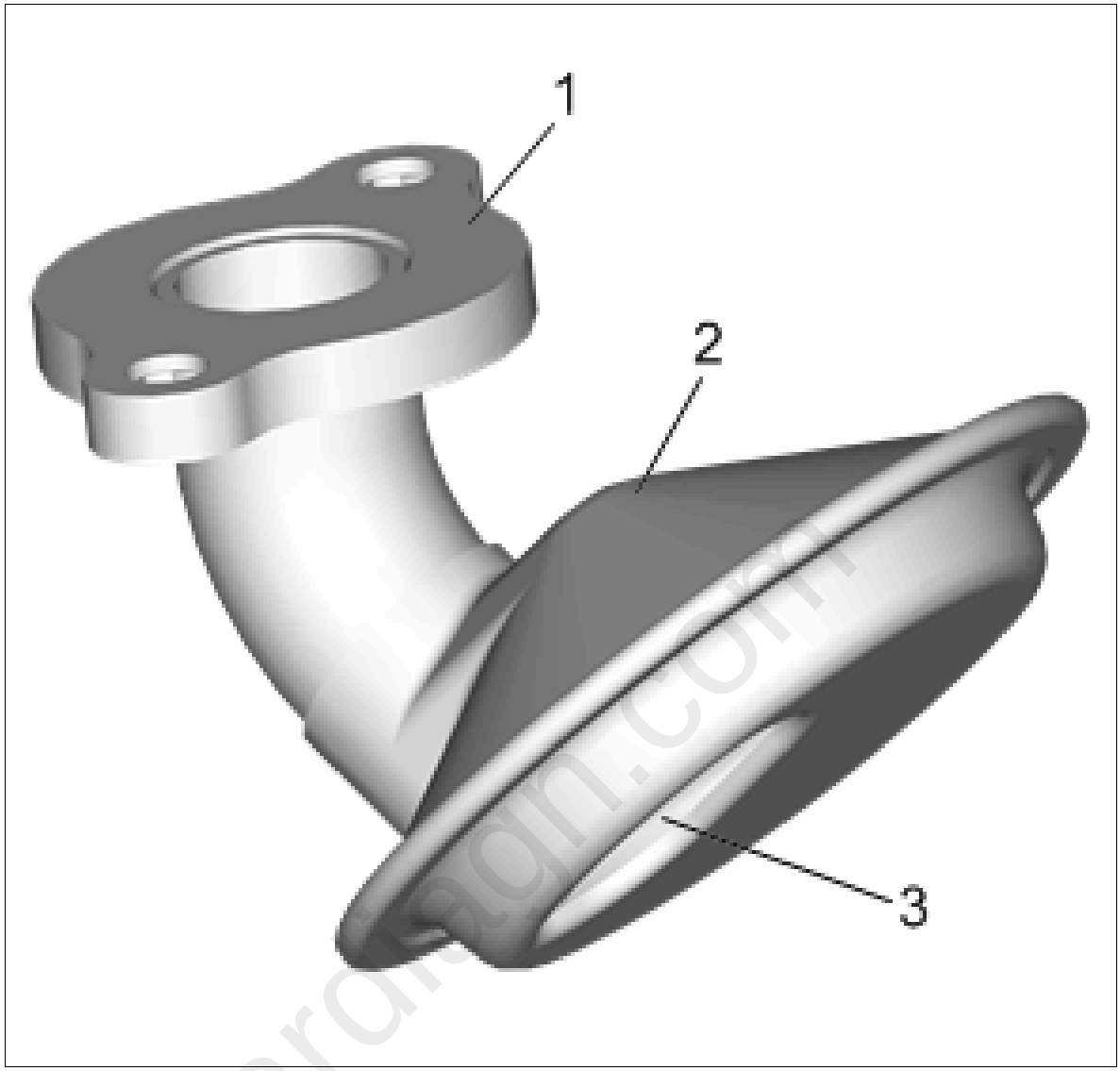
> *WARNING:*
>
> *Refer to Safety Glasses Warning .*

2. Dry the oil pump pipe and screen with compressed air.

REPAIR INSTRUCTIONS - OFF VEHICLE > OIL PUMP SUCTION PIPE AND SCREEN CLEANING AND INSPECTION > INSPECTION PROCEDURE

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Fig 1: Oil Pump Pickup Inspection Points



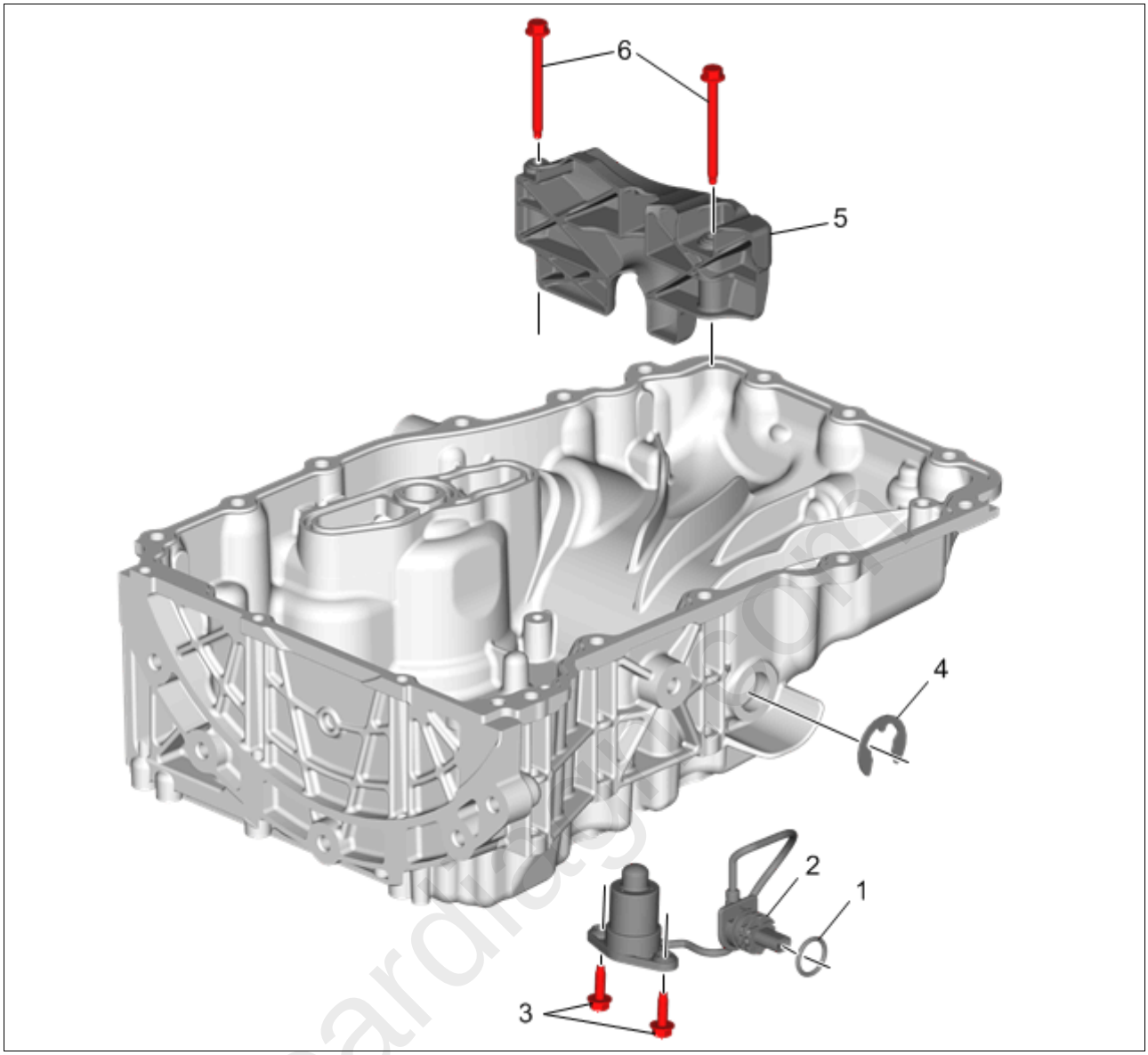
Courtesy of GENERAL MOTORS COMPANY

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1. Inspect the mounting surface (1) for possible leakage paths.
2. Inspect the oil pump pipe tube (2) for cracks, imperfections and/or damage.
3. Inspect the oil pump screen (3) for blockage, foreign material, tears, cracks and/or damage.

REPAIR INSTRUCTIONS - OFF VEHICLE > OIL PAN ASSEMBLE > OIL PAN BAFFLE AND ENGINE OIL LEVEL INDICATOR SWITCH ASSEMBLE

Fig 1: Oil Pan Baffle and Engine Oil Level Indicator Switch Assemble



Courtesy of GENERAL MOTORS COMPANY

Oil Pan Baffle and Engine Oil Level Indicator Switch Assemble

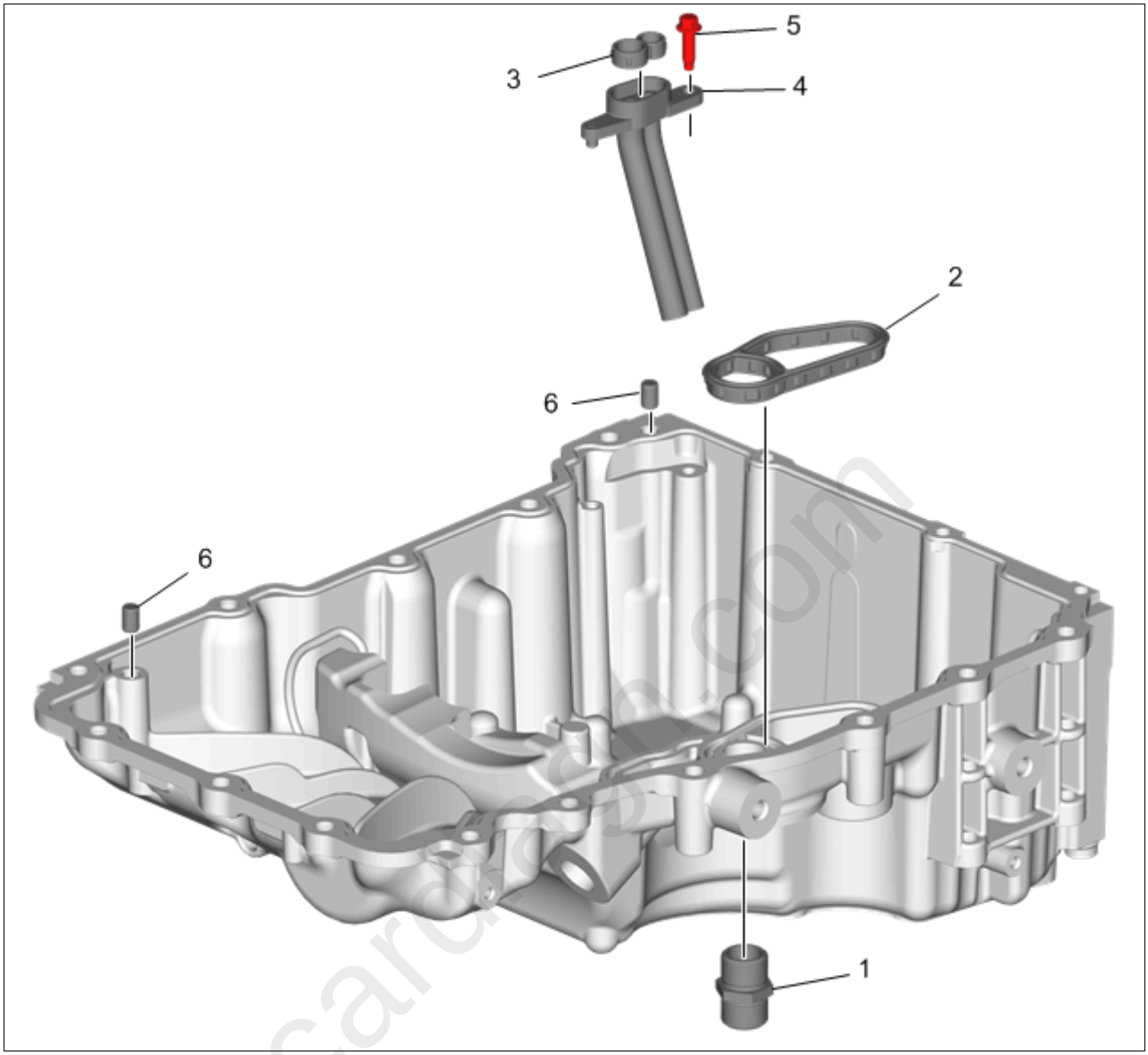
Callout	Component Name
1	Engine Oil Level Indicator Switch O-Ring Seal *NOTE:* *Install a NEW seal.*
2	Engine Oil Level Indicator Switch

3	Engine Oil Level Indicator Switch Bolt (Qty: 2) *CAUTION:* *Refer to Fastener Caution .* **Tighten** 10 N.m (89 lb in)
4	Engine Oil Level Switch Clip
5	Oil Pan Baffle
6	Oil Pan Baffle Bolt (Qty: 2) **Tighten** 10 N.m (89 lb in)

REPAIR INSTRUCTIONS - OFF VEHICLE > OIL PAN ASSEMBLE > OIL FILTER ADAPTER FITTING, OIL PAN HIGH PRESSURE SEAL, POSITIVE CRANKCASE VENTILATION OIL SEPARATOR DRAIN, AND DOWEL PINS ASSEMBLE

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Fig 1: Oil Filter Adapter Fitting, Oil Pan High Pressure Seal, Positive Crankcase Ventilation Oil Separator Drain, and Dowel Pins Assemble



Courtesy of GENERAL MOTORS COMPANY

Oil Filter Adapter Fitting, Oil Pan High Pressure Seal, Positive Crankcase Ventilation Oil Separator Drain, and Dowel Pins Assemble

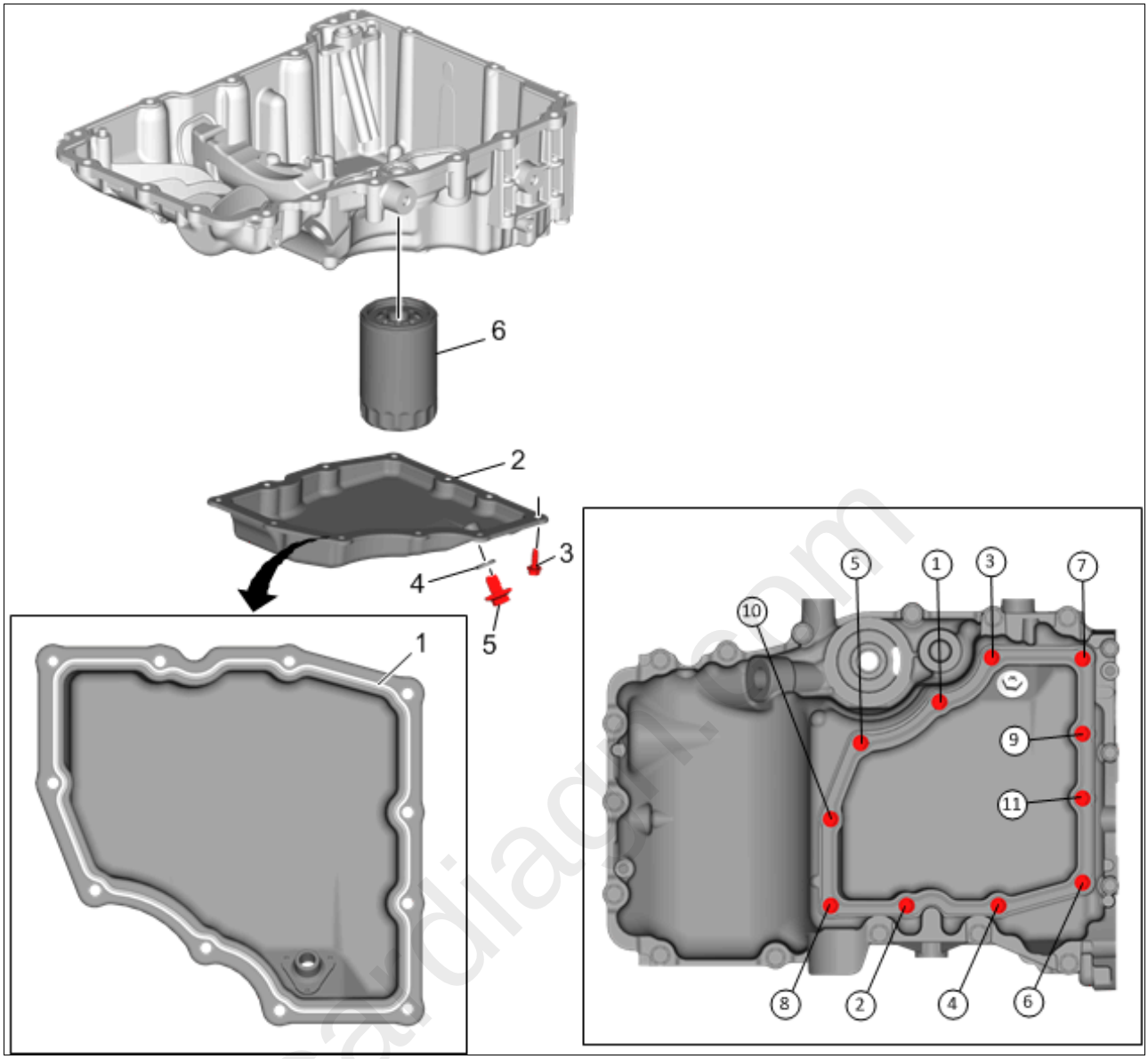
Callout	Component Name
1	Oil Filter Adapter Fitting **Tighten** 50 N.m (37 lb ft)
2	Oil Pan High Pressure Port Seal *NOTE:*

	Install a NEW seal.
3	Positive Crankcase Ventilation Oil Separator Seal *NOTE:* *Install a NEW seal.*
4	Positive Crankcase Ventilation Oil Separator
5	Positive Crankcase Ventilation Oil Separator Bolt **Tighten** 10 N.m (89 lb in)
6	Dowel Pin

REPAIR INSTRUCTIONS - OFF VEHICLE > OIL PAN ASSEMBLE > LOWER OIL PAN, DRAIN PLUG AND OIL FILTER ASSEMBLE

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Fig 1: Lower Oil Pan, Drain Plug and Oil Filter Assemble



Courtesy of GENERAL MOTORS COMPANY

Lower Oil Pan, Drain Plug and Oil Filter Assemble

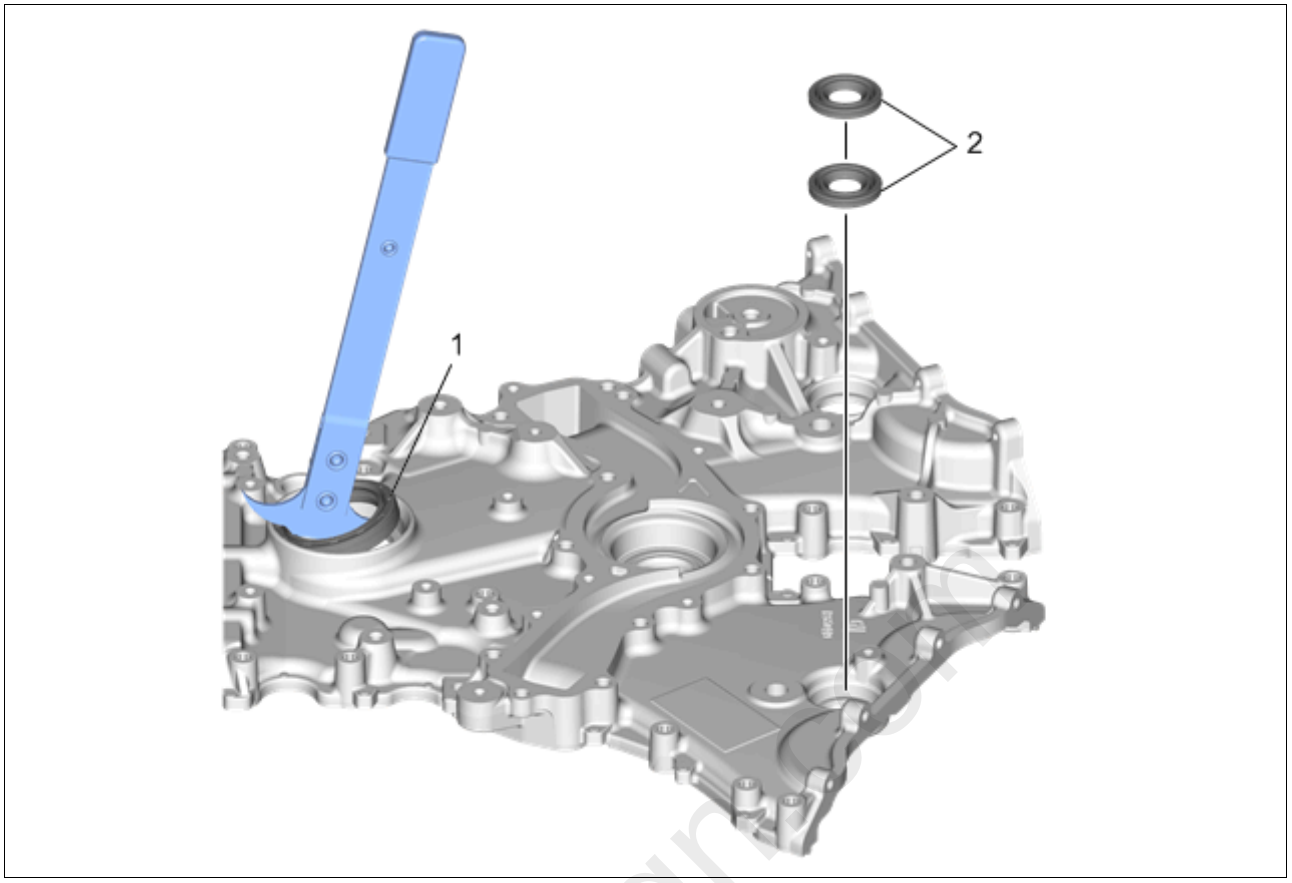
Callout	Component Name
1	Lower Oil Pan *NOTE:* *Apply proper sealant, Refer to Adhesives, Fluids, Lubricants, and Sealers .*

2	Lower Oil Pan Bolt (Qty: 11) **Tighten in sequence** 10 N.m (89 lb in)
3	Oil Pan Drain Plug Seal *NOTE:* *Install a NEW seal.*
4	Oil Pan Drain Plug **Tighten** 10 N.m (89 lb in)
5	Oil Filter **Tighten** Install a NEW oil filter and tighten 3/4 to 1 full turn after the gasket makes contact with the sealing surface on the filter mounting flange.

REPAIR INSTRUCTIONS - OFF VEHICLE > ENGINE FRONT COVER DISASSEMBLE > CRANKSHAFT FRONT OIL SEAL DISASSEMBLE

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Fig 1: Crankshaft Front Oil Seal Disassemble



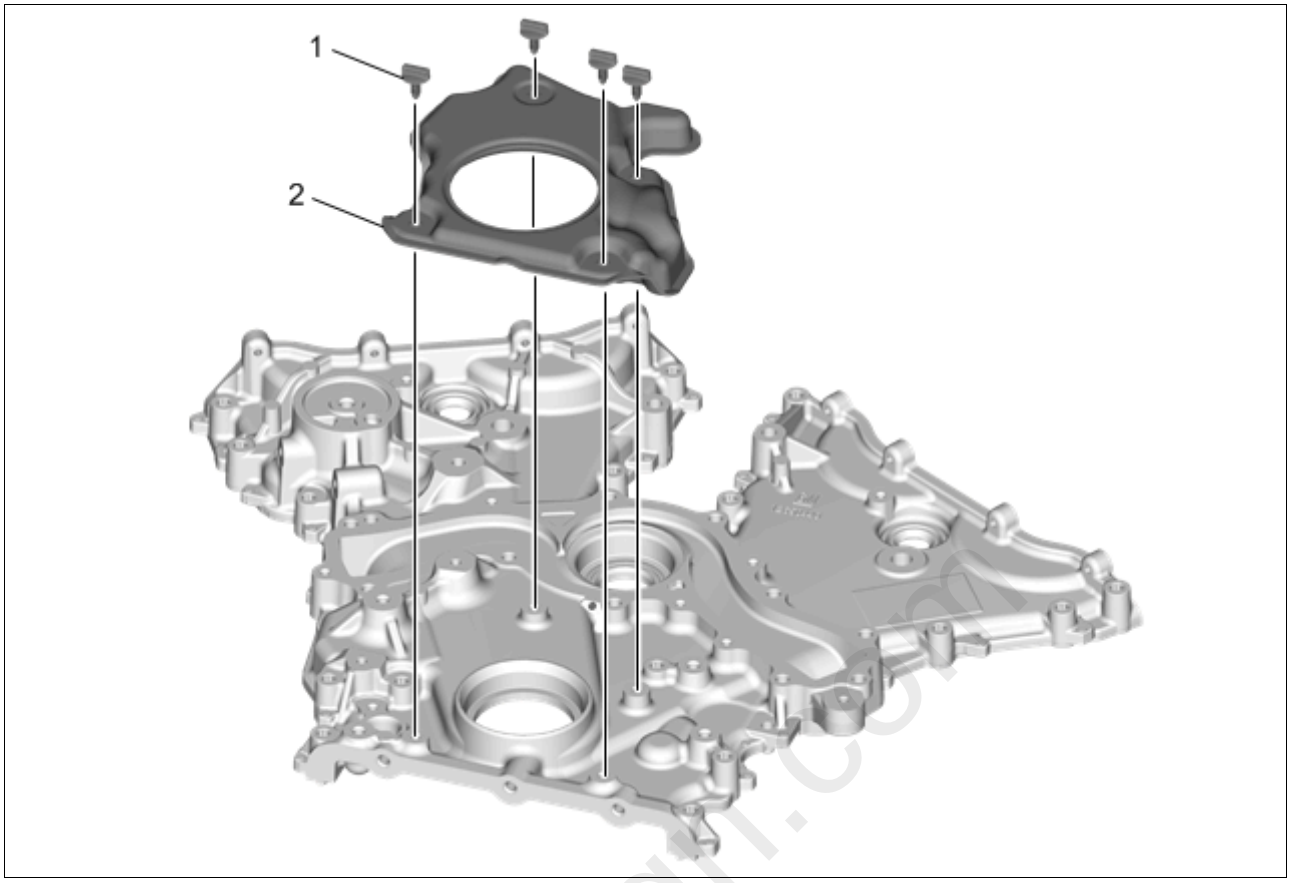
Courtesy of GENERAL MOTORS COMPANY

Crankshaft Front Oil Seal Disassemble

Callout	Component Name
1	Crankshaft Front Oil Seal **Special Tools** **EN-45000** Seal Remover For equivalent regional tools, refer to Special Tools .
2	Camshaft Position Actuator Control Valve Seal (Qty: 2)

REPAIR INSTRUCTIONS - OFF VEHICLE > ENGINE FRONT COVER DISASSEMBLE > ENGINE FRONT COVER INSULATOR DISASSEMBLE

Fig 1: Engine Front Cover Insulator Disassemble



Courtesy of GENERAL MOTORS COMPANY

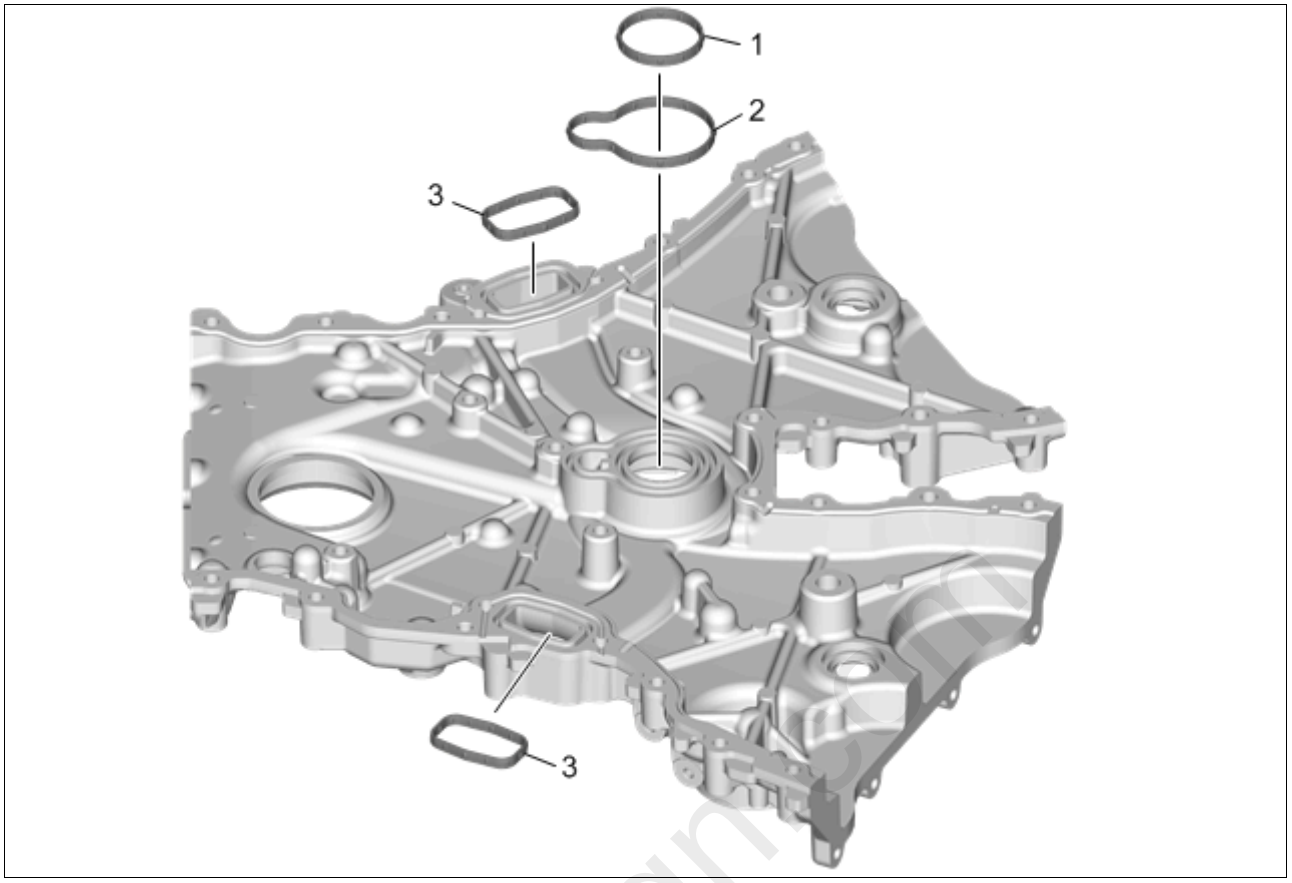
Engine Front Cover Insulator Disassemble

Callout	Component Name
1	Engine Front Cover Retainer (Qty: 4)
2	Engine Front Cover Insulator

REPAIR INSTRUCTIONS - OFF VEHICLE > ENGINE FRONT COVER DISASSEMBLE > WATER PUMP SEAL DISASSEMBLE

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Fig 1: Water Pump Seal Disassemble



Courtesy of GENERAL MOTORS COMPANY

Water Pump Seal Disassemble

Callout	Component Name
1	Water Pump Seal
2	Water Pump Seal
3	Water Pump Seal (Qty: 2)

REPAIR INSTRUCTIONS - OFF VEHICLE > ENGINE FRONT COVER CLEANING AND INSPECTION

Special Tools

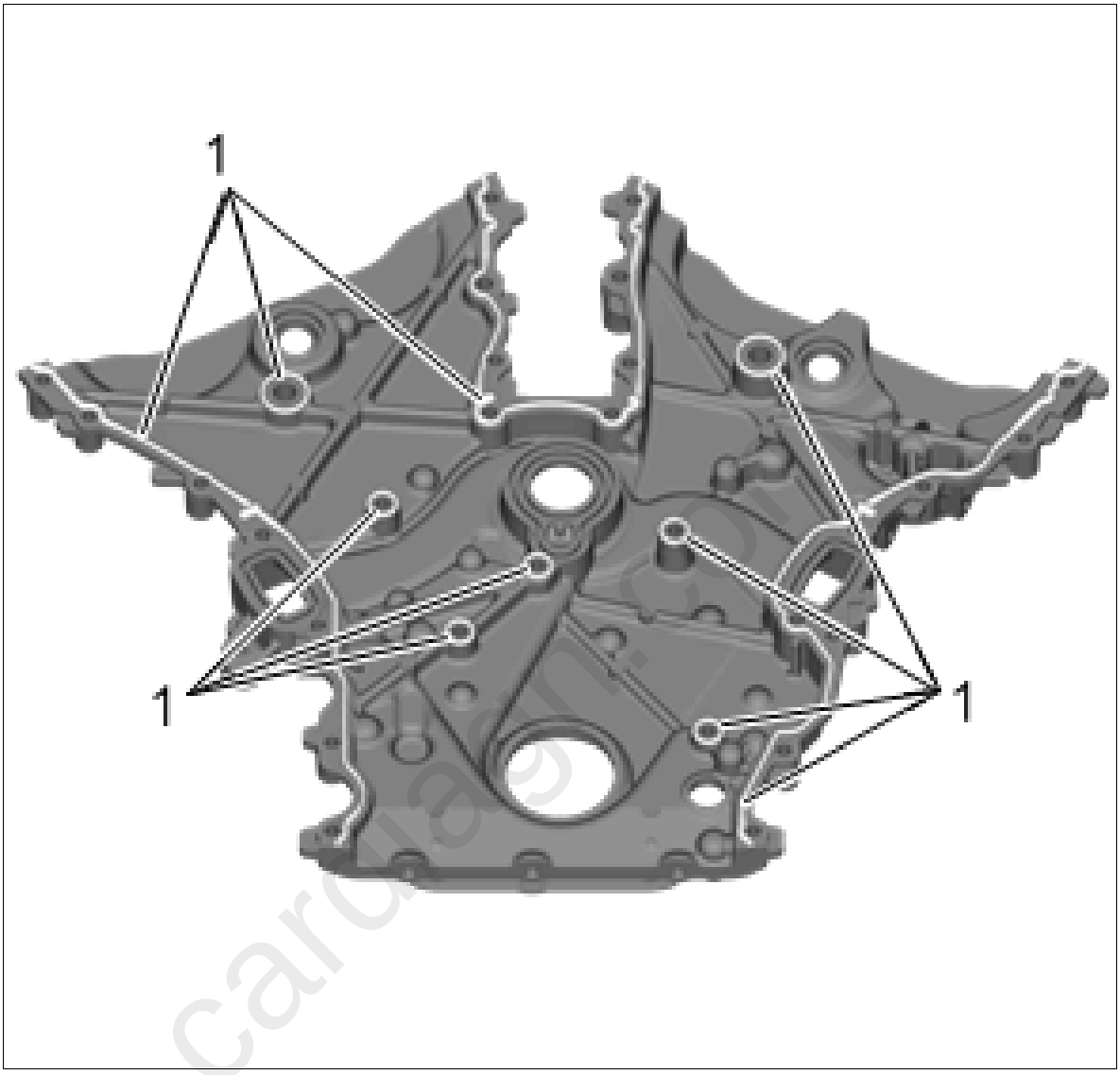
EN-28410 Gasket Remover

For equivalent regional tools, refer to Special Tools .

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REPAIR INSTRUCTIONS - OFF VEHICLE > ENGINE FRONT COVER CLEANING AND INSPECTION > CLEANING PROCEDURE

Fig 1: Engine Front Cover



Courtesy of GENERAL MOTORS COMPANY

1. Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant
2. Remove any RTV sealant (1) from the engine front cover using **EN-28410** remover.
3. Clean out debris from the bolt holes.
4. Clean the engine front cover in solvent.

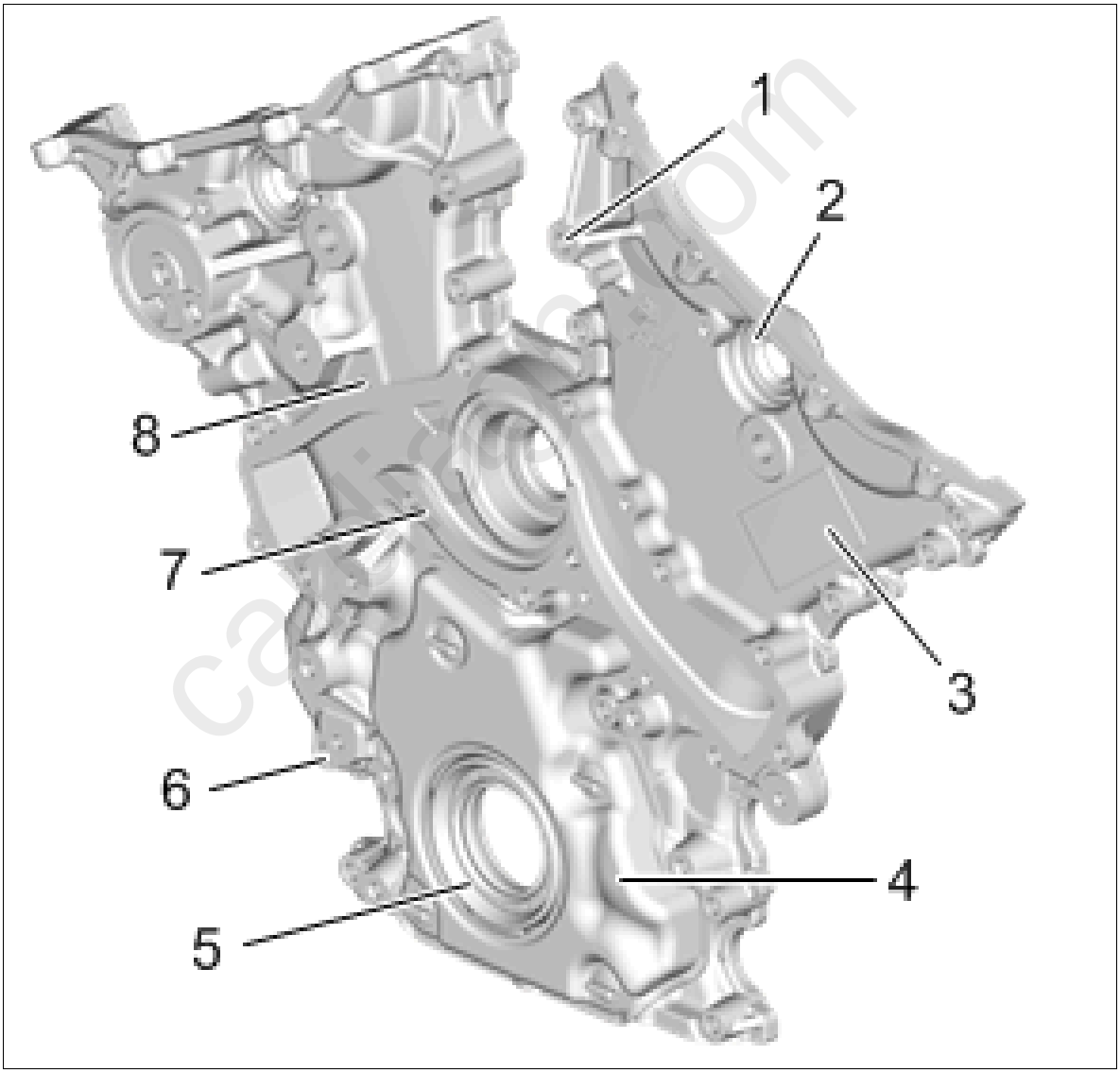
WARNING:

Refer to Safety Glasses Warning .

5. Dry the engine front cover with compressed air.

REPAIR INSTRUCTIONS - OFF VEHICLE > ENGINE FRONT COVER CLEANING AND INSPECTION > INSPECTION PROCEDURE

Fig 1: Engine Front Cover Inspection Points

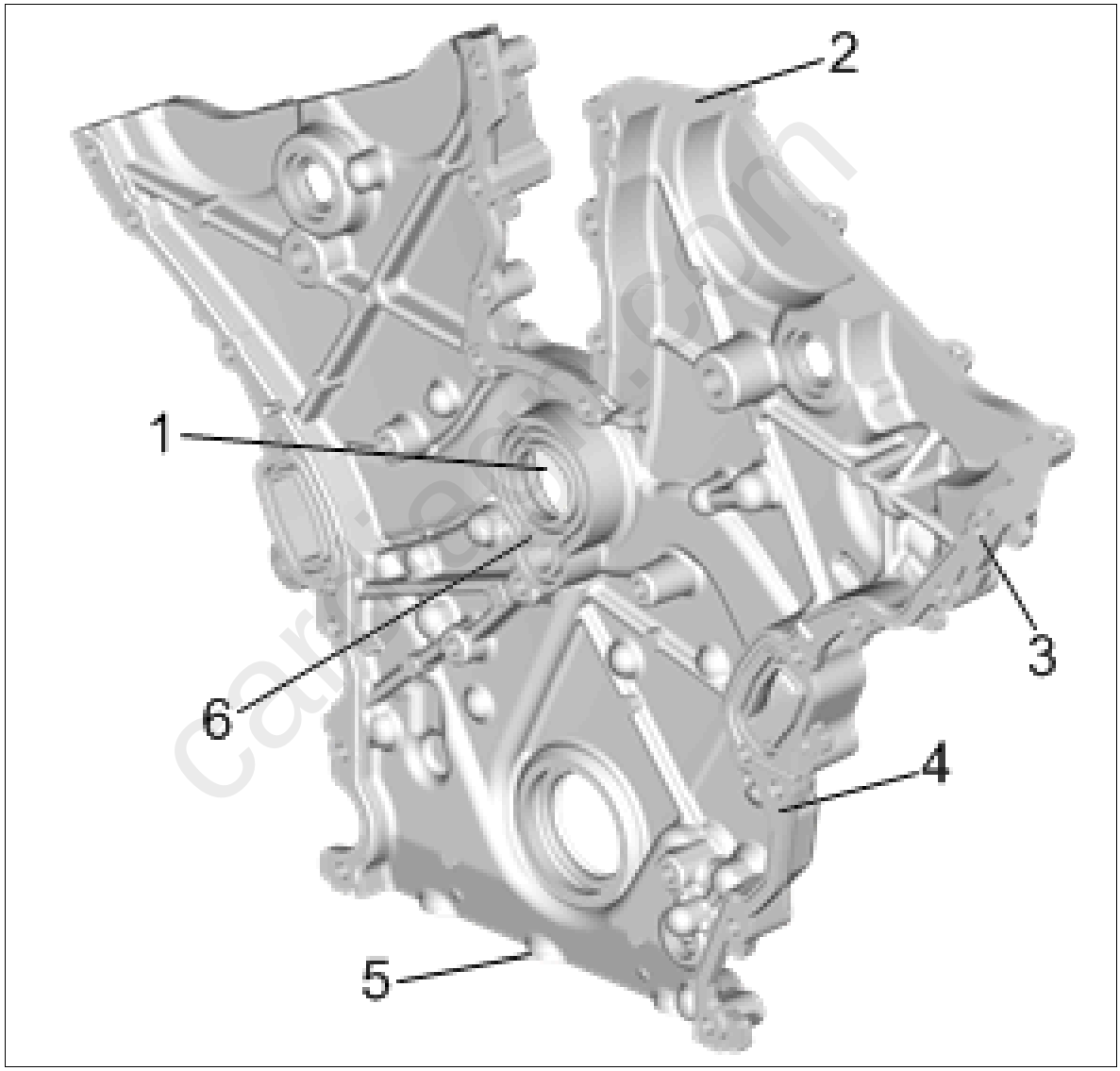


Courtesy of GENERAL MOTORS COMPANY

1. Inspect the exterior of the engine front cover for the following conditions:
    1. Damage to the engine front cover bolt holes (1)

2. Damage to the camshaft position actuator valve oil seals and bores (2)
3. Damage and/or corrosion to the engine front cover (3)
4. Damage to the engine front cover insulator (4)
5. Damage to the crankshaft front oil seal bore (5)
6. Damage to the oil pump flow control valve wire mounting surface (6)
7. Gouges or damage to the water pump sealing surfaces (7)
8. Damage to the water pump bolt hole threads (8)

Fig 2: Engine Front Cover Inspection Points



Courtesy of GENERAL MOTORS COMPANY

2. Inspect the interior of the engine front cover for the following conditions:
    1. Damage and/or corrosion to the engine coolant passage (1)
    2. Gouges or damage to the engine front cover sealing surfaces to the engine block (6), oil

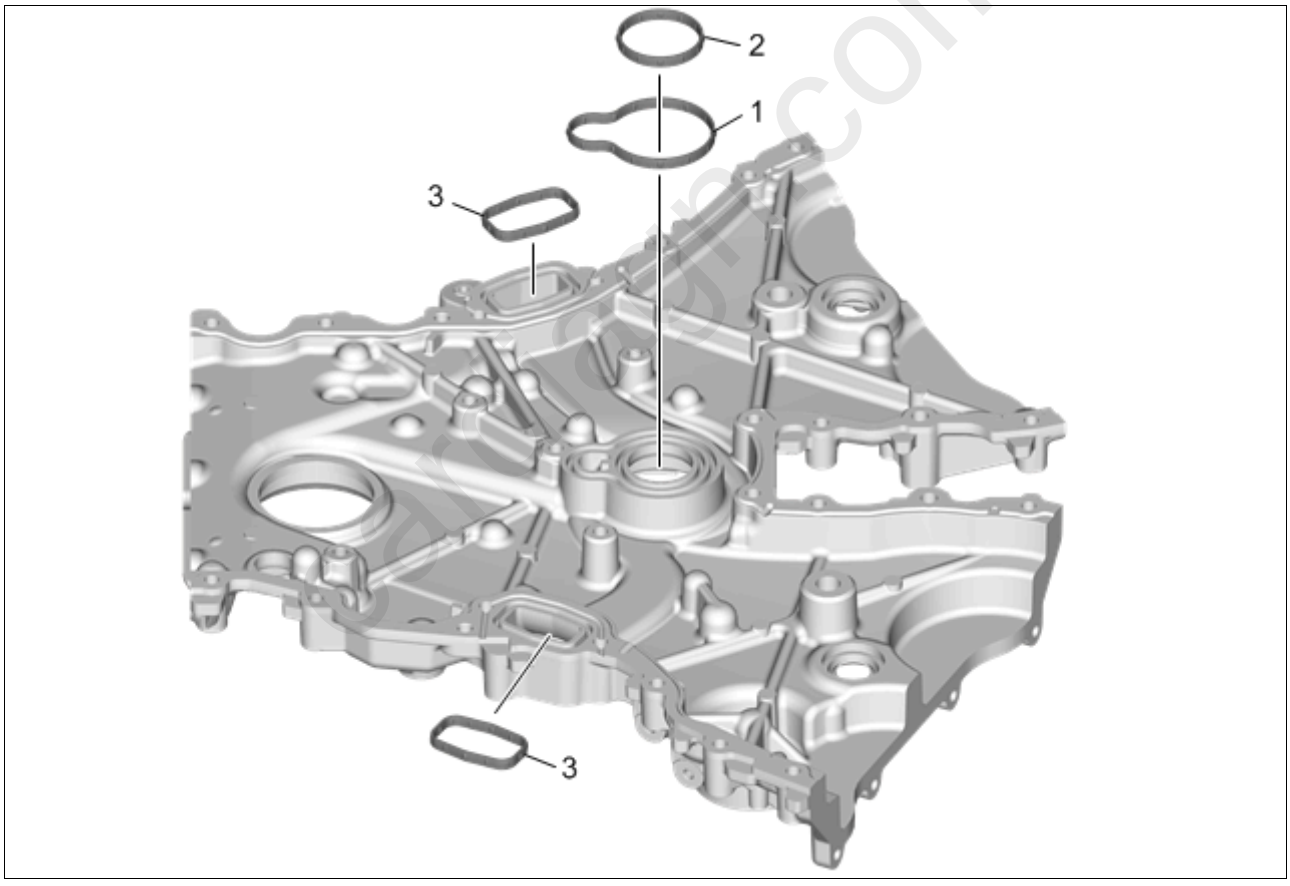
pan (4), and/or camshaft covers (2)

3. Damage to the engine front cover bolt holes (3)
4. Damage to the engine front cover to oil pan mounting bolt holes (5)
5. Gouges or damage to the water pump seal area
6. Damage to the crankshaft front oil seal bore
7. Gouges or damage to the O-ring sealing areas

3. Repair or replace the engine front cover as necessary.

REPAIR INSTRUCTIONS - OFF VEHICLE > ENGINE FRONT COVER ASSEMBLE > WATER PUMP SEAL ASSEMBLE

Fig 1: Water Pump Seal Assemble



Courtesy of GENERAL MOTORS COMPANY

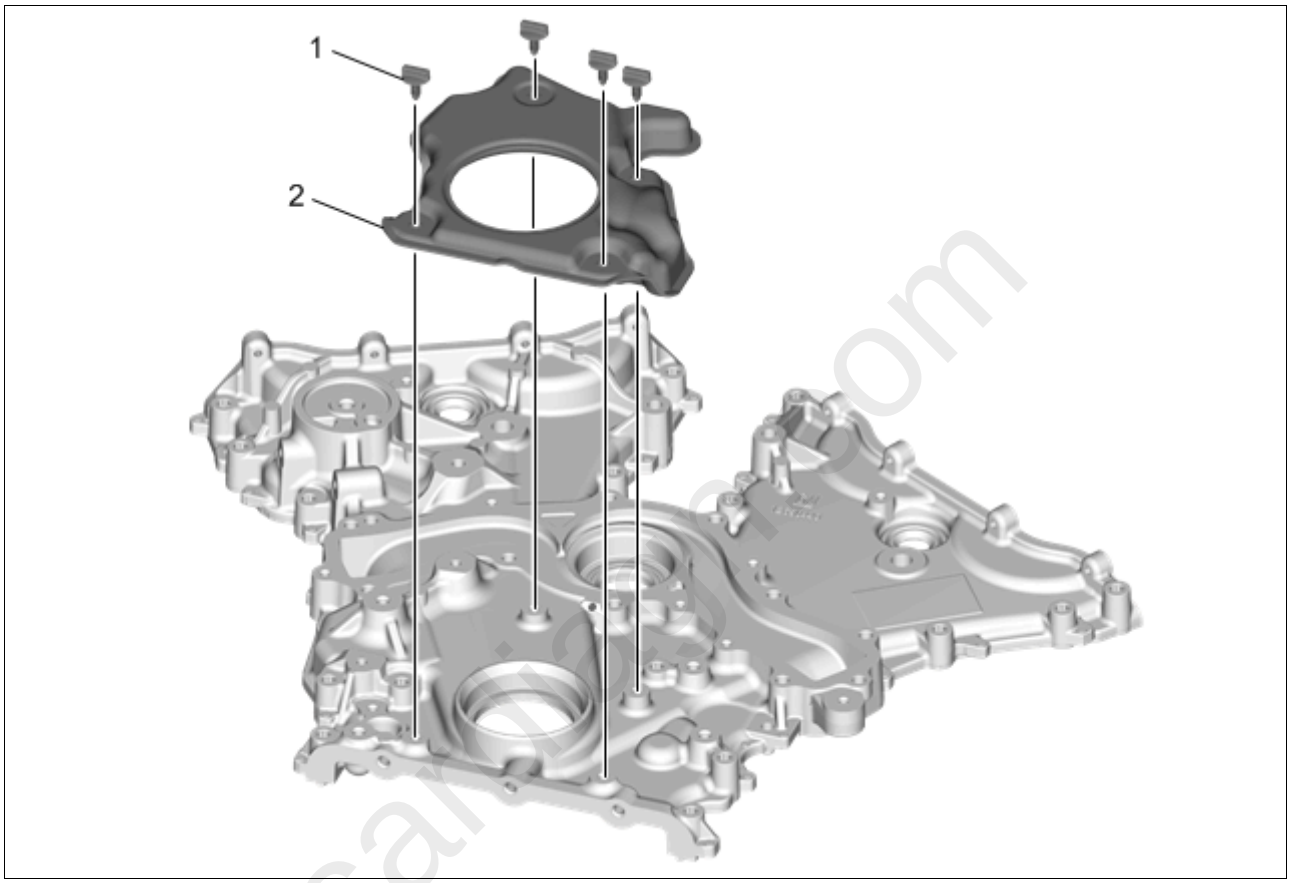
Water Pump Seal Assemble

Callout	Component Name
1	Water Pump Seal

2	Water Pump Seal
3	Water Pump Seal (Qty: 2)

REPAIR INSTRUCTIONS - OFF VEHICLE > ENGINE FRONT COVER ASSEMBLE > ENGINE FRONT COVER INSULATOR ASSEMBLE

Fig 1: Engine Front Cover Insulator Disassemble



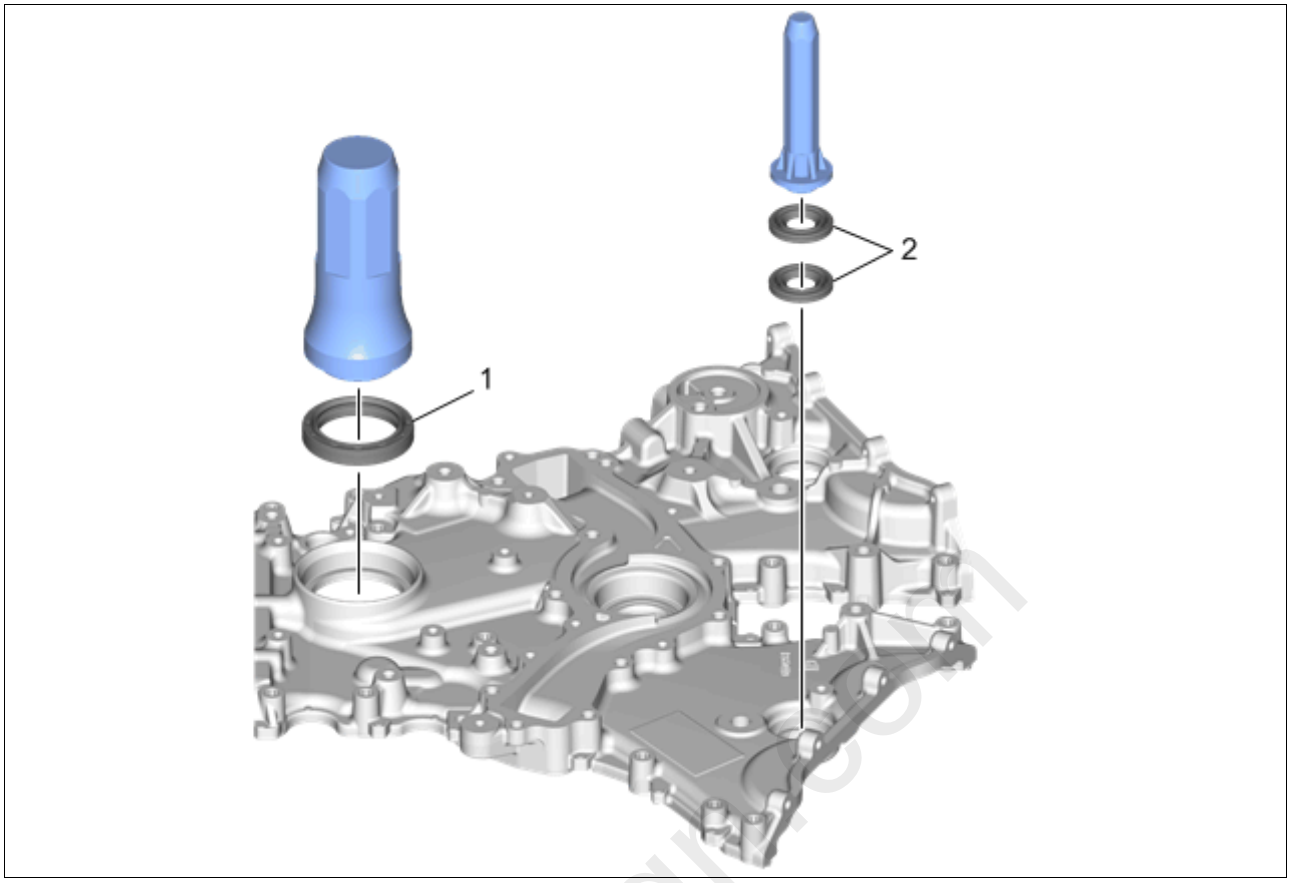
Courtesy of GENERAL MOTORS COMPANY

Engine Front Cover Insulator Assemble

Callout	Component Name
1	Engine Front Cover Insulator
2	Engine Front Cover Retainer (Qty: 4)

REPAIR INSTRUCTIONS - OFF VEHICLE > ENGINE FRONT COVER ASSEMBLE > CRANKSHAFT FRONT OIL SEAL ASSEMBLE

Fig 1: Crankshaft Front Oil Seal Assemble



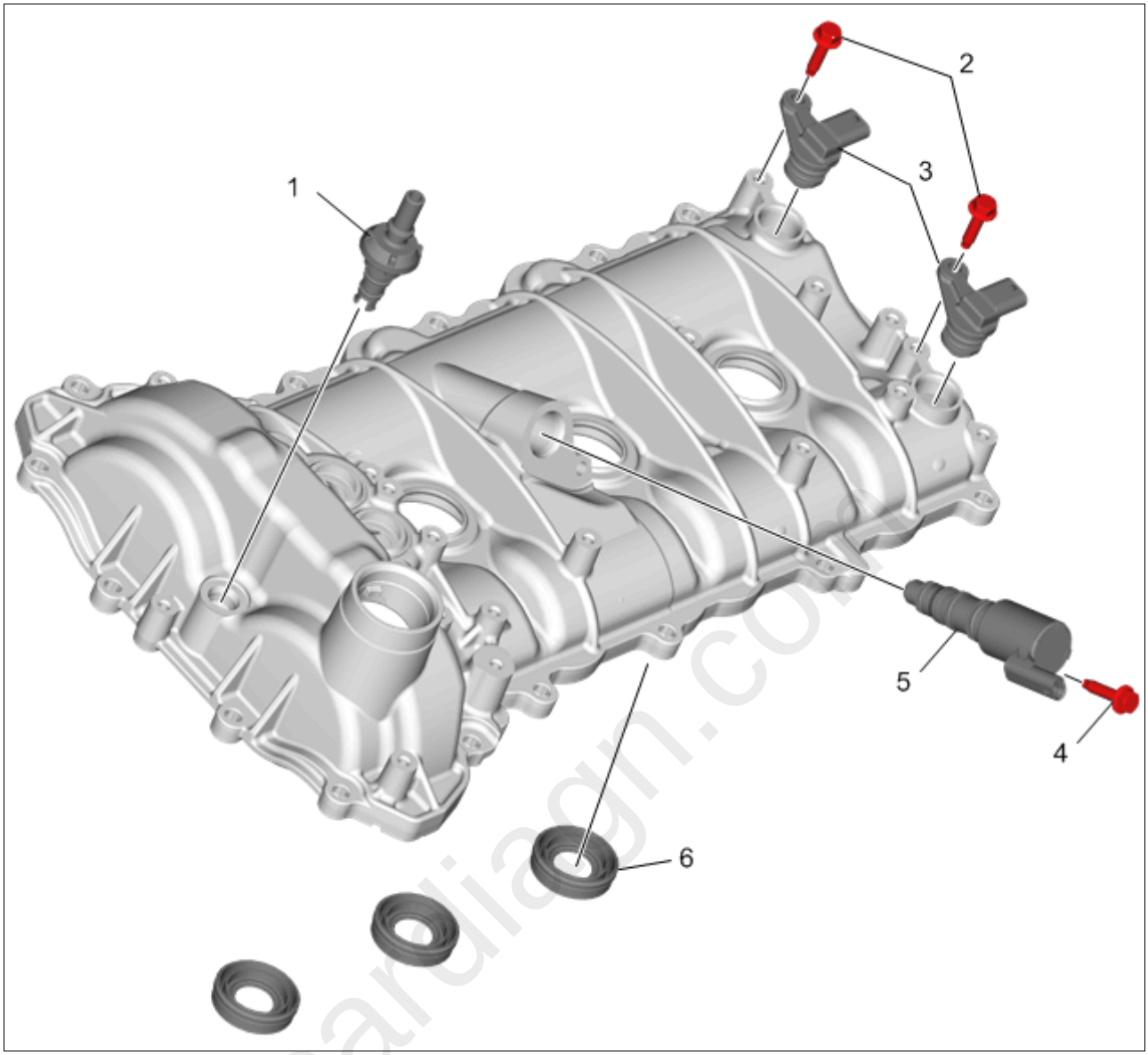
Courtesy of GENERAL MOTORS COMPANY

Crankshaft Front Oil Seal Assemble

Callout	Component Name
1	Crankshaft Front Oil Seal **Special Tools** **EN-29184** Seal Installer For equivalent regional tools, refer to Special Tools .
2	Camshaft Position Actuator Control Valve Seal (Qty: 2) **Special Tools** **EN-46103** Camshaft Actuator Valve Seal Installer

REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT COVER DISASSEMBLE > LEFT CAMSHAFT COVER

Fig 1: Left Camshaft Cover



Courtesy of GENERAL MOTORS COMPANY

Left Camshaft Cover

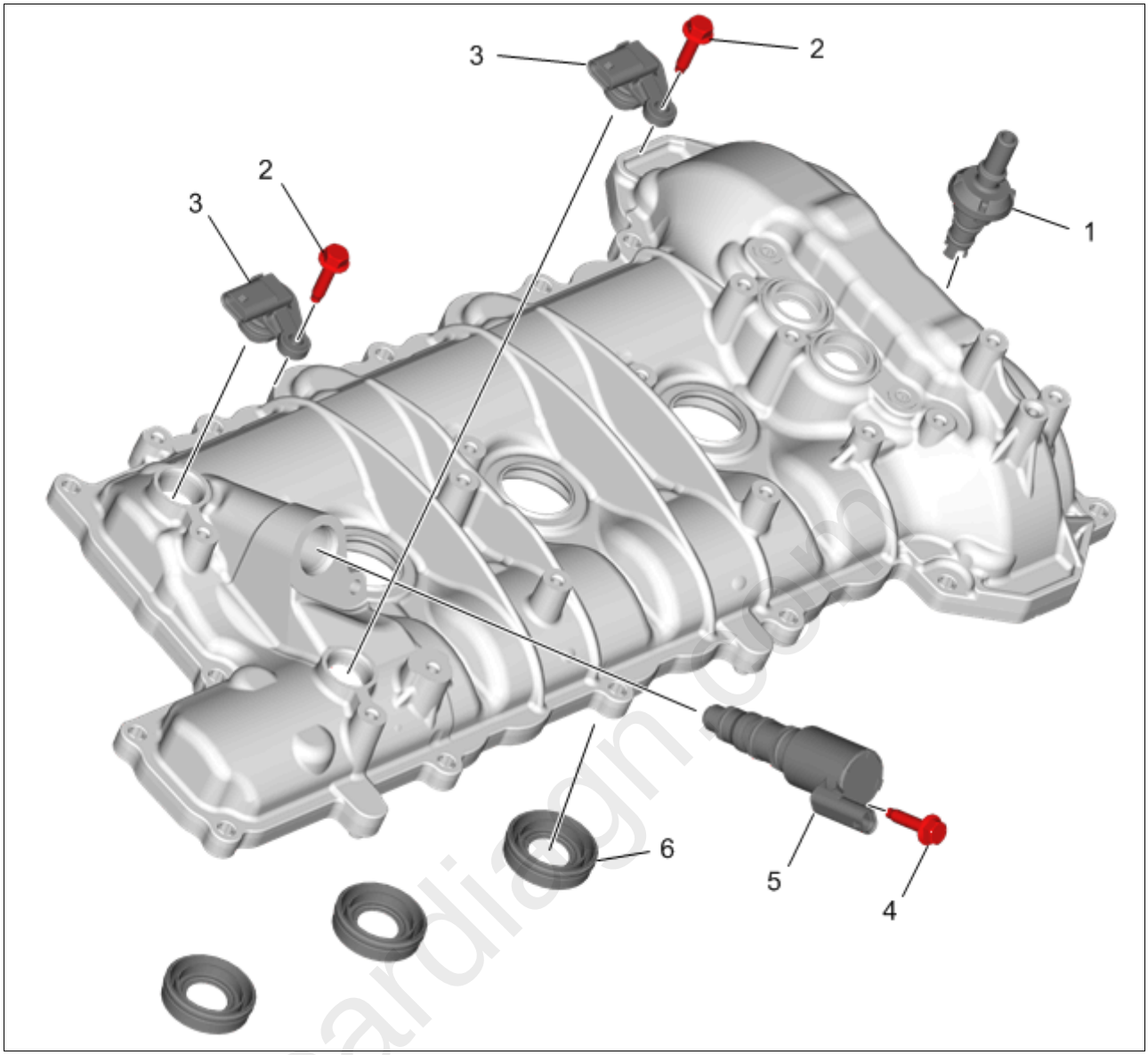
Callout	Component Name
1	Positive Crankcase Ventilation Valve *NOTE:* *These components have tamper-proof connections and cannot be disassembled.*

2	Camshaft Position Sensor Bolt (Qty: 2)
3	Camshaft Position Sensor (Qty: 2)
4	Valve Rocker Arm Oil Control Valve Bolt
5	Valve Rocker Arm Oil Control Valve
6	Spark Plug Shield Seal *NOTE:* *Remove and DISCARD the seal.*

REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT COVER DISASSEMBLE > RIGHT CAMSHAFT COVER

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Fig 1: Right Camshaft Cover



Courtesy of GENERAL MOTORS COMPANY

Right Camshaft Cover

Callout	Component Name
1	Positive Crankcase Ventilation Valve *NOTE:* *These components have tamper-proof connections and cannot be disassembled.*

2	Camshaft Position Sensor Bolt (Qty: 2)
3	Camshaft Position Sensor (Qty: 2)
4	Valve Rocker Arm Oil Control Valve Bolt
5	Valve Rocker Arm Oil Control Valve
6	Spark Plug Shield Seal *NOTE:* *Remove and DISCARD the seal.*

REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT COVER CLEANING AND INSPECTION > CLEANING PROCEDURE

1. Clean the camshaft covers in solvent.

   WARNING:

   Refer to Safety Glasses Warning .

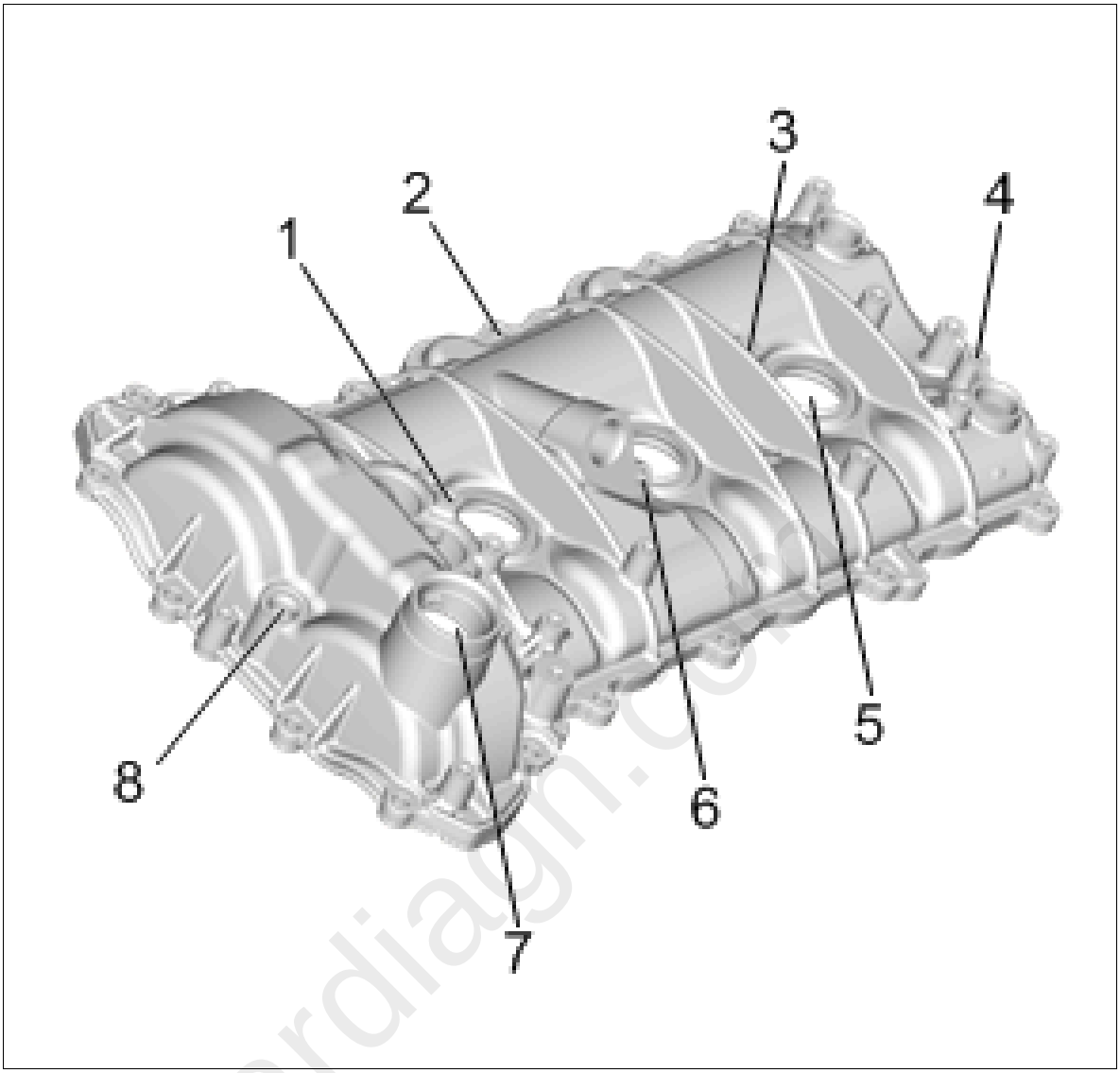
2. Dry the camshaft covers with compressed air.

REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT COVER CLEANING AND INSPECTION > INSPECTION PROCEDURE

1. Inspect each camshaft cover for the dents or damage to the exterior. A dented or damaged camshaft cover may:
   1. Leak engine oil
   2. Affect crankcase ventilation
   3. Interfere with the camshafts
   4. Interfere with the ignition coil sealing
   5. Allow water or condensation to enter the engine

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Fig 1: Camshaft Cover Inspection Points



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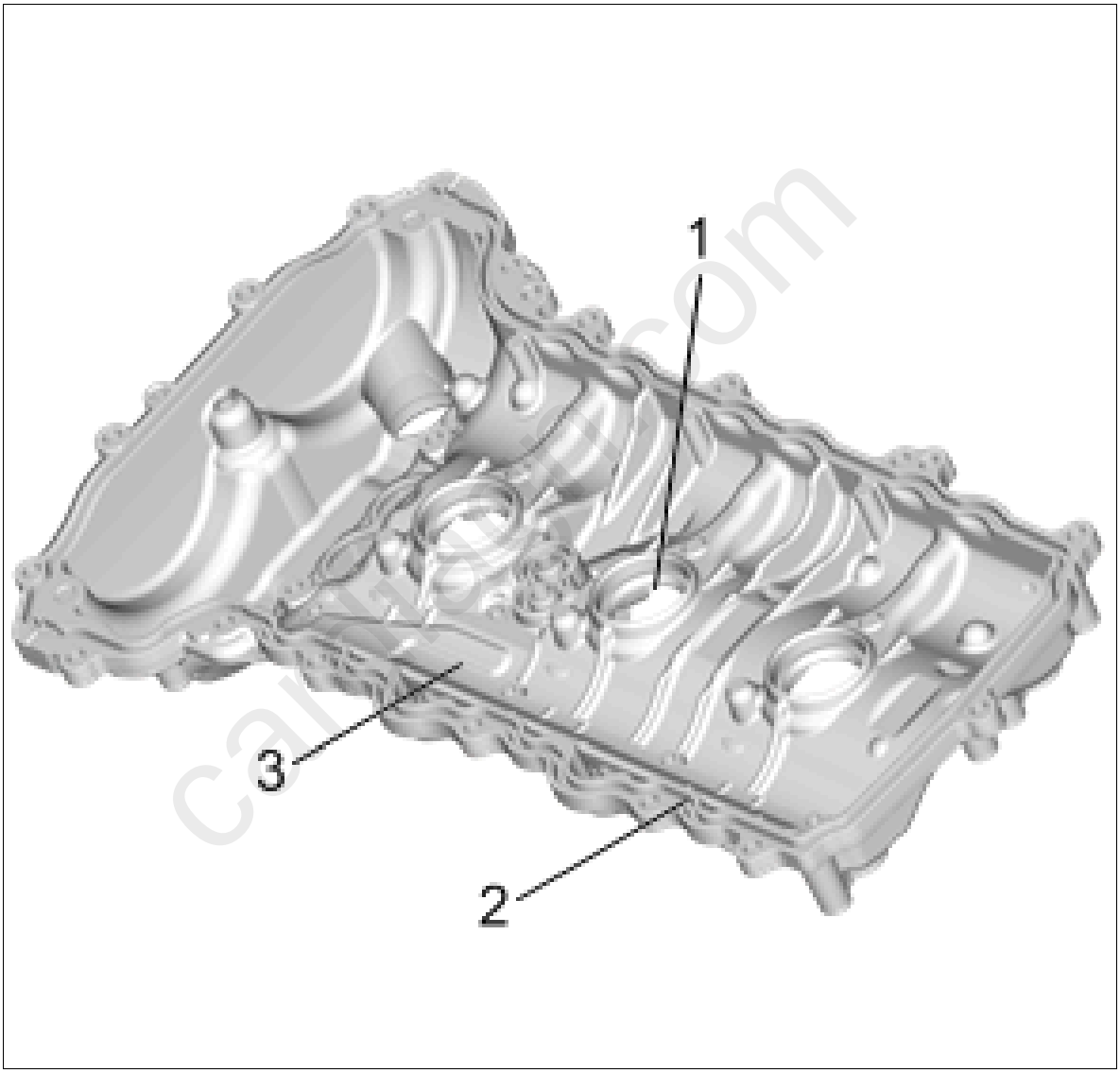
2. Inspect the exterior of the right camshaft cover for the following conditions:
    1. Damage to the camshaft position actuator solenoid valve bolt hole (1).
    2. Damage to the camshaft cover bolt holes (2)
    3. Damage to the mounting holes (3) for the ignition coil assembly and fuel injector sight shield ballstud.
    4. Damage to the camshaft position sensor bolt hole (4).
    5. Damage to the spark plug shield seal bore (5)
    6. Damage to the valve rocker arm oil control valve bolt hole (6).
    7. Damage to the oil fill hole (7)

NOTE:

Not servicable - cam cover must be removed to replace PCV check valve. Can't service check valve alone (tangs will break on removal thus leaving foreign material in engine)

8. Damage to the positive crankcase ventilation (PCV) hose connector (8)-A damaged PCV hose connector is not replaceable.

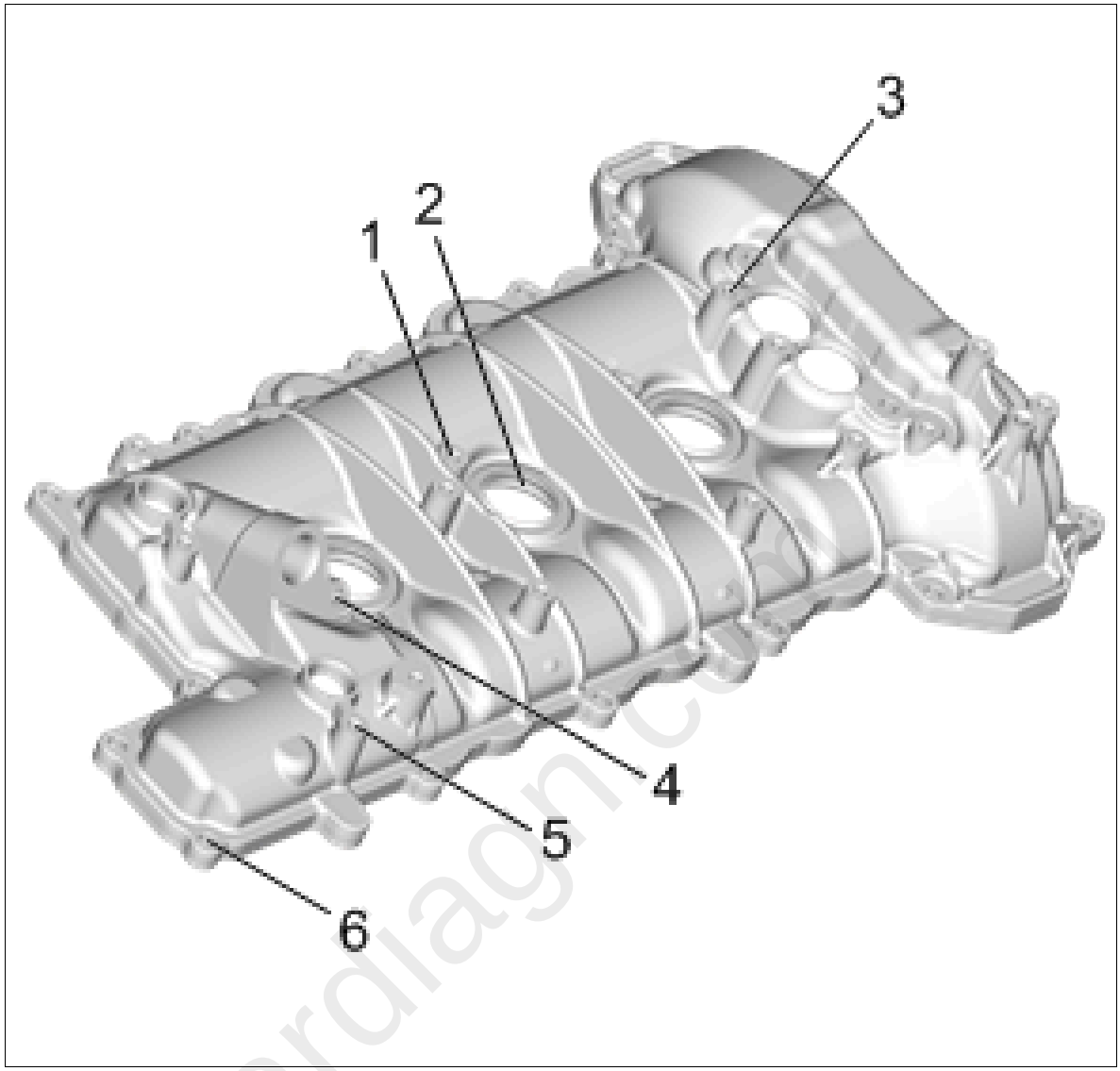
Fig 2: Camshaft Cover Inspection Points



Courtesy of GENERAL MOTORS COMPANY

3. Inspect the interior of the right camshaft cover for the following conditions:
    1. Gouges or damage to the spark plug shield seal bore (1)
    2. Gouges or damage to the camshaft cover sealing groove (2)
    3. Damaged, loose or missing baffle (3)

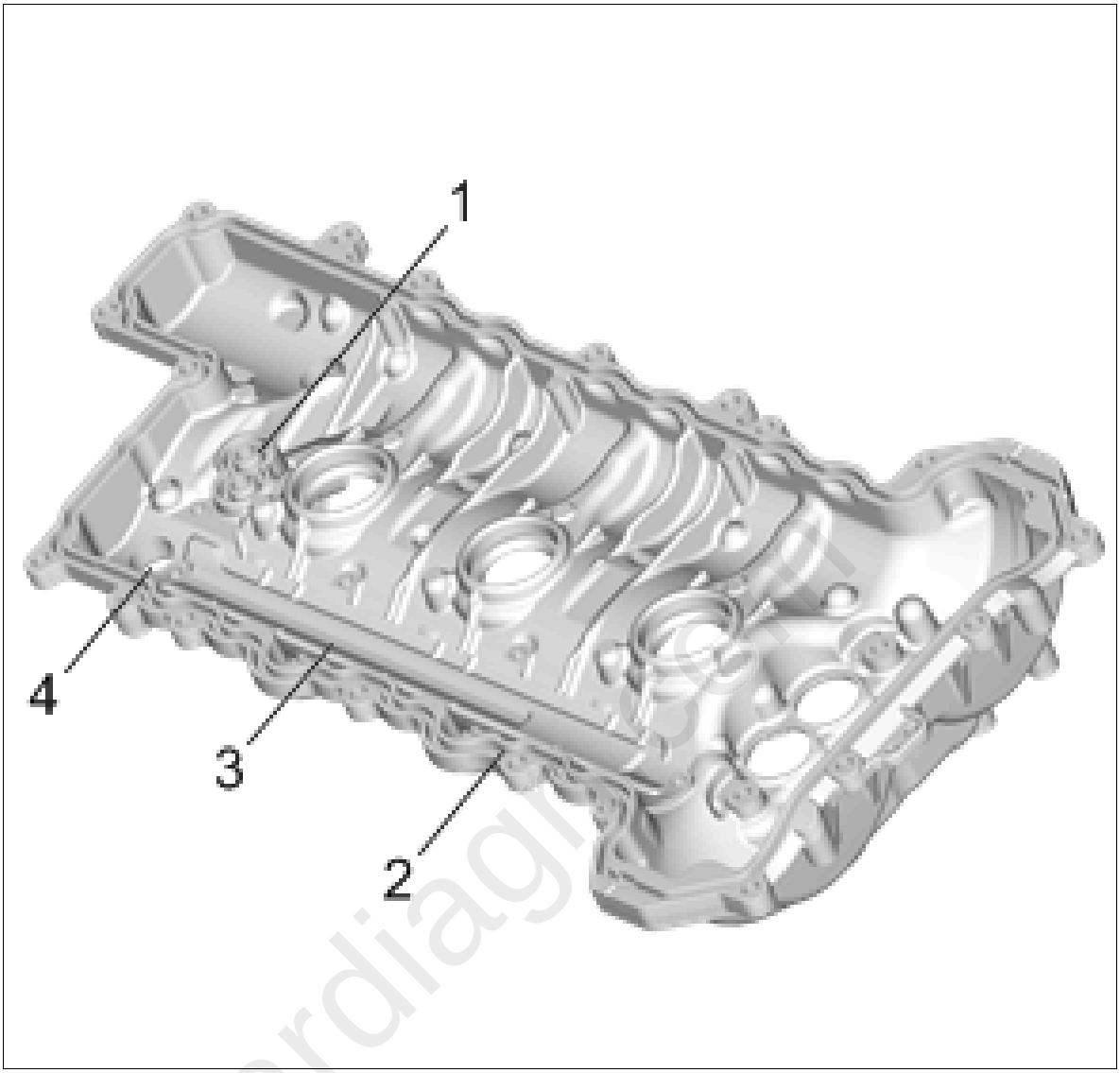
Fig 3: Camshaft Cover Inspection Points



Courtesy of GENERAL MOTORS COMPANY

4. Inspect the exterior of the left camshaft cover for the following conditions:
    1. Damage to the mounting holes (1) for the ignition coil assembly
    2. Gouges or damage to the spark plug shield seal bore (2)
    3. Damage to the camshaft position actuator solenoid valve bolt hole (3).
    4. Damage to the valve rocker arm oil control valve bolt hole (4).
    5. Damage to the camshaft position sensor bolt hole (5).
    6. Damage to the camshaft cover bolt holes (6)

Fig 4: Camshaft Cover Inspection Points



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5. Inspect the interior of the left camshaft cover for the following conditions:
    1. Gouges or damage to the spark plug shield seal bore (1)
    2. Gouges or damage to the camshaft cover sealing groove (2)
    3. Damaged, loose or missing baffle (3)

> *NOTE:*
>
> *Not servicable - cam cover must be removed to replace PCV check valve. Can't service check valve alone (tangs will break on removal thus leaving foreign material in engine)*

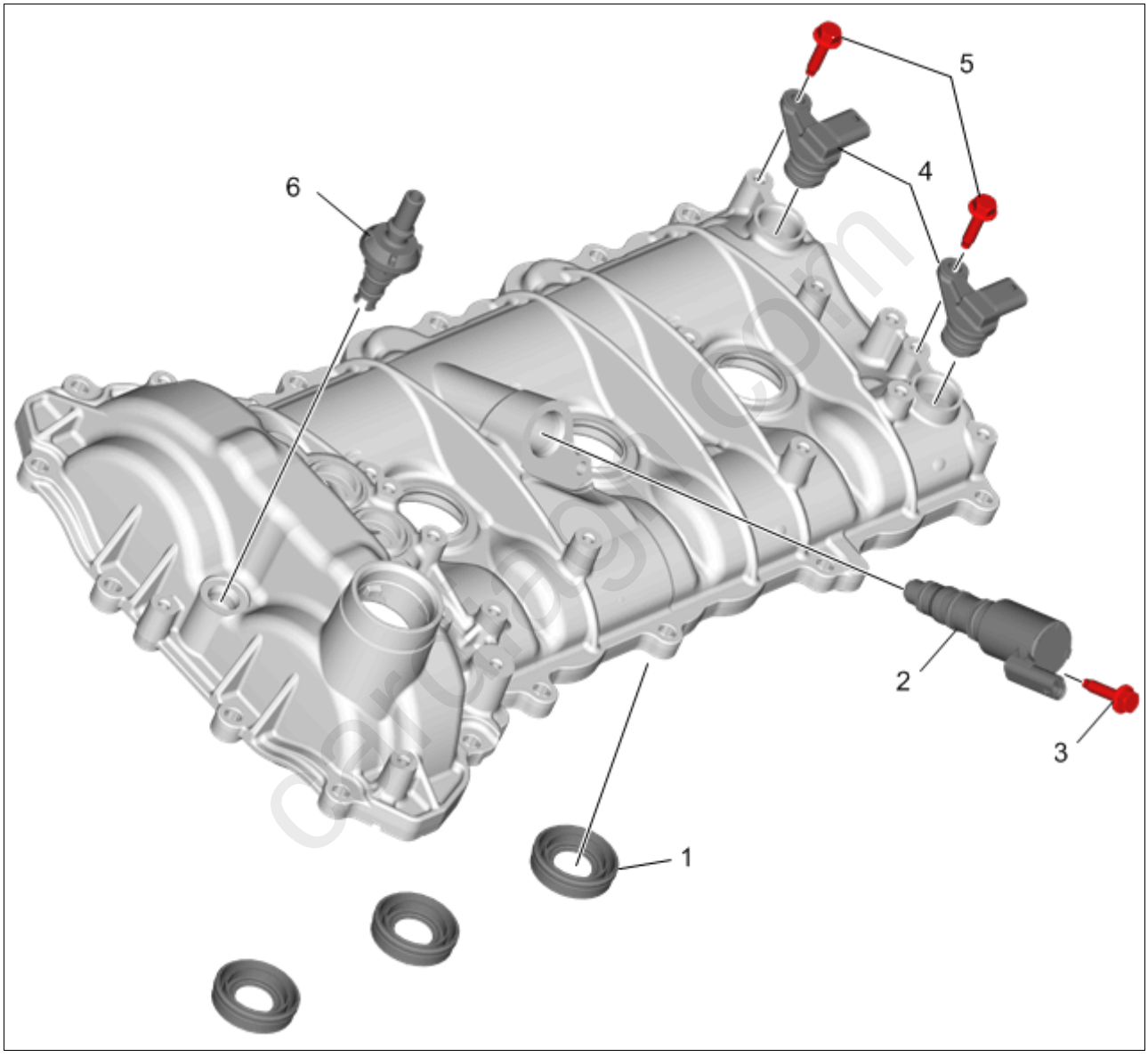
    4. Damage to the positive crankcase ventilation (PCV) hose connector (8)-A damaged PCV

hose connector is not replaceable.

6. Repair or replace the camshaft cover or covers as necessary.

REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT COVER ASSEMBLE > LEFT CAMSHAFT COVER

Fig 1: Left Camshaft Cover



Courtesy of GENERAL MOTORS COMPANY

Left Camshaft Cover

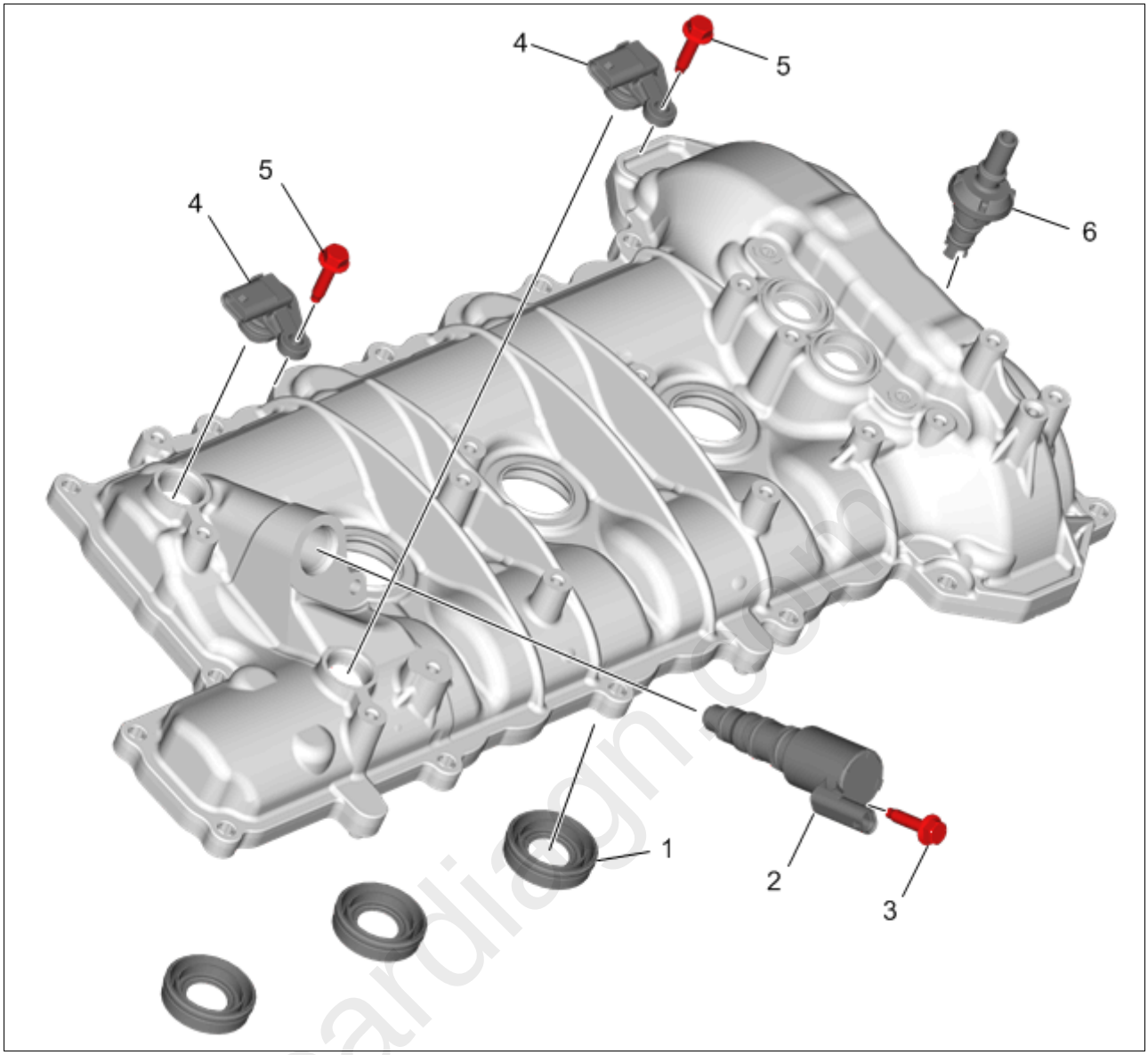
Callout	Component Name
1	Spark Plug Shield Seal

	NOTE: *Install a NEW seal.* **Special Tools** **J-46103** Camshaft Actuator Valve Seal Installer For equivalent regional tools, refer to Special Tools .
2	Valve Rocker Arm Oil Control Valve
3	Valve Rocker Arm Oil Control Valve Bolt *CAUTION:* *Refer to Fastener Caution .* **Tighten** 10 N.m (89 lb in)
4	Camshaft Position Sensor (Qty: 2)
5	Camshaft Position Sensor Bolt (Qty: 2) **Tighten** 10 N.m (89 lb in)
6	Positive Crankcase Ventilation Valve *NOTE:* *These components have tamper-proof connections and cannot be disassembled.*

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REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT COVER ASSEMBLE > RIGHT CAMSHAFT COVER

Fig 1: Right Camshaft Cover



Courtesy of GENERAL MOTORS COMPANY

Right Camshaft Cover

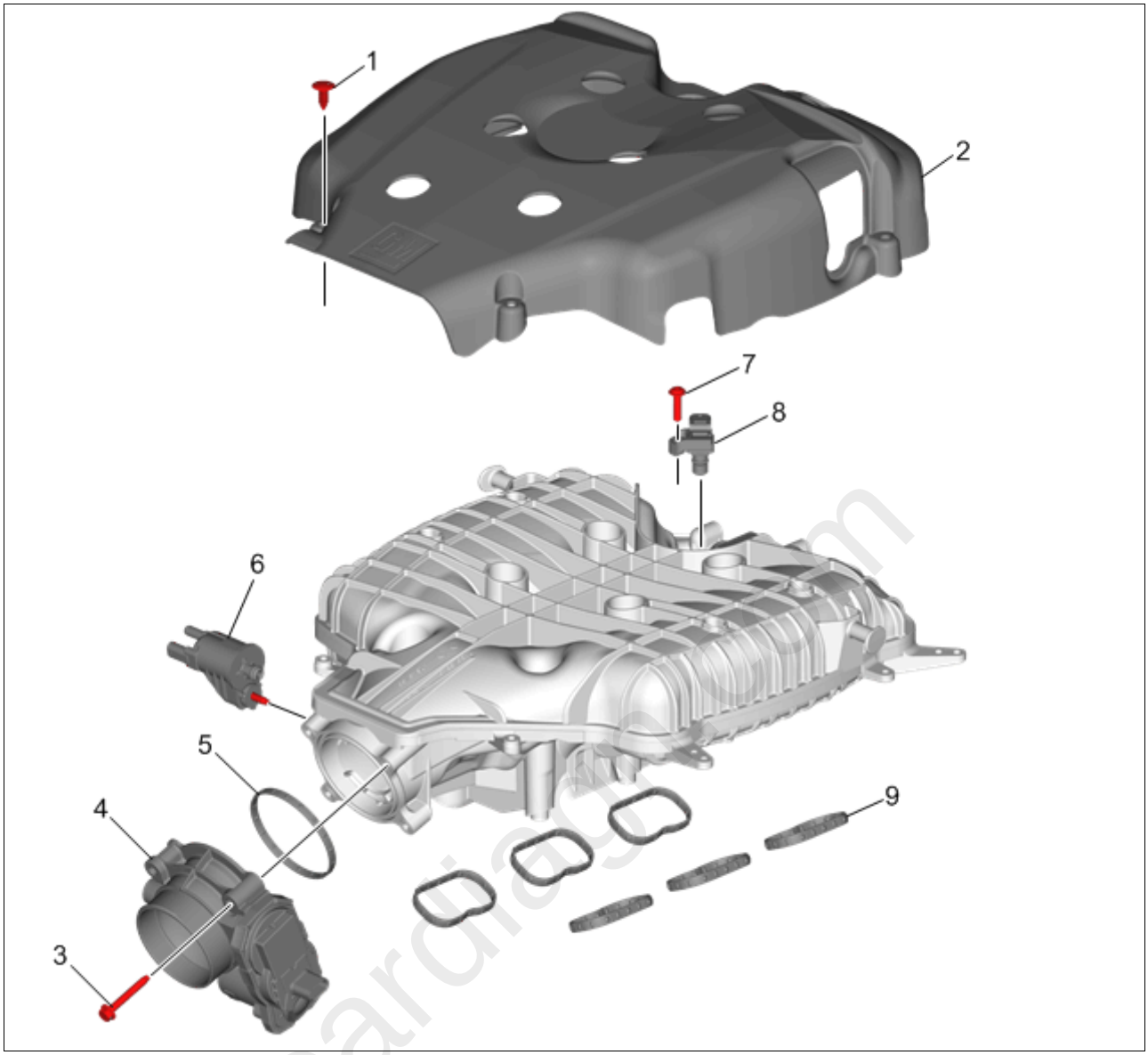
Callout	Component Name
1	Spark Plug Shield Seal *NOTE:* *Install a NEW seal.* **Special Tools**

	J-46103 Camshaft Actuator Valve Seal Installer For equivalent regional tools, refer to Special Tools .
2	Valve Rocker Arm Oil Control Valve
3	Valve Rocker Arm Oil Control Valve Bolt **Tighten** 10 N.m (89 lb in)
4	Camshaft Position Sensor (Qty: 2)
5	Camshaft Position Sensor Bolt (Qty: 2) **Tighten** 10 N.m (89 lb in)
6	Positive Crankcase Ventilation Valve *NOTE:* *These components have tamper-proof connections and cannot be disassembled.*

REPAIR INSTRUCTIONS - OFF VEHICLE > INTAKE MANIFOLD DISASSEMBLE

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Fig 1: Intake Manifold Disassemble (LGX)



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Intake Manifold Insulator Retainer (Qty: 4)
2	Intake Manifold Insulator
3	Throttle Body Bolt (Qty: 4)
4	Throttle Body
5	Throttle Body Gasket

	NOTE: *Remove and DISCARD the gasket.*
6	Evaporative Emission Canister
7	Manifold Absolute Pressure Sensor Bolt
8	Manifold Absolute Pressure Sensor
9	Intake Manifold Seal NOTE: *Remove and DISCARD the seal.*

REPAIR INSTRUCTIONS - OFF VEHICLE > INTAKE MANIFOLD CLEANING AND INSPECTION > INTAKE MANIFOLD CLEANING PROCEDURE

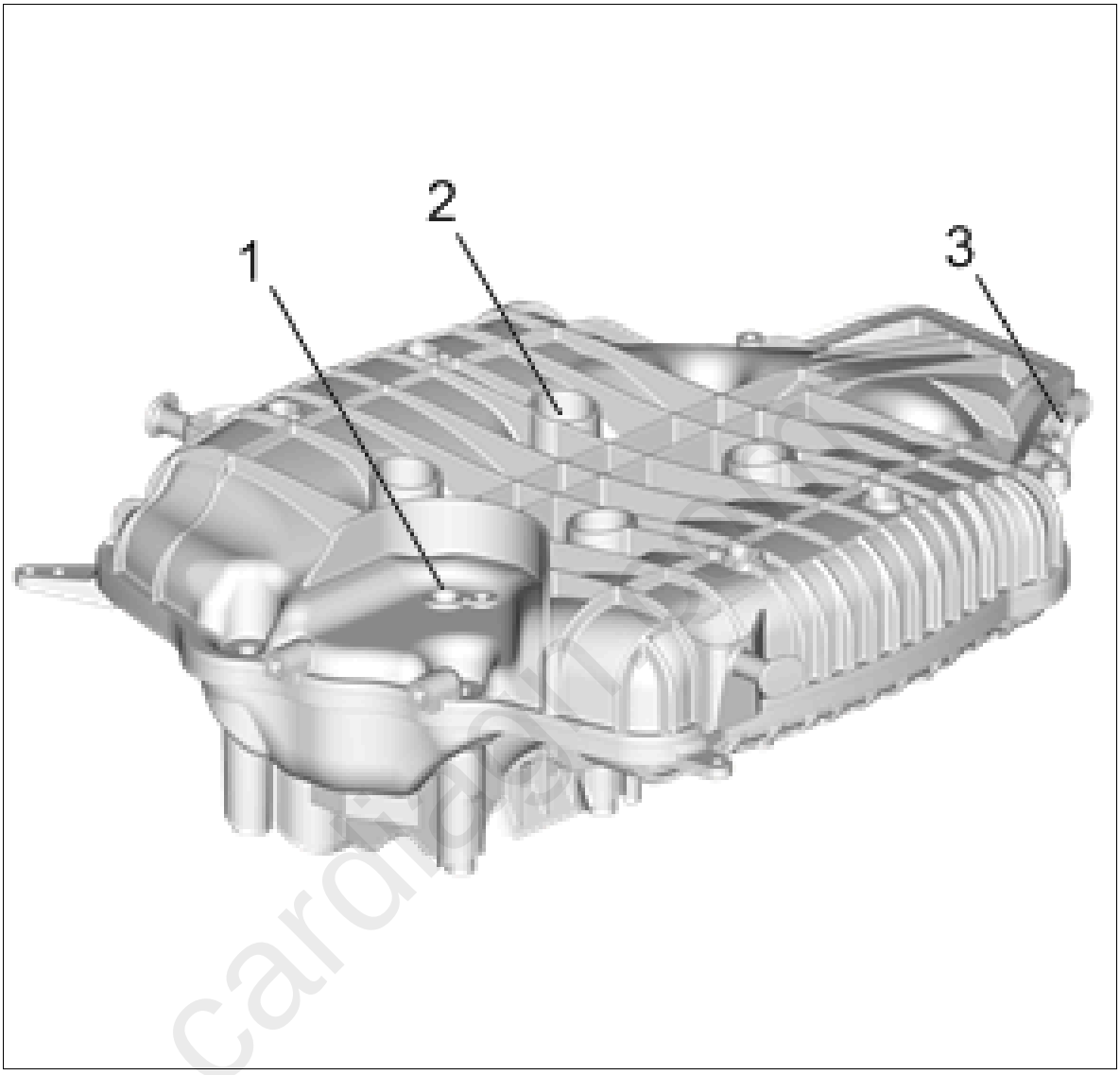
1. Remove any remaining gasket and/or gasket material from the following:
    1. Throttle body
    2. Intake manifold
2. Clean the following intake manifold areas in solvent.
    1. Intake manifold gasket sealing areas
    2. Intake manifold passages
    3. Brake booster hose passage
    4. Evaporative emission (EVAP) solenoid passage
    5. Positive crankcase ventilation (PCV) vacuum hose passages

    WARNING:
    Refer to Safety Glasses Warning .
3. Dry the intake manifold and throttle body with compressed air.

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REPAIR INSTRUCTIONS - OFF VEHICLE > INTAKE MANIFOLD CLEANING AND INSPECTION > INSPECTION PROCEDURE

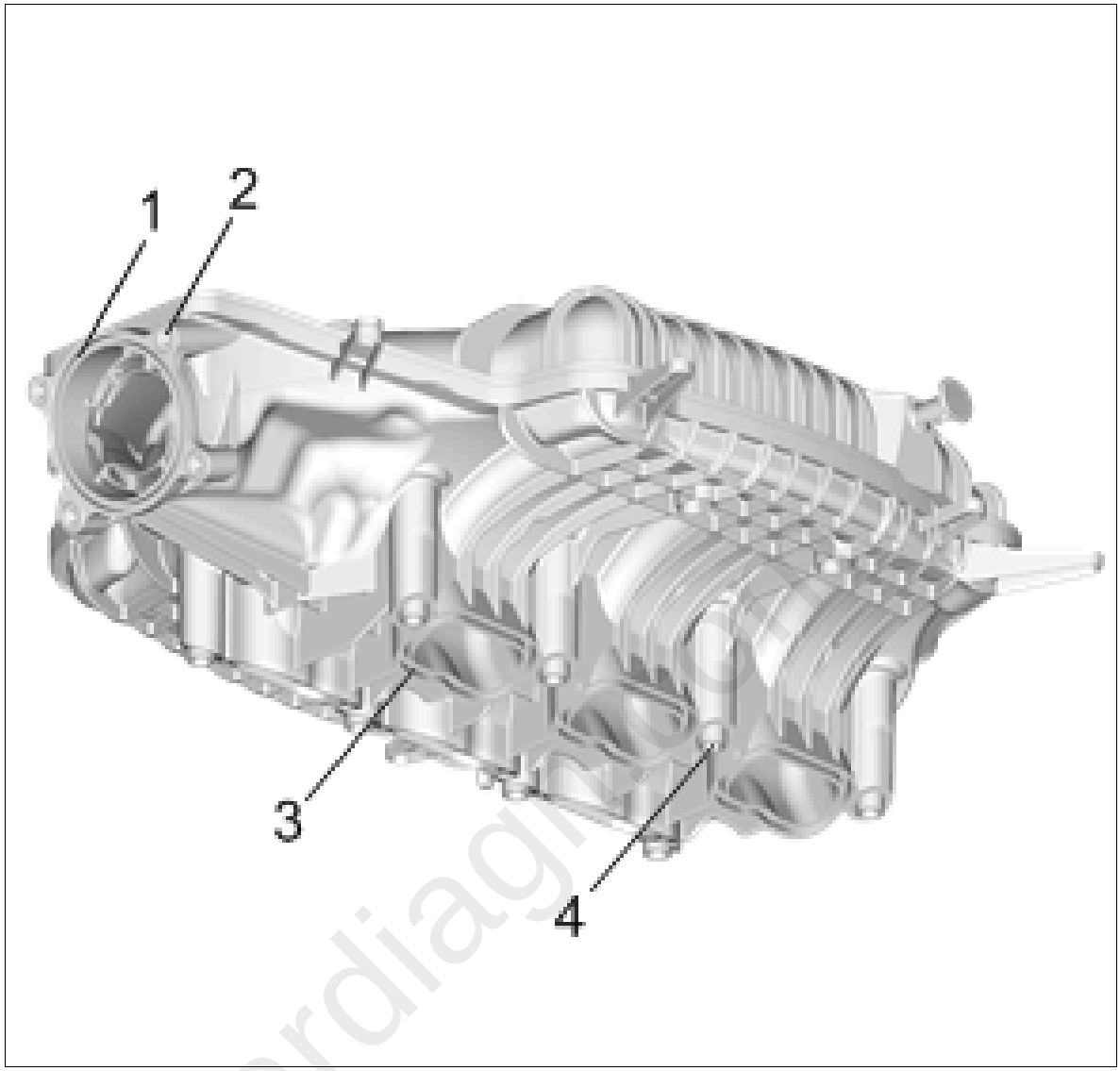
Fig 1: Intake Manifold Inspection Points



Courtesy of GENERAL MOTORS COMPANY

1. Inspect the intake manifold for the following conditions:
    1. Damage, debris or restrictions to the MAP sensor hole (1)
    2. Damage to the intake manifold bolt holes (2)
    3. Damage, debris or restrictions to the (EVAP) (3)

Fig 2: Lower Intake Manifold Inspection Points



Courtesy of GENERAL MOTORS COMPANY

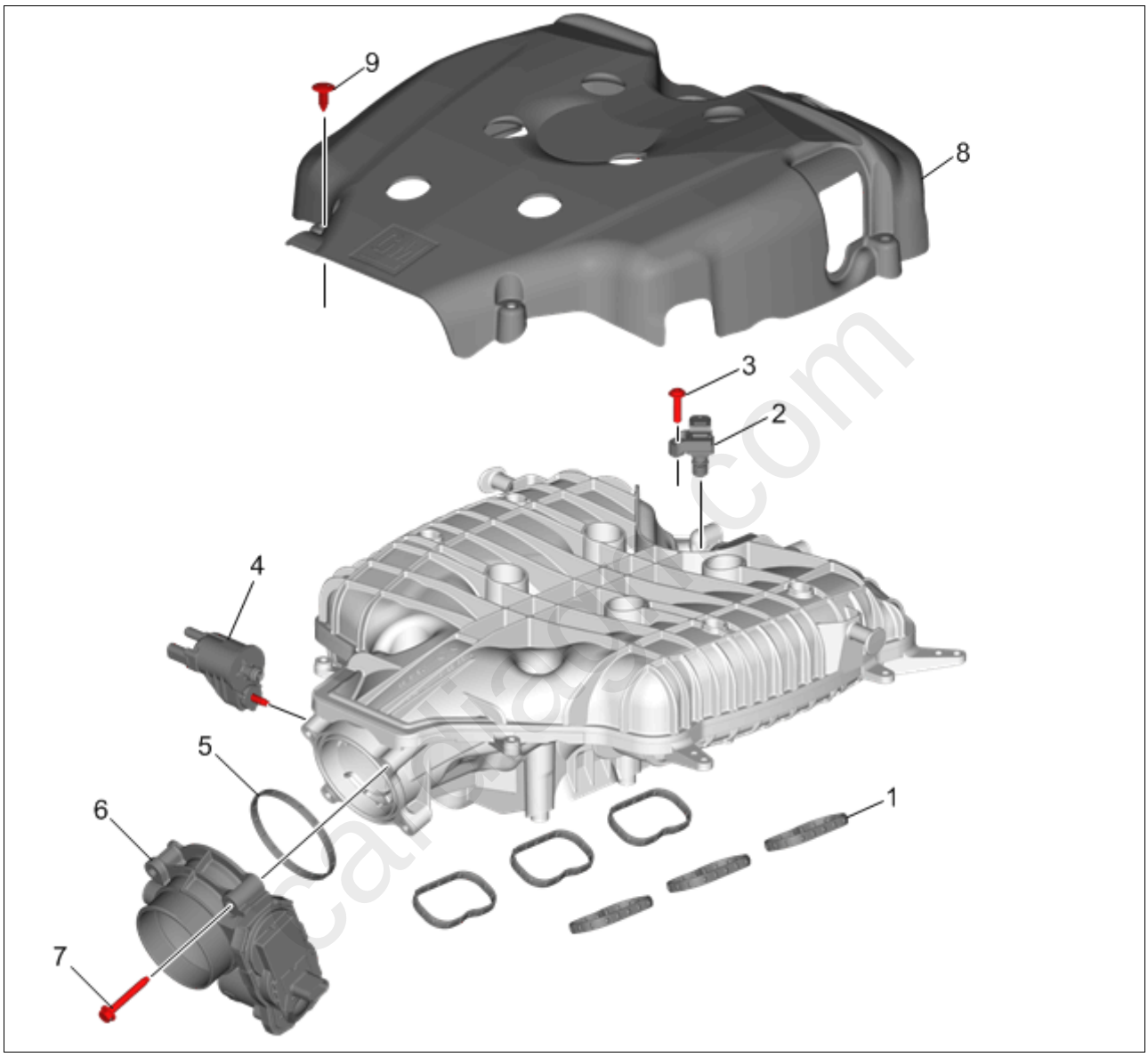
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2. Inspect the lower intake manifold for the following conditions:
    1. Damage to the throttle body sealing surface (1)
    2. Damage, debris or restrictions to the throttle body hole (2)
    3. Gouges or damage to the intake manifold sealing surfaces (3)
    4. Damage to the intake manifold tube (4)
3. Inspect the lower intake manifold sealing surface for warpage.
    1. Locate a straight edge across the lower intake manifold sealing surface.
    2. Insert a feeler gauge between the lower intake manifold and the straight edge. An lower intake manifold with warpage in excess of 0.50 mm (0.020 in) must be replaced.

4. Repair or replace the intake manifold as necessary.

REPAIR INSTRUCTIONS - OFF VEHICLE > INTAKE MANIFOLD ASSEMBLE

Fig 1: Intake Manifold Assemble (LGX)

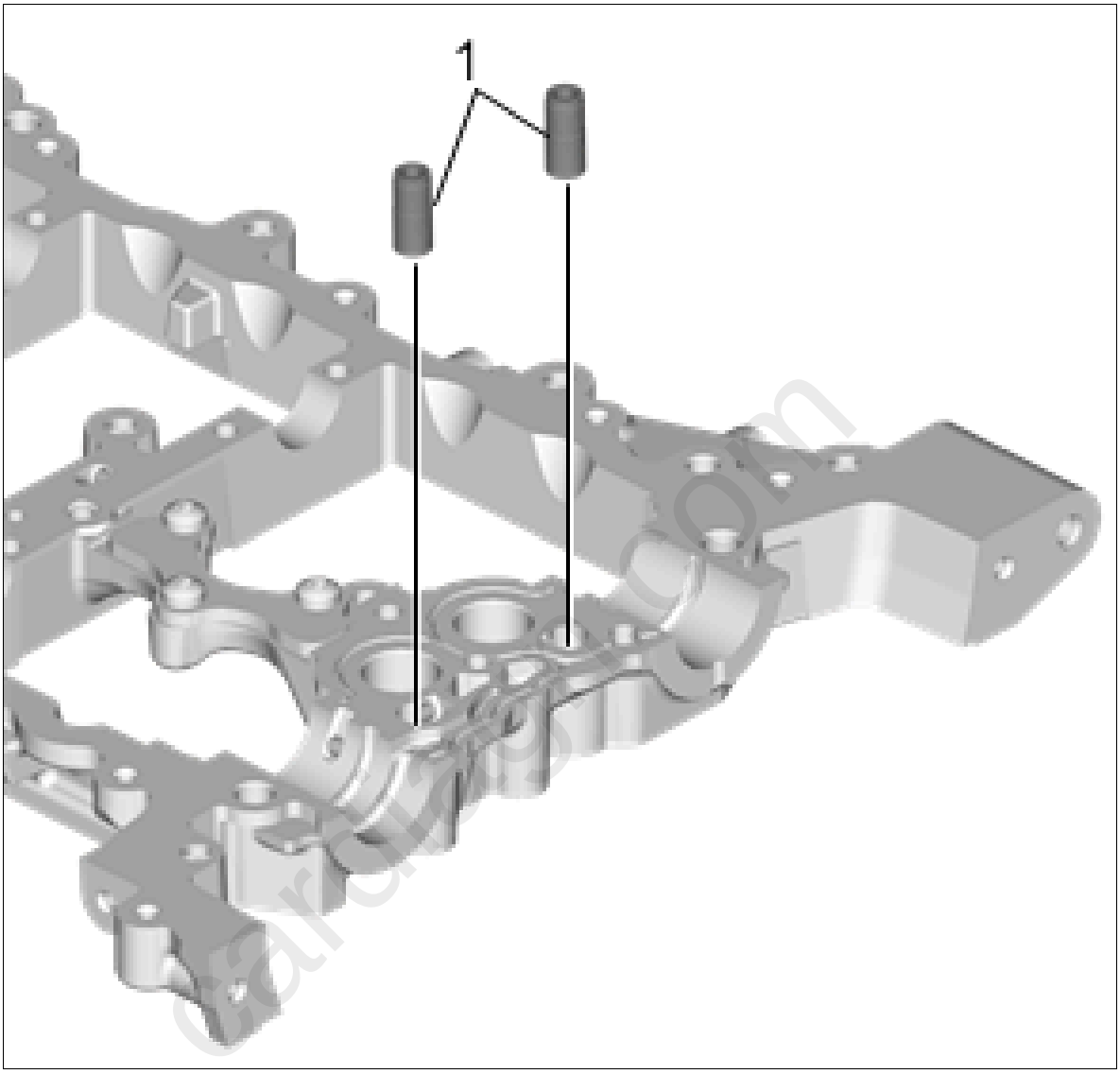


Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Intake Manifold Seal *NOTE:* *Install a NEW seal.*

REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT CARRIER DISASSEMBLE

Fig 1: Camshaft Position Actuator Oil Feed Check Valves



Courtesy of GENERAL MOTORS COMPANY

1. Inspect the camshaft position actuator oil feed check valves (1). Damaged, restricted or clogged check valves must be replaced. If check valves require replacement, proceed to step 2.
2. Flip over and push out from the bottom side.
3. Clean check valve bore and related passages thoroughly to remove any debris.

REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT CARRIER CLEANING AND INSPECTION

Special Tools

EN-28410 Gasket Remover

For equivalent regional tools, refer to Special Tools

REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT CARRIER CLEANING AND INSPECTION > CLEANING PROCEDURE

1. Remove any old thread sealant, gasket material or RTV sealant using **EN-28410** remover.
2. Clean the camshaft carriers using a non corrosive solvent.
3. Clean out debris from the bolt holes.

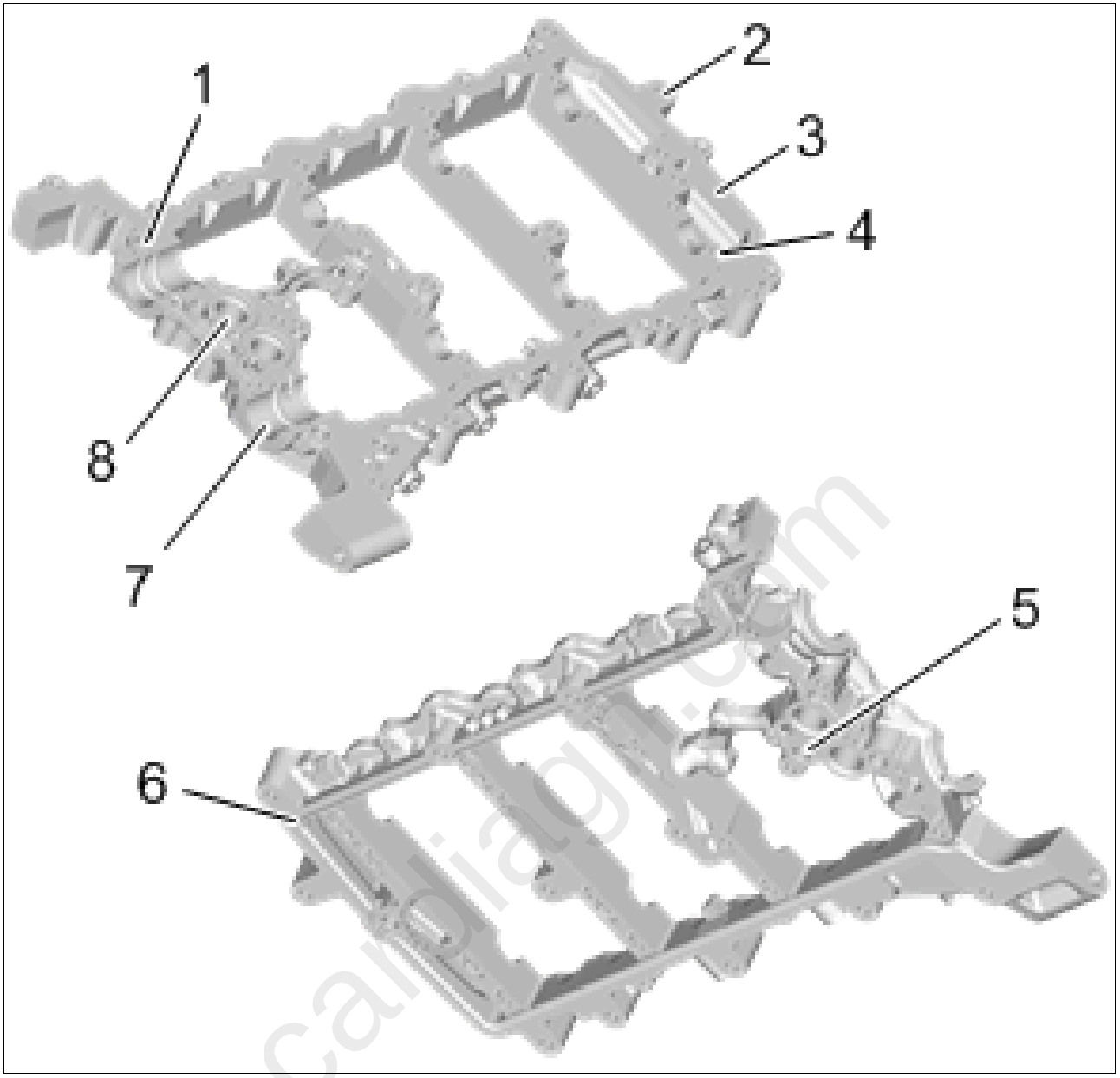
> *WARNING:*
>
> *Refer to Safety Glasses Warning .*

4. Dry the camshaft carriers with compressed air.

REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT CARRIER CLEANING AND INSPECTION > INSPECTION PROCEDURE RIGHT CAMSHAFT CARRIER

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Fig 1: Camshaft Carrier Conditions



Courtesy of GENERAL MOTORS COMPANY

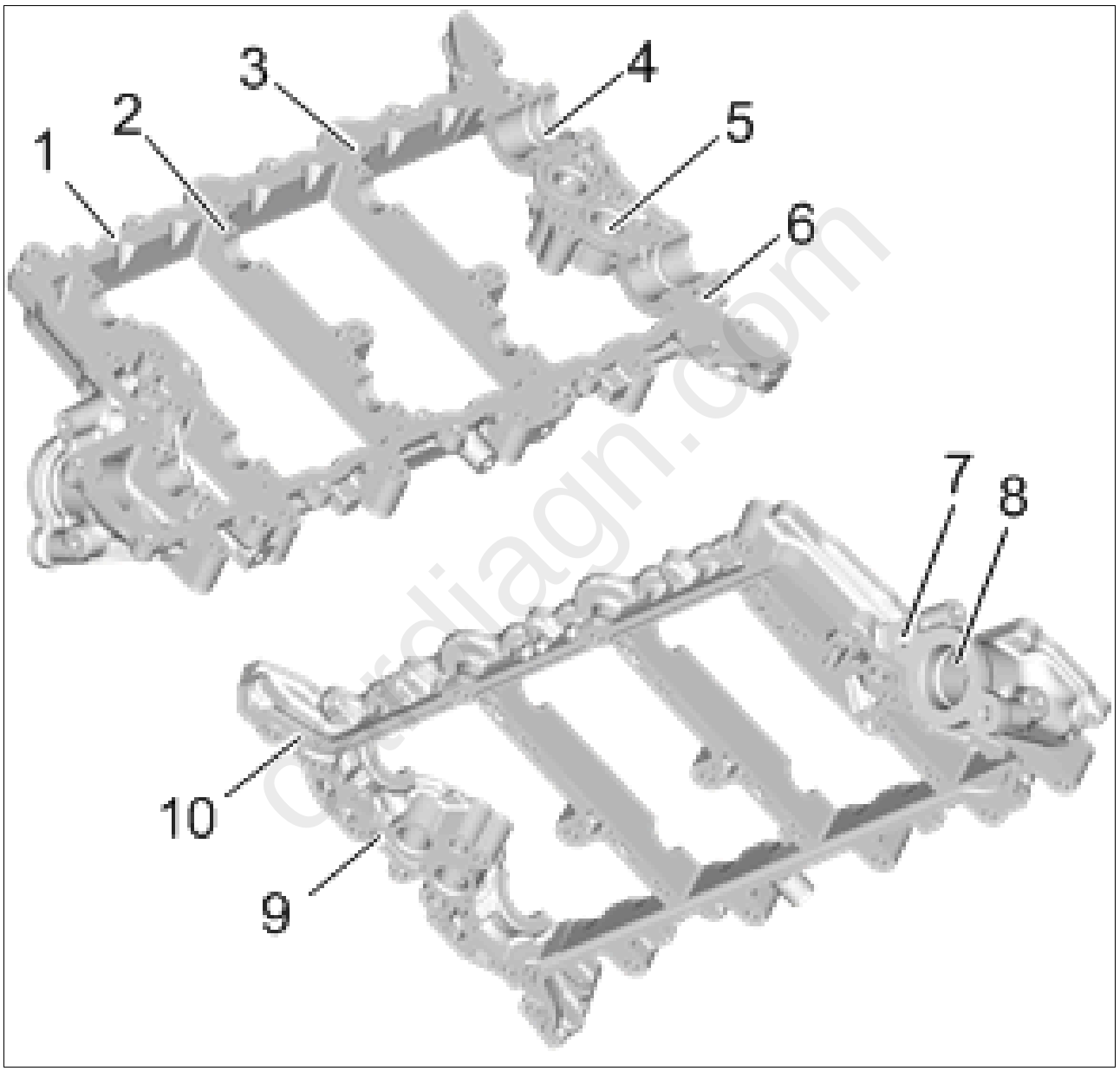
1. Inspect the camshaft carrier for the following conditions:
    1. Damage to the camshaft bearing cap bolt holes (1)
    2. Damage to the camshaft carrier bolt holes (2)
    3. Damage to the top sealing surface (3)
    4. Damage to the camshaft bearing cap bolt holes (4)
    5. Damage to the engine oil manifold check valve mounting areas (5)
    6. Damage to the bottom sealing surface (6)
    7. Damage to the camshafts mounting surface areas (7)

8. Damage to the camshaft position actuator solenoid valve holes (8)

2. Repair or replace the camshaft carrier as necessary.

REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT CARRIER CLEANING AND INSPECTION > INSPECTION PROCEDURE LEFT CAMSHAFT CARRIER

Fig 1: Camshaft Carrier Conditions



Courtesy of GENERAL MOTORS COMPANY

1. Inspect the camshaft carrier for the following conditions:

    1. Damage to the top sealing surface (1)

    2. Damage to the camshaft bearing cap bolt holes (2)

3. Damage to the camshaft carrier bolt holes (3)
4. Damage to the camshafts mounting surface areas (4)
5. Damage to the camshaft position actuator solenoid valve holes (5)
6. Damage to the camshaft bearing cap bolt holes (6)
7. Damage to the fuel pump bolt holes (7)
8. Damage to the fuel pump mounting surface and the valve lifter follower area (8)
9. Damage to the engine oil manifold check valve mounting areas (9)
10. Damage to the bottom sealing surface (10)

2. Repair or replace the camshaft carrier as necessary.

REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT CARRIER ASSEMBLE

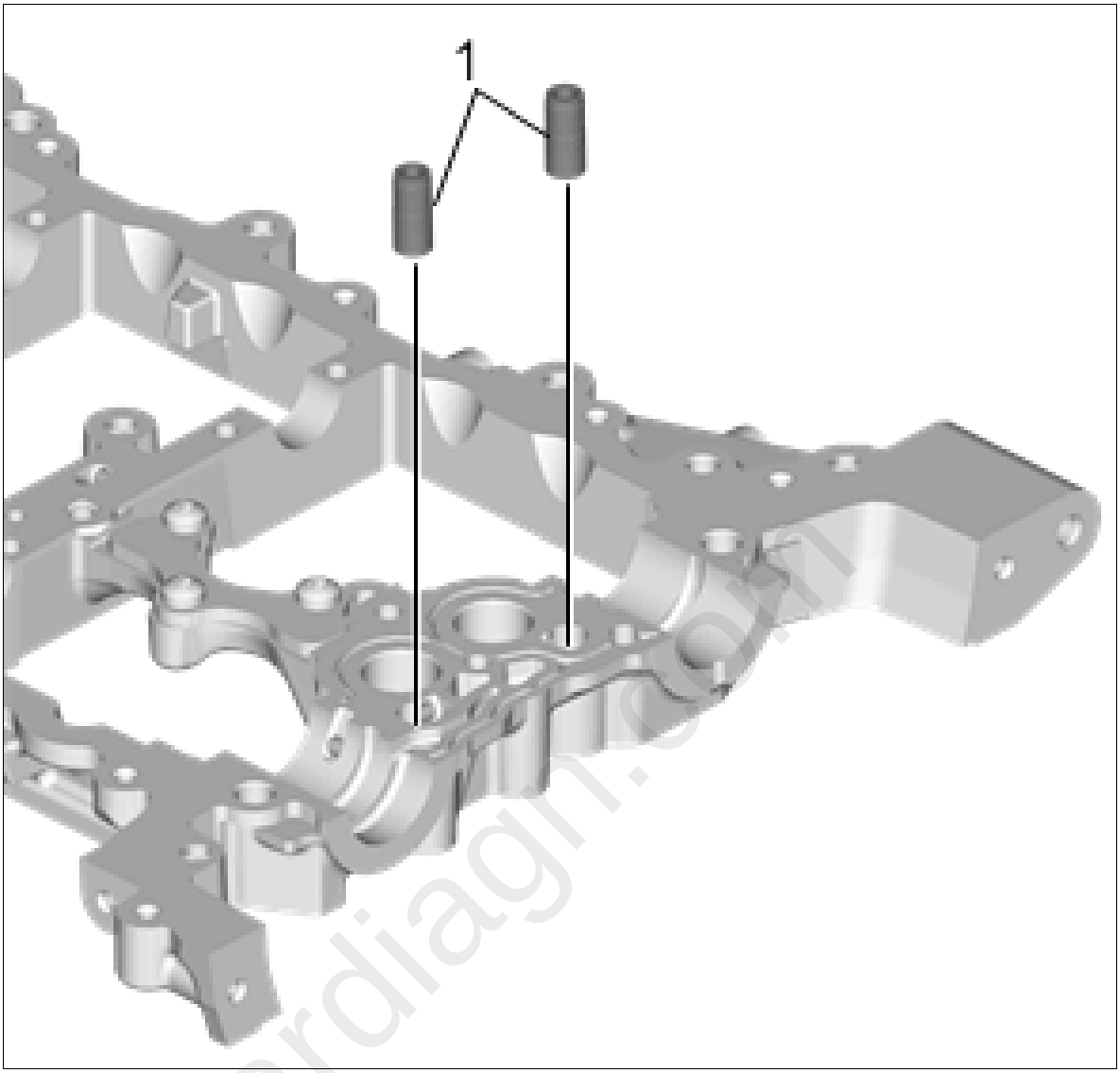
Special Tools

EN-46122 Camshaft Position Actuator Check-Ball Valve Remover/Installer

For equivalent regional tools, refer to Special Tools .

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Fig 1: Camshaft Position Actuator Oil Feed Check Valves

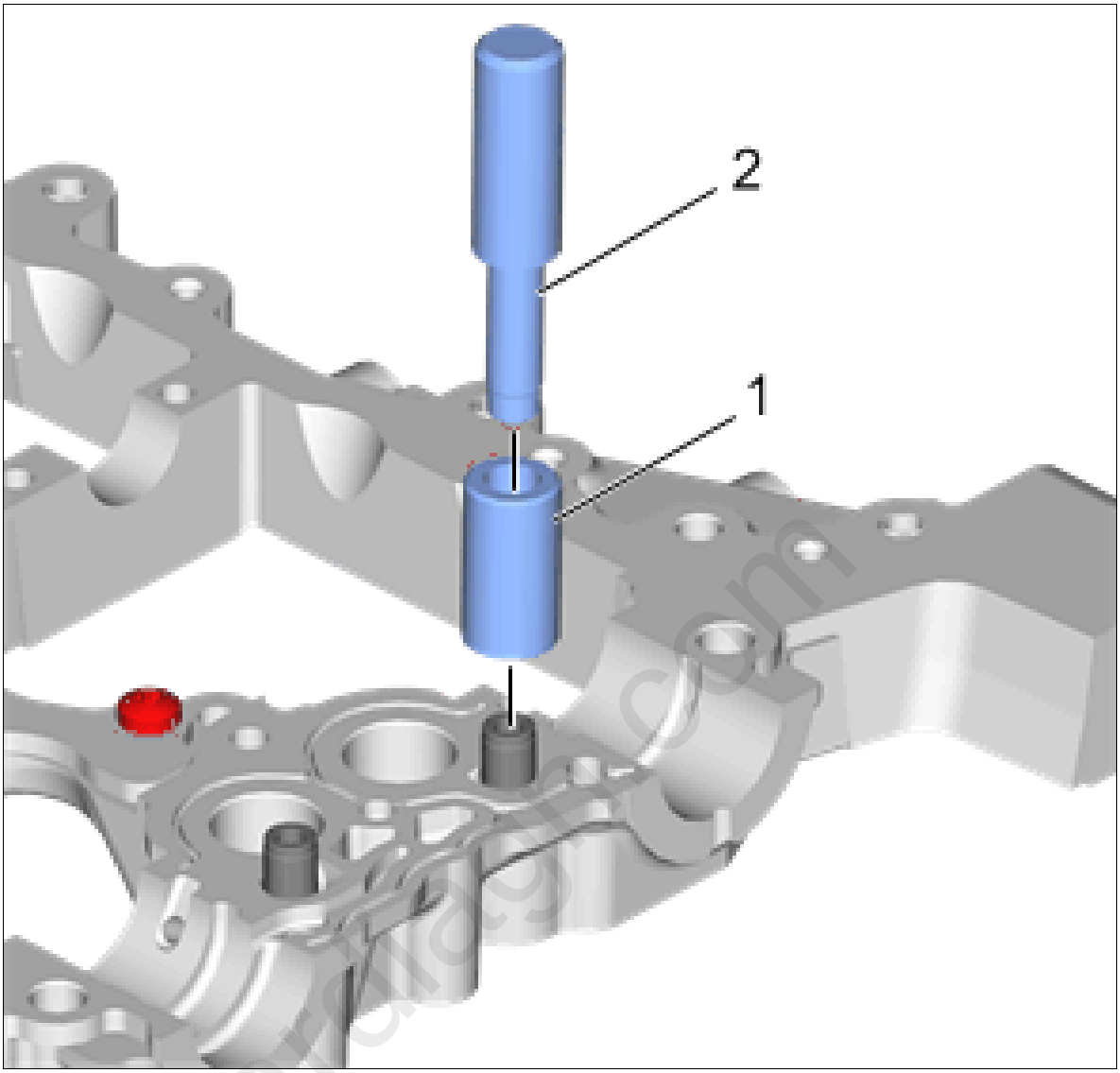


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1. Use lubricant included with **EN-46122** remover/installer to lubricate outside of new check valve (1).
2. With the check ball end of the check valve facing UP, away from the head, insert the NEW check valve into the check valve bore in the cylinder head.

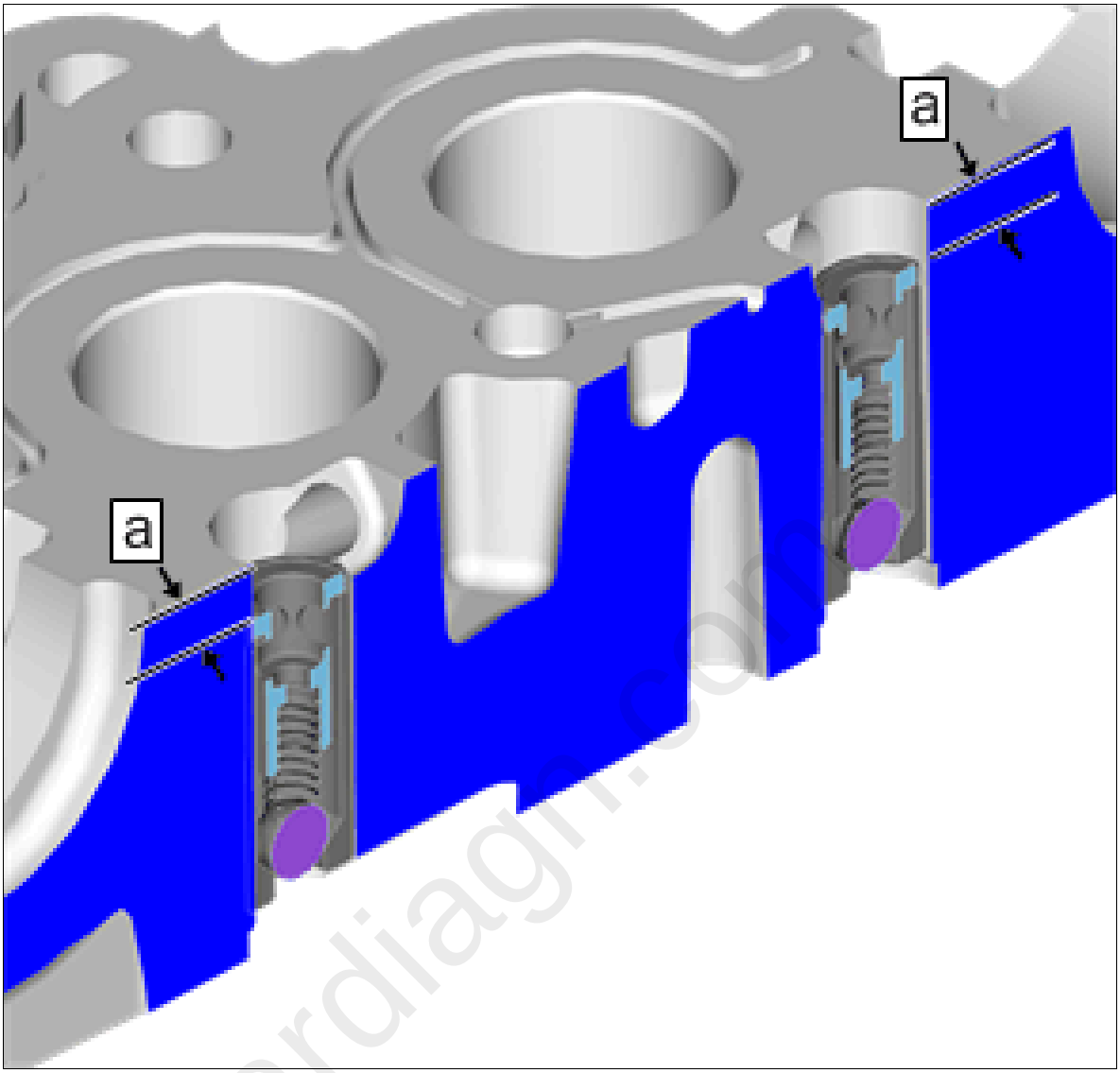
Fig 2: Camshaft Carrier Check Valves



Courtesy of GENERAL MOTORS COMPANY

3. Place collar **EN-46122-2** (1) over the new check valve with the slightly-larger inside diameter of the collar DOWN toward the cylinder head.
4. Using the driver **EN-46122-1** (2), lightly tap the new check valve into place until the driver stops against the top of the collar.

Fig 3: Camshaft Position Actuator Oil Feed Check Valve Installed Depth



Courtesy of GENERAL MOTORS COMPANY

5. Inspect the camshaft position actuator oil feed check valves in order to ensure they are properly installed in the cylinder head. The camshaft position actuator oil feed check valve should be flush to.75 mm (0.0295 in) below the cylinder head deck surface (a).

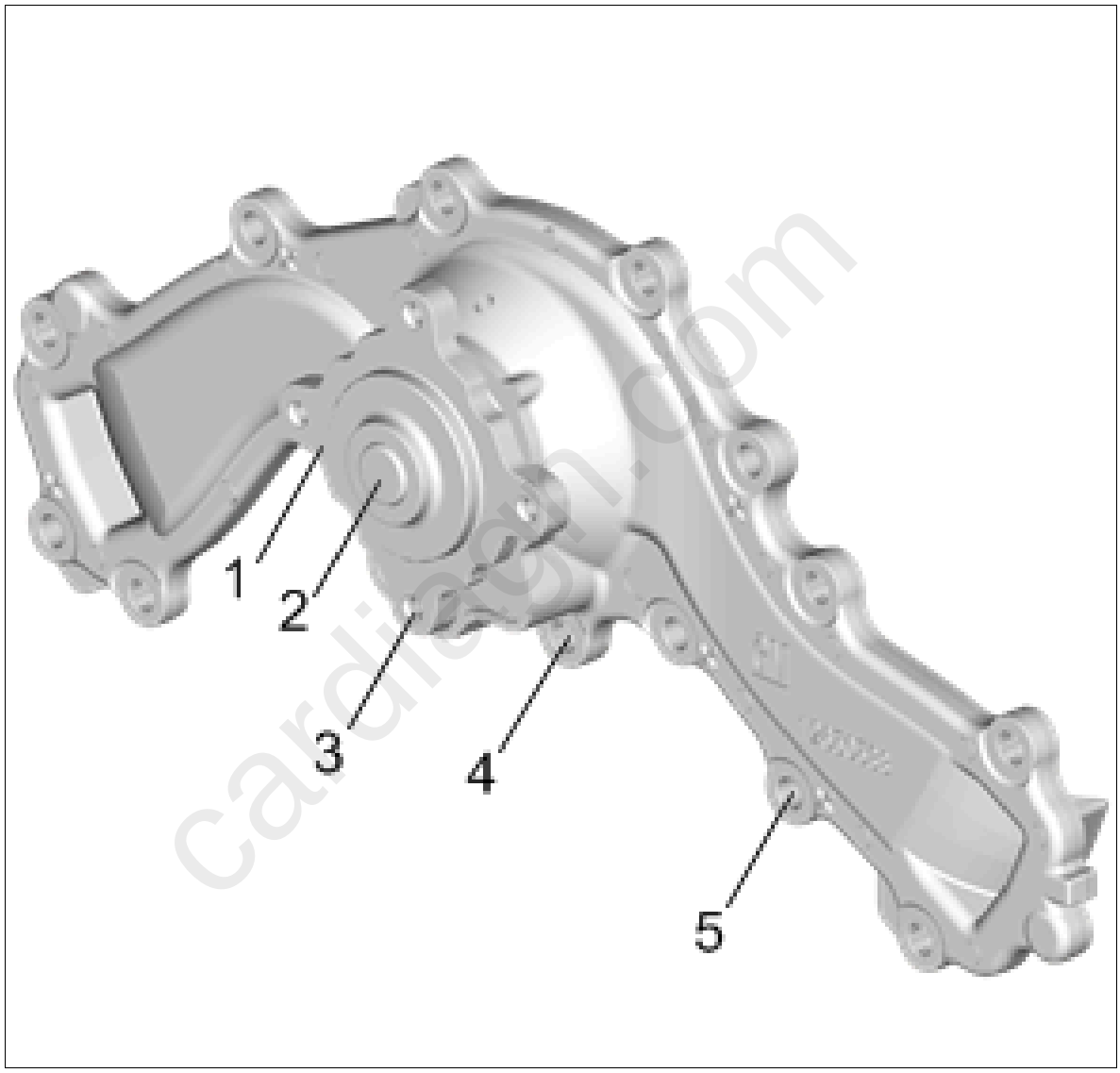
REPAIR INSTRUCTIONS - OFF VEHICLE > WATER PUMP CLEANING AND INSPECTION > CLEANING PROCEDURE

> ⚠ *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.

REPAIR INSTRUCTIONS - OFF VEHICLE > WATER PUMP CLEANING AND INSPECTION > INSPECTION PROCEDURE

Fig 1: Water Pump Hub

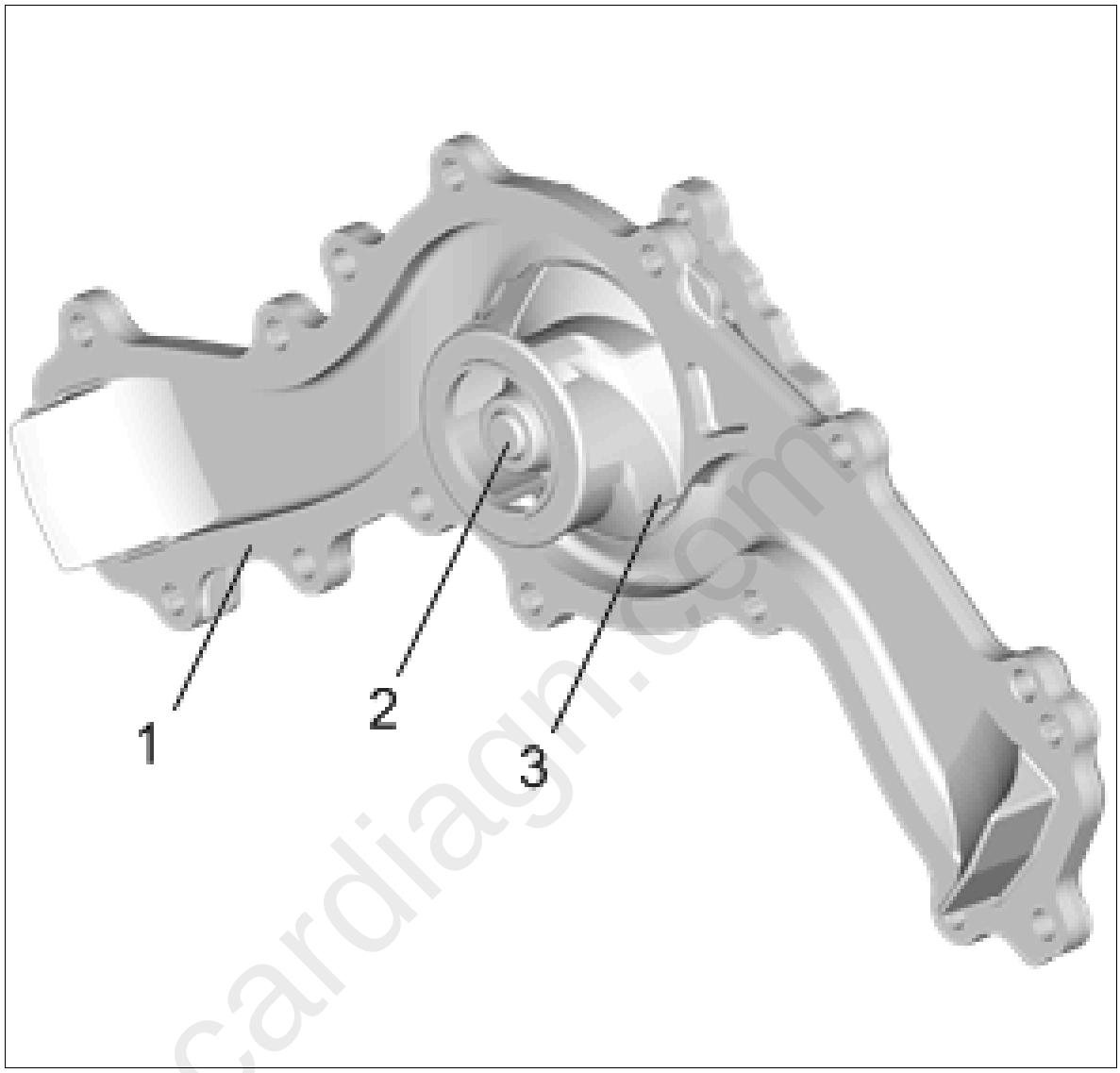


Courtesy of GENERAL MOTORS COMPANY

1. Rotate the water pump hub (2). 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.
2. Inspect the exterior of the water pump for the following:
    1. Damage to the water pump hub mating surface (1) for the water pump pulley
    2. Damage to the water pump hub bolt threads (3) for the water pump pulley

3. Damage to the water pump axy rads (4)
4. Damage to the water pump bolt holes (5)

Fig 2: Water Pump Inspection Points



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3. Inspect the interior of the water pump for the following:
    1. Damage to the water pump gasket sealing surface (1)
    2. Damage, corrosion or restrictions to the water pump impeller (2)
    3. Damage, corrosion or restrictions to the coolant passages (3)
4. Repair or replace the water pump as necessary.

REPAIR INSTRUCTIONS - OFF VEHICLE > THREAD REPAIR

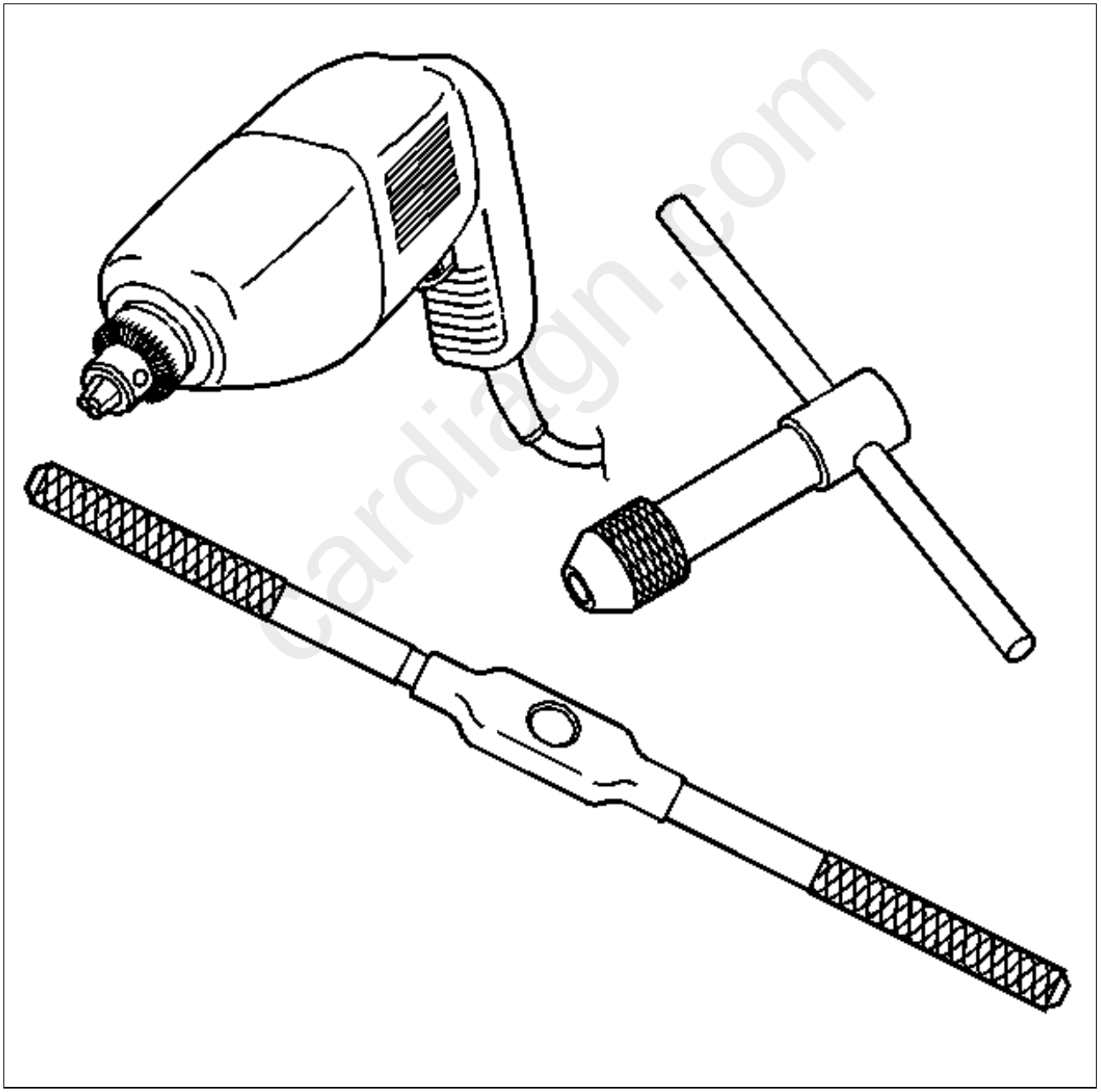
Special Tools

- **EN-42385-70** Head Bolt Thread Repair Fixture
- **EN-42385-700** High Feature Thread Repair Kit
- **EN-42385-2000** Thread Insert Kit
- **EN-43965** Thread Repair Extension Kit

For equivalent regional tools, refer to Special Tools .

The thread repair process involves a solid, thin walled, self-locking, carbon steel, bushing type insert. During the insert installation process, the installation driver tool cold-rolls the bottom internal threads and expands the bottom external threads of the insert into the base material. This action mechanically locks the insert into place.

Fig 1: Tool Kit

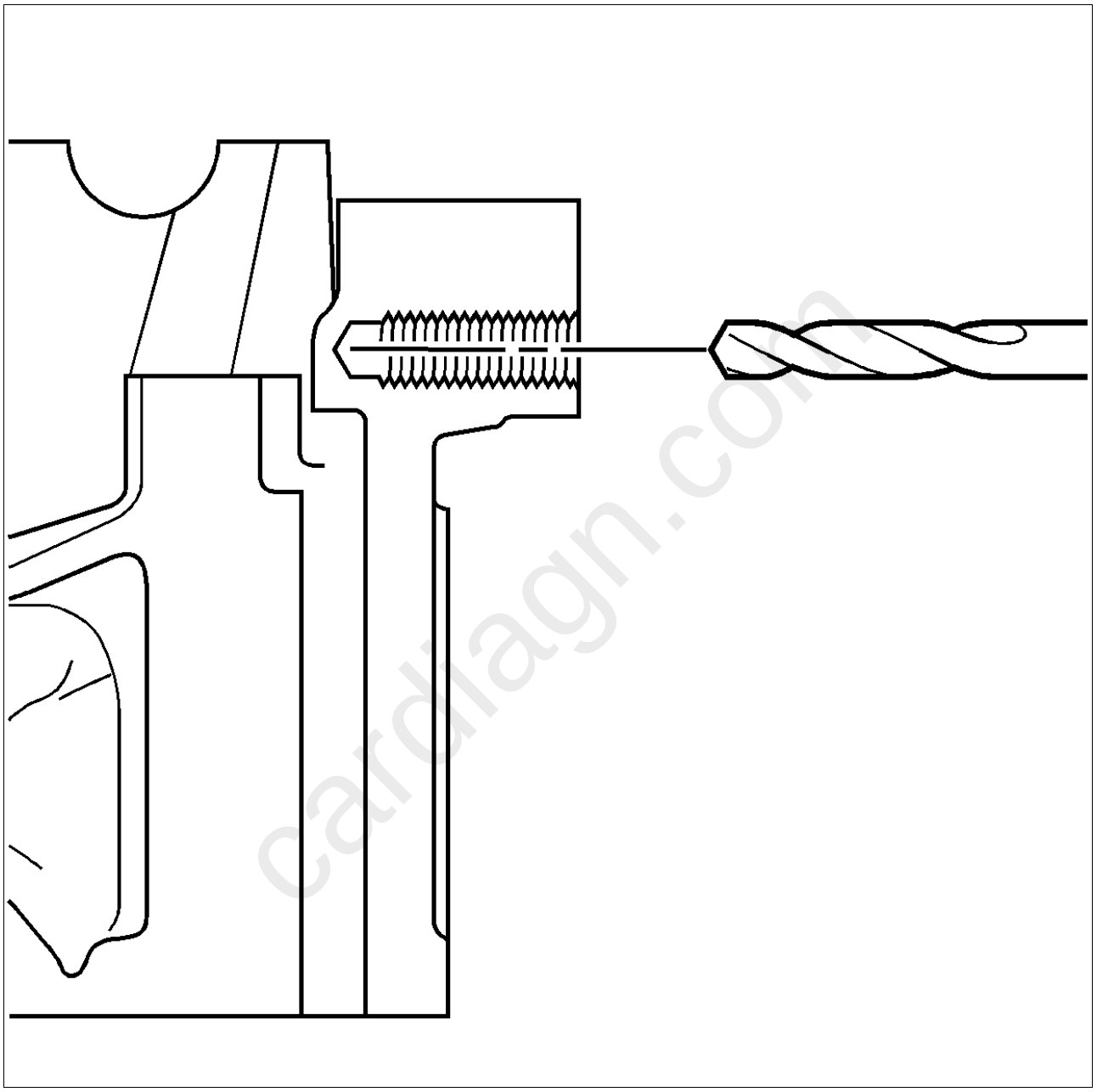


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Courtesy of GENERAL MOTORS COMPANY

The drill bit and counter bore tool from the tool kit **EN-42385-700** kit and **EN-42385-2000** insert kit is designed for use with either a suitable tap wrench or drill motor. Limited access and larger hole repair may process better using a tap wrench. An extension from kit **EN-43965** extension kit may also be necessary to drive the thread repair tooling dependent on access to the hole being repaired. Use only a tap wrench when tapping the hole and during installation of the insert.

Fig 2: Hole Centerline

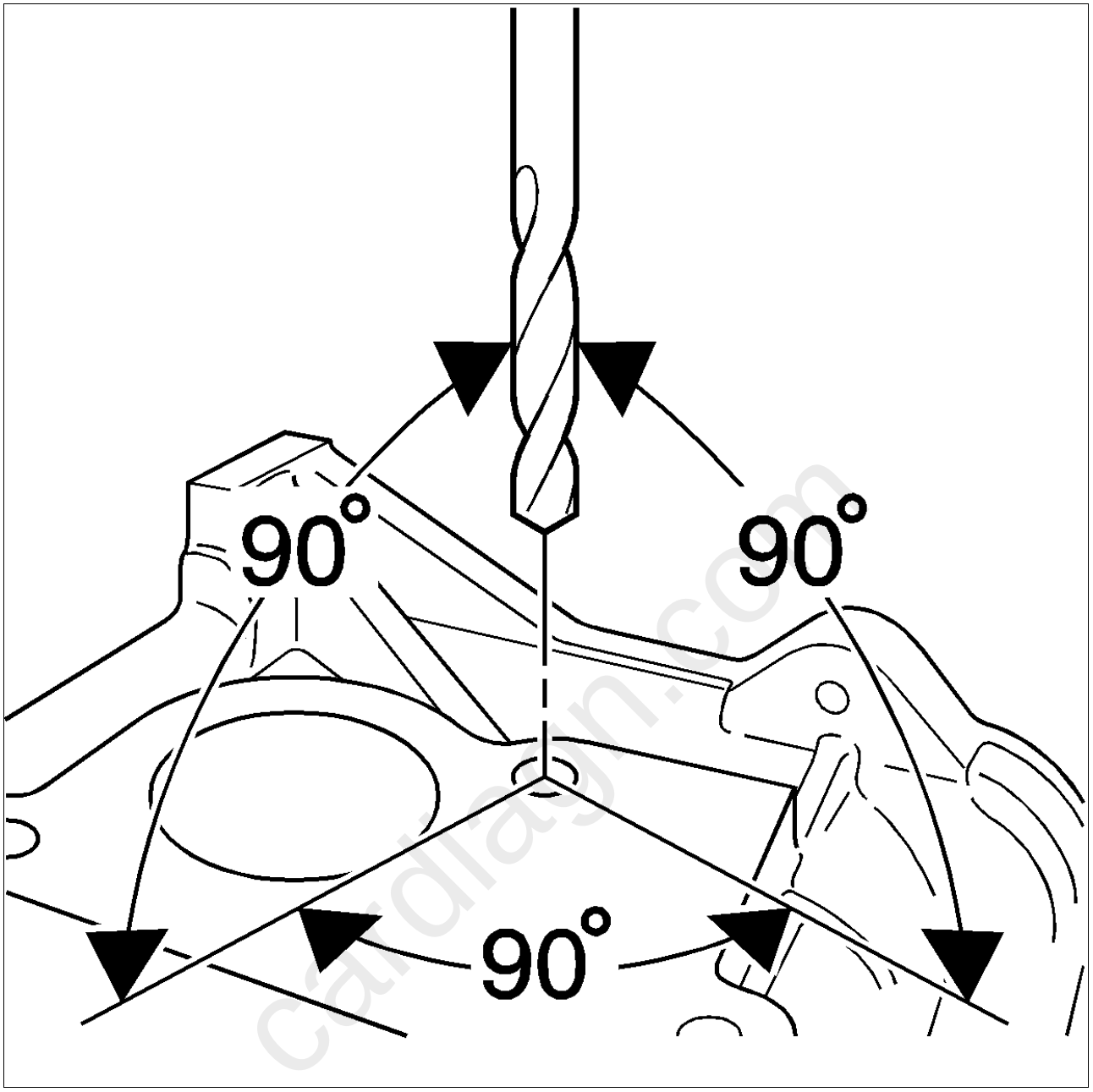


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It is critical that the drilling, counterboring and tapping of the hole to be repaired follows the same centerline as the original hole.

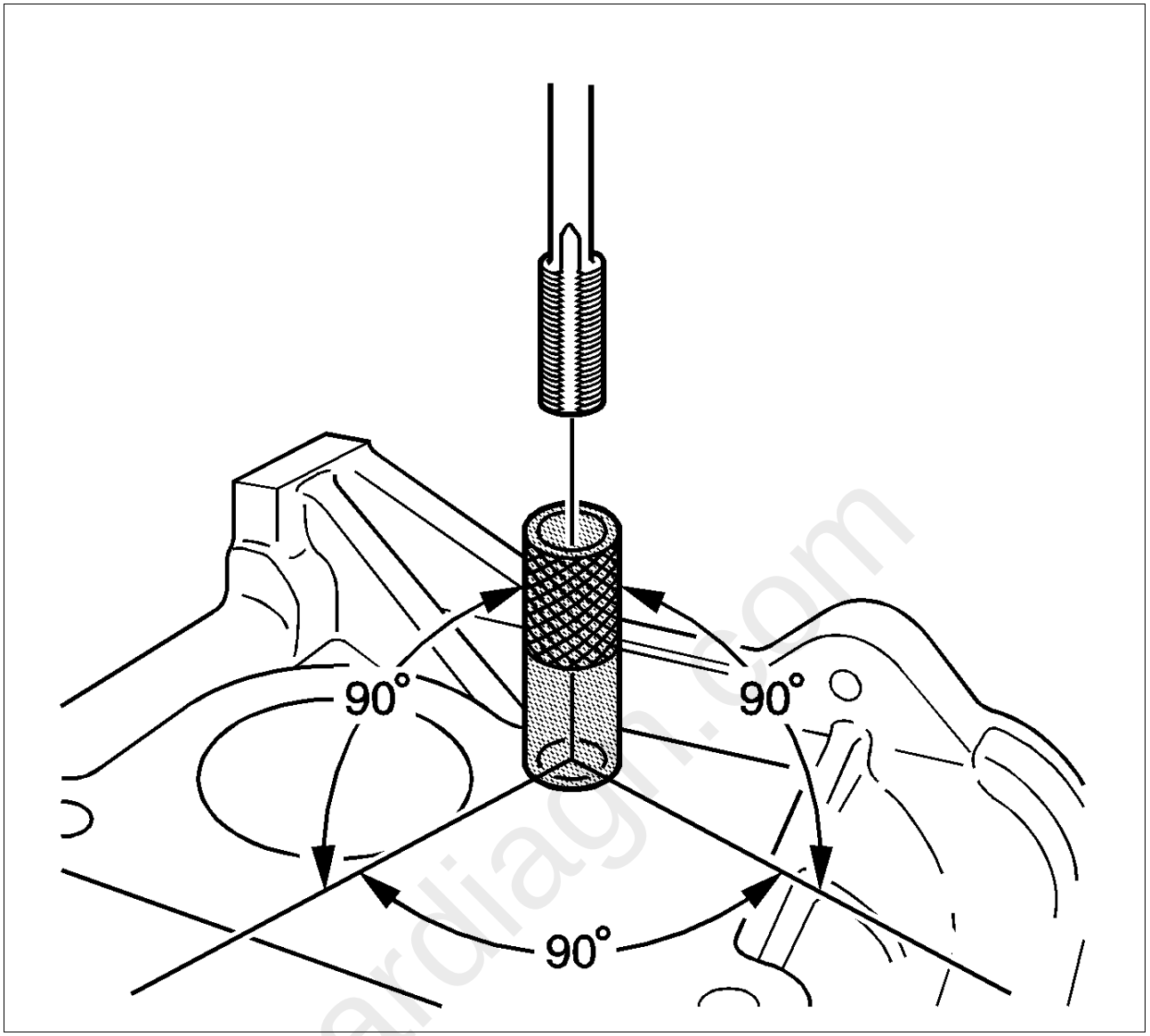
Fig 3: Drilling Angle



Courtesy of GENERAL MOTORS COMPANY

During the drilling and tapping of the hole being repaired ensure the tooling is consistently machining perpendicular to the surface of the base material.

Fig 4: Tapping Guide



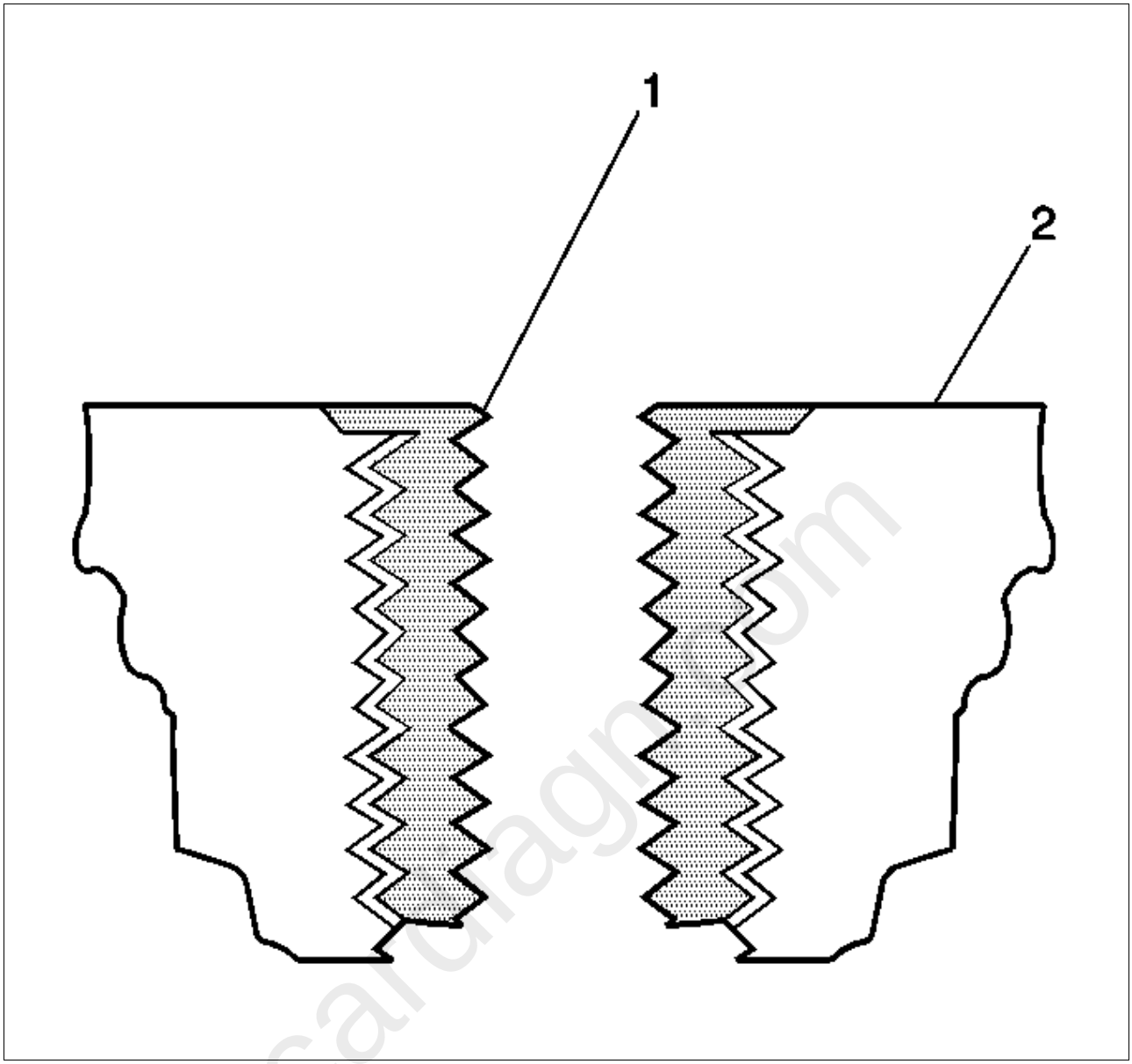
Courtesy of GENERAL MOTORS COMPANY

If the threaded hole being repaired has a base surface perpendicular to the hole centerline, tapping guides are available to aid in tapping the hole.

Tap Size	Tap Guide	Tap Size	Tap Guide	Tap Size	Tap Guide
-	EN 42385-	-	EN 42385-	-	EN 42385-
6 x 1.0	729	10 x 1.5	731	14 x 1.5	736
8 x 1.25	730	12 x 1.5	732	20 x 1.5	737

REPAIR INSTRUCTIONS - OFF VEHICLE > THREAD REPAIR > STANDARD THREAD REPAIR - FLUSH HOLE

Fig 1: Bushing Type Insert & Base Material



Courtesy of GENERAL MOTORS COMPANY

WARNING:

Refer to Safety Glasses Warning .

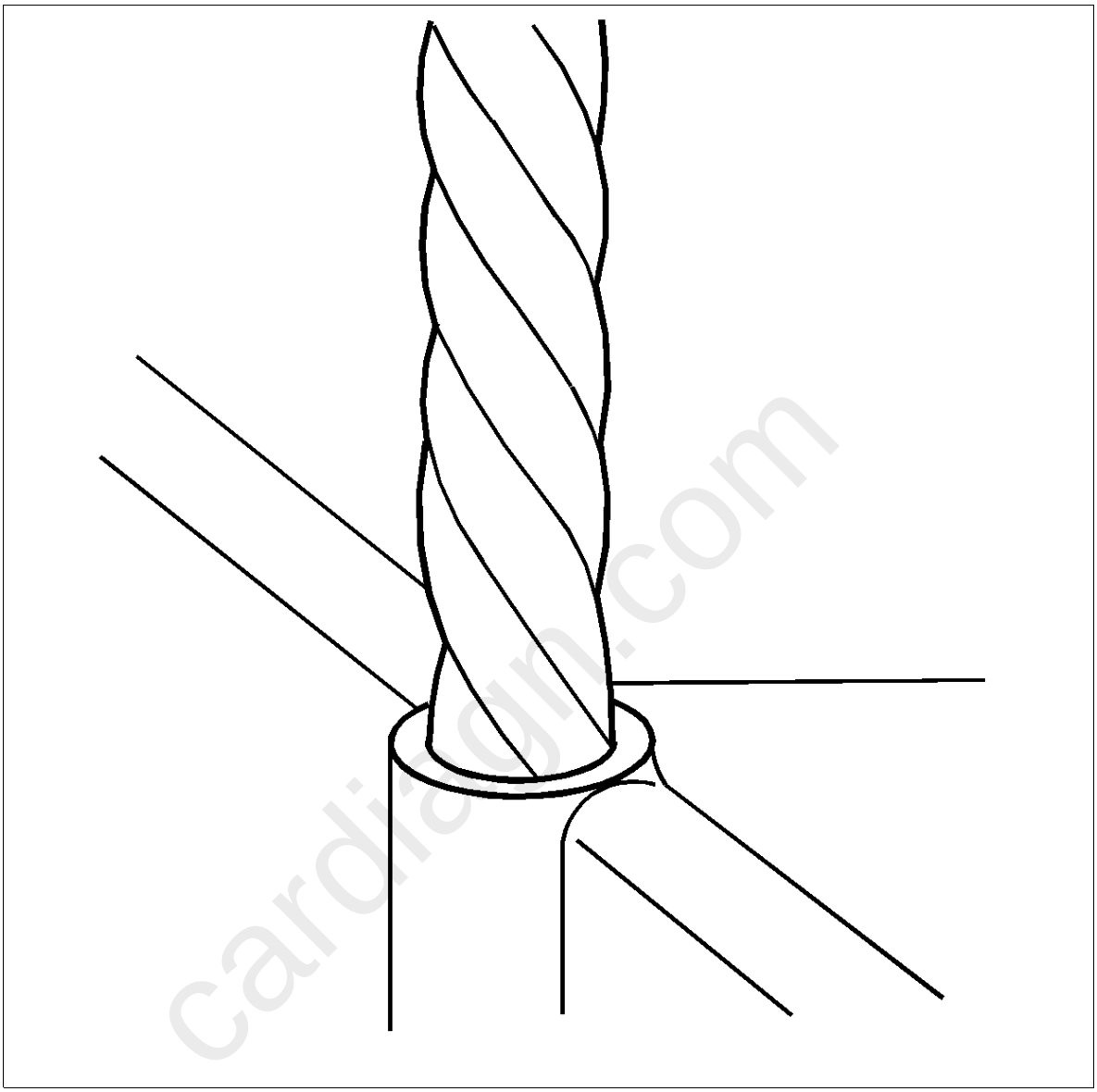
NOTE:

The use of a cutting type fluid is recommended when performing the drilling, counterboring and tapping procedures. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended cutting fluid.

When installed to the proper depth, the flange (1) of the insert will be seated against the

counterbore of the drilled/tapped hole and just below the surface (2) of the base material.

Fig 2: Threads Of Damaged Hole



Courtesy of GENERAL MOTORS COMPANY

NOTE:

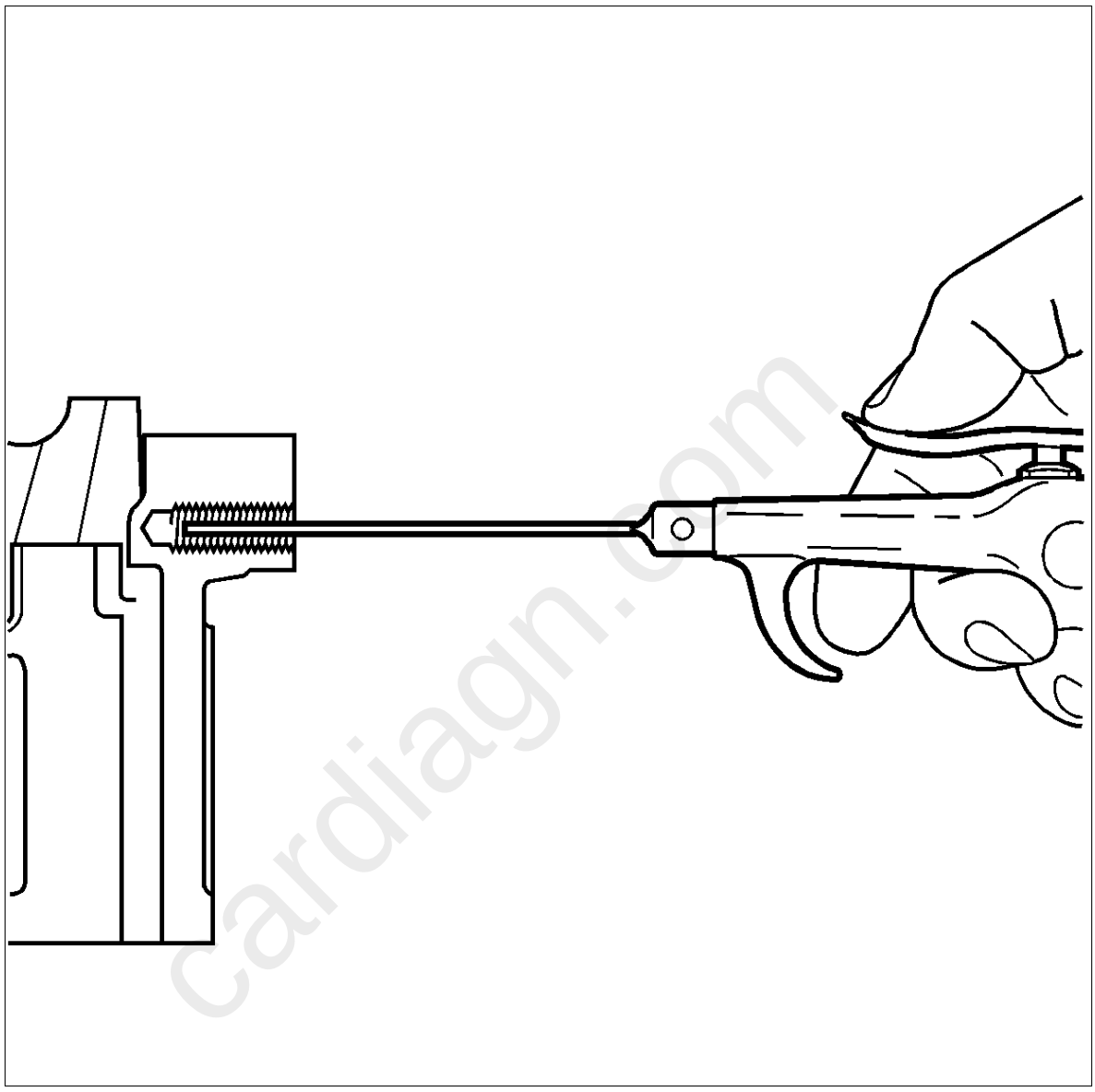
1. *During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.*
2. *Do NOT drill any further than the original hole depth.*

1. Drill out the threads of the damaged hole.

Specifications

1. M6 inserts require a minimum drill depth of 15 mm (0.59 in).
2. M8 inserts require a minimum drill depth of 20 mm (0.79 in).
3. M10 inserts require a minimum drill depth of 23.5 mm (0.93 in).

Fig 3: Metal Chips



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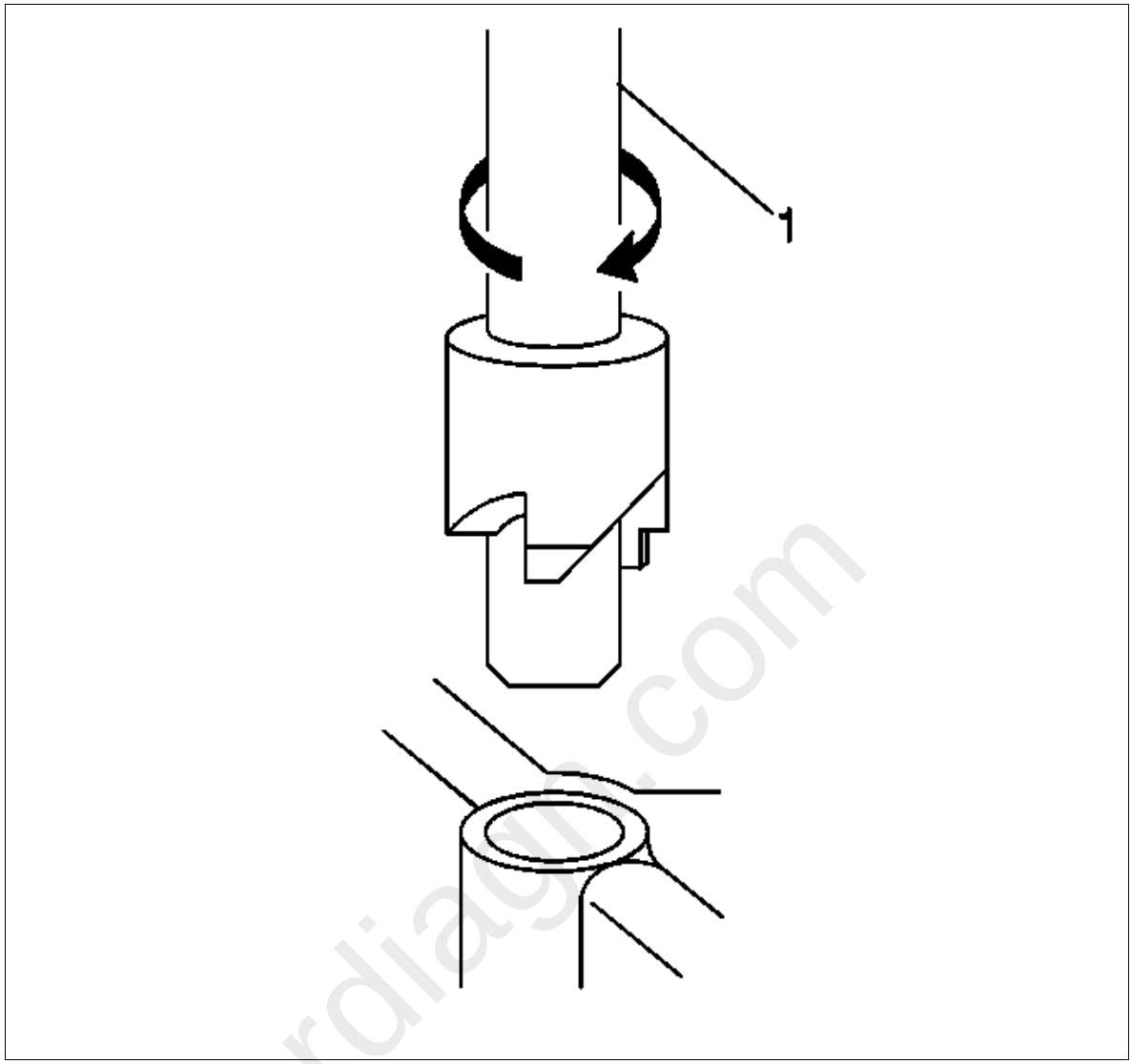
Courtesy of GENERAL MOTORS COMPANY

NOTE:

All chips must be removed from the drilled hole prior to tapping.

2. Using compressed air, clean out any chips.

Fig 4: Counterbore Hole Tool



Courtesy of GENERAL MOTORS COMPANY

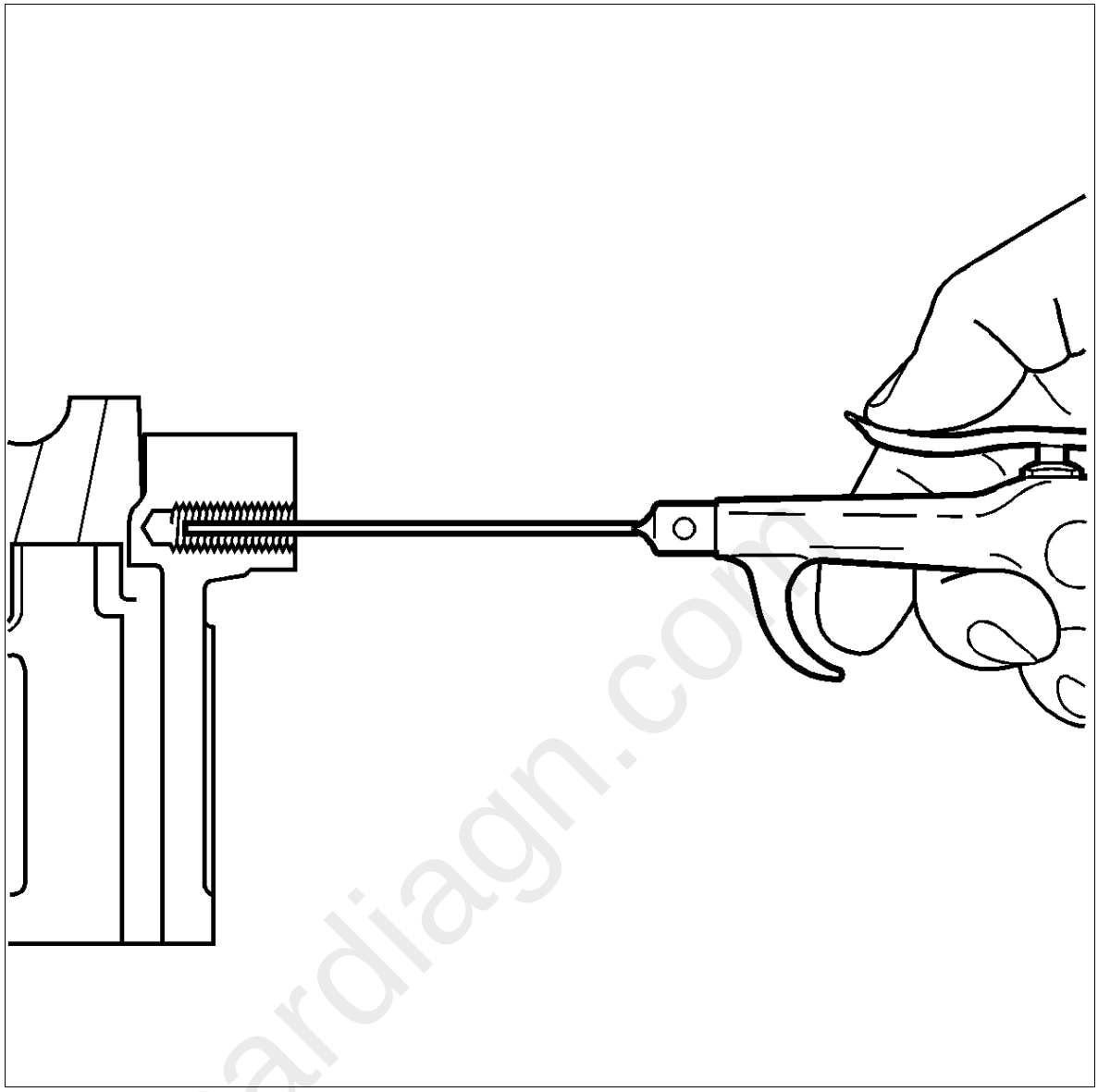
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NOTE:

A properly counterbored hole will show a slight burnishing on the surface of the base material for 360 degrees around the drilled hole.

3. Counterbore the drilled hole to the full depth permitted by the tool (1).

Fig 5: Metal Chips



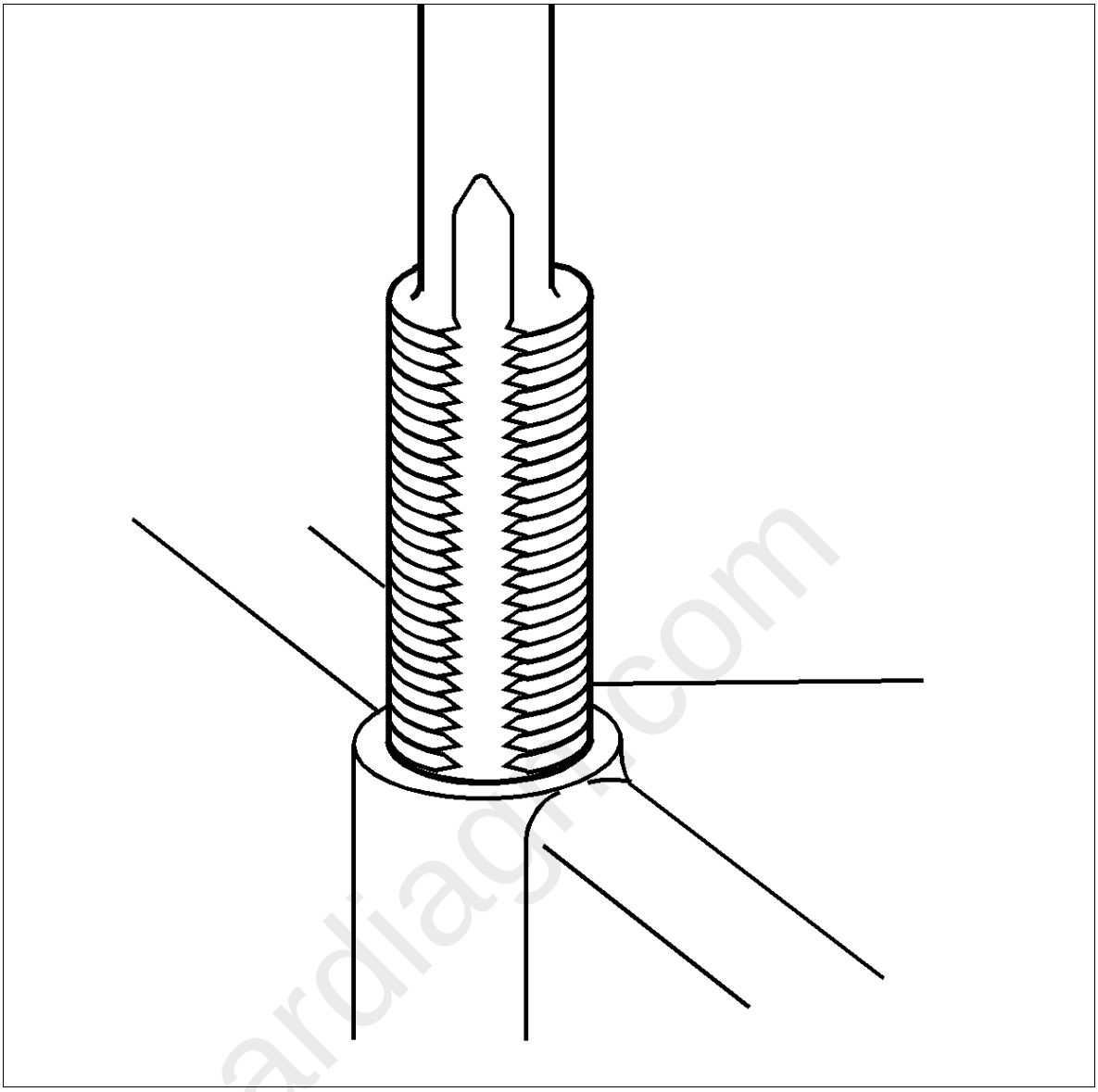
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> *NOTE:*
>
> *All chips must be removed from the drilled hole prior to tapping.*

4. Using compressed air, clean out any chips.

Fig 6: Threads Of Drilled Hole



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NOTE:

1. *During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.*
2. *Ensure the tap has created full threads at least to the depth equal to the insert length.*

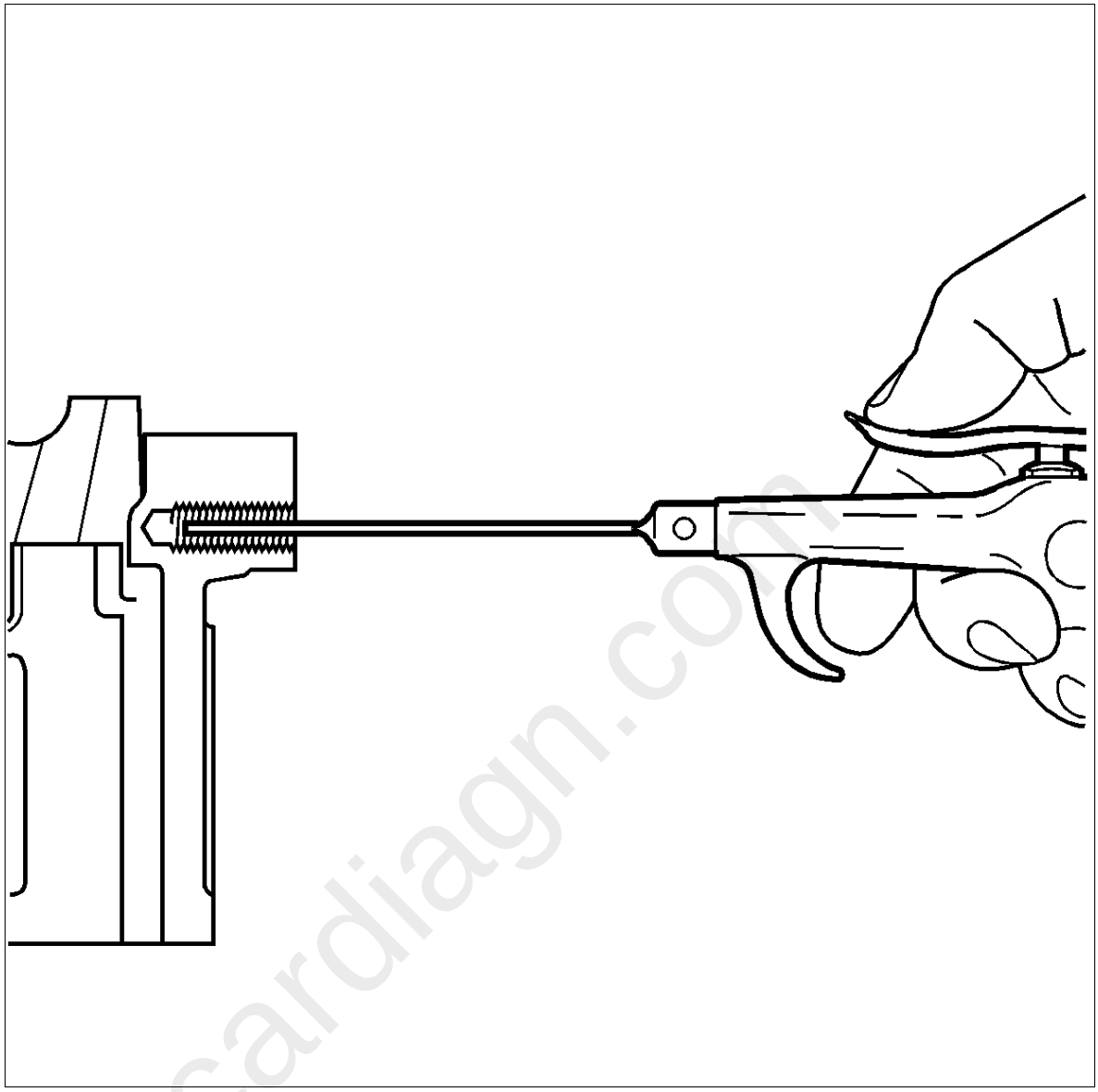
5. Using a suitable tapping wrench, tap the threads of the drilled hole by hand only.

Specifications

1. M6 inserts require a minimum tap depth of 15 mm (0.59 in).
2. M8 inserts require a minimum tap depth of 20 mm (0.79 in).

3. M10 inserts require a minimum tap depth of 23.5 mm (0.93 in).

Fig 7: Metal Chips



Courtesy of GENERAL MOTORS COMPANY

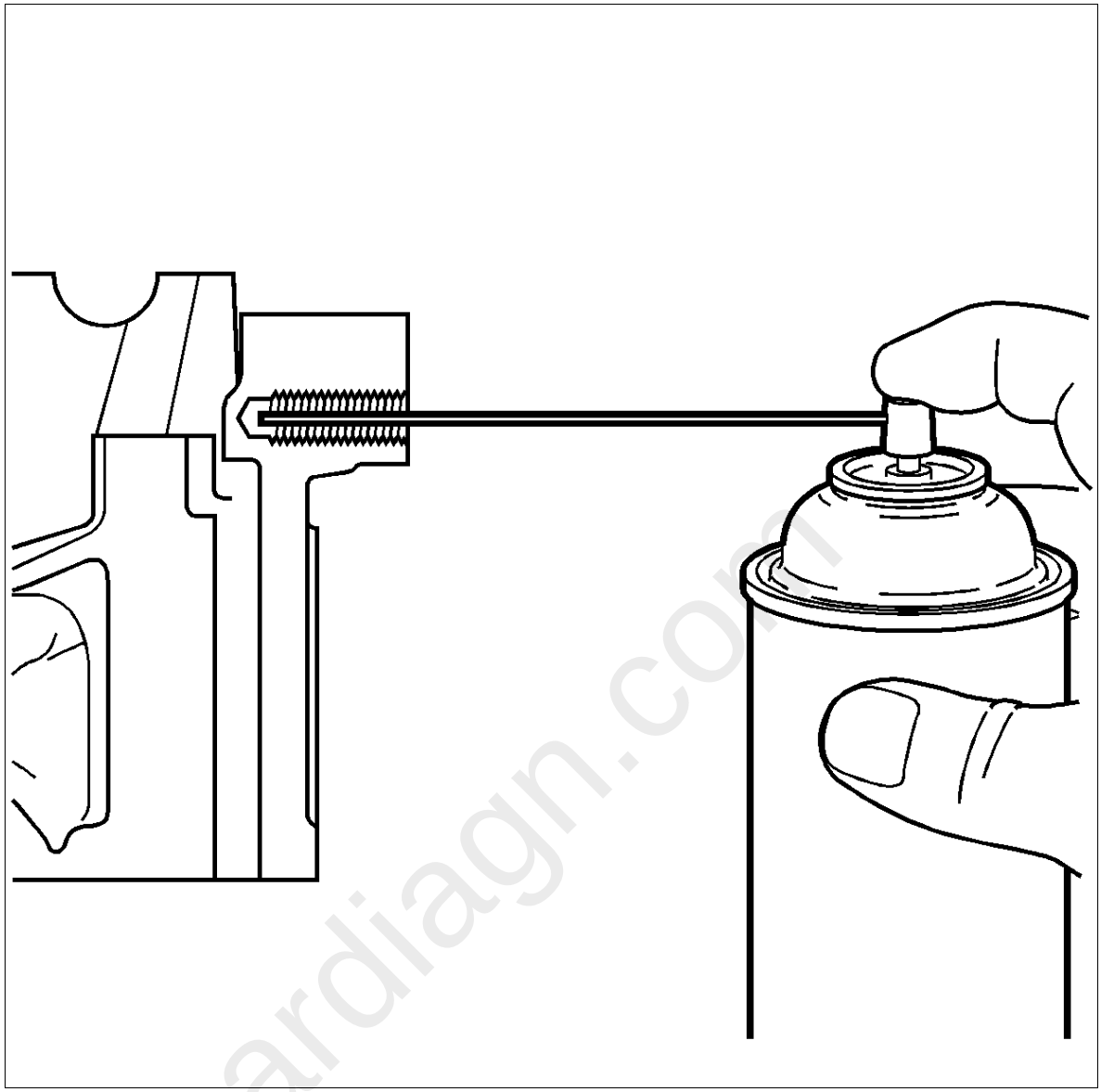
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NOTE:

All chips must be removed from the tapped hole prior to insert installation.

6. Using compressed air, clean out any chips.

Fig 8: Cleaner Into Tapped Hole

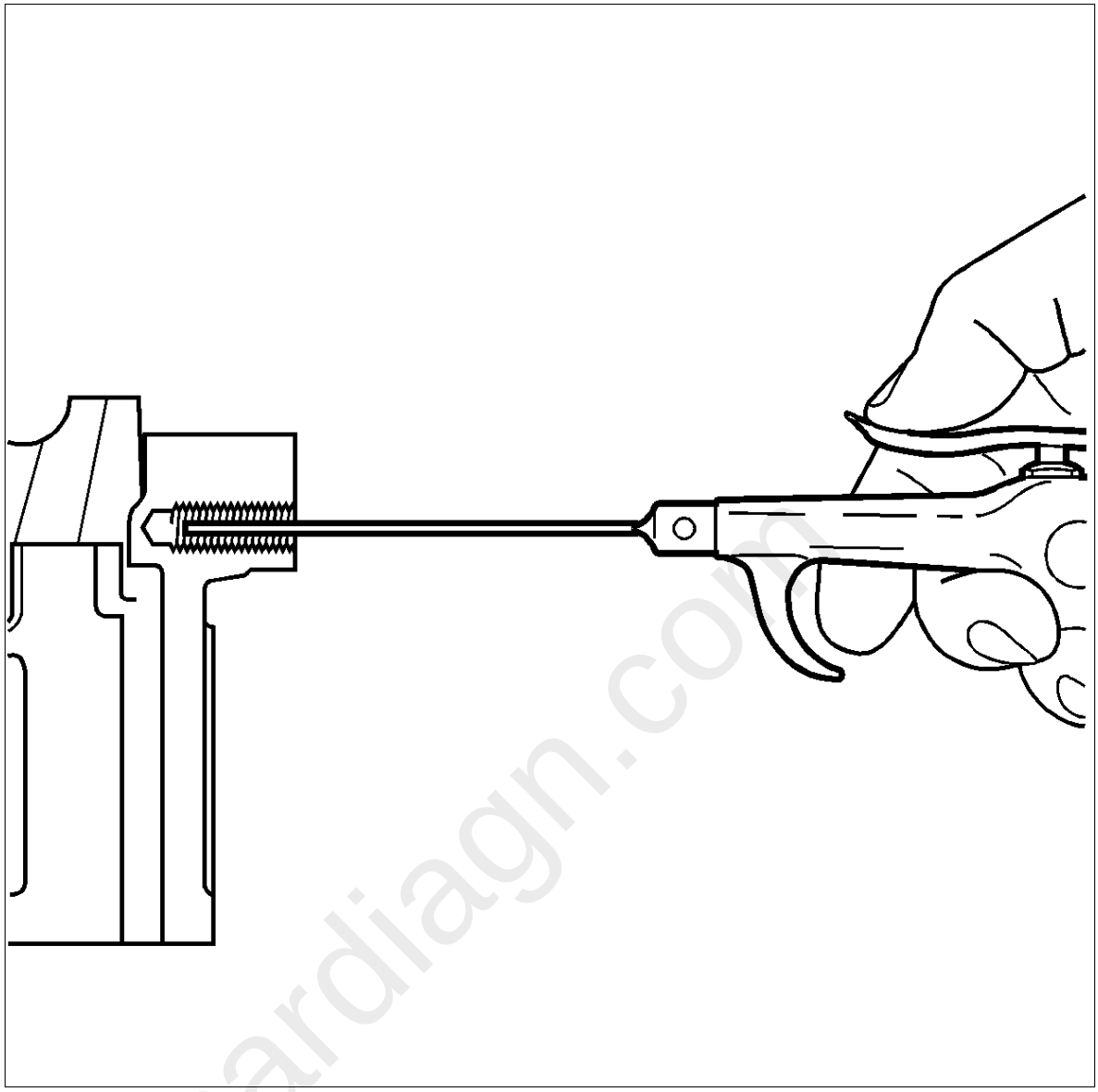


Courtesy of GENERAL MOTORS COMPANY

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7. Spray cleaner into the tapped hole. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended cleaner.

Fig 9: Metal Chips



Courtesy of GENERAL MOTORS COMPANY

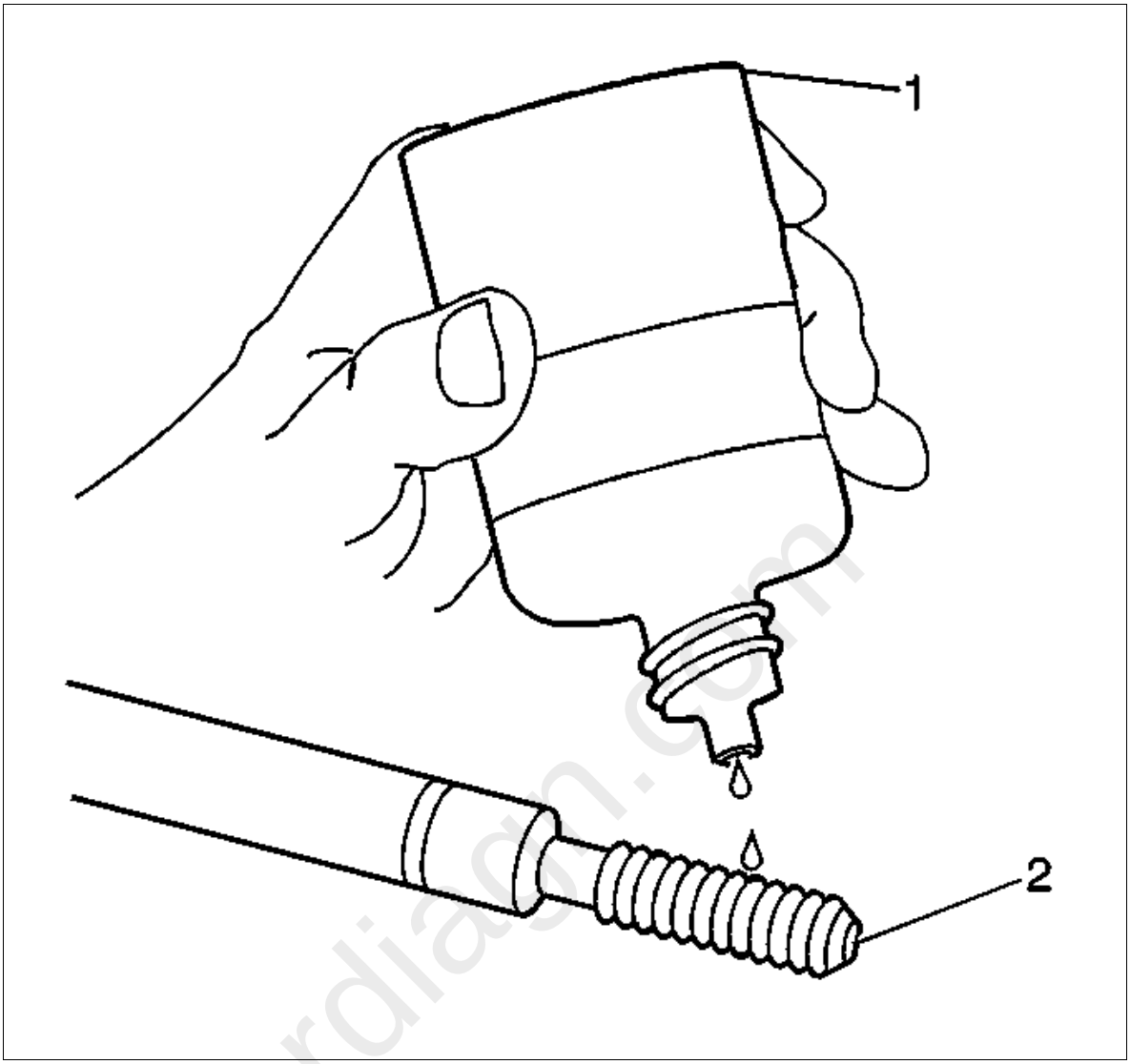
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NOTE:

All chips must be removed from the tapped hole prior to insert installation.

8. Using compressed air, clean out any chips.

Fig 10: Lubricating Installer Tool Using Driver Oil



Courtesy of GENERAL MOTORS COMPANY

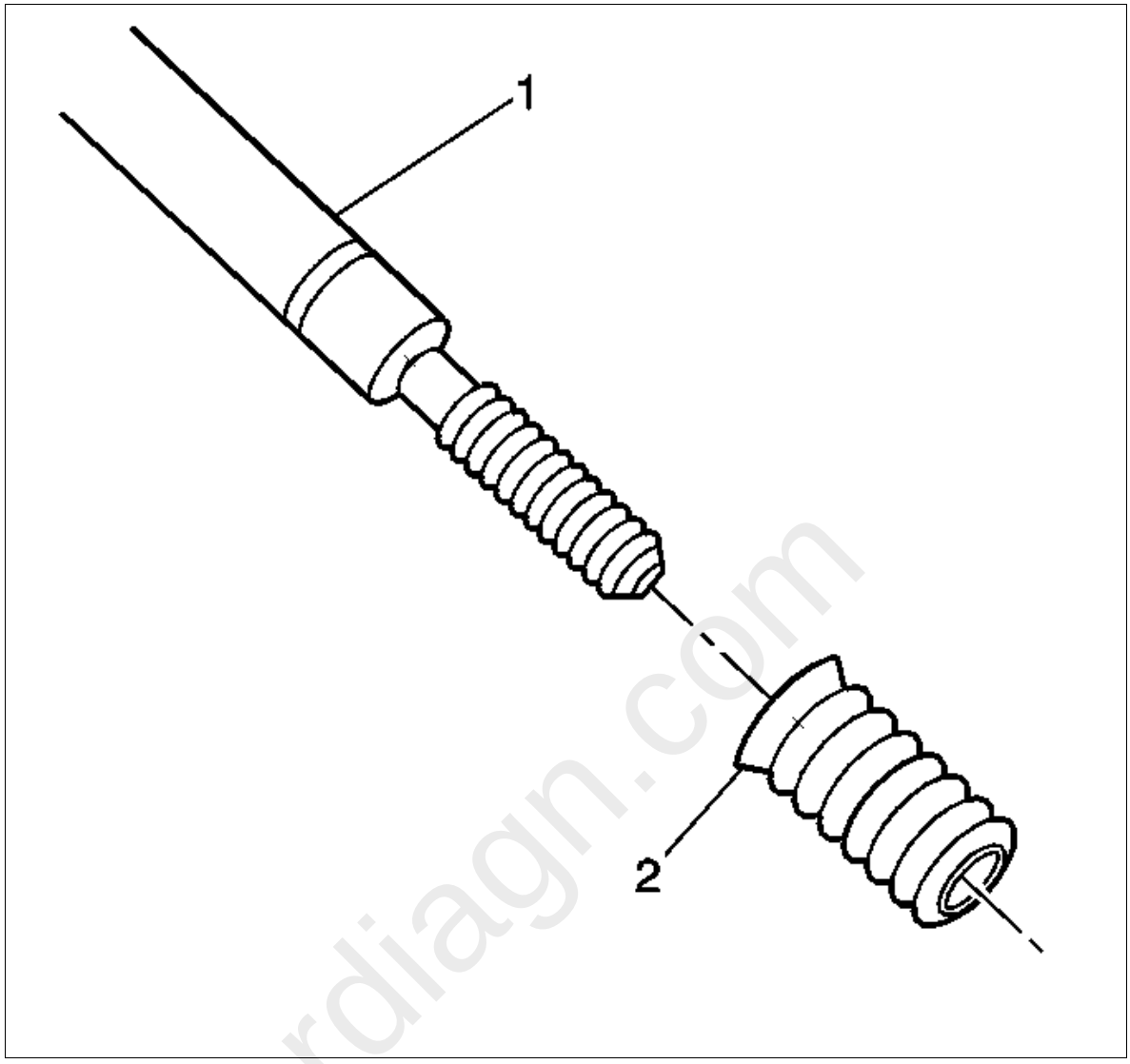
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NOTE:

Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

9. Lubricate the threads of the driver installation tool (2) with the **EN-42385-110** (1).

Fig 11: Bushing Type Insert

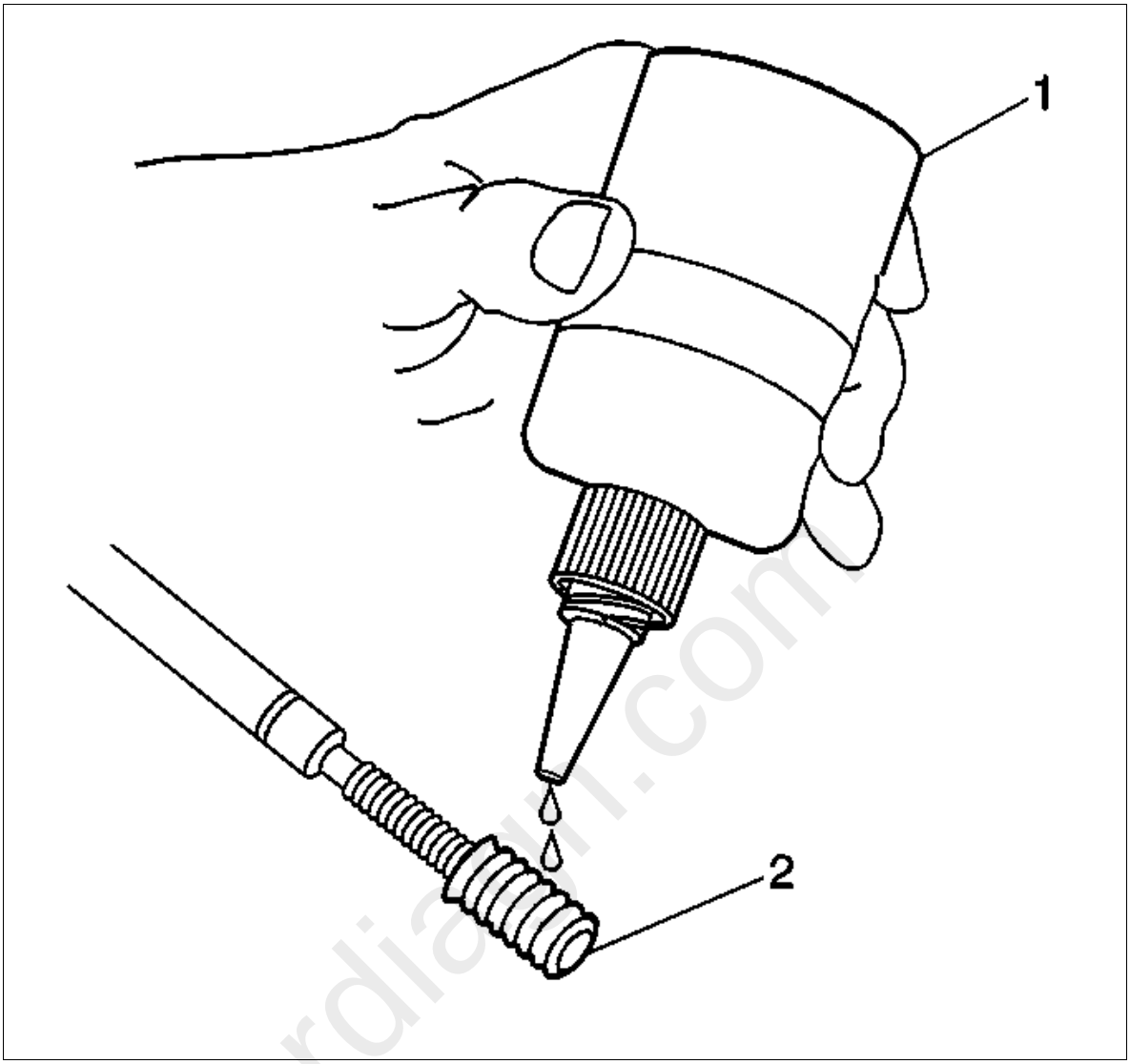


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10. Install the insert (2) onto the driver installation tool (1).

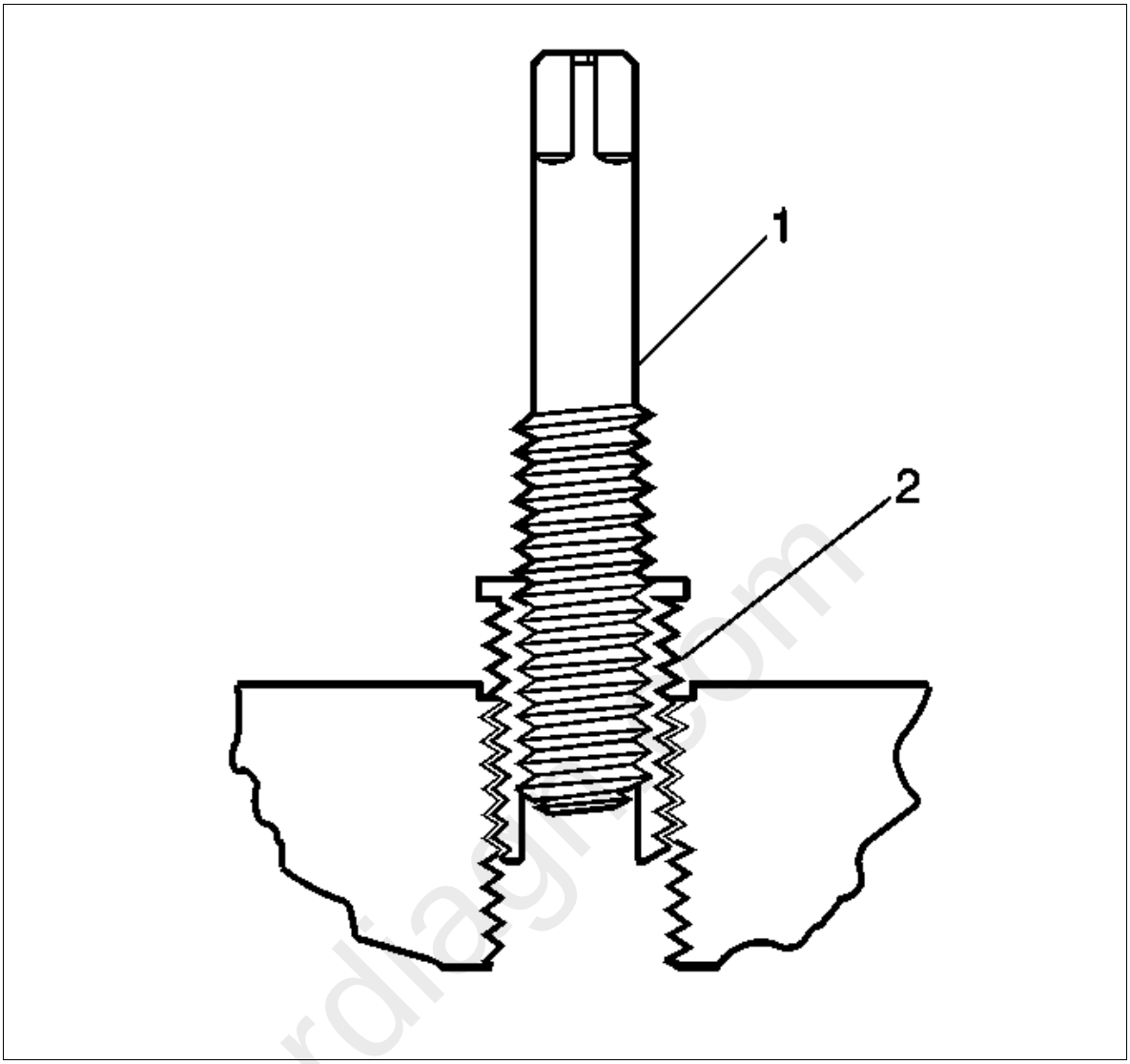
Fig 12: Threadlock To Insert



Courtesy of GENERAL MOTORS COMPANY

11. Apply threadlock sealant, **EN-42385-109** , LOCTITE 277® or equivalent (1) to the insert OD threads (2). Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended sealant.

Fig 13: Tapped Bolt Hole



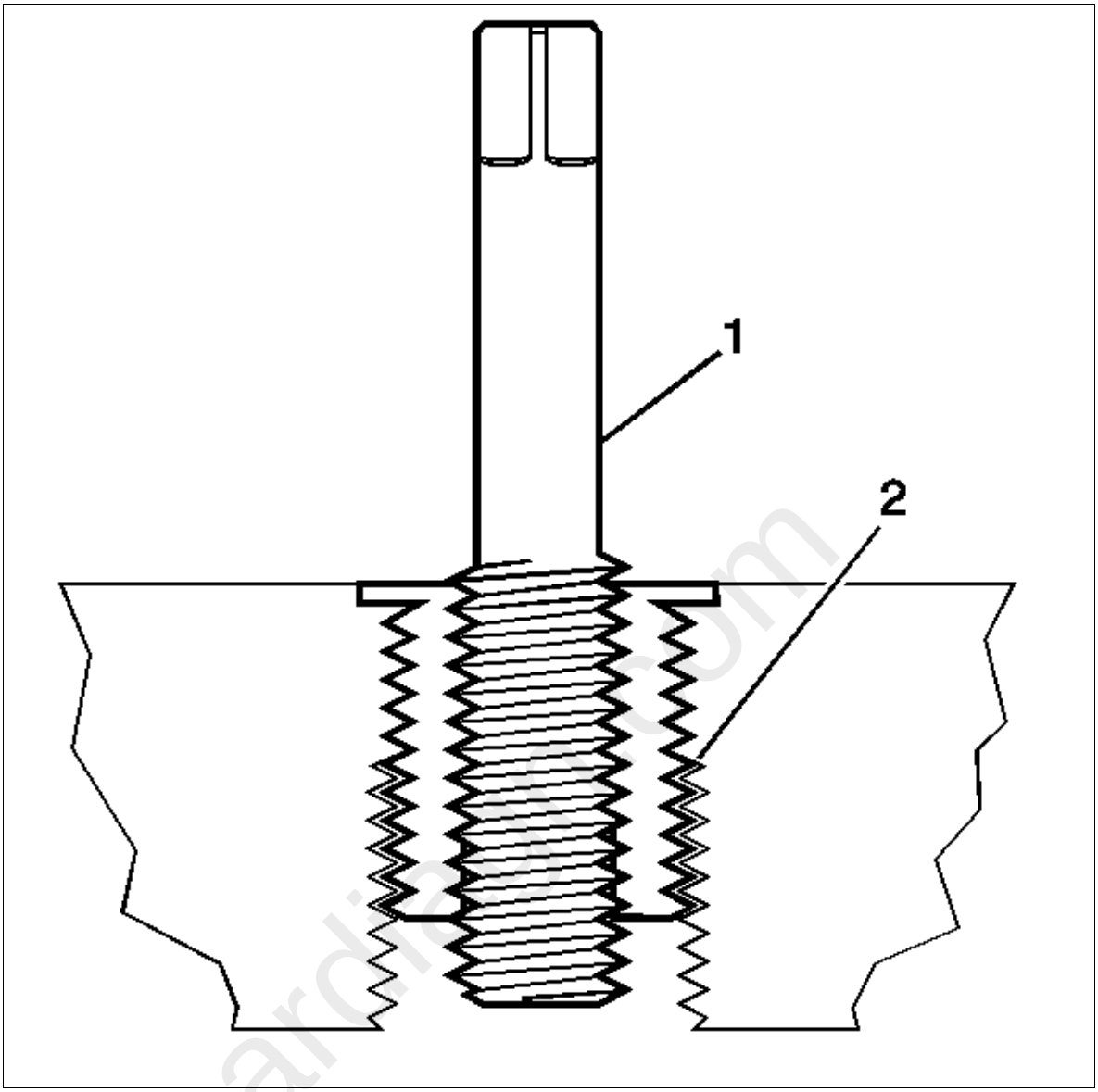
Courtesy of GENERAL MOTORS COMPANY

12. Install the insert (2) into the tapped hole by hand only.

> *NOTE:*
>
> *If the insert will not thread down until the flange contacts the counterbored surface, remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or improper tapping.*

13. Install the insert until the flange (2) of the insert contacts the counterbored surface.

Fig 14: Insert & Tool - Standard Thread



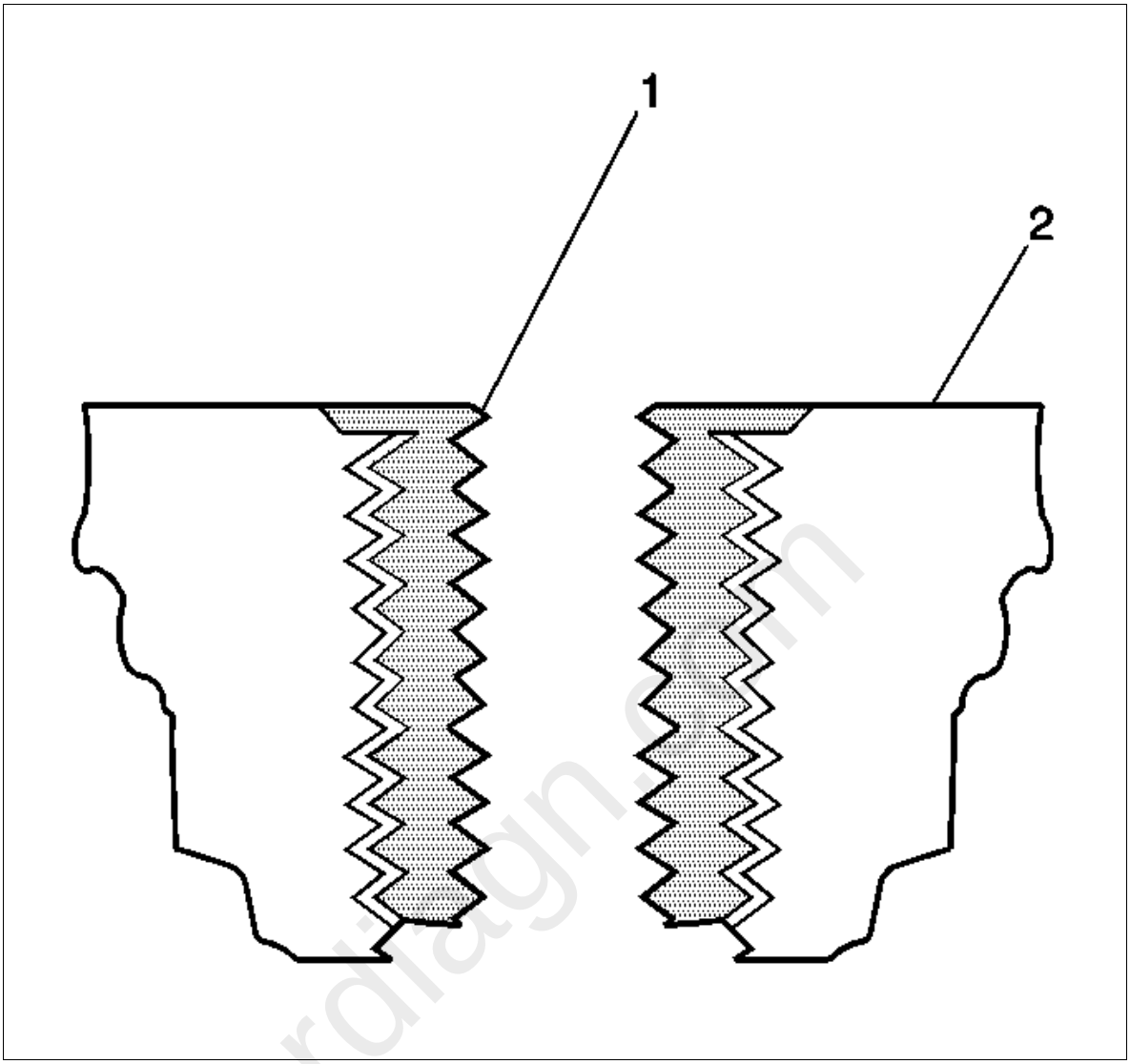
Courtesy of GENERAL MOTORS COMPANY

NOTE:

The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the insert are being formed and the insert is mechanically locking the insert into the base material threads.

14. Continue to rotate the driver installation tool (1) through the insert (2).

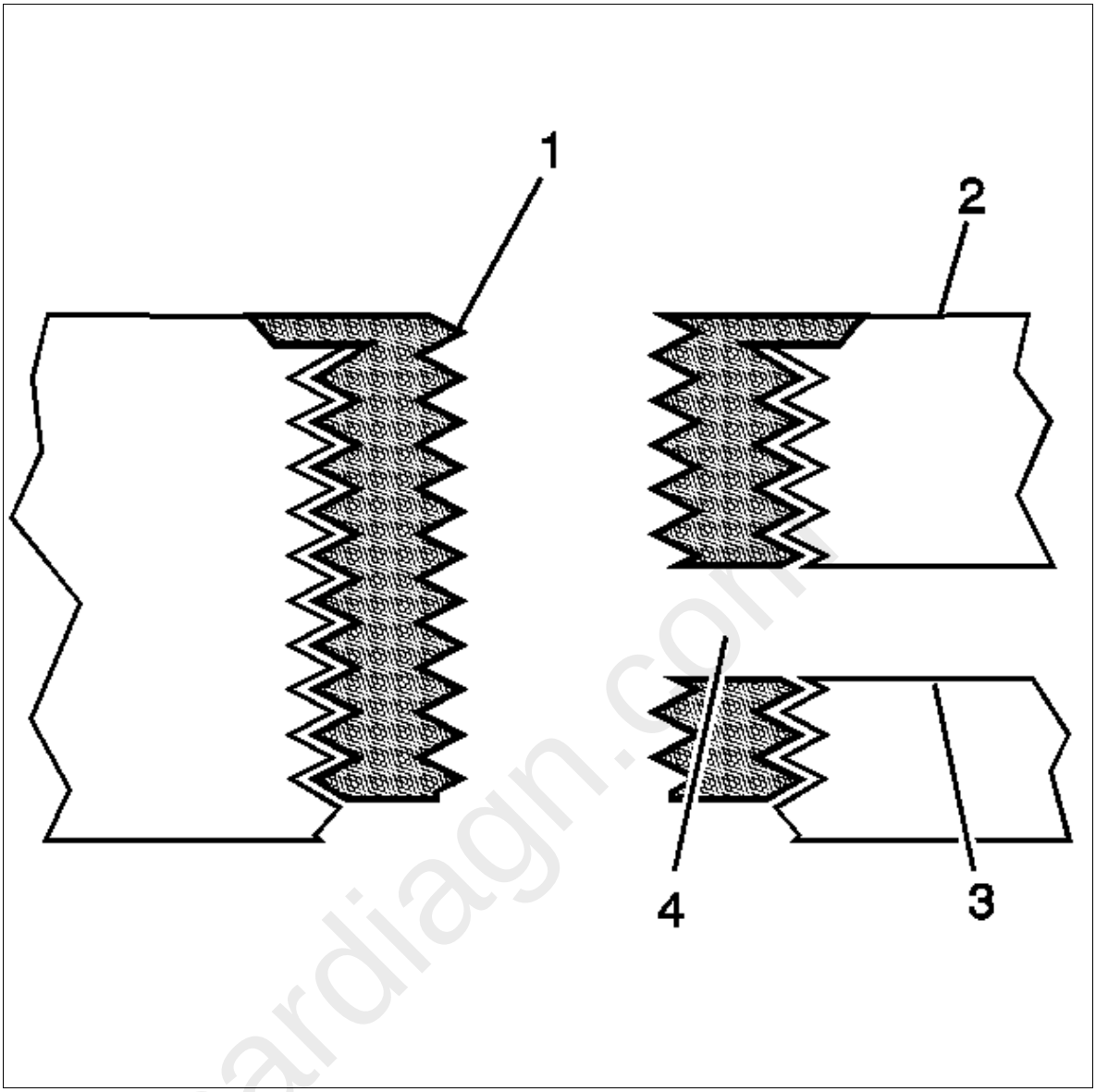
Fig 15: Bushing Type Insert & Base Material



Courtesy of GENERAL MOTORS COMPANY

15. Inspect the insert for proper installation into the tapped hole. A properly installed insert (1) will be either flush or slightly below flush with the surface of the base material (2).

Fig 16: Restricted Engine Coolant Passages - Standard Thread Repair

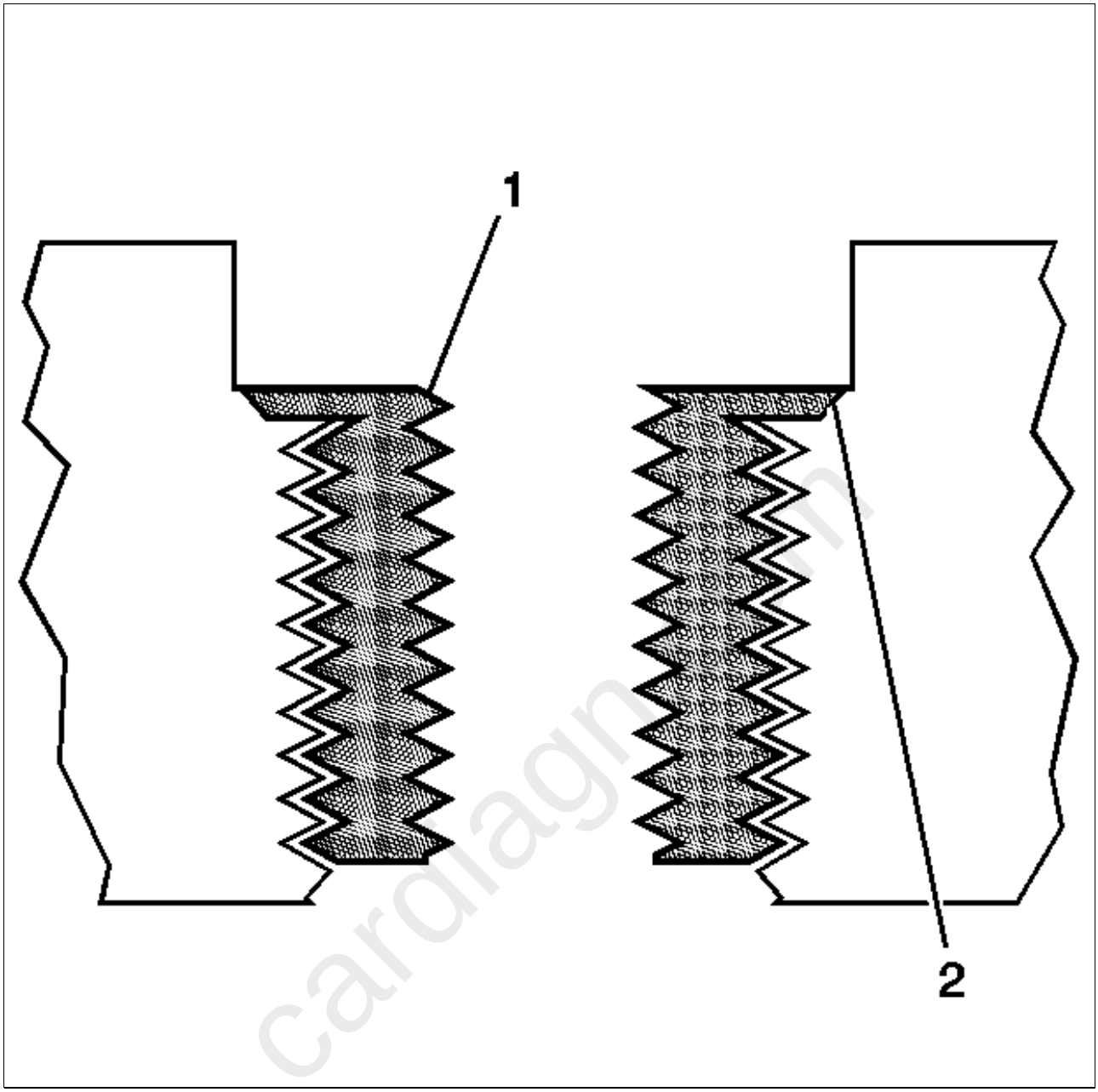


Courtesy of GENERAL MOTORS COMPANY

16. Any installed insert that restricts or blocks an oil or engine coolant passage (3) will need to have the oil or engine coolant passage drilled out (4) to the original size of the oil or engine coolant passage. After drilling the restriction or blockage, clean out any chips and thread the installation driver tool through the insert again to remove any burrs caused by the drilling of the oil or engine coolant passage.

REPAIR INSTRUCTIONS - OFF VEHICLE > THREAD REPAIR > RECESSED THREAD REPAIR

Fig 1: Insert For Proper Installation - Recessed Thread



Courtesy of GENERAL MOTORS COMPANY

WARNING:

Refer to Safety Glasses Warning .

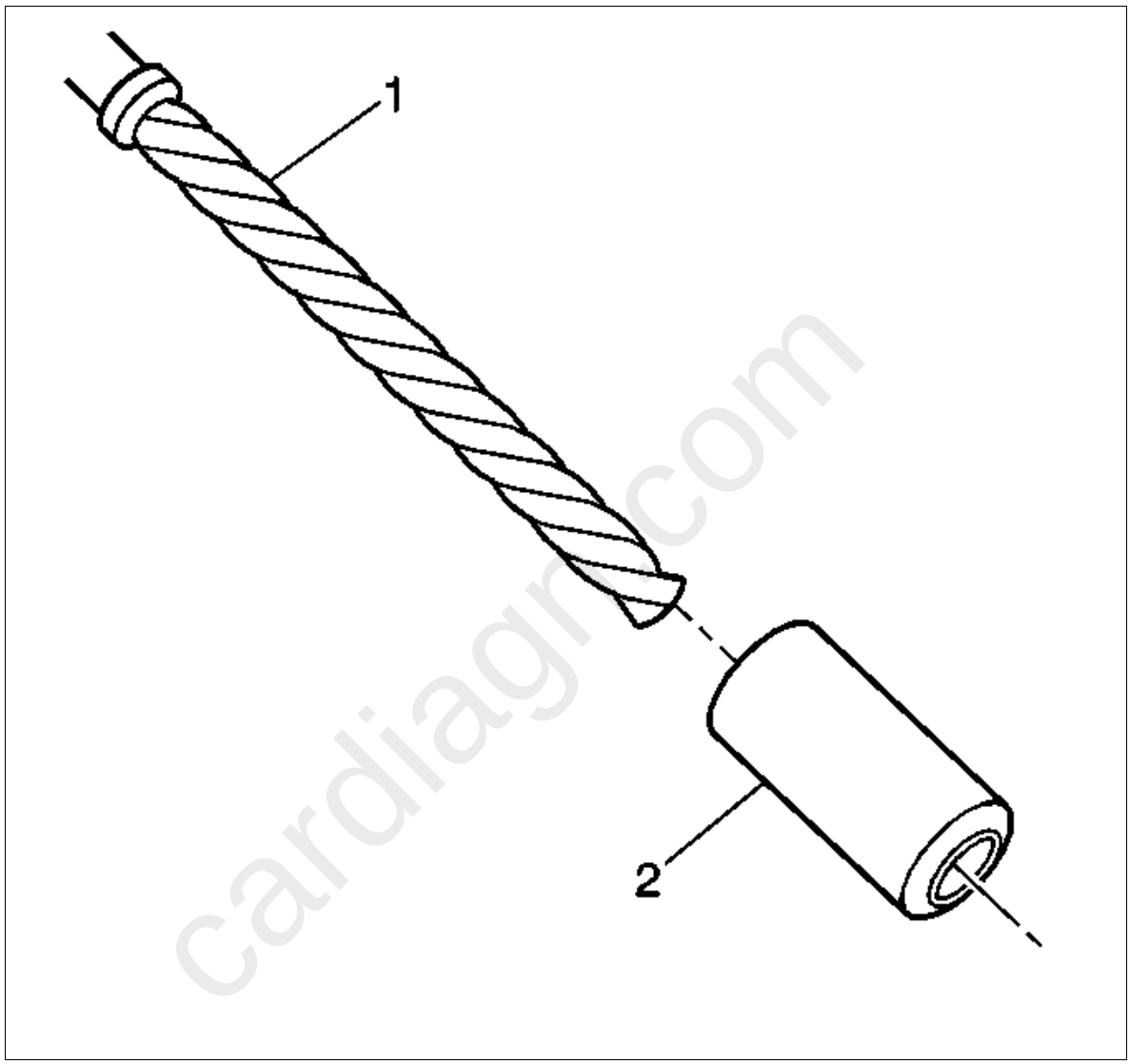
NOTE:

- *The use of a cutting type fluid, WD 40® or equivalent is recommended when performing the drilling, counterboring and tapping procedures. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended cutting fluid.*

- *Do NOT remove the original stop collar from a counterbore drill.*

When installed to the proper depth, the flange of the insert (1) will be seated against the counterbore (2) of the drilled/tapped hole.

Fig 2: Stop Collar & Counterbore Drill

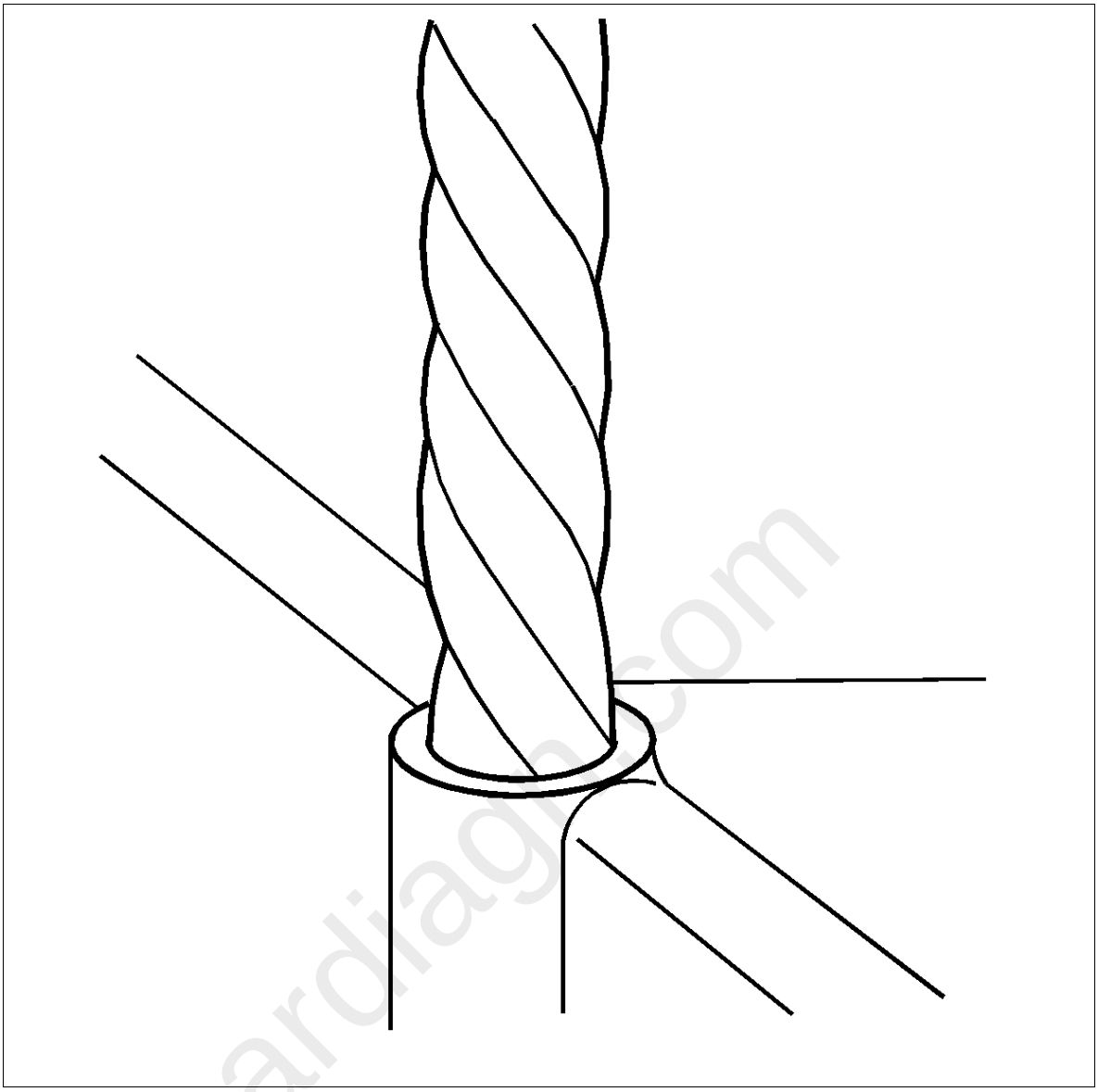


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Courtesy of GENERAL MOTORS COMPANY

1. Install a stop collar (2) on the counterbore drill (1), if required.

Fig 3: Threads Of Damaged Hole



Courtesy of GENERAL MOTORS COMPANY

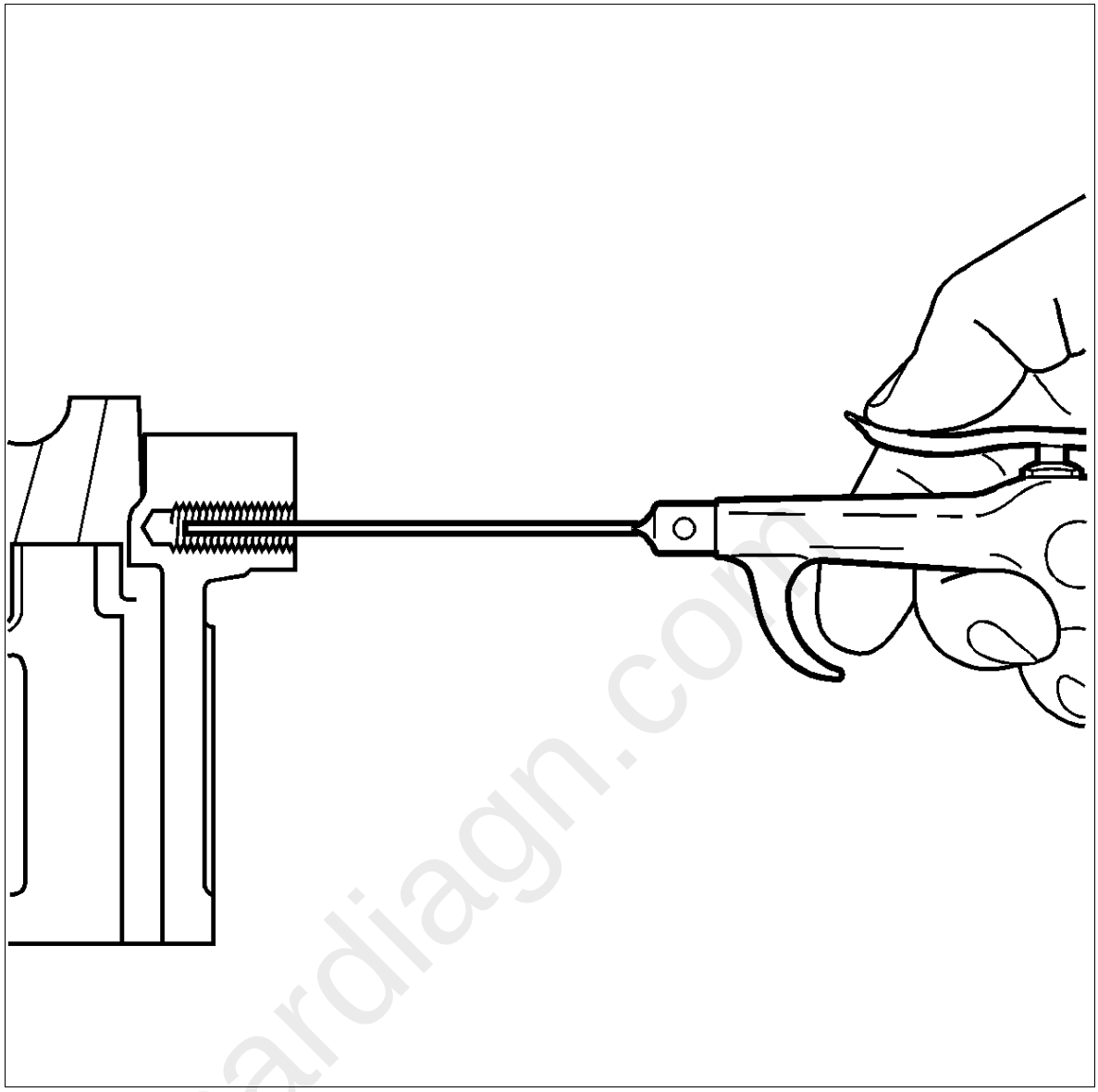
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NOTE:

1. *During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.*
2. *Drill the hole until the stop collar contacts the surface of the base material.*

2. Drill out the threads of the damaged hole.

Fig 4: Metal Chips



Courtesy of GENERAL MOTORS COMPANY

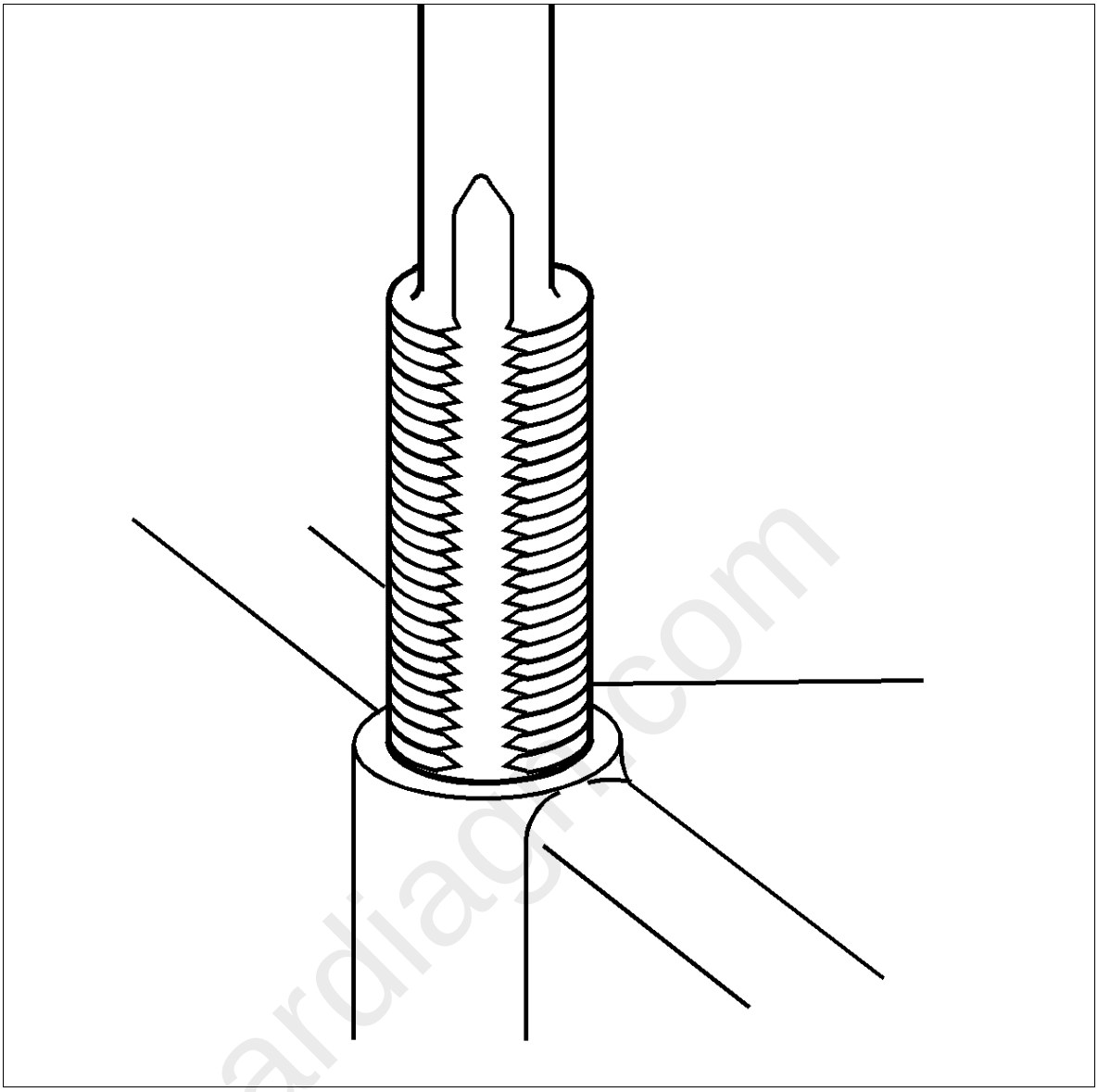
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NOTE:

All chips must be removed from the drilled hole prior to tapping.

3. Using compressed air, clean out any chips.

Fig 5: Threads Of Drilled Hole



Courtesy of GENERAL MOTORS COMPANY

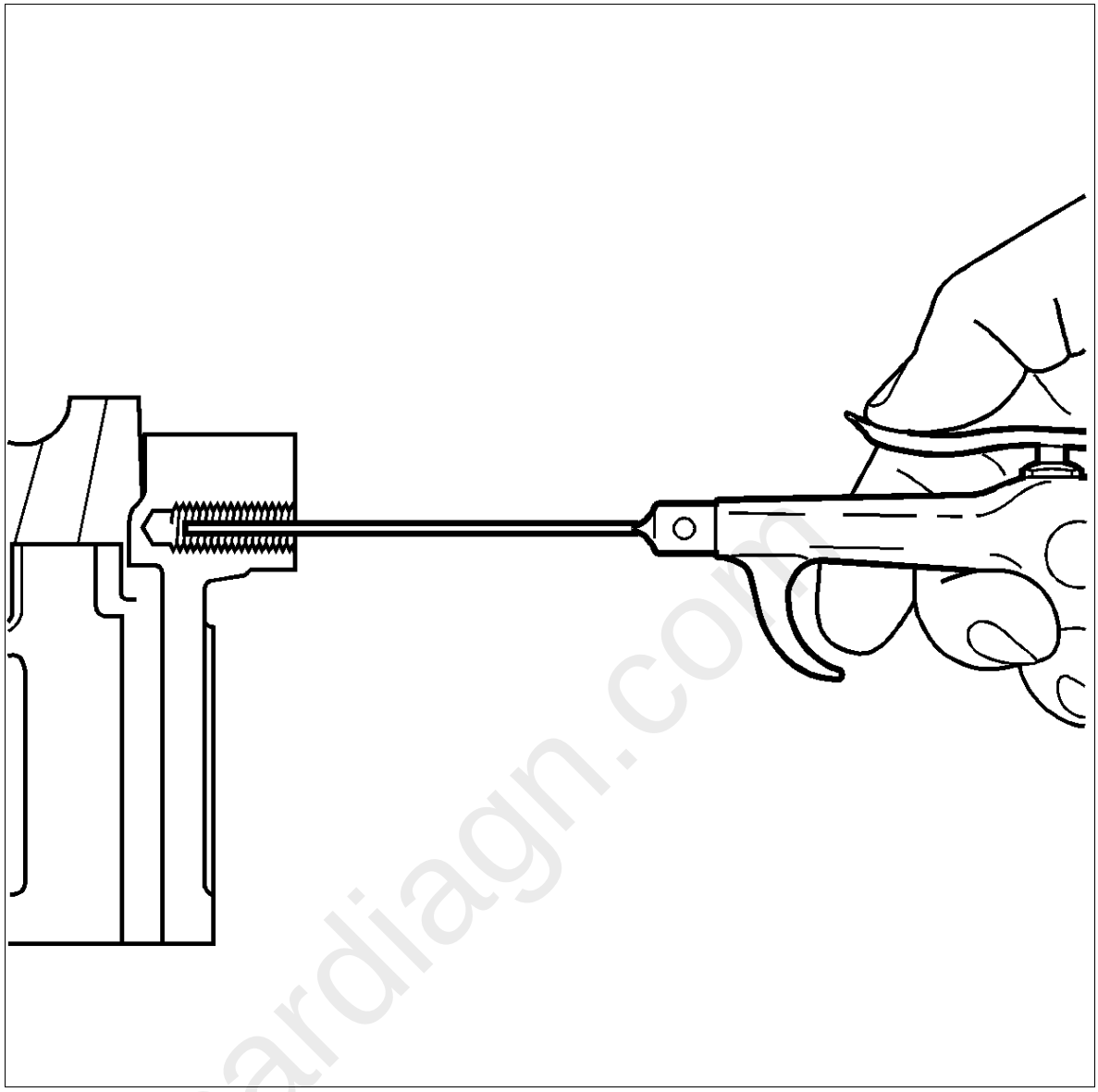
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NOTE:

1. *During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.*
2. *Ensure the tap has created full threads at least to the depth equal to the insert length.*

4. Using a suitable tapping wrench, tap the threads of the drilled hole by hand only.

Fig 6: Metal Chips



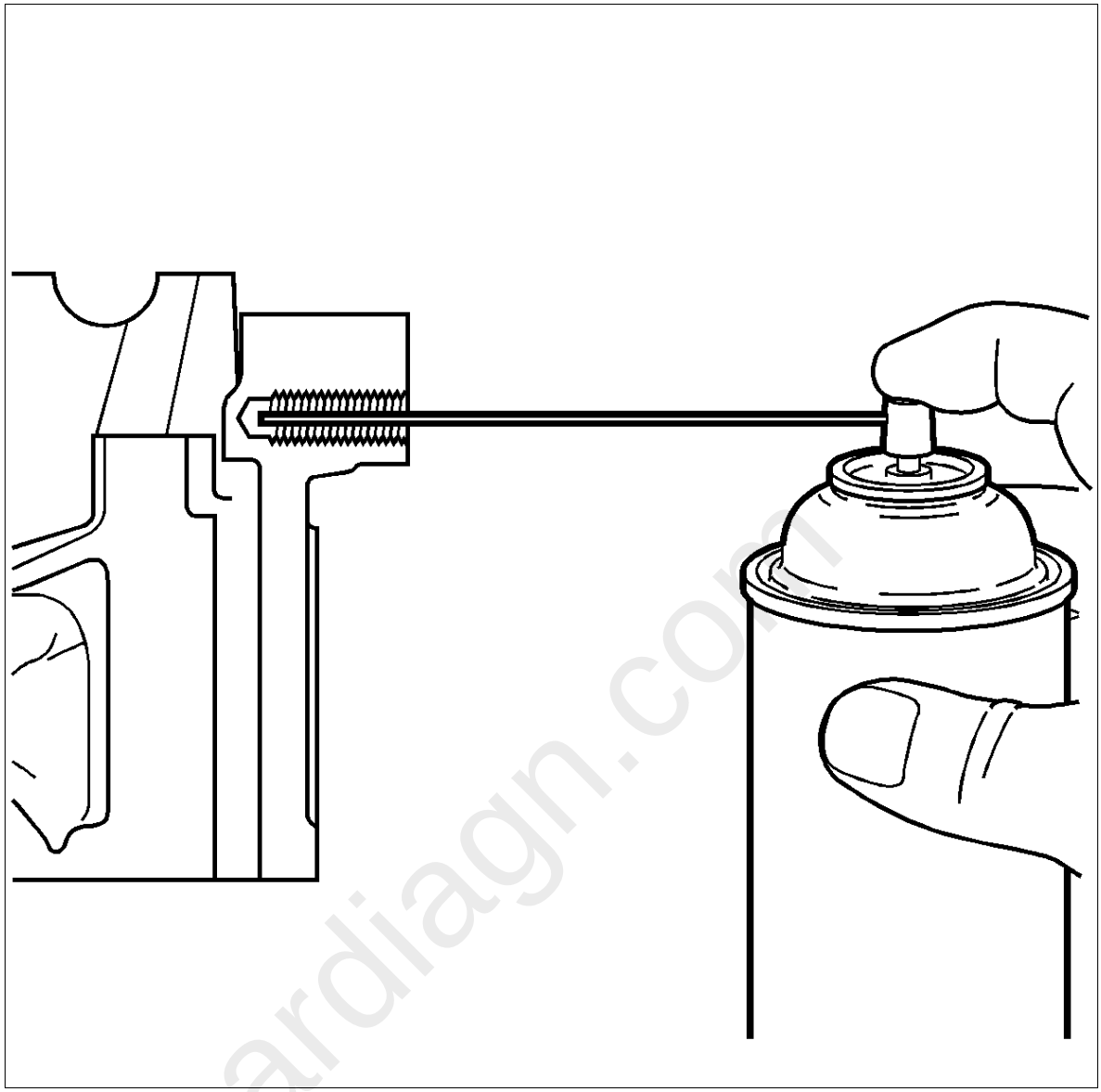
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> *NOTE:*
>
> *All chips must be removed from the tapped hole prior to insert installation.*

5. Using compressed air, clean out any chips.

Fig 7: Cleaner Into Tapped Hole

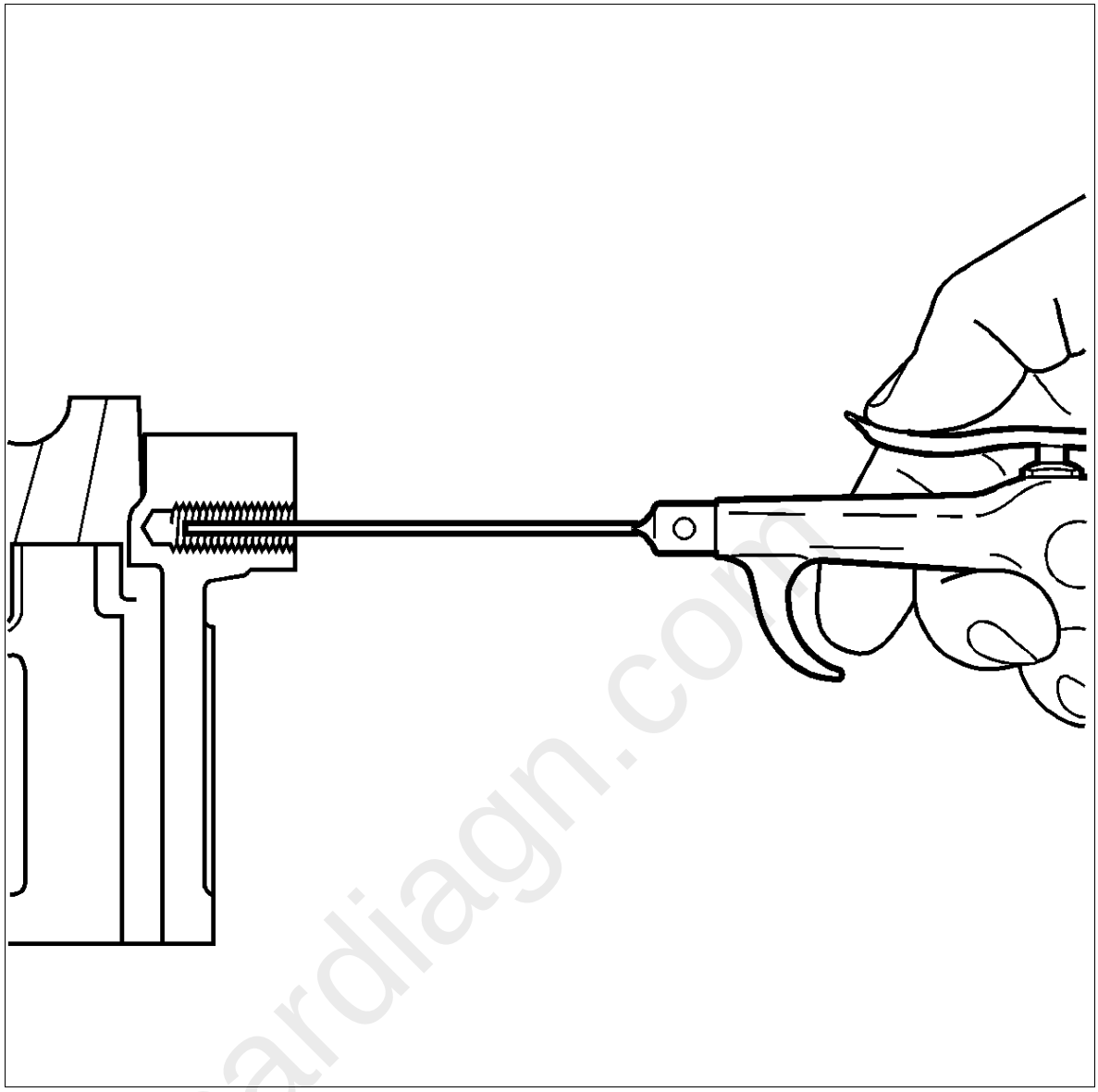


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6. Spray cleaner into the tapped hole. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended cleaner.

Fig 8: Metal Chips



Courtesy of GENERAL MOTORS COMPANY

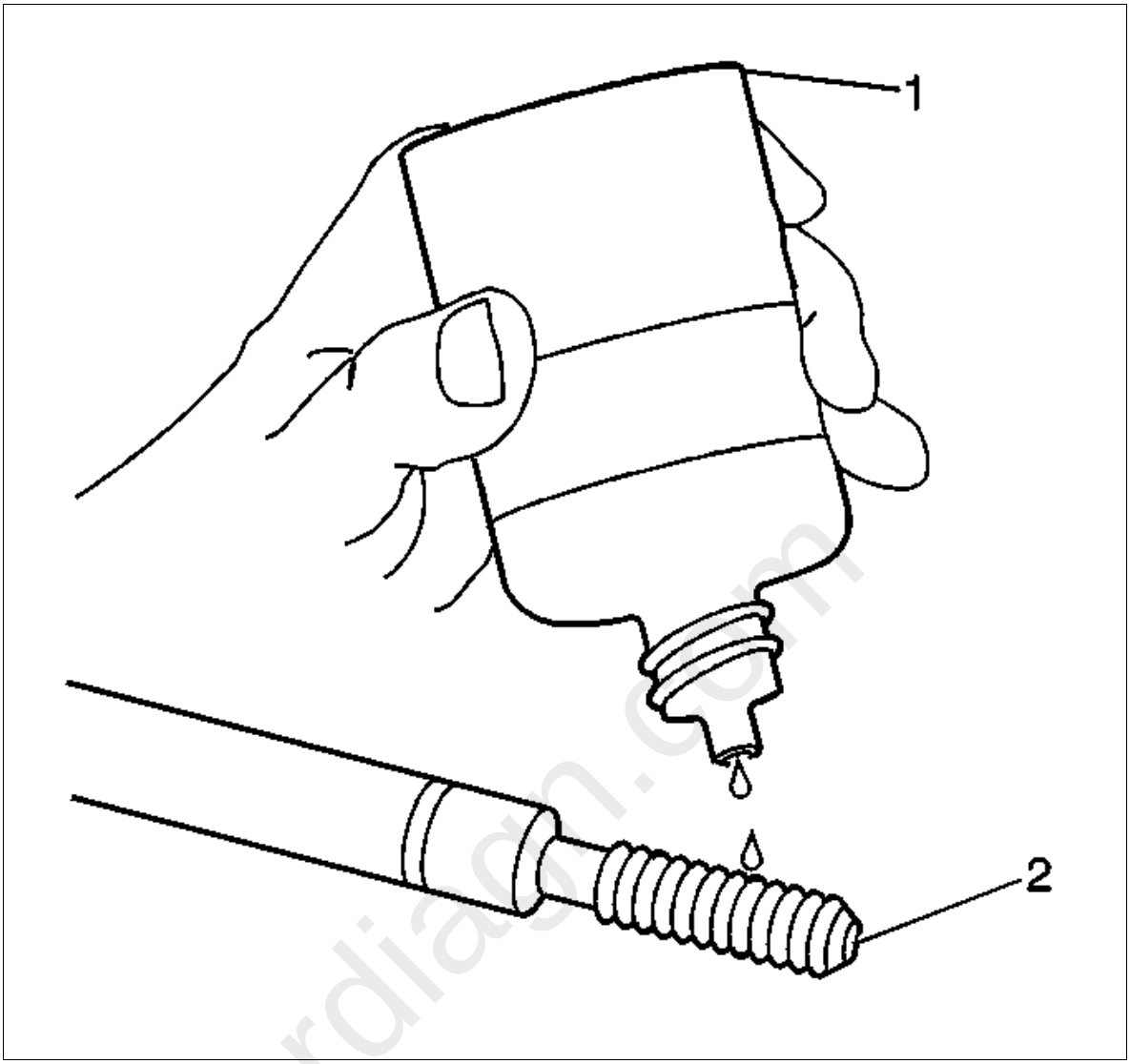
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NOTE:

All chips must be removed from the tapped hole prior to insert installation.

7. Using compressed air, clean out any chips.

Fig 9: Lubricating Installer Tool Using Driver Oil



Courtesy of GENERAL MOTORS COMPANY

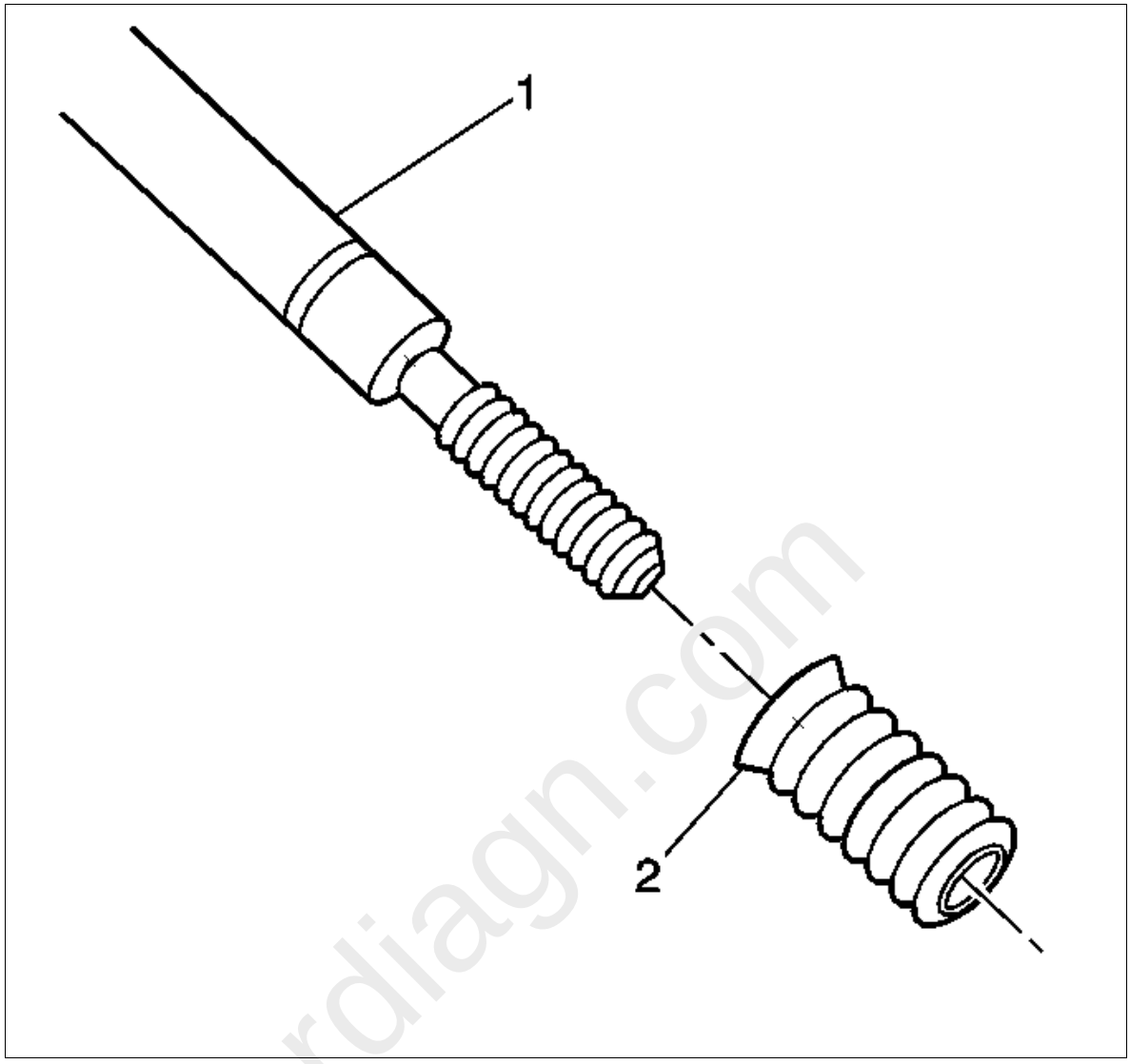
NOTE:

Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

8. Lubricate the threads of the driver installation tool (2) with the EN 42385-110 (1).

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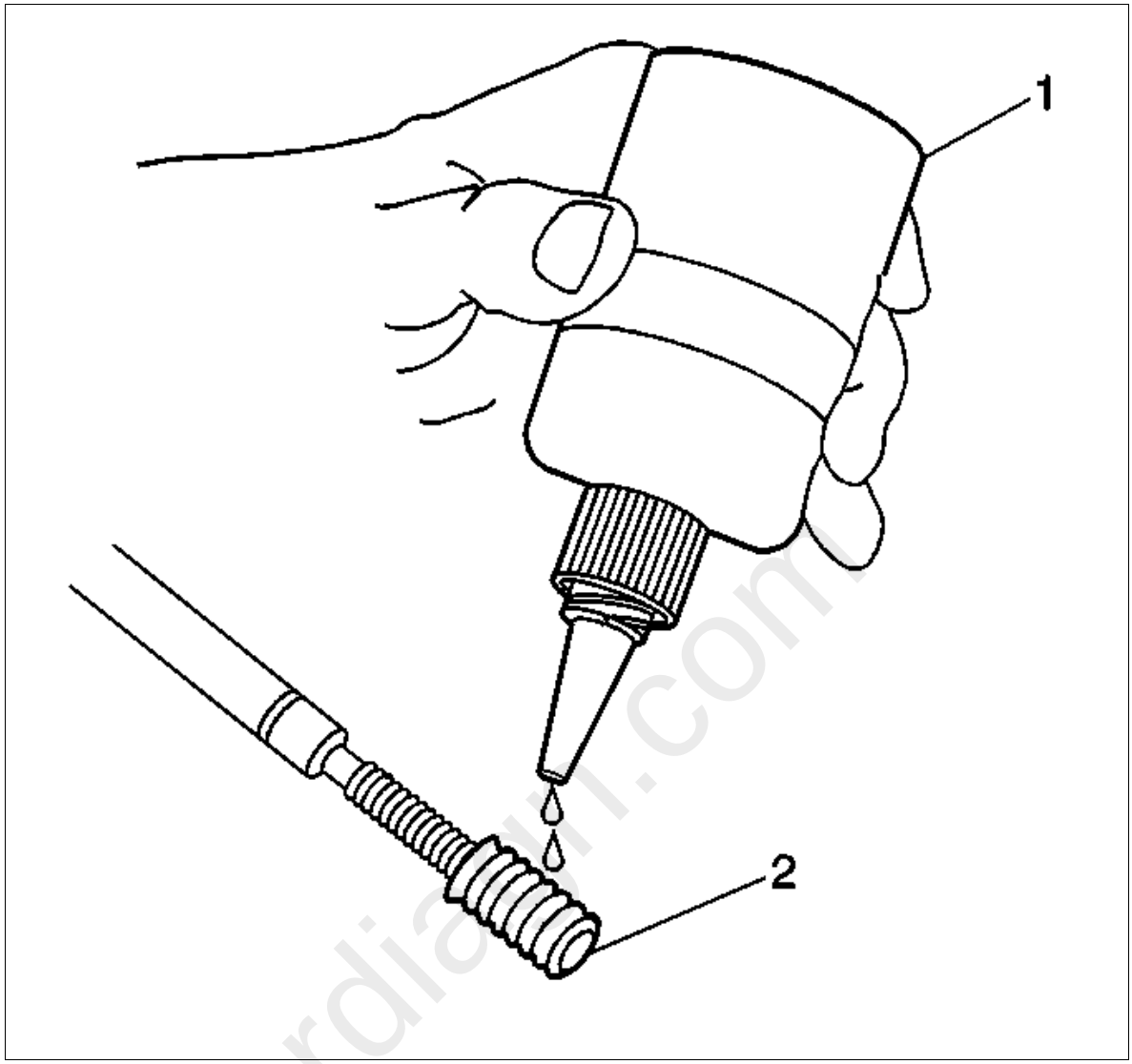
Fig 10: Bushing Type Insert



Courtesy of GENERAL MOTORS COMPANY

9. Install the insert (2) onto the driver installation tool (1).

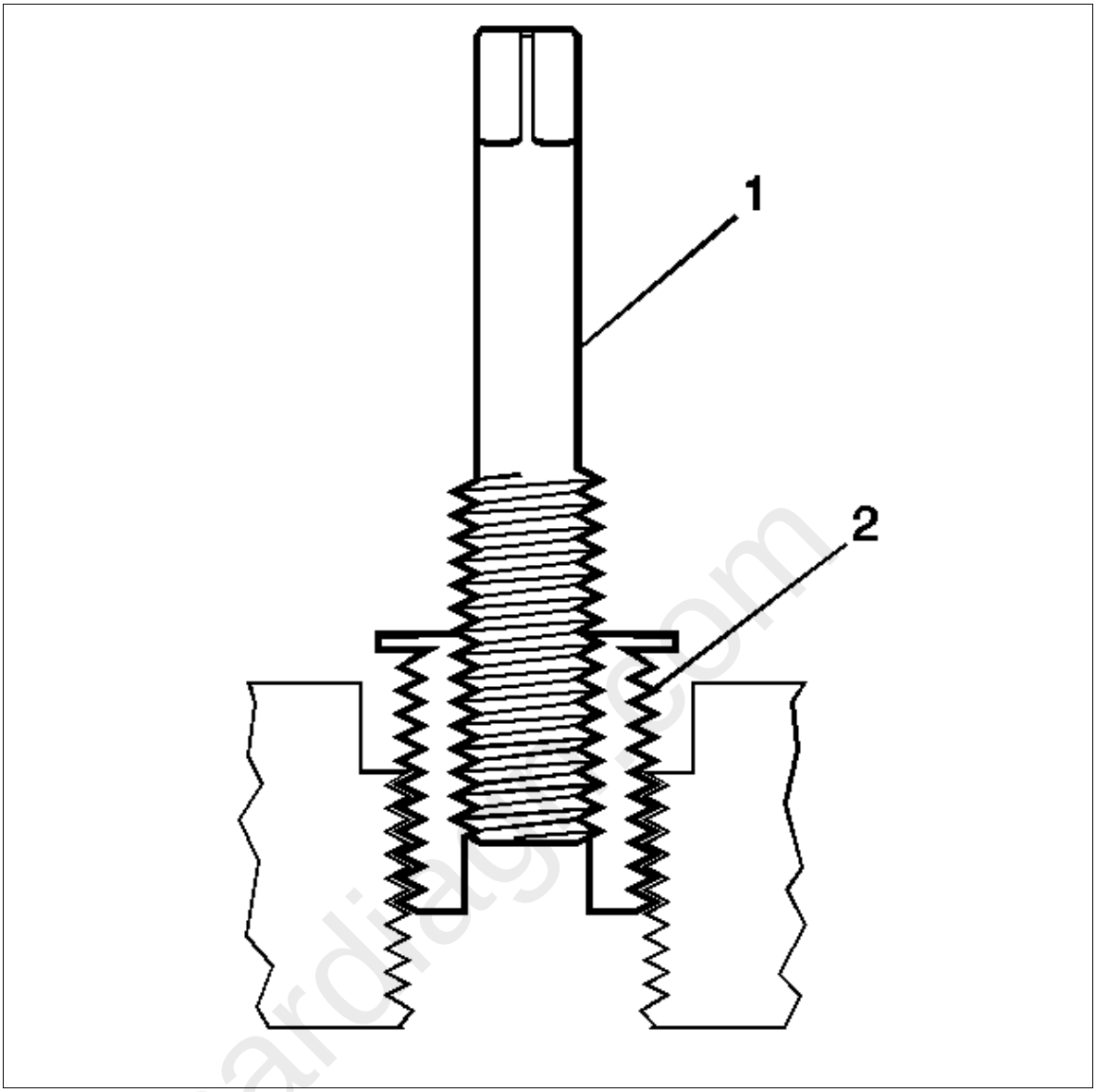
Fig 11: Threadlock To Insert



Courtesy of GENERAL MOTORS COMPANY

10. Apply threadlock sealant, **EN-42385-109** , LOCTITE 277® or equivalent (1) to the insert OD threads (2). Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended sealant.

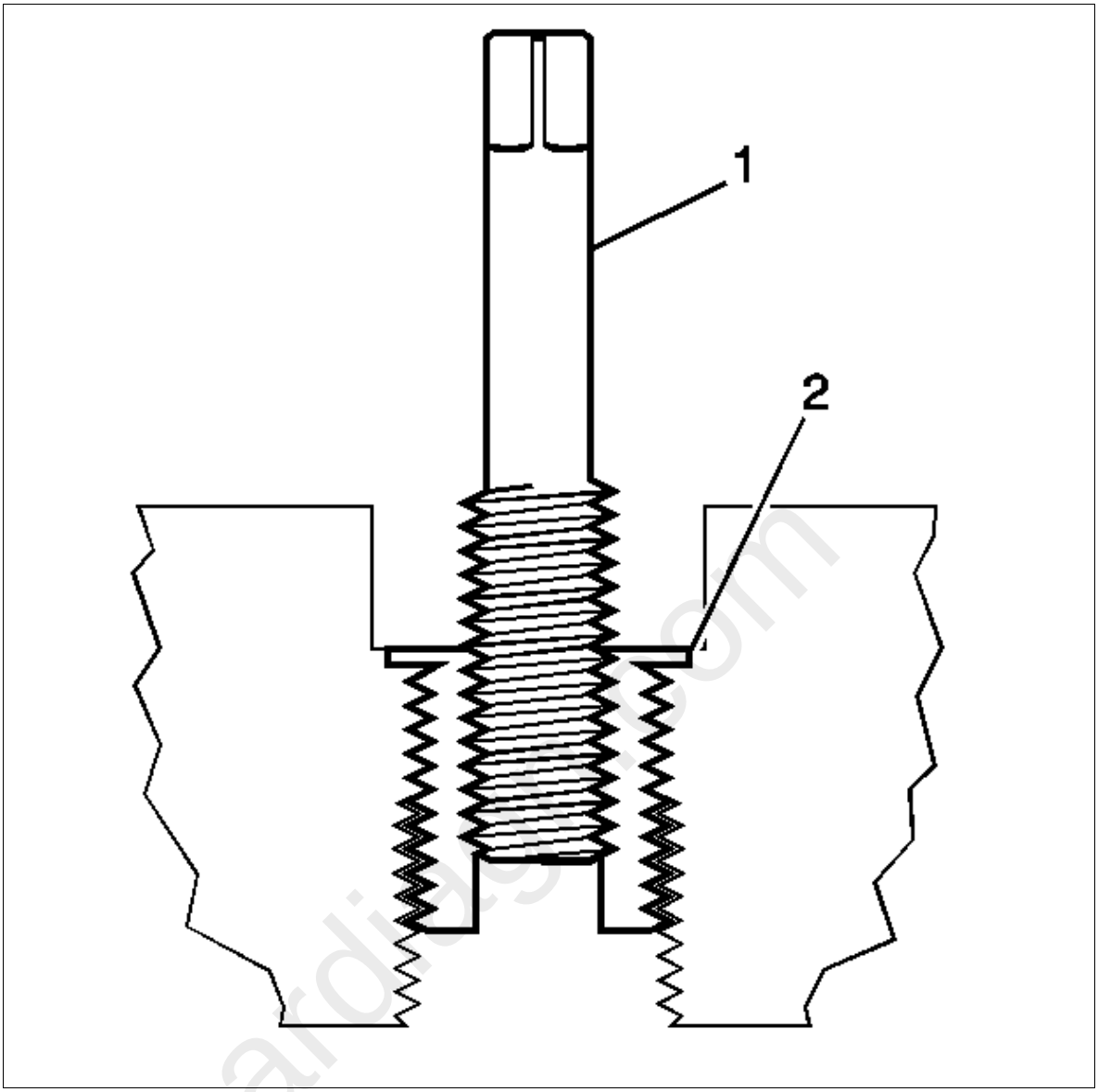
Fig 12: Insert - Recessed Thread



Courtesy of GENERAL MOTORS COMPANY

11. Install the insert (2) into the tapped hole by hand only.

Fig 13: Insert - Recessed Thread



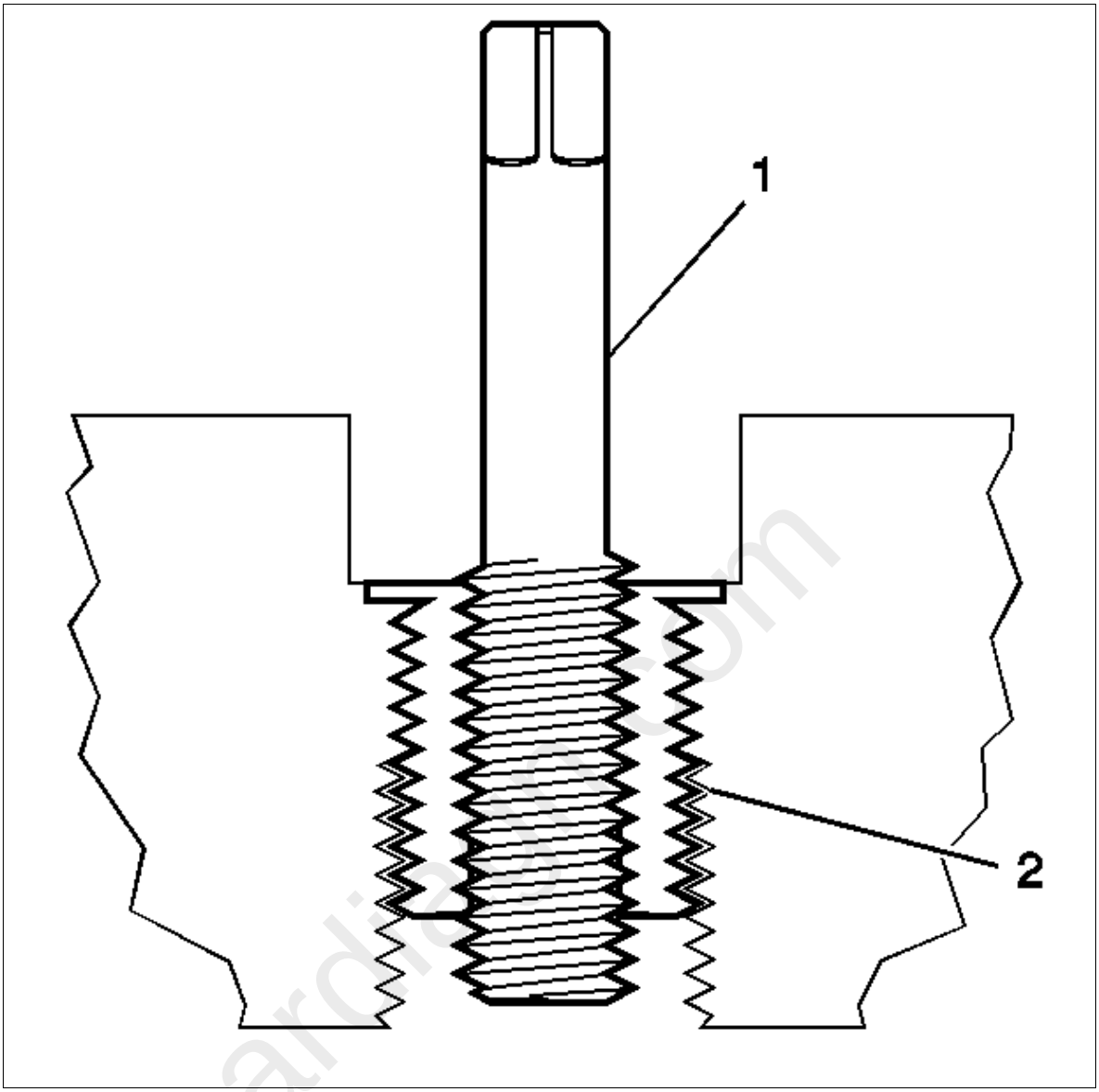
Courtesy of GENERAL MOTORS COMPANY

NOTE:

If the insert will not thread down until the flange contacts the counterbored surface remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or improper tapping.

12. Install the insert until the flange (2) of the insert contacts the counterbored surface.

Fig 14: Insert - Recessed Thread Repair



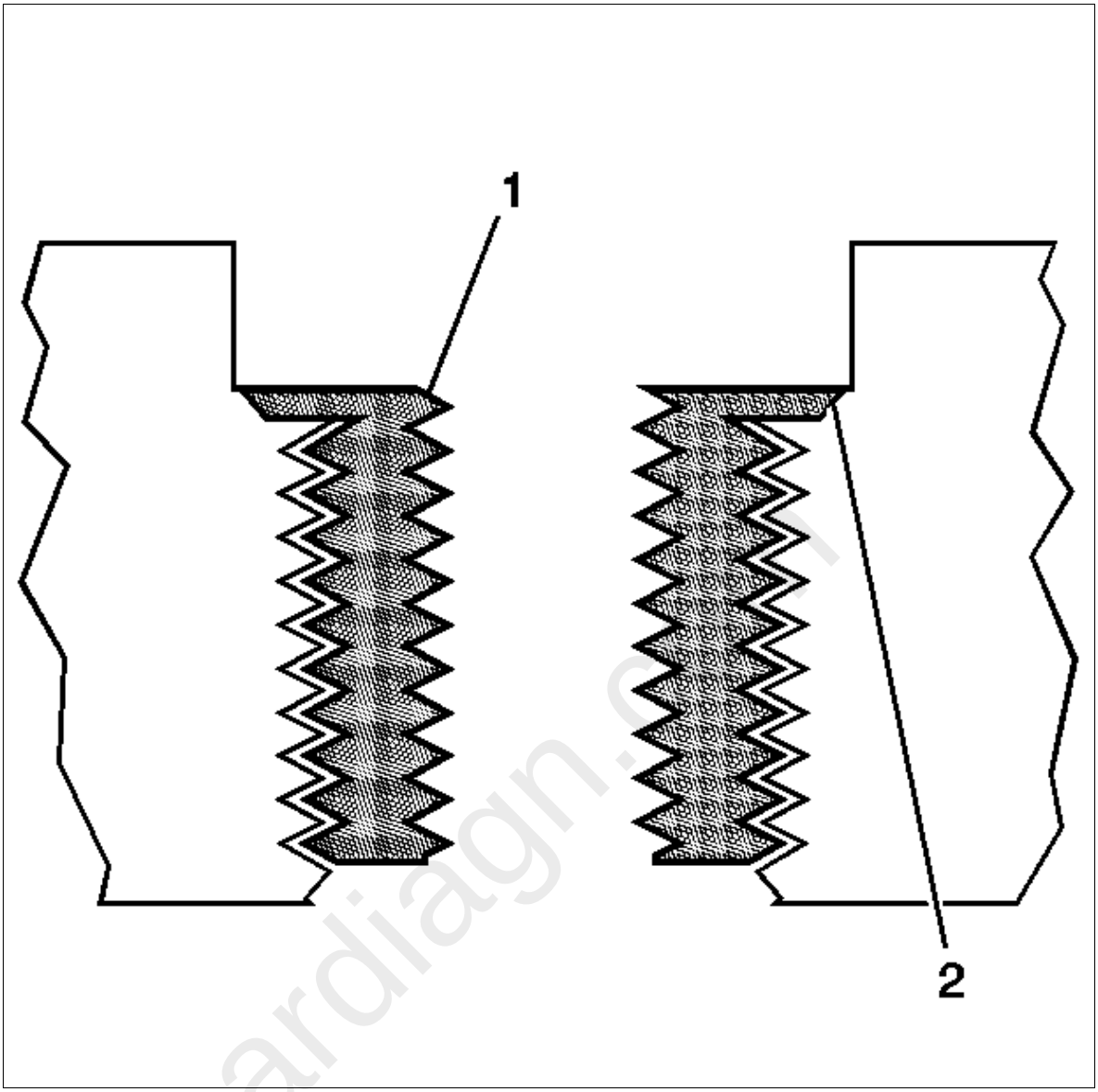
Courtesy of GENERAL MOTORS COMPANY

NOTE:

The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the insert are being formed and the insert is mechanically locking the insert into the base material threads.

13. Continue to rotate the driver installation tool (1) through the insert (2).

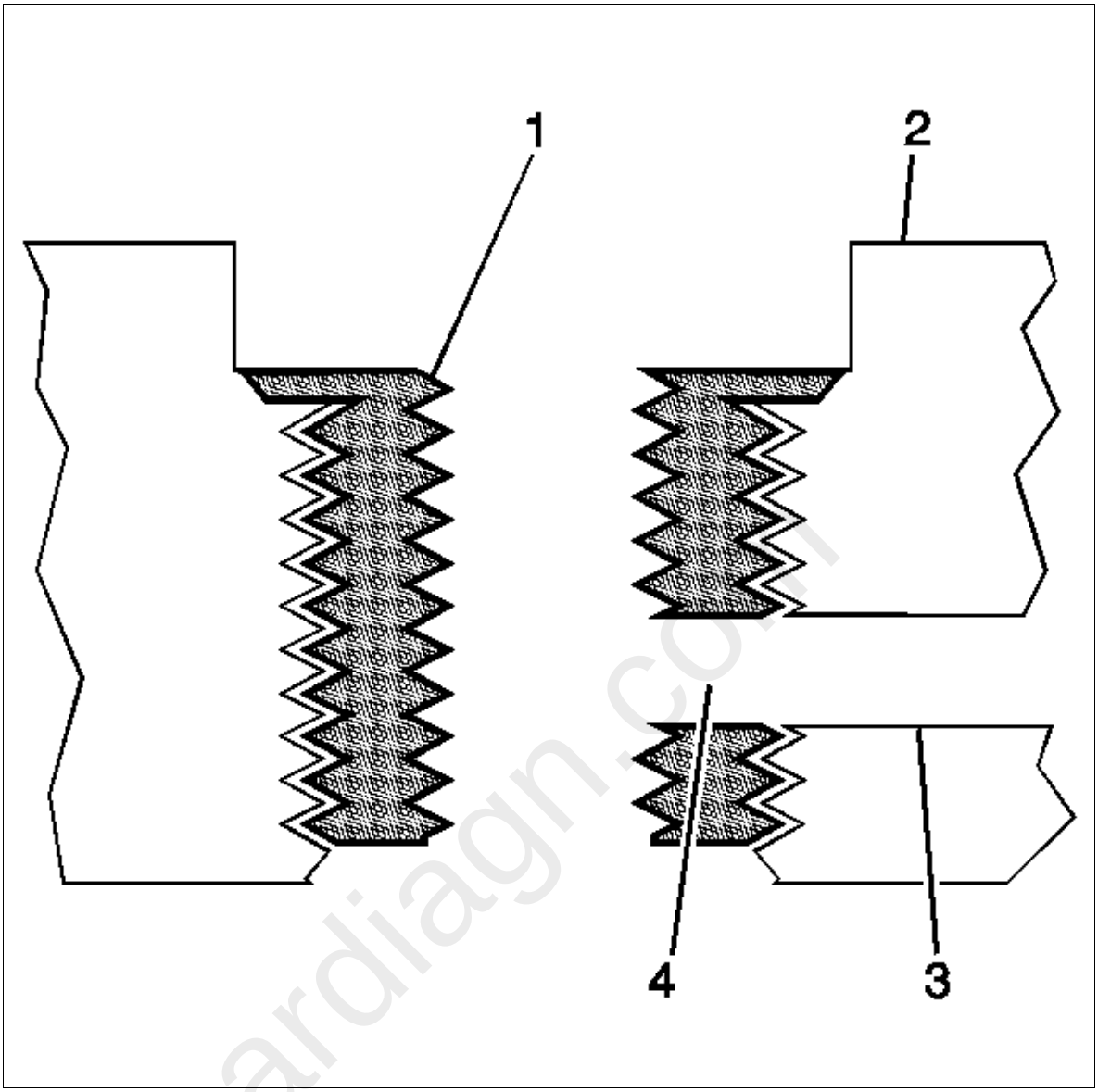
Fig 15: Insert For Proper Installation - Recessed Thread



Courtesy of GENERAL MOTORS COMPANY

14. Inspect the insert (1) for proper installation (2) into the tapped hole.

Fig 16: Restricted Engine Coolant Passage - Recessed Thread Repair



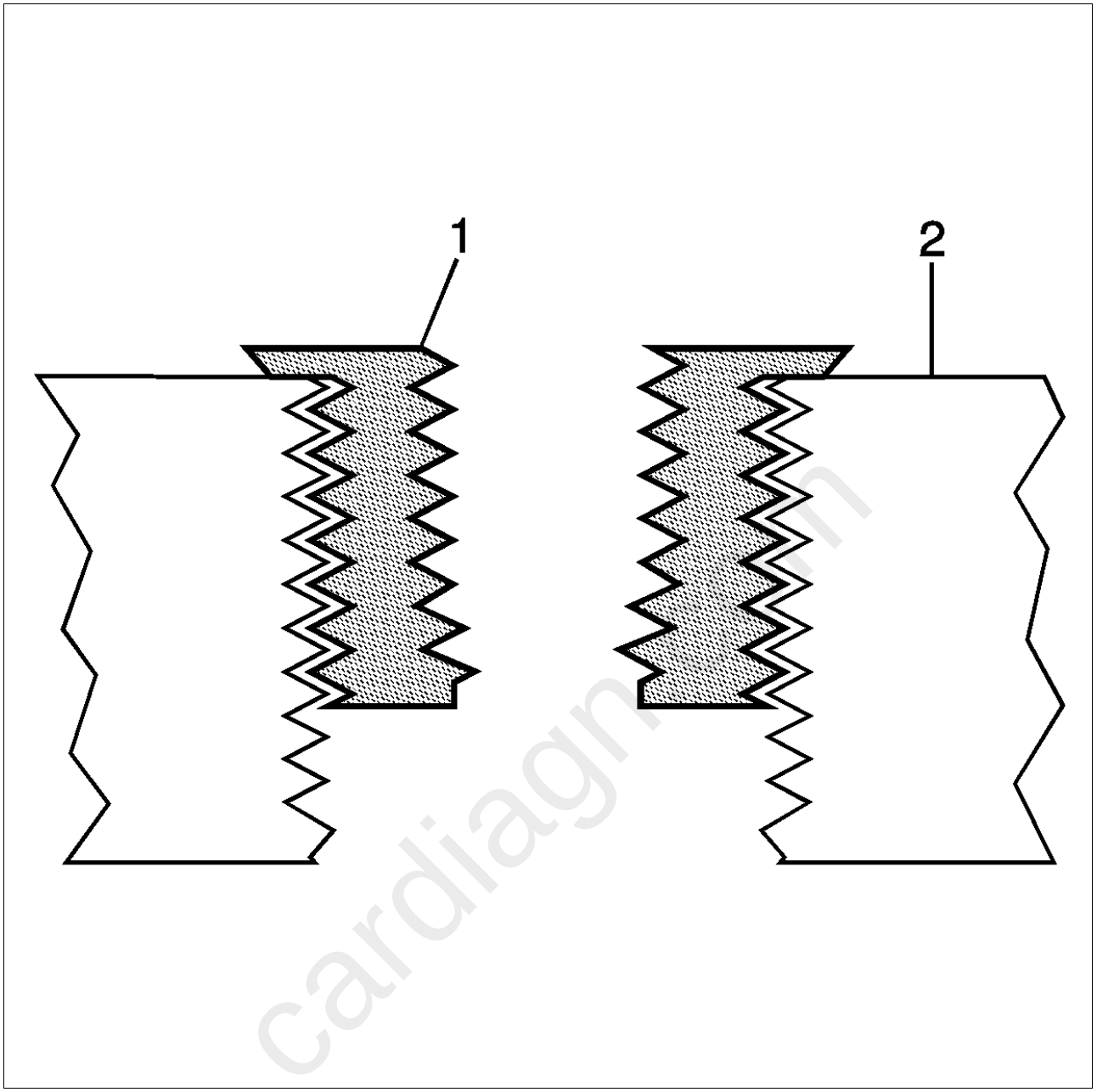
Courtesy of GENERAL MOTORS COMPANY

15. Any installed insert that restricts or blocks an oil or engine coolant passage (3) will need to have the oil or engine coolant passage drilled out (4) to the original size of the oil or engine coolant passage. After drilling the restriction or blockage, clean out any chips and thread the installation driver tool through the insert again to remove any burrs caused by the drilling of the oil or engine coolant passage.

REPAIR INSTRUCTIONS - OFF VEHICLE > THREAD REPAIR > TAPERED PIPE THREAD REPAIR

The thread repair insert for tapered pipe threads is coated with a clear silver zinc coating.

Fig 1: Insert For Proper Installation - Tapered Thread



Courtesy of GENERAL MOTORS COMPANY

WARNING:

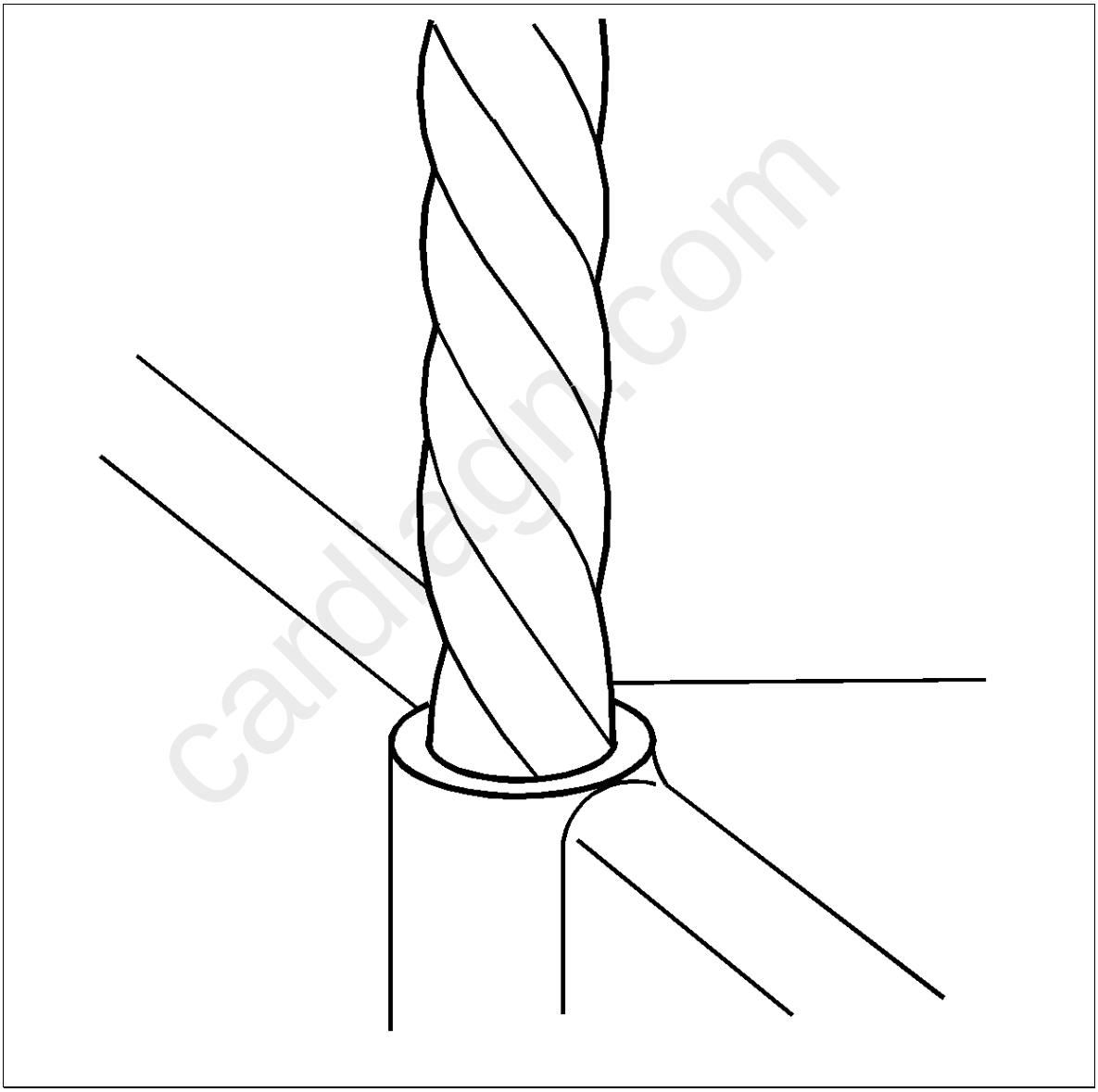
Refer to Safety Glasses Warning .

NOTE:

The use of a cutting type fluid, WD 40® or equivalent is recommended when performing the drilling, counterboring and tapping procedures. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended cutting fluid.

When installed to the proper depth, the flange (1) of the insert will be seated against surface (2) of the base material of the drilled/tapped hole.

Fig 2: Threads Of Damaged Hole



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NOTE:

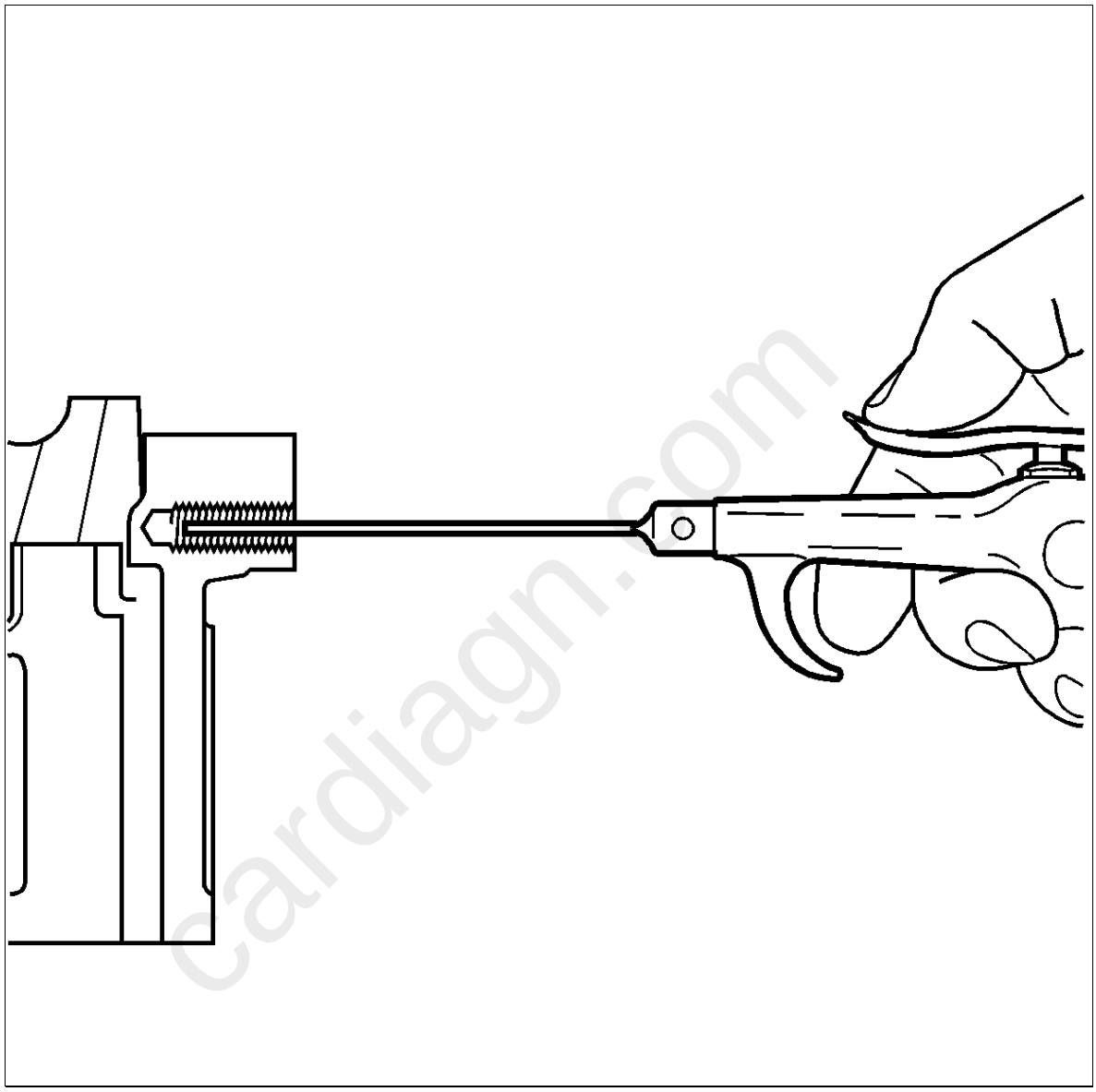
1. During the drilling process, it is necessary to repeatedly remove the drill and

clean chips from the hole and the flutes of the drill.

2. Drill the hole until the stop collar contacts the surface of the base material.

1. Drill out the threads of the damaged hole.

Fig 3: Metal Chips



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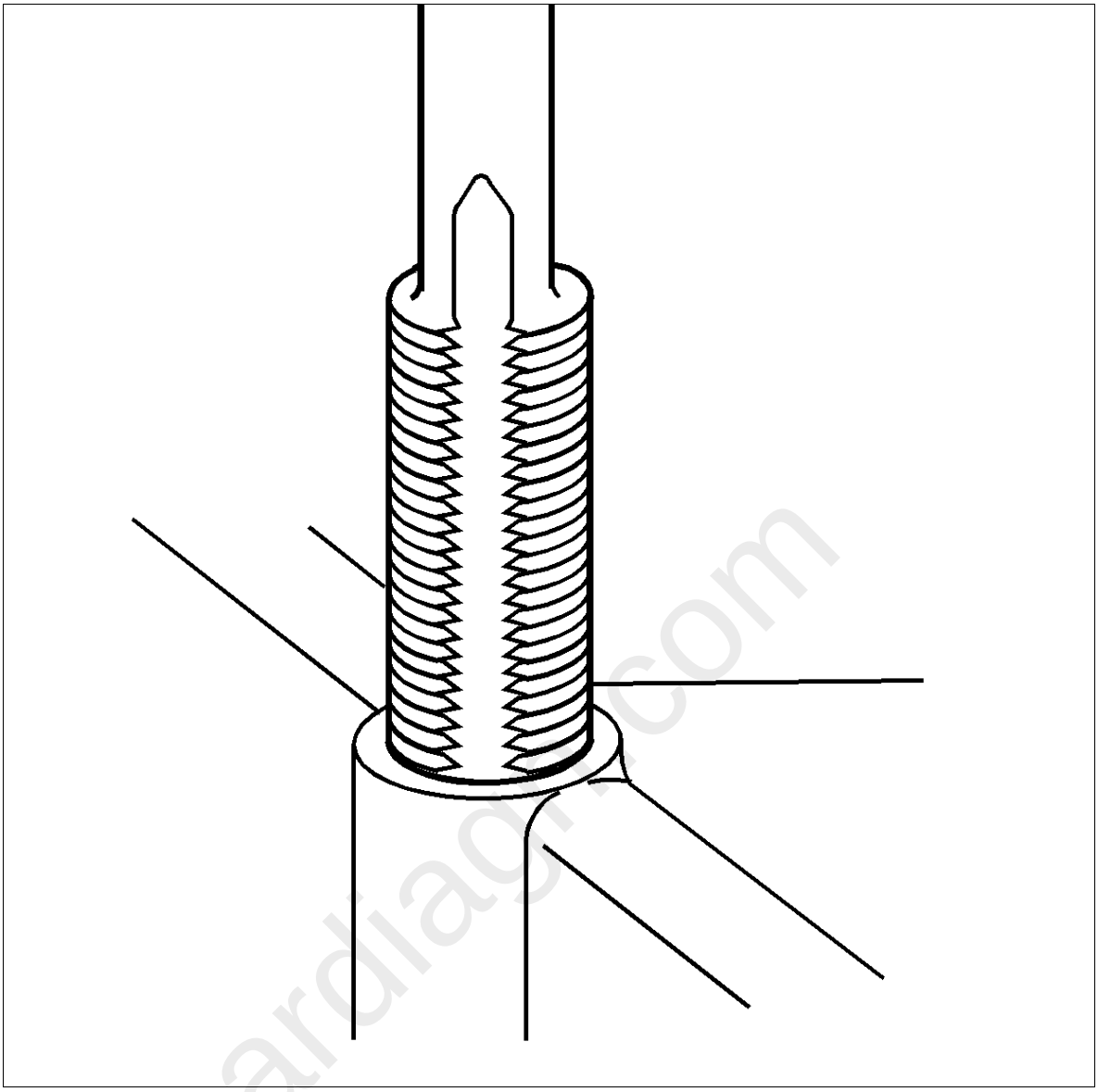
Courtesy of GENERAL MOTORS COMPANY

NOTE:

All chips must be removed from the drilled hole prior to tapping.

2. Using compressed air, clean out any chips.

Fig 4: Threads Of Drilled Hole



Courtesy of GENERAL MOTORS COMPANY

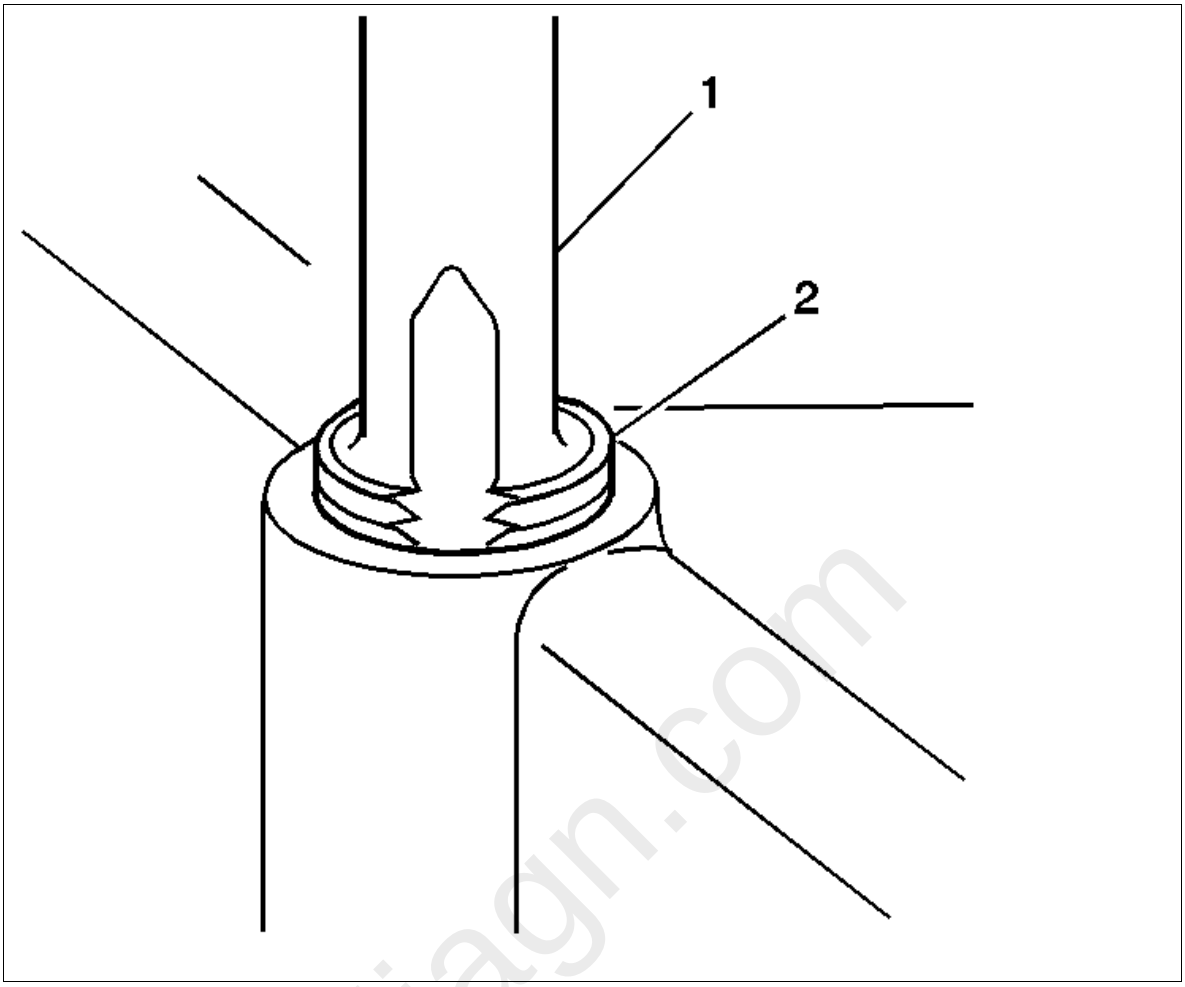
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NOTE:

1. *During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.*
2. *Ensure the tap has created full threads at least to the depth equal to the insert length.*

3. Using a suitable tapping wrench, tap the threads of the drilled hole by hand only.

Fig 5: Tapping Distance - Tapered Thread

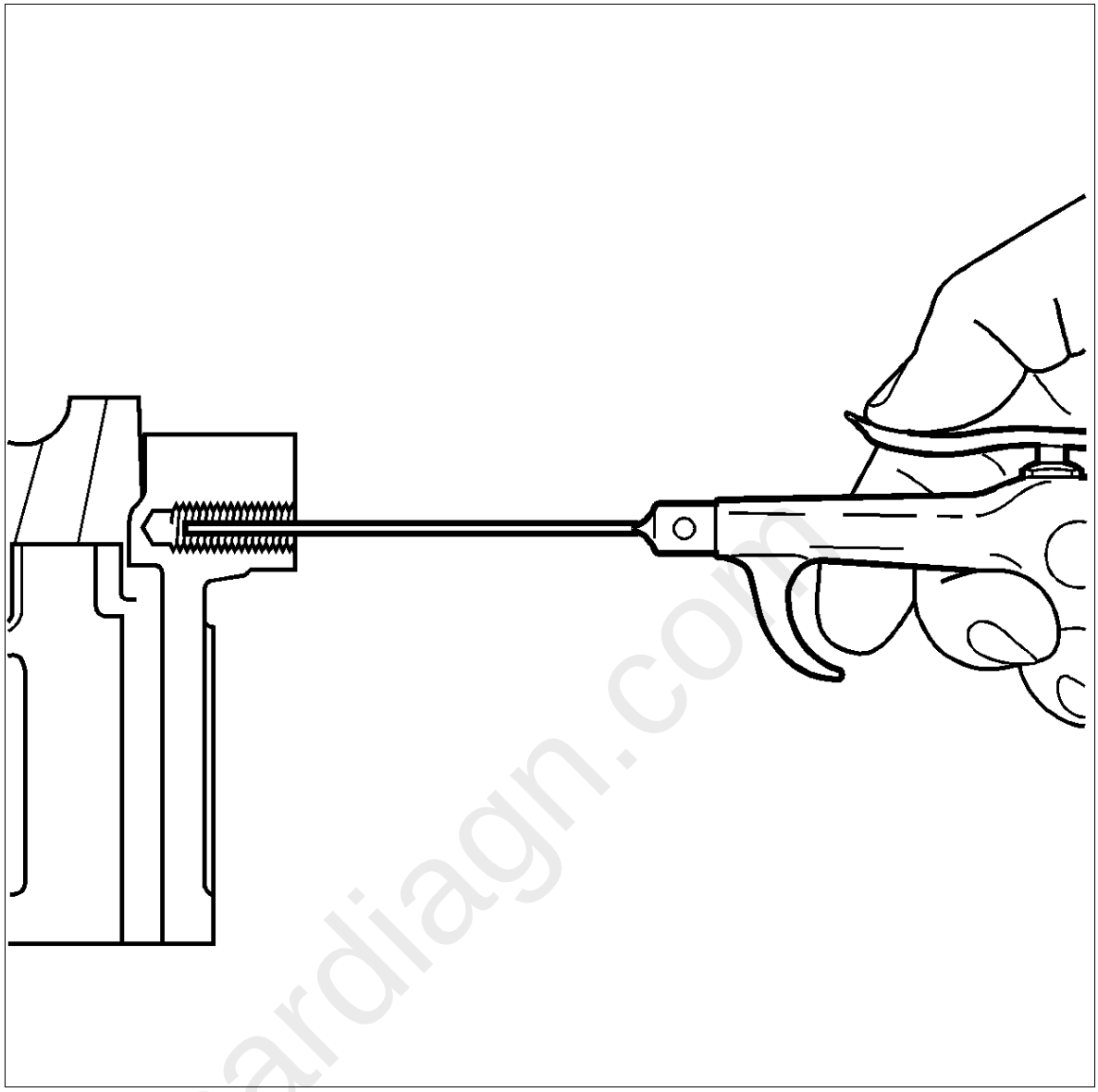


Courtesy of GENERAL MOTORS COMPANY

4. Tap the drilled hole until the threads at the top of the tap (2) are down to the surface of the base material.

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Fig 6: Metal Chips



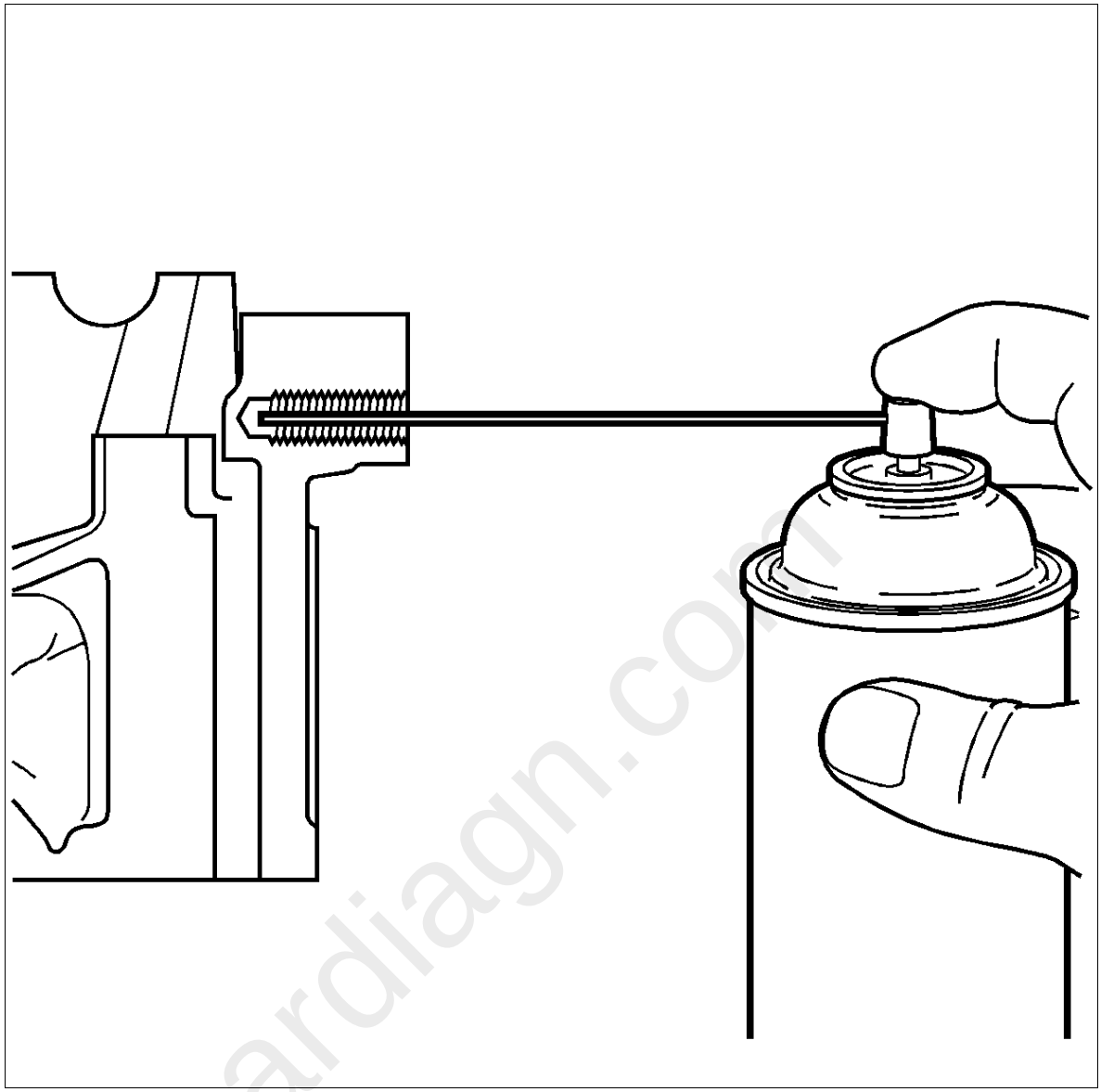
Courtesy of GENERAL MOTORS COMPANY

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> *NOTE:*
>
> *All chips must be removed from the tapped hole prior to insert installation.*

5. Using compressed air, clean out any chips.

Fig 7: Cleaner Into Tapped Hole

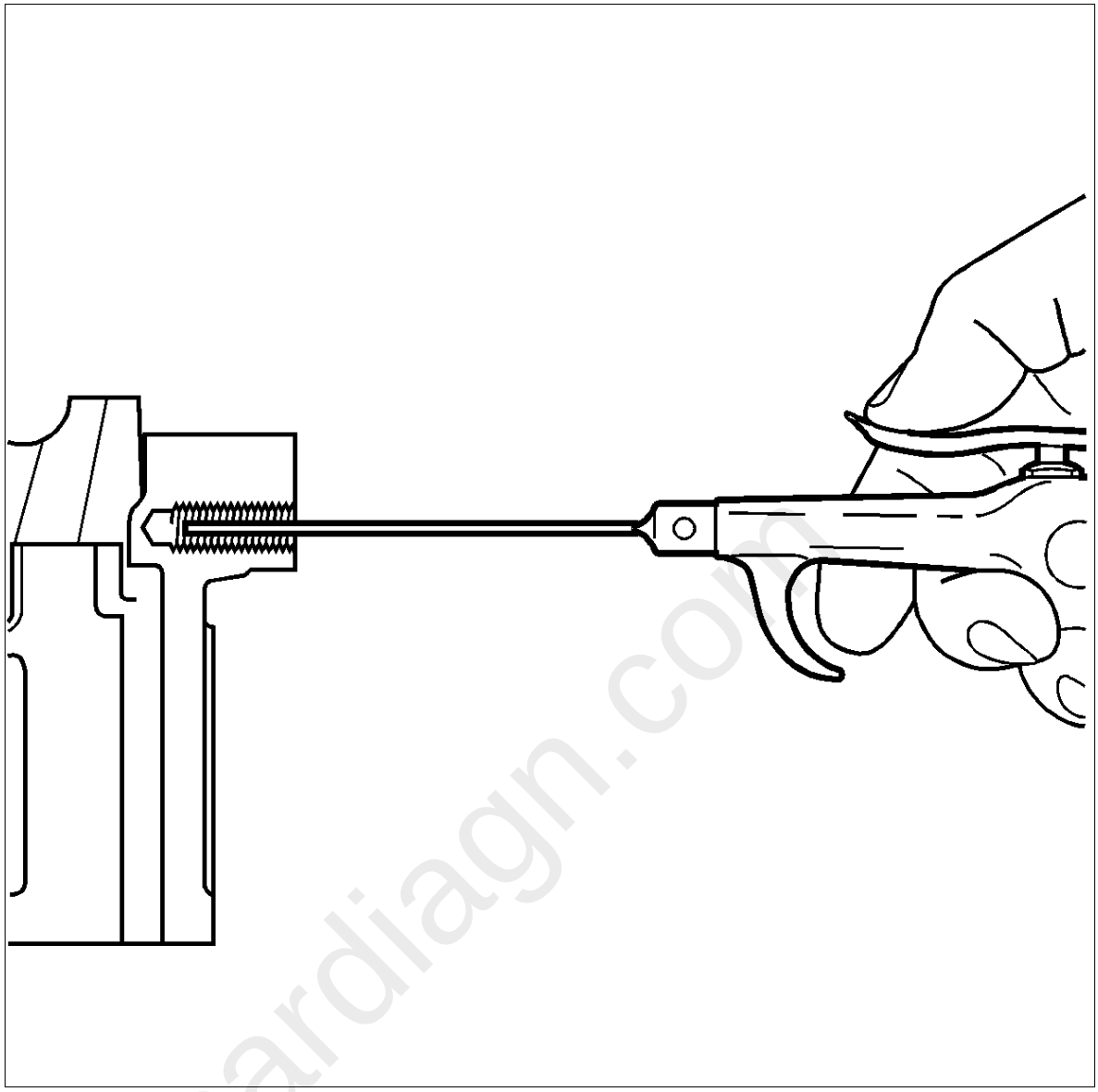


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6. Spray cleaner into the tapped hole. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended cleaner.

Fig 8: Metal Chips



Courtesy of GENERAL MOTORS COMPANY

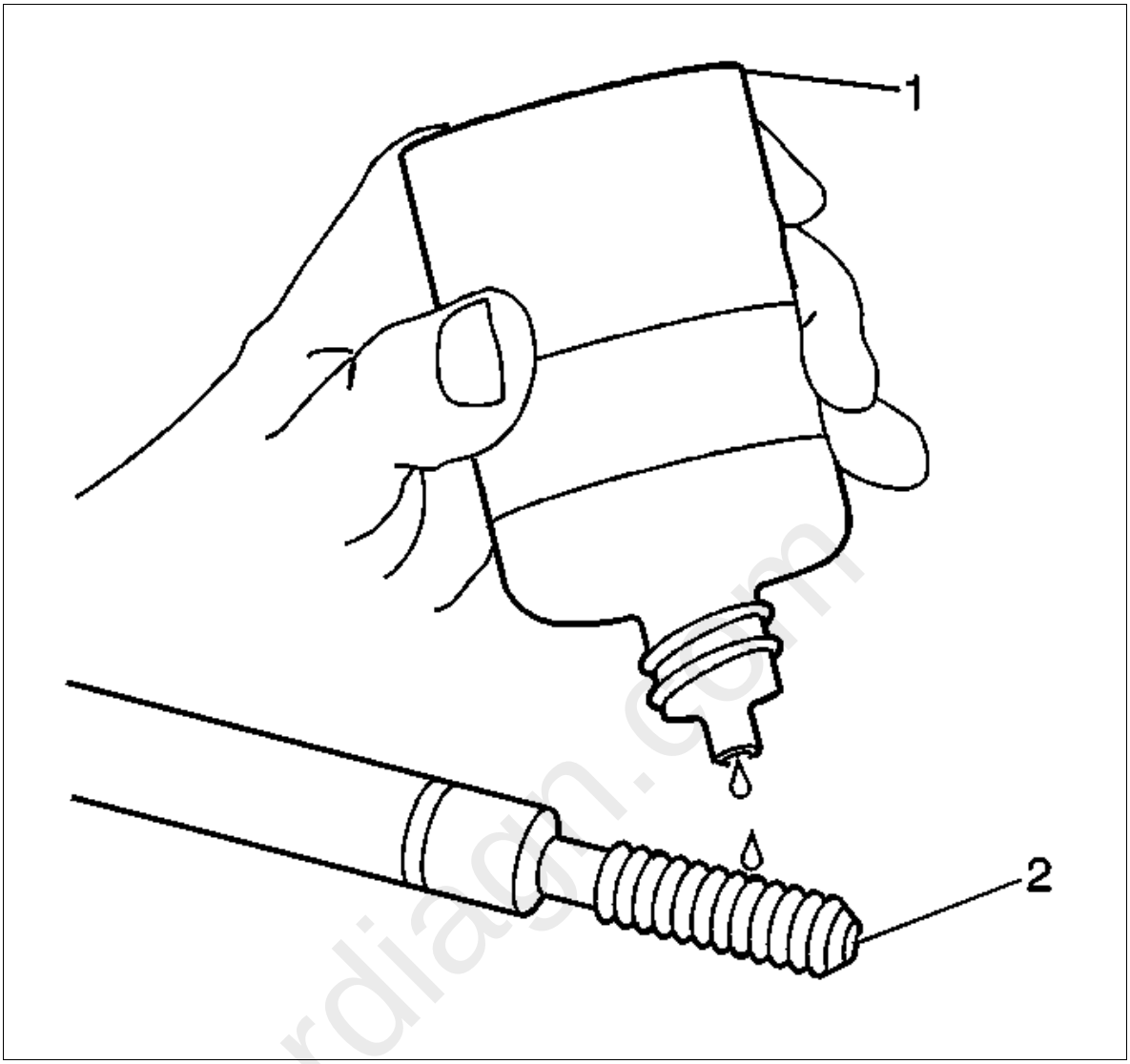
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NOTE:

All chips must be removed from the tapped hole prior to insert installation.

7. Using compressed air, clean out any chips.

Fig 9: Installer Tool Using Driver Oil



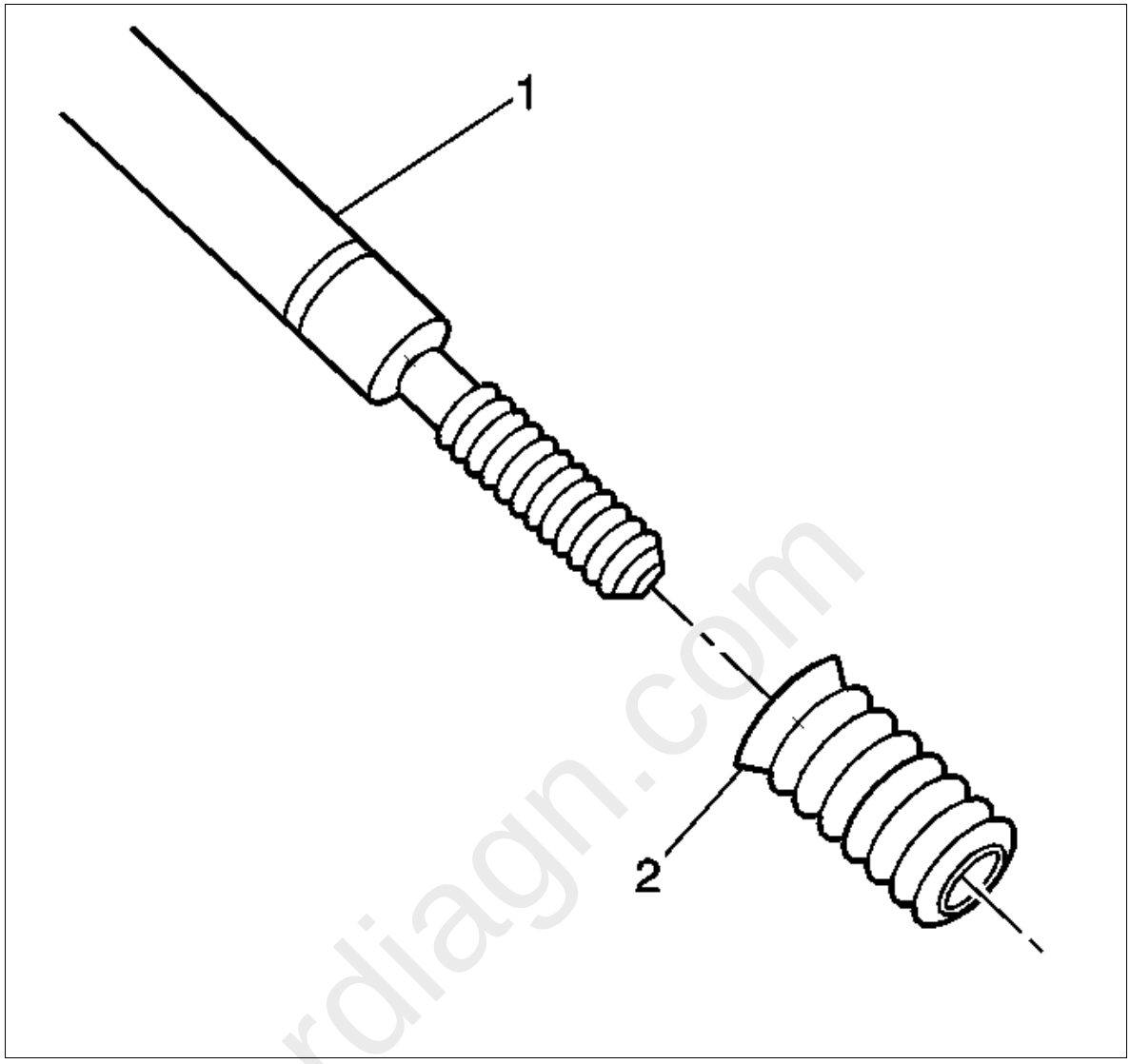
Courtesy of GENERAL MOTORS COMPANY

NOTE:

Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

8. Lubricate the threads of the driver installation tool (2) with the EN 42385-110 (1).

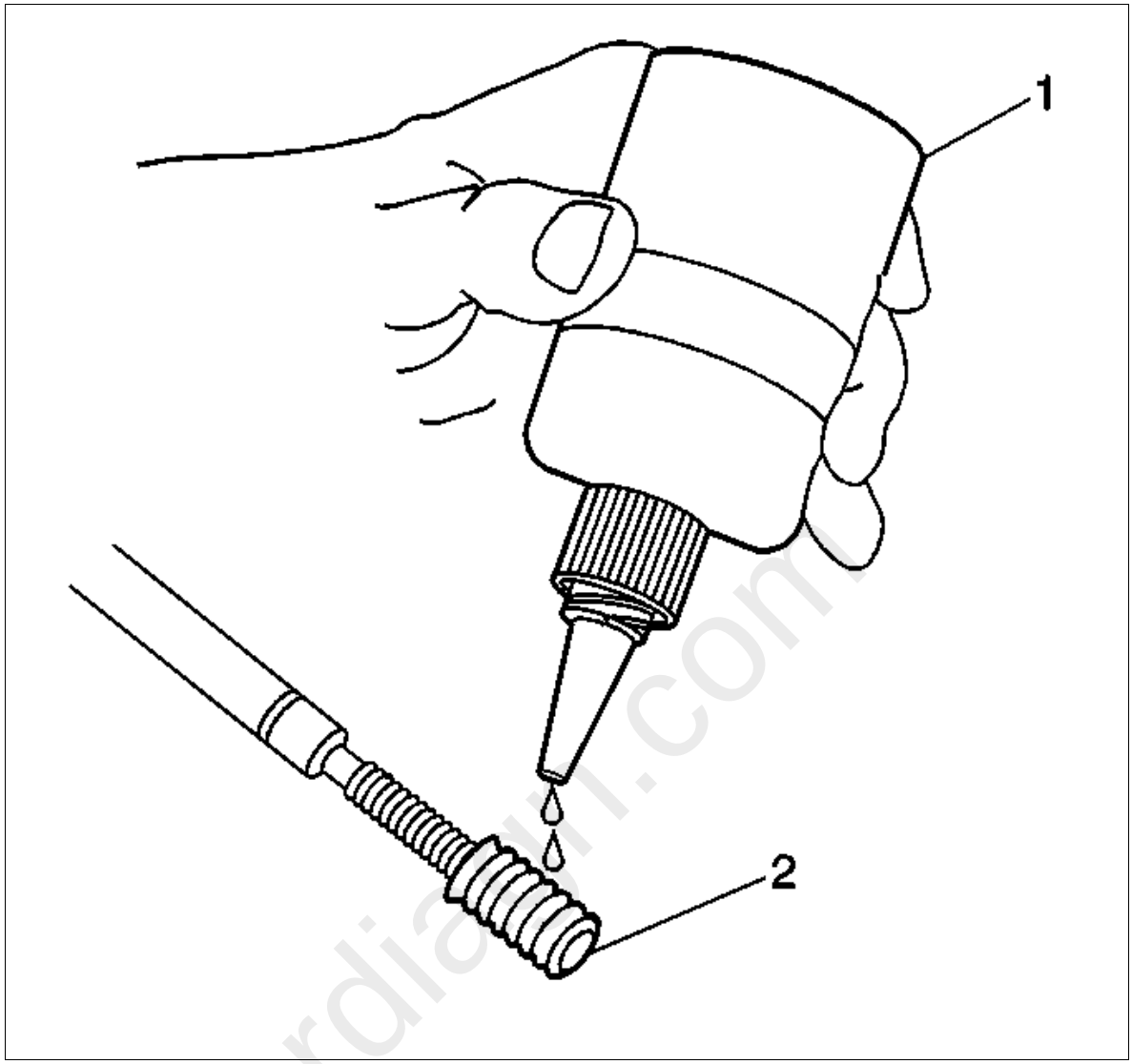
Fig 10: Bushing Type Insert



Courtesy of GENERAL MOTORS COMPANY

9. Install the insert (2) onto the driver installation tool (1).

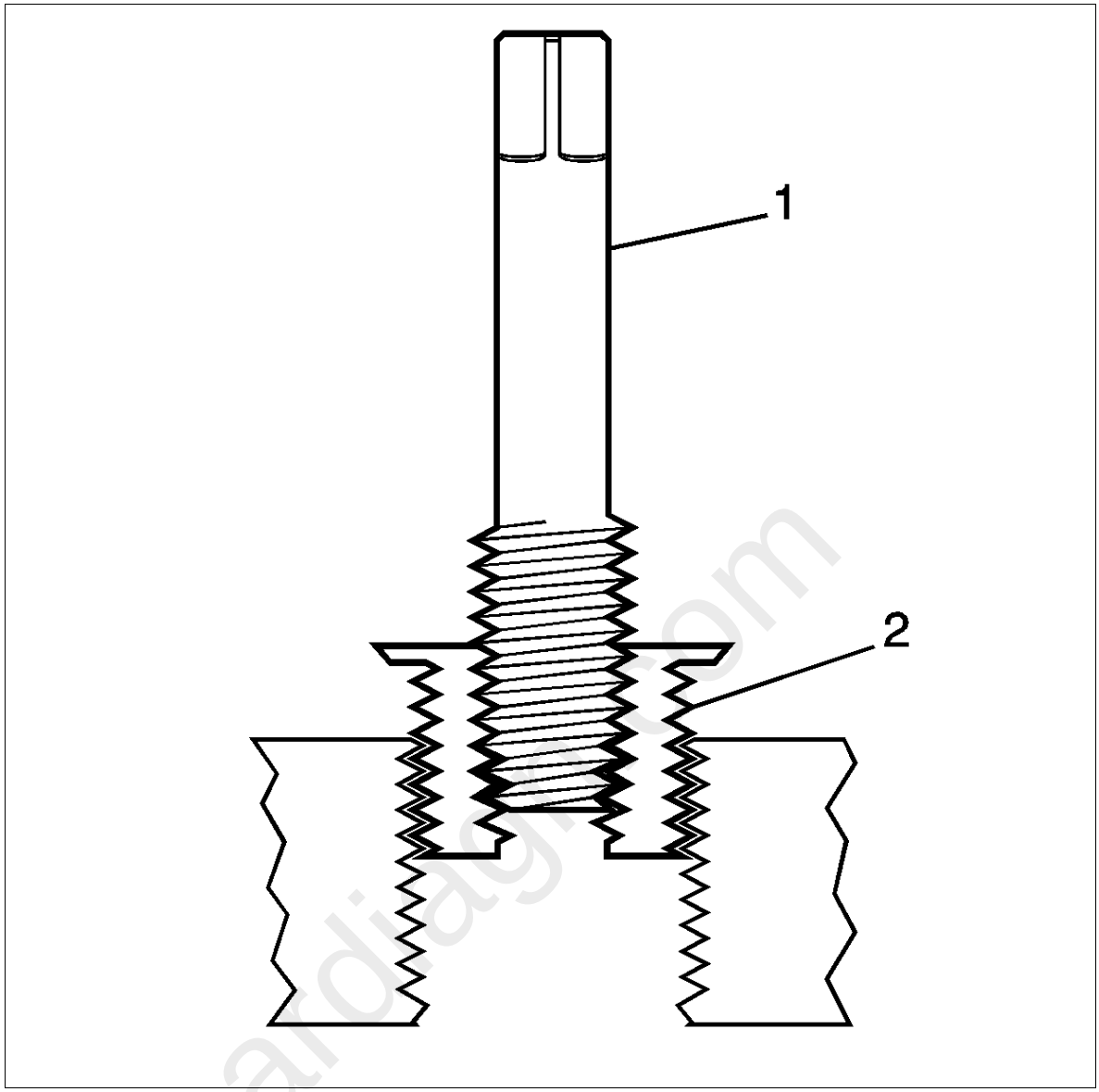
Fig 11: Threadlock To Insert



Courtesy of GENERAL MOTORS COMPANY

10. Apply threadlock sealant, **EN-42385-109** , LOCTITE 277® or equivalent (1) to the insert OD threads (2). Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended sealant.

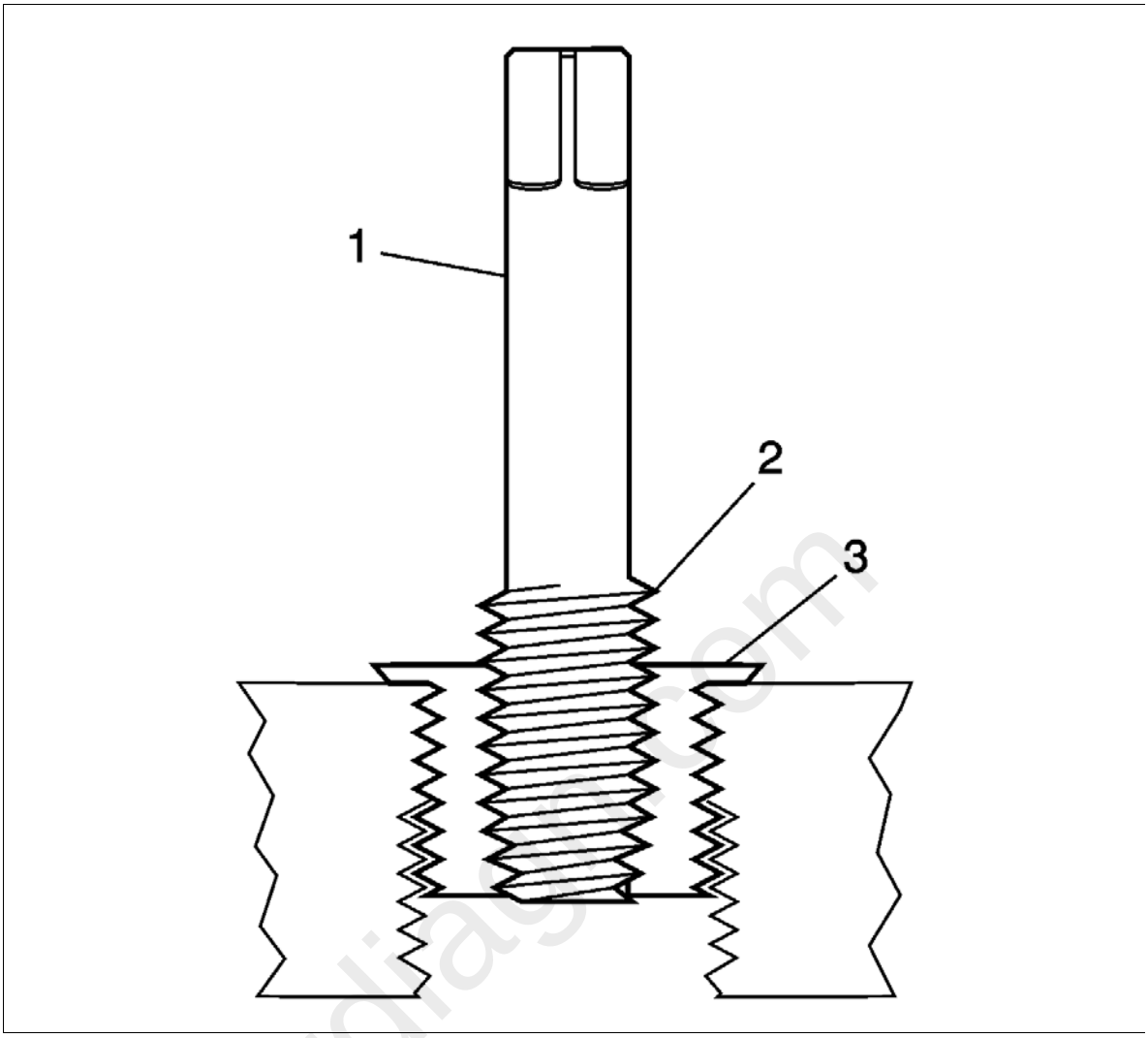
Fig 12: Insert - Tapered Thread



Courtesy of GENERAL MOTORS COMPANY

11. Install the insert (2) into the tapped hole by hand only.

Fig 13: Insert - Tapered Pipe Thread Repair



Courtesy of GENERAL MOTORS COMPANY

NOTE:

If the insert will not thread down until the flange contacts the surface of the base material remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or improper tapping.

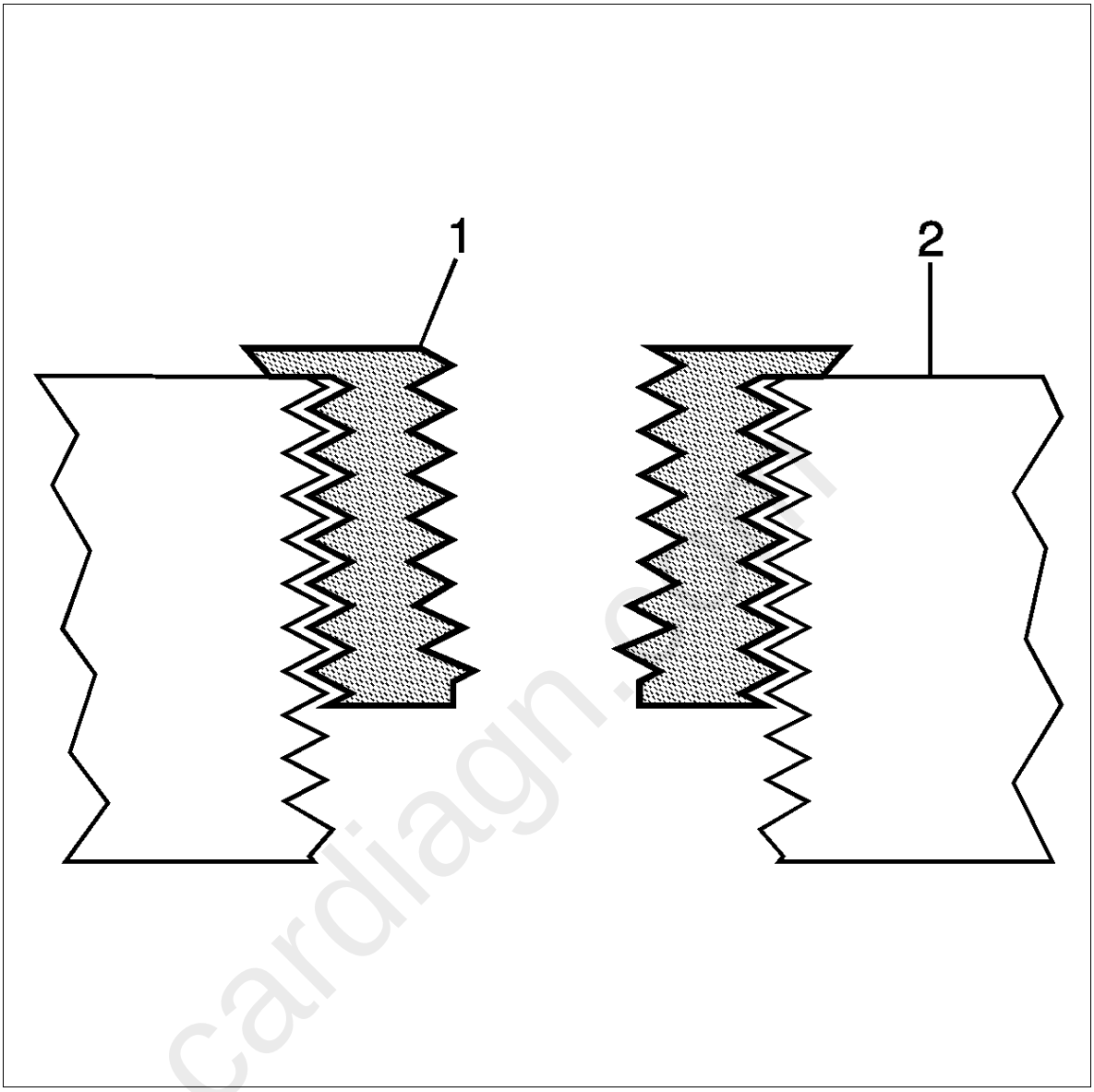
12. Install the insert until the flange of the insert (3) contacts the surface of the base material.

NOTE:

The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the insert are being formed and the insert is mechanically locking the insert into the base material threads.

13. Continue to rotate the driver installation tool (1) until the top of the threaded section (2) is level with the top of the insert (3).

Fig 14: Insert For Proper Installation - Tapered Thread

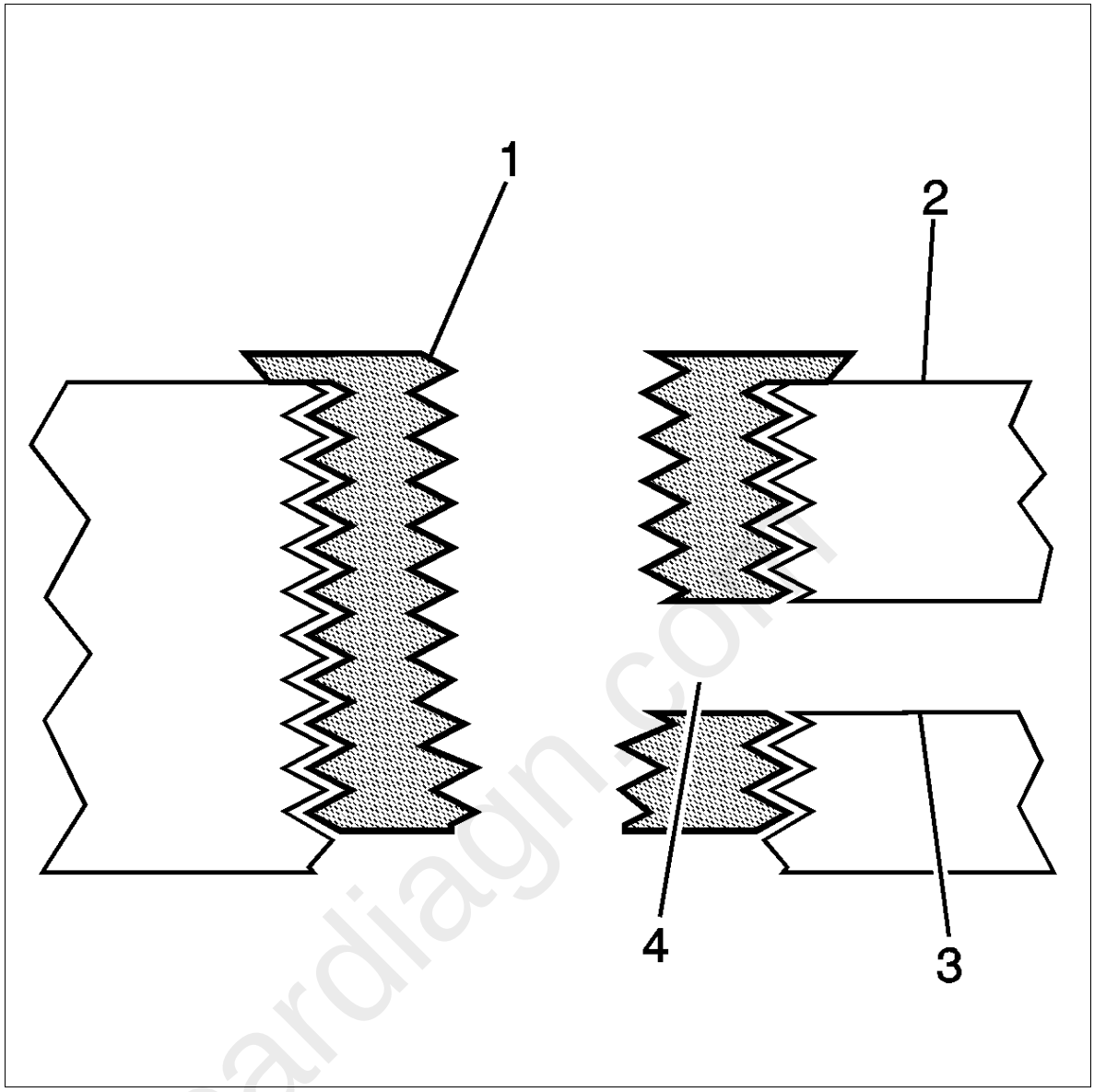


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14. Inspect the insert (1) for proper installation (2) into the tapped hole.

Fig 15: Restricted Engine Coolant Passages - Tapered Pipe Thread Repair



Courtesy of GENERAL MOTORS COMPANY

15. Any installed insert that restricts or blocks an oil or engine coolant passage (3) will need to have the oil or engine coolant passage drilled out (4) to the original size of the oil or engine coolant passage. After drilling the restriction or blockage, clean out any chips and thread the installation driver tool through the insert again to remove any burrs caused by the drilling of the oil or engine coolant passage.

REPAIR INSTRUCTIONS - OFF VEHICLE > THREAD REPAIR > CYLINDER HEAD BOLT HOLE THREAD REPAIR

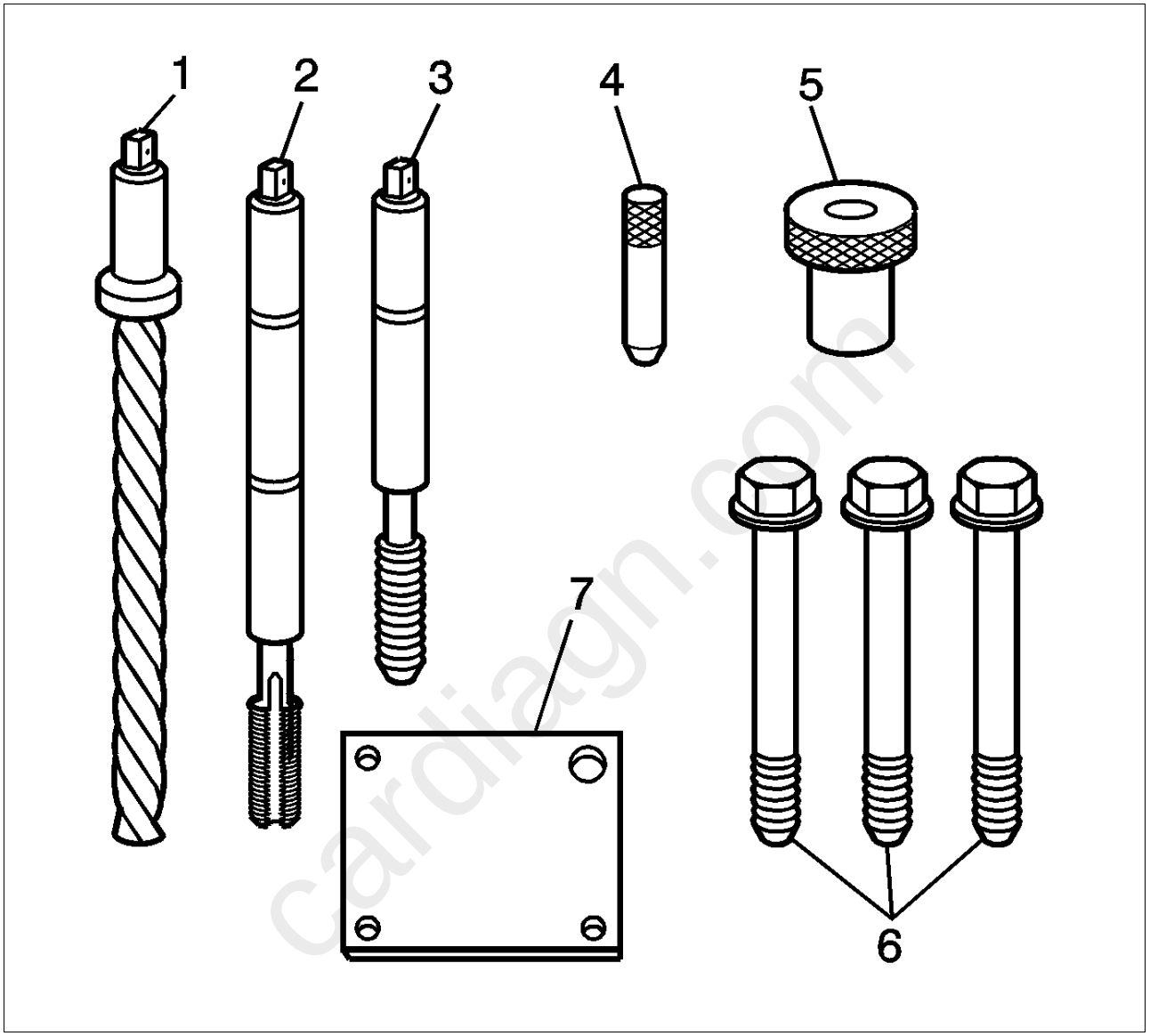
Special Tools

- **EN-42385-70** Head Bolt Thread Repair Fixture

- **EN-42385-700** High Feature Thread Repair Kit
- **EN-42385-2000** Thread Insert Kit

For equivalent regional tools, refer to Special Tools .

Fig 1: Cylinder Head Bolt Hole Thread Repair Kit Components



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The cylinder head bolt hole thread repair tooling are in the kits **EN-42385-2000** insert kit and **EN-42385-700** kit. The cylinder head bolt hole thread repair components consist of the following:

- **EN-42385-723** Drill (1)
- **EN-42385-724** Tap (2)
- **EN-42385-725** Installation driver (3)
- **EN-42385-303** Alignment pin (4)

- **EN-42385-70** Bushing (5)
- **EN-42385-733** Bolts (6)
- **EN-42385-70** Fixture plate (7)

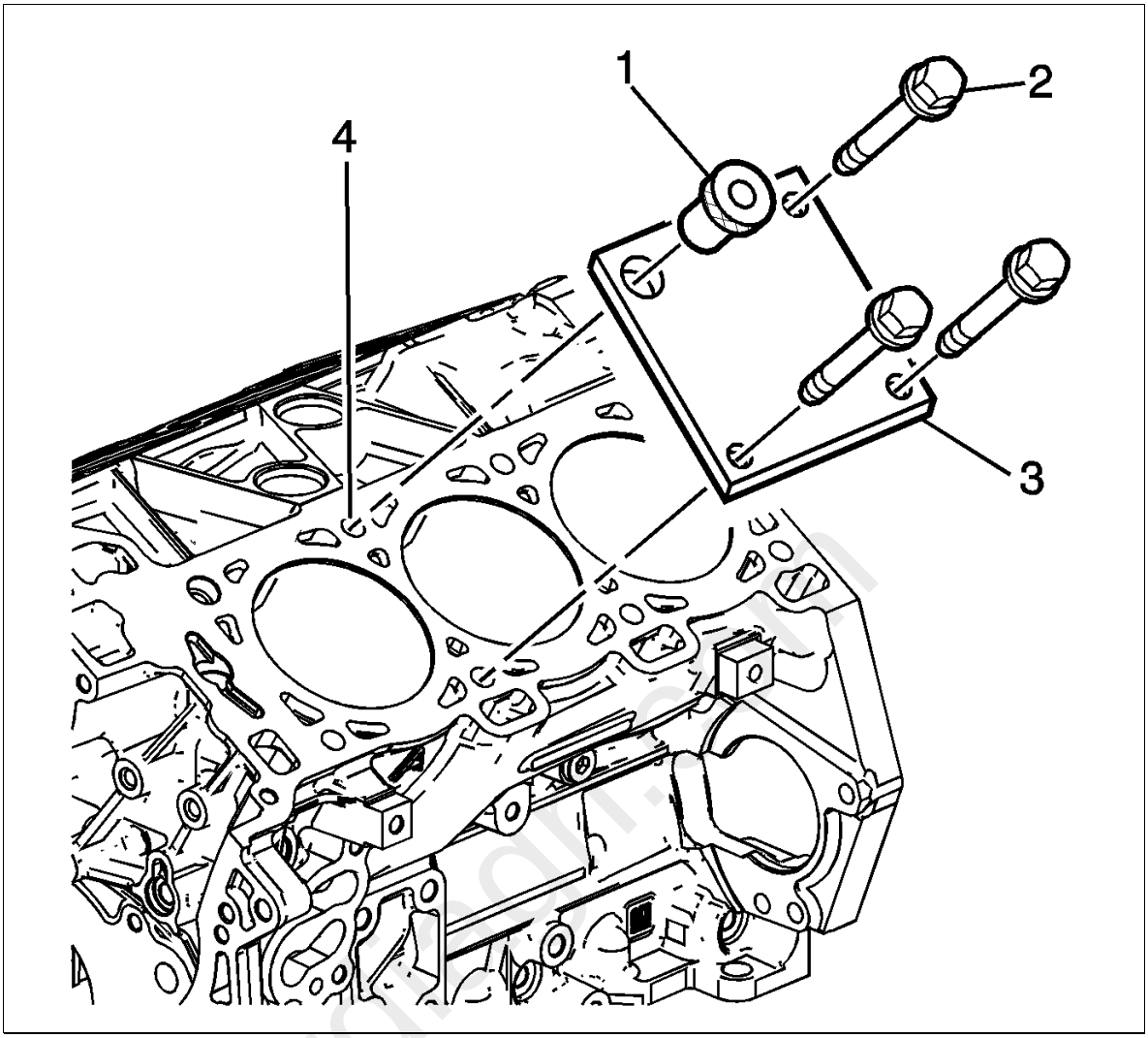
> *WARNING:*
>
> *Refer to Safety Glasses Warning .*

> *NOTE:*
>
> - *Remove the fixture plate prior to installing the insert with the installer tool.*
> - *The use of a cutting type fluid, WD 40®; or equivalent is recommended when performing the drilling, counterboring and tapping procedures. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended cutting fluid.*

When installed to the proper depth, the flange of the insert will be seated against the counterbore of the drilled/tapped hole.

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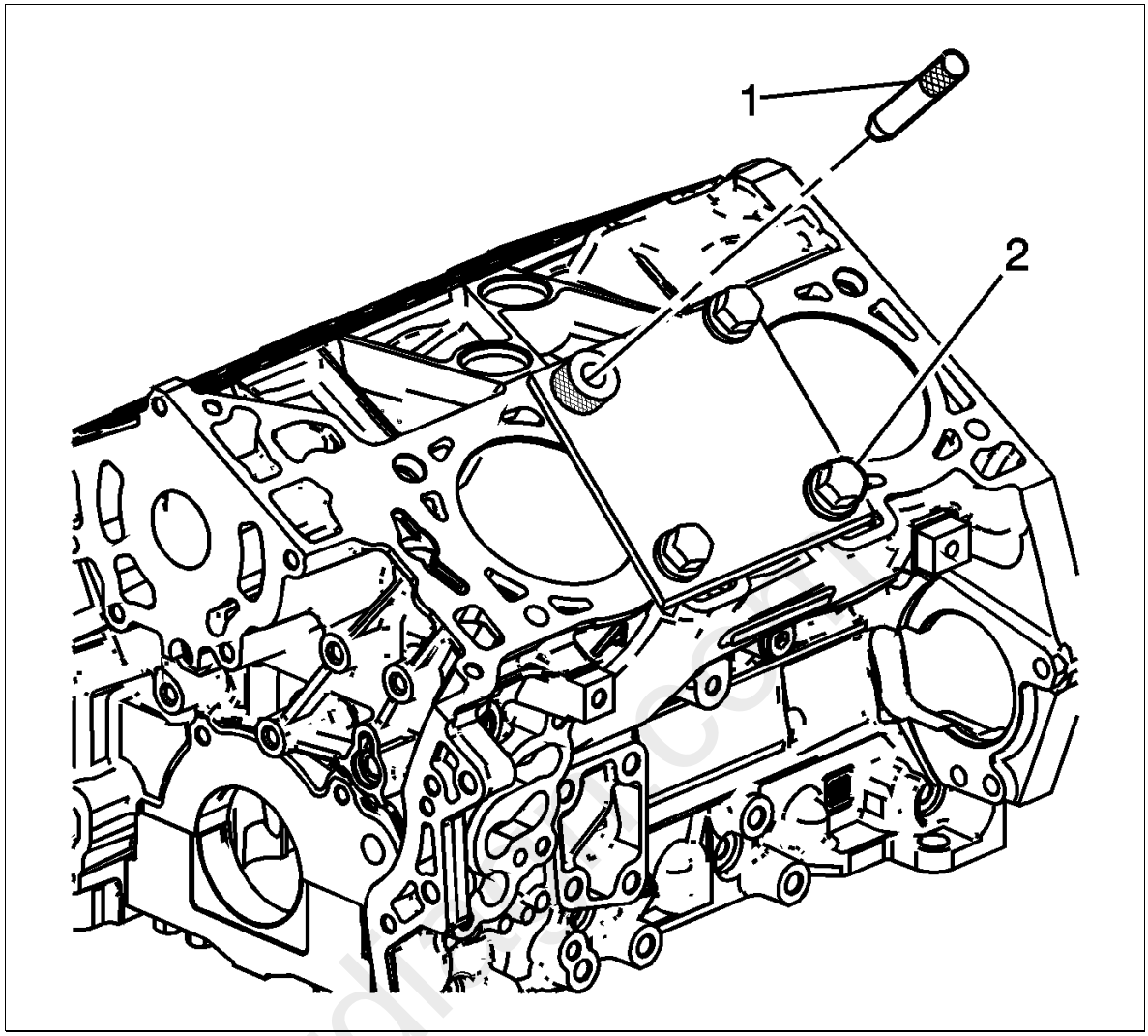
Fig 2: Fixture Plate & Components - Cylinder Head Bolt Hole



Courtesy of GENERAL MOTORS COMPANY

1. Position the fixture plate (3) with the bushing (1) installed over the cylinder head bolt hole to be repaired (4).
2. Loosely install the fixture plate bolts (2) into the remaining cylinder head bolt holes.

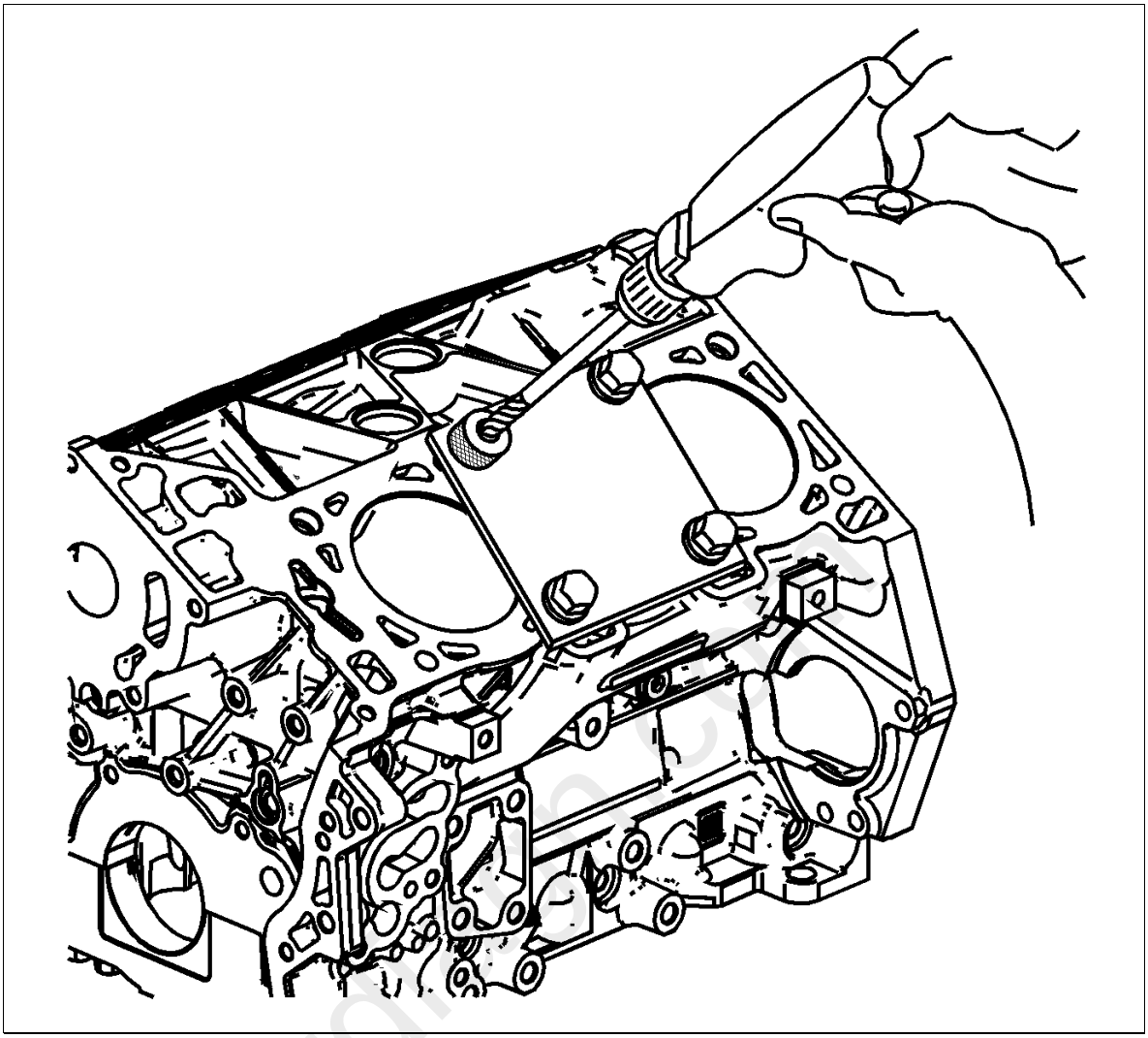
Fig 3: Alignment Pin



Courtesy of GENERAL MOTORS COMPANY

3. Position the alignment pin (1) through the bushing and into the cylinder head bolt hole.
4. With the alignment pin in the desired cylinder head bolt hole, tighten the fixture retaining bolts (2).
5. Remove the alignment pin (1) from the cylinder head bolt hole.

Fig 4: Threads Of Damaged Hole - Cylinder Head Bolt Hole



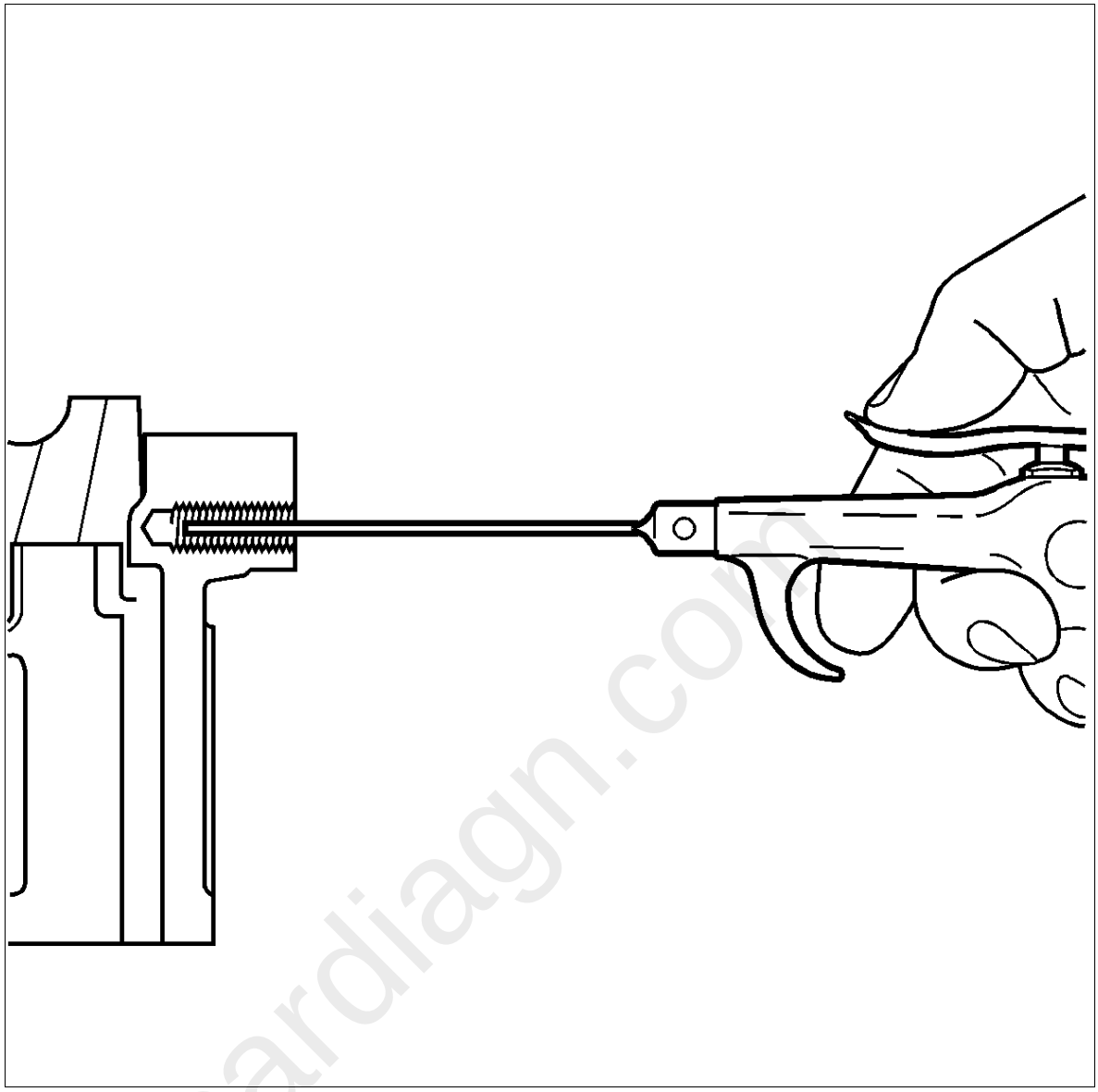
Courtesy of GENERAL MOTORS COMPANY

NOTE:

1. *During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.*
2. *Drill the hole until the stop collar contacts the top of the drill bushing.*

6. Drill out the threads of the damaged hole.

Fig 5: Metal Chips



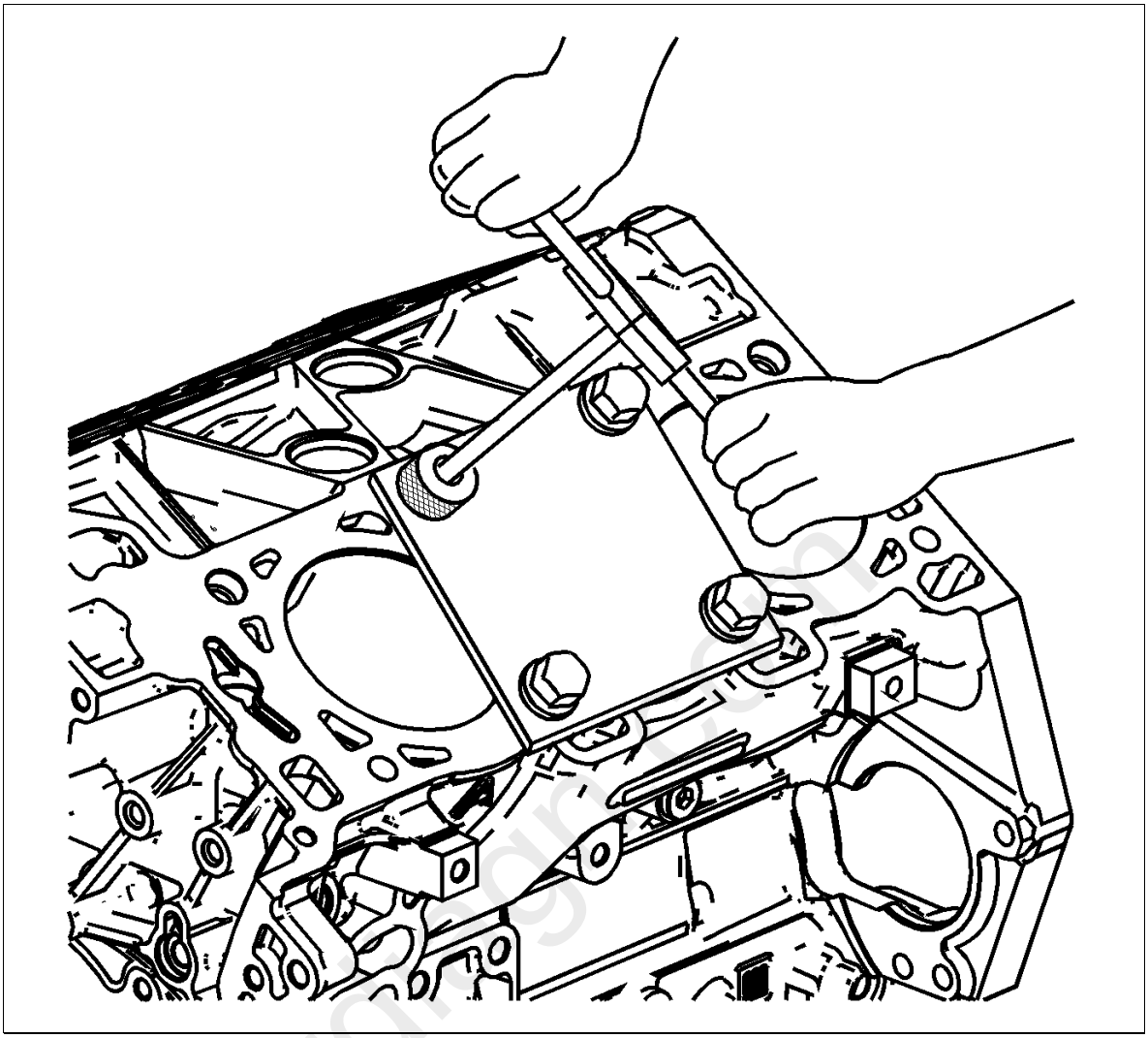
Courtesy of GENERAL MOTORS COMPANY

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> *NOTE:*
>
> *All chips must be removed from the drilled hole prior to tapping.*

7. Using compressed air, clean out any chips.

Fig 6: Threads Of Drilled Hole Using Tapping Wrench - Cylinder Head Bolt Hole



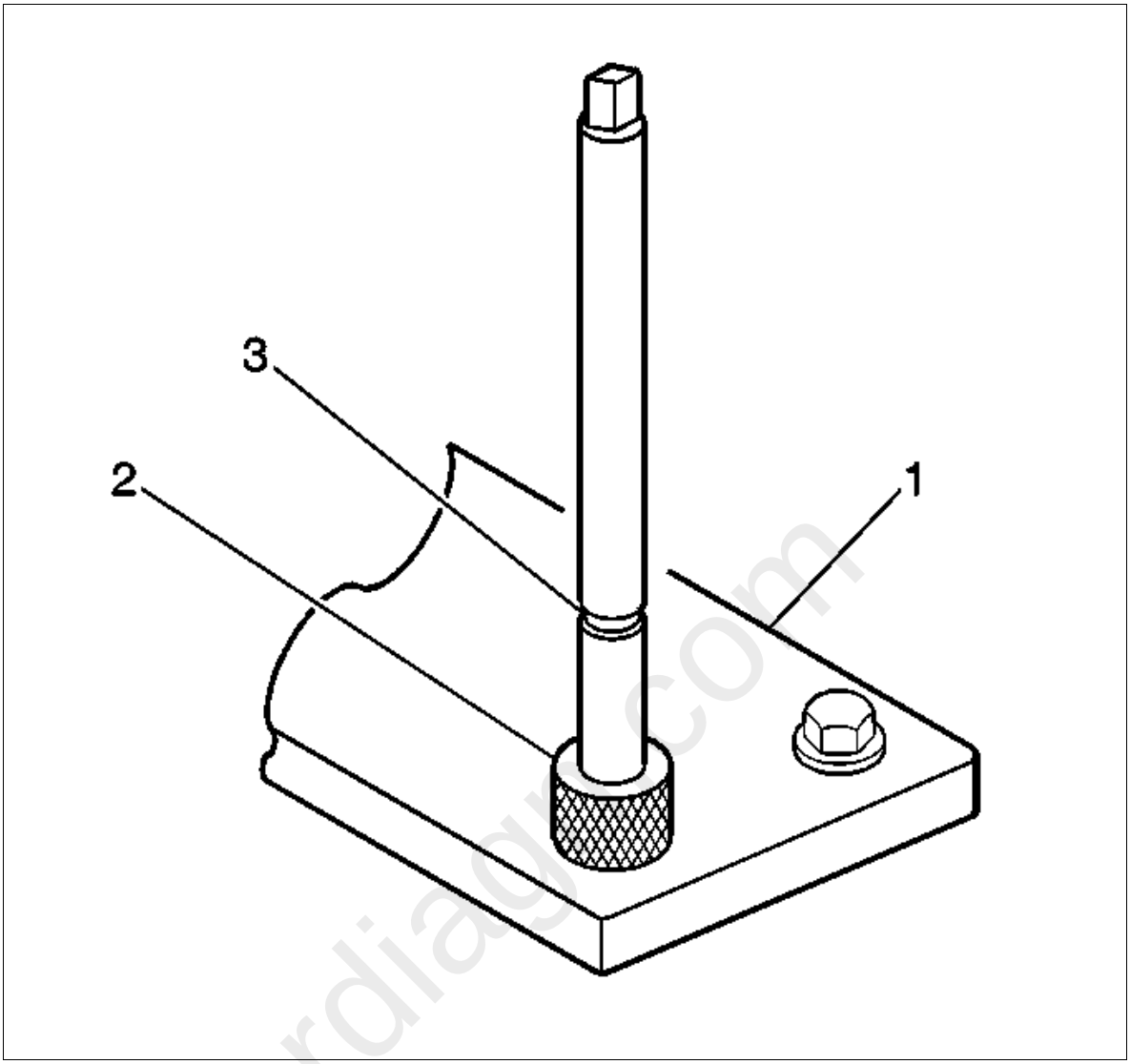
Courtesy of GENERAL MOTORS COMPANY

NOTE:

1. *During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.*
2. *Ensure the tap has created full threads at least to the depth equal to the insert length.*

8. Using a suitable tapping wrench, tap the threads of the drilled hole by hand only.

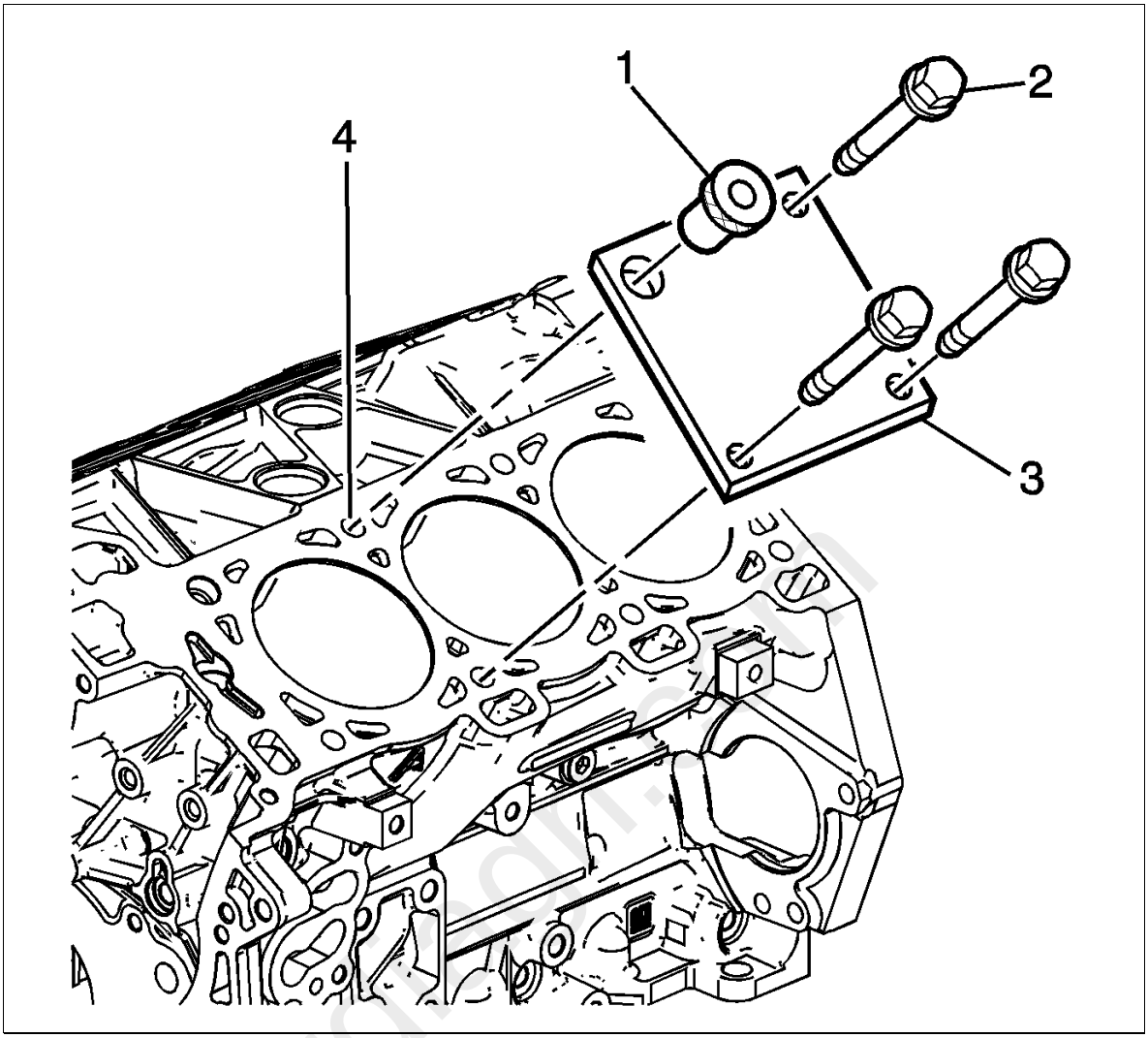
Fig 7: Fixture Plate, Drill Bushing & Tool Marking



Courtesy of GENERAL MOTORS COMPANY

9. In order to tap the new threads for the insert to the proper depth, rotate the tap into the cylinder head bolt hole until the mark (3) on the tap aligns with the top of the drill bushing (2).

Fig 8: Fixture Plate & Components - Cylinder Head Bolt Hole



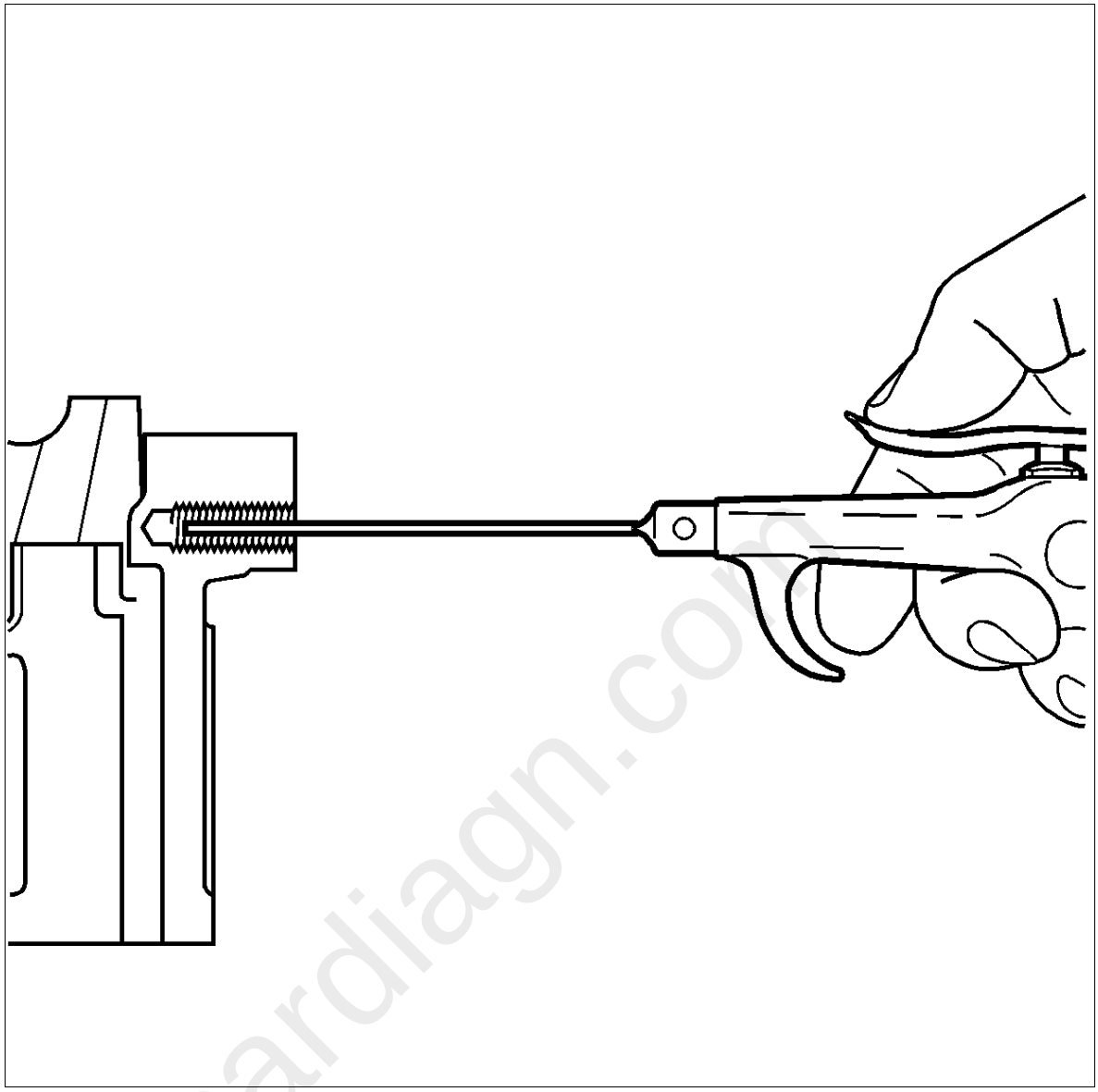
Courtesy of GENERAL MOTORS COMPANY

NOTE:

Remove the fixture plate prior to installing the insert with the installer tool.

10. Remove the fixture plate bolts (2).
11. Remove the fixture plate (3) and bushing (1).

Fig 9: Metal Chips



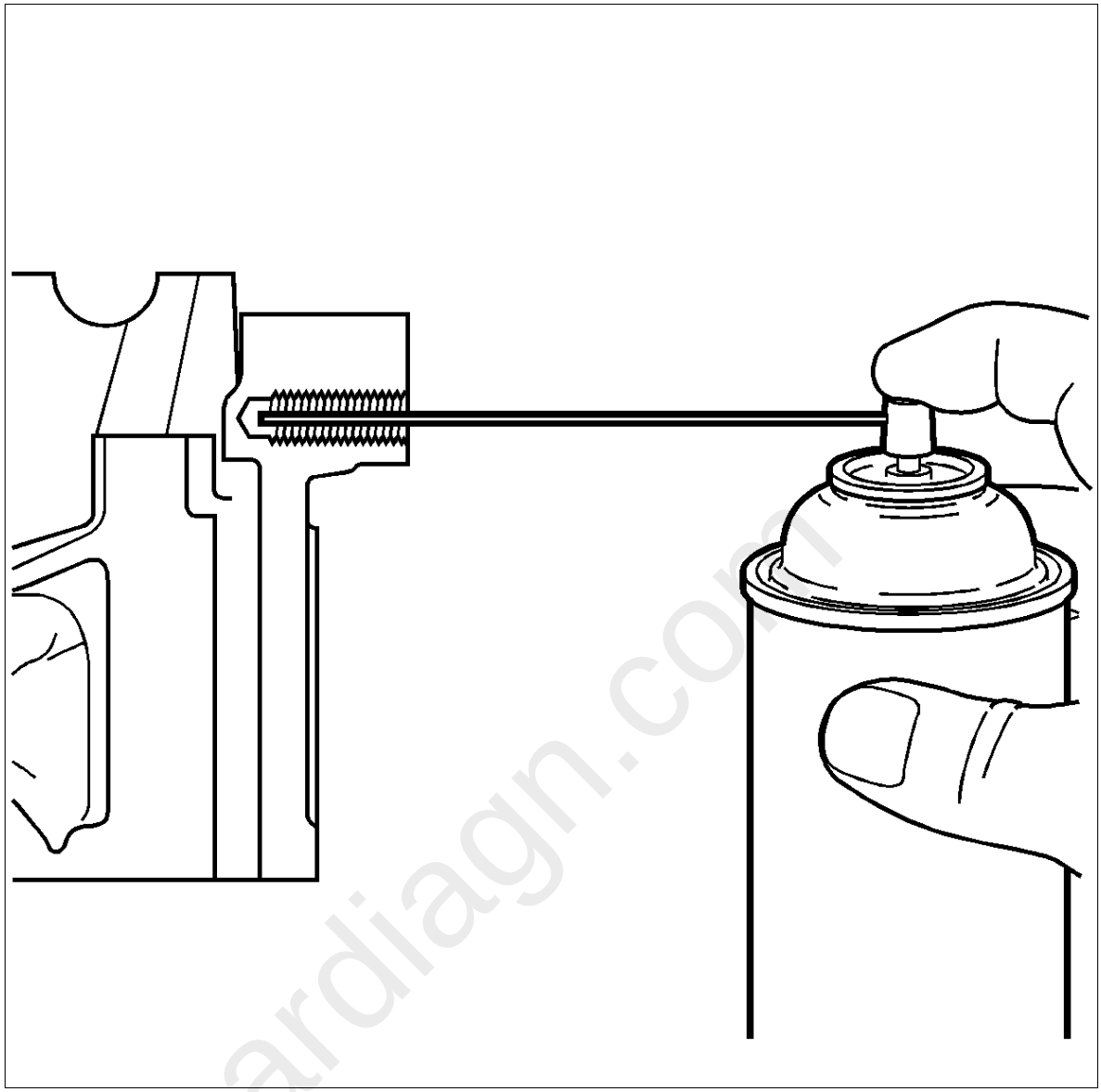
Courtesy of GENERAL MOTORS COMPANY

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> *NOTE:*
>
> *All chips must be removed from the tapped hole prior to insert installation.*

12. Using compressed air, clean out any chips.

Fig 10: Cleaner Into Tapped Hole

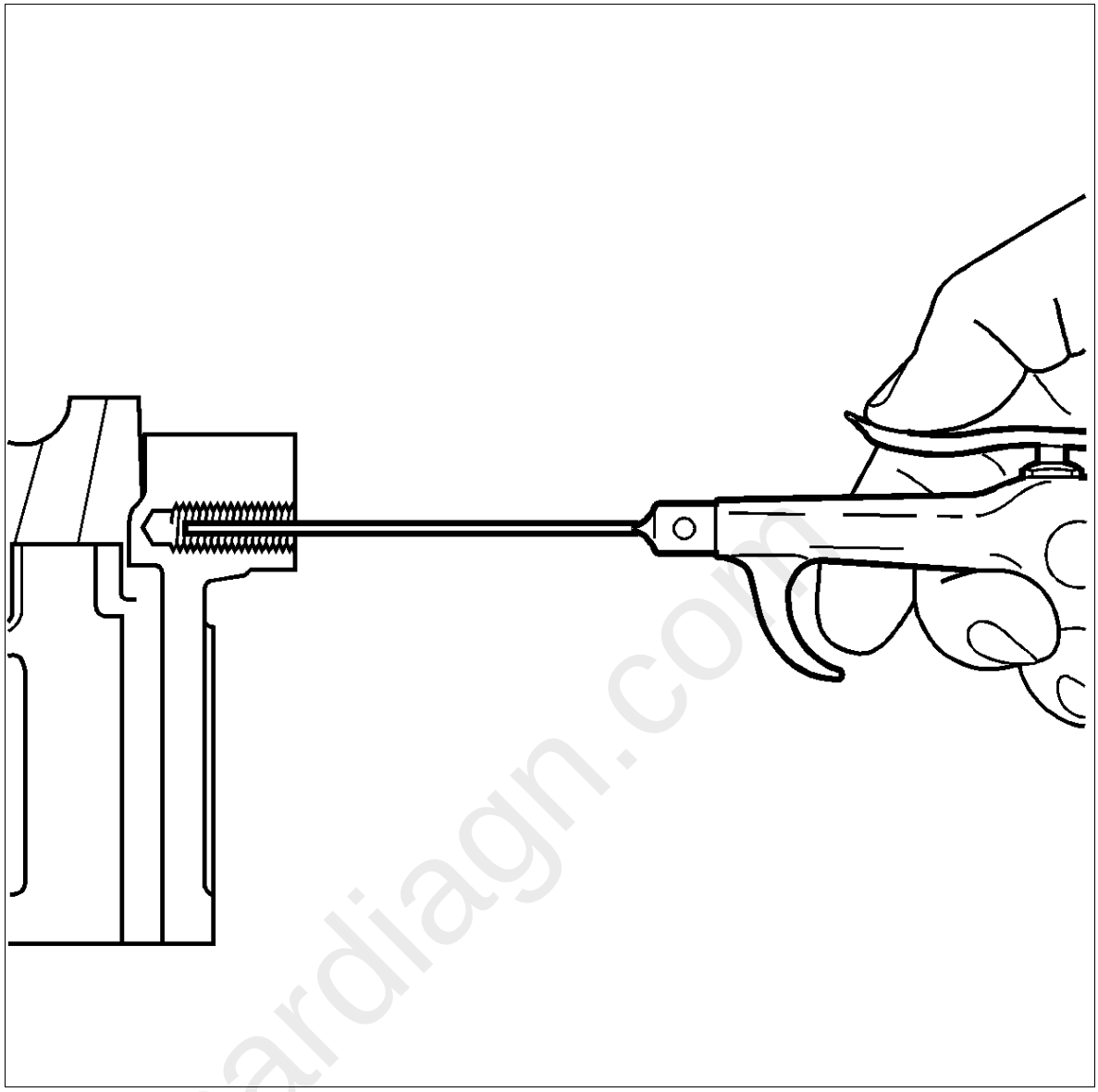


Courtesy of GENERAL MOTORS COMPANY

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13. Spray cleaner into the tapped hole. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended cleaner.

Fig 11: Metal Chips



Courtesy of GENERAL MOTORS COMPANY

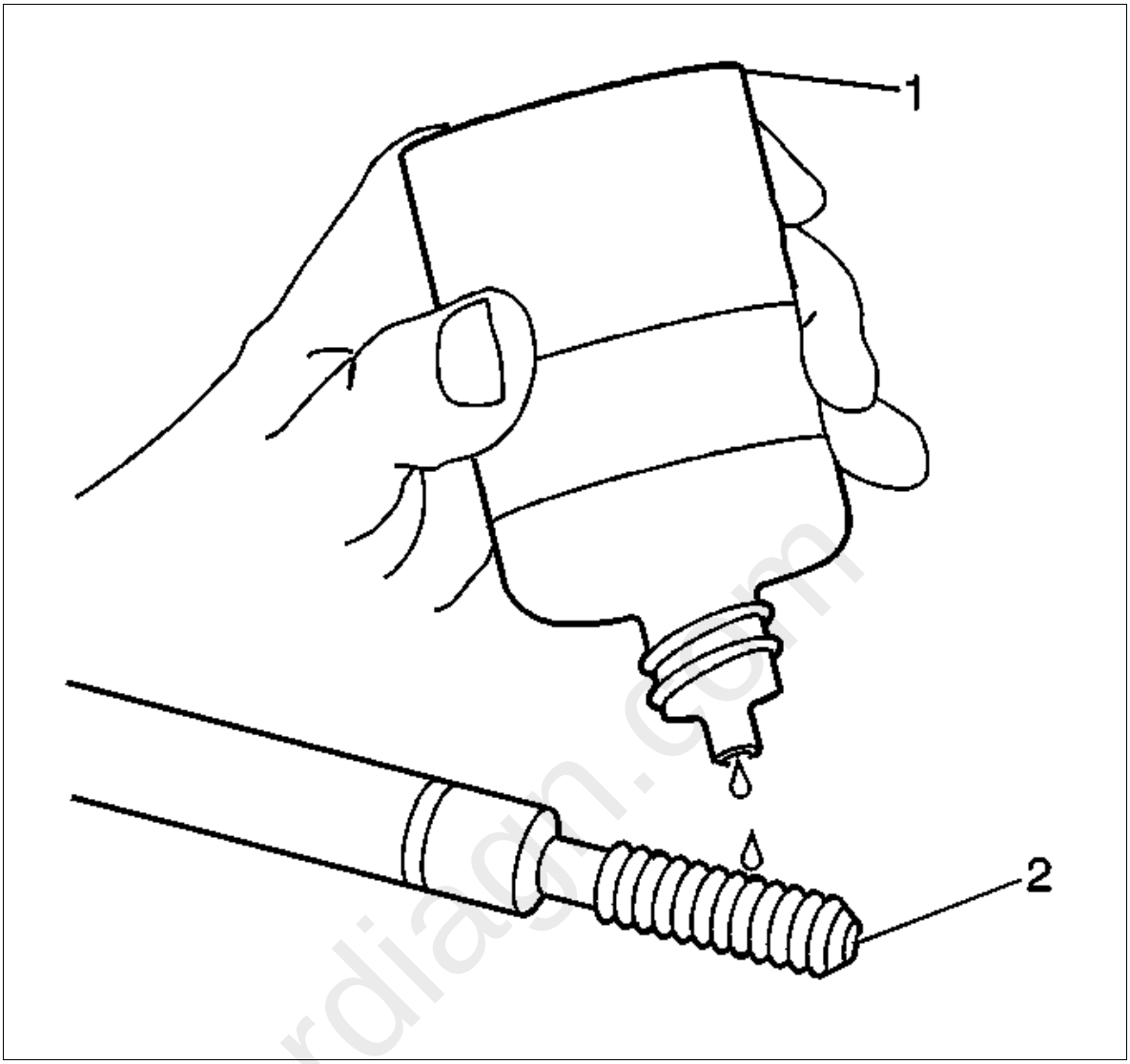
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NOTE:

All chips must be removed from the tapped hole prior to insert installation.

14. Using compressed air, clean out any chips.

Fig 12: Lubricating Installer Tool Using Driver Oil



Courtesy of GENERAL MOTORS COMPANY

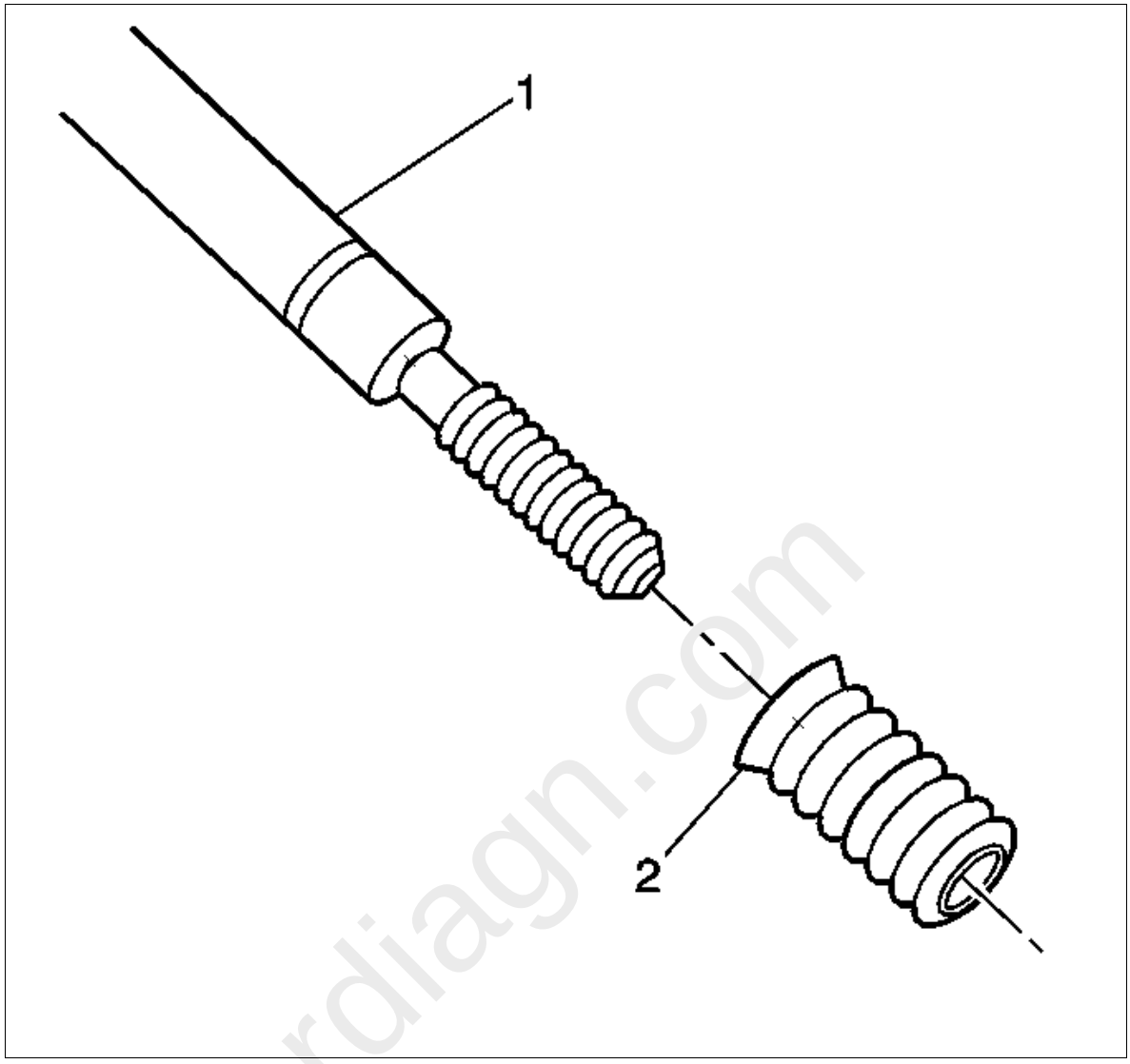
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NOTE:

Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

15. Lubricate the threads of the driver installation tool (2) with the **EN-42385-110** (1).

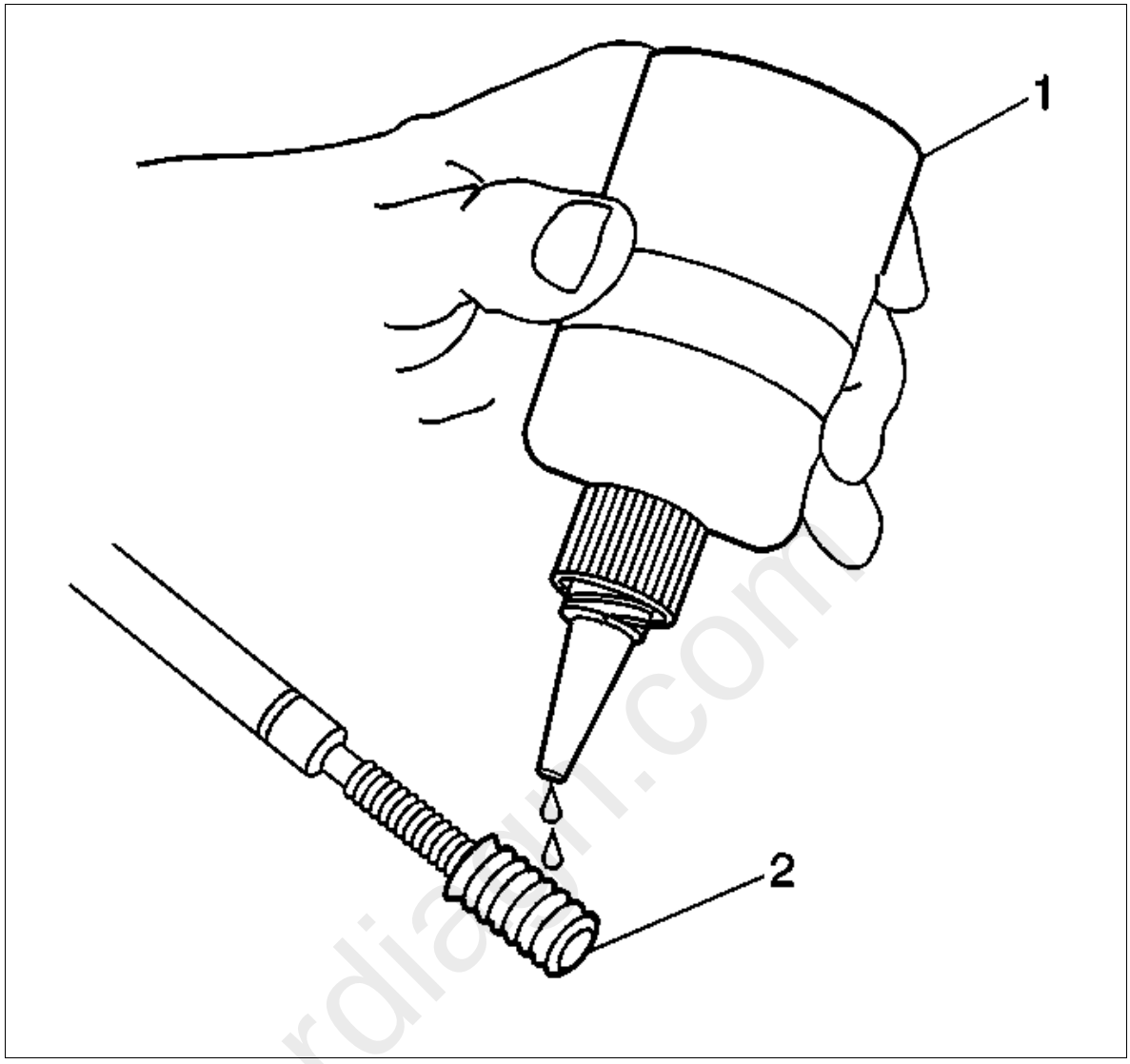
Fig 13: Bushing Type Insert



Courtesy of GENERAL MOTORS COMPANY

16. Install the insert (2) onto the driver installation tool (1).

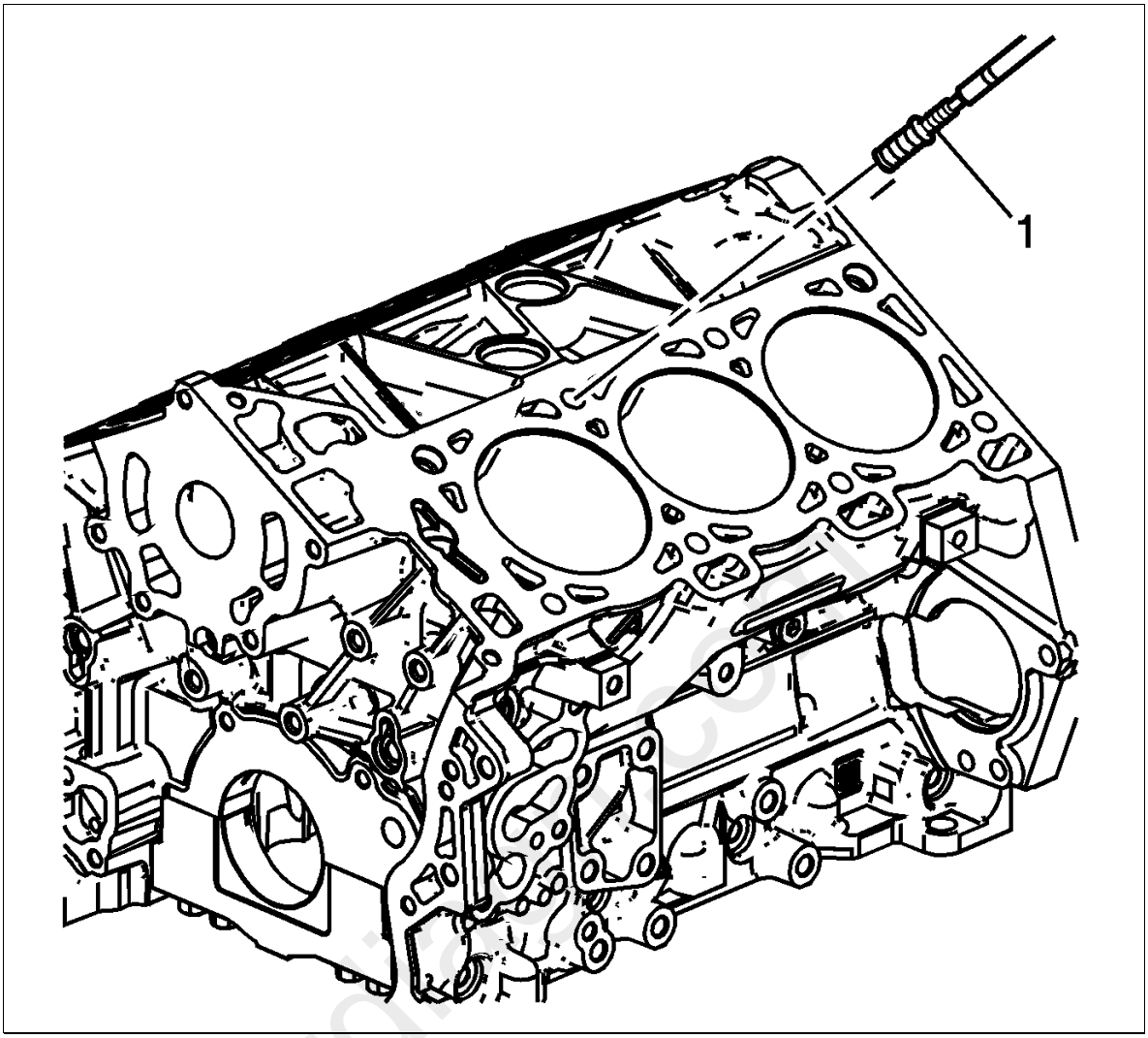
Fig 14: Threadlock To Insert



Courtesy of GENERAL MOTORS COMPANY

17. Apply threadlock sealant, **EN-42385-109** , LOCTITE 277®; or equivalent (1) to the insert OD threads (2). Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended sealant.

Fig 15: Installation Driver By Hand



Courtesy of GENERAL MOTORS COMPANY

18. Install the insert and installation driver (1) into the tapped hole by hand only.
19. Start the insert into the threaded hole.

> *NOTE:*
>
> *If the insert will not thread down until the flange contacts the counterbored surface remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or improper tapping.*

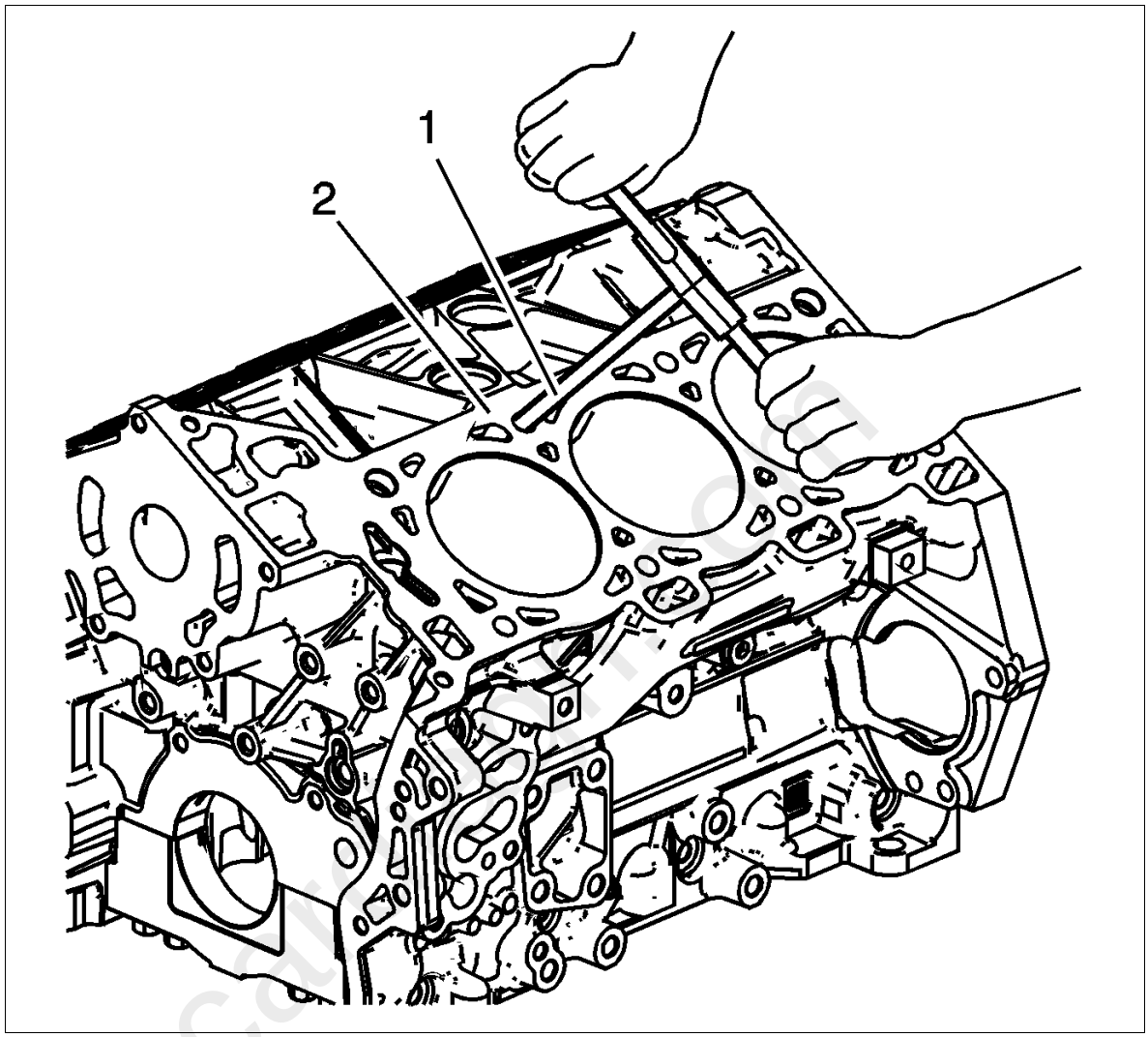
20. Install the insert until the flange of the insert contacts the counterbored surface.

> *NOTE:*
>
> *The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the insert are being formed*

and the insert is mechanically locking the insert into the base material threads.

21. Continue to rotate the driver installation tool through the insert.

    Fig 16: Driver Installation Tool & Surface Of Engine Block Deck



Courtesy of GENERAL MOTORS COMPANY

22. In order to completely form the new threads in the insert, rotate the driver installation tool through the insert until the mark (1) on the driver installation tool aligns with the surface of the engine block deck (2).

23. Inspect the insert for proper installation into the tapped hole.

REPAIR INSTRUCTIONS - OFF VEHICLE > THREAD REPAIR > CRANKSHAFT MAIN BOLT HOLE THREAD REPAIR

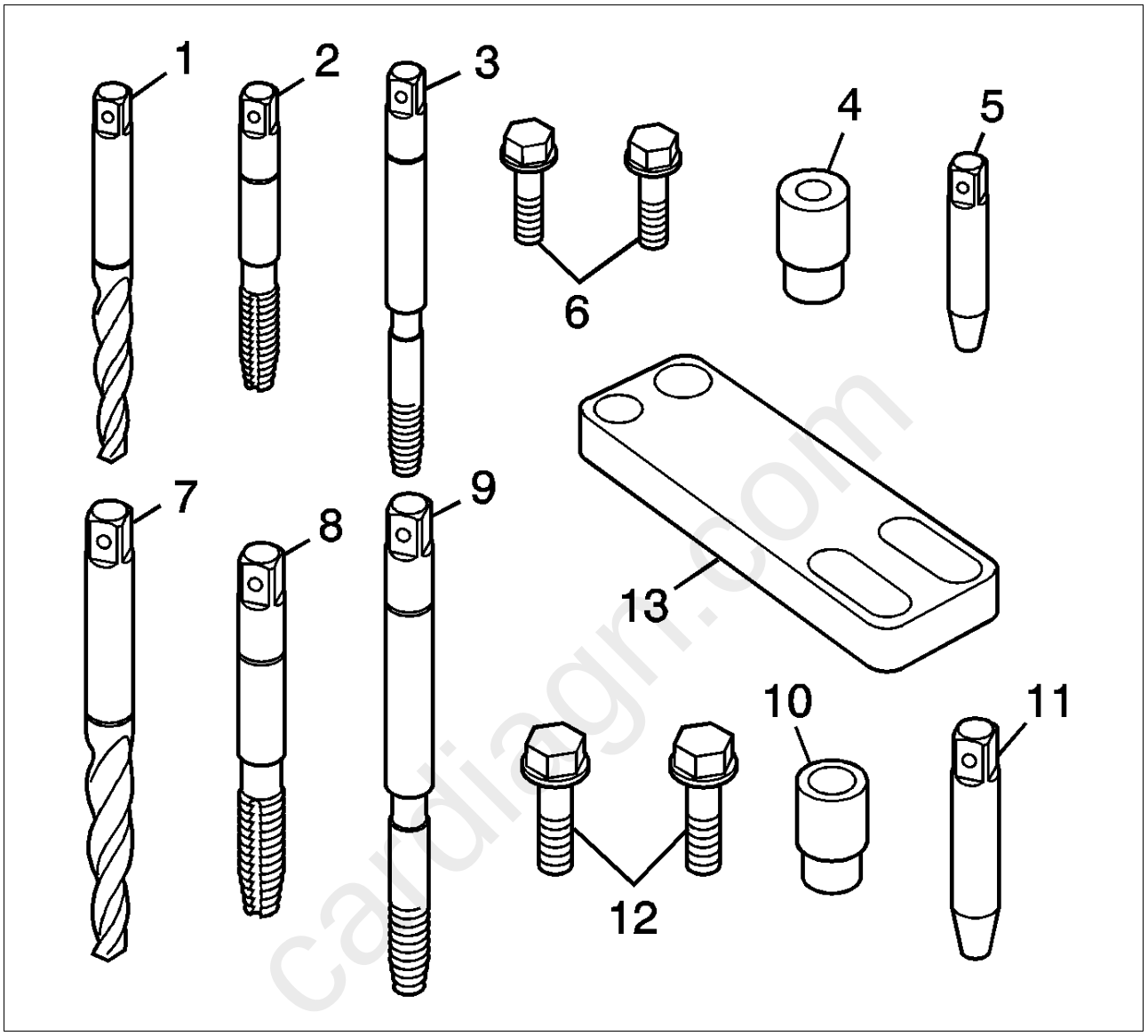
Special Tools

- **EN-42385-700** High Feature Thread Repair Kit

- **EN-42385-2000** Thread Insert Kit

For equivalent regional tools, refer to Special Tools .

Fig 1: High Feature Thread Repair Kit



Courtesy of GENERAL MOTORS COMPANY

NOTE:

- *In order to repair some crankshaft main bolt holes it will be necessary to mount the fixture plate upside down.*
- *Do NOT remove the fixture plate prior to installing the insert with the installation driver. The fixture plate remains in position throughout the thread repair process.*

The crankshaft main bearing bolt hole thread repair tooling are in the kits **EN-42385-2000** insert kit and **EN-42385-700** kit. The crankshaft main bearing bolt hole thread repair components consist of the

following:

- **EN-42385-702** Drill (1) for outboard holes
- **EN-42385-703** Tap (2) for outboard holes
- **EN-42385-704** Installation driver (3) for outboard holes
- **EN-42385-726** Bushing (4) for outboard holes
- **EN-42385-727** Alignment pin (5) for outboard holes
- **EN-42385-728** Bolts (6) for outboard holes
- **EN-42385-720** Drill (7) for inboard holes
- **EN-42385-721** Tap (8) for inboard holes
- **EN-42385-722** I nstallation driver (9) for inboard holes
- **EN-42385-713** Bushing (10)
- **EN-42385-308** Alignment pin (11)
- **EN-42385-734** Bolts (12)
- **EN-42385-712** Fixture plate (13)

REPAIR INSTRUCTIONS - OFF VEHICLE > THREAD REPAIR > OUTBOARD BOLT HOLES

WARNING:

Refer to Safety Glasses Warning .

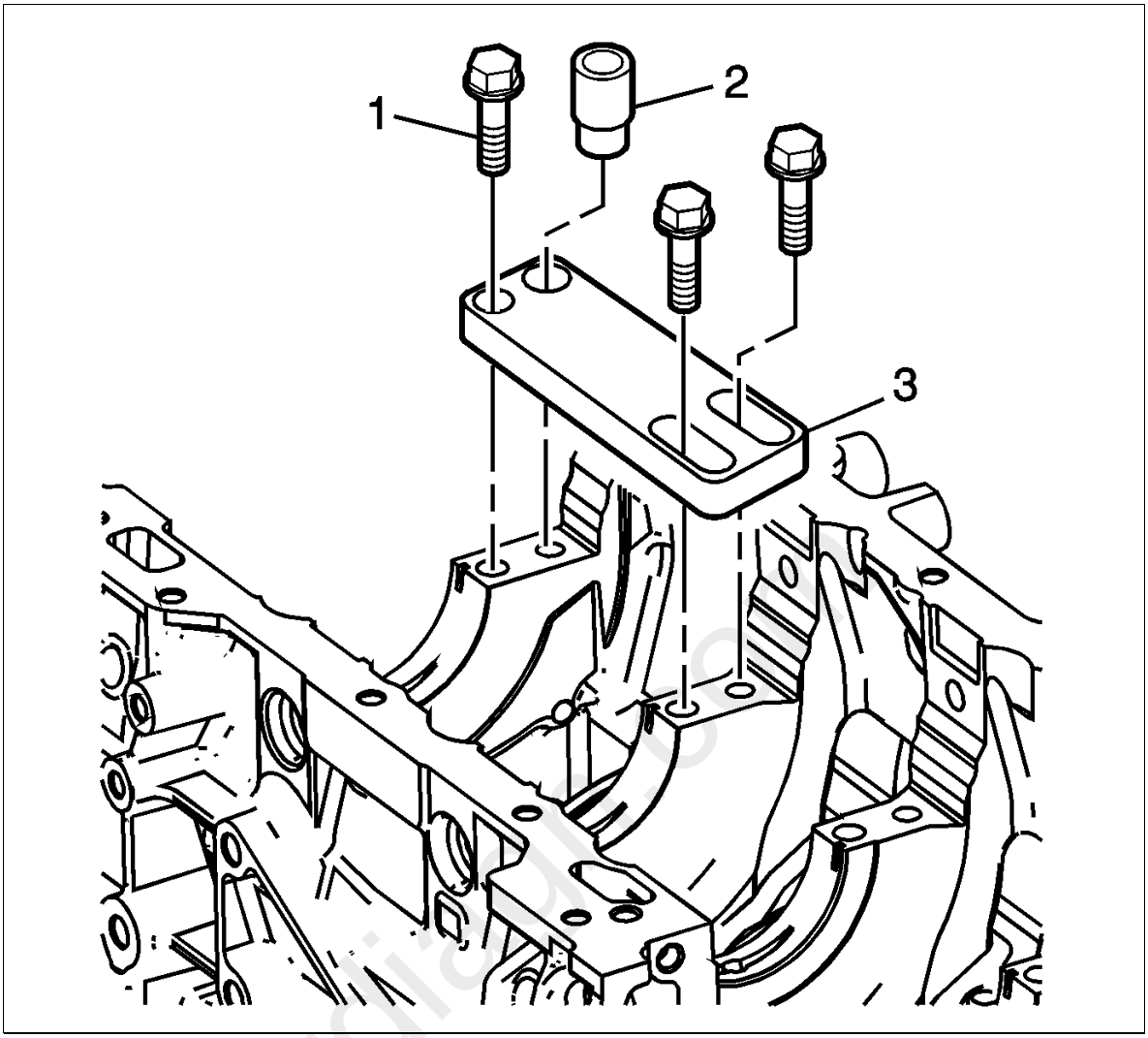
NOTE:

- *Ensure the fixture plate is installed during the machining and installation processes of the insert.*
- *The use of a cutting type fluid, WD 40® or equivalent is recommended when performing the drilling, counterboring and tapping procedures. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended cutting fluid.*

When installed to the proper depth, the flange of the insert will be seated against the counterbore of the drilled/tapped hole.

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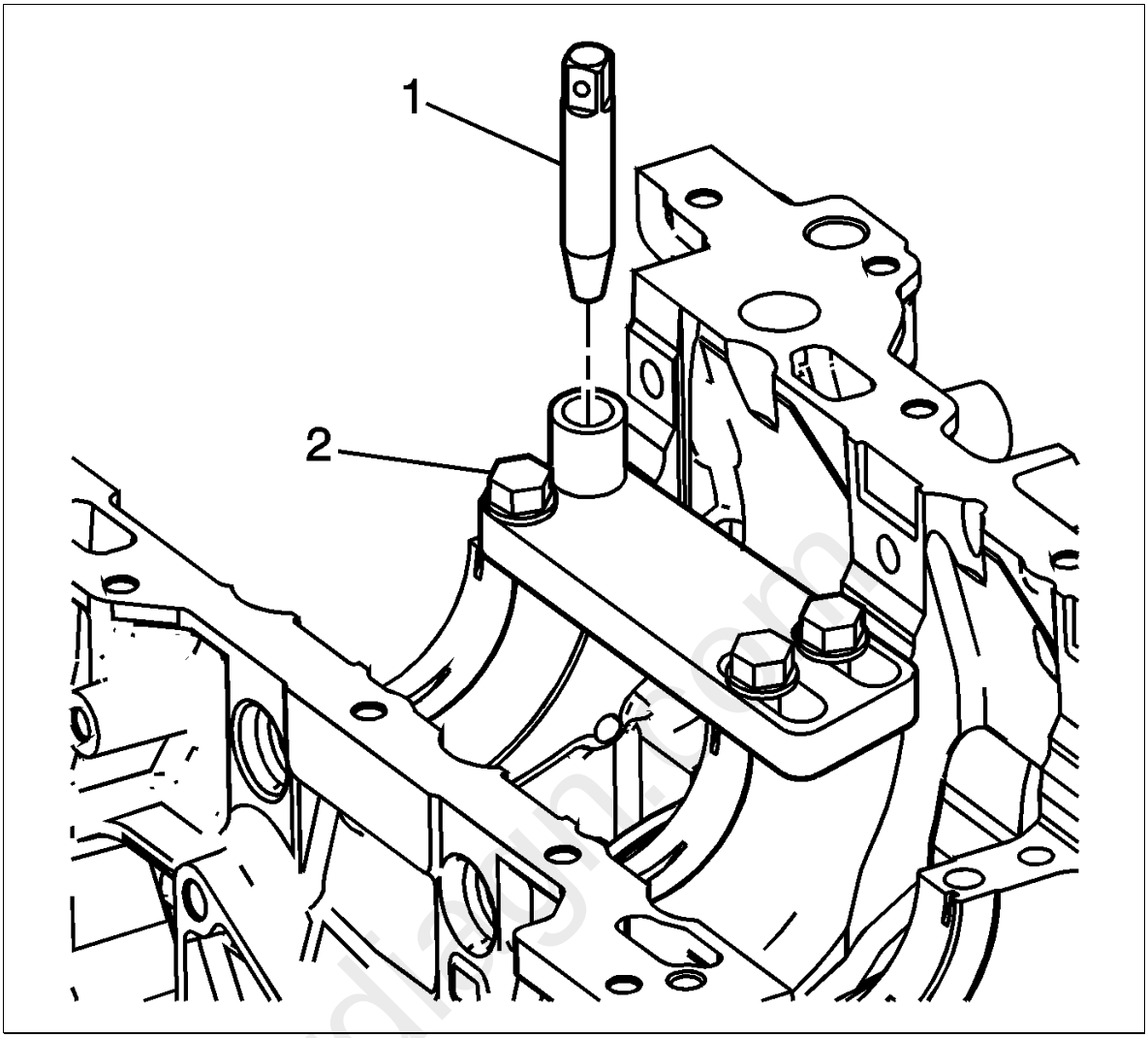
Fig 1: Fixture Plate Over Crankshaft Main Cap Bolt Hole



Courtesy of GENERAL MOTORS COMPANY

1. Position the fixture plate (3) with the bushing (2) installed over the crankshaft main cap bolt hole to be repaired.
2. Loosely install the fixture plate bolts (1) into the remaining crankshaft main cap bolt holes.

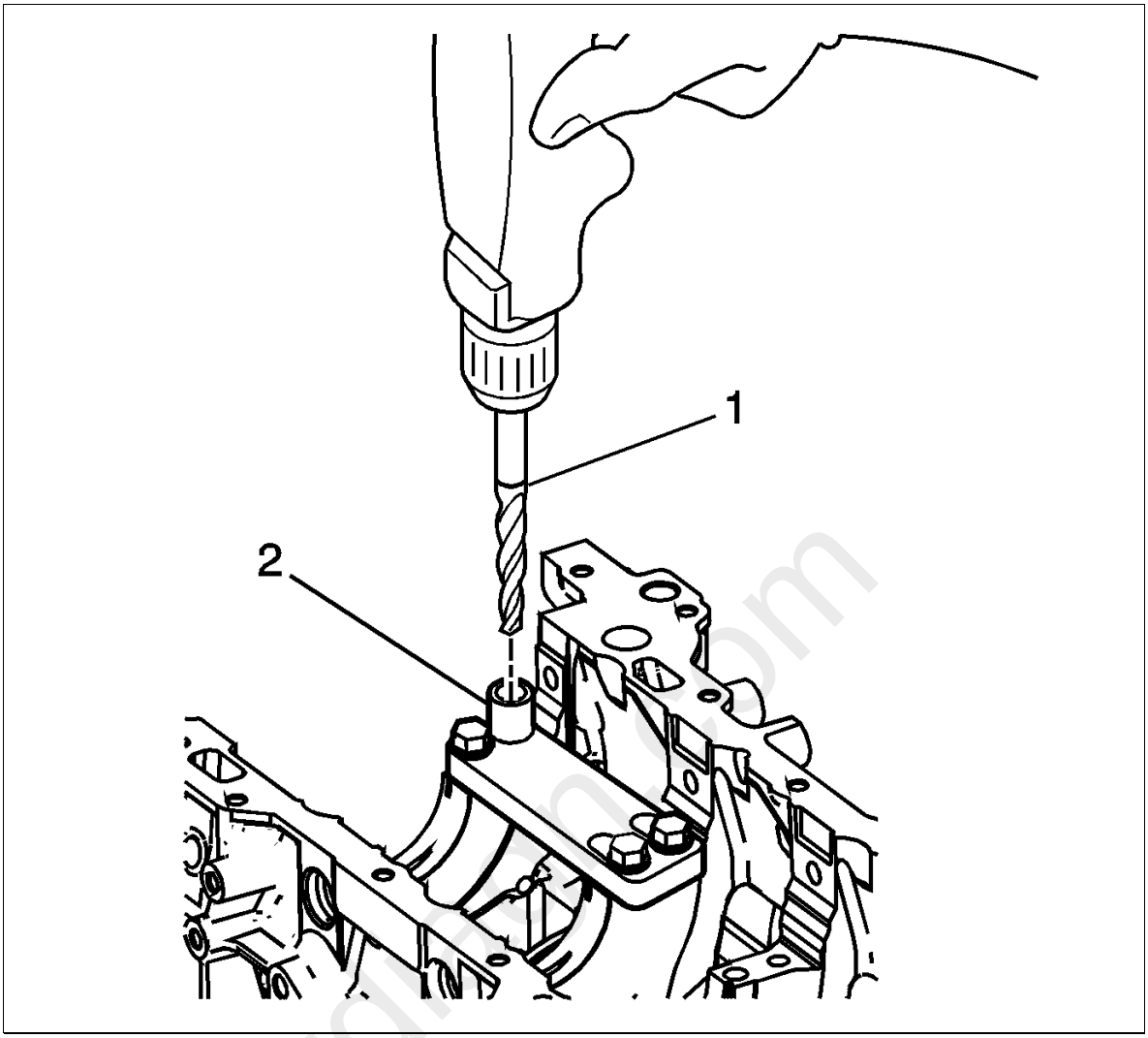
Fig 2: Alignment Pin & Bushing



Courtesy of GENERAL MOTORS COMPANY

3. Position the alignment pin (1) through the bushing and into the crankshaft main cap bolt hole.
4. With the alignment pin in the desired crankshaft main cap bolt hole, tighten the fixture retaining bolts (2).
5. Remove the alignment pin (1) from the crankshaft main cap bolt hole.

Fig 3: Drill & Drill Bushing



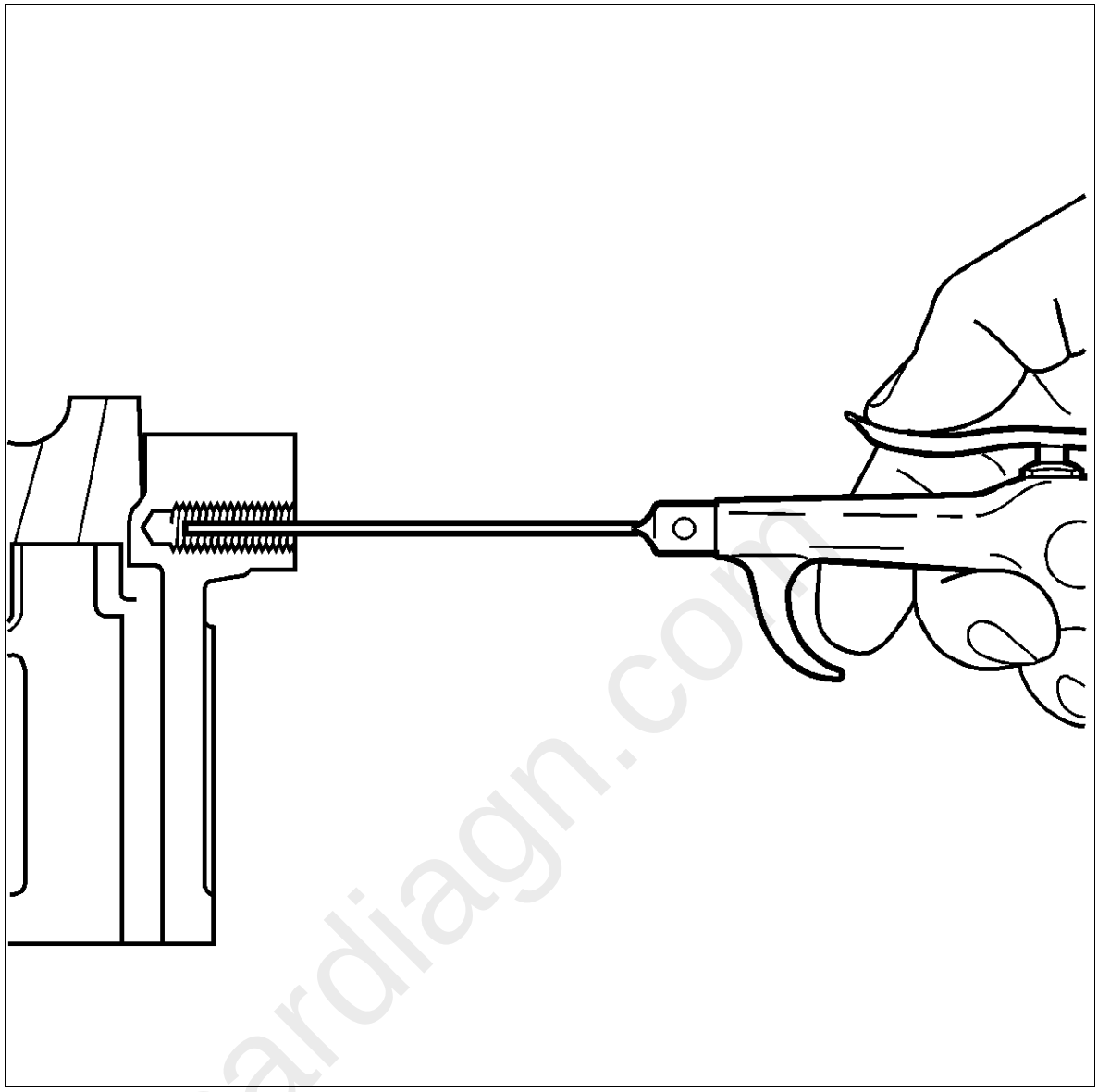
Courtesy of GENERAL MOTORS COMPANY

NOTE:

1. *During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.*
2. *Drill the crankshaft main bolt hole until the mark (1) on the drill aligns with the top of the drill bushing (2).*

6. Drill out the threads of the damaged hole.

Fig 4: Metal Chips



Courtesy of GENERAL MOTORS COMPANY

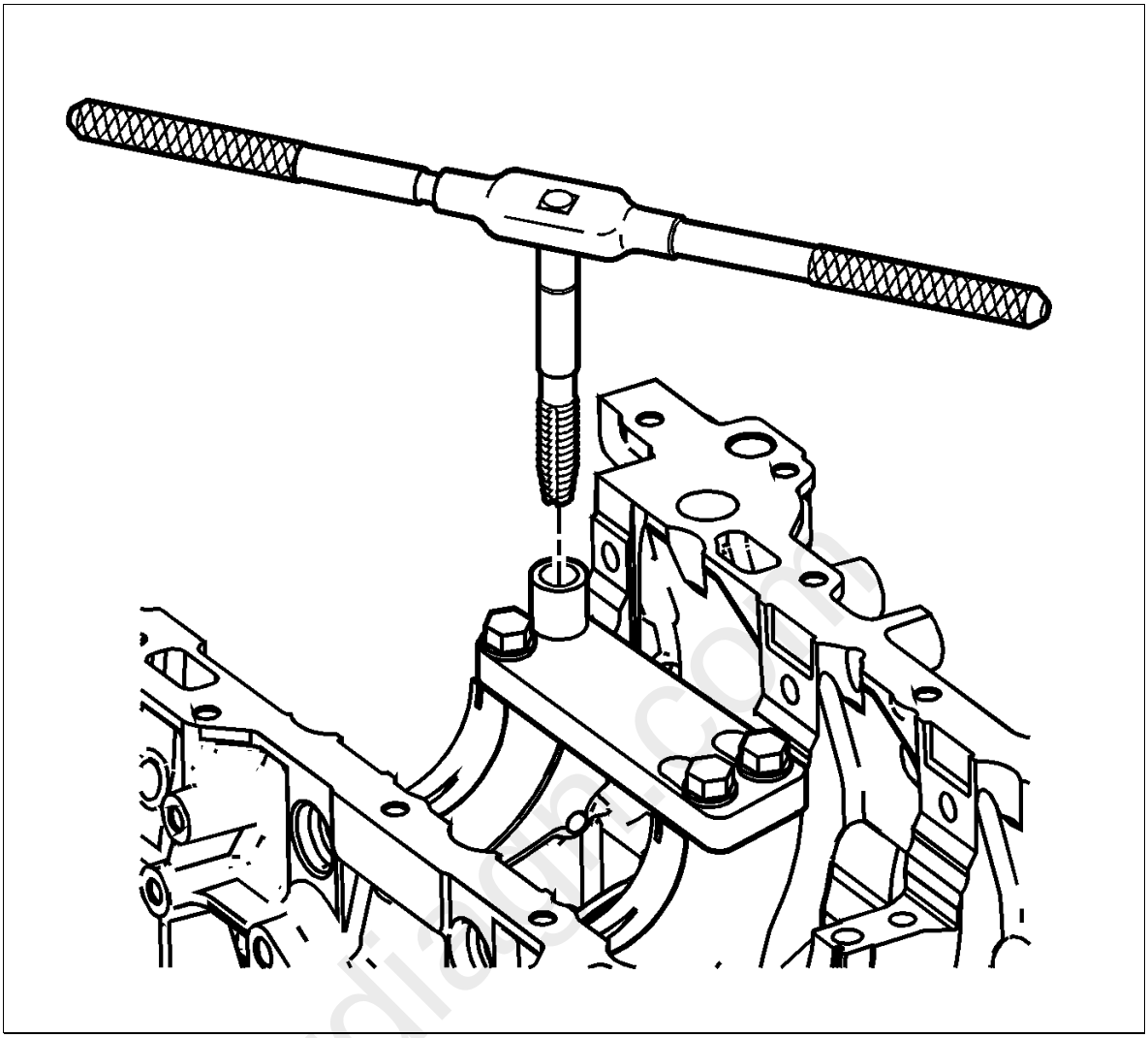
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NOTE:

All chips must be removed from the drilled hole prior to tapping.

7. Using compressed air, clean out any chips.

Fig 5: Tapping Wrench



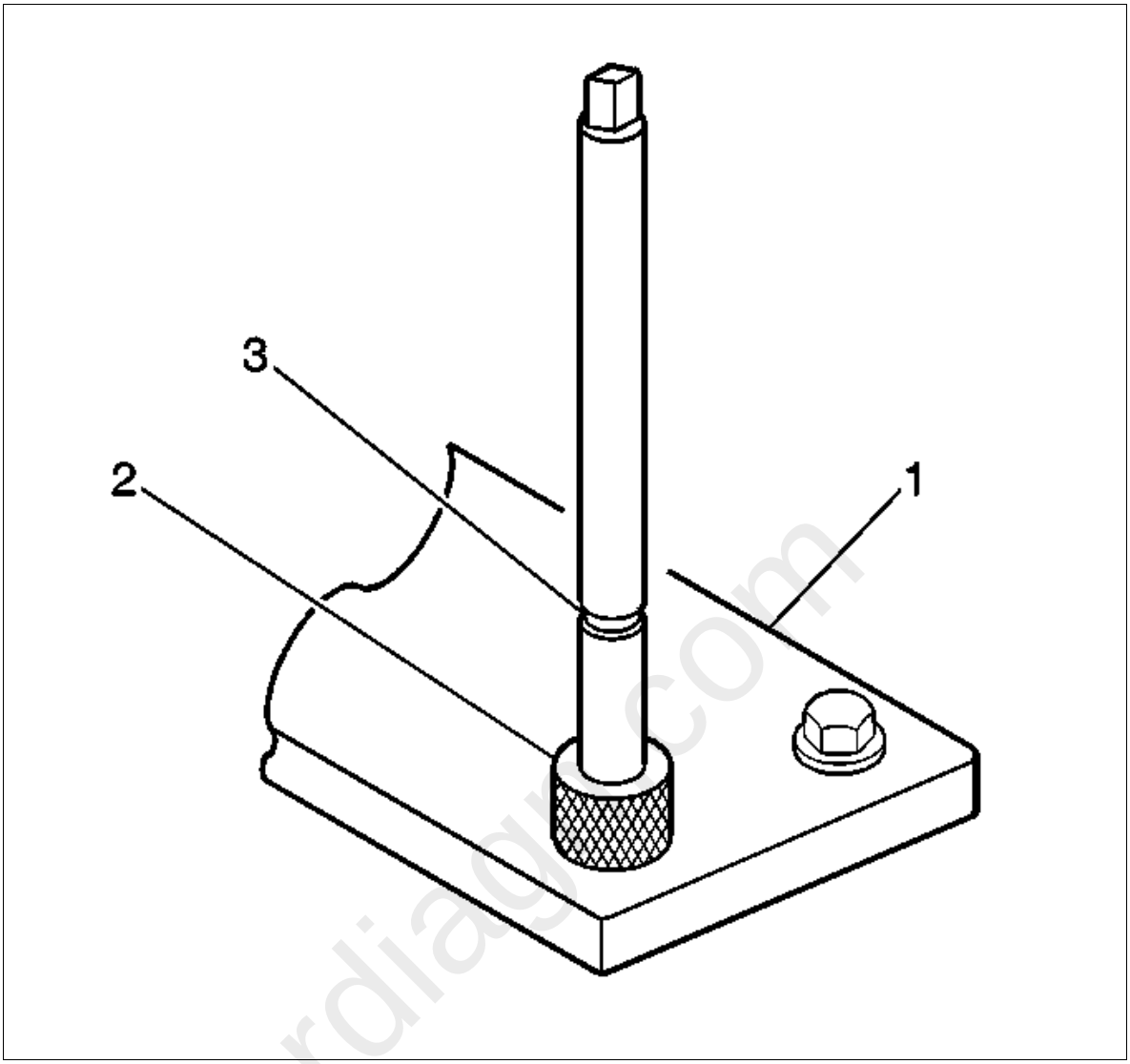
Courtesy of GENERAL MOTORS COMPANY

NOTE:

1. *Do not remove the fixture plate, ensure the fixture plate is installed during the machining and installation processes of the insert.*
2. *During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.*
3. *Ensure the tap has created full threads at least to the depth equal to the insert length.*

8. Using a suitable tapping wrench, tap the threads of the drilled hole by hand only.

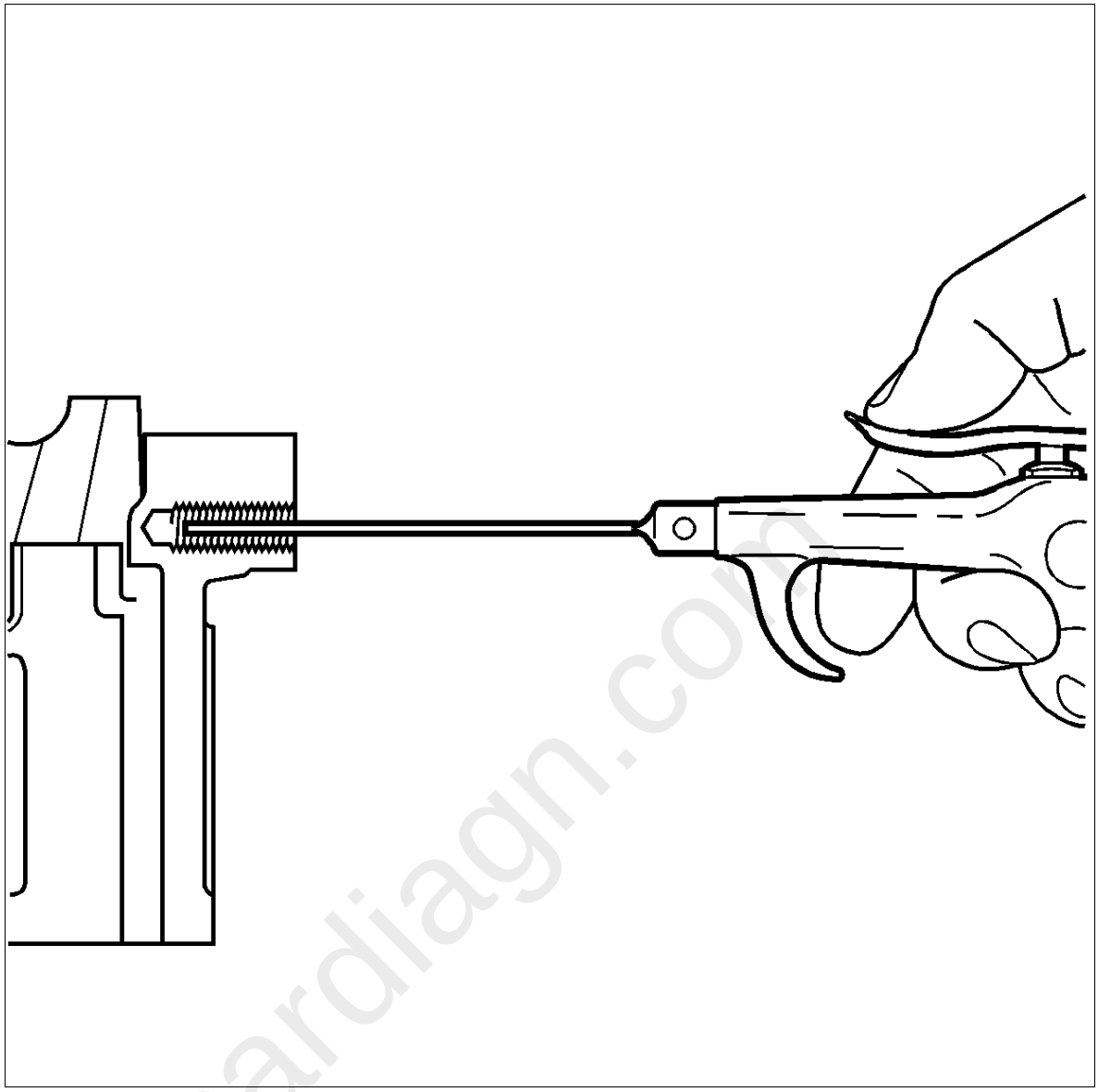
Fig 6: Fixture Plate, Drill Bushing & Tool Marking



Courtesy of GENERAL MOTORS COMPANY

9. In order to tap the new threads for the insert to the proper depth, rotate the tap into the crankshaft main cap bolt hole until the mark (3) on the tap aligns with the top of the drill bushing (2).

Fig 7: Metal Chips



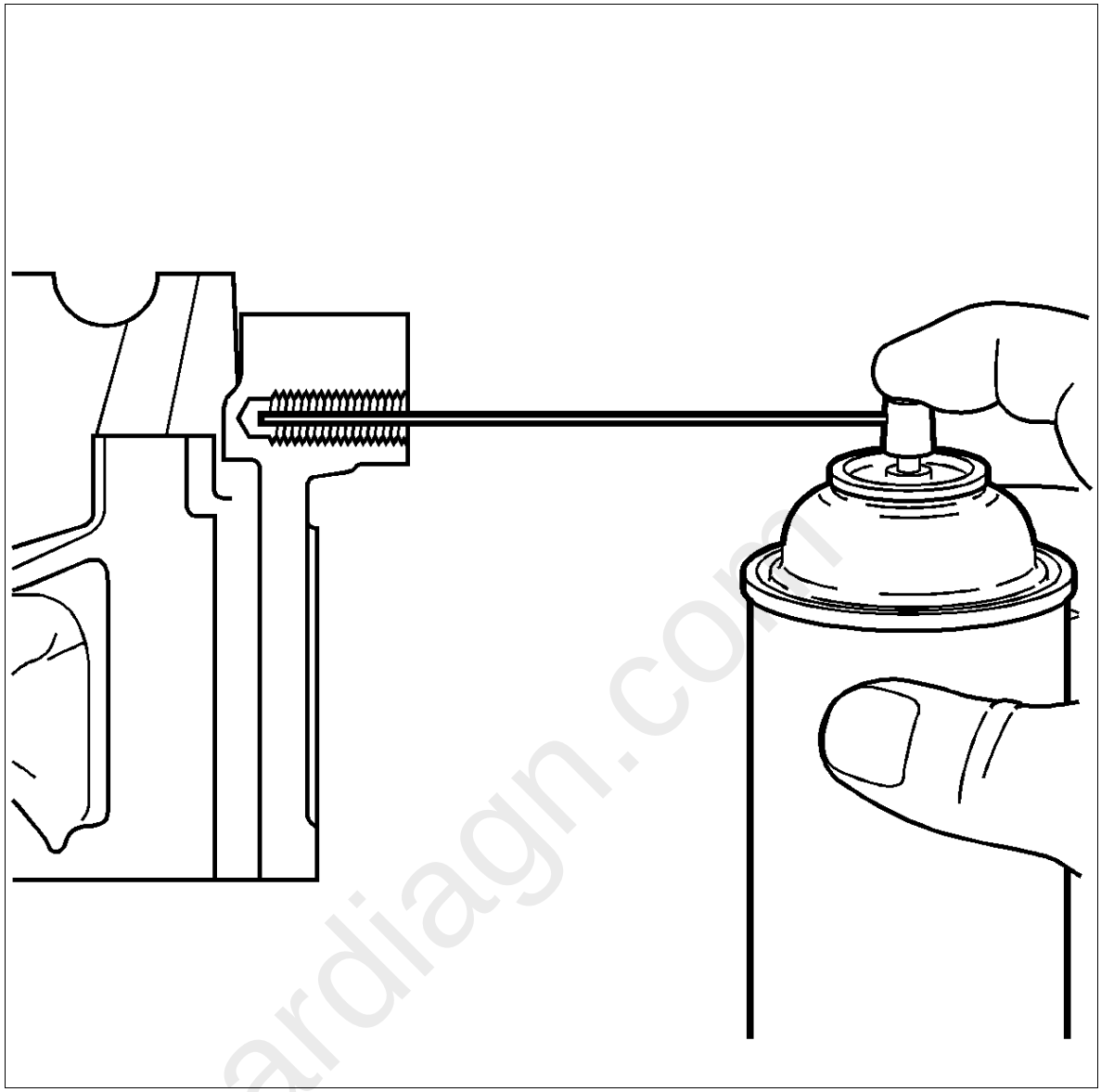
Courtesy of GENERAL MOTORS COMPANY

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> *NOTE:*
>
> *All chips must be removed from the tapped hole prior to insert installation.*

10. Using compressed air, clean out any chips.

Fig 8: Cleaner Into Tapped Hole

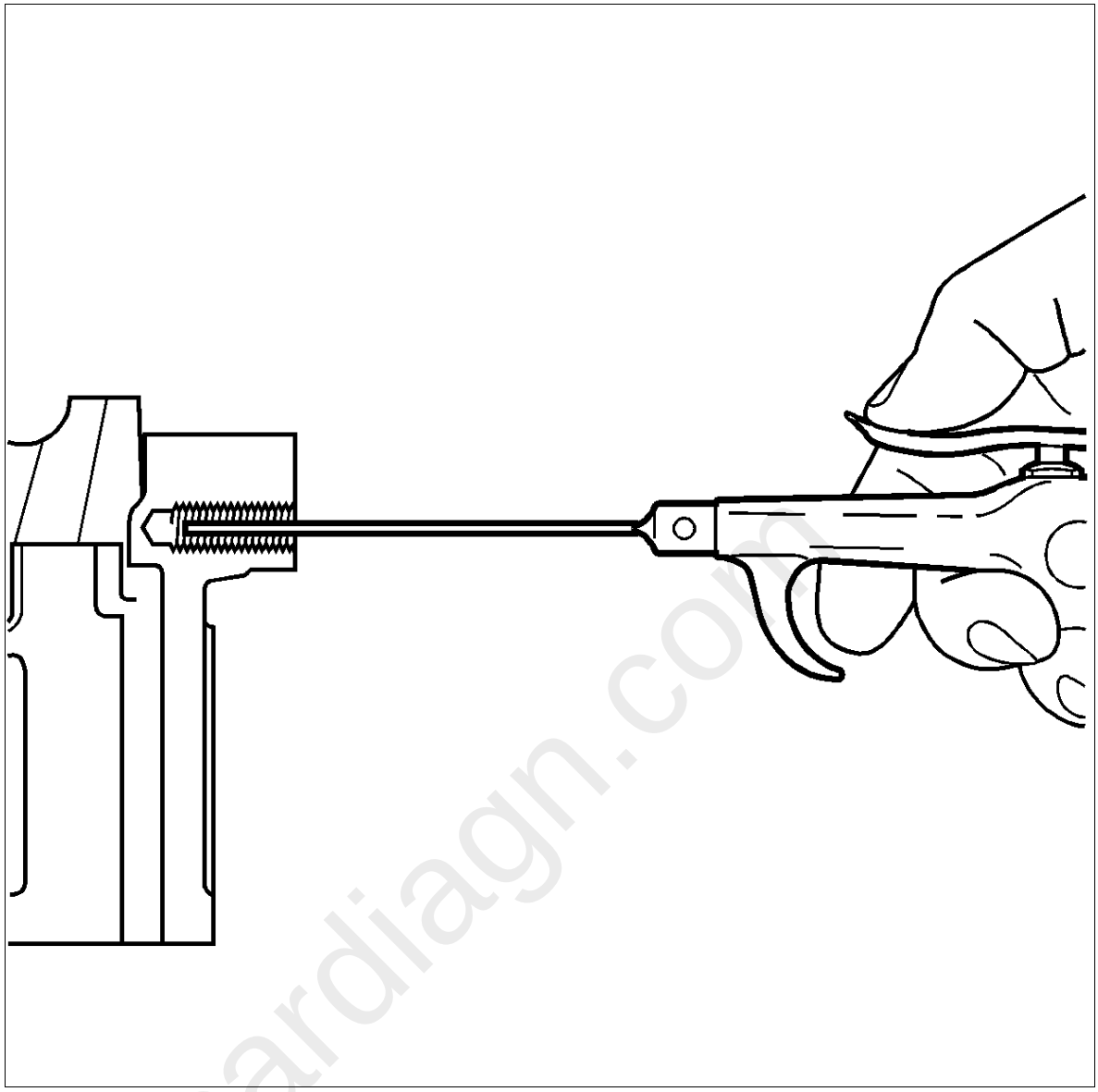


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11. Spray cleaner into the tapped hole. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended cleaner.

Fig 9: Metal Chips



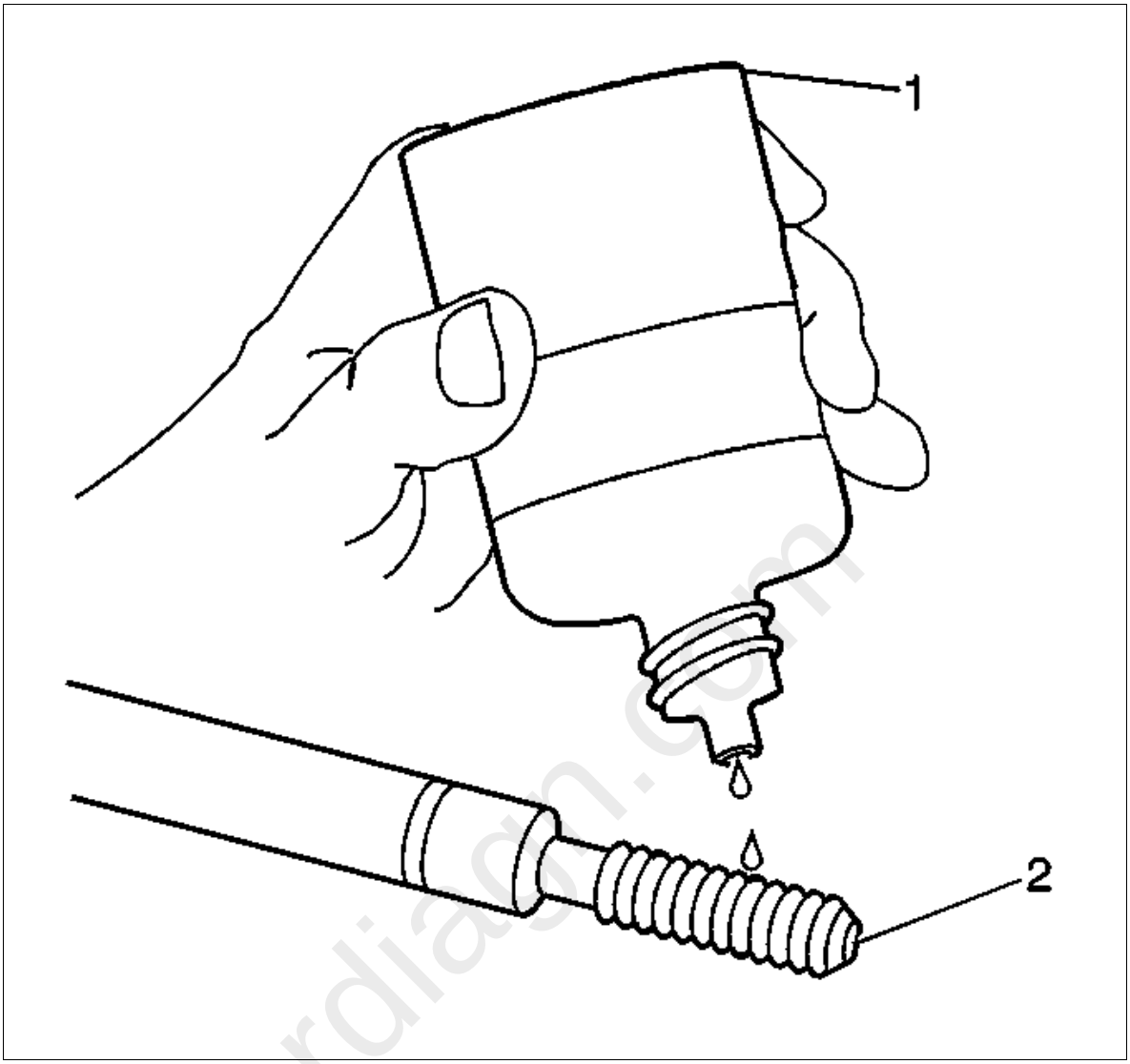
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> *NOTE:*
>
> *All chips must be removed from the tapped hole prior to insert installation.*

12. Using compressed air, clean out any chips.

Fig 10: Lubricating Installer Tool Using Driver Oil



Courtesy of GENERAL MOTORS COMPANY

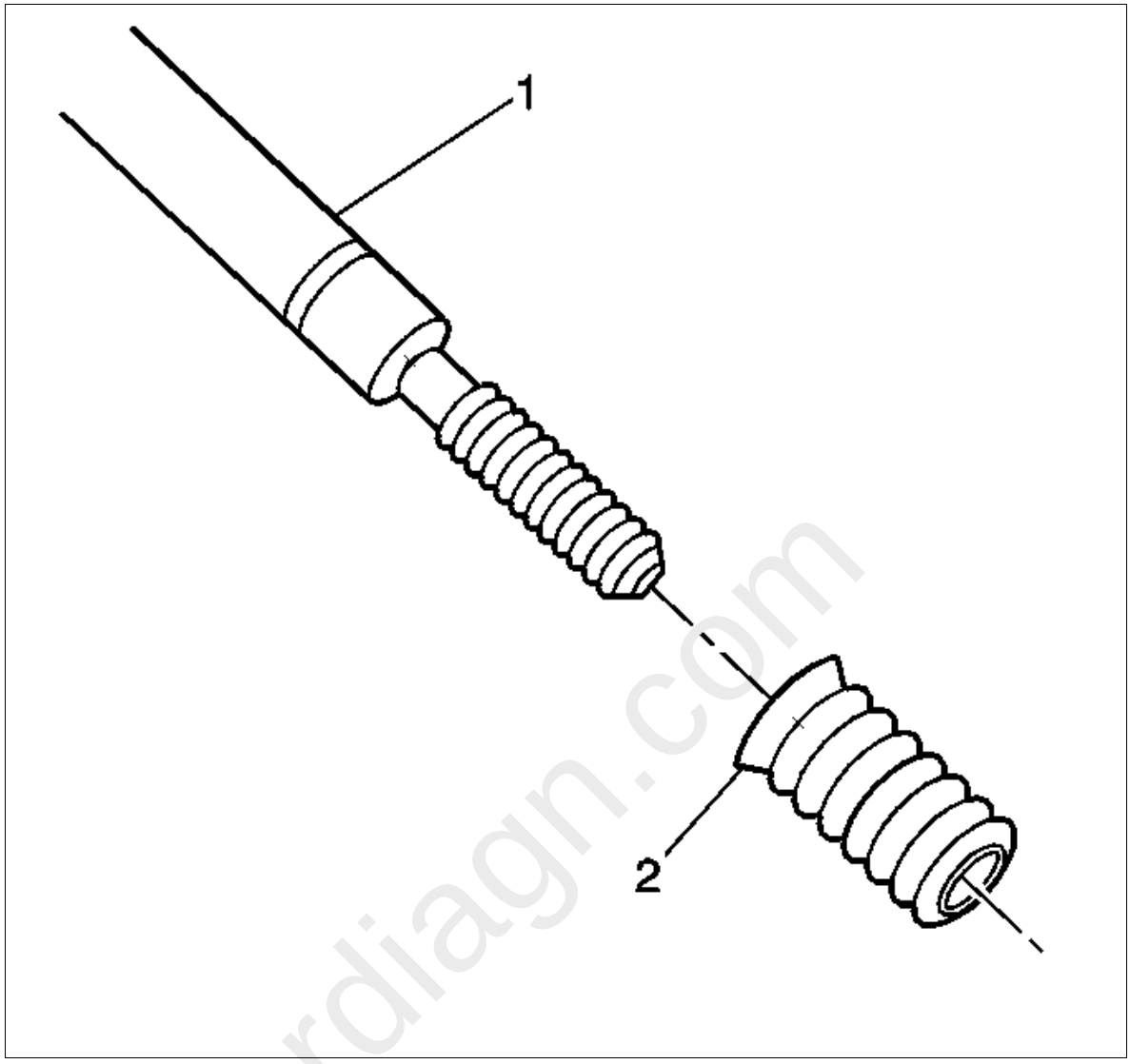
NOTE:

1. *Do not remove the fixture plate, ensure the fixture plate is installed during the installation process of the insert.*
2. *Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.*

13. Lubricate the threads of the driver installation tool (2) with the **EN-42385-110** (1).

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Fig 11: Bushing Type Insert

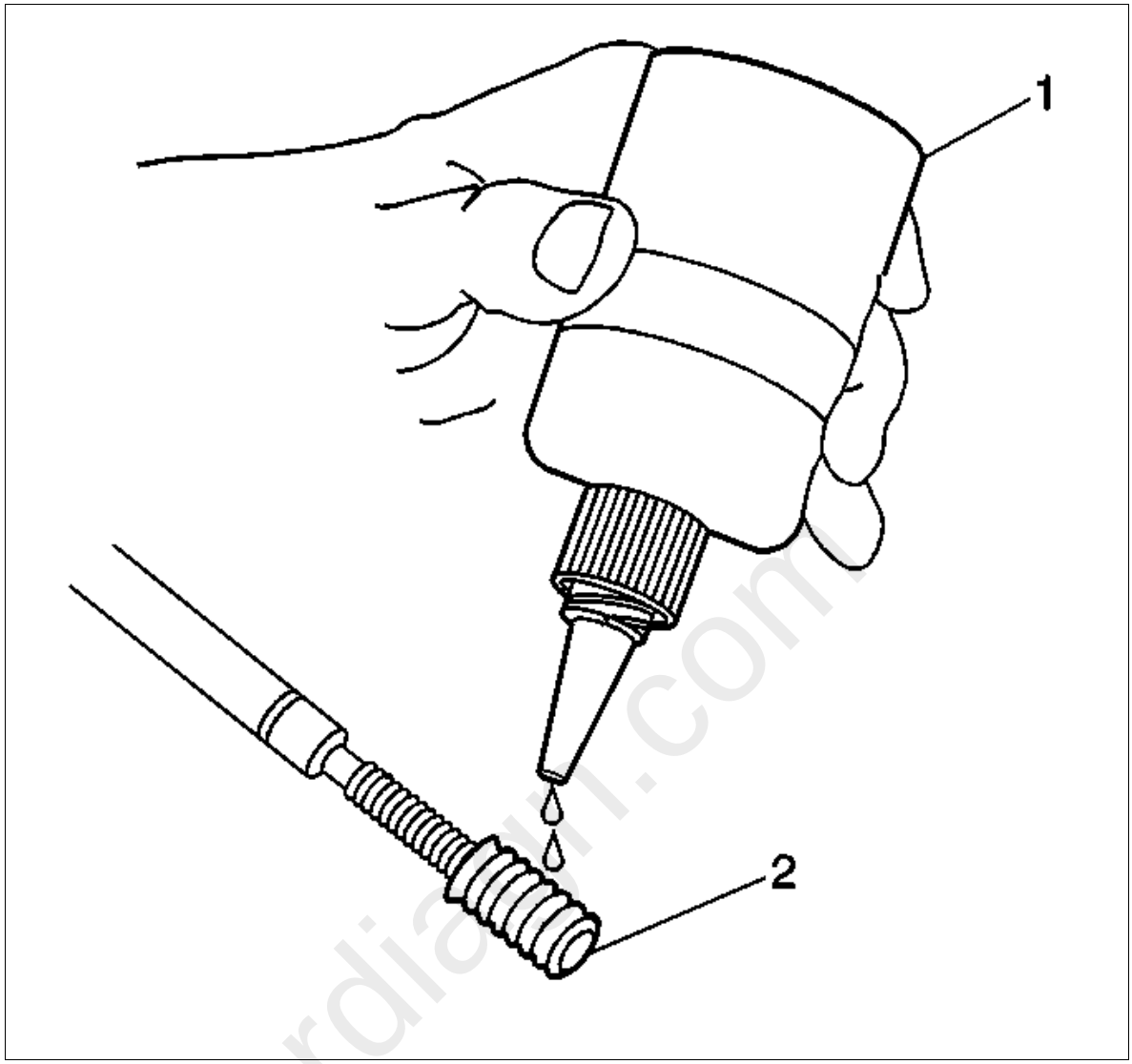


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14. Install the insert (2) onto the driver installation tool (1).

Fig 12: Threadlock To Insert

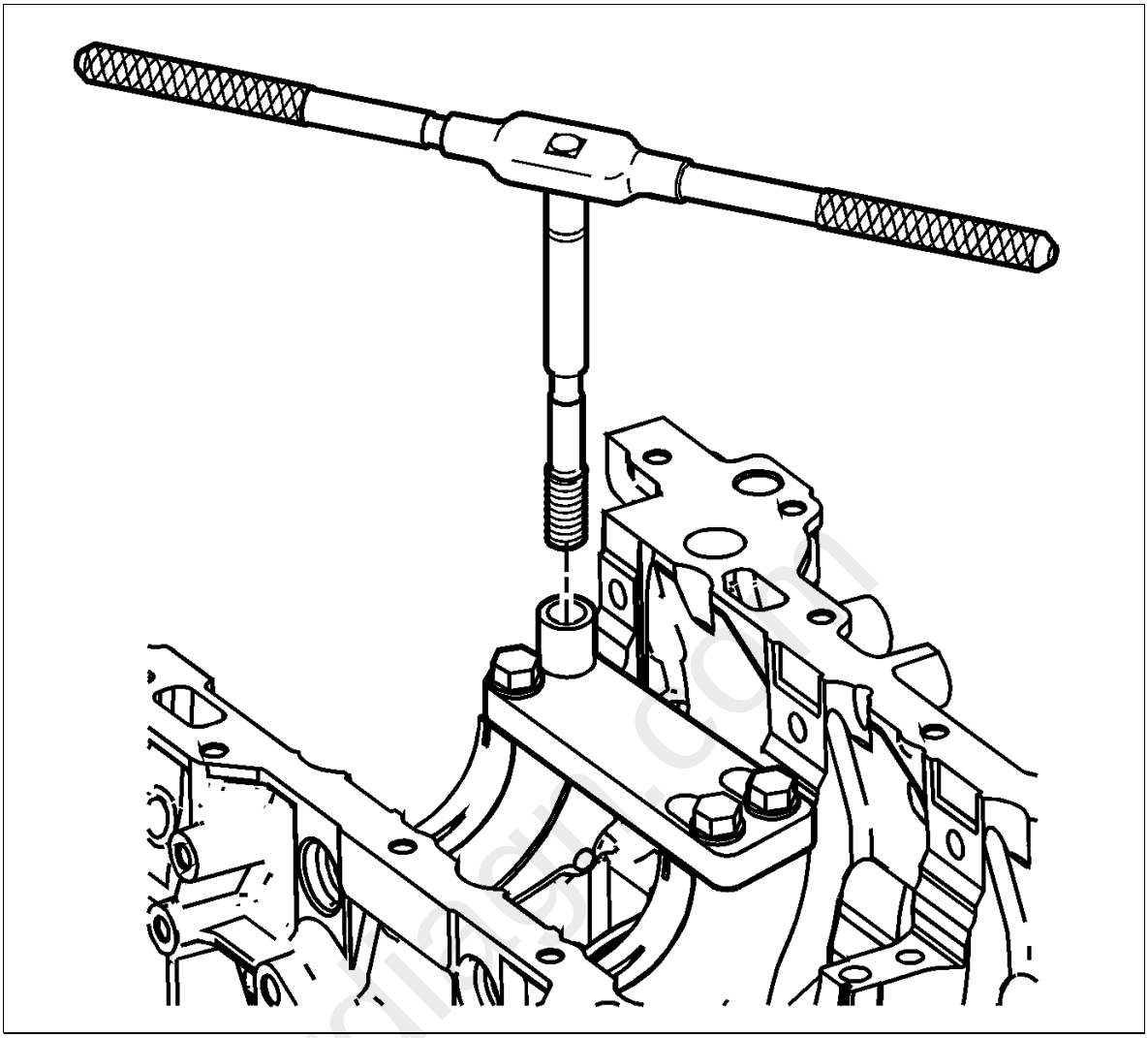


Courtesy of GENERAL MOTORS COMPANY

15. Apply threadlock sealant, **EN-42385-109** , LOCTITE 277®, or equivalent (1) to the insert OD threads (2). Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended sealant.

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Fig 13: Tapping Wrench



Courtesy of GENERAL MOTORS COMPANY

16. Install the insert and installation driver into the tapped hole by hand only.
17. Start the insert into the threaded hole.

> *NOTE:*
>
> *If the insert will not thread down until the flange contacts the counterbored surface remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or improper tapping.*

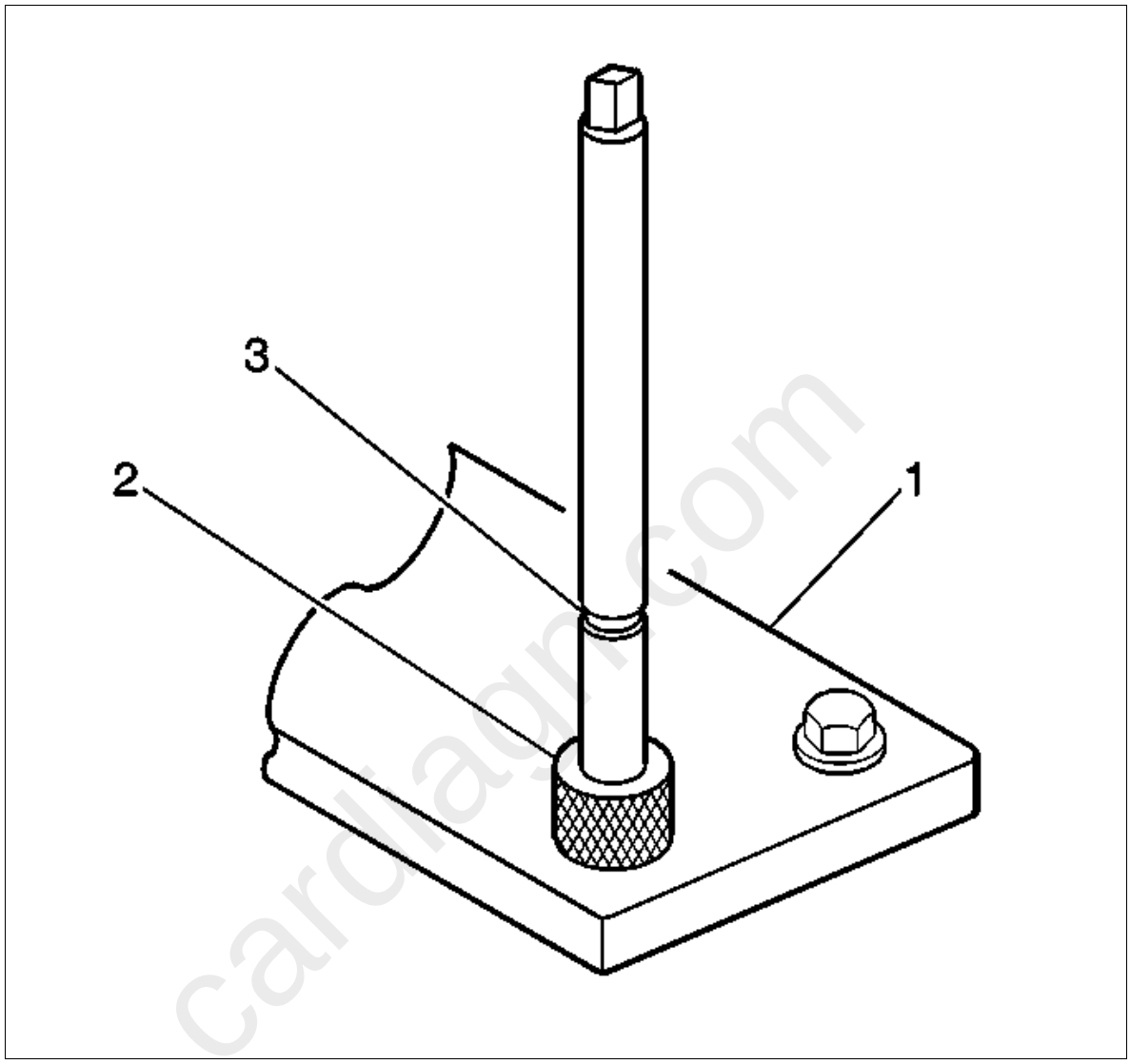
18. Install the insert until the flange of the insert contacts the counterbored surface.

> *NOTE:*
>
> *The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the insert are being formed*

and the insert is mechanically locking the insert into the base material threads.

19. Continue to rotate the driver installation tool through the insert.

Fig 14: Fixture Plate, Drill Bushing & Tool Marking



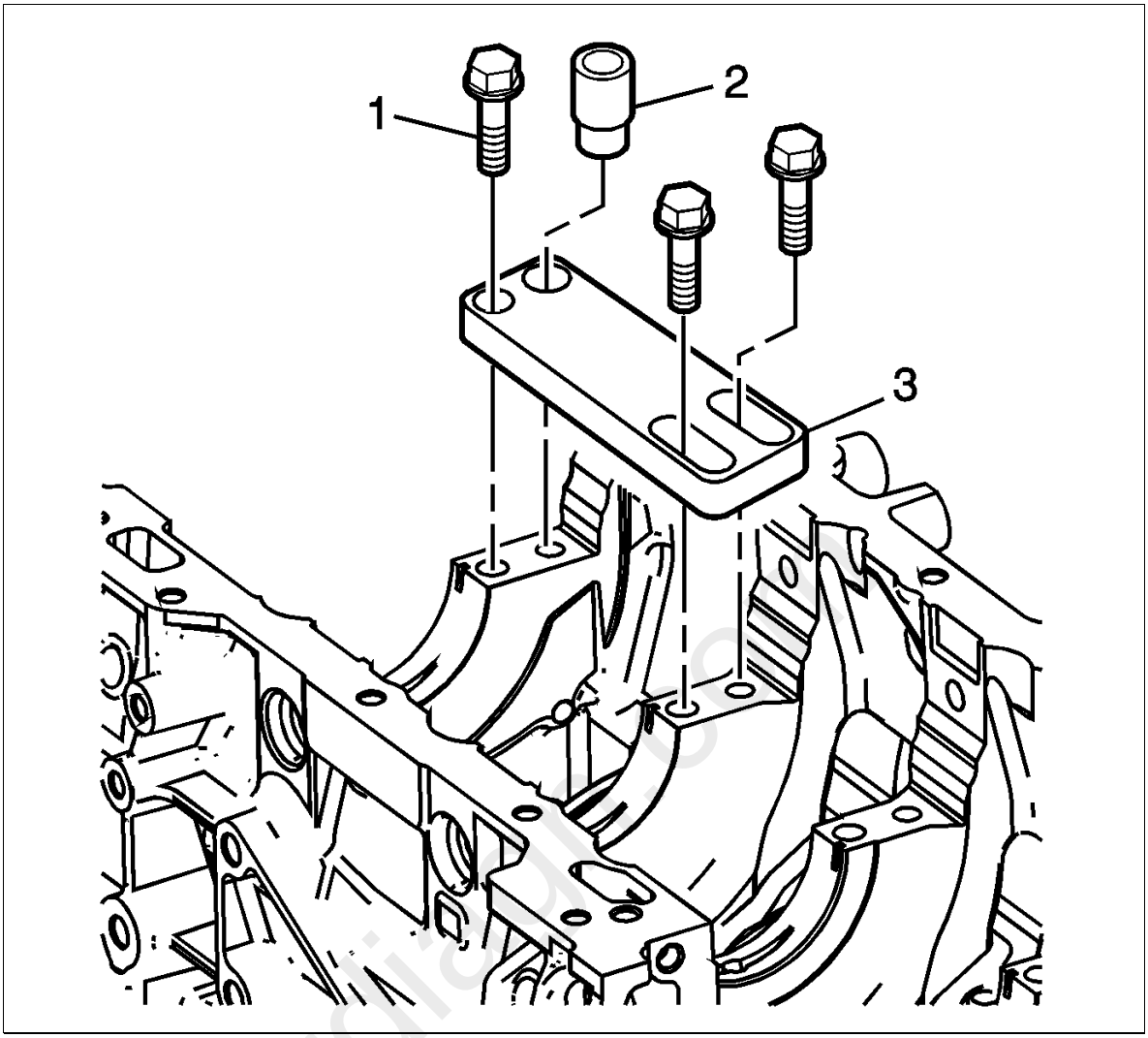
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20. Rotate the driver installation tool until the mark (3) on the driver installation tool aligns with the top of the drill bushing (2).

21. Inspect the insert for proper installation into the tapped hole.

Fig 15: Fixture Plate Over Crankshaft Main Cap Bolt Hole

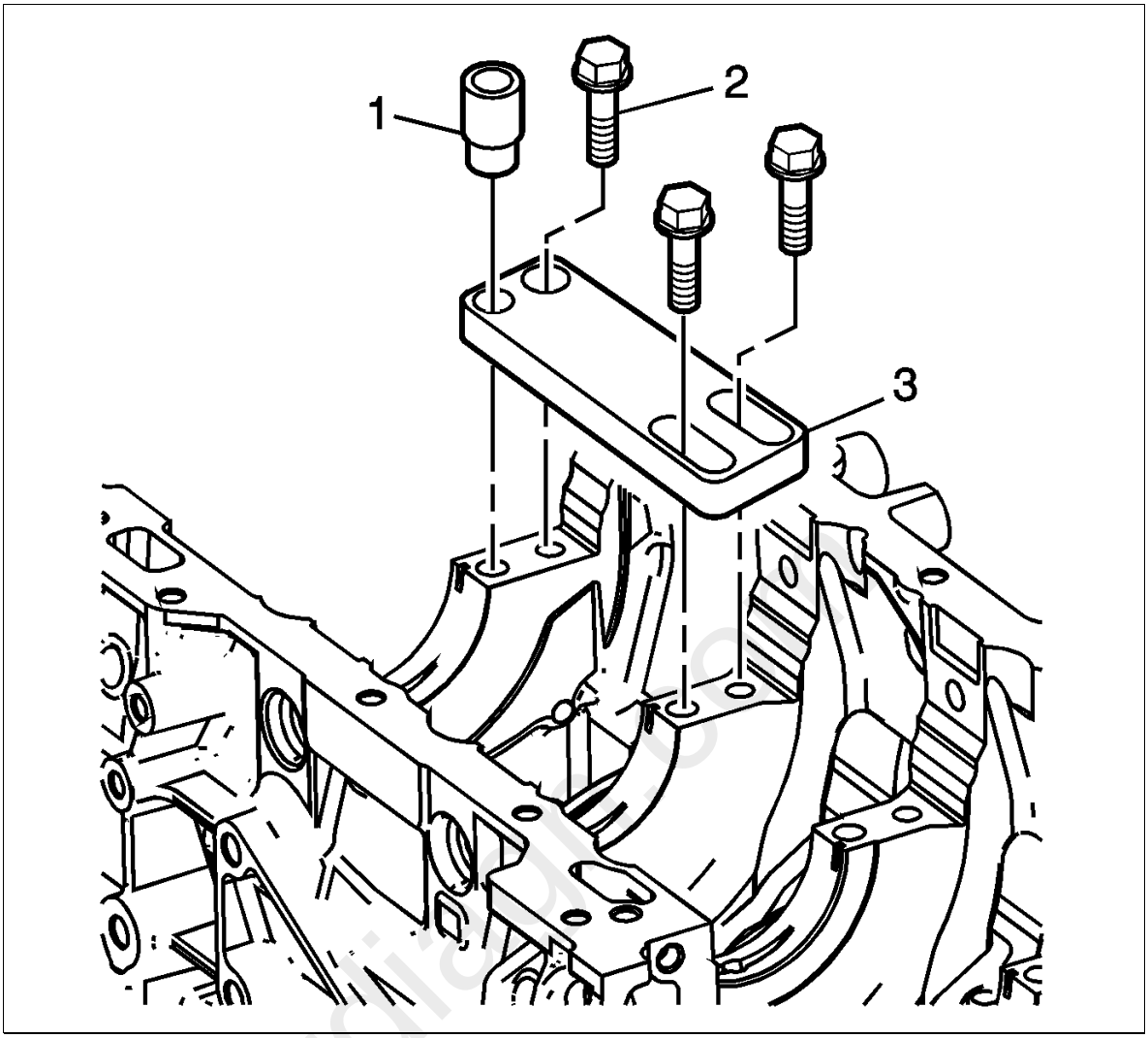


Courtesy of GENERAL MOTORS COMPANY

22. Remove the fixture plate bolts (1).
23. Remove the fixture plate (3) and bushing (2).

REPAIR INSTRUCTIONS - OFF VEHICLE > THREAD REPAIR > INBOARD BOLT HOLES

Fig 1: Fixture Plate & Components - Inboard Bolt Holes



Courtesy of GENERAL MOTORS COMPANY

WARNING:

Refer to Safety Glasses Warning .

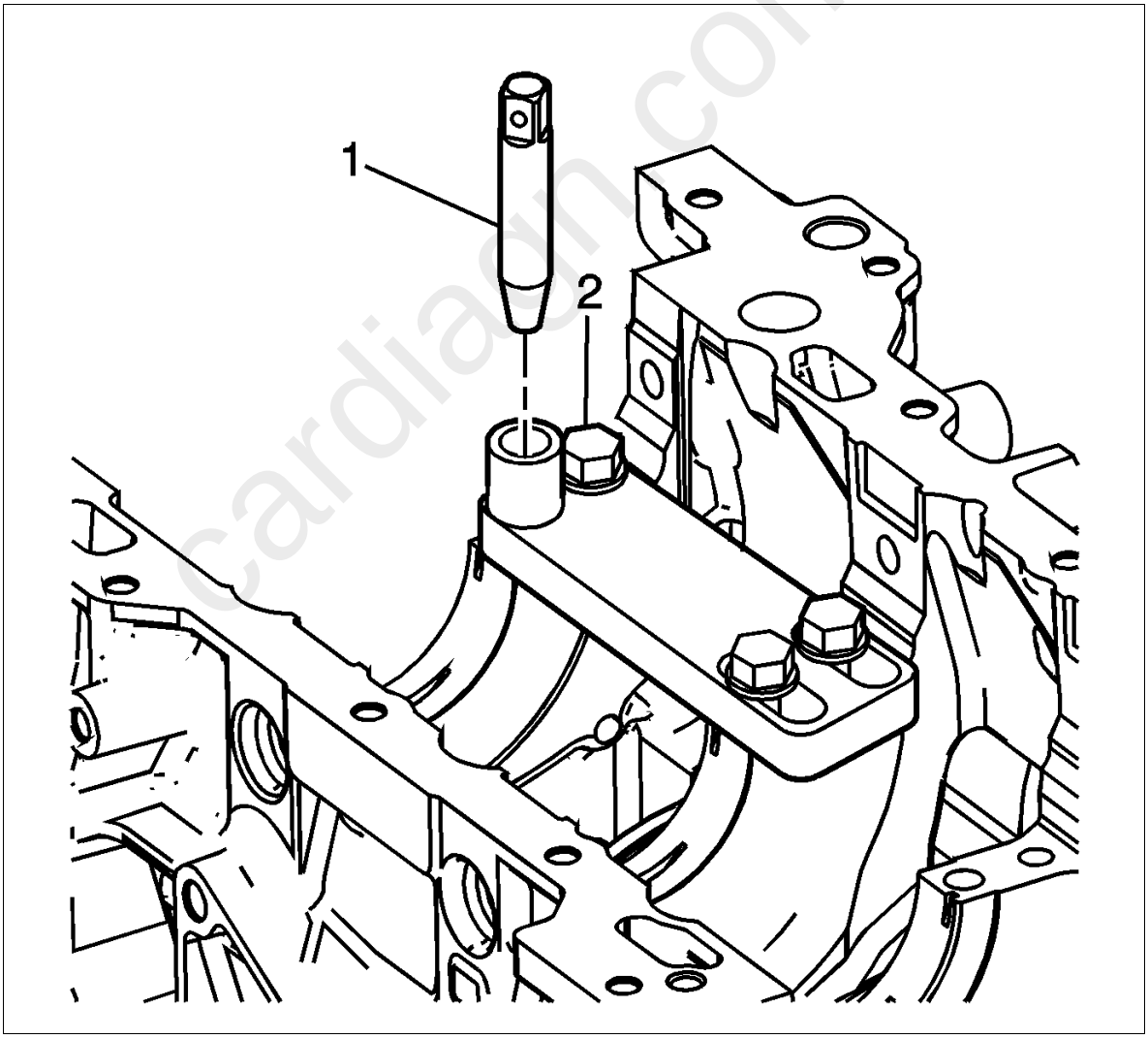
NOTE:

1. *Ensure the fixture plate is installed during the machining and installation processes of the insert.*
2. *The use of a cutting type fluid, WD 40® or equivalent is recommended when performing the drilling, counterboring and tapping procedures. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended cutting fluid.*

   When installed to the proper depth, the flange of the insert will be seated against the counterbore of the drilled/tapped hole.

1. Position the fixture plate (3) with the bushing (1) installed over the crankshaft main cap bolt hole to be repaired.
2. Loosely install the fixture plate bolts (2) into the remaining crankshaft main cap bolt holes.

Fig 2: Alignment Pin



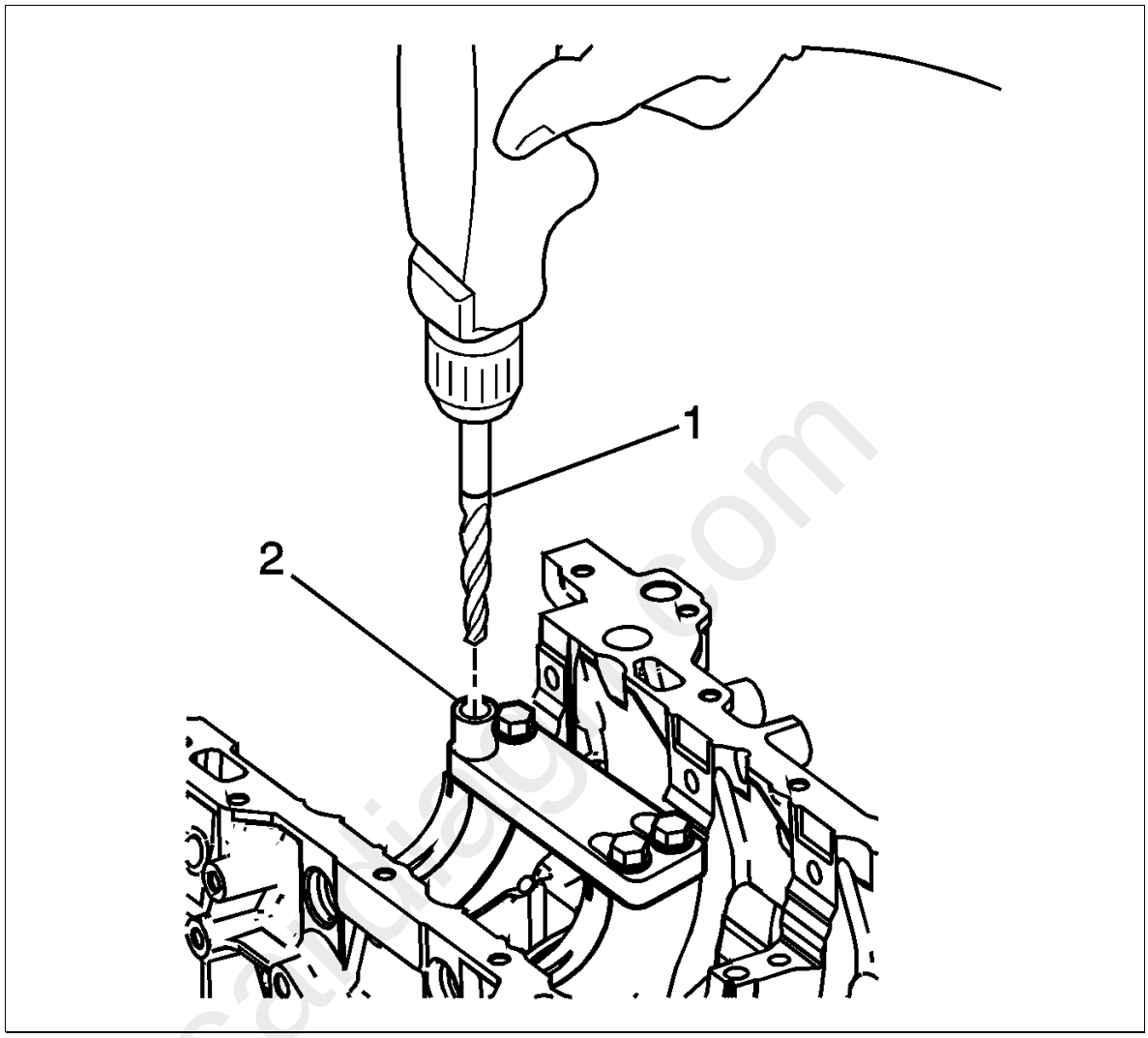
Courtesy of GENERAL MOTORS COMPANY

3. Position the alignment pin (1) through the bushing and into the crankshaft main cap bolt hole.

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4. With the alignment pin in the desired crankshaft main cap bolt hole, tighten the fixture retaining bolts (2).
5. Remove the alignment pin (1) from the crankshaft main cap bolt hole.

Fig 3: Threads Of Damaged Hole - Inboard Bolt Holes



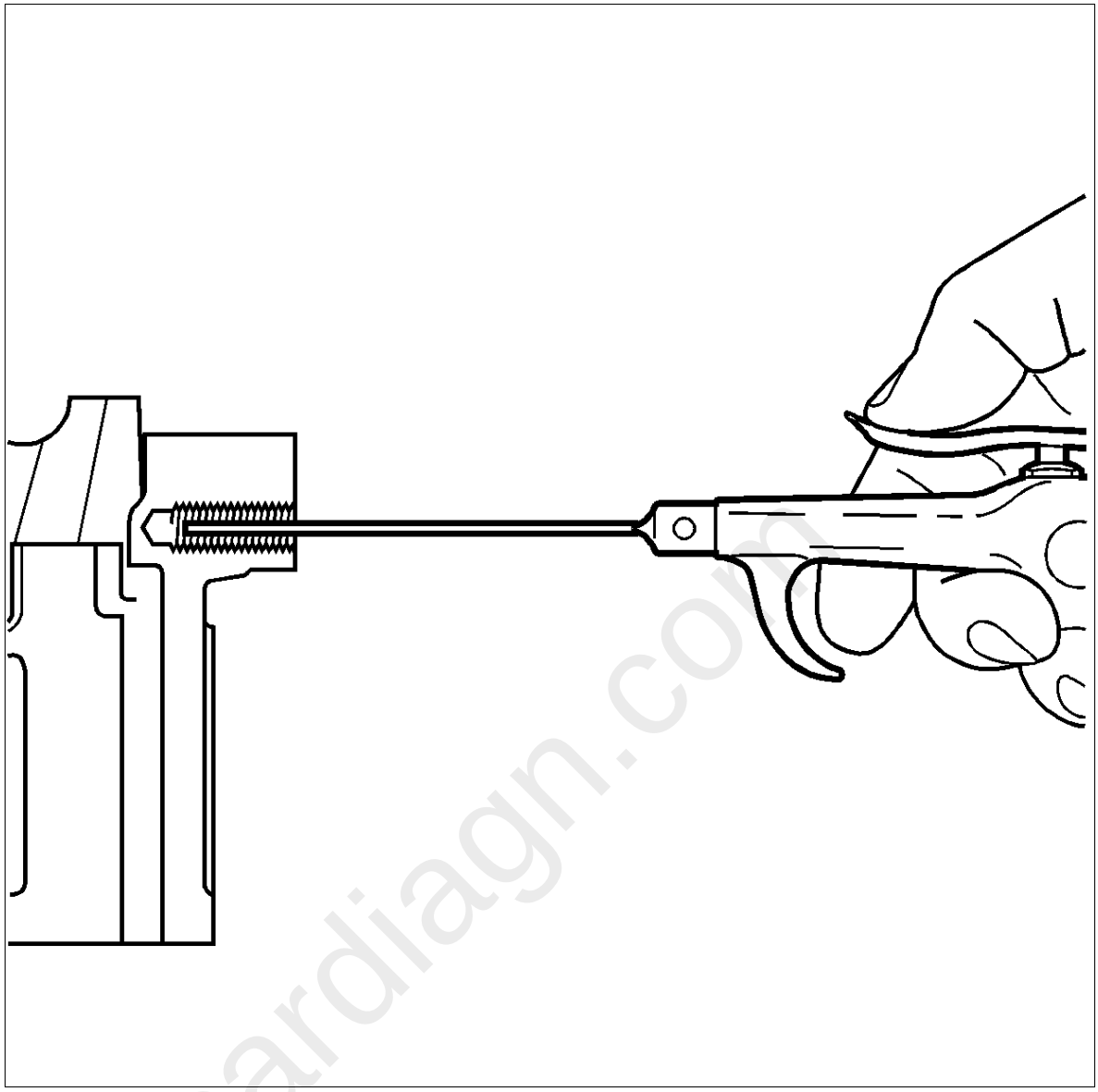
Courtesy of GENERAL MOTORS COMPANY

NOTE:

1. *During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.*
2. *Drill the crankshaft main bolt hole until the mark (1) on the drill aligns with the top of the drill bushing (2).*

6. Drill out the threads of the damaged hole.

Fig 4: Metal Chips



Courtesy of GENERAL MOTORS COMPANY

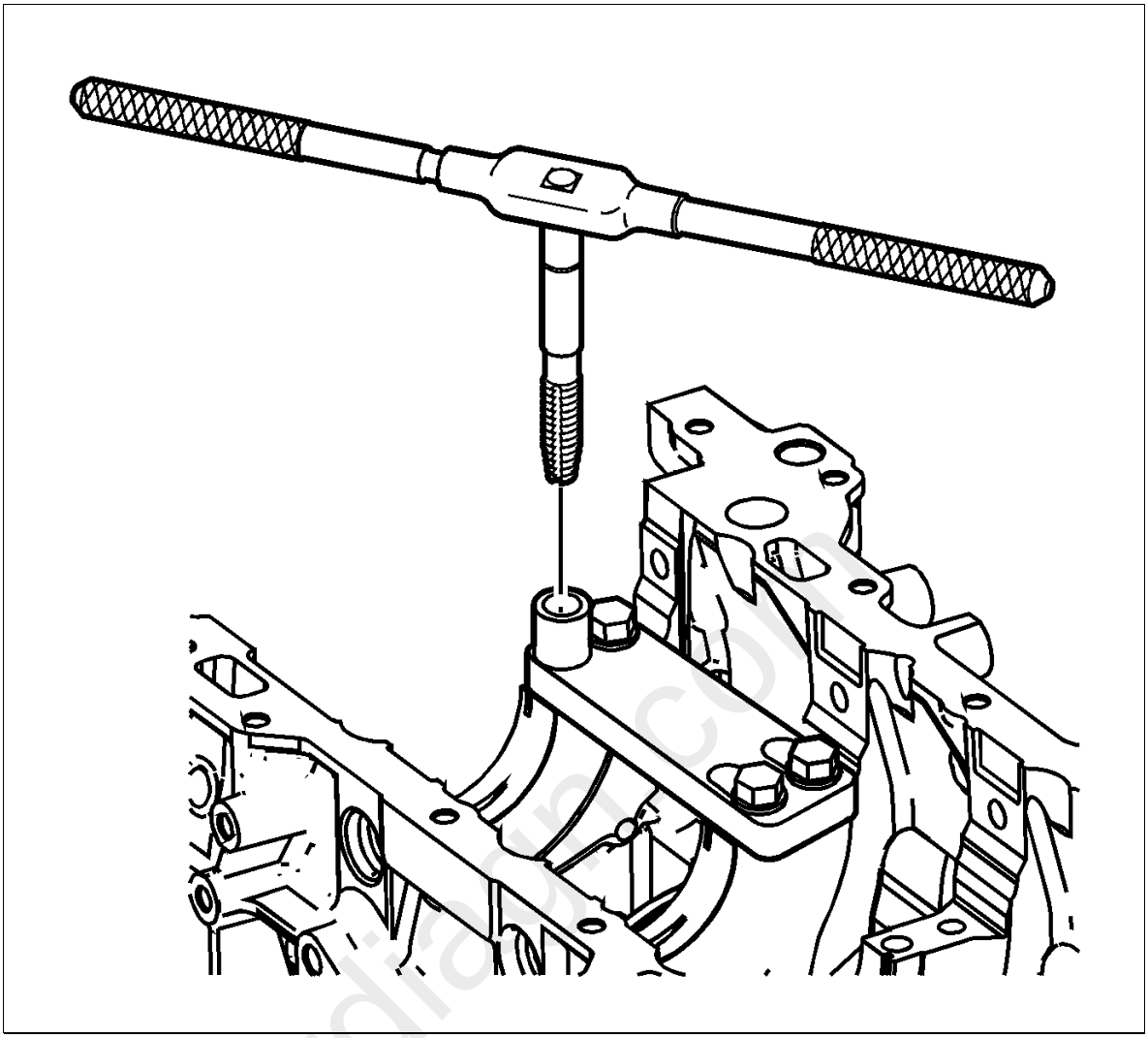
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NOTE:

All chips must be removed from the drilled hole prior to tapping.

7. Using compressed air, clean out any chips.

Fig 5: Tapping Wrench



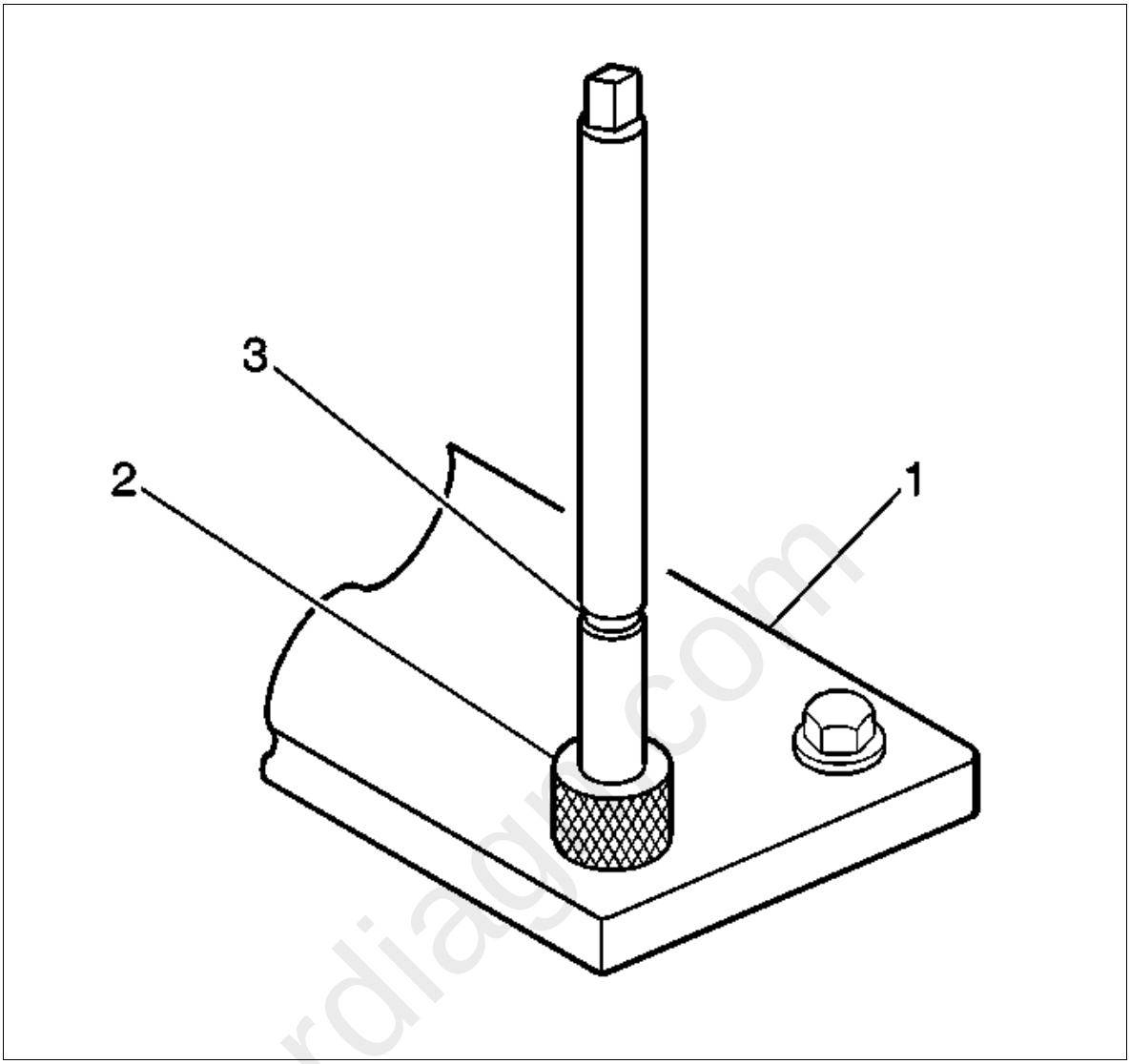
Courtesy of GENERAL MOTORS COMPANY

NOTE:

1. *Do not remove the fixture plate, ensure the fixture plate is installed during the machining and installation processes of the insert.*
2. *During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.*
3. *Ensure the tap has created full threads at least to the depth equal to the insert length.*

8. Using a suitable tapping wrench, tap the threads of the drilled hole by hand only.

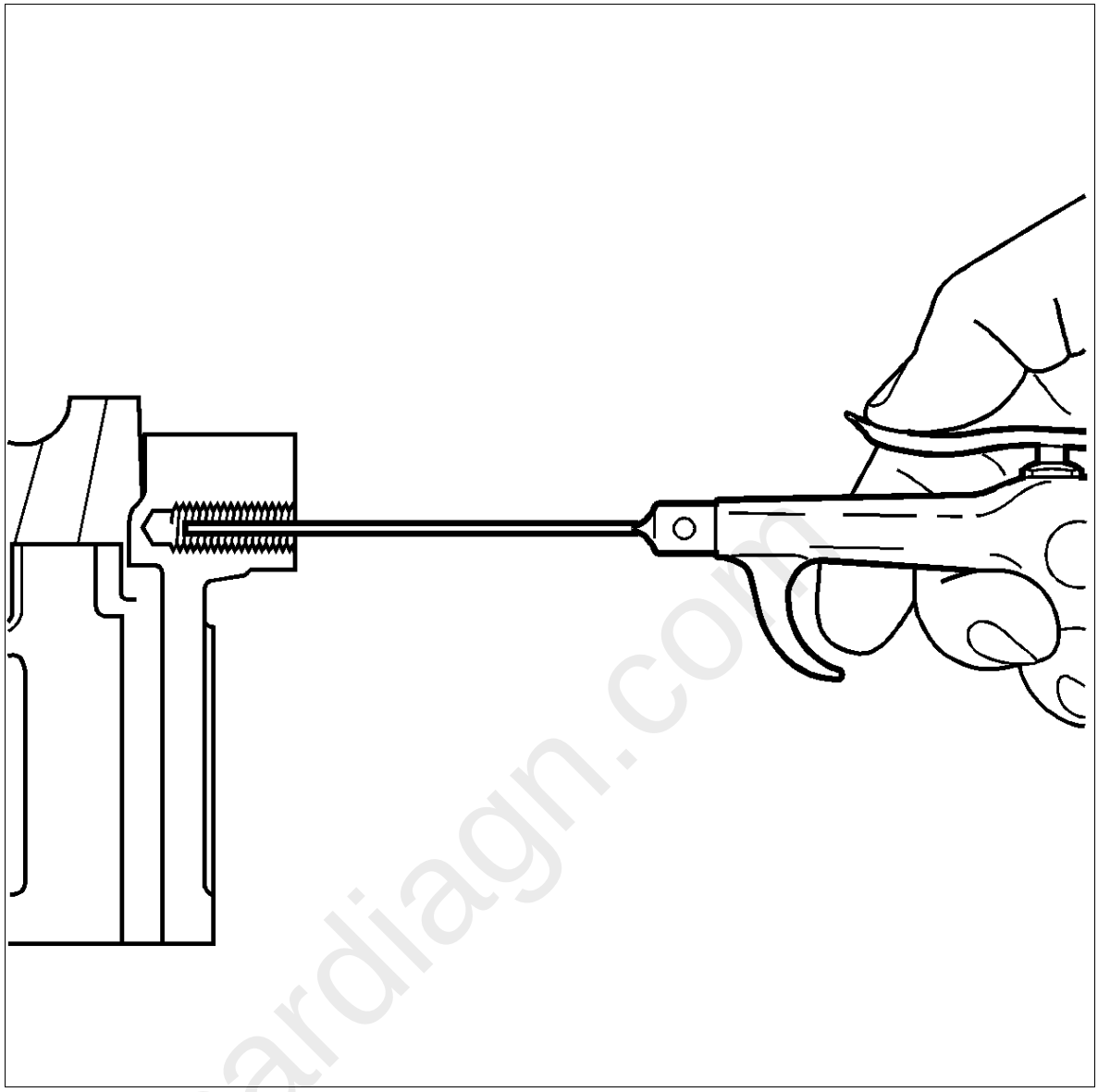
Fig 6: Fixture Plate, Drill Bushing & Tool Marking



Courtesy of GENERAL MOTORS COMPANY

9. In order to tap the new threads for the insert to the proper depth, rotate the tap into the crankshaft main cap bolt hole until the mark (3) on the tap aligns with the top of the drill bushing (2).

Fig 7: Metal Chips



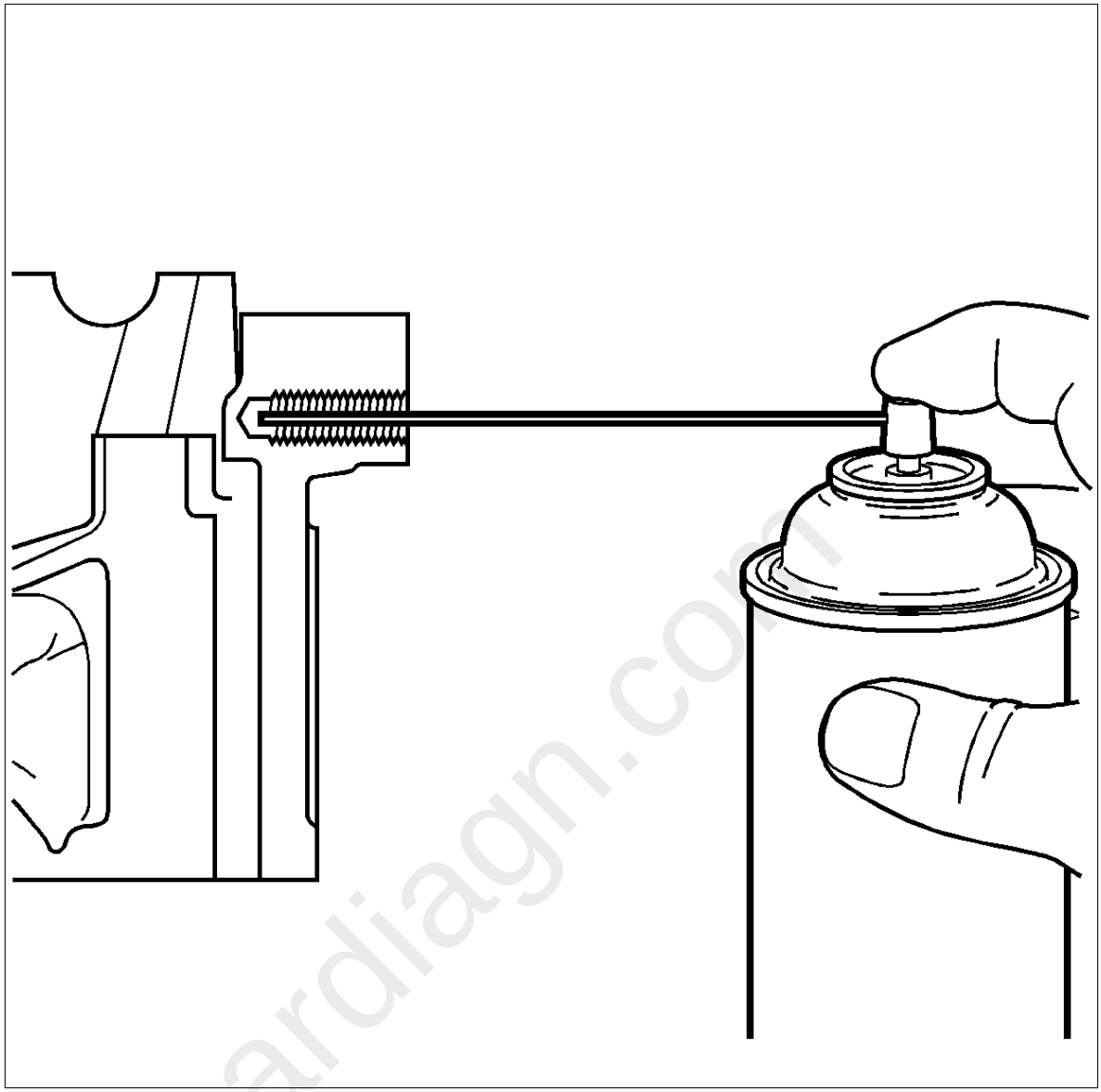
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> *NOTE:*
>
> *All chips must be removed from the tapped hole prior to insert installation.*

10. Using compressed air, clean out any chips.

Fig 8: Cleaner Into Tapped Hole

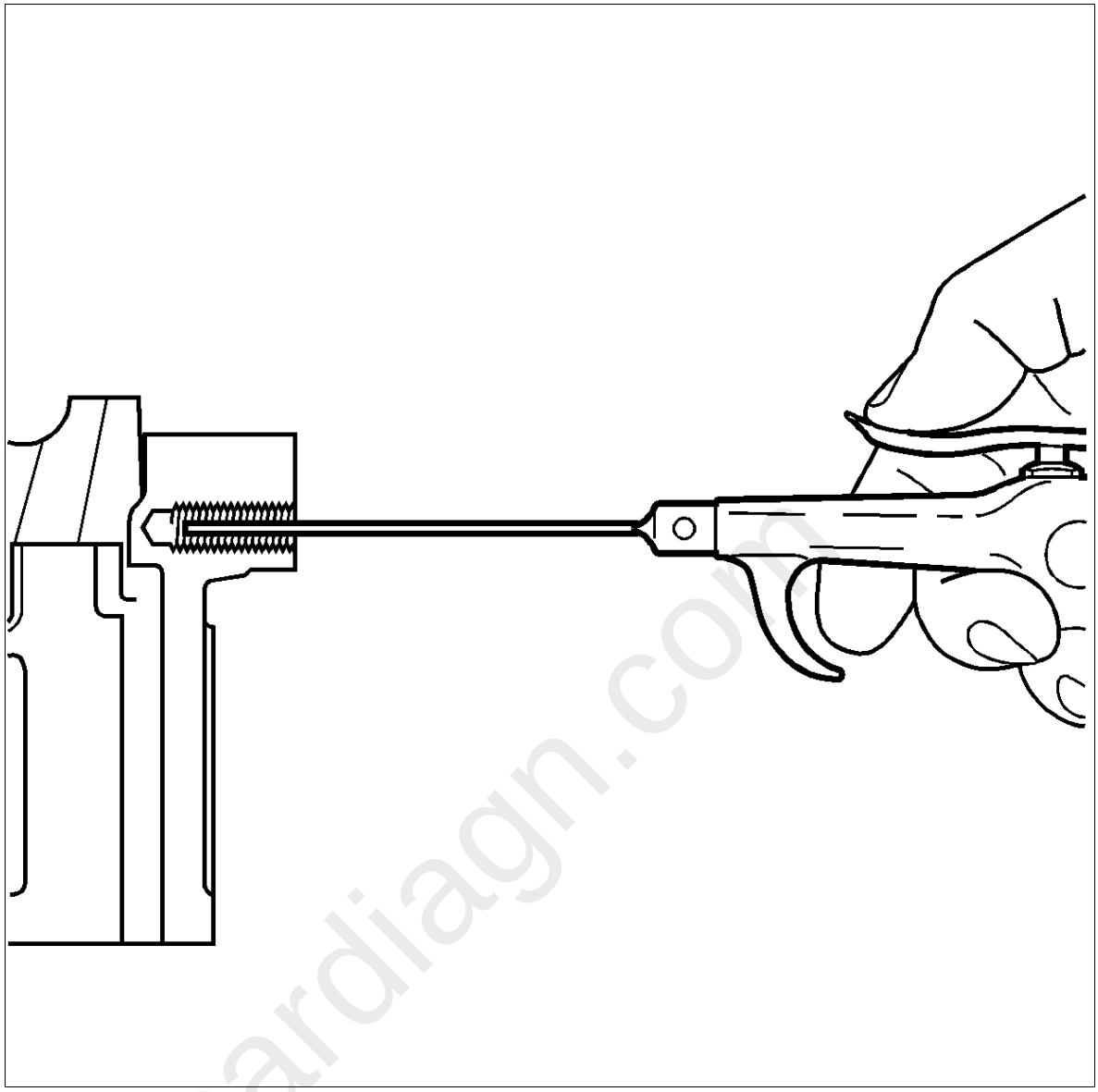


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11. Spray cleaner into the tapped hole. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended cleaner.

Fig 9: Metal Chips



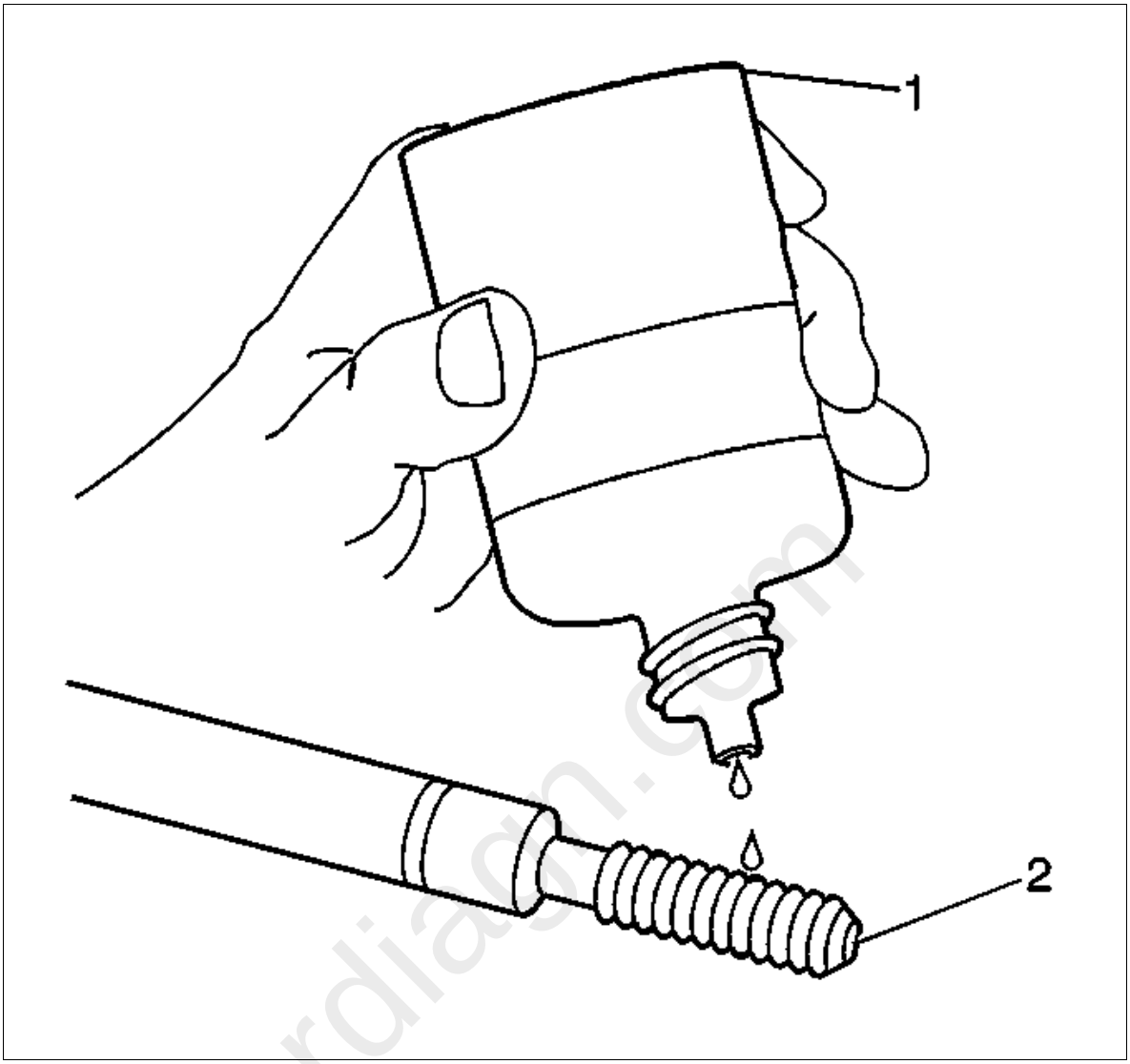
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> *NOTE:*
>
> *All chips must be removed from the tapped hole prior to insert installation.*

12. Using compressed air, clean out any chips.

Fig 10: Lubricating Installer Tool Using Driver Oil



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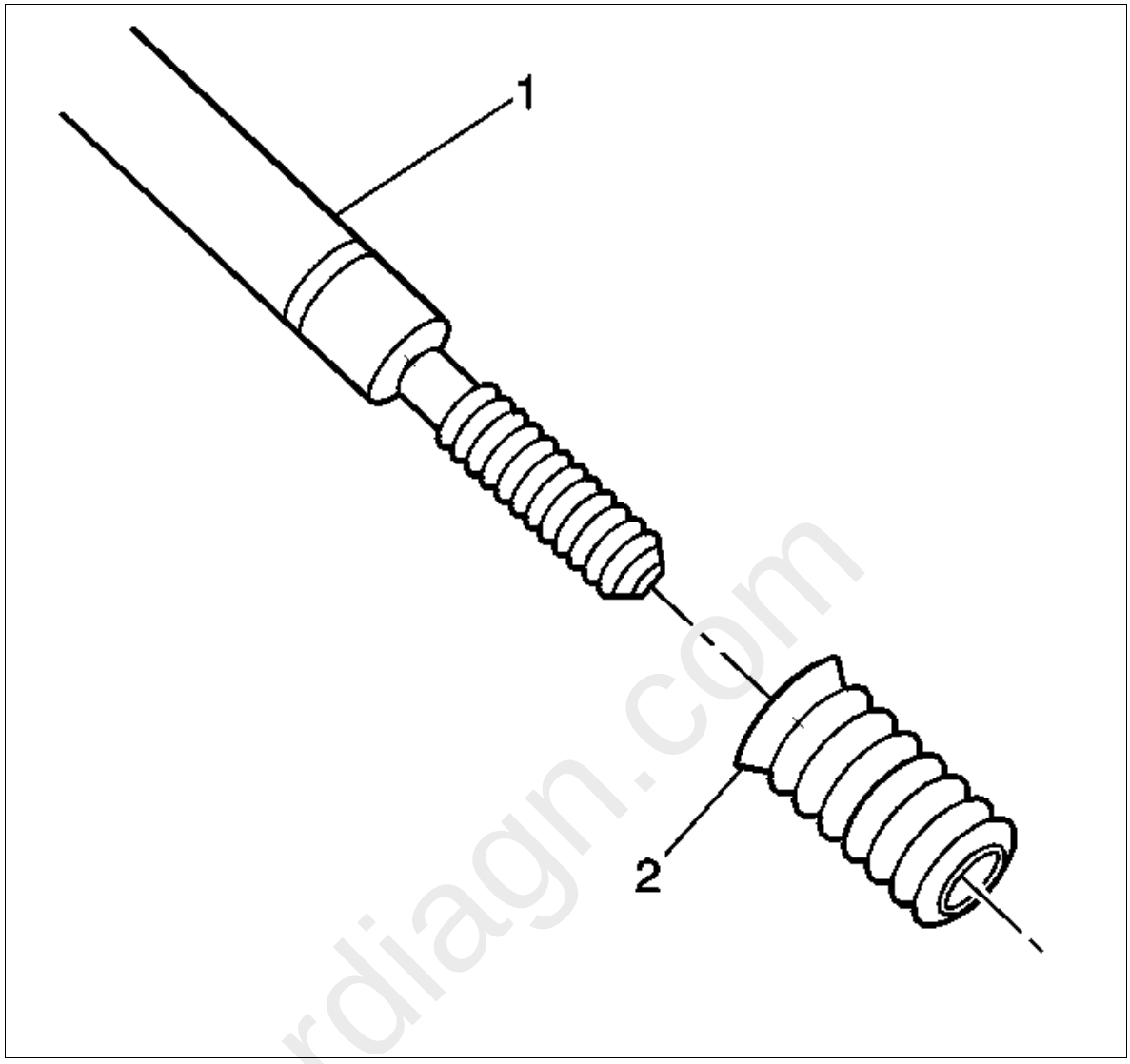
NOTE:

1. *Do not remove the fixture plate, ensure the fixture plate is installed during the installation process of the insert.*
2. *Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.*

13. Lubricate the threads of the driver installation tool (2) with the **EN-42385-110** (1).

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Fig 11: Bushing Type Insert

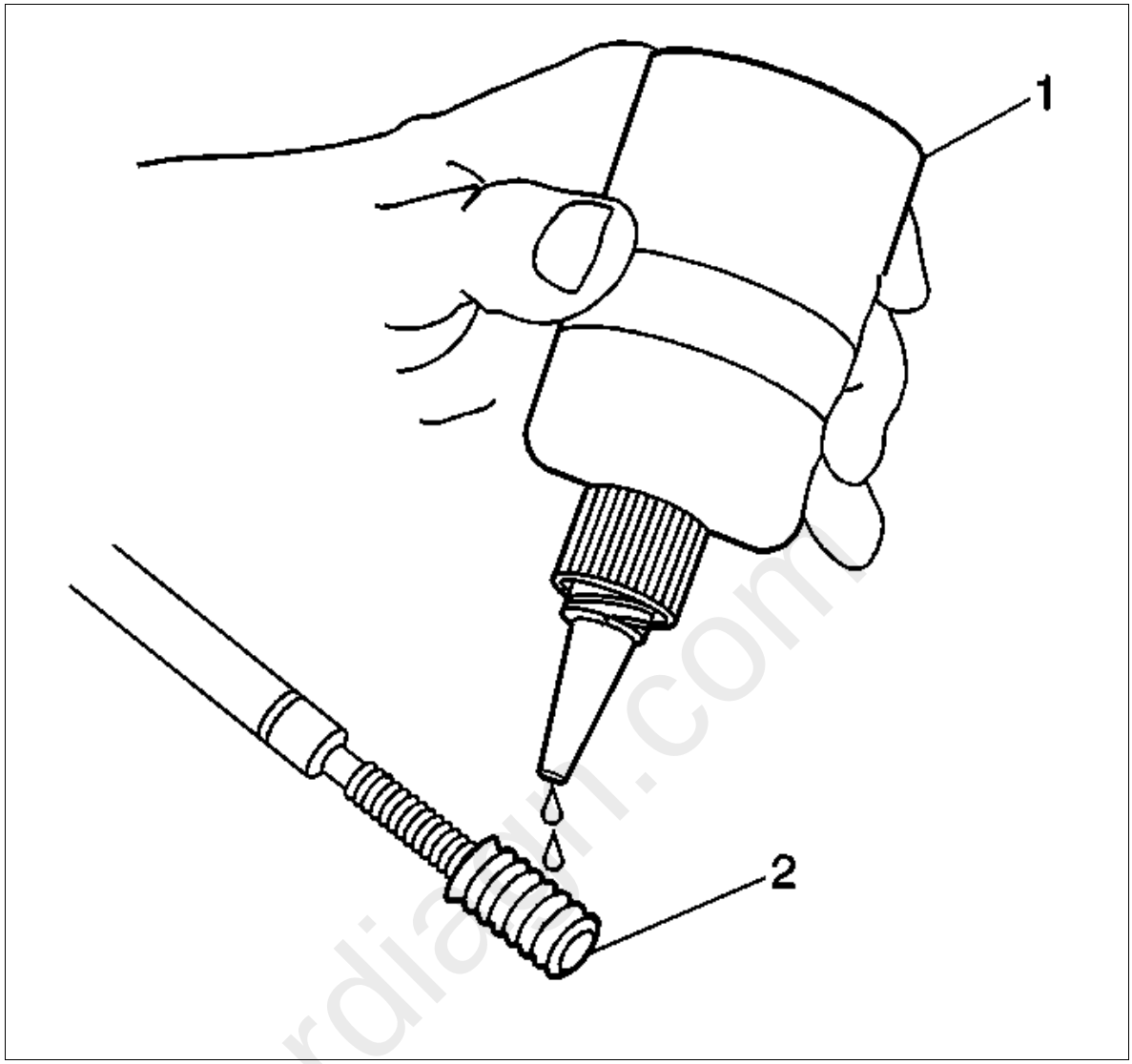


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14. Install the insert (2) onto the driver installation tool (1).

Fig 12: Threadlock To Insert

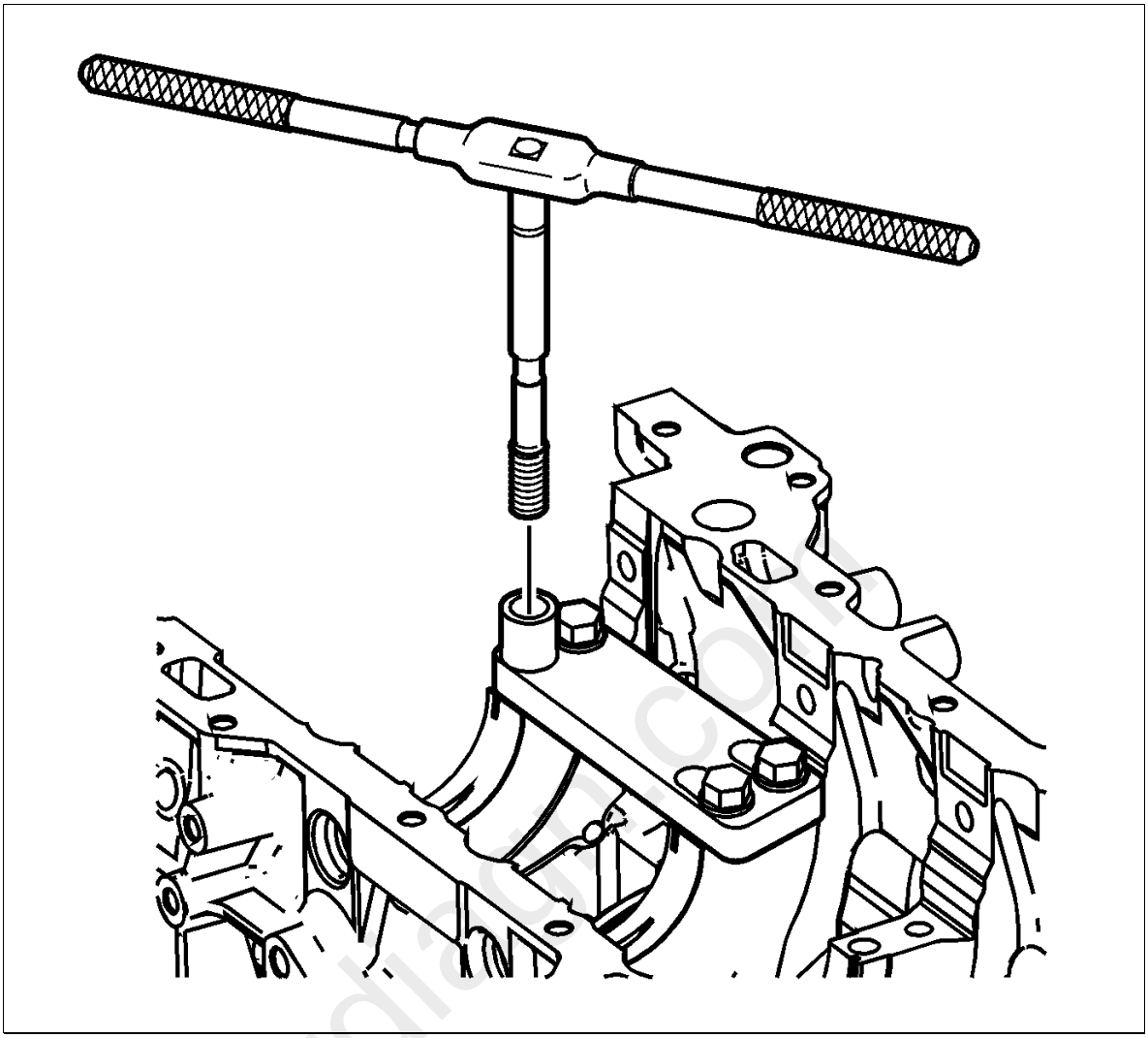


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15. Apply threadlock sealant, **EN-42385-109** , LOCTITE 277®, or equivalent (1) to the insert OD threads (2). Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended sealant.

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Fig 13: Insert & Installation Driver



Courtesy of GENERAL MOTORS COMPANY

16. Install the insert and installation driver into the tapped hole by hand only.
17. Start the insert into the threaded hole.

> *NOTE:*
>
> *If the insert will not thread down until the flange contacts the counterbored surface remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or improper tapping.*

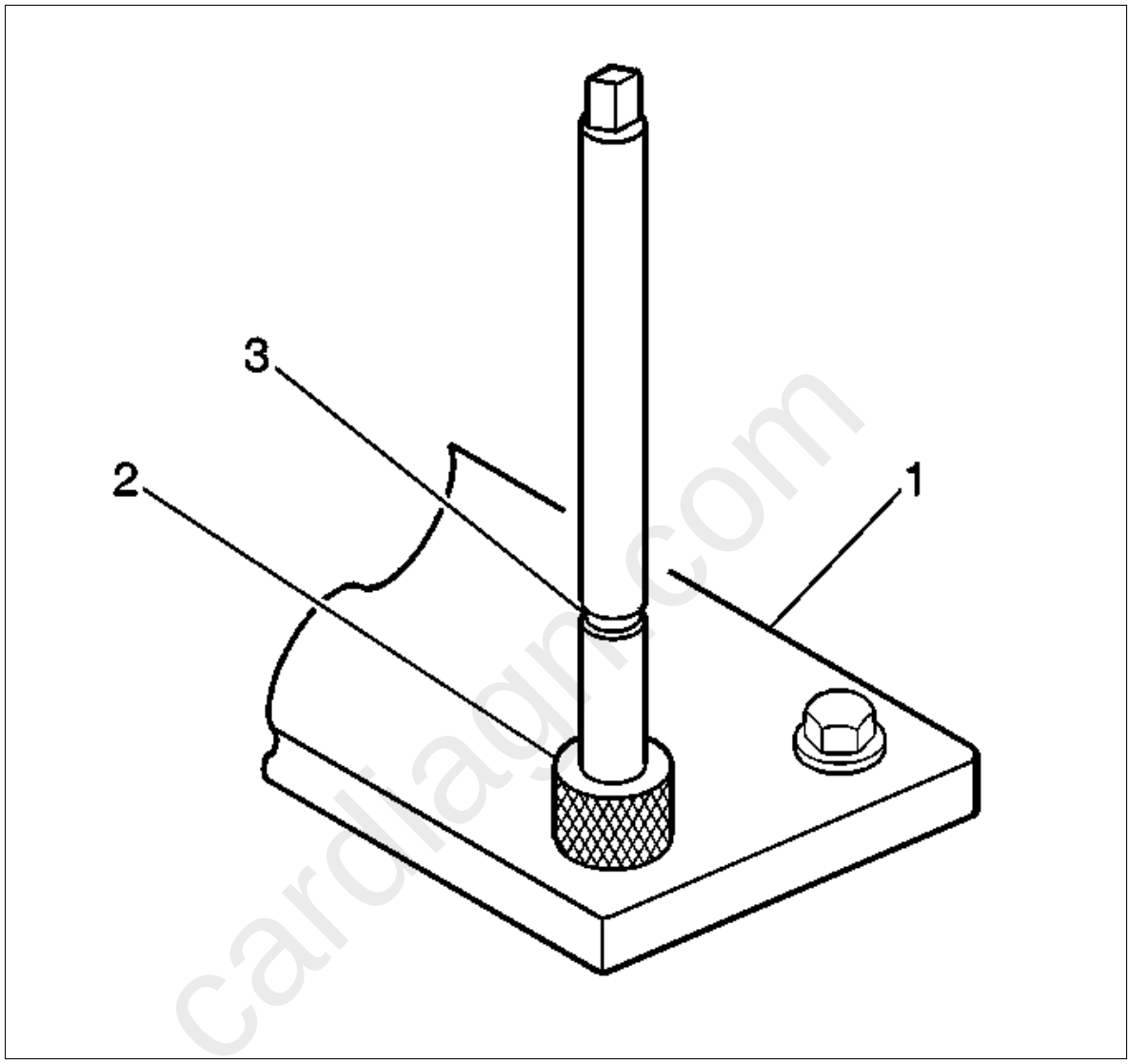
18. Install the insert until the flange of the insert contacts the counterbored surface.

> *NOTE:*
>
> *The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the insert are being formed*

and the insert is mechanically locking the insert into the base material threads.

19. Continue to rotate the driver installation tool through the insert.

Fig 14: Fixture Plate, Drill Bushing & Tool Marking



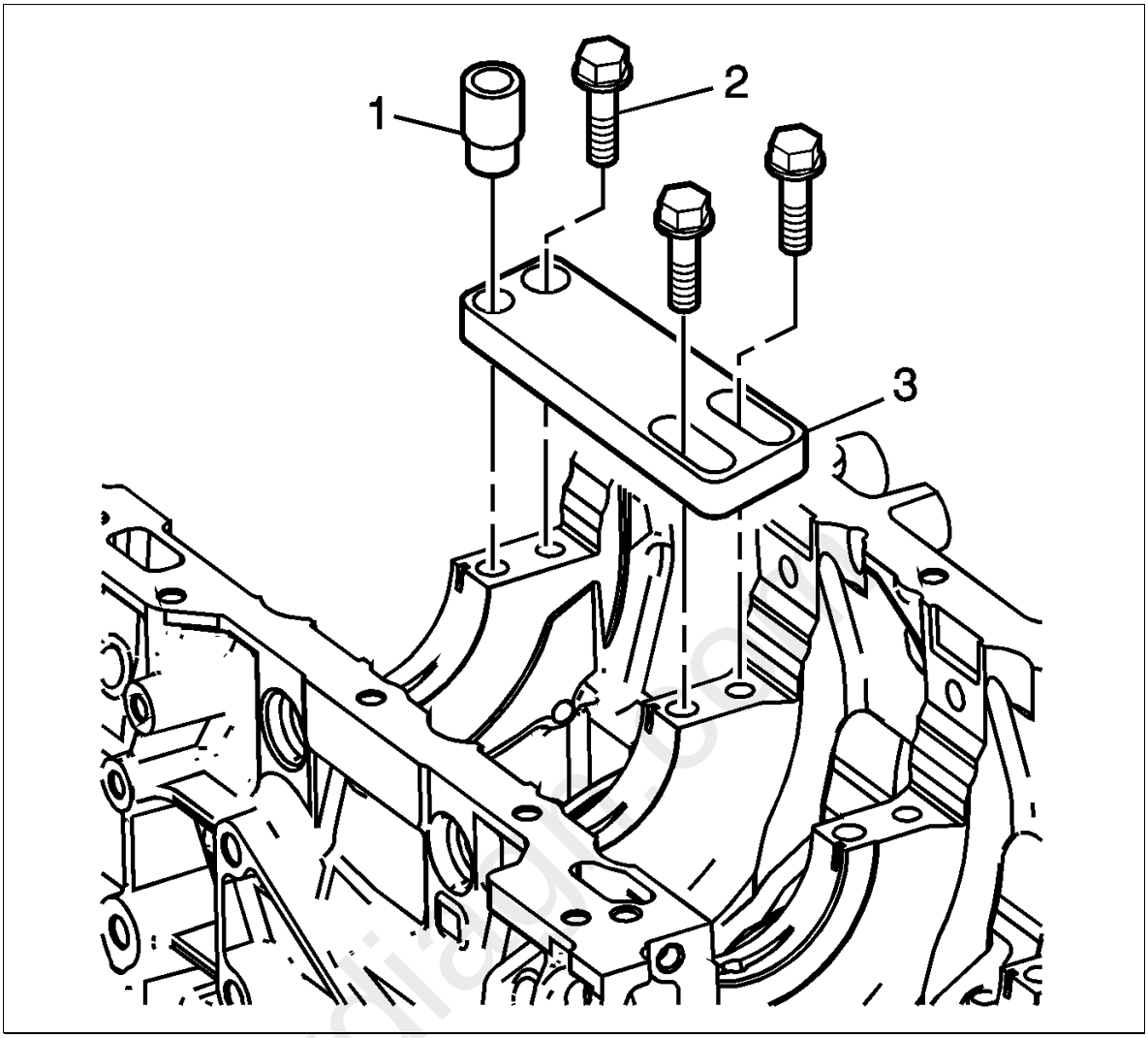
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20. Rotate the driver installation tool until the mark (3) on the driver installation tool aligns with the top of the drill bushing (2).

21. Inspect the insert for proper installation into the tapped hole.

Fig 15: Fixture Plate & Components - Inboard Bolt Holes



Courtesy of GENERAL MOTORS COMPANY

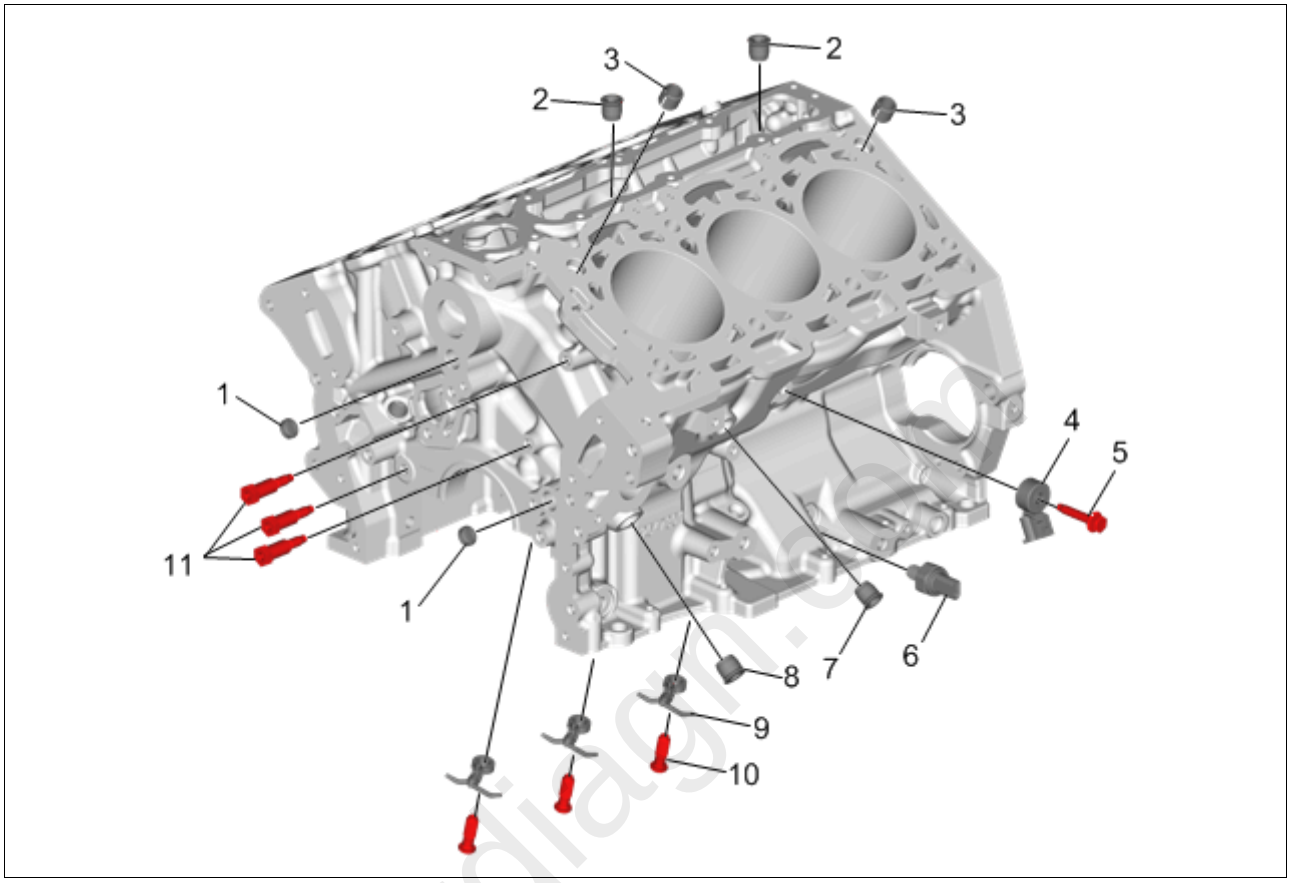
22. Remove the fixture plate bolts (2).
23. Remove the fixture plate (3) and bushing (1).

REPAIR INSTRUCTIONS - OFF VEHICLE > SERVICE PRIOR TO ASSEMBLY

- Dirt will cause premature wear of the rebuilt engine. Clean all the components.
- Use the proper tools to measure the components when checking for excessive wear. Components not within the manufacturer's specification must be repaired or replaced.
- When the components are reinstalled into an engine, return the components to their original location, position, and direction.
- During assembly, lubricate all the moving parts with clean engine oil (unless otherwise specified). This will provide initial lubrication when the engine is first started.

REPAIR INSTRUCTIONS - OFF VEHICLE > ENGINE BLOCK ASSEMBLE > ENGINE BLOCK - LEFT - FRONT

Fig 1: Engine Block - Left - Front



Courtesy of GENERAL MOTORS COMPANY

Engine Block - Left - Front

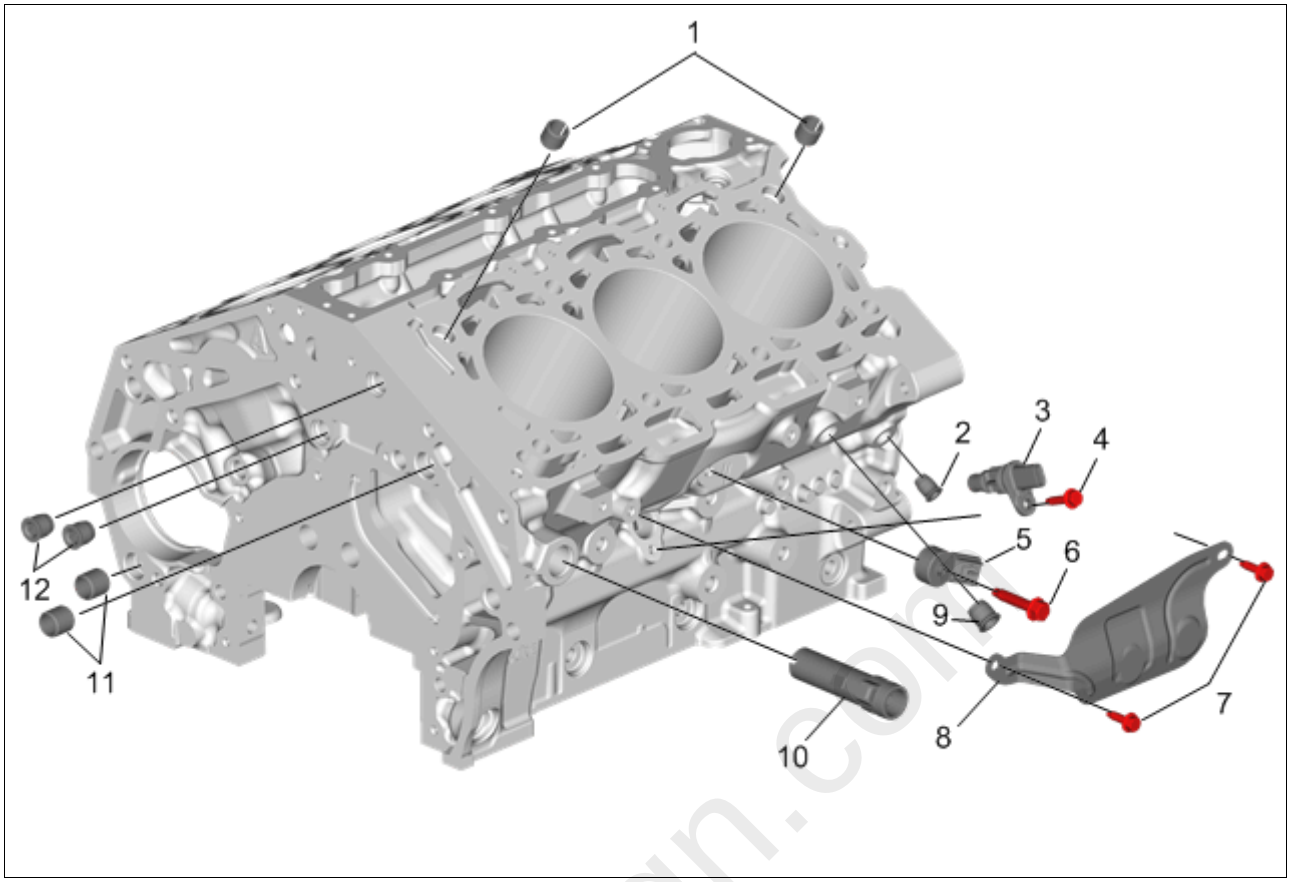
Callout	Component Name
1	Engine Block Oil Gallery Plug Cap (Qty: 2)
2	Engine Block Oil Gallery Plug (Qty: 2) *CAUTION:* *Refer to Fastener Caution .* Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant **Tighten**

	40 N.m (30 lb ft)
3	Cylinder Head Locating Pin (Qty: 2)
4	Knock Sensor
5	Knock Sensor Bolt **Tighten** 25 N.m (18 lb ft)
6	Engine Oil Pressure Sensor **Tighten** 35 N.m (26 lb ft)
7	Engine Block Core Hole Plug **Tighten** 45 N.m (33 lb ft)
8	Engine Block Oil Gallery Plug M16 **Tighten** 40 N.m (30 lb ft)
9	Piston Oil Nozzle (Qty: 3)
10	Piston Oil Nozzle Bolt (Qty: 3) **Tighten** 10 N.m (89 lb in)
11	Engine Front Cover Stud (Qty: 3) **Tighten** 15 N.m (11 lb ft)

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REPAIR INSTRUCTIONS - OFF VEHICLE > ENGINE BLOCK ASSEMBLE > ENGINE BLOCK - RIGHT - REAR

Fig 1: Engine Block - Right - Rear



Courtesy of GENERAL MOTORS COMPANY

Engine Block - Right - Rear

Callout	Component Name
1	Cylinder Head Locating Pin (Qty: 2)
2	Engine Block Core Hole Plug Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant **Tighten** 40 N.m (30 lb ft)
3	Crankshaft Position Sensor
4	Crankshaft Position Sensor Bolt **Tighten** 10 N.m (89 lb in)
5	Knock Sensor
6	Knock Sensor Bolt **Tighten** 25 N.m (18 lb ft)

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7	Knock Sensor Heat Shield Bolt (Qty: 2) **Tighten** 10 N.m (89 lb in)
8	Knock Sensor Heat Shield
9	Engine Block Oil Gallery Plug M16 **Tighten** 40 N.m (30 lb ft)
10	Engine Coolant Temperature Sensor **Tighten** 9 N.m (80 lb in)
11	Crankshaft Rear Oil Seal Housing Locating Pin (Qty: 2)
12	Engine Block Oil Gallery Plug (Qty: 2) **Tighten** 40 N.m (30 lb ft)

REPAIR INSTRUCTIONS - OFF VEHICLE > CRANKSHAFT AND BEARING INSTALLATION

Special Tools

- **GE 6125-1B** Slide Hammer Adapter
- **EN 45059** Angle Meter
- **EN 49102** Crankshaft Bearing Cap Remover

For equivalent regional tools, refer to Special Tools .

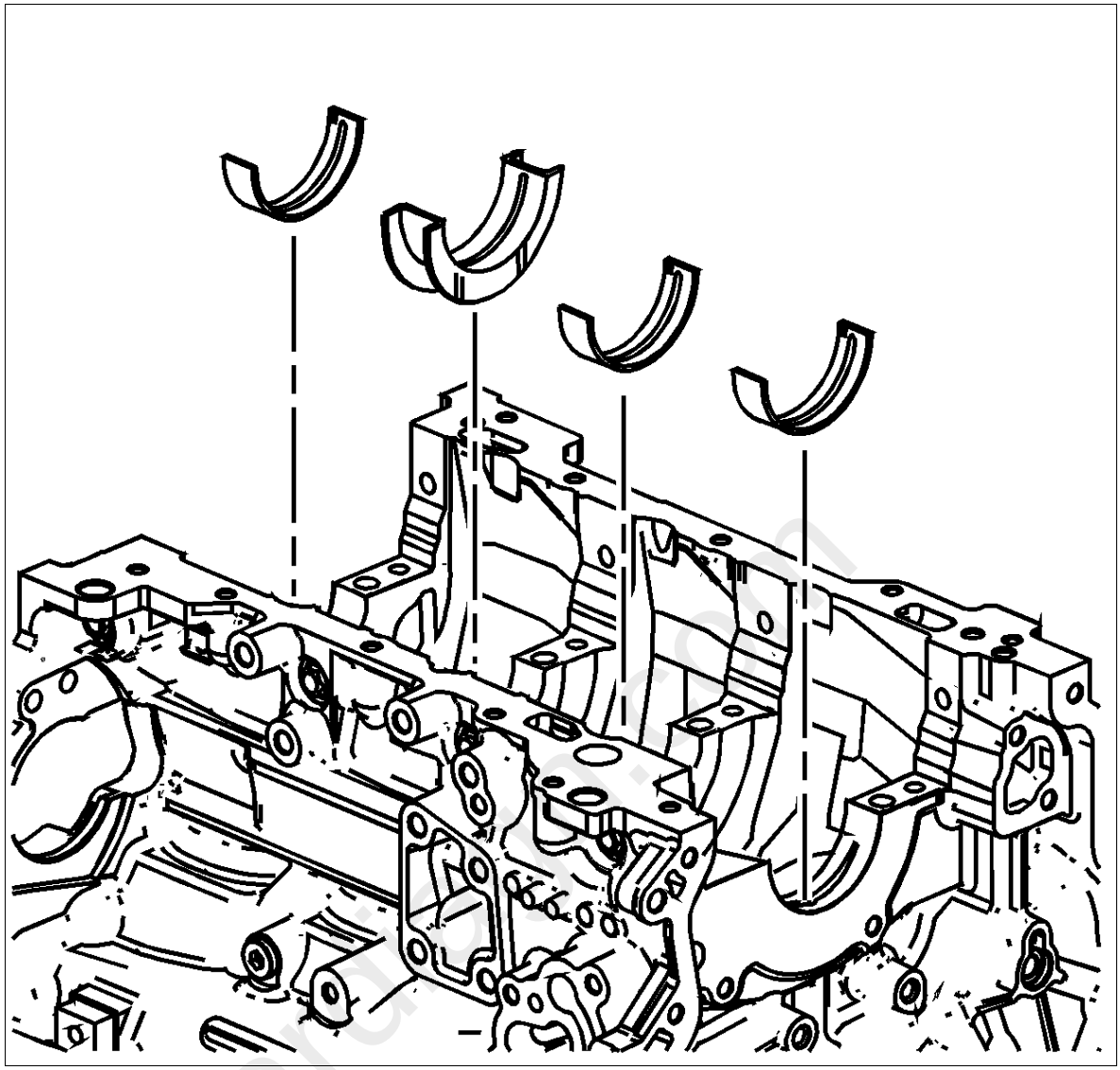
REPAIR INSTRUCTIONS - OFF VEHICLE > CRANKSHAFT AND BEARING INSTALLATION > CRANKSHAFT BEARING INSTALLATION PROCEDURE

> *NOTE:*
>
> *If the crankshaft bearings have been used in a running engine, you must replace them with NEW crankshaft bearings for reassembly.*

1. Clean the crankcase crank bore with a lint-free cloth.
2. Clean all the oil from the backside of new bearing halves.

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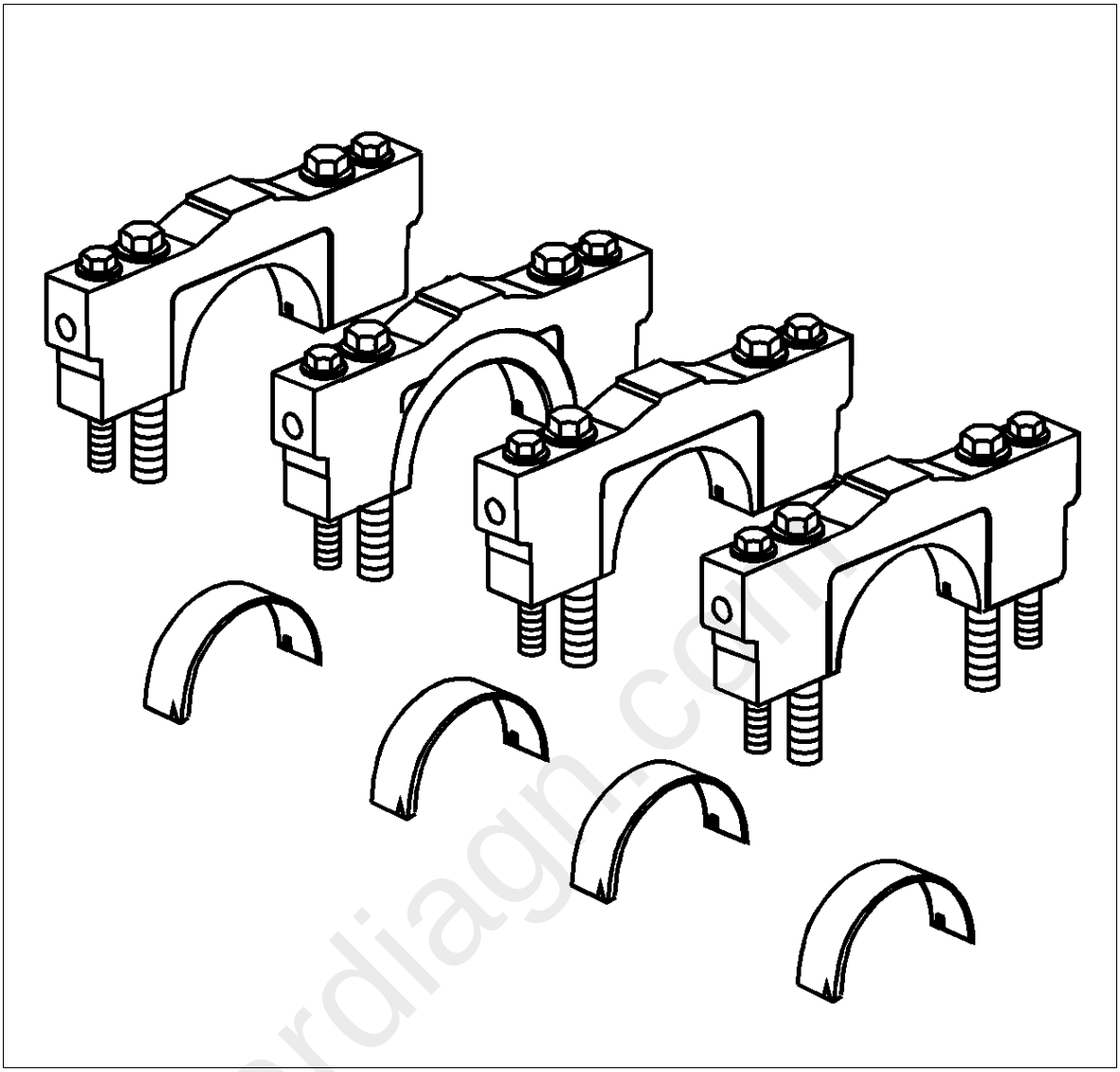
Fig 1: Upper Crankshaft Bearings



Courtesy of GENERAL MOTORS COMPANY

3. Install the NEW upper crankshaft bearings into position. The thrust bearing belongs in the number 3 journal. Ensure that the upper bearing insert contains the oil transfer hole and groove. Roll the bearing into position so that the lock tang engages the crank slot. The bearing must fit flush with the upper crankcase.

Fig 2: Crankshaft Bearing Caps & Lower Bearing Halves



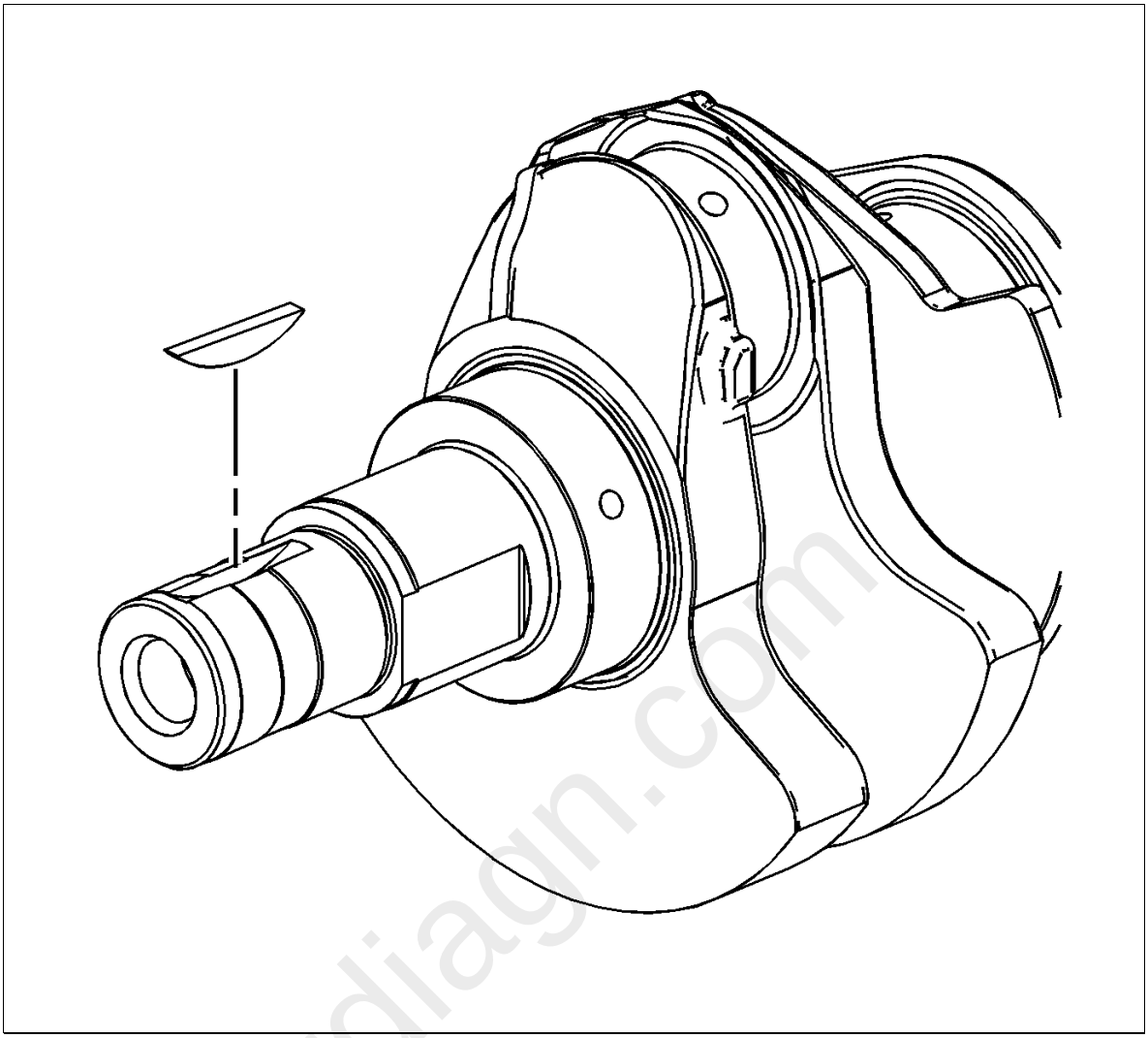
Courtesy of GENERAL MOTORS COMPANY

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4. Install the NEW lower crankshaft bearings into position in the main bearing caps. The lower crankshaft bearings are identified by NO grooves or holes. The bearings must fit flush with the crankshaft bearing caps.

REPAIR INSTRUCTIONS - OFF VEHICLE > CRANKSHAFT AND BEARING INSTALLATION > CRANKSHAFT INSTALLATION PROCEDURE

Fig 1: Crankshaft Sprocket Drive Pin

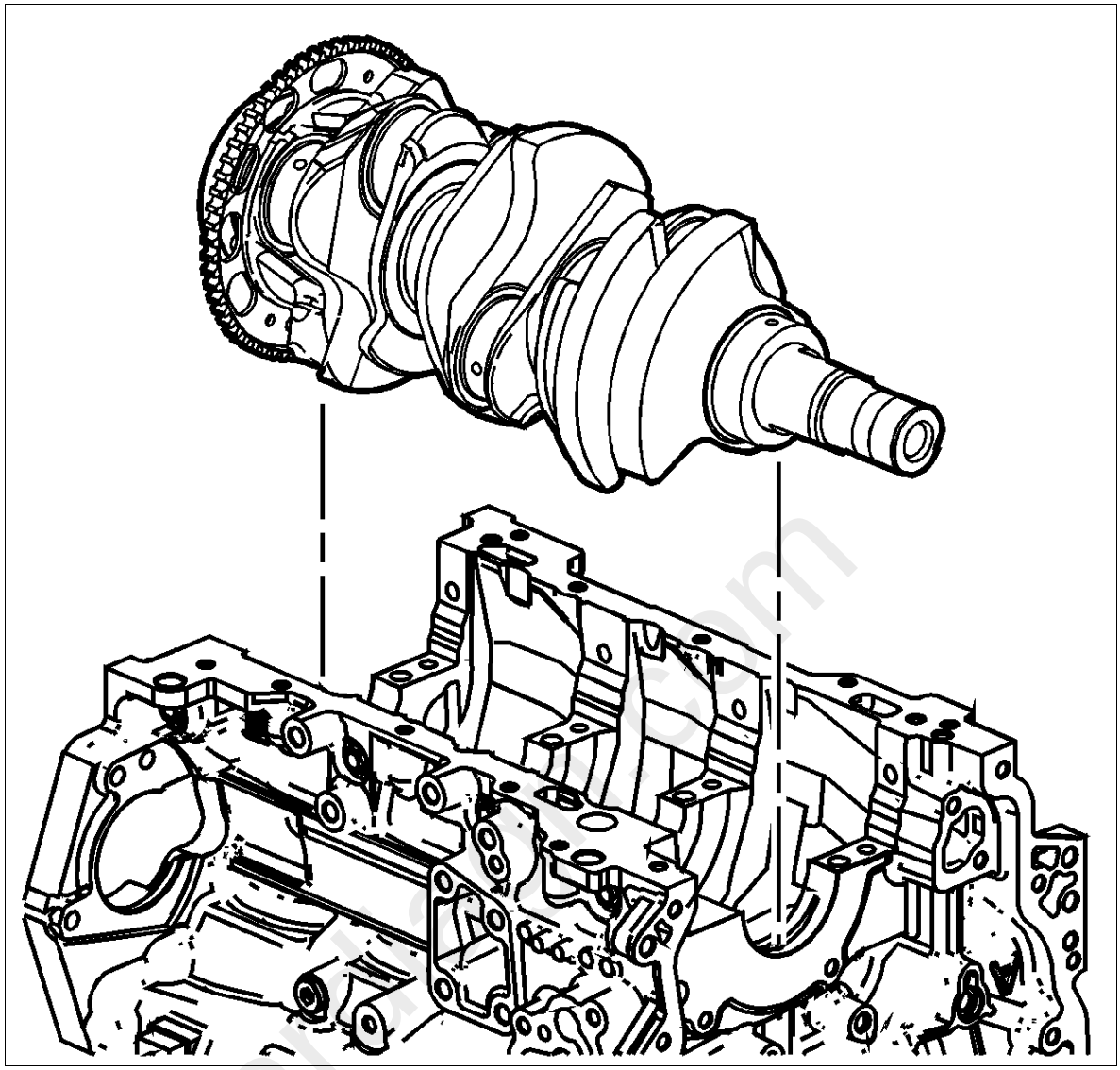


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1. If removed, install the crankshaft key. Lightly tap the key in place with a small soft face, bronze/plastic, hammer until it bottoms in the keyway.

Fig 2: Crankshaft

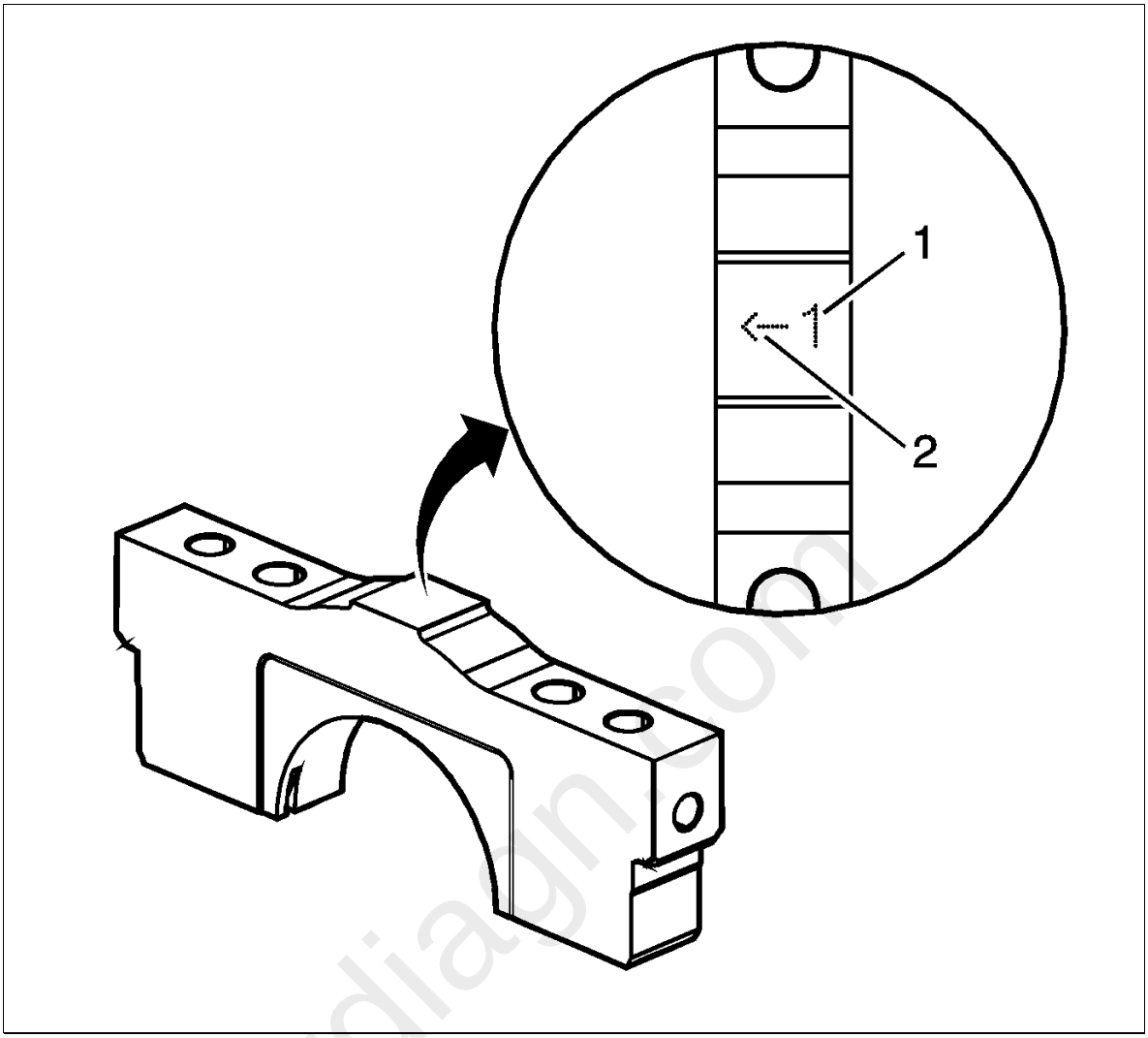


Courtesy of GENERAL MOTORS COMPANY

2. Gently lower the crankshaft into position in the cylinder block.

REPAIR INSTRUCTIONS - OFF VEHICLE > CRANKSHAFT AND BEARING INSTALLATION > CRANKSHAFT BEARING CLEARANCE MEASUREMENT PROCEDURE

Fig 1: Front Main Bearing Cap

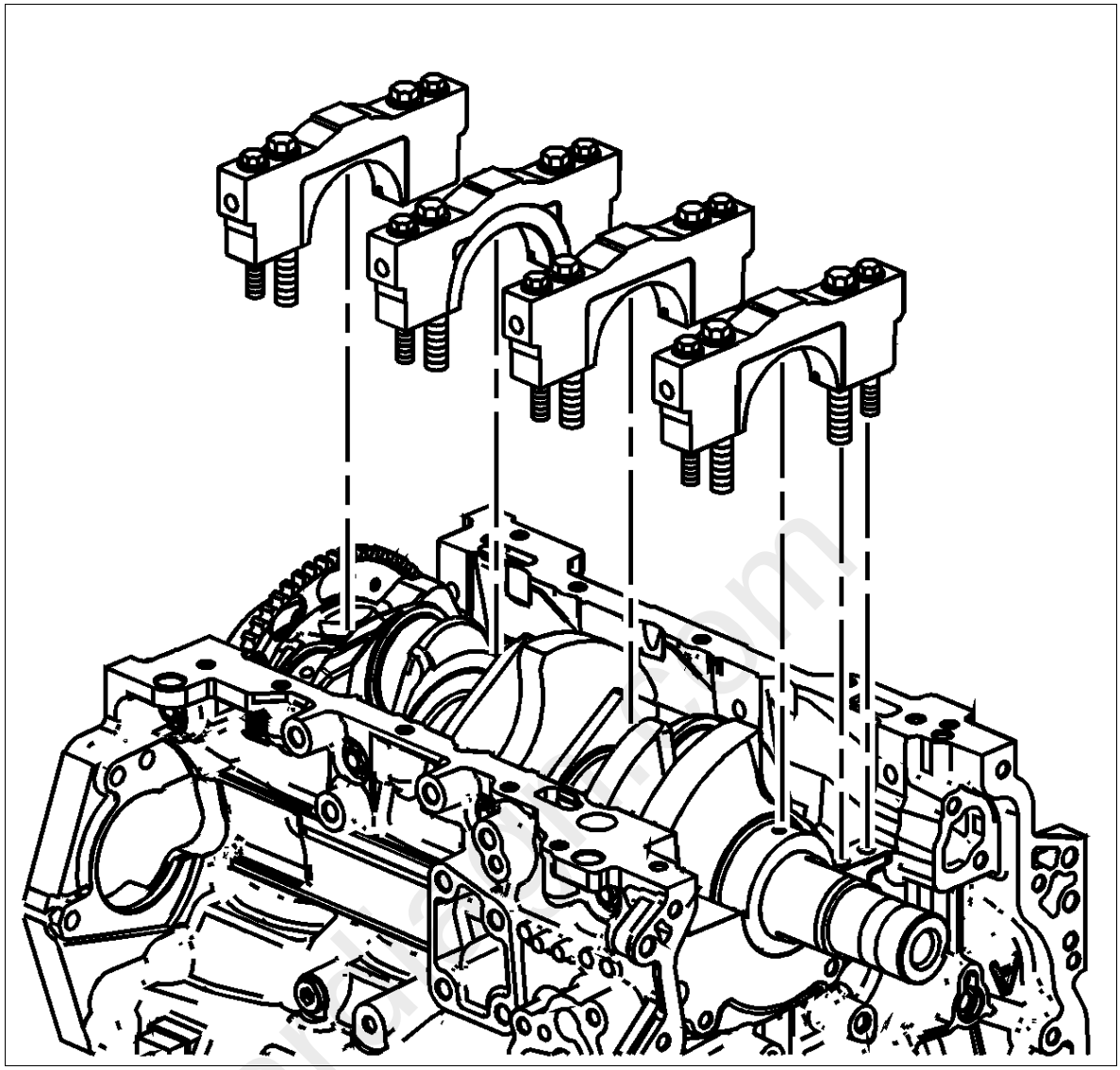


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1. Place a length of fresh, room temperature plastic gaging material all the way across all the crankshaft bearing journals.
2. Identify the proper order of the main bearing caps. The main bearing caps are numbered 1 (1) through 4, with the front main bearing cap marked with the number 1. The arrow (2) is to be oriented to the front of the engine.

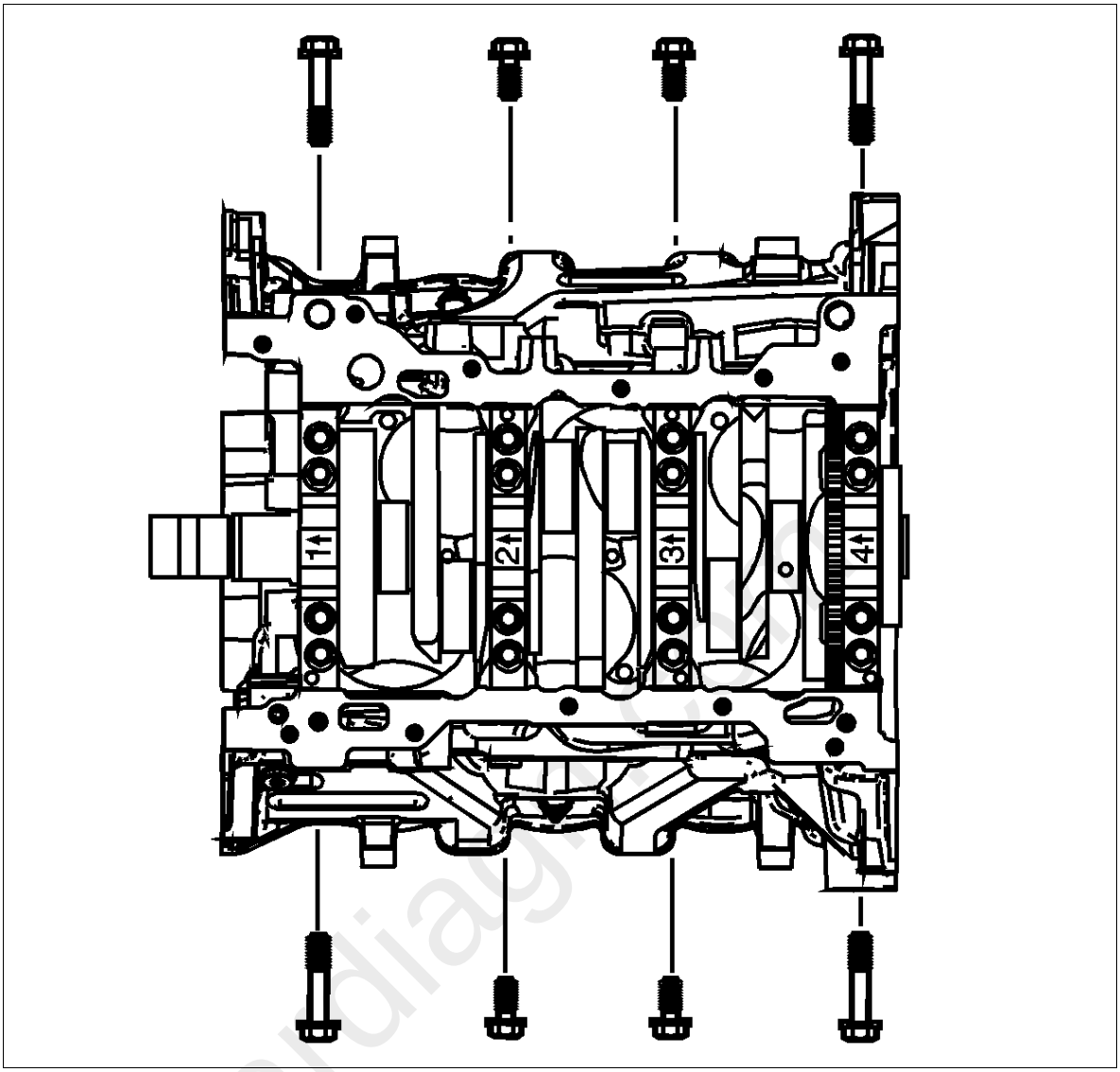
Fig 2: Crankshaft Main Bearing Caps



Courtesy of GENERAL MOTORS COMPANY

3. Install the crankshaft main bearing caps.
4. Loosely install the original inner main cap bolts.
5. Loosely install the original outer main cap bolts.

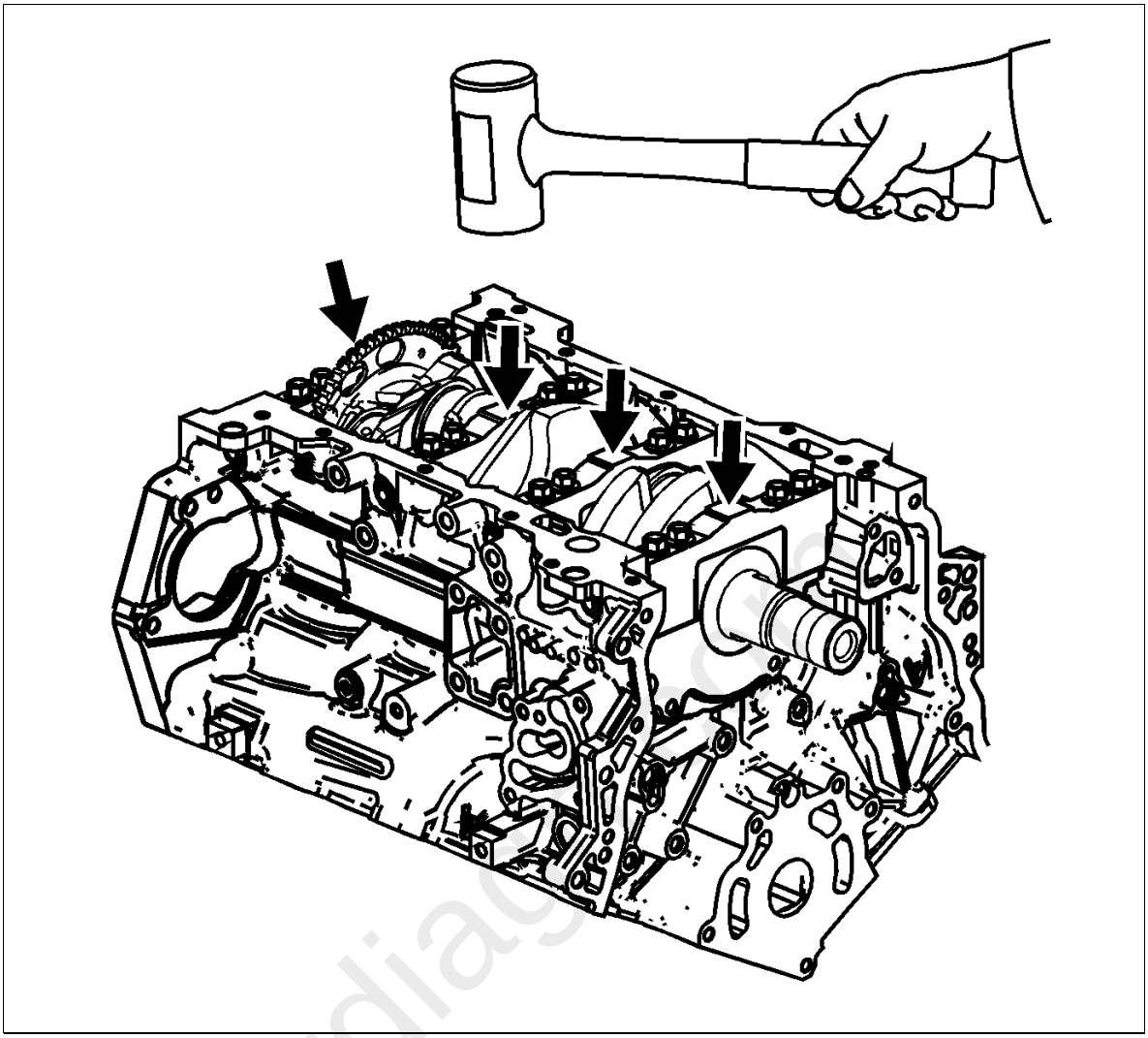
Fig 3: Crankshaft Main Bearing Cap Side Bolts



Courtesy of GENERAL MOTORS COMPANY

6. Loosely install the original short/inner side main cap bolts.
7. Loosely install the original long/outer side main cap bolts.

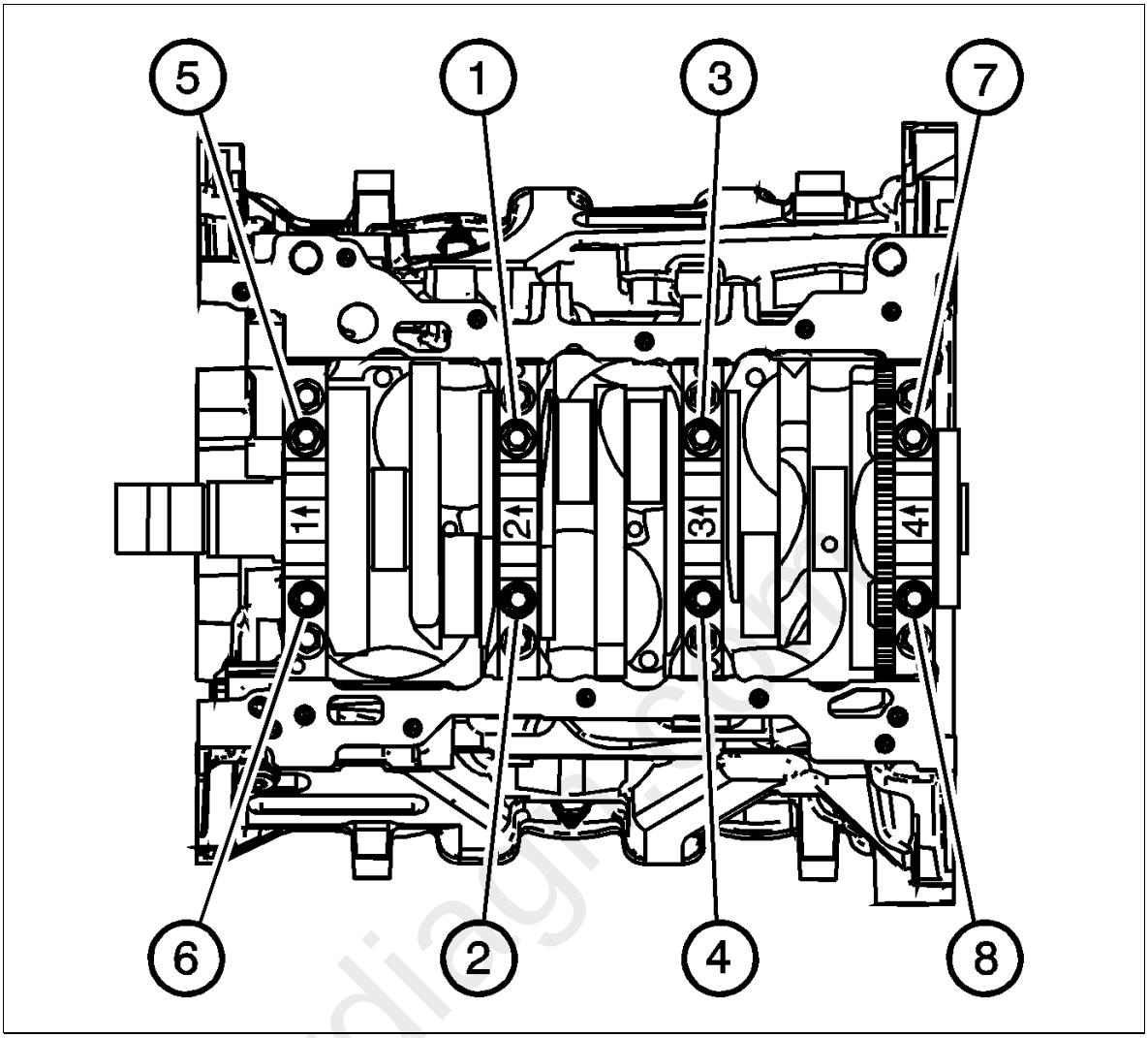
Fig 4: Setting Crankshaft Main Bearing Caps



Courtesy of GENERAL MOTORS COMPANY

8. Tap the crankshaft main bearing caps with a soft-faced hammer.

Fig 5: Crankshaft Main Bearing Inboard Bolt Tightening Sequence



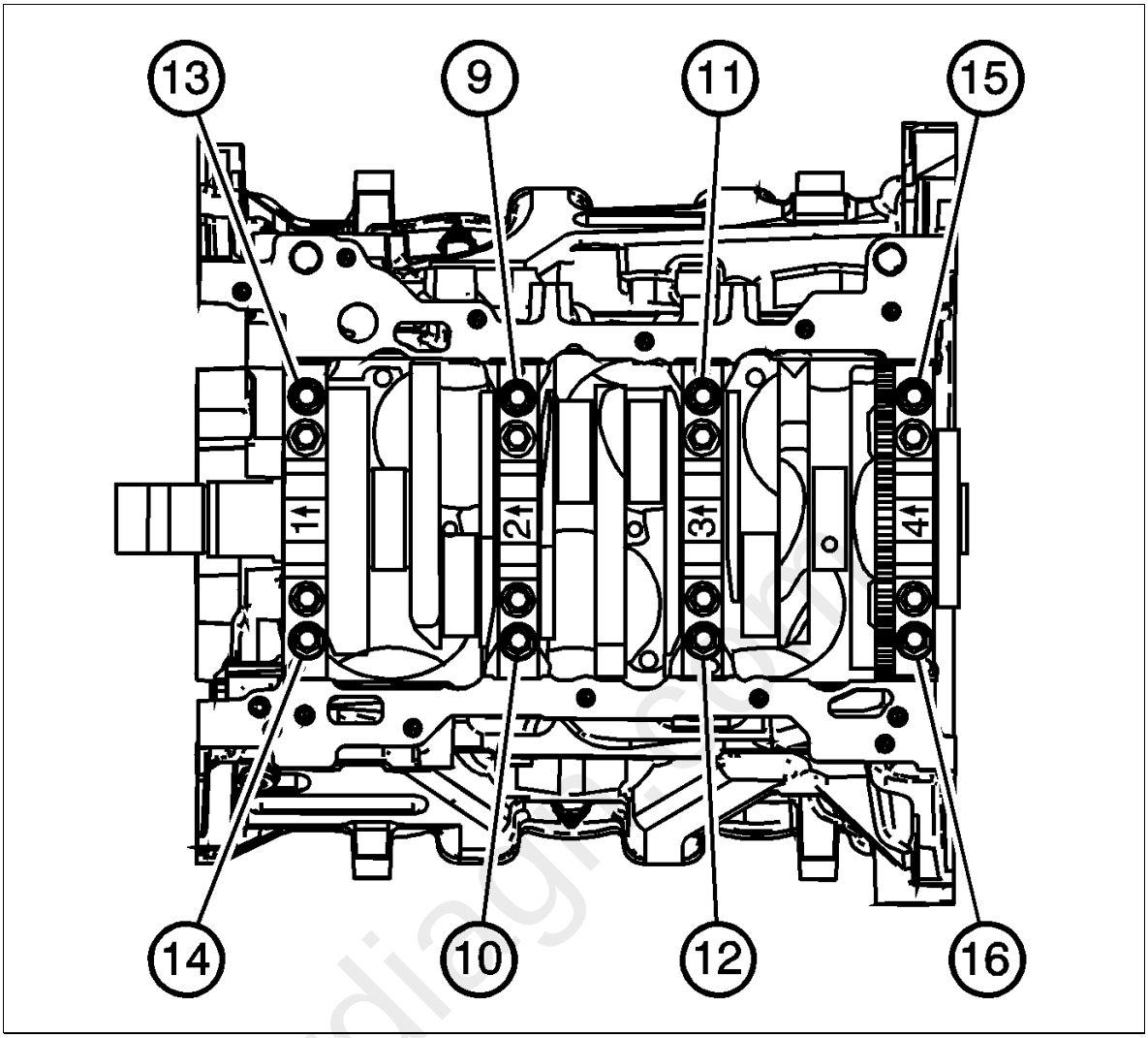
Courtesy of GENERAL MOTORS COMPANY

9. Tighten the main caps bolts using the **EN 45059** meter in the following sequence:

> ⚠ *CAUTION:*
>
> *Refer to Fastener Caution .*

10. Tighten the inboard bolts (1-8) first, in two passes.
    1. Tighten the inboard bolts to 20 N.m (15 lb ft) on the first pass.
    2. Tighten the inboard bolts (1-8) an additional 80 degrees on the 2nd pass.

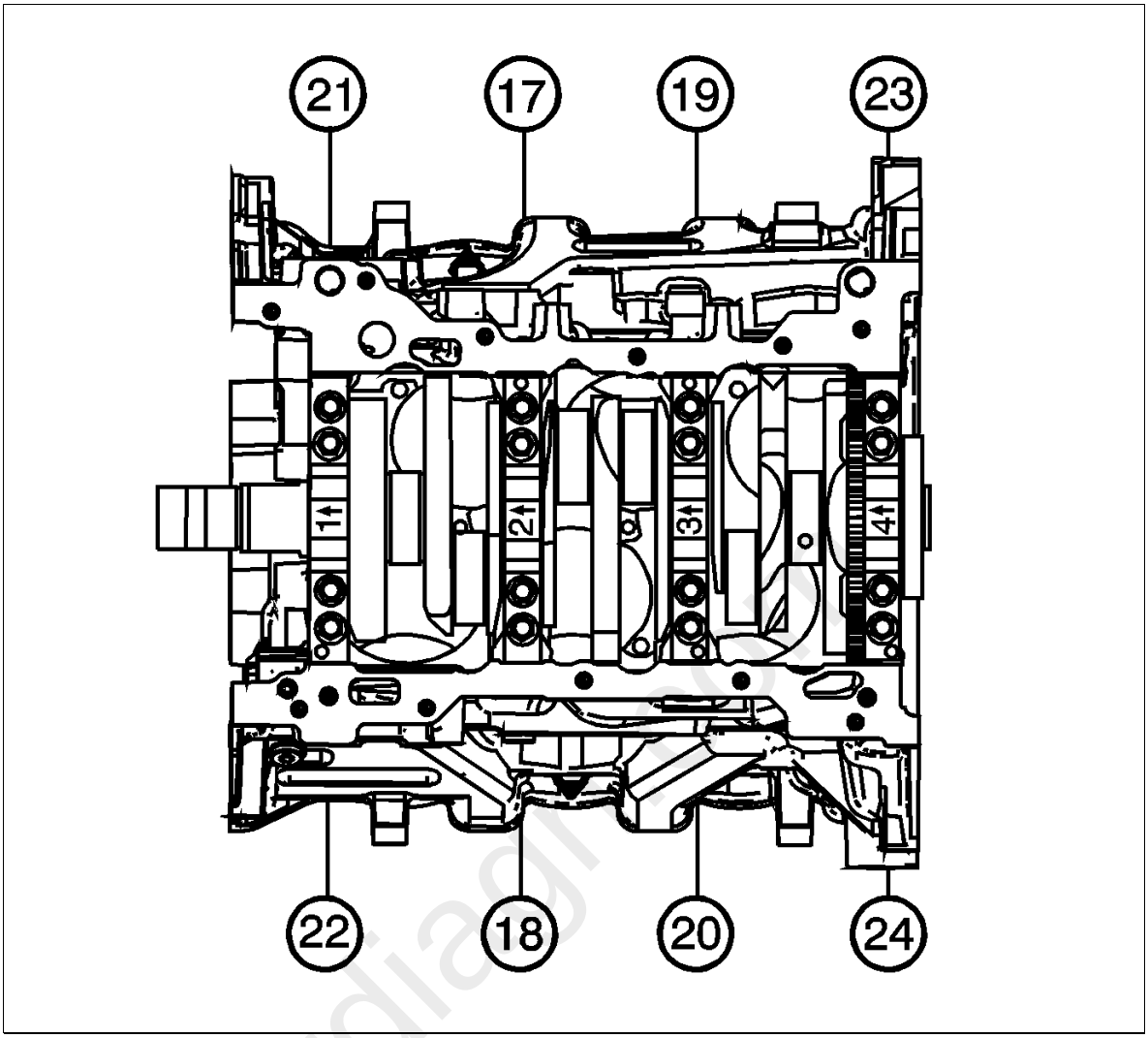
Fig 6: Outboard Crankshaft Main Bearing Bolt Tightening Sequence



Courtesy of GENERAL MOTORS COMPANY

11. Tighten the outboard bolts (9-16) second, in two passes.
    1. Tighten the outboard bolts to 15 N.m (11 lb ft) on the first pass.
    2. Tighten the outboard bolts (9-16) an additional 110 degrees on the 2nd pass.

Fig 7: Short/Inner Crankshaft Main Bearing (Bolt Tightening Sequence)



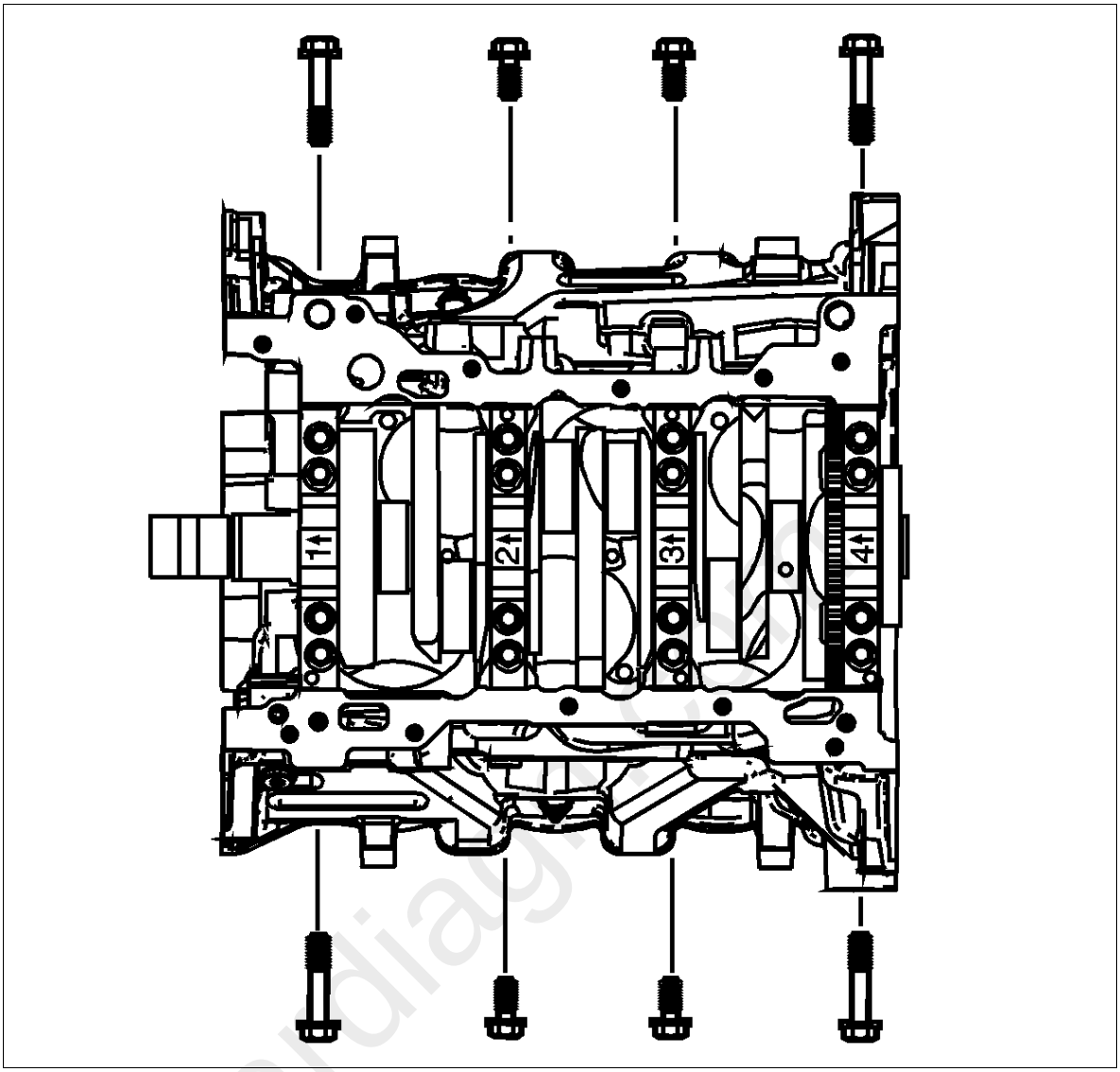
Courtesy of GENERAL MOTORS COMPANY

12. Tighten the short/inner bolts (17-20) third, in two passes.
    1. Tighten the short/inner bolts to 30 N.m (22 lb ft) on the first pass.
    2. Tighten the short/inner bolts (17-20) an additional 60 degrees on the 2nd pass.
13. Tighten the long/outer bolts (21-24) fourth, in two passes.
    1. Tighten the long/outer bolts to 30 N.m (22 lb ft) on the first pass.
    2. Tighten the long/outer bolts (21-24) an additional 60 degrees on the 2nd pass.

> *NOTE:*
>
> *Do not rotate the crankshaft.*

14. After reaching final torque, allow the assembly to sit for 2 minutes.

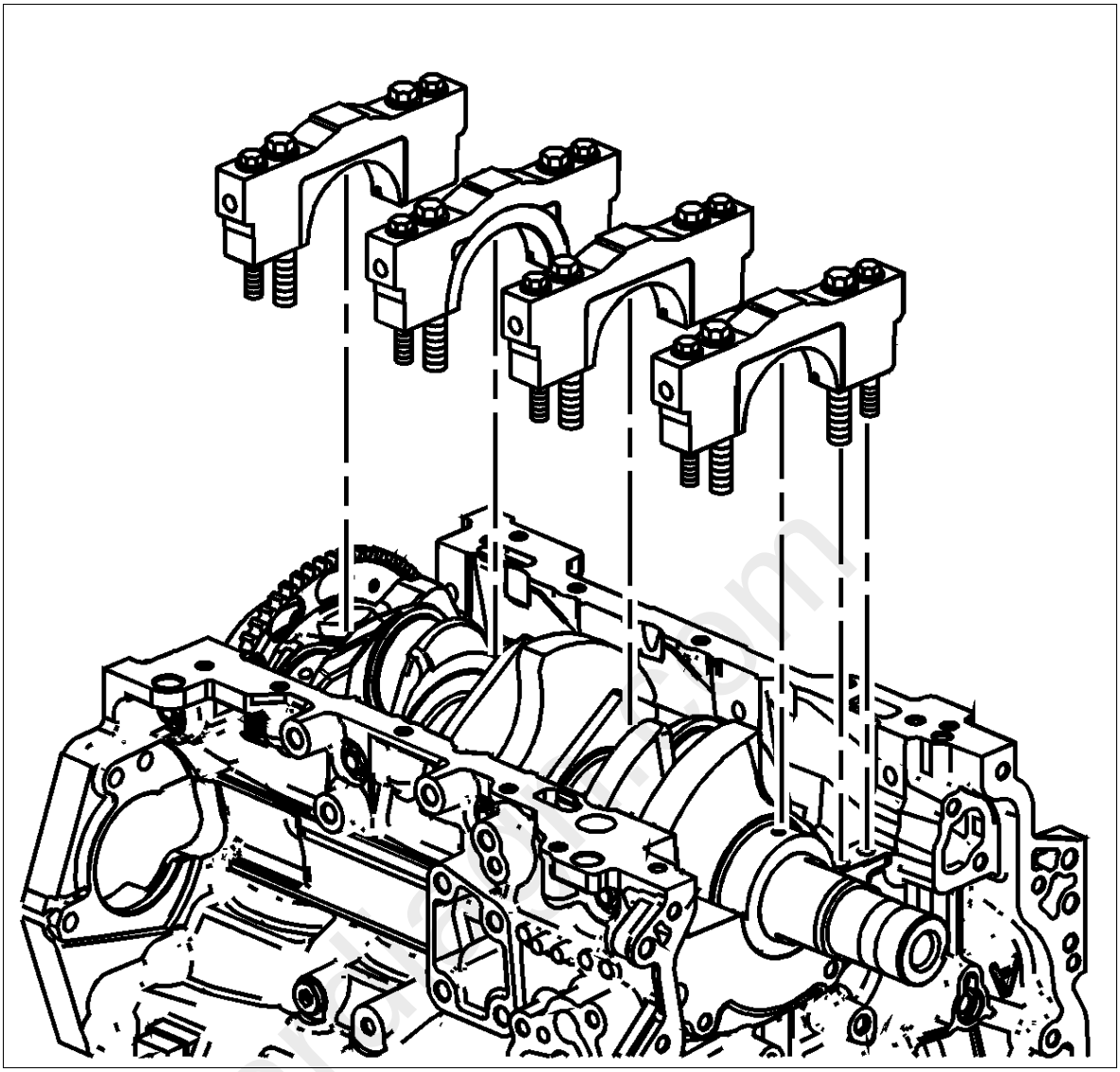
Fig 8: Crankshaft Main Bearing Cap Side Bolts



Courtesy of GENERAL MOTORS COMPANY

15. Remove the crankshaft bearing cap side bolts.

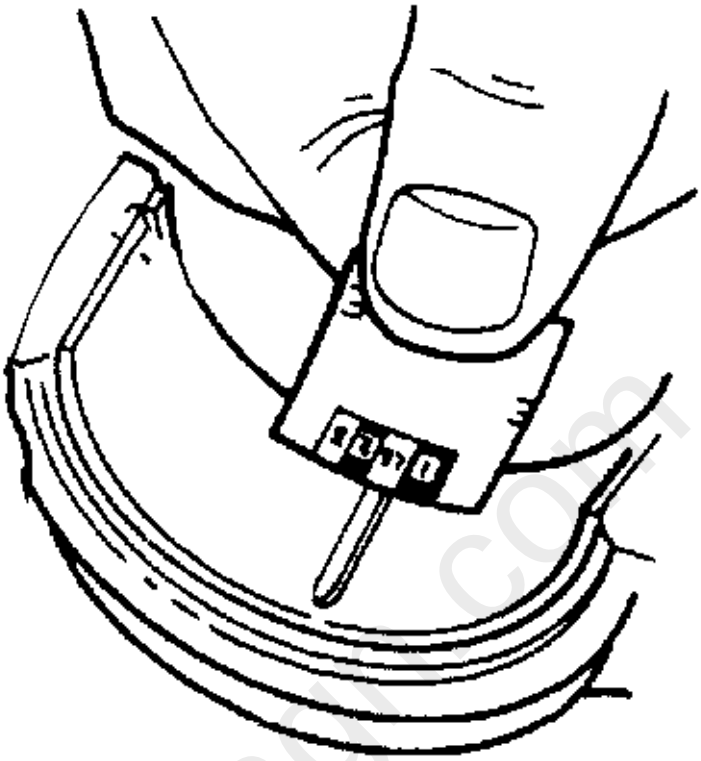
Fig 9: Crankshaft Main Bearing Caps



Courtesy of GENERAL MOTORS COMPANY

16. Remove the crankshaft bearing cap outer bolts.
17. Remove the crankshaft bearing cap inner bolts.
18. Remove the crankshaft bearing caps using the **GE 6125-1B** adapter and **EN 49102** remover.

Fig 10: Plastigage



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19. Determine the crankshaft bearing clearance by comparing the width of the flattened plastic gaging material at its widest point with the graduation on the gaging material container.

> *NOTE:*
>
> *The crankshaft bearings CAN be reused after checking the clearance if the bearings have never been used in a running engine.*

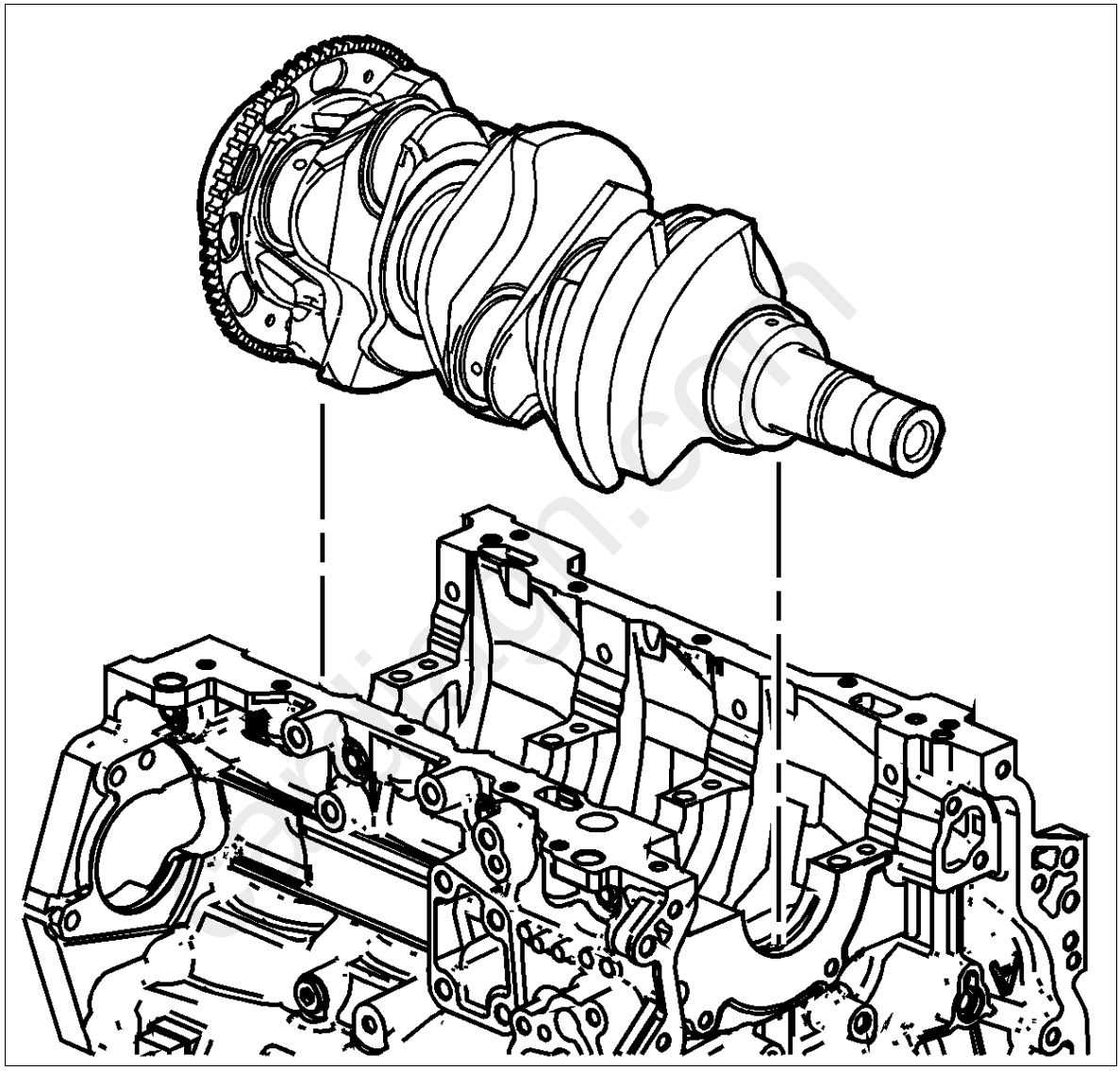
20. Compare your measurements with the Engine Mechanical Specifications . If the new bearings do not provide the proper crankshaft to bearing clearance, inspect the following:
    1. Re-measure the crankshaft journals for the correct specified size and ensure the proper new bearings are being installed. If the crankshaft journals are incorrectly

sized, replace or regrind the crankshaft. Crankshaft machining is permitted and undersized bearings are available.

2. Re-measure the engine block crankshaft bearing bore diameter to ensure proper size. The engine block crankshaft bearing bore is not machinable and the block must be replaced if out of specification.

21. Clean the plastic gaging material from the crankshaft bearing journals with a soft, lint-free cloth.

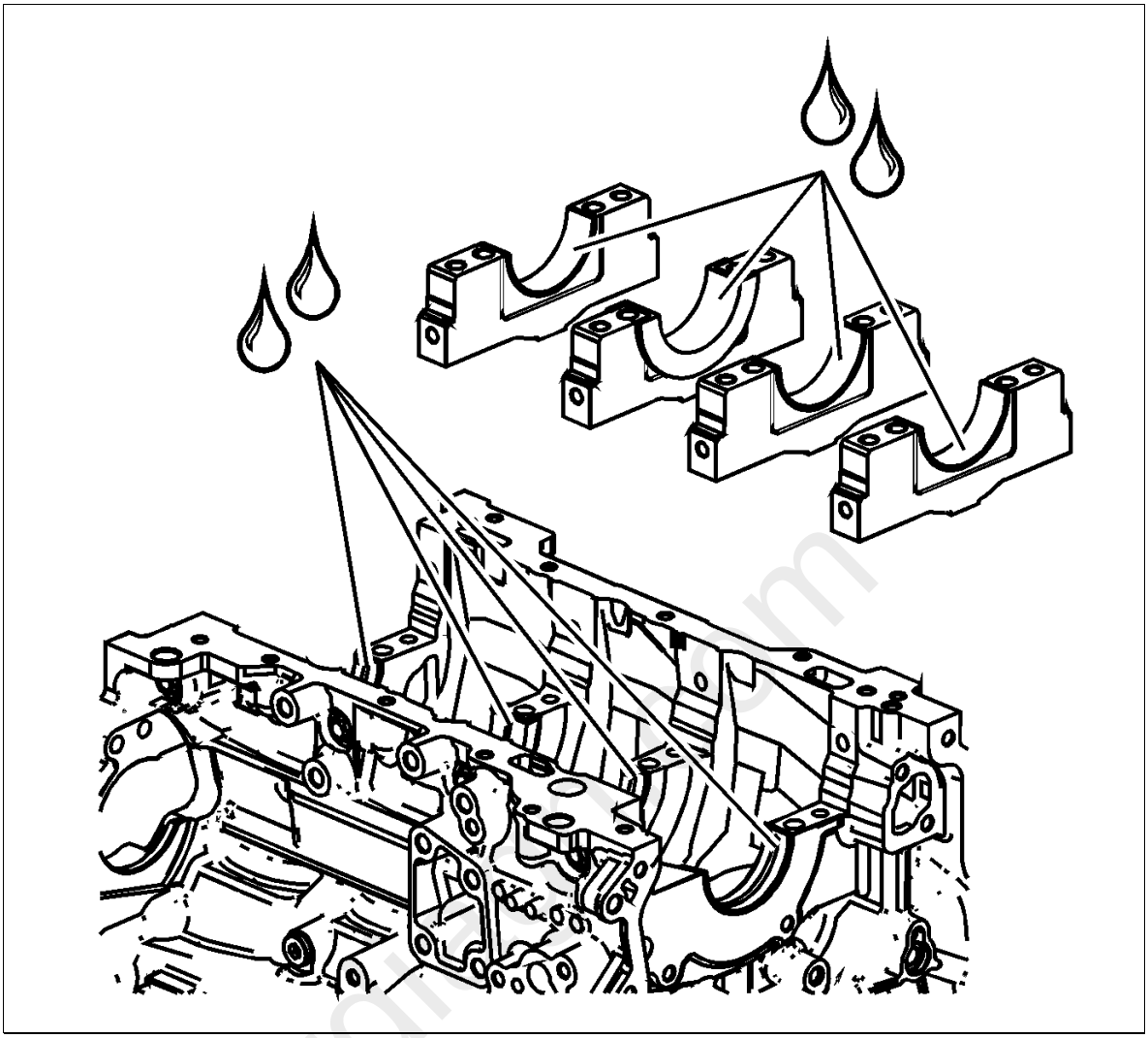
Fig 11: Crankshaft



Courtesy of GENERAL MOTORS COMPANY

22. Lift the crankshaft out of the cylinder block.

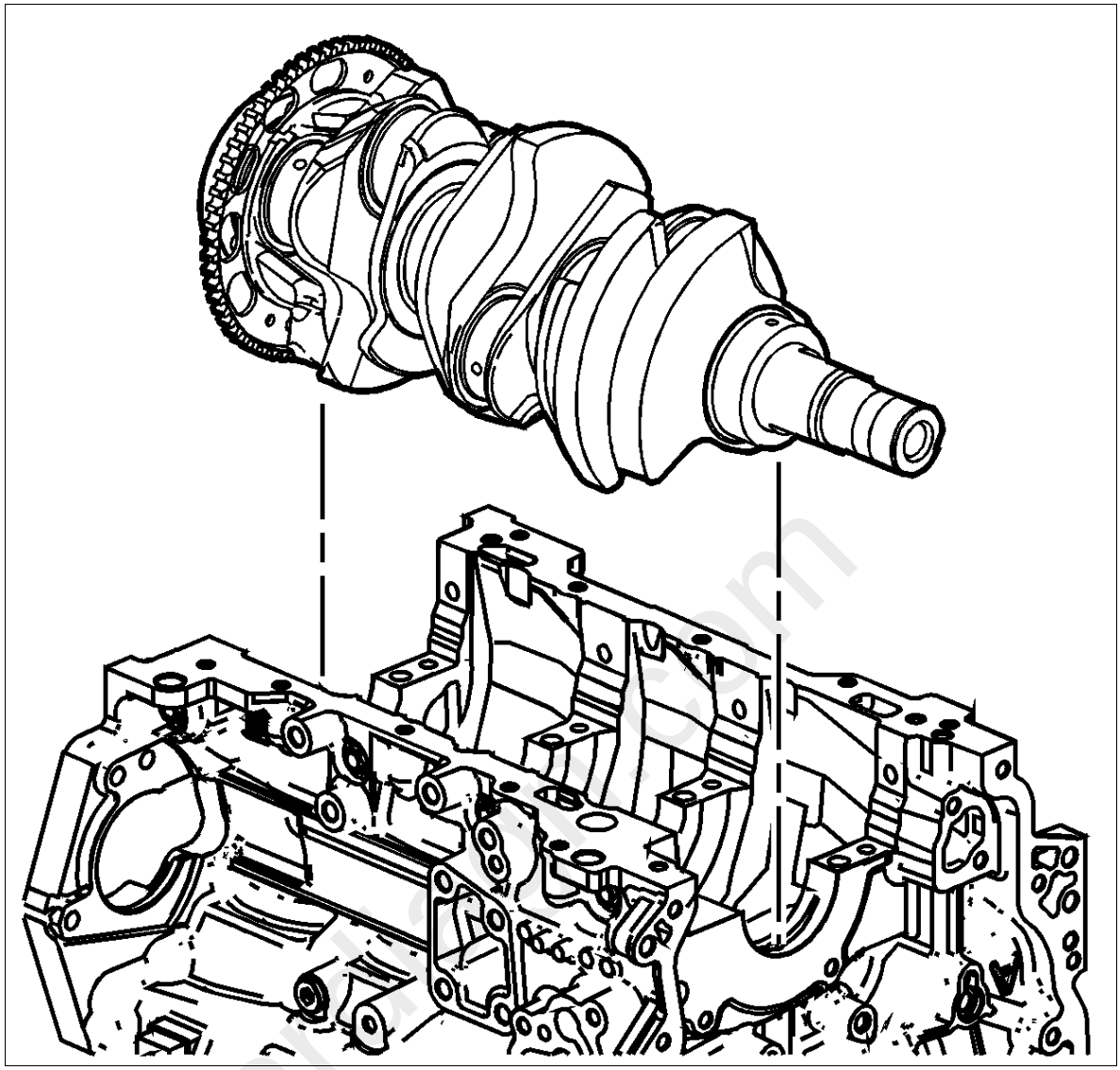
Fig 12: Prelubing Upper & Lower Bearing Surfaces



Courtesy of GENERAL MOTORS COMPANY

23. Apply a liberal amount of crankshaft prelube or clean engine oil to the upper and lower bearing surfaces. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended lubricant.

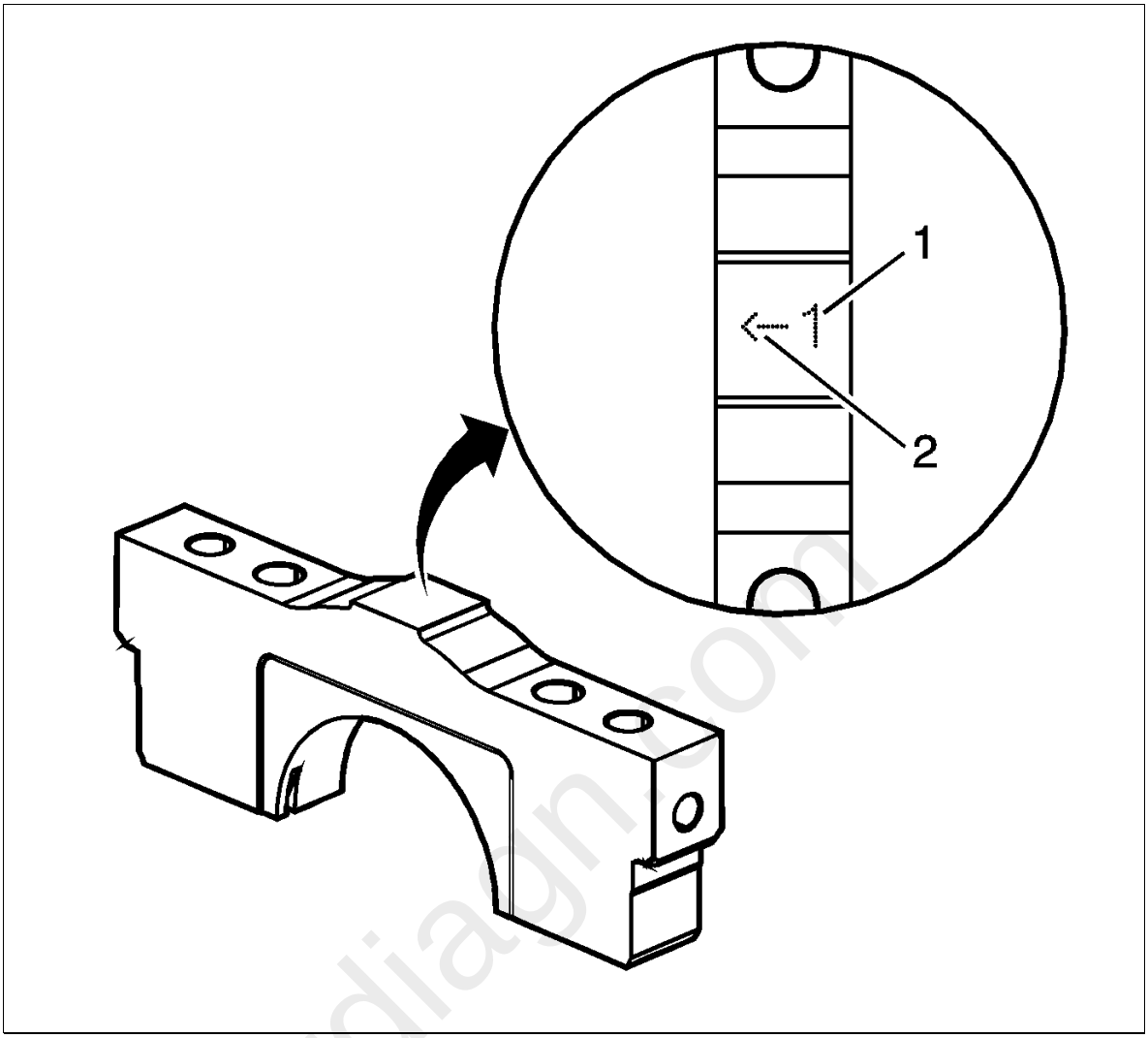
Fig 13: Crankshaft



Courtesy of GENERAL MOTORS COMPANY

24. Gently lower the crankshaft into position in the cylinder block.

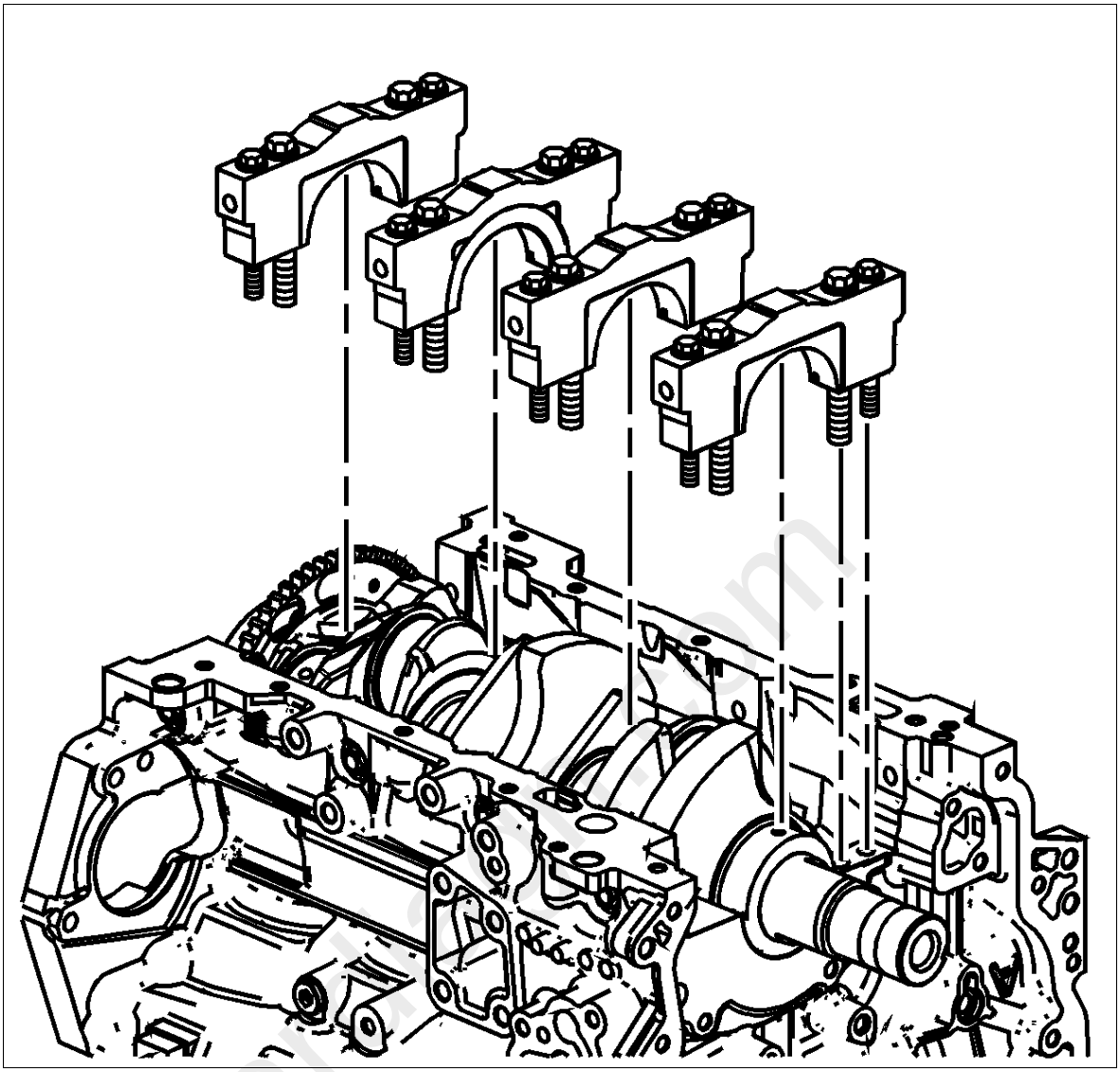
Fig 14: Front Main Bearing Cap



Courtesy of GENERAL MOTORS COMPANY

25. Identify the proper order of the main bearing caps. The main bearing caps are numbered 1 (1) through 4, with the front main bearing cap marked with the number 1. The arrow (2) is to be oriented to the front of the engine.

Fig 15: Crankshaft Main Bearing Caps



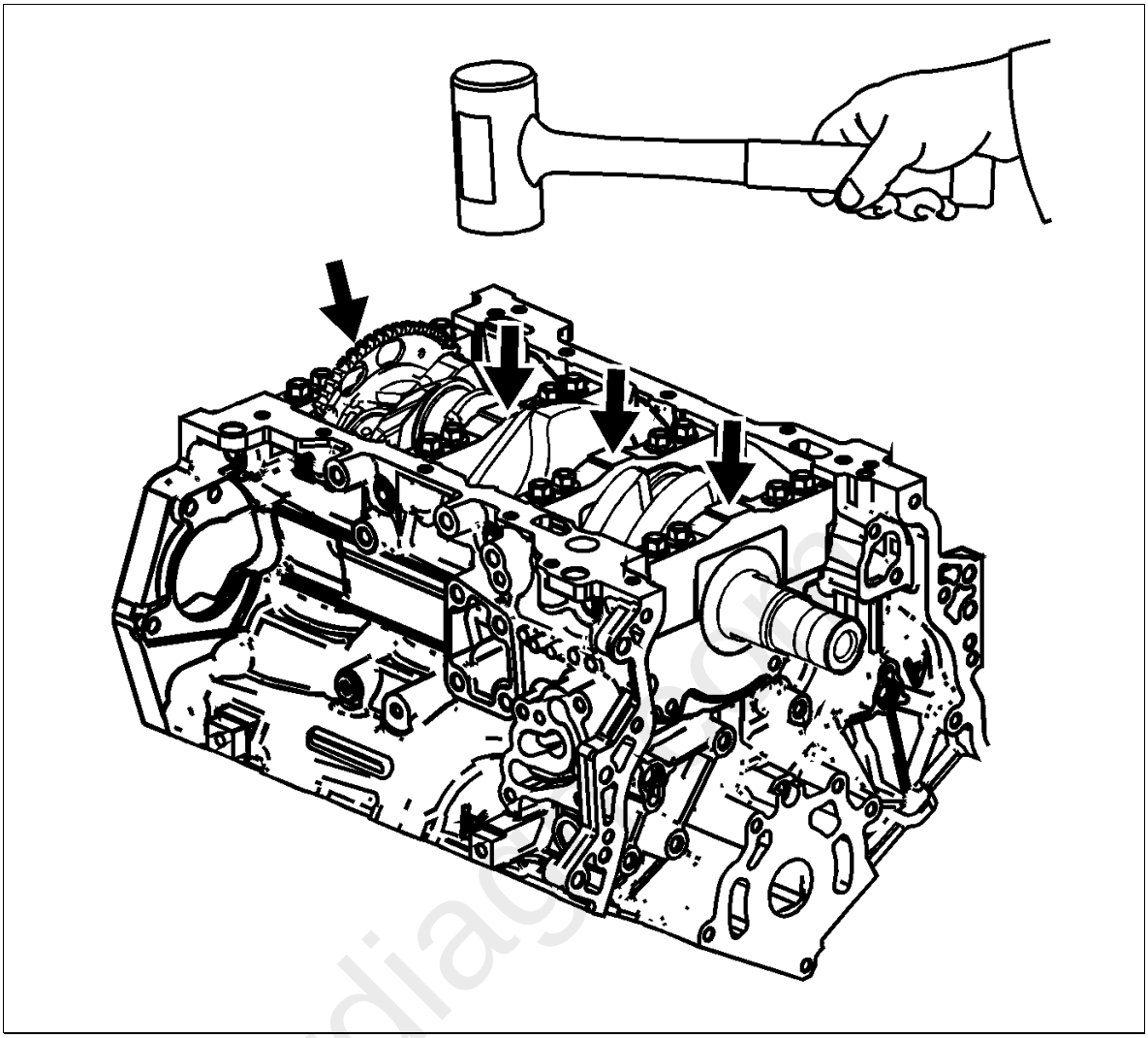
Courtesy of GENERAL MOTORS COMPANY

26. Install the crankshaft main bearing caps.

> ⚠ *CAUTION:*
>
> *This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.*

27. Loosely install the NEW inner main cap bolts.
28. Loosely install the NEW outer main cap bolts.

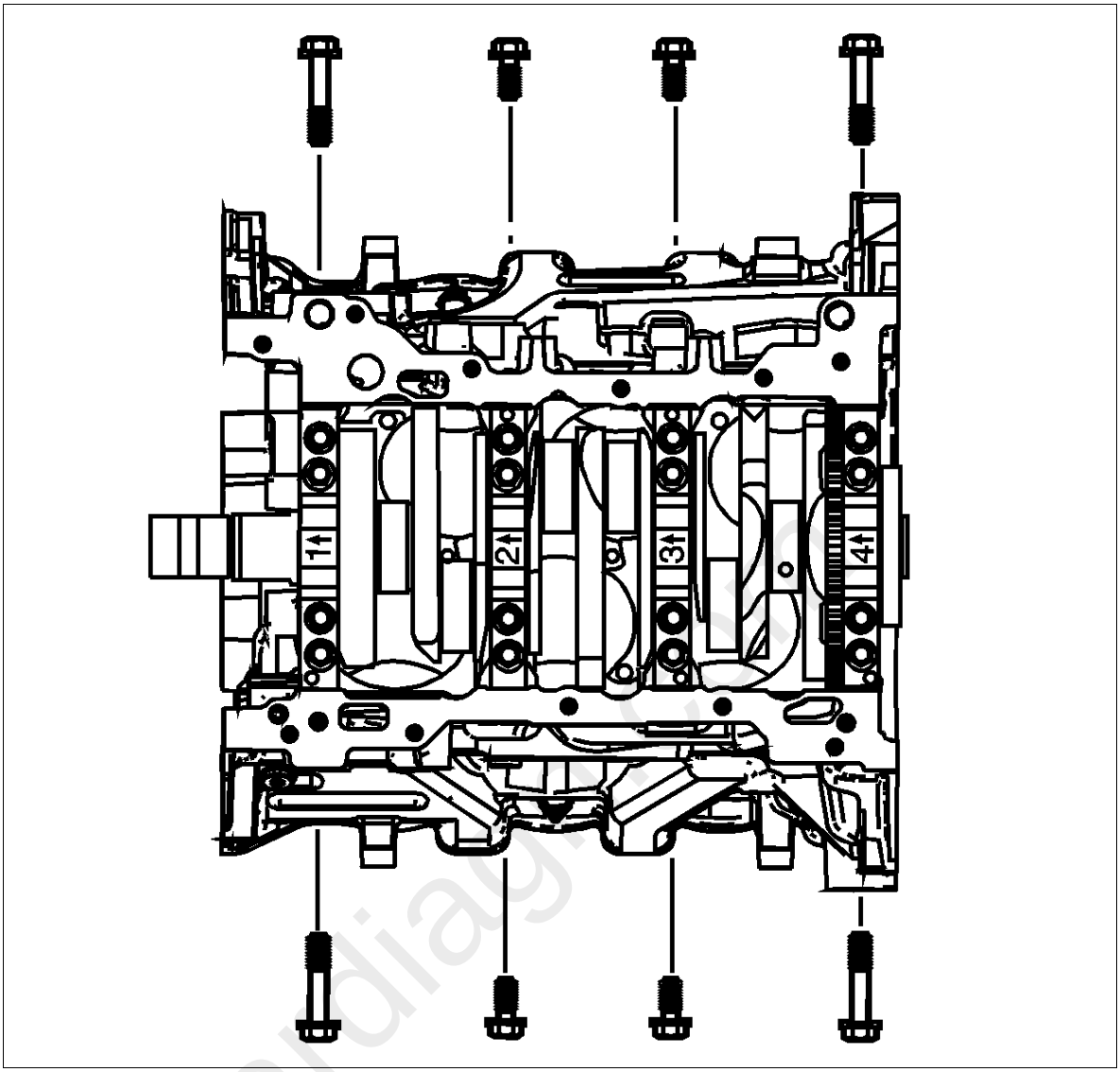
Fig 16: Setting Crankshaft Main Bearing Caps



Courtesy of GENERAL MOTORS COMPANY

29. Tap the crankshaft main bearing caps with a soft-faced hammer.

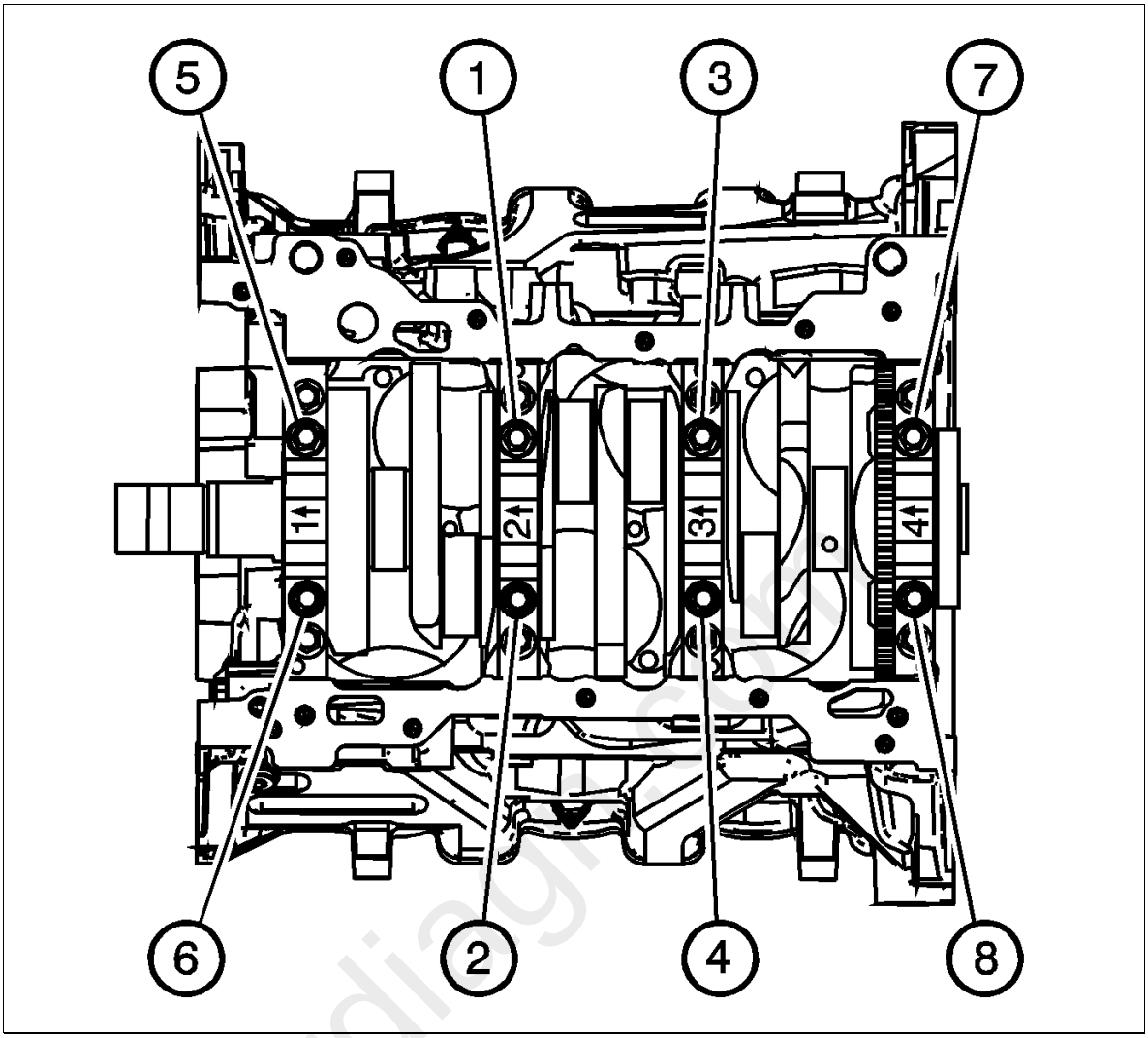
Fig 17: Crankshaft Main Bearing Cap Side Bolts



Courtesy of GENERAL MOTORS COMPANY

30. Loosely install the NEW short/inner side main cap bolts.
31. Loosely install the NEW long/outer side main cap bolts.

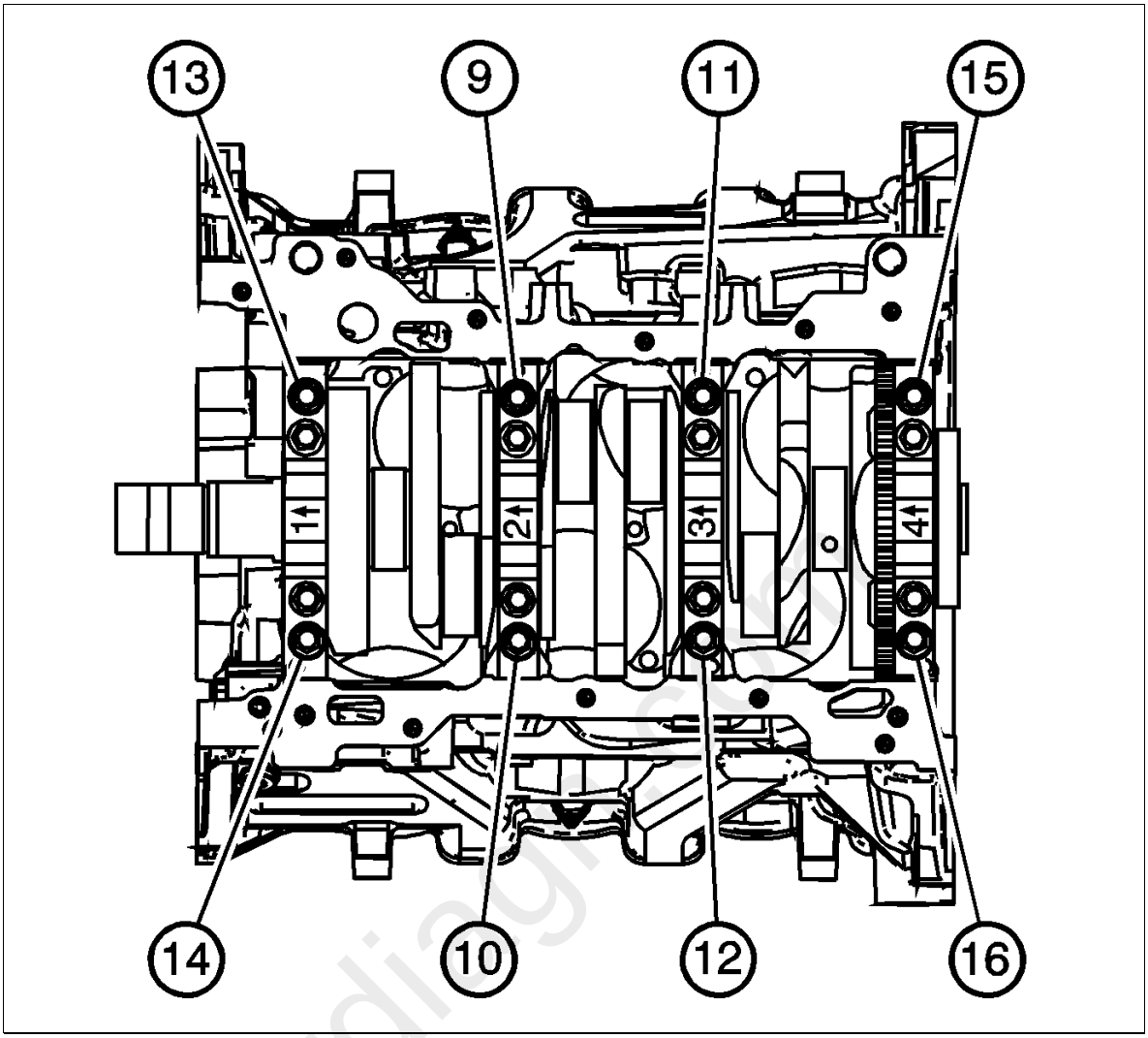
Fig 18: Crankshaft Main Bearing Inboard Bolt Tightening Sequence



Courtesy of GENERAL MOTORS COMPANY

32. Tighten the main cap bolts using the **EN 45059** meter in the following sequence:
33. Tighten the inboard bolts (1-8) first, in two passes.
    1. Tighten the inboard bolts to 20 N.m (15 lb ft) on the first pass.
    2. Tighten the inboard bolts (1-8) an additional 80 degrees on the 2nd pass.

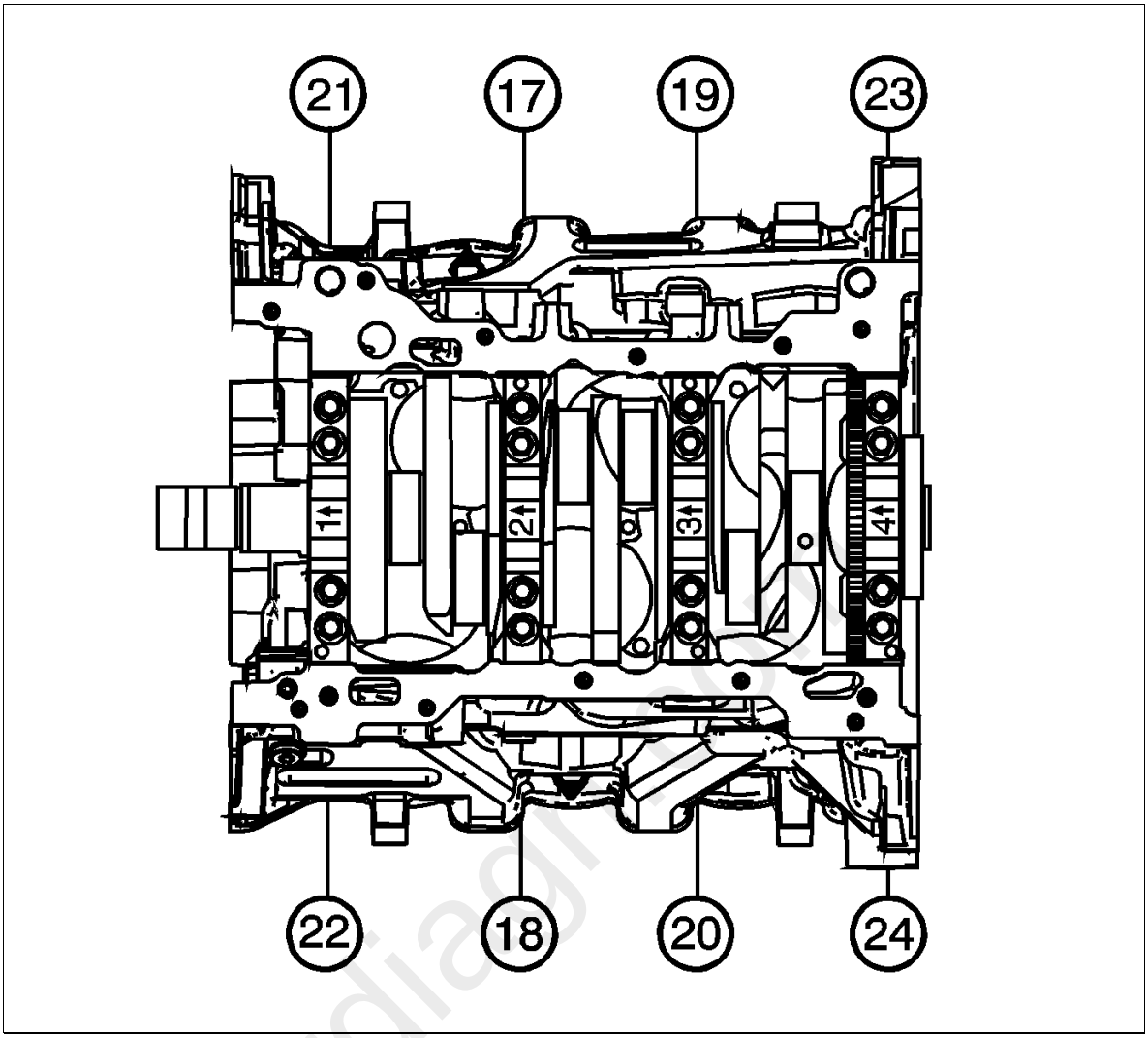
Fig 19: Outboard Crankshaft Main Bearing Bolt Tightening Sequence



Courtesy of GENERAL MOTORS COMPANY

34. Tighten the outboard bolts (9-16) second, in two passes.
    1. Tighten the outboard bolts to 15 N.m (11 lb ft) on the first pass.
    2. Tighten the outboard bolts (9-16) an additional 110 degrees on the 2nd pass.

Fig 20: Short/Inner Crankshaft Main Bearing (Bolt Tightening Sequence)



Courtesy of GENERAL MOTORS COMPANY

35. Tighten the short/inner bolts (17-20) third, in two passes.
    1. Tighten the short/inner bolts to 30 N.m (22 lb ft) on the first pass.
    2. Tighten the short/inner bolts (17-20) an additional 60 degrees on the 2nd pass.
36. Tighten the long/outer bolts (21-24) fourth, in two passes.
    1. Tighten the long/outer bolts to 30 N.m (22 lb ft) on the first pass.
    2. Tighten the long/outer bolts (21-24) an additional 60 degrees on the 2nd pass.
37. Ensure that the crankshaft turns without binding or noise.

REPAIR INSTRUCTIONS - OFF VEHICLE > PISTON, CONNECTING ROD, AND BEARING INSTALLATION

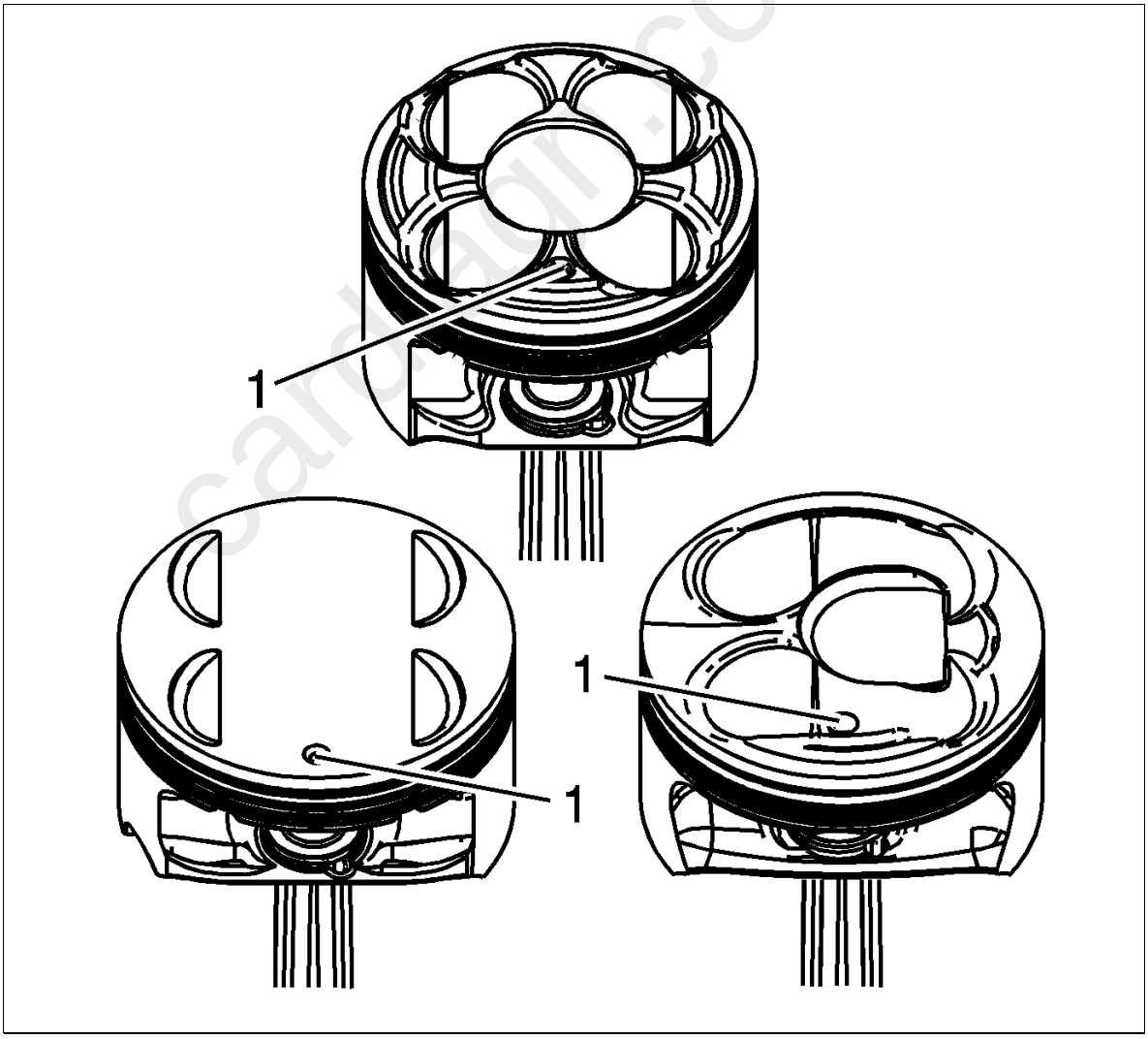
Special Tools

- **EN-43690-A** Rod Bearing Clearance Checking Tool
- **EN-43690-100** Rod Bearing Clearance Checking Tool - Adapter Kit
- **EN-45059** Angle Meter
- **EN-46121** Connecting Rod Guide Pin Set
- **EN-48589** Crankshaft Rotation Socket

For equivalent regional tools, refer to Special Tools .

REPAIR INSTRUCTIONS - OFF VEHICLE > PISTON, CONNECTING ROD, AND BEARING INSTALLATION > PISTON AND CONNECTING ROD ASSEMBLY PROCEDURE

Fig 1: Lubrication Points of the Piston Ring Assembly



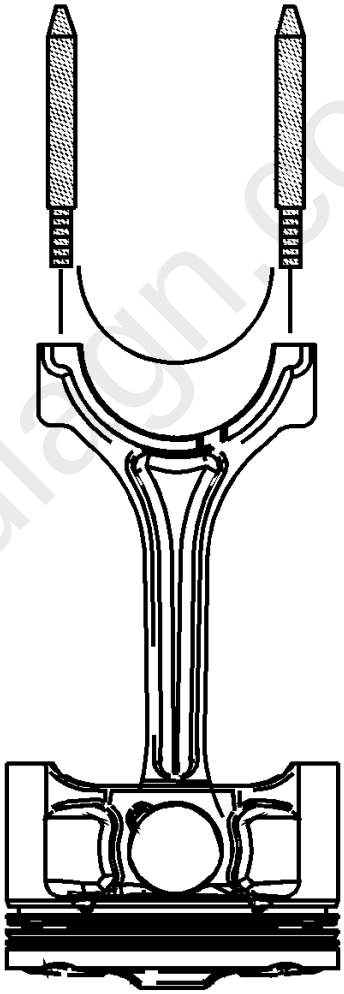
Courtesy of GENERAL MOTORS COMPANY

1. Liberally lubricate the cylinder walls, piston rings and piston skirts with engine oil.

> *NOTE:*
>
> 1. *The piston is directional and must be installed in the engine block in the proper direction. The dot on the top of the piston must face the front of the engine.*
> 2. *Ensure the Bowl of the piston faces the intake.*

2. Select the correctly numbered piston/connecting rod assembly for the cylinder. A dot (1) showing proper piston orientation is located on the top of the piston. Piston is model dependent.

Fig 2: Crankshaft Protector Pins Installed in Connecting Rod Bolt Holes



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> *NOTE:*
>
> *If the connecting rod bearings have been used in a running engine, you must*

replace them with NEW connecting rod bearings for reassembly.

3. Install the connecting rod bearing into the connecting rod.
4. Install the **EN-46121** set into the connecting rod bolt holes.
5. Compress the piston rings using the a ring compressor sleeve or equivalent.

NOTE:

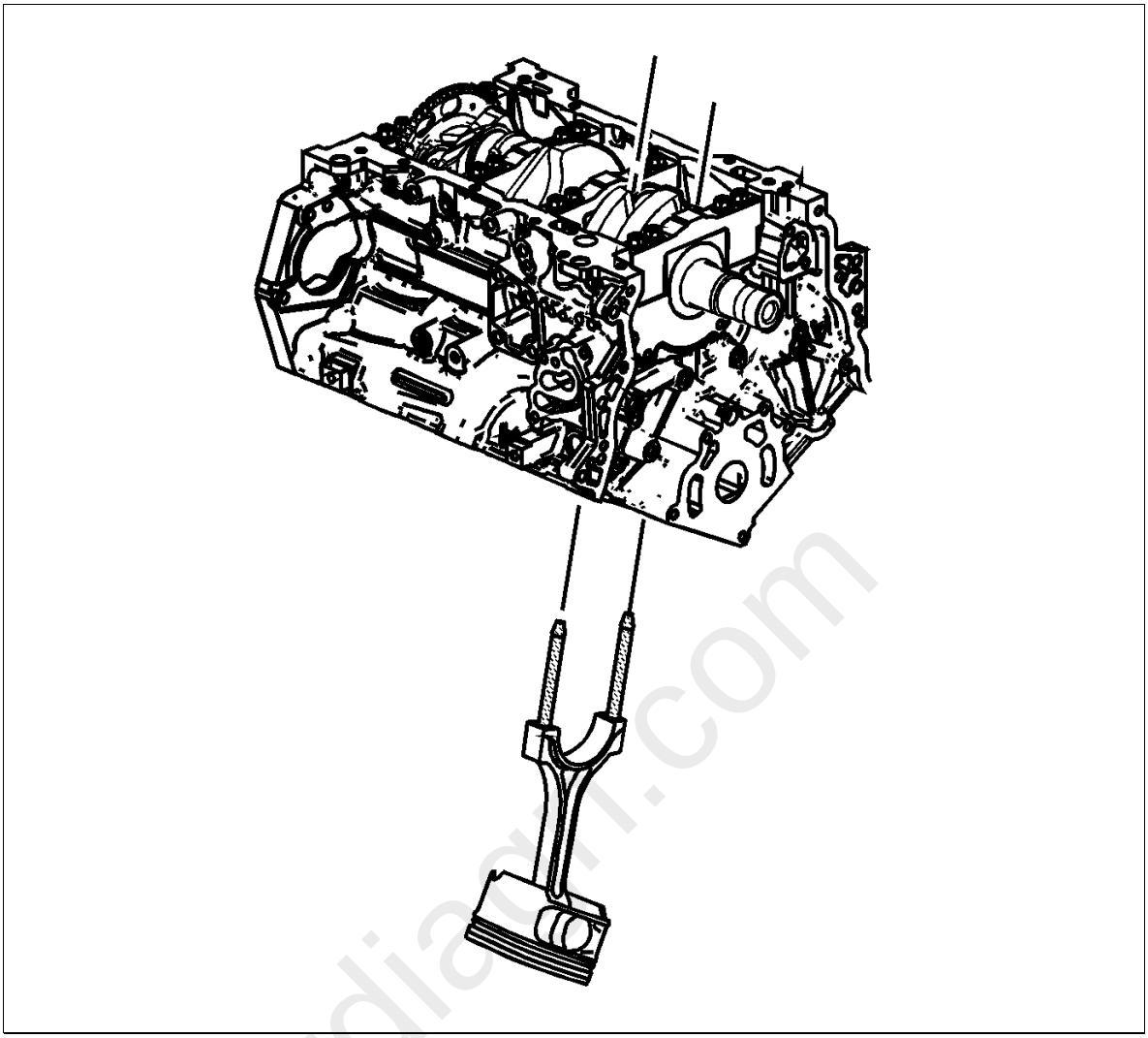
When installing a piston into a cylinder, use a ring compressor sleeve or equivalent for best results. The following features should be looked for when selecting a ring compressor sleeve.

1. *Hard anodized and Teflon coated for low friction and prolonged wear resistance.*
2. *Smooth radius that tapers down to the specific bore size.*
3. *Sleeve should compress the piston rings smoothly and evenly.*
4. *Using a ring compressor sleeve greatly reduces the difficulty with installing thin high-performance oil rings.*

If a ring compressor sleeve is unavailable, a universal ring compressor will work but is more difficult to use.

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Fig 3: Connecting Rod & Piston Assembly



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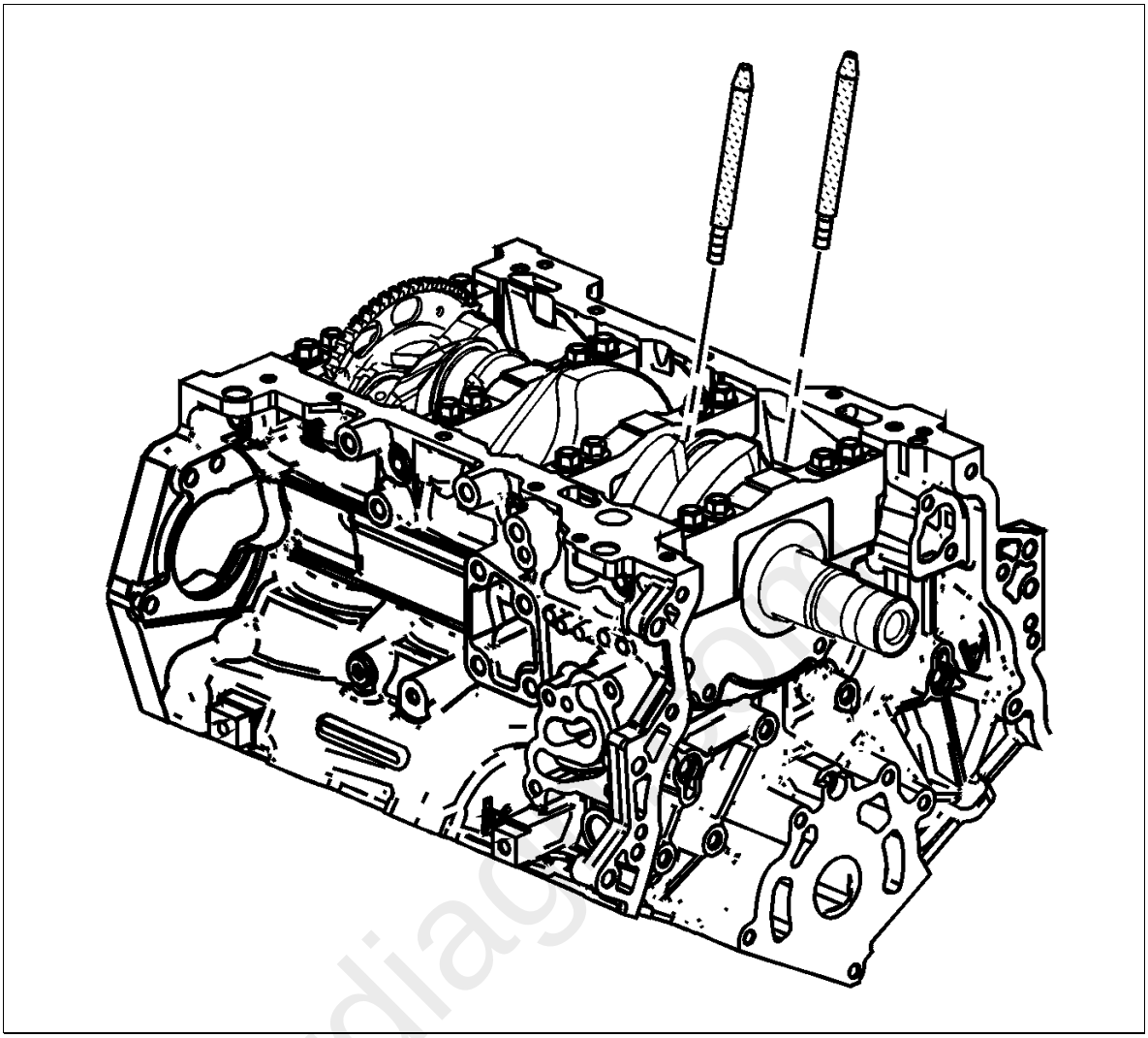
NOTE:

Extreme care must be used when installing the piston and connecting rod in order to be sure the rod does not scrape or nick the cylinder bore, the oil jets, or the crankshaft surfaces.

6. Using both hands, slowly guide the piston and connecting rod assembly into the cylinder from the top and bottom of the cylinder. DO NOT allow the connecting rod to contact the cylinder wall.

7. Tap the piston into its bore with a hammer handle. Guide the connecting rod to the connecting rod journal using the **EN-46121** set while gently tapping the piston into place. Hold the ring compressor sleeve or equivalent against the engine block until all the rings have entered the cylinder bore.

Fig 4: Crankshaft Protector Pins Installed in Connecting Rod Bolt Holes



Courtesy of GENERAL MOTORS COMPANY

8. Remove the **EN-46121** set from the connecting rod bolt holes.

REPAIR INSTRUCTIONS - OFF VEHICLE > PISTON, CONNECTING ROD, AND BEARING INSTALLATION > CONNECTING ROD BEARING CLEARANCE MEASUREMENT PROCEDURE - USING PLASTIC GAGING

NOTE:

Connecting rod bearings that have been run in an engine should NEVER be reused.

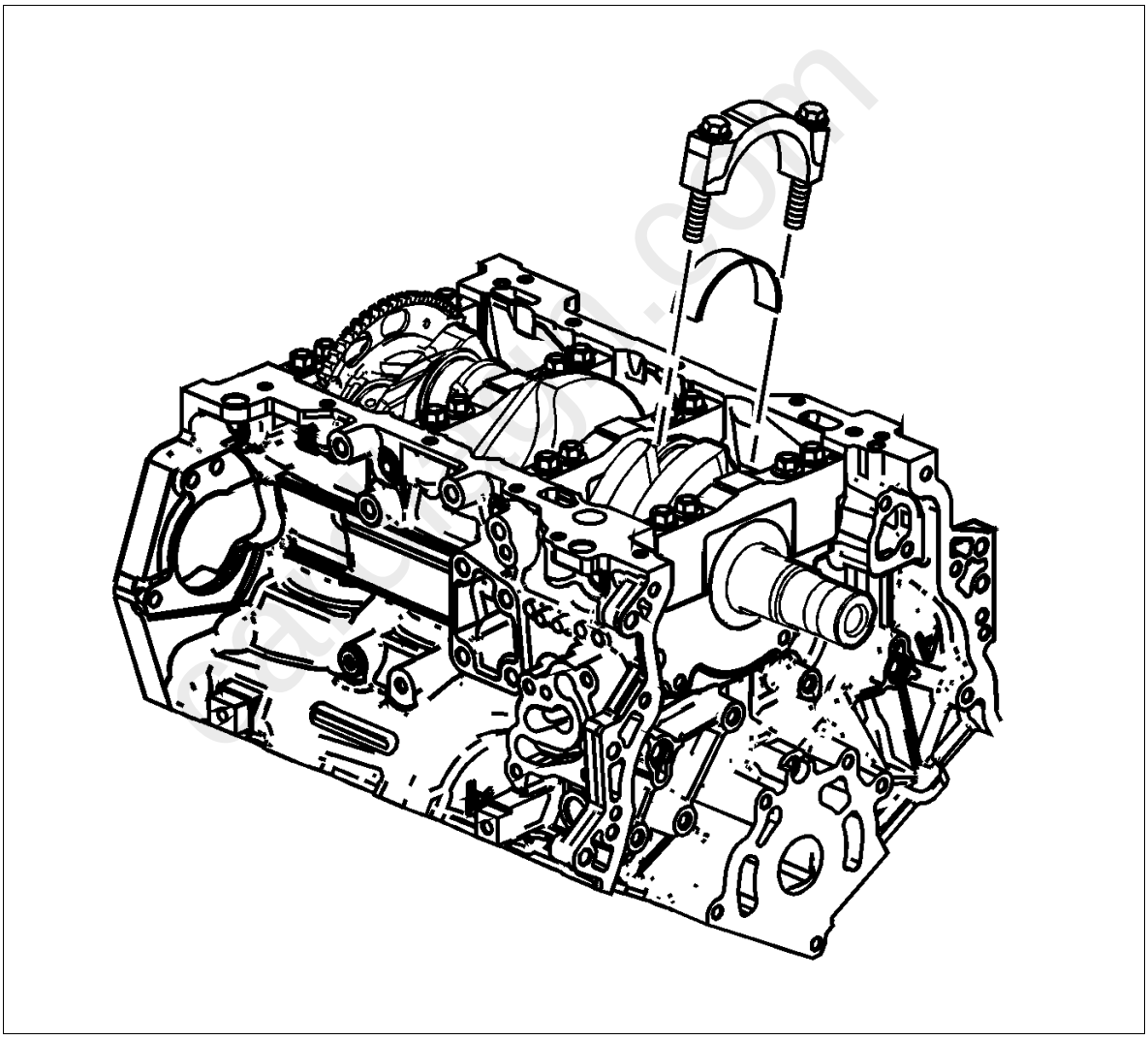
Before final assembly it is important to check the clearance of the new connecting rod bearings.

1. Place a length of fresh, room temperature plastic gaging material all the way across the connecting rod bearing journal.
2. Install the connecting rod bearing into the connecting rod cap.

> *NOTE:*
>
> *The connecting rod is non-directional therefore the connecting rod bearing lock tangs can face inboard or outboard.*

3. Install the connecting rod end cap on its original connecting rod and ensure the bearing lock tangs are aligned on the same side of the rod.

Fig 1: Connecting Rod Bearing & Cap



Courtesy of GENERAL MOTORS COMPANY

> ⚠ *CAUTION:*
>
> *Refer to Fastener Caution .*

> ⚠ *CAUTION:*
>
> *Do not lubricate the NEW connecting rod bolts. The NEW bolts have a pre-applied graphite lubricant. Applying lubricant to the connecting rod bolts will effect the clamp load when the connecting rod bolts are torqued. Improper clamp load can lead to component failure and extensive engine damage.*

> 📌 *NOTE:*
>
> *Reuse the old connecting rod bolts ONLY for measuring the connecting rod bearing clearance.*

4. Install the connecting rod bolts into the connecting rod cap.
5. Tighten the connecting rod bolts.
    1. First Pass

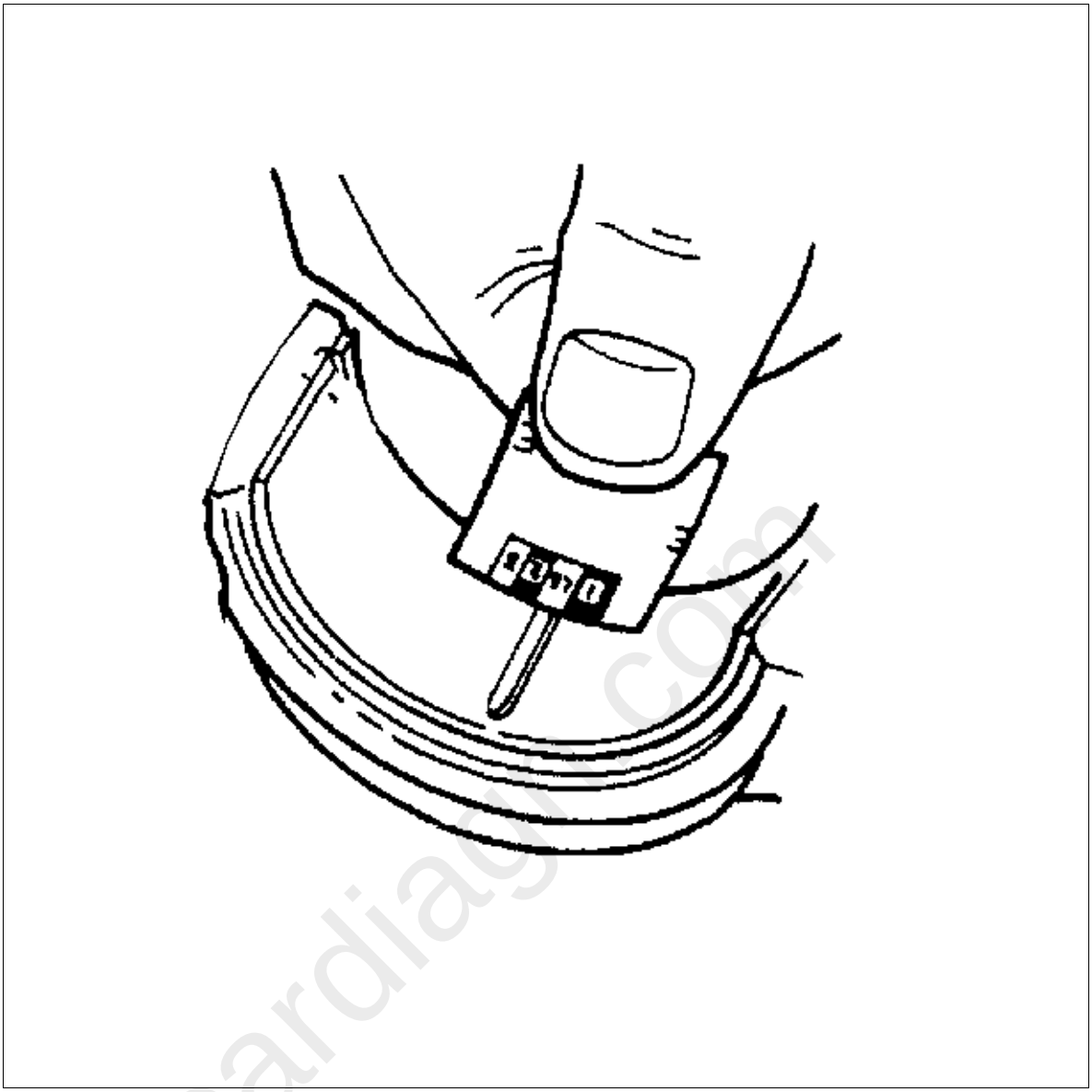
        Tighten the connecting rod bolts to 25 N.m (18 lb ft).

    2. Final Pass

        Tighten the connecting rod bolts an additional 110 degrees using the **EN-45059** meter.
6. Allow the assembly to sit for at least 2 minutes.
7. Remove the connecting rod cap bolts.
8. Remove the connecting rod cap.

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Fig 2: Plastigage



Courtesy of GENERAL MOTORS COMPANY

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9. Determine the connecting rod bearing clearance by comparing the width of the flattened plastic gaging material at its widest point with the graduation on the gaging material container.

10. Compare your measurements with the engine mechanical specifications. If the new bearings do not provide the proper crankshaft to connecting rod bearing clearance, inspect the following:

    1. Re-measure the crankshaft connecting rod journals for the correct specified size and ensure the proper new bearings are being installed. If the crankshaft connecting rod journals are incorrectly sized, replace or regrind the crankshaft. Crankshaft machining is permitted and undersized bearings are available.

    2. Re-measure the connecting rod bearing bore diameter to ensure proper size. The connecting rod is not machinable and the connecting rod must be replaced if out of specification.

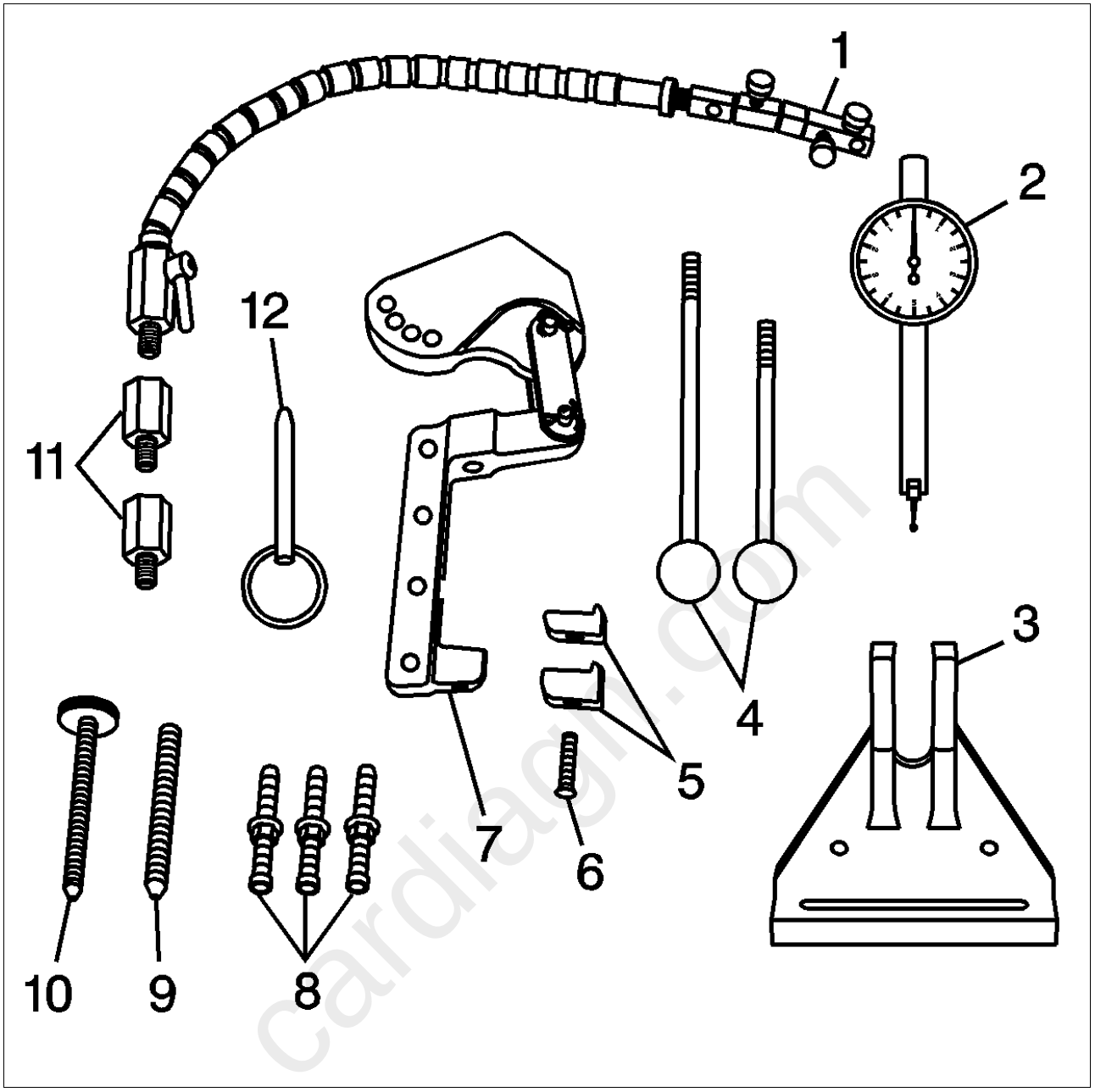
11. Clean the plastic gaging material from the connecting rod bearing journals using a soft lint-free cloth.

REPAIR INSTRUCTIONS - OFF VEHICLE > PISTON, CONNECTING ROD, AND BEARING INSTALLATION > CONNECTING ROD BEARING CLEARANCE MEASUREMENT PROCEDURE - USING EN-43690-A AND EN-43690-100

The **EN-43690-A** tool and the **EN-43690-100** kit have been developed as a more accurate method to measure connecting rod bearing clearances. The instructions below provide an over tool set-up and usage. For more detailed information, refer to the tool instruction sheets as supplied by the tool manufacturer.

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Fig 1: Rod Bearing Clearance Checking Tool



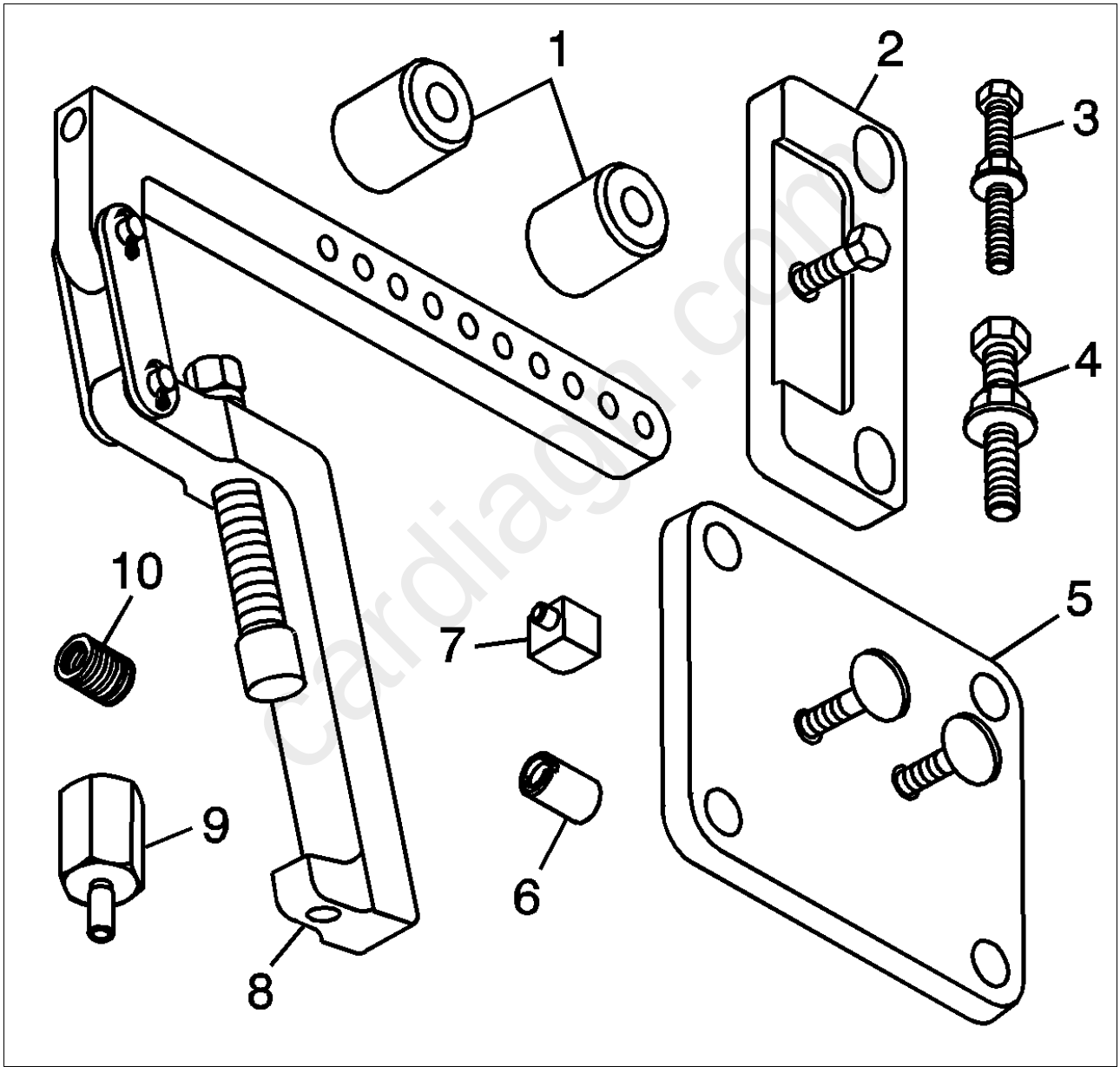
Courtesy of GENERAL MOTORS COMPANY

EN-43690-A tool

- EN-43690-20 Swivel Base (1)
- EN-43690-19 Dial Indicator (2)
- EN-43690-2 Base (3)
- EN-43690-5, -6 Handle (4)
- EN-43690-10, -11 Foot (5)
- 280307 Screw (6)

- EN-43690-1 Pivot Arm Assembly (7)
- EN-43690-3, -7, -8 Screws (8)
- 280319 Screw (9)
- 280311 Screw (10)
- EN-43690-17, -18 Adapter (11)
- 280310 Pin (12)

Fig 2: Rod Bearing Clearance Tool - Adapter Kit



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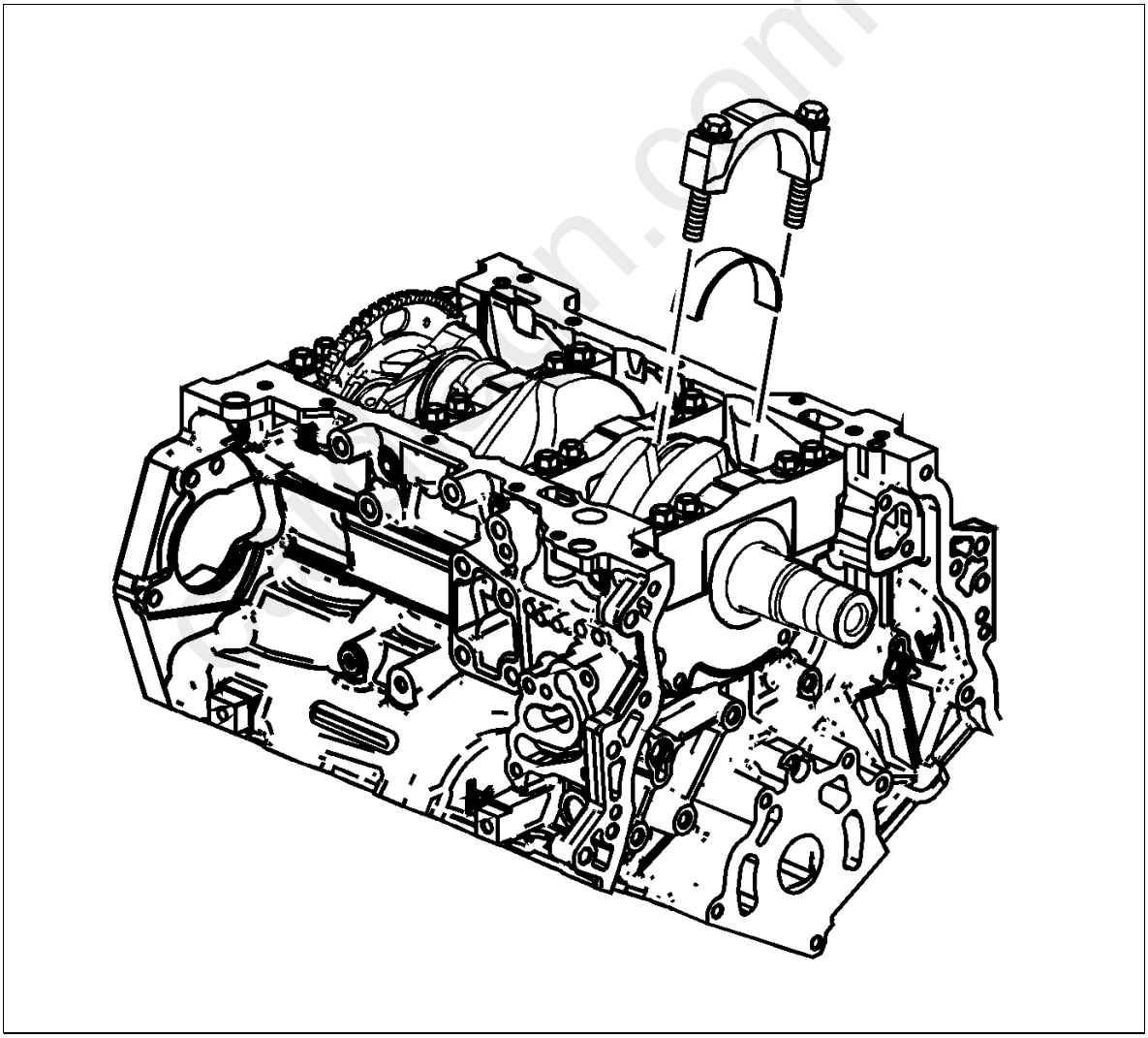
Courtesy of GENERAL MOTORS COMPANY

EN-43690-100 kit

- EN-43690-104 Spacer (1)

- EN-43690-105 Retainer Plate (2)
- 505478 Bolt (3)
- 511341 Bolt (4)
- EN-43690-106 Retainer Plate (5)
- EN-43690-107 Cap (6)
- EN-43690-102 Foot (7)
- EN-43690-101 Pivot Arm Assembly (8)
- EN-43690-103 Adapter (9)
- 505439 Adapter (10)

Fig 3: Connecting Rod Bearing & Cap



Courtesy of GENERAL MOTORS COMPANY

NOTE:

Connecting rod bearings that have been run in an engine should NEVER be reused.

Before final assembly it is important to check the clearance of the new connecting rod bearings.

1. Install the connecting rod bearing into the connecting rod cap.

> *NOTE:*
>
> *The connecting rod is non-directional therefore the connecting rod bearing lock tangs can face inboard or outboard.*

2. Install the connecting rod end cap on its original connecting rod and ensure the bearing lock tangs are aligned on the same side of the rod.

> *CAUTION:*
>
> *Refer to Fastener Caution .*

> *CAUTION:*
>
> *Do not lubricate the NEW connecting rod bolts. The NEW bolts have a pre-applied graphite lubricant. Applying lubricant to the connecting rod bolts will effect the clamp load when the connecting rod bolts are torqued. Improper clamp load can lead to component failure and extensive engine damage.*

> *NOTE:*
>
> *Reuse the old connecting rod bolts ONLY for measuring the connecting rod bearing clearance.*

3. Install the connecting rod bolts into the connecting rod cap.
4. Tighten the connecting rod bolts.
    1. First Pass

       Tighten the connecting rod bolts to 25 N.m (18 lb ft).
    2. Final Pass

       Tighten the connecting rod bolts an additional 110 degrees using the **EN-45059** meter.

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5. Rotate the crankshaft until the crankshaft journal and the connecting rod to be measured is in the 12 o'clock position.

> *NOTE:*
>
> *The crankshaft must be secure with no movement or rotation in order to obtain an accurate reading.*

6. Remove the crankshaft main bolts required to install the retainer plate **EN-43690-105** .

> *NOTE:*
>
> *Do not allow the **EN-43690-105** retainer plate screw to contact the reluctor ring.*

7. Install the EN 43690-105 and crankshaft main bolts.
8. Loosen the connecting rod bolts until the torque reading is zero.
9. Re-tighten the connecting rod bolts.
    1. First Pass

       Tighten the connecting rod bolts to 25 N.m (18 lb ft).
    2. Final Pass

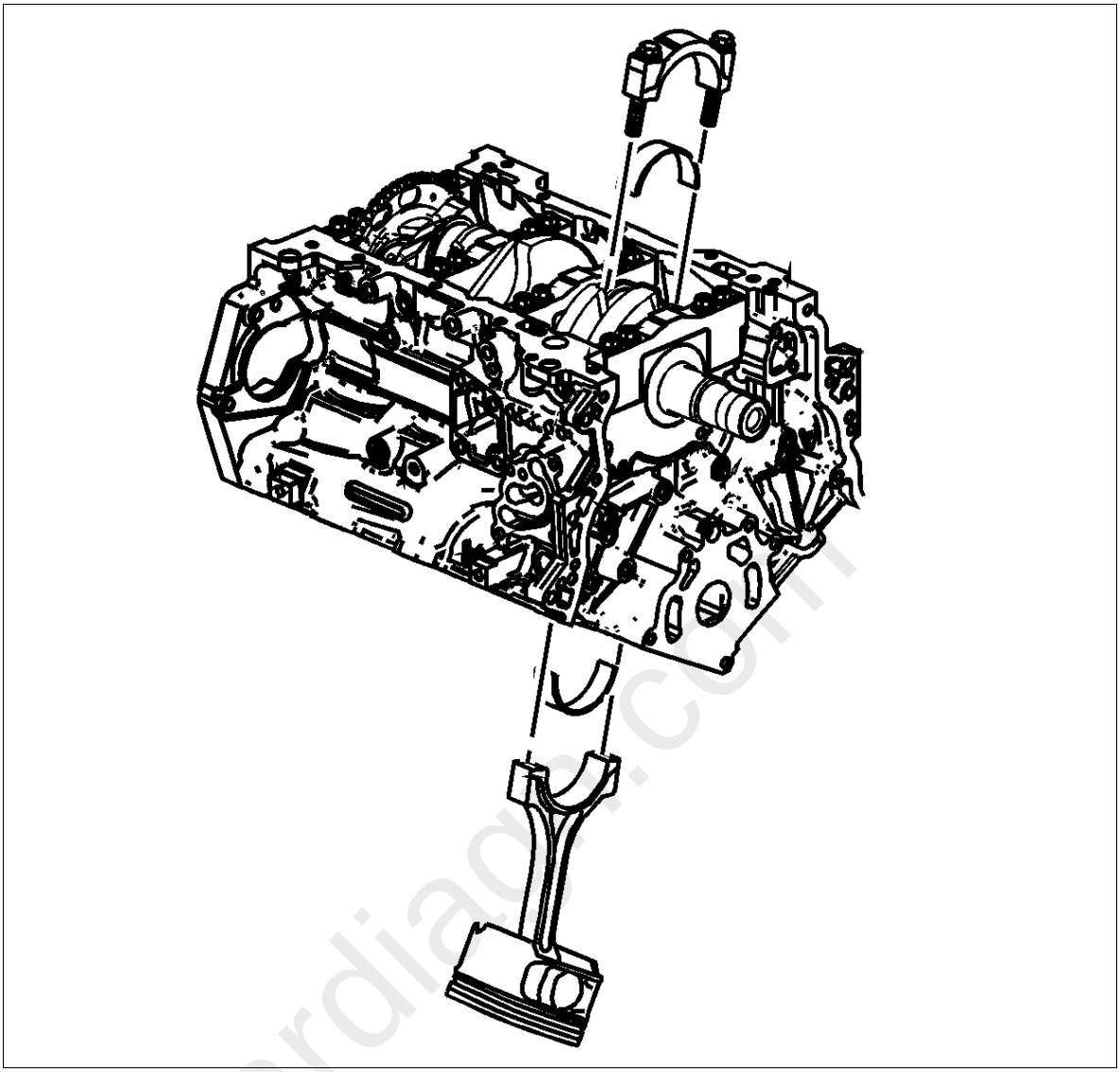
       Tighten the connecting rod bolts an additional 110 degrees using the **EN-45059** meter.
10. During and after installation, ensure each piston is positioned properly in the correct cylinder. The locating arrow on the top of each piston must be pointing toward the front of the engine.
11. Repeat these procedures for the remaining piston/connecting rod assemblies using the **EN-48589** socket in order to rotate the crankshaft.

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REPAIR INSTRUCTIONS - OFF VEHICLE > PISTON, CONNECTING ROD, AND BEARING INSTALLATION > CONNECTING ROD FINAL ASSEMBLY PROCEDURE

1. Guide the connecting rod away from the crankshaft connecting rod journal in order to lubricate the crankshaft connecting rod bearing journal.
2. Apply a liberal amount of crankshaft prelube to the crankshaft connecting rod bearing journal. Refer to Adhesives, Fluids, Lubricants, and Sealers .
3. Guide the connecting rod to the crankshaft connecting rod journal.
4. Install the connecting rod end cap on its original connecting rod and ensure the bearing lock tangs are aligned on the same side of the rod.

Fig 1: Piston & Connecting Rod Assembly



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⚠ *CAUTION:*

Do not lubricate the NEW connecting rod bolts. The NEW bolts have a pre-applied graphite lubricant. Applying lubricant to the connecting rod bolts will effect the clamp load when the connecting rod bolts are torqued. Improper clamp load can lead to component failure and extensive engine damage.

> ⚠ *CAUTION:*
>
> *This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.*

5. Install the NEW connecting rod bolts into the connecting rod cap.
6. Tighten the connecting rod bolts.
    1. First Pass

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

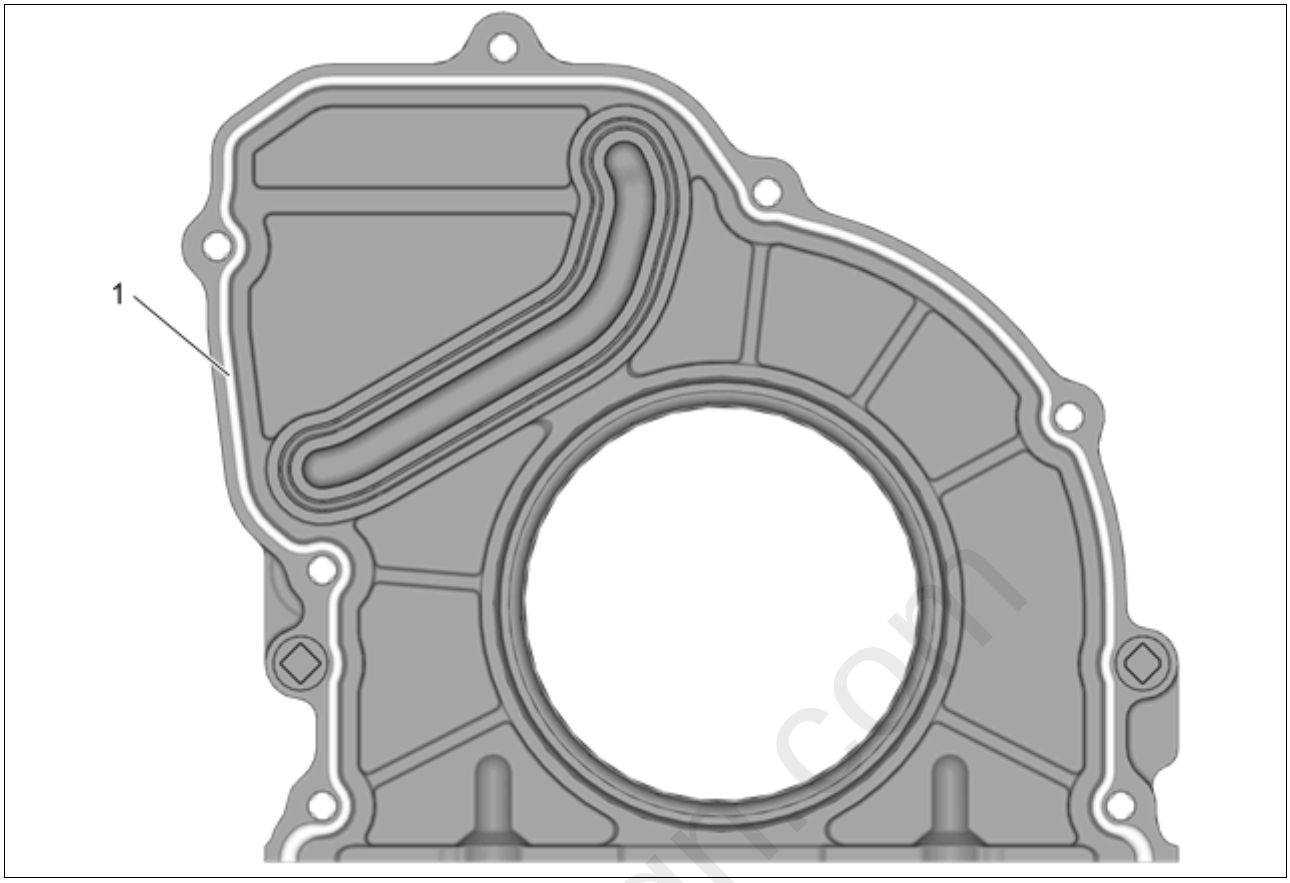
    2. Final Pass

       Tighten the connecting rod bolts an additional 110 degrees using the **EN-45059** meter.
7. During and after installation, ensure each piston is positioned properly in the correct cylinder. The locating arrow on the top of each piston must be pointing toward the front of the engine.
8. Repeat these procedures for the remaining piston/connecting rod assemblies using the **EN-48589** socket in order to rotate the crankshaft.

REPAIR INSTRUCTIONS - OFF VEHICLE > CRANKSHAFT REAR OIL SEAL AND HOUSING INSTALLATION

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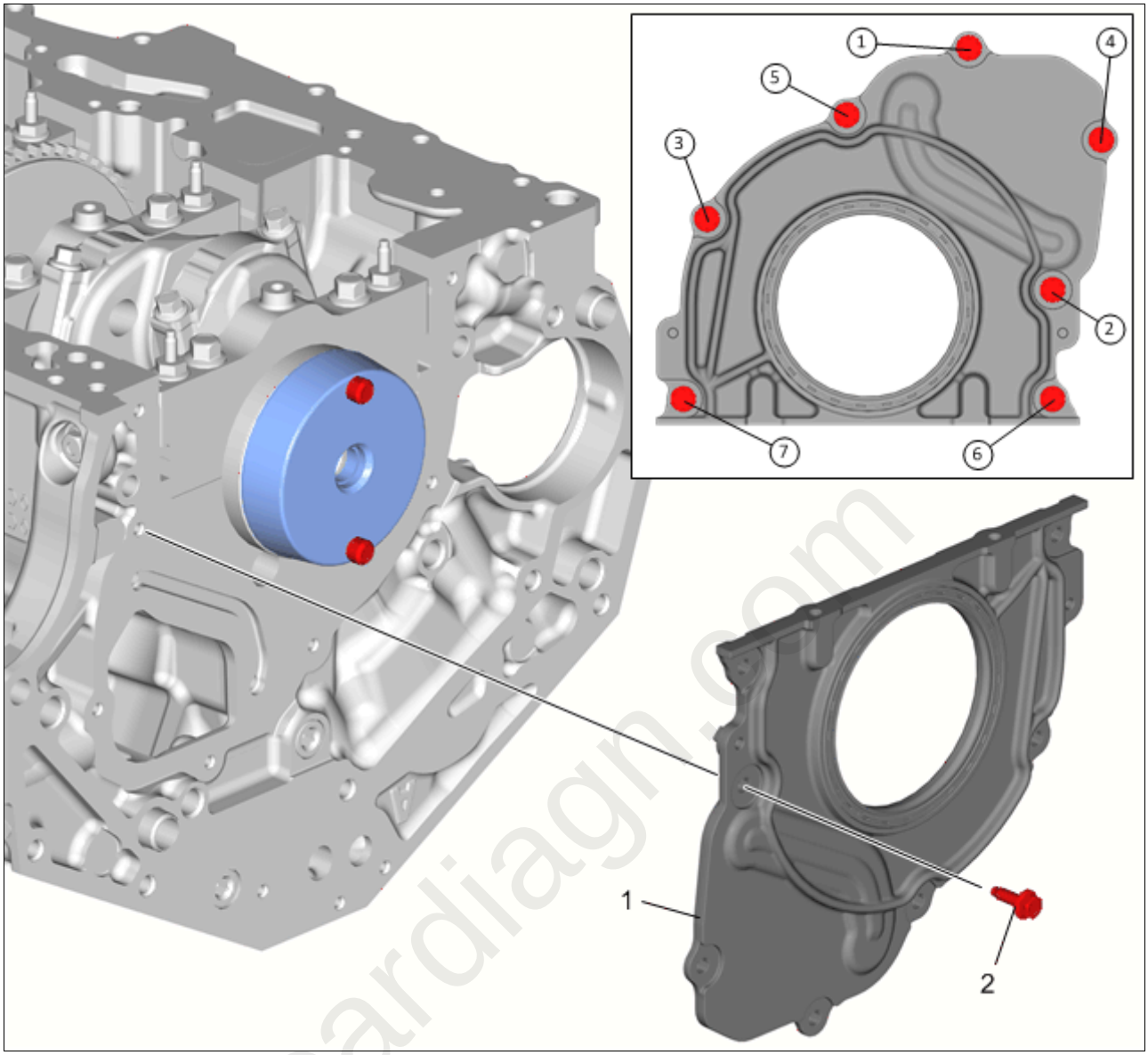
Fig 1: Crankshaft Rear Oil Seal and Housing Sealant Application Points (LGX)



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Sealant Procedure 1. Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant 2. Place a 3 mm (0.118 in) bead of RTV sealant to the NEW crankshaft rear oil seal housing as shown (1). Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended sealant. *NOTE:* *DO NOT allow any engine oil on the area where the crankshaft rear oil seal housing is to be installed.*

Fig 2: Crankshaft Rear Oil Seal and Housing (LGX)



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name

Procedure

1. Install the **EN-51766** tool onto the rear of the crankshaft flange.
2. Install the crankshaft rear oil seal housing (1) to the engine block.
3. Install the crankshaft rear oil seal housing bolts (2) and tighten in sequence shown.
4. Remove the **EN-51766** tool from the crankshaft flange.

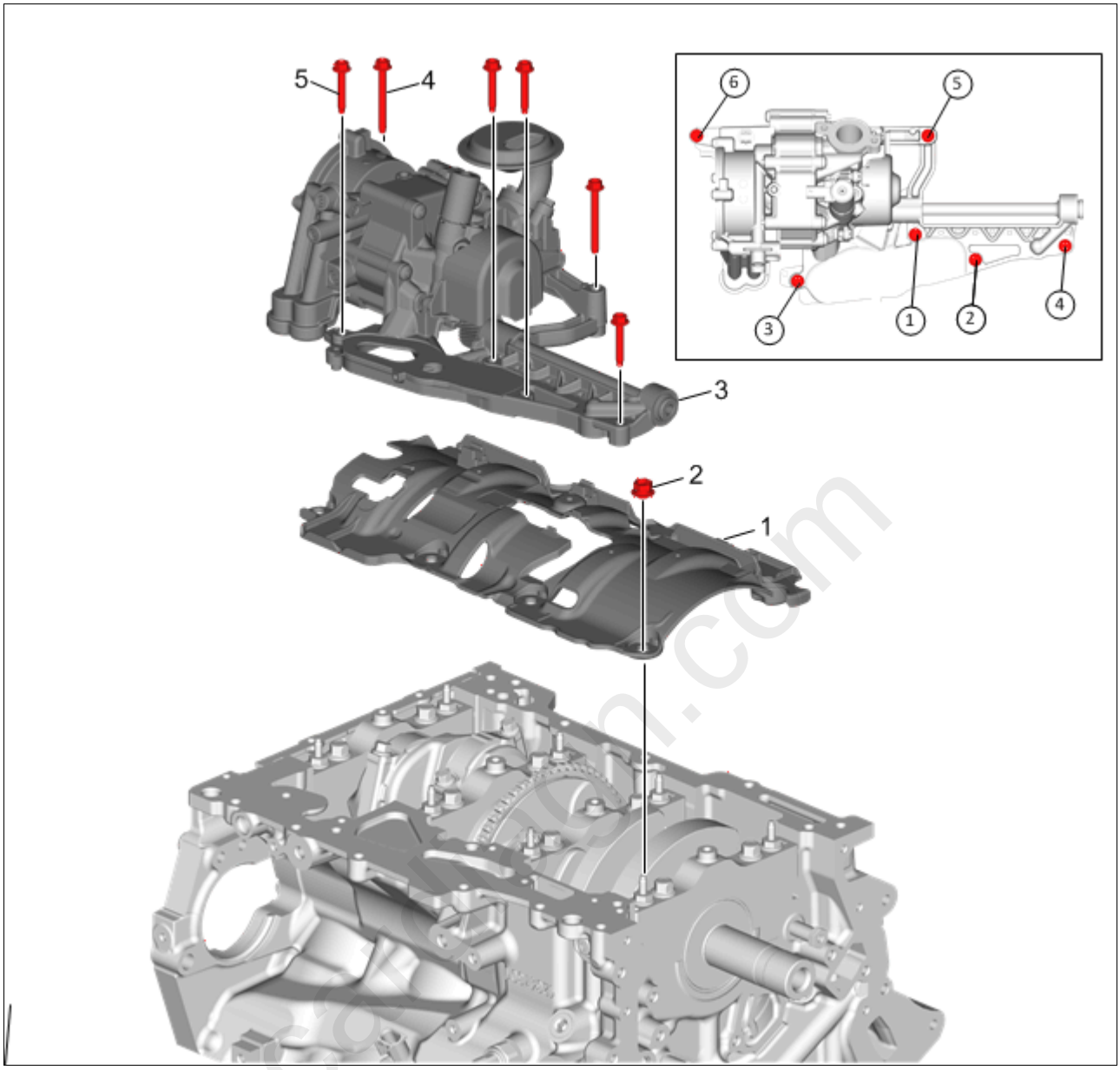
Special Tools **EN-51766** Crankshaft Rear Oil Seal Installation ToolFor equivalent regional tools, refer to Special Tools .

1	Crankshaft Rear Oil Seal Housing
2	Crankshaft Rear Oil Seal Housing Bolt (Qty: 7) *CAUTION:* *Refer to Fastener Caution .* **Tighten in sequence** 10 N.m (89 lb in)

REPAIR INSTRUCTIONS - OFF VEHICLE > OIL PUMP INSTALLATION

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Fig 1: Oil Pump (LGX)



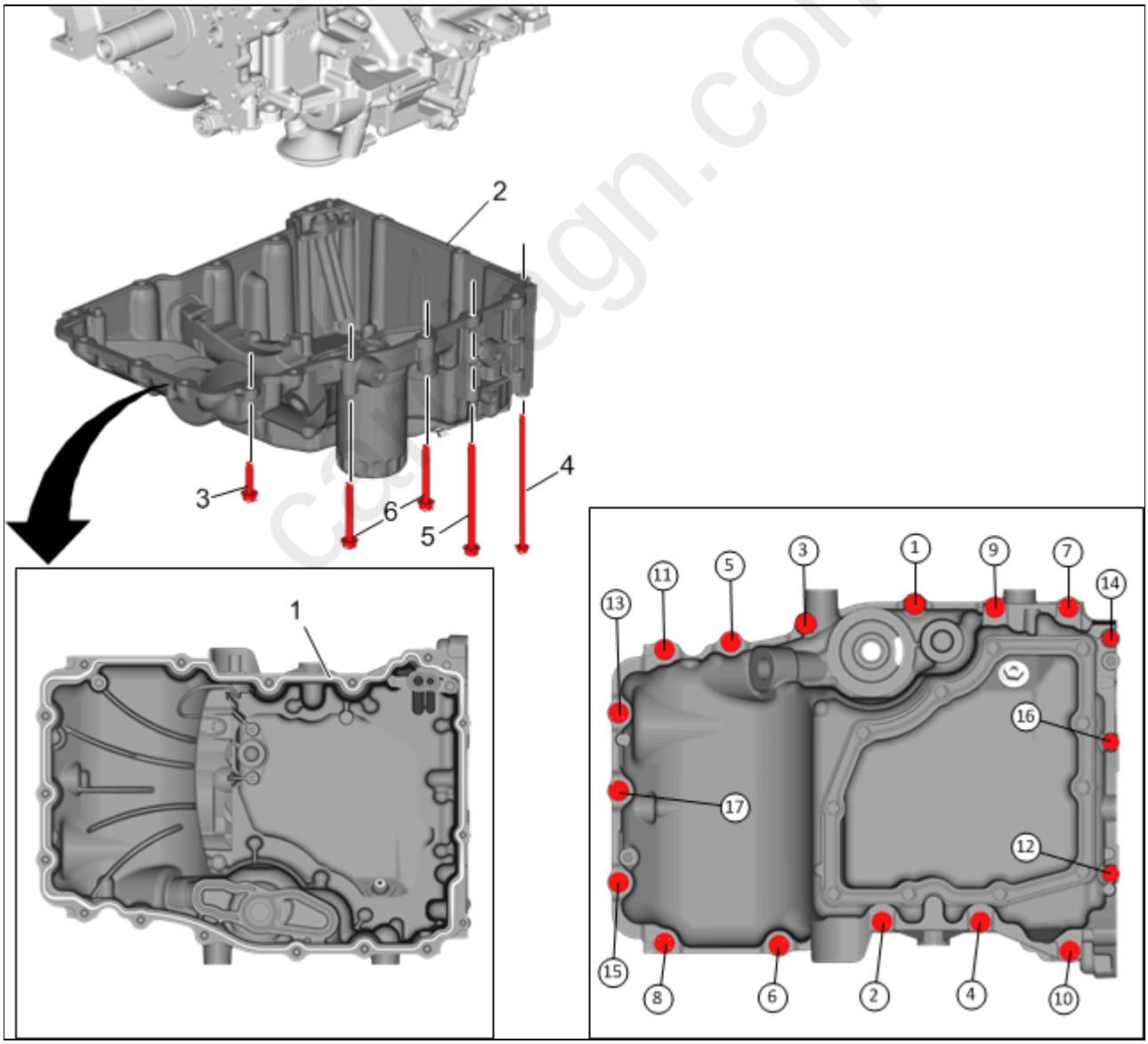
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Crankshaft Oil Deflector
2	Crankshaft Oil Deflector Nut (Qty: 8)
3	Oil Pump
4	Oil Pump Bolt (Qty: 2) M6 x 53.65

	CAUTION: *Refer to Fastener Caution .* **Tighten in sequence** 15 N.m (11 lb ft)
5	Oil Pump Bolt (Qty: 4) M6 x 35.65 **Tighten in sequence** 15 N.m (11 lb ft)

REPAIR INSTRUCTIONS - OFF VEHICLE > OIL PAN INSTALLATION

Fig 1: Oil Pan (LGX RWD)



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Sealant Procedure 1. Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant 2. Place a 3 mm (0.118 in) bead of RTV sealant on the block pan rail and the crankshaft rear oil seal housing (1). Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended sealant.
2	Oil Pan
3	Oil Pan Bolt (Qty: 7) *CAUTION:* *Refer to Fastener Caution .* *NOTE:* *Tighten the oil pan bolts in sequence shown.* **Tighten** 25 N.m (18 lb ft)
4	Oil Pan Bolt (Qty: 3) *NOTE:* • *Install a NEW bolt. Do NOT reuse the old bolt.* • *Tighten the bolts in the sequence shown.* Tighten 1. First Pass: 7 N.m (62 lb in) 2. Final Pass: 180 Degrees
5	Oil Pan Bolt (Qty: 5) **Tighten** 25 N.m (18 lb ft)

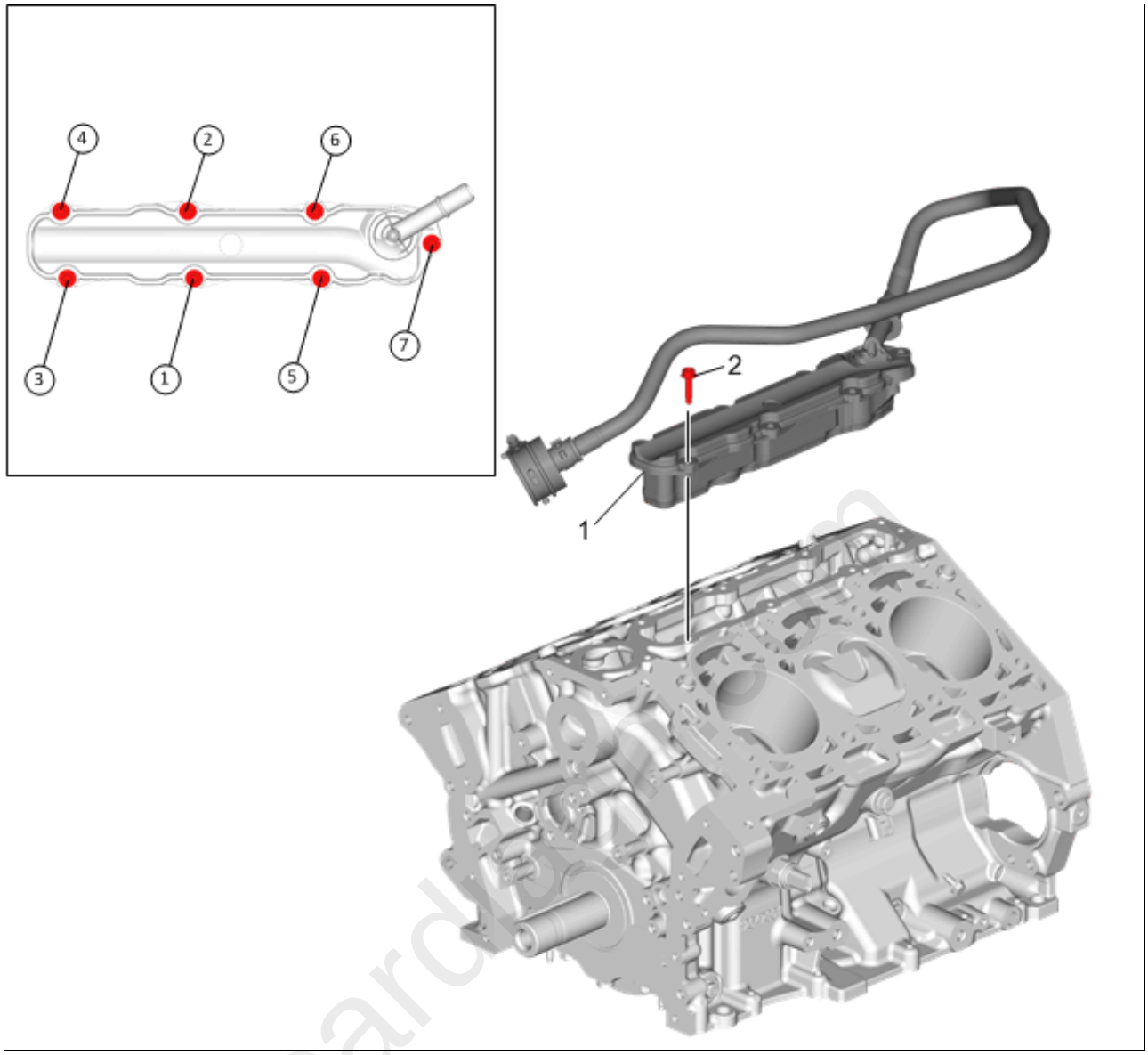
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	NOTE: *Tighten the oil pan bolts in sequence shown.*
6	Oil Pan Bolt (Qty: 2) *NOTE:* *Tighten the oil pan bolts in sequence shown.* **Tighten** 25 N.m (18 lb ft)

REPAIR INSTRUCTIONS - OFF VEHICLE > POSITIVE CRANKCASE VENTILATION OIL SEPARATOR INSTALLATION

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Fig 1: Positive Crankcase Ventilation Oil Separator



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Positive Crankcase Ventilation Oil Separator *NOTE:* *These components have tamper-proof connections and cannot be disassembled.*
2	Positive Crankcase Ventilation Oil Separator Bolt (Qty: 7)

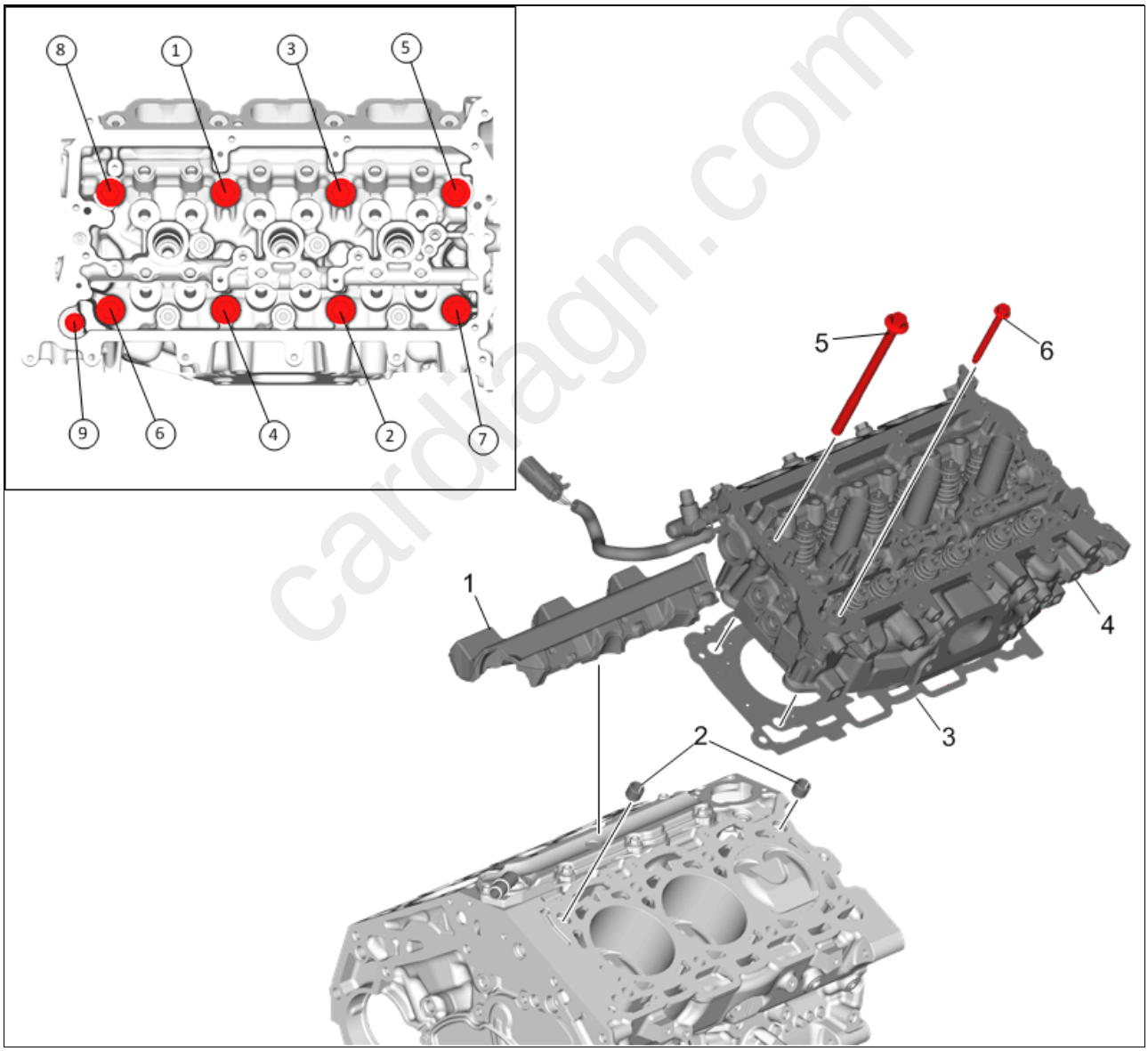
CAUTION:

Refer to Fastener Caution .

Tighten in sequence
10 N.m (89 lb in)

REPAIR INSTRUCTIONS - OFF VEHICLE > CYLINDER HEAD INSTALLATION - RIGHT SIDE

Fig 1: Cylinder Hea - Right Side (LGX)



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Courtesy of GENERAL MOTORS COMPANY

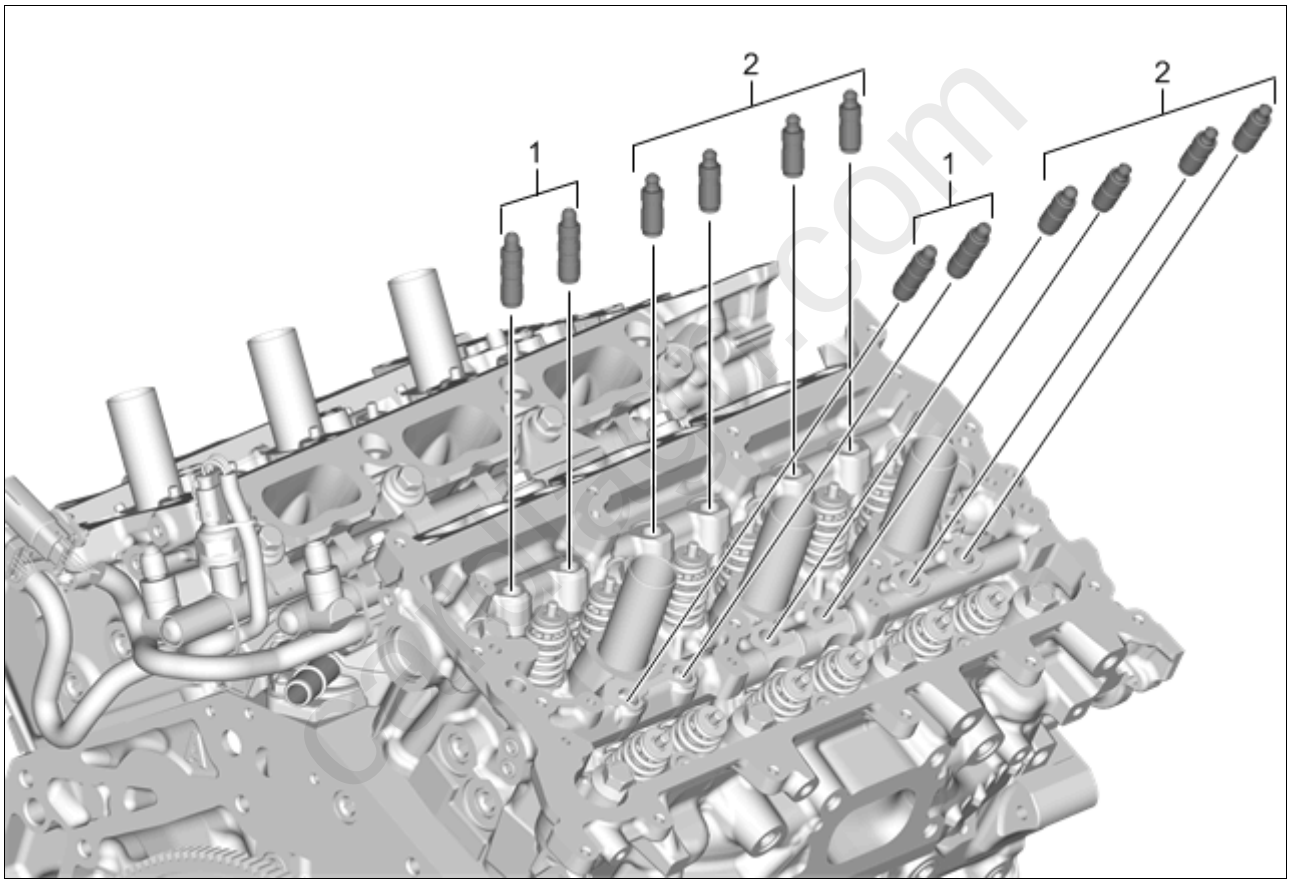
Callout	Component Name
1	Fuel Injection Fuel Rail Noise Shield *WARNING:* *The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage, and possible injury or death.*
2	Cylinder Head Locating Pin (Qty: 2) *NOTE:* *Ensure the cylinder head locating pins are securely mounted in the cylinder block deck face.*
3	Cylinder Head Gasket *NOTE:* *Install a NEW gasket.*
4	Cylinder Head
5	Cylinder Head Bolt (Qty: 8) M11 x 178 *CAUTION:* *Refer to Fastener Caution .* Tighten in sequence 1. First Pass: 80 N.m (59 lb ft) 2. Final Pass: 150 degrees **Special Tools** **EN-45059** Angle Meter For equivalent regional tools, refer to Special Tools .

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6	Cylinder Head Bolt M8 x 80.8 Tighten in sequence 1. First Pass: 15 N.m (11 lb ft) 2. Final Pass: 75 degrees

REPAIR INSTRUCTIONS - OFF VEHICLE > VALVE LIFTER INSTALLATION - RIGHT SIDE

Fig 1: Valve Lifter - Right Side (LGX)



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure 1. Fill the adjusters with clean engine oil. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended engine oil. Take precautions to prevent scratching the pivot sphere area of the. 2. Lubricate the adjusters bores in the cylinder head with clean engine oil.	

3. Install the adjusters in the cylinder head.

4. Apply a liberal amount of lubricant to the adjusters pivot spheres.

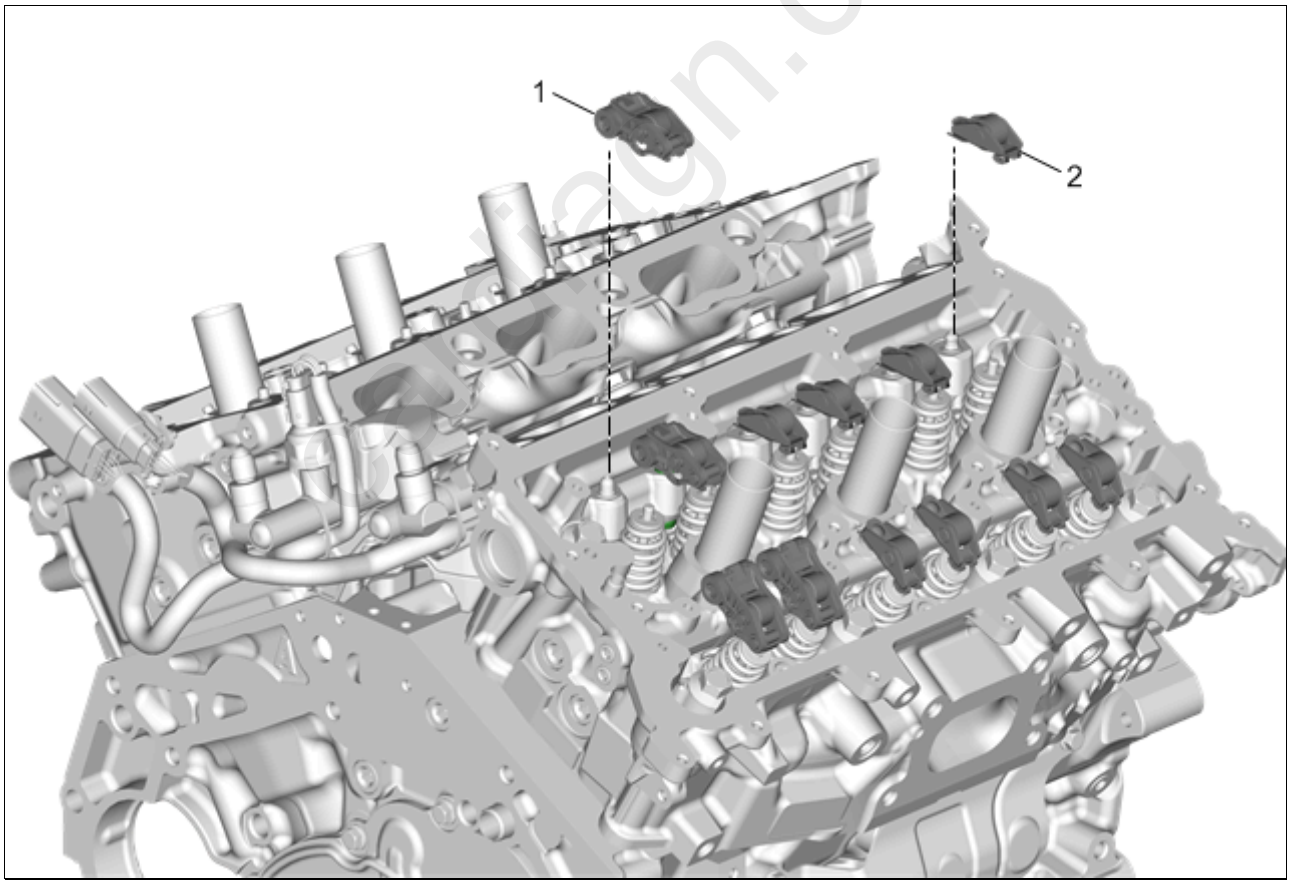
NOTE:

- *Do not stroke/cycle the adjusters without oil in the lower pressure chamber.*
- *Do not allow the adjusters to tip over, plunger down, after the oil fill.*

1	Dual Feed Hydraulic Valve Adjustor (Qty: 4)
2	Hydraulic Valve Lash Adjuster (Qty: 8)

REPAIR INSTRUCTIONS - OFF VEHICLE > VALVE ROCKER ARM INSTALLATION - RIGHT SIDE

Fig 1: Valve Rocker Arm - Right Side (LGX)



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name

Preliminary Procedure

1. Apply a liberal amount of lubricant to the pivot pocket, roller and valve slot areas of the camshaft followers. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended lubricant.
2. Place the camshaft followers in position on the valve tip and adjuster.
3. The rounded head end of the follower goes on the adjuster while the flat end goes on the valve tip.
4. Clean the camshaft journals and carriers with a clean, lint-free cloth.

NOTE:

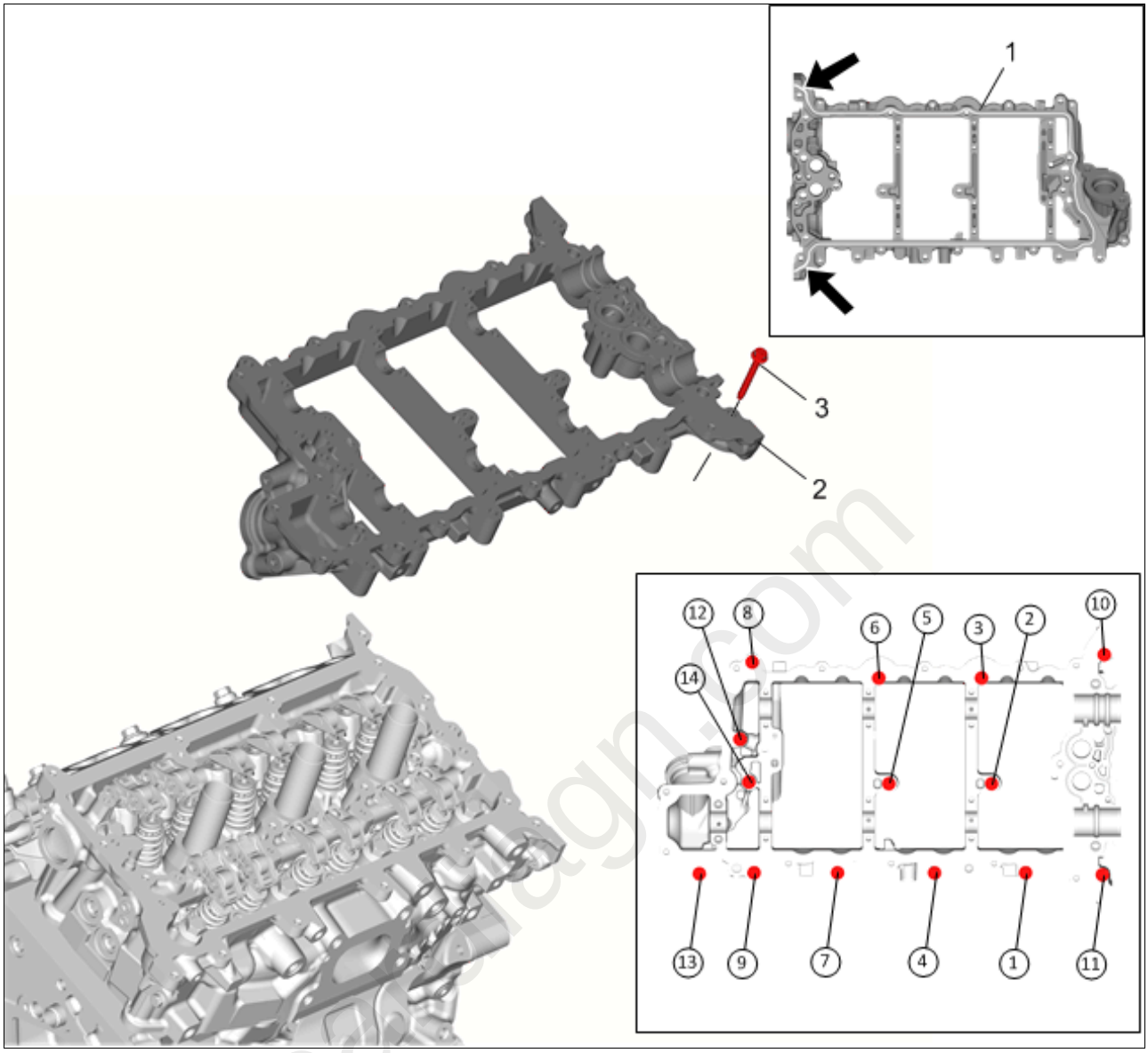
The follower must be positioned squarely on the valve tip so that the full width of the roller will completely contact the camshaft lobe. If the followers are being reused you must put them back in their original location.

1	Valve Rocker Switching Arm (Qty: 4)
2	Valve Rocker Arm (Qty: 8)

REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT CARRIER INSTALLATION - RIGHT SIDE

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Fig 1: Camshaft Carrier - Right Side



Courtesy of GENERAL MOTORS COMPANY

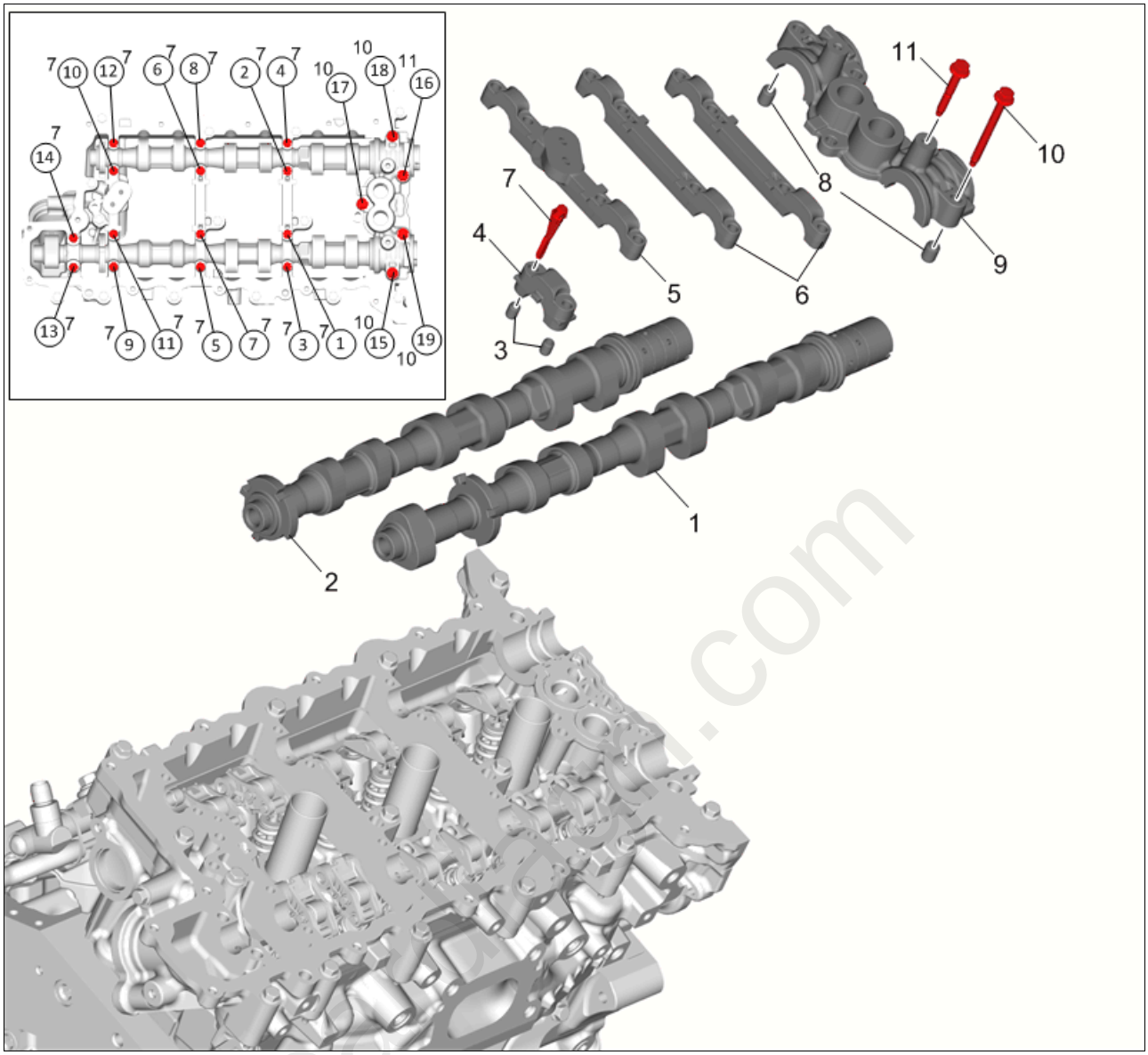
Callout	Component Name
1	Sealant *CAUTION:* *Do not apply more room temperature vulcanization (RTV) silicone than specified. Excess RTV silicone could plug up oil passage holes in the camshaft carrier and lead to engine damage.* Procedure 1. Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room

	Temperature Vulcanizing (RTV) and Anaerobic Sealant 2. Place a 3 mm (0.118 in) bead of RTV sealant on the bottom of the camshaft carrier, following the specific bead path. 3. Place a 5 mm (0.197 in) bead of RTV sealant on the bottom of the camshaft carrier as arrows show. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended sealant. *NOTE:* *Camshaft carrier surfaces should be free and clean of oil and foreign substances.*
2	Camshaft Carrier - Right
3	Camshaft Carrier Bolt *CAUTION:* *Refer to Fastener Caution .* **Tighten in sequence** 13 N.m (115 lb in)

REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT INSTALLATION - RIGHT SIDE

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Fig 1: Camshaft - Right Side (LGX)



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Exhaust Camshaft *NOTE:* *Ensure the flat is facing upward when installed to help when installing timing chains.*
2	Intake Camshaft

	NOTE: *Ensure the flat is facing upward when installed to help when installing timing chains.*
3	Dowel Pin
4	Camshaft Bearing Cap - Intermediate
5	Camshaft Bearing Cap
6	Camshaft Bearing Cap
7	Camshaft Bearing Cap Bolt *CAUTION:* *Refer to Fastener Caution .* Tighten in sequence 1. First Pass: 6 N.m (53 lb in) 2. Final Pass: 60 degrees
8	Dowel Pin
9	Camshaft Bearing Cap
10	Camshaft Carrier Bolt **Tighten in sequence** 10 N.m (89 lb in)
11	Camshaft Bearing Cap Bolt **Tighten in sequence** 10 N.m (89 lb in)

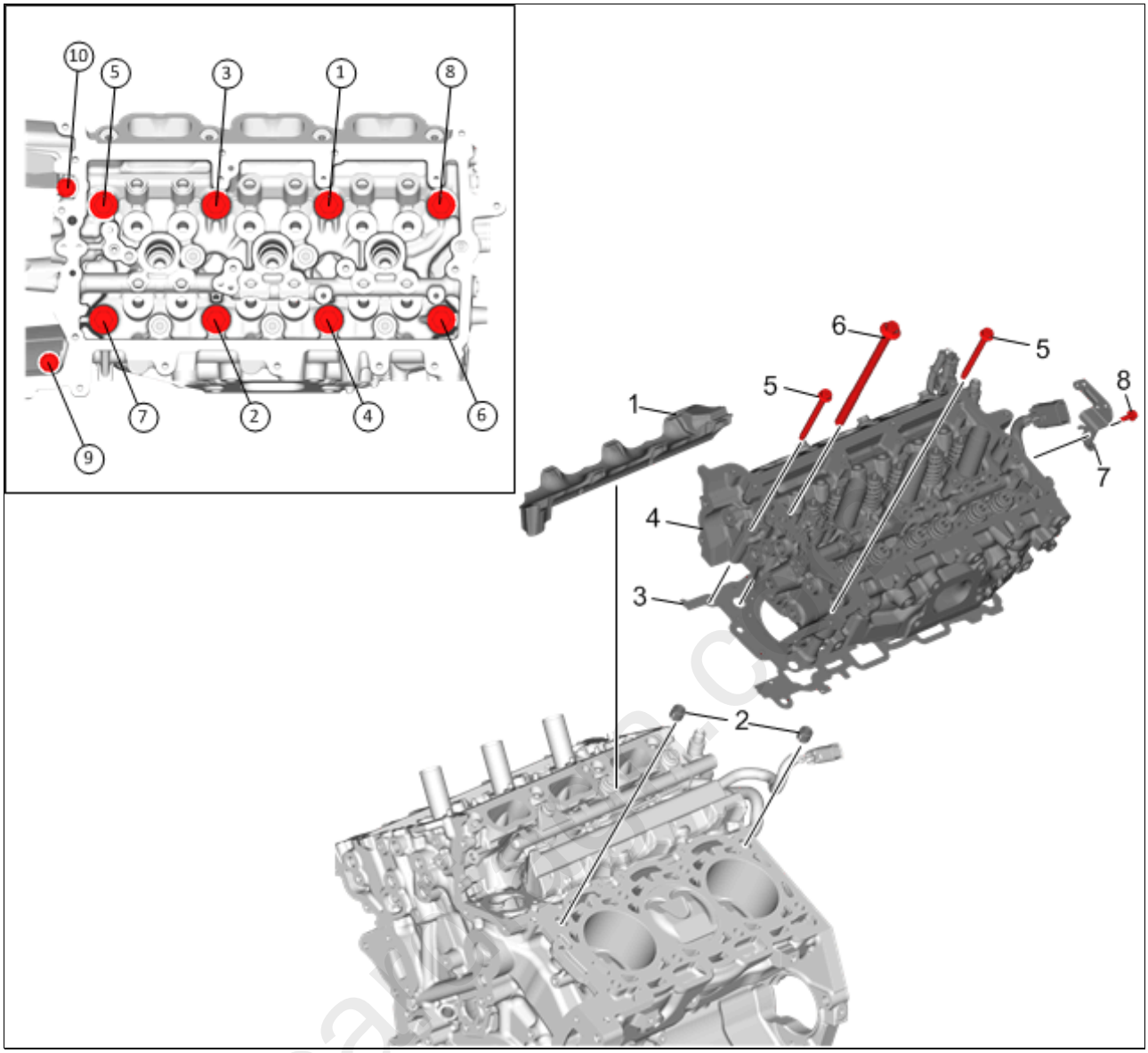
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REPAIR INSTRUCTIONS - OFF VEHICLE > FUEL RAIL INSTALLATION

Refer to Cylinder Head Assemble .

REPAIR INSTRUCTIONS - OFF VEHICLE > CYLINDER HEAD INSTALLATION - LEFT SIDE

Fig 1: Cylinder Head - Left Side (LGX)



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Fuel Injection Fuel Rail Noise Shield *WARNING:* *The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage, and possible injury or death.*

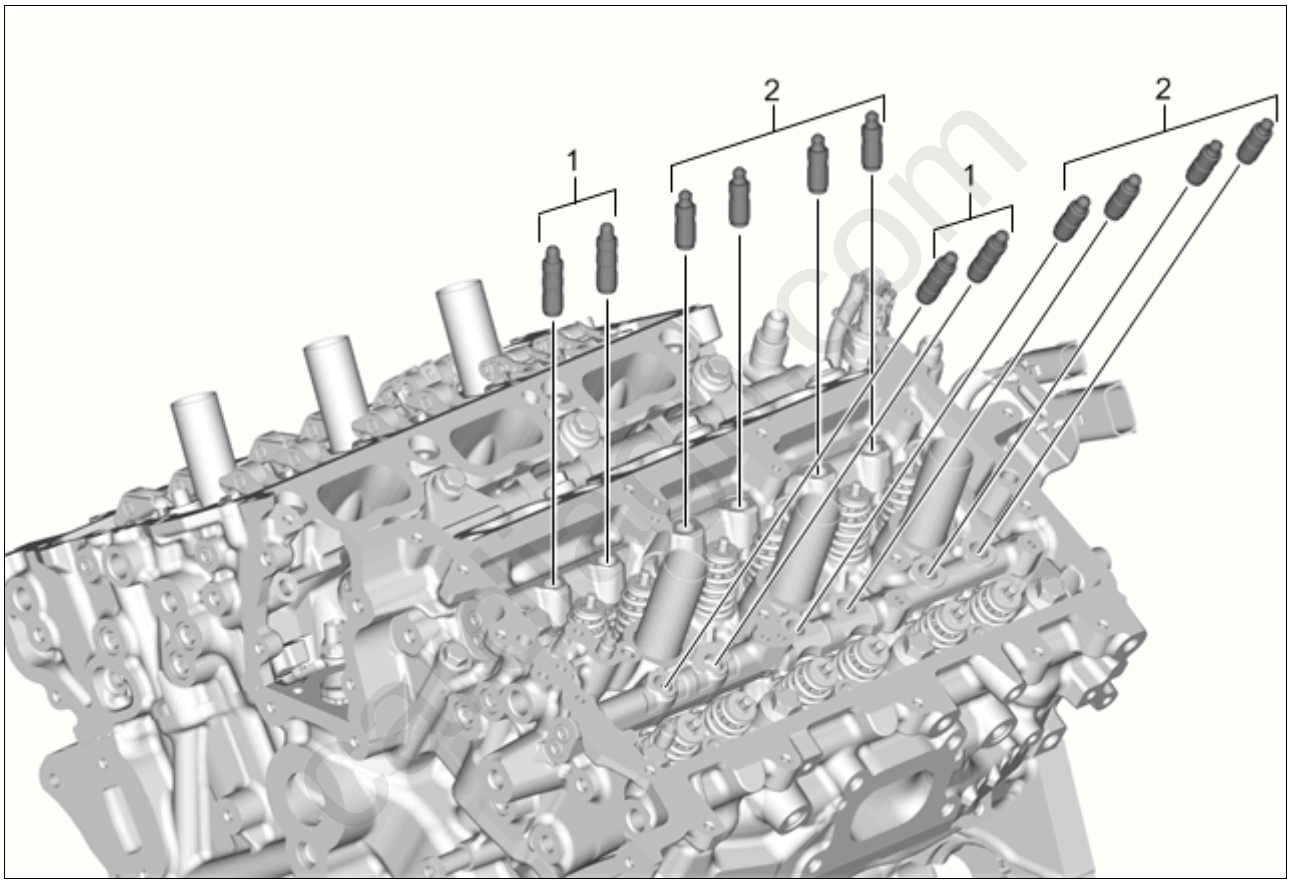
2	Cylinder Head Locating Pin *NOTE:* *Ensure the cylinder head locating pins are securely mounted in the cylinder block deck face.*
3	Cylinder Head Gasket *NOTE:* *Install a NEW gasket.*
4	Cylinder Head
5	Cylinder Head Bolt (Qty: 2) M8 x 80.8 *CAUTION:* *Refer to Fastener Caution .* *CAUTION:* *This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.* Tighten in sequence 1. First Pass: 15 N.m (11 lb ft) 2. Final Pass: 75 degrees **Special Tools** **EN-45059** Angle Meter For equivalent regional tools, refer to Special Tools .
6	Cylinder Head Bolt (Qty: 8) M11 x 178 Tighten in sequence 1. First Pass: 80 N.m (59 lb ft)

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	2. Final Pass: 150 degrees
7	Fuel Injector Wiring Harness Bracket
8	Fuel Injector Wiring Harness Bracket Bolt Tighten 10 N.m (89 lb in)

REPAIR INSTRUCTIONS - OFF VEHICLE > VALVE LIFTER INSTALLATION - LEFT SIDE

Fig 1: Valve Lifter - Left Side (LGX)



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure 1. Fill the adjusters with clean engine oil. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended engine oil. Take precautions to prevent scratching the pivot sphere area of the. 2. Lubricate the adjusters bores in the cylinder head with clean engine oil. 3. Install the adjusters in the cylinder head.	

4. Apply a liberal amount of lubricant to the adjusters pivot spheres.

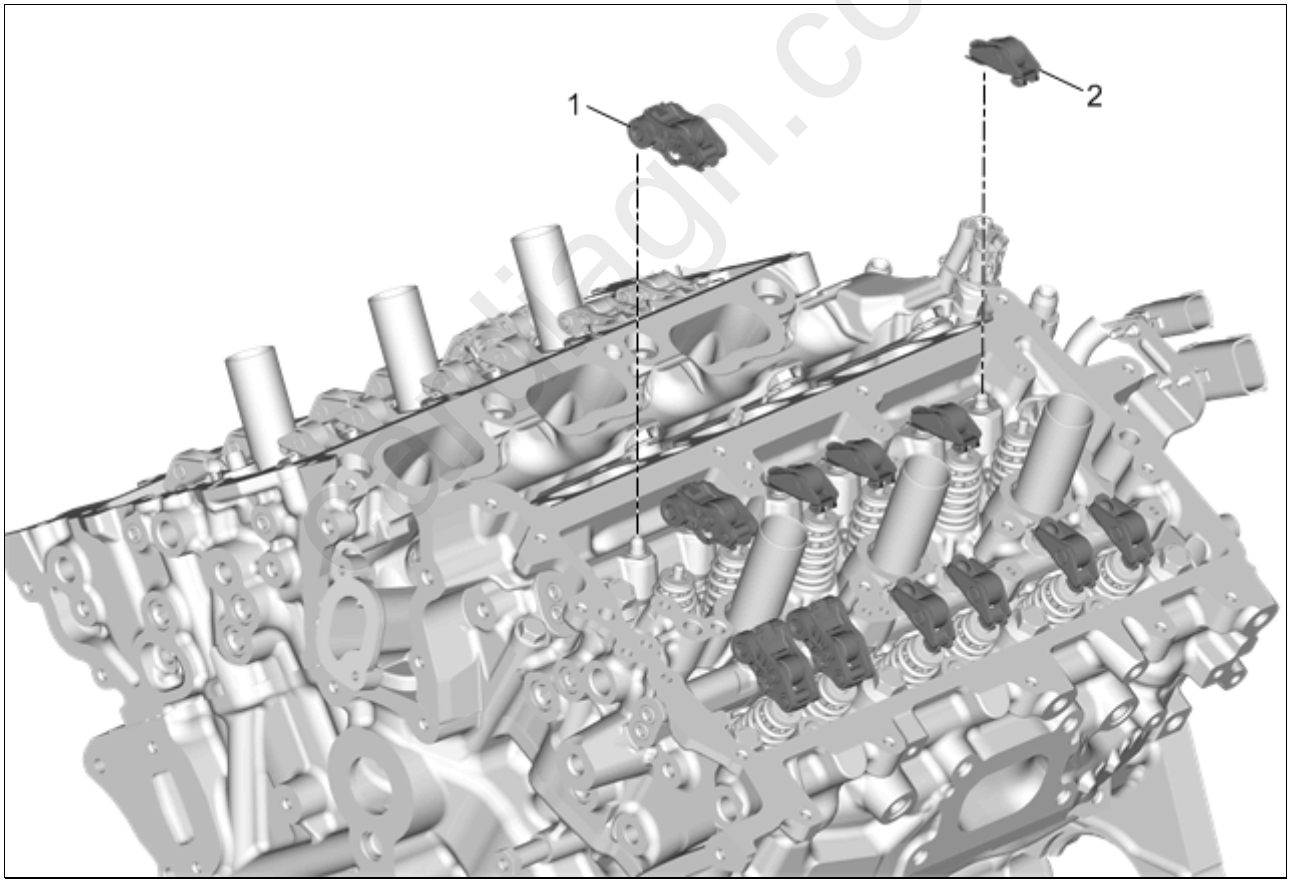
NOTE:

- *Do not stroke/cycle the adjusters without oil in the lower pressure chamber.*
- *Do not allow the adjusters to tip over, plunger down, after the oil fill.*

1	Dual Feed Hydraulic Valve Adjustor (Qty: 4)
2	Hydraulic Valve Lash Adjuster (Qty: 8)

REPAIR INSTRUCTIONS - OFF VEHICLE > VALVE ROCKER ARM INSTALLATION - LEFT SIDE

Fig 1: Valve Rocker Arm - Left Side (LGX)



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure	

1. Apply a liberal amount of lubricant to the pivot pocket, roller and valve slot areas of the camshaft followers. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended lubricant.
2. Place the camshaft followers in position on the valve tip and adjuster.
3. The rounded head end of the follower goes on the adjuster while the flat end goes on the valve tip.
4. Clean the camshaft journals and carriers with a clean, lint-free cloth.

NOTE:

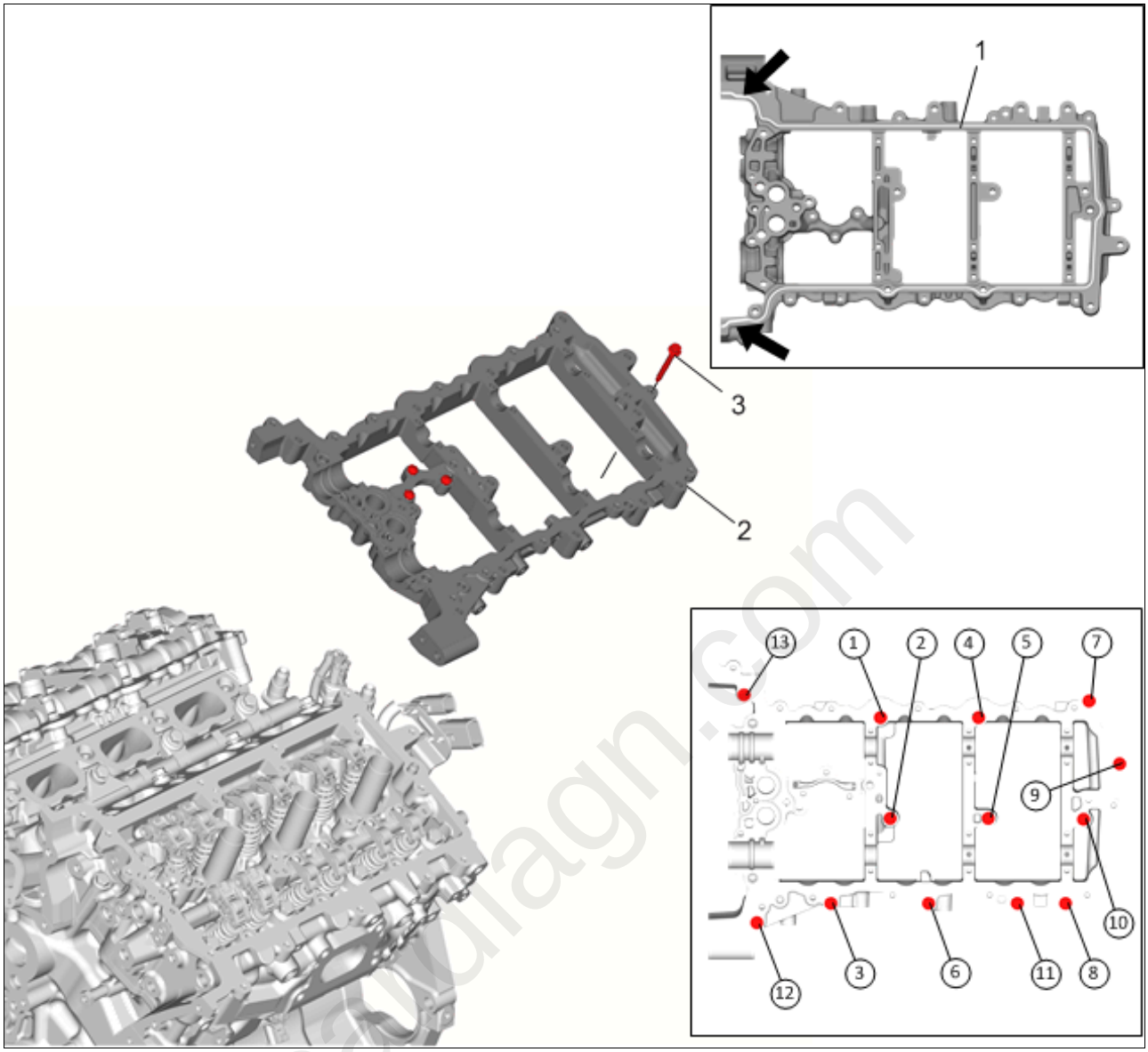
The follower must be positioned squarely on the valve tip so that the full width of the roller will completely contact the camshaft lobe. If the followers are being reused you must put them back in their original location.

1	Valve Rocker Switching Arm (Qty: 4)
2	Valve Rocker Arm (Qty: 8)

REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT CARRIER INSTALLATION - LEFT SIDE

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Fig 1: Camshaft Carrier - Left Side



Courtesy of GENERAL MOTORS COMPANY

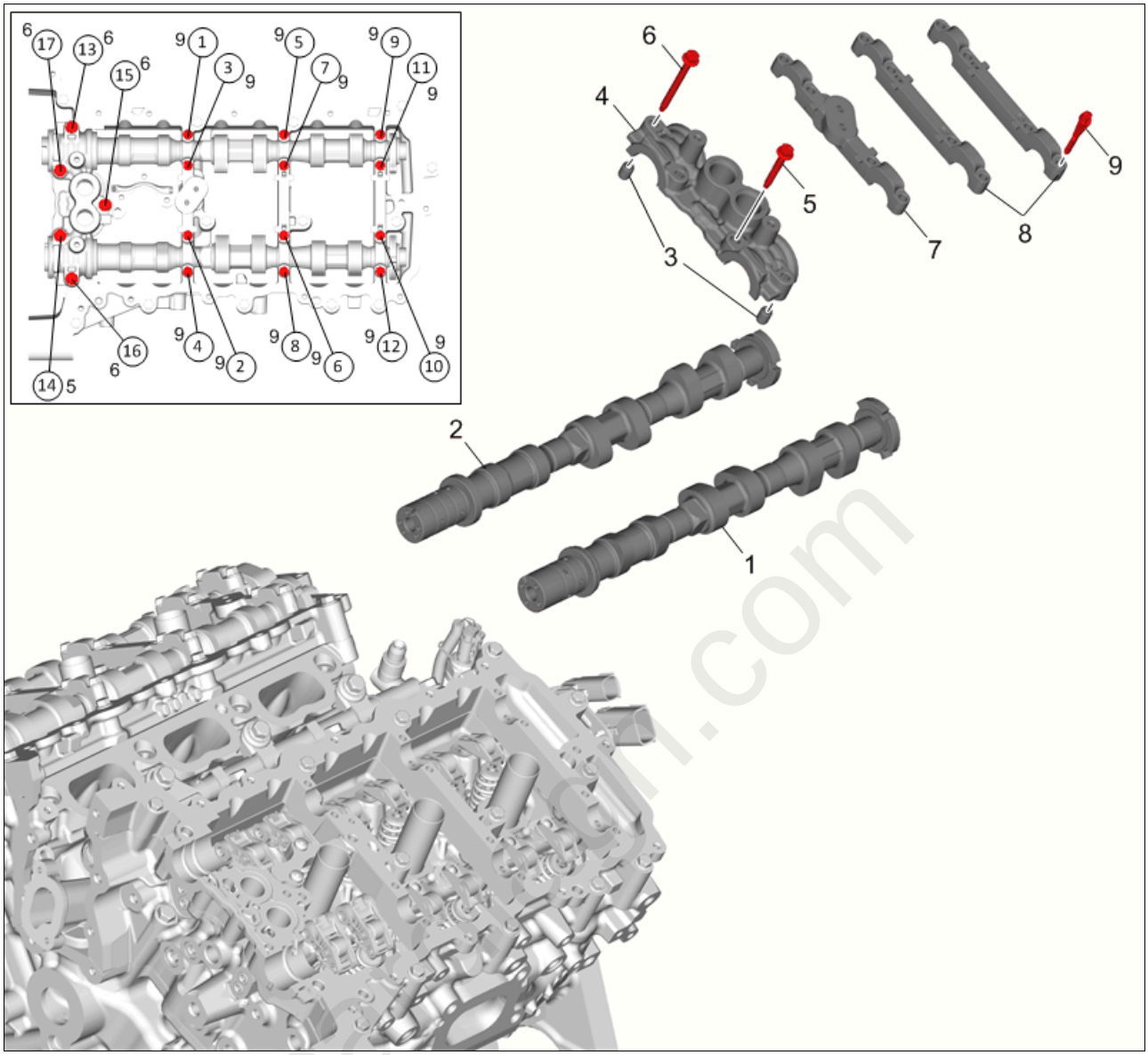
Callout	Component Name
1	Sealant *CAUTION:* *Do not apply more room temperature vulcanization (RTV) silicone than specified. Excess RTV silicone could plug up oil passage holes in the camshaft carrier and lead to engine damage.* Procedure 1. Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room

	Temperature Vulcanizing (RTV) and Anaerobic Sealant 2. Place a 3 mm (0.118 in) bead of RTV sealant on the bottom of the camshaft carrier, following the specific bead path. 3. Place a 5 mm (0.197 in) bead of RTV sealant on the bottom of the camshaft carrier as arrows show. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended sealant. *NOTE:* *Camshaft carrier surfaces should be free and clean of oil and foreign substances.*
2	Camshaft Carrier - Left
3	Camshaft Bearing Cap Bolt *CAUTION:* *Refer to Fastener Caution .* **Tighten in sequence** 13 N.m (115 lb in)

REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT INSTALLATION - LEFT SIDE

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Fig 1: Camshaft - Left Side (LGX)



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Exhaust Camshaft *NOTE:* *Ensure the flat is facing upward when installed to help when installing timing chains.*
2	Intake Camshaft

	NOTE: *Ensure the flat is facing upward when installed to help when installing timing chains.*
3	Dowel Pin
4	Camshaft Bearing Cap
5	Camshaft Bearing Cap Bolt *CAUTION:* *Refer to Fastener Caution .* **Tighten in sequence** 10 N.m (89 lb in)
6	Camshaft Carrier Bolt **Tighten in sequence** 10 N.m (89 lb in)
7	Camshaft Bearing Cap
8	Camshaft Bearing Cap
9	Camshaft Bearing Cap Bolt Tighten in sequence 1. First Pass: 6 N.m (53 lb in) 2. Final Pass: 60 degrees

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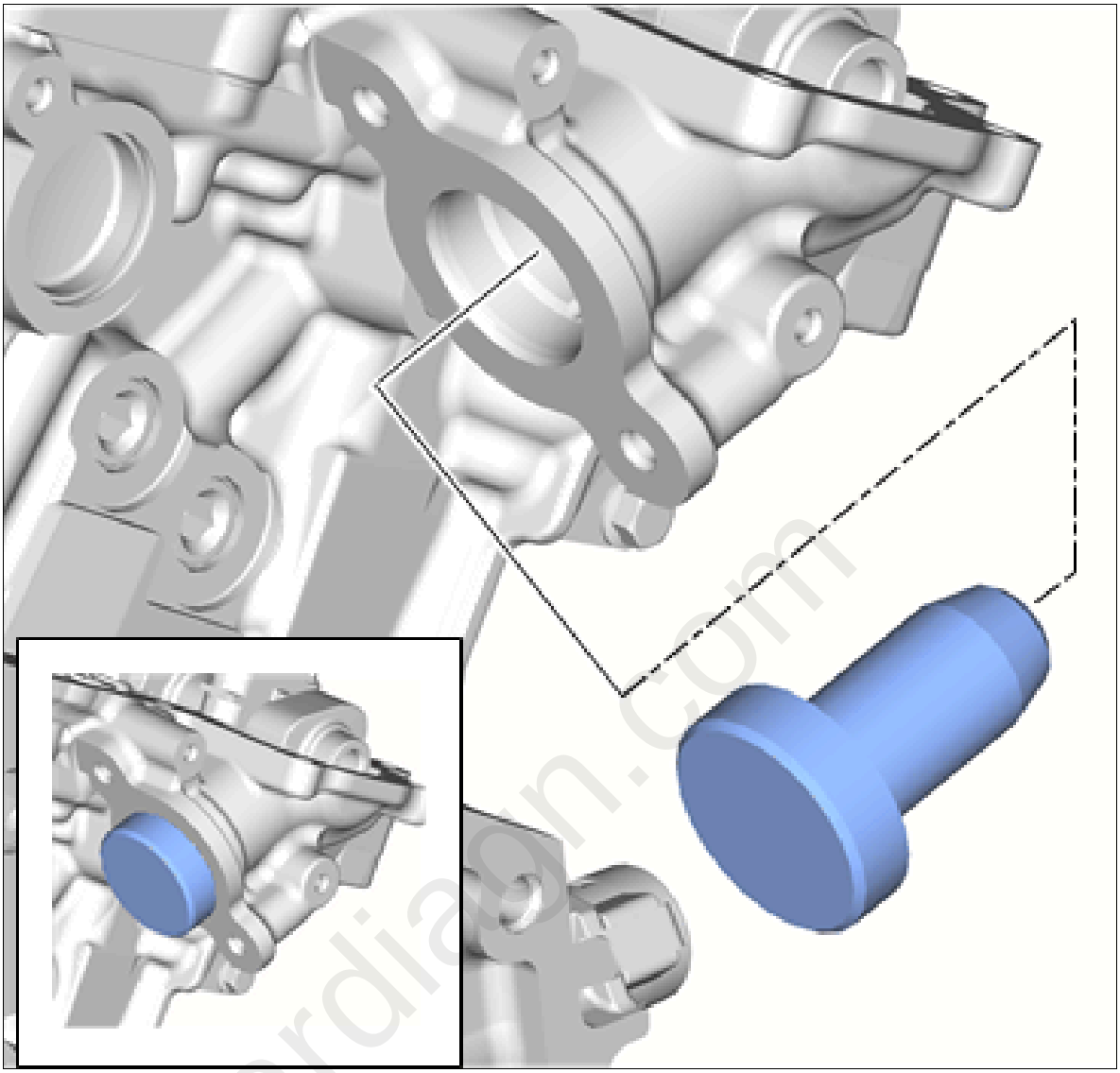
REPAIR INSTRUCTIONS - OFF VEHICLE > FUEL PUMP INSTALLATION

Special Tools

EN-48896 HP Fuel Pump Installation Alignment Gauge

For equivalent regional tools, refer to Special Tools .

Fig 1: Camshaft Alignment Gauge



Courtesy of GENERAL MOTORS COMPANY

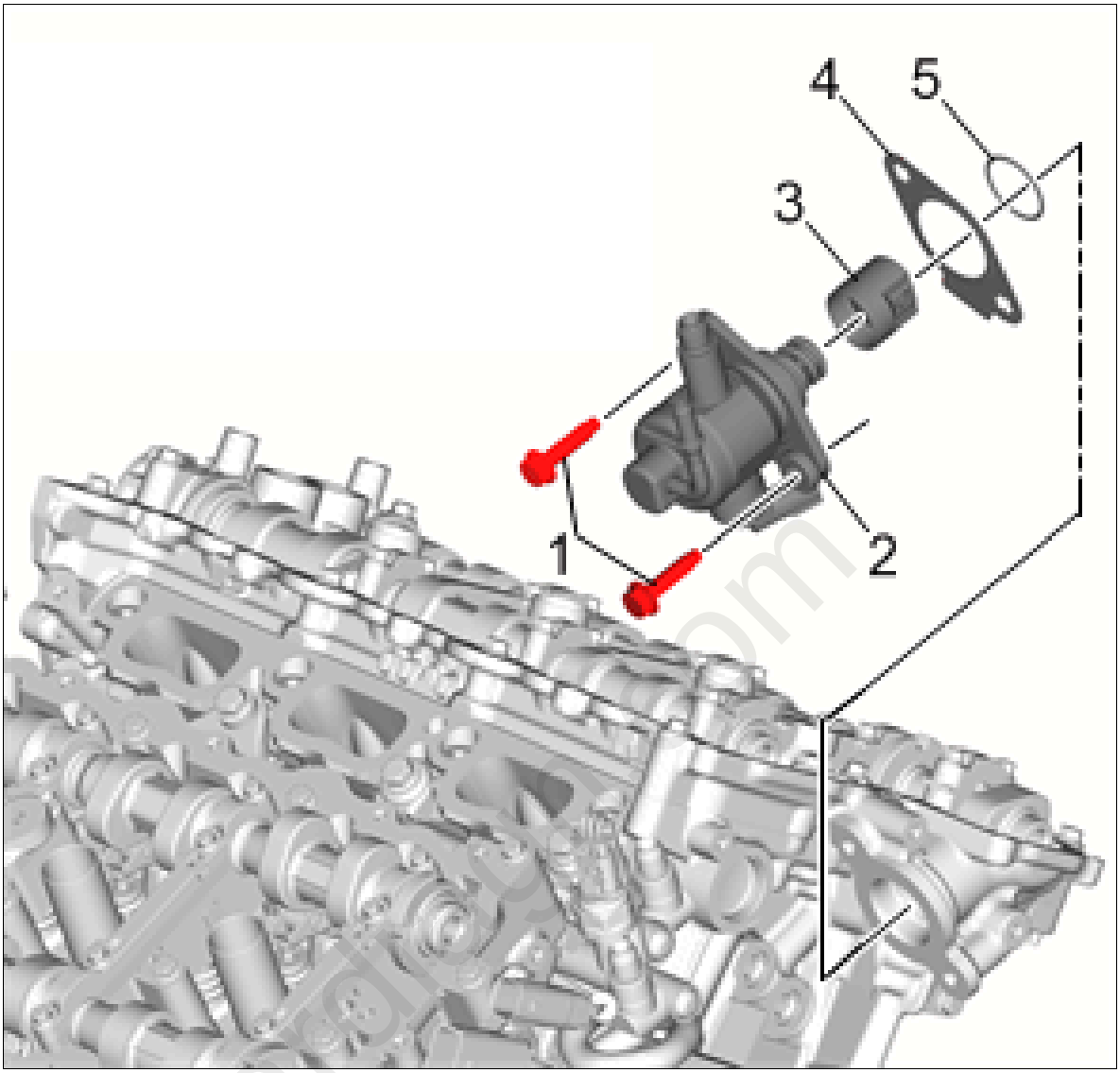
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NOTE:

The camshaft must be in the base circle position before the high pressure fuel pump is installed.

1. Use the **EN-48896** alignment gauge to ensure that the camshaft lobe is in the base circle position. At base circle position, the tool will be flush with the head.

Fig 2: High Pressure Fuel Pump



Courtesy of GENERAL MOTORS COMPANY

2. Lubricate the high pressure fuel pump cylinder head bore with clean engine oil.

> *NOTE:*
>
> *Ensure that the high pressure fuel pump roller lifter is oriented properly, the camshaft is at base circle and the number 1 piston is at top dead center (TDC) on the exhaust stroke.*

3. Lubricate the high pressure fuel pump roller lifter with clean engine oil and install into the cylinder head bore.

4. Install a NEW high pressure fuel pressure fuel pump gasket (4).

> *NOTE:*

If a high pressure pump is replaced on an engine which originally had a pump WITH a gasket, it must be rebuilt WITH a pump kit that includes the gasket; if a high pressure pump is replaced on an engine which originally had a pump WITHOUT a gasket, it must be rebuilt WITHOUT a gasket.

5. Lubricate NEW high pressure fuel pump O-ring (5) with one drop of clean engine oil and install.

NOTE:

Ensure the plastic bolt retainers are installed in the high pressure fuel pump mounting holes before installing.

6. Install the valve lifter follower (3).
7. Install the high pressure fuel pump (2).

CAUTION:

Refer to Fastener Caution .

CAUTION:

Alternately hand-tighten the fuel pump bolts one turn at a time until the pump is fully seated. Trying to draw down the pump without even side-to-side tightening may result in pump plunger damage.

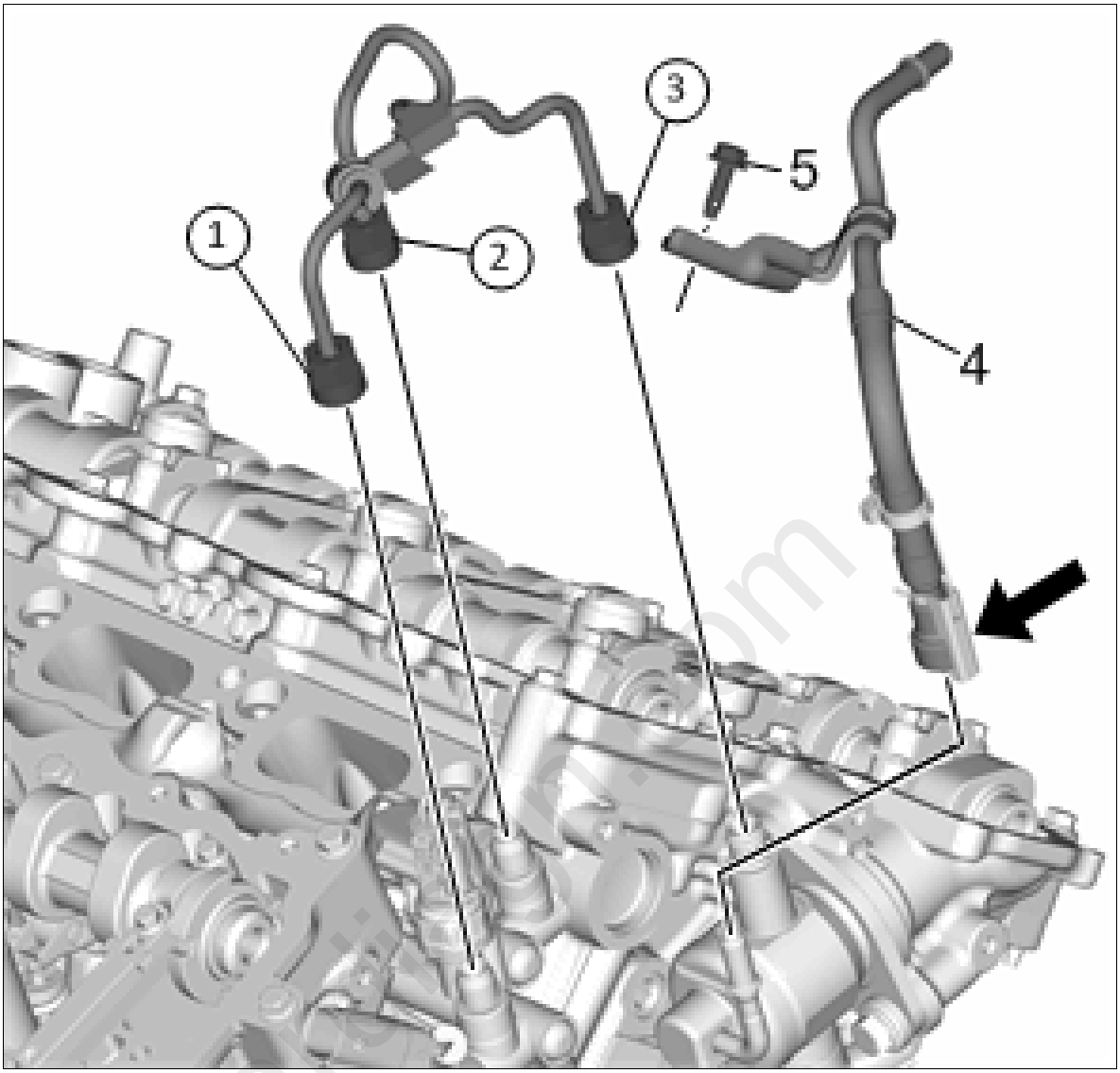
CAUTION:

This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

8. Start and hand-tighten the NEW high pressure fuel pump bolts (1) evenly.
9. Tighten the fuel pump bolts (1) to 25 N.m (19 lb ft).

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Fig 3: Fuel Crossover Pipe Fitting Nuts



Courtesy of GENERAL MOTORS COMPANY

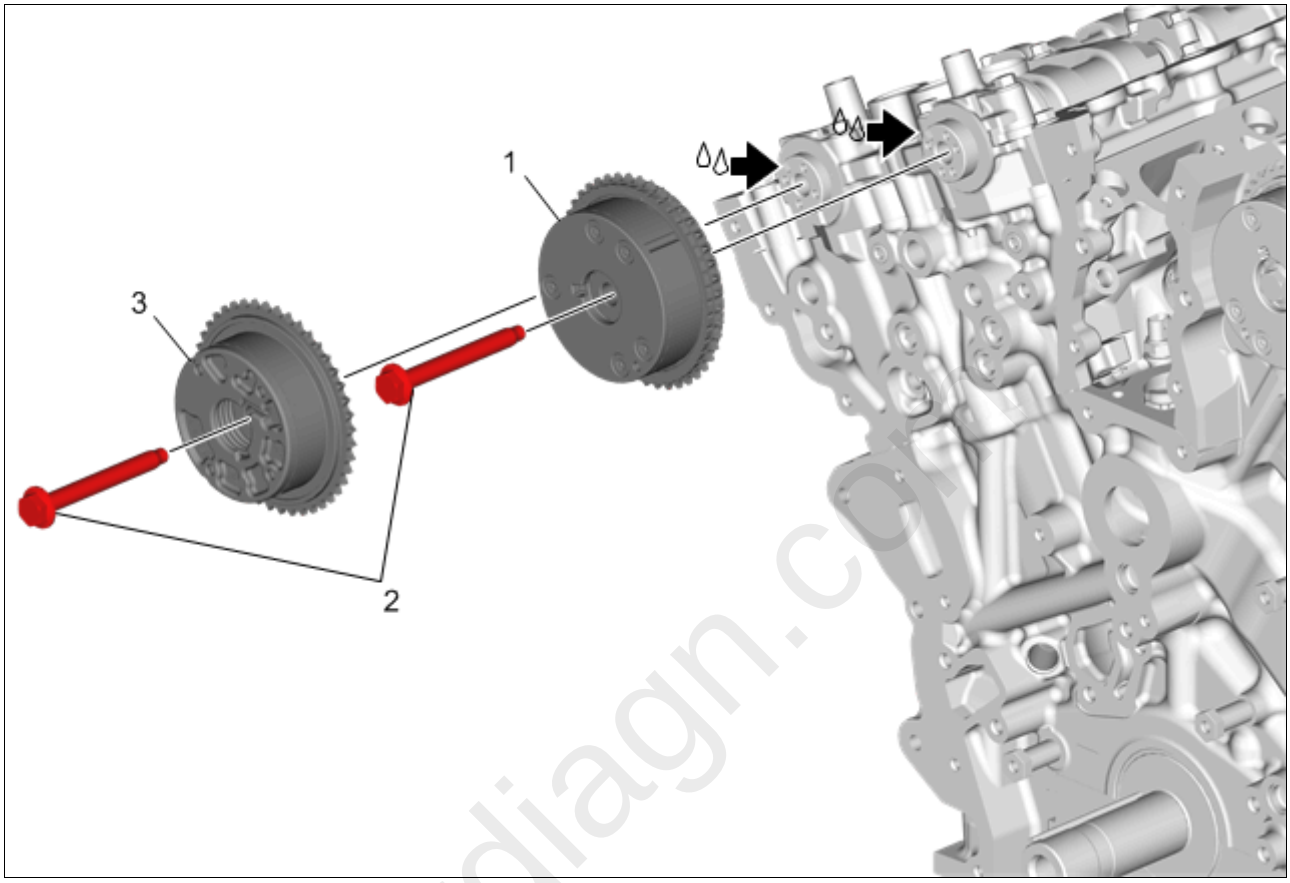
NOTE:

1. *DO NOT reuse the high pressure fuel rail crossover pipe.*
2. *The tightening order and torque are critical to proper fuel system fit and function. Be sure to follow installation and tightening steps exactly.*

10. Install the NEW high pressure LH to RH fuel rail crossover pipe by starting all three fuel crossover pipe fitting nuts (1), (2) and (3) to finger-tight only.
11. Tighten the fuel feed intermidiate pipe fittings to 28 N.m (21 lb ft) in the following order: (1) Left Fuel Rail, (2) Right Fuel Rail, then (3) Fuel Pump.
12. Install the fuel feed pipe (4) by installing the fuel line nut to the fuel pump finger-tight.
13. Tighten the fuel feed pipe bolt (5) to 10 N.m (89 lb in).

REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT POSITION ACTUATOR INSTALLATION - BANK 1

Fig 1: Camshaft Position Actuator - Bank 1



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Exhaust Camshaft Position Actuator Bank 1 *CAUTION:* *Ensure the proper camshaft position actuator is installed in the correct position. Failure to install the proper camshaft position actuator can effect engine performance and set an engine code.* *CAUTION:* *Refer to Torque Reaction Against Timing Drive Chain Caution .*

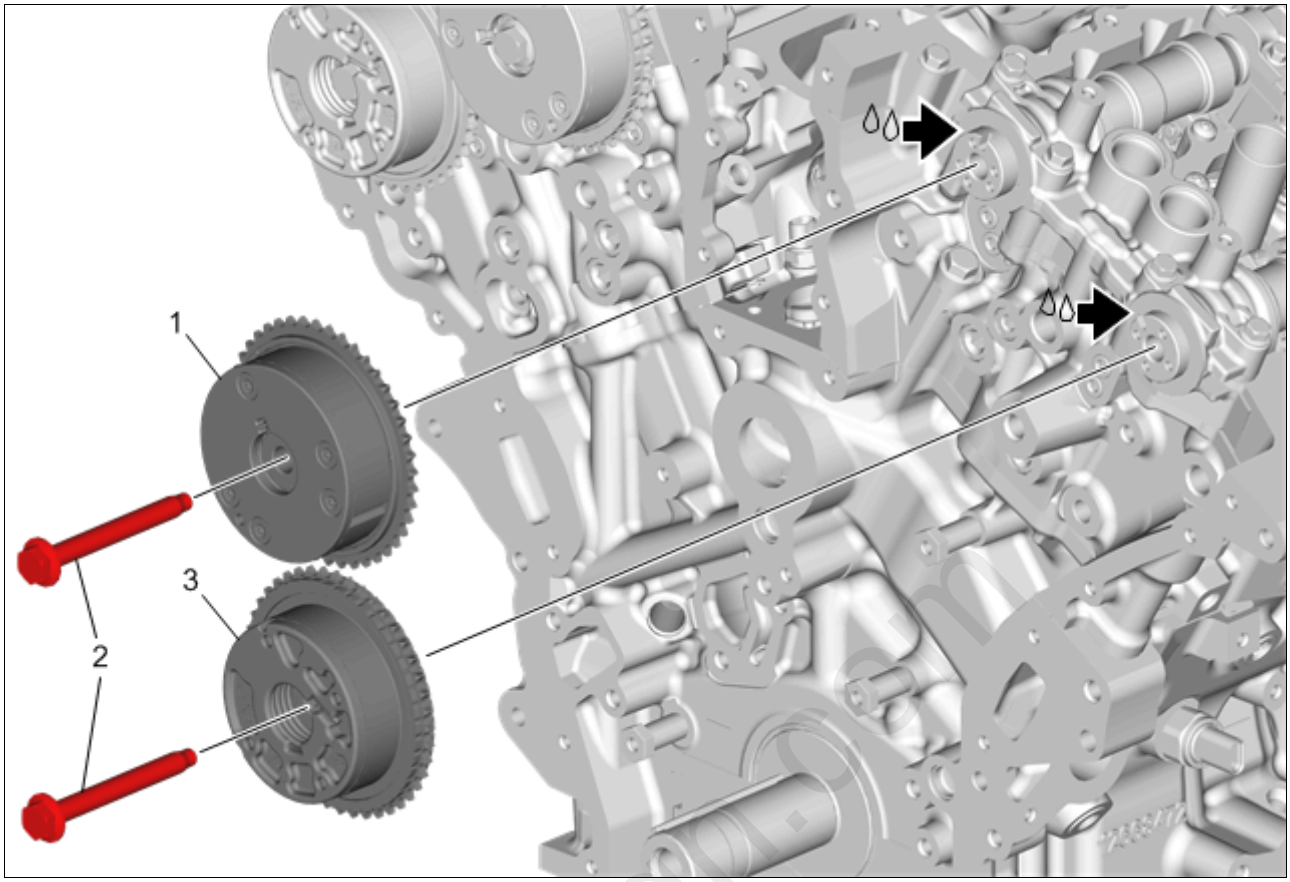
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	Procedure 1. Use an open wrench on the hex cast into the camshaft in order to prevent camshaft rotation when tightening the camshaft position actuator bolt. 2. Apply a liberal amount of lubricant to the back of the camshaft position actuator and front of the camshaft bearing cap. Refer to Adhesives, Fluids, Lubricants, and Sealers .
2	Camshaft Position Actuator Bolt (Qty: 2) *CAUTION:* *Refer to Fastener Caution .* **Tighten** First Pass: 20 N.m (15 lb ft) Final Pass: 45 Degrees
3	Intake Camshaft Position Active Counter Bank 1 Procedure 1. Use an open wrench on the hex cast into the camshaft in order to prevent camshaft rotation when tightening the camshaft position actuator bolt. 2. Apply a liberal amount of lubricant to the back of the camshaft position actuator and front of the camshaft bearing cap. Refer to Adhesives, Fluids, Lubricants, and Sealers .

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REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT POSITION ACTUATOR INSTALLATION - BANK 2

Fig 1: Camshaft Position Actuator - Bank 2



Courtesy of GENERAL MOTORS COMPANY

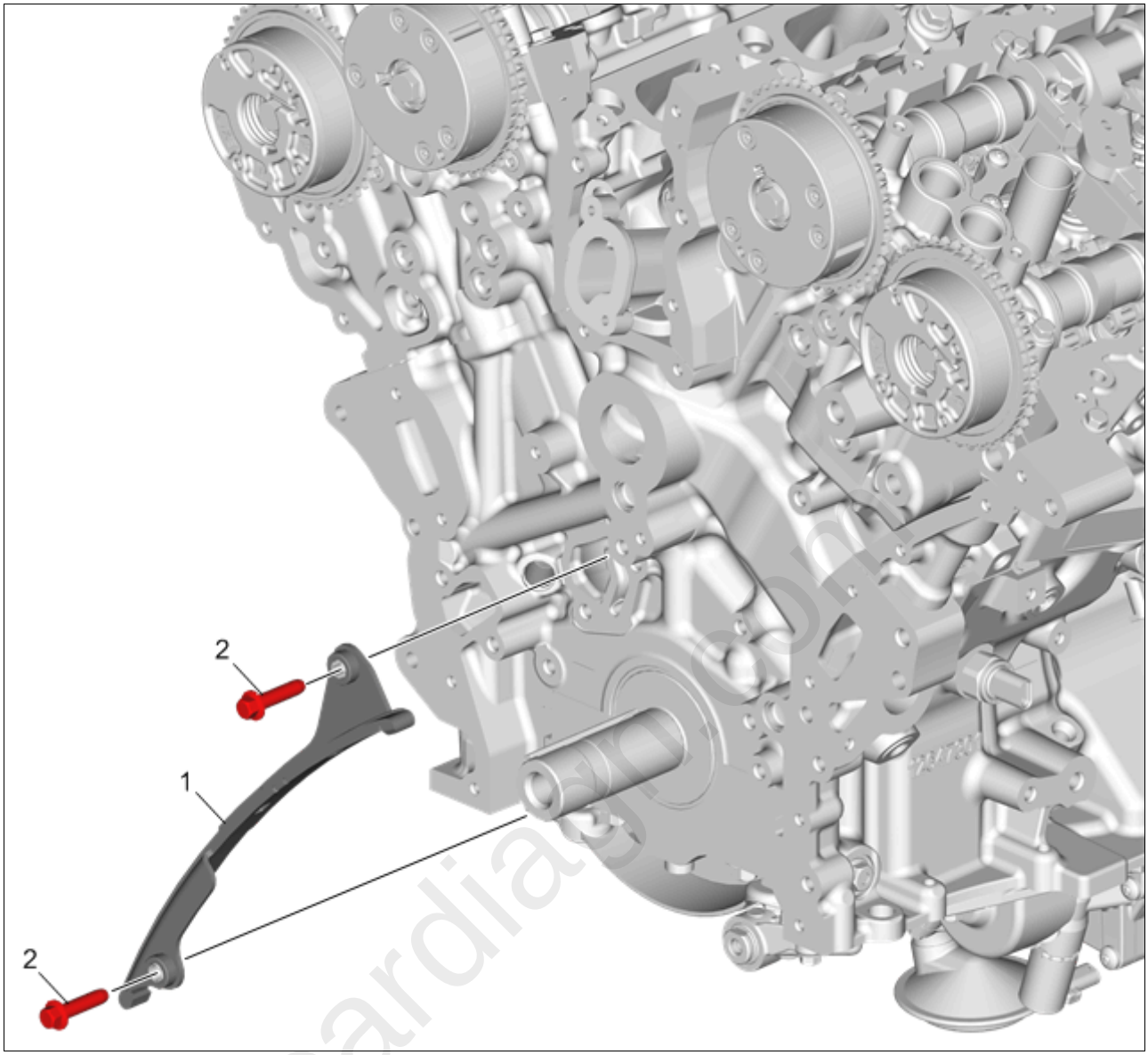
Callout	Component Name
1	Intake Camshaft Position Actuator Bank 2 *CAUTION:* *Ensure the proper camshaft position actuator is installed in the correct position. Failure to install the proper camshaft position actuator can effect engine performance and set an engine code.* *CAUTION:* *Refer to Torque Reaction Against Timing Drive Chain Caution .* Procedure 1. Use an open wrench on the hex cast into the camshaft in order to prevent camshaft rotation when tightening the camshaft position actuator bolt. 2. Apply a liberal amount of lubricant to the back of the camshaft position actuator

	and front of the camshaft bearing cap. Refer to Adhesives, Fluids, Lubricants, and Sealers .
2	Camshaft Position Actuator Bolt (Qty: 2) *CAUTION:* *Refer to Fastener Caution .* **Tighten** First Pass: 20 N.m (15 lb ft) Final Pass: 45 Degrees
3	Exhaust Camshaft Position Actuator Bank 2 Procedure 1. Use an open wrench on the hex cast into the camshaft in order to prevent camshaft rotation when tightening the camshaft position actuator bolt. 2. Apply a liberal amount of lubricant to the back of the camshaft position actuator and front of the camshaft bearing cap. Refer to Adhesives, Fluids, Lubricants, and Sealers .

REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT TIMING CHAIN COMPONENTS INSTALLATION > LEFT TIMING CHAIN GUIDE INSTALLATION

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Fig 1: Left Timing Chain Guide



Courtesy of GENERAL MOTORS COMPANY

Left Timing Chain Guide Installation

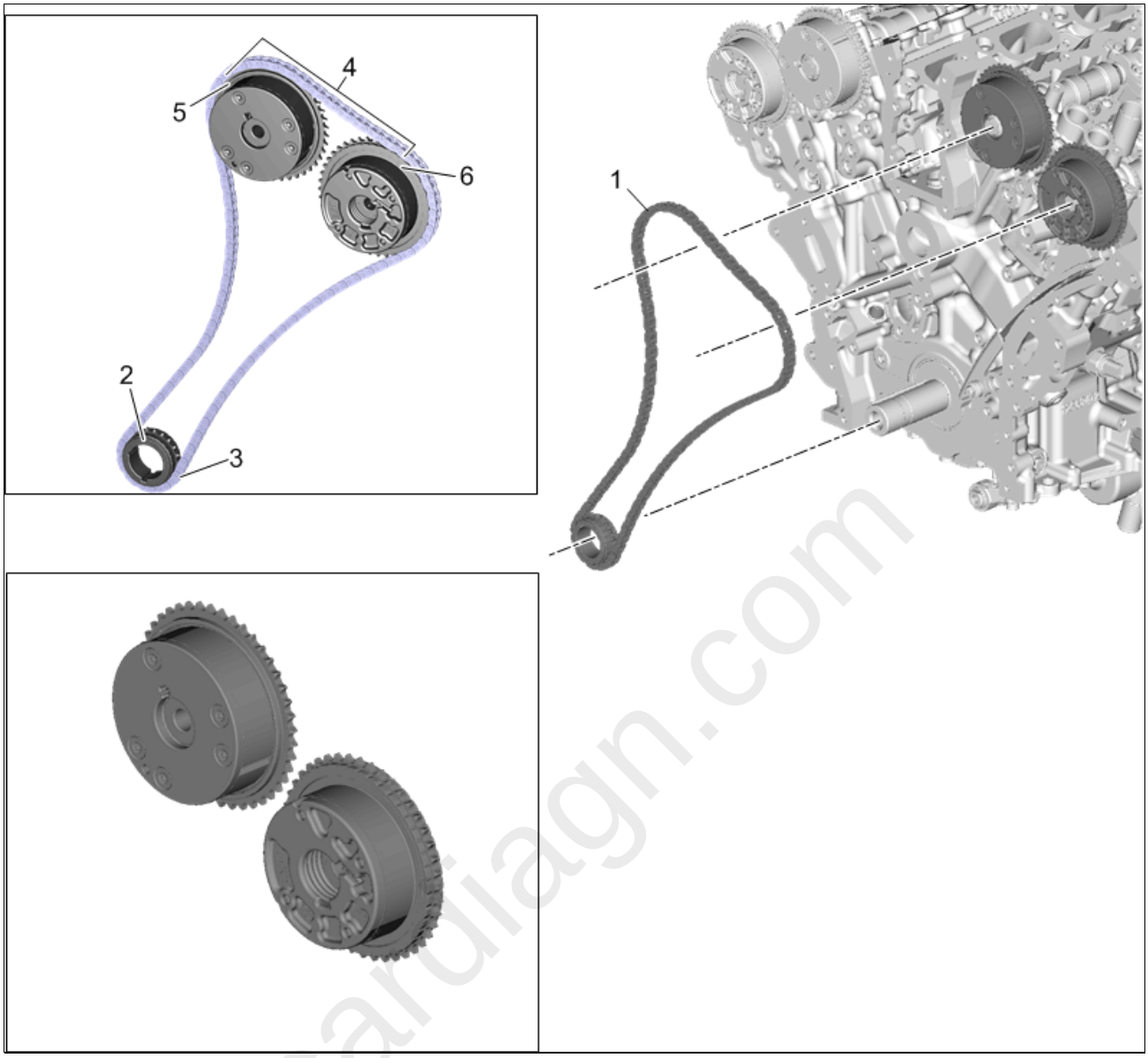
Callout	Component Name
1	Timing Chain Guide - Left Side *NOTE:* *Check that the specific Intake and exhaust actuators are in there proper position. There are specific Right and Left actuators.*

2	Timing Chain Guide Bolt (Qty: 2) *CAUTION:* *Refer to Fastener Caution .* **Tighten** 25 N.m (18 lb ft)

REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT TIMING CHAIN COMPONENTS INSTALLATION > LEFT TIMING CHAIN INSTALLATION

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Fig 1: Left Timing Chain



Courtesy of GENERAL MOTORS COMPANY

Left Timing Chain Installation

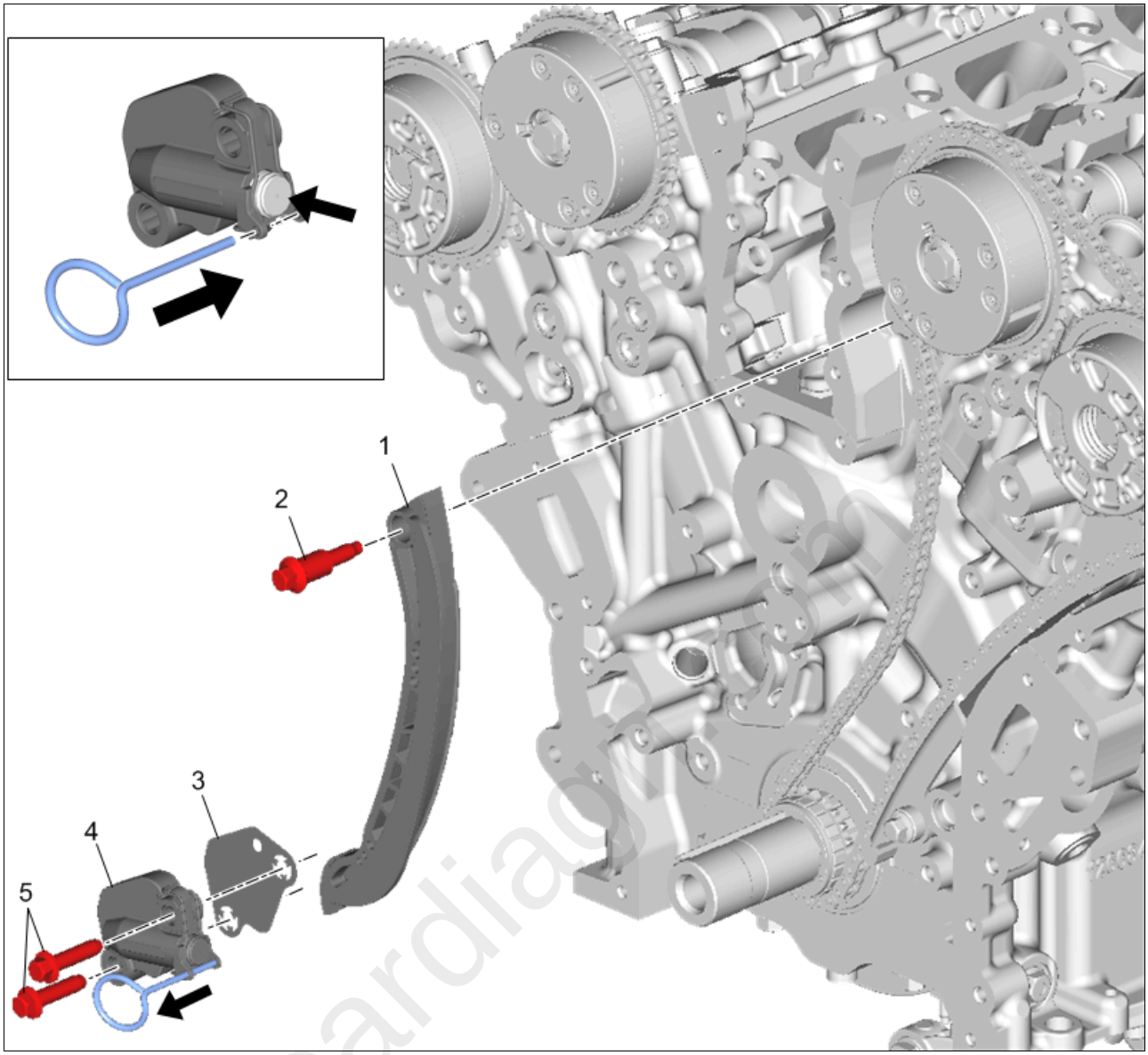
Callout	Component Name
1	Timing Chain - Left Side Procedure 1. Preassemble the crank sprocket to the left timing chain (1). 2. Install the crank sprocket on the crankshaft while holding up the timing chain. 3. Guide timing chain onto the guide, and not resting on the plastic side ribs. 4. Use an open ended wrench on the cast hexagonal portion of the camshaft to

	rotate the camshafts, which will aid in the aligning of the timing marks. 5. There may be more than one marking on the camshaft actuator sprocket area. Locate the (L) on the face of the actuator body. The correct timing mark can be a circle or triangle located straight inboard on the sprocket tooth in line with the (L) identifier (5 or 6). 6. Align the left (L) exhaust camshaft position actuator sprocket alignment circle or triangle mark (6) with the camshaft drive chain timing link. 7. Align the left (L) intake camshaft position actuator sprocket alignment circle or triangle mark (5) with the camshaft drive chain timing link.
2	Crankshaft Timing Sprocket Timing Mark
3	Timing Chain Links
4	Timing Chain Links
5	Left Intake Actuator Timing Sprocket Timing Mark
6	Left Exhaust Actuator Timing Sprocket Timing Mark

REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT TIMING CHAIN COMPONENTS INSTALLATION > LEFT TIMING CHAIN GUIDE AND TIMING CHAIN TENSIONER INSTALLATION

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Fig 1: Left Timing Chain Guide and Timing Chain Tensioner



Courtesy of GENERAL MOTORS COMPANY

Left Timing Chain Guide and Timing Chain Tensioner Installation

Callout	Component Name
1	Timing Chain Guide - Left Side
2	Timing Chain Guide Bolt **Tighten** 25 N.m (18 lb ft)
3	Timing Chain Tensioner Gasket *NOTE:*

Ensure the left timing chain tensioner mounting surface on the left cylinder head does not have any burrs or defects that would degrade the sealing of the NEW left timing chain tensioner gasket.

4

Timing Chain Tensioner - Left Side

WARNING:

The timing chain tensioner plunger is under high tension and must be retained by using the tensioner retraction pin during removal or installation of the timing chain tensioner. Failure to retain the timing chain tensioner plunger may cause it to be ejected with intense force and cause personal injury.

Procedure

1. Reset the timing chain tensioner plunger using your thumb and **EN-52234** or a 1/8" drill bit to retain the plunger.
2. Compress the plunger into the body and lock the right timing chain tensioner by inserting **EN-52234** or 1/8" drill bit into the access hole in the side of the right timing chain tensioner body.
3. Slowly release pressure on the right timing chain tensioner. The right timing chain tensioner should remain compressed.

Special Tools
EN-52234 Timing Chain Tensioner Retaining Pins
For equivalent regional tools, refer to Special Tools .

5

Timing Chain Tensioner Bolt

Procedure

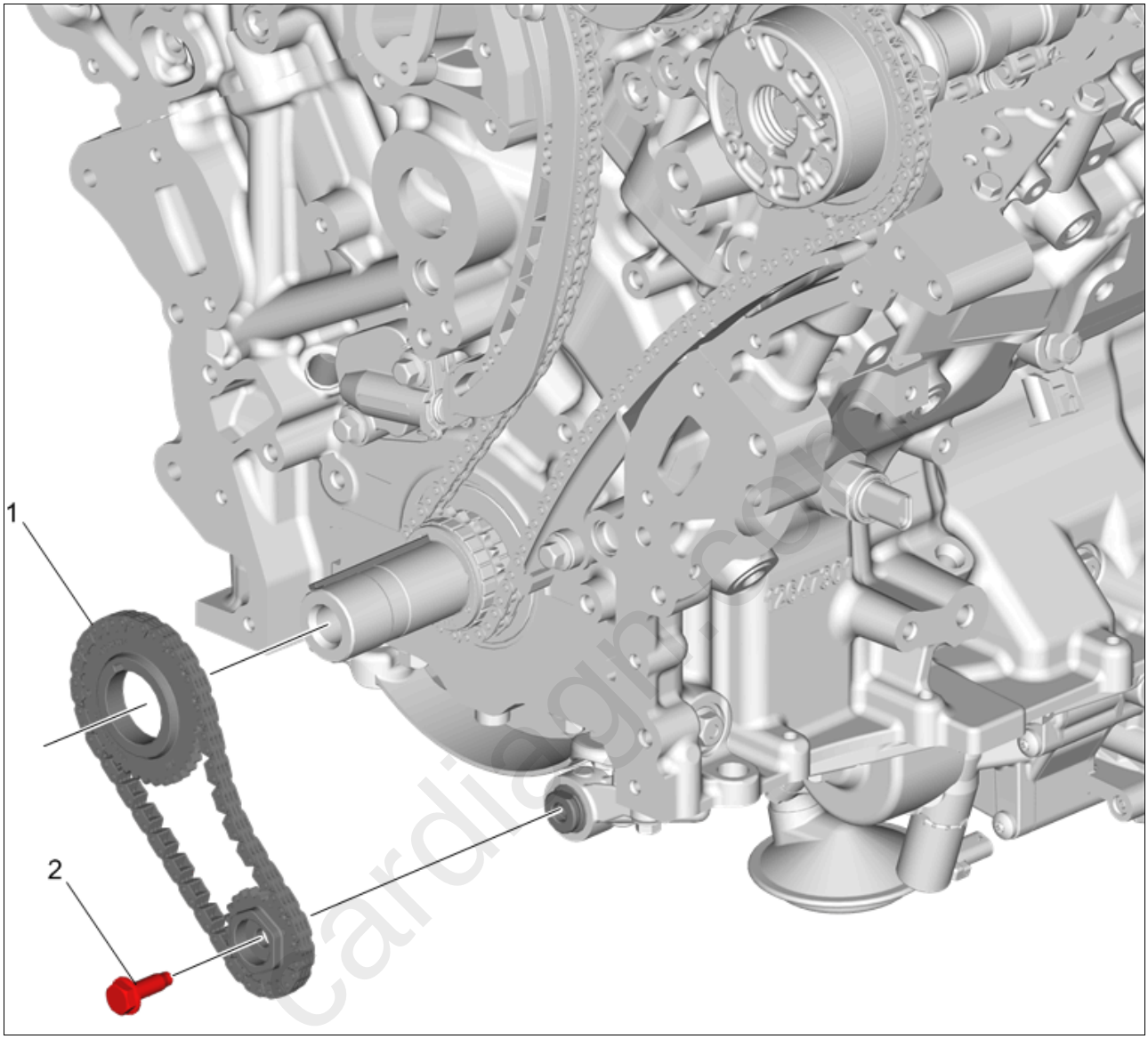
1. Place the chain tensioner into position and loosely install the bolts to the block.
2. Tighten the timing chain tensioner bolts.
3. Verify the timing marks are in the correct position before releasing the drive chain tensioner.
4. Release the timing chain tensioner plunger by pulling out the suitable tool.
5. Verify the left timing chain timing mark alignments by referring to Timing Chain Alignment Diagram - Stage One.

Tighten
25 N.m (18 lb ft)

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REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT TIMING CHAIN COMPONENTS INSTALLATION > OIL PUMP TIMING CHAIN INSTALLATION

Fig 1: Oil Pump Timing Chain



Courtesy of GENERAL MOTORS COMPANY

Oil Pump Timing Chain Installation

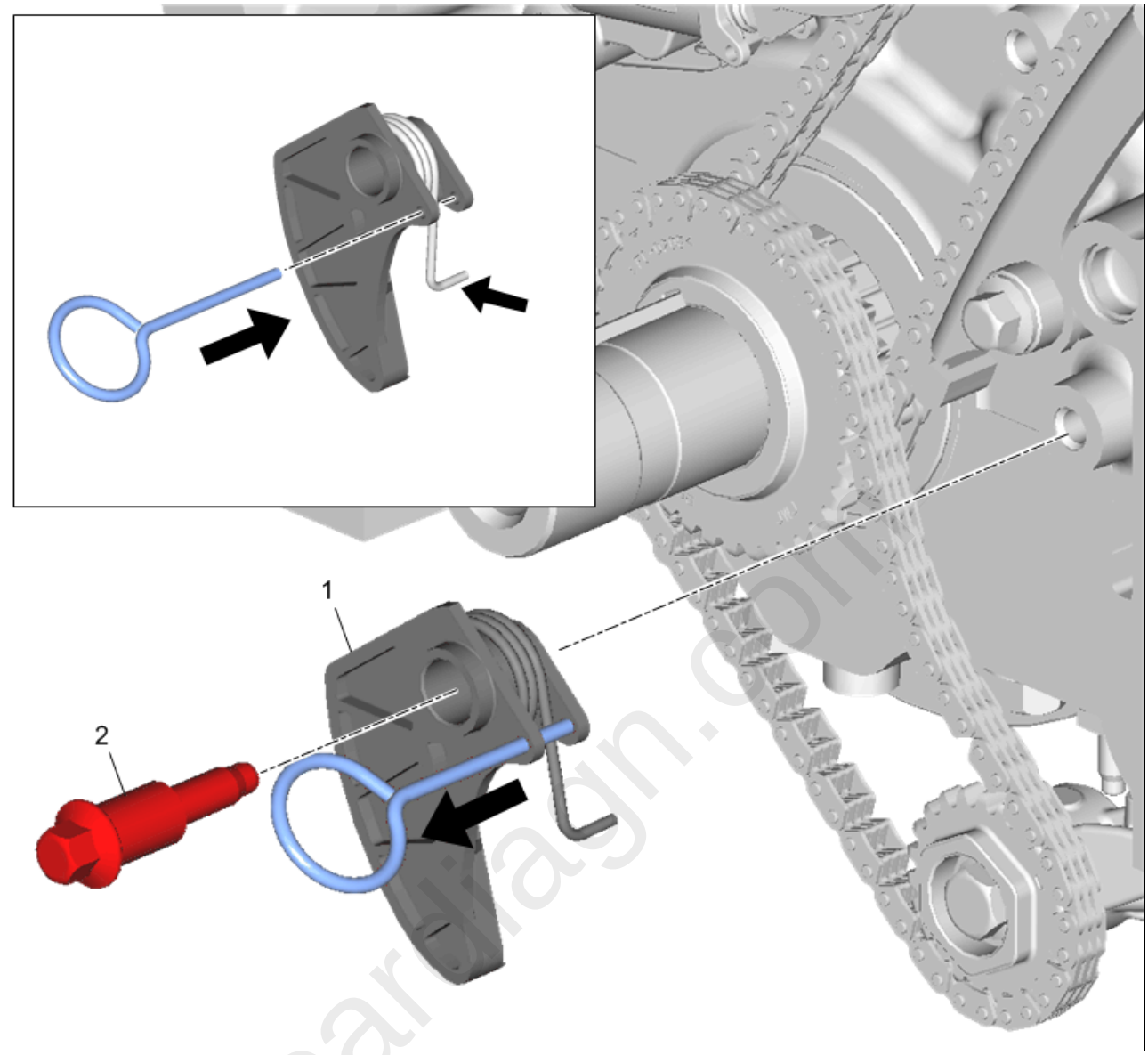
Callout	Component Name
1	Oil Pump Timing Chain Procedure 1. Preassemble the crankshaft sprocket, oil pump sprocket and the timing chain using the timing marks on the sprockets and the timing chain. 2. The timing chain timing mark (4) will align with timing chain timing link (3).

	3. The timing chain timing mark (6) will align with timing chain timing link (5). 4. Install the pre-assembly to the crankshaft first while holding the timing chain to both sprockets. 5. Install the oil pump sprocket to the oil pump, verify engagement to the D-flat. 6. Install the oil pump sprocket bolt.
2	Oil Pump Drive Bolt Tighten in sequence 1. First Pass: 15 N.m (11 lb ft) 2. Final Pass: 110 degrees
3	Timing Chain Timing Link
4	Crankshaft Sprocket Timing Mark
5	Timing Chain Timing Link
6	Oil Pump Sprocket Timing Mark

REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT TIMING CHAIN COMPONENTS INSTALLATION > OIL PUMP TIMING CHAIN TENSIONER INSTALLATION

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Fig 1: Oil Pump Timing Chain Tensioner



Courtesy of GENERAL MOTORS COMPANY

Oil Pump Timing Chain Tensioner Installation

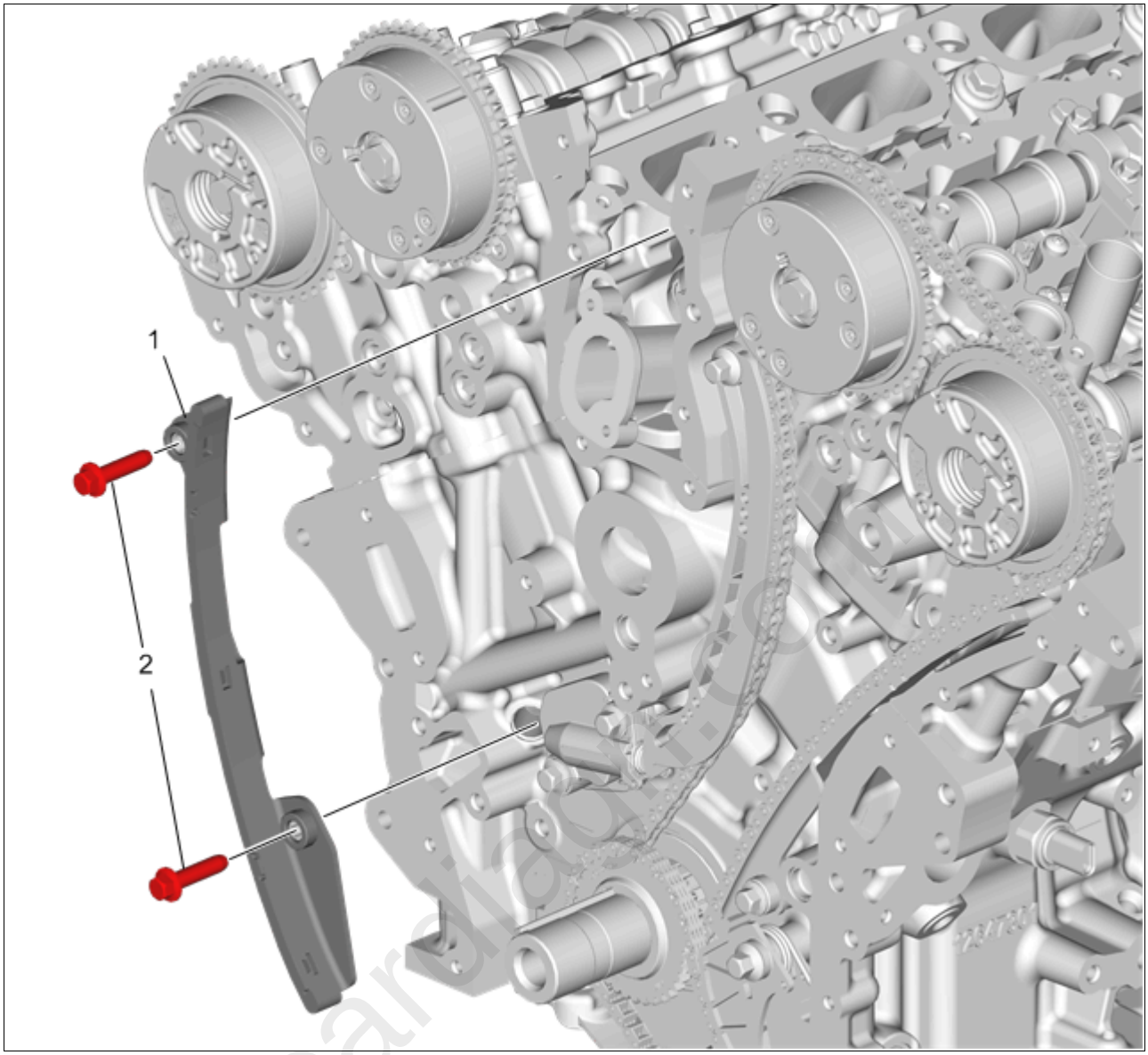
Callout	Component Name
1	Timing Chain Tensioner **Procedure** Collapse the oil pump timing tensioner by hand and install **EN-52234** or a 1/8" drill bit to hold it in place. **Special Tools** **EN-52234** Timing Chain Tensioner Retaining Pins For equivalent regional tools, refer to Special Tools .
2	Timing Chain Tensioner Bolt

	Procedure 1. Place the chain tensioner into position and loosely install the bolt to the block 2. Tighten the timing chain tensioner bolt. 3. Verify the timing marks are in the correct position before releasing the drive chain tensioner. 4. Release the drive chain tensioner by pulling out the suitable tool. **Tighten** 25 N.m (18 lb ft)

REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT TIMING CHAIN COMPONENTS INSTALLATION > RIGHT TIMING CHAIN GUIDE INSTALLATION

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Fig 1: Oil Pump Timing Chain Tensioner



Courtesy of GENERAL MOTORS COMPANY

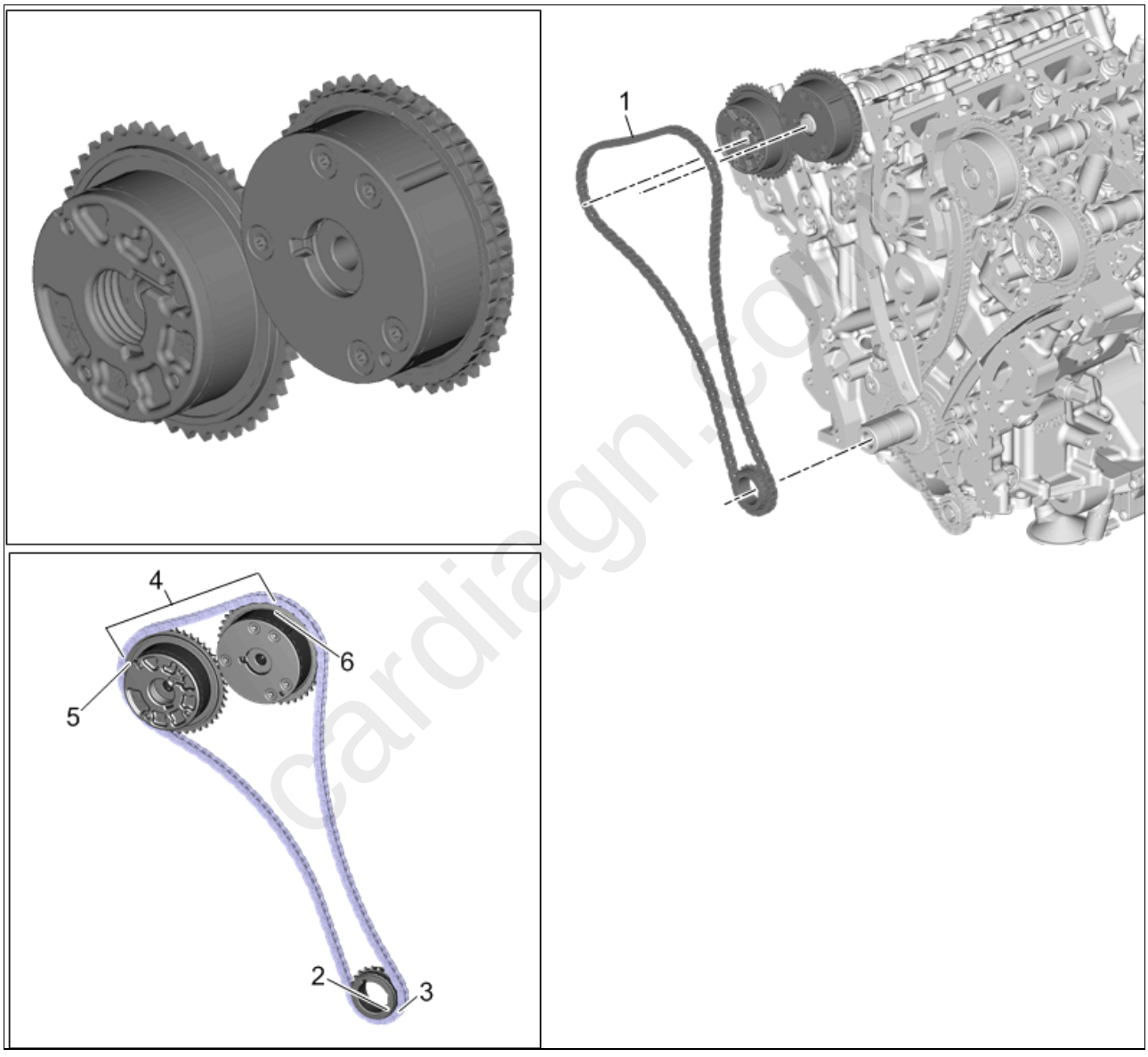
Right Timing Chain Guide Installation

Callout	Component Name
1	Timing Chain Guide - Right Side *NOTE:* *Check that the specific Intake and exhaust actuators are in there proper position. There are specific Right and Left actuators.*

2	Timing Chain Guide Bolt **Tighten** 25 N.m (18 lb ft)

REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT TIMING CHAIN COMPONENTS INSTALLATION > RIGHT TIMING CHAIN INSTALLATION

Fig 1: Right Timing Chain



Courtesy of GENERAL MOTORS COMPANY

Right Timing Chain Installation

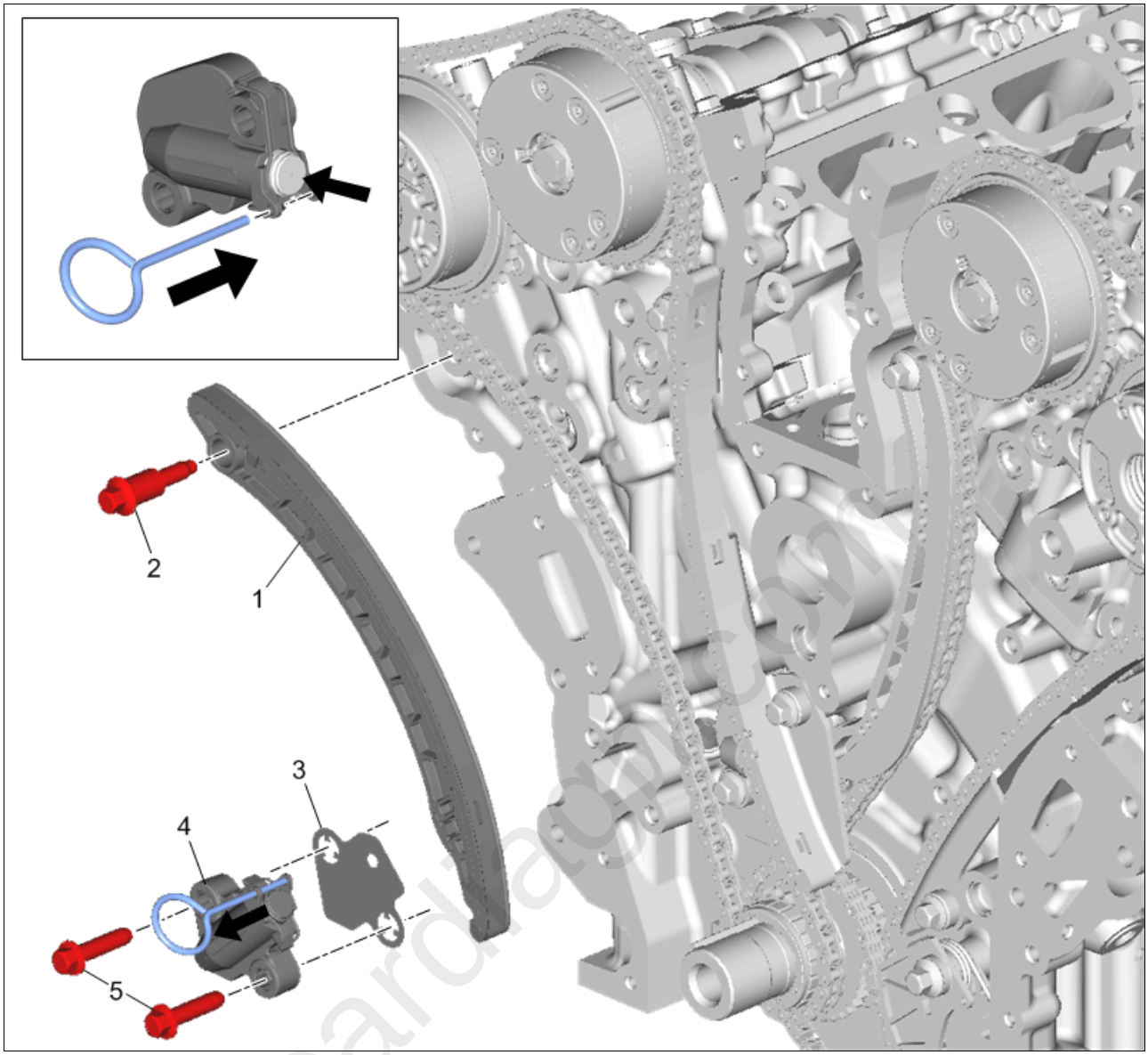
Callout	Component Name
1	Timing Chain - Right Side

	Procedure 1. Preassemble the crank sprocket to the right timing chain (1). 2. Install the crank sprocket on the crankshaft while holding up the timing chain. 3. Guide timing chain onto the guide, and not resting on the plastic side ribs. 4. Use an open ended wrench on the cast hexagonal portion of the camshaft to rotate the camshafts, which will aid in the aligning of the timing marks. 5. There may be more than one marking on the camshaft actuator sprocket area. Locate the (R) on the face of the actuator body. The correct timing mark can be a circle or triangle located straight inboard on the sprocket tooth in line with the (R) identifier (5 or 6). 6. Align the right (R) exhaust camshaft position actuator sprocket alignment circle or triangle mark (6) with the camshaft drive chain timing link. 7. Align the right (R) intake camshaft position actuator sprocket alignment circle or triangle mark (5) with the camshaft drive chain timing link.
2	Crankshaft Timing Sprocket Timing Mark
3	Timing Chain Links
4	Timing Chain Links
5	Right Intake Actuator Timing Sprocket Timing Mark
6	Right Exhaust Actuator Timing Sprocket Timing Mark

REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT TIMING CHAIN COMPONENTS INSTALLATION > RIGHT TIMING CHAIN GUIDE AND TIMING CHAIN TENSIONER INSTALLATION

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Fig 1: Right Timing Chain Guide and Timing Chain Tensioner



Courtesy of GENERAL MOTORS COMPANY

Right Timing Chain Guide and Timing Chain Tensioner Installation

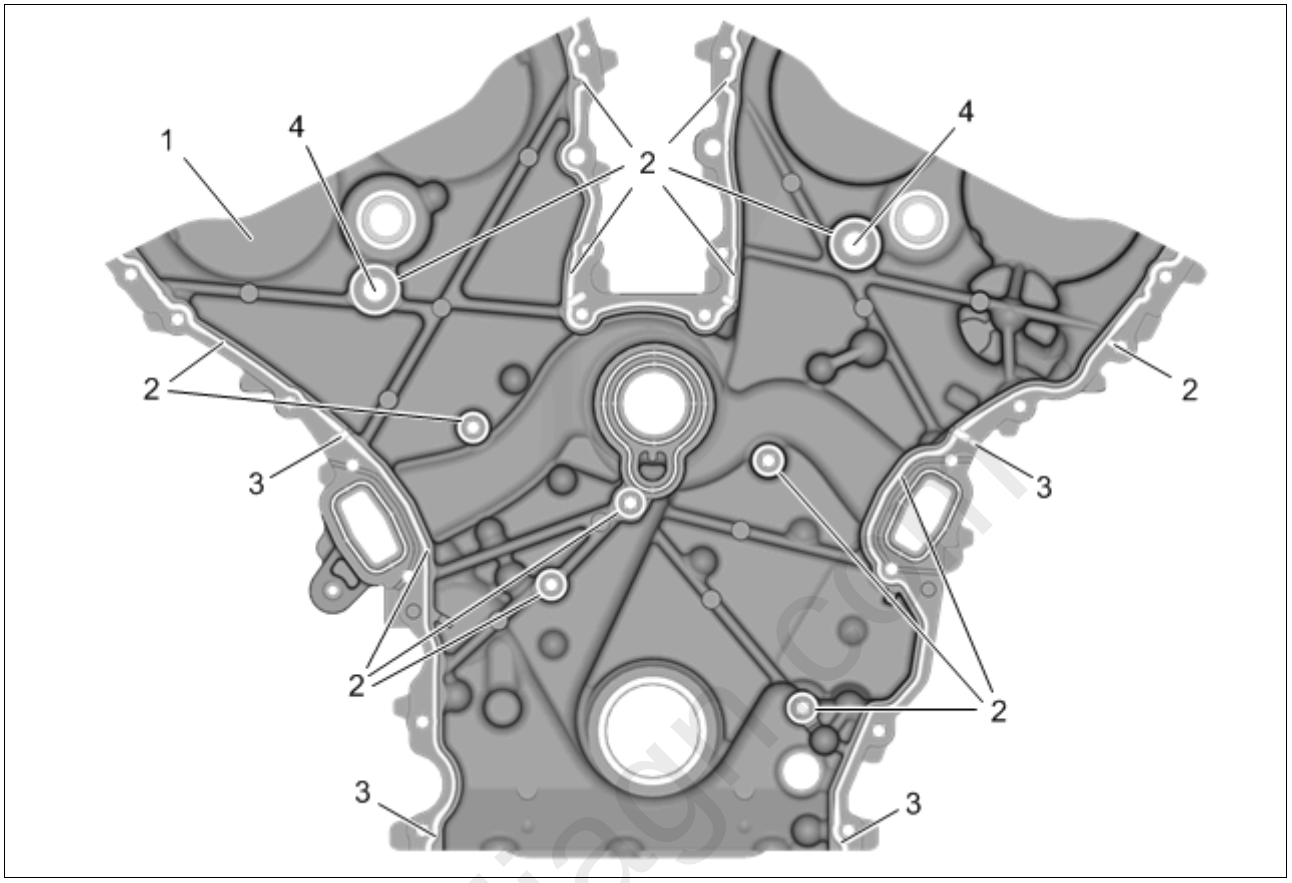
Callout	Component Name
1	Timing Chain Guide - Right Side
2	Timing Chain Guide Bolt **Tighten** 25 N.m (18 lb ft)
3	Timing Chain Tensioner Gasket *NOTE:*

	Ensure the right timing chain tensioner mounting surface on the right cylinder head does not have any burrs or defects that would degrade the sealing of the NEW right timing chain tensioner gasket.
4	Timing Chain Tensioner - Right Side *WARNING:* *The timing chain tensioner plunger is under high tension and must be retained by using the tensioner retraction pin during removal or installation of the timing chain tensioner. Failure to retain the timing chain tensioner plunger may cause it to be ejected with intense force and cause personal injury.* Procedure 1. Reset the timing chain tensioner plunger using your thumb and **EN-52234** or a 1/8" drill bit to retain the plunger. 2. Compress the plunger into the body and lock the right timing chain tensioner by inserting **EN-52234** or 1/8" drill bit into the access hole in the side of the right timing chain tensioner body. 3. Slowly release pressure on the right timing chain tensioner. The right timing chain tensioner should remain compressed. **Special Tools** **EN-52234** Timing Chain Tensioner Retaining Pins For equivalent regional tools, refer to Special Tools .
5	Timing Chain Tensioner Bolt Procedure 1. Place the chain tensioner into position and loosely install the bolts to the block. 2. Tighten the timing chain tensioner bolts. 3. Verify the timing marks are in the correct position before releasing the drive chain tensioner. 4. Release the timing chain tensioner plunger by pulling out the suitable tool. 5. Verify the left timing chain timing mark alignments by referring to Timing Chain Alignment Diagram - Stage Two. **Tighten** 25 N.m (18 lb ft)

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REPAIR INSTRUCTIONS - OFF VEHICLE > ENGINE FRONT COVER INSTALLATION > SEALANT APPLICATION

Fig 1: Engine Front Cover Sealant Application Points



Courtesy of GENERAL MOTORS COMPANY

Sealant Application

Callout	Component Name
1	Engine Front Cover Procedure 1. Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant 2. Apply a 3 mm (0.118 in) bead of RTV sealant on the engine front cover as shown. 3. Apply a 5 mm (0.197 in) bead of RTV sealant on the engine front cover as shown. Refer to Adhesives, Fluids, Lubricants, and Sealers . *NOTE:*

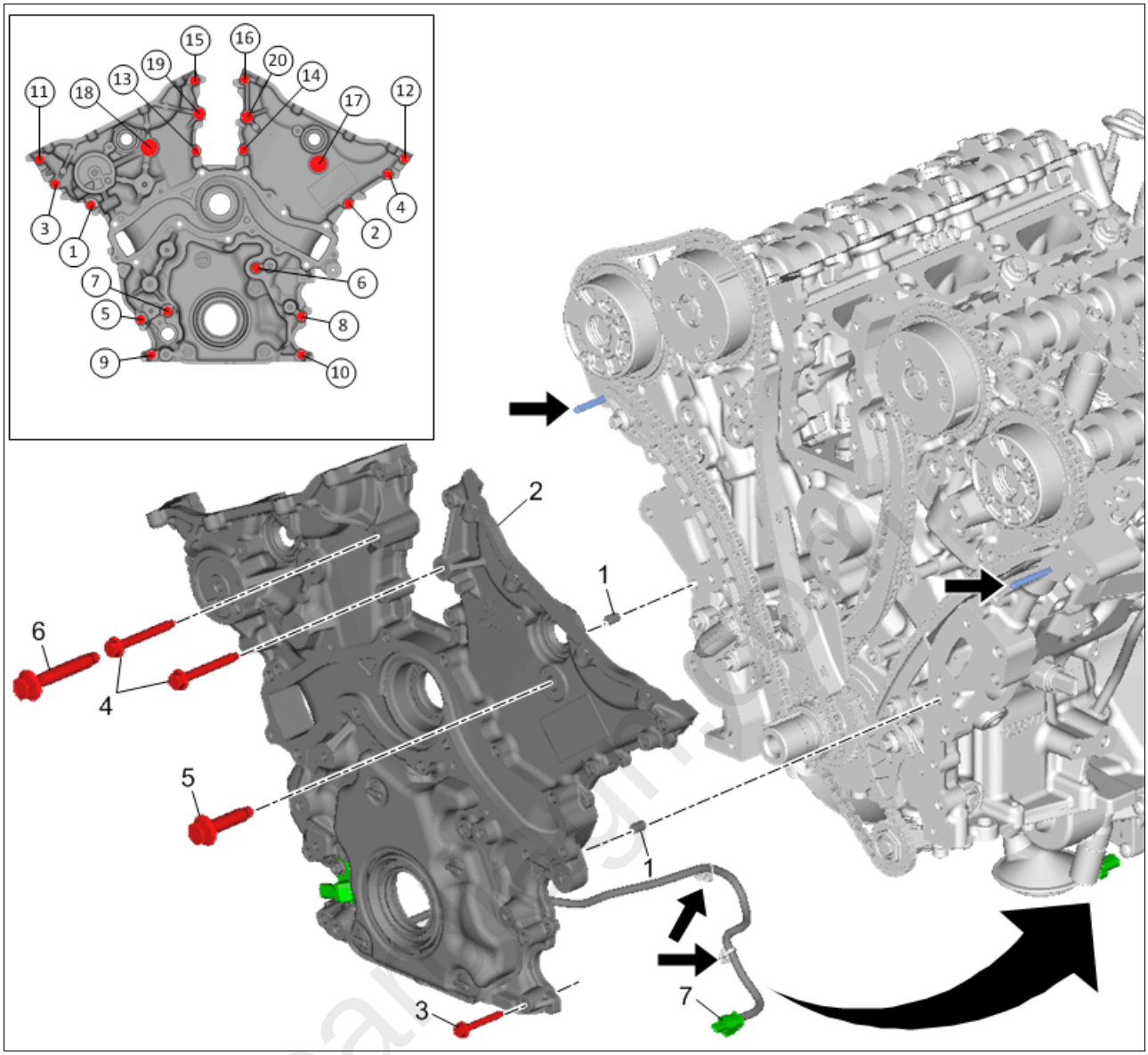
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	• *No RTV sealant should be visible in the M12 bolt holes upon final assembly of front cover to engine.* • *Keep the RTV bead path on the outward edge of the t-joints to ensure proper sealant coverage.*
2	3 mm (0.118 in) Bead of RTV Sealant
3	5 mm (0.197 in) Bead of RTV Sealant
4	M12 Bolt Holes

REPAIR INSTRUCTIONS - OFF VEHICLE > ENGINE FRONT COVER INSTALLATION > FRONT COVER INSTALLATION

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Fig 1: Front Cover



Courtesy of GENERAL MOTORS COMPANY

Front Cover Installation

Callout	Component Name
Preliminary Procedure If the oil pan was removed it is easier to install after the front cover installation.Refer to:Oil Pan Installation . Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant	
1	Engine Front Cover Locating Pin (Qty: 2)
2	Engine Front Cover Procedure

	1. Install the **EN-46109** Guide Pins 2. Install the engine front cover. 3. Loosely install the engine front cover bolts. 4. Remove the **EN-46109** Guide Pins **Special Tools** **EN-46109** Guide Pins For equivalent regional tools, refer to Special Tools .
3	Engine Front Cover Bolt (Qty: 16) *CAUTION:* *Refer to Fastener Caution .* **Tighten in sequence** 10 N.m (89 lb in)
4	Engine Front Cover Bolt (Qty: 2) **Tighten in sequence** 15 N.m (11 lb ft)
5	Engine Front Cover Bolt *NOTE:* *Part of engine mount on Front Wheel Drive version.* **Tighten in sequence** 60 N.m (44 lb ft)
6	Engine Front Cover Bolt *NOTE:* *Part of engine mount on Front Wheel Drive version.* **Tighten in sequence** 60 N.m (44 lb ft)
7	Oil Pump Flow Control Valve Electrical Connector

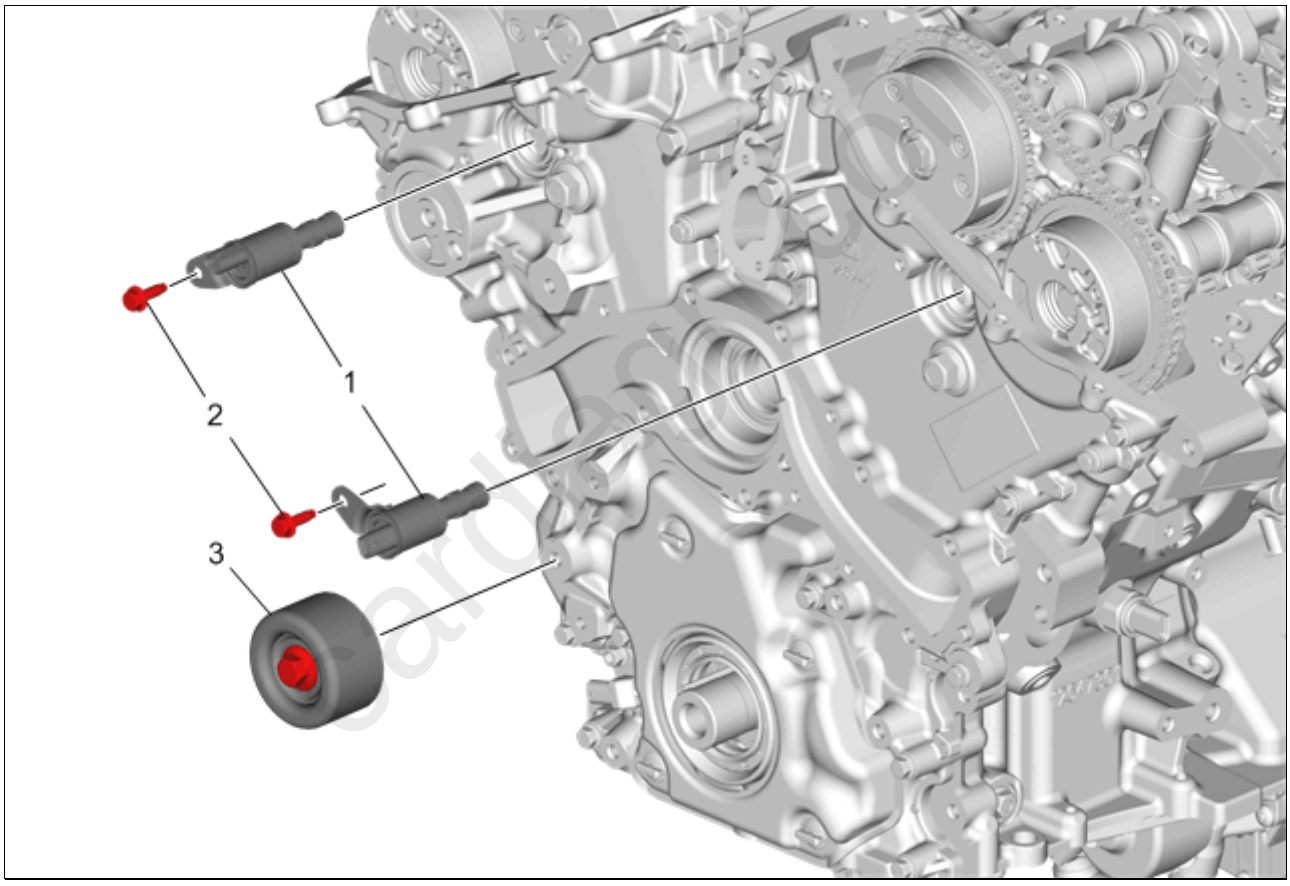
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NOTE:

The retaining clips attached to the oil pump flow control solenoid wire are used for initial production only and should be removed and discarded.

REPAIR INSTRUCTIONS - OFF VEHICLE > ENGINE FRONT COVER INSTALLATION > CAMSHAFT POSITION ACTUATOR CONTROL VALVE AND BELT IDLER PULLEY INSTALLATION

Fig 1: Camshaft Position Actuator Control Valve and Belt Idler Pulley



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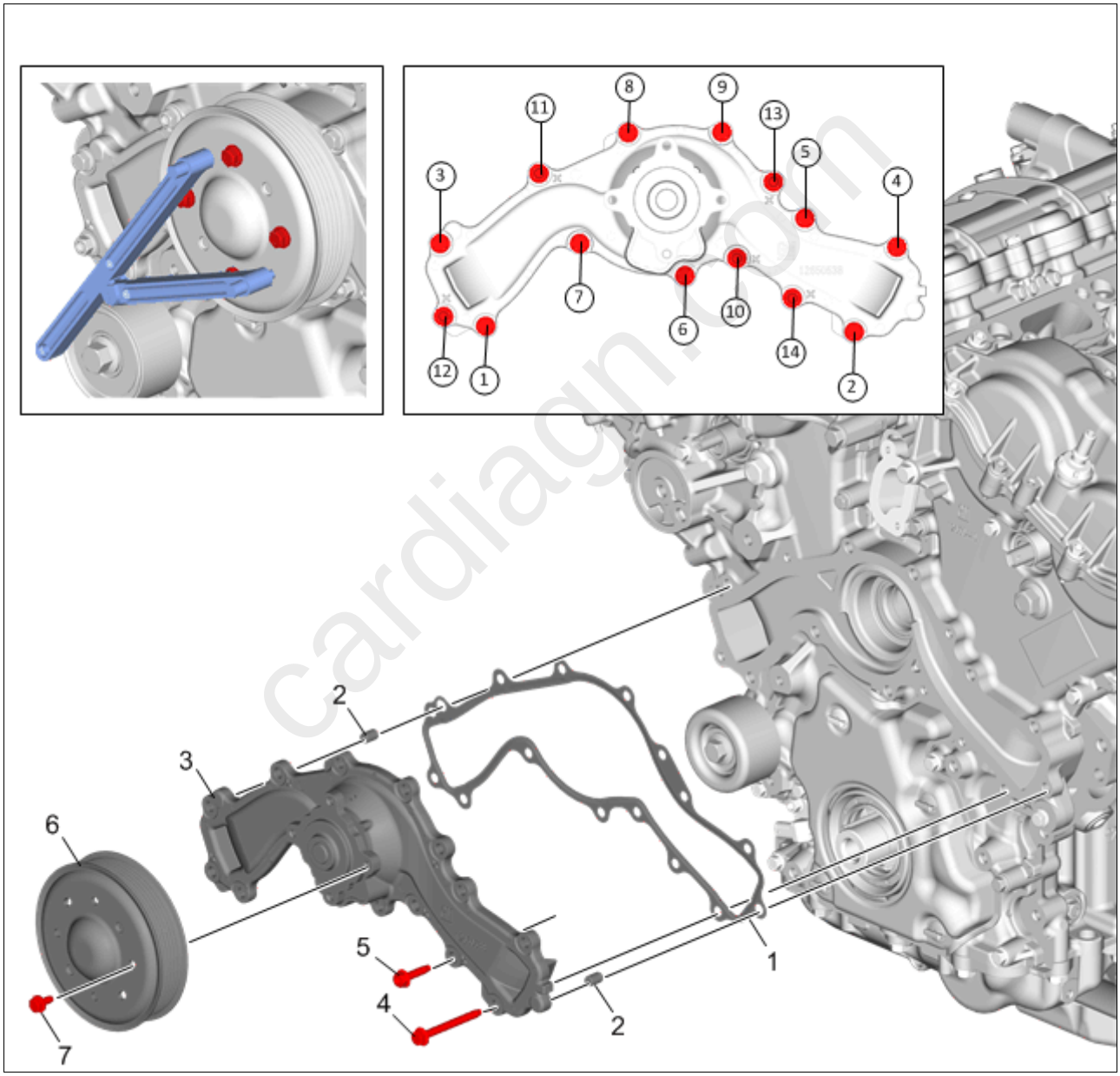
Camshaft Position Actuator Control Valve and Belt Idler Pulley Installation

Callout	Component Name
1	Camshaft Position Actuator Control Valve (Qty: 2)

2	Camshaft Position Actuator Control Valve Bolt (Qty: 2) **Tighten** 10 N.m (89 lb in)
3	Belt Idler Pulley **Tighten** 10 N.m (89 lb in)

REPAIR INSTRUCTIONS - OFF VEHICLE > WATER PUMP INSTALLATION

Fig 1: Water Pump (LGX)



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name

1	Water Pump Gasket *NOTE:* *Install a NEW gasket.*
2	Water Pump Locating Pin (Qty: 2)
3	Water Pump
4	Engine Front Cover Bolt (Qty: 9) *CAUTION:* *Refer to Fastener Caution .* **Tighten in sequence** 15 N.m (11 lb ft)
5	Water Pump Bolt (Qty: 5) *CAUTION:* *This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.* *NOTE:* *Install NEW bolts.* **Tighten in sequence** 15 N.m (11 lb ft)
6	Water Pump Pulley Procedure 1. Install the **EN-46104** Water Pump Pulley Holding Tool onto the water pump pulley mounting holes. 2. Install the water pump pulley bolts.

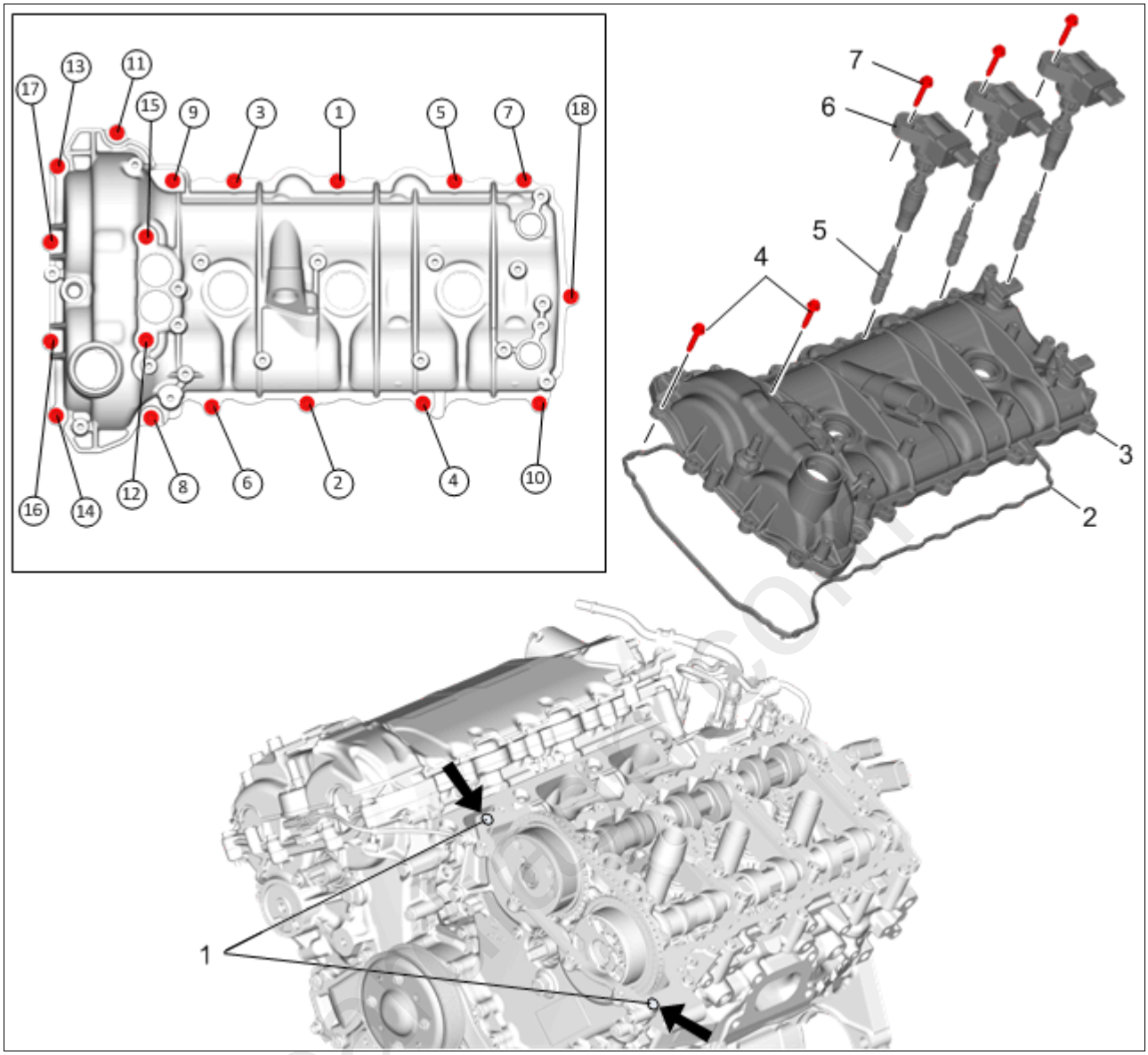
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	3. Remove the **EN-46104** Water Pump Pulley Holding Tool from the water pump pulley. **Special Tools** **EN-46104** Water Pump Pulley Holding Tool For equivalent regional tools, refer to Special Tools .
7	Water Pump Pulley Bolt (Qty: 4) **Tighten** 10 N.m (89 lb in)

REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT COVER INSTALLATION - LEFT SIDE > IGNITION COIL, SPARK PLUG, CAMSHAFT COVER, AND SEAL INSTALLATION

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Fig 1: Ignition Coil, Spark Plug, Camshaft Cover, and Seal



Courtesy of GENERAL MOTORS COMPANY

Ignition Coil, Spark Plug, Camshaft Cover, and Seal Installation

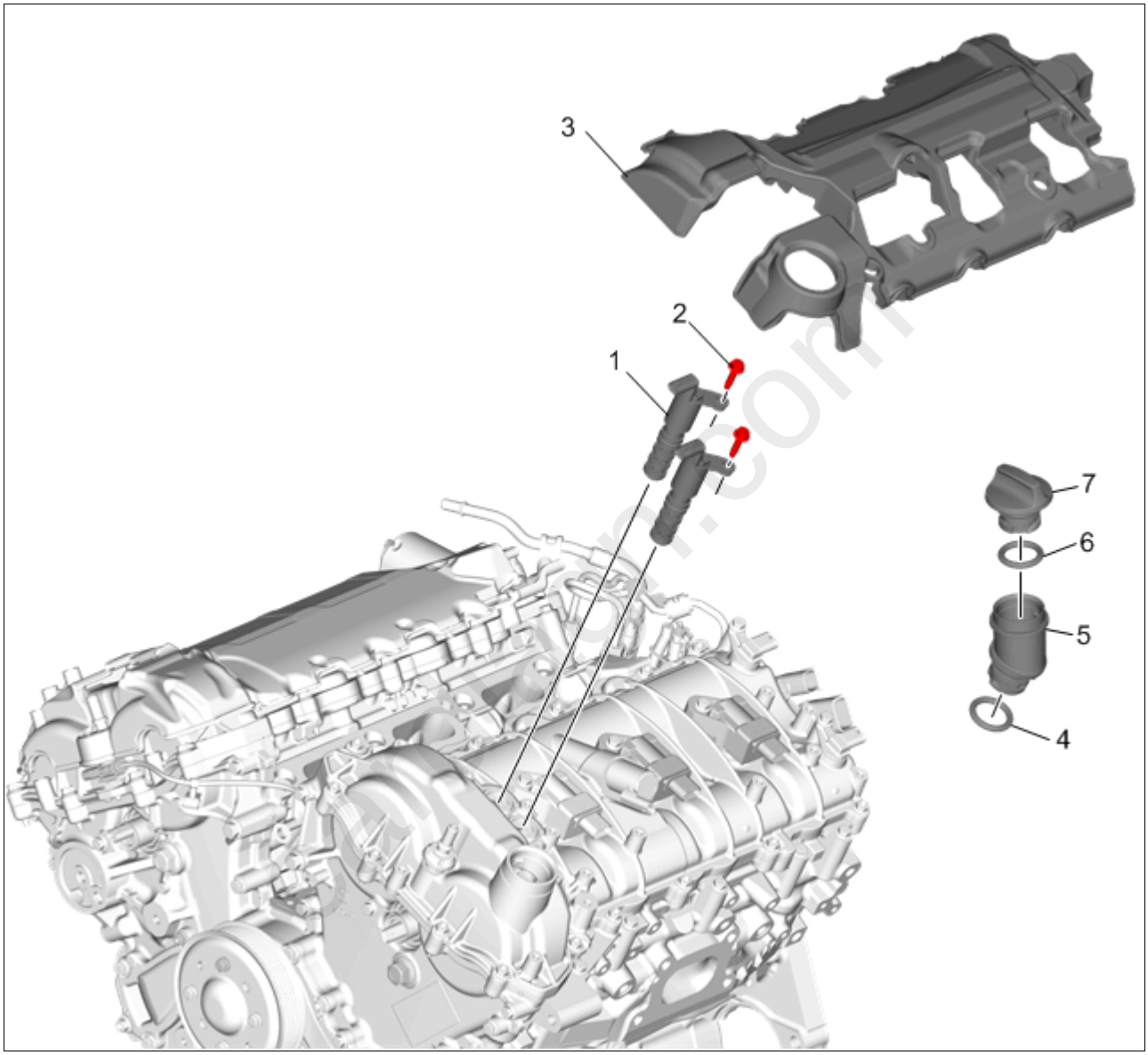
Callout	Component Name
1	Sealant Procedure 1. Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant 2. Place a bead 8 mm (0.3150 in) in diameter by 4 mm (0.1575 in) in height of RTV sealant on the engine front cover split lines. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended sealant.

2	Camshaft Cover Seal Left Side *NOTE:* *Install a NEW seal.*
3	Camshaft Cover Left Side
4	Camshaft Cover Bolt (Qty: 18) *CAUTION:* *Refer to Fastener Caution .* **Tighten in sequence** 15 N.m (11 lb ft)
5	Spark Plug (Qty: 3) *NOTE:* *Install the NEW spark plugs.* **Tighten** 18 N.m (13 lb ft)
6	Ignition Coil (Qty: 3) Procedure • Inspect the inside of the ignition coil rubber boot for a thin, even coat of grease. If there is no grease present or additional grease is necessary, complete the following procedure: 1. Apply a thin coating of dielectric grease evenly to the inside of the ignition coil rubber boot, up to a depth of 15 mm from the end of the boot. Refer to Adhesives, Fluids, Lubricants, and Sealers . 2. Remove any excess grease from around the end of the boot, and ensure there is not an excessive amount within the boot.
7	Ignition Coil Bolt (Qty: 3) **Tighten** 10 N.m (89 lb in)

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REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT COVER INSTALLATION - LEFT SIDE > OIL FILLER CAP AND TUBE, CAMSHAFT HOUSING COVER INSULATOR, AND CAMSHAFT POSITION ACTUATOR SOLENOID VALVE INSTALLATION

Fig 1: Oil Filler Cap and Tube, Camshaft Housing Cover Insulator, and Camshaft Position Actuator Solenoid Valve



Courtesy of GENERAL MOTORS COMPANY

Oil Filler Cap and Tube, Camshaft Housing Cover Insulator, and Camshaft Position Actuator Solenoid Valve Installation

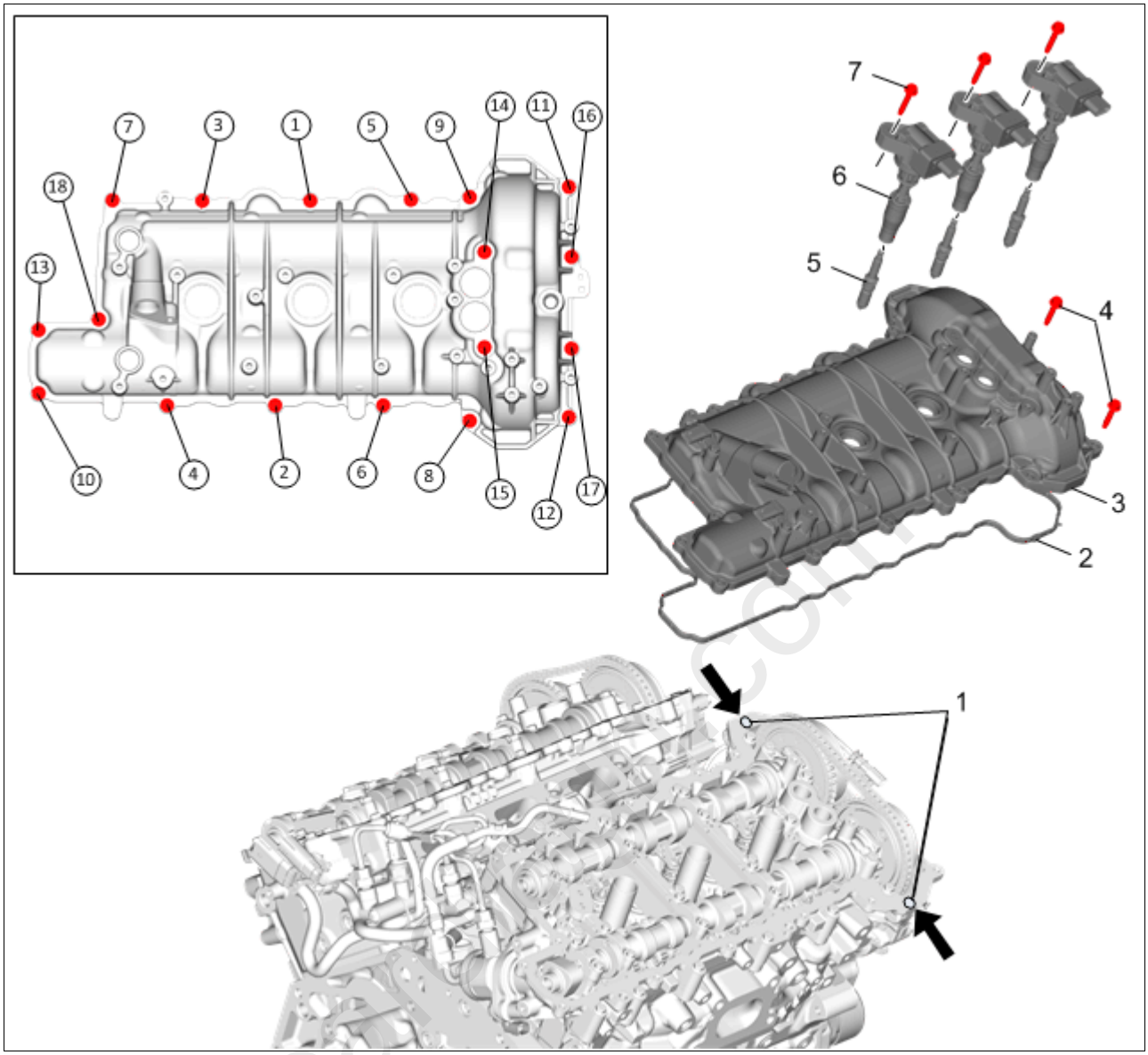
Callout	Component Name
1	Camshaft Position Actuator Solenoid Valve (Qty: 2)

2	Camshaft Position Actuator Solenoid Valve Bolt (Qty: 2) **Tighten** 10 N.m (89 lb in)
3	Camshaft Housing Cover Insulator Left Side *WARNING:* *The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage, and possible injury or death.*
4	Oil Filler Cap Tube Seal *NOTE:* *Install a NEW seal.*
5	Oil Filler Cap Tube - Model Dependent
6	Oil Filler Cap Seal *NOTE:* *Install a NEW seal.*
7	Oil Filler Cap

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REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT COVER INSTALLATION - RIGHT SIDE > IGNITION COIL, SPARK PLUG, CAMSHAFT COVER, AND SEAL INSTALLATION

Fig 1: Ignition Coil, Spark Plug, Camshaft Cover, and Seal



Courtesy of GENERAL MOTORS COMPANY

Ignition Coil, Spark Plug, Camshaft Cover, and Seal Installation

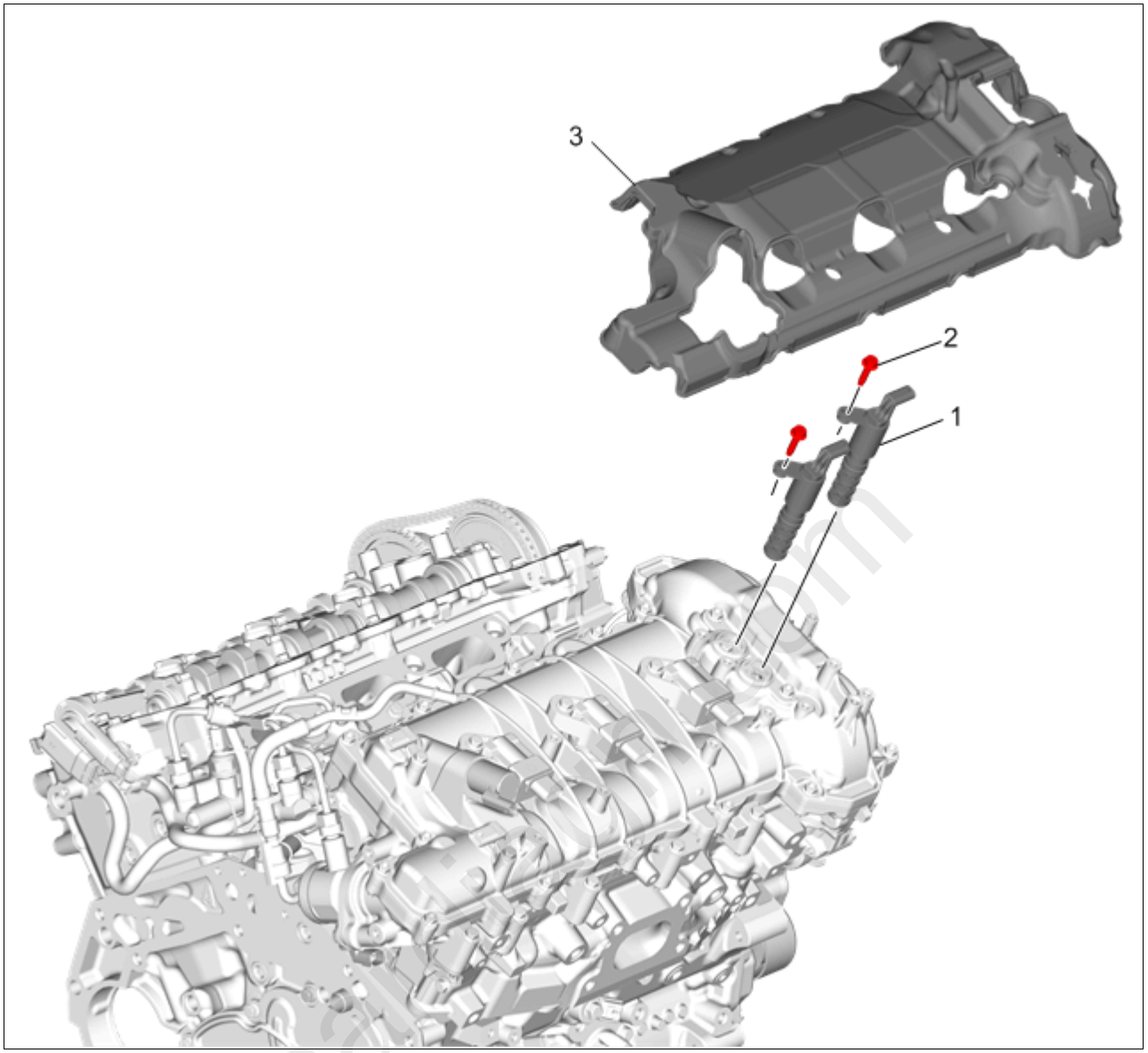
Callout	Component Name
1	Sealant Procedure 1. Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant 2. Place a bead 8 mm (0.3150 in) in diameter by 4 mm (0.1575 in) in height of RTV sealant on the engine front cover split lines. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended sealant.

2	Camshaft Cover Seal Right Side *NOTE:* *Install a NEW seal.*
3	Camshaft Cover Right Side
4	Camshaft Cover Bolt (Qty: 18) *CAUTION:* *Refer to Fastener Caution .* **Tighten in sequence** 15 N.m (11 lb ft)
5	Spark Plug (Qty: 3) **Tighten** 18 N.m (13 lb ft)
6	Ignition Coil (Qty: 3) Procedure • Inspect the inside of the ignition coil rubber boot for a thin, even coat of grease. If there is no grease present or additional grease is necessary, complete the following procedure: 1. Apply a thin coating of dielectric grease evenly to the inside of the ignition coil rubber boot, up to a depth of 15 mm from the end of the boot. Refer to Adhesives, Fluids, Lubricants, and Sealers . 2. Remove any excess grease from around the end of the boot, and ensure there is not an excessive amount within the boot.
7	Ignition Coil Bolt (Qty: 3) **Tighten** 10 N.m (89 lb in)

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REPAIR INSTRUCTIONS - OFF VEHICLE > CAMSHAFT COVER INSTALLATION - RIGHT SIDE > CAMSHAFT HOUSING COVER INSULATOR AND CAMSHAFT POSITION ACTUATOR SOLENOID VALVE INSTALLATION

Fig 1: Camshaft Housing Cover Insulator and Camshaft Position Actuator Solenoid Valve



Courtesy of GENERAL MOTORS COMPANY

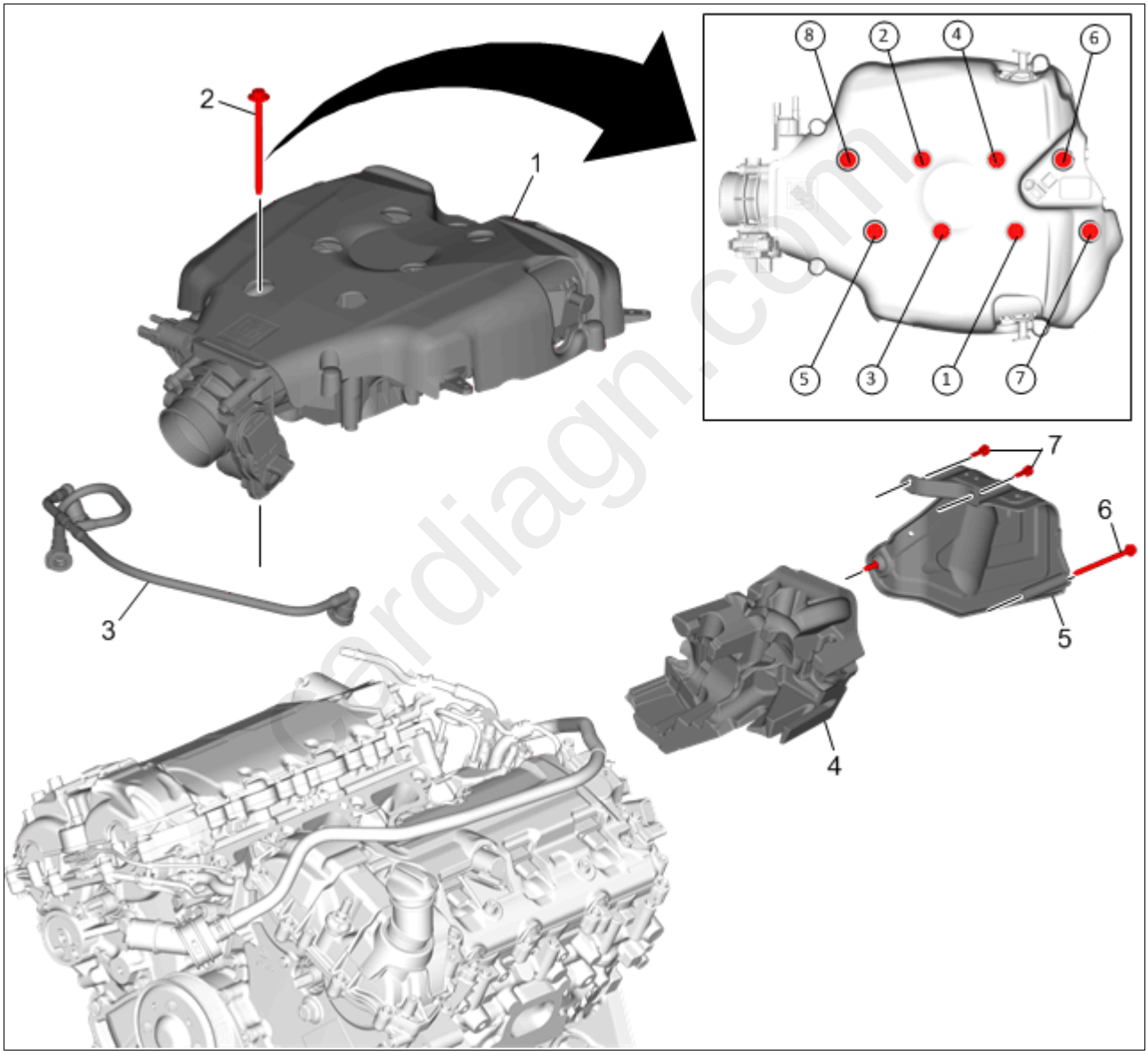
Camshaft Housing Cover Insulator and Camshaft Position Actuator Solenoid Valve Installation

Callout	Component Name
1	Camshaft Position Actuator Solenoid Valve (Qty: 2)
2	Camshaft Position Actuator Solenoid Valve Bolt (Qty: 2) **Tighten** 10 N.m (89 lb in)
3	Camshaft Housing Cover Insulator Right Side *WARNING:*

The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage, and possible injury or death.

REPAIR INSTRUCTIONS - OFF VEHICLE > INTAKE MANIFOLD INSTALLATION

Fig 1: Intake Manifold (LGX)



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Intake Manifold

2	Intake Manifold Bolt (Qty: 8) *CAUTION:* *Refer to Fastener Caution .* **Tighten in sequence** 25 N.m (18 lb ft)
3	Positive Crankcase Ventilation Tube Connector
4	Engine Rear Noise Shield *WARNING:* *The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage, and possible injury or death.*
5	Fuel Pipe Shield
6	Fuel Pipe Shield Bolt **Tighten** 10 N.m (89 lb in)
7	Fuel Pipe Shield Bolt (Qty: 2) **Tighten** 10 N.m (89 lb in)

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REPAIR INSTRUCTIONS - OFF VEHICLE > CLUTCH PILOT BEARING INSTALLATION

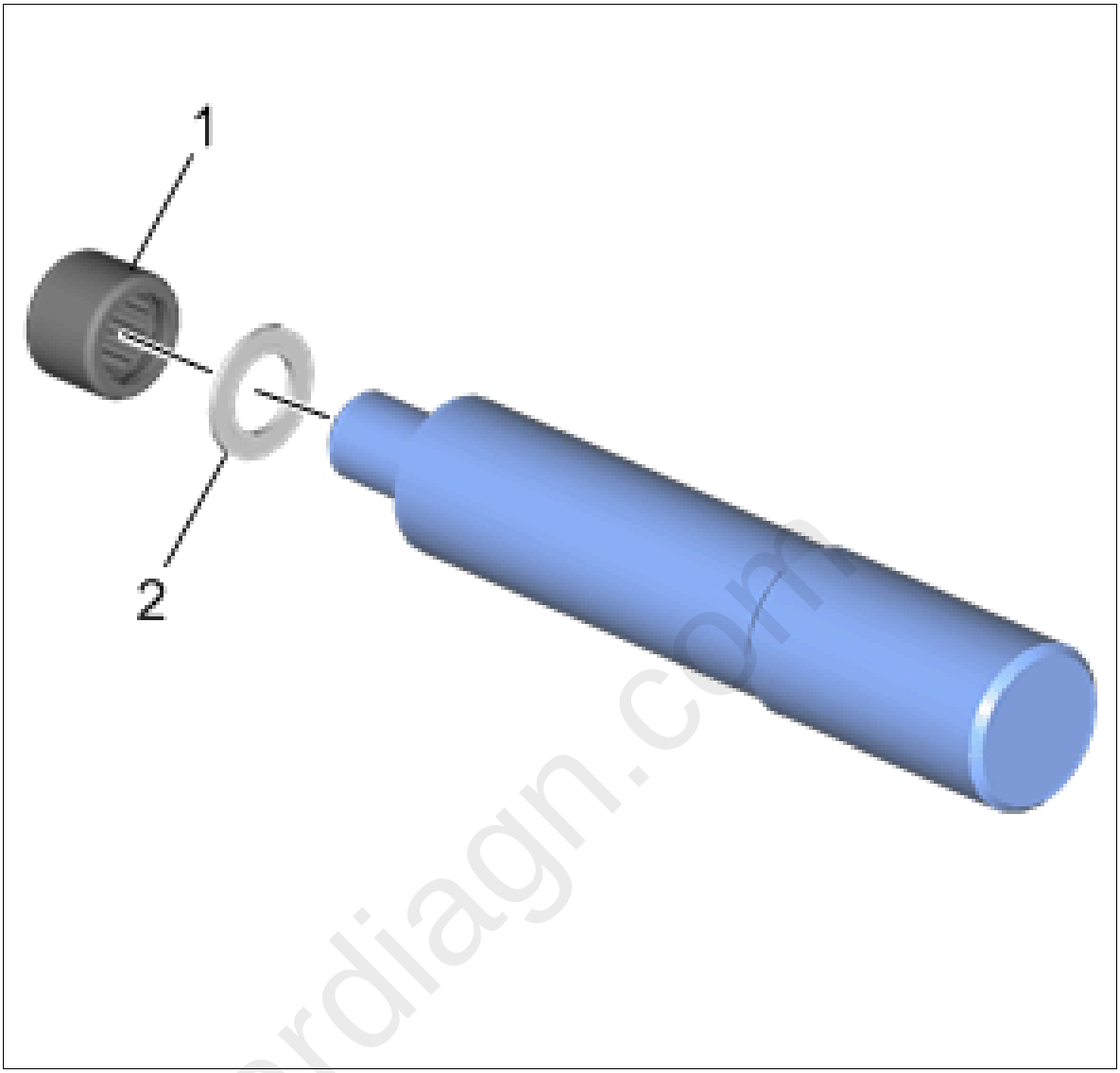
Special Tools

EN-38836 Pilot Bushing Installer/Clutch

For equivalent regional tools, refer to Special Tools .

REPAIR INSTRUCTIONS - OFF VEHICLE > CLUTCH PILOT BEARING INSTALLATION > INSTALLATION PROCEDURE

Fig 1: Pilot Bushing Installer/Clutch

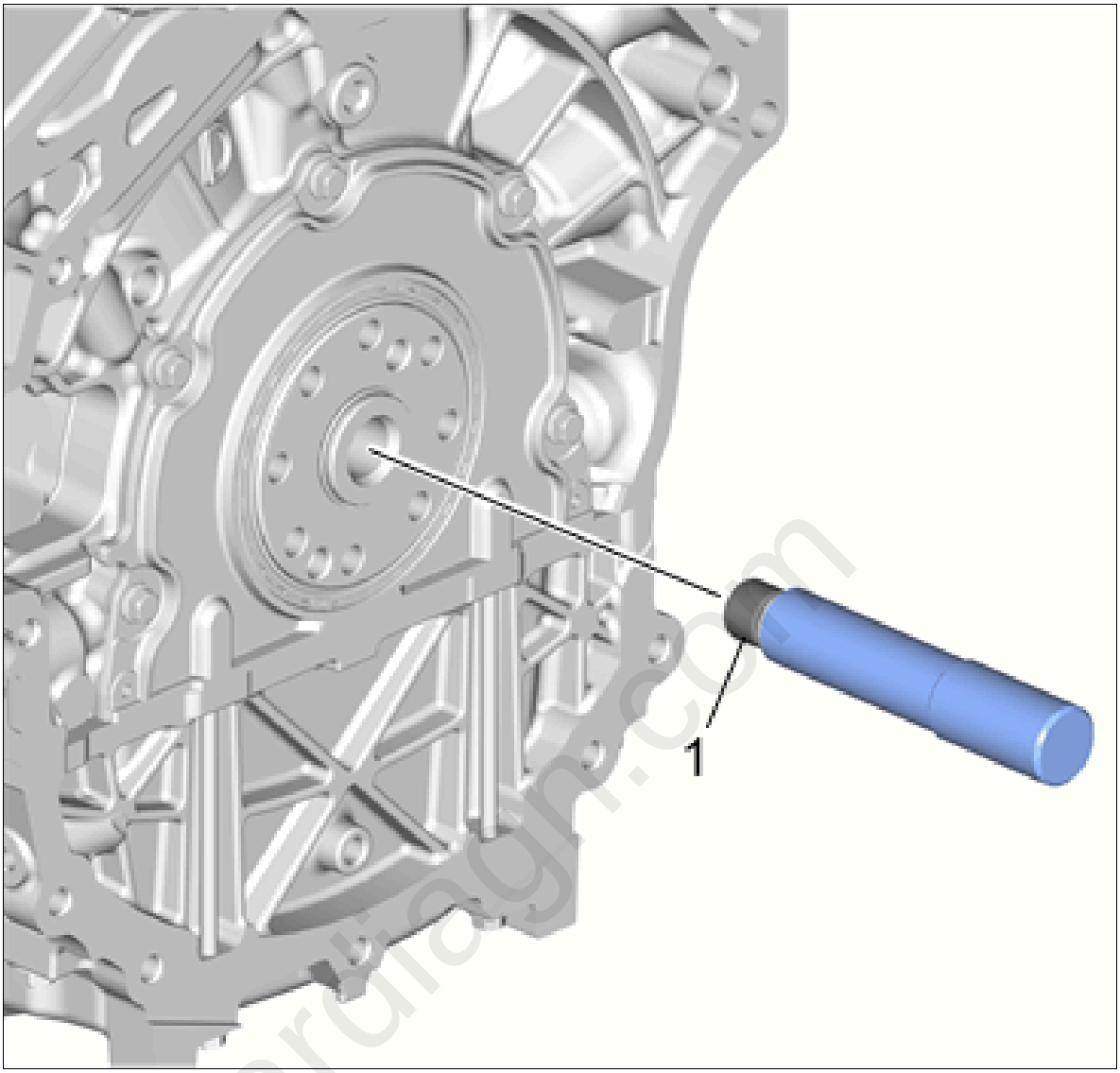


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1. Install a 5/8 inch washer (2) onto the **EN-38836** or equivalent. The washer serves as a stop against the crankshaft face and will assist in installing the bearing to the proper depth.
2. Install the new pilot bearing (1) onto the tool.

Fig 2: New Pilot Bearing



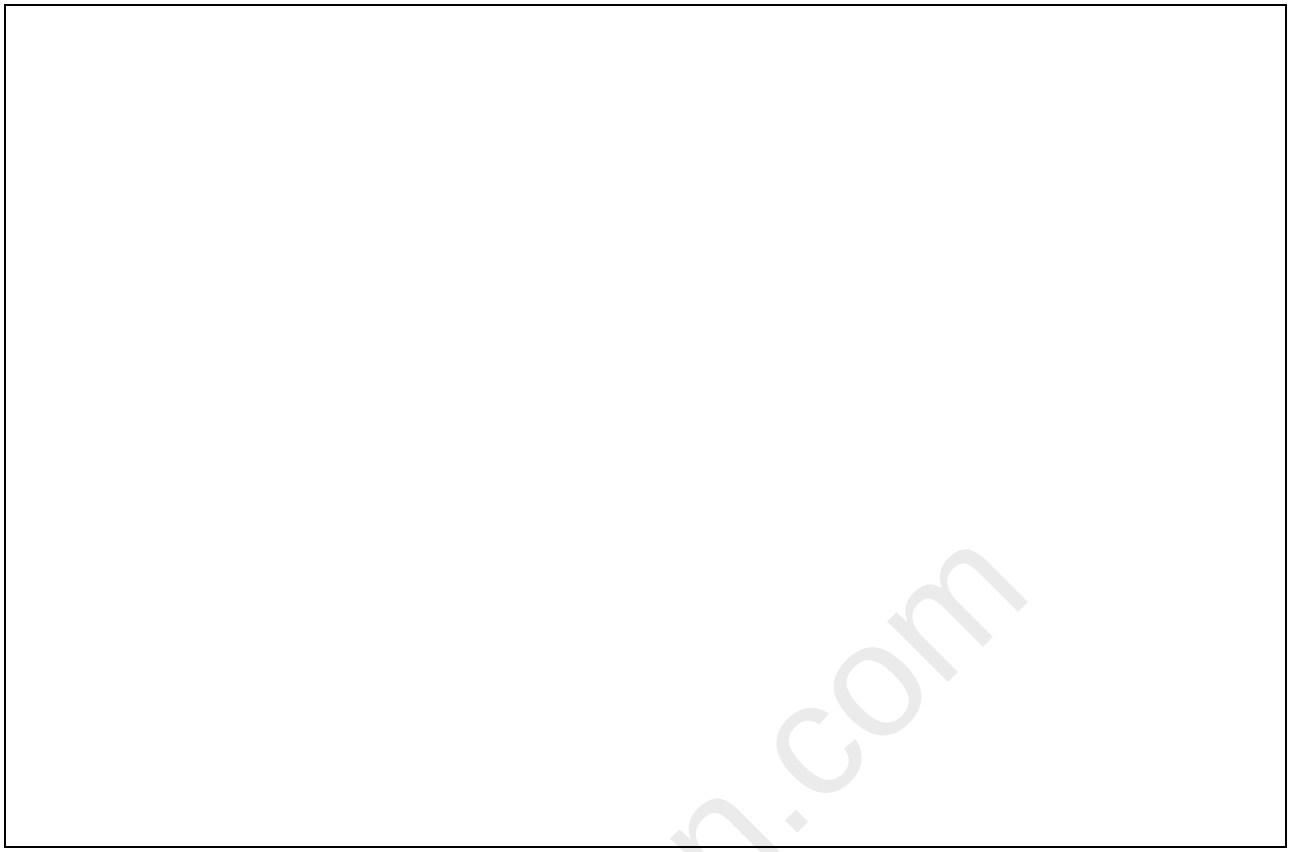
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3. Install a new pilot bearing into the crankshaft using the **EN-38836** .
4. Inspect the clutch pilot bearing for proper installation. A properly installed clutch pilot bearing will be installed until flush to the rear of the crankshaft.

REPAIR INSTRUCTIONS - OFF VEHICLE > AUTOMATIC TRANSMISSION FLEX PLATE INSTALLATION

Fig 1: Automatic Transmission Flex Plate



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Callout	Component Name
1	A/Trans Flex Plate
2	A/Trans Flex Plate Bolt *CAUTION:* *This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.* *CAUTION:* *Refer to Fastener Caution .* Procedure 1. Install 2 NEW bolts (2) in location at the top and bottom of the flex plate bolt pattern allowing the flex plate (2) to hang in position.

2. Install the **EN-46106** Flywheel Holding Tool through the starter mounting hole.
3. Install the remaining NEW flex plate bolts and tighten to specifications.
    1. Tighten the bolts a first pass to 30 N.m (22 lb ft)
    2. Tighten the bolts a final pass to 45 degrees using the **EN-45059** Angle Meter.
4. Remove the **EN-46106** Flywheel Holding Tool through the starter mounting hole.

Special Tools

- **EN-46106** Flywheel Holding Tool
- **EN-45059** Angle Meter

For equivalent regional tools, refer to Special Tools .

REPAIR INSTRUCTIONS - OFF VEHICLE > ENGINE FLYWHEEL INSTALLATION

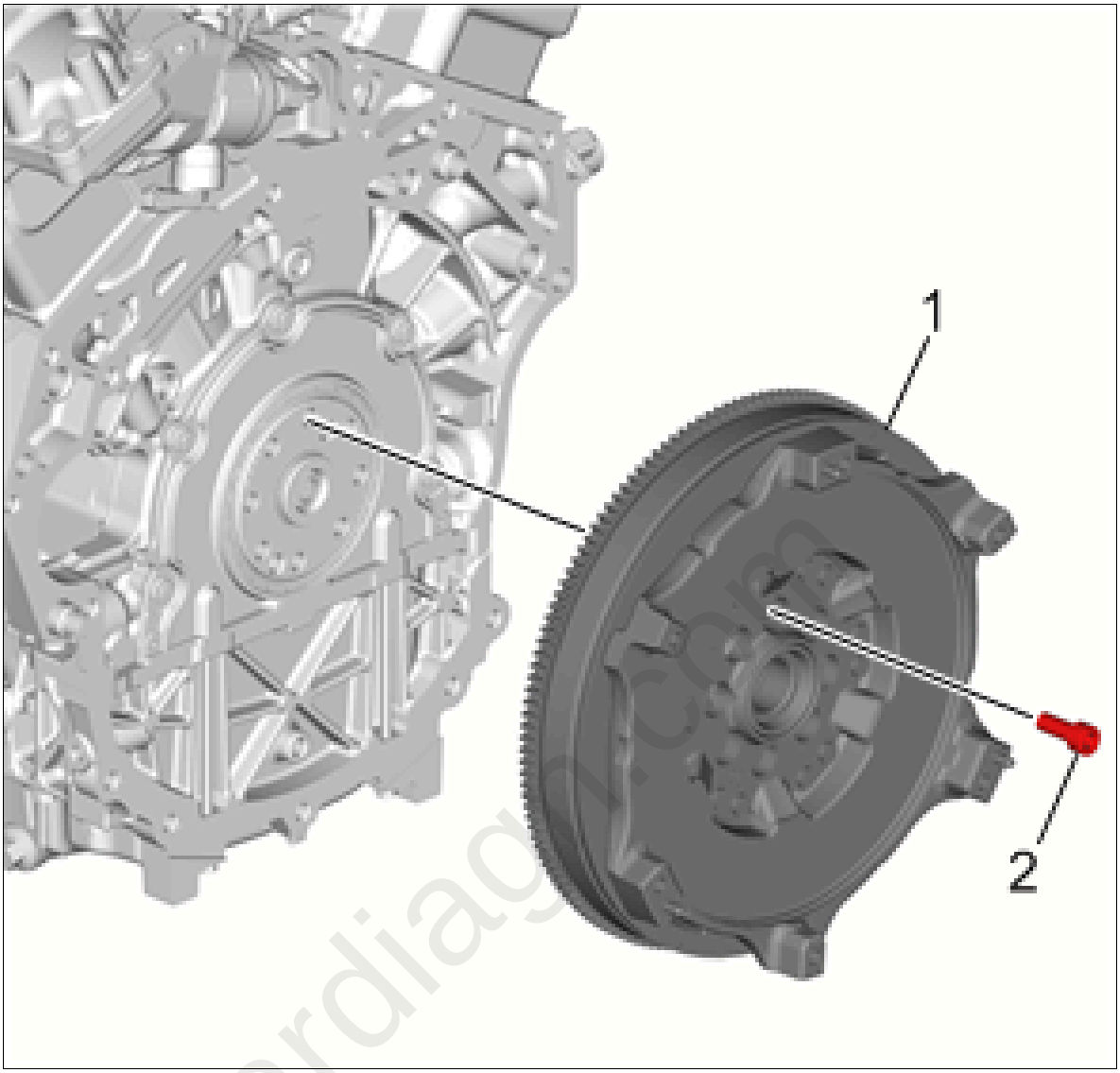
Special Tools

- **EN-46106** Flywheel Holding Tool
- **EN-45059** Torque Angle Meter

For equivalent regional tools, refer to Special Tools .

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Fig 1: Flywheel Removed



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⚠ *CAUTION:*

This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

NOTE:

The flywheel does not use a locating pins for alignment and will not initially seat against the crankshaft flange, but will be pulled onto the crankshaft by the engine flywheel bolts.

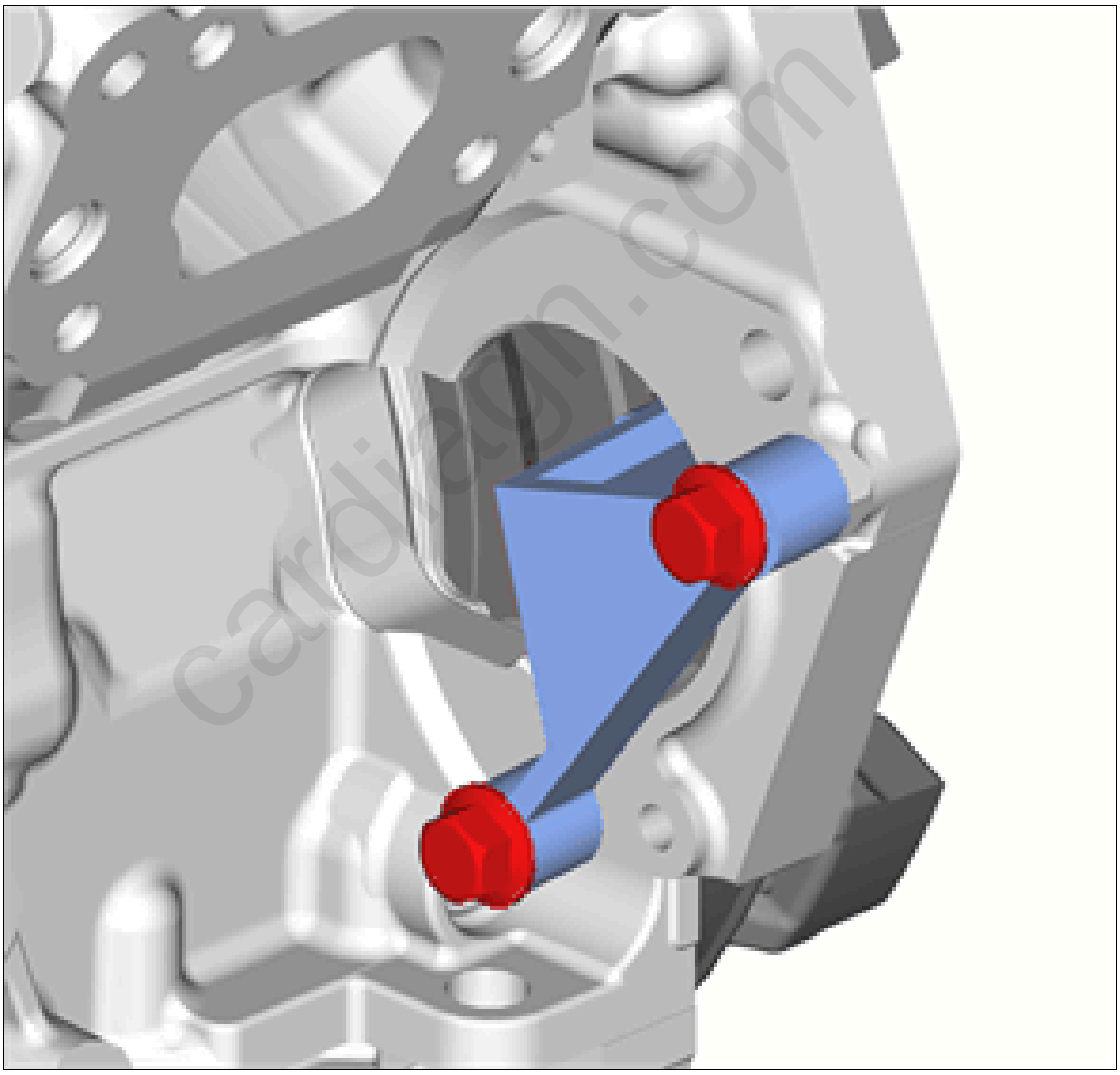
1. Install the flywheel (1) to the crankshaft.

> ⚠ *CAUTION:*
>
> *This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.*

2.

3. Install and hand tighten the NEW flywheel bolts (2).

Fig 2: Flywheel Holding Tool



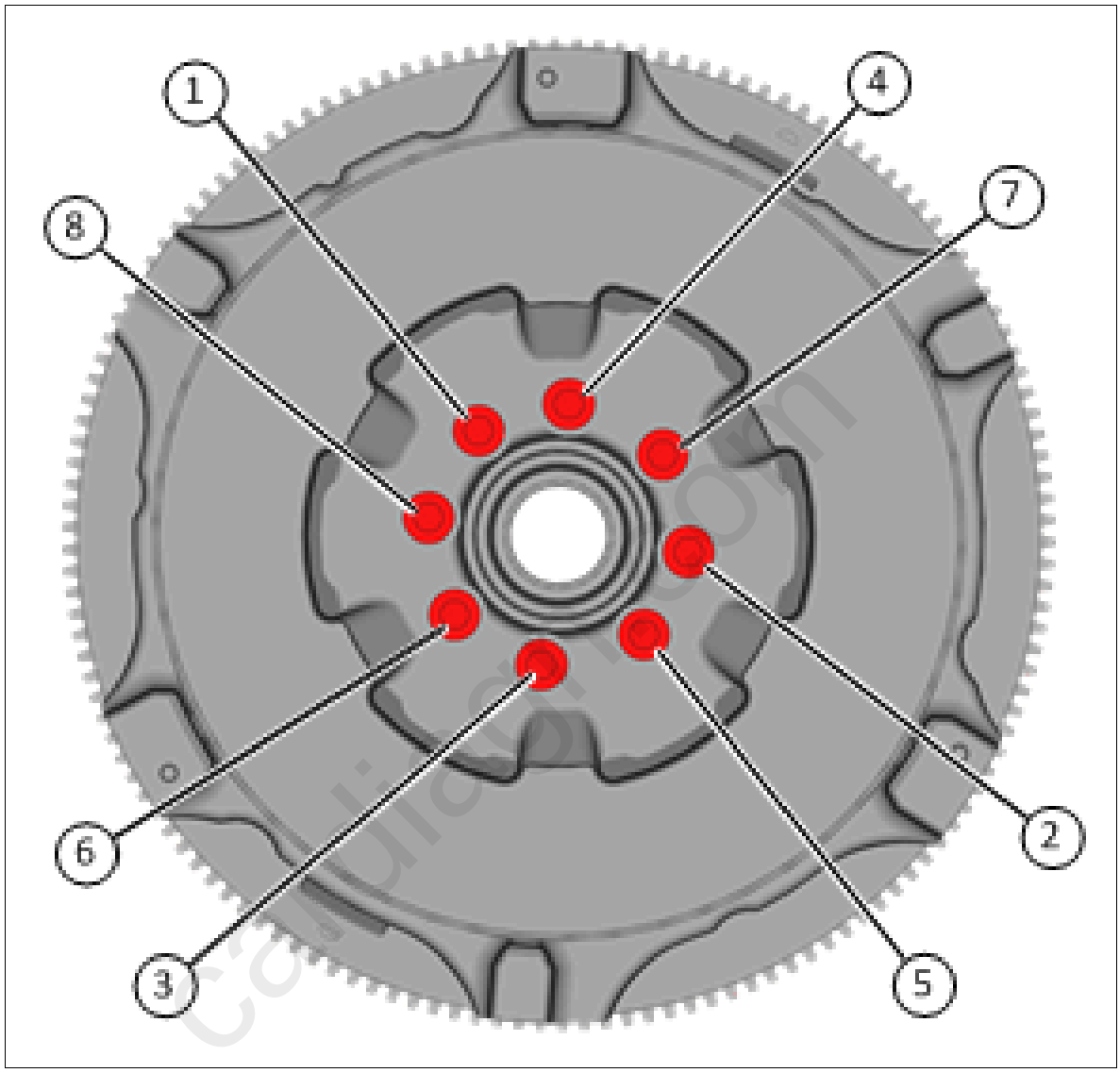
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> ⚠ *CAUTION:*

Refer to Fastener Caution .

4. Install the **EN-46106** and bolts.

Fig 3: Flywheel Bolt Installation Sequence



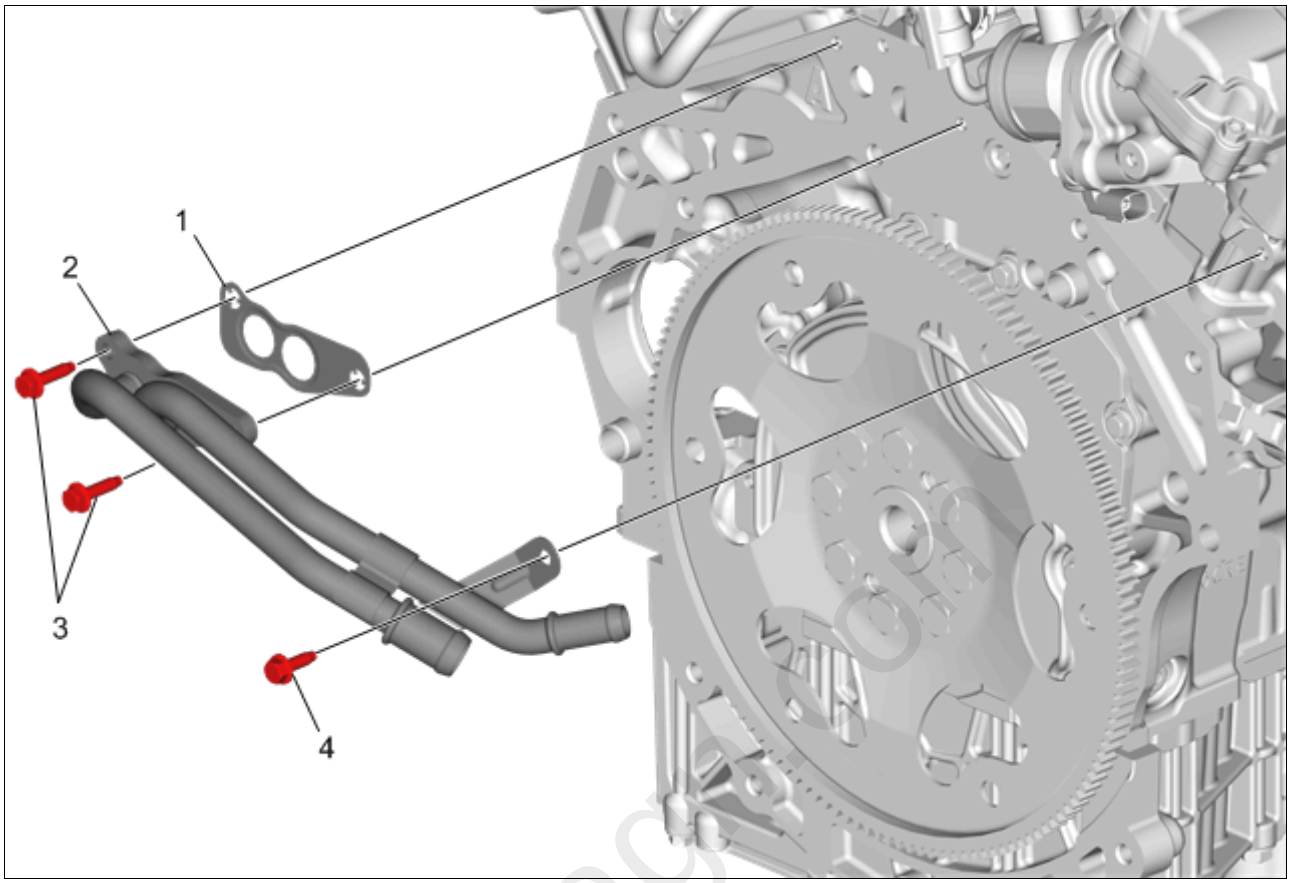
Courtesy of GENERAL MOTORS COMPANY

5. Tighten the flywheel bolts (1).
    1. Tighten the bolts (1-8) a first pass in sequence to 30 N.m (22 lb ft).
    2. Tighten the bolts (1-8) a final pass in sequence an additional 60 degrees using **EN-45059** .
6. Remove the **EN-46106** .

REPAIR INSTRUCTIONS - OFF VEHICLE > HEATER INLET AND OUTLET PIPE

INSTALLATION

Fig 1: Heater Inlet and Outlet Pipe



Courtesy of GENERAL MOTORS COMPANY

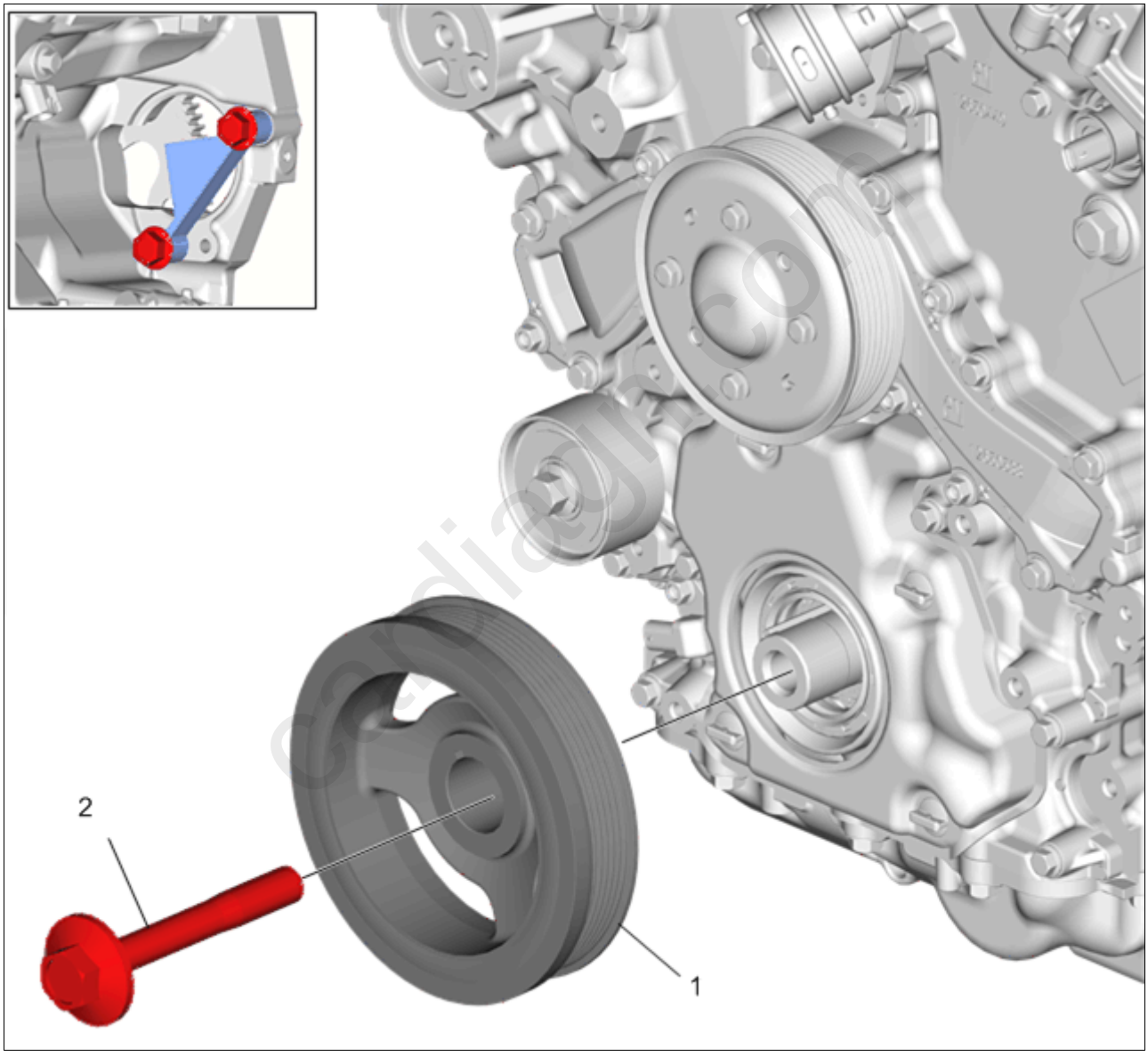
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Callout	Component Name
1	Heater Inlet and Outlet Pipe Gasket *NOTE:* *Install a NEW gasket.*
2	Heater Inlet and Outlet Pipe
3	Heater Inlet and Outlet Pipe Bolt (Qty: 2) *CAUTION:* *Refer to Fastener Caution .*

	Tighten 9 N.m (80 lb in)
4	Heater Inlet and Outlet Pipe Bolt M6 x 20 **Tighten** 9 N.m (80 lb in)

REPAIR INSTRUCTIONS - OFF VEHICLE > CRANKSHAFT BALANCER INSTALLATION

Fig 1: Crankshaft Balancer (LGX)



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name

CAUTION:

This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

Preliminary Procedures

1. Install the **EN-46106** Flywheel Holding Tool through the starter mounting hole.
2. Apply lubricant to the inside of the crankshaft balancer hub bore.
3. Use the **EN-41478-A** Crankshaft Balancer Installer to install the crankshaft balancer.
4. Thread the **EN-41478-A** Crankshaft Balancer Installer in the crankshaft. Ensure you engage at least 10 threads of the **EN-41478-A** Crankshaft Balancer Installer before pressing the crankshaft balancer in place.
5. Push the crankshaft balancer into position by tightening the nut on the **EN-41478-A** Crankshaft Balancer Installer until the large washer bottoms out on the crankshaft end.
6. Remove the **EN-41478-A** Crankshaft Balancer Installer.
7. Install the NEW crankshaft balancer bolt.
8. Remove the **EN-46106** Flywheel Holding Tool tool through the starter mounting hole.

Special Tools

- **EN-41478-A** Crankshaft Balancer Installer
- **EN-46106** Flywheel Holding Tool
- **EN-45059** Angle Meter

Equivalent regional tools:Special Tools .

1	Crankshaft Balancer *NOTE:* *Do not lubricate the crankshaft front oil seal or crankshaft balancer sealing surfaces. The crankshaft balancer is installed into a dry seal.*
2	Crankshaft Balancer Bolt

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CAUTION:

Refer to Fastener Caution .

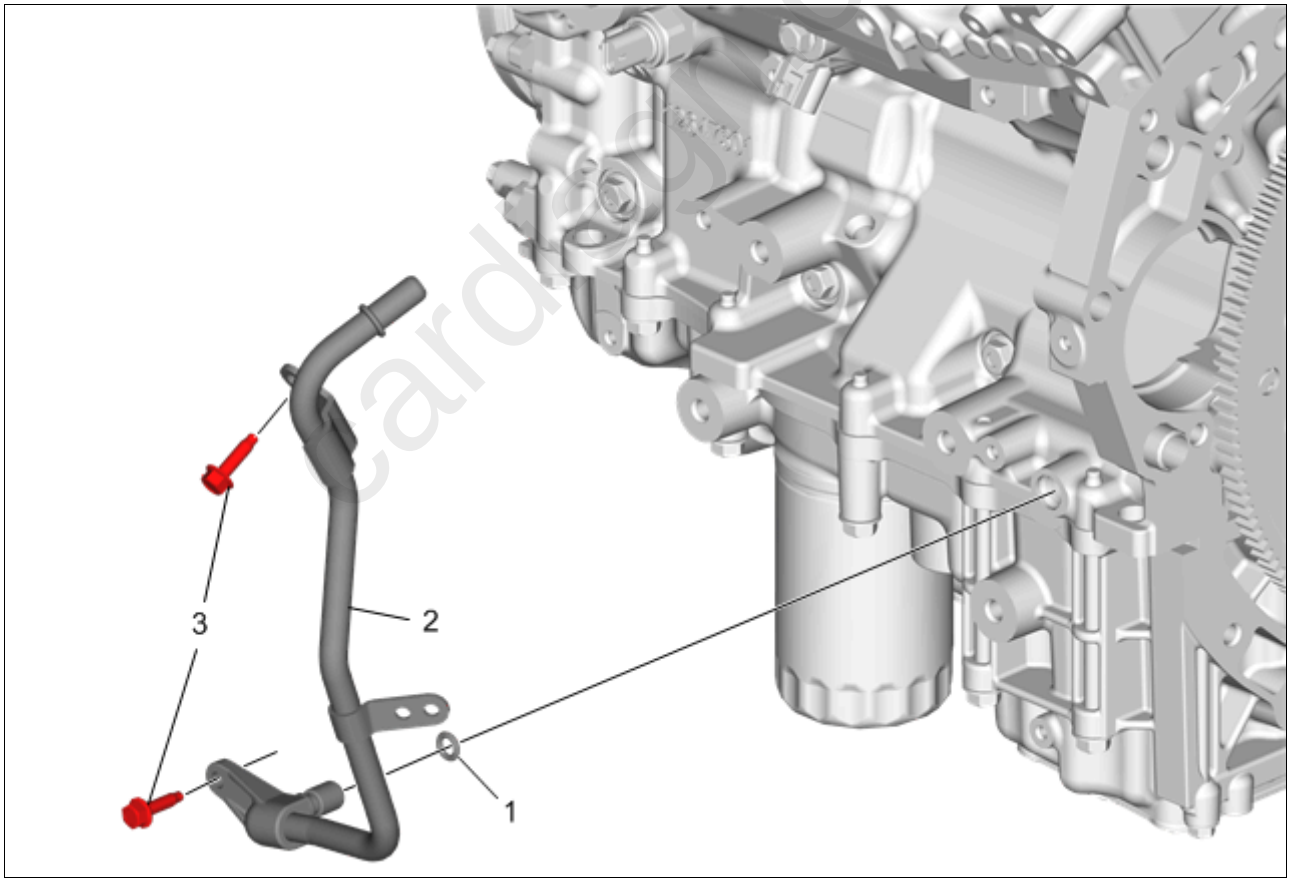
NOTE:

Install a NEW crankshaft balancer bolt.

Tighten
First Pass : 80 N.m (59 lb ft)
Final Pass: 125 degrees

REPAIR INSTRUCTIONS - OFF VEHICLE > VACUUM PUMP PIPE INSTALLATION

Fig 1: Vacuum Pump Pipe



Courtesy of GENERAL MOTORS COMPANY

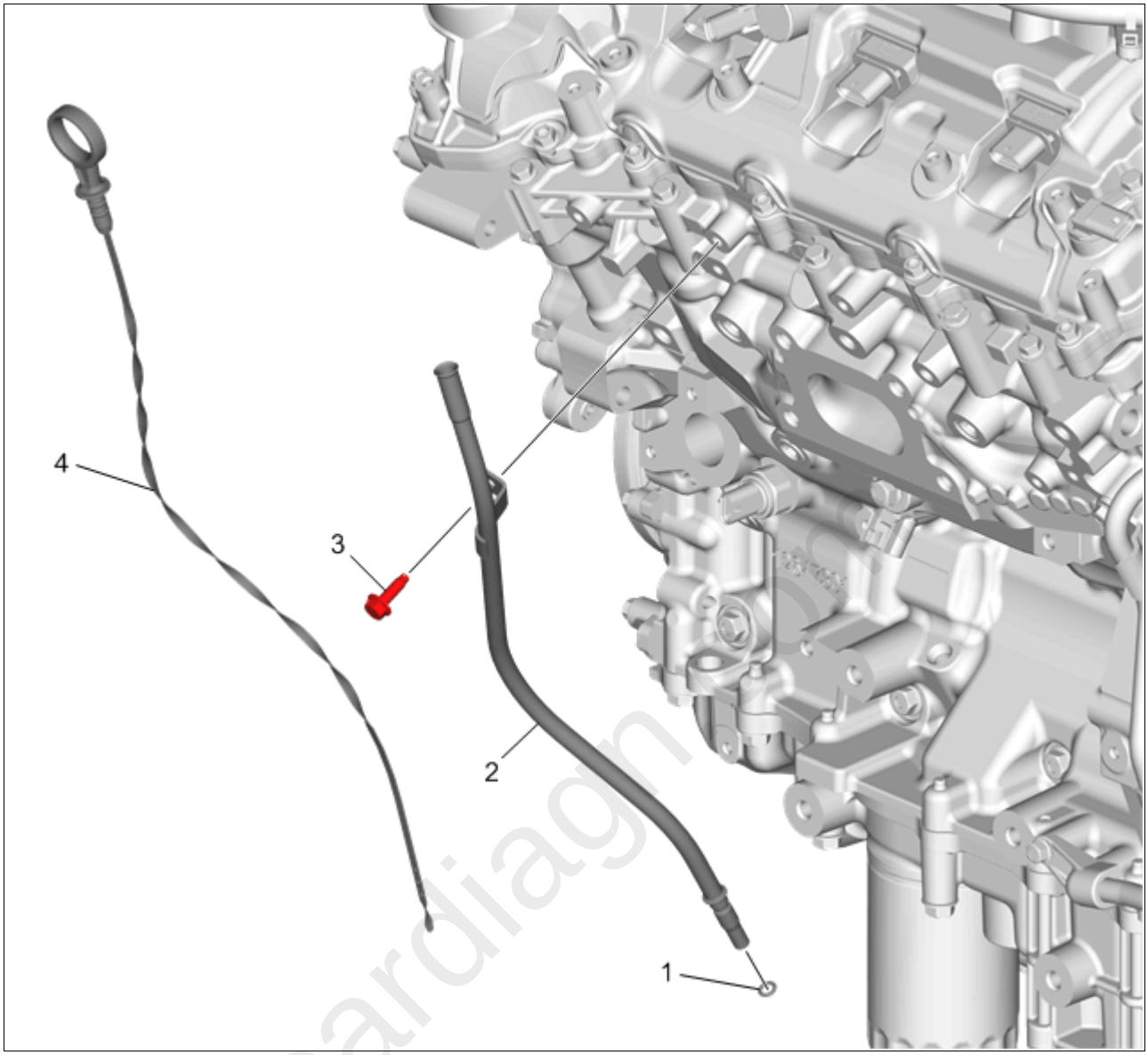
Callout	Component Name

1	Vacuum Pump Pipe Seal
2	Vacuum Pump Pipe
3	Vacuum Pump Pipe Bolt (Qty: 2) *CAUTION:* *Refer to Fastener Caution .* **Tighten** 10 N.m (89 lb in)

REPAIR INSTRUCTIONS - OFF VEHICLE > OIL LEVEL INDICATOR AND TUBE INSTALLATION

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Fig 1: Oil Level Indicator and Tube (LGX)



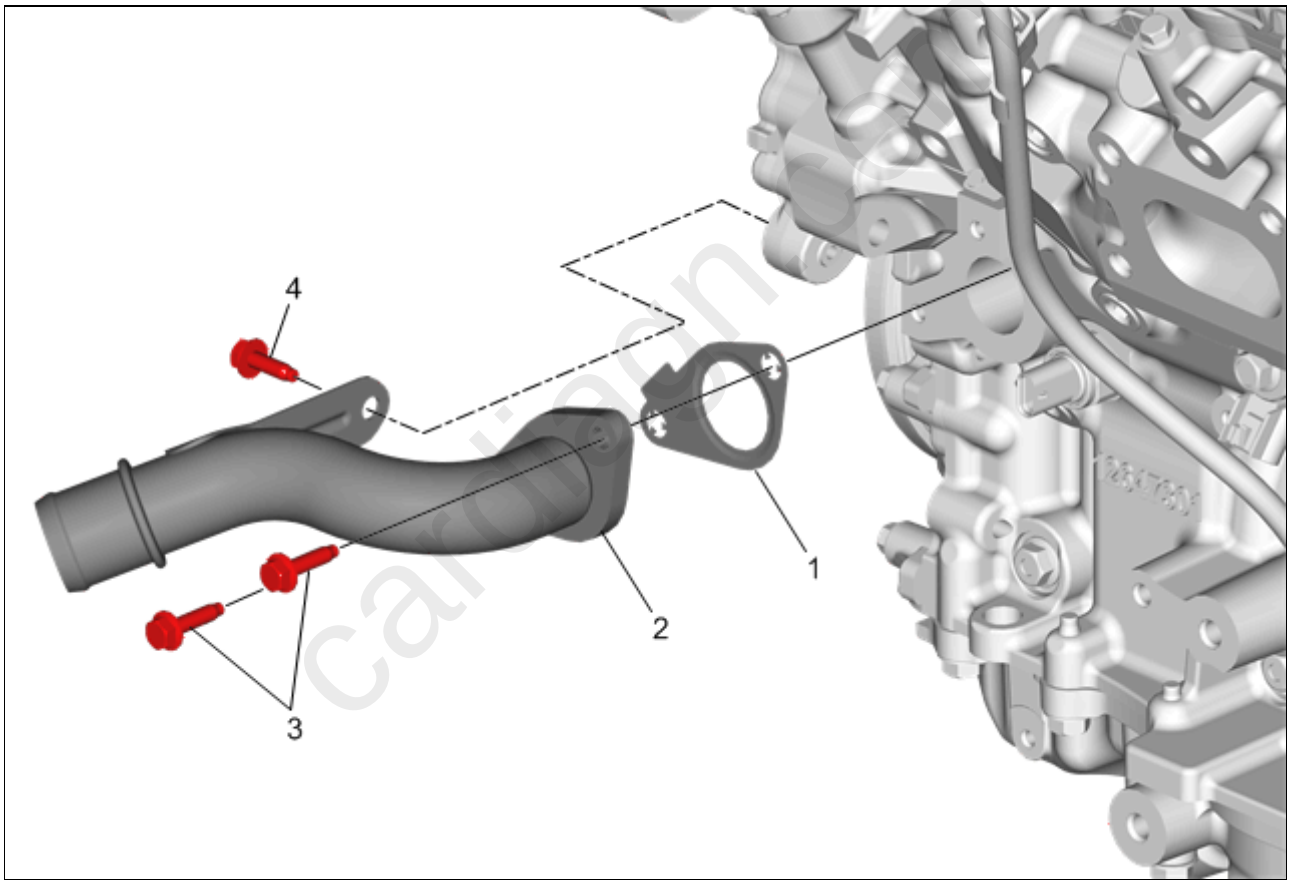
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Oil Level Indicator Tube Seal *NOTE:* *Install a NEW seal.*
2	Oil Level Indicator Tube
3	Oil Level Indicator Tube Bolt

	CAUTION: *Refer to Fastener Caution .* **Tighten** 10 N.m (89 lb in)
4	Oil Level Indicator

REPAIR INSTRUCTIONS - OFF VEHICLE > WATER PUMP INLET PIPE INSTALLATION

Fig 1: Water Pump Inlet Pipe



Courtesy of GENERAL MOTORS COMPANY

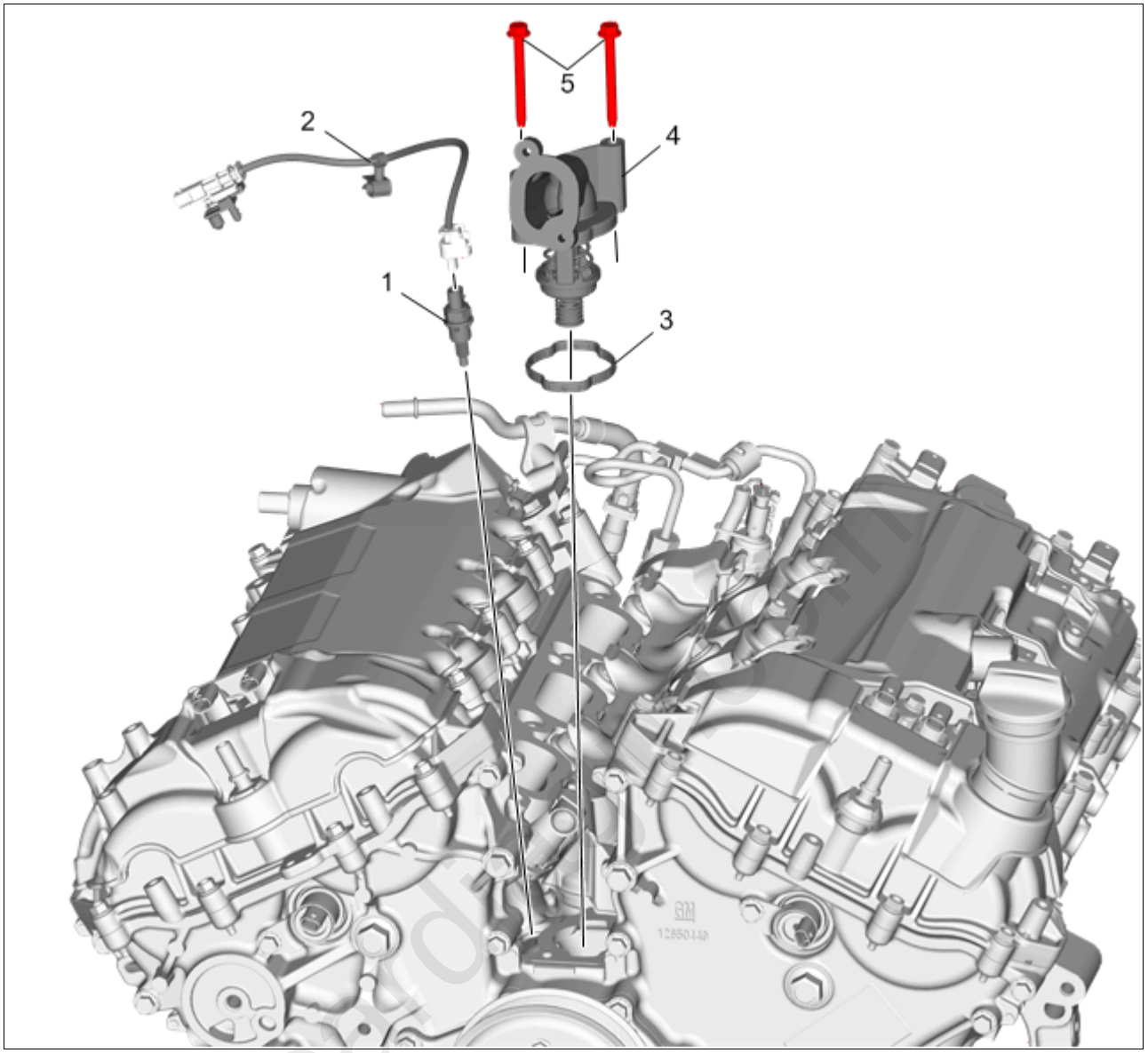
Callout	Component Name
1	Water Inlet Seal

	NOTE: *Install a NEW seal.*
2	Water Pump Inlet Pipe
3	Water Pump Inlet Pipe Bolt *CAUTION:* *Refer to Fastener Caution .* **Tighten** 15 N.m (11 lb ft)
4	Water Pump Inlet Pipe Bolt **Tighten** 15 N.m (11 lb ft)

REPAIR INSTRUCTIONS - OFF VEHICLE > ENGINE COOLANT THERMOSTAT HOUSING INSTALLATION

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Fig 1: Engine Coolant Thermostat Housing (LGX)



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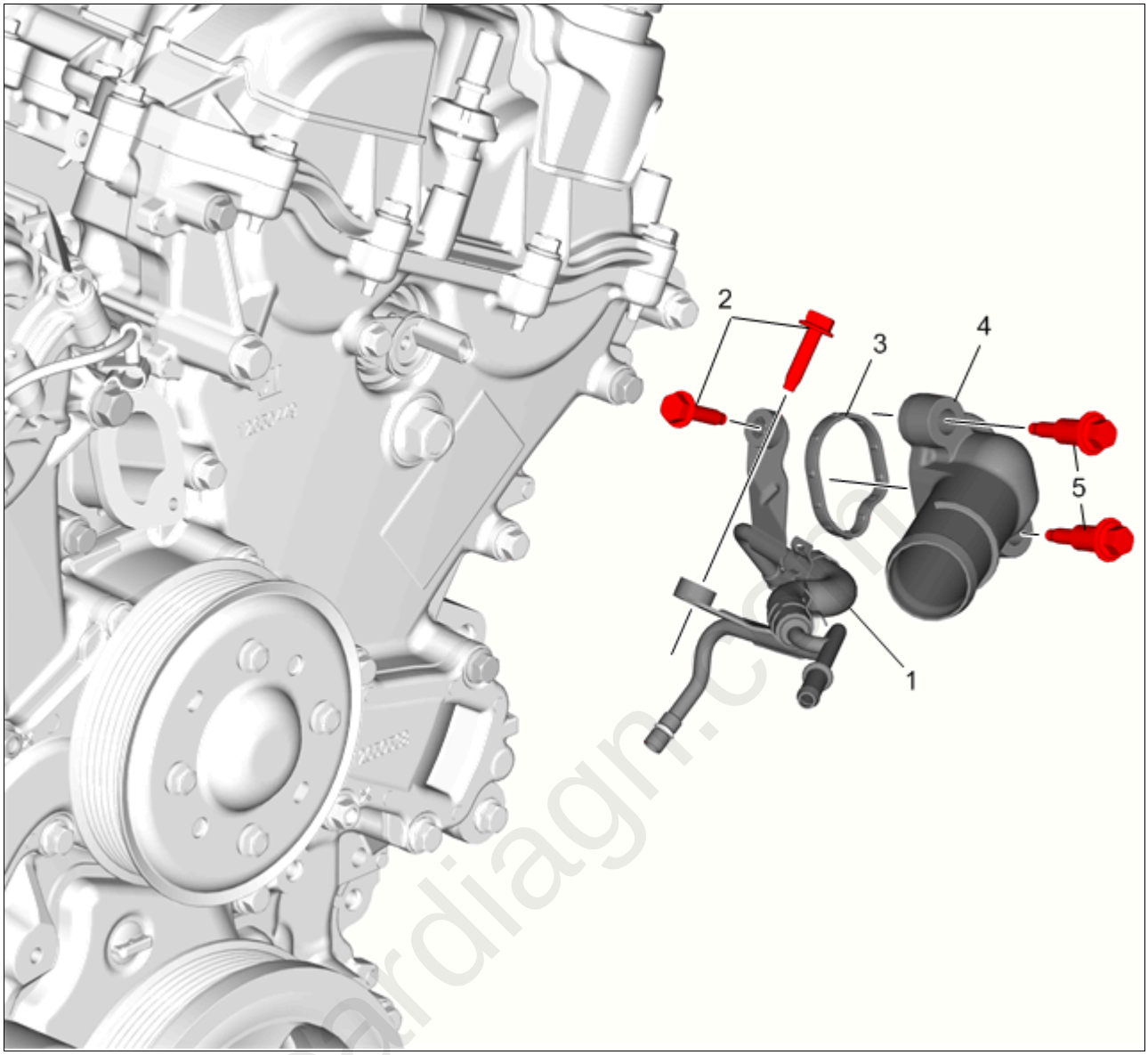
Callout	Component Name
1	Engine Coolant Temperature Sensor *CAUTION:* *Refer to Fastener Caution .* **Tighten** 9 N.m (80 lb in)
2	Engine Coolant Temperature Sensor Wire

3	Engine Coolant Thermostat Gasket *NOTE:* *Install a NEW gasket.*
4	Engine Coolant Thermostat Housing
5	Engine Coolant Thermostat Housing Bolt **Tighten** 10 N.m (89 lb in)

REPAIR INSTRUCTIONS - OFF VEHICLE > WATER OUTLET INSTALLATION

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Fig 1: Water Outlet (LGX)



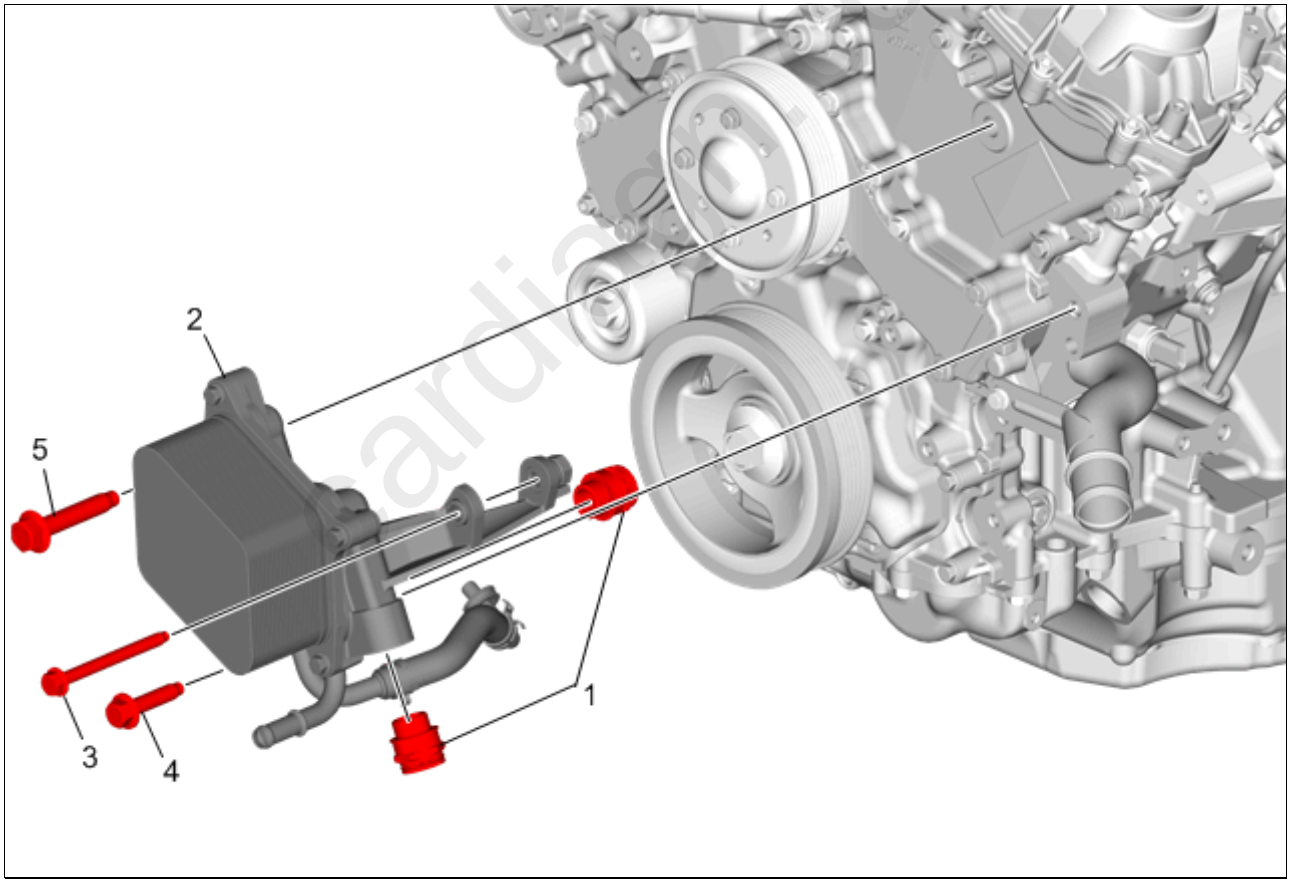
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Engine Coolant Air Bleed Pipe
2	Engine Coolant Air Bleed Pipe Bolt (Qty: 2) *CAUTION:* *Refer to Fastener Caution .* **Tighten** 10 N.m (89 lb in)

3	Water Outlet Seal *NOTE:* *Install a NEW seal.*
4	Water Outlet
5	Water Outlet Bolt (Qty: 2) **Tighten** 10 N.m (89 lb in)

REPAIR INSTRUCTIONS - OFF VEHICLE > ENGINE OIL COOLER ADAPTER INSTALLATION > ENGINE OIL COOLER ADAPTER INSTALLATION

Fig 1: Engine Oil Cooler Adapter



Courtesy of GENERAL MOTORS COMPANY

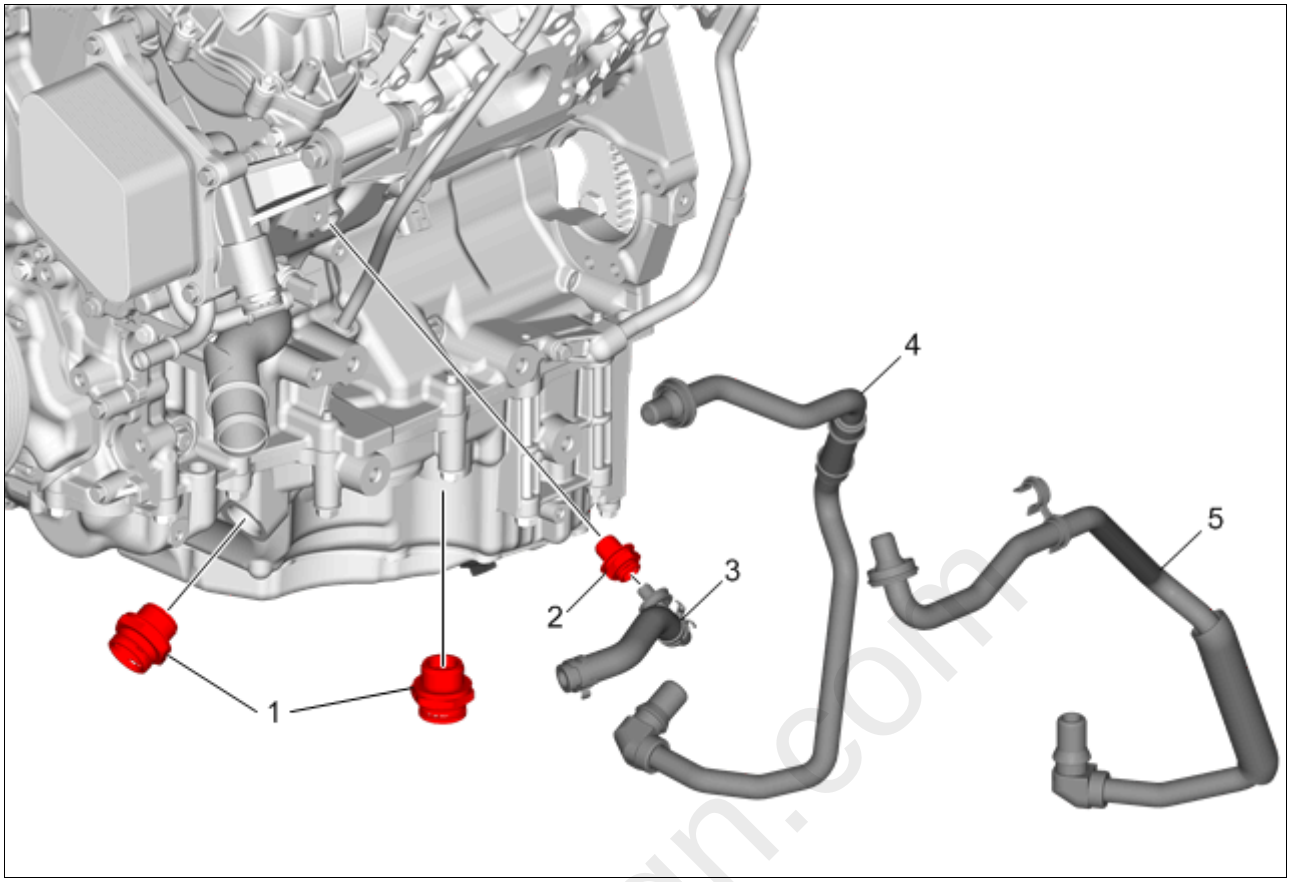
Engine Oil Cooler Adapter Installation

Callout	Component Name
1	Engine Oil Cooler Fitting (Qty: 2) *CAUTION:* *Refer to Fastener Caution .* **Tighten** 25 N.m (18 lb ft)
2	Engine Oil Cooler Adapter Assembly
3	Engine Oil Cooler Adapter Bolt M8 x 90.8 **Tighten** 22 N.m (16 lb ft)
4	Engine Oil Cooler Adapter Bolt M10 x 45.75 *NOTE:* *Make Sure all axi-rads are present for proper alignment of the oil cooler to the oil pan.* **Tighten** 58 N.m (43 lb ft)
5	Engine Oil Cooler Adapter Bolt M12 x 65.90 *NOTE:* *Make Sure all axi-rads are present for proper alignment of the oil cooler to the oil pan.* **Tighten** 100 N.m (74 lb ft)

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REPAIR INSTRUCTIONS - OFF VEHICLE > ENGINE OIL COOLER ADAPTER INSTALLATION > ENGINE OIL COOLER PIPES AND FITTINGS INSTALLATION

Fig 1: Engine Oil Cooler Pipes and Fittings



Courtesy of GENERAL MOTORS COMPANY

Engine Oil Cooler Pipes and Fittings Installation

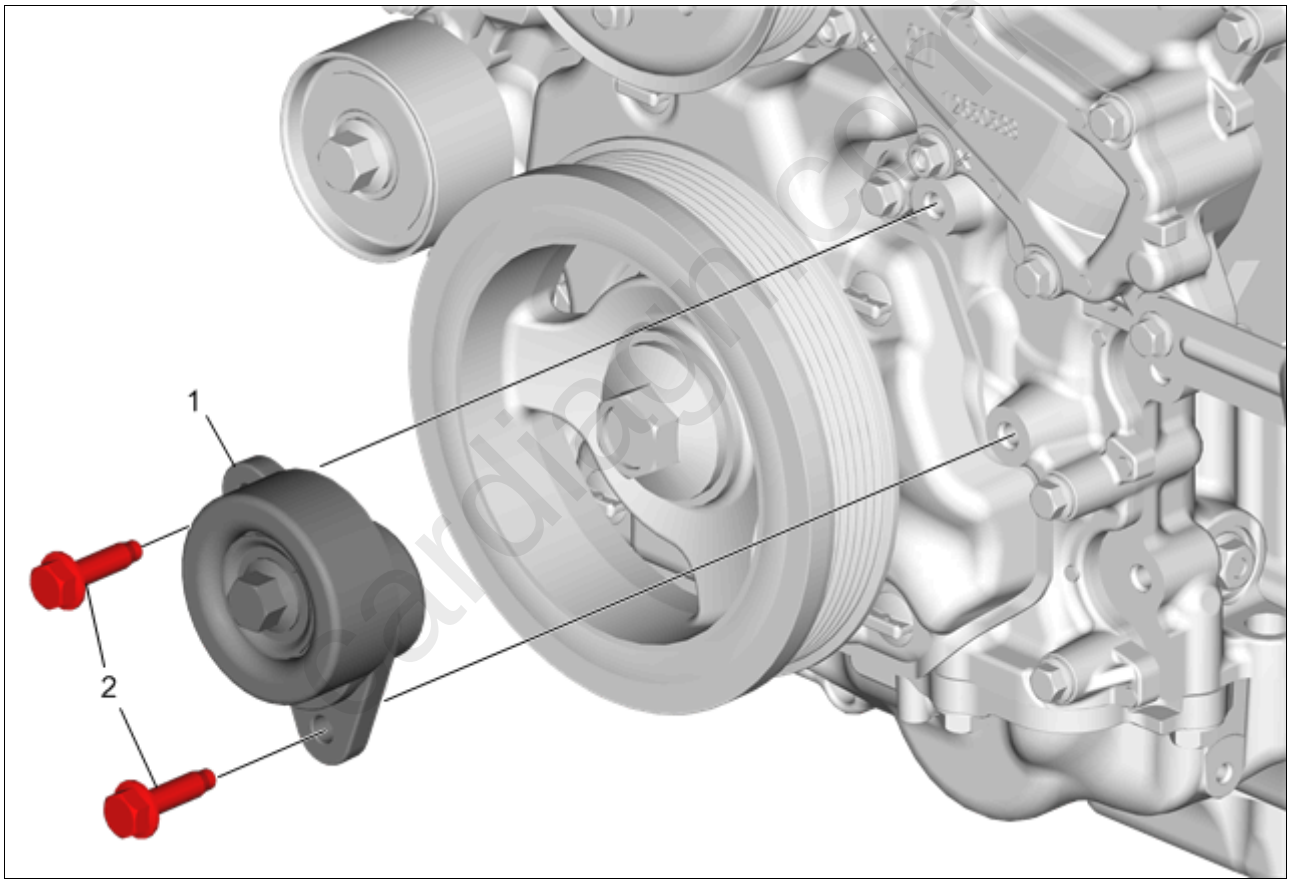
Callout	Component Name
1	Engine Oil Cooler Fitting *CAUTION:* *Refer to Fastener Caution .* *CAUTION:* *When installing the fitting, first remove the oil filter. When torquing the fitting, use a standard or thin wall socket (not an impact socket) in order to prevent the wall of the socket from contacting the oil pan. Contact between the socket and filter or pan would reduce the torque applied to fitting, potentially resulting in a loose fitting.*

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	Tighten 25 N.m (18 lb ft)
2	Engine Oil Cooler Fitting **Tighten** 25 N.m (18 lb ft)
3	Engine Oil Cooler Inlet Pipe
4	Engine Oil Cooler Pipe
5	Engine Oil Cooler Pipe

REPAIR INSTRUCTIONS - OFF VEHICLE > DRIVE BELT TENSIONER INSTALLATION

Fig 1: Drive Belt Tensioner (LGX)



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Drive Belt Tensioner
2	Drive Belt Tensioner Bolt (Qty: 2) *CAUTION:*

Refer to Fastener Caution .

Tighten
30 N.m (22 lb ft)

REPAIR INSTRUCTIONS - OFF VEHICLE > ENGINE PRELUBING

NOTE:

This procedure is not used in Europe.

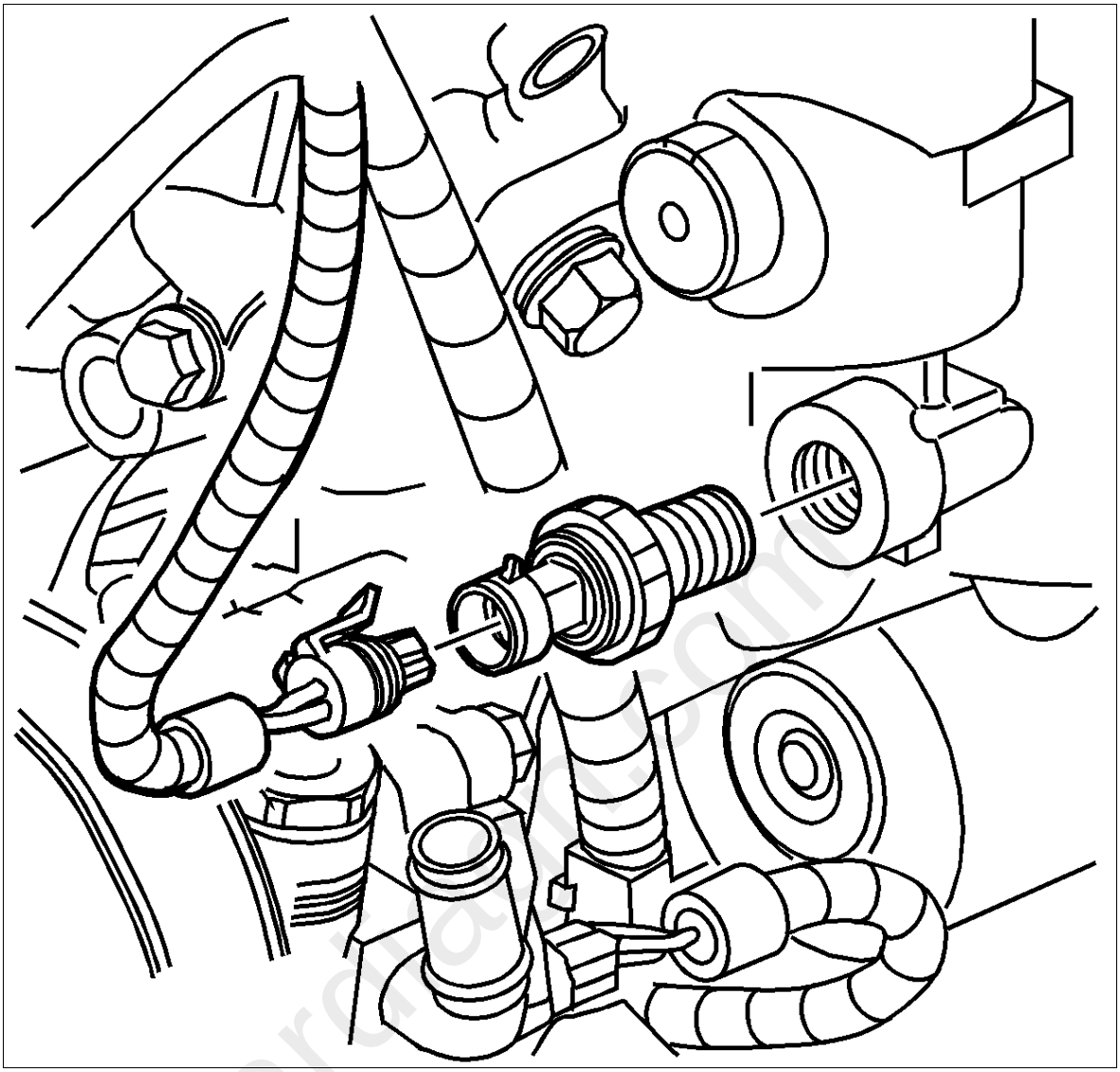
Special Tools

- **EN 21867-6** Oil Pressure Adapter Fitting
- **EN 45299** Engine Preluber

For equivalent regional tools, refer to Special Tools

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Fig 1: Oil Pressure Sending Unit



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NOTE:

A constant and continuous flow of clean engine oil is required in order to properly prime the engine. Be sure to use an approved engine oil as specified in the owners manual.

1. Remove the oil filter cap.
2. Install the NEW oil filter cartridge.
3. Lubricate the threads of the oil filter cap with clean engine oil.

CAUTION:

Refer to Fastener Caution .

4. Install the oil filter cap and tighten to 25 N.m (18 lb ft).
5. Remove the oil pressure sending unit from the oil filter adapter.
6. Install the **EN 21867-6** fitting.

   Fig 2: Preluber Flexible Hose



Courtesy of GENERAL MOTORS COMPANY

7. Install the flexible hose to the adapter and open the valve.
8. Pump the handle on the **EN 45299** preluber in order to flow a minimum of 1-1.9 liters (1-2 quarts) of engine oil. Observe the flow of engine oil through the flexible hose and into the engine assembly.
9. Close the valve and remove the flexible hose and adapter from the engine.
10. Install the oil pressure sending unit and tighten to 20 N.m (15 lb ft).

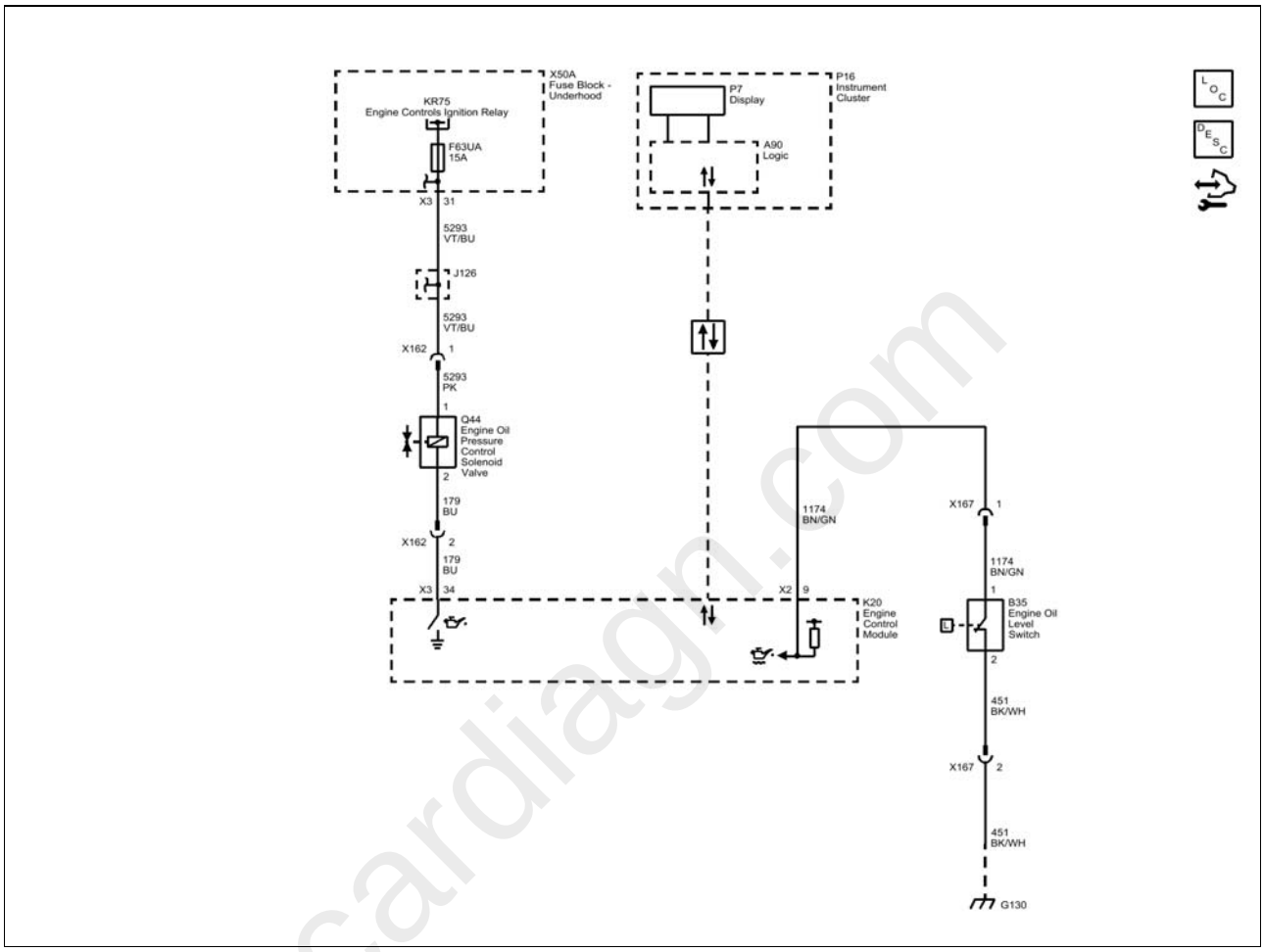
11. Top-off the engine oil to the proper level.

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Service Manual: ENGINE MECHANICAL - 3.6L (LGX) -
SCHEMATIC WIRING DIAGRAMS

SCHEMATIC WIRING DIAGRAMS > ENGINE MECHANICAL WIRING SCHEMATICS > ENGINE OIL LEVEL AND PRESSURE CONTROL

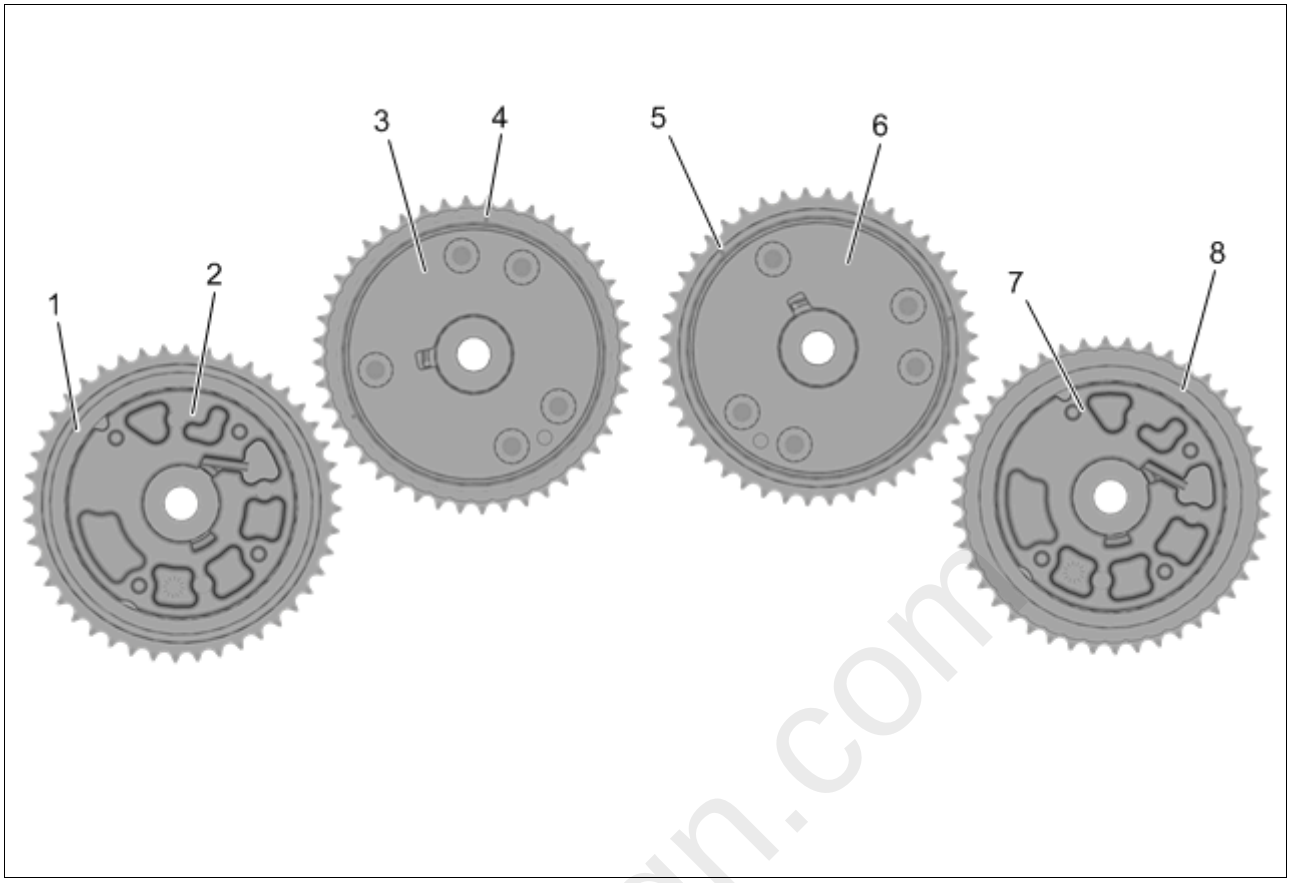
Fig 1: Engine Oil Level and Pressure Control



Courtesy of GENERAL MOTORS COMPANY

SCHEMATIC WIRING DIAGRAMS > TIMING CHAIN ALIGNMENT WIRING DIAGRAM > CAMSHAFT POSITION ACTUATOR TIMING MARKS

Fig 1: Camshaft Position Actuator Timing Marks

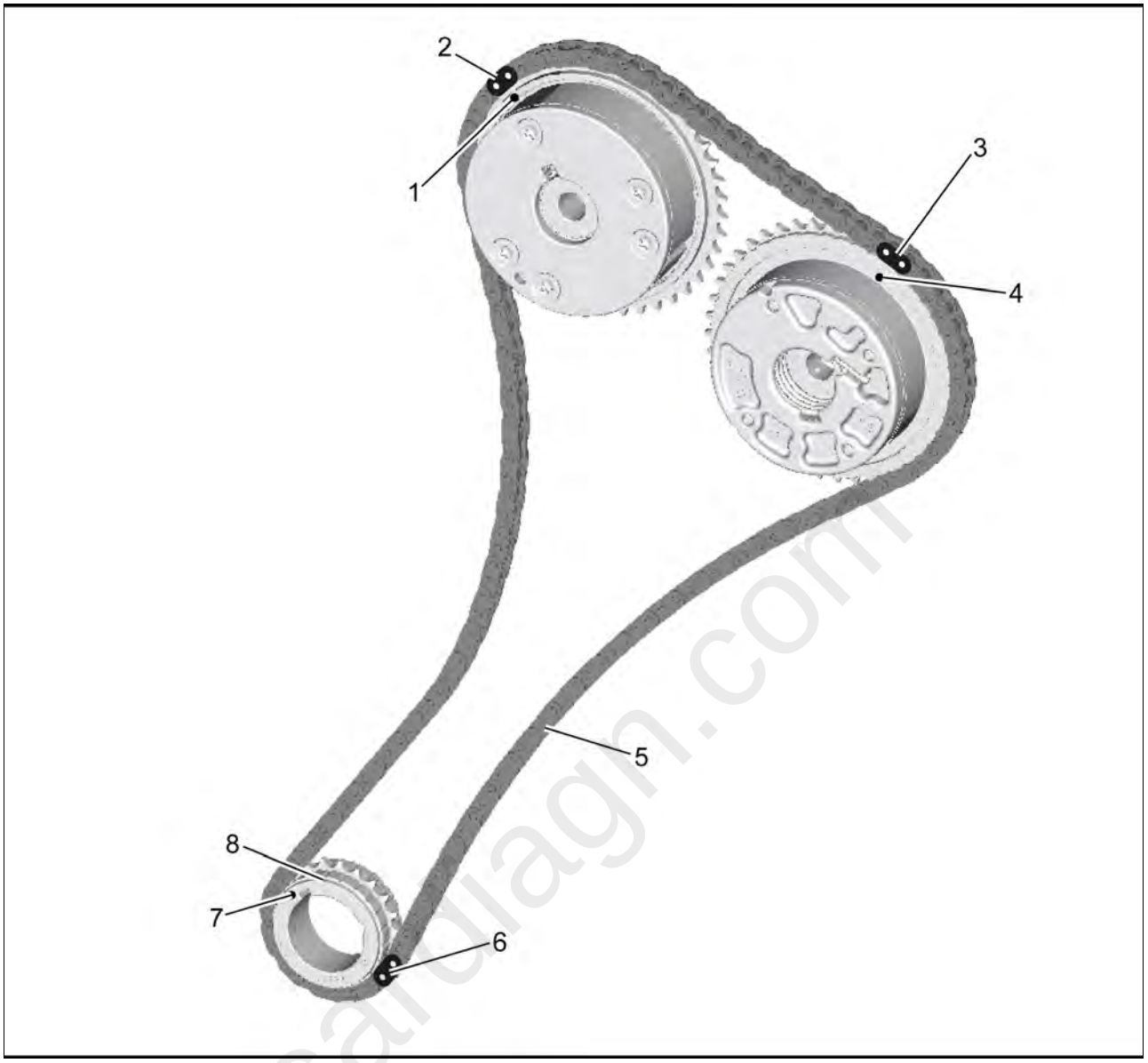


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SCHEMATIC WIRING DIAGRAMS > TIMING CHAIN ALIGNMENT WIRING DIAGRAM > STAGE ONE

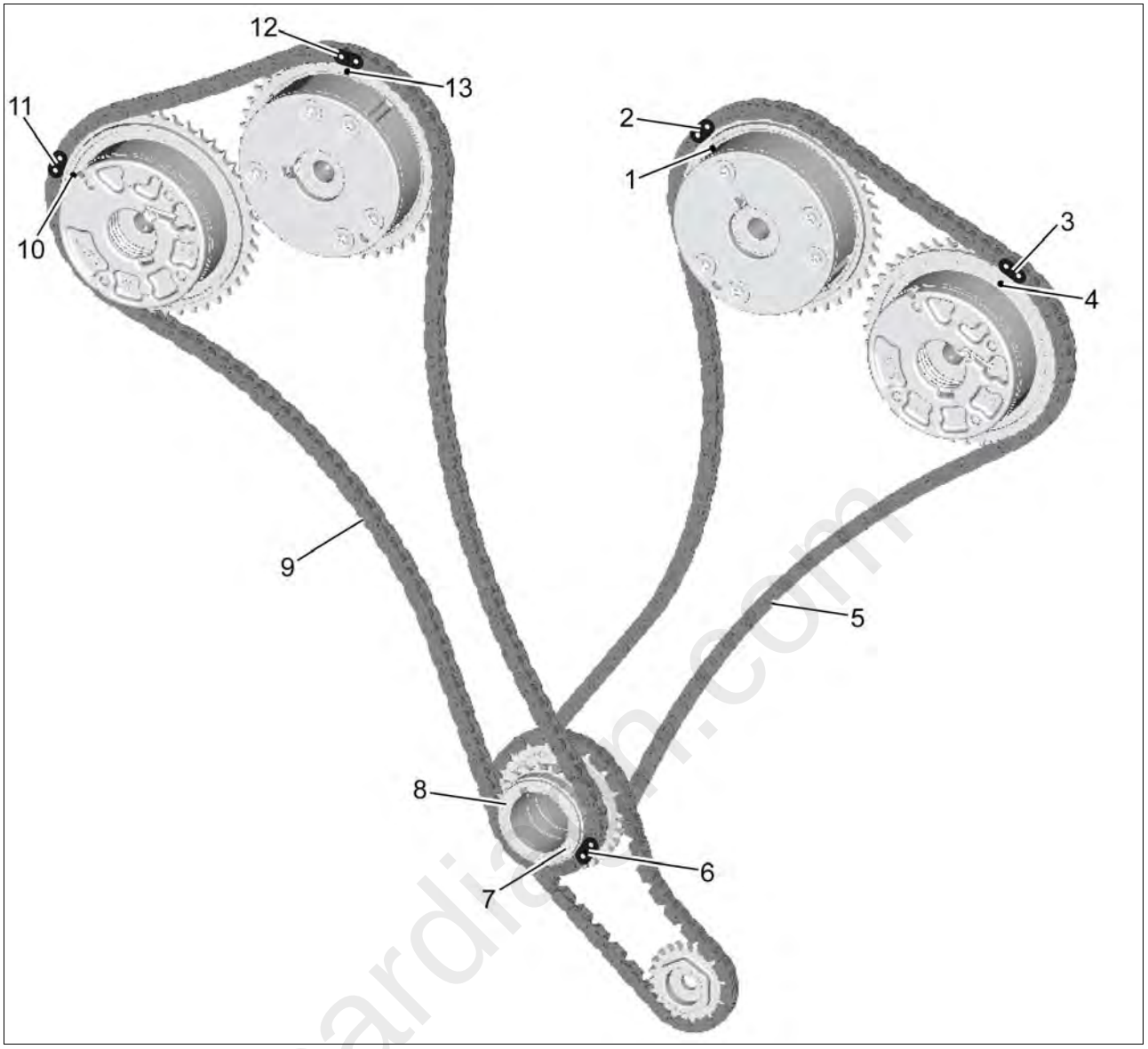
Fig 1: Stage One



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SCHEMATIC WIRING DIAGRAMS > TIMING CHAIN ALIGNMENT WIRING DIAGRAM > STAGE TWO

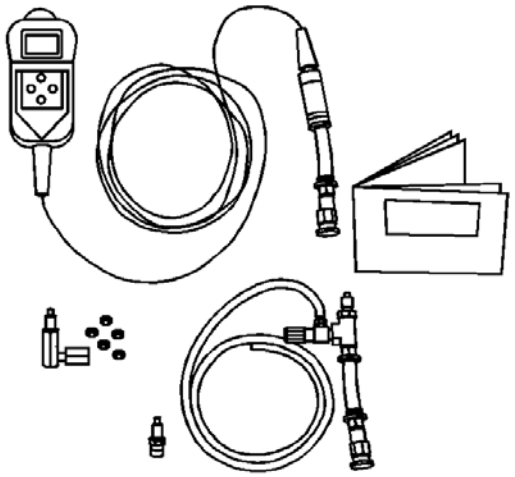
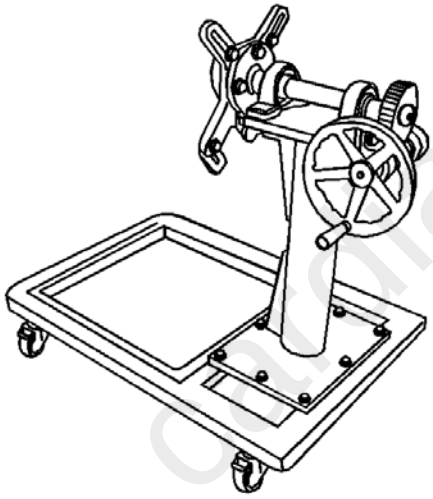
Fig 1: Stage Two



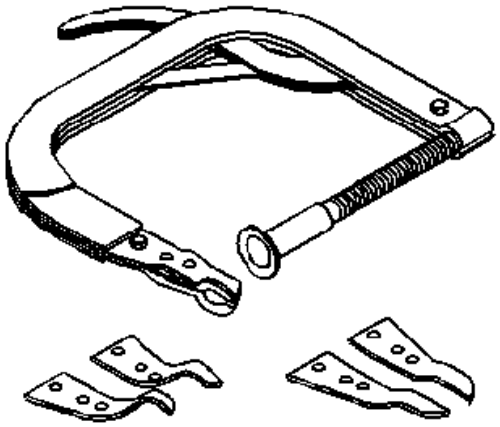
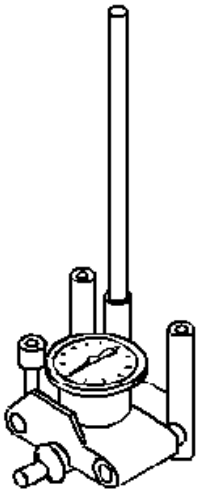
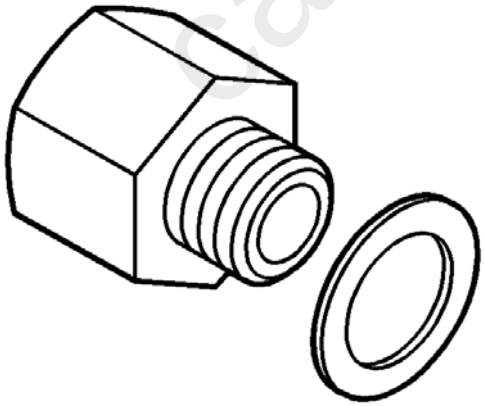
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Service Manual: ENGINE MECHANICAL - 3.6L (LGX) -
SPECIAL TOOLS AND EQUIPMENT

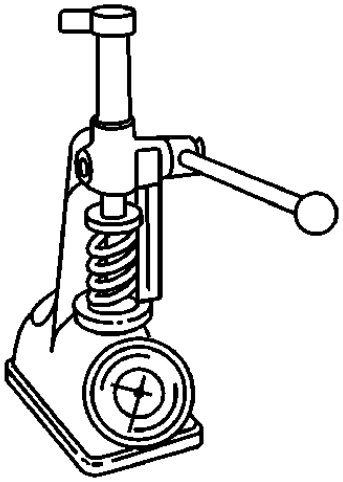
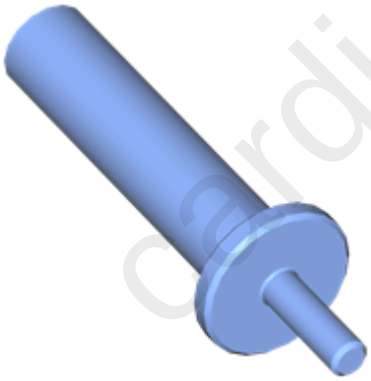
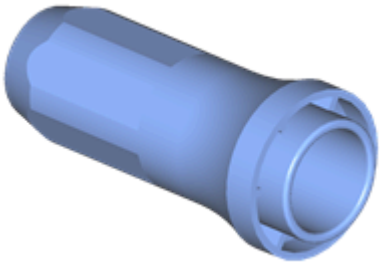
SPECIAL TOOLS AND EQUIPMENT > SPECIAL TOOLS

Illustration	Tool Number/Description
	CH-48027 DW-100-010 EN-49495 J-21867 Digital Pressure Gauge
	DW-110-030 Engine Overhaul Stand

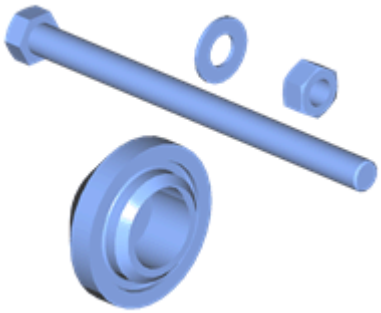
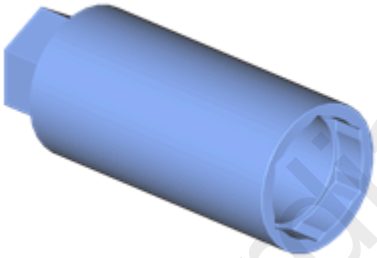
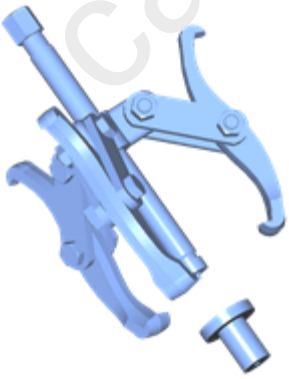
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	EN-8062 J-8062 Valve Spring Compressor - Head Off
	EN-8087 J-8087 Cylinder Bore Gauge
	EN-21867-6 J-21867-6 83 93 852 Oil Pressure Adapter Fitting

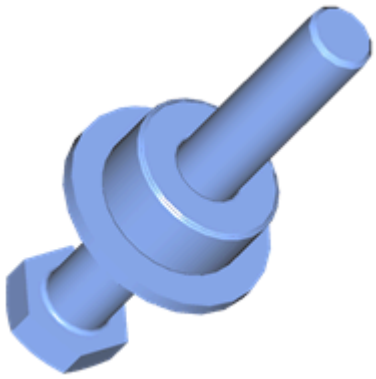
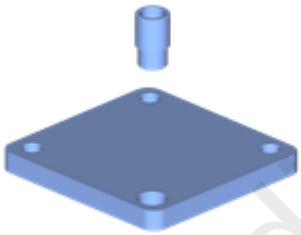
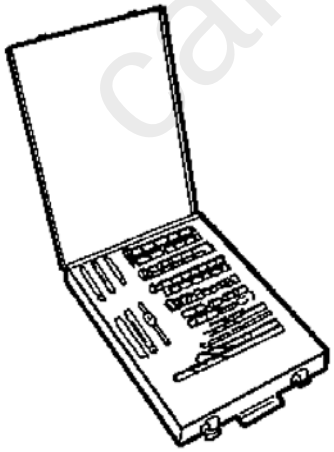
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	EN-22738-B J-22738-B Valve Spring Tester
	EN-28410 J-28410 Gasket Remover
	EN-28467-13 J-28467-13 J-28467-20 Strut Tower to Support Beam Adapters
	EN-29184 EN-47635 & J-41998-B EN-47635 J-29184 Oil Seal Installer

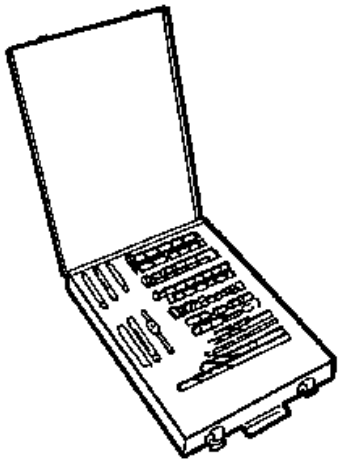
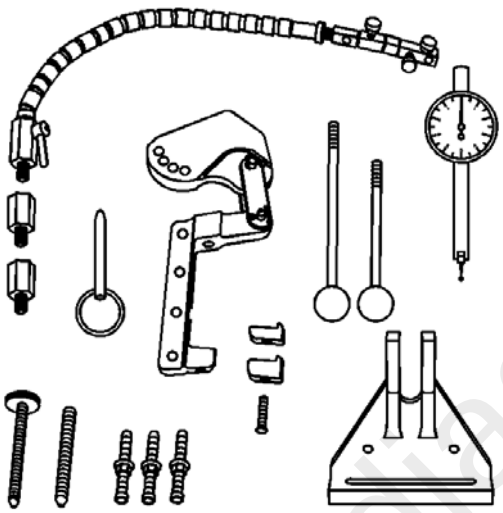
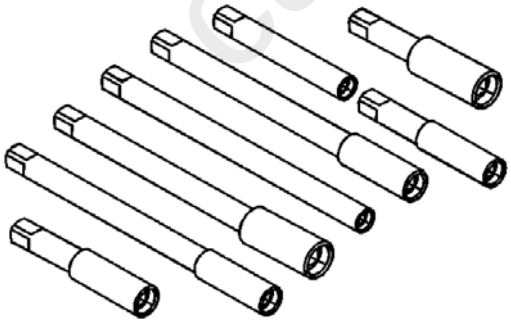
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	EN-36857 J-36857 Engine Lift Bracket
	EN-41478 J-41478 Crankshaft Front Oil Seal Installer
	EN-41712 J-41712 Oil Pressure Switch Socket
	EN-41816 J-41816 Crankshaft Balancer Remover

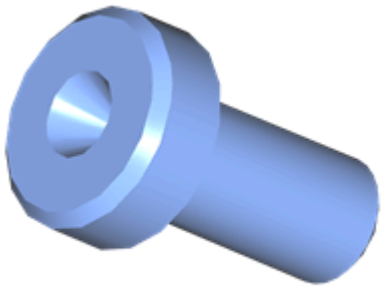
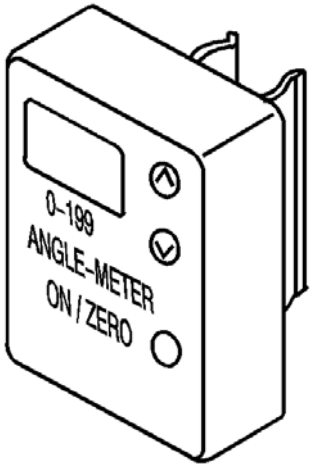
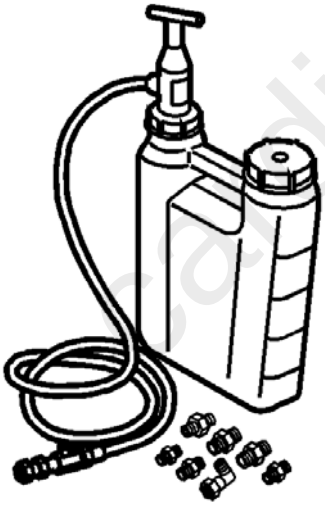
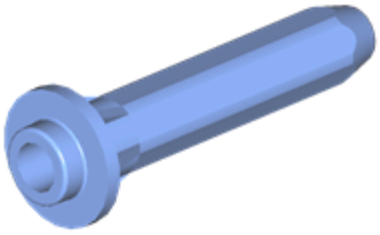
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	EN-41998-B J-41998-B J-41998 Crankshaft Balancer Installer
	EN-42183 J-42183 Driver Handle
	EN-42385-70 Head Bolt Thread Repair Fixture
	EN-42385-700 J-42385-700 High Feature Thread Repair Kit

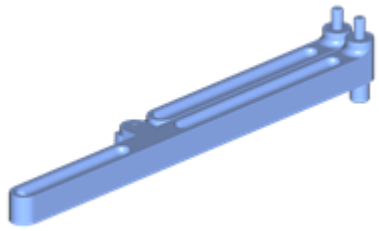
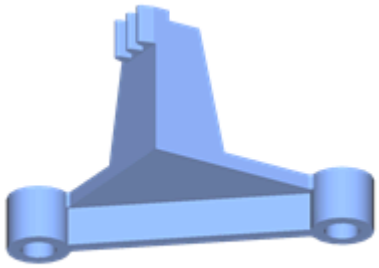
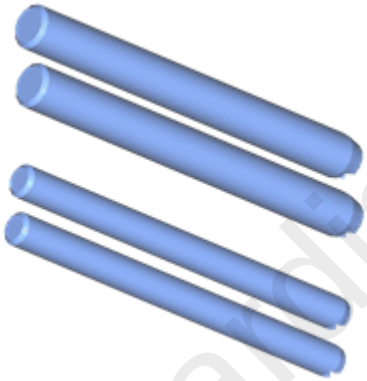
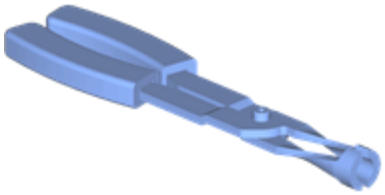
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	EN-42385-2000 J-42385-2000 Thread Insert Kit
	EN-43690-A J-43690-A Rod Bearing Clearance Checking Tool
	EN-43965 J-43965 Thread Repair Extension Kit

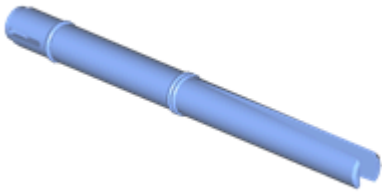
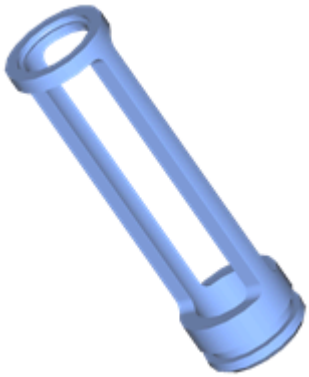
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	EN-44226-5 Cranshaft Protector
	EN-45059-A J-45059-A KM-470-B Angle Meter
	EN-45299 J-45299 Engine Preluber
	EN-46103 J-46103 Camshaft Actuator Valve Seal Installer

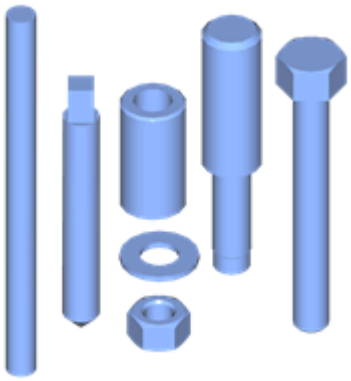
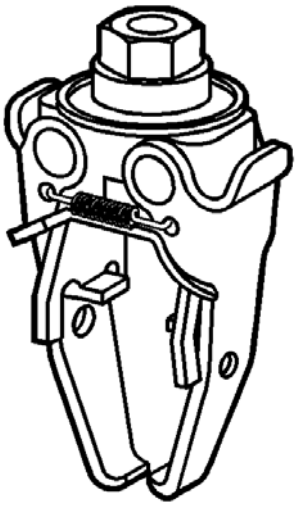
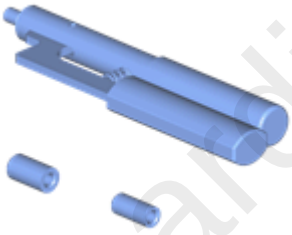
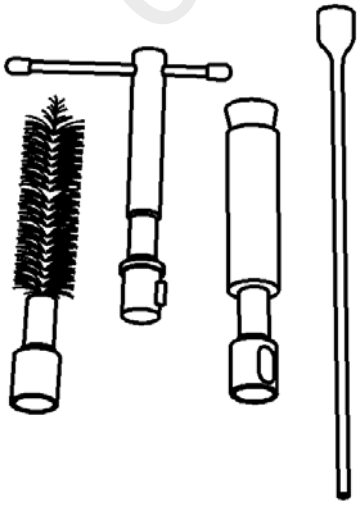
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	EN-46104 J-46104 Water Pump Pulley Holding Tool
	EN-46106 J-46106 KM-652 Flywheel Holding Tool
	EN-46109 J-46109 Guide Pins
	EN-46116 KM-840 (Remover)/EN-47986 (Installer) 83 94 157 Valve Stem Seal Remover/Installer

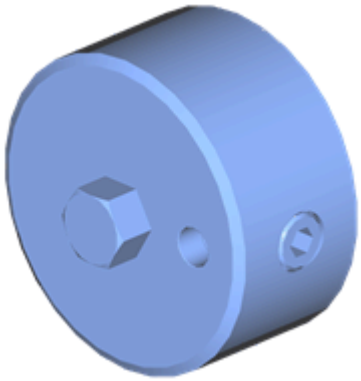
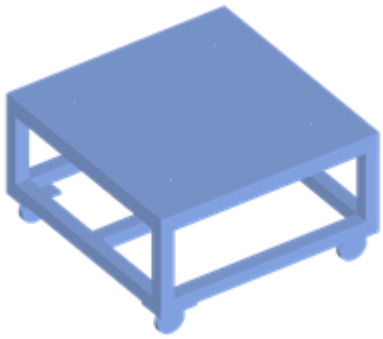
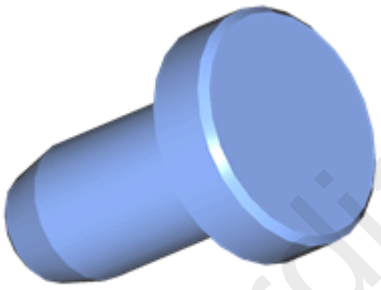
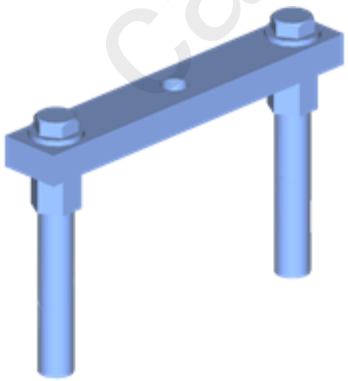
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	EN-46117 Valve Stem Key Remover/Installer
	EN-46119 Off-Vehicle Valve Spring Compressor Adapter
	EN-46120 Valve Guide Reamer
	EN-46121 Connecting Rod Guide Pin Set

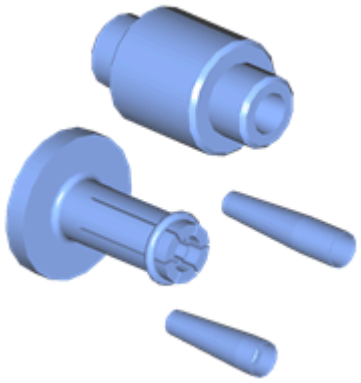
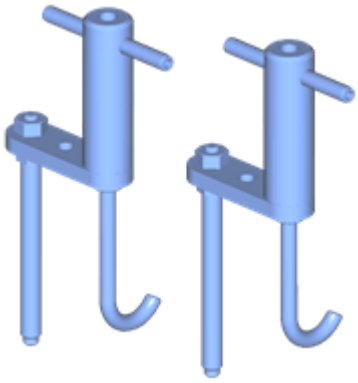
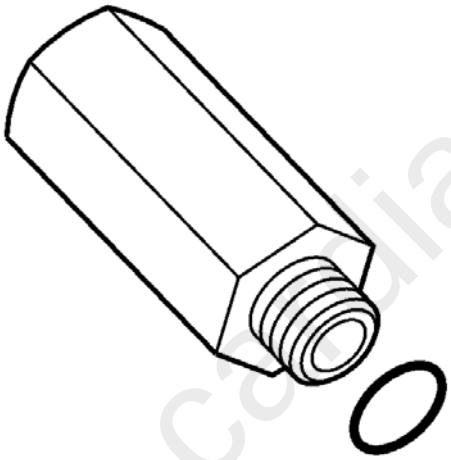
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	EN-46122 Camshaft Position Actuator Check-Ball Valve Remover/Installer
	EN-46335-A Valve Spring Compressor
	EN-46745 J-43654 Piston Pin Clip Remover/Installer
	EN-47909 Injector Bore and Sleeve Cleaning Kit

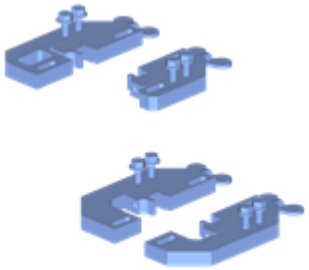
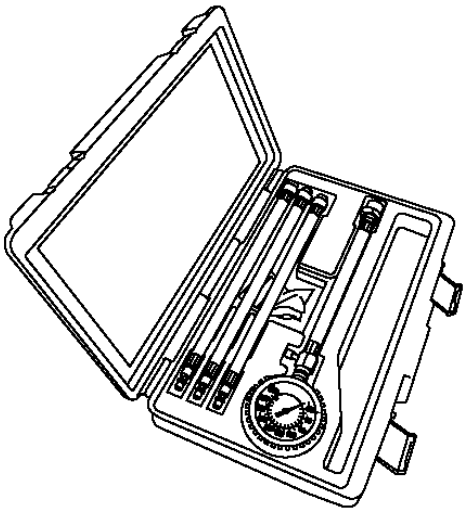
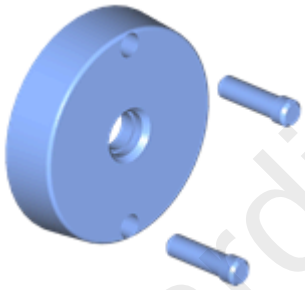
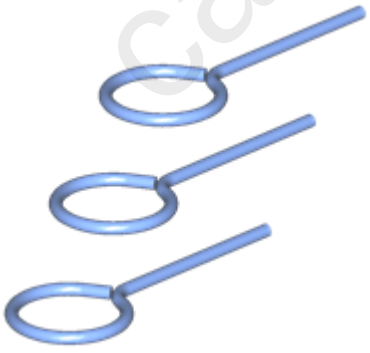
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	EN-47971 Oil Pressure Gauge Adapter
	EN-48244 Engine Assembly Remove/Install Pallet Supporter
	EN-48896 HP Fuel Pump Installation Alignment Gauge
	EN-49102 J-41818 & EN-47985 Crankshaft Bearing Cap Remover

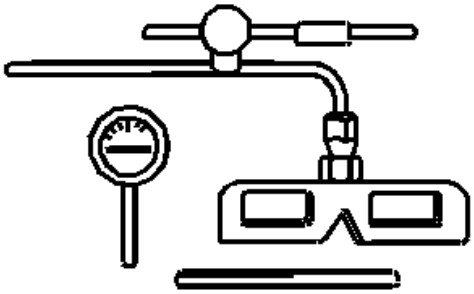
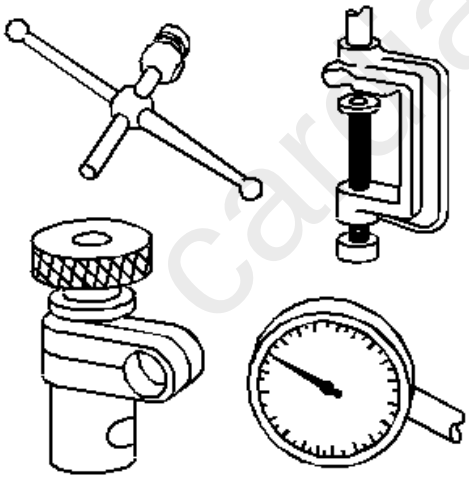
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	EN-49245 Injector Seal Installer Kit
	EN-49248 Injector Rail Assembly Remover
	EN-50789 Oil Pressure Adapter Fitting
	EN-51096 DT-51096 Crankshaft Rear Oil Seal Remover.

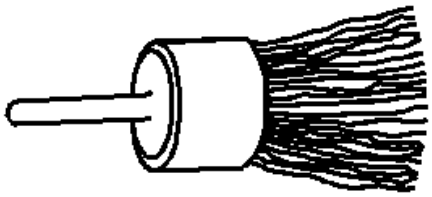
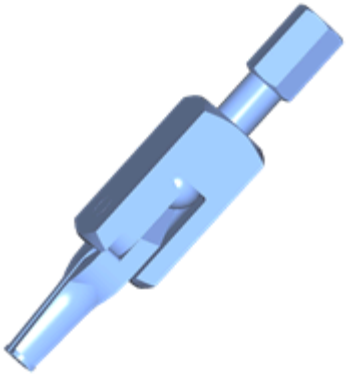
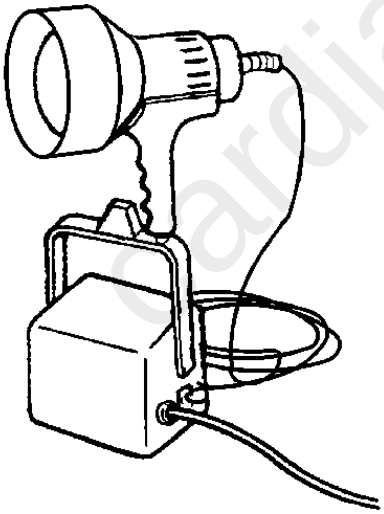
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	EN-51333 Timing Chain Retainer
	EN-51749 Compression Gauge Tester Kit
	EN-51766 Crankshaft Rear Oil Seal Installer
	EN-52234 Timing Chain Tensioner Retaining Pins

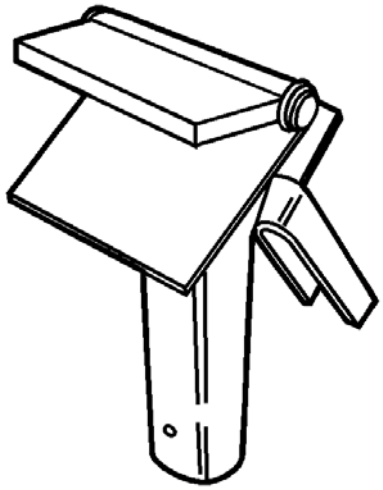
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	GE-6125-1B J-6125-1B Slide Hammer Adapter
	GE-7872 J-7872 Magnetic Base Dial Indicator
	GE-8001 J-8001 Dial Indicator Set

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	GE-8358 J-8358 Carbon Removal Brush
	GE-23907 Slide Hammer with Bearing Adapter
	GE-28428-E J-28428-E High Intensity Black Light Kit

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	GE-48326 Sealant Dispenser

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Service Manual: ENGINE MECHANICAL - 3.6L (LGX) - SPECIFICATIONS

SPECIFICATIONS > FASTENER SPECIFICATIONS

Application	Specification	
	Metric	English
Automatic Transmission Flex Plate Bolt		
First Pass:	30 N.m (1)	22 lb ft (1)
Final Pass:	45 Degrees	
Belt Idler Pulley Bolt	10 N.m	89 lb in
Camshaft Bearing Cap Bolt M6 x 43.4		
First Pass:	6 N.m	53 lb in
Final Pass:	60 Degrees	
Camshaft Bearing Cap Bolt M6 x 43.4	10 N.m	89 lb in
Camshaft Carrier Bolt M6 x 60	10 N.m	89 lb in
Camshaft Carrier Bolt M6 x 60	13 N.m	115 lb in
Camshaft Cover Bolt	10 N.m	89 lb in
Camshaft Position Actuator Bolt		
First Pass:	20 N.m	15 lb ft
Final Pass:	45 Degrees	
Camshaft Position Actuator Solenoid Valve Bolt	10 N.m	89 lb in
Camshaft Position Sensor Bolt	10 N.m	89 lb in
Clutch Pressure Plate Bolt	30 N.m	22 lb ft
Connecting Rod Bolt		
First Pass:	25 N.m (1)	18 lb ft (1)
Final Pass:	110 Degrees	
Coolant Drain Plug	50 N.m	37 lb in
Coolant Drain Plug	75 N.m	55 lb in
Coolant Outlet Bolt	10 N.m	89 lb in
Crankshaft Balancer Bolt		
First Pass:	100 N.m (1)	74 lb ft (1)
Final Pass:	150 Degrees	
Crankshaft Bearing Cap Bolt - Inner		

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First Pass:	20 N.m (1)	15 lb ft (1)
Final Pass:	80 degrees	
Crankshaft Bearing Cap Bolt - Outer		
First Pass:	15 N.m (1)	11 lb ft (1)
Final Pass:	110 Degrees	
Crankshaft Bearing Cap Bolt M8 x 25 - Side		
First Pass:	30 N.m (1)	22 lb ft (1)
Final Pass:	60 Degrees	
Crankshaft Bearing Cap Bolt M8 x 50.4 - Side		
First Pass:	30 N.m (1)	22 lb ft (1)
Final Pass:	60 Degrees	
Crankshaft Oil Deflector Nut	10 N.m	89 lb in
Crankshaft Position Sensor Bolt	10 N.m	89 lb in
Crankshaft Rear Oil Seal Housing Bolt	10 N.m	89 lb in
Cylinder Head Bolt M8 x 80.8		
First Pass:	15 N.m (1)	11 lb ft (1)
Final Pass:	75 Degrees	
Cylinder Head Bolt M11 x 178		
First Pass:	60 N.m (1)	44 lb ft (1)
Final Pass:	185 degrees	
Cylinder Head Core Hole Plug M9	15 N.m	11 lb ft
Cylinder Head Core Hole Plug M12	25 N.m	18 lb ft
Cylinder Head Core Hole Plug M14	35 N.m	26 lb ft
Drive Belt Tensioner Bolt	30 N.m	22 lb ft
Engine Block Oil Gallery Plug	25 N.m	18 lb ft
Engine Block Oil Gallery Plug M16 (Qty: 2)	40 N.m	30 lb ft
Engine Block Core Hole Plug M18	45 N.m	33 lb ft
Engine Coolant Air Bleed Pipe Bolt	10 N.m	89 lb in
Engine Coolant Temperature Sensor	9 N.m	80 lb in
Engine Coolant Thermostat Housing Bolt	10 N.m	89 lb in
Engine Flywheel Bolt	67 N.m (1)	49 lb ft (1)
Engine Front Cover Bolt M6 x 45	10 N.m	89 lb in
Engine Front Cover Bolt M6 x 60	10 N.m	89 lb in

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Engine Front Cover Bolt M8 x 66	15 N.m	11 lb ft
Engine Front Cover Bolt M12 x 55.8	60 N.m	44 lb ft
Engine Front Cover Bolt M12 x 75.9	60 N.m	44 lb ft
Engine Mount Fasteners	62 (1)	46 lb ft (1)
Engine Front Cover Stud	15 N.m	11 lb ft
Engine Oil Cooler Adapter Bolt M8 x 90.8	22 N.m	16 lb ft
Engine Oil Cooler Adapter Bolt M10 x 45.75	58 N.m	43 lb ft
Engine Oil Cooler Adapter Bolt M12 x 65.90	100 N.m	74 lb ft
Engine Oil Cooler Adapter Fitting	25 N.m	18 lb ft
Engine Oil Level Indicator Switch Bolt	10 N.m	89 lb in
Engine Oil Pressure Sensor	35 N.m	26 lb ft
Evaporative Emission Canister Purge Solenoid Valve Bolt	10 N.m	89 lb in
Engine Wiring Harness Bracket Bolt	15 N.m	11 lb ft
Fuel Feed Intermediate Pipe Bolt	28 N.m	21 lb ft
Fuel Feed Pipe Bolt	10 N.m	89 lb in
Fuel Injection Fuel Rail Bolt	25 N.m	18 lb ft
Fuel Injection Fuel Rail Fuel Pressure Sensor	33 N.m	25 lb ft
Fuel Pipe Shield Bolt	10 N.m	89 lb in
Fuel Pump Bolt	15 N.m (1)	11 lb ft (1)
Fuel Rail Crossover Pipe Fitting	30 N.m	22 lb ft
Heater Inlet and Outlet Pipe Bolt M6 x 20	9 N.m	80 lb in
Heater Inlet and Outlet Pipe Bolt M6 x 25 (Qty: 2)	9 N.m	80 lb in
Ignition Coil Bolt	10 N.m	89 lb in
Intake Manifold Bolt	25 N.m	18 lb ft
Knock Sensor Bolt	25 N.m	18 lb ft
Manifold Absolute Pressure Sensor Bolt	4	35 lb in
Oil Filter	3/4 to 1 full turn after gasket makes contact with the sealing surface on the filter mounting flange	
Oil Filter Adapter Fitting	50 N.m	37 lb ft
Oil Gallery Plug M14	50 N.m	37 lb ft
Oil Gallery Plug M20	75 N.m	55 lb ft
Oil Level Indicator Tube Bolt	10 N.m	89 lb in

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Oil Pan Baffle Bolt	10 N.m	89 lb in
Lower Oil Pan Bolt	10 N.m	89 lb in
Oil Pan Bolt M6 x 151		
First Pass:	7 (1)	(62 lb in) (1)
Final Pass:	180 Degrees	
Oil Pan Bolt M8 x 20	25 N.m	18 lb ft
Oil Pan Bolt M8 x 36	25 N.m	18 lb ft
Oil Pan Bolt M8 x 66	25 N.m	18 lb ft
Oil Pan Drain Plug	25 N.m	18 lb ft
Oil Pump Bolt M6 x 35.65	15 N.m	11 lb ft
Oil Pump Bolt M6 x 53.65	15 N.m	11 lb ft
Oil Pump Drive Bolt		
First Pass:	15 N.m	11 lb ft
Final Pass:	110 Degrees	
Oil Pump Suction Pipe Bolt	10 N.m	89 lb in
Oil Pump Flow Control Valve Bolt	5 N.m	44 lb in
Positive Crankcase Ventilation Oil Separator Drain Bolt	10 N.m	89 lb in
Positive Crankcase Ventilation Oil Separator Bolt	15 N.m	11 lb ft
Positive Crankcase Ventilation Oil Separator Bolt	15 N.m	11 lb ft
Positive Crankcase Ventilation Oil Separator Drain Pipe Bolt	10 N.m	89 lb in
Piston Oil Cooling Nozzle Bolt	10 N.m	89 lb in
Spark Plug	18 N.m	13 lb ft
Timing Chain- Right		
• Timing Chain Guide Bolt	25 N.m	18 lb ft
• Timing Chain Tensioner Bolt	25 N.m	18 lb ft
Timing Chain- Left		
• Timing Chain Guide Bolt	25 N.m	18 lb ft
• Timing Chain Tensioner Bolt	25 N.m	18 lb ft

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Throttle Body Bolt	10 N.m	89 lb in
Vacuum Pump Pipe Bolt	10 N.m	89 lb in
Water Outlet Bolt	10 N.m	89 lb in
Water Pump Bolt	15 N.m	11 lb ft
Water Pump Inlet Pipe Bolt	15 N.m	11 lb ft
Water Pump Inlet Pipe Bolt	15 N.m	11 lb ft
Water Pump Pulley Bolt	10 N.m	89 lb in
Wiring Harness Connector Bolt	10 N.m (1)	89 lb in (1)
1. Use NEW fastener.		

SPECIFICATIONS > APPROXIMATE FLUID CAPACITIES

Application	Specification	
	Metric	English
3.6L LGX		
• Oil Capacity - with Filter	5.7 Liters	6.0 Quarts

SPECIFICATIONS > ENGINE MECHANICAL SPECIFICATIONS

Application	Specification	
	Metric	English
General		
• Engine Type	V-6	
• Displacement	3.6 Liter	220 cu in
• RPO	LGX	
• VIN	8	

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• Bore	95 mm	3.7402 in
• Stroke	85.6 mm	3.37 in
• Compression Ratio	11.5:1	
• Firing Order	1-2-3-4-5-6	
• Spark Plug Gap	0.90 mm	0.035 in
Block		
• Crankshaft Main Bearing Bore Diameter	76.021-76.035 mm	2.9929-2.9935 in
• Cylinder Bore Diameter	94.992-95.008 mm	3.7398-3.7405 in
• Cylinder Bore Out-of-Round - Production Max.	0.026 mm	0.001 in
Camshaft		
• Camshaft Bearing Inside Diameter - Front Number 1	31.000-31.020 mm	1.2205-1.2213 in
• Camshaft Bearing Inside Diameter - Middle and Rear Number 2-4	24.000-24.020 mm	0.9449-0.9457 in
• Camshaft End Play	0.055-0.465 mm	0.0022-0.0183 in
• Camshaft Journal Diameter - Front Number 1	30.936-30.960 mm	0.9424-0.9433 in
• Camshaft Journal Diameter - Middle and Rear Number 2-4	23.936-23.960 mm	1.0605-1.0614 in
• Camshaft Journal Out-of-Round	0.006 mm	0.0002 in

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• Camshaft Journal to Bore Clearance	0.040-0.084 mm	0.0016-0.0033 in
• Camshaft Lobe Lift - Exhaust AFM	40.557-40.707 mm	1.5967-1.6026 in
• Camshaft Lobe Lift - Exhaust Non AFM	42.519-42.669 mm	1.6740-1.6799 in
• Camshaft Lobe Lift - Intake AFM	40.353-42.503 mm	1.5887-1.5946 in
• Camshaft Lobe Lift - Intake Non AFM	42.317-42.467 mm	1.6660-1.6719 in
• Camshaft Runout - Front and Rear Number 1 and 4	0.025 mm	0.0010 in
• Camshaft Runout - Middle 2 and 3	0.050 mm	0.0020 in
• Valve Lift - Exhaust AFM	11.350 mm	0.4468 in
• Valve Lift - Exhaust Non AFM	11.222 mm	0.4418 in
• Valve Lift - Intake AFM	11.00 mm	0.4331 in
• Valve Lift - Intake Non AFM	10.872 mm	0.4280 in
Connecting Rod		
• Connecting Rod Bearing Clearance	0.010-0.070 mm	0.0004-0.0026 in
• Connecting Rod Bore Diameter - Bearing End	60.920-60.936 mm	2.3984-2.3990 in
• Connecting Rod Bore Diameter - Pin End - Production	23.007-23.017 mm	0.9056-0.9062 in
• Connecting Rod Bore Diameter - Pin End - Service Maximum	23.021 mm	0.9063 in

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• Connecting Rod Length - Center to Center	148.8 mm	5.86 in
• Connecting Rod Side Clearance	0.095-0.355 mm	0.00037-0.0140 in
• Connecting Rod Width - Bearing End		
• Production	21.775 mm	0.8573 in
• Service	21.725-21.825 mm	0.8553-0.8593 in
• Connecting Rod Width - Pin End		
• Production	21.775 mm	0.8573 in
• Service	21.725-21.825 mm	0.8553-0.8593 in
Crankshaft		
• Connecting Rod Journal Diameter	57.292-57.308 mm	2.2556-2.2556 in
• Connecting Rod Journal Out-of-Round	0.005 mm	0.0002 in
• Connecting Rod Journal Taper	0.005 mm	0.0002 in
• Connecting Rod Journal Width		
• Production	23.000 mm	0.9055 in
• Service	22.920-23.080 mm	0.9024-0.9417 in
• Crankshaft End Play	0.100-0.330 mm	0.0039-0.0130 in
• Crankshaft Main Bearing Clearance	0.028-0.063 mm	0.0011-0.0025 in

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• Crankshaft Main Journal Diameter	70.992-71.008 mm	2.7950-2.7956 in
• Crankshaft Main Journal Out-of-Round	0.005 mm	0.0002 in
• Crankshaft Main Journal Taper	0.005 mm	0.0002 in
• Crankshaft Main Journal Thrust Wall		
• Runout	0.000-0.040 mm	0.0000-0.0016 in
• Square	0.000-0.010 mm	0.0000-0.0004 in
• Crankshaft Main Journal Width, #2, 4		
• Production	25.500 mm	1.0040 in
• Service	25.400-25.600 mm	1.0000-1.0079 in
• Crankshaft Main Journal Width, #3		
• Production	25.900 mm	1.0197 in
• Service	25.875-25.925 mm	1.0187-1.0207 in
• Crankshaft Pilot Bearing Bore Diameter	20.965-20.995 mm	0.8254-0.8266 in
• Crankshaft Rear Flange Runout	0.025 mm	0.0010 in
• Crankshaft Reluctor Ring Runout - Maximum	1.500 mm	0.0591 in
• Crankshaft Runout	0.030 mm	0.0012 in

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• Crankshaft Thrust Bearing Clearance	0.076-0.305 mm	0.0030-0.0120 in
• Crankshaft Thrust Surface - Height Diameter	99.500 mm	3.9173 in
• Crankshaft Thrust Surface Runout	0.040 mm	0.0016 in
Cylinder Head		
• Valve Guide Bore - Exhaust	6.000-6.020 mm	0.2362-0.2370 in
• Valve Guide Bore - Intake	6.000-6.020 mm	0.2362-0.2370 in
• Valve Guide Installed Height	16.050-16.550 mm	0.6319-0.5516 in
• Valve Seat Width - Exhaust Seating Surface	1.550-1.950 mm	0.0610-0.0768 in
• Valve Seat Width - Exhaust Relief Surface	0.780-0.980 mm	0.0307-0.0386 in
• Valve Seat Width - Intake Seating Surface	1.000-1.400 mm	0.0394-0.0551 in
• Valve Seat Width - Intake Relief Surface	0.500-0.700 mm	0.0197-0.0276 in
• Valve Lifter Bore Diameter	12.008-12.030 mm	0.4728-0.4736 in
Lubrication System		
• Oil Pressure - Minimum @ Idle	69 kPa	10 psi
• Oil Pressure - Minimum @ 2, 000 RPM	136 kPa	20 psi
• Piston Cooling Jet Valve Opening Pressure	3.15-3.85 bar	45.7-55.8 psi
Piston Rings		
• Piston Ring End Gap		

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• First Compression Ring - Nominal	0.140-0.240 mm	0.0055-0.0102 in
• First Compression Ring - Maximum, Ring in Bore	0.290 mm	0.0094 in
• Second Compression Ring - Nominal	0.300-0.450 mm	0.0118-0.0177 in
• Second Compression Ring - Maximum, Ring in Bore	0.490 mm	0.0193 in
• Oil Control Ring	0.150-0.350 mm	0.0059-0.0138 in
• Piston Ring to Groove Clearance		
• First Compression Ring	0.03-0.08 mm	0.0011-0.0031 in
• Second Compression Ring	0.020-0.060 mm	0.0007-0.0024 in
• Oil Control Ring	0.06-0.19 mm	0.0024-0.0075 in
• Piston Ring Thickness		
• First Compression Ring	0.975-0.990 mm	0.0384-0.0390 in
• Second Compression Ring	1.170-1.195 mm	0.0461-0.0470 in
• Oil Control Ring	1.360-1.480 mm	0.0535-0.0583 in
Pistons and Pins		
• Piston		
• Piston Diameter - Measured Over Skirt Coating	94.976-95.014 mm	3.7392-3.7407 in

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• Piston Diameter - Service Limit Minimum w/more than 10K miles	94.926 mm	3.7372 in
• Piston Pin Bore Diameter	23.004-23.009 mm	0.9055-0.9056 in
• Piston Ring Groove Width - First Compression Ring	1.02-1.05 mm	0.0402-0.0413 in
• Piston Ring Groove Width - Second Compression Ring	1.210-1.230 mm	0.0476-0.0484 in
• Piston Ring Groove Width - Oil Control Ring	2.01-2.03 mm	0.0791-0.0799 in
• Piston to Bore Clearance - Production; Measured at Skirt Coating	0.022-0.032 mm	0.0009-0.0013 in
• Piston to Bore Clearance - Service Limit Maximum, w/more than 10k miles	0.050 mm	0.0020 in
• Pin		
• Piston Pin Clearance to Connecting Rod Bore - Production	0.007-0.020 mm	0.0002-0.0007 in
• Piston Pin Clearance to Connecting Rod Bore - Service Maximum	0.030 mm	0.0012 in
• Piston Pin Clearance to Piston Pin Bore - Production	0.004-0.012 mm	0.0002-0.0005 in
• Piston Pin Clearance to Piston Pin Bore - Service Maximum	0.015 mm	0.0006 in
• Piston Pin Diameter	22.997-23.000 mm	0.9053-0.9055 in
• Piston Pin Length	55.7-56.0 mm	2.193-2.205 in

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SPECIFICATIONS > ADHESIVES, FLUIDS, LUBRICANTS, AND SEALERS

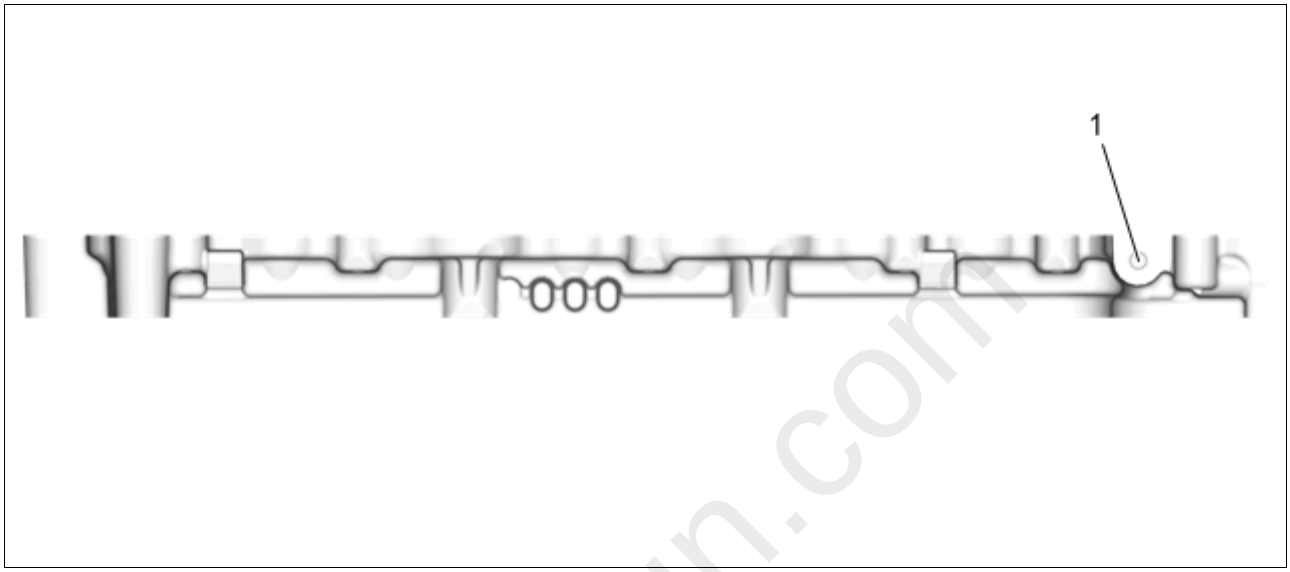
Application	Type of Material	GM Part Number	
		United States	Canada
Block Pan Rail *	Sealant	19330905	19330906
Camshaft Prelube	Lubricant	88862586	88862827
Coolant Drain Threaded Plug	Sealant	12346004	10953480
Coolant Expansion Plugs	Threadlocker	12345382	10953489
Coolant and Oil Plug Threads	Sealant	12346004	10953480
Crankshaft Bearing Surfaces	5W-30	19293000	19286321
Crankshaft Connecting Rod Bearing Journal	5W-30	19293000	19286321
Crankshaft Prelube	5W-30	19293000	19286321
Crankshaft Rear Oil Seal Housing *	Sealant	19330905	19330906
Engine Front Cover/Split Lines *	Sealant	19330905	19330906
Engine Oil	5W-30	19293000	19386321
Fuel Injection Fuel Rail Fuel Pressure Sensor Sealing Cone/Threads	5W-30	19293000	19286321
Fuel Rail Sealing Cone/Threads	5W-30	19293000	19286321
Ignition Coils	Lubricant	19260901	19260902
Oil Gallery Threaded Plug	Sealant	12346004	10953480
Oil Pan *	Sealant	19330905	19330906
Piston Pin Bores	5W-30	19293000	19286321
Positive Crankcase Ventilation (PCV) Orifice	Sealant	19330905	19330906
(SHLA)	5W-30	19293000	19286321
SHLA Bores in Cylinder Head	5W-30	19293000	19286321
SHLA Pivot Spheres	5W-30	19293000	19286321
Thread Repair	Cleaner	88862650	88901247
	Threadlocker	89021297	10953488
Thread Repair Cutting Oil	Lubricant	1052864	992881
Valve Stem/Guide ID	5W-30	19293000	19286321

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* Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant

SPECIFICATIONS > THREAD REPAIR SPECIFICATIONS > LEFT CYLINDER HEAD CAMSHAFT CARRIER LEFT FACE

Fig 1: Left Cylinder Head Camshaft Carrier Left Face



Courtesy of GENERAL MOTORS COMPANY

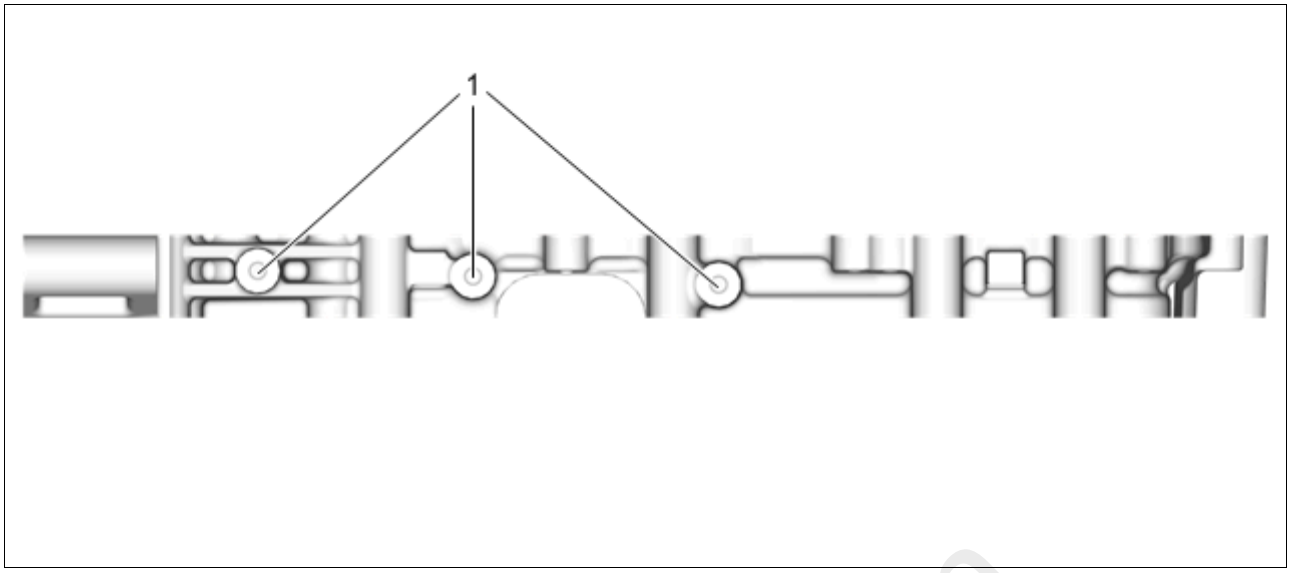
Left Cylinder Head Camshaft Carrier Left Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
		J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	63	23.0	.907	23.0	.907

SPECIFICATIONS > THREAD REPAIR SPECIFICATIONS > LEFT CYLINDER HEAD CAMSHAFT CARRIER RIGHT FACE

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Fig 1: Left Cylinder Head Camshaft Carrier Right Face



Courtesy of GENERAL MOTORS COMPANY

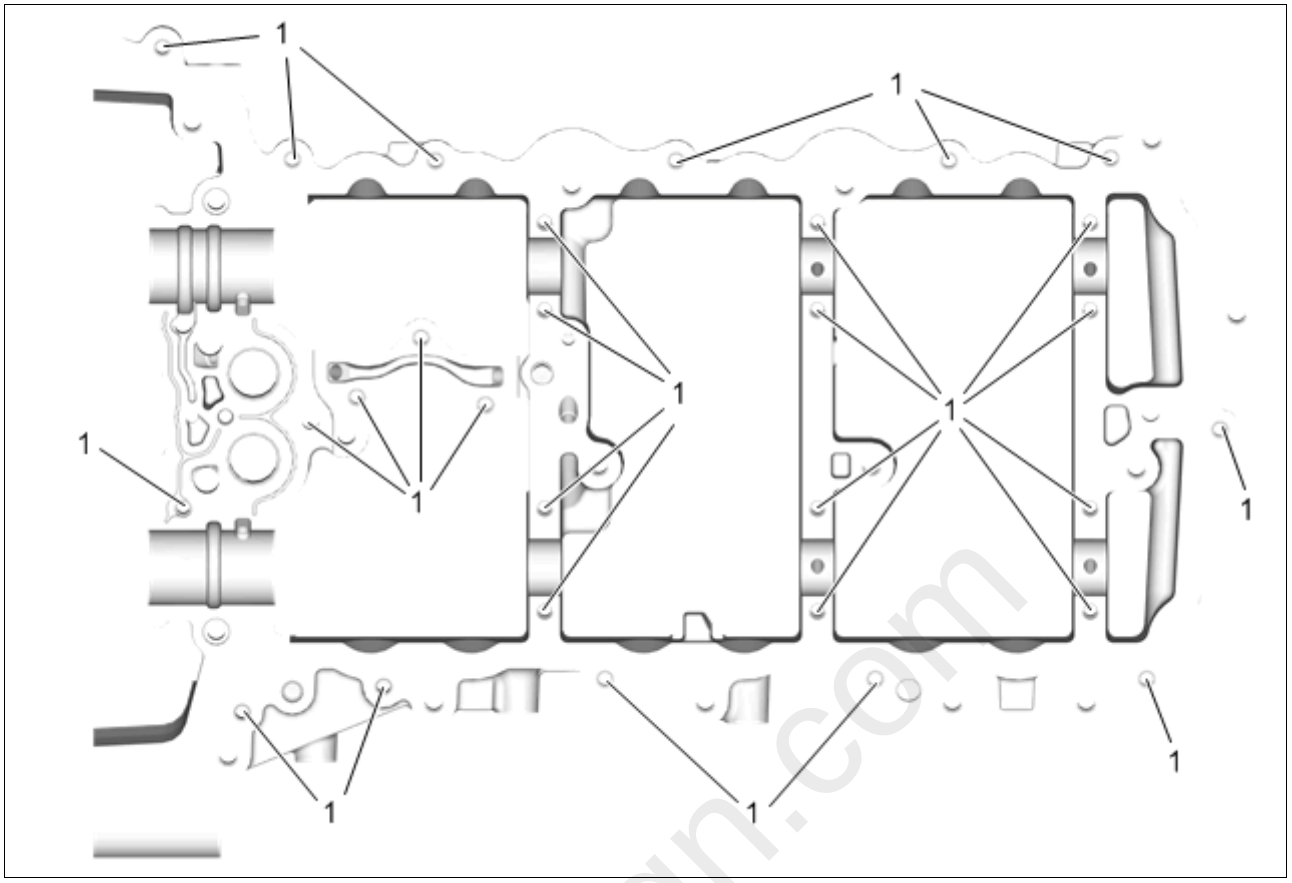
Left Cylinder Head Camshaft Carrier Right Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
		J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	63	23.0	.907	23.0	.907

SPECIFICATIONS > THREAD REPAIR SPECIFICATIONS > LEFT CYLINDER HEAD CAMSHAFT CARRIER TOP FACE

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Fig 1: Left Cylinder Head Camshaft Carrier Top Face



Courtesy of GENERAL MOTORS COMPANY

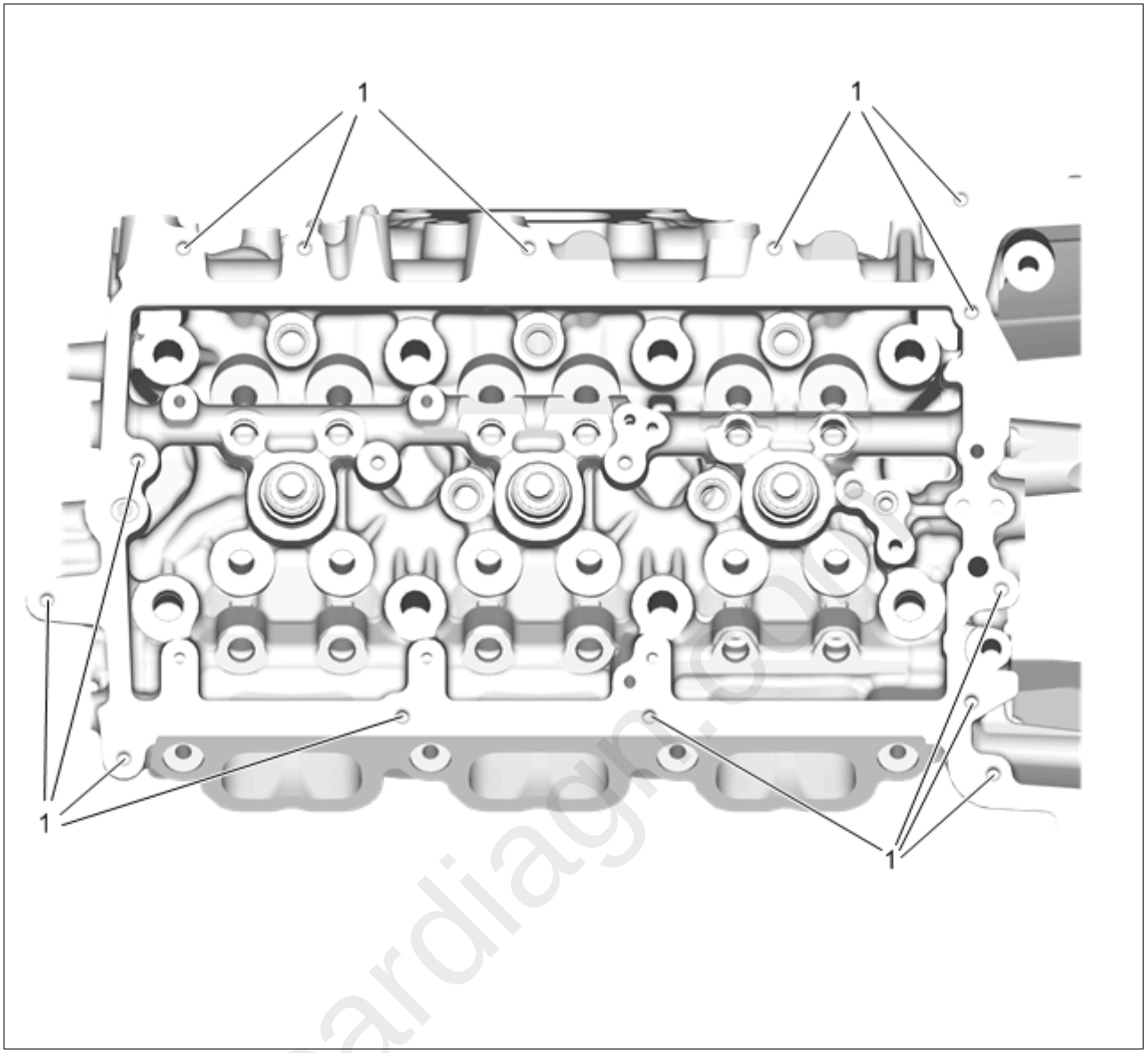
Left Cylinder Head Camshaft Carrier Top Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
		J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	63	23.0	.907	23.0	.907

SPECIFICATIONS > THREAD REPAIR SPECIFICATIONS > LEFT CYLINDER HEAD TOP FACE

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Fig 1: Left Cylinder Head Top Face



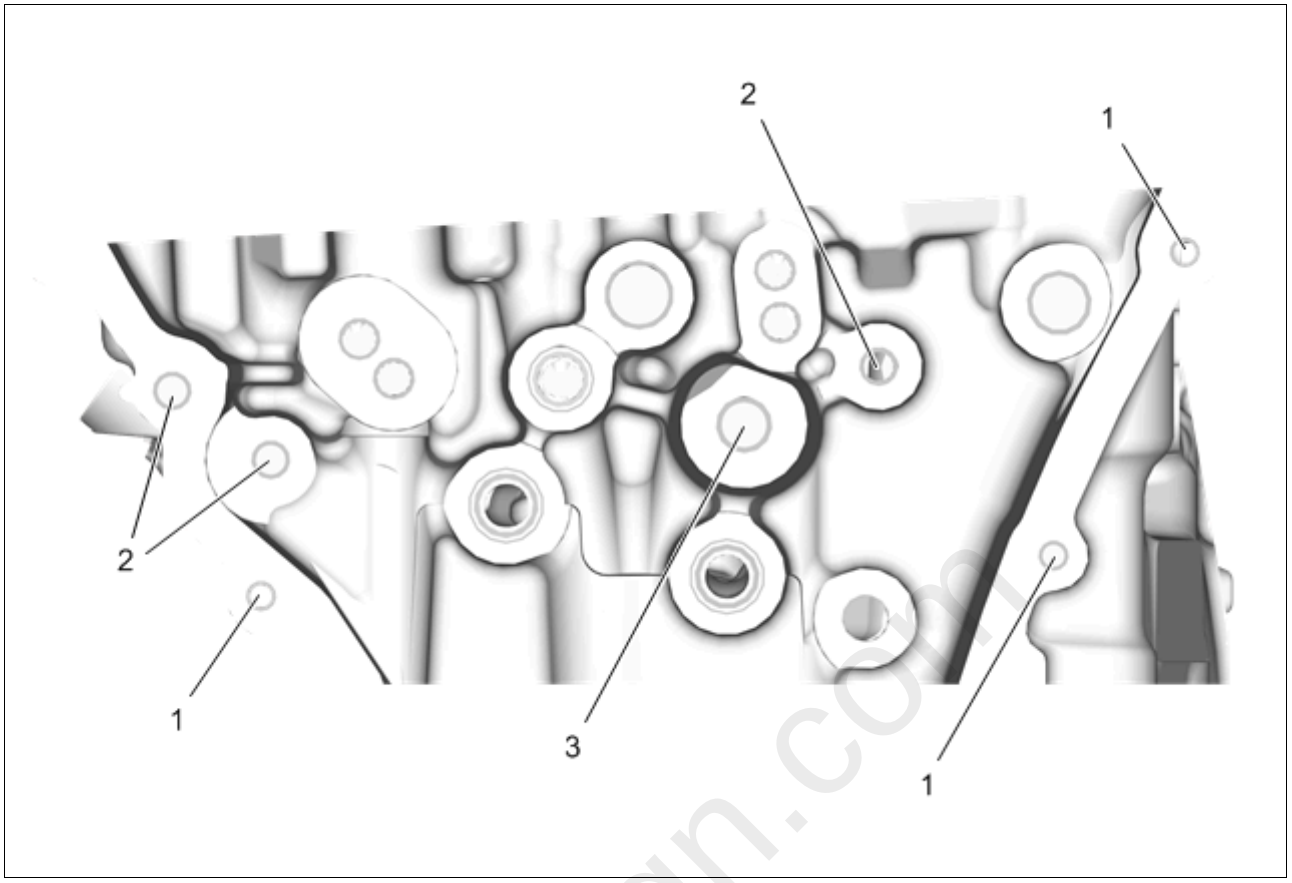
Courtesy of GENERAL MOTORS COMPANY

Left Cylinder Head Top Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
		J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	63	23.0	.907	23.0	.907

SPECIFICATIONS > THREAD REPAIR SPECIFICATIONS > LEFT CYLINDER HEAD FRONT FACE

Fig 1: Left Cylinder Head Front Face



Courtesy of GENERAL MOTORS COMPANY

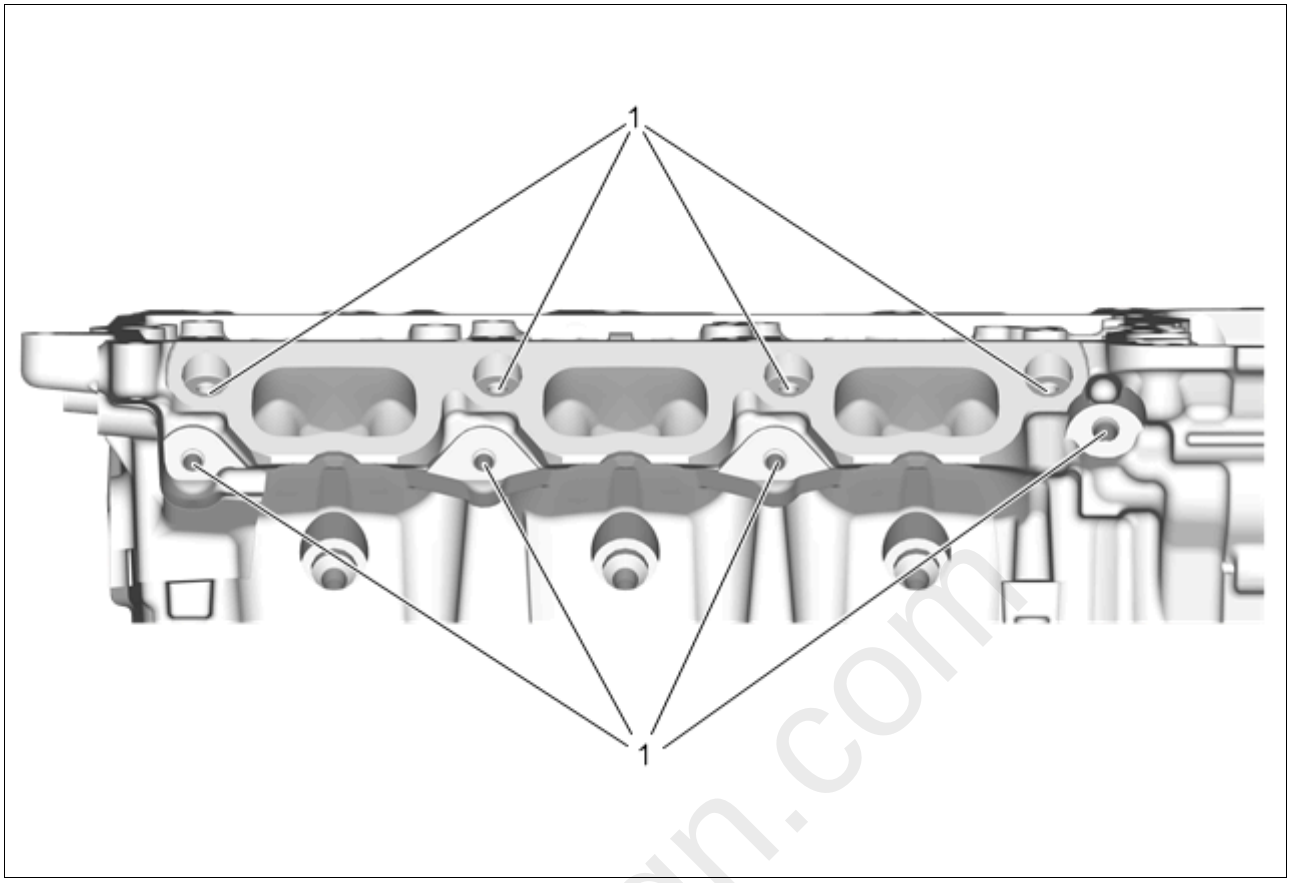
Left Cylinder Head Front Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
		J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	63	23.0	.907	23.0	.907
2	M8 x 1.25	206	207	N/A	208	209	61	29.0	1.14	29.0	1.14
3	M12 x 1.75	856	857	N/A	858	859	58	35.0	1.38	35.0	1.38

SPECIFICATIONS > THREAD REPAIR SPECIFICATIONS > LEFT CYLINDER HEAD INTAKE FACE

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Fig 1: Left Cylinder Head Intake Face



Courtesy of GENERAL MOTORS COMPANY

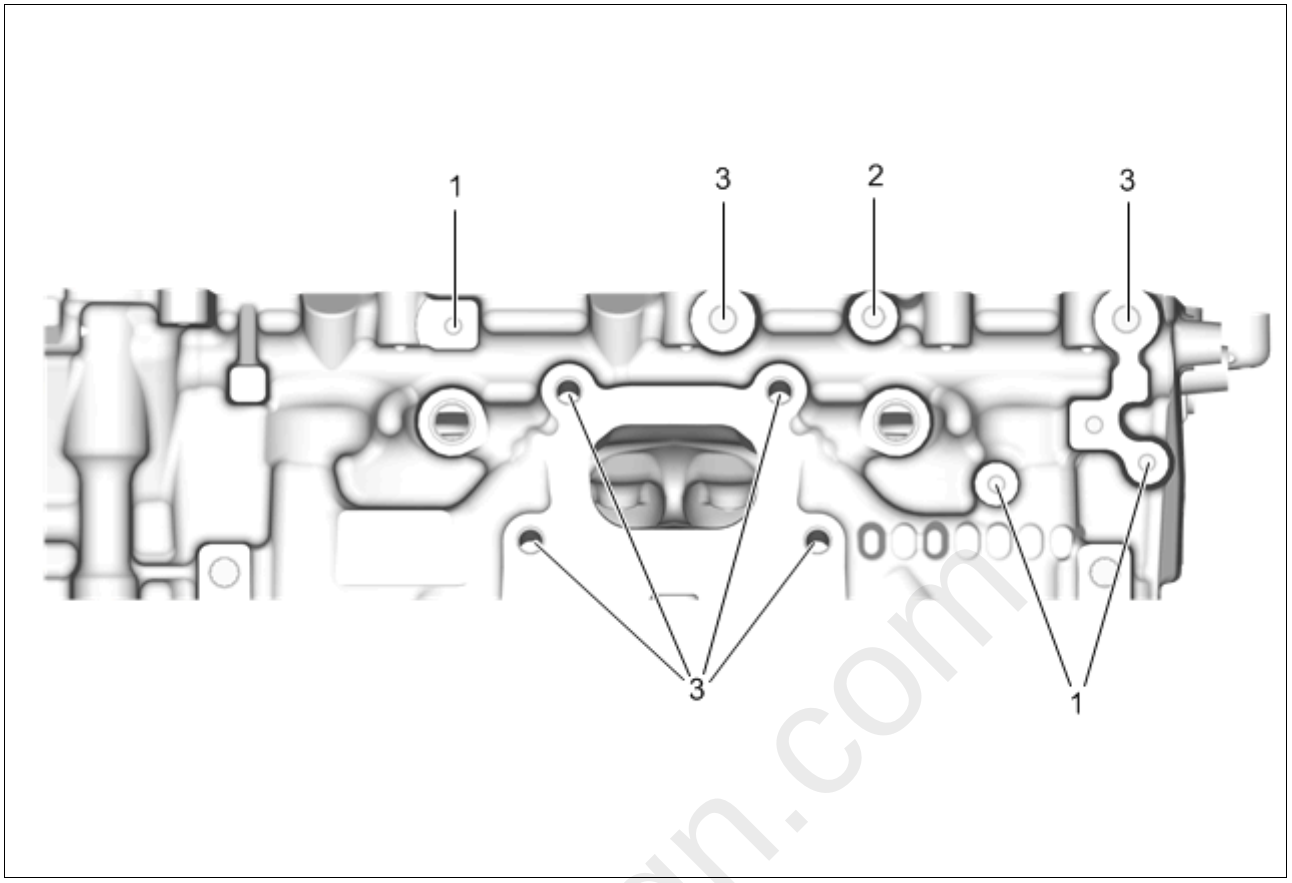
Left Cylinder Head Intake Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
		J 42385-						MM	(IN)	MM	(IN)
1	M8 x 1.25	206	207	N/A	208	209	61	29.0	1.14	29.0	1.14

SPECIFICATIONS > THREAD REPAIR SPECIFICATIONS > LEFT CYLINDER HEAD EXHAUST FACE

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Fig 1: Left Cylinder Head Exhaust Face



Courtesy of GENERAL MOTORS COMPANY

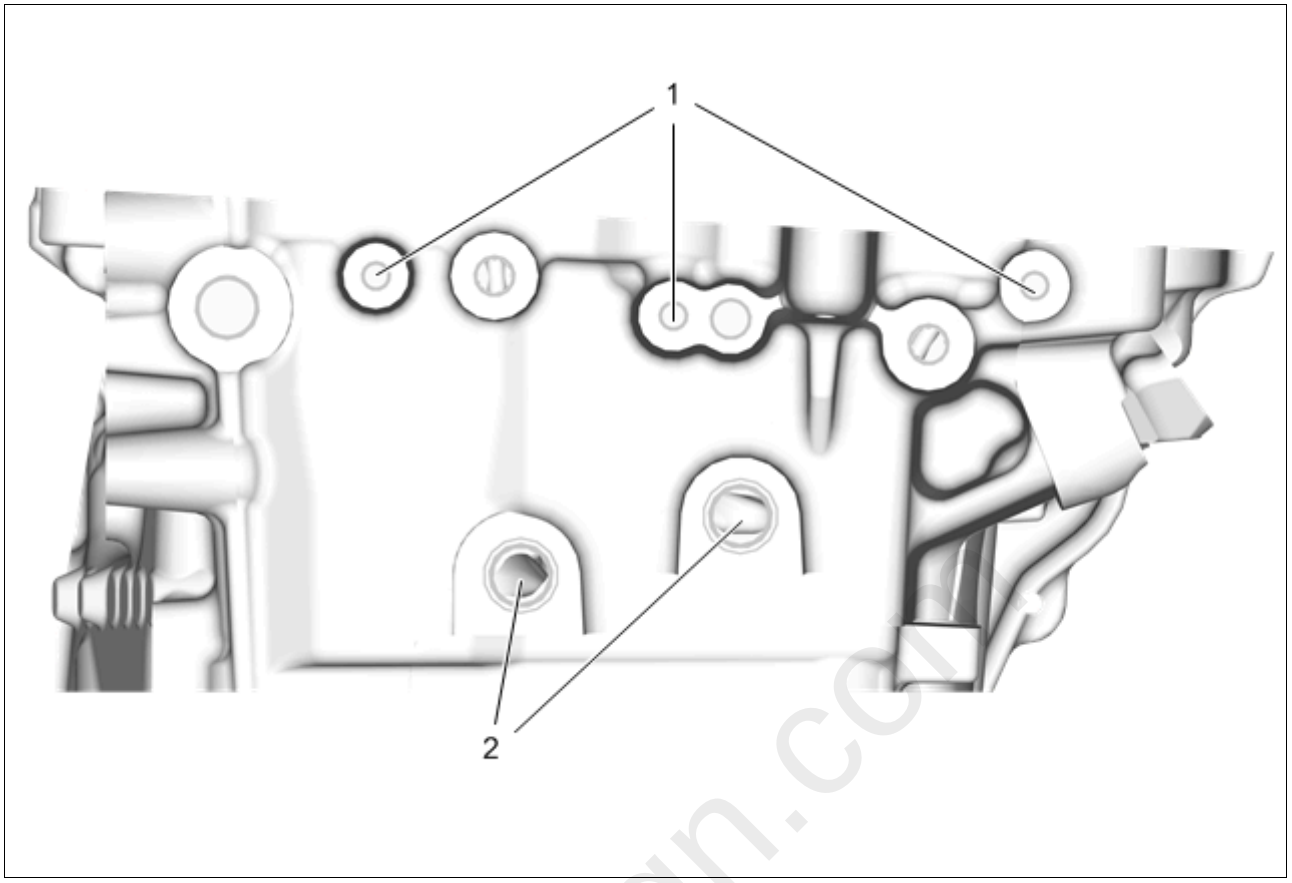
Left Cylinder Head Exhaust Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
		J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	63	23.0	.907	23.0	.907
2	M8 x 1.25	206	207	N/A	208	209	61	29.0	1.14	29.0	1.14
3	M10 x 1.5	211	212	N/A	213	214	514	34.0	1.35	34.0	1.35

SPECIFICATIONS > THREAD REPAIR SPECIFICATIONS > LEFT CYLINDER HEAD REAR FACE

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Fig 1: Left Cylinder Head Rear Face



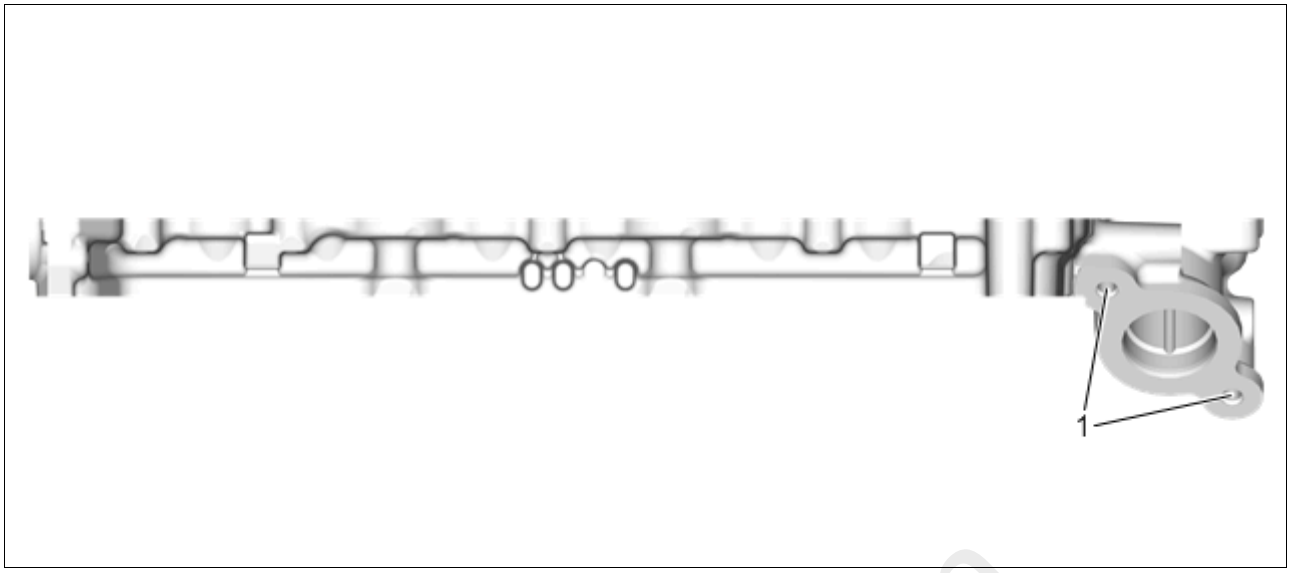
Courtesy of GENERAL MOTORS COMPANY

Left Cylinder Head Rear Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
		J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	63	23.0	.907	23.0	.907
2	14 x 1.5	409	410	N/A	411	412	735	19.0	.748	19.0	.748

SPECIFICATIONS > THREAD REPAIR SPECIFICATIONS > RIGHT CYLINDER HEAD CAMSHAFT CARRIER LEFT FACE

Fig 1: Right Cylinder Head Camshaft Carrier Left Face



Courtesy of GENERAL MOTORS COMPANY

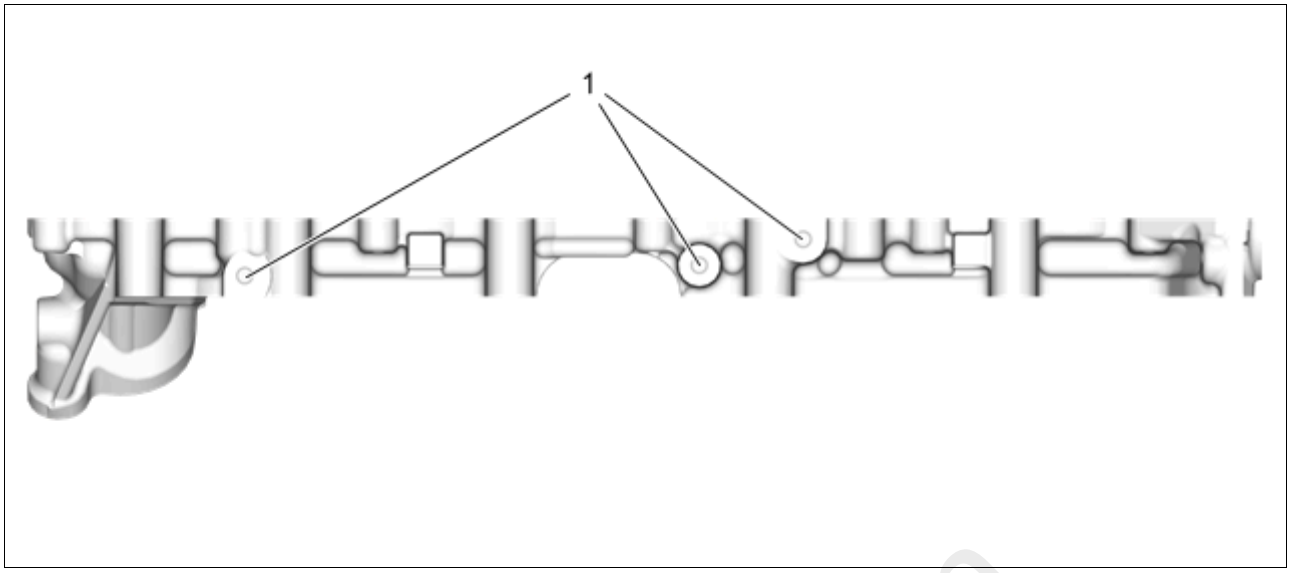
Right Cylinder Head Camshaft Carrier Left Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
		J 42385-						MM	(IN)	MM	(IN)
1	M8 x 1.25	206	207	N/A	208	209	61	29.0	1.14	29.0	1.14

SPECIFICATIONS > THREAD REPAIR SPECIFICATIONS > RIGHT CYLINDER HEAD CAMSHAFT CARRIER RIGHT FACE

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Fig 1: Right Cylinder Head Camshaft Carrier Right Face



Courtesy of GENERAL MOTORS COMPANY

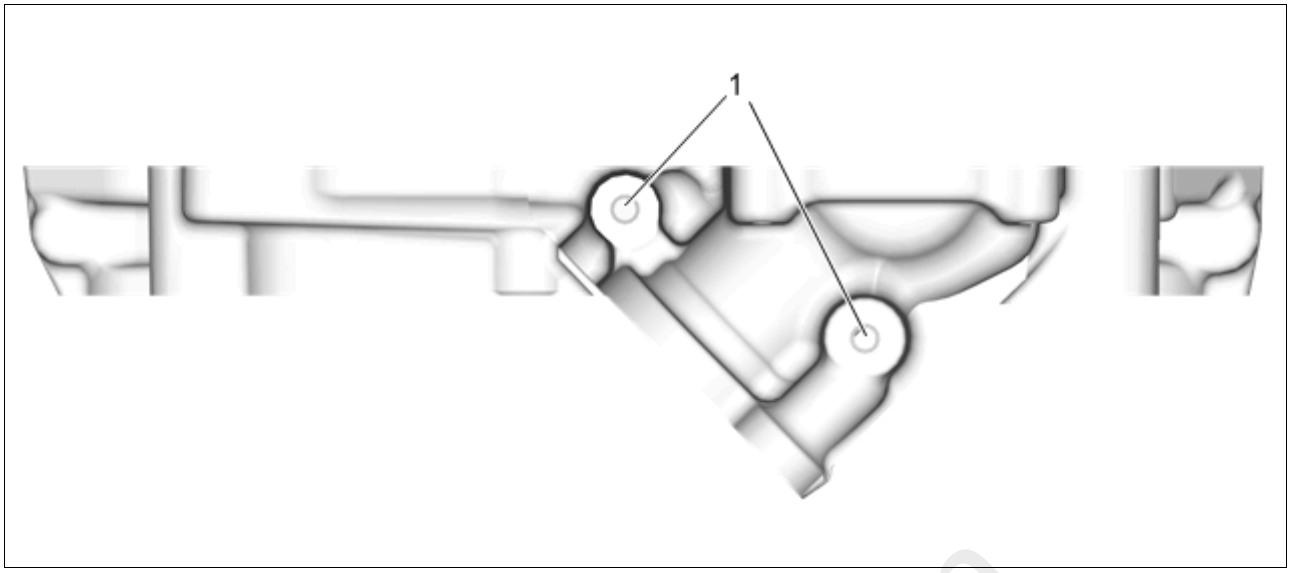
Right Cylinder Head Camshaft Carrier Right Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
		J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	63	23.0	.907	23.0	.907

SPECIFICATIONS > THREAD REPAIR SPECIFICATIONS > RIGHT CYLINDER HEAD CAMSHAFT CARRIER REAR FACE

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Fig 1: Right Cylinder Head Camshaft Carrier Rear Face



Courtesy of GENERAL MOTORS COMPANY

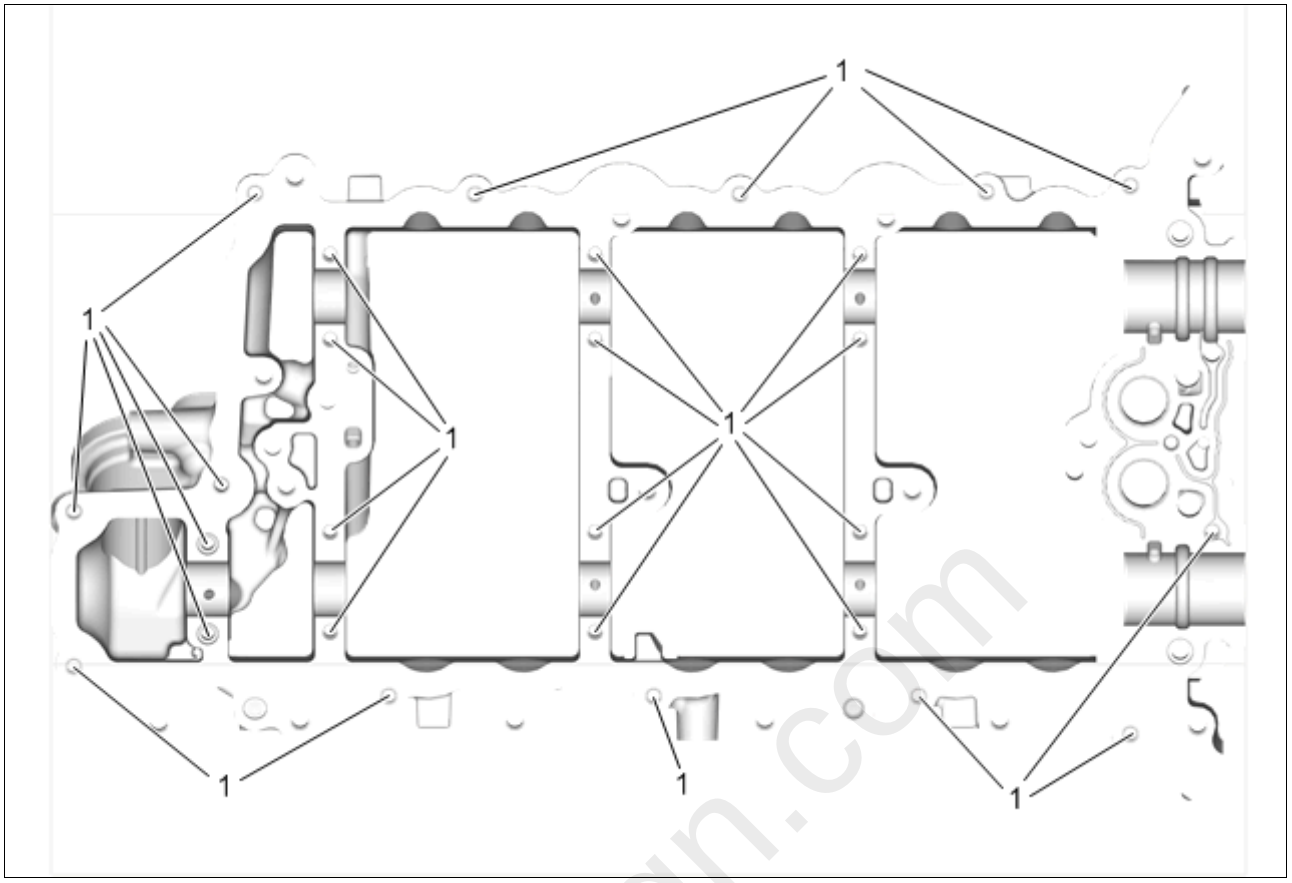
Right Cylinder Head Camshaft Carrier Rear Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
		J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	63	23.0	.907	23.0	.907

SPECIFICATIONS > THREAD REPAIR SPECIFICATIONS > RIGHT CYLINDER HEAD CAMSHAFT CARRIER TOP FACE

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Fig 1: Right Cylinder Head Camshaft Carrier Top Face



Courtesy of GENERAL MOTORS COMPANY

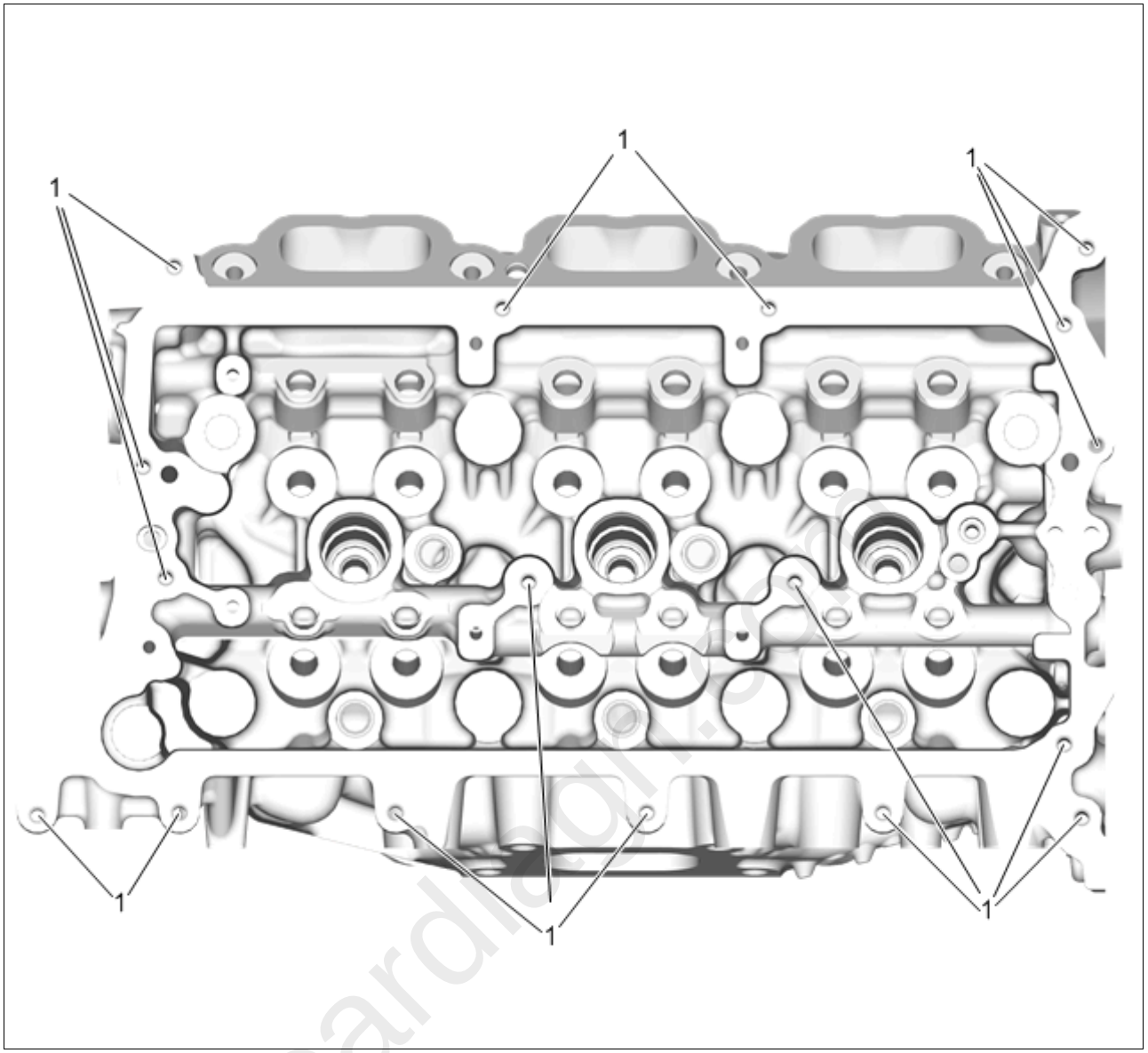
Right Cylinder Head Camshaft Carrier Top Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
		J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	63	23.0	.907	23.0	.907

SPECIFICATIONS > THREAD REPAIR SPECIFICATIONS > RIGHT CYLINDER HEAD TOP FACE

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Fig 1: Right Cylinder Head Top Face



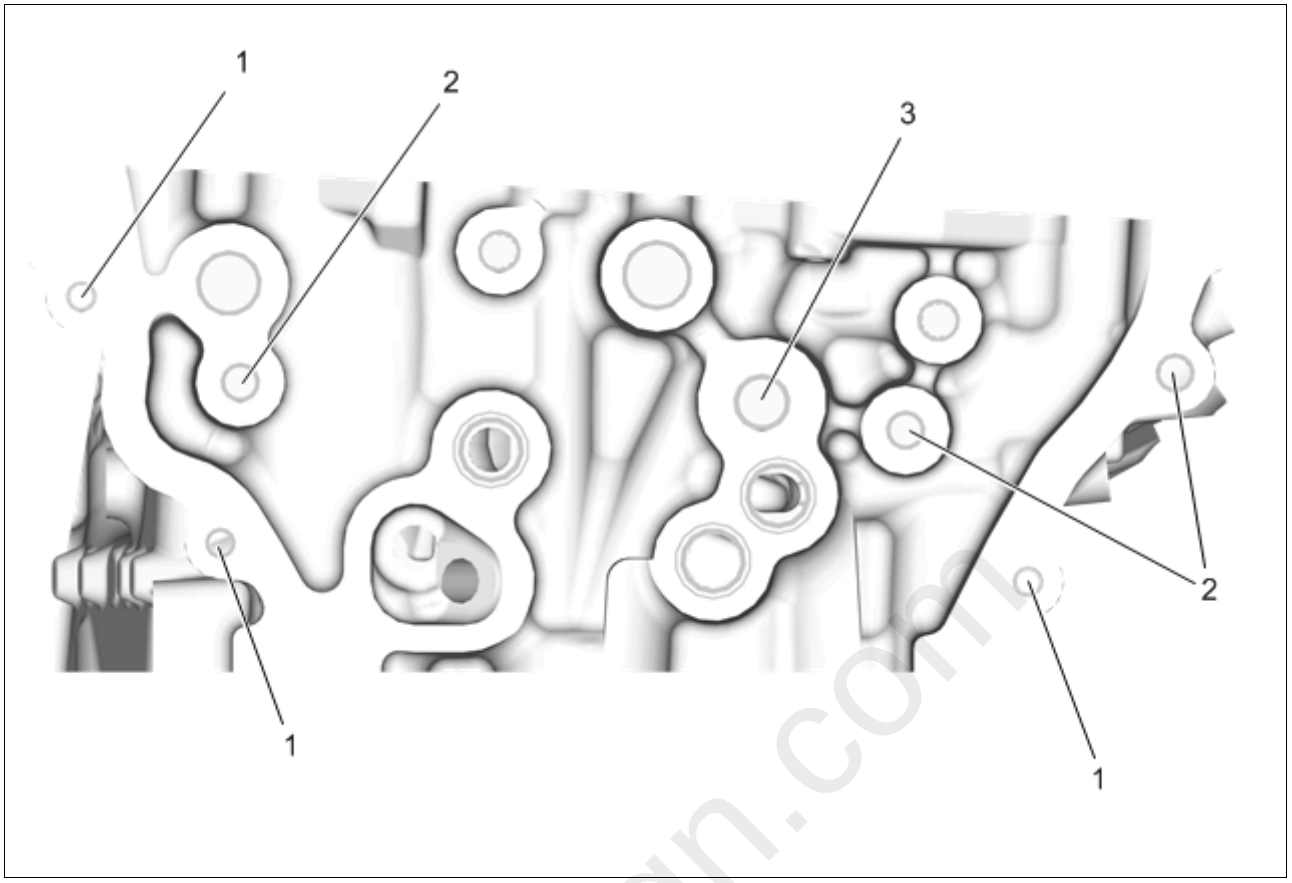
Courtesy of GENERAL MOTORS COMPANY

Right Cylinder Head Top Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
		J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	63	23.0	.907	23.0	.907

SPECIFICATIONS > THREAD REPAIR SPECIFICATIONS > RIGHT CYLINDER HEAD FRONT FACE

Fig 1: Right Cylinder Head Front Face



Courtesy of GENERAL MOTORS COMPANY

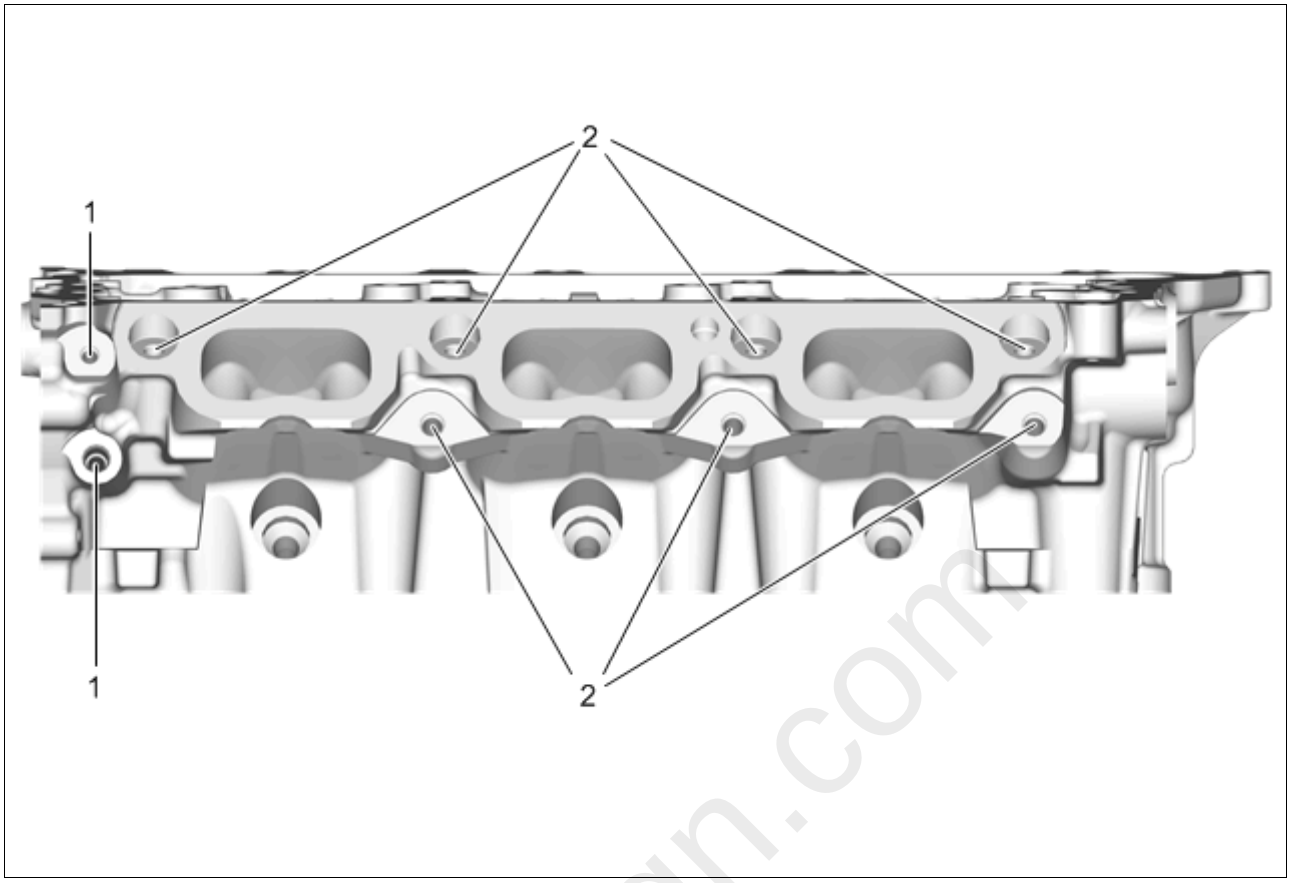
Right Cylinder Head Front Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
		J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	63	23.0	.907	23.0	.907
2	M8 x 1.25	206	207	N/A	208	209	61	29.0	1.14	29.0	1.14
3	M12 x 1.75	856	857	N/A	858	859	58	35.0	1.38	35.0	1.38

SPECIFICATIONS > THREAD REPAIR SPECIFICATIONS > RIGHT CYLINDER HEAD INTAKE FACE

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Fig 1: Right Cylinder Head Intake Face



Courtesy of GENERAL MOTORS COMPANY

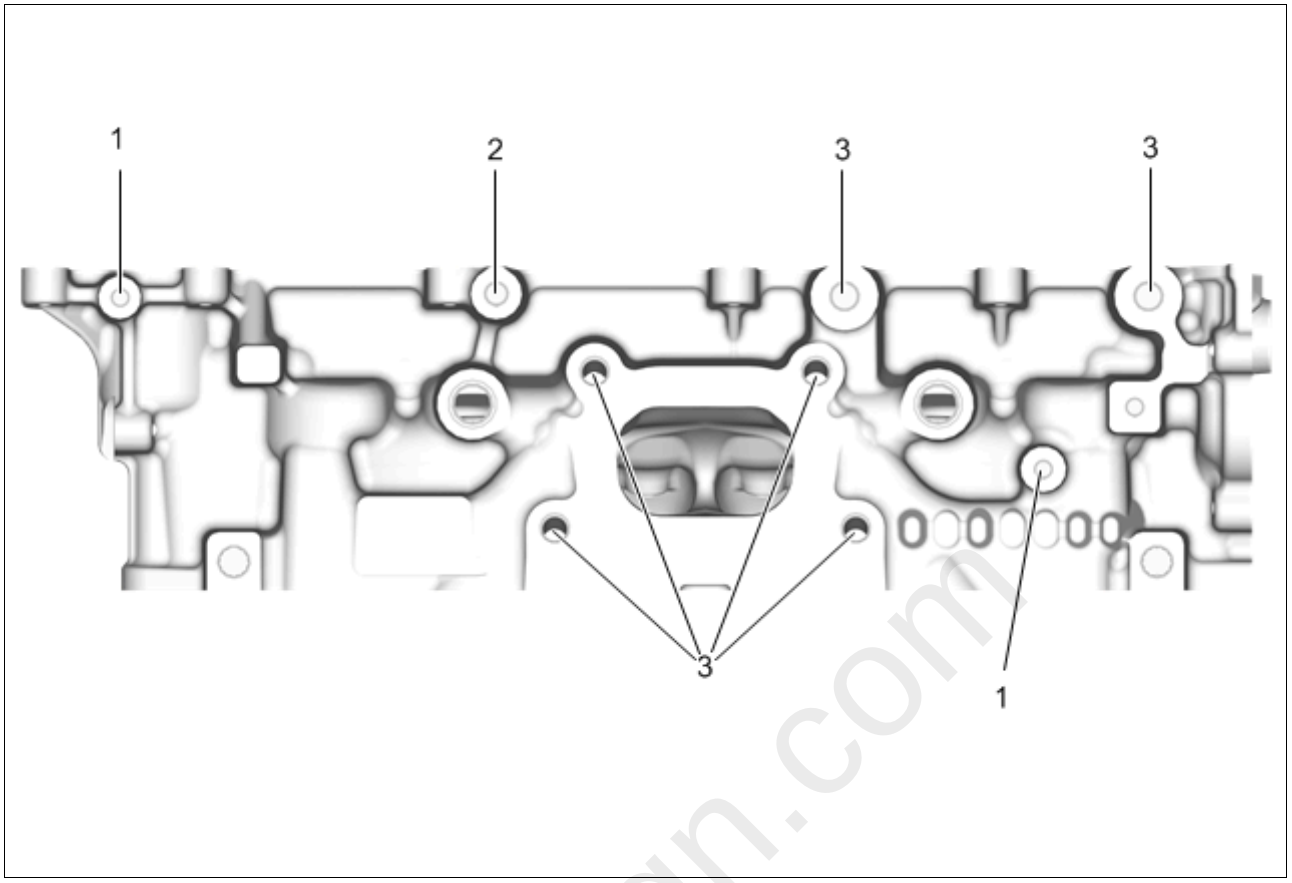
Right Cylinder Head Intake Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
		J 42385-						MM	(IN)	MM	(IN)
1	M6 x1.0	201	202	N/A	203	204	63	23.0	.907	23.0	.907
2	M8 x 1.25	206	207	N/A	208	209	61	29.0	1.14	29.0	1.14

SPECIFICATIONS > THREAD REPAIR SPECIFICATIONS > RIGHT CYLINDER HEAD EXHAUST FACE

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Fig 1: Right Cylinder Head Exhaust Face



Courtesy of GENERAL MOTORS COMPANY

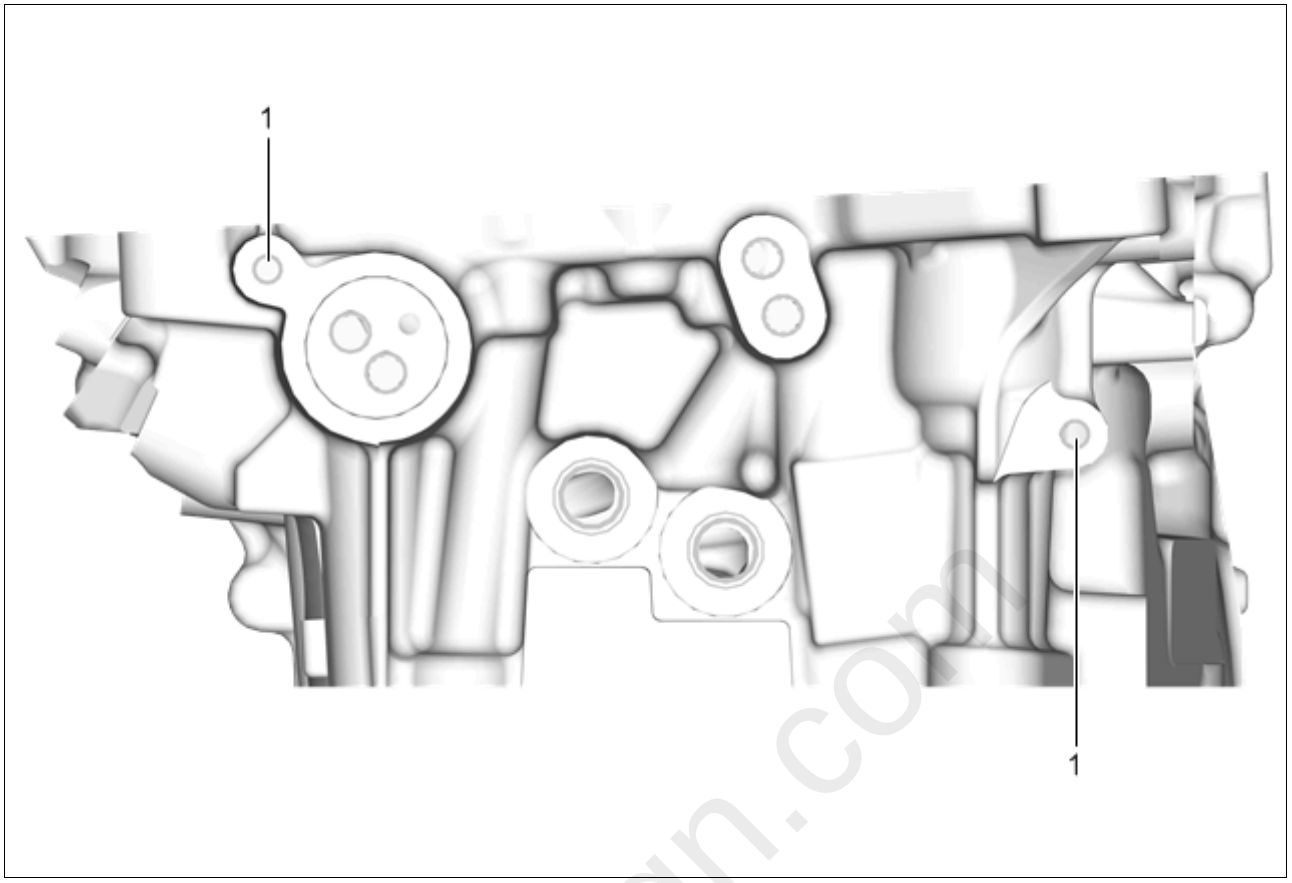
Right Cylinder Head Exhaust Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
		J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	63	23.0	.907	23.0	.907
2	M8 x 1.25	206	207	N/A	208	209	61	29.0	1.14	29.0	1.14
3	M10 x 1.5	211	212	N/A	213	214	514	34.0	1.35	34.0	1.35

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SPECIFICATIONS > THREAD REPAIR SPECIFICATIONS > RIGHT CYLINDER HEAD REAR FACE

Fig 1: Right Cylinder Head Rear Face



Courtesy of GENERAL MOTORS COMPANY

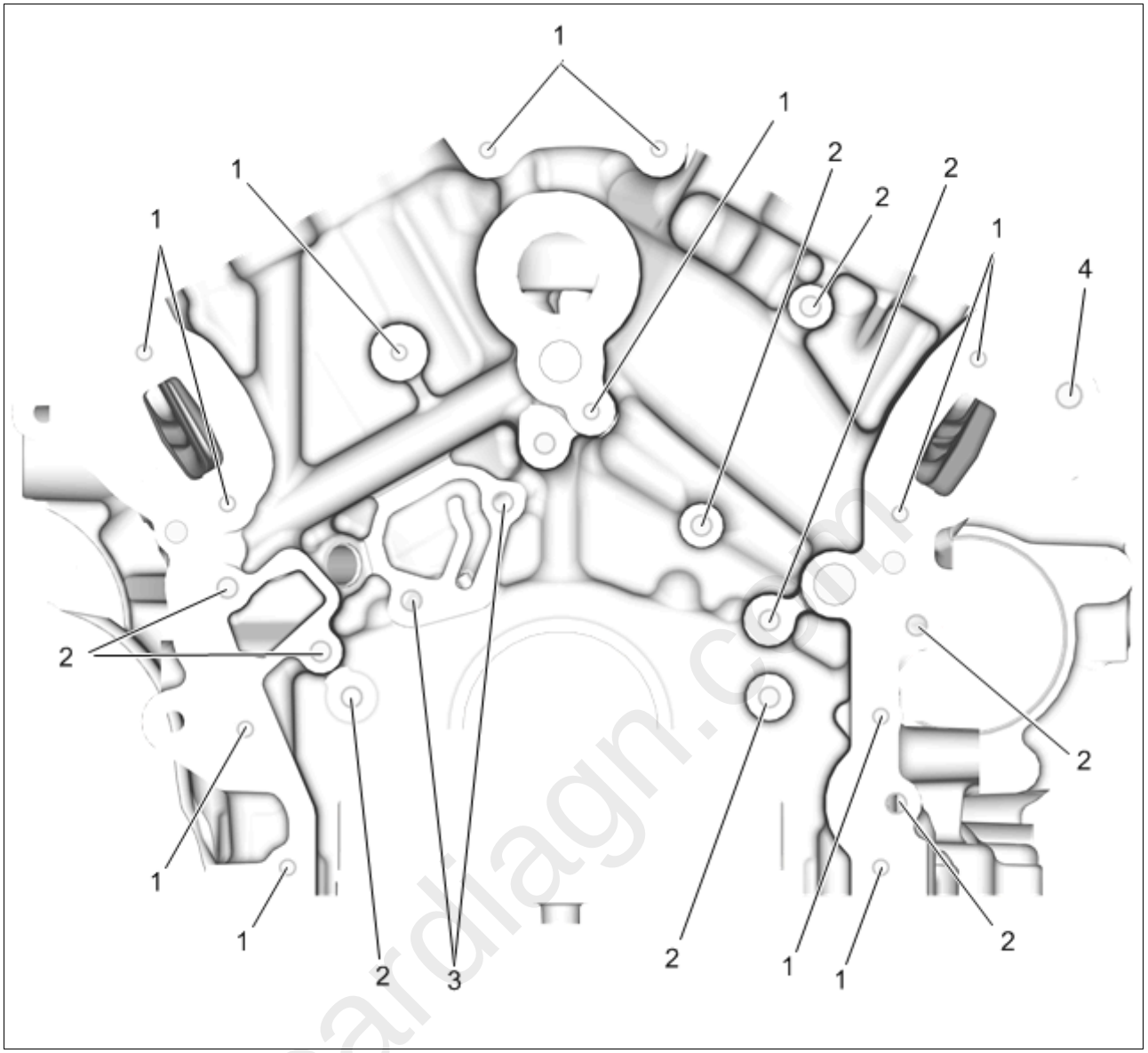
Right Cylinder Head Rear Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
		J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	63	23.0	.907	23.0	.907

SPECIFICATIONS > THREAD REPAIR SPECIFICATIONS > ENGINE BLOCK FRONT FACE

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Fig 1: Engine Block Front Face



Courtesy of GENERAL MOTORS COMPANY

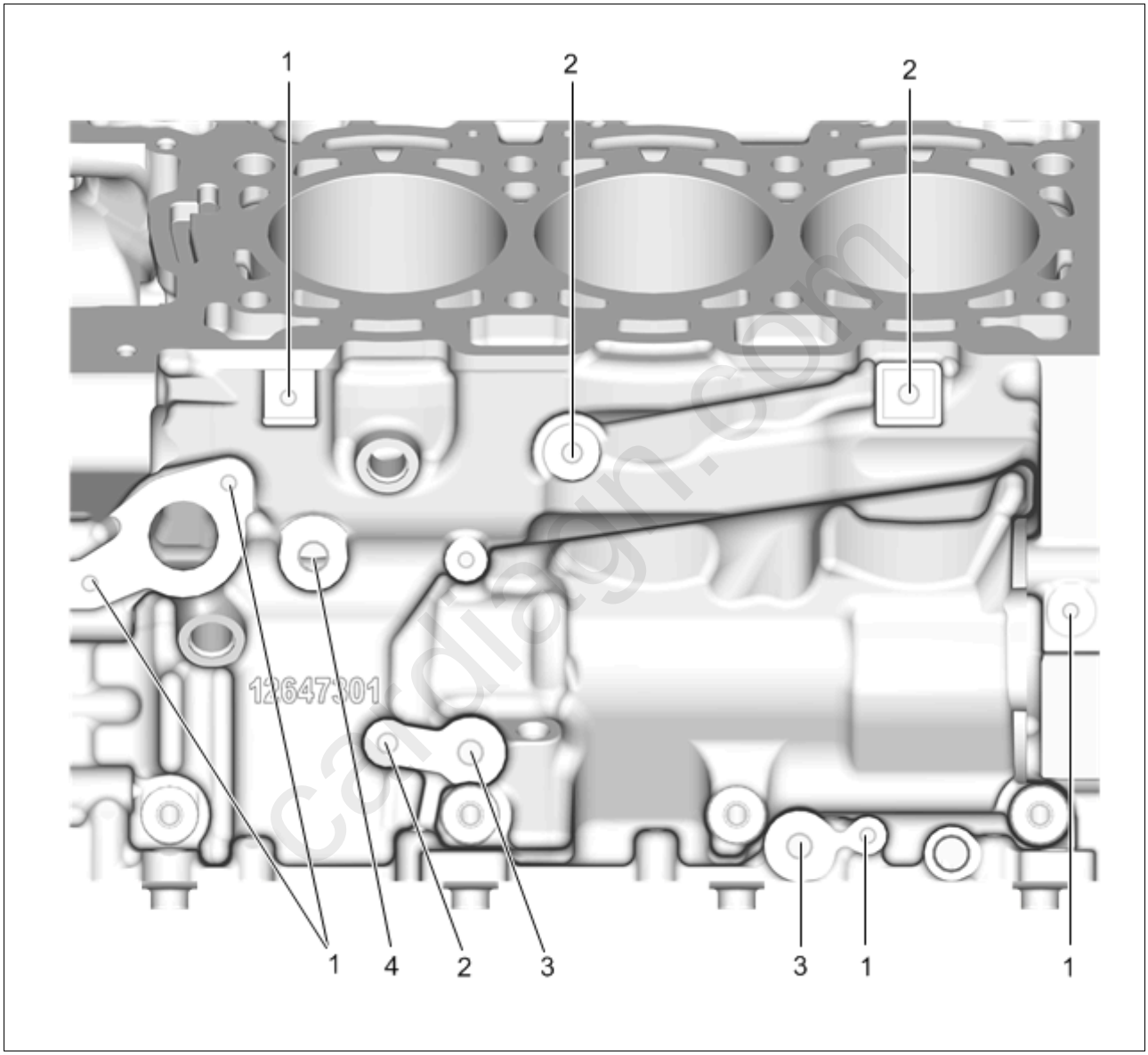
Engine Block Front Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
		J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	63	23.0	.907	23.0	.907
2	M8 x 1.25	206	207	N/A	208	209	61	29.0	1.14	29.0	1.14
3	M8 x 1.25	206	207	N/A	208	209	210	23.0	.905	23.0	.905

4	M10 x 1.5	211	212	N/A	213	214	215	34.0	1.35	34.0	1.35

SPECIFICATIONS > THREAD REPAIR SPECIFICATIONS > ENGINE BLOCK LEFT FACE

Fig 1: Engine Block Left Face



Courtesy of GENERAL MOTORS COMPANY

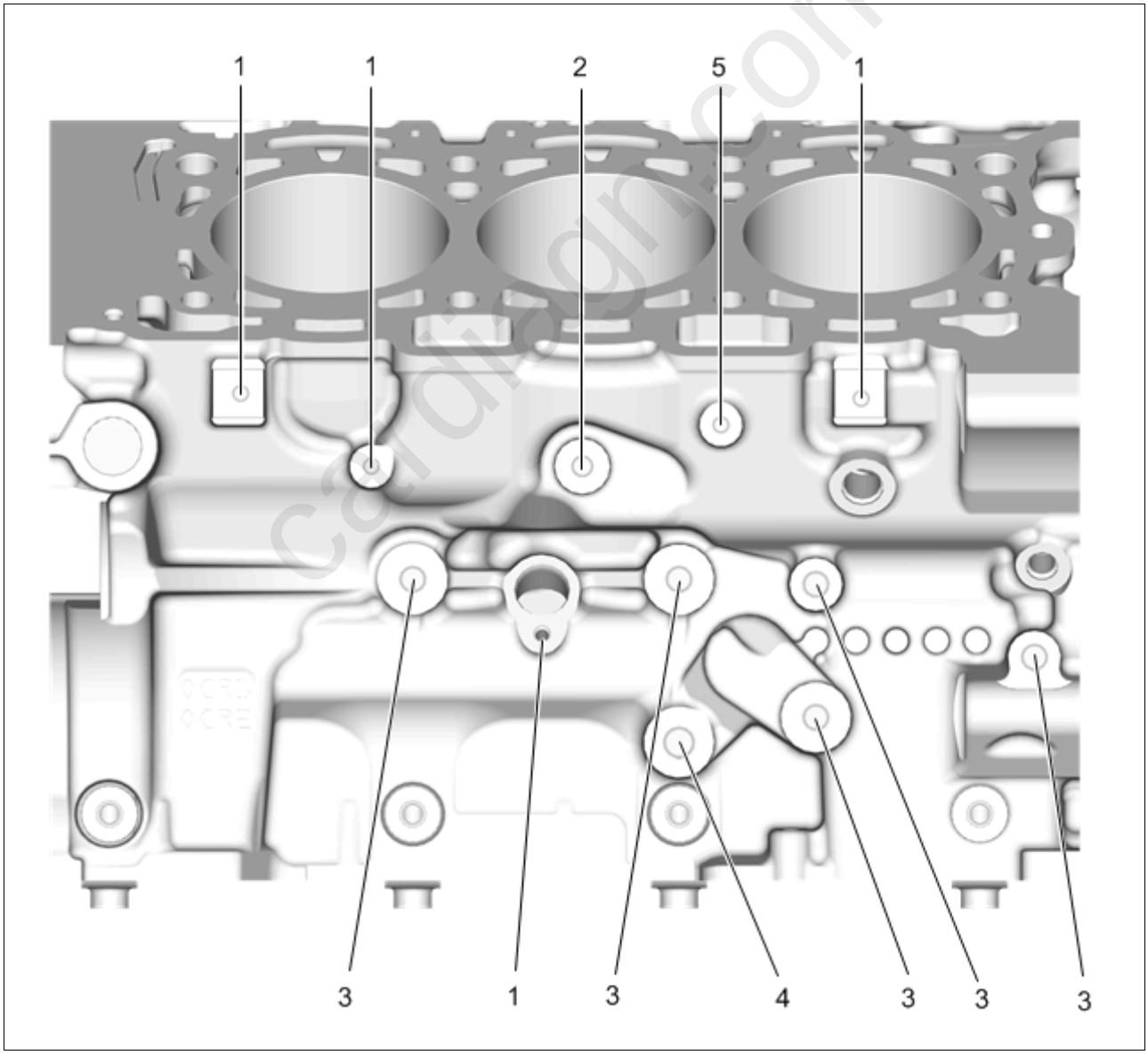
Engine Block Left Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)	Tap Depth (Minimum)

		J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	210	202	N/A	203	204	205	18.0	.709	18.0	.709
2	M8 x 1.25	206	207	N/A	208	209	61	29.0	1.14	29.0	1.14
3	M10 x 1.5	211	212	N/A	213	214	215	34.0	1.35	34.0	1.35
4	M12 x 1.75	856	857	N/A	858	859	416	23.0	.905	23.0	.905

SPECIFICATIONS > THREAD REPAIR SPECIFICATIONS > ENGINE BLOCK RIGHT FACE

Fig 1: Engine Block Right Face



Courtesy of GENERAL MOTORS COMPANY

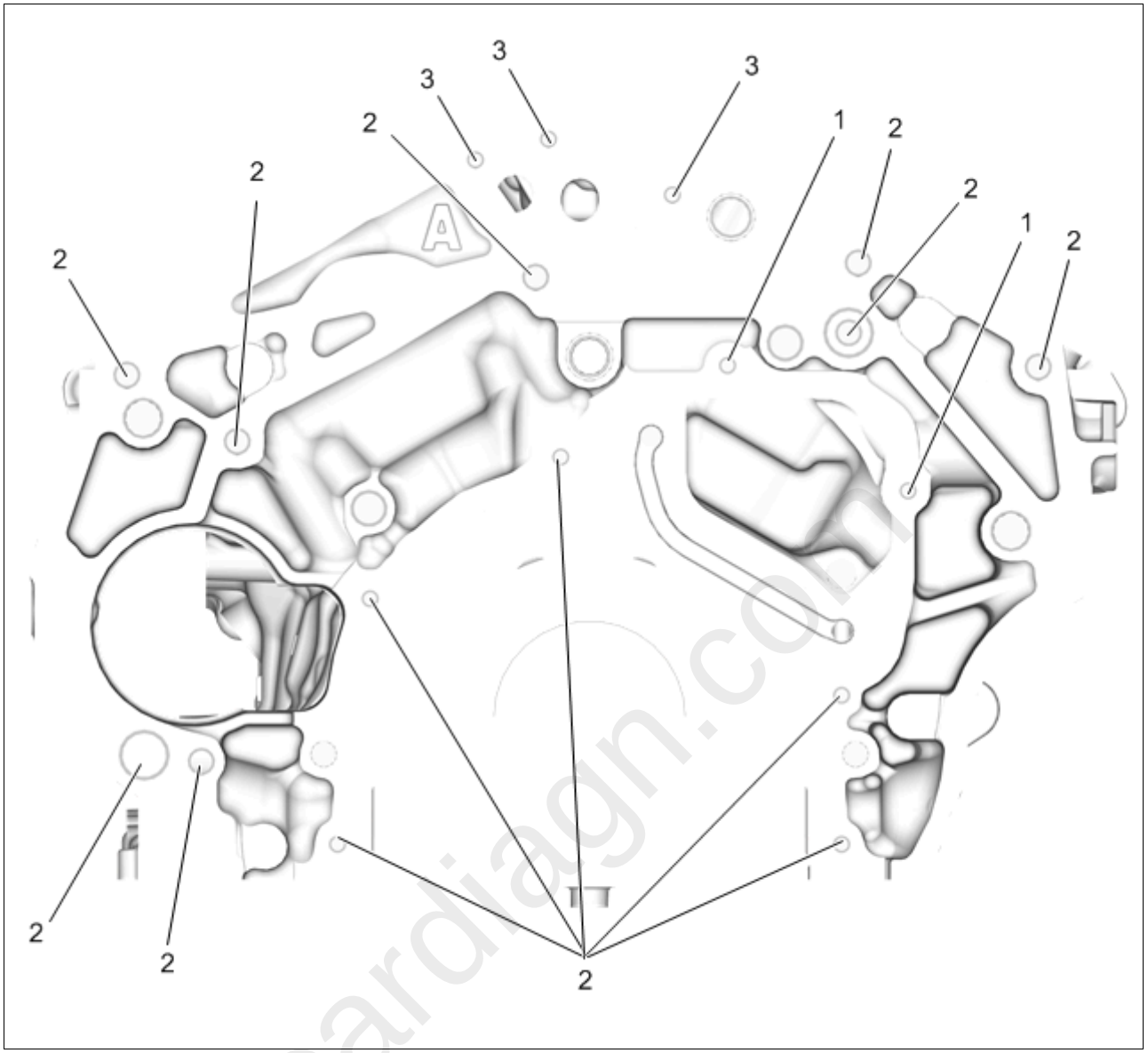
Engine Block Right Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
		J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	210	202	N/A	203	204	63	23.0	.907	23.0	.907
2	M8 x 1.25	206	207	N/A	208	209	61	29.0	1.14	29.0	1.14
3	M10 x 1.5	211	212	N/A	213	214	215	34.0	1.35	34.0	1.35
4	M12 x 1.75	856	857	N/A	858	859	416	23.0	.905	23.0	.905
5	M6 x 1.0	210	202	N/A	203	204	205	18.0	.709	18.0	.709

SPECIFICATIONS > THREAD REPAIR SPECIFICATIONS > ENGINE BLOCK REAR FACE

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Fig 1: Engine Block Rear Face



Courtesy of GENERAL MOTORS COMPANY

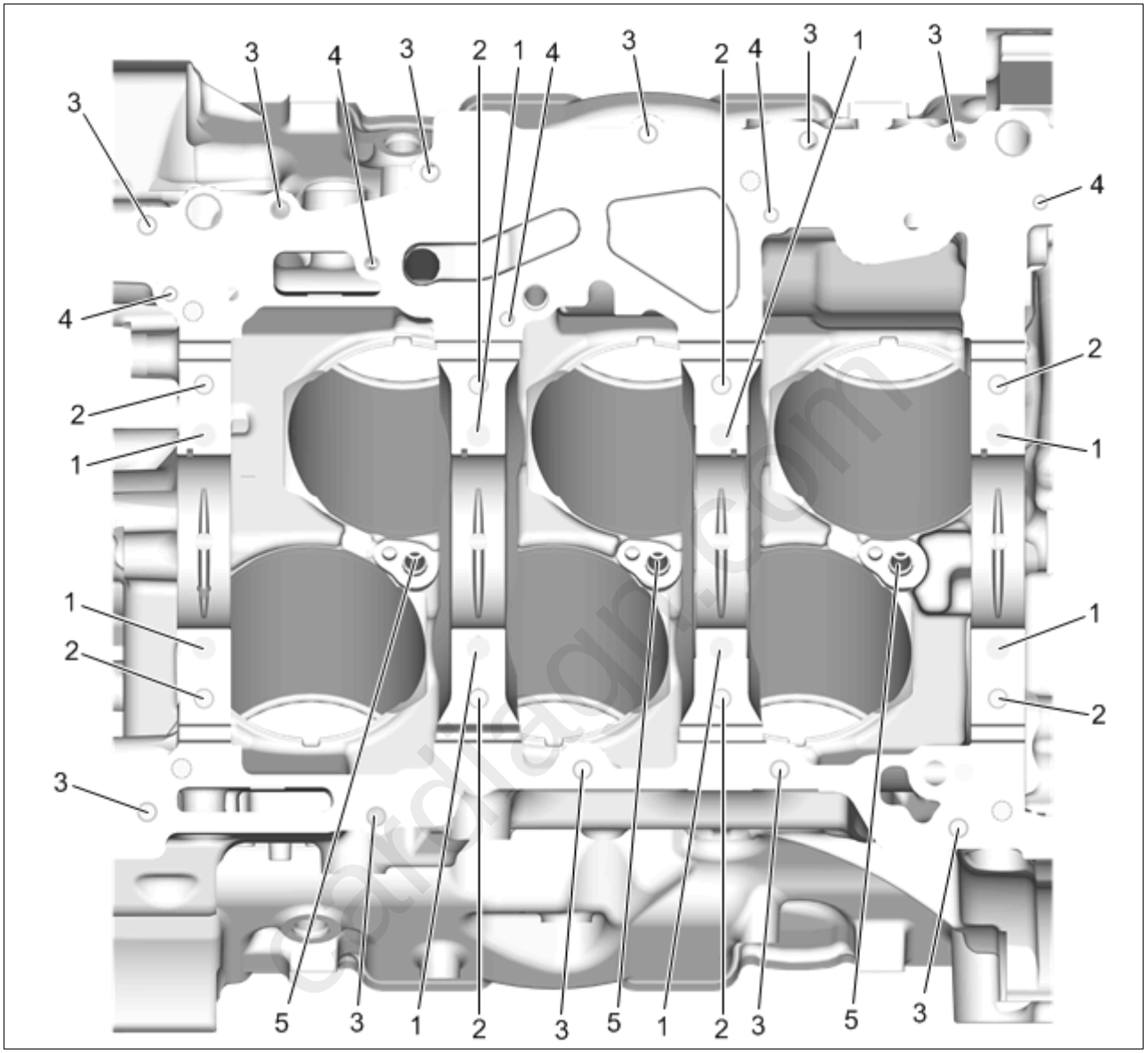
Engine Block Rear Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
		J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	210	202	N/A	203	204	205	18.0	.709	18.0	.709
2	M10 x 1.5	211	212	N/A	213	214	215	34.0	1.35	34.0	1.35
3	M6 x 1.0	210	202	N/A	203	204	63	23.0	.907	23.0	.907

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SPECIFICATIONS > THREAD REPAIR SPECIFICATIONS > ENGINE BLOCK BOTTOM FACE

Fig 1: Engine Block Bottom Face



Courtesy of GENERAL MOTORS COMPANY

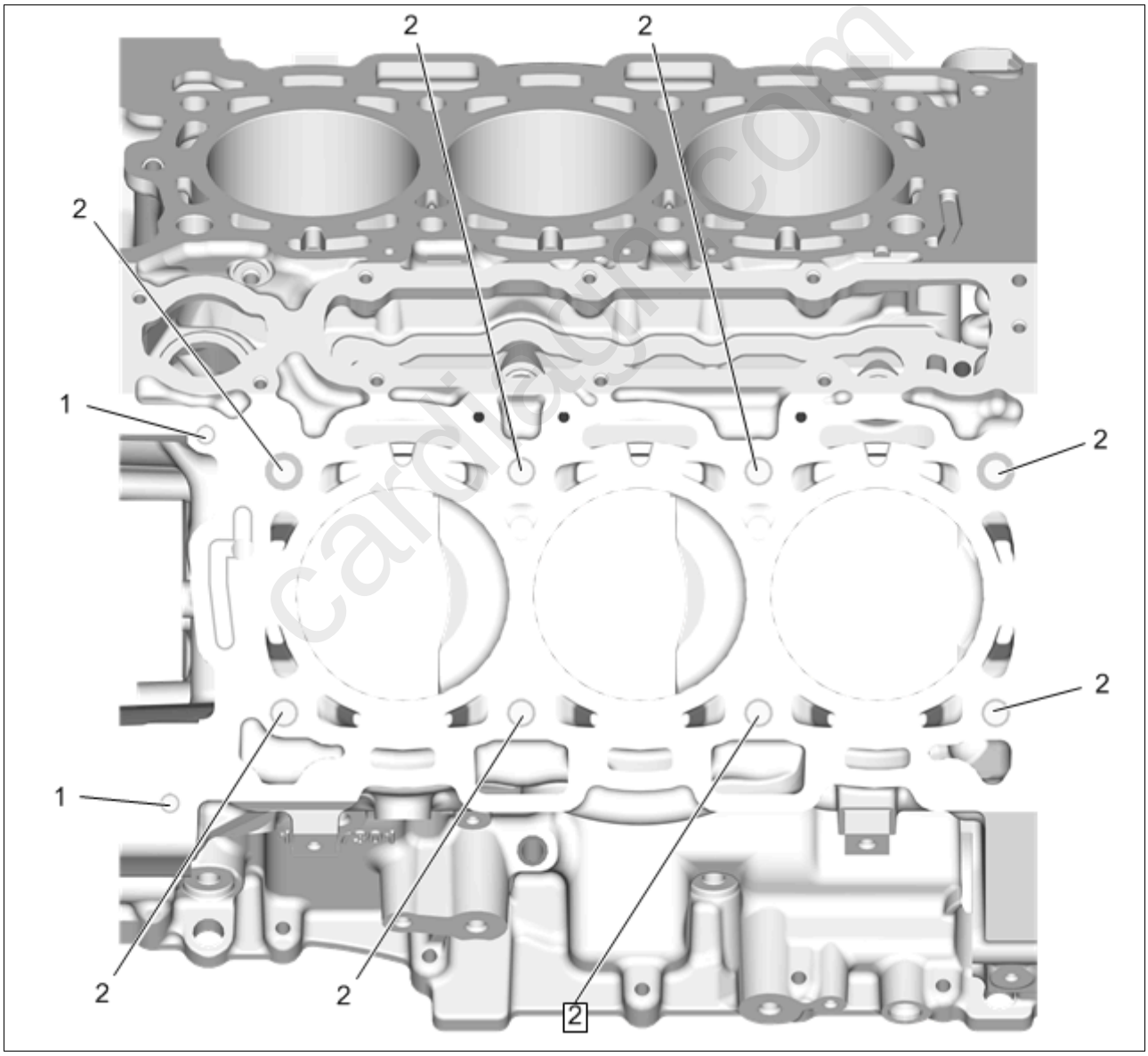
Engine Block Bottom Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
		J 42385-						MM	(IN)	MM	(IN)
1	M10 x 2.0	101	N/A	N/A	102	103	104	52.0	2.047	52.0	2.047

2	M8 x 1.25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3	M8 x 1.25	206	207	N/A	208	209	61	29.0	1.14	29.0	1.14
4	M6 x 1.0	210	202	N/A	203	204	205	18.0	.709	18.0	.709
5	M10 x 1.5	211	212	N/A	213	214	215	34.0	1.35	34.0	1.35

SPECIFICATIONS > THREAD REPAIR SPECIFICATIONS > ENGINE BLOCK LEFT DECK FACE

Fig 1: Engine Block Left Deck Face



Courtesy of GENERAL MOTORS COMPANY

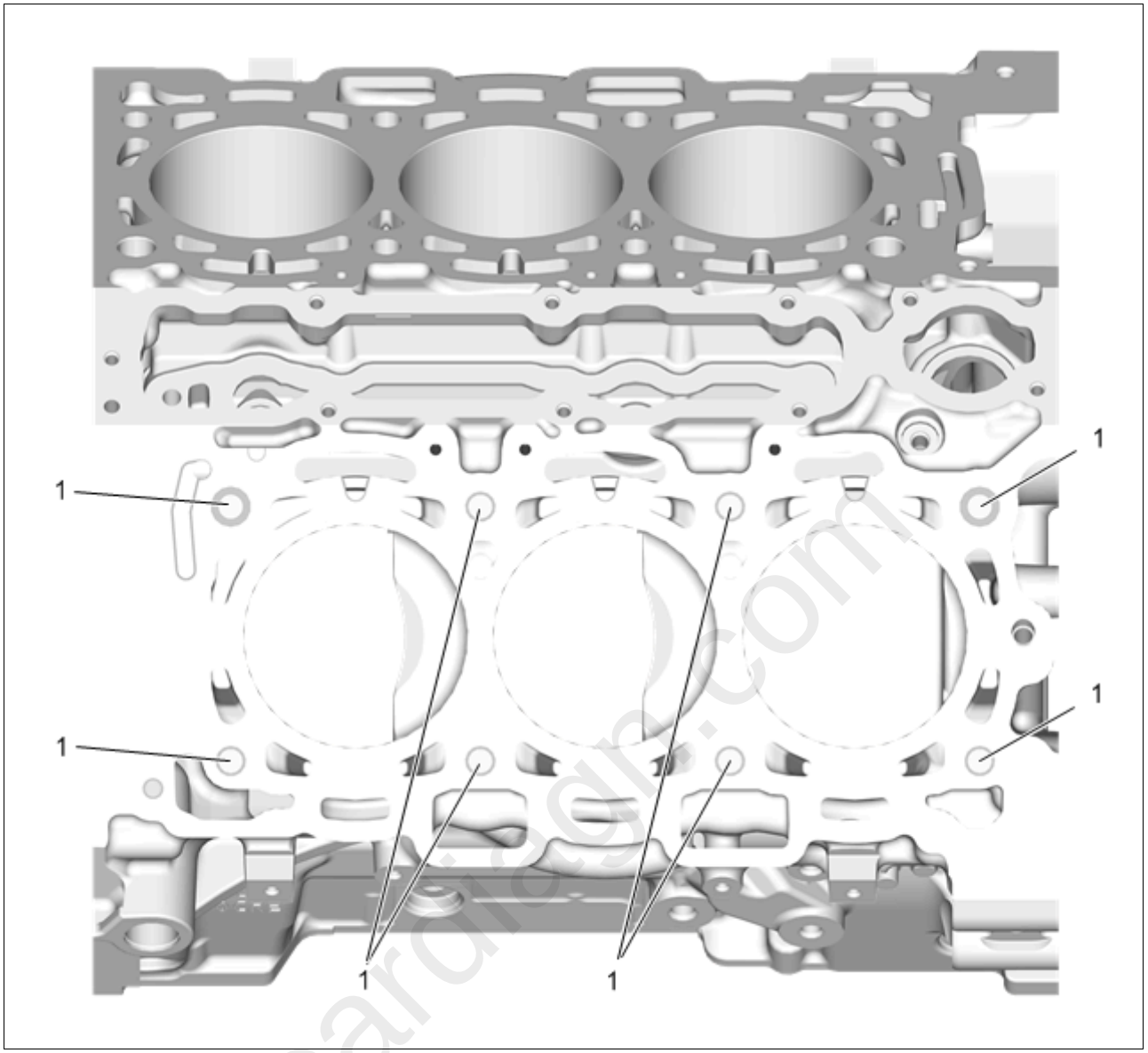
Engine Block Left Deck Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
		J 42385-						MM	(IN)	MM	(IN)
1	M8 x 1.25	206	207	N/A	208	209	61	29.0	1.14	29.0	1.14
2	M12 x 1.75	EN-51	N/A	N/A	EN-52	EN-53	EN-58	29.0	1.14	29.0	1.14

SPECIFICATIONS > THREAD REPAIR SPECIFICATIONS > ENGINE BLOCK RIGHT DECK FACE

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Fig 1: Engine Block Right Deck Face



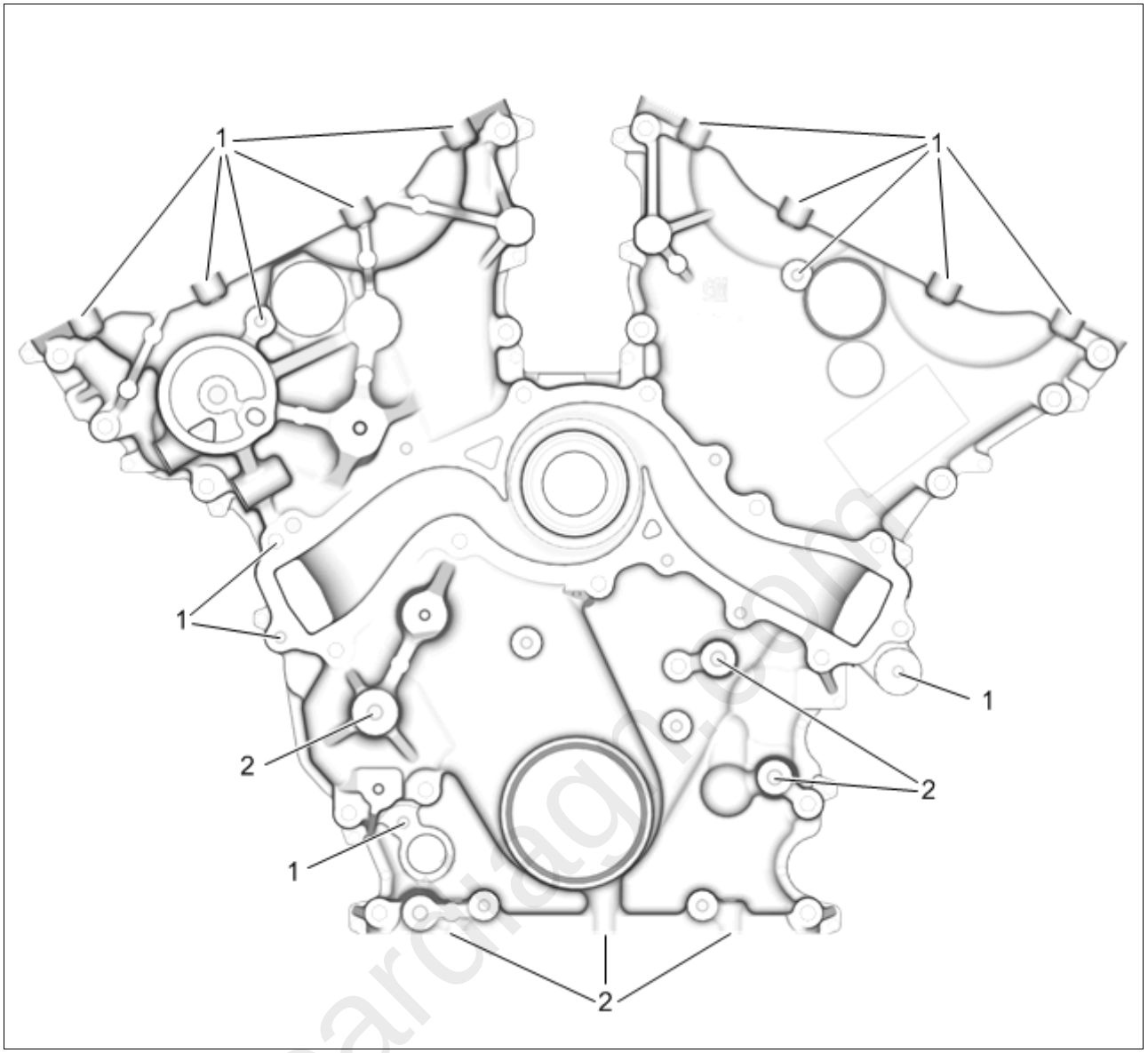
Courtesy of GENERAL MOTORS COMPANY

Engine Block Right Deck Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
		J 42385-						MM	(IN)	MM	(IN)
1	M12 x 1.75	EN-51	N/A	N/A	EN-52	EN-53	EN-58	29.0	1.14	29.0	1.14

SPECIFICATIONS > THREAD REPAIR SPECIFICATIONS > ENGINE FRONT COVER

Fig 1: Engine Front Cover



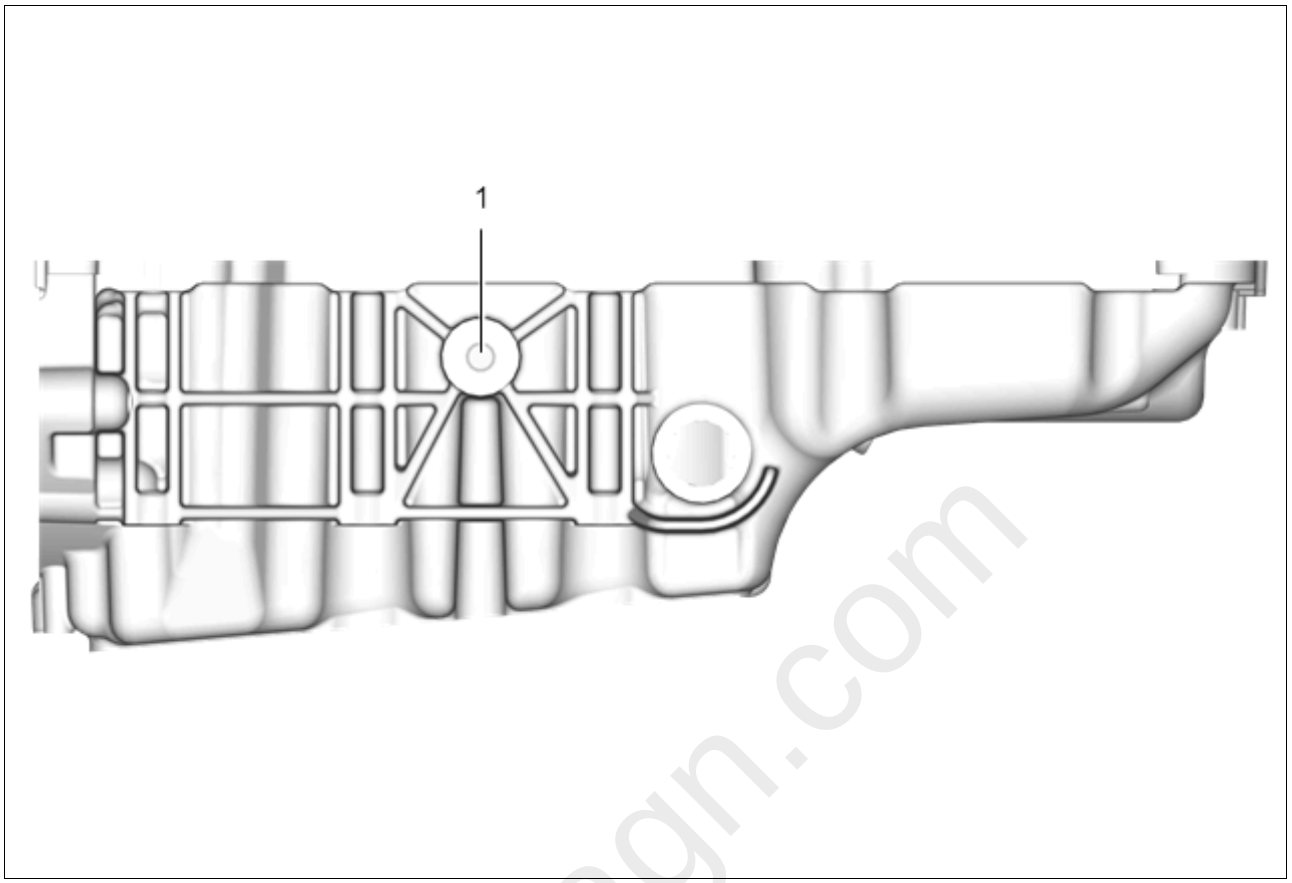
Courtesy of GENERAL MOTORS COMPANY

Engine Front Cover

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
J 42385-								MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	63	23.0	.907	23.0	.907
2	M8 x 1.25	206	207	N/A	208	209	61	29.0	1.14	29.0	1.14

SPECIFICATIONS > THREAD REPAIR SPECIFICATIONS > OIL PAN LEFT SIDE

Fig 1: Oil Pan Left Side



Courtesy of GENERAL MOTORS COMPANY

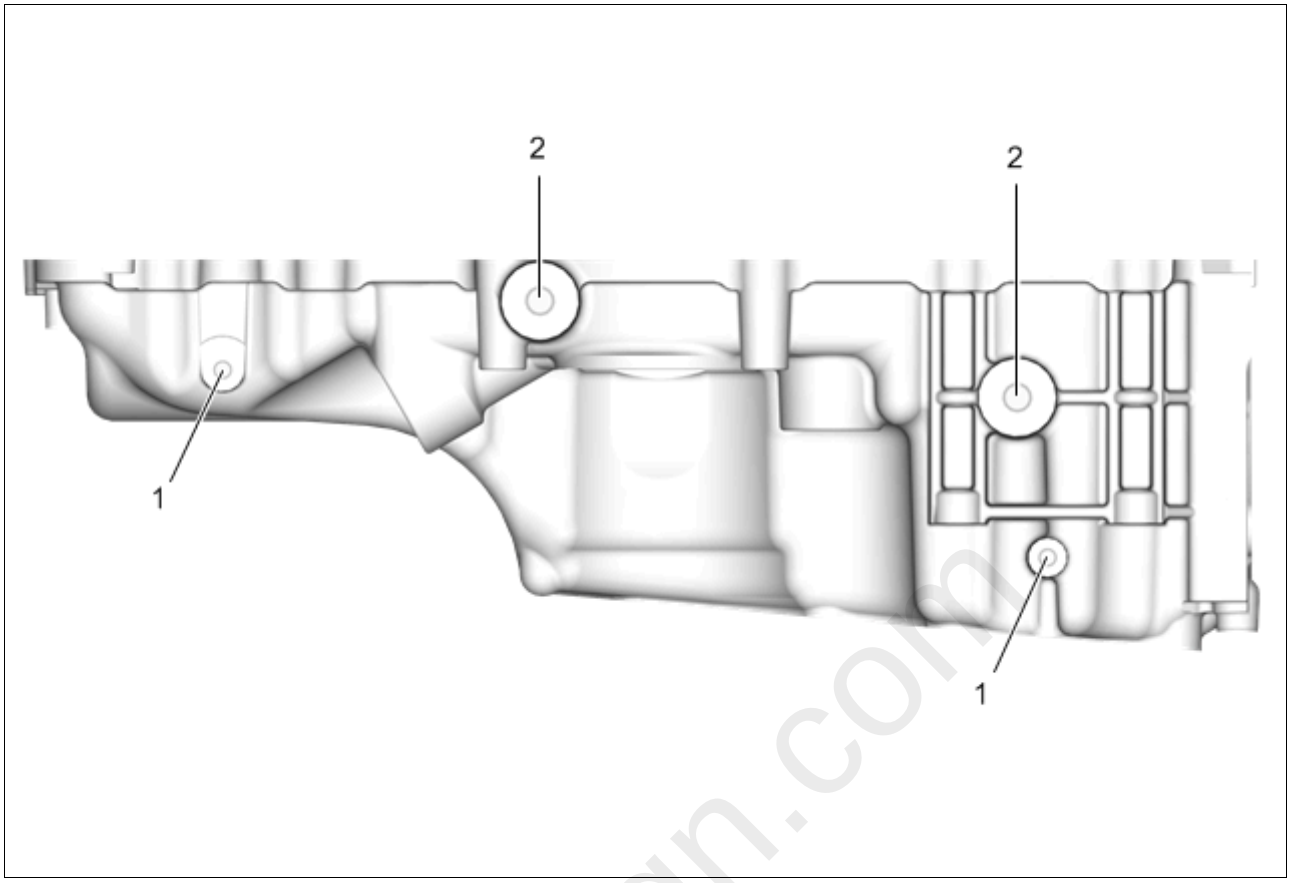
Oil Pan Left Side

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
		J 42385-						MM	(IN)	MM	(IN)
1	M10 x 1.5	211	212	N/A	213	214	514	34.0	1.35	34.0	1.35

SPECIFICATIONS > THREAD REPAIR SPECIFICATIONS > OIL PAN RIGHT SIDE

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Fig 1: Oil Pan Right Side



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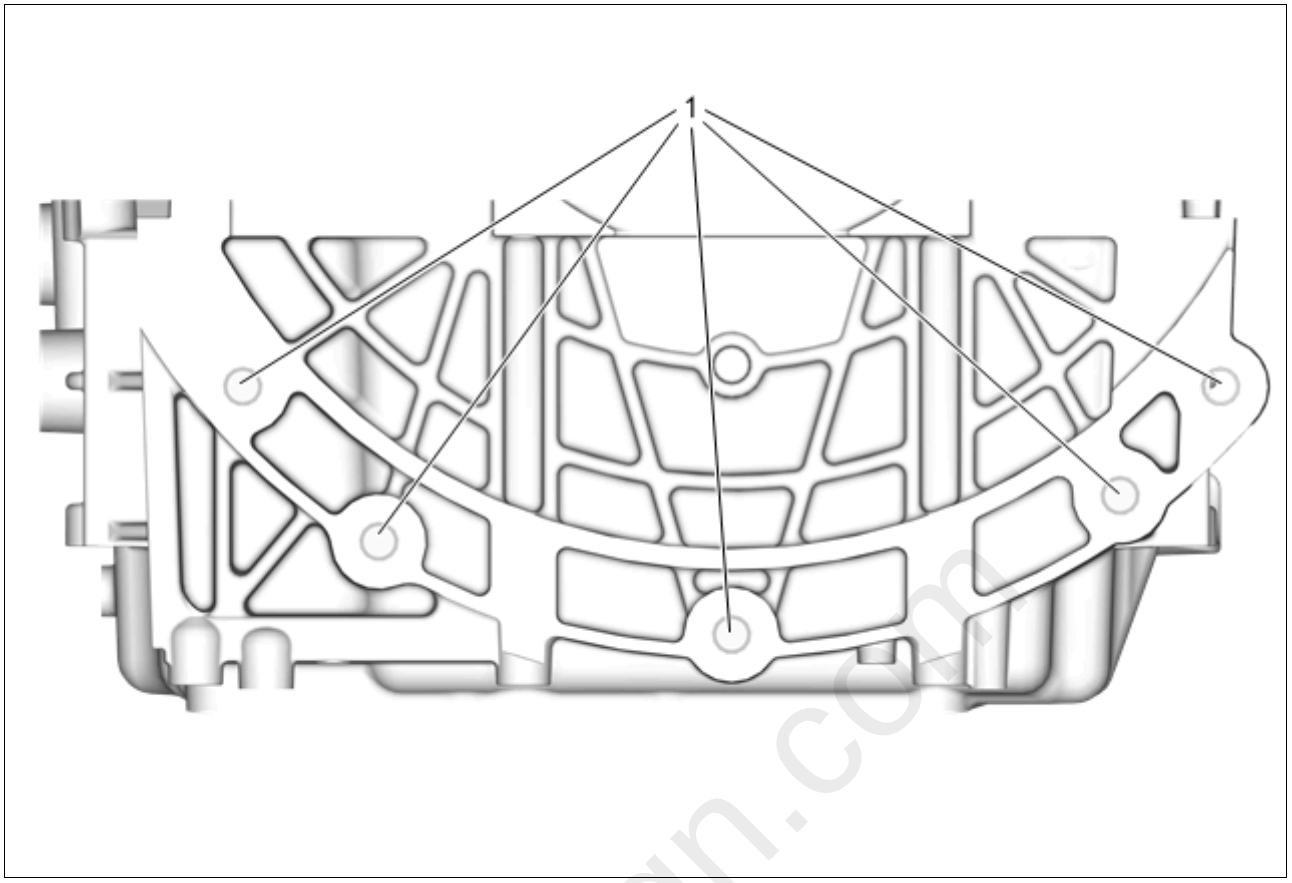
Oil Pan Right Side

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
		J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	63	23.0	.907	23.0	.907
2	M10 x 1.5	211	212	N/A	213	214	514	34.0	1.35	34.0	1.35

SPECIFICATIONS > THREAD REPAIR SPECIFICATIONS > OIL PAN REAR FACE

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Fig 1: Oil Pan Rear Face



Courtesy of GENERAL MOTORS COMPANY

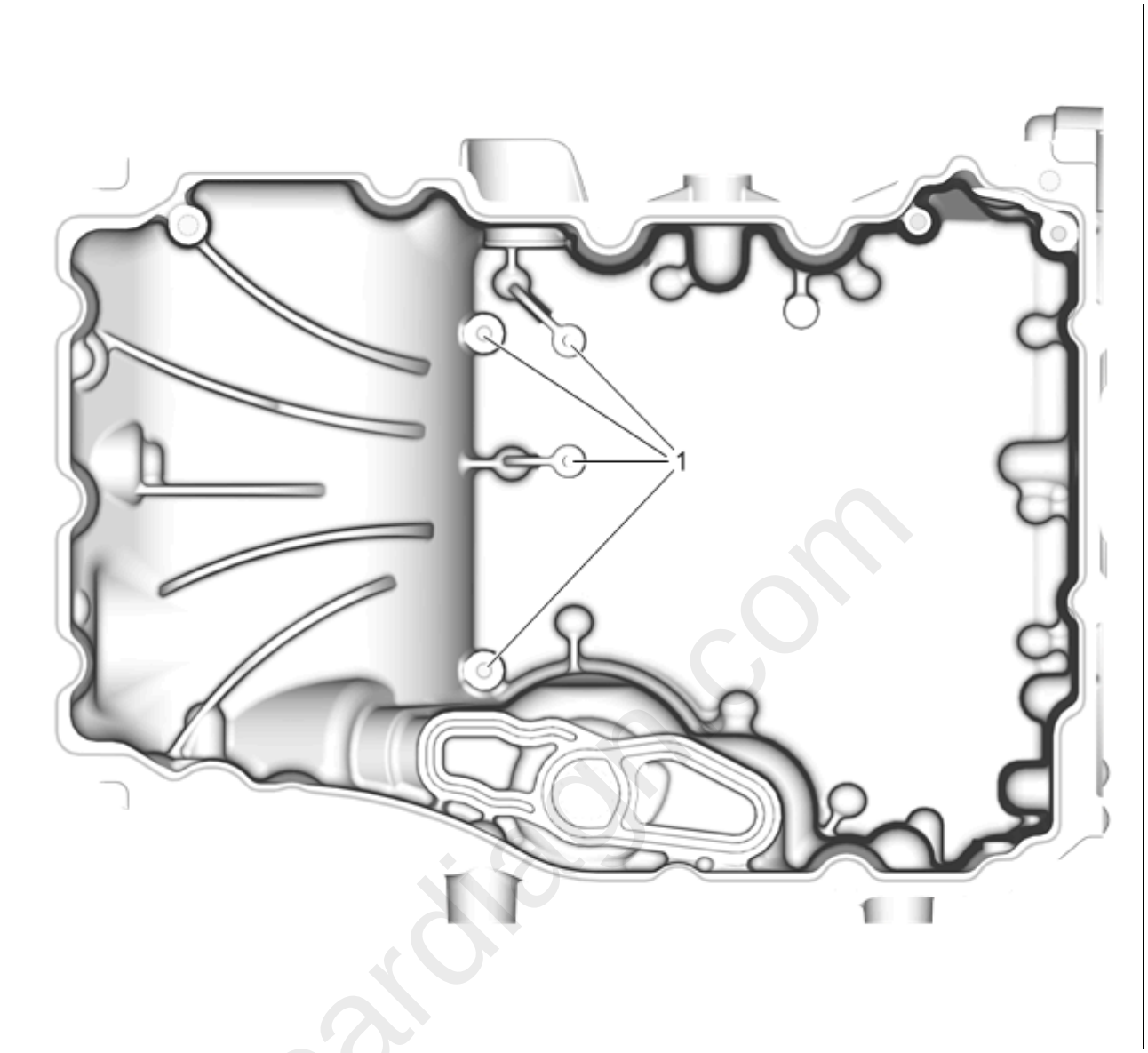
Oil Pan Rear Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
		J 42385-						MM	(IN)	MM	(IN)
1	M10 x 1.5	211	212	N/A	213	214	514	34.0	1.35	34.0	1.35

SPECIFICATIONS > THREAD REPAIR SPECIFICATIONS > OIL PAN TOP FACE

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Fig 1: Oil Pan Top Face



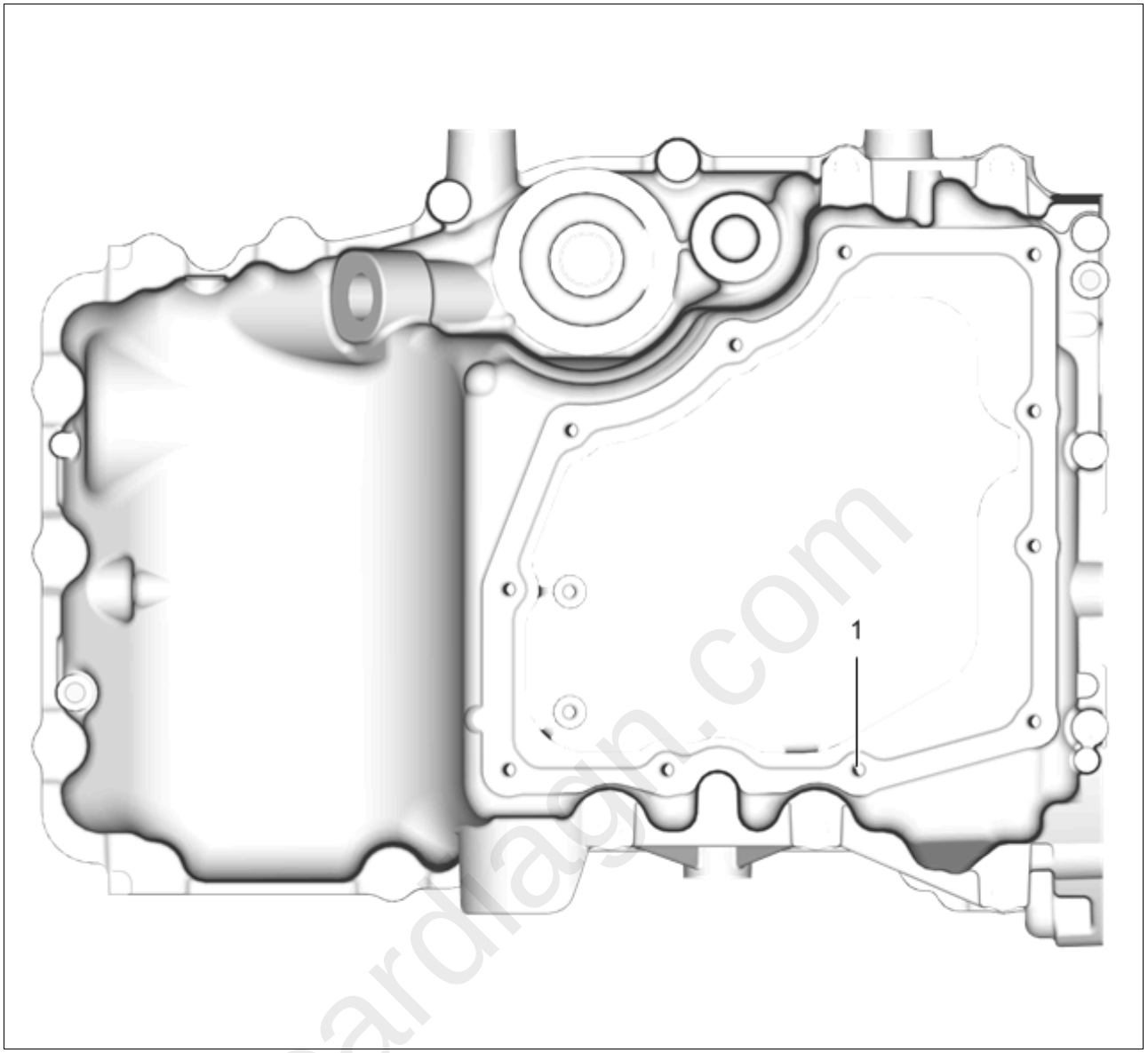
Courtesy of GENERAL MOTORS COMPANY

Oil Pan Top Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
		J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	63	23.0	.907	23.0	.907

SPECIFICATIONS > THREAD REPAIR SPECIFICATIONS > OIL PAN BOTTOM FACE

Fig 1: Oil Pan Bottom Face



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Oil Pan Bottom Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
		J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	63	23.0	.907	23.0	.907