

1996-97 ENGINES

2.4L 4-Cylinder

ENGINE IDENTIFICATION

NOTE: For repair procedures not covered in this article, see **ENGINE OVERHAUL PROCEDURES** article in **GENERAL INFORMATION**.

Vehicle Identification Number (VIN) is stamped on a metal tab, attached to top left end of instrument panel, near the windshield. Engine can also be identified by an engine code (3rd character) stamped on left side of cylinder block. See **Fig. 1**. See the **ENGINE IDENTIFICATION CODES** table.

ENGINE IDENTIFICATION CODES

Application	VIN Code	Engine ID
2.4L DOHC SFI	T	LD9

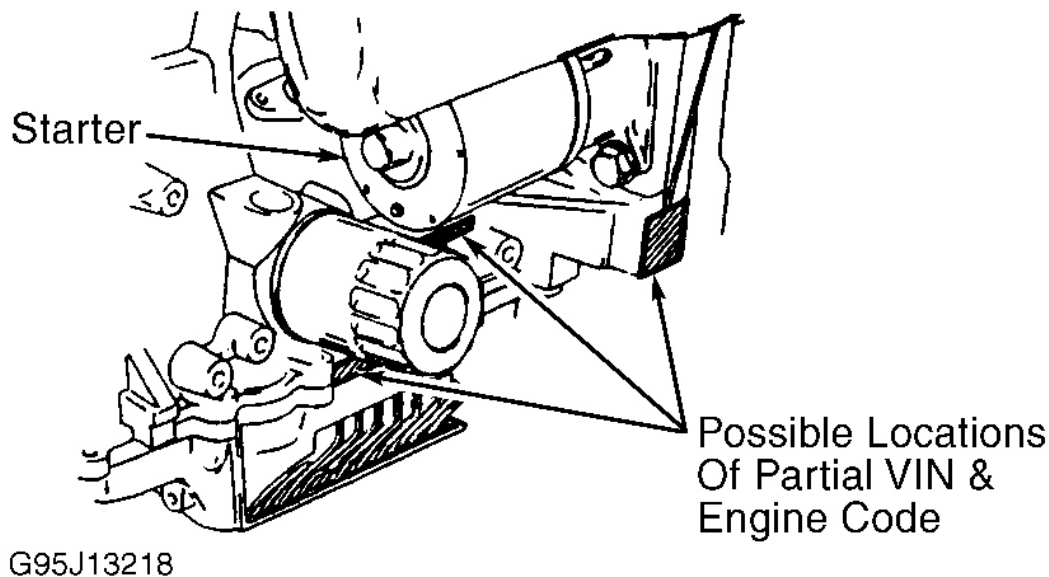


Fig. 1: Locating Partial VIN & Engine Code
Courtesy of GENERAL MOTORS CORP.

ADJUSTMENTS

VALVE CLEARANCE ADJUSTMENT

Engine is equipped with non-adjustable hydraulic valve lifters.

TROUBLE SHOOTING

NOTE: To trouble shoot engine mechanical components, see ENGINE MECHANICAL in BASIC TROUBLE SHOOTING article in GENERAL INFORMATION.

REMOVAL & INSTALLATION

CAUTION: When battery is disconnected, vehicle computer and memory systems may lose memory data. Driveability problems may exist until computer systems have completed a relearn cycle. See COMPUTER RELEARN PROCEDURES article in GENERAL INFORMATION.

NOTE: For reassembly reference, label all electrical connectors, vacuum hoses and fuel lines before removal. Also place mating marks on engine hood and other major assemblies before removal.

FUEL PRESSURE RELEASE

Disconnect negative battery cable. Loosen fuel filler cap. Install Fuel Pressure Gauge (J-34730-1) on fuel pressure connector of fuel rail. Wrap shop towel around pressure connection when installing fuel pressure gauge to absorb fuel leakage. Install gauge bleed hose into container. Open bleed valve to bleed fuel pressure.

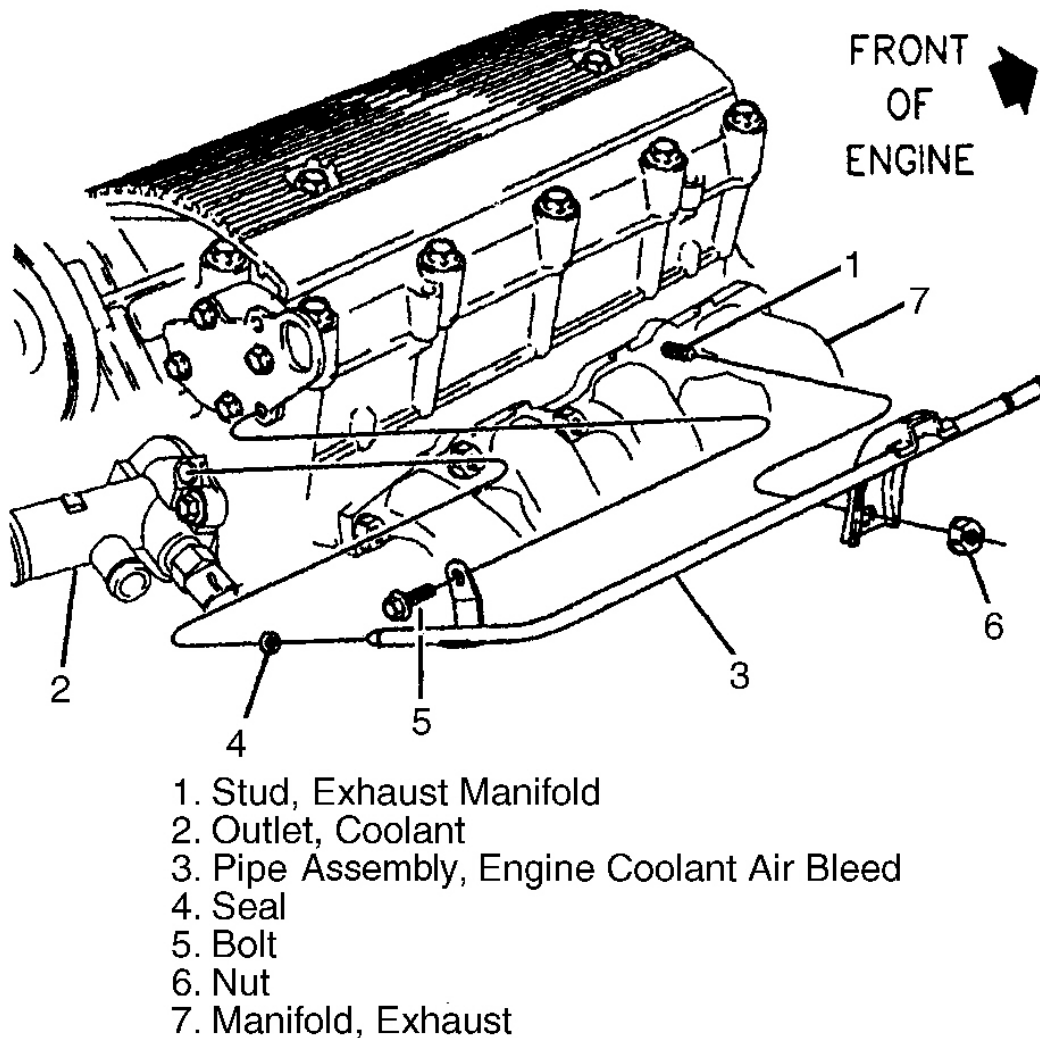
COOLING SYSTEM BLEEDING

CAUTION: With a pressurized cooling system, the coolant temperature in the radiator can be considerably higher than the boiling point of the solution at atmospheric pressure. Removal of the surge tank cap, while the cooling system is hot and under high pressure, causes the solution to boil instantaneously with explosive force. This will cause the solution to spew out over the engine, the fenders, and the person removing the cap. Serious bodily injury may result.

CAUTION: Under some conditions, the ethylene glycol engine coolant is combustible. In order to help avoid being burned, **DO NOT** spill the antifreeze or the coolant on the exhaust system or the hot engine parts.

NOTE: When adding coolant, use DEX-COOL® coolant. If silicated coolant is added to the system, premature engine, heater core or radiator corrosion may result. In addition, the engine coolant will require change sooner at 30,000 miles or 24 months.

Partially drain and recover coolant. Remove the coolant bleed pipe retaining bolt and nut. See Fig. 2. Remove hose clamp from coolant tank hose. Pull the pipe from the coolant outlet housing. To install, reverse removal procedure. Tighten all fasteners to specification. See TORQUE SPECIFICATIONS.



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Fig. 2: Removing/Installing Engine Coolant Air Bleed Assembly (2.4L)

Courtesy of GENERAL MOTORS CORP.

ENGINE**Removal**

NOTE: Remove engine and transaxle as an assembly through bottom of engine compartment.

1. Release fuel pressure. See **FUEL PRESSURE RELEASE**. Disconnect negative battery cable. Drain cooling system. Discharge air conditioning system (if equipped) using approved refrigerant recovery/recycling equipment.

2. Remove left sound insulator and disconnect push rod from clutch pedal assembly (if equipped). Disconnect control cables, coolant hoses, electrical connectors, vacuum hoses, and fuel lines as necessary. Remove air cleaner assembly. Remove cooling fan. Disconnect air conditioning hose assembly from compressor (if equipped). Discard "O" rings.
3. Remove throttle cable and bracket. Remove power steering pump bolts and pump (leave hoses connected). Disconnect shift cables. Disconnect clutch actuator (slave cylinder) hydraulic line. Remove exhaust manifold and heat shield. See **EXHAUST MANIFOLD**.
4. Support engine from above with Engine Support Fixture (J-28467-A). Remove coolant recovery tank (leave hoses connected) and position aside. Remove engine mount from timing chain end of engine. Raise and support vehicle. Remove front wheels. Remove right splash shield. Remove engine mount strut and transaxle mount. Separate ball joints from steering knuckles.
5. Put a suitable supporting device under suspension support, crossmember and stabilizer shaft. Remove heater outlet hose from radiator outlet pipe. Remove axle shaft from transaxle and intermediate shaft (manual transaxle only) and position aside.
6. Remove flywheel housing cover. Put a suitable supporting device under engine and transaxle assembly and lower vehicle onto support. Mark threads on engine upper support fixture hooks for installation reference. Remove engine upper support fixture hooks. Raise vehicle slowly from engine and transaxle assembly. Separate engine from transaxle (note bolt location for reassembly reference).

Installation

1. Assemble engine to transaxle, ensuring bolts are in correct locations. On automatic transaxle models, clean torque converter bolts and bolt holes. Apply sealant to bolts. On all models, position engine and transaxle assembly under engine compartment. Lower vehicle until transaxle mount is aligned. Install transaxle mount bolt.
2. Install Engine Support Fixture (J-28467-A) above engine, adjusting it to previous setting. Install engine mount at timing chain end of engine. Install engine mount at transaxle. Raise vehicle. Remove supporting device from below engine and transaxle assembly. Install axle shafts.
3. Install suspension support, crossmember and stabilizer shaft assembly. Tighten suspension support rear bolts, center bolts and then front bolts to specification. See **TORQUE SPECIFICATIONS** table. Connect ball joints. Install engine mount strut. To complete installation, reverse removal procedure. Evacuate and charge air conditioning system. Fill cooling system and crankcase.

INTAKE MANIFOLD**Removal**

1. Disconnect negative battery cable. Disconnect electrical connectors and vacuum hoses from intake manifold components as necessary. Disconnect air intake tube. Remove throttle cable bracket.
2. Remove generator mount bolt. Remove EGR pipe from EGR adapter. Raise and support vehicle. Remove intake manifold support brace. Lower vehicle. Remove intake manifold nuts and bolts. Remove intake manifold and gasket.

Installation

1. Intake manifold gasket is reusable unless damaged. Numbered side of intake manifold gasket must face

intake manifold. Install intake manifold brace and hand-tighten bolts.

2. Tighten vertical bolt (brace-to-manifold), then tighten brace-to-block bolts to specifications. Tighten all intake manifold nuts and bolts to specification in sequence. See **Fig. 3**. See **TORQUE SPECIFICATIONS** table. To complete installation, reverse removal procedure.

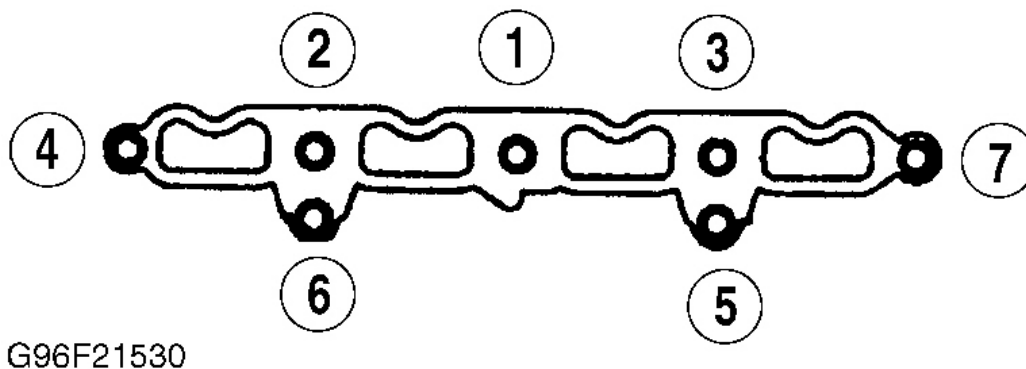


Fig. 3: Intake Manifold Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

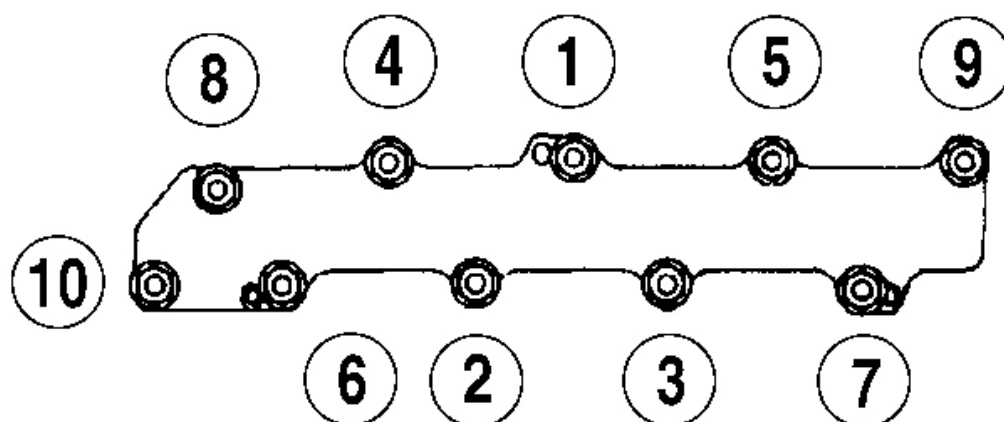
EXHAUST MANIFOLD

Removal

1. Disconnect negative battery cable. Disconnect oxygen sensor connector. Raise and support vehicle. Remove exhaust manifold brace bolt. Remove upper heat shield. Disconnect exhaust pipe flex decoupler from manifold. DO NOT allow flex decoupler to bend more than 3 degrees in any direction, as damage will result.
2. Pull down and back on exhaust pipe to disengage it from manifold. Lower vehicle. Remove exhaust manifold nuts. Remove exhaust manifold, seals and gaskets.

Installation

To install, reverse removal procedure using NEW gaskets. Tighten bolts to specification in sequence. See **TORQUE SPECIFICATIONS** table. See **Fig. 4**. If oxygen sensor was removed, coat threads with Anti-Seize Compound (5612695) before installation.



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Fig. 4: Exhaust Manifold Tightening Sequence

Courtesy of GENERAL MOTORS CORP.

CYLINDER HEAD**Removal**

1. Disconnect negative battery cable. Drain cooling system. Remove throttle body-to-air cleaner duct. Disconnect heater hose and throttle body hose from water outlet. Remove power brake vacuum hose from throttle body.
2. Disconnect electrical connectors, vacuum hoses, and coolant hoses as necessary. Remove generator mount bolt. Remove intake manifold brace. Remove intake manifold. See **INTAKE MANIFOLD**.
3. Remove generator mount bolt. Install Engine Support Fixtures (J-28467-400 and J-28467-A). Remove exhaust manifold. See **EXHAUST MANIFOLD**. Remove ignition coil and module assembly connectors. Remove attaching bolts and remove coil assembly from camshaft housing by pulling it straight up. See **Fig. 14**.
4. Disconnect camshaft position sensor connector. Remove power steering pump. Remove fuel line retaining clamp from bracket on top of intake camshaft housing. Remove fuel rail from cylinder head, and leaving fuel lines attached, position on top of master cylinder. Cover injector openings in head and injector nozzles.

CAUTION: Turn camshaft housing upside down immediately after removing from vehicle, or valve lifters will fall out and may be damaged.

5. Disconnect timing chain housing at intake camshaft housing but DO NOT remove from vehicle. On automatic transaxles, remove dipstick tube. Remove bolts attaching intake camshaft housing to cylinder

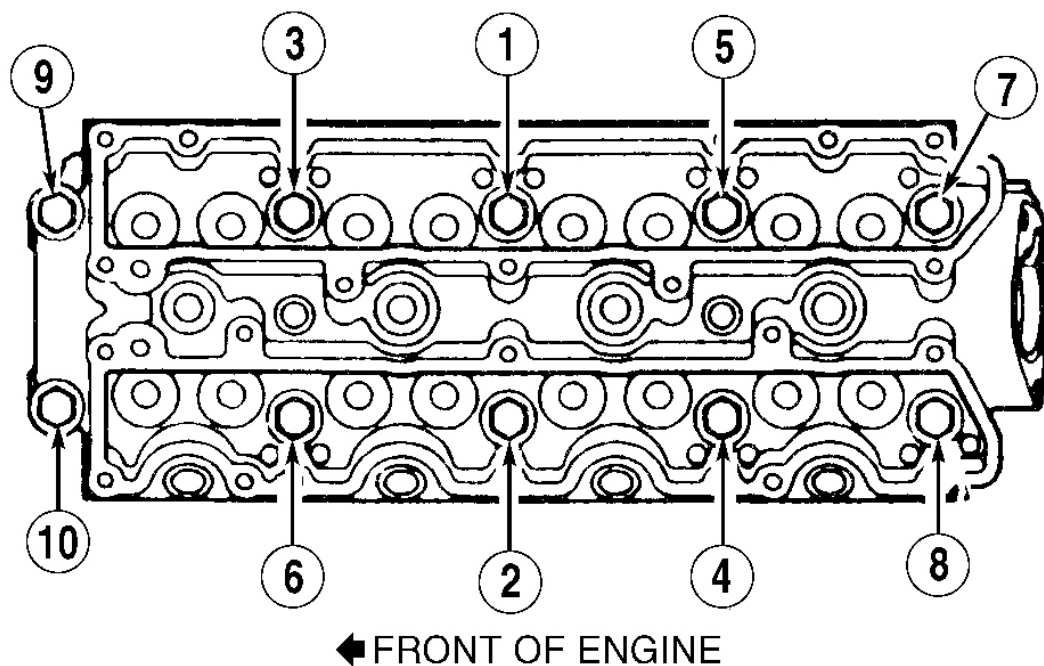
head bolts in reverse of tightening sequence. See **Fig. 15**. Remove camshaft housing. Repeat procedure with exhaust camshaft housing. See **Fig. 15**.

6. Disconnect radiator inlet hose from coolant outlet and disconnect coolant temperature sensor connectors. Remove cylinder head bolts in reverse order of tightening sequence. See **Fig. 5**. Remove cylinder head and gasket. See **CYLINDER HEAD** under OVERHAUL.

Installation

CAUTION: DO NOT use a thread tap to clean cylinder head bolt holes. Remove all fluids from bolt holes.

Clean threads of cylinder head bolts and bolt holes. Lightly coat bolt threads with engine oil. Install NEW gasket, ensuring all holes are aligned with cylinder block. Install cylinder head and tighten cylinder head bolts to specification in sequence. See **TORQUE SPECIFICATIONS** table. To complete installation, reverse removal procedure. See **Fig. 5**.



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Fig. 5: Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

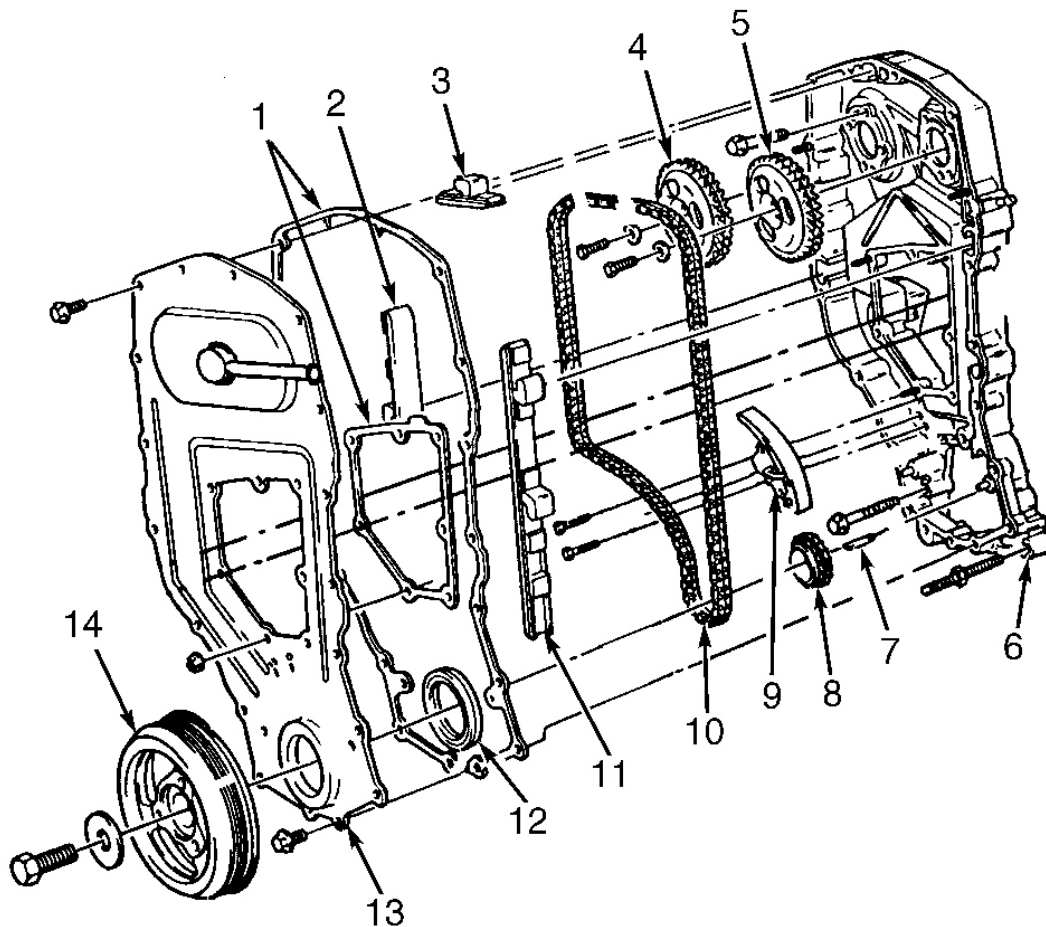
FRONT COVER

Removal

1997 Buick Skylark Gran Sport

1996-97 ENGINES 2.4L 4-Cylinder

1. Disconnect negative battery cable. Drain cooling system. Remove coolant recovery tank. Remove serpentine drive belt. Remove generator (leave wiring attached). Attach Engine Support Fixture (J-28467-400 and J-28467-A) to engine and generator stud. Remove bolts from upper half of front cover. See **Fig. 6**.
2. Remove engine mount assembly from timing chain end of engine. Remove engine mounting bracket adapter. Raise and support vehicle. Remove right front wheel and splash shield. Remove crankshaft balancer bolt. Remove crankshaft balancer with a puller. Remove lower bolts from front cover. Lower vehicle. Remove front cover and gaskets.



- | | |
|------------------------------|--------------------------------|
| 1. Gaskets | 8. Crankshaft Sprocket |
| 2. Right Chain Guide | 9. Chain Tensioner Shoe |
| 3. Upper Chain Guide | 10. Timing Chain |
| 4. Exhaust Camshaft Sprocket | 11. Left Chain Guide |
| 5. Intake Camshaft Sprocket | 12. Crankshaft Front Seal |
| 6. Timing Chain Housing | 13. Front Cover |
| 7. Woodruff Key | 14. Crankshaft Pulley/Balancer |

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Fig. 6: Exploded View Of Timing Chain Components
 Courtesy of GENERAL MOTORS CORP.

Installation

To install, reverse removal procedure. Cover gasket is reusable if not damaged. Lubricate front seal with grease before installing crankshaft balancer. To complete installation, reverse removal procedure. Tighten nuts and

bolts to specification. See **TORQUE SPECIFICATIONS** table. Fill cooling system.

CRANKSHAFT FRONT SEAL

Removal & Installation

Disconnect negative battery cable. Remove front cover. See **FRONT COVER**. Support cover, and drive seal through rear of cover. Take care not to damage cover. Note direction of seal installation. To install, use Seal Installer (J-36010).

TIMING CHAIN, SPROCKETS & TENSIONER

NOTE: This procedure has been revised due to GM service manual update (SMU) # 00-06-01-002 dated Feb, 2000

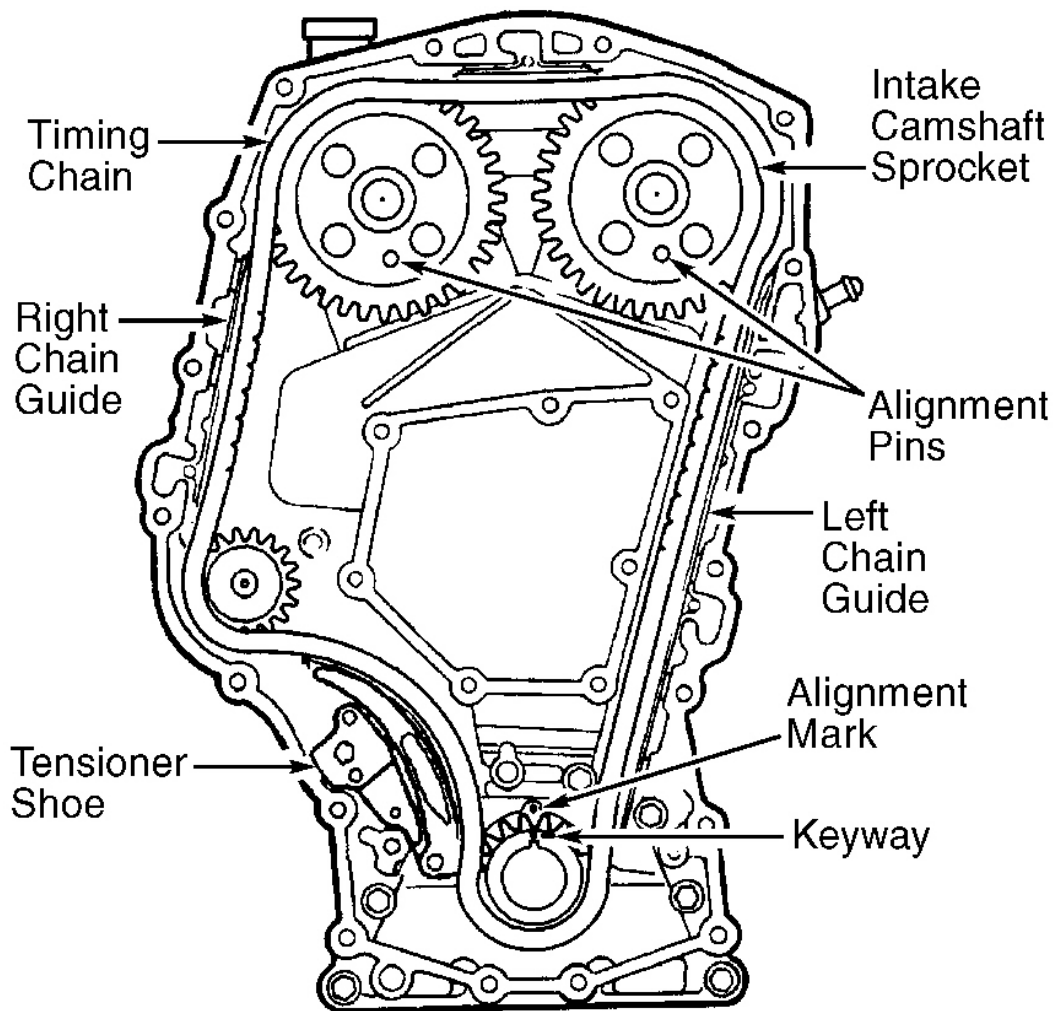
Removal

CAUTION: To prevent severe engine damage, carefully follow procedure.

1. Disconnect negative battery cable. Remove front cover. See **FRONT COVER**. See . Rotate crankshaft in normal direction of rotation (clockwise, as viewed from front of engine) until cylinder No. 1 is at TDC of compression stroke.
2. The camshaft sprocket dowel pin hole should line up with holes on timing chain housing. The crankshaft sprocket keyway should point upwards. See **Fig. 7**. Remove timing chain guides. Raise and support vehicle. Make sure slack in chain is above tensioner assembly, then remove chain tensioner.
3. Note that timing chain must be disengaged from any wear grooves in tensioner shoe before removing shoe. Slide a screwdriver blade between chain and tensioner shoe, while pulling shoe outward (this should disengage chain from wear grooves in shoe). If timing chain is not difficult to remove, go to step 5). If it is difficult to remove timing chain shoe, go to next step.

CAUTION: To prevent damage to sprocket or timing chain housing, use a puller to remove sprocket from camshaft. DO NOT pry sprocket from camshaft.

4. Lower vehicle. Hold intake camshaft sprocket with Sprocket Wrench (J-39579) and remove sprocket bolt. Remove washer from bolt and rethread bolt into camshaft by hand. Remove camshaft sprocket using a 3-jawed puller. DO NOT attempt to pry sprocket off or damage will result.
5. Remove tensioner assembly bolts and tensioner. Mark outer surface of timing chain and crankshaft sprocket for reassembly reference. Remove timing chain.



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Fig. 7: Aligning Timing Marks

Courtesy of GENERAL MOTORS CORP.

Installation

1. Install the camshaft sprockets. The sprockets are identical and interchangeable. Clean the old sealer off of the bolts with a wire brush. Clean the threaded hole in the camshaft with a nylon bristle brush. Coat the camshaft bolts with Adhesive/Sealant Compound (GM 1234593) or equivalent. See **Fig. 8**.
2. Install the camshaft sprocket bolts and washers while holding the sprockets with Tool (J- 39579). Tighten the bolts to 52 ft. lbs. (70 N.m).

NOTE: Ensure camshaft sprocket alignment pins are in the cylinder block and the timing chain housing, prior to installing the timing chain housing. The

camshaft sprocket alignment pins ensure proper chain housing and front cover location for correct front oil seal to crankshaft alignment.

3. Install Tool (J-36008-A) through the holes in the camshaft sprockets and into the holes in the timing chain housing. This will position the camshaft for correct timing. Use the following steps if the camshafts are out of position and must be rotated more than 1/8 turn in order to install the alignment dowel pins:
 - A. The crankshaft must be rotated 90 degrees clockwise from TDC to give the valves adequate clearance to open.
 - B. Once the camshafts are in position and the dowels are installed, rotate the crankshaft counter clockwise back to TDC.

CAUTION: DO NOT rotate the crankshaft clockwise to TDC. Valve or piston damage could occur. The timing chain and crankshaft sprocket must be put in a specific direction for chain noise and wear considerations. The surfaces that were marked during removal should be showing when the chain and crankshaft sprocket are installed.

4. Install the timing chain over the exhaust camshaft sprocket around the coolant pump sprocket and around the crankshaft sprocket. Remove the alignment dowel pin from the intake camshaft. Use Tool (J-39579) in order to rotate the intake camshaft sprocket counter clockwise enough to allow the timing chain to slide over the intake camshaft sprocket. Release Tool (J-39579). The length of the chain between the two camshaft sprockets will tighten.
5. If properly timed, the intake camshaft alignment dowel pin will slide in easily. If the dowel pin does not fully index, the camshafts are not timed correctly and the procedure must be repeated. Leave the alignment dowel pins installed. The keyway on the crankshaft and the mark on the cylinder block should be aligned when the slack is removed from the chain between the intake camshaft sprocket and the crankshaft sprocket. If the mark and the keyway are not aligned, move the chain one tooth forward or rearward. Remove the slack and recheck the marks.

NOTE: Use the following steps in order to reset the timing chain tensioner assembly to the zero position:

- A. Reset the timing chain tensioner assembly.
 - B. Insert the tensioner plunger assembly into the tensioner housing.
 - C. With the tensioner plunger fully extended, turn the complete assembly upside down on a bench or other flat surface. See **Fig. 9**.
 - D. With the plunger face against the workbench, press firmly on the bottom of the tensioner housing.
 - E. Compress the plunger until the plunger is seated flush in the tensioner. See **Fig. 10**.
6. Check the plunger to ensure the plunger is out of the cylinder at the correct dimension. The correct dimension for the plunger to extend out of the cylinder is .070" (1.7 mm) maximum. See **Fig. 10**. Loosely install the tensioner assembly and bolts to the timing chain housing. See **Fig. 11**. Install the timing chain

tensioner shoe on the stud. Apply hand pressure to the timing chain tensioner shoe until the locking tab seats in the groove in the stud. Tighten the timing chain tensioner bolts. DO NOT over tighten. Tighten the bolts to 89 INCH lbs. (10 N.m).

CAUTION: If the timing chain tensioner plunger is not released from the installation position, engine damage will occur when the engine is started.

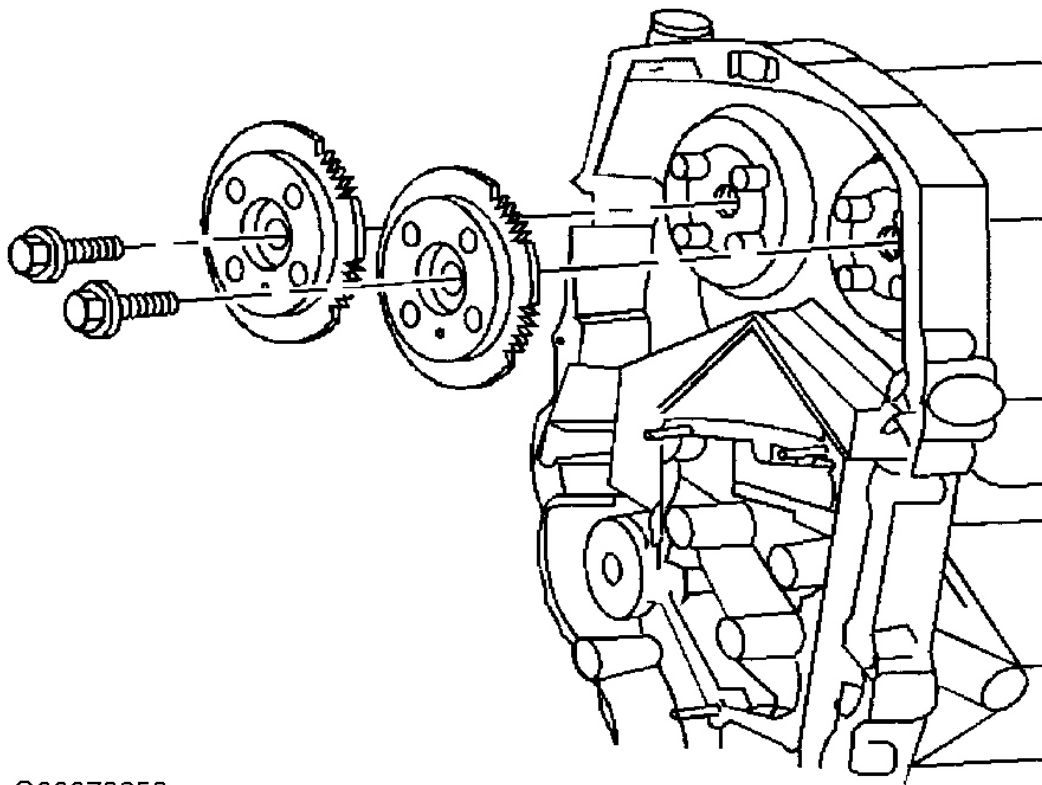
7. Release the timing chain tensioner plunger using the following procedure:
 - A. Using a flat blade screwdriver, cotter pin remover, or a similar tool, press firmly against the face of the timing chain tensioner plunger. See **Fig. 12**.

NOTE: If the timing chain tensioner plunger cannot be depressed, the plunger is not properly reset and the procedure for resetting the timing chain tensioner should be repeated.

- B. Depress the timing chain tensioner plunger until the plunger is bottomed out in the bore of the timing chain tensioner. See **Fig. 10**.
 - C. Release the tensioner plunger. See **Fig. 12**. The plunger should press firmly against the back of the timing chain tensioner shoe. Remove Tool (J- 36008-A) from the camshaft sprockets.

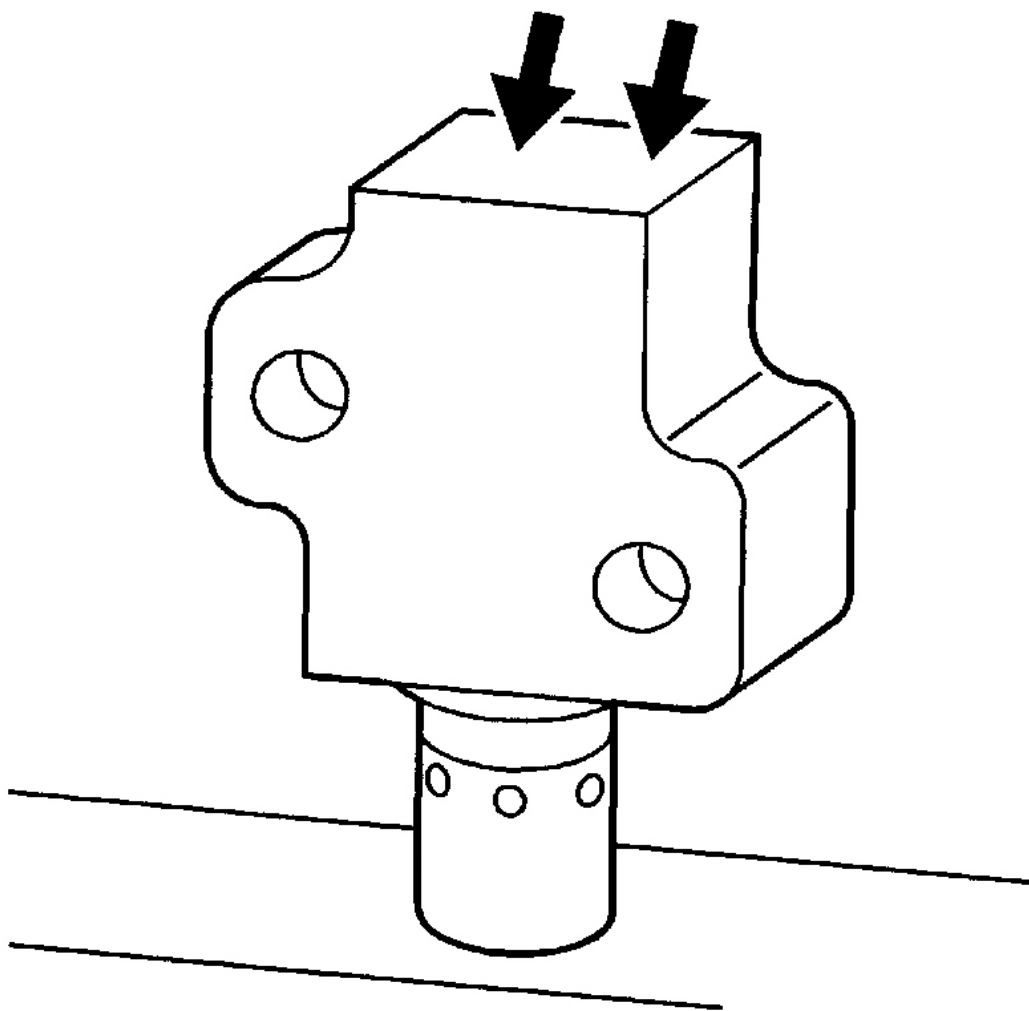
CAUTION: Beginning with the 1998 model year, the timing chain on the LD9 (VIN T) Twin Cam Engine is different from the chain found on earlier versions of this engine, and is not to be replaced with a timing chain from earlier model year engines. The timing sprockets were also changed beginning in 1998, and the shape of the chain links matches the sprockets. Engine damage may result if the wrong timing chain is used. The timing chain and the crankshaft sprocket must be marked so that they are reinstalled in the same side facing out at the time of assembly.

8. Rotate the crankshaft clockwise two full rotations. Align the crankshaft keyway with the mark on the cylinder block and reinstall the alignment dowel pins. The alignment dowel pins will slide in easily if the engine is timed correctly. Install the timing chain guides.



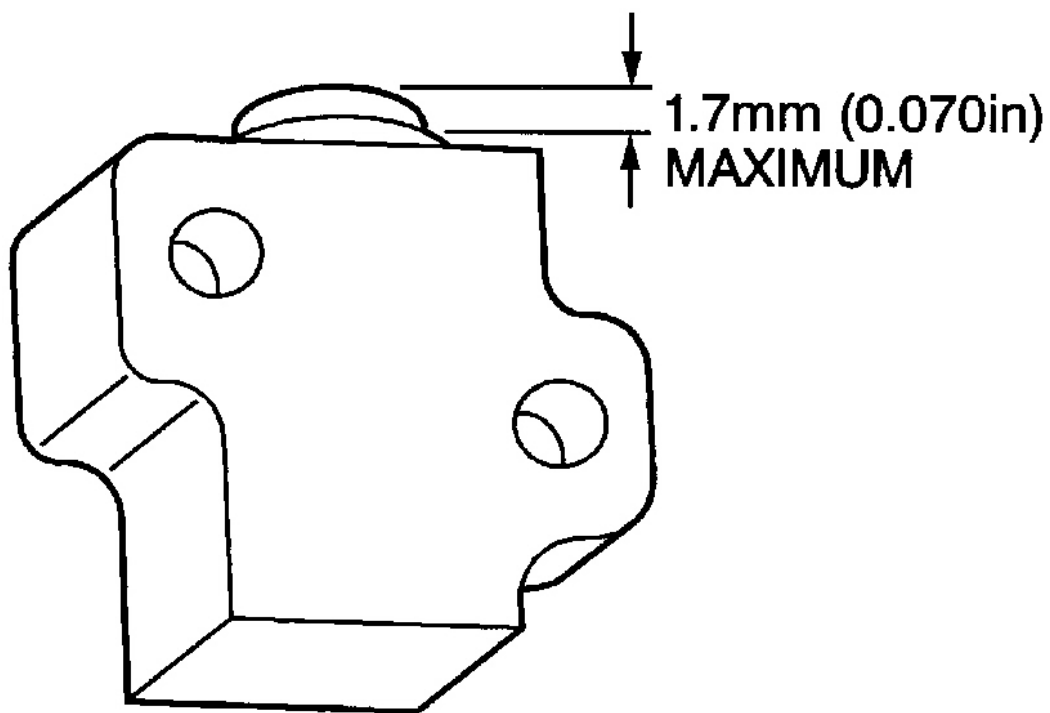
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Fig. 8: Installing Timing Chain Sprockets
Courtesy of GENERAL MOTORS CORP.



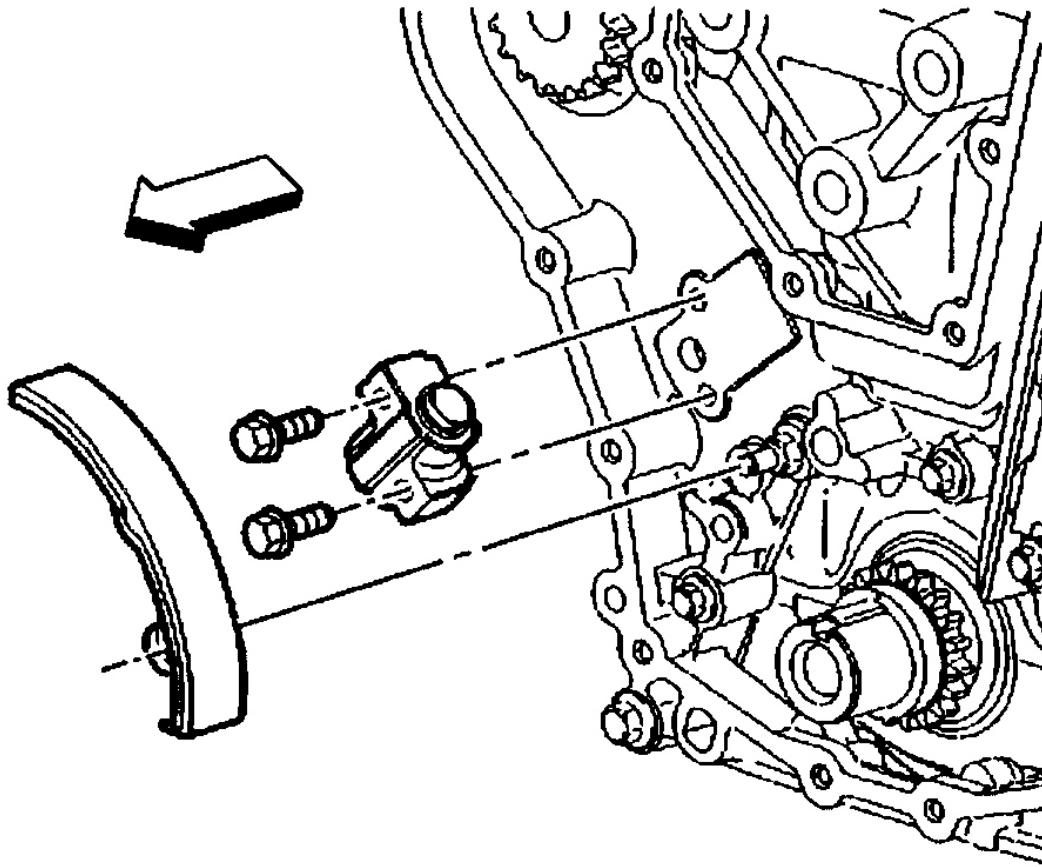
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Fig. 9: Released View Of Timing Chain Tensioner Assembly
Courtesy of GENERAL MOTORS CORP.



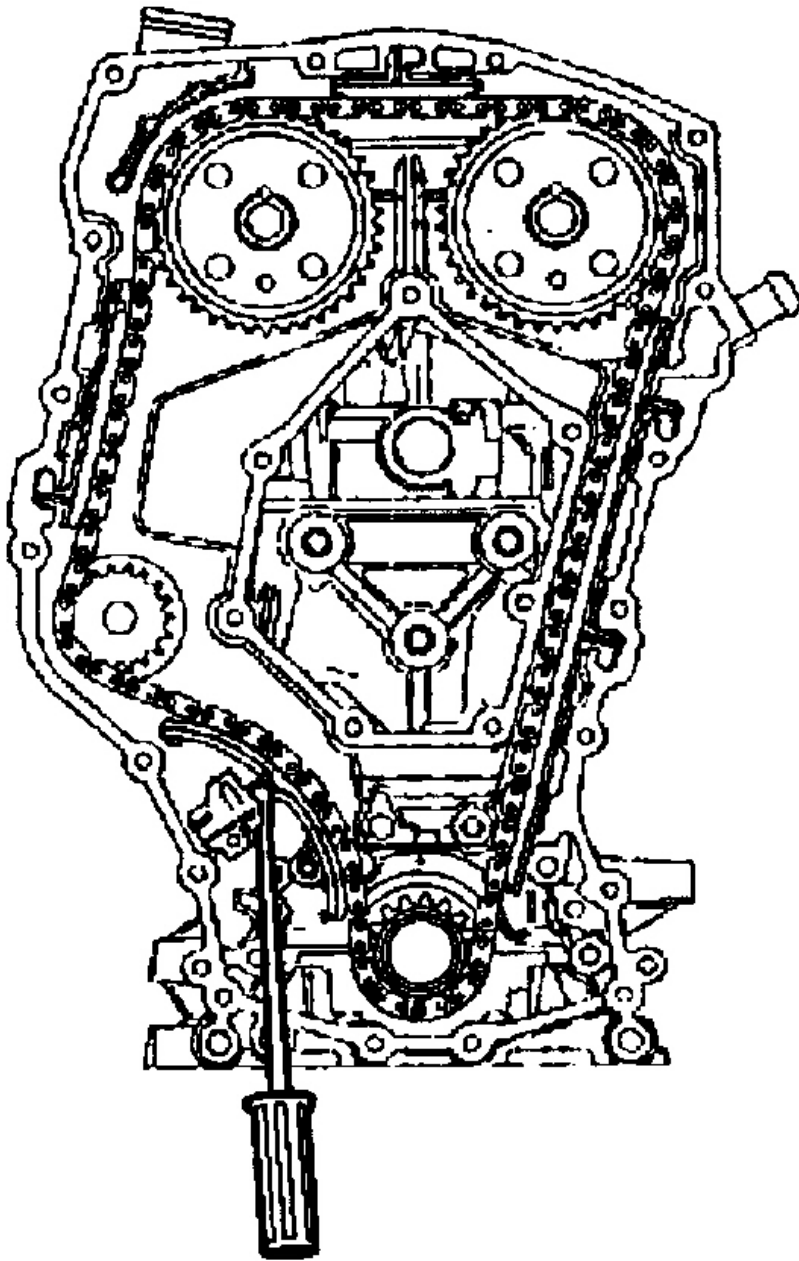
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Fig. 10: Compressed View Of Timing Chain Tensioner Assembly
Courtesy of GENERAL MOTORS CORP.



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Fig. 11: Installing Shoe & Timing Chain Tensioner Assembly
Courtesy of GENERAL MOTORS CORP.



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Fig. 12: Releasing Timing Chain Tensioner Assembly
Courtesy of GENERAL MOTORS CORP.

TIMING CHAIN HOUSING

Removal

NOTE: Timing chain housing does not need to be completely removed if replacing gasket between cylinder head or cylinder block and timing chain housing.

1. Disconnect negative battery cable. Remove front cover. See **FRONT COVER**. Raise and support vehicle. Drain cooling system by disconnecting heater hose from thermostat housing. See **Fig. 16** Remove nuts securing water pump to timing chain housing. Remove timing chain and tensioner, making sure to mark chain and sprocket outside surfaces. See **TIMING CHAIN, SPROCKETS & TENSIONER**.
2. Remove fasteners attaching timing chain housing to block. Remove 4 bolts securing oil pan to front cover. Remove stud from lowest point on timing chain housing (if left installed, stud prevents removal of housing).
3. Lower vehicle. Hold camshaft sprockets with Sprocket Wrench (J-39579) and remove sprocket bolts. Remove bolts securing timing chain housing to camshaft housings. Remove timing chain housing and gaskets (if necessary, raise engine slightly from above).
4. If necessary, remove timing chain idler sprocket and bearing. See **TIMING CHAIN IDLER SPROCKET & BEARING**.

Installation

1. Replace oil pan gasket if damaged. If silicone bead at corner joints is damaged, repair it by applying just enough Silicone Sealant (12345739) to restore it to its original dimension (too much sealant may cause part misalignment, resulting in oil leaks).
2. Ensure dowel pins are installed in cylinder block. Install timing chain housing with NEW gaskets (without sealer). Install and hand-tighten all timing chain housing bolts, then tighten to specification. See **TORQUE SPECIFICATIONS** table. To install remaining components, reverse removal procedure. Fill cooling system.

TIMING CHAIN IDLER SPROCKET & BEARING**Removal**

1. Remove timing chain housing. See **TIMING CHAIN HOUSING**. Remove snap ring securing bearing in housing. See **Fig. 13**. Install Remover/Installer Plate (J-36998-4) on front side of housing, engaging alignment pins into bolt holes in housing.

NOTE: Replace bearing whenever idler sprocket is removed.

2. Using Handle (J-36998-2), press sprocket out of bearing. Reposition remover/installer plate onto rear side of housing, engaging water pump studs into holes in plate. Using Remover/Installer (J-36998-1) and Handle (J-36998-2), press bearing out of housing.

Installation

Clean snap ring groove in housing. Coat surfaces of housing and NEW bearing with Sealant (12345493). Install remover/installer plate on front side of housing. Using remover/installer and handle, press bearing into housing.

Reposition remover/installer plate to rear side of housing. Using remover/installer and handle, press idler sprocket through bearing. Install bearing snap ring. Install timing chain housing. See **TIMING CHAIN HOUSING**.

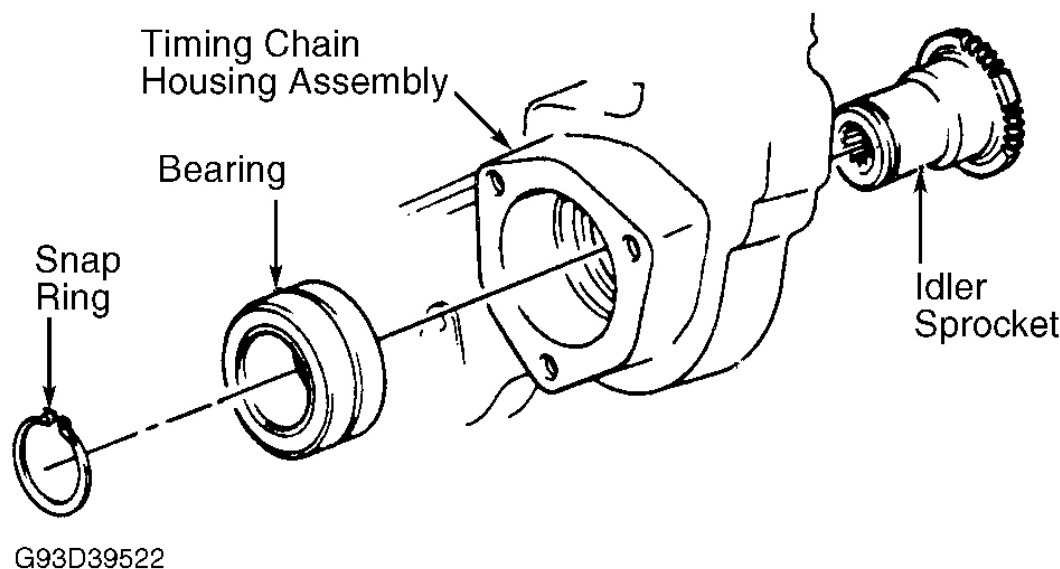


Fig. 13: Exploded View Of Timing Chain Idler Sprocket Assembly
Courtesy of GENERAL MOTORS CORP.

INTAKE CAMSHAFT & HOUSING

Removal

1. Disconnect negative battery cable. Disconnect ignition coil electrical connector. Remove bolts, and remove ignition coil and module assembly by pulling it straight up. See **Fig. 14**. It may be necessary to use Spark Plug Wire Remover (J-36011) to break plug wire connectors loose by twisting and then pulling.
2. Disconnect camshaft position sensor connector. Remove power steering pump and set aside (leave hoses connected). Disconnect vacuum line from fuel pressure regulator. Disconnect fuel injector harness connector. Remove fuel line clamp from top of intake camshaft housing. Remove fuel rail bolts.
3. Remove fuel rail (leave fuel lines attached). Cover injector openings in cylinder head. Cover injector nozzles. Remove timing chain and camshaft sprockets. See **TIMING CHAIN, SPROCKETS & TENSIONER**. Remove bolts securing timing chain housing to camshaft housing.

CAUTION: Any time camshaft housing bolts are loosened or removed, gasket between camshaft housing and cylinder head must be replaced.

4. Remove bolts that secure camshaft housing cover to camshaft housing. Working in reverse order of

tightening sequence, evenly loosen and remove bolts securing camshaft housing to cylinder head (leave 2 bolts loosely in place to keep camshaft housing in place while separating cover from housing). See **Fig. 15**.

5. Install 4 camshaft housing-to-cylinder head bolts into tapped holes in camshaft housing cover. Evenly tighten bolts to separate cover from housing. Remove 2 loosely installed camshaft housing bolts. Remove camshaft housing cover and seals.

NOTE: If removing lifters, keep them in order; they must be installed in their original locations. To prevent bleed-down, store lifters upside down in clean engine oil.

6. Install and hand-tighten one camshaft housing bolt to keep camshaft housing in place while removing camshaft and lifters. For installation reference, note position of dowel pin (on timing chain sprocket) in relation to camshaft housing. Remove camshaft. Remove camshaft housing and lifters as an assembly. If necessary, remove lifters from camshaft housing.

Inspection

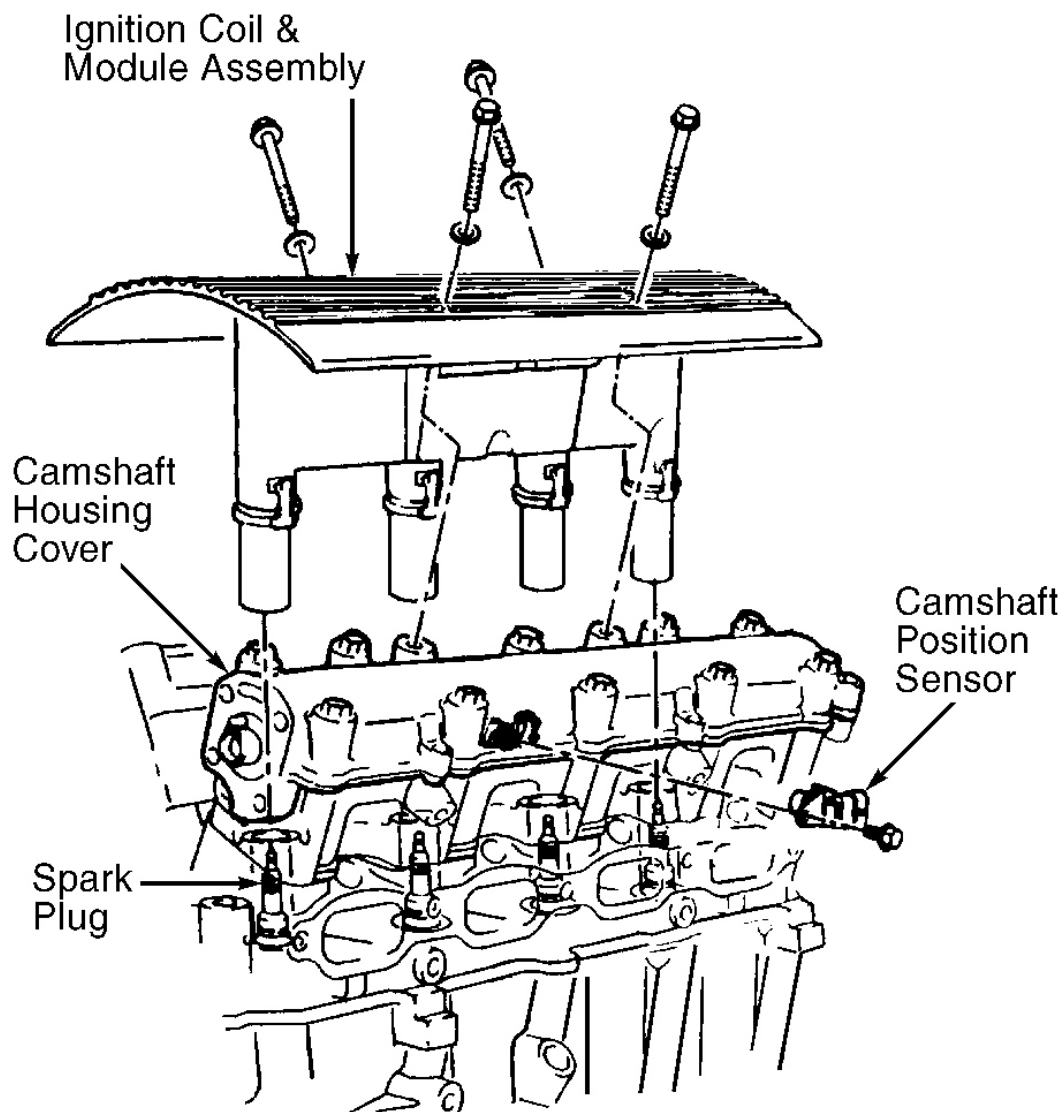
If camshaft journal diameter, lobe lift, end play or oil clearance is not within specification, replace components as necessary. See **CAMSHAFT SPECIFICATIONS** table under ENGINE SPECIFICATIONS. Check camshaft housing. See **CAMSHAFT HOUSING** under OVERHAUL.

Installation

NOTE: If replacing camshaft or lifters, add Engine Oil Supplement (1052367) to crankcase. If camshaft is replaced, lifters must also be replaced.

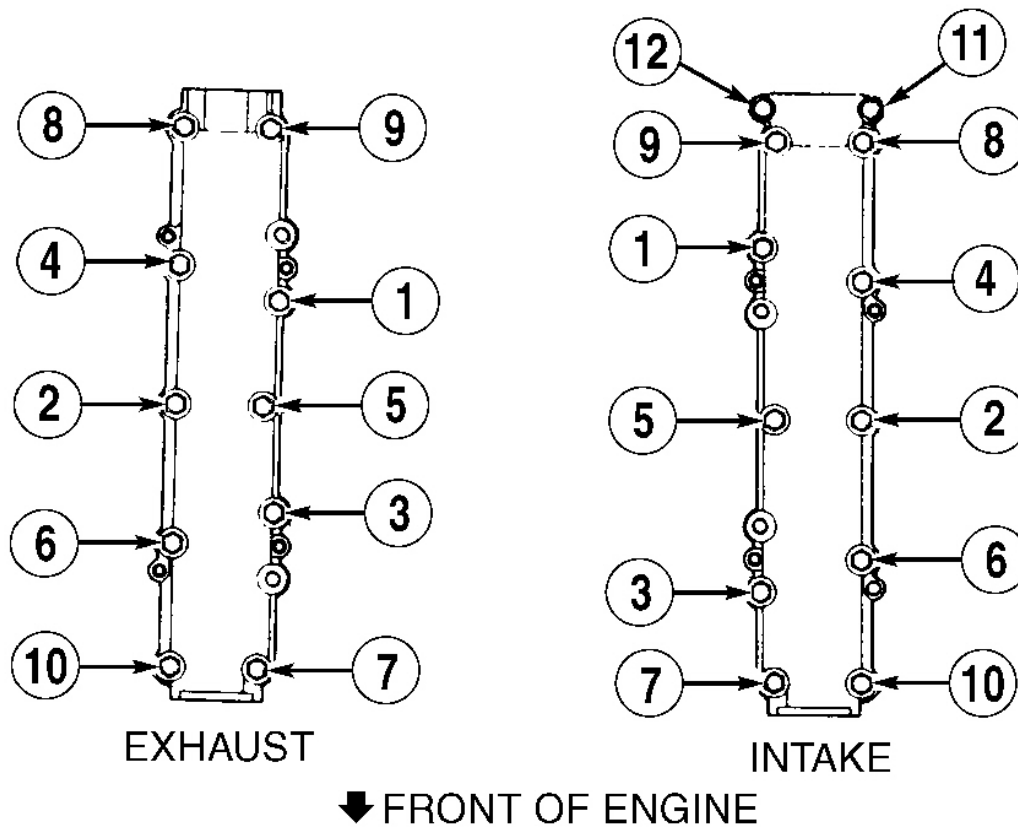
1. Ensure dowel pins aligning camshaft housing with cylinder head are installed. Install camshaft housing with a NEW gasket (no sealant required). Loosely install one camshaft housing bolt to keep camshaft housing in place while installing lifters and camshaft.
2. Coat lifters and camshaft with Prelube (12345501). Install lifters in their original locations. Install camshaft, ensuring dowel pin on timing chain sprocket is in same position as when removed. Dowel pin should point straight up and lined up with centerline of lifter bore. Install NEW Green camshaft housing cover seals into cover (no sealant is required).
3. Remove bolt installed to keep camshaft housing in place. Apply GM Pipe Sealant (1052080) to threads of bolts securing housing to cylinder head and cover to housing. Tighten camshaft housing bolts to specification in sequence. See **Fig. 15**. Note that bolts 11 and 12 have a different final torque than bolts 1-10. See **TORQUE SPECIFICATIONS** table.
4. Install timing chain housing and timing chain in reverse order of removal. Lubricate NEW "O" ring seals with engine oil, and install them onto injectors. Install fuel rail. To install remaining components, reverse removal procedure.
5. If a spark plug boot connector remained on a spark plug when ignition coil and module assembly was removed, remove it from spark plug and install it onto ignition coil and module assembly. Set ignition coil and module assembly in place and press straight down to install assembly onto spark plugs.
6. Clean oil from threads of bolts securing assembly to camshaft housing. Apply GM Pipe Sealant (1052080) to ignition coil-to-camshaft housing bolt threads. To complete installation, reverse removal

procedure.



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Fig. 14: Camshaft Housing & Ignition Coil/Module Assembly
Courtesy of GENERAL MOTORS CORP.



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Fig. 15: Camshaft Housing Bolt Tightening Sequence
 Courtesy of GENERAL MOTORS CORP.

EXHAUST CAMSHAFT & HOUSING

Removal

CAUTION: Any time camshaft housing bolts are loosened or removed, gasket between camshaft housing and cylinder head must be replaced.

1. Disconnect negative battery cable. Disconnect ignition coil electrical connector. Remove bolts, and remove ignition coil and module assembly by pulling it straight up. See **Fig. 14**. It may be necessary to use Spark Plug Wire Remover (J-36011) to break plug wire connectors loose by twisting and then pulling.
2. Disconnect oil pressure switch connector. Disconnect timing chain housing at exhaust camshaft housing but DO NOT remove from vehicle. See **TIMING CHAIN HOUSING**. Remove exhaust camshaft cover

and gasket.

3. Working in reverse order of tightening sequence, evenly loosen and remove bolts securing camshaft housing to cylinder head (leave 2 bolts loosely in place to keep camshaft housing in place while separating cover from housing). See **Fig. 15**. Install 4 camshaft housing-to-cylinder head bolts into tapped holes in camshaft housing cover.
4. Evenly tighten bolts to separate cover from housing. Remove 2 loosely installed camshaft housing bolts. Remove camshaft housing cover and seals.

NOTE: If removing lifters, keep them in order; they must be installed in their original locations. To prevent bleed-down, store lifters upside down in clean engine oil.

5. Install and hand-tighten one camshaft housing bolt to keep camshaft housing in place while removing camshaft and lifters. For installation reference, note position of dowel pin (on timing chain sprocket) in relation to camshaft housing. Remove camshaft. Remove camshaft housing and lifters as an assembly. If necessary, remove lifters from camshaft housing.

Inspection

If camshaft journal diameter, lobe lift, end play or oil clearance is not within specification, replace components as necessary. See **CAMSHAFT SPECIFICATIONS** table under ENGINE SPECIFICATIONS. Check camshaft housing. See **CAMSHAFT HOUSING** under OVERHAUL.

Installation

NOTE: If replacing camshaft or lifters, add Engine Oil Supplement (1052367) to crankcase. If camshaft is replaced, lifters must also be replaced.

1. Ensure dowel pins aligning camshaft housing with cylinder head are installed. Install camshaft housing with NEW gasket (no sealant required). Loosely install one camshaft housing bolt to keep camshaft housing in place while installing lifters and camshaft.
2. Coat lifters and camshaft with Prelube (12345501). Install lifters in their original locations. Install camshaft, ensuring dowel pin on timing chain sprocket is in same position as when removed. Dowel pin should point straight up and lined up with centerline of lifter bore. Install NEW Orange seals into cover (no sealant is required).
3. Remove bolt installed to keep camshaft housing in place. Apply GM Pipe Sealant (1052080) to threads of bolts securing housing to cylinder head and cover to housing. Tighten camshaft housing bolts to specification in sequence. See **Fig. 15**. Note that bolts 11 and 12 have a different final torque than bolts 1-10. See **TORQUE SPECIFICATIONS** table.
4. Install timing chain housing and timing chain in reverse order of removal. To install remaining components, reverse removal procedure. If a spark plug boot connector remained on a spark plug when ignition coil and module assembly was removed, remove connector from spark plug and install it onto ignition coil and module assembly.
5. Set ignition coil and module assembly in place and press straight down to install assembly onto spark plugs. Clean oil from threads of bolts securing assembly to camshaft housing. Apply GM Pipe Sealant (1052080) to ignition coil-to-camshaft housing bolt threads. To complete installation, reverse removal

procedure.

CRANKSHAFT REAR OIL SEAL

Removal

1. Disconnect negative battery cable. Remove transaxle. For M/T, see appropriate article in CLUTCHES. For A/T, see TRANSMISSION REMOVAL & INSTALLATION article in TRANSMISSION SERVICING.
2. On manual transaxle models, mark pressure plate in relation to flywheel for installation reference. Remove flexplate/flywheel assembly. Remove oil pan-to-seal housing bolts. Remove seal housing-to-block bolts and gasket. See **Fig. 30**.
3. Note direction of seal installation. Lay seal housing onto 2 wood blocks, with transaxle side of seal housing facing down. To prevent seal housing damage, ensure wood blocks that seal housing are supported across dowel pin and center bolt holes on both sides of seal opening. Using a small chisel in seal relief grooves, evenly drive seal out of seal housing without scraping sealing surface.

Installation

1. Using Crankshaft Rear Seal Installer (J-36005), press NEW seal into housing. Replace oil pan gasket if damaged. If silicone bead at corner joints is damaged, repair it by applying just enough Silicone Sealant (12345739) to restore it to its original dimension (too much sealant may cause part misalignment, resulting in oil leaks).
2. Set NEW seal housing-to-block gasket in place on dowel pins. Lubricate NEW seal lip with engine oil. Install seal housing, but DO NOT install oil pan bolts. Tighten bolts securing seal housing to cylinder block to specification. See **TORQUE SPECIFICATIONS** table. Install and tighten oil pan-to-seal housing bolts to specification.
3. To install remaining components, reverse removal procedure. Apply Sealant (12345493) to flexplate/flywheel bolts before installing them. Align reference marks on pressure plate and flywheel (manual transmission).

OIL FLOW CHECK VALVE

Removal

CAUTION: During check valve removal, DO NOT allow tool to impact ball at bottom of check valve, as this may cause ball to dislodge. If check ball is dislodged, it may fall into oil galley. Locate check ball if it is missing.

1. Oil flow check valve is located below surface of cylinder block deck, near front of engine, and is accessible with cylinder head removed. See **Fig. 33**. Attach a slide hammer to check valve using Check Valve Remover (J-38123) or a modified common 3/16 x 4" round-head machine screw. To modify screw, grind 2 flat spots on outside diameter of screw head, parallel with screwdriver slot and 180 degrees across from each other.
2. Insert check valve remover (or modified machine screw) into check valve, then rotate tool 90 degrees so

it will lock into indentations in check valve. DO NOT allow tools to contact check ball as it can drop into engine oil galleries. Pull check valve out of its bore.

Installation

If check ball is missing, it has dropped into oil galleries and must be retrieved before installation. Using slide hammer and check valve remover (opposite end), or a hammer and drift punch, drive NEW check valve into its bore until it is seated (normally, check valve will seat slightly below surface). A distinct change of sound will result when check valve seats.

VALVE LIFTERS**Removal & Installation**

To remove and install valve lifters, remove camshafts and camshaft housings. See **INTAKE CAMSHAFT & HOUSING**. Also refer to **EXHAUST CAMSHAFT & HOUSING**.

THERMOSTAT**Removal & Installation**

1. Disconnect negative battery cable. Drain and recover engine coolant. Access and remove or loosen coolant outlet housing bolt through exhaust manifold. See **Fig. 16**.
2. Raise vehicle. Remove radiator outlet pipe stud. Remove 2nd coolant inlet housing bolt. Remove coolant inlet housing. Remove thermostat.
3. Clean mating surfaces. Install thermostat. To complete installation, reverse removal procedures.

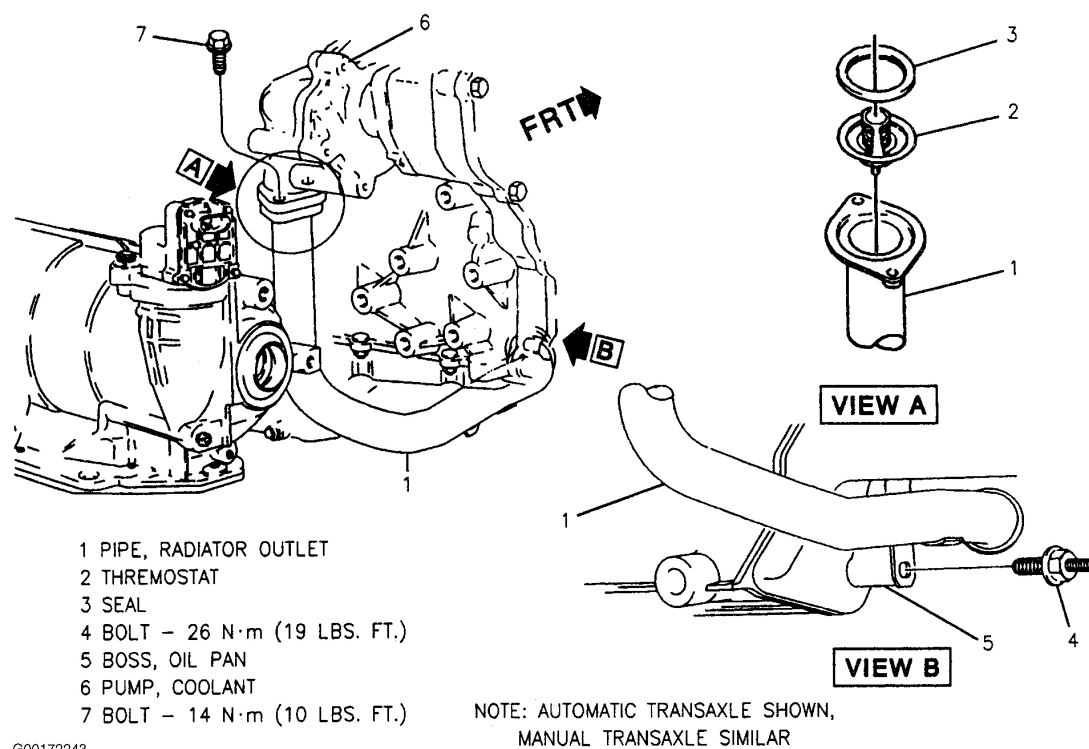


Fig. 16: Removing & Installing Thermostat
Courtesy of GENERAL MOTORS CORP.

RADIATOR

Removal & Installation

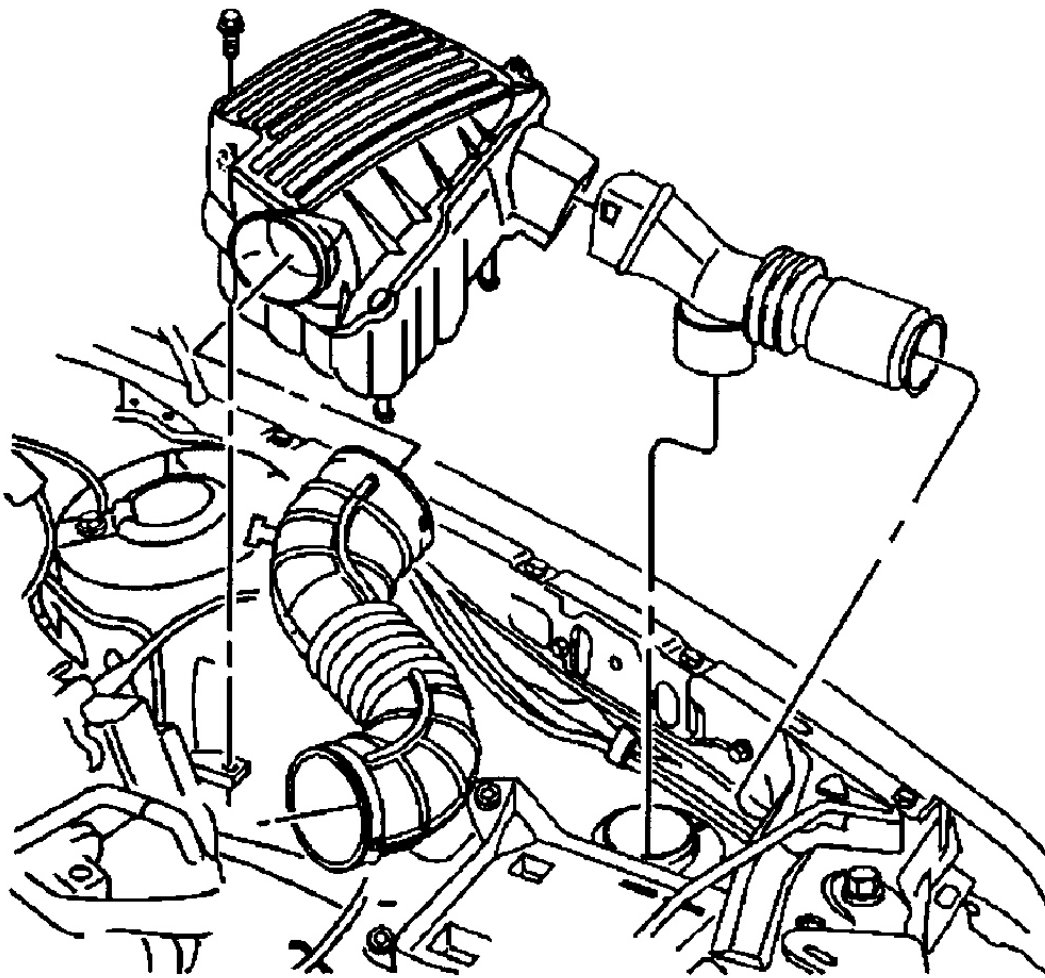
CAUTION: Before servicing any electrical component, the ignition key must be in the OFF or LOCK position and all electrical loads must be OFF, unless instructed otherwise in these procedures. If a tool or equipment could easily come in contact with a live exposed electrical terminal, also disconnect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

NOTE: When adding coolant, use DEX-COOL® coolant. If silicated coolant is added to the system, premature engine, heater core or radiator corrosion may result. In addition, the engine coolant will require change sooner-at 30,000 miles or 24 months.

NOTE: Use the correct fastener in the correct location. Replacement fasteners must be the correct part number for that application. Fasteners requiring replacement or fasteners requiring the use of thread locking compound or sealant are identified

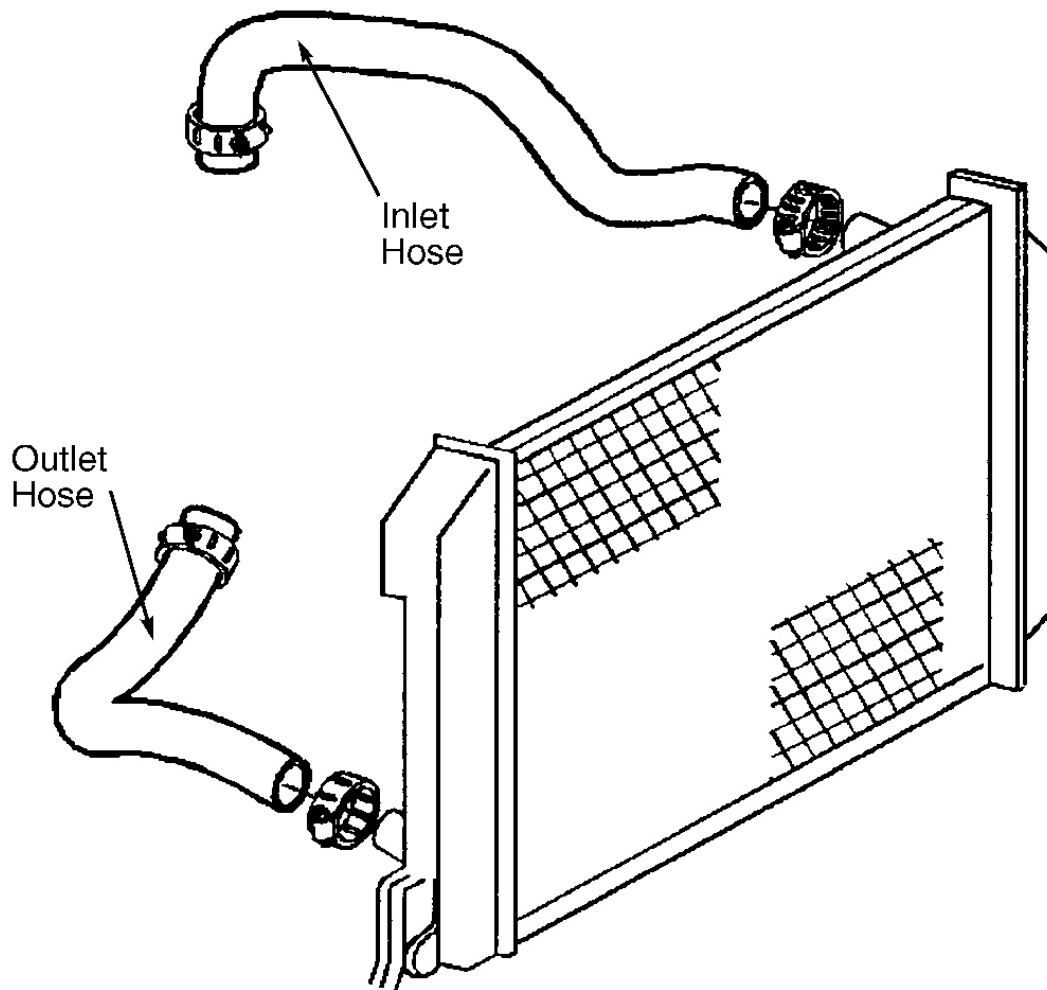
in the service procedure. DO NOT use paints, lubricants, or corrosion inhibitors on fasteners or fastener joint surfaces unless specified. These coatings affect fastener torque and joint clamping force and may damage the fastener. Use the correct tightening sequence and specifications when installing fasteners in order to avoid damage to parts and systems.

1. Disconnect the negative battery cable. Drain the cooling system. See **COOLING SYSTEM BLEEDING**.
2. Remove the air cleaner outlet duct to the upper air cleaner. See **Fig. 17**. Remove the lower air cleaner mounting bolt. Remove the air intake duct from the air cleaner assembly. Remove the upper and lower air cleaner assembly.
3. Disconnect the upper transaxle oil cooler line from the radiator (Automatic Transmission). Disconnect the radiator inlet hose and the clamp from the radiator. See **Fig. 18**.
4. Raise and support the vehicle. Disconnect the lower transaxle oil cooler line from the radiator. Disconnect the cooling fan electrical connector. See **Fig. 19**. Remove the fan retaining bolt and remove the cooling fan.
5. Remove the splash shield that is below the radiator outlet hose. Disconnect the radiator outlet hose from the radiator. See **Fig. 17**.
6. Lower the vehicle. Remove the retaining clip from the condenser line. See **Fig. 20**. Remove the condenser to radiator bolts.
7. Disconnect the surge tank inlet hose and the clamp from the radiator. See **Fig. 21**. Remove the radiator retaining bolts and the mounts. See **Fig. 22**. Remove the radiator.
8. To install, reverse removal procedure. Tighten all fasteners to specification. See **TORQUE SPECIFICATIONS**. Start the engine. After the engine reaches normal operating temperature, check for coolant leaks.



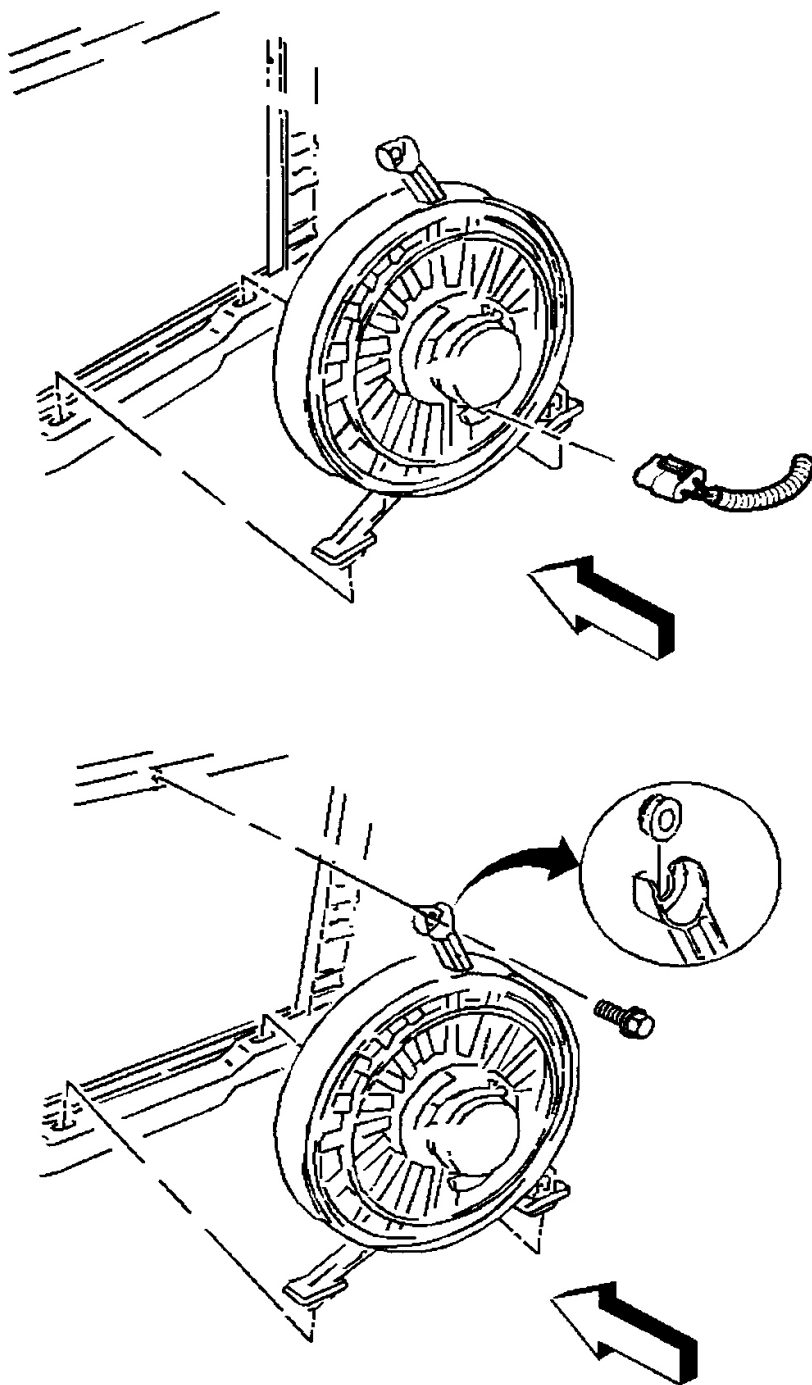
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Fig. 17: Removing/Installing Air Cleaner Assembly (2.4L)
Courtesy of GENERAL MOTORS CORP.



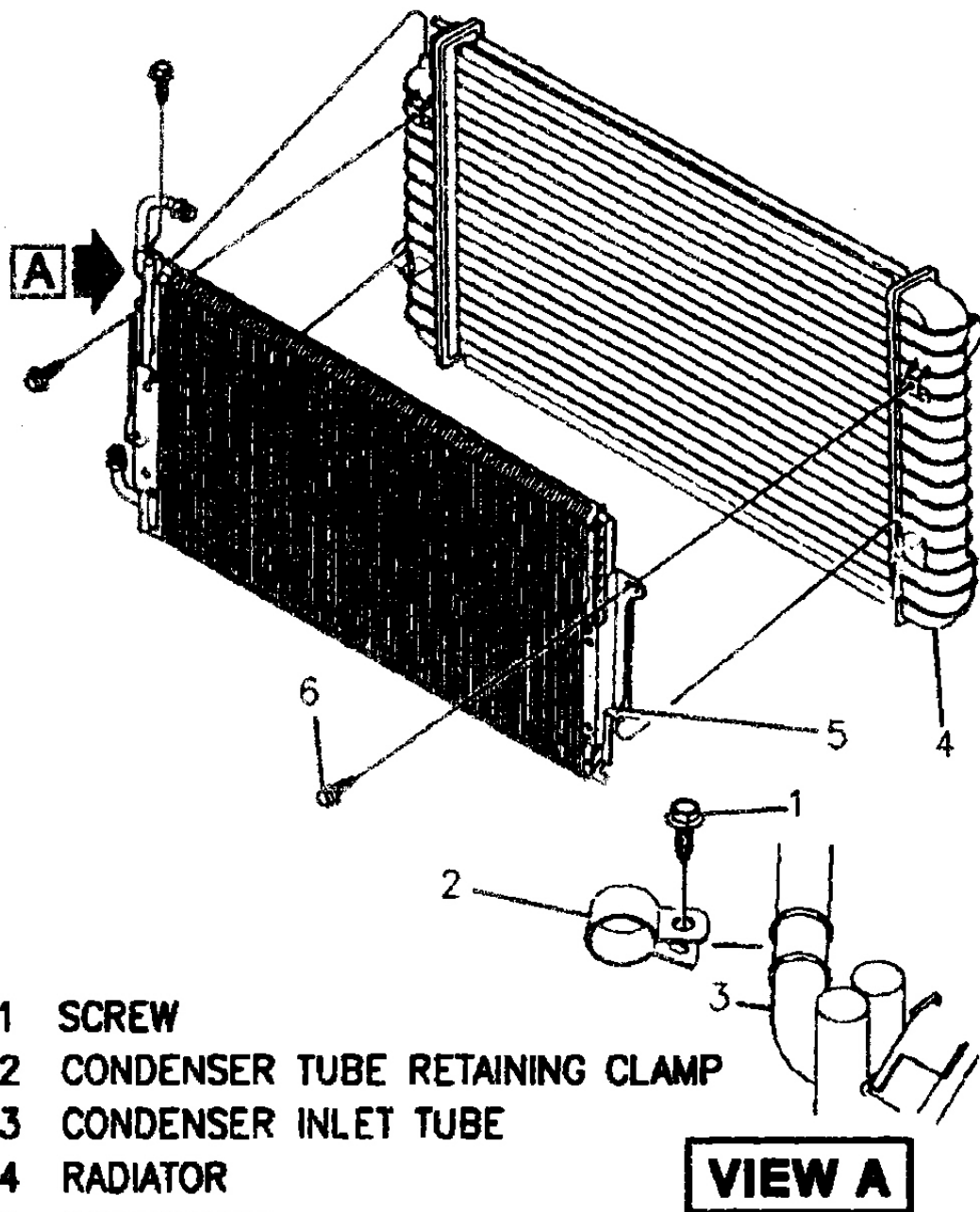
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Fig. 18: Removing/Installing Radiator Inlet Hose (2.4L)
Courtesy of GENERAL MOTORS CORP.



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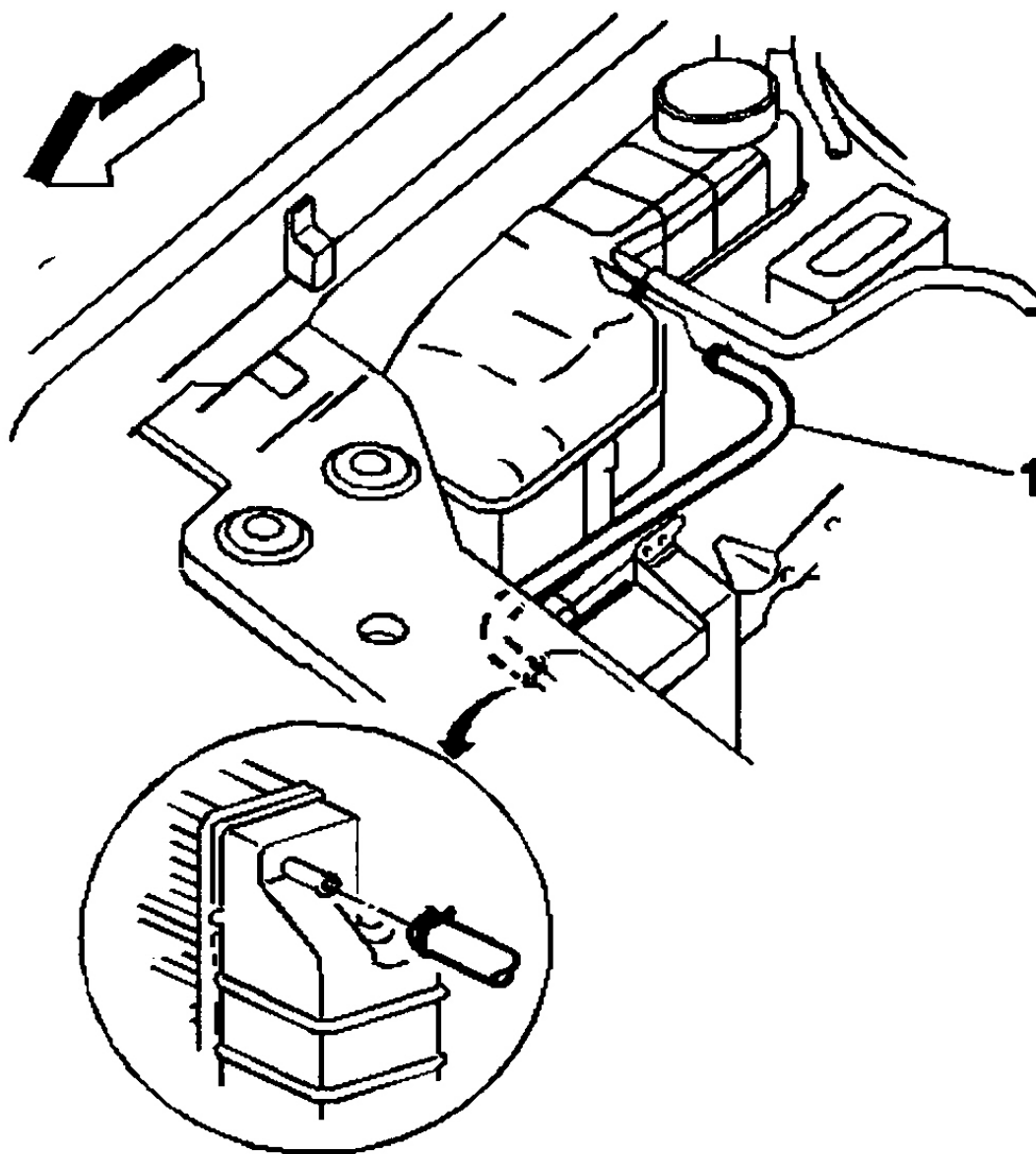
Fig. 19: Removing/Installing Cooling Fan (2.4L)
Courtesy of GENERAL MOTORS CORP.



- 1 SCREW
- 2 CONDENSER TUBE RETAINING CLAMP
- 3 CONDENSER INLET TUBE
- 4 RADIATOR
- 5 CONDENSER
- 6 SCREW

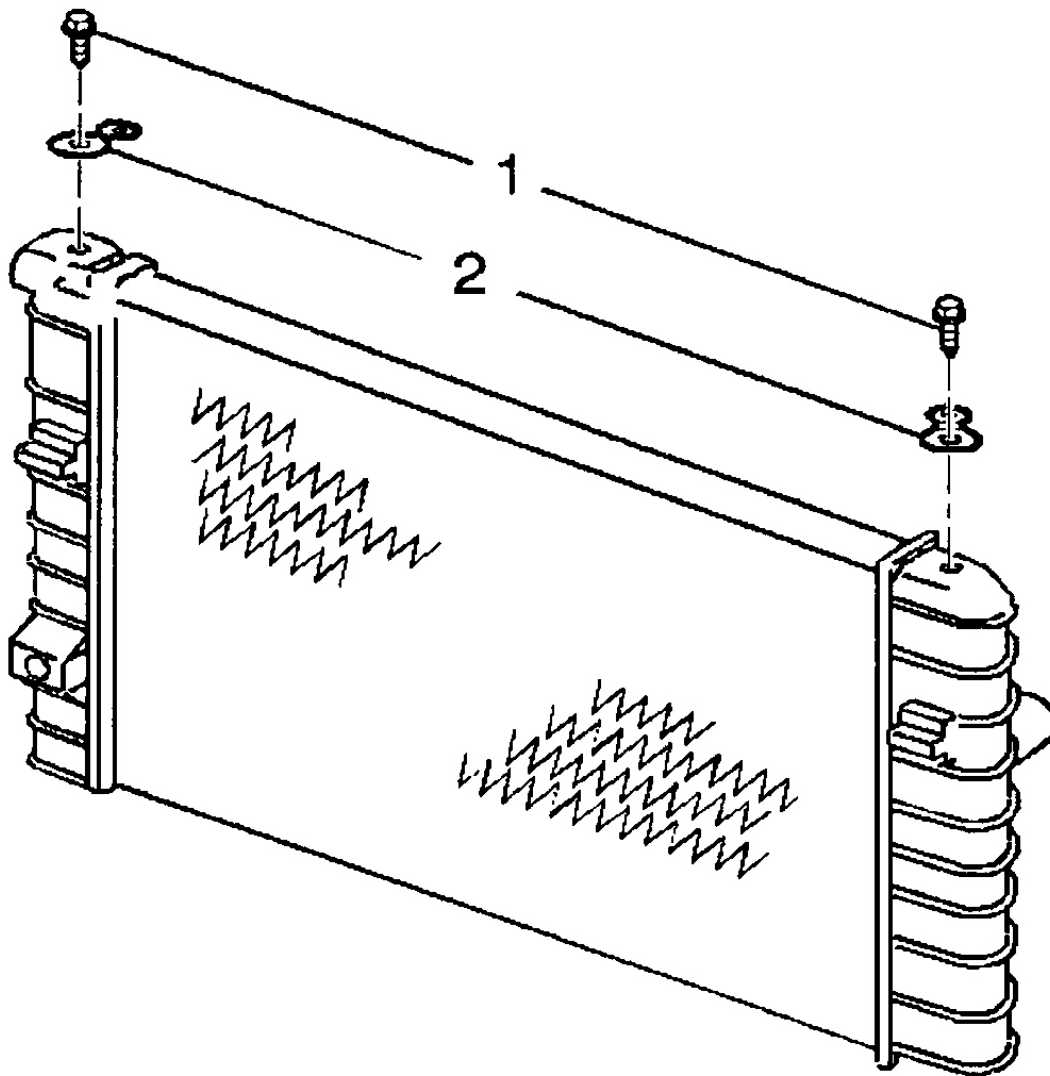
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Fig. 20: Removing/Installing Retaining Clip From Condenser Line (2.4L)
 Courtesy of GENERAL MOTORS CORP.



G00255810

Fig. 21: Disconnecting/Connecting Surge Tank Inlet Hose (2.4L)
Courtesy of GENERAL MOTORS CORP.



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Fig. 22: Removing/Installing Radiator Retaining Bolts & Mounts (2.4L)

Courtesy of GENERAL MOTORS CORP.

WATER PUMP

Removal

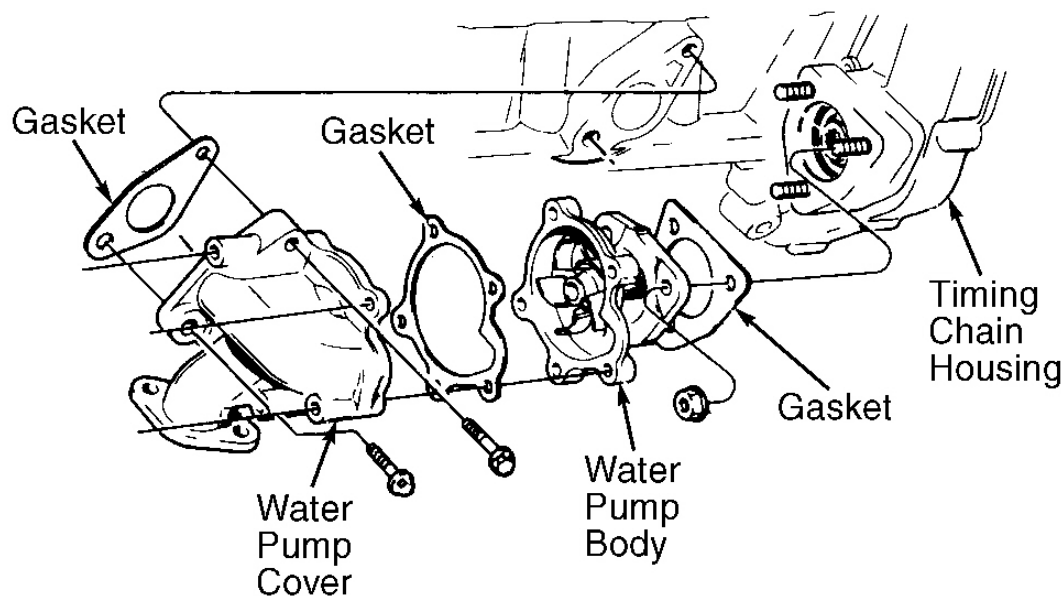
1. Water pump is driven by timing chain idler and is mounted on rear of timing chain housing. See **Fig. 23**. Disconnect negative battery cable. Drain cooling system. Disconnect oxygen sensor connector.
2. Remove upper exhaust manifold heat shield. Remove exhaust manifold brace. Remove lower exhaust manifold heat shield. Loosen exhaust manifold-to-exhaust manifold spring loaded nuts. Remove radiator outlet pipe to water pump cover bolts. Disconnect exhaust pipe from manifold.

3. Pull down on exhaust pipe to disconnect it from exhaust manifold bolts. See **EXHAUST MANIFOLD**. Disconnect outlet pipe from oil pan and transaxle. If equipped with manual transaxle, remove exhaust manifold brace. Leave lower radiator hose attached and pull down on radiator outlet pipe to disengage from water pump. Leave outlet pipe hanging.
4. Lower vehicle. Remove exhaust manifold to cylinder head nuts. Remove exhaust manifold. Remove timing chain front cover. See **FRONT COVER**. Remove timing chain tensioner. See **TIMING CHAIN, SPROCKETS & TENSIONER**. Remove bolts securing water pump cover to cylinder block. Remove water pump-to-timing chain housing nuts.
5. Remove water pump attaching nuts. Remove water pump and cover assembly. Separate components as necessary.

Installation

NOTE: Before installing water pump, read entire installation procedure. It contains important information about tightening sequences that affect sealing.

1. Install the water pump cover to the coolant pump assembly
2. Install the water pump bolts. Finger tighten bolts.
3. Install the cover to block bolts. Finger tighten bolts.
4. Install the pump to chain housing nuts. Finger tighten the nuts.
5. Tighten bolts and nuts to specification in following sequence. See **TORQUE SPECIFICATIONS** table.
 - Pump Assembly-To-Timing Chain Housing Nuts.
 - Pump Cover-To-Pump Body Bolts.
 - Pump Cover-To-Cylinder Block Bolts (Bottom Bolt First).
 - Outlet Pipe-To-Cover Bolts.
6. To complete installation, reverse removal procedure. Fill cooling system.



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Fig. 23: Exploded View Of Water Pump Assembly
 Courtesy of GENERAL MOTORS CORP.

OIL PAN

Removal

1. Disconnect negative battery cable. Raise and support vehicle. Drain crankcase. Drain cooling system. Remove flywheel cover. Remove right front wheel. Remove splash shield. Remove serpentine drive belt. Remove air conditioning compressor lower bolts.
2. Remove transaxle-to-engine brace. Remove engine mount strut bracket. Remove radiator outlet pipe bolts. Remove outlet pipes from oil pan. Remove exhaust manifold brace.
3. Remove bolt and nut securing oil pan to flywheel cover. Remove flywheel cover stud (for clearance during removal). Disconnect radiator outlet pipe from lower radiator hose and oil pan. Disconnect oil level sensor connector. Remove oil pan bolts, pan and gasket.

Installation

If oil pan gasket is not damaged, reuse it. Install oil pan and gasket. Loosely install oil pan bolts. Place spacer in approximate installed location, but allow clearance to tighten pan bolt located directly above spacer. Tighten oil pan bolts to specification. See **TORQUE SPECIFICATIONS** table. To complete installation, reverse removal procedure.

BALANCE SHAFT CHAIN COVER

Removal & Installation

Remove negative battery cable. Remove oil pan. See **OIL PAN**. Remove balance shaft cover retainers and cover. To install, reverse removal procedure.

BALANCE SHAFT CHAIN TENSIONER

Removal

Remove balance shaft chain cover. See **BALANCE SHAFT CHAIN COVER**. Remove balance shaft chain guide. Remove tensioner assembly. See **Fig. 29**.

Installation

1. Install chain guide. Loosely install adjustment bolt at chain guide. Adjust chain tension as follows: Insert a .040" (1.0 mm) brass feeler gauge between chain and guide. See **Fig. 30**. Press chain against guide with 3 lbs. (1.4 kg) of force.
2. Tighten chain guide adjustment bolt to specification. Press chain against guide with 3 lbs. (1.4 kg) of force.
3. Tighten chain guide adjustment bolt to specification. Install chain cover. Tighten cover nut and bolt to specification. See **TORQUE SPECIFICATIONS** table. To complete installation, reverse removal procedure.

BALANCE SHAFT ASSEMBLY

Removal & Installation

1. Disconnect negative battery cable. Remove oil pan. See **OIL PAN**. Remove balance shaft cover retainers and cover. Loosen but do not remove chain tensioner. Remove oil pump cover. Remove oil pump. Rotate crankshaft until No. 1 piston is at TDC. Install Balance Shaft Holder (41088) to prevent shafts from turning. See **Fig. 26**.

CAUTION: Bolt securing driven sprocket to balance shaft is a left-hand thread bolt. Turn bolt clockwise to remove or counterclockwise to install. DO NOT reuse bolt, as sprocket may slip.

2. Remove balance shaft driven sprocket bolt. Mark outside surfaces of sprockets for reassembly reference, and remove driven sprocket. Remove balance shaft assembly bolts and remove assembly.

Inspection

1. Check end play with a dial indicator. Set up indicator to read off back of shafts. Press against one shaft and note movement. Repeat for other shaft. Backlash should be .0003-.0034" (.008-.086 mm).
2. Note that balance shafts must be pulled in same direction to ensure proper reading. If out of specifications, check thrust plate for wear. If end play is excessive and thrust plate is not worn, replace balance shafts.

Installation

NOTE: Balance shafts and drive chains must be replaced as a pair.

1. Install balance shaft assembly to engine and tighten to specifications. Use Sealer (12345493) on bolts. See **TORQUE SPECIFICATIONS** table. Install balance shaft driven sprocket. Tighten NEW left-hand thread bolt to specification, with Balance Shaft Holder (41088) installed to prevent shafts from turning. See **Fig. 26**. See **TORQUE SPECIFICATIONS** table.
2. Install oil pump. Install balance shaft tensioner and tighten and adjust. See **BALANCE SHAFT CHAIN TENSIONER**. Install balance shaft chain cover. See **BALANCE SHAFT CHAIN COVER**. To complete installation, reverse removal procedure.

BALANCE SHAFT DRIVE CHAIN

1. Remove engine and transaxle. See **ENGINE**. Remove starter motor. Remove transaxle from engine. Remove flexplate/flywheel. Remove crankshaft balancer from engine. See **FRONT COVER**. Install engine to stand.
2. Remove bolts and remove ignition coil and module assembly by pulling it straight up. See **Fig. 14**. Remove spark plugs. Remove engine front cover. See **FRONT COVER**. Rotate engine to "timed" position and remove timing chain. See **Fig. 7**.
3. Remove timing chain housing. See **TIMING CHAIN HOUSING**. Rotate engine on stand 180 degrees and remove oil pan. See **OIL PAN**. Remove balance shaft assembly. See **BALANCE SHAFT ASSEMBLY**. Remove crankshaft and balance shaft drive chain. See **Fig. 28**.

Installation

Install crankshaft and balance shaft drive chain. Install balance shaft assembly. See **BALANCE SHAFT ASSEMBLY**. Install oil pan. Rotate engine 180 degrees on stand. Install timing chain housing. See **TIMING CHAIN HOUSING**. To complete installation, reverse removal procedures.

BALANCE SHAFT COMPONENTS

Removal

Remove balance shaft assembly. See **BALANCE SHAFT ASSEMBLY**. Remove attaching bolts and split housings. See **Fig. 24**. Remove shafts, bearings and thrust plate from housing.

Inspection

1. Clean all parts in solvent. Inspect housing for cracks, scored bearing bores and damaged threads. If housing is damaged, replace entire assembly. Check all sprocket teeth for bent, broken, chipped or other damage. Check sprocket for burrs, damaged bolt hole or scored surfaces. Inspect shafts for scores or burrs, cracks or missing pieces.
2. Inspect balance shaft journals for correct diameter, and out-of-round. Check balance shaft gear backlash. See inspection procedure under **BALANCE SHAFT ASSEMBLY**. Inspect bearings for damage. Determine clearance with Plastigage or by measuring journal and bearing diameters. Bearing clearance should be .0017-.0044" (.044-.111 mm).
3. Inspect thrust plate for gouges or burrs and measure thickness. Thrust plate thickness should be .1159-

.1199 (2.945-3.045 mm).

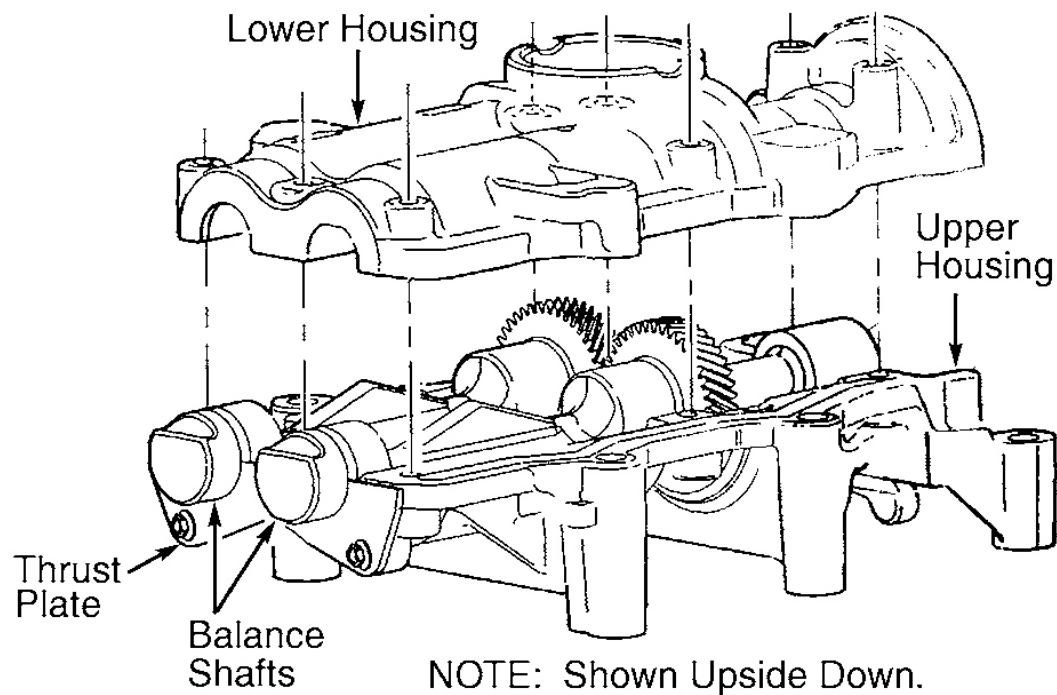
Installation

1. Install thrust plate and tighten to specifications. See **TORQUE SPECIFICATIONS** table. Install bearing halves into housing and lubricate. Install balance shaft and balance shaft gear subassemblies into housing. Make sure timing marks line up. See **Fig. 25**.
2. Install upper housing half to lower half. Tighten bolts to initial torque of 44 INCH lbs. (5 N.m). Final tightening will be accomplished after installation on engine. See **Fig. 27**. To complete installation, reverse removal procedure.

NOTE: **DO NOT install oil pump pickup screen until housing bolts have been tightened to final specification.**

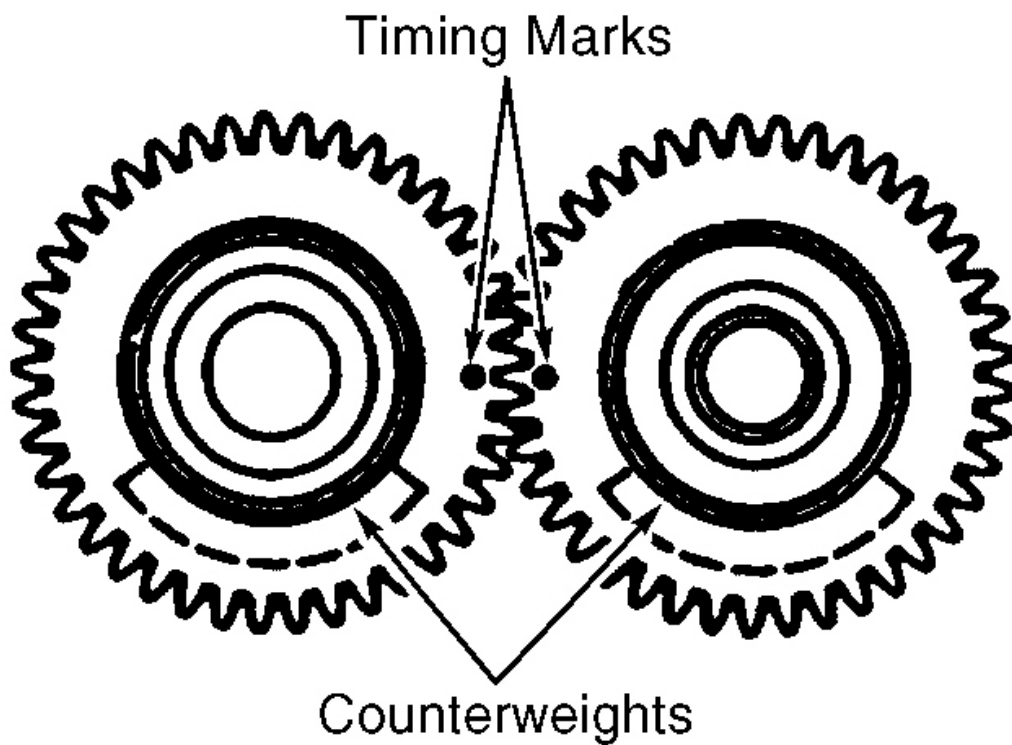
BALANCE SHAFT TIMING

1. Place No. 1 piston at TDC. Rotate crankshaft an additional 90 degrees in either direction (keyway on crankshaft should be aligned with split line of main bearing). See **Fig. 26**. Rotate balance shafts as necessary, then install Balance Shaft Holder (J-41088) onto ends of balance shafts. Balance shafts are now timed in relation to crankshaft.
2. Install chain and driven sprocket onto balance shaft. If installing old sprocket, ensure same surface of sprocket, as when removed, faces balance shaft. If installing NEW sprocket, either surface of sprocket can be placed against balance shaft.
3. Install and finger-tighten (left-hand threads). Install chain guide. While tightly pressing chain guide against chain, temporarily install and tighten chain guide adjustment bolt. Tighten NEW sprocket bolt to specification. See **TORQUE SPECIFICATIONS** table. Remove balance shaft holder from ends of balance shafts.



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Fig. 24: Partially Exploded View Of Balance Shaft Housing
Courtesy of GENERAL MOTORS CORP.



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Fig. 25: Aligning Timing Marks On Balance Shafts
Courtesy of GENERAL MOTORS CORP.

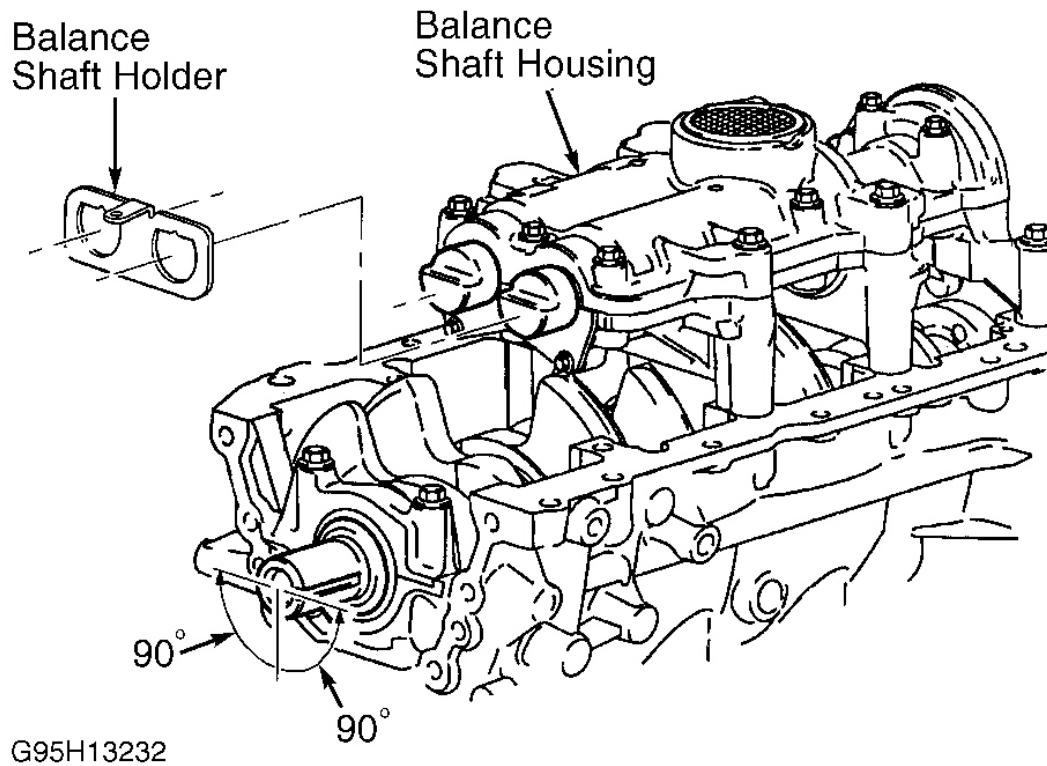
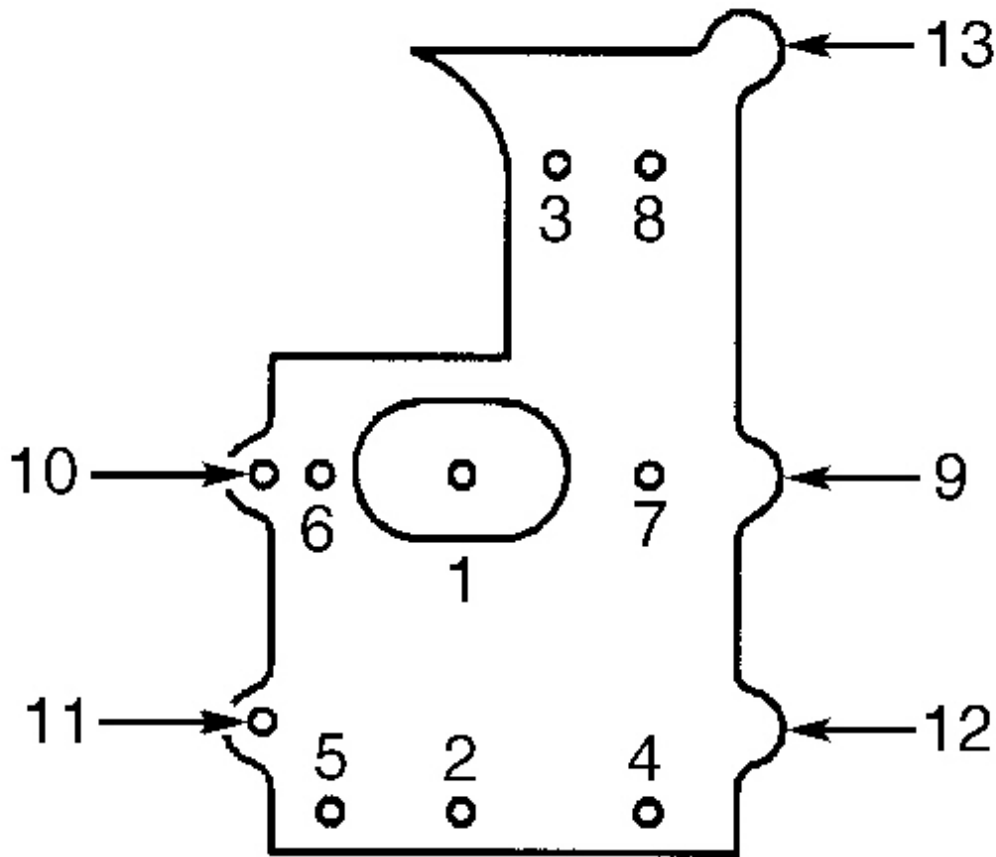
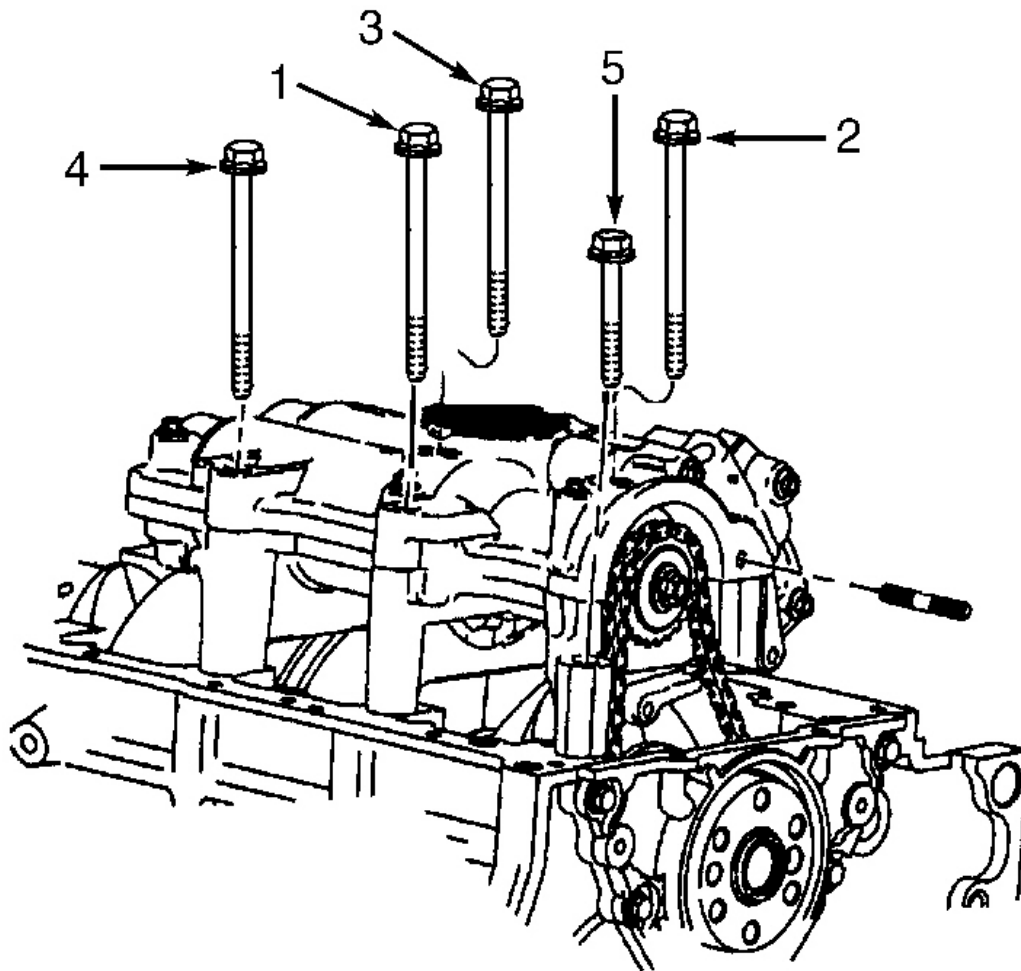


Fig. 26: Timing Balance Shafts In Relation To Crankshaft
Courtesy of GENERAL MOTORS CORP.



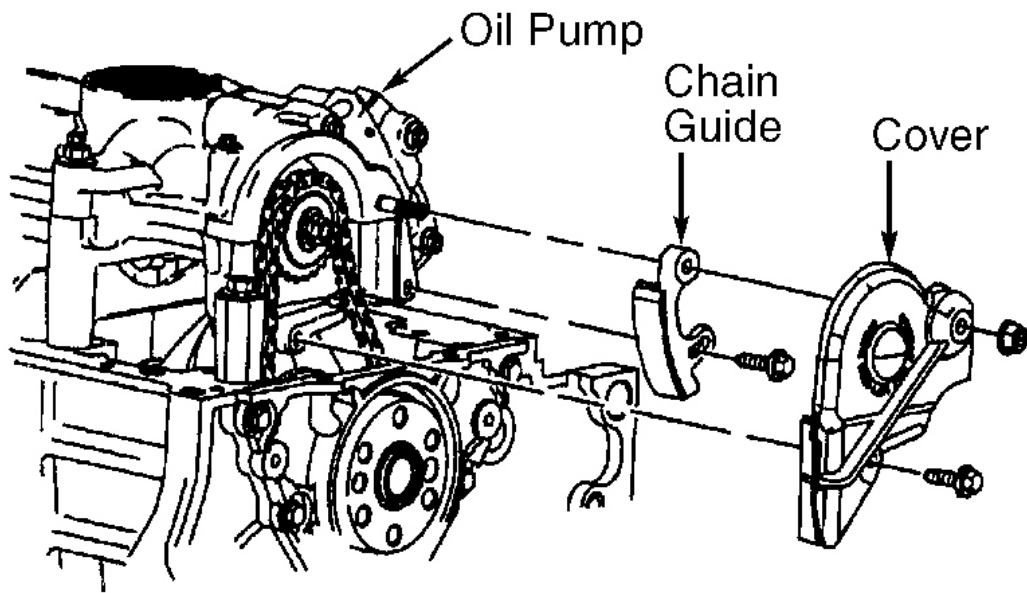
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Fig. 27: Balance Shaft Upper-to-Lower Housing Bolt Tightening Sequence
 Courtesy of GENERAL MOTORS CORP.



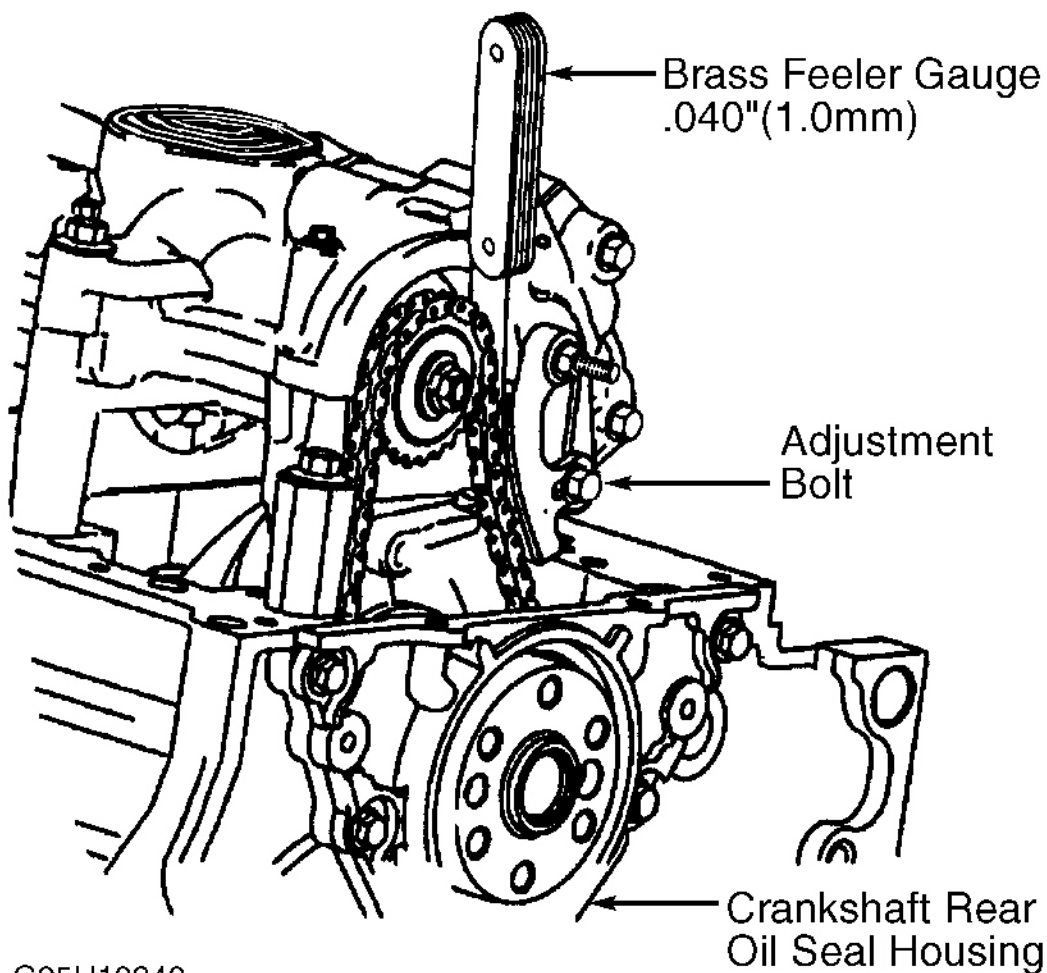
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Fig. 28: Balance Shaft Housing-to-Block Torque Sequence
Courtesy of GENERAL MOTORS CORP.



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Fig. 29: Exploded View Of Balance Shaft Chain Cover & Guide
Courtesy of GENERAL MOTORS CORP.



G95H13240

Fig. 30: Adjusting Balance Shaft Chain
Courtesy of GENERAL MOTORS CORP.

OVERHAUL

CYLINDER HEAD

Gasket Surfaces

Using a straightedge and feeler gauge, measure warpage of cylinder head deck surface and manifold surfaces. If warp is less than .003" (.076 mm), cylinder head is okay and does not require resurfacing. If warp is .003-.010" (.076-.25 mm), resurface head. See **CYLINDER HEAD** table under ENGINE SPECIFICATIONS. If warpage exceeds .010" (.25 mm), replace cylinder head.

Valve Springs

1997 Buick Skylark Gran Sport

1996-97 ENGINES 2.4L 4-Cylinder

Check squareness, free length and pressure of valve springs. See **VALVES & VALVE SPRINGS** table under ENGINE SPECIFICATIONS. Replace any spring that is not within specification.

Valve Stem Oil Seals

Remove seals with Seal Remover (J-36017). Install seals with Seal Installer (J-36007).

Valve Guides

If stem-to-guide oil clearance exceeds specification, ream valve guide with GM Reamer (J-36019-A) and/or replace valve. See **VALVES & VALVE SPRINGS** and **CYLINDER HEAD** tables under ENGINE SPECIFICATIONS. Information on valve guide replacement is not available from manufacturer.

Valve Seats

Set seat angle and seat width to specification. Refer to the **CYLINDER HEAD** table under ENGINE SPECIFICATIONS. Remove only enough metal to clean seat. Valve seat replacement information is not available from manufacturer.

Valve Face

If resurfacing valve face, remove only enough metal to clean face. Set face angle to specification. See **VALVES & VALVE SPRINGS** table under ENGINE SPECIFICATIONS.

Valve Dimensions

If valve dimensions are not as specified, replace valve. See **VALVES & VALVE SPRINGS** table under ENGINE SPECIFICATIONS.

Valve Seat Correction Angles

If seat and face make contact too close to valve stem, grind seat with a 20-degree stone. If seat and face make contact too close to valve margin, grind seat with a 70-degree stone.

Valve Installed Height

Valve installed height is distance from tip of valve stem to top of camshaft housing. If installed height is not as specified, grind valve seat or replace valve as necessary. See **VALVES & VALVE SPRINGS** table under ENGINE SPECIFICATIONS.

CAMSHAFT HOUSING

Measure valve lifter O.D. and lifter bore I.D. Determine oil clearance. Inspect camshaft housing warpage. Replace components if necessary. See **VALVE LIFTERS** table under ENGINE SPECIFICATIONS.

CYLINDER BLOCK ASSEMBLY

Piston & Rod

Orientation Arrow on top of piston must face front of engine. Oil hole in connecting rod must face exhaust manifold side of engine. See **Fig. 31**.

Piston Pin

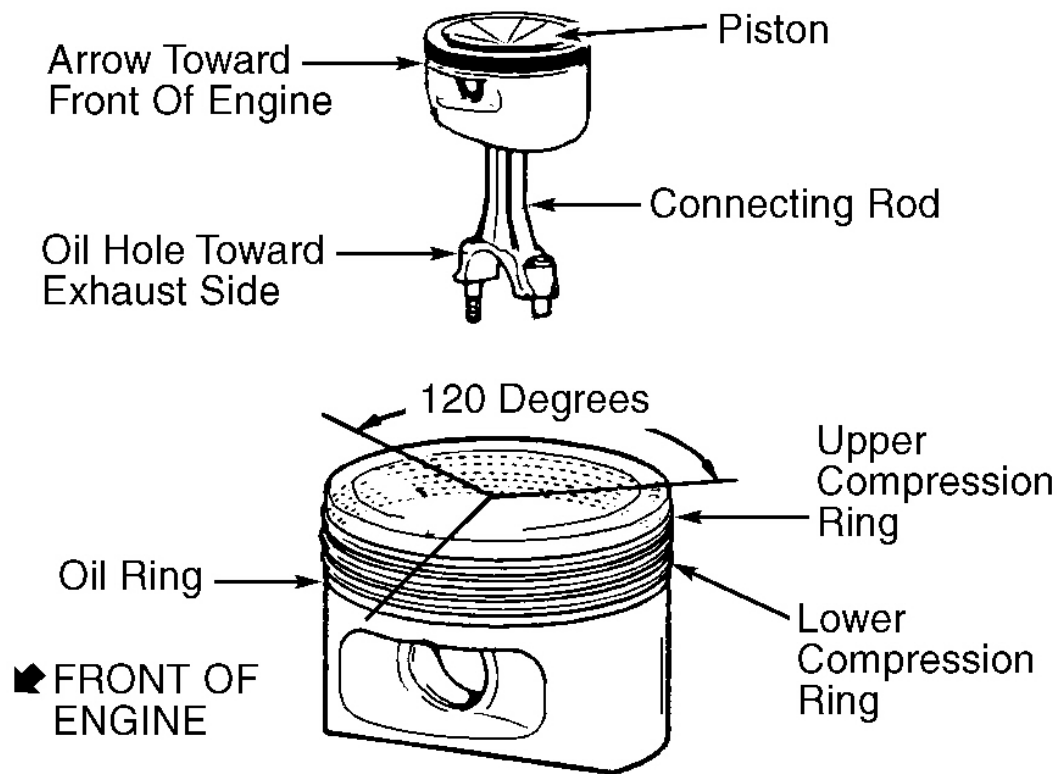
Remove retainer rings from each end of pin bore. No special tools are required to remove and install piston pin. If piston fit is not within specification, replace piston and/or pin. See **PISTONS, PINS & RINGS** table under ENGINE SPECIFICATIONS.

Fitting Pistons

Measure diameter of piston at a 90-degree angle to piston pin, at .47" (12 mm) up from center of piston skirt tail. If piston clearance exceeds specification, replace pistons and/or machine cylinders. Refer to **PISTONS, PINS & RINGS** and **CYLINDER BLOCK** tables under ENGINE SPECIFICATIONS.

Piston Rings

If end gap or side clearance exceeds specification, replace piston and/or rings. See **PISTONS, PINS & RINGS** table under ENGINE SPECIFICATIONS. Ring No. 2 (second ring) must be installed with mark on ring flat facing upward. Before installing piston, stagger ring end gaps 120 degrees apart. See **Fig. 31**.



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Fig. 31: Installing Piston & Rings
 Courtesy of GENERAL MOTORS CORP.

Rod Bearings

1. Mark cylinder number on bearing caps for reassembly reference. If connecting rod side clearance exceeds specification, replace connecting rod and/or crankshaft as necessary. See **CONNECTING RODS** table under ENGINE SPECIFICATIONS.
2. If connecting rod journal dimensions are not within specification, replace crankshaft. If oil clearance is not within proper specification, replace connecting rod bearings. See **CRANKSHAFT, MAIN & CONNECTING ROD BEARINGS** table under ENGINE SPECIFICATIONS.

Crankshaft & Main Bearings

Main bearing caps are numbered 1 through 5. If main bearing journal dimensions are not within specification, replace crankshaft. See **CRANKSHAFT, MAIN & CONNECTING ROD BEARINGS** table under ENGINE SPECIFICATIONS. If oil clearance is not within specification, replace bearings.

Thrust Bearing

Thrust bearing is part of main bearing No. 3. Using a rubber mallet, tap crankshaft forward then rearward to seat thrust bearing. With main bearing cap bolts tight, check crankshaft end play. If end play exceeds specification, replace main bearing No. 3 and/or crankshaft. See **CRANKSHAFT, MAIN & CONNECTING ROD BEARINGS** table under ENGINE SPECIFICATIONS.

Crankshaft Balance Shaft Drive Sprocket

1. Inspect sprocket. If replacement is required, drill a hole between 2 teeth of sprocket. Split gear with a chisel to remove it from crankshaft. Ensure crankshaft is free of burrs.
2. Preheat oven to 392°F (200°C) for one hour. Smear some Tempilstik (J-24731-425) material onto teeth of replacement sprocket. Heat gear in oven for 25-30 minutes or until Tempilstik starts to melt. Install gear on crankshaft, ensuring it is fully seated against counterweight.

Cylinder Bores

Measure diameter of cylinder bore at midstroke. If cylinder dimensions are not as specified, machine cylinder as necessary and/or replace piston. See **CYLINDER BLOCK** table under ENGINE SPECIFICATIONS.

Cylinder Block Deck Warpage

If cylinder block deck warpage exceeds specification, machine cylinder head. See **CYLINDER BLOCK** table under ENGINE SPECIFICATIONS. DO NOT remove more than .010" (.25 mm) of material from original surface.

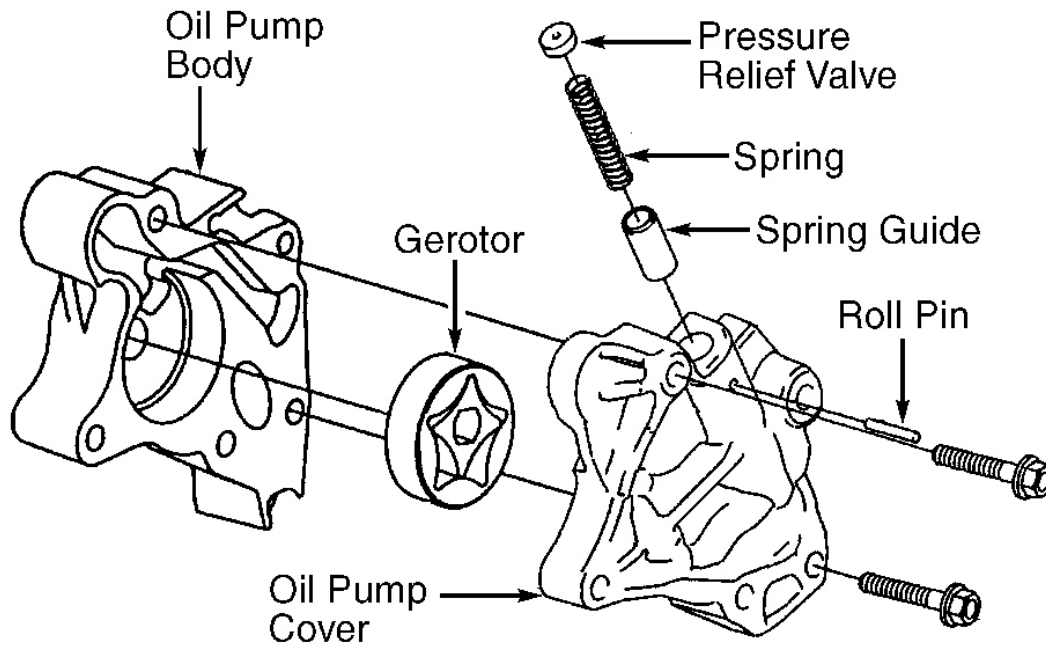
ENGINE OILING

ENGINE LUBRICATION SYSTEM

Oil pump is located near rear end of balance shaft housing (accessible after oil pan has been removed). A chain at rear end of crankshaft drives long balance shaft, which drives short balance shaft. Short balance shaft drives oil pump. Oil is forced through oil filter to main gallery. See **Fig. 33**. If oil filter becomes clogged, a by-pass valve in cylinder block opens.

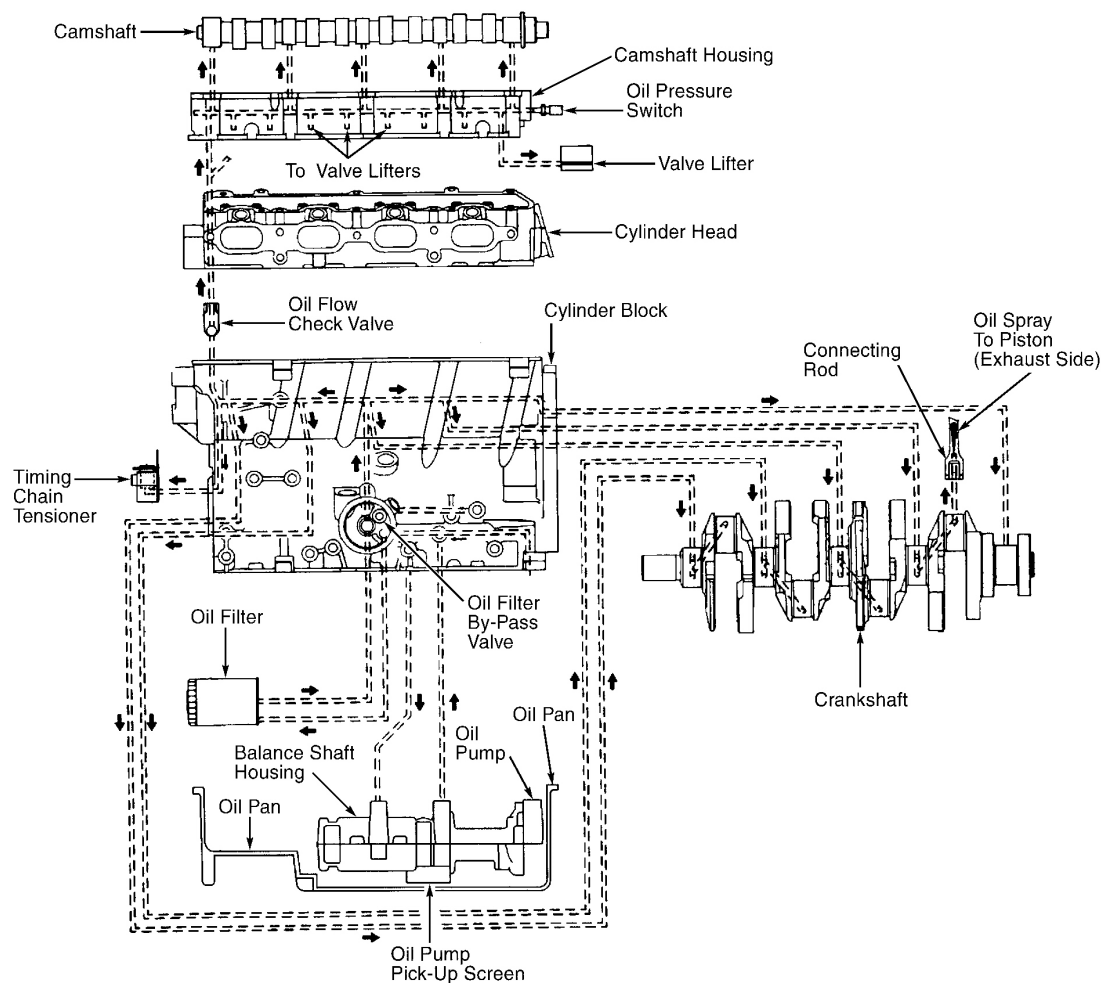
From main gallery, oil is distributed to balance shafts, crankshaft, timing chain hydraulic tensioner, lifters, and camshaft. Main bearings and connecting rod bearings are oiled through passages in crankshaft. Cylinder walls are oiled through a hole in connecting rod. Oil passes through oil flow check valve, into cylinder head, and then into each camshaft housing.

Oil is fed to valve lifters and camshaft bearings. Crankcase Capacity Oil capacity is 4 qts. (3.8L) without oil filter. When checking oil pressure, ensure that engine is at normal operating temperature. Oil pressure should be at least 10 psi (69.0 kPa) at 900 RPM, or 30 psi (206.9 kPa) at 2000 RPM.



G95I13209

Fig. 32: Exploded View Of Oil Pump
Courtesy of GENERAL MOTORS CORP.



G95C13211

Fig. 33: Cross-Sectional View Of Engine Oil Circuit
Courtesy of GENERAL MOTORS CORP.

OIL PUMP

WARNING: Spring under relief valve (pressure regulator) is under pressure. When removing roll pin, relief valve may be ejected from bore.

Removal

Remove oil pan. See **OIL PAN** under REMOVAL & INSTALLATION. Remove balance shaft chain cover. See **BALANCE SHAFT CHAIN COVER** under REMOVAL & INSTALLATION. Remove chain tensioner. See **BALANCE SHAFT CHAIN TENSIONER** under REMOVAL & INSTALLATION. Remove oil pump cover and oil pump.

Disassembly & Inspection

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Remove oil pump cover. See **Fig. 32**. Remove oil pump body and gerotor. To remove relief valve, carefully remove drift pin (valve is under spring pressure). If oil pump components are damaged or if clearances and component dimensions are not within specification, replace oil pump. See **OIL PUMP SPECIFICATIONS** table.

Reassembly & Installation

Coat components with oil. Pack oil pump cavities with petroleum jelly (to prime oil pump). To reassemble and install, reverse removal and disassembly procedure. Tighten bolts to specification. See **TORQUE SPECIFICATIONS** table.

OIL PUMP SPECIFICATIONS

Application	In. (mm)
Drive-To-Driven Gear Backlash	.009-.020 (.23-.51)
Gerotor Cavity	
Depth	.6736-.6756 (17.110-17.160)
Diameter	2.1273-2.1293 (54.033-54.083)
Gerotor Tip Clearance (Maximum)	.006 (.15)
Outer Gerotor-To-Cavity Clearance	.0013-.0052 (.033-.133)
Outer Gerotor Thickness	.6727-.6732 (17.087-17.099)

TORQUE SPECIFICATIONS**TORQUE SPECIFICATIONS**

Application	Ft. Lbs. (N.m)
Balance Shaft Driven Sprocket Bolt ⁽¹⁾	
Step 1	30 (40)
Step 2	Additional 45 Degrees
Balance Shaft Housing-To-Block Bolt ⁽²⁾	
Step 1	
Bolts No. 1, 2 & 4	18 (25)
Bolt No. 3	30 (40)
Bolt No. 5	39 (53)
Step 2	
Bolts No. 1, 2 & 4	Additional 70°
Bolt No. 3	Additional 60°
Bolt No. 5	Leave As Is
Balance Shaft Lower-To-Upper Housing Bolt	
Step 1	(3)
Step 2 (All Bolts)	Additional 40°
Balance Shaft Thrust Plate Bolt	10 (14)

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Camshaft Housing Bolt ⁽⁴⁾ ⁽⁵⁾	
Step 1	11 (15)
Step 2	(6)
Camshaft Sprocket Bolt ⁽⁷⁾	52 (70)
Clutch Cover (Pressure Plate) Bolt	
Step 1	15 (20)
Step 2	Additional 45°
Connecting Rod Nut	
Step 1	18 (24)
Step 2	Additional 80°
Coolant Air Bleed Pipe Nut	31 (42)
Coolant Outlet Bolt	19 (26)
Crankshaft Balancer Bolt	
Step 1	129 (175)
Step 2	Additional 90°
Crankshaft Bearing Cap Bolt	
Step 1	15 (20)
Step 2	Additional 90°
Cylinder Head Bolt	
Step 1	
Bolts 1-8	40 (65)
Bolts 9-10	30 (40)
Step 2 (All Bolts)	Additional 90°
EGR Pipe-To-Adapter Nut	19 (26)
Engine Mount Bracket-To-Block Bolt	
Step 1	44 (50)
Step 2	Additional 90°
Engine Mount Nut Right-To-Body	32 (44)
Engine Mount-To-Bracket Bolt (Right Side)	44 (50)
Engine Strut Bracket	
Front	49 (66)
Bottom	96 (130)
Engine Strut-To-Bracket Through-Bolt	88 (112)
Exhaust Manifold Brace Bolt	41 (56)
Exhaust Manifold Brace Nut	19 (26)
Exhaust Manifold Heat Shield Bolt	10 (14)
Exhaust Pipe-To-Manifold Nut	26 (35)
Flywheel/Flexplate Bolt	
Step 1	22 (30)
Step 2	Additional 45°
Fuel Pipe Bracket Bolt	

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Step 1	11 (15)
Step 2	Additional 30°
Fuel Rail Bolt	19 (26)
Ignition Coil & Module Bolt ⁽⁴⁾	16 (22)
Intake Manifold Bolt	18 (24)
Intake Manifold Brace Bolt	
Brace-To-Manifold	35 (47)
Brace-To-Block	18 (24)
Oil Pan-To-Cylinder Block	18 (24)
Oil Pump Bolt	40 (54)
Throttle Body Bolt	19 (26)
Timing Chain Housing	
To Camshaft Housing Bolt	19 (26)
To Cylinder Block Bolt	21 (29)
Torque Converter Bolt	46 (62)
Transaxle Lower Oil Cooler Line Fitting	22(30)
Transaxle Upper Oil Cooler Line Fitting	22 (30)
Water Pump	
To Cylinder Block Bolt	19 (26)
To Timing Chain Housing Nut	19 (26)
To Water Pump Cover Bolt	10 (14)
INCH Lbs. (N.m)	
Air Cleaner Lower Mounting Bolt	53 (6)
Air Cleaner Outlet Duct Clamps	44 (5)
Balance Shaft & Chain Guide Tensioner	115 (13)
Condenser Tube Retaining Clamp Screw	27 (3)
Condenser-To-Radiator Screw	54 (6)
Coolant Air Bleed Pipe Bolt	124 (14)
Cooling Fan Bracket Bolt	97 (11)
Crankshaft Rear Oil Seal Housing Bolt	106 (12)
Engine Front Cover Bolt	106 (12)
Exhaust Manifold Nut	115 (13)
Oil Pan Bolt-To-Timing Chain Housing	106 (12)
Oil Pan-To-Seal Housing	106 (12)
Radiator Mounting Bolts	89 (10)
Timing Chain Tensioner Bolt	89 (10)
(1) Left-hand threads. Replace bolt after one use. (2) Tighten in sequence. See Fig. 28. (3) Tighten bolts evenly. Tighten all bolts to 89 INCH lbs. (10N.m). Tighten 2 bolts next to balance shaft drive chain to 11ft. lbs. (15 N.m). Finally, tighten all bolts an additional 40 degrees.	

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- (4) Apply Pipe Sealant (1052080) to bolt threads.
- (5) Tighten in sequence. See **Fig. 15**.
- (6) Tighten bolts No. 1-10 an additional 90 degrees. Tighten bolts No. 11 and 12 an additional 30 degrees.
- (7) Apply Adhesive/Sealant (12345493) to bolt threads.

ENGINE SPECIFICATIONS

GENERAL SPECIFICATIONS

GENERAL SPECIFICATIONS

Application	Specification
Displacement	146 Cu. In. (2.4L)
Bore	3.54" (90.0 mm)
Stroke	3.70" (94.0 mm)
Compression Ratio	9.5:1
Fuel System	SFI
Horsepower @ RPM	150 @ 5,600
Torque Ft. Lbs. @ RPM	155 @ 4,400

CRANKSHAFT, MAIN BEARINGS & CONNECTING ROD BEARINGS SPECIFICATIONS

CRANKSHAFT, MAIN & CONNECTING ROD BEARINGS

Application	In. (mm)
Crankshaft	
End Play	.0034-.0096 (.087-.243)
Runout	.0010 (.025)
Main Bearings	
Journal Diameter	2.3634-2.3626 (60.031-60.010)
Journal Out-Of-Round	.0002 (.005)
Journal Taper	.0003 (.007)
Oil Clearance	.0005-.0030 (.013-.075)
Thrust Bearing Width ⁽¹⁾	1.0959-1.0989 (27.837-27.913)
Connecting Rod Bearings	
Journal Diameter	1.8887-1.8897 (47.975-48.000)
Journal Out-Of-Round	.0002 (.005)
Journal Taper	.0002 (.005)
Journal Width	.9161-.9220 (23.270-23.420)
Oil Clearance	.0005-.0021 (.013-.053)
(1) Including fillets.	

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CONNECTING RODS SPECIFICATIONS**CONNECTING RODS**

Application	In. (mm)
Bore Diameter	
Piston Pin Bore	.8664-.8672 (22.007-22.027)
Crankpin Bore	2.0144-2.0155 (51.167-51.193)
Center-To-Center Length	5.6125-5.6146 (142.450-147.550)
Rod Width	
Small End	.9122-.9142 (23.170-23.220)
Large End	.9122-.9142 (23.170-23.220)
Maximum Bend	(1)
Maximum Twist	(1)
Side Play	.006-.018 (.15-.45)
(1) Replace rod if any bend or twist exists.	

PISTONS, PISTON PINS & PISTON RINGS SPECIFICATIONS**PISTONS, PINS & RINGS**

Application	In. (mm)
Pistons	
Piston Clearance	.0004-.0017 (.010-.042)
Piston Diameter	3.542-3.543 (89.968-89.984)
Pin Bore Diameter	.8662-.8664 (22.002-22.006)
Ring Groove Width	
Ring No. 1	.048-.049 (1.23-1.25)
Ring No. 2	.060-.061 (1.52-1.54)
Ring No. 3 (Oil)	.12 (3.0)
Pins	
Diameter	.8659-.8661 (21.995-22.000)
Piston Fit	.00008-.00043 (.0020-.0110)
Rod Fit	.0003-.0012 (.007-.031)
End Play	.000-.024 (.00-.60)
Rings	
No. 1	
Thickness	.0461-.0469 (1.170-1.190)
End Gap	.006-.012 (.15-.30)
Side Clearance	.0016-.0031 (.040-.080)
No. 2	
Thickness	.0461-.0469 (1.170-1.190)
End Gap	.012-.016 (.30-.41)

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Side Clearance	.0012-.0028 (.030-.070)
No. 3 (Oil)	
Thickness	.0196-.0206 (.497-.523)
End Gap	.016-.055 (.40-1.40)
Side Clearance	.0010-.0256 (.025-.65)

CYLINDER BLOCK SPECIFICATIONS**CYLINDER BLOCK**

Application	In. (mm)
Cylinder Bore	
Standard Diameter	3.5431-3.5435 (89.994-90.006)
Maximum Taper ⁽¹⁾	.0003 (.008)
Maximum Out-Of-Round	.0004 (.010)
Deck Warpage (Maximum)	.008" (.20)
(1) Compare diameter measured near top of cylinder with diameter measured 4.20" (106.0 mm) from top of cylinder block deck.	

ENGINE VALVES & VALVE SPRINGS SPECIFICATIONS**VALVES & VALVE SPRINGS**

Application	Specification
Intake Valves	
Face Angle	46°
Face Runout (Maximum)	.0015" (.038 mm)
Head Diameter	1.396-1.399" (35.47-35.53 mm)
Minimum Margin	.010" (.25 mm)
Length	4.227" (107.29 mm)
Tip-To-Groove Distance	.1346" (3.420 mm)
Stem Diameter	.2331-.2339" (5.921-5.941 mm)
Installed Height ⁽¹⁾	.9787-1.002" (24.86-25.62 mm)
Exhaust Valves	
Face Angle	45.5°
Face Runout (Maximum)	.0015" (.038 mm)
Head Diameter	1.137-1.147" (28.87-29.13 mm)
Minimum Margin	.010" (.25 mm)
Length	4.259" (108.17 mm)
Tip-To-Groove Distance	.1346" (3.420 mm)

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Stem Diameter	.2326-.2334" (5.908-5.928 mm)
Installed Height ⁽¹⁾	.9787-1.002" (24.86-25.62 mm)
Lbs. @ In. (kg @ mm)	
Valve Spring Pressure	
Valve Closed	50-55 @ 1.44 (22.7-24.9 @ 36.5)
Valve Open	122-133 @ 1.06 (55.3-60.3 @ 27.0)
(1) Distance from valve stem tip upward to valve cover gasket surface.	

CYLINDER HEAD SPECIFICATIONS**CYLINDER HEAD**

Application	Specification
Maximum Warpage	⁽¹⁾ .010" (.25 mm)
Valve Seats	
Seat Angle	45°
Seat Width	.037-.075" (.94-1.90 mm)
Seat Margin (Minimum)	.010" (.25 mm)
Valve Guides	
Intake Valve	
Valve Guide Inner Diameter	.2331-.2339" (5.921-5.941 mm)
Stem-To-Guide Oil Clearance	.0010-.0028" (.024-.070 mm)
Exhaust Valve	
Valve Guide Inner Diameter	.2326-.2334" (5.908-5.928 mm)
Stem-To-Guide Oil Clearance	.0015-.0032" (.037-.082 mm)
(1) DO NOT resurface if measurement is .003" (.076 mm) or less.	

CAMSHAFT SPECIFICATIONS**CAMSHAFT SPECIFICATIONS**

Application	In. (mm)
End Play	.0010-.0089 (.025-.225)
Journal Diameter	
No. 1	1.572-1.573 (39.930-39.950)
No. 2-5	1.375-1.376 (34.930-34.950)

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Lobe Lift

Intake	.354 (9.00)
Exhaust	.346 (8.80)
Lobe Taper ⁽¹⁾	.0018-.0033 (.046-.083)
Oil Clearance	.0020-.0043 (.050-.110)

(1) On diameter in .5512" (14 mm) length.

CAMSHAFT HOUSING SPECIFICATIONS**CAMSHAFT HOUSING**

Application	In. (mm)
Cam Carrier Flatness	.0028 (.07 mm)
Camshaft Bore Warpage ⁽¹⁾	.002 (.05)
Housing-To-Cylinder Head Surface Warpage ⁽²⁾	.0010 (.025)

(1) To measure bore warpage, lay a straightedge in bearing saddle. Slide a feeler gauge between straightedge and each bearing.

(2) Per 4.0" (100 mm) of length.

VALVE LIFTERS SPECIFICATIONS**VALVE LIFTERS**

Application	In. (mm)
Bore Diameter	1.3381-1.3393 (33.989-34.019)
Lifter Diameter	1.3369-1.3375 (33.959-34.975)
Oil Clearance	.0006-.0023 (.016-.058)

BALANCE SHAFTS SPECIFICATIONS**BALANCE SHAFTS**

Application	In. (mm)
Bearing Inner Diameter	1.1819-1.1835 (30.019-30.061)
Bearing Thickness	.0590-.0593
Bore Roundness	.0009 (.025)
End Play	.0073-.0179 (.185-.455)
Housing Bore	1.3001-1.1801 (33.025-33.050)
Housing Warpage Maximum	.0030 (.076)
Journal Roundness Maximum	.0002 (.005)
Journal Taper	.0000-.0004 (.000-.010)
Oil Clearance	.0017-.0044 (.044-.111)
Shaft Journal Outer Diameter	1.1791-1.1801 (29.950-29.975)
Thrust Plate Thickness	.1159-.1199 (2.945-3.045)