

3.8 & 4.1 LITER V6

IDENTIFICATION CODING

ENGINE IDENTIFICATION

Engine may be identified from the Vehicle Identification Number (VIN) stamped on a metal tab located on top of instrument panel at lower left of windshield. VIN number code also appears as part of a production or unit number stamped on left rear of cylinder block on all models except Oldsmobile and Pontiac. On Oldsmobile and Pontiac models, a code tape is found on front of left side valve cover. The VIN number contains 17 digits. The 8th digit identifies the engine and the 10th digit establishes the model year.

Engine Code	
Engine	Code
3.8L (231") 2-Bbl.	A
3.8L (231") Turbocharged 4-Bbl.	3
4.1L (252") 4-Bbl.	4

ENGINE REMOVAL

See *Engine Removal at end of ENGINE Section.*

CYLINDER HEAD & MANIFOLDS

INTAKE MANIFOLD

Removal — 1) Disconnect battery, remove air cleaner and drain cooling system. Disconnect upper radiator hose, heater hose and accelerator linkage and bracket. Disconnect cruise control chain, booster vacuum line, and fuel line at carburetor. Disconnect vacuum modulator line if equipped with automatic transmission.

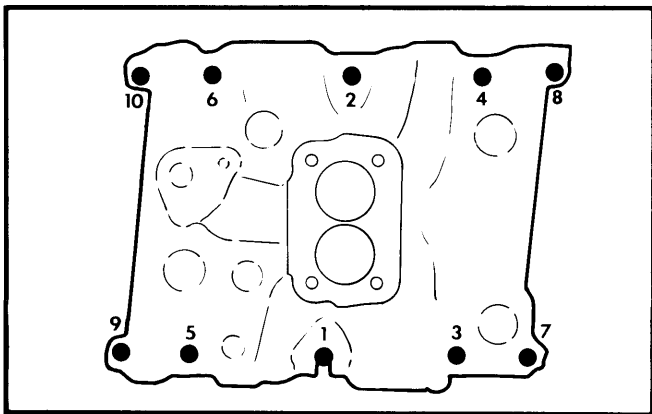


Fig. 1 Intake Manifold Tightening Sequence

2) Disconnect idle stop solenoid lead (if equipped). Disconnect distributor wires and temperature sending unit lead. Disconnect vacuum hoses from distributor TVS and EFE valve pipe and vacuum tank hose. Disconnect coolant by-pass hose at manifold. Remove distributor cap and rotor to gain access to intake manifold Torx head bolt. Remove Torx head bolt using suitable tool (J-24394). Remove accelerator linkage and A/C compressor top bracket. Remove intake manifold and carburetor as an assembly.

Installation — Install new intake manifold gaskets and position new rubber seals on front and rear rails on cylinder block. Make sure pointed end of seal fits tight against block and head. Apply RTV sealer or equivalent to ends of seals. Install intake manifold and bolts. Tighten in sequence shown. Reverse removal procedure to complete installation. See Fig. 1.

EXHAUST MANIFOLD

Removal & Installation — Raise and support vehicle on stands. Remove crossover pipe. Disconnect EFE from left side of engine. Remove exhaust manifold. Install manifold by reversing removal procedure.

CYLINDER HEAD

Removal — 1) On vehicles equipped with Air Injection System, disconnect rubber hosing at injection tubing check valve. Disconnect negative battery cable, remove intake manifold. When removing right cylinder head, remove belts and wires from alternator.

2) If equipped with A/C, remove compressor from mounting bracket and position out of way. Remove alternator with mounting bracket. When removing left cylinder head, remove oil dipstick and power steering pump with bracket and position out of way.

3) Disconnect spark plug wires, remove exhaust manifold bolts from head being removed. Remove rocker arm cover and rocker arm shaft assembly. Remove push rods and mark them for reinstallation in same location. Remove cylinder head bolts and remove cylinder head.

Installation — Make sure mating surfaces and bolt holes are clean. Position new head gasket on block with "bead" side down toward block. Position head on block. Coat head bolts with a heavy duty sealer and install. Tighten head bolts in 3 steps in sequence shown. Reverse removal procedure to complete installation. See Fig. 2.

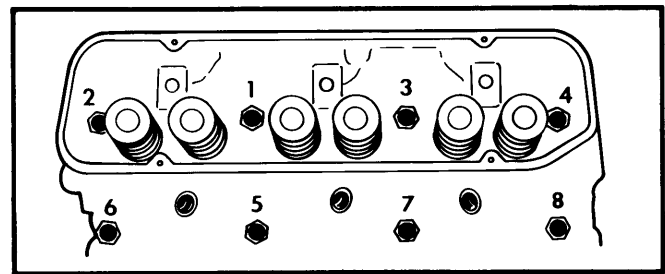


Fig. 2 Cylinder Head Tightening Sequence

VALVES

VALVE ARRANGEMENT

E-I-E-I-E (Left side, front to rear)
E-I-E-I-E (Right side, front to rear)

VALVE GUIDE SERVICING

If stem-to-guide clearance is excessive, replace valve. Some valves with oversize stems are used in production, and can be identified by stamped number on back side of valve head. Valve guide reamers are available in .003", .006" and .010" (.076, .152 and .250 mm) oversize. When reconditioning, always use next oversize reamer and replacement valve. Service valves are available in .003", .006" and .010" (.076, .152 and .250 mm) oversize.

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VALVE STEM OIL SEALS

Valve stem oil seals are installed on intake valves only. Seal is mounted on valve guide. A new seal should be installed whenever valve spring is removed. To install new seals, carefully slide seal over valve stem and push down until it contacts valve guide. Using a suitable tool (J-22509) push seal onto guide until seal bottoms against guide.

VALVE SPRINGS

Removal — With cylinder head removed, compress valve spring with a suitable spring compressor and remove valve keepers. Release spring compressor and remove spring retainer and spring. Remove valve stem oil seal from intake valves.

Installation — Check valve springs in a suitable valve spring tester and replace as necessary. Install valve stem oil seals on intake valves only. Both intake and exhaust valve springs may be installed with either end up. Reverse removal procedure to complete installation.

ROCKER ARM ASSEMBLY

With rocker arm removed, remove nylon rocker arm retainers and remove rocker arms from shaft. Inspect shaft and rocker arms for wear, scoring or damage. Replace components as necessary. If rocker arms are being replaced, note that rocker arms are marked left and right. Reverse disassembly procedure to assemble rocker arm. Rocker arms must be installed in correct order on shafts. Center each arm on $\frac{1}{4}$ " (6.35 mm) hole in shaft. Install new nylon retainers in $\frac{1}{4}$ " (6.35 mm) holes, using a drift punch with at least $\frac{1}{2}$ " (12.70 mm) diameter shaft.

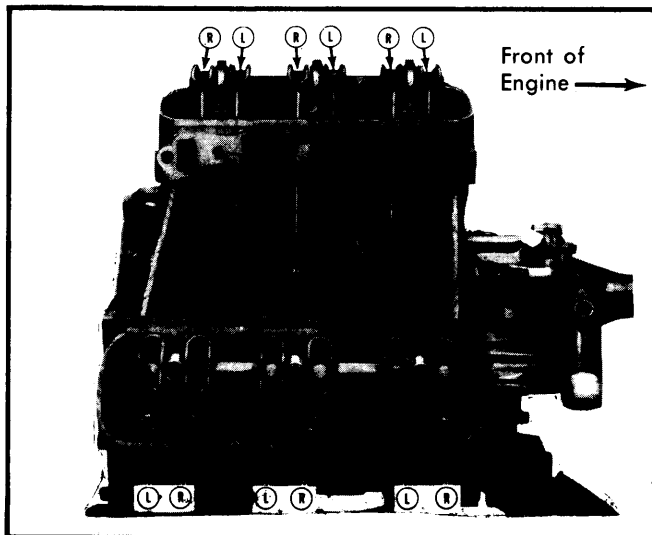


Fig. 3 Rocker Arm Positioning

HYDRAULIC VALVE LIFTER ASSEMBLY

If hydraulic valve lifters are being removed, mark or identify lifters to ensure that they are installed in original position.

Lifters are serviced as complete assemblies only. If lifter is damaged or worn, complete lifter must be replaced. If lifters are disassembled for cleaning and inspection, after reassembly they should be tested using a suitable leakdown rate tester.

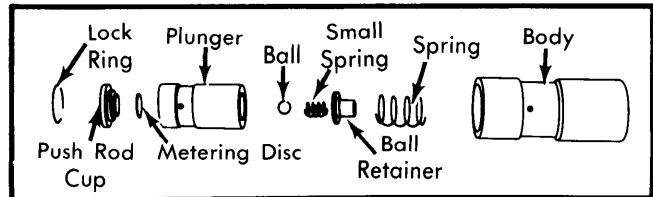


Fig. 4 Exploded View of Hydraulic Lifter Assembly

PISTONS, PINS & RINGS

OIL PAN

See *Oil Pan Removal at end of ENGINE Section.*

PISTON & ROD ASSEMBLY

Removal — With cylinder heads removed, check top of cylinder bore for a ridge. Remove ridge using a suitable ridge reamer. Mark or identify pistons to cylinders to ensure that they are installed in original position. With oil pan removed, rotate engine until number one rod is straight down. Remove rod nuts and cap. Install suitable guide on rod bolts and push piston and rod assembly out top of cylinder bore. Follow same procedure to remove remaining piston and rod assemblies. Install rod caps on rods from which they were removed.

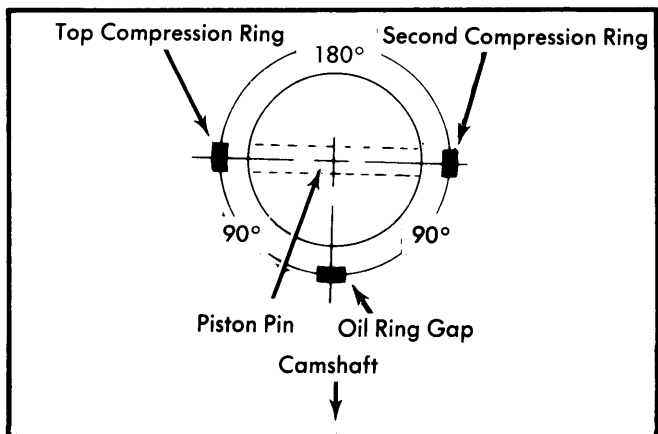


Fig. 5 Piston Ring Gap Positioning

Installation — 1) Position rings on piston as shown in Fig. 5. Make sure cylinder bore, pistons and bearing journals are clean. Coat bearing surfaces, piston and cylinder bore with engine oil. Rotate crankshaft until rod journal of piston and rod assembly being installed is straight down.

2) Place bearing insert in rod and install guides on rod bolts. Compress piston rings using suitable ring compressor. Position piston in bore so that notch in top of piston is facing toward front of engine. Push piston into bore, carefully guiding rod over crankshaft until bearing is seated against journal. Remove guides and install rod cap and bearing. Tighten rod cap nuts. See Figs. 6 and 7.

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FITTING PISTONS

With piston and rod assembly removed, thoroughly clean cylinder bore. Inspect bore for scoring or grooves. Measure cylinder bore for taper or out-of-round. If cylinder tapers more than .005" (.13 mm) or is out-of-round more than .003" (.076 mm), cylinder must be bored and oversize pistons and rings installed. Measure piston diameter at right angle to piston pin and $\frac{1}{4}$ " (6.35 mm) below oil ring groove. If clearance between piston and cylinder is excessive, cylinder must be bored and oversize pistons and rings installed.

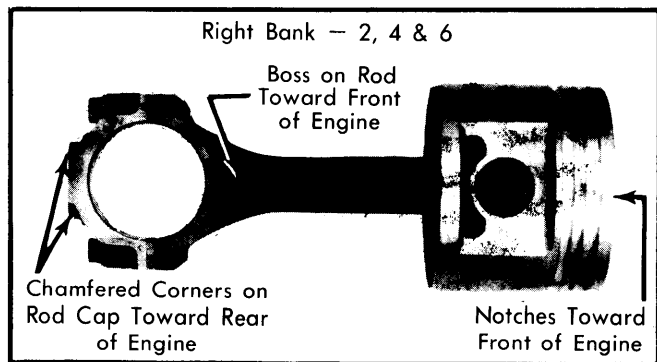


Fig. 6 Right Bank Piston & Rod Assembly

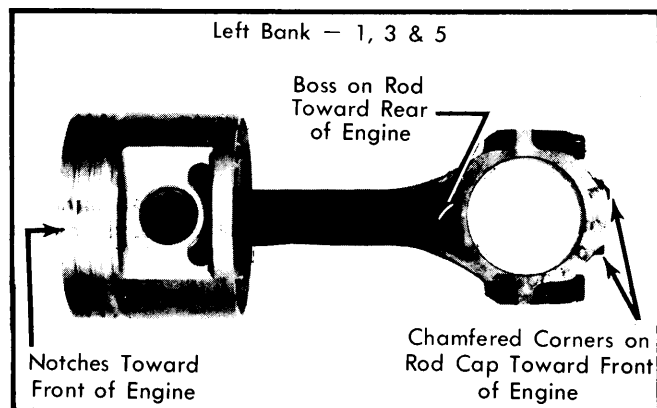


Fig. 7 Left Bank Piston & Rod Assembly

FITTING RINGS

1) Position ring in the cylinder bore where it will be used. Push ring down to point in bore where ring wear is not encountered. Use head of piston to position ring squarely in bore.

2) Measure gap between ends of ring using feeler gauge; if not to specification, file ends of rings carefully using a smooth file to obtain proper ring gap.

NOTE — Use care to avoid damage to ring or cylinder bore.

PISTON PINS

NOTE — Pin-to-piston fit, is a easy finger push fit at 70° F (21° C). Pin-to-rod is a press fit.

1) Piston pin is selective press fit in connecting rod. Using a suitable piston pin pressing tool set and a press, remove piston pin and separate piston and rod. See Fig. 8.

2) Inspect pin for wear and/or scoring. Check clearance of pin in piston. If clearance is excessive, piston and pin assembly must be replaced. Place piston on rod in correct position for bank in which piston and rod are being installed. See Fig. 6

and 7. Lubricate piston pin and press into piston and rod using tool set and press used during removal. See Fig. 8.

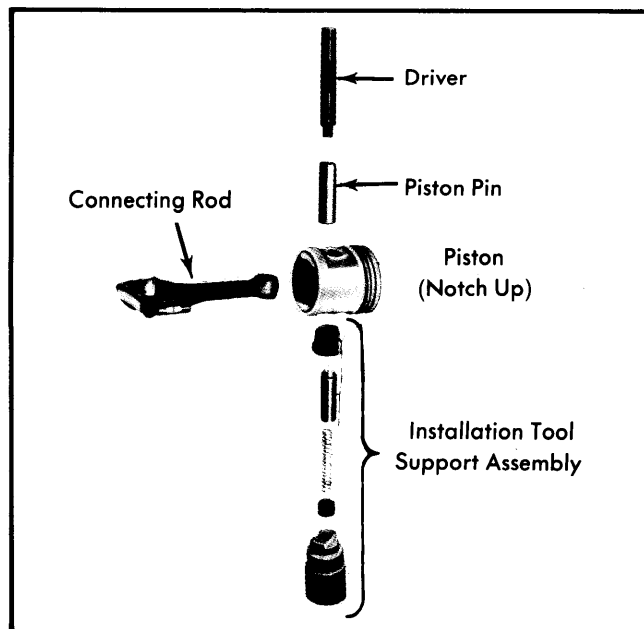


Fig. 8 Piston Pin Removal & Installation

CRANKSHAFT & ROD BEARINGS

MAIN & CONNECTING ROD BEARINGS

NOTE — Ends of bearings must never be filed flush with parting surfaces of rod and cap or cylinder block and cap.

Connecting Rod Bearings — 1) With rod cap removed, inspect bearings for flaking or wear. Check connecting rod journal for scoring or grooves. Measure rod journal with micrometer and check journal for out-of-round conditions. Journal should not exceed .0015" (.038 mm) out-of-round. Check bearing-to-journal clearance using Plastigage method.

2) If clearance exceeds .003" (.076 mm), a selective fit undersize bearing may be installed to obtain correct clearance. If clearance is excessive, crankshaft must be replaced or reconditioned. Measure rod side clearance using feeler gauge. Clearance should be .006-.023" (.152-.584 mm).

Main Bearings — 1) Upper bearing halves are grooved to supply oil to connecting rod bearings. Lower cap bearing halves are not grooved. With main bearing cap removed, inspect bearing for wear or grooves. Check journal for out-of-round conditions with a micrometer. If journal is out-of-round more than .0015" (.038 mm), crankshaft must be replaced.

NOTE — To remove upper bearing, place suitable tool (J-8080) in crankshaft oil hole and rotate crankshaft. When installing bearing caps, arrows must point to front of engine.

2) Check bearing-to-journal clearance using Plastigage method. If clearance exceeds .003" (.076 mm), a selective fit undersize bearing may be installed to obtain correct clearance. If clearance is excessive, crankshaft must be replaced or reconditioned.

NOTE — If main journals on turbocharged engine are scored or ridged, crankshaft must be replaced. Regrinding would remove fillets, reducing crankshaft durability.

3.8 & 4.1 LITER V6 (Cont.)

REAR MAIN BEARING OIL SEAL

NOTE — Upper half of seal can only be replaced if crankshaft is removed. A seal that leaks can be repaired without being replaced.

Oil Seal Repair — 1) With rear main bearing cap removed, insert a suitable packing tool (J-21526-2) against one end of seal in block. Pack seal in until tight, by driving in against seal with tool. Seal should be approximately $\frac{1}{4}$ " (6.35 mm) to $\frac{3}{4}$ " (19.05 mm) below edge of cylinder block. Repeat this procedure on both ends of seal. Measure amount that is packed into groove and add $\frac{1}{16}$ " (1.58 mm). Measure this total on seal removed from main bearing cap and cut off amount. Cut off amount for opposite side also.

2) Install a suitable guide tool (J-21526-1) on cylinder block. Using packing tool, drive cut off piece into groove until packing tool reaches stop on guide tool. Follow same procedure to pack cut off piece into opposite side. Install new seal into rear main bearing cap. Install rear main bearing cap.

Oil Seal Replacement — With crankshaft removed, pry old seals out of cylinder block and main bearing cap. Position new seal halves in grooves. Roll seals into grooves with hammer handle. Continue rolling seal until ends protrude $\frac{1}{16}$ " (1.58 mm) above edge and cut off flush with a razor blade. Lubricate seal contact surface on crankshaft. Install crankshaft and main bearing cap.

Main Bearing Cap Side Seals — Neoprene seals are placed on sides of bearing cap. Seals are slightly undersize when newly installed (and may leak) since neoprene composition swells in presence of heat and oil. Seals are slightly longer than grooves in cap, but should not be cut off. Soak seals in light oil or kerosene for 1 or 2 minutes before installation. After seals are installed, force up into cap with end of hammer handle. Apply RTV sealer to mating surface of main bearing cap before installation.

THRUST BEARING ALIGNMENT

With thrust bearing cap bolts finger tight, move crankshaft forward and backward, with last movement being forward. Tighten all main bearing cap bolts and rotate crankshaft. Be sure there is no excessive drag. Measure crankshaft end play. End play should be .003-.009" (.076-.228 mm) using a dial indicator.

CAMSHAFT

FRONT ENGINE COVER

Removal — 1) Drain cooling system and disconnect upper and lower radiator hoses and heater hose at water pump. Remove drive belts, fan and pulleys. If equipped, loosen A.I.R. pump and position out of way. Disconnect fuel lines and remove fuel pump. Remove alternator and brackets.

2) Remove distributor, and if timing chain and sprockets are not being removed, note position of rotor on distributor for reinstallation. Loosen front clamp on thermostat by-pass hose. Remove harmonic balancer. Remove front engine cover bolts and 2 oil pan-to-front cover attaching bolts and remove front cover.

Installation — Oil pump cover should be removed and petroleum jelly packed around oil pump gears whenever front engine cover is removed. Oil pump may lose its prime when front engine cover is removed. Make sure gasket surfaces are clean and use new gasket. Use sealer on bolt threads. Reverse removal procedure to install front engine cover.

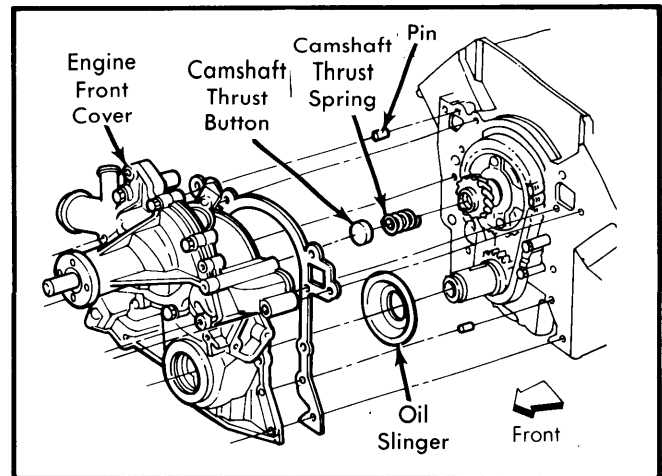


Fig. 9 Front Cover Assembly

FRONT COVER OIL SEAL

Removal — With front engine cover removed, drive seal out from front to rear of cover, using a drift punch.

Installation — Coil new packing around opening so that ends are at top. Using a suitable punch, drive in shudder and stake in place at three points. Size packing by rotating a hammer handle around packing until balancer hub can be inserted through opening.

TIMING CHAIN

NOTE — Timing chain should be replaced if in and out movement exceeds 1" (25.4 mm) on slack side of chain.

Removal — 1) With front cover removed, temporarily install harmonic balancer washer and bolt. Rotate engine until timing marks on sprockets are aligned. See Fig. 11. Remove harmonic balancer bolt without disturbing position of sprockets. Remove front oil slinger.

2) Remove camshaft sprocket bolts and alternately pry sprockets on camshaft and crankshaft to enable removal of timing chain and sprockets. Clean all parts thoroughly and replace any part showing wear and/or damage.

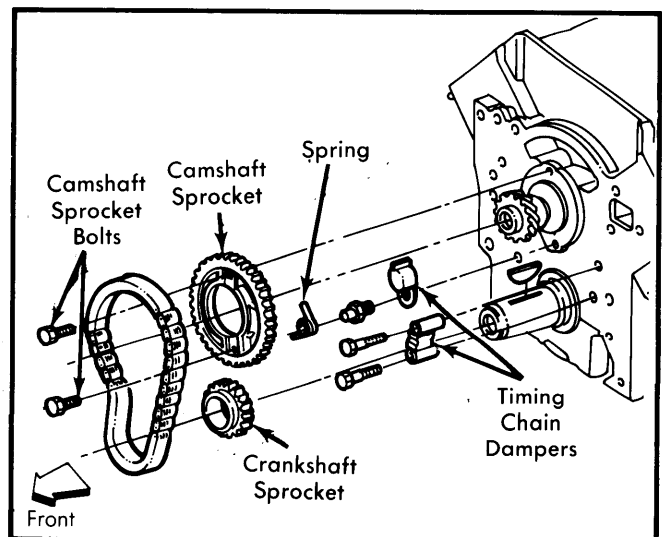


Fig. 10 Exploded View of Timing Chain Assembly

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Installation — 1) Make sure No. 1 piston is at TDC and align camshaft and crankshaft timing marks. Carefully install timing chain and sprockets without disturbing alignment of marks. Place oil slinger (with concave side toward front of engine) on crankshaft.

2) Install camshaft sprocket bolts and tighten. Install camshaft thrust spring, button and timing chain dampers. Install front cover and attaching bolts and tighten. See Fig. 10.

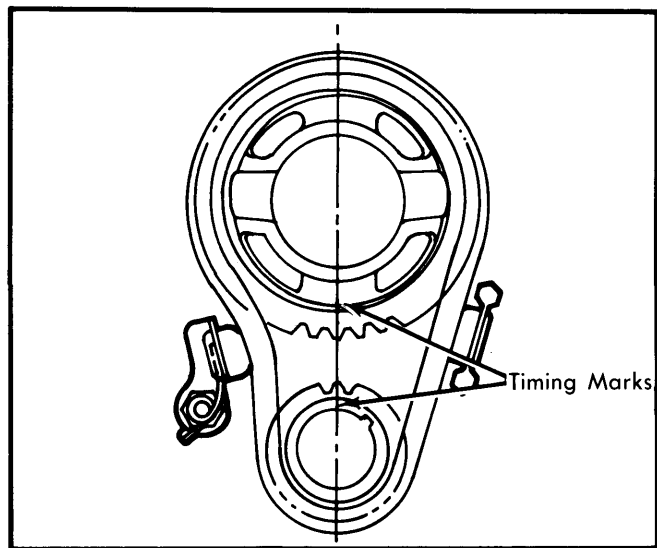


Fig. 11 Timing Chain Sprocket Alignment

CAMSHAFT

Removal — Remove intake manifold, rocker arm assemblies, push rods and lifters. Mark or identify push rods and lifters to ensure that they are installed in original position. Remove front engine cover and timing chain with sprockets. Carefully slide camshaft out to avoid damaging camshaft bearings or lobes.

Installation — Thoroughly clean and inspect camshaft. Lubricate journals and camshaft lobes. Carefully insert camshaft taking care not to damage bearings or camshaft lobes. Reverse removal procedures to complete installation.

CAMSHAFT BEARINGS

Remove camshaft and crankshaft. Using suitable camshaft bearing removal tool, remove inner bearings first. In order to remove rear bearing, welch plug must be removed. Front bearings may be removed by using a spacer between engine block and puller plate and remove from rear. Bearings are installed by reversing removal procedures and carefully pulling into place with same tool. Be sure oil holes in bearing and journal are aligned. Use non-hardening sealer on welch plug before installation.

ENGINE OILING

Crankcase Capacity — 4 quarts without filter change and 5 quarts with filter change.

Oil Filter — Replace at first oil change and then every other oil change. Filter is spin-on disposable type.

Normal Oil Pressure — Oil pressure should be 37 psi at 2400 RPM.

Pressure Regulator Valve — Located in oil pump, non-adjustable.

ENGINE OILING SYSTEM

Lubrication is force-feed type. Oil is supplied under full pressure to crankshaft, connecting rods, camshaft bearings and valve lifters. Controlled volume of oil is supplied to rocker arms and push rods. All other moving parts are lubricated by splash or gravity flow.

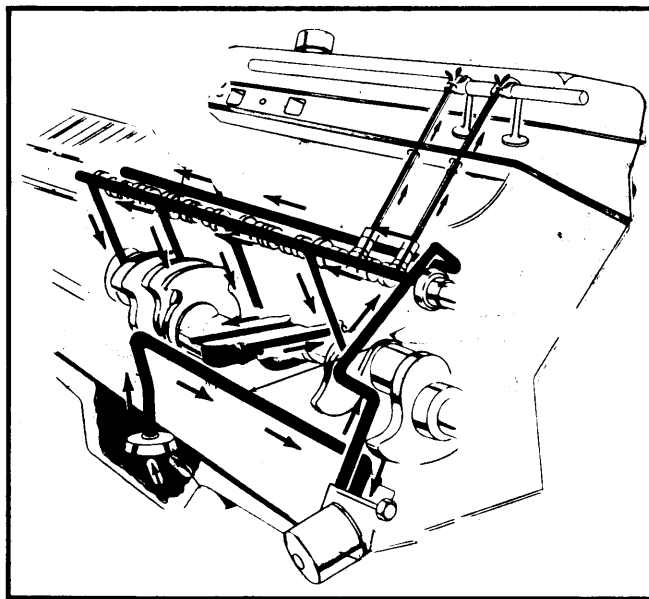


Fig. 12 Engine Oiling System

OIL PUMP

NOTE — Oil filter by-pass valve and spring are staked in place. Do not attempt to remove.

Removal — Remove oil filter. Remove bolts securing oil pump cover assembly to front engine cover. Remove cover assembly and slide pump gears out of pocket. Remove pressure regulator plug, spring and valve from cover assembly.

Inspection — Thoroughly clean all components and inspect for wear or damage. Check fit of valve in bore. If clearance is excessive, replace valve and/or cover. Position gears in pocket in cover. Place a straightedge across gears and measure clearance between straightedge and gasket surface with a feeler gauge. Specified clearance is .002-.006" (.051-.150 mm). If clearance is less than .002" (.051 mm), check gear pocket for wear.

Installation — Pack gear pocket with petroleum jelly and insert gears into pocket, making sure that jelly is packed into all pockets. Lubricate and install regulator valve in cover. Install spring, gasket and plug. Install new gasket and position cover on oil pump. Tighten cover retaining bolts.

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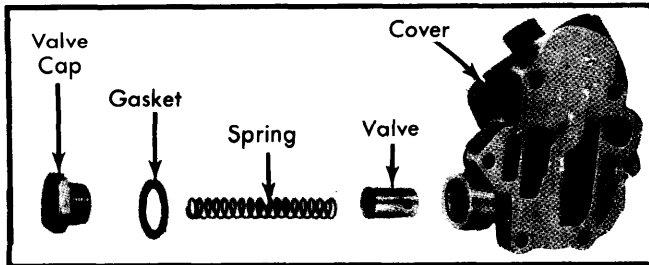


Fig. 13 Oil Pump and Components

power steering brackets. Remove water pump attaching bolts and remove water pump. Clean all surfaces to ensure proper seal.

Installation — If installing new water pump, transfer pulley from old pump. Apply a $\frac{1}{8}$ " bead of sealant to water pump sealing surface. While sealant is wet, install water pump and tighten attaching bolts. Install all accessory drive belts and connect negative battery cable.

NOTE — For further information on cooling system capacities and other cooling system components, see appropriate article in ENGINE COOLING SYSTEMS section.

Oil Pump Specifications

Application	Specification In. (mm)
Pump Cover Flatness000-.001 (.000-.025)
Length of Gear8720-.8735 (22.15-22.19)
Diameter of Gear	1.664-1.666 (42.27-42.32)
Depth of Gear Pocket8677-.8697 (22.04-22.09)
Diameter of Gear Pocket	1.671-1.674 (42.44-42.52)
Gear Face-to-Gasket Surface002-.006 (.051-.152)
Gear Teeth-to-Side Wall002-.005 (.051-.127)

TIGHTENING SPECIFICATIONS

Application	Ft. Lbs. (N·m)
Cylinder Head.....	80 (108)
Connecting Rod	40 (54)
Main Bearing Caps	100 (136)
Harmonic Balancer Bolt	225 (306)
Flywheel-to-Crankshaft Bolts	60 (81)
Intake Manifold	45 (61)
Exhaust Manifold	25 (35)
Front Engine Cover Bolts	30 (41)
Camshaft Sprocket Bolts	22 (30)
Rocker Arm Assembly	30 (41)
Pulley-to-Harmonic Balancer	27 (37)
Compressor Housing-to-Manifold (Turbo)	35 (47)
Compressor Housing-to-Turbine Housing	15 (21)
Outlet Elbow-to-Compressor Housing	15 (21)
Water Pump Bolts	7 (10)

ENGINE COOLING

WATER PUMP

Removal — Disconnect negative battery cable and drain cooling system. Disconnect lower radiator hose at water pump. Disconnect heater hose and by-pass at water pump (if so equipped). Remove fan assembly and all pulley belts. Remove water pump pulley. Disconnect alternator, A/C compressor and

ENGINE SPECIFICATIONS

GENERAL SPECIFICATIONS

Engine	HP at RPM	Torque (Ft. Lbs. at RPM)	Compr. Ratio	Bore		Stroke		Displ.	
				in.	mm	in.	mm	cu. ins.	cc
3.8L (231")	110@3800	190@1600	8.0:1	3.80	96.32	3.40	86.36	231	3800
3.8L (231")									
Turbo	170@4000	275@2400	8.0:1	3.80	96.52	3.40	86.36	231	3800
4.1L (252")	125@4000	205@2000	8.0:1	3.97	100.84	3.40	86.36	252	4100

VALVES

Engine & Valve	Head Diam. In. (mm)	Face Angle	Seat Angle	Seat Width In. (mm)	Stem Diameter In. (mm)	Stem Clearance In. (mm)	Valve Lift In. (mm)
All Models							
Int.	1.705-1.715 (43.31-43.56)	45°	45°	.063 (1.600)	.3402-.3412 (8.641-8.666)	.0015-.0035 (.038-.089)
Exh.	1.495-1.505 (37.97-38.23)	45°	45°	.094 (2.390)	.3405-.3412 (8.649-8.666)	.0015-.0032 (.038-.081)

General Motors V6 Engines

3.8 & 4.1 LITER V6 (Cont.)

ENGINE SPECIFICATIONS (Cont.)

VALVE SPRINGS			
Engine	Free Length In. (mm)	PRESSURE Lbs. @ In. (kg @ mm)	
		Valve Closed	Valve Open
All Models	88-98@1.73 (42@43.94)	210-230@1.34 (100@34.04)

CAMSHAFT			
Engine	Journal Diam. In. (mm)	Clearance In. (mm)	Lobe Lift In. (mm)
All Models	1.785-1.786 (45.34-45.36)	①.0005-.0025 (.013-.063) ②.0005-.0035 (.013-.089)

① — Journal No. 1.

② — Remaining journals.

PISTONS, PINS, RINGS						
Engine	PISTONS	PINS		RINGS		
	①Clearance In. (mm)	Piston Fit In. (mm)	Rod Fit② In. (mm)	Rings	End Gap In. (mm)	Side Clearance In. (mm)
All Models	.0013-.0035 (.033-.089)	.0004-.0007 (.010-.018)	②.00075-.00125 (.019-.032)	1	.013-.023 (.33-.58)	.003-.005 (.08-.13)
				2	.013-.023 (.33-.58)	.003-.005 (.08-.13)
				3	.015-.035 (.38-.89)	.0001-.0035 (.003-.089)

① — Measured at bottom of piston skirt.

② — Press fit.

CRANKSHAFT MAIN & CONNECTING ROD BEARINGS							
Engine	MAIN BEARINGS				CONNECTING ROD BEARINGS		
	Journal Diam. In. (mm)	Clearance In. (mm)	Thrust Bearing	Crankshaft End Play In. (mm)	Journal Diam. In. (mm)	Clearance In. (mm)	Side Play① In. (mm)
All Models	2.4995 (63.49)	.0003-.0018 (.008-.046)	2	.003-.009 (.08-.23)	2.2487-2.2495 (57.13-57.14)	.0005-.0026 (.013-.066)	.006-.023 (.15-.58)

① — Total of both rods.