V-8 ENGINE

ENGINE ASSEMBLY

Description

The 304, 360 and 401 CID engine are V-8 designs incorporating overhead valves. Service procedures for all V-8 engines are essentially the same.

Bridged pivot assemblies control movement of intake and exhaust rocker arms that are paired by cylinders (fig. 1B-1 and 1B-2). The cylinders are numbered from front to rear 1-3-5-7 on the left bank and 2-4-6-8 on the right bank. The cylinder firing order is 1-8-4-3-6-5-7-2.

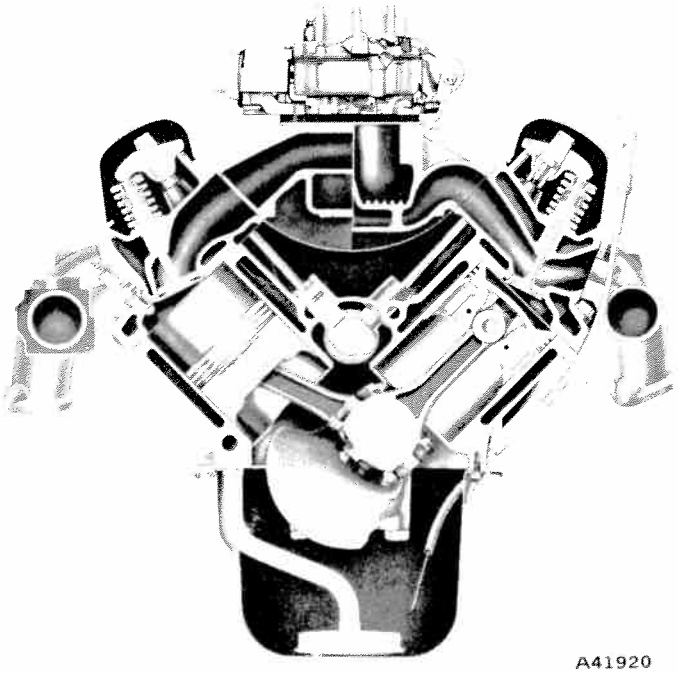

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Fig. 1B-1 Sectional View of V-8 Engine Assembly

The crankshaft, supported by five two-piece main bearings, rotates in a counterclockwise direction as viewed from the rear. The camshaft is supported by five one-piece, line-bored bearings.

Identification

Build Date Code

The engine Build Date Code is located on a tag attached to the right bank cylinder head cover (fig. 1B-3).

The code numbers identify the year, month, and day that the engine was built. The code letter identifies the cubic inch displacement, carburetor type, and compression ratio.

The letters are coded as follows:

Code	CID	Carburetor	Compression Ratio
H	304	2V	8.4:1
N	360	2V	8.25:1
P	360	4V	8.25:1
Z	401	4V	8.25:1

Engine Build Date Code Explanation

1st Character (year)	2nd and 3rd Character (month)	4th Character (engine type)	5th Character (day)
6—1973 7—1974	01-12	H, N, P or Z	01-31
Example:	7	03	P	18

The example code identifies a 360 CID with 4V carburetor and 8.25:1 compression ratio built on March 18, 1974.

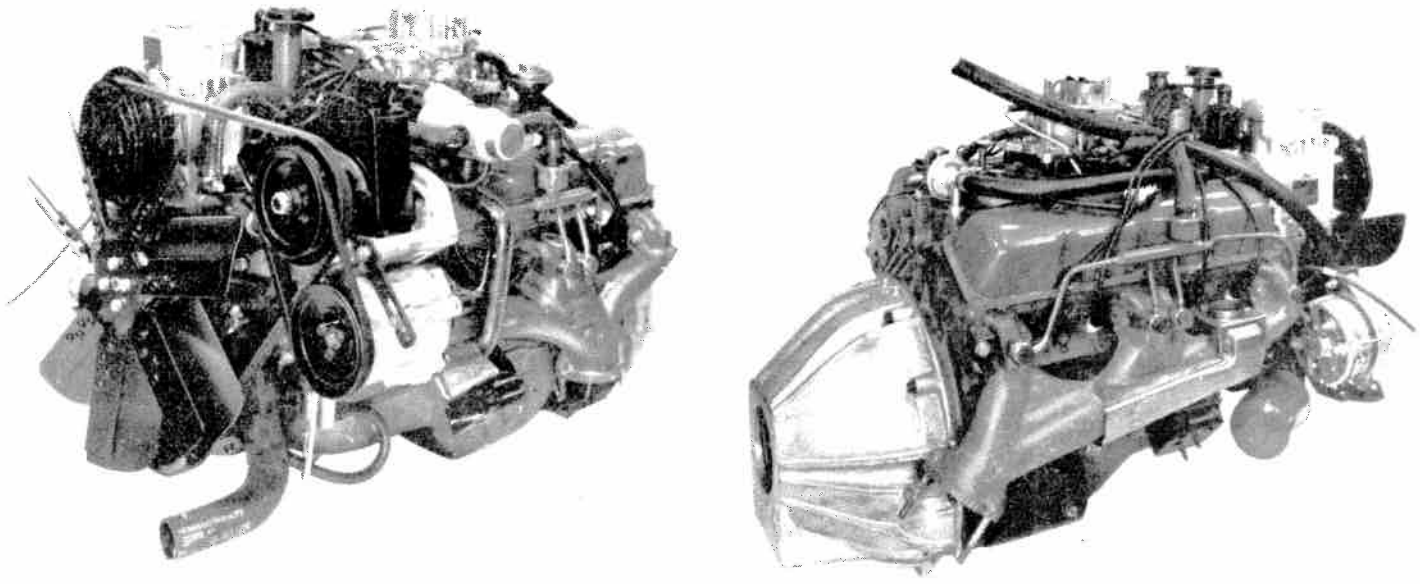

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Fig. 1B-2 Typical V-8 Engine Assembly

NOTE: *360-401 CID engines in heavy duty trucks are painted red. These engines do not use exhaust valve rotators. Otherwise they are the same as all other 360-401 CID engines. Refer to Exhaust Valve Rotator for details.*

Odd Size Engines

On vehicles equipped with odd-sized engines, it is sometimes necessary to machine all cylinder bores to 0.010 inch oversize, all crankshaft main bearing journals, all connecting rod journals to 0.010 inch undersize, or all camshaft bearing bores 0.010 inch oversize. These engines have a single or double letter code stamped adjacent to the Build Date Code on the tag attached to the right bank cylinder head cover. The letters are coded as follows:

Single letter B . . . . . cylinder bore 0.010-inch oversize
Single letter M . . . . . main bearings 0.010-inch undersize
Single letter P . . . . . connecting rod bearings 0.010-inch undersize
Double letters PM . . . . . main and connecting rod bearings 0.010-inch undersize
Single letter C . . . . . camshaft bearing bores 0.010-inch oversize

Lubrication System

A gear-type, positive displacement oil pump is incorporated in the timing chain cover. A cavity in the cover forms the body of the pump while drive and idler gears rotate within the cavity. The drive gear shaft is driven by the distributor.

The oil filter adapter body seals the end of the oil pump cavity and also mounts the oil filter. The oil pressure relief valve assembly is located in the adapter body (fig. 1B-4).

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Fig. 1B-3 Build Date Code Location V-8

Oil is drawn from the sump area of the oil pan through a tube and screen assembly to a horizontal oil gallery located at the lower right side of the engine block. A passage in the timing chain cover channels oil into the oil pump. Pressure is developed when oil is driven between the gears and pump body.

The oil is forced from the pump through a passage in the oil filter adapter body to the oil filter (fig. 1B-5).

The oil passes through the filtering elements and on to an outlet passage in the adapter body. From the adapter body passage, the oil enters an adjoining passage in the timing chain cover and then is channeled into a gallery which extends up the left front of the cylinder block. This gallery channels oil directly to the right main oil gallery which intersects with a short passage that channels oil to the left main oil gallery.

The left and right main oil galleries extend the

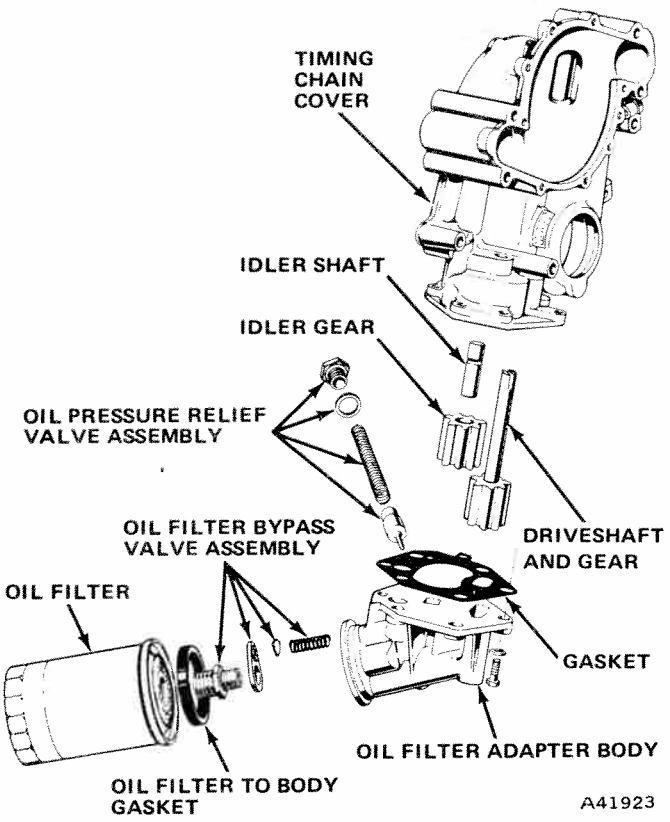

Fig. 1B-4 Oil Pump and Filter Assembly

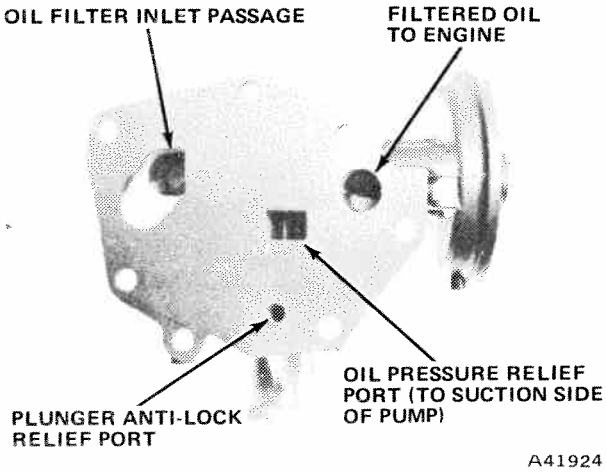

Fig. 1B-5 Oil Filter Adapter Body

length of the cylinder block. The left oil gallery channels oil to each hydraulic tappet on the left bank. The right oil gallery channels oil to each hydraulic tappet on the right bank. In addition, five passages extend down from the right oil gallery to each camshaft bearing and on to each upper main bearing insert. The crankshaft is cross-drilled which allows oil to flow from each main journal to the adjacent connecting rod journals. A squirt hole in each connecting rod bearing cap distributes oil on the cylinder walls, pistons and piston pins as the crankshaft rotates.

A small passage in the front camshaft bearing journal channels oil to the timing chain cover area where the chain and sprockets throw off oil to lubricate the

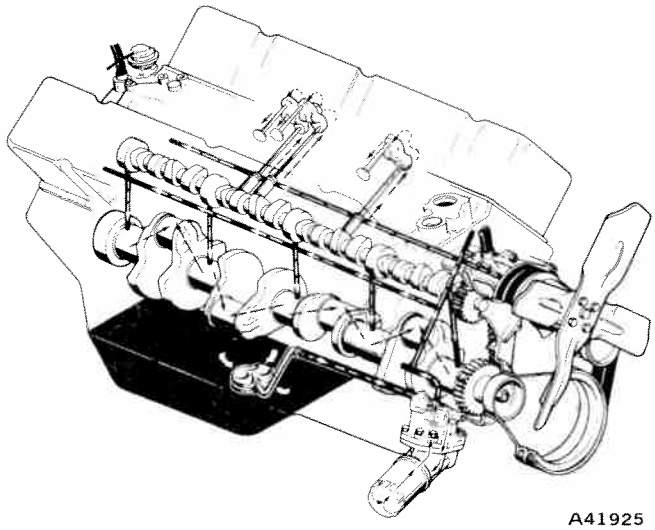

Fig. 1B-6 Lubrication System

distributor gears and fuel pump eccentric. This oil returns to the oil pan by passing under the front main bearing.

The oil supply for the rocker arm assemblies is metered through the hydraulic valve tappets and routed through hollow push rods to the rocker arms. A squirt hole in the rocker arm directs oil to the valve train. This oil returns to the oil pan through channels in the cylinder head (fig. 1B-6).

Mounting

Resilient rubber mounting cushions support the engine and transmission at three points. A cushion is located at each side on the centerline of the engine with the rear supported by a cushion between the transmission extension housing and the rear support crossmember (fig. 1B-7).

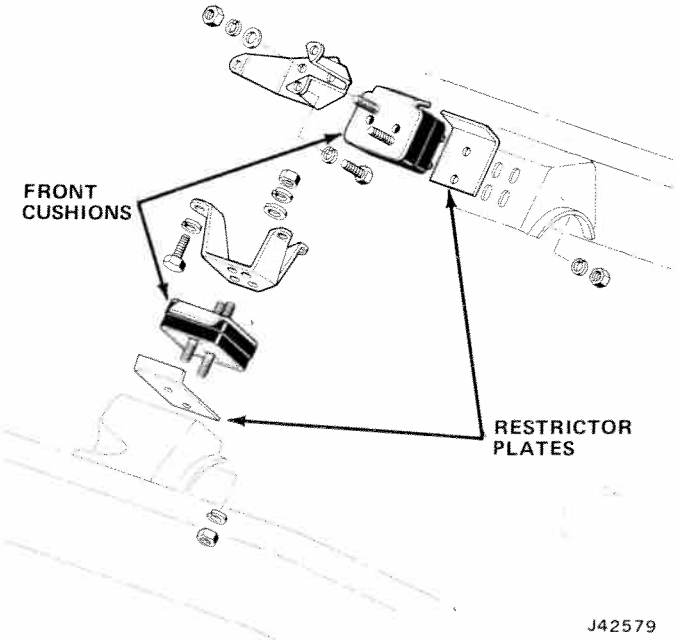

Fig. 1B-7 V-8 Engine Mounting - Typical

Removal or replacement of any cushion may be accomplished by supporting the weight of the engine or transmission at the area of the cushion.

If necessary to remove the front engine mounts and front crossmember to perform service such as oil pan removal, an engine holding fixture may be fabricated as illustrated in figure 1B-43 at the end of this section.

SERVICE DIAGNOSIS

Condition	Possible Cause	Correction
EXTERNAL OIL LEAKS	(1) Fuel pump gasket broken or improperly seated.	(1) Replace gasket.
	(2) Cylinder head cover gasket broken or improperly seated.	(2) Replace gasket; check cylinder head cover gasket flange and cylinder head gasket surface for distortion.
	(3) Oil filter gasket broken or improperly seated.	(3) Replace oil filter.
	(4) Oil pan side gasket broken or improperly seated.	(4) Replace gasket; check oil pan gasket flange for distortion.
	(5) Oil pan front oil seal broken or improperly seated.	(5) Replace seal; check timing chain cover and oil pan seal flange for distortion.
	(6) Oil pan rear oil seal broken or improperly seated.	(6) Replace seal; check oil pan rear oil seal flange; check rear main bearing cap for cracks, plugged oil return channels, or distortion in seal groove.
	(7) Timing chain cover oil seal broken or improperly seated.	(7) Replace seal.
	(8) Oil pan drain plug loose or stripped threads.	(8) Repair as necessary and tighten.
	(9) Rear oil gallery plug loose.	(9) Use appropriate sealant on gallery plug and tighten.
	(10) Rear camshaft plug loose or improperly seated.	(10) Seat camshaft plug or replace and seal, as necessary.
EXCESSIVE OIL CONSUMPTION	(1) Oil level too high.	(1) Lower oil level to specifications.
	(2) Oil too thin.	(2) Replace with specified oil.
	(3) Valve stem oil seals are damaged, missing, or incorrect type.	(3) Replace valve stem oil seals.
	(4) Valve stems or valve guides worn.	(4) Check stem-to-guide clearance and repair as necessary.
	(5) Piston rings broken, missing.	(5) Replace missing or broken rings.
	(6) Piston rings incorrect size.	(6) Check ring gap, repair as necessary.
	(7) Piston rings sticking or excessively loose in grooves.	(7) Check ring side clearance, repair as as necessary.
	(8) Compression rings installed upside down.	(8) Repair as necessary.
	(9) Cylinder walls worn, scored, or glazed.	(9) Repair as necessary.

SERVICE DIAGNOSIS (Continued)

Condition	Possible Cause	Correction
EXCESSIVE OIL CONSUMPTION (Continued)	(10) Piston ring gaps not staggered.	(10) Repair as necessary.
	(11) Excessive main or connecting rod bearing clearance.	(11) Check bearing clearance, repair as necessary.
NO OIL PRESSURE	(1) Low oil level.	(1) Add oil to correct level.
	(2) Oil pressure gauge or sending unit inaccurate.	(2) Refer to Section 3, Oil Pressure Gauge and Sending Unit Test.
	(3) Oil pump malfunction.	(3) Refer to Oil Pump.
	(4) Oil pressure relief valve sticking.	(4) Remove and inspect oil pressure relief valve assembly.
	(5) Oil passages on pressure side of pump obstructed.	(5) Inspect oil passages for obstructions.
	(6) Oil pickup screen or tube obstructed.	(6) Inspect oil pickup for obstructions.
LOW OIL PRESSURE	(1) Low oil level.	(1) Add oil to correct level.
	(2) Oil excessively thin due to dilution, poor quality, or improper grade.	(2) Drain and refill crankcase with recommended oil.
	(3) Oil pressure relief spring weak or sticking.	(3) Remove and inspect oil pressure relief valve assembly.
	(4) Oil pickup tube and screen assembly has restriction or air leak.	(4) Remove and inspect oil pickup tube and screen assembly. (Fill pickup with lacquer thinner to find leaks.)
	(5) Oil pump malfunctioning.	(5) Refer to Oil Pump.
	(6) Excessive main, rod, or camshaft bearing clearance.	(6) Measure bearing clearances, repair as necessary.
HIGH OIL PRESSURE	(1) Improper grade oil.	(1) Drain and refill crankcase with correct grade oil.
	(2) Oil pressure gauge or sending unit inaccurate.	(2) Refer to Section 3, Oil Pressure Gauge and Sending Unit Test.
	(3) Oil pressure relief valve sticking closed.	(3) Remove and inspect oil pressure relief valve assembly.
MAIN BEARING NOISE	(1) Insufficient oil supply.	(1) Check for low oil level or low oil pressure.
	(2) Main bearing clearance excessive.	(2) Check main bearing clearance, repair as necessary.
	(3) Crankshaft end play excessive.	(3) Check end play, repair as necessary.
	(4) Loose flywheel or torque converter.	(4) Tighten flywheel or converter attaching bolts.
	(5) Loose or damaged vibration damper.	(5) Repair as necessary.
CONNECTING ROD BEARING	(1) Insufficient oil supply.	(1) Check for low oil level or low oil pressure.

SERVICE DIAGNOSIS (Continued)

Condition	Possible Cause	Correction
CONNECTING ROD BEARING (Continued)	(2) Bearing clearance excessive or bearing missing.	(2) Check clearance, repair as necessary.
	(3) Crankshaft connecting rod journal out-of-round.	(3) Check journal measurements, repair or replace as necessary.
	(4) Misaligned connecting rod.	(4) Repair as necessary.
	(5) Connecting rod bolts tightened improperly.	(5) Tighten bolts to specified torque.
PISTON NOISE	(1) Piston-to-cylinder wall clearance excessive.	(1) Check clearance, repair as necessary.
	(2) Cylinder walls excessively tapered or out-of-round.	(2) Check cylinder wall measurements, repair as necessary.
	(3) Piston ring broken.	(3) Replace ring.
	(4) Loose or seized piston pin.	(4) Check piston-to-pin clearance, repair as necessary.
	(5) Connecting rods misaligned.	(5) Check rod alignment, repair as necessary.
	(6) Piston ring side clearance excessively loose or tight.	(6) Check ring side clearance, repair as necessary.
	(7) Carbon build-up on piston is excessive.	(7) Clean carbon from piston.
VALVE TRAIN NOISE *NOTE: A clicking noise, upon starting the engine, reducing in level and disappearing after a short period of time is normal. This noise is due to a slight oil leak-down condition caused by valve spring pressure exerted on the tappets.*	(1) Insufficient oil supply.	(1) Check for: (a) Low oil level. (b) Low oil pressure. (c) Plugged rocker arm shaft. (d) Wrong hydraulic tappet. (e) Plugged oil gallery in block.
	(2) Push rods worn or bent.	(2) Replace worn or bent push rods.
	(3) Rocker arms worn.	(3) Replace worn rocker arms.
	(4) Dirt or chips in hydraulic tappets.	(4) Clean tappets.
	(5) Excessive tappet leak-down.	(5) Replace valve tappet.
	(6) Tappet face worn.	(6) Replace tappet; check corresponding cam lobe for wear.
	(7) Broken or cocked valve springs.	(7) Properly seat cocked springs; replace broken springs.
	(8) Stem-to-guide clearance excessive.	(8) Check stem-to-guide clearance, repair as necessary.
	(9) Valve bent.	(9) Replace valve.
	(10) Loosen rocker arms.	(10) Tighten capscrews to specified torque.
	(11) Valve seat runout excessive.	(11) Regrind valve seat/valve.

ENGINE REMOVAL

The engine is removed without the transmission and bell housing.

(1) On Cherokee, Wagoneer and Truck the hood must be removed. Mark hinge locations at hood panel for alignment during installation. Remove hood from hinges.

(2) Remove air cleaner assembly.

(3) Drain cooling system and disconnect upper and lower radiator hoses.

(4) If equipped with automatic transmission, disconnect cooler lines from radiator.

NOTE: *If vehicle is equipped with a radiator shroud, it is necessary to separate the shroud from the radiator to facilitate removal and installation of the radiator and engine fan.*

(5) Remove radiator.

(6) Remove engine fan.

If equipped with power steering, remove fluid from pump reservoir and disconnect hoses.

(7) If equipped with air conditioning, turn both service valves clockwise to the front seated position. Bleed compressor refrigerant charge by slowly loosening service valve fittings.

(8) Disconnect condenser and evaporator lines from compressor.

(9) Disconnect receiver outlet at the disconnect coupling.

(10) Remove condenser and receiver assembly.

(11) Remove the battery and tray if required.

(12) On Wagoneer, Cherokee, and Truck models, remove the heater core housing and charcoal canister from firewall.

(13) Disconnect the following wires (if so equipped) at:

- starter motor
- coil positive terminal
- temperature gauge sending unit
- alternator
- oil pressure gauge sending unit
- solenoid vacuum valve
- solenoid control switch
- throttle stop solenoid

(14) Disconnect the following lines (if so equipped):

- fuel line from tank at fuel pump
- vacuum line for power brake unit at intake manifold
- vacuum line for heater damper doors at intake manifold

(15) If equipped with automatic transmission, disconnect the transmission filler tube bracket from right cylinder head. Do not remove filler tube from the transmission.

(16) Remove both engine front support cushion-to-frame retaining nuts.

(17) Support weight of engine with a lifting device.

(18) On CJ models, remove transfer case shift lever boot, floor (if so equipped) and transmission access cover.

(19) On vehicles equipped with automatic transmission, remove upper bolts securing the transmission bell housing-to-engine.

If equipped with manual transmission, remove upper bolts securing clutch housing-to-engine.

(20) Disconnect exhaust pipes at exhaust manifolds and support bracket.

(21) Remove starter motor.

(22) Support transmission with a floor jack.

(23) If equipped with automatic transmission, remove engine adapter plate inspection cover. Mark assembled position of converter and flex plate and remove the converter to flex plate cap screws.

(24) Remove remaining bolts securing transmission bell housing to engine.

If equipped with manual transmission, remove clutch housing lower cover and remaining bolts securing clutch housing to engine.

(25) Remove engine by pulling upward and forward.

CAUTION: *If equipped with power brakes, care must be taken to avoid damaging the power unit while removing the engine.*

ENGINE INSTALLATION

(1) Lower engine slowly into engine compartment and align with transmission bell housing (automatic transmission) or clutch housing (manual transmission). On manual transmissions, make certain clutch shaft is aligned properly with splines of clutch driven plate.

(2) Install the transmission bell housing-to-engine bolts (automatic transmission) or the clutch housing-to-engine bolts (manual transmission). Tighten bolts to specified torque (Automatic Trans: 28 foot-pounds; Manual Trans: 27 foot-pounds).

(3) Remove floor jack which was used to support transmission.

(4) If equipped with automatic transmission, align marks previously made on converter and flex plate, install converter-to-flex plate cap screws and tighten to torque.

(5) Install inspection cover (automatic transmission) or the clutch housing lower cover (manual transmission).

(6) Install starter motor.

(7) Lower engine onto frame supports, remove the lifting device.

(8) Install front support cushion retaining nuts. Tighten the nuts to 33 foot-pounds torque.

(9) Connect exhaust pipes at exhaust manifolds and support bracket.

(10) If equipped with automatic transmission, connect transmission filler tube bracket to right cylinder head.

(11) On Wagoneer, Cherokee, and Truck models, install the heater core housing and charcoal canister to firewall.
(12) If removed, install battery and tray.
(13) Connect all wires, lines, linkage and hoses which were previously disconnected from engine.
(14) If removed, install air conditioning condenser and receiver assembly.
(15) Connect receiver outlet to the disconnect coupling. Connect the condenser and evaporator lines to the compressor.
(16) Purge the compressor of air as outlined in the Section 13 - Air Conditioning.

CAUTION: *Both service valves must be open before the air conditioning system is operated.*

(17) If equipped with power steering, connect hoses and fill pump reservoir to specified level.
(18) Install engine fan and tighten the retaining bolts to 18 foot-pounds torque.
(19) Install radiator and connect upper and lower hoses. If equipped with automatic transmission, connect cooler lines.
(20) Fill the cooling system to specified level.
(21) Install air cleaner assembly.
(22) Start engine. Check all connections for leaks. Stop engine.
(23) If removed, install and align hood assembly.
(24) If removed, install transmission access cover, floor mat and transfer case shift lever boot.

CYLINDER HEAD COVER AND GASKET

Removal

(1) Remove air cleaner assembly.
(2) Disconnect air delivery hose at air distribution manifold, if so equipped.
(3) Left side:
(a) Disconnect power brake vacuum hose at intake manifold.
(b) Disconnect throttle stop solenoid wire, if so equipped.
Right side:
(a) Remove Thermostatically Controlled Air Cleaner (TAC) hot air hose.
(b) Remove heater hose from choke cover clamp.
(4) Disconnect spark plug wires and remove plastic wire separator from cylinder head cover bracket.
(5) Remove retaining screws and washers, separate cylinder head cover and gasket from cylinder head.

Installation

(1) Place gasket on cylinder head cover flange (make certain gasket tabs are positioned in cut out openings of the cover).
(2) Position cylinder head cover and gasket on engine.
(3) Install retaining screws and washers. Tighten screws to 50 inch-pounds torque.
(4) Connect spark plug wires and install plastic wire separator to cylinder head cover bracket.
(5) Right side:
(a) Install heater hose to choke cover clamp.
(b) Install TAC hot air hose.
Left side:
(a) Connect power brake vacuum hose at intake manifold.
(b) Connect throttle stop solenoid wire, if so equipped.
(6) Connect air delivery hose to air distribution manifold.
(7) Install air cleaner assembly.

ROCKER ARM ASSEMBLY

The intake and exhaust rocker arms of each cylinder, pivot on a bridged pivot assembly which is secured to the cylinder head by two capscrews as shown in figure 1B-8.

The push rods are hollow and serve as oil galleries to lubricate the rocker arm assemblies. The push rods also serve as guides to maintain correct rocker arm-to-valve stem relationship; therefore, a pattern on the push rods where they contact the cylinder head is normal.

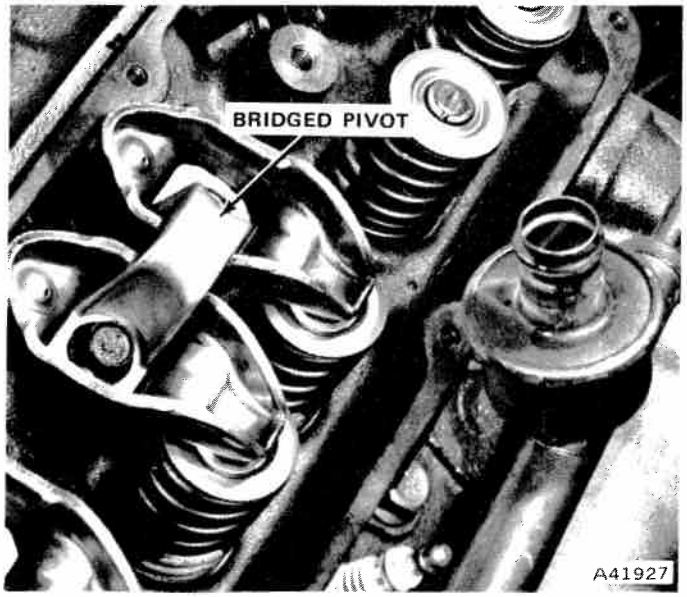

Fig. 1B-8 Rocker Arm Assembly—V-8 Engine

Removal

(1) Remove cylinder head cover and gasket.
(2) Remove capscrews from bridged pivot assemblies.

(3) Remove bridged pivot assembly.
(4) Remove rocker arms.
(5) Remove push rod.

NOTE: *Keep all parts in the same order as they are removed from the engine.*

Cleaning and Inspection

Clean all parts with a good cleaning solvent and use compressed air to clean out the oil passages in the rocker arms and push rods.

Inspect the pivot surface of each rocker and pivot assembly, replace any parts which are scuffed, pitted or excessively worn. Inspect the valve stem contact surface of each rocker arm and replace any rocker arm which is deeply pitted. Inspect each push rod end for scuffing or excessive wear, replace as required.

NOTE: *If any push rod is excessively worn due to lack of oil, the push rod as well as the matching hydraulic valve tappet and rocker arm must be replaced.*

Installation

(1) Install push rods. **Make certain the bottom end of each rod is centered in the plunger cap of hydraulic valve tappet.**
(2) Install the rocker arms.
(3) Install bridged pivot assemblies.
(4) Install capscrews and tighten to 19 foot-pounds torque.
(5) Install cylinder head cover and gasket.
(6) Install retaining screws and washers. Tighten screws to specified torque.

VALVE SPRING—VALVE STEM OIL SEAL

Nylon valve stem oil seals are installed on each valve stem to prevent the oil used for rocker arm lubrication from entering the combustion chamber through the valve guides. Replace oil seals whenever valve service is performed or if the seals become deteriorated.

Each valve spring is held in place on the valve stem by a retainer and a set of valve locks. On the exhaust valves of the 360 and 401 CID (except red engines used in heavy duty trucks) engines a valve rotator is used. Remove valve locks by compressing the valve spring.

NOTE: *Exhaust valve springs used with rotators are shorter than standard valve springs. Refer to Specifications.*

Valve springs and oil seals can be removed without removing the cylinder head. Refer to Cylinder Head Reconditioning for removal procedure with the cylinder head removed.

Exhaust Valve Rotator

Exhaust valve rotators perform two functions; they hold the valve spring in place and they positively induce rotation of the exhaust valve which increases durability of the valve seat and face.

The outer housing of the rotator rides on the exhaust valve spring and remains stationary. The inner retainer with valve locks retains the exhaust valve and outer housing. In addition, the inner retainer rotates slightly when the exhaust valve is off its seat. This rotation is caused by the spring being crushed between the inner retainer and the washer when pressure is applied during exhaust valve opening (fig. 1B-9).

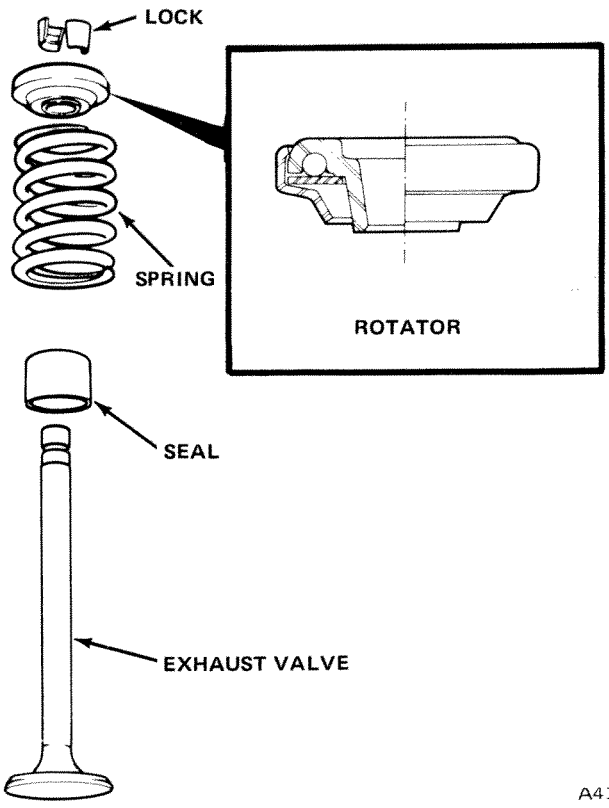

Fig. 1B-9 Exhaust Valve Rotator

NOTE: *The red 360-401 engines in heavy duty trucks do not use exhaust valve rotators. The exhaust valve spring and retainer is the same as the intake valve spring and retainer.*

Removal

(1) Remove cylinder head cover and gasket.
(2) Remove rocker arm assemblies and push rods.

NOTE: *Keep rocker arm assemblies and push rods in the same order as removed.*

(3) Remove spark plug from cylinder which requires valve spring or oil seal removal.
(4) Install a 14 mm thread size air adapter in spark plug hole.

NOTE: *Fabricate an adapter from the body of a spark plug from which the porcelain has been removed and fasten an air hose connection to the body of the plug.*

(5) Connect air hose to adapter and maintain at least 90 psi in the cylinder to hold valves against their seats.

(6) Use Valve Spring Remover and Installer Tools J-21931-2, J-22534-1 and J-22534-2 to compress the valve spring and allow removal of the valve locks (fig. 1B-10).

(7) Remove valve spring and retainer or rotator from cylinder head.

(8) Remove oil seal if replacement is required.

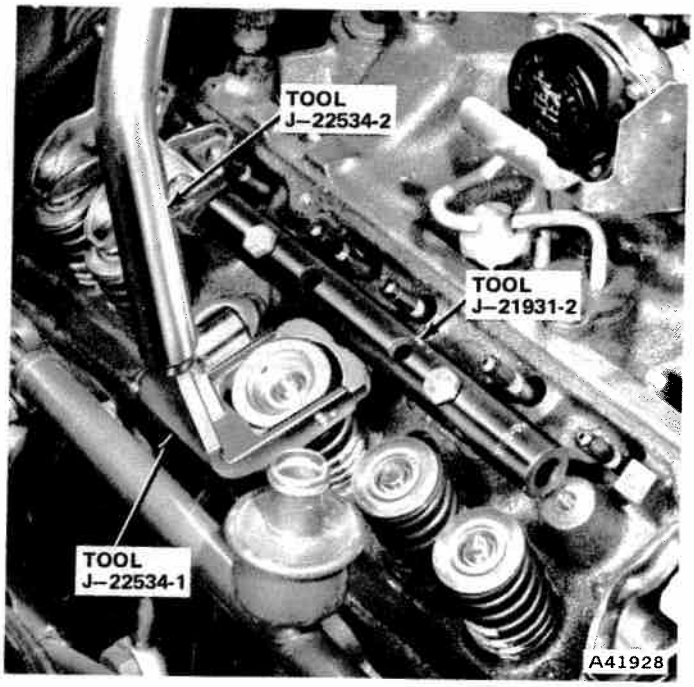

Fig. 1B-10 Valve Spring Removal

Valve Spring Tension Test

Use Valve Spring Tester J-8056 to test each removed valve spring from the specified tension values, if required (fig. 1B-11). Replace all valve springs which are not within specifications.

Installation

(1) If removed, install oil seal on valve stem.

IMPORTANT: *A close-coiled valve spring is used on all valves except the exhaust valves with rotators on the 360 and 401 CID engines which are equipped with evenly spaced spring coils. The close-coiled end, identified by paint stripes, must face the cylinder head when installing the springs.*

(2) Install valve spring and retainer or rotator.

(3) Compress valve spring with Valve Spring Remover and Installer Tools J-21931-2, J-22534-1 and J-22534-2.

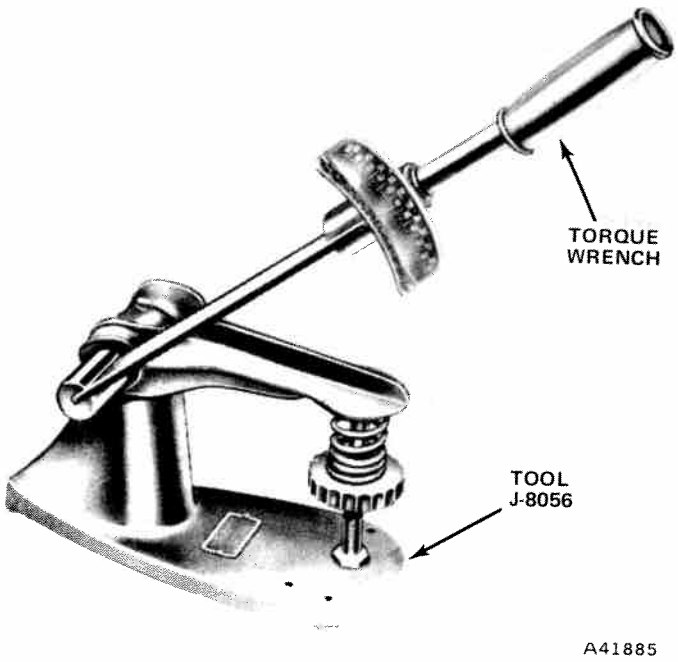

Fig. 1B-11 Valve Spring Tester

(4) Release spring tension and remove tool.

(5) Tap valve spring from side to side with a light hammer to be certain spring is seated properly at cylinder head.

(6) Disconnect air hose and remove air adapter from spark plug hole.

(7) Install spark plug.

(8) Install push rods making certain bottom end of each rod is centered in plunger cap of hydraulic valve tappet.

(9) Install rocker arm assembly. Tighten capscrews to 19 foot-pounds torque.

(10) Install cylinder head cover and gasket.

(11) Install retaining screws and washers. Tighten screws to specified torque.

INTAKE MANIFOLD

The cast iron intake manifold is designed to enclose and seal the tappet area between the two cylinder heads. A one-piece metal gasket, used to seal the intake manifold to the cylinder heads and block, also serves as an oil splash baffle.

The intake manifold contains coolant passages, a crankcase ventilator passage, an exhaust crossover passage, and induction system passages to uniformly distribute the fuel and air mixture to the combustion chamber of each cylinder. Exhaust passages are also incorporated within the intake manifold for the Exhaust Gas Recirculation (EGR) system.

The left bore(s) of the carburetor supply fuel-air mixture through passages in the intake manifold to numbers 1, 7, 4 and 6 cylinder intake ports. The right bore supplies 3, 5, 2 and 8.

Removal

(1) Drain coolant from radiator.
(2) Remove air cleaner assembly.
(3) Disconnect spark plug wires.
(4) Remove spark plug wire plastic separators from the cylinder head cover brackets.
(5) Disconnect radiator upper hose and bypass hose from intake manifold.
(6) Disconnect ignition coil bracket and lay the coil and bracket assembly aside.
(7) Remove TCS solenoid vacuum valve and solenoid control switch, if so equipped, from right side cylinder head cover.
(8) Disconnect all hoses, lines, linkages and wires from the carburetor and intake manifold.
(9) Disconnect air delivery hoses at the air injection manifold.
(10) Disconnect diverter valve from air pump output hoses and lay valve and delivery hoses aside.
(11) Remove carburetor.
(12) Remove intake manifold, metal gasket and end seals.
(13) Clean mating surfaces of engine block, cylinder heads and intake manifold.

Installation

(1) Apply Perfect Seal compound, or equivalent, to both sides of new manifold gasket.
(2) Position gasket by aligning two rear locators at the rear of the cylinder head, then while holding the rear in place, align the two front locators.
(3) Install the two end seals and apply Permatex No. 2, or equivalent, to seal ends.
(4) Install intake manifold and retaining bolts, Tighten bolts to 43 foot-pounds torque.
(5) Install carburetor. Tighten nuts to 14 foot-pounds torque.
(6) Install diverter valve and connect air pump output hose.
(7) Connect air delivery hoses to air injection manifolds.
(8) Connect all previously disconnected hoses, lines, linkages, and wires to intake manifold and carburetor.
(9) Install TCS solenoid vacuum valve and solenoid control switch, if so equipped, to right side cylinder head cover.
(10) Install ignition coil and bracket assembly.
(11) Connect radiator upper hose and bypass hose.
(12) Install spark plug wire plastic separators to cylinder head cover brackets.
(13) Connect spark plug wires.
(14) Install air cleaner assembly.

EXHAUST MANIFOLD

The swept flow design of the cast iron exhaust manifold provides efficient removal of exhaust gases and minimizes cylinder back pressure. The mating surface of the exhaust manifold and the cylinder head are machined smooth to eliminate the need for a gasket.

Vehicles equipped with Air Guard Systems have air injection manifolds attached at number 1, 3, and 5 exhaust ports of the left exhaust manifold and number 2, 4, 6 and 8 of the right exhaust manifold.

Removal

(1) Disconnect spark plug wires.
(2) Disconnect air delivery hose at the injection manifold.
(3) Remove air injection manifold and injection tubes.
(4) Disconnect exhaust pipe at exhaust manifold.
(5) Remove exhaust manifold retaining nuts.
(6) Separate exhaust manifold from cylinder head.

Installation

(1) Clean mating surfaces of exhaust manifold and cylinder head. **Do not nick or scratch.**
(2) Install exhaust manifold and retaining bolts. Tighten bolts to 25 foot-pounds torque.
(3) Connect exhaust pipe using a new asbestos seal if required. Tighten nuts to 23 foot-pounds torque.
(4) Place new gaskets on each air injection tube and install air injection manifold and injection tubes.
(5) Connect the air delivery hose to air injection manifold.
(6) Connect spark plug wires.

CYLINDER HEAD AND GASKET

Removal

(1) Drain cooling system.
(2) Remove cylinder head cover and gasket.
(3) Remove rocker arm assemblies and push rods.

NOTE: *Keep rocker arm assemblies and push rods in the same order as removed.*

(4) Remove spark plugs.
(5) Remove intake manifold.
(6) Remove exhaust manifold.
(7) Loosen all drive belts.
(8) Right Side:
(a) If equipped with air conditioning, remove compressor mount bracket and battery negative cable from cylinder head.
(b) Disconnect alternator support brace from cylinder head.
Left side: Disconnect air pump and/or power steering pump bracket from cylinder head (if so equipped).

(9) Remove cylinder head retaining bolts.
(10) Remove cylinder head and gasket.

Cleaning and Inspection

Thoroughly clean the gasket surface of the cylinder head and block to remove all dirt and gasket cement. Remove the carbon deposits from the combustion chambers and the top of each piston.

Use a straight edge and feeler gauge to check the flatness of the cylinder head and block mating surfaces.

Refer to Specifications for surface flatness tolerances.

If the cylinder head is to be replaced and the original valves reused, remove the valves and measure the stem diameter. Replace oversize valves. **Only standard size valves may be used with a service replacement head.**

If the original valves are standard size, remove all carbon buildup and reface the valves as outlined under Valve Refacing. Install the valves in the cylinder head using new valve stem oil seals. Transfer all attached components from the original head which are not included with the replacement head.

Installation

NOTE: *The 304 CID engine utilizes an aluminum coated embossed steel gasket and the 360 and 401 CID engines utilize an aluminum coated laminated steel and asbestos gasket. Retorqueing is not necessary with either gasket.*

(1) Apply an even coat of Perfect Seal sealing compound or equivalent to both sides of new head gasket.

NOTE: *Do not apply sealing compound on head and block surfaces or allow sealer to enter cylinder bores.*

(2) Position gasket on block with stamped word TOP facing upward.
(3) Install cylinder head and retaining bolts.

NOTE: *Wire brush the threads of bolts prior to installation as dirt will affect the torque readings.*

(4) Cylinder head capscrews must be tightened evenly to 80 foot-pounds torque following the sequence outlined in figure 1B-12. Then follow the sequence again and tighten screws to 110 foot-pounds torque.
(5) Left side: connect air pump mount bracket to cylinder head and/or power steering pump, if so equipped.
(6) Right side:
(a) Connect alternator support bracket to cylinder head.
(b) Install air conditioning compressor mounting bracket and battery negative cable to cylinder head, if so equipped.

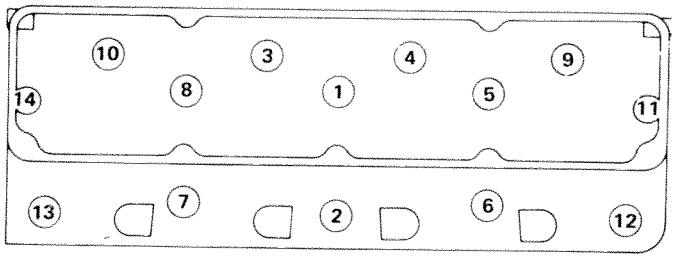

Fig. 1B-12 Cylinder Head Torque Sequence—V-8

(7) Adjust all drive belts to specified tension.
(8) Install the exhaust manifold and tighten retaining bolts to 25 foot-pounds torque.
(9) Install intake manifold. Tighten manifold retaining bolts to 43 foot-pounds torque.
(10) Install all lines, hoses, linkages, and wires previously disconnected.
(11) Install rocker arm assemblies and push rods in the same order as removed. Tighten capscrews to 19 foot-pounds torque.
(12) Install cylinder head cover and gasket and tighten retaining screws to specified torque.
(13) Install spark plugs and connect the spark plug wires.
(14) Fill the cooling system to specified level.

CYLINDER HEAD RECONDITIONING

The following procedures apply after the cylinder head has been removed from the engine.

Diassembly

(1) Compress each valve spring with C-clamp type spring compressor tool and remove the valve locks, and retainers or rotators.
(2) Release compressor and remove valve spring.
(3) Remove valve stem oil seals.
(4) Remove valves one at a time and place them in a rack in the same order as in cylinder head.

Cleaning and Inspection

Clean all carbon buildup from the combustion chambers, valve ports, valve stems, and heads.

Remove all dirt and gasket cement from the cylinder head gasket mating surface.

Inspect for cracks in the combustion chambers and valve ports and in the gasket surface at each coolant passage.

Inspect for burned or cracked valve heads and damaged valve stems.

Reconditioning

Use a valve refacing machine to reface intake and exhaust valves to specified angle. Replace any valve which is bent or warped. After refacing, at least 1/32-inch margin must remain or the valve must be replaced. Examples of correct and incorrect valve refacing are shown in figure 1B-13.

Resurface and rechamber the valve stem tip when worn. **Never remove more than 0.010 inch.**

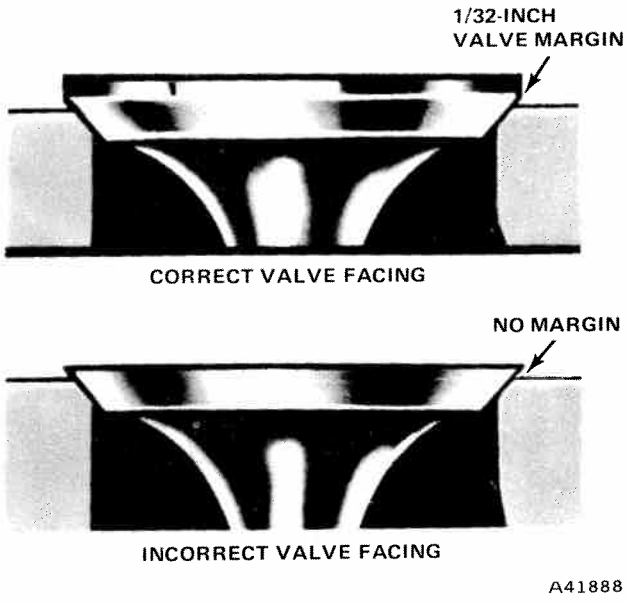

Fig. 1B-13 Valve Refacing

Valve Seat Refacing

Install a pilot of the correct size in the valve guide and reface the valve seat to the specified angle with a good dressed stone. Remove only enough metal to provide a smooth finish. Use tapered stones to obtain the specified seat widths when required. Maximum seat runout is 0.0025 inch (fig. 1B-14).

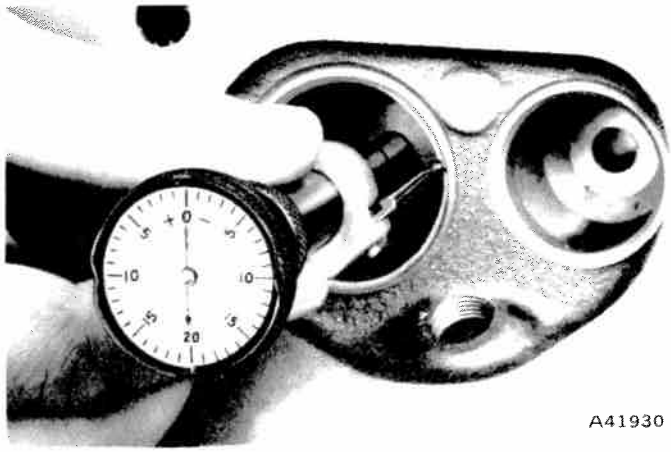

Fig. 1B-14 Valve Seat Runout

Valve Guides

The valve guides are an integral part of the cylinder head and are not replaceable. When the stem-to-guide clearance is excessive, ream the valve guides to the next larger size so that proper clearance can be obtained. Oversize service valves are available in 0.003 inch, 0.005 inch and 0.030 inch.

The following oversize valve guide reamers may be used.

J-6042-1	0.003 inch
J-6042-5	0.015 inch
J-6042-4	0.030 inch

NOTE: *Ream guides in steps. Start with the 0.003 inch oversize reamer and progress to the size required.*

Valve Stem-to-Guide Clearance

Check valve stem-to guide clearance by two methods:

NOTE: *Make certain the valve stem and guide bore are thoroughly cleaned before measuring.*

(1) (a) Measure valve stem diameter with a caliper micrometer midway between valve head and tip.

(b) Select a pilot from a valve refacing kit which fits snugly in valve guide bore.

(c) Determine valve stem-to-guide clearance by subtracting diameter of valve stem from size of the pilot selected.

(2) (a) Mount a dial indicator adjacent to valve guide to be checked.

(b) Position valve slightly off its seat,with valve stem push laterally away from dial indicator.

(c) Set dial indicator push rod on stem of valve near tip and set gauge to zero (fig. 1B-15).

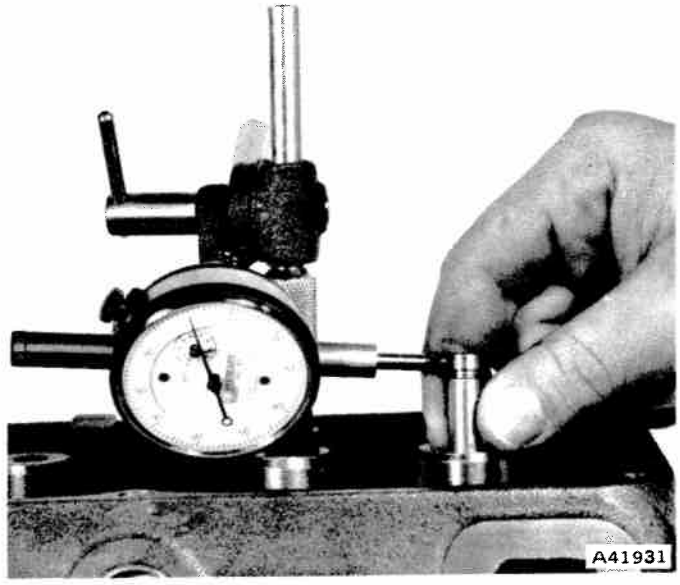

Fig. 1B-15 Valve Stem-to-Guide Clearance Measurement

(d) Rear dial indicator while moving valve stem laterally toward dial indicator. Stem-to-guide clearance is indicated on gauge.

Assembly

(1) Thoroughly clean valve stems and valve guide bores.

(2) Install each valve in the same valve guide from which it was removed.

(3) Install new valve stem oil seal on each valve stem.

(4) Position each valve spring and retainer or rotator on cylinder head and compress the valve spring with compressor tool.

(5) Install valve locks and release tool.

(6) Tap each valve spring from side-to-side with a light hammer to seat the spring properly at cylinder head.

HYDRAULIC VALVE TAPPETS

The hydraulic valve tappet consists of a body, plunger, plunger return spring, check valve assembly, metering disc, plunger cap, and lockring (fig. 1B-16).

The tappet operates in a guide bore which has an oil passage drill into the adjoining oil gallery.

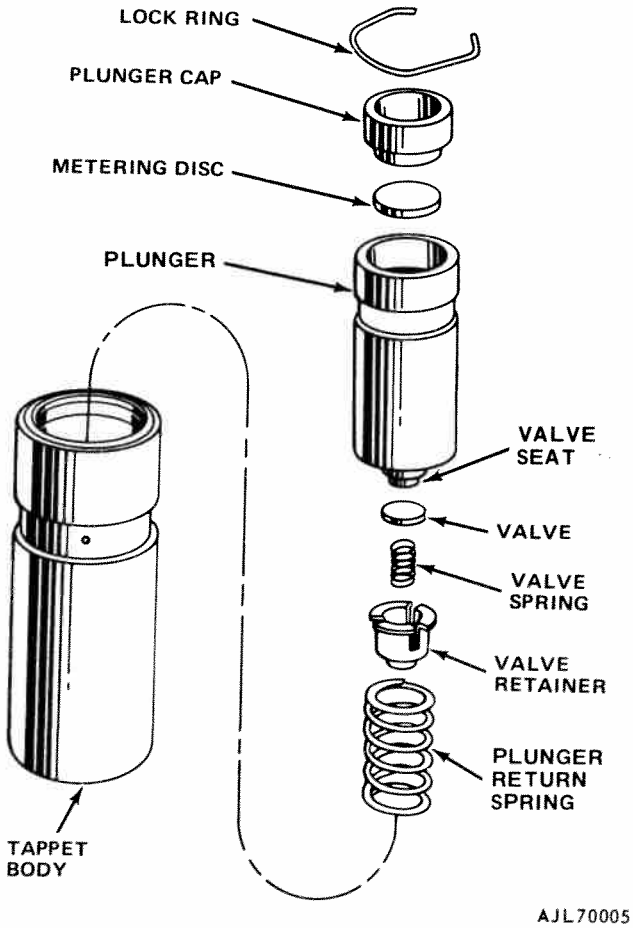

Fig. 1B-16 Typical Hydraulic Tappet Assembly

When the tappet is on the heel of the cam lobe, the plunger return spring indexes with an oil hole undercut in the plunger and allows the oil supply to be admitted through the tappet body. Oil under pressure flows into the body through the check valve assembly maintaining the tappet fully charged (fig. 1B-17). This cycle of operation occurs when the tappet leaks off some oil during the normal valve opening events. Contact with the cam lobe causes tappet body movement, closing the check valve and transmitting zero-lash movement of the push rod to open the intake or exhaust valve.

In addition, oil under pressure in the plunger also flows through the metering disc, plunger cap, and hollow push rod to the rocker arm assembly.

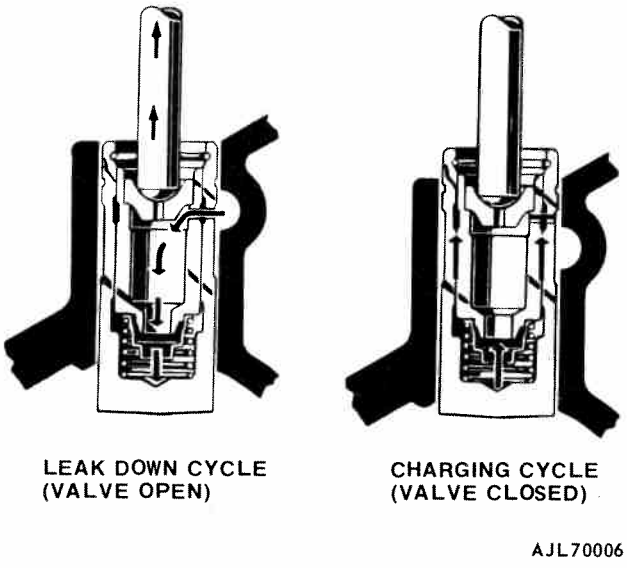

Fig. 1B-17 Hydraulic Tappet Operation Cycles

Removal

(1) Remove cylinder head cover and gasket.

(2) Remove rocker arms and bridged pivot assemblies.

(3) Remove push rods.

NOTE: *Keep rocker arm assemblies and push rods in the same order as removed.*

(4) Remove intake manifold, metal gaskets and end seals.

(5) Remove tappet from guide bore in engine block.

Disassembly

(1) Release the lock ring.

(2) Remove the plunger cap, plunger assembly, and plunger return spring from tappet body.

NOTE: *Keep the tappets and all components in the same order as removed.*

Cleaning and Inspection

Clean all components of the hydraulic tappet assembly in a good cleaning solvent to remove all varnish or gum deposits.

A visual inspection of each tappet assembly is required.

The inspection should include checking for signs of scuffing on the barrel and face of the tappet. Inspect tappet face for wear using a straight edge across the tappet face. If the tappet face is concave, the corresponding lobe on the camshaft is worn and the replacement of the camshaft and tappets is necessary.

If any components of a tappet assembly are noticeably worn or damaged, replace the entire assembly.

Hydraulic Tappet Leak-Down Test and Assembly

After cleaning and inspection, the tappet must be leak-down tested to ensure its zero-lash operating ability. Figure 1B-18 shows Tool J-5790 used to accurately test tappet leak-down.

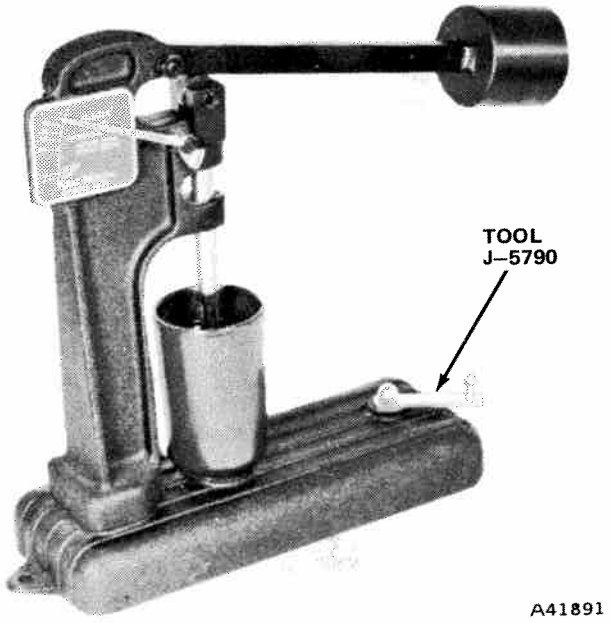

Fig. 1B-18 Hydraulic Tappet Leak-Down Tester—J-5790

(1) Fill tappet body with Valve Tappet Test Oil J-5268.

(2) Install plunger return spring, plunger assembly, and plunger cap in tappet body. Do not install lockring for test.

(3) Place a 0.312 to 0.313-inch diameter ball bearing on plunger cap.

(4) Place tappet in tester.

(5) Lift weighted arm, place tester push rod on ball bearing in plunger cap, adjust push rod to set tester gauge to START.

(6) Release weighted arm and time tappet leak-down.

(7) A good tappet will take 20 to 110 seconds to leak-down with a load travel of 0.125 inch as indicated on tester gauge.

(8) Install lockrings on those tappets which passed test. Discard those that failed and replace with new tappet assemblies.

NOTE: *Do not charge the tappet assemblies with engine oil as they will charge themselves within three to eight minutes of engine operation.*

Installation

(1) Dip each tappet assembly in Jeep Engine Oil Supplement (EOS) or equivalent, and install tappet in same bore from which it was removed.

(2) Install the push rods in the same order as removed.

(3) Install the rocker arm and bridged pivot assemblies. Tighten screws to 19 foot-pounds torque.

(4) Pour remaining EOS over entire valve train mechanism.

NOTE: *Do not drain the EOS from the engine for at least 1,000 miles or until the next scheduled oil change.*

(5) Install cylinder head cover and gasket. Tighten retaining screws to specified torque.

(6) Install the intake manifold and new gasket and end seals. Tighten manifold retaining bolts to 43 foot-pounds torque.

(7) Install all lines, hoses, linkages, and wires previously disconnected from intake manifold.

VIBRATION DAMPER

The vibration damper is balanced independently and then rebalanced as part of the complete crankshaft assembly.

Do not attempt to duplicate original damper balance holes when installing a service replacement. The vibration damper is not repairable and is serviced only as a complete assembly.

Removal

(1) Loosen alternator drive belt.

(2) Loosen air conditioning drive belt and move aside, if so equipped.

(3) Loosen power steering drive belt and move aside, if so equipped.

(4) Remove drive pulley retaining bolts and drive pulley from damper.

(5) Remove damper retaining bolt.

(6) Use Vibration Damper Removal Tool J-21791 to remove damper from crankshaft as shown in figure 1B-19.

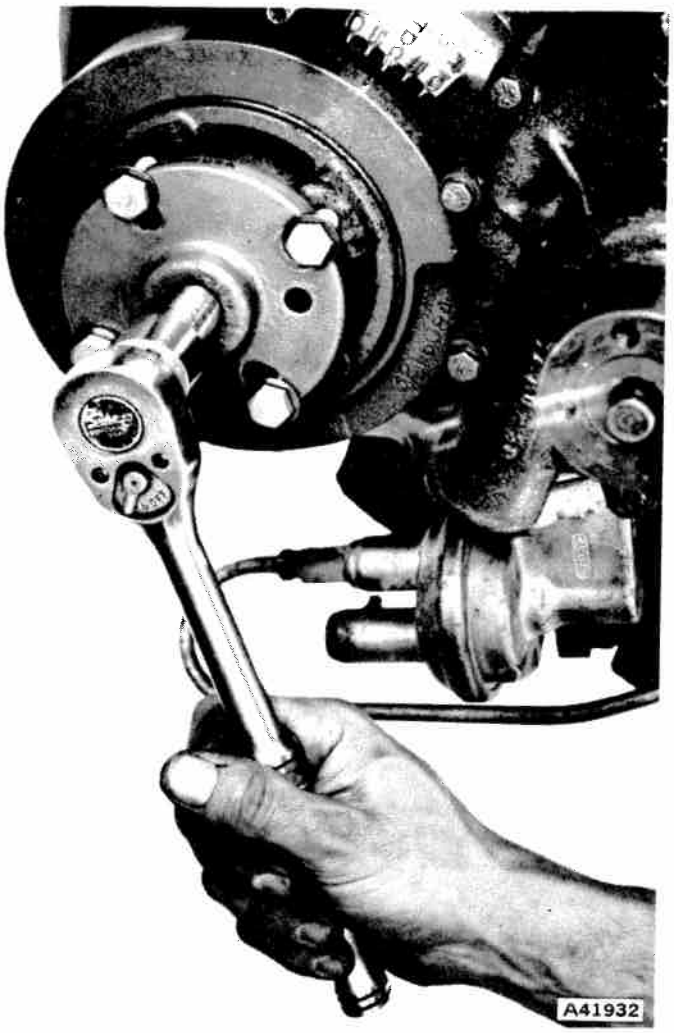

Fig. 1B-19 Vibration Damper Removal

Installation

(1) Apply a light film of engine oil to seal contacting surface of vibration damper.
(2) Align key slot of vibration damper with crankshaft.
(3) Tap damper onto crankshaft with hammer.
(4) Install damper retaining bolt and tighten to 55 foot-pounds torque.
(5) Install drive pulley and retaining bolts. Tighten bolts to 23 foot-pounds torque.
(6) Install drive belts and tighten to specified torque.

TIMING CHAIN COVER

The timing chain cover is die-cast aluminum with a crankshaft oil seal to prevent oil leakage at the vibration damper hub (fig. 1B-20). The oil seal is installed from the back side of the timing chain cover; therefore, it is necessary to remove the cover whenever oil seal replacement is required.

The engine oil pump, oil passages and coolant passages are incorporated within the timing chain cover

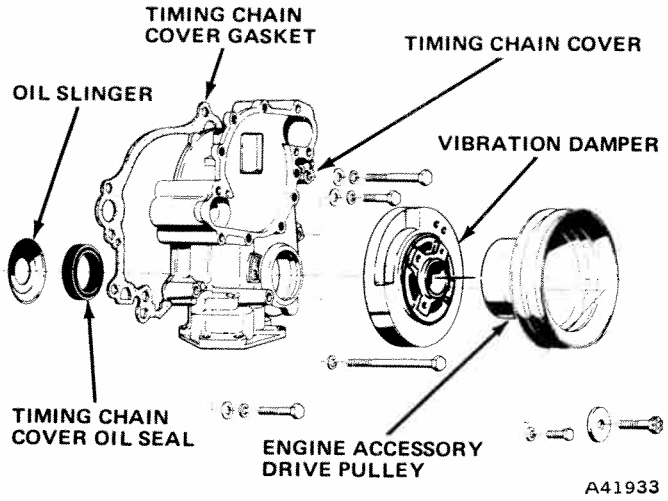

Fig. 1B-20 Timing Chain Cover Assembly—Exploded View

casting. The timing chain cover casting is also used to mount the fuel pump, distributor and water pump.

Removal

(1) Drain cooling system.
(2) Disconnect radiator hoses and bypass hose.
(3) Remove all drive belts.
(4) Remove fan and hub assembly.
(5) If equipped with air conditioning, remove compressor and bracket assembly from engine and move aside. **Do not disconnect the air conditioning hoses.**
(6) Remove air conditioning back idler pulley assembly, if so equipped.
(7) Remove alternator and front portion of alternator mount bracket as an assembly from the engine.
(8) Disconnect heater hose at water pump.
(9) Remove power steering pump and/or air pump and mount bracket as an assembly. Do not disconnect power steering hoses.
(10) Remove distributor cap and note the rotor position.
(11) Remove distributor.
(12) Remove fuel pump.
(13) Remove drive pulley and retaining bolts.
(14) Remove vibration damper.
(15) Remove the two front oil pan bolts.
(16) Remove bolts which secure timing chain cover to engine block.

NOTE: *The cover retaining bolts vary in length and must be installed in the same location as removed.*

(17) Remove cover by pulling forward until free of the locating dowel pins.
(18) Clean gasket surface of cover.
(19) Remove oil seal.

NOTE: *The oil seal should always be replaced whenever the timing chain cover is removed. refer to Oil Seal Replacement later in this section for procedure.*

Installation

(1) Remove lower locating dowel pin from engine block.

NOTE: *The dowel pin is required for correct cover alignment and must be either reused or a replacement dowel installed after the cover is in position.*

(2) Use a sharp knife or razor blade to cut both sides of oil pan gasket flush with engine block.

(3) Using the old gasket as a guide, trim a new gasket to correspond to the amount cut off at the oil pan (fig. 1B-21).

(4) Apply cement to both sides of new gasket and install gasket on the timing chain cover.

(5) Install new front oil pan seal.

(6) Align tongues of new oil pan gasket pieces with oil pan seal and cement into place on cover (fig. 1B-21).

(7) Apply a stripe of Permatex No. 2, or equivalent, to cut-off edges of original oil pan gaskets.

(8) Place timing chain cover into position and install the two front oil pan bolts.

(9) Tighten bolts slowly and evenly until cover aligns with upper locating dowel.

(10) Install lower dowel through cover and drive into corresponding hole in engine block.

(11) Install cover retaining bolts in the same location as removed. Tighten to 25 foot-pounds torque.

(12) Install vibration damper. Tighten retaining bolt to 55 foot-pounds torque.

(13) Install drive pulley and retaining bolts.

(14) Install fuel pump.

(15) Install distributor with the rotor in the same position as it was prior to removal.

(16) Install the distributor cap. Connect the heater hose.

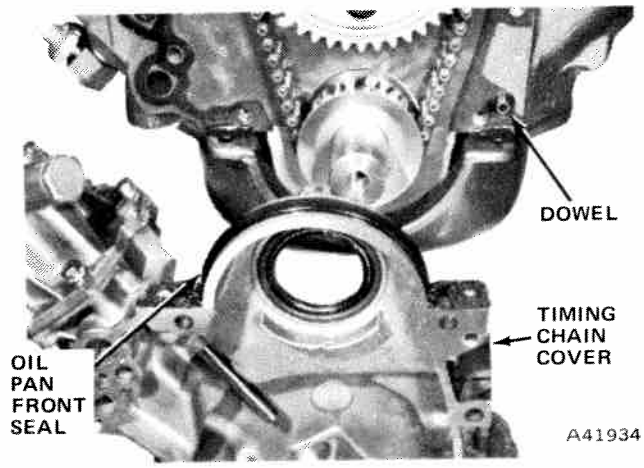

Fig. 1B-21 Oil Pan Front Seal Installation

(17) Install the power steering pump and/or air pump and bracket (if equipped).

(18) Install alternator and front portion of alternator bracket.

(19) Install air conditioning back idler pulley assembly (if equipped).

(20) If removed, install air conditioning compressor and bracket assembly.

(21) Install fan and hub assembly.

(22) Install all drive belts and tighten to the specified tension.

(23) Connect radiator hoses and bypass hose.

(24) Fill cooling system to specified level.

(25) Start engine and check for oil or coolant leaks.

(26) Adjust initial ignition timing to specified setting.

Fig. 1B-22 Timing Chain Cover Oil Seal Replacement

Oil Seal Replacement

Timing chain cover must be removed to replace seal.

(1) Pry out original seal from inside timing chain cover and clean seal bore.

(2) Apply a light coat of perfect Seal compound, or equivalent, to outer surface of a new seal.

(3) Drive the seal into place from inside the cover with Seal Installer Tool J-22533 until it contacts the outer flange of the cover (fig. 1B-22).

(4) Apply a light film of engine oil to the lips of neoprene seal.

TIMING CHAIN

To ensure correct valve timing, install the timing chain with the timing marks of the crankshaft and

camshaft sprockets properly aligned. A worn timing chain will adversely affect valve timing. If the timing chain deflects more than 1/2 inch, it should be replaced.

Checking Valve Timing

(1) Remove spark plugs.
(2) Remove cylinder head covers and gaskets.
(3) Remove rocker arms and bridged pivot assemblies from No. 1 cylinder.
(4) Rotate crankshaft until No. 6 piston is at Top Dead Center (TDC) on compression stroke (this places No. 1 Piston at TDC on the exhaust stroke in valve overlap position).
(5) Rotate crankshaft counterclockwise 90° as viewed from front.
(6) Install a dial indicator on No. 1 intake valve rocker arm push rod end.
(7) Set dial indicator to zero.
(8) Crank the engine slowly in direction of rotation (clockwise) until dial indicator indicates 0.020 inch for 304 and 360 CID engines, and 0.025 inch for 401 CID engines.
(9) At this point, milled timing mark on vibration damper should be in line with TDC or zero marking on timing chain cover.

If more than 1/2 inch variation in either direction exists, remove timing chain cover and inspect timing chain installation.

Removal

(1) Remove timing chain cover and gasket.
(2) Remove crankshaft oil slinger.
(3) Remove camshaft sprocket retaining bolt and washer.
(4) Remove distributor drive gear and fuel pump eccentric.
(5) Rotate the crankshaft until the "0" timing mark on the crankshaft sprocket is closest to and in a centerline with the "0" timing mark on the camshaft sprocket as shown in figure 1B-23.
(6) Remove crankshaft sprocket, camshaft sprocket and timing chain as an assembly.

Installation

(1) Assemble timing chain, crankshaft sprocket, and camshaft sprocket with the timing marks aligned as shown in figure 1B-23.
(2) Install assembly to crankshaft and camshaft.
(3) Install fuel pump eccentric and distributor drive gear.
(4) Install camshaft sprocket, washer, and retaining bolt. Tighten bolt to 30 foot-pounds torque.

NOTE: *The fuel pump eccentric must be installed with the stamped word REAR facing the chamshaft sprocket.*

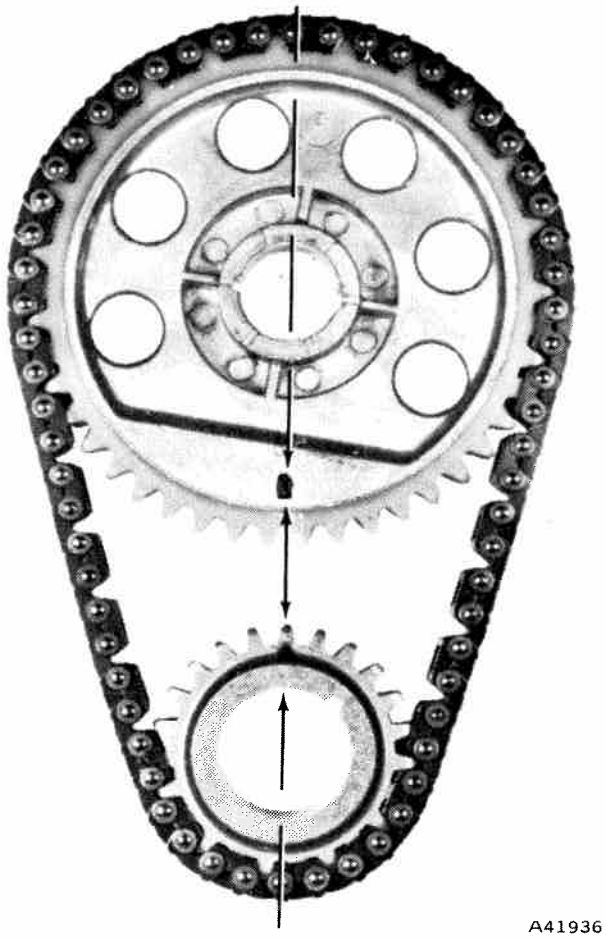

Fig. 1B-23 Timing Chain and Sprockets Alignment

(5) To ensure correct installation of timing chain:
(a) Rotate crankshaft until timing mark on camshaft sprocket is on a horizontal line at 3 o'clock position.
(b) Beginning with pin directly adjacent to camshaft sprocket timing mark, count number of pins downward to timing mark on crankshaft sprocket.
(c) There should be 20 pins between these two points. **The crankshaft sprocket timing mark must be between pins 20 and 21** (fig. 1B-24).
(6) Install crankshaft oil slinger.
(7) Install the timing chain cover using a new gasket, tighten retaining bolts to 25 foot-pounds torque.

CAMSHAFT AND BEARINGS

The camshaft is supported by five steel-shelled, babbitt-lined bearings which have been pressed into the block and line reamed. The camshaft bearings are step bored, being larger at the front bearing than at the rear, to permit easy removal and installation of

the camshaft. All camshaft bearings are lubricated under pressure.

NOTE: *Do not replace camshaft bearings unless equipped with special removing, installing and reaming tools.*

Camshaft end play is maintained by the load placed on the camshaft by the oil pump and distributor drive gear.

The helical cut of the gear holds the camshaft sprocket thrust face against the cylinder block face to hold camshaft end play to zero during engine operation.

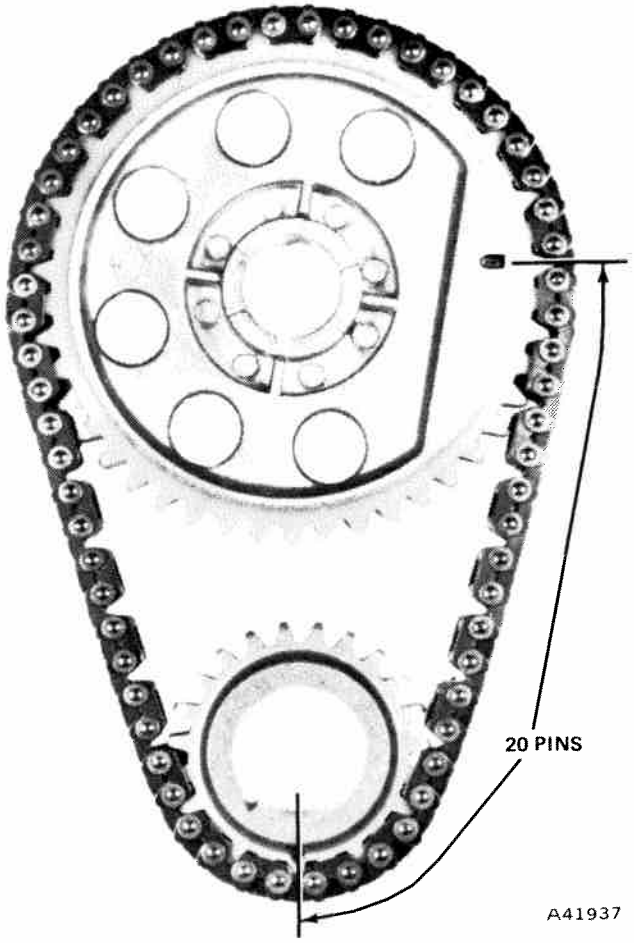

Fig. 1B-24 Correct Timing Chain Installation

Camshaft Identification

All 401 CID engine camshafts, different from the 304 and 360 CID camshafts, are identified by white paint marks between the number 4 and 5 camshaft bearings. The 304 and 360 CID engine camshafts, which are the same, have no identifying paint marks.

Cam Lobe Lift Measurement

Cam lift may be checked with a dial indicator.

(1) Remove cylinder head cover and gasket.

(2) Remove spark plugs.

(3) Install dial indicator on push rod end of rocker arm (fig. 1B-25).

(4) Rotate crankshaft until cam lobe base circle (push rod down) is under the valve tappet.

(5) Set dial indicator to zero.

(6) Rotate crankshaft until point of maximum push rod upward movement occurs.

(7) Read travel at dial indicator. (An excess of minus 0.006 inch from specified dimensions indicates defective cam.)

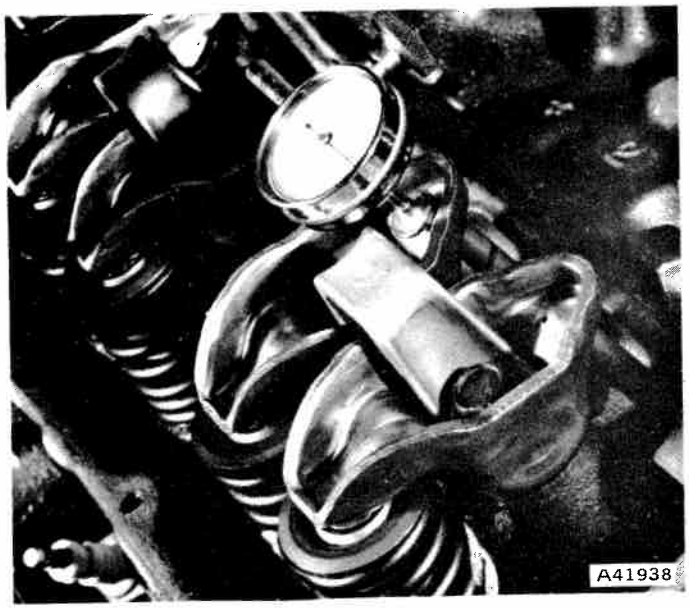

Fig. 1B-25 Cam Lobe Lift Measurement

Removal

(1) Drain cooling system.

(2) Remove radiator assembly.

(3) If equipped with air conditioning, remove condenser and receiver assembly as charged unit. Refer to Section 13A - Air Conditioning for detailed procedure.

(4) Remove cylinder head covers and gaskets.

(5) Remove rocker arms and bridged pivot assemblies.

(6) Remove push rods.

NOTE: *Keep the push rods, rocker arm assemblies, and tappets in the same order as removed.*

(7) Remove intake manifold assembly.

(8) Remove drive belts.

(9) Remove fan and hub assembly.

(10) Remove distributor.

(11) Remove drive pulley.

(12) Remove vibration damper.
(13) Remove timing chain cover.
(14) Remove timing chain cover oil seal.
(15) Rotate the crankshaft until "0" timing mark on crankshaft sprocket is closest to and in a centerline with "0" timing mark on camshaft sprocket.
(16) Remove retaining bolt from camshaft.
(17) Remove crankshaft sprocket, camshaft sprocket and timing chain as an assembly.
(18) Remove distributor drive gear and fuel pump eccentric from the camshaft.
(19) Remove hood latch support bracket upper retaining screws and move bracket, as required, to allow removal of camshaft.
(20) Remove front bumper or grille, as required, and remove camshaft.

Inspection

Inspect the camshaft bearing journals for an uneven wear pattern or rough finish. Either condition will necessitate camshaft replacement.

Inspect the distributor drive gear for damage or excessive wear.

Inspect fuel pump eccentric for excessive wear.

Inspect each cam lobe and the matching hydraulic valve tappet for wear. If the face of the tappet(s) is worn concave and the matching camshaft lobe(s) is also worn, both the camshaft and the tappet(s) must be replaced.

Installation

(1) Lubricate entire camshaft generously with Jeep Engine Oil Supplement (EOS), or equivalent.
(2) Carefully install camshaft into engine block.
(3) Install fuel pump eccentric and distributor drive gear to camshaft.
(4) Assemble timing chain, crankshaft sprocket and camshaft sprocket with the "0" timing marks aligned as during removal.
(5) Install chain and sprockets assembly to engine. (Recheck installation as shown in figure 1B-24.)
(6) Install new timing chain cover gasket, refer to Timing Chain Cover described earlier in this section. Install a new oil seal and apply light film of engine oil to the lips of seal.
(7) Install timing chain cover.
(8) Install vibration damper.
(9) Install drive pulley and retaining bolts, tighten bolts in specified torque.
(10) Install hydraulic valve tappets lubricated with EOS.

NOTE: *The hydraulic valve tappets and all valve train components should be lubricated with Jeep engine Oil Supplement, or equivalent, during installation. Do not drain the EOS from the engine for at least 1,000 miles or until the next scheduled oil change.*

(11) Install intake manifold assembly.
(12) Install push rods.
(13) Install rocker arms and bridged pivot assemblies.
(14) Install cylinder head covers and gaskets.
(15) Install fuel pump.
(16) Rotate crankshaft until No. 1 piston is at TDC position on compression stroke.
(17) Install distributor so that rotor is aligned with No. 1 terminal of the cap when fully seated on block.
(18) Install distributor cap.
(19) Install spark plug wires.
(20) If removed, install air conditioning condenser and receiver assembly. Refer to Section 13A —Air Conditioning for procedure to purge compressor of air.

CAUTION: *Both service valves must be open before the air conditioning system is operated.*

(21) Install hood latch support bracket retaining screws and tighten securely.
(22) If removed, install front bumper or grille.
(23) Install radiator.
(24) Fill cooling system to specified level.

OIL PAN

Removal

(1) Drain engine oil.
(2) Remove starter.
(3) Remove oil pan.
(4) Remove oil pan front and rear neoprene oil seals. Thoroughly clean the gasket surfaces of oil pan and engine block. Remove all sludge and dirt from oil pan sump.

Installation

(1) Install new oil pan front seal to timing chain cover and apply a generous amount of Permatex No. 2, or equivalent, to end tabs.
(2) Cement new oil pan side gaskets into position on engine block and apply a generous amount of Permatex No. 2, or equivalent, to gasket ends.
(3) Coat inside curved surface of new oil pan rear seal with soap and apply a generous amount of Permatex No. 2, or equivalent, to side gasket contacting surface of seal end tabs.
(4) Install seal in the recess of rear main bearing cap making certain it is fully seated.
(5) Apply engine oil to oil pan contacting surface of front and rear oil pan seals.
(6) Install oil pan and tighten drain plug securely.
(7) Install starter.
(8) Fill crankcase to specified level with new oil.

OIL FILTER

A full flow oil filter mounted on the lower right hand side of the engine is accessible from below the chassis.

A bypass valve, incorporated in the filter mounting base, provides a safety factor in the event the filter becomes inoperative as a result of dirt or sludge accumulation. Oil Filter Remover Tool. J-22700 will facilitate removal.

Before installation, apply a thin film of oil to the filter gasket. **Do not use grease.** Install filter until gasket contacts the seat of the adapter. Tighten by hand only, following instructions on replacement filter. Operate engine at fast idle and check for leaks.

OIL PUMP

A positive displacement gear type oil pump is used and is driven by the distributor shaft, which in turn is driven by a gear on the camshaft. The pump, which is part of the timing chain cover, incorporates a pressure relief valve to regulate maximum pressure.

Crankcase oil enters the pump after being drawn through the pick-up tube and screen assembly, the horizontal main oil gallery and the connecting passage in the timing chain cover.

Oil pump removal or replacement will not affect distributor timing as the distributor drive gear remains in mesh with the camshaft gear.

Oil Pressure Relief Valve

The oil pressure relief valve is not adjustable. A setting of 75 pounds maximum pressure is built into the tension of the spring.

In the relieved position, the valve permits oil to bypass through a passage in the pump cover to the inlet side of the pump.

Removal

(1) Remove retaining screws and separate the oil pump cover, gasket and oil filter as an assembly from pump body (timing chain cover).

(2) Remove drive gear and shaft, and driven or idler gear by sliding them out of body.

(3) If required, oil pressure relief valve may be removed from pump cover for cleaning by removing cap from pump cover.

Gear End Clearance Measurement

(1) Place straightedge across gears and pump body.

(2) Select a feeler gauge which will fit snugly but freely between straightedge and pump body (fig. 1B-26).

Fig. 1B-26 Gear End Clearance Measurement

NOTE: *Make certain gears are up as far as possible into body. Refer to Specifications pages for correct clearance.*

If gear end clearance is less than specified, replace timing chain cover and gear and shaft assemblies.

Gear-to-Body Clearance

(1) Insert a feeler gauge between gear tooth and pump body inner wall directly opposite the point of gear mesh. Select a feeler gauge which fits snugly but freely (fig. 1B-27).

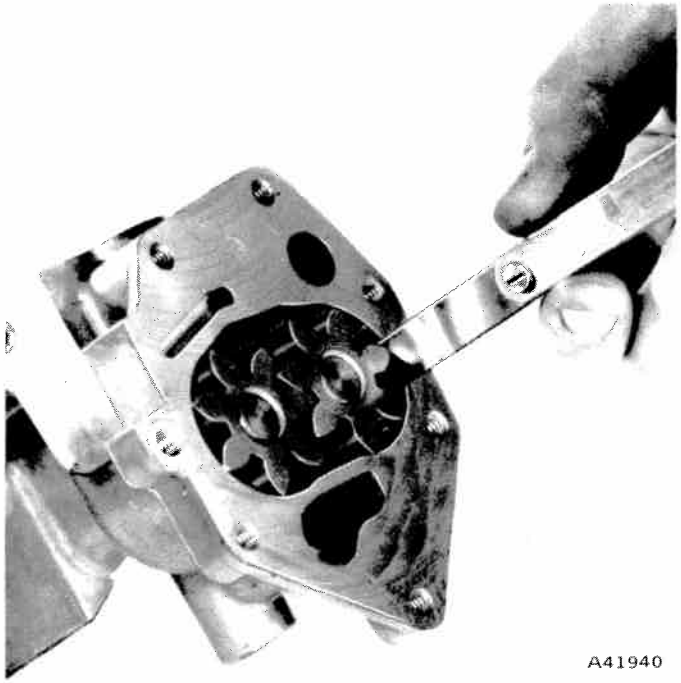

Fig. 1B-27 Gear-to-Body Clearance Measurement

(2) Rotate gears to check each tooth in this manner. Refer to the Specifications pages for the correct clearance.

(3) If gear-to-body clearance is more than specified, replace idler gear, idler shaft, and drive gear assembly.

Installation

(1) If removed, install oil pressure relief valve in the pump cover.

(2) Install idler shaft, idler gear, and drive gear assembly.

NOTE: *To ensure self-priming of the oil pump, the pump must be filled with petroleum jelly prior to the installation of the oil pump cover.* **Do not use grease of any type.**

(3) Install pump cover and oil filter assembly with a new gasket. Tighten retaining screws to 55 inch-pounds torque.

REAR MAIN BEARING OIL SEAL

The rear main bearing oil seal consists of a two piece, neoprene, single lip seal to seal the rear of the crankshaft. Correct installation of the seal will ensure leak-free engine operation (fig. 1B-28).

Removal

(1) Drain engine oil.

(2) Remove oil pan.

(3) Remove oil pan front and rear neoprene oil seals.

(4) Remove oil pan side gaskets.

(5) Thoroughly clean gasket surfaces of oil pan and engine block. Remove all sludge and dirt from oil pan.

(6) Remove rear main bearing cap.

(7) Remove and discard lower seal.

NOTE: *To ensure leak-free operation, the upper and lower seal halves must be replaced in pairs.*

(8) Clean main bearing cap thoroughly to remove all sealer.

(9) Loosen all remaining main bearing capscrews.

(10) With a brass drift and hammer, tap the upper seal until sufficient seal is protruding to permit pulling seal out completely.

Installation

(1) Wipe seal surface of the crankshaft clean and then oil lightly.

(2) Coat block contacting surface of the new upper seal with soap, and lip of seal with engine oil.

(3) Install upper seal into engine block.

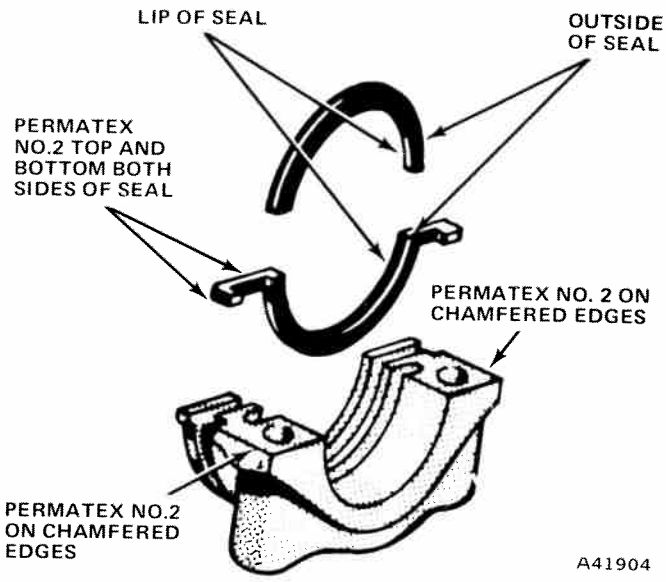

Fig. 1B-28 Rear Main Oil Seal Installation

NOTE: *The lip of the seal must face to the front of the engine.*

(4) Coat both sides of new lower seal end tabs with Permatex No. 2 or equivalent being careful not to apply sealer to lip of seal.

(5) Coat outer curved surface of lower seal with soap and lip of seal with engine oil.

(6) Install seal into cap recess and seat firmly.

(7) Place Permatex No. 2 or equivalent on both chamfered edges of rear main bearing cap.

(8) Install rear main bearing inserts.

(9) Tighten all main bearing capscrews to 100 foot-pounds torque.

(10) Install oil pan using new gaskets and seals. Tighten drain plug securely.

(11) Fill the crankcase to specified level with new oil.

CYLINDER BLOCK

Disassembly

(1) Remove engine assembly as outlined earlier in this section.

(2) Use engine stand to support engine assembly.

(3) Remove the cylinder head covers and gasket.

(4) Remove rocker arms and bridged pivot assemblies.

(5) Remove push rods.

(6) Remove intake manifold assembly.

(7) Remove valve tappets.

(8) Remove cylinder heads and gaskets.

(9) Position pistons one at a time near bottom of their stroke and use ridge reamer to remove any ridge from top end of cylinder walls.

(10) Remove drive pulley and vibration damper.

(11) Remove timing chain cover.
(12) Drain engine oil and remove oil pan.
(13) Remove camshaft.
(14) Remove connecting rod bearing caps and inserts and keep in same order as removed.

NOTE: *Connecting rods and caps are stamped with the number of the cylinder to which they were assembled.*

(15) Remove connecting rod and piston assemblies through top of cylinder bores. **Be careful that connecting rod bolts do not scratch connecting rod journals or cylinder walls.**
(16) Remove oil pickup tube and screen assembly.
(17) Remove main bearing caps and inserts.
(18) Remove crankshaft.

Cylinder Bore Reconditioning

Inspect the cylinder bores for scoring, taper, and out-of-round. Check with an inside micrometer or telescope gauge from the top to the bottom of the cylinders for taper. Check for an out-of-round condition by measuring across the cylinder bores at two points; parallel to the crankshaft and perpendicular to the crankshaft.

If cylinder taper does not exceed 0.005 inch and out-of-round does not exceed 0.003 inch, the cylinder bore may be corrected by honing.

If the cylinder taper or out-of-round condition exceeds these limits, the cylinder must be bored and then honed for an oversize piston.

After honing the cylinder bores, move the hone up and down at sufficient speed to produce a uniform crosshatch pattern on the cylinder walls.

Removal of glaze from the cylinder wall for quicker ring seating can be accomplished by various methods. When an expanding type hone is used, do not use more than ten strokes (each stroke down and return) to recondition a cylinder wall.

Successful ring installation depends upon cleanliness during the honing operation and careful handling of parts. The engine bearings and lubrication system must be protected from abrasives.

Rigid type hones are not to be used to remove cylinder glaze as there is always a slight amount of taper in cylinder walls after the engine has been in service.

Prior to fitting pistons, the cylinder bores should be scrubbed clean with a hot water and detergent solution. After cleaning, apply light engine oil to the cylinder walls and then wipe with a clean lint-free cloth.

NOTE: *If crankshaft remains in block, cover the connecting rod journals with clean cloths during the cleaning operation.*

Assembly

(1) Install upper main bearing inserts.
(2) Install crankshaft.
(3) Install main bearing cap and inserts.
(4) Install new oil pickup tube and screen assembly.
(5) Install camshaft.
(6) After thoroughly cleaning cylinder bores, apply a light film of clean engine oil to bores with a clean lint-free cloth.
(7) Prior to installing the connecting rod and piston assemblies into cylinder block, arrange piston ring gaps so that:
(a) No. 1 compression ring gap is 180° from No. 2 compression ring gap.
(b) Oil control ring spacer expander gap is at least 90° from No. 2 compression ring gap.
(c) Oil control ring gaps are 90° between each ring gap (fig. 1B-29).

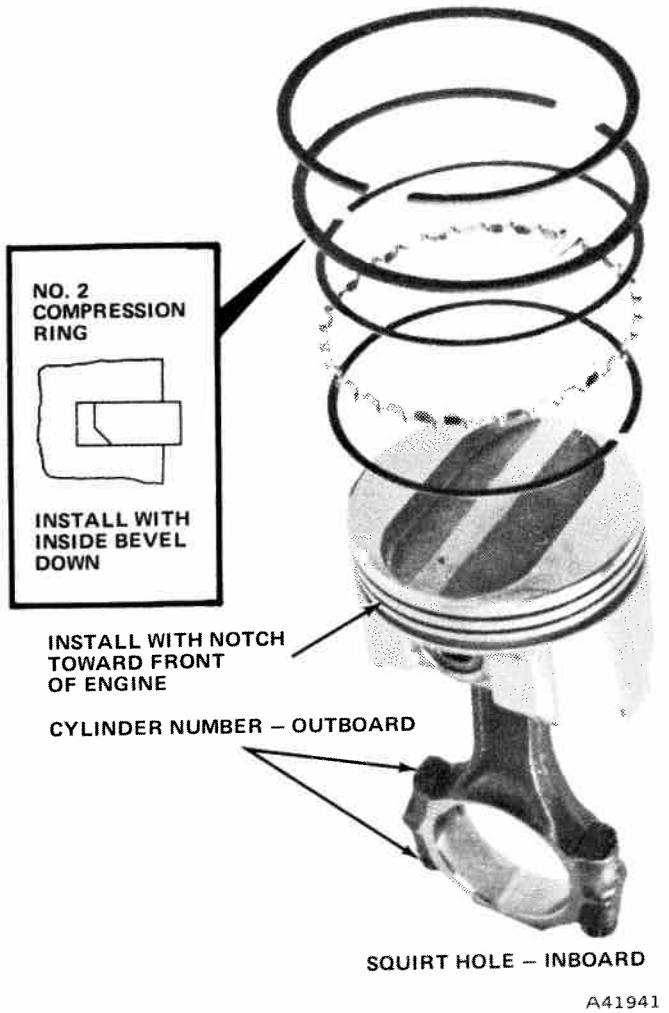

Fig. 1B-29 Piston Ring Sequence

(8) Lubricate piston and ring surfaces with clean engine oil.
(9) Use a piston ring compressor tool to install connecting rod and piston assemblies through top of cylinder bores. **Be careful that connecting rod bolts do not scratch connecting rod journals or cylinder walls.**

NOTE: *Place lengths of rubber hose over the connecting rod bolts for protection during installation.*

(10) Install connecting rod bearing caps and inserts in same order as removed. On vehicles equipped with 304 and 360 CID engines, tighten nuts to 28 foot-pounds torque. Vehicles equipped with 401 CID engines tighten nuts to 38 foot-pounds torque.
(11) Install engine oil pan using new gaskets and seals. Tighten drain plug securely.
(12) Install timing chain cover and gaskets, refer to Timing Chain Cover as detailed earlier in this section.
(13) Install vibration damper and drive pulley.
(14) Install cylinder head and new gaskets.
(15) Install valve tappets.
(16) Install intake manifold and new gaskets.
(17) Install push rods.
(18) Install rocker arms and bridged pivot assemblies.

NOTE: *Install valve train components in same order as removed.*

(19) Install transmission to engine.
(20) Remove engine from stand.
(21) Install engine assembly as outlined earlier in this section.

CONNECTING ROD AND PISTON ASSEMBLIES

Use these procedures to service connecting rods and pistons with the engine in the car.

Removal

(1) Remove cylinder head covers and gaskets.
(2) Remove rocker arms and bridged pivot assemblies.
(3) Remove push rods.
(4) Remove intake manifold assembly.
(5) Remove cylinder head and gasket.
(6) Position pistons one at a time near bottom of their stroke and use a ridge reamer to remove any ridge from top end of cylinder walls.
(7) Drain engine oil.
(8) Remove the oil pan.
(9) Remove connecting rod bearing caps and inserts. Keep in same order as removed.

NOTE: *Connecting rods and caps are stamped with the number of the cylinder to which they were assembled.*

(10) Remove connecting rod and piston assemblies through the top of cylinder bores. **Be careful that connecting rod bolts do not scratch connecting rod journals or cylinder walls.**

Installation

(1) After thoroughly cleaning cylinder bores, apply a light film of clean engine oil to bores with a clean lint-free cloth.
(2) Prior to installing the connecting rod and piston assemblies into engine, arrange piston ring gaps so that:
(a) No. 1 compression ring gap is 180° from the No. 2 compression ring gap;
(b) Oil control ring spacer expander gap is at least 90° from the No. 2 compression ring gap;
(c) Oil control ring gaps are 90° from the spacer gap with as least 30° between each ring gap (fig. 1B-29).
(3) Lubricate the piston and ring surfaces with clean engine oil.
(4) Use piston ring compressor tool to install connecting rod and piston assemblies through top of cylinder bores. **Be careful that connecting rod bolts do not scratch connecting rod journals or cylinder walls.**

NOTE: *Place lengths of rubber hose over the connecting rod bolts for protection during installation.*

(5) Install the connecting rod bearing caps and inserts in same order as removed. Tighten retaining nuts to 28 foot-pounds torque on 304 and 360 CID equipped vehicles and 38 foot-pounds for 401 CID equipped vehicles.
(6) Install the engine oil pan using new gaskets and seals. Tighten drain plug securely.
(7) Install cylinder heads and new gaskets.
(8) Install push rods.
(9) Install rocker arms and bridged pivot assemblies.
(10) Install intake mainfold.
(11) Install cylinder head covers and gaskets.
(12) Fill crankcase to specified level with new oil.

CONNECTING RODS

The connecting rods for 304 and 360 CID engines are cast-iron, while 401 CID engines have forged steel connecting rods. Both types are independently balanced. The crankshaft end of the connecting rods incorporates a two-piece bearing insert. The removable bearing cap has a number from 1 through 8 stamped on it and the adjacent machined surface of the rod to identify the cylinder in which the rod was assembled. The piston end of the rod is a 2000 pound press-fit to the piston pin.

Have the connecting rod alignment checked by a competent machine shop whenever engine wear patterns or damage indicate probable rod misalignment. Always replace bent connecting rods.

Connecting Rod Bearings

The connecting rod bearings are steel-backed, sintered copper, lead alloy precision type.

Each bearing is select fit to its respective journal to obtain the desired operating clearance. In production the select fit is obtained by using various sized color coded bearing inserts as shown in the bearing fitting chart.

The rod journal size is identified in production by a color coded paint mark on the adjacent cheek or counterweight toward the flanged (rear) end of the crankshaft. Use color codes shown in the bearing fitting chart to identify journal size and select the correct bearing inserts to obtain proper clearance.

When required, different sized upper and lower bearing inserts may be used as a pair; therefore, a standard size insert is sometimes used in combination with a 0.001 inch undersize insert to reduce clearance by 0.005 inch (1/2 thousandth of an inch).

CAUTION: *Never use bearing inserts with greater than 0.01 inch difference in size in pairs.*

Example:

Correct	Incorrect
Upper—Standard	Standard
Lower—0.001-inch undersize	0.002-inch undersize

Service replacement bearing inserts are available in pairs in the following sizes: standard, 0.001-inch undersize, 0.002-inch undersize, 0.010-inch undersize and 0.012-inch undersize. The size is stamped on the back of the inserts.

Removal

Use this procedure to service connecting rod bearing with the engine in car.

(1) Drain engine oil.

(2) Remove oil pan.

(3) Rotate crankshaft as required to position two pistons at a time at bottom of their stroke.

(4) Remove bearing caps and lower inserts.

(5) Remove upper insert by spinning it out of connecting rod.

NOTE: Do not mix bearing caps. *Each connecting rod and matching cap is stamped with the cylinder number on a machined surface which faces the camshaft side of the engine block. The numbers are located on a machined surface opposite the squirt holes (fig. 1B-30).*

(6) Inspect bearing inserts and replace if worn or damaged.

Measuring Connecting Rod Journal With Micrometer

(1) Wipe connecting rod journals clean.

(2) Using a micrometer, measure journal diameter at a number of points. Note difference between maximum and minimum diameters.

(3) Refer to specifications for maximum allowable taper and out-of-round. If any rod journal is beyond specifications, it must be reconditioned and fitted with new undersize bearing inserts.

(4) Compare maximum reading obtained with journal diameters listed in bearing fitting chart.

(5) Select inserts required to obtain specified bearing clearance.

Measuring Bearing Clearance With Plastigage

(1) Wipe bearing inserts and rod journal clean.

(2) Place a strip of Plastigage across full width of lower insert at center of bearing cap.

(3) Install bearing cap to connecting rod and tighten retaining nuts to 28 foot-pounds torque on 304

CONNECTING ROD BEARING FITTING CHART

Crankshaft Connecting Rod Journal Color Code and Diameter	Bearing Color Code	
	Upper Insert Size	Lower Insert Size
Yellow - 2.0955 to 2.0948 inches Orange - 2.0948 to 2.0941 inches Black - 2.0941 to 2.0934 inches Red - 2.0855 to 2.0848 inches	Yellow - Standard Yellow - Standard Black - .001-inch undersize Red - .010-inch undersize	Yellow - Standard Black - .001-inch undersize Black - .001-inch undersize Red - .010-inch undersize
	401 CID ENGINE	
Yellow - 2.2485 to 2.2478 inches Orange - 2.2478 to 2.2471 inches Black - 2.2471 to 2.2464 inches Red - 2.2385 to 2.2378 inches	Yellow - Standard Yellow - Standard Black - .001-inch undersize Red - .010-inch undersize	Yellow - Standard Black - .001-inch undersize Black - .001-inch undersize Red - .010-inch undersize

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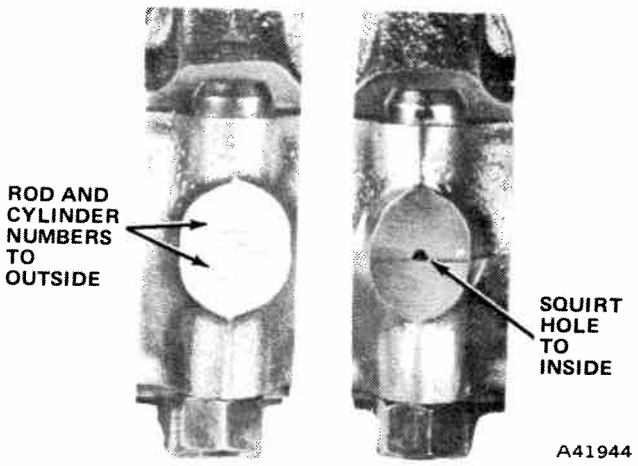

Fig. 1B-30 Rod Number and Squirt Hole Location

and 360 CID equipped vehicles and 38 foot-pounds torque on 401 CID equipped vehicles.

(4) Remove bearing cap and determine amount of clearance by measuring width of the compressed Plastigage with scale furnished as shown in figure 1B-31.

Connecting Rod Side Clearance Measurement

(1) Rotate crankshaft until connecting rod journal is at bottom of stroke.

(2) Insert snug fitting feeler gauge between connecting rods (fig. 1B-32).

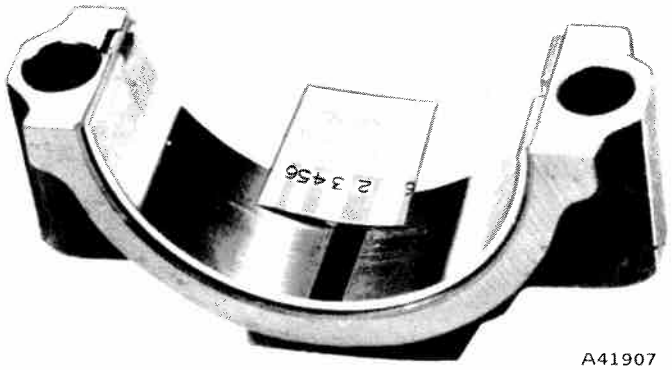

Fig. 1B-31 Connecting Rod Bearing Clearance Measurement With Plastigage

(3) Compare feeler gauge measurement to clearance specified. Replace rods not to specifications.

Installation

(1) Rotate crankshaft to rod journal at bottom of stroke.

(2) Lubricate bearing surface of each insert with clean engine oil.

(3) Install bearing inserts, cap and retaining nuts. Tighten to 28 foot-pounds torque on 304 and 360 CID equipped vehicles and 38 foot-pounds on 401 CID equipped vehicles.

CAUTION: *Exercise care when rotating the crankshaft with bearing caps removed. Be sure the connecting rod bolts do not accidentally come in contact with the rod journals and scratch the finish, which can cause bearing failure.*

(4) Install oil pan using new gaskets and seals. Tighten drain plug securely.

(5) Fill crankcase to specified level with new oil.

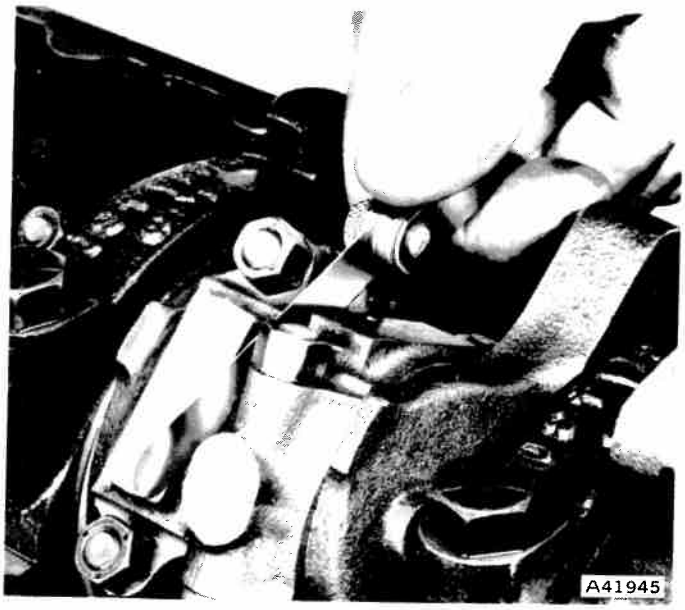

Fig. 1B-32 Connecting Rod Side Clearance Measurement

PISTONS

Aluminum alloy autothermic pistons, steel reinforced for strength and controlled expansion are used.

The pistons are cam-ground and therefore, not perfectly round. The ring belt area contains three piston rings, two compression and one oil control ring above the piston pin.

The piston pin boss is offset from the piston centerline to place it nearer the thrust side of the piston.

To ensure correct installation of the pistons in the bore, two notches are cast in the top perimeter of the piston heads on 304 and 360 CID engines and one notch on the 401 CID engine. The notches must face forward (fig. 1B-33).

Piston Fitting

(1) Using an inside micrometer, measure cylinder bore inside diameter at a point 2-5/16 inch below top of bore.

(2) Using an outside micrometer, measure diameter of piston at right angles to piston pin at centerline of pin as shown in figure 1B-34.

(3) The difference between cylinder bore diameter and piston diameter dimensions is the piston-to-bore clearance.

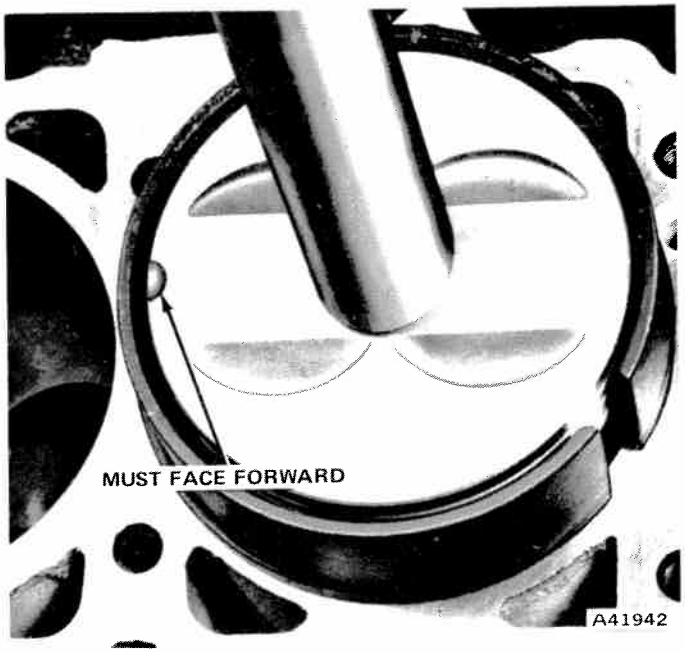

Fig. 1B-33 Installing Piston Assembly Into Bore

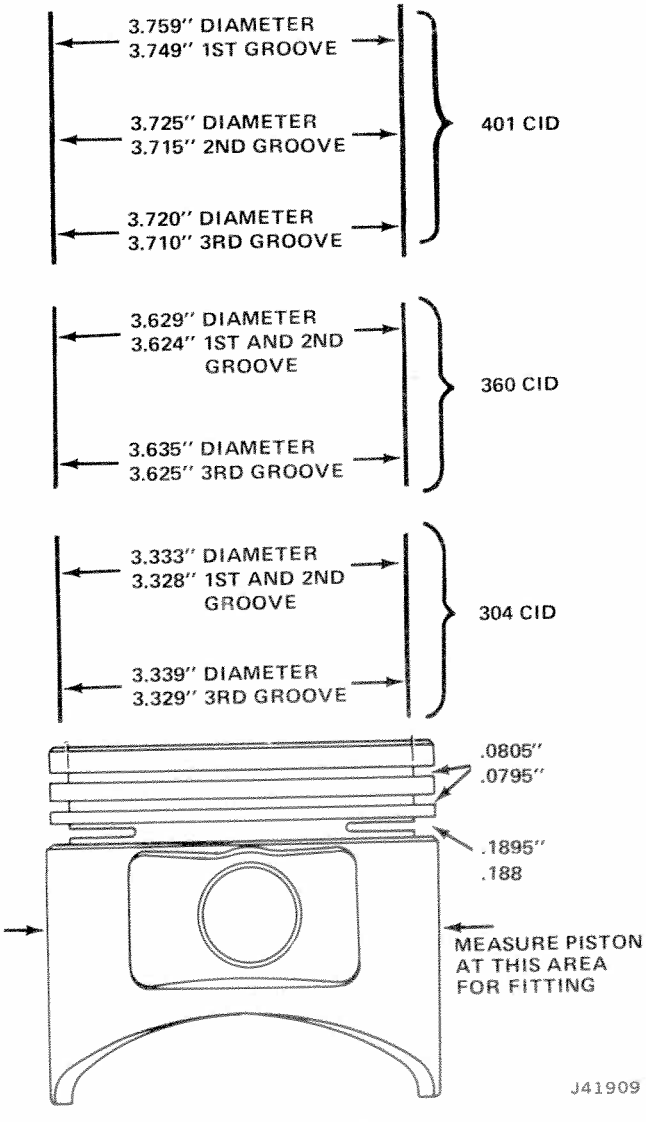

Fig. 1B-34 Piston Measurements

Piston Pins

The piston pins are a 2000 pound press-fit into the rods and require no locking device. The piston pins for 304 and 360 CID engines are the same diameter, while the piston pin for 401 CID engines is larger in diameter. Two different tools are required to service piston pins; J-21872 is used on 304 and 360 pins and J-23194 is used on 401 pins.

Removal

(1) Using Piston Pin Remover (J-21872 or J-23194) and an arbor press, place piston on remover support (J-21872-1 or J-23194 or J-23194-3) as shown in figure 1B-35.

(2) Using piloted driver (J-21872-3 or J-23194-3), press pin completely out of piston. Note position of pin through gauge window of remover support (fig. 1B-35).

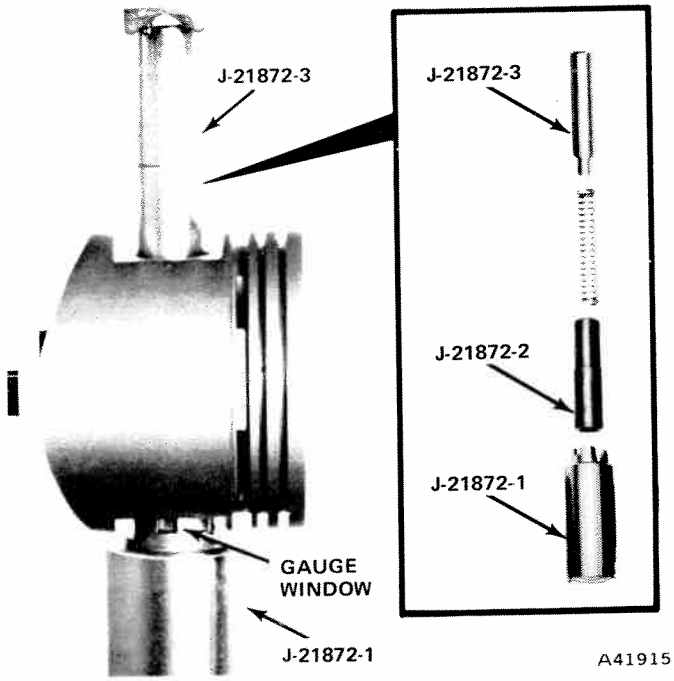

Fig. 1B-35 Piston Pin Removal and Installation

Pin Fitting

(1) Inspect pin and pin bore for nicks and burrs; remove as necessary.

(2) With pin removed from piston, clean and dry piston pin bore and piston pin.

(3) Position piston so that pin bore is in a vertical position. Insert pin in bore. At room temperature, pin should slide completely through pin bore without pushing.

(4) Replace piston and pin if pin jams in bore.

Installation

(1) Place pin pilot (J-21862-2 or J-23194) through piston and connecting rod pin bores (fig. 1B-35).

(2) Place pin pilot, piston, and connecting rod an support (J-21872-1 or J-23194-1).

(3) Place piston pin through upper piston pin bore and into connecting rod pin bore (fig. 1B-35).

(4) Place piloted driver (J-21872-3 or J-23194-3) inside piston pin (fig. 1B-35).

(5) Using arbor press, press piston pin through connecting rod and piston until pin pilot indexes with mark on support (fig. 1B-35).

NOTE: *The piston is a 2000 pound press-fit. If little effort is required to install piston pin in connecting rod, or if rod moves along pin, a new connecting rod is required.*

(6) Remove piston and connecting rod assembly from press. Pin should be centered in rod plus or minus 1/32 inch.

Piston Rings

Both compression rings are made of cast iron while the oil control is a three-piece steel design.

Ring Fitting

(1) Clean carbon from all ring grooves. The oil drain openings in the oil ring grooves and pin boss must be cleared. Be careful not to remove metal from the grooves or from the lands since this will change the ring groove clearances and destroy ring-to-land seating.

(2) Check ring side clearance with a feeler gauge fitted snugly between ring land and ring. Roll ring around groove in which it is to operate. It must fit freely at all points (fig. 1B-36). Side clearance between land and rings should be as listed in the Specifications.

Fig. 1B-36 Ring Side Clearance Measurement

Fig. 1B-37 Ring Gap Measurement

(3) Place ring in bore. With an inverted piston, push ring down near lower end of ring travel area. Measure ring gap or joint clearance with feeler gauge fitted snugly in ring opening (fig. 1B-37).

NOTE: *When using other than standard ring sizes, fit rings individually into their repective bores.*

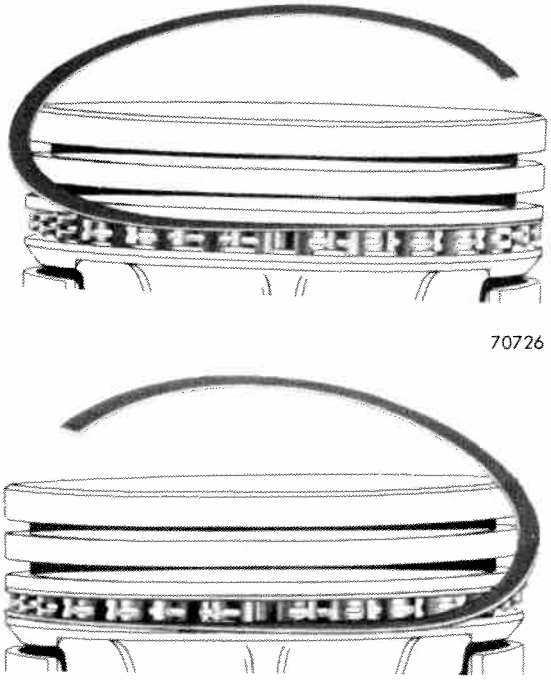

Fig. 1B-38 Installing Upper and Lower Rails.

Installation

(1) Install oil control rings as indicated by instructions in package. It is not necessary to use a tool to install upper and lower rails. They are rolled into place as shown in figure 1B-38.

(2) Install lower compression using ring installer to expand ring around piston.

NOTE: *Make certain upper and lower compression rings are not installed upside down. Figure 1B-39 shows typical ring markings to indicate the top side of the ring.*

(3) Install upper compression ring using ring installer to expand ring around piston (fig. 1B-40).

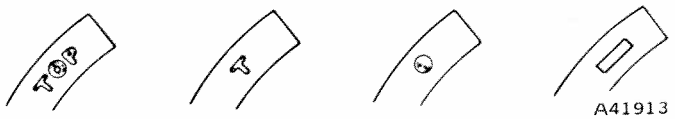

Fig. 1B-39 Typical Piston Ring Markings

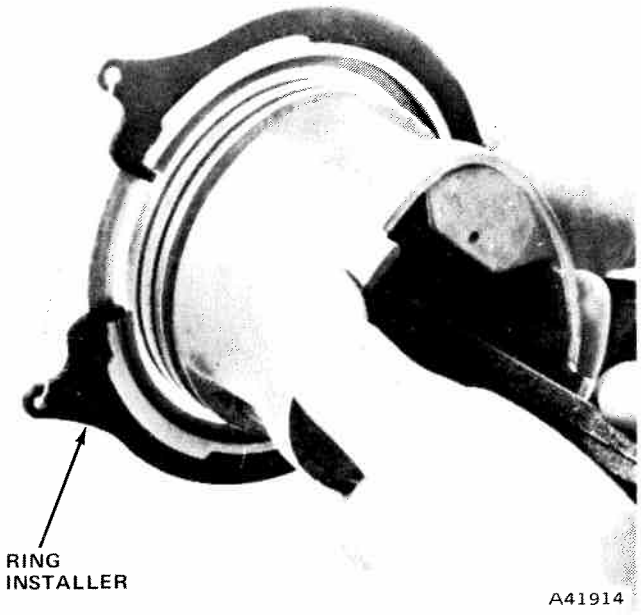

Fig. 1B-40 Compression Ring Installation

CRANKSHAFT

The crankshaft is counterweighted and balanced independently. The component parts of the crankshaft assembly are individually balanced, and then the complete assembly is balanced as a unit; therefore, service replacement dampers, crankshafts, flywheels, torque converters, and clutch components may be replaced without rebalancing the assembly.

There are five main bearings and four connecting rod journals. The end thrust is controlled by No. 3 main bearing.

The rear main bearing oil seal is protected from excessive oil by a slinger which is a machined part of the crankshaft.

NOTE: *On automatic transmission equipped engines, the torque converter and converter flexplate must be marked prior to removal and installed in this position upon assembly.*

Replacement

If the crankshaft is damaged beyond reconditioning, it must be replaced. Use the procedures outlined under Cylinder Block in this section to replace the crankshaft.

Checking End Play

The crankshaft end play is controlled at the No. 3 main bearing which is flanged for this purpose.

(1) Attach a dial indicator to crankcase adjacent to No. 3 main bearing.

(2) Set dial indicator push rod on face of an adjacent counterweight (fig. 1B-41).

(3) Pry crankshaft fore and aft.

(4) Read dial indicator. End play is different on high and low indications.

(5) If end play is incorrect, according to Specifications, replace thrust bearing.

NOTE: *When replacing the thrust bearings, pry the crankshaft fore and aft to align the thrust faces of the bearings.*

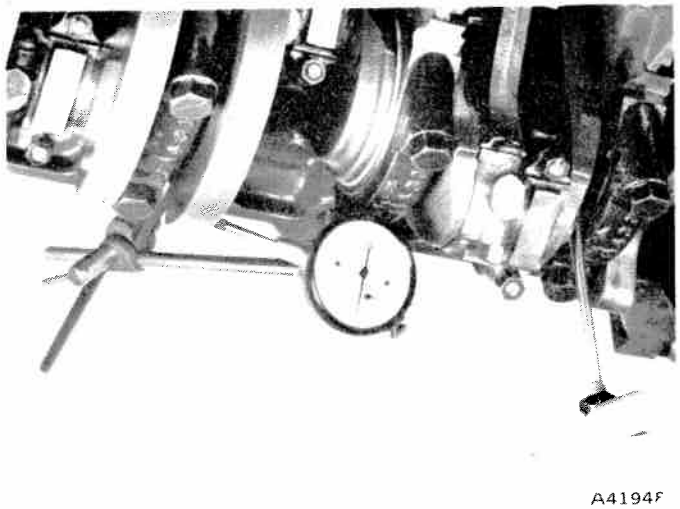

Fig. 1B-41 Crankshaft End Play Measurement

Measuring Main Bearing Journal with a Micrometer (Crankshaft Out of Block)

(1) Wipe main bearing journal clean.

(2) Using a micrometer, measure journal diameter at a number of points. Note difference between maximum and minimum diameters.

(3) Refer to Specifications for maximum allowable taper and out-of-round.

(4) Compare maximum reading obtained with jour-

nal diameters listed in bearing fitting chart.

(5) Select inserts required to obtain specified bearing clearance.

Crankshaft Main Bearings

The main bearings are steel-backed, sintered-copper, lead-alloy precision type. The main bearing caps are numbered (front to rear) from 1 through 5 with an arrow to indicate forward position.

Each bearing is selective fit to its respective journal to obtain the desired operating clearance. In production the select fit is obtained by using various sized color coded bearing inserts as shown in the Main Bearing Fitting Chart.

The main bearing journal size is identified in production by a color coded paint mark on the adjacent cheek toward the flanged (rear) end of the crankshaft except for the rear main journal. The paint mark for the rear main journal is on the crankshaft rear flange.

Use the Bearing Fitting Chart to select proper bearing inserts to obtain the specified bearing clearance.

When required, different sized upper and lower bearing inserts may be used as a pair; therefore, a standard size upper insert may be used in combination with a 0.001 inch undersize lower insert to reduce clearance by 0.0005 inch (1/2 thousandth of an inch).

Example:

Correct	Upper—Standard Lower—0.001 inch undersize
Incorrect	Standard 0.002 inch undersize

NOTE: *Replace inserts of the same size either all on the top or all on the bottom. Never use bearing inserts with greater than 0.001 inch difference in pairs.*

Service replacement bearing inserts are available as pairs in the following sizes: standard, 0.001-inch undersize, 0.002-inch undersize, 0.010-inch undersize and 0.012-inch undersize. The size is stamped on back of inserts.

Removal and Inspection

This procedure may be used to check main bearing with engine in vehicle.

(1) Drain engine oil and remove pan.

(2) Remove main bearing cap and insert.

(3) Inspect bearing insert for abnormal wear or damage.

(4) If either condition exists, both upper and lower inserts must be replaced. (Refer to Measuring Bearing Clearance with Plastigage, as described in this section, to select bearing inserts required to obtain specified bearing clearance.)

(5) Inspect the crankshaft main journal. If damaged, either recondition or replace crankshaft.

(6) Remove upper insert by loosening all of the other bearing caps and inserting a cotter pin about 1/2-inch long in the crankshaft oil hole (head of pins should be large enough so that it will not fall into oil hole, yet thinner than bearing).

(7) With pin in place, rotate shaft so that upper bearing insert will rotate in the direction of its locating tongue.

(8) Remove and inspect the remaining bearings in same manner.

Measuring Main Bearing Clearance with Plastigage (Crankshaft in Block)

(1) Support weight of the crankshaft with a jack placed under counterweight which is adjacent to main bearing being checked.

NOTE: *Check each bearing clearance one at a time. All other bearings must remain tightened.*

(2) Remove main bearing cap and insert.

(3) Wipe insert and exposed portion of the crankshaft journal clean.

MAIN BEARING CHART

Crankshaft Main Bearing Journal Color Code and Diameter	Bearing Color Code	
	Upper Insert Size	Lower Insert Size
Yellow - 2.7489 to 2.7484 inches	Yellow - Standard	Yellow - Standard
Orange - 2.7484 to 2.7479 inches	Yellow - Standard	Black - .001-inch undersize
Black - 2.7479 to 2.7474 inches	Black - .001-inch undersize	Black - .001-inch undersize
Green - 2.7474 to 2.7469 inches	Black - .001-inch undersize	Green - .002-inch undersize
Red - 2.7389 to 2.7384 inches	Red - .010-inch undersize	Red - .010-inch undersize

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(4) Place a strip of Plastigage across full width of bearing insert.

(5) Install bearing cap and tighten retaining bolts to 100 foot-pounds torque.

(6) Remove bearing cap and determine amount of clearance by measuring width of compressed Plastigage with scale furnished as shown in figure 1B-42.

Fig. 1B-42 Main Bearing Clearance Measurement

Installation

(1) Lubricate bearing surface of each insert with clean engine oil.

(2) Loosen all main bearing caps.

(3) Install main bearing upper insert(s).

(4) Install main bearing cap(s) and lower insert(s). Tighten retaining bolts evenly to 100 foot-pounds torque.

(5) After installation, turn crankshaft by hand to check for free operation.

(6) Install oil pan using new gaskets and seals. Tighten drain plug securely.

(7) Fill crankcase to specified level with new oil.

FLYWHEEL AND STARTER RING GEAR ASSEMBLY

Replace the starter ring gear on vehicles with manual transmission only. The starter ring gear is welded to and balanced as part of the converter drive plate on vehicles with automatic transmission.

Removal

(1) Place flywheel on an arbor press with steel blocks equally spaced under the gear.

(2) Press flywheel through ring gear.

NOTE: *The ring gear can also be removed by breaking it with a chisel.*

Installation

(1) Apply heat to expand inside diameter of ring gear.

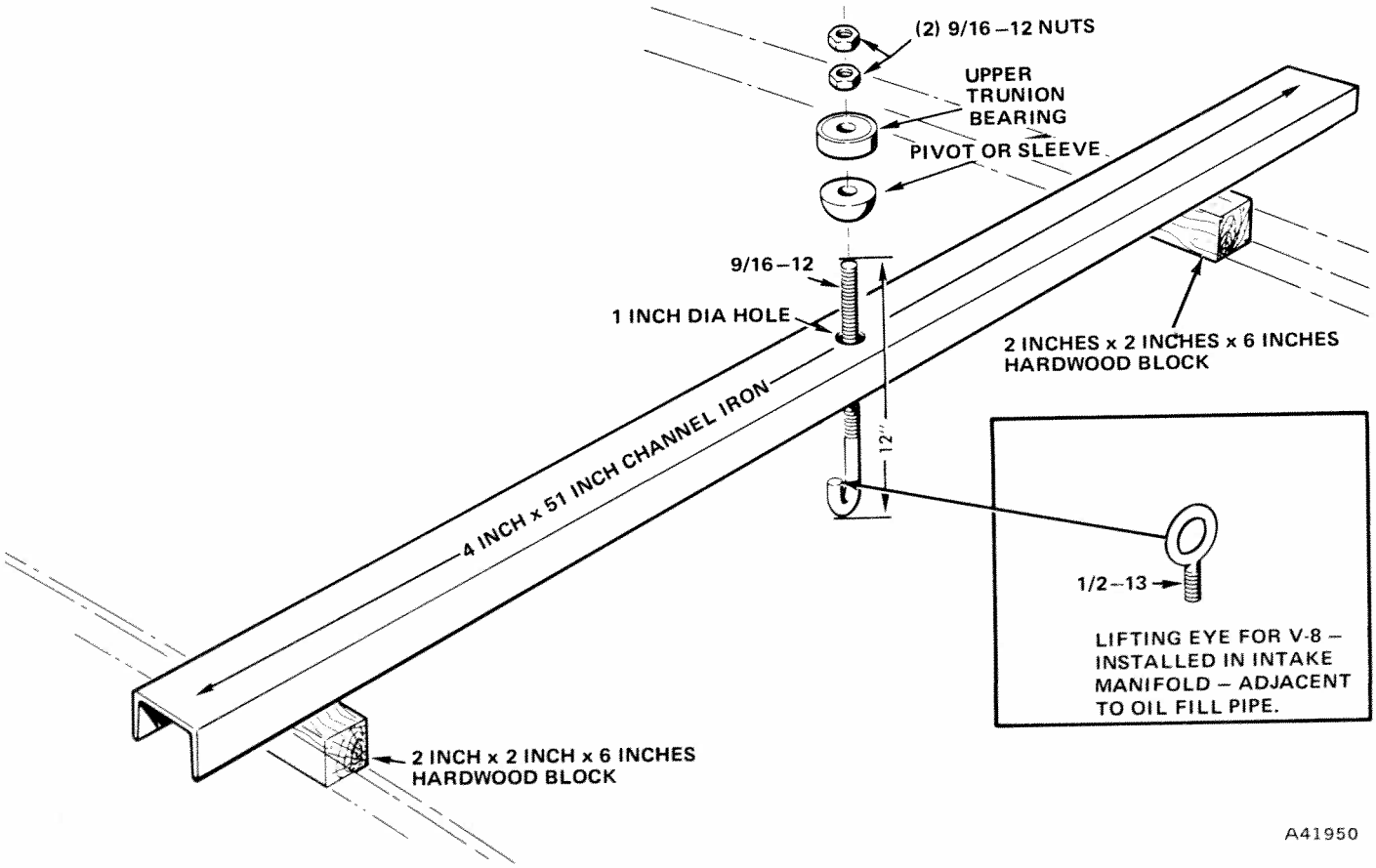

Fig. 1B-43 Engine Holding Fixture

(2) Press ring gear over flywheel.

NOTE: *On manual transmission, the flywheel is balanced as an individual component and also as part of the crankshaft assembly.* **Do not attempt to duplicate original flywheel balance holes when installing a service replacement.**

SHORT ENGINE ASSEMBLY

A service replacement short engine assembly may be installed whenever the original engine block is damaged beyond repair. The short engine assembly consists of engine block, piston and rod assemblies, crankshaft, camshaft, timing gears and chain.

NOTE: *Whenever installing a short engine assembly, always install a new engine oil pump pickup tube and screen assembly.*

Transfer component parts from the original engine and clean and torque tightening as required. Follow the appropriate procedure outlined.

V-8 ENGINE SPECIFICATIONS

Bore	
304	3.75 inches
360	4.08 inches
401	4.17 inches
Stroke	
304	3.44 inches
360	3.44 inches
401	3.68 inches
Displacement	
304	304 cu. inches
360	360 cu. inches
401	401 cu. inches
Compression Ratio	
304	8.40:1
360 (2V or 4V)	8.25:1
401	8.25:1
Compression Pressure	
304	140 psi
360 (2V or 4V)	140 psi
401	140 psi
Maximum Variation Between Cylinders	20 psi
Net Brake Horsepower	
304	150 at 4200 rpm
360 (2V)	175 at 4000 rpm
360 (4V)	195 at 4400 rpm
401	215 at 4200 rpm
Net Torque	
304	245 at 2500 rpm
360 (2V)	285 at 2400 rpm
360 (4V) Single Exhaust	295 at 2900 rpm
401	320 at 2800 rpm
Taxable Horsepower	
304	45.00
360	53.27
401	55.51
Fuel	Regular, low lead, or no lead

CAMSHAFT

Fuel Pump Eccentric Diameter	2.182 inch to 2.192 inch
Tappet Clearance	Zero lash (hydraulic tappets)
End Play	Zero (engine operating)
Bearing Clearance	0.001 inch to 0.003 inch

V-8 ENGINE SPECIFICATIONS (Continued)

Bearing Journal Diameter	
No. 1	2.1195 inch to 2.1205 inch
No. 2	2.0895 inch to 2.0905 inch
No. 3	2.0595 inch to 2.0605 inch
No. 4	2.0295 inch to 2.0305 inch
No. 5	1.9995 inch to 2.0005 inch
Base Circle Runout	0.001 inch maximum
Cam Lobe Lift	
304/360	0.266 inch
401	0.286 inch
Intake Valve Timing	
Opens 304/360	14.75° BTDC
401	25.57° BTDC
Closes 304/360	68.75° BTDC
401	90.75° BTDC
Exhaust Valve Timing	
Opens 304/360	56.75° BBDC
401	80.80° BBDC
Closes 304/360	26.75° ATDC
401	42.75° ATDC
Valve Overlap	
304/360	41.50°
401	68.32°
Intake Duration	
304/360	263.50°
401	296.32°
Exhaust Duration	
304/360	263.50°
401	303.55°

CONNECTING RODS

Total Weight (Less Bearings)	
304/360	681 to 689 grams
401	794 to 802 grams
Total Length (Center-to-Center)	
304/360	5.873 inch to 5.877 inch
401	5.856 inch to 5.860 inch
Bearing Clearance	0.001 inch to 0.003 inch (0.0025 inch preferred)
Side Clearance	0.006 inch to 0.018 inch
Maximum Twist	0.0005 inch per inch
Maximum Bend	0.001 inch per inch

CRANKSHAFT

End Play	0.003 inch to 0.008 inch
Main Bearing Journal Diameter	
No. 1, 2, 3, 4	2.7474 inch to 2.7489 inch
Rear Main	2.7464 inch to 2.7479 inch
Main Bearing Journal Width	
304/360	
No. 1	1.2635 inch to 1.2695 inch
No. 2	1.246 inch to 1.248 inch
No. 3	1.273 inch to 1.275 inch
No. 4	1.246 inch to 1.248 inch
No. 5	1.215 inch to 1.217 inch

V-8 ENGINE SPECIFICATIONS (Continued)

401	
No. 1	1.244 inch to 1.269 inch
No. 2	1.222 inch to 1.232 inch
No. 3	1.273 inch to 1.275 inch
No. 4	1.222 inch to 1.232 inch
No. 5	1.202 inch to 1.217 inch
Main Bearing Clearance	0.001 inch to 0.003 inch (0.0025 inch preferred)
Rear Main	0.001 inch to 0.003 inch (0.003 inch preferred)
Connecting Rod Journal Diameter	
304/360	2.0934 inch to 2.0955 inch
401	2.2464 inch to 2.2485 inch
Connecting Rod Journal Width	
304/360	1.998 inch to 2.004 inch
401	1.846 inch to 1.852 inch
Connecting Rod Bearing Clearance	0.001 inch to 0.003 inch (0.0025 inch preferred)

CYLINDER BLOCK

Deck Height	9.205 inch to 9.211 inch
Deck Clearance	
304/360	0.0145 inch (below block)
401	0.0045 inch (below block)
Maximum Cylinder Taper	0.005 inch
Maximum Cylinder Out-of-Round	0.003 inch
Tappet Bore Diameter	0.9055 inch to 0.9065 inch
Cylinder Block Flatness	0.001/1 inch; 0.002/6 inch: 0.008 inch maximum

CYLINDER HEAD

Combustion Chamber Volume	
304	57.42 to 60.42 cc
360/401	58.62 to 61.62 cc
Valve Arrangement	EI-IE-EI-IE
Valve Guide ID (Integral)	0.3735 inch to 0.3745 inch
Valve Stem-to-Guide Clearance	0.001 inch to 0.003 inch
Intake Valve Seat Angle	30°
Exhaust Valve Seat Angle	44.5°
Valve Seat Width	0.040 inch to 0.060 inch
Valve Seat Runout	0.0025 inch maximum
Cylinder Head Flatness	0.001/1 inch: 0.002/6 inch: 0.008 inch maximum

LUBRICATION SYSTEM

Engine Oil Capacity	4 quarts (add 1 quart with filter change)
Normal Operating Pressure	13 psi at 600 rpm; 37 psi at 1600 rpm; 75 psi maximum
Oil Pressure Relief	75 psi maximum
Gear-to-Body Clearance	0.0005 inch to 0.0025 inch (0.0005 inch preferred)
Gear End Clearance	0.002 inch to 0.006 inch (0.006 inch preferred)

V-8 ENGINE SPECIFICATIONS (Continued)

PISTONS

Weight (Less Pin)
- 304 . . . . . 506 to 510 grams
- 360 . . . . . 601 to 105 grams
- 401 . . . . . 590 to 594 grams

Piston Pin Bore CL - to Piston Top
- 304/360 . . . . . 1.599 inch to 1.603 inch
- 401 . . . . . 1.506 inch to 1.510 inch

Piston-to-Bore Clearance
- 304/401 . . . . . 0.0010 inch to 0.0018 inch
- 360 . . . . . 0.0012 inch to 0.0020 inch
- All V-8 . . . . . 0.0014 inch preferred

Piston Ring Gap Clearance
- No. 1 and No. 2 . . . . . 0.010 inch to 0.020 inch

Oil Control Steel Rail
- 304 . . . . . 0.010 inch to 0.025 inch
- 360 . . . . . 0.015 inch to 0.045 inch
- 401 . . . . . 0.015 inch to 0.055 inch

Piston Ring Side Clearance
- 304
- 304
  - No. 1 . . . . . 0.0015 inch to 0.0035 inch (0.0015 inch preferred)
  - No. 2 . . . . . 0.0015 inch to 0.003 inch (0.0015 inch preferred)
  - Oil Control . . . . . 0.0011 inch to 0.008 inch
- 360/401
  - No. 1 . . . . . 0.0015 inch to 0.003 inch (0.0015 inch preferred)
  - No. 2 . . . . . 0.0015 inch to 0.0035 inch (0.0015 inch preferred)
  - Oil Control . . . . . 0.000 inch to 0.007 inch

Piston Ring Groove Height
- No. 1 and No. 2 . . . . . 0.0795 inch to 0.0805 inch
- Oil Control . . . . . 0.1880 inch to 0.1895 inch

Piston Ring Groove Diameter
- 304
  - No. 1 and No. 2 . . . . . 3.328 inch to 3.333 inch
  - Oil Control . . . . . 3.329 inch to 3.339 inch
- 360
  - No. 1 and No. 2 . . . . . 3.624 inch to 3.629 inch
  - Oil Control . . . . . 3.624 inch to 3.635 inch
- 401
  - No. 1 . . . . . 3.749 inch to 3.759 inch
  - No. 2 . . . . . 3.715 inch to 3.725 inch
  - Oil Control . . . . . 3.710 inch to 3.720 inch

Piston Pin Diameter
- 304/360 . . . . . 0.9308 inch to 0.9313 inch
- 401 . . . . . 1.0009 inch to 1.0012 inch

Piston Pin Bore Diameter
- 304/360 . . . . . 0.9288 inch to 0.9298 inch
- 401 . . . . . 0.9988 inch to 0.9998 inch

Piston-to-Pin Clearance . . . . . 0.0003 inch to 0.0005 inch

ROCKER ARMS, PUSH RODS, AND TAPPETS

Rocker Arm Ratio 1.6:1

V-8 ENGINE SPECIFICATIONS (Continued)

Push Rod Length. . . . . 7.790 inch to 7.810 inch
Push Rod Diameter. . . . . 0.312 inch to 0.315 inch
Hydraulic Tappet Diameter. . . . . 0.9040 inch to 0.9045 inch
Tappet-to-Bore Clearance. . . . . 0.001 inch to 0.0025 inch

VALVES

Valve Length
(Tip-to-Gauge Dim. Line). . . . . 4.7895 inch to 4.8045 inch
360/401 Exhaust Valve
With Rotator. . . . . inch to 4.8245 inch
Valve Stem Diameter. . . . . inch to 0.3725 inch
Stem-to-Guide Clearance. . . . . inch to 0.003 inch
Intake Valve Head Diameter
304. . . . . 1.782 inch to 1.792 inch
360/401. . . . . 2.020 inch to 2.030 inch
Intake Valve Face Angle. . . . . 29°
Exhaust Valve Head Diameter
304. . . . . 1.401 inch to 1.411 inch
360/401. . . . . 1.675 inch to 1.685 inch
Exhaust Valve Face Angle. . . . . 44°

VALVE SPRINGS

Free Length. . . . . 2.200 inch
(with Rotators). . . . . 2.000 inch
Spring Tension
Valve Closed. . . . . 80 to 88 pounds at 1-13/16 inch
(with Rotators). . . . . 80 to 88 pounds at 1-5/8 inch
Valve Open. . . . . 210 to 216 pounds at 1-23/64 inch
(with Rotators). . . . . 210 to 216 pounds at 1-3/16 inch
Inside Diameter (All). . . . . 1.000 inch to 1.020 inch

TORQUE SPECIFICATIONS

Service Set-To Torques should be used when assembling components. Service In-Use Recheck Torques should be used for checking a pre-torqued item. All torque values given in foot-pounds with dry fits unless otherwise specified.

	Service Set-To Torque	Service In Use Recheck Torque
Air Injection Tube-to-Manifold	38	30 to 45
Air Pump-to-Bracket	20	15 to 22
Air Pump Brackets-to-Engine-AC Compressor or Pedestals	25	18 to 28
Air Pump Adjusting Strap-to-Pump	20	15 to 22
Alternator Pivot Bolt or Nut	28	20 to 35
Alternator Adjusting Bolt	18	15 to 20
Alternator Mounting Bracket Bolt-to-Engine	28	23 to 30
Alternator Pivot Mounting Bolt-to-Head	33	30 to 35
Camshaft Gear Retainer Screw	30	25 to 35
Carburetor Adapter-to-Manifold Screws-2V	14	12 to 15
Carburetor Holddown Nuts	14	12 to 15
Clutch Housing Spacer-to-Block Screws	12	9 to 15
Clutch Housing-to-Block Screws	27	22 to 30
Connecting Rod Bolt Nuts	28 (304 & 360) 38 (401)	26 to 30 (304 & 360) 35 to 40 (401)

TORQUE SPECIFICATIONS (Continued)

	Service Set-To Torque	Service In-Use Recheck Torque
Crankshaft Pulley-to-Damper	23	18 to 28
Cylinder Head Capscrews	110	100 to 120
Cylinder Head Cover Screws	50 in-lb	42 to 58 in-lb
Distributor Bracket Screw	13	10 to 18
Drive Plate-to-Converter Screw	22	20 to 25
EGR Valve-to-Manifold	13	9 to 18
Exhaust Manifold Bolts	25	20 to 30
Exhaust Pipe-to-Manifold Nuts	23	18 to 28
Fan and Hub Assembly Bolts	18	12 to 18
Flywheel or Drive Plate-to-Crankshaft	105	95 to 120
Front Support Cushion Bracket-to-Block	28	22 to 38
Front Support Cushion-to-Bracket	33	27 to 38
Front Support Cushion to Frame	33	27 to 37
Fuel Pump Screws	16	13 to 19
Idler Pulley Bearing Shaft-to-Bracket Nut	33	28 to 38
Idler Pulley Bracket-to-Front Cover Nut	7	4 to 9
Intake Manifold Screws	43	37 to 47
Main Bearing Capscrews	100	90 to 105
Oil Pump Cover Screws	55 in-lb	45 to 65 in-lb
Oil Pan Screws		
1/4 inch - 20	7	5 to 9
5/16 inch - 18	11	9 to 13
Oil Release Valve Cap	28	22 to 35
Power Steering Pump Adapter Screw	23	18 to 28
Power Steering Pump Bracket Screw	43	37 to 47
Power Steering Pump Mounting Screw	28	25 to 35
Rear Insulator Bracket-to-Trans. Stud Nut	33	27 to 38
Rear Support Insulator-to-Bracket Nut	48	40 to 55
Rear Support Cushion-to-Crossmember Screw Nut	18	12 to 25
Rocker Arm Capscrew	19	16 to 26
Spark Plugs	28	22 to 33
Thermostat Housing Screw	13	10 to 18
Timing Chain Cover-to-Block	25	18 to 33
Automatic Transmission to Block	28	22 to 38
Vibration Damper Screw	55	48 to 64
Water Pump Screws	48 in-lb	40 to 55 in-lb

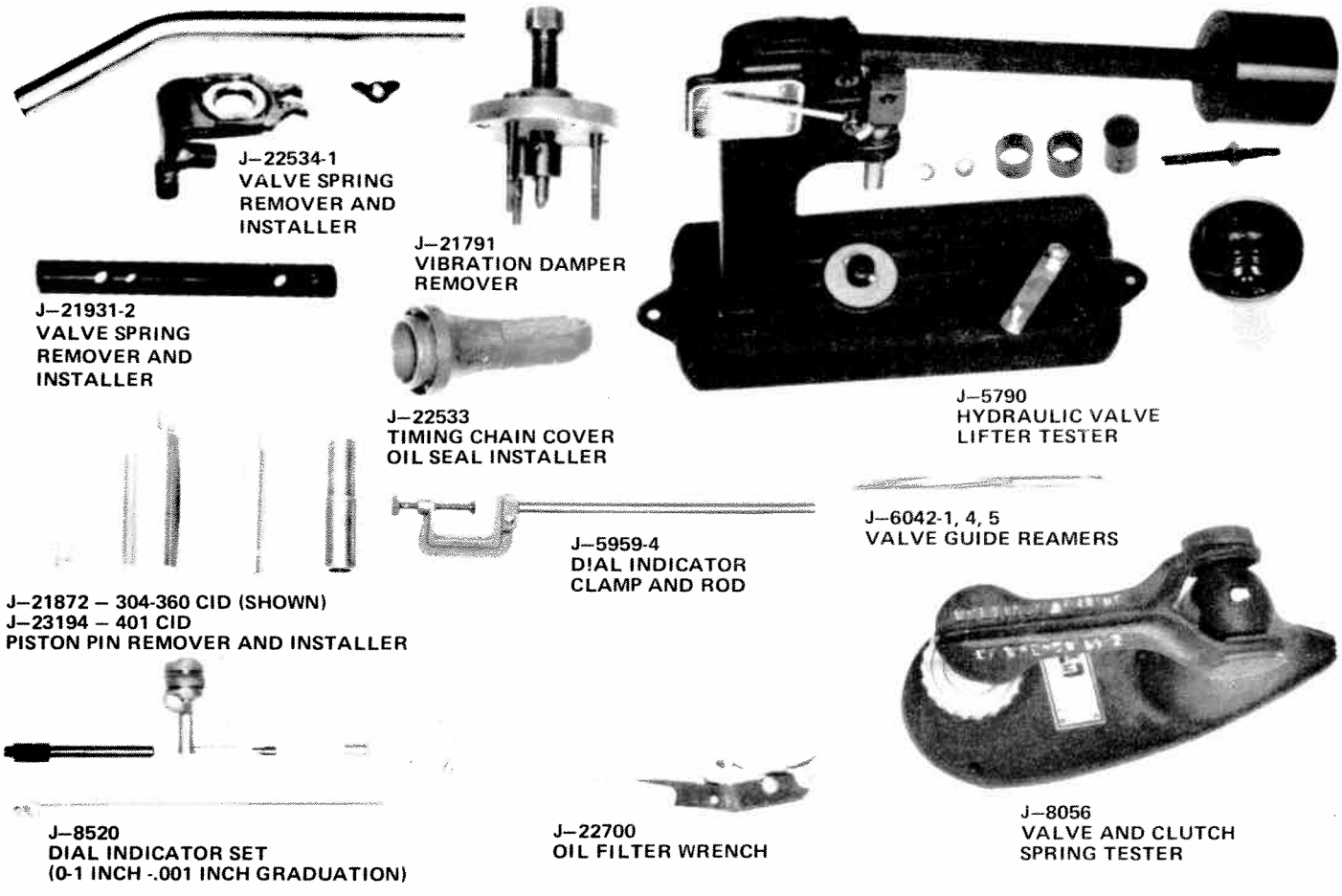

Fig. 1B-44 Special Tools

TECHNICAL SERVICE LETTER REFERENCE

Date	Letter No.	Subject	Changes Information on Page No.