

## 5.9L 24-VALVE TURBO DIESEL ENGINE

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## DESCRIPTION AND OPERATION (Continued)

## ENGINE IDENTIFICATION

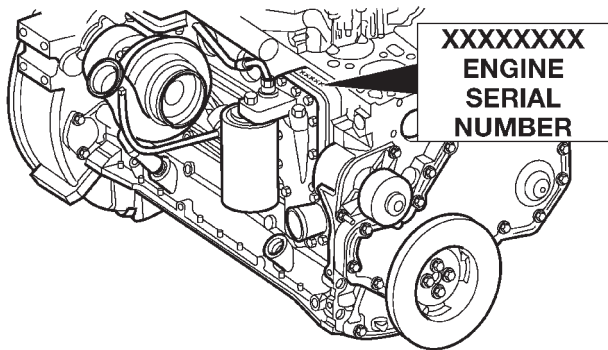
## ENGINE DATA PLATE

The engine data plate contains specific information that is helpful to servicing and obtaining parts for the engine. The data plate is located on the left side of the engine, affixed to the gear housing. Information that can be found on the data plate includes:

- Date of Engine Manufacture
- Engine Serial Number
- Control Parts List (CPL)
- Engine Rated Horsepower
- Engine Firing Order
- Engine Displacement
- Valve Lash Reset Specifications

## ENGINE SERIAL NUMBER

If the engine data plate is missing or not legible, the engine serial number is used for engine identification. The engine serial number is stamped on the right side of the block, on top of the oil cooler cavity (Fig. 1).



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**Fig. 1 Engine Serial Number Location**

## LUBRICATION SYSTEM

## OIL CIRCUIT DESCRIPTION

**NOTE:** Refer to (Fig. 2) and (Fig. 3) for circuit illustrations.

A gerotor style oil pump draws oil from the crankcase through the suction tube and delivers it through the block where it enters the oil cooler cover and pressure regulator valve. When oil pressure exceeds 449 kPa (65 PSI), the valve opens exposing the dump port, which routes excess oil back to the inlet side of the oil pump.

At the same time, oil is directed to a cast in passage in the oil cooler cover, leading to the oil cooler element. As the oil travels through the element

plates, it is cooled by engine coolant traveling past the outside of the plates. It is then routed to the oil filter head and through a full flow oil filter. If a plugged filter is encountered, the filter by-pass valve opens, allowing unfiltered oil to lubricate the engine. This condition can be avoided by frequent oil and filter changes, per the maintenance schedules found in the owners manual. The by-pass valve is calibrated to open when it sees a pressure drop of more than 172 kPa (25 PSI) across the filter head.

The oil filter head then divides the oil between the engine and the turbocharger. The turbocharger receives filtered, cooled and pressurized oil through a supply line from the filter head. The oil lubricates the turbocharger and returns to the pan by way of a drain line connecting the bottom of the turbocharger to a pressed in tube in the cylinder block.

Oil is then carried across the block to an angle drilling which intersects the main oil rifle. The main oil rifle runs the length of the block and delivers oil to the crankshaft main journals and valve train. Oil travels to the crankshaft through a series of transfer drillings (one for each main bearing) and lubricates a groove in the main bearing upper shell. From there another drilling feeds the camshaft main journals. The piston cooling nozzles are also supplied by the main bearing upper shell. Crankshaft internal cross-drillings supply oil to the connecting rod journals.

Another series of transfer drillings intersecting the main oil rifle supply the valve train components. Oil travels up the drilling, through a hole in the head gasket, and through a drilling in the cylinder head (one per cylinder), where it enters the rocker arm pedestal and is divided between the intake and exhaust rocker arm. Oil travels up and around the rocker arm mounting bolt, and lubricates the rocker shaft by cross drillings that intersect the mounting bolt hole. Grooves at both ends of the rocker shaft supply oil through the rocker arm where the oil travels to the push rod and socket balls.

## 5.9L DIESEL ENGINE COMPONENTS

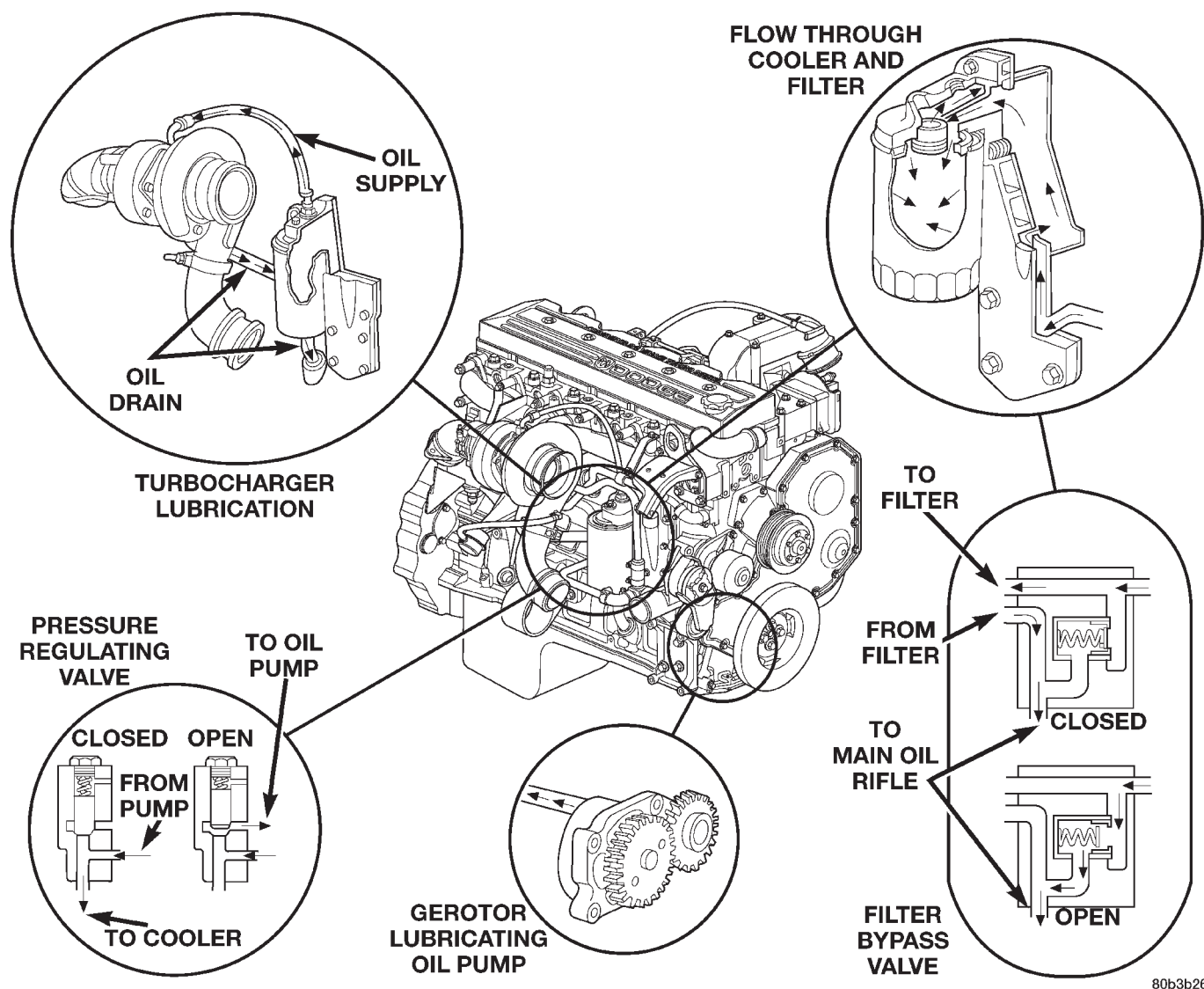
## CYLINDER BLOCK

The cylinder block is constructed of cast iron. The casting is a skirted design which incorporates longitudinal ribs for superior strength and noise reduction. The block incorporates metric straight thread o-ring fittings at lubrication oil access points.

## CRANKSHAFT

The crankshaft is a forged steel, integrally balanced unit. It is supported by seven main bearings, with position number six designated as the thrust journal. The crankshaft is held in place by main caps and 12 mm capscrews. The crankshaft also has a two-piece tone wheel, which supplies crankshaft

## DESCRIPTION AND OPERATION (Continued)



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**Fig. 2 Lubrication System Circulation**

speed and position, mounted between the number five and six journals. Internal cross drillings supply the connecting rods with engine oil.

**PISTONS AND CONNECTING RODS**

The piston is constructed of aluminum and is gravity cast, free floating design. The piston incorporates a centrally located high swirl combustion bowl, and utilizes a "keystone" style top compression ring (Fig. 4), and a rectangular intermediate ring (Fig. 4), for superior cylinder wall scraping. Piston cooling nozzles cool the piston and pin with engine oil supplied by the crankshaft main journals.

The connecting rods are a split angle design constructed of forged steel construction. The rods have a pressed in place wrist pin bushing which is lubricated by the piston cooling nozzle oil spray.

**CYLINDER HEAD**

The cylinder head is constructed of cast iron and is a one piece cross flow design with four valves per cylinder. The arrangement of two intake and two exhaust valves per cylinder allows for a centrally located injector. The cylinder head also includes an integral intake manifold, an integral thermostat housing, and a longitudinal fuel return rifle, which exits at the rear of the head. The 24 valve design also includes integrally cast valve guides and hardened intake and exhaust valve seats.

**VALVES AND VALVE SPRINGS**

The valves are made of heat resistant steel, and have chrome plated stems to prevent scuffing. The intake and exhaust valves are both similar in head diameter and overall length, but they have unique face angles which makes them non-interchangeable.



## DESCRIPTION AND OPERATION (Continued)

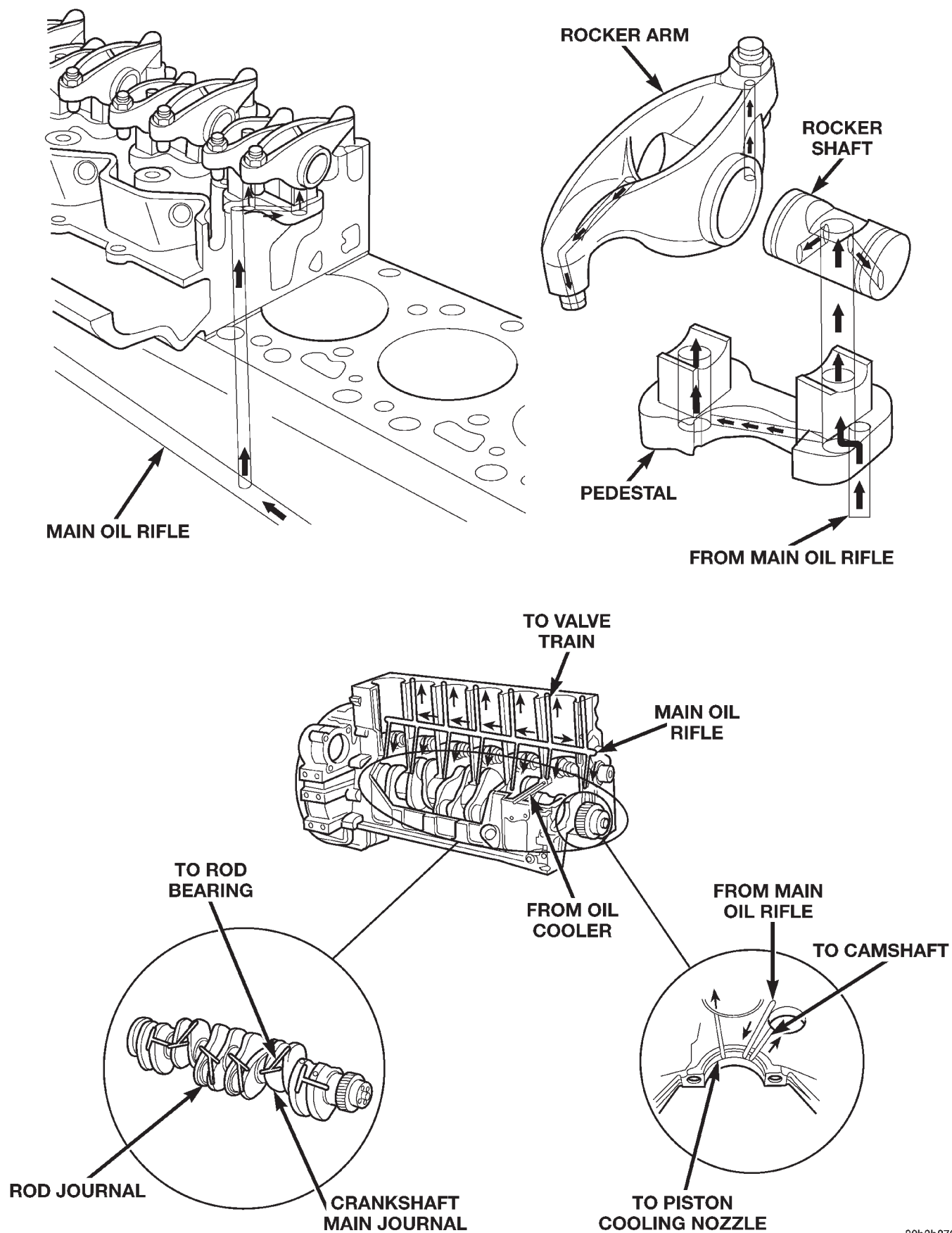
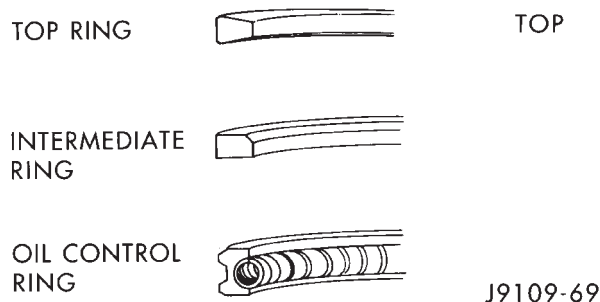


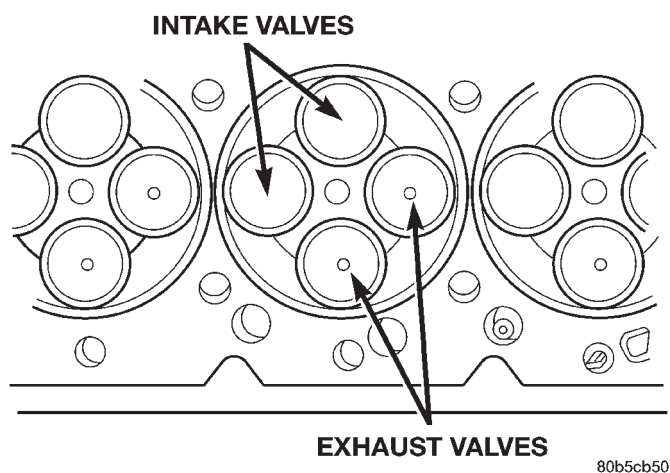
Fig. 3 Lubrication System Circulation—Cont'd

## DESCRIPTION AND OPERATION (Continued)

**Fig. 4 Piston Ring Identification**

The valves are distinguished by unique dimples on the exhaust valve head (Fig. 5).

The exhaust valve springs are made from high strength, chrome silicon steel. The exhaust valve springs are also exhaust brake compatible.

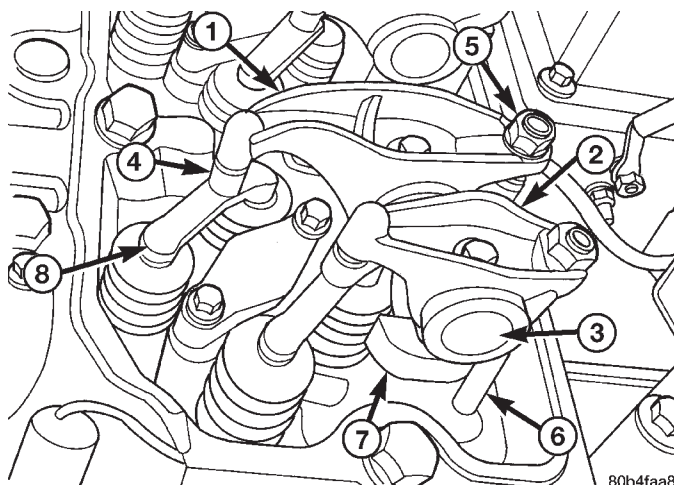
**Fig. 5 Valve Identification****CAMSHAFT AND TAPPETS**

The camshaft is constructed of ductile iron and is shot-peened in the #1 journal and valve lobe area for superior strength and durability. The camshaft is supported by a bushing at the #1 journal location, and is lubricated by a film of oil supplied by the crankshaft main journals. The camshaft is driven by a pressed on gear and its lateral movement is controlled by a thrust plate. The engine also uses solid "mushroom" style tappets to open and close the valves.

**PUSH RODS, ROCKER ARMS, AND CROSSHEADS**

The 24-valve overhead system incorporates rocker arms that are designed to allow fuel injector service without removing the rocker arms and pedestals. The unique intake and exhaust rocker arms have their own rocker shafts and are lubricated by passages intersecting the cylinder block main oil rifle. Cross-heads are used (Fig. 6), which allow each rocker arm to operate two valves.

The solid push rods are hardened at the rocker arm and tappet contact areas for superior strength and durability.

**Fig. 6 Overhead System Components**

1) Exhaust Rocker Arm	5) Adjusting Screw Lock Nut
2) Intake Rocker Arm	6) Push Rod
3) Rocker Shaft	7) Pedestal
4) Socket	8) Crosshead

**ENGINE LUBRICATION**

The lubrication system is a pressure fed, full flow filtration system. The oil pump is a gerotor style and is driven by the crankshaft gear. The lubrication system also incorporates a pressure regulator and an oil filter by-pass valve.

**VACUUM PUMP**

The vacuum pump and the power steering pump are combined into a single assembly on diesel engine models (Fig. 7). Both pumps are operated by a drive gear attached to the vacuum pump shaft. The shaft gear is driven by the camshaft gear.

The vacuum pump is a constant displacement, vane-type pump. Vacuum is generated by four vanes mounted in the pump rotor. The rotor is located in the pump housing and is pressed onto the pump shaft.

The vacuum and steering pumps are operated by a single drive gear pressed onto the vacuum pump shaft. The drive gear is operated by the engine camshaft gear.

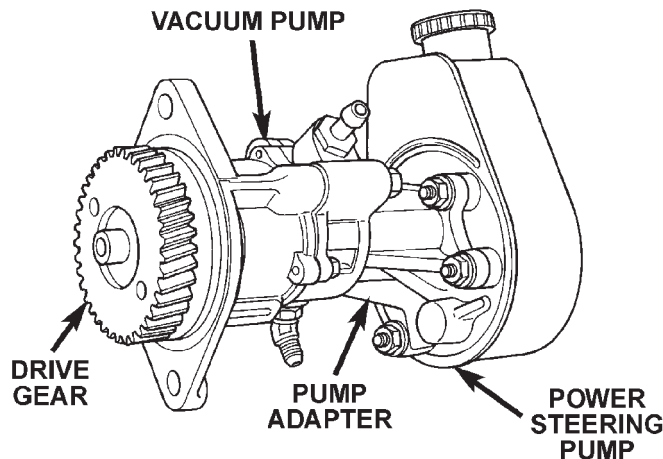
The vacuum and power steering pump shafts are connected by a coupling. Each pump shaft has an adapter with drive lugs that engage in the coupling.

The vacuum pump rotating components are lubricated by engine oil. Lubricating oil is supplied to the

## DESCRIPTION AND OPERATION (Continued)

pump through an oil line at the underside of the pump housing.

The complete assembly must be removed in order to service either pump. However, the power steering pump can be removed and serviced separately when necessary.



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**Fig. 7 Diesel Vacuum & Power Steering Pump Assembly**

The vacuum pump is not a serviceable component. If diagnosis indicates a pump malfunction, the pump must be replaced as an assembly. Do not disassemble or attempt to repair the pump.

The combined vacuum and steering pump assembly must be removed for access to either pump. However, the vacuum pump can be removed without having to disassemble the power steering pump.

If the power steering pump requires service, simply remove the assembly and separate the two pumps. Refer to the pump removal and installation procedures in this section.

## VACUUM PUMP OPERATION

Vacuum pump output is transmitted to the HEVAC, speed control, and EGR systems through a supply hose. The hose is connected to an outlet port on the pump housing and uses an in-line check valve to retain system vacuum when vehicle is not running.

Pump output ranges from a minimum of 8.5 to 25 inches vacuum.

The pump rotor and vanes are rotated by the pump drive gear. The drive gear is operated by the camshaft gear.

## DIAGNOSIS AND TESTING

## ENGINE OIL PRESSURE

(1) Remove the engine oil pressure sensor and install Oil Pressure Line and Gauge Tool C-3292 with a suitable adapter.

(2) Start engine and warm to operating temperature.

(3) Record engine oil pressure and compare with engine oil pressure chart.

**CAUTION:** If engine oil pressure is zero at idle, **DO NOT RUN THE ENGINE.**

## Engine Oil Pressure (MIN)

At Idle	68.9 kPa (10 psi)
At 2000 rpm	206.9 kPa (30 psi)

If minimum engine oil pressure is below these ranges, refer to the Engine Mechanical Diagnosis Charts in this section.

(4) Remove oil pressure gauge and install the oil pressure sensor. Tighten the sensor to 16 N·m (144 in. lbs.) torque.

## ENGINE DIAGNOSIS—MECHANICAL

## MECHANICAL DIAGNOSIS CHART—DIESEL ENGINES

CONDITION	POSSIBLE CAUSES	CORRECTION
LUBRICATING OIL PRESSURE LOW	<ol style="list-style-type: none"> <li>1. Low oil level.</li> <li>2. Oil viscosity thin, diluted or wrong specification.</li> <li>3. Improperly operating pressure switch/gauge.</li> <li>4. Relief valve stuck open.</li> <li>5. Plugged oil filter.</li> <li>6. If cooler was replaced, shipping plugs left in cooler.</li> <li>7. Worn oil pump.</li> <li>8. Suction tube loose or seal leaking.</li> <li>9. Loose main bearing cap.</li> <li>10. Worn bearings or wrong bearings installed.</li> <li>11. Oil jet under piston bad fit into main carrier.</li> </ol>	<ol style="list-style-type: none"> <li>1. A. Check and fill with clean engine oil. B. Check for a severe external oil leak that could reduce the pressure.</li> <li>2. Verify the correct oil is being used. Check for oil dilution. Refer to Contaminated Lube Oil (Engine Diagnosis Mechanical).</li> <li>3. Verify the pressure switch is functioning correctly. If not, replace switch/gauge.</li> <li>4. Check/replace valve.</li> <li>5. Change oil filter. Oil filter change interval may need to be revised.</li> <li>6. Check/remove shipping plugs.</li> <li>7. Check and replace oil pump.</li> <li>8. Check and replace seal.</li> <li>9. Check and install new bearing and tighten cap to proper torque.</li> <li>10. Inspect and replace connecting rod or main bearings. Check and replace piston cooling nozzles.</li> <li>11. Check oil jet position.</li> </ol>
LUBRICATING OIL PRESSURE TOO HIGH	<ol style="list-style-type: none"> <li>1. Pressure switch/gauge not operating properly.</li> <li>2. Engine running too cold.</li> <li>3. Oil viscosity too thick.</li> <li>4. Oil pressure relief valve stuck closed or binding.</li> </ol>	<ol style="list-style-type: none"> <li>1. Verify the pressure switch is functioning correctly. If not, replace switch/gauge.</li> <li>2. Refer to Coolant Temperature Below Normal (Engine Diagnosis Performance).</li> <li>3. Make sure the correct oil being used, (Refer to Group 0, Lubrication and Maintenance).</li> <li>4. Check and replace valve.</li> </ol>
LUBRICATING OIL LOSS	<ol style="list-style-type: none"> <li>1. External leaks.</li> <li>2. Crankcase being overfilled.</li> <li>3. Incorrect oil specification or viscosity.</li> <li>4. Oil cooler leak.</li> <li>5. High blow-by forcing oil out the breather.</li> <li>6. Turbocharger leaking oil to the air intake.</li> <li>7. Piston rings not sealing (oil being consumed by the engine).</li> </ol>	<ol style="list-style-type: none"> <li>1. Visually inspect for oil leaks. Repair as required.</li> <li>2. Verify that the correct dipstick is being used.</li> <li>3. A. Make sure the correct oil is being used. B. Look for reduced viscosity from dilution with fuel. C. Review/reduce the oil change intervals.</li> <li>4. Check and replace the oil cooler.</li> <li>5. Check the breather tube area for signs of oil loss. Perform the required repairs.</li> <li>6. Inspect the air ducts for evidence of oil transfer. Repair as required.</li> <li>7. Perform blow-by check. Repair as required.</li> </ol>



## DIAGNOSIS AND TESTING (Continued)

## MECHANICAL DIAGNOSIS CHART—DIESEL ENGINES—CONT.

CONDITION	POSSIBLE CAUSES	CORRECTION
COMPRESSION KNOCKS	<ol style="list-style-type: none"> <li>1. Air in the fuel system.</li> <li>2. Poor quality fuel or water/gasoline contaminated fuel.</li> <li>3. Engine overloaded.</li> <li>4. Incorrect injection pump timing.</li> <li>5. Improperly operating injectors.</li> </ol>	<ol style="list-style-type: none"> <li>1. Bleed the fuel system (refer to Group 14, Fuel System).</li> <li>2. Verify by operating from a temporary tank with good fuel. Clean and flush the fuel supply tanks. Replace fuel/water separator filter.</li> <li>3. Verify the engine load rating is not being exceeded.</li> <li>4. Check and time injection pump (refer to Group 14, Fuel System).</li> <li>5. Check and replace inoperative injectors.</li> </ol>
EXCESSIVE VIBRATION	<ol style="list-style-type: none"> <li>1. Loose or broken engine mounts.</li> <li>2. Damaged fan or improperly operating accessories.</li> <li>3. Improperly operating vibration damper.</li> <li>4. Improperly operating viscous fan drive.</li> <li>5. Worn or damaged generator bearing.</li> <li>6. Flywheel housing misaligned.</li> <li>7. Loose or broken power component.</li> <li>8. Worn or unbalanced driveline components.</li> </ol>	<ol style="list-style-type: none"> <li>1. Replace engine mounts.</li> <li>2. Check and replace the vibrating components.</li> <li>3. Inspect/replace the vibration damper.</li> <li>4. Inspect/replace the fan drive.</li> <li>5. Check/replace the generator.</li> <li>6. Check/correct flywheel alignment.</li> <li>7. Inspect the crankshaft and rods for damage that causes an unbalance. repair/replace as required.</li> <li>8. Check/repair driveline components.</li> </ol>
EXCESSIVE ENGINE NOISES	<ol style="list-style-type: none"> <li>1. Drive belt squeal, insufficient tension or abnormally high loading.</li> <li>2. Intake air or exhaust leaks.</li> <li>3. Excessive valve lash.</li> <li>4. Turbocharger noise.</li> <li>5. Gear train noise.</li> <li>6. Power function knock.</li> </ol>	<ol style="list-style-type: none"> <li>1. Check the automatic tensioner and inspect the drive belt. Make sure water pump, tensioner pulley, fan hub and generator turn freely.</li> <li>2. Refer to Excessive Exhaust smoke (Engine Diagnosis Performance).</li> <li>3. Adjust valves. Make sure the push rods are not bent and rocker levers or adjusting screws are not severely worn. Replace bent or severely worn pads.</li> <li>4. Check turbocharger impeller and turbine wheel for housing contact. Repair/replace as required.</li> <li>5. Visually inspect and measure gear backlash. Replace gears as required.</li> <li>6. Check/replace rod and main bearings.</li> </ol>
GENERATOR NOT CHARGING OR INSUFFICIENT CHARGING	<ol style="list-style-type: none"> <li>1. Loose or corroded battery.</li> <li>2. Generator belt slipping.</li> <li>3. Generator pulley loose on shaft.</li> <li>4. Improperly operating generator.</li> </ol>	<ol style="list-style-type: none"> <li>1. Clean/tighten battery connection.</li> <li>2. Check/replace automatic belt tensioner. Check/replace drive belt.</li> <li>3. Tighten pulley.</li> <li>4. Check/replace generator.</li> </ol>

## DIAGNOSIS AND TESTING (Continued)

## SMOKE DIAGNOSIS CHARTS

The following charts include possible causes and corrections for **excess or abnormal** exhaust smoke.

Small amounts of exhaust smoke (at certain times) are to be considered normal for a diesel powered engine.

EXCESSIVE BLACK SMOKE	
POSSIBLE CAUSE	CORRECTION
Air filter dirty or plugged.	Check Filter Minder® at air filter. Refer to Air Cleaner Housing/Element Removal/Installation in Group 14, Fuel System. Replace filter if necessary.
Air intake system restricted.	Check entire air intake system including all hoses and tubes for restrictions, collapsed parts or damage. Repair/replace as necessary.
Diagnostic Trouble Codes (DTC's) active or multiple, intermittent DTC's.	Refer to Powertrain Diagnostic Procedures manual.
Engine Control Module (ECM) not calibrated or ECM has incorrect calibration.	Refer to Powertrain Diagnostic Procedures manual.
Exhaust system restriction is above specifications.	Check exhaust pipes for damage/restrictions. Repair as necessary. Refer to Group 11, Exhaust System and Turbocharger.
Fuel grade is not correct or fuel quality is poor.	Temporarily change fuel brands and note condition. Change brand if necessary.
Fuel injection pump malfunctioning.	A DTC should have been set. If so, refer to Powertrain Diagnostic Procedures manual.
Fuel injector malfunctioning.	A DTC should have been set. Perform "Cylinder Balance Test" using DRB scan tool to isolate individual cylinders. Also refer to Powertrain Diagnostic Procedures manual and, to Fuel Injector Testing in Group 14, Fuel System.
Fuel return system restricted.	Check fuel return line by checking overflow valve. Refer to Fuel Transfer Pump Pressure Test in Group 14, Fuel System.
Intake manifold restricted.	Remove restriction. Refer to Group 9, Engines.
Manifold Air Pressure (Boost) Sensor or sensor circuit malfunctioning.	A DTC should have been set. Refer to Powertrain Diagnostic Procedures manual. Also refer to Boost Pressure Test in Group 14, Fuel System.
Raw fuel in intake manifold.	Fuel injectors leaking on engine shutdown. Do Fuel Injector Test. Refer to Group 14, Fuel System.
Static timing not correct.	A DTC should have been set. If so, refer to Powertrain Diagnostic Procedures manual. Also refer to Fuel Injection Pump Timing in Group 14, Fuel System.
Turbocharger air intake restriction.	Refer to Group 11, Exhaust System and Turbocharger.
Turbocharger damaged.	Refer to Group 11, Exhaust System and Turbocharger.
Turbocharger has excess build up on compressor wheel and/or diffuser vanes.	Refer to Group 11, Exhaust System and Turbocharger.
Turbocharger wheel clearance out of specification.	Refer to Group 11, Exhaust System and Turbocharger.

## DIAGNOSIS AND TESTING (Continued)

EXCESSIVE WHITE SMOKE	
POSSIBLE CAUSE	CORRECTION
Air in fuel supply: Possible leak in fuel supply side (between transfer pump and fuel tank module).	Refer to Fuel Transfer Pump Pressure Test in Group 14, Fuel System.
Coolant leaking into combustion chamber.	Do pressure test of cooling system. Refer to Group 7, Cooling System
Diagnostic Trouble Codes (DTC's) active or multiple, intermittent DTC's.	Refer to Powertrain Diagnostic Procedures manual.
In very cold ambient temperatures, engine block heater is malfunctioning (if equipped).	Refer to Group 7, Cooling System.
Engine coolant temperature sensor malfunctioning.	A DTC should have been set. Refer to Powertrain Diagnostic Procedures manual. Also check thermostat operation. Refer to Group 7, Cooling System.
Engine Control Module (ECM) not calibrated or has incorrect calibration.	A DTC should have been set. Refer to Powertrain Diagnostic Procedures manual.
Fuel filter plugged.	Perform Fuel Pressure Drop Test. Refer to Fuel Transfer Pump Pressure Testing in Group 14, Fuel System.
Fuel grade not correct or fuel quality is poor.	Temporarily change fuel brands and note condition. Change brand if necessary.
Fuel heater element or fuel heater temperature sensor malfunctioning. This will cause wax type build-up in fuel filter.	Refer to Fuel Heater Testing in Group 14, Fuel System.
Fuel injector malfunctioning.	A DTC should have been set. Perform "Cylinder Balance Test" using DRB scan tool to isolate individual cylinders. Also refer to Powertrain Diagnostic Procedures manual and, to Fuel Injector Testing in Group 14, Fuel System.
Fuel injector protrusion not correct.	Check washer (shim) at bottom of fuel injector for correct thickness. Refer to Fuel Injector Removal/Installation in Group 14, Fuel System.
Fuel injection pump malfunctioning.	A DTC should have been set. Refer to Powertrain Diagnostic Procedures manual.
Fuel supply side restriction to transfer pump.	Refer to Fuel Transfer Pump Pressure Test in Group 14, Fuel System
Fuel transfer (lift) pump malfunctioning.	A DTC should have been set. Refer to Powertrain Diagnostic Procedures manual. Also refer to Fuel Transfer Pump Pressure Testing in Group 14, Fuel System.
Intake/Exhaust valve adjustments not correct (too tight).	Refer to Group 9, Engines.
Intake manifold air temperature sensor malfunctioning.	A DTC should have been set. Refer to Powertrain Diagnostic Procedures manual.
Intake manifold heater circuit not functioning correctly in cold weather.	A DTC should have been set. Refer to Powertrain Diagnostic Procedures manual. Also check heater elements for correct operation.
Intake manifold heater elements not functioning correctly in cold weather.	A diagnostic trouble code WILL NOT BE SET if heater elements are malfunctioning. Refer to NTC tests in Powertrain Diagnostic Procedures manual.
Internal engine damage (scuffed cylinder).	Analyze engine oil and inspect oil filter to locate area of probable damage.
Restriction in fuel supply side of fuel system.	Refer to Fuel Transfer Pump Pressure Testing in Group 14, Fuel System.
Static timing incorrect.	A DTC should have been set. If so, refer to Fuel injection Pump Timing in Group 14, Fuel System.

## DIAGNOSIS AND TESTING (Continued)

EXCESSIVE BLUE SMOKE	
POSSIBLE CAUSE	CORRECTION
Dirty air cleaner or restricted turbocharger intake duct.	Check Filter Minder at air filter housing. Refer to Air Cleaner Housing/Element Removal/Installation in Group 14, Fuel System. Replace air remove obstruction and/or replace air cleaner element as necessary.
Air leak in boost system between turbocharger compressor outlet and intake manifold.	Refer to Turbocharger System Diagnostics in Group 11, Exhaust System and Turbocharger.
Obstruction in exhaust manifold.	Remove exhaust manifold and inspect for blockage. Refer to Group 11, Exhaust System and Turbocharger.
Restricted turbocharger drain tube.	Remove turbocharger drain tube and remove obstruction. Refer to Group 11, Exhaust System and Turbocharger.
Crankcase ventilation system plugged.	Inspect crankcase breather and vent tube for sludge formation or obstructions.
Valve seals are worn, brittle, or improperly installed.	Replace valve stem oil seals. Refer to Valve Spring and/or Seal Removal/Installation in this group.
Valve stems and/or guides are worn.	Remove valves and inspect valves and guides. Refer to procedure in this group.
Broken or Improperly installed piston rings.	Tear down engine and inspect piston rings.
Excessive piston ring end gap.	Remove pistons and measure piston ring end gap. Refer to Piston and Connecting Rod Removal/Installation in this group.
Excessive cylinder bore wear and taper.	Remove pistons and measure cylinder bore wear and taper. Refer to applicable procedures in this group.
Cylinder damage.	Remove pistons and inspect cylinder bore for cracks or porosity. Repair with cylinder liner if necessary. Refer to procedure in this group.
Piston damage.	Remove pistons and inspect for cracks, holes. Measure piston for out-of-round and taper. Refer to Piston and Connecting Rod Removal/Installation in this group.
Turbocharger failure.	Refer to Turbocharger Diagnostics in Group 11, Exhaust System and Turbocharger.

**VACUUM PUMP OUTPUT**

The vacuum pump supplies necessary vacuum to components in the following systems:

- HEVAC system
- Speed Control System

A quick check to determine if the vacuum pump is the cause of the problem in any of these systems is to road test the vehicle and verify that all of these systems are functioning properly. If only one of these has a vacuum related failure, then it is likely the vacuum pump is not the cause.

A standard vacuum gauge can be used to check pump output when necessary. Simply disconnect the pump supply hose and connect a vacuum gauge to the outlet port for testing purposes. With the engine running, vacuum output should be a minimum of 25 inches, depending on engine speed.

**DIAGNOSING LOW VACUUM OUTPUT CONDITION**

If the vacuum pump is suspected of low vacuum output, check the pump and vacuum harnesses as follows:

(1) Visually inspect the vacuum harness for obvious failures (i.e. disconnected, cracks, breaks etc.)

(2) Disconnect the vacuum supply hose at the vacuum pump check valve. Connect vacuum gauge to this valve and run engine at various throttle openings. Output should be a minimum 25 inches of vacuum. If vacuum is consistently below 25 inches, the vacuum pump should be replaced. If output is within specified limits, the vacuum harness should be suspected as the cause.

(3) Disconnect and isolate the vacuum supply harness. Cap off open ends and apply roughly 15 inches of vacuum to the harness. If the vacuum gauge does

## DIAGNOSIS AND TESTING (Continued)

not hold its reading, then there is an open in the harness and it should be repaired or replaced.

(4) If the vacuum loss is still not detected at this point, then the pump and harness are not the cause of the low vacuum condition. Apply vacuum to the related components of the vacuum supply system (i.e. valves, servos, solenoids, etc.) to find the source of the vacuum loss.

## SERVICE PROCEDURES

## ENGINE OIL / FILTER SERVICE

**WARNING:** NEW OR USED ENGINE OIL CAN BE IRRITATING TO THE SKIN. AVOID PROLONGED OR REPEATED SKIN CONTACT WITH ENGINE OIL. CONTAMINANTS IN USED ENGINE OIL, CAUSED BY INTERNAL COMBUSTION, CAN BE HAZARDOUS TO YOUR HEALTH. THOROUGHLY WASH EXPOSED SKIN WITH SOAP AND WATER. DO NOT WASH SKIN WITH GASOLINE, DIESEL FUEL, THINNER, OR SOLVENTS, HEALTH PROBLEMS CAN RESULT. DO NOT POLLUTE. DISPOSE OF USED ENGINE OIL PROPERLY.

## ENGINE OIL SPECIFICATION

**CAUTION:** Do not use non-detergent or straight mineral oil when adding or changing crankcase lubricant. Engine failure can result.

## API SERVICE GRADE CERTIFIED

Standard engine-oil identification notations have been adopted to aid in the proper selection of engine oil. The identifying notations are located on the label of engine oil plastic bottles and the top of engine oil cans.

In diesel engines, use an engine oil that conforms to API Service Grade CF-4 or CG-4/SH (Fig. 8). MOPAR® provides an engine oil that conforms to this particular grade.

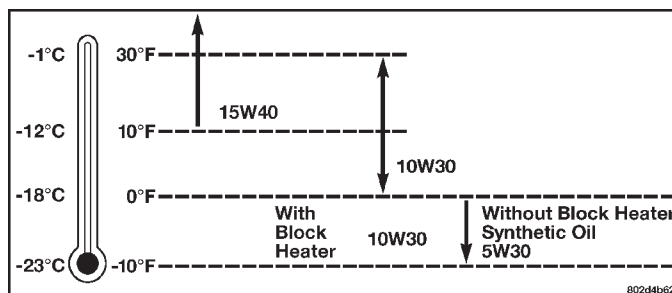


**Fig. 8 API Service Grade Certification Label—Diesel Engine Oil**

## SAE VISCOSITY

An SAE viscosity grade is used to specify the viscosity of engine oil. SAE 15W-40 specifies a multiple viscosity engine oil.

When choosing an engine oil, consider the range of temperatures the vehicle will be operated in before the next oil change. Select an engine oil that is best suited to your area's particular ambient temperature range and variation. For diesel engines, refer to (Fig. 9).



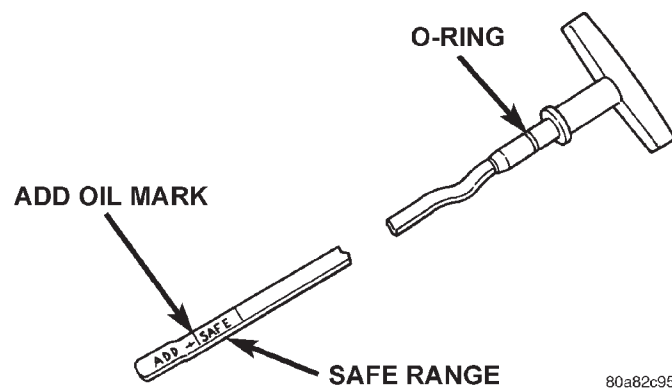
**Fig. 9 Engine Oil Viscosity Recommendation—Diesel Engines**

## CRANKCASE OIL LEVEL INSPECTION

**CAUTION:** Do not overfill crankcase with engine oil, oil foaming and oil pressure loss can result.

To ensure proper lubrication of an engine, the engine oil must be maintained at an acceptable level. The acceptable oil level is in the SAFE RANGE on the engine oil dipstick (Fig. 10).

Unless the engine has exhibited loss of oil pressure, run the engine for about five minutes before checking oil level. Checking engine oil level of a cold engine is not accurate.



**Fig. 10 Oil Level Indicator (Dipstick)**

- (1) Position vehicle on level surface.
- (2) With engine OFF, allow approximately ten minutes for oil to settle to bottom of crankcase, remove engine oil dipstick.
- (3) Wipe dipstick clean.



## SERVICE PROCEDURES (Continued)

- (4) Replace dipstick and verify it is seated in the tube.
- (5) Remove dipstick, with handle held above the tip, take oil level reading.
- (6) Add oil only if level is below the SAFE RANGE area on the dipstick.
- (7) Replace dipstick

## ENGINE OIL AND FILTER CHANGE

**WARNING: HOT OIL CAN CAUSE PERSONAL INJURY.**

**NOTE: Change engine oil and filter at intervals specified in the owner's manual.**

- (1) Operate the engine until the water temperature reaches 60°C (140°F). Shut the engine off.
- (2) Use a container that can hold at least 14 liters (15 quarts) to hold the used oil. Remove the oil drain plug and drain the used engine oil into the container.
- (3) Always check the condition of the used oil. This can give you an indication of engine problems that might exist.
  - Thin, black oil indicates fuel dilution.
  - Milky discoloration indicates coolant dilution.
- (4) Clean the area around the oil filter head. Remove the filter using a 90-95 mm filter wrench.
- (5) Clean the gasket surface of the filter head. The filter canister O-Ring seal can stick on the filter head. Make sure it is removed.
- (6) Fill the oil filter element with clean oil before installation. Use the same type oil that will be used in the engine.
- (7) Apply a light film of lubricating oil to the sealing surface before installing the filter.

**CAUTION: Mechanical over-tightening may distort the threads or damage the filter element seal.**

- (8) Install the filter as specified by the filter manufacturer.
- (9) Clean the drain plug and the sealing surface of the pan. Check the condition of the threads and sealing surface on the oil pan and drain plug.
- (10) Install the drain plug. Tighten the plug to 60 N·m (44 ft. lbs.) torque.
- (11) Use only High-Quality Multi-Viscosity lubricating oil in the Cummins Turbo Diesel engine. Choose the correct oil for the operating conditions outlined in Group 0, Lubrication and Maintenance.
- (12) Fill the engine with the correct grade of new oil. Refer to Group 0, Lubrication and Maintenance for the correct oil fill capacity.
- (13) Start the engine and operate it at idle for several minutes. Check for leaks at the filter and drain plug.

- (14) Stop engine. Wait several minutes to allow the oil to drain back to the pan and check the level again.

## USED ENGINE OIL DISPOSAL

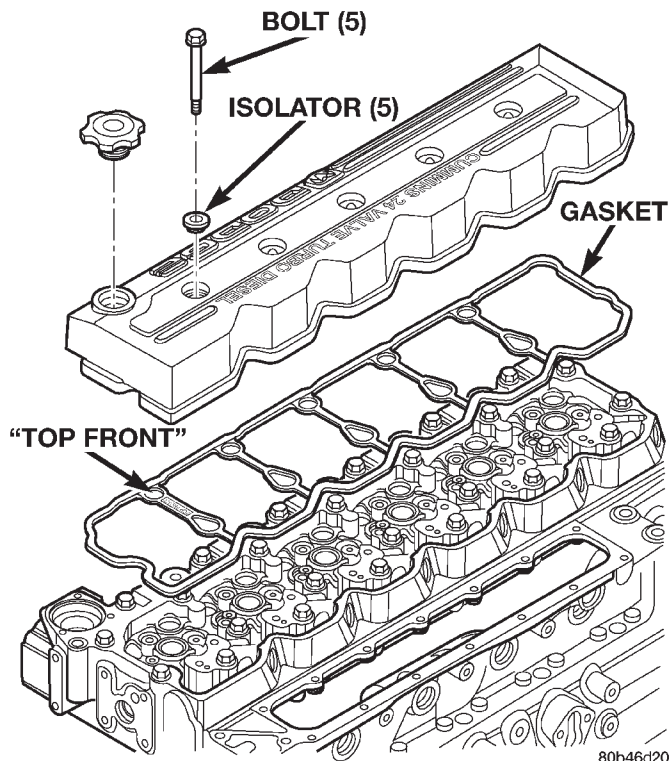
Care should be exercised when disposing of used engine oil after it has been drained from a vehicle's engine.

## VALVE LASH VERIFICATION &amp; ADJUSTMENT

**NOTE: To obtain accurate readings, valve lash measurements AND adjustments should only be performed when the engine coolant temperature is less than 60° C (140° F).**

The 24-valve overhead system is a "low-maintenance" design. Routine adjustments are no longer necessary, however, measurement should still take place when trouble-shooting performance problems, or upon completion of a repair that includes removal and installation of the valve train components.

- (1) Disconnect battery negative cables.
- (2) Remove cylinder head cover (Fig. 11). Refer to procedure in this group.
- (3) Remove the fuel pump gear access cover (Fig. 12).



**Fig. 11 Cylinder Head Cover and Gasket**

- (4) Using the crankshaft barring tool #7471B, rotate the engine and align the pump gear mark with

## SERVICE PROCEDURES (Continued)

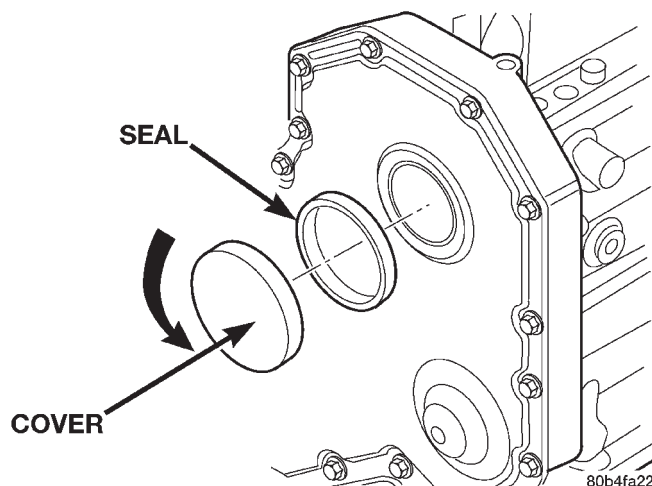


Fig. 12 Fuel Pump Gear Access Cover

the top dead center (TDC) mark on the gear housing cover (Fig. 13).

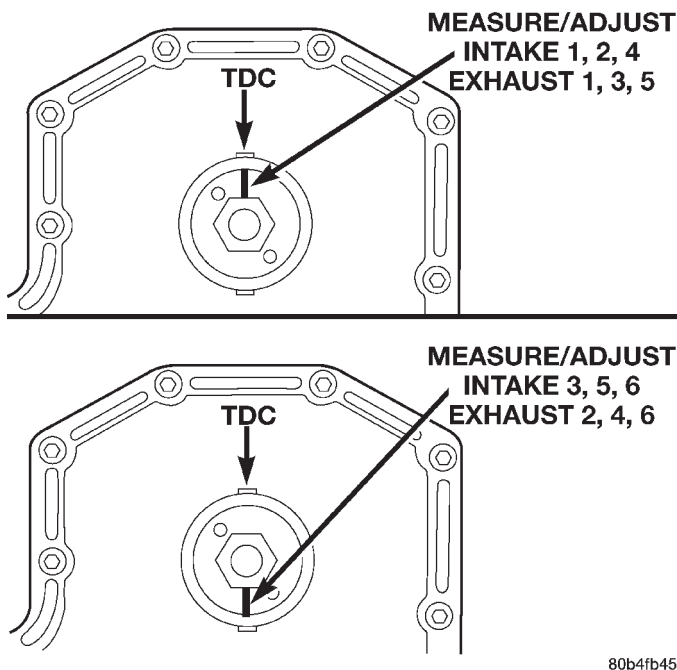


Fig. 13 Fuel Pump Gear Timing Mark Orientation

(5) With the engine in this position (pump gear mark at 12 o'clock), valve lash can be measured at the following rocker arms: **INTAKE 1-2-4 / EXHAUST 1-3-5**. Measure the valve lash by inserting a feeler gauge between the rocker arm socket and crosshead (Fig. 14). Refer to the Valve Lash Limit Chart for the correct specifications. If the measurement falls **within** the limits, adjustment/resetting is **not** necessary. If measurement finds the lash **outside** of the limits, adjustment/resetting is required.

## VALVE LASH LIMIT CHART

INTAKE	EXHAUST
0.152 mm ( 0.006 in.) MIN.	0.381 mm (0.015 in.) MIN.
0.381 mm (0.015 in.) MAX.	0.762 mm (0.030 in.) MAX.

**NOTE:** If measured valve lash falls within these specifications, no adjustment/reset is necessary. Engine operation within these ranges has no adverse affect on performance, emissions, fuel economy or level of engine noise.

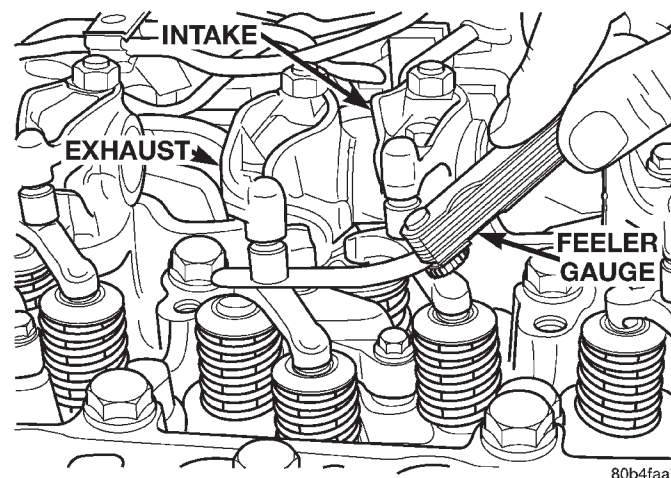


Fig. 14 Measuring Valve Lash

(6) If adjustment/resetting is required, loosen the lock nut on rocker arms and turn the adjusting screw until the desired lash is obtained:

- **INTAKE** 0.254 mm (0.010 in.)
- **EXHAUST** 0.508 mm (0.020 in.)

(6) Tighten the lock nut and re-check the valve lash.

(7) Using the crankshaft barring tool, rotate the **crankshaft** one revolution (360°) to align the pump gear mark to the 6 o'clock position in relation to the TDC mark on the gear housing cover (Fig. 13).

(8) With the engine in this position (pump gear mark at 6 o'clock), valve lash can be measured at the remaining rocker arms: **INTAKE 3-5-6 / EXHAUST 2-4-6**. Use the same method as above for determining whether adjustment is necessary, and adjust those that are found to be outside of the limits.

(9) Install the cylinder head cover (Fig. 11).

(10) Install the fuel pump gear access cover.

(11) Connect the battery negative cables.

## CYLINDER BORES—DE-GLAZE

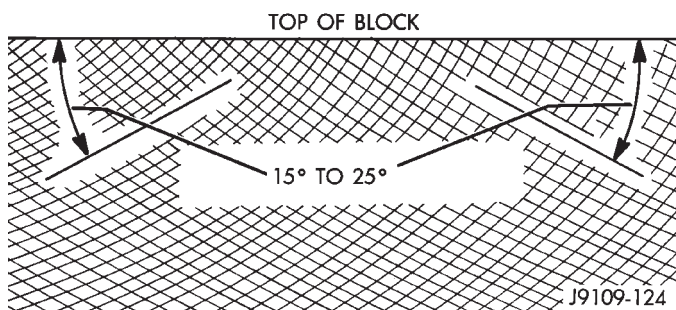
(1) New piston rings may not seat in glazed cylinder bores.

## SERVICE PROCEDURES (Continued)

(2) De-glazing gives the bore the correct surface finish required to seat the rings. The size of the bore is not changed by proper de-glazing.

(3) Cover the lube holes in the top of the block with waterproof tape.

(4) A correctly honed surface will have a cross-hatch appearance with the lines at 15° to 25° angles (Fig. 15). For the rough hone, use 80 grit honing stones. To finish hone, use 280 grit honing stones.



**Fig. 15 Cylinder Bore Crosshatch Pattern**

(5) Use a drill, a fine grit Flex-hone and a mixture of equal parts of mineral spirits and SAE 30W engine oil to de-glaze the bores.

(6) The crosshatch angle is a function of drill speed and how fast the hone is moved vertically (Fig. 16).

(7) Vertical strokes MUST be smooth continuous passes along the full length of the bore (Fig. 16).

(8) Inspect the bore after 10 strokes.

(9) Use a strong solution of hot water and laundry detergent to clean the bores. Clean the cylinder bores immediately after de-glazing.

(10) Rinse the bores until the detergent is removed and blow the block dry with compressed air.

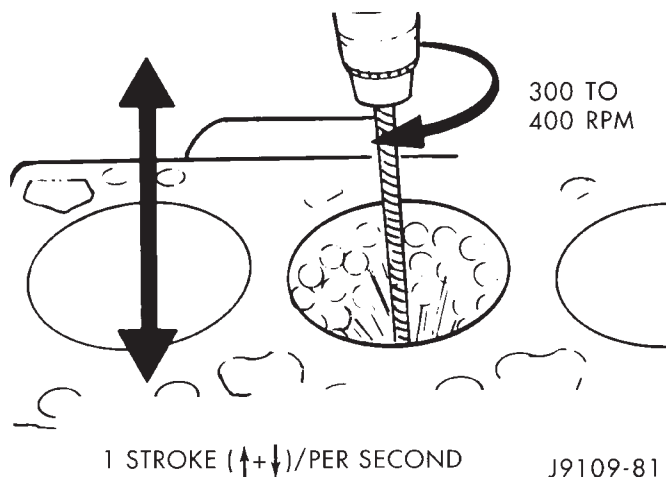
(11) Check the bore cleanliness by wiping with a white, lint free, lightly oiled cloth. If grit residue is still present, repeat the cleaning process until all residue is removed. Wash the bores and the complete block assembly with solvent and dry with compressed air.

(12) Be sure to remove the tape covering the lube holes after the cleaning process is complete.

### CYLINDER BLOCK REFACING

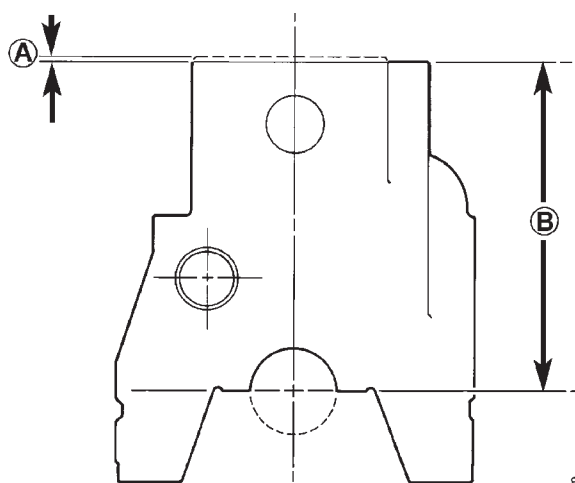
(1) The combustion deck can be refaced twice. The first reface should be 0.25 mm (0.0098 inch). If additional refacing is required, an additional 0.25 mm (0.0098 inch) can be removed. Total allowed refacing is 0.50 mm (0.0197 inch) - (Fig. 17).

(2) The upper right corner of the rear face of the block must be stamped with a X when the block is refaced to 0.25 mm (0.0098 inch). A second X must be stamped beside the first when the block is refaced to 0.50 mm (0.0197 inch) - (Fig. 18).



**Fig. 16 De-Glazing Drill Speed and Vertical Speed**  
CYLINDER BLOCK REFACING DIMENSIONS

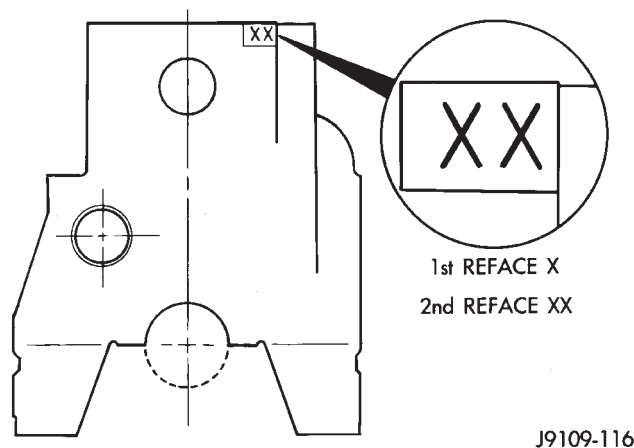
DIMENSION "A"		
1st Reface	0.25mm	(0.0098 in.)
2nd Reface	0.25mm	(0.0098 in.)
Dim (A) Total	0.50 mm	(0.0197 in.)
DIMENSION "B"		
Dim. "B" (STD.)	323.00 mm ± 0.10 mm	(12.7165 in. ± 0.0039 in.)
1st Reface	322.75 mm ± 0.10 mm	(12.7067 in. ± 0.0039 in.)
2nd Reface	322.50 mm ± 0.10 mm	(12.6968 in. ± 0.0039 in.)



**Fig. 17 Refacing Dimensions of the Cylinder Block**

(3) Consult the parts catalog for the proper head gaskets which must be used with refaced blocks to ensure proper piston-to-valve clearance.

## SERVICE PROCEDURES (Continued)



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**Fig. 18 Stamp Block after Reface****CYLINDER BORE REPAIR**

Cylinder bore(s) can be repaired by one of two methods:

- Method 1:—Over boring and using oversize pistons and rings.
- Method 2:—Boring and installing a repair sleeve to return the bore to standard dimensions.

**METHOD 1—OVERSIZE BORE**

Oversize pistons and rings are available in two sizes - 0.50 mm (0.0197 inch) and 1.00 mm (0.0393 inch).

Any combination of standard, 0.50 mm (0.0197 inch) or 1.00 mm (0.0393 inch) overbore may be used in the same engine.

If more than 1.00 mm (0.0393 inch) overbore is needed, a repair sleeve can be installed (refer to Method 2—Repair Sleeve).

Cylinder block bores may be bored twice before use of a repair sleeve is required (Fig. 19). The first bore is 0.50 mm (0.0197 inch) oversize. The second bore is 1.00 mm (0.0393 inch) oversize.

After boring to size, use a honing stone to chamfer the edge of the bore (Fig. 19).

A correctly honed surface will have a crosshatch appearance with the lines at 15° to 25° angles with the top of the cylinder block (Fig. 20). For the rough hone, use 80 grit honing stones. To finish hone, use 280 grit honing stones.

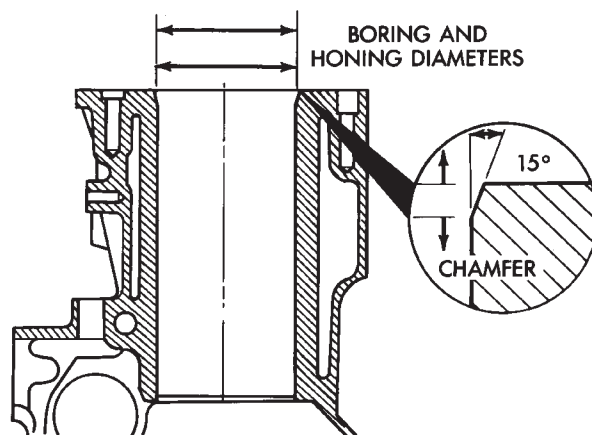
A maximum of 1.2 micrometer (48 microinch) surface finish must be obtained.

After finish honing is complete, immediately clean the cylinder bores with a strong solution of laundry detergent and hot water.

After rinsing, blow the block dry.

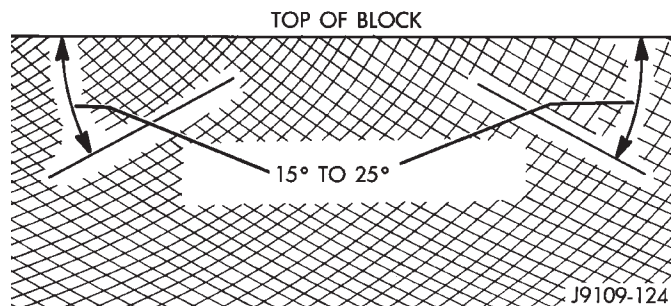
Check the bore cleanliness by wiping with a white, lint-free, lightly-oiled cloth. There should be no grit residue present.

If the block is not to be used right away, coat it with a rust-preventing compound.



<u>BORING DIAMETER DIMENSION</u>	
1st REBORE	102.469 mm (4.0342 inch)
2nd REBORE	102.969 mm (4.0539 inch)
<u>HONING DIAMETER DIMENSIONS</u>	
STANDARD	102.020 ± 0.020 mm (4.0165 ± 0.0008 inch)
1st REBORE	102.520 ± 0.020 mm (4.0362 ± 0.0008 inch)
2nd REBORE	103.020 ± 0.020 mm (4.0559 ± 0.0008 inch)
<u>CHAMFER DIMENSIONS</u>	
Approx. 1.25 mm (0.049 inch) by 15°	

J9109-119

**Fig. 19 Cylinder Bore Dimensions**

J9109-124

**Fig. 20 Crosshatch Pattern of Repaired Sleeve(s)****METHOD 2—REPAIR SLEEVE**

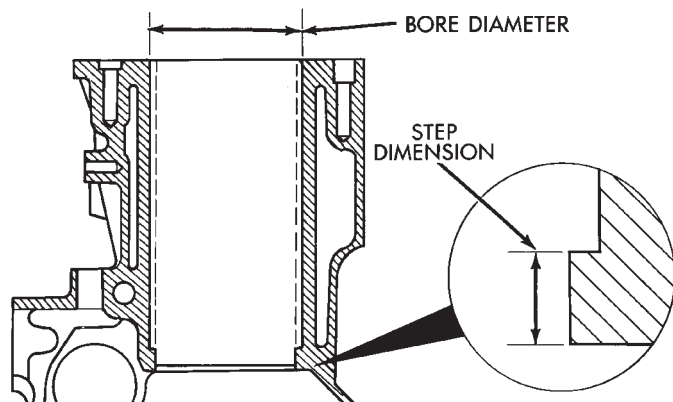
If more than a 1.00 mm (0.03937 inch) diameter oversize bore is required, the block must be bored and a repair sleeve installed.

Bore the block cylinder bore to 104.500-104.515 mm (4.1142-4.1148 inch) - (Fig. 21).



## SERVICE PROCEDURES (Continued)

Repair sleeves can be replaced by using a boring bar to bore out the old sleeve. DO NOT cut the cylinder bore beyond the oversize limit.

**BLOCK REBORE FOR REPAIR SLEEVE**

BORE DIA. - 104.500 +0.015 mm  
(4.1142 +0.0006 inch)  
STEP DIM. - 6.35 mm (0.25 inch)

J9109-120

**Fig. 21 Block Bore for Repair Sleeve Dimensions**

After machining the block for the new repair sleeve, thoroughly clean the bore of all metal chips, debris and oil residue before installing the sleeve.

Cool the repair sleeve(s) to a temperature of -12°C (10°F) or below for a minimum of one hour. Be ready to install the sleeve immediately after removing it from the freezer.

Apply a coat of Loctite 620, or equivalent to the bore that is to be sleeved.

Wear protective gloves to push the cold sleeve into the bore as far as possible.

Using a sleeve driver, drive the sleeve downward until it contacts the step at the bottom of the bore (Fig. 22).

A sleeve driver can be constructed as follows (Fig. 23).

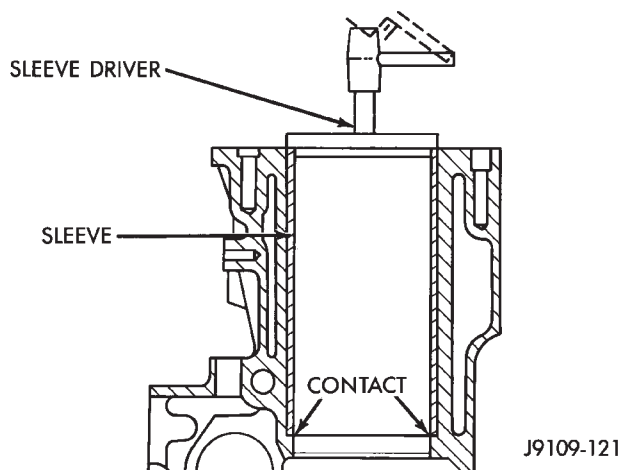
Set up a boring bar and machine the sleeve to 101.956 mm (4.014 inch) - (Fig. 24).

After removing the boring bar, use a honing stone to chamfer the corner of the repair sleeve(s) - (Fig. 24).

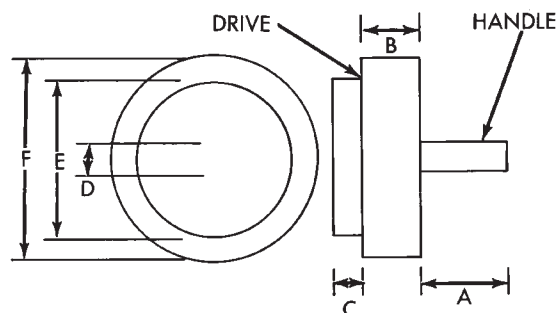
A correctly honed surface will have a crosshatch appearance with the lines at 15° to 25° angles with the top of the cylinder block. For the rough hone, use 80 grit honing stones. To finish hone, use 280 grit honing stones.

Finished bore inside dimension is 102.020 ±0.020 mm (4.0165 ±0.0008 inch).

A maximum of 1.2 micrometer (48 microinch) surface finish must be obtained.



J9109-121

**Fig. 22 Sleeve Installation**

DRIVE - ALUMINUM  
HANDLE - STEEL

A = 127 mm (5 inch)  
B = 38 mm (1.5 inch)  
C = 6.35 mm (0.25 inch)  
D = 25.4 mm (1 inch)  
E = 101 mm (3.976 inch)  
F = 107.343 mm (4.226 inch)

J9109-122

**Fig. 23 Sleeve Driver Construction**

After finish honing is complete, immediately clean the cylinder bores with a strong solution of laundry detergent and hot water.

After rinsing, blow the block dry with compressed air.

Wipe the bore with a white, lint-free, lightly oiled cloth. Make sure there is no grit residue present.

Apply a rust-preventing compound if the block will not be used immediately.

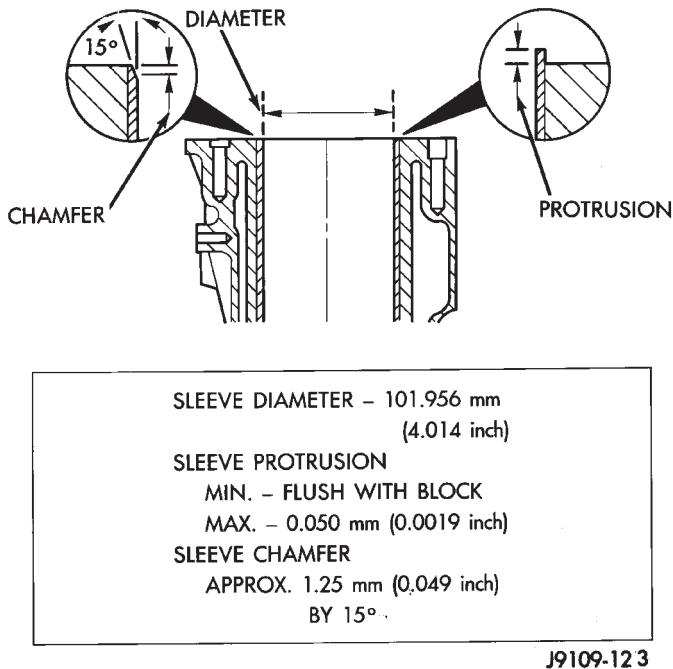
A standard diameter piston and a piston ring set must be used with a sleeved cylinder bore.

**CAM BORE REPAIR**

The front cam bushing bore can be bored to 59.235 Mm ±0.013 mm (2.332 inch ±0.0006 inch) oversize. DO NOT bore the intermediate or rear cam bore to



## SERVICE PROCEDURES (Continued)

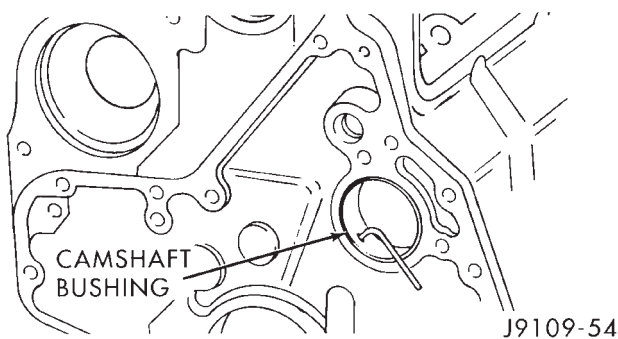
**Fig. 24 Sleeve Machining Dimensions**

the front cam bore oversize dimensions. Intermediate and rear cam bores may be bored to 57.235 mm  $\pm 0.013$  mm (2.253 inch  $\pm 0.0006$ - inch) oversize.

A surface finish of 2.3 micrometers (92 microinch) must be maintained. Not more than 20% of an area of any one bore may be 3.2 micrometers (126 micro-inch).

Camshaft bores can be repaired individually. It is not necessary to repair undamaged cam bores in order to repair individually damaged cam bores. The standard front bushing cannot be used to repair intermediate or rear bores.

Install all cam bushings flush or below the front cam bore surface. The oil hole must align to allow a 3.2 mm (0.125 inch) rod to pass through freely (Fig. 25).

**Fig. 25 Oil Hole Alignment****CYLINDER BLOCK CUP PLUG REPLACEMENT**

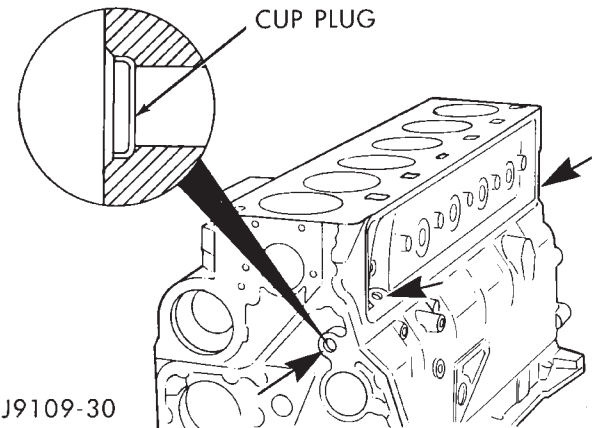
(1) Remove the cup plugs from the oil passages (Fig. 26).

(2) Apply a bead of Loctite 277 around the outside diameter of the oil passage cup plugs.

(3) Drive the cup plugs in until they bottom in the bore (Fig. 26).

(4) Fill the engine with oil. Run the engine and check for leaks.

(5) Stop the engine and check the oil level with the dipstick.

**Fig. 26 Cup Plug Locations in Cylinder Block****PISTON GRADING PROCEDURE**

• When rebuilding an engine with the original cylinder block, crankshaft and pistons, make sure the pistons are installed in their original cylinder.

• If replacing the piston(s), make sure the replacement piston(s) are the same grade as the one being replaced.

• If a new cylinder block and/or crankshaft is used, the piston grading procedure **MUST** be performed to determine the proper piston grade for each cylinder.

(1) Install any of the original connecting rod and piston assemblies into the No.1 cylinder. DO NOT install the piston rings.

(2) Install the upper bearing shell in the connecting rod with the tang of the bearing in the slot of the connecting rod. The connecting rod bearing shell must be installed in the original connecting rod and cap. Use clean lubricating oil to coat the inside diameter of the connecting rod bearing shell.

(3) Install the bearing shell in the connecting rod cap with the tang of the bearing in the slot to the cap. Use clean lubricating oil to coat the inside diameter of the bearing shell.

(4) The four digit number stamped on the connecting rod and cap at the parting line must match and be installed on the oil cooler side of the engine. Install the connecting rod cap and capscrews. Tighten the capscrews to 35 N·m (26 ft. lbs.) torque.

(5) Use a fine grit stone to remove any burrs from the cylinder block head deck. Zero the dial indicator to the cylinder block head deck.

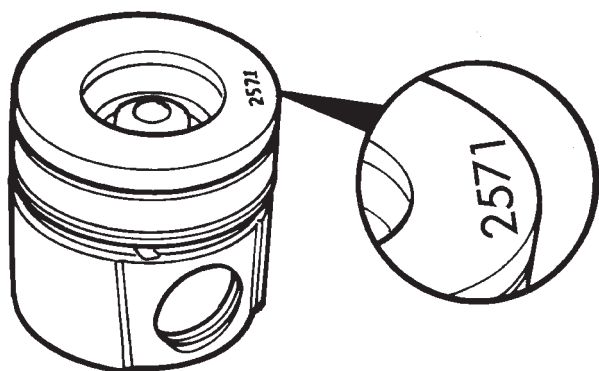
## SERVICE PROCEDURES (Continued)

(6) Move the dial indicator directly over the piston pin to eliminate any side-to-side movement.

(7) Rotate the crankshaft to top dead center (TDC). Rotate the crankshaft clockwise and counter-clockwise to find the highest dial indicator reading. Record the reading.

(8) Remove the piston and connecting rod assembly from the No.1 cylinder and install the assembly into the No.2 cylinder. Repeat the procedure for every cylinder using the same piston and connecting rod assembly.

(9) Determine the grade of the piston being used by referring to the Piston Protrusion Chart below. Four digits on top of the piston can be cross referenced to a Chrysler part number for replacement (Fig. 27). If the number on the piston cannot be seen, measure from the top of the piston to the top of the piston pin to see what grade piston is used (Fig. 28).



J9509-2

**Fig. 27 Piston Grading Number Location**

**NOTE:** Use the table below when piston grading numbers are missing or not legible.

### CONNECTING ROD BEARING AND CRANKSHAFT JOURNAL CLEARANCE

Measure the connecting rod bore with the bearings installed and the bolts tightened to 100 N·m (73 ft. lbs.) torque.

Record the smaller diameter.

Measure the diameter of the rod journal at the location shown (Fig. 29). Calculate the average diameter for each side of the journal.

The clearance is the difference between the connecting rod bore (smallest diameter) and the average diameter for each side of the crankshaft journal.

If the crankshaft is within limits, replace the bearing. If the crankshaft is out of limits, grind the crankshaft to the next smaller size and use oversize rod bearings.

### PISTON PROTRUSION CHART

IF MEASURING PISTON IS GRADING #:	AND PROTRUSION IS:	USE GRADE:
3708	0.609-0.711 mm (0.024-0.028 in.)	A
3708	0.508-0.609 mm (0.020-0.024 in.)	B
3708	0.406-0.508 mm (0.016-0.020 in.)	C
3709	0.711-0.813 mm (0.028-0.032 in.)	A
3709	0.609-0.711 mm (0.024-0.028 in.)	B
3709	0.508-0.609 mm (0.020-0.024 in.)	C
3710	0.813-0.914 mm (0.032-0.036 in.)	A
3710	0.711-0.813 mm (0.028-0.032 in.)	B
3710	0.609-0.711 mm (0.024-0.028 in.)	C

### ALTERNATIVE GRADE IDENTIFICATION METHOD

DIMENSION "A"	REF. NUMBER	GRADE
51.554-51.607 mm (2.029-2.031 in.)	3708	A
51.654-51.707 mm (2.033-2.035 in.)	3709	B
51.754-51.807 mm (2.037-2.039 in.)	3710	C

### MAIN BEARING CLEARANCE

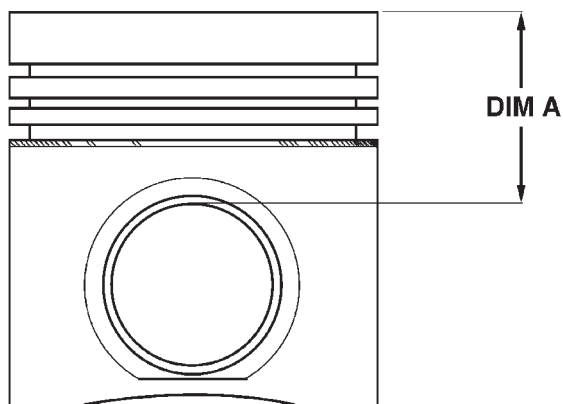
Inspect the main bearing bores for damage or abnormal wear.

Install the crankshaft main bearings and measure main bearing bore diameter with the main bolts tightened to 176 N·m (130 ft. lbs.) torque (Fig. 30).

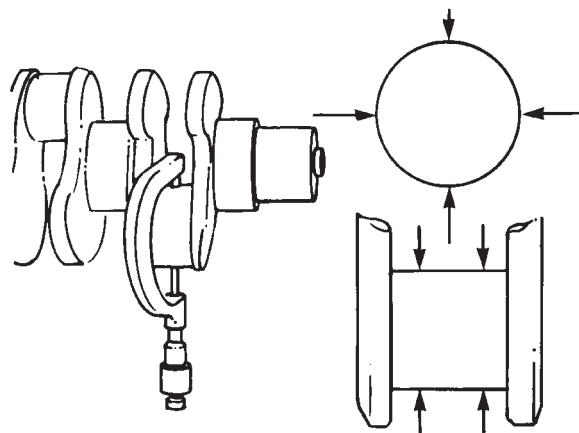
Measure the diameter of the main journal at the locations shown (Fig. 31). Calculate the average diameter for each side of the journal.

Calculate the main bearing journal to bearing clearance. The clearance specifications are 0.119 mm (0.00475 inch). If the crankshaft journal is within limits, replace the main bearings. If not within spec-

## SERVICE PROCEDURES (Continued)



80a82c90

**Fig. 28 Piston Grading Measurement**

MIN.	68.962 mm	(2.715 inch)
MAX.	69.013 mm	(2.717 inch)

Out-of-Round - Max.  
0.050 mm (0.002 inch)

Taper - Max.  
0.013 mm (0.0005 inch)

Bearing Clearance - Max.  
0.089 mm (0.0035 inch)

J9109-91

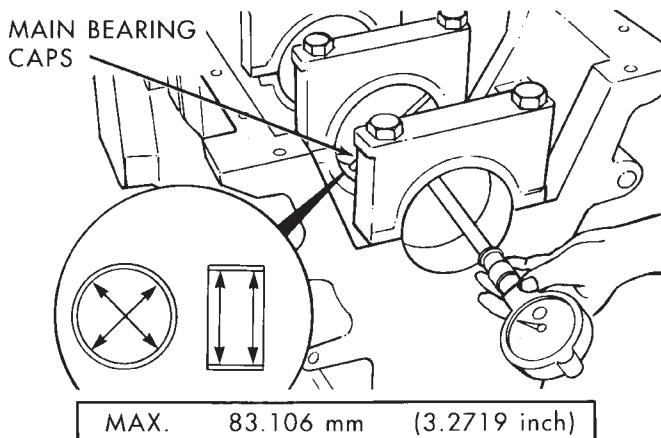
**Fig. 29 Connecting Rod Journal Diameter Limits**

ifications, grind the crankshaft to next size and use oversize bearings.

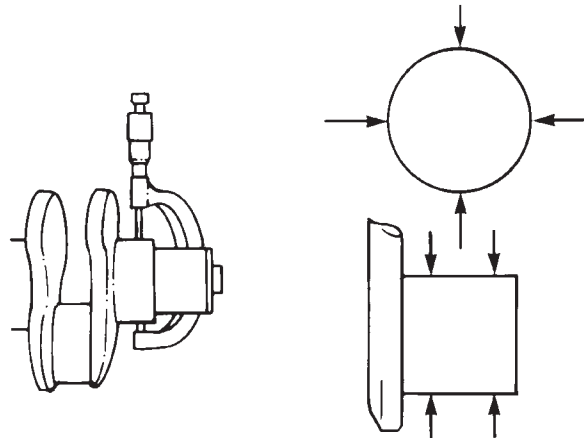
**CRANKSHAFT SERVICE**

Crankshaft main and rod journals may be ground in increments of 0.25 mm (0.0098 inch) up to a total of 1.00 mm (0.0394 inch).

The only exception is the main journal thrust width surface. This journal must be ground in increments of 0.50 mm (0.0197 inch) up to a total of 1.00



J9109-92

**Fig. 30 Crankshaft Main Bearing Bore Diameter**

MIN.	82.962 mm	(3.2662 inch)
MAX.	83.103 mm	(3.2682 inch)

J9109-93

**Fig. 31 Crankshaft Main Journal Diameter**

mm (0.0394 inch). The thrust surface is located on the No.6 main bearing. When the thrust surface requires grinding, the main journal must be ground to the same undersize dimension.

**CAUTION:** Welding of the crankshaft is not allowed. Failure of the crankshaft will result.

**MAIN JOURNAL**

All main journals are to be ground in the opposite direction of engine rotation (clockwise as viewed from the front of crankshaft). Polish the journals in the same direction as engine rotation.

The main bearing grinding specifications are shown in (Fig. 32).

## SERVICE PROCEDURES (Continued)

STANDARD MAIN JOURNAL DIAMETER	
83.000 $\pm$ 0.013 mm (3.2677 $\pm$ 0.0005 inch)	
WORN MAIN JOURNAL DIAMETER LIMIT	
82.962 (3.2662 inch)	
UNDERSIZES	REGRIND TO
0.25 mm (0.0098 inch)	82.750 $\pm$ 0.013 mm (3.2579 $\pm$ 0.0005 inch)
0.50 mm (0.0197 inch)	82.500 $\pm$ 0.013 mm (3.2480 $\pm$ 0.0005 inch)
0.75 mm (0.0295 inch)	82.250 $\pm$ 0.013 mm (3.2381 $\pm$ 0.0005 inch)
1.00 mm (0.0394 inch)	82.000 $\pm$ 0.013 mm (3.2283 $\pm$ 0.0005 inch)
OUT-OF ROUND & TAPER (MAX.)	
0.005 mm (0.0002 inch)	
ALL MAIN JOURNALS ARE TO BE PARALLEL TO THE FRONT AND REAR MAINS WITHIN: 0.030 mm (0.001 inch)	

J9109-125

**Fig. 32 Crankshaft Main Journal Dimensions**

Thrust journals can be ground in the same increments and using the same specifications as all other main journals. The main journal radius may be ground using either the preferred or the alternative procedure providing the thrust surface width is not being ground. The preferred procedure must be used when the main bearing thrust width surface is ground. When the thrust surface width requires grinding, the main journal must be ground to the same undersize dimension (Fig. 33).

THRUST JOURNAL WIDTH	
37.500 $\pm$ 0.025 mm (1.4764 $\pm$ 0.001 inch)	
UNDERSIZES	REGRIND WIDTH TO
0.50 mm (0.0197 inch)	38.000 $\pm$ 0.025 mm (1.4961 $\pm$ 0.001 inch)
1.00 mm (0.0394 inch)	38.500 $\pm$ 0.025 mm (1.5158 $\pm$ 0.001 inch)

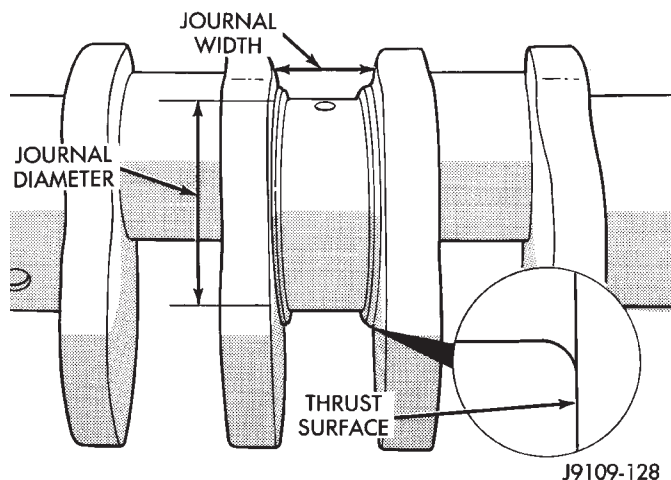
J9109-127

**Fig. 33 Crankshaft Thrust Journal Width Dimensions**

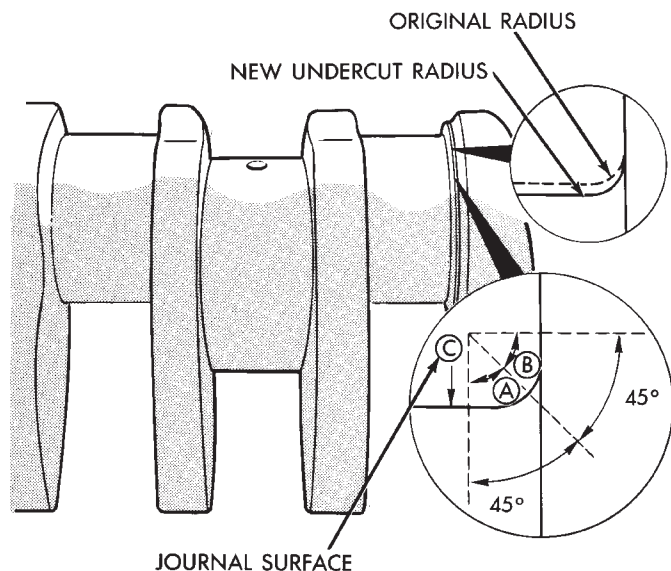
The thrust surface is to be ground on center within 0.10 mm (0.004 inch). It also must be perpendicular to the front and rear mains within 0.0015 mm (0.00006 inch) per radial inch on the thrust area (Fig. 34). The surface finish requirement is 0.04 micrometer (16.0 microinch).

**PREFERRED PROCEDURE:**

Smoothly blend a 4.20  $\pm$  0.020 mm (0.1654  $\pm$  0.0008 inch) radius to the ground diameters (Fig. 35).



J9109-128

**Fig. 34 Crankshaft Thrust Surface**

JOURNAL SURFACE

**SURFACE FINISH**

- (A) 0.8 micrometer (32.0 microinch)  
for a minimum of 45° into the  
fillet beyond journal surface
- (B) 1.6 micrometer (64.0 microinch)  
for remainder of fillet
- (C) 0.4 micrometer (16.0 microinch)

J9109-129

**Fig. 35 Grind Crankshaft Main Journal—Preferred Method**

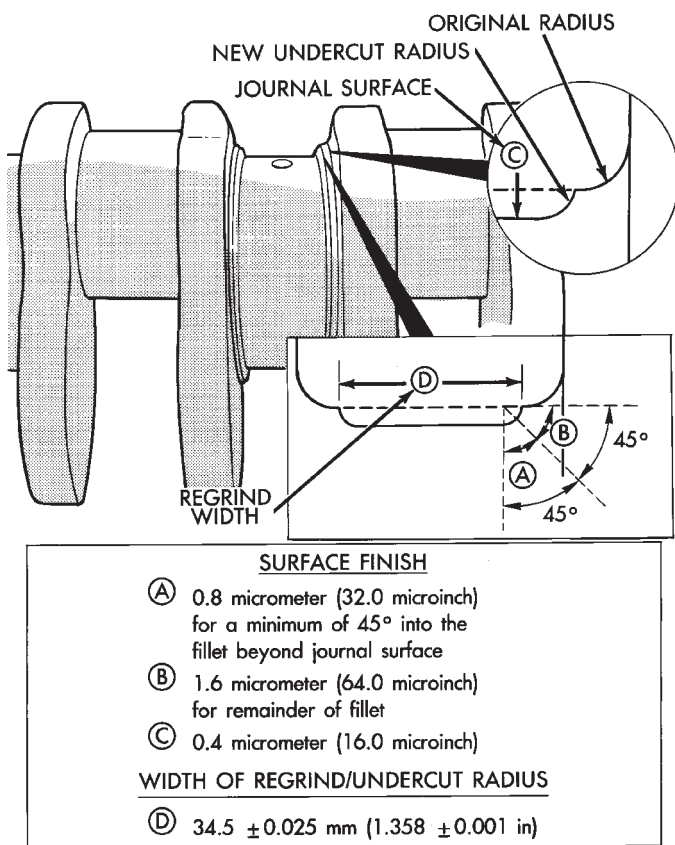
**CAUTION: DO NOT** use the Alternative Procedure when the thrust surface width is ground.

**ALTERNATIVE PROCEDURE:**

Smoothly blend a 1.25  $\pm$  0.020 mm (0.0492  $\pm$  0.0008 inch) radius to the ground diameters (Fig. 36).



## SERVICE PROCEDURES (Continued)



J9109-130

**Fig. 36 Grind Crankshaft Main Journal—Alternative Method****ROD JOURNAL**

All rod journals are to be ground in the opposite direction of engine rotation (clockwise as viewed from the front of crankshaft). Polish the journals in the same direction as engine rotation.

The rod bearing grinding specifications are shown in (Fig. 37).

**PREFERRED PROCEDURE:**

Smoothly blend a  $4.00 \pm 0.020$  ( $0.1575 \pm 0.0008$  inch) radius to the ground diameters and side faces (Fig. 38).

**ALTERNATIVE PROCEDURE:**

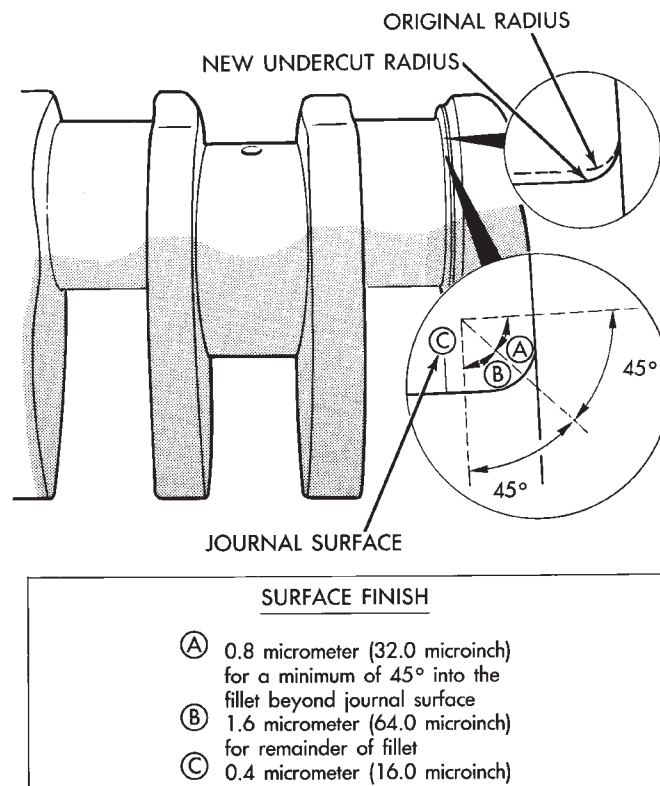
Smoothly blend a  $1.25 \pm 0.020$  mm ( $0.0492 \pm 0.0008$  inch) radius to the ground journals (Fig. 39).

**REMOVAL AND INSTALLATION****ENGINE MOUNTS—FRONT****REMOVAL**

- (1) Disconnect the battery negative cables.
- (2) Remove the viscous fan/drive assy.
- (3) Raise vehicle on hoist.

STANDARD ROD JOURNAL DIAMETER	
$69.000 \pm 0.013$ mm ( $2.7165 \pm 0.0005$ inch)	
WORN ROD JOURNAL DIAMETER LIMIT	
68.962 (2.7150 inch)	
UNDERSIZES	REGRIND TO
0.25 mm (0.0098 inch)	$68.750 \pm 0.013$ mm ( $2.7067 \pm 0.0005$ inch)
0.50 mm (0.0197 inch)	$68.500 \pm 0.013$ mm ( $2.6969 \pm 0.0005$ inch)
0.75 mm (0.0295 inch)	$68.250 \pm 0.013$ mm ( $2.6870 \pm 0.0005$ inch)
1.00 mm (0.0394 inch)	$68.000 \pm 0.013$ mm ( $2.6772 \pm 0.0005$ inch)
OUT-OF ROUND & TAPER (MAX.)	
0.005 mm (0.0002 inch)	
ALL MAIN JOURNALS ARE TO BE PARALLEL TO THE FRONT AND REAR MAINS WITHIN:	
0.030 mm (0.001 inch)	

J9109-126

**Fig. 37 Crankshaft Rod Journal Dimensions**

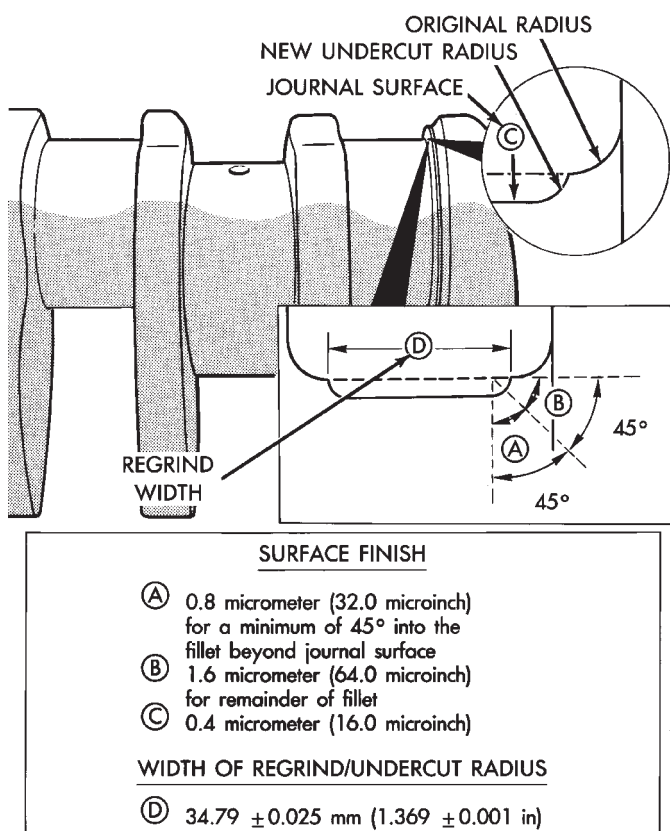
J9109-131

**Fig. 38 Crankshaft Rod Journal Grind—Preferred Method**

- (4) Support engine with a screw jack and wood block.
- (5) Loosen the thru-bolt and nut (Fig. 40).



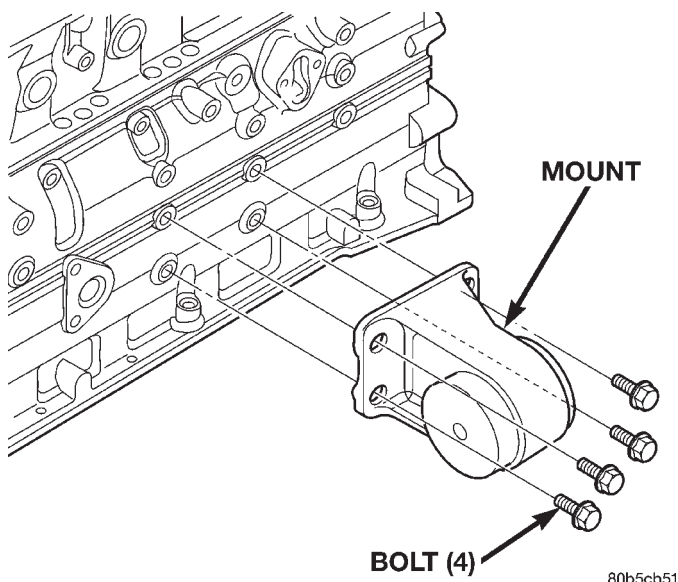
## REMOVAL AND INSTALLATION (Continued)



J9109-132

**Fig. 39 Grind Crankshaft Rod Journal—Alternative Method**

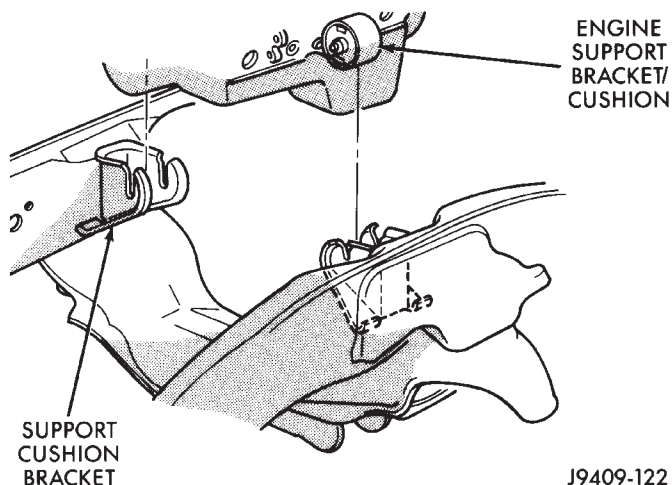
- (6) Passenger side mount: Remove the two (2) transmission oil cooler bracket to engine mount bolts.
- (7) Lift the engine SLIGHTLY and remove the four (4) mount to block bolts.
- (8) Remove the mount from the vehicle.



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**Fig. 40 Front Engine Mount—Typical****INSTALLATION**

- (1) With engine raised SLIGHTLY, position the engine mount to the block. Install the bolts and tighten to 149 N·m (110 ft. lbs.) torque.
- (2) Install the thru-bolt into the engine mount.
- (3) Lower the engine while guiding the mount and thru-bolt into the frame mounted support cushion brackets (Fig. 41).



J9409-122

**Fig. 41 Positioning Engine Front Mounts**

- (4) Install the thru-bolt nut and tighten the nut to 88 N·m (65 ft. lbs.) torque.
- (5) Passenger side: Install the two (2) transmission oil cooler bracket to mount bolts. Tighten the bolts to 47 N·m (35 ft. lbs.) torque.
- (6) Remove lifting fixture.
- (7) Lower the vehicle.
- (8) Install the viscous fan/drive assy. and torque to 57 N·m (42 ft. lbs.) torque.
- (9) Connect the battery negative cables.

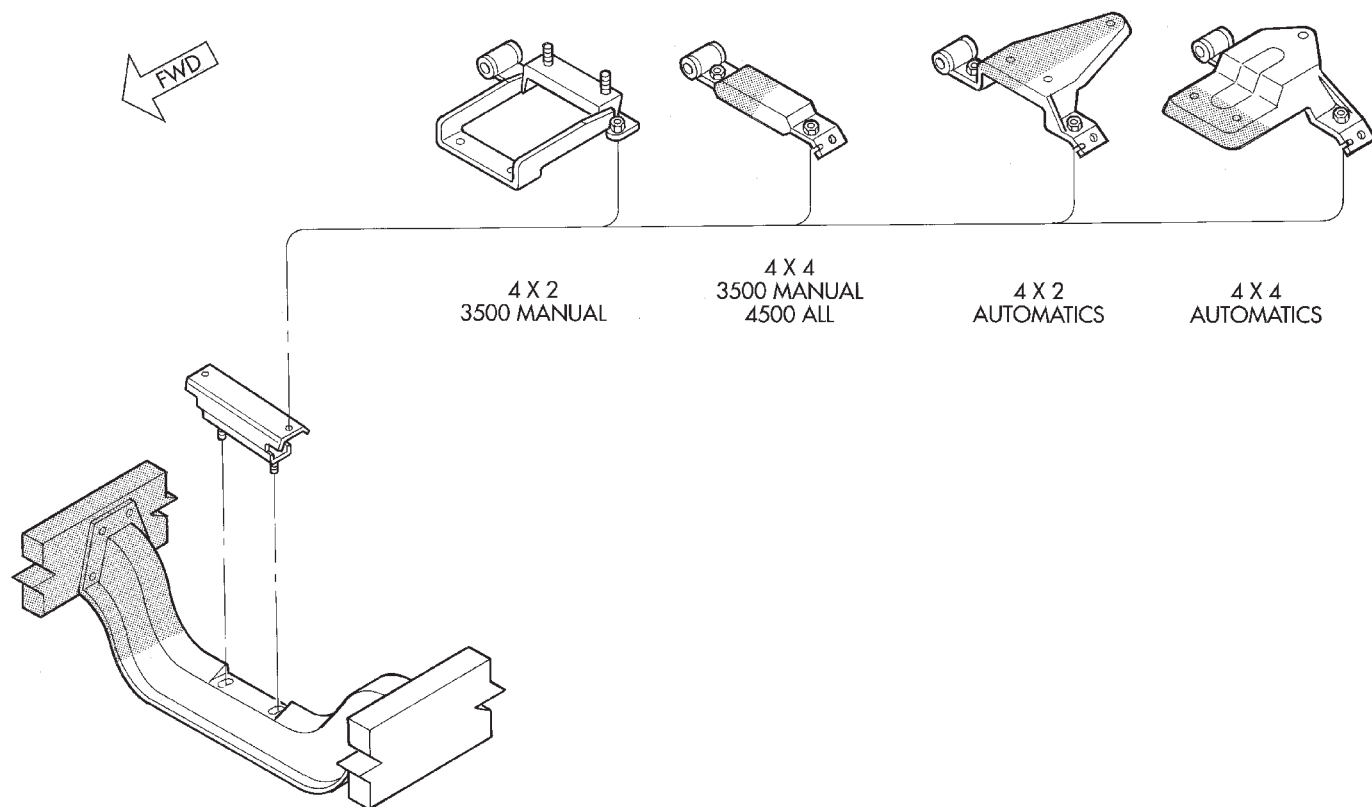
**ENGINE MOUNT—REAR****REMOVAL**

- (1) Raise the vehicle on a hoist.
- (2) Position a transmission jack in place.
- (3) Remove support cushion stud nuts (Fig. 42).
- (4) Raise rear of transmission and engine SLIGHTLY.
- (5) Remove the bolts holding the support cushion to the transmission support bracket. Remove the support cushion.
- (6) If necessary, remove the bolts holding the transmission support bracket to the transmission.

**INSTALLATION**

- (1) If removed, position the transmission support bracket to the transmission. Install new attaching bolts and tighten to 102 N·m (75 ft. lbs.) torque.

## REMOVAL AND INSTALLATION (Continued)



J9509-126

**Fig. 42 Engine Rear Support Cushion Assemblies**

(2) Position support cushion to transmission support bracket. Install stud nuts and tighten to 47 N·m (35 ft. lbs.) torque.

(3) Using the transmission jack, lower the transmission and support cushion onto the crossmember (Fig. 42).

(4) Install the support cushion bolts and tighten to 47 N·m (35 ft. lbs.) torque.

(5) Remove the transmission jack.

(6) Lower the vehicle.

**ENGINE ASSEMBLY****REMOVAL**

(1) Disconnect both battery negative cables.

(2) Recover A/C refrigerant (if A/C equipped). Refer to Group 24, Heating and Air Conditioning for the correct procedure.

(3) Raise vehicle on hoist.

(4) Drain engine coolant into container suitable for re-use.

(5) Remove engine oil drain plug and drain engine oil.

(6) Lower vehicle.

(7) Remove radiator upper hose.

(8) Remove the cooling fan shroud-to-radiator mounting bolts.

(9) Using a 36 mm wrench, remove viscous fan/drive assembly. **The fan hub and nut have left hand threads.** Remove the cooling fan and shroud together.

(10) Disconnect the coolant recovery bottle hose from the radiator filler neck and remove bottle from fan shroud (Fig. 43).

(11) Disconnect heater core supply and return hoses from the cylinder head fitting and coolant pipe.

(12) Raise vehicle on hoist.

(13) Remove transmission and transfer case (if equipped.) Refer to Group 21, Transmission and Transfer Case for the correct procedures.

(14) Disconnect exhaust pipe from turbocharger extension pipe (Fig. 44).

(15) Remove starter motor.

(16) Disconnect A/C suction/discharge hose from the rear of the A/C compressor.

(17) Lower vehicle.

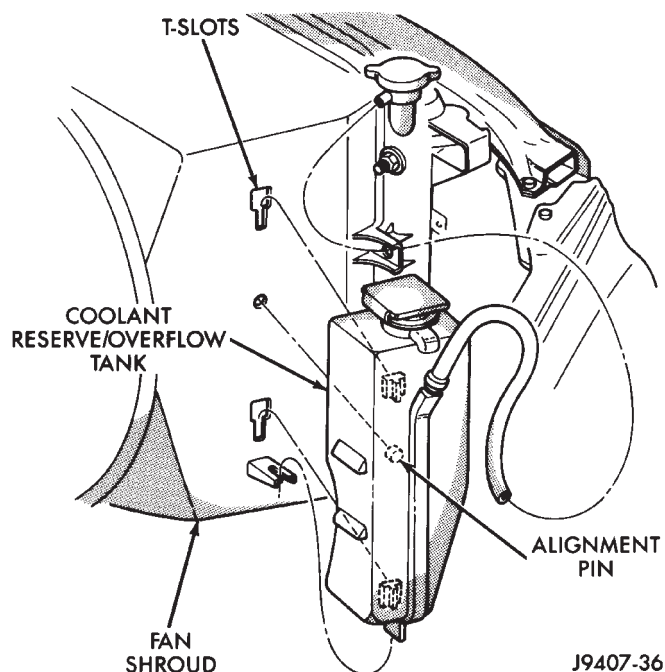
(18) Disconnect lower radiator hose from radiator outlet.

(19) **Automatic Transmission models:** Disconnect transmission oil cooler lines from radiator using special tool #6931.

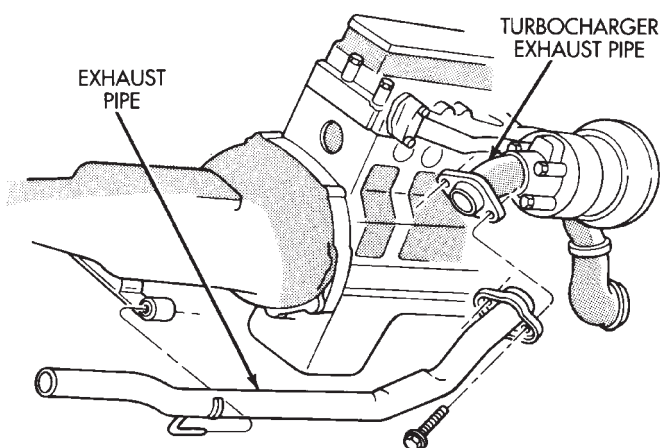
(20) Remove radiator mounting screws and lift radiator out of engine compartment.

(21) Remove upper radiator support panel.

## REMOVAL AND INSTALLATION (Continued)



J9407-36

**Fig. 43 Coolant Recovery Bottle**

J9411-18

**Fig. 44 Exhaust Pipe Connection at Turbocharger**

(22) Remove front bumper assy. Refer to Group 13, Frame and Bumpers for the correct procedure.

(23) If A/C equipped, disconnect A/C condenser refrigerant lines. Refer to Group 24, Heating and Air Conditioning for the correct procedures.

(24) Disconnect charge air cooler piping.

(25) Remove the two charge air cooler mounting bolts.

(26) Remove charge air cooler (and A/C condenser if equipped) from vehicle.

(27) Disconnect engine block heater connector.

(28) Disconnect A/C compressor electrical connectors.

(29) Remove the passenger battery ground cable from the engine block.

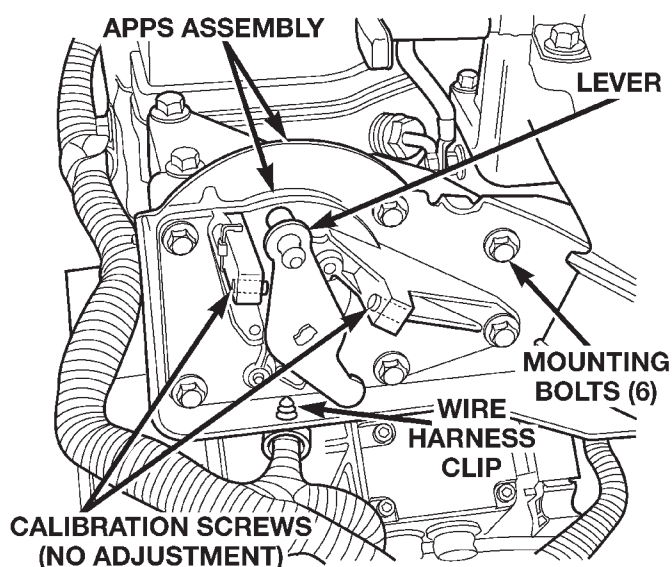
(30) Disconnect power steering pump pressure and return lines.

(31) Remove accelerator linkage cover.

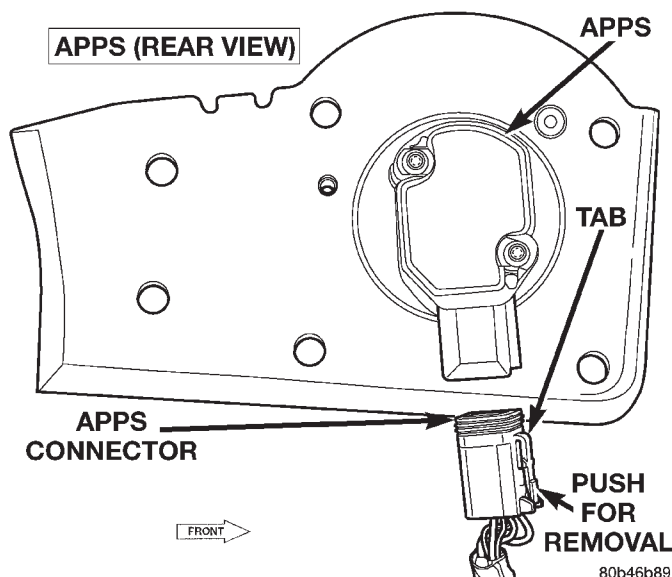
(32) Leaving all cables attached, remove accelerator pedal position sensor assy. (APPS) (Fig. 45) from cylinder head bracket and secure out of the way.

(33) Disconnect APPS connector (Fig. 46).

(34) Disconnect vacuum pump supply hose (Fig. 47).



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**Fig. 45 APPS Assembly**

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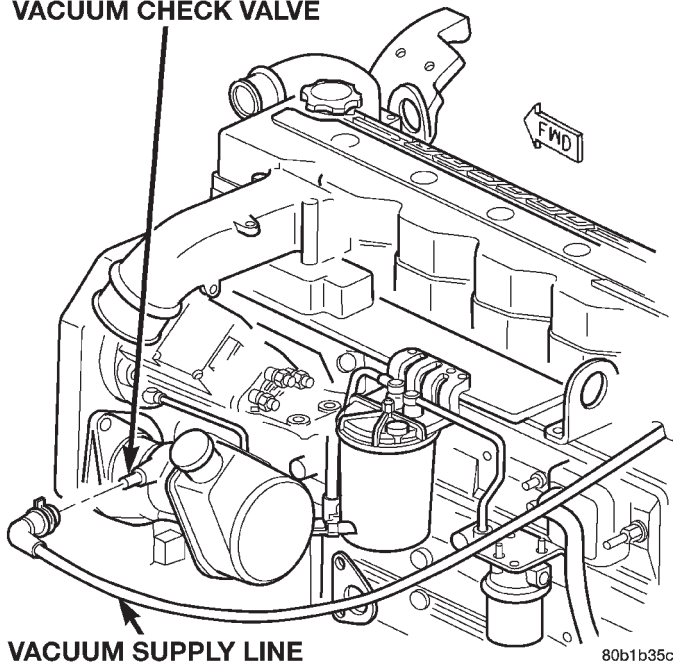
**Fig. 46 APPS Connector**

(35) Disconnect the engine harness and ground cable from the PDC.

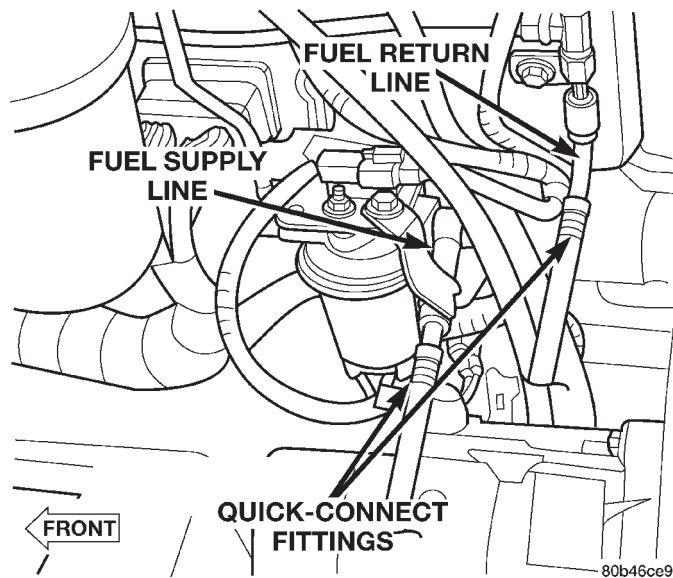
(36) Disconnect the fuel supply and return hoses (Fig. 48).

(37) Remove the cylinder head cover.

## REMOVAL AND INSTALLATION (Continued)

**VACUUM CHECK VALVE****Fig. 47 Vacuum Pump Supply Hose**

(38) Remove the #5 and #6 cylinder intake and exhaust rocker arms and pedestals (Fig. 49). Note the original location for re-assembly.

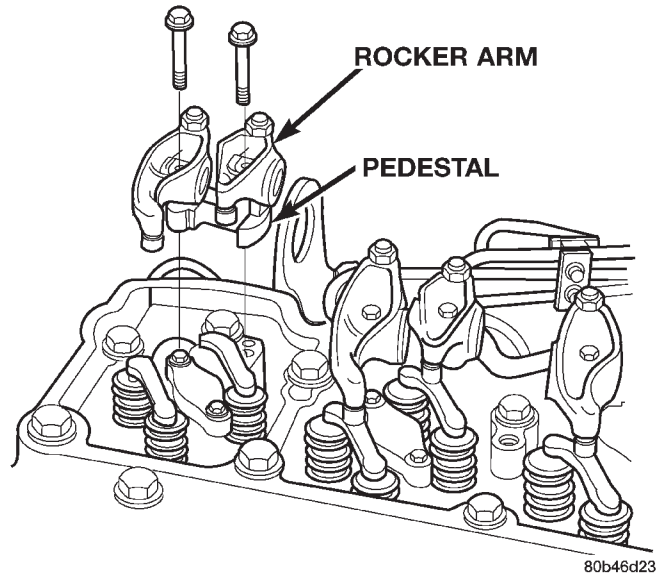
**Fig. 48 Fuel Return and Supply Line Quick-Connect Locations**

(39) Loosen but do not remove engine mount through bolts and nuts.

(40) Attach chain across engine lift brackets.

(41) Lift engine up and out of engine compartment.

(42) Install engine to suitable engine stand.

**Fig. 49 Rocker Arm and Pedestal—Removal/Installation****INSTALLATION**

(1) Install the engine with the cylinder head cover and the #5 and 6 rocker arm assemblies removed.

(2) Lower the engine into the compartment and install the engine mount through bolts and nuts.

(3) Tighten the mount through bolts and nuts to 88 N·m (65 ft. lbs.) torque.

(4) Remove the engine lifting device.

(5) Install the #5 and #6 rocker arms and pedestals in their original locations (Fig. 49). Torque the mounting bolts to 36 N·m (27 ft. lbs.) torque.

(6) Install the cylinder head cover and gasket. Tighten the bolts to 24 N·m (18 ft. lbs.) torque.

(7) Connect the fuel supply and return hoses (Fig. 48). Refer to Group 14, Fuel System for the correct procedure.

(8) Connect the engine harness connector and ground cable to the PDC.

(9) Connect the vacuum pump supply hose.

(10) Connect the APPS connector (Fig. 46).

(11) Install the APPS assembly bracket to the cylinder head bracket.

(12) Install the throttle linkage cover.

(13) Connect the power steering pressure and return lines.

(14) Connect the passenger battery ground cable to the engine block. Tighten the bolt to 77 N·m (57 ft. lbs.) torque.

(15) Connect the engine block heater connector.

(16) Connect the a/c compressor electrical connectors.

(17) Install the charge air cooler and a/c condenser (if a/c equipped). Install and tighten the charge air cooler mounting bolts to 2 N·m (17 in. lbs.) torque.



## REMOVAL AND INSTALLATION (Continued)

(18) Connect the charge air cooler piping. Torque all clamps to 8 N·m (72 in. lbs.) torque.

(19) Connect the a/c refrigerant lines to the a/c condenser (if equipped). Refer to Group 24, Heating and Air Conditioning for the correct procedures.

(20) Install the front bumper assy. Refer to Group 13, Frame and Bumpers for the correct procedure.

(21) Install the radiator upper support panel.

(22) Install the radiator and tighten the mounting bolts to 11 N·m (95 in. lbs.) torque.

(23) Connect the transmission quick-connect oil cooler lines to the radiator. Push together until an audible "click" is heard. Verify connection by pulling apart.

(24) Raise vehicle.

(25) Connect a/c compressor suction/discharge hose (if a/c equipped). Refer to Group 24, Heating and Air Conditioning for the correct procedure.

(26) Install the radiator lower hose and clamps.

(27) Install the starter motor and connect the wires. Refer to Group 8B, Starting Systems for the correct procedures.

(28) Install the transmission and transfer case (if equipped). Refer to Group 21, Transmission and Transfer Case for the correct procedures.

(29) Connect the exhaust pipe to the turbocharger elbow (Fig. 44). Torque the bolts to 34 N·m (25 ft. lbs.) torque.

(30) Connect the transmission auxiliary oil cooler lines (if equipped).

(31) Lower the vehicle

(32) Connect the heater core supply and return hoses.

(33) Install the cooling fan and shroud at the same time. Tighten the fan nut to 57 N·m (42 ft. lbs.) torque. Tighten the fan shroud to radiator bolts to 11 N·m (95 in. lbs.) torque.

(34) Install the coolant recovery bottle to the fan shroud (Fig. 43) and connect the hose to the radiator filler neck.

(35) Install the windshield washer bottle to the fan shroud and connect the pump supply hose and electrical connections.

(36) Install the radiator upper hose and clamps.

(37) Change oil filter and install new engine oil.

(38) Fill cooling system with coolant.

(39) Connect battery negative cables.

(40) Perform the fuel line air bleed procedure. Refer to Group 14, Fuel System for the correct procedure.

(41) Start engine and inspect for engine oil, coolant, and fuel leaks.

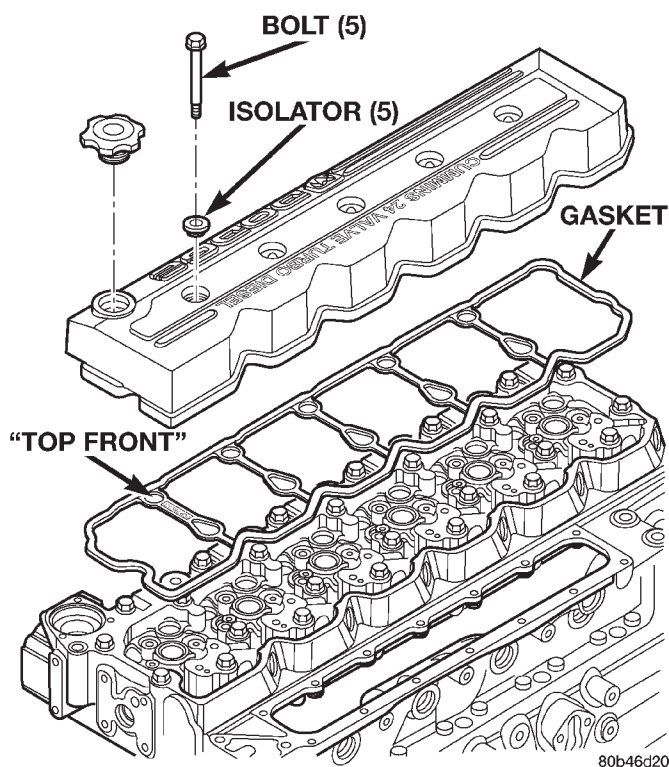
## CYLINDER HEAD COVER

## REMOVAL

(1) Disconnect both battery negative cables.

(2) Loosen the five (5) cylinder head cover bolts (Fig. 50). Remove the front three bolts and leave the rear two bolts in the cover.

(3) Lift cover off of cylinder head.



**Fig. 50 Cylinder Head Cover and Gasket**

## CLEANING

Using a suitable solvent, Clean and dry gasket mating surfaces on cylinder head and cover. Wipe gasket dry and inspect for re-use.

## INSPECTION

**The cylinder head cover gasket and isolators are reusable.** However, should cracks be present in the rubber/silicone construction, the defective components should be replaced.

## INSTALLATION

(1) Install the gasket as shown in (Fig. 50). Make sure the gasket is properly located around the cylinder head bolts, with the words "top front" facing up and towards front of engine.

(2) Place two bolts and isolators into the rear two mounting holes and install the cover.

(3) Install the remaining bolts and isolators. Starting with the center bolt, torque in a circular pattern to 24 N·m (18 ft. lbs.).

(4) Connect both battery negative cables.



## REMOVAL AND INSTALLATION (Continued)

## ROCKER ARMS, CROSSHEADS, AND PUSH RODS

## REMOVAL

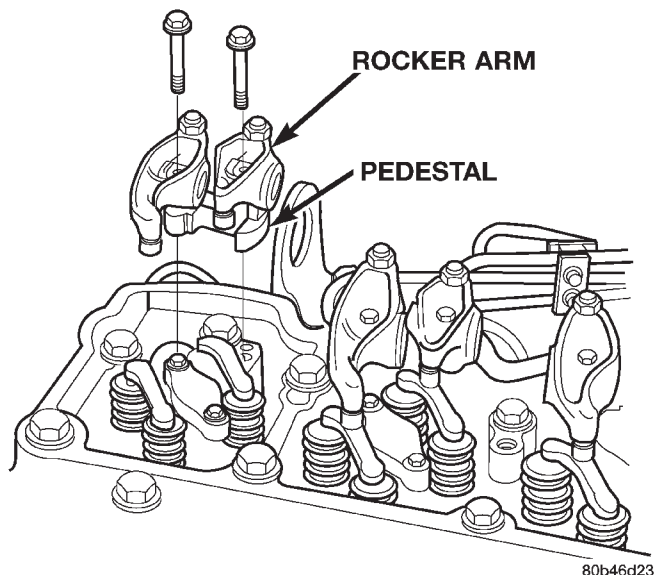
- (1) Disconnect the battery negative cables.
- (2) Remove cylinder head cover (Fig. 51). Refer to procedure in this group.
- (3) Remove the rocker arm/pedestal fasteners (Fig. 52) and remove rocker arm and pedestal from cylinder head. Mark the arms and pedestals so they can be installed in their original position.

**CAUTION:** When removing the rocker arms, the sockets (Fig. 53) may come loose and fall into the engine. Make sure they stay with the arm upon removal/installation.

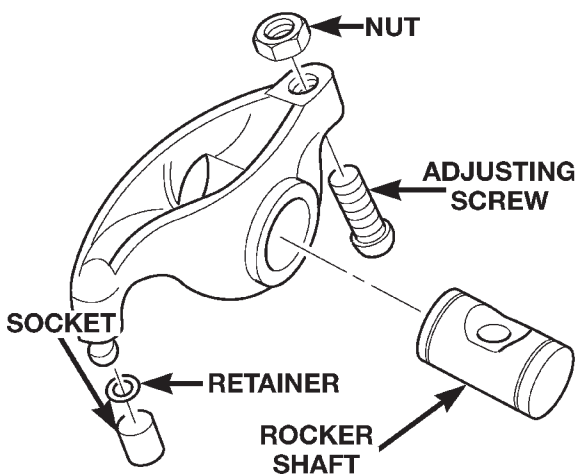
- (4) Lift the push rod(s) up and out of the engine (Fig. 54). Mark them so they can be installed in their original position.

**NOTE:** The #5 cyl. exhaust and #6 cyl. intake and exhaust push rods must be raised through the provided cowl panel access holes.

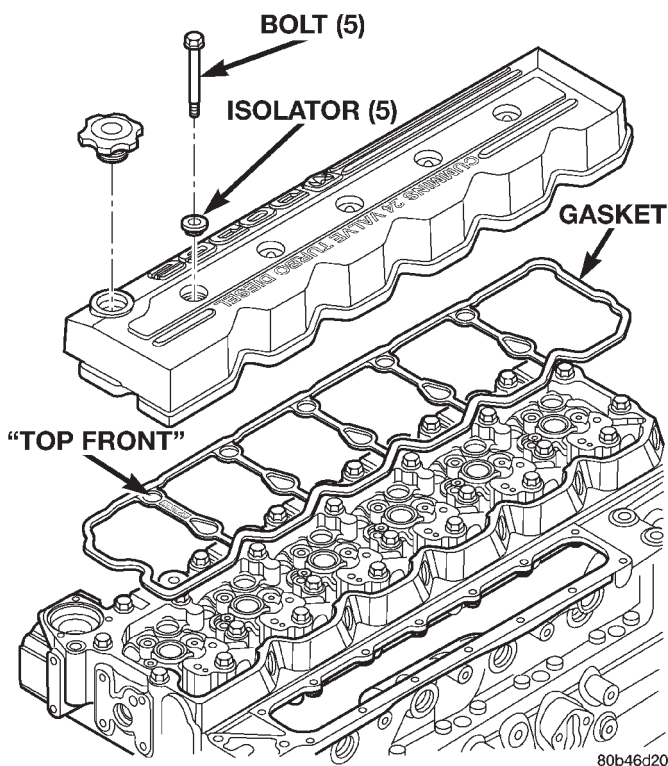
- (5) Lift the crosshead(s) off of the valve stems. Mark them so they can be installed in their original position.



**Fig. 52 Rocker Arms and Pedestals—Removal/Installation**



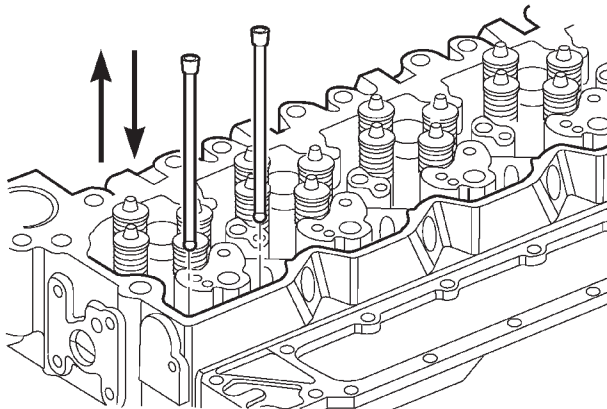
**Fig. 53 Rocker Arm Assembly Identification**



**Fig. 51 Cylinder Head Cover—Removal/Installation**

## CLEANING

Clean all components in a suitable solvent. If necessary, use a wire brush or wheel to remove stubborn



**Fig. 54 Push Rod Removal/Installation**

## REMOVAL AND INSTALLATION (Continued)

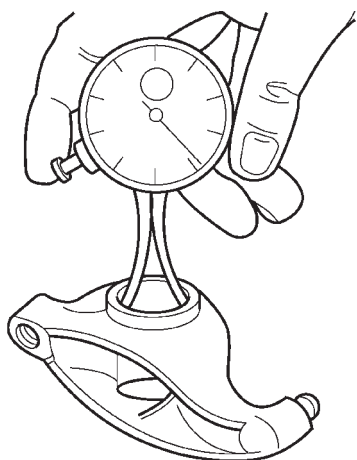
deposits. Rinse in hot water and blow dry with compressed air. Inspect oil passages in rocker arms and pedestals. Apply compressed air to lubrication orifices to purge contaminants.

## INSPECTION

## Rocker Arms

(1) Remove rocker shaft and inspect for cracks and excessive wear in the bore or shaft. Remove socket and inspect ball insert and socket for signs of wear. Replace retainer if necessary.

Measure the rocker arm bore and shaft (Fig. 55)(Fig. 56).

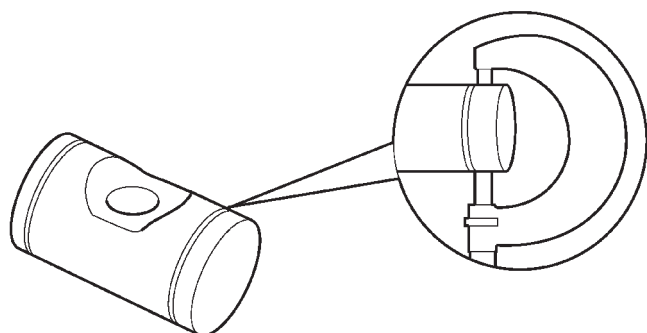


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Fig. 55 Measuring Rocker Arm Bore

## ROCKER ARM BORE (MAX.)

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 22.027 mm (.867 in.)


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Fig. 56 Measuring Rocker Arm Shaft

## ROCKER ARM SHAFT (MIN.)

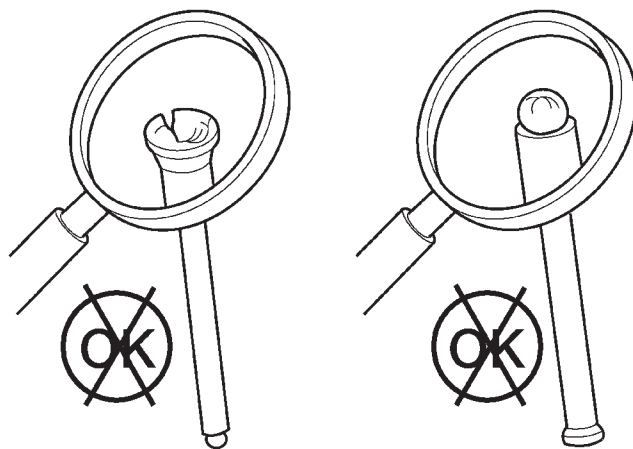
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 21.965 mm (.865 in.)

## Push Rods

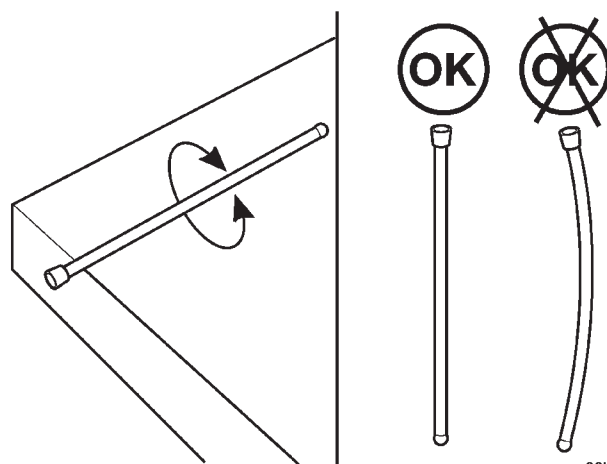
Inspect the push rod ball and socket for signs of scoring. Check for cracks where the ball and the socket are pressed into the tube (Fig. 57).

Roll the push rod on a flat work surface with the socket end hanging off the edge (Fig. 58). Replace any push rod that appears to be bent.



80b4fa24

Fig. 57 Inspecting Push Rod for Cracks



80b4fa23

Fig. 58 Inspecting Push Rod for Flatness

## Crossheads

Inspect the crossheads for cracks and/or excessive wear on rocker lever and valve tip mating surfaces (Fig. 59).

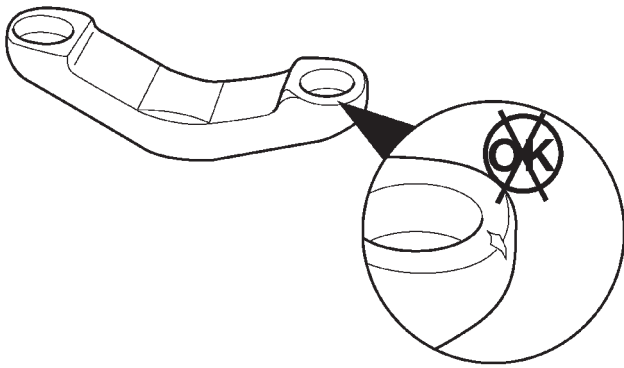
## INSTALLATION

(1) If previously removed, install the push rods in their original location (Fig. 54). **Verify that they are seated in the tappets.**

(2) Lubricate the valve tips and install the crossheads in their original locations.

(3) Lubricate the crossheads and push rod sockets and install the rocker arms and pedestals (Fig. 52) in their original locations. Tighten bolts to 36 N·m (27 ft. lbs.) torque.

## REMOVAL AND INSTALLATION (Continued)



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**Fig. 59 Inspecting Crosshead for Cracks**

(4) **Verify valve lash adjustment. Refer to Valve Lash Verification/Adjustment in Service Procedures.**

(5) Install cylinder head cover and reusable gasket (Fig. 51). Torque bolts to 24 N·m (18 ft. lbs.).

(6) Connect battery negative cables.

**VALVE SPRINGS AND SEALS (IN VEHICLE)****REMOVAL**

(1) Disconnect the battery negative cables.

(2) Remove the cylinder head cover (Fig. 61).

(3) Remove the rocker arms and crossheads (Fig. 62) from the cylinder(s) to be serviced. Mark each component so they can be installed in their original position.

(4) Remove the fuel pump gear access cover (Fig. 64).

(5) Using the crankshaft barring tool #7471B (Fig. 60), rotate the engine to line up the mark on the pump gear with the TDC mark on the cover. **At this engine position, cylinders #1 and #6 can be serviced.**

(6) Remove the accessory drive belt. Refer to Group 7, Cooling for the correct procedure.

(7) With the fuel injection pump gear mark aligned at TDC, add a paint mark anywhere on the gear housing cover next to the crankshaft damper. Place another mark on the vibration damper in alignment with the mark you just made on the cover.

(8) Divide the crankshaft damper into three equally sized segments as follows:

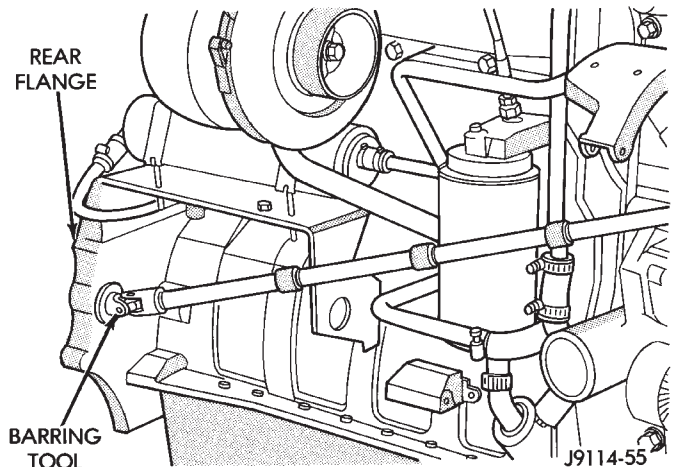
(a) Using a tape measure, measure the circumference of the crankshaft damper and divide the measurement by three (3).

(b) Measure that distance in a counter-clockwise direction from the first balancer mark and place another mark on the balancer.

(c) From the second damper mark, again measure in a counter-clockwise direction and place a

mark on the damper at the same distance you measured when placing the second damper mark.

The damper should now be marked in three equally spaced locations and the fuel pump gear mark should still be aligned with the TDC mark on the cover.

**Fig. 60 Rotating Engine with Barring Tool**

(9) Compress the valve springs at cyls. #1 and #6 as follows:

(a) Remove the injector clamp (Fig. 63) from the cylinder(s) to be serviced. **Do not remove the bolt shown in (Fig. 63).**

(b) Install the valve spring compressor mounting base as shown in (Fig. 65). Reinstall the injector clamp bolt finger tight.

(c) Install the top plate, washer, and nut. Using a suitable wrench tighten the nut (clock-wise) (Fig. 66) to compress the valve springs and remove the collets.

(d) Rotate the compressor nut counter-clockwise to relieve tension on springs. Remove spring compressor.

(e) Remove and replace retainers, springs, and seals as necessary.

(f) **Do not rotate the engine until the springs and retainers are re-installed.**

(g) Install seals, springs and retainers. Install spring compressor, compress valve springs and install the collets.

(h) Release the spring tension and remove the compressor. Verify that the collets are seated by tapping on the valve stem with a plastic hammer.

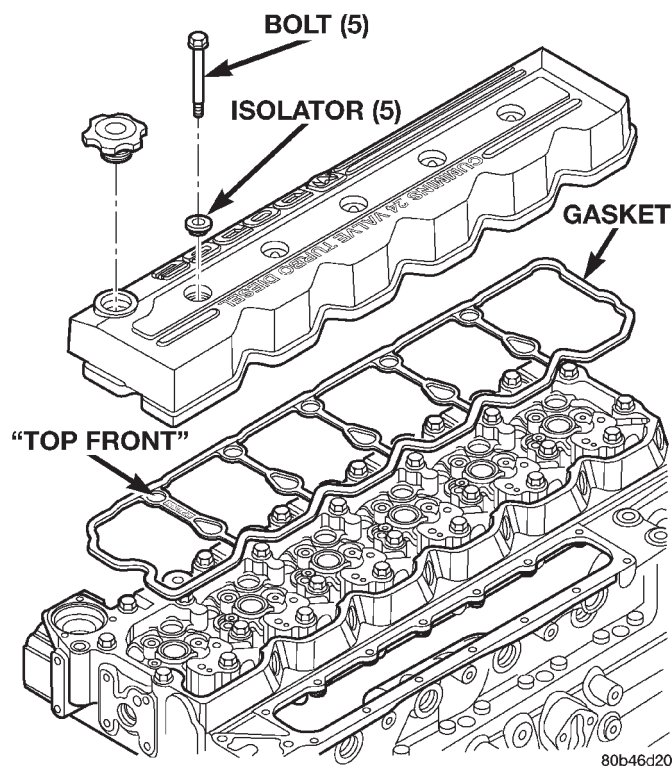
(10) Using the crankshaft barring tool, rotate the engine clockwise until the next crankshaft damper paint mark aligns with the mark you placed on the cover. **In this position, cylinders #2 and #5 can be serviced.**

(11) Repeat the valve spring compressing procedure previously performed and service the retainers, springs, and seals as necessary.

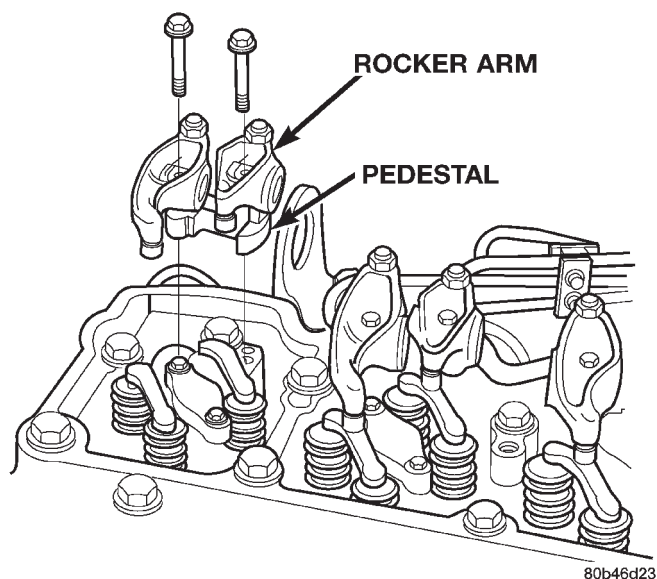
## REMOVAL AND INSTALLATION (Continued)

(12) Using the crankshaft barring tool, rotate the engine clockwise until the next crankshaft damper paint mark aligns with the mark you placed on the cover. **In this position, cylinders #3 and #4 can be serviced.**

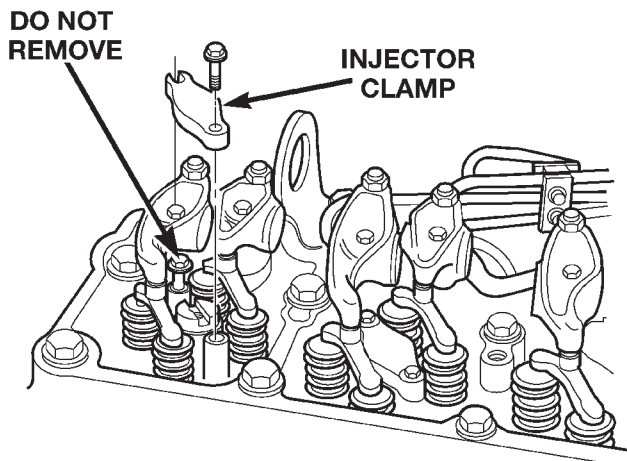
(13) Repeat the spring compressing procedure previously performed and service the retainers, springs, and seals as necessary.



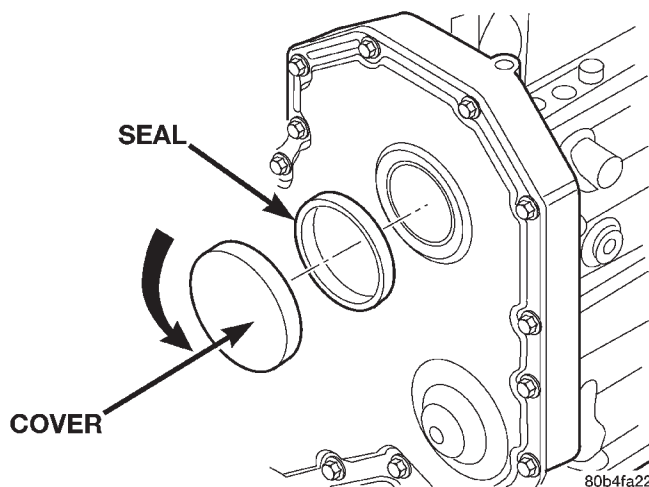
**Fig. 61 Cylinder Head Cover Removal/Installation**



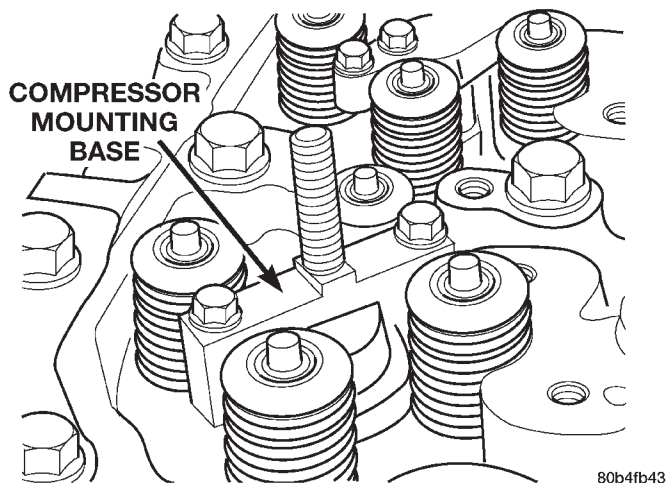
**Fig. 62 Rocker Arm and Crosshead Removal/Installation**



**Fig. 63 Injector Clamp Removal/Installation**



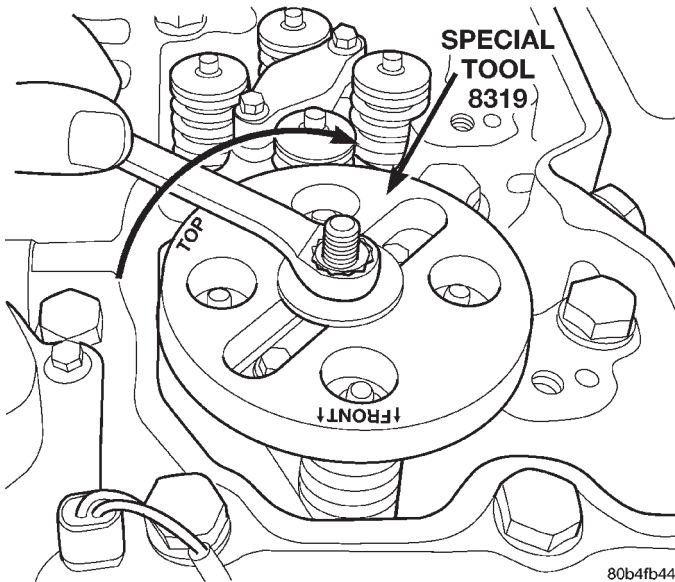
**Fig. 64 Fuel Pump Gear Access Cover**



**Fig. 65 Spring Compressor Mounting Base—Part of Tool 8319**



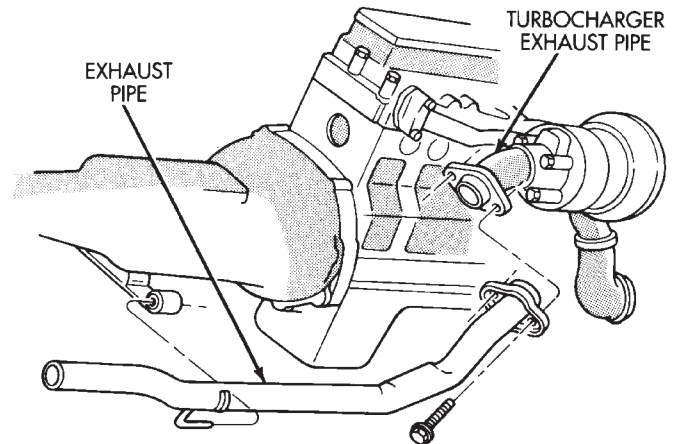
## REMOVAL AND INSTALLATION (Continued)

**Fig. 66 Compressing Valve Springs with Tool 8319****INSTALLATION**

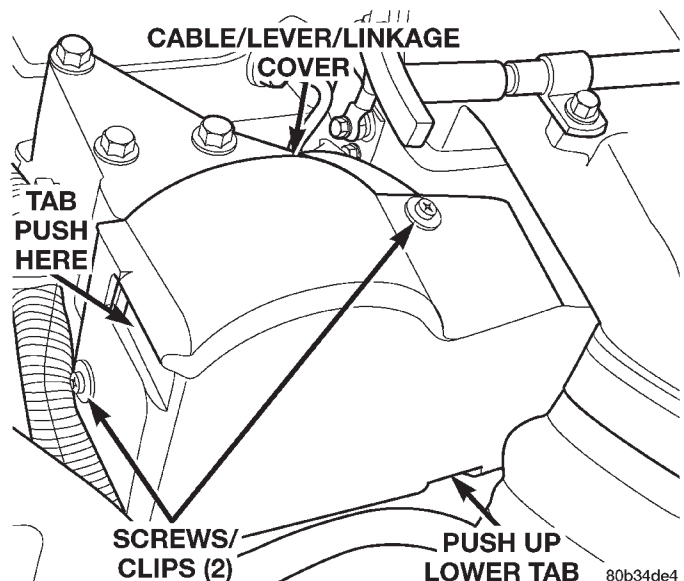
- (1) Install all injector clamps into their original location (Fig. 63). Tighten the hold down bolt to 10 N·m (89 in. lbs.) torque.
- (2) Lubricate the valve tips and install the cross-heads in their original locations .
- (3) Lubricate the crossheads and push rod sockets and install the rocker arms and pedestals in their original locations (Fig. 62). Tighten bolts to 36 N·m (27 ft. lbs.) torque.
- (4) **Verify valve lash adjustment. Refer to Valve Lash Verification/Adjustment in Service Procedures.**
- (5) Install cylinder head cover and reusable gasket (Fig. 61). Torque bolts to 24 N·m (18 ft. lbs.).
- (6) Install the accessory drive belt. Refer to Group 7, Cooling for the correct procedure.
- (7) Connect battery negative cables.

**CYLINDER HEAD ASSEMBLY****REMOVAL**

- (1) Disconnect battery negative cables.
- (2) Raise vehicle on hoist.
- (3) Drain engine coolant.
- (4) Disconnect exhaust pipe from turbocharger elbow (Fig. 67).
- (5) Lower vehicle.
- (6) Remove air cleaner housing and snorkel from the vehicle. Cap off turbocharger air inlet to prevent intrusion of dirt or foreign material.
- (7) Disconnect cab heater core supply and return hoses from the cylinder head and heater pipe.
- (8) Disconnect turbocharger oil drain tube at rubber hose connection. Cap off open ports to prevent intrusion of dirt or foreign material.

**Fig. 67 Exhaust Pipe-to-Turbocharger Elbow**

- (9) Disconnect turbocharger oil supply line at the turbocharger end. Cap off open ports to prevent intrusion of dirt or foreign material.
- (10) Remove exhaust manifold-to-cylinder head bolts and spacers. Remove exhaust manifold and turbocharger from the vehicle as an assembly.
- (11) Remove accessory drive belt. Refer to Group 7, Cooling Systems for the correct procedures.
- (12) Remove generator upper bracket.
- (13) Disconnect radiator upper hose from the thermostat housing.
- (14) Disconnect the coolant temperature sensor connector.
- (15) Remove the engine harness to cylinder head attaching bolt at front of head.
- (16) Remove the engine harness ground fastener at front of head below the thermostat housing.
- (17) Remove the throttle linkage cover (Fig. 68).

**Fig. 68 Throttle Linkage Cover**



## REMOVAL AND INSTALLATION (Continued)

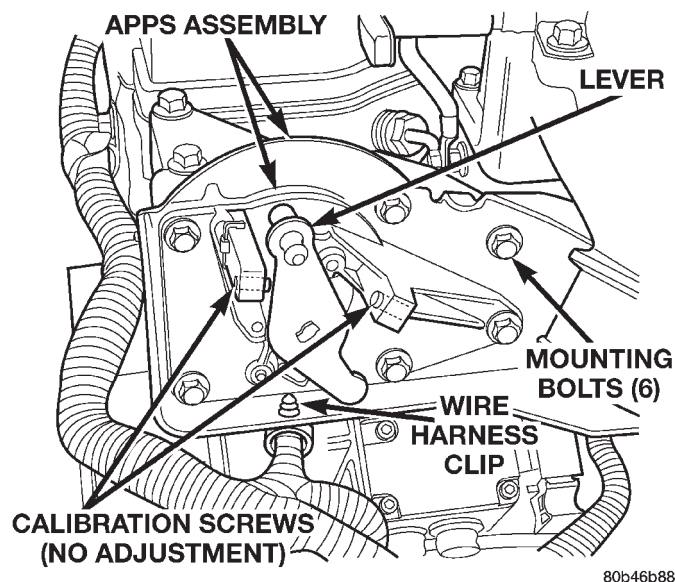


Fig. 69 APPS Assembly

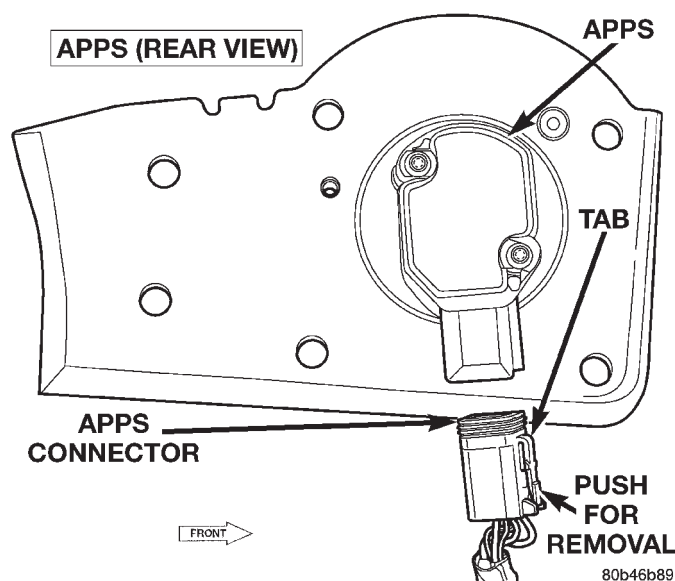


Fig. 70 APPS Connector

(18) Remove the six (6) accelerator pedal position sensor assy.-to-cylinder head bracket bolts (Fig. 69) and secure the entire assembly out of the way. Disconnect the APPS connector (Fig. 70). **It is not necessary to disconnect the cables from the throttle control assy.** Refer to Group 14, Fuel Systems for applicable cautions and warnings.

(19) Remove the intake air grid heater wires from the grid heater.

(20) Remove engine oil level indicator tube attaching bolt from the air inlet housing.

(21) Remove the charge air cooler-to-air inlet housing pipe.

(22) Remove the air inlet housing and intake grid heater from the intake manifold cover.

(23) Remove the engine lift bracket from the rear of the cylinder head.

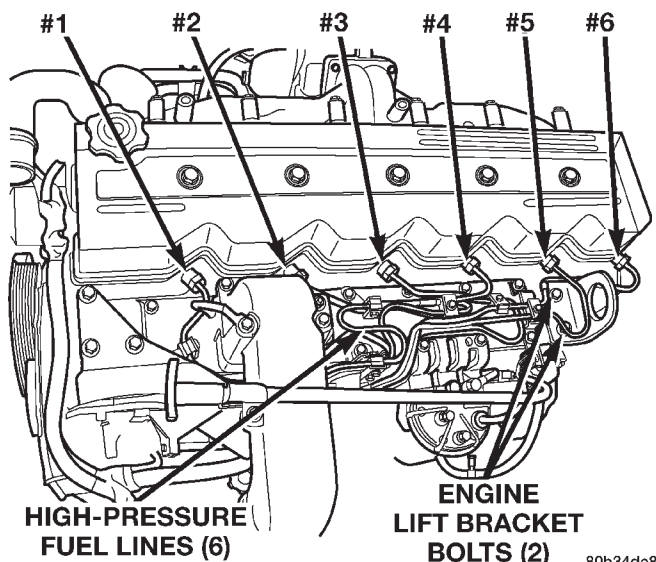


Fig. 71 High-Pressure Lines at Cylinder Head

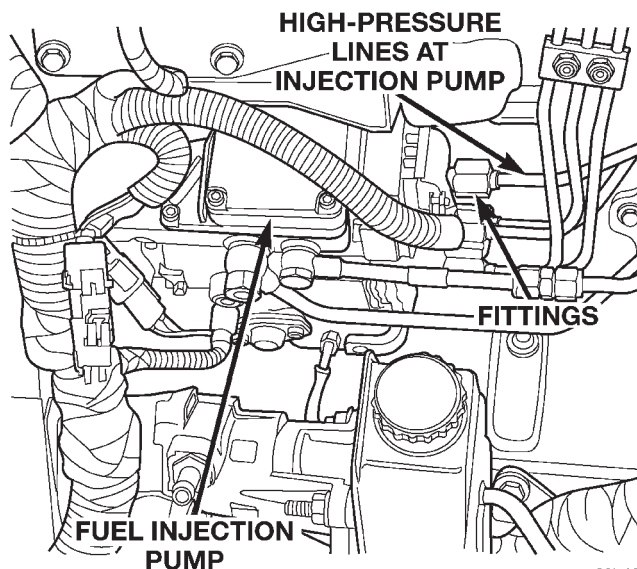


Fig. 72 High-Pressure Lines at Fuel Injection Pump

(24) Remove the high pressure fuel lines (Fig. 71)(Fig. 72) from the engine as follows:

(a) Remove all injection line-to-intake manifold cover support bracket bolts.

(b) Loosen the #1, 2, and 4 cylinder high pressure lines at the injection pump.

(c) Loosen the #1, 2, and 4 cylinder high pressure lines at the cylinder head.

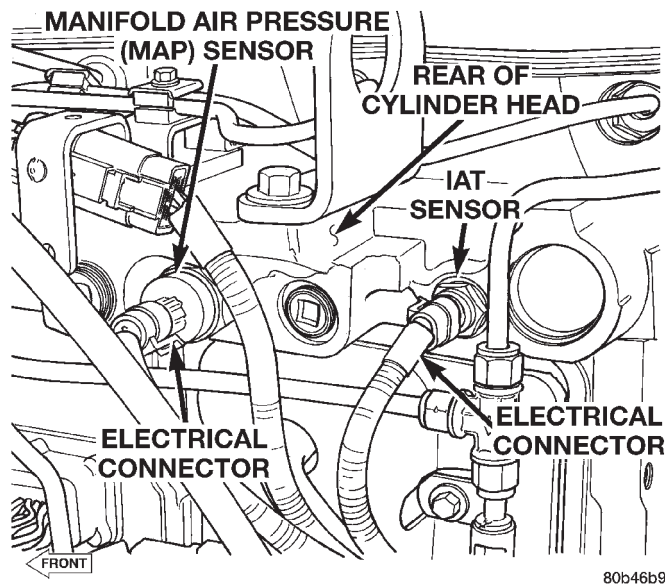
(d) Remove the #1, 2, and 4 cylinder high pressure line bundle from the engine.

(e) Loosen the #3, 5, and 6 cylinder high pressure lines at the injection pump.

## REMOVAL AND INSTALLATION (Continued)

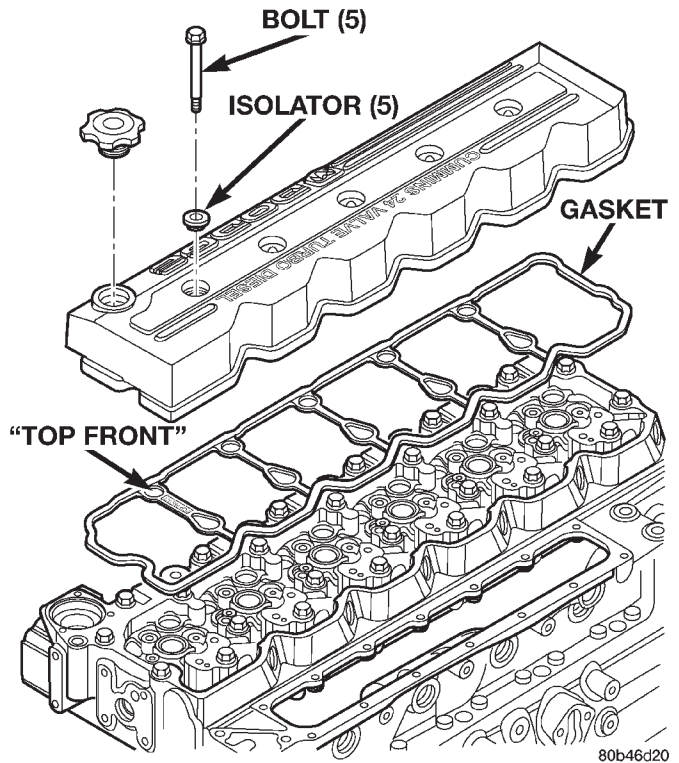
- (f) Loosen the #3, 5, and 6 cylinder high pressure lines at the cylinder head.
- (g) Remove the #3, 5, and 6 cylinder high pressure line bundle from the engine.
- (25) Remove the lift pump-to-fuel filter low pressure line.
- (26) Remove the fuel filter-to-injection pump low pressure line.
- (27) Disconnect the water-in-fuel and fuel heater connectors.
- (28) Remove the fuel filter assy.-to-manifold cover bolts and remove filter assy. from vehicle.
- (29) Disconnect the Intake Air Temperature and Manifold Air Pressure sensor connectors (Fig. 73).
- (30) Remove the cylinder head cover (Fig. 74). Refer to procedure in this group.
- (31) Remove the rocker levers (Fig. 75), cross heads and push rods (Fig. 76). Mark each component so they can be installed in their original positions.

**NOTE:** The #5 cylinder exhaust and the #6 cylinder intake and exhaust pushrods are removed by lifting them up and through the provided cowl panel access holes. Remove the rubber plugs to expose these relief holes.

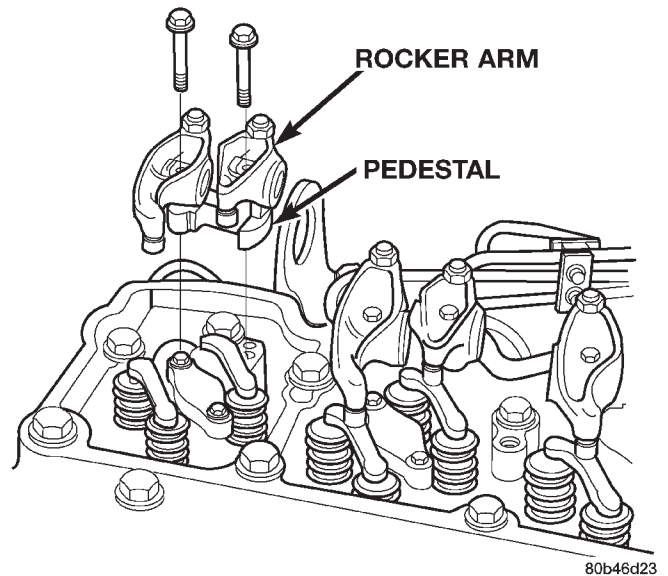


**Fig. 73 IAT and MAP Sensor Location**

- (32) Remove the fuel return line banjo bolt at the rear of the cylinder head (Fig. 77). Be careful not to drop the two (2) sealing washers.
- (33) Reinstall the engine lift bracket at the rear of cylinder head.
- (34) Remove twenty six (26) cylinder head-to-block bolts.
- (35) Attach an engine lift crane to engine lift brackets and lift cylinder head off engine and out of vehicle.



**Fig. 74 Cylinder Head Cover Removal**



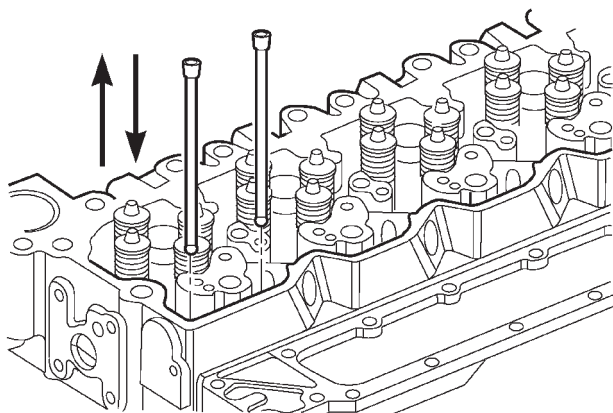
**Fig. 75 Rocker Arms and Pedestal Removal**

- (36) Remove the head gasket and inspect for failure.

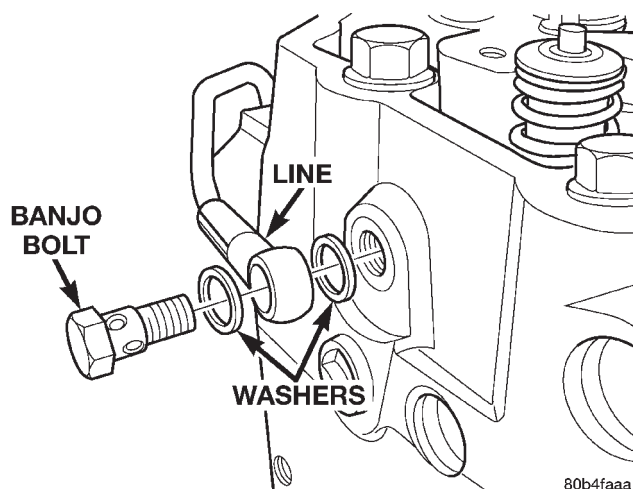
### CLEANING

Clean the cylinder head and cylinder block mating surfaces with an ordinary scraper. Remove all excess gasket material and carbon. Use a quality wire brush on stubborn areas. Inspect head bolt holes for damage and remove any foreign material.

## REMOVAL AND INSTALLATION (Continued)



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**Fig. 76 Push Rod Removal**

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**Fig. 77 Fuel Drain Fitting at Rear of Head**

Clean the cylinder head bolts with a wire brush or a soft wire wheel. Remove deposits from the shank and threads.

Remove any excess coolant, oil, or foreign material from the top of the pistons and inside the piston bowls.

**INSPECTION****CHECKING FOR CRACKS**

Inspect the cylinder head for cracks in the combustion surface. Pressure test any cylinder head that is visibly cracked. A cylinder head that is cracked between the injector bore and valve seat can be pressure tested and re-used if o.k.; however, if the crack extends **into** the valve seat, the valve seat **must** be replaced.

**SURFACE CONDITION**

Visually inspect the cylinder block and head combustion surfaces for localized dips or imperfections. Check the cylinder head and block combustion sur-

faces for overall out-of-flatness. If either the visual or manual inspection exceeds the limits, then the head or block must be surfaced.

**CYLINDER HEAD FLATNESS (MAX)**

End to End	0.305 mm (0.012 in.)
Side to Side	0.076 mm (0.003 in.)

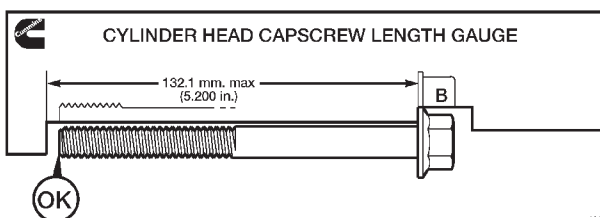
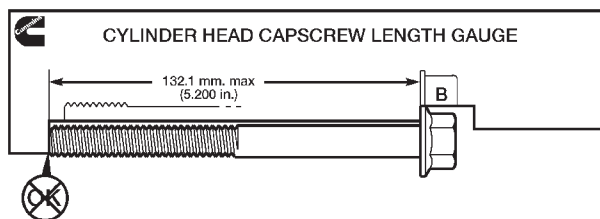
**CYLINDER BLOCK FLATNESS (MAX)**

End to End	0.075 mm (0.003 in.)
Side to Side	0.075 mm (0.003 in.)

**HEAD BOLT INSPECTION**

Visually inspect the cylinder head bolts for damaged threads, corroded/pitted surfaces, or a reduced diameter due to bolt stretching.

If the bolts are not damaged, their "free length" should be measured using the capscrew stretch gauge provided with the replacement head gasket. Place the head of the bolt against the base of the slot and align the bolt with the straight edge of gauge (Fig. 78). If the end of the bolt touches the foot of the gauge, the bolt **must** be discarded. **The maximum bolt free length is 132.1 mm (5.200 in.).**

**Fig. 78 Head Bolt Stretch Gauge**

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**INSTALLATION**

**WARNING: THE OUTSIDE EDGE OF THE HEAD GASKET IS VERY SHARP. WHEN HANDLING THE NEW HEAD GASKET, USE CARE NOT TO INJURE YOURSELF.**

(1) Install a new gasket with the part number side up, and locate the gasket over the dowel sleeves.

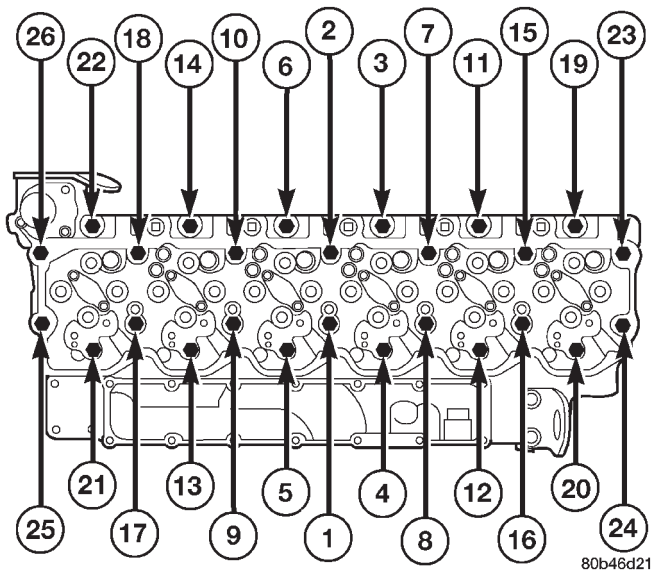
(2) Using an engine lifting crane, lower the cylinder head onto the engine.

(3) Lightly lubricate head bolts with engine oil and install. Using the sequence shown in (Fig. 79), torque bolts in the following three (3) steps:



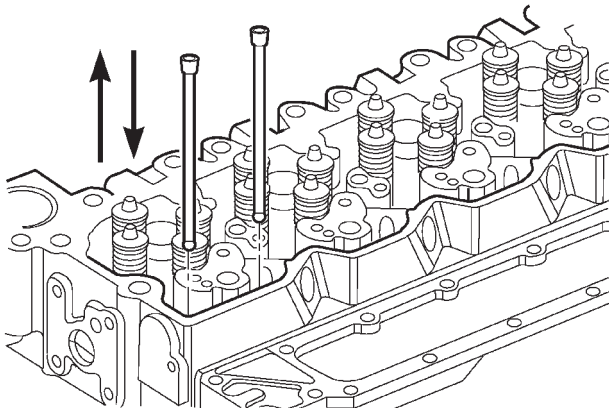
## REMOVAL AND INSTALLATION (Continued)

- (a) Torque bolts to 90 N·m (66 ft. lbs.)
- (b) Re-check all bolts to 90 N·m (66 ft. lbs.)
- (c) Torque all bolts an additional ¼ turn (90°)



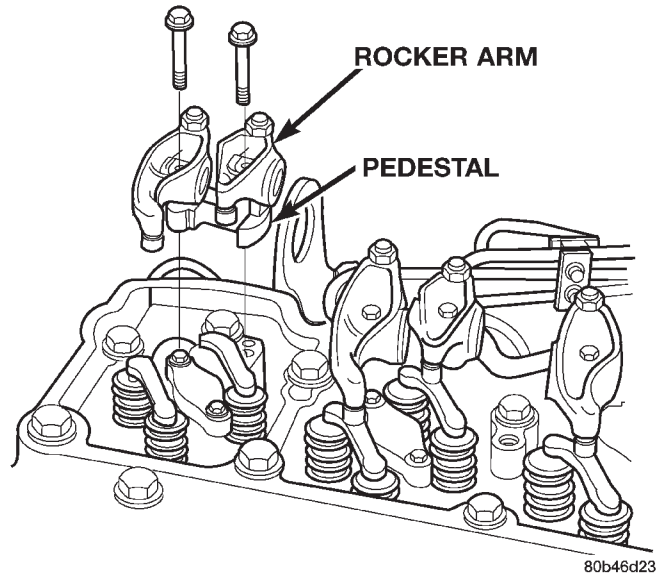
**Fig. 79 Cylinder Head Bolt Torque Sequence**

- (4) Connect fuel return line at rear of head (Fig. 77). Install both sealing washers and torque banjo bolt to 24 N·m (18 ft. lbs.).
- (5) Install push rods into their original locations (Fig. 80). **Verify that they are seated in the tappets.**
- (6) Lubricate valve stem tips and install the cross-heads in their original locations.
- (7) Lubricate the rocker arms and pedestals and install them in their original locations (Fig. 81). Install the bolts and torque them to 36 N·m (27 ft. lbs.).
- (8) Verify that the valve lash settings are maintained. Refer to Valve Lash Verification/Adjustment in the Service Procedures section of this group.
- (9) Install cylinder head cover (Fig. 82). Refer to procedure in this group.

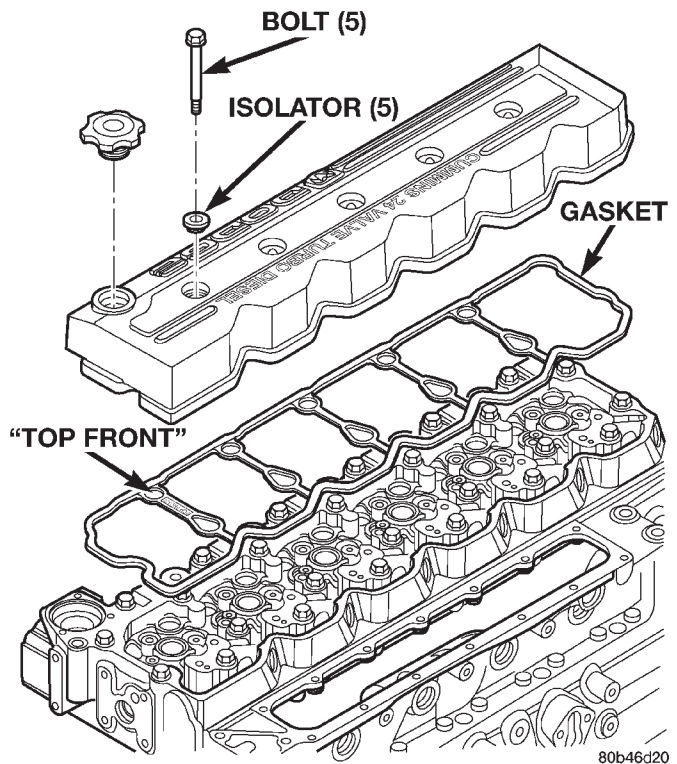


**Fig. 80 Push Rod Installation**

- (10) Connect the IAT and MAP sensor connectors.



**Fig. 81 Rocker Arms and Pedestal Installation**



**Fig. 82 Cylinder Head Cover Installation**

- (11) Install the fuel filter canister assy. and torque mounting bolts to 24 N·m (18 ft. lbs.).
- (12) Connect the lift pump to fuel filter low pressure line. Torque fittings to 24 N·m (18 ft. lbs.).
- (13) Connect the Water-in-Fuel and Fuel Heater Element connectors at the filter assy.
- (14) Remove the engine lift bracket at rear of cylinder head.
- (15) **Install the high pressure fuel lines (Fig. 71)(Fig. 72) as follows:**

## REMOVAL AND INSTALLATION (Continued)

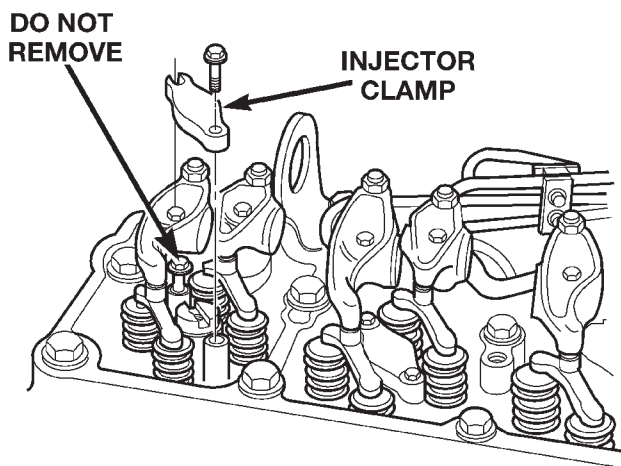
- (a) Lubricate the threads (both ends) of the high pressure line nuts with diesel fuel or engine oil.
- (b) Install the rear line bundle (cyls. #3,5, and 6), and tighten the threads at the head and pump by hand.
- (c) Torque the connections at the cylinder head first. Torque connections to 40 N·m (30 ft. lbs.).
- (d) Torque the line connections at the injection pump to 24 N·m (18 ft. lbs.).
- (e) Install the front line bundle (cyls. #1,2, and 4) following the same procedure used for the rear line bundle.
- (f) Torque the connections at the cylinder head first. Torque connections to 40 N·m (30 ft. lbs.).
- (g) Torque the line connections at the injection pump to 24 N·m (18 ft. lbs.).
- (h) Install the injection line support bracket to intake cover/cylinder head bolts and torque to 24 N·m (18 ft. lbs.).
- (16) Install the engine lift bracket at the rear of cylinder head.
- (17) Install the fuel filter to injection pump low pressure line. Inspect and replace sealing washers if necessary. Torque banjo bolts to 24 N·m (18 ft. lbs.).
- (18) Using new gaskets, install the intake grid heater and air inlet housing. Torque bolts to 24 N·m (18 ft. lbs.).
- (19) Connect the APPS connector (Fig. 70).
- (20) Install the APPS assy. to the cylinder head bracket and torque bolts to 12 N·m (105 in. lbs.).
- (21) Install the throttle linkage cover (Fig. 68).
- (22) Install the charge air cooler-to-air inlet housing duct assy. Torque all clamps to 8 N·m (71 in. lbs.).
- (23) Connect intake grid heater wires.
- (24) Fasten engine harness to front of cylinder head with bolt.
- (25) Install engine harness ground wire and torque bolt to 24 N·m (18 ft. lbs.).
- (26) Connect engine coolant temperature sensor connector.
- (27) Connect radiator upper hose to thermostat housing.
- (28) Install generator upper bracket and torque bolts to 41 N·m (31 ft. lbs.).
- (29) Install accessory drive belt. Refer to Group 7, Cooling System for the correct procedure.
- (30) Install exhaust manifold/turbocharger assy. and start all bolts/spacers by hand. Torque bolts to 43 N·m (32 ft. lbs.).
- (31) Connect turbocharger oil drain tube.
- (32) Perform the turbocharger pre-lube procedure. Refer to Group 11, Exhaust System and Turbocharger for the correct procedure.
- (33) Connect the turbocharger oil supply line.
- (34) Install air cleaner housing and duct.

- (35) Raise vehicle on hoist.
- (36) Install exhaust pipe to turbocharger elbow (Fig. 67). Torque bolts to 34 N·m (25 ft. lbs.).
- (37) Lower vehicle.
- (38) Add coolant.
- (39) Start engine and check for leaks.

## VALVES, SPRINGS, AND SEALS (OFF VEHICLE)

## REMOVAL

- (1) Remove cylinder head. Refer to Cylinder Head Removal and Installation in this group.
- (2) Support cylinder head on stands, or install head bolts upside down (through combustion surface side) to protect injector tips from damage from work bench.
- (3) Remove the injector clamp (Fig. 83) from the cylinder(s) to be serviced. **Do not remove the bolt shown in (Fig. 83).**
- (4) Install the valve spring compressor mounting base (special tool 8319) as shown in (Fig. 84). Reinstall the injector clamp bolt finger tight.
- (5) Install the compressor top plate, washer, and nut. Using a suitable wrench, tighten the nut (clockwise) to compress the valve springs (Fig. 85) and remove the locks.
- (6) Rotate the compressor nut counter-clockwise to relieve tension on the springs. Remove the spring compressor.
- (7) Remove the retainers, springs, valve seals (if necessary), and valves (Fig. 86). Arrange or number all components so they can be installed in their original locations.
- (8) Repeat the procedure on all cylinders to be serviced.

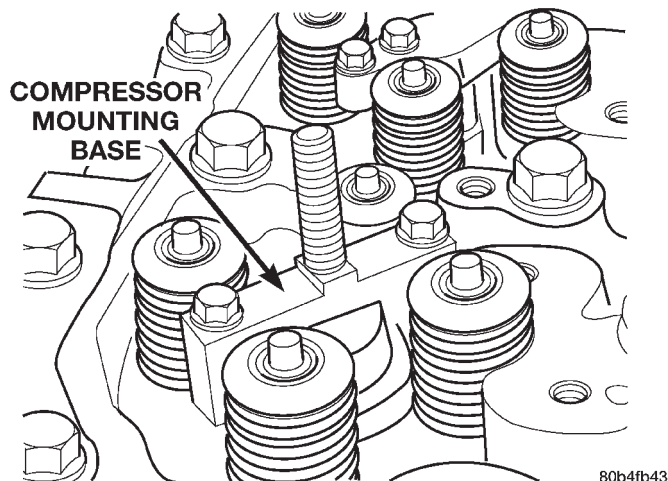


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**Fig. 83 Injector Clamp Removal/Installation**

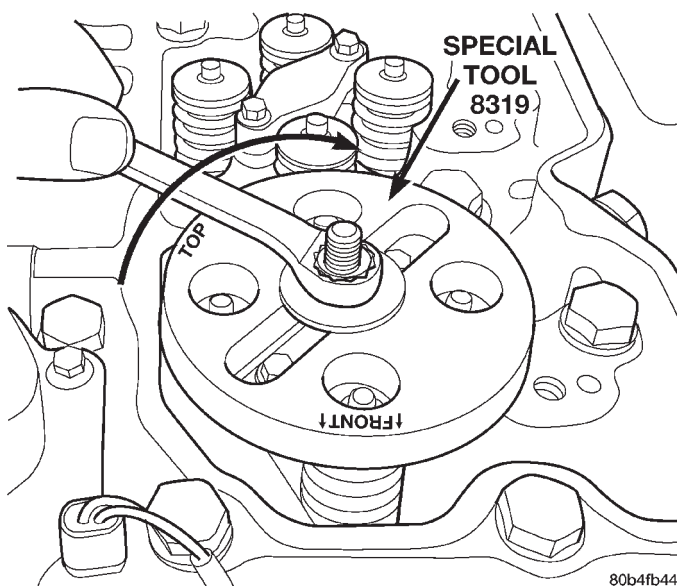


## REMOVAL AND INSTALLATION (Continued)



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**Fig. 84 Spring Compressor Mounting Base—Part of Tool 8319**



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**Fig. 85 Compressing Valve Springs with Tool 8319**

## CLEANING

Clean the valve stems with crocus cloth or a Scotch-Brite™ pad. Remove carbon with a soft wire brush. Clean valves, springs, retainers, and valve retaining locks in a suitable solvent. Rinse in hot water and blow dry with compressed air.

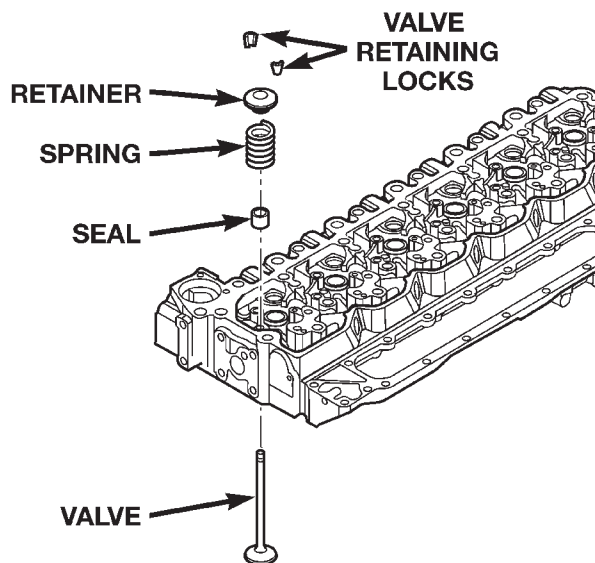
## INSPECTION

Visually inspect the valves for abnormal wear on the heads, stems, and tips. Replace any valve that is worn out or bent (Fig. 87).

Measure the valve stem diameter in three places as shown in (Fig. 88).

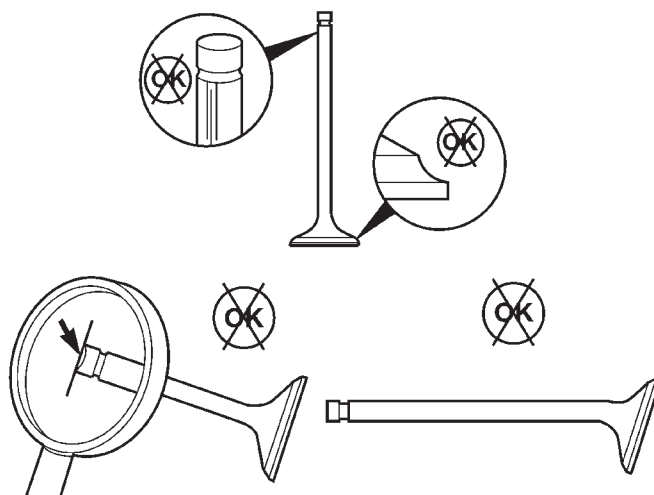
Measure the cylinder head valve guide bore (Fig. 89). Subtract the corresponding valve stem diameter to obtain valve stem-to-guide clearance.

Measure valve margin (rim thickness) (Fig. 90).



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**Fig. 86 Valve Spring, Seal, and Retainers**



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**Fig. 87 Visually Inspect Valves for Abnormal Wear**

Measure the valve spring free length and maximum inclination (Fig. 91).

Test valve spring force with tool C-647 (Fig. 92).

## INSTALLATION

(1) Install new valve seals. The yellow seals are for the intake valves and the green seals are for the exhaust valves.

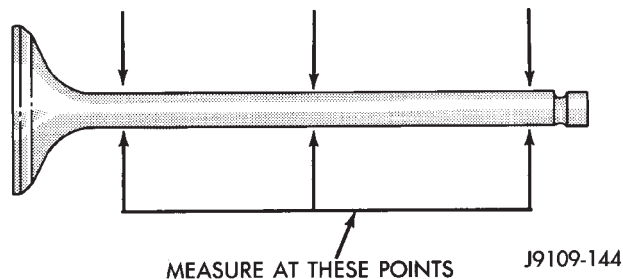
(2) Install the valves in their original position. The exhaust valves are identified by a dimple on the valve head (Fig. 93).

(3) Install the valve springs and retainer.

(4) Install the valve spring compressor tool 8319 as shown in (Fig. 84) and (Fig. 85).

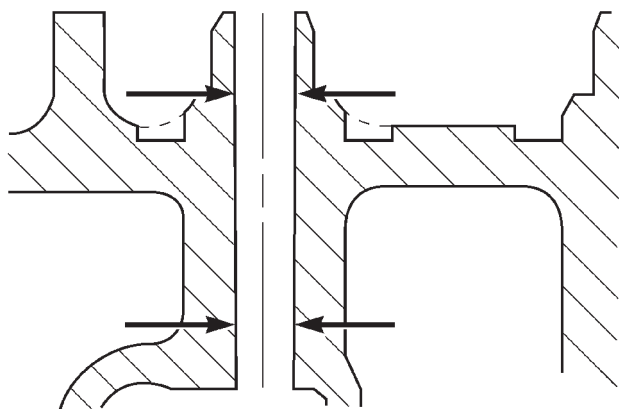
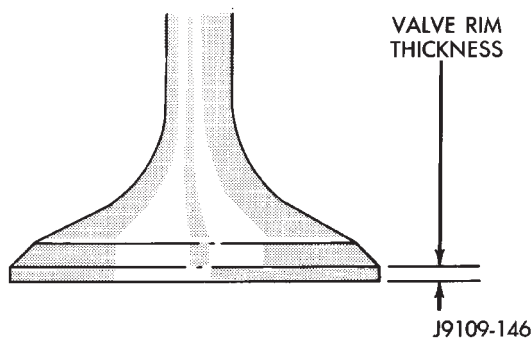
(5) Compress the valve springs and install the valve retaining locks (Fig. 86).

## REMOVAL AND INSTALLATION (Continued)

**Fig. 88 Measure Valve Stem Diameter****VALVE STEM DIAMETER**

6.990 mm (0.2752 in.) MIN

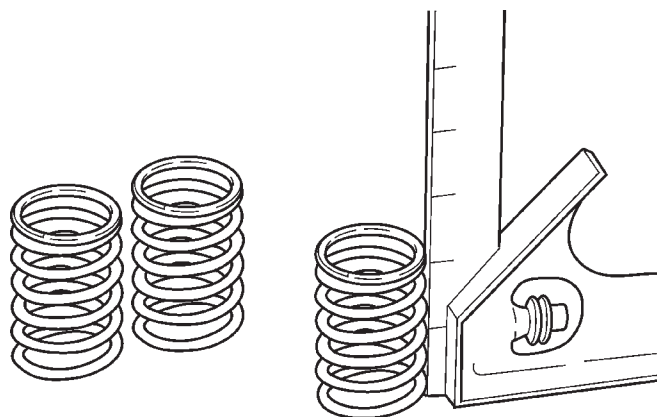
7.010 mm (0.2760 in.) MAX

**Fig. 89 Measure Valve Guide Bore****Fig. 90 Measure Valve Margin (Rim Thickness)****VALVE MARGIN (RIM THICKNESS)**

0.72 mm (0.031 in.) MIN.

(6) Remove the compressor and repeat the procedure on the remaining cylinders.

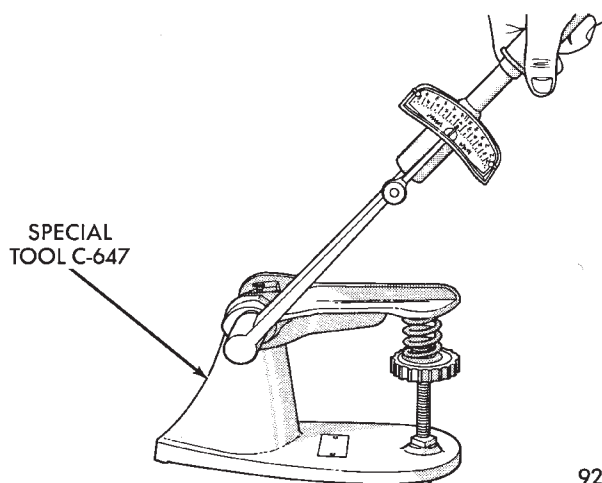
(7) Install the injector clamp and hold down bolts and tighten to 10 N·m (89 in. lbs.) torque.

**Fig. 91 Measure Valve Spring Free Length and Max. Inclination****VALVE SPRING FREE LENGTH**

47.75 mm (1.88 in.)

**MAX INCLINATION**

1.5 mm (.059 in.)

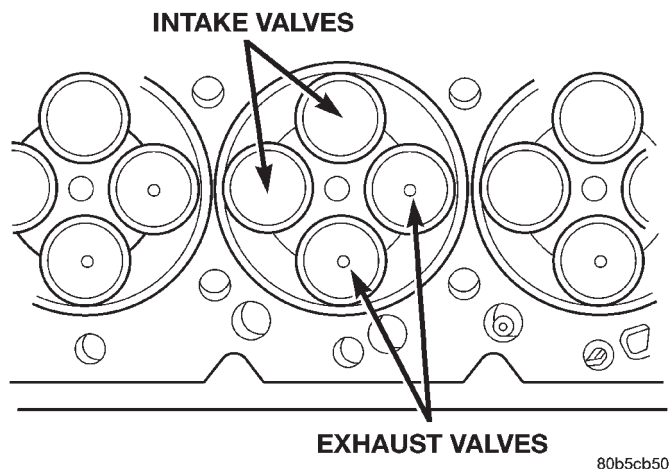
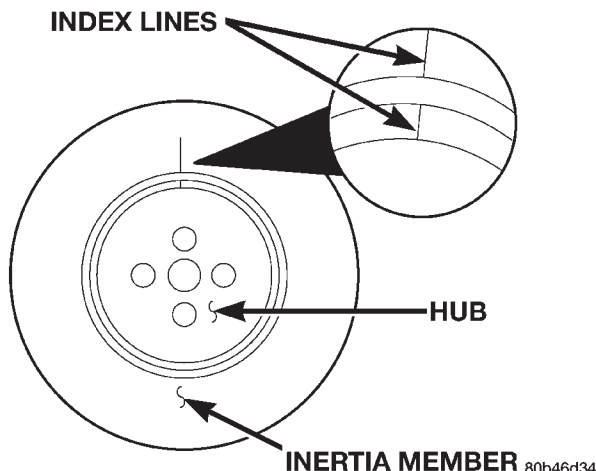
**Fig. 92 Testing Valve Spring with Tool C-647****VALVE SPRING MINIMUM LOAD**

@ 35.33 mm — 339.8 N

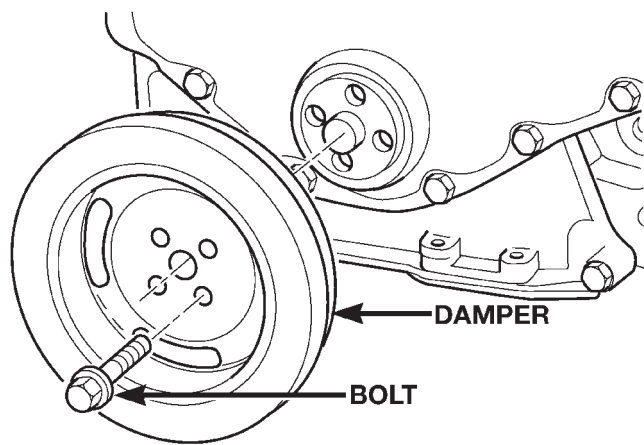
@ 1.39 in. — 76.4 lbs.

(8) Install the cylinder head. Refer to Cylinder Head Removal and Installation in this group.

## REMOVAL AND INSTALLATION (Continued)

**Fig. 93 Valve Identification****Fig. 95 Inspect Index Lines for Alignment****CRANKSHAFT DAMPER****REMOVAL**

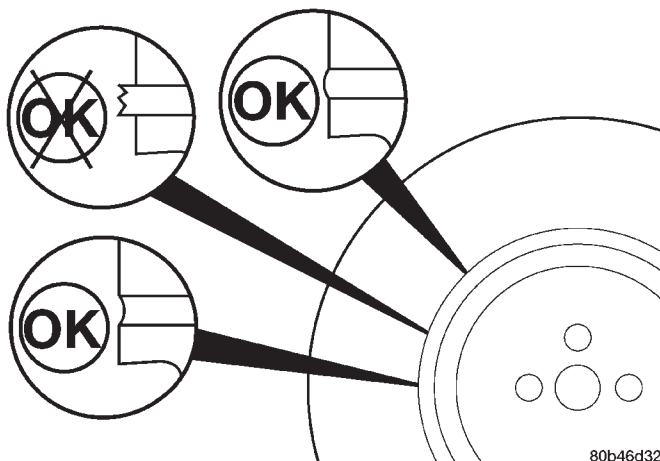
- (1) Remove the accessory drive belt. Refer to Group 7, Cooling System for the correct procedure.
- (2) Remove the four (4) damper to crankshaft bolts and remove damper (Fig. 94).

**Fig. 94 Crankshaft Damper Removal/Installation****INSPECTION**

- (1) Inspect the damper hub for cracks and replace if any are found.
- (2) Inspect the index lines on the damper hub and the inertia member (Fig. 95). If the lines are more than 1.59 mm (1/16 in.) out of alignment, replace the damper.
- (3) Inspect the rubber member for deterioration or missing segments (Fig. 96).

**INSTALLATION**

- (1) Install the crankshaft damper and bolts (Fig. 94). Tighten bolts to 125 N·m (92 ft. lbs.) torque.

**Fig. 96 Inspect Damper Rubber Member**

- (2) Install the accessory drive belt. Refer to Group 7, Cooling System for the correct belt schematic and procedure.

**CRANKSHAFT OIL SEAL—FRONT****REMOVAL**

- (1) Disconnect both battery negative cables.
- (2) Raise vehicle on hoist.
- (3) Partially drain engine coolant into container suitable for re-use.
- (4) Lower vehicle.
- (5) Remove radiator upper hose.
- (6) Disconnect coolant recovery bottle from radiator filler neck and lift bottle off of fan shroud.
- (7) Disconnect windshield washer pump supply hose and electrical connections and lift washer bottle off of fan shroud.
- (8) Remove the fan shroud-to-radiator mounting bolts.

## REMOVAL AND INSTALLATION (Continued)

(9) Remove viscous fan/drive assembly. **The fan drive nut has left handed threads.** Refer to Group 7, Cooling System for the correct procedure.

(10) Remove cooling fan shroud and fan assy. from the vehicle.

(11) Remove the accessory drive belt. Refer to Group 7, Cooling for the correct procedure.

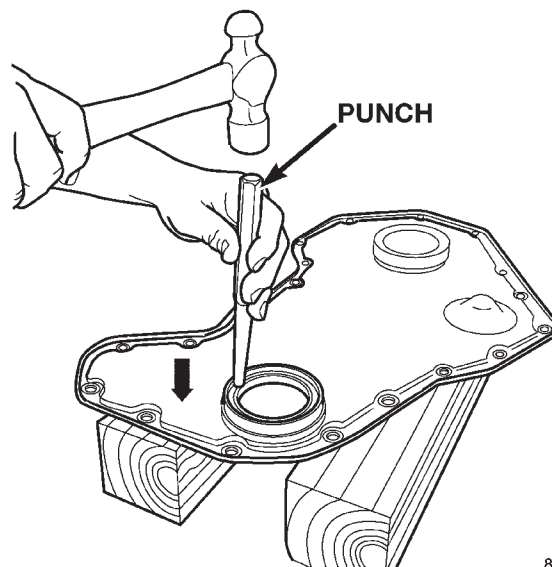
(12) Remove the cooling fan support/hub from the front of the engine (Fig. 97).

(13) Raise the vehicle on hoist.

(14) Remove the vibration damper (Fig. 98).

(15) Remove the gear cover-to-housing bolts and gently pry the cover away from the housing, taking care not to mar the gasket surfaces.

(16) Support the cover on a flat work surface with wooden blocks (Fig. 99), and using a suitable punch and hammer, drive the old seal out of the cover from the the outside of the cover (Fig. 99).



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**Fig. 99 Removing Seal from Cover**

## CLEANING

Clean cover and housing gasket mating surfaces. Use a suitable scraper and be careful not to damage the gear housing surface, since it is aluminum. Remove any old sealer from the oil seal bore. Thoroughly clean the front seal area of the crankshaft. The seal lip and the sealing surface on the crankshaft must be free from all oil residue to prevent seal leaks.

## INSPECTION

Inspect the gear housing and cover for cracks and replace if necessary. Carefully straighten any bends or imperfections in the gear cover with a ball-peen hammer on a flat surface. Inspect the crankshaft front journal for any grooves or nicks that would affect the integrity of the new seal.

## INSTALLATION

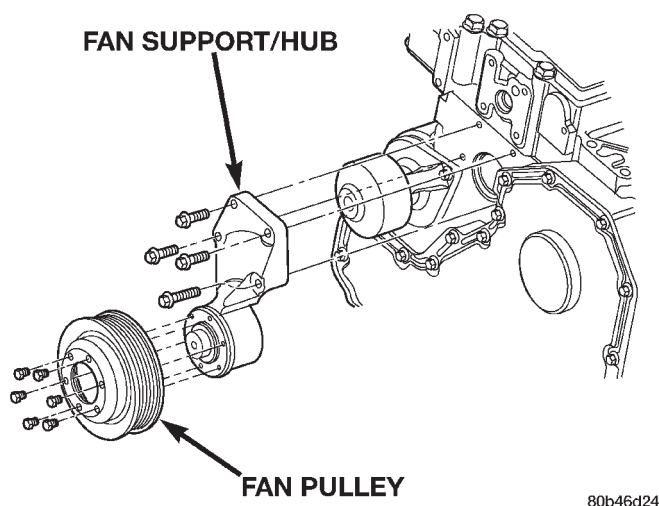
(1) Apply a bead of Loctite 277® or equivalent to the outside diameter of the seal. Do not lubricate the inside diameter of the new seal.

(2) With the cover supported by wood blocks, install the seal into the rear of the cover using crankshaft seal installer tool #8281 and universal driver handle C4171 (Fig. 100). Strike the driver handle until the installation tool bottoms out on the inside of the cover.

(3) Install the plastic seal pilot (provided with seal kit) into the crankshaft seal.

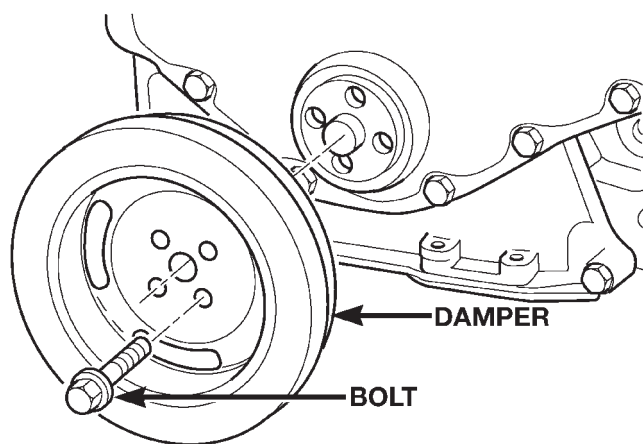
(4) Apply a bead of Mopar® Silicone Rubber Adhesive Sealant or equivalent to the cover sealing surface.

(5) Install the cover to the gear housing, aligning the seal pilot with the nose of the crankshaft (Fig. 101).



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**Fig. 97 Fan Support Hub Assembly—Removal/Installation**

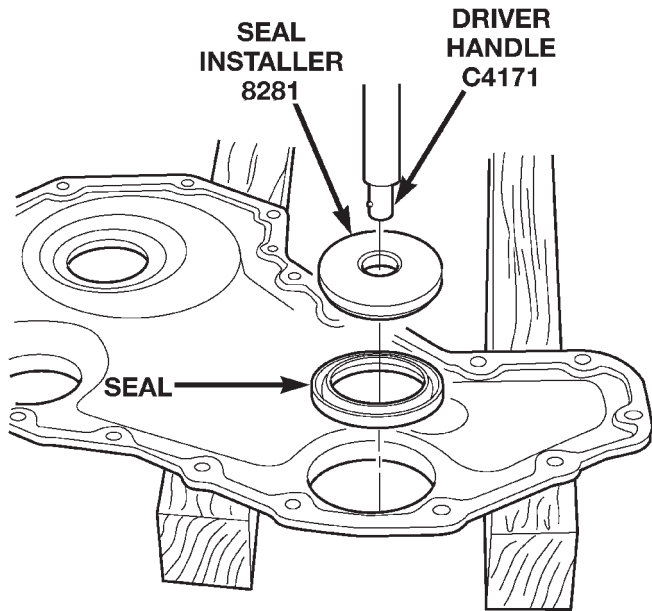


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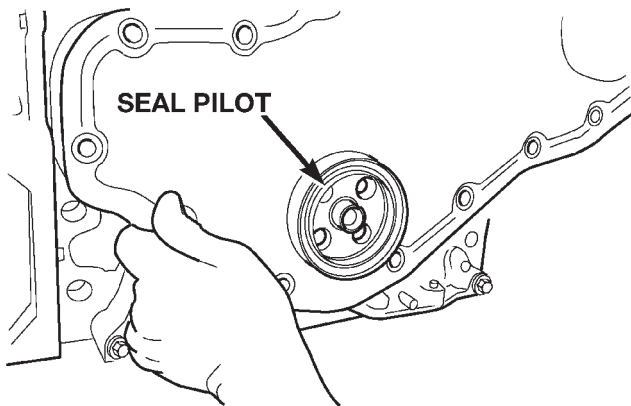
**Fig. 98 Vibration Damper—Removal/Installation**



## REMOVAL AND INSTALLATION (Continued)



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**Fig. 100 Installing Seal Into Cover With Tool 8281**

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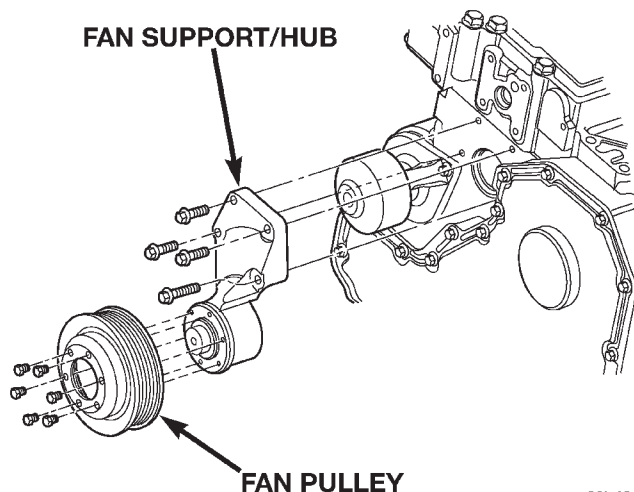
**Fig. 101 Installing Front Cover with Seal Pilot**

- (6) Install the cover bolts and tighten to 24 N·m (18 ft. lbs.) torque. Remove pilot tool.
- (7) Install the vibration damper (Fig. 98) and torque the bolts to 125 N·m (92 ft. lbs.). Use the engine barring tool to keep the engine from rotating during tightening operation.
- (8) Install the fan support/hub assembly (Fig. 97) and torque bolts to 24 N·m (18 ft. lbs.).
- (9) Install the accessory drive belt. Refer to Group 7, Cooling for the correct procedure.
- (10) Connect battery negative cables.
- (11) Start engine and check for oil leaks.

## GEAR HOUSING COVER

## REMOVAL

- (1) Disconnect both battery negative cables.
- (2) Raise vehicle on hoist.
- (3) Partially drain engine coolant into container suitable for re-use.
- (4) Lower vehicle.
- (5) Remove radiator upper hose.
- (6) Disconnect coolant recovery bottle hose from radiator filler neck and lift bottle off of fan shroud.
- (7) Disconnect windshield washer pump supply hose and electrical connections and lift washer bottle off of fan shroud.
- (8) Remove the fan shroud-to-radiator mounting bolts.
- (9) Remove viscous fan/drive assembly. **The fan drive nut has left handed threads.** Refer to Group 7, Cooling System for the correct procedure.
- (10) Remove cooling fan shroud and fan assy. from the vehicle.
- (11) Remove the accessory drive belt. Refer to Group 7, Cooling for the correct procedure.
- (12) Remove the cooling fan support/hub from the front of the engine (Fig. 102).
- (13) Raise the vehicle on hoist.
- (14) Remove the crankshaft damper (Fig. 103).
- (15) Lower the vehicle.
- (16) Remove the gear cover-to-housing bolts and gently pry the cover away from the housing, taking care not to mar the gasket surfaces.



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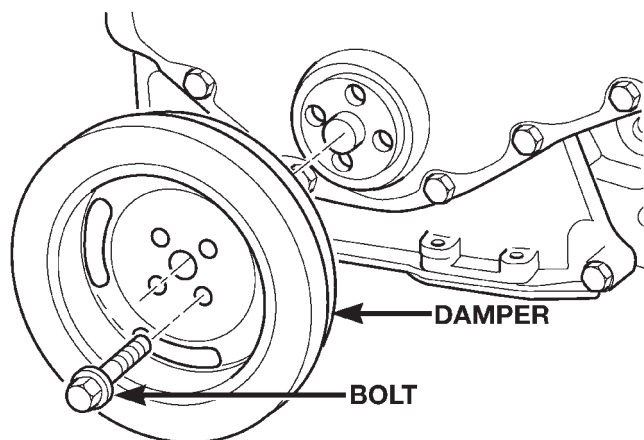
**Fig. 102 Fan Support/Hub Assembly—Removal/Installation**

## CLEANING

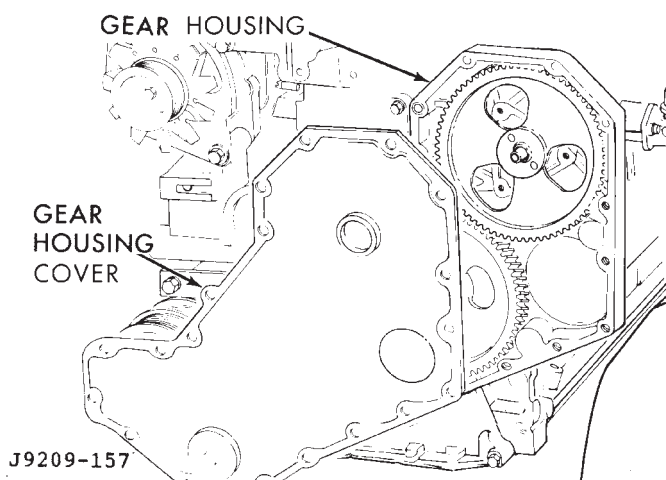
Clean cover and housing gasket mating surfaces. Use a suitable scraper and be careful not to damage the gear housing surface, since it is aluminum. Thor-



## REMOVAL AND INSTALLATION (Continued)



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**Fig. 103 Crankshaft Damper—Removal/Installation****Fig. 104 Gear Housing and Cover**

oroughly clean the front seal area of the crankshaft. The seal lip and the sealing surface on the crankshaft must be free from all oil residue to prevent seal leaks.

**INSPECTION**

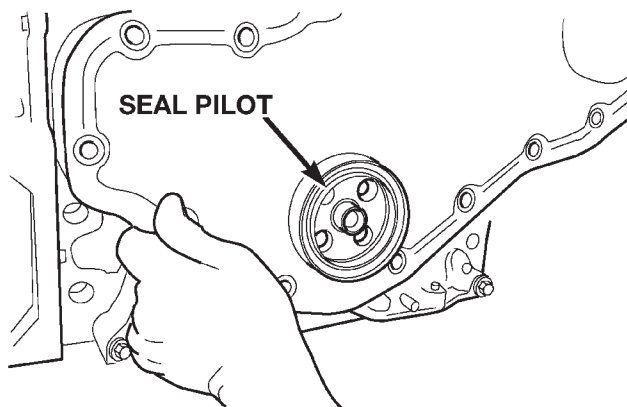
Inspect the gear housing and cover for cracks and replace if necessary. Carefully straighten any bends or imperfections in the gear cover with a ball-peen hammer on a flat surface. Inspect the crankshaft front seal and journal for imperfections and replace seal if necessary. Refer to procedure in this group.

**INSTALLATION**

(1) Obtain a seal pilot/installation tool from a crankshaft front seal service kit and install the pilot into the seal.

(2) Apply a bead of Mopar® Silicone Rubber Adhesive Sealant or equivalent to the gear housing cover. Be sure to surround all through holes.

(3) Using the seal pilot to align the cover (Fig. 105), install the cover to the housing and install the bolts. Tighten the bolts to 24 N·m (18 ft. lbs.) torque.



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**Fig. 105 Installing Cover with Seal Pilot**

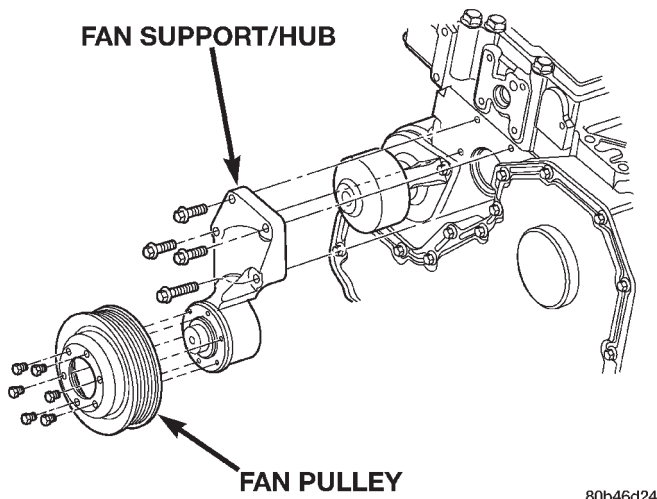
- (4) Remove the seal pilot.
- (5) Raise the vehicle.
- (6) Install the crankshaft damper (Fig. 103) and tighten bolts to 125 N·m (92 ft. lbs.) torque.
- (7) Lower vehicle.
- (8) Install the fan support/hub assy. (Fig. 102) and tighten bolts to 24 N·m (18 ft. lbs.) torque.
- (9) Install the accessory drive belt. Refer to Group 7, Cooling System for the correct procedure.
- (10) Install the cooling fan and shroud together. Start fan nut and fan shroud-to-radiator bolts by hand.
- (11) Torque fan drive nut to 57 N·m (42 ft. lbs.) torque.
- (12) Torque fan shroud-to-radiator bolts to 11 N·m (95 in. lbs.) torque.
- (13) Install the windshield washer reservoir to the fan shroud and connect the washer pump supply hose and electrical connection.
- (14) Install the coolant recovery bottle to the fan shroud and connect the hose to the radiator filler neck.
- (15) Install the radiator upper hose and clamps.
- (16) Add coolant.
- (17) Connect the battery cables.
- (18) Start engine and inspect for leaks.

**GEAR HOUSING****REMOVAL**

- (1) Disconnect the battery negative cables.
- (2) Raise vehicle on hoist.
- (3) Remove the oil pan and suction tube. Refer to procedure in this group.
- (4) Partially drain engine coolant into container suitable for re-use.

## REMOVAL AND INSTALLATION (Continued)

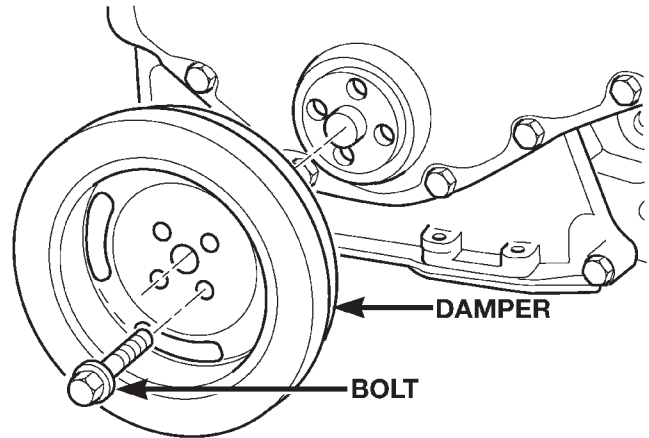
- (5) Lower vehicle.
- (6) Remove radiator upper hose.
- (7) Disconnect coolant recovery bottle hose from radiator filler neck and lift bottle off of fan shroud.
- (8) Disconnect windshield washer pump supply hose and electrical connections and lift washer bottle off of fan shroud.
- (9) Remove the fan shroud-to-radiator mounting bolts.
- (10) Remove viscous fan/drive assembly. **The fan drive nut has left handed threads.** Refer to Group 7, Cooling System for the correct procedure.
- (11) Remove cooling fan shroud and fan assy. from the vehicle.
- (12) Remove the accessory drive belt. Refer to Group 7, Cooling for the correct procedure.
- (13) Remove the cooling fan support/hub from the front of the engine (Fig. 106).
- (14) Raise the vehicle on hoist.
- (15) Remove the crankshaft damper (Fig. 107).
- (16) Lower the vehicle.
- (17) Remove the gear cover-to-housing bolts and gently pry the cover away from the housing (Fig. 108), taking care not to mar the gasket surfaces.



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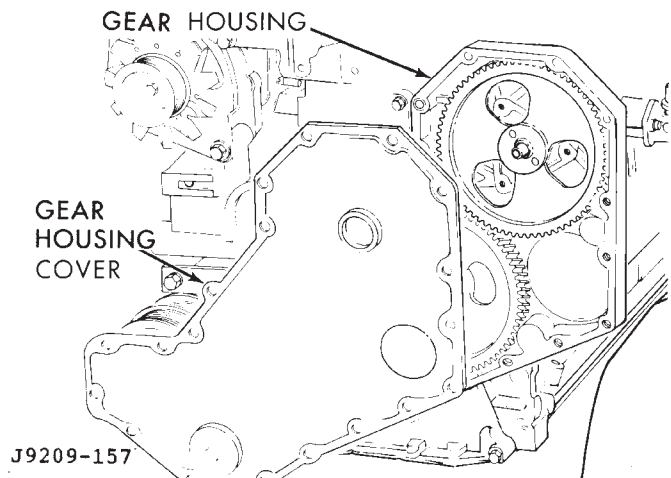
**Fig. 106 Fan Support/Hub Assembly—Removal/Installation**

- (18) Remove the fuel injection pump. Refer to Group 14, Fuels Systems for the correct procedure.
- (19) Disconnect the camshaft position sensor connector.
- (20) Raise the tappets and remove the camshaft. Refer to procedure in this group.
- (21) Remove the gear housing and gasket (Fig. 109).
- (22) Clean the gasket material from the cylinder block.



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**Fig. 107 Crankshaft Damper—Removal/Installation**

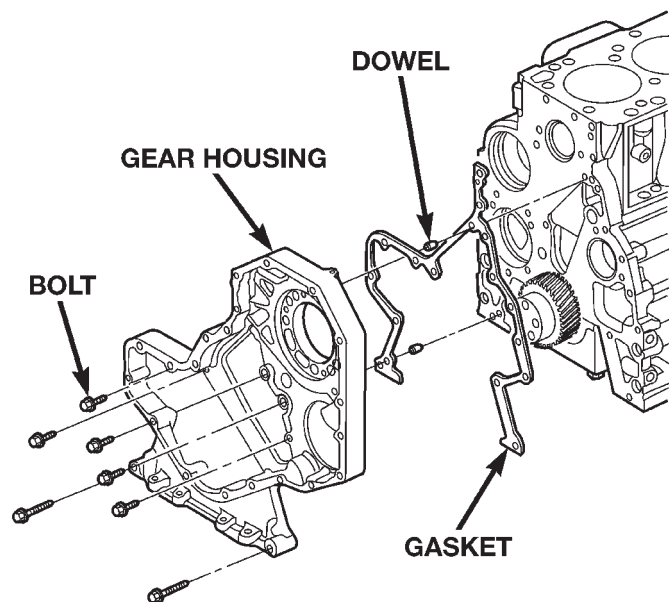


**Fig. 108 Gear Housing and Cover**

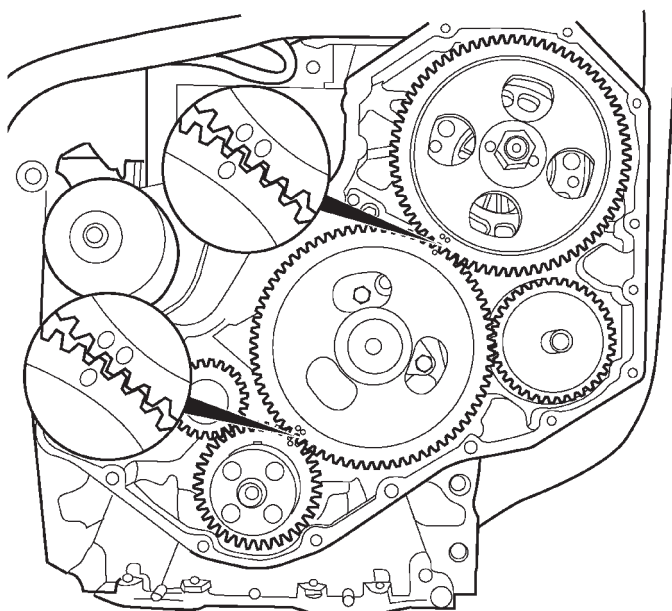
## INSTALLATION

- (1) Install a new gasket and the gear housing (Fig. 109). Tighten the bolts to 24 N·m (18 ft. lbs.) torque.
- (2) Connect the camshaft position sensor connector.
- (3) Install the injection pump. Refer to Group 14, Fuel System for the correct procedure.
- (4) Install the camshaft. Align the crankshaft, camshaft, and injection pump gear marks as shown in (Fig. 110).
- (5) If a new housing is installed, the camshaft position sensor must be transferred to the new housing.
- (6) Obtain a seal pilot/installation tool from a crankshaft front seal service kit and install the pilot into the crankshaft front oil seal.
- (7) Apply a bead of Mopar® Silicone Rubber Adhesive Sealant or equivalent to the gear housing cover. Be sure to surround all through holes.
- (8) Using the seal pilot to align the cover (Fig. 111), install the cover to the housing and install the bolts. Tighten the bolts to 24 N·m (18 ft. lbs.) torque.

## REMOVAL AND INSTALLATION (Continued)



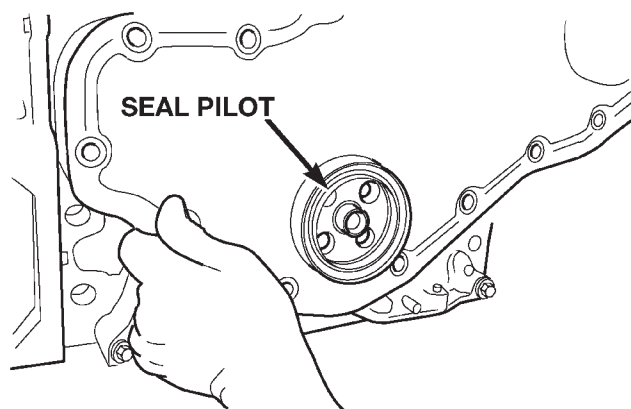
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**Fig. 109 Gear Housing and Gasket**

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**Fig. 110 Camshaft/Crankshaft Gear Alignment**

- (9) Remove the seal pilot.
- (10) Raise the vehicle.
- (11) Trim any excess gear housing gasket to make it flush with the oil pan rail.
- (12) Using a new gasket, install the oil pan and suction tube. Refer to procedure in this group.
- (13) Install the crankshaft damper (Fig. 107) and tighten bolts to 125 N·m (92 ft. lbs.) torque.
- (14) Lower vehicle.



80b46d27

**Fig. 111 Installing Cover with Seal Pilot**

- (15) Install the fan support/hub assy. (Fig. 106) and tighten bolts to 24 N·m (18 ft. lbs.) torque.
- (16) Install the accessory drive belt. Refer to Group 7, Cooling System for the correct procedure.
- (17) Install the cooling fan and shroud together. Start fan nut and fan shroud-to-radiator bolts by hand.
- (18) Torque fan drive nut to 57 N·m (42 ft. lbs.) torque.
- (19) Torque fan shroud-to-radiator bolts to 11 N·m (95 in. lbs.) torque.
- (20) Install the windshield washer reservoir to the fan shroud and connect the washer pump supply hose and electrical connection.
- (21) Install the coolant recovery bottle to the fan shroud and connect the hose to the radiator filler neck.
- (22) Install the radiator upper hose and clamps.
- (23) Add engine oil.
- (24) Add coolant.
- (25) Connect the battery cables.
- (26) Start engine and inspect for leaks.

**CAMSHAFT**

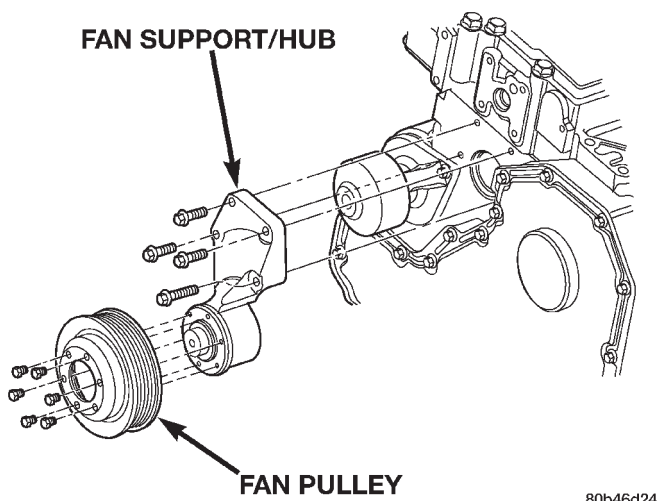
**NOTE:** This procedure requires use of the Cummins Tappet Replacement Tool Kit #3822513.

**REMOVAL**

- (1) Disconnect both battery negative cables.
- (2) Recover A/C refrigerant (if A/C equipped). Refer to Group 24, Heating and Air Conditioning for the correct procedure.
- (3)
- (3) Raise vehicle on hoist.
- (4) Drain engine coolant into container suitable for re-use.
- (5) Lower vehicle.

## REMOVAL AND INSTALLATION (Continued)

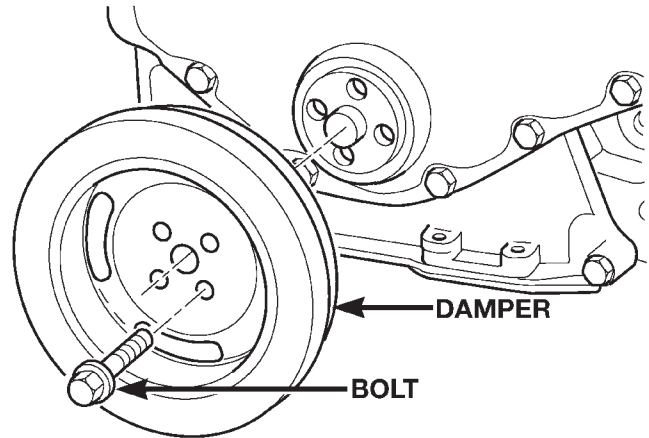
- (6) Remove radiator upper hose.
- (7) Remove viscous fan/drive assembly.
- (8) Disconnect the coolant recovery bottle hose from the radiator filler neck.
- (9) Remove cooling fan shroud.
- (10) Disconnect lower radiator hose from radiator outlet.
- (11) **Automatic Transmission models:** Disconnect transmission oil cooler lines from radiator using special tool #6931 (unless equipped with finger-release disconnect).
- (12) Remove radiator mounting screws and lift radiator out of engine compartment.
- (13) Remove upper radiator support panel.
- (14) Remove front bumper assy. Refer to Group 13, Frame and Bumpers for the correct procedure.
- (15) If A/C equipped, disconnect A/C condenser refrigerant lines. Refer to Group 24, Heating and Air Conditioning for the correct procedures.
- (16) Disconnect charge air cooler piping from the cooler inlet and outlet.
- (17) Remove the two charge air cooler mounting bolts.
- (18) Remove charge air cooler (and A/C condenser if equipped) from vehicle.
- (19) Remove accessory drive belt. Refer to Group 7, Cooling System for the correct procedure.
- (20) Remove the fan support/hub assembly (Fig. 112).
- (21) Remove crankshaft damper (Fig. 113).
- (22) Remove the pump gear access cover by rotating counter-clockwise (Fig. 114).



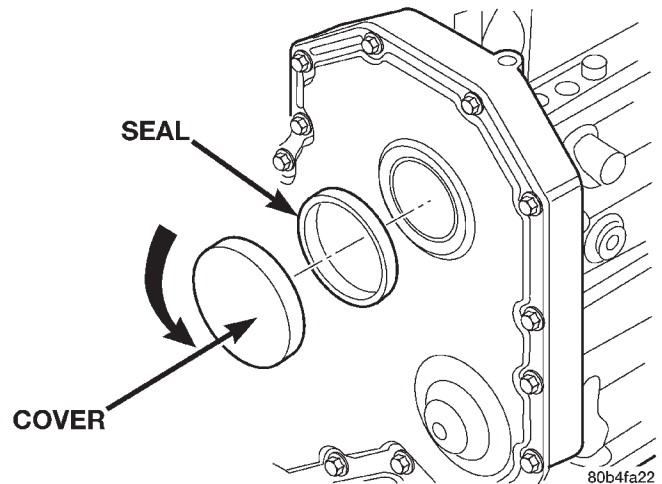
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**Fig. 112 Fan Support/Hub Removal/Installation**

- (23) Using an engine barring tool, rotate the crankshaft to bring the engine to TDC #1.



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**Fig. 113 Crankshaft Damper Removal/Installation**

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**Fig. 114 Removing Injection Pump Gear Access Cover**

- (24) Remove the gear cover-to-housing bolts and gently pry the cover away from the housing, taking care not to mar the sealing surfaces.

- (25) Remove the cylinder head cover (Fig. 115).

- (26) Remove the rocker arms (Fig. 116), cross heads, and push rods (Fig. 117). Mark each component so they can be installed in their original positions.

**NOTE:** The #5 cylinder exhaust and the #6 cylinder intake and exhaust pushrods are removed by lifting them up and through the provided cowl panel access holes. Remove the rubber plugs to expose these relief holes.

- (27) Raise the tappets as follows, using the wooden dowel rods (Fig. 118) provided with the Cummins tappet replacement tool kit #3822513:

- (a) Insert the slotted end of the dowel rod into the tappet. **The dowel rods for the rear two cylinders will have to be cut for cowl panel**



## REMOVAL AND INSTALLATION (Continued)

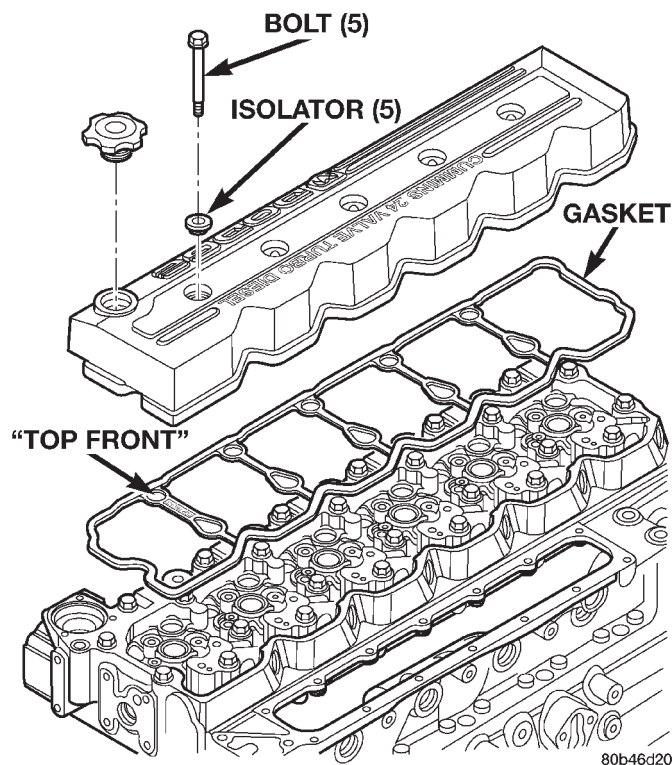


Fig. 115 Cylinder Head Cover Removal/Installation

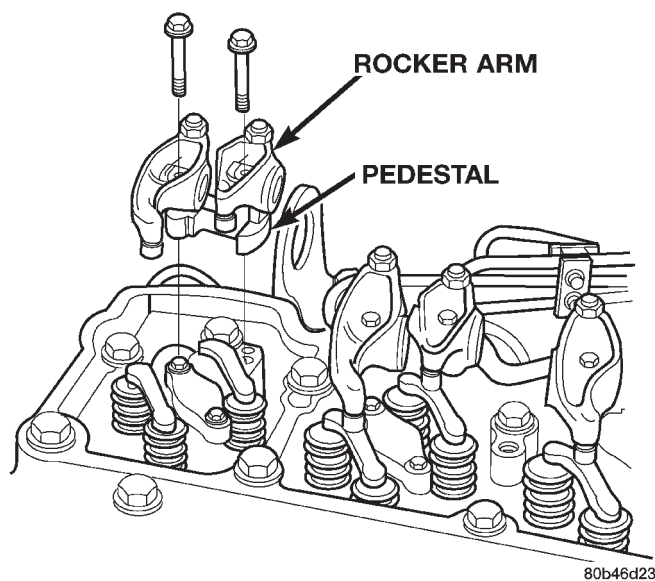
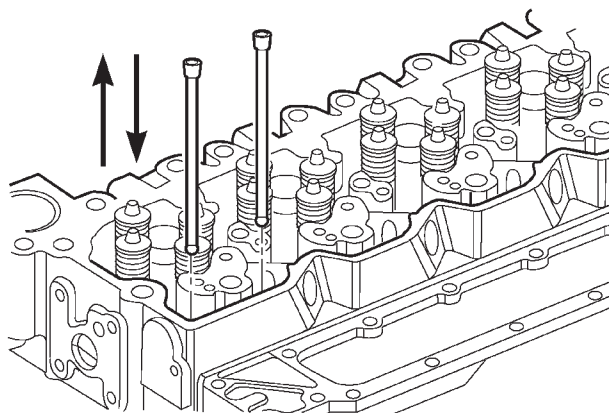


Fig. 116 Rocker Arm and Pedestal Removal/Installation

**clearance.** Press firmly to ensure that it is seated in the tappet.

(b) Raise the dowel rod to bring the tappet to the top of its travel, and wrap a rubber band around the dowel rods (Fig. 118) to prevent the tappets from dropping into the crankcase.

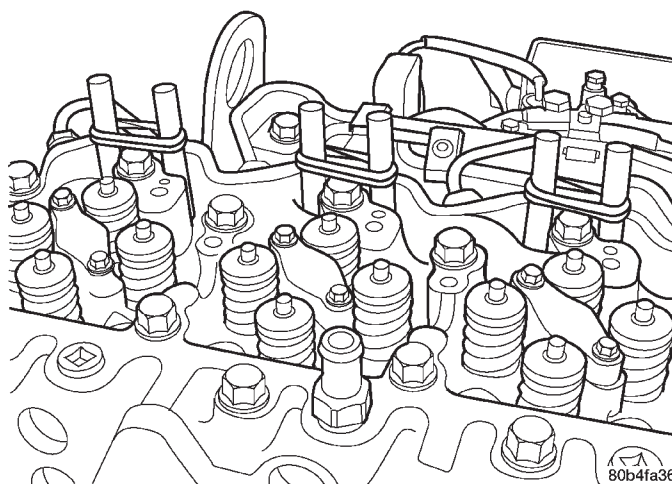
(c) Repeat this procedure for the remaining cylinders.



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Fig. 117 Push Rod Removal/Installation

(28) Verify that the camshaft timing marks are aligned with the crankshaft and injection pump marks (Fig. 119).



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Fig. 118 Use Wooden Dowel Rods to Secure Tappets in Place

(29) Remove the bolts from the thrust plate (Fig. 120).

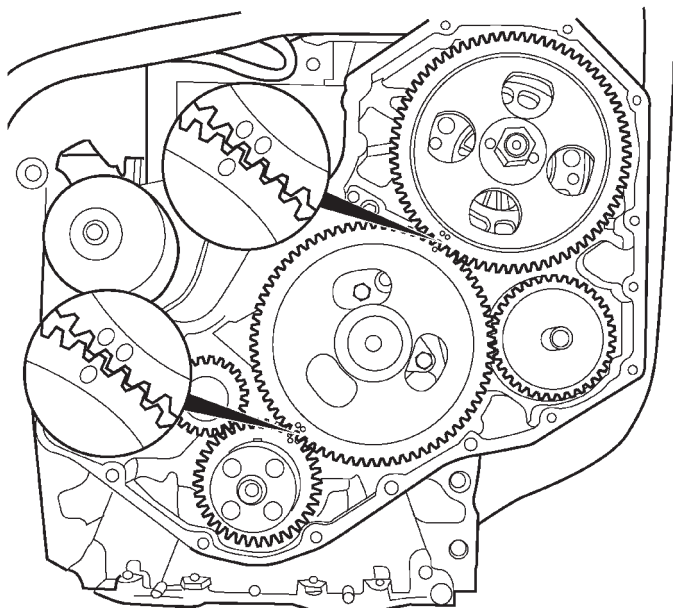
**CAUTION:** When removing the camshaft and thrust plate, grab the thrust plate to prevent it from falling into the crankcase.

(30) Remove the camshaft (Fig. 121) and thrust plate.

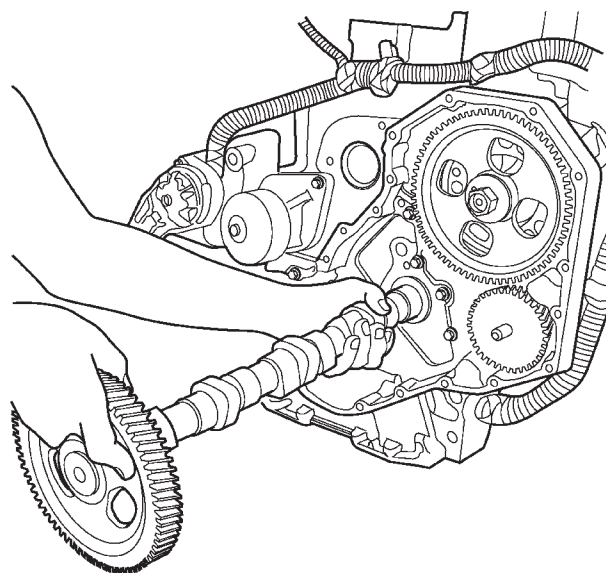
## CLEANING

Clean the camshaft with a suitable solvent. Rinse in hot water and blow dry with compressed air.

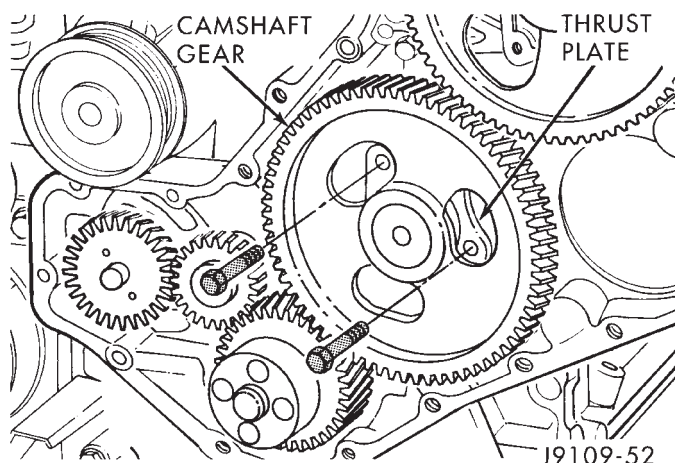
## REMOVAL AND INSTALLATION (Continued)



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**Fig. 119 Timing Mark Alignment**

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**Fig. 121 Camshaft Removal/Installation**

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**Fig. 120 Thrust Plate Bolt Location****INSPECTION****Camshaft**

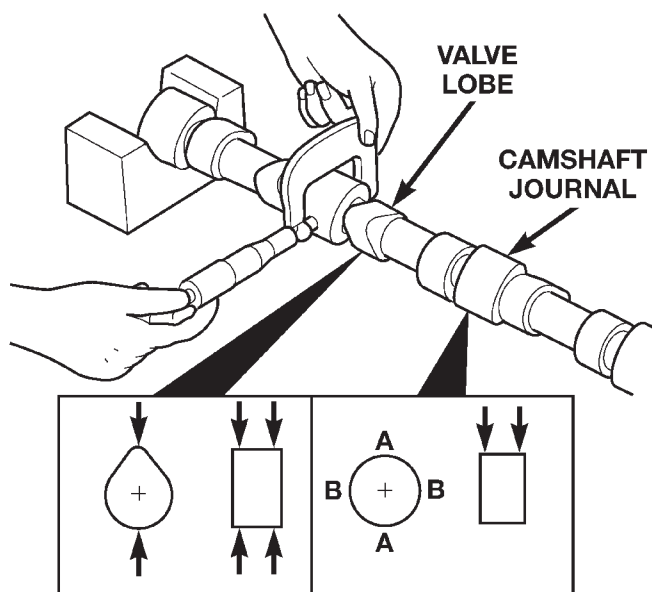
(1) Inspect the valve lobes and bearing journals for cracks, pitting, scoring, or generally excessive wear. Replace any camshaft that exceeds the allowable limits.

(2) Measure the bearing journals and lobes (Fig. 122).

**CAUTION:** If Camshaft lobes are worn, requiring camshaft replacement, it is necessary to replace the tappets also. Refer to Tappet Removal and Installation in this group.

**Camshaft Bushing/Bores**

Camshaft bores No. 2-7 **do not** use a bushing.



80b4fa37

**Fig. 122 Measuring Camshaft Main Journals and Lobes**  
**Camshaft Journal Diameter**

**Journal #1** 54.028 mm (2.1270 in.) MIN.

**Journal #2-7** 53.987 mm (2.1245 in.) MIN.

**Camshaft Lobe Height**

**Intake Lobe** 47.173 mm (1.857 in.) MIN.

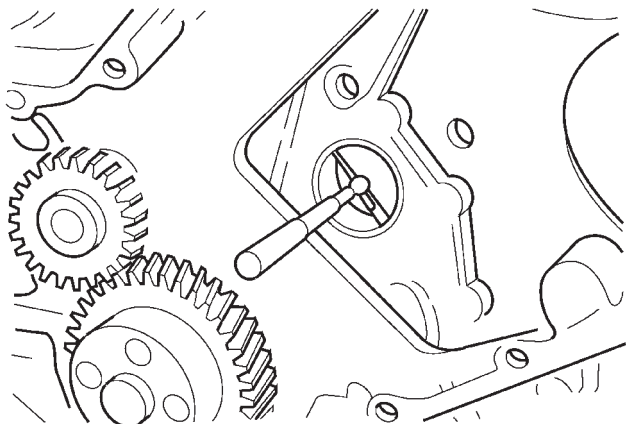
**Exhaust Lobe** 45.636 mm (1.796 in.) MIN.

## REMOVAL AND INSTALLATION (Continued)

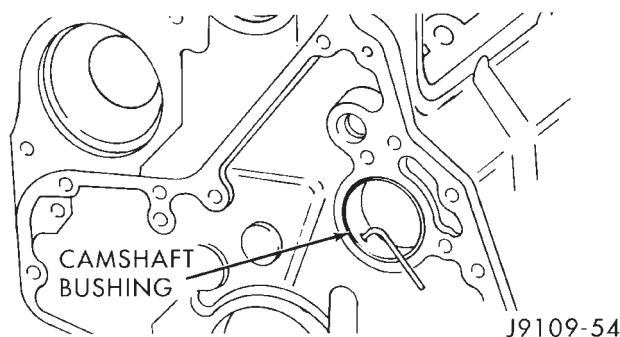
(1) Inspect the camshaft bushing and bores for signs of excessive wear.

(2) Measure the camshaft bushing and bores (Fig. 123) with a telescoping bore gauge and micrometer. If out of specification, refer to Camshaft Bushing Removal and Installation for replacement procedures.

(3) Inspect the camshaft bushing oil hole for alignment with cylinder block (Fig. 124).



**Fig. 123 Measuring Camshaft Bushing and Bores**



**Fig. 124 Inspecting Oil Hole Alignment**

#### Camshaft Gear

Inspect the camshaft gear for cracks (gear and hub) (Fig. 125), and chipped/broken/fretted teeth (Fig. 126). If replacement is necessary, refer to Camshaft Gear Removal and Installation in this group.

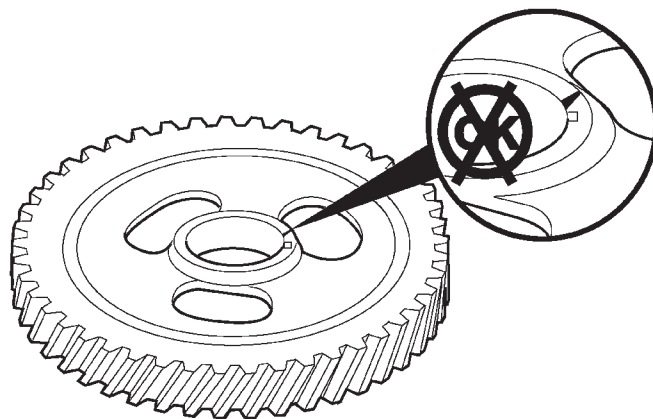
#### Thrust Plate

Inspect the camshaft thrust plate for excessive wear in the camshaft contact area. Measure thrust plate thickness using the following chart. Replace any thrust plate that falls outside of these specifications:

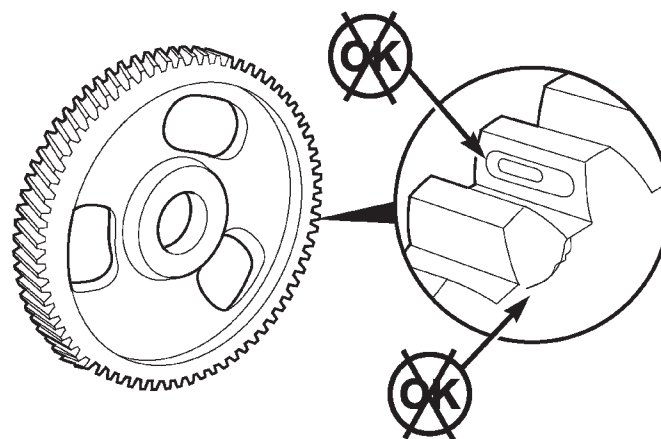
#### CAMSHAFT THRUST PLATE THICKNESS

9.34 mm (0.368 in.) MIN.

9.58 mm (0.377 in.) MAX.



**Fig. 125 Inspect Camshaft Gear Hub for Cracks**



**Fig. 126 Inspect Camshaft Gear for Cracks and Fretting**

#### BUSHING REPLACEMENT

(1) Measure the diameter of each bore. (The limit for the bushing in the No.1 bore is the same as for the other bores without bushings). The limit of the inside diameter is 54.133 mm (2.1312 inch). If the camshaft bore for the first cam bushing is worn beyond the limit, install a new service bushing. Inspect the rest of the camshaft bores for damage or excessive wear.

(2) If the bores without a bushing are worn beyond the limit, the engine must be removed for machining and installation of service bushings. If badly worn, replace the cylinder block.

(3) Remove the bushing from the No.1 bore, using a universal cam bushing tool.

(4) Mark the cylinder block so you can align the oil hole in the cylinder block with the oil hole in the bushing.

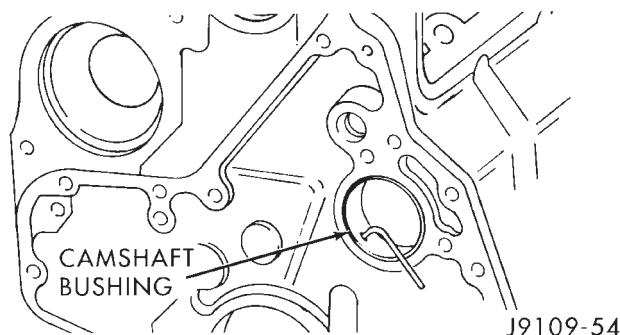
Apply a coating of Loctite® 609 to the backside of the new bushing. Avoid getting Loctite® in the oil hole.



## REMOVAL AND INSTALLATION (Continued)

(5) Use a universal cam bushing installation tool and install the bushing so that it is even with the front face of the cylinder block. The oil hole must be aligned. A 3.2 mm (0.128 inch) diameter rod must be able to pass through the hole (Fig. 127).

(6) Measure the installed bushing. The limit of the inside diameter is 54.133 mm (2.1312 inch).



**Fig. 127 Oil Hole Alignment**

## INSTALLATION

(1) Lubricate the camshaft bushing and bores with fresh engine oil or suitable equivalent.

(2) Liberally coat the camshaft lobes, journals, and thrust washer with fresh engine oil or suitable equivalent.

**CAUTION:** When installing the camshaft (Fig. 121), **DO NOT** push it in farther than it will go with the thrust washer in place. Pushing it too far can dislodge the plug in the rear of the camshaft bore and cause an oil leak.

(3) Install the camshaft (Fig. 121) and thrust plate. Align the timing marks as shown in (Fig. 119).

(4) Install the thrust plate bolts and tighten to 24 N·m (18 ft. lbs.) torque.

(5) Measure camshaft back lash and end clearance (Fig. 128).

(6) Remove the wooden dowel rods and rubber bands from the tappets.

(7) Lubricate the push rods with engine oil and install in their original location (Fig. 117). **Verify that they are seated in the tappets.**

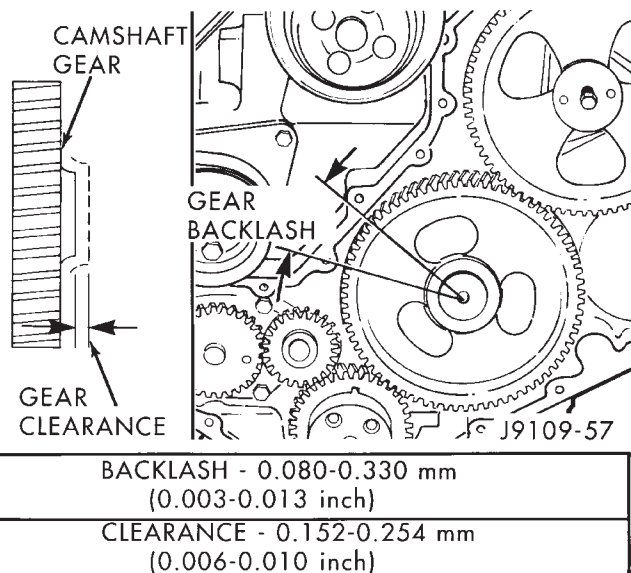
(8) Lubricate the valve tips with engine oil and install the crossheads in their original locations.

(9) Lubricate the crossheads and push rod sockets with engine oil and install the rocker arms and pedestals in their original locations (Fig. 116).

(10) **Verify valve lash adjustment. Refer to Valve Lash Verification and Adjustment in Service Procedures.**

(11) Install the cylinder head cover and reusable gasket (Fig. 115). Torque bolts to 24 N·m (18 ft. lbs.).

(12) Apply a bead of Mopar® Silicone Rubber Adhesive Sealant or equivalent to the gear housing



**Fig. 128 Camshaft Backlash and End Clearance**

cover. Install and tighten bolts to 24 N·m (18 ft. lbs.) torque.

(13) Install the crankshaft damper (Fig. 113) and tighten bolts to 125 N·m (92 ft. lbs.) torque.

(14) Install the fan support/hub assy. (Fig. 112) and tighten bolts to 24 N·m (18 ft. lbs.) torque.

(15) Install the fuel pump gear access cover. Tighten clock-wise by hand.

(16) Install the charge air cooler (with a/c condenser and auxiliary transmission oil cooler, if equipped) and tighten the mounting bolts to 2 N·m (17 in. lbs.) torque.

(17) Connect charge air cooler inlet and outlet pipes. Tighten clamps to 8 N·m (72 in. lbs.) torque.

(18) Install the radiator upper support panel.

(19) Close radiator petcock and lower the radiator into the engine compartment. Tighten the mounting bolts to 11 N·m (95 in. lbs.) torque.

(20) Raise vehicle on hoist.

(21) Connect radiator lower hose and install clamp.

(22) Connect transmission auxiliary oil cooler lines (if equipped).

(23) Lower vehicle.

(24) Install the fan shroud and tighten the mounting screws to 6 N·m (50 in. lbs.) torque.

(25) Install the viscous fan/drive assy. and tighten to 57 N·m (42 ft. lbs.) torque.

(26) Install the coolant recovery and windshield washer fluid reservoirs to the fan shroud.

(27) Connect the coolant recovery hose to the radiator filler neck.

(28) Install the accessory drive belt. Refer to Group 7, Cooling for the correct procedure.

(29) Install the front bumper assy. Refer to Group 13, Frame and Bumper for the correct procedure.



## REMOVAL AND INSTALLATION (Continued)

- (30) Add engine coolant.
- (31) Connect the battery negative cables.
- (32) Start engine and check for engine oil and coolant leaks.
- (33) Charge A/C system with refrigerant (if A/C equipped). Refer to Group 24, Heating and Air Conditioning for the correct procedure.

## CAMSHAFT GEAR (CAMSHAFT REMOVED)

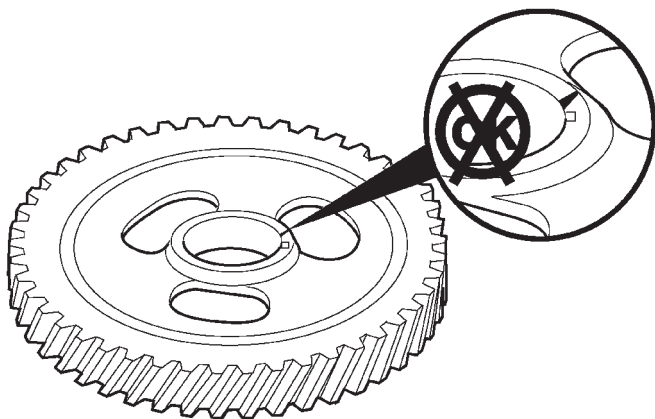
**CAUTION:** DO NOT use an oxygen/acetylene torch to heat the gear upon removal from the camshaft. This will weaken the gear-to-hub joint and result in gear failure.

## REMOVAL

- (1) Remove camshaft. Refer to Camshaft Removal and Installation in this group.
- (2) Support gear hub and press the camshaft out of the gear.
- (3) Remove all burrs and smooth any rough surfaces caused by removing the gear.

## INSPECTION

Visually inspect the camshaft gear for cracks (hub and gear), chipped or broken teeth, or excessive fretting (Fig. 129)(Fig. 130). Inspect and replace the keyway, if damaged.



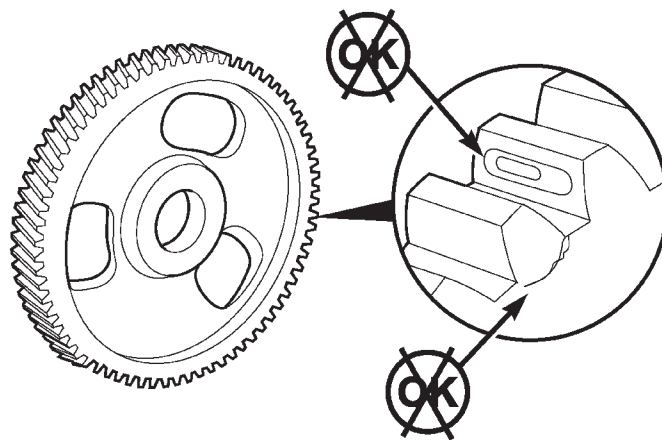
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**Fig. 129 Inspecting Camshaft Gear Hub for Cracks**

## INSTALLATION

- (1) If replacing the camshaft, make sure the keyway is transferred to the new camshaft.
- (2) Lubricate the camshaft surface with Lubriplate 105, or equivalent.

**CAUTION:** The camshaft gear will be permanently distorted if overheated. The oven temperature should never exceed 177°C (350°F).



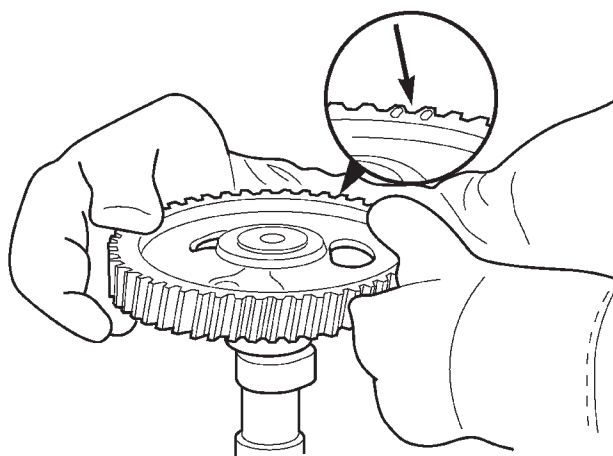
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**Fig. 130 Inspecting Camshaft Gear for Cracks and Fretting**

- (3) Heat the gear in an oven at 177°C (350°F) for 45 minutes.

**WARNING:** WEAR PROTECTIVE GLOVES (Fig. 131) TO HANDLE THE HOT GEAR.

- (4) Install the gear with the timing marks visible (Fig. 131). Be sure the gear is seated against the camshaft shoulder (Fig. 132).
- (5) If the camshaft is not to be used immediately, lubricate the lobes and journals to prevent rust.
- (6) Install the camshaft, referring to the Camshaft Removal and Installation procedure in this group.



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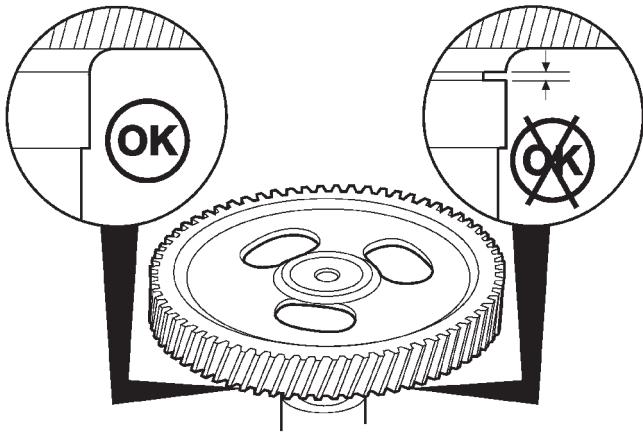
**Fig. 131 Installing Camshaft Gear**

## TAPPETS

**NOTE:** This procedure requires use of the Cummins Tappet Replacement Tool Kit #3822513.

- (1) Raise tappets and remove camshaft. Refer to Camshaft Removal and Installation procedure in this group.

## REMOVAL AND INSTALLATION (Continued)



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**Fig. 132 Verify Correct Gear Installation**

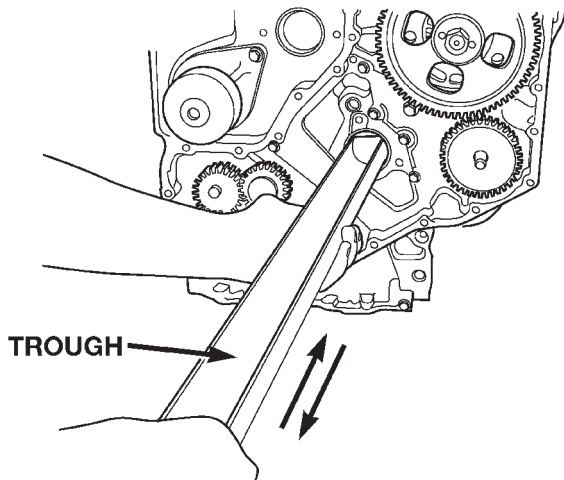
(2) Insert the trough (provided with tool kit) the full length of the camshaft bore (Fig. 133). Make sure the cap end goes in first and the open side faces up (towards lifters).

(3) **Remove only one tappet at a time.** Remove rubber band from one cylinder pair and attach tappet dowel not being removed to the next cylinder pair (Fig. 134).

(4) Raise dowel rod (disengage from tappet) and allow tappet to fall into trough (Fig. 135).

(5) Carefully remove trough (**do not rotate**) and tappet. If the tappet is not being replaced, mark it so it can be installed in its original location.

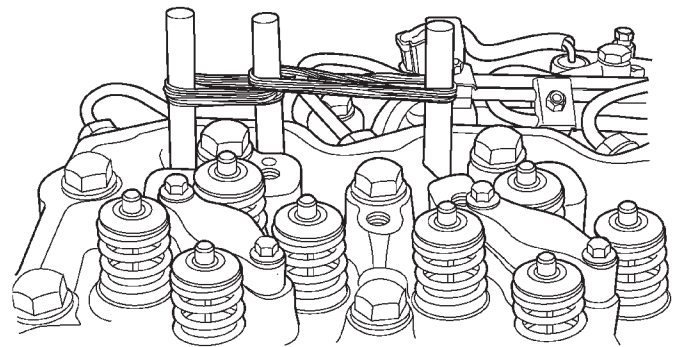
(6) Re-install trough and repeat procedure on remaining tappets.



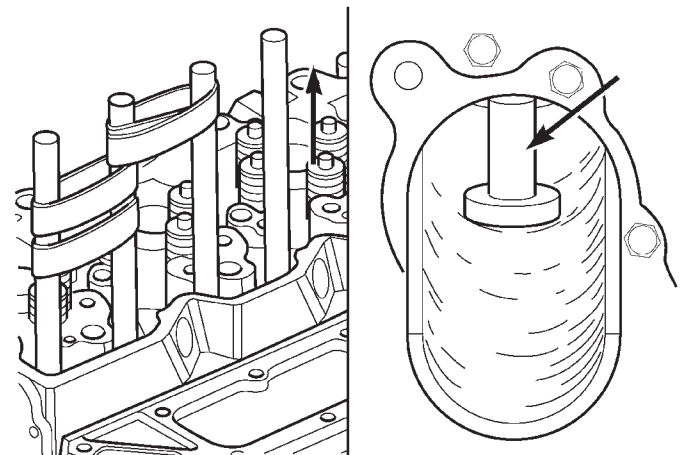
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**Fig. 133 Inserting the Trough****CLEANING**

Clean tappet with a suitable solvent. Rinse in hot water and blow dry with a clean shop rag or compressed air.



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**Fig. 134 Secure Dowel/Tappet to Adjacent Cylinder**

80b4faa1

**Fig. 135 Lift Dowel Rod to Disengage from Tappet****INSPECTION**

(1) Visually inspect the tappet the tappet socket, stem, and face for excessive wear, cracks, or obvious damage (Fig. 136).

(2) Measure the tappet stem diameter. Replace the tappet if it falls below the minimum size (Fig. 136).

**INSTALLATION**

(1) Insert the trough the full length of the camshaft bore (Fig. 133). Again, make sure the cap end goes in first and the open side faces up (towards lifters).

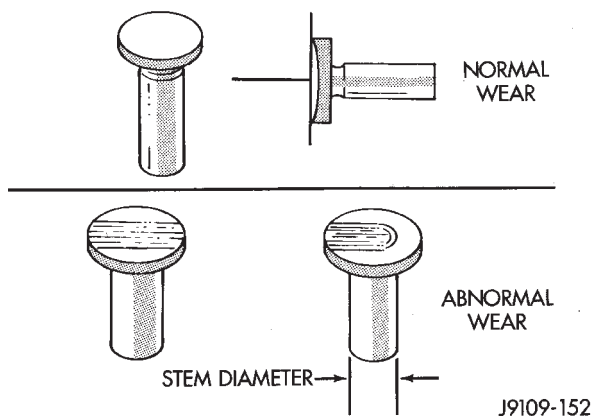
(2) Lower the tappet installation tool through the push rod hole (Fig. 137) and into the trough.

(3) Retrieve the tappet installation tool using the hooked rod provided with the tool kit (Fig. 138).

(4) Lubricate the tappet with clean engine oil or suitable equivalent and install the tappet to the installation tool (Fig. 139).

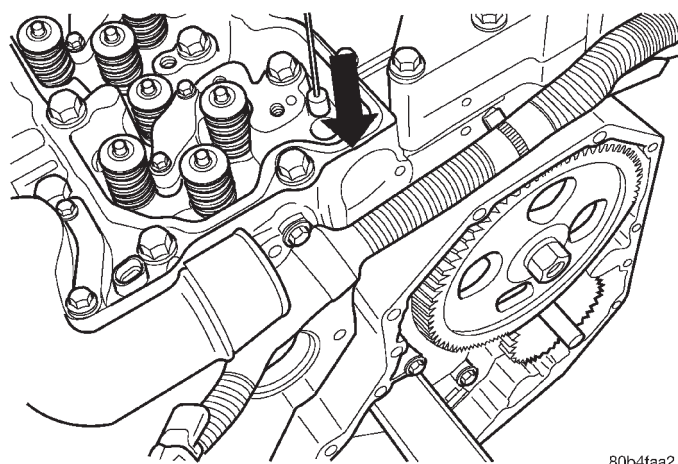
(5) Pull the tappet up and into position (Fig. 139). If difficulty is experienced getting the tappet to make

## REMOVAL AND INSTALLATION (Continued)

**Fig. 136 Tappet Inspection****TAPPET STEM DIAMETER**

15.925 mm (0.627 in.) MIN.

15.977 mm (0.629 in.) MAX.

**Fig. 137 Insert Installation Tool through Push Rod Hole**

the turn into the tappet bore, wiggle the trough while **gently** pulling up on the tappet.

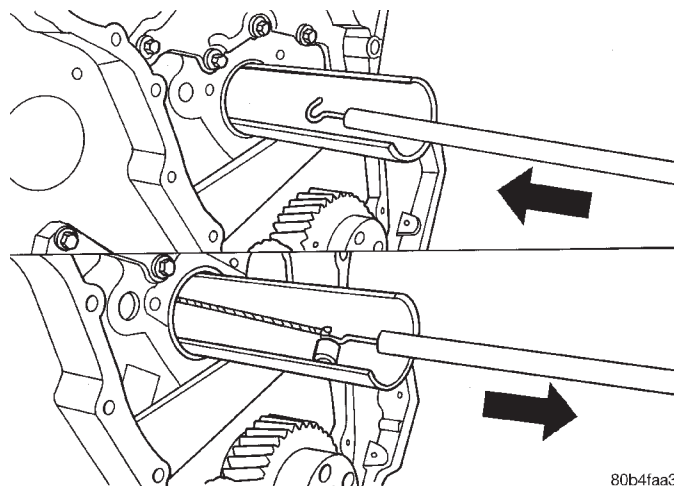
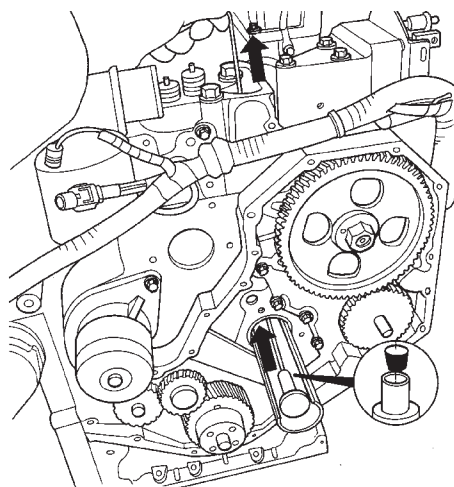
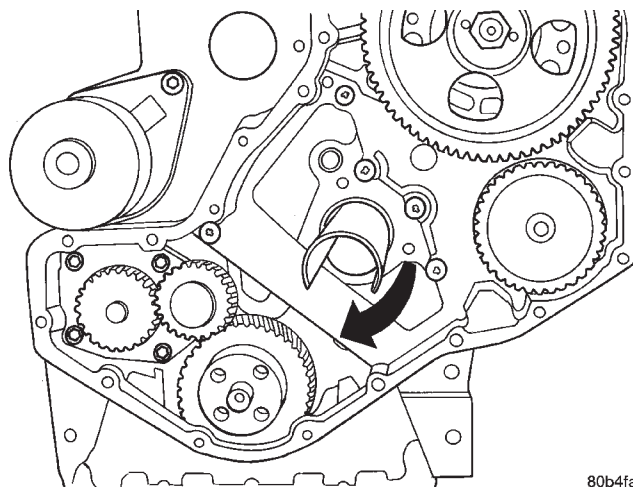
(6) With the tappet in place, rotate the trough one half turn so the open side is down (toward crankshaft) (Fig. 140).

(7) Remove the tappet installation tool from the tappet.

(8) Re-install a dowel rod and secure the rod with a rubber band.

(9) Rotate the trough one half turn and repeat the procedure for the remaining tappets.

(10) Install the camshaft and previously removed components. Refer to Camshaft Removal and Installation in this group.

**Fig. 138 Retrieve Tappet Installation Tool through Cam Bore****Fig. 139 Insert Tool and Pull Tappet Into Place****Fig. 140 Rotate Trough One Half Turn (180°)**

## REMOVAL AND INSTALLATION (Continued)

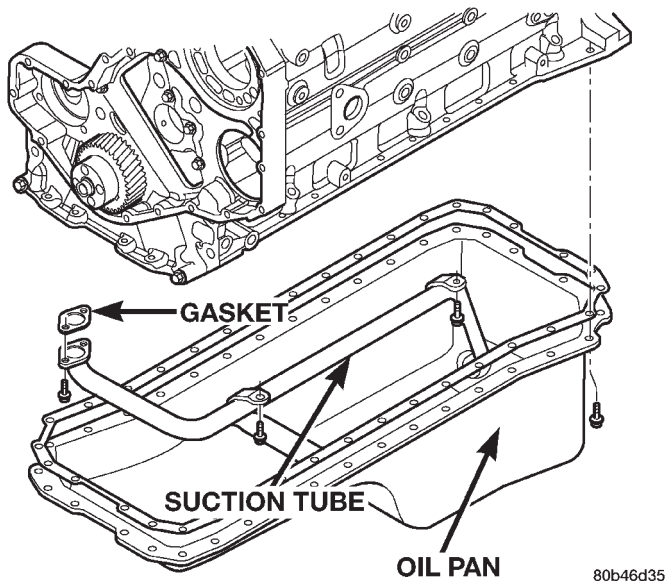
## OIL PAN AND SUCTION TUBE

## REMOVAL

- (1) Disconnect the battery negative cables.
- (2) Raise vehicle on hoist.
- (3) Remove transmission and transfer case (if equipped) from vehicle, refer to Group 21 Transmission and Transfer Case.
- (4) Remove flywheel.
- (5) Disconnect starter cables from starter motor.
- (6) Remove starter motor and transmission adapter plate assembly.

**WARNING: HOT OIL CAN CAUSE PERSONAL INJURY.**

- (7) Drain the used engine oil. Dispose of the used oil properly.
- (8) Install the oil pan drain plug with a new sealing washer and tighten to 60 N·m (44 ft. lbs.) torque.
- (9) Remove oil pan bolts, break the pan to block seal, and lower pan slightly and remove oil suction tube fasteners.
- (10) Remove oil pan and suction tube (Fig. 141).

**Fig. 141 Oil Pan, Suction Tube and Gasket**

## CLEANING

Remove all gasket material from the oil pan and cylinder block sealing surfaces. Extra effort may be required around T-joint areas. Clean oil pan and flush suction tube with a suitable solvent.

## INSPECTION

Inspect the oil pan, suction tube, and tube braces for cracks and damage. Replace any defective component. Inspect the oil drain plug and drain hole threads. Inspect the oil pan sealing surface for straightness. Repair any minor imperfections with a

ball-peen hammer. Do not attempt to repair an oil pan by welding.

## INSTALLATION

- (1) Fill the T-joint between the pan rail/gear housing and pan rail/rear seal retainer with sealant. Use Mopar® Silicone Rubber Adhesive Sealant or equivalent.
- (2) Place suction tube in oil pan and guide them into place (Fig. 141). Using a new tube to oil pump gasket, install and tighten the suction tube bolts by hand. Starting with the oil pump inlet bolts, tighten the bolts to 24 N·m (18 ft. lbs.) torque. Tighten the remaining tube brace bolts to 24 N·m (18 ft. lbs.) torque.
- (3) Starting in the center and working outward, tighten the oil pan bolts to 24 N·m (18 ft. lbs.) torque.
- (4) Install the flywheel housing assembly with the starter motor attached and tighten bolts to 60 N·m (44 ft. lbs.) torque.
- (5) Connect starter motor cables.
- (6) Install transmission and transfer case (if equipped). Refer to Group 21, Transmission and Transfer Case.
- (7) Lower vehicle.
- (8) Install battery negative cables.
- (9) Fill the crankcase with new engine oil.
- (10) Start engine and check for leaks. Stop engine, check oil level, and adjust if necessary.

## PISTON AND CONNECTING ROD ASSEMBLY

## REMOVAL

- (1) Disconnect the battery cables.
- (2) Remove the cylinder head. Refer to procedure in this group.
- (3) Remove the oil pan and suction tube. Refer to procedure in this group.
- (4) Using the crankshaft barring tool #7471B, rotate the crankshaft so all of the pistons are below TDC.
- (5) Before removing the piston(s) from the bore(s):
  - (a) Remove any carbon ridge formations or deposits at the top of the bore with a dull scraper or soft wire brush.
  - (b) If cylinder bore wear ridges are found, use a ridge reamer to cut the ridge from the bore. DO NOT remove more metal than necessary to remove the ridge.

**NOTE: If cylinders have ridges, the cylinders are oversize and will more than likely need boring.**

- (6) Using a hammer and steel stamp, identify the front of the piston by stamping the cylinder number in each piston to be removed at the top of the piston toward the front of the engine. DO NOT stamp in the outside 5 mm (.197 in.) of the piston diameter.



## REMOVAL AND INSTALLATION (Continued)

(7) Mark the connecting rod and cap with the corresponding cylinder numbers.

(8) Remove the connecting rod bolts and rod caps. Use care so the cylinder bores and connecting rods are not damaged.

(9) Use a hammer handle or similar object to push the piston and connecting rod through the cylinder bore.

(10) Store the piston/rod assemblies in a rack.

(11) If a piston must be replaced, replace with the same part number (grading) that was removed.

**PISTON GRADING PROCEDURE**

- If a new cylinder block and/or crankshaft is used, the piston grading procedure **MUST** be performed to determine the proper piston grade for each cylinder.

- When rebuilding an engine with the original cylinder block, crankshaft and pistons, make sure the pistons are installed in their original cylinder.

- If replacing the piston(s), make sure the replacement piston(s) are the same grade as the one being replaced.

(1) Install any of the original connecting rod and piston assemblies into the No.1 cylinder. DO NOT install the piston rings.

(2) Install the upper bearing shell in the connecting rod with the tang of the bearing in the slot of the connecting rod. The connecting rod bearing shell must be installed in the original connecting rod and cap. Use clean lubricating oil to coat the inside diameter of the connecting rod bearing shell.

(3) Install the bearing shell in the connecting rod cap with the tang of the bearing in the slot to the cap. Use clean lubricating oil to coat the inside diameter of the bearing shell.

(4) The number stamped on the connecting rod and cap at the parting line must match and be installed on the oil cooler side of the engine. Install the connecting rod cap and capscrews. Tighten the capscrews to 35 N·m (26 ft. lbs.) torque.

(5) Use a fine grit stone to remove any burrs from the cylinder block head deck. Zero the dial indicator to the cylinder block head deck.

(6) Move the dial indicator directly over the piston pin to eliminate any side-to-side movement.

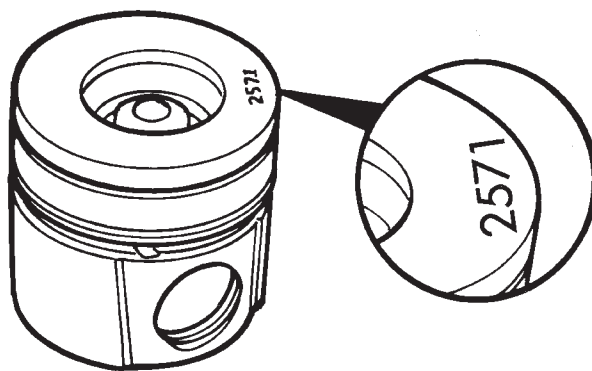
(7) Rotate the crankshaft to top dead center (TDC). Rotate the crankshaft clockwise and counter-clockwise to find the highest dial indicator reading. Record the reading.

(8) Remove the piston and connecting rod assembly from the No.1 cylinder and install the assembly into the No.2 cylinder. Repeat the procedure for every cylinder using the same piston and connecting rod assembly.

(9) Determine the grade of the piston being used by referring to the Piston Protrusion Chart below. Four digits on top of the piston can be cross referenced by a letter to a Chrysler part number for replacement (Fig. 142). If the number on the piston cannot be seen, use

the alternate method for determining grade by measuring from the top of the piston to the top of the piston pin bore to see what grade piston is used. Refer to the illustration and chart (Fig. 143).

**Ideal piston protrusion is 0.610 to 0.711 mm (0.024 to 0.028 in.)**



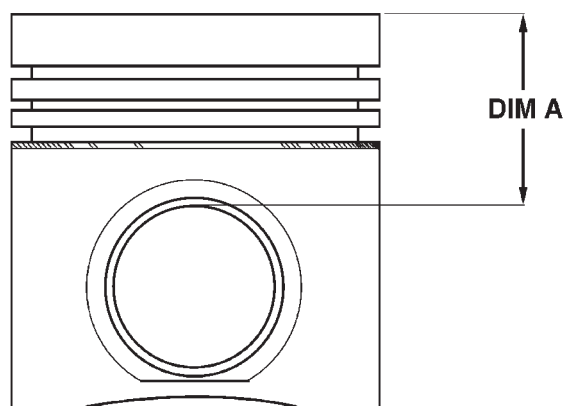
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**Fig. 142 Piston Grading Number Location**

**PISTON PROTRUSION CHART**

IF MEASURING PISTON IS GRADING #:	AND PROTRUSION IS:	USE GRADE:
3708	0.609-0.711 mm (0.024-0.028 in.)	A
3708	0.508-0.609mm (0.020-0.024 in.)	B
3708	0.406-0.508 mm (0.016-0.020 in.)	C
3709	0.711-0.813 mm (0.028-0.032 in.)	A
3709	0.609-0.711 mm (0.024-0.028 in.)	B
3709	0.508-0.609 mm (0.020-0.024 in.)	C
3710	0.813-0.914 mm (0.032-0.036 in.)	A
3710	0.711-0.813 mm (0.028-0.032 in.)	B
3710	0.609-0.711 mm (0.024-0.028 in.)	C

## REMOVAL AND INSTALLATION (Continued)



80a82c90

**Fig. 143 Piston Grading Measurement**

**NOTE:** Use the table below when piston grading numbers are missing or not legible.

ALTERNATIVE GRADE IDENTIFICATION  
METHOD

DIMENSION "A"	REF. NUMBER	GRADE
51.554-51.607 mm (2.029-2.031 in.)	3708	A
51.654-51.707 mm (2.033-2.035 in.)	3709	B
51.754-51.807 mm (2.037-2.039 in.)	3710	C

**DISASSEMBLY**

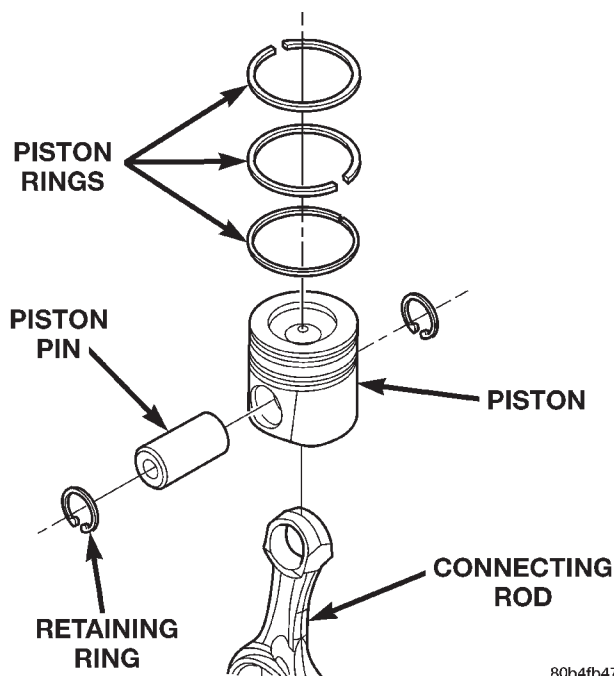
- (1) Remove the retaining rings from the piston (Fig. 144).
- (2) Slide the piston pin out of the bore. Heating the connecting rod is not required.
- (3) Remove the piston rings (Fig. 151).

**CLEANING****Pistons**

Clean the pistons and pins in a suitable solvent, rinse in hot water and blow dry with compressed air. Soaking the pistons over night will loosen most of the carbon build up. De-carbon the ring grooves with a broken piston ring and again clean the pistons in solvent. Rinse in hot water and blow dry with compressed air.

**Connecting Rods**

Clean the connecting rods in a suitable solvent, rinse in hot water and blow dry with compressed air.

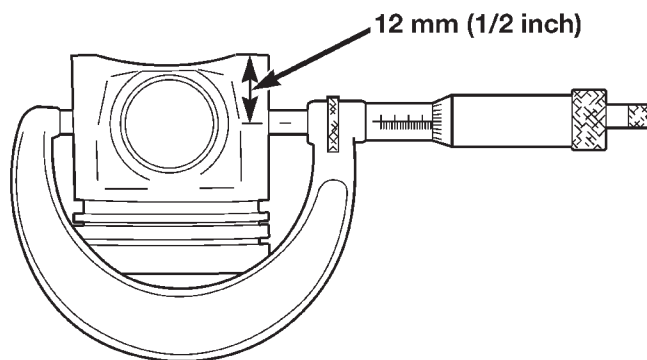


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**Fig. 144 Piston and Connecting Rod Assembly****INSPECTION****Pistons**

Inspect the pistons for damage and excessive wear. Check top of the piston, ring grooves, skirt and pin bore. Measure the piston skirt diameter (Fig. 145). If the piston is out of limits, replace the piston.

Uses new piston rings to measure the ring side



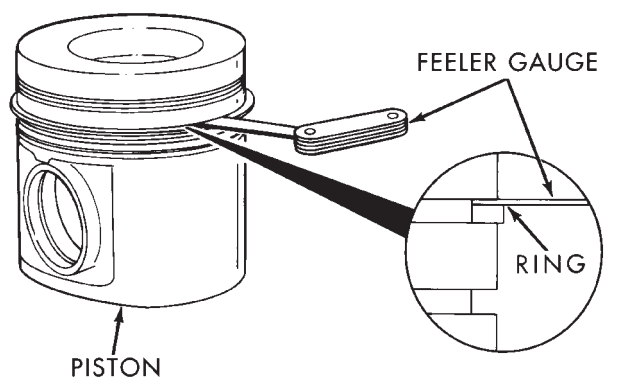
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**Fig. 145 Piston Skirt Diameter****PISTON SKIRT DIAMETER (MIN.)**

101.864 mm (4.0104 in.)

clearance (Fig. 146). Refer to the illustration and chart for specifications.

## REMOVAL AND INSTALLATION (Continued)



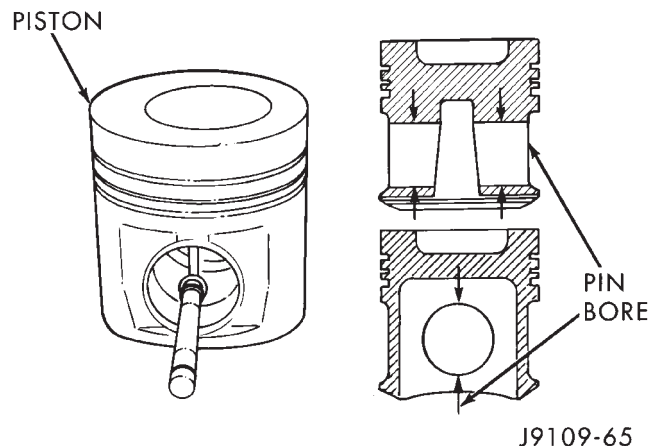
J9109-64

**Fig. 146 Intermediate and Oil Ring Clearances**

RING SIDE CLEARANCE	
TOP KEYSTONE	0.075 mm (0.003 in.) MIN
	0.150 mm (0.006 in.) MAX
INTERMEDIATE	0.045 mm (0.0018 in.) MIN
	0.095 mm (0.0037 in.) MAX
OIL CONTROL	0.040 mm (0.0016 in.) MIN
	0.085 mm (0.0033 in.) MAX

Measure the pin bore (Fig. 147). The maximum diameter is 40.025 mm (1.5758 inch). If the bore is over limits, replace the piston.

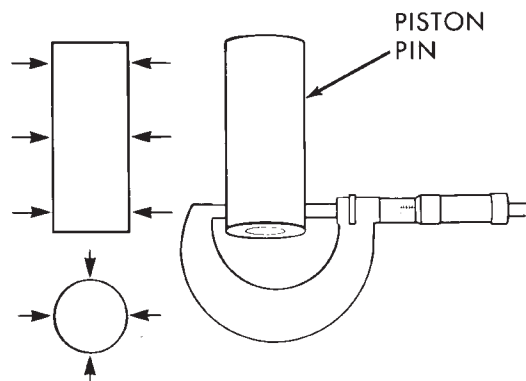
Inspect the piston pin for nicks, gouges and excessive wear. Measure the pin diameter (Fig. 148). The minimum diameter is 39.990 mm (1.5744 inch). If the diameter is out of limits, replace the pin.



J9109-65

**Fig. 147 Piston Pin Bore****Connecting Rods**

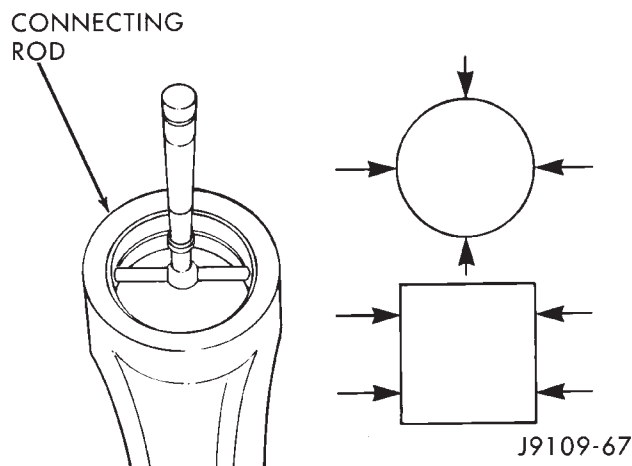
Inspect the connecting rod for damage and wear. The I-Beam section of the connecting rod cannot have dents or other damage. Damage to this part can cause stress risers which will progress to breakage.



J9109-66

**Fig. 148 Piston Pin Diameter**

Measure the connecting rod pin bore (Fig. 149). The maximum diameter is 40.042 mm (1.5764 inch). If out of limits, replace the connecting rod.



J9109-67

**Fig. 149 Connecting Rod Pin Bore****ASSEMBLY**

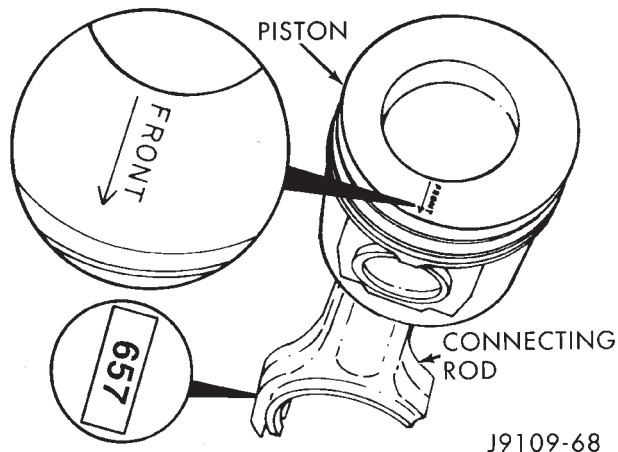
**NOTE:** The piston is symmetrical and can be installed to the connecting rod in either direction. It is good practice to re-install the piston in the same orientation as it was removed.

(1) Position the rod into the piston, orienting the mark you made on removal and the numbers on the rod and cap the same way (Fig. 150). Install the retaining ring into the pin groove on the one side of the piston.

(2) Lubricate the pin and bore with engine oil.

(3) Install the piston pin in the opposite side of the installed retaining pin. Pistons and rods do not

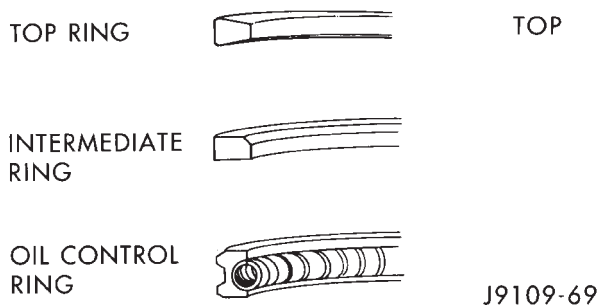
## REMOVAL AND INSTALLATION (Continued)



**Fig. 150 Proper Markings on the Piston and Connecting Rod**

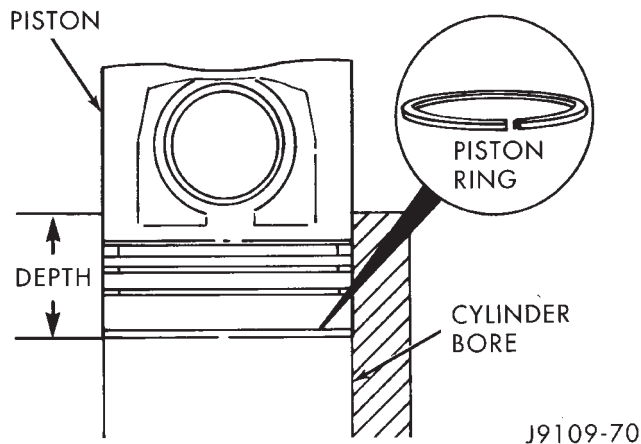
require heating to install the pin, however, the piston does need to be at room temperature or above.

(4) Determine the piston diameter and obtain the appropriate ring set. The piston rings can be identified as shown in (Fig. 151).



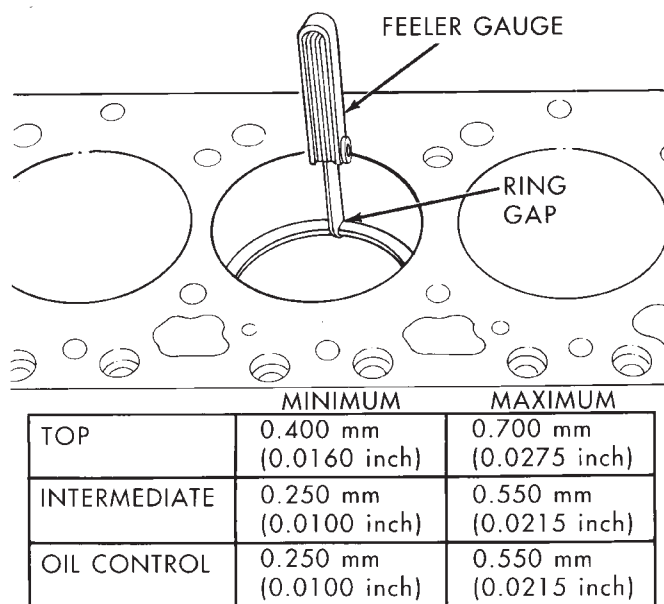
**Fig. 151 Piston Ring Identification**

(5) Position each ring in the cylinder and use a piston to square it with the bore at a depth of 89.0 mm (3.5 inch) - (Fig. 152).



**Fig. 152 Position of Ring in Cylinder Bore**

(6) Use a feeler gauge to measure the piston ring gap (Fig. 153).

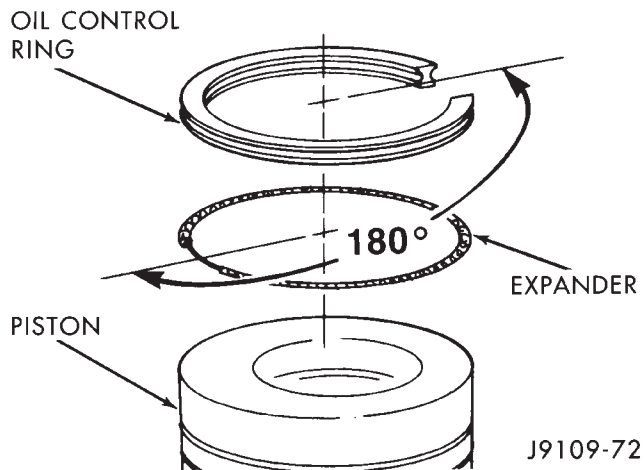


**Fig. 153 Piston Ring Gap**

(7) The top surface of all of the rings are identified with the word TOP or the supplier's MARK. Assemble the rings with the word TOP or the supplier's MARK up.

(8) Position the oil ring expander in the oil control ring groove (bottom groove).

(9) Install the oil control ring with the end gap OPPOSITE the ends on the expander (Fig. 154).



**Fig. 154 Oil Control Ring/Expander Location in Groove**

(10) Install the intermediate piston ring in the second groove (Fig. 152).

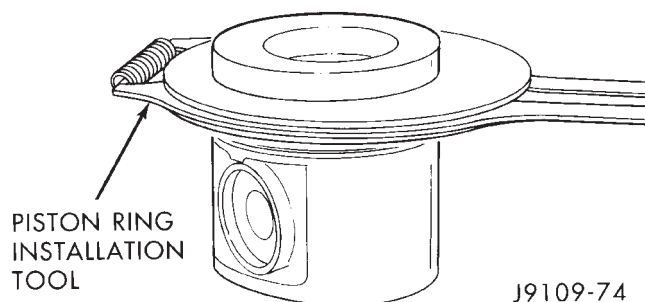
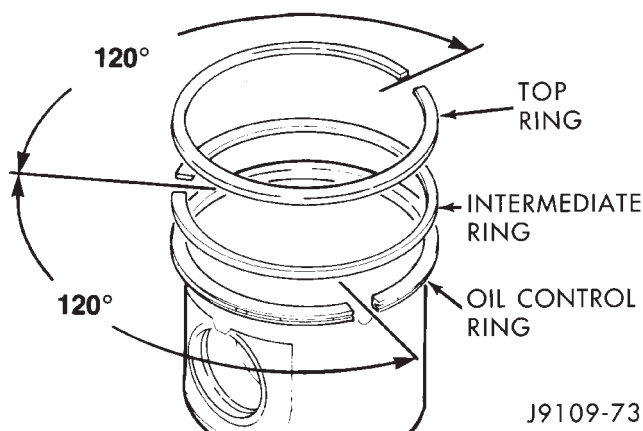
(11) Install the top piston ring in the top groove (Fig. 155).

(12) Position the rings as shown in (Fig. 156).

(13) Install the original bearings as removed or install new bearings. If new bearings are used, be

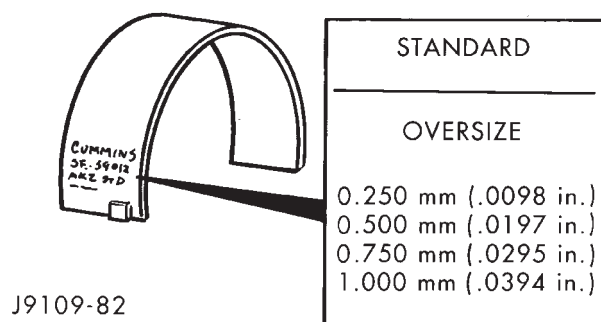


## REMOVAL AND INSTALLATION (Continued)

**Fig. 155 Piston Ring Installation Tool****Fig. 156 Piston Ring Orientation**

sure to obtain the proper bearing clearance (Fig. 157).

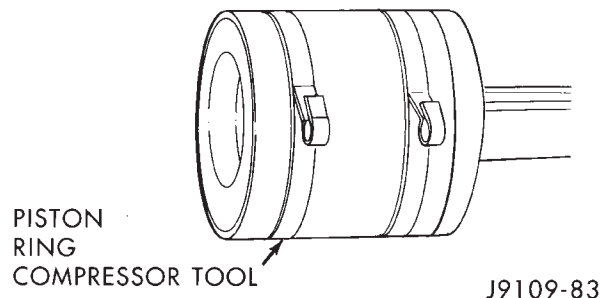
(14) DO NOT lubricate the side of the bearing that is against the connecting rod or cap. Apply a coat of Lubriplate 105, or equivalent to the new upper and lower connecting rod bearings.

**Fig. 157 Connecting Rod Bearing Size Location**  
INSTALLATION

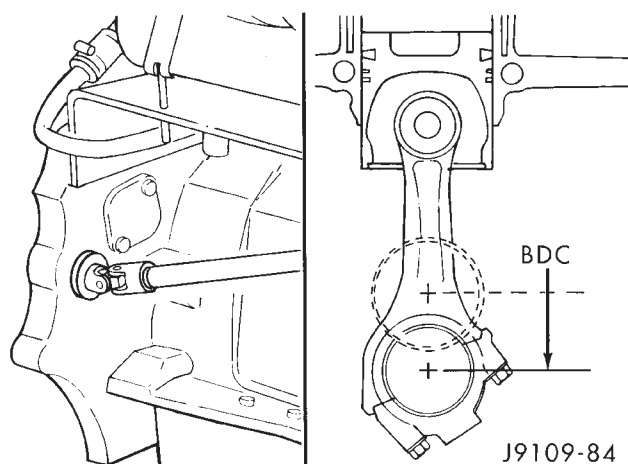
(1) Lubricate the cylinder bores with clean engine oil.

(2) Generously lubricate the rings and piston skirts with clean engine oil.

(3) Compress the rings using a piston ring compressor tool (Fig. 158). If using a strap-type ring compressor, make sure the inside end of the strap does not hook on a ring gap and break the ring.

**Fig. 158 Piston Ring Compressor Tool**

(4) Bar the crankshaft so the rod journal for the piston to be installed is at BDC (Bottom Dead Center) - (Fig. 159).

**Fig. 159 Piston/Rod Assembly at BDC**

(5) Be sure the mark you made on the piston and the numbers on the rod and cap are oriented as illustrated.

(6) Position the piston and rod assembly into the cylinder bore with the mark you made on the piston towards the front of the cylinder block. In this position the numbers on the connecting rod should be facing the oil cooler side of the engine, and the rod bolt holes toward the camshaft. Use care when you install the piston and connecting rod so the cylinder bore is not damaged.

(7) Push the piston into the bore until the top of the piston is approximately 50 mm (2 inch) below the top of the block. Carefully pull the connecting rod onto the crankshaft journal.

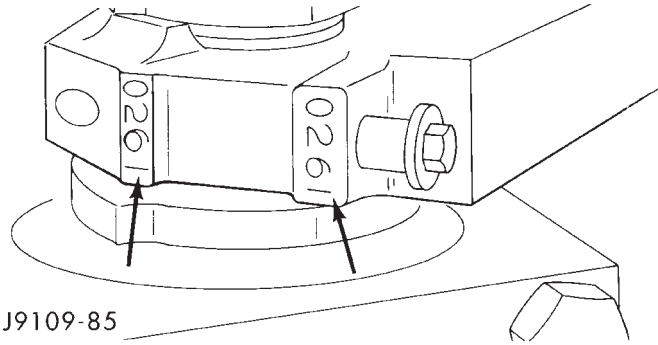
(8) Use clean engine oil to lubricate the threads and under the heads of the connecting rod bolts.

(9) The number stamped on the rod cap at the parting line must match and be installed towards the oil cooler side of the engine (Fig. 160).

(10) Install the rod cap and bolts to the connecting rod. Tighten the connecting rod and bolt evenly in 3 steps.

- Tighten the bolts to 35 N·m (26 ft. lbs.) torque.

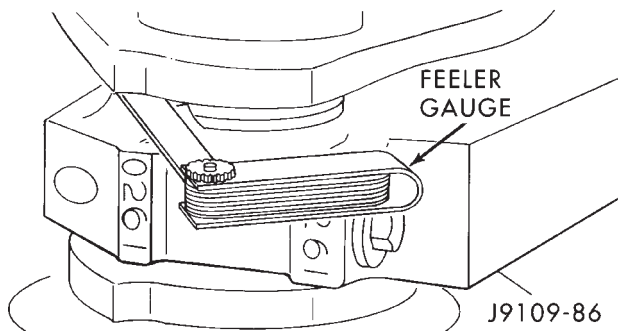
## REMOVAL AND INSTALLATION (Continued)

**Fig. 160 Correct Rod Cap Installation**

- Tighten the bolts to 70 N·m (51 ft. lbs.) torque.
- Tighten the bolts to 100 N·m (73 ft. lbs.) torque.

(11) The crankshaft must rotate freely. Check for freedom of rotation as the caps are installed. If the crankshaft does not rotate freely, check the installation of the rod bearing and the bearing size.

(12) Measure the side clearance between the connecting rod and the crankshaft (Fig. 161). DO NOT measure the clearance between the cap and crankshaft.

**SIDE CLEARANCE LIMITS**

MIN.	0.100 mm	(0.004 inch)
MAX.	0.300 mm	(0.012 inch)

**Fig. 161 Side Clearance between Connecting Rod/Crankshaft**

(13) Install the suction tube and oil pan. Refer to Procedure in this Group.

(14) Install the cylinder head onto the engine. Refer to Procedure in this group.

(15) Install a new filter and fill the crankcase with new engine oil.

(16) Connect the battery negative cables and start engine.

**CRANKSHAFT OIL SEAL—REAR****REMOVAL**

- (1) Disconnect the battery negative cables.

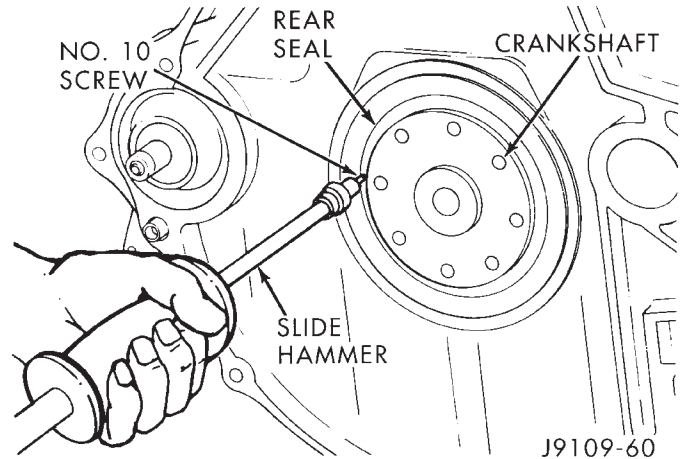
(2) Remove the transmission and transfer case (if equipped). Refer to Group 21, Transmission and transfer case for the correct procedures.

(3) Remove the clutch cover and disc (if manual trans equipped).

(4) Remove the flywheel or converter drive plate.

(5) Drill holes 180° apart into the seal. Be careful not to get the drill against the crankshaft.

(6) Install #10 sheet metal screws in the drilled holes and remove the rear seal with a slide hammer (Fig. 162).

**Fig. 162 Crankshaft Rear Seal Removal****CLEANING**

Clean the crankshaft journal with a suitable solvent and dry with a clean shop towel or compressed air. Wipe the inside bore of the crankshaft seal retainer with a clean shop towel.

**INSPECTION**

Inspect the crankshaft journal for gouges, nicks, or other imperfections. If the seal groove in the crankshaft is excessively deep, install the new seal 1/8" deeper into the retainer bore, or obtain a crankshaft wear sleeve that is available in the aftermarket.

**INSTALLATION**

**CAUTION:** The seal lip and the sealing surface on the crankshaft must be free from all oil residue to prevent seal leaks. The crankshaft and seal must be completely dry when the seal is installed.

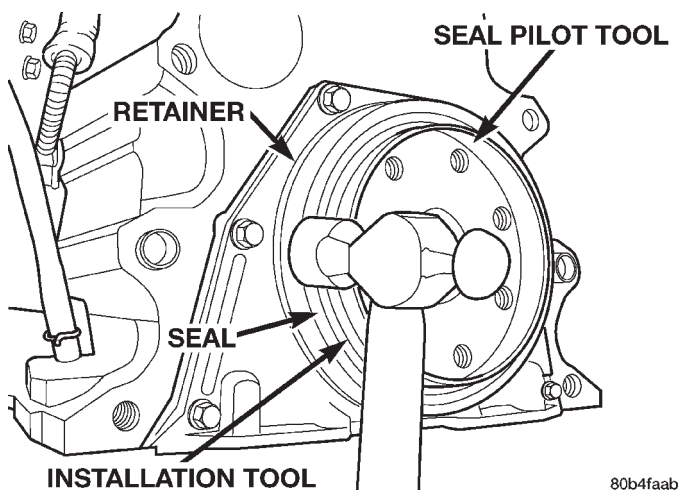
(1) Install the seal pilot, provided in the replacement kit, onto the crankshaft.

(2) Using the provided alignment/installation tool, start the seal over the pilot and into the retainer by hand.

(3) Using a ball peen hammer, strike the tool at the 12, 3, 6, and 9 o'clock positions until the alignment tool bottoms out on the retainer (Fig. 163).

(4) Remove the seal pilot.

## REMOVAL AND INSTALLATION (Continued)



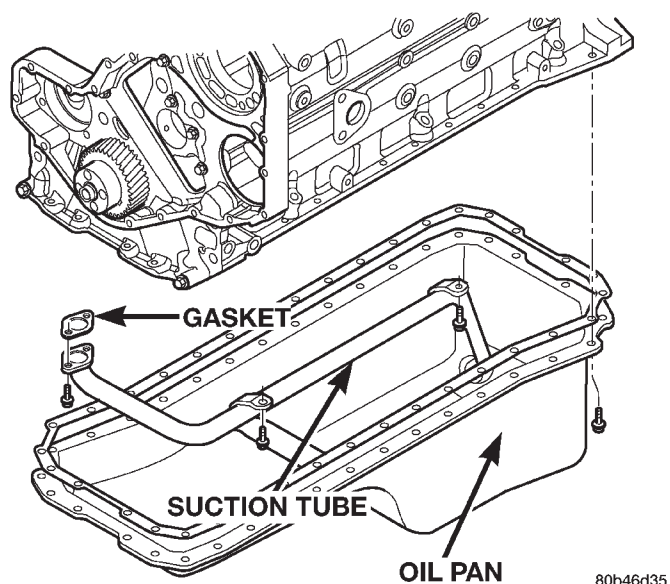
**Fig. 163 Seal Installation using Alignment Tool and Hammer**

- (5) Install the flywheel or converter drive plate. Tighten the bolts to 137 N·m (101 ft. lbs.) torque.
- (6) Install the clutch cover and disc (if equipped). Refer to Group 6, Clutch for the correct procedures.
- (7) Install the transmission and transfer case (if equipped). Refer to Group 21, Transmission and Transfer Case for the correct procedures.
- (8) Lower vehicle.
- (9) Connect battery negative cables.
- (10) Check engine oil level and adjust, if necessary.
- (11) Start engine and check for oil leaks.

## CRANKSHAFT REAR SEAL RETAINER

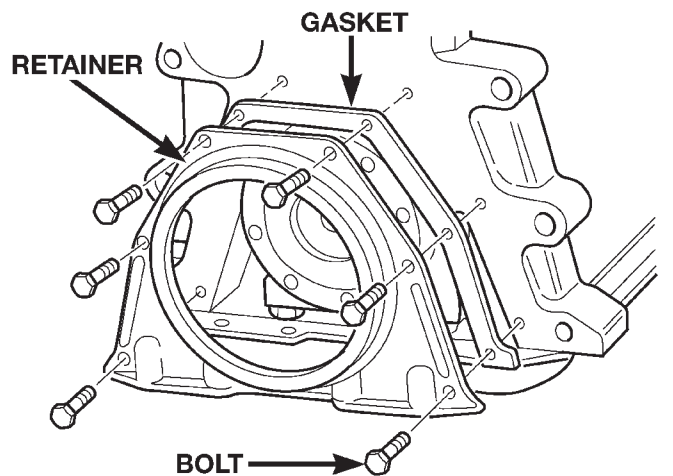
## REMOVAL

- (1) Disconnect the battery negative cables.
- (2) Raise vehicle on hoist.
- (3) Remove the oil pan drain plug and drain the engine oil. Re-install plug and torque to 60 N·m (44 ft. lbs.) torque.
- (4) Remove transmission and transfer case (if equipped) from vehicle, refer to Group 21, Transmission and Transfer Case.
- (5) Remove flywheel or torque converter drive plate.
- (6) Disconnect starter cables from starter motor.
- (7) Remove starter motor and transmission adapter plate assembly.
- (8) Disconnect cables from starter motor.
- (9) Remove the eight flywheel housing to block bolts and remove housing and starter motor as an assembly.
- (10) Remove oil pan bolts, break the pan to block seal, and lower pan slightly and remove oil suction tube fasteners.
- (11) Remove oil pan and suction tube (Fig. 164).
- (12) Remove the six (6) retainer-to-block bolts (Fig. 165).



**Fig. 164 Oil Pan, Suction Tube and Gasket**

- (13) Remove the rear seal retainer and gasket (Fig. 165).
- (14) Support the seal retainer and drive out the crankshaft seal with a hammer and suitable punch.



**Fig. 165 Crankshaft Rear Seal Housing and Gasket**

## CLEANING

Clean the cylinder block and seal retainer gasket surfaces with a suitable scraper. Use care not to allow any gasket material to fall into the crankcase. Clean and dry the crankshaft sealing surface. **The seal lip and the sealing surface on the crankshaft must be free from all oil residue to prevent seal leaks.**

## INSPECTION

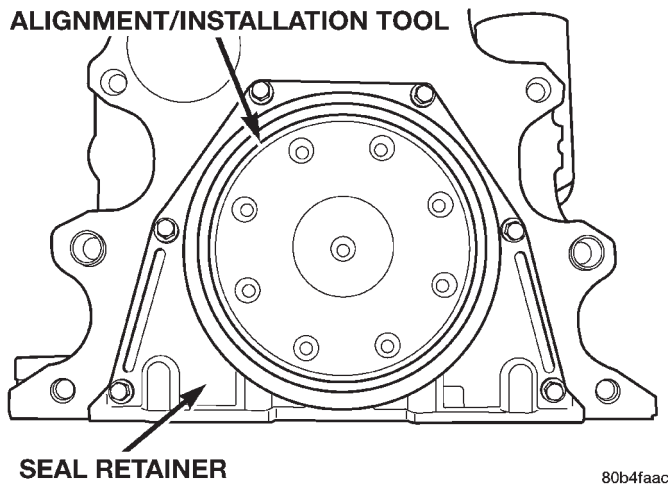
Inspect the crankshaft flange for nicks or an excessively deep seal groove. Inspect the seal retainer for cracks and replace if necessary.

## REMOVAL AND INSTALLATION (Continued)

## INSTALLATION

(1) If using the old seal retainer, it is recommended that the crankshaft seal is replaced. Support the seal retainer and drive out the old seal.

(2) Using the retainer alignment/seal installation tool provided in the seal service kit, install the alignment tool into the retainer and install to the cylinder block (Fig. 166), using a new gasket. Tighten the six (6) mounting bolts by hand.



**Fig. 166 Aligning Seal Retainer with Alignment/Installation**

(3) Starting with the center two bolts, tighten the retainer in a circular pattern to 9 N·m (80 in. lbs.). Remove the alignment tool.

**NOTE:** Install the crankshaft seal dry, with no lubrication on either the inside or outside diameters.

(4) Make sure the provided seal pilot is installed into the new crankshaft seal. Use the alignment/installation tool and press the seal onto the crankshaft (Fig. 167). Alternately drive the seal at the 12, 3, 6 and 9 o'clock positions.

(5) Remove the alignment tool and trim the retainer gasket even with the oil pan mounting surface (Fig. 168).

(6) Remove the seal pilot.

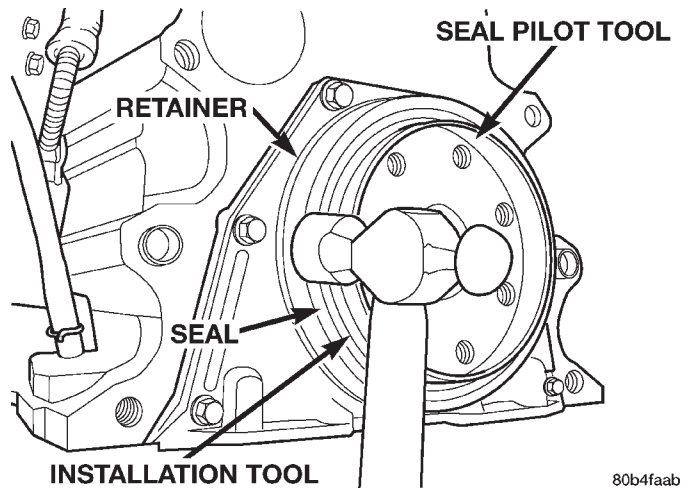
(7) Apply a small amount of Mopar® Silicone Rubber Adhesive Sealant to the oil pan rail T-joints.

(8) Install the oil pan, suction tube and gaskets. Tighten the suction tube fasteners to 24 N·m (18 ft. lbs.). Tighten the oil pan mounting bolts, starting from the center and working outward, to 24 N·m (18 ft. lbs.) torque.

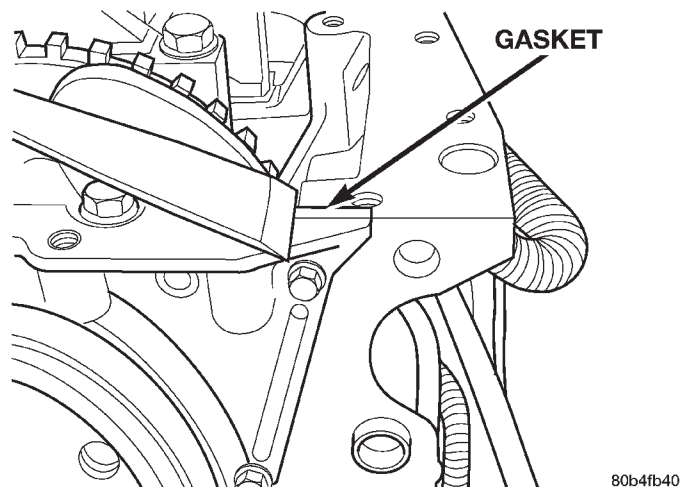
(9) Install the flywheel housing and bolts. Tighten the bolts to 60 N·m (44 ft. lbs.) torque.

(10) Connect the starter motor wires.

(11) Install the flywheel or converter drive plate. Tighten bolts to 137 N·m (101 ft. lbs.)



**Fig. 167 Installing Seal Using Alignment/Installation Tool**



**Fig. 168 Trimming Excess Gasket Material**

(12) Install the transmission and transfer case (if equipped). Refer to Group 21, Transmission and Transfer Case for the correct procedures.

(13) Lower vehicle.

(14) Fill the crankcase with new engine oil.

(15) Connect the battery negative cables.

(16) Start engine and check for oil leaks.

## CRANKSHAFT

## REMOVAL

(1) Remove engine from vehicle and place on a stand. Refer to procedure in this group.

(2) Remove oil pan and suction tube. Refer to procedure in this group.

(3) Remove the crankshaft rear seal retainer. Refer to procedure in this group.

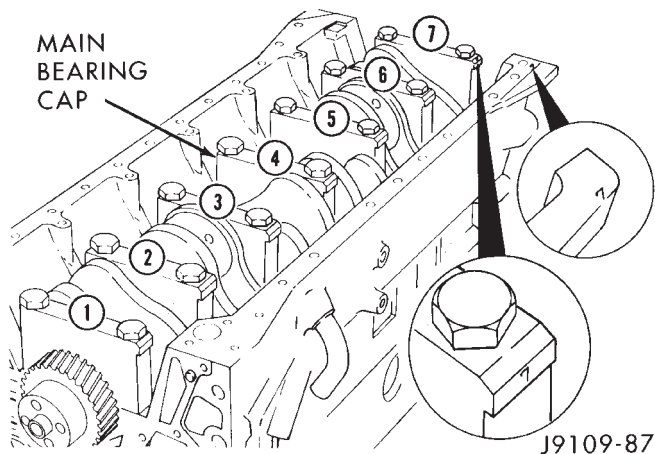
(4) Remove the front gear housing. Refer to procedure in this group.

(5) The main bearing caps should be numbered. If they are not, be sure to mark them, beginning with



## REMOVAL AND INSTALLATION (Continued)

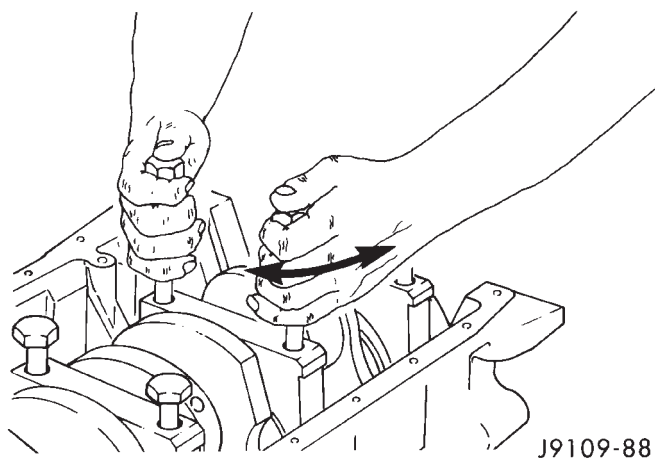
number one at the front and ending with number seven at the rear (Fig. 169).



**Fig. 169 Numbering Main Bearing Caps**

**CAUTION:** DO NOT pry on the main caps to free them from the cylinder block.

(6) Use two of the main bearing cap bolts to wiggle the main cap loose (Fig. 170), being careful not to damage the bolt threads. Remove all caps in the same manner.



**Fig. 170 Main Bearing Cap Removal**

**WARNING:** USE A HOIST TO AVOID INJURY.

(7) Lift the crankshaft and gear from the cylinder block (Fig. 171).

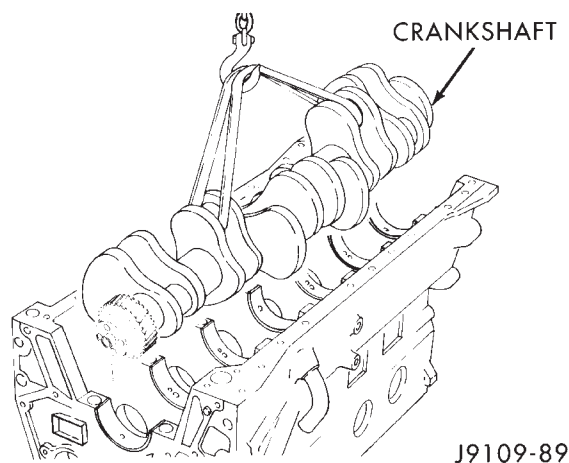
(8) Remove the main bearings from the block and the main caps.

(9) Remove the piston cooling nozzles by using a 3/16 inch pin punch to push them out (Fig. 172).

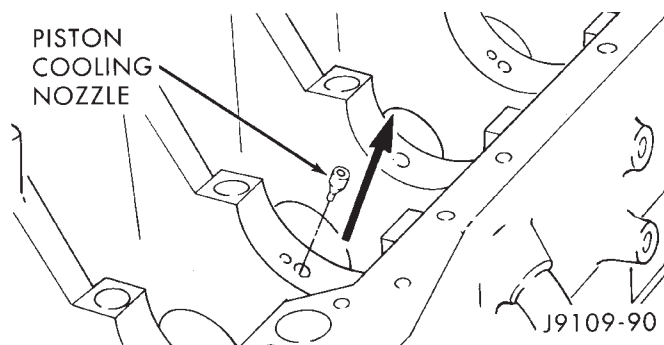
#### CLEANING

Clean the crankshaft oil galley holes with a nylon brush.

Rinse in clean solvent and dry with compressed air.



**Fig. 171 Lifting Crankshaft Out of Cylinder Block**



**Fig. 172 Piston Cooling Nozzles**

#### INSPECTION

Inspect the rod and main journal for deep scores, signs of overheating and other abnormal marks. Inspect the front and rear seal contact areas of the crankshaft for scratches or grooving.

The service seal kit will position the seal slightly deeper into the seal bore so it will contact the crankshaft at a different location. If this has already been done and the crankshaft has two worn areas, install a wear sleeve to provide a new contact surface for the seal.

(1) Visually inspect the tone wheel for missing teeth, cracks, and out-of-round.

**NOTE:** For additional crankshaft procedures, refer to "Crankshaft Service" in the Service Procedures section of this group.

#### INSTALLATION

**CAUTION:** Use only hand force to push the nozzle in place. If driven with a hammer, the nozzle will be damaged.

## REMOVAL AND INSTALLATION (Continued)

(1) Use a center punch to push the piston cooling nozzle into place. Install nozzles so they are flush with or slightly below the saddle surface.

(2) Make sure the saddle surface is clean and dry. Install the upper main bearings.

(3) Install the combination thrust/main bearing in the number six main bearing location.

(4) Lubricate the bearings with Lubriplate 105, or equivalent.

**WARNING: TO AVOID INJURY, USE A HOIST TO INSTALL THE CRANKSHAFT.**

(5) If replacing the crankshaft, transfer the tone wheel to the new crankshaft.

(a) Install the large section of the tone wheel.

(b) Coat the bolts with Mopar® Lock 'N Seal or Loctite® 242, install and torque to 8 N·m (71 in. lbs.) torque.

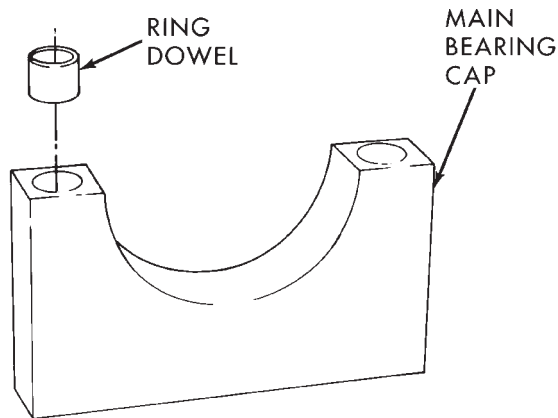
(c) Rotate the crankshaft and install the small section of the tone wheel.

(d) Coat the bolts with Mopar® Lock 'N Seal or Loctite® 242, install and torque to 8 N·m (71 in. lbs.) torque.

(6) Install the crankshaft.

**CAUTION: Crankshaft must be lowered onto the bearings straight to prevent damage to thrust bearings.**

(7) Install the ring dowels in the main bearing caps (Fig. 173).



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**Fig. 173 Install Ring Dowels**

(8) Install the lower main bearings in the caps.

(9) Lubricate the bearings with Lubriplate, or equivalent.

(10) Numbers on the main bearings caps face the oil cooler side of the engine with number one at the front of the engine.

(11) Place the caps in their respective positions.

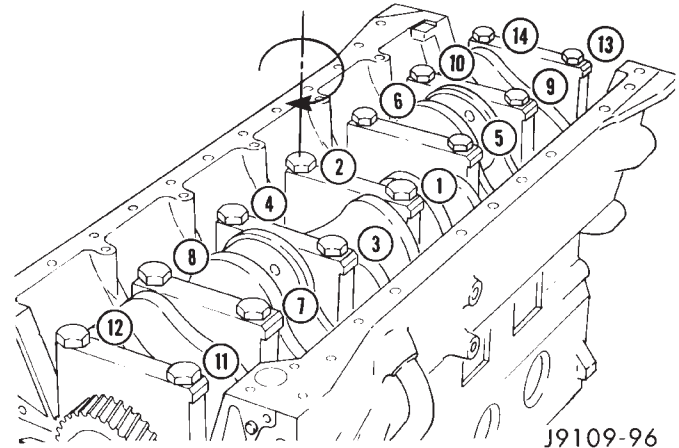
(12) Lubricate the main bearing bolt threads and underside of the bolt head with clean engine oil.

(13) Tighten the bolts in the sequence shown in (Fig. 174) using the following steps:

- STEP 1—Torque all bolts in sequence to 60 N·m (44 ft. lbs.) torque.

- STEP 2—Torque all bolts in sequence to 119 N·m (88 ft. lbs.) torque.

- STEP 3—Torque all bolts in sequence to 176 N·m (129 ft. lbs.) torque.

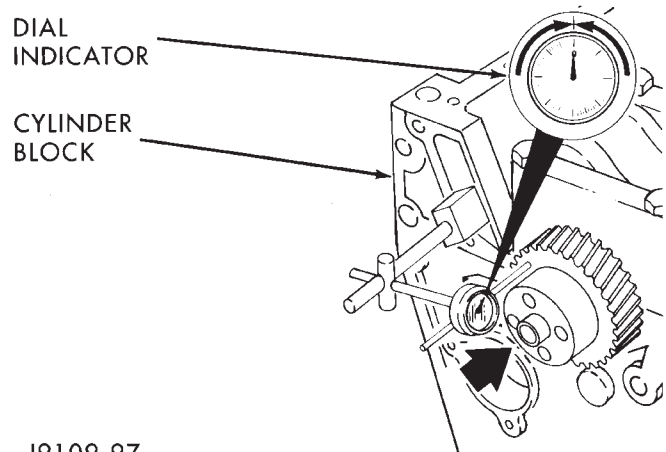


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**Fig. 174 Crankshaft Main Bearing Bolt Torque Sequence**

(14) Turn the crankshaft to determine that it will rotate freely all 360°. Check the main bearing cap installations and/or the bearing sizes if the shaft does not turn easily.

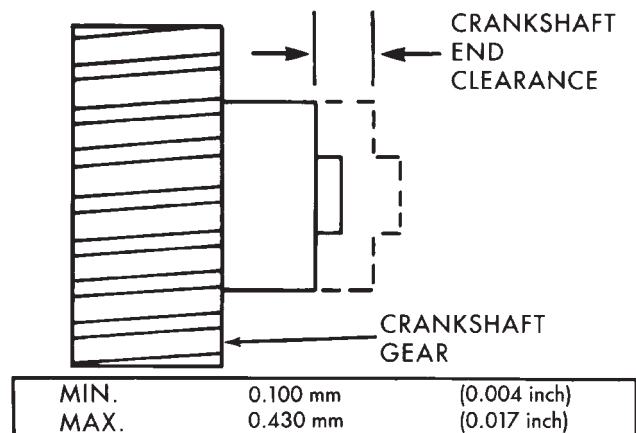
(15) **Verify crankshaft end play:** Push the crankshaft towards one end of its thrust and place a dial indicator as shown in (Fig. 175). Zero the indicator needle and push the crankshaft towards the other end of its thrust and record the crankshaft end clearance (Fig. 176).



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**Fig. 175 Measuring Crankshaft End Play**

## REMOVAL AND INSTALLATION (Continued)



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**Fig. 176 Crankshaft End Clearance****CRANKSHAFT END PLAY SPECIFICATIONS**

MIN	0.100 mm (0.004 in.)
MAX	0.430 mm (0.017 in.)

(16) Install the front gear housing. Refer to procedure in this group.

(17) Install the crankshaft rear oil seal retainer. Refer to procedure in this group.

(18) Install the oil pan and suction tube. Refer to procedure in this group.

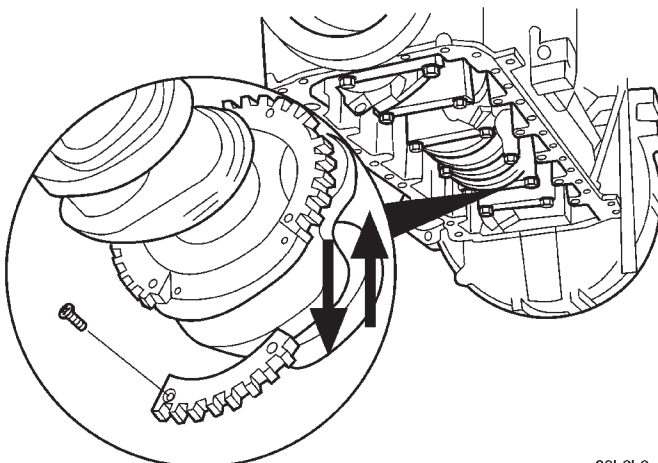
(19) Install engine into vehicle. Refer to procedure in this group.

**CRANKSHAFT TONE WHEEL****REMOVAL**

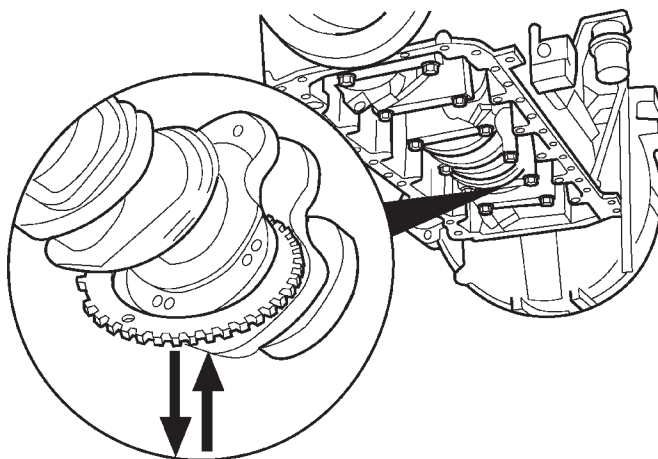
- (1) Disconnect the battery negative cables.
- (2) Remove the oil pan and suction tube. Refer to procedure in this group.
- (3) Using the crankshaft barring tool #7471B, rotate the crankshaft so the small section of the ring is facing away from the engine.
- (4) Remove the #6 main bearing cap.
- (5) Remove the two bolts fastening the small section of the wheel to the crankshaft. Remove the small section (Fig. 177).
- (6) Using the barring tool, rotate the crankshaft and remove the three bolts from the large section of the tone wheel.
- (7) Rotate the large section of the ring off of the crankshaft (Fig. 178). The crankshaft might have to be rotated to allow clearance for removal.

**CLEANING**

Clean the tone wheel with a suitable solvent. Rinse with hot water and blow dry with compressed air. Make sure the mounting surface of the wheel and crankshaft are free of all debris.



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**Fig. 177 Removing/Installing Small Section of Tone Wheel**

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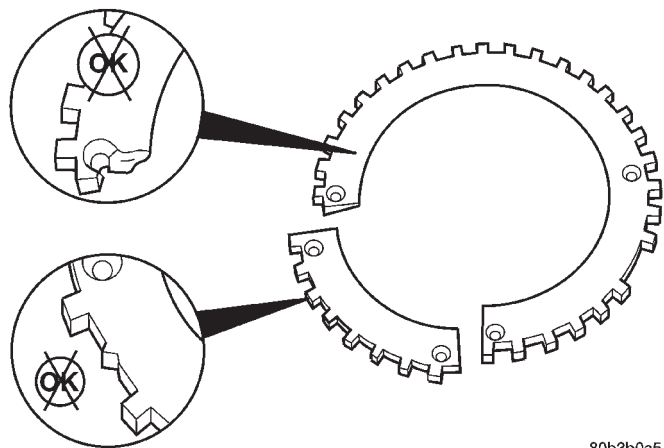
**Fig. 178 Removing/Installing Large Section of Tone Wheel****INSPECTION**

Inspect the tone wheel for missing teeth, cracks, or a damaged mounting surface (Fig. 179). Place the wheel on a known flat surface and verify that it is not out of flat. Replace the tone wheel if any of these conditions are found.

**INSTALLATION**

- (1) Install the large section of the tone wheel.
- (2) Coat the bolts with Mopar® Lock 'N Seal or Loctite® 242, install and torque to 8 N·m (71 in. lbs.) torque.
- (3) Rotate the crankshaft and install the small section of the tone wheel.
- (4) Coat the bolts with Mopar® Lock 'N Seal or Loctite® 242, install and torque to 8 N·m (71 in. lbs.) torque.
- (5) Install the #6 main bearing cap. Install the bolts and torque in three steps:

## REMOVAL AND INSTALLATION (Continued)



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**Fig. 179 Inspecting Tone Wheel for Damage**

Step 1—Preliminary ..... 60 N·m (44. ft. lbs.)  
 Step 2—Secondary ..... 119 N·m (88 ft. lbs.)  
 Step 3—Final ..... 176 N·m (129 ft. lbs.)

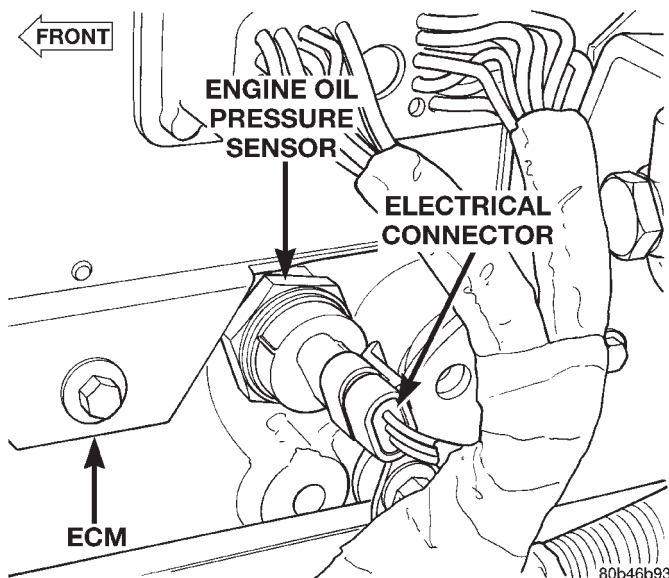
(6) Using a new gasket, install the oil pan and suction tube. Refer to procedure in this group.

(7) Add engine oil.

(8) Connect the battery negative cables and start engine.

**OIL PRESSURE SENSOR****REMOVAL**

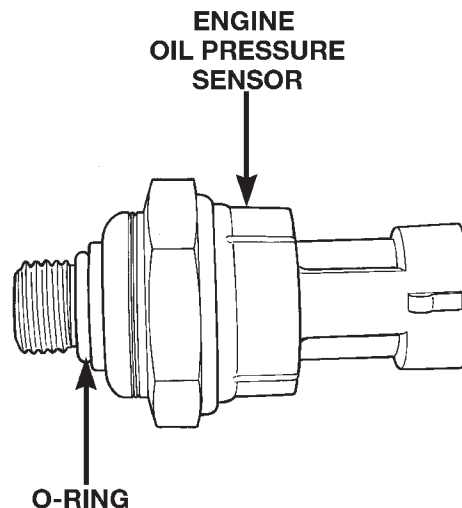
- (1) Disconnect the battery negative cables.
- (2) Disconnect the oil pressure sensor connector (Fig. 180).
- (3) Using a suitable socket, remove the oil pressure sensor from the block (counter-clockwise).



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**Fig. 180 Oil Pressure Sensor Location****INSTALLATION**

- (1) If the sensor is not being replaced, inspect the o-ring (Fig. 181) and replace if necessary.
- (2) Install the oil pressure sensor and tighten to 16 N·m (144 in. lbs.) torque.
- (3) Connect the battery negative cables.
- (4) Start engine and check for oil leaks at the sensor.

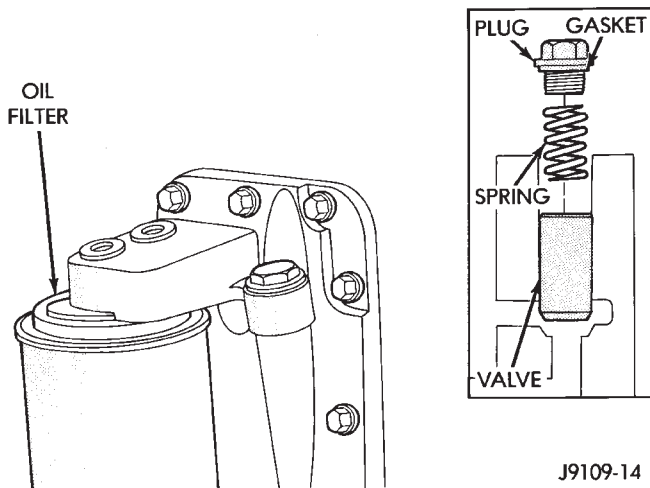


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**Fig. 181 Oil Pressure Sensor and O-Ring**  
**OIL PRESSURE REGULATOR VALVE AND SPRING****REMOVAL**

- (1) Disconnect the battery negative cables.
- (2) Remove the threaded plug, spring and plunger (Fig. 182). Insert a finger or a seal pick to lift the plunger from the bore.

**NOTE:** If the plunger is stuck in the bore, it will be necessary to remove the filter head.



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**Fig. 182 Oil Pressure Regulator**



## REMOVAL AND INSTALLATION (Continued)

## CLEANING

(1) Clean the regulator spring and plunger with a suitable solvent and blow dry with compressed air. If the plunger bore requires cleaning, it is necessary to remove the oil filter head to avoid getting debris into the engine.

## INSPECTION

Inspect the plunger and plunger bore for cracks and excessive wear. Polished surfaces are acceptable. Verify that the plunger moves freely in the bore.

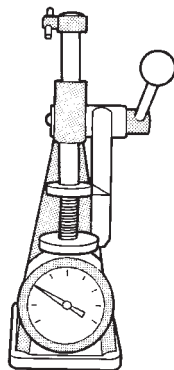
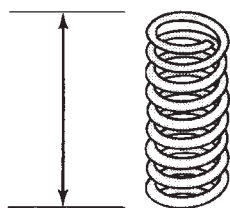
Check the spring for height and load limitations (Fig. 183). Replace the spring if out of limits shown in the figure.

Inspect the plug o-ring for cracks or brittleness, and replace as necessary.

## VALVE OPEN

- HEIGHT: 41.25mm (1.62 inch)
- LOAD: 126 N (28.4 lb)

FREE LENGTH: 66mm (2.6 inch)



J9509-161

**Fig. 183 Oil Pressure Regulator Spring Check**

## INSTALLATION

(1) Install the plunger, spring, and plug as shown in (Fig. 183). Tighten the plug to 80 N·m (60 ft. lbs.) torque.

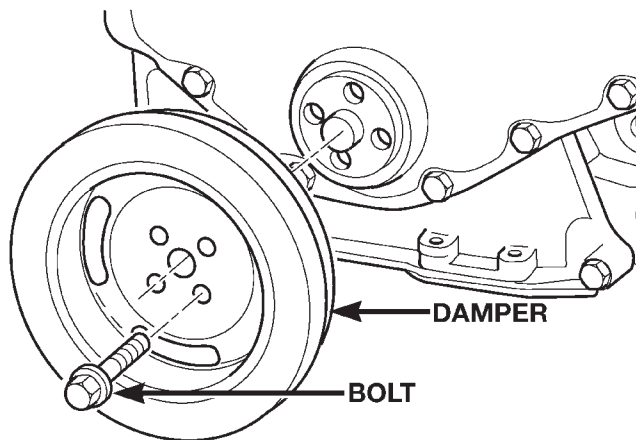
(2) Connect the battery negative cables.

(3) Start the engine and verify that it has oil pressure.

## OIL PUMP

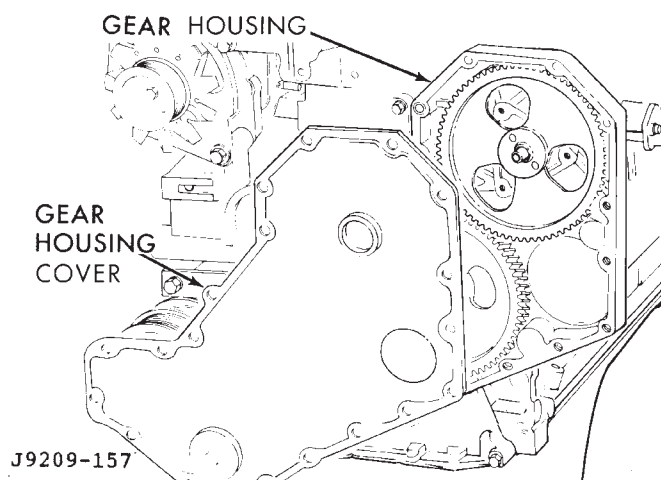
## REMOVAL

- (1) Disconnect the battery negative cables.
- (2) Remove fan/drive assembly.
- (3) Remove the accessory drive belt.
- (4) Remove the fan support/hub assembly.
- (5) Remove crankshaft damper (Fig. 184).
- (6) Remove the gear cover-to-housing bolts and gently pry the cover away from the housing, taking care not to mar the gasket surfaces (Fig. 185).
- (7) Remove the four mounting bolts and pull the pump from the bore in the cylinder block (Fig. 186).



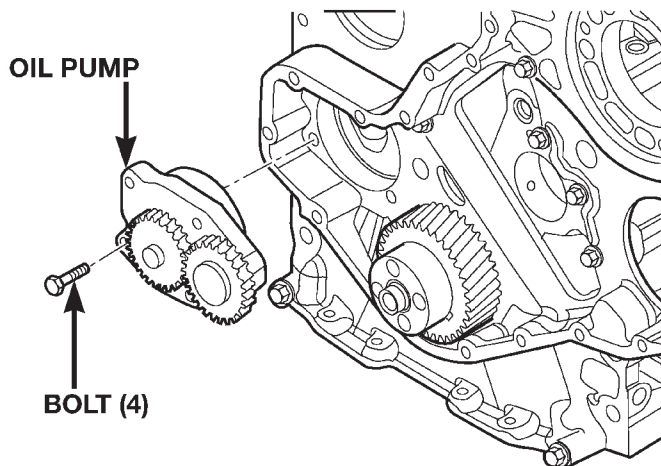
80b46d29

**Fig. 184 Crankshaft Damper Removal/Installation**



J9209-157

**Fig. 185 Gear Housing and Cover**



80b46d36

**Fig. 186 Oil Pump Removal**

## REMOVAL AND INSTALLATION (Continued)

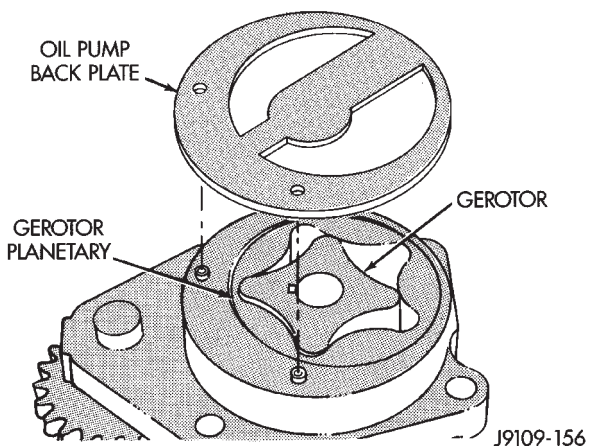
## CLEANING

Clean all parts in solvent and dry with compressed air. Clean the old sealer residue from the back of the gear housing cover and front of the gear housing.

## INSPECTION

**Disassemble and inspect the oil pump as follows:**

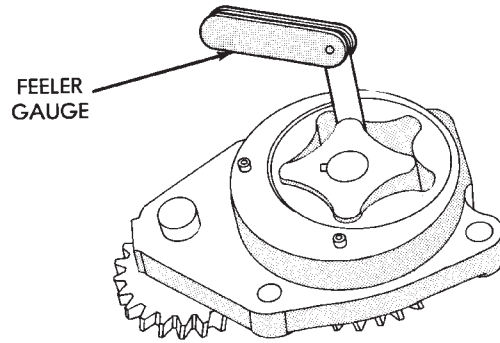
- (1) Visually inspect the lube pump gears for chips, cracks or excessive wear.
- (2) Remove the back plate (Fig. 187).
- (3) Mark TOP on the gerotor planetary using a felt tip pen (Fig. 187).
- (4) Remove the gerotor planetary (Fig. 187). Inspect for excessive wear or damage. Inspect the pump housing and gerotor drive for damaged and excessive wear.
- (5) Install the gerotor planetary in the original position. The chamfer must be on the O.D. and down.
- (6) Measure the tip clearance (Fig. 188). Maximum clearance is 0.1778 mm (0.007 inch). If the oil pump is out of limits, replace the pump.
- (7) Measure the clearance of the gerotor drive/gerotor planetary to port plate (Fig. 189). Maximum clearance is 0.127 mm (0.005 inch). If the oil pump is out of limits, replace the pump.
- (8) Measure the clearance of the gerotor planetary to the body bore (Fig. 190). Maximum clearance is 0.381 mm (0.015 inch). If the oil pump is out of limits, replace the pump.
- (9) Measure the gears backlash (Fig. 191). The limits of a used pump is 0.080- 0.380 mm (0.003-0.015 inch). If the backlash is out of limits, replace the oil pump.
- (10) Install the back plate.



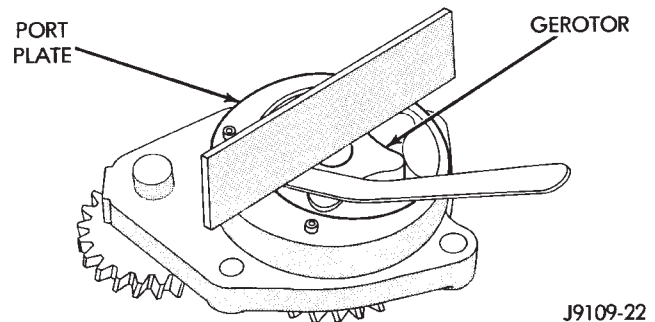
**Fig. 187 Gerotor Planetary and Gerotor**

## INSTALLATION

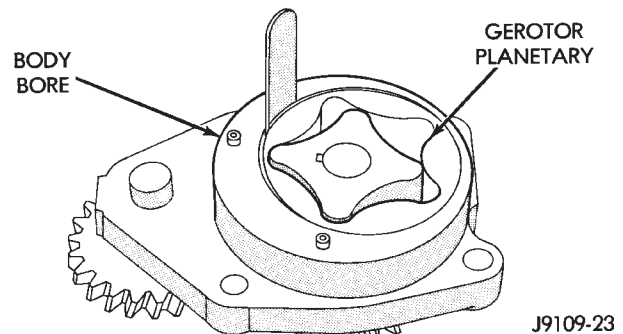
- (1) Lubricate the pump with clean engine oil. Filling the pump with clean engine oil during installation will help to prime the pump at engine start up.



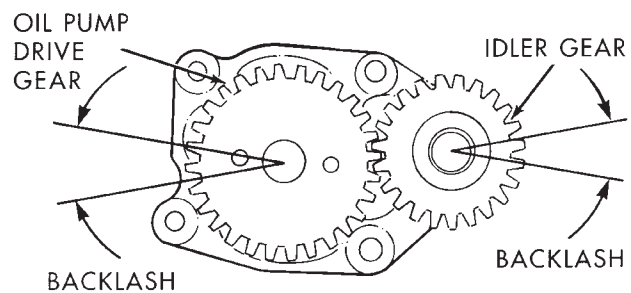
**Fig. 188 Measuring Tip Clearance**



**Fig. 189 Measuring Gerotor to Port Plate Clearance**



**Fig. 190 Measuring Gerotor Planetary to Body Bore Clearance**



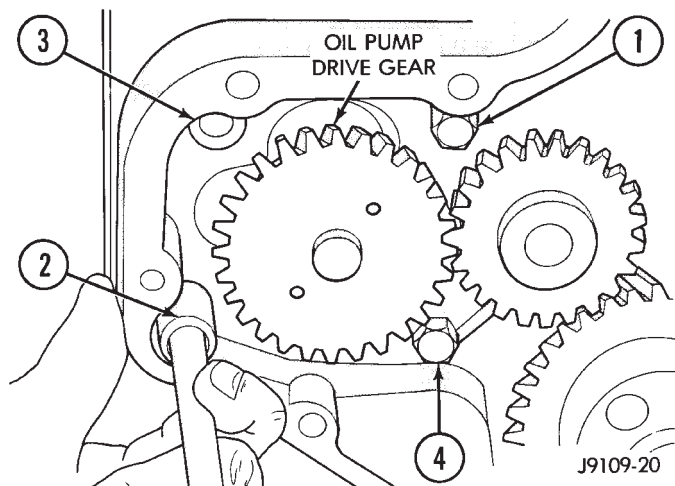
**Fig. 191 Measure Gear Backlash**

- (2) Verify the idler gear pin is installed in the locating bore in the cylinder block.

## REMOVAL AND INSTALLATION (Continued)

(3) Install the pump (Fig. 186). Tighten the oil pump mounting bolts in two steps, in the sequence shown in (Fig. 192).

- Step 1—Tighten to 5 N·m (44 in. lbs.) torque.
- Step 2—Tighten to 24 N·m (18 ft. lbs.) torque.

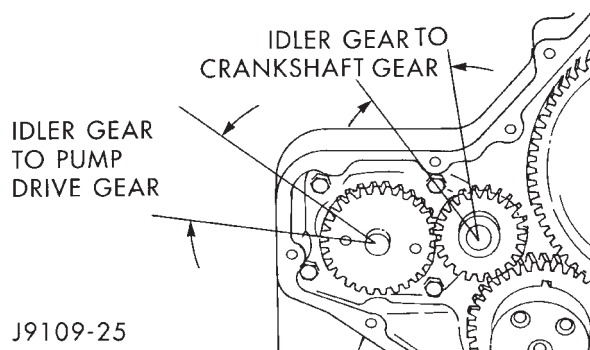


**Fig. 192 Oil Pump Mounting Bolt Torque Sequence**

(4) The back plate on the pump seats against the bottom of the bore in the cylinder block. When the pump is correctly installed, the flange on the pump will not touch the cylinder block.

(5) Measure the idler gear to pump drive gear backlash and the idler gear to crankshaft gear backlash (Fig. 193). The backlash should be 0.080- 0.330 mm (0.003-0.013 inch). If the backlash is out of limits, replace the oil pump drive gear and the idler gear.

(6) If the adjoining gear moves when you measure the backlash, the reading will be incorrect.



**Fig. 193 Idler Gear to Pump Drive Gear and Crankshaft Gear Backlash**

(7) Apply a bead of Mopar® Silicone Rubber Adhesive Sealant or equivalent to the gear housing cover sealing surface.

(8) Install the gear housing cover and tighten to 24 N·m (18 ft. lbs.) torque.

(9) Install the vibration damper and torque the bolts to 125 N·m (92 ft. lbs.). Use the engine barring tool to keep the engine from rotating during tightening operation.

(10) Install the fan support/hub assembly and torque bolts to 24 N·m (18 ft. lbs.).

(11) Install the accessory drive belt. Refer to Group 7, Cooling for the correct procedure.

(12) Connect battery negative cables.

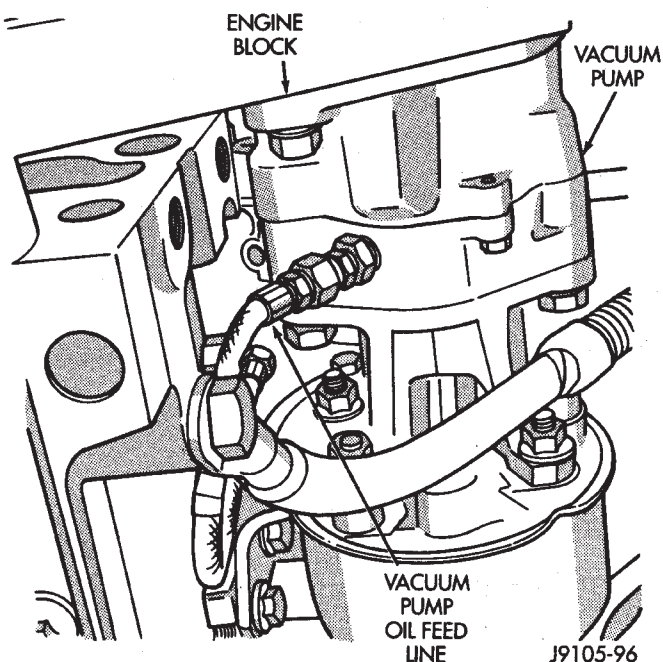
(13) Start engine and check for oil leaks.

## VACUUM PUMP

## REMOVAL

- (1) Disconnect battery negative cables.
- (2) Position drain pan under power steering pump.
- (3) Disconnect vacuum and steering pump hoses.
- (4) Disconnect lubricating oil feed line from fitting at underside of vacuum pump (Fig. 194).
- (5) Remove lower bolt that attaches pump assembly to engine block (Fig. 195).

(6) Remove bottom, inboard nut that attaches adapter to steering pump. This nut secures a small bracket to engine block. Nut and bracket must be removed before pump assembly can be removed from block.



**Fig. 194 Vacuum Pump Oil Feed Line**

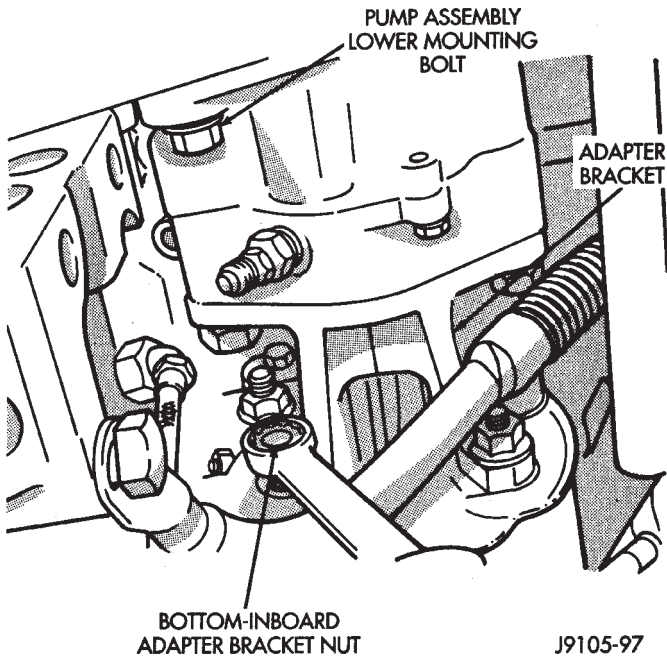
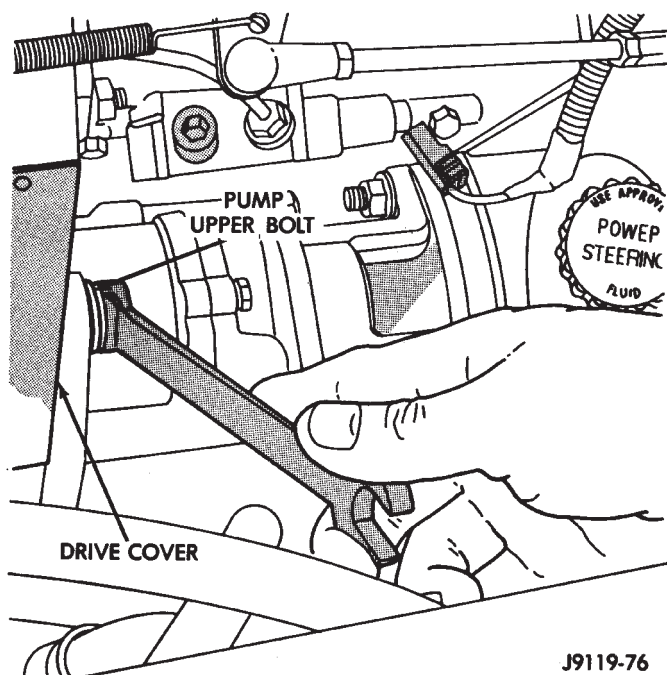
(7) Remove upper bolt that attaches pump assembly to engine block (Fig. 196).

(8) Remove pump assembly from vehicle.

(9) Remove nuts attaching vacuum pump to adapter (Fig. 197).



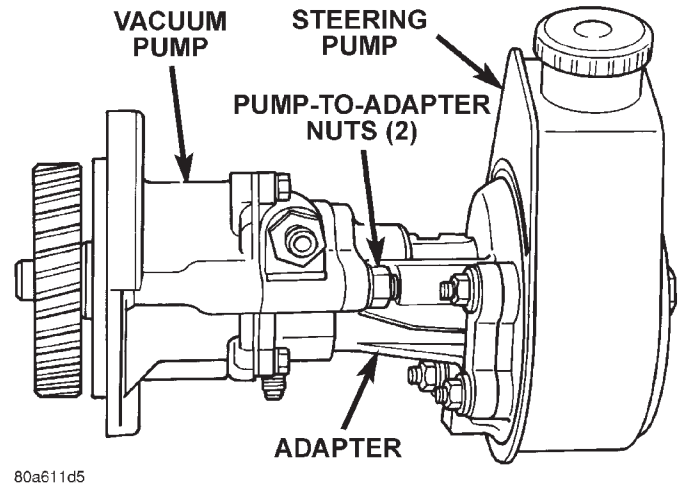
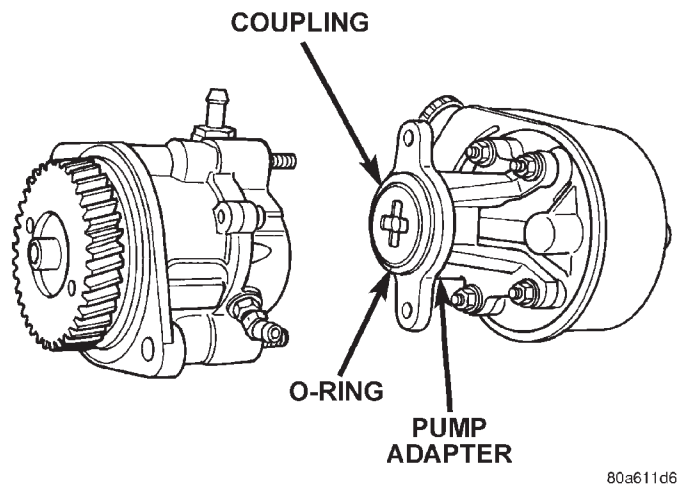
## REMOVAL AND INSTALLATION (Continued)

**Fig. 195 Vacuum Pump Mounting****Fig. 196 Pump Assembly Upper Mounting Bolt**

(10) Remove vacuum pump from adapter (Fig. 198). Turn pump gear back and forth to disengage pump shaft from coupling.

(11) Remove coupling from adapter (Fig. 199).

(12) Remove remaining adapter attaching nuts and remove adapter from steering pump (Fig. 200). If steering pump will be serviced, remove spacer from each inboard mounting stud on pump.

**Fig. 197 Pump Assembly****Fig. 198 Vacuum Pump Adapter****INSTALLATION**

(1) Clean and lubricate pump shaft with engine oil.

(2) Install spacers on steering pump studs.

(3) Install O-ring on adapter.

(4) Position adapter on pump studs.

(5) Install attaching nuts on outboard stud and on the two upper pump studs. Do **not** install nut on lower, inboard stud at this time. Tighten nuts to 24 N·m (18 ft. lbs.).

(6) Install coupling on pump shaft. Be sure coupling is securely engaged in shaft drive tangs.

(7) Install vacuum pump on adapter. Rotate drive gear until tangs on pump shaft engage in coupling. Verify that pump is seated before installing attaching nuts.

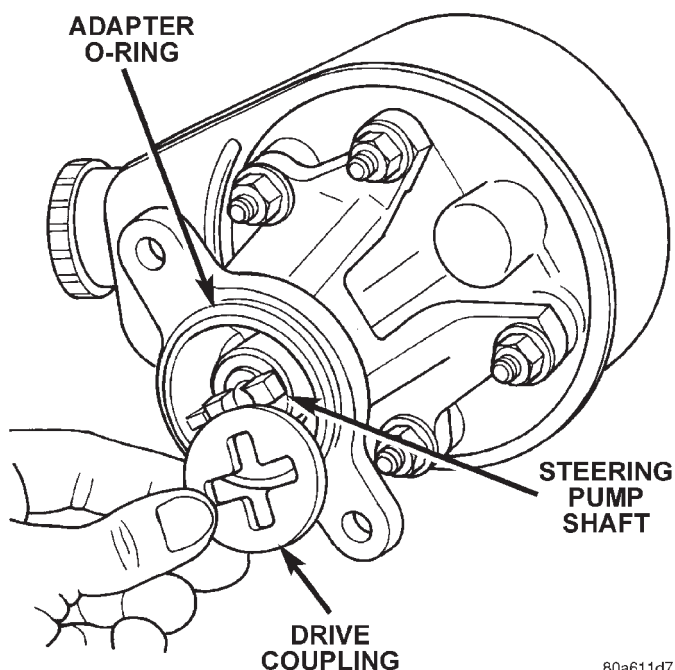
(8) Install and tighten vacuum pump attaching nuts.

(9) Inspect adapter O-ring and replace O-ring if cut or torn.

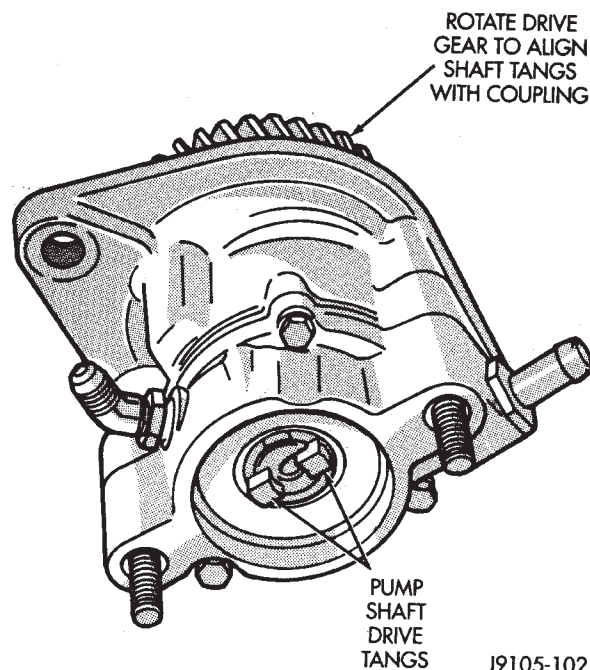
(10) Lubricate adapter O-ring with engine oil.



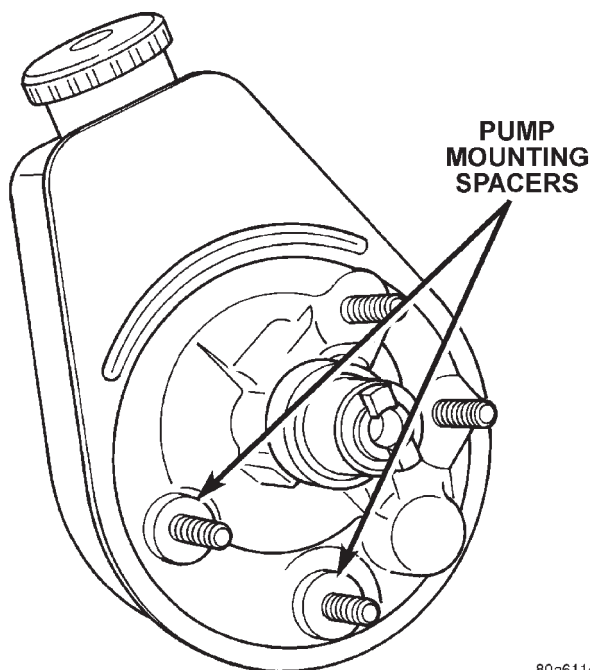
## REMOVAL AND INSTALLATION (Continued)



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**Fig. 199 Pump Drive Coupling**

J9105-102

**Fig. 201 Pump Shaft Drive Tangs**

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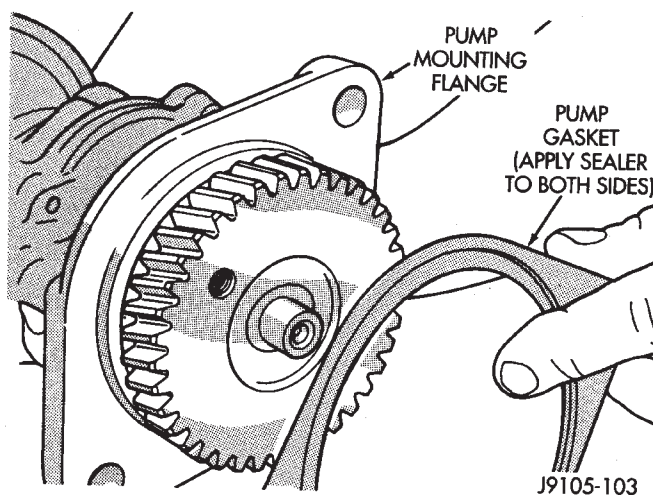
**Fig. 200 Steering Pump Mounting Stud Spacers**

(11) Note position of drive slots in coupling (Fig. 201). Then rotate drive gear to align tangs on vacuum pump shaft with coupling.

(12) Verify that pump is seated in adapter and coupling.

(13) Install and tighten pump attaching nuts and washers.

(14) Position new gasket on vacuum pump mounting flange (Fig. 202). Use Mopar Perfect Seal, or silicone adhesive/sealer to hold gasket in place.



J9105-103

**Fig. 202 Pump Mounting Flange Gasket**

(15) Insert pump assembly upper attaching bolt in mounting flange and gasket. Use sealer or grease to hold bolt in place if necessary.

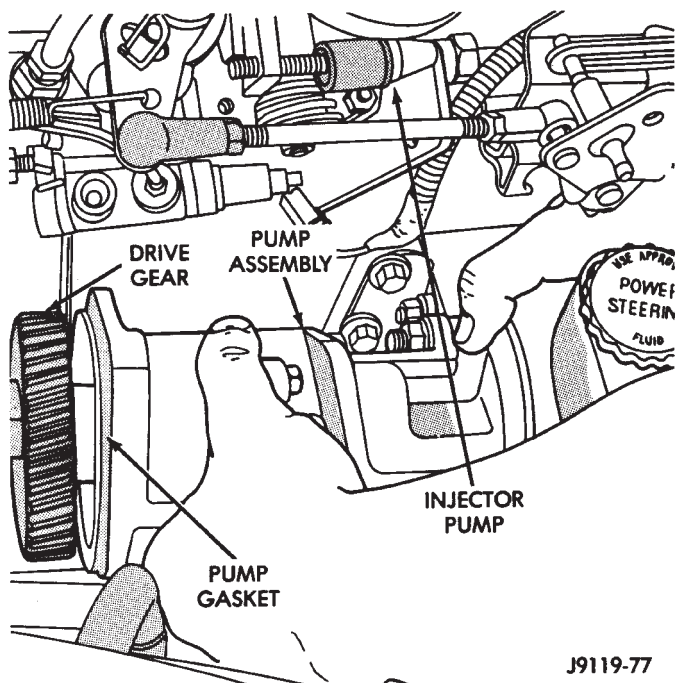
(16) Position pump assembly on engine and install upper bolt (Fig. 203). Tighten upper bolt only enough to hold assembly in place at this time.

(17) Working from under vehicle, install pump assembly lower attaching bolt. Then tighten upper and lower bolt to 77 N·m (57 ft. lbs.).

(18) Position bracket on steering pump inboard stud. Then install remaining adapter attaching nut on stud. Tighten nut to 24 N·m (18 ft. lbs.).

(19) Connect oil feed line to vacuum pump connector and tighten line fitting.

## REMOVAL AND INSTALLATION (Continued)

**Fig. 203 Installing Pump Assembly On Engine**

(20) Connect steering pump pressure and return lines to pump. Tighten pressure line fitting to 30 N·m (22 ft. lbs.).

(21) Connect vacuum hose to vacuum pump.

(22) Connect battery cables, if removed.

(23) Fill power steering pump reservoir.

(24) Purge air from steering pump lines. Start engine and slowly turn steering wheel left and right to circulate fluid and purge air from system.

(25) Stop engine and top off power steering reservoir fluid level.

(26) Start engine and verify that steering action is correct. Do this before moving vehicle.

## CLEANING AND INSPECTION

## CYLINDER BLOCK

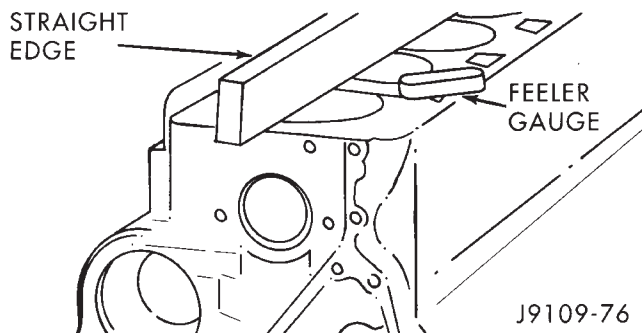
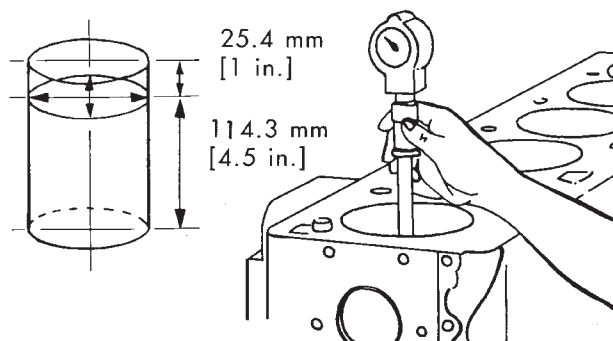
## INSPECTION

Measure the combustion deck face using a straight edge and a feeler gauge (Fig. 204). The distortion of the combustion deck face is not to exceed 0.010 mm (0.0004 inch) in any 50.00 mm (2.0 inch) diameter. Overall variation end to end or side to side is 0.075 mm (0.003 inch).

If the surface exceeds the limit, refer to Cylinder Block Refacing.

Inspect the cylinder bores for damage or excessive wear.

Measure the cylinder bores (Fig. 205). If the cylinder bores exceeds the limit, refer to Cylinder Bore Repair.

**Fig. 204 Combustion Deck Face Measurement**

MIN.	102.0 mm	(4.0157 inch)
MAX.	102.116 mm	(4.0203 inch)
Out-of-Round 0.038 mm (0.0015 inch)		
Taper 0.076 mm (0.003 inch)		
Oversize pistons and rings are available for bored cylinder blocks.		

J9209-167

**Fig. 205 Cylinder Bore Diameter**

Inspect the camshaft bores for scoring or excessive wear.

Measure the camshaft bores. Refer to engine specifications at the rear of this section. Limit for the No.1 bore applies to the ID of the bushing.

If a bore exceeds the limit, refer to Camshaft Bore Repair.

Inspect the tappet bores for scoring or excessive wear (Fig. 206). If out of limits, replace the cylinder block.

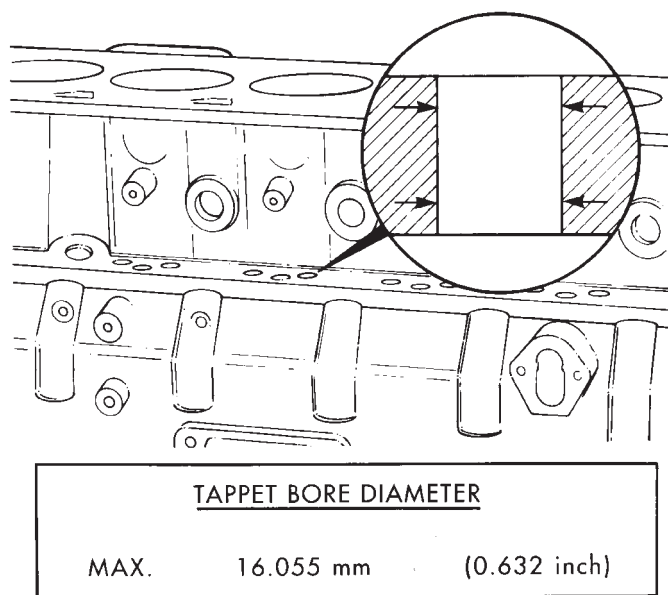
## CYLINDER HEAD

## INSPECTION

Remove the cup plugs and inspect the coolant passages. A large build up of rust and lime will require removal of the cylinder block for cleaning in a hot tank.

Inspect the cylinder bores for damage or excessive wear. Rotate the crankshaft so the piston is at Bottom Dead Center (BDC) to inspect the bores.

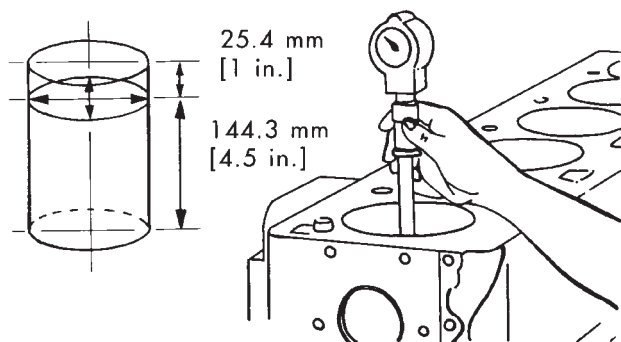
## CLEANING AND INSPECTION (Continued)



J9109-79

**Fig. 206 Tappet Bore Diameter**

Measure the cylinder bores (Fig. 207). DO NOT proceed with in-chassis repair if the bores are damaged or worn beyond the limits (refer to Cylinder Bore Repair - Cylinder Block).



MIN.	102.0 mm	(4.0157 inch)
MAX.	102.116 mm	(4.0203 inch)
Out-of-Round	0.038 mm	(0.0015 inch)
Taper	0.76 mm	(0.003 inch)
Oversize pistons and rings are available for bored cylinder blocks.		

J9109-75

**Fig. 207 Cylinder Bore Diameter**

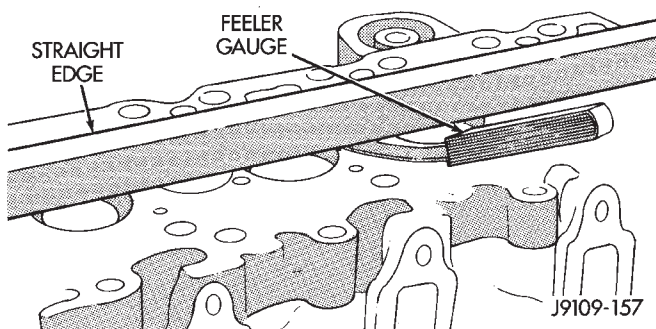
Check the top surface for damage caused by the cylinder head gasket leaking between cylinders.

Inspect the block and head surface for nicks, erosion, etc.

Check the head distortion (Fig. 208). The distortion of the combustion deck face is not to exceed 0.010

mm (0.0004 inch) in any 50.8 mm (2.00 inch) diameter. Overall variation end to end or side to side 0.30 mm (0.012 inch).

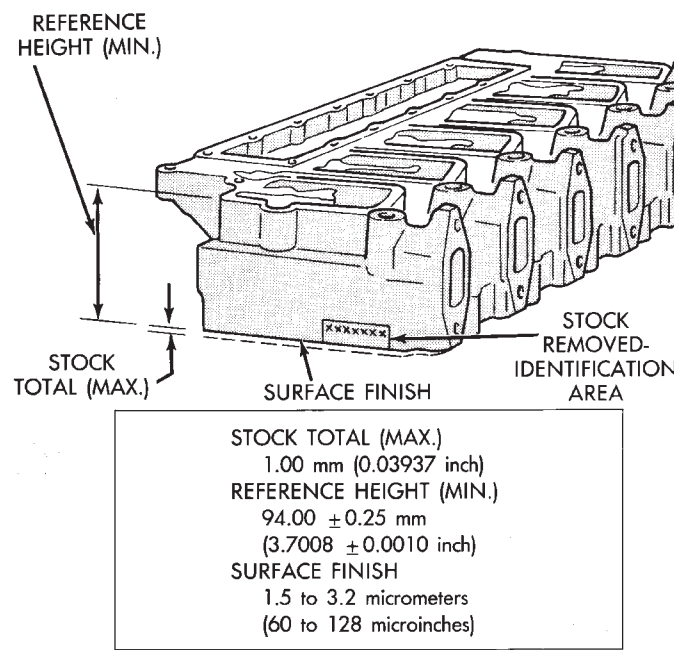
DO NOT proceed with the in-chassis overhaul if the cylinder head or block surface is damaged or not flat (within specifications).

**Fig. 208 Cylinder Head Combustion Deck Face Measurement**

## REFACING HEAD SURFACE

The cylinder head combustion deck may be refaced in whatever increments necessary to clean up the surface and maintain the surface finish and flatness tolerances. The combined total of stock removed must not exceed 1.00 mm (0.03937 inch). The amount of stock removed each time must be steel stamped above combustion deck edge, on the lower right hand corner of the rear face (Fig. 209). Check valve protrusion after head surface refacing.

Surface finish requirements are 1.5-3.2 micrometers (60-126 microinch).



J9109-134

**Fig. 209 Cylinder Head Stock Removal**

## CLEANING AND INSPECTION (Continued)

## CLEANING

Clean the carbon from the injector nozzle seat with a nylon or brass brush.

Scrape the gasket residue from all gasket surfaces.

Wash the cylinder head in hot soapy water solution (88°C or 140°F).

After rinsing, use compressed air to dry the cylinder head.

Polish the gasket surface with 400 grid paper. Use an orbital sander or sanding block to maintain a flat surface.

## VALVES AND VALVE SPRINGS

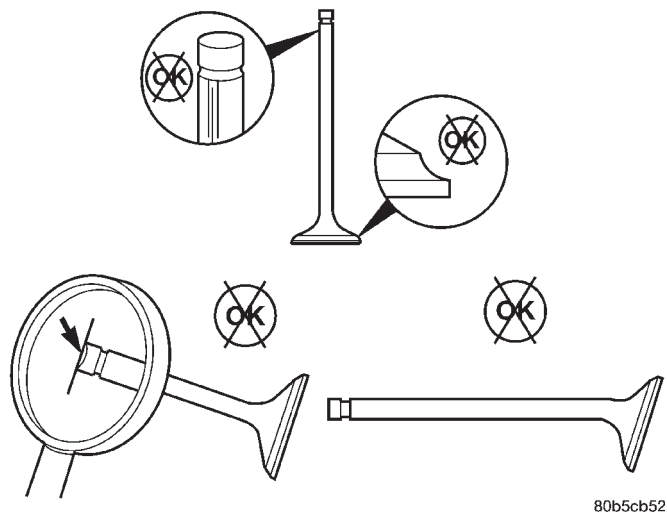
## CLEANING

Clean the valve stems with crocus cloth or a Scotch-Brite™ pad. Remove carbon with a soft wire brush. Clean valves, springs, retainers, and collets in a suitable solvent. Rinse in hot water and blow dry with compressed air.

## INSPECTION

Visually inspect the valves for abnormal wear on the heads, stems, and tips. Replace any valve that is worn out or bent (Fig. 210).

Measure the valve stem diameter in three places



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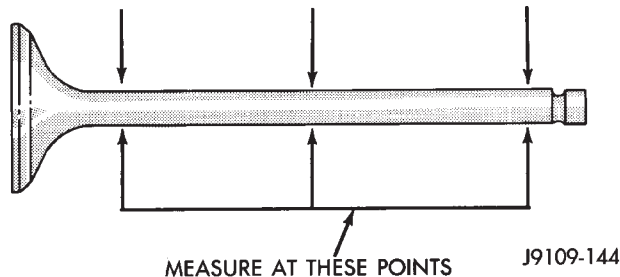
**Fig. 210 Visually Inspect Valves for Abnormal Wear** as shown in (Fig. 211).

Measure the cylinder head valve guide bore (Fig. 212). Subtract the corresponding valve stem diameter to obtain valve stem-to-guide clearance.

Measure valve margin (rim thickness) (Fig. 213).

Measure the valve spring free length and maximum inclination (Fig. 214).

Test valve spring force with tool C-647 (Fig. 215).



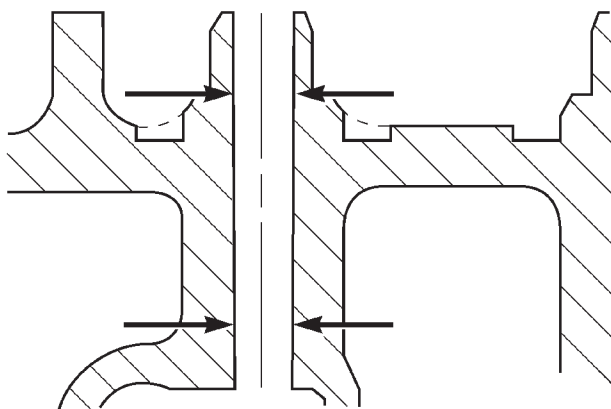
J9109-144

**Fig. 211 Measure Valve Stem Diameter**

## VALVE STEM DIAMETER

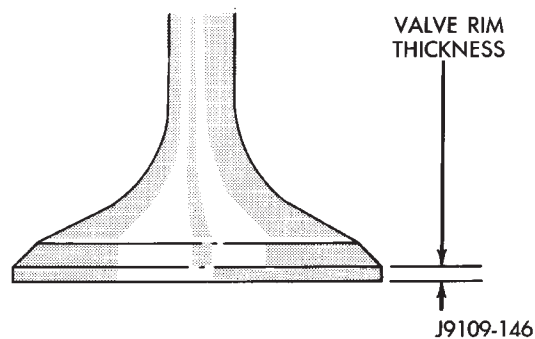
6.990 mm (0.2752 in.) MIN

7.010 mm (0.2760 in.) MAX



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**Fig. 212 Measure Valve Guide Bore**



J9109-146

**Fig. 213 Measure Valve Margin (Rim Thickness)**

## VALVE MARGIN (RIM THICKNESS)

0.72 mm (0.031 in.) MIN.

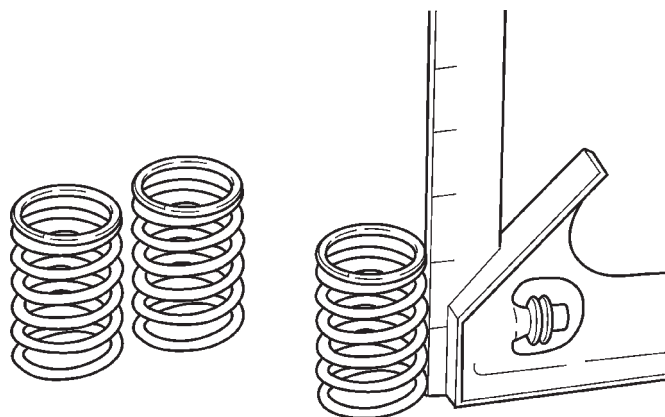
## CRANKSHAFT

## CLEANING AND INSPECTION

Clean the crankshaft oil galley holes with a nylon brush.



## CLEANING AND INSPECTION (Continued)



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**Fig. 214 Measure Valve Spring Free Length and Max. Inclination**

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**VALVE SPRING FREE LENGTH**

47.75 mm (1.88 in.)

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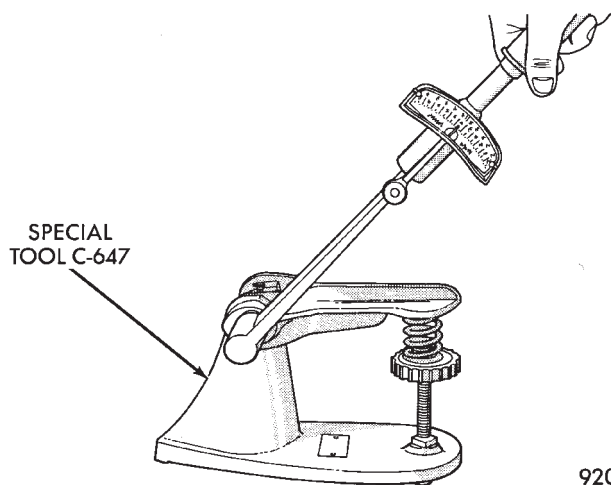


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**MAX INCLINATION**

1.5 mm (.059 in.)

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9209-37

**Fig. 215 Testing Valve Spring with Tool C-647**

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**VALVE SPRING MINIMUM LOAD**

@ 35.33 mm — 339.8 N

@ 1.39 in. — 76.4 lbs.

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Rinse in clean solvent and dry with compressed air. Inspect the front and rear seal contact areas of the crankshaft for scratches or grooving.

The service seal kit will position the seal slightly deeper into the seal bore so it will contact the crankshaft at a different location. If this has already been done and the crankshaft has two worn areas, install

a wear sleeve to provide a new contact surface for the seal.

Inspect the rod and main journal for deep scores, signs of overheating and other abnormal marks.

## PISTON AND CONNECTING ROD ASSEMBLY

### CLEANING

#### Pistons

**CAUTION:** DO NOT use bead blast to clean the pistons. DO NOT clean the pistons and rods in an acid tank.

Clean the pistons and pins in a suitable solvent, rinse in hot water and blow dry with compressed air. Soaking the pistons over night will loosen most of the carbon build up. De-carbon the ring grooves with a broken piston ring and again clean the pistons in solvent. Rinse in hot water and blow dry with compressed air.

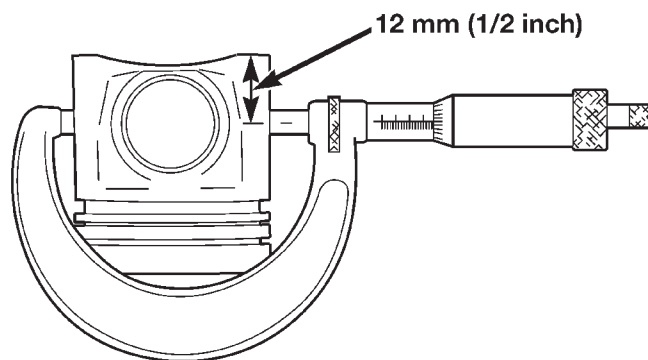
#### Connecting Rods

Clean the connecting rods in a suitable solvent, rinse in hot water and blow dry with compressed air.

### INSPECTION

#### Pistons

Inspect the pistons for damage and excessive wear. Check top of the piston, ring grooves, skirt and pin bore. Measure the piston skirt diameter (Fig. 216). If the piston is out of limits, replace the piston.



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**Fig. 216 Piston Skirt Diameter**

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**PISTON SKIRT DIAMETER (MIN.)**

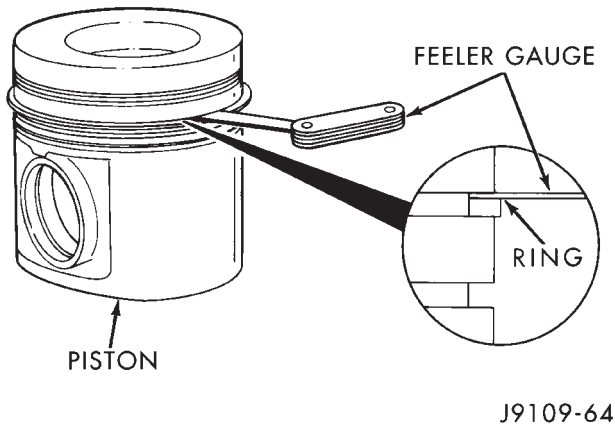
101.864 mm (4.0104 in. )

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## CLEANING AND INSPECTION (Continued)

The upper groove only needs to be inspected for damage. Use a new piston ring to measure the clearance in the intermediate ring groove (Fig. 217). If the clearance of the intermediate ring exceeds 0.152 mm (0.006 inch), replace the piston.

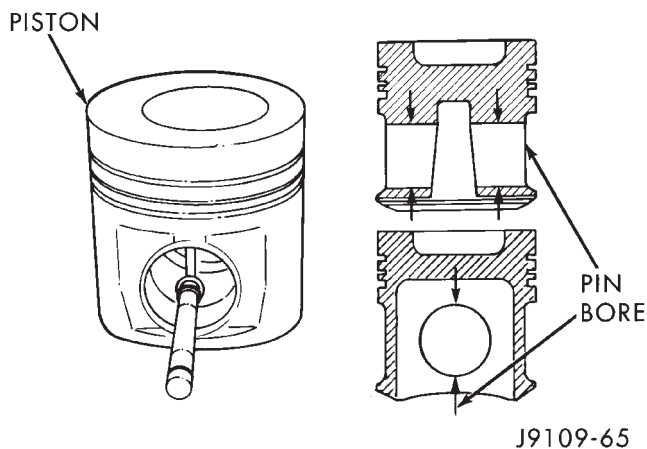
Use a new oil ring to measure the clearance in the oil groove (Fig. 217). If the clearance exceeds 0.127 mm (0.005 inch), replace the piston.



**Fig. 217 Intermediate and Oil Ring Clearances**

Measure the pin bore (Fig. 218). The maximum diameter is 40.025 mm (1.5758 inch). If the bore is over limits, replace the piston.

Inspect the piston pin for nicks, gouges and excessive wear. Measure the pin diameter (Fig. 219). The minimum diameter is 39.990 mm (1.5744 inch). If the diameter is out of limits, replace the pin.

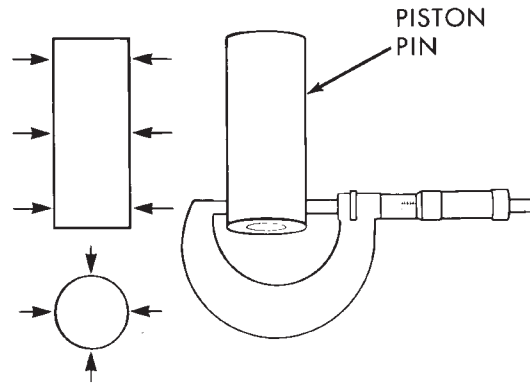


**Fig. 218 Piston Pin Bore**

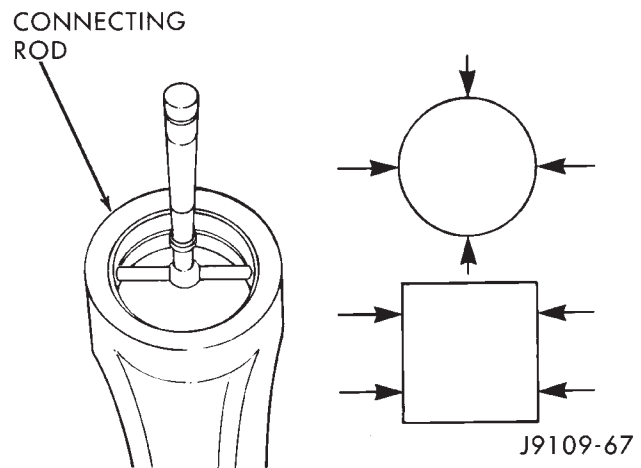
#### Connecting Rods

Inspect the connecting rod for damage and wear. The I-Beam section of the connecting rod cannot have dents or other damage. Damage to this part can cause stress risers which will progress to breakage.

Measure the connecting rod pin bore (Fig. 220). The maximum diameter is 40.042 mm (1.5764 inch). If out of limits, replace the connecting rod.



**Fig. 219 Piston Pin Diameter**



**Fig. 220 Connecting Rod Pin Bore**

#### CAMSHAFT

##### CLEANING

Clean the camshaft in a suitable solvent. Rinse in hot water and blow dry with compressed air.

##### INSPECTION

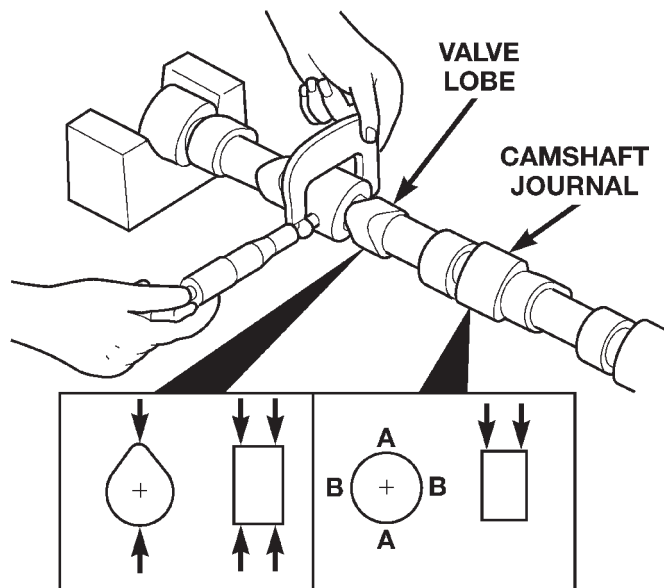
**NOTE:** For camshaft gear inspection, refer to procedure in this group.

(1) Inspect the valve lobes and bearing journals for cracks, pitting, scoring, or generally excessive wear. Replace any camshaft that exceeds the allowable limits.

(2) Measure the bearing journals and lobes (Fig. 221).

**CAUTION:** If Camshaft lobes are worn, requiring camshaft replacement, it is necessary to replace the tappets also. Refer to Tappet Removal and Installation in this group.

## CLEANING AND INSPECTION (Continued)



80b4fa37

**Fig. 221 Measuring Camshaft Main Journals and Lobes**

#### Camshaft Journal Diameter

**Journal #1** 54.028 mm (2.1270 in.) MIN.  
**Journal #2-7** 53.987 mm (2.1245 in.) MIN.

#### Camshaft Lobe Height

**Intake Lobe** 47.173 mm (1.857 in.) MIN.  
**Exhaust Lobe** 45.636 mm (1.796 in.) MIN.

## CAMSHAFT GEAR

### INSPECTION

Visually inspect the camshaft gear for cracks (hub and gear), chipped or broken teeth, or excessive fretting (Fig. 222)(Fig. 223). Inspect and replace the key-way, if damaged.

## TAPPETS

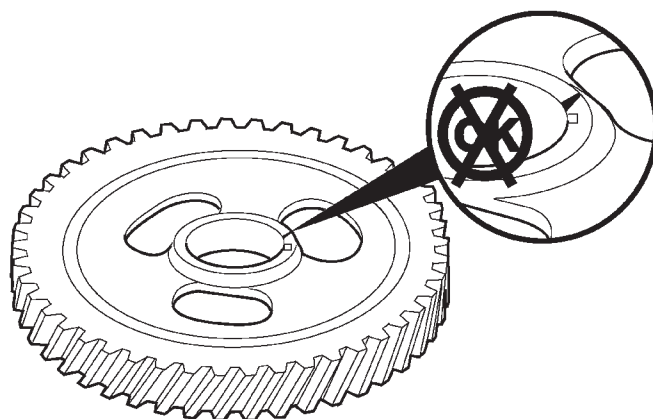
### CLEANING

Clean tappet with a suitable solvent. Rinse in hot water and blow dry with a clean shop rag or compressed air.

### INSPECTION

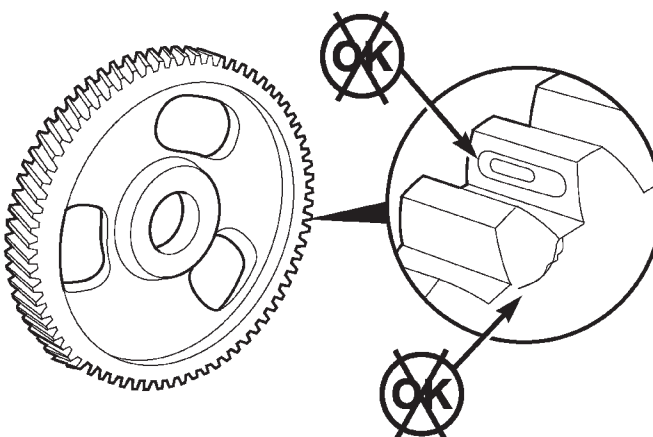
(1) Visually inspect the tappet the tappet socket, stem, and face for excessive wear, cracks, or obvious damage (Fig. 224).

(2) Measure the tappet stem diameter. Replace the tappet if it falls below the minimum size (Fig. 224).



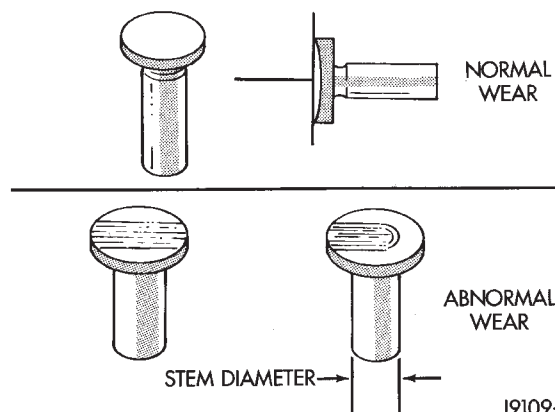
80b4fa30

**Fig. 222 Inspecting Camshaft Gear Hub for Cracks**



80b4fa31

**Fig. 223 Inspecting Camshaft Gear for Cracks and Fretting**



J9109-152

**Fig. 224 Tappet Inspection**

#### TAPPET STEM DIAMETER

15.925 mm (0.627 in.) MIN.

## CLEANING AND INSPECTION (Continued)

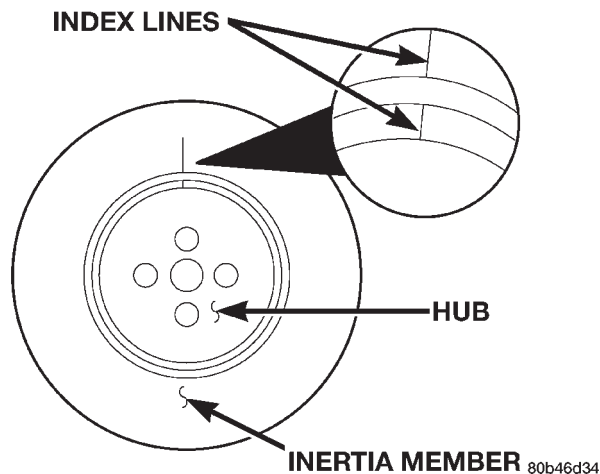
## CRANKSHAFT DAMPER

## INSPECTION

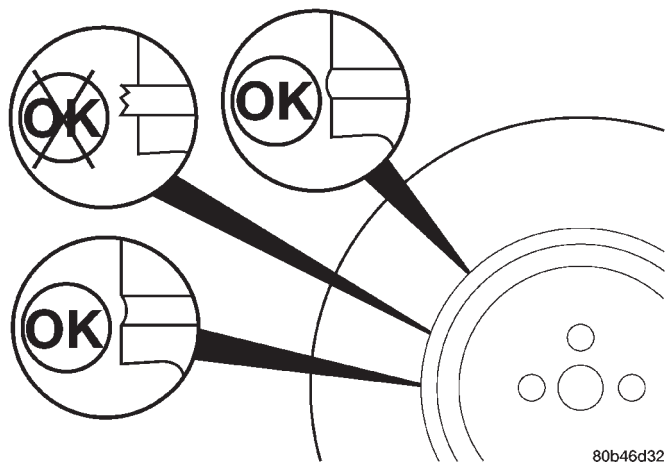
(1) Inspect the damper hub for cracks and replace if any are found.

(2) Inspect the index lines on the damper hub and the inertia member (Fig. 225). If the lines are more than 1.59 mm (1/16 in.) out of alignment, replace the damper.

(3) Inspect the rubber member for deterioration or missing segments (Fig. 226).



**Fig. 225 Inspect Index Lines for Alignment**

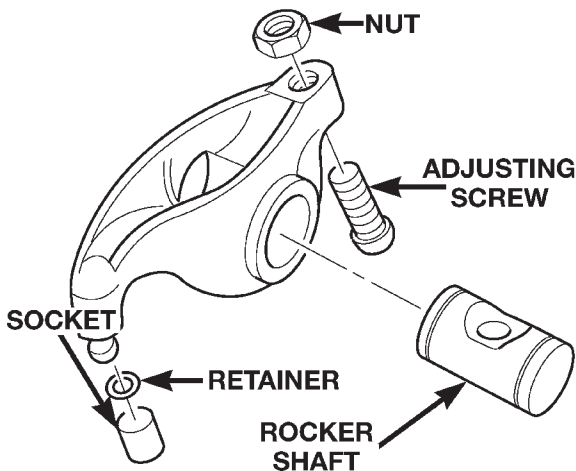


**Fig. 226 Inspect Damper Rubber Member**

## ROCKER ARM AND SHAFT

## CLEANING

Disassemble and clean the rocker arm(s) (Fig. 227) in a suitable solvent. Rinse in hot water and blow dry with compressed air. If necessary, use a wire brush or wheel to remove stubborn deposits. Inspect oil passages in rocker arms and pedestals. Apply compressed air to oil orifices to purge contaminants.

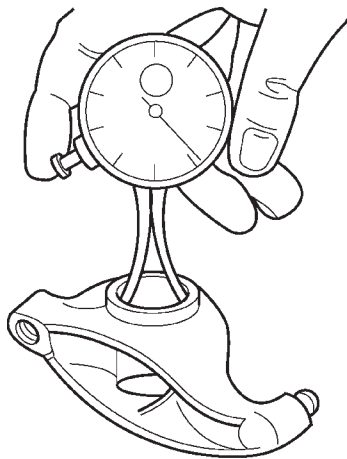


**Fig. 227 Rocker Arm Assembly**

## INSPECTION

(1) Remove rocker shaft and inspect for cracks and excessive wear in the bore or shaft. Remove socket and inspect ball insert and socket for signs of wear. Replace retainer if necessary.

(2) Measure the rocker arm bore and shaft (Fig. 228)(Fig. 229).



**Fig. 228 Measuring Rocker Arm Bore**

## ROCKER ARM BORE (MAX.)

22.027 mm (.867 in.)

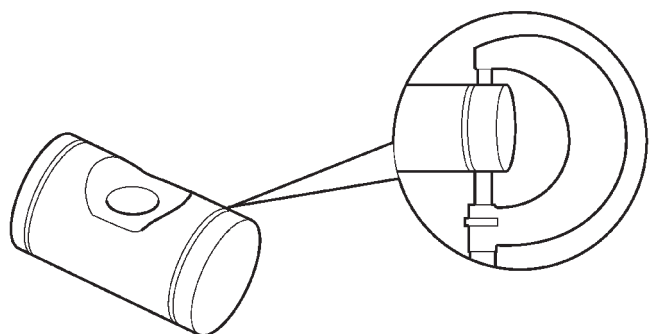
## PUSHRODS

## CLEANING

Clean the push rods in a suitable solvent. Rinse in hot water and blow dry with compressed air. If necessary, use a wire brush or wheel to remove stubborn deposits.



## CLEANING AND INSPECTION (Continued)



80b4fa29

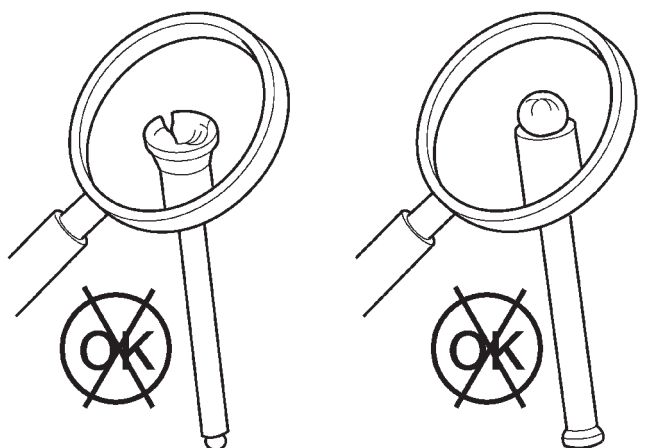
**Fig. 229 Measuring Rocker Arm Shaft****ROCKER ARM SHAFT (MIN.)**

21.965 mm (.865 in.)

**INSPECTION**

Inspect the push rod ball and socket for signs of scoring. Check for cracks where the ball and the socket are pressed into the tube (Fig. 230).

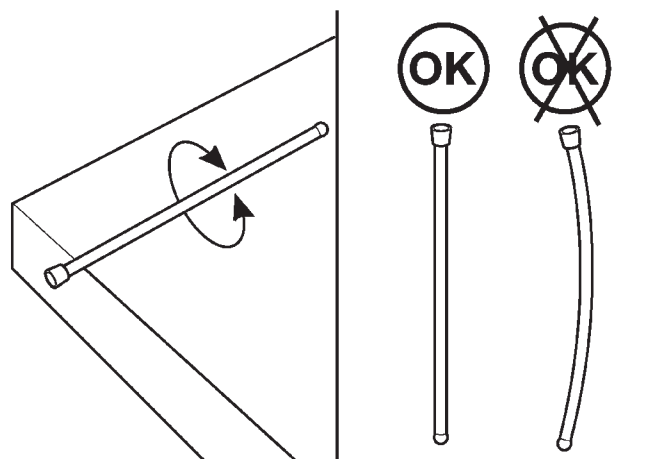
Roll the push rod on a flat work surface with the socket end hanging off the edge (Fig. 231). Replace any push rod that appears to be bent.



80b4fa24

**Fig. 230 Inspecting Push Rod for Cracks****CROSSHEADS****CLEANING**

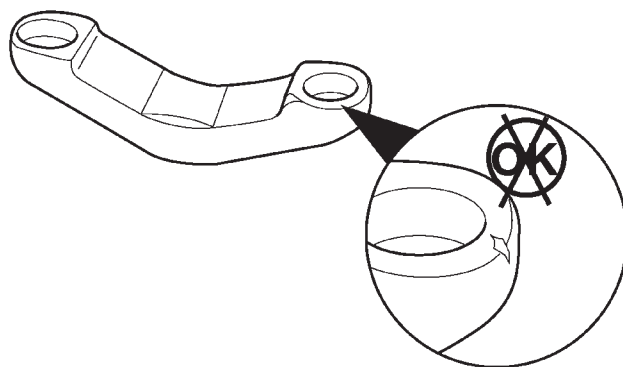
Clean all crossheads in a suitable solvent. If necessary, use a wire brush or wheel to remove stubborn deposits. Rinse in hot water and blow dry with compressed air.



80b4fa23

**Fig. 231 Inspecting Push Rod for Flatness****INSPECTION**

Inspect the crossheads for cracks and/or excessive wear on rocker lever and valve tip mating surfaces (Fig. 232). Replace any crossheads that exhibit abnormal wear or cracks.



80b4fa27

**Fig. 232 Inspecting Crosshead for Cracks****OIL COOLER ELEMENT AND GASKET****CLEANING AND INSPECTION**

Clean the sealing surfaces.

Apply 483 kPa (70 psi) air pressure to the element to check for leaks. If the element leaks, replace the element.

**OIL PRESSURE REGULATOR VALVE AND SPRING****CLEANING**

(1) Clean the regulator spring and plunger (Fig. 233) with a suitable solvent and blow dry with compressed air. If the plunger bore requires cleaning, it is necessary to remove the oil filter head to avoid getting debris into the engine.

## CLEANING AND INSPECTION (Continued)

## INSPECTION

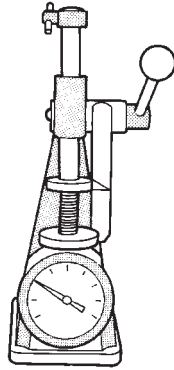
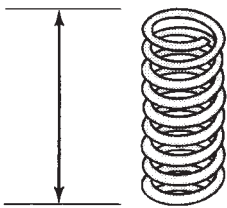
Inspect the plunger and plunger bore for cracks and excessive wear. Polished surfaces are acceptable. Verify that the plunger moves freely in the bore.

Check the spring for height and load limitations (Fig. 233). Replace the spring if out of limits shown in the figure.

## VALVE OPEN

- HEIGHT: 41.25mm (1.62 inch)
- LOAD: 126 N (28.4 lb)

FREE LENGTH: 66mm (2.6 inch)



J9509-161

**Fig. 233 Oil Pressure Regulator Spring Check**

## OIL PUMP

## CLEANING

Clean all parts in a suitable solvent. Rinse with hot water and blow dry with compressed air. Clean the old sealer residue from the back of the gear housing cover and front of the gear housing.

## INSPECTION

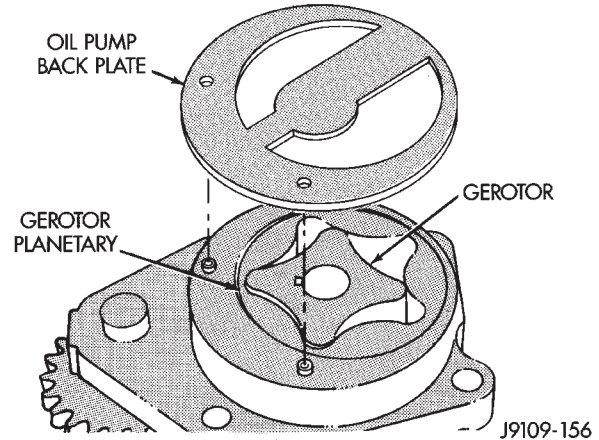
**Disassemble and inspect the oil pump as follows:**

- (1) Visually inspect the lube pump gears for chips, cracks or excessive wear.
- (2) Remove the back plate (Fig. 234).
- (3) Mark TOP on the gerotor planetary using a felt tip pen (Fig. 234).
- (4) Remove the gerotor planetary (Fig. 234). Inspect for excessive wear or damage. Inspect the pump housing and gerotor drive for damaged and excessive wear.
- (5) Install the gerotor planetary in the original position. The chamfer must be on the O.D. and down.
- (6) Measure the tip clearance (Fig. 235). Maximum clearance is 0.1778 mm (0.007 inch). If the oil pump is out of limits, replace the pump.
- (7) Measure the clearance of the gerotor drive/gerotor planetary to port plate (Fig. 236). Maximum clearance is 0.127 mm (0.005 inch). If the oil pump is out of limits, replace the pump.
- (8) Measure the clearance of the gerotor planetary to the body bore (Fig. 237). Maximum clearance is

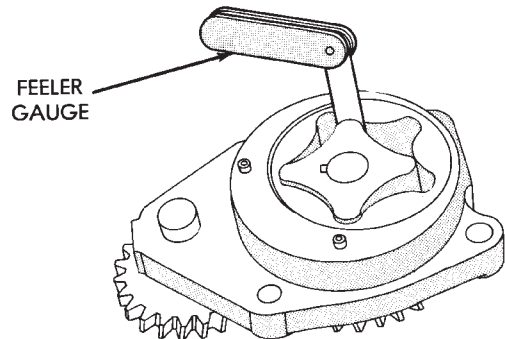
0.381 mm (0.015 inch). If the oil pump is out of limits, replace the pump.

(9) Measure the gears backlash (Fig. 238). The limits of a used pump is 0.080- 0.380 mm (0.003-0.015 inch). If the backlash is out of limits, replace the oil pump.

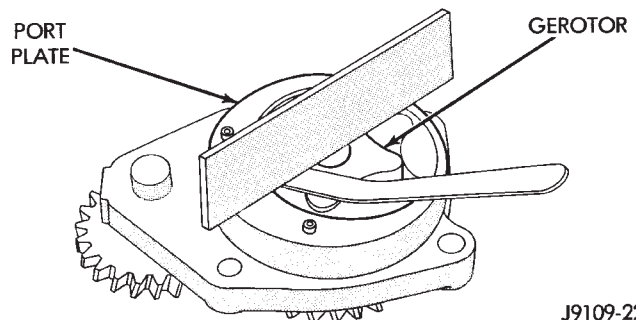
(10) Install the back plate.



**Fig. 234 Gerotor Planetary and Gerotor**

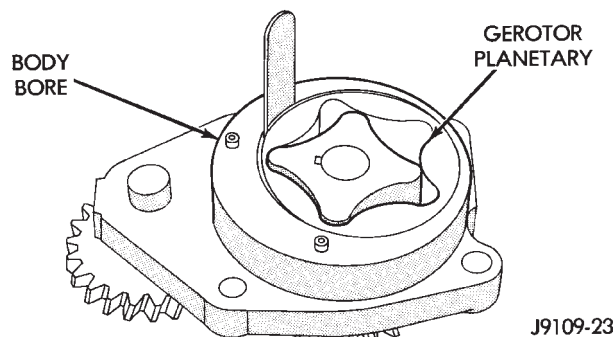


**Fig. 235 Measuring Tip Clearance**

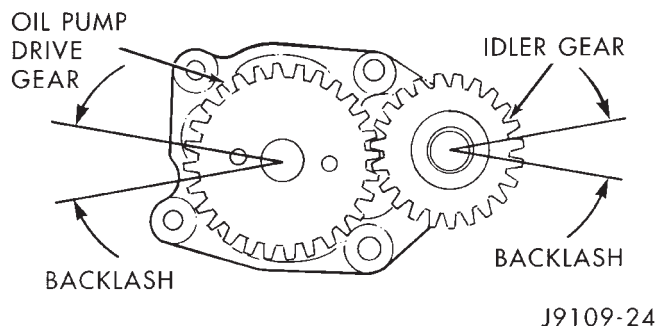


**Fig. 236 Measuring Gerotor to Port Plate Clearance**

## SPECIFICATIONS (Continued)



**Fig. 237 Measuring Gerotor Planetary to Body Bore Clearance**



**Fig. 238 Measure Gear Backlash**

## SPECIFICATIONS

## 5.9L DIESEL ENGINE SPECIFICATIONS

**CAMSHAFT AND TAPPETS****Camshaft**

Journal Diameter (#1)	54.028 – 54.048 mm (2.127 – 2.128 in.)
Journal Diameter (#2–7)	53.987 – 54.013 mm (2.1245 – 2.1265 in.)
Intake Lobe (Min. dia. @ peak)	47.173 mm (1.857 in.)
Exhaust Lobe (Min. dia. @ peak)	45.636 mm (1.796 in.)
End Play	0.100 – 0.46 mm (0.005 – 0.018 in.)
Gear Backlash	0.076 – 0.330 mm (0.003 – 0.013 in.)
Cam Bore Dia. (Max.) #1 w/o bushing	59.248 mm (2.3326 in.)
Cam Bore Dia. (Max.) #1 w/ bushing	54.133 mm (2.1312 in.)
Cam Bore Dia. (Max.) #2–7 (no bushing)	54.133 mm (2.1314 in.)

**Tappets**

Stem Diameter (Min.)	15.925 mm (0.627 in.)
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**CYLINDER BLOCK**

Cylinder Bore Diameter (Max. Std.)	102.116 mm (4.0203 in.)
Cylinder Bore Out of Round (Max.)	0.038 mm (0.0015 in.)
Cylinder Bore Taper (Max.)	0.076 mm (0.003 in.)
Tappet Bore Diameter (Max.)	16.055 mm (0.632 in.)
Deck Surface Flatness (Max. Overall)	0.075 mm (0.003 in.)
First Reface	0.250 mm (0.0098 in.)
Second Reface	0.250 mm (0.0098 in.)
Total Reface	0.500 mm (0.197 in.)
Surface Finish	1.50 – 3.20 micrometers (60–126 microinches)
Main bearing Bore Dia. (Max. w/Bearing Installed)	83.106 mm (3.2719 in.)
Cam Bore Dia. (Max.) #1 w/o bushing	59.248 mm (2.3326 in.)
Cam Bore Dia. (Max.) #2–7 (no bushing)	54.139 mm (2.1314 in.)
Cam Bore Dia. (Max.) #1 w/ bushing	54.133 mm (2.1312 in.)

**PISTONS AND CONNECTING RODS****Pistons**

Skirt Diameter	101.864 – 101.896 mm (4.0104 – 4.0117 in.)
Ring Groove Clearance-Intermediate (Max.)	0.095 mm (0.0037 in.)
Ring Groove Clearance-Oil Control (Max.)	0.085 mm (0.0033 in.)

**Piston Pins**

Diameter (Min.)	39.990 mm (1.5744 in.)
Bore Diameter (Max.)	40.025 mm (1.5758 in.)

**Piston Rings**

End Gap (Top)	0.400 – 0.700 mm (0.016 – 0.0275 in.)
End Gap (Intermediate)	0.250 – 0.550 mm (0.010 – 0.0215 in.)
End Gap (Oil Control)	0.250 – 0.550 mm (0.010 – 0.0215 in.)

**Connecting Rods**

Pin Bore Diameter (Max.)	40.042 mm (1.5764 in.)
Side Clearance	0.100 – 0.330 mm (0.004 – 0.013 in.)

## SPECIFICATIONS (Continued)

**CRANKSHAFT**

Main Bearing Journal Diameter (Std.) Min. . . . .	82.962 mm (3.2662 in.)
Main Journal Out of Round (Max.) . . . . .	0.050 mm (0.002 in.)
Main Journal Taper (Max.) . . . . .	0.013 mm (0.0005 in.)
Main Journal Oil Clearance (Max.) . . . . .	0.119 mm (0.0047 in.)
Rod Bearing Journal Diameter (Std.) Min. . . . .	68.9745 mm (2.7155 in.)
Rod Journal Out of Round (Max.) . . . . .	0.050 mm (0.002 in.)
Rod Journal Taper (Max.) . . . . .	0.013 mm (0.0005 in.)
Rod Journal Oil Clearance (Max.) . . . . .	0.089 mm (0.0035 in.)
End Play . . . . .	0.100 – 0.430 mm (0.004 – 0.017 in.)
Gear Backlash . . . . .	0.076 – 0.330 mm (0.003 – 0.013 in.)

**CYLINDER HEAD AND VALVES****Cylinder Head**

Overall Flatness End to End (Max.) . . . . .	0.30 mm (0.012 in.)
Overall Flatness Side to Side (Max.) . . . . .	0.076 mm (0.003 in.)
Intake Valve Seat Angle . . . . .	30°
Exhaust Valve Seat Angle . . . . .	45°
Valve Seat Width (Min.) . . . . .	1.49 mm (0.059 in.)
Valve Seat Width (Max.) . . . . .	1.80 mm (0.071 in.)
Valve Margin (Min.) . . . . .	0.72 mm (0.031 in.)

**Valves**

Clearance (Intake) . . . . .	0.152 – 0.381 mm (.006 – .015 in.)
Clearance (Exhaust) . . . . .	0.381 – 0.762 mm (0.015 – 0.030)
Guide Bore Diameter . . . . .	7.042 – 7.062 mm (0.2772 – 0.2780 in.)
Stem Diameter . . . . .	6.990 – 7.010 mm (0.2752 – 0.2760 in.)
Depth (Installed) Intake . . . . .	0.59 – 1.11 mm (0.023 – 0.044 in.)
Depth (Installed) Exhaust . . . . .	0.96 – 1.48 mm (0.038 – 0.058 in.)

**Valve Springs**

Free Length . . . . .	60 mm (2.36 in.)
Installed Height . . . . .	35.33 mm (1.39 in.)
Inclination (Max.) . . . . .	1.5 mm (0.059 in.)
Minimum Load . . . . .	@ 35.33 mm — 339.8 N ( @ 1.39 in. — 76.4 lbs.)

**OIL PUMP/LUBRICATION****Oil Pump**

Tip Clearance (Max.) . . . . .	0.1778 mm (0.007 in.)
Gerotor Drive/Planetary to Port Plate Clearance (Max.) . . . . .	0.127 mm (0.005 in.)
Gerotor Planetary to Body Clearance (Max.) . . . . .	0.381 mm (0.015 in.)
Gear Backlash (Used Pump) . . . . .	0.076 – 0.330 mm (0.003 – 0.015 in.)

**Oil Pressure (Min.)**

At Idle Speed* . . . . .	69 kPa (10 psi)
At 2,500 rpm* . . . . .	207 kPa (30 psi)
Regulating Valve Opening Pressure . . . . .	448 kPa (65 psi)

**Oil Filter**

Diff. Pressure to Open Filter Bypass . . . . .	172.3 kPa (25 psi)
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**CAUTION:** If oil pressure is ZERO at curb idle, DO NOT run engine.

**TORQUE SPECIFICATIONS****5.9L DIESEL ENGINE**

DESCRIPTION	TORQUE
<b>Battery Cable (Negative)-to-Block</b>	
Bolt . . . . .	77 N·m (57 ft. lbs.)
<b>Belt Tensioner</b>	
Bolt . . . . .	43 N·m (32 ft. lbs.)
<b>Block Heater</b>	
Element . . . . .	43 N·m (32 ft. lbs.)
<b>Camshaft Thrust Plate</b>	
Bolts . . . . .	24 N·m (18 ft. lbs.)
<b>Charge Air Cooler</b>	
Bolts . . . . .	2 N·m (17 in. lbs.)
<b>Clutch Cover-to-Flywheel</b>	
Bolts . . . . .	23 N·m (17 ft. lbs.)
<b>Connecting Rod Bolts</b>	
Step 1 – Preliminary . . . . .	35 N·m (26 ft. lbs.)
Step 2 – Secondary . . . . .	70 N·m (51 ft. lbs.)
Step 3 – Final . . . . .	100 N·m (73 ft. lbs.)
<b>Cooling Fan-to-Fan Clutch</b>	
Bolts . . . . .	20 N·m (15 ft. lbs.)
<b>Crankshaft Main Bearing Bolts</b>	
Step 1 – Preliminary . . . . .	60 N·m (44 ft. lbs.)
Step 2 – Secondary . . . . .	119 N·m (88 ft. lbs.)
Step 3 – Final . . . . .	176 N·m (129 ft. lbs.)
<b>Crankshaft Pulley/Damper</b>	
Bolts . . . . .	125 N·m (92 ft. lbs.)
<b>Crankshaft Rear Seal Retainer</b>	
Bolts . . . . .	9 N·m (80 in. lbs.)



## SPECIFICATIONS (Continued)

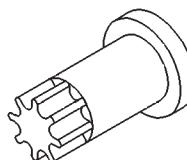
DESCRIPTION	TORQUE	DESCRIPTION	TORQUE
<b>Crankshaft Tone Wheel</b>		<b>Injection Pump-to-Gear Housing</b>	
Bolts . . . . .	8 N·m (71 in. lbs.)	Nuts . . . . .	43 N·m (32 ft. lbs.)
<b>Cylinder Head</b>		<b>Intake Manifold Cover</b>	
Step 1 – (All Bolts) . . . . .	90 N·m (66 ft. lbs.)	Bolts . . . . .	24 N·m (18 ft. lbs.)
Step 2 – (Re-check All Bolts) . . .	90 N·m (66 ft. lbs.)	<b>Charge Air Cooler Pipe Clamp</b>	
Step 3 – (Rotate All Bolts) .	Additional ¼ Turn-(90°)	Nuts . . . . .	8 N·m (72 in. lbs.)
<b>Cylinder Head Cover</b>		<b>Lift Bracket (Rear)</b>	
Bolts . . . . .	24 N·m (18 in. lbs.)	Bolts . . . . .	77 N·m (57 ft. lbs.)
<b>Exhaust Manifold</b>		<b>Lift Bracket (Front )</b>	
Bolts . . . . .	43 N·m (32 ft. lbs.)	Bolts . . . . .	43 N·m (32 ft. lbs.)
<b>Fan Clutch Mounting-to-Fan Hub</b>		<b>Lift Pump Mounting</b>	
Left Hand Thread . . . . .	57 N·m (42 ft. lbs.)	Nuts . . . . .	12 N·m (9 ft. lbs.)
<b>Fan Hub Bracket</b>		<b>Lift Pump Mounting Bracket</b>	
Bolts . . . . .	24 N·m (18 ft. lbs.)	Bolts . . . . .	24 N·m (18 ft. lbs.)
<b>Fan Hub Bearing</b>		<b>Oil Cooler Assembly</b>	
Bolt . . . . .	77 N·m (57 ft. lbs.)	Bolts . . . . .	24 N·m (18 ft. lbs.)
<b>Fan Pulley-to-Fan Hub</b>		<b>Oil Filter</b>	
Bolts . . . . .	9 N·m (84 in. lbs.)	Gasket . . . . .	¾ Turn After Gasket Contact
<b>Fan Shroud Mounting</b>		<b>Oil Pan</b>	
Bolts . . . . .	11 N·m (95 in. lbs.)	Bolts . . . . .	24 N·m (18 ft. lbs.)
<b>Flywheel</b>		<b>Oil Pan</b>	
Bolts . . . . .	137 N·m (101 ft. lbs.)	Drain Plug . . . . .	60 N·m (44 ft. lbs.)
<b>Flywheel Housing (Aluminum)</b>		<b>Oil Pressure Regulator</b>	
Bolts . . . . .	60 N·m (44 ft. lbs.)	Plug . . . . .	80 N·m (60 ft. lbs.)
<b>Flywheel Housing Access Plate</b>		<b>Oil Pressure Sender/Switch</b>	
Bolts . . . . .	24 N·m (18 ft. lbs.)	Sender/Switch . . . . .	16 N·m (12 ft. lbs.)
<b>Fuel Delivery Lines (High Pressure)</b>		<b>Oil Pump</b>	
At Pump . . . . .	24 N·m (18 ft. lbs.)	Bolts . . . . .	24 N·m (18 ft. lbs.)
<b>Fuel Delivery Lines (High Pressure)</b>		<b>Oil Suction Tube (Flange)</b>	
At Cyl. Head . . . . .	40 N·m (30 ft. lbs.)	Bolts . . . . .	24 N·m (18 ft. lbs.)
<b>Fuel Drain Line (rear of head)</b>		<b>Oil Suction Tube (Brace)</b>	
Banjo . . . . .	24 N·m (18 ft. lbs.)	Bolt . . . . .	24 N·m (18 ft. lbs.)
<b>Fuel Filter Cannister</b>		<b>Oil Supply-to-Vacuum Pump</b>	
Nut . . . . .	14 N·m (10 ft. lbs.)	Nut . . . . .	10 N·m (89 in. lbs.)
<b>Fuel Injection Pump Gear Retaining Nut</b>		<b>Rear Mount – Support Cushion-to-Crossmember</b>	
Nut . . . . .	170 N·m (125 ft. lbs.)	Nut . . . . .	47 N·m (35 ft. lbs.)
<b>Fuel Injection Pump Support Bracket</b>		<b>Rear Mount –</b>	
Bolts . . . . .	24 N·m (18 ft. lbs.)	<b>Support Cushion-to-Support Bracket</b>	
<b>Fuel System Low Pressure Lines</b>		Nuts . . . . .	47 N·m (35 ft. lbs.)
Banjo Fittings . . . . .	24 N·m (18 ft. lbs.)	<b>Rear Mount – Support Bracket-to-Transmission</b>	
<b>Generator Mounting</b>		Bolts . . . . .	102 N·m (75 ft. lbs.)
Bolts . . . . .	41 N·m (30 ft. lbs.)	<b>Rear Support Plate-to-Transfer Case</b>	
<b>Generator Pulley</b>		Bolts . . . . .	41 N·m (30 ft. lbs.)
Nut . . . . .	80 N·m (59 ft. lbs.)	<b>Rocker Arm/Pedestal</b>	
<b>Generator Support</b>		Bolts . . . . .	36 N·m (27 ft. lbs.)
Bolt . . . . .	24 N·m (18 ft. lbs.)	<b>Starter Mounting</b>	
<b>Gear Housing-to-Block</b>		Bolts . . . . .	43 N·m (32 ft. lbs.)
Bolts . . . . .	24 N·m (18 ft. lbs.)	<b>Thermostat Housing</b>	
<b>Gear Housing Cover</b>		Bolts . . . . .	24 N·m (18 ft. lbs.)
Bolts . . . . .	24 N·m (18 ft. lbs.)	<b>Throttle Control Bracket-to-Cylinder Head</b>	
<b>Injector Clamp</b>		Bolts . . . . .	56 N·m (40 ft. lbs.)
Bolts . . . . .	10 N·m (89 in. lbs.)		

# SPECIFICATIONS (Continued)

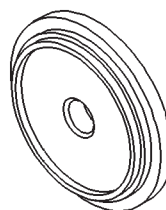
DESCRIPTION	TORQUE
<b>Torque Converter Drive Plate</b>	
Bolts . . . . .	47 N·m (35 ft. lbs.)
<b>Transfer Case-to-Insulator Mounting Plate</b>	
Nuts . . . . .	204 N·m (150 ft. lbs.)
<b>Transmission Support Bracket - (2wd)</b>	
Bolts . . . . .	68 N·m (50 ft. lbs.)
<b>Transmission Support Spacer - (4wd)</b>	
Bolts . . . . .	68 N·m (50 ft. lbs.)
<b>Transmission Support Spacer-to-Insulator Mounting Plate - (4wd)</b>	
Bolts . . . . .	204 N·m (150 ft. lbs.)
<b>Turbocharger/CAC System Clamp(s) (All)</b>	
Nut . . . . .	8 N·m (71 in. lbs.)
<b>Turbocharger Oil Supply Line</b>	
Nut . . . . .	20 N·m (15 ft. lbs.)
<b>Turbocharger Oil Drain Pipe</b>	
Bolts . . . . .	27 N·m (20 ft. lbs.)
<b>Turbocharger-to-Exhaust Manifold</b>	
Nuts . . . . .	45 N·m (33 ft. lbs.)
<b>Vacuum Pump-to-adapter</b>	
Nuts . . . . .	24 N·m (18 ft. lbs.)
<b>Vacuum Pump adapter-to-P/S Pump</b>	
Nuts . . . . .	24 N·m (18 ft. lbs.)
<b>Vacuum Pump-to-Gear Housing</b>	
Bolts . . . . .	77 N·m (57 ft. lbs.)
<b>Vacuum Pump Oil Supply Line</b>	
Fitting . . . . .	10 N·m (89 in. lbs.)
<b>Water Pump</b>	
Bolts . . . . .	24 N·m (18 ft. lbs.)
<b>Water In Fuel Sensor</b>	
Sensor . . . . .	3 N·m (20 in. lbs.)

## SPECIAL TOOLS

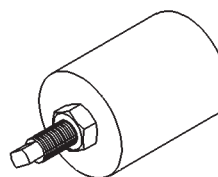
### 5.9L DIESEL ENGINE



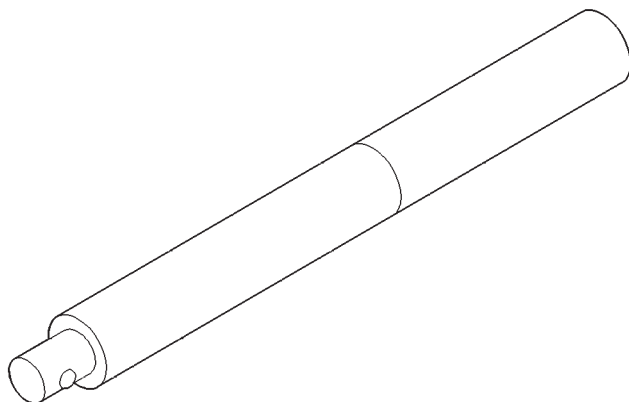
*Crankshaft Barring Tool—7471B*



*Crankshaft Front Oil Seal Installer—8281*

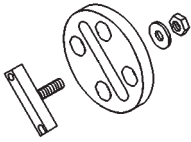


*Injector Removal Tool—8318*

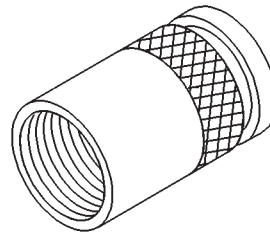


*Fig. 239 Universal Driver Handle—C 4171*

SPECIAL TOOLS (Continued)



***Valve Spring Compressor—8319***



***Injector Connector Removal Tool—8324***