ENGINE

CONTENTS

GENERAL INFORMATION

ENGINE IDENTIFICATION

The engine model code (3-digit number/letter code) and serial number are stamped on the forward facing side of the engine block (Fig. 1).

HYDRAULIC TAPPETS

Before disassembling any part of the engine to correct tappet noise, check the oil pressure. If vehicle has no oil pressure gauge, install a reliable gauge at the pressure sending unit. The pressure should be between 4 bars (50 psi) at 3000 RPM.

Check the oil level after the engine reaches normal operating temperature. Allow 5 minutes to stabilize oil level, check dipstick. The oil level in the pan should never be above the FULL mark or below the ADD OIL mark on dipstick. Either of these 2 conditions could be responsible for noisy tappets:

OIL LEVEL HIGH

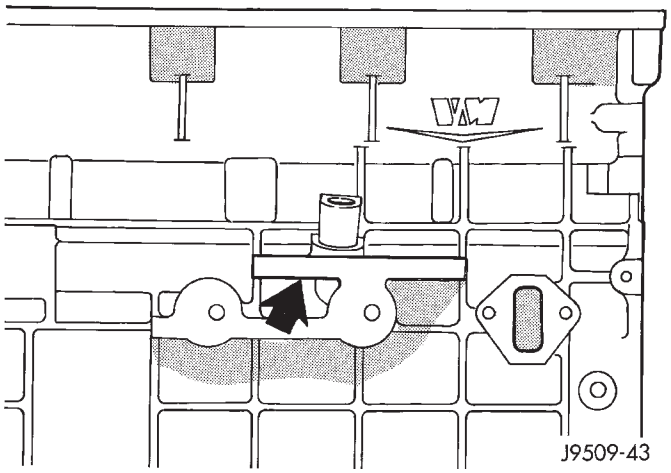

Fig. 1 Engine Code Location

If oil level is above the FULL mark, it is possible for the connecting rods to dip into the oil. With the

GENERAL INFORMATION (Continued)

Displacement	2.5L (2499 cc)
Bore	92.00
Stroke	94.00
Compression Ratio	20.95:1
Vacuum at idle	600 mm/Hg (23.6 In/Hg)
Belt Tension	53 DaN - New 30 DaN - Used
Thermostat Opening	80°C ± 2°C
Generator Rating	Bosch 50/120 Amp
Cooling System Capacity	9.5 Liter
P/S Capacity	0.75 Liter
Engine Oil Capacity	6.8 Liter w/filter change
Timing System	Pushrod operated overhead valves, with gear-driven camshaft in crankcase.
Air Intake	Dry filter.
Fuel Feed	Vane pump incorporated in injection pump.
Fuel System	Indirect fuel injection (precombustion chamber).
Combustion Cycle	4 stroke.
Cooling System	Water cooling.
Injection Pump	Rotary pump with built-in mechanical regulator.
Lubrication	Pressure lubrication by rotary pump, full-flow filtration.
Engine Rotation	Clockwise viewed from front cover.

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Engine Description

engine running, this condition could create foam in the oil pan. Foam in oil pan would be fed to the hydraulic tappets by the oil pump causing them to lose length and allow valves to seat noisily.

OIL LEVEL LOW

Low oil level may allow oil pump to take in air. When air is fed to the tappets, they lose length which allows valves to seat noisily. Any leaks on intake side of oil pump through which air can be drawn will create the same tappet action. Check the lubrication system from the intake strainer to the pump cover, including the relief valve retainer cap. When tappet noise is due to aeration, it may be intermittent or constant, and usually more than 1 tappet will be noisy. When oil level and leaks have been corrected, operate the engine at fast idle. Run engine for a sufficient time to allow all of the air inside the tappets to be bled out.

DIAGNOSIS AND TESTING

SERVICE DIAGNOSIS—DIESEL—PERFORMANCE

CONDITION	POSSIBLE CAUSES	CORRECTION
ENGINE WILL NOT CRANK OR CRANKS SLOWLY	1. Starting motor operating, but not cranking the engine.	1. Remove the starter motor. Check for broken flywheel teeth or a broken starting motor spring.
	2. Crankshaft rotation restricted.	2. Rotate the engine to check for rotational resistance.
	3. Starting circuit connections loose or corroded.	3. Clean and tighten connections.
	4. Neutral safety switch or starter relay inoperative.	4. Check starter relay supply voltage and proper operation of neutral safety switch (if equipped). Replace defective parts.
	5. Battery charge low.	5. Check battery voltage. Replace battery if a charge cannot be held.
	6. No voltage to starter solenoid.	6. Check voltage to solenoid. If necessary, replace the solenoid.
	7. Solenoid or starter motor inoperative.	7. Replace starter motor.
ENGINE CRANKS, BUT WILL NOT START NO SMOKE	1. No fuel in supply tank.	1. Fill fuel supply.
	2. Electrical fuel shutdown solenoid not operating.	2. Check for loose wires and verify that the fuel shutdown solenoid and fuel shutdown solenoid relay is functioning.
	3. Air intake or exhaust plugged.	3. Remove the obstruction.
	4. Fuel filter plugged.	4. Drain fuel/water separator and replace fuel filter.
	5. Excessive fuel inlet restriction.	5. Check fuel inlet restriction. Correct cause.
	6. Injection pump not getting fuel or fuel is aerated.	6. Check fuel flow/bleed fuel system.
	7. One or more injectors worn or not operating properly.	7. Check/replace bad or improperly operating injectors.
	8. Worn or inoperative injection pump.	8. Visually check delivery with externally connected injector to one of the pump outlets. Repair or replace the pump if fuel is not being delivered.
	9. Camshaft out of time.	9. Check/correct gear train timing alignment.
ENGINE HARD TO START, OR WILL NOT START SMOKE FROM EXHAUST	1. Incorrect starting procedure.	1. The fuel shutoff solenoid control must be in the run position. Ensure proper procedure is being used.
	2. Cranking speed too slow.	2. (A) Verify that the transmission is not engaged. (B) Check the battery, starting motor and look for loose or corroded wiring connections.
	3. Cylinder heads heater plugs relay defective.	3. Verify system is working. Repair/replace inoperative parts.
	4. One or more cylinder head heater plugs defective.	4. Verify system is working. Repair/replace inoperative parts.
	5. Insufficient intake air.	5. Inspect or replace filter and check for obstruction to the air supply tube.

DIAGNOSIS AND TESTING (Continued)

CONDITION	POSSIBLE CAUSES	CORRECTION
ENGINE HARD TO START, OR WILL NOT START SMOKE FROM EXHAUST (CONT.)	6. Air in fuel system or the fuel supply is inadequate.	6. Check the flow through the filter and bleed the system. Locate and eliminate the air source.
	7. Contaminated fuel.	7. Verify by operating the engine with clean fuel from a temporary tank. Check for presence of gasoline. Drain and flush fuel supply tank. Replace fuel/water separator filter.
	8. Fuel screen plugged.	8. Check fuel screen.
	9. One or more injectors worn or not operating properly.	9. Check/replace improperly operating injectors.
	10. Worn or inoperative injection pump.	10. Visually check fuel delivery with an externally connected injector to one of the pump outlets. Repair or replace the pump if fuel is not being delivered.
	11. Injection pump out of time.	11. Check/Time the pump (refer to Group 14, Fuel System).
	12. Engine compression low.	12. Check compression to identify the problem.
ENGINE STARTS, BUT WILL NOT KEEP RUNNING	1. Cylinder heads heater plugs relay defective.	1. Verify system is working. Repair/ replace inoperative parts.
	2. One or more cylinder head heater plugs defective.	2. Verify system is working. Repair/ replace inoperative parts.
	3. Intake air or exhaust system restricted.	3. Visually check for exhaust restriction and inspect the air intake. Repair/replace restricting parts.
	4. Air in the fuel system or the fuel supply is inadequate.	4. Check flow through the filter and bleed the system. Locate and eliminate the air source.
	5. Fuel waxing due to extremely cold weather.	5. Verify by inspecting the fuel filter. Clean the system and use climatized fuel. Replace fuel/water separator filter. Check fuel heater for proper operation.
	6. Contaminated fuel.	6. Verify by operating the engine with clean fuel from a temporary supply tank. Check for presence of gasoline. Replace fuel/water separator filter.
SURGING (SPEED CHANGE)	1. If the condition occurs at idle, the idle speed is set too low for the accessories.	1. Adjust the idle speed.
	2. High pressure fuel leak.	2. Inspect/correct leaks in the high pressure lines. Fittings and delivery valve sealing washers.
	3. One or more injectors worn or not operating properly.	3. Check/replace the inoperative injectors.
	4. Improperly operating injection pump.	4. Replace the injector pump.

DIAGNOSIS AND TESTING (Continued)

CONDITION	POSSIBLE CAUSES	CORRECTION
ROUGH IDLE (IRREGULARLY FIRING OR ENGINE SHAKING)	1. If engine is cold, glow plug relay on glow plug(s) defective. 2. Engine mounts damaged or lose. 3. High pressure fuel leaks. 4. Air in the fuel system. 5. Sticking needle valve in an injector.	1. Refer to troubleshooting for cylinder head heater plugs (see Group 14, Fuel System). 2. Repair or replace mounts. 3. Correct leaks in the high pressure lines, fittings or delivery valves. 4. Bleed the fuel system and eliminate the source of the air. 5. Check and replace the injector with the sticking needle valve.
ENGINE RUNS ROUGH	1. Fuel injection lines leaking. 2. Air in the fuel or the fuel supply is inadequate. 3. Contaminated fuel. 4. Incorrect valve operation. 5. Injection pump timing incorrect. 6. Improperly operating injectors. 7. Defective injection pump (delivery valve). 8. Camshaft out of time. 9. Damaged camshaft or tappets. 10. Automatic timing advance not operating.	1. Correct leaks in the high pressure lines, fittings, injectors sealing washers or delivery valves. 2. Check the flow through the filter and bleed the system. Locate and eliminate the air source. 3. Verify by operating the engine with clean fuel from a temporary supply tank. Check for presence of gasoline. Replace fuel/water separator filter. 4. Check for a bent push rod and adjust valves. Replace push rod, if necessary. 5. Check/time pump (refer to Group 14, Fuel System). 6. Replace inoperative injectors. 7. Repair or replace injection pump. 8. Check/correct gear train timing alignment. 9. Inspect camshaft valve lift. Replace camshaft and tappets. 10. Check injection pump. Check fuel injector sensor at number 1 cylinder injector.
ENGINE RPM WILL NOT REACH RATED SPEED	1. Engine overload. 2. Improperly operating tachometer. 3. Inadequate fuel supply. 4. Air/fuel controls leak.	1. Verify high idle speed without load. Investigate operation to be sure correct gear is being used. 2. Verify engine speed with hand tachometer, correct as required. 3. Check the fuel flow through the system to locate the reason for inadequate fuel supply, correct as required. 4. Check and repair leak. Check AFC tubing for obstruction.

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DIAGNOSIS AND TESTING (Continued)

CONDITION	POSSIBLE CAUSES	CORRECTION
ENGINE RPM WILL NOT REACH RATED SPEED (CONT.)	6. Improperly operating injection pump.	6. Repair or replace injection pump.
LOW POWER	1. Fuel control lever not moving to full throttle.	1. Check/correct for stop-to-stop travel.
	2. High oil level.	2. Check/correct oil level.
	3. Engine overloaded.	3. Check for added loading from accessories or driven units, brakes dragging and other changes in vehicle loading. Repair/replace as needed.
	4. Slow throttle response caused by leaking or obstructed air control tube or improperly operating control in the pump.	4. Check for leaks and obstructions. Tighten the fittings. Repair or replace the pump if the controls are not functioning.
	5. Inadequate intake air flow.	5. Inspect/replace air cleaner element. Look for other restrictions.
	6. Inadequate fuel supply. Air in the fuel.	6. Check the flow through the filter to locate the source of the restriction. Check fuel pressure and inlet restriction.
	7. Excessive exhaust restriction.	7. Check/correct the restriction in the exhaust system.
	8. High fuel temperature.	8. Verify that fuel heater is off when engine is warm. Check for restricted fuel drain tubes. Repair/replace as needed.
	9. Poor quality fuel or fuel contaminated with gasoline.	9. Verify by operating from a temporary tank with good fuel. Check for presence of gasoline. Replace fuel/water separator filter.
	10. Air leak between the turbocharger and the intake manifold.	10. Check/correct leaks in hoses, gaskets, charge air cooler and around mounting capscrews or through holes in the manifold cover.
	11. Exhaust leak at the manifold or turbocharger.	11. Check/correct leaks in the manifold or turbocharger gaskets. If manifold is cracked, replace manifold.
	12. Improperly operating turbocharger.	12. Inspect/replace turbocharger.
	13. Wastegate operation.	13. Check wastegate operation.
	14. Valve not operating.	14. Check for bent push rod, replace if necessary.
	15. Worn or improperly operating injectors.	15. Check/replace injectors.
	16. Incorrect injection pump timing.	16. Verify injection pump timing (see Group 14, Fuel System).
	17. Improperly operating injection pump.	17. Repair or replace injection pump.

DIAGNOSIS AND TESTING (Continued)

CONDITION	POSSIBLE CAUSES	CORRECTION
EXCESSIVE EXHAUST SMOKE	1. Engine running too cold (white smoke).	1. Refer to troubleshooting for coolant temperature below normal (refer to Group 7, Cooling System). Inspect cylinder head heater plugs for proper operation.
	2. Improper starting procedure (white smoke).	2. Use proper starting procedures.
	3. Fuel supply inadequate.	3. Check fuel supply pressure and inlet restriction.
	4. Injection pump timing.	4. Check and time pump (refer to Group 14, Fuel System).
	5. Inadequate intake air.	5. Inspect/change air filter. Look for other restriction. Check charge air cooler for obstructions.
	6. Air leak between turbocharger and intake manifold.	6. Check/correct leaks in the air crossover tube, hoses, gaskets, mounting capscrews or through holes in the manifold cover.
	7. Exhaust leak at the manifold or turbocharger.	7. Check/correct leaks in the manifold or turbocharger gaskets. If cracked replace manifold.
	8. Improperly operating turbocharger.	8. Inspect/replace turbocharger.
	9. Improperly operating injectors.	9. Check and replace inoperative injectors.
	10. Improperly operating or overfueled injector pump.	10. Repair or replace injection pump.
	11. Piston rings not sealing (blue smoke).	11. Perform blow-by check. Correct as required.
ENGINE WILL NOT SHUT-OFF	1. Fuel shutoff solenoid inoperative.	1. Check/replace fuel shutoff solenoid.
	2. Engine running on fumes drawn into the air intake.	2. Check the air intake ducts for the source of fumes. **WARNING: In case of engine runaway due to flammable fumes from gasoline spills or turbocharger oil leaks being sucked into the engine, shut off engine ignition switch first then use a CO2 fire extinguisher and direct the spray under the front bumper to remove oxygen supply. The engine air intake is on the passenger side behind the bumper. The fire extinguisher must be directed at this location for emergency shutdown conditions.**
	3. Fuel injection pump malfunction.	3. Repair or replace fuel injection pump.

DIAGNOSIS AND TESTING (Continued)

CONDITION	POSSIBLE CAUSES	CORRECTION
COOLANT TEMPERATURE ABOVE NORMAL	1. Low coolant level.	1. Check coolant level. Add coolant, if necessary. Locate and correct the source of the coolant loss, (refer to Group 7, Cooling).
	2. Incorrect/improperly operating pressure cap.	2. Replace cap with the correct rating for the system.
	3. Loose drive belt on water pump/fan.	3. Check/replace belt or belt tensioner.
	4. Inadequate air flow to the radiator.	4. Check/repair radiator core, fan shroud and viscous fan drive as required.
	5. Radiator fins plugged.	5. Blow debris from fins.
	6. Collapsed radiator hose.	6. Replace the hose. Check coolant tank cap operation, (refer to Group 7, Cooling Tanks).
	7. Improperly operating temperature sensor/gauge.	7. Verify that the gauge and temperature sensor are accurate. Replace gauge/sensor, if bad.
	8. Improperly operating, incorrect or no thermostat.	8. Check and replace the thermostat.
	9. Air in the cooling system.	9. (A) make sure the fill rate is not being exceeded and the correct vented thermostat is installed. (B) Check for loose hose clamps. Tighten if loose. (C) If aeration continued, check for a compression leak through the head gasket.
	10. Inoperative water pump.	10. Check and replace the water pump.
	11. Incorrect injection pump timing.	11. Verify pump timing marks are aligned. Check/time the injector pump(refer to Group 14, Fuel System).
	12. Overfueled injection pump.	12. Repair or replace the injection pump.
	13. Plugged cooling passages in radiator, head, head gasket or block.	13. Flush the system and fill with clean coolant.
	14. Engine overloaded.	14. Verify that the engine load rating is not being exceeded.
COOLANT TEMPERATURE BELOW NORMAL	1. Too much air flow across the radiator.	1. Check/repair viscous fan drive as required.
	2. Incorrect thermostat or contamination in thermostat.	2. Check and replace thermostat.
	3. Temperature sensor or gauge inoperative.	3. Verify that the gauge and sensor are accurate. If not, replace gauge/sensor.
	4. Coolant not flowing by temperature sensor.	4. Check and clean coolant passages.

DIAGNOSIS AND TESTING (Continued)

SERVICE DIAGNOSIS—DIESEL—MECHANICAL.

CONDITION	POSSIBLE CAUSES	CORRECTION
LUBRICATING OIL PRESSURE LOW	1. Low oil level.	1. (A) Check and fill with clean engine oil. (B) Check for a severe external oil leak that could reduce the pressure.
	2. Oil viscosity thin, diluted or wrong specification.	2. Verify the correct oil is being used. Check for oil dilution. Refer to Contaminated Lube Oil (Engine Diagnosis Mechanical).
	3. Improperly operating pressure switch/gauge.	3. Verify the pressure switch is functioning correctly. If not, replace switch/gauge.
	4. Relief valve stuck open.	4. Check/replace valve.
	5. Plugged oil filter.	5. Change oil filter. Oil filter change interval may need to be revised.
	6. If cooler was replaced, shipping plugs left in cooler.	6. Check/remove shipping plugs.
	7. Worn oil pump.	7. Check and replace oil pump.
	8. Suction tube loose or seal leaking.	8. Check and replace seal.
	9. Loose main bearing cap.	9. Check and install new bearing and tighten cap to proper torque.
	10. Worn bearings or wrong bearings installed.	10. Inspect and replace connecting rod or main bearings. Check and replace piston cooling nozzles.
	11. Oil jet under piston bad fit into main carrier.	11. Check oil jet position.
LUBRICATING OIL PRESSURE TOO HIGH	1. Pressure switch/gauge not operating properly.	1. Verify the pressure switch is functioning correctly. If not, replace switch/gauge.
	2. Engine running to cold.	2. Refer to Coolant Temperature Below Normal (Engine Diagnosis Performance).
	3. Oil viscosity too thick.	3. Make sure the correct oil being used, (Refer to Group 0, Lubrication and Maintenance).
	4. Oil pressure relief valve stuck closed or binding.	4. Check and replace valve.
LUBRICATING OIL LOSS	1. External leaks.	1. Visually inspect for oil leaks. Repair as required.
	2. Crankcase being overfilled.	2. Verify that the correct dipstick is being used.
	3. Incorrect oil specification or viscosity.	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.
	4. Oil cooler leak.	4. Check and replace the oil cooler.
	5. High blow-by forcing oil out the breather.	5. Check the breather tube area for signs of oil loss. Perform the required repairs.

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DIAGNOSIS AND TESTING (Continued)

CONDITION	POSSIBLE CAUSES	CORRECTION
LUBRICATING OIL LOSS (CONT.)	6. Turbocharger leaking oil to the air intake. 7. Piston rings not sealing (oil being consumed by the engine).	6. Inspect the air ducts for evidence of oil transfer. Repair as required. 7. Perform blow-by check. Repair as required.
COMPRESSION KNOCKS	1. Air in the fuel system. 2. Poor quality fuel or water/gasoline contaminated fuel. 3. Engine overloaded. 4. Incorrect injection pump timing. 5. Improperly operating injectors.	1. Bleed the fuel system (refer to Group 14, Fuel System). 2. Verify by operating from a temporary tank with good fuel. Clean and flush the fuel supply tanks. Replace fuel/water separator. 3. Verify the engine load rating is not being exceeded. 4. Check and time injection pump (refer to Group 14, Fuel System). 5. Check and replace inoperative injectors.
EXCESSIVE VIBRATION	1. Loose or broken engine mounts. 2. Damaged fan or improperly operating accessories. 3. Improperly operating vibration damper. 4. Improperly operating viscous fan drive. 5. Worn or damaged generator bearing. 6. Flywheel housing misaligned. 7. Loose or broken power component. 8. Worn or unbalanced driveline components.	1. Replace engine mounts. 2. Check and replace the vibrating components. 3. Inspect/replace the vibration damper. 4. Inspect/replace the fan drive. 5. Check/replace the generator. 6. Check/correct flywheel alignment. 7. Inspect the crankshaft and rods for damage that causes an unbalance. Repair/replace as required. 8. Check/repair driveline components.
EXCESSIVE ENGINE NOISES	1. Drive belt squeal, insufficient tension or abnormally high loading. 2. Intake air or exhaust leaks. 3. Turbocharger noise. 4. Gear train noise. 5. Power function knock.	1. Check the automatic tensioner and inspect the drive belt. Make sure water pump, tensioner pulley, fan hub and generator turn freely. 2. Refer to Excessive Exhaust smoke (Engine Diagnosis Performance). 3. Check turbocharger impeller and turbine wheel for housing contact. Repair/replace as required. 4. Visually inspect and measure gear backlash. Replace gears as required. 5. Check/replace rod and main bearings.

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DIAGNOSIS AND TESTING (Continued)

CONDITION	POSSIBLE CAUSES	CORRECTION
GENERATOR NOT CHARGING OR INSUFFICIENT CHARGING	1. Loose or corroded battery. 2. Generator belt slipping. 3. Generator pulley loose on shaft. 4. Improperly operating generator.	1. Clean/tighten battery connection. 2. Check/replace automatic belt tensioner. Check/replace and adjust belt. 3. Tighten pulley. 4. Check/replace generator.

DIAGNOSIS AND TESTING (Continued)

TAPPET NOISE

(1) To determine source of tappet noise, operate engine at idle with cylinder head covers removed.

(2) Feel each valve spring or rocker arm to detect noisy tappet. The noisy tappet will cause the affected spring and/or rocker arm to vibrate or feel rough in operation.

NOTE: Worn valve guides or cocked springs are sometimes mistaken for noisy tappets. If such is the case, noise may be dampened by applying side thrust on the valve spring. If noise is not appreciably reduced, it can be assumed the noise is in the tappet. Inspect the rocker arm push rod sockets and push rod ends for wear.

(3) Valve tappet noise ranges from light noise to a heavy click. A light noise is usually caused by excessive leak down around the unit plunger or by the plunger partially sticking in the tappet body cylinder. The tappet should be replaced. A heavy click is caused by a tappet check valve not seating or by foreign particles becoming wedged between the plunger and the tappet body. This will cause the plunger to stick in the down position. This heavy click will be accompanied by excessive clearance between the valve stem and rocker arm as valve closes. In either case, tappet assembly should be removed for inspection and cleaning.

The valve train generates a noise very much like a light tappet noise during normal operation. Care must be taken to ensure that tappets are making the noise. In general, if more than one tappet seems to be noisy, its probably not the tappets.

SERVICE PROCEDURES

VALVE SERVICE

This procedure is done with the engine cylinder head removed from the block.

DISASSEMBLY

(1) Remove the engine cylinder head from the cylinder block (refer to cylinder head removal in this section).

(2) Use Valve Spring Compressor Tool and compress each valve spring.

(3) Remove the valve locks, retainers, and springs.

(4) Use an Arkansas smooth stone or a jewelers file to remove any burrs on the top of the valve stem, especially around the groove for the locks.

(5) Remove the valves, and place them in a rack in the same order as removed.

VALVE CLEANING

(1) Clean all carbon deposits from the combustion chambers, valve ports, valve stems, valve stem guides and head.

(2) Clean all grime and gasket material from the engine cylinder head machined gasket surface.

INSPECTION

(1) Inspect for cracks in the combustion chambers and valve ports.

(2) Inspect for cracks on the exhaust seat.

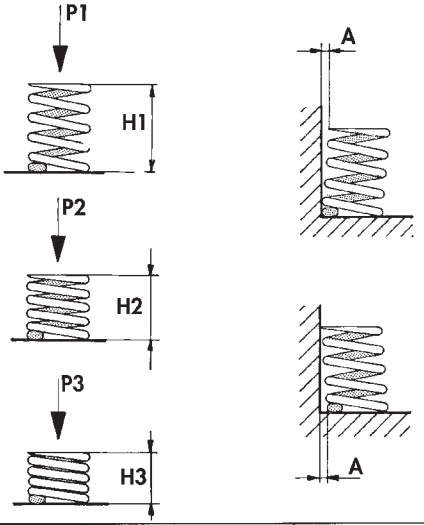
(3) Inspect for cracks in the gasket surface at each coolant passage.

(4) Inspect valves for burned, cracked or warped heads.

(5) Inspect for scuffed or bent valve stems.

(6) Replace valves displaying any damage.

(7) Check valve spring height (Fig. 2).



LOAD Kg		HEIGHT mm		STATE
P1	0.00	H1	44.65	FREE LENGTH
P2	33-35	H2	38.60	VALVE CLOSED
P3	90-95	H3	28.20	VALVE OPEN

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Fig. 2 Valve Spring Chart

VALVE REFACING

(1) Use a valve refacing machine to reface the intake and exhaust valves to the specified angle.

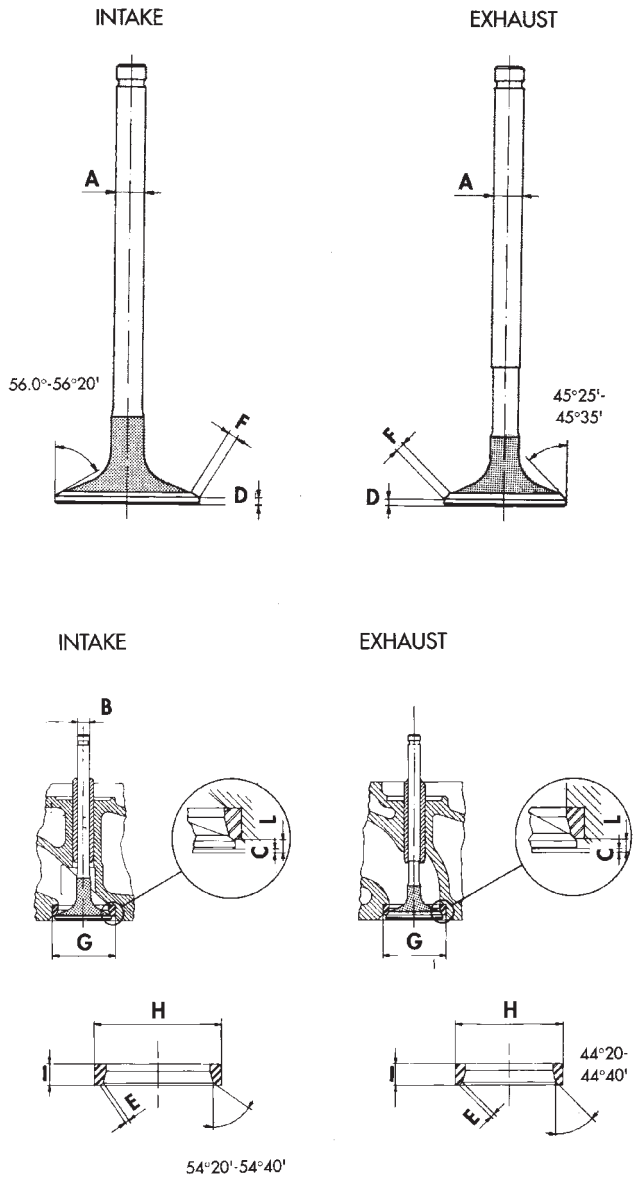
(2) After refacing, a margin of at least 4.52-4.49 mm (.178-.177 inch) must remain (Fig. 3). If the margin is less than 4.49 mm (.177 inch), the valve must be replaced.

VALVE SEAT REFACING

(1) Install a pilot of the correct size in the valve guide bore. Reface the valve seat to the specified angle with a good dressing stone. Remove only enough metal to provide a smooth finish.

(2) Use tapered stones to obtain the specified seat width when required.

SERVICE PROCEDURES (Continued)



MEASUREMENT	INTAKE	EXHAUST
A	7.940-7.960	7.922-7.940
B	8.00-8.015	8.000-8.015
C	0.880-1.140	0.990-1.250
D	2.2±0.08	$2.09^{+0.07}_{-0.09}$
E	1.80-2.20	1.65-2.05
F	2.73-3.44	2.45-3.02
G	41.962-41.985	35.964-35.987
H	42.070-42.086	36.050-36.066
I	7.14-7.19	7.00-7.05
L	3.11-3.26	3.10-3.25

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Fig. 3 Valve Specification

VALVE STAND DOWN

Valve stand down is to maintain the adequate compression ratio.

(1) Invert cylinder head.

(2) Fit each valve to its respective valve guide.

(3) Using a straight edge and feeler gauge (Fig. 4), check valve head stand down: Inlet valve head stand down .80 to 1.2 mm (.031 to .047 in.) and exhaust valve stand down .79 to 1.19 mm (.031 to .047 in).

(4) If valve head stand down is not in accordance with above, discard original valves, check stand down with new valves and recut valve seat inserts to obtain correct stand down.

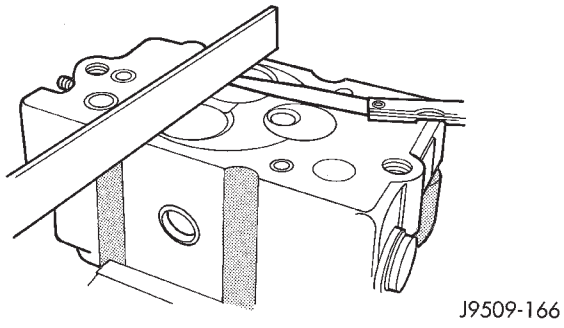

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Fig. 4 Checking Valve Stand Down

VALVE GUIDES

(1) Valve Guides height requirement.

(2) Measurement A (Fig. 5): 13.50 - 14.00 mm.

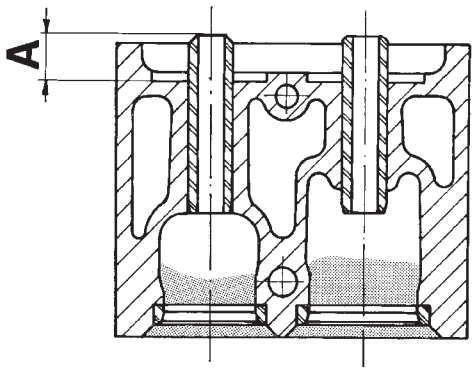

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Fig. 5 Valve Guide Height

VALVE STEM-TO-GUIDE CLEARANCE MEASUREMENT

(1) Measure and record internal diameter of valve guides. Valve guide internal diameter is 8.0 to 8.015 mm (.3149 to .3155 ins.).

(2) Measure valve stems and record diameters. Intake valve stem diameter 7.94 to 7.96 mm (.3125 to .3133 in). Exhaust valve stem diameter 7.92 to 7.94 mm (.3118 to .31215 in).

SERVICE PROCEDURES (Continued)

(3) Subtract diameter of valve stem from internal diameter of its respective valve guide to obtain valve stem clearance in valve guide. Clearance of inlet valve stem in valve guide is .040 to .075 mm (.0015 to .0029 in). Clearance of exhaust valve stem in valve guide is .060 to .095 mm (.0023 to .0037 in).

(4) If valve stem clearance in valve guide exceeds tolerances, new valve guides must be installed.

REMOVAL AND INSTALLATION

ENGINE MOUNTS—FRONT

The front mounts support the engine at each side. These supports are made of resilient rubber.

REMOVAL—RIGHT SIDE

(1) Disconnect negative cable from battery.
(2) Raise the vehicle.
(3) Support the engine.
(4) Remove through bolt nut. DO NOT remove the through bolt (Fig. 6).
(5) Remove insulator sill plate bolts.
(6) Remove engine mount bracket bolts.
(7) Raise engine up.
(8) Remove the through bolt.
(9) Remove insulator.
(10) Remove engine bracket.

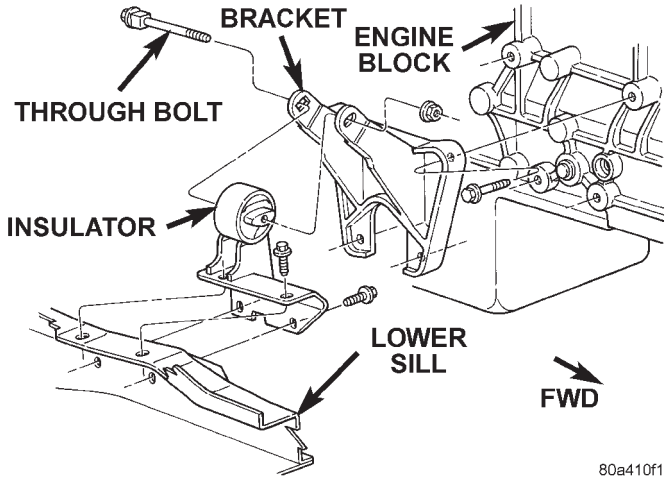

Fig. 6 Front Mount—Right Side

INSTALLATION—RIGHT SIDE

(1) Install the engine support bracket and bolts, tighten bolts to 61 N·m (45 ft. lbs.).
(2) Secure the insulator assembly on the lower sill. Tighten the bolts to 65 N·m (48 ft. lbs.).
(3) Lower engine and place the insulator assembly into the bracket.
(4) Install the through bolt nut. Tighten the through bolt nut to 65 N·m (48 ft. lbs.).
(5) Remove the engine support.
(6) Lower the vehicle.
(7) Connect negative cable to battery

REMOVAL—LEFT SIDE

(1) Disconnect negative cable from battery.
(2) Raise the vehicle.
(3) Support the engine.
(4) Remove through bolt nut. DO NOT remove the through bolt (Fig. 7).
(5) Remove insulator sill plate bolts.
(6) Remove engine mount bracket bolts.
(7) Raise engine up.
(8) Remove the through bolt.
(9) Remove insulator.
(10) Remove engine bracket.

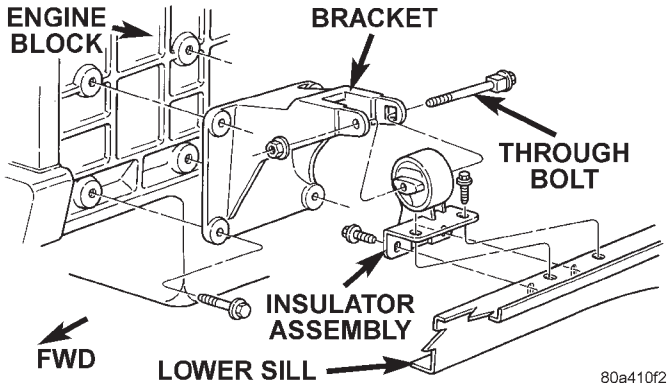

Fig. 7 Front Mount—Left Side

INSTALLATION—LEFT SIDE

(1) Install the engine support bracket and bolts, tighten bolts to 61 N·m (45 ft. lbs.).
(2) Secure the insulator assembly on the lower sill. Tighten the bolts to 65 N·m (48 ft. lbs.).
(3) Lower engine and place the insulator assembly into the bracket.
(4) Install the through bolt nut. Tighten the through bolt nut to 65 N·m (48 ft. lbs.).
(5) Remove the engine support.
(6) Lower the vehicle.
(7) Connect negative cable to battery.

ENGINE MOUNT—REAR

A resilient rubber cushion supports the transmission at the rear between the transmission extension housing and the rear support crossmember or skid plate.

REMOVAL

(1) Disconnect negative cable from battery.
(2) Raise the vehicle and support the transmission.
(3) Remove the nuts holding the support cushion to the bracket (Fig. 8). Remove the crossmember.
(a) Remove the support cushion nuts and remove the cushion.

REMOVAL AND INSTALLATION (Continued)

(b) If necessary, remove the bolts holding the transmission support bracket to the transmission. Remove the bracket.

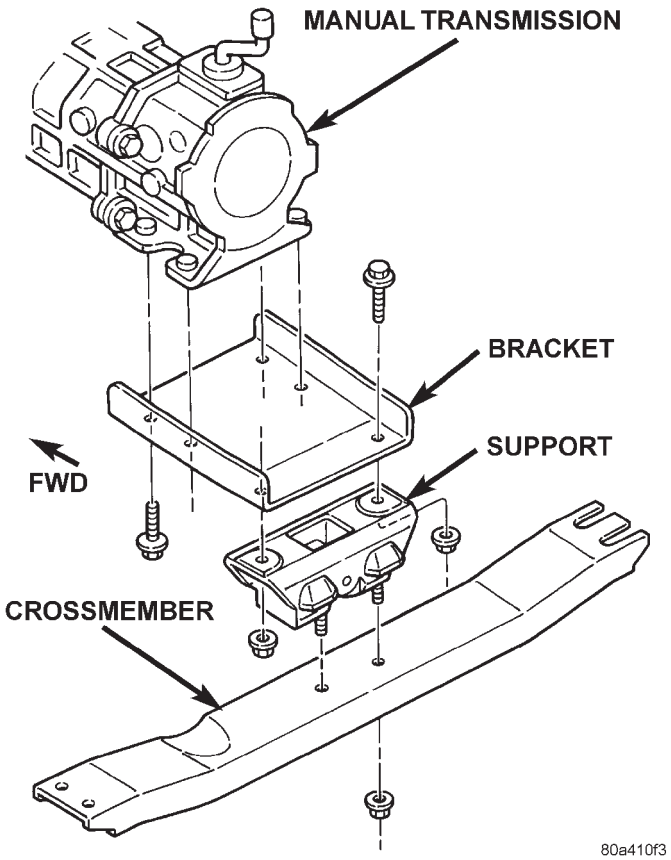

Fig. 8 Rear Mount

INSTALLATION

(1) If removed, position the transmission support bracket to the transmission and install the bolts. Tighten the bolts to 46 N·m (34 ft. lbs.) torque.

(2) Position the support cushion onto the transmission support crossmenber. Tighten the nuts to 54 N·m (40 ft. lbs.) torque.

(3) Install crossmember.

(4) Secure support cushion to bracket. Tighten the nuts to 54 N·m (40 ft. lbs.) torque.

(5) Remove transmission support and lower vehicle.

(6) Connect negative battery cable.

ENGINE ASSEMBLY

REMOVAL

(1) Disconnect the battery cables. Remove the battery.

(2) Mark the hinge locations on the hood panel for alignment reference during installation. Disconnect the engine compartment lamp wiring connection. Remove the hood.

WARNING: THE COOLANT IN A RECENTLY OPERATED ENGINE IS HOT AND PRESSURIZED. USE CARE TO PREVENT SCALDING BY HOT COOLANT. CAREFULLY RELEASE THE PRESSURE BEFORE REMOVING THE RADIATOR DRAIN COCK AND CAP.

(3) Drain the cooling system (refer to Group 7, Cooling).

(4) Discharge the air conditioning system, if equipped (refer to Group 24, Heating and Air Conditioning for service procedures).

(5) Remove the lower radiator hose.

(6) Remove the upper radiator hose and coolant recovery hose (Fig. 9).

(7) Remove upper crossmember, refer to Group 23, Body Components for procedure.

(8) Remove air cleaner hose from turbocharger and breather hose.

(9) Remove the air cleaner assembly.

(10) Disconnect A/C lines from condenser (Refer to Group 24, Heating and Air Conditioning) cap lines to keep foreign particles out.

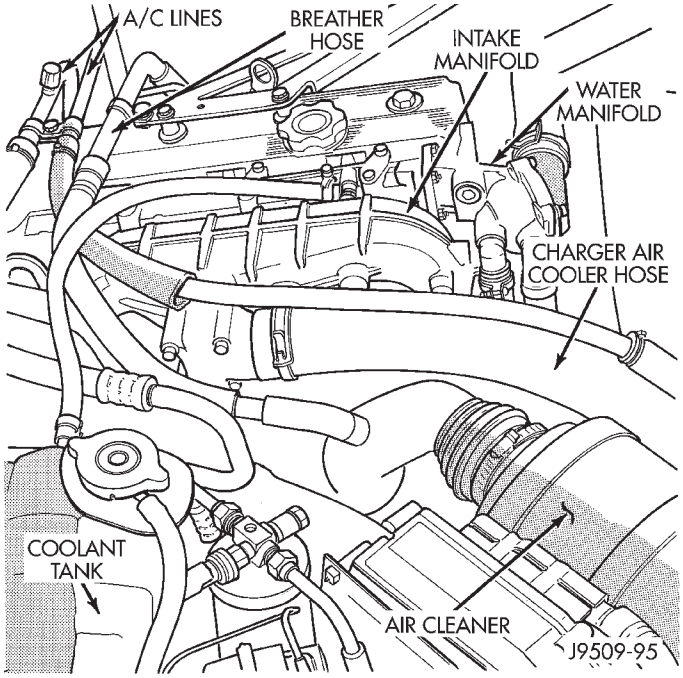

Fig. 9 Right side of Engine

(11) Tip radiator, A/C condenser, and fan shroud assembly away from engine.

(12) Remove fan and set fan inside fan shroud.

(13) Remove fan, fan shroud, radiator, and A/C condenser as an assembly.

(14) Disconnect the heater hoses and coolant recovery bottle hose (Fig. 9).

(15) Remove fuel lines, fuel filter, refer to Group 14, Fuel Systems.

(16) If equipped with air conditioning, remove the service valves and cap the compressor ports (refer to Group 14, Fuel System).

REMOVAL AND INSTALLATION (Continued)

(17) Remove the power brake vacuum check valve from the booster, if equipped.

(18) If equipped with power steering (Fig. 10):

(a) Disconnect the power steering pressure hoses from the steering gear.

(b) Disconnect return line from reservoir and drain the pump reservoir.

(c) Cap the fittings on the hoses and steering gear to prevent foreign material from entering the system.

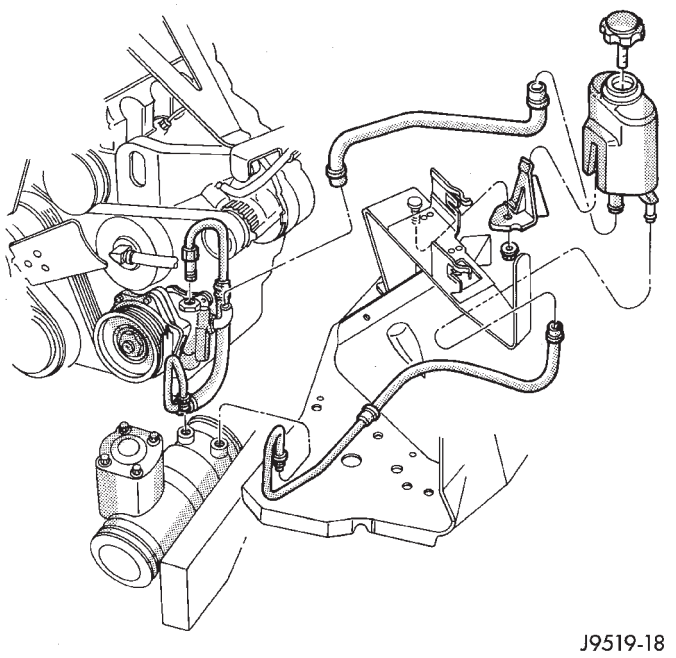

Fig. 10 Power Steering Lines

(19) Identify, tag and disconnect all necessary wire connectors and vacuum hoses.

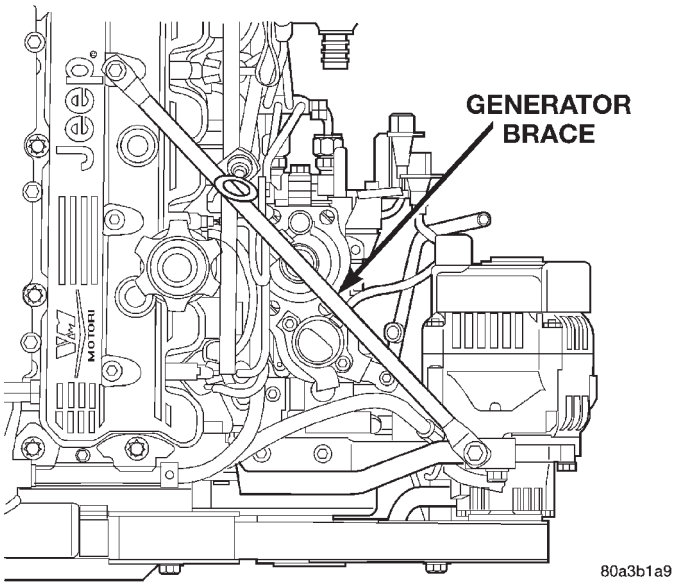

Fig. 11 Left Side of Engine

(20) Remove gear shift levers (refer to Group 21, Transmissions).

(21) Raise and support the vehicle.

(22) Remove Prop shafts (refer to Group 2, Suspension and Driveshafts).

(23) Disconnect the exhaust pipe from the exhaust down manifold (refer to Group 11, Exhaust system and Intake Manifolds).

(24) Remove rear crossmember and transmission mount, support transmission.

(25) Tip transmission to remove four bolts on top of transmission to engine block. Disconnect wiring from transmission.

(26) Support transmission, remove lower bolts and brackets, remove transmission.

(27) Remove the engine support cushion-to-engine compartment bracket nuts.

(28) Lower the vehicle.

(29) Attach a lifting device to the engine.

(30) Lift the engine out of the engine compartment. Install the engine on an engine stand.

INSTALLATION

(1) Lift the engine off the stand and lower it into the engine compartment.

(2) Install the engine support cushions (if removed).

(3) Lower the engine and engine support cushions onto the engine compartment brackets.

(4) Raise the vehicle.

(5) Install transmission to engine refer to Group 21, transmissions.

(6) Support transmission.

(7) Remove the engine lifting device.

(8) Install rear crossmember tighten bolts to 42 N·m (31 ft. lbs.).

(9) Install transmission rear mount, for procedure refer to Engine Mount—Rear in this section.

(10) Tighten the engine support cushion through-bolt nuts 65 N·m (48 ft. lbs.).

(11) Install the exhaust pipe support.

(12) Connect the exhaust down pipe to the exhaust system refer to Group 11, Exhaust System and Intake Manifold.

(13) Lower the vehicle.

(14) Connect all the vacuum hoses and wire connectors.

(15) If equipped with power steering:

(a) Remove the protective caps.

(b) Connect the pressure hoses to the steering gear. Tighten the nut to 28 N·m (21 ft. lbs.).

(c) Connect return line from reservoir to the pump.

(d) Fill the pump reservoir with fluid.

(16) Connect the service valves to the A/C compressor ports, if equipped with air conditioning.

REMOVAL AND INSTALLATION (Continued)

(17) Install fuel filter and bracket. Tighten bolts to 28 N·m (250 in. lbs.).
(18) Connect the fuel supply and return lines.
(19) Connect brake booster hose.
(20) Connect the heater hoses and recovery bottle hose.
(21) Connect charge air cooler hoses to turbo and intake manifold.
(22) Install the fan, fan shroud and radiator/condenser (if equipped with air conditioning).
(23) Install fan, tighten to 56 N·m (41 ft. lbs.).
(24) Connect the upper and lower radiator hoses.
(25) Install upper crossmember, refer to Group 23, Body Components.
(26) Install air cleaner and bracket.
(27) Connect air cleaner hose to turbo and connect breather hose.
(28) Install battery tray and battery.
(29) Connect the battery cables.
(30) Fill the cooling system.
(31) If equipped, If system was opened, evacuate and charge the air conditioning system (refer to Group 24, Heater and Air Conditioning).
(32) Install the hood.
(33) Install the air cleaner.
(34) Start the engine and inspect for leaks.
(35) Stop the engine and check the fluid levels. Add fluid, as required.

CYLINDER HEAD COVER

REMOVAL

(1) Disconnect the battery cable.

WARNING: DO NOT REMOVE THE CYLINDER BLOCK DRAIN PLUGS OR LOOSEN THE RADIATOR DRAIN COCK WITH THE SYSTEM HOT AND PRESSURIZED BECAUSE SERIOUS BURNS FROM THE COOLANT CAN OCCUR.

(2) Drain the cooling system (refer to Group 7, Cooling).
(3) Discharge the air conditioning system, if equipped (refer to Group 24, Heating and Air Conditioning for service procedures).
(4) If equipped with air conditioning, remove the A/C lines at the compressor and cap (refer to Group 24, Heating and Air Conditioning). Remove A/C line bracket attached to cylinder head cover, and move A/C lines away from cylinder head.
(5) Remove generator support brace (Fig. 12).
(6) Remove Crankcase breather hose from rear of the valve cover
(7) Remove the upper radiator hose and coolant tank hose.
(8) Remove water manifold.

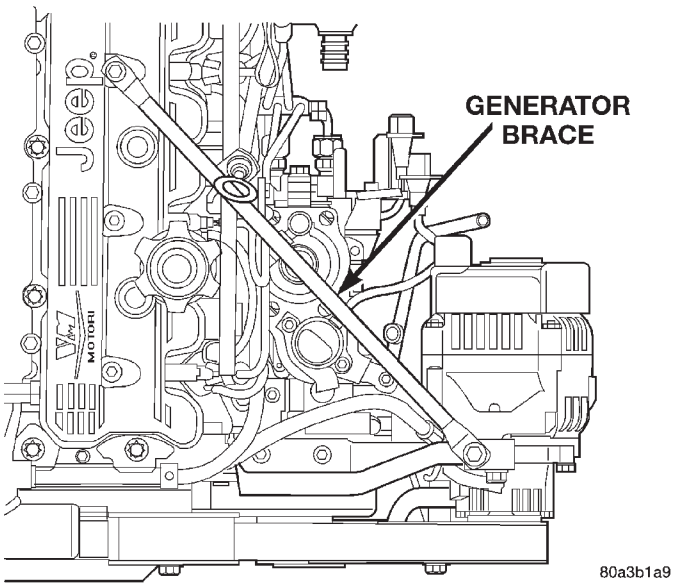

Fig. 12 Generator Brace

(9) Loosen cylinder head cover bolts and raise cylinder head cover.
(10) Raise vehicle on hoist.
(11) Support transmission with a suitable jack.
(12) Remove lower attaching bolt.
(13) Remove entire crossmember.
(14) Take the lowest brake line on dash out of all the mounting clips (RHD Vehicles only).
(15) Lower the entire transmission and transfer case assembly approximately 130 mm.

WARNING: Ensure the transmission and transfer case are adequately supported.

(16) Remove the engine cylinder head cover.

INSTALLATION

(1) Position valve cover on cylinder heads.
(2) Raise the entire transmission and transfer case assembly approximately 130 mm.
(3) Reinstall the lowest brake line on dash into all the mounting clips (RHD Vehicles only).
(4) Install the entire crossmember.
(5) Install the lower attaching bolt.
(6) Install transmission support.
(7) Lower vehicle.
(8) Install valve cover, tighten nuts to 19 N·m (168 in. lbs.).
(9) Connect crankcase breather hose.
(10) Install water manifold and tighten bolts to 12 N·m (106 in. lbs.).
(11) Install generator support brace.
(12) Connect coolant tank hose to water manifold.
(13) Connect the upper radiator hose.

REMOVAL AND INSTALLATION (Continued)

(14) Connect the A/C lines to compressor and install bracket on cylinder head cover, if equipped with air conditioning.

(15) Connect negative cable to battery.

(16) If equipped with A/C, evacuate and charge the air conditioning system (refer to Group 24, Heater and Air Conditioning).

(17) Fill the cooling system. Check for leaks.

WARNING: USE EXTREME CAUTION WHEN THE ENGINE IS OPERATING. DO NOT STAND IN DIRECT LINE WITH THE FAN. DO NOT PUT HANDS NEAR THE PULLEYS, BELTS OR FAN. DO NOT WEAR LOOSE CLOTHING.

(18) Operate the engine with the radiator cap off. Inspect for leaks and continue operating the engine until the thermostat opens. Add coolant, if required.

HYDRAULIC TAPPETS

REMOVAL

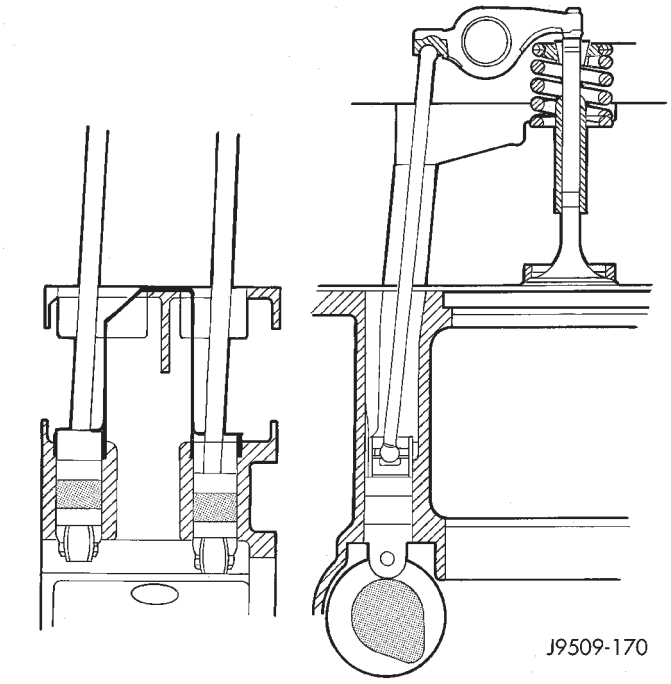

Fig. 13 Tappet And Rocker Arm Assembly

(1) Remove the air cleaner.

(2) Remove cylinder head cover (refer to cylinder valve cover removal in this section).

(3) Remove rocker assembly and push rods (Fig. 13). Identify push rods to ensure installation in original location.

(4) Remove cylinder head, intake manifold, and exhaust manifold, refer to cylinder head removal in this section.

(5) Remove yoke retainer and aligning yokes (Fig. 14).

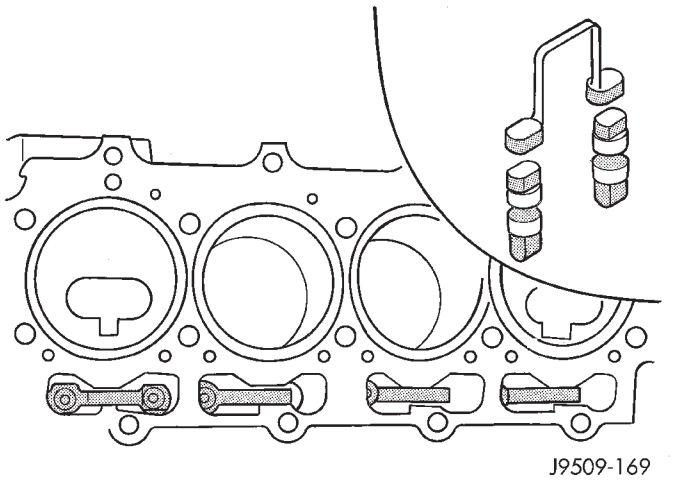

Fig. 14 Tappet And Yoke

(6) Slide Hydraulic Tappet Remover/Installer Tool through opening in block and seat tool firmly in the head of tappet.

(7) Pull tappet out of bore with a twisting motion. If all tappets are to be removed, identify tappets to ensure installation in original location.

(8) If the tappet or bore in cylinder block is scored, scuffed, or shows signs of sticking, ream the bore to next oversize. Replace with oversize tappet.

CAUTION: The plunger and tappet bodies are not interchangeable. The plunger and valve must always be fitted to the original body. It is advisable to work on one tappet at a time to avoid mixing of parts. Mixed parts are not compatible. DO NOT disassemble a tappet on a dirty work bench.

INSTALLATION

(1) Lubricate tappets.

(2) Install tappets and yoke retainers in their original positions. Ensure that the oil feed hole in the side of the tappet body faces up (away from the crankshaft).

(3) Install cylinder head, intake manifold, and exhaust manifold, refer to cylinder head installation in this section.

(4) Install push rods in original positions.

(5) Install rocker arms (refer to rocker arms in this section).

(6) Install cylinder head cover (refer to cylinder valve cover installation in this section).

(7) Start and operate engine. Warm up to normal operating temperature.

CAUTION: To prevent damage to valve mechanism, engine must not be run above fast idle until all hydraulic tappets have filled with oil and have become quiet.

REMOVAL AND INSTALLATION (Continued)

ROCKER ARMS AND PUSH RODS

REMOVAL

(1) Disconnect the battery cables.

(2) Discharge the air conditioning system, if equipped (refer to Group 24, Heating and Air Conditioning for service procedures).

(3) If equipped with air conditioning, remove the service valves and cap the compressor ports (refer to Group 24, Heating and Air Conditioning).

(4) Remove generator bracket.

(5) Remove breather hose.

(6) Remove cylinder head cover.

(7) Remove rocker retaining nut (Fig. 15).

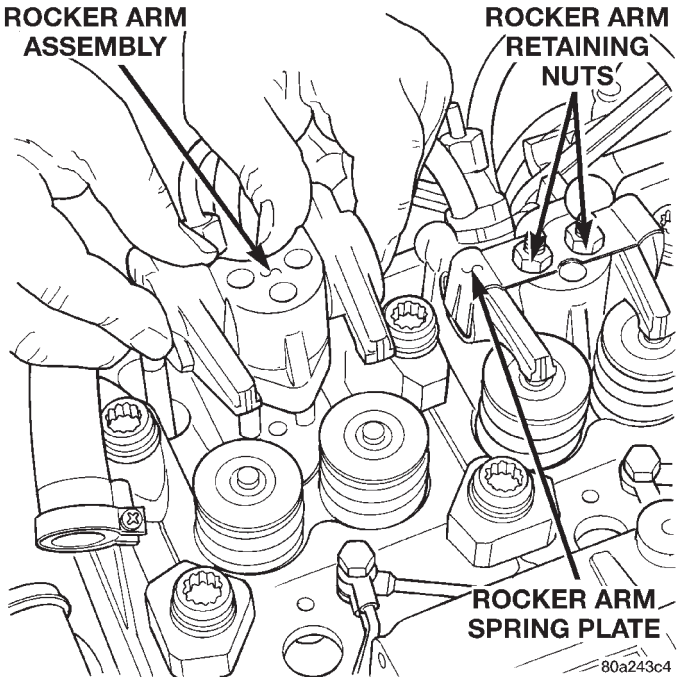

Fig. 15 Rocker Arm Retaining Nut

(8) Remove rocker assembly. Place them on a bench in the same order as removed.

(9) Remove the push rods and place them on a bench in the same order as removed.

INSTALLATION

(1) Rotate the crankshaft until the mark lines up with the TDC mark on the timing cover.

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

(3) Install rocker arm assemblies in the same order as removed. Tighten the rocker arm nuts to 29.4 N·m (264 in. lbs.) torque.

(4) Install cylinder head cover, torque nuts to 19 N·m (168 in. lbs.).

(5) Install breather hose.

(6) Install generator bracket, tighten bolts to 7 N·m (4 ft. lbs.).

(7) Connect the service valves to the A/C compressor ports, if equipped with air conditioning.

(8) If equipped, evacuate and charge the air conditioning system (refer to Group 24, Heater and Air Conditioning).

(9) Connect battery cable.

VALVE SPRINGS

This procedure can be done with the engine cylinder head installed on the block.

REMOVAL

Each valve spring is held in place by a retainer and a set of conical valve locks. The locks can be removed only by compressing the valve spring.

(1) Remove the engine cylinder head cover, refer to cylinder head cover removal in this section.

(2) Remove rocker arms assemblies for access to each valve spring to be removed.

(3) Remove push rods. Retain the push rods, and rocker arms assemblies in the same order and position as removed.

(4) Inspect the springs and retainer for cracks and possible signs of weakening.

(5) Install an air hose adaptor in the fuel injector hole.

(6) Connect an air hose to the adapter and apply air pressure slowly. Maintain at least 621 kPa (90 psi) of air pressure in the cylinder to hold the valves against their seats.

(7) Tap the retainer or tip with a rawhide hammer to loosen the lock from the retainer. Use Valve Spring Compressor Tool to compress the spring and remove the locks.

(8) Remove valve spring and retainer.

(9) Inspect the valve stems, especially the grooves. An Arkansas smooth stone should be used to remove nicks and high spots.

INSTALLATION

(1) Install valve spring and retainer.

(2) Compress the valve spring with Valve Spring Compressor Tool and insert the valve locks. Release the spring tension and remove the tool. Tap the spring from side-to-side to ensure that the spring is seated properly on the engine cylinder head.

(3) Disconnect the air hose. Remove the adaptor from the fuel injector hole and install the fuel injector.

(4) Repeat the procedures for each remaining valve spring to be removed.

(5) Install the push rods. Ensure the bottom end of each rod is centered in the plunger cap seat of the hydraulic valve tappet.

(6) Install the rocker arm assemblies, at their original location.

REMOVAL AND INSTALLATION (Continued)

(7) Tighten the rocker arm assembly nut to 35 N·m (26 ft. lbs.) torque.

(8) Install the engine cylinder head cover, refer to cylinder head cover installation in this section.

ENGINE CYLINDER HEAD

REMOVAL

(1) Disconnect the battery cable.

WARNING: DO NOT REMOVE THE CYLINDER BLOCK DRAIN PLUGS OR LOOSEN THE RADIATOR DRAIN COCK WITH THE SYSTEM HOT AND PRESSURIZED BECAUSE SERIOUS BURNS FROM THE COOLANT CAN OCCUR.

(2) Drain the cooling system (refer to Group 7, Cooling).

(3) Discharge the air conditioning system, if equipped (refer to Group 24, Heating and Air Conditioning for service procedures).

(4) If equipped with air conditioning, remove the A/C lines at the compressor and cap (refer to Group 24, Heating and Air Conditioning). Remove A/C line bracket attached to cylinder head cover, and move A/C lines away from cylinder head.

(5) Remove air cleaner hose from turbocharger and breather hose.

(6) Remove the air cleaner assembly and breather hose.

(7) Remove generator support bracket.

(8) Loosen cylinder head cover bolts.

(9) Raise vehicle on hoist.

(10) Remove transmission crossmember bolts, and lower rear of engine.

(11) Remove the upper radiator hose and coolant recovery hose.

(12) Remove water manifold and recovery hose.

(13) Disconnect the heater hoses and coolant recover bottle hose.

(14) Disconnect EGR tube from EGR valve.

(15) Remove EGR valve.

(16) Remove exhaust heat shield from exhaust manifold.

(17) Remove exhaust heat shield from down pipe.

(18) Remove exhaust down pipe from turbocharger (Fig. 16).

(19) Disconnect oil feed line from turbocharger.

(20) Disconnect oil drain line from turbocharger.

(21) Remove Exhaust manifold (refer to Group 11, Exhaust System and Intake Manifold).

(22) Remove Intake manifold (refer to Group 11, Exhaust System and Intake Manifold).

(23) Remove oil feed line for rocker arm assemblies (Fig. 17).

(24) Remove Crankcase breather hose from rear of the valve cover.

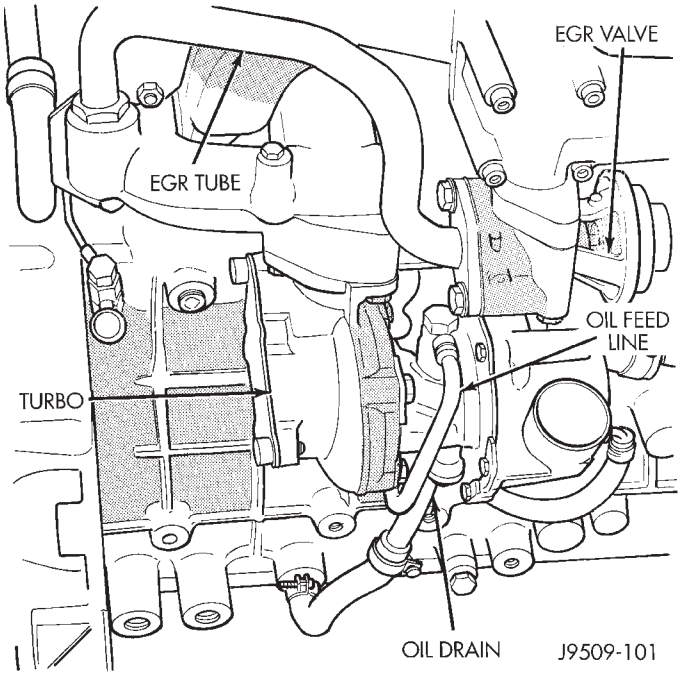

Fig. 16 Turbocharger

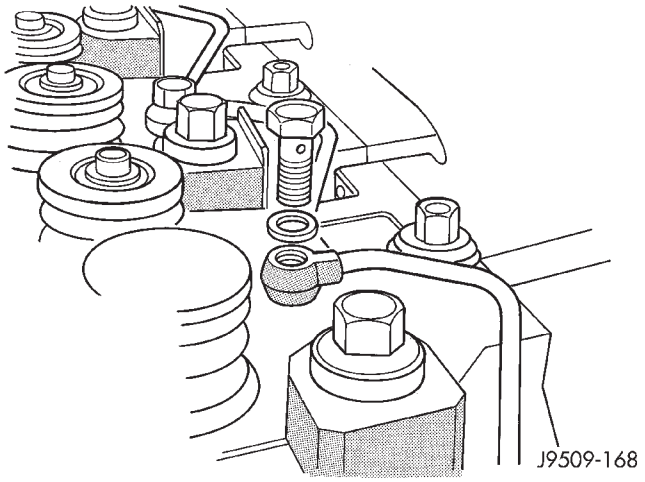

Fig. 17 Rocker Arm Oil Feed Lines

(25) Remove the injector sensor wire and the glow plug hot lead.

(26) Remove fuel lines, fuel filter, refer to Group 14, Fuel Systems.

(27) Remove injector fuel lines from injectors to pump.

(28) Remove fuel injectors with tool VM-1012A (Fig. 18) (refer to Group 14, Fuel System).

(29) Remove the engine cylinder head cover.

(30) Remove rocker retaining nuts (Fig. 20).

(31) Remove rocker assembly. Place them on a bench in the same order as removed.

(32) Remove the push rods and place them on a bench in the same order as removed.

(33) Mark cylinder head positions.

REMOVAL AND INSTALLATION (Continued)

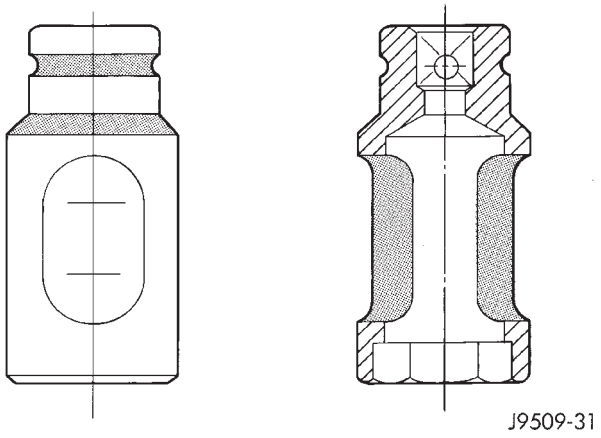

Fig. 18 Fuel Injector Tool VM-1012A

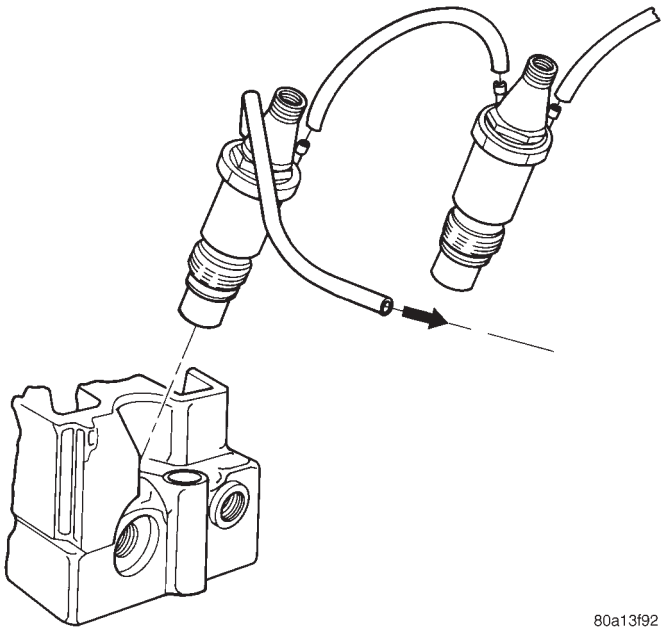

Fig. 19 Fuel Injector

(34) Remove the engine cylinder head bolts with special tool VM-1018 and VM-1019.

(35) Remove the engine cylinder head and gasket.

(36) Stuff clean lint free shop towels into the cylinder bores.

CYLINDER HEAD GASKETS

A steel cylinder head gasket is used for all four cylinder heads.

Cylinder head gaskets are available in three thicknesses. Identification holes in the right front corner of the gasket indicate the thickness of the gasket (Fig. 21).

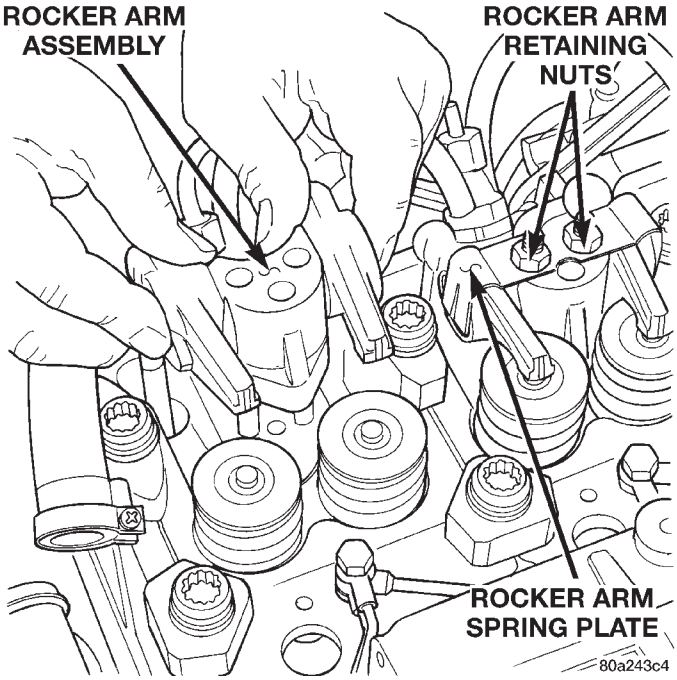

Fig. 20 Rocker Arm Retaining Nuts

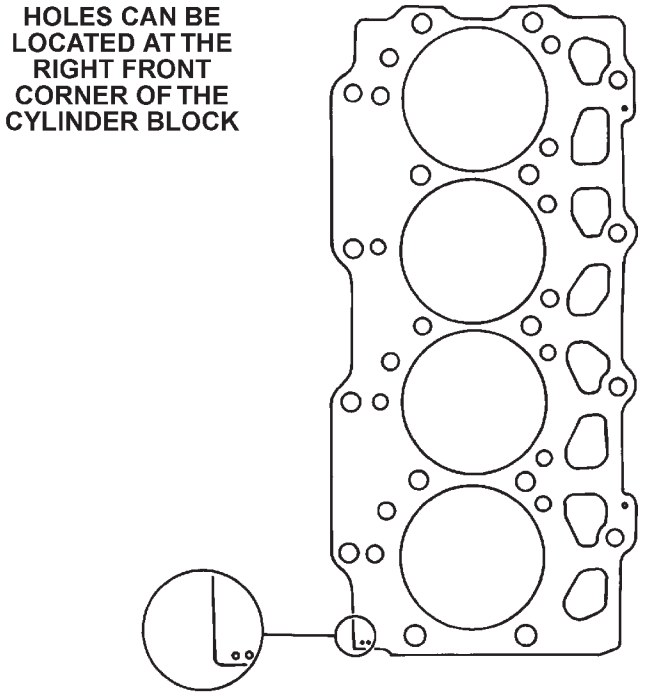

Fig. 21 Steel Type Cylinder Head Gasket—identification

CAUTION: Piston protrusion must be measured, to determine cylinder head gasket thickness, if one or more cylinder wall liners have been replaced.

REMOVAL AND INSTALLATION (Continued)

NOTE: If cylinder wall liners have not been removed; the same thickness head gasket removed, may be used.

MEASURING PISTON PROTRUSION

(1) Use special tool VM-1010 with dial indicator special tool VM-1013 (Fig. 22).

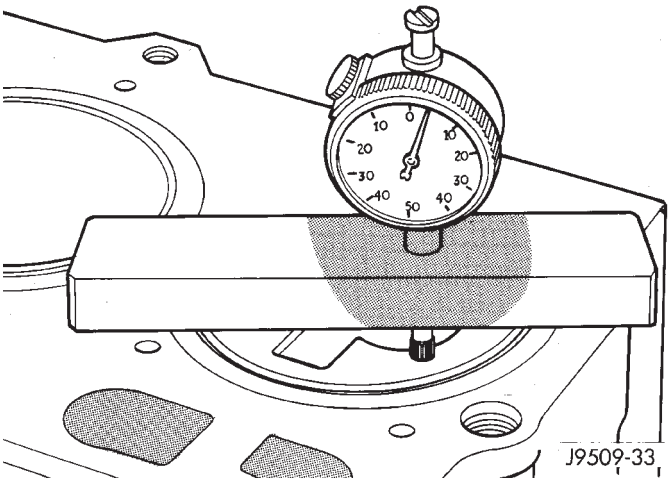

Fig. 22 Measuring Piston Protrusion

(2) Bring the piston of cylinder no. 1 exactly to top dead center.

(3) Zero the dial indicator on the cylinder block mating surface.

(4) Setup the dial indicator on the piston crown (above the center of the piston pin) 5mm (1/8 in.) from the edge of the piston and note the measurement (Fig. 23).

(5) Repeat the procedure with the rest of the cylinders.

(6) Establish the thickness of the steel gasket for all four cylinder heads on the basis of the greatest piston protrusion (Fig. 21).

Measured dimension (mm)	0.53 - 0.62
Cyl. head gasket thickness (mm)	1.42
Piston clearance (mm)	0.80 - 0.89
Measured dimension (mm)	0.63 - 0.72
Cyl. head gasket thickness (mm)	1.52
Piston clearance (mm)	0.80 - 0.89
Measured dimension (mm)	0.73 - 0.82
Cyl. head gasket thickness (mm)	1.62
Piston clearance (mm)	0.80 - 0.89

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Fig. 23 Piston Protrusion Chart

CAUTION: Gaskets are to be installed DRY. DO NOT use a gasket sealing compound on the gasket.

INSTALLATION

(1) Remove the shop towels from the cylinder bores. Coat the bores with clean engine oil.

(2) Install cylinder head alignment studs (VM-1009).

(3) After determining the correct head gasket thickness, clean the block and head mating surfaces, place the engine cylinder head gasket over the dowels.

(4) Place the engine cylinder head over the dowels.

CAUTION: New cylinder head bolts should be used.

(5) Tighten the engine cylinder head bolts in sequence according to the following procedure (Fig. 24):

(a) The threads and underside heads of the bolts should be lubricated. Use the cylinder head alignment studs tool number VM-1009. Position the heads on the block and secure with the ten large center bolts and spacers (clamps), finger tight only. Be sure that the various clamps are installed correctly and the head gaskets remain in their proper position, completely covered. Then, lubricate and install the eight small bolts, also finger tight.

(6) Hand tighten oil feed line for rocker arm assemblies.

(7) Install the intake and exhaust manifolds with new gaskets, partially tightening the nuts to a maximum of 5 N·m (44 in. lbs.). This will align the heads (refer to Group 11, Exhaust System and Intake Manifold for the proper procedures).

(8) Then, tighten the 12mm bolts with special tool VM-1019 in the following manner:

1st Phase: Head Bolts Tightening -- (Fig. 24)

Central bolts (A-L): Tighten all bolts, starting with bolt A then B-C-D-E-F-G-H-I-L, to 30 N·m. Repeat the operation with the same torque. Following the same sequence rotate each bolt through an angle of 70° using angle torque tool. Then rotate the bolts an additional 70° following tightening sequence.

(9) Then, tighten the 14mm bolts with special tool VM-1018 in the following manner:

Side bolts (M1-M2): Tighten M1 bolts to 30 N·m, then rotate them 85°(+/-5). Tighten M2 bolts to 30 N·m, then rotate them 85°(+/-5).

NOTE: If vehicle is equipped with A/C do not install A/C lines to compressor and charge A/C till Phase 2 is complete.

(10) 2nd Phase: After 20 minutes of engine operation at operating temperature, allow engine to cool down completely. Then re-torque the head bolts as follows:

Central bolts A-L: Starting from bolt A, slacken and re-torque it immediately to 30 N·m + 65°. Rotate the bolt an additional 65°. Then proceed in the same

REMOVAL AND INSTALLATION (Continued)

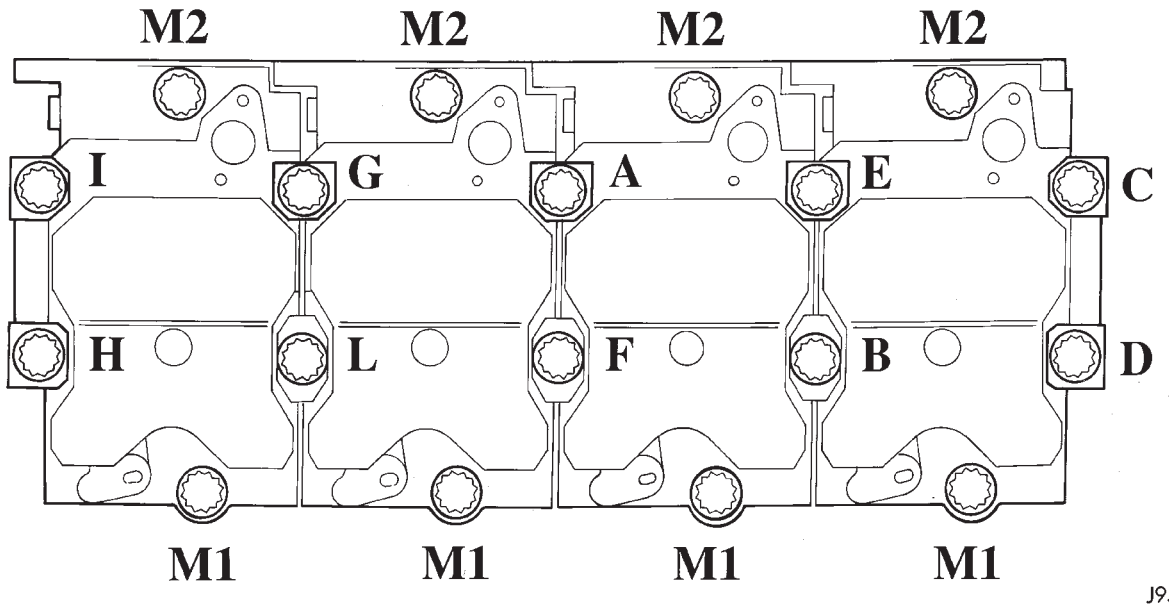

Fig. 24 Engine Cylinder Head Bolt Tightening Sequence

way, bolt by bolt, following alphabetical order, as indicated.

Side bolts M1-M2: **Without slackening** , torque bolts M1 then bolts M2 to 90 N·m (66 ft. lbs.).

(11) Tighten intake nuts to 30 N·m (22 ft. lbs.) and exhaust manifolds nuts to 30 N·m (22 ft. lbs.) specified torque after completing Phase 2.

If the engine cylinder head is to be replaced and the original valves used, measure the valve stem diameter. Only standard size valves can be used with a service replacement engine cylinder head unless the replacement head valve stem guide bores are reamed to accommodate oversize valve stems. Remove all carbon buildup and reface the valves.

(12) Tighten oil feed lines for rocker arm assemblies to 13 N·m (112 in. lbs.).

(13) Install push rods and rocker arm assemblies, tighten nut to 35 N·m (26 ft. lbs.).

(14) Install valve cover, tighten nuts to 19 N·m (168 in. lbs.).

(15) Connect crankcase breather hose.

(16) Connect the injector sensor wire and the glow plug hot lead.

(17) Install turbocharger oil feed line, tighten banjo bolts to 27 N·m (20 ft. lbs), and install oil drain line to turbocharger.

(18) Install water manifold and tighten bolts to 12 N·m (106 in. lbs.).

(19) Install generator support bracket.

(20) Raise vehicle on hoist.

(21) Install transmission crossmember bolts.

(22) Install exhaust down pipe to turbocharger, tighten bolts to 22 N·m (16 ft. lbs.).

(23) Install exhaust down pipe heat shield.

(24) Install exhaust heat shield, Tighten bolts to 11 N·m (8 ft. lbs.).

(25) Install EGR valve to intake manifold, tighten bolts to 26 N·m (19 ft. lbs.).

(26) Install EGR tube to EGR valve, tighten bolts to 26 N·m (19 ft. lbs.).

(27) Install lower Charge air cooler hose to turbocharger.

(28) Install air cleaner assembly and hose.

(29) Install oil breather hose to air cleaner hose.

(30) Install upper charge cooler hose to turbocharger.

(31) Connect recover bottle hose to water manifold.

(32) Install fuel injectors use tool VM-1012 (refer to Group 14, Fuel System).

(33) Install fuel injector lines from the pump to injectors, tighten nuts to 23 N·m (17 ft. lbs.).

(34) Connect the A/C lines to compressor and install bracket on cylinder head cover, if equipped with air conditioning.

(35) Install fuel filter, Tighten bolts to 28 N·m (250 in. lbs.).

(36) Connect the fuel supply and return lines.

(37) Connect the upper radiator hose.

(38) Connect negative cable to battery.

(39) If equipped with A/C, evacuate and charge the air conditioning system (refer to Group 24, Heater and Air Conditioning).

(40) Fill the cooling system. Check for leaks.

REMOVAL AND INSTALLATION (Continued)

WARNING: USE EXTREME CAUTION WHEN THE ENGINE IS OPERATING. DO NOT STAND IN DIRECT LINE WITH THE FAN. DO NOT PUT HANDS NEAR THE PULLEYS, BELTS OR FAN. DO NOT WEAR LOOSE CLOTHING.

(41) Operate the engine with the radiator cap off. Inspect for leaks and continue operating the engine until the thermostat opens. Add coolant, if required.

CAUTION: After rebuild or cylinder head gasket replacement, the cylinder head must be retorqued within the first 20,000km. If individual fiber type head gaskets were used.

NOTE: The one piece steel type head gasket does not require, the above mentioned, retorque procedure.

CYLINDER HEAD RE-TORQUE

Within the first 20,000 km after rebuild, retorque the head bolts as follows: (Fig. 24) Central bolts A-L: Without slackening the bolts, following alphabetical order tighten the bolts through an angle of 15°. Side bolts M1-M2: Without slackening, tighten M1 then M2 bolts through an angle of 15°.

VIBRATION DAMPER

REMOVAL

(1) Disconnect the battery cable.

(2) Remove fan and set fan inside fan shroud then remove fan shroud and fan as an assembly.

(3) Remove accessary drive belt, (refer to Group 7, Cooling).

(4) Remove vibration damper nut.

(5) Install tool VM-1000-2 to remove vibration damper (Fig. 26).

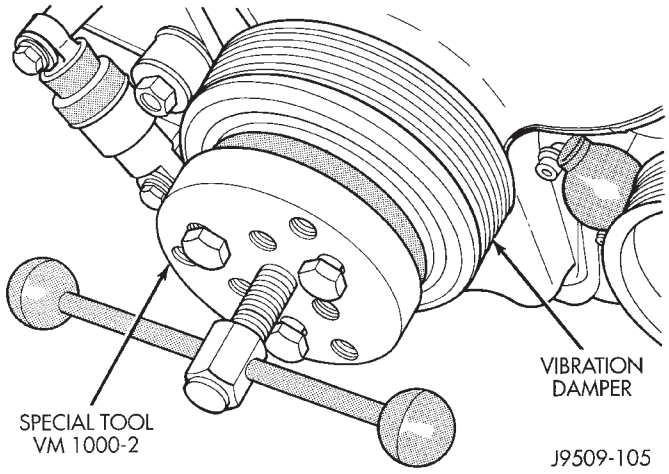

Fig. 26 Vibration Damper Removal With Tool VM-1000-2

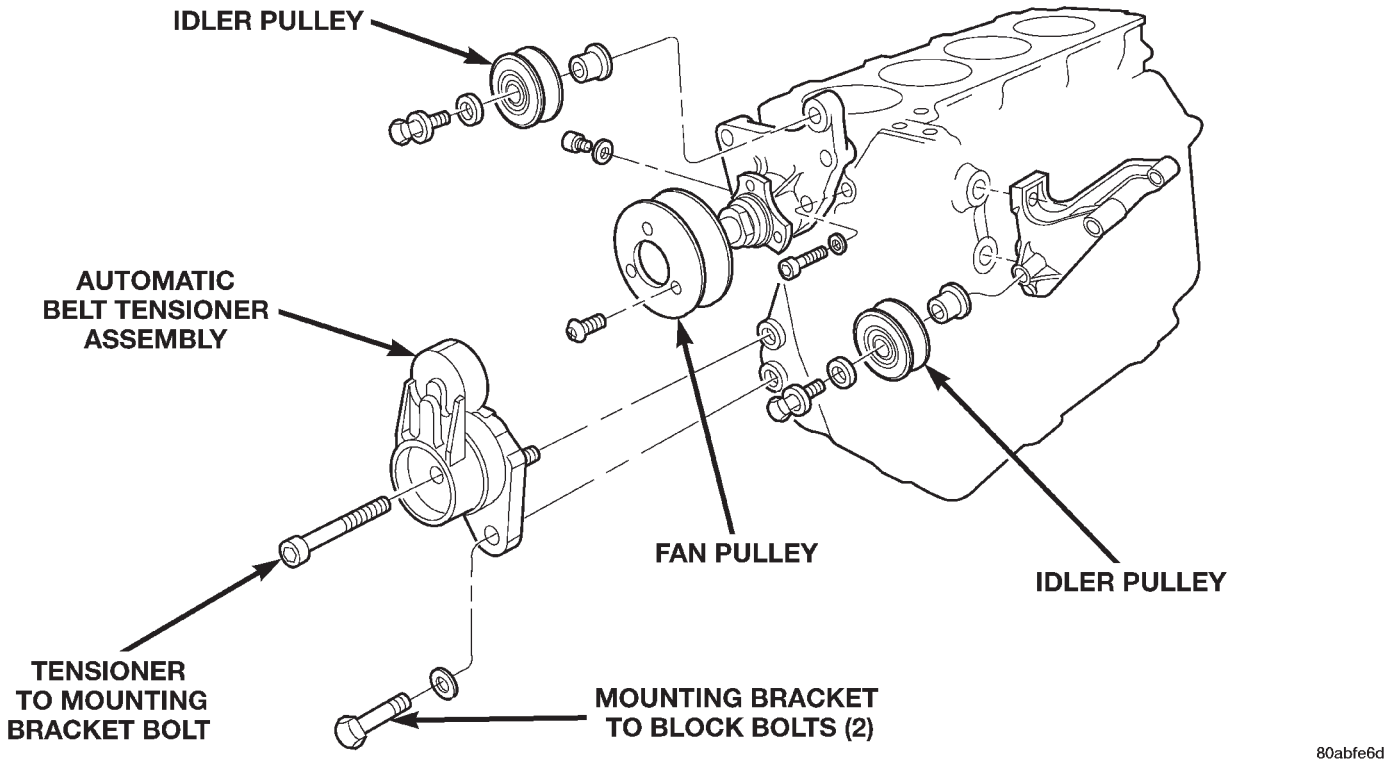

Fig. 25 Accessary Drive System

REMOVAL AND INSTALLATION (Continued)

INSTALLATION

(1) Install vibration damper and align with key way.

(2) Install vibration damper nut and tighten to 160 N·m (118 ft. lbs.).

(3) Install accessary drive belt (refer to Group 7, Cooling).

(4) Connect the battery cable.

TIMING CASE COVER OIL SEAL

REMOVAL

(1) Disconnect the battery cable.

(2) Remove vibration damper (refer to vibration damper removal in this section).

(3) Pry out seal.

INSTALLATION

Remove the oil seal ring. The seating diameter must be 68.000 - 68.030 mm.

(1) Install new seal using special tool VM-1015.

(2) Install vibration damper (refer to vibration damper installation in this section).

(3) Connect the battery cable.

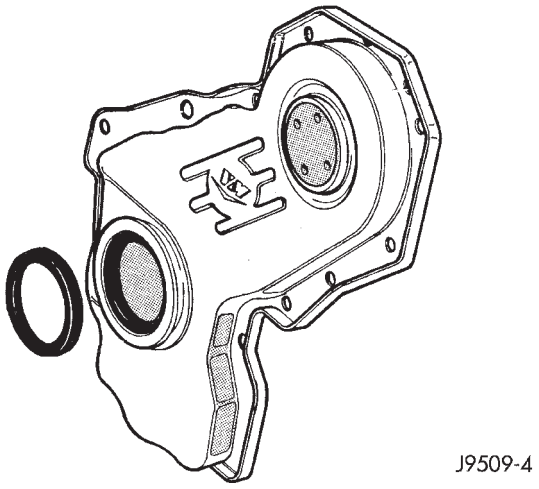

Fig. 27 Front Cover Seal

TIMING CASE COVER

REMOVAL

(1) Disconnect the battery cable.

(2) Remove fan and set fan inside fan shroud then remove fan shroud and fan as an assembly.

(3) Remove accessary drive belt, (refer to Group 7, Cooling).

(4) Remove vibration damper nut.

(5) Install tool VM-1000-2 to remove vibration damper.

(6) Remove fan pulley.

(7) Remove idler pulley and bracket. Idler pulley bolt have left hand threads.

(8) Remove the automatic belt tensioner.

(9) Disconnect the oil drain back hose from external vacuum pump to timing cover.

(10) Remove Power steering pulley.

(11) Remove cover.

INSTALLATION

(1) Be sure mating surfaces of chain case cover and cylinder block are clean and free from burrs.

(2) Apply a continuous 3 mm bead of Silicone Sealer (Fig. 28) to timing cover, install within 10 minutes, tighten 6mm bolts to 10.3 N·m (91 in. lbs) and tighten 8mm bolts to 26.2 N·m (19 ft. lbs.).

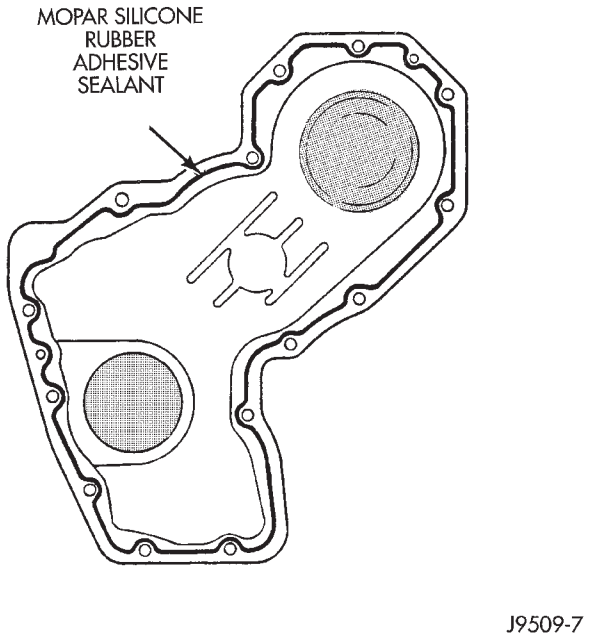

Fig. 28 Front Cover Sealer Location

(3) Install Power steering pulley, tighten to 130 N·m (96 ft. lbs.).

(4) Connect oil drain to cover.

(5) Install automatic belt tensioner.

(6) Install idler pulley bracket, tighten bolts to 40 N·m (29 ft. lbs.).

(7) Install idler pulley, bolt has left hand thread, tighten to 65 N·m (48 ft. lbs.).

(8) Install fan pulley, tighten bolts to 56 N·m (41 ft. lbs.).

(9) Install vibration damper align with keyway.

(10) Tighten vibration damper nut to 160 N·m (118 ft. lbs.).

(11) Install accessary drive belt (refer to Group 7, cooling for procedure).

(12) Install fan and fan shroud (refer to Group 7, Cooling for procedure).

(13) Connect battery cable.

REMOVAL AND INSTALLATION (Continued)

CAMSHAFT

REMOVAL

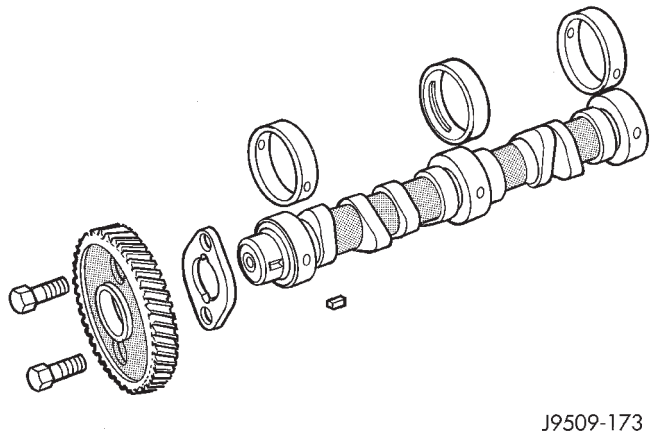

Fig. 29 Camshaft Assembly

(1) Disconnect the battery cable.
(2) Remove valve cover, refer to valve cover removal in this section.
(3) Remove cylinder head (refer to cylinder head removal in this section).
(4) Remove rocker arms, push rods, and hydraulic tappets, refer to the respective groups in this section.
(5) Remove fan and set fan inside fan shroud then remove fan shroud and fan as an assembly.
(6) Remove accessary drive belt.
(7) Remove radiator (refer to Group 7, Cooling).
(8) Remove A/C condenser (refer to Group 24, Heating and Air Conditioning).
(9) Remove vibration damper, refer to vibration damper removal in this section.
(10) Remove power steering pulley.
(11) Remove timing case cover, refer to timing case cover removal in this section.
(12) Unscrew flange bolts and remove camshaft (Fig. 30).

THRUST PLATE INSPECTION

Check the thickness (Fig. 31) of the plate at points a-b-c-d. If the measurement is not between 3.950 - 4.050 it must be changed.

INSTALLATION

(1) Coat the camshaft journals with clean engine oil and carefully install the camshaft complete with thrust plate and gear. Tighten retaining bolts to 24 N·m (18 ft. lbs.) torque. Be sure to align the timing marks as shown (Fig. 32).
(2) Install hydraulic tappets and retaining yokes.
(3) Install cylinder heads (refer to cylinder heads in this section).

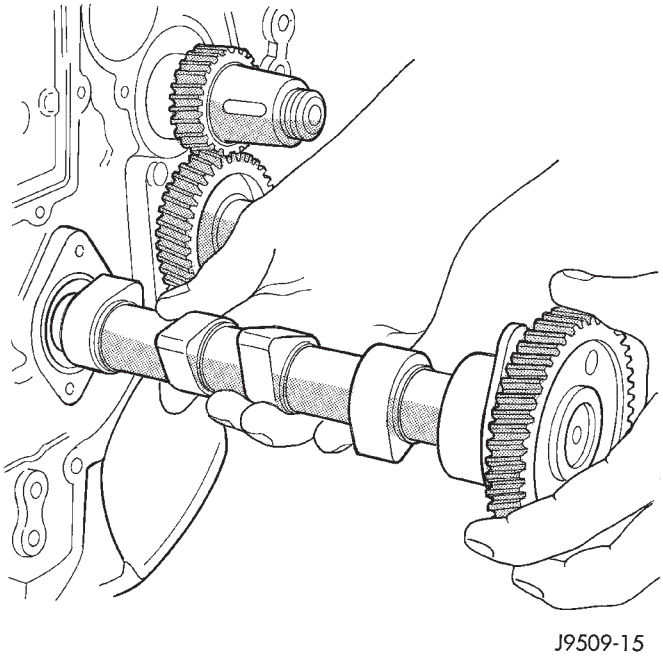

Fig. 30 Camshaft Removal

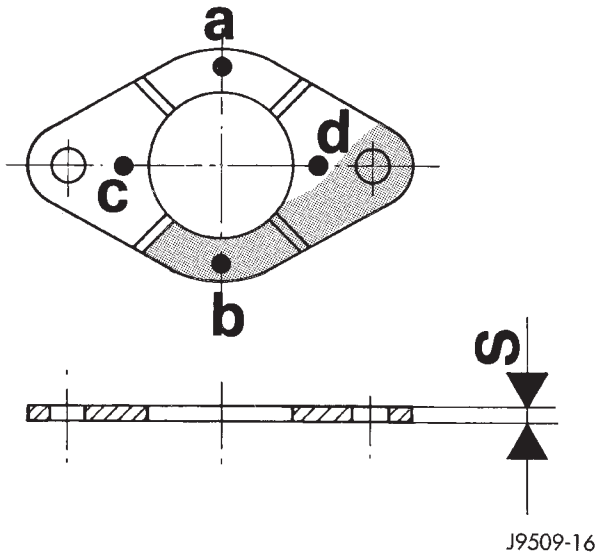

Fig. 31 Camshaft Thrust Plate

(4) Push rods, and rocker arm assemblies, refer to the respective sections.
(5) Install valve cover (refer to valve cover installation in this section).
(6) Install Timing case cover (refer to the timing case cover installation in this section).
(7) Install Vibration damper (refer to the vibration installation in this section).
(8) Install the A/C condenser (refer to Group 24, Heating and Air Conditioning).

REMOVAL AND INSTALLATION (Continued)

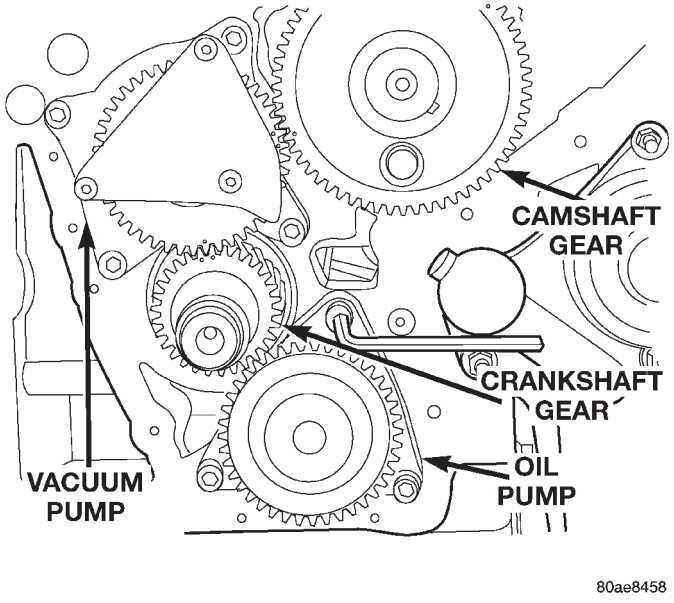

Fig. 32 Timing Marks

(9) Install radiator (refer to group 7, Cooling).

(10) Install fan and fan shroud, tighten fan to 56 N·m (41 ft. lbs.).

(11) If equipped, evacuate and charge the air conditioning system (refer to Group 24, Heater and Air Conditioning).

(12) Fill the cooling system. Check for leaks.

WARNING: USE EXTREME CAUTION WHEN THE ENGINE IS OPERATING. DO NOT STAND IN DIRECT LINE WITH THE FAN. DO NOT PUT HANDS NEAR THE PULLEYS, BELTS OR FAN. DO NOT WEAR LOOSE CLOTHING.

(13) Operate the engine with the radiator cap off. Inspect for leaks and continue operating the engine until the thermostat opens. Add coolant, if required.

CAMSHAFT BEARINGS

This procedure requires that the engine is removed from the vehicle.

REMOVAL

(1) With engine completely disassembled, remove camshaft rear plate and o-ring.

(2) Install proper size adapters and horseshoe washers (part of Camshaft Bearing Remover/Installer Tool) at back of each bearing shell. Drive out bearing shells.

INSTALLATION

(1) Install new camshaft bearings with Camshaft Bearing Remover/Installer Tool by sliding the new camshaft bearing shell over proper adapter.

(2) Position rear bearing in the tool. Install horseshoe lock and by reversing removal procedure, carefully drive bearing shell into place.

(3) Install remaining bearings in the same manner. Bearings must be carefully aligned to bring oil holes into full register with oil passages from the main bearing. If the camshaft bearing shell oil holes are not in exact alignment, remove and install them correctly. Install a new rear plate o-ring at the rear of camshaft. **Be sure this seal does not leak.**

OIL PAN

REMOVAL

(1) Disconnect battery cable.

(2) Raise vehicle on hoist.

(3) Drain oil.

(4) Remove oil pan lower bolts on sump.

(5) Remove bolts from lower oil pan. Remove the 4 bolts that are on the inside of the oil pan.

(6) Remove oil pan.

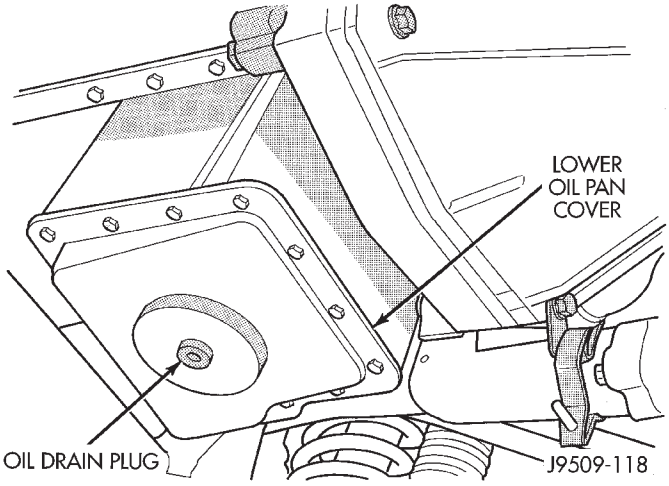

Fig. 33 Oil Pan

INSTALLATION

(1) Remove all gasket material from cylinder block. Be careful not gouge or scratch aluminum pan sealing surface.

(2) Install oil pan. Apply a continuous 3 mm bead of Silicone Sealer to oil pan, install within 10 minutes.

(3) Install inside oil pan bolts and torque bolts to 11 N·m (8 ft. lbs.).

(4) Install lower oil pan bolts and torque to 11 N·m (8 ft. lbs.).

(5) Install oil drain plug tighten to 79 N·m (58 ft. lbs).

(6) Lower vehicle.

(7) Fill engine with proper amount of oil.

(8) Connect battery cable.

REMOVAL AND INSTALLATION (Continued)

OIL PUMP

REMOVAL

(1) Remove front cover, (refer to front cover removal in this section).

(2) Remove oil pump (Fig. 34).

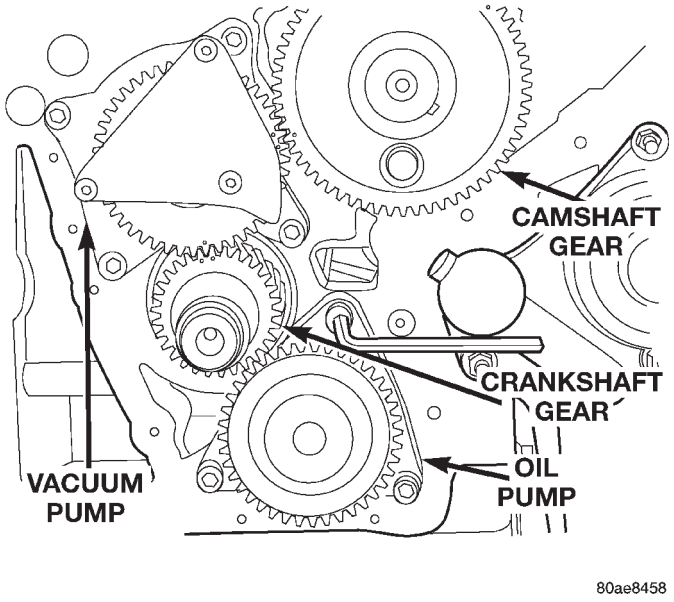

Fig. 34 Oil Pump Removal

INSTALLATION

(1) Install new O-ring and lubricate with clean engine oil.

(2) Install oil pump and tighten retaining screws to 24.5-29.9 N·m (22.7-28.3 ft. lbs.). Check for normal backlash between pump and crankshaft gears.

(3) Install front cover, refer to front cover installation in this section.

INTERNAL VACUUM PUMP

REMOVAL

(1) Remove the front cover refer to front cover removal in this section.

(2) Remove 4 bolts.

(3) Remove internal vacuum pump. Vacuum gear has a spring-loaded friction wheel which eliminates backlash and thus reduces running noise. This braces the two wheels against one another and offsets the teeth so that the backlash is eliminated between the meshing gears.

INSTALLATION

(1) To install the vacuum pump, align the outer part of the gear with the inner part using a screwdriver or similar tool, align with timing marks on gear set and install.

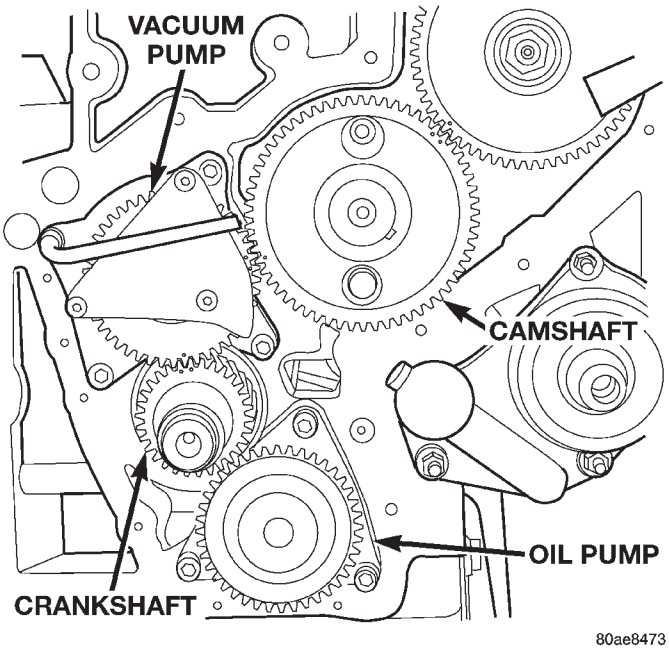

Fig. 35 Vacuum Pump

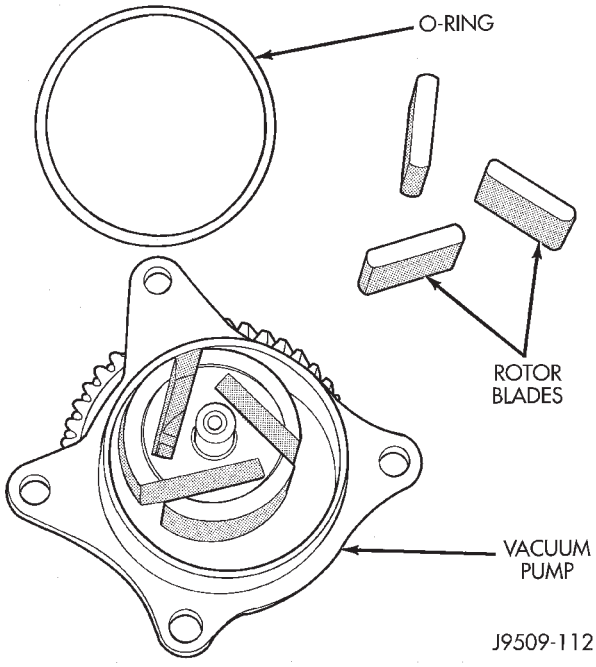

Fig. 36 Vacuum Pump Parts

(2) Install bolts and tighten to 20 N·m (15 ft. lbs.).

(3) Install front cover.

OIL PUMP PRESSURE RELIEF VALVE

REMOVAL

(1) Remove oil pan.

(2) Remove clip retaining relief valve.

(3) Remove relief valve cap, spring, and plunger (Fig. 39).

REMOVAL AND INSTALLATION (Continued)

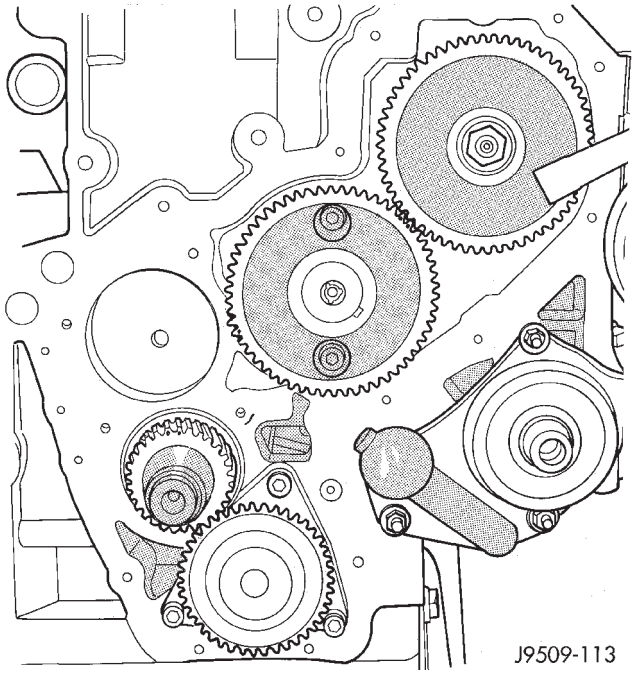

Fig. 37 Vacuum Pump Mounting Hole

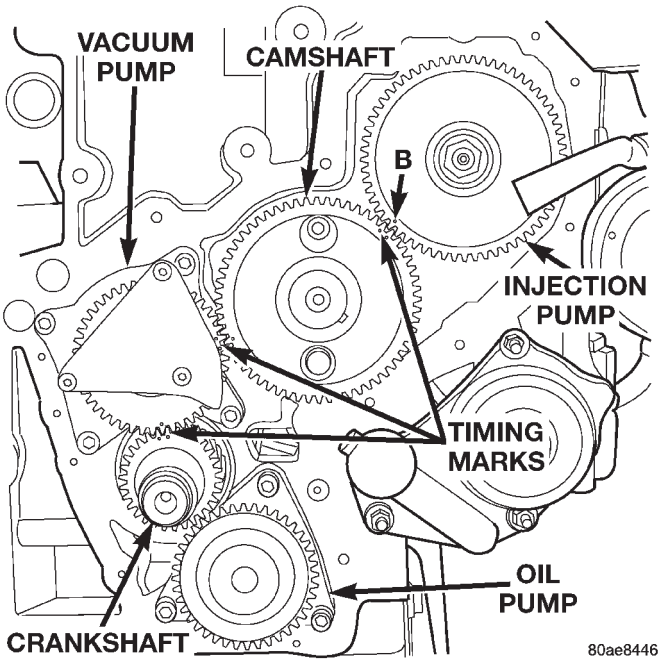

Fig. 38 Timing Marks

(4) Check relief valve spring length. Relief valve spring free length is 57.5mm (2.263 in.). If spring length is less or spring is distorted it must be replaced.

(5) Check plunger for scoring, replace if necessary.

INSTALLATION

(1) Thoroughly clean all components and relief valve pocket in cylinder block.

(2) Fit plunger, spring and cap into block.

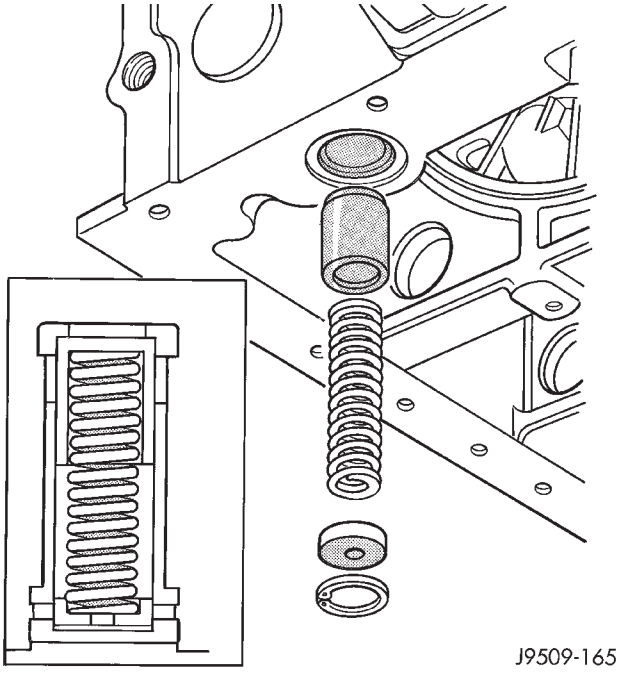

Fig. 39 Oil Pressure Relief Valve

(3) Compress spring and install retaining clip. Ensure clip is completely seated in groove.

OIL FILTER ADAPTER

REMOVAL

(1) Remove oil filter.

(2) Remove oil filter adapter with socket wrench.

(3) Remove oil filter base, allen bolt in center of adapter.

(4) Remove oil cooler adapter bolt.

(5) Remove oil cooler (Fig. 40).

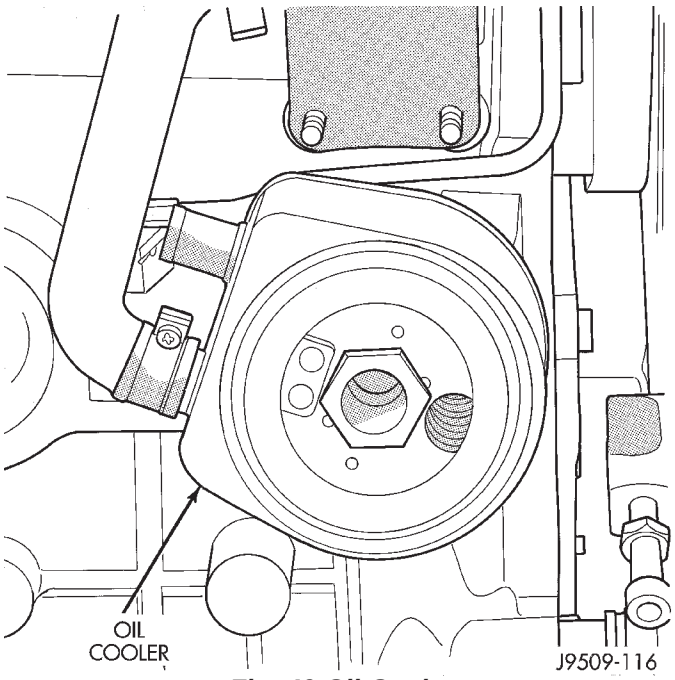

Fig. 40 Oil Cooler

REMOVAL AND INSTALLATION (Continued)

INSTALLATION

(1) Install oil cooler with new gasket, tighten oil cooler adapter bolt to 60 N·m (44 ft. lbs.).

(2) Install oil filter base with new o-ring and tighten bolt to 46.6 N·m (34 ft. lbs.).

(3) Install oil filter adapter to oil filter base and tighten to 46.6 N·m (34 ft. lbs.).

(4) Install oil filter and tighten to 18 N·m (13 ft. lbs.) and add oil.

PISTONS AND CONNECTING ROD ASSEMBLY

REMOVAL

(1) Disconnect the battery cable.

(2) Remove cylinder heads, refer to cylinder head removal in this section.

(3) Raise vehicle on host.

(4) Remove oil pan, refer to oil pan removal in this section.

(5) Remove top ridge of cylinder bores with a reliable ridge reamer before removing pistons from cylinder block. **Be sure to keep tops of pistons covered during this operation** . Mark piston with matching cylinder number.

(6) Pistons and connecting rods must be removed from top of cylinder block. Rotate crankshaft so that each connecting rod is centered in cylinder bore.

(7) Remove connecting rod cap. Install connecting rod bolt protectors on connecting rod bolts. Push each piston and rod assembly out of cylinder bore.

NOTE: Be careful not to nick crankshaft journals.

(8) After removal, install bearing cap on the mating rod.

PISTON PIN—REMOVAL

(1) Secure connecting rod in a soft jawed vice.

(2) Remove 2 clips securing piston pin.

(3) Push piston pin out of piston and connecting rod.

PISTON RING—REMOVAL

(1) ID mark on face of upper and intermediate piston rings must point toward piston crown.

(2) Using a suitable ring expander, remove upper and intermediate piston rings (Fig. 42).

(3) Remove the upper oil ring side rail, lower oil ring side rail and then oil ring expander from piston.

(4) Carefully clean carbon from piston crowns, skirts and ring grooves ensuring the 4 oil holes in the oil control ring groove are clear.

PISTON RING FITTING

(1) Wipe cylinder bore clean. Insert ring and push down with piston to ensure it is square in bore. The ring gap measurement must be made with the ring positioning at least 12 mm (0.50 in.) from bottom of cylinder bore. Check gap with feeler gauge. Top compression ring gap .25 to .50mm (.0098 to .0196 in.). Second compression ring gap .25 to .35mm (.0098 to .0137 in.). Oil control ring gap .25 to .58mm (.0098 to .0228 in.).

(2) If ring gaps exceed dimension given, new rings or cylinder liners must be fitted. Keep piston rings in piston sets.

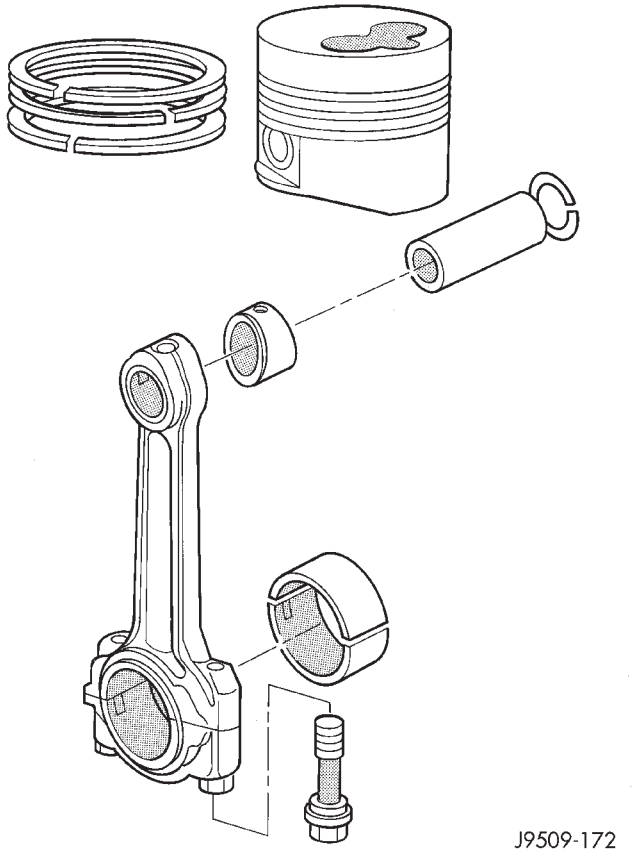

Fig. 41 Piston Assembly

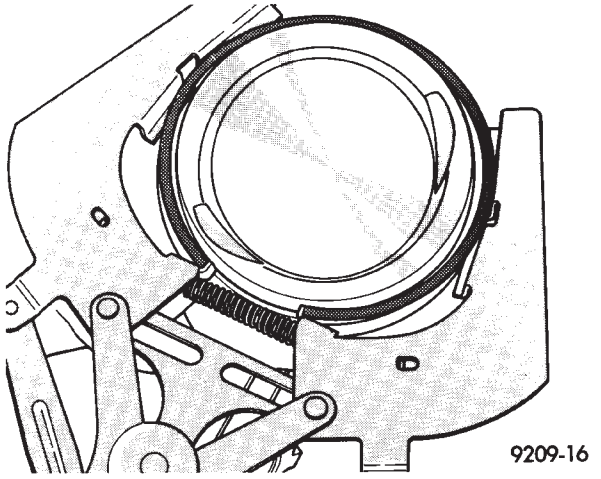

Fig. 42 Piston Rings—Removing and Installing

REMOVAL AND INSTALLATION (Continued)

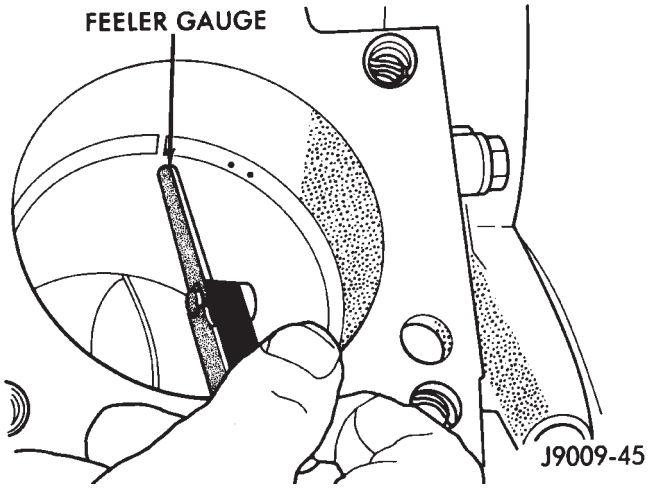

Fig. 43 Ring Gap Measurement

(3) Check piston ring to groove clearance. Top compression ring gap .08 to .130mm (.0031 to .0051 in.). Second compression ring gap .070 to .102mm (.0027 to .0040 in.). Oil control ring gap .040 to .072mm (.0015 to .0028 in.).

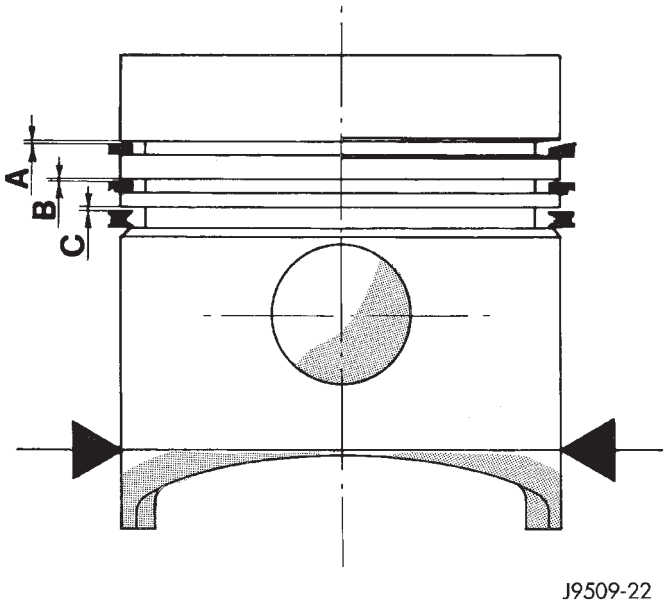

Fig. 44 Piston Ring Side Clearance

PISTON RINGS—INSTALLATION

(1) Install rings on the pistons using a suitable ring expander (Fig. 45).

(2) Top compression ring is tapered and chromium plated. The second ring is of the scraper type and must be installed with scraping edge facing bottom of the piston. The third is an oil control ring. Ring gaps must be positioned, before inserting piston into the liners, as follows (Fig. 47).

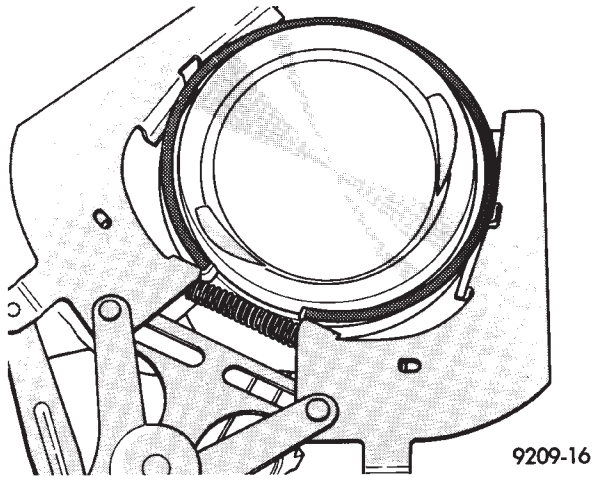

Fig. 45 Piston Rings—Removing and Installing

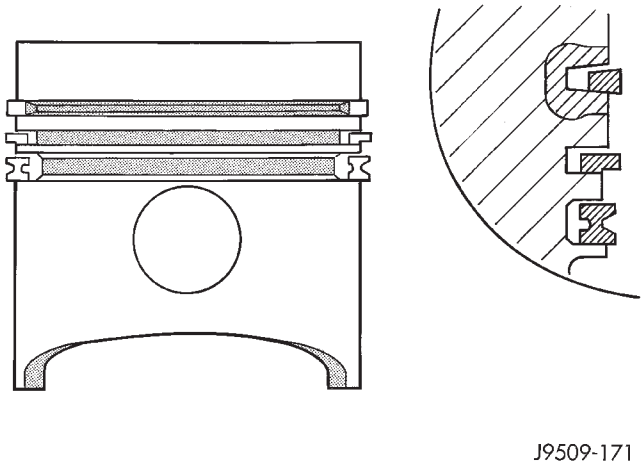

Fig. 46 Piston Ring Identification

(3) Top ring gap must be positioned at 30 degrees to the right of the combustion chamber recess (looking at the piston crown from above).

(4) Second piston ring gap should be positioned on the opposite side of the combustion chamber recess.

(5) Oil control ring gap to be located 30 degrees to the left of combustion chamber recess.

(6) When assembling pistons check that components are installed in the same position as before disassembly, determined by the numbers stamped on the crown of individual pistons. Engine cylinders are numbered starting from gear train end of the engine. **Face chamber recess side of piston towards camshaft** . Therefore, the numbers stamped on con rod big end should also face in the same direction. To insert piston into cylinder use a ring compressor as shown in (Fig. 45).

PISTON PIN INSTALLATION

(1) Secure connecting rod in soft jawed vice.

(2) Lubricate piston pin and piston with clean oil.

(3) Position piston on connecting rod.

REMOVAL AND INSTALLATION (Continued)

CAUTION: Ensure combustion recess in piston crown and the bearing cap numbers on the connecting rod are on the same side.

(4) Install piston pin.
(5) Install clips in piston to retain piston pin.
(6) Remove connecting rod from vice.

INSTALLATION

(1) Before installing pistons, and connecting rod assemblies into the bore, be sure that compression ring gaps are staggered so that neither is in line with oil ring rail gap (Fig. 47).

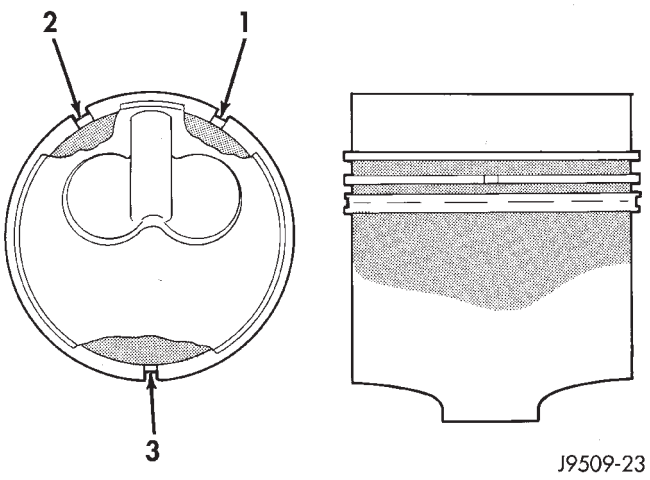

Fig. 47 Piston Ring Gap Location

(2) Before installing the ring compressor, make sure the oil ring expander ends are butted and the rail gaps located as shown in (Fig. 47).

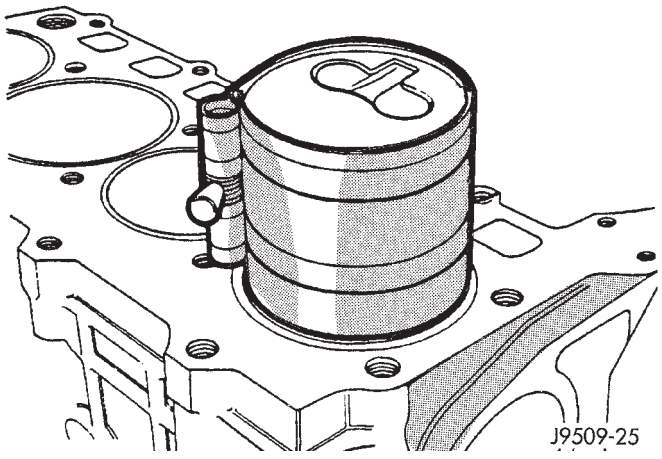

Fig. 48 Installing Piston

(3) Immerse the piston head and rings in clean engine oil, slide the ring compressor, over the piston and tighten with the special wrench (Fig. 48). **Ensure position of rings does not change during this operation**.

(4) Face chamber recess side of piston towards camshaft.
(5) Install connecting rod bolt protectors on rod bolts.
(6) Rotate crankshaft so that the connecting rod journal is on the center of the cylinder bore. Insert rod and piston into cylinder bore and guide rod over the crankshaft journal.
(7) Tap the piston down in cylinder bore, using a hammer handle. At the same time, guide connecting rod into position on connecting rod journal.
(8) Install rod caps. Install nuts on cleaned and oiled rod bolts and tighten nuts to 29.5 N·m (22 ft. lb.) plus 60°.

CYLINDER WALL LINER ASSEMBLY

REMOVAL

(1) Remove cylinder heads.
(2) Remove Oil pan.
(3) Remove pistons.
(4) Use tool VM-1001 to remove liners (Fig. 49).

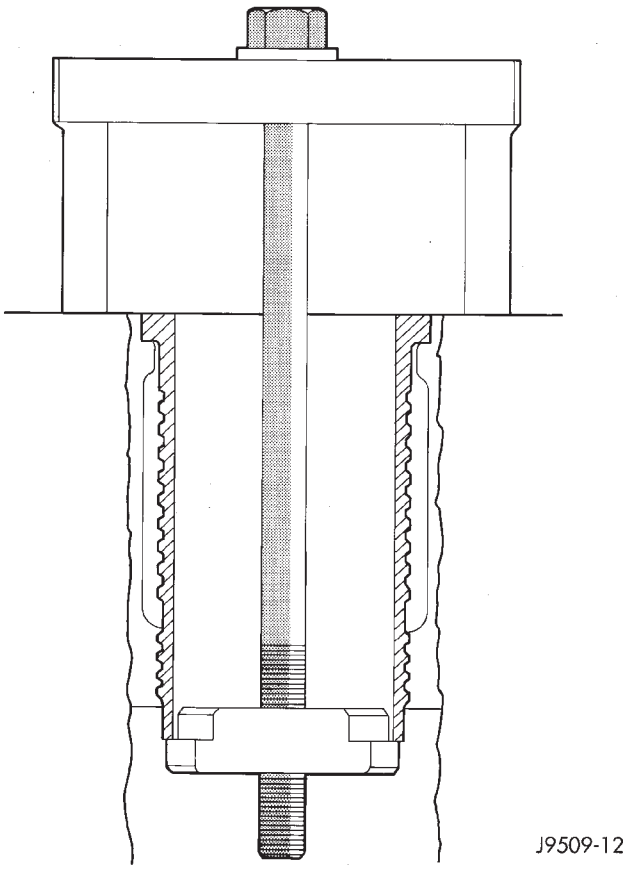

Fig. 49 Liner Removal Tool

(5) Remove shims from cylinder liner or cylinder block recess. Keep shims with each cylinder liner.

REMOVAL AND INSTALLATION (Continued)

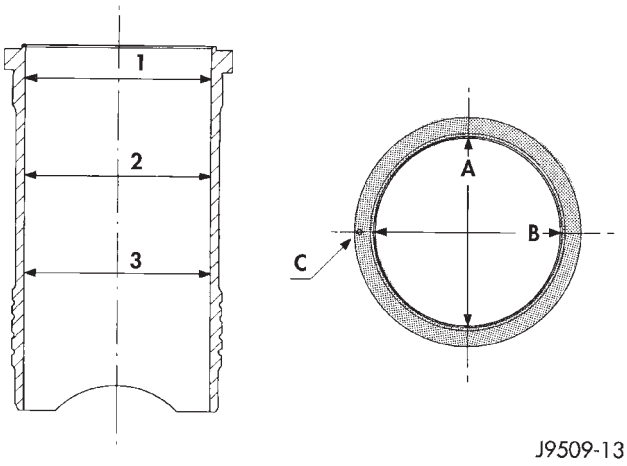

Fig. 50 Liner Inspection

INSTALLATION

(1) Carefully clean residual LOCTITE from liner and crankcase, and degrease the crankcase where it comes into contact with the liners. Install the liners in the crankcase as shown (A), rotating them back and forth by 45° in order to guarantee correct positioning (Fig. 51).

(2) Measure the liner recess relative to block deck with a dial indicator mounted on a special tool VM-1010 A. **All the measurements must be taken on camshaft side** . Zero dial gauge on block deck.

(3) Move dial gauge to cylinder liner record reading on dial gauge.

(4) Remove liner and special tool.

(5) Then select the correct shim thickness to give proper protrusion (0.01 - 0.06 mm).

(6) Fit the shim and the O-rings onto the liner.

(7) Lubricate the lower liner location in the block. Apply LOCTITE AVX to the corner of the liner seat. Apply LOCTITE AVX uniformly to the upper part of the liner at area.

(8) Fit the liners in the crankcase making sure that the shim is positioned correctly in the seat. Lock

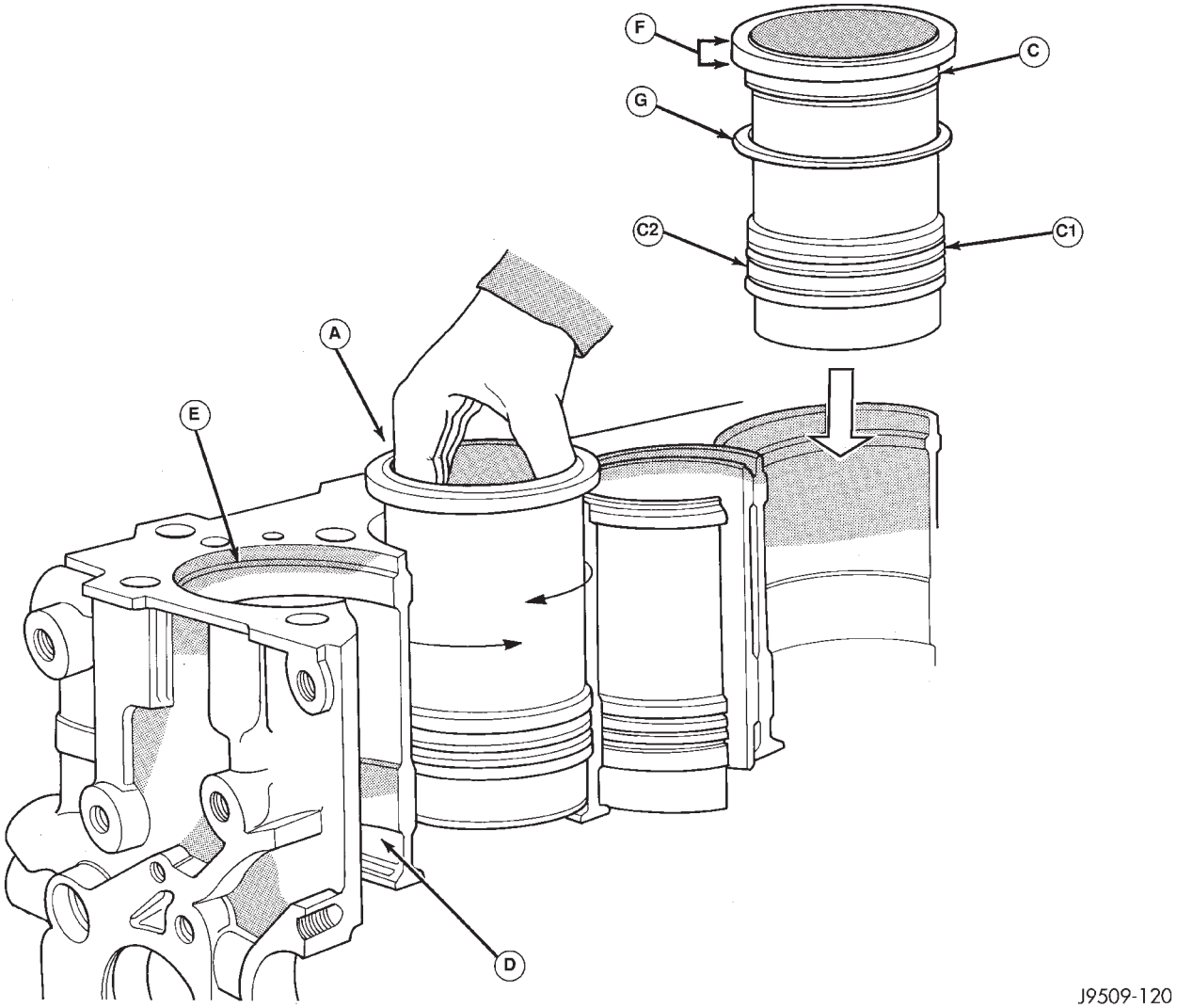

Fig. 51 Liner Installation

REMOVAL AND INSTALLATION (Continued)

the liners in position using special tool (VM-1016) and bolts (Fig. 52). Clean the residual LOCTITE on the upper surface of the block deck.

(9) Recheck the liner protrusion. It should be 0.01 - 0.06 mm.

NOTE: A period of six hours must elapse between the liners being installed and engine start-up. If engine assembly is not continued after liner installation, the liners need to be clamped for twelve hours minimum.

CRANKSHAFT MAIN BEARINGS

REMOVAL

(1) Disconnect battery cable.

(2) Remove engine from vehicle, refer to engine removal in this section.

(3) Install engine to engine stand.

(4) Remove accessary drive system.

(5) Remove cylinder head cover, refer to cylinder head cover removal in this section.

(6) Remove rocker arm and push rods, refer to rocker arm and push rod section in this section.

(7) Remove intake, exhaust manifold and turbocharger, refer to Group 11, Exhaust System and Intake Manifold.

(8) Remove water manifold.

(9) Remove oil feed lines to rocker arms.

(10) Remove cylinder heads.

(11) Remove oil pan and oil pick-up.

(12) Remove piston and connecting rods from crankshaft journals.

(13) Remove pistons and connecting rods from block.

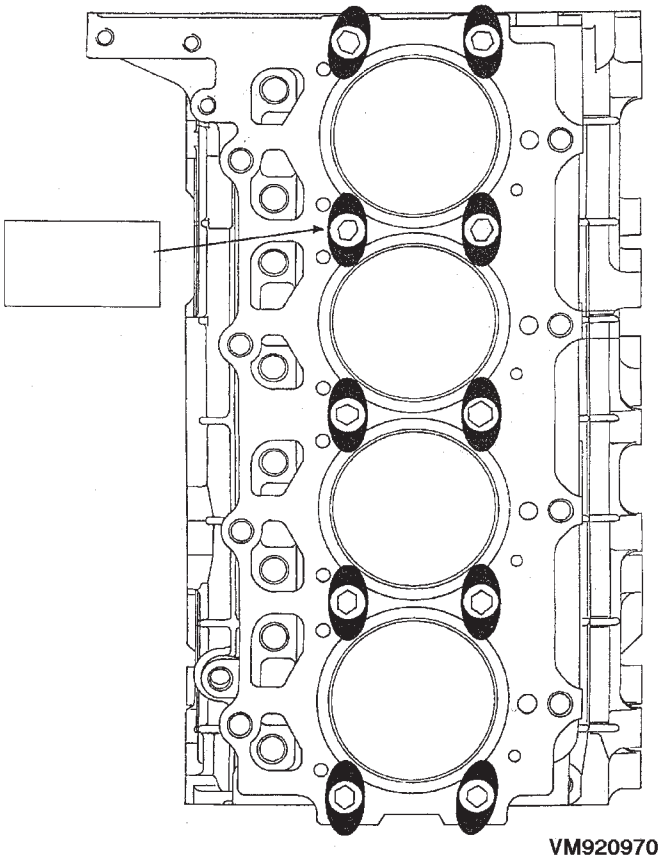

Fig. 52 Liner Clamp Location

(14) Remove vibration damper, refer to vibration damper removal in this section.

(15) Remove front cover, refer to front cover removal in this section.

(16) Remove oil pump and vacuum pump from block.

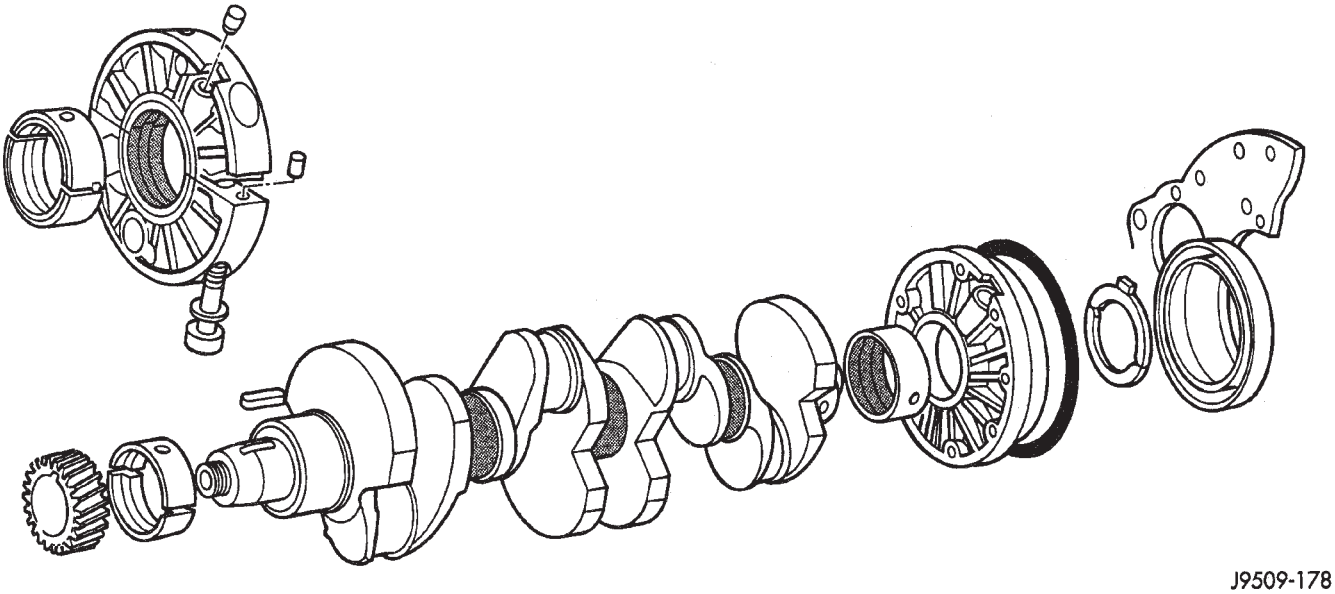

Fig. 53 Crankshaft and Bearing Assembly

REMOVAL AND INSTALLATION (Continued)

(17) Install special tool VM-1004 onto crankshaft over gear (Fig. 54).

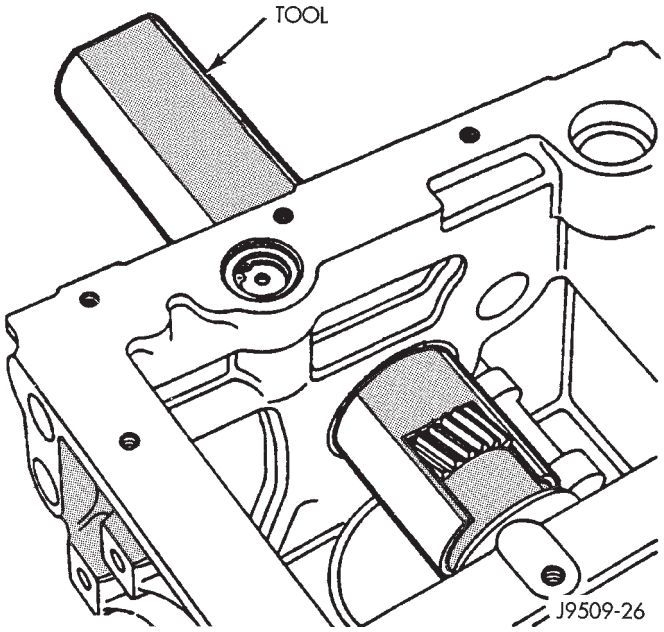

Fig. 54 Crankshaft Special Tool VM-1004

(18) Remove main bearing oil feed and carrier locators from block.

(19) Remove flywheel and adaptor plate from engine block.

(20) Remove thrust bearings from rear main bearing carrier.

(21) Slide crankshaft and bearing carriers rearward to rear of block. If you encounter difficulty in removing the complete assembly as previously described, slide the assembly rearward sufficiently to gain access to the main bearing carrier bolts. Mark the carriers for assembly and remove the bolts, two for each carrier (Fig. 55).

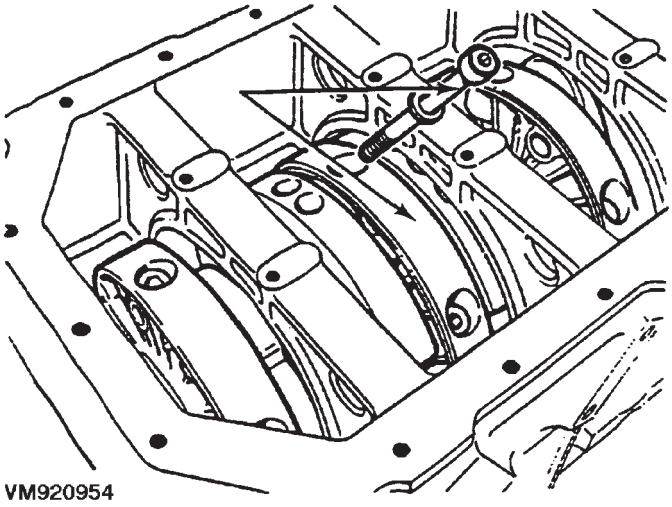

Fig. 55 Carrier Bolts

(22) Separate the two halves of each carrier, remove from the crankshaft and temporarily re-assemble the carriers (Fig. 56). Withdraw the crankshaft through the rear of the crankcase.

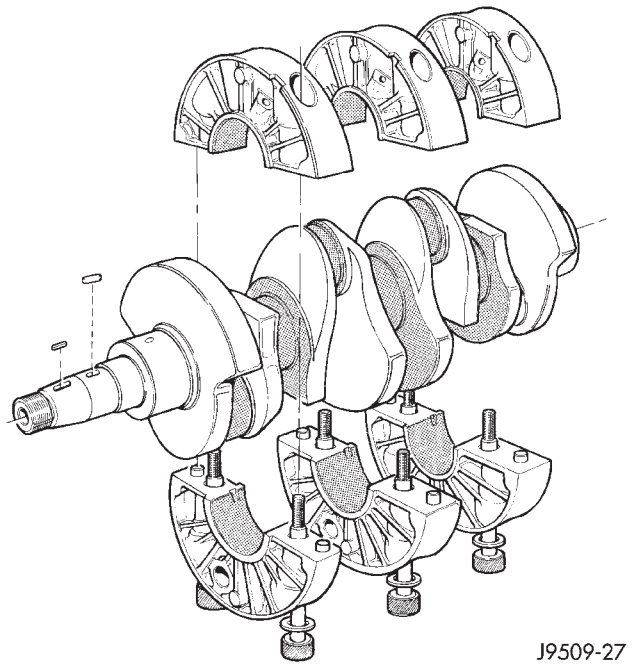

Fig. 56 Crankshaft and Carrier Bearing Assembly

INSTALLATION

(1) Fit main bearing carriers together and torque to 42 N·m (31 ft. lbs.).

(2) Check internal diameter of bearings.

(3) If internal diameter of original bearing is being checked and figures are not within specifications, new bearings must be used.

(4) Check crankshaft main bearing journals to bearing clearances. Clearances of main bearings is .03 to .088mm (.0011 to .0035 in.).

NOTE: Assemble engine according to sequence described, thus saving time and preventing damages to engine components. Clean parts with a suitable solvent and dry them with compressed air before assembly. Use new gaskets where applicable and torque wrenches for correct tightening of components.

(5) Thoroughly clean crankcase and oil passages, and blow dry with compressed air.

(6) Install new main bearing shells in each of the carrier halves. Assemble the carriers to the crankshaft journals, ensuring that the carriers are installed in their original locations and that the **piston jet notch is towards the front of the crankshaft** . Secure each carrier with the two bolts tightening evenly to 42 N·m (31 ft. lbs.). Check that the oil jet is in position (Fig. 56).

REMOVAL AND INSTALLATION (Continued)

(7) Slide special tool (VM-1002) over the crankshaft gear and, insert the crankshaft and carrier assembly into the crankcase in the same manner used for removal.

(8) Align the holes in the lower carriers, with the center of the crankcase webs (Fig. 57).

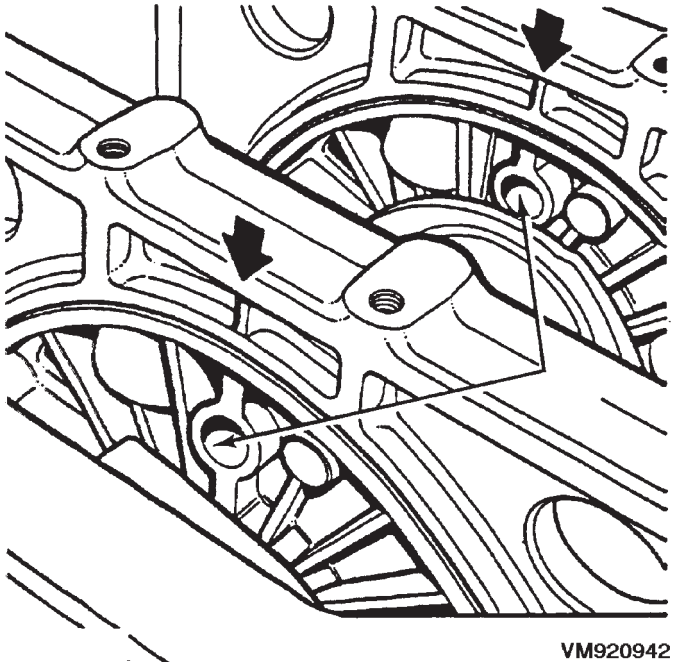

Fig. 57 Main Bearing Carrier Alignment

(9) Secure each carrier assembly to the crankcase with the main bearing oil feed and carrier locators and tighten them to 54 N·m (40 ft. lbs).

(10) Install rear main bearing carrier onto crankshaft ensuring arrow on bearing carrier aligns with vertical web in center of crankcase.

(11) Install rear oil seal.

(12) Install new O-rings in adaptor plate.

(13) Install adaptor plate to block and tighten nuts to 26.5 N·m (20 ft. lbs.).

(14) Install Allen bolts through adaptor plate to rear main bearing carrier and tighten to 11 N·m (97 in. lbs.).

(15) Position flywheel and O-ring on crankshaft and align bolt holes.

NOTE: For purposes of checking crankshaft end play, used flywheel bolts may be used. Final assembly requires new flywheel bolts.

(16) Install 2 flywheel bolts, 180° apart, and tighten bolts to 20 N·m plus 60° (15 ft. lbs.) plus 60°.

(17) Attach dial indicator to engine block.

(18) Move crankshaft toward front of engine and zero indicator.

(19) Move crankshaft toward the rear of engine and record measurement.

(20) Subtract specified crankshaft end play from figure obtained. Crankshaft end play .153 to .304mm (.0060 to .0119 in.).

(21) Select thrust washers which will give correct end play.

(22) Remove tools and flywheel.

(23) Lubricate thrust washer halves and fit them into the rear main bearing carrier.

(24) Ensure that crankshaft end and flywheel mating surfaces are clean and dry. Install ''O'' ring in flywheel groove.

(25) To verify correct end play, install 2 flywheel bolts 180° apart, and tighten bolts to 20 N·m plus 60° (15 ft. lbs. plus 60°).

(26) Measure crankshaft end play with a dial gauge. Crankshaft end play should not exceed .153 to .304mm (.0060 to .0119 in.) (Fig. 58).

(27) Mount flywheel on crankshaft. Lightly oil and install NEW bolts, tightening to 20 N·m in diametrically opposite pairs. Check that all bolts are at 20 N·m. Tighten each bolt a further 60° +0-5°, tightening bolts in diametral pairs. Check that all bolts are tightened to 130 N·m.

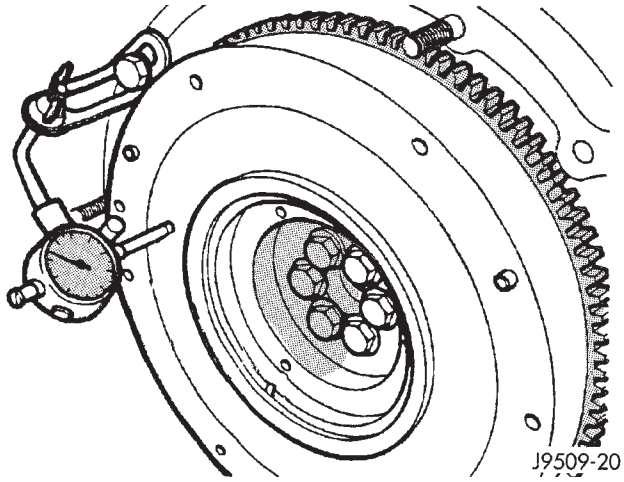

Fig. 58 Measuring Crankshaft End Play

(28) Install pistons and connecting rod assemblies, refer to piston and connecting rods in this section.

(29) Install oil pick up tube and tighten bolts to 25 N·m (18 ft. lbs.).

(30) Install oil pan, refer to oil pan installation in this section.

(31) Install vacuum pump, being careful to align the gear timing marks with those on the crankshaft gear. Tighten retaining screws to 20 N·m (15 ft. lbs.).

(32) Before installing oil pump check pump bore depth in block (A) and pump body height (B) (Fig. 59). Difference between A and B should be 0.020-0.082 mm (.0007 to 0032 in.).

(33) Install oil pump and tighten retaining screws to 27 N·M (20 ft.lbs.). Check for normal backlash between pump and crankshaft gears.

REMOVAL AND INSTALLATION (Continued)

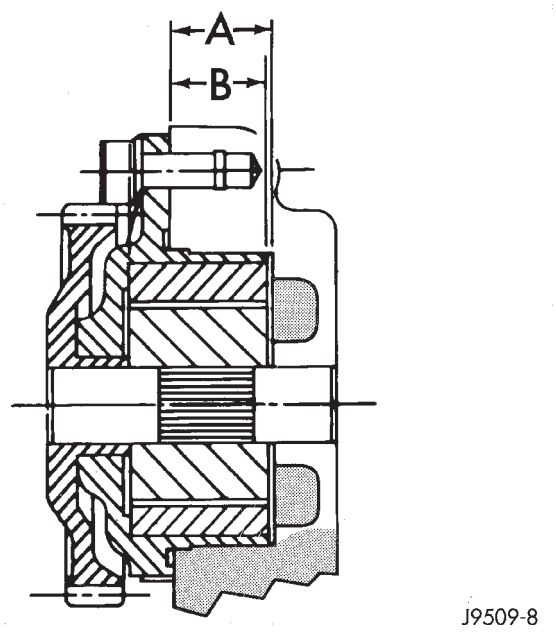

Fig. 59 Oil Pump Bore Depth

(34) Install front cover, refer to front cover installation in this section.

(35) Install vibration damper, refer to vibration damper installation in this section.

(36) Install cylinder heads, refer to cylinder head installation in this section.

(37) Install rocker arms and push rods, refer to rocker arm and push rod in this section.

(38) Install cylinder head cover, refer to cylinder head cover in this section.

(39) Install accessary drive system.

(40) Install engine in vehicle, refer to engine installation in this section.

(41) Fill engine with the correct amount of fluids specified.

(42) Connect battery cable.

DISASSEMBLY AND ASSEMBLY

HYDRAULIC TAPPETS

DISASSEMBLE

(1) Pry out plunger retainer spring clip.

(2) Clean varnish deposits from inside of tappet body above plunger cap.

(3) Invert tappet body and remove plunger cap, plunger, check valve, check valve spring, check valve retainer and plunger spring. Check valve could be flat or ball.

ASSEMBLE

(1) Clean all tappet parts in a solvent that will remove all varnish and carbon.

(2) Replace tappets that are unfit for further service with new assemblies.

(3) If plunger shows signs of scoring or wear, install a new tappet assembly. If valve is pitted, or valve seat on end of plunger is prevented from seating, install a new tappet assembly.

(4) Assemble tappets.

CLEANING AND INSPECTION

CYLINDER HEAD

CLEANING

Thoroughly clean the engine cylinder head and cylinder block mating surfaces. Clean the intake and exhaust manifold and engine cylinder head mating surfaces. Remove all gasket material and carbon.

Check to ensure that no coolant or foreign material has fallen into the tappet bore area.

Remove the carbon deposits from the combustion chambers and top of the pistons.

INSPECTION

Use a straightedge and feeler gauge to check the flatness of the engine cylinder head and block mating surfaces (Fig. 60).

Minimum cylinder head thickness 89.95mm (3.541 in.)

CAUTION: If only one cylinder head is found to be distorted and requires machining, it will also be necessary to machine the remaining cylinders heads and end plates by a corresponding amount to maintain correct cylinder alignment.

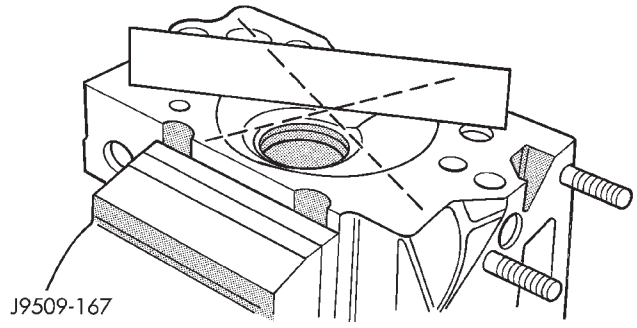

Fig. 60 Checking Cylinder Head Flatness

ROCKER ARMS AND PUSH RODS

CLEANING

Clean all the components (Fig. 61) with cleaning solvent.

Use compressed air to blow out the oil passages in the rocker arms and push rods.

CLEANING AND INSPECTION (Continued)

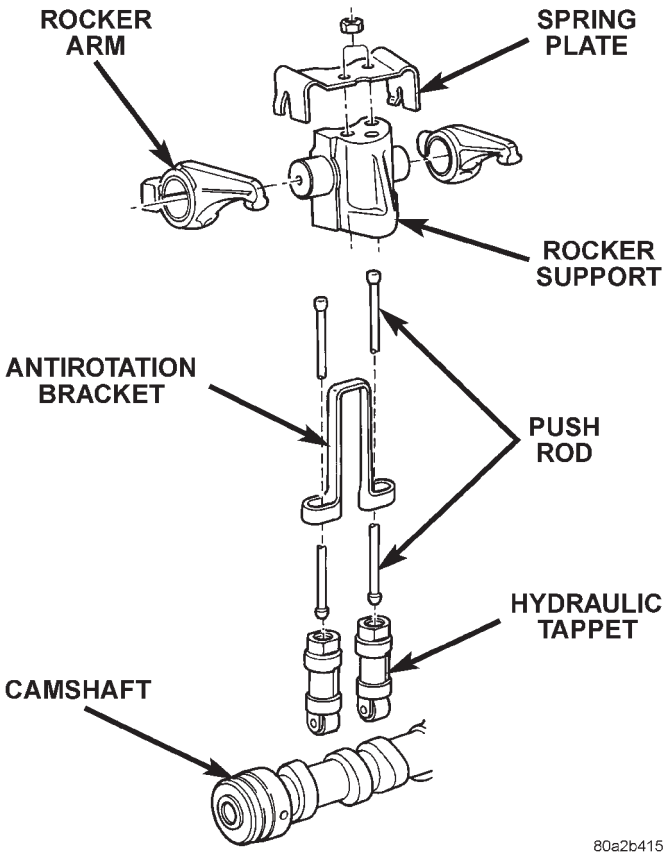

Fig. 61 Rocker Arm Components

INSPECTION

Inspect the pivot surface area of each rocker arm. Replace any that are scuffed, pitted, cracked or excessively worn.

Inspect the valve stem tip contact surface of each rocker arm and replace any rocker arm that is deeply pitted.

Inspect each push rod end for excessive wear and replace as required. If any push rod is excessively worn because of lack of oil, replace it and inspect the corresponding hydraulic tappet for excessive wear.

Inspect the push rods for straightness by rolling them on a flat surface or by shining a light between the push rod and the flat surface.

A wear pattern along the length of the push rod is not normal. Inspect the engine cylinder head for obstruction if this condition exists.

PISTONS AND CONNECTING ROD ASSEMBLY

INSPECTION—PISTONS

(1) Piston Diameter: Size Group A: 91.93-91.94mm (3.6191-3.6196 in.) Size Group B: 91.94-91.95mm (3.6196-3.6200 in.). Maximum wear limit .05mm (.0019 in.).

(2) Check piston pin bores in piston for roundness. Make 3 checks at 120° intervals. Maximum out of roundness .05mm (.0019in.).

(3) The piston diameter should be measured approximately 15 mm (.590 in.) up from the base.

(4) Skirt wear should not exceed 0.1 mm (.00039 in.).

(5) The clearance between the cylinder liner and piston should not exceed 0.25 mm (.0009 in.).

(6) Make sure the weight of the pistons does not differ by more than 5 g.

INSPECTION—CONNECTING ROD

(1) Assemble bearing shells and bearing caps to their respective connecting rods ensuring that the serrations on the cap and reference marks are aligned.

(2) Tighten bearing cap bolts to 29N·m (21 ft. lbs.) plus 60°.

(3) Check and record internal diameter of crank end of connecting rod.

NOTE: When changing connecting rods, all four must have the same weight and be stamped with the same number. Replacement connecting rods will only be supplied in sets of four.

Connecting rods are supplied in sets of four since they all must be of the same weight category. Max allowable weight difference is 18 gr.

NOTE: On one side of the big end of the con-rod there is a two-digit number which refers to the weight category. On the other side of the big end there is a four digit number on both the rod and the cap. These numbers must both face the camshaft as well as the recess on the piston crown (Fig. 63). Lightly heat the piston in oven. Insert piston pin in position and secure it with provided snap rings.

The Four digit numbers marked on con rod big end and rod cap must be on the same side as the camshaft (Fig. 63). After having coated threads with Molyguard, tighten con rod bolts to 29 N·m (21 ft. lbs.) plus 60°.

INSPECTION—PISTON PIN

(1) Measure the diameter of piston pin in the center and both ends.

(2) Piston pin diameter is 29.990 to 29.996mm (1.1807 to 1.1809 in.).

INSPECTION—CRANKSHAFT JOURNALS

(1) Using a micrometer, measure and record crankshaft connecting rod journals, take reading of each journal 120° apart. Crankshaft journal diameter is 53.84 to 53.955mm (2.1196 to 2.1242 in.).

CLEANING AND INSPECTION (Continued)

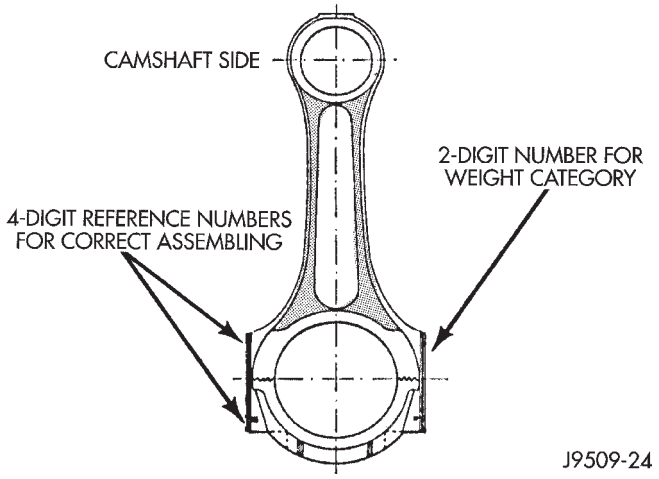

Fig. 62 Connecting Rod Identification

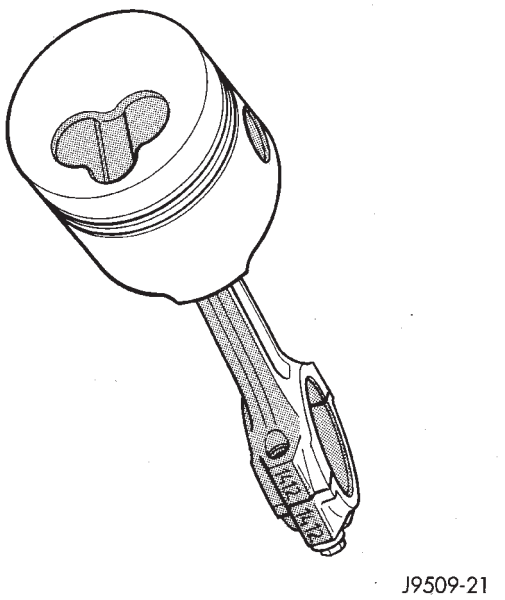

Fig. 63 Piston and Connecting Rod Assembly

(2) Crankshaft journals worn beyond limits or show signs of out of roundness must be reground or replaced. Minimum reground diameter is 53.69mm (2.1137 in.).

BEARING-TO-JOURNAL CLEARANCE

Compare internal diameters of connecting rod with crankshaft journal diameter. Maximum clearance between connecting rod and crankshaft journals .022 to .076mm (.0008 to .0029 in.).

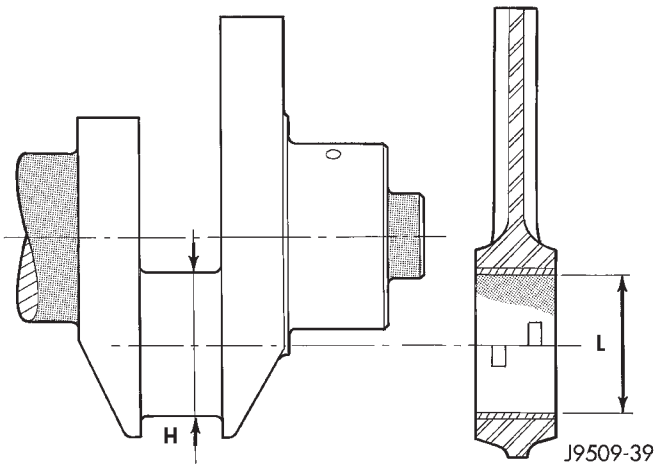

Fig. 64 Bearing Clearance

CYLINDER WALL LINER ASSEMBLY

INSPECTION

The cylinder walls should be checked for out-of-round and taper with dail bore gauge. The cylinder bore out-of-round is 0.100 mm (.0039 inch) maximum and cylinder bore taper is 0.100 mm (0.0039 inch) maximum. If the cylinder walls are badly scuffed or scored, new liners should be installed and honed, and new pistons and rings fitted.

Measure the cylinder bore at three levels in directions A and B (Fig. 65). Top measurement should be 10 mm (3/8 inch) down and bottom measurement should be 10 mm (3/8 inch.) up from bottom of bore.

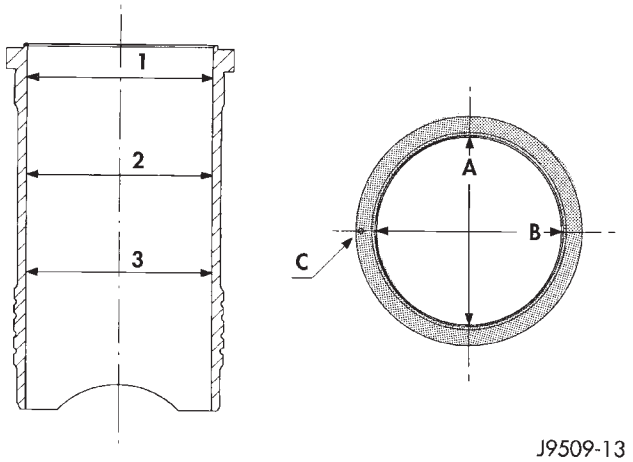

Fig. 65 Liner Inspection

CLEANING AND INSPECTION (Continued)

OIL PUMP

CLEANING

Wash all parts in a suitable solvent and inspect carefully for damage or wear.

INSPECTION

(1) Before installing oil pump check pump bore depth in block (A) and pump body height (B) (Fig. 66). Difference between A and B should be 0.020-0.082 mm.

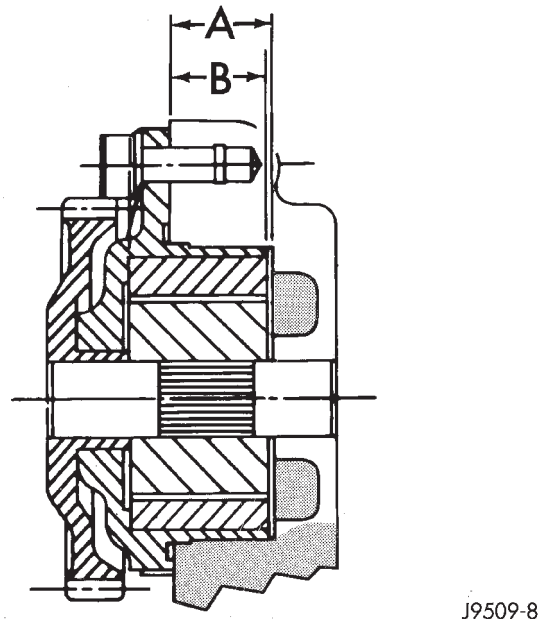

Fig. 66 Oil Pump Bore Depth

(2) Check clearance between rotors (Fig. 68).

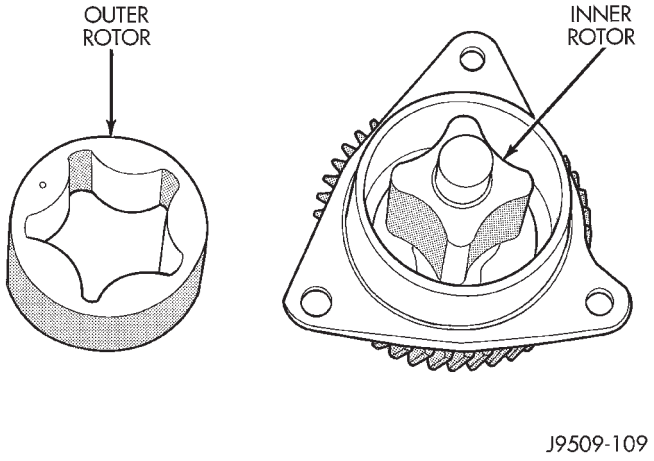

Fig. 67 Oil Pump Inner and Outer Rotors

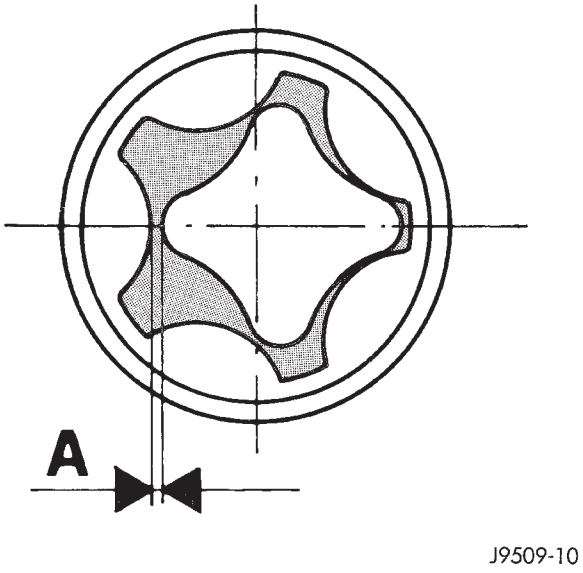

Fig. 68 Checking Rotor Clearance

SPECIFICATIONS

ENGINE SPECIFICATIONS

Description	Specifications
Type	425CLIRX (23B)
Number of cylinders	4
Bore	92 mm
Stroke	94 mm
Capacity	2499.5 cm3
Injection order	1-3-4-2
Compression ratio	21 : 1 (+/- 0.5)
Gasket	Asbestos free
Crankshaft	
Front journal diameter	
Nominal	62.985-63.000 mm
-0.25	62.745-62.760 mm
-0.125	62.860-62.875 mm
Front bearing diameter	
Nominal	63.043-63.088 mm
-0.25	62.810-62.860 mm
-0.125	62.918-62.963 mm
Clearance between journal and bearing: 0.043-0.103	
Center journal diameter	
Nominal	63.005-63.020 mm
-0.25	62.755-62.770 mm
-0.125	62.880-62.895 mm
Center bearing diameter	
Nominal	63.050-63.093 mm
-0.25	62.800-62.843 mm
-0.125	63.550-62.968 mm
Clearance between journal and bearing: 0.030-0.088	
Rear journal diameter	
Nominal	69.980-70.000 mm
-0.25	69.735-69.750 mm
-0.125	69.855-69.875 mm
Rear bearing diameter	
Nominal	70.030-70.055 mm
-0.25	69.780-69.805 mm
-0.125	69.905-69.980 mm
Clearance between journal and bearing: 0.030-0.075	
Wear limit: 0.200 mm.	
Connecting rod journal	
Nominal	53.940-53.955 mm
-0.25	53.690-53.705 mm
-0.125	53.815-53.830 mm
Connecting rod bearing	
Nominal	53.977-54.016 mm
-0.25	53.727-53.766 mm
-0.125	53.852-53.891 mm
Clearance between journal and bearing: 0.022-0.076	
Wear limit: 0.200 mm	

Description	Specifications
Crankshaft end play	
End play	0.153-0.304 mm
Adjustment.	Thrust washers
Thrust washers available:	2.311-2.362 mm
	2.411-2.462 mm
	2.511-2.562 mm
Main bearing carriers	
Internal diameter	
Front	67.025-67.050 mm
Center	66.670-66.687 mm
Rear	75.005-75.030 mm
Liners	
Internal diameter	92.000-92.010 mm
Protrusion	0.01-0.06 mm
Adjustment	Shims
Available shims:	0.15 mm
	0.17 mm
	0.20 mm
	0.23 mm
	0.25 mm
Cylinder head	
Minimum thickness	89.95-90.05 mm
Gaskets thickness:	1.42 mm +/- 0.04, 0 notches
	1.62 mm +/- 0.04, 1 notches
	1.52 mm +/- 0.04, 2 notches
End plates:	
Height	91.26-91.34 mm
Connecting rods	
Weight (without the crank bearing): 1129-1195 grams	
Small end bearing	
Internal diameter	
Minimum	30.035 mm
Maximum	30.050 mm
Crankshaft bearings	
Standard Internal diameter	53.977-54.016 mm
Pistons	
Skirt diameter	91.935-91.945 mm
(measured at approximately 15 mm above the bottom of the skirt).	
Piston clearance:	0.055-0.075 mm
Top of piston to cylinder head	0.80-0.89 mm
Piston protrusion	0.53 - 0.62 Fit gasket Number (1.42),0 notches
	0.73 - 0.82 Fit gasket Number (1.62),1 notches
	0.63 - 0.72 Fit gasket Number (1.52),2 notches

SPECIFICATIONS (Continued)

Description	Specifications
Piston pins	
Type	Fully floating
Pin diameter	29.990-29.996 mm
Clearance	0.039-0.060 mm
Piston rings	
Clearance in groove:	
Top	0.080-0.130 mm
Second.	0.070-0.102 mm
Oil control	0.040-0.072 mm
Fitted gap:	
Top	0.25-0.50 mm
Second.	0.20-0.35 mm
Oil control	0.25-0.58 mm
Camshaft	
Journal diameter, front	53.495-53.51 mm
Bearing clearance	0.030-0.095 mm
Center	53.45-53.47 mm
Bearing clearance	0.07-0.14 mm
Rear	53.48-53.50 mm
Bearing clearance	0.04-0.11 mm
Tappets	
Outside diameter	14.965-14.985 mm
Rocker gear	
Shaft diameter	21.979-22.00 mm
Bush internal diameter	22.020-22.041 mm
Assembly clearance	0.020-0.062 mm
Valves	
Intake valve:	
Opens	22° B.T.D.C.
Closes	46° A.B.D.C.
Exhaust valve:	
Opens.	60° B.B.D.C.
Closes	24° A.T.D.C.

Description	Specifications
Face angle:	
Intake	56° - 56° 20`
Exhaust.	45° 25` - 45° 35`
Head diameter:	
Intake	40.05-40.25 mm
Exhaust.	33.8-34.0 mm
Head stand down:	
Intake	0.88-1.14 mm
Exhaust.	0.99-1.25 mm
Stem diameter:	
Intake	7.940-7.960 mm
Exhaust.	7.922-7.940 mm
Clearance in guide:	
Intake	0.040-0.075 mm
Exhaust.	0.060-0.093 mm
Valve guide	
Inside diameter	8.0-8.015 mm
Fitted height	13.5-14 mm
Valve springs	
Free length	44.65 mm
Fitted length	38.6 mm
Load at fitted length	34 +/- 3% Kg
Load at top of lift.	92.5 +/- 3% Kg
Number of coils	5.33 Valve timing
Lubrication	
System pressure at 4000 rev/min	3.5 to 5.0 bar (oil at 90-100°C)
Pressure relief valve opens	6.38 bar
Pressure relief valve spring - free length	57.5 mm
Oil pump:	
Outer rotor end float	0.02-0.08 mm
Inner rotor end float	0.02-0.08 mm
Outer rotor to body diam. clearance	0.130-0.230 mm
Rotor body to drive gear clearance (pump not fitted)	0.30 - 0.56 mm

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SPECIFICATIONS (Continued)

TORQUE SPECIFICATIONS

DESCRIPTION	TORQUE
Adaptor Plate to Block	
Nuts (6)	26.5 N·m (20 ft. lbs.)
Automatic Belt Tensioner to Block	
Bolts (2)	121 N·m
Automatic Belt Tensioner to Mounting Bracket	
Bolt (1)	75 N·m
Generator belt	
Tensioner	79 N·m
Generator bracket	
Mounting bolts (6 mm)	10 N·m
Mounting bolts (8 mm)	24.4 N·m
Generator	
Mounting bolt	47 N·m
Camshaft thrust plate	
Bolts	24 N·m
Connecting rod	
Mounting bolt	29.5 N·m +60°
Crankshaft bearing	
Carrier screw	42 N·m
Crankshaft pulley	
Locknut	160 N·m
Crossmember	
Bolts	42 N·m
Diesel delivery	
Union nut	18.5 N·m
EGR valve	
To intake manifold	26 N·m
EGR tube	
To EGR valve	26 N·m
Engine mount—Front	
Engine support bracket	61 N·m
Support Cushion	47 N·m
Support cushion bracket bolts	54 N·m
Support cushion bracket stud nuts	41 N·m
Support Cushion through bolt	65 N·m
Engine mount—Rear	
Transmission support bracket	46 N·m
Support Cushion nuts	75 N·m
Support Cushion through bolt	65 N·m
Exhaust down pipe	
To turbocharger	22 N·m
Exhaust heat shield	
Screws	11 N·m
Exhaust manifold collar	
Mounting nut	24.5 to 29.5 N·m
Exhaust manifold	
Mounting nut	32.5 N·m
Fan drive	
To fan hub	56 N·m
Flywheel	
Lock bolt	20 N·m +60°

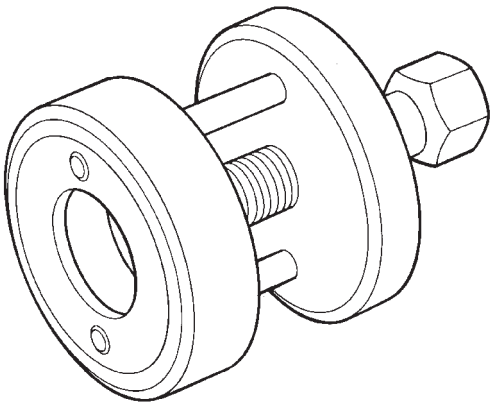
DESCRIPTION	TORQUE
Front timing cover	
6 mm bolts	10 N·m
8 mm bolts	26 N·m
Fuel filter	
Nuts	28 N·m
Glow plug	
Torque	13.0 N·m
Idler pulley bracket	
Bolts	40 N·m
Idler pulley	
Bolt (left hand thread)	47 N·m
Injection pump fuel lines	
Nut	23 N·m
Injection pump gear	
Lock nut	86 N·m
Injection pump	
Mounting nut	27.5 N·m
Injector	
Torque	68.5 N·m
Intake manifold	
Mounting nut	32.5 N·m
Main bearing oil delivery	
Union	54 N·m
Water hose to cylinder head	
Nut	8 to 10 N·m
Oil cooler adaptor	
Bolt	60 N·m
Oil feed line	
For rocker arms	12 N·m
To block	27 N·m
To vacuum pump	15 N·m
Oil filter	
Torque	18 N·m
Oil filter adapter	
Torque	46.6 N·m
Oil filter base	
Torque	46.6 N·m
Oil pan	
Mounting bolts	13 N·m
Oil pickup tube	
Torque	25 N·m
Oil pump	
Mounting screw	27 N·m
Oil sump drain plug	
Torque	54 N·m
Power steering pressure hose	
Nut	28 N·m
Power steering pulley	
Nut	130 N·m
Rear crankshaft bearing carrier Allen Bolts	
Torque	11 N·m
Rocker cover	
Bolts	19 N·m

SPECIFICATIONS (Continued)

DESCRIPTION	TORQUE
Rocker mounting	
Lock Nut	35 N·m
Steering pump	
Bolts	28 N·m
Turbocharger	
Mounting nuts	32.5 N·m
Turbocharger	
Oil delivery fitting	27.5 N·m
Turbocharger oil drain	
Plug	10.8 N·m
Vacuum pump	
Torque	27 N·m
Water manifold	
Bolts	12 N·m
Water pump pulley	
Nut	27 N·m

SPECIAL TOOLS

SPECIAL TOOLS



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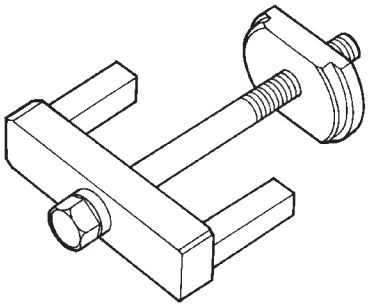
Crankshaft Pulley and Gear Remover VM. 1000A



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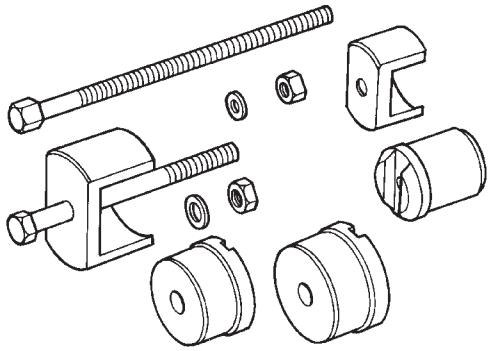
Cylinder Liner Puller VM, 1001



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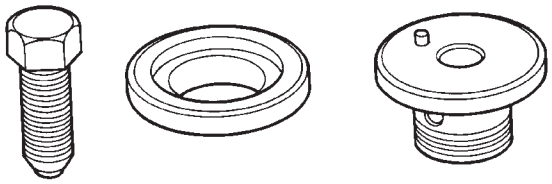
Crankshaft Bearing Remover/Replacer VM. 1002



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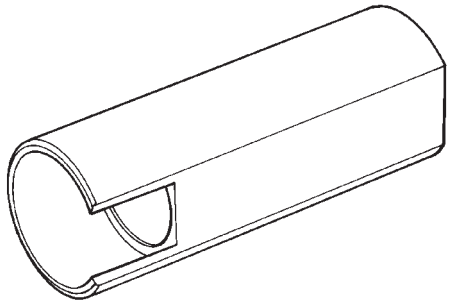
Injection Pump Puller and Gear retainer VM. 1003

SPECIAL TOOLS (Continued)



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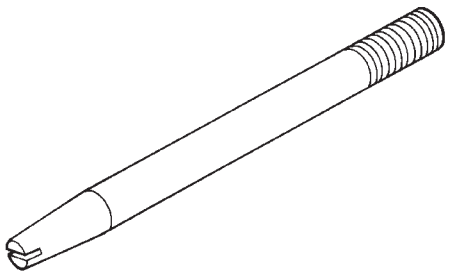
Crankshaft Remover/Replacer Sleeve VM. 1004



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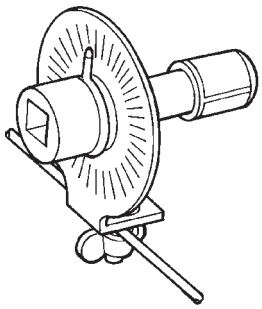
Cylinder Head Guide Studs VM. 1009



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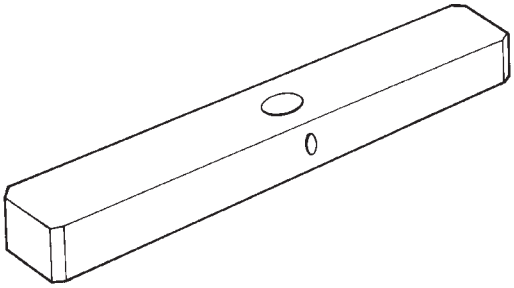
Torque Angle Gauge VM. 1005



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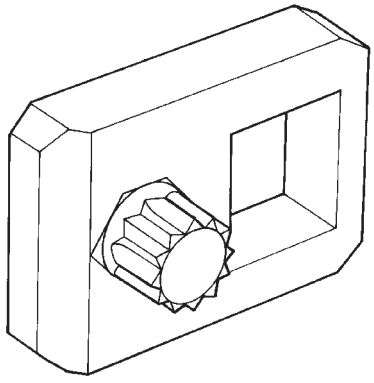
Cylinder Liner Protrusion Tool VM. 1010



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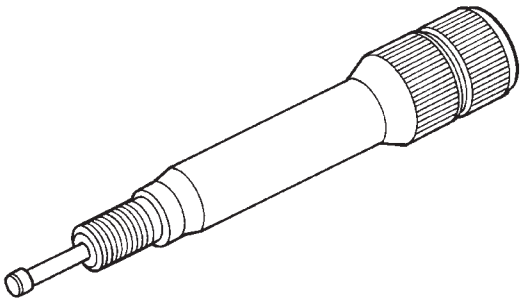
Cylinder Head Bolt Wrench VM. 1006A



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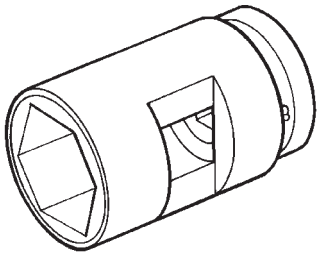
Bosch Pump Timing Adapter VM. 1011

SPECIAL TOOLS (Continued)



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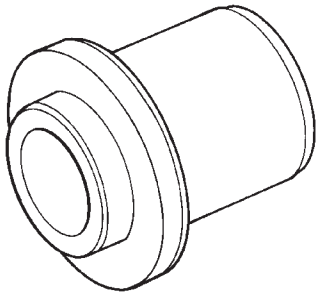
Injector Remover/Replacer Socket VM. 1012



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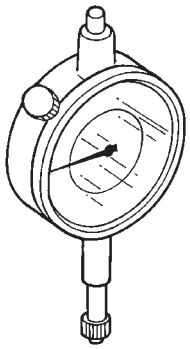
Timing Cover Oil Seal Replacer VM. 1015



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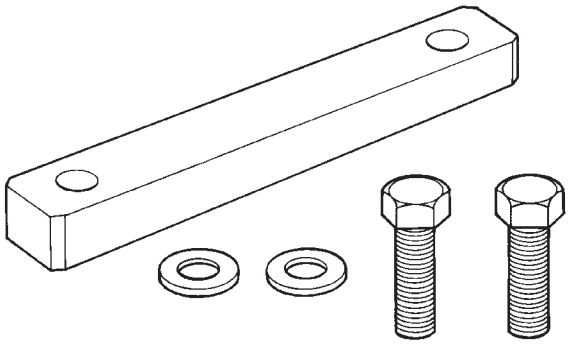
Dial Indicator Gauge VM. 1013



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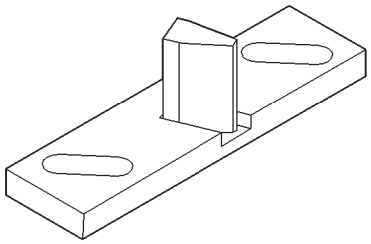
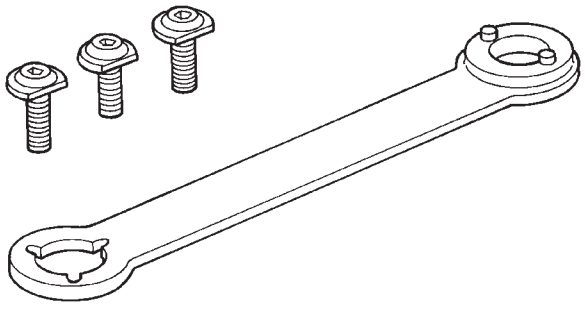
Cylinder Retainer VM. 1016



Flywheel Locking Tool VM. 1014



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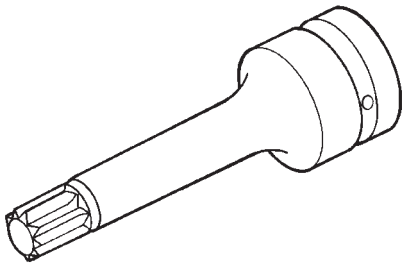
Crankshaft and Water Pump Pulley Holder VM. 1017

SPECIAL TOOLS (Continued)



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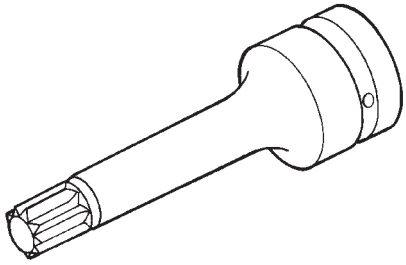
Cylinder Head Bolt Wrench M12 VM. 1018



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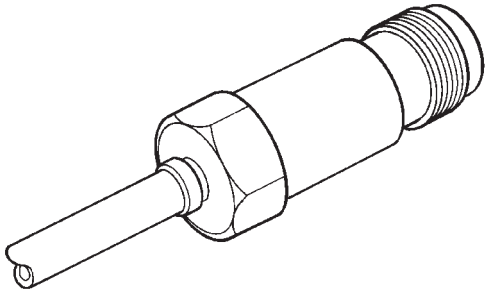
Cylinder Head Bolt Wrench M14 VM. 1019



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Cylinder Leakage Tester Adapter VM. 1021