Chapter 2 Part B
General engine overhaul procedures

Contents

Specifications

B1600, B1800 and B2000 engines (with timing chain)

General

Cylinder numbers (front-to-rear)	1-2-3-4
Firing order	1-3-4-2
Compression pressure	
Standard	169 PSI
Service limit	118 PSI
Oil pressure (engine at normal operating temperature)	
At idle	4.3 PSI
At 3000 rpm	48 to 64 PSI

Cylinder head

Maximum permissible distortion	0.006 in (0.15 mm)
Maximum refinish	0.010 in (0.25 mm)
Valve seat angle (intake and exhaust)	45°
Valve guide inside diameter	0.3174 to 0.3182 in (8.06 to 8.08 mm)
Valve stem-to-guide clearance	
Intake	0.0007 to 0.0021 in (0.0178 to 0.053 mm)
Exhaust	0.0007 to 0.0023 in (0.0178 to 0.058mm)
Service limit	0.008 in (0.20 mm)
Intake valve	
Stem diameter	
Standard	0.3161 to 0.3167 in (8.029 to 8.044 mm)
Service limit	0.002 in (0.05 mm)
Margin width	
Standard	0.059.1 ± 0.0079 in (1.5 ± 0.2 mm)
Service limit	
B16000	0197 in (0.5 mm)
B1800 and B2000	0.039 in (1.0 mm)
Exhaust valve	
Stem diameter	
Standard	0.3159 to 0.3167 in (8.024 to 8.044 mm)
Service limit	0.002 in (0.05 mm)
Margin width (minimum)	0.039 in (1.0 mm)

Valve spring free length (outer)	
Standard	
B1600 and B1800	1.469 in (373.3 mm)
B2000	1.598 in (40.6 mm)
Service limit	
B1600 and B1800	1.425 in (36.2 mm)
B2000 (except 1984)	1.551 in (39.4 mm)
B2000 (1984 only)	1.587 in (40.3 mm)
Valve spring installed height (outer)	
B1600 and B1800	1.339 in (34 mm)
B2000	1.385 in (34.5 mm)
Valve spring free length (inner)	
Standard	1.449 in (36.8 mm)
Service limit	1.406 in (35.7 mm)

Camshaft and related components

Rocker arm bore	0.7488 to 0.7501 in (19.02 to 19.053 mm)
Rocker arm shaft diameter	
B1600	0.7469 to 0.7477 in (18.72 to 18.93 mm)
B1800	0.7477 to 0.7479 in (18.972 to 18.993 mm)
B2000	0.7483 to 0.7491 in (19.007 to 19.028 mm)
Rocker arm-to-shaft clearance	
Standard	0.0011 in to 0.0032 in (0.28 to 0.081 mm)
Service limit	0.004 in (0.1 mm)
Camshaft journal diameter	
Front	1.7701 to 1.7695 in (44.96 to 44.945 mm)
Center	1.7691 to 1.7697 in (44.94 to 44.95 mm)
Rear	1.7701 to 1.7695 in (44.96 to 44.945 mm)
Service limit	0.002 in (0.05 mm)
Cam lobe height	
B1800 and B2000	
Standard	1.7731 in (45.037 mm)
Service limit	0.008 in (0.020 mm)
B1600	
Intake	1.7605 in (44.715 mm)
Exhaust	1.7592 in (44.682 mm)
Camshaft end play	
Standard	0.001 to 0.007 in (0.02 to 0.18 mm)
Service limit	0.008 in (0.20 mm)
Camshaft runout limit	0.0012 in (0.03 mm)
Camshaft bearing oil clearance	
Front and rear journals	0.0007 to 0.0027 in (0.019 to 0.069 mm)
Center journal	0.0011 to 0.0031 in (0.029 to 0.079 mm)
Service limit	0.0059 in (0.15 mm)

Connecting rods, pistons and bearings

Connecting rod distortion (twist) limit	0.002 in per 5 in (0.02 mm per 50 mm)
Connecting rod end play (side clearance)	
Standard	0.004 to 0.008 in (0.11 to 0.21 mm)
Service limit	0.014 in (0.356 mm)
Bearing oil clearance	
B1600	0.0011 to 0.003 in (0.027 to 0.077 mm)
B1800	0.001 to 0.0025 in (0.025 to 0.065 mm)
B2000	0.0011 to 0.0030 in (0.027 to 0.077 mm)
Service limit (all)	0.0039 in (0.10 mm)
Piston diameter (B1600) — measured 0.67-inch (17 mm) below oil ring groove, 90° to piston pin	
Piston marked A	3.0689 to 3.0691 in (77.949 to 77.955 mm)
Piston unmarked	3.0687 ± 0.002 in (77.945 ± 0.004 mm)
Piston marked C	3.0683 to 3.0685 in (77.935 to 77.941 mm)
Piston diameter (B1800) — measured 0.81-inch (20.5 mm) below oil ring groove, 90° to piston pin	3.1474 to 3.1482 in (79.944 to 79.964 mm)
Piston diameter (B2000) — measured 0.73-inch (18.5 mm) below oil ring groove, 90° to piston pin	3.1474 to 3.1482 in (79.944 to 79.964 mm)
Piston-to-cylinder clearance	
Standard	
B1600	0.0022 to 0.0028 in (0.057 to 0.072 mm)
B1800 and B2000	0.0019 to 0.0025 in (0.048 to 0.063 mm)
Service limit	0.006 in (0.15 mm)
Piston ring side clearance	
Top compression ring	0.0012 to 0.0028 in (0.035 to 0.070 mm)
Second compression ring	0.0012 to 0.0025 in (0.030 to 0.064 mm)
Oil control ring	0.0012 to 0.0025 in (0.030 to 0.064 mm)
Piston ring end gap	
Compression rings	0.008 to 0.016 in (0.2 to 0.4 mm)
Oil control ring	0.012 to 0.035 in (0.3 to 0.9 mm)

B1600, B1800 and B2000 engines (with timing chain) (continued)

Crankshaft and main bearings

Main journal diameter	
Standard	
B1600	2.4779 to 2.4875 in (62.94 to 63.18 mm)
B1800 and B2000	2.4780 to 2.4786 in (62.940 to 62.955 mm)
Service limit	0.002 in (0.05 mm)
Connecting rod journal diameter	
Standard	
B1600 and B1800	2.0842 to 2.0848 in (52.94 to 52.95 mm)
B2000	2.0884 to 2.0890 in (53.045 to 53.060 mm)
Service limit	0.002 in (0.05 mm)
Crankshaft end play	
Standard	0.003 to 0.009 in (0.08 to 0.24 mm)
Service limit	0.012 in (0.30 mm)
Crankshaft runout (measured at flywheel face)	0.0012 in (0.03 mm)
Main bearing oil clearance	
Standard	
B1600 and B1800	0.0012 to 0.0024 in (0.031 to 0.061 mm)
B2000	0.0012 to 0.0020 in (0.031 to 0.050 mm)
Service limit	0.0031 in (0.08 mm)

Engine block

Bore diameter	
B1600	
Mark A	3.0714 to 3.0716 in (78.013 to 78.019 mm)
Mark B	3.0709 to 3.0711 in (78.000 to 78.006 mm)
Unmarked	3.0711 to 3.0714 in (78.006 to 78.013 mm)
B1800 and B2000	3.1497 to 3.1504 in (80.0 to 80.019 mm)
Wear limit	0.006 in (0.15 mm)
Maximum regrind to correct deck distortion	0.010 in (0.25 mm)

Torque specifications*	Ft-lbs
Main bearing cap bolts	61 to 65
Connecting rod cap nuts	30 to 33
Oil pressure switch	9 to 13

* **Note:** *Refer to Part A for additional torque specifications.*

B2000 and B2200 engines (with timing belt)

General

Compression pressure (at 300 rpm)	
Standard	173 PSI
Minimum	121 PSI
Cylinder numbers (front-to-rear)	1-2-3-4
Firing order	1-3-4-2
Oil pressure	43 to 57 PSI at 3000 rpm

Cylinder head, valves and related components

Cylinder head warpage limit	0.006 in (0.15 mm)
Valve face angle	45°
Valve seat angle	45°
Valve margin width (minimum)	
Intake	0.020 in (0.5 mm)
Exhaust	0.039 in (1.0 mm)
Valve stem diameter	
Intake	0.3161 to 0.3167 in (8.030 to 8.045 mm)
Service limit	0.3142 in (7.980 mm)
Exhaust	0.3159 to 0.3165 in (8.025 to 8.040 mm)
Service limit	0.3140 in (7.975 mm)
Stem-to-guide clearance	
Intake	0.0010 to 0.0024 in (0.025 to 0.060 mm)
Exhaust	0.0012 to 0.0026 in (0.030 to 0.065 mm)
Service limit (intake and exhaust)	0.0079 in (0.20 mm)
Valve spring out-of-square limit	
Outer	0.07 in (1.8 mm)
Inner	0.06 in (1.5 mm)
Valve spring free length	
Inner	1.732 in (44.0 mm)
Service limit	1.681 in (42.7 mm)
Outer	2.047 in (52.0 mm)
Service limit	1.984 in (50.4 mm)
Rocker arm and shaft	
Rocker arm bore	0.6300 to 0.6310 in (16.000 to 16.027 mm)
Shaft diameter	0.6286 to 0.6293 in (15.966 to 15.984 mm)
Rocker arm-to-shaft clearance	0.0006 to 0.0024 in (0.016 to 0.061 mm)
Service limit	0.004 in (0.010 mm)

Crankshaft and connecting rods

Crankshaft end play	0.0031 to 0.0071 in (0.08 to 0.18 mm)
Service limit	0.0118 in (0.030 mm)
Connecting rod end play (side clearance)	0.004 to 0.010 in (0.110 to 0.262 mm)
Service limit	0.012 in (0.30 mm)
Main bearing journal diameter	2.359 to 2.360 in (59.937 to 59.955 mm)
Service limit	0.002 in (0.05 mm)
Grinding limit	0.03 in (0.75 mm)
Main bearing oil clearance	0.0012 to 0.0019 in (0.031 to 0.049 mm)
Service limit	0.0031 in (0.08 mm)
Connecting rod bearing journal diameter	2.005 to 2.006 in (50.940 to 50.955 mm)
Service limit	0.0020 in (0.05 mm)
Grinding limit	0.03 in (0.75 mm)
Connecting rod wrist pin bore diameter	0.8640 to 0.8646 in (21.943 to 21.961 mm)
Connecting rod bearing oil clearance	0.0010 to 0.0026 in (0.027 to 0.067 mm)
Service limit	0.0039 in (0.10 mm)
Crankshaft journal taper/out-of-round limit	0.0020 in (0.05 mm)
Crankshaft runout limit	0.0012 in (0.03 mm)

Engine block

Cylinder bore diameter	3.3859 to 3.3866 in (86.000 to 86.019 mm)
Service limit	0.060 in (0.15 mm)
Deck warpage limit	0.006 in (0.15 mm)

Pistons and rings

Piston diameter	3.3837 to 3.3845 in (85.944 to 85.964 mm)
Piston-to-bore clearance	0.0014 to 0.0030 in (0.036 to 0.075 mm)
Ring groove width	
Compression rings	0.059 to 0.060 in (1.52 to 1.54 mm)
Oil control ring	0.1583 to 0.1591 in (4.02 to 4.04 mm)
Piston ring side clearance (compression rings only)	
Standard	0.0012 to 0.0028 in (0.03 to 0.07 mm)
Service limit	0.006 (0.015 mm)
Piston ring end gap	
Top compression ring	0.008 to 0.014 in (0.2 to 0.3 mm)
Second compression ring	0.006 to 0.012 in (0.15 to 0.3 mm)
Oil control ring	0.012 to 0.035 in (0.3 to 0.9 mm)
Service limit	0.039 in (1.0 mm)
Piston pin diameter	0.8651 to 0.8654 in (21.974 to 21.980 mm)
Pin-to-piston clearance	Loose — 0 to 0.0009 in (0 to 0.024 mm)
Pin-to-rod clearance	Press fit

Camshaft

Runout	0.0012 in (0.03 mm)
End play	0.003 to 0.006 in (0.08 to 0.016 mm)
Service limit	0.008 in (0.20 mm)
Bearing journal diameter	
Front (number 1)	1.257 to 1.258 in (31.940 to 31.965 in
Center (numbers 2, 3, 4)	1.256 to 1.257 in (31.910 to 31.935 mm)
Rear (number 5)	1.257 to 1.258 in (31.940 to 31.965 mm)
Service limit	0.002 in (0.05 mm)
Bearing oil clearance	
Front (number 1)	0.0014 to 0.0033 in (0.035 to 0.085 mm)
Center (numbers 2, 3, 4)	0.0026 to 0.0045 in (0.065 to 0.115 mm)
Rear (number 5)	0.0014 to 0.0033 in (0.035 to 0.085 mm)
Service limit	0.0059 in (0.015 mm)
Lobe lift (intake and exhaust)	
Standard	1.5030 to 1.5050 in (38.176 to 38.226 mm)
Service limit	1.4961 in (38.001 mm)

Torque specifications*	**Ft-lbs**
Main bearing cap bolts	61 to 65
Connecting rod nuts	37 to 41
Camshaft cap bolts	13 to 20

Note: *Refer to Part A for additional torque specifications.*

B2600 (2.6L) engine (through 1988)

General

Cylinder numbers (front-to-rear)	1-2-3-4
Firing order	1-3-4-2
Compression pressure	
1972 through 1988	149 psi at 250 rpm
1989 and 1990	185 psi at 280 rpm
1991 and later	182 psi at 270 rpm
Oil pressure (engine warm)	45 to 90 PSI at 3000 rpm (6 PSI at idle)

B2600 (2.6L) engine (continued)

Engine block

Cylinder bore diameter	3.5874 to 3.5882 in (91.12 to 91.14 mm)
Taper and out-of-round limits	0.0008 in (0.020 mm)
Block deck distortion limit	0.0039 in (0.10 mm)

Pistons and rings

Piston diameter*	3.5874 to 3.5882 in (91.12 to 91.14 mm)
Piston ring side clearance	
Standard	
Top compression ring	0.0020 to 0.0035 in (0.05 to 0.09 mm)
Second compression ring	0.008 to 0.0024 in (0.02 to 0.061 mm)
Oil control ring	Side rails must rotate freely after assembly
Service limit	
Top compression ring	0.006 in (0.15 mm)
Second compression ring	0.0039 in (0.099 mm)
Piston ring end gap	
Standard	
Top compression ring	0.012 to 0.018 in (0.30 to 0.45 mm)
Second compression ring	0.010 to 0.016 in (0.25 to 0.40 mm)
Oil control ring	0.012 to 0.024 in (0.30 to 0.60 mm)
Service limit	
Top compression ring	0.039 in (0.99 mm)
Second compression ring	0.039 in (0.99 mm)
Oil control ring	0.059 in (1.50 mm)

** Measured 90° to pin bore, 1.65-inch up from lower edge of piston*

Crankshaft and flywheel

Main journal diameter	2.3614 to 2.3622 in (59.980 to 60.000 mm)
Taper and out-of-round limits	0.0012 in (0.030 mm)
Main bearing oil clearance	0.0008 to 0.0020 in (0.020 to 0.050 mm)
Connecting rod journal diameter	2.0866 in (53.000 mm)
Connecting rod bearing oil clearance	0.0008 to 0.0024 in (0.020 to 0.060 mm)
Connecting rod end play (side clearance)	0.004 to 0.010 in (0.10 to 0.25 mm)
Crankshaft end play	0.002 to 0.007 in (0.05 to 0.18 mm)

Camshaft

Bearing oil clearance	0.002 to 0.004 in (0.05 to 0.10 mm)
Lobe height (intake and exhaust)	
Standard	1.6669 in (42.400 mm)
Service limit	1.650 in (41.9 mm)
End play	
Standard	0.0008 to 0.0070 in (0.02 to 0.18 mm)
Service limit	0.008 in (0.20 mm)

Cylinder head and valve train

Head warpage limit	0.006 in (0.15 mm)
Head resurfacing limit	0.008 in (0.20 mm)
Valve seat angle	45°
Valve seat width	
Intake	0.028 to 0.047 in (0.71 to 1.19 mm)
Exhaust	0.039 to 0.079 in (0.99 to 2.01 mm)
Valve stem-to-guide clearance	
Intake	
Standard	0.0010 to 0.0025 in (0.025 to 0.061 mm)
Service limit	0.0079 in (0.20 mm)
Exhaust	
Standard	0.0020 to 0.0035 in (0.051 to 0.089 mm)
Service limit	0.0079 in (0.20 mm)
Valve spring free length	
Standard	1.961 in (49.80 mm)
Service limit	1.921 in (48.8 mm)
Out-of-square service limit	3° max
Valve spring installed height	Not available

Torque specifications*	**Ft-lbs**
Main bearing cap bolts	54 to 61
Connecting rod bearing cap nuts	33 to 35
Crankshaft rear oil seal housing bolts	7.3 to 8.7
Jet valve assembly	13 to 15
Oil pressure sending unit	11 to 15

* **Note:** *Refer to Part A for additional torque specifications.*

B2600i (2.6L) engine (1989 and later)

General

Displacement	158.97 cubic inches (2.6 liters)
Bore	3.62 inches
Stroke	3.86 inches
Cylinder compression pressure	
Standard	185 psi
Minimum	142 psi
Oil pressure	
At 1000 rpm	16 to 29 psi
At 3000 rpm	45 to 58 psi

Engine block

Cylinder taper limit	0.0007 inches
Cylinder out-of-round limit	0.0007 inches

Pistons and rings

Piston diameter	
1989	3.6194 to 3.6202 inches
1990 and 1991	3.6195 to 3.6203 inches
1992	3.6194 to 3.6202 inches
Piston ring side clearance	
Top compression ring	
Standard	0.0012 to 0.0028 inches
Service limit	0.006 inch
Second compression ring	
Standard	0.0012 to 0.0028 inches
Service limit	0.006 inch
Piston ring end gap	
Top compression ring	
Standard	0.008 to 0.014 inch
Service limit	Not available
Second compression ring	
Standard	0.010 to 0.016 inch
Service limit	Not available
Oil ring	
Standard	0.008 to 0.028 inch
Service limit	0.039 inch
Piston-to-cylinder wall clearance	
Standard	0.0023 to 0.0029 inch
Service limit	0.006 inch

Crankshaft and connecting rods

Endplay	
Standard	0.0031 to 0.0071 inch
Service limit	0.0118 inch
Crankshaft runout	0.0012 inch
Main bearing journals	
Diameter	
Standard	2.3597 to 2.3604 inches
Minimum	2.358 inches
Out-of-round	0.0020 inch
Main bearing oil clearance	
Standard	0.0010 to 0.0017 inch
Service limit	0.0031 inch
Connecting rod journal	
Diameter	
Standard	2.0055 to 2.0061 inches
Minimum	2.004 inches
Out-of-round	0.0020 inch
Connecting rod bearing oil clearance	
Standard	0.0011 to 0.0026 inch
Service limit	0.0039 inch
Connecting rod endplay (side clearance)	
Standard	0.0044 to 0.0103 inch
Service limit	0.012 inch

Cylinder head and valves

Head warpage limit	0.006 inch
Head warpage at manifold surfaces	0.006 inch
Valve seat angle	45-degrees
Valve face angle	45-degrees
Valve margin width	
Intake	0.039 inch
Exhaust	0.059 inch

Valve stem-to-guide clearance	
Standard	
Intake	0.0010 to 0.0024 inch
Exhaust	0.0012 to 0.0026 inch
Service limit	0.008 inch
Valve stem diameter	
Intake	0.2744 to 0.2750 inch
Exhaust	0.2743 to 0.2748 inch
Valve spring	
Free length	
Standard	1.970 inches
Minimum	1.963 inches
Out-of-square	0.069 inch
Valve stem installed height	
Standard	
Intake	1.929 to 1.948 inches
Exhaust	1.929 to 1.948 inches
Service limit	
Intake	1.949 to 1.988 inches
Exhaust	1.949 to 1.988 inches

Torque specifications*

	Ft-lbs (unless otherwise indicated)
Main bearing cap bolts	61 to 65
Connecting rod bearing cap nuts	48 to 50
Oil jet valves	104 to 156 in-lbs
Balance shaft thrust plate bolts	69 to 95 in-lbs

** Refer to Part A for additional torque specifications*

1 General information

Included in this portion of Chapter 2 are the general overhaul procedures for the cylinder head and internal engine components.

The information ranges from advice concerning preparation for an overhaul and the purchase of replacement parts to detailed, step-by-step procedures covering removal and installation of internal engine components and the inspection of parts.

The following Sections have been written based on the assumption that the engine has been removed from the vehicle. For information concerning in-vehicle engine repair, as well as removal and installation of the external components necessary for the overhaul, see Part A of this Chapter and Section 7 of this Part.

The Specifications included in this Part are only those necessary for the inspection and overhaul procedures which follow. Refer to Part A for additional Specifications.

2 Engine overhaul — general information

Refer to illustration 2.4

It's not always easy to determine when, or if, an engine should be completely overhauled, as a number of factors must be considered.

High mileage is not necessarily an indication that an overhaul is needed, while low mileage doesn't preclude the need for an overhaul. Frequency of servicing is probably the most important consideration. An engine that's had regular and frequent oil and filter changes, as well as other required maintenance, will most likely give many thousands of miles of reliable service. Conversely, a neglected engine may require an overhaul very early in its life.

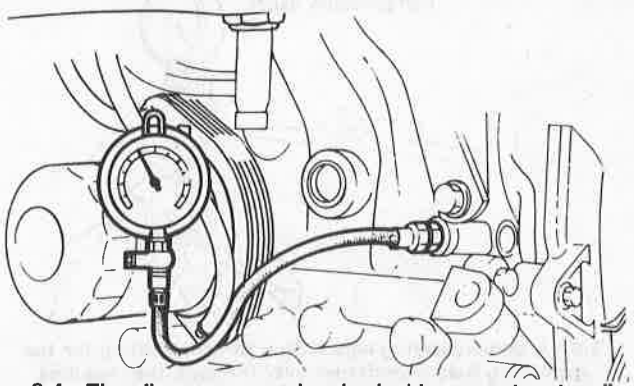
Excessive oil consumption is an indication that piston rings, valve seals and/or valve guides are in need of attention. Make sure that oil leaks aren't responsible before deciding that the rings and/or guides are bad. Perform a cylinder compression check to determine the extent of the work required (see Section 3).

Check the oil pressure with a gauge installed in place of the oil pressure sending unit **(see illustration)** and compare it to the Specifications. If it's extremely low, the bearings and/or oil pump are probably worn out.

Loss of power, rough running, knocking or metallic engine noises, excessive valve train noise and high fuel consumption rates may also point to the need for an overhaul, especially if they're all present at the same time. If a complete tune-up doesn't remedy the situation, major mechanical work is the only solution.

An engine overhaul involves restoring the internal parts to the specifications of a new engine. During an overhaul, the piston rings are replaced and the cylinder walls are reconditioned (rebored and/or honed). If a rebore is done by an automotive machine shop, new oversize pistons will also be installed. The main bearings, connecting rod bearings and camshaft bearings are generally replaced with new ones and, if necessary, the crankshaft may be reground to restore the journals. Generally, the valves are serviced as well, since they're usually in less-than-perfect condition at this point. While the engine is being overhauled, other components, such as the distributor, starter and alternator, can be rebuilt as well. The end result should be a like new engine that will give many trouble free miles. **Note:** *Critical cooling system components such as the hoses, drivebelts, thermostat and water pump MUST be replaced with new parts when an engine is overhauled. The radiator should be checked carefully to ensure that it isn't clogged or leaking (see Chapter 3). Also, we don't recommend overhauling the oil pump — always install a new one when an engine is rebuilt.*

Before beginning the engine overhaul, read through the entire procedure to familiarize yourself with the scope and requirements of the job. Overhauling an engine isn't difficult, but it is time consuming. Plan on the vehicle being tied up for a minimum of two weeks, especially if parts must be taken to an automotive machine shop for repair or reconditioning. Check on availability of parts and make sure that any necessary special tools and equipment are obtained in advance. Most work can be done with typical hand tools, although a number of precision measuring tools are required for inspecting parts to determine if they must be replaced. Often an automotive machine shop will handle the inspection of parts and offer advice concerning reconditioning and



2.4 The oil pressure can be checked by removing the oil pressure sending unit and installing a gauge in the hole (located just ahead of the oil filter)

replacement. **Note:** *Always wait until the engine has been completely disassembled and all components, especially the engine block, have been inspected before deciding what service and repair operations must be performed by an automotive machine shop.* Since the block's condition will be the major factor to consider when determining whether to overhaul the original engine or buy a rebuilt one, never purchase parts or have machine work done on other components until the block has been thoroughly inspected. As a general rule, time is the primary cost of an overhaul, so it doesn't pay to install worn or substandard parts.

As a final note, to ensure maximum life and minimum trouble from a rebuilt engine, everything must be assembled with care in a spotlessly clean environment.

3 Cylinder compression check

Refer to illustration 3.6

1 A compression check will tell you what mechanical condition the upper end (pistons, rings, valves, head gaskets) of your engine is in. Specifically, it can tell you if the compression is down due to leakage caused by worn piston rings, defective valves and seats or a blown head gasket. **Note:** *The engine must be at normal operating temperature and the battery must be fully charged for this check. Also, the choke valve must be all the way open to get an accurate compression reading (if the engine's warm, the choke should be open).*

2 Begin by cleaning the area around the spark plugs before you remove them (compressed air should be used, if available, otherwise a small brush or even a bicycle tire pump will work). The idea is to prevent dirt from getting into the cylinders as the compression check is being done.

3 Remove all of the spark plugs from the engine (Chapter 1).

4 Block the throttle wide open.

5 Detach the coil wire from the center of the distributor cap and ground it on the engine block. Use a jumper wire with alligator clips on each end to ensure a good ground.

6 Install the compression gauge in the number one spark plug hole **(see illustration).**

7 Crank the engine over at least seven compression strokes and watch the gauge. The compression should build up quickly in a healthy engine. Low compression on the first stroke, followed by gradually increasing pressure on successive strokes, indicates worn piston rings. A low compression reading on the first stroke, which doesn't build up during successive strokes, indicates leaking valves or a blown head gasket (a cracked head could also be the cause). Deposits on the undersides of the valve heads can also cause low compression. Record the highest gauge reading obtained.

8 Repeat the procedure for the remaining cylinders and compare the results to the Specifications.

9 Add some engine oil (about three squirts from a plunger-type oil can) to each cylinder, through the spark plug hole, and repeat the test.

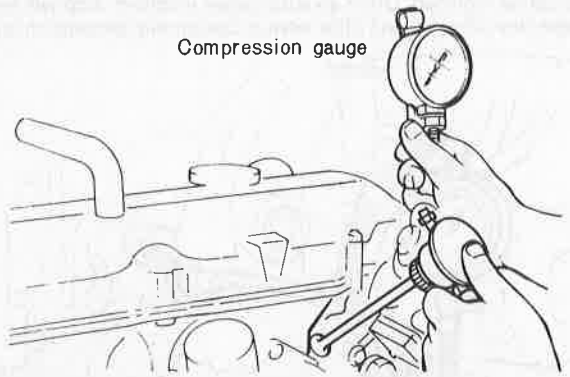
10 If the compression increases after the oil is added, the piston rings are definitely worn. If the compression doesn't increase significantly, the leakage is occurring at the valves or head gasket. Leakage past the valves may be caused by burned valve seats and/or faces or warped, cracked or bent valves.

11 If two adjacent cylinders have equally low compression, there's a strong possibility that the head gasket between them is blown. The appearance of coolant in the combustion chambers or the crankcase would verify this condition.

12 If one cylinder is 20 percent lower than the others, and the engine has a slightly rough idle, a worn exhaust lobe on the camshaft could be the cause.

13 If the compression is unusually high, the combustion chambers are probably coated with carbon deposits. If that's the case, the cylinder head should be removed and decarbonized.

14 If compression is way down or varies greatly between cylinders, it would be a good idea to have a leak-down test performed by an automotive repair shop. This test will pinpoint exactly where the leakage is occurring and how severe it is.



3.6 A compression gauge with a threaded fitting for the spark plug hole is preferred over the type that requires hand pressure to maintain the seal — be sure to open the throttle and choke valves as far as possible during the compression check!

4 Engine removal — methods and precautions

If you've decided that an engine must be removed for overhaul or major repair work, several preliminary steps should be taken.

Locating a suitable place to work is extremely important. Adequate work space, along with storage space for the vehicle, will be needed. If a shop or garage isn't available, at the very least a flat, level, clean work surface made of concrete or asphalt is required.

Cleaning the engine compartment and engine before beginning the removal procedure will help keep tools clean and organized.

An engine hoist or A-frame will also be necessary. Make sure the equipment is rated in excess of the combined weight of the engine and accessories. Safety is of primary importance, considering the potential hazards involved in lifting the engine out of the vehicle.

If the engine is being removed by a novice, a helper should be available. Advice and aid from someone more experienced would also be helpful. There are many instances when one person cannot simultaneously perform all of the operations required when lifting the engine out of the vehicle.

Plan the operation ahead of time. Arrange for or obtain all of the tools and equipment you'll need prior to beginning the job. Some of the equipment necessary to perform engine removal and installation safely and with relative ease are (in addition to an engine hoist) a heavy duty floor jack, complete sets of wrenches and sockets as described in the front of this manual, wooden blocks and plenty of rags and cleaning solvent for mopping up spilled oil, coolant and gasoline. If the hoist must be rented, make sure that you arrange for it in advance and perform all of the operations possible without it beforehand. This will save you money and time.

Plan for the vehicle to be out of use for quite a while. A machine shop will be required to perform some of the work which the do-it-yourselfer can't accomplish without special equipment. These shops often have a busy schedule, so it would be a good idea to consult them before removing the engine in order to accurately estimate the amount of time required to rebuild or repair components that may need work.

Always be extremely careful when removing and installing the engine. Serious injury can result from careless actions. Plan ahead, take your time and a job of this nature, although major, can be accomplished successfully.

5 Engine — removal and installation

Refer to illustration 5.24

Warning: *The air conditioning system is under high pressure! Have a dealer service department or service station discharge the system before disconnecting any A/C system hoses or fittings.*

Removal

1 Disconnect the negative cable from the battery.

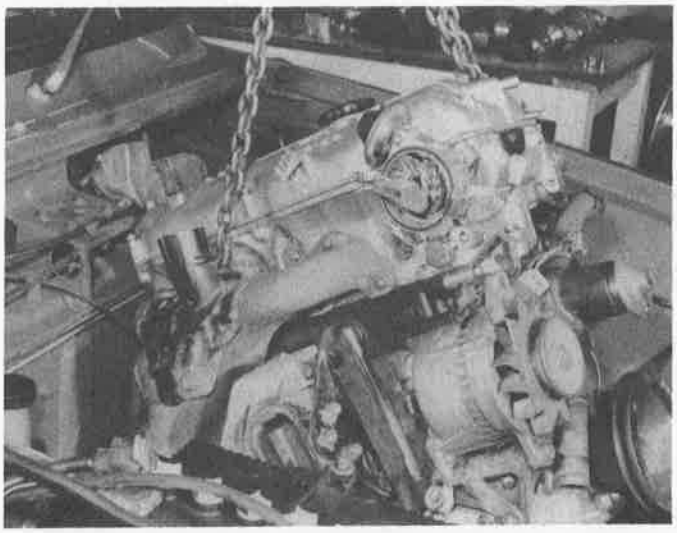
2 Cover the fenders and cowl and remove the hood (see Chapter 11). Special pads are available to protect the fenders, but an old bedspread or blanket will also work.

3 Remove the air cleaner assembly.

4 Drain the cooling system (see Chapter 1).

5 Label the vacuum lines, emissions system hoses, wiring connec-

tors, ground straps and fuel lines, to ensure correct reinstallation, then detach them. Pieces of masking tape with numbers or letters written on them work well. If there's any possibility of confusion, make a sketch of the engine compartment and clearly label the lines, hoses and wires.
6 Label and detach all coolant hoses from the engine.
7 Remove the cooling fan, shroud and radiator (see Chapter 3).
8 Remove the drivebelts (see Chapter 1).
9 **Warning:** *Gasoline is extremely flammable, so extra precautions must be taken when working on any part of the fuel system. DO NOT smoke or allow open flames or bare light bulbs near the vehicle. Also, don't work in a garage if a natural gas appliance with a pilot light is present.* Disconnect the fuel lines running from the engine to the chassis (see Chapter 4). Plug or cap all open fittings/lines.
10 Disconnect the throttle linkage (and TV linkage/speed control cable, if equipped) from the engine (see Chapter 4).
11 On power steering equipped vehicles, unbolt the power steering pump (see Chapter 10). Leave the lines/hoses attached and make sure the pump is kept in an upright position in the engine compartment (use wire or rope to restrain it out of the way).
12 On A/C equipped vehicles, unbolt the compressor (see Chapter 3) and set it aside. Do not disconnect the hoses.
13 Drain the engine oil (Chapter 1) and remove the filter.
14 Remove the starter motor (see Chapter 5).
15 Remove the alternator (see Chapter 5).
16 Unbolt the exhaust system from the engine (see Chapter 4).
17 If you're working on a vehicle with an automatic transmission, refer to Chapter 7 and remove the torque converter-to-driveplate fasteners.
18 Support the transmission with a jack. Position a block of wood between them to prevent damage to the transmission. Special transmission jacks with safety chains are available – use one if possible.
19 Attach an engine sling or a length of chain to the lifting brackets on the engine.
20 Roll the hoist into position and connect the sling to it. Take up the slack in the sling or chain, but don't lift the engine. **Warning:** *DO NOT place any part of your body under the engine when it's supported only by a hoist or other lifting device.*
21 Remove the gussets (braces) from the rear of the oil pan, then remove the transmission-to-engine block bolts.
22 Remove the engine mount-to-frame bolts.
23 Recheck to be sure nothing is still connecting the engine to the transmission or vehicle. Disconnect anything still remaining.
24 Raise the engine slightly. Carefully work it forward to separate it from the transmission. If you're working on a vehicle with an automatic transmission, be sure the torque converter stays in the transmission (clamp a pair of vise-grips to the housing to keep the converter from sliding out). If you're working on a vehicle with a manual transmission, the input shaft must be completely disengaged from the clutch. Slowly raise the engine out of the engine compartment **(see illustration)**. Check carefully to make sure nothing is hanging up.
25 Remove the flywheel/driveplate and mount the engine on an engine stand.



5.24 Make sure the chain is securely attached to the engine brackets and the hoist before lifting out the engine

Installation

26 Check the engine and transmission mounts. If they're worn or damaged, replace them.
27 If you're working on a manual transmission equipped vehicle, install the clutch and pressure plate (Chapter 7). Now is a good time to install a new clutch.
28 Carefully lower the engine into the engine compartment – make sure the engine mounts line up.
29 If you're working on an automatic transmission equipped vehicle, guide the torque converter into the crankshaft following the procedure outlined in Chapter 7.
30 If you're working on a manual transmission equipped vehicle, apply a dab of high-temperature grease to the input shaft and guide it into the crankshaft pilot bearing until the bellhousing is flush with the engine block.
31 Install the transmission-to-engine bolts and tighten them securely. **Caution:** *DO NOT use the bolts to force the transmission and engine together!*
32 Reinstall the remaining components in the reverse order of removal.
33 Add coolant, oil, power steering and transmission fluid as needed.
34 Run the engine and check for leaks and proper operation of all accessories, then install the hood and test drive the vehicle.
35 Have the A/C system recharged and leak tested.

6 Engine rebuilding alternatives

The do-it-yourselfer is faced with a number of options when performing an engine overhaul. The decision to replace the engine block, piston/connecting rod assemblies and crankshaft depends on a number of factors, with the number one consideration being the condition of the block. Other considerations are cost, access to machine shop facilities, parts availability, time required to complete the project and the extent of prior mechanical experience on the part of the do-it-yourselfer.

Some of the rebuilding alternatives include:

Individual parts – If the inspection procedures reveal that the engine block and most engine components are in reusable condition, purchasing individual parts may be the most economical alternative. The block, crankshaft and piston/connecting rod assemblies should all be inspected carefully. Even if the block shows little wear, the cylinder bores should be surface honed.

Short block – A short block consists of an engine block with a crankshaft and piston/connecting rod assemblies already installed. All new bearings are incorporated and all clearances will be correct. The existing cylinder head and external parts can be bolted to the short block with little or no machine shop work necessary.

Long block – A long block consists of a short block plus an oil pump, oil pan, cylinder head, rocker arm cover, camshaft and valve train components, timing sprockets and chain or gears and timing cover. All components are installed with new bearings, seals and gaskets incorporated throughout. The installation of manifolds and external parts is all that's necessary.

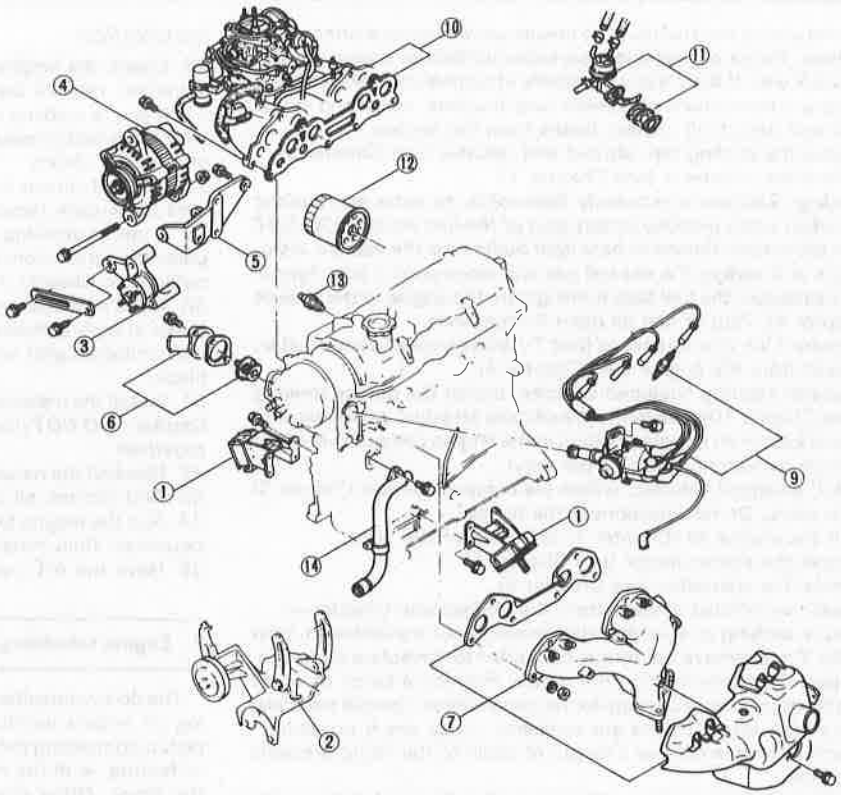
Give careful thought to which alternative is best for you and discuss the situation with local automotive machine shops, auto parts dealers and experienced rebuilders before ordering or purchasing replacement parts.

7 Engine overhaul – disassembly sequence

Refer to illustrations 7.3a, 7.3b, 7.3c, 7.3d, 7.5a, 7.5b and 7.5c

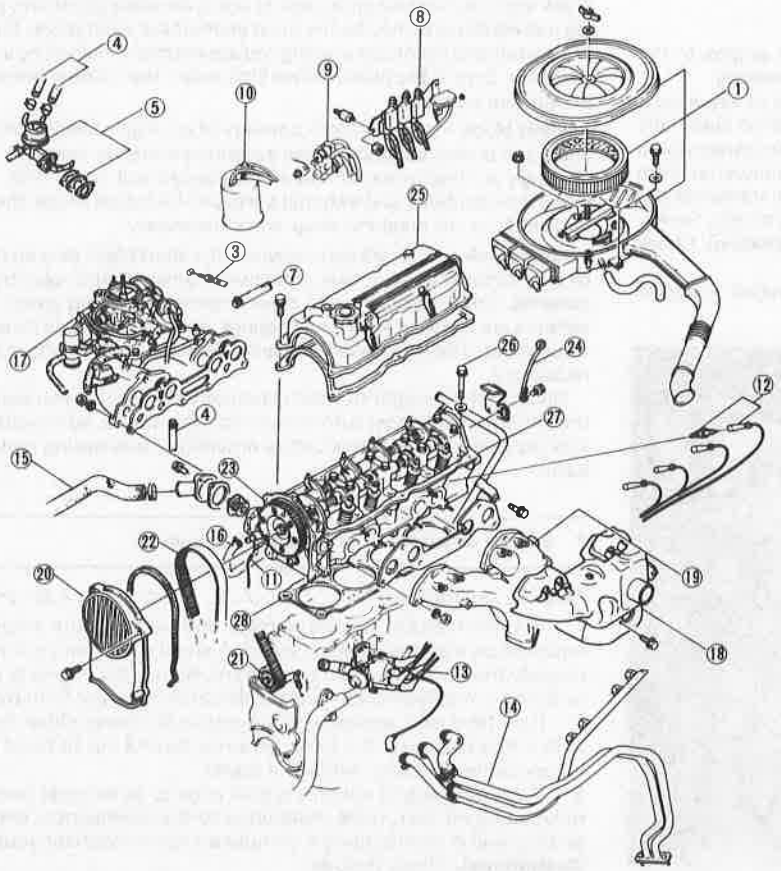
1 It's much easier to disassemble and work on the engine if it's mounted on a portable engine stand. A stand can often be rented quite cheaply from an equipment rental yard. Before the engine is mounted on a stand, the flywheel/driveplate should be removed from the engine.
2 If a stand isn't available, it's possible to disassemble the engine with it blocked up on the floor. Be extra careful not to tip or drop the engine when working without a stand.
3 If you're going to obtain a rebuilt engine, all external components must come off first, to be transferred to the replacement engine, just as they will if you're doing a complete engine overhaul yourself **(see illustrations)**. These include:

*Alternator and brackets**
*A/C compressor and brackets**



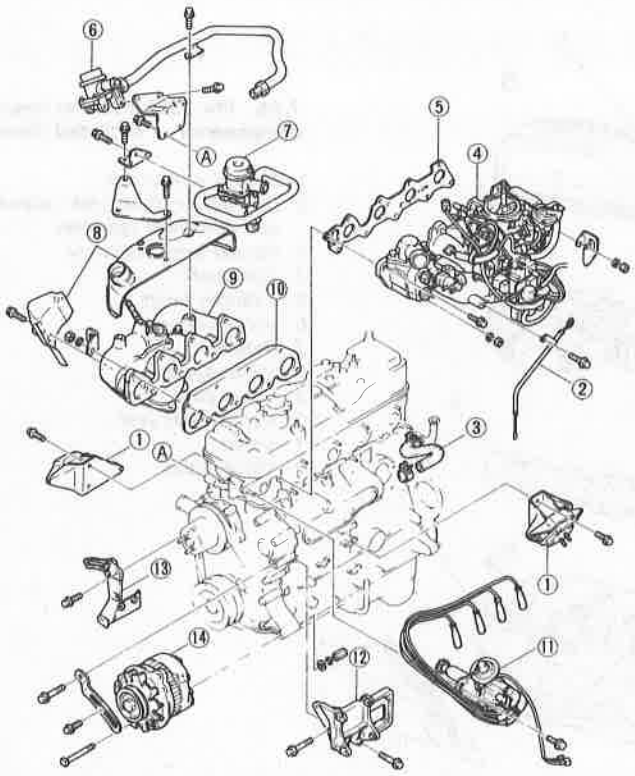
7.3a B2200 engine external components — exploded view

1 Engine mount
2 A/C compressor and power steering pump bracket
3 Cooling fan bracket
4 Alternator
5 Alternator bracket
6 Thermostat and housing
7 Exhaust manifold
8 N/A
9 Distributor
10 Intake manifold
11 Fuel pump
12 Oil filter
13 Oil pressure sending unit
14 Lower radiator hose



7.3b B2200 engine internal components — exploded view

1 Air cleaner assembly
2 Not used
3 Throttle cable
4 Fuel hose
5 Fuel pump (M/T)
6 Not used
7 Brake vacuum hose
8 3-way solenoid valves and vacuum sensor assembly
9 Duty solenoid valve assembly
10 Canister hose
11 Engine harness connector
12 Spark plugs/wires
13 Distributor
14 Secondary air hose assembly
15 Upper radiator hose
16 Coolant bypass hose
17 Intake manifold
18 Exhaust manifold shroud
19 Exhaust manifold
20 Upper timing belt cover
21 Timing belt tensioner and spring
22 Timing belt
23 Camshaft sprocket
24 Engine ground wire
25 Rocker arm cover
26 Head bolt
27 Cylinder head
28 Head gasket

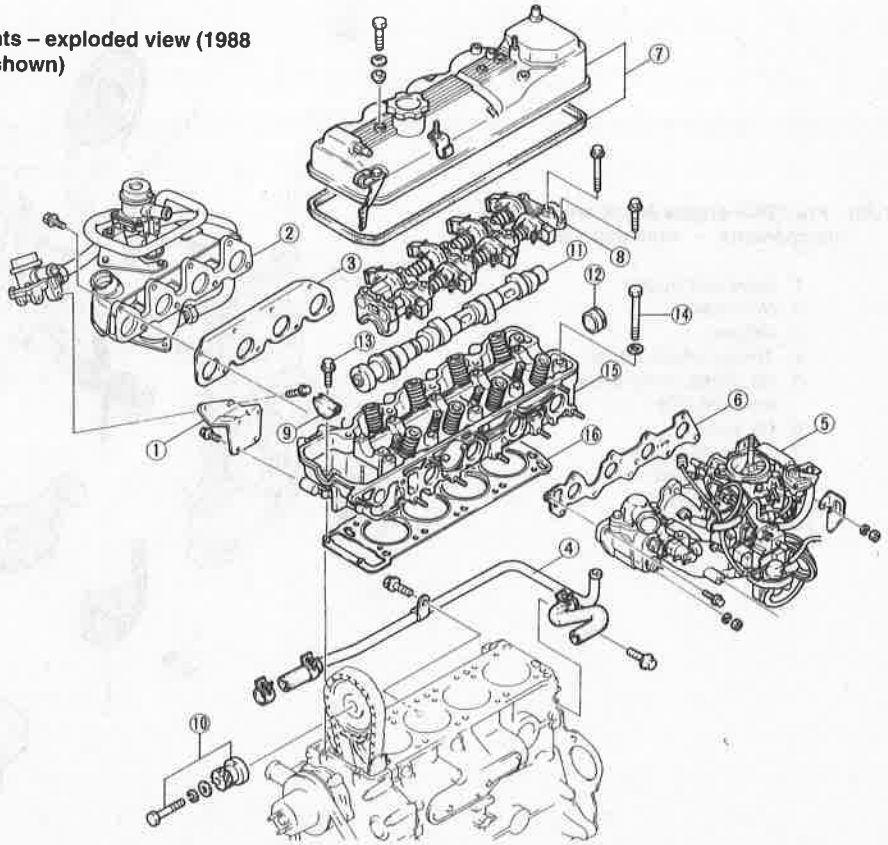


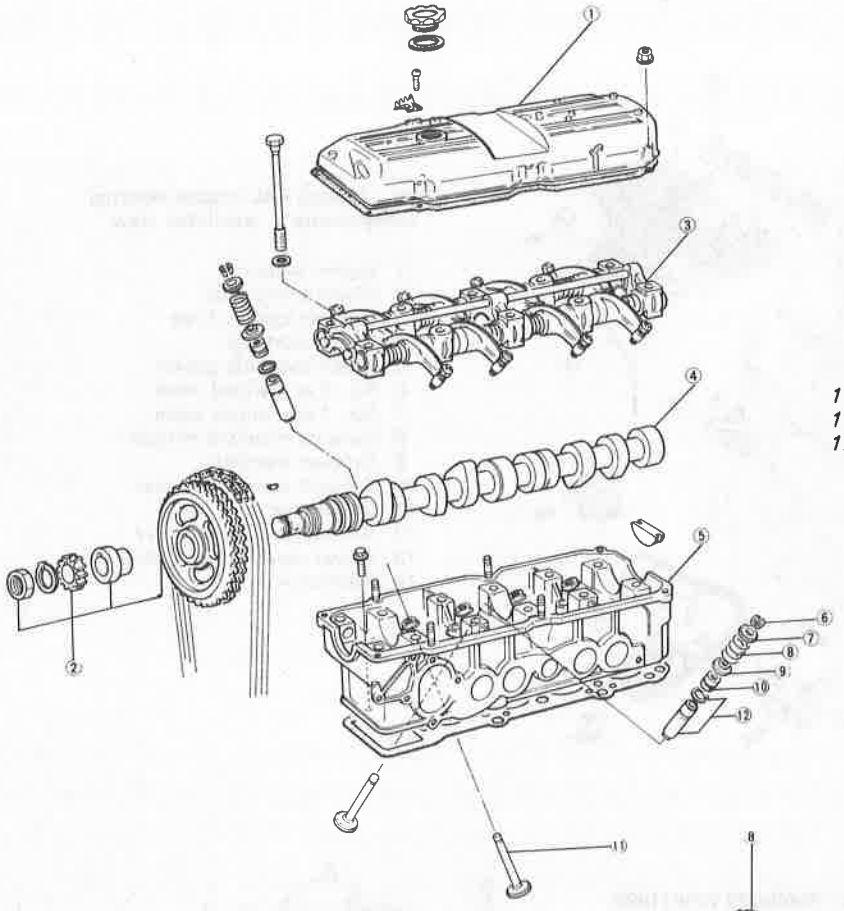
7.3c Typical 2.6L engine external components — exploded view

1 *Engine mount*
2 *Dipstick and tube*
3 *Coolant bypass hose*
4 *Intake manifold*
5 *Intake manifold gasket*
6 *No. 2 air control valve*
7 *No. 1 air control valve*
8 *Exhaust manifold shroud*
9 *Exhaust manifold*
10 *Exhaust manifold gasket*
11 *Distributor*
12 *A/C compressor bracket*
13 *Power steering pump bracket*
14 *Alternator*

7.3d 2.6L engine internal components – exploded view (1988 and earlier model shown)

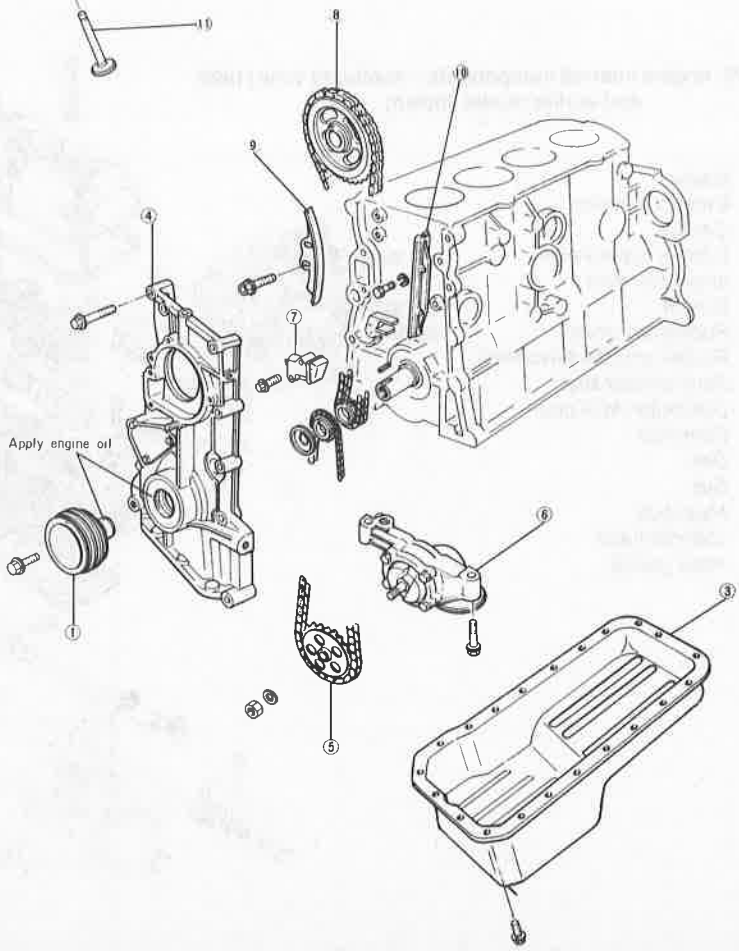
1 *Bracket*
2 *Exhaust manifold*
3 *Gasket*
4 *Coolant bypass pipe*
5 *Intake manifold*
6 *Gasket*
7 *Rocker arm cover*
8 *Rocker arm shaft assembly*
9 *Semi-circular seal*
10 *Distributor drive gear*
11 *Camshaft*
12 *Seal*
13 *Bolt*
14 *Head bolt*
15 *Cylinder head*
16 *Head gasket*





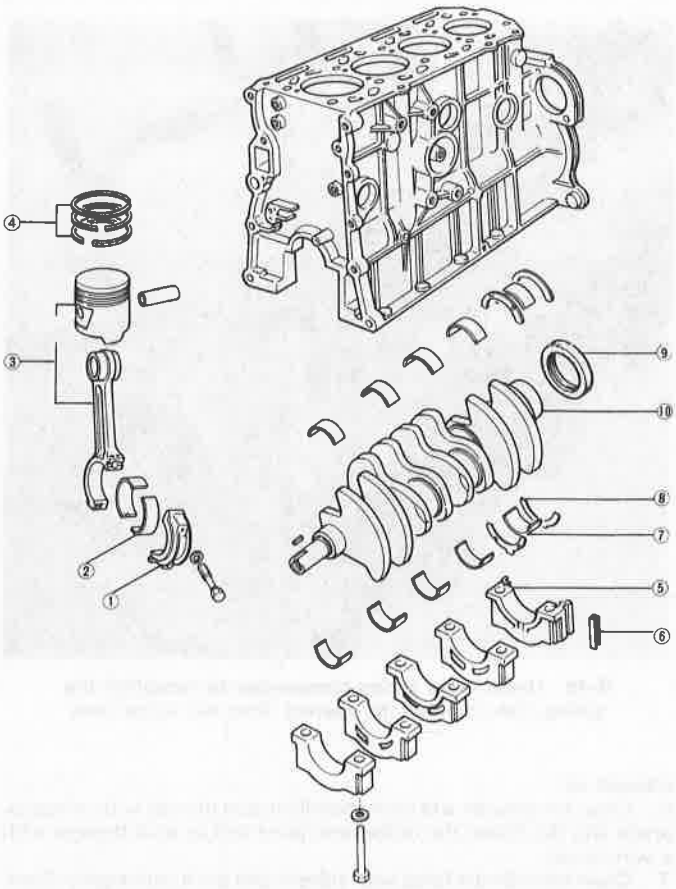
7.5a Pre-1985 cylinder head components — exploded view

1 Rocker arm cover
2 Distributor drive gear, spacer and camshaft sprocket
3 Rocker arm assembly
4 Camshaft
5 Cylinder head
6 Valve keepers
7 Retainer
8 Valve spring
9 Valve seat
10 Valve stem seal
11 Valve
12 Valve guide



7.5b Pre-1985 engine block and related components — exploded view

1 Drivebelt pulley
2 Not used
3 Oil pan
4 Timing chain cover
5 Oil pump drive chain and sprocket
6 Oil pump
7 Chain tensioner
8 Timing chain
9 Chain guide
10 Chain guide



7.5c Pre-1985 engine internal components — exploded view

1 Connecting rod cap	*6 Side seal*
2 Connecting rod bearing	*7 Main bearing*
3 Connecting rod and piston	*8 Thrust bearing*
4 Piston rings	*9 Crankshaft rear oil seal*
5 Main bearing cap	*10 Crankshaft*

*Power steering pump and brackets**
Emissions control components
*Distributor, spark plug wires and spark plugs**
Thermostat and housing cover
Water pump
Carburetor
Intake/exhaust manifolds
*Oil filter**
Engine mounts
Clutch and flywheel/driveplate
Engine rear plate

**Usually done as part of engine removal procedure*

Note: *When removing the external components from the engine, pay close attention to details that may be helpful or important during installation. Note the installed position of gaskets, seals, spacers, pins, brackets, washers, bolts and other small items.*

4 If you're obtaining a short block, which consists of the engine block, crankshaft, pistons and connecting rods all assembled, then the cylinder head, oil pan and oil pump will have to be removed as well. See *Engine rebuilding alternatives* for additional information regarding the different possibilities to be considered.

5 If you're planning a complete overhaul, the engine must be disassembled and the internal components **(see illustrations)** removed in the following order:

Rocker arm cover
Intake and exhaust manifolds
Timing cover
Timing chain or belt and sprockets
Rocker arm assembly and camshaft
Cylinder head
Oil pan

8.3 A small plastic bag, with an appropriate label, can be used to store the valve train components so they can be kept together and reinstalled in the correct guide

Oil pump
Piston/connecting rod assemblies
Crankshaft and main bearings

6 Before beginning the disassembly and overhaul procedures, make sure the following items are available. Also, refer to *Engine overhaul — reassembly sequence* for a list of tools and materials needed for engine reassembly.

Common hand tools
Small cardboard boxes or plastic bags for storing parts
Gasket scraper
Ridge reamer
Micrometers
Telescoping gauges
Dial indicator set
Valve spring compressor
Cylinder surfacing hone
Piston ring groove cleaning tool
Electric drill motor
Tap and die set
Wire brushes
Oil gallery brushes
Cleaning solvent

8 Cylinder head — disassembly

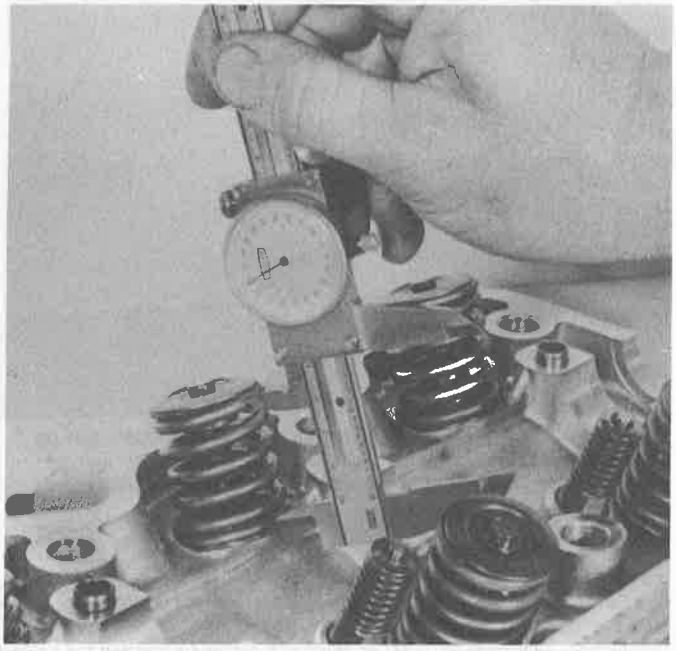
Refer to illustrations 8.3, 8.4a and 8.4b

Note: *New and rebuilt cylinder heads are commonly available for most engines at dealerships and auto parts stores. Due to the fact that some specialized tools are necessary for the disassembly and inspection procedures, and replacement parts may not be readily available, it may be more practical and economical for the home mechanic to purchase a replacement head rather than taking the time to disassemble, inspect and recondition the original.*

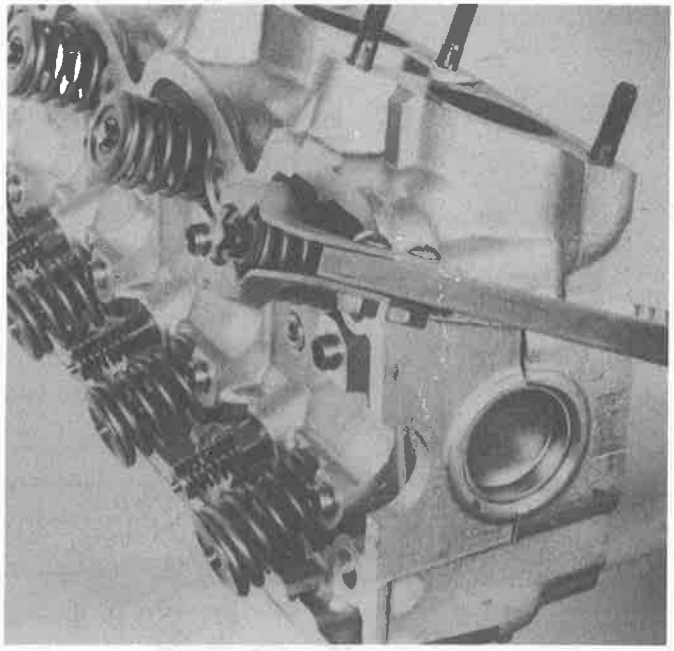
1 Cylinder head disassembly involves removal of the intake and exhaust valves and related components. The camshaft and rocker arm assembly should have been removed previously and the bearing caps (and bearings — if equipped) stored separately in order.

2 The jet valves should be removed from the cylinder head of the 2.6L engine before removal of the intake and exhaust valves. Use a six-point socket and a breaker bar to unscrew them. **Caution:** *Do not tilt the socket — excessive force exerted on the valve spring retainers can easily bend the jet valve stems.* Label each jet valve to ensure installation in its original position. The jet valves can be disassembled by carefully compressing the spring and removing the keepers, the retainer and the spring. Slide the valve out of the body and pull off the seal with a pair of pliers. Discard the old seals. Use new ones during reassembly. Do not allow the parts for one jet valve assembly to become accidentally interchanged with those of another.

3 Before the intake and exhaust valves are removed, arrange to label and store them, along with their related components, so they can be kept separate and reinstalled in the same valve guides they are removed from **(see illustration)**.



8.4a Measuring the valve spring installed height with a dial caliper



8.4b Use a valve spring compressor to compress the spring, then remove the keepers from the valve stem

4 Measure the valve spring installed height for each valve and compare it to the Specifications **(see illustration)**. If it is greater than specified the valve seats and faces need attention. Compress the springs on the first valve with a spring compressor and remove the keepers **(see illustration)**. Carefully release the valve spring compressor and remove the retainer, the spring and the spring seat (if used).

5 Pull the valve out of the head, then remove the oil seal from the guide. If the valve binds in the guide (won't pull through), push it back into the head and deburr the area around the keeper groove with a fine file or whetstone.

6 Repeat the procedure for the remaining valves. Remember to keep all the parts for each valve together so they can be reinstalled in the same locations.

7 Once the valves and related components have been removed and stored in an organized manner, the head should be thoroughly cleaned and inspected. If a complete engine overhaul is being done, finish the engine disassembly procedures before beginning the cylinder head cleaning and inspection process.

9 Cylinder head — cleaning and inspection

1 Thorough cleaning of the cylinder head and related valve train components, followed by a detailed inspection, will enable you to decide how much valve service work must be done during the engine overhaul. **Note:** *If the engine was overheated, the cylinder head is probably warped.*

Cleaning

Refer to illustration 9.4

2 Scrape away all traces of old gasket material and sealing compound from the head gasket, intake manifold and exhaust manifold sealing surfaces. **Caution:** *Do not gouge the cylinder head.* Special gasket removal solvents which dissolve the gasket, making removal much easier, are available at auto parts stores.

3 Remove any built up scale around the coolant passages.

4 Run a stiff wire brush through the oil holes, the EGR gas ports and the jet air passages to remove any deposits that may have formed in them **(see illustration)**.

5 Run an appropriate size tap into each of the threaded holes to remove any corrosion and thread sealant that may be present. If compressed air is available, use it to clear the holes of debris produced by this operation. **Warning:** *Wear eye protection when using compressed air.*

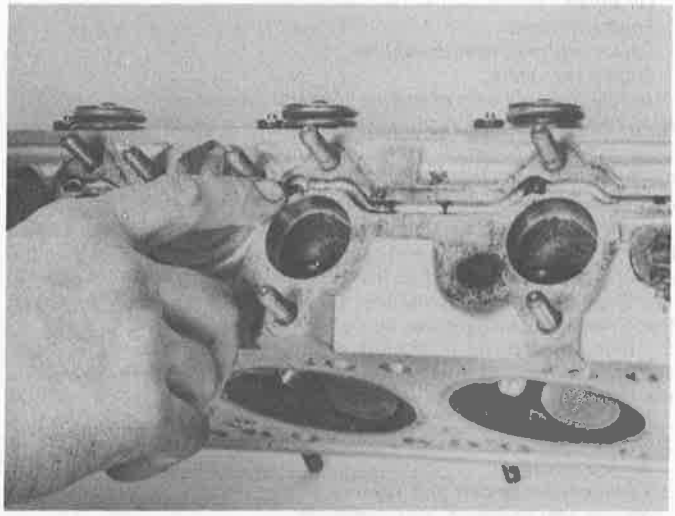
6 Clean the exhaust and intake manifold stud threads with an appropriate size die. Clean the rocker arm pivot bolt or stud threads with a wire brush.

7 Clean the cylinder head with solvent and dry it thoroughly. Compressed air will speed the drying process and ensure that all holes and recessed areas are clean. **Note:** *Decarbonizing chemicals may prove helpful for cleaning cylinder heads and valve train components. They are very caustic and should be used with caution. Be sure to follow the instructions on the container.*

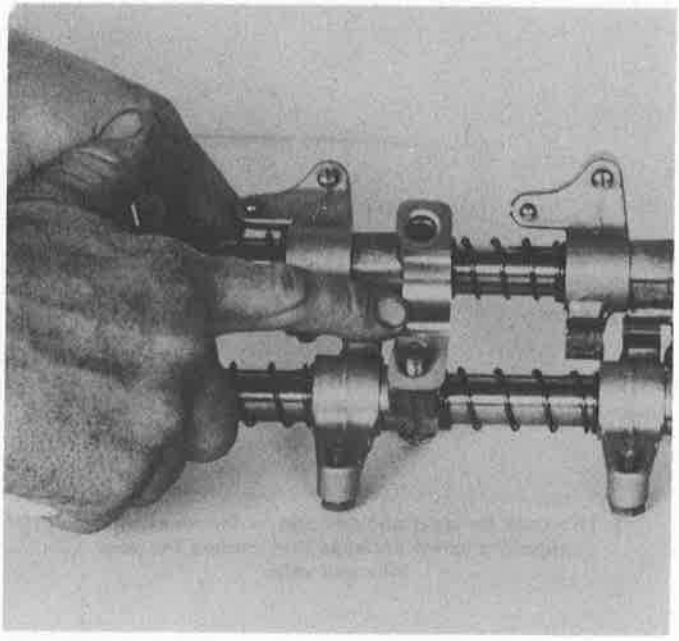
8 Without dismantling the rocker arm assembly, clean the rocker arms and shafts with solvent and dry them thoroughly. Compressed air will speed the drying process and can be used to clean out the oil passages.

9 Clean all the valve springs, keepers and retainers with solvent and dry them thoroughly. Clean these assemblies one at a time to avoid mixing up the parts.

10 Scrape off any heavy deposits that may have formed on the valves, then use a motorized wire brush to remove the remaining deposits from



9.4 The Jet air passages, EGR ports and oil holes must be clean and clear



9.11 Inspect the camshaft bearing caps for signs of wear and damage such as galling and pitting

the valve heads and stems. Again, do not mix up the valves. If you are servicing a 2.6L engine cylinder head, also clean the jet valve components with solvent. Do one jet valve assembly at a time so the parts are not accidentally interchanged. Carefully remove any deposits from the stems and valve heads with a fine wire brush. **Caution:** *Do not bend the valve stems of the jet valves while cleaning them.*

Inspection

Cylinder head

Refer to illustrations 9.11, 9.12, 9.14 and 9.15

11 Inspect the head very carefully for cracks, evidence of coolant leakage and other damage. If cracks are discovered, a new cylinder head must be obtained. Check the camshaft bearing surfaces in the head and the bearing caps **(see illustration)**. On engines without replaceable cam bearings, if there is evidence of excessive cam bearing galling or scoring, the head must be replaced. Failure to do so can lead to camshaft seizure.

12 Using a precision straightedge and feeler gauges, check the head gasket mating surface for warpage **(see illustration)**. If the warpage exceeds the specified amount, the head should be resurfaced at an automotive machine shop.

13 Examine the valve seats in each of the combustion chambers. If they are pitted, cracked or burned, take the head to an automotive machine shop for a valve job. This procedure is beyond the scope of the home mechanic.

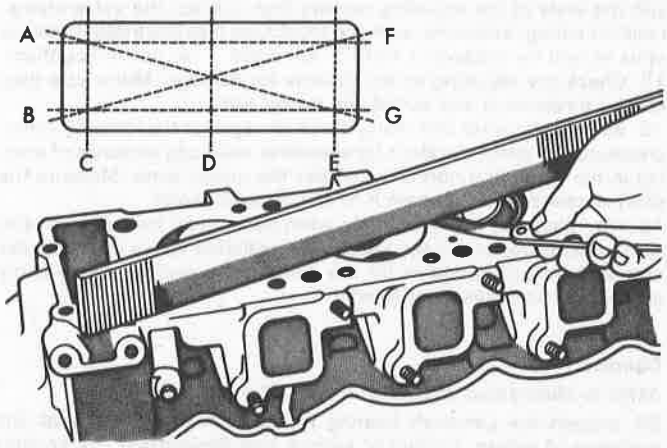
14 Check the valve stem-to-valve guide clearance. Use a dial indicator to measure the lateral movement of each valve stem with the valve in the guide and raised off the seat slightly **(see illustration)**. If there is still some doubt regarding the condition of the valve guides after this check, the exact clearance and condition of the guides can be checked by an automotive machine shop.

15 To check the camshaft end play, install the camshaft in the cylinder head. Mount a dial indicator with the stem resting against the end of the camshaft **(see illustration)**. Push the camshaft all the way to the rear and zero the dial indicator. Push the camshaft forward and note how far it moves. Compare the reading to the Specifications.

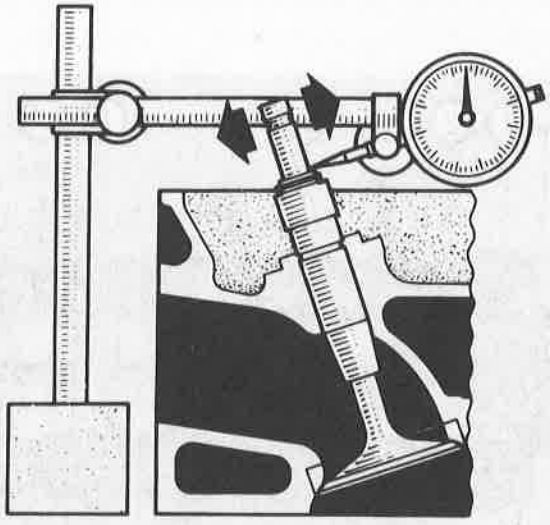
Rocker arm assembly (2.6L engine)

Refer to illustrations 9.16, 9.19a, 9.19b, 9.19c, 9.19d and 9.19e

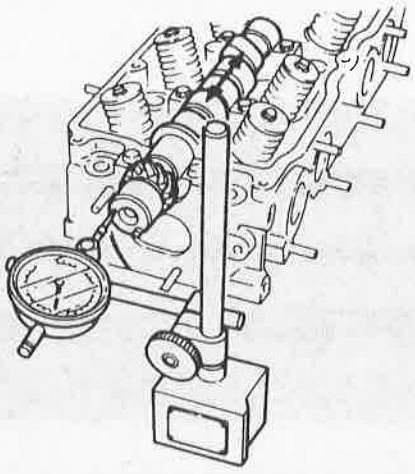
16 The rocker arms are mounted on shafts that rest in the camshaft bearing caps and they are held together by the mounting bolts. The rocker arms contact the valve on one end and the camshaft on the



9.12 Check the cylinder head gasket surface for warpage by trying to slip a feeler gauge under the straightedge (see the Specifications for the maximum warpage allowed and use a feeler gauge of that thickness)



9.14 A dial indicator can be used to determine the valve stem-to-guide clearance (move the valve stem as indicated by the arrows)



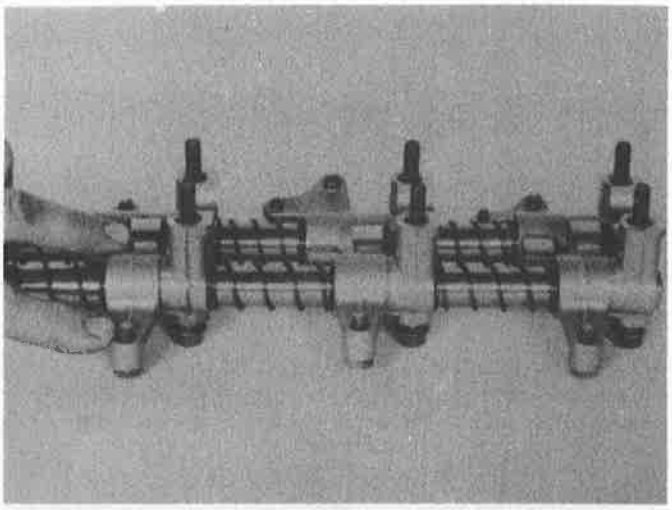
9.15 Measure the camshaft end play with a dial indicator

other end. Check the rocker arm faces that contact the camshaft lobes and the ends of the adjusting screws that contact the valve stems. Look for pitting, excessive wear and roughness **(see illustration)**. Rocker arms should be replaced if worn or damaged — do not reface them.

17 Check the adjusting screw threads for damage. Make sure they can be threaded in and out of the rocker arms.

18 Slide each rocker arm along the shaft, against the locating spring pressure, and check the shaft for excessive wear and evidence of scoring in the areas that normally contact the rocker arms. Measure the shaft diameter and compare it to the Specifications.

19 Any damaged or excessively worn parts must be replaced with new ones. Refer to the accompanying exploded views of the rocker arm assembly components for the correct sequence of disassembly and reassembly **(see illustrations)**.

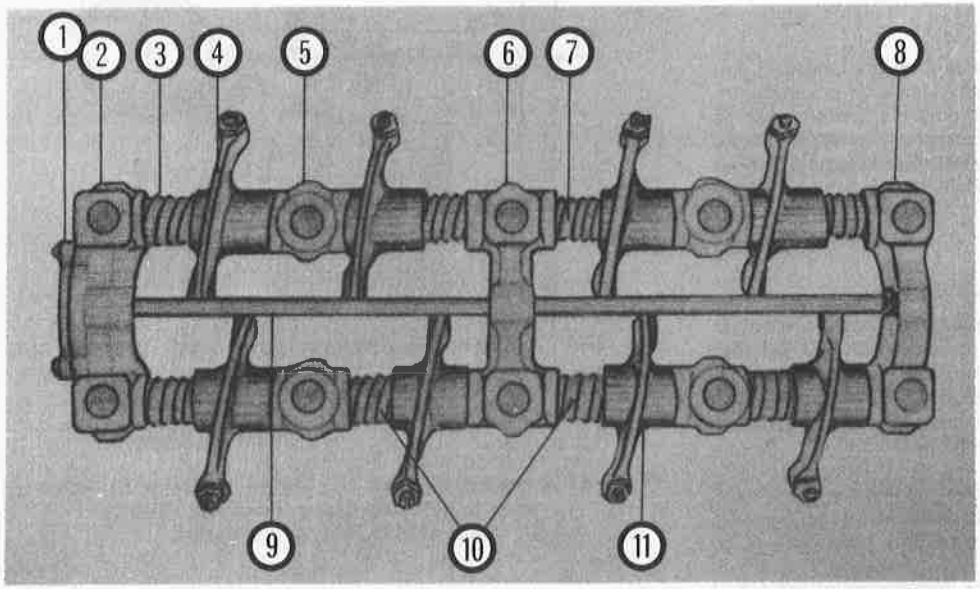


9.16 Look for wear and damage on the rocker arm and adjusting screw surfaces that contact the cam lobe and valve

Camshaft

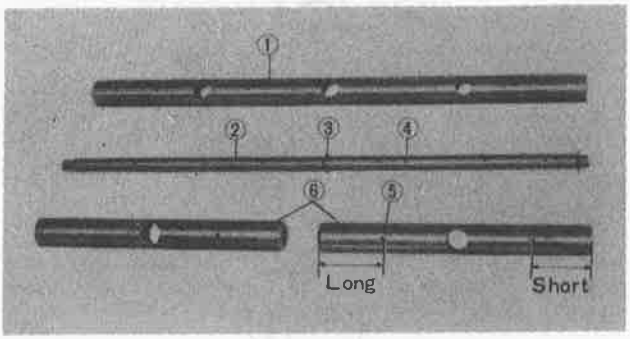
Refer to illustrations 9.20a, 9.20b, 9.21 and 9.23

20 Inspect the camshaft bearing journals for excessive wear and evidence of galling, scoring or seizure **(see illustration)**. On engines without replaceable cam bearings, if the journals are damaged, the bearing surfaces in the head and bearing caps are probably damaged as well. Both the camshaft and cylinder head will have to be replaced. Pre-1985 models have replaceable cam bearings **(see illustration)** available in several undersizes. This allows the cam to be machined undersize and re-used with the proper bearings.



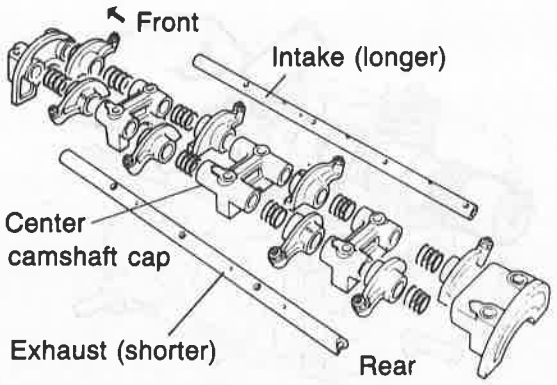
9.19a The oil pipe is installed with the oil ejection holes facing the camshaft and the O-ring in the center bearing cap (pre-1985 models)

1 Thrust plate
2 Front bearing cap
3 Spring
4 Exhaust rocker arm
5 Support
6 Center bearing cap
7 Exhaust rocker shaft
8 Rear bearing cap
9 Oil distribution pipe
10 Intake rocker shaft
11 Intake rocker arm

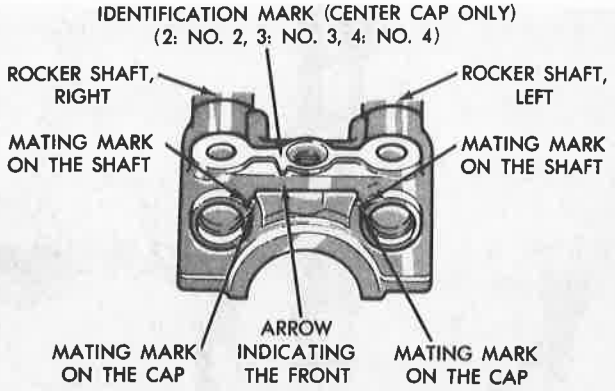


9.19b Pre-1985 rocker shaft components (the ends of the two intake shafts with the longer distance between the oil hole and shaft end must face each other)

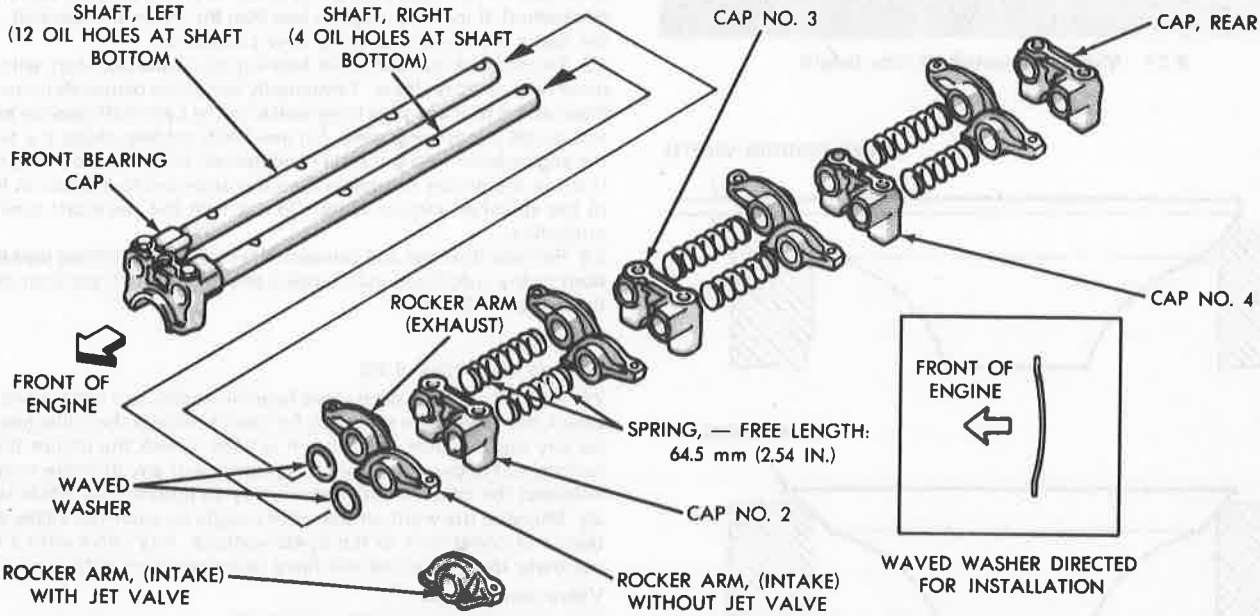
1 Exhaust-side shaft
2 Oil distribution pipe
3 O-ring
4 Oil hole
5 Oil hole
6 Intake-side shaft (two-piece)



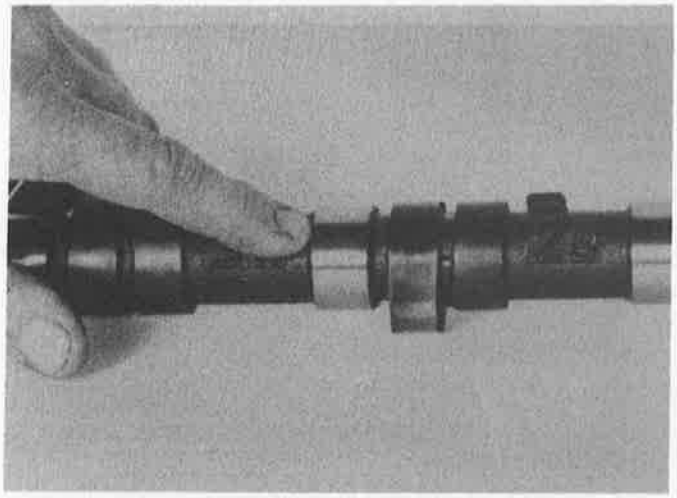
9.19c Rocker arm and shaft components — exploded view (engines with timing belt)



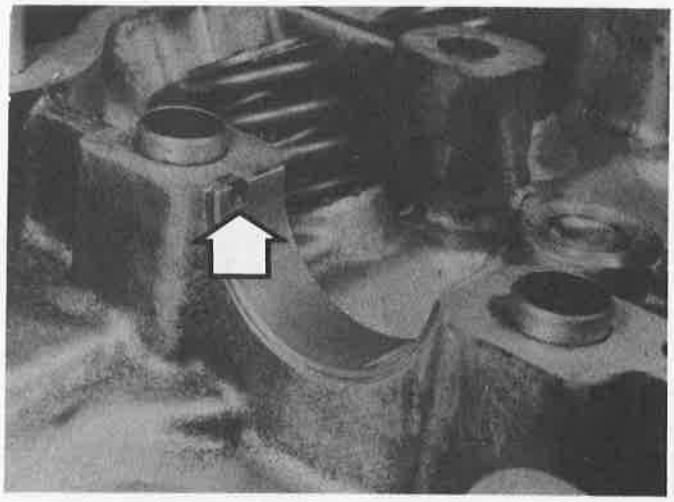
9.19d 2.6L engine camshaft bearing cap marks (1988 and earlier models)



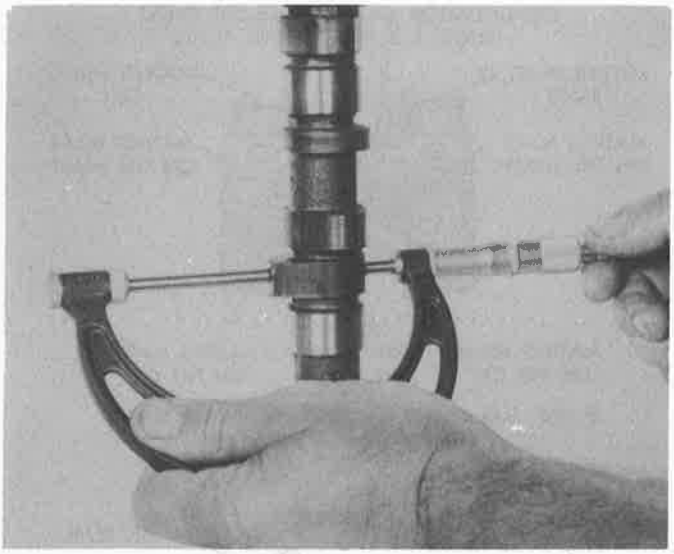
9.19e 2.6L engine rocker arm shaft components – exploded view (1988 and earlier models shown, others similar)



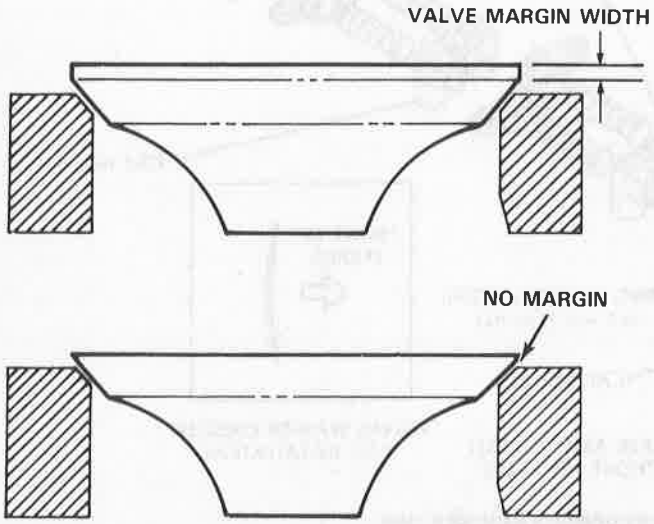
9.20a If the camshaft bearing journals are worn, scored or pitted, a new camshaft is required



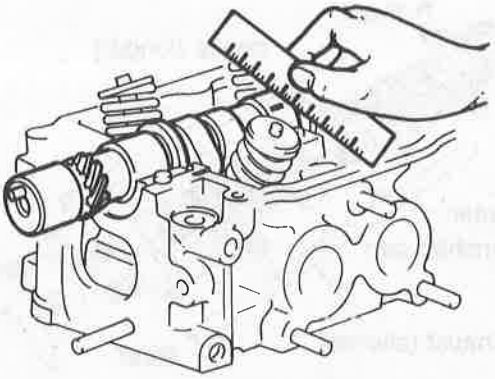
9.20b Pre-1985 models have replaceable cam bearings. The tang (arrow) must line up with the notch in the head



9.21 Measuring camshaft lobe height



9.25 The margin width on each valve must be as specified (if no margin exists, the valve cannnot be reused)



9.23 Compare the width of the crushed Plastigage to the scale on the envelope

21 Check the cam lobes for grooves, flaking, pitting and scoring. Measure the cam lobe height and compare it to the Specifications **(see illustration)**. If the lobe height is less than the minimum specified, and/or the lobes are damaged, get a new camshaft.

22 To measure the camshaft bearing oil clearance, start with clean parts with no oil on them. Temporarily install the camshaft in the head. Place strips of Plastigage lengthwise on the camshaft bearing journals and install the bearing caps. On pre-1985 models, place the head on the engine block, using the old head gasket. Install the bolts and tighten them in the proper sequence (see the appropriate Section in Part A) to the specified torque. **Note:** *Do not turn the camshaft during this procedure.*

23 Remove the caps and compare the Plastigage readings **(see illustration)** to the specifications. Replace any parts which are worn beyond the specified limits.

Valves

Refer to illustration 9.25

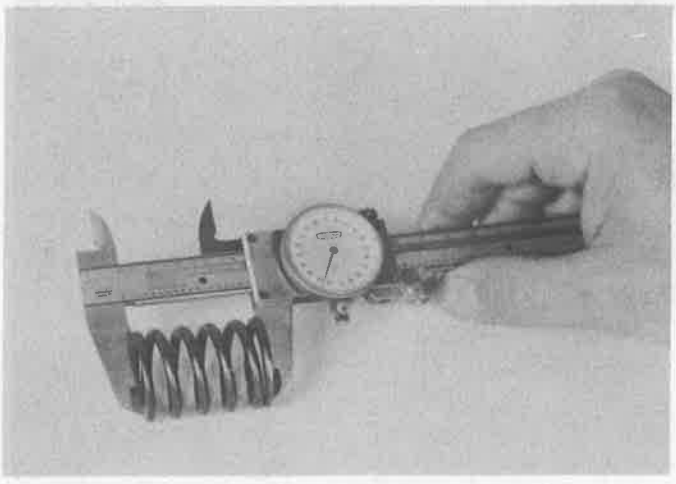
24 Carefully inspect each valve face for cracks, pits and burned spots. Check the valve stem and neck for cracks. Rotate the valve and check for any obvious indication that it is bent. Check the end of the stem for pits and excessive wear. The presence of any of these conditions indicates the need for valve service by an automotive machine shop.

25 Measure the width of the valve margin on each valve **(see illustration)** and compare it to the Specifications. Any valve with a margin narrower than specified will have to be replaced with a new one.

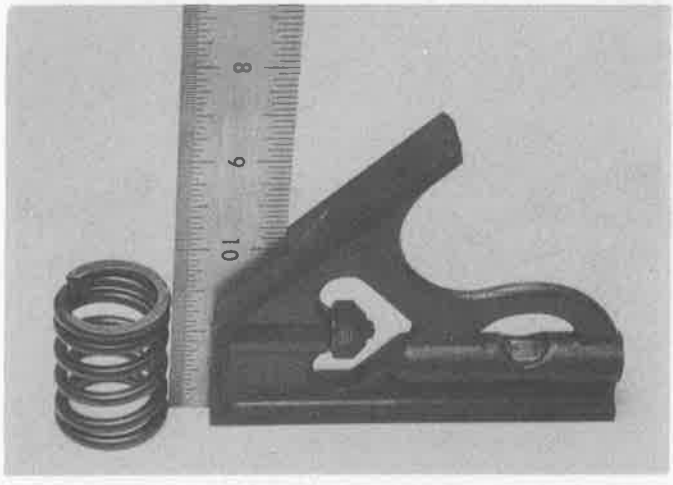
Valve components

Refer to illustrations 9.26a and 9.26b

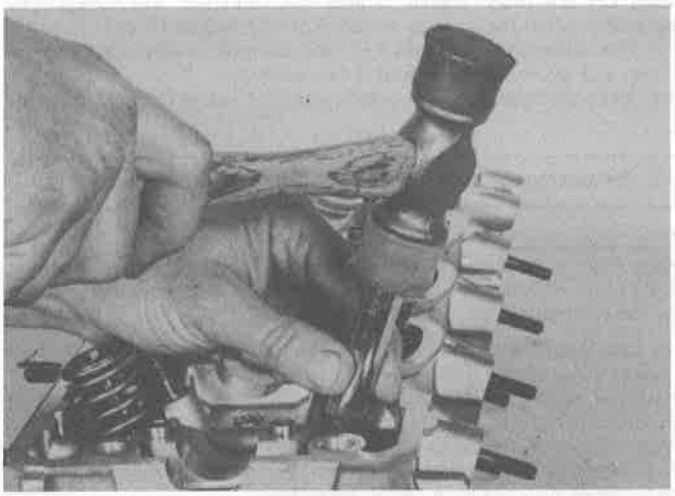
26 Check each valve spring for wear and pitting. Measure the free length and compare it to the Specifications **(see illustration)**. If a spring is shorter than specified, it has sagged and should not be reused. Stand the spring on a flat surface and check it for squareness **(see illustration)**.



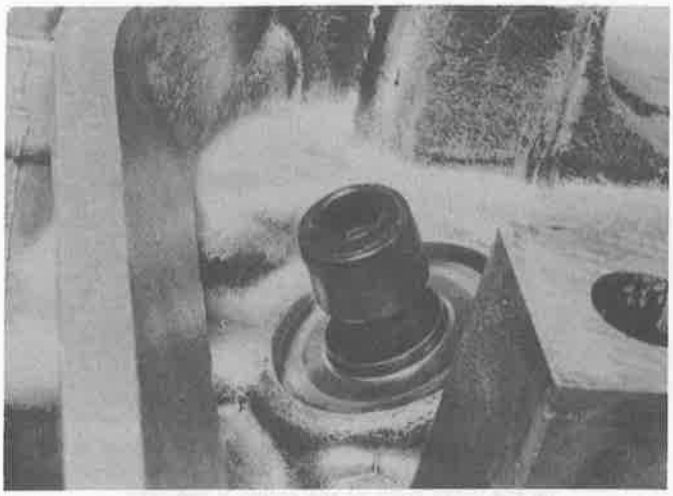
9.26a Measure the free length of each valve spring with a dial or vernier caliper



9.26b Check each valve spring for squareness



11.4a Install the new valve guide seals with a hammer and deep socket — don't hammer on the seals once they're seated!



11.4b Make sure the seals are completely seated on the valve guides

27 Check the spring retainers and keepers for obvious wear and cracks. Any questionable parts should be replaced with new ones. In the event that a retainer or keeper should fail during operation of the engine, extensive damage will occur.

Jet valve assemblies (2.6L engines through 1988)

28 Make sure the valves slide freely in their respective bodies, with no detectable side play. Check each valve head and seat for cracks and pits. Check each spring for wear (on the ends) and cracks. Measure the valve spring free length and the diameter of the stem. Compare the results to the Specifications.

29 If defects are found in any of the components, the entire valve assembly should be replaced with a new one.

30 If the inspection process indicates that the valve components are in generally poor condition and worn beyond the limits specified, which is often the case in an engine being overhauled, reassemble the valves in the cylinder head and refer to Section 10 for valve servicing recommendations.

31 If the inspection turns up no excessively worn parts, and if the valve faces and seats are in good condition, the valve train components can be reinstalled in the cylinder head without major servicing. Refer to the appropriate Section for cylinder head reassembly procedures.

10 Valves — servicing

1 Because of the complex nature of the job and the special tools and equipment needed, servicing of the valves, the valve seats and the valve guides, commonly known as a valve job, should be done by a professional.

2 The home mechanic can remove and disassemble the head, do the initial cleaning and inspection, then reassemble and deliver it to a dealer service department or an automotive machine shop for the actual service work. Doing the inspection will enable you to see what condition the head and valvetrain components are in and will ensure that you know what work and new parts are required when dealing with an automotive machine shop.

3 The dealer service department, or automotive machine shop, will remove the valves and springs, recondition or replace the valves and valve seats, recondition the valve guides, check and replace the valve springs, spring retainers and keepers (as necessary), replace the valve seals with new ones, reassemble the valve components and make sure the installed spring height is correct. The cylinder head gasket surface will also be resurfaced if it's warped.

4 After the valve job has been performed by a professional, the head will be in like new condition. When the head is returned, be sure to clean it again before installation on the engine to remove any metal particles and abrasive grit that may still be present from the valve service or head resurfacing operations. Use compressed air, if available, to blow out all the oil holes and passages.

11 Cylinder head — reassembly

Refer to illustrations 11.4a, 11.4b, 11.6 and 11.7

1 Regardless of whether or not the head was sent to an automotive repair shop for valve servicing, make sure it's clean before beginning reassembly.

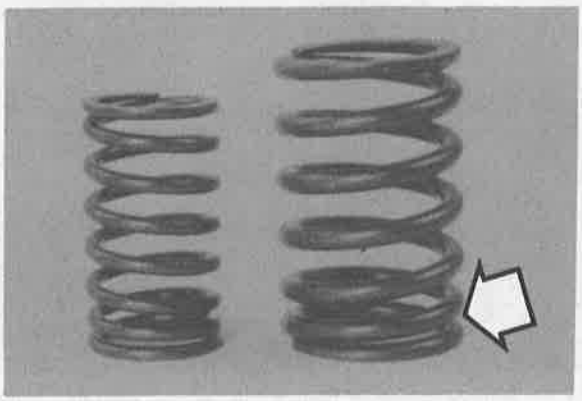
2 If the head was sent out for valve servicing, the valves and related components will already be in place. Begin the reassembly procedure with Step 8.

3 Install the valve spring seats (where applicable) prior to valve seal installation.

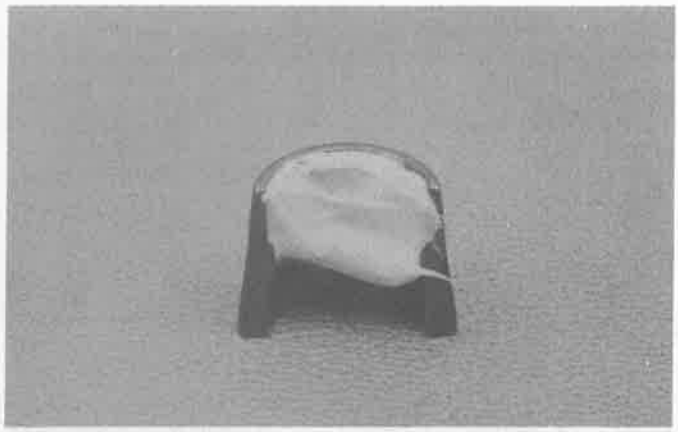
4 Install new seals on each of the valve guides with a hammer and deep socket. Gently tap each valve seal into place until it's seated on the guide **(see illustrations). Caution:** *Don't hammer on the valve seals once they're seated or you may damage them. Don't twist or cock the seals during installation or they won't seal properly on the valve stems.*

5 Apply moly-base grease or engine assembly lube to the first valve and install it in the head. Don't damage the new valve guide oil seal. Set the retainer and keepers in place. Check the installed spring height by lifting up on the retainer until the valve is seated. Measure the distance between the top of the spring seat and the underside of the retainer. Compare your measurement to the specified installed height. Add shims, if necessary to obtain the specified height.

6 Once the correct height is established, remove the keepers and retainer and install the valve springs. **Note:** *The outer spring has a graduated pitch. Install it with the narrow pitch end against the cylinder head* **(see illustration).**



11.6 Make sure each outer valve spring (right) is installed with the narrow pitch end (arrow) against the cylinder head



11.7 Apply a small dab of grease to each keeper as shown here before installation — it will hold them in place on the valve stem as the spring is released

7 Compress the springs and retainer with a valve spring compressor and slip the keepers into place. Release the compressor and make sure the keepers are seated properly in the valve stem groove. If necessary, grease can be used to hold the keepers in place as the compressor is released **(see illustration)**.

8 Double-check the installed valve spring height for each valve and compare it to the specified installed height **(see illustration 8.4a)**. If it was correct prior to reassembly, it should still be within the specified limits. If it isn't, you must install more shims until it's correct. **Caution:** *Don't, under any circumstances shim the springs to the point where the installed height is less than specified!*

9 If you're working on a 2.6L engine, install new seals on each of the jet valve bodies. Gently tap them into place with a hammer and deep socket. Lubricate and install the valves and make sure the stems slide smoothly in the valve bodies. Install the springs, the retainers and the keepers. When compressing the springs, be careful not to damage the valve stems or the new seals.

10 Install a new O-ring on each jet valve body and apply a thin coat of clean engine oil or grease to each O-ring, the jet valve threads and the seating surfaces.

11 Carefully thread the jet valve assemblies into the cylinder head and tighten them to the specified torque. **Caution:** *Do not tilt the socket — the valve stems bend very easily.*

12 On 2.6L engines and engines with a timing belt, install the camshaft and rocker arm shaft assembly (see Part A, Section 18). **Note:** *Lubricate all moving parts with moly-base grease or engine assembly lube.* On pre-1985 models, install the camshaft and rocker arm assembly when the head is installed on the engine block.

13 The valves should be adjusted cold (Chapter 1) after installing the head, and again after the engine has been run.

14 Store the head in a clean plastic bag until you're ready to install it.

12 Pistons/connecting rods — removal

Refer to illustrations 12.1, 12.3, 12.4 and 12.6

Note: *Prior to removing the piston/connecting rod assemblies, remove the cylinder head, the oil pan and the oil pump strainer by referring to the appropriate Sections in Chapter 2, Part A.*

1 Use your fingernail to feel if a ridge has formed at the upper limit of ring travel (about 1/4-inch down from the top of each cylinder). If carbon deposits or cylinder wear have produced ridges, they must be completely removed with a special tool **(see illustration)**. Follow the manufacturer's instructions provided with the tool. Failure to remove the ridges before attempting to remove the piston/connecting rod assemblies may result in piston breakage.

2 After the cylinder ridges have been removed, turn the engine upside-down so the crankshaft is facing up.

3 Before the connecting rods are removed, check the end play with feeler gauges. Slide them between the first connecting rod and the crankshaft throw until the play is removed **(see illustration)**. The end play is equal to the thickness of the feeler gauge(s). If the end play exceeds the service limit, new connecting rods will be required. If new rods (or a new crankshaft) are installed, the end play may fall under the specified minimum (if it does, the rods will have to be machined to restore it — consult an automotive machine shop for advice if necessary). Repeat the procedure for the remaining connecting rods.

4 Check the connecting rods and caps for identification marks. If they aren't plainly marked, use a small center punch to make the appropriate number of indentations on each rod and cap (1, 2, 3, etc., depending on the cylinder they're associated with) **(see illustration)**.

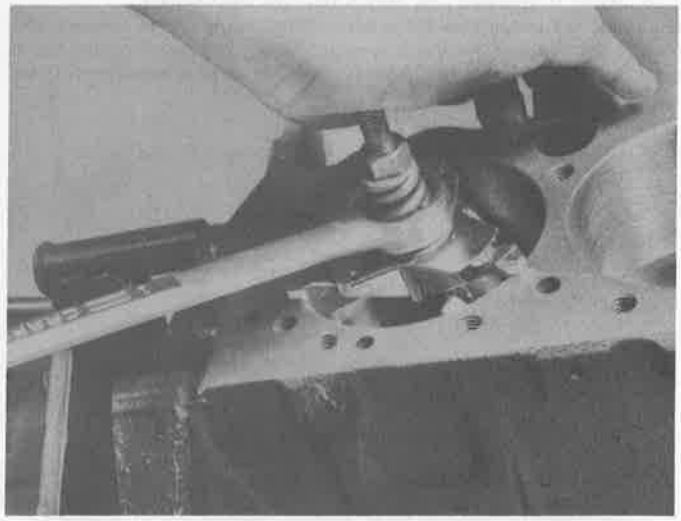
5 Loosen each of the connecting rod cap nuts 1/2-turn at a time until they can be removed by hand. Remove the number one connecting rod cap and bearing insert. Don't drop the bearing insert out of the cap.

6 Slip a short length of plastic or rubber hose over each connecting rod cap bolt to protect the crankshaft journal and cylinder wall as the piston is removed **(see illustration)**.

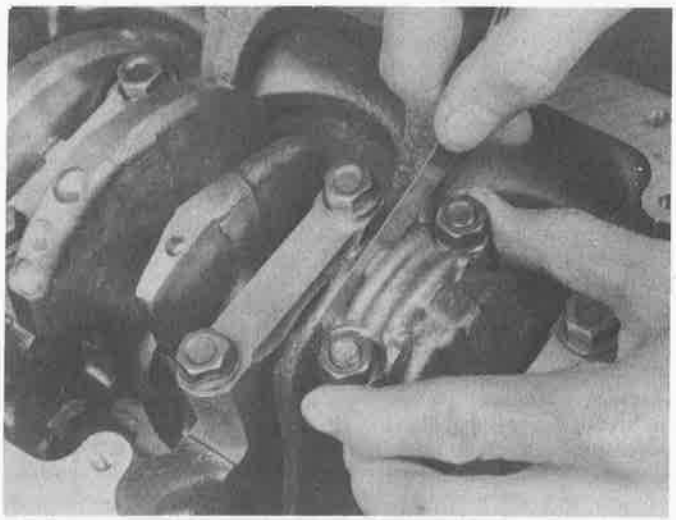
7 Remove the bearing insert and push the connecting rod/piston assembly out through the top of the engine. Use a wooden hammer handle to push on the upper bearing surface in the connecting rod. If resistance is felt, double-check to make sure that all of the ridge was removed from the cylinder.

8 Repeat the procedure for the remaining cylinders.

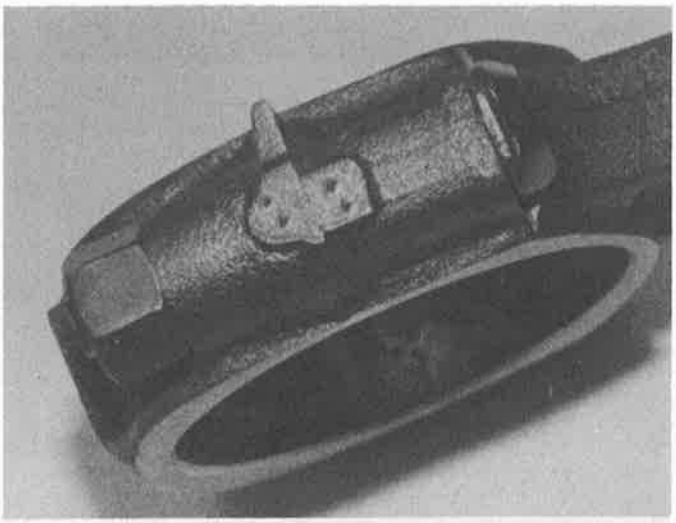
9 After removal, reassemble the connecting rod caps and bearing



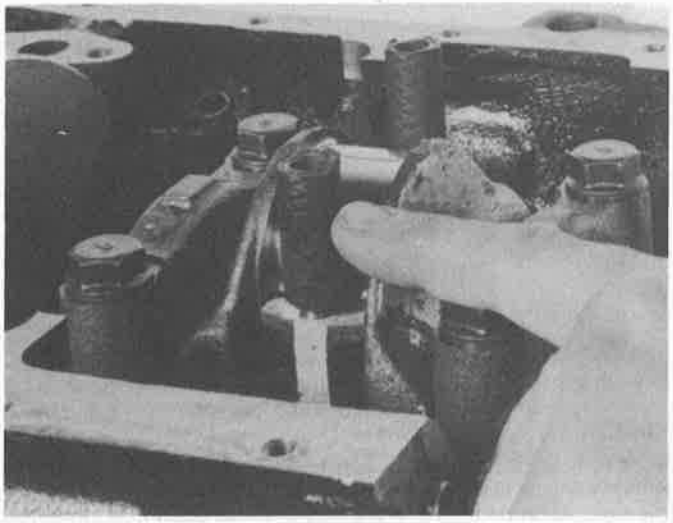
12.1 A ridge reamer is required to remove the ridge from the top of each cylinder — do this before removing the pistons!



12.3 Check the connecting rod side clearance with a feeler gauge as shown



12.4 The connecting rods and caps should be marked to indicate which cylinder they're installed in — if they aren't, mark them with a center punch to avoid confusion during reassembly



12.6 To prevent damage to the crankshaft journals and cylinder walls, slip sections of hose over the rod bolts before removing the pistons

inserts in their respective connecting rods and install the cap nuts finger tight. Leaving the old bearing inserts in place until reassembly will help prevent the connecting rod bearing surfaces from being accidentally nicked or gouged.

10 Don't separate the pistons from the connecting rods (see Section 17 for additional information).

13 Crankshaft — removal

Refer to illustrations 13.1, 13.4 and 13.5

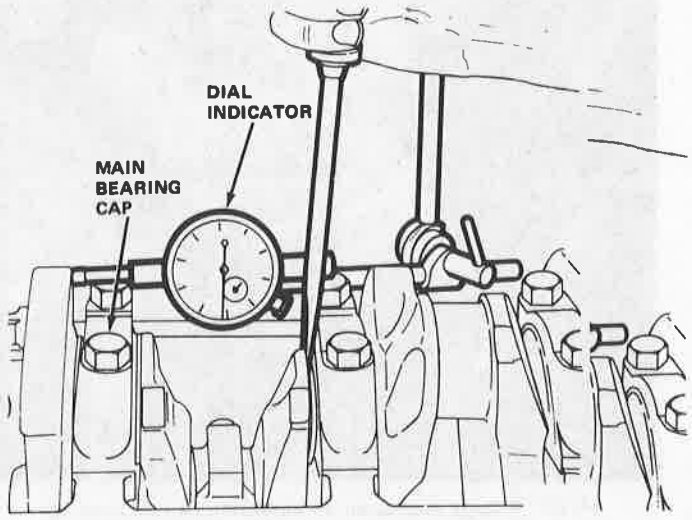
Note: *The crankshaft can be removed only after the engine has been removed from the vehicle. It's assumed that the flywheel or driveplate, vibration damper, timing chain or belt, oil pan, oil pump, front cover and piston/connecting rod assemblies have already been removed. If your engine is equipped with a seal housing, it must be unbolted and separated from the block before proceeding with crankshaft removal.*

1 Before the crankshaft is removed, check the end play. Mount a dial indicator with the stem in line with the crankshaft and just touching one of the crank throws **(see illustration)**.

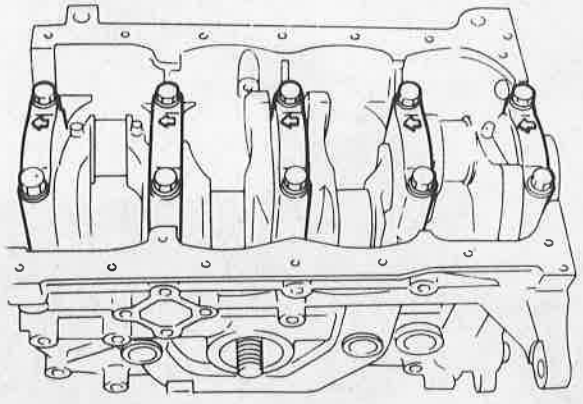
2 Push the crankshaft all the way to the rear and zero the dial indicator. Next, pry the crankshaft to the front as far as possible and check the reading on the dial indicator. The distance that it moves is the end play. If it's greater than specified, check the crankshaft thrust surfaces for wear. If no wear is evident, new main bearings or thrust bearings should correct the end play.

3 If a dial indicator isn't available, feeler gauges can be used. Gently pry or push the crankshaft all the way to the front of the engine. Slip feeler gauges between the crankshaft and the front face of the thrust main bearing to determine the clearance. The thrust bearing on pre-1985 engines is the rear main, while on 1986 and later engines it's the number three (center) main.

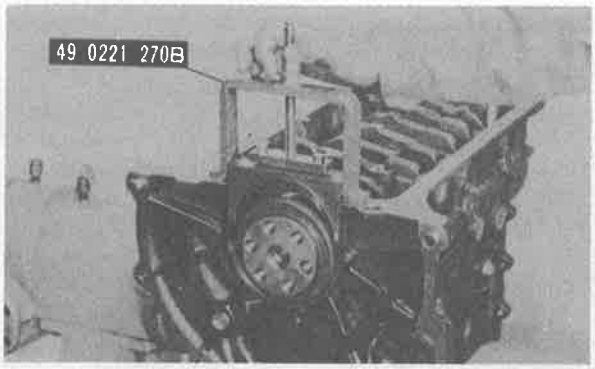
4 Check the main bearing caps to see if they're marked to indicate their locations. They should be numbered consecutively from the front of the engine to the rear. If they aren't, mark them with number stamping dies or a center punch. Main bearing caps generally have a cast-in arrow, which points to the front of the engine **(see illustration)**. Loosen the main bearing cap bolts 1/4-turn at a time each, until they can be removed by hand. Note if any stud bolts are used and make sure they're returned to their original locations when the crankshaft is reinstalled.



13.1 Checking crankshaft end play with a dial indicator



13.4 The main bearing caps have arrows facing toward the front of the engine



13.5 Using the special tool to remove the rear main bearing cap (pre-1985 engines)

5 Gently tap the caps with a soft-face hammer, then separate them from the engine block. If necessary, use the bolts as levers to remove the caps. **Note:** *On pre-1985 engines, a special puller may be needed to remove the rear bearing cap* **(see illustration).** Try not to drop the bearing inserts if they come out with the caps.

6 Carefully lift the crankshaft out of the engine. It may be a good idea to have an assistant available, since the crankshaft is quite heavy. With the bearing inserts in place in the engine block and main bearing caps, return the caps to their respective locations on the engine block and tighten the bolts finger tight. Store the crankshaft thrust bearings with the appropriate main bearing shells.

14 Engine block — cleaning

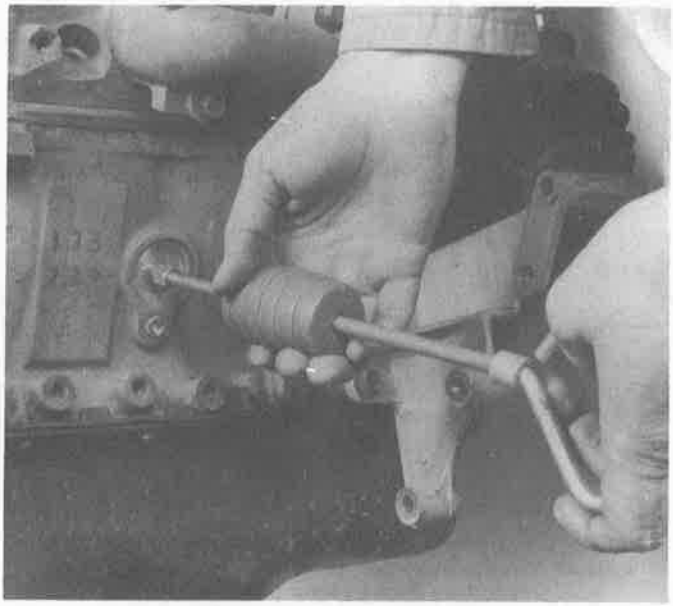
Refer to illustrations 14.1, 14.8 and 14.10

Caution: *The core plugs (also known as freeze or soft plugs) may be difficult or impossible to retrieve if they're driven into the block coolant passages.*

1 Drill a small hole in the center of each core plug and pull them out with an auto body type dent puller **(see illustration).**

2 Using a gasket scraper, remove all traces of gasket material from the engine block. Be very careful not to nick or gouge the gasket sealing surfaces.

3 Remove the main bearing caps and separate the bearing inserts from the caps and the engine block. Tag the bearings, indicating which cylinder they were removed from and whether they were in the cap or the block, then set them aside.

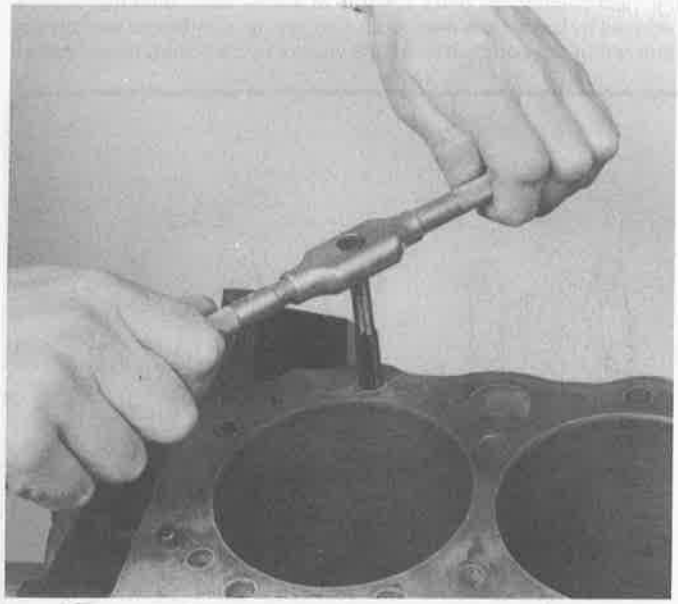


14.1 The core plugs should be removed with a puller — if they're driven into the block they may be impossible to retrieve

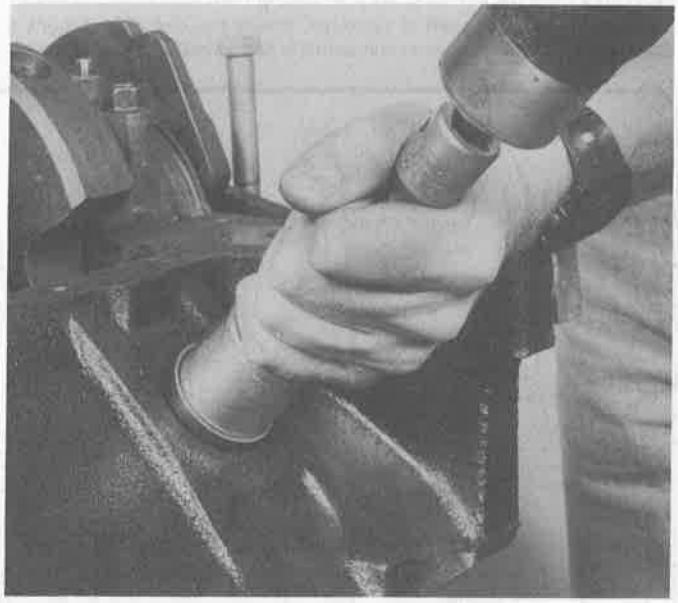
4 Remove all of the threaded oil gallery plugs from the block. The plugs are usually very tight — they may have to be drilled out and the holes retapped. Use new plugs when the engine is reassembled.

5 If the engine is extremely dirty it should be taken to an automotive machine shop to be steam cleaned or hot tanked.

6 After the block is returned, clean all oil holes and oil galleries one more time. Brushes specifically designed for this purpose are available at most auto parts stores. Flush the passages with warm water until the water runs clear, dry the block thoroughly and wipe all machined surfaces with a light, rust preventive oil. If you have access to compressed air, use it to speed the drying process and to blow out all the



14.8 All bolt holes in the block — particularly the main bearing cap and head bolt holes — should be cleaned and restored with a tap (be sure to remove debris from the holes after this is done)



14.10 A large socket on an extension can be used to drive the new core plugs into the bores

oil holes and galleries. **Warning:** *Wear eye protection when using compressed air!*

7 If the block isn't extremely dirty or sludged up, you can do an adequate cleaning job with hot soapy water and a stiff brush. Take plenty of time and do a thorough job. Regardless of the cleaning method used, be sure to clean all oil holes and galleries very thoroughly, dry the block completely and coat all machined surfaces with light oil.

8 The threaded holes in the block must be clean to ensure accurate torque readings during reassembly. Run the proper size tap into each of the holes to remove rust, corrosion, thread sealant or sludge and restore damaged threads **(see illustration)**. If possible, use compressed air to clear the holes of debris produced by this operation. Now is a good time to clean the threads on the head bolts and the main bearing cap bolts as well.

9 Reinstall the main bearing caps and tighten the bolts finger tight.

10 After coating the sealing surfaces of the new core plugs with Permatex no. 2 sealant, install them in the engine block **(see illustration)**. Make sure they're driven in straight and seated properly or leakage could result. Special tools are available for this purpose, but a large socket, with an outside diameter that will just slip into the core plug, a 1/2-inch drive extension and a hammer will work just as well.

11 Apply non-hardening sealant (such as Permatex no. 2 or Teflon pipe sealant) to the new oil gallery plugs and thread them into the holes in the block. Make sure they're tightened securely.

12 If the engine isn't going to be reassembled right away, cover it with a large plastic trash bag to keep it clean.

15 Engine block — inspection

Refer to illustrations 15.4a, 15.4b, 15.4c and 15.13

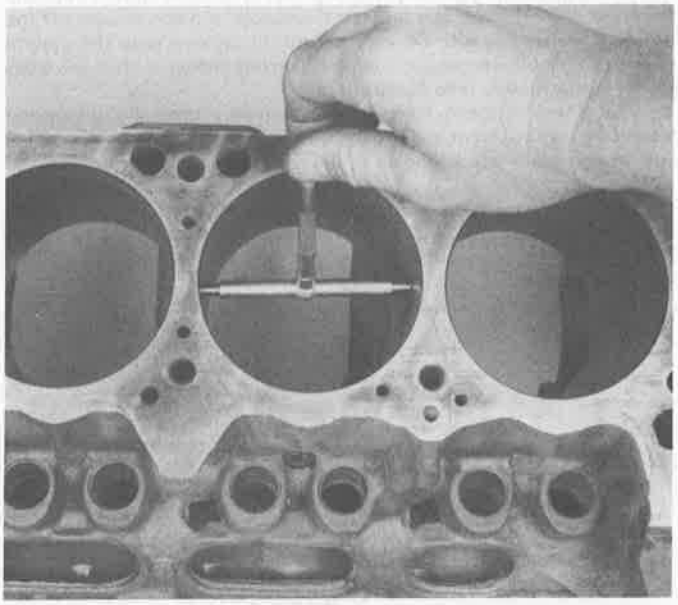
1 Before the block is inspected, it should be cleaned as described in Section 14.

2 Visually check the block for cracks, rust and corrosion. Look for stripped threads in the threaded holes. It's also a good idea to have the block checked for hidden cracks by an automotive machine shop that has the special equipment to do this type of work. If defects are found, have the block repaired, if possible, or replaced.

3 Check the cylinder bores for scuffing and scoring.

4 Measure the diameter of each cylinder at the top (just under the ridge area), center and bottom of the cylinder bore, parallel to the crankshaft axis **(see illustrations)**.

5 Next, measure each cylinder's diameter at the same three locations *across* the crankshaft axis. Compare the results to the Specifications.



15.4b The ability to "feel" when the telescoping gauge is at the correct point will be developed over time, so work slowly and repeat the check until you're satisfied that the bore measurement is accurate

6 If the required precision measuring tools aren't available, the piston-to-cylinder clearances can be obtained, though not quite as accurately, using feeler gauge stock. Feeler gauge stock comes in 12-inch lengths and various thicknesses and is generally available at auto parts stores.

7 To check the clearance, select a feeler gauge and slip it into the cylinder along with the matching piston. The piston must be positioned exactly as it normally would be. The feeler gauge must be between the piston and cylinder on one of the thrust faces (90° to the piston pin bore).

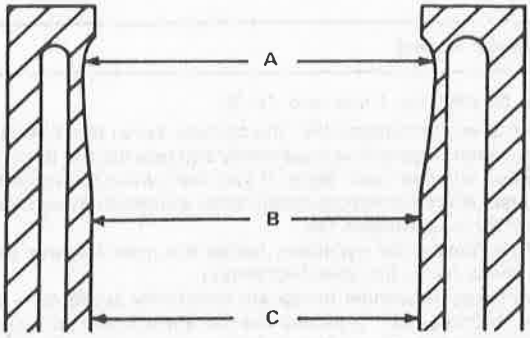
8 The piston should slip through the cylinder (with the feeler gauge in place) with moderate pressure.

9 If it falls through or slides through easily, the clearance is excessive and a new piston will be required. If the piston binds at the lower end of the cylinder and is loose toward the top, the cylinder is tapered. If tight spots are encountered as the piston/feeler gauge is rotated in the cylinder, the cylinder is out-of-round.

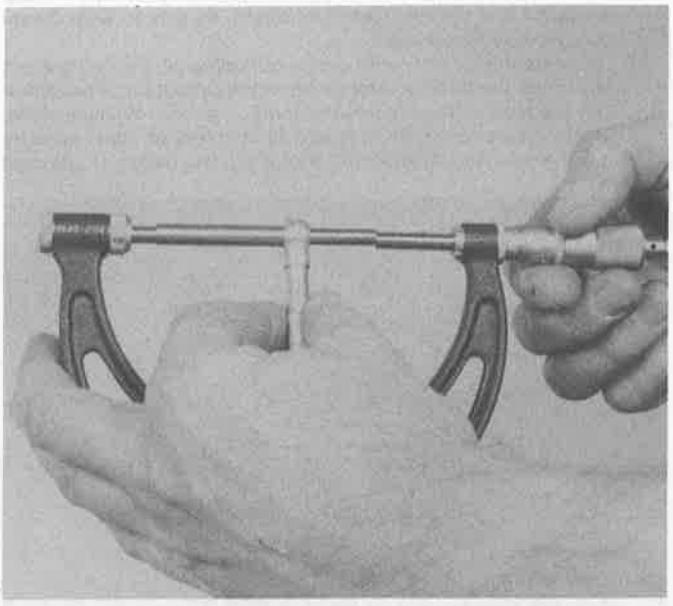
10 Repeat the procedure for the remaining pistons and cylinders.

11 If the cylinder walls are badly scuffed or scored, or if they're out-of-round or tapered beyond the limits given in the Specifications, have the engine block rebored and honed at an automotive machine shop. If a rebore is done, oversize pistons and rings will be required.

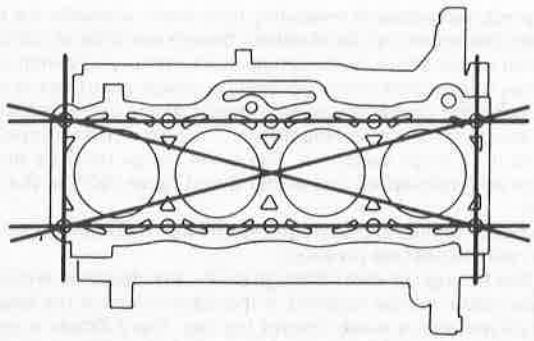
12 If the cylinders are in reasonably good condition and not worn to the outside of the limits, and if the piston-to-cylinder clearances can be maintained properly, then they don't have to be rebored. Honing is all that's necessary (Section 16).



15.4a Measure the diameter of each cylinder just under the wear ridge (A), at the center (B) and at the bottom (C)



15.4c The gauge is then measured with a micrometer to determine the bore size



15.13 Check the block deck for distortion with a precision straightedge and feeler gauges

13 Using a precision straightedge and feeler gauge, check the clock deck (the surface that mates with the cylinder head) for distortion **(see illustration)**. If it's distorted beyond the specified limit, it can be resurfaced by an automotive machine shop. The amount that can be taken off is determined by the amount taken off the head, if resurfacing was done. The total that can be removed (head plus block) cannot exceed 0.008-inch. If it does, new components (block and/or head) will be needed. If the block is replaced, new pistons may also be required — check with a dealer service department.

16 Cylinder honing

Refer to illustrations 16.3a and 16.3b

1 Prior to engine reassembly, the cylinder bores must be honed so the new piston rings will seat correctly and provide the best possible combustion chamber seal. **Note:** *If you don't have the tools or don't want to tackle the honing operation, most automotive machine shops will do it for a reasonable fee.*

2 Before honing the cylinders, install the main bearing caps and tighten the bolts to the specified torque.

3 Two types of cylinder hones are commonly available — the flex hone or "bottle brush" type and the more traditional surfacing hone with spring-loaded stones. Both will do the job, but for the less experienced mechanic the "bottle brush" hone will probably be easier to use. You'll also need some kerosene or honing oil, rags and an electric drill motor. Proceed as follows:

a) Mount the hone in the drill motor, compress the stones and slip it into the first cylinder **(see illustration)**. Be sure to wear safety goggles or a face shield!

b) Lubricate the cylinder with plenty of honing oil, turn on the drill and move the hone up-and-down in the cylinder at a pace that will produce a fine crosshatch pattern on the cylinder walls. Ideally, the crosshatch lines should intersect at approximately a 60° angle **(see illustration)**. Be sure to use plenty of lubricant and don't take off any more material than is absolutely necessary to produce the desired finish. **Note:** *Piston ring manufacturers may specify a smaller crosshatch angle than the traditional 60° — read and follow any instructions included with the new rings.*

c) Don't withdraw the hone from the cylinder while it's running. Instead, shut off the drill and continue moving the hone up-and-down in the cylinder until it comes to a complete stop, then compress the stones and withdraw the hone. If you're using a "bottle brush" type hone, stop the drill motor, then turn the chuck in the normal direction of rotation while withdrawing the hone from the cylinder.

d) Wipe the oil out of the cylinder and repeat the procedure for the remaining cylinders.

4 After the honing job is complete, chamfer the top edges of the cylinder bores with a small file so the rings won't catch when the pistons are installed. **Be very careful not to nick the cylinder walls with the end of the file.**

5 The entire engine block must be washed again very thoroughly with warm, soapy water to remove all traces of the abrasive grit produced during the honing operation. **Note:** *The bores can be considered clean when a lint-free white cloth — dampened with clean engine oil — used to wipe them out doesn't pick up any more honing residue, which will show up as gray areas on the cloth.* Be sure to run a brush through all oil holes and galleries and flush them with running water.

6 After rinsing, dry the block and apply a coat of light rust preventive oil to all machined surfaces. Wrap the block in a plastic trash bag to keep it clean and set it aside until reassembly.

17 Pistons/connecting rods — Inspection

Refer to illustrations 17.4a, 17.4b, 17.5, 17.10 and 17.11

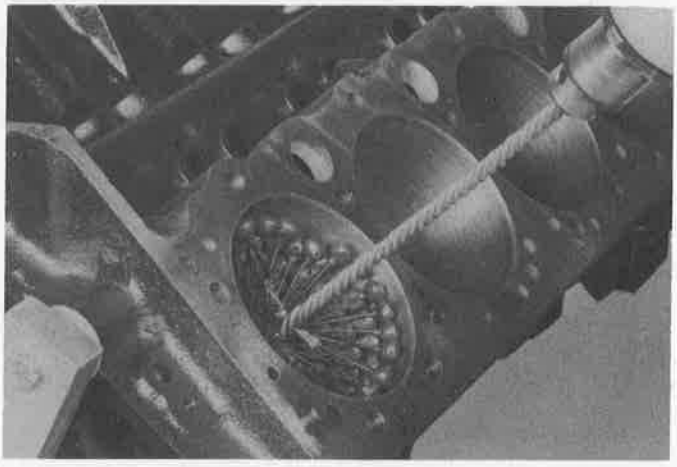
1 Before the inspection process can be carried out, the piston/connecting rod assemblies must be cleaned and the original piston rings removed from the pistons. **Note:** *Always use new piston rings when the engine is reassembled.*

2 Using a piston ring installation tool, carefully remove the rings from the pistons. Be careful not to nick or gouge the pistons in the process.

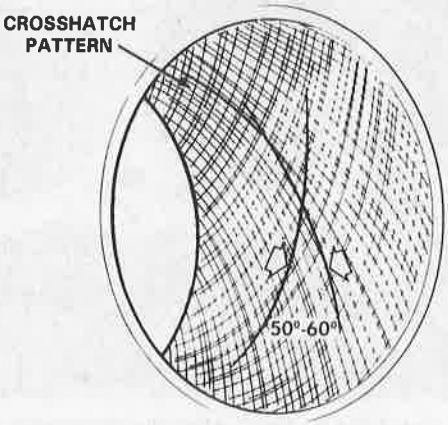
3 Scrape all traces of carbon from the top of the piston. A hand-held wire brush or a piece of fine emery cloth can be used once the majority of the deposits have been scraped away. Do not, under any circumstances, use a wire brush mounted in a drill motor to remove deposits from the pistons. The piston material is soft and may be eroded away by the wire brush.

4 Use a piston ring groove cleaning tool to remove carbon deposits from the ring grooves. If a tool isn't available, a piece broken off the old ring will do the job. Be very careful to remove only the carbon deposits — don't remove any metal and do not nick or scratch the sides of the ring grooves **(see illustrations)**.

5 Once the deposits have been removed, clean the piston/rod assemblies with solvent and dry them with compressed air (if available). Make sure the oil return holes in the back sides of the ring grooves

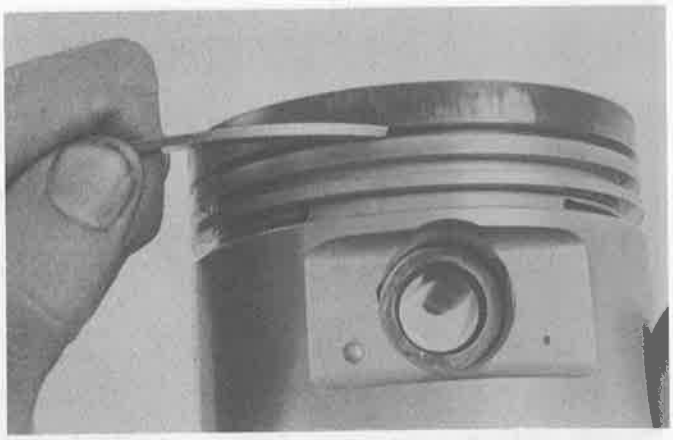


16.3a A "bottle brush" hone will produce better results if you have never done cylinder honing before



16.3b The cylinder hone should leave a smooth, crosshatch pattern with the lines intersecting at approximately a 60-degree angle

17.4a The piston ring grooves can be cleaned with a special tool, as shown here, . . .



17.4b . . . or a section of a broken ring

and the oil hole in the lower end of each rod are clear **(see illustration)**.

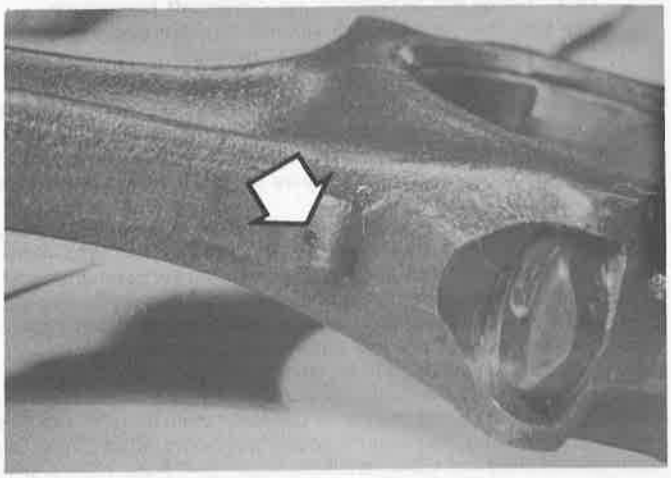
6 If the pistons and cylinder walls aren't damaged or worn excessively, and if the engine block is not rebored, new pistons won't be necessary. Normal piston wear appears as even vertical wear on the piston thrust surfaces and slight looseness of the top ring in its groove. New piston rings, however, should always be used when an engine is rebuilt.

7 Carefully inspect each piston for cracks around the skirt, at the pin bosses and at the ring lands.

8 Look for scoring and scuffing on the thrust faces of the skirt, holes in the piston crown and burned areas at the edge of the crown. If the skirt is scored or scuffed, the engine may have been suffering from overheating and/or abnormal combustion, which caused excessively high operating temperatures. The cooling and lubrication systems should be checked thoroughly. A hole in the piston crown is an indication that abnormal combustion (preignition) was occurring. Burned areas at the edge of the piston crown are usually evidence of spark knock (detonation). If any of the above problems exist, the causes must be corrected or the damage will occur again. The causes may include intake air leaks, incorrect fuel/air mixture, incorrect ignition timing and EGR system malfunctions.

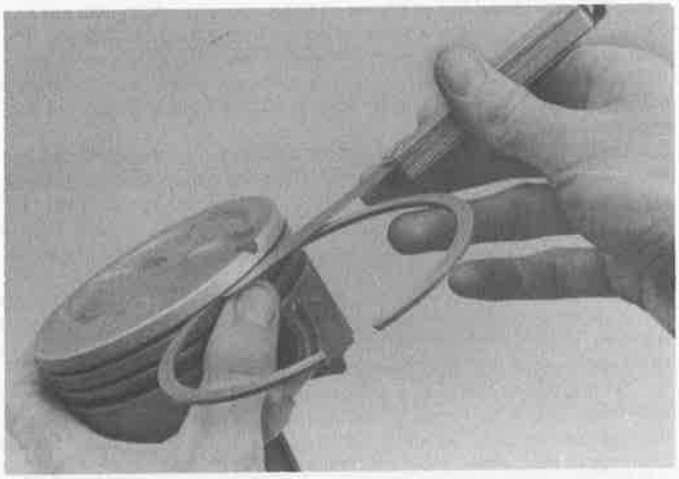
9 Corrosion of the piston, in the form of small pits, indicates that coolant is leaking into the combustion chamber and/or the crankcase. Again, the cause must be corrected or the problem may persist in the rebuilt engine.

10 Measure the piston ring side clearance by laying a new piston ring in each ring groove and slipping a feeler gauge in beside it **(see illustration)**. Check the clearance at three or four locations around each groove. Be sure to use the correct ring for each groove — they are different. If the side clearance is greater than specified, new pistons will have to be used.



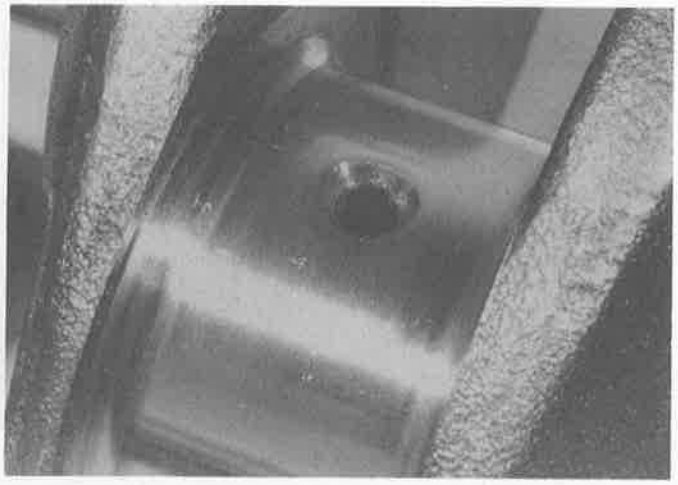
17.5 Make sure the oil hole in the lower end of each connecting rod is clear — if the rods are separated from the pistons, make sure the oil hole is on the correct side when they're reassembled!

11 Check the piston-to-bore clearance by measuring the bore (see Section 15) and the piston diameter. Make sure the pistons and bores are correctly matched. Measure the piston across the skirt, at a 90° angle to the piston pin (refer to the Specifications for the specific location) **(see illustration)**. Subtract the piston diameter from the bore diameter to obtain the clearance. If it's greater than specified, the block will have to be rebored and new pistons and rings installed.

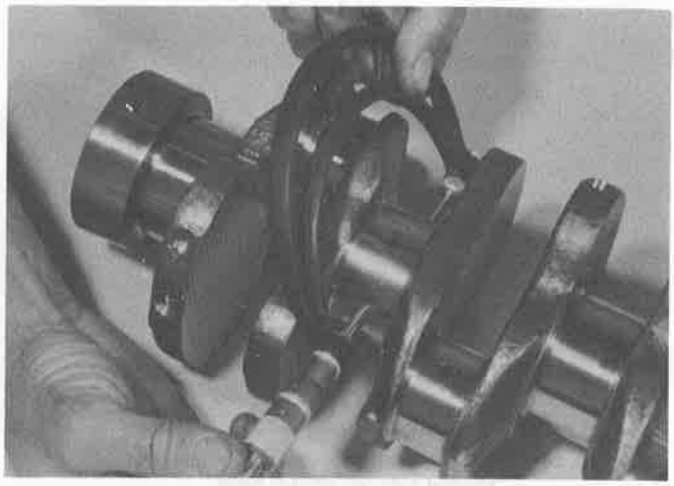


17.10 Check the ring side clearance with a feeler gauge at several points around the groove

17.11 Measure the piston diameter at the specified point, at right angles to the piston pin



18.4 Check the oil holes in the crankshaft journals to make sure they're clean and smooth — sharp edges here will damage the new bearings!



18.6 Measure the diameter of each crankshaft journal at several points to detect taper and out-of-round conditions

12 Check the piston-to-rod clearance by twisting the piston and rod in opposite directions. Any noticeable play indicates excessive wear, which must be corrected. The piston/connecting rod assemblies should be taken to an automotive machine shop to have the pistons and rods resized and new pins installed.

13 If the pistons must be removed from the connecting rods for any reason, they should be taken to an automotive machine shop. While they are there have the connecting rods checked for bend and twist, since automotive machine shops have special equipment for this purpose. **Note:** *Unless new pistons and/or connecting rods must be installed, do not disassemble the pistons and connecting rods.*

14 Check the connecting rods for cracks and other damage. Temporarily remove the rod caps, lift out the old bearing inserts, wipe the rod and cap bearing surfaces clean and inspect them for nicks, gouges and scratches. After checking the rods, replace the old bearings, slip the caps into place and tighten the nuts finger tight. **Note:** *If the engine is being rebuilt because of a connecting rod knock, be sure to install new rods.*

18 Crankshaft — inspection

Refer to illustrations 18.4 and 18.6

1 Clean the crankshaft with solvent and dry it with compressed air (if available). Be sure to clean the oil holes with a stiff brush and flush them with solvent.

2 Check the main and connecting rod bearing journals for uneven wear, scoring, pits and cracks.

3 Rub a penny accross each journal several times. If a journal picks up copper from the penny, it's too rough and must be reground.

4 Remove all burrs from the crankshaft oil holes with a stone, file or scraper **(see illustration)**.

5 Check the rest of the crankshaft for cracks and other damage. It should be magnafluxed to reveal hidden cracks — an automotive machine shop will handle the procedure.

6 Using a micrometer, measure the diameter of the main and connecting rod journals and compare the results to the Specifications **(see illustration)**. By measuring the diameter at a number of points around each journal's circumference, you'll be able to determine whether or not the journal is out-of-round. Take the measurement at each end of the journal, near the crank throws, to determine if the journal is tapered.

7 If the crankshaft journals are damaged, tapered, out-of-round or worn beyond the limits given in the Specifications, have the crankshaft reground by an automotive machine shop. Be sure to use the correct size bearing inserts if the crankshaft is reconditioned.

8 Check the oil seal journals at each end of the crankshaft for wear and damage. If the seal has worn a groove in the journal, or if it's nicked or scratched, the new seal may leak when the engine is reassembled. In some cases, an automotive machine shop may be able to repair the journal by pressing on a thin sleeve. If repair isn't feasible, a new or different crankshaft should be installed.

9 Refer to Section 19 and examine the main and rod bearing inserts.

19 Main and connecting rod bearings — inspection

Refer to illustration 19.1

1 Even though the main and connecting rod bearings should be replaced with new ones during the engine overhaul, the old bearings should be retained for close examination, as they may reveal valuable information about the condition of the engine **(see illustration)**.

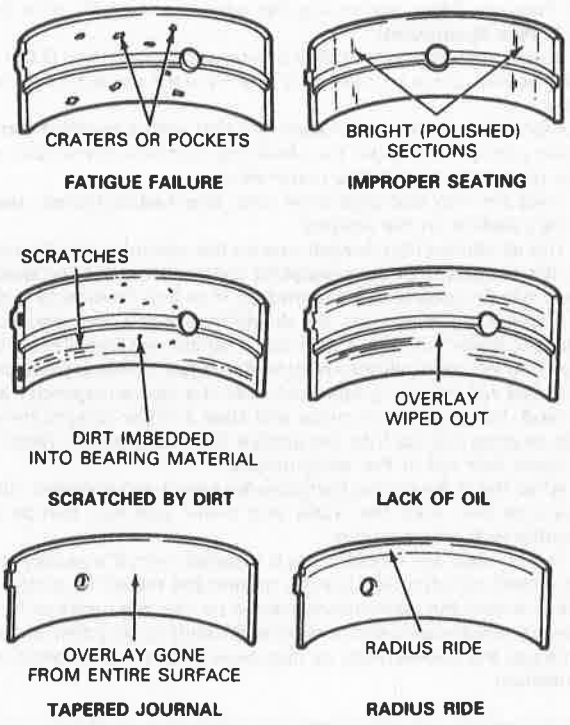
2 Bearing failure occurs because of lack of lubrication, the presence of dirt or other foreign particles, overloading the engine and corrosion. Regardless of the cause of bearing failure, it must be corrected before the engine is reassembled to prevent it from happening again.

3 When examining the bearings, remove them from the engine block, the main bearing caps, the connecting rods and the rod caps and lay them out on a clean surface in the same general position as their location in the engine. This will enable you to match any bearing problems with the corresponding crankshaft journal.

4 Dirt and other foreign particles get into the engine in a variety of ways. It may be left in the engine during assembly, or it may pass through filters or the PCV system. It may get into the oil, and from there into the bearings. Metal chips from machining operations and normal engine wear are often present. Abrasives are sometimes left in engine components after reconditioning, especially when parts are not thoroughly cleaned using the proper cleaning methods. Whatever the source, these foreign objects often end up embedded in the soft bearing material and are easily recognized. Large particles will not embed in the bearing and will score or gouge the bearing and journal. The best prevention for this cause of bearing failure is to clean all parts thoroughly and keep everything spotlessly clean during engine assembly. Frequent and regular engine oil and filter changes are also recommended.

5 Lack of lubrication (or lubrication breakdown) has a number of interrelated causes. Excessive heat (which thins the oil), overloading (which squeezes the oil from the bearing face) and oil leakage or throw off (from excessive bearing clearances, worn oil pump or high engine speeds) all contribute to lubrication breakdown. Blocked oil passages, which usually are the result of misaligned oil holes in a bearing shell, will also oil starve a bearing and destroy it. When lack of lubrication is the cause of bearing failure, the bearing material is wiped or extruded from the steel backing of the bearing. Temperatures may increase to the point where the steel backing turns blue from overheating.

6 Driving habits can have a definite effect on bearing life. Full throttle, low speed operation (lugging the engine) puts very high loads on bearings, which tends to squeeze out the oil film. These loads cause the bearings to flex, which produces fine cracks in the bearing face (fatigue failure). Eventually the bearing material will loosen in pieces and tear away from the steel backing. Short trip driving leads to corrosion of



19.1 Typical bearing failures

bearings because insufficient engine heat is produced to drive off the condensed water and corrosive gases. These products collect in the engine oil, forming acid and sludge. As the oil is carried to the engine bearings, the acid attacks and corrodes the bearing material.

7 Incorrect bearing installation during engine assembly will lead to bearing failure as well. Tight fitting bearings leave insufficient bearing oil clearance and will result in oil starvation. Dirt or foreign particles trapped behind a bearing insert result in high spots on the bearing which lead to failure.

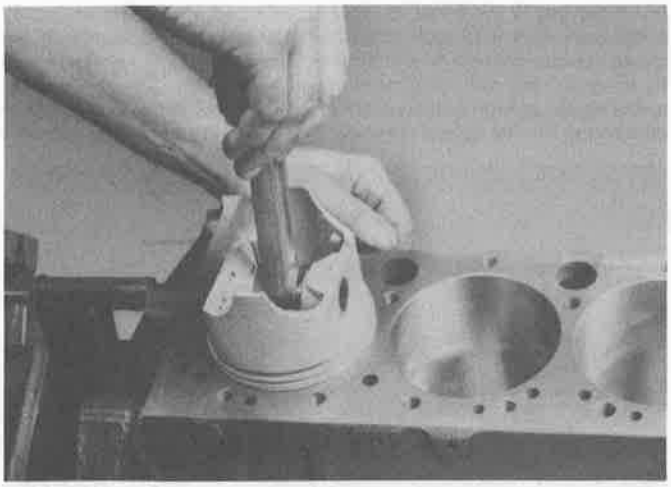
20 Engine overhaul — reassembly sequence

1 Before beginning engine reassembly, make sure you have all the necessary new parts, gaskets and seals as well as the following items on hand:

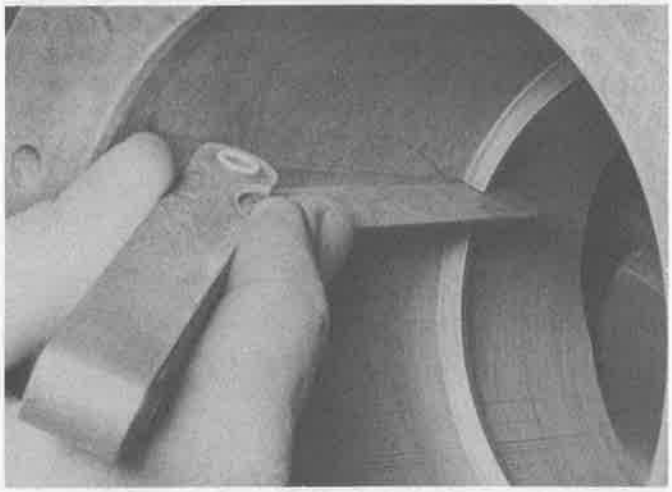
Common hand tools
A 1/2-inch drive torque wrench
Piston ring installation tool
Piston ring compressor
Short lengths of rubber or plastic hose to fit over connecting rod bolts
Plastigage
Feeler gauges
A fine-tooth file
New engine oil
Engine assembly lube or moly-base grease
Gasket sealant
Thread locking compound

2 In order to save time and avoid problems, engine reassembly must be done in the following general order:

Piston rings
Crankshaft and main bearings
Piston/connecting rod assemblies
Crankshaft rear oil seal
Cylinder head
Camshaft
Rocker arm assembly
Timing chain or belt and sprockets
Oil pump
Timing chain cover



21.3 When checking piston ring end gap, the ring must be square in the cylinder bore (this is done by pushing the ring down with the top of a piston as shown)



21.4 With the ring square in the cylinder, measure the end gap with a feeler gauge

Oil pan
Intake and exhaust manifolds
Rocker arm cover
Engine rear plate
Flywheel/driveplate

21 Piston rings — installation

Refer to illustrations 21.3, 21.4, 21.5, 21.9a, 21.9b, 21.11 and 21.12

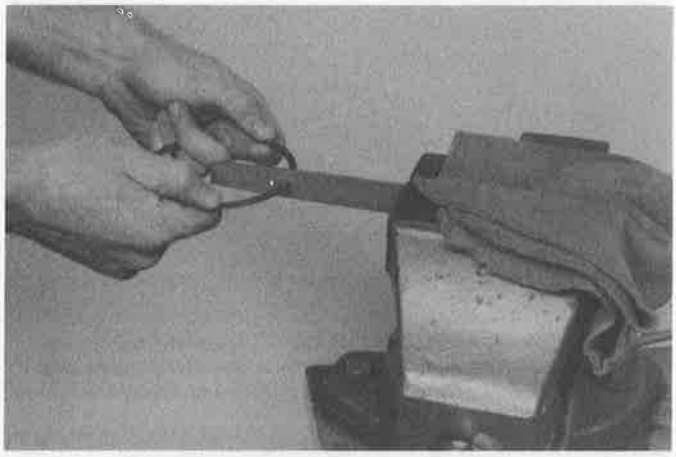
1 Before installing the new piston rings, the ring end gaps must be checked. It's assumed that the piston ring side clearance has been checked and verified correct (Section 17).

2 Lay out the piston/connecting rod assemblies and the new ring sets so the ring sets will be matched with the same piston and cylinder during the end gap measurement and engine assembly.

3 Insert the top (number one) ring into the first cylinder and square it up with the cylinder walls by pushing it in with the top of the piston (**see illustration**). The ring should be near the bottom of the cylinder, at the lower limit of ring travel.

4 To measure the end gap, slip feeler gauges between the ends of the ring until a gauge equal to the gap width is found (**see illustration**). The feeler gauge should slide between the ring ends with a slight amount of drag. Compare the measurement to the Specifications. If the gap is larger or smaller than specified, double-check to make sure you have the correct rings before proceeding.

5 If the gap is too small, it must be enlarged or the ring ends may come in contact with each other during engine operation, which can cause serious damage to the engine. The end gap can be increased by filing the ring ends very carefully with a fine file. Mount the file in a vise equipped with soft jaws, slip the ring over the file with the ends contacting the file face and slowly move the ring to remove material from the ends. When performing this operation, file only from the outside in (**see illustration**).



21.5 If the end gap is too small, clamp a file in a vise and file the ring ends (from the outside in only) to enlarge the gap slightly

6 Excess end gap isn't critical unless it's greater than 0.040-inch. Again, double-check to make sure you have the correct rings for your engine.

7 Repeat the procedure for each ring that will be installed in the first cylinder and for each ring in the remaining cylinders. Remember to keep rings, pistons and cylinders matched up.

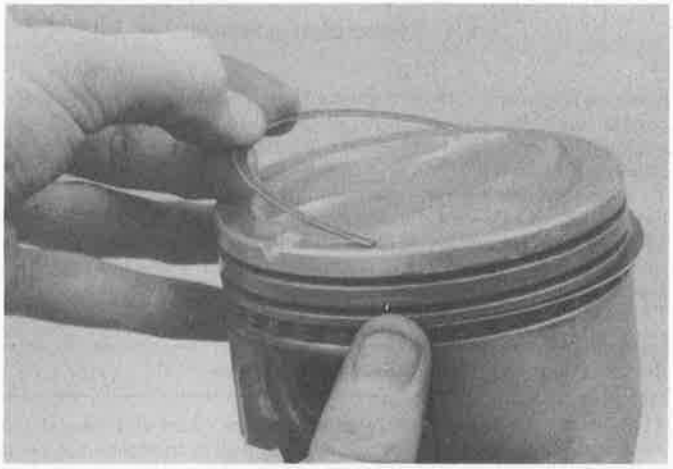
8 Once the ring end gaps have been checked/corrected, the rings can be installed on the pistons.

9 The oil control ring (lowest one on the piston) is usually installed first. It's composed of three separate components. Slip the spacer/expander into the groove (**see illustration**). If an anti-rotation tang is used, make sure it's inserted into the drilled hole in the ring groove. Next, install the lower side rail. Don't use a piston ring installation tool on the oil ring side rails, as they may be damaged. Instead, place one end of the side rail into the groove between the spacer/expander and the ring land, hold it firmly in place and slide a finger around the piston while pushing the rail into the groove (**see illustration**). Next, install the upper side rail in the same manner.

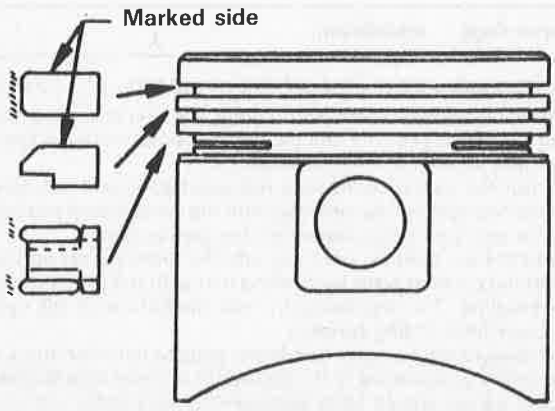
10 After the three oil ring components have been installed, check to make sure that both the upper and lower side rails can be turned smoothly in the ring groove.

11 The number two (middle) ring is installed next. It's usually stamped with a mark which must face up, toward the top of the piston. **Note:** *Always follow the instructions printed on the ring package or box — different manufacturers may require different approaches. Do not mix up the top and middle rings, as they have different cross sections* **(see illustration)**.

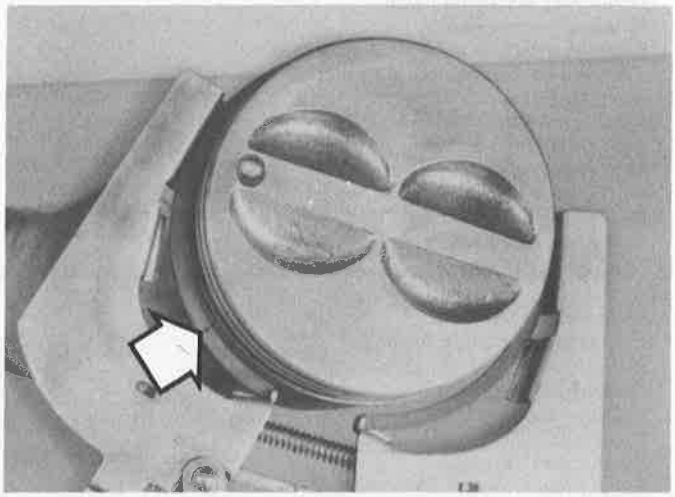
21.9a Installing the spacer/expander in the oil control ring groove



21.9b DO NOT use a piston ring installation tool when installing the oil ring side rails



21.11 The piston rings have different shapes, so make sure they aren't mixed up — the marked side must face up!



21.12 Installing the compression rings with a ring expander — the mark (arrow) must face up

12 Use a piston ring installation tool and make sure the identification mark is facing the top of the piston, then slip the ring into the middle groove on the piston (**see illustration**). Don't expand the ring any more than necessary to slide it over the piston.
13 Install the number one (top) ring in the same manner. Make sure the mark is facing up. Be careful not to confuse the number one and number two rings.
14 Repeat the procedure for the remaining pistons and rings.

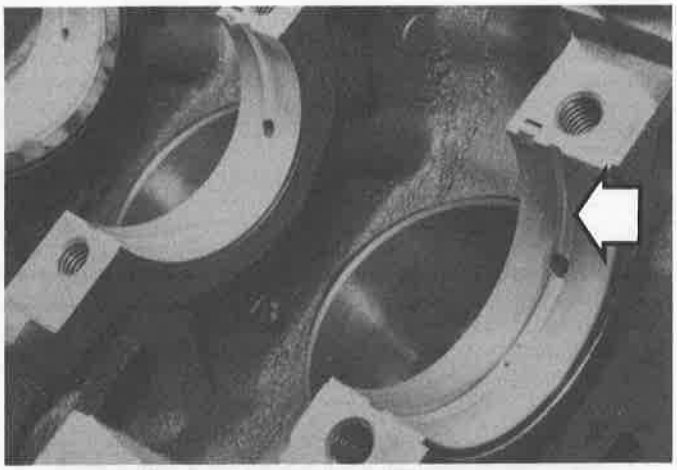
22 Crankshaft — installation and main bearing oil clearance check

Refer to illustrations 22.5, 22.6a, 22.6b, 22.11, 22.15, 22.22 and 22.31

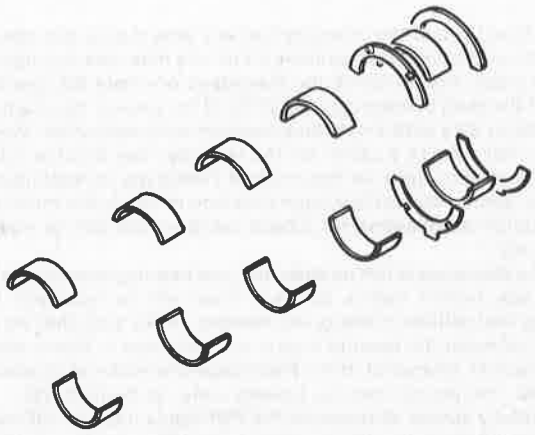
1 Crankshaft installation is the first step in engine reassembly. It's assumed at this point that the engine block and crankshaft have been cleaned, inspected and repaired or reconditioned.
2 Position the engine with the bottom facing up.
3 Remove the main bearing cap bolts and lift out the caps. Lay them out in the proper order to ensure correct installation.
4 If they're still in place, remove the original bearing inserts from the block and the main bearing caps. Wipe the bearing surfaces of the block and caps with a clean, lint-free cloth. They must be kept spotlessly clean.

Main bearing oil clearance check

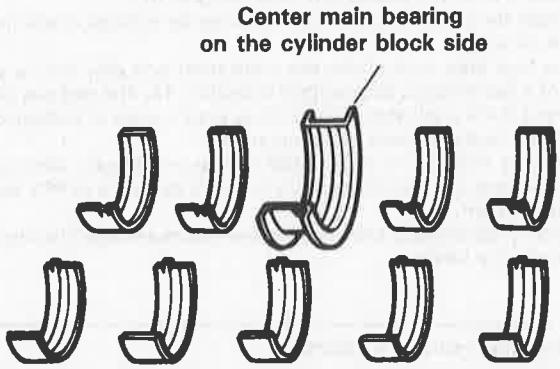
5 Clean the back sides of the new main bearing inserts and lay one in each main bearing saddle in the block. If one of the bearing inserts from each set has a large groove in it, make sure the grooved insert is installed in the block. Lay the other bearing from each set in the corresponding main bearing cap. Make sure the tab on the bearing insert fits into the recess in the block or cap. **Caution:** *The oil holes in the block must line up with the oil holes in the bearing insert* (**see illustration**). *Do not hammer the bearing into place and don't nick or gouge the bearing faces. No lubrication should be used at this time.*
6 On 1986 and newer engines, the flanged thrust bearing must be installed in the number three (center) cap and saddle. On pre-1985 engines, the thrust bearings must be installed in the rear cap and saddle (**see illustrations**).
7 Clean the faces of the bearings in the block and the crankshaft main bearing journals with a clean, lint-free cloth.
8 Check or clean the oil holes in the crankshaft, as any dirt here can go only one way — straight through the new bearings.
9 Once you're certain the crankshaft is clean, carefully lay it in position in the main bearings.
10 Before the crankshaft can be permanently installed, the main bearing oil clearance must be checked.
11 Cut several pieces of the appropriate size Plastigage (they must be slightly shorter than the width of the main bearings) and place one piece on each crankshaft main bearing journal, parallel with the journal axis (**see illustration**).
12 Clean the faces of the bearings in the caps and install the caps in their respective positions (don't mix them up) with the arrows pointing toward the front of the engine. Don't disturb the Plastigage.
13 Starting with the center main and working out toward the ends, tighten the main bearing cap bolts, in three steps, to the specified



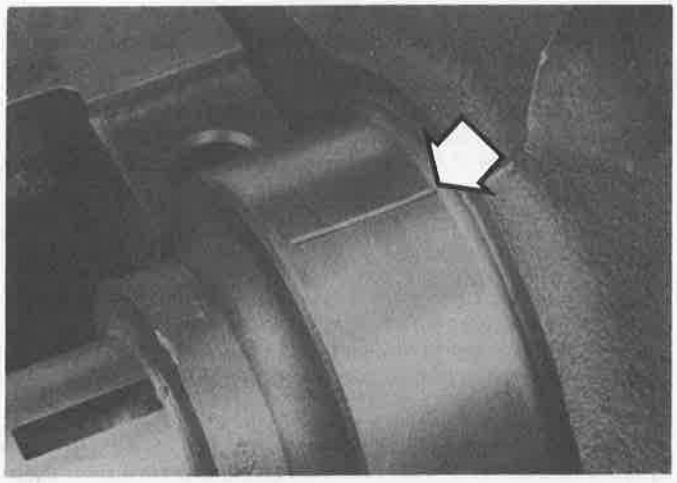
22.5 The bearing inserts with the oil groove (arrow) must be installed in the block



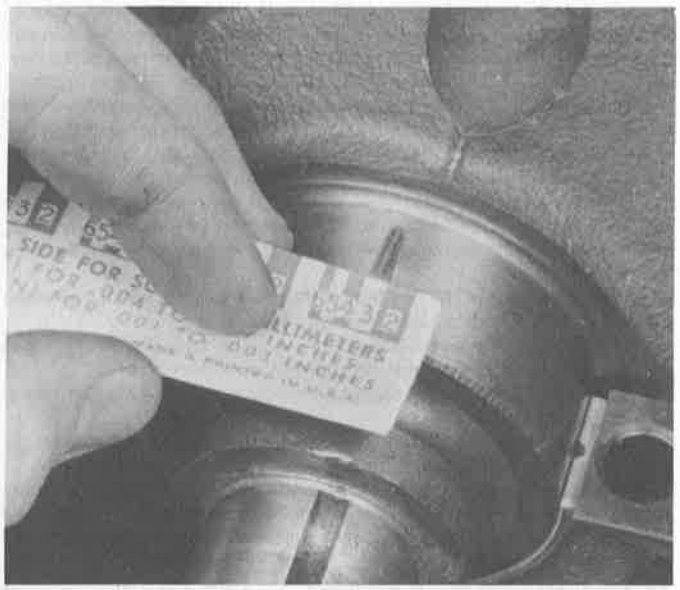
22.6a On pre-1985 models, install the thrust bearings without tangs in the block and the ones with tangs in the caps



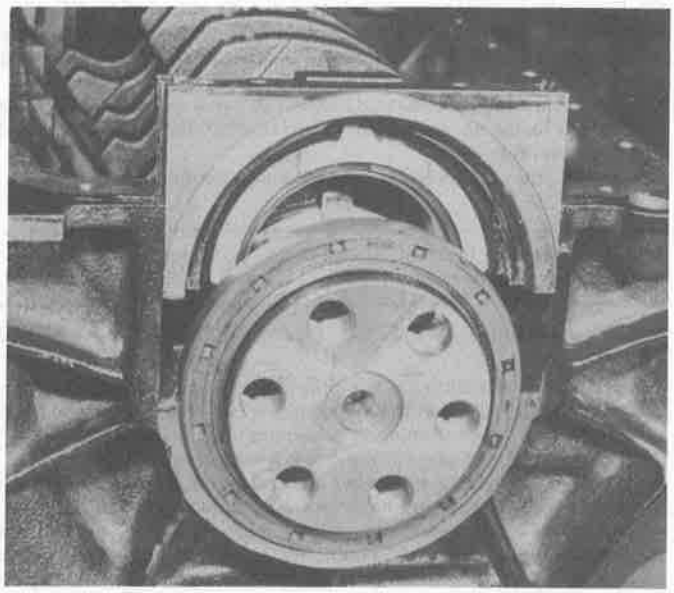
22.6b 1986 and later model main bearings



22.11 Lay the Plastigage strips (arrow) on the main bearing journals, parallel to the crankshaft centerline



22.15 Compare the width of the crushed Plastigage to the scale on the envelope to determine the main bearing oil clearance (always take the measurement at the widest point of the Plastigage); be sure to use the correct scale — standard and metric scales are included

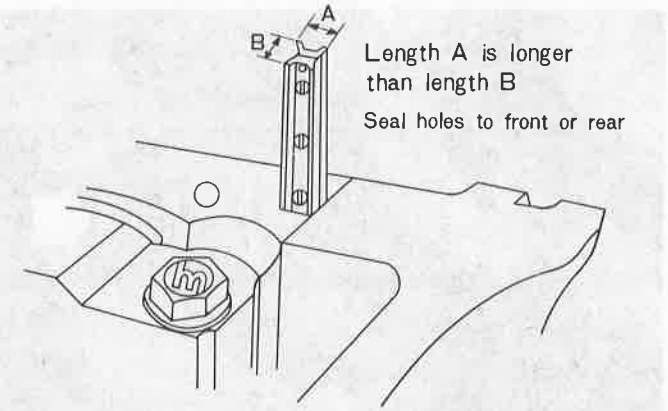


22.22 Slip the new seal over the crankshaft before you install the rear bearing cap (pre-1985 models)

torque. Don't rotate the crankshaft at any time during this operation.
14 Remove the bolts and carefully lift off the main bearing caps. Keep them in order. Don't disturb the Plastigage or rotate the crankshaft. If any of the main bearing caps are difficult to remove, tap them gently from side-to-side with a soft-face hammer to loosen them. Pre-1985 engines may require a puller for the rear cap (see Section 13).
15 Compare the width of the crushed Plastigage on each journal to the scale printed on the Plastigage envelope to obtain the main bearing oil clearance (**see illustration**). Check the Specifications to make sure it's correct.
16 If the clearance is not as specified, the bearing inserts may be the wrong size (which means different ones will be required). Before deciding that different inserts are needed, make sure that no dirt or oil was between the bearing inserts and the caps or block when the clearance was measured. If the Plastigage was wider at one end than the other, the journal may be tapered (refer to Section 18).
17 Carefully scrape all traces of the Plastigage material off the main bearing journals and/or the bearing faces. Use your fingernail or the edge of a credit card — don't nick or scratch the bearing faces.

Final crankshaft installation

18 Carefully lift the crankshaft out of the engine.
19 Clean the bearing faces in the block, then apply a thin, uniform layer of moly-base grease or engine assembly lube to each of the bearing surfaces. Be sure to coat the thrust faces as well as the journal face of the thrust bearing.
20 Make sure the crankshaft journals are clean, then lay the crankshaft back in place in the block.
21 Clean the faces of the bearings in the caps, then apply lubricant to them.
22 Install the caps in their respective positions with the arrows pointing toward the front of the engine. **Note:** *On pre-1985 engines, apply moly-base grease to the lip of the new rear main seal and slide it onto the rear of the crankshaft, then install the rear bearing cap* **(see illustration)**.
23 Install the bolts.
24 Tighten all except the thrust bearing cap bolts to the specified torque (work from the center out and approach the final torque in three steps).
25 Tighten the thrust bearing cap bolts to 10-to-12 ft-lbs.
26 Tap the ends of the crankshaft forward and backward with a lead or brass hammer to line up the main bearing and crankshaft thrust surfaces.
27 Retighten all main bearing cap bolts to the specified torque, starting with the center main and working out toward the ends.



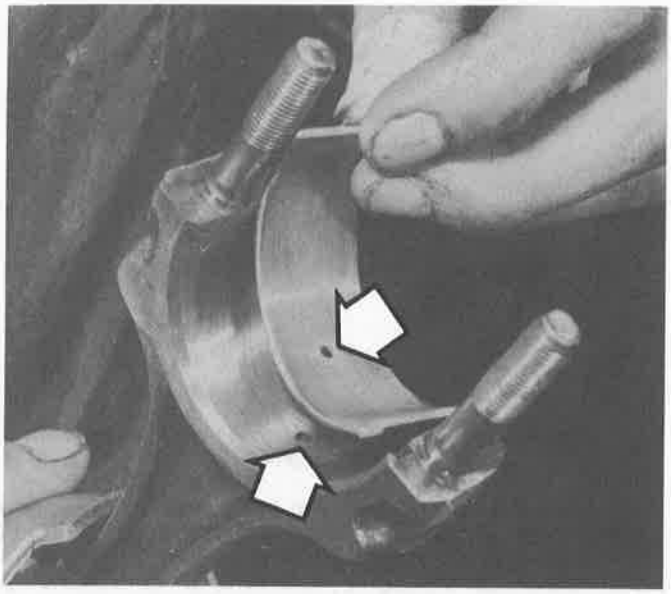
22.31 On pre-1985 models, install the side seals in the rear main bearing cap after coating them with a small amount of RTV sealant

28 On manual transmission equipped models, install a new pilot bearing in the end of the crankshaft (see Chapter 8).
29 Rotate the crankshaft a number of times by hand to check for any obvious binding.
30 The final step is to check the crankshaft end play with a feeler gauge or a dial indicator as described in Section 13. The end play should be correct if the crankshaft thrust faces aren't worn or damaged and new thrust bearings have been installed.
31 If you're working on a pre-1985 engine, install new side seals in the rear bearing cap after coating them with a thin layer of RTV sealant **(see illustration)**.
32 Refer to Section 23 and install a new rear main seal, then bolt the housing to the block.

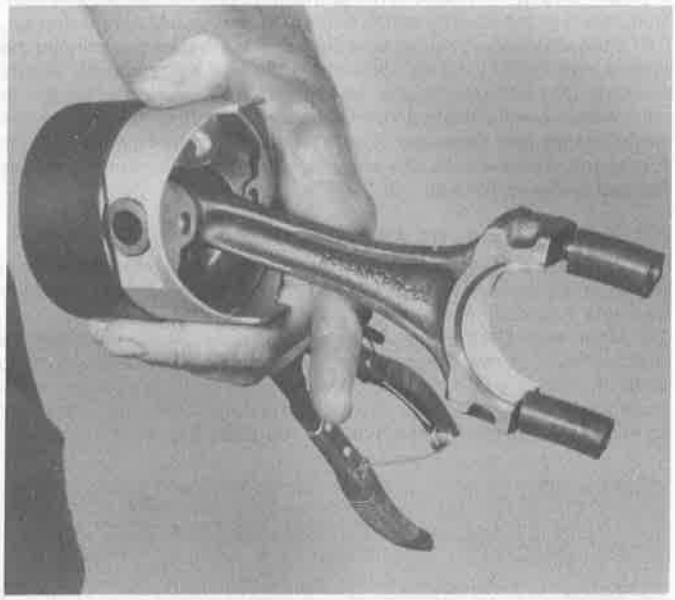
23 Rear main oil seal installation

Pre-1985 engines

Refer to Section 22 — rear main oil seal installation on these models is done as part of the crankshaft installation procedure.



24.3 The tab on each bearing insert must fit into the recess in the rod or cap and the oil holes must line up (arrows)



24.7 Slip sections of rubber hose over the rod bolts, then compress the rings with a ring compressor — leave the bottom of the piston sticking out so it will slip into the cylinder

Engines with seal housing that bolts to block

1 The crankshaft must be installed first and the main bearing caps bolted in place, then the new seal should be installed in the housing and the housing bolted to the block.

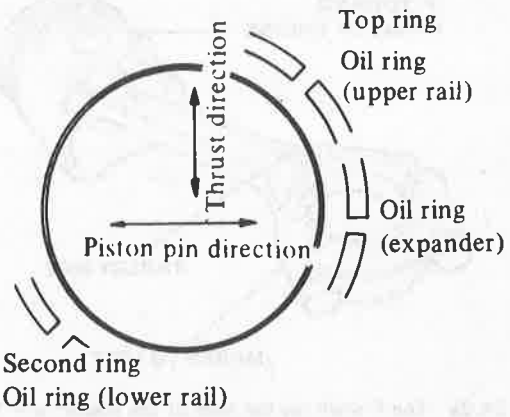
2 Before installing the crankshaft, check the seal contact surface very carefully for scratches and nicks that could damage the new seal lip and cause oil leaks. If the crankshaft is damaged, the only alternative is a new or different crankshaft.

3 The old seal can be removed from the housing with a hammer and punch by driving it out from the back side. Be sure to note how far it's recessed into the housing bore before removing it; the new seal will have to be recessed an equal amount. Be very careful not to scratch or otherwise damage the bore in the housing or oil leaks could develop.

4 Make sure the housing is clean, then apply a thin coat of engine oil to the outer edge of the new seal. The seal must be pressed squarely into the housing bore, so hammering it into place is not recommended. If you don't have access to a press, sandwich the housing and seal between two smooth pieces of wood and press the seal into place with the jaws of a large vise. The pieces of wood must be thick enough to distribute the force evenly around the entire circumference of the seal. Work slowly and make sure the seal enters the bore squarely.

5 The seal lips must be lubricated with moly-base grease or engine assembly lube before the seal/housing is slipped over the crankshaft and bolted to the block. Use a new gasket — and RTV sealant — and make sure the dowel pins are in place before installing the housing. If you're working on a 2.6L engine, make sure the oil separator is in place in the housing **(see illustration 22.17 in Part A)**.

6 Tighten the bolts a little at a time until they're all snug.



24.5 Stagger the piston ring end gaps as shown here before installing the piston/connecting rod assemblies in the engine

24 Pistons/connecting rods — installation and rod bearing oil clearance check

Refer to illustrations 24.3, 24.5, 24.7, 24.9a, 24.9b, 24.11, 24.13 and 24.17

1 Before installing the piston/connecting rod assemblies, the cylinder walls must be perfectly clean, the top edge of each cylinder must be chamfered, and the crankshaft must be in place.

2 Remove the cap from the end of the number one connecting rod (refer to the marks made during removal). Remove the original bearing inserts and wipe the bearing surfaces of the connecting rod and cap with a clean, lint-free cloth. They must be kept spotlessly clean.

Connecting rod bearing oil clearance check

3 Clean the back side of the new upper bearing insert, then lay it in place in the connecting rod. Make sure the tab on the bearing fits into the recess in the rod **(see illustration)**. Don't hammer the bearing insert into place and be very careful not to nick or gouge the bearing face. Don't lubricate the bearing at this time.

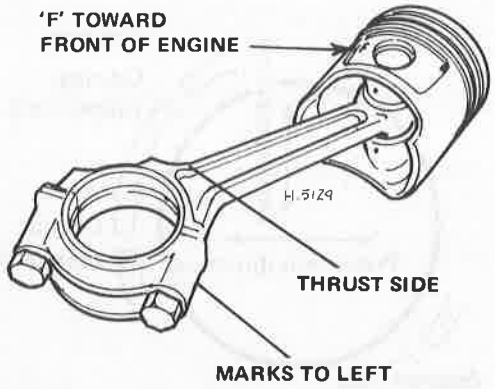
4 Clean the back side of the other bearing insert and install it in the rod cap. Again, make sure the tab on the bearing fits into the recess in the cap, and don't apply any lubricant. It's critically important that the mating surfaces of the bearing and connecting rod are perfectly clean and oil free when they're assembled.

5 Position the piston ring gaps at staggered intervals around the piston **(see illustration)**.

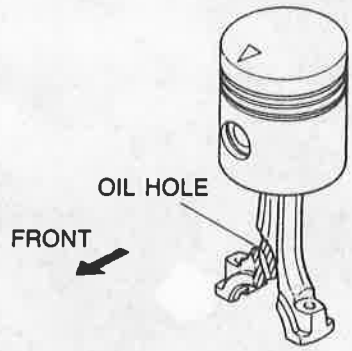
6 Slip a section of plastic or rubber hose over each connecting rod cap bolt.

7 Lubricate the piston and rings with clean engine oil and attach a piston ring compressor to the piston. Leave the skirt protruding about 1/4-inch to guide the piston into the cylinder. The rings must be compressed until they're flush with the piston **(see illustration)**.

8 Rotate the crankshaft until the number one connecting rod journal is at BDC (bottom dead center) and apply a coat of engine oil to the cylinder walls.



24.9a The F mark on the side of the piston (pre-1985 model shown) . . .



24.9b . . . or the arrow (2.6L engine) must face the front of the engine

9 With the F mark on the side of the piston or the arrow on top of the piston (**see illustrations**) facing the front of the engine, gently insert the piston/connecting rod assembly into the number one cylinder bore and rest the bottom edge of the ring compressor on the engine block.

10 Tap the top edge of the ring compressor to make sure it's contacting the block around its entire circumference.

11 Gently tap on the top of the piston with the end of a wooden hammer handle (**see illustration**) while guiding the end of the connecting rod into place on the crankshaft journal. The piston rings may try to pop out of the ring compressor just before entering the cylinder bore, so keep some downward pressure on the ring compressor. Work slowly, and if any resistance is felt as the piston enters the cylinder, stop immediately. Find out what's hanging up and fix it before proceeding. Do not, for any reason, force the piston into the cylinder — you might break a ring and/or the piston.

12 Once the piston/connecting rod assembly is installed, the connecting rod bearing oil clearance must be checked before the rod cap is permanently bolted in place.

13 Cut a piece of the appropriate size Plastigage slightly shorter than the width of the connecting rod bearing and lay it in place on the number one connecting rod journal, parallel with the journal axis (**see illustration**).

14 Clean the connecting rod cap bearing face, remove the protective hoses from the connecting rod bolts and install the rod cap. Make sure the mating mark on the cap is on the same side as the mark on the connecting rod.

15 Install the nuts and tighten them to the specified torque, working up to it in three steps. **Note:** *Use a thin-wall socket to avoid erroneous torque readings that can result if the socket is wedged between the rod cap and nut. If the socket tends to wedge itself between the nut and the cap, lift up on it slighty until it no longer contacts the cap.* Do not rotate the crankshaft at any time during this operation.

16 Remove the nuts and detach the rod cap, being very careful not to disturb the Plastigage.

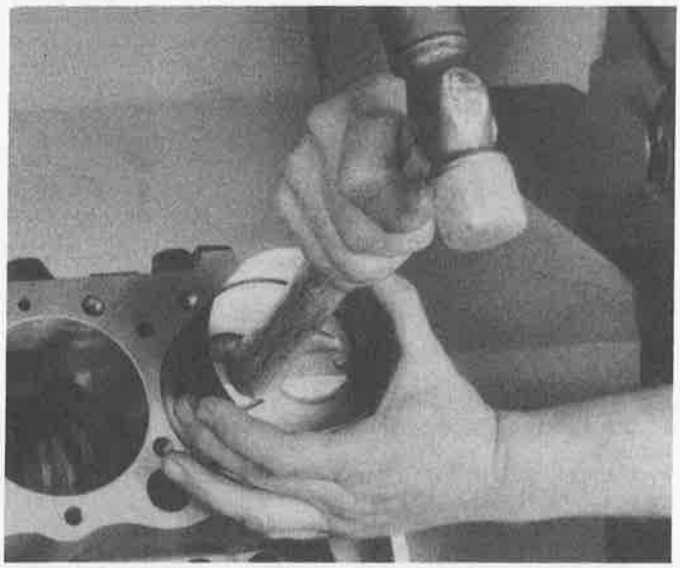
17 Compare the width of the crushed Plastigage to the scale printed on the Plastigage envelope to obtain the oil clearance (**see illustration**). Compare it to the Specifications to make sure the clearance is correct.

18 If the clearance is not as specified, the bearing inserts may be the wrong size (which means different ones will be required). Before deciding that different inserts are needed, make sure that no dirt or oil was between the bearing inserts and the connecting rod or cap when the clearance was measured. Also, recheck the journal diameter. If the Plastigage was wider at one end than the other, the journal may be tapered (refer to Section 18).

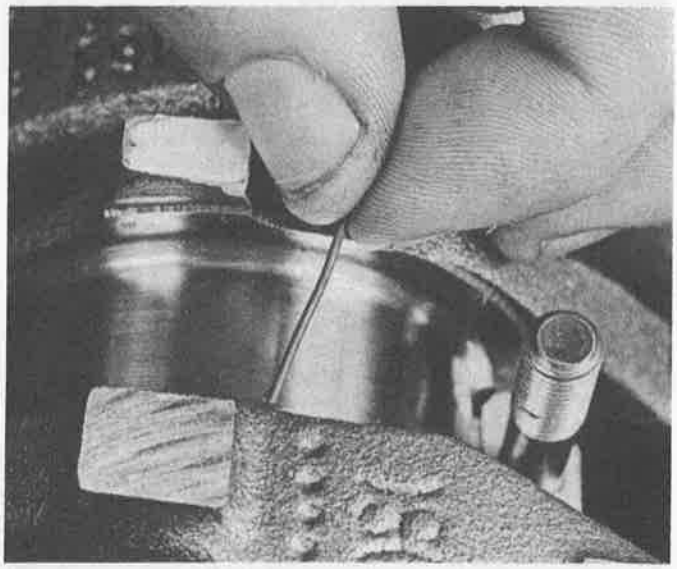
Final connecting rod installation

19 Carefully scrape all traces of the Plastigage material off the rod journal and/or bearing face. Be very careful not to scratch the bearing — use your fingernail or the edge of a credit card.

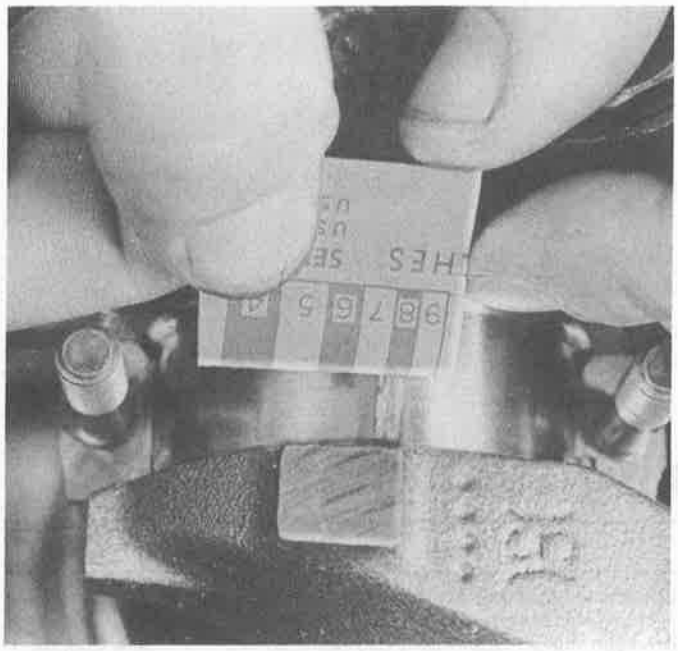
20 Make sure the bearing faces are perfectly clean, then apply a uniform layer of clean moly-base grease or engine assembly lube to both of them. You'll have to push the piston into the cylinder to expose the face of the bearing insert in the connecting rod — be sure to slip the protective hoses over the rod bolts first.



24.11 The piston can be driven (gently) into the cylinder bore with the end of a wooden hammer handle



24.13 Lay the Plastigage strips on each rod bearing journal, parallel to the crankshaft centerline



24.17 Measuring the width of the crushed Plastigage to determine the rod bearing oil clearance (be sure to use the correct scale — standard and metric scales are included)

21 Slide the connecting rod back into place on the journal, remove the protective hoses from the rod cap bolts, install the rod cap and tighten the nuts to the specified torque. Again, work up to the torque in three steps.
22 Repeat the entire procedure for the remaining pistons/connecting rods.
23 The important points to remember are . . .
a) Keep the back sides of the bearing inserts and the insides of the connecting rods and caps perfectly clean when assembling them.
b) Make sure you have the correct piston/rod assembly for each cylinder.
c) The arrow or F mark on the piston must face the front of the engine.
d) Lubricate the cylinder walls with clean oil.
e) Lubricate the bearing faces when installing the rod caps after the oil clearance has been checked.
24 After all the piston/connecting rod assemblies have been properly installed, rotate the crankshaft a number of times by hand to check for any obvious binding.
25 As a final step, the connecting rod end play must be checked. Refer to Section 12 for this procedure.
26 Compare the measured end play to the Specifications to make sure it's correct. If it was correct before disassembly and the original crankshaft and rods were reinstalled, it should still be right. If new rods or a new crankshaft were installed, the end play may be inadequate. If so, the rods will have to be removed and taken to an automotive machine shop for resizing.

25 Initial start-up and break-in after overhaul

Warning: *Have a fire extinguisher handy when starting the engine for the first time.*

1 Once the engine has been installed in the vehicle, double-check the engine oil and coolant levels.
2 With the spark plugs out of the engine and the ignition system disabled (see Section 3), crank the engine until oil pressure registers on the gauge or the light goes out.
3 Install the spark plugs, hook up the plug wires and restore the ignition system functions (Section 3).
4 Start the engine. It may take a few moments for fuel to reach the carburetor, but the engine should start without a great deal of effort.
Note: *If backfiring occurs through the carburetor, recheck the valve timing and ignition timing.*
5 After the engine starts, it should be allowed to warm up to normal operating temperature. While the engine is warming up, make a thorough check for fuel, oil and coolant leaks.
6 Shut the engine off and recheck the engine oil and coolant levels.
7 Drive the vehicle to an area with minimum traffic, accelerate at full throttle from 30 to 50 mph, then allow the vehicle to slow to 30 mph with the throttle closed. Repeat the procedure 10 or 12 times. This will load the piston rings and cause them to seat properly against the cylinder walls. Check again for oil and coolant leaks.
8 Drive the vehicle gently for the first 500 miles (no sustained high speeds) and keep a constant check on the oil level. It is not unusual for an engine to use oil during the break-in period.
9 At approximately 500 to 600 miles, change the oil and filter and retorque the cylinder head bolts (if the gasket manufacturer recommends it).
10 For the next few hundred miles, drive the vehicle normally. Do not pamper it or abuse it.
11 After 2000 miles, change the oil and filter again and consider the engine broken in.