

# Mitsubishi Engine Overhaul Procedures for the 2.0L, 2.4L, 2.6L & 3.0L Engines

This is a chapter section from an Auto Manual dealing only with the overhauling of the above mentioned Mitsubishi Motors.

## Chapter 2 Part D General engine overhaul procedures

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### Specifications

#### 2.6L engine

##### General

Displacement .....	155.9 cubic inches
Bore .....	3.59 inches
Stroke .....	3.86 inches
Cylinder compression pressure .....	130 to 150 psi at 250 rpm
Oil pressure (at 3000 rpm) .....	25 to 90 psi

##### Engine block

Cylinder taper limit .....	0.0008 inch
Cylinder out-of-round limit .....	0.0008 inch

**2.6L engine (continued)****Pistons and rings**

Piston diameter .....	3.5866 inches
Piston ring side clearance	
1983 through 1986	
Top compression ring	
Standard .....	0.002 to 0.004 inch
Service limit .....	Not available
Second compression ring	
Standard .....	0.001 to 0.002 inch
Service limit .....	Not available
1987 on	
Top compression ring	
Standard .....	0.0020 to 0.0035 inch
Service limit .....	0.0047 inch
Second compression ring	
Standard .....	0.0008 to 0.0024 inch
Service limit .....	0.0039 inch
Piston ring end gap	
1983 models only	
Top compression ring	
Standard .....	0.010 to 0.015 inch
Service limit .....	Not available
Second compression ring	
Standard .....	0.010 to 0.018 inch
Service limit .....	Not available
Oil ring	
Standard .....	0.012 to 0.024 inch
Service limit .....	Not available
1984 through 1986	
Top compression ring	
Standard .....	0.012 to 0.018 inch
Service limit .....	Not available
Second compression ring	
Standard .....	0.010 to 0.015 inch
Service limit .....	Not available
Oil ring	
Standard .....	0.012 to 0.024 inch
Service limit .....	Not available
1987 on	
Top compression ring	
Standard .....	0.0118 to 0.0177 inch
Service limit .....	0.031 inch
Second compression ring	
Standard .....	0.0098 to 0.0157 inch
Service limit .....	0.031 inch
Oil ring	
Standard .....	0.0118 to 0.0315 inch
Service limit .....	0.039 inch

**Crankshaft and connecting rods**

Endplay (standard) .....	0.002 to 0.007 inch
Main bearing journal	
Diameter .....	2.3622 inches
Taper limit	
1983 through 1986 .....	0.0004 inch
1987 on .....	0.0002 inch
Out-of-round limit	
1983 through 1986 .....	0.0004 inch
1987 on .....	0.0006 inch
Connecting rod journal	
Diameter .....	2.086 inches
Taper limit	
1983 through 1986 .....	0.0004 inch
1987 on .....	0.0002 inch
Out-of-round limit	
1983 through 1986 .....	0.0004 inch
1987 on .....	0.0006 inch

Main bearing oil clearance	
1983 through 1986	
Standard .....	0.0008 to 0.0020 inch
Service limit .....	0.004 inch
1987 on	
Standard .....	0.0008 to 0.0018 inch
Service limit .....	0.004 inch
Connecting rod bearing oil clearance	
1983 through 1987	
Standard .....	0.0008 to 0.0024 inch
Service limit .....	0.004 inch
1988 on	
Standard .....	0.0007 to 0.0022 inch
Service limit .....	0.004 inch
Connecting rod endplay (side clearance) .....	
	0.004 to 0.010 inch
<b>Camshaft</b>	
Endplay .....	0.004 to 0.008 inch
<b>Silent shafts</b>	
1983 through 1986	
Front bearing journal diameter .....	0.906 inch
Front bearing oil clearance .....	0.0008 to 0.0024 inch
Rear bearing journal diameter .....	1.693 inch
Rear bearing oil clearance .....	0.0024 to 0.0039 inch
1987 on	
Right silent shaft	
Front bearing journal diameter .....	0.830 inch
Front bearing oil clearance .....	Not available
Rear bearing journal diameter .....	1.693 inch
Rear bearing oil clearance .....	0.0039 to 0.0053 inch
Left silent shaft	
Front bearing journal diameter .....	0.906 inch
Front bearing oil clearance .....	0.0008 to 0.0024 inch
Rear bearing journal diameter .....	1.693 inch
Rear bearing oil clearance .....	0.0039 to 0.0053 inch
<b>Cylinder head and valves</b>	
Head warpage limit .....	0.004 inch
Valve seat angle .....	45-degrees
Valve face angle .....	45-degrees
Valve margin width	
Intake	
Standard .....	0.047 inch
Service limit .....	0.028 inch
Exhaust	
Standard .....	0.079 inch
Service limit (1983 through 1986) .....	Not available
Service limit (1987 on) .....	0.059 inch
Valve stem-to-guide clearance	
Intake	
Standard .....	0.0012 to 0.0024 inch
Service limit .....	0.004 inch
Exhaust	
Standard .....	0.0020 to 0.0035 inch
Service limit .....	0.006 inch
Valve spring free length	
1983 and 1984	
Standard .....	1.869 inch
Service limit .....	1.479 inch
1985 on	
Standard .....	1.961 inch
Service limit .....	1.922 inch
Valve spring installed height	
Standard .....	1.590 inch
Service limit .....	1.629 inch
Jet valves	
Stem diameter .....	0.1693 inch
Seat angle .....	45-degrees
Spring free length .....	1.165 inch
Spring pressure .....	7.7 lbs. at 0.846 inch

**2.6L engine (continued)****Torque specifications\***

	<b>Ft-lbs</b> (unless otherwise indicated)
Jet valves .....	14
Main bearing cap bolts .....	58
Connecting rod bearing cap nuts .....	34

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

**2.0L and 2.4L engines****General**

<b>Displacement</b>	
2.0L .....	121.9 cubic inches
2.4L .....	143.4 cubic inches
<b>Bore</b>	
2.0L .....	3.35 inches
2.4L .....	3.41 inches
<b>Stroke</b>	
2.0L .....	3.46 inches
2.4L .....	3.94 inches
Cylinder compression pressure .....	130 to 150 psi at 250 rpm
Oil pressure (at 3000 rpm) .....	25 to 90 psi

**Cylinder head and valves**

<b>Head warpage limit</b>	
Standard .....	0.002 inch
Service limit .....	0.008 inch
<b>Valve margin width</b>	
<b>Intake</b>	
Standard .....	0.047 inch
Service limit .....	0.028 inch
<b>Exhaust</b>	
Standard .....	0.079 inch
Service limit .....	0.059 inch
Valve stem diameter (intake and exhaust) .....	0.3100 inch
<b>Valve stem-to-guide clearance</b>	
1987 only	
<b>Intake</b>	
Standard .....	0.0012 to 0.0020 inch
Service limit .....	Not available
<b>Exhaust</b>	
Standard .....	0.0020 to 0.0031 inch
Service limit .....	Not available
<b>All others</b>	
<b>Intake</b>	
Standard .....	0.0012 to 0.0024 inch
Service limit .....	0.004 inch
<b>Exhaust</b>	
Standard .....	0.0020 to 0.0035 inch
Service limit .....	0.006 inch
<b>Valve spring</b>	
Out-of-square limit .....	3-degrees
Pressure .....	72 lbs (322 N)
Installed height .....	1.591 inch
<b>Free length</b>	
1983 and 1984	
Standard .....	1.870 inch
Service limit .....	Not available
1985 on	
Standard .....	1.960 inch
Service limit .....	1.921 inch
<b>Jet valves</b>	
<b>Stem diameter</b>	
1987 through 1989 .....	0.1693 inch
All others .....	Not available
<b>Face/seat angle</b>	
1987 through 1989 .....	45-degrees
All others .....	Not available

Spring	
Free length	
1987 through 1989 .....	1.165 inch
All others .....	Not available
Load	
1987 through 1989 .....	7.7 lbs at 0.846 in
All others .....	Not available
<b>Crankshaft and connecting rods</b>	
Connecting rod journal	
1983 through 1987	
Diameter .....	1.7720 inch
Out-of-round/taper limits .....	0.0004 inch
Bearing oil clearance .....	0.0008 to 0.0020 inch
1988 on	
Diameter .....	1.7720 inch
Out-of-round .....	0.0006 inch
Taper limits .....	0.0002 inch
Bearing oil clearance .....	0.0006 to 0.0020 inch
Connecting rod endplay (side clearance) .....	0.004 to 0.010 inch
Main bearing journal	
1983 through 1987	
Diameter .....	2.2440 inches
Out-of-round limits/taper limits .....	0.0004 inch
Bearing oil clearance .....	0.0008 to 0.0020 inch
1988 on	
Diameter .....	2.2440 inches
Out-of-round limits .....	0.0006 inch
Taper limit .....	0.0002 inch
Bearing oil clearance .....	0.0008 to 0.0020 inch
Crankshaft endplay .....	0.002 to 0.007 inch
<b>Cylinder bore</b>	
Diameter (nominal)	
2.0L engines .....	3.346 inches
2.4L engines .....	3.406 inches
Out-of-round/taper limits .....	0.0008 inches
<b>Pistons and rings</b>	
Piston diameter (nominal)*	
2.0L .....	3.346 inches
2.4L .....	3.406 inches
Piston-to-bore clearance	
2.0L .....	0.0004 to 0.0012 inch
2.4L .....	0.0008 to 0.0016 inch
Piston ring end gap	
1983 and 1984	
Number 1 (top) compression ring	
Standard .....	0.010 to 0.018 inch
Service limit .....	Not available
Number 2 compression ring	
Standard .....	0.008 to 0.016 inch
Service limit .....	Not available
Oil ring	
Standard .....	0.008 to 0.020 inch
Service limit .....	Not available
1985 and 1986	
Number 1 compression ring	
Standard .....	0.010 to 0.018 inch
Service limit .....	Not available
Number 2 compression ring	
Standard .....	0.008 to 0.016 inch
Service limit .....	Not available
Oil ring	
Standard .....	0.008 to 0.028 inch
Service limit .....	Not available
1987 on	
Number 1 compression ring	
Standard .....	0.010 to 0.016 inch
Service limit .....	0.031 inch

**2.0L and 2.4L engines (continued)**

Number 2 compression ring (2.0L only)	
Standard	0.008 to 0.014 inch
Service limit	0.031 inch
Number 2 compression ring (2.4L only)	
Standard	0.008 to 0.016 inch
Service limit	0.031 inch
Oil ring	
Standard	0.008 to 0.028 inch
Service limit	0.039 inch
Piston ring side clearance	
1986 and earlier	
No. 1 (top) compression ring	
Standard	0.002 to 0.004 inch
Service limit	Not available
No. 2 compression ring	
Standard	0.001 to 0.002 inch
Service limit	Not available
1987 on	
No. 1 (top) compression ring	
Standard	0.0012 to 0.0028 inch
Service limit	0.004 inch
No. 2 compression ring	
Standard	0.0008 to 0.0024 inch
Service limit	0.004 inch

\* Measured 5/64-inch up from bottom of skirt

**Silent shafts**

Right silent shaft	
Front bearing journal diameter	1.650 inch
Front bearing oil clearance	
1987 only	0.0031 to 0.0043 inch
All others	0.0008 to 0.0024 inch
Rear bearing journal diameter	1.610 inch
Rear bearing oil clearance	
1987 only	0.0043 to 0.0055 inch
All others	0.0020 to 0.0036 inch
Left silent shaft	
Front bearing journal diameter	0.728 inch
Front bearing oil clearance	
1983 through 1986	0.0008 to 0.0020 inch
1987 only	0.0008 to 0.0021 inch
All others	0.0008 to 0.0024 inch
Rear bearing journal diameter	1.610 inch
Rear bearing oil clearance	
1987 only	0.0043 to 0.0055 inch
All others	0.0020 to 0.0036 inch

**Torque specifications\***

Main bearing cap bolts	<b>Ft-lbs</b> 37 to 39
Connecting rod cap nuts	37 to 38
Jet valves	13 to 16

\* Note: Refer to Part B for additional torque specifications.

**3.0L engine****General**

Displacement	181 cubic inches
Bore	3.587 inches
Stroke	2.992 inches
Cylinder compression pressure	119 at 250 rpm
Oil pressure	11.4 psi at idle

**Engine block**

Inside diameter	3.586 to 3.587 inches
Cylinder taper limit	0.0008 inch
Cylinder out-of-round limit	0.0008 inch

**Pistons and rings**

Piston diameter .....	3.587 inches
Piston ring side clearance	
Top compression ring	
Standard .....	0.0012 to 0.0035 inch
Service limit .....	0.004 inch
Second compression ring	
Standard .....	0.0008 to 0.0024 inch
Service limit .....	0.004 inch
Piston ring end gap	
Top compression ring	
Standard .....	0.0118 to 0.0177 inch
Service limit .....	0.031 inch
Second compression ring	
Standard .....	0.0098 to 0.0157 inch
Service limit .....	0.031 inch
Oil ring	
Standard .....	0.0079 to 0.0276 inch
Service limit .....	0.040 inch

**Crankshaft and connecting rods**

Endplay	
Standard .....	0.002 to 0.010 inch
Service limit .....	0.012 inch
Main bearing journal	
Diameter .....	2.361 to 2.362 inches
Taper limit .....	0.0002 inch
Out-of-round limit .....	0.001 inch
Connecting rod journal	
Diameter .....	1.968 to 1.969 inch
Taper limit .....	0.0002 inch
Out-of-round limit .....	0.001 inch
Main bearing oil clearance .....	0.0008 to 0.0019 inch
Connecting rod bearing oil clearance .....	0.0006 to 0.0018 inch
Connecting rod endplay (side clearance)	
Standard .....	0.004 to 0.010 inch
Service limit .....	0.016 inch

**Cylinder head and valves**

Head warpage limit .....	0.002 inch
Valve seat angle .....	45-degrees
Valve face angle .....	45-degrees
Valve margin width	
Intake	
Standard .....	0.047 inch
Service limit .....	0.027 inch
Exhaust	
Standard .....	0.079 inch
Service limit .....	0.059 inch
Valve stem-to-guide clearance	
Intake	
Standard .....	0.0012 to 0.0024 inch
Service limit .....	0.004 inch
Exhaust	
Standard .....	0.0020 to 0.0035 inch
Service limit .....	0.006 inch
Valve spring free length	
Standard .....	1.988 inch
Service limit .....	1.949 inch
Valve spring installed height	
Standard .....	1.591 inch
Service limit .....	1.630 inch
Valve stem diameter	
Intake .....	0.313 to 0.314 inch
Exhaust .....	0.312 to 0.313 inch

**Torque specifications**

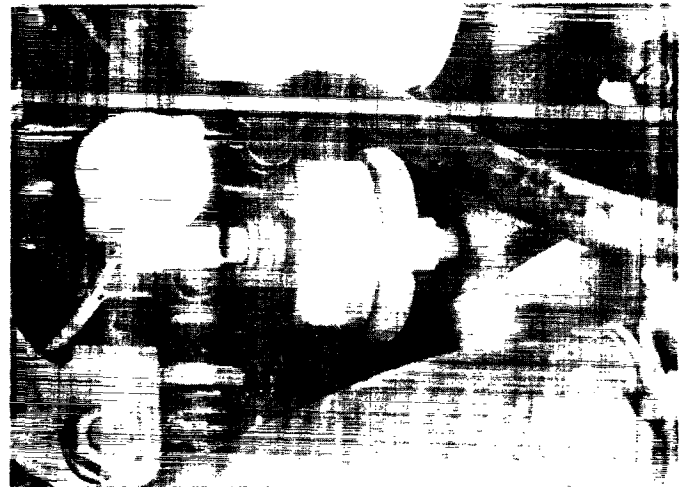
	<b>Ft-lbs</b> (unless otherwise indicated)
Main bearing cap bolts .....	60
Connecting rod bearing cap nuts .....	34

\* Note: Refer to Part C for additional torque specifications.

Four cylinder and V-6 engines

Model	Engine number (Displacement)	Valve type
<b>Pick-up</b>		
G63B	(2.0L) (1983-1984)	Adjustable w/Jet valve
G63B	(2.0L) (1985-1989)	Hydraulic w/Jet valve
G54B	(2.6L) (1983-1984)	Adjustable w/Jet valve
G54B	(2.6L) (1985-1989)	Hydraulic w/Jet valve
4G64	(2.4L) (1990 on)	Hydraulic w/Jet valve
6G72	(3.0L) (1990 on)	Hydraulic w/Jet valve
<b>Montero</b>		
6G72	(3.0L) (1989 on)	Hydraulic w/Jet valve
G54B	(2.6L)	Hydraulic w/Jet valve

1.4 Engine Identification Chart



2.4a Remove the oil pressure sending unit (switch) and install a pressure gauge in its place (2.6L engine shown)

2 Engine overhaul – general information

Refer to illustrations 2.4a, 2.4b and 2.4c

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 isn't necessarily an indication 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 oil leaks aren't responsible before deciding the rings and/or guides are bad. Perform a cylinder compression check to determine the extent of the work required (see Section 3).

Remove the oil pressure sending unit and check the oil pressure with a gauge installed in its place (see illustrations). Compare the results to this Chapter's Specifications. As a general rule, engines should have ten psi oil pressure for every 1,000 rpm's. If the pressure is extremely low, the bearings and/or oil pump are probably worn out.

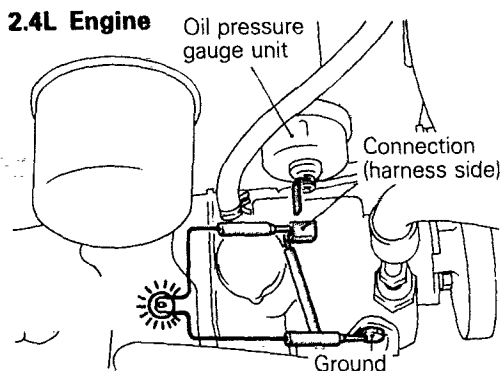
1 General information

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

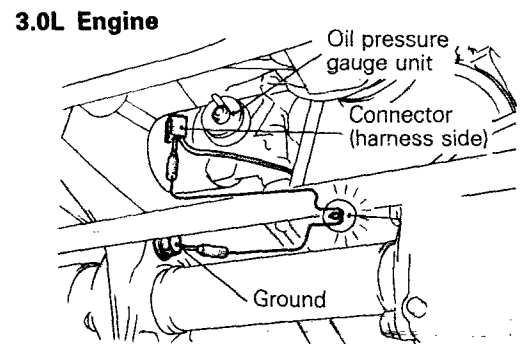
The information ranges from advice concerning preparation for an overhaul and the purchase of replacement parts to detailed, step-by-step procedures covering removal and installation of internal engine components and the inspection of parts.

The following Sections have been written based on the assumption 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 (2.6L engine), Part B (2.0L and 2.4L engines) or Part C (3.0L V6 engine) of this Chapter.

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



2.4b Location of the oil pressure sending unit on 2.4L engines



2.4c Location of the oil pressure sending unit on 3.0L engines

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 re-bore 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 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 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 particularly difficult, if you follow all of the instructions carefully, have the necessary tools and equipment and pay close attention to all specifications; however, it can be 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 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 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 the 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.*

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 (see Chapter 1).

4 Block the throttle wide open.

5 Disable the fuel system by removing the fuel pump fuse (see Chapter 4).

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 this Chapter's Specifications.

9 If the readings are below normal, 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 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 about 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(s) 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.

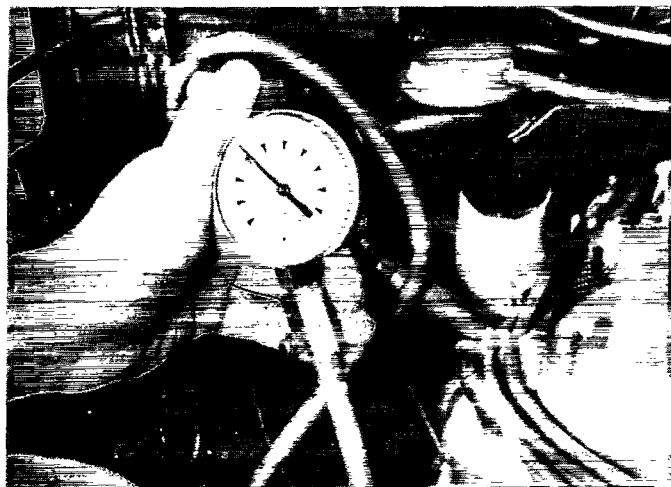
### 4 Engine removal - methods and precautions

If you've decided the 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 its



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

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, be sure to 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 5.5

**Warning:** Gasoline is extremely flammable, so take extra precautions when you work on any part of the fuel system. Don't smoke or allow open flames or bare light bulbs near the work area, and don't work in a garage where a natural gas-type appliance (such as a water heater or clothes dryer) with a pilot light is present. If you spill any fuel on your skin, rinse it off immediately with soap and water. When you perform any kind of work on the fuel system, wear safety glasses and have a Class B type fire extinguisher on hand. Also, the air conditioning system is under high pressure—have a dealer service department or service station discharge the system before disconnecting any of the hoses or fittings.

**Note:** Read through the following steps carefully and familiarize yourself with the procedure before beginning work.

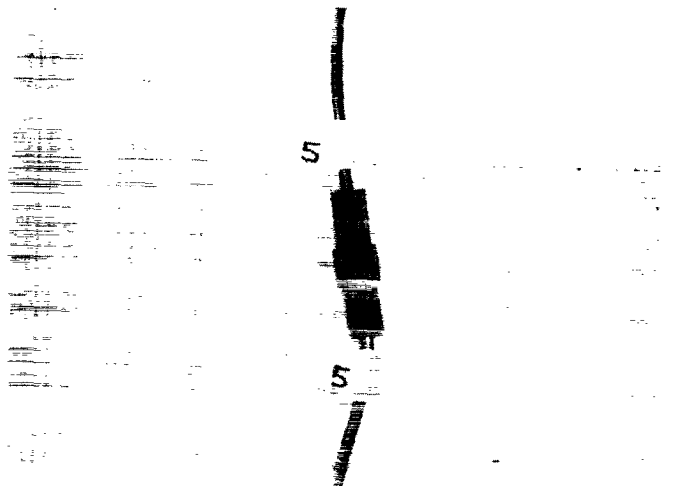
### Removal

- 1 On air conditioned models only, have the air conditioning system discharged by a dealer service department or service station.
- 2 Refer to Chapter 4 and relieve the fuel system pressure, then disconnect the negative cable from the battery.
- 3 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.
- 4 Remove the air cleaner assembly (see Chapter 4).
- 5 Label the vacuum lines, emissions system hoses, electrical connectors, 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 (see illustration). If there's any possibility of confusion, make a sketch of the engine compartment and clearly label the lines, hoses and wires.
- 6 Raise the vehicle and support it securely on jackstands. Drain the cooling system (see Chapter 1).
- 7 Label and detach all coolant hoses from the engine.
- 8 Remove the coolant reservoir, cooling fan, shroud and radiator (see Chapter 3).
- 9 Remove the drivebelt(s) and idler, if equipped (see Chapter 1).
- 10 Disconnect the fuel lines running from the engine to the chassis (see Chapter 4). Plug or cap all open fittings/lines.
- 11 Disconnect the throttle linkage (and TV linkage/cruise control cable, if equipped) from the engine (see Chapters 4 and 7).

- 12 Unbolt the power steering pump and set it aside (see Chapter 10). Leave the lines/hoses attached and make sure the pump is kept in an upright position in the engine compartment.
- 13 Unbolt the air conditioning compressor (see Chapter 3) and set it aside. Do not disconnect the hoses.
- 14 Drain the engine oil and remove the filter (see Chapter 1).
- 15 Remove the starter and the alternator (see Chapter 5).
- 16 Check for clearance and remove the brake master cylinder, if necessary, to allow clearance for the engine (see Chapter 9).
- 17 Disconnect the exhaust system from the engine (see Chapter 4).
- 18 If the vehicle is equipped with an automatic transmission, remove the torque converter bolts (see Chapter 7, Part B). Do not remove any of the transmission-to-engine mounting bolts.
- 19 Support the transmission with a jack. Position a block of wood on the jack head to prevent damage to the transmission.
- 20 Attach an engine sling or a length of chain to the lifting brackets on the engine.
- 21 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.
- 22 Remove the driveshaft(s) (see Chapter 8).
- 23 Remove the engine mount-to-chassis bolts. Refer to the appropriate Chapter (2A, 2B or 2C) for the complete illustrations of the engine mounts.
- 24 Remove the engine-to-transmission bellhousing bolts.
- 25 Recheck to be sure nothing is still connecting the engine to the transmission. Disconnect anything still remaining.
- 26 Raise the engine slightly to disengage the mounts. Also, slightly raise the jack supporting the transmission. Move the engine forward, disengaging it from the transmission. If the vehicle is equipped with a manual transmission, be sure the clutch pressure plate is clear of the transmission input shaft. If the vehicle is equipped with an automatic transmission, make sure the torque converter stays with the transmission and doesn't stick to the driveplate. Slowly raise the engine out of the vehicle. Check carefully to make sure nothing is hanging up as the hoist is raised.
- 27 Once the engine assembly is out of the vehicle, be sure the torque converter (automatic transmission) stays in place (clamp a pair of visegrips to the housing to keep the converter from sliding out).
- 28 Lower the engine to the ground and support it with blocks of wood. Remove the clutch and flywheel or driveplate and mount the engine on an engine stand.

### Installation

- 29 Check the engine and transmission mounts. If they're worn or damaged, replace them.
- 30 If you're working on a manual transmission equipped vehicle, install the clutch and pressure plate (see Chapter 7). Now is a good time to install a new clutch. Apply a dab of high-temperature grease to the input shaft.



5.5 Label each wire before unplugging the connector

31 Carefully lower the engine into the engine compartment and mate it to the transmission. **Caution:** *DO NOT use the bellhousing bolts to force the transmission and engine together.* If you're working on an automatic transmission equipped vehicle, take great care when installing the torque converter, following the procedure outlined in Chapter 7B. Line up the holes in the engine mounts with the holes in the frame and install the bolts, tightening them securely.

32 Add coolant, oil, power steering and transmission fluid as needed. If the brake master cylinder was removed, bleed the brakes (see Chapter 9). Recheck the fluid level and test the brakes.

33 Run the engine and check for leaks and proper operation of all accessories, then install the hood and test drive the vehicle.

34 If the air conditioning system was discharged, have it evacuated, recharged and leak tested by the shop that discharged it.

## 6 Engine rebuilding alternatives

The home mechanic 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.

Some of the rebuilding alternatives include:

**Individual parts** – If the inspection procedures reveal 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 camshaft, valve train components, cylinder head(s) 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(s), valve cover(s), camshaft and valve train components, timing sprockets and chain and timing chain 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 7.5a, 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 it's 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. These include:

- Alternator and brackets
- Emissions control components
- Ignition coil/module assembly, spark plug wires and spark plugs
- Thermostat and housing cover
- Water pump
- Carburetor/EFI components
- Intake/exhaust manifolds

- Oil filter
- Engine mounts
- Clutch and flywheel/driveplate

**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(s), 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 removed in the following general order (see illustrations on following page):

### 2.6L engine

- Valve cover
- Cylinder head and camshaft
- Timing chain housing
- Silent shaft chain and sprockets
- Timing chain and sprockets
- Oil pan
- Oil pump
- Piston/connecting rod assemblies
- Rear main oil seal housing
- Crankshaft and main bearings

### 2.0L and 2.4L engines

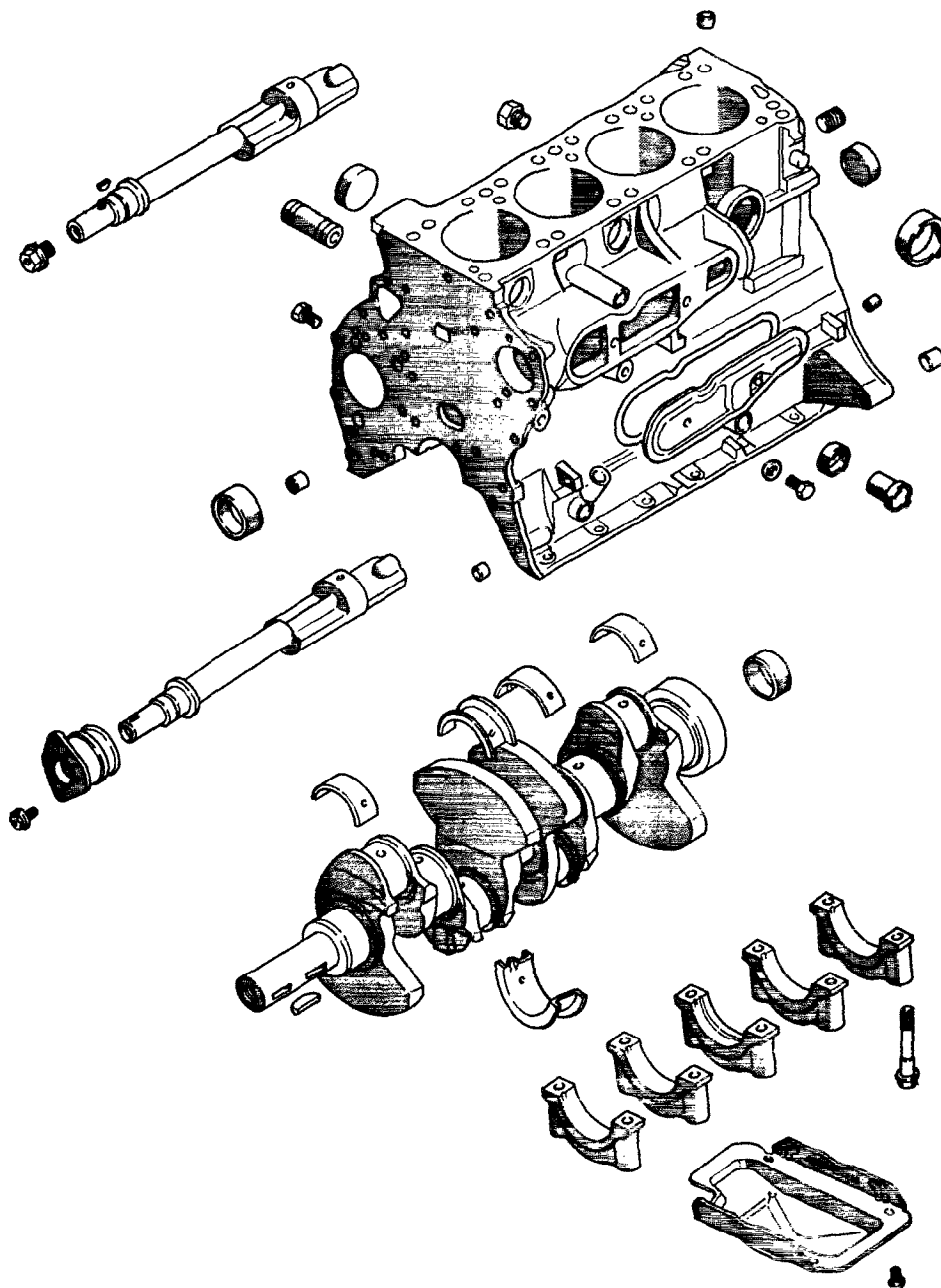
- Valve cover
- Intake/exhaust manifolds
- Rocker arm assembly
- Hydraulic lash adjusters (if equipped)
- Camshaft
- Timing belt cover
- Timing belt and sprockets
- Cylinder head
- Oil pan
- Oil pump
- Piston/connecting rod assemblies
- Crankshaft and main bearings

### 3.0L V6 engine

- Valve covers
- Exhaust manifolds
- Rocker arm assemblies and camshafts
- Rocker arms
- Intake manifold
- Timing belt cover
- Timing belt and sprockets
- Cylinder heads
- Oil pan
- Oil pump
- Piston/connecting rod assemblies
- Rear main oil seal housing
- 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
- Vibration damper puller
- Micrometers
- Telescoping gauges
- Dial indicator set
- Valve spring compressor
- Cylinder surfacing hone
- Piston ring groove cleaning tool



7.5a Exploded view of the cylinder block and internal engine components (2.6L engine)

Electric drill motor  
Tap and die set  
Wire brushes  
Oil gallery brushes  
Cleaning solvent

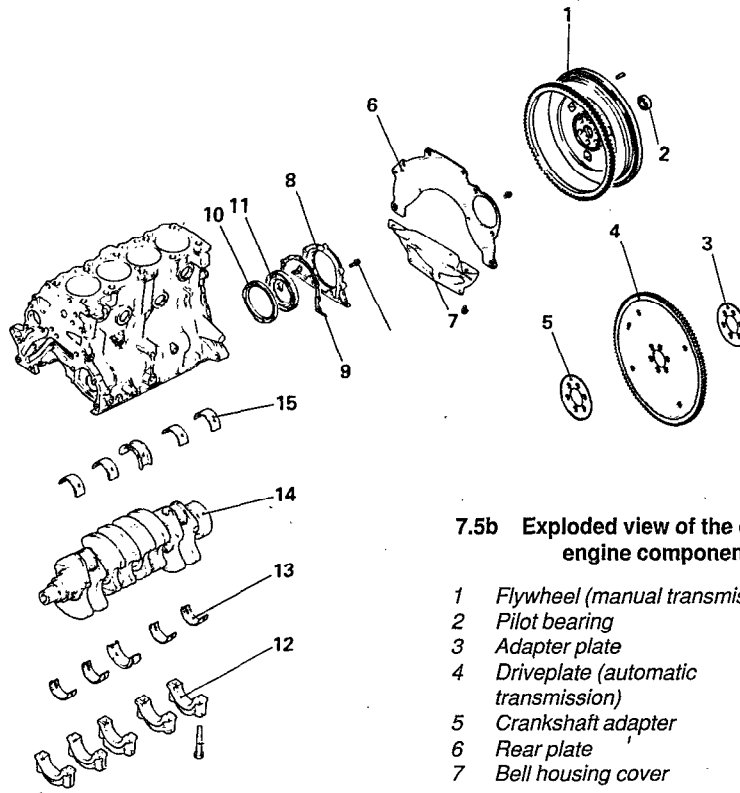
## 8 Cylinder head - disassembly

Refer to illustrations 8.2, 8.3 and 8.4

**Note:** New and rebuilt cylinder heads are commonly available for most en-

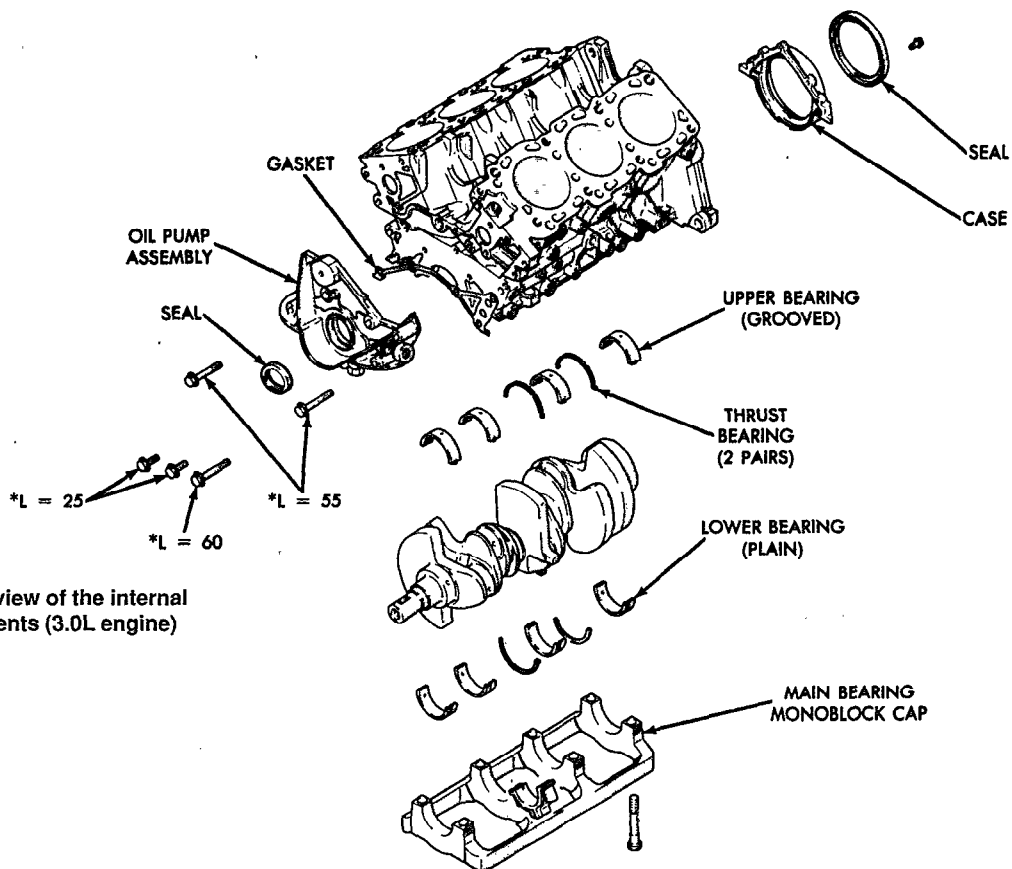
gines at dealerships and auto parts stores. Due to the fact that some specialized tools are necessary for the disassembly and inspection procedures, and replacement parts aren't always readily available, it may be more practical and economical for the home mechanic to purchase replacement head(s) rather than taking the time to disassemble, inspect and recondition the original(s).

1 Cylinder head disassembly involves removal of the intake and exhaust valves and related components. The rocker arm assemblies and camshaft(s) must be removed before beginning the cylinder head disassembly procedure (see Part A, B or C of this Chapter). Label the parts or store them separately so they can be reinstalled in their original locations.

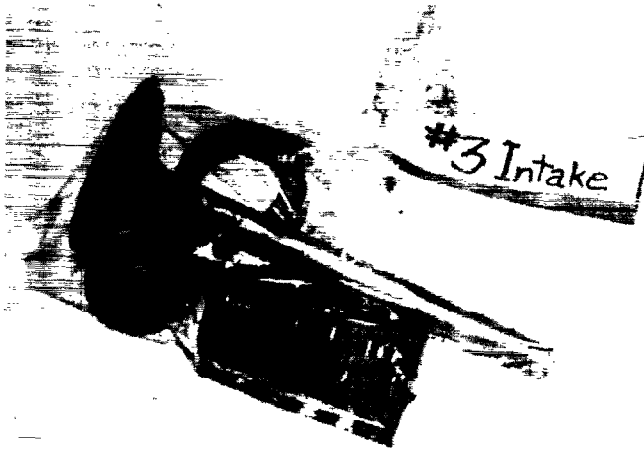


7.5b Exploded view of the cylinder block and internal engine components (2.4L engine)

- |                                       |                       |
|---------------------------------------|-----------------------|
| 1 Flywheel (manual transmission)      | 8 Oil seal case       |
| 2 Pilot bearing                       | 9 Gasket              |
| 3 Adapter plate                       | 10 Oil separator      |
| 4 Driveplate (automatic transmission) | 11 Rear main oil seal |
| 5 Crankshaft adapter                  | 12 Bearing cap        |
| 6 Rear plate                          | 13 Lower bearing      |
| 7 Bell housing cover                  | 14 Crankshaft         |
|                                       | 15 Upper bearing      |



7.5c Exploded view of the internal engine components (3.0L engine)



**8.2** 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 original location

- 2 Before the valves are removed, arrange to label and store them, along with their related components, so they can be kept separate and reinstalled in their original locations (see illustration).
- 3 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).
- 4 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 (see illustration).
- 5 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.
- 6 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(s) 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 severely overheated, the cylinder head is probably warped.

### Cleaning

- 2 Scrape all traces of old gasket material and sealant off the head gasket, intake manifold and exhaust manifold mating surfaces. Be very careful not to gouge the cylinder head. Special gasket removal solvents that soften gaskets and make removal much easier are available at auto parts stores.
- 3 Remove all built-up scale from the coolant passages.
- 4 Run a stiff wire brush through the various holes to remove deposits that may have formed in them.
- 5 Run an appropriate size tap into each of the threaded holes to remove 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 camshaft bearing cap bolt 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 are available and



**8.3** Use a valve spring compressor to compress the spring, then remove the keepers from the valve stem



**8.4** If the valve won't pull through the guide, deburr the edge of the stem end and the area around the top of the keeper groove with a file or whetstone

may prove very useful when cleaning cylinder heads and valve train components. They're very caustic and should be used with caution. Be sure to follow the instructions on the container.

8 Clean the rocker arms and bearing caps with solvent and dry them thoroughly (don't mix them up during the cleaning process). Compressed air will speed the drying process and can be used to clean out the oil passages.

9 Clean all the valve springs, spring seats, keepers and retainers with solvent and dry them thoroughly. Do the components from one valve 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 deposits from the valve heads and stems. Again, make sure the valves don't get mixed up.

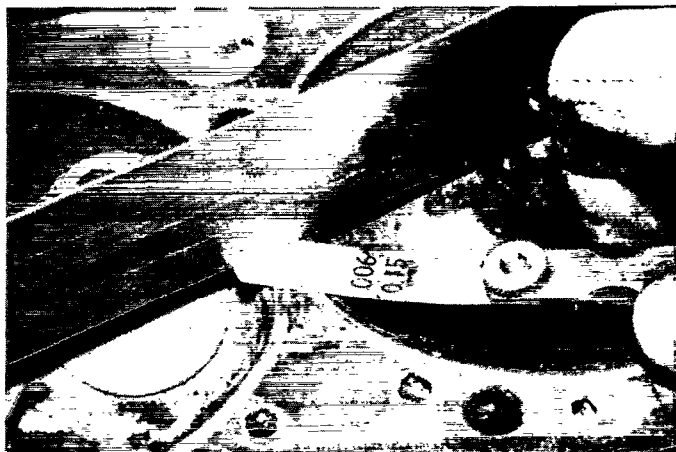
### Inspection

Refer to illustrations 9.12, 9.14, 9.15, 9.16, 9.17, and 9.18

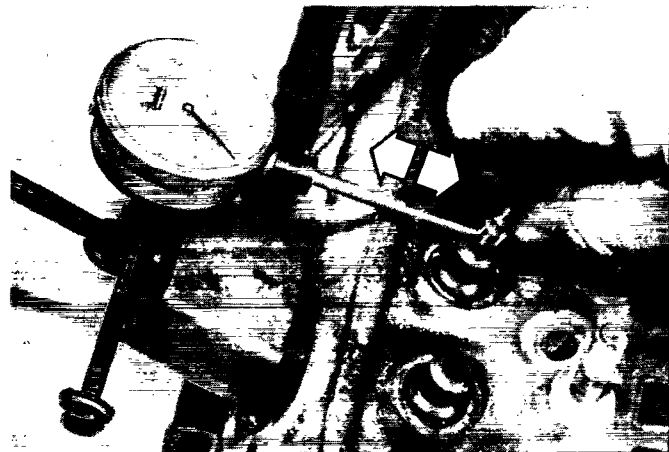
**Note:** Be sure to perform all of the following inspection procedures before concluding machine shop work is required. Make a list of the items that need attention.

### Cylinder head

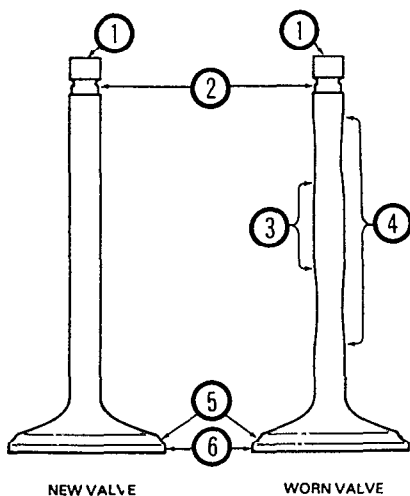
11 Inspect the head very carefully for cracks, evidence of coolant leakage and other damage. If cracks are found, check with an automotive machine shop concerning repair. If repair isn't possible, a new cylinder head should be obtained.



9.12 Check the cylinder head gasket surface for warpage by trying to slip a feeler gauge under the straightedge (see this Chapter's 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 Check for valve wear at the points shown here

- |                          |                         |
|--------------------------|-------------------------|
| 1 Valve tip              | 4 Stem (most worn area) |
| 2 Keeper groove          | 5 Valve face            |
| 3 Stem (least worn area) | 6 Margin                |

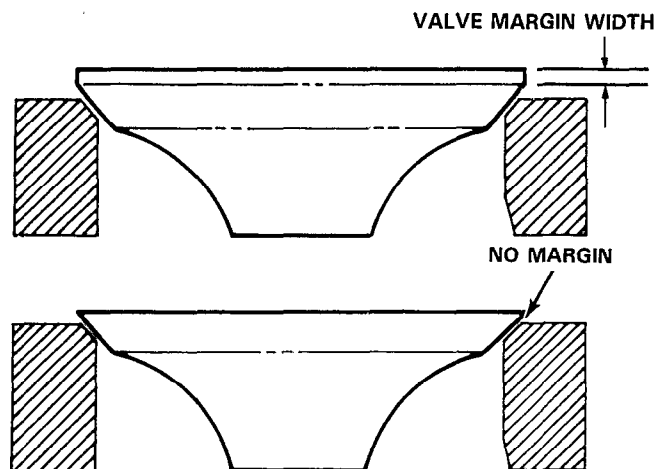
12 Using a straightedge and feeler gauge, check the head gasket mating surface for warpage (see illustration). If the warpage exceeds the limit in this Chapter's Specifications, it can be resurfaced at an automotive machine shop. **Note:** If the V6 engine heads are resurfaced, the intake manifold flanges will also require machining.

13 Examine the valve seats in each of the combustion chambers. If they're pitted, cracked or burned, the head will require valve service that's beyond the scope of the home mechanic.

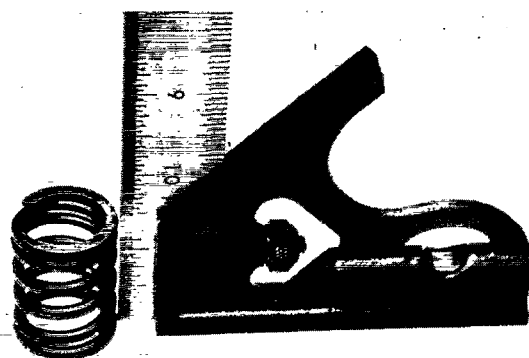
14 Check the valve stem-to-guide clearance by measuring the lateral movement of the valve stem with a dial indicator attached securely to the head (see illustration). The valve must be in the guide and approximately 1/16-inch off the seat. The total valve stem movement indicated by the gauge needle must be divided by two to obtain the actual clearance. After this is done, if there's still some doubt regarding the condition of the valve guides, they should be checked by an automotive machine shop (the cost should be minimal).

### Valves

15 Carefully inspect each valve face for uneven wear, deformation, cracks, pits and burned areas. Check the valve stem for scuffing and galling and the neck for cracks. Rotate the valve and check for any obvious indication that it's bent. Look for pits and excessive wear on the end of the



9.16 The margin width on each valve must be as specified (if no margin exists, the valve cannot be reused)



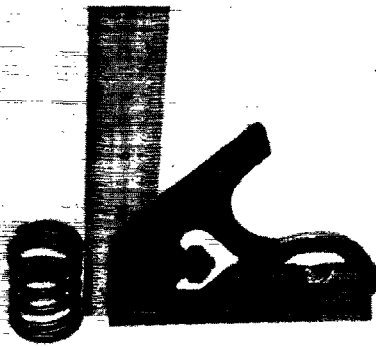
9.17 Measure the free length of each valve spring with a dial or vernier caliper

stem. The presence of any of these conditions (see illustration) indicates the need for valve service by an automotive machine shop.

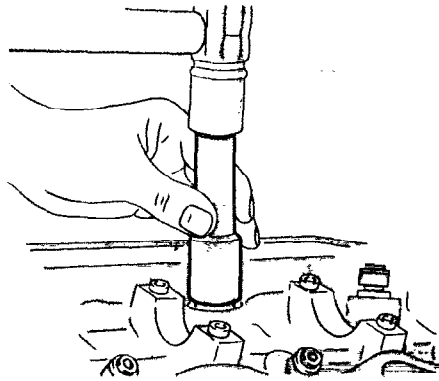
16 Measure the margin width on each valve (see illustration). Any valve with a margin narrower than specified in this Chapter will have to be replaced with a new one.

### Valve components

17 Check each valve spring for wear (on the ends) and pits. Measure the free length and compare it to this Chapter's Specifications (see illustra-



9.18 Check each valve spring for squareness



11.4 Make sure the valve stem seals are installed evenly and carefully to avoid damage



11.6 Apply a small dab of grease to each keeper as shown here before installation – it'll hold them in place on the valve stem as the spring is released

tion). Any springs that are shorter than specified have sagged and shouldn't be reused. The tension of all springs should be checked with a special fixture before deciding they're suitable for use in a rebuilt engine (take the springs to an automotive machine shop for this check).

18 Stand each spring on a flat surface and check it for squareness (see illustration). If any of the springs are distorted or sagged, replace all of them with new parts.

19 Check the spring retainers and keepers for obvious wear and cracks. Any questionable parts should be replaced with new ones, as extensive damage will occur if they fail during engine operation.

20 If the inspection process indicates the valve components are in generally poor condition and worn beyond the limits specified, which is usually the case in an engine that's being overhauled, reassemble the valves in the cylinder head and refer to Section 11 for valve servicing recommendations.

## 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, rotators, 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 11.4, 11.6, 11.8, 11.9 and 11.12

1 Regardless of whether or not the head was sent to an automotive re-

pair 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 spring seats or valve rotators (if equipped) before the valve seals.

4 Install new seals on each of the valve guides. Using a hammer and a deep socket or seal installation tool, gently tap each seal into place until it's completely seated on the guide (see illustration). Don't twist or cock the seals during installation or they won't seal properly on the valve stems.

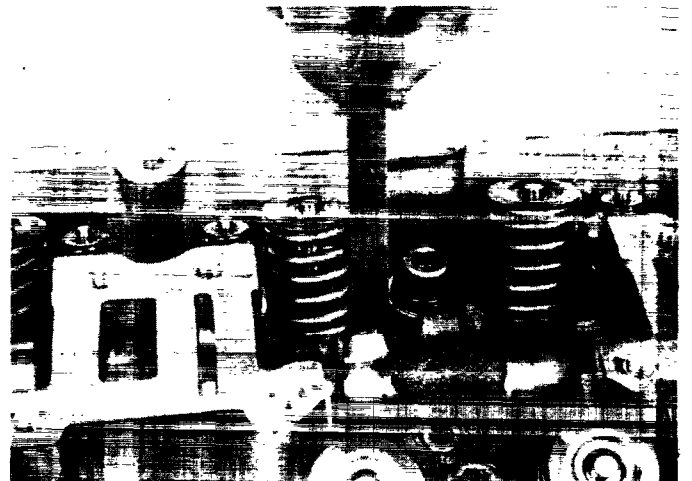
5 Beginning at one end of the head, lubricate and install the first valve.

Apply moly-base grease or clean engine oil to the valve stem.

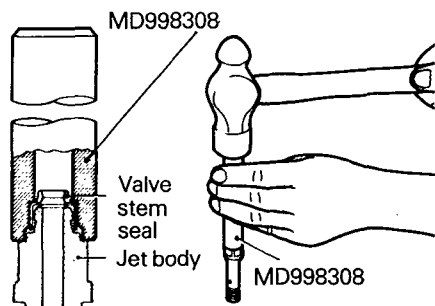
6 Position the valve springs (and shims, if used) over the valves. Compress the springs with a valve spring compressor and carefully install the keepers in the groove, then slowly release the compressor and make sure the keepers seat properly. Apply a small dab of grease to each keeper to hold it in place if necessary (see illustration).

7 Repeat the procedure for the remaining valves. Be sure to return the components to their original locations – don't mix them up!

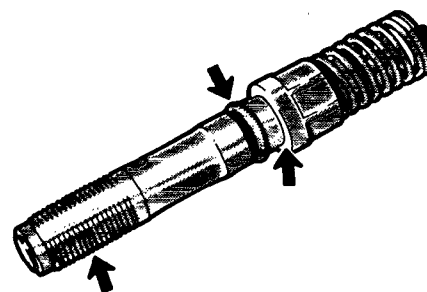
8 Check the installed valve spring height with a ruler graduated in 1/32-inch increments or a dial caliper. If the head was sent out for service work, the installed height should be correct (but don't automatically assume it is). The measurement is taken from the top of each spring seat to the bottom of the retainer (see illustration). If the height is greater than listed in this Chapter's Specifications, shims can be added under the springs to correct it. **Caution:** Do not, under any circumstances, shim the



11.8 Be sure to check the valve spring installed height (the distance from the top of the seat/shims to the top of the spring)



11.9 A special tool is available for jet valve stem seal replacement



11.12 Be sure to use new O-rings when reinstalling the jet valves and apply engine oil to the O-rings, threads and seat area (arrows)

*springs to the point where the installed height is less than specified.*

9 If the engine is equipped with jet valves (refer to the chart in Section 1), install new valve stem seals and O-rings onto each assembly. Using the special tool, drive the jet valve stem seal into place on the valve body (**see illustration**). If the special tool isn't available, a deep socket of the appropriate size can be used if you're careful. Do not reuse the old seals and don't try to install the seals with any other type of tool.

10 Apply engine oil to the jet valve stem when installing it in the valve body. Take care not to damage the valve stem seal lip. Make sure the jet valve stem slides smoothly in the body.

11 Compress the spring with special tool and install it together with the valve spring retainer. Install the retainer lock. Be careful not to damage the valve stem seal with the bottom of the retainer.

12 Install a new O-ring in the jet valve body groove and apply a thin coat of engine oil to it (**see illustration**). Apply oil to the threads and seat as well.

13 Reinstall the jet valves and tighten them to the specified torque.

14 Apply moly-base grease to the rocker arm faces, the camshaft and the rocker shafts, then install the camshaft, rocker arms and shafts (refer to Part A).

15 Install the camshafts, hydraulic lash adjusters and rocker arm assemblies onto the head.

16 Apply moly-base grease to the rocker arm faces and the pivot balls, then install the rocker arm assembly on the cylinder head.

## 12 Pistons and connecting rods – removal

Refer to illustrations 12.1, 12.3 and 12.6

**Note:** Prior to removing the piston/connecting rod assemblies, remove the

cylinder head(s), the oil pan and the oil pump by referring to the appropriate Sections in Parts A, B or C of Chapter 2.

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 endplay with feeler gauges. Slide them between the first connecting rod and the crankshaft throw until the play is removed (**see illustration**). The endplay is equal to the thickness of the feeler gauge(s). If the endplay exceeds the service limit, new connecting rods will be required. If new rods (or a new crankshaft) are installed, the endplay may fall under the minimum listed in this Chapter's Specifications (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 engine type and cylinder they're associated with).

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**).



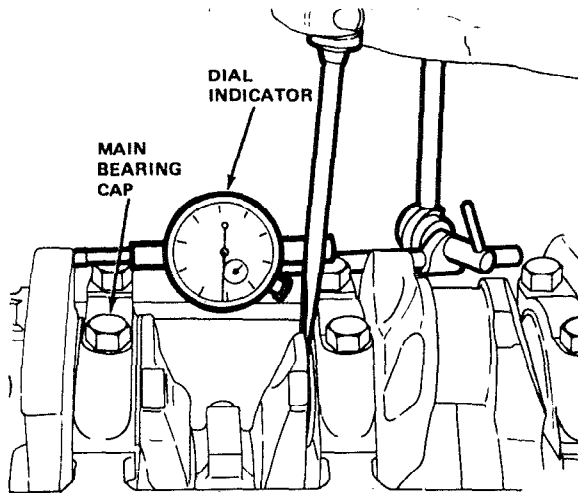
12.1 A ridge reamer is required to remove the ridge from the top of each cylinder – do this before removing the pistons!



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



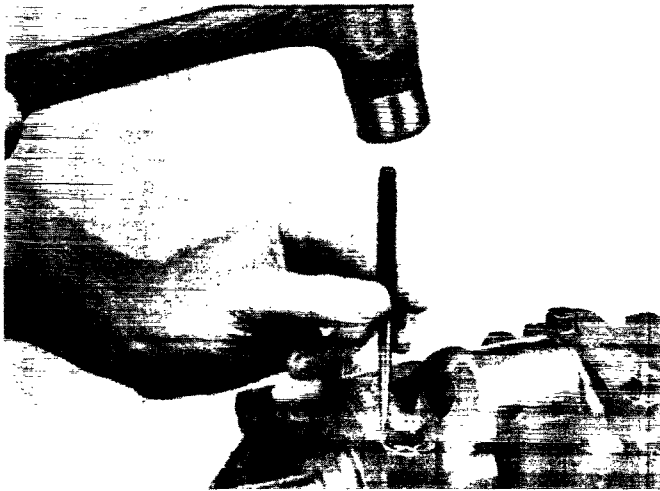
12.6 To prevent damage to the crankshaft journals and cylinder walls, slip sections of rubber or plastic hose over the rod bolts before removing the pistons



13.1 Checking crankshaft endplay with a dial indicator



13.3 Checking crankshaft endplay with a feeler gauge



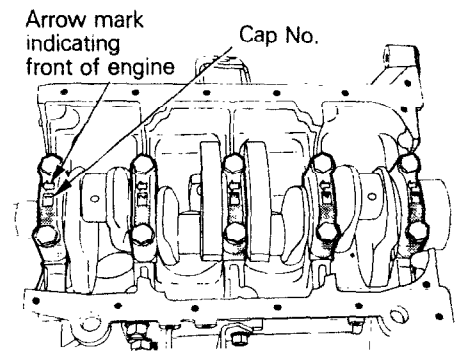
13.4a Use a center punch or number stamping dies to mark the main bearing caps to ensure installation in their original locations on the block (make the punch marks near one of the bolt heads)

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

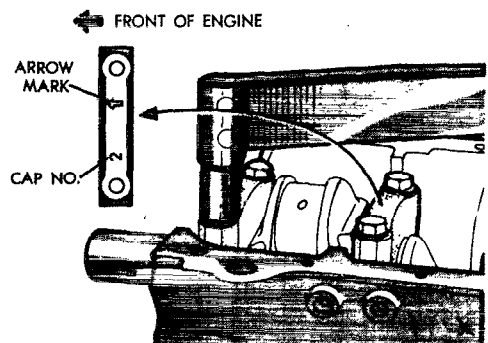
8 Repeat the procedure for the remaining cylinders.

9 After removal, reassemble the connecting rod caps and bearing 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).



13.4b The main bearing cap numerals (arrows) are easily visible on the 2.4L engine



13.4c The main bearing caps on the 2.6L have arrows that point to the front of the engine

### 13 Crankshaft - removal

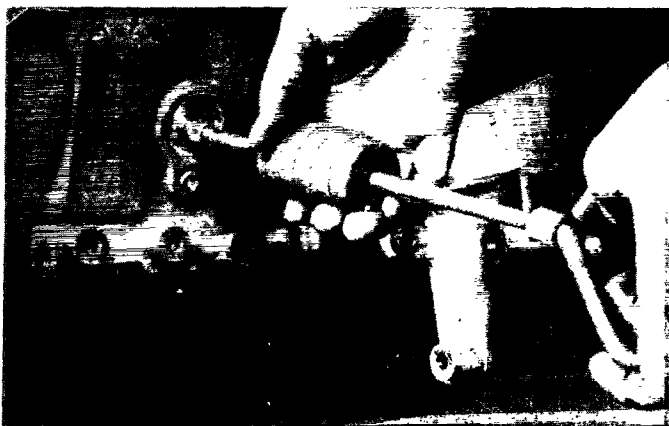
Refer to illustrations 13.1, 13.3, 13.4a, 13.4b and 13.4c

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

1 Before the crankshaft is removed, check the endplay. Mount a dial indicator with the stem in line with the crankshaft and 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 it moves is the endplay. If it's greater than specified in this Chapter, check the crankshaft thrust surfaces for wear. If no wear is evident, new main bearings should correct the endplay.

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 (see illustration).



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



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

- 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 (see illustrations). 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.
- 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. 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.

#### 14 Engine block – cleaning

Refer to illustrations 14.4, 14.8 and 14.10

- 1 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.
- 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 all of the covers and 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.

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

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 blow out all the 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.

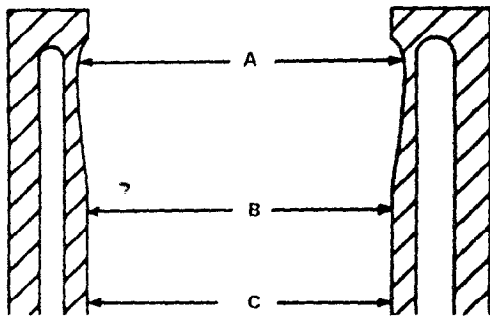
11 Apply non-hardening sealant (such as Permatex no. 2 or Teflon pipe sealant) to the new oil gallery plugs and thread them into the holes in the block. Make sure they're tightened securely.

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 and 15.4c

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



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

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). **Note:** These measurements should not be made with the bare block mounted on an engine stand – the cylinders will be distorted and the measurements will be inaccurate.

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

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.

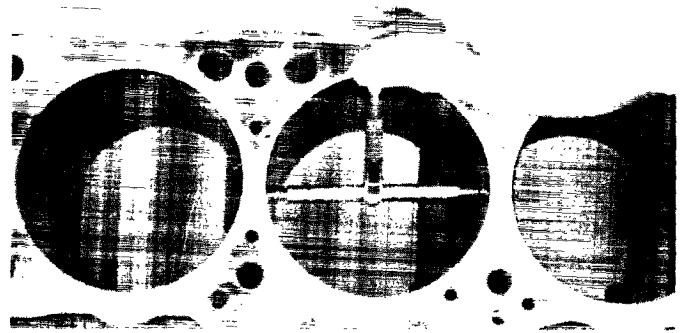
7 To check the clearance, select a feeler gauge and slip it into the cylinder along with the matching piston. The piston must be positioned exactly as it normally would be. The feeler gauge must be between the piston and cylinder on one of the thrust faces (90-degrees to the piston pin bore).

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-



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 the bore measurement is accurate



16.3a A "bottle brush" hone will produce better results if you've never honed cylinders before

round or tapered beyond the limits given in this Chapter's Specifications, have the engine block rebored and honed at an automotive machine shop. If a rebores 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, they don't have to be rebored. Honing is all that's necessary (see Section 16).

## 16 Cylinder honing

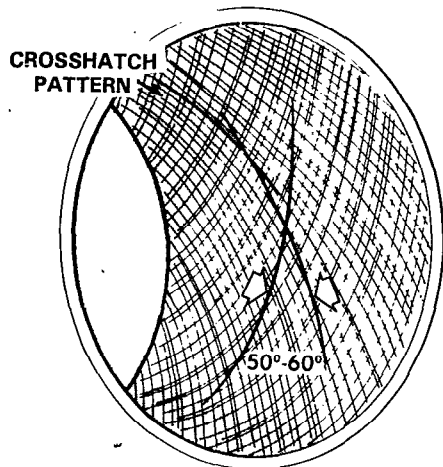
Refer to illustrations 16.3a and 16.3b

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 honing oil (kerosene will work if honing oil isn't available), 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!



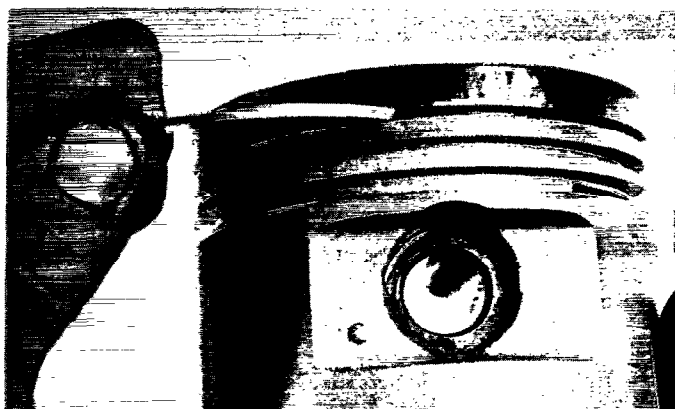
16.3b The cylinder hone should leave a smooth, crosshatch pattern with the lines intersecting at approximately a 60-degree angle



17.2 Use a special tool to remove the piston rings from the piston



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

- 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-degree 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-degrees – 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.

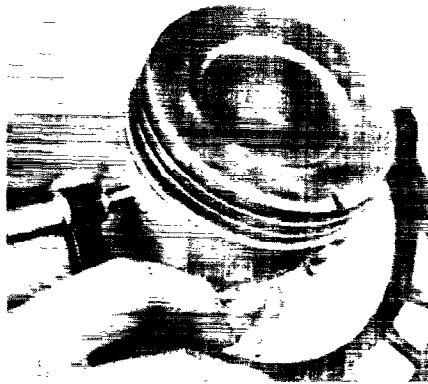
## 17 Pistons and connecting rods – inspection

Refer to illustrations 17.2, 17.4a, 17.4b, 17.10 and 17.11

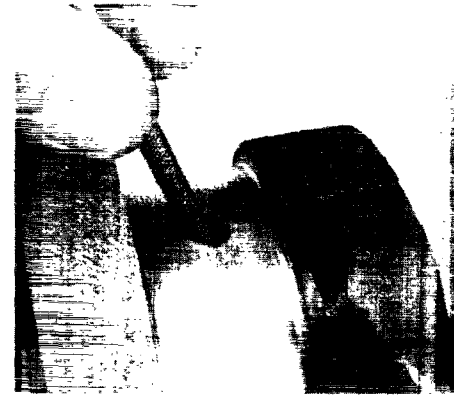
- 1 Before the inspection process can be carried out, the piston/connecting rod assemblies must be cleaned and the original piston rings removed from the pistons. **Note:** Always use new piston rings when the engine is reassembled.
- 2 Using a piston ring installation tool (see illustration), carefully 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). **Warning:** Wear eye protection. Make sure the oil return holes in the back sides of the ring grooves are clear.
- 6 If the pistons and cylinder walls aren't damaged or worn excessively, and if the engine block isn't 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



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



**17.11** Measure the piston diameter at a 90-degree angle to the piston pin and in line with it



**18.1** The oil holes should be chamfered so sharp edges don't gouge or scratch the new bearings

occur again. The causes may include intake air leaks, incorrect fuel/air mixture, low octane fuel, ignition timing and EGR system malfunctions.

9 Corrosion of the piston, in the form of small pits, indicates 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 in this Chapter, new pistons will have to be used.

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-degree angle to the piston pin (see illustration) below the axis of the piston pin.

12 Subtract the piston diameter from the bore diameter to obtain the clearance. If it's greater than listed in this Chapter's Specifications, the block will have to be rebored and new pistons and rings installed.

13 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.

14 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.

15 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 18.1, 18.2, 18.4, 18.6 and 18.8

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

2 Clean the crankshaft with solvent and dry it with compressed air (if available). **Warning:** Wear eye protection when using compressed air. Be sure to clean the oil holes with a stiff brush (see illustration) and flush them with solvent.

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

4 Rub a penny across each journal several times (see illustration). If a journal picks up copper from the penny, it's too rough and must be reground.

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.

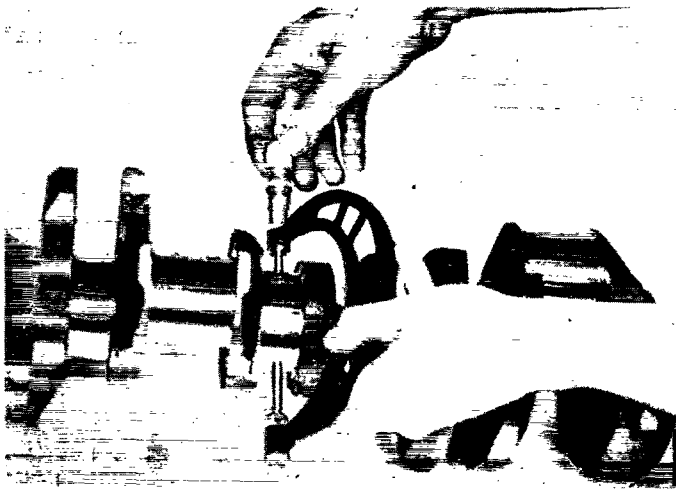
6 Using a micrometer, measure the diameter of the main and connecting rod journals and compare the results to this Chapter's Specifications



**18.2** Use a wire or stiff plastic bristle brush to clean the oil passages in the crankshaft



**18.4** Rubbing a penny lengthwise on each journal will reveal its condition – if copper rubs off and is embedded in the crankshaft, the journals should be reground



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

(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 re-ground 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 (see illustration), 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.



18.8 If the seals have worn grooves in the crankshaft journals, or if the seal contact surfaces are nicked or scratched, the new seals will leak

## 19 Main and connecting rod bearings - inspection

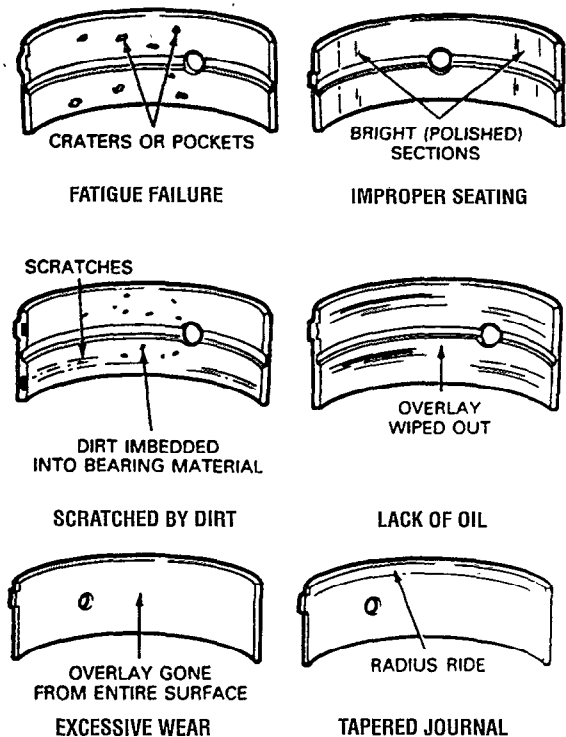
Refer to illustration 19.1

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.

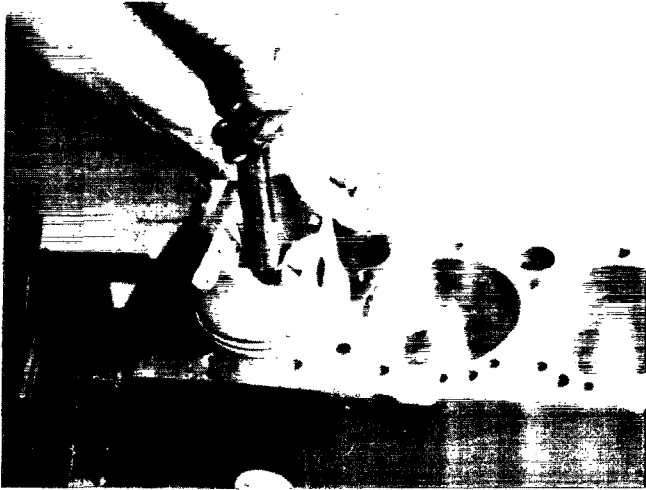
4 Dirt and other foreign particles get into the engine in a variety of ways. It may be left in the engine during assembly, or it may pass through filters or the PCV system. It may get into the oil, and from there into the bearings. Metal chips from machining operations and normal engine wear are often present. Abrasives are sometimes left in engine components after reconditioning, especially when parts aren't 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 won't 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.



19.1 Typical bearing failures

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,



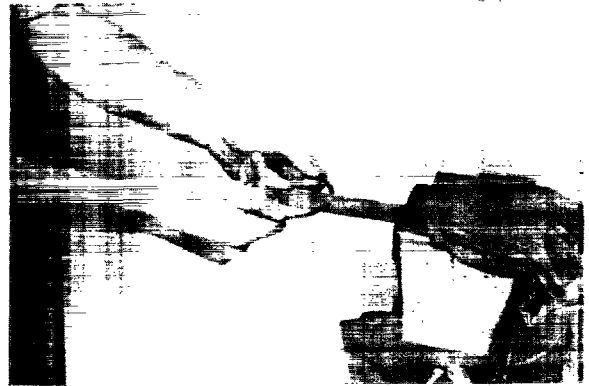
**21.3** When checking piston ring end gap, the ring must be square in the cylinder bore (this is done by pushing the ring down with the top of a piston as shown)



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

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 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 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.



**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

## 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*
- Torque wrench (1/2-inch drive)*
- Piston ring installation tool*
- Piston ring compressor*
- Vibration damper installation tool*
- Short lengths of rubber or plastic hose to fit over connecting rod bolts*
- Plastigage*
- Feeler gauges*
- 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:

### 2.6L engine

- Crankshaft and main bearings*
- Rear main oil seal housing*
- Piston/connecting rod assemblies*
- Oil pump*
- Oil pan*
- Timing chain housing*
- Timing chain and sprockets*
- Silent shaft chain and sprockets*
- Intake and exhaust manifolds*
- Cylinder head, camshaft and rocker arms*

- Valve cover*
- Flywheel/driveplate*

### 2.0L and 2.4L engines

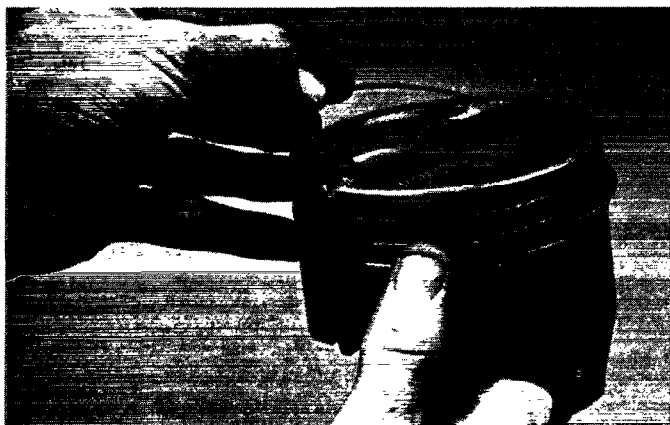
- Crankshaft and main bearings*
- Rear main oil seal housing*
- Piston/connecting rod assemblies*
- Oil pump*
- Timing belt and sprockets*
- Timing belt cover*
- Oil pan*
- Cylinder head, camshaft and rocker arms*
- Intake/exhaust manifolds*
- Valve cover*
- Engine rear plate (if equipped)*
- Flywheel/driveplate*

### 3.0L V6 engine

- Crankshaft and main bearings*
- Rear main oil seal housing*
- Piston/connecting rod assemblies*
- Oil pump*
- Oil pan*
- Timing belt cover*
- Timing belt and sprockets*
- Cylinder heads, camshafts and rocker arms*
- Intake and exhaust manifolds*
- Valve covers*
- Flywheel/driveplate*



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 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 the piston ring side clearance has been checked and verified correct (see Section 17).

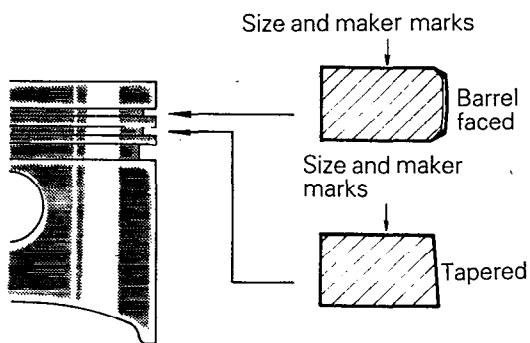
2 Lay out the piston/connecting rod assemblies and the new ring sets so the ring sets will be matched with the same piston and cylinder during the end gap measurement and engine assembly.

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.

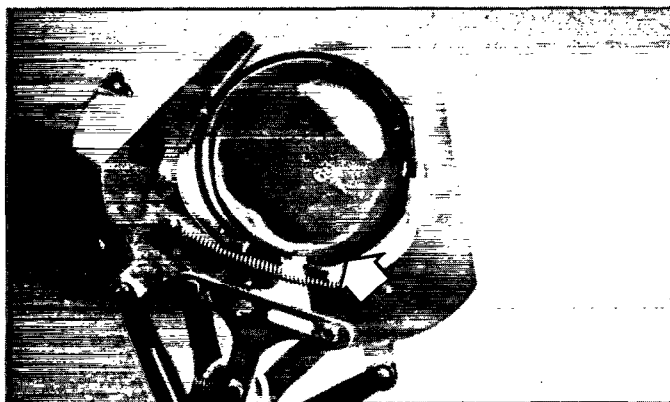
4 To measure the end gap, slip feeler gauges between the ends of the ring until a gauge equal to the gap width is found (see illustration). The feeler gauge should slide between the ring ends with a slight amount of drag. Compare the measurement to this Chapter's Specifications. If the gap is larger 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 engine damage. 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 teeth and slowly move the ring to remove material from the ends. When performing this operation, file only from the outside in (see illustration).

6 Excess end gap isn't critical unless it's greater than 0.040-inch.



21.11 The number 1 (top) and number 2 compression rings have different cross-sections – be sure to install them in the correct locations with the marks facing UP



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

Again, double-check to make sure you have the correct rings for the 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.

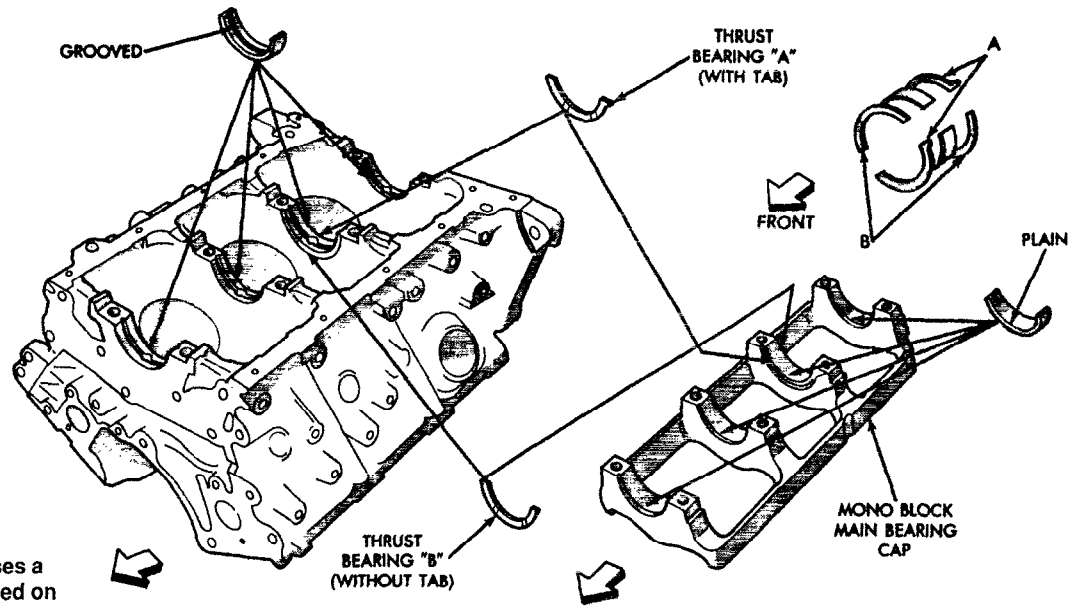
8 Once the ring end gaps have been checked/corrected, the rings can be installed on the pistons.

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.

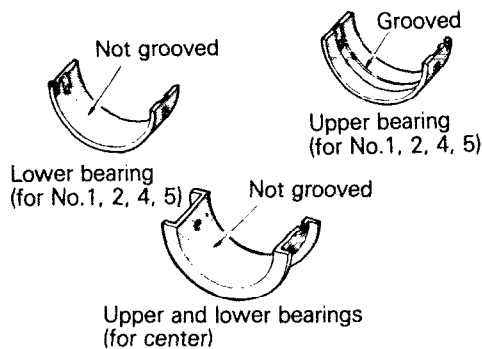
10 After the three oil ring components have been installed, check to make sure both the upper and lower side rails can be turned smoothly in the ring groove.

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 (see illustration). **Note:** Always follow the instructions printed on the ring package or box – different manufacturers may require different approaches. Don't mix up the top and middle rings, as they have different cross sections.

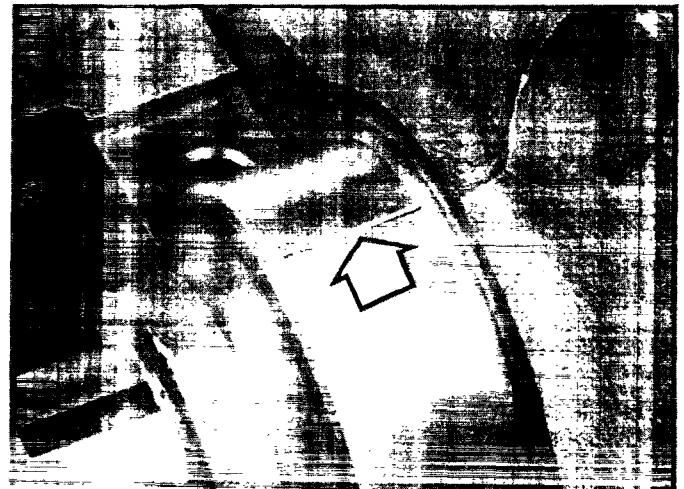
12 Use a piston ring installation tool and make sure the identification mark is facing the top of the piston, then slip the ring into the middle groove on the piston (see illustration). Don't expand the ring any more than necessary to slide it over the piston.



22.3 The 3.0L engine uses a thrust bearing (shim) located on the number 3 journal



22.6 Main bearing designations for the 2.0L and 2.4L engines – the thrust bearing is installed in the number three cap and saddle



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

- 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

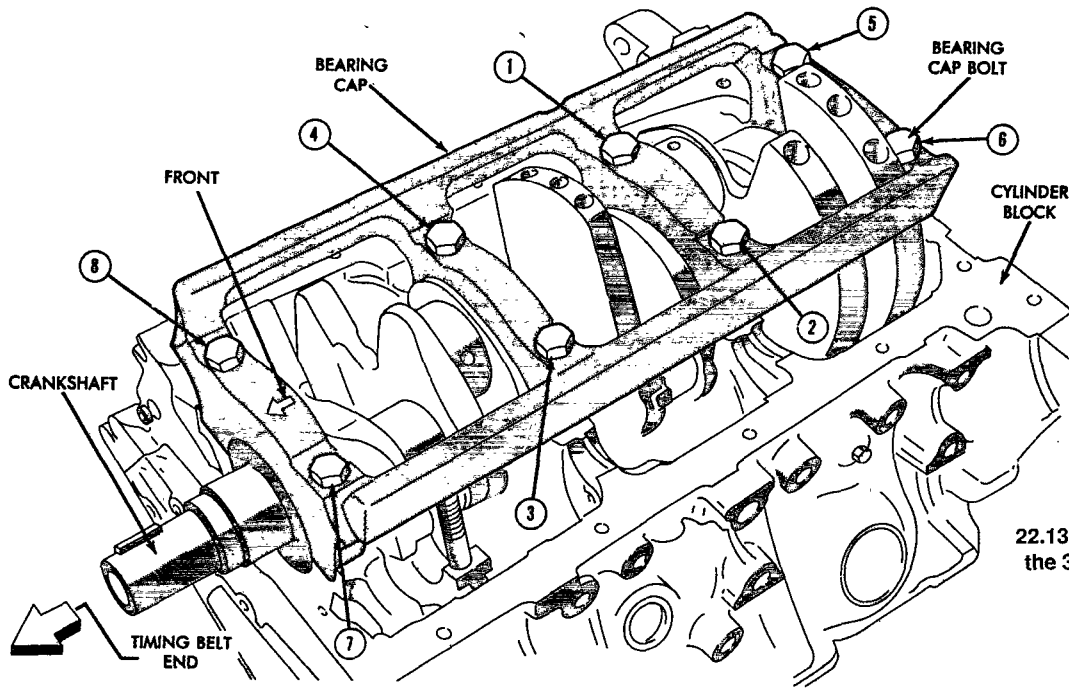
Refer to illustrations 22.3, 22.6, 22.11, 22.13 and 22.15

- 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 (**see illustration**).
- 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.

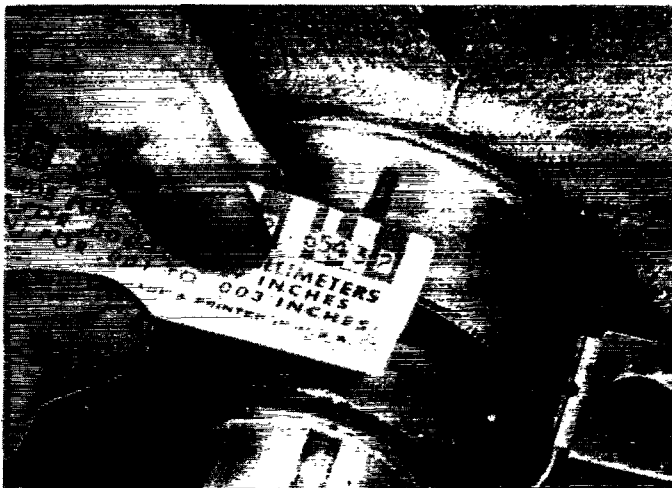
### Main bearing oil clearance check

**Note:** Don't touch the faces of the new bearing inserts with your fingers. Oil and acids from your skin can etch the bearings.

- 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 inserts. 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 The flanged thrust bearing must be installed in the number two cap and saddle (counting from the front of the engine) on 2.6L engines. On the 2.0L, 2.4L (**see illustration**) and 3.0L engines the thrust bearing must be installed in the number three (center) cap and saddle.
- 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.



22.13 Tightening sequence for the 3.0L V6 main bearing caps (mono-block)



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 ones are included

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 should 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 original locations (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 torque figure listed in this Chapter's Specifications. Don't rotate the crankshaft at any time during this operation. **Note:** On 3.0L V6 engines, torque bolts on the mono-block in the proper sequence (see illustration).

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.

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 at the beginning of this Chapter 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 different inserts are needed, make sure 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 (see 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 original locations with the arrows pointing toward the front of the engine.

23 Install the bolts.

24 Tighten all except the thrust bearing cap bolts to the torque listed in this Chapter's Specifications (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.

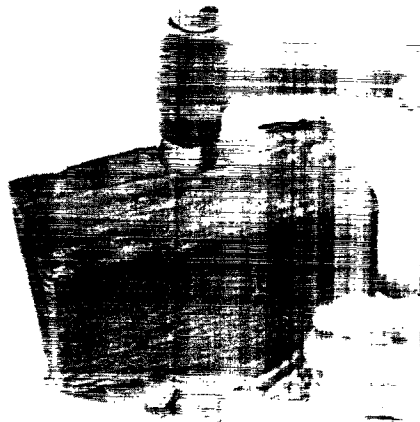
27 Retighten all main bearing cap bolts to the torque listed in this Chapter's Specifications, starting with the center main and working out toward the ends.

28 Rotate the crankshaft a number of times by hand to check for any obvious binding.

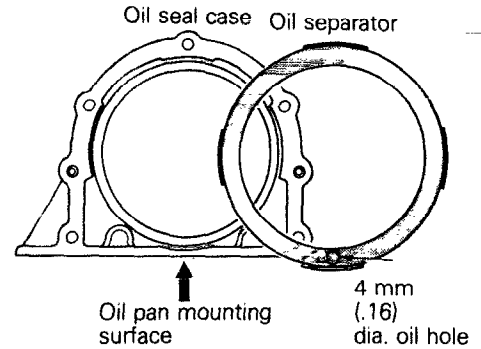
29 The final step is to check the crankshaft endplay with feeler gauges or



**23.1** To remove the old seal, support the housing on a pair of wood blocks and drive out the seal with a punch or screwdriver and hammer – make sure you don't damage the seal bore



**23.2a** To install the new rear seal in the housing, simply lay the housing on a clean, flat workbench, lay a block of wood on the seal and carefully tap it into place with a hammer



**23.2b** Be sure to mount the oil separator with the oil hole positioned at the bottom

a dial indicator as described in Section 13. The endplay should be correct if the crankshaft thrust faces aren't worn or damaged and new bearings have been installed.

30 Refer to Section 23 and install the new rear main oil seal.

**23 Rear main oil seal – installation**

Refer to illustrations 23.1, 23.2a, 23.2b and 23.3

**Note:** The crankshaft must be installed and the main bearing caps bolted in place before the new seal and housing assembly can be bolted to the block.

1 Remove the old seal from the housing with a hammer and punch by driving it out from the back side (see illustration). 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.

2 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 isn't 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. If you don't have a vise big enough, lay the housing on a workbench and drive the seal into place with a block of wood and hammer (see illustration). 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. **Note:** On 2.0L and 2.4L engines, after the oil seal has been installed press the oil separator into the housing making sure the oil hole is positioned at the bottom (see illustration)

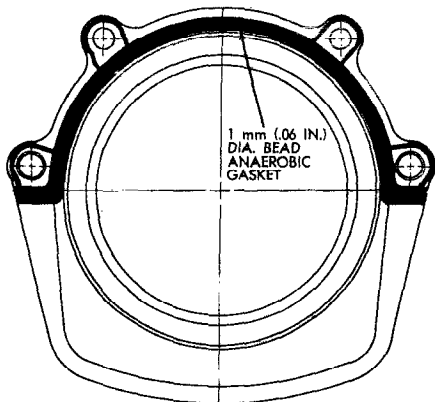
3 Lubricate the seal lips with moly-based grease or engine assembly lube before you slip the seal/housing over the crankshaft and bolt it to the block. Apply anaerobic sealer on the upper portion of the retainer (see illustration) before installing the housing.

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

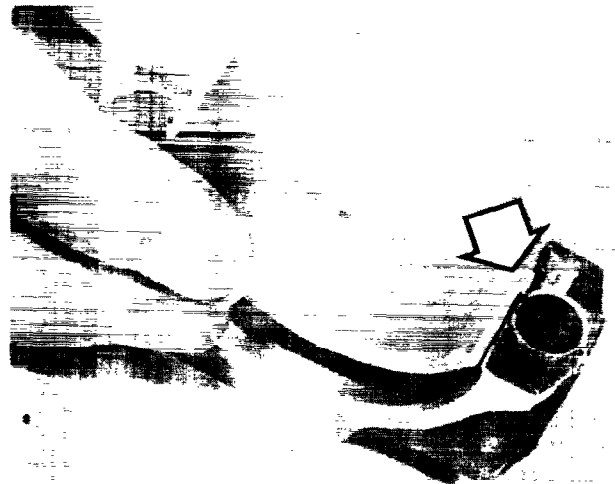
**24 Pistons and connecting rods – installation and rod bearing oil clearance check**

Refer to illustrations 24.4, 24.5, 24.9a, 24.9b, 24.11, 24.13, 24.14 and 24.17

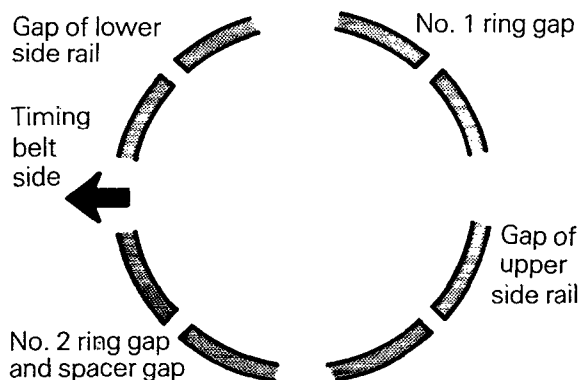
1 Before installing the piston/connecting rod assemblies, the cylinder walls must be perfectly clean, the top edge of each cylinder must be chamfered, and the crankshaft must be in place.



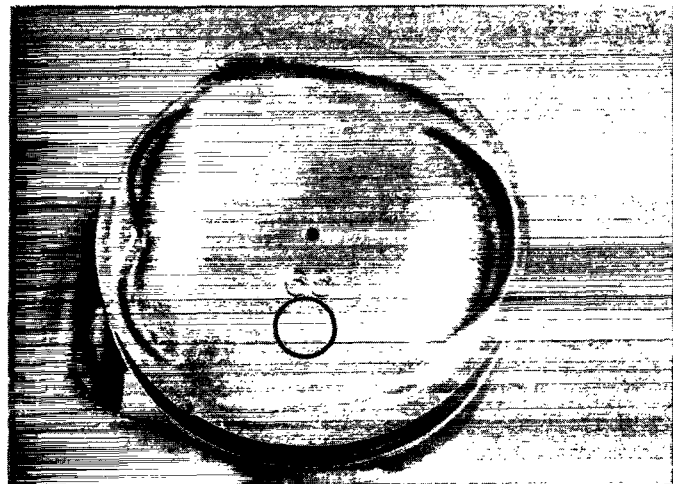
**23.3** Apply anaerobic sealer onto the upper portion of the retainer



**24.4** The tab on the bearing (arrow) must fit into the cap recess so the bearing will seat properly



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



24.9a On four-cylinder engines, the arrow on the piston must face the front of the engine

2 Remove the cap from the end of the number one connecting rod (check 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

**Note:** Don't touch the faces of the new bearing inserts with your fingers. Oil and acids from your skin can etch the bearings.

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. 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 (see illustration), 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 120-degree 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.

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.

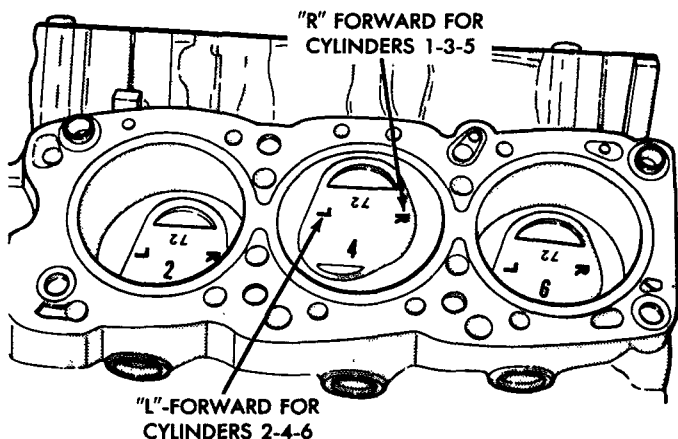
9 With the mark or notch on top of the piston facing the front of the engine (see illustrations), gently insert the piston/connecting rod assembly into the number one cylinder bore and rest the bottom edge of the ring compressor on the engine block.

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 or plastic 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



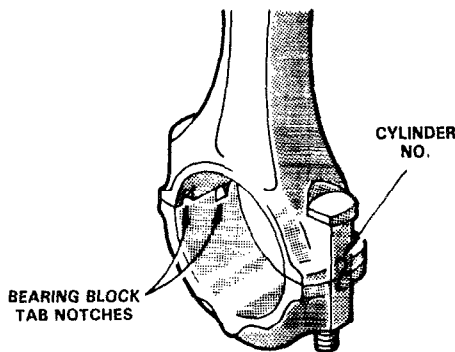
24.9b On the V6 engine, the proper letter must be positioned towards the front of the engine (R for cylinders 1, 3 and 5; L for cylinders 2, 4 and 6)



24.11 Drive the piston gently into the cylinder bore with the end of a wooden or plastic hammer handle



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



**24.14** Match up the cylinder number marks and the bearing tab notches when installing the connecting rod caps



**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 ones are included)

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 (see illustration).

15 Install the nuts and tighten them to the torque listed in this Chapter's Specifications. Work 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 slightly 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 this Chapter's 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 different inserts are needed, make sure 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 (see 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.

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 torque specified in this Chapter. Again, work up to the torque in three steps. **Note:** Again, make sure the mating mark on the cap is on the same side as the mark on the connecting rod (see illustration 24.14).

22 Repeat the entire procedure for the remaining pistons/connecting rods.

23 The important points to remember are . . .

- Keep the back sides of the bearing inserts and the insides of the connecting rods and caps perfectly clean when assembling them.
- Make sure you have the correct piston/rod assembly for each cylinder.
- The arrow or mark on the piston must face the front (timing chain end) 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 endplay must be checked. Refer to Section 12 for this procedure.

26 Compare the measured endplay to this Chapter's 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 endplay 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 (see Section 3).

4 Start the engine. It may take a few moments for the fuel system to build up pressure, but the engine should start without a great deal of effort.

**Note:** If backfiring occurs through the carburetor or throttle body, 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 isn't unusual for an engine to use oil during the break-in period.

9 At approximately 500 to 600 miles, change the oil and filter.

10 For the next few hundred miles, drive the vehicle normally. Don't pamper it or abuse it.

11 After 2000 miles, change the oil and filter again and consider the engine broken in.