Chapter 2 Part A
4.2 litre petrol engine

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2A

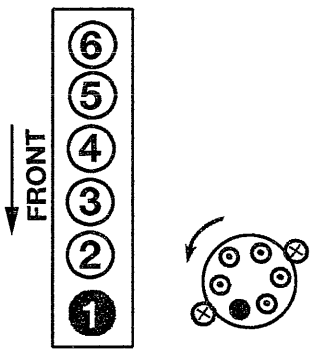
Specifications

General

Displacement	4169 cc
Bore	96 mm
Stroke	96 mm
Cylinder numbers (front-to-rear)	1-2-3-4-5-6
Firing order	1-5-3-6-2-4
Compression pressure	
Standard	1,177 kPa
Minimum	883 kPa
Maximum difference between cylinders	98 kPa

Camshaft

Number of bearing journals	7
Bearing oil clearance	
Standard	0.020 to 0.109 mm
Limit	0.15 mm
Journal diameter	
Front	50.721 to 50.740 mm
Second	50.521 to 50.540 mm
Third	50.321 to 50.340 mm
Fourth	50.121 to 50.140 mm
Fifth	49.921 to 49.940 mm
Sixth	49.721 to 49.740 mm
Rear	49.521 to 49.540 mm
Bend limit	0.06 mm
End play	
Standard	0.08 mm to 0.28 mm
Limit	0.5 mm
Cam lobe	
Total measurement	42.311 to 42.561 mm
Wear limit	0.15 mm



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Cylinder location and distributor rotation

The blackened terminal shown on the distributor cap indicates the Number One spark plug wire position

Cylinder head

Allowable surface machining	0.2 mm
Warpage limit	0.2 mm

Oil pump

Outer rotor to body clearance	0.14 to 0.22 mm
Inner rotor to outer rotor clearance	0.0 to 0.12 mm
Rotor end clearance	0.050 to 0.110 mm

Torque specifications

	Nm
Camshaft sprocket bolt	132 to 142
Camshaft retainer bolts	7 to 8
Crankshaft pulley bolt	142 to 152
Cylinder head bolts	
First step	29
Second step	57 to 67
Third step	Loosen fully
Fourth step	29
Preferred fifth step	69 to 74-degrees additional rotation
Alternate fifth step	64 to 74
Exhaust manifold bolts	27 to 31
Front cylinder head bolt	7 to 8
Flywheel/driveplate-to-crankshaft bolts	147 to 167
Fuel pump cam nut (carburetted models)	16 to 19
Inlet manifold bolts	16 to 19
Sump mounting bolts	7 to 8
Oil cooler cover bolts	16 to 21
Oil cooler nuts	16 to 21
Oil pump chain tensioner bolts	7 to 8
Oil pump cover bolts	7 to 8
Oil pump pickup bolts	16 to 19
Oil pump relief plug	40 to 70
Oil pump sprocket bolt	24 to 28
Rear oil seal retainer bolts	21 to 26
Rocker arm lock nuts	16 to 22
Rocker shaft bolts	16 to 19
Timing chain guide bolt	7 to 8
Timing chain tensioner bolt	7 to 8
Timing chain cover-to-block bolts	21 to 26
Valve cover-to-cylinder head screws	1 to 3

1 General information

This Part of Chapter 2 is devoted to in-vehicle engine repair procedures for the 4.2 litre petrol six-cylinder pushrod engine. Information concerning engine removal and refitting, as well as engine block and cylinder head overhaul, can be found in Part D of this Chapter.

The following repair procedures are based on the assumption that the engine is fitted in the vehicle. If the engine has been removed from the vehicle and mounted on a stand, many of the steps included in this Part of Chapter 2 will not apply.

The specifications included in this Part of Chapter 2 apply only to the engine and procedures in this Part. The specifications necessary for rebuilding the block and cylinder head are found in Part D.

The engine uses pushrods and lifters with a timing chain as part of the valve train. The oil pump is mounted on the front of the block and is driven by a separate chain from the crankshaft.

2 Repair operations possible with the engine in the vehicle

Many major repair operations can be accomplished without removing the engine from the vehicle.

Clean the engine compartment and the exterior of the engine with some type of pressure washer before any work is done. A clean engine will make the job easier and will help keep dirt out of the internal areas of the engine.

If vacuum, exhaust, oil or coolant leaks have developed, indicating a need for gasket or seal renewal, the repairs can generally be made with the engine in the vehicle. The inlet and exhaust manifold gaskets, sump gasket and cylinder head gasket are all accessible with the engine in place.

Exterior engine components such as the inlet and exhaust manifolds, the sump (and the oil pump), the water pump, the starter motor, the alternator, the distributor and the carburettor or fuel injection components can be removed for repair with the engine in place.

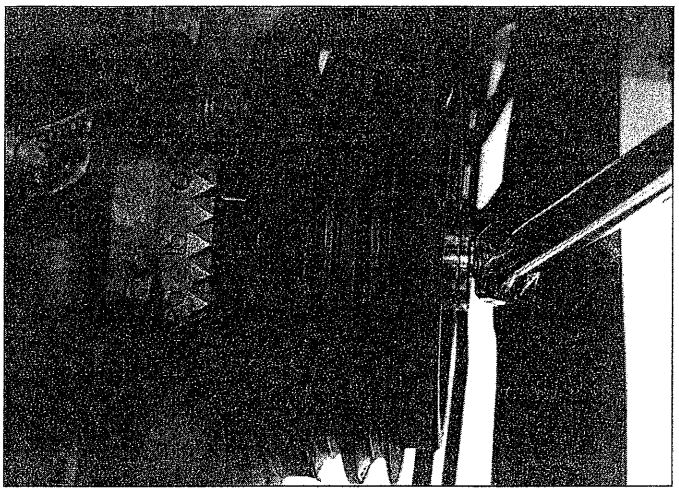
Since the cylinder head can be removed without pulling the engine, valve component servicing can also be accomplished with the engine in the vehicle.

In extreme cases caused by a lack of necessary equipment, repair or renewal of piston rings, pistons, connecting rods and rod bearings is possible with the engine in the vehicle. However, this practice is not recommended because of the cleaning and preparation work that must be done to the components involved.

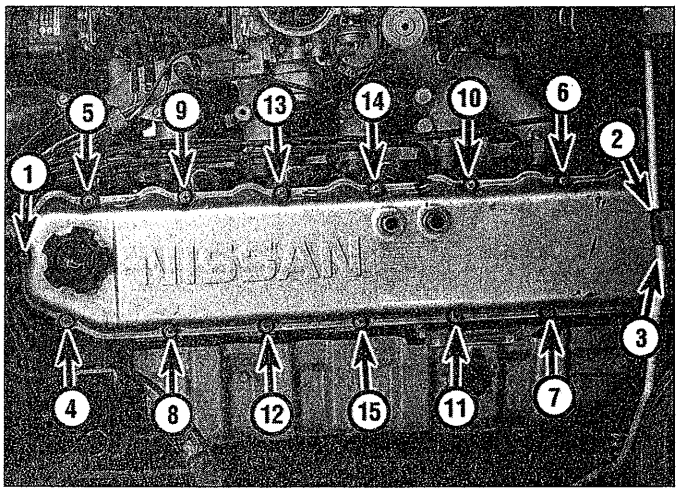
3 Top Dead Centre (TDC) for number one piston - locating

Refer to illustration 3.4

Note: *The following procedure is based on the assumption that the distributor is correctly fitted. If you are trying to locate TDC to refit the distributor correctly, piston position must be determined by feeling for compression at the number one spark plug hole as the engine is rotated, then aligning the ignition timing marks as described in Step 8.*



3.4 Use a large socket and breaker bar to rotate the crankshaft to TDC



4.7 Remove the valve cover bolts in this order. When tightening them, work in reverse

1 Top Dead Centre (TDC) is the highest point in the cylinder that each piston reaches as it travels up-and-down when the crankshaft turns. Each piston reaches TDC on the compression stroke and again on the exhaust stroke, but TDC generally refers to piston position on the compression stroke.

2 Positioning the piston(s) at TDC is an essential part of many procedures such as rocker arm removal, camshaft and timing chain/sprocket removal and distributor removal.

3 Before beginning this procedure, be sure to place the transmission in Neutral and apply the parking brake or block the rear wheels. Also, remove the spark plugs (see Chapter 1) and disable the ignition system. Detach the coil wire from the centre terminal of the distributor cap and earth it on the block with a jumper wire.

4 In order to bring any piston to TDC, the crankshaft must be turned using one of the methods outlined below. When looking at the front of the engine, normal crankshaft rotation is clockwise.

a) *The preferred method is to turn the crankshaft with a socket and ratchet attached to the bolt threaded into the front of the crankshaft* **(see illustration).**

b) *A remote starter switch, which may save some time, can also be used. Follow the instructions included with the switch. Once the piston is close to TDC, use a socket and ratchet, as described in the previous paragraph.*

c) *If an assistant is available to turn the ignition switch to the Start position in short bursts, you can get the piston close to TDC without a remote starter switch. Make sure your assistant is out of the vehicle, away from the ignition switch, then use a socket and ratchet (as described in Paragraph a) to complete the procedure.*

5 Note the position of the terminal for the number one spark plug wire on the distributor cap. If the terminal isn't marked, follow the plug wire from the number one cylinder spark plug to the cap.

6 Use a felt-tip pen or chalk to make a mark on the distributor body directly under the terminal. Do not use a lead pencil.

7 Detach the cap from the distributor and set it aside (see Chapter 1 if necessary).

8 Turn the crankshaft (see Paragraph 3 above) until the notch in the crankshaft pulley is aligned with the 0 on the timing plate **(see illustration 3.4).**

9 Look at the distributor rotor - it should be pointing directly at the mark you made on the distributor body. If it is, go to Step 12.

10 If the rotor is 180 degrees off, the number one piston is at TDC on the exhaust stroke. Go to Step 11.

11 To get the piston to TDC on the compression stroke, turn the crankshaft one complete turn (360 degrees) clockwise. The rotor should now be pointing at the mark on the distributor. When the rotor is pointing at the number one spark plug wire terminal in the distributor cap and the ignition timing marks are aligned, the number one piston is at TDC on the compression stroke. **Note:** *If it is impossible to align the ignition timing marks when the rotor is pointing to the alignment mark on the number 1 cylinder, the distributor may be refitted incorrectly, the timing chain or gears may be refitted incorrectly or the timing chain has jumped off the timing sprocket.*

12 After the number one piston has been positioned at TDC on the compression stroke, TDC for any of the remaining pistons can be located by turning the crankshaft and following the firing order. Mark the remaining spark plug wire terminal locations on the distributor body just like you did for the number one terminal, then number the marks to correspond with the cylinder numbers. As you turn the crankshaft, the rotor will also turn. When it's pointing directly at one of the marks on the distributor, the piston for that particular cylinder is at TDC on the compression stroke.

4 Valve cover - removal and refitting

Refer to illustration 4.7

1 Disconnect the negative cable from the battery.

2 On carburetted engines, remove the air cleaner. On fuel-injected models, remove the air inlet hose, the airflow meter and the air cleaner assembly (see Chapter 4B).

3 Label and then remove all hoses and/or wires necessary to provide clearance for valve cover removal.

4 If the spark plug wires can be disconnected from their brackets and moved aside, do so now. If not, label each spark plug wire, remove them and lay them aside individually.

5 Disconnect the throttle cable (see Chapter 4), the cruise control cable (if equipped) and the choke cable (if equipped).

6 Remove the alternator adjusting bracket if it interferes.

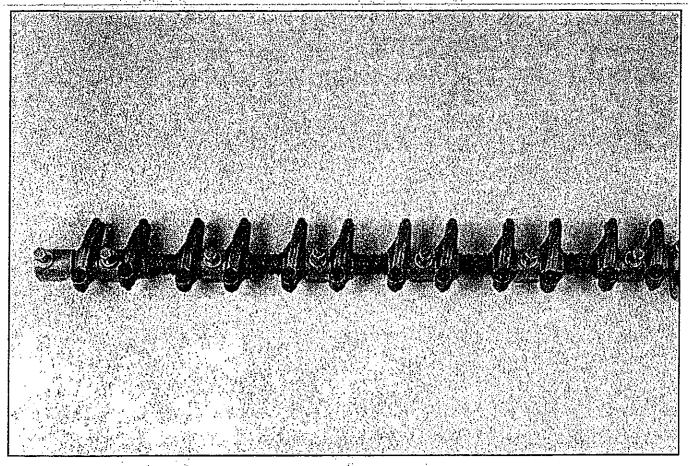
7 Loosen the valve cover screws, working in the proper sequence **(see illustration).** Loosen them only a quarter turn at a time each until they are all loose.

8 Remove the valve cover retaining screws and lift off the cover. The cover may stick. If the valve cover is stuck to the cylinder head, bump the end with a wood block and hammer to jar it loose. If that doesn't work, try to detach the cover by breaking the seal with a putty knife or razor blade. **Caution:** *Don't prise at the valve cover-to-cylinder head joint or damage to the sealing surfaces may occur, leading to oil leaks after the valve cover is refitted.*

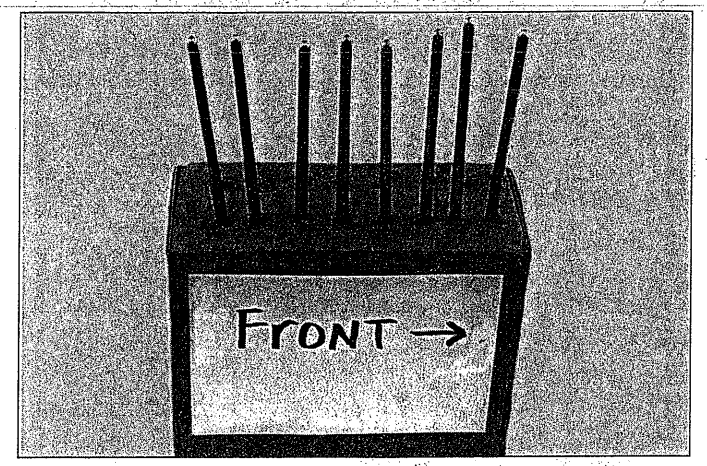
9 Prior to refitting, remove all traces of dirt, oil and old gasket material from the cover and cylinder head. Clean the mating surfaces with lacquer thinner or acetone and a clean rag.

10 Inspect the mating surface on the cover for damage and warpage. Straighten or renew it as necessary.

11 Fit a new gasket. Make sure that all the



5.4 Keep the rocker shaft in one piece when you lift it from the engine



5.5 A perforated cardboard box can be used to store the pushrods to ensure they are refitted in their original locations

parts are completely clean. If there is residue or oil around the mating surfaces when the valve cover is refitted, oil leaks may develop.

12 Apply a thin coating of RTV silicone sealer to the new gasket and adhere it to the valve cover. Apply a thin coating to the cylinder head side of the gasket.

13 Place the valve cover on the cylinder head while the sealant is still wet and refitting the mounting bolts. Tighten the bolts in the reverse of the removal sequence **(see illustration 4.8)**. Tighten the bolts a little at a time until the torque listed in this Chapter's Specifications is reached.

14 Complete the refitting procedure by reversing the removal procedure.

15 Start the engine and check for oil leaks.

5 Rocker arms and pushrods - removal, inspection and refitting

Refer to illustrations 5.4, 5.5, 5.7a and 5.7b

Note: *It is not possible to remove the lifters from this engine without first removing the cylinder head.*

Removal

1 Detach the valve cover from the cylinder head, referring to Section 4.

2 Loosen each valve adjusting lock-nut, then unscrew each adjusting screw all the way (but don't remove them from the rocker arms).

3 Gradually loosen the rocker shaft retaining bolts. Start with the outer bolts and work towards the centre until all of the bolts are free.

4 Remove the rocker arm assembly as a single unit. Be careful not to let any of the components slide off the rocker shaft **(see illustration)**.

5 Remove the pushrods and store them separately to make sure they don't get mixed up during refitting **(see illustration)**.

Inspection

6 Check each rocker arm for wear, cracks and other damage, especially where the pushrods and valve stems contact the rocker arm faces.

7 Make sure the oil holes in the rocker shaft are clear. Use a caliper to check the outside diameter of the shaft and the inside diameter of the rockers **(see illustrations)**. If the clearances vary or are excessive, renew the components.

8 Check each rocker arm pivot area for wear, cracks and galling. If the rocker arms are worn or damaged, renew them and use new pivots as well.

9 Inspect the pushrods for cracks and excessive wear at the ends. Roll each pushrod across a piece of plate glass to see if it's bent (if it wobbles, it's bent).

Refitting

10 Lubricate the lower ends of the pushrods with clean engine oil or moly-base grease and refit them in their original locations. Make sure each pushrod seats completely in the lifter socket.

11 Lubricate the rockers and the shaft with engine oil as you assemble them. Apply moly-base grease to the ends of the valve stems and the upper ends of the pushrods before positioning the rocker arms and refit the bolts.

12 Set the rocker arm assembly in place, then refit the bolts. Tighten the bolts, a little at a time, to the torque listed in this Chapter's Specifications. Begin with the centre bolts, then work outwards.

13 Refer to Chapter 1 and adjust the valves.

14 Refit the valve cover and run the engine. Check for oil leaks and unusual valve train noises.

6 Valve springs, retainers and seals - renewal

Refer to illustrations 6.4, 6.9, 6.10, 6.15 and 6.17

Note: *Broken valve springs and defective valve stem seals can be renewed without removing the cylinder head. Two special tools and a compressed air source are normally required to perform this operation, so read through this Section carefully and rent or buy the tools before beginning the job. If compressed air isn't available, a length of nylon rope can be used to keep the valves from falling into the cylinder during this procedure.*

1 Remove the valve cover referring to Section 4.

2 Remove the spark plug from the cylinder which has the defective component. If all of the valve stem seals are being renewed, all of the spark plugs should be removed.

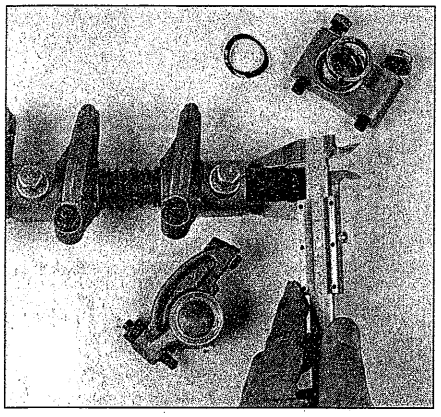
3 Turn the crankshaft until the piston in the affected cylinder is at top dead centre (TDC) on the compression stroke (see Section 3 for instructions). If you're renewing all of the valve stem seals, begin with cylinder number one and work on the valves for one cylinder at a time. Move from cylinder-to-cylinder following the firing order sequence (see the Specifications listed at the beginning of this Chapter). (If the piston is at TDC, then it will not be forced down when air pressure is applied. Having the piston at it's highest point may also prevent the valve from being completely lost if air pressure is suddenly removed.)

4 Thread an adapter into the spark plug hole **(see illustration)** and connect an air hose from a compressed air source to it. Most auto parts stores can supply the air hose adapter. **Note:** *Many cylinder compression gauges utilise a screw-in fitting that may work with your air hose quick-disconnect fitting.*

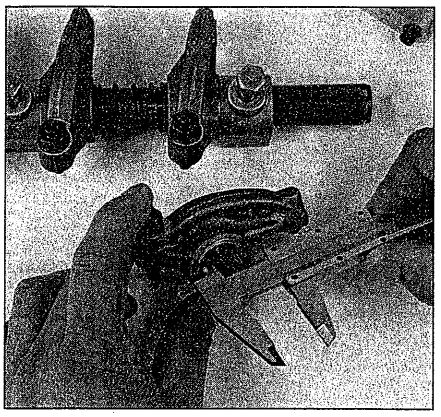
5 Remove the rocker shaft assembly (see Section 5).

6 Apply compressed air to the cylinder. **Warning:** *The piston may be forced down by compressed air, causing the crankshaft to turn suddenly. If the spanner used when positioning the number one piston at TDC is still attached to the bolt in the crankshaft nose, it could cause damage or injury when the crankshaft moves.*

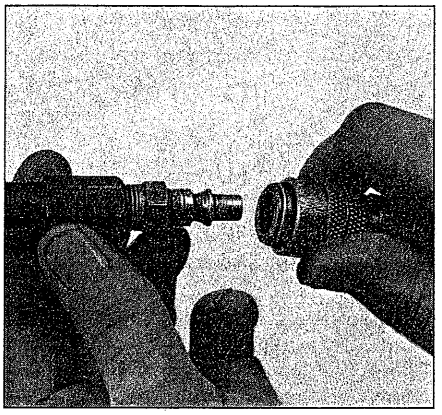
7 The valves should be held in place by the air pressure. If the valve faces or seats are in poor condition, leaks may prevent air pressure from retaining the valves - refer to the alternative procedure below.



5.7a Measure the rocker shaft in the area where each rocker arm rides . . .



5.7b . . . and the bore of each rocker arm



6.4 This is what the air hose adapter that threads into the spark plug looks like - they're commonly available from auto part stores

8 If you don't have access to compressed air, an alternative method can be used. Position the piston at a point approximately 45-degrees (1/8 turn) before TDC on the compression stroke, then feed a long piece of nylon rope through the spark plug hole until it fills the combustion chamber. Be sure to leave the end of the rope hanging out of the spark plug hole so it can be removed easily. Use a large ratchet and socket to rotate the crankshaft in the normal direction of rotation until slight resistance is felt.

9 Stuff shop rags into the cylinder head holes above and below the valves to prevent parts and tools from falling into the engine, then use a valve spring compressor to compress the spring. Remove the collets with small needle-nose pliers or a magnet **(see illustration)**. **Note:** *A couple of different types of tools are available for compressing the valve springs with the head in place. Consult a local tool store or rental yard for the correct tool.*

10 Remove the spring retainer and valve spring, then use a screwdriver or pliers to remove the guide seal **(see illustration)**. **Note:** *If air pressure fails to hold the valve in the closed position during this operation, the valve face and/or seat is probably damaged. If so, the cylinder head will have to be removed for additional repair operations.*

11 Wrap a rubber band or tape around the top of the valve stem so the valve won't fall into the combustion chamber, then release the air pressure.

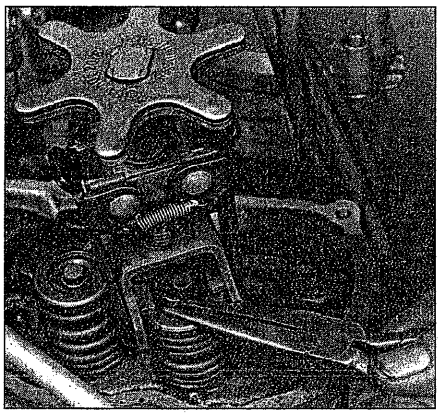
12 Inspect the valve stem for damage. Rotate the valve in the guide and check the end for eccentric movement, which would indicate that the valve is bent.

13 Move the valve up-and-down in the guide and make sure it doesn't bind. If the valve stem binds, either the valve is bent or the guide is damaged. In either case, the head will have to be removed for repair.

14 Reapply air pressure to the cylinder to retain the valve in the closed position, then remove the tape or rubber band from the valve stem.

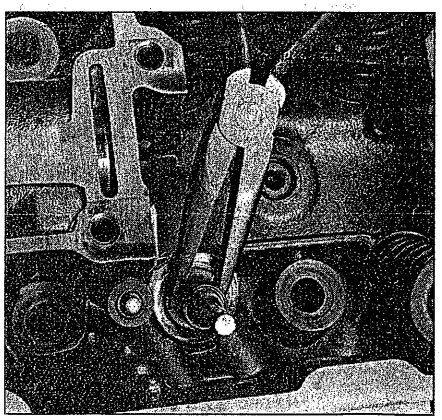
15 Lubricate the valve stem with engine oil and fit a new guide seal. Tap the new seal into position on the valve guide boss with a hammer and a deep socket of the appropriate size **(see illustration)**. Drive the seal onto the guide until the clearance between the bottom of the seal and the spring seat on the cylinder head surface is 4.6 mm. **Note:** *Most valve seals are supplied with a temporary cover for the end of the valve to protect the seal as it slides over the valve grooves.*

16 Refit the spring in position over the valve. The spring must be refitted with the closely spaced coils towards the cylinder head.



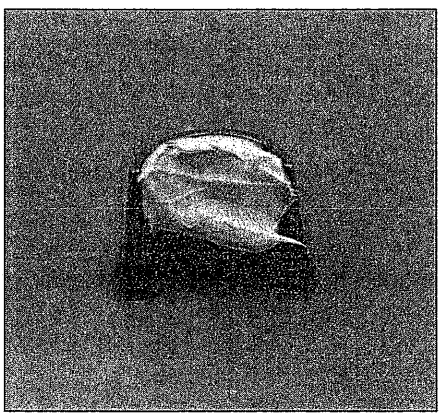
6.9 Once the spring is compressed, the collets can be removed with a magnet or needle-nose pliers

17 Refit the valve spring retainer. Compress the valve spring and carefully position the collets in the groove. Apply a small dab of grease to the inside of each collet to hold it in place **(see illustration)**.

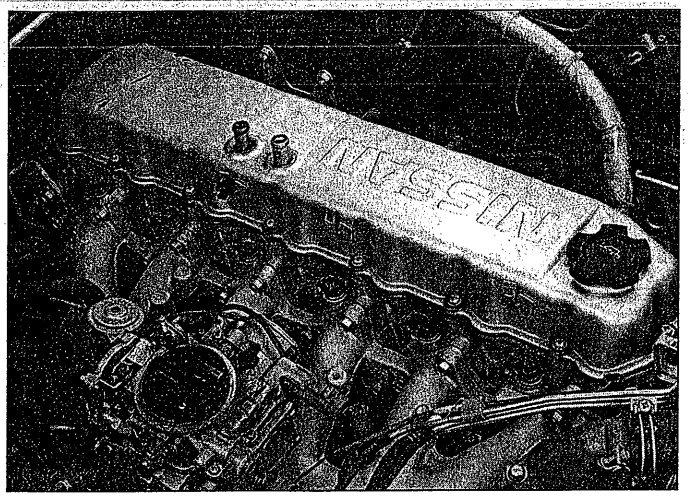


6.10 Use pliers to pull the valve seal from the valve guide boss - remember that the valve stem must not be damaged as you do this

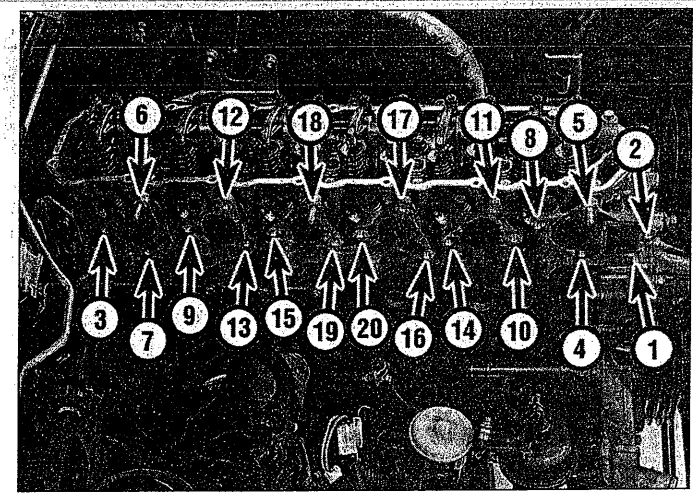
6.15 Gently tap the new seals into place - maintain the correct clearance between the bottom of the seal and the spring seat



6.17 Apply a small dab of grease to the collets before refitting - it will hold them in place on the valve stem as the spring is released



7.5 There are several hoses, wires and cables which must be tied out of the way prior to removing the manifold bolts



7.8 Remove the inlet manifold bolts in this sequence. When tightening them, simply work backwards (manifold removed for clarity)

18 Remove the pressure from the compressor and make sure the collets are seated.
19 Disconnect the air hose and remove the adapter from the spark plug hole. If a rope was used in place of air pressure, rotate the engine anti-clockwise and then pull it out of the cylinder.
20 Refer to Section 5 and refit the rocker shaft.
21 Refit the spark plug(s) and hook up the wire(s).
22 Refer to Section 4 and refit the valve cover.
23 Start and run the engine, then check for oil leaks and unusual sounds coming from the valve cover area.

7 Inlet manifold - removal and refitting

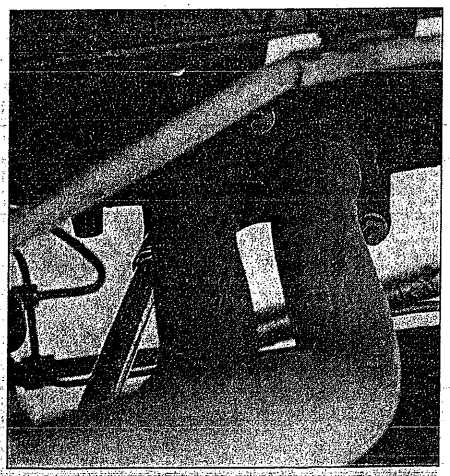
Refer to illustrations 7.5 and 7.8

Carburetted models

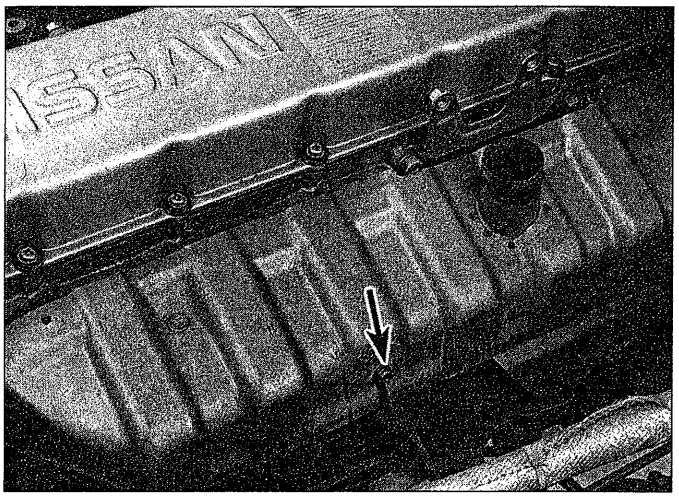
1 Disconnect the negative battery cable from the battery.
2 Remove the air cleaner assembly.
3 Drain several litres of coolant from the radiator (refer to Chapter 1). Disconnect the upper radiator hose from the thermostat housing.
4 Disconnect the lower heater hose at the firewall.
5 Label and then disconnect all of the vacuum hoses, fuel hoses and wiring which interfere with the removal of the manifold. Use wire to secure them out of the way, if necessary **(see illustration)**.
6 Disconnect the accelerator cable (refer to Chapter 4).
7 Remove the oil dipstick and then unbolt and remove the dipstick tube.
8 Loosen the manifold bolts and nuts a little at a time. Follow the sequence shown **(see illustration)**.
9 Carefully remove the inlet manifold. The manifold can be stripped of the carburettor and other components at this time, if necessary.
10 Place clean rags into the inlet ports and water jacket opening to prevent the entrance of debris.
11 Check the manifold carefully for cracks or other damage. A precision machinist's straightedge can be used to check the sealing surface for warpage. If the manifold has become excessively warped, it may be possible for a machine shop to resurface it.
12 Refitting is the reverse of removal. Always use new gaskets.
13 Tighten the manifold fasteners gradually, working in the order opposite that of the loosening sequence **(see illustration 7.8)**. Tighten the fasteners to the torque listed in this Chapter's Specifications.

Fuel-injected models

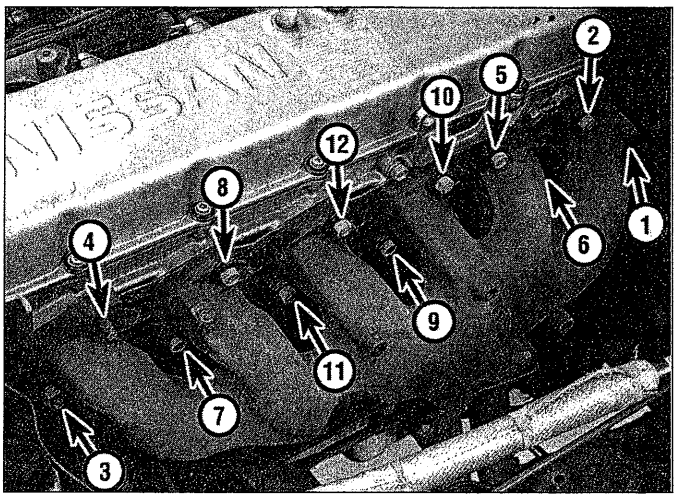
14 Relieve the fuel system pressure (refer to Chapter 4B).
15 Disconnect the negative battery cable from the battery.
16 Label and then disconnect all of the vacuum hoses, fuel hoses and wiring which interfere with the removal of the manifold. Use wire to secure them out of the way, if necessary. It will be necessary to methodically examine the entire assembly for all interfering components and make certain that all hoses, etc. are disconnected.
17 Drain several litres of coolant from the radiator (refer to Chapter 1). Disconnect the upper radiator hose from the thermostat housing.
18 Disconnect the upper radiator hose from the engine. Disconnect the smaller coolant bypass hose from the front of the manifold.
19 Remove the air inlet tube. Refer to Chapter 4.
20 Disconnect the throttle cable. Refer to Chapter 4.
21 Remove the bolts from the heater hose tubes. Label the heater hoses and then disconnect them from the inlet manifold.
22 Loosen the manifold bolts and nuts a little at a time. Follow the reverse of the tightening sequence **(see illustration 7.8)**. until they are all removed.
23 Carefully remove the complete inlet manifold assembly. The upper plenum can be removed from the lower manifold at this time, if necessary.
24 Check the manifold carefully for cracks or other damage. A precision machinist's straightedge can be used to check the sealing surface for warpage. If the manifold has become excessively warped, it may be possible for a machine shop to resurface it.
25 Refitting is the reverse of removal. Always use new gaskets.
26 Tighten the manifold fasteners gradually, working in the order opposite that of the loosening sequence. Tighten the fasteners to the torque listed in this Chapter's Specifications.



8.3 You will have to work from beneath the vehicle in order to remove the bolts from the exhaust pipes - a long extension on your ratchet is very helpful



8.5 The earth strap (arrow) has to be disconnected before removing the heat shield - don't tuck it out of the way or you may forget to refit it later



8.6 Exhaust manifold nut and bolt removal sequence. Work in reverse when refitting it

8 Exhaust manifold - removal and refitting

Refer to illustrations 8.3, 8.5 and 8.6

1 Disconnect the negative battery cable from the battery.

2 Raise the vehicle and support it securely on jackstands.

3 Disconnect the exhaust pipes from the exhaust manifold **(see illustration)**. **Note:** *It may be necessary to apply penetrating oil to the fasteners if they are seized. Apply it liberally and allow it to soak in.*

4 Lower the vehicle. Remove the air inlet tube for access to the exhaust manifold. Refer to Chapter 4 if necessary.

5 Remove the heat shield and the earth cable from the manifold **(see illustration)**.

6 Loosen the manifold bolts and nuts a little at a time. Follow the proper sequence **(see illustration)** until they are all removed.

7 Carefully remove the manifold.

8 Check the manifold carefully for cracks or other damage. A precision machinist's straightedge can be used to check the sealing surface for warpage. If the manifold has become excessively warped, it may be possible for a machine shop to resurface it.

9 Refitting is the reverse of removal. Always use new gaskets.

10 Tighten the manifold fasteners gradually, working in the order opposite that of the loosening sequence **(see illustration 8.6)**. Tighten the fasteners to the torque listed in this Chapter's Specifications.

9 Cylinder head - removal and refitting

Refer to illustrations 9.7, 9.8 and 9.10

Warning: *The engine must be completely cool before starting this procedure.*

1 If you're working on a fuel-injected model, relieve the fuel system pressure (see Chapter 4B).

2 Drain the cooling system (refer to Chapter 1). Remove the inlet and exhaust manifolds (see Sections 7 and 8).

3 Label and then disconnect the spark plug wires from the spark plugs. Take the wires from their brackets and lay them out of the way. Keep them attached to the distributor.

4 Remove the alternator adjusting bar.

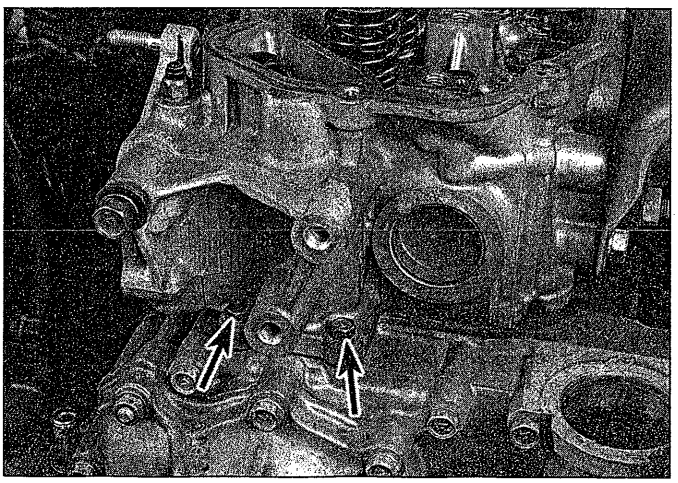
5 Remove the valve cover (refer to Section 4).

6 Remove the rocker shaft assembly and the pushrods (refer to Section 5).

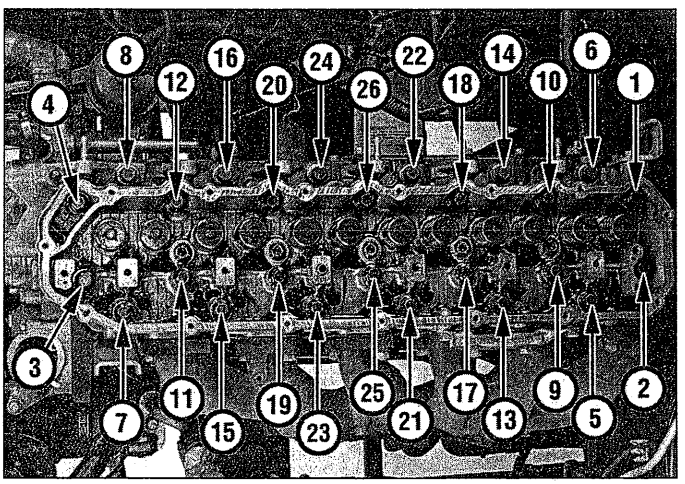
7 Remove the two bolts which secure the front cover to the head **(see illustration)**.

8 Loosen the cylinder head bolts in three gradual steps. Loosen the bolts in the proper sequence **(see illustration)**.

9 Carefully lift the cylinder head from the engine compartment. If the head is stuck to the engine block, it may be necessary to tap it with a soft-face hammer or a block of wood and a hammer to break the seal. **Caution:** *Because cylinder head bolts are often damaged by stretching and threads collapsing or stripping, have each head bolt examined by a qualified machinist. If in doubt about the integrity of the cylinder head bolts, renew them.*

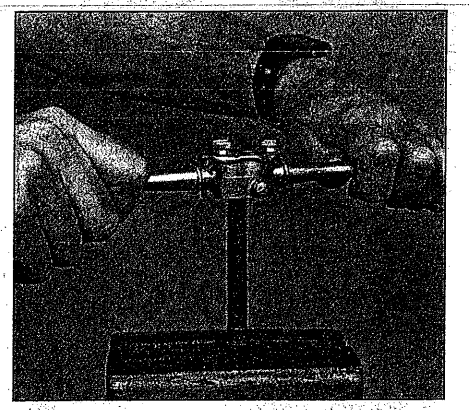


9.7 It is easy to forget these two bolts - remove them before unscrewing the longer head bolts



9.8 Cylinder head bolt removal sequence - work in reverse when refitting the cylinder head

10 Stuff clean shop towels into the cylinders. Thoroughly clean the gasket surfaces, removing all traces of gasket material. Run an appropriate sized tap into the bolt holes in the cylinder head and run a die over the bolt threads **(see illustration)**. Ensure all bolt holes are clean and dry.
11 Inspect the cylinder head for cracks and check it for warpage. Refer to Chapter 2 Part D for cylinder head servicing procedures.
12 Fit the new gasket dry (without any sealing compound).
13 Make sure the gasket is refitted with the word TOP **(see illustration)** facing up. Place the cylinder head on the engine.
14 Place the washers on the head bolts. The chamfered side of the washers must face towards the bolt head. Refit the bolts and tighten them in the reverse of the removal sequence **(see illustration 9.8)**. Tighten them in the steps and to the torque listed in this Chapter's Specifications. The preferred last step requires an angle meter type torque wrench. If you cannot obtain one of these wrenches, it is acceptable to use a standard torque wrench for the final step.
15 Refit the remaining components in the reverse order of removal.
16 Change the oil and filter (see Chapter 1).
17 Refill the cooling system and run the engine, checking for leaks and proper operation.



9.10 A die should be used to remove sealant and corrosion from the head bolt threads

10 Lifters - removal, inspection and refitting

Removal

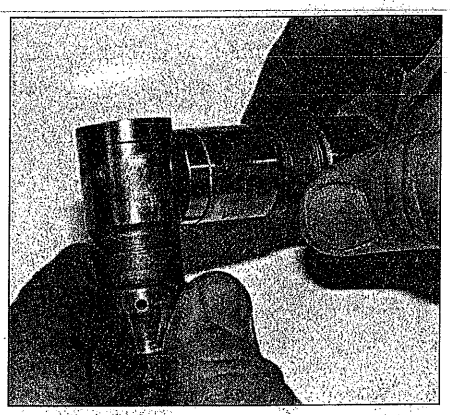
Refer to illustrations 10.7a, 10.7b, 10.7c and 10.7d

1 A noisy valve lifter can be isolated when the engine is idling. Place a length of hose or tubing on the valve cover near the position of each valve while listening at the other end. Or remove the valve cover and, with the engine idling, place a finger on each of the valve spring retainers, one at a time. If a valve lifter is defective, it'll be evident from the shock felt at the retainer as the valve opens.

2 The most likely cause of a noisy valve lifter is worn lifters or damaged camshaft lobes. It is recommended that the camshaft as well as the lifters be renewed if the lifters are diagnosed as worn and damaged.
3 Remove the cylinder head (refer to Section 9). Remove the head gasket if it is stuck to the block.
4 Remove the lifters from the block one at a time, keeping them in order.
5 Store the lifters in a clearly labeled box to insure their rerefitting in the same lifter bores.

Inspection

6 Clean the lifters with solvent and dry them thoroughly. Do this one lifter at a time to avoid mixing them up.
7 Check each lifter wall, pushrod seat and foot for scuffing, score marks and uneven wear. Each lifter foot (the surface that rides on the cam) must be slightly convex, although this can be difficult to determine by eye **(see illustration)**. If the base of the lifter is concave or rough **(see illustrations)**, the lifters and camshaft must be renewed. If the lifter walls are damaged or worn (which isn't very likely), inspect the lifter bores in the engine block as well. If the pushrod seats **(see illustration)** are worn, check the pushrod ends.



10.7a The foot of each lifter should be slightly convex - the side of another lifter can be used as a straightedge to check it; if it appears flat, it's worn and must not be reused

8 If new lifters are being fitted, a new camshaft should also be fitted. If a new camshaft is fitted, then always use new lifters as well. Never refit used lifters unless the original camshaft is used and the lifters can be refitted in their original locations!

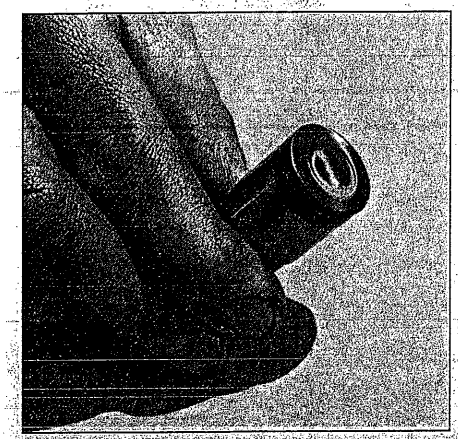
Refitting

9 The used lifters must be refitted in their original bores. Coat them with moly-base grease or engine assembly lube.
10 Lubricate the bearing surfaces of the lifter bores with engine oil.
11 Refit the lifter(s) in the lifter bore(s).
12 The remainder of the assembly procedure is the reverse of disassembly.

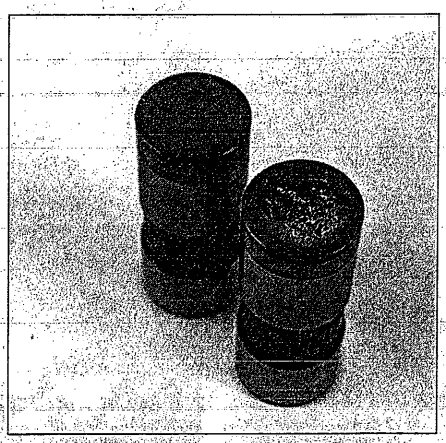
11 Crankshaft pulley/vibration damper - removal and refitting

Refer to illustration 11.6

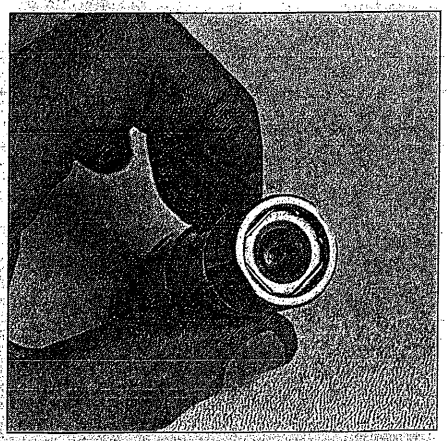
1 Remove the cable from the negative battery terminal.
2 Raise the vehicle and support it securely on jackstands.
3 Use a long breaker bar and a socket to



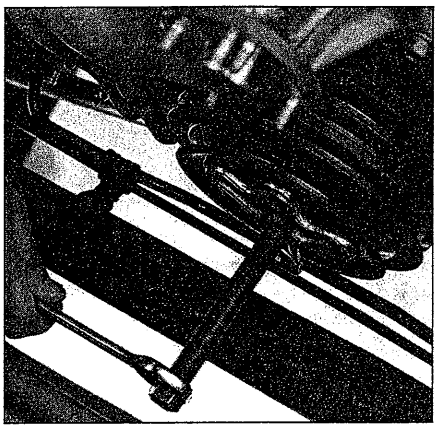
10.7b If the bottom (foot) of any lifter is worn concave (shown here), scratched or galled, renew the entire set of lifters



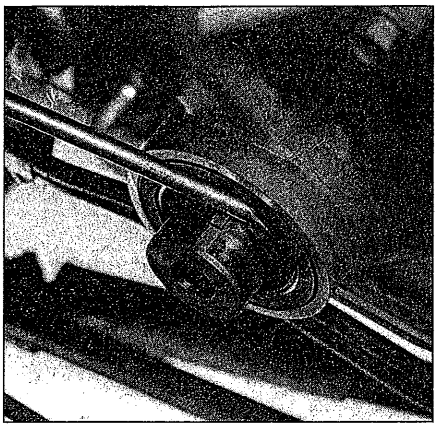
10.7c If the lifters are pitted or rough, they shouldn't be reused



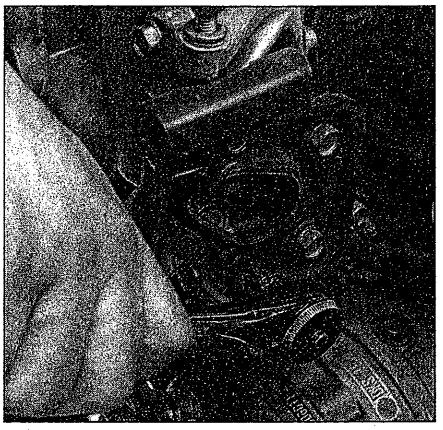
10.7d The pushrod end of the lifter must be inspected also



11.6 Remove the vibration damper with a puller that attaches to the damper hub



12.2 The crankshaft front oil seal can be removed with a seal removal tool or a screwdriver



13.5 Check on all sides of the cover to ensure that all interfering brackets have been removed

remove the damper centre bolt. The drivebelts should hold the crankshaft from turning as you do this. If not, remove the torque converter access cover (automatic transmission) or starter (manual transmission) and wedge a screwdriver into the ring gear teeth to prevent the crankshaft from turning.

4 Remove the drivebelts (Chapter 1). Tag each belt as it is removed to simplify rerefitting. If the vehicle is equipped with a fan shroud, unscrew the mounting bolts and position the shroud out of the way.

5 On most models, it is necessary to remove the radiator in order to get adequate clearance for a puller to be used. Refer to Chapter 1 for the collant draining procedure and Chapter 3 for the radiator removal procedure. **Warning:** *Wait until the engine is completely cool before draining the coolant.*

6 Use a puller that threads into the holes provided in the damper to remove the vibration damper **(see illustration)**. Do not allow the puller to damage the threads in the crankshaft. If necessary, fit a narrow deep socket into the nose of the crankshaft for the puller screw to bear on. **Caution:** *Do not use a jaw-type puller that applies force to the outer portion of the pulley!*

7 Refer to Section 12 for the front oil seal renewal procedure if it appears to be leaking.

8 Inspect the surface of the damper that contacts the front seal. There may be a groove worn in this surface. If so, the damper can be renewed or a sleeve can be fitted over the damper hub. **Note:** *These sleeves are available at auto parts stores. If a worn damper is refitted with a new seal, the seal will probably leak.*

9 Apply a thin layer of multi-purpose grease to the seal contact surface of the vibration damper.

10 Slide the vibration damper onto the crankshaft. Note that the slot in the hub must be aligned with the Woodruff key in the end of the crankshaft. Once the key is aligned with the slot, tap the damper onto the crankshaft with a soft-face hammer. The retaining bolt can be used to press the damper into position, although a damper refitting tool is preferred.

11 Refitting is the reverse of removal.

12 Refit the drivebelt(s) (Chapter 1).

13 Tighten the damper centre bolt to the torque listed in this Chapter's Specifications.

12 Crankshaft front oil seal - renewal

Note: *The crankshaft front oil seal can be renewed with the timing chain cover in place. However, due to the limited amount of room available, you may conclude that the procedure would be easier if the cover were removed from the engine first. If so, refer to Section 13 for the cover removal and refitting procedure.*

Timing chain cover in place

Refer to illustration 12.2

1 Disconnect the negative battery cable from the battery, then remove the vibration damper (see Section 11).

2 Note how the seal is fitted - the new one must face the same direction! Carefully prise the oil seal out of the cover with a seal puller or a large screwdriver **(see illustration)**. Be very careful not to distort the cover or scratch the crankshaft!

3 Apply clean engine oil or multi-purpose grease to the outer edge of the new seal, then fit it in the cover with the lip (open end) facing in. Drive the seal into place with a large socket and a hammer (if a large socket isn't available, a piece of pipe will also work). Make sure the seal enters the bore squarely and stop when the front face is flush with the cover.

4 Refit the vibration damper (see Section 11).

Timing chain cover removed

5 Remove the timing chain cover as described in Section 13.

6 Support the front cover with blocks of wood and drive the old seal out from the inside with a hammer and punch. Be careful not to distort the cover or scratch the wall of the seal bore. If the engine has accumulated a lot of kilometres, apply penetrating oil to the seal-to-cover joint and allow it to soak in before attempting to remove the seal.

7 Clean the bore to remove any old seal material and corrosion. Support the cover on a block of wood and position the new seal in the bore with the lip (open end) of the seal facing in. A small amount of oil applied to the outer edge of the new seal will make refitting easier - don't overdo it!

8 Drive the seal into the bore with a large socket and hammer until it's completely seated. Select a socket that's the same outside diameter as the seal. A section of pipe or even a block of wood can be used if a socket isn't available.

9 Refit the timing chain cover.

13 Timing chain cover - removal and refitting

Refer to illustrations 13.5, 13.7 and 13.9

1 Remove the vibration damper (see Section 11).

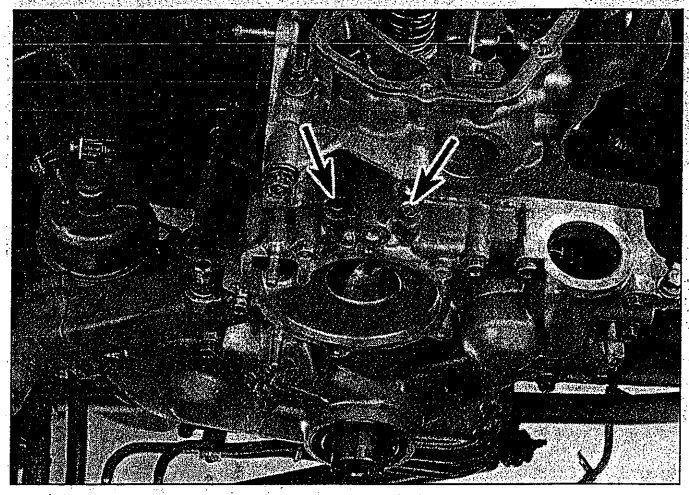
2 Remove the radiator and the fan assembly, if not already done (see Chapter 3).

3 Disconnect the coolant hoses from the timing cover and secure them out of the way.

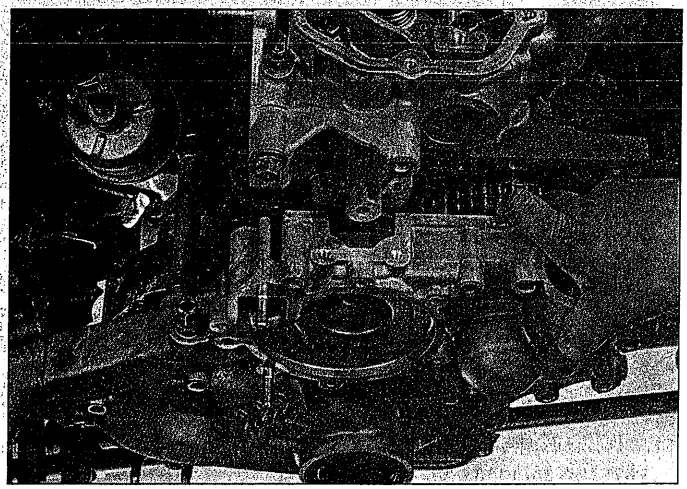
4 Remove the power steering pump bracket bolts and position the complete power steering pump assembly out of the way.

5 Remove the air conditioning compressor from it's mounting bracket (refer to Chapter 3). Do not disconnect any air conditioning hoses. Position the compressor out of the way. Remove the air conditioning compressor bracket and any other brackets which interfere **(see illustration)**.

6 Remove the sump (see Section 17). **Note:** *The sump only needs to be lowered in the front enough to clear the timing cover. It is not necessary to remove it completely from the vehicle. An alternative procedure is to remove all of the sump bolts except the rear*



13.7 The cylinder head is secured to the cover by these two bolts



13.9 Slide the cover directly forward to remove it

ones. Break the seal and use wood wedges to gently lower the front of the sump. When the timing cover has been refitted, clean the sump sealing surface very thoroughly (with acetone or lacquer thinner) and seal it with RTV silicone sealer before refitting the sump bolts.

7 Remove the bolts which secure the cylinder head to the timing cover **(see illustration).**

8 Remove the timing cover bolts.

9 Tap the timing cover with a soft-faced hammer to break the seal, then remove it **(see illustration).**

10 Thoroughly clean the cover and all sealing surfaces, removing all traces of gasket material. Drive the old oil seal out from the rear of the timing chain cover and renew it (see Section 12).

11 Clean all the sealing surfaces again with lacquer thinner or acetone. Apply a 3 mm bead of RTV sealant to the cover, inboard of the bolt holes. Make sure that there is adequate sealer where the cover contacts the sump and the cylinder head.

12 Position the timing chain cover on the engine block and refit the bolts. Tighten the fasteners to the torque listed in this Chapter's Specifications.

13 Refit the sump, using RTV sealant as necessary to ensure a leak-proof seal. Refer to Section 17.

14 Refit the remaining parts in the reverse order of removal.

15 Run the engine and check for oil leaks.

14 Timing chain and sprockets - removal, inspection and refitting

Refer to illustrations 14.5a, 14.5b, 14.6, 14.7, 14.8, 14.9, 14.11, 14.14a, 14.14b, 14.16 and 14.23

1 Set the number one piston at Top Dead Centre (TDC) on the compression stroke (see Section 3).

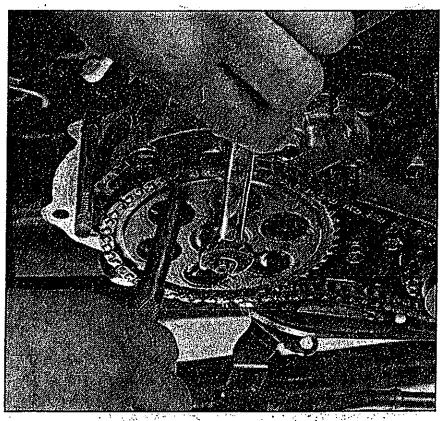
2 Remove the distributor (refer to Chapter 5). **Note:** *The rotor must be pointing to the spark plug wire for number one cylinder and the body of the distributor must be marked to in relation to the engine block before removal.*

3 Remove the timing chain cover (see Section 13).

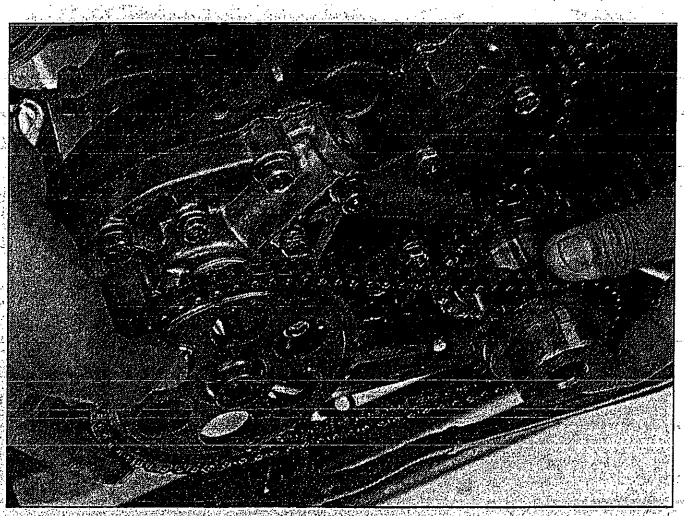
4 Loosen the two bolts that secure the oil pump chain tensioner. Release the tension on the oil pump chain.

5 Remove the nut which secures the oil pump sprocket to the oil pump **(see illustration).** Remove both oil pump chain sprockets along with the chain **(see illustration).**

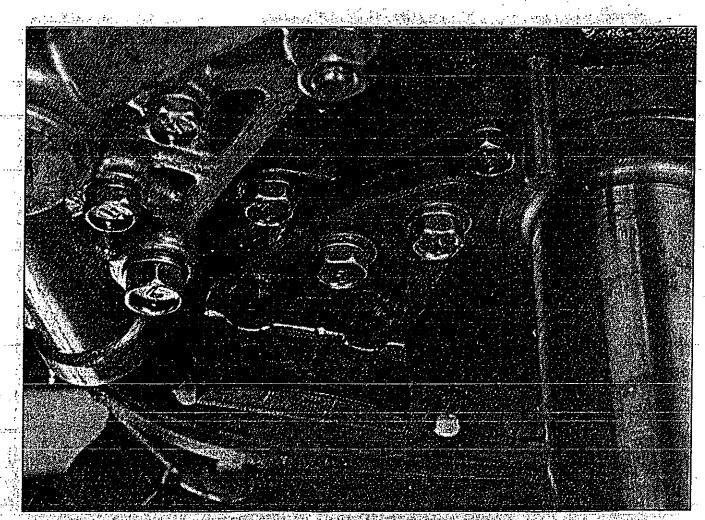
6 Remove the tensioner assembly **(see illustration).**



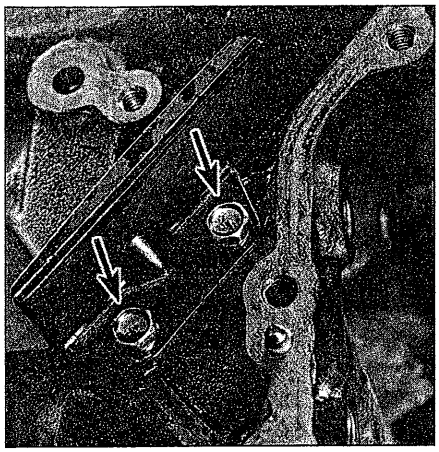
14.5a Lock the sprocket through one of its holes to remove the fastener



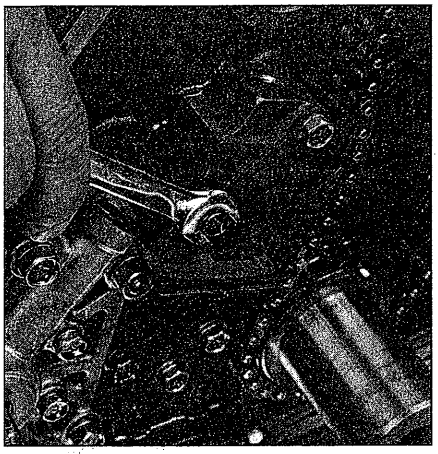
14.5b Slide the sprockets off simultaneously along with the chain



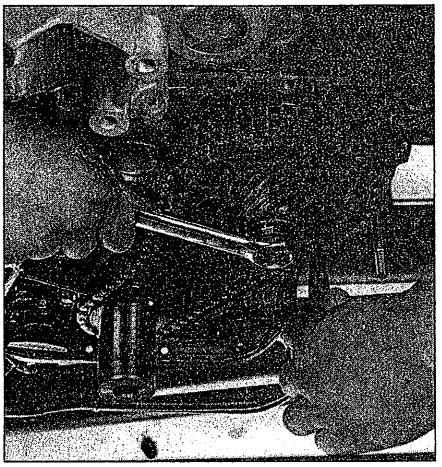
14.6 Remove the tensioner assembly



14.7 The guide can be removed at this time - remove the bolts (arrows)



14.8 Remove the timing chain tensioner assembly. There are small parts inside that can fall out - it is best to seal the top of the sump with a rag first



14.9 The camshaft bolt can be removed in the same way as the oil pump sprocket fastener was removed

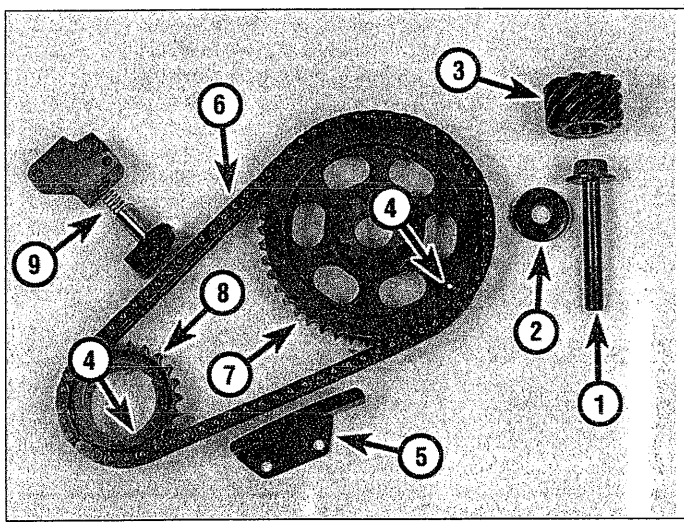
2A

7 Remove the timing chain guide **(see illustration)**.

8 Remove the timing chain tensioner assembly **(see illustration). Caution:** *Do not drop the tensioner spring into the sump.*

9 Remove the camshaft sprocket bolt and remove the washer and distributor drive gear **(see illustration)**.

10 Prise off the timing chain sprockets along with the chain. **Warning:** *Do not rotate the engine with the timing chain removed.*



14.11 These are the components of the timing chain assembly

1 *Bolt*
2 *Washer*
3 *Distributor gear*
4 *Timing chain alignment marks*
5 *Chain guide*
6 *Chain*
7 *Camshaft gear*
8 *Crankshaft gear*
9 *Tensioner assembly*

The pistons will contact the valves, resulting in valve damage.

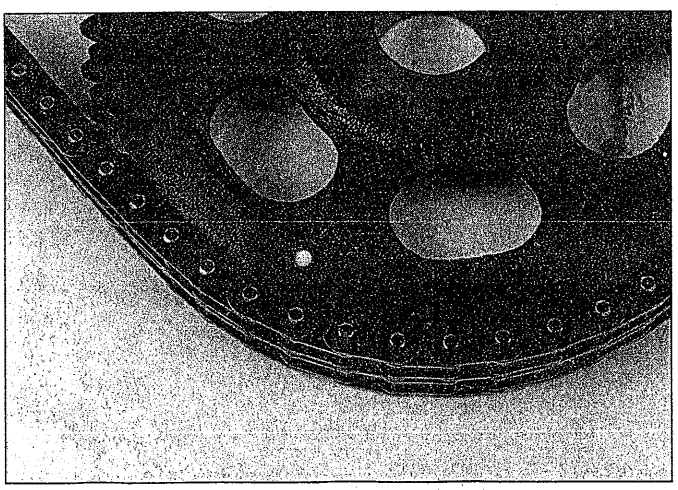
11 Clean the components and inspect for wear and damage **(see illustration)**. Timing gear teeth that are deformed, chipped, pitted or discoloured call for renewal. Always renew the timing gears as a set. Make sure the engine block is clean and the crankshaft does not have any burrs, scratches or damage that will prevent the timing gear from sliding over the surface easily.

12 Check the guide and the tensioners for wear and smooth operation. Renew them as necessary.

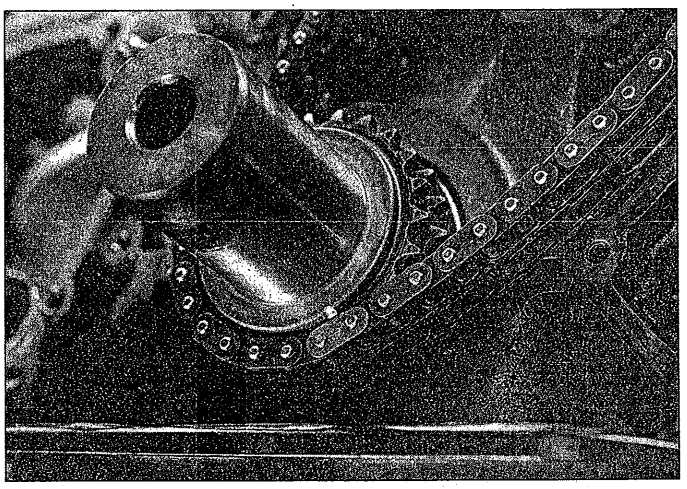
13 Before refitting the sprockets and chains, make certain that the crankshaft key and the camshaft key are near the 12 o'clock position.

14 Loop the timing chain onto the sprockets. Line up the bright links in the chain with the dimple marks in the sprockets **(see illustrations)**.

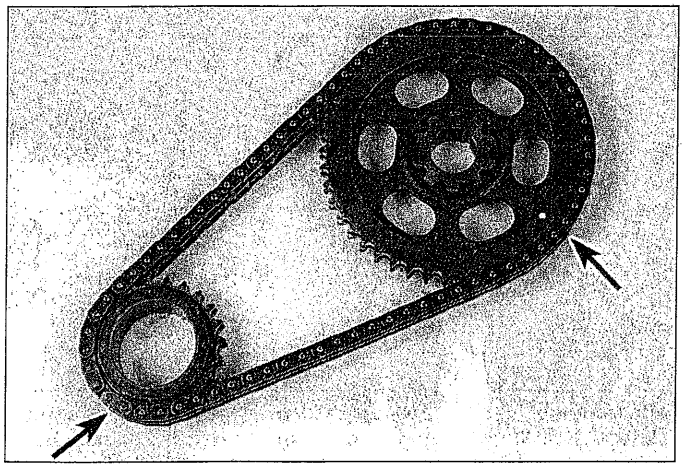
15 Refit the chain and sprocket assembly onto the crankshaft and camshaft simultaneously. It may be necessary to slightly rotate the crankshaft during this procedure.



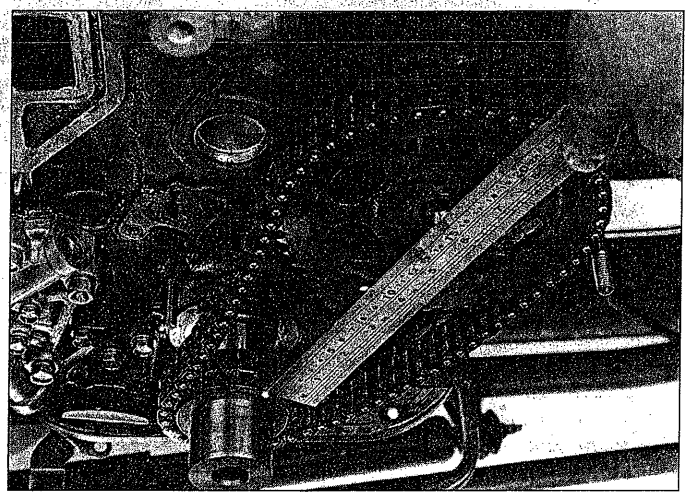
14.14a Align the bright link in the chain with the camshaft sprocket mark



14.14b The other bright link must align with the mark on the crankshaft sprocket



14.16 When both bright links are aligned correctly, they will be in this orientation (arrows)



14.23 The timing chain alignment can be double-checked like this

16 Check that the bright colored links are still properly lining up with the marks on the sprockets **(see illustration)**.

17 Refit the distributor drive gear, the washer and the camshaft bolt. Tighten the camshaft sprocket bolt to the torque listed in this Chapter's Specifications, using the same method as you did to prevent the camshaft from turning.

18 Refit the tensioner unit with the tensioner foot and plunger compressed into the tensioner body as far as it will go. Tighten the fasteners to the torque listed in this Chapter's Specifications.

19 Refit the guide and tighten the fasteners to the torque listed in this Chapter's Specifications.

20 Refit the oil pump chain and sprockets. Make certain that the longer hub on the oil pump sprocket faces towards the front of the vehicle.

21 Tighten the oil pump bolt to the torque listed in this Chapter's Specifications.

22 Refit the oil pump chain tensioner. Use a finger to force the tensioner against the chain while tightening the bolts. Tighten the fasteners to the torque listed in this Chapter's Specifications.

23 Refit the remaining parts in the reverse order of removal. Refer to the appropriate Sections and Chapters for instructions. **Note:** *After all of the internal components are fitted, it should be possible to line up the marks on the timing sprockets if the crankshaft is rotated* **(see illustration)**.

15 Oil pump - removal, inspection and refitting

Refer to illustrations 15.3a, 15.3b, 15.4, 15.5, 15.6, 15.7a, 15.7b, 15.8, 15.9, 15.10a, 15.10b, 15.12 and 15.13

Removal

1 Remove the oil pump chain and sprockets (refer to Section 14).

2 On carburetted models, remove the fuel pump (refer to Chapter 4).

3 Remove the oil pump bolts **(see illustration)**. Pull out the oil pump **(see illustration)**.

4 Remove the five bolts which retain the front cover **(see illustration)**.

5 Remove the four bolts which retain the rear cover **(see illustration)**.

6 On carburetted models, remove the small nut which retains the fuel pump cam **(see illustration)**. Disassemble the internal components and lay them carefully out in order.

7 Remove the plug from the pressure relief valve **(see illustration)**. Remove the washer, spring and the relief plunger. Keep all the parts in order **(see illustration)**.

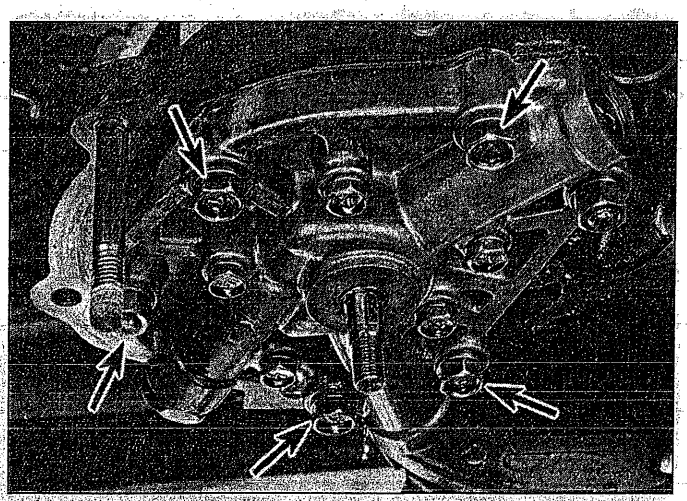
Inspection

8 Visually inspect all components for obvious wear or damage **(see illustration)**.

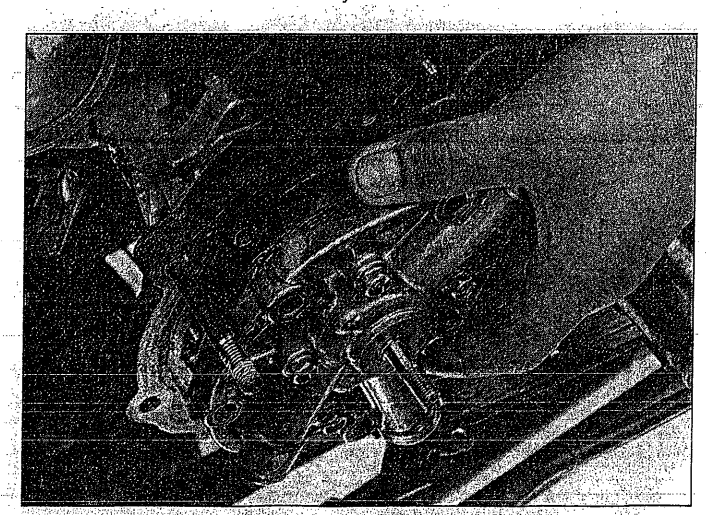
9 Use feeler gauges to measure the clearance between the ends of the rotors and a straightedge placed across the body of the pump **(see illustration)**. Compare the readings to the specifications in this Chapter.

10 In a similar manner, check the clearances between the outer rotor and the body of the pump and between the apex of the inner rotor and the shoulder of the outer rotor **(see illustrations)**. Compare the reading to the specifications in this Chapter.

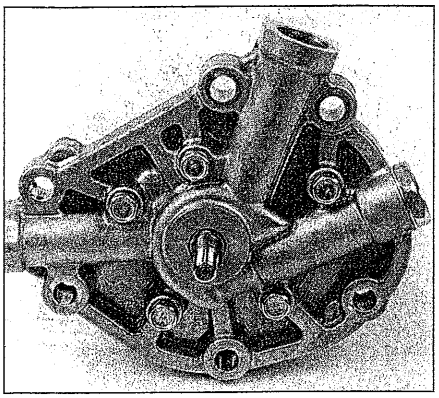
11 Check the relief mechanism components. Make certain that the plunger slides smoothly in it's bore.



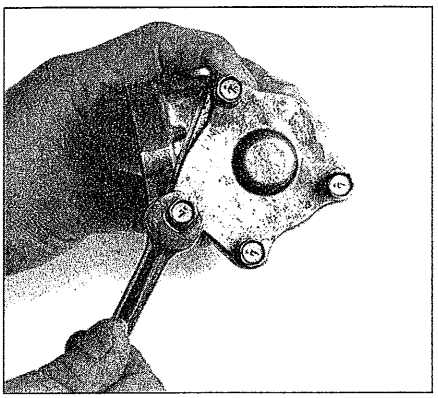
15.3a Remove these bolts to release the oil pump from the block



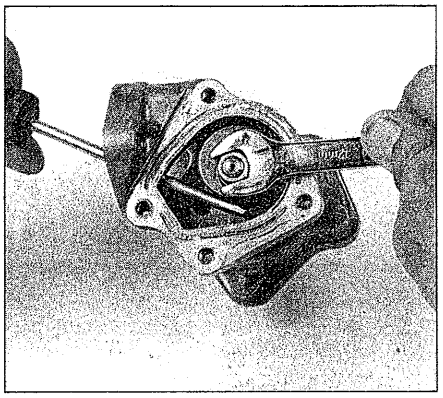
15.3b Pull the pump from the engine block



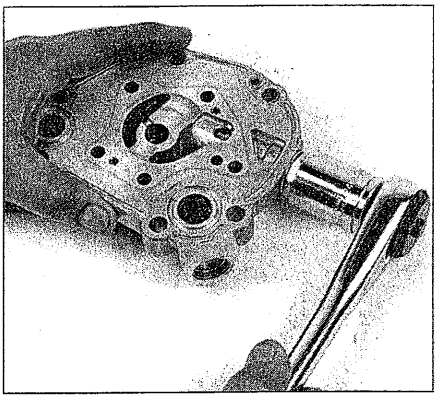
15.4 The five remaining bolts hold the front cover of the pump in place



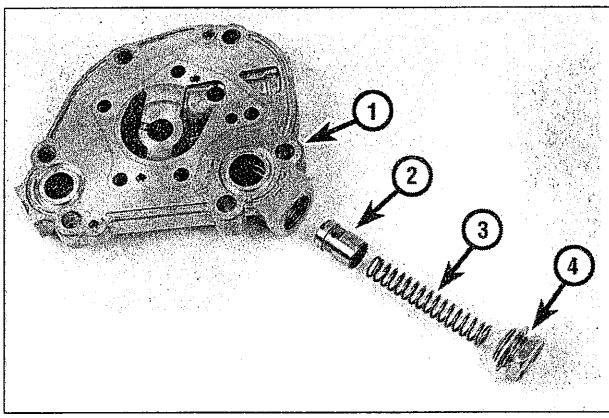
15.5 Remove the bolts from the rear cover plate



15.6 A screwdriver can be used to wedge the fuel pump cam so the nut can be removed from the shaft



15.7a The oil pressure relief mechanism is located beneath this cover - do not clamp the housing in a vice when removing the plug



15.7b The components of the pressure relief assembly

1 *Front cover*
2 *Plunger*
3 *Spring*
4 *Plug and washer*

12 Drive the bearing out of the body of the pump and renew it **(see illustration)**.
13 Renew all O-rings **(see illustration)**. Renew any worn components (or the complete pump) at this time.

Refitting

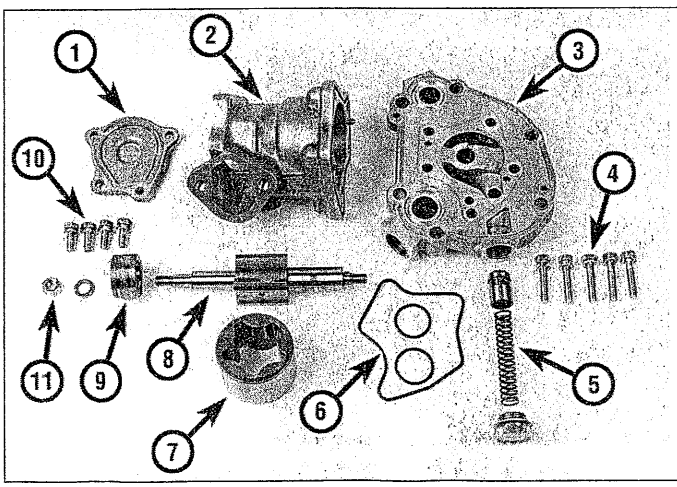
14 Tighten the fuel pump cam nut to the torque listed in this Chapter's Specifications.
15 Clean all of the cover sealing surfaces with lacquer thinner or acetone. Refit the front and rear covers. Tighten the fasteners to the torque listed in this Chapter's Specifications.
16 The remainder of the refitting is the reverse of the disassembly procedure.

16 Camshaft and bearings - removal, inspection and refitting

Refer to illustration 16.15, 16.19, 16.22 and 16.25

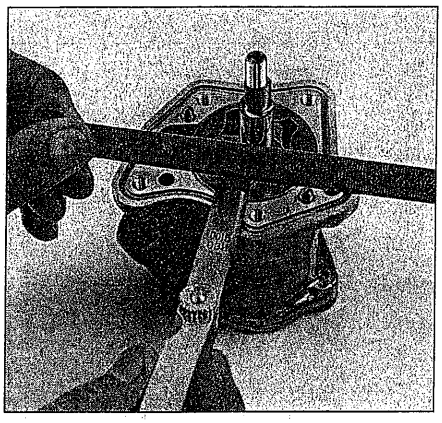
Camshaft lift check

1 To determine the extent of cam wear, the lobe lift should be checked prior to camshaft removal. Refer to Section 4 and remove the valve cover.
2 Position the number one piston at TDC on the compression stroke (see Section 3).
3 Beginning with the number one cylinder valves, mount a dial indicator on the engine and position the plunger against the top surface of the first rocker arm. The plunger should be directly above and in line with the pushrod.
4 Zero the dial indicator, then very slowly turn the crankshaft in the normal direction of rotation until the indicator needle stops and begins to move in the opposite direction. The point at which it stops indicates maximum

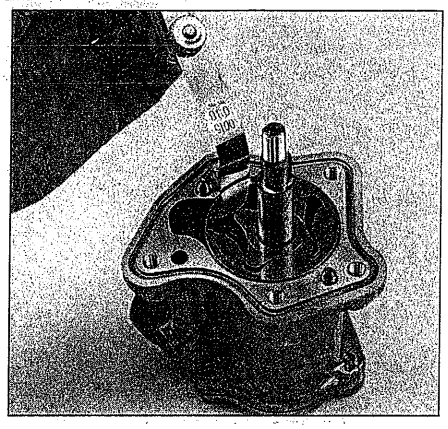


15.8 All of the components must be inspected carefully. Individual parts are available - the O-rings should always be renewed any time the pump is disassembled

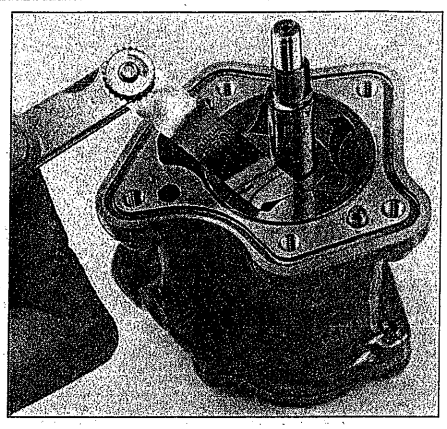
1 *Rear cover*
2 *Body*
3 *Front cover*
4 *Bolts*
5 *Pressure relief assembly*
6 *O-rings and seal*
7 *Outer rotor*
8 *Inner rotor*
9 *Cam and bearing*
10 *Bolts*
11 *Nut and washer*



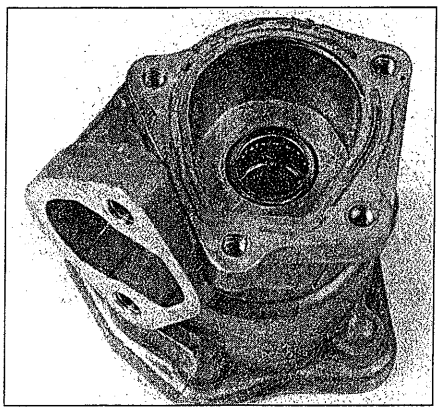
15.9 Check the pump end clearance like this



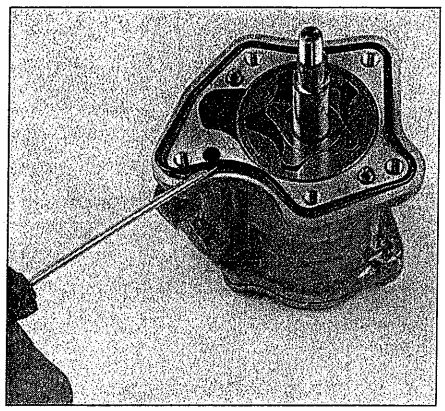
15.10a Insert the feeler gauge between the housing and the rotor and compare your reading with the Specifications



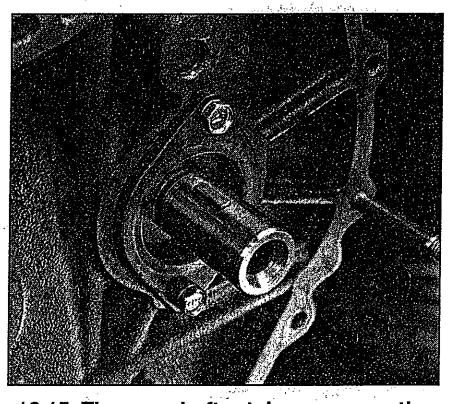
15.10b The clearance between the two rotors should also be checked



15.12 The inner bearing can be driven out with a hammer and punch - tap the new one in at its outer diameter only



15.13 The O-rings are very critical yet inexpensive - renew them whenever they are accessible



16.15 The camshaft retainer secures the camshaft in the engine block - after removing, check it for wear on its inner surface

cam lobe lift.

5 Record this figure for future reference, then reposition the piston at TDC on the compression stroke.

6 Move the dial indicator to the remaining number one cylinder rocker arm and repeat the check. Be sure to record the results for each valve.

7 Repeat the check for the remaining valves. Since each piston must be at TDC on the compression stroke for this procedure, work from cylinder-to-cylinder following the firing order sequence.

8 If the lift measurement is substantially lower on any one rocker arm (greater than 0.15 mm), the camshaft is excessively worn.

Removal

9 Disconnect the negative cable from the battery.

10 Remove the radiator (see Chapter 3), the grille (see Chapter 12) and the air conditioning condenser (see Chapter 3).

11 Remove the lifters (see Section 10).

12 Remove the timing chain and sprockets (see Section 14).

13 Mount a dial indicator on the front of the engine and place the indicator tip on the nose of the camshaft, in line with it.

14 Move the camshaft fore and aft and measure the freeplay. Compare your reading to the figure in the specifications in this Chapter.

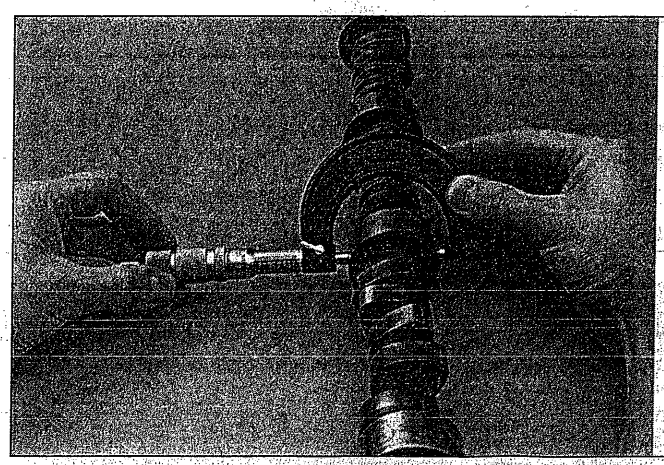
15 Remove the camshaft retainer **(see illustration)**.

16 Obtain a long bolt with the same thread as the nose of the camshaft. Thread this bolt into the camshaft to act as a handle when extracting the camshaft.

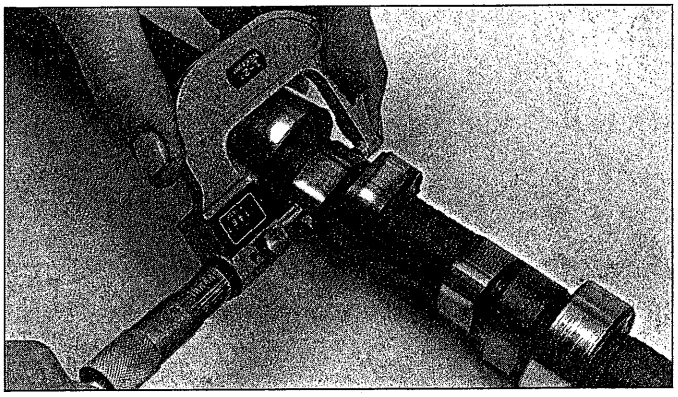
17 Carefully slide the camshaft out. Be very careful to avoid nicking the soft bearings as you do so. **Caution:** *To avoid damage to the camshaft bearings as the lobes pass over them, support the camshaft near the block as it is withdrawn.*

Inspection

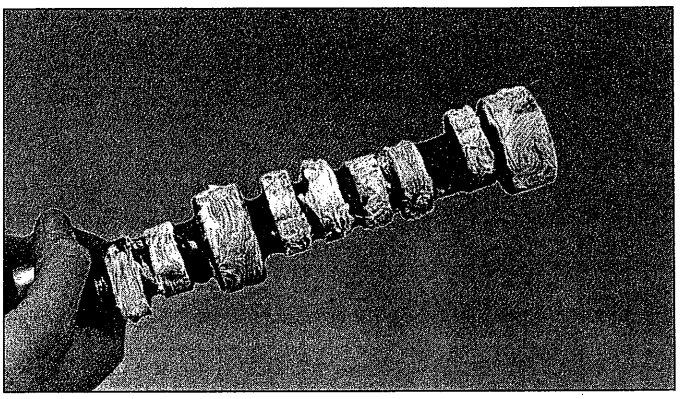
18 After the camshaft has been removed from the engine, cleaned with solvent and dried, inspect the bearing journals for uneven wear, pitting and evidence of seizure. If the journals are damaged, the bearing inserts in the block are probably damaged also. Both the camshaft and bearings will have to be renewed.



16.19 The camshaft bearing journal diameters are checked to pinpoint excessive wear and out-of-round conditions



16.22 Measure the height of each cam lobe and compare your findings to the values listed in this Chapter's Specifications



16.25 Be sure to apply camshaft refitting lube to the cam lobes and bearing journals before refitting the camshaft

19 If the bearing journals are in good condition, measure them with a micrometer and record the measurements **(see illustration)**. Measure each journal at several locations around its circumference. If you get different measurements at different locations, the journal is out of round.

20 Check the inside diameter of each camshaft bearing with a telescoping gauge and measure the gauge with a micrometer. Subtract each cam journal diameter from the corresponding camshaft bearing inside diameter to obtain the bearing oil clearance. Compare the clearance for each bearing to the specifications. If it is excessive, for any of the bearings, have new bearings refitted by an automotive machine shop.

21 Inspect the distributor drive gear for wear. Renew the camshaft if the gear is worn.

22 Measure the cam lobe heights with a micrometer **(see illustration)** and compare your findings with the values listed in this Chapter's Specifications. Inspect the camshaft lobes for heat discolouration, score marks, chipped areas, pitting and uneven wear. If the lobes are in good condition and if the lobe measurements are as specified, the camshaft can be reused.

23 Inspect the retainer. If the retainer is worn or if the camshaft end play is excessive, renew it.

Bearing renewal

24 Camshaft bearing renewal requires special tools and expertise that place it outside the scope of the home mechanic. Take the engine block (see Chapter 2D) to an automotive machine shop to ensure the job is done correctly.

Refitting

25 Lubricate the camshaft bearing journals and lobes with camshaft refitting lube **(see illustration)**.

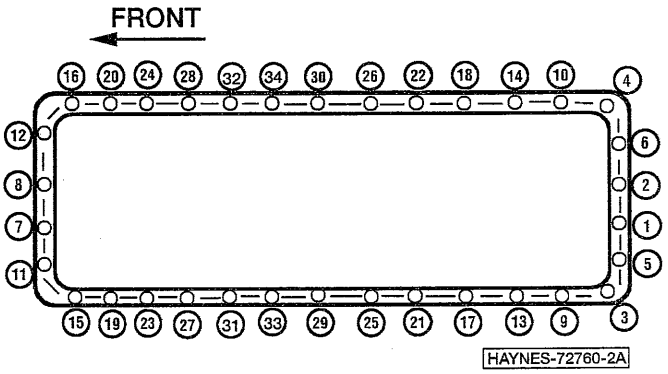
26 Refit the long bolt used previously into the front of the camshaft.

27 Slide the camshaft into the engine. Support the cam near the block and be careful not to scrape or nick the bearings.

28 Refit the remaining components in the reverse order of removal. Refer to the appropriate Sections for refitting instructions. **Note:** *If the original cam and lifters are being refitted, be sure to refit the lifters in their original locations. If a new camshaft was fitted, be sure to fit new lifters also.*

29 Add coolant and change the oil and filter (see Chapter 1).

30 Start the engine and check the ignition timing. Check for leaks and unusual noises.



17.6 The sump bolt removal sequence - when tightening the pan bolts, simply reverse the order

17 Sump - removal and refitting

Refer to illustration 17.6

1 Disconnect the cable from the negative battery terminal.

2 Raise the vehicle and support it securely on jackstands.

3 Drain the engine oil and remove the oil filter (refer to Chapter 1).

4 Remove the driveplate cover from the lower bellhousing.

5 Remove the transmission support brackets.

6 Remove the sump bolts in the proper order **(see illustration)** and detach the sump. **Note:** *Don't prise between the block and pan or damage to the sealing surfaces may result and oil leaks could develop. If the pan is stuck and is sealed with a gasket, dislodge it with a soft-face hammer or a block of wood and a hammer. If the pan was refitted with an RTV silicone seal, use a razor blade or knife to cut the seal.*

7 Use a scraper to remove all traces of sealant from the pan and block, then clean the mating surfaces with lacquer thinner or acetone. **Note:** *A new gasket or a 3 mm bead of RTV sealant can be used to seal the sump.*

8 Refit the sump and tighten the mounting bolts to the torque listed in this Chapter's Specifications. Tighten the bolts in the reverse of the order used to remove it.

9 The remainder of the refitting procedure is the reverse of disassembly.

10 Fit a new filter and add oil to the engine (see Chapter 1).

11 Reconnect the negative battery cable.

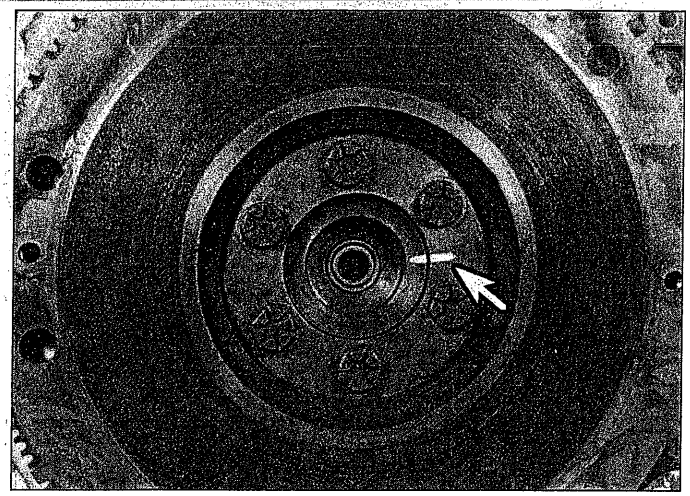
12 Start the engine and check for leaks.

18 Flywheel/driveplate - removal and refitting

Refer to illustration 18.3

1 Raise the vehicle and support it securely on jackstands, then refer to Chapter 7 and remove the transmission. If it's leaking, now would be a very good time to renew the front pump seal/O-ring (automatic transmission only).

2 Remove the pressure plate and clutch disc (see Chapter 8) (manual transmission equipped vehicles). Now is a good time to check/renew the clutch components and pilot bearing.



18.3 Make alignment marks on the flywheel/driveplate and crankshaft to ensure correct refitting

19.7 Drive the old seal from the retainer after supporting it with wood blocks

3 Make alignment marks on the flywheel/driveplate and crankshaft to ensure correct alignment during refitting **(see illustration)**.

4 Remove the bolts that secure the flywheel/driveplate to the crankshaft. If the crankshaft turns, hold the flywheel with a lever or wedge a screwdriver into the ring gear teeth to jam the flywheel.

5 Remove the flywheel/driveplate from the crankshaft. Since the flywheel is fairly heavy, be sure to support it while removing the last bolt.

6 Clean the flywheel/driveplate to remove grease and oil. Inspect the surface for cracks, rivet grooves, burned areas and score marks. Light scoring can be removed with emery cloth. Check for cracked and broken ring gear teeth or a loose ring gear. Lay the flywheel on a flat surface and use a straightedge to check for warpage.

7 Clean and inspect the mating surfaces of the flywheel/driveplate and the crankshaft. If the crankshaft rear seal is leaking, renew it before refitting the flywheel/driveplate.

8 Position the flywheel/driveplate against the crankshaft. Be sure to align the marks made during removal. Note that some engines have an alignment dowel or staggered bolt holes to ensure correct refitting. Before refitting the bolts, apply a non-hardening thread locking compound to the threads.

9 Wedge a screwdriver into the ring gear teeth to keep the flywheel/driveplate from turning. Using a criss-cross sequence, tighten the bolts to the torque listed in this Chapter's Specifications.

10 The remainder of refitting is the reverse of the removal procedure.

19 Rear main oil seal - renewal

Refer to illustrations 19.7 and 19.10

1 The rear main bearing oil seal can be renewed without removing the sump or crankshaft.

2 Remove the transmission (see Chapter 7).

3 If equipped with a manual transmission, remove the pressure plate and clutch disc (see Chapter 8).

4 Remove the flywheel or driveplate (see Section 18).

5 Remove the sump (see Section 17).

6 Remove the rear seal retainer. **Note:** It is also possible to simply loosen the sump bolts at the rear enough to allow it to drop slightly away from the rear seal retainer

7 Support the retainer on blocks of wood and drive out the old seal with a hammer and a punch **(see illustration)**.

8 Clean the bore in the retainer and the seal contact surface on the crankshaft. Check the crankshaft surface for scratches and nicks that could damage the new seal lip and cause oil leaks.

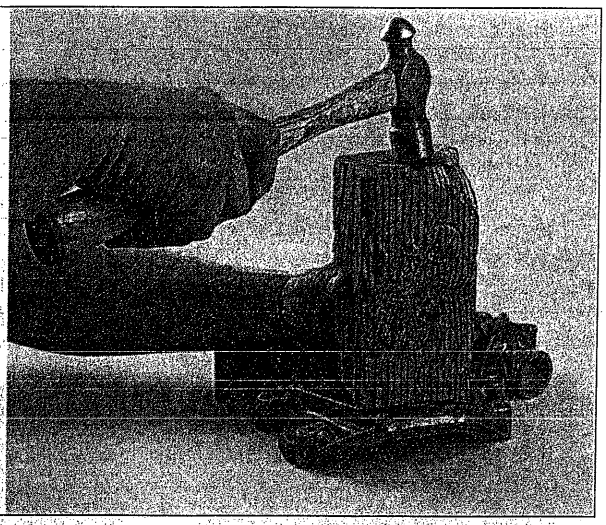
9 Apply a light coat of engine oil or multipurpose grease to the outer edge of the new seal. Lubricate the seal lip with multi-purpose grease.

10 Drive the new seal into the retainer using a block of wood **(see illustration)**. **Note:** *Make certain that the seal is facing the correct direction. The outer dust seal lip must be at the rear and the inner oil seal lip must be near the centre of the seal and facing forward.*

11 Clean the retainer with lacquer thinner or acetone, then apply a bead of RTV silicone sealer to the sealing surfaces of the retainer, inboard of the bolt holes.

12 Refit the retainer. Tighten the fasteners to the torque listed in this Chapter's Specifications.

13 The remainder of the refitting is the reverse of the disassembly procedure.



19.10 A wood block is useful when fitting the new seal - make sure that the retainer is on a flat and hard surface

20 Engine oil cooler – removal and refitting

Note: *The engine oil cooler is not used on some 4.2 litre petrol engines. If the vehicle is not equipped with an oil cooler, a special block-off plate is fitted in its place, above the oil filter on the driver's side of the engine.*

1 Drain sufficient coolant from the radiator to lower its level below the oil cooler. Use a clean drain pan so that the coolant may be reused.

2 Remove the outer bolts and then

21.5 A long screwdriver or lever can be used to check the mounts

21.8 There are access holes provided in the crossmember to allow removal of the mount bolts - a long extension is needed

remove the cover from the engine. Do not remove the yellow nuts.

3 Remove the oil filter element by removing the four mounting nuts.

4 Check the oil cooler for signs of leaks. Blow through it to check for clogging. Renew it if necessary.

5 Renew the small O-rings and both gaskets when fitting the cooler to the housing.

6 Clean the sealing surfaces of the cooler cover and the engine with acetone or lacquer thinner. Apply a 3mm bead of RTV silicone sealer to the cover, inside of the bolt holes.

7 Refitting is the reverse of removal. Tighten the fasteners to the torque listed in this Chapter's Specifications.

21 Engine mounts - check and renewal

1 Engine mounts seldom require attention, but broken or deteriorated mounts should be renewed immediately or the added strain placed on the driveline components may cause damage or wear.

Check

Refer to illustration 21.5

2 During the check, the engine must be raised slightly to remove the weight from the mounts.

3 Raise the vehicle and support it securely on jackstands, then position a jack under the engine sump. Place a large block of wood between the jack head and the sump, then carefully raise the engine just enough to take the weight off the mounts. **Warning:** *DO NOT place any part of your body under the engine when it's supported only by a jack!*

4 Check the mounts to see if the rubber is cracked, hardened or separated from the metal plates. Sometimes the rubber will split right down the centre.

5 Check for relative movement between the mount plates and the engine or frame (use a large screwdriver or lever to attempt to move the mounts) **(see illustration)**. If movement is noted, lower the engine and tighten the mount fasteners.

6 Rubber preservative should be applied to the mounts to slow deterioration.

Renewal

Refer to illustration 21.8

7 Disconnect the negative battery cable from the battery, then raise the vehicle and support it securely on jackstands (if not already done).

8 Remove the nut on the engine mount stud **(see illustration)**.

9 Raise the engine slightly with a jack or hoist (make sure the fan doesn't hit the radiator or shroud). Remove the two mounting bolts and detach the mount from the engine.

10 Refitting is the reverse of removal. Use a non-hardening thread locking compound on the mount fasteners and be sure to tighten them securely.

Notes

Chapter 2 Part B
3.0 litre engine

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Crankshaft front oil seal - renewal	12
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Cylinder head - removal and refitting	10
Drivebelt check, adjustment and renewal	See Chapter 1
Engine - removal and refitting	See Chapter 2D
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Engine oil and filter change	See Chapter 1
Engine oil level check	See Chapter 1
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Exhaust manifold - removal and refitting	8
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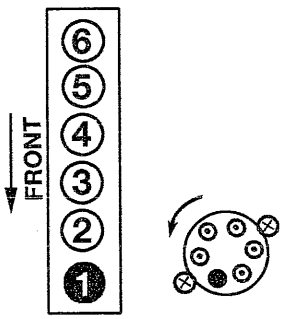
Specifications

General

Displacement	2962 cc
Cylinder numbers (front-to-rear)	1-2-3-4-5-6
Firing order	1-5-3-6-2-4

Camshaft

Endplay	0.03 to 0.06 mm
Camshaft journal-to-bearing (oil) clearance	
Numbers 1 to 6	0.045 to 0.090 mm
Number 7	0.065 to 0.110 mm
Maximum allowable, numbers 1 to 7	0.15 mm
Camshaft journal diameter	
Numbers 1 to 6	46.935 to 46.955 mm
Number 7	46.4125 to 46.435 mm
Camshaft runout limit	0.10 mm
Camshaft lobe height	39.242 to 39.432 mm
Camshaft lobe wear limit	0.15 mm
Lifter-to-guide clearance	0.043 to 0.066 mm
Rocker arm-to-rocker shaft clearance	0.007 to 0.049 mm



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Cylinder location and distributor rotation

The blackened terminal shown on the distributor cap indicates the Number One spark plug wire position

Oil pump

Body to outer gear	0.11 to 0.20 mm
Inner gear to crescent	0.22 to 0.33 mm
Outer gear to crescent	0.21 to 0.32 mm
Cover-to-inner gear end clearance	0.05 to 0.09 mm
Cover-to-outer gear end clearance	0.05 to 0.11 mm
Inner gear-to-housing oil clearance	0.106 to 0.152 mm

Torque specifications

	Nm (unless otherwise indicated)
Camshaft front retainer bolts	6.3 to 8.3
Camshaft sprocket bolts	16 to 22
Crankshaft front pulley	142 to 152
Crankshaft rear seal housing bolts	6.3 to 8.3
Cylinder head bolts **(see illustration for tightening sequence)**	
First step	29
Second step	78
Third step	Loosen completely
Fourth step	29
Preferred fifth step	100 to 105 degrees additional rotation
Alternate fifth step	78 to 88
Cylinder head corner bolts	9 to 12
Exhaust manifold nuts	27 to 31
Flywheel/driveplate bolts	142 to 152
Inlet manifold to head bolts	18 to 22
Inlet manifold plenum to manifold bolts	18 to 22
Inlet manifold brace bolts	30 to 40
Main bearing cradle bolts (lubricated threads)	44 to 54
Sump mounting bolts	5 to 7
Oil pump assembly to block bolts	6.3 to 8.3
Oil pump cover screws	5
Oil pump pick-up bolts	21
Oxygen sensor	41 to 51
Rocker shaft bolts	18 to 22
Timing belt tensioner pulley nut	44 to 58
Timing cover bolts	3 to 5
Valve cover-to-cylinder head bolts	2 to 4

1 General information

This Part of Chapter 2 is devoted to in-vehicle repair procedures for the 3.0 litre inline six-cylinder engine. All information concerning engine removal and refitting and engine block and cylinder head overhaul can be found in Part C of this Chapter.

The following repair procedures are based on the assumption that the engine is fitted in the vehicle. If the engine has been removed from the vehicle and mounted on a stand, many of the steps outlined in this Part of Chapter 2 will not apply.

The Specifications included in this Part of Chapter 2 apply only to the procedures contained in this Part. Part C of Chapter 2 contains the Specifications necessary for cylinder head and engine block rebuilding.

2 Repair operations possible with the engine in the vehicle

Many major repair operations can be accomplished without removing the engine from the vehicle.

Clean the engine compartment and the exterior of the engine with some type of pressure washer before any work is done. It will make the job easier and help keep dirt out of the internal areas of the engine.

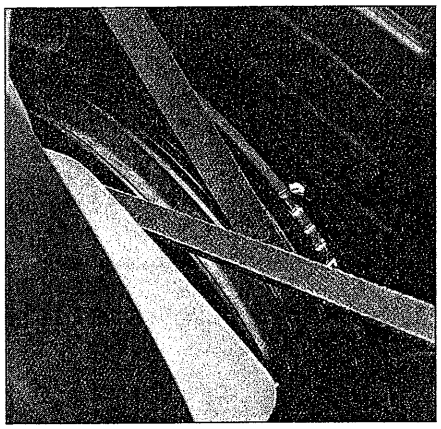
Remove the bonnet, if necessary, to improve access to the engine as repairs are performed (refer to Chapter 11 if necessary).

If vacuum, exhaust, oil or coolant leaks develop, indicating a need for gasket or seal renewal, the repairs can generally be made with the engine in the vehicle. The inlet and exhaust manifold gaskets, sump gasket, crankshaft oil seals and cylinder head gasket are all accessible with the engine in place.

Exterior engine components, such as the inlet and exhaust manifolds, the sump (and the oil pump), the water pump, the starter motor, the alternator, the distributor and the fuel system components can be removed for repair with the engine in place.

Since the cylinder head can be removed without pulling the engine, valve component servicing can also be accomplished with the engine in the vehicle. Renewal of the camshaft and timing belt is also possible with the engine in the vehicle.

In extreme cases caused by a lack of necessary equipment, repair or renewal of piston rings, pistons, connecting rods and rod bearings is possible with the engine in the vehicle. However, this practice is not recommended because of the cleaning and preparation work that must be done to the components involved.



3.8 Align the mark on the pulley with the zero on the timing scale

3 Top Dead Centre (TDC) for number one piston - locating

Refer to illustration 3.8

Note: *The following procedure is based on the assumption that the distributor is correctly fitted. If you are trying to locate TDC on cylinder number one to refit the distributor correctly, number one piston position must be determined by feeling for compression at the number one spark plug hole as the engine is slowly rotated by hand, then aligning the ignition timing marks as described in Step 8.*

1 Top Dead Centre (TDC) is the highest point in the cylinder that each piston reaches as it travels up-and-down when the crankshaft turns. Each piston reaches TDC on the compression stroke and again on the exhaust stroke, but TDC generally refers to piston position on the compression stroke only, when neither valve is open.

2 Positioning the piston(s) at TDC is an essential part of many procedures such as rocker arm removal, camshaft and timing belt/sprocket removal and distributor removal.

3 Before beginning this procedure, be sure to place the transmission in Neutral and apply the parking brake or block the rear wheels. Also, remove the spark plugs (see Chapter 1) and disable the ignition system. Detach the coil wire from the centre terminal of the distributor cap and earth it on the block with a jumper wire.

4 In order to bring any piston to TDC, the crankshaft must be turned using one of the methods outlined below. When looking at the front of the engine, normal crankshaft rotation is clockwise.

a) *The preferred method is to turn the crankshaft with a socket and ratchet attached to the bolt threaded into the front of the crankshaft.*

b) *A remote starter switch, which may save some time, can also be used. Follow the instructions included with the switch. Once the piston is close to TDC, use a socket and ratchet, as described in the previous paragraph.*

c) *If an assistant is available to turn the ignition switch to the Start position in short bursts, you can get the piston close to TDC without a remote starter switch. Make sure your assistant is out of the vehicle, away from the ignition switch, then use a socket and ratchet (as described in Paragraph a) to complete the procedure.*

5 Note the position of the terminal for the number one spark plug wire on the distributor cap. If the terminal isn't marked, follow the plug wire from the number one cylinder spark plug to the cap.

6 Use a felt-tip pen or chalk to make a mark on the distributor body directly under the terminal.

7 Detach the cap from the distributor and set it aside (see Chapter 1 if necessary).

8 Turn the crankshaft (see Paragraph 3 above) until the notch in the crankshaft sprocket is aligned with the 0 on the timing plate (located at the front of the engine) **(see illustration)**.

9 Look at the distributor rotor - it should be pointing directly at the mark you made on the distributor body. If it is, go to Step 12.

10 If the rotor is 180 degrees off, the number one piston is at TDC on the exhaust stroke. Go to Step 11.

11 To get the piston to TDC on the compression stroke, turn the crankshaft one complete turn (360 degrees) clockwise. The rotor should now be pointing at the mark on the distributor. When the rotor is pointing at the number one spark plug wire terminal in the distributor cap and the ignition timing marks are aligned, the number one piston is at TDC on the compression stroke.

12 After the number one piston has been positioned at TDC on the compression stroke, TDC for any of the remaining pistons can be located by turning the crankshaft clockwise and following the firing order. Mark the remaining spark plug wire terminal locations on the distributor body just like you did for the number one terminal, then number the marks to correspond with the cylinder numbers. As you turn the crankshaft, the rotor will also turn. When it's pointing directly at one of the marks on the distributor, the piston for that particular cylinder is at TDC on the compression stroke.

4 Valve cover - removal and refitting

Refer to illustrations 4.8a, 4.8b and 4.11

1 Disconnect the negative battery cable.

2 Pull the crankcase breather tube and hose off the valve cover.

3 Disconnect or remove any accessories which interfere.

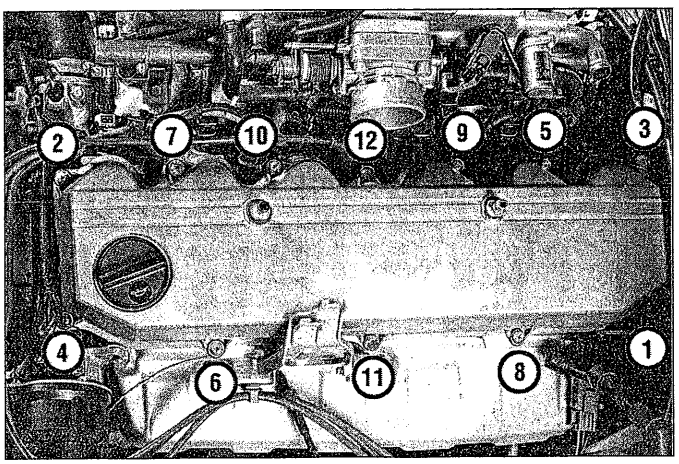
4 Remove the air cleaner assembly (see Chapter 4).

5 Remove the spark plug wires from the brackets, noting their locations.

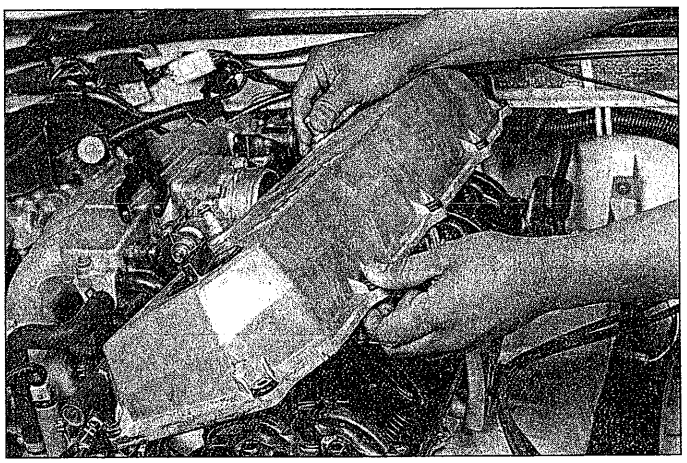
6 Remove the mounting bracket that connects to the head bolts.

7 Remove any wire harness clips, noting the locations of their studs for refitting.

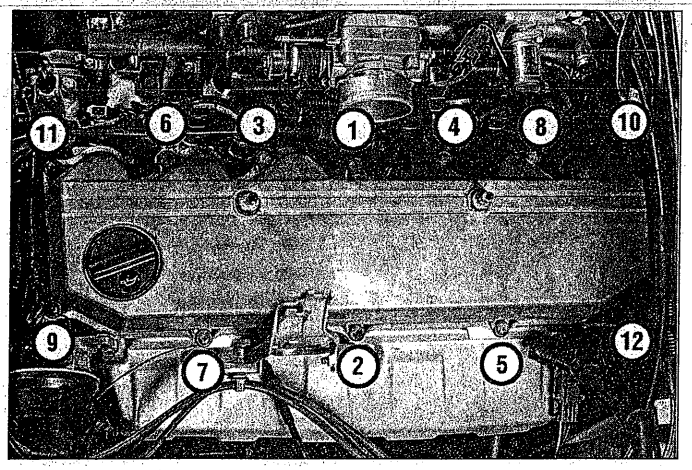
8 Remove the valve cover retaining bolts in the sequence shown **(see illustration)**. If the cover is stuck, tap on it gently with a soft-face mallet and then remove it **(see illustration)**.



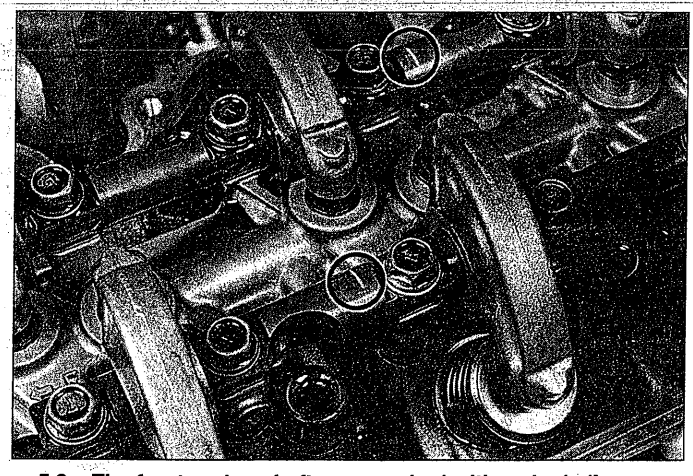
4.8a The valve cover bolts should be removed in this order



4.8b Place the bolts in a secure place and then lift the cover from the engine



4.11 Tighten the valve cover bolts in this sequence to avoid distorting the cover



5.3a The front rocker shafts are marked with a single line . . .

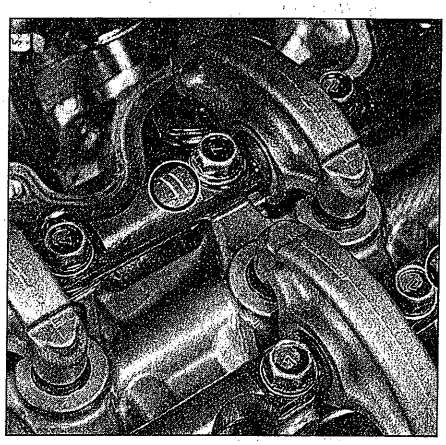
9 Clean the sealing surfaces, removing any traces of oil with lacquer thinner, brake cleaner or acetone with a clean rag.
10 Lay a new seal into the valve cover groove.
11 Refit the cover and bolts. Tighten the bolts to the torque listed in this Chapter's Specifications. Use the tightening sequence shown **(see illustration)**.
12 Refit the components previously removed.
13 Run the engine and check for oil leaks.

5 Rocker arm assemblies and lifters- removal, inspection and refitting

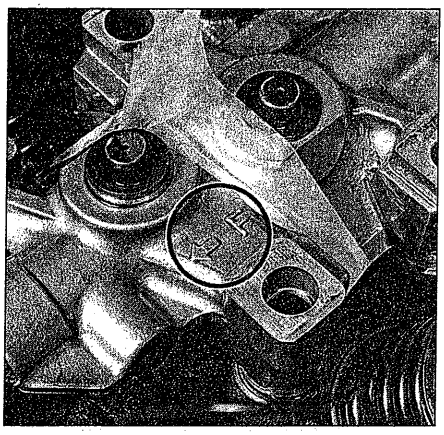
Removal

Refer to illustrations 5.3a, 5.3b, 5.4, 5.5a and 5.5b

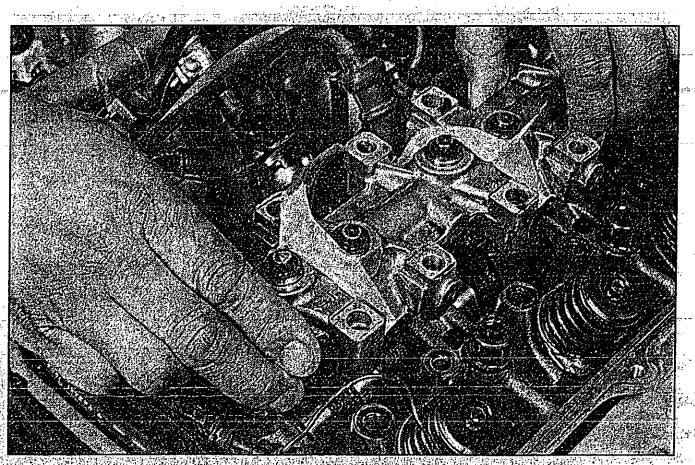
1 Remove the valve cover (see Section 4). Put number one cylinder on TDC with both valves closed (on the compression stroke) (see Section 3).
2 Remove the rocker shaft bolts.
3 Remove the rocker arm assemblies. Keep everything in order so that they can be refitted in the same positions. **Note:** *The two front rocker shafts are marked with a I. The two rear ones are marked with a II* **(see illustrations)**.
4 Use wire or tape to secure the lifters so they do not drop when the lifter guides are removed. **Note:** *The front lifter guide is marked with a small F and an arrow pointing to the front* **(see illustration)**. *The rear one is marked with a small R and an arrow pointing to the rear.*
5 Lift off the two lifter guides with the lifters **(see illustration)**. Remove the lifters and carefully put them in order **(see illustration)**. Keep the lifters upright at all times.



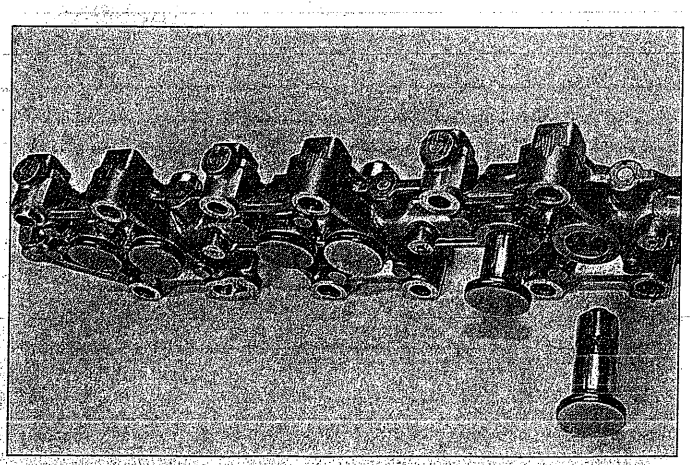
5.3b . . . while the rears have two lines



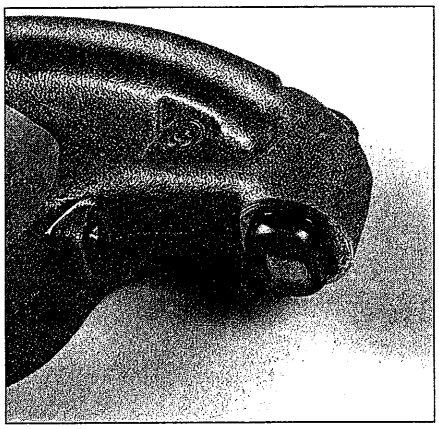
5.4 This arrow on the front lifter retainer must face forward. The rear retainer has an R which faces to the rear. Wire or tape the lifters in position . . .



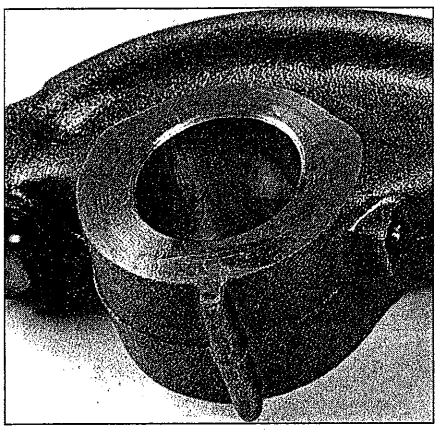
5.5a . . . and then lift the retainer off



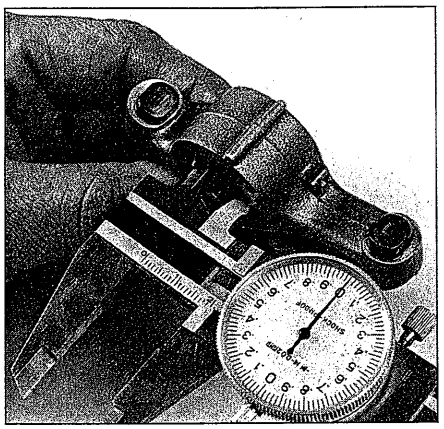
5.5b All the individual lifters must be kept in their original positions. Do not allow them to get out of order



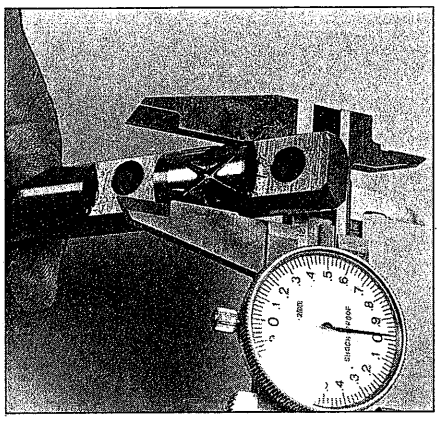
5.6a Each end of each rocker must be inspected for damage



5.6b Check the shaft hole for signs of obvious wear



5.6c Measure the rocker pivot holes



5.6d Also measure the rocker shafts in the areas where the rocker arms ride

Inspection

Refer to illustrations 5.6a, 5.6b, 5.6c, 5.6d and 5.7

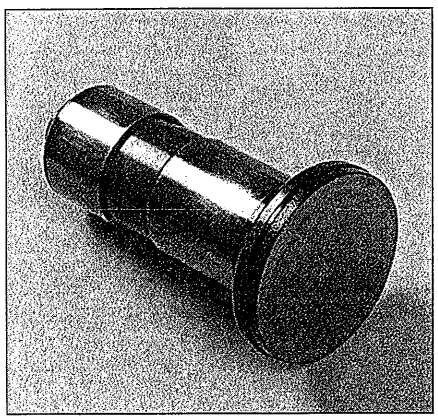
6 Check each rocker arm for wear, cracks and other damage, especially where the lifters and valve stems contact the rocker arm faces. Check the pivot hole in each rocker arm. Look for galling, stress cracks and unusual wear patterns **(see illustrations)**. If the rocker arms are worn or damaged, renew them. **Caution:** *Keep the rockers in order at all times! The rocker arms for the front three cylinders are different from the others.*

7 Carefully examine each lifter for wear at the rocker arm end and especially at the cam end **(see illustration)**. If a lifter is severely eroded at the cam end, the camshaft may need to be renewed as well. Keep the lifters in the upright position at all times.

8 If any lifters were noisy, it is best to renew them as a set. They are not rebuildable.

9 Check the bores in the lifter guides for wear. Measure them and the diameter of the lifters to obtain the oil clearance. The proper clearance is in the Specifications section of this Chapter.

10 Inspect the rocker shafts. If they appear worn, measure them and the rockers to obtain the oil clearance **(see illustration 5.6d)**. The proper clearance is in the Specifications of this Chapter.

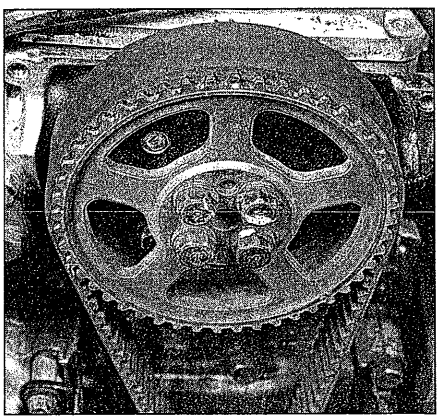


5.7 Inspect each lifter one at a time so that they do not get out of order

Refitting

Refer to illustration 5.12

11 Apply moly-base engine assembly lube to the bases of the lifters to prevent damage to the mating surfaces. Lubricate all other wear surfaces with clean engine oil. Refit all the components in their original locations.



5.12 When the engine is at TDC on the compression stroke for the number one cylinder, the mark on the camshaft will be straight up

12 Make sure that the number one cylinder is at TDC on the compression stroke. The mark on the camshaft gear will be up **(see illustration)**. Tighten the rocker shaft bolts for the rear three cylinders to the torque listed in this Chapter's Specifications.

13 Rotate the crankshaft 360 degrees so the mark on the camshaft gear is pointing down. Repeat the tightening procedure for the front three cylinders.

14 Refit the valve cover (see Section 4).

15 Start the engine, listen for unusual valvetrain noises and check for oil leaks at the valve cover joint. Run the engine for at least ten minutes to allow any lifter noises to disappear.

6 Valve springs, retainers and seals - renewal

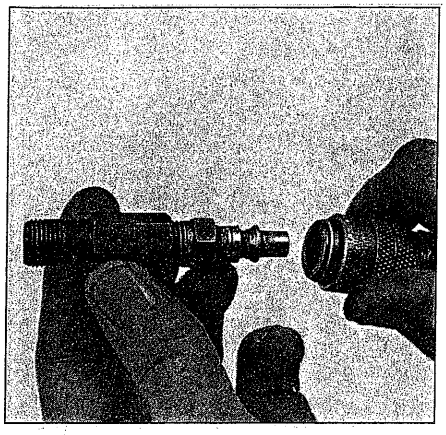
Refer to illustrations 6.4, 6.9, 6.10, 6.15, 6.16 and 6.17

Note: *Broken valve springs and defective valve stem seals can be renewed without removing the cylinder heads. Two special tools and a compressed air source are normally required to perform this operation, so read through this Section carefully and rent or buy the tools before beginning the job. If compressed air isn't available, a length of nylon rope can be used to keep the valves from falling into the cylinder during this procedure.*

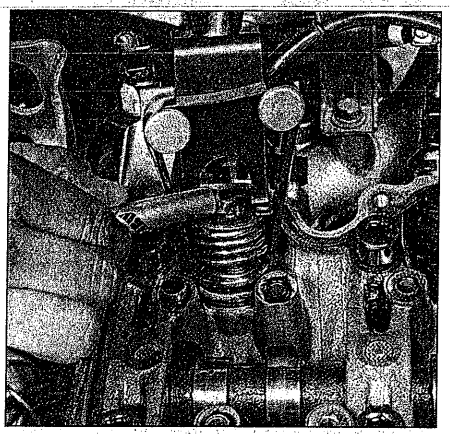
1 Remove the valve cover (Section 4).

2 Remove the spark plug from the cylinder which has the defective component. If all of the valve stem seals are being renewed, all of the spark plugs should be removed.

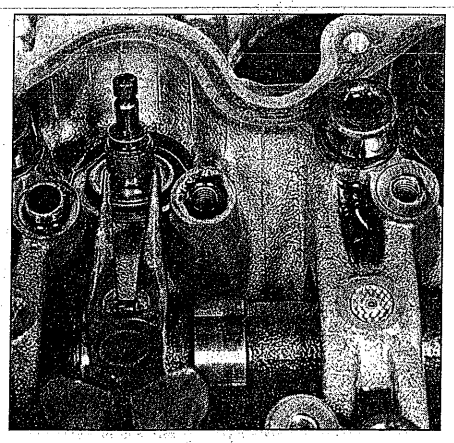
3 Turn the crankshaft until the piston in the affected cylinder is at top dead centre (TDC) on the compression stroke (see Section 3 for instructions). If you're renewing all of the valve stem seals, begin with cylinder number one and work on the valves for one cylinder at a time. Move from cylinder-to-cylinder following the firing order sequence (see the Specifications listed at the beginning of this Chapter).



6.4 An adapter for applying air pressure through a spark plug hole



6.9 Compress the valve spring with a special tool. There are several types available



6.10 The valve seals can be pried off using pliers or two screwdrivers

4 Thread an adapter into the spark plug hole **(see illustration)** and connect an air hose from a compressed air source to it. Most auto parts stores can supply the air hose adapter. **Note:** *Many cylinder compression gauges utilise a screw-in fitting that may work with your air hose quick-disconnect fitting.*

5 Remove the rocker arm shaft assemblies (see Section 5).

6 Apply compressed air to the cylinder. **Warning:** *The piston may be forced down by compressed air, causing the crankshaft to turn suddenly. If the spanner used when positioning the number one piston at TDC is still attached to the bolt in the crankshaft nose, it could cause damage or injury when the crankshaft moves.*

7 The valves should be held in place by the air pressure. If the valve faces or seats are in poor condition, leaks may prevent air pressure from retaining the valves - refer to the alternative procedure below.

8 If you don't have access to compressed air, an alternative method can be used. Position the piston at a point approximately 45-degrees (1/8 turn) before TDC on the compression stroke, then feed a long piece of nylon rope through the spark plug hole until it fills the combustion chamber. Be sure to leave the end of the rope hanging out of the spark plug hole so it can be removed easily. Use a large ratchet and socket to rotate the crankshaft in the normal direction of rotation until slight resistance is felt.

9 Stuff shop rags into the cylinder head holes around the valves to prevent parts and tools from falling into the engine, then use a valve spring compressor to compress the spring **(see illustration)**. Remove the collets with small needle-nose pliers or a magnet. **Note:** *A couple of different types of tools are available for compressing the valve springs with the head in place. One type grips the lower spring coils and presses on the retainer as the knob is turned, while the other type, shown here, utilises the rocker arm capscrew for leverage. Both types work very well, although the lever type is usually less expensive.*

10 Remove the spring retainer and valve spring, then remove the seal. The seals must be pried off using two screwdrivers at the same time, or pliers **(see illustration)**. **Note:** *If air pressure fails to hold the valve in the closed position during this operation, the valve face and/or seat is probably damaged. If so, the cylinder head will have to be removed for additional repair operations.*

11 Wrap a rubber band or tape around the top of the valve stem so the valve won't fall into the combustion chamber, then release the air pressure. **Note:** *If a rope was used instead of air pressure, turn the crankshaft slightly in the direction opposite normal rotation.*

12 Inspect the valve stem for damage. Rotate the valve in the guide and check the end for eccentric movement, which would indicate that the valve is bent.

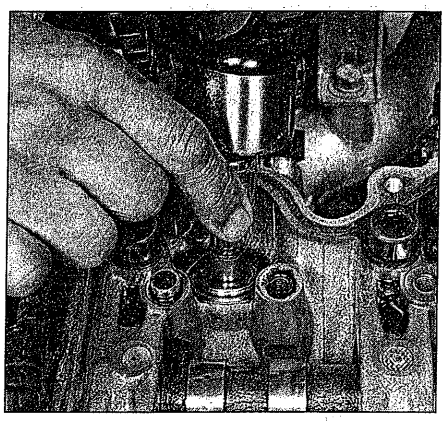
13 Move the valve up-and-down in the guide and make sure it doesn't bind. If the valve stem binds, either the valve is bent or the guide is damaged. In either case, the head will have to be removed for repair.

14 Reapply air pressure to the cylinder to retain the valve in the closed position, then remove the tape or rubber band from the valve stem. If a rope was used instead of air pressure, rotate the crankshaft in the normal direction of rotation until slight resistance is felt.

15 Lubricate the valve stem with engine oil and fit a new seal. Inlet and exhaust valve seals are different. The inlet seals must be tapped on with a hammer and a socket. Exhaust valve seals can be pushed onto the valve guide boss by hand **(see illustration)**.

16 Refit the spring in position over the valve. Make sure the proper spacer is under each spring. **Note:** *Cylinders one through three have specific exhaust valve springs that are different from the others. The inner spring is painted pink, the outer is painted green. On all valve springs, the painted side of the valve spring with the narrow winding pitch must be positioned down against the head* **(see illustration)**.

17 Refit the valve spring retainer. Compress the valve spring and carefully position

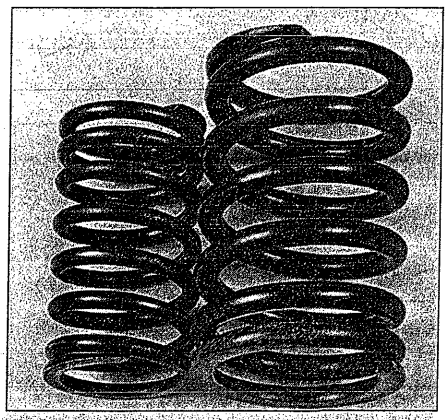


6.15 Tap the new seal on with a hammer and a socket

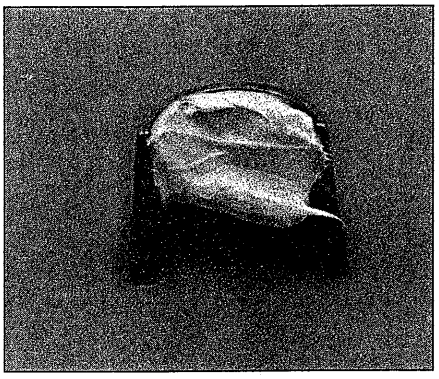
the collets in the groove. Apply a small dab of grease to the inside of each collet to hold it in place **(see illustration)**.

18 Remove the force from the spring tool and make sure the collets are seated.

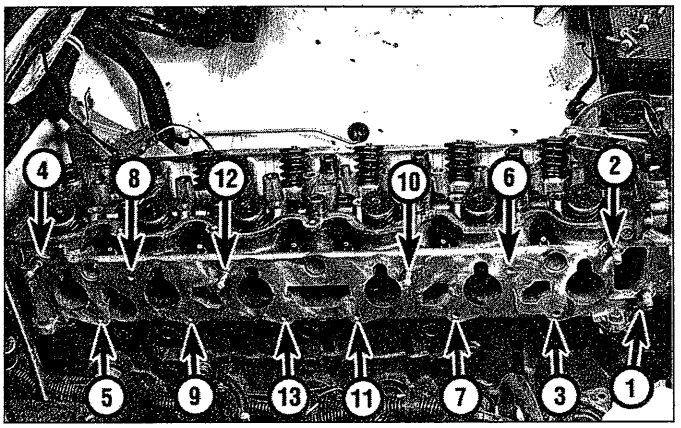
19 Disconnect the air hose and remove the adapter from the spark plug hole. If a rope was used in place of air pressure, pull it out of the cylinder.



6.16 The end of the valve spring with the paint mark and the more tightly wound coils faces down. Keep all the springs in order as you work. They must be returned to their original positions



6.17 A dab of grease will hold the collet in place while the spring is compressed



7.11 Loosen the inlet manifold bolts in this sequence

20 Refer to Section 5 and refit the rocker arm assemblies.
21 The rest of the refitting is the reverse of removal.
22 Start and run the engine, then check for oil leaks and unusual sounds coming from the valve cover area.

7 Inlet manifold - removal and refitting

Refer to illustration 7.11

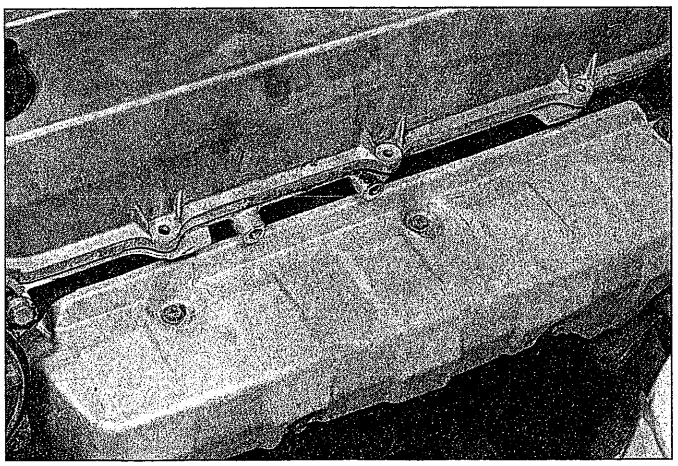
1 Disconnect the negative battery cable.
2 Remove the air cleaner assembly.
3 Drain the cooling system about halfway (see Chapter 3).
4 Remove the upper radiator hose and the heater hoses.
5 Label and then disconnect all of the vacuum lines from the inlet manifold.
6 Disconnect the throttle cable and the cruise control cable (see Chapter 4).
7 Label and remove all interfering wiring including the carburettor wires and the spark plug wires for the rear cylinders.
8 Remove the coil and its bracket from the manifold.
9 Disconnect the tubes from the EGR valve.
10 Remove the inlet manifold brace bolts. It is not necessary to remove the wiring from it or to remove the brace from the vehicle.
11 Remove the inlet manifold nuts and carefully remove the manifold. The bolts must be removed in the correct sequence **(see illustration)**.
12 Clean all gasket surfaces very carefully.
13 Refitting is the reverse of removal. Tighten the manifold nuts to the torque listed in the Specifications of this Chapter, tightening them in the opposite order of the loosening sequence.

8 Exhaust manifold - removal and refitting

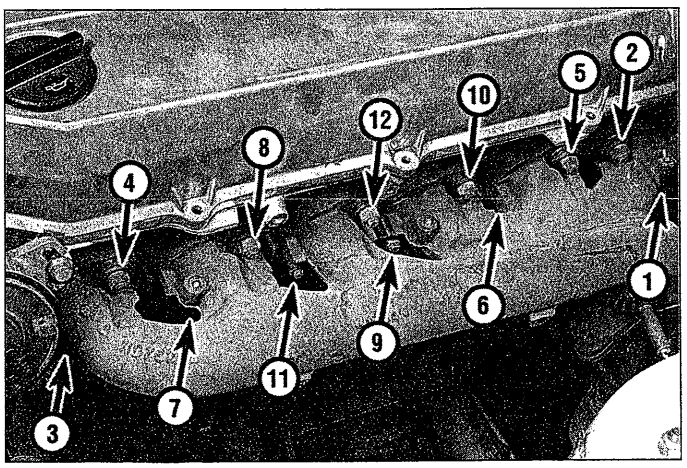
Refer to illustrations 8.4 and 8.6

Warning: *Allow the engine to cool completely before following this procedure.*

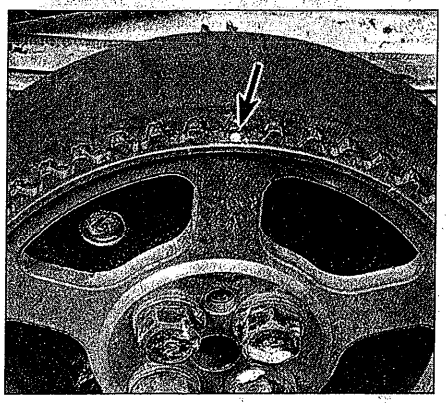
1 Raise the front of the vehicle and support it securely on jackstands.
2 Disconnect the negative battery cable from the battery.
2 Apply penetrating oil to the threads of the exhaust manifold attaching studs and the exhaust pipe-to-manifold attaching nuts.
3 Remove the nuts and pull the exhaust pipe down. **Note:** *If the studs break, you will have to have them removed by a machine shop or you may drill them out and renew them with through-bolts.*
4 Remove the heat shield from the exhaust manifold **(see illustration)**.
5 Disconnect the tube for the EGR system from the exhaust manifold.
6 Remove the nuts that secure the exhaust manifold to the cylinder head and pull the manifold off the engine. The nuts must be removed in the proper sequence **(see illustration)**.
7 Remove all traces of old gasket material from the mating surfaces.
8 If the manifold gasket was blown out, have the manifold checked for warpage by an automotive machine shop with a precision straightedge and machined as necessary.
9 Position a new gasket and slide the manifold on.
10 Refit the fasteners finger tight. Tighten them to the correct torque in the reverse of the order used for removal. **Note:** *Each stud uses a thick washer, a thin washer and a nut. The convex (domed) sides of the washers faces away from the engine. The thick washers with the larger outside diameter go onto the eight outer studs that have a larger stud hole.*
11 Fit a new exhaust pipe seal if necessary. Reconnect the exhaust pipe, run the engine and check for leaks.



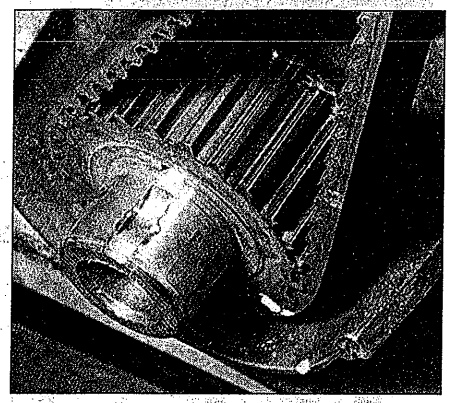
8.4 The exhaust manifold heat shield must be removed to get access to the manifold bolts



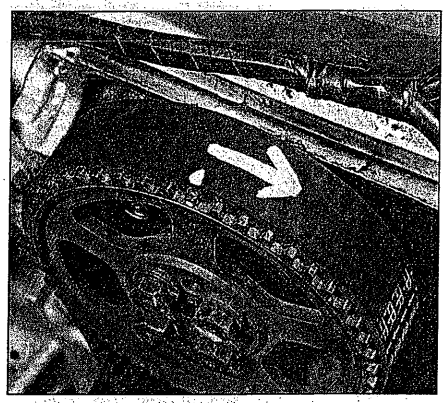
8.6 The exhaust manifold bolts must be loosened in this sequence



9.6 Make sure the cam mark is straight up . . .



9.8 . . . and the crankshaft mark is next to the mark on the oil pump



9.11 If you are going to refit the old belt, mark it for direction of rotation and where it mates with the marks on the sprockets

9 Timing belt - removal and refitting

Refer to illustrations 9.6, 9.8, 9.11 and 9.12

Removal

Note: *The timing belt should be renewed at 100,000 km intervals.*

1 Disconnect the negative battery cable.

2 Refer to Chapter 3 and remove the radiator, fan, fan clutch, water pump pulley and fan shroud.

3 Remove all of the drive belts (Chapter 1).

4 Remove all spark plug wires and other wiring from the timing belt cover.

5 Remove the upper timing belt cover.

6 Rotate the engine by hand to TDC (Section 3) for cylinder number one on the compression stroke. The mark on the camshaft sprocket will be pointing up **(see illustration)**.

7 Remove the crankshaft pulley (Section 11).

8 Remove the lower timing belt cover. The mark on the crankshaft sprocket should be lined up with the mark on the oil pump housing **(see illustration)**.

9 Slide off the plate from the front of the crankshaft.

10 If the belt is going to be refitted, mark it for direction of rotation **(see illustration)**. Also mark the belt at the points where the marks on the sprockets meet it.

11 Loosen the belt tensioner locknut.

12 Rotate the tensioner clockwise by using an Allen spanner **(see illustration)**. Remove the belt.

13 Refer to Section 5 and loosen all of the rocker shaft bolts. This will relieve pressure on the camshaft and allow the timing belt tension to be set properly.

Refitting

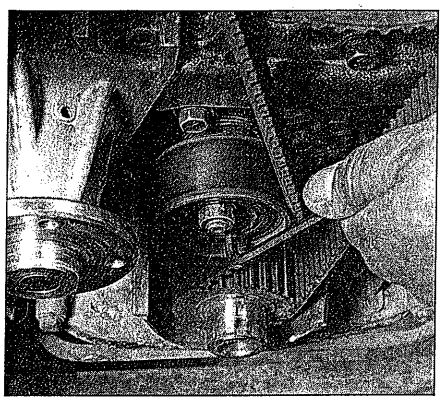
14 Make sure that the mark on the crankshaft sprocket is pointing at the mark on the oil pump housing. Make sure that the belt is being refitted in the proper rotation direction.

15 Refit the belt. If a new belt is being fitted, the marks on it must line up with the marks on the sprockets. If the old belt is being refitted, the marks you previously made must align.

16 Snap the tensioner into position. Using the 5 mm hex key, rock the tensioner a few times to seat it properly. The exhaust manifold side of the belt must be tight.

17 Tighten the tensioner nut to the correct torque.

18 The rest of refitting is the reverse of removal. Torque the rocker shaft bolts for the rear three cylinders first, then rotate the crankshaft one revolution so that the camshaft mark is pointing down. Torque the front rocker shaft bolts.



9.12 Rotate the spring loaded tensioner with a hex key

10 Cylinder head - removal and refitting

Refer to illustrations 10.9, 10.10 and 10.17

Caution: *Allow the engine to cool completely before following this procedure. The head may warp if it is removed when warm.*

Removal

1 Disconnect the negative cable from the battery.

2 Drain about half of the coolant from the radiator (see Chapter 1). Remove the upper radiator hose.

3 Remove the valve cover (Section 4).

4 Detach any interfering electrical or vacuum lines. Make sure to label them as you remove them.

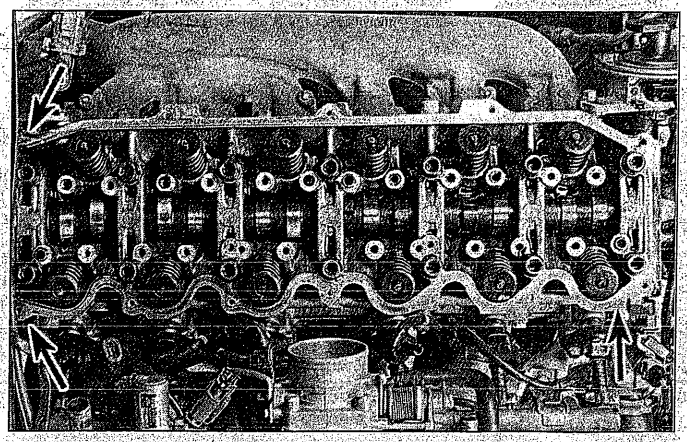
5 Remove the timing belt (Section 9).

6 Remove the inlet manifold (Section 7).

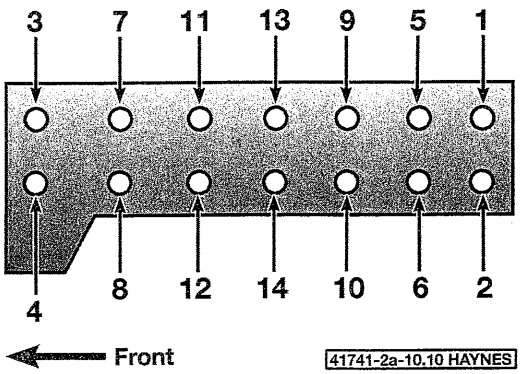
Note: *The inlet manifold can be left attached to the cylinder head if you have a hoist or an assistant to aid you in lifting the assembly from the vehicle. If you elect to leave it attached, disconnect all the interfering hoses, cables and wires* (see Section 7).

7 Raise the front of the vehicle and support it securely on jackstands. Disconnect the exhaust pipe from the exhaust manifold.

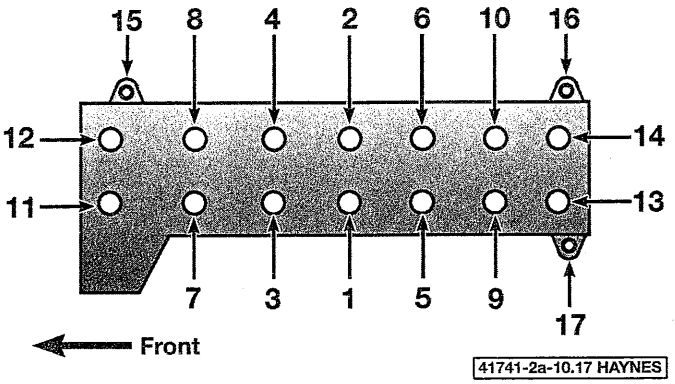
9 Remove the three cylinder head corner bolts **(see illustration)**. **Note:** *The two rear bolts are longer than the front one.*



10.9 There are three small outer cylinder head bolts (arrows)



10.10 Use this sequence for removing the head bolts



10.17 Use this sequence when you tighten the head bolts

10 Remove the cylinder head bolts in the correct order **(see illustration)**. A 10 mm Allen head socket will be required. Lift the head off the engine. **Warning:** *The cylinder head is heavy - to prevent injury, it's a good idea to have an assistant help you lift it off.*

11 Thoroughly clean the gasket mating surfaces, removing all traces of old gasket material. Stuff shop towels into each cylinder so scraped material doesn't fall in.

12 Inspect the head for cracks and warpage (see Chapter 2D). Also see Chapter 2D for cylinder head servicing information. If you are renewing the cylinder head, be sure to transfer all fittings, etc. to the new head.

Refitting

13 Position the new head gasket on the engine block, making sure it is fitted correctly.

14 Refit the cylinder head on the engine block.

15 Clean the head bolts with a wire wheel and apply a little engine oil to their threads before refitting. **Note:** *The chamfered side of the head bolt washers goes away from the engine.*

16 Refit the three corner bolts finger tight.

17 Tighten the main cylinder head bolts in sequence to the torque values listed in this Chapter's Specifications **(see illustration)**. The bolts must be tightened in five steps. **Note:** *A torque angle meter type torque spanner is the preferred tool for the final tightening procedure, However, the bolts can be tightened using a standard torque spanner if that is all that is available to you.*

18 Torque the three corner bolts to the value listed in the Specifications Section.

19 Refit the remaining components in the reverse order of removal. Refer to the appropriate Sections for the refitting of the various assemblies.

20 Add coolant and run the engine, checking for proper operation as well as coolant and oil leaks.

11 Crankshaft pulley - removal and refitting

Refer to illustration 11.5

1 Disconnect the negative battery cable from the battery.

2 Drain the cooling system (see Chapter 1). Remove the radiator (see Chapter 3).

3 Remove the centre crankshaft pulley bolt. This can usually be removed with a pneumatic impact spanner. If an impact spanner is not available the drivebelts should be able to hold the pulley from turning as you use a large ratchet. If they will not hold it, remove the starter and have an assistant lock the flywheel with a screwdriver while you loosen the pulley bolt.

4 Remove the drivebelts (see Chapter 1).

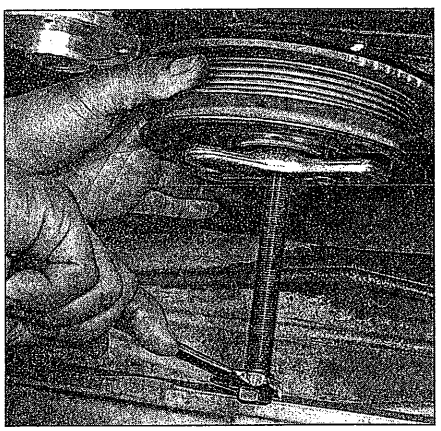
5 Remove the pulley using a puller that bolts to the pulley hub - NOT a jaw-type puller **(see illustration)**.

6 Inspect the surface of the damper that contacts the front seal. There may be a groove worn in this surface. If so, the damper can be renewed or a sleeve can be fitted over the damper hub. **Note:** *These sleeves are available at auto parts stores. If a worn damper is refitted with a new seal, the seal will probably leak.*

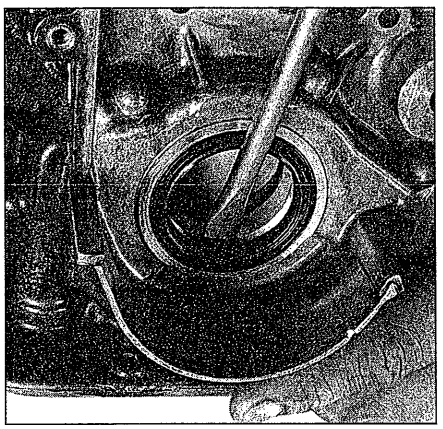
7 Apply a thin layer of multi-purpose grease to the seal contact surface of the vibration damper.

8 Slide the vibration damper onto the crankshaft. Note that the slot in the hub must be aligned with the Woodruff key in the end of the crankshaft. Once the key is aligned with the slot, tap the damper onto the crankshaft with a soft-face hammer. The retaining bolt can be used to press the damper into position, although a damper refitting tool is preferred.

9 Refitting is the reverse of removal. Tighten the bolt to the torque listed in this Chapter's Specifications after refitting the drivebelts.



11.5 To remove the crankshaft pulley, use a puller that bolts to the hub



12.2 Prise the old seal out with a screwdriver or a seal puller. The cover is removed here for clarity

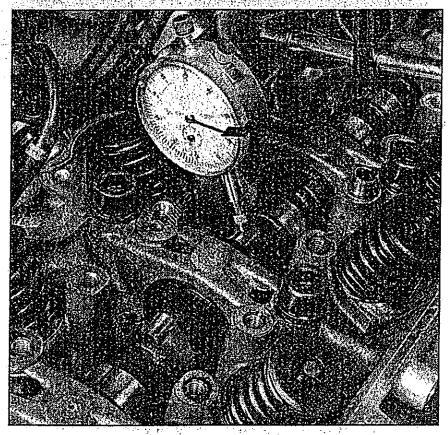
12 Crankshaft front oil seal - renewal

Refer to illustration 12.2

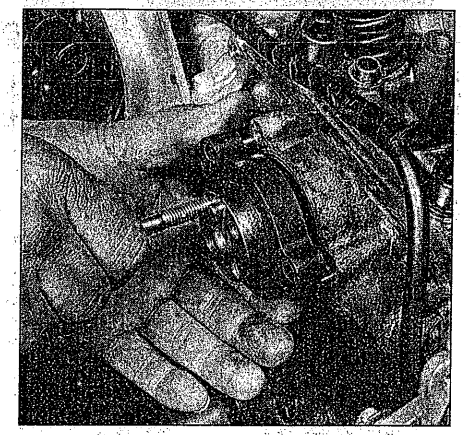
1 Remove the crankshaft pulley (see Section 11). Remove the timing belt (see Section 9) and the crankshaft sprocket. A puller may be required to remove the sprocket from the crankshaft.

2 Carefully prise the oil seal out of the front cover with a seal removal tool or screwdriver **(see illustration)**. Don't scratch the cover bore or damage the crankshaft in the process (if the crankshaft is damaged the new seal will end up leaking).

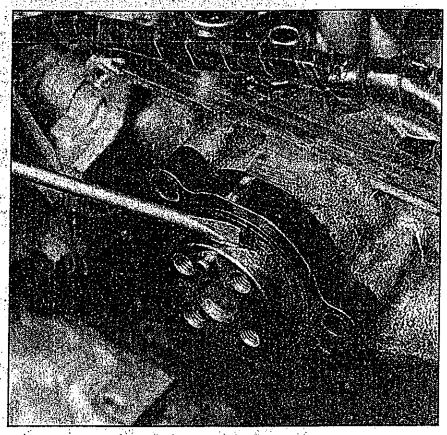
3 Clean the bore in the cover and coat the outer edge of the new seal with sealer. Using a socket with an outside diameter slightly



13.6 Mount a dial indicator firmly to the cylinder head to measure cam lift



13.17 Temporarily screw a long bolt into the camshaft to provide a better grip when sliding it out



13.19 The seal can be removed without removing the camshaft. Be careful to not damage the seal surface of the camshaft

smaller than the outside diameter of the seal, carefully drive the new seal into place with a hammer. If a socket isn't available, a short section of large diameter pipe will work. Check the seal after refitting to be sure that the internal spring didn't pop out of place.

4 Refit the crankshaft sprocket, timing belt (see Section 9) and crankshaft pulley.

5 Run the engine and check for leaks.

13 Camshaft - removal, inspection and refitting

Pre-removal inspection

Refer to illustration 13.6

1 If you are unsure about the condition of the camshaft lobes, perform Steps 2 through 8.

2 Remove the valve cover (see Section 4).

3 Have an assistant operate the starter (ignition system disabled) while you observe the operation of the rocker arms.

4 If any rocker arm has substantially less movement than the others, the camshaft must be renewed.

5 If you are still not certain, remove the rocker arm assemblies and the lifters (Section 5).

6 Position a dial indicator as shown on each camshaft lobe, one at a time **(see illustration)**.

7 Using a spanner on the crankshaft bolt, slowly rotate the engine and note the minimum and maximum readings for each lobe. The difference between these two readings is the lift. If any lobe has a lift substantially less than the others, the camshaft must be renewed.

8 See the Specifications in this Chapter for the allowable wear limit.

Removal

Refer to illustrations 13.17 and 13.19

9 Remove the lifters (Section 5).

10 Remove the timing belt (Section 9).

11 Remove the distributor (Chapter 5).

12 Insert a screwdriver into a slot in the camshaft sprocket to hold it from turning. Remove the four sprocket bolts and remove the sprocket.

13 Remove the three camshaft retainer bolts.

14 Unbolt the fan shroud so it can be positioned out of the way.

15 Remove the radiator (Chapter 3).

16 It may be necessary to remove the front engine mount through-bolts and use a floor jack to raise the engine enough so the camshaft will clear the radiator core support. Use a block of wood on the head of the jack and be careful to not crush any upper engine components while jacking.

17 Temporarily refit a long bolt into one of the four camshaft front holes to use as a handle **(see illustration)**. Carefully slide the camshaft out of the cylinder head. It is easy to damage the camshaft bearings while doing this, so proceed slowly.

18 Remove the retainer O-ring from the rear of the retainer.

19 Drive the oil seal out of the retainer. Be very careful to avoid scratching the seal surface of the camshaft if it is to be refitted. The retainer can then be removed by sliding it across and then forward. The camshaft seal can also be removed without removing the camshaft **(see illustration)**.

Inspection

Refer to illustrations 13.20 and 13.27

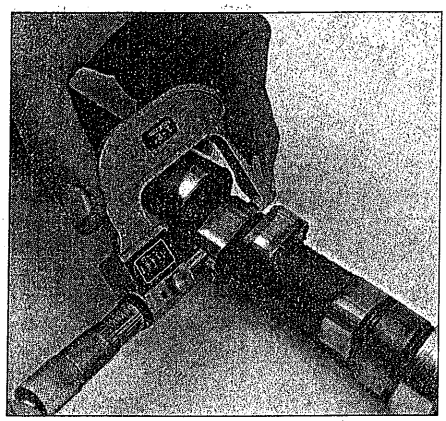
20 If you are in doubt about wear to the camshaft lobes, use a micrometer to measure each lobe **(see illustration)**. Compare the readings to the Specifications in this Chapter.

21 If any of the readings are less than those specified, that lobe is bad and the camshaft must be renewed. If all the readings are almost identical, the camshaft is good. **Note:** *If the camshaft is to be renewed, you MUST Fit new lifters. Also, it is highly recommended that a new camshaft be fitted if the lifters are to be renewed.*

22 If you suspect that the camshaft is bent, build a pair of simple V-blocks out of wood.

23 Support each end of the camshaft in the blocks on the bearing journals.

24 Position a dial indicator with the tip on a centre journal.



13.20 Measure the height of each cam lobe - if any lobe height is less than the specified minimum, renew the camshaft

25 Slowly rotate the camshaft and see if the needle moves more than the allowable limit shown in the Specifications in this Chapter.

26 To check the end play, refit the camshaft in the cylinder head and bolt the front retainer on.

27 Position a dial indicator on the camshaft **(see illustration)**.

28 Prise the camshaft forward and rearward. Compare the endplay with the value listed in this Chapter's Specifications. If the endplay is greater than the specified allowable maximum, then either the retainer or the camshaft is worn and must be renewed.

Refitting

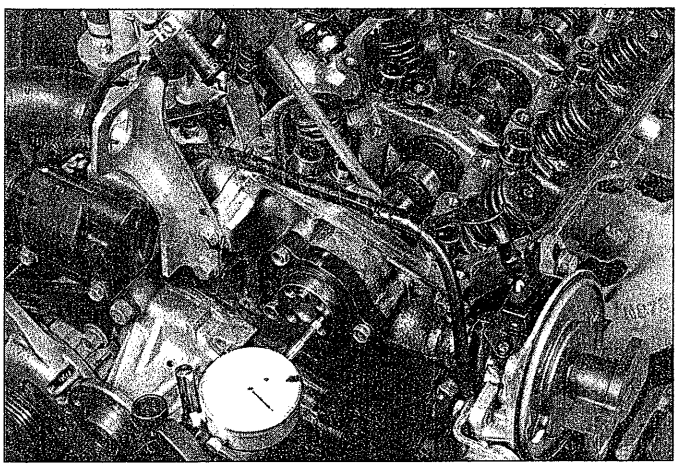
Refer to illustration 13.29

29 Lubricate the camshaft bearing journals and the lobes liberally with camshaft refitting lubricant **(see illustration)**.

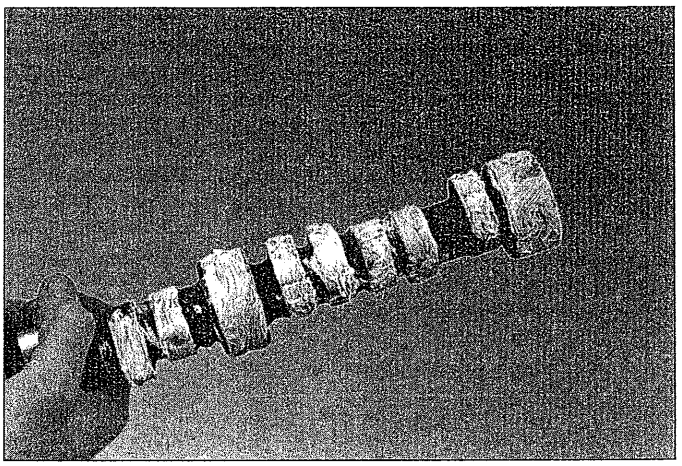
30 Very carefully slide the camshaft into place using the long bolt as before.

31 Refit the O-ring on the camshaft.

32 Refit the retainer without the seal. Make sure that the washers are refitted with the chamfered part of the hole towards the head of the bolt. Torque the bolts using the Speci-



13.27 This is the correct setup for checking camshaft endplay



13.29 Lubricate the camshaft thoroughly with camshaft lube

fications in this Chapter.
33 Apply engine oil to the lip of a new seal. Drive the seal into the retainer using a large socket and a hammer.
34 The rest of the refitting is the reverse of removal.

14 Sump - removal and refitting

Refer to illustration 14.12

Removal

1 Disconnect the negative cable from the battery.
2 Raise the vehicle and support it securely on jackstands.
3 Drain the oil (see Chapter 1).
4 Remove the sump shield if the vehicle is equipped with one.
5 Remove the transmission-to-engine reinforcing brackets that interfere.
6 Remove the sump bolts and lower the sump. Loosen the bolts in the reverse of the tightening sequence **(see illustration 14.12)**. Avoid levering on the sump flange. This will bend it. Strike the sump sideways with a soft-faced hammer if necessary to remove it. In extreme cases, the silicone seal will have to be cut with a blade.
7 Remove the sump from the vehicle.

Refitting

8 Scrape and clean all components thoroughly. Sealing surfaces must be cleaned with lacquer thinner, acetone or brake cleaner.
9 Check the flange of the sump and straighten it if necessary using a hammer and flat anvil.
10 Apply a 4 mm bead of RTV sealant around the pan inboard of the bolt holes. Fit a new O-ring on the oil pump pick-up flange.
11 The remainder of the operation is the reverse of removal.
12 Tighten the bolts to the correct torque listed in this Chapter's Specifications. Use the sequence shown **(see illustration)**.

15 Oil pump - removal, inspection and refitting

Refer to illustrations 15.3, 15.12a, 15.12b, 15.12d and 15.13

Removal

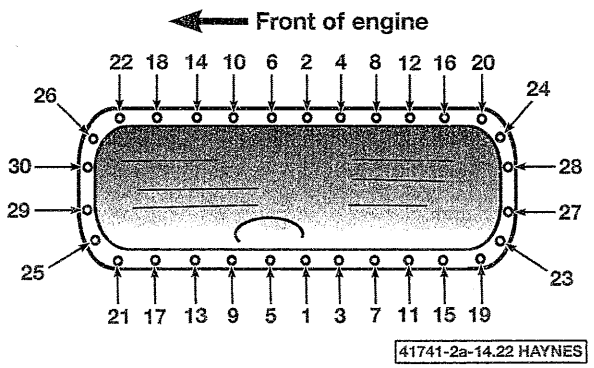
1 Remove the timing belt (see Section 9).
2 Remove the crankshaft sprocket and the guide plate from the crankshaft.
3 Remove the Woodruff key from the crankshaft snout **(see illustration)**. Set it aside in a safe place.
4 The oil pump cannot be removed from the engine without first lowering the sump approximately 25 mm at the front because of interference between the inner pressure relief assembly and the sump. If the sump needs to be removed for any other reason, do so now (see Section 14). If not, proceed with the next step.
5 Remove the bolts from the front two-thirds of the sump.
6 Prise the front lip of the sump down using two screwdrivers as wedges. The oil pump can now be removed.
7 To refit the sump (after refitting the oil pump), first clean the sealing surfaces extremely well with lacquer thinner or acetone. Apply a 4 mm bead of RTV silicone into the small opening along the sump rail.
8 Refit the sump bolts and tighten them to the torque listed in this Chapter's Specifications.
9 Remove the seven oil pump rear cover screws and take off the cover.
10 Remove the inner and outer gears. Note exactly how they were assembled. **Note:** *The grooved side of the inner gear goes towards the rear of the assembly. The larger chamfer on the outside of the outer gear goes towards the rear of the assembly.*

Inspection

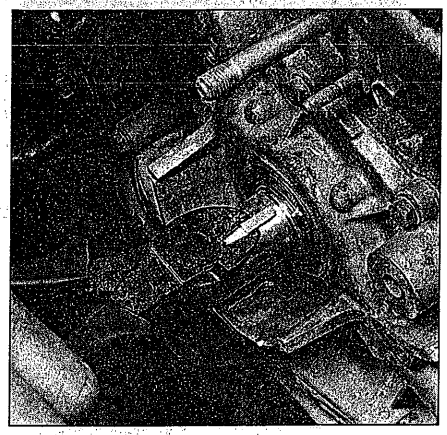
11 Visually check the body, the cover and the gears for damage and obvious wear.
12 There are five internal measurements of the oil pump components which can be made at this time **(see illustrations)**. Consult the Specifications at the beginning of this Chapter.
13 Disassemble the pressure relief assembly and check for damage **(see illustration)**.

Refitting

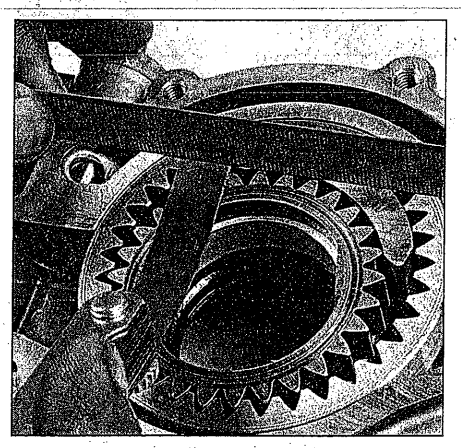
14 Fit a new seal into the pump housing. Apply sealant to the outer edge of the seal and oil to the inner lip. The front of the seal should be flush with the pump housing when it is fitted correctly.
15 Renew the necessary gaskets. Make sure that all sealing surfaces are perfectly clean.
16 Refitting is the reverse of removal.



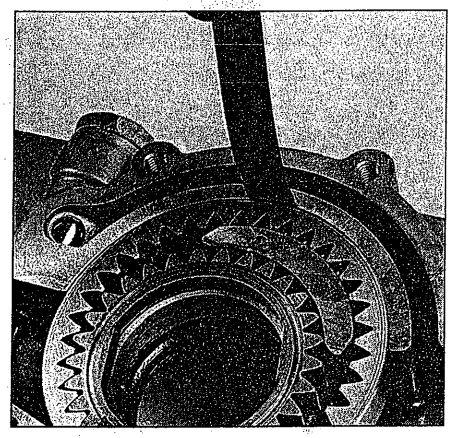
14.12 The sump should have its bolts tightened in this sequence



15.3 Use care when handling the Woodruff key. It can get lost very easily



15.12a Measure the housing to inner gear clearance like this. The housing to outer gear clearance is checked in a similar manner



15.12b Checking the housing-to-outer gear radial clearance

16 Flywheel/driveplate - removal and refitting

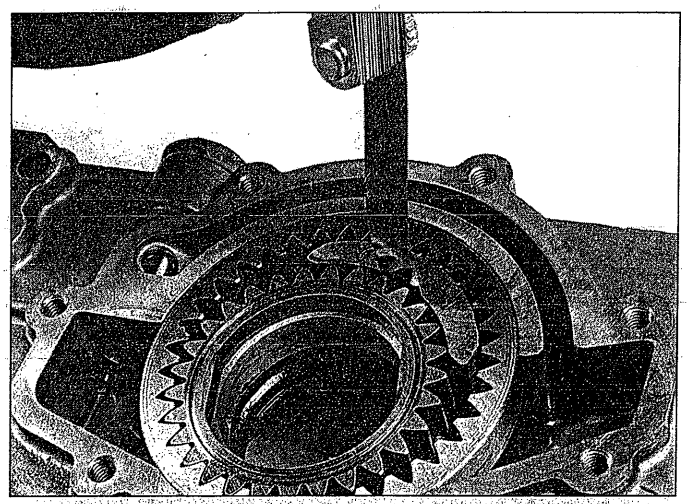
1 Remove the transmission (see Chapter 7A or 7B).
2 Remove the clutch (manual transmission models) (see Chapter 8).
3 Hold the flywheel/driveplate with a flywheel turning tool or a large screwdriver wedged into the ring gear teeth. Remove the bolts and then remove the flywheel/driveplate. **Warning:** *Manual transmission flywheels are heavy. Be very careful or better yet, get some assistance for this operation.*
4 Examine the teeth for damage. Check the surface of the manual transmission flywheel for wear and have it machined or renew it, if necessary. **Note:** *If the manual transmission flywheel ring needs to be renewed, take the flywheel to an automotive machine shop.*
5 Refitting is the reverse of removal. Tighten the bolts to the torque listed in this Chapter. **Note:** *The automatic transmission driveplate uses a reinforcing plate. It must be refitted so that the chamfer faces the engine.*

17 Rear main oil seal - renewal

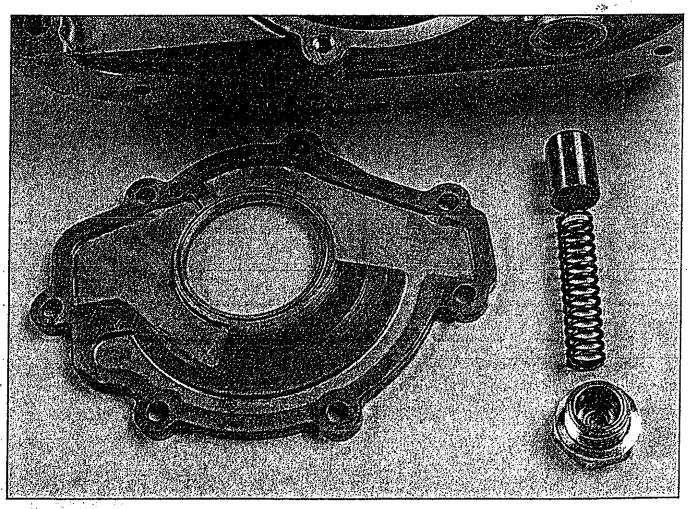
Note: *Before renewing the rear oil seal, it may be worthwhile to try adding engine oil stop-leak fluid to the oil. This will swell the existing seal and may stop a leak.*
1 Remove the flywheel or driveplate (Section 16).
2 Prise out the old seal using a screwdriver.
3 Lubricate the inside of the new seal with grease to help it slip over the crankshaft.
4 Coat the outside edge of the seal with sealant and refit it, tapping it into place with a hammer. **Note:** *The inner oil seal must face the front of the engine and the outer dust seal must be towards the rear.* Check that the small spring in the seal is still in place. Seat it fully using a blunt punch.
5 The remainder of the procedure is the reverse of removal.

18 Engine mounts - check and renewal

Refer to Chapter 2, Part A, for the engine mount check and renewal procedure.



15.12d Measure the inner gear-to-crescent clearance like this. The outer gear-to-crescent clearance is checked in a similar manner



15.13 The pressure relief assembly laid out for inspection

Chapter 2 Part C
4.2 litre diesel engine

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2C

Specifications

General

Displacement	4,169 cc
Cylinder numbers (front to rear)	1-2-3-4-5-6
Firing order	1-4-2-6-3-5

Camshaft

Endplay	
Standard	0.08 to 0.28 mm
Limit	0.50 mm
Camshaft journal-to bearing (oil) clearance	
Standard	0.020 to 0.109 mm
Limit	0.15 mm
Camshaft journal diameter	
Front	50.721 to 50.740 mm
Number 2	50.521 to 50.540 mm
Number 3	50.321 to 50.340 mm
Number 4	50.121 to 50.140 mm
Rear	49.921 to 49.940 mm
Camshaft runout limit	0.06 mm
Cam (lobe) height	
Inlet	
Standard	41.71 to 41.75 mm
Limit	41.20 mm
Exhaust	
Standard	41.88 to 41.92 mm
Limit	41.30 mm

Timing gears

Backlash	
Standard	0.06 to 0.12 mm
Maximum	0.20 mm
Idler gear to thrust plate clearance	
Standard	0.14 to 0.30 mm
Maximum	0.30 mm

Oil pump

Oil pressure	
At idle	78 kPa minimum
At 3,000 rpm	294 to 392 kPa
Gear side clearance	0.13 mm maximum
Gear backlash	0.30 mm maximum
Pump bush clearance	0.15 mm maximum
Pump bushing inside diameter	13.012 to 13.098 mm
Driveshaft outside diameter	12.974 to 12.992 mm

Torque specifications

	Nm (unless otherwise noted)
Camshaft gear bolt	78 to 88
Camshaft thrust plate bolts	4 to 6
Crankshaft pulley nut	294 to 324
Cylinder head bolts	
Step 1	49 to 59
Step 2	98 to 108
Exhaust head pipe nuts	43 to 50
Exhaust manifold fasteners	25 to 29
Flywheel bolts	147 to 167
Fuel injection pump drive gear bolt	43 to 51
Front cover fasteners	16 to 21
Inlet manifold fasteners	15 to 20
Oil cooler fasteners	16 to 21
Oil pump bolts	13 to 19
Oil pump relief valve bolts	16 to 21
Oil pump relief plug	29 to 49
Rear seal retainer bolts	16 to 21
Rocker arm lock nuts	15 to 20
Rocker shaft bolts	14 to 18
Sump bolts	7 to 9
Timing idler gear bolts	19 to 26
Valve cover bolts	1 to 2

1 General information

This Part of Chapter 2 is dedicated to in-vehicle repair procedures for the 4.2 litre diesel inline six-cylinder engine. All information regarding engine removal and refitting and engine block and cylinder head overhaul can be found in Part D of this Chapter.

The following repair procedures are based on the assumption that the engine is in the vehicle. If the engine has been removed and mounted on an engine stand, many of the Steps outlined in this Part of Chapter 2 will not apply.

The Specifications included in this Part of Chapter 2 apply only to the procedures contained in this Part. Part D of Chapter 2 contains the Specifications necessary for cylinder head and engine block rebuilding.

2 Repair operations possible with the engine in the vehicle

Many major repair operations can be accomplished without removing the engine from the vehicle.

Clean the engine compartment and the exterior of the vehicle with some type of pressure washer before any work is done. It will make the job easier and will help keep dirt out of the internal areas of the engine.

Remove the bonnet, if necessary, to improve access to the engine as repairs are performed (refer to Chapter 11 if necessary).

If exhaust, oil or coolant leaks develop, indicating a need for gasket or seal renewal, the repairs can generally be made with the engine in the vehicle. The inlet and exhaust manifold gaskets, sump gasket, crankshaft oil seals and cylinder head gasket are all accessible with the engine in place.

Other exterior components such as the oil pump, water pump, injection pump, starter and alternator can be removed for repair with the engine in place.

Since the cylinder head can be removed without pulling the engine, valve component servicing can also be accomplished with the engine in the vehicle. Renewal of the camshaft and the timing gears is also possible with the engine in the vehicle.

In extreme cases caused by a lack of necessary equipment, repair or renewal of piston rings, pistons, connecting rods and rod bearings can be performed with the engine in the vehicle. However, this practice is not recommended because of the cleaning and preparation work which must be done to the components involved.

3 Top Dead Centre (TDC) for number one piston - locating

Refer to illustration 3.7

1 Top Dead Centre (TDC) is the highest point in the cylinder that each piston reaches as it travels up and down as the crankshaft turns. Each piston reaches TDC on the compression stroke and again on the exhaust stroke, but TDC generally refers to piston position on the compression stroke only, when neither valve is open.

2 Positioning the pistons at TDC is an essential part of many procedures such as rocker arm removal and camshaft/timing gear removal.

3 Before beginning this procedure, be sure to place the transmission in Neutral and apply the parking brake or block the rear wheels. Also, remove the fuel injectors (refer to Chapter 4C).

4 In order to bring any piston to TDC, the crankshaft must be turned using one of the methods outlined below. When looking at the front of the engine, normal crankshaft rotation is clockwise.

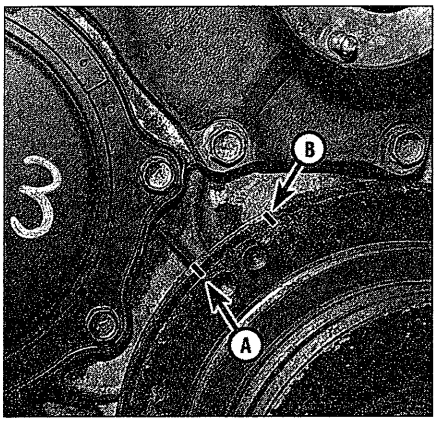
a) *The preferred method is to turn the crankshaft with a socket and ratchet attached to the nut on the front of the crankshaft.*

b) *A remote starter switch, which may save some time, can also be used. Follow the instructions included with the switch. Once the piston is close to TDC, use a socket and ratchet as described in the previous paragraph.*

c) *If an assistant is available to turn the ignition switch to the Start position in short bursts, you can get the piston close to TDC without a remote starter switch. Make sure your assistant is out of the vehicle, away from the ignition switch, then use a socket and ratchet (as described in Paragraph a) to complete the procedure.*

5 Slowly rotate the engine by hand as the timing marks on the crankshaft pulley come closer to the mark on the front cover. Place a finger over the fuel injector hole in the cylinder head and continue to slowly rotate the engine.

6 If engine compression forces your finger from the hole as the marks come into alignment, number one cylinder is on the compression stroke. If not, continue to rotate the engine an additional revolution until it does so.



3.7 Align the mark on the crankpulley (A) with the mark on the front cover (B)

7 Align the left pulley timing mark with the mark on the engine front cover **(see illustration)**.

8 After the number one piston has been positioned at TDC on the compression stroke, TDC for any of the remaining pistons can be located by turning the crankshaft clockwise (a third of a complete revolution at a time) and following the firing order. At every third of a revolution, the next cylinder in the firing order will arrive at TDC.

4 Valve cover - removal and refitting

Refer to illustration 4.8

1 Disconnect the negative battery cable. Position it so that it cannot contact the positive cable.

2 Remove the air cleaner components. Place a rag in the open engine air inlet to avoid dropping small parts inside.

3 Label and then disconnect any hoses which interfere with valve cover removal

4 Loosen the valve cover bolts a quarter turn at a time starting with the outer bolts and working towards the centre **(refer to Chapter 2A, illustration 4.7)**.

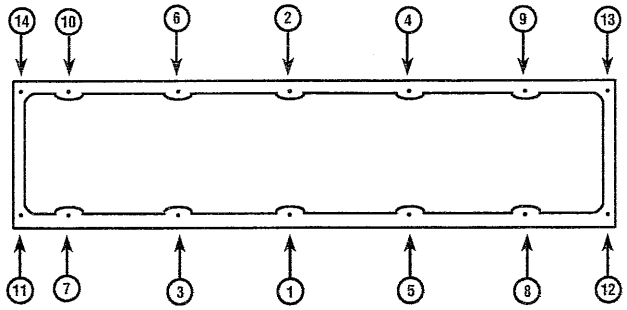
5 Remove the valve cover. If it is stuck, dislodge it by striking it from the side with a rubber mallet or a steel hammer with a block of wood.

6 Clean the sealing surfaces with a scraper and lacquer thinner or acetone. Remove all oil traces.

7 Coat both the cylinder head surface and the valve cover with a thin film of RTV sealer and then fit a new gasket.

8 Refit the valve cover and hand tighten the screws. Tighten the screws to the torque listed in this Chapter's Specifications in two steps. Start with the centre screws and work towards the outer ones **(see illustration)**.

9 The rest of the refitting is the reverse of removal. Check closely for oil leaks before placing the vehicle in service.



4.8 Valve cover bolt tightening sequence

5 Rocker arm assemblies and lifters - removal inspection and refitting

Refer to illustration 5.1

Refer to Chapter 2A, Section 5 for information on this procedure. **Caution:** *If it difficult to remove the rocker shaft supports from the shaft, soak the assembly in heated oil for five minutes. Do not strike the support with a hammer.* **Note:** *There is a small punch mark on the front of the rocker shaft which must face forward* **(see illustration)**.

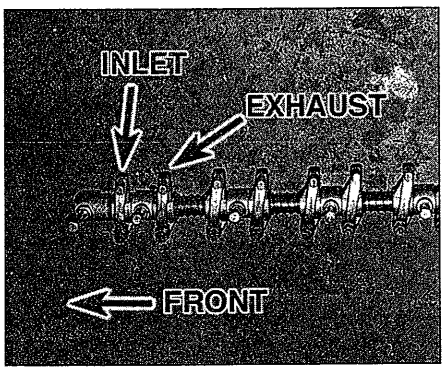
6 Valve springs, retainers and seals - renewal

Refer to Chapter 2A, Section 6 for information on this procedure. **Note:** *Use an adapter fitted to the fuel injector holes (rather than the spark plug holes) if you use compressed air to hold the valves in position.*

7 Inlet manifold - removal and refitting

1 Disconnect the negative battery cable. Position it so that it cannot contact the positive cable.

2 Remove the air cleaner assembly (refer to Chapter 4C).



5.1 Make sure the punch mark on the front of the rocker shaft is facing forward

3 Disconnect the wiring and brackets from the manifold. Remove the restriction switch from the adapter.
4 Make notes of the locations of the various brackets used. Disconnect any interfering hose or injection tube brackets.
5 Loosen the mounting bolts a quarter turn at a time working from the outer ends towards the centre. Remove the manifold from the cylinder head.
6 Clean the sealing surfaces thoroughly and check the manifold for warpage using a precision straightedge. If it is warped, a machine shop may be able to resurface it.
7 Refitting is the reverse of removal. Use a new gasket and tighten the fasteners to the torque listed in this Chapter's Specifications. Tighten them in several stages, working in the reverse of the pattern used for removal.

8 Exhaust manifold - removal and refitting

Refer to Chapter 2A, Section 8 for information on this procedure.

9 Cylinder head - removal and refitting

1 Disconnect the negative battery cable. Position it so that it cannot contact the positive cable.
2 Drain the cooling system (refer to Chapter 1). Remove the inlet and exhaust manifolds (refer to Section 7 and Section 8).
3 Remove the valve cover (refer to Section 4). Remove the rocker shaft assembly and the pushrods (refer to Section 5).
4 Position number one cylinder at TDC on the compression stroke (refer to Section 3).
5 Remove the alternator adjusting bolt.
6 Disconnect the coolant hose from the thermostat.
7 Remove the fuel injector tubes (refer to Chapter 4C). Make note of the positions of the clamps as you do so.
8 Remove the seal nuts from the fuel injectors (refer to Chapter 4C). Remove the injector fuel return tube.
9 Remove the fuel injectors (refer to Chapter 4).
10 Remove the thermostat cover from the housing.
11 Loosen the cylinder head bolts in three steps, working in the correct sequence (refer to Chapter 2A, illustration 9.8). Remove the bolts and lift the head from the vehicle.
12 Stuff clean towels into the cylinders. Thoroughly clean the gasket surfaces. Run an appropriate sized tap into the bolt holes in the cylinder head and run a die over the bolt threads (refer to Chapter 2A). Ensure that all bolt holes are clean and dry.
13 Inspect the cylinder head for cracks and check it for warpage. Refer to Chapter 2 Part D for cylinder head servicing procedures.
14 Fit a new cylinder head gasket dry (no sealer). **Caution:** *A grading (thickness) number is stamped on the corners of head gaskets. The number on the new gasket should match that on the old one. If the block has been machined or if pistons or liners have been renewed, piston protrusion must be measured and the appropriate head gasket selected. Refer to Chapter 2D for more information.*
15 Carefully set the cylinder head onto the block. Place washers (if used) on the head bolts with the chamfers facing towards the bolt heads. Lightly oil the threads and the bolt head bases.
16 Refit the bolts and tighten them in the steps and to the torques listed in this Chapter's Specifications. Work in the reverse of the sequence used in Step 11.
17 Refit the remaining components in the reverse order of removal.
18 Change the engine oil and filter (refer to Chapter 1).
19 Refill the cooling system and run the engine, checking for leaks and proper operation.

10 Lifters - removal, inspection and refitting

Refer to Chapter 2A, Section 10 for information on this procedure.

11 Crankshaft pulley/vibration damper - removal and refitting

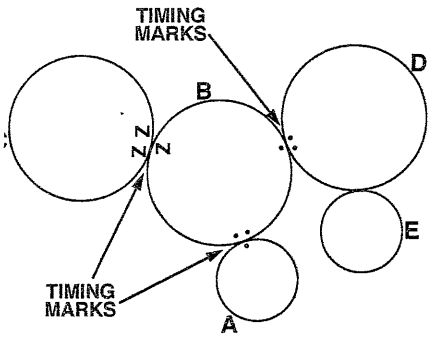
1 Disconnect the negative battery cable. Position it so that it cannot contact the positive cable.
2 Raise the vehicle and support it securely on jackstands.
3 If the vehicle is equipped with a fan shroud, remove its mounting bolts and position it out of the way.
4 Remove the nut from the crankshaft pulley. This nut is very tight. If possible, use a pneumatic impact spanner. If one is not available, a long breaker bar will have to be used. In this case, it will probably be necessary to remove the torque converter access cover (automatic transmission) or the starter (manual transmission) to wedge the flywheel with a large screwdriver to prevent it from turning.
5 Remove the drivebelts (refer to Chapter 1). Label each belt as it is removed to simplify refitting. Remove any other components required for clearance.
6 Thread the nut on the crankshaft by hand. Tap it lightly with a hammer to loosen the cone from the pulley. Remove the nut and the cone.
7 Remove the pulley.
8 Refer to Section 12 for the front oil seal renewal procedure if it appears to be leaking. Inspect the surface of the pulley that contacts the seal. There may be a groove worn on this surface. If so, the pulley can be repaired by fitting a sleeve over its hub. **Note:** *These sleeves are available at auto parts stores. If a worn pulley is refitted with a new seal, the seal will probably leak.*
9 Apply a thin coating of multi-purpose grease to the seal contact surface of the pulley before refitting.
10 Refitting is the reverse of removal. Have an assistant prevent the flywheel from turning with a large screwdriver (refer to Step 4) and tighten the nut to the torque listed in this Chapter's Specifications.

12 Crankshaft front oil seal - renewal

Refer to Chapter 2A, Section 12 for information on this procedure.

13 Timing cover - removal and refitting

1 Disconnect the negative battery cable. Position it so that it cannot contact the positive cable.
2 Raise the vehicle and support it securely on jackstands.
3 Drain the engine oil (refer to Chapter 1).
4 Remove any interfering stoneguards. Remove the support frame.
5 Disconnect the power steering pump from the engine and lay it out of the way. It is not necessary to disconnect the hoses.
6 Refer to Chapter 3 and remove the radiator, water pump, thermostat housing and the hoses.
7 Remove the gear cover from the fuel injection pump.
8 Set the engine at TDC for the number one cylinder. The left mark on the crankshaft pulley will be aligned with the mark on the front cover **(see illustration 3.7)**. Look through the hole in the front cover and check that the marks on the injection pump timing gears are also aligned.
9 Remove the fuel injection pump gear nut. Using a puller if necessary, remove the gear.
10 Remove the crankshaft pulley (refer to Section 11). **Caution:** *Do not rotate the engine after this point. The alignment of the timing gears and the crankshaft pulley must be maintained.*
11 Remove the belt tension pulleys from the front cover.
12 Remove the bolts which secure the sump to the front cover. Slightly loosen the remaining sump bolts to allow it to drop slightly from the cover. **Note:** *The sump only needs to be lowered in front enough to clear the timing cover. It is not necessary to remove it completely from the vehicle.*
13 Remove all the nuts and bolts which secure the front cover to the engine block including the alternator bracket bolt. **Note:** *There are fasteners which are difficult to see. Prise the cover from the engine block only after you are certain that all fasteners have*



14.4 Timing gear alignment diagram

A Crankshaft gear
B Timing idler gear
C Injection pump drive gear
D Camshaft drive gear
E Oil pump gear

been removed. Prise only at one of the six indentations in the cover.

14 Thoroughly clean the cover and all sealing surfaces, removing all traces of gasket material. Drive the old oil seal from the cover and renew it (refer to Section 12).

15 Renew the three O-ring seals. Clean the gasket surfaces with lacquer thinner or acetone, then apply a bead of RTV sealer. Also apply sealer around the seals.

16 The remainder of refitting is the reverse of removal. Tighten all fasteners to the torque listed in this Chapter's Specifications. Check the alignment of the crankshaft pulley marks and the timing gear marks.

14 Timing gears - removal, inspection and refitting

Refer to illustration 14.4

1 Remove the engine timing cover (refer to Section 12). The drive gear for the fuel injection pump will be removed during this procedure. Replace it at this time in order to check its backlash.

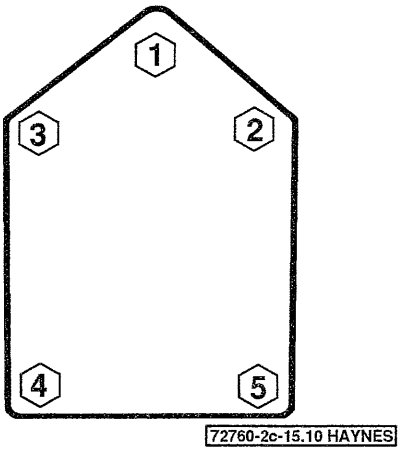
2 Mount a dial indicator to the engine block with the plunger perpendicular to and resting on one of the gear teeth. Rock the gear back and forth and measure the amount of backlash at the gear tooth. Using a feeler gauge, check the clearance between the rear of the idler gear and the thrust plate. Likewise check the clearance between the camshaft drive gear and its thrust plate.

3 Compare the readings to the values listed in this Chapter's Specifications. If they are more than that allowed, check the condition of the thrust plates, gears, the idler gear shaft and its bush. Renew components as required.

4 If any gears have been removed, check the positions of the alignment marks. All of the timing gears (with the exception of the oil pump) must be aligned so that the gear teeth with one dot or Z are meshed with a dot or Z on each side of it from a corresponding gear **(see illustration)**.

5 Before assembling the engine, verify that the oil jet is aimed at the crankshaft gear where it meets the idler gear. Use compressed air to clear the jet orifice if necessary.

6 The assembly sequence is the reverse of disassembly.



15.10 Tighten the bolts on the oil pump housing in this sequence

15 Oil pump - removal, inspection and refitting

Refer to illustration 15.10

1 Remove the front cover (refer to Section 13).

2 Rotate the engine so that all of the timing marks are aligned.

3 Remove the camshaft gear.

4 Remove the oil pump assembly.

5 Visually inspect the drive shaft body and gears for any damage.

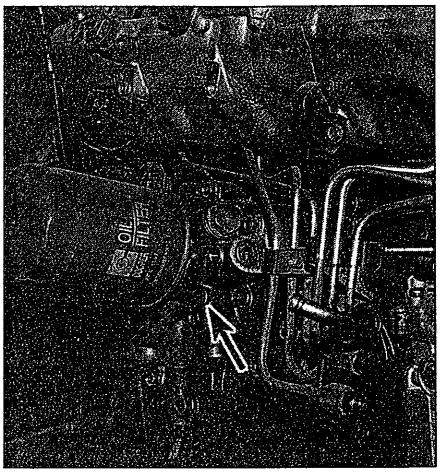
6 Using a feeler gauge, measure the clearance between the oil pump gears and the pump body. If the clearance is more than that listed in this Chapter's Specifications, renew the pump.

7 Check the backlash between the pump gears using a feeler gauge. Renew the pump if the clearance is excessive.

8 If the proper measuring instruments are available, also check the drive shaft outside diameter, the drive shaft bush inside diameter and the clearance between the two. If the clearance is more than that listed in this Chapter's Specifications, renew the components.

9 Renew the O-ring on the pump housing and refit it on the engine block.

10 Tighten the bolts in several gradual steps to the torque listed in this Chapter's Specifications. Turn the drive gear frequently to ensure that the gears are not binding as you proceed. Follow the correct tightening sequence **(see illustration)**.



16.1 Typical oil cooler location (arrow)

11 The remainder of the refitting procedure is the reverse of removal.

16 Oil cooler and oil pump relief valve - removal and refitting

Oil cooler

Removal

Refer to illustrations 16.1 and 16.6

1 The oil cooler is mounted to the right side of the diesel engine **(see illustration)**. It incorporates two oil filters and its own relief valve assembly.

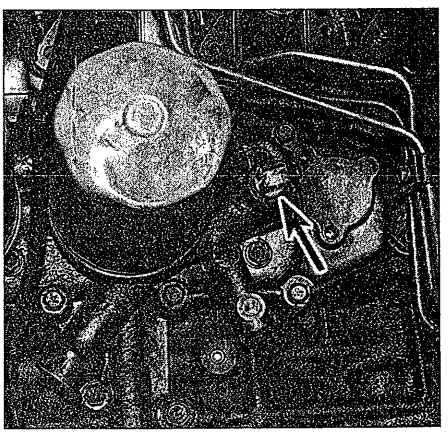
2 Disconnect the negative battery cable. Position it so that it cannot contact the positive cable.

3 Place a drain pan beneath the oil filters, then remove them (refer to Chapter 1).

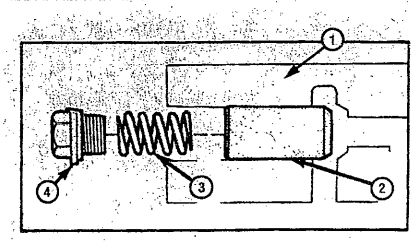
4 Drain the cooling system down to a sufficient level (refer to Chapter 1).

5 Remove the wiring harness clips from the engine. Pull the wiring out of the way and secure it.

6 Disconnect the oil pressure switch wiring and remove the switch **(see illustration)**.



16.6 Typical oil pressure switch location (arrow)



16.15 Typical oil pump pressure relief valve

1 Body
2 Plug and gasket
3 Spring
4 Valve

7 Remove the injector tube lower mounting bracket. It will be necessary to first remove the injector tube clamps.
8 Remove the dipstick tube.
9 Unbolt and remove the oil cooler. The unit can now be disassembled by removing both end plugs. Be certain to lay all parts out in order and clean them thoroughly as you proceed.
10 Use compressed air, if available, to blow out all passages. Check all components for damage and wear.

Refitting

11 Renew all gaskets and O-rings before assembly.
12 Refitting is the reverse of removal.

Oil pump relief valve

Removal

Refer to illustration 16.15

13 The oil pump relief valve is bolted to the left side of the engine near the rear of the block under the exhaust manifold.
14 Remove the three mounting bolts and lift the assembly from the engine.
15 To inspect the internal components, unscrew the plug and remove the gasket, seal and plunger **(see illustration)**.
16 Clean and inspect all components thoroughly. The plunger must slide freely in the bore and the spring must not be deformed. Check the plug washer for damage and renew it if necessary.

Refitting

17 Renew the two O-rings which seal the unit to the engine block. They can be held in place during assembly with petroleum jelly if required.
18 Tighten the fasteners to the torque listed in this Chapter's Specifications.

17 Camshaft and bearings - removal, inspection and refitting

Camshaft lift check

Refer to Chapter 2A, Section 16 for this procedure.

Removal

Note: *Camshaft renewal is much easier with the engine removed from the vehicle. Make certain that there will be adequate clearance at the front of your particular vehicle to slide the camshaft forward far enough for removal before beginning this procedure.*

1 Remove the radiator, grille and air conditioning condenser (refer to the appropriate Chapters for details on these procedures). Verify that there will be sufficient clearance for camshaft removal.
2 Remove the lifters (refer to Section 10).
3 Remove the front cover (refer to Section 13).
4 Remove the gear from the camshaft.
5 Remove the camshaft thrust plate.
6 Refit a long bolt of the correct thread into the front of the camshaft to act as a handle until it is moved far enough forward to be grasped. If a long bolt is not available, refit the drive gear and use it in the same manner.
7 Very carefully slide the camshaft out of the block. Do not damage the camshaft bearings as you maneuver it forward. It may be necessary to remove the front engine plate for clearance in some instances.

Inspection

Refer to Chapter 2A Section 16 for this procedure.

Bearing renewal

8 Camshaft bearing renewal requires special tools and expertise that place it outside the scope of the home mechanic. Take the engine block (refer to Chapter 2D) to an automotive machine shop to ensure that the job is done correctly.

Refitting

Refer to Chapter 2A Section 16 and Steps 1 through 7 in this Section for this procedure.

18 Sump - removal and refitting

Refer to Chapter 2A Section 17 for this procedure.

19 Flywheel/driveplate - removal and refitting

Refer to Chapter 2A Section 18 for this procedure.

20 Rear main oil seal - renewal

Refer to Chapter 2A Section 19 for this procedure.

21 Engine mounts - check and renewal

Refer to Chapter 2A Section 20 for this procedure.

Chapter 2 Part D
General engine overhaul procedures

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Specifications

3.0 litre inline six-cylinder engine

General

Displacement	2,962 cc
Bore and stroke	86 mm x 85 mm
Cylinder compression	
Standard	1,196 kPa
Minimum	883 kPa
Difference limit	98 kPa

Cylinder block

Cylinder bore diameter (standard)	
Grade 1	86.000 to 86.010 mm
Grade 2	86.010 to 86.020 mm
Grade 3	86.020 to 86.030 mm
Grade 4	86.030 to 86.040 mm
Grade 5	86.040 to 86.050 mm
Wear limit	0.20 mm
Taper limit	0.010 mm
Out of round limit	0.015 mm
Deck flatness	
Standard	0.03 mm
Limit	0.10 mm

Pistons and rings

Piston diameter (measured at 47 mm below crown)	
Grade 1	85.975 to 85.985 mm
Grade 2	85.985 to 85.995 mm
Grade 3	85.995 to 86.005 mm
Grade 4	86.005 to 86.015 mm
Grade 5	86.015 to 86.025 mm
Piston to bore clearance	0.015 to 0.035 mm
Ring side clearance	
Top ring	0.040 to 0.073 mm
Second ring	0.030 to 0.063 mm
Ring end gap	
Top ring	0.24 to 0.31 mm
Second ring	0.18 to 0.28 mm

Crankshaft and connecting rods

Main bearing clearance	
Standard	0.020 to 0.047 mm
Limit	0.090 mm
Main journal diameter	
Grade 0	54.967 to 54.975 mm
Grade 1	54.959 to 54.967
Grade 2	54.951 to 54.959 mm
Connecting rod bearing clearance	
Standard	0.011 to 0.035 mm
Limit	0.090 mm
Rod journal diameter	
Grade 0	49.968 to 49.974 mm
Grade 1	49.961 to 49.968 mm
Out of round limit	0.005 mm
Taper limit	0.005 mm
Endplay	
Standard	0.05 to 0.17 mm
Limit	0.30 mm
Connecting rod side clearance	
Standard	0.20 to 0.30 mm
Limit	0.40 mm
Connecting rod bend limit	0.025 mm/100 mm

Cylinder head and valve train

Cylinder head thickness	
Standard	106.3 to 106.7 mm
Limit	106.1 mm
Surface flatness limit	0.2 mm
Valve stem diameter	
Inlet	6.965 to 6.980 mm
Exhaust	7.965 to 7.970 mm
Valve seat angle	45 degrees, 15 minutes to 45 degrees, 45 minutes
Valve margin minimum thickness	0.5 mm
Valve length	
Inlet	125.3 to 125.9 mm
Exhaust	124.2 to 124.8 mm
Valve stem tip grinding limit	0.2 mm
Valve spring free height	
Outer	51.2 mm
Inner	44.1 mm
Load at height	
Outer	524/30.0 kg/mm
Inner	255/25.0 kg/mm
Out of square limit	
Outer	2.2 mm
Inner	1.9 mm
Valve stem to guide clearance	
Inlet	0.020 to 0.053 mm
Exhaust	0.030 to 0.046 mm
Limit	0.1 mm
Valve deflection limit	0.2 mm

4.2 litre inline six-cylinder petrol engine

General

Displacement	4,169 cc
Bore and stroke	96 mm x 96 mm
Cylinder compression	
Standard	1,177 kPa
Minimum	883 kPa
Difference limit	98 kPa

Cylinder block

Cylinder bore diameter (standard)	
Grade 1	96.000 to 96.010 mm
Grade 2	96.010 to 96.020 mm
Grade 3	96.020 to 96.030 mm
Grade 4	96.030 to 96.040 mm
Grade 5	96.040 to 96.050 mm
Wear limit	0.20 mm
Taper limit	0.010 mm
Out of round limit	0.015 mm
Deck flatness	
Standard	0.03 mm
Limit	0.10 mm

Pistons and rings

Piston diameter (measured at 20 mm above bottom of piston)	
Grade 1	95.975 to 95.985 mm
Grade 2	95.985 to 95.995 mm
Grade 3	95.995 to 96.005 mm
Grade 4	96.005 to 96.015 mm
Grade 5	96.015 to 96.025 mm
Piston to bore clearance	0.015 to 0.035 mm
Ring side clearance	
Top ring	0,040 to 0,073 mm
Second ring	0.030 to 0.063 mm
Ring end gap	
Top ring	0.30 to 0.45 mm
Second ring	0.30 to 0.45 mm
Oil ring	0.20 to 0.60 mm

Crankshaft and connecting rods

Main bearing clearance	
Standard	0.041 to 0.087 mm
Limit	0.09 mm
Main journal diameter	70.907 to 70.920 mm
Connecting rod bearing clearance	
Standard	0.027 to 0.061 mm
Limit	0.09 mm
Rod journal diameter	56.913 to 56.926 mm
Main and rod journal out of round limit	0.0025 mm
Main and rod journal taper limit	0.0025 mm
Endplay	
Standard	0.05 to 0.17 mm
Limit	0.30 mm
Connecting rod side clearance	
Standard	0.20 to 0.30 mm
Limit	0.40 mm
Connecting rod bend limit	0.015 mm/100 mm

Cylinder head and valve train

Cylinder head thickness	
Standard	117.19 to 117.59 mm
Limit	116.99 mm
Surface flatness limit	0.2 mm
Valve stem diameter	
Inlet	7,965 to 7.980 mm
Exhaust	7.945 to 7.960 mm
Valve seat angle	45 degrees, 30 minutes
Valve margin minimum thickness	0.5 mm

Cylinder head and valve train

Valve length	
Inlet	116.7n to 117.0 mm
Exhaust	117.0 to 117.3 mm
Valve stem tip grinding limit	0.2 mm
Valve spring free height	
Outer	49.77 mm
Inner	44.10 mm
Load at height	
Outer	512.9/30.0 kg/mm
Inner	255.0/25.0 kg/mm
Assembled height	
Outer	40.0 mm
Inner	35.0 mm
Out of square limit	
Outer	2.2 mm
Inner	1.9 mm
Valve stem to guide clearance	
Inlet	0.020 to 0.053 mm
Exhaust	0.040 to 0.073 mm
Limit	0.1 mm
Valve deflection limit	0.2 mm

4.2 litre inline diesel six-cylinder engine

General

Displacement	4,169 cc
Bore and stroke	96 x 96 mm
Cylinder compression	
Standard	2,942 kPa
Minimum	2,452 kPa
Difference limit	294 kPa

Cylinder block

Cylinder bore (standard)	
Grade 1	96.000 to 96.010 mm
Grade 2	96.010 to 96.020 mm
Grade 3	96.020 to 96.030 mm
Wear limit	0.20 mm
Taper limit	0.020 mm
Out of round limit	0.20 mm
Deck flatness	
Standard	0.05 mm
Limit	0.20 mm
Cylinder liner protrusion	0.020 to 0.090 mm

Pistons and rings

Piston diameter (measured at 70 mm below top of piston)	
Grade 1	95.940 to 95.950 mm
Grade 2	95.950 to 95.960 mm
Piston to bore clearance	0.05 to 0.07 mm
Ring side clearance	
Top ring	0.06 to 0.10 mm
Second ring	0.04 to 0.08 mm
Oil ring	0.02 to 0.06 mm
Ring end gap	
Top ring	0.30 to 0.45 mm
Second ring	0.20 to 0.35 mm
Oil ring	0.30 to 0.50 mm

Crankshaft and connecting rods

Main bearing clearance	
Standard	0.035 to 0.087 mm
Limit	0.15 mm
Main journal diameter	70 907 to 70.920 mm
Connecting rod bearing clearance	
Standard	0.035 to 0.081 mm
Limit	0.15 mm
Rod journal diameter	56.919 to 56.926 mm
Main and rod journal out of round limit	0.02 mm

Main and rod journal taper limit	0.02 mm
Endplay	
Standard	0.055 to 0.14 mm
Limit	0.40 mm
Connecting rod side clearance	
Standard	0.10 to 0.22 mm
Limit	0.22 mm
Connecting rod bend limit	0.05 per 100 mm

Cylinder head and valve train

Surface flatness limit	0.07 mm
Valve stem diameter	
Inlet	7.962 to 7.977 mm
Exhaust	7.945 to 7.960 mm
Valve seat angle	45 to 45 -degrees
Valve margin minimum thickness	1.0 mm
Valve length	
Inlet	117 mm
Valve stem tip grinding limit	0.2 mm
Valve spring free height	
Red	52.15 mm
Yellow	53.0 mm
Load at height	
Red	32.3/672.8 mm/N
Yellow	31.8/697.3 mm/N
Assembled height	42.3 mm
Out of square limit	2.0 mm
Valve stem to guide clearance	
Inlet	0.023 to 0.053 mm
Exhaust	0.04 to 0.07 mm
Valve deflection limit	
Inlet	0.30 mm
Exhaust	0.40 mm

Torque specifications*

Nm (unless otherwise specified)

Main bearing cap bolts	
3.0 litre	46 to 52
4.2 litre petrol	162 to 172
4.2 litre diesel	167 to 177
Connecting rod cap nuts	
3.0 litre	
Step 1	14 to 16
Preferred step 2	tighten an additional 60 to 65-degrees
Alternate step 2	38 to 44
4.2 litre petrol	
Step 1	38 to 40
Preferred step 2	tighten an additional 40 to 45-degrees
Alternate step 2	67 to 71
4.2 litre diesel	78 to 83

***Note:** *Refer to either Part A, Part B or Part C for additional specifications.*

***Using an angle-meter torque wrench.*

1 General information

Included in this portion of Chapter 2 are the general overhaul procedures for cylinder heads and internal engine components. The information ranges from advice concerning preparation for an overhaul and the purchase of new parts to detailed, step-by-step procedures covering removal and refitting of internal engine components and the inspection of parts.

The following Sections have been written based on the assumption that the engine has been removed from the vehicle. For information concerning in-vehicle engine repair, as well as removal and refitting of the external components necessary for the overhaul, see Parts A, B and C of this Chapter and Section 8 of this Part.

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

2 Engine removal - methods and precautions

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

Locating a suitable work area is extremely important. A shop is, of course, the most desirable place to work. Adequate work space, along with storage space for the vehicle, will be needed. If a shop or garage is not 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 organised.

An engine hoist or A-frame will be needed. Make sure that the equipment is rated in excess of the combined weight of the engine and its 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 will need prior to beginning the job. Some of the equipment necessary to perform engine removal and refitting 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 petrol. If the hoist is to be rented, make sure that you arrange for it in advance and perform beforehand all of the operations possible without it. This will save you money and time.

Plan for the vehicle to be out of use for a considerable amount of time. A machine shop will be required to perform some of the work which the do-it-yourselfer cannot accomplish due to a lack of special equipment. These shops often have a busy schedule, so it would be wise 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 use extreme caution when removing and refitting 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.

3 Engine overhaul - general information

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

A high number of kilometres is not necessarily an indication that an overhaul is needed, while a low number of kilometres does not preclude the need for an overhaul. Frequency of servicing is probably the most important consideration. An engine that has had regular and frequent oil and filter changes, as well as other required maintenance, will most likely give many thousands of kilometres 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 and/or valve guides are in need of attention. Make sure that oil leaks are not responsible before deciding that the rings and/or guides are bad. Test the cylinder compression (see Section 4) or have a leakdown test performed by an experienced tune-up mechanic to determine the extent of the work required.

If the engine is making obvious knocking or rumbling noises, the connecting rod and/or main bearings are probably at fault. To accurately test oil pressure, temporarily connect a mechanical oil pressure gauge in place of the oil pressure sending unit. Compare the reading to the pressure listed in this Chapter's Specifications. If the pressure is extremely low, the bearings and/or oil pump are probably worn out.

Loss of power, rough running, excessive valve train noise and high fuel consumption rates may also point to the need for an overhaul, especially if they are all present at the same time. If a complete tune-up does not 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 renewed and the cylinder walls are reconditioned (rebored and/or honed). If a rebore is done, new pistons are required. The main bearings, connecting rod bearings and camshaft bearings are generally renewed and, if necessary, the crankshaft may be reground to restore the journals. Generally, the valves are serviced as well, since they are usually in less-than-perfect condition at this point. While the engine is being overhauled, other components, such as the distributor, starter and alternator, can be rebuilt as well. The end result should be a like-new engine that will give many thousands of trouble-free kilometres. **Note:** *Critical cooling system components such as the hoses, the drivebelts, the thermostat and the water pump MUST be renewed with new parts when an engine is overhauled. Some professional engine rebuilders will not guarantee their rebuilt short-blocks or long-blocks unless the customer has the radiator reconditioned at a radiator shop. The radiator should be professionally cleaned. If in doubt, renew it.*

Before beginning the engine overhaul, read through the entire procedure to familiarise yourself with the scope and requirements of the job. Overhauling an engine is not difficult if you take your time and follow all procedures carefully. But it is time consuming. Plan on the vehicle being tied up for a minimum of two weeks, especially if parts must be taken to an automotive machine shop for repair or reconditioning. Check on availability of parts and make sure that any necessary special tools and equipment are obtained in advance. Most work can be done with typical hand tools, although a number of precision measuring tools are required for inspecting parts to determine if they must be renewed. Often an automotive machine shop will handle the inspection of parts and offer advice concerning reconditioning and renewal. **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 does not pay to refit worn or sub-standard 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.

4 Compression check

Refer to illustration 4.4

1 A compression check will tell you what mechanical condition the pistons, rings,

valves and head gaskets of your engine are 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 for this check and the battery must be fully charged.*

2 On petrol engines, begin by cleaning the area around the spark plugs before you remove them (compressed air works best for this). On diesel engines, the injectors must be removed (refer to Chapter 4C). **Warning:** *Always wear eye protection when using compressed air!* This will prevent dirt from getting into the cylinders as the compression check is being done. Remove all of the spark plugs from the engine.

3 On petrol engines, block the throttle wide open and disconnect the primary wires from the coil. On diesel engines, disconnect the fuel cut solenoid wire at the injection pump. In either case, prevent unnecessary fuel or spark while the engine is being cranked.

4 With the compression gauge threaded in the number one spark plug hole, crank the engine over at least four compression strokes and watch the gauge **(see illustration)**. 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 does not build up during successive strokes, indicates leaking valves or a blown head gasket (a cracked head could also be the cause). Record the highest gauge reading obtained.

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

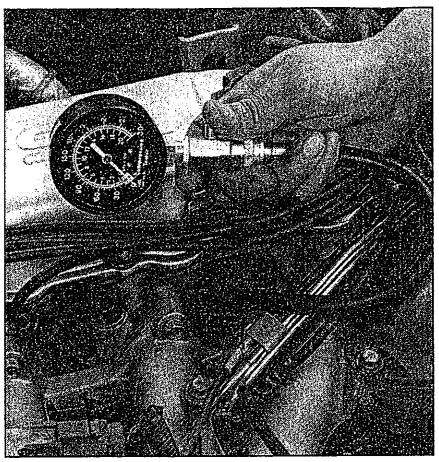
6 Add some engine oil (about three squirts from a plunger-type oil can) to each cylinder, through the spark plug hole, and repeat the test.

7 If the compression increases after the oil is added, the piston rings are definitely worn. If the compression does not 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.

8 If two adjacent cylinders have equally low compression, there is a strong possibility that the head gasket between them is blown. The appearance of coolant in the combustion chambers or the oil would verify this condition. Generally, coolant will cause the oil on the dipstick to look light-coloured (milky).

9 If the compression is unusually high, the combustion chambers are probably coated with carbon deposits. If that is the case, the cylinder heads should be removed and decarbonised.

10 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.



4.4 A compression gauge with a threaded fitting for the spark plug hole is preferred over the type that requires hand pressure to maintain the seal - be sure to open the throttle valve as far as possible during the compression check

5 Vacuum gauge diagnostic checks (petrol engines)

Refer to illustration 5.4

A vacuum gauge provides valuable information about what is going on in the engine at a low cost. You can check for worn rings or cylinder walls, leaking head or inlet manifold gaskets, incorrect carburettor adjustments, restricted exhaust, stuck or burned valves, weak valve springs, improper ignition or valve timing and ignition problems.

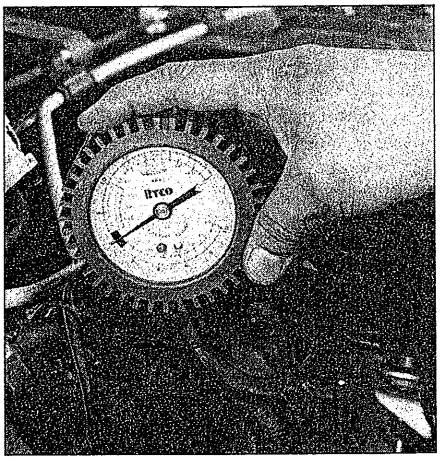
Unfortunately, vacuum gauge readings are easy to misinterpret, so they should be used in conjunction with other tests to confirm the diagnosis.

Both the gauge readings and the rate of needle movement are important for accurate interpretation. Most gauges measure vacuum in inches of mercury (in-Hg). As vacuum increases (or atmospheric pressure decreases), the reading will increase. Also, for every 305-metre) (1,000-foot) increase in elevation above sea level, the gauge readings will decrease about one inch of mercury.

Connect the vacuum gauge directly to inlet manifold vacuum, not to ported (carburettor) vacuum **(see illustration)**. Be sure no hoses are left disconnected during the test or false readings will result.

Before you begin the test, allow the engine to warm up completely. Block the wheels and set the parking brake. With the transmission in Park, start the engine and allow it to run at normal idle speed. **Warning:** *Carefully inspect the fan blades for cracks or damage before starting the engine. Keep your hands and the vacuum tester clear of the fan and do not stand in front of the vehicle or in line with the fan when the engine is running.*

Read the vacuum gauge; an average, healthy engine should normally produce about 60 to 75 kPa of vacuum with a fairly



5.4 A simple vacuum gauge connected to manifold vacuum can tell you a lot about a petrol engine's condition

steady needle. Refer to the following vacuum gauge readings and what they indicate about the engine's condition:

1 A low, steady reading usually indicates a leaking gasket between the inlet manifold and carburettor or throttle body, a leaky vacuum hose, late ignition timing or incorrect camshaft timing. Check ignition timing with a timing light and eliminate all other possible causes, utilising the tests provided in this Chapter before you remove the timing chain cover to check the timing marks.

2 If the reading is 10 to 25 kPa below normal and it fluctuates at that low reading, suspect an inlet manifold gasket leak at an intake port.

3 If the needle has regular drops of about two to four inches at a steady rate, the valves are probably leaking. Perform a compression or leak-down test to confirm this.

4 An irregular drop or down-flick of the needle can be caused by a sticking valve or an ignition misfire. Perform a compression or leak-down test and read the spark plugs.

5 A rapid vibration of about 10 kPa vibration at idle combined with exhaust smoke indicates worn valve guides. Perform a leak-down test to confirm this. If the rapid vibration occurs with an increase in engine speed, check for a leaking inlet manifold gasket or head gasket, weak valve springs, burned valves or ignition misfire.

6 A slight fluctuation, say one inch up and down, may mean ignition problems. Check all the usual tune-up items and, if necessary, run the engine on an ignition analyser.

7 If there is a large fluctuation, perform a compression or leak-down test to look for a weak or dead cylinder or a blown head gasket.

8 If the needle moves slowly through a wide range, check for a clogged PCV system, incorrect idle fuel mixture, carburettor/throttle body or inlet manifold gasket leaks.

9 Check for a slow return after revving the engine by quickly snapping the throttle open until the engine reaches about 2,500 rpm and

let it shut. Normally the reading should drop to near zero, rise above normal idle reading (about 15 kPa over) and then return to the previous idle reading. If the vacuum returns slowly and doesn't peak when the throttle is snapped shut, the rings may be worn. If there is a long delay, look for a restricted exhaust system (often the muffler or catalytic converter). An easy way to check this is to temporarily disconnect the exhaust ahead of the suspected part and re-test.

6 Engine rebuilding alternatives

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

Some of the rebuilding alternatives include:

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

Crankshaft kit - This rebuild package consists of a reground crankshaft and a matched set of pistons and connecting rods. The pistons will already be refitted on the connecting rods. Piston rings and the necessary bearings will be included in the kit. These kits are commonly available for standard-size cylinder bores, as well as for engine blocks which have been bored to a standard oversize. These kits are not assembled.

Short block - A short block consists of an engine block with a camshaft, timing chain and gears, crankshaft and piston/connecting rod assemblies already refitted. All new bearings are incorporated and all clearances will be correct. The existing cylinder head(s), valve train components 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, cylinder head(s) and valve train components. All components are refitted with new bearings, seals and gaskets incorporated throughout. The refitting of manifolds and external parts is all that is necessary.

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

7 Engine - removal and refitting

Refer to illustrations 7.10, 7.21 and 7.22

Warning: *Petrol is extremely flammable, so take extra precautions when disconnecting any part of the fuel system. Don't smoke or allow open flames or bare light bulbs in or near the work area and don't work in a garage where a natural gas appliance (such as a clothes dryer or water heater) is refitted. If you spill petrol on your skin, rinse it off immediately. Have a fire extinguisher rated for petrol fires handy and know how to use it! Also, the air conditioning system is under high pressure - have a dealer service department or service station discharge the system and recapture the refrigerant before disconnecting any of the hoses or fittings.*

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

Removal

1 On air-conditioned models, inspect the compressor mounting to determine if the compressor can be unbolted and moved aside without disconnecting the refrigerant lines (see Chapter 3). If this is not possible, have the system discharged by a dealer or service station (see the **Warning** at the beginning of this Section).

2 Remove the bonnet (see Chapter 11). Relieve the fuel system pressure on fuel injected models (see Chapter 4).

3 Remove the air cleaner or air inlet duct assembly and all hoses connected to it (see Chapter 4).

4 Drain the cooling system and remove the drivebelts (see Chapter 1). **Note:** *Mark all the accessory drivebelts with markers to indicate which components they drive, i.e. alternator, air conditioning compressor, power steering pump, and also number the belts to indicate which order they go onto the pulleys. This will eliminate confusion on reassembly, which might be days or weeks later.*

5 Remove the radiator, shroud and fan (see Chapter 3).

6 Detach the radiator and heater hoses from the engine.

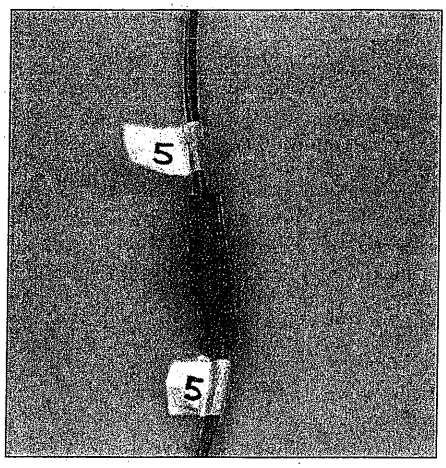
7 Disconnect the accelerator cable (see Chapter 4) and throttle rod (automatic transmission only - see Chapter 7B) from the carburettor.

8 Remove the power steering pump and brackets (if equipped) without disconnecting the hoses and tie it out of the way (see Chapter 10).

9 Remove the alternator (see Chapter 5).

10 Label and disconnect all wires from the engine **(see illustration)**. Masking tape and/or a touch-up paint applicator work well for marking items. **Note:** *Take instant photos or sketch the locations of components and brackets to help with reassembly.*

11 Disconnect the fuel lines at the engine (see Chapter 4) and plug the lines to prevent fuel loss.



7.10 Label each wire before disconnecting the connector

12 Label and detach all vacuum lines from the inlet manifold.

13 Raise the vehicle and support it securely on jackstands.

14 Drain the engine oil (see Chapter 1).

15 Refer to Chapter 4 and disconnect the exhaust pipe from the exhaust manifold.

16 Support the transmission with a floor jack or use a length of chain to keep it in place when the engine is separated for removal. **Note:** *On automatic-transmission models, unbolt the transmission dipstick tube from the cylinder head, but leave it attached to the transmission.*

17 On some early models, the heater core/blower motor housing on the firewall must be removed for clearance (see Chapter 3).

18 Disconnect the wires from the starter solenoid and remove the starter (see Chapter 5).

19 Remove the flywheel or torque converter inspection cover (see Chapter 7B).

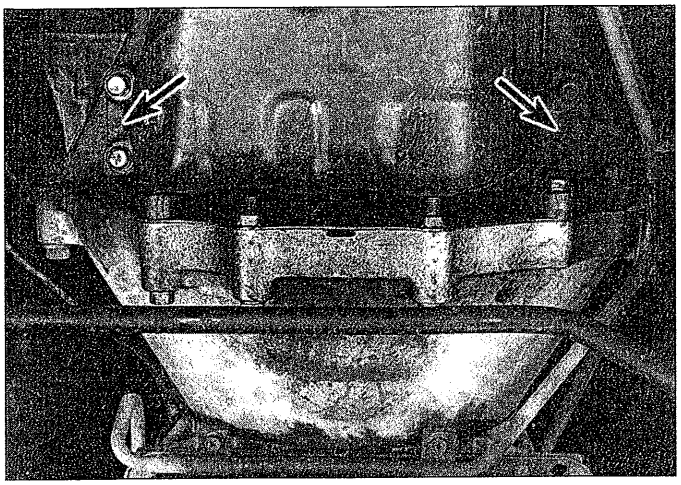
20 If equipped with an automatic transmission, remove the torque converter-to-driveplate bolts (see Chapter 7B). In order to turn the engine to reach all the bolts, use a socket and breaker bar on the bolt in the front end of the crankshaft to turn the driveplate to the needed positions.

21 Remove the transmission-to-engine bolts and the transmission support bracket **(see illustration)**.

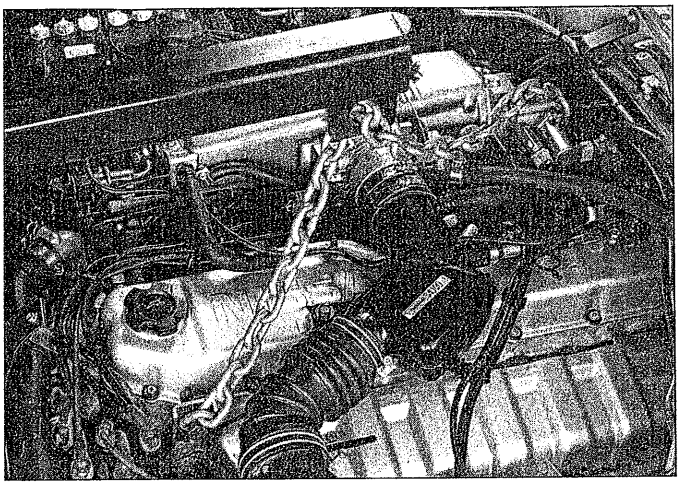
22 Attach an engine hoist to the engine and raise the engine slightly to remove the weight from the engine mounts **(see illustration)**.

23 Remove the engine mount bolts or stud nuts (see Chapter 2A, 2B or 2C). On most models, disconnect the earth strap connected to one of the engine mounts or the exhaust manifold heat shield.

24 Lift the engine slightly and separate the engine from the transmission. Carefully work it forward to separate it from the transmission. If you're working on a vehicle with an automatic transmission, be sure the torque converter stays in the transmission (clamp a pair of locking pliers to the housing to keep



7.21 There are two engine-to-transmission brackets (arrows) which will have to be removed when you disconnect the transmission



7.22 Use longer bolts in the inlet and exhaust manifold bolt holes to attach the engine hoist like this

the converter from sliding out). If you're working on a vehicle with a manual transmission, the input shaft must be completely disengaged from the clutch.

25 Check to make sure everything is disconnected, then lift the engine out of the vehicle. The engine will probably need to be tilted and/or manoeuvred as it's lifted out, so have an assistant handy. **Warning:** *Do not place any part of your body under the engine when it is supported only by a hoist or other lifting device.*

26 Remove the flywheel/driveplate and mount the engine on an engine stand or set the engine on the floor and support it so it doesn't tip over. Then disconnect the engine hoist.

Refitting

27 Check the engine mounts. If they're worn or damaged, renewal them.

28 On manual transmission models, inspect the clutch components (see Chapter 8). On automatic models, inspect the converter seal and bush.

29 Apply a dab of grease to the pilot bush on manual transmission models, or to the torque converter hub on automatic transmission models.

30 Attach the hoist to the engine and carefully lower the engine into the engine compartment.

31 Carefully guide the engine into place. Follow the procedure outlined in Chapter 7 for transmission attachment. **Caution:** *Do not use the bolts to force the engine and transmission into alignment. It may crack or damage major components.*

32 Align the engine to the engine mounts. Refit the nuts or bolts and tighten them securely. **Note:** *If it was detached from the engine, reconnect the automatic transmission dipstick to the engine.*

33 Refit the remaining components in the reverse order of removal.

34 Add coolant, oil, power steering and transmission fluid as needed (see Chapter 1).

35 Run the engine and check for proper operation and leaks. Shut off the engine and recheck fluid levels. See Section 25 for procedures to break-in a new engine.

8 Engine overhaul - disassembly sequence

1 It is much easier to disassemble and work on the engine if it is mounted on a portable engine stand. These stands can often be rented quite cheaply from an equipment rental yard. Before the engine is mounted on a stand, the flywheel/driveplate should be removed from the engine (refer to Chapter 2A, 2B or 2C).

2 If a stand is not available, it is possible to disassemble the engine with it blocked up on a sturdy workbench or on the floor. Be extra careful not to tip or drop the engine when working without a stand.

3 If you are going to obtain a rebuilt engine, all external components must come off first, to be transferred to the renewal engine, just as they will if you are doing a complete engine overhaul yourself. These include:

Alternator and brackets
Emissions control components
Distributor, spark plug wires and spark plugs (petrol engines)
Injection pump (diesel engines)
Thermostat and housing cover
Water pump
Carburettor or fuel injection components
Intake/exhaust manifolds
Oil pump assembly
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 refitting. Note the refitted position of gaskets, seals, spacers, pins, washers, bolts and other small items.*

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

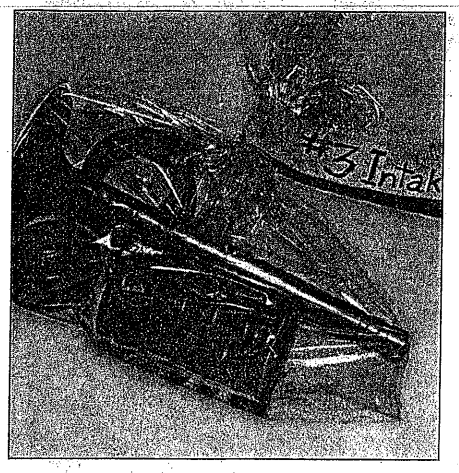
5 If you are planning a complete overhaul, the engine must be disassembled and the internal components removed in the general following order:

Valve cover
Intake and exhaust manifolds
Rocker shaft assembly
Cylinder head
Valve lifters
Sump
Fuel pump (carburetted models)
Timing cover
Timing chain and sprockets
Oil pump
Camshaft
Piston/connecting rod assemblies
Crankshaft and main bearings

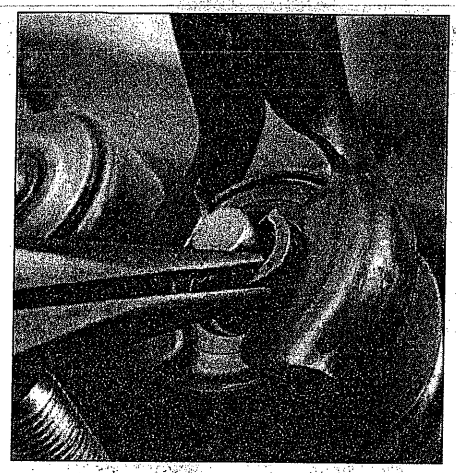
6 Critical cooling system components such as the hoses, the drivebelts, the thermostat and the water pump MUST be renewed parts when an engine is overhauled. If you are buying a rebuilt engine or short-block, some rebuilders will not guarantee their engines unless you have proof that the radiator has been professionally cleaned. Also, new components should be used in the oil pump housing.

7 Before beginning the disassembly and overhaul procedures, make sure the following items are available:

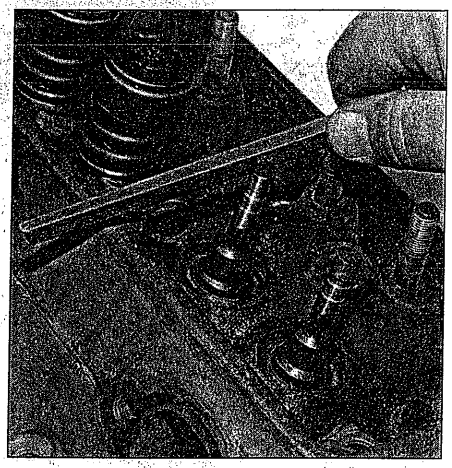
Common hand tools
Small cardboard boxes or plastic bags for storing parts
Gasket scraper
Ridge reamer
Vibration damper puller
Micrometers
Telescoping gauges
Dial indicator set



9.2 A small plastic bag, with an appropriate label, can be used to store the valve train components so they can be kept together and refitted in the original position



9.3a Use a valve spring compressor to compress the spring, then remove the collets from the valve stem with a magnet or needle-nose pliers



9.3b If the valve won't pull through the guide, deburr the edge of the stem end and the area around the top of the collet groove with a file or whetstone

Valve spring compressor
Cylinder surfacing hone
Piston ring groove cleaning tool
Electric drill motor
Tap and die set
Wire brushes
Oil gallery brushes
Cleaning solvent

9 Cylinder head - disassembly

Refer to illustrations 9.2, 9.3a and 9.3b

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

1 Cylinder head disassembly involves removal of the intake and exhaust valves and related components. If it is still in place, remove the rocker arm shaft assembly. Label the parts or store them separately so they can be refitted in their original locations.

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

3 Compress the springs on the first valve with a spring compressor and remove the collets **(see illustration)**. Carefully release the valve spring compressor and remove the retainer and (if used) rotators, the shield, the springs and the spring seat or shims (if used). Rotators are generally used only on the exhaust valves. Remove the oil seal(s) from the valve stem and the umbrella-type seal from over the guide boss (if used), then pull the valve from the head. If the valve binds in the guide (won't pull through), push it back into the head and deburr the area around the collet groove with a fine file or whetstone **(see illustration)**.

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

5 Once the valves and related components have been removed and stored in an organised 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.

10 Cylinder head - cleaning and inspection

1 Thorough cleaning of the cylinder heads 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.

Cleaning

2 Scrape away all traces of old gasket material and sealing compound from the head gasket, inlet manifold and exhaust manifold sealing surfaces. Be very careful not to gouge the cylinder head. Special gasket-removal solvents, which soften gaskets and make removal much easier, are available at auto parts stores.

3 Remove any built-up scale from the coolant passages.

4 Run a stiff wire brush through the various holes to remove any deposits that may have formed in them.

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

6 Check the condition of the spark plug threads.

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:** *Decarbonising chemicals are available and may prove very useful when cleaning cylinder heads and valve train components. They are very caustic and should be used with caution. Be sure to follow the instructions on the container.*

8 Clean the rocker arms, shafts and pushrods (if used) 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, shields, collets 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 wire brush mounted in a drill motor to remove deposits from the valve heads and stems. Again, make sure the valves do not get mixed up.

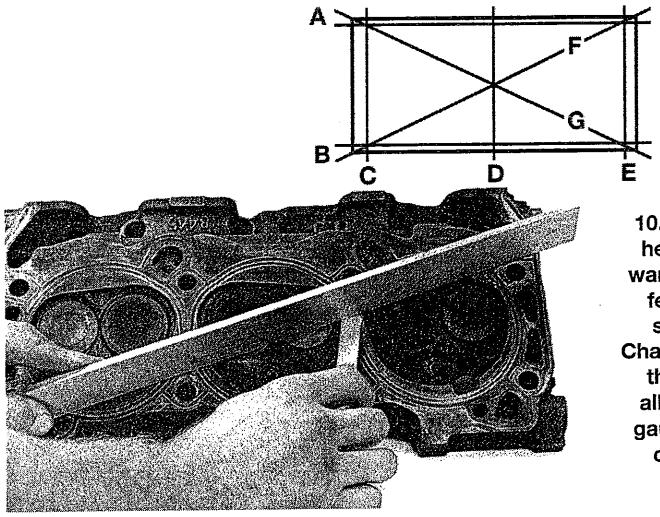
Inspection

Cylinder head

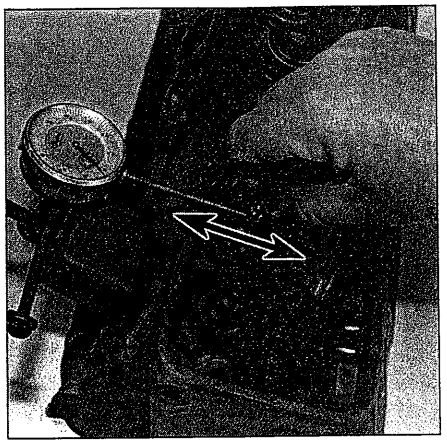
Refer to illustrations 10.12 and 10.14

11 Inspect the head very carefully for cracks, evidence of coolant leakage and other damage. If cracks are found, a new cylinder head should be obtained.

12 Using a precision straightedge and feeler gauge, check the head gasket mating surface for warpage **(see illustration)**. If the warpage exceeds the limit specified in this Chapter's Specifications, it can be resurfaced at an automotive machine shop. Make certain that the head is not machined to a thickness less than that listed in this Chapter's Specifications.



10.12 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) - check straight across and diagonally



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

13 Examine the valve seats in each of the combustion chambers. If they are pitted, cracked or burned, the head will require valve service with special equipment that is beyond the scope of most home mechanics, especially from an equipment stand point.

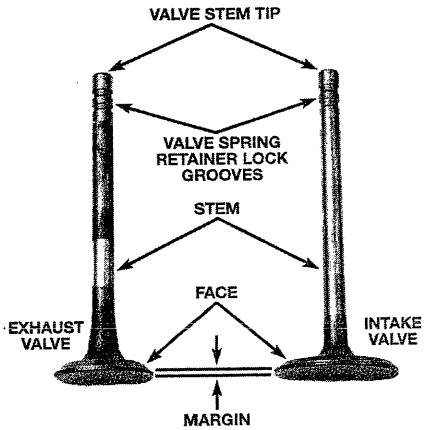
14 Check the valve stem-to-guide clearance by measuring the lateral movement of the valve stem with a dial indicator attached securely to the head **(see illustration)**. The valve must be in the guide and approximately 1 mm off the seat. The total valve stem movement indicated by the gauge needle must be divided by two to obtain the actual clearance. After this is done, if there is still some doubt regarding the condition of the valve guides they should be checked by an automotive machine shop (the cost should be minimal). The guide dimensions can also be checked with a small-hole gauge, which can detect taper in the guide. When using a small-hole gauge or telescoping snap gauge, put the gauge down to the middle portion of the guide (where wear should be minimal) and tighten the gauge. Move the gauge up and down and if the guide isn't worn the feel of the gauge should stay the same all the way. Loose areas indicate wear. If they are worn, they can often be restored at a machine shop or renewed.

Valves

Refer to illustrations 10.15 and 10.16

15 Carefully inspect each valve face for uneven wear, deformation, cracks, pits and burned spots **(see illustration)**. Check the valve stem for scuffing and galling and the neck for cracks. Rotate the valve and check for any obvious indication that it is bent. Look for pits and excessive wear on the end of the stem. The presence of any of these conditions indicates the need for valve service by an automotive machine shop.

16 Measure the margin width on each valve. Any valve with a margin that is narrower than listed in the Specifications in this Chapter should be discarded and renewed **(see illustration)**.



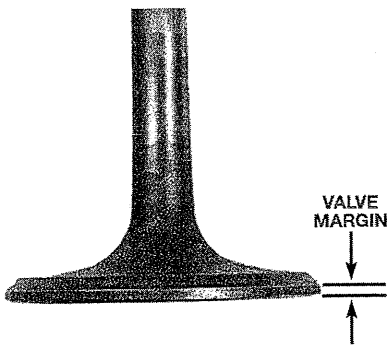
10.15 Check for valve wear at the points shown here

Valve components

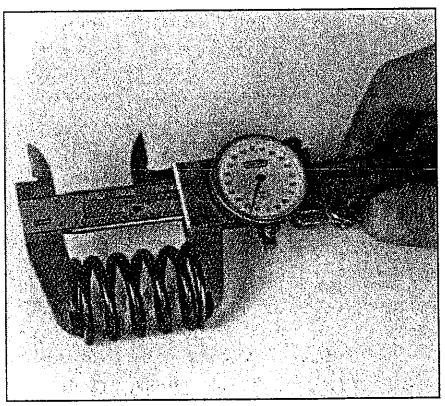
Refer to illustrations 10.17 and 10.18

17 Check each valve spring for wear (on the ends) and pits. Measure the free length and compare it to the Specifications in this Chapter **(see illustration)**. Any springs that are shorter than specified have sagged and should not be reused. The tension of all springs should be checked with a special fixture before deciding that they are suitable for use in a rebuilt engine (take the springs to an automotive machine shop for this check).

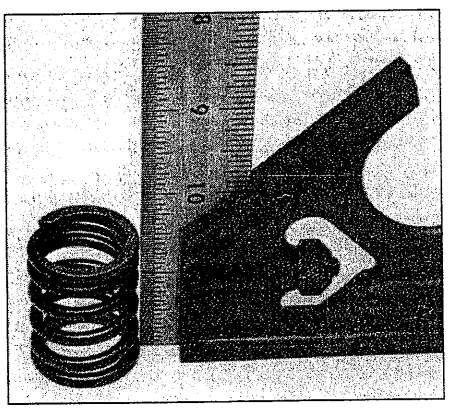
18 Stand each spring on a flat surface and check it for squareness **(see illustration)**. If any of the springs are distorted or sagged, renew all of them.



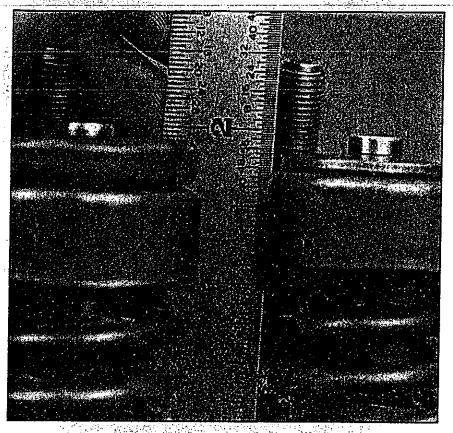
10.16 The margin width on each valve must be as specified (if no margin exists, the valve cannot be reused)



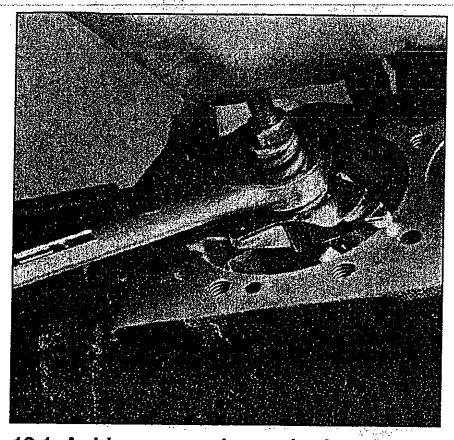
10.17 Measure the free length of each valve spring with a dial or vernier caliper



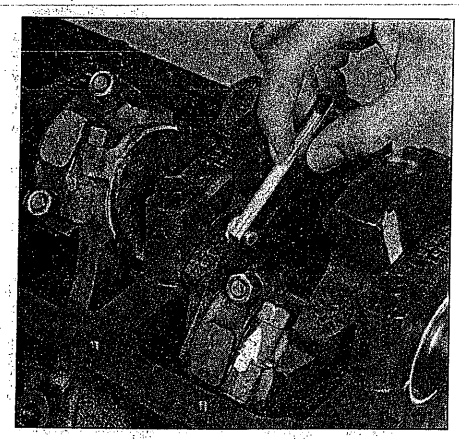
10.18 Check each valve spring for squareness - if it is bent, it should be renewed



12.8 Valve spring refitted height is the distance from the spring seat to the top of the spring (not including the retainer or rotator)



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



13.3 Check the connecting rod side clearance (endplay) with a feeler gauge as shown here

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

Rocker arm components

20 Check the rocker arm faces (the areas that contact the pushrod ends and valve stems) for pits, wear, galling, cracks, score marks and rough spots.

21 On 4.2 litre engines, inspect the pushrod ends for scuffing and excessive wear. Roll each pushrod on a flat surface, such as plate glass, to determine if it is bent.

22 Check the rocker shaft bolt holes in the cylinder heads for damaged threads.

23 Any damaged or excessively worn parts must be renewed.

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

11 Valves - servicing

1 Because of the complex nature or 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") is best left to a professional.

2 The home mechanic can remove and disassemble the cylinder heads, do the initial cleaning and inspection, then reassemble and deliver the cylinder heads to a dealer service department or an automotive machine shop for the actual valve servicing.

3 The dealer service department, or automotive machine shop, will remove the valves and springs, recondition or renew the valves and valve seats, recondition the valve guides, check and renew the valve springs, spring retainers or rotators and collets (as necessary), renew the valve seals, reassemble the valve components and make sure the refitted spring height is correct. The cylinder head gasket surface will also be resurfaced if it is 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 refitting 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.

12 Cylinder head - reassembly

Refer to illustration 12.8

1 Regardless of whether or not the cylinder heads were sent to an automotive machine shop for valve servicing, make sure they are clean before beginning reassembly.

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

3 Beginning at one end of the head, lubricate and refit the first valve. Apply moly-base grease or clean engine oil to the valve stem.

4 Different types of valve stem oil seals are used on the intake and exhaust. On some applications, an umbrella type seal which extends down over the valve guide boss is used over the valve stem.

5 Drop the spring seat or shim(s), if used, over the valve guide and set the valve spring and retainer (or rotator) in place.

6 Compress the springs with a valve spring compressor. Position the collets in the upper groove, then slowly release the compressor and make sure the collets seat properly. Apply a small dab of grease to each collet to hold it in place if necessary.

7 Repeat the procedure for the remaining valves. Be sure to return the components to their original locations - do not mix them up!

8 Check the refitted valve spring height with a ruler graduated in fine increments or a dial caliper **(see illustration)**. If the cylinder heads were sent out for service work, the refitted height should be correct (but don't automatically assume that it is). The measurement is taken from the top of each spring seat or shim(s) to the bottom of the retainer/rotator. 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 springs to the point where the refitted height is less than specified. A condition called "coil bind" will be caused when the spring is compressed.*

13 Piston/connecting rod assembly - removal

Refer to illustrations 13.1, 13.3, 13.4 and 13.5

Note: *Prior to removing the piston/connecting rod assemblies, remove the cylinder head(s), the sump and the oil pump pickup screen assembly by referring to the appropriate Sections in Chapter 2, Part A, Part B or Part C.*

1 Completely remove the ridge at the top of each cylinder with a ridge reaming tool **(see illustration)**. Follow the manufacturer's instructions provided with the tool. Failure to remove the ridge before attempting to remove the piston/connecting rod assemblies could result in piston breakage.

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

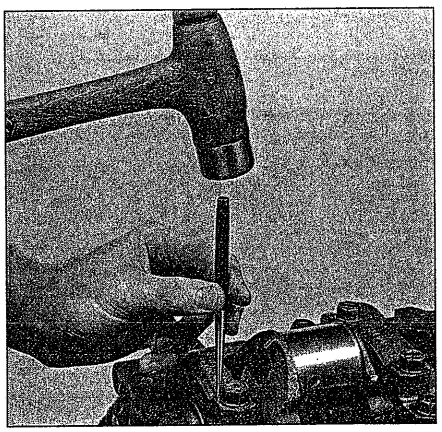
3 Before the connecting rods are removed, check the endplay (side clearance) with a feeler gauge. Slide the feeler gauge between the first connecting rod and the crankshaft throw until the play is removed **(see illustration)**. The endplay is equal to the thickness of the feeler gauge. If the endplay exceeds the service limit listed in this Chapter's Specifications, new connecting rods will

13.4 The connecting rods should be marked with numbers at the parting line of each rod and cap - the number corresponds to the engine cylinder number - on reassembly, be sure the numbers are on the same side, facing each other, as shown

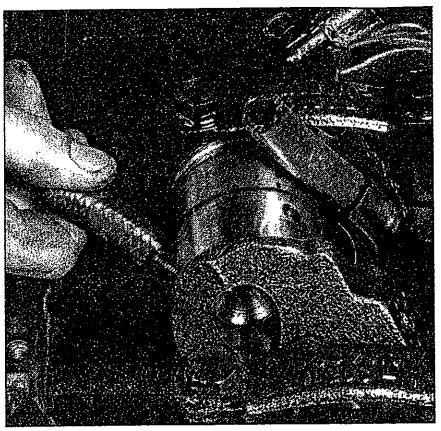
be required. If new rods (or a new crankshaft) are refitted, the endplay may fall under the specified minimum. If it does, the rods will have to be machined to restore it - consult an automotive machine shop for advice if necessary. Repeat the procedure for the remaining connecting rods.

4 Check the connecting rods and caps for identification marks **(see illustration)**. If they are not plainly marked, use a small centre-punch to make the appropriate number of indentations on each rod and cap.

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. Do not drop the bearing insert out of the cap. Slip a short length of plastic or rubber hose over each connecting rod cap bolt to protect



14.4 The 4.2 litre engine main bearing caps are marked to indicate their locations - they should be numbered consecutively from the front of the engine to the rear, and have arrows to indicate which way faces the front of the engine - if they're not marked, mark them with a punch and hammer



13.5 To prevent damage to the crankshaft journals and cylinder walls, slip sections of rubber hose over the rod bolts before removing the piston/rod assemblies

the crankshaft journal and cylinder wall when the piston is removed **(see illustration)**. Push the connecting rod/piston assembly out through the top of the engine. Use a wooden hammer handle to push on the upper bearing insert in the connecting rod. If resistance is felt, double-check to make sure that all of the ridge was removed from the cylinder.

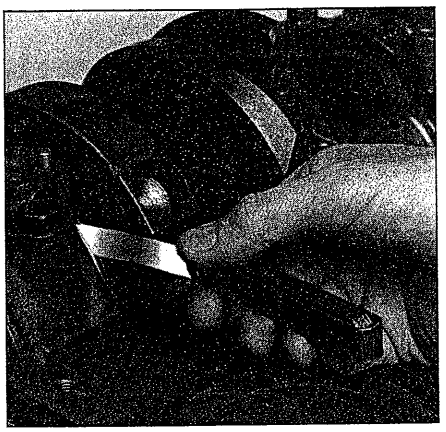
6 Repeat the procedure for the remaining cylinders. After removal, reassemble the connecting rod caps and bearing inserts in their respective connecting rods and refit the cap nuts finger tight. Leaving the old bearing inserts in place until reassembly will help prevent the connecting rod bearing surfaces from being accidentally nicked or gouged.

14 Crankshaft - removal

Refer to illustrations 14.3, 14.4, 14.5a and 14.5b

Note: *The crankshaft can best be removed only after the engine has been removed from the vehicle. It is assumed that the flywheel or driveplate, vibration damper or crankshaft pulley, timing chain, sump and piston/connecting rod assemblies have already been removed.*

1 Before the crankshaft is removed, check the endplay. Mount a dial indicator with the



14.3 Checking crankshaft endplay with a feeler gauge

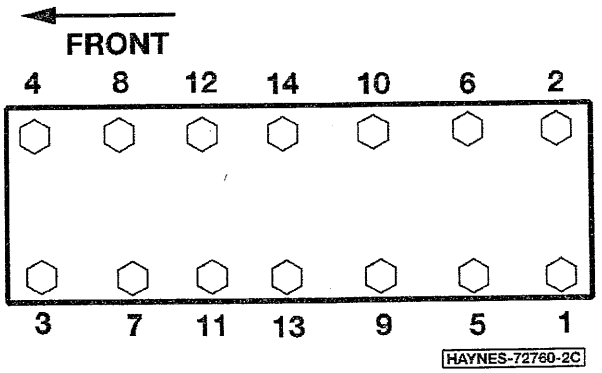
stem in line with the crankshaft and touching one of the crank throws or the end of the crank.

2 Push the crankshaft all the way to the rear and zero the dial indicator. Next, prise the crankshaft to the front as far as possible and check the reading on the dial indicator. The distance that it moves is the endplay. If it is greater than the maximum listed in this Chapter's Specifications, check the crankshaft thrust surfaces for wear. If no wear is evident, new main bearings should correct the endplay.

3 If a dial indicator is not available, a feeler gauge can be used. Gently prise or push the crankshaft all the way to the front of the engine. Slip the feeler gauge between the crankshaft and the front face of the thrust main bearing to determine the clearance **(see illustration)**.

4 Check the main bearing caps (on 4.2 litre engines) to see if they are 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 centre-punch **(see illustration)**.

5 On 4.2 litre engines, loosen the main cap bolts in three steps, following the correct sequence **(see illustration)**. On 3.0 litre engines, loosen the main cap bolts in three steps, following the correct sequence **(see illustration)**.

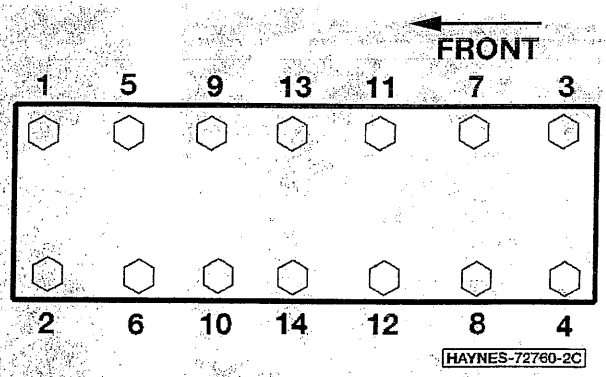


14.5a 4.2 litre engine main bearing cap bolt removal sequence

2D

6 **Note:** *3.0 litre engines use a one-piece main bearing support rather than individual main bearing caps. This manual refers to the caps as being individual ones as on 4.2 litre engines.* On 4.2 litre engines, 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.

7 Carefully lift the crankshaft out of the engine. It is 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.



14.5b 3.0 litre engine main bearing cap removal sequence

15 Engine block - cleaning

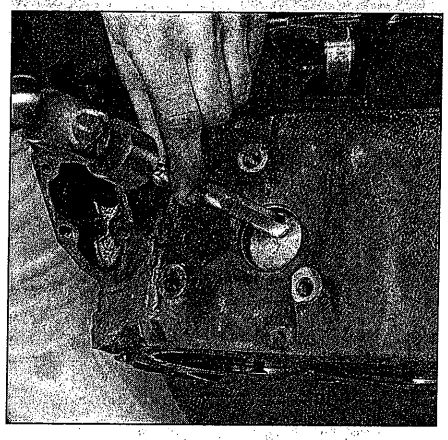
Refer to illustrations 15.1a, 15.1b, 15.8 and 15.10

1 Using the wide end of a punch tap in on the outer edge of the core plug to turn the plug sideways in the bore. Then, using a pair of pliers, pull the core plug from the engine block **(see illustrations)**. Don't worry about the condition of the old core plugs as they are being removed because they will be renewed on reassembly with new plugs.

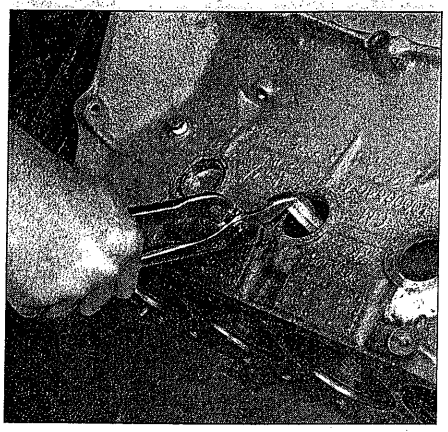
2 Using a gasket scraper, remove all traces of gasket material from the engine block. On diesel engines, remove all six piston-cooling oil jet assemblies. Each jet must be blown out with air and checked for damage. Each jet plug/valve must be cleaned and the small valve tested by pressing in on it with a soft object. If it does not operate smoothly, renew it.

3 Remove the main bearing caps or cap assembly 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.

4 Remove all of the threaded oil gallery plugs from the block. The plugs are usually very tight - they may have to be drilled out and the holes retapped. If drilled out or damaged during removal, use new plugs when the engine is reassembled.



15.1a A hammer and a large punch can be used to knock the core plugs sideways in their bores

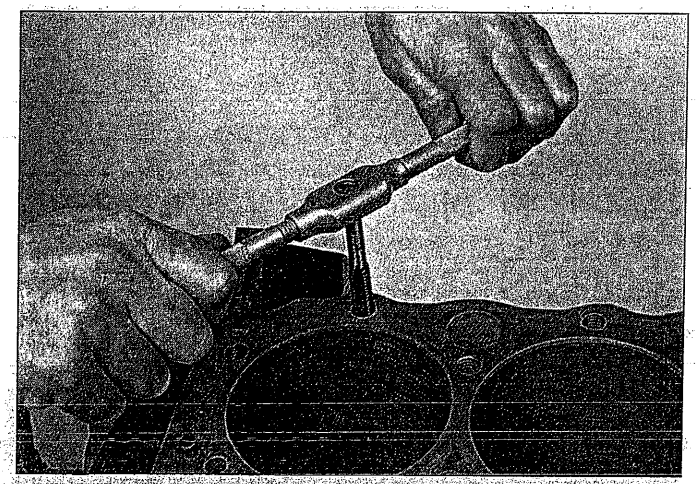


15.1b Pull the core plugs from the block with pliers

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

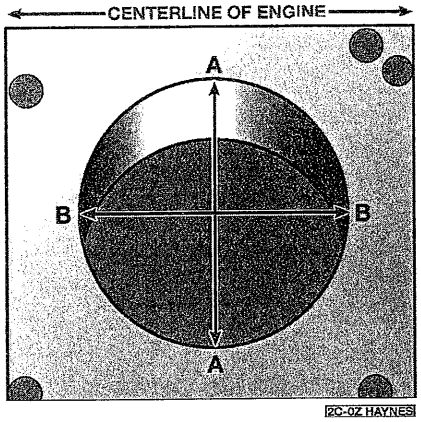
6 After the block is returned, clean all oil holes and oil galleries one more time. Brushes specifically designed for this purpose are available at most auto parts stores. Flush the passages with warm water until the water runs clear, dry the block thoroughly and wipe all machined surfaces with a light,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

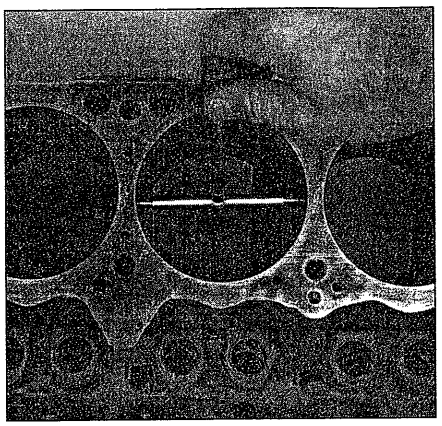


15.8 All bolt holes in the block - particularly the main bearing cap and head bolt holes - should be cleaned and restored with a tap (be sure to remove debris from the holes after this is done)

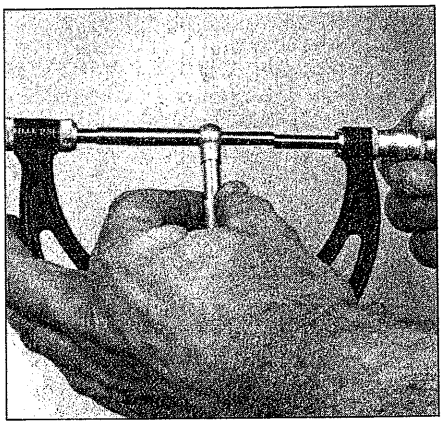
15.10 A large socket on an extension can be used to drive the new core plugs into the bores



16.4a Measure the diameter of each cylinder at a right angle to the engine centreline (A), and parallel to engine centreline (B) - out-of-round is the difference between A and B; taper is the difference between A and B at he top of the cylinder and A and B at the bottom of the cylinder



16.4b Use a telescoping gauge to measure the bore - the ability to "feel" when it 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



16.4c The gauge is then measured with a micrometer to determine the bore size

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 Refit the main bearing caps and tighten the bolts finger tight.

10 After coating the sealing surfaces of the new core plugs with a good sealant, refit them in the engine block **(see illustration)**. Make sure they're driven in straight 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 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.

16 Engine block - inspection

Refer to illustrations 16.4a, 16.4b and 16.4c

1 Before the block is inspected, it should be cleaned (see Section 15).

2 Visually check the block for cracks, rust and corrosion. Look for stripped threads in the threaded holes and make plans to have them repaired as required. 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 renewed.

3 Check the cylinder bores for scuffing and scoring.

4 Check the cylinders for taper and out-of-round conditions as follows **(see illustrations)**.

5 Measure the diameter of each cylinder at the top (just under the ridge area), centre and bottom of the cylinder bore, parallel to the crankshaft axis.

6 Next measure each cylinder's diameter at the same three locations perpendicular to the crankshaft axis.

7 The taper of the cylinder is the difference between the bore diameter at the top of the cylinder and the diameter at the bottom. The out-of-round specification of the cylinder bore is the difference between the parallel and perpendicular readings. Compare your results to those listed in this Chapter's Specifications.

8 If the cylinder walls are badly scuffed or scored, or if they're out-of-round or tapered beyond the specified limits, have the engine block rebored and honed at an automotive machine shop.

9 If a rebore is done, new pistons and rings will be required.

10 Using a precision straightedge and feeler gauge, check the block deck (the surface that mates with the cylinder head(s) for distortion as you did with the cylinder head(s) **(see illustration 10.12)**. If it's distorted beyond the specified limit, it can be resurfaced by an automotive machine shop.

11 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, then they don't have to be rebored. Honing is all that's necessary (see Section 17).

17 Cylinder honing

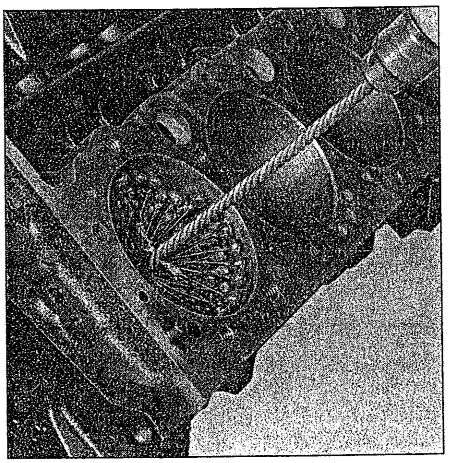
Refer to illustrations 17.3a and 17.3b

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 do not have the tools or do not want to tackle the honing operation, most automotive machine shops will do it for a reasonable fee.*

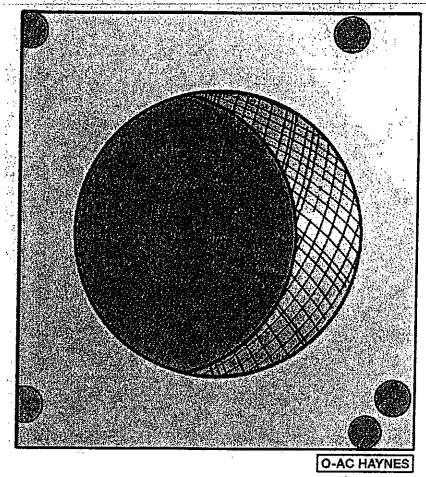
2 Before honing the cylinders, refit the main bearing caps and tighten the bolts to the specified torque.

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 the "bottle brush" hone will be easier to use and will produce a superior finish. You will also need plenty of light oil or honing oil, some 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)**.



17.3a A "bottle brush" hone will produce better results than the spring-loaded stone type



17.3b The cylinder hone should leave a smooth, crosshatch pattern with the lines intersecting at approximately a 60-degree angle

b) *Lubricate the cylinder with plenty of oil, turn on the drill and move the hone up-and-down in the cylinder at a pace which will produce a fine crosshatch pattern on the cylinder walls. Ideally, the crosshatch lines should intersect at approximately a 60-degree angle* **(see illustrations)**. *Be sure to use plenty of lubricant and do not 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, typically 45-degrees, so read and follow any instructions printed on the piston ring packages.*

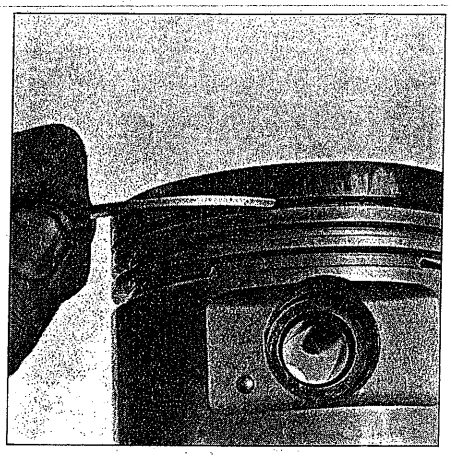
c) *Do not withdraw the hone from the cylinder while it is running. Instead, shut off the drill and continue moving the hone up-and-down in the cylinder until it comes to a complete stop, then compress the stones and withdraw the hone. If you are using a "bottle brush" type hone, stop the drill motor, 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 will not catch when the pistons are refitted. 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 white cloth - dampened with clean engine oil - used to wipe down the bores does not pick up any more honing residue, which will show up as grey areas on the cloth. Be sure to run a brush through all oil holes and galleries and flush them with running water.*

18.4a The piston ring grooves can be cleaned with a special tool, as shown here . . .



18.4b . . . or a section of a broken ring

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.

18 Piston/connecting rod assembly - inspection

Refer to illustrations 18.4a, 18.4b, 18.10 and 18.11

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.*

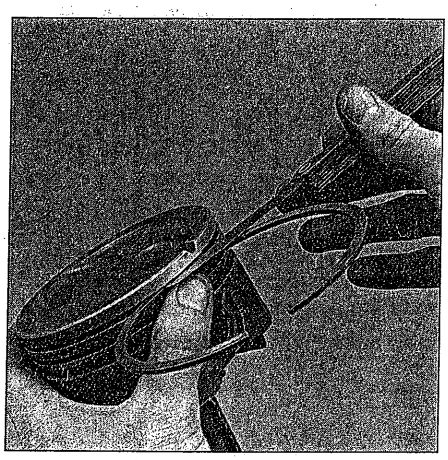
2 Using a piston ring refitting tool, carefully remove the rings from the pistons. Be careful not to nick or gouge the pistons in the process.

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

4 Use a piston ring groove-cleaning tool to remove carbon deposits from the ring grooves. If a tool isn't available, a piece broken off an 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 when using compressed air!* Make sure the oil return holes in the back sides of the ring grooves and the oil hole in the lower end of each rod are clear.

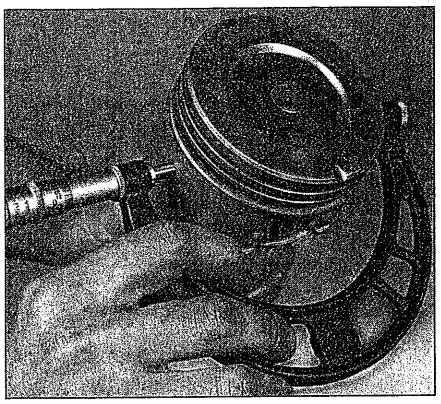
6 If the pistons and cylinder walls aren't damaged or worn excessively, and if the engine block is not rebored, new pistons won't be necessary. Normal piston wear appears as even vertical wear on the piston thrust surfaces and slight looseness of the top ring in its groove. New piston rings, however,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



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

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

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



18.11 Measure the piston at the point listed in the Specifications at the start of this Chapter - the point is different for all three engines

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

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

11 Check the piston-to-bore clearance by measuring the bore (see Section 16) 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, at the point listed in the Specifications in this Chapter **(see illustration)**. Subtract the piston diameter from the bore diameter to obtain the clearance. If it's greater than specified, the block will have to be rebored and new pistons and rings refitted.

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

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

14 Check the connecting rods for cracks and other damage. Temporarily remove the rod caps, lift out the old bearing inserts, wipe the rod and cap bearing surfaces clean and inspect them for nicks, gouges and scratches.

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

After checking the rods, renew 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 check with an automotive machine shop on the possibility of re-sizing the rods. If this isn't possible, refit new rods.*

19 Crankshaft - inspection

Refer to illustrations 19.1, 19.2, 19.5 and 19.7

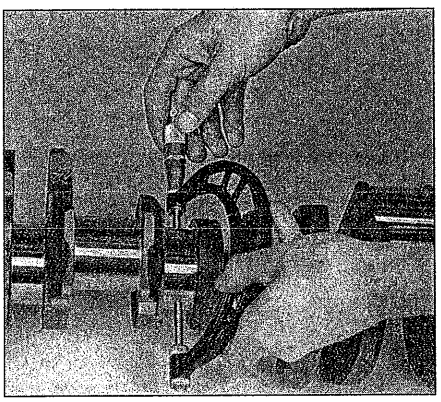
1 Remove all burrs from the crankshaft oil holes with a stone, file or scraper **(see illustration)**.

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

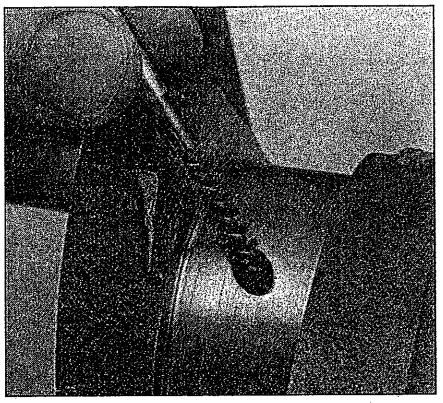
3 Check the main and connecting rod bearing journals for uneven wear, scoring, pits and cracks.

4 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.

5 Using a micrometer, measure the diameter of the main and connecting rod journals and compare the results to the Specifications



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



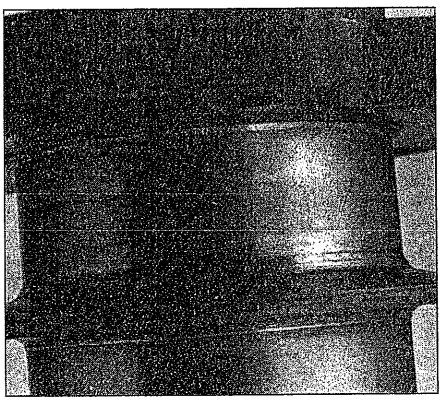
19.2 Use a wire or stiff plastic bristle brush to clean the oil passages in the crankshaft - flush the passages out with solvent

(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. Crankshaft runout should be checked also, but large V-blocks and a dial indicator are needed to do it correctly. If you don't have the equipment, have a machine shop check the runout.

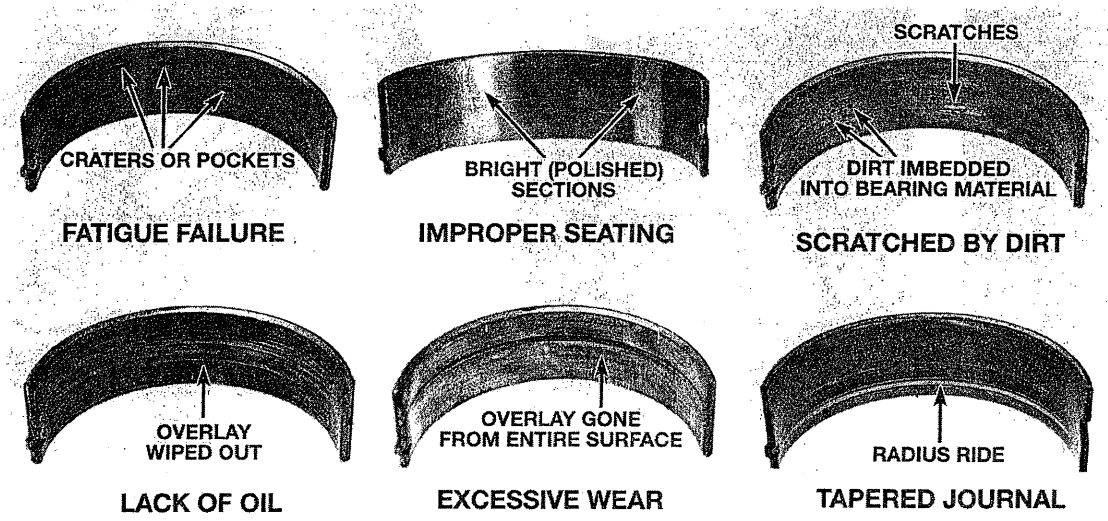
6 If the crankshaft journals are damaged, tapered, out-of-round or worn beyond the limits given in the Specifications, have the crankshaft reground by an automotive machine shop. Be sure to use the correct size bearing inserts if the crankshaft is reconditioned.

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

8 Examine the main and rod bearing inserts (see Section 20).



19.7 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



20.1 Before discarding the used bearings, examine them for indications of any possible problems with the crankshaft, noting the bearing location it came from. Here are some typical bearing failures

20 Main and connecting rod bearings - inspection and selection

Inspection

Refer to illustration 20.1

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

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

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

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

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

6 Driving habits can have a definite effect on bearing life. Low speed operation in too high a gear (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 refitting during engine assembly will lead to bearing failure as well. Tight fitting bearings leave insufficient bearing oil clearance and will result in oil starvation. Dirt or foreign particles trapped behind a bearing insert result in high spots on the bearing which lead to failure.

Selection

8 If a new or original crankshaft is refitted, the size of each journal should be indicated by a colour coded mark on the adjacent counterweight cheek, toward the rear end of the crankshaft. The bearing inserts are colour coded on the edge of the insert. The accompanying charts should be consulted to determine the correct bearings. **Caution:** *Always check the bearing oil clearance with Plastigage during final refitting of the crankshaft and piston/connecting rod assemblies.*

9 If necessary to achieve the desired oil clearance, different size upper and lower bearing inserts may be used on the same journal, but the size difference must never exceed 0.025 mm. **Caution:** *The odd size inserts, if used, must all be placed in the same locations - i.e. all in the caps or all in the block/rod.*

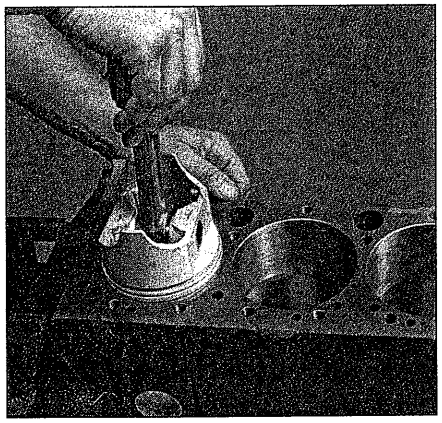
10 If a reground crankshaft is used, the automotive machine shop or parts store will supply the correct size bearing inserts.

11 Remember, the oil clearance is the final judge when selecting new bearing sizes for either main or rod bearings. If you have any questions or are unsure which bearings to use, get help from a dealer parts or service department or other parts supplier. **Note:** *Some engines have factory oversized or undersized components, see Section 16.*

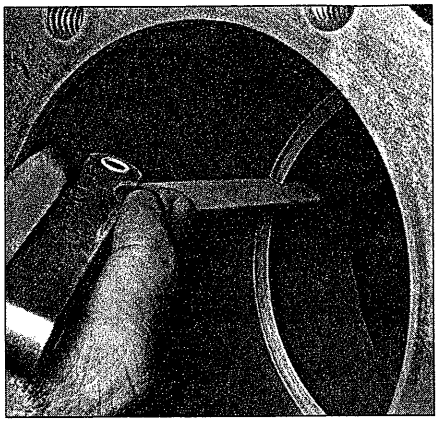
21 Engine overhaul - reassembly sequence

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

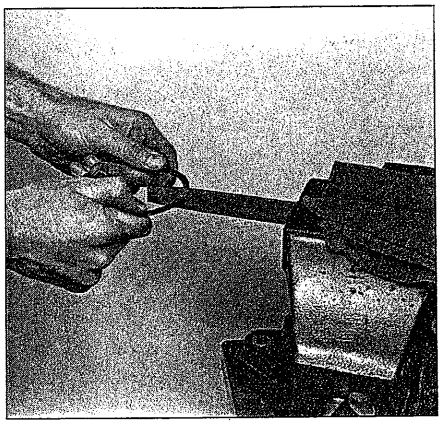
Common hand tools
A torque wrench
Piston ring refitting tool
Piston ring compressor
Short lengths of rubber or plastic hose to fit over connecting rod bolts
Plastigage
Feeler gauges
A fine-tooth file
New engine oil
Engine assembly lube or moly-base grease
Gasket sealant
Thread locking compound



22.3 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)



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



22.5 If the end gap is slightly too small, clamp a file in a vice and file the ring ends by pushing the ring over the file toward the vice - after filing to correct size, deburr the ring ends with fine emery cloth or a whetstone

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

Piston rings
Crankshaft and main bearings
Rear main oil seal
Piston/connecting rod assemblies
Camshaft
Oil pump
Timing chain and gears
Lifters
Cylinder head, pushrods (if used) and rocker arms
Oil pick-up tube
Sump
Valve cover
Intake and exhaust manifolds
Flywheel/driveplate

22 Piston rings - refitting

Refer to illustrations 22.3, 22.4, 22.5, 22.10a, 22.10b and 22.13

1 Before refitting the new piston rings, the ring end gaps must be checked. It's assumed that the piston ring side clearance has been checked and verified correct (see Section 22).

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 damage to the engine. The end gap can be increased by filing the ring ends very carefully with a fine file. Mount the file in a vice equipped with soft jaws, slip the ring over the file with the ends contacting the file face and slowly move the ring to remove material from the ends **(see illustration)**. **Caution:** *When performing this operation, file only from the outside in.*

6 Excess end gap is not critical unless it is greater than that listed in the Specifications in this Chapter. Again, double-check to make sure you have the correct rings for your engine.

7 Repeat the procedure for the rest of the rings. Remember to keep rings, pistons and cylinders matched up.

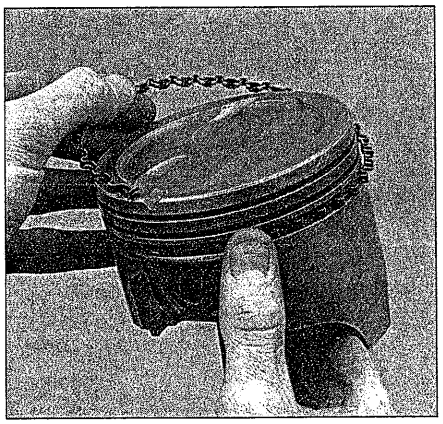
8 Repeat the procedure for each ring that will be refitted in the first cylinder and for each ring in the remaining cylinders. Remember to keep rings, pistons and cylinders matched up.

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

10 The oil control ring (lowest one on the piston) is usually refitted 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, refit the lower side rail. Don't use a piston ring refitting 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, refit the upper side rail in the same manner.

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

12 The number two (middle) ring is refitted next. It's usually stamped with a mark which must face up, toward the top of the piston. **Note:** *Always follow the instructions printed on the ring package or box - different manu-*



22.10a Refitting the spacer/expander in the oil control ring groove . . .

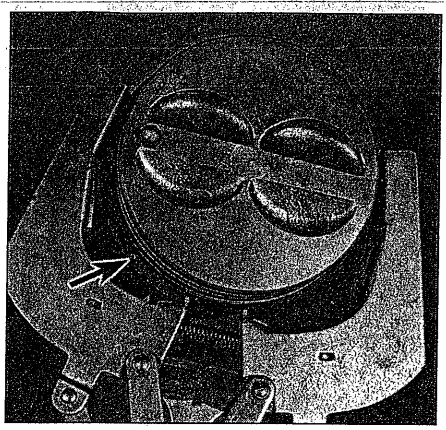
22.10b . . . followed by the side rails - DO NOT use a piston ring refitting tool when refitting the oil ring side rails

facturers may require different approaches. Do not mix up the top and middle rings, as they have different cross sections.

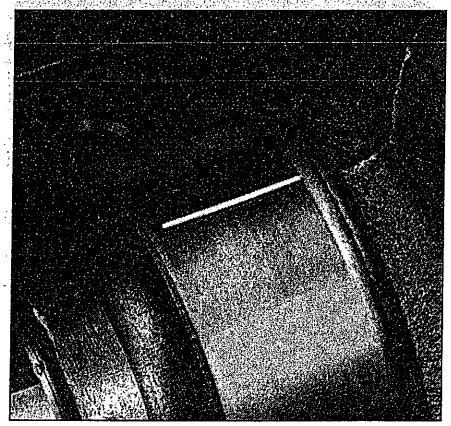
13 Use a piston ring refitting tool and make sure the identification mark is facing the top of the piston; then slip the ring into the middle groove on the piston. Don't expand the ring any more than necessary to slide it over the piston **(see illustration)**.

14 Refit 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.

15 Repeat the procedure for the remaining pistons and rings.



22.13 Refitting the compression rings with a ring expander - the mark (arrow) must face up



23.10 Lay the Plastigage strips on the main bearing journals, parallel to the crankshaft centreline

23 Crankshaft - refitting and main bearing oil clearance check

1 Crankshaft refitting is the first major 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 the caps out in the proper order to ensure correct refitting.

4 If they're still in place, remove the old bearing inserts from the block and the main bearing caps. Wipe the main bearing surfaces of the block and caps with a clean, lint-free cloth. They must be kept spotlessly clean!

Main bearing oil clearance check

Refer to illustrations 23.10, 23.12a, 23.12b, and 23.14

5 Clean the back sides of the new main bearing inserts and lay the bearing half with the oil groove and hole in each main bearing saddle in the block (on all engines covered by this manual, the bearings with oil holes go in the block and those without oil holes go in the caps). Lay the other bearing half from each bearing set in the corresponding main bearing cap. Make sure the tab on each bearing insert fits into the recess in the block or cap. Also, the oil holes in the block must line up with the oil holes in the bearing insert.

Caution: *Do not hammer the bearings into place and don't nick or gouge the bearing faces. No lubrication should be used at this time.*

6 The thrust bearings must be refitted in the correct position.

7 Clean the faces of the bearings in the block and the crankshaft main bearing journals with a clean, lint-free cloth. Check or clean the oil holes in the crankshaft, as any dirt here can go only one way - straight through the new bearings.

8 Once you're certain the crankshaft is clean, carefully lay it in position in the main bearings. No lubricant should be used at this time.

9 Before the crankshaft can be permanently refitted, the main bearing oil clearance must be checked.

10 Trim several pieces of the appropriate size Plastigage (they must be slightly shorter than the width of the main bearings) and place one piece on each crankshaft main bearing journal, parallel with the journal axis **(see illustration)**.

11 Clean the faces of the bearings in the caps and refit the caps in their respective positions (don't mix them up) with the arrows pointing toward the front of the engine. Don't disturb the Plastigage. Apply a light coat of oil to the bolt threads and the under sides of the bolt heads, then refit them.

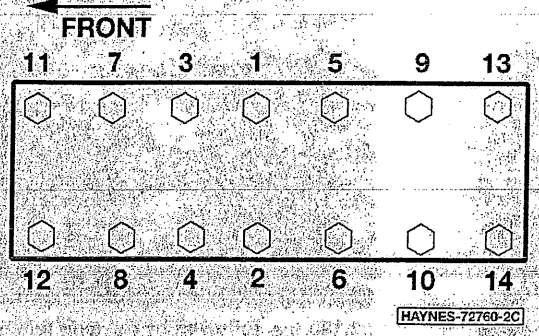
12 On 4.2 litre engines tighten the main bearing cap in three steps, working in the correct sequence with each step **(see illustration)**. Don't rotate the crankshaft at any time during this operation! On 3.0 litre engines tighten the main bearing cap in three steps, working in the correct sequence with each step **(see illustration)**

13 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.

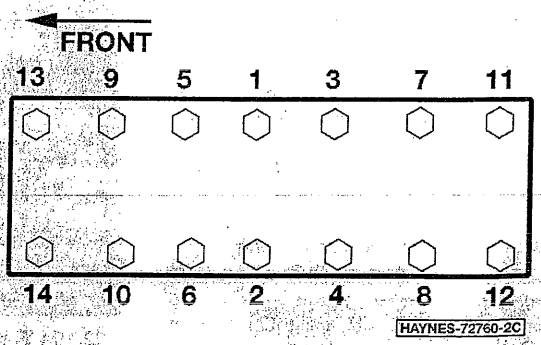
14 Compare the width of the crushed Plastigage on each journal to the scale printed on the Plastigage envelope to obtain the main bearing oil clearance **(see illustration)**. Check the Specifications to make sure it's correct.

15 If the clearance is not as specified, the bearing inserts may be the wrong size which means different ones will be required. Before deciding that different inserts are needed, make sure that no dirt or oil was between the bearing inserts and the caps or block when the clearance was measured. If the Plastigage is noticeably wider at one end than the other, the journal may be tapered (see Section 20).

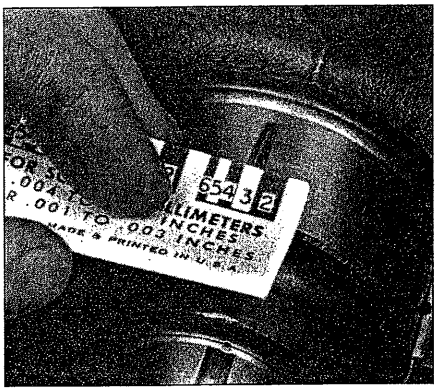
16 Carefully scrape all traces of the Plastigage material off the main bearing journals and/or the bearing faces. Don't nick or scratch the bearing faces.



23.12a 4.2 litre engine main bearing cap bolt tightening sequence



23.12b 3.0 litre engine main bearing cap bolt tightening sequence



23.14 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

Final crankshaft refitting

17 Carefully lift the crankshaft out of the engine. Clean the bearing faces in the block, then apply a thin, uniform layer of clean moly-base grease or engine assembly lube to each of the bearing surfaces. Coat the thrust washers as well.

18 Lubricate the crankshaft surfaces that contact the oil seals with moly-base grease, engine assembly lube or clean engine oil.

19 Make sure the crankshaft journals are clean, then lay the crankshaft back in place in the block. Clean the faces of the bearings in the caps or cap assembly, then apply the same lubricant to them. Refit the caps in their respective positions with the arrows pointing toward the front of the engine.

20 Apply a light coat of oil to the bolt threads and the under sides of the bolt heads, then refit them. Tap the ends of the crankshaft forward and backward with a lead or brass hammer to line up the thrust bearings and crankshaft surfaces. Tighten all main bearing cap bolts to the specified torque, following the recommended sequence.

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

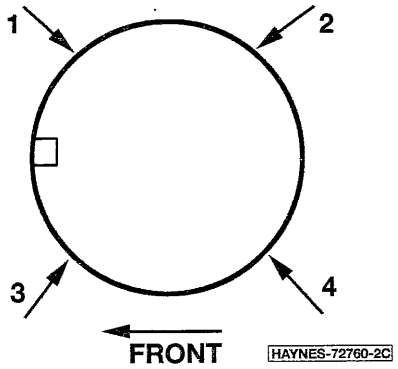
22 Check the crankshaft endplay with a feeler gauge or a dial indicator (see Section 19). The endplay should be correct if the crankshaft thrust faces aren't worn or damaged and new bearings have been refitted.

24 Pistons/connecting rods - refitting and rod bearing oil clearance check

Refer to illustrations 24.5a, 24.5b, 24.9, 24.11, 24.13, 24.17 and 24.31

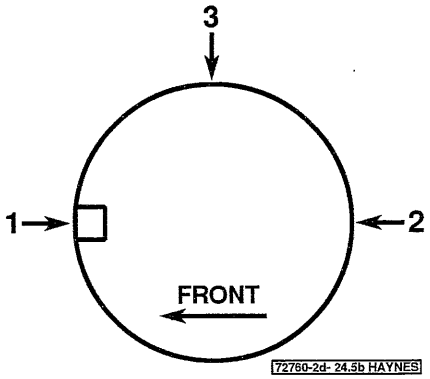
1 Before refitting the piston/connecting rod assemblies, the cylinder walls must be perfectly clean, the top edge of each cylinder must be chamfered, and the crankshaft must be in place.

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



24.5a Piston ring spacing for 3.0 litre and 4.2 litre petrol engines

1 *Oil ring expander*
2 *Top ring and oil ring upper rail*
3 *Second ring*
4 *Oil ring lower rail*



24.5b Piston ring gap spacing for the 4.2 litre diesel engine

1 *Top ring and upper oil ring gaps*
2 *Second ring and lower oil ring gaps*
3 *Oil ring expander gap*

Connecting rod bearing oil clearance check

3 Clean the back side of the new upper bearing insert, then lay it in place in the connecting rod. Make sure the tab on the bearing fits into the recess in the rod so the oil holes align. 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 refit it in the rod cap. Again, make sure the tab on the bearing fits into the recess in the cap, and don't apply any lubricant. It's critically important that the mating surfaces of the bearing and connecting rod are perfectly clean and oil free when they're assembled.

5 Position the piston ring gaps at the proper spacing around the piston **(see illustrations)**.

6 Slip a section of plastic or rubber hose over each connecting rod cap bolt **(see illustration 13.5)**.

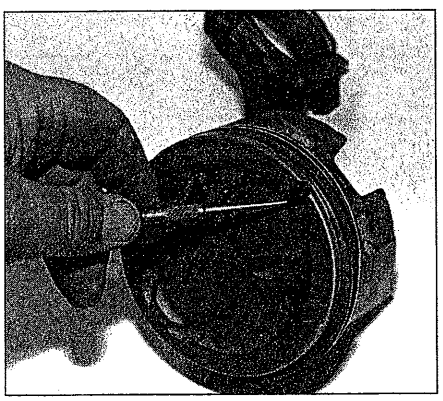
7 Lightly lubricate the piston and rings with clean engine oil and attach a piston ring compressor to the piston. Leave the skirt protruding about 6 mm to guide the piston into the cylinder. The rings must be compressed until they're flush with the piston.

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

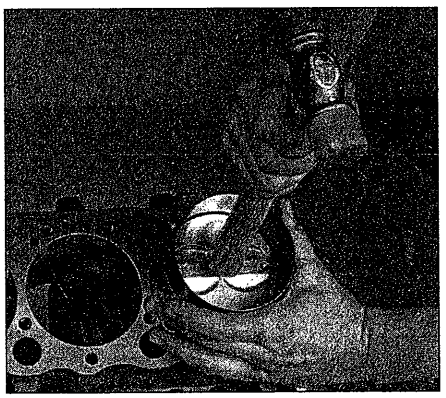
9 With the mark on top of the piston **(see illustration)** facing the front (timing chain end) of the engine, gently insert the piston/connecting rod assembly into the number one cylinder bore and rest the bottom edge of the ring compressor on the engine block.

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

11 Gently tap on the top of the piston with the end of a wooden or plastic hammer handle **(see illustration)** while guiding the end of



24.9 When refitted, the arrow or notch on the piston must face the front of the engine



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

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 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 refitted, the connecting rod bearing oil clearance must be checked before the rod cap is permanently bolted in place.

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

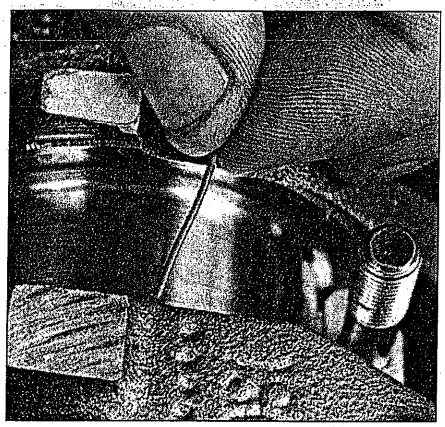
14 Clean the connecting rod cap bearing face, remove the protective hoses from the connecting rod bolts and refit the rod cap. Make sure the mating mark on the cap is on the same side as the mark on the connecting rod. Check the cap to make sure the front mark is facing the timing chain end of the engine.

15 Apply a light coat of oil to the undersides of the nuts, then refit and tighten them to the torque listed in this Chapter's Specifications. 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.

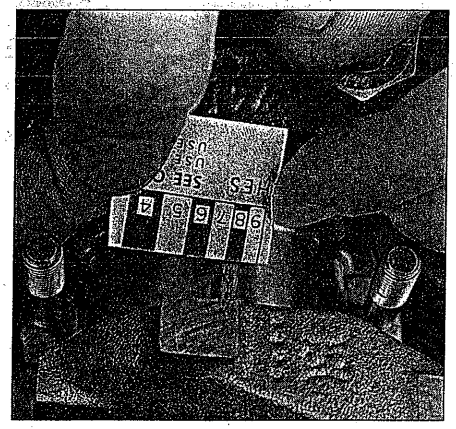
16 Remove the nuts and detach the rod cap, being very careful not to disturb the Plastigage.

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 the Specifications to make sure the clearance is correct.

18 If the clearance is not as specified, the bearing inserts may be the wrong size (which means different ones will be required). Before deciding that different inserts are needed, make sure that no dirt or oil was between the bearing inserts and the connecting rod or cap when the clearance was measured. Also, recheck the journal diameter. If the Plastigage was wider at one end than the other, the journal may be tapered (see Section 20).



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



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)

Final connecting rod refitting

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, refit the rod cap and tighten the nuts to the torque listed in this Chapter's Specifications.

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

23 The important points to remember are:

a) *Keep the back sides of the bearing inserts and the insides of the connecting rods and caps perfectly clean when assembling them.*

b) *Make sure you have the correct piston/rod assembly for each cylinder.*

c) *The arrow/notch on the piston must face the front (timing chain end) of the engine.*

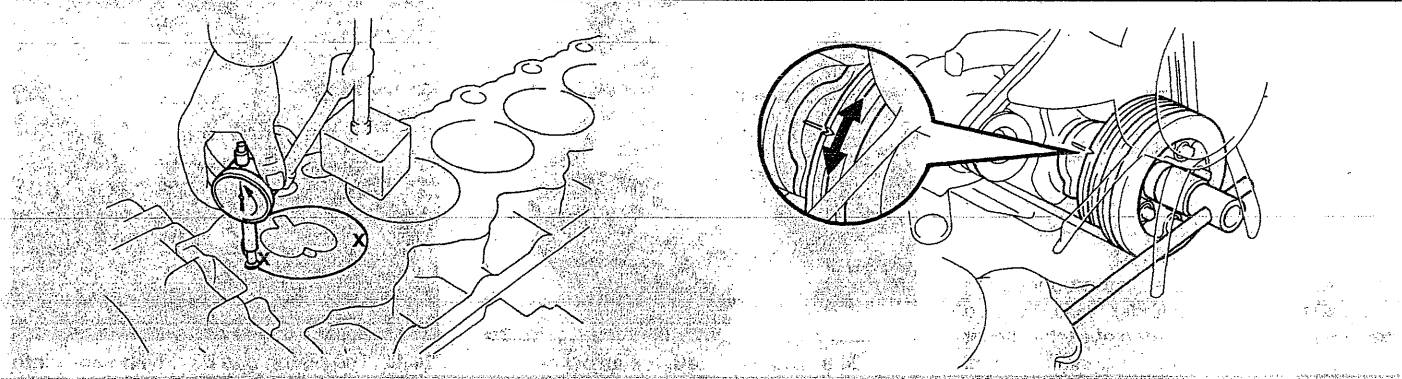
d) *Lubricate the cylinder walls with clean engine oil.*

e) *Lubricate the bearing faces when refitting the rod caps after the oil clearance has been checked.*

24 After all the piston/connecting rod assemblies have been properly refitted, rotate the crankshaft a number of times by hand to check for any obvious binding. **Note:** *On diesel engines, the small swirl chambers on the piston crowns must face the right (injection pump) side of the engine. The connecting rod numbers must be on the opposite side.*

25 As a final step, the connecting rod side clearance (endplay) must be checked (see Section 13).

26 Compare the measured side clearance to the Specifications to make sure it's correct. If it was correct before disassembly and the original crankshaft and rods were refitted, it should still be right. If new rods or a new crankshaft were refitted, the side clearance may be inadequate. If so, the rods will have to be removed and taken to an automotive



24.31 Install the dial indicator and check piston protrusion at the spots marked with an "X"

machine shop for re-sizing.

27 The rest of the assembly procedure is the reverse of the removal procedure.

Diesel piston protrusion measurement

28 It is critical on diesel engines to measure the piston protrusion (the distance that the crown of the piston rises above the top of the cylinder block when the piston is at top dead centre. This measurement is required to select a head gasket of the correct thickness. To do this, the short block must first be assembled with all six pistons/rods.

29 Obtain a dial indicator and a solid (non-adjustable) stand (sometimes called a bridge if it spans the cylinder bore).

30 Place the apparatus on the cylinder block deck and zero the dial indicator.

31 Now position the plunger of the indicator directly over one of the proper areas of the number one piston indicated **(see illustration)**.

32 Slowly rotate the crankshaft while observing the dial indicator. As the piston rises and begins to exit the top of the cylinder, the dial indicator will begin to move. At the point that the needle slows and then stops and begins to reverse, stop turning the engine. This is TDC for that cylinder.

33 Make a note of the dial indicator reading. The difference between this reading and the reading you took from the deck surface is the piston protrusion. Make several measurements in the proper areas of the piston and average the readings.

34 Perform this procedure for all six pistons. The largest protrusion will be used by your parts supplier to select the correct head gasket.

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 refitted in the vehicle, double-check the engine oil and coolant levels.

2 Start the engine. It may take a few moments for the petrol to reach the carburettor on models without fuel injection but the engine should start without a great deal of effort.

3 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 oil and coolant leaks.

4 Shut the engine off and recheck the engine oil and coolant levels.

5 Drive the vehicle to an area with no traffic, accelerate from 50 to 70 kph, then allow the vehicle to slow to 50 kph 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.

6 Drive the vehicle gently for the first 1,000 km (no sustained high speeds) and keep a constant check on the oil level. It is not unusual for an engine to use oil during the break-in period.

7 At approximately 1,000 km, change the oil and filter.

8 For the next few hundred kilometres, drive the vehicle normally. Do not pamper it or abuse it.

9 After 4,000 kilometres, change the oil and filter again and consider the engine fully broken in.

Notes