Chapter 2 Part B: Engine removal and general engine overhaul procedures

Contents

Degrees of difficulty

Easy, suitable for novice with little experience

Fairly easy, suitable for beginner with some experience

Fairly difficult, suitable for competent DIY mechanic

Difficult, suitable for experienced DIY mechanic

Very difficult, suitable for expert DIY or professional

Specifications

Cylinder head

Maximum permissible gasket surface distortion	0.10 mm
Valve seat included angle	90°
Valve guide bore	6.060 to 6.091 mm

Valves - general

	Inlet	Exhaust
Valve lift	7.500 to 7.685 mm	7.610 to 7.765 mm
Valve length	96.870 to 97.330 mm	96.470 to 96.930 mm
Valve head diameter:		
1.6 litre engine	26.0 mm	24.5 mm
1.8 and 2.0 litre engines	32.0 mm	28.0 mm
Valve stem diameter	6.028 to 6.043 mm	6.010 to6.025 mm
Valve stem-to-guide clearance	0.017 to 0.064 mm	0.035 to 0.081 mm

Cylinder block

Cylinder bore diameter - 1.6 litre engine:	
Class 1	76.000 to 76.010 mm
Class 2	76.010 to 76.020 mm
Class 3	76.020 to 76.030 mm
Cylinder bore diameter - 1.8 litre engine:	
Class 1	80.600 to 80.610 mm
Class 2	80.610 to 80.620 mm
Class 3	80.620 to 80.630 mm
Cylinder bore diameter - 2.0 litre engine:	
Class 1	84.800 to 84.810 mm
Class 2	84.810 to 84.820 mm
Class 3	84.820 to 84.830 mm

Pistons and piston rings

Piston diameter - 1.6 litre engine:	
Class 1	75.975 to 75.985 mm
Class 2	75.985 to 75.995 mm
Class 3	75.995 to 76.005 mm
Piston diameter - 1.8 litre engine:	
Class 1	80.570 to 80.580 mm
Class 2	80.580 to 80.590 mm
Class 3	80.590 to 80.600 mm
Piston diameter - 2.0 litre engine:	
Class 1	84.770 to 84.780 mm
Class 2	84.780 to 84.790 mm
Class 3	84.790 to 84.800 mm
Oversizes - all engines	None available
Piston-to-cylinder bore clearance	No information available at time of writing
Piston ring end gaps - installed:	
Top compression ring - 1.6 and 1.8 litre engines	0.30 to 0.50 mm
Top compression ring - 2.0 litre engine	0.26 to 0.50 mm
Second compression ring	0.30 to 0.50 mm
Oil control ring - 1.6 litre engine	0.25 to 1.00 mm
Oil control ring - 1.8 litre engine	0.38 to 1.14 mm
Oil control ring - 2.0 litre engine	0.40 to 1.40 mm

Gudgeon pin

Diameter:	
White colour code/piston crown marked “A”	20.622 to 20.625 mm
Red colour code/piston crown marked “B”	20.625 to 20.628 mm
Blue colour code/piston crown marked “C”	20.628 to 20.631 mm
Clearance in piston	0.010 to 0.016 mm
Connecting rod small-end eye internal diameter	20.589 to 20.609 mm
Interference fit in connecting rod	0.011 to 0.042 mm

Crankshaft and bearings

Main bearing shell standard inside diameter - installed	58.011 to 58.038 mm
Main bearing journal standard diameter	57.980 to 58.000 mm
Main bearing journal-to-shell running clearance	0.011 to 0.058 mm
Main bearing shell undersizes available	0.02 mm, 0.25 mm
Big-end bearing shell standard inside diameter - installed	46.926 to 46.960 mm
Crankpin (big-end) bearing journal standard diameter	46.890 to 46.910 mm
Crankpin (big-end) bearing journal-to-shell running clearance	0.016 to 0.070 mm
Big-end bearing shell undersizes available	0.02 mm, 0.25 mm
Crankshaft endfloat	0.090 to 0.310 mm

Torque wrench settings

	Nm	lbf ft
Main bearing cap bolts and nuts	80	59
Big-end bearing cap bolts:		
Stage 1	18	13
Stage 2	Angle-tighten a further 90°	
Piston-cooling oil jet/blanking plug Torx screws	10	7
Cylinder block and head oilway blanking plugs:		
M6 x 10	8 to 11	6 to 8
M10 x 11.5 - in block	24	17
1/4 PTF plug - in block	25	18
Power steering pump/air conditioning compressor mounting bracket-to-cylinder block bolts	47	35
Exhaust manifold heat shield mounting bracket-to-cylinder block bolts	32	24
Crankcase breather system:		
Oil separator-to-cylinder block bolts	10	7
Pipe-to-cylinder head bolt	23	17
Water pump bolts	See Chapter 3	
Driveshaft support bearing bracket-to-cylinder block bolts	48	35
Transmission-to-engine bolts	See Part A of this Chapter	
Engine/transmission mounting fasteners	See Part A of this Chapter	
Front suspension subframe bolts	130	96

Note: *Refer to Part A of this Chapter for remaining torque wrench settings.*

1 General information

How to use this Chapter

This Part of Chapter 2 is devoted to engine/transmission removal and refitting, to those repair procedures requiring the removal of the engine/transmission from the vehicle, and to the overhaul of engine components. It includes only the Specifications relevant to those procedures. Refer to Part A for additional Specifications, if required.

General information

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

The following Sections have been written based on the assumption that the engine has been removed from the vehicle. For information concerning in-vehicle engine repair, as well as removal and installation of the external components necessary for the overhaul, see Part A of this Chapter and Section 5 of this Part.

When overhauling this engine, it is essential to establish first exactly what replacement parts are available. At the time of writing, components such as the piston rings are not available separately from the piston/connecting rod assemblies; pistons, gudgeon pins and valve guides are not available separately, and very few under- or oversized components are available for engine reconditioning. In most cases, it would appear that the easiest and most economically-sensible course of action is to replace a worn or damaged engine with an exchange unit.

2 Engine overhaul - general information

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

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

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

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

An engine overhaul involves restoring all internal parts to the specification of a new engine. **Note:** *Always check first what replacement parts are available before planning any overhaul operation; refer to Section 1 of this Part. Ford dealers, or a good engine reconditioning specialist/automotive parts supplier may be able to suggest alternatives which will enable you to overcome the lack of replacement parts.*

During an overhaul, it is usual to renew the piston rings, and to rebore and/or hone the cylinder bores; where the rebore is done by an automotive machine shop, new oversize pistons and rings will also be installed - all these operations, of course, assume the availability of suitable replacement parts. The main and big-end 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're usually in less-than-perfect condition at this point. While the engine is being overhauled, other components, such as the starter and alternator, can be renewed as well, or rebuilt, if the necessary parts can be found. The end result should be an as-new engine that will give many trouble-free miles. **Note:** *Critical cooling system components such as the hoses, drivebelt, thermostat and water pump MUST be replaced with new parts when an engine is overhauled. The radiator should be checked carefully, to ensure that it isn't clogged or leaking (see Chapter 3). Also, as a general rule, the oil pump should be renewed when an engine is rebuilt.*

Before beginning the engine overhaul, read through the entire procedure to familiarise yourself with the scope and requirements of the job. Overhauling an engine isn't difficult, but it is time-consuming. Plan on the vehicle being off the road for a minimum of two weeks, especially if parts must be taken to an automotive machine shop for repair or reconditioning. Check on availability of parts, and make sure that any necessary special tools and equipment are obtained in advance. Most work can be done with typical hand tools, although a number of precision measuring tools are required, for inspecting parts to determine if they must be replaced. Often, an automotive machine shop will handle the inspection of parts, and will offer advice concerning reconditioning and replacement. **Note:** *Always wait until the engine has been completely dismantled, and all components, especially the cylinder block/crankcase, 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 cylinder block/crankcase has been thoroughly inspected.* As a general rule, time is the primary cost of an overhaul, so it doesn't pay to install worn or 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.

3 Engine/transmission removal - methods and precautions

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

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

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

The engine can only be withdrawn by removing it complete with the transmission; the vehicle's body must be raised and supported securely, sufficiently high that the engine/transmission can be unbolted as a single unit and lowered to the ground; the engine/transmission unit can then be withdrawn from under the vehicle and separated. An engine hoist or A-frame will therefore be necessary. Make sure the equipment is rated in excess of the combined weight of the engine and transmission. Safety is of primary importance, considering the potential hazards involved in removing the engine/transmission from the vehicle.

If this is the first time you have removed an engine, a helper should ideally 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 removing the engine/transmission from the vehicle.

Plan the operation ahead of time. Arrange for, or obtain, all of the tools and equipment you'll need prior to beginning the job. Some of the equipment necessary to perform engine/transmission removal and installation

safely and with relative ease, and which may have to be hired or borrowed, includes (in addition to the engine hoist) a heavy-duty trolley jack, a strong pair of axle stands, some wooden blocks, and an engine dolly (a low, wheeled platform capable of taking the weight of the engine/transmission, so that it can be moved easily when on the ground). A complete set of spanners and sockets (as described in the front of this manual) will obviously be needed, together with plenty of rags and cleaning solvent for mopping-up spilled oil, coolant and fuel. If the hoist is to be hired, make sure that you arrange for it in advance, and perform all of the operations possible without it beforehand. This will save you money and time.

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

Always be extremely careful when removing and installing the engine/transmission. Serious injury can result from careless actions. By planning ahead and taking your time, the job (although a major task) can be accomplished successfully.

4 Engine/transmission - removal and refitting

Warning: Petrol is extremely flammable, so take extra precautions when disconnecting any part of the fuel system. Don't smoke, or allow naked 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 installed. 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.

Note: *Read through the entire Section, as well as reading the advice in the preceding Section, before beginning this procedure. The engine and transmission are removed as a unit, lowered to the ground and removed from underneath, then separated outside the vehicle.*

Removal

1 Park the vehicle on firm, level ground, apply the handbrake firmly, and slacken the nuts securing both front roadwheels.

2 Relieve the fuel system pressure (see Chapter 4).

3 Disconnect the battery negative (earth) lead - see Chapter 5, Section 1. For better access the battery may be removed completely (see Chapter 5).

4 Place protective covers on the wings and engine compartment front crossmember, then remove the bonnet (see Chapter 11).

5 Whenever you disconnect any vacuum lines, coolant and emissions hoses, wiring loom connectors, earth straps and fuel lines as part of the following procedure, always label them clearly, so that they can be correctly reassembled.

6 Unplug the two electrical connectors, disconnect the vacuum hose (where fitted) and disconnect the crankcase breather hose from the cylinder head cover, then remove the complete air cleaner assembly, with the air mass meter, the resonator and the plenum chamber (see Chapter 4).

7 Equalise the pressure in the fuel tank by removing the filler cap, then undo the fuel feed and return lines connecting the engine to the chassis (see Chapter 4). Plug or cap all open fittings **(see illustration)**.

8 Disconnect the accelerator cable from the throttle linkage as described in Chapter 4 - where fitted, also disconnect the cruise control actuator cable (see Chapter 12). Secure the cable(s) clear of the engine/transmission.

9 Releasing its wire clip, unplug the power steering pressure switch electrical connector, then unbolt the power steering high-pressure pipe and the earth lead from the cylinder head rear support plate/engine lifting eye **(see illustrations)**.

10 Marking or labelling all components as they are disconnected (see paragraph 5 above), disconnect the vacuum hoses as follows:

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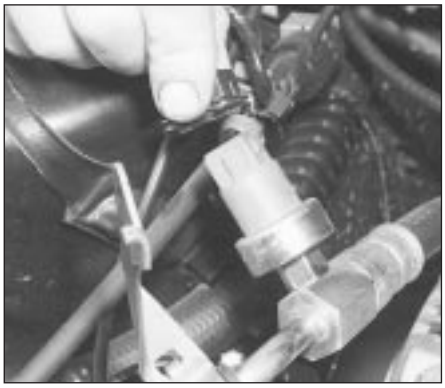
Whenever any wiring is disconnected, mark or label it as shown, to ensure correct reconnection . . .

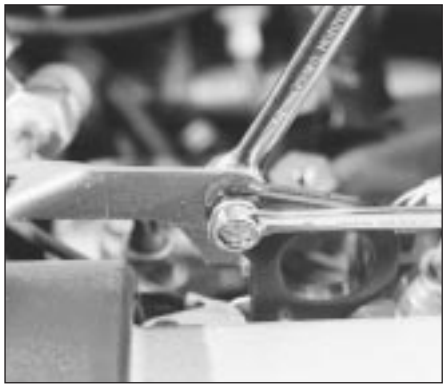
. . . vacuum hoses and pipes should be similarly marked

Masking tape and/or a touch-up paint applicator work well for marking items. Take instant photos, or sketch the locations of components and brackets.

4.7 Note colour-coding of unions when disconnecting fuel feed and return lines



4.9A Unplug the power steering pressure switch electrical connector . . .



4.9B . . . unbolt the power steering high-pressure pipe . . .

4.9C . . . and the earth lead from the cylinder head rear support plate/engine lifting eye

4.10A Disconnect vacuum hose shown from rear of throttle housing . . .

4.10B . . . vacuum hose (arrowed) from union on left-hand end on inlet manifold . . .

(a) One from the rear of the throttle housing (only the one hose - there is no need to disconnect the second hose running to the fuel pressure regulator) ***(see illustration)****.*

(b) One from the union on the inlet manifold's left-hand end ***(see illustration)****.*

(c) The braking system vacuum servo unit hose - from the inlet manifold (see Chapter 9 for details).

(d) Also disconnect the vacuum hoses from the Exhaust Gas Recirculation system components - one from the EGR valve, two from the EGR pipe (note that these last two are of different sizes, as are their pipe stubs, so that they can only be connected the correct way round).

(e) While you are there, trace the vacuum line from the pulse-air filter housing over the top of the transmission, and disconnect it by pulling the plastic pipe out of the rubber hose just beneath the bulkhead-mounted pulse-air solenoid valve ***(see illustration)****.*

(f) Secure all these hoses so that they won't get damaged as the engine/transmission is removed.

11 Unbolt the engine/transmission-to-body earth lead from the transmission's top surface **(see illustration)**. Disconnect the speedometer drive cable (see Chapter 12) and secure it clear of the engine/transmission.

12 Where the vehicle is fitted with manual transmission, disconnect the clutch cable (see Chapter 8). Where automatic transmission is fitted, disconnect the selector cable (see Chapter 7, Part B). Secure the cable clear of the engine/transmission.

13 Marking or labelling all components as they are disconnected (see paragraph 5 above), disconnect the engine wiring loom from the body as follows:

(a) Starting at the left-hand side of the engine compartment, release and unplug the three large electrical connectors clipped to the suspension mounting - note the wire clips fitted to some connectors ***(see illustration)****.*

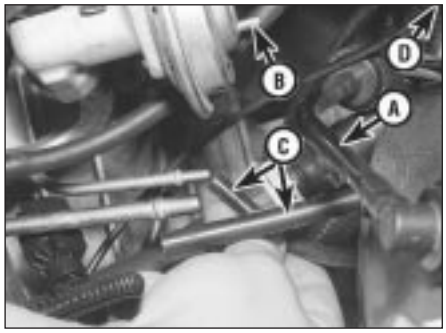
(b) Disconnect and/or release the battery-to-starter motor wiring, noting the single connector which must be unplugged.

(c) Unplug the electrical connector(s) to disconnect the vehicle speed sensor, oxygen sensor and, where fitted, the oil level sensor wiring - unclip the connectors to release the wiring where necessary.

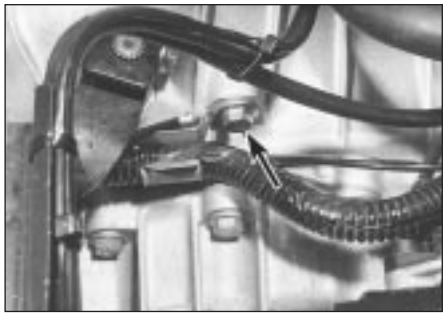
(d) Work along the loom to the bulkhead, unclipping the loom and unplugging the various bulkhead-mounted components connected into it, until you reach the right-hand side of the engine compartment ***(see illustration)****.*

(e) Carefully prise the power steering fluid reservoir upwards out of its clip on the suspension mounting, then unscrew the ECU connector's retaining bolt and unplug the connector ***(see illustration)****.*

(f) Unbolt the earth lead from the right-hand

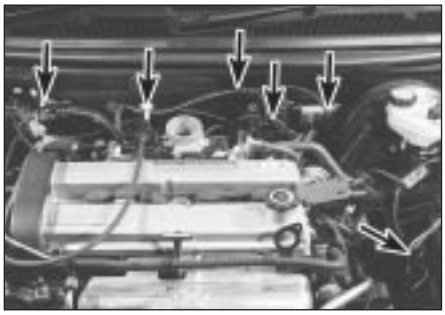


4.10C . . . also brake servo hose (A), EGR valve hose (B), EGR pipe hoses (C) - noting their different sizes - and pulse-air filter vacuum line (D)



4.11 Unbolt the engine/transmission-to-body earth lead - hidden behind wiring loom guide - from location (arrowed) on the transmission's top surface

4.13A Unplug three large electrical connectors (arrowed) . . .

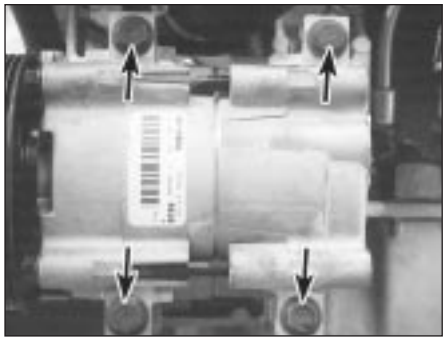


4.13B . . . unplug engine wiring loom from battery wiring and bulkhead components (arrowed) . . .

4.13C . . . and disconnect ECU wiring and earth lead (arrowed) to release engine wiring loom from vehicle body

4.25A Use split pins as shown to secure radiator in its raised position . . .

4.25B . . . while you unbolt the bottom mountings (arrowed) - note that the mountings are handed, and do not lose the mounting rubbers



4.30 Unscrew bolts (arrowed) to release air conditioning compressor from engine

inner wing panel, release the engine wiring loom and refit the power steering fluid reservoir.

(g) Secure the engine wiring loom neatly to the engine/transmission so that it cannot be damaged as the unit is removed from the vehicle.

14 Unbolt both parts of the exhaust manifold heat shield; unclip the coolant hose to allow the upper part to be withdrawn.

15 Remove the auxiliary drivebelt (see Chapter 1).

16 Unbolt the power steering pump (see Chapter 10); secure it as far as possible (without disconnecting the system's hoses) clear of the engine/transmission.

17 Raise the vehicle and support it securely on axle stands, then remove the front roadwheels. Drain the cooling system and (if the engine is to be dismantled) drain the engine oil and remove the oil filter (see Chapter 1). Also drain the transmission as described in the relevant Part of Chapter 7.

18 Withdraw the lower part of the exhaust manifold heat shield.

19 Unscrew the nuts to disconnect the exhaust system front downpipe from the manifold, then unhook all the system's rubber mountings and withdraw the complete exhaust system from under the vehicle (see Chapter 4 for details).

20 Where the vehicle is fitted with manual transmission, mark their positions, then disconnect the gearchange linkage and transmission support rods from the rear of the transmission. Unscrew the retaining nuts, and withdraw the gear linkage heat shield from the underbody. Unbolt the rear end of the linkage from the underbody, swivel the linkage around to the rear, and tie it to the underbody (see Chapter 7, Part A, for details).

21 Disconnect both anti-roll bar links from their respective suspension strut - note the flexible brake hose bracket attached to each link stud - and both track rod ends from their steering knuckles. Unfasten the clamp bolt securing each front suspension lower arm balljoint to its steering knuckle (see Chapter 10 for details). Check that both balljoints can be released from the knuckle assemblies when required, but leave them in place for the time being, secured by the clamp bolts if necessary.

22 Where the vehicle is fitted with air conditioning, unbolt the accumulator/dehydrator from the subframe; secure it as far as possible (without disconnecting the system's hoses) clear of the engine/transmission.

Warning: Do not disconnect the refrigerant hoses.

23 Unbolt the steering gear from the subframe; if the bolts are not accessible from above, a Ford service tool will be required to reach them from underneath the vehicle (see Chapter 10 for details).

24 Unscrew the two bolts securing the power steering system pipes to the right-hand side of the subframe.

25 Hold the radiator in its raised position, by inserting split pins through the holes in the rear of the engine compartment front crossmember and into the radiator's upper mounting extensions. Unbolt the radiator mounting brackets from the subframe; note that they are handed, and are marked to ensure correct refitting **(see illustrations)**. Collect and store the bottom mounting rubbers for safekeeping, noting which way up they are fitted.

26 Unbolt the engine/transmission rear mounting from the subframe - where the vehicle is fitted with automatic transmission, a separate damper may be fitted beneath the subframe, which must be unbolted to reach the mounting's fasteners. Where the vehicle is fitted with manual transmission, also unscrew the mounting centre bolt, and unbolt the mounting bracket from the transmission.

27 Unscrew the engine/transmission front mounting centre bolt, and unbolt the mounting from the subframe, noting the location of the wiring connector bracket.

28 Use white paint or similar (do not use a sharp-pointed scriber, which might break the underbody protective coating and cause rusting) to mark the exact relationship of the subframe to the underbody. Unscrew the four mounting bolts from the subframe (note their different-sized washers - see also illustration 4.47A) and allow the subframe to hang down on the suspension lower arm balljoints. Disconnect the balljoints one at a time from the steering knuckle assemblies (see Chapter 10) and lower the subframe to the ground; withdraw the subframe from under the vehicle.

29 Marking or labelling all components as they are disconnected (see paragraph 5 above) and catching as much as possible of the escaping coolant in the drain tray, disconnect the cooling system hoses and pipes as follows - refer to Chapter 3 for further details, if required:

(a) Remove the radiator top hose.

(b) Remove the (heater) hose running from the thermostat to the engine compartment bulkhead union.

(c) Disconnect from the thermostat the hose running to the expansion tank - secure the hose clear of the working area.

(d) Disconnect from the thermostat the coolant hose/pipe which runs to the radiator bottom hose.

(e) Disconnect the radiator bottom hose from the radiator union, from the (sump) heater coolant pipe and from the water pump union - secure the hose clear of the working area.

(f) Unbolt the (heater) coolant pipe from the sump, trace the pipe/hose round to the engine compartment bulkhead union, disconnecting (where fitted) the oil cooler hoses from the cooler unions, then remove it.

(g) Unless the vehicle has air conditioning fitted, secure the radiator as far forwards as possible while it is in its raised position; if air conditioning is fitted, remove the radiator completely (see Chapter 3).

30 Where the vehicle is fitted with air conditioning, unplug the compressor's electrical connector, and unbolt the compressor from the engine **(see illustration)**. Secure it as far as possible (without disconnecting the system's hoses) clear of the engine/transmission.

Warning: Do not disconnect the refrigerant hoses.

31 Where the vehicle is fitted with manual transmission, disconnect the driveshafts from the transmission as follows, referring to Chapter 8 for further details when required:

(a) Unscrew the nuts securing the right-hand driveshaft support bearing, and withdraw the heat shield.
(b) Pull the right-hand driveshaft out of the transmission; be prepared to catch any spilt oil.
(c) Secure the driveshaft clear of the engine/transmission - remember that the unit is to be lowered out of the vehicle - and ensure that the inner joint is not turned through more than 18°.
(d) Prise the left-hand driveshaft out of the transmission - again, be prepared for oil spillage. Secure the driveshaft clear of the engine/transmission, and ensure that its inner joint is not turned through more than 18°.

32 Where the vehicle is fitted with automatic transmission, proceed as follows, referring to Chapter 7, Part B and to Chapter 8 for further details when required:

(a) Unscrew its centre bolt, then unbolt the engine/transmission rear mounting bracket from the transmission.
(b) Disconnect the fluid cooler pipe from the rear of the transmission, and secure it clear of the unit.
(c) Prise the left-hand driveshaft out of the transmission; be prepared to catch any spilt oil.
(d) Secure the driveshaft clear of the engine/transmission - remember that the unit is to be lowered out of the vehicle - and ensure that the inner joint is not turned through more than 18°.
(e) Unscrew the nuts securing the right-hand driveshaft support bearing, and withdraw the heat shield.
(f) Pull the right-hand driveshaft out of the transmission - again, be prepared for oil spillage. Secure the driveshaft clear of the engine/transmission, and ensure that its inner joint is not turned through more than 18°.
(g) Disconnect the fluid cooler pipe from the front of the transmission, and secure it clear of the unit.

33 The engine/transmission unit should now be hanging on the right- and left-hand mountings only, with all components which connect it to the rest of the vehicle disconnected or removed and secured well clear of the unit. Make a final check that this is the case, then ensure that the body is securely supported, high enough to permit the withdrawal of the engine/transmission unit from underneath; allow for the height of the engine dolly, if used.

34 Take the weight of the engine/transmission unit, using the lifting eyes provided on the cylinder head. Unscrew the six nuts securing the right-hand mounting bracket, then the three nuts securing the left-hand bracket.

Warning: Do not put any part of your body under the vehicle, or under the engine/transmission unit, when they are supported only by a hoist or other lifting equipment.

35 Lower the engine/transmission to the ground, and withdraw it from under the vehicle **(see illustration)**.

36 Referring to the relevant part of Chapter 7, separate the transmission from the engine.

37 While the engine/transmission is removed, check the mountings; renew them if they are worn or damaged. Similarly, check the condition of all coolant and vacuum hoses and pipes (see Chapter 1); components that are normally hidden can now be checked properly, and should be renewed if there is any doubt at all about their condition. Where the vehicle is fitted with manual transmission, take the opportunity to overhaul the clutch components (see Chapter 8). It is regarded by many as good working practice to renew the clutch assembly as a matter of course, whenever major engine overhaul work is carried out. Check also the condition of all components (such as the transmission oil seals) disturbed on removal, and renew any that are damaged or worn.

Refitting

38 Refitting is the reverse of the removal procedure, noting the following points. Tighten all fasteners to the torque wrench settings given; where settings are not quoted in the Specifications Sections of the two Parts of this Chapter, refer to the Specifications Section of the relevant Chapter of this manual.

39 In addition to the points noted in paragraph 37 above, always renew any circlips and self-locking nuts disturbed on removal.

40 Where wiring, etc, was secured by cable ties which had to be cut on removal, ensure that it is secured with new ties on refitting.

41 With all overhaul operations completed, refit the transmission to the engine as described in Chapter 7.

42 Manoeuvre the engine/transmission unit under the vehicle, attach the hoist, and lift the unit into position until the right- and left-hand mountings can be reassembled; tighten the (new) nuts only lightly at this stage. Do not yet release the hoist; the weight of the engine/transmission unit must not be taken by the mountings until all are correctly aligned.

43 Using new circlips, and ensuring that the inner joints are not twisted through too great an angle (see Chapter 8), refit the driveshafts. Where the vehicle is fitted with manual transmission, the procedure is the reverse of that outlined in paragraph 31 above. Where the vehicle is fitted with automatic transmission, proceed as follows, referring to Chapter 7, Part B and to Chapter 8 for further details when required:

(a) Refit the left-hand driveshaft.
(b) Using the clips provided to ensure that they are correctly routed, and tightening the couplings to the specified torque wrench setting where possible, reconnect the fluid cooler pipes, first to the rear, then to the front, of the transmission.
(c) Refit the right-hand driveshaft to the transmission, refit the heat shield, and tighten the support bearing nuts to the specified torque wrench setting.
(d) Refit the engine/transmission rear mounting bracket to the transmission, tightening the bolts to the torque wrench setting specified, then refit the mounting, tightening the centre bolt only lightly at this stage.

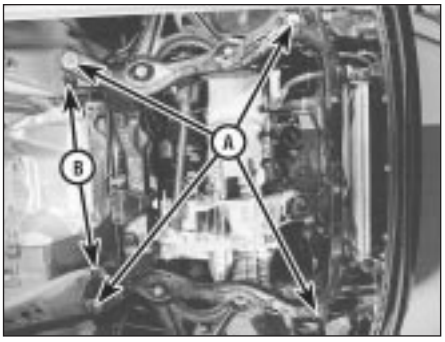
4.35 Lowering the engine/transmission unit out of the vehicle

44 Where the vehicle is fitted with air conditioning, do not forget to refit the compressor; tighten the bolts to the specified torque wrench setting, and plug in its electrical connector.

45 Using the marks and notes made on removal, refit the cooling system hoses. Where they are left disconnected or unclipped for the time being, do not forget to secure them at the appropriate moment during the reassembly procedure. Refit the radiator (if removed), using split pins to secure it in the raised position.

46 Offer up the subframe one side at a time, and hold it by securing the suspension lower arm balljoints to the steering knuckle assemblies. Refit the subframe bolts, ensuring that the washers are refitted correctly, and tightening the bolts only lightly at this stage.

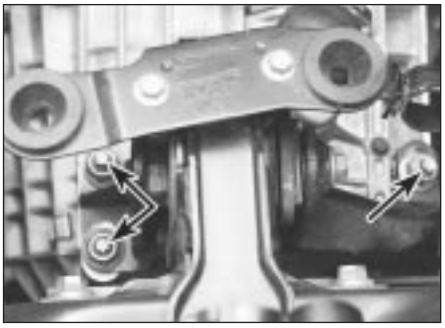
47 The subframe must now be aligned on the underbody. Ford specify the use of service tool 15-097, which is a pair of tapered guides, with attachments to hold them in the subframe as it is refitted. However, since the working diameter of these tools is 20.4 mm, and since the corresponding aligning holes in the subframe and underbody are respectively 21 mm and 22 mm in diameter, there is a significant in-built tolerance possible in the subframe's alignment, even if the correct tools are used. If these tools are not available, you can align the subframe by eye, centring the subframe aligning holes on those of the underbody, and using the marks made on removal for assistance. Alternatively, you can align the subframe using a tapered drift (such as a clutch-aligning tool), or even a deep



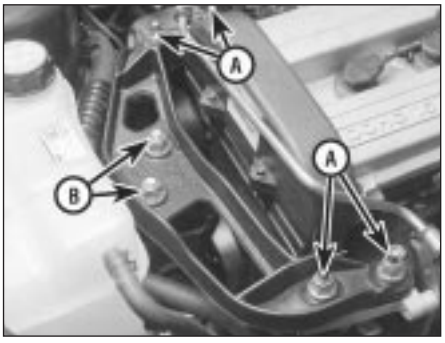
4.47A Tighten subframe mounting bolts (A) while ensuring that alignment remains correct - Ford service tools (B) shown in use here . . .

4.47B . . . but alternative methods using ordinary hand tools can achieve acceptable alignment, with care

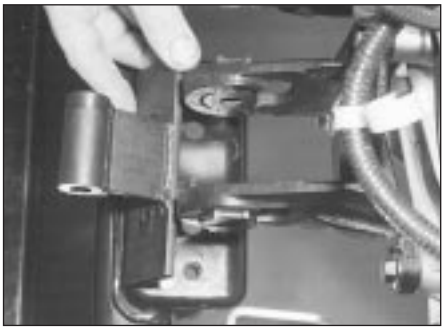
4.49 Special tool required to hold engine/transmission unit precisely, so that mountings can be tightened into correct position



4.50A Do not allow the left-hand mounting to twist as its nuts (arrowed) are tightened



4.50B Tighten the right-hand mounting's four bracket-to-engine nuts (A), release the hoist, then tighten the two bracket-to-mounting nuts (B). Do not allow mounting to twist



4.50C Unbolt special tool . . .

socket spanner of suitable size **(see illustrations)**.

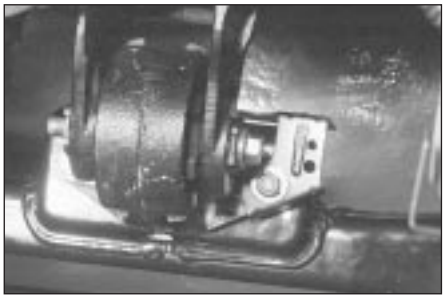
48 Once the subframe is aligned as precisely as possible, tighten its bolts to the specified torque wrench setting without disturbing its position. Recheck the alignment once all the bolts are securely tightened.

49 With the subframe aligned and securely fastened, the engine/transmission unit must now be positioned precisely, before the mountings can be reassembled. Ford specify the use of service tool 21-172; this is a fixture bolted to the subframe in place of the engine/transmission front mounting, so that when the mounting's centre bolt is refitted, it is held 60 mm above the subframe's top surface, and offset 20 mm to the rear of the mounting's subframe bolt holes (centres). DIY mechanics are advised to obtain the Ford tool; the only alternative is to have a copy fabricated **(see illustration)**.

50 Fasten the tool to the subframe in place of the engine/transmission front mounting, and lightly tighten the mounting's centre bolt. Refit the engine/transmission mountings in the following sequence:

*(a) Tighten the left-hand mounting's nuts to the specified torque wrench setting - do not allow the mounting to twist as it is tightened **(see illustration)**.*

(b) Tighten the right-hand mounting's four bracket-to-engine nuts to the specified torque wrench setting.



4.50D . . . then refit front mounting - do not forget wiring connector bracket - tighten the mounting's nuts first, then its centre bolt

(c) Slowly release the hoist so that the weight of the engine/transmission unit is taken by the mountings.

*(d) Tighten the right-hand mounting's two bracket-to-mounting nuts to the specified torque wrench setting - do not allow the mounting to twist as it is tightened **(see illustration)**.*

(e) Reassemble the engine/transmission rear mounting, tightening the fasteners to the specified torque wrench settings; tighten the centre bolt last.

(f) Refit the steering gear to the subframe; if the Ford service tool is used to tighten the bolts from underneath the vehicle (see Chapter 10 for details), note that a torque wrench which can tighten in an anti-clockwise direction will be required.

*(g) Unbolt the special tool from the front mounting, refit the mounting - do not forget the wiring connector bracket - and tighten first the mounting's bolts/nuts, then its centre bolt, to their respective specified torque wrench settings **(see illustrations)**.*

51 Refit the bottom mounting rubbers to the radiator - ensure that both are the correct way up - then refit the radiator mounting brackets to the subframe, ensuring that each is returned to its correct (marked) location, and tightening the bolts to the torque wrench setting specified. Remove the split pins, and secure the coolant hose connections (where necessary).

52 Refit the air conditioning accumulator/dehydrator (where appropriate) to the subframe.

53 Tighten the two bolts securing the power steering system pipes to the right-hand side of the subframe.

54 Fasten each front suspension lower arm balljoint and track rod end to their respective steering knuckles, and both anti-roll bar links to their respective suspension strut. Note the flexible brake hose bracket attached to each link stud (see Chapter 10 for details).

55 Where the vehicle is fitted with manual transmission, swivel the linkage around to the front, tighten its rear fasteners, then refit the

gear linkage heat shield. Reconnect the gearchange linkage and transmission support rods to the transmission, adjusting the linkage using the marks made on removal (see Chapter 7, Part A, for details).

56 Re-install the remaining components and fasteners in the reverse order of removal.

57 Add coolant, engine oil and transmission fluids as needed (see Chapter 1).

58 Run the engine, and check for proper operation and the absence of leaks. Shut off the engine, and recheck the fluid levels.

59 Remember that, since the front suspension subframe and steering gear have been disturbed, the wheel alignment and steering angles must be checked fully and carefully as soon as possible, with any necessary adjustments being made. This operation is best carried out by an experienced mechanic, using proper checking equipment; the vehicle should therefore be taken to a Ford dealer or similarly-qualified person for attention.

5 Engine overhaul - dismantling sequence

1 It is much easier to dismantle and work on the engine if it is mounted on a portable engine stand. These stands can often be hired from a tool hire shop. Before the engine is mounted on a stand, the flywheel/driveplate should be removed (Part A of this Chapter, Section 21) so that the stand bolts can be tightened into the end of the cylinder block/crankcase.

2 If a stand is not available, it is possible to dismantle the engine with it mounted on blocks, 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 reconditioned engine, all external components must be removed first, to be transferred to the replacement engine (just as they will if you are doing a complete engine overhaul yourself).

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

(a) Alternator and brackets (Chapter 5).
(b) HT leads and spark plugs (Chapter 1).
(c) Thermostat and housing (Chapter 3).
(d) Dipstick tube.
(e) Fuel injection system components (Chapter 4).
(f) All electrical switches and sensors - refer to the appropriate Chapter.
(g) Inlet and exhaust manifolds (Part A of this Chapter).
(h) Oil filter (Chapter 1).
(i) Engine/transmission mounting brackets (Part A of this Chapter, Section 22).
(j) Flywheel/driveplate (Part A of this Chapter, Section 21).

4 If you are obtaining a "short" engine (which consists of the engine cylinder block/crankcase, crankshaft, pistons and connecting rods all assembled), then the cylinder head, sump, oil pump, and timing belt will have to be removed also.

5 If you are planning a complete overhaul, the engine can be dismantled and the internal components removed in the following order.

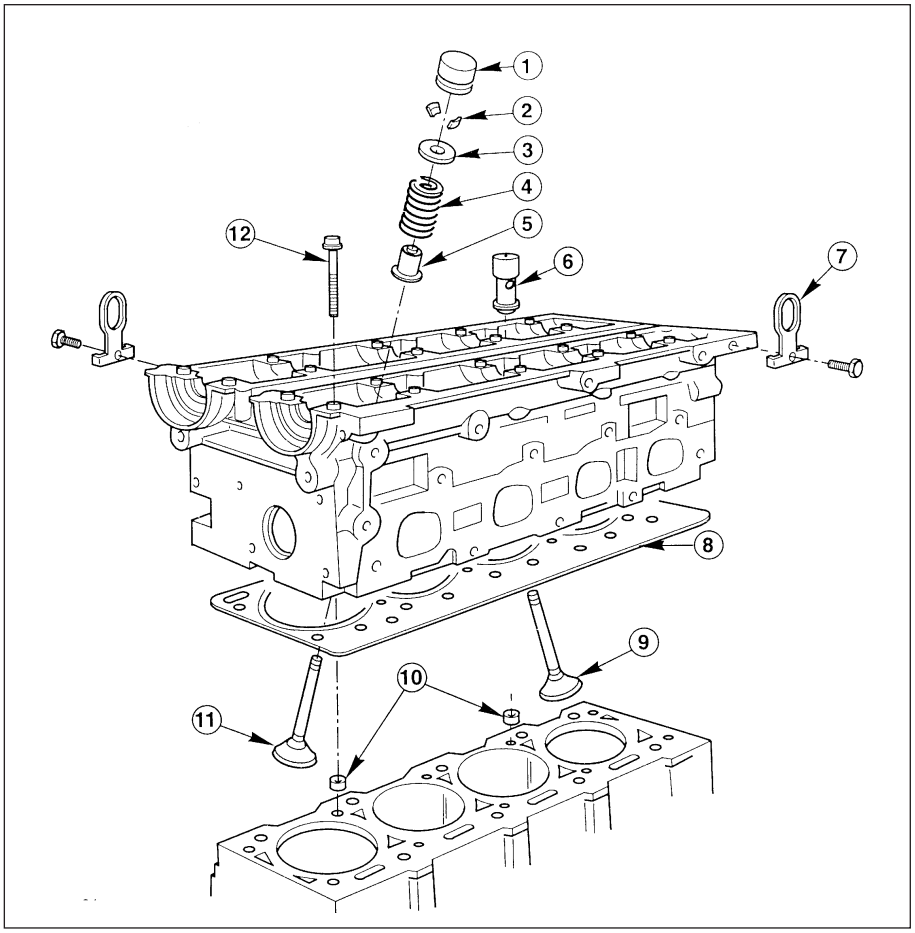
(a) Inlet and exhaust manifolds (Part A of this Chapter).
(b) Timing belt, toothed pulleys and tensioner, and timing belt inner cover (Part A of this Chapter).
(c) Cylinder head (Part A of this Chapter, Section 14).
(d) Flywheel/driveplate (Part A of this Chapter, Section 21).
(e) Sump (Part A of this Chapter, Section 15).
(f) Oil pump (Part A of this Chapter, Section 16).
(g) Piston/connecting rod assemblies (Section 9).
(h) Crankshaft (Section 10).

6 Before beginning the dismantling and overhaul procedures, make sure that you have all of the correct tools necessary. Refer to the introductory pages at the beginning of this manual for further information.

6 Cylinder head - dismantling

Note: *New and reconditioned cylinder heads are available from the manufacturers, and from engine overhaul specialists. Due to the fact that some specialist tools are required for the dismantling and inspection procedures, and new components may not be readily available (refer to Section 1 of this Part), it may be more practical and economical for the home mechanic to purchase a reconditioned head, rather than to dismantle, inspect and recondition the original head.*

1 Remove the camshafts and hydraulic tappets (Part A of this Chapter, Section 13), being careful to store the hydraulic tappets as described **(see illustration)**.



6.1 Cylinder head components

1 Hydraulic tappet
2 Valve collets
3 Valve spring upper seat
4 Valve spring
5 Valve spring lower seat/stem oil seal
6 Oil-retaining valve
7 Engine lifting eye
8 Cylinder head gasket
9 Inlet valve
10 Locating dowels
11 Exhaust valve
12 Cylinder head bolt

6.3A Standard valve spring compressor modified as shown . . .

6.3B . . . or purpose-built special version, is required to compress valve springs without damaging cylinder head . . .

6.3C . . . so that both valve split collets can be removed from the valve's stem - small magnetic pick-up tool prevents loss of small metal components on removal and refitting

2 Remove the cylinder head (Part A of this Chapter, Section 14).

3 Using a valve spring compressor, compress each valve spring in turn until the split collets can be removed. A special valve spring compressor will be required, to reach into the deep wells in the cylinder head without risk of damaging the hydraulic tappet bores; such compressors are now widely available from most good motor accessory shops. Release the compressor, and lift off the spring upper seat and spring **(see illustrations)**.

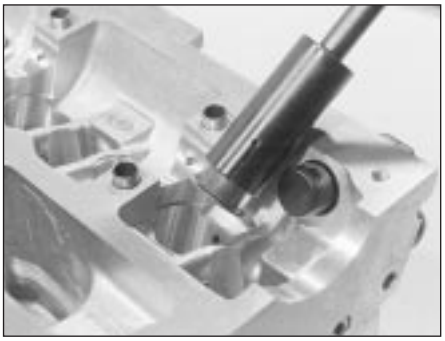
4 If, when the valve spring compressor is screwed down, the spring upper seat refuses to free and expose the split collets, gently tap the top of the tool, directly over the upper seat, with a light hammer. This will free the seat.

5 Withdraw the valve through the combustion chamber. If it binds in the guide (won't pull through), push it back in, and de-burr the area around the collet groove with a fine file or whetstone; take care not to mark the hydraulic tappet bores.

6 Ford recommend the use of their service tool 21-160 to extract the valve spring lower seat/stem oil seals; while this is almost indispensable if the seals are to be removed without risk of (extremely expensive) damage to the cylinder head, we found that a serviceable substitute can be made from a strong spring of suitable size. Screw on the tool or spring so that it bites into the seal, then draw the seal off the valve guide **(see illustrations)**.

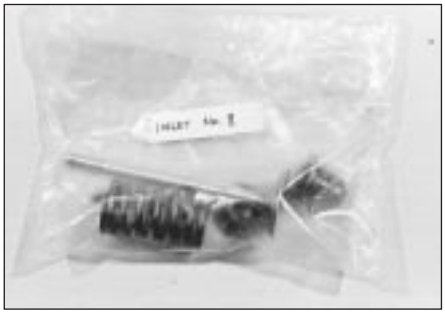
7 It is essential that the valves are kept together with their collets, spring seats and springs, and in their correct sequence (unless they are so badly worn that they are to be renewed). If they are going to be kept and used again, place them in a labelled polythene bag or similar small container **(see illustration)**. Note that No 1 valve is nearest to the timing belt end of the engine.

8 If the oil-retaining valve is to be removed (to flush out the cylinder head oil galleries thoroughly), seek the advice of a Ford dealer as to how it can be extracted; it may be that the only course of action involves destroying the valve as follows. Screw a self-tapping screw into its ventilation hole, and use the screw to provide purchase with which the valve can be drawn out; a new valve must be purchased and pressed into place on reassembly **(see illustration)**.

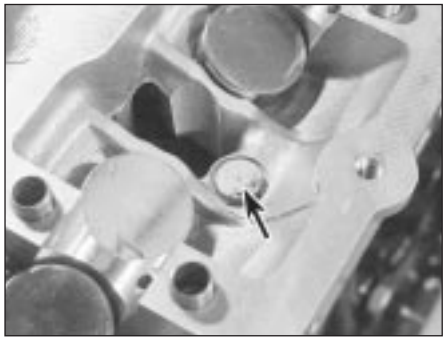


6.6A Ford service tool in use to remove valve spring lower seat/stem oil seals . . .

6.6B . . . can be replaced by home-made tool if suitable spring can be found



6.7 Use clearly-marked containers to identify components and to keep matched assemblies together



6.8 Cylinder head oil-retaining valve (arrowed)

7 Cylinder head and valve components - cleaning and inspection

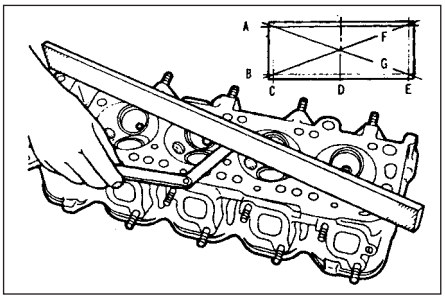
Note: *Always check first what replacement parts are available before planning any overhaul operation; refer to Section 1 of this Part. A Ford dealer, or a good engine reconditioning specialist/automotive parts supplier, may be able to suggest alternatives which will enable you to overcome the lack of replacement parts.*

1 Thorough cleaning of the cylinder head and valve components, followed by a detailed inspection, will enable you to decide how much valve service work must be carried out during the engine overhaul. **Note:** *If the engine has been severely overheated, it is best to assume that the cylinder head is warped, and to check carefully for signs of this.*

Cleaning

2 Scrape away all traces of old gasket material and sealing compound from the cylinder head (see Part A of this Chapter, Section 14 for details).

3 Scrape away the carbon from the combustion chambers and ports, then wash the cylinder head thoroughly with paraffin or a suitable solvent.



7.6 Check the cylinder head gasket surfaces for warpage, in the planes indicated (A to G). Try to slip a feeler gauge under the precision straight edge (see the Specifications for the maximum distortion allowed, and use a feeler blade of that thickness)

4 Scrape off any heavy carbon deposits that may have formed on the valves, then use a power-operated wire brush to remove deposits from the valve heads and stems.

Inspection

Note: *Be sure to perform all the following inspection procedures before concluding that the services of a machine shop or engine overhaul specialist are required. Make a list of all items that require attention.*

Cylinder head

5 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.

6 Use a straight edge and feeler blade to check that the cylinder head gasket surface is not distorted **(see illustration)**. If it is, it may be possible to re-surface it.

7 Examine the valve seats in each of the combustion chambers. If they are severely pitted, cracked or burned, then they will need to be renewed or re-cut by an engine overhaul specialist. If they are only slightly pitted, this can be removed by grinding-in the valve heads and seats with fine valve-grinding compound, as described below.

8 If the valve guides are worn, indicated by a side-to-side motion of the valve, new guides must be fitted. Measure the diameter of the existing valve stems (see below) and the bore of the guides, then calculate the clearance, and compare the result with the specified value; if the clearance is excessive, renew the valves or guides as necessary.

9 The renewal of valve guides is best carried out by an engine overhaul specialist.

10 If the valve seats are to be re-cut, this must be done *only after* the guides have been renewed.

Valves

11 Examine the head of each valve for pitting, burning, cracks and general wear, and check the valve stem for scoring and wear ridges. Rotate the valve, and check for any obvious indication that it is bent. Look for pits and excessive wear on the tip of each valve stem. Renew any valve that shows any such signs of wear or damage.

12 If the valve appears satisfactory at this stage, measure the valve stem diameter at several points, using a micrometer **(see illustration)**. Any significant difference in the readings obtained indicates wear of the valve stem. Should any of these conditions be apparent, the valve(s) must be renewed.

13 If the valves are in satisfactory condition, they should be ground (lapped) into their respective seats, to ensure a smooth gas-tight seal. If the seat is only lightly pitted, or if it has been re-cut, fine grinding compound *only* should be used to produce the required finish. Coarse valve-grinding compound should *not* be used unless a seat is badly burned or deeply pitted; if this is the case, the cylinder head and valves should be inspected by an expert, to decide whether seat re-cutting, or even the renewal of the valve or seat insert, is required.

14 Valve grinding is carried out as follows. Place the cylinder head upside-down on a bench, with a block of wood at each end to give clearance for the valve stems.

15 Smear a trace of (the appropriate grade of) valve-grinding compound on the seat face, and press a suction grinding tool onto the valve head. With a semi-rotary action, grind the valve head to its seat, lifting the valve occasionally to redistribute the grinding compound **(see illustration)**. A light spring placed under the valve head will greatly ease this operation.

16 If coarse grinding compound is being used, work only until a dull, matt even surface is produced on both the valve seat and the valve, then wipe off the used compound, and repeat the process with fine compound. When a smooth unbroken ring of light grey matt finish is produced on both the valve and seat, the grinding operation is complete. *Do not* grind in the valves any further than absolutely necessary, or the seat will be prematurely sunk into the cylinder head.

17 When all the valves have been ground-in, carefully wash off *all* traces of grinding compound, using paraffin or a suitable solvent, before reassembly of the cylinder head.

Valve components

18 Examine the valve springs for signs of damage and discolouration, and also measure their free length by comparing each of the existing springs with a new component.

19 Stand each spring on a flat surface, and check it for squareness **(see illustration)**. If any of the springs are damaged, distorted, or have lost their tension, obtain a complete set of new springs.

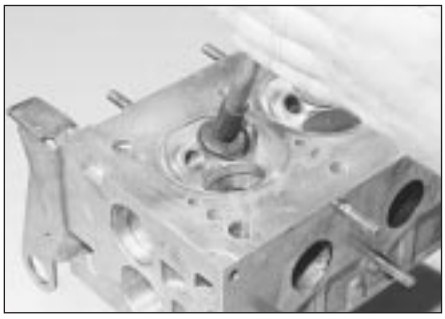
20 Check the spring upper seats and collets for obvious wear and cracks. Any questionable parts should be renewed, as extensive damage will occur if they fail during engine operation. Any damaged or excessively-worn parts must be renewed; the valve spring lower seat/stem oil seals must be renewed as a matter of course whenever they are disturbed.

21 Check the hydraulic tappets as described in Part A of this Chapter, Section 13.

8 Cylinder head - reassembly

1 Regardless of whether or not the head was sent away for repair work of any sort, make sure that it is clean before beginning reassembly. Be sure to remove any metal particles and abrasive grit that may still be present from operations such as valve

7.12 Measuring the diameter of a valve stem - if any significant difference is found in the readings obtained, excessive valve stem wear is indicated



7.15 Grinding-in a valve seat - do not grind in the valves any more than absolutely necessary, or their seats will be prematurely sunk into the cylinder head

7.19 Check each valve spring for squareness

8.3 Valve spring pressure is sufficient to seat lower seat/stem oil seals on reassembly

8.5 Apply a small dab of grease to each collet before installation - it will hold them in place on the valve stem until the spring is released

9.4 Removing the oil baffle to provide access to crankshaft and bearings

grinding or head resurfacing. Use compressed air, if available, to blow out all the oil holes and passages.

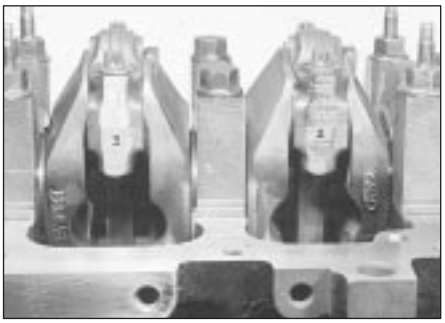
2 Beginning at one end of the head, lubricate and install the first valve. Apply molybdenum disulphide-based grease or clean engine oil to the valve stem, and refit the valve. Where the original valves are being re-used, ensure that each is refitted in its original guide. If new valves are being fitted, insert them into the locations to which they have been ground.

3 Fit the plastic protector supplied with new valve spring lower seat/stem oil seals to the end of the valve stem, then put the new seal squarely on top of the guide, and leave it there; the action of refitting the valve spring presses the lower seat/stem oil seal into place **(see illustration)**.

4 Refit the valve spring and upper seat.

5 Compress the spring with a valve spring compressor, and carefully install the collets in the stem groove. Apply a small dab of grease to each collet to hold it in place if necessary **(see illustration)**. Slowly release the compressor, and make sure the collets seat properly.

6 When the valve is installed, place the cylinder head flat on the bench and, using a hammer and interposed block of wood, tap the end of the valve stem gently, to settle the components.



9.5A Each connecting rod and big-end bearing cap will have a flat-machined surface visible from the front (exhaust) side of the engine, with the cylinder number etched in it

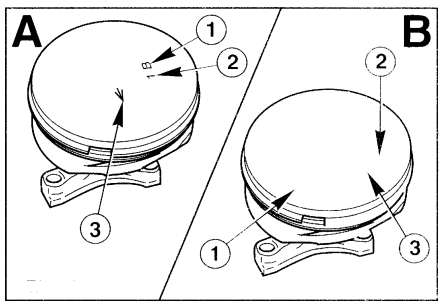
7 Repeat the procedure for the remaining valves. Be sure to return the components to their original locations - don't mix them up!

8 Refit the hydraulic tappets (Part A of this Chapter, Section 13).

9 Piston/connecting rod assemblies - removal

Note: *Always check first what replacement parts are available before planning any overhaul operation; refer to Section 1 of this Part. A Ford dealer, or a good engine reconditioning specialist/automotive parts supplier, may be able to suggest alternatives which will enable you to overcome the lack of replacement parts.*

Note: *While this task is theoretically possible when the engine is in place in the vehicle, in practice, it requires so much preliminary dismantling, and is so difficult to carry out due to the restricted access, that owners are advised to remove the engine from the vehicle first. In addition to the new gaskets and other replacement parts required, a hoist will be needed. Alternatively, an adjustable engine support bar, fitting into the water drain channels on each side of the bonnet aperture, and having a hook which will engage the engine lifting eyes and allow the height of the engine to be adjusted, could be used. Lifting equipment such as this can be hired from most tool hire shops - be sure that any such equipment is rated well in excess of the combined weight of the engine/transmission unit.*



9.5B Piston crown markings

A 1.6 and 1.8 litre engines
B 2.0 litre engines
1 Gudgeon pin diameter grade - when used
2 Piston skirt diameter grade
3 Arrow mark - pointing to timing belt end of engine

1 Remove the cylinder head (Part A of this Chapter, Section 14).

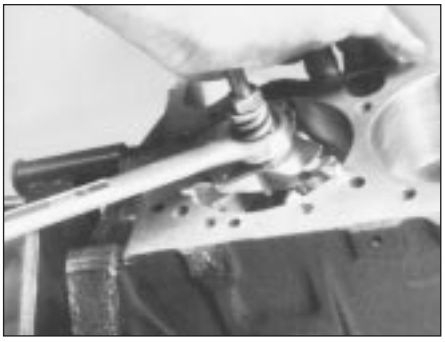
2 Bolt lifting eyes to suitable points on the engine and transmission, then attach the lifting equipment so that the engine/transmission unit is supported securely.

3 Remove the sump (Part A of this Chapter, Section 15).

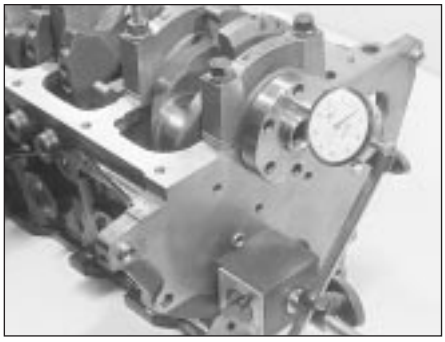
4 Undo the screws securing the oil pump pick-up/strainer pipe to the pump, then unscrew the four nuts, and withdraw the oil pump pick-up/strainer pipe and oil baffle **(see illustration)**.

5 Temporarily refit the crankshaft pulley, so that the crankshaft can be rotated. Note that each piston/connecting rod assembly can be identified by its cylinder number (counting from the timing belt end of the engine) etched into the flat-machined surface of both the connecting rod and its cap. The numbers are visible from the front (exhaust side) of the engine. Furthermore, each piston has an arrow stamped into its crown, pointing towards the timing belt end of the engine. If no marks can be seen, make your own before disturbing any of the components, so that you can be certain of refitting each piston/connecting rod assembly the right way round, to its correct (original) bore, with the cap also the right way round **(see illustrations)**.

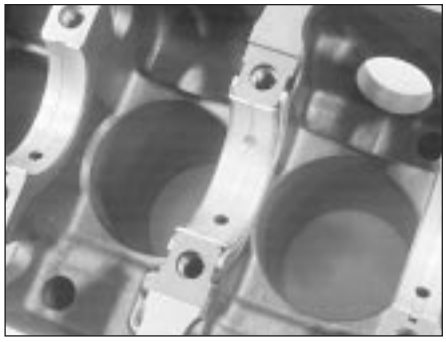
6 Use your fingernail to feel if a ridge has formed at the upper limit of ring travel (about a quarter-inch down from the top of each cylinder). If carbon deposits or cylinder wear have produced ridges, they must be completely removed with a special tool **(see illustration)**. Follow the manufacturer's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



9.6 A ridge reamer may be required, to remove the ridge from the top of each cylinder - do this before removing the pistons!



10.1 Checking crankshaft endfloat with a dial gauge



10.2 Thrustwashers integral with No 3 (centre) main bearing upper shell control crankshaft endfloat

remove the piston/connecting rod assemblies may result in piston ring breakage.

7 Slacken each of the big-end bearing cap bolts half a turn at a time, until they can be removed by hand. Remove the No 1 cap and bearing shell. Don't drop the shell out of the cap.

8 Remove the upper bearing shell, and push the connecting rod/piston assembly out through the top of the engine. Use a wooden hammer handle to push on the connecting rod's bearing recess. If resistance is felt, double-check that all of the ridge was removed from the cylinder.

9 Repeat the procedure for the remaining cylinders.

10 After removal, reassemble the big-end bearing caps and shells on their respective connecting rods, and refit the bolts finger-tight. Leaving the old shells in place until reassembly will help prevent the bearing recesses from being accidentally nicked or gouged. New shells should be used on reassembly.

11 Don't attempt to separate the pistons from the connecting rods - see Section 12.

10 Crankshaft - removal

Note: *The crankshaft can be removed only after the engine/transmission has been removed from the vehicle. It is assumed that the transmission and flywheel/driveplate, timing belt, cylinder head, sump, oil pump pick-up/strainer pipe and oil baffle, oil pump, and piston/connecting rod assemblies, have already been removed. The crankshaft left-hand oil seal carrier must be unbolted from the cylinder block/crankcase before proceeding with crankshaft removal.*

1 Before the crankshaft is removed, check the endfloat. Mount a DTI (Dial Test Indicator, or dial gauge) with the stem in line with the crankshaft and just touching the crankshaft **(see illustration)**.

2 Push the crankshaft fully away from the gauge, and zero it. Next, lever the crankshaft towards the gauge as far as possible, and check the reading obtained. The distance that the crankshaft moved is its endfloat; if it is greater than specified, check the crankshaft thrust surfaces for wear. If no wear is evident, new thrustwashers should correct the endfloat; these are part of the No 3 (centre) main bearing upper shell **(see illustration)**.

3 If no dial gauge is available, feeler gauges can be used. Gently lever or push the crankshaft all the way towards the right-hand end of the engine. Slip feeler gauges between the crankshaft and the right-hand face of the No 3 (centre) main bearing to determine the clearance **(see illustration)**.

4 Check the main bearing caps, to see if they are marked to indicate their locations **(see illustration)**. They should be numbered consecutively from the timing belt end of the engine - if not, mark them with number-stamping dies or a centre-punch. The caps will also have an embossed arrow pointing to the timing belt end of the engine. Noting the different fasteners (for the oil baffle nuts) used on caps 2 and 4, slacken the cap bolts a quarter-turn at a time each, starting with the left- and right-hand end caps and working toward the centre, until they can be removed by hand.

5 Gently tap the caps with a soft-faced hammer, then separate them from the cylinder block/crankcase. If necessary, use the bolts as levers to remove the caps. Try not to drop the bearing shells if they come out with the caps.

10.3 Checking crankshaft endfloat with a feeler gauge

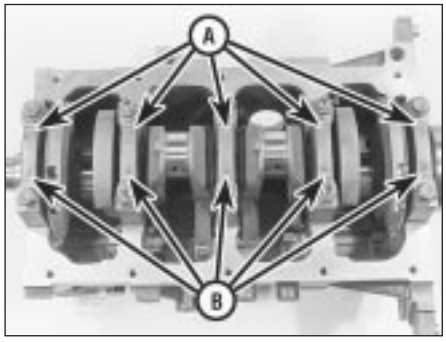
6 Carefully lift the crankshaft out of the engine. It may be a good idea to have an assistant available, since the crankshaft is quite heavy. With the bearing shells in place in the cylinder block/crankcase and main bearing caps, return the caps to their respective locations on the block, and tighten the bolts finger-tight. Leaving the old shells in place until reassembly will help prevent the bearing recesses from being accidentally nicked or gouged. New shells should be used on reassembly.

11 Cylinder block/crankcase - cleaning and inspection

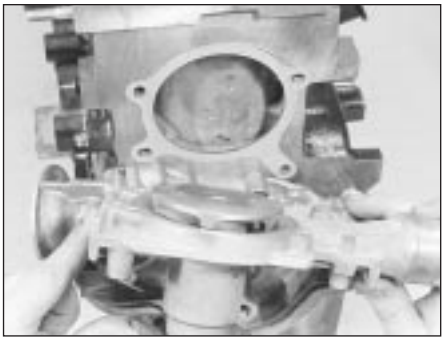
Note: *Always check first what replacement parts are available before planning any overhaul operation; refer to Section 1 of this Part. A Ford dealer, or a good engine reconditioning specialist/automotive parts supplier may be able to suggest alternatives which will enable you to overcome the lack of replacement parts.*

Cleaning

1 For complete cleaning, remove the water pump, all external components, and all electrical switches/sensors. Unbolt the piston-cooling oil jets or blanking plugs (as



10.4 Before unbolting crankshaft main bearing caps, note arrows pointing to timing belt end of engine (A), and bearing numbers (B) consecutive from timing belt end



11.1A Remove water pump . . .

11.1B . . . crankcase breather pipe and PCV valve . . .

11.1C . . . unbolt crankcase ventilation system oil separator . . .

applicable); note that Ford state that the piston-cooling oil jets (where fitted) must be renewed whenever the engine is dismantled for full overhaul **(see illustrations)**.

2 Remove the main bearing caps, and separate the bearing shells from the caps and the cylinder block/crankcase. Mark or label the shells, indicating which bearing they were removed from, and whether they were in the cap or the block, then set them aside **(see illustration)**. Wipe clean the block and cap bearing recesses, and inspect them for nicks, gouges and scratches.

3 Scrape all traces of gasket from the cylinder block/crankcase, taking care not to damage the sealing surfaces.

4 Remove all oil gallery plugs (where fitted). The plugs are usually very tight - they may have to be drilled out and the holes re-tapped. Use new plugs when the engine is reassembled. Drill a small hole in the centre of each core plug, and pull them out with a car bodywork dent puller **(see illustration)**.

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

5 If any of the castings are extremely dirty, all should be steam-cleaned.

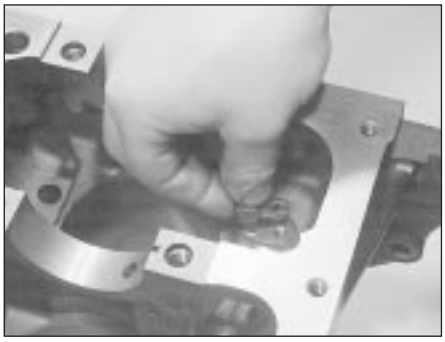
6 After the castings are returned from steam-cleaning, clean all oil holes and oil galleries one more time. Flush all internal passages with warm water until the water runs clear, then dry thoroughly, and apply a light film of oil to all machined surfaces, to prevent rusting. If you have access to compressed 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 castings are not very dirty, you can do an adequate cleaning job with hot soapy water (as hot as you can stand!) and a stiff brush. Take plenty of time, and do a thorough job. Regardless of the cleaning method used, be sure to clean all oil holes and galleries very thoroughly, and to dry all components completely; protect the machined surfaces as described above, to prevent rusting.

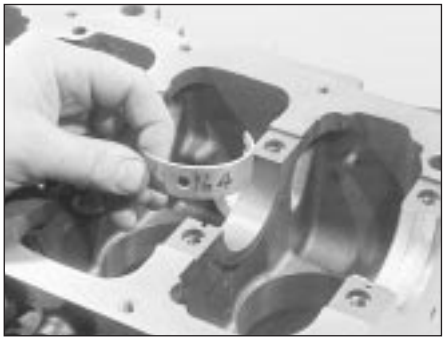
8 All threaded holes must be clean and dry, to ensure accurate torque readings during reassembly; now is also a good time to clean and check the threads of all principal bolts - however, note that some, such as the cylinder head and flywheel/driveplate bolts, are to be renewed as a matter of course whenever they are disturbed. Run the proper-size tap into

11.1D . . . remove electrical switches/sensors such as crankshaft speed/position sensor . . .

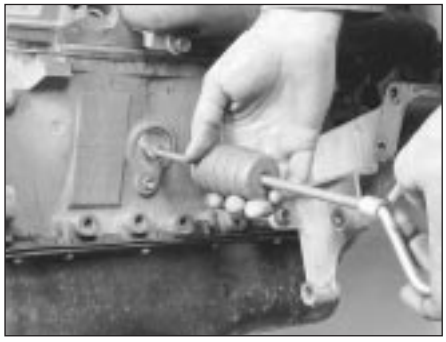


11.1E . . . unbolt blanking plugs (where fitted) to clean out oilways . . .

11.1F . . . but note that piston-cooling oil jets (where fitted) must be renewed as a matter of course whenever engine is overhauled



11.2 Felt marker pens can be used as shown to identify bearing shells without damaging them



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

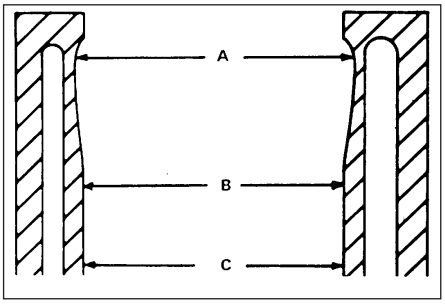
11.8 All bolt holes in the block - particularly the main bearing cap and head bolt holes - should be cleaned and restored with a tap (be sure to remove debris from the holes after this is done)

each of the holes, to remove rust, corrosion, thread sealant or sludge, and to restore damaged threads **(see illustration)**. If possible, use compressed air to clear the holes of debris produced by this operation; a good alternative is to inject aerosol-applied water-dispersant lubricant into each hole, using the long spout usually supplied.

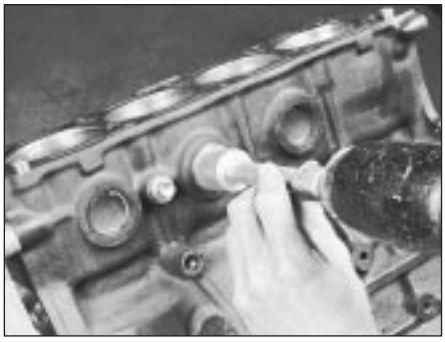
Warning: Wear eye protection when cleaning out these holes in this way, and be sure to dry out any excess liquid left in the holes.

9 When all inspection and repair procedures are complete (see below) and the block is ready for reassembly, apply suitable sealant to the new oil gallery plugs, and insert them into the holes in the block. Tighten them securely. After coating the sealing surfaces of the new core plugs with suitable sealant, install them in the cylinder block/crankcase **(see illustration)**. Make sure they are driven in straight and seated properly, or leakage could result. Special tools are available for this purpose, but a large socket with an outside diameter that will just slip into the core plug, used with an extension and hammer, will work just as well.

10 Refit the blanking plugs or (new) piston-cooling oil jets (as applicable), tightening their Torx screws to the torque wrench setting specified **(see illustration)**. Refit also all other external components removed, referring to



11.14A Measure the diameter of each cylinder just under the wear ridge (A), at the centre (B) and at the bottom (C)



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

the relevant Chapter of this manual for further details where required. Refit the main bearing caps, and tighten the bolts finger-tight.

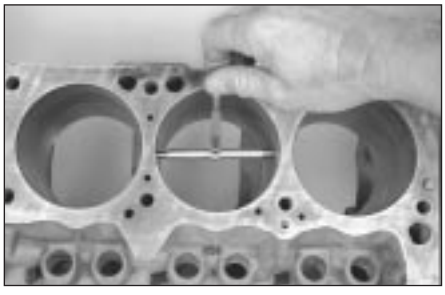
11 If the engine is not going to be reassembled right away, cover it with a large plastic bag to keep it clean; protect the machined surfaces as described above, to prevent rusting.

Inspection

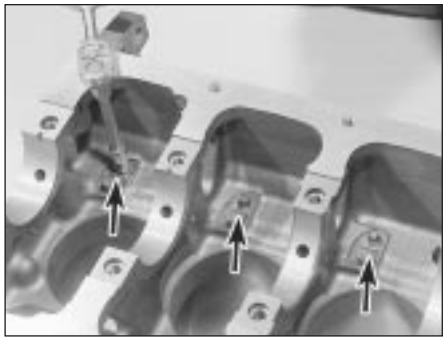
12 Visually check the castings for cracks and corrosion. Look for stripped threads in the threaded holes. If there has been any history of internal coolant leakage, it may be worthwhile having an engine overhaul specialist check the cylinder block/crankcase for cracks with special equipment. If defects are found, have them repaired, if possible, or renew the assembly **(see illustration)**.

13 Check each cylinder bore for scuffing and scoring.

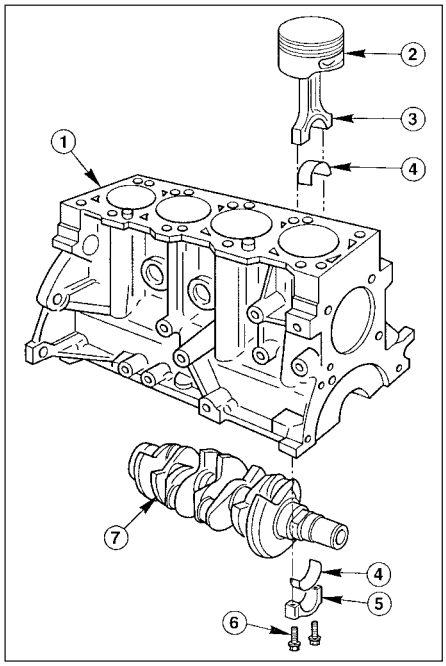
14 Noting that the cylinder bores must be measured with all the crankshaft main bearing caps bolted in place (without the crankshaft and bearing shells), to the specified torque wrench settings, measure the diameter of each cylinder at the top (just under the ridge area), centre and bottom of the cylinder bore, parallel to the crankshaft axis. Next, measure each cylinder's diameter at the same three locations across the crankshaft axis **(see illustrations)**. Note the measurements obtained.



11.14B The ability to "feel" when the telescoping gauge is at the correct point will be developed over time, so work slowly, and repeat the check until you're satisfied that the bore measurement is accurate



11.10 Do not forget to refit all components - such as oilway blanking plugs (three of four arrowed) - tighten fasteners to torque wrench settings specified



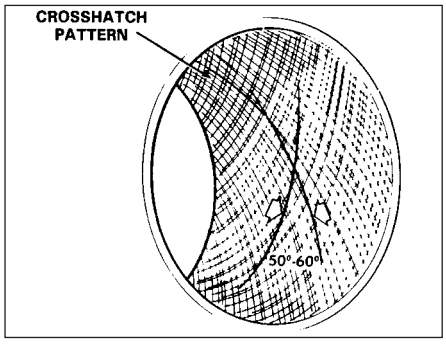
11.12 Cylinder block, piston/connecting rod and crankshaft details

1 Cylinder block/crankcase
2 Piston
3 Connecting rod
4 Big-end bearing shell
5 Big-end bearing cap
6 Big-end bearing cap bolts
7 Crankshaft

11.14C The gauge is then measured with a micrometer to determine the bore size

11.15 Measure the piston skirt diameter at right-angles to the gudgeon pin axis, just above the base of the skirt

11.23A A "bottle-brush" hone will produce better results if you have never honed cylinders before



11.23B The cylinder hone should leave a smooth, cross-hatch pattern with the lines intersecting at approximately a 60º angle

15 Measure the piston diameter at right-angles to the gudgeon pin axis, just above the bottom of the skirt; again, note the results **(see illustration)**.

16 If it is wished to obtain the piston-to-bore clearance, measure the bore and piston skirt as described above, and subtract the skirt diameter from the bore measurement. If the precision measuring tools shown are not available, the condition of the pistons and bores can be assessed, though not quite as accurately, by using feeler gauges as follows. Select a feeler gauge of thickness equal to the specified piston-to-bore clearance, and slip it into the cylinder along with the matching piston. The piston must be positioned exactly as it normally would be. The feeler gauge must be between the piston and cylinder on one of the thrust faces (at right-angles to the gudgeon pin bore). The piston should slip through the cylinder (with the feeler gauge in place) with moderate pressure; if it falls through or slides through easily, the clearance is excessive, and a new piston will be required. If the piston binds at the lower end of the cylinder, and is loose toward the top, the cylinder is tapered. If tight spots are encountered as the piston/feeler gauge is rotated in the cylinder, the cylinder is out-of-round (oval).

17 Repeat these procedures for the remaining pistons and cylinder bores.

18 Compare the results with the Specifications at the beginning of this Chapter; if any measurement is beyond the dimensions specified for that class (check the piston crown marking to establish the class of piston fitted), or if any bore measurement is significantly different from the others (indicating that the bore is tapered or oval), the piston or bore is excessively-worn.

19 Worn pistons must be renewed; at the time of writing, pistons are available as Ford replacement parts only as part of the complete piston/connecting rod assembly. See a Ford dealer or engine reconditioning specialist for advice.

20 If any of the cylinder bores are badly scuffed or scored, or if they are excessively-worn, out-of-round or tapered, the usual course of action would be to have the cylinder block/crankcase rebored, and to fit new, oversized, pistons on reassembly. See a Ford dealer or engine reconditioning specialist for advice.

21 If the bores are in reasonably good condition and not excessively-worn, then it may only be necessary to renew the piston rings.

22 If this is the case (and if new rings can be found), the bores should be honed, to allow the new rings to bed in correctly and provide the best possible seal; before honing the bores, refit the main bearing caps (without the bearing shells), and tighten the bolts to the specified torque wrench setting. **Note:** *If you don't have the tools, or don't want to tackle the honing operation, most engine reconditioning specialists will do it for a reasonable fee.*

23 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 and are used with a power drill, but for the less-experienced mechanic, the "bottle-brush" hone will probably be easier to use. You will also need some paraffin or honing oil, and rags. Proceed as follows:

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

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

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

(d) Wipe the oil out of the bore, and repeat the procedure for the remaining cylinders.

(e) When all the cylinder bores are honed, chamfer the top edges of the bores with a small file, so the rings won't catch when the pistons are installed. Be very careful not to nick the cylinder walls with the end of the file.

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

(g) When the cylinder block/crankcase is completely clean, rinse it thoroughly and dry it, then lightly oil all exposed machined surfaces, to prevent rusting.

24 The cylinder block/crankcase should now be completely clean and dry, with all components checked for wear or damage, and repaired or overhauled as necessary. Refit as many ancillary components as possible, for safekeeping (see paragraphs 9 and 10 above). If reassembly is not to start immediately, cover the block with a large plastic bag to keep it clean, and protect the machined surfaces as described above to prevent rusting.

12 Piston/connecting rod assemblies - inspection

Note: *Always check first what replacement parts are available before planning any overhaul operation; refer to Section 1 of this Part. A Ford dealer, or a good engine reconditioning specialist/automotive parts supplier may be able to suggest alternatives which will enable you to overcome the lack of replacement parts.*

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. The rings should have smooth, polished working surfaces, with no dull or carbon-coated sections (showing that the ring is not sealing correctly against the bore wall, so allowing combustion gases to blow by) and no traces of wear on their top and bottom surfaces. The end gaps should be clear of carbon, but not polished (indicating a too-small end gap), and all the rings (including the elements of the oil control ring) should be free to rotate in their grooves, but without excessive up-and-down movement. If the rings appear to be in good condition, they are probably fit for further use; check the end gaps (in an unworn part of the bore) as described in Section 16. If any of the rings appears to be worn or damaged, or has an end gap significantly different from the specified value, the usual course of action is to renew all of them as a set. **Note:** *While it is usual always to renew piston rings when an engine is overhauled, this of course assumes that rings are available separately - if not, it follows that great care must be taken not to break or damage any of the rings during the following procedures, and to ensure that each ring is marked on removal so that it is refitted* ***only*** *the original way up, and* ***only*** *to the same groove.*

2 Using a piston ring renoval tool, carefully remove the rings from the pistons. Be careful not to nick or gouge the pistons in the process, and mark or label each ring as it is removed, so that its original top surface can be identified on reassembly, and so that it can be returned to its original groove. Take care also with your hands - piston rings are sharp!

TOOL TiP

If a piston ring removal tool is not available, the rings can be removed by hand, expanding them over the top of the pistons. The use of two or three old feeler blades will be helpful in preventing the rings dropping into empty grooves.

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, but replacement rings have been found, a piece broken off the old ring will do the job. Be very careful to remove only the carbon deposits - don't remove any metal, and do not nick or scratch the sides of the ring grooves **(see illustrations)**. Protect your fingers - piston rings are sharp!

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

12.4A The piston ring grooves can be cleaned with a special tool, as shown here . . .

12.4B . . . or a section of a broken ring, if available

6 If the pistons and cylinder walls aren't damaged or worn excessively - refer to Section 11 for details of inspection and measurement procedures - and if the cylinder block/crankcase 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.

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

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 (pre-ignition) 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, or EGR system malfunctions.

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

10 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 a Ford dealer or engine reconditioning specialist to have the pistons, gudgeon pins and rods checked, and new components fitted as required.

11 *Don't* attempt to separate the pistons from the connecting rods (even if non-genuine replacements are found elsewhere). This is a task for a Ford dealer or similar engine reconditioning specialist, due to the special heating equipment, press, mandrels and supports required to do the job. If the piston/connecting rod assemblies do require this sort of work, have the connecting rods checked for bend and twist, since only such engine repair specialists will have the facilities for this purpose.

12 Check the connecting rods for cracks and other damage. Temporarily remove the big-end bearing caps and the old bearing shells, wipe clean the rod and cap bearing recesses, and inspect them for nicks, gouges and scratches. After checking the rods, replace the old shells, slip the caps into place, and tighten the bolts finger-tight.

13.3 Rubbing a penny lengthwise along each journal will reveal its condition - if copper rubs off and is embedded in the crankshaft, the journals should be reground

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

13 Crankshaft - inspection

Note: *Always check first what replacement parts are available before planning any overhaul operation; refer to Section 1 of this Part. A Ford dealer, or a good engine reconditioning specialist/automotive parts supplier, may be able to suggest alternatives which will enable you to overcome the lack of replacement parts.*

1 Clean the crankshaft, and dry it with compressed air if available.

Warning: Wear eye protection when using compressed air! Be sure to clean the oil holes with a pipe cleaner or similar probe.

2 Check the main and crankpin (big-end) bearing journals for uneven wear, scoring, pitting and cracking.

3 Rub a penny across each journal several times **(see illustration)**. If a journal picks up copper from the penny, it is too rough.

4 Remove all burrs from the crankshaft oil holes with a stone, file or scraper.

5 Using a micrometer, measure the diameter of the main bearing and crankpin (big-end) journals, and compare the results with the Specifications at the beginning of this Chapter **(see illustration)**.

6 By measuring the diameter at a number of points around each journal's circumference, you will be able to determine whether or not the journal is out-of-round. Take the measurement at each end of the journal, near the webs, to determine if the journal is tapered.

7 If the crankshaft journals are damaged, tapered, out-of-round, or worn beyond the limits specified in this Chapter, the crankshaft must be taken to an engine overhaul specialist, who will regrind it, and who can supply the necessary undersize bearing shells.

8 Check the oil seal journals at each end of the crankshaft for wear and damage. If either seal has worn an excessive groove in its journal, consult an engine overhaul specialist, who will be able to advise whether a repair is possible, or whether a new crankshaft is necessary.

14 Main and big-end bearings - inspection

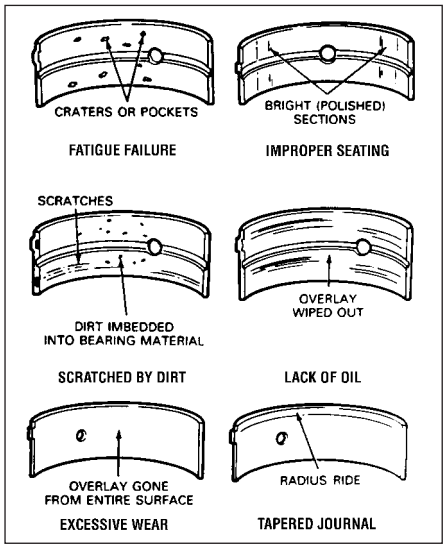
Note: *Always check first what replacement parts are available before planning any overhaul operation; refer to Section 1 of this Part. A Ford dealer, or a good engine reconditioning specialist/automotive parts supplier, may be able to suggest alternatives which will enable you to overcome the lack of replacement parts.*

1 Even though the main and big-end bearing shells should be renewed during the engine overhaul, the old shells 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 bearing shells, remove them from the cylinder block/crankcase and main bearing caps, and from the connecting rods and the big-end bearing caps, then 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. *Do not* touch any shell's bearing surface with your fingers while checking it, or the delicate surface may be scratched.

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



14.1 When inspecting the main and big-end bearings, look for these problems

5 Lack of lubrication (or lubrication breakdown) has a number of inter-related causes. Excessive heat (which thins the oil), overloading (which squeezes the oil from the bearing face) and oil leakage (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 starve a bearing of oil, and destroy it. When lack of lubrication is the cause of bearing failure, the bearing material is wiped or extruded from the shell's steel backing. Temperatures may increase to the point where the steel backing turns blue from overheating.

6 Driving habits can have a definite effect on bearing life. Full-throttle, low-speed operation (labouring the engine) puts very high loads on bearings, which tends to squeeze out the oil film. These loads cause the shells 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-distance driving leads to corrosion of bearings, because insufficient engine heat is produced to drive off 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 shell refitting during engine assembly will lead to bearing failure as well. Tight-fitting shells leave insufficient bearing running clearance, and will result in oil starvation. Dirt or foreign particles trapped behind a bearing shell result in high spots on the bearing, which lead to failure. *Do not* touch any shell's bearing surface with your fingers during reassembly; there is a risk of scratching the delicate surface, or of depositing particles of dirt on it.

15 Engine overhaul - reassembly sequence

1 Before reassembly begins, ensure that all new parts have been obtained, and that all necessary tools are available. Read through the entire procedure, to familiarise yourself with the work involved, and to ensure that all items necessary for reassembly of the engine are at hand. In addition to all normal tools and materials, suitable sealant will be required for two of the joint faces (Ford recommend Hylosil 102 for the cylinder block/crankcase-to-sump/oil pump/oil seal carrier joints, and Loctite 518 for the camshaft right-hand bearing caps). In all other cases, provided the relevant mating surfaces are clean and flat, new gaskets will be sufficient to ensure joints are oil-tight. *Do not* use any kind of silicone-based sealant on any part of the fuel system or inlet manifold, and *never* use exhaust sealants upstream of the catalytic converter.

2 In order to save time and avoid problems, engine reassembly can be carried out in the following order:

(a) Crankshaft (Section 17).
(b) Piston/connecting rod assemblies (Section 18).
(c) Oil pump (Part A of this Chapter, Section 16).
(d) Sump (Part A of this Chapter, Section 15).
(e) Flywheel/driveplate (Part A of this Chapter, Section 21).
(f) Cylinder head (Part A of this Chapter, Section 14).
(g) Timing belt inner cover, tensioner and toothed pulleys, and timing belt (Part A of this Chapter).
(h) Engine external components.

3 At this stage, all engine components should be absolutely clean and dry, with all faults repaired; they should be laid out (or in individual containers) on a completely-clean work surface.

16 Piston rings - refitting

1 Before installing new piston rings, check the end gaps. Lay out each piston set with a piston/connecting rod assembly, and keep them together as a matched set from now on.

2 Insert the top compression 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.

3 To measure the end gap, slip feeler gauges between the ends of the ring, until a gauge equal to the gap width is found **(see illustration)**. The feeler gauge should slide between the ring ends with a slight amount of drag. Compare the measurement to the value given in the Specifications Section of this Chapter; if the gap is larger or smaller than specified, double-check to make sure you have the correct rings before proceeding. If you are assessing the condition of used rings, have the cylinder bores checked and measured by a Ford dealer or similar engine reconditioning specialist, so that you can be sure of exactly which component is worn, and seek advice as to the best course of action to take.

4 If the end gap is still too small, it must be opened up by careful filing of the ring ends using a fine file. If it is too large, this is not as serious, unless the specified limit is exceeded, in which case very careful checking is required of the dimensions of all components, as well as of the new parts.

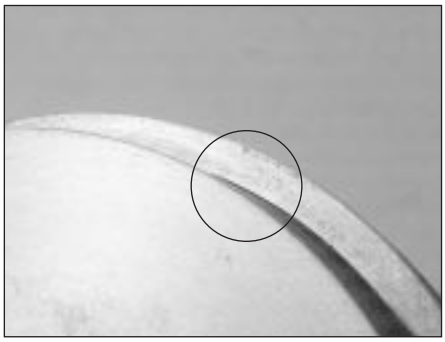
5 Repeat the procedure for each ring that will be installed in the first cylinder, and for each ring in the remaining cylinders. Remember to keep rings, pistons and cylinders matched up.

6 Refit the piston rings as follows. Where the original rings are being refitted, use the marks or notes made on removal, to ensure that each ring is refitted to its original groove and the same way up. New rings generally have their top surfaces identified by markings (often an indication of size, such as "STD", or the word "TOP") - the rings must be fitted with such markings uppermost **(see illustration)**. **Note:** *Always follow the instructions printed on the ring package or box - different manufacturers may require different approaches. Do not mix up the top and second compression rings, as they usually have different cross-sections.*

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

16.2 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)

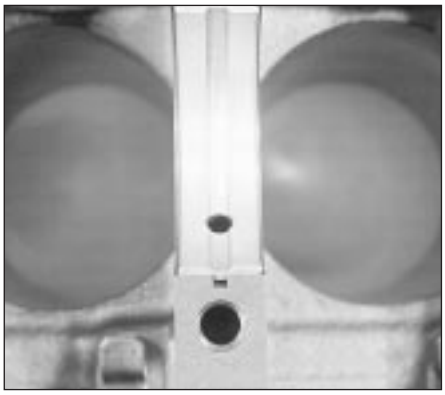
16.3 With the ring square in the bore, measure the end gap with a feeler gauge



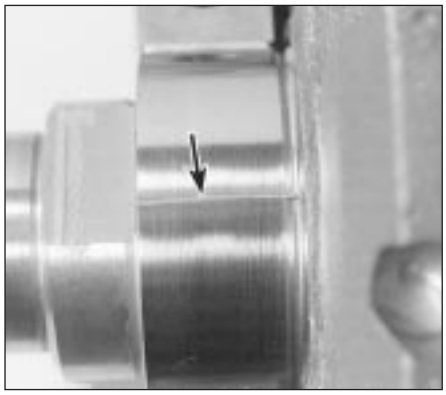
16.6 Look for etched markings ("STD" - indicating a standard-sized ring - shown here) identifying piston ring top surface

16.7A Installing the spacer/expander in the oil control ring groove

16.7B DO NOT use a piston ring installation tool when installing the oil ring side rails



17.4 Tab on each bearing shell must engage with notch in block or cap, and oil holes in upper shells must align with block oilways



17.6 Lay the Plastigage strips (arrowed) on the main bearing journals, parallel to the crankshaft centre-line

(see illustration). Next, install the upper side rail in the same manner.

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

9 The second compression (middle) ring is installed next, followed by the top compression ring - ensure their marks are uppermost, and be careful not to confuse them. Don't expand either ring any more than necessary to slide it over the top of the piston.

10 With all the rings in position, space the ring gaps (including the elements of the oil control ring) uniformly around the piston at 120° intervals. Repeat the procedure for the remaining pistons and rings.

17 Crankshaft - refitting and main bearing running clearance check

1 Crankshaft refitting is the first major step in engine reassembly. It is assumed at this point that the cylinder block/crankcase and crankshaft have been cleaned, inspected and repaired or reconditioned as necessary. Position the engine upside-down.

2 Remove the main bearing cap bolts, and lift out the caps. Lay the caps out in the proper order, to ensure correct installation.

3 If they're still in place, remove the old bearing shells from the block and the main bearing caps. Wipe the bearing recesses of the block and caps with a clean, lint-free cloth. They must be kept spotlessly-clean!

17.7 Refit the main bearing caps and tighten the bolts as specified

Main bearing running clearance check

4 Clean the backs of the new main bearing shells. Fit the shells with an oil groove in each main bearing location in the block; note the thrustwashers integral with the No 3 (centre) main bearing upper shell. Fit the other shell from each bearing set in the corresponding main bearing cap. Make sure the tab on each bearing shell fits into the notch in the block or cap. Also, the oil holes in the block must line up with the oil holes in the bearing shell **(see illustration)**.

Caution: Don't hammer the shells into place, and don't nick or gouge the bearing faces. No lubrication should be used at this time.

5 Clean the bearing surfaces of the shells 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.

17.10 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; Imperial and metric scales are included

6 Once you're certain the crankshaft is clean, carefully lay it in position in the main bearings. 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 crankshaft centre-line **(see illustration)**.

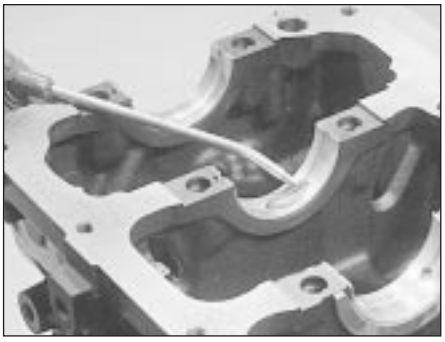
7 Clean the bearing surfaces of the cap shells, and install the caps in their respective positions (don't mix them up) with the arrows pointing to the timing belt end of the engine. Don't disturb the Plastigage **(see illustration)**.

8 Working on one cap at a time, from the centre main bearing outwards (and ensuring that each cap is tightened down squarely and evenly onto the block), tighten the main bearing cap bolts to the specified torque wrench setting. Don't rotate the crankshaft at any time during this operation!

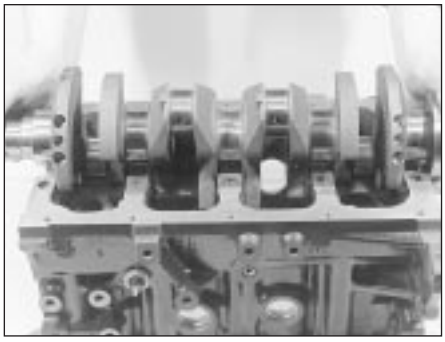
9 Remove the bolts, and carefully lift off the main bearing caps. Keep them in order. Don't disturb the Plastigage or rotate the crankshaft. If any of the main bearing caps are difficult to remove, tap them gently from side-to-side with a soft-faced mallet to loosen them.

10 Compare the width of the crushed Plastigage on each journal with the scale printed on the Plastigage envelope to obtain the main bearing running clearance **(see illustration)**. Check the Specifications to make sure that the clearance is correct.

11 If the clearance is not as specified, seek the advice of a Ford dealer or similar engine reconditioning specialist - if the crankshaft journals are in good condition (see Section 13), it may be possible simply to renew the shells to achieve the correct clearance. If this is not possible, the crankshaft must be reground by a specialist who can supply the necessary undersized shells. First though,



17.13 Ensure bearing shells are absolutely clean, lubricate liberally . . .



17.15 . . . and refit the crankshaft

make sure that no dirt or oil was between the bearing shells 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 13).

12 Carefully scrape all traces of the Plastigage material off the main bearing journals and the bearing surfaces. Be very careful not to scratch the bearing - use your fingernail or the edge of a credit card.

Final refitting

13 Carefully lift the crankshaft out of the engine. Clean the bearing surfaces of the shells in the block, then apply a thin, uniform layer of clean molybdenum disulphide-based grease, engine assembly lubricant, or clean engine oil to each surface **(see illustration)**. Coat the thrustwasher surfaces as well.

14 Lubricate the crankshaft oil seal journals with molybdenum disulphide-based grease, engine assembly lubricant, or clean engine oil.

15 Make sure the crankshaft journals are clean, then lay the crankshaft back in place in the block **(see illustration)**. Clean the bearing surfaces of the shells in the caps, then lubricate them. Install the caps in their respective positions, with the arrows pointing to the timing belt end of the engine.

16 Working on one cap at a time, from the centre main bearing outwards (and ensuring that each cap is tightened down squarely and evenly onto the block), tighten the main bearing cap bolts to the specified torque wrench setting.

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

18 Check the crankshaft endfloat (see Section 10). It should be correct if the crankshaft thrust faces aren't worn or damaged, and if the No 3 (centre) main bearing's upper shell has been renewed.

19 Refit the crankshaft left-hand oil seal carrier, and install a new seal (see Part A of this Chapter, Section 20).

18 Piston/connecting rod assemblies - refitting and big-end bearing running clearance check

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

2 Remove the big-end bearing cap from No 1 cylinder connecting rod (refer to the marks noted or made on removal). Remove the original bearing shells, and wipe the bearing recesses of the connecting rod and cap with a clean, lint-free cloth. They must be kept spotlessly-clean!

Big-end bearing running clearance check

3 Clean the back of the new upper bearing shell, fit it to the connecting rod, then fit the other shell of the bearing set to the big-end bearing cap. Make sure the tab on each shell fits into the notch in the rod or cap recess **(see illustration)**.

Caution: Don't hammer the shells into place, and don't nick or gouge the bearing face. Don't lubricate the bearing at this time.

4 It's critically important that all mating surfaces of the bearing components are perfectly clean and oil-free when they're assembled.

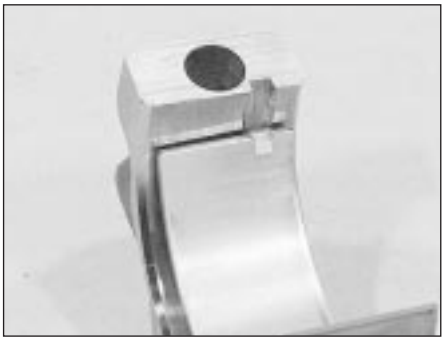
5 Position the piston ring gaps as described in Section 16, lubricate the piston and rings with clean engine oil, and attach a piston ring compressor to the piston. Leave the skirt protruding about a quarter-inch, to guide the piston into the cylinder bore. The rings must be compressed until they're flush with the piston.

6 Rotate the crankshaft until No 1 crankpin (big-end) journal is at BDC (Bottom Dead Centre), and apply a coat of engine oil to the cylinder walls.

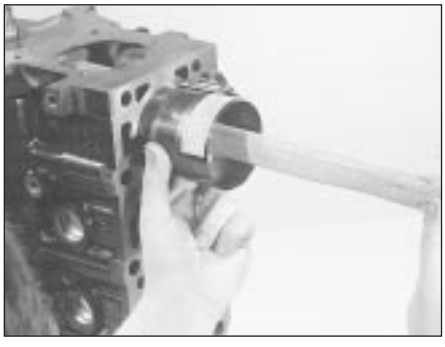
7 Arrange the No 1 piston/connecting rod assembly so that the arrow on the piston crown points to the timing belt end of the engine. The cylinder number (counting from the timing belt end of the engine) is etched into the flat-machined surface of the connecting rod and its cap, and must be visible from the front (exhaust side) of the engine (see illustrations 9.5A and 9.5B). Gently insert the assembly into the No 1 cylinder bore, and rest the bottom edge of the ring compressor on the engine block.

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

9 Gently tap on the top of the piston with the end of a wooden hammer handle **(see illustration)**, while guiding the connecting



18.3 Tab on each big-end bearing shell must engage with notch in connecting rod or cap



18.9 The piston can be driven gently into the cylinder bore with the end of a wooden or plastic hammer handle

18.11 The connecting rod and big-end bearing cap of each assembly must share the same etched cylinder number, visible from the same (front/exhaust) side of the engine

rod's big-end onto the crankpin. 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 binding, 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.

10 To check the big-end bearing running clearance, 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 No 1 crankpin (big-end) journal, parallel with the crankshaft centre-line (see illustration 17.6).

11 Clean the connecting rod-to-cap mating surfaces, and refit the big-end bearing cap. Make sure the etched number on the cap is on the same side as that on the rod **(see illustration)**. Tighten the cap bolts evenly - first use a torque wrench to tighten the bolts to the specified (first stage) torque setting, then use an ordinary socket extension bar and an angle gauge to tighten the bolts further through the specified (second stage) angle. Use a thin-wall socket, to avoid erroneous torque readings that can result if the socket is wedged between the 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. Don't rotate the crankshaft at any time during this operation!

12 Unscrew the bolts and detach the cap, being very careful not to disturb the Plastigage.

13 Compare the width of the crushed Plastigage to the scale printed on the Plastigage envelope, to obtain the running clearance (see illustration 17.10). Compare it to the Specifications, to make sure the clearance is correct.

14 If the clearance is not as specified, seek the advice of a Ford dealer or similar engine reconditioning specialist - if the crankshaft journals are in good condition (see Section 13), it may be possible simply to renew the shells to achieve the correct clearance. If this is not possible, the crankshaft must be reground by a specialist, who can also supply the necessary undersized shells. First though, make sure that no dirt or oil was trapped between the bearing shells and the connecting rod or cap when the clearance was measured. Also, recheck the crankpin diameter. If the Plastigage was wider at one end than the other, the crankpin journal may be tapered (see Section 13).

15 Carefully scrape all traces of the Plastigage material off the journal and the bearing surface. Be very careful not to scratch the bearing - use your fingernail or the edge of a credit card.

Final piston/connecting rod refitting

16 Make sure the bearing surfaces are perfectly clean, then apply a uniform layer of clean molybdenum disulphide-based grease, engine assembly lubricant, or clean engine oil, to both of them. You'll have to push the piston into the cylinder to expose the bearing surface of the shell in the connecting rod.

17 Slide the connecting rod back into place on the crankpin (big-end) journal, refit the big-end bearing cap, and then tighten the bolts in two stages, as described above.

18 Repeat the entire procedure for the remaining piston/connecting rod assemblies.

19 The important points to remember are:

(a) Keep the backs of the bearing shells and the recesses of the connecting rods and caps perfectly clean when assembling them.

(b) Make sure you have the correct piston/rod assembly for each cylinder - use the etched cylinder numbers to identify the front-facing side of both the rod and its cap.

(c) The arrow on the piston crown must face the timing belt end of the engine.

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

(e) Lubricate the bearing surfaces when refitting the big-end bearing caps after the running clearance has been checked.

20 After all the piston/connecting rod assemblies have been properly installed, rotate the crankshaft a number of times by hand, to check for any obvious binding.

19 Engine - initial start-up after overhaul

1 With the engine refitted in the vehicle, double-check the engine oil and coolant levels. Make a final check that everything has been reconnected, and that there are no tools or rags left in the engine compartment.

2 With the spark plugs removed and the ignition system disabled by unplugging the ignition coil's electrical connector, remove fuse 14 to disconnect the fuel pump. Turn the engine on the starter until the oil pressure warning light goes out.

3 Refit the spark plugs, and connect all the spark plug (HT) leads (Chapter 1). Reconnect the ignition coil wiring, refit the fuel pump fuse, then switch on the ignition and listen for the fuel pump; it will run for a little longer than usual, due to the lack of pressure in the system.

4 Start the engine, noting that this also may take a little longer than usual, due to the fuel system components being empty.

5 While the engine is idling, check for fuel, coolant and oil leaks. Don't be alarmed if there are some odd smells and smoke from parts getting hot and burning off oil deposits. If the hydraulic tappets have been disturbed, some valve gear noise may be heard at first; this should disappear as the oil circulates fully around the engine, and normal pressure is restored in the tappets.

6 Keep the engine idling until hot water is felt circulating through the top hose, check that it idles reasonably smoothly and at the usual speed, then switch it off.

7 After a few minutes, recheck the oil and coolant levels, and top-up as necessary (Chapter 1).

8 If they were tightened as described, there is no need to re-tighten the cylinder head bolts once the engine has first run after reassembly - in fact, Ford state that the bolts *must not* be re-tightened.

9 If new components such as pistons, rings or crankshaft bearings have been fitted, the engine must be run-in for the first 500 miles (800 km). Do not operate the engine at full-throttle, or allow it to labour in any gear during this period. It is recommended that the oil and filter be changed at the end of this period.