9.8 Locate the seal, and tap it into position over the guide

9.9 Insert the valve into its guide

9.11 Insert the split collets into the groove in the valve stem

or press the seal squarely into place, using a suitable tube or socket **(see illustration)**.

9 To protect the seal lips from being damaged by the collet grooves in the valve stem as it is passed through the seal, wipe any oil from the stem at the top, and mask the split collet groove on the stem with insulating tape. Lubricate the lips of the valve stem seal, and insert the valve **(see illustration)**.

10 Remove the tape from the grooved section of the valve stem, then locate the spring and the upper retainer over the valve.

11 Locate the valve spring compressor into position, and compress the spring and cup down the valve stem so that the collet's groove is exposed above the upper retainer. Lightly grease the collet's groove in the stem, (to retain the collets in position) then locate the split collets into the groove in the stem. Slowly release and remove the valve spring compressor. As the compressor is released, ensure that the collets remain fully seated in the groove, and the upper retainer rides up over them to secure them in position **(see illustration)**.

12 Repeat the above operations on the remaining valves, ensuring that each valve assembly is returned to its original position, or where new valves have been fitted, onto the seat to which it was ground.

13 When all of the valves have been fitted, support the cylinder head on a wooden block, and using a plastic or copper-faced hammer, lightly tap the end of each valve stem in turn to seat the respective valve assemblies.

14 Refit the camshaft, tappets and rocker arms to the cylinder head as described in Part B of this Chapter.

Zetec engines

15 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.

16 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)**.

17 Refit the valve spring and upper seat.

18 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. Slowly release the compressor, and make sure the collets seat properly.

19 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.

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

21 Refit the hydraulic tappets as described in Part C of this Chapter.

10 Camshaft and tappets - removal, inspection and refitting (HCS engines)

Removal

1 Refer to the applicable Sections in Part A of this Chapter and remove the cylinder head, timing chain and camshaft sprocket, and the sump.

2 Invert the engine so that it is supported on its cylinder head face (on a clean work area). This is necessary to make all of the tappets slide to the top of their stroke, thus allowing the camshaft to be withdrawn. Rotate the camshaft through a full turn, to ensure that all of the tappets slide up their bores, clear of the camshaft.

3 Before removing the camshaft, check its endfloat using a dial gauge mounted on the front face of the engine or feeler gauges. Pull the camshaft fully towards the front (timing chain) end of the engine, then insert feeler gauges between the camshaft sprocket flange and the camshaft thrust plate to assess the endfloat clearance **(see illustration)**. The camshaft endfloat must be as specified.

4 Undo the two retaining bolts, and remove the camshaft thrust plate.

5 Carefully withdraw the camshaft from the front end of the engine **(see illustration)**.

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

10.3 Checking the camshaft endfloat

10.5 Withdrawing the camshaft from the front of the engine

6 Extract each tappet in turn. Keep them in order of fitting by inserting them in a card with eight holes in it, numbered 1 to 8 (from the timing chain end of the engine). A valve grinding suction tool will be found to be useful for the removal of tappets **(see illustration)**.

Inspection

7 Examine the camshaft bearing journals and lobes for damage or excessive wear. If evident, the camshaft must be renewed.
8 Examine the camshaft bearing internal surfaces for signs of damage or excessive wear. If evident, the bearings must be renewed by a Ford dealer.
9 If not carried out on removal, check the camshaft endfloat as described in paragraph 3. If the endfloat is exceeds the specified tolerance, renew the thrust plate.
10 It is seldom that the tappets wear excessively in their bores, but it is likely that after a high mileage, the cam lobe contact surfaces will show signs of depression or grooving.
11 Where this condition is evident, renew the tappets. Grinding out the grooves and wear marks will reduce the thickness of the surface hardening, and will accelerate further wear.

Refitting

12 To refit the tappets and the camshaft, it is essential that the crankcase is inverted.
13 Lubricate their bores and the tappets. Insert each tappet fully into its original bore in the cylinder block.
14 Lubricate the camshaft bearings, camshaft and thrust plate, then insert the camshaft into the crankcase from the timing case end.
15 Fit the thrust plate and tighten the retaining bolts to the specified torque setting **(see illustration)**. Check that the camshaft is able to rotate freely, and that the endfloat is as specified.

11 Piston/connecting rod assemblies - removal and inspection

Removal

HCS engines

1 Refer to Part A of this Chapter and remove the cylinder head and sump, then remove the oil pick-up pipe and strainer.
2 Temporarily refit the crankshaft pulley, so that the crankshaft can be rotated. Check that the connecting rod big-end caps have adjacent matching numbers facing towards the camshaft side 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.

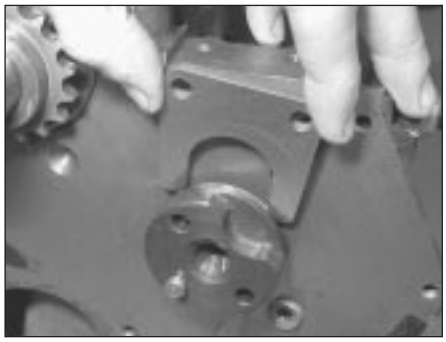
10.6 Tappet withdrawal using a valve grinding tool suction cup

CVH and PTE engines

3 Refer to Part B of this Chapter and remove the cylinder head and sump, then remove the oil pick-up pipe and strainer.
4 Temporarily refit the crankshaft pulley, so that the crankshaft can be rotated. Check that the connecting rods have identification numbers - these should be found on the exhaust side of the big-ends. No 1 assembly is at 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.

Zetec engines

5 Refer to Part C of this Chapter and remove the cylinder head and sump.
6 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)**.
7 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 **(see illustration)**. 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.

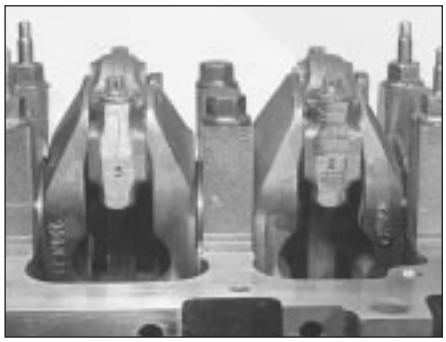


10.15 Refitting the camshaft thrust plate

All engines

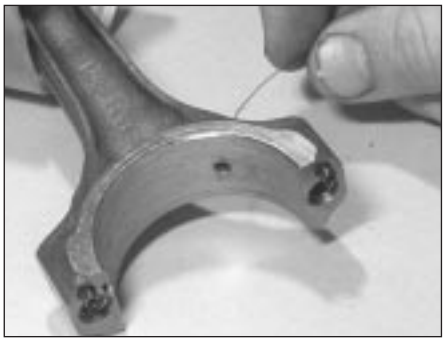
8 Use your fingernail to feel if a ridge has formed at the upper limit of ring travel (about a quarter-inch down from the top of each cylinder). If carbon deposits or cylinder wear have produced ridges, they must be completely removed with a special tool. Follow the tool manufacturer's instructions provided. Failure to remove the ridges before attempting to remove the piston/connecting rod assemblies may result in piston ring breakage.
9 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.
10 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.
11 Repeat the procedure for the remaining cylinders.

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

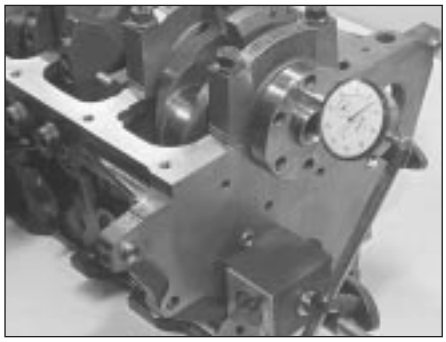


11.7 Each connecting rod and big-end bearing cap will have a flat-machined surface with the cylinder number etched in it

11.14 Using feeler gauge blades to remove piston rings



11.24 Check that the connecting rod oilway on CVH engines is clear



12.1 Checking crankshaft endfloat with a dial gauge

12 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.

Inspection

13 Before the inspection process can begin, the piston/connecting rod assemblies must be cleaned, and the original piston rings removed from the pistons.

14 Carefully expand the old rings 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 **(see illustration)**. Be careful not to scratch the piston with the ends of the ring. The rings are brittle, and will snap if they are spread too far. They are also very sharp - protect your hands and fingers. Note that the third ring may incorporate an expander. Always remove the rings from the top of the piston. Keep each set of rings with its piston if the old rings are to be re-used.

15 Scrape away 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.

16 Remove the carbon from the ring grooves in the piston using an old ring. Break the ring in half to do this (be careful not to cut your fingers - piston rings are sharp). Be careful to remove only the carbon deposits - do not remove any metal, and do not nick or scratch the sides of the ring grooves.

17 Once the deposits have been removed, clean the piston/connecting rod assembly with paraffin or a suitable solvent, and dry thoroughly. Make sure that the oil return holes in the ring grooves are clear.

18 If the pistons and cylinder liners/bores are not damaged or worn excessively, the original pistons can be refitted. Normal piston wear shows up as even vertical wear on the piston thrust surfaces, and slight looseness of the top ring in its groove. New piston rings should always be used when the engine is reassembled.

19 Carefully inspect each piston for cracks around the skirt, around the gudgeon pin holes, and at the piston ring "lands" (between the ring grooves).

20 Look for scoring and scuffing on the piston 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. Scorch marks on the sides of the pistons show that blow-by has occurred. A hole in the piston crown, or burned areas at the edge of the piston crown, indicates that abnormal combustion (pre-ignition, knocking, or detonation) has been occurring. If any of the above problems exist, the causes must be investigated and corrected, or the damage will occur again. The causes may include incorrect ignition timing, or a carburettor or fuel injection system fault.

21 Corrosion of the piston, in the form of pitting, indicates that coolant has been leaking into the combustion chamber and/or the crankcase. Again, the cause must be corrected, or the problem may persist in the rebuilt engine.

22 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.

23 *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.

24 Check the connecting rods for cracks and other damage. Also on CVH engines, check that the oilway in the base of the connecting rod is clear by probing with a piece of wire **(see illustration)**. 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.

12 Crankshaft - removal and inspection

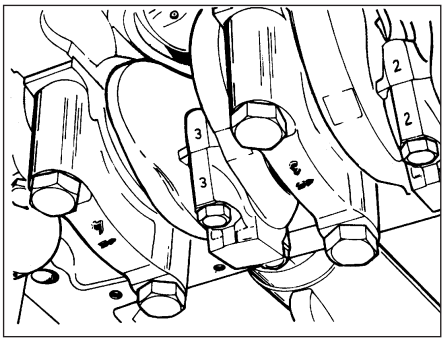
Removal

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

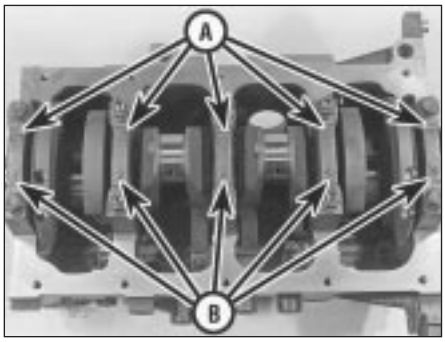
1 Before the crankshaft is removed, check the endfloat. Mount a DTI (Dial Test Indicator, or dial gauge) with the stem in line with the crankshaft and just touching the crankshaft **(see illustration)**.

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.

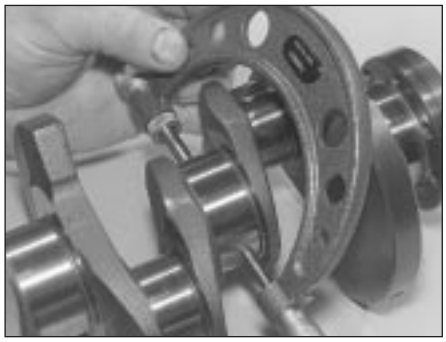
3 If no dial gauge is available, feeler gauges can be used. Gently lever or push the crankshaft all the way towards the right-hand end of the engine. Slip feeler gauges between the crankshaft and the main bearing incorporating the thrustwashers to determine the clearance.



12.4 Connecting rod big-end bearing cap and main bearing cap markings



12.12 Crankshaft main bearing cap arrows point to timing belt end of engine (A), and bearing numbers (B) are consecutive from timing belt end



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

HCS engines

4 Check that the main bearing caps have marks to indicate their respective fitted positions in the block. They also have arrow marks pointing towards the timing chain cover end of the engine to indicate correct orientation **(see illustration)**.

5 Unscrew the retaining bolts, and remove the main bearing caps. If the caps are reluctant to separate from the block face, lightly tap them free using a plastic- or copper-faced hammer. If the bearing shells are likely to be used again, keep them with their bearing caps for safekeeping. However, unless the engine is known to be of low mileage, it is recommended that they be renewed.

6 Lift the crankshaft out from the crankcase, then extract the upper bearing shells and side thrustwashers. Keep them with their respective caps for correct repositioning if they are to be used again.

7 Remove the crankshaft oil seals from the timing cover and the rear oil seal housing.

CVH and PTE engines

8 Check that each main bearing cap is numerically marked for position. Each cap should also have an arrow marking to indicate its direction of fitting (arrow points to the timing belt end).

9 Unscrew the retaining bolts, and remove the main bearing caps. As they are removed, keep each bearing shell with its cap (in case they are to used again). Note that the bearing shells in the main bearing caps are plain (no groove). It is recommended that the shells be renewed, unless the engine is known to be of low mileage.

10 Lift out the crankshaft from the crankcase.

11 Remove each bearing shell in turn from the crankcase, and keep them in order of fitting. Note that the upper shell halves are grooved. Also remove the semi-circular thrustwasher from each side of the central main bearing web, and keep them in their order of fitting.

Zetec engines

12 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.

13 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.

14 Carefully lift the crankshaft out of the engine.

15 Remove each bearing shell in turn from the cylinder block/crankcase, and keep them in order of fitting.

Inspection

16 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.

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

18 Big-end bearing wear is accompanied by distinct metallic knocking when the engine is running (particularly noticeable when the engine is pulling from low speed) and some loss of oil pressure.

19 Main bearing wear is accompanied by severe engine vibration and rumble - getting progressively worse as engine speed increases - and again by loss of oil pressure.

20 Check the bearing journal for roughness by running a finger lightly over the bearing surface. Any roughness (which will be accompanied by obvious bearing wear) indicates that the crankshaft requires regrinding (where possible) or renewal.

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

22 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)**.

23 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.

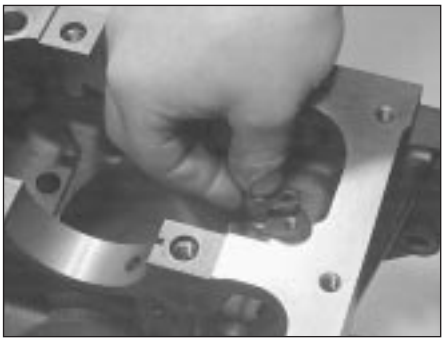
24 If the crankshaft journals are damaged, tapered, out-of-round, or worn beyond the limits specified in this Chapter, the crankshaft must be taken to an engine overhaul specialist, who will regrind it, and who can supply the necessary undersize bearing shells.

25 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.

13 Cylinder block/crankcase - cleaning and inspection

Cleaning

1 Prior to cleaning, remove all external components and senders. On HCS engines, make sure that the camshaft and tappets are removed before carrying out thorough cleaning of the block. On the CVH and PTE engines, remove the engine ventilation cap from the recess in the rear corner of the cylinder block and if still fitted, undo the retaining screw and withdraw the engine speed sensor from the bellhousing face. On Zetec engines, unbolt the piston-cooling oil jets or blanking plugs (as applicable); note that Ford state that the piston-cooling oil jets (where fitted) must be renewed whenever the



13.1a Unbolt blanking plugs (where fitted) to clean out oilways . . .

13.1b . . . but note that piston-cooling oil jets (where fitted) must be renewed whenever engine is overhauled - Zetec engines

13.6 All bolt holes in the block should be cleaned and restored with a tap

engine is dismantled for full overhaul **(see illustrations)**.

2 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.

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.

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

4 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!

5 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.

6 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 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.

7 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. 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.

8 On Zetec engines, refit the blanking plugs or (new) piston-cooling oil jets (as applicable), tightening their Torx screws to the torque wrench setting specified. On all engines, refit all other external components removed, referring to the relevant Chapter of this manual for further details where required. Refit the main bearing caps, and tighten the bolts finger-tight.

9 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

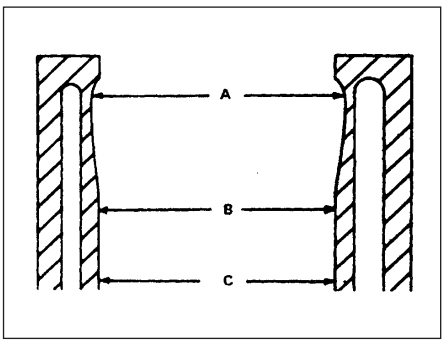
10 Visually check the castings for cracks and corrosion. Look for stripped threads in the threaded holes. If there has been any history of internal coolant leakage, it may be worthwhile having an engine overhaul specialist check the cylinder block/crankcase for cracks with special equipment. If defects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

11 Check each cylinder bore for scuffing and scoring.

12 The cylinder bores must be measured with all the crankshaft main bearing caps bolted in place (without the crankshaft and bearing shells), and tightened 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 illustration)**. Note the measurements obtained.

13 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)**.

14 If it is wished to obtain the piston-to-bore clearance, measure the bore and piston skirt as described above, and subtract the skirt



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

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

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

16 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.

17 Worn pistons must be renewed; on some engines, the 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.

18 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.

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

20 If this is the case, the bores should be honed, to allow the new rings to bed in correctly and provide the best possible seal. Honing is an operation that will be carried out for you by an engine reconditioning specialist.

21 After all the machining operations have been carried out, the entire block/crankcase must be washed very thoroughly with warm soapy water to remove all traces of abrasive grit produced during the machining operations. When completely clean, rinse it thoroughly and dry it, then lightly oil all exposed machined surfaces to prevent rusting.

22 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. If reassembly is not to start immediately, cover the block with a large plastic bag to keep it clean.

14 Main and big-end bearings - inspection

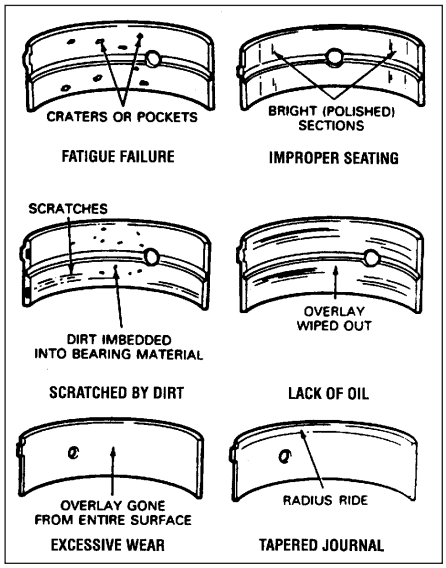
1 Even though the main and big-end bearing shells should be renewed during the engine overhaul, the old shells should be retained for close examination, as they may reveal valuable information about the condition of the engine **(see illustration)**.

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 recognised. 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.

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.



14.1 Typical bearing failures

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.

7 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.

8 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.

9 *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, jointing and thread locking compound will be needed during engine reassembly. For general-purpose applications, it is recommended that Loctite 275 setting sealer or Hylomar PL32M non-setting sealer be used for joints where required, and Loctite 270 for stud and bolt thread-locking. For specific applications on Zetec engines, 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 should be used. These are recommended by, and obtained from, Ford dealers. 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.

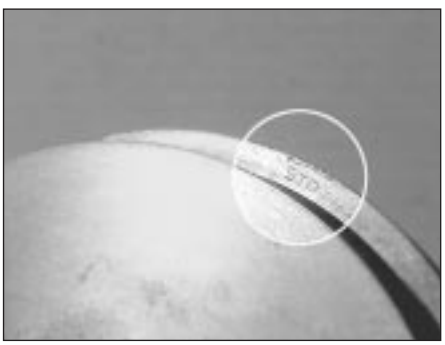
2 In order to save time and avoid problems, engine reassembly can be carried out in the following order (as applicable).

a) Engine ventilation cap (CVH and PTE engines).
b) Tappets and camshaft (HCS engines).
c) Crankshaft and main bearings.
d) Pistons and connecting rods.
e) Oil pump.
f) Sump.
g) Flywheel/driveplate.
h) Cylinder head.
i) Timing sprockets and chain/belt.
j) Engine external components.

3 Ensure that everything is clean prior to reassembly. As mentioned previously, dirt and metal particles can quickly destroy bearings and result in major engine damage. Use clean engine oil to lubricate during reassembly.

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.



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

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. 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. 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 in 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. 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. 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 On HCS engines, when all of the rings are fitted to each piston, arrange them so that the gaps are positioned as described in the Specifications at the start of this Chapter.

11 On the CVH and PTE engines, when all of the rings are fitted to each piston, arrange them so that the gaps are spaced at 120º intervals, with no gaps positioned above the gudgeon pin hole.

12 On Zetec engines, when all the rings are fitted to each piston, space the ring gaps (including the elements of the oil control ring) uniformly around the piston at 120º intervals.

17 Crankshaft - refitting and main bearing running clearance check

1 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!

Main bearing running clearance check

HCS engines

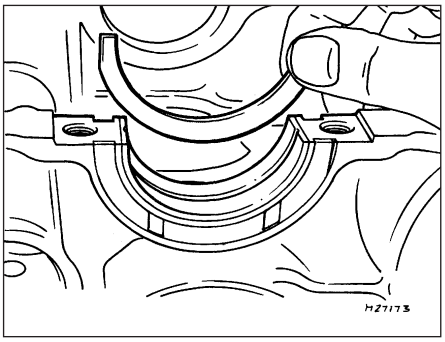
4 Wipe clean the main bearing shell seats in the crankcase, and clean the backs of the bearing shells. Insert the respective upper shells (dry) into position in the crankcase. Note that the upper shells have grooves in them (the lower shells are plain, and have a wider location lug). Where the old main bearings are being refitted, ensure that they are located in their original positions. Make sure that the tab on each bearing shell fits into the notch in the block or cap.

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 Place the crankshaft thrustwashers into position in the crankcase, so that their oil grooves are facing outwards (away from the central web) **(see illustration)**.

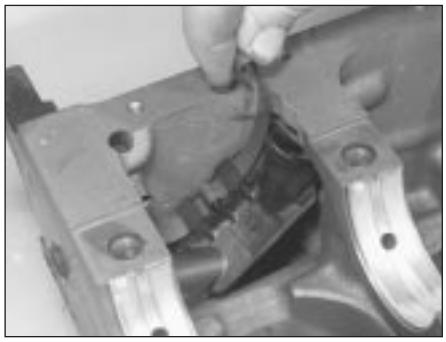
CVH and PTE engines

6 Wipe clean the main bearing shell seats in the crankcase, and clean the backs of the bearing shells. Insert the respective upper shells (dry) into position in the crankcase. Note that with the exception of the front main bearing, the upper shells have grooves in



17.5 Place the crankshaft thrustwashers into position in the crankcase so that their oil grooves are facing outwards

17.6 Fit the bearing shells to the main bearing housings in the crankcase



17.7 Fit the crankcase ventilation cap and its retaining spring

them (the lower half bearings are plain). The upper and lower front shells are narrower in section, and both have an oil groove in them. Where the old main bearings are being refitted, ensure that they are located in their original positions **(see illustration)**. Make sure that the tab on each bearing shell fits into the notch in the block or cap.

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.

7 Relocate the crankcase ventilation cap and its retaining spring into position in the crankcase **(see illustration)**.

8 Place the crankshaft thrustwashers into position in the crankcase so that their oil grooves are facing outwards (away from the central web).

Zetec engines

9 Wipe clean the main bearing shell seats in the crankcase, and 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.

All engines

10 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.

11 Once you're certain the crankshaft is clean, carefully lay it in position in the main bearings. Trim several pieces of the appropriate-size Plastigauge (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)**.

12 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 chain/belt end of the engine. Don't disturb the Plastigauge.

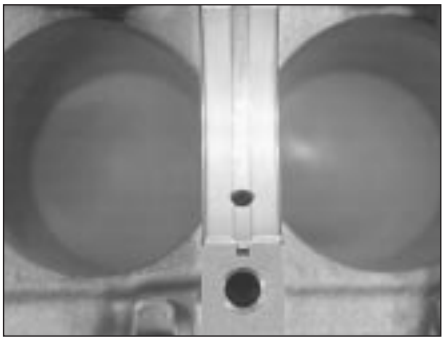
13 Working on one cap at a time, from the centre main bearing outwards (and ensuring that each cap is tightened down squarely and evenly onto the block), tighten the main bearing cap bolts to the specified torque wrench setting. Don't rotate the crankshaft at any time during this operation!

14 Remove the bolts, and carefully lift off the main bearing caps. Keep them in order. Don't disturb the Plastigauge 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.

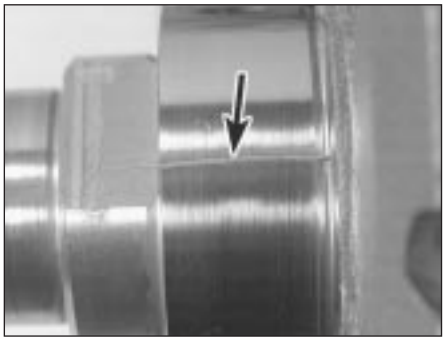
15 Compare the width of the crushed Plastigauge on each journal with the scale printed on the Plastigauge envelope to obtain the main bearing running clearance **(see illustration)**. Check the Specifications to make sure that the clearance is correct.

16 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, 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, make sure that no dirt or oil was between the bearing shells and the caps or block when the clearance was measured. If the Plastigauge is noticeably wider at one end than the other, the journal may be tapered.

17 Carefully scrape all traces of the Plastigauge material off the main bearing journals and the bearing surfaces. Be very

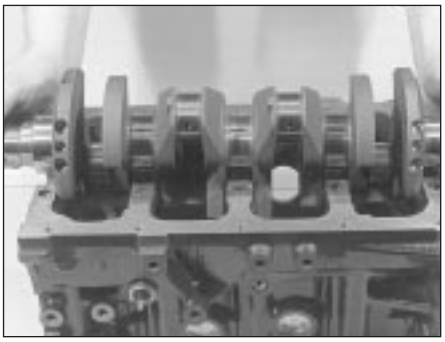


17.9 Tab on each bearing shell must engage with notch in block or cap, and oil holes in upper shells must align with block oilways



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

17.15 Compare the width of the crushed Plastigauge to the scale on the envelope to determine the main bearing running clearance



17.20 Refit the crankshaft after checking bearing clearances

careful not to scratch the bearing - use your fingernail or the edge of a credit card.

Final crankshaft refitting

18 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. Coat the thrustwasher surfaces as well.

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

20 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/chain end of the engine.

21 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.

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

23 Check the crankshaft endfloat (see Section 12). It should be correct if the crankshaft thrust faces aren't worn or damaged.

24 Refit the crankshaft left-hand oil seal carrier, and install a new seal (see Part A, B or C of this Chapter according to engine type).

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

Note: *On HCS engines,* ***new*** *big-end bearing cap retaining bolts will be required for reassembly.*

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 that 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/chain end of the engine. 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 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.

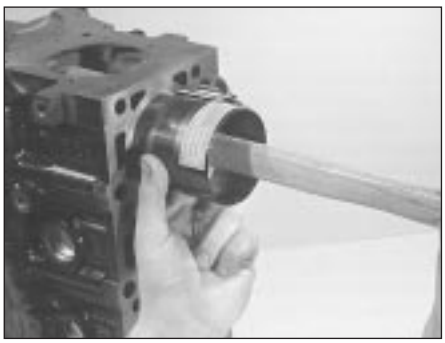
10 To check the big-end bearing running clearance, cut a piece of the appropriate-size Plastigauge slightly shorter than the width of the connecting rod bearing, and lay it in place on the No 1 crankpin (big-end) journal, parallel with the crankshaft centre-line **(see illustration 17.11).**

11 Clean the connecting rod-to-cap mating surfaces, and refit the big-end bearing cap. Tighten the cap bolts evenly - on the HCS and Zetec engines, first use a torque wrench to tighten the bolts to the Stage 1 torque setting, then use an ordinary socket extension bar and an angle gauge to tighten the bolts further through the Stage 2 angle **(see illustration)**. On the CVH and PTE engines, tighten the bolts progressively to the specified torque; further angle-tightening is not required on these engines. 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 Plastigauge.

13 Compare the width of the crushed

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 Angle-tightening the big-end bolts using the correct tool

Plastigauge to the scale printed on the Plastigauge envelope, to obtain the running clearance **(see illustration 17.15)**. 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 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 Plastigauge was wider at one end than the other, the crankpin journal may be tapered.

15 Carefully scrape all traces of the Plastigauge 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 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/chain 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.

21 On HCS engines, if the oil pick-up pipe and strainer was removed, this is a good time to refit it. First clean the joint area, then coat the area indicated with the specified activator (available from Ford dealers) **(see illustration)**. Wait for a period of ten minutes, then smear the shaded area with the specified adhesive and immediately press the inlet pipe into position in the crankcase.

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 the fuel pump fuse (fuel injection engines) to disconnect the fuel pump (see Chapter 12). 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. On fuel injection engines, refit the fuel pump fuse, 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.

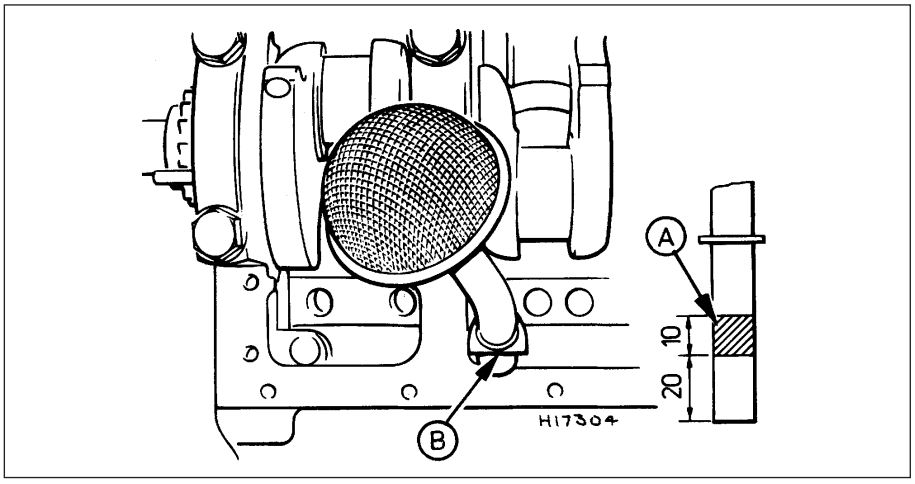
5 While the engine is idling, check for fuel, coolant and oil leaks. Don't be alarmed if there are some odd smells and smoke from parts getting hot and burning off oil deposits. If the hydraulic tappets (where applicable) have been disturbed, some valve gear noise may be heard at first; this should disappear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



18.21 Oil inlet pipe refitting details on the HCS engine

A Area of sealant application - dimensions in mm
B Edge must be parallel with engine longitudinal axis