



# Engine

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### Protection of paintwork

Before commencing work within the engine compartment, always fit new liners RH 2685 to the inside of the wing covers RH 2684 and position them on the front wings of the vehicle.



# Issue record sheet

The dates quoted below refer to the issue date of individual pages within this chapter.

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## Introduction

The power unit is an over square, eight cylinder four stroke, designed in a 90° Vee formation.

The two banks (each of four cylinders) are designated 'A' bank and 'B' bank. 'A' bank of cylinders is situated on the right-hand side when viewed from the driver's seat. It is located 25,40 mm (1.0 in) further forward than the cylinders of 'B' bank.

The crankcase is manufactured from cast aluminium alloy and on 1989 model year engines it is also ribbed and cross-bolted. It is fitted with detachable, full length, wet cylinder liners of centrifugally spun cast iron. Rubber 'O' rings are used at the top and bottom of each liner to seal in engine coolant. This allows the coolant to circulate directly onto and around the centre portion of the liners.

The crankshaft is forged from chrome molybdenum steel which is subsequently nitride hardened.

Five main bearings support the crankshaft. The bearings are split steel backed shells, lined with an aluminium-tin material. They are retained in position by forged aluminium bearing caps. Crankshaft end-

float is controlled by thrust washers fitted on each side of the centre main bearing.

The 'H' section connecting rods and caps are forged from chrome molybdenum steel. The small-end bushes are lead-bronze with a steel backing. The bushes are pressed into the connecting rods and machined to size. The big-end bearings are split, steel backed shells with an aluminium-tin lining.

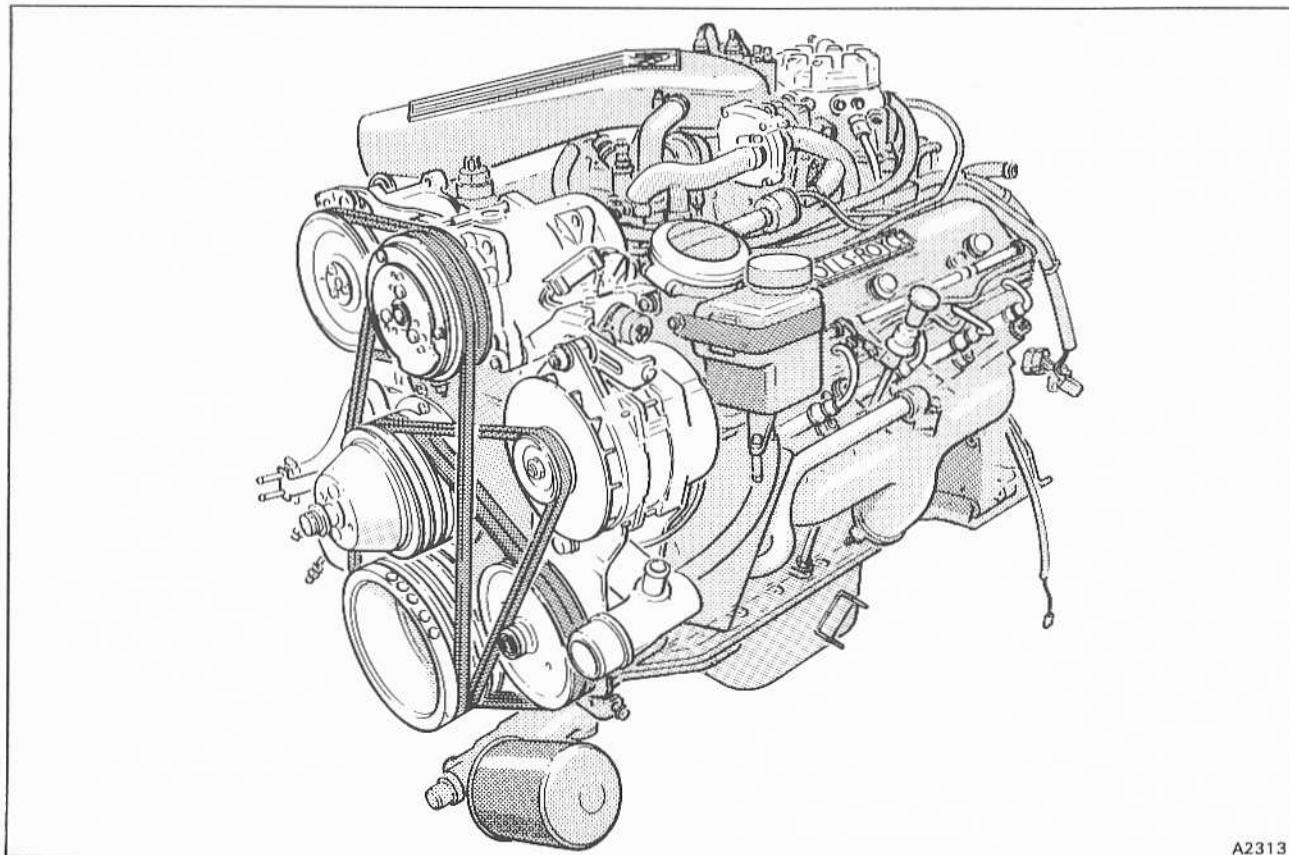
The pistons are manufactured from aluminium alloy and are tin plated. They are carried on fully floating, hardened steel gudgeon pins.

The compression ratio is either 8:1 or 9:1 depending upon the specification of the engine. The shape of the piston crown changes the compression ratio.

On all engines, steel struts are cast into the wall of each piston.

The pistons have two compression rings and an oil control ring.

The two aluminium alloy cylinder heads each have four separate inlet and exhaust ports. The cylinder heads are fitted with phosphor-bronze



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Fig. E2-1 Fuel injected engine



exhaust valve guides, cast iron inlet valve guides, and heat treated alloy cast iron valve seat inserts.

The exhaust valves are austenitic steel with stellite tips and valve seat faces. Early inlet valves are alloy steel with induction hardened tips. However, from approximately mid-March 1988, they are manufactured from austenitic steel.

On turbocharged engines, the inlet valves are manufactured from austenitic steel.

The overhead valve mechanism is operated by push rods, rocker arms, and self-adjusting hydraulic tappets from a centrally positioned camshaft which is carried directly in bores machined in the crankcase. The hydraulic tappets are carried in detachable blocks located in the crankcase.

Two eccentrics on the camshaft drive the hydraulic pumps mounted on the tappet cover. These pumps provide the hydraulic pressure for the braking and levelling systems.

Engine lubrication is provided by a pressurized system. First stage filtration is accomplished through a fine mesh strainer and pick-up located in the engine oil sump. Oil from the sump strainer passes into a gear type pump situated at the front of the crankcase. The pump is driven by skew gears from the crankshaft. A relief valve in the oil pump regulates the oil pressure at approximately 2,76 bar (40 lbf/in<sup>2</sup>). Final filtration of the oil is through a disposable 'full flow' filter, prior to its circulation around the engine.

High pressure oil is delivered to the turbocharger assembly (if fitted), crankshaft, connecting rods, camshaft bearing surfaces, timing gears, tappets, push rods, and rocker ball end seatings.

Low pressure oil is fed through the front camshaft bearing to the rocker shaft, rocker arms, and valve tips. The connecting rod small-ends, gudgeon pins, and cylinder walls are splash fed with oil from the crankcase.

The engine is cooled by a mixture of anti-freeze and water circulating around the coolant passages. A coolant pump which is mounted at the front of the power unit and belt driven from the crankshaft,

circulates the warm coolant around the engine, through the thermostat and then to the radiator where it is cooled.

Crankcase emissions are controlled by a recirculatory closed breather system. Basically, two systems are used depending upon the engine i.e. naturally aspirated or turbocharged.

For further details of the crankcase emission control system, refer to TSD 4737, Engine Management Systems.

### Engine identification number

The identification number is stamped on a crankcase boss adjacent to the ignition distributor (see fig. E2-2). It is the only number stamped on the engine and should be used for all identification purposes.

The number is made up of the following components.

1. A five digit build sequence number which commences at 60000.
2. A 5 or 6 character engine type code which denotes whether the engine is naturally aspirated or turbocharged (L410I or L410IT).
3. A single digit compression ratio identification, either 8 (8:1 compression ratio), or 9 (9:1 compression ratio).

Example

60001 L410IT/8=Turbocharged with 8:1 compression ratio.

In addition, 1989 model year turbocharged cars have the letter I as the final digit.

Example

60001 L410IT/I=Turbocharged with intercooler.

### Engine oils

Prolonged and repeated contact with mineral oil will result in the removal of natural fats from the skin, leading to dryness, irritation, and dermatitis. In addition, used engine oil contains potentially harmful contaminants which may cause skin cancer. Adequate means of skin protection and washing facilities should be provided.

For full details on engine oil precautions, reference should be made to Chapter A.

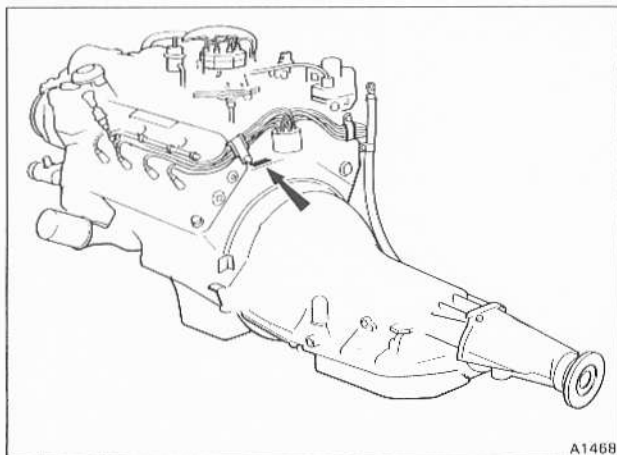


Fig. E2-2 Engine identification number



# Specification

<b>General</b>		<b>Connecting rods</b>	
Type	Over square 90° Vee formation liquid cooled.	Type	'H' section. Forged to size. Weighed and colour coded into sets.
Number of cylinders	Eight – in two banks of four.	Material	Chrome molybdenum steel.
Bore	104,14 mm (4.10 in).	Big-end bearings	Steel backed shells with a tin-aluminium lining.
Stroke	99,06 mm (3.90 in).	Gudgeon pin bushes	Pressed into connecting rod small-end bosses and machined to size.
Cubic capacity	6,75 litres (411.91 in <sup>3</sup> ) nominal.	Material	Lead-bronze, steel backed.
Compression ratio	9:1 or 8:1 dependent upon the specification of the vehicle.	Gudgeon pins	Fully floating.
Firing order	A1, A3, B3, A2, B2, B1, A4, B4.	Material	EN 32 B.
<b>Cylinder block</b>		<b>Pistons</b>	
Type	Monobloc casting.	Type	Aeconoguide, skirt relieved for crankweb clearance. Recessed crown and offset gudgeon pin.
1989 model year	Ribbed and cross-bolted.		All engines have steel struts cast into the wall of the pistons.
Material	Cast aluminium alloy.		Aluminium alloy – Tin plated.
<b>Cylinder liners</b>		<b>Rings</b>	
Type	Detachable wet liners.	Material	Three
Material	Centrifugally spun cast iron.		a. Two compression, manufactured from cast iron. Top ring molybdenum sprayed on periphery.
<b>Cylinder heads</b>			
Description	Two detachable heads, each having four separate inlet and exhaust ports.	b. One oil control ('H' flex). Top and bottom steel rails have a chromium plated periphery. Equalizer (expander and centre spacer) is manufactured from carbon steel.	
Material	Aluminium alloy, with phosphor-bronze exhaust valve guides and cast iron inlet valve guides. Valve seat inserts of heat treated alloy cast iron.		
<b>Crankshaft</b>		<b>Valve gear</b>	
Description	Dynamically balanced, five journal crankshaft with four crankpins (incorporating integral balance weights and sludge traps).	Valves	Overhead push rod operated. Seat angle 45°.
Material	Chrome molybdenum steel with nitride hardened journals and crankpins.	Material	<b>Naturally aspirated engines.</b>
Damper	Metalastik rubber vibration damper.	Inlet valve	Alloy steel with induction hardened tips.
Direction of rotation	Clockwise (viewed from the front of the engine).		From approximately mid-March 1988, as Turbocharged engines.
End thrust	Taken on centre main bearing.		<b>Turbocharged engines.</b>
<b>Main bearings</b>		Exhaust valve	Austenitic steel with Stellite tips.
Material	Steel backed shells with a tin-aluminium lining.	Valve timing	Austenitic steel with Stellite tips and valve seats.
Number	Five.	Tappets	Marks on gears.
			Self-adjusting hydraulic tappets with spherical base.



Material Heat treated chilled cast iron.  
Push rods Ball-ended tubes.  
Material Cold drawn steel or  
copper plated Bundy tube.

#### Camshaft

Material Chilled cast iron.  
Cams 5' to 7' longitudinal taper.  
Number of journals Four.  
Bearings Runs direct in crankcase.  
Thrust taken On front end.  
Drive Through helical tooth gears.  
Material Crankshaft gear – steel.  
Camshaft gear – aluminium.

#### Lubrication system

General High pressure oil feed to  
turbocharger (if fitted),  
crankshaft, connecting rods,  
camshaft bearings, camshaft  
timing gears, tappets, push  
rods, and rocker ball end  
seatings.  
Low oil pressure fed through  
the front camshaft bearing to  
rocker shafts, rocker arms, and  
valve tips. Splash feed to  
connecting rod small-ends,  
gudgeon pins, and cylinder  
walls.  
Type Pressurized, wet sump  
system.  
High pressure supply 2,76 bar (40 lbf/in<sup>2</sup>) at  
2000 rev/min.  
Relief valve 2,76 bar (40 lbf/in<sup>2</sup>).  
Oil pump Helical gear type with fine  
mesh strainer pick-up.  
Drive By gears from crankshaft.  
Oil filter Full flow, disposable canister  
type.

#### Associated systems

Fuel and ignition systems Refer to TSD 4737,  
Engine Management Systems.  
Cooling system Refer to Chapter L.  
Exhaust system Refer to Chapter Q.



Description	Dimension	Permissible worn dimensions	Remarks
<b>Main bearing housings</b>			
Bore diameter	2.8735 in to 2.8740 in		This diameter should be checked with the main bearing caps in position and the retaining bolts tightened to between 79 Nm and 84 Nm (8,0 kgf m and 8,5 kgf m; 58 lbf ft and 62 lbf ft)
<b>Main bearing cap</b>			
Width of cap	5.1005 in to 5.1010 in		
Crankcase location gap	5.1000 in to 5.1010 in		
Fit – Interference	0.001 in		
Clearance	0.0005 in		
<b>Cross-bolting beam</b>			
Width of beam	6.4000 in to 6.4005 in		
Crankcase location gap	6.4000 in to 6.402 in		
Fit – Interference	0.0005 in		
Clearance	0.002 in		
<b>Crankshaft diameter</b>	<b>Crankshaft journal diameter</b>	<b>Main shell bearing diameter</b>	
Crankshaft grinding dimensions			
Standard	2.6378 in – 0.0005 in	2.6388 in + 0.001 in	
0.010 in undersize	2.6278 in – 0.0005 in	2.6288 in + 0.001 in	
0.020 in undersize	2.6178 in – 0.0005 in	2.6188 in + 0.001 in	
<b>Crankshaft size</b>	<b>Crankpin</b>	<b>Big-end bearing</b>	
Crankshaft grinding dimensions			
Standard	2.249 in – 0.0005 in	2.2505 in + 0.001 in	
0.010 in undersize	2.239 in – 0.0005 in	2.2405 in + 0.001 in	
0.020 in undersize	2.229 in – 0.0005 in	2.2305 in + 0.001 in	
<b>Valve gear</b>			
Camshaft timing gear backlash	0.001 in to 0.0035 in	0.006 in	
Camshaft gear face run-out	0.000 in to 0.002 in		



Description	Dimension	Permissible worn dimensions	Remarks
Camshaft end-float	0.002 in to 0.006 in		
Camshaft journal diameter	1.9975 in to 1.998 in	1.9965 in	
Camshaft bearing bore	2.000 in to 2.0005 in	2.002 in	
Camshaft journal clearance	0.002 in to 0.003 in	0.004 in	
Cam base circle (inlet and exhaust)	1.467 in to 1.472 in	1.457 in	Dimensions apply on centre line of cam at the small end
Height of cam (inlet and exhaust)	1.721 in		
Exhaust valve guide – external diameter	0.6275 in to 0.628 in		Standard Blue + 0.002 in Green + 0.005 in Yellow + 0.010 in
Cylinder head bore diameter for exhaust valve guide	0.625 in to 0.626 in		
Interference in head	0.0015 in to 0.003 in		
Exhaust valve guide – internal diameter	0.375 in to 0.3755 in	0.3775 in	Finish reamed after fitting. 'Bellmouth' at the lower end is permissible up to 0.006 in for a depth of 0.3725 in
Inlet valve stem diameter	0.3735 in to 0.374 in	0.37275 in	New diameter will increase nominally 0.0002 in after tufftriding
Clearance	0.001 in to 0.002 in	0.0035 in	
Valve spring poundage test (inlet and exhaust)	1st test Weight between 83.6 lbf and 92.4 lbf to compress spring to 1.340 in  2nd test Weight between 158 lbf and 170 lbf to compress spring to 0.940 in		
Exhaust valve – overall length	4.891 in		Nominal dimension
Exhaust valve stem diameter	0.3735 in to 0.374 in	0.37275 in	New diameter will increase nominally 0.0002 in after tufftriding
Clearance	0.001 in to 0.002 in	0.0035 in	
Exhaust and inlet valve seat angle	45°		After regrinding the exhaust valve seat can be 'crowned' with 30° cutter to avoid pocketing



Description	Dimension	Permissible worn dimensions	Remarks
Exhaust valve seat insert – external diameter	1.7540 in to 1.7545 in		Standard Green + 0.005 in Yellow + 0.010 in Blue + 0.015 in
Cylinder head bore diameter for exhaust seat insert	1.750 in to 1.751 in		
Interference	0.003 in to 0.0045 in		
Inlet valve seat insert – external diameter	2.0290 in to 2.0295 in		Standard Green + 0.005 in Yellow + 0.010 in Blue + 0.015 in
Cylinder head bore diameter	2.025 in to 2.026 in		
Interference	0.003 in to 0.0045 in		
Inlet valve guide – external diameter	0.6275 in to 0.628 in		Standard Blue + 0.002 in Green + 0.005 in Yellow + 0.010 in
Cylinder head bore diameter for inlet valve guide	0.625 in to 0.626 in		
Interference in head	0.0015 in to 0.003 in		
Inlet valve guide – internal diameter	0.375 in to 0.3755 in	0.3775 in	Finish reamed after fitting
Inlet valve – overall length	4.905 in		Nominal dimension
Distributor gear backlash	0.002 in to 0.008 in	0.009 in	Measured by turning small gear on distributor drive-shaft
Rocker bore diameter	0.74925 in to 0.74975 in	0.751 in	
Rocker shaft diameter	0.74825 in to 0.7485 in		
Clearance	0.00075 in to 0.0015 in	0.0035 in	
Hydraulic brake pump push rod lift	0.522 in to 0.525 in		This measurement is taken from the top face of the mounting flange to the top of the push rod
Hydraulic brake pump shim sizes	0.003 in and 0.007 in		
<b>Oil pump</b>			
Driving shaft diameter	0.4990 in to 0.4995 in	0.4970 in	
Shaft bore diameter	0.500 in to 0.5005 in		



Description	Dimension	Permissible worn dimensions	Remarks
Shaft clearance in casing bore	0.0005 in to 0.0015 in	0.003 in	
Stationary spindle diameter	0.499 in to 0.4995 in	0.4975 in	
Driven gear internal diameter	0.500 in to 0.5005 in	0.5015 in	
Clearance on spindle	0.0005 in to 0.0015 in	0.003 in	Permissible only when the radial clearance of the gears in the case exceeds this figure
Diametrical clearance between gears and side of chamber	0.002 in to 0.0035 in	0.006 in	
Pump gears backlash	0.003 in to 0.007 in	0.0085 in	Oil pump internal gears
Pump gears end-float	0.001 in to 0.004 in	0.005 in	
Drive gear backlash	0.001 in to 0.008 in	0.012 in	Measured by turning small gear on oil pump
Drive gear end-float	0.001 in to 0.004 in	0.005 in	

## Crankcase, cylinder liners, and crankshaft

### Crankcase

The crankcase is a monobloc casting of aluminium alloy.

Centrifugally spun cast iron 'wet type' cylinder liners are sealed in the crankcase by a single 'O' ring at the top and by two 'O' rings at the bottom.

The main bearing caps are aluminium forgings and have an interference fit in the crankcase.

Various setscrew holes in the crankcase have heli-coil inserts. The threads in the crankcase (into which these heli-coil inserts screw) are non-standard sizes. Therefore, setscrews should not be fitted until the heli-coils have been correctly installed.

Cylinder head studs (colour coded for size) screw directly into the crankcase, their threads having an interference fit of up to 0,05mm (0.002in).

### Cylinder liners and seals (see fig. E5-1)

**The cylinder bore dimensions should only be checked when all the liners from any one bank are in position. Any deviation from this rule could result in false readings.**

From the measurements taken of the cylinder bore, calculate the wear and ovality. If the figures exceed those quoted in Section E4, Dimensional data, a new liner assembly and piston assembly must be fitted.

Cylinder liner seal leakage can be detected by 'tell-tale' holes in the side of the crankcase.

If engine coolant issues from the 'tell-tale' hole, the upper of the two bottom rings is leaking. If oil issues from the 'tell-tale' hole, the lower sealing ring is leaking. In either case, the appropriate liner should be removed and new sealing rings fitted.

**Note** The sealing ring lubricant used during engine assembly, will melt when the engine is initially run and may flow from the 'tell-tale' holes, staining the crankcase. This situation is normal and must not be confused with a sealing ring leak.

### Cylinder liner – To remove (see fig. E5-1)

This operation can be carried out whether or not the crankcase is fitted in the vehicle.

1. Dismantle the engine as necessary.
2. Using the cylinder liner extraction tool RH 7095, withdraw the liner from the top face of the crankcase.

In certain instances it may be beneficial to carry out this operation with the crankcase heated.

### Cylinder liner – To fit (see fig. E5-1)

1. Ensure that the coolant drain hole and the seal leakage 'tell-tale' holes in the crankcase wall are clean and unobstructed.
2. Ensure that the sealing ring grooves are absolutely clean.
3. Inspect the cylinder liner (item 1), the liner location bore, and the crankcase counterbore. Remove any burrs

and thoroughly clean the parts, particularly the mating faces, with Genklene or a similar alternative.

**Meticulous care should be taken when carrying out these operations. Any dirt or burrs will have an adverse effect on the fit of the liner in the crankcase and may also distort the liner bore.**

4. When a cylinder liner is fitted into the crankcase, it should stand proud of the top face by the amount stated in Section E4, Dimensional data. This is to provide a 'nip' when the cylinder head and gasket are fitted.

To obtain the correct 'nip' (item 2), carry out Operations 5 to 8 inclusive.

5. Measure the depth of the cylinder liner collar and also that of the counterbore in the crankcase.

6. Subtract the counterbore dimension from the collar measurement, to obtain the 'nip' figure.

7. If the figure obtained does not correspond with the figures quoted in Section E4, either,

a. grind the excess metal from the top face of the liner (always clean the liner after grinding).

b. try another liner.

8. Ensure that the bore number is etched onto the top face. Other information that is etched onto the top of the liner includes the piston grade (always ensure that the cylinder liner is of the required grade).

9. Fit three new rubber sealing rings into the crankcase. Smear the rings and location diameters with Palmolive grease or its equivalent.

10. Ensure that the crankcase counterbore and liner are clean.

11. Fit the cylinder liner into the crankcase bore, ensuring that the cylinder bore reference number etched on the top face of the liner is positioned at the top (i.e. nearest point to the camshaft).

12. Using a plastic headed mallet, tap evenly around the top face of the liner to ensure that it is seating correctly.

**Note** In certain instances it may be beneficial to carry out Operations 11 and 12 with the crankcase heated.

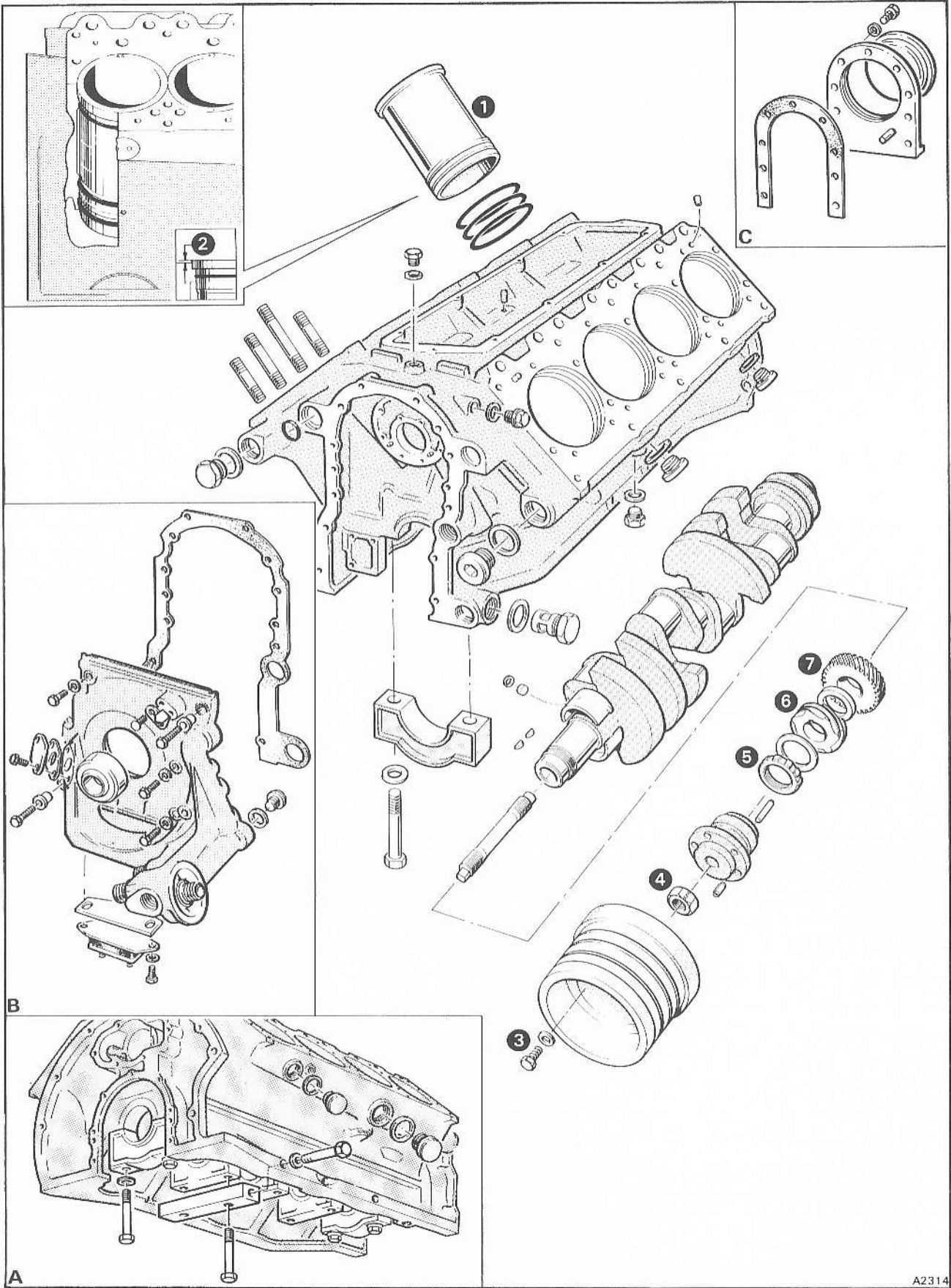
13. Using a depth micrometer, measure the amount that the liner stands proud above the crankcase face (refer to Section E4, Dimensional data).

14. If the liner stands proud by more than the specified limits, again tap around the top face of the liner using a plastic headed mallet.

15. If fitment does not conform with the figures given in Section E4, the liner should be withdrawn and the cause investigated.

### Crankshaft pulley/damper – To remove (see fig. E5-1)

1. Carry out the usual workshop safety precautions.
2. Slacken the driving belts.
3. Remove the setscrews (item 3) from the centre of the crankshaft pulley.
4. Withdraw the pulley/damper assembly.



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Fig. E5-1 Crankcase, crankshaft, and cylinder liners

### **Crankshaft pulley/damper – To fit** (see fig. E5-1)

To fit the pulley/damper, reverse the procedure given for removal noting the following.

1. The pulley/damper assembly can only be fitted one way due to the locating pin.
2. Fit the setscrews and torque tighten them to the figures given in Section E15.
3. Fit the drive belts and tension them as described in Section E13.

### **Crankshaft – To remove** (see fig. E5-1)

**It is important that the position of any component removed from the engine is noted so that it can be returned to its original position. Otherwise, wear characteristics and engine balance may be impaired.**

1. Remove the engine from the vehicle (see Section E12).
2. Fit the engine to a turnover stand.
3. Ensure that the engine oil has been drained.
4. Turn the engine over.
5. Remove the retaining setscrews and withdraw the sump. Discard the gasket.
6. Remove the setscrews and withdraw the oil pedestal and strainer assembly.
7. Remove the coolant pump (see Chapter L).  
On turbocharged engines also remove the heatshields.
8. Unscrew and remove the setscrews (item 3) in the centre of the crankshaft pulley.
9. Withdraw the pulley/damper assembly.
10. Remove the nut (item 4) securing the drive flange to the crankshaft.
11. Using extractor RH 9765, withdraw the drive flange. The flange is dowelled to the crankshaft.
12. Ensure that all weight is removed from the engine front mounting foot. Then, remove the setscrews from the engine mounting situated below the timing cover.
13. Remove all the setscrews securing the lower timing cover (see inset B).
14. Carefully withdraw the lower timing cover (the cover is dowelled to the crankcase).
15. Remove the setscrews retaining the oil pump. Withdraw the assembly and dowel inserts, together with the pipes and 'O' rings.
16. Remove the setscrews securing the flexplate assembly to the rear of the crankshaft. Withdraw the flexplate assembly.
17. Unscrew the setscrews and withdraw the backplate (see inset C). The backplate is dowelled to the crankcase. Discard the gasket.
18. Remove the nuts from the connecting rod bolts. Then, withdraw the connecting rod caps.
19. Fit protective rubber tubing over the connecting rod bolts to prevent damage to the crankpins.
20. Remove the shell bearings from both the connecting rods and caps.
21. Push the connecting rod and piston assemblies to the top of their respective bores.
22. On 1989 model year engines, remove the cross-bolting setscrews from either side of the crankcase in the three inner bearing cap positions (see inset A).

23. Unscrew the main bearing cap bolts. Withdraw the cross-bolting beams (if fitted) and caps.

24. Remove the crankshaft thrust washers from the centre main bearings.

25. Carefully lift the crankshaft from the crankcase.

### **Crankshaft – To dismantle** (see fig. E5-1)

1. Using the special spanner RH 12055, unscrew and remove the serrated nut (item 5) and washer from the front of the crankshaft (the nut has a left-hand thread).
2. Ensure that the front face of the oil pump drive gear is identified (to enable it to be installed in its original position).
3. Withdraw the oil pump drive gear (item 6). Remove the Woodruff key.
4. Withdraw the distance piece (spacer).
5. Withdraw the timing gear (item 7). Remove the Woodruff key.
6. Dismantle the sludge traps by removing the retaining circlip and withdrawing the plug (item 8).
7. Remove the stud from the front of the crankshaft (if necessary) using tool RH 12054.

### **Crankshaft – To inspect** (see fig. E5-2)

1. Thoroughly clean the crankshaft. This can usually be achieved by washing the shaft in a paraffin bath, then drying it with compressed air.
2. Mount the crankshaft in 'Vee' blocks on an inspection table.
3. Using a micrometer and an indicator gauge, check the crankshaft journals and crankpins for size, ovality, parallelism, and bow. Refer to Section E4, Dimensional data, for the service dimensions. If necessary, regrind the crankshaft.
4. Inspect the Woodruff keys and keyways for wear. Oversize keys are available. However, if wear is apparent with the largest size Woodruff keys installed, a replacement crankshaft should be fitted.

### **Crankshaft – To regrind**

1. The crankshaft should be reground when wear or ovality exceeds 0,025 mm (0.001 in), when the crankpins and journals are heavily scored, or when the bow in the crankshaft exceeds 0,25 mm (0.010 in).
2. Replacement bearings are available in the following sizes, standard, minus 0,25 mm (0.010 in), and minus 0,50 mm (0.020 in).
3. The crankpins and journals should be ground to suit the nearest undersize bearing. Refer to Section E4, Dimensional data.
4. When grinding, use a stone having a grit and grade equivalent to a NORTON A 46 MV or one grade softer.

#### **A harder stone must not be used.**

5. For 'plunge' grinding, the width of the stone must be 0,50 mm (0.020 in) **less** than the dimension between the journal or crankpin end faces and the machine must be fitted with hydraulic stops. For traverse grinding a suitable width of stone should be selected.
6. Care must be taken to ensure that no sharp edges are left in the radii where the grinding wheel traverse

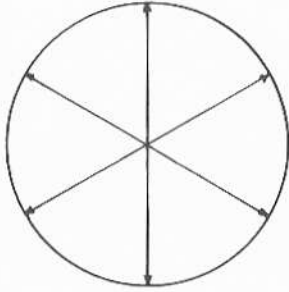
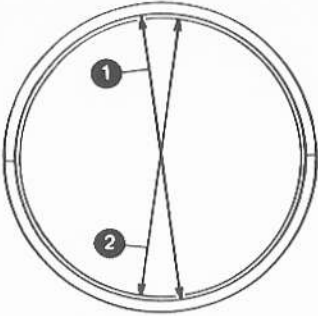
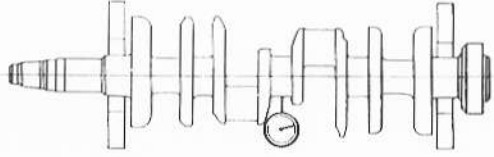
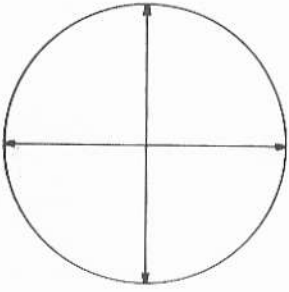
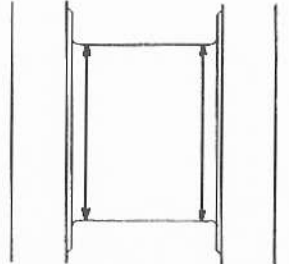
Measurement	Method
<p><b>Mean size</b></p> 	<p><b>Obtained on crankshaft main journal, crankpins, and bearing shells</b></p> <ol style="list-style-type: none"> <li>(a) Measure the diameter of the journal or crankpin in two planes one at right-angles to the other.</li> <li>(b) Ensure that the shell bearings are fitted in position and the retaining nuts correctly tightened. Measure the bore of the bearing in three places as shown.</li> </ol> <ol style="list-style-type: none"> <li>Add the two journal or crankpin readings together (three readings for the shell bearings) and divide by two (three for shell bearings).</li> </ol>
<p><b>Bearing clearance</b></p> 	<p><b>Obtained between crankshaft main journals/crankpins and bearing shells</b></p> <ol style="list-style-type: none"> <li>Obtain mean size of shell bearing.</li> <li>Obtain mean size of crankshaft main journal/crankpin.</li> <li>Subtract measurement obtained in 2 from measurement obtained in 1 to give bearing clearance.</li> </ol>
<p><b>Bow</b></p> 	<p><b>Measured on the crankshaft centre main journal</b></p> <ol style="list-style-type: none"> <li>Mount the crankshaft main journals 1 and 5 in 'Vee' blocks on a surface table.</li> <li>Position the indicator gauge on the side of the centre main journal.</li> <li>Rotate the shaft until the lowest reading is obtained on the gauge. Zero the gauge.</li> <li>Rotate the shaft 180° and note the reading on the gauge.</li> <li>Divide the reading by two to obtain the crankshaft bow.</li> </ol>
<p><b>Ovality</b></p> 	<p><b>Measured on the crankshaft main journals and crankpins</b></p> <ol style="list-style-type: none"> <li>Measure across the centre of the journal or crankpin in two planes one at right-angles to the other.</li> <li>Subtract the smaller reading from the larger reading to give the ovality.</li> </ol> <p><b>Note</b> This operation should be carried out at several points to establish the largest and smallest diameters.</p>
<p><b>Parallelism (Taper)</b></p> 	<p><b>Measured on the crankshaft main journals and crankpins</b></p> <ol style="list-style-type: none"> <li>Measure the diameter at both ends of the journal or crankpin, ensure that the measurements are taken on the same plane.</li> <li>Subtract the smaller reading from the larger reading to give the taper.</li> </ol>

Fig. E5-2 Method of measuring the crankshaft

ends and the radii of the grinding wheel must be carefully controlled to ensure that the grinding fades out not more than half-way up the radius of the crankshaft.

**On no account must the grinding wheel touch the side faces of the crankpin or journal.**

7. Lubrication must be continuous during regrinding and the lubricant should be fed liberally onto the ingoing side of the grinding wheel. The grinding wheel must not be allowed to contact the journal or crankpin until the shaft is thoroughly wet. Any approved lubricant can be used.

8. After grinding, test the hardness of the journals and crankpins. The minimum acceptance figure for the hardened crankshaft is 570 VPN/30 kg using a Vickers Diamond Pyramid Machine.

9. If the necessary equipment is available, the shaft should be magnetically crack tested.

#### **Crankshaft – To assemble** (see fig. E5-1)

1. Ensure that the crankshaft is thoroughly clean.
2. If the sludge traps have been dismantled, ensure that new plugs are fitted.

Fit the plugs using a punch. Each plug must be retained with a circlip.

3. Fit a Woodruff key to the crankshaft, then fit the timing gear. Ensure the timing marks are to the front and the gear slides freely into position, making face contact with the crankshaft shoulder.
4. Check that the timing gear key does not protrude beyond the timing gear. Then, slide the spacer into position, ensuring face contact with the timing gear.
5. Fit the second Woodruff key to the crankshaft, then fit the oil pump drive gear. Ensure the gear is fitted with the front face outwards (marked during dismantling), and it locates correctly on the Woodruff key.
6. Apply a light application of engine oil onto the threads of the crankshaft. Then, fit the washer and ringnut (item 5).

**Note** The nut has a left-hand thread.

7. Using special spanner RH 12055 torque tighten the nut to between 488 Nm and 597 Nm (50 kgf m and 61 kgf m; 360 lbf ft and 440 lbf ft).

**The crankshaft should be held firmly whilst tightening the nut.** This can be accomplished by fitting two long setscrews in the rear of the crankshaft and inserting a bar between them. The force needed to tighten the nut can be off-set by levering on the bar.

#### **Crankshaft – To fit** (see fig. E5-1)

All engines

1. Ensure that the bearing shells are the correct size for the journal and crankpins.
2. Ensure that all parts are clean. A lint-free cloth should be used for wiping all parts.
3. Position the upper bearing shells in the crankcase and lightly smear them with clean engine oil.
4. Place the crankshaft into position, noting that the marks on the crankshaft and camshaft timing gears align. Fit the upper halves of the thrust washer to the centre main bearing.

Engines prior to 1989 model year

5. Fit the main bearing caps and shells together with the two lower thrust washers for the centre main bearing. When fitting the bearing caps it may be necessary to tap them lightly into position. If this is done, ensure that the bearing shells are not dislodged. Fit and torque tighten the main bearing cap bolts to the figures quoted in Section E15.

1989 model year engines

5. Fit the main bearing caps and shells together with the two lower thrust washers for the centre main bearing as follows.

a. Engage the setscrews (through the bearing caps) in the crankcase tappings and location diameters **before** the bearing caps are lightly tapped into position. Ensure the bearing shells are not dislodged.

**Note** Do not engage the bearing caps in the crankcase by pulling them down with the setscrews.

b. On the centre and intermediate bearing caps only, the setscrews should then be removed to allow the fitting of the cross-bolting beams.

c. The setscrews should then be passed through the beams and bearing caps and engaged in the crankcase tappings and location diameters **before** the cross-bolting beams are lightly tapped into position.

d. Before the main bearing setscrews are torque tightened, the cross-bolting setscrews must be engaged in the tappings of the cross-beams.

e. The main bearing setscrews should then be torque tightened, followed by the torque tightening of the cross-bolting setscrews, to the figures quoted in Section E15.

All engines

6. Check that the crankshaft rotates freely.
7. Check the crankshaft end-float. Refer to Section E4, Dimensional data.
8. Fit the bearing shells to the connecting rods and caps. Then, lightly smear the shells with clean engine oil.
9. Locate the lowest crankpin (with the engine inverted this will be the crankpin that is uppermost).
10. Pull the two connecting rods upwards and position the big-ends around the crankpin.
11. Remove the protective rubber sleeve from each bolt.
12. Assemble the connecting rod big-ends (see Section E6).
13. Fit the oil pump and delivery pipes, ensuring new rubber 'O' rings are used.
14. Fit the oil strainer pick-up and pedestal.
15. Assemble the front of the engine, using a new gasket.

**Fit a new Neoprene seal between the lower front cover and the coolant pump.**

16. On turbocharged engines, fit the turbocharger oil return pipe to the lower front cover. Remove the oil feed pipe and prime the turbocharger with engine oil. Fit the feed pipe.

17. Lightly oil the threads of the centre stud and screw it into the crankshaft, ensuring that the threads are free. Torque tighten the stud to between 305 Nm and



373 Nm (31 kgf m and 38 kgf m; 225 lbf ft and 275 lbf ft).

18. Smear the inside bore of the pulley flange and locate the flange onto the crankshaft. Ensure that the location dowel is aligned correctly.

19. Lightly oil the threads on the end of the centre stud. Then, run the centre nut down the stud to press the flange onto the interference fit of the crankshaft.

20. Torque tighten the centre nut to between 488 Nm and 597 Nm (50 kgf m and 61 kgf m; 360 lbf ft and 440 lbf ft).

21. Fit the crankshaft pulley/damper assembly, ensuring the locating pin aligns correctly.

22. Fit the driving belts, ensuring that they are correctly tightened (see Section E13).

23. Fit the engine backplate and flexplate assembly.

24. Fit the engine sump, using a new gasket.

25. Fit the engine to the vehicle (see Section E12).

#### **Crankshaft front oil seal – To remove and fit**

(see fig. E5-1)

1. Carry out the usual workshop safety precautions.

2. Remove the coolant pump (see Chapter L).

3. Remove the crankshaft pulley/damper assembly.

4. Using extractor RH 9765, withdraw the pulley driving flange.

5. Remove the setscrews that secure the sump to the front lower timing cover.

6. Remove all weight from the engine front mounting foot.

7. Withdraw the setscrews from the engine front mounting beneath the front cover.

8. Remove all setscrews retaining the front lower cover.

9. Carefully insert a feeler gauge or similar tool between the bottom of the cover and the sump gasket. Slowly work the feeler gauge around the joint to 'break' the seal.

10. Withdraw the front cover (the cover is dowelled to the crankcase). Discard the gasket.

11. Remove the oil seal from the front cover.

12. Inspect both the cover oil seal bore and the crankshaft driving flange for score marks and/or wear.

13. Press the new oil seal into the housing until it is correctly positioned.

14. Fit the cover to the engine by reversing the removal procedure, noting that a new gasket and Neoprene seal should be fitted.

#### **Crankshaft rear oil seal – To remove and fit**

(see fig. E5-1)

1. Ensure that the usual workshop safety precautions are carried out.

2. Remove the transmission (see Chapter T).

3. Remove the setscrews securing the flexplate and withdraw the assembly from the rear of the engine.

4. Locate the engine rear backplate and remove the retaining setscrews. Withdraw the backplate noting that it is dowelled to the crankcase.

5. Discard the crankcase gasket.

6. Press the seal out of the rear of the backplate.

7. Press a new seal into the backplate, **noting that it should be installed dry**. This instruction must be

strictly adhered to. Fit the backplate assembly over the end of the crankshaft and into position.

Always ensure a new gasket is fitted to the crankcase prior to the installation of the backplate assembly.

8. Secure the backplate and complete the assembly by reversing the removal procedure.



## Connecting rods and pistons

### Connecting rod bearings – To remove (see fig. E6-1)

The big-end bearings can be renewed whilst the engine is fitted in the car. To undertake this exercise, carry out the usual workshop safety precautions and proceed as follows.

1. Place the car on a ramp beneath an overhead pulley.
2. Firmly apply the parking brake and chock the road wheels.
3. Disconnect the battery.
4. Drain the engine oil into a suitable container. Fit the sump plug.
5. Remove the steering rack assembly (see Chapter N).
6. Suitably position a sling around the front upper half of the engine. Connect the sling to the overhead pulley and 'take the weight' of the engine.
7. Remove the setscrews from the front engine mount.
8. Remove the engine oil level transmitter shield and disconnect the electrical lead.
9. Remove the setscrews securing the transmission oil cooler pipes to the sump.
10. On turbocharged cars, remove the heatshield and exhaust system connecting pipe between 'A' bank and 'B' bank manifolds.
11. Raise the engine and then remove the remaining setscrews securing the sump.

Some difficulty may be encountered when removing the setscrews due to the close proximity of the sub-frame crossmember.

Ensure the sump is supported before all the setscrews are withdrawn.

12. 'Break' the seal that will have formed between the sump and the crankcase bottom face.
13. Carefully withdraw the sump assembly.
14. Remove the oil pedestal and fine mesh strainer.
15. Remove the sparking plugs (this will facilitate easier rotation of the crankshaft assembly).
16. Rotate the crankshaft until one pair of connecting rod caps are at their lowest point.
17. Remove the cap retaining nuts (item 7) and carefully 'ease off' the cap (item 6).
18. Fit protective rubber sleeving over the connecting rod bolts, to prevent damage to the crankshaft journal (see inset A). **Do not remove the connecting rod bolts.**
19. To facilitate removal of the shell bearings, push the connecting rod and piston assembly upwards away from the crankshaft.
20. Collect the shell bearings (item 5) from the connecting rod (item 4) and cap (item 6).
21. Repeat Operations 16 to 20 inclusive to the other connecting rod big-end bearings on the crankpin.

**Note** Only one pair of big-end bearings should be dismantled at any one time. The position of the bearing shells should be noted so that if the bearings are to be used again, they can be fitted in their original position.

### Crankpins and bearings – To inspect (see fig. E6-1)

1. Thoroughly clean each crankpin with a lint free cloth. Measure each crankpin diameter for wear and ovality (see Section E5, Crankshaft – To regrind).
2. The running clearance between the connecting rod big-end bearing and the crankpin is 0,038 mm to 0,076 mm (0.0015 in to 0.003 in). The size and wear tolerances are given in Section E4, Dimensional data.

New bearing shells should be fitted if the specified limits are exceeded due to wear, or if the shells are scored.

### Connecting rod bearings – To fit (see fig. E6-1)

1. Fit protective sleeves to the connecting rod bolts.
2. If both halves of a shell bearing are considered serviceable, they can be used again **provided that each is kept in its original position**. However, if the shell bearings have seen considerable service, it is advisable to replace with new ones.
3. Before fitting new bearings to the connecting rods and caps, etch the cylinder number onto the outside of the locating tang of each bearing shell.
4. Thoroughly clean the shells and the crankpin. Ensure that the crankpin oil feed holes from the main bearings are not blocked by sludge or dirt.
5. Lightly smear the upper half of the shell bearing surface with clean engine oil and fit it into the connecting rod.
6. Pull the connecting rod downwards onto the crankpin. Ensure that the rod bolts do not damage the crankpin.
7. Remove the protective sleeving from the connecting rod bolts.
8. Fit the lower half of the shell bearing into the connecting rod cap and lightly smear it with clean engine oil.
9. Ensure that the tang on each half of the shell bearing is located correctly in its respective recess.
10. Place the cap onto the rod, ensuring that the two tangs are on the same side of the crankpin.

If necessary, carefully tap the cap into position until it is fully seated. **Take care to ensure that neither the shell nor the connecting rod bolts become displaced during this operation.**

11. Using a micrometer, measure the overall length of the connecting rod bolts. These should have an overall length of between 71,95 mm and 72,01 mm (2.833 in and 2.835 in).

Any bolt not conforming to the dimensions quoted, should be carefully removed from the connecting rod (using a hide mallet) and a new bolt fitted.

12. Ensure that the shell bearings are correctly positioned, then fit the cap to the connecting rod.
13. Lubricate the connecting rod bolt threads with engine oil and screw the retaining nuts onto the bolts. Each nut should be screwed on by hand and lightly

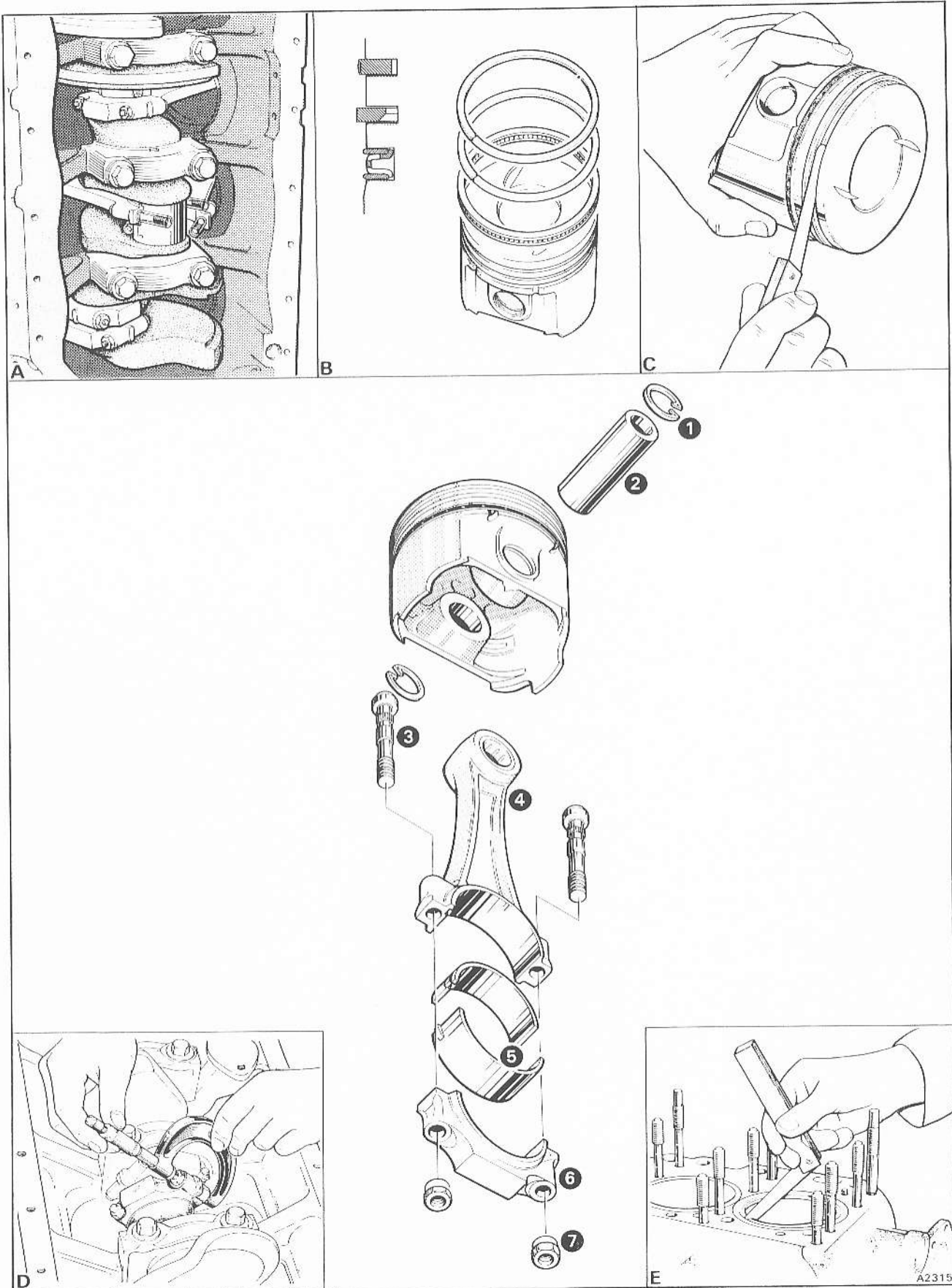


Fig. E6-1 Connecting rods and pistons

'nipped' using a handbrace and socket.

The nuts should be easy to screw on, if any effort is required, the threads should be examined for burrs, damage, or malformation and the offending parts replaced.

14. Torque tighten the nuts to obtain a bolt stretch of between 0,15 mm and 0,38 mm (0.006 in and 0.015 in). This bolt stretch range should be achieved between 48 Nm and 61 Nm (4,9 kgf m and 6,2 kgf m; 35 lbf ft and 45 lbf ft).

15. **If any bolt has not stretched sufficiently**, increase the torque tightness to 68 Nm (7,0 kgf m; 50 lbf ft) and again check the bolt stretch (see inset D).

16. If any bolt is still under stretched, slacken both nuts of that particular connecting rod and measure the free length of the offending bolt. If this measurement is outside the limits quoted in Operation II, fit a new bolt.

Should the measurement be inside the limits quoted in Operation II, repeat Operations 13 and 14. Again measure the bolt stretch. If the bolt now conforms it is acceptable. If not, slacken both nuts and replace the suspect bolt with a new one.

17. **If any bolt has been over stretched** when

tightening, slacken both nuts on the connecting rod and replace the offending bolt.

18. Repeat Operations 11 to 17 inclusive to the remainder of the connecting rod big-end bearings.

19. Fit the engine sump, using a new gasket.

20. Fit all other parts by reversing the procedure given for their removal.

21. Set the engine stop plate gap (see Section E12, Engine removal and installation).

#### Connecting rod and piston – To remove (see fig. E6-1)

1. Remove the cylinder head (see Section E8).
2. Remove any carbon build-up in the bore at the top of the liner.
3. Remove the connecting rod cap from the big-end bearing (see Connecting rod bearings – To remove).
4. Push the connecting rod upwards so that the piston and connecting rod assembly can be withdrawn from the top face of the crankcase.
5. Repeat these operations on the remaining piston and connecting rod assemblies.

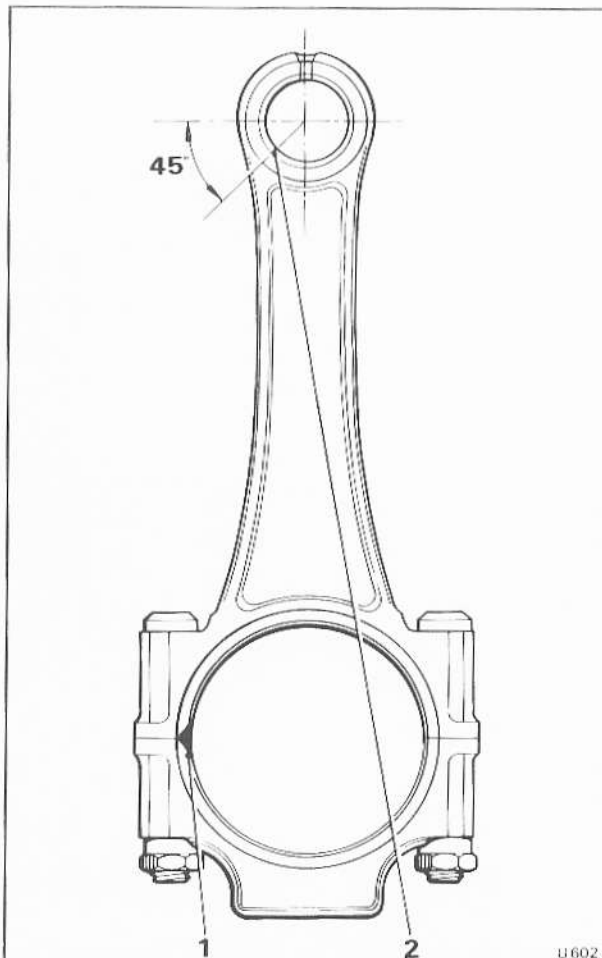


Fig. E6-2 Position of small-end bush

- 1 Tangs
- 2 Split in bush

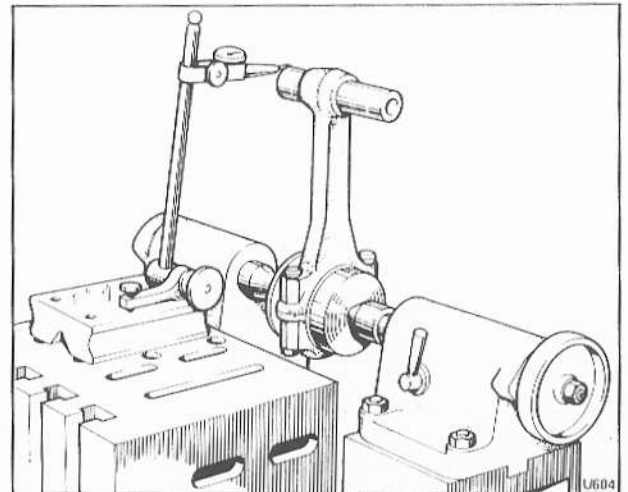


Fig. E6-3 Checking the connecting rod alignment

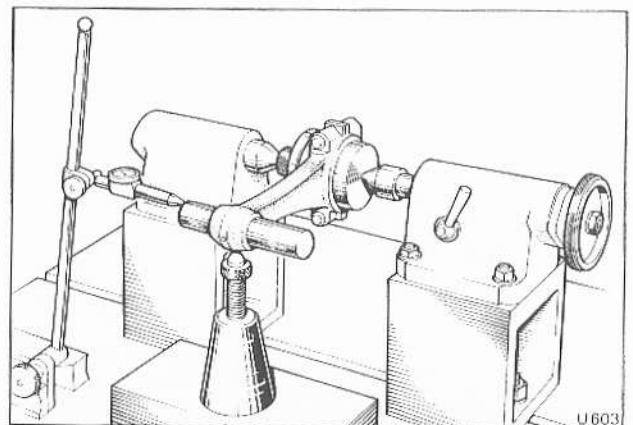


Fig. E6-4 Checking the connecting rod for twist

### Connecting rod and piston – To dismantle

(see fig. E6-1)

1. Remove the circlips from the piston. The circlips are located one at either end of the gudgeon pin bore.
2. Thoroughly warm the piston assembly. This can be achieved by either immersing the piston in a bath of hot oil or placing the piston crown on a hotplate.
3. When the piston is thoroughly warm, push the gudgeon pin out using a suitable guide.

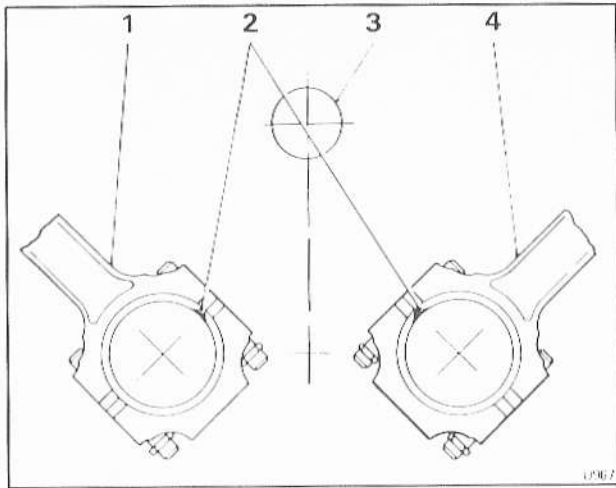


Fig. E6-5 Position of the connecting rod tangs

- 1 'A' bank connecting rod
- 2 Position of tangs
- 3 Camshaft
- 4 'B' bank connecting rod

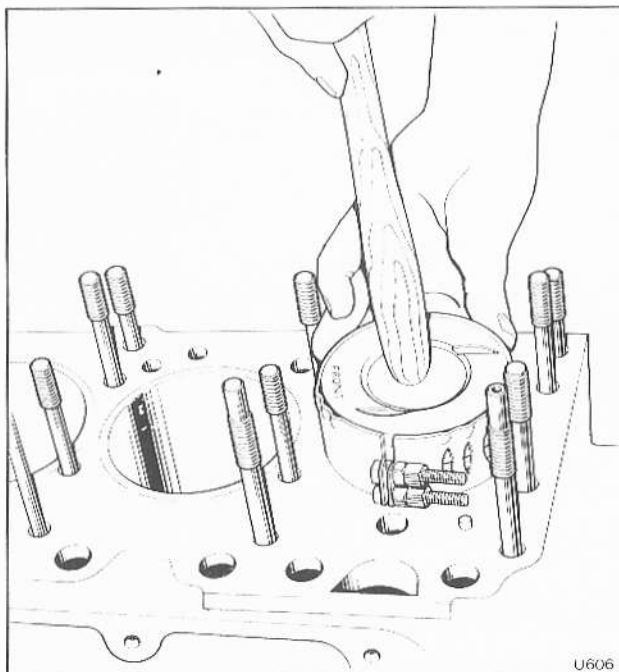


Fig. E6-6 Fitting a piston

### Piston – To inspect (see fig. E6-1)

1. Remove the rings from the piston using a suitable expander tool.
2. Remove the carbon deposits from the rings and pistons. Ensure that all the deposits are removed from the piston ring grooves.
3. Thoroughly clean all components.
4. Check that the clearance of the piston rings in their respective grooves (see inset C), is as given in Section E4, Dimensional data.
5. Check the compression rings in either a 104,14 mm (4.10 in) diameter ring gauge, or an unworn part of the cylinder, after first ensuring that no carbon deposits exist in the unworn bore. If the rings are in good condition, no light should show around the circumference of the rings.
6. Check the closed gap of each compression ring whilst it is fitted into either the ring gauge or the unworn part of the cylinder (see inset E and Section E4, Dimensional data).
7. Visually check the condition of the oil control ring.
8. Check the piston dimensions. The measurements and grades of pistons are given in Section E4.

### Small-end bush – To inspect and renew

(see fig. E6-1)

1. Check the diameter of both the gudgeon pin and the small-end bush. If the clearance exceeds 0,013 mm (0.0005 in) renew the bush.
2. Using a suitable drift, remove the small-end bush.
3. Visually inspect the condition of the connecting rod small-end.
4. Measure the internal diameter of the connecting rod small-end.
5. Measure the external diameter of the new small-end bush.
6. Compare the measurements obtained in Operations 4 and 5. An interference fit between the new bush and small-end bore of 0,05 mm to 0,076 mm (0.002 in to 0.003 in) is essential.
7. Position the new bush so that the chamfered outer edge is towards the connecting rod. Also ensure that the split in the bush is 45° away from the centre axis of the rod and on the same side of the rod as the locating recesses for the big-end bearing shells (see fig. E6-2). In this position the oil hole in the bush should line up with the oil hole in the small-end boss.
8. Press the small-end bush into position until it is flush with the connecting rod boss.
9. Finally, either diamond bore or ream the bush to the finished diameter quoted in Section E4, Dimensional data. The gudgeon pin clearance in the small-end bush should be between 0,003 mm and 0,013 mm (0.0001 in and 0.0005 in).

### Connecting rods – To check alignment and twist

The correct alignment of a connecting rod is of the utmost importance. Any connecting rod that has had a new bush fitted and bored must be checked for alignment using a reliable alignment fixture.

Connecting rods that are bent will cause uneven and premature wear between the cylinder walls and pistons.

If an alignment fixture is not available the

**alignment twist** of the connecting rods can be checked as follows.

#### Alignment

1. Fit the gudgeon pin to the small-end bush.
2. Fit a mandrel to the big-end.
3. Mount the connecting rod on an inspection surface table as shown in figure E6-3.
4. Using a dial indicator gauge, take a reading at both ends of the gudgeon pin.
5. The difference between the two readings must not exceed 0,02 mm (0.001 in) per 25,40 mm (1.0 in) length of the gudgeon pin.

#### Twist

1. Fit the gudgeon pin to the small-end bush.
2. Fit a mandrel to the big-end.
3. Mount the connecting rod on an inspection surface table as shown in figure E6-4.
4. Using a dial indicator gauge, take a reading at both ends of the gudgeon pin.
5. The difference between the two readings must not exceed 0,07 mm (0.003 in) per 25,40 mm (1.0 in) length of gudgeon pin.

#### Connecting rods and pistons – To assemble

(see fig. E6-1)

To assemble the connecting rods to the pistons, reverse the procedure given for dismantling noting the following.

1. Pistons and gudgeon pins are supplied as an assembly, the gudgeon pin being a selective fit. On no account must pistons and gudgeon pins be interchanged.
2. When fitting the rings to the piston, fit the oil control ring assembly first.

Commence by fitting the centre spacer, then fit the steel rails either side of the spacer. Ensure that the gaps in the various components of the oil control ring are spaced equally around the circumference of the piston.

Fit the two compression rings (see inset B).

3. Ensure that the gudgeon pin, piston, and connecting rod are always assembled as follows.
  - a. Fit the pin to the piston so that the cylinder number on the pin is on the same side as the cylinder number on the pistons.
  - b. The tangs on the connecting rod and cap should always be nearest the camshaft (see fig. E6-5).

#### Connecting rods and pistons – To fit (see fig. E6-1)

To fit the connecting rods and piston assemblies to the engine, reverse the procedure for removal noting the following.

1. Space the ring gaps around the piston.
2. Liberally cover the pistons with either graphogen grease or clean engine oil. Then, fit a ring compressor over the piston rings.
3. Ensure that the head of each connecting rod bolt is seated on the connecting rod. If not, carefully tap the head of the bolt into position. Fit a protective rubber sleeve to each bolt before fitting the piston and connecting rod assembly to the engine.

4. Ensure that the shell bearings are correctly located in both the connecting rod and cap.
5. Fit the piston and connecting rod assembly into the cylinder bore from the top.
6. Tighten the piston ring compressor, hold it against the cylinder liner and push the piston into the bore (see fig. E6-6).
7. Carefully position the connecting rod onto the crankshaft big-end journal. Remove the protective sleeving from the bolts and finally check the location of the big-end bearing shells; fit the cap.
8. Fit the nuts to the connecting rod bolts and tighten them in accordance with the procedure given in Connecting rod bearings – To fit.

## Camshaft and valve mechanism

This section contains information relating to the camshaft timing gear, distributor drive gear, hydraulic tappets, push rods, and rockers.

For information relating to the valves and their associated components, refer to Section E8.

### Rocker shaft assembly – To remove and dismantle (see fig. E7-1)

1. Carry out the usual workshop safety precautions.
2. Unscrew the cap nuts retaining the ignition harness to the rocker cover. Also, remove the nut and bolt securing the engine dipstick tube to the harness shaft.
3. Remove the reach nuts securing the rocker cover to the cylinder head.
4. Carefully prise around the joint face of the rocker cover. Once the joint has been freed, lift the rocker cover from the engine.
5. Unscrew the five setscrews (item 1) securing the rocker shaft in position. **Do not withdraw the setscrews.**
6. Carefully withdraw the rocker shaft from its position. Leave the setscrews positioned through the pedestals to retain the rocker arms (item 2) and springs (item 3) in position on the shaft (item 4).
7. Place the rocker shaft assembly on a bench and withdraw the end setscrew whilst holding the pedestal (item 5) in position. Ensure that the spring does not force any components off the end of the shaft.

Slowly release the hand pressure applied to the end of the rocker shaft and allow the spring to push the pedestal off the rocker shaft.

8. Collect the end pedestal, first rocker arm, spring, and second rocker arm. Ensure that the rocker arms are identified so that they can be returned to their original positions.
9. Repeat Operations 7 and 8 to the next pedestal and continue repeating the exercise until both rocker shafts are dismantled.

### Rocker shaft assembly – To inspect (see fig. E7-1)

1. Examine the pads on the rocker arms for wear and renew any that are badly worn.

Slight 'scuffing' or pitting on the pads may be removed with a smooth stone.

2. Rocker pads are case hardened to a depth of between 0,63 mm and 0,76 mm (0.025 in and 0.030 in) and the rockwell hardness value should be between C57 and C65.
3. If the hardness value is below these figures, the rocker arms should be renewed.

### Rocker shaft assembly – To assemble and fit (see fig. E7-1)

Assemble and fit the rocker shaft by reversing the removal and dismantling procedures, noting the following.

1. The rockers are handed and should be fitted in pairs so that the arms point inwards to the cylinder bore (see inset A).
2. The cylinder heads have rocker shaft dowel pins fitted. Ensure that the rocker shaft is correctly located on the pins so that the oil feed holes align.
3. When tightening, commence with the centre setscrew and alternate on either side towards the end setscrew.
4. Torque tighten the rocker shaft retaining setscrews to between 11 Nm and 13 Nm (1,2 kgf m and 1,3 kgf m; 8 lbf ft and 10 lbf ft).

### Push rods – To remove, inspect, and fit (see fig. E7-1)

1. Carry out the usual workshop safety precautions.
2. Remove the rocker cover and rocker shaft.
3. Withdraw the push rods (item 6). Label each one for identification purposes during assembly, noting top and bottom.
4. Check the push rods for bow. If any push rod has a total indicator reading or more than 0,51 mm (0.020 in) it should be discarded and a new push rod fitted.
5. Ensure that the holes in the ball ends are not blocked by dirt, etc.
6. When fitting the push rods reverse the removal procedure. Always ensure that the push rods are returned to their original positions and that they are correctly seated in both the hydraulic tappets and the rocker arms.

### Hydraulic tappets (see fig. E7-1, inset C)

A tappet which is found to be defective in service should be replaced by a complete assembly.

#### Individual components must not be renewed.

Where a tappet is noisy but otherwise appears to be serviceable and replacement tappets are not readily available, it is recommended that the tappet is dismantled and thoroughly washed in clean paraffin.

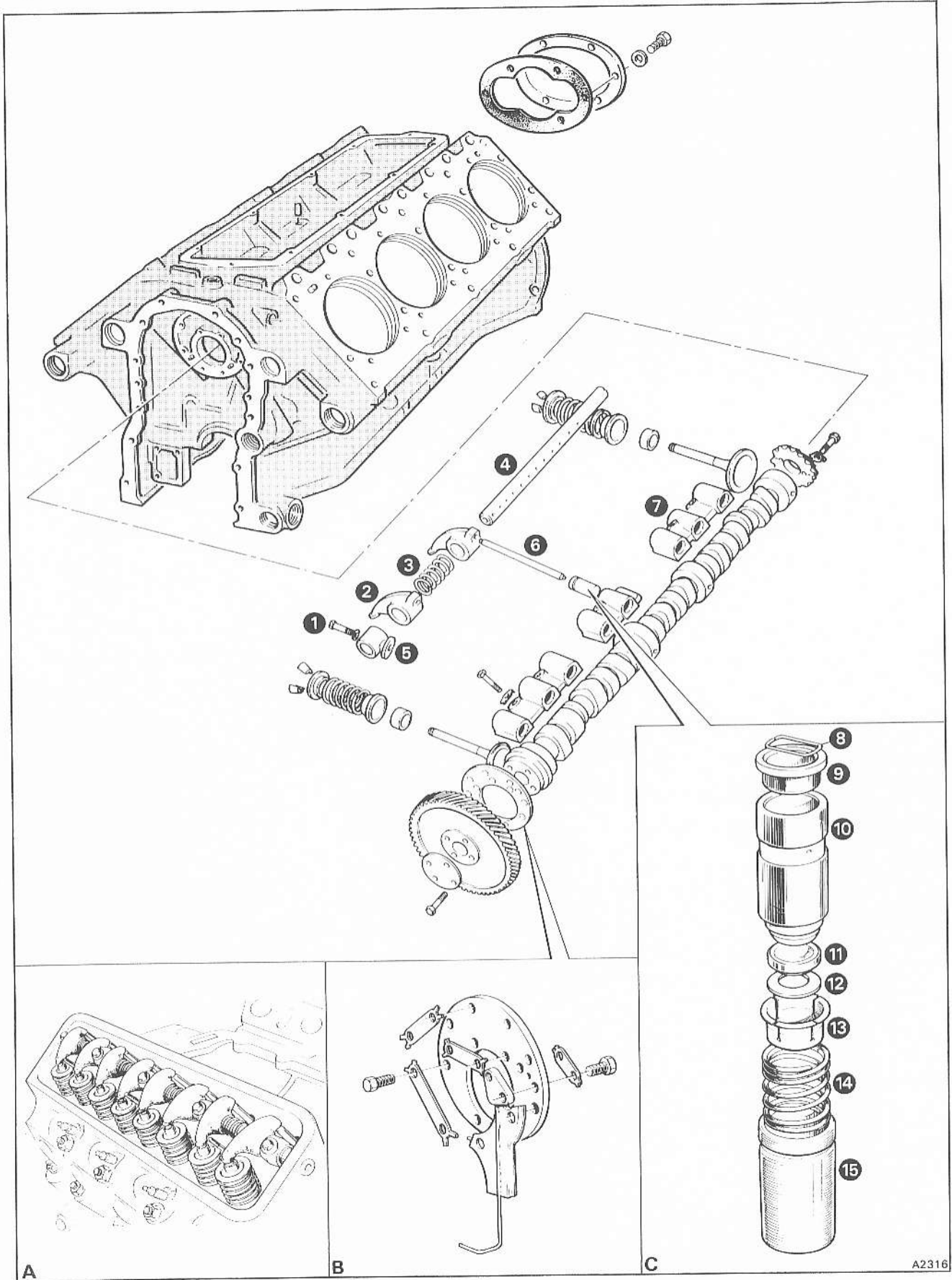
### Tappet noise

A defective tappet makes a noise like a 'rifle crack'. It is usually caused by one or more tappets collapsing and can be heard with each revolution of the camshaft. This could be caused by dirt which has infiltrated into the tappet(s), in which case the tappet(s) should be dismantled and cleaned. If cleaning the tappet does not cure the fault, the tappet should be renewed.

To determine a defective tappet, manually depress each tappet in turn whilst the engine is running. The defective tappet can be identified by a change in noise when any 'sponge' in the tappet is taken up.

If the noise is not caused by a collapsed tappet(s) one of the following causes should be suspected.

1. Air may have been drawn into the tappets if the engine has been standing for a period of time (i.e. overnight) and one of the tappets may not clear itself. It



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Fig. E7-1 Camshaft and valve mechanism

is possible that a tappet may not clear even after 30 minutes of hot running.

2. Occasionally a tappet leaks down too quickly at high temperatures causing a knock. This is really a milder case of the 'rifle crack' failure and should be renewed.

3. Occasionally a tappet will stick in the bore of the tappet block at high temperatures causing a knock. This will show itself by being consistently noisy when the engine is very hot but quiet at other times.

Should this situation be encountered (and all other tappet rectification measures failed to effect a cure), the suspect tappet block should be checked for incorrect crankcase bedding. Lightly smear the seating face with engineers blue and fit the block in the crankcase. If the check proves conclusively that the tappet block bedding is faulty, the crankcase can be scraped to improve the situation.

**Extreme care must be exercised when carrying out this operation and the minimum amount of metal removed from the crankcase.**

#### Tappet wear

It should not be necessary to reject tappets due to an appearance of wear on the bottom face of the tappet. The only occasion when rejection may become necessary is if the cam peak on the camshaft is also badly worn.

It may cause problems to replace a mildly worn tappet with a new one unless the camshaft is also changed. For this reason only the tappets which are actually causing a problem should be renewed.

If it is found necessary to fit a new camshaft to an engine, a complete set of new tappets must also be fitted.

#### Hydraulic tappets – To remove (see fig. E7-1)

1. Carry out the usual workshop safety precautions.
2. Remove either the fuel injection system equipment or turbocharging equipment as applicable (refer to Engine Management Systems Manual – TSD 4737).
3. Drain the engine coolant (see Chapter L).
4. Depressurize the hydraulic systems (see Chapter G).
5. Remove the induction manifold.
6. Progressively unscrew the setscrews securing the tappet chest cover to the crankcase. The setscrews must be removed progressively. If the brake pump operating cams happen to be at their peak, distortion could occur to the tappet chest cover.
7. Remove the rocker covers.
8. Progressively unscrew the setscrews securing the rocker pedestals to each cylinder head. Then, remove the rocker shaft assemblies.
9. Remove the push rods.
10. Withdraw the hydraulic tappets from the tappet blocks (item 7).

#### Hydraulic tappets – To dismantle (see fig. E7-1)

1. Press down the spherical cap situated in the top of the tappet and remove the snap ring holding the cap in.

After gradually releasing the pressure from the spherical cap, the tappet can be dismantled (see inset C).

2. Remove the plunger and valve from the tappet

barrel. Examine the tappet for any signs of wear on its base.

#### Hydraulic tappets – To assemble and prime (see fig. E7-1)

In order to obtain the high degree of accuracy necessary for efficient operation of the hydraulic tappets, it is essential that extreme precautions are taken when assembling the components to ensure complete cleanliness.

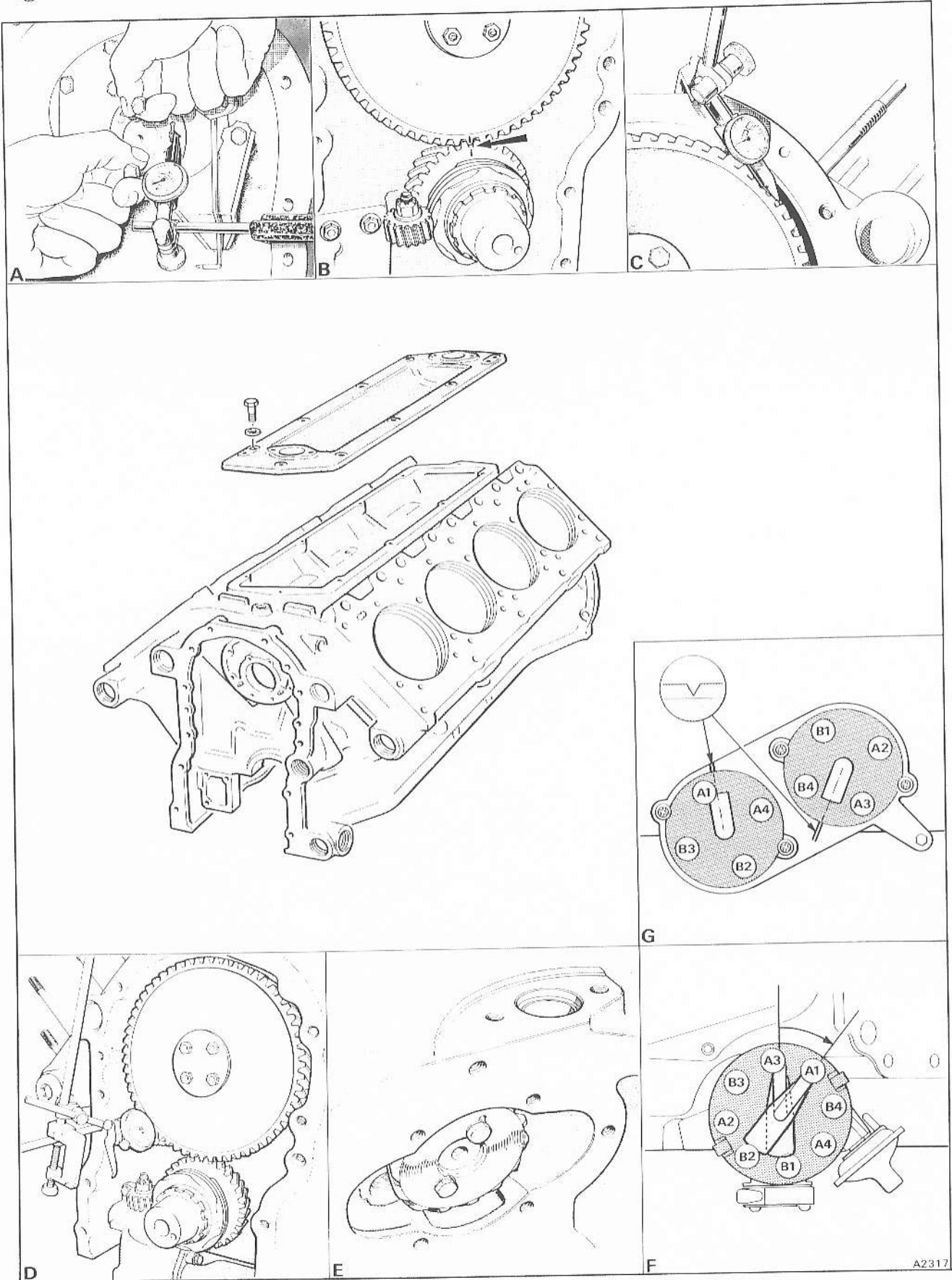
It is therefore most important that particular attention is given to the following points before commencing the assembly procedure.

Due to the highly critical surfaces and dimensions of the hydraulic tappets, great care and cleanliness are of the utmost importance when handling tappet components. If a cloth has to be used, ensure that it is lint free.

Ensure that the assembly tank is perfectly clean before adding paraffin. Only clean fresh paraffin must be used.

Wash all tappet components in clean paraffin, taking care that the components of each tappet are retained as an assembly and are not interchanged with parts of another tappet.

1. Fit the spring washer (item 12) and valve (item 11) in the retainer (item 13).
2. Using 'finger' pressure, carefully press the retainer assembly onto the spigot of the plunger (item 10).
3. Fit the spring (item 14) onto the retainer assembly.
4. Fit the valve assembly (plunger, valve, spring washer, retainer, and spring), into the tappet barrel (item 15).
5. Fit the cap (item 9) into the top of the plunger.
6. Using an old push rod press the cap downwards until it is possible to fit the retaining snap ring (item 8) into the groove located inside the top of the barrel.
7. Release the pressure.
8. Submerge the tappet assembly in clean Esso TSD 1047 rust inhibiting paraffin.
9. Using a small probe push the valve off its seat. The probe should be carefully positioned through the small hole in the tappet cap and pushed down into the tappet until it contacts the valve. A slight increase in pressure will then be required to overcome the spring washer loading and open the valve.
10. Continue to hold the valve open and place a small screwdriver into the cap adjacent to the probe.
11. Apply pressure to both the probe and screwdriver. Press the cap downwards in the tappet barrel, compressing the spring. Note the air bubbles that are expelled from the tappet barrel oil inlet hole.
12. When the air bubbles cease, release the pressure from the cap and valve.
13. Repeat Operations 9 to 12 inclusive, until the air bubbles have ceased to appear throughout the cycle of operations.
14. Withdraw the probe from the small hole in the centre of the cap.
15. Again apply pressure to the cap with a small screwdriver. If the assembly feels solid it can be assumed that it is operating satisfactorily and can be



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Fig. E7-2 Camshaft build sequence checks

removed from the paraffin.

**When tappets are to be fitted immediately after overhaul, they should be primed with clean engine oil.**

**Hydraulic tappets – To fit** (see fig. E7-1)

1. Oil the bores of the tappet blocks (item 7).
2. Fit the tappets.
3. Fit the push rods to the engine, into the same position from which they were removed.
4. Fit the rocker shafts. Then, progressively tighten the securing nuts.
5. Fit the tappet chest cover.

**Tappet chest cover – To fit** (see fig. E7-2)

1. Rotate the camshaft until the brake pump eccentrics are at approximately bottom dead centre (bdc).
2. To prevent the possibility of a hydraulic lock, ensure the brake pumps are drained of fluid.
3. If necessary, check that the position of the two brake pump rods is correct and fit the brake pumps (see Section E11).
4. Apply a 1,27 mm (0.050 in) wide bead of Loctite 573 sealing compound onto the crankcase tappet cover joint face, **so that it surrounds all the tapped holes.**
5. Complete the engine build by reversing the procedure given for dismantling, noting the following.
6. Fit new joints and sealing rings.
7. Refer to Chapter P and Section E15 for torque tightening figures.
8. Ensure that the brake pipes are not overtightened, otherwise damage to the conical seatings may occur.
9. Any hoses showing signs of deterioration should be renewed.
10. Ensure that the driving belts are adjusted to the correct tension (see Section E13).

**Camshaft – To remove** (see fig. E7-2)

Engines prior to 1989 model year

1. Remove the hydraulic tappets.
2. Remove the transmission (see Chapter T).
3. Remove the flexplate assembly.
4. Remove the distributor assembly.
5. Remove the cover from the rear end of the crankcase, to expose the distributor driving gear (see inset E).
6. Remove the skew gear from the end of the camshaft.
7. Remove the radiator grille, refrigeration condenser, and radiator matrix.
8. Remove the coolant pump and lower front cover from the front of the engine.
9. Unscrew the setscrews from the camshaft and withdraw the cam gear.
10. Remove the camshaft thrust plate together with the timing gear lubricating oil pipe assembly (see fig. E7-1, inset B). Withdraw the camshaft through the front end of the crankcase. Take care that the bearing bores are not damaged by the cam lobes.

1989 model year engines

To remove the camshaft, it will be necessary to remove the engine from the car (see Section E12). Then, refer to the relevant Sections within this Chapter for detailed dismantling procedures.

**Camshaft – To inspect**

1. Inspect the cams for wear and pitting. The cam lift dimensions are given in Section E4, Dimensional data.
2. If wear is in excess of the figures given, the camshaft must be renewed.

**Camshaft – To fit** (see fig. E7-1)

1. Lightly smear the camshaft bearings with clean engine oil. Lubricate the camshaft lobes with EP (extreme pressure) oil such as Castrol Hypress SC 140. Fit the camshaft through the front end of the crankcase, taking care that the cam lobes do not damage the camshaft bearing bores.
2. Fit the timing gear lubricating jet assembly to the thrust plate and secure with a new tab-washer.
3. Fit and secure the camshaft thrust plate to the crankcase; use new tab-washers. Torque tighten the setscrews to the figures quoted in Chapter P; lock the tab-washers.

**Camshaft end-float – To check** (see fig. E7-2)

1. Fit a dial test indicator to the crankcase and position the indicator onto the end of the camshaft; set the scale to zero (see inset A).
2. Fit two setscrews to the end of the camshaft.
3. Grip the setscrews, then move the camshaft backward and forward and note the reading on the dial test indicator.
4. The camshaft end-float should be between the figures quoted in Section E4, Dimensional data.

**Valve gear – To time** (see fig. E7-2)

1. Rotate the crankshaft until the mark on the crankshaft timing gear is vertical and towards the top of the crankcase (see inset B).
2. Fit the camshaft timing gear to the camshaft so that the mark on the gear is aligned with the mark on the crankshaft timing gear; do not fit any setscrews at this stage.
3. Carefully rotate the camshaft until the holes in the camshaft timing gear align exactly with the threaded holes in the camshaft (one hole is offset).
4. Fit the end plate cover and secure the timing gear and cover to the camshaft. Torque tighten the setscrews to the figures quoted in Section E15.

**Camshaft timing gear backlash and run-out – To check** (see fig. E7-2)

1. Fit a dial test indicator to the crankcase and position the indicator onto the timing gear (see inset C); set the scale to zero.
2. Rock the cam gear and check the backlash. The backlash should be between the figures quoted in Section E4, Dimensional data.



3. Check the backlash on various teeth around the circumference of the gear.
4. Check the timing gear run-out as follows (see inset D).
5. Move the indicator pointer so that it touches the front face of the cam gear.
6. Rotate the crankshaft and check the run-out shown on the indicator dial. The run-out should not exceed the figures quoted in Section E4.

#### **Distributor and driving gear – To fit** (see fig. E7-2)

1. Fit the camshaft distributor driving skew gear, noting that it will only fit one way due to the two holes being offset.
2. Rotate the crankshaft until the timing marks on the camshaft and crankshaft gears are in line (see inset B).
3. On naturally aspirated engines, the timing pointer should be on the 10° btdc mark on the damper.

Holding the distributor with the ignition module to the rear of the engine, position the rotor forward down the centre line of the engine.

As the distributor is fitted, the rotor will turn slightly (as it engages with the camshaft distributor driving gear) and point directly towards A1 cylinder and to A1 cylinder contact in the distributor cap (see inset F).

Fit the distributor clamp and tighten the setscrew fingertight, plus half a turn.

4. On turbocharged engines, the timing pointer should be on the 42° btdc mark on the damper.

Holding the distributor assembly as shown in inset G, with the twin rotors to the notches in the top face of the casting (caps removed), lower the distributor into position.

Seal the distributor adapter to the crankcase using Loctite 510. Tighten the securing setscrews to the figures quoted in Chapter P.

5. Using a dial test indicator in a similar manner to that shown in inset C, check the backlash of the distributor driving gear. This should be between the figures quoted in Section E4, Dimensional data.
6. Fit the camshaft rear cover (if fitted) using a new joint.

#### **Engine assembly – To complete**

Complete the engine assembly by reversing the procedure given for camshaft removal, noting the following.

1. All setscrews, nuts, and bolts must be torque tightened to the figures quoted in the appropriate section.
2. Renew all joints.
3. Fit a new Neoprene seal between the lower front casing and the coolant pump.
4. Ensure that the tappet cover is fitted correctly.
5. Check the ignition timing as described in the Engine Management Systems Manual – TSD 4737.
6. If a new camshaft is fitted to an engine, a complete set of new tappets must also be fitted.
7. On 1989 model year engines, apply a 1,3mm (0.050in) wide bead of Loctite 573 sealing compound onto the crankcase rear face so that it surrounds the

tapped holes of the camshaft gear aperture, prior to fitting the transmission adapter plate to the engine.