Chapter E

# Engine

Section



**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.

# Engine

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Sections



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August 1984

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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 25,40mm (1.0in) further forward than the cylinders of 'B' bank and situated on the right-hand side when viewed from the driver's seat.

The engine has a bore of 104,14mm (4.10in) and a stroke of 99,06mm (3.90in), giving a total capacity of 6,75 litres (411.91in$^3$). The compression ratio is either 9:1 or 8:1 depending upon the specification of the engine.

The crankcase is manufactured from cast aluminium alloy. 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 which is allowed to circulate directly onto and around the centre portion of the liners.

The crankshaft is forged from chrome molybdenum

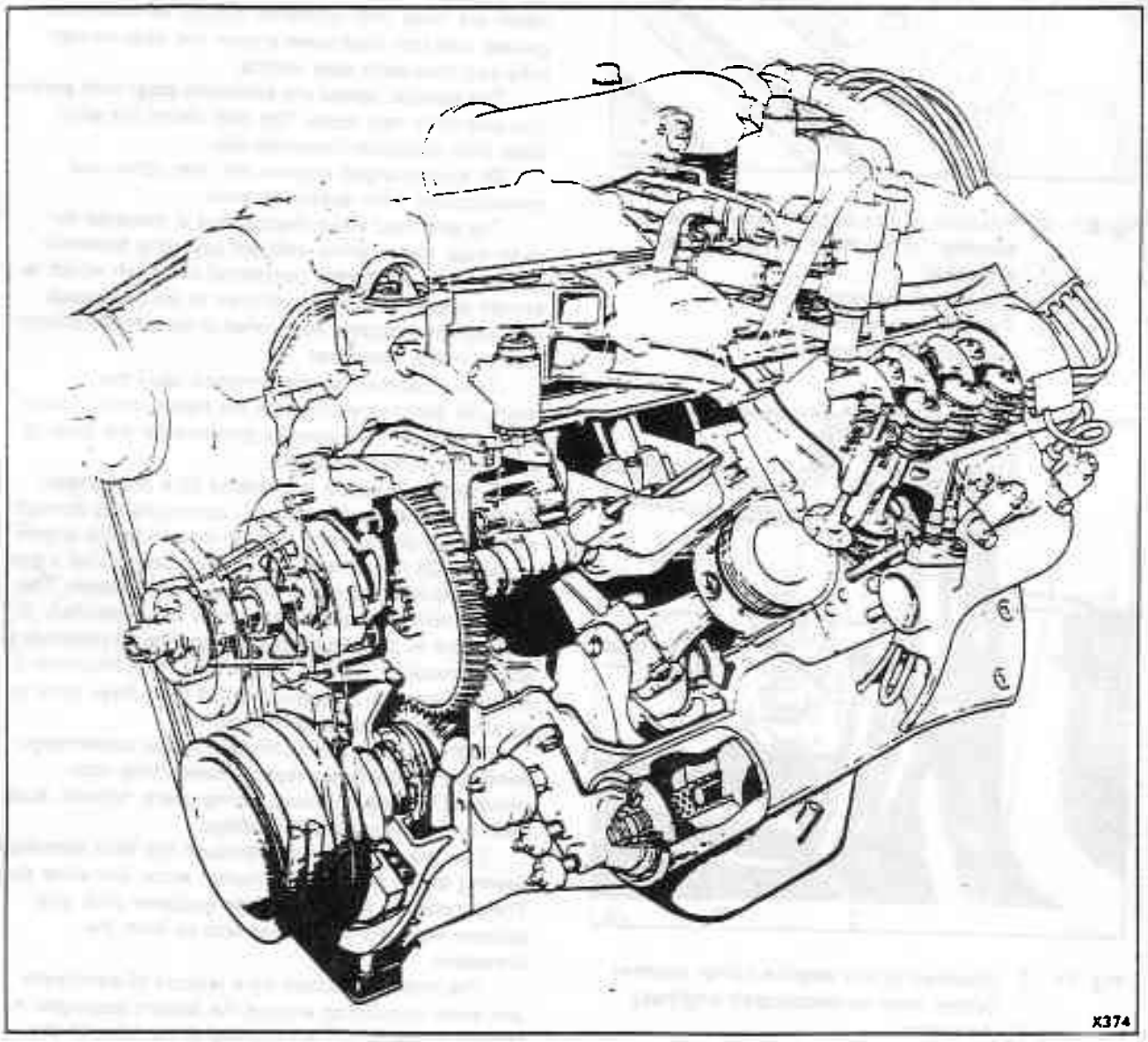



**Fig. E1 - 1 Cut-away view of engine**

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.

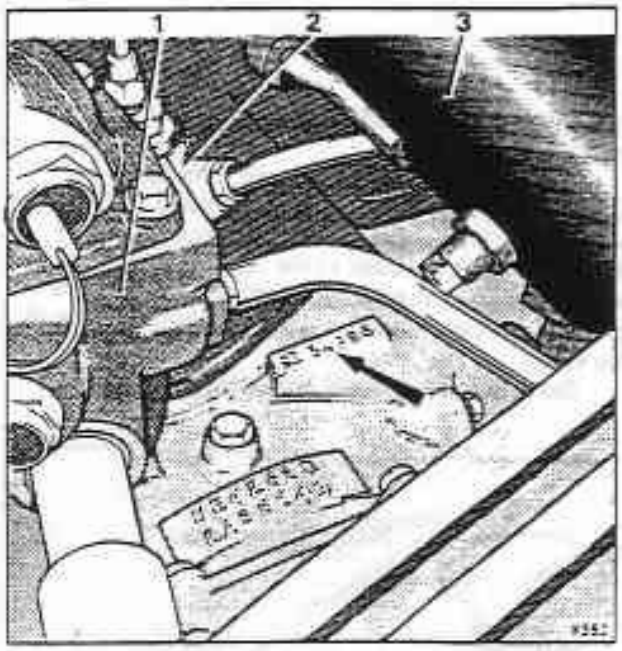



Fig. E1 - 2 **Position of the engine build code number (other than turbocharged engines)**
1 Thermostat housing
2 Front hydraulic pump
3 Refrigeration compressor

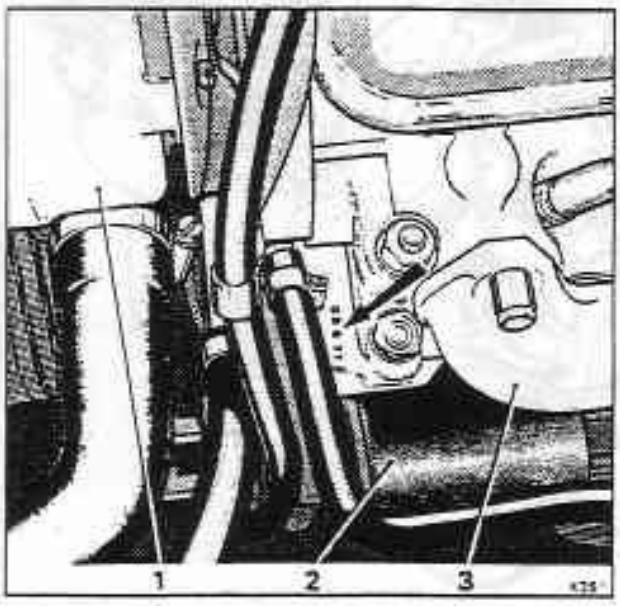



Fig. E1 - 3 **Position of the engine serial number (other than turbocharged engines)**
1 Alternator
2 Oil filter
3 'B' bank exhaust manifold

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 which are slightly off-set from the centre line of the piston towards the thrust face.

On turbocharged 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 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. The inlet valves are alloy steel with induction hardened tips.

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 height control systems.

Engine lubrication is provided by a pressurized system. First stage filteration 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$^2$). Final filteration 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.

**Engine build code number and Engine serial number**

The engine build code number is stamped on a crankcase boss beneath the rear of the refrigeration compressor. The letters refer to the engine code and the number refers to the engine build sequence (see fig. E1 - 2).

The engine serial number is stamped on a boss at the front of the crankcase beneath the rear of the alternator (see fig. E1 - 3).

**On turbocharged engines the positions of the engine serial number and the engine build code number, are reversed.**

# Specification

| | |
|---|---|
| **General** | |
| Type | Over square 90° Vee formation liquid cooled. |
| Number of cylinders | Eight - in two banks of four. |
| Bore | 104,14mm (4.10in). |
| Stroke | 99,06mm (3.90in). |
| Cubic capacity | 6,75 litres (411.91in$^3$) nominal. |
| Compression ratio | 9:1 or 8:1 dependent upon the specification of the vehicle. |
| Firing order | A1, B1, A4, B4, B2, A3, B3, A2. |
| **Cylinder block** | |
| Type | Monobloc casting. |
| Material | Cast aluminium alloy. |
| **Cylinder liners** | |
| Type | Detachable wet liners. |
| Material | Centrifugally spun cast iron. |
| **Cylinder heads** | |
| Description | Two detachable heads, each having four separate inlet and exhaust ports. |
| Material | Aluminium alloy, with phosphor-bronze exhaust valve guides and cast iron inlet valve guides. Valve seat inserts of heat treated alloy cast iron. |
| **Crankshaft** | |
| Description | Dynamically balanced, five journal crankshaft with four crankpins (incorporating integral balance weights and sludge traps). |
| Material | Chrome molybdenum steel with nitride hardened journals and crankpins. |
| Damper | Metalastik rubber vibration damper. |
| Direction of rotation | Clockwise (viewed from the front of the engine). |
| End thrust | Taken on centre main bearing. |
| **Main bearings** | |
| Material | Steel backed shells with a tin-aluminium lining. |
| Number | Five. |
| **Connecting rods** | |
| Type | 'H' section. Forged to size. Weighed and colour coded into sets. |
| Material | Chrome molybdenum steel. |
| Big-end bearings | Steel backed shells with a tin-aluminium lining. |
| Gudgeon pin bushes | Pressed into connecting rod small-end bosses and machined to size. |
| Material | Lead-bronze, steel backed. |
| Gudgeon pins | Fully floating. |
| Material | EN 32 B. |
| **Pistons** | |
| Type | Cam ground, full skirt design relieved for crankweb clearance. Recessed crown and offset gudgeon pin. **Turbocharged engines** have steel struts cast into the wall of the pistons. |
| Material | Aluminium alloy - Tin plated. |
| Rings | Three<br>a) Two compression - internal stepped and manufactured from cast iron - top ring molybdenum sprayed onto periphery.<br>b) One oil control (scraper). **Other than turbocharged engines.** Top and bottom steel rails have a chromium plated periphery. Equalizer (expander and centre spacer) is manufactured from carbon steel. **Turbocharged engines.** Single piece cast iron ring with chromium plated lands and a coiled internal control spring. |
| **Valve gear** | |
| Valves | Overhead push rod operated. Seat angle 45°. |
| Material | |
| Inlet valve | **Turbocharged engines.** 21 - 4N. Stellited tips.<br>**Other than turbocharged engines.** EN24 with induction hardened tips. |

| | |
|---|---|
| Exhaust valve | 21 - 4N. Stellited tips and valve seats.<br>**Note**<br>All valves have tufftriding on stems [early turbocharged engines and fuel injection engines have valves with PTFE (Xylan) sprayed on stems]. |
| Valve timing | Marks on gears. |
| Tappets | Self-adjusting hydraulic tappets with spherical base. |
| Material | Heat treated chilled cast iron. |
| Push rods | Ball-ended tubes. |
| Material | 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.<br>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 | 2.81 kgf/cm $^2$ (40 lbf/in$^2$) at 2000 rev/min. |
| Relief valve | 2.81 kgf/cm $^2$ (40 lbf/in$^2$). |
| 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 systems | Refer to Chapter K or Chapter U. |
| Cooling system | Refer to Chapter L. |
| Exhaust system | Refer to Chapter Q. |
| Ignition system | Refer to Chapter M or Chapter U. |

# Dimensional data

| Description | Dimension | Permissible worn dimensions | Remarks |
|---|---|---|---|
| **Crankcase and Cylinders** | | | |
| Cylinder liner bore grading | S 4.10040 in to 4.10095 in<br>T 4.10095 in to 4.10150 in<br>X 4.1016 in to 4.1020 in | 0.004 in wear | If these measurements are exceeded a new assembly of liner and piston must be fitted |
| Cylinder liner 'nip' | 0.002 in to 0.003 in | | New liners must be selectively fitted or ground on the end to give this dimension |
| **Pistons** | | | |
| Piston grading | Other than turbocharged engines<br>S 4.0985 in to 4.0990 in<br>T 4.0990 in to 4.0996 in<br>X 4.0996 in to 4.1003 in | | Pistons measured between 1.312 in and 1.563 in from the bottom of the skirt across the thrust axis |
| | Turbocharged engines<br>S 4.0986 in to 4.0992 in<br>T 4.0992 in to 4.0997 in<br>X 4.09975 in to 4.10045 in | | Pistons measured 0.960 inch from the bottom of the skirt across the thrust axis |
| Compression ring groove widths | 0.0807 in to 0.0817 in | | The rings should be assembled with staggered gaps |
| Compression ring widths | 0.0777 in to 0.0787 in | | |
| Clearance | 0.002 in to 0.004 in | 0.005 in | |
| Compression rings closed gap | 0.013 in to 0.025 in | | |
| Oil control (scraper) ring groove width | 0.1575 in to 0.1585 in | | |
| Oil control (scraper) ring closed gap | | | |

| Engine | Piston Assy (Piston) | Gap | | Piston Assy (Piston) | Gap |
|---|---|---|---|---|---|
| Fuel injection | UE 45864 (UE 45566) | 0.0118 in to 0.0177 in | Alternative piston assy. | UE 46310 (UE 46311) | 0.0150 in to 0.0449 in |
| Turbocharged | UE 45865 (UE 45568) | | Alternative piston assy. | UE 46312 (UE 46313) | |
| Other engines | UE 45863 (UE 45564) | | Alternative piston assy. | UE 46305 (UE 46306) | |

| Description | Dimension | Permissible worn dimensions | Remarks |
|---|---|---|---|
| **Crankshaft and Connecting rods** | | | |
| Connecting rod small-end bush internal diameter | 1.0003 in to 1.0005 in | | |
| Gudgeon pin clearance in small-end bush | Size to 0.0004 in | | At room temperature 20°C to 22°C |
| Big-end bearing housing, internal diameter | 2.395 in to 2.3955 in | | This diameter should be checked with the big-end bolts in position and the nuts torque tightened to 47,08 Nm (4,8 kgf m, 35 lbf ft) |
| Big-end bearing shell, internal diameter | 2.2505 in to 2.2515 in | | |
| Crankpin diameter | 2.2485 in to 2.249 in | 2.2475 in | |
| Clearance | 0.0015 in to 0.003 in | 0.004 in | Clearance measured vertically |
| Small-end bush housing internal diameter | 1.140 in to 1.1405 in | | |
| Connecting rod twist | Maximum of 0.003 inch per inch in length | | |
| Connecting rod vertical alignment | Maximum of 0.001 inch per inch in length | | |
| Connecting rod and cap bolt holes diameter for location | 0.375 in to 0.3755 in | | On location diameter |
| Connecting rod bolt diameter for location | 0.3745 in to 0.375 in | | On location diameter |
| Clearance | Size to 0.001 in | | |
| Connecting rod bolt interference on knurled diameter | Size to 0.0069 in | | Bolts should not be removed from rods unless they are to be renewed |
| Connecting rod end-float | 0.008 in to 0.017 in | | Controlled by clearance between rods and crankpin end. faces |
| Main bearing diametral clearance | 0.0011 in to 0.0026 in | 0.0035 in | |
| Crankshaft end-float | 0.004 in to 0.010 in | 0.012 in | |
| Connecting rod bolt stretch | | | Refer to Section E6 |
| Crankshaft bow | | 0.01 in | Regrind crankshaft if this figure is exceeded |
| Crankshaft journals and crankpins | | 0.001 in | Regrind crankshaft if this figure is exceeded |

| Description | Dimension | Permissible worn dimensions | Remarks |
|---|---|---|---|
| **Gudgeon pins** | | | |
| Bore diameter in piston | Green<br>1.0003 in to 1.0004 in | | Colour code marked on the underside of the piston boss |
| | Red<br>1.0002 in to 1.0003 in | | |
| Gudgeon pin diameter | Green<br>1.0001 in to 1.0002 in | | Colour code marked on the end of the gudgeon pin |
| | Red<br>1.0002 in to 1.0003 in | | |
| Clearance in boss | 0.0001 in to 0.0003 in | | |
| **Main bearing housings** | | | |
| Bore diameter | 2.8735 in to 2.8740 in | | This diameter should be checked with the main bearing caps in position and the retaining nuts tightened to the following 78,64 Nm to 84,06 Nm (8,0 kgf m to 8,5 kgf m, 58 lbf ft to 62 lbf ft) |
| **Main bearing cap** | | | |
| 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 | | |

| Crankshaft diameter | Crankshaft journal diameter | Main shell bearing diameter |
|---|---|---|
| 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 |
| **Crankshaft size** | **Crankpin** | **Big-end bearing** |
| 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 |

| Description | Dimension | Permissible worn dimensions | Remarks |
|---|---|---|---|
| **Valve gear** | | | |
| Camshaft timing gear backlash | 0.001 in to 0.0045 in | 0.006 in | |
| Camshaft gear face run-out | 0.000 in to 0.002 in | | |
| 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) | 1.72 in | | |
| Tappet block bore diameter | | | |
| Colour code white | 0.90475 in to 0.9050 in | | Groove(s) etched onto the top face of the tappet barrel. Tappets marked with one groove should be used with tappet block bores colour coded white and tappets marked with two grooves should be used with tappet block bores colour coded red |
| Colour code red | 0.9050 in to 0.90525 in | | |
| Tappet external diameter | | | |
| One groove | 0.9040 in to 0.90425 in | | |
| Two grooves | 0.90425 in to 0.9045 in | | |
| Clearance | 0.0005 in to 0.001 in | 0.0015 in | |
| Exhaust valve guide - external diameter | 0.6275 in to 0.628 in | | Standard<br>Blue + 0.002 in<br>Green + 0.005 in<br>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 | 0.37375 in to 0.374 in | 0.37275 in | |
| Clearance | 0.001 in to 0.00175 in | 0.0035 in | |

| Description | Dimension | Permissible worn dimensions | Remarks |
|---|---|---|---|
| Inlet valve spring poundage test | Type A<br>74,4 kgf to 81 kgf to compress spring to 30,5 mm<br>(164 lbf to 179 lbf to compress spring to 1.200 in) | - | Type A = inlet valve springs are shorter than exhaust valve springs |
| | Type B<br>1st test 37,9 kgf to 42 kgf to compress spring to 34 mm<br>(83.5 lbf to 92.5 lbf to compress spring to 1.340 in) | | Type B = both inlet valve springs and exhaust valve springs generally appear the same length |
| | 2nd test 71,7 kgf to 77,2 kgf to compress spring to 23,9 mm<br>(158 lbf to 170 lbf to compress spring to 0.940 in) | | |
| Gland spring compressed to 12,7 mm (0.5 in) | Other than turbocharged engines and fuel injection engines | | |
| | 10,9 kgf to 13,17 kgf<br>(24 lbf to 29 lbf) | 9,08 kgf<br>(20 lbf) | |
| Exhaust valve - overall length | Other than turbocharged engines<br>4.886 in to 4.896 in | | |
| | Turbocharged engines<br>4.915 in to 4.930 in | | |
| Exhaust valve stem diameter | 0.37375 in to 0.374 in | 0.37275 in | |
| Clearance | 0.001 in to 0.00175 in | 0.0035 in | |
| Exhaust valve spring poundage test | Type A<br>1st test 39,01 kgf to 42,68 kgf to compress spring to 43,8 mm<br>(86 lbf to 94 lbf to compress spring to 1.725 in) | | Type A = exhaust valve springs are longer than inlet valve springs |
| | 2nd test 71,7 kgf to 77,2 kgf to compress spring to 33,6 mm (158 lbf to 170 lbf to compress spring to 1.325 in) | | |
| | Type B<br>1st test 37,9 kgf to 42 kgf to compress spring to 34 mm<br>(83.5 lbf to 92.5 lbf to compress spring to 1.340 in) | | Type B = both exhaust valve springs and inlet valve springs generally appear the same length |
| | 2nd test 71,7 kgf to 77,2 kgf to compress spring to 23,9 mm<br>(158 lbf to 170 lbf to compress spring to 0.940 in) | | |

| Description | Dimension | Permissible worn dimensions | Remarks |
|---|---|---|---|
| Exhaust and inlet valve seat angle | 45° | | After re-grinding the exhaust valve seat can be 'crowned' with 30° cutter to avoid pocketing |
| Exhaust valve seat insert - external diameter | 1.7540 in to 1.7545 in | | Standard<br>Green + 0.005 in<br>Yellow + 0.010 in<br>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<br>Green + 0.005 in<br>Yellow + 0.010 in<br>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<br>Blue + 0.002 in<br>Green + 0.005 in<br>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 | Other than turbocharged engines<br>4.917 in to 4.933 in<br><br>Turbocharged engines<br>4.863 in to 4.897 in | | |
| 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 | | |

| Description | Dimension | Permissible worn dimensions | Remarks |
|---|---|---|---|
| **Oil pump** | | | |
| Driving shaft diameter | 0.4990 in to 0.4995 in | 0.4970 in | |
| Shaft bore diameter | 0.500 in to 0.5005 in | | |
| 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 and Cylinder liners

The crankcase and cylinders form a monobloc casting of aluminium alloy that carries 'wet-type' cylinder liners.

The centrifugally spun cast iron liners are sealed by a single rubber 'O' ring at the top and by two rubber 'O' rings at the bottom (see fig. E4-2).

The main bearing caps are an aluminium forging and have an interference fit in the crankcase of up to 0.0254 mm (0.001 in).

The camshaft runs in bores machined directly in the crankcase.

Each cast iron tappet block is located by two dowels fitted into the crankcase. One of the locating holes in the tappet block is elongated and forms a slot to allow for the different rates of expansion between the two metals.

The bores of the tappet blocks are graded into two sizes and colour coded either white or red.

Some setscrew holes in the crankcase are fitted with 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

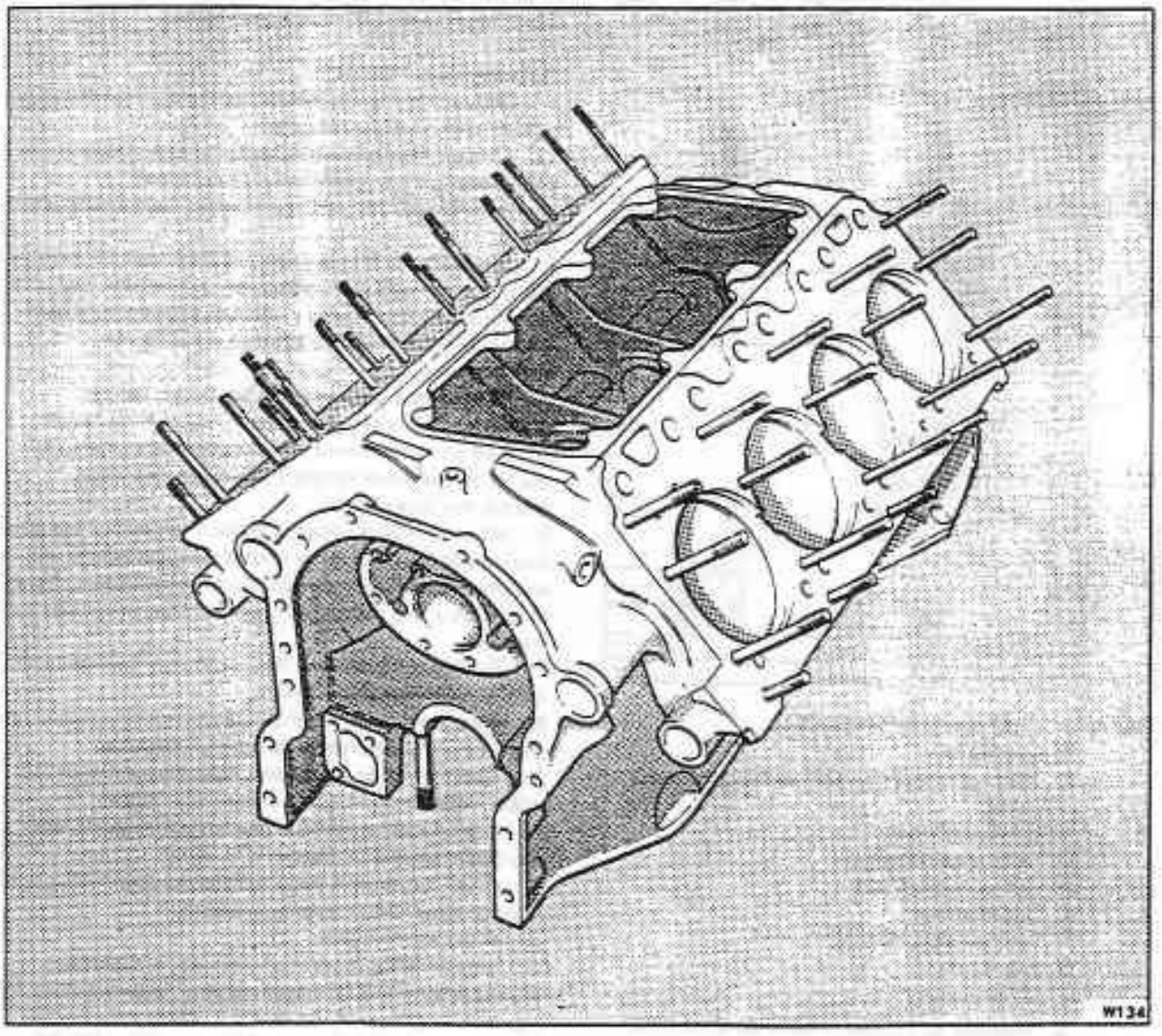



**Fig. E4-1 Crankcase**

the heli-coils have been correctly installed.

Studs (colour coded for size) screw directly into the crankcase, their threads having an interference fit of up to 0,0508 mm (0.002 in).

**Cylinder liners and seals**

**The cylinder bore dimensions should only be checked with all the liners from any one bank 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 E3, Dimensional data, a new liner (with new sealing rings) and piston assembly should 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 into the crankcase (see fig. E4-2).

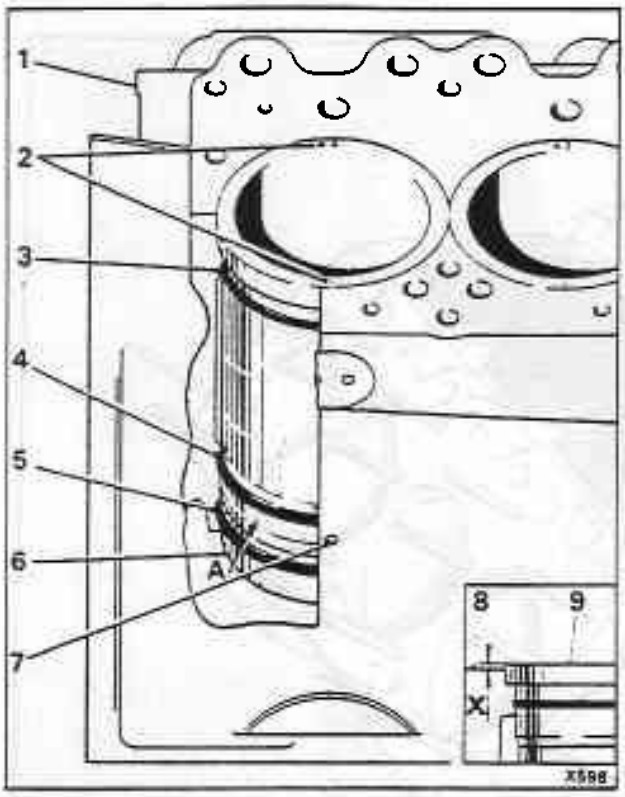



**Fig. E4-2 Cylinder liner in position**

1 Crankcase
2 Bore reference number and piston grade letter
3 Rubber 'O' ring
4 Upper sealing ring
5 Lower sealing ring
6 Cylinder liner
7 Tell-tale hole (8 off)
8 Crankcase
9 Cylinder liner
A Position of corrosion build-up on cylinder liner and crankcase
X Cylinder liner nip

**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**

This operation can be achieved whether or not the crankcase is fitted into the vehicle. One cylinder liner or a complete set of cylinder liners can be removed from the crankcase in the following manner.

1. Dismantle the engine as necessary.
2. Using the cylinder liner extraction tool RH 7095 as shown in figure E4-3, withdraw the liner from the top face of the crankcase.

**Note**

In certain instances it may be beneficial to carry out Operation 2 with the crankcase heated.

**Cylinder liner - To fit**

1. Ensure that the coolant drain hole in the crankcase wall is clean and unobstructed.
2. Ensure that the seal leakage 'tell-tale' holes in the crankcase wall are clean and unobstructed.
3. Ensure that the sealing ring grooves are absolutely clean.
4. Inspect the cylinder liner, the liner location bore in the crankcase 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 allowed to remain will have an adverse affect on the fit of the liner in the crankcase and may distort the liner bore.**

5. When a cylinder liner is fitted into the crankcase it should stand proud of the crankcase top face by the amount stated in Section E3, Dimensional data. This is to provide a 'nip' when the cylinder head and gasket are fitted.

To obtain the correct 'nip' carry out Operations 6 to 9 inclusive (see fig. E4-2).

6. Measure the depth of the cylinder liner collar and also that of the counterbore in the crankcase.
7. Subtract the counterbore measurement from the collar measurement to obtain the 'nip' figure.
8. If the figure obtained does not correspond with the figure quoted in Section E3, either

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

b. or try another liner.

9. Before fitting a cylinder liner into a crankcase always ensure that the bore number is etched onto the top face as shown in figure E4-2. Other information that is etched onto the top of the liner includes the piston grade letter (always ensure that the cylinder

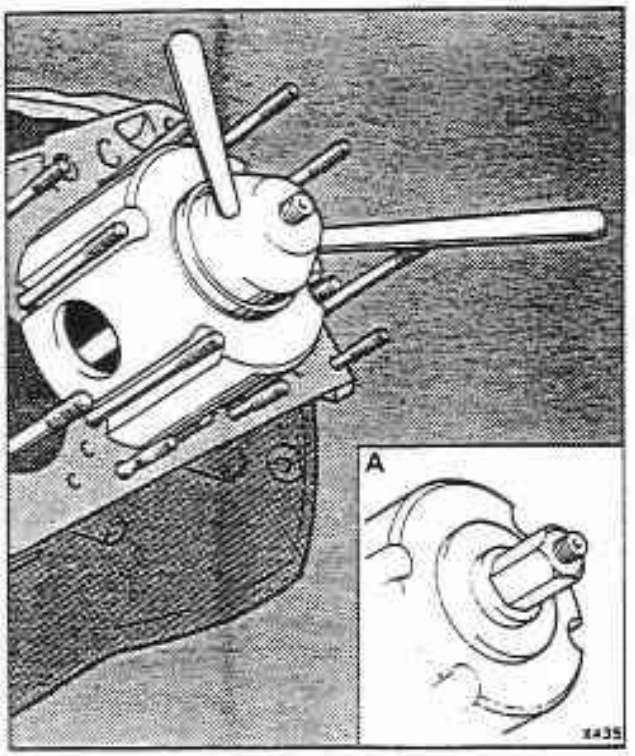



**Fig. E4-3 Cylinder liner extraction**

A Alternative nut, to allow cylinder liners to be removed with the engine remaining in the vehicle

liner is the required grade) and on a very limited number of engines the letters O/L adjacent to the piston grade.

The letters O/L refer to oversize liners (outside diameter) and these liners may be fitted to some reconditioned engines.

10. Fit three new rubber sealing rings into the crankcase. Thinly smear the rings and location diameters with Palmolive grease or its equivalent.
11. Ensure that the crankcase counterbore and liner collar are clean.
12. Fit the cylinder liner into the crankcase bore ensuring that the cylinder bore reference etched on the top face of the liner is positioned at the top (i.e. nearest point to the camshaft) as shown in figure E4-2.
13. 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 12 and 13 with the crankcase heated.

14. Using a depth micrometer, measure the amount that the liner stands proud above the crankcase face (refer to Section E3, Dimensional data).
15. If the liner stands proud of the crankcase by more than the specified limits, again tap around the top face of the liner using a plastic headed mallet.
16. Should the liner either remain in excess of the stand proud limit or be below the limit, the liner should be withdrawn and the cause investigated.

# Crankshaft and Main bearings

The crankshaft is forged from chrome molybdenum steel. There are five main journals and four crankpins, each crankpin carries two connecting rods. The main journals and crankpins run in split, steel backed shell bearings that have an aluminium-tin lining.

The crankpins are drilled and plugged to form sludge traps that prevent dirt from reaching the bearings.

To improve the wear characteristics, the crankshaft is nitride hardened.

Crankshaft end-float is controlled by split thrust washers fitted on either side of the centre main bearing assembly.

The crankshaft has integral balance weights and is dynamically balanced before it is fitted to the engine. When the engine is partially built the crankshaft, connecting rods, and pistons are dynamically balanced in the crankcase.

A 'lip' type of oil seal is fitted to the front and rear of the crankshaft.

**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.**

### Crankshaft - To remove

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. Unscrew the retaining setscrews and withdraw the sump. Discard the gasket.
6. Unscrew the setscrews and withdraw the oil pedestal and strainer assembly.
7. Remove the coolant pump (see Chapter L).
8. Locate the lock-plate situated in the centre of the crankshaft pulley.
9. Unscrew the setscrews and withdraw the lock-plate.
10. Using the special spanner RH 7131 unscrew the serrated nut from the crankshaft.
11. Withdraw the pulley and damper.
12. Using an extractor RH 9765 withdraw the pulley driving flange and collect the Woodruffe key.
13. On turbocharged engines, remove the turbocharger heatshields and disconnect the oil return pipe at the joint on the front cover.
14. Ensure that all weight is removed from the engine front mounting foot and remove the setscrews from the engine mounting situated below the timing cover.
15. Unscrew and remove the necessary nuts, setscrews, and studs retaining the lower timing cover (see fig. E5-2).
16. Carefully withdraw the lower timing cover (the cover is dowelled to the crankcase), ensuring that the rubber bung situated inside the casing is not lost.
17. Unscrew the three setscrews retaining the oil pump. Withdraw the assembly and dowel inserts together with the pipe and rubber 'O' ring.
18. Unscrew the setscrews securing the flexplate assembly (flywheel) to the crankshaft.
19. Withdraw the flexplate assembly.
20. Unscrew the setscrews and withdraw the backplate (see fig. E5-2). The backplate is dowelled to the crankcase. Discard the gasket.
21. Unscrew the nuts from the connecting rod bolts and then withdraw the connecting rod caps.
22. Fit protective rubber tubing over the connecting rod bolts to prevent damage to the crankpins (see fig. E6-4).
23. Remove the shell bearings from both the connecting rod and cap.
24. Push the piston and connecting rod assemblies to the top of their respective bores.
25. Unscrew the main bearing cap nuts and withdraw the caps using the extractor RH 7208 and attachment RH 7498 as shown in figure E5-3.
26. Remove the crankshaft thrust washers from the centre main bearing.
27. Fit protective rubber tubing over the main bearing studs to prevent damage to the crankshaft journals.
28. Carefully lift the crankshaft from the crankcase.

### Crankshaft - To dismantle

1. Using the special spanner RH 7110 unscrew and remove the serrated nut and washer from the front of the crankshaft (the nut has a left-hand thread). Withdraw the spacer washer.
2. Ensure that the front face of the oil pump drive gear is identified (so that the gear can be fitted in its original position when assembling the crankshaft).
3. Withdraw the oil pump driving gear.
4. Using a soft drift, remove the Woodruffe key.
5. Withdraw the space washer.
6. Withdraw the timing gear and Woodruffe key.
7. Dismantle the sludge traps by removing the retaining circlip and withdrawing the plug.

### Crankshaft - To inspect

1. Thoroughly clean the crankshaft. This can usually be achieved by washing the shaft in a paraffin bath then drying it with compressed air. A set of small brushes may be useful to remove obstinate dirt.

2. Mount the crankshaft in 'Vee' blocks on an inspection table.
3. Using a micrometer check the crankshaft journals and crankpins for size, ovality, parallelism, and bow (see fig. E5-4). Refer to Section E3, Dimensional data, for the service dimensions. If necessary, regrind the crankshaft.
4. Inspect the taper on the front of the crankshaft for

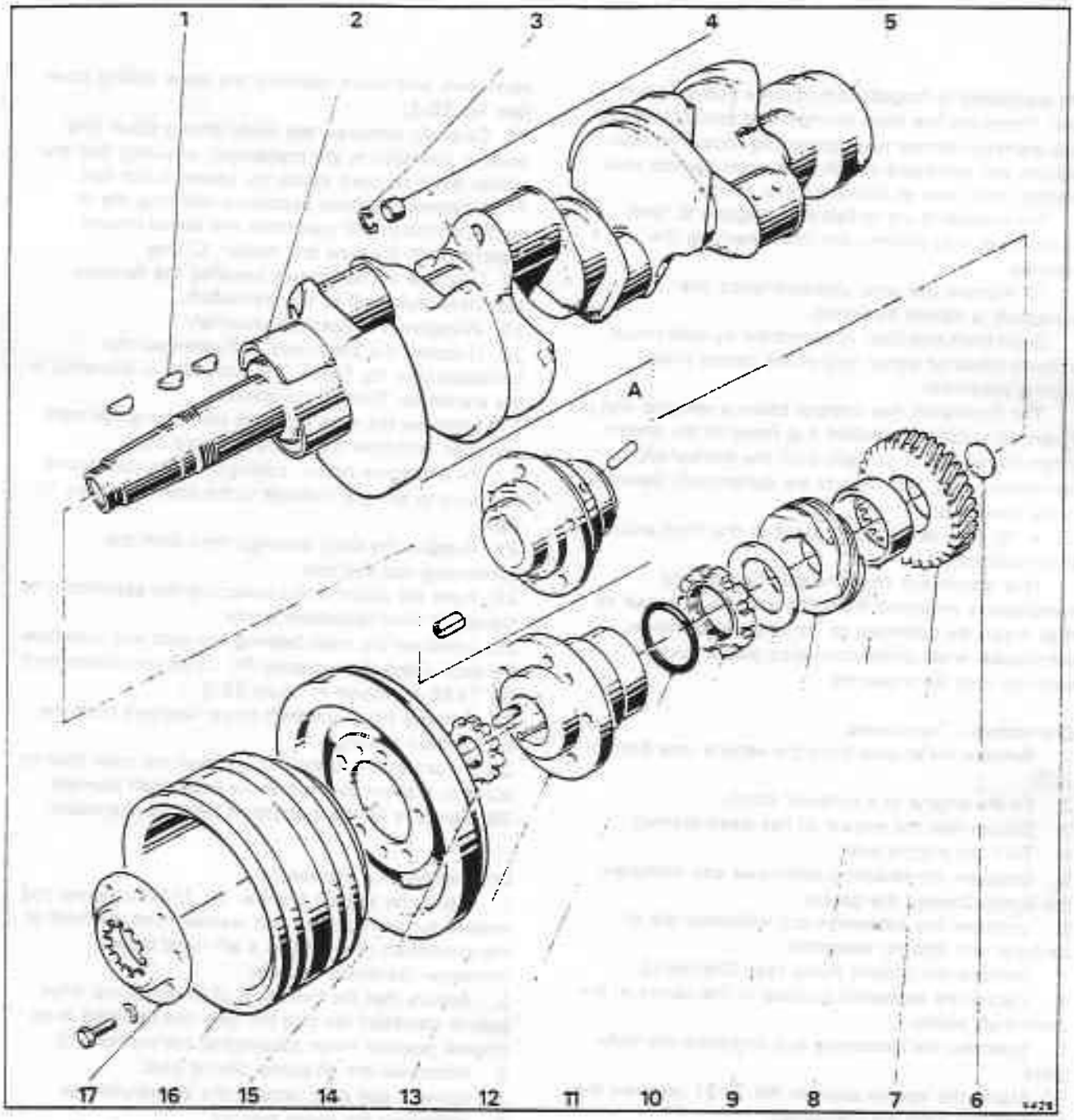



**Fig. E5-1 Crankshaft assembly**

1 Woodruffe key
2 Main shell bearing
3 Circlip
4 Plug
5 Crankshaft
6 Blanking disc
7 Timing gear
8 Distance piece (large)
9 Oil pump driving gear
10 Washer
11 Nut
12 Rubber 'O' ring
13 Driving flange (other than turbocharged engines)
14 Nut
15 Damper
16 Pulley
17 Lock-plate
A Driving flange (turbocharged engines)

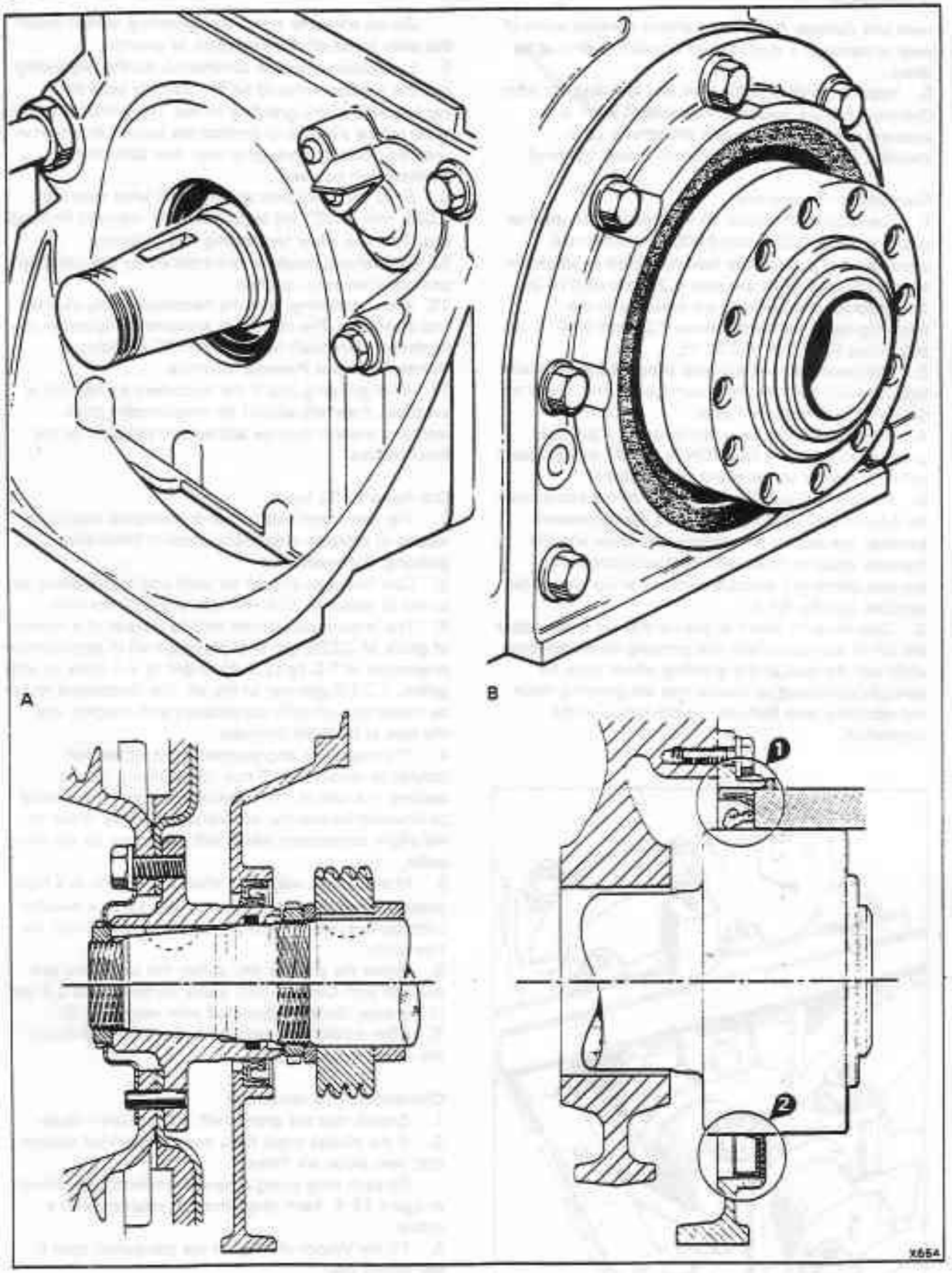



**Fig. E5-2 Crankshaft seal arrangements**

1 Early type of rear seal
2 Late type of rear seal

A Front seal
B Rear seal

wear and damage. If the taper shows obvious signs of wear or damage, a replacement crankshaft should be fitted.

5. Inspect the Woodruffe keys and keyways for wear. Oversize keys are available. However, if wear is apparent with the largest size Woodruffe 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 and lapped to suit the nearest undersize bearing. Refer to Section E3, 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 (see fig. E5-5).
6. Care must be taken to ensure that no sharp edges are left in the radii where the grinding wheel traverse 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.

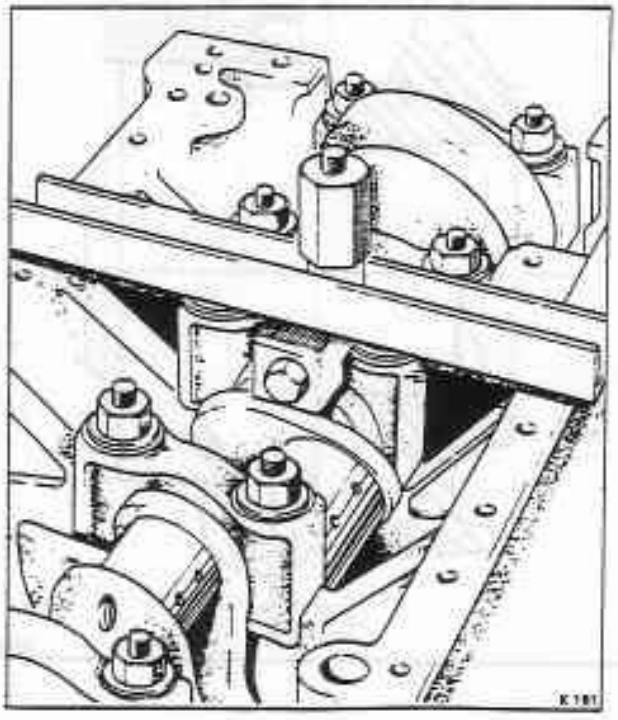


Fig. E5-3 Removing the main bearing caps

**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. Grind the crankpins and journals until they are 0,025 mm (0.001 in) larger than the required finished size. This will allow for lapping and polishing.
9. Crankshafts must be re-hardened by the nitriding process after each re-grind.
10. After hardening, 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.
11. After grinding and if the necessary equipment is available, the shaft should be magnetically crack tested. It should then be lapped and polished to the finished size.

**Crankshaft - To lap**

1. The crankshaft journals and crankpins should be lapped to produce a perfectly smooth finish after grinding and hardening.
2. Cast iron laps should be used and the machine set to run at between 220 rev/min and 250 rev/min.
3. The lapping compound should consist of a mixture of grade M 303½ grit and vegetable oil in approximate proportion of 1,0 kg (2.5 lb) of grit to 4,5 litres (1 Imp gallon, 1.2 US gallons) of the oil. The compound must be mixed to a smooth consistency and injected into the laps at frequent intervals.
4. The crankpins and journals must be lapped parallel to within 0,010 mm (0.0004 in). Whilst lapping, the size of the crankpins and journals should be checked frequently; allowances must be made for the slight contraction which will take place as the shaft cools.
5. After lapping, wash the shaft thoroughly in a high pressure paraffin wash; blow off any surplus paraffin with compressed air and dry the shaft with a soft lint free cloth.
6. When the shaft is dry, polish the crankpins and journals with Corolite 320 grade abrasive tape 2,5 cm (1 in) wide liberally lubricated with vegetable oil.
7. After polishing, again wash the shaft and repeat the cleaning procedure.

**Crankshaft - To assemble**

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

   Fit each plug using a punch similar to that shown in figure E5-6. Each plug must be retained with a circlip.
3. Fit the Woodruffe key to the crankshaft then fit the timing gear.

   Ensure that the timing gear locates correctly onto the Woodruffe key.
5. Fit the larger of the two spacers.

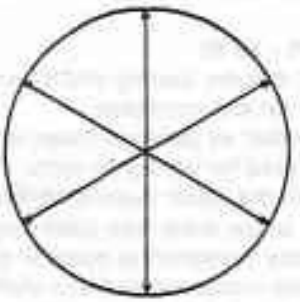
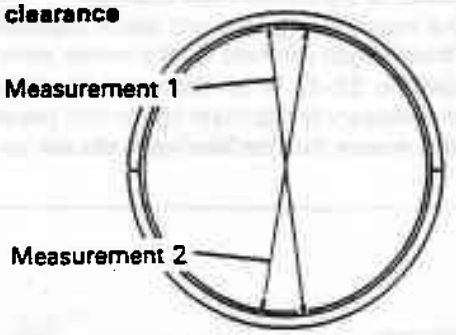
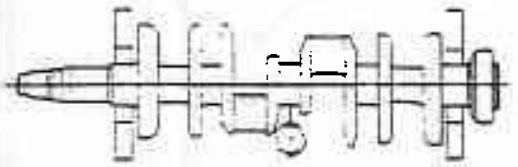
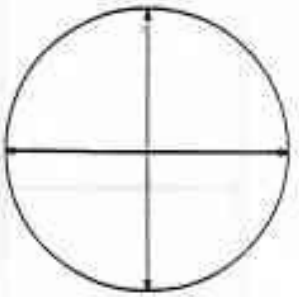
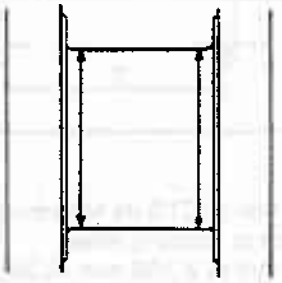
| Measurement | Method |
|---|---|
| **Mean size**  | **Obtained on crankshaft main journal, crankpins, and bearing shells**<br>1. (a) Measure the diameter of the journal or crankpin in two planes one at right angles to the other.<br>(b) Ensure that the shell bearings are fitted in position and the retaining nuts correctly tightened. Measure the bore of the bearing in three places as shown.<br>2. Add the two journal or crankpin readings together (three readings for the shell bearings) and divide by two (three for shell bearings). |
| **Bearing clearance**   | **Obtained between crankshaft main journals/crankpins and bearing shells**<br>1. Obtain mean size of shell bearing.<br>2. Obtain mean size of crankshaft main journal/crankpin.<br>3. Subtract measurement obtained in 2 from measurement obtained in 1 to give bearing clearance. |
| **Bow**  | **Measured on the crankshaft centre main journal**<br>1. Mount the crankshaft main journals 1 and 5 in 'Vee' blocks on a surface table.<br>2. Position the indicator gauge on the side of the centre main journal.<br>3. Rotate the shaft until the lowest reading is obtained on the gauge. Zero the gauge.<br>4. Rotate the shaft 180° and note the reading on the gauge.<br>5. Divide the reading by two to obtain the crankshaft bow. |
| **Ovality**  | **Measured on the crankshaft main journals and crankpins**<br>1. Measure across the centre of the journal or crankpin in two planes one at right angles to the other.<br>2. Subtract the smaller reading from the larger reading to give the ovality.<br>**Note**<br>This operation should be carried out at several points to establish the largest and smallest diameters. |
| **Parallelism (Taper)**  | **Measured on the crankshaft main journals and crankpins**<br>1. Measure the diameter at both ends of the journal or crankpin, ensure that the measurements are taken on the same plane.<br>2. Subtract the smaller reading from the larger reading to give the taper. |

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**Fig. E5-4 Method of measuring the crankshaft**

6. Fit the second Woodruffe key to the crankshaft, then fit the oil pump drive gear. Ensure that the gear is fitted with the front face towards the front of the crankshaft.

If a new gear is fitted, the mating gear on the oil pump should also be replaced.

Ensure that the oil pump drive gear locates correctly on the Woodruffe key.

7. Fit the smaller of the two spacers and the serrated nut.

**Important**

Always fit a new serrated nut. The nut has a left-hand thread.

8. Using special box spanner RH 7110 torque tighten the serrated nut to the figures quoted in Section E15

The crankshaft should be held firm whilst tightening the serrated 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 serrated nut can be off-set by levering on the bar.**

**Crankshaft - To fit**

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 in position noting that the marks on the crankshaft and camshaft timing gears align (see Section E7). Fit the upper halves of the thrust washer to the centre main bearing.

5. Fit the main bearing caps and shells together with the two lower thrust washers for the centre main bearing (see fig. E5-7). 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

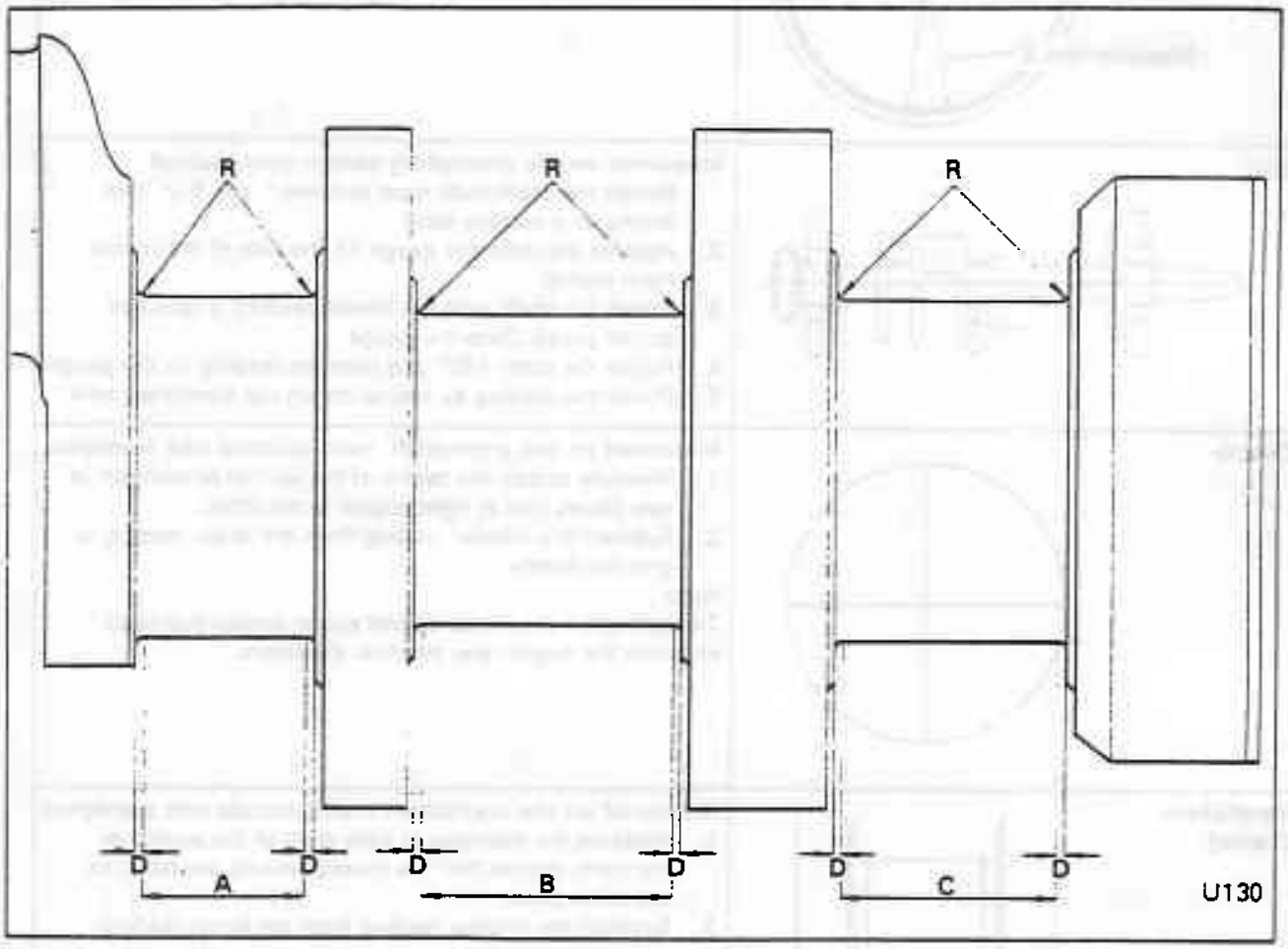



**Fig. E5-5 Crankpin and journal grinding dimensions**

A 32,97 mm (1.298 in) Grinding wheel travel - journals 2, 3, and 4

B 50,29 mm (1.980 in) Grinding wheel travel - crankpins

C 42,67 mm (1.680 in) Grinding wheel travel - journal 5

D 0,254 mm (0.010 in) Minimum distance - side face to grinding wheel

R 2,362 mm to 2,108 mm (0.093 in to 0,083 in) Radius

dislodged. The cap nuts should be torque tightened to the figures quoted in Section E15.

6. Check that the crankshaft rotates freely.
7. Check the crankshaft end-float as shown in figure E5-8. Refer to Section E3, Dimensional data.
8. Fit the bearing shells to the connecting rods and caps, then lightly smear the shells with clean 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 oil filter delivery pipe, using the new rubber 'O' rings.
14. Fit the oil strainer pick-up and pedestal (see fig. E5-9).
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 into the lower front cover. Remove the oil feed pipe and prime the turbocharger with engine oil. Fit the feed pipe.
17. Fit a new rubber 'O' ring into the pulley driving flange.
18. Fit the pulley driving flange.
19. Fit the damper and crankshaft pulley.
20. Fit the serrated nut and torque tighten to the figure given in Section E15 using the special spanner RH 7131.
21. Check that the lock-plate aligns with the five setscrew holes. If necessary, further tighten the serrated nut to align the setscrew holes.
22. Fit the setscrews and torque tighten them to the figures given in Section E15.

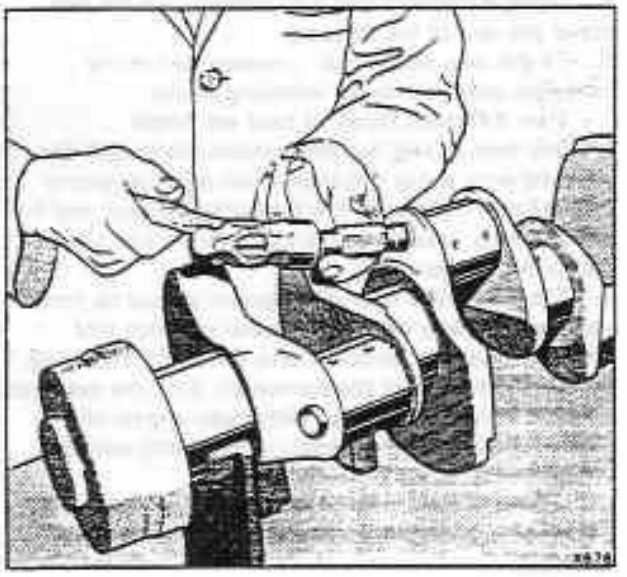


**Fig. E5-6 Fitting the sludge trap plugs**

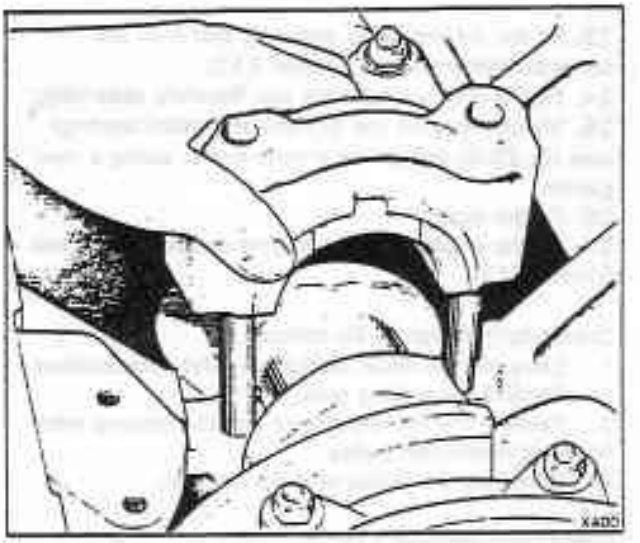


**Fig. E5-7 Fitting the centre main bearing cap**

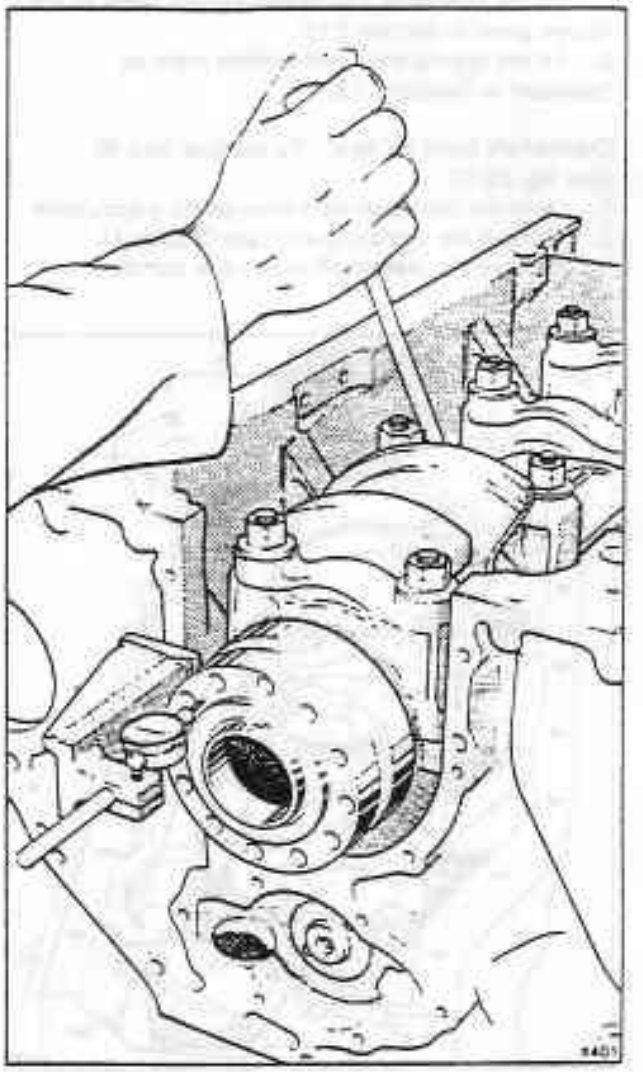


**Fig. E5-8 Checking the crankshaft end-float**

23. Fit the driving belts, ensuring that they are correctly tightened (see Section E13).
24. Fit the engine backplate and flexplate assembly.
25. Visually inspect the big-end and main bearings (see fig. E5-9) and fit the engine sump, using a new gasket.
26. Fit the dipstick.
27. Fit the engine into the engine compartment (see Section E12).

**Crankshaft damper - To remove**

1. Carry out the usual workshop safety precautions.
2. Slacken the driving belts.
3. Remove the five setscrews and the locking plate from the crankshaft pulley.
4. Withdraw the pulley and the damper.

**Crankshaft damper - To fit**

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

1. The damper and crankshaft pulley can only be fitted one way due to the positioning of the locating dowel(s).
2. Fit the setscrews and torque tighten them to the figures given in Section E15.
3. Fit the driving belts and tension them as described in Section E13.

**Crankshaft front oil seal - To remove and fit (see fig. E5-2)**

1. Carry out the usual workshop safety precautions.
2. Remove the coolant pump (see Chapter L).
3. Remove the crankshaft pulley and damper.

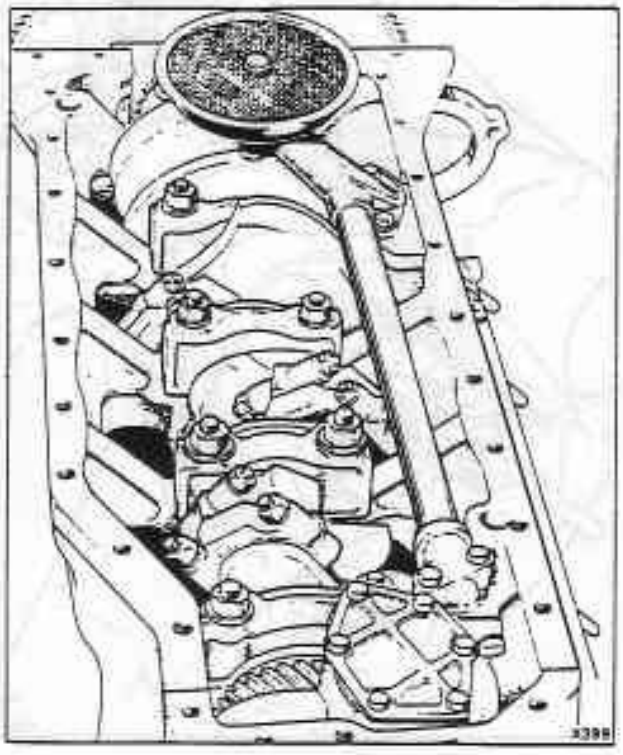


**Fig. E5-9 View with the sump removed**

4. Using extractor RH 9765 withdraw the pulley driving flange and collect the Woodruffe key.
5. Unscrew the setscrews that secure the sump to the front lower timing cover.
6. Remove all weight from the engine front mounting foot.
7. Unscrew the setscrews from the engine mounting situated below the timing cover.
8. Remove the necessary nuts, setscrews, and studs retaining the front lower timing cover (see fig. E5-2).
9. Carefully thread a feeler gauge or similar object 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 lower timing cover (the cover is dowelled to the crankcase), ensuring that the rubber bung situated inside the casing does not become mislaid. 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. Coat the outside of the new seal with Palmolive grease and press the seal into the housing until it is correctly positioned (see fig. E5-2).
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. E5-2)**

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 backplate and unscrew the retaining setscrews. Collect the washers and withdraw the backplate. The backplate is dowelled to the crankcase.
5. Discard the crankcase gasket.
6. Using a hammer and drift carefully tap the seal out of the rear of the housing.
7. Fit the new seal into a unworn part of the backplate bore noting the following points.

**Two different types of seal are fitted**

a. One type of seal has the instructions **install dry** stamped onto it and this instruction must be strictly adhered to. Fit the seal into the backplate bore and fit the backplate assembly carefully over the end of the crankshaft into position.

b. The alternative seal arrangement should be fitted into the backplate using the special insertion tool RH 9646. Seal protection sleeve RH 9655 should be fitted onto the end of the crankshaft. Both the seal and sleeve should be lubricated with clean engine oil before the backplate assembly is fitted into position. Withdraw the seal protection sleeve.

c. Always ensure that 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 rods

The connecting rods (see fig. E6-1) are 'H' section forgings of chrome molybdenum steel. They are accurately balanced before fitting to the engine by machining excess metal from the balance pad on the big-end and from the boss on the small-end.

Drillings in the crankshaft webs carry oil from the main bearings to the big-end journals, for the lubrication of the big-end bearings. Oil splash and mist collecting under the crown of the piston falls onto the connecting rod small-end boss and then passes through a recessed drilling in the boss and a hole in the bush, to provide lubrication for the gudgeon pin and small-end bush.

The detachable big-end bearings are split steel backed shells with a tin-aluminium lining.

The small-end bush which is pressed into the small-end boss, is split and has a steel backing lined with lead-bronze. After being pressed into the small-end boss, the bush is machine bored to the final diameter.

### Pistons

The pistons are manufactured from 12% silicon aluminium alloy. They are cam ground to provide an ideal bearing surface that will maintain an adequate oil film and minimise the possibility of 'scuffing' under adverse operating conditions.

On turbocharged engines, the pistons are diamond turned.

The pistons are finally tin-plated to a depth of 0,0076 mm (0.0003 in).

Each piston has three rings (two compression and one oil control), a gudgeon pin that is off-set from the centre line of the piston and a full skirt which is shaped to allow for clearance with the crankshaft web.

Turbocharged engines have steel struts cast into the sides of the pistons.

The top piston ring is an internally stepped type of compression ring, manufactured from cast-iron. The top ring is molybdenum sprayed for a depth of 0,10 mm (0.004 in). This provides the ring with a hard wear resistant face.

The second ring is basically a compression ring although it does combine these duties with that of an auxiliary oil scraper ring. This ring is 'internally stepped' and manufactured from cast iron. It is granolite treated to provide additional lubrication for the ring during the initial running-in period.

The oil control (scraper) ring comprises top and bottom steel rails that are chromium plated on the periphery to a minimum depth of 0,13 mm (0.005 in). The equalizer (expander and centre spacer) is manufactured from carbon steel.

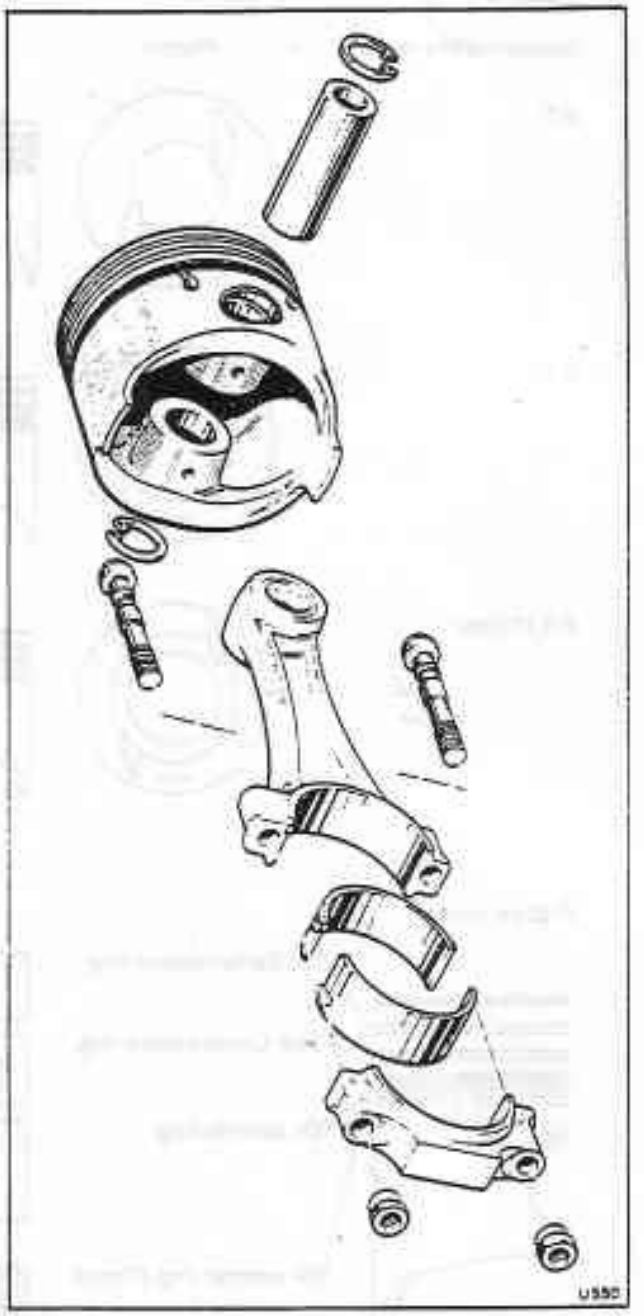


Fig. E6-1 Connecting rod and piston assembly

On turbocharged engines, the oil control ring is a single piece cast iron ring with chrome plated lands and a coiled internal control spring.

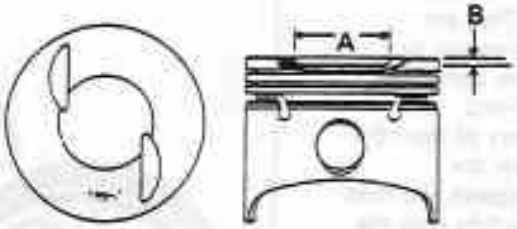
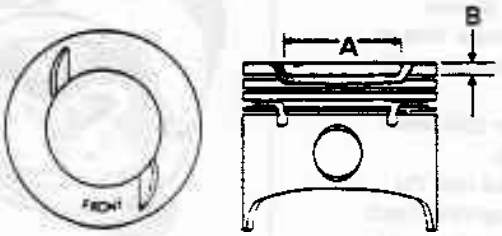
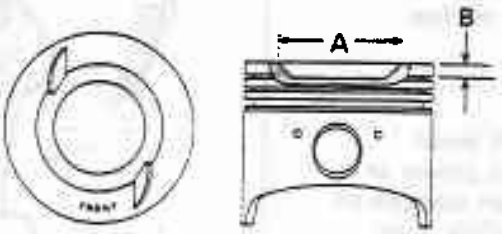
Further details of the piston rings are given in figure E6-2.

## Compression ratio

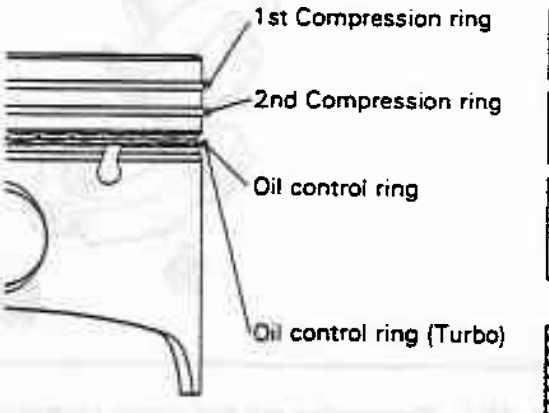
**Australia, Japan, and North America**
8:1

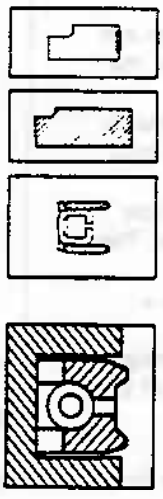
**Other than Australia, Japan, and North America**
9:1
8:1 (Bentley Mulsanne Turbo)

## Pistons

| Compression ratio | Piston | |
|---|---|---|
| 9:1 |  | A 50,80 mm (2.00 in)<br>B 3,60 mm (0.142 in) |
| 8:1 |  | A 62,23 mm (2.450 in)<br>B 6,35 mm (0.250 in) |
| 8:1 (Turbo) |  | A 67,99 mm (2.677 in)<br>B 8,30 mm (0.327 in) |

## Piston rings



Edge of ring molybdenum sprayed to a depth of 0,10 mm (0.004 in) min.

Produced from cast iron and Granolite treated

Steel rails chromium plated to a depth of 0,13 mm (0.005 in) min.
Centre equalizer produced from high carbon steel

Cast iron ring with chromium plated periphery.
Coiled internal control spring

**Note** The compression ratio is changed by the shape of the piston crown.

X735

Fig. E6-2 Details of pistons

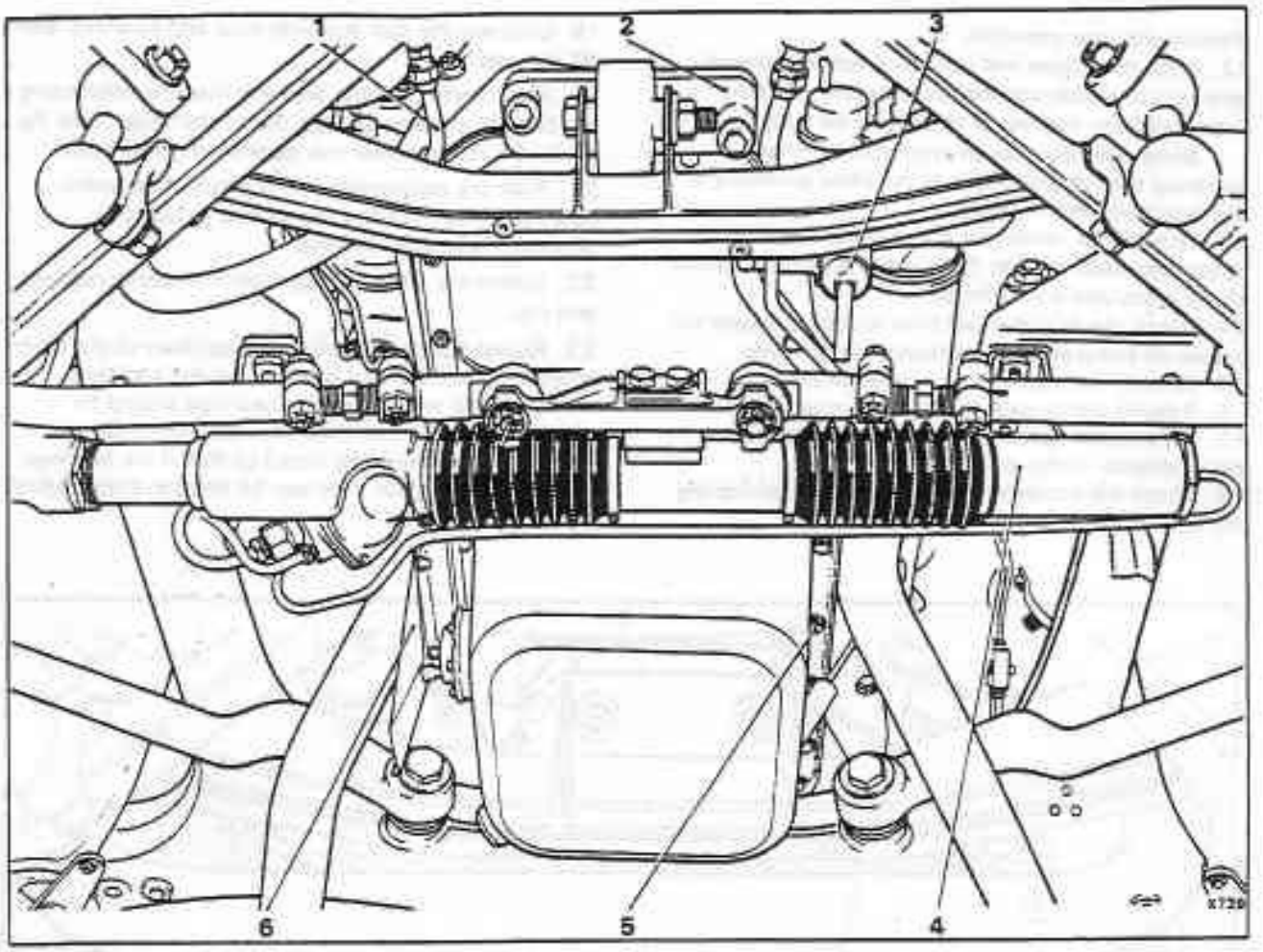



**Fig. E6-3 Removing the engine sump (other than turbocharged engines)**

1 Transmission oil cooler pipe
2 Front engine mount
3 Fuel drain valve
4 Steering rack
5 Sump setscrew
6 Oil level transmitter shield

**Gudgeon pin**

The piston is carried on the connecting rod by a gudgeon pin. This pin is fully floating when the engine is running under normal conditions.

Two Seeger clips are used to retain the gudgeon pin (see fig. E6-1).

The gudgeon pin is case hardened to a depth of between 0,25 mm and 0,50 mm (0.010 in and 0.020 in).

**Connecting rod bearings - To remove**

The big-end bearing 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.

**Refer to figure E6-3 or E6-4 for identification of the components to be removed.**

5. Remove the steering rack assembly (see Chapter Chapter N).
6. Suitably position a sling around the upper front of the engine. Connect the sling to the overhead pulley and 'take the weight' of the engine.

On turbocharged cars, fit the front section of the lifting eye RH 9730 and connect to the overhead pulley via the front sling. Take the weight of the engine.

7. Detach the front engine mount, noting the number of spacer shims.
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 (if applicable).
10. Remove the sump setscrews retaining the fuel drain valve in position (if fitted). Secure the valve away from the area of the engine sump.
11. Unscrew and remove the nut, bolt, and setscrew securing the dipstick tube to the engine. Withdraw the

dipstick and tube assembly.

12. Raise the engine and using a suitable universal joint type of socket spanner unscrew the retaining setscrews from the rear of the engine oil sump.

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

13. Remove the remainder of the sump retaining setscrews, ensuring that the sump is supported before all the setscrews are withdrawn.

14. 'Break' the seal that will have formed between the engine oil sump and the crankcase bottom face.

15. Carefully withdraw the sump assembly.

16. Remove the oil pedestal and fine mesh strainer.

17. Remove the sparking plugs (this will facilitate easier rotation of the crankshaft assembly).

18. Rotate the crankshaft until one pair of connecting rod caps are at their lowest point.

19. Unscrew the cap retaining nuts and carefully 'ease off' the cap.

20. Fit protective rubber sleeving over the connecting rod bolts to prevent damage to the crankshaft (see fig. E6-5). **Do not remove the connecting rod bolts.**

21. Push the connecting rod and piston assembly upwards away from the crankshaft, to facilitate removal of the shell bearing.

22. Collect the shell bearing from the connecting rod and cap.

23. Repeat Operations 20 to 22 inclusive to the other connecting rod big-end bearings on the crankpin.

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.

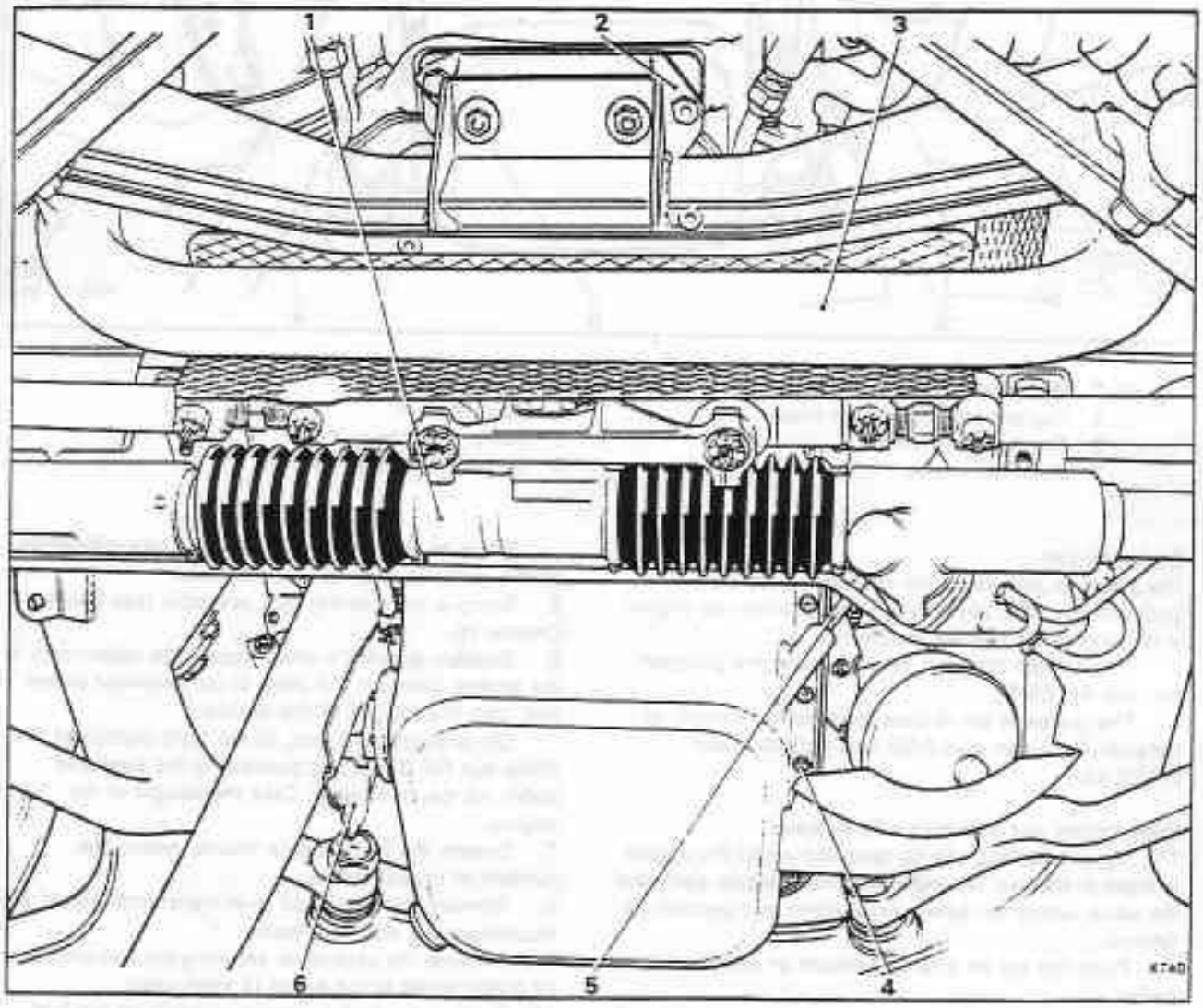



**Fig. E6-4 Removing the engine sump (turbocharged engines)**

1 Steering rack
2 Front engine mount
3 Exhaust pipe
4 Sump setscrew
5 Dipstick tube
6 Oil level transmitter shield

**Crankpins and bearings - To inspect**

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 E3, Dimensional data.

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

**Connecting rod bearings - To fit**

1. Fit protective sleeves to the connecting rod bolts.
2. If the upper and lower 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 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 (see fig. E6-9).

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 (use 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 '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.

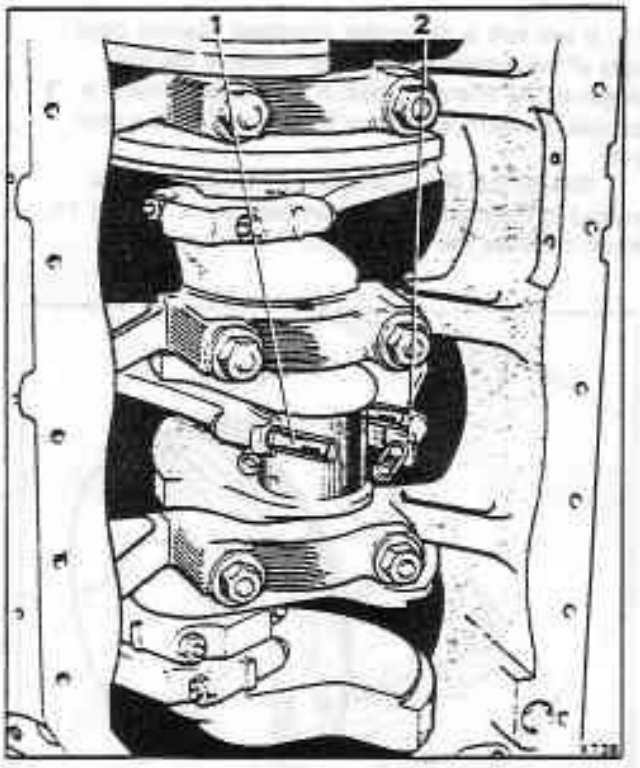



**Fig. E6-5 Removing the big-end bearing shells**
1 Connecting rod bolt fitted with protective rubber sleeve
2 Connecting rod bolt pushed away from the crankshaft

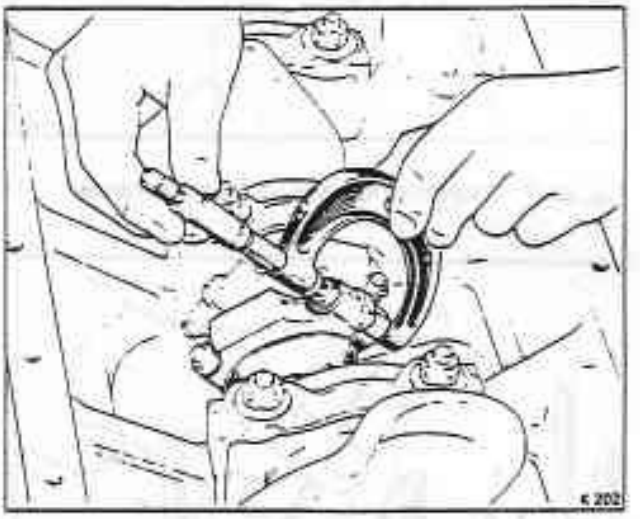


**Fig. E6-6 Checking connecting rod bolt stretch**

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 4,84 kgf m and 6,22 kgf m (35 lbf ft and 45 lbf ft).
15. **If any bolt has not been stretched sufficiently,** increase the torque tightness to 6,91 kgf m (50 lbf ft) and again check the bolt stretch.

16. If any bolt is still under stretched, slacken both nuts of the connecting rod and measure the free length of the offending bolt. If this measurement is outside the limits quoted in Operation 11, fit a new bolt.

Should this measurement be inside the limits quoted in Operation 11, 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.

Repeat Operations 11 to 14 inclusive.

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).

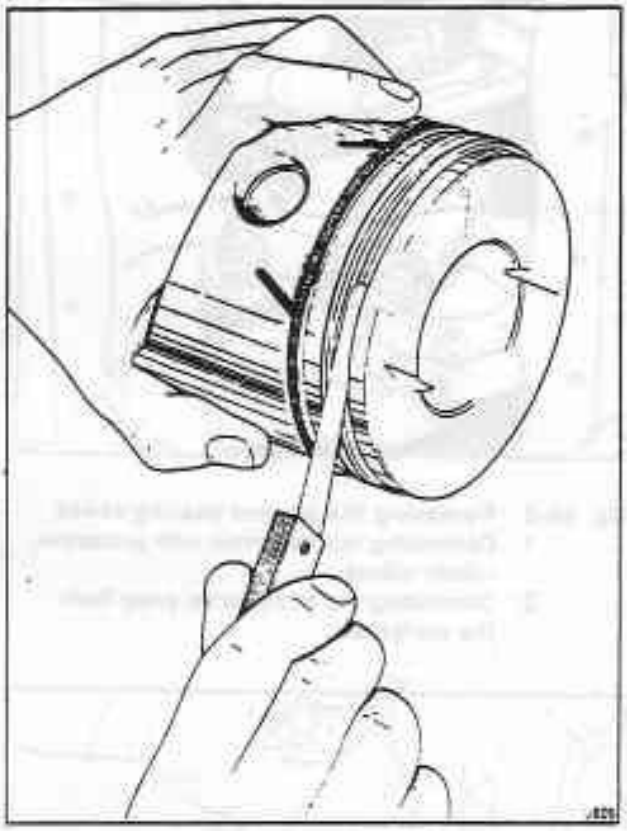


Fig. E6-7 Checking the piston ring clearance

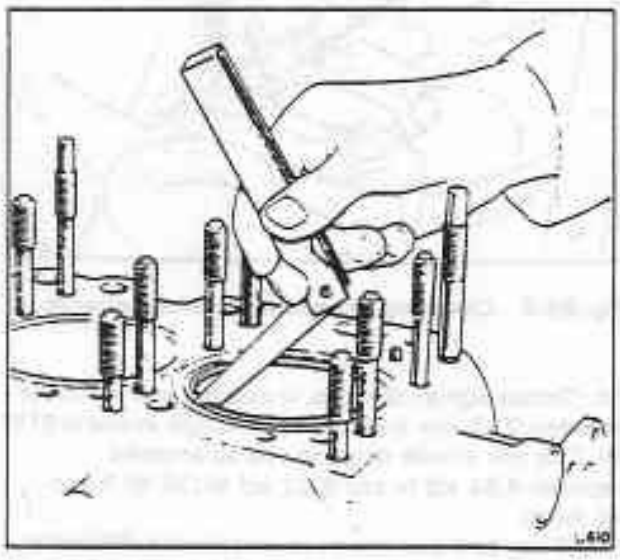


Fig. E6-8 Checking the piston ring gap

**Connecting rod and piston - To remove**

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

**Connecting rod and piston - To dismantle**

1. Remove the circlip 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 hot plate.
3. When the piston is thoroughly warm, push the gudgeon pin out using a suitable guide.

**Piston - To inspect**

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 deposit is removed from the piston ring grooves.
3. Thoroughly clean all components.
4. Check that the clearance of the piston rings in their respective grooves is as given in Section E3, Dimensional data (see fig. E6-7).
5. Check the compression rings in either a 104,14 mm (4.10 in) diameter ring gauge, or an unworn part of the cylinder (see fig. E6-8), 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 bore (see Section E3).
7. Visually check the condition of the oil control ring.
8. Check the dimension of the piston across the thrust axis. The measurement should be taken at the piston grading point which is 23,0 mm (0.906 in) above the bottom of the skirt. The measurements and grades of the pistons are given in Section E3.

**Small-end bush - To inspect and renew**

1. Check the diameter of both the gudgeon pin and the small-end bush. If the clearance exceeds

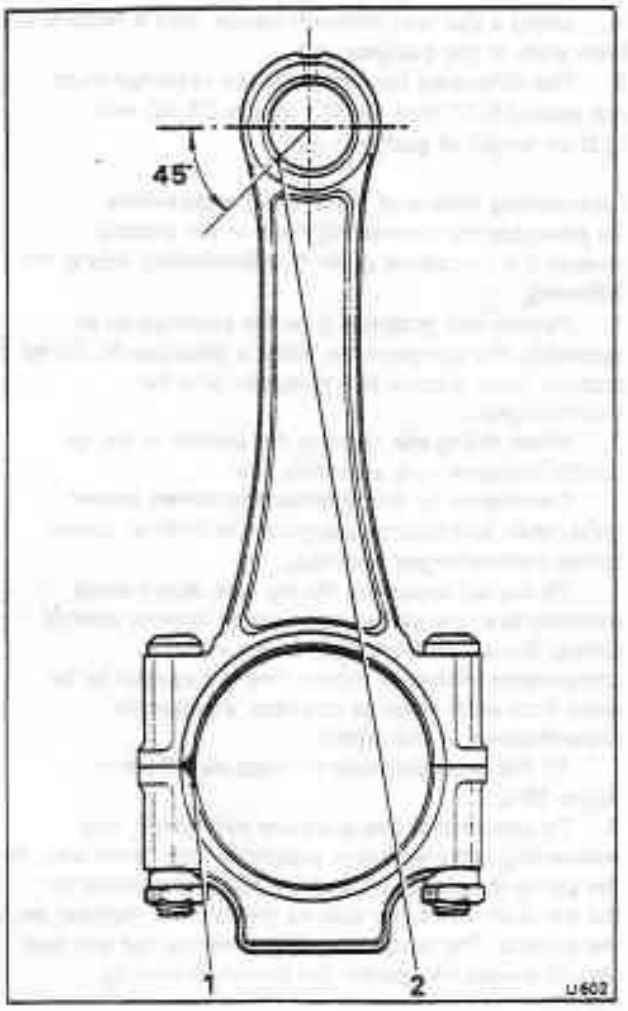



Fig. E6-9 Position of small-end bush
1 Tangs
2 Split in bush

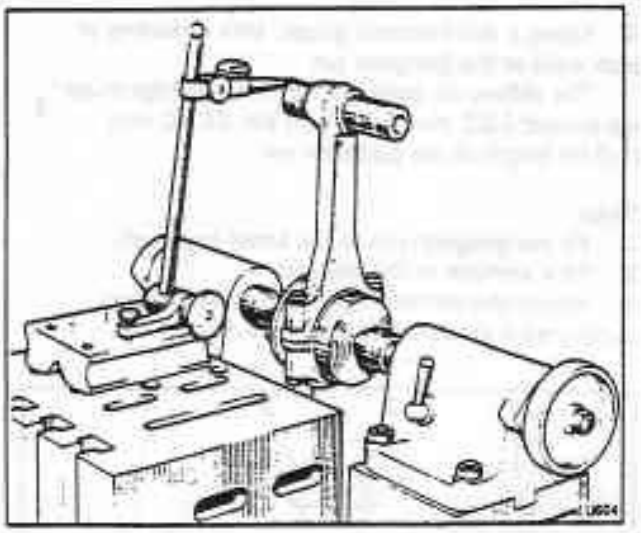



Fig. E6-10 Checking the connecting rod alignment

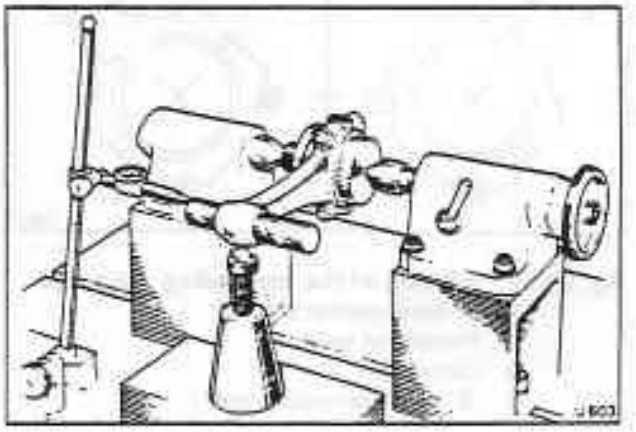



Fig. E6-11 Checking the connecting rod for twist

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 0,051 mm to 0,089 mm (0.002 in to 0.0035 in) is essential.
7. Position the new bush so that the chamfered 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. E6-9). 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 E3. Dimensional data. The gudgeon pin fit in the small-end bush should be from a size fit to 0,00635 mm (0.00025 in) clearance.

**Connecting rods - To check alignment and twist**

The correct alignment of a connecting rod is of the utmost importance and 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 E6-10.

4. Using a dial indicator gauge, take a reading at both ends of the gudgeon pin.

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 E6-11.

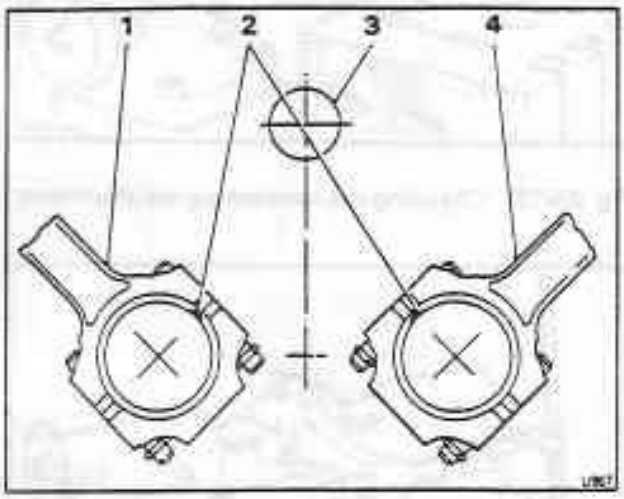



**Fig. E6-12 Position of the connecting rod tangs**

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

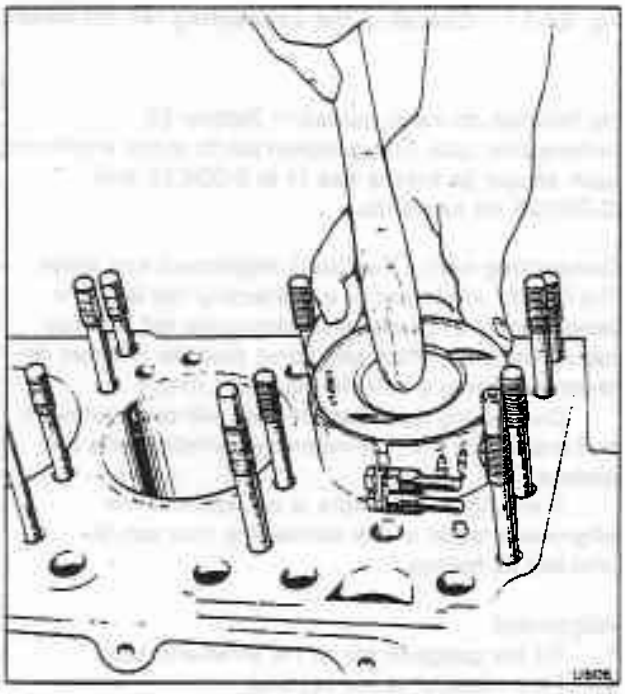


**Fig. E6-13 Fitting a piston**

4. Using a dial test 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**

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 (scraper) ring assembly first.

Commence by fitting either the centre spacer (other than turbocharged engines) or internal control spring (turbocharged engines).

Fit the rail assembly, taking care that it seats correctly over the centre equalizer or internal control spring. Ensure that the gaps in the various components of the oil control ring are spaced as far away from each other as possible, around the circumference of the piston.

Fit the two compression rings as shown in figure E6-2.

3. To ensure that the gudgeon pin, piston, and connecting rod are always assembled the same way, 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. The tangs on the connecting rod and cap should always be nearest the camshaft (see fig. E6-12).

**Connecting rods and piston - To fit**

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 or clean engine oil and 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. E6-13).
7. Carefully position the connecting rod onto the crankshaft big-end journal. Remove the protective sleeving from the bolts, finally check the location of the big-end bearing shells and 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.

Refer to Section E8, for information relating to the valves and their associated components.

The camshaft is manufactured from cast iron and has chilled cast cam peaks. It is centrally positioned between the two banks of cylinders and runs directly in bores machined in the crankcase.

The camshaft is driven through helical gears from the crankshaft. The camwheel is aluminium and the crankshaft gear is steel.

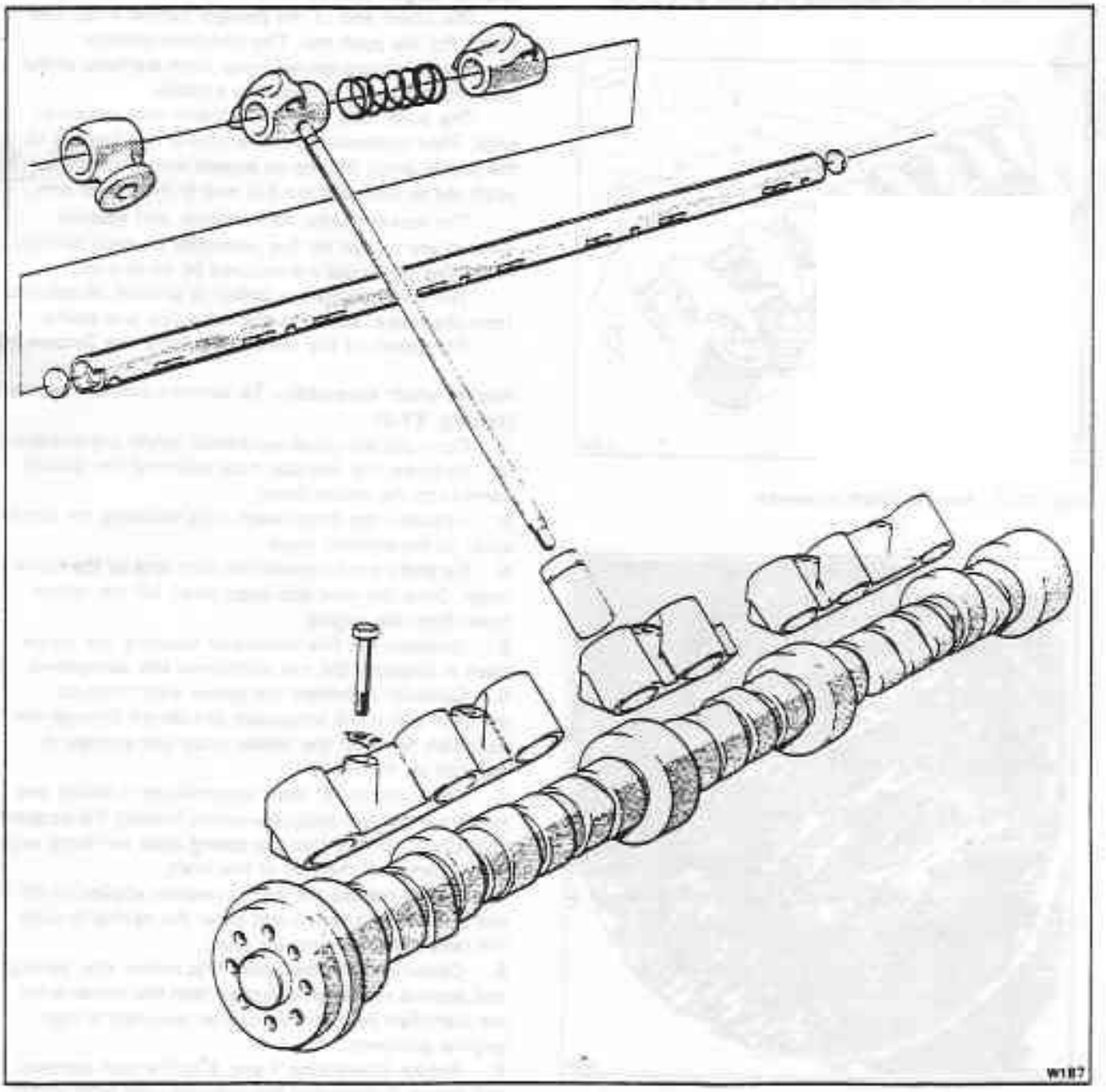


Fig. E7-1 Camshaft and Valve mechanism

End thrust is taken on a thrust collar and is controlled by the thrust plate situated at the front of the camshaft.

Lubrication of the camshaft timing gear and the crankshaft gear is effected by the high pressure oil jet sprayed directly onto the two gears. The feed for this is via a tapping block adapter secured to the camshaft thrust plate. This plate is also the oil gallery cover plate.

A skew gear secured by two setscrews to the rear of the camshaft provides the drive for the distributor. The two setscrews are off-set to ensure correct positioning.

The camshaft incorporates two eccentrics to drive the hydraulic system pumps (see Section E11).

The hydraulic tappets are carried in detachable blocks fitted into the crankcase on either side of the camshaft. The tappets are self-adjusting and require no maintenance. The tappet barrels are produced from cast iron and have a spherical base. These seat onto the camshaft where the cams have a slight longitudinal taper that rotates the tappets thus ensuring even wear of the tappet barrel and base.

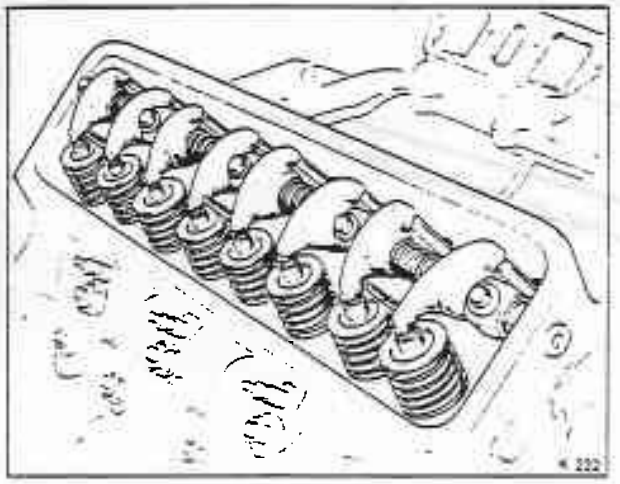


Fig. E7-2 Rocker shaft assembly

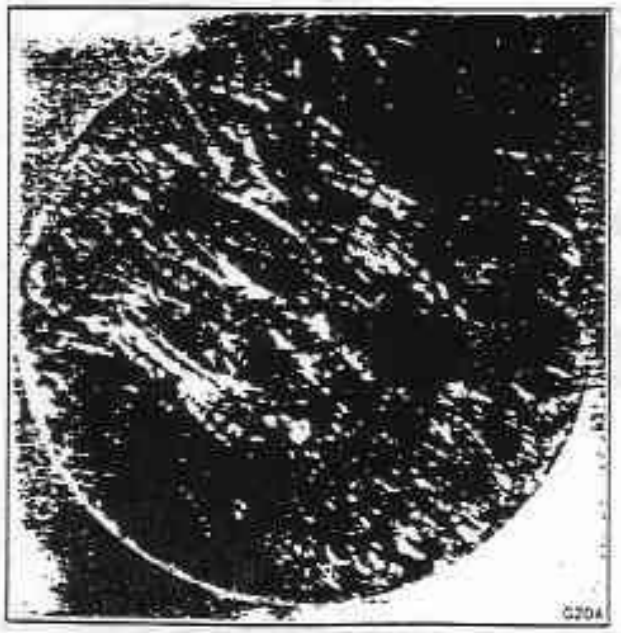


Fig. E7-3 Severely scuffed tappet base

A longitudinal flat is machined on the tappet barrel, this supplies oil from the groove in the tappet body to the cam face.

The hydraulic tappet (see fig. E7-4) comprises a cylindrical barrel, closed at the bottom end which seats onto the camshaft. Inserted into this body is a plunger that is free to slide up and down; the clearance between the body and plunger is very small. At the lower end of the plunger is a one-way valve. The valve is held closed by a wave washer that is housed in a retainer spigot, clipped onto the end of the plunger.

The upper end of the plunger carries a cap into which fits the push rod. The complete plunger assembly is spring-loaded away from the base of the tappet body and is retained by a circlip.

The push rods are hollow tubes with spherical ends. They transmit the movement of the tappets to the rocker arms. Engine oil passes along the hollow push rod to lubricate the ball end at the rocker arm.

The rocker shafts, rocker arms, and spacing springs are carried on five pedestals on each cylinder head. The pedestals are secured by setscrews.

The rocker arms are drilled to provide oil delivery from the rocker shafts to the valve tips and stems.

For details of the valve assemblies see Section E8.

**Rocker shaft assembly - To remove and dismantle (see fig. E7-2)**

1. Carry out the usual workshop safety precautions.
2. Unscrew the two cap nuts retaining the ignition harness to the rocker cover.
3. Unscrew the three 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 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 and springs in position on the shaft.
7. Place the rocker shaft assembly on a bench and withdraw the end setscrew whilst holding the pedestal 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.

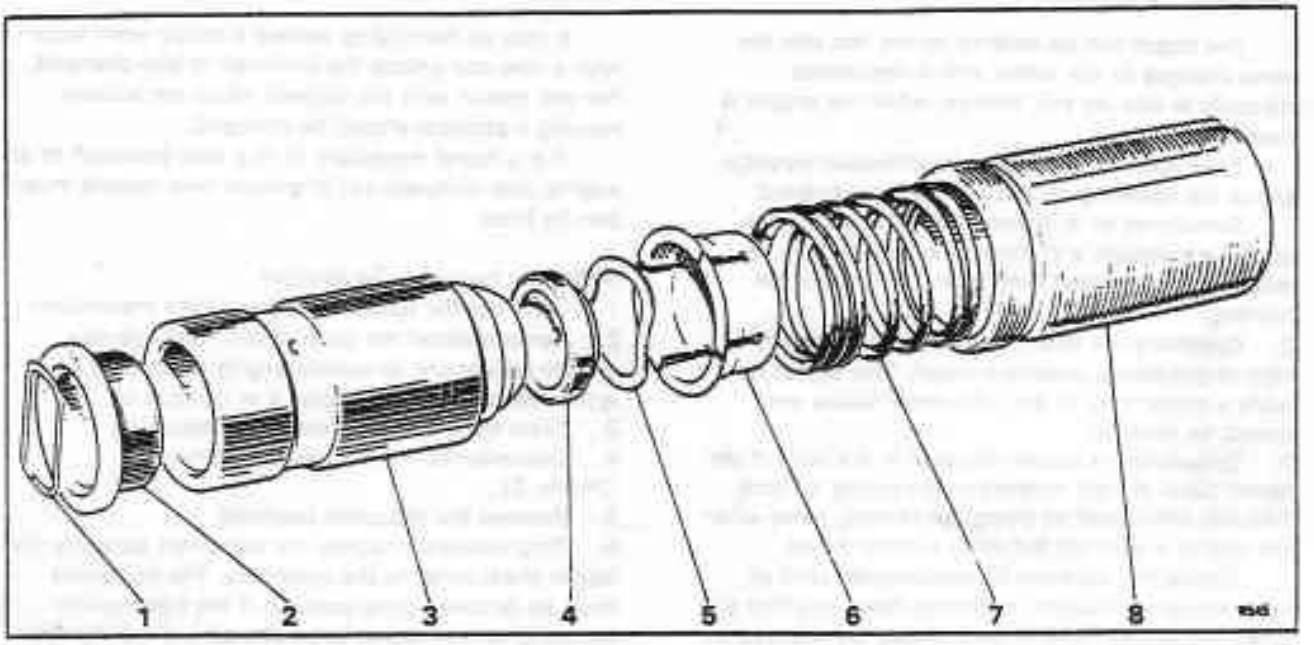



**Fig. E7-4 Hydraulic tappet**

1 Circlip
2 Cap
3 Plunger
4 Valve
5 Wave washer
6 Retainer
7 Spring
8 Tappet barrel

**Rocker shaft assembly - To inspect**

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**

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.
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 the figures quoted in Section E15.

**Push rods - To remove, inspect, and fit**

1. Carry out the usual workshop safety precautions.
2. Remove the rocker cover and rocker shaft.
3. Withdraw the push rods. 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**

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 may be worthwhile dismantling the existing tappet and thoroughly washing it in clean paraffin. After cleaning, refit the tappet.

**Tappet noise**

A defective tappet makes a noise like a 'rifle crack' and is usually caused by one or more tappets collapsing, it 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.

The tappet can be isolated by the fact that the noise changes as the rocker arm is depressed manually to take up any 'sponge' while the engine is running.

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

1. Sometimes air is drawn into the tappets after standing overnight and one of the tappets may be reluctant to clear itself even after 30 minutes hot running.
2. Occasionally a tappet leaks down too quickly at high temperatures causing a knock. This tappet 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**

There is seldom a cause for rejecting tappets due to an appearance of wear on the bottom face unless the cam peak on the camshaft is also badly worn.

It may be harmful 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 changed.

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

**Hydraulic tappets - To remove**

1. Carry out the usual workshop safety precautions.
2. Remove either the carburetters, fuel injection system equipment, or turbocharging equipment as applicable (see either Chapter K or Chapter U).
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 five 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.

**Hydraulic tappets - To dismantle**

1. Press down the spherical cap situated in the top of the tappet and remove the circlip holding the cap in place. After gradually releasing the pressure from the

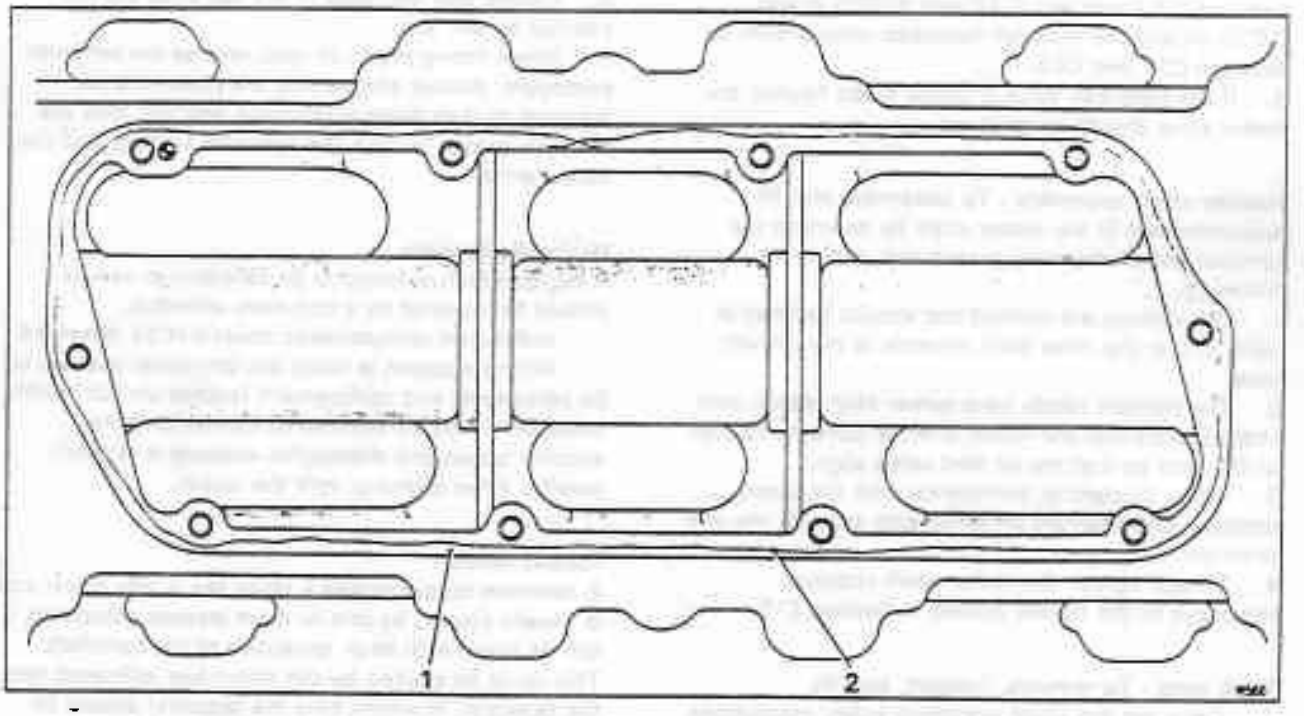



**Fig. E7-5 Crankcase to tappet cover joint**

1 Crankcase tappet cover face
2 Silk sealing thread

spherical cap, the tappet can be dismantled (see fig. E7-4).
2. Remove the plunger and valve from the tappet barrel. The tappet barrel should be examined for any signs of wear on the base.

**Hydraulic tappets - To assemble and prime**
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. Commence assembly of the tappet by fitting the wave washer (see fig. E7-4) and valve in the retainer.
2. Using 'finger' pressure, carefully press the retainer assembly onto the spigot of the plunger.
3. Fit the spring onto the retainer assembly.
4. Fit the valve assembly (plunger, valve, wave washer, retainer, and spring), into the tappet barrel.
5. Fit the cap into the top of the plunger.
6. Using an old push rod press the cap downwards until it is possible to fit the retaining circlip 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 wave 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, therefore it can be removed from the paraffin.

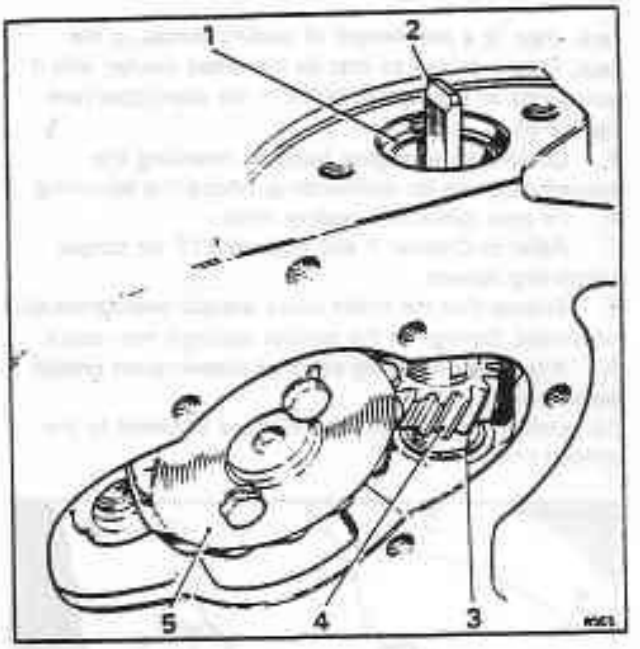



**Fig. E7-6 Distributor driving gears (other than turbocharged engines, and all engines conforming to 1983 model year specifications and onwards)**
1 Locating plug
2 Distributor driving shaft
3 Thrust washer
4 Driving spindle and integral gear
5 Skew gear

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

**Hydraulic tappets - To fit**
1. Oil the bores of the tappet blocks.
2. Check that if new tappets are being fitted, the grade of each tappet corresponds with the bore of the tappet block. The tappet barrel grading marks are etched onto the top lip of the barrel.
3. Fit the tappets.
4. Fit the push rods to the engine, into the same position from which they were removed.
5. Fit the rocker shafts, then progressively tighten the securing nuts.
6. Fit the tappet chest cover.

**Tappet chest cover - To fit**
1. Rotate the camshaft until the brake pump eccentrics are at approximately bottom dead centre (bdc).
2. To prevent the possibility of 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 Wellseal to the crankcase tappet cover joint

face, then fit a new length of sealing thread to the face. Fit the thread so that its two ends overlay and it surrounds all the tapped holes in the crankcase (see fig. E7-5).
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.

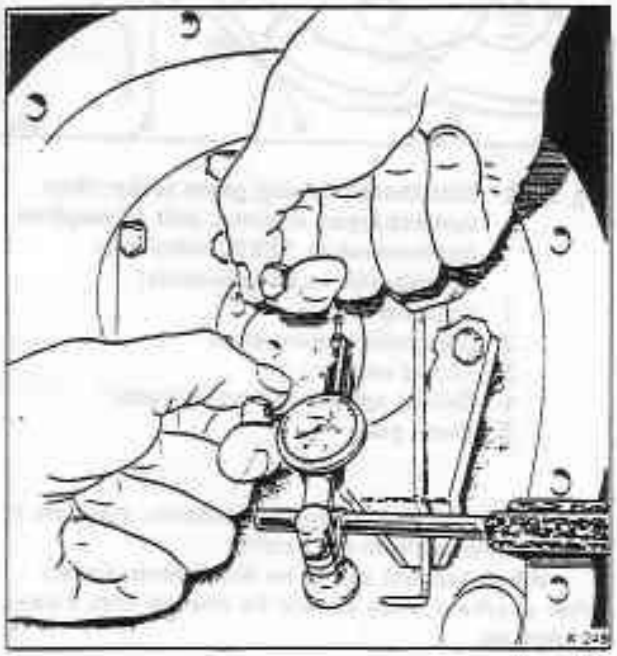


Fig. E7-7 Checking the camshaft end-float

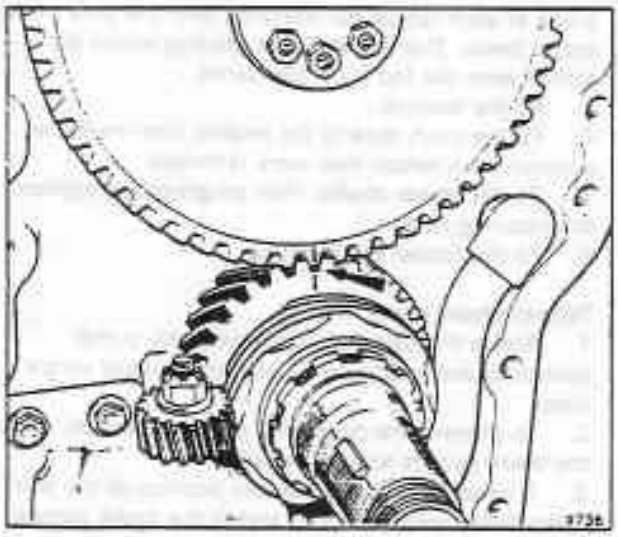


Fig. E7-8 Valve timing marks

**Camshaft - To remove**
1. Remove the hydraulic tappets.
2. Remove the transmission (see Chapter T).
3. Remove the flexplate assembly.
4. Remove the distributor, together with its pedestal if fitted. Refer to Chapter M.
5. Remove the pressed steel cover from the rear end of the crankcase to expose the distributor driving gears (see fig. E7-6).
6. Withdraw the distributor driving shaft together with the locating plug and 'O' ring.
7. Withdraw the distributor driving spindle and integral gear together with the thrust washer.
8. Remove the skew gear from the rear end of the camshaft.
9. Remove the radiator grille, refrigeration condenser, and radiator matrix. On turbocharged cars, also remove the oil cooler.
10. Remove the coolant pump and lower front cover from the front of the engine.
11. Unscrew the setscrews from the camshaft and withdraw the cam gear.
12. Remove the camshaft thrust plate together with the timing gear lubricating oil pipe assembly. Withdraw the camshaft through the front end of the crankcase. Take care that the bearing bores are not damaged by the cam lobes.

**Camshaft - To inspect**
1. Inspect the cams for wear and pitting. The cam lift dimensions are given in Section E3, Dimensional data.
2. If wear is in excess of the figures given, the camshaft must be renewed.

**Camshaft - To fit**
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 boxes.
2. Fit the timing gear lubricating jet to the thrust plate and secure it with two setscrews and tab-washers.
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. E7-7)**
1. Fit a dial test indicator to the crankcase and position the indicator onto the end of the camshaft; set the scale to zero.
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 E3, Dimensional data.

**Valve gear - To time (see fig. E7-8)**

1. Rotate the crankshaft until the mark on the crankshaft timing gear is vertical and towards the top of the crankcase.
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 with eight setscrews. Torque tighten the setscrews to the figures quoted in Section E15.

**Camshaft timing gear backlash and run-out - To check**

1. Fit a dial test indicator to the crankcase and position the indicator onto the timing gear as shown in figure E7-8; set the scale to zero.
2. Rock the cam gear and check the backlash. The backlash should be between the figures quoted in Section E3, 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 fig. E7-10).
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 E3.

**Distributor driving gear - To fit (other than turbocharged engines, and all engines conforming to 1983 model year specifications and onwards)**

1. Fit the camshaft distributor driving gear.
2. Rotate the crankshaft until the timing marks on the camshaft and crankshaft gears are in line (see fig. E7-8).
3. Fit the thrust washer to the distributor driving gear spindle, then fit the gear into the recess in the crankcase. It will help in fitting this gear if the washer is held to the gear with a light smear of grease.
4. When the gear is fitted, the slot in the top of the gear spindle should be in line with the camshaft (see fig. E7-6).

   On no account should the setting of the crankshaft and camshaft be disturbed whilst fitting this gear.
5. Fit the distributor driving shaft to the driving spindle, then fit the locating plug.
6. If necessary, renew the rubber 'O' ring on the locating plug.
7. Using a dial test indicator in a similar manner to that shown in figure E7-9, check the backlash of the distributor driving gear. This should be between the figures quoted in Section E3, Dimensional data.
8. Fit the camshaft rear cover using a new paper joint.

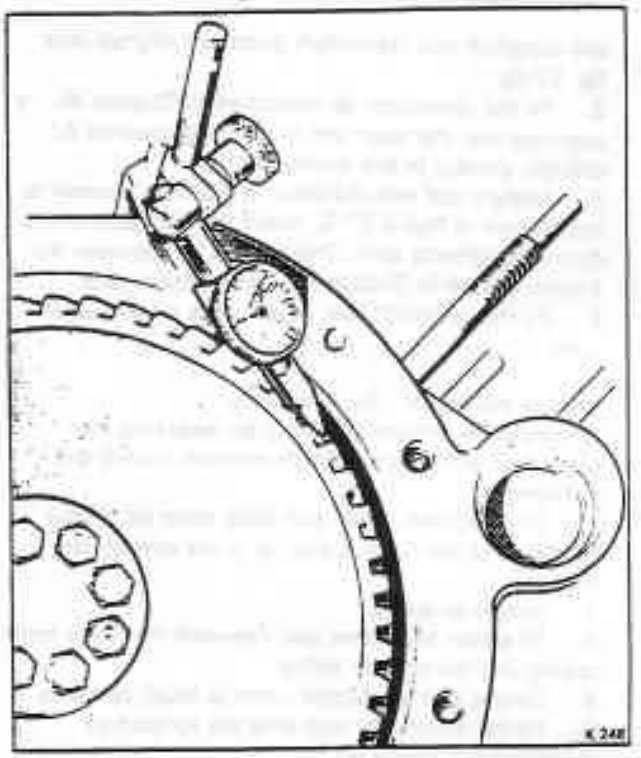


**Fig. E7-9 Checking the timing gear backlash**

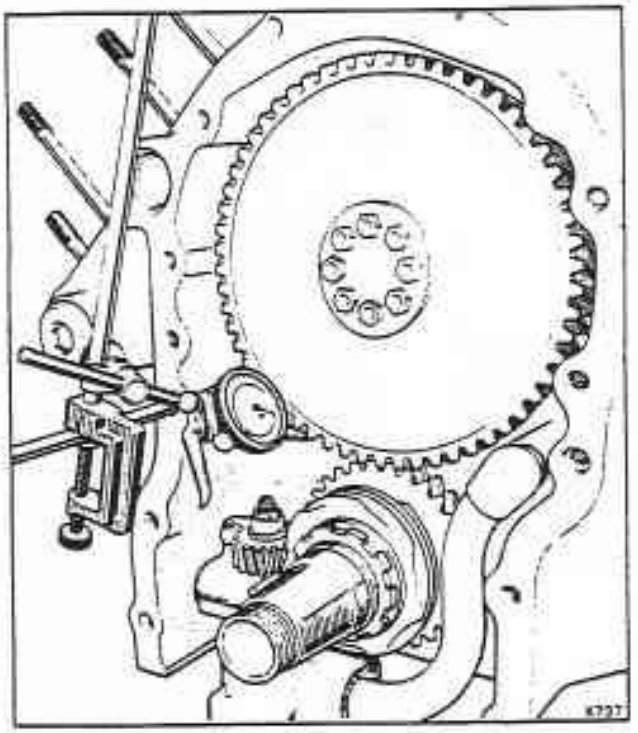


**Fig. E7-10 Checking the timing gear run-out**

**Distributor driving gear - To fit (turbocharged engines, and all engines conforming to 1983 model year specifications and onwards)**

1. Fit the camshaft distributor driving gear.
2. Rotate the crankshaft until the timing marks on

the camshaft and crankshaft gears are aligned (see fig. E7-8).
3. Fit the distributor as described in Chapter M, ensuring that the rotor arm is pointing towards A1 cylinder contact in the distributor cap.
4. Using a dial test indicator in a similar manner to that shown in figure E7-9, check the backlash of the distributor driving gear. This should be between the figures quoted in Section E3, Dimensional data.
5. Fit the camshaft rear cover using a new paper 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. Fit the distributor and time the ignition as described in Chapter M.
6. If a new camshaft is fitted to an engine, one complete set of sixteen new tappets must also be fitted.

# Cylinder heads and Valves

The two detachable cylinder heads are produced from cast aluminium alloy, each having four separate inlet and exhaust ports. The cylinder heads are fitted with phosphor bronze exhaust valve guides and cast iron inlet valve guides. The valve seat inserts are alloy cast iron.

The inlet valves are produced from alloy steel with induction hardened tips. The exhaust valves are austenitic steel with a Stellite tip and valve seat face.

The valve stem oil seal is either a 'waxed string' type of grommet or a moulded rubber cover; the two are not interchangeable.

The valves fitted with the rubber cover type of stem seal arrangement have an additional treatment that is an aid to running-in. This was originally in the form of a P.T.F.E. (blue) coating on the valve stem but subsequently changed to Tufftriding treatment which appears as a black coating on the stem.

In either case **do not remove the coating from the valve stem** refer to Valves - To fit.

**Cylinder heads - To remove**

The operations listed form the basic procedure to be followed. In service, minor variations to this procedure will be encountered due to the specification of the vehicle.

1. Carry out the usual workshop safety precautions.
2. Drain the cooling system (see Chapter L).
3. Depressurize the hydraulic systems (see Chapter G).
4. Slacken the drive belts situated at the front of the engine.
5. Remove the fuel metering equipment fitted above the induction manifold as follows.

a. **Carburetter(s) and weakening system** refer to Chapter K (Part 1).

*For cars produced to an Australian or Middle East specification refer to Chapter U.*

b. **Fuel injection system** refer to Chapter U.

c. **Turbocharged system** refer to Chapter K (Part 2).

**Induction manifold**

6. Detach the refrigeration compressor from its mountings and move it from the vicinity of 'B' bank cylinder head.
7. Remove the alternator (see Chapter M).

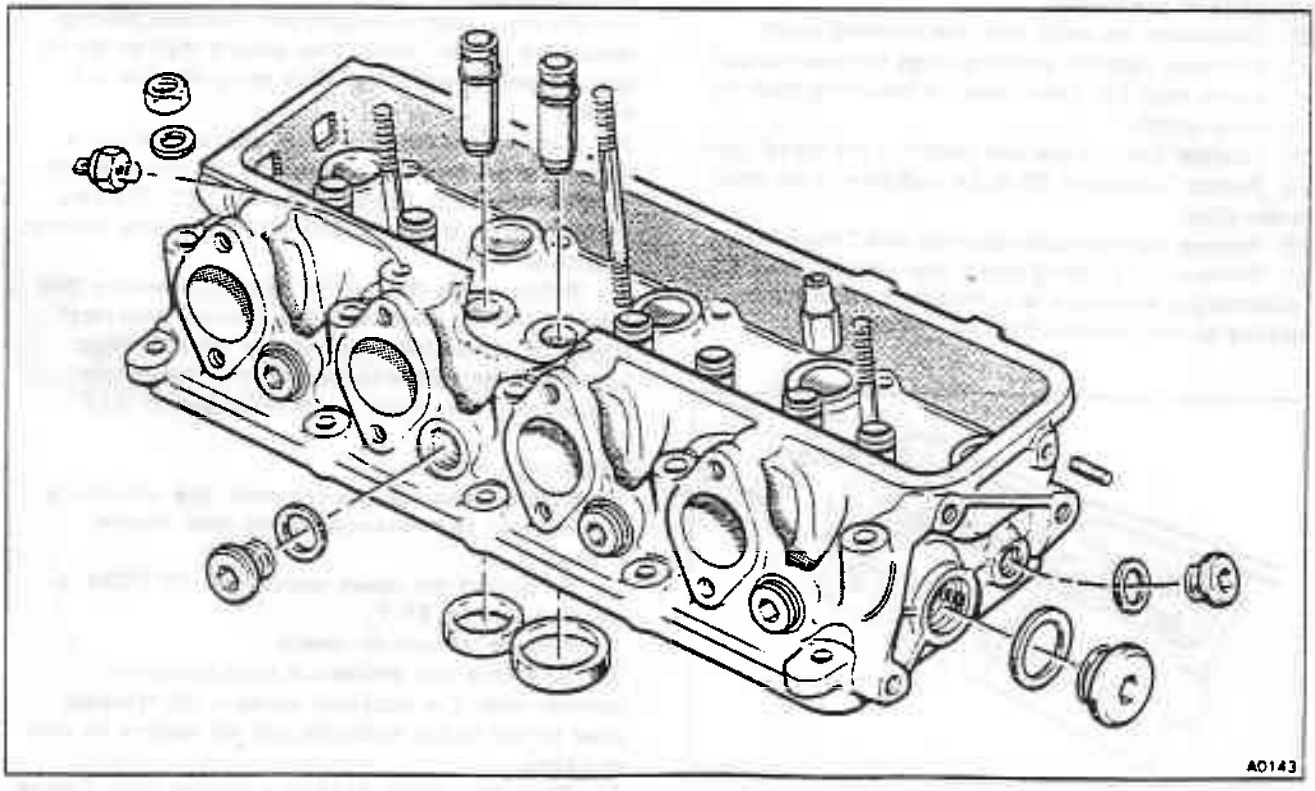



**Fig. E8-1 Cylinder head assembly**

8. Disconnect the ball joint at the top of the throttle linkage long control rod.
9. Detach the throttle linkage trapeze mounting bracket from the body longeron.
10. Disconnect the coolant hose from the thermostat housing outlet connection.
11. Unscrew the setscrews securing the heater feed pipe to the side of the thermostat housing. Free the joint.
12. Detach all electrical connections from the thermostat housing switches. Label each one to facilitate assembly.
13. Unscrew the setscrews securing the thermostat by-pass pipe to the coolant pump.
14. Unscrew the transmission modulator pipe from the union situated in the induction manifold.
15. On turbocharged engines, disconnect the knock sensor lead.
16. Disconnect the pipes from the hydraulic brake pumps.
17. Rotate the front hydraulic pump until the inlet connection is situated adjacent to the thermostat housing.
18. Unscrew the induction manifold setscrews. Withdraw the setscrews and collect the washers.
19. Carefully withdraw the induction manifold. Discard the gaskets.

**Rocker covers**

20. Unscrew both the cap and reach nuts from the rocker covers.
21. Remove the speed control bellows assembly situated towards the rear of 'B' bank rocker cover (if not removed previously).
22. Disconnect the leads from the sparking plugs.
23. Withdraw both the sparking plugs harness/conduit and engine loom ('A' bank) from the mounting studs on the rocker covers
24. Carefully free the seal and withdraw the rocker cover.
25. Repeat Operations 20 to 24 inclusive to the other rocker cover.
26. Remove the hydraulic reservoir (see Chapter G).
27. Remove the steering pump (see Chapter N). On turbocharged engines it is sufficient to detach the steering pump reservoir from its mountings.

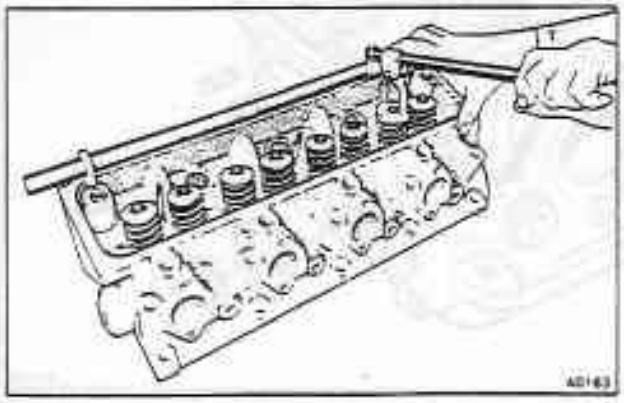


**Fig. E8-2 Removing/Fitting a valve using RH 7094**

**Cylinder head**

28. Unscrew the rocker shaft retaining setscrews. Ensure that the setscrews situated at both ends of the shaft are unscrewed but remain through the shaft. Failure to observe this instruction will result in the springs forcing the rocker arms, etc., off the end of the shaft as it is withdrawn.
29. Withdraw the rocker shaft assembly.
30. Repeat Operations 28 and 29 on the other rocker shaft.
31. Withdraw the push rods.
32. Remove the exhaust manifolds (see Chapter Q).
33. Using the special box spanner RH 7126 unscrew the cylinder head nuts. Commence unscrewing the nuts at each end of the assemblies and progressively work inwards. Collect any nuts and washers that would otherwise fall off as the cylinder head(s) is removed.
34. Carefully free the cylinder head(s) and withdraw it from the engine. Take care to ensure that the studs do not damage the face of the cylinder head(s) or that the threads of the studs are not damaged as the cylinder head(s) is withdrawn.
35. Withdraw and discard the cylinder head gasket(s).

**Cylinder head - To fit**

Fit the cylinder head(s) by reversing the procedure given for removal, noting the following.

1. Always ensure that the cylinder head gasket(s) is fitted the correct way around, otherwise, incorrect alignment of the coolant holes in the gasket(s) and cylinder head(s) may occur.
2. All cylinder head gaskets (except those fitted to turbocharged engines which are of a different material and design) should be coated with Wellseal jointing compound on both sides. They should then be left for approximately 5 minutes before being fitted to the engine.
3. If any core plugs are to be fitted, ensure that a new aluminium washer is used and the thread of the plug is coated with Loctite Superfast 572. The core plug should be torque tightened to the figures given in Section E15.
4. Before fitting the cylinder head nuts, ensure that the stud threads are clean and lubricated with clean engine oil. Screw the nuts onto the threads 'finger tight' and then torque tighten them in the correct sequence. These details are given in Section E15.

**Valves - To remove**

Label the parts as they are removed; this will ensure that they can be re-assembled into their original position.

To remove the valves, special tool RH 7094 is required (see fig. E8-2).

1. Remove the cylinder heads.
2. Fit a valve tool pedestal at each end of the cylinder head. The pedestals locate in the recesses used for the rocker pedestals and are secured by nuts and bolts.
3. Place the cylinder head on a suitable base. Ensure that four wooden blocks fit into the combustion

chambers. The blocks support the valves whilst the springs are compressed.
4. Insert the fulcrum bar through the holes in the pedestals.
5. Fit the hook of the valve spring compressing tool under the fulcrum bar and fit the stirrup over the valve top washer.
6. Compress the valve spring and remove the two collets.
7. Gradually release the pressure from the spring compressing tool.

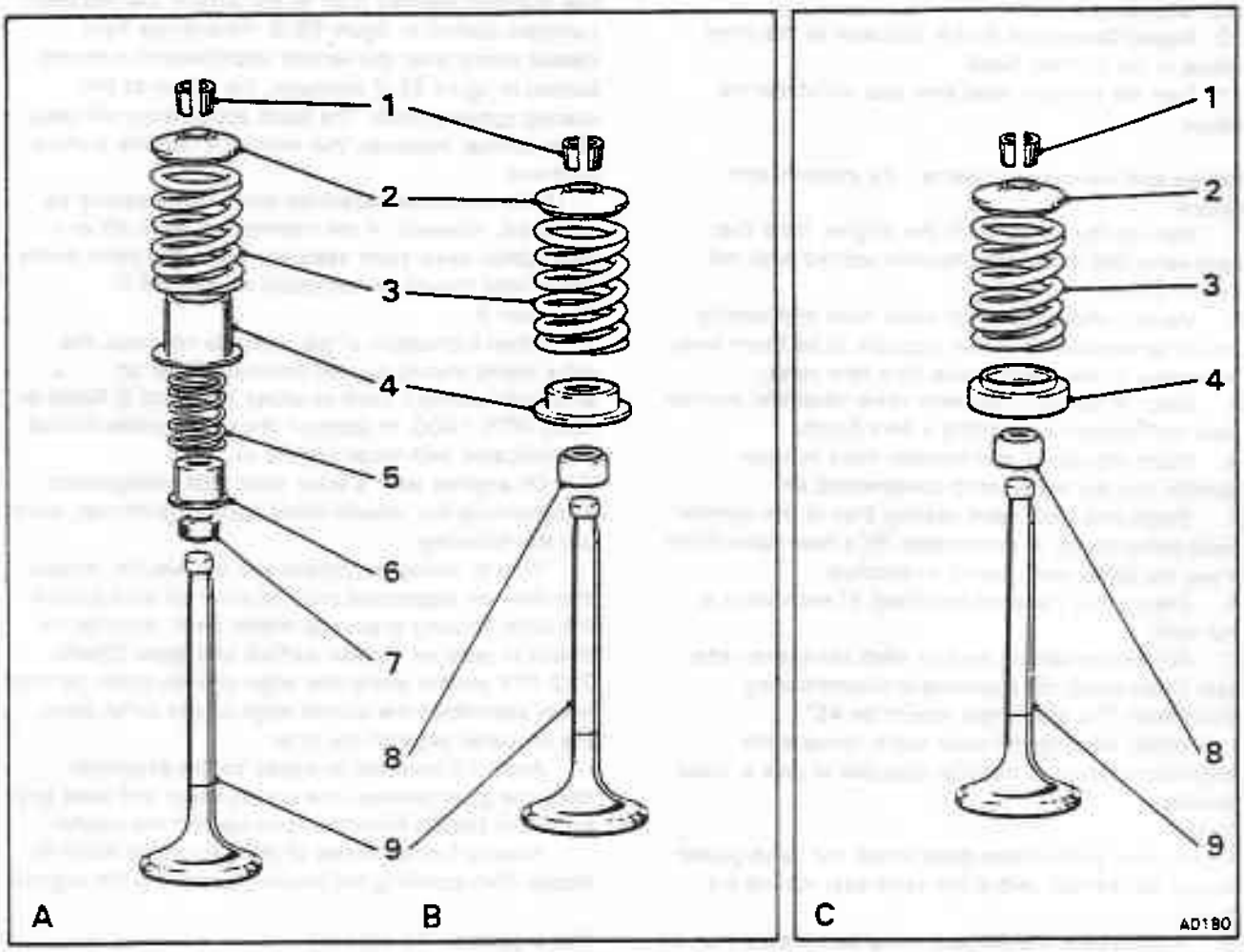



**Fig. E8-3 Valve and valve spring assemblies**

1 Collets
2 Top washer
3 Valve spring
4 Bottom washer
5 Gland spring
6 Grommet housing
7 Grommet
8 Valve stem seal
9 Valve

A Usually fitted on engines with carburetters (except Turbo)
B Usually fitted on engines with a fuel injection system
C All engines [carburetter(s), fuel injection system, or turbocharged system]

**A and B arrangements** are fitted to cars prior to the following vehicle identification numbers
**C arrangement** is fitted to cars from the following vehicle identification numbers
*Countries other than North America and Japan*
Silver Spirit and Mulsanne (except Turbo) *SCAZS0001DCH06751*
Silver Spur *SCAZN0003DCH06645*
Mulsanne Turbo cars (i.e. *SCBZS0T05CCH04233* onwards)
Bentley Eight *SCBZS8004ECH08862*
Corniche/Continental *SCAZD0003DCX06662*
*North America and Japan*
Silver Spirit and Mulsanne (except Turbo) *SCAZS42A3DCX06338*
Silver Spur *SCAZN42A3DCX06364* (*SCAZN42A9DCX06305* has later valve arrangement)
Corniche/Continental *SCAYD42A6DCX05700*

8. Move the stirrup from the valve top washer.
9. Dismantle the assembly as follows (refer to fig. E8-3).
a. Withdraw the top washer, valve spring, bottom washer, gland spring, grommet housing, and grommet.
b. Withdraw the top washer, valve spring, valve stem seal, and bottom washer.
10. Repeat Operations 5 to 9 inclusive to the other valves in the cylinder head.
11. Turn the cylinder head over and withdraw the valves.

**Valves and valve seat inserts - To inspect and reface**

1. Remove the valves from the engine. Note that each valve has its cylinder number etched onto the side of the tip.
2. Visually check that each valve head and seating area is serviceable. If a valve appears to be burnt away or cracked in the seating area, fit a new valve.
3. Clean all carbon from each valve head and cylinder head combustion area, using a wire brush.
4. Wash the valves and cylinder head in clean paraffin and dry them using compressed air.
5. Check that each valve seating area in the cylinder head (valve insert) is serviceable. Fit a new valve insert if any are badly worn, burnt, or cracked.
6. Ensure that the stem and head of each valve is not bent.
7. Reface the seating area on each valve and valve seat insert using the appropriate reconditioning equipment. The seat angle should be 45°.

When refacing the valve seats, remove the minimum amount of material possible to give a 'clean' seating.

**Note**

If new valve guides have been fitted, the valve guides should be reamed before the valve seat inserts are faced.

8. If necessary, the exhaust valve seat inserts may be crowned with a 30° cutter to prevent pocketing.
9. Using a fine, good quality lapping paste, lightly lap each valve to its seat. Check the seating using Prussian blue.
10. Thoroughly wash the cylinder head(s) and valves in paraffin to remove all grinding dust and lapping paste. Dry using compressed air.

**Valves - To fit**

To fit the valves reverse the procedure given for removal noting the following.

1. If any parts are serviceable, always ensure that they are fitted to their original positions.
2. Check that the valves operate smoothly in their respective guides and that they are seating correctly.
3. On cars produced prior to the vehicle identification numbers quoted in figure E8-3, note that the inlet valve spring is slightly shorter than the exhaust valve spring.
4. On engines fitted with 'waxed string' type grommet valve stem seals, the grommets should be soaked in engine oil prior to fitting. The valve stems and guides should also be lubricated as detailed in Operation 6.
5. On engines fitted with a 'rubber' type of valve stem seal, the valve stems are specially treated to aid running-in (refer to the start of the section). These valves with blue coloured stems were usually fitted to fuel injection engines prior to the vehicle identification numbers quoted in figure E8-3. All engines have treated stems after the vehicle identification numbers quoted in figure E8-3 although, the colour of this coating appears black. The black appearance will wear off in service, however, this will not affect the surface hardness.

**Under no circumstances must this coating be removed.** However, if the coating has worn off or if new rubber valve stem seals are fitted, the valve stems and guides should be lubricated as detailed in Operation 6.

6. When lubrication of the valves is required, the valve stems should be well lubricated with an assembly lubricant such as either Molykote G Rapid or Rocol MTS 1000. In addition the valve guides should be lubricated with clean engine oil.
7. On engines with a valve stem seal arrangement incorporating the 'waxed string' type of grommet, carry out the following.

Prior to fitting the collets and top washer, ensure that they are degreased and the valve tip area around the collet locating groove is wiped clean. Arrange the collets in pairs on a clean surface and apply Silastic 732 RTV sealant along one edge of each collet, so that when assembled the coated edge of one collet abuts the uncoated edge of the other.

Allow 10 minutes to elapse before assembly. Keep the gaps between the collets equal and wipe any excessive sealant from the valve tip and top washer.

Allow a further period of at least twelve hours to elapse from applying the sealant to running the engine.

**Valve guides - To inspect**

The valve guides should be inspected whilst they are still fitted into the cylinder head.

1. Obtain a new valve guide. Examine the existing valve guides for wear using the new guide for comparison.
2. The maximum permissible wear on the valve guides is given in Section E3, Dimensional data. If the wear tolerance is exceeded, the valve guides should be removed from the cylinder head and new ones fitted as described in Valve guides - To remove and Valve guides - To fit.
3. 'Bellmouthing' at the bottom end of the valve guides is permissible within the tolerances specified in Section E3, Dimensional data.
4. Check for clearance in the bore between each valve stem and its respective guide. The maximum permissible clearance is given in Section E3, Dimensional data.

**Valve springs - To inspect and test**

1. Dismantle the valve arrangement, refer to Valves - To remove.

2. Wash the springs in clean paraffin and dry using compressed air.
3. Visually examine the valve springs for defects.
4. Check the poundage of each spring on a valve spring tester. Data for this poundage check can be found in Section E3, Dimensional data. Poundage checks for two types of valve spring arrangements are quoted.

Type A springs are those where the inlet valve springs [new free length approximately 50,8 mm (2.0 in)] are slightly shorter than the exhaust valve springs [new free length approximately 55,57 mm (2.188 in)].

Type B springs are those where the inlet and exhaust valve springs are identical [new free length approximately 46,99 mm (1.850 in)].

**The two types of valve springs are not interchangeable.**

**Valve guides - To remove**

1. Remove the cylinder head(s).
2. Dismantle the valve assemblies.
3. Remove the valve guides as shown in figure E8-4. Withdraw the guides from the top (rocker side) of the cylinder head using the special tool RH 7207.

**Valve guides - To fit**

1. Thoroughly clean the valve guide bores in the cylinder head and accurately measure the bore diameters.
2. Select a new set of oversize guides that will give the correct interference fit when installed in the cylinder head (see Section E3, Dimensional data).
3. Using the special tool RH 7207 assembled as shown in figure E8-4, draw the valve guides into the cylinder head from the top (rocker side). Ensure that the shoulder of the guide abuts the cylinder head.
4. Using the special reamer RH 7825 or the tungsten carbide tipped version RH 7827, ream both the inlet and exhaust valve guides to the finished size.

**Valve seat inserts - To remove**

1. The valve seat inserts should be machined out of the cylinder head, leaving a thin skin of the insert material approximately 0,25 mm (0.010 in) thick remaining in the cylinder head.
2. After machining, carefully lift the insert shell from the bore in the cylinder head.

**Valve seat inserts - To fit**

1. Compare the size of the insert bore in the cylinder head with the standard figures given in Section E3, Dimensional data.
2. If the bores do not conform to the size quoted it will be necessary to machine them to a larger diameter and to fit oversize seat inserts (refer to the Parts List).
3. Ensure that the correct interference fit is maintained when the inserts are fitted into the cylinder head (see Section E3, Dimensional data).
4. To fit the seats, place the cylinder head in an oven or heat evenly to a temperature of 150°C (302°F) for a period of one hour.
5. The cylinder head should be quickly removed from the oven and the insert(s) driven into position using a soft drift.
6. Ensure that the shoulder of each valve guide is in

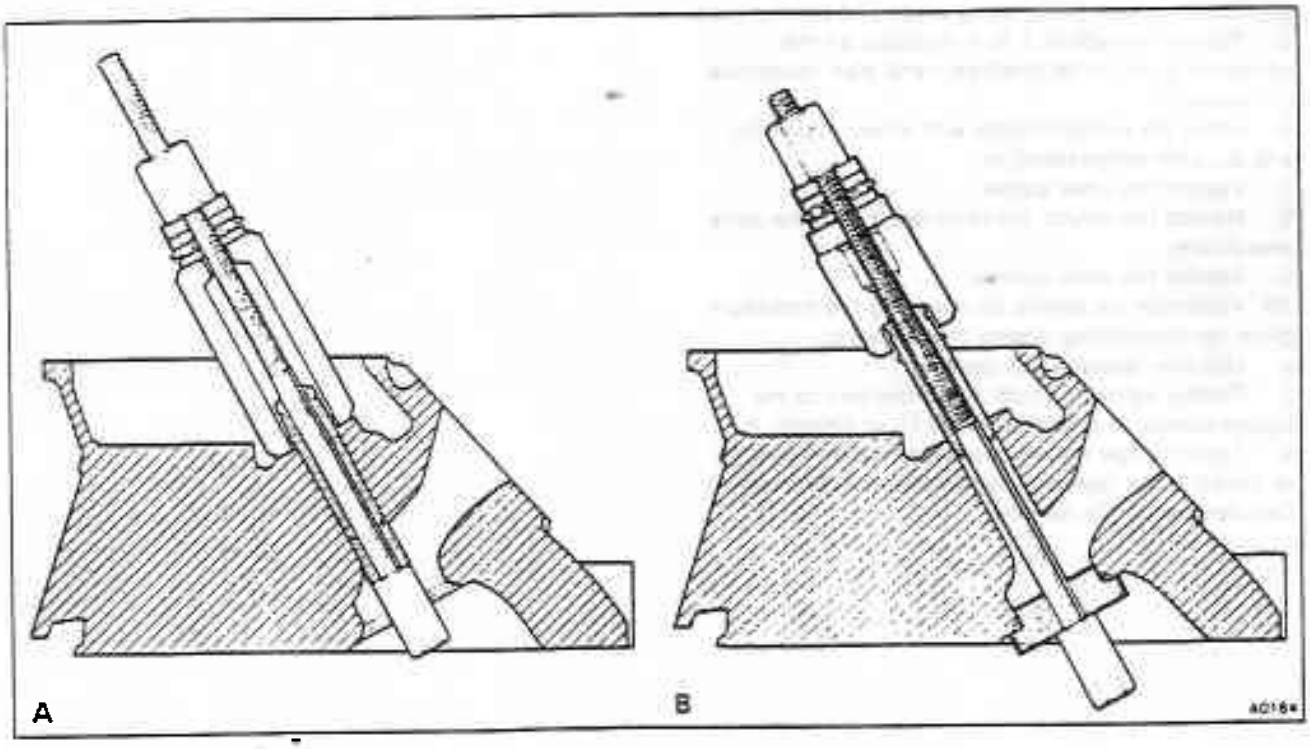



**Fig. E8-4 Valve guide renewal using RH 7207**
A Removing B Fitting



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contact with the cylinder head (i.e. that it has not moved during the time that the cylinder head was in the oven or when the valve seat inserts were driven into position).

**Note**

Do not finish machine the valve seats until after the valve guides have been reamed.

If the necessary service facilities are not available, it is recommended that the cylinder heads be returned to Rolls-Royce Motors Limited for this work to be carried out.

**Decarbonizing**

Carbon deposits form in the combustion chambers and affect the cylinder heads, valves, and piston crowns.

To decarbonize the engine it will be necessary to remove and dismantle the cylinder heads, then proceed as follows.

1. Ensure that the piston is at tdc. Using a blunt tool carefully remove the carbon deposit from the piston crown and the top face of the liner. Do not use a wire brush.
2. Carry out a similar exercise with the blunt tool on the valves. Complete the removal of the carbon deposit using a wire brush.

Take care not to damage the valve seat or to make heavy score marks in the cylinder heads. Heavy score marks will quickly accumulate carbon and seriously impair engine performance.

3. Ensure that as the carbon is removed, it does not enter the coolant passages of the crankcase and cylinder heads.
4. Discard the sparking plugs for new ones or alternatively, clean the existing plugs and set the gaps.
5. Repeat Operations 1 to 4 inclusive on the remaining combustion chambers and their respective components.
6. Wash the cylinder heads and valves in paraffin and dry with compressed air.
7. Inspect the valve guides.
8. Inspect the valves, the valve seats, and the valve seat inserts.
9. Inspect the valve springs.
10. Assemble the engine by reversing the procedure given for dismantling, noting the following.

a. Use new gaskets and seals.

b. Torque tighten all nuts and setscrews to the figures quoted in either Section E15 or Chapter P.

c. Tune the fuel metering equipment of the engine as stated in the relevant chapter listed in Operation 5, Cylinder heads - To remove.

# Crankcase breather system

For details of the crankcase emission control system fitted to cars produced to the Australian, Japanese, Middle East or North American specification refer to the appropriate section of Chapter U.

Crankcase emissions are controlled by a recirculating closed breather system. Basically, three different systems are used depending upon the type of carburetter and air induction system.

**Rolls-Royce Silver Spirit, Silver Spur, Bentley Eight, and Mulsanne (excluding Turbo) - SU HIF7 carburetters**

The engine crankcase is ventilated from the rear of 'A' bank cylinder head to an adapter on the choke butterfly housing, via a moulded rubber hose (see fig. E9-1). At the specified time/mileage intervals the system should be dismantled and cleaned as follows.

1. Withdraw the windscreen wiper motor relay (preferably number three) and remove the wiper mechanism cover.
2. Disconnect the breather hose from the flame trap housing on the rear of 'A' bank cylinder head.
3. Unscrew the three setscrews from the housing cover and remove the cover.
4. Remove the circlip retaining the gauze filter situated on the underside of the housing cover.
5. Thoroughly clean the gauze assembly with a suitable cleaning solvent and dry with compressed air.
6. Ensure that the breather pipe and housing are also clean.
7. To clean the adapter fitted to the choke housing remove the single setscrew from the breather pipe end connection and detach the pipe.
8. Clean the adapter fitted to the choke housing and ensure that the holes in the adapter are clear.
9. Assemble the flame trap, adapter, and breather pipe in the reverse order.

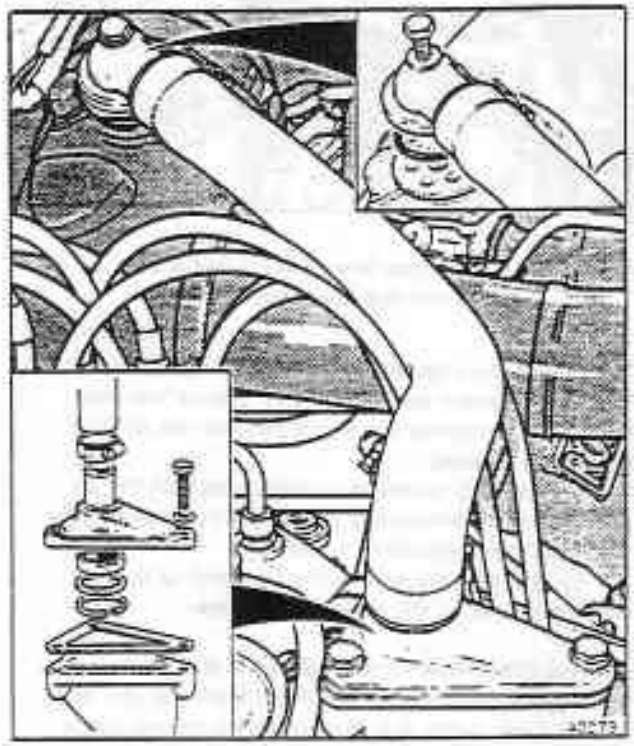

Fig. E9-1 Crankcase breather (SU HIF7 carburetters)

**Rolls-Royce Corniche and Bentley Continental - Solex 4 A 1 carburetter**

The engine crankcase is ventilated from the engine oil filler housing on 'B' bank cylinder head to a connection on the underside of the air intake cleaner assembly (see fig. E9-2). At the specified time/mileage intervals the system should be dismantled and cleaned as follows.

1. Slacken the worm drive clip situated at both ends of the moulded rubber breather tube. Withdraw the breather tube.
2. Remove the setscrew securing the breather tube adapter and flame trap assembly to the oil filler pedestal.
3. Withdraw the adapter.

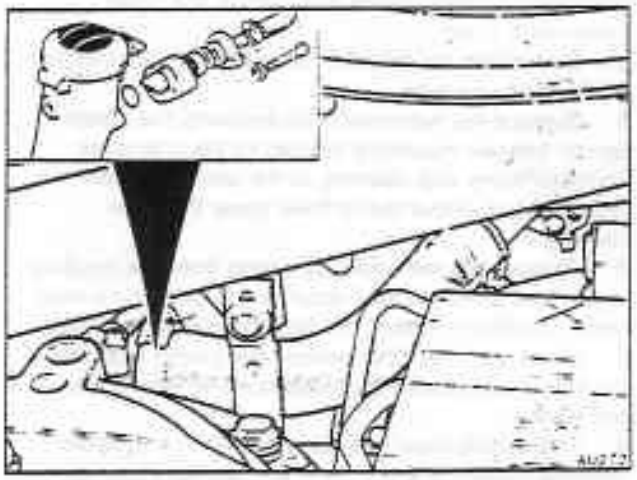

Fig. E9-2 Crankcase breather (Solex 4 A 1 carburetters other than Mulsanne Turbo)

4. Withdraw the flame trap assembly.
5. Collect the flame trap gauze assembly.
6. Thoroughly clean the components in a suitable cleaning solvent and dry them with compressed air.

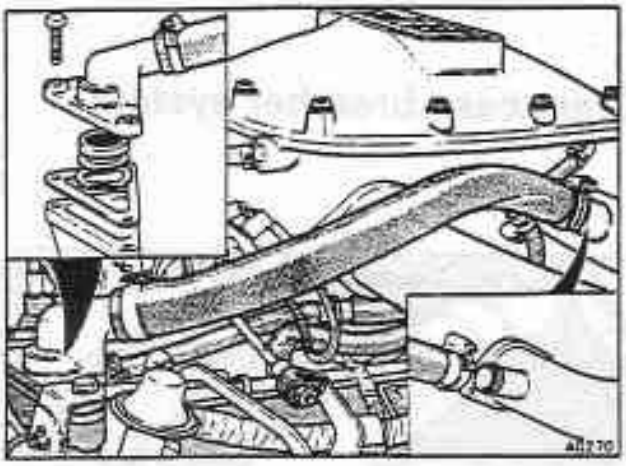

**Fig. E9-3 Crankcase breather (Solex 4 A 1 carburetters Mulsanne Turbo)**

7. Whilst the engine air filter element is removed during the service operations, also ensure that the breather pipe connection in the base of the air filter housing is cleaned.
8. If necessary renew the sealing rings on the oil filler pedestal connections and fit the components by reversing the dismantling procedure.
9. Ensure that the earth braid (if fitted) is located under the head of the securing setscrew.

**Bentley Mulsanne Turbo - Solex 4 A 1 carburetter**

The engine crankcase is ventilated from the rear of 'A' bank cylinder head to a connection on the air dump pipe, via a moulded rubber hose (see fig. E9-3). At the specified time/mileage intervals the system should be dismantled and cleaned as follows.
1. Withdraw the windscreen wiper motor relay (preferably number three) and remove the wiper mechanism cover.
2. Disconnect the breather hose from the connection on the air dump pipe.
3. Remove the two setscrews securing the speed control bellows mounting bracket to the crankcase breather/flame trap housing at the rear of 'A' bank cylinder head. Move the bellows away from the housing.
4. Remove the remaining setscrew from the housing cover. This setscrew also secures the ignition harness clamp. Carefully remove the housing cover and hose.
5. Invert the cover and remove the circlip retaining the filter gauze assembly. Withdraw the filter gauze and washer.
6. Thoroughly clean the components in a suitable cleaning solvent and dry them with compressed air.
7. Fit the components by reversing the removal procedure.
8. Ensure that the earth cable (if fitted) is located under the head of the housing securing setscrew.

# Engine lubrication system

Oil is circulated around the various parts of the engine lubrication system under pressure, supplied by a helical gear type of pump, driven from the crankshaft.

Oil drawn from the sump enters the suction side of the pump via a pick-up tube fitted with a fine mesh strainer. A relief valve incorporated in the oil pump is designed to relieve pressure whenever it exceeds 2,76 bar (40 lbf/in²).

The discharge side of the pump is connected to the full flow filter, this is a disposable canister type.

The oil, pressurized and filtered then passes along the various galleries and pipes to lubricate the engine components.

On turbocharged engines, when the oil reaches a pre-determined temperature a diverter valve directs the pressurized lubricant through a cooler before it is filtered.

Certain components of the engine are not pressure lubricated; these are lubricated by either oil splash or mist.

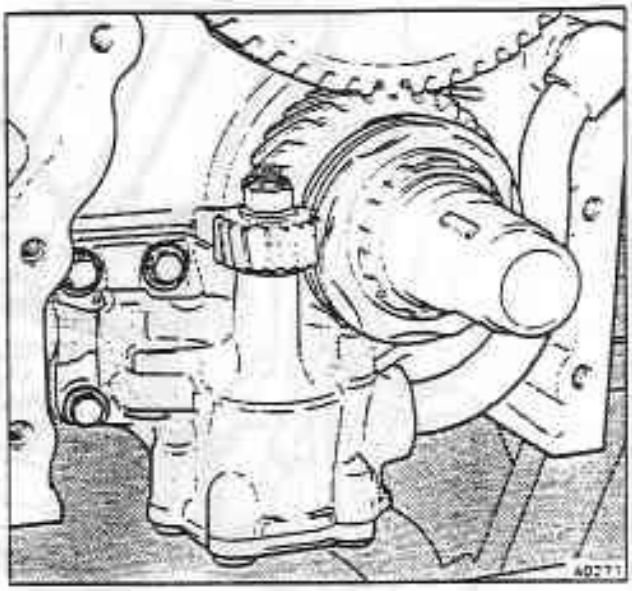

Fig. E10-1 Engine oil pump

**Oil pump - To remove**

The operations listed form the basic procedure to be followed. In service, minor variations may be encountered due to the specification of the engine.

**All cars**

1. Drive the vehicle onto a ramp and chock the road wheels.
2. Carry out the usual workshop safety precautions.
3. Drain the engine coolant (see Chapter L).
4. Drain the engine oil.
5. Remove the bonnet and radiator grille (see Chapter S).
6. Remove the engine drive belts (see Section E13).
7. Remove the alternator (see Chapter M).

**Mulsanne Turbo only**

8. Remove the oil cooler and pipes.

**All cars**

9. Remove the auxiliary cooling fan(s) (see Chapter M).
10. Remove the refrigeration condenser (see Chapter C), radiator matrix and cowl, header tank (if fitted), viscous coupling, and cooling fan (see Chapter L).

**Mulsanne Turbo only**

11. Remove the exhaust downtake manifold pipe between the turbocharger and the flexible bellows (see Chapter Q). Also remove the large heatshield; this is retained by two setscrews (no washers) to the turbocharger and a nut and washer to the top left mounting stud on the lower front cover.
12. Remove the heatshield from beneath the sump.
13. Remove the lower section of the turbocharger oil return pipe to the front cover. This pipe is secured at the top by a worm drive clip, whilst two setscrews retain the lower connection to the front cover, collect the washers and gasket.
14. Detach the two engine oil cooler pipes from the crankcase (below the oil filter assembly). Each pipe is secured by two setscrews, collect the washers and the gasket.
15. Disconnect the pipe support brackets located beneath the steering pump. Move the oil cooler pipes from the vicinity of the lower front cover.

**Silver Spirit, Silver Spur, and Mulsanne (except Turbo)**

16. Slacken the steady bracket outer mounting bolt. Unscrew and remove the socket headed screw from the inner end of the steady bracket, swing the steady bracket downwards away from the lower front cover. Ensure that the distance piece is retained in the inner mount.
17. Unscrew and remove the two setscrews retaining the steady bracket mounting to the engine. Collect the washers and the bracket.

**All cars (except Turbo)**

18. Unscrew the pivot nut and adjustment bracket setscrew from the jockey pulley, collect the washers and withdraw the jockey pulley assembly.

**Cars fitted with an air injection system**

19. Remove the air injection pump (see Chapter U). The pump adjustment strut will be removed with

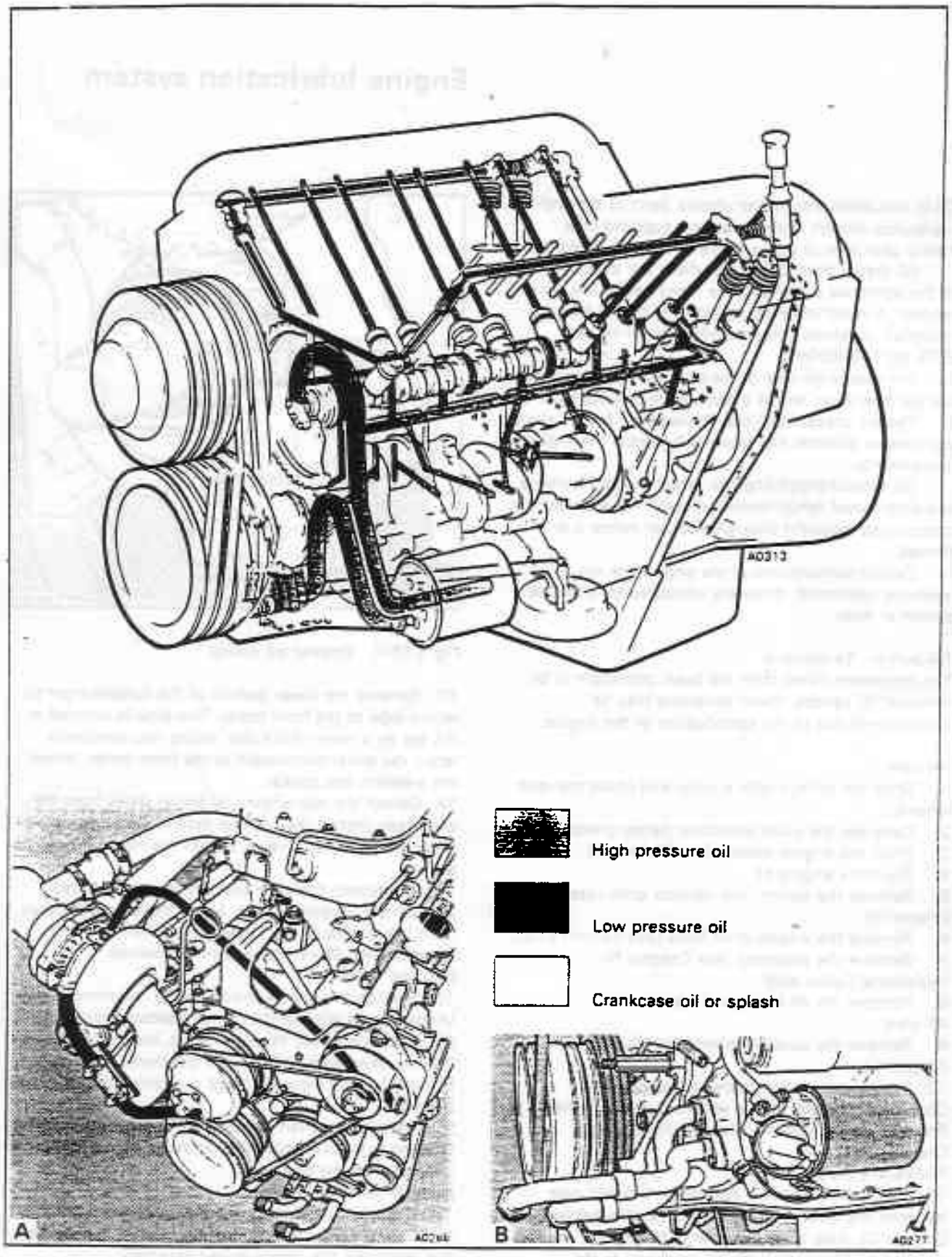


**Fig. E10-2 Engine lubrication system**
A Turbocharger lubrication
B Oil filter (Turbocharged engines)

the steering pump tension adjusting bracket and the pivot bracket will be removed with the refrigeration compressor mounting bracket.

**All cars**

20. Unscrew the setscrews retaining the refrigeration compressor mounting bracket to the engine. Collect the washers and move the compressor and mounting bracket from the vicinity of the coolant pump.
21. Remove the steering pump (see Chapter N).
22. Disconnect the engine coolant pipes (including the heater pipes) from the coolant pump.
23. Disconnect the thermostat by-pass pipe at the coolant pump.
24. Unscrew and remove the setscrews securing the coolant pump to the crankcase; withdraw the coolant pump.
25. Discard the Neoprene seal which fits between the coolant pump and front lower cover.
26. Remove the lock-plate and setscrews securing the pulley and damper to the drive flange; withdraw the pulley and damper.
27. Using the special spanner RH 7131, unscrew the serrated nut from the crankshaft.
28. Using the special withdrawal tool RH 9765, withdraw the pully driving flange (see fig. E10-4).
29. Support the weight at the front of the engine.

**Note**

This can be achieved by placing the base of the jack on a support across the ramp and positioning the head of the jack below the sump towards the front of the engine. Always position a piece of soft wood between the head of the jack and engine sump. Carefully allow the jack to take the weight at the front of the engine.

30. Unscrew and remove the two setscrews securing the front engine mounting to the bottom of the front lower cover.
31. Carefully slide any packing pieces from between the bottom of the front lower cover and the mounting foot. Slightly raise the engine if necessary. Take note of the packing pieces so that they can be returned to the correct positions.
32. Unscrew and remove the setscrews securing the front lower cover to the front of the crankcase. Collect the washer fitted to each setscrew.
33. The casing is dowelled to the crankcase in two places. Carefully prise the dowels from their positions and withdraw the cover. Take care not to lose the rubber bung from inside the cover.
34. Detach the oil pipe connecting the pump to the filter intake, ensuring that the rubber 'O' ring fitted at the filter end of the pipe is also removed.
35. Remove the setscrews securing the pump to the crankcase and withdraw the pump together with the dowel inserts.

When withdrawing the oil pump it may be necessary to either turn the assembly from side to side as it is removed, or in extreme cases, remove the drive gear.

**Oil pump driving gear - To remove**

The gear is situated at the front of the crankshaft. Therefore, it will be necessary to remove the front lower cover (refer to Oil Pump - To remove) and then to proceed as follows.

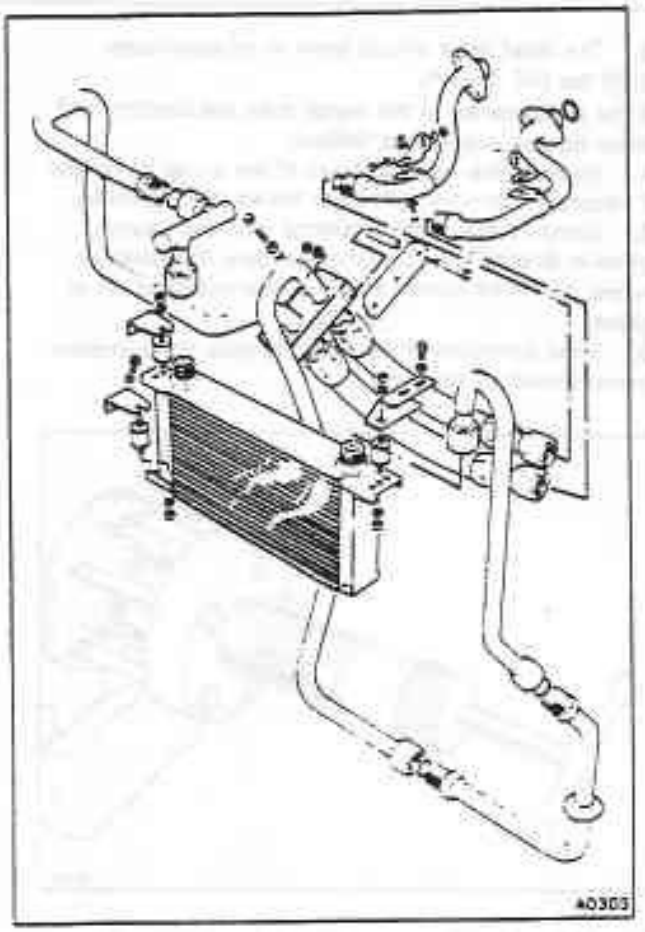


**Fig. E10-3 Engine oil cooler and associated pipes (Turbocharged engines)**

1. Using the special spanner RH 7110, unscrew the serrated nut from the crankshaft. The nut has a left-hand thread therefore, it is unscrewed by turning it in a clockwise direction.
2. Withdraw the small spacer washer and the bronze oil pump driving gear.

**Oil pump - To test**

The pump must be tested on a rig which has a variable orifice so that the oil delivery pressure from the pump can be restricted. The rig should also be able to drive the pump at a controlled speed and be capable of maintaining a constant temperature of 80°C (176°F) for the duration of the test.

If these facilities are available, the pump should be tested as follows.

1. Drive the pump at 200 rev/min, then adjust the variable orifice until the pump is delivering oil at 1.30 bar ( 15 lbf/in²). With the orifice at this setting the oil pump delivery should be at least 4,55 litres/min (1 gal/min).
2. Maintain the orifice at this setting then increase the speed to 1500 rev/min, the pump should deliver no less than 9,0 litres/min (2 gal/min at 2,89 bar (42 lbf/in²).

3. The relief valve should blow at approximately 2,89 bar (42 lbf/in²).
If the performance of the pump does not conform to these figures, proceed as follows.
4. Examine the working faces of the pump cover and if necessary, remove light wear marks by machining.
5. Compare the pump clearance with the figures given in Section E3 - Dimensional data. If necessary renew the pump casing and fit a new matched set of gears.
6. If the condition of the pump is poor, the complete pump should be renewed.

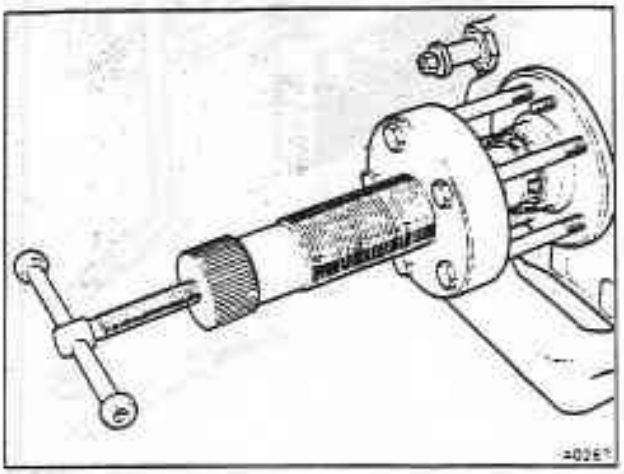

Fig. E10-4 Withdrawing the pulley driving flange

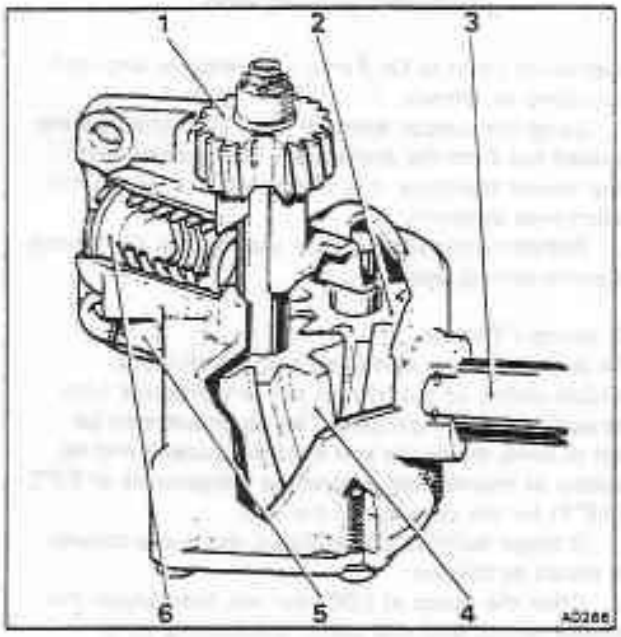


Fig. E10-5 Cut-away view of oil pump
1 Crankshaft driven gear
2 Oil pump driven gear
3 Oil filter delivery pipe
4 Oil pump driving gear
5 Oil pump body
6 Relief valve

**Oil pump - To dismantle (see fig. E10-5)**
1. Hold the external driving gear in a suitable fixture, taking care that sufficient protection is provided to ensure that the teeth of the gear are not damaged.
2. Remove the split pin, nut, and washer securing the driving gear to the driving shaft; carefully withdraw the gear using the extractor RH 8141. Remove the Woodruff key from the shaft.
3. Unscrew the six setscrews, remove the end cover and withdraw the two gears from the casing.

**Oil pump - To assemble (see fig. E10-5)**
1. Assemble the oil pump by reversing the procedure given for dismantling noting the following.
2. Examine all working parts for wear and inspect the end cover and casing for distortion; renew if necessary. If the end cover is lightly scored the marks may be removed by machining.
3. If the drive gear is serviceable, always ensure that it is fitted into position the same way around as it was removed.
4. Check that the end-float in the gears and the backlash between the pump driving gear and driven gear (internal gears) is correct (see Section E3, Dimensional data).
5. Torque tighten the setscrews, nuts, and bolts to the figures specified in Chapter P.

**Oil pump - To fit**
1. Fit the oil pump by reversing the procedure given for removal, noting the following.
2. Always ensure that the oil pump gear is of a different material to the mating gear on the crankshaft. The oil pump gear should be steel and the crankshaft gear bronze.

**Under no circumstances should gears of like metals be fitted.**

If a new oil pump driven gear is to be fitted, also fit a new oil pump driving gear to the crankshaft.
3. If the drive gear is serviceable, always ensure that it is fitted into position the same way around as it was removed.
4. Ensure that all setscrews, nuts, and bolts are torque tightened to the figures specified in Chapter P.
5. Ensure that the backlash between the driving gear on the crankshaft and the gear on the pump is correct (refer to Section E3, Dimensional data and figure E10-6).
6. When fitting the setscrews securing the pump to the engine, ensure that the dowel inserts are fitted to the holes from which they were removed.
7. The filter delivery pipe is held in position by means of a rubber pad attached to the front cover. Ensure that this pad is in position before fitting the cover. Renew the delivery pipe 'O' rings.
8. Fit new joints to the lower front cover and the oil pump. If the front cover to sump joint is damaged or in poor condition it will be necessary to remove the sump to enable a new joint to be fitted (refer to Section E6).
9. **On Corniche, Mulsanne Turbo, and Continental cars,** set the engine mounting stop plate

gap. This procedure is described in Section E12.
10. Fit a new Neoprene seal between the coolant pump casing and the lower front cover; also renew the coolant pump 'O' rings.
11. Examine all coolant hoses for deterioration and replace any that are considered unserviceable.
12. Ensure that the driving belts are fitted and adjusted correctly (refer to Section E13).
13. Fill the engine cooling system with the correct anti-freeze mixture (refer to Chapter L).
14. Fill the engine with an approved oil (refer to Engine oil, Sump - To fill).

**Oil filter canister - To renew (see fig. E10-7)**

1. Drain the oil from the engine by carrying out Operations 1 to 8 inclusive, under the heading Engine oil, Sump - To drain.
2. Position a suitable container beneath the oil filter.
3. Support the filter and unscrew, using a suitable strap spanner.
4. Discard the complete filter canister assembly.
5. Examine the new canister to ensure that it is a suitable approved replacement and that the rubber sealing ring is positioned correctly.
6. Lightly smear the sealing ring with clean engine oil.
7. Fit the new canister and tighten, using hand pressure.

**Note**

On left-hand drive Mulsanne Turbo cars it will be necessary to remove the steering column to steering unit linkage (refer to Chapter N) before the engine oil filter canister is removed.

**Oil pressure gauge transmitter - To renew (see fig. E10-7)**

1. Carry out the usual workshop safety precautions.
2. Disconnect the electrical cable at the 'Lucar' connection adjacent to the transmitter assembly.
3. Using the appropriate size of spanner unscrew the transmitter anti-clockwise.
4. Fit the assembly in the reverse order, noting that the 'Lucar' connection must be positioned toward the top and within 30° either side of vertical.

The correct position for the transmitter can be achieved by fitting an additional copper washer onto the threaded section that screws into the filter housing.

**Note**

On Mulsanne Turbo engines the position of the 'Lucar' is not critical but in addition, it will be necessary to remove the small heatshield positioned around the oil filter pedestal prior to carrying out the work.

**Oil pressure switches - To renew (see fig. E10-7)**

1. Carry out the usual workshop safety precautions.
2. Disconnect the electrical cable at the appropriate 'Lucar' connection adjacent to the oil pressure switches.
3. Using the appropriate size spanner unscrew the pressure switch anti-clockwise.
4. Fit the assembly in the reverse order.

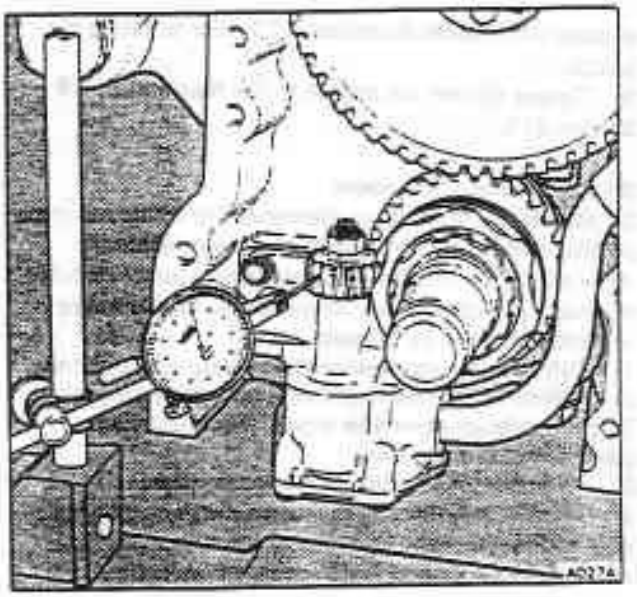

**Fig. E10-6 Checking backlash of oil pump gears**

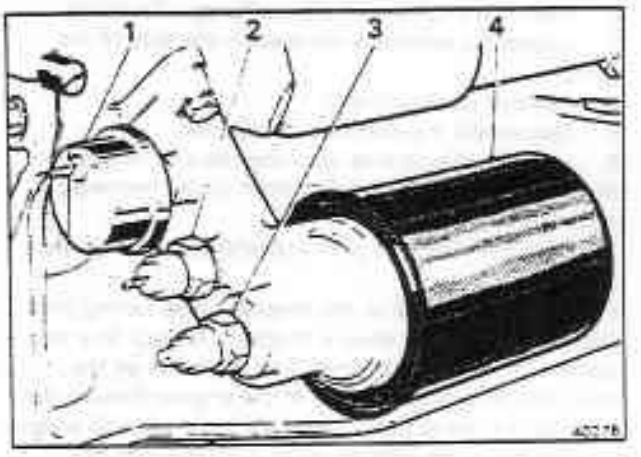


**Fig. E10-7 Oil filter and elbow assembly**

1 Oil pressure transmitter (facia oil gauge)
2 Oil pressure switch (warning lamp)
3 Oil pressure switch (fuel pump relay)
4 Oil filter canister

**Note**

Either one or two pressure switches are fitted depending upon the specification of the vehicle.

On Mulsanne Turbo engines, it will be necessary to remove the small heatshield positioned around the oil filter pedestal prior to carrying out the work.

**Oil temperature switch - To renew**

On certain engines an oil temperature switch replaces one of the oil pressure switches. The oil temperature switch should be renewed as follows.

1. Carry out the usual workshop safety precautions.
2. Using the appropriate size spanner unscrew the switch anti-clockwise.
3. Fit the assembly in the reverse order, noting that the aluminium sealing washer fitted under the hexagon of the unit is in good condition. Coat the

threads with Loctite Superfast 572 prior to fitting the switch.
4. Torque tighten the switch to the figure given in Section E15.

**Oil thermostat - To renew**
On Mulsanne Turbo cars a thermostat is fitted into the oil filter elbow. The function of the thermostat is to allow oil to flow through the engine oil cooler when it reaches a pre-determined temperature. To renew the assembly proceed as follows.
1. Carry out the usual workshop safety precautions.
2. Remove the small heatshield situated adjacent to 'B' bank exhaust downtake pipe. This heatshield covers the oil filter elbow.
3. Unscrew the thermostat from the elbow.
4. Fit the assembly in the reverse order, noting that the aluminium washer is in good condition and that the threads are coated with Loctite Superfast 572.

**Oil level sender unit - To renew**
1. Carry out the usual workshop safety precautions.
2. Drain the engine oil (refer to Sump - To drain).
3. Locate the assembly situated in the side of the sump.
4. Remove the heatshield.
5. Disconnect the electrical connection.
6. Unscrew the screws securing the unit in position and collect the spring washer from under the head of each screw.
7. Carefully 'free' the joint and withdraw the sender unit.
8. Fit the assembly in the reverse order, noting that the joint faces must always be clean. Always fit a new gasket. Check that the word 'Top' stamped on the assembly is towards the top of the engine. Ensure that a spring washer is fitted under the head of each screw.
Fill the sump with oil (refer to Sump - To fill).

## Engine oil

**Sump - To drain**
1. Position the car on a ramp and carry out the usual workshop safety precautions.
2. Raise the ramp.
3. Position a suitable container beneath the sump drain plug.
4. Clean the drain plug, sealing washer, and a small area of the sump around the drain hole.
5. Unscrew the drain plug, collect the aluminium sealing washer and allow the oil to drain into the container.
6. Examine the condition of the aluminium sealing washer and renew if necessary.
7. Ensure that the plug and washer seating area on the sump is both clean and dry.
8. Fit the sealing washer and plug to the sump and tighten.
9. Fit a new oil filter canister if necessary by carrying out Operation 2 to 7 inclusive, under the heading Oil filter canister - To renew.

**Sump - To fill**
It is most important that only engine oil of an approved grade and manufacture is used, refer to Chapter D.
10. Raise the bonnet and open the filler cap.
11. Pour 8,4 litres (14.8 Imp pt. 17.7 US pt) of fresh approved oil into the system via the filler, 9,4 litres (16.5 Imp pt. 19.8 US pt) if the filter has been changed.
12. Check the oil level by carrying out Operations 13 to 17 inclusive.

**Sump - oil level to check**
The vehicle must be standing on level ground and the engine switched off.
13. If the sump has just been filled with fresh oil or if the engine has been switched off, allow at least four minutes for the oil to drain into the sump.
14. Withdraw the engine oil dipstick and wipe it clean.
15. Insert the dipstick into its position.
16. Withdraw the dipstick and read the oil level. Maximum and mimimum oil level marks are indicated on the dipstick.
17. Top-up the oil level if necessary by carrying out Operations 18 to 21 inclusive.

**Sump - To top-up**
It is most important that only engine oil of an approved grade and manufacture is used, refer to Chapter D.
18. Carry out Operations 13 to 16 inclusive.
19. If necessary, top-up by pouring a small quantity of fresh engine oil through the filler.
20. Repeat Operations 13 to 19 inclusive until the oil level reaches the maximum mark on the dipstick.
**Do not overfill the engine.**
21. After topping-up ensure that the filler cap and bonnet are properly closed.

**Important**
a. Do not operate the engine if the oil level is below the minimum mark of the dipstick. Failure to observe this precaution could result in serious damage to the engine.
b. If the filter canister and/or the sump drain plug have been disturbed, check for oil leaks around the two components, immediately after the engine has been started.

# Hydraulic pump push rod assemblies

The two hydraulic pumps are fitted to the tappet chest cover and activated by camshaft operated push rod assemblies.

Each push rod assembly is secured to the underside of the tappet chest cover with two setscrews.

**Hydraulic pump push rod assembly - To remove**

1. Carry out the usual workshop safety precautions.
2. Remove either the carburetters, fuel injection system equipment, or turbocharging equipment as applicable (see either Chapter K or Chapter U).
3. Drain the engine coolant (see Chapter L).
4. Depressurize the hydraulic system and remove the hydraulic systems pumps (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,** otherwise if the brake pump operating cams are at their peak, distortion could occur to the tappet chest cover.
7. Withdraw the tappet chest cover.
8. From the underside of the tappet chest cover tap back the tabs of the lock-washers.
9. Unscrew the two setscrews securing the push-rod guides to the tappet chest covers. Collect the lock-washers.
10. Remove the guides. Collect the shims (if fitted) as the pump flange and push rod guide are detached.

**Push rod guides - To dismantle and assemble (see fig. E11-1)**

1. Slide the push rod through the hole in the guide flange.
2. Press the cam follower into the centre chamber of the guide. Lift out the cam follower.
3. Discard the 'O' ring.
4. Examine the components for wear.
5. Clean the groove in the cam follower and fit a new 'O' ring.
6. Wash all components in clean paraffin.
7. Assemble the components be reversing the dismantling procedure.

**Hydraulic pump push rod and guide assembly - To fit (see fig. E11-1)**

1. Ensure that all components are clean, particularly the mating faces of the tappet chest cover and the crankcase.
2. Fit the push rod guide assemblies to the underside of the cover.
3. Fit the pump flange and shim(s) on top of the cover and secure in position with two setscrews and lock-washers.

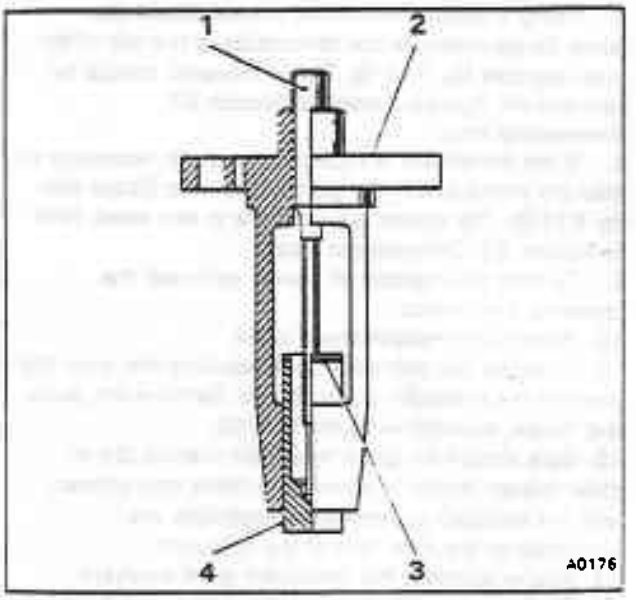


**Fig. E11-1 Hydraulic pump push rod assembly**
1 Push rod
2 Guide
3 'O' ring
4 Cam follower

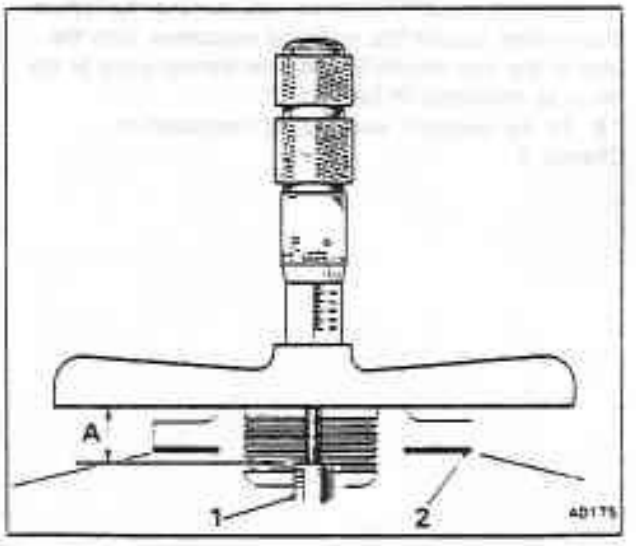


**Fig. E11-2 Measuring the pump flange to push rod dimension**
1 Push rod
2 Shims
A Depth micrometer measurement



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4. To check that the push rods are correctly set, rotate the camshaft until both hydraulic pump eccentrics are at approximately bottom dead centre (bdc).
5. Temporarily fit the tappet cover and progressively tighten the setscrews.
6. Rotate the engine to find the exact bdc position of the hydraulic pump push rod.
7. Using a depth micrometer placed across the pump flange measure the dimension to the top of the push rod (see fig. E11-2). This dimension should be between the figures quoted in Section E3, Dimensional data.
8. If the dimension is incorrect it will be necessary to alter the shims under the pump mounting flange (see fig. E11-2). The shims are available in two sizes, refer to Section E3, Dimensional data.
9. To alter the number of shims, carry out the following operations.
10. Remove the tappet chest cover.
11. Unscrew the two setscrews securing the push rod guide to the hydraulic pump flange. Remove the guide and flange, together with the shim(s).
12. Care should be taken to ensure that no dirt or other foreign matter is allowed to come into contact with the exposed components, especially the eccentrics or the cam face of the followers.
13. Add or subtract the necessary shim washers.
14. Fit the push rod guide, shims, and pump flange to the tappet chest cover.
15. Fit the push rod.
16. Temporarily fit the tappet chest cover assembly to the crankcase. Using a depth micrometer, confirm that the dimension from the pump flange to the top face of the push rod is correct (see fig. E11-2) refer to Section E3, Dimensional data.
17. When the dimension from the pump flange to the top face of the push rod is correct, remove the tappet chest cover, secure the retaining setscrews with the tabs of the lock-washers, and then permanently fit the cover as described in Section E7.
18. Fit the hydraulic pump(s) as described in Chapter G.

# Engine removal and installation

This section describes the removal of the engine through the bonnet aperture. Details for the removal of the engine, torque converter transmission, and front sub-frame as one unit from beneath the car, are given in Chapter H.

The operations listed in this section are the basic steps to be followed when removing the engine and should enable a skilled mechanic to carry out the exercise. The sequence of operations may vary slightly as the operator becomes more familiar with the work.

It should also be noted that the specification of the engine can vary slightly dependent upon the destination of the car and it is always advisable to check that all cables, looms, pipes, etc., have been disconnected before lifting the engine out of the vehicle.

**Note**

Whenever an operation refers to another chapter [e.g. Drain the cooling system (see Chapter L)], it should be noted that the full procedure to carry out the operation will be found within that particular chapter.

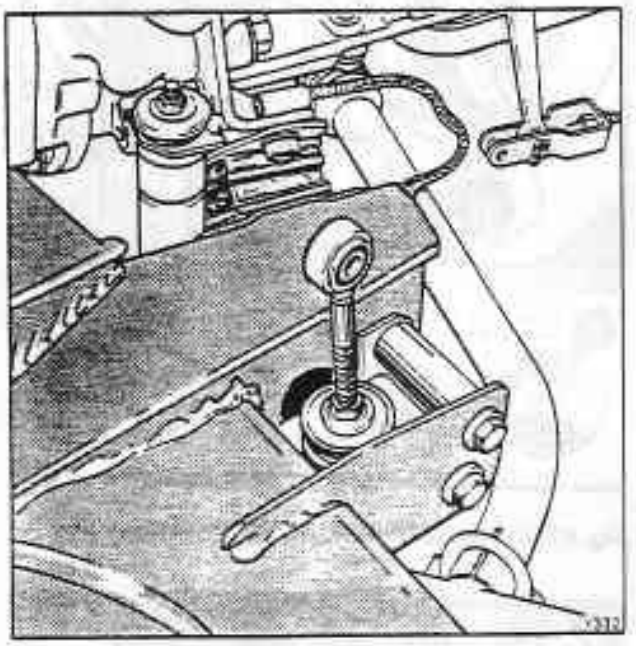

**Fig. E12-1 A typical engine to sub-frame damper mounting**

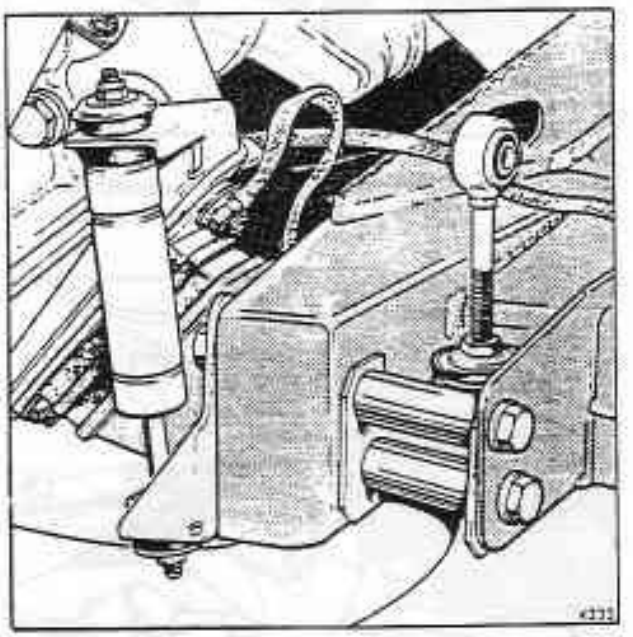

**Fig. E12-2 Engine to sub-frame damper fitted to early fuel injection engines only**

**Engine - To remove**

1. Drive the car onto a ramp.
2. Carry out the usual workshop safety precautions.
3. Chock both the front and rear road wheels.
4. Disconnect the battery leads.
5. Raise the bonnet and ensure that the wing covers RH 2684 and liners RH 2685 are fitted.
6. Remove the bonnet (see Chapter S).
7. Drain the engine cooling system (see Chapter L).
8. Depressurize the hydraulic systems (see Chapter G).
9. Drain the engine oil (see Section E10).
10. Discharge the refrigerant (see Chapter C).
11. Remove the windscreen wiper mechanism (see Chapter M).
12. Remove the top and bottom radiator hoses and blank the open connections. Half fill the radiator with coolant.
13. On Corniche and Continental cars, remove the header tank and top half of the fan cowl (see Chapter L).
14. Remove the engine fan assembly (see Chapter L).
15. Disconnect the feed hose from the heater tap and also the return hose from the engine connection.
16. Disconnect the refrigerant pipes from the rear of the compressor.
17. Remove the air intake ducting (see Chapter K or U).
18. Disconnect the steering pump to oil cooler hoses. Allow the oil to drain into a container and then blank the connections.



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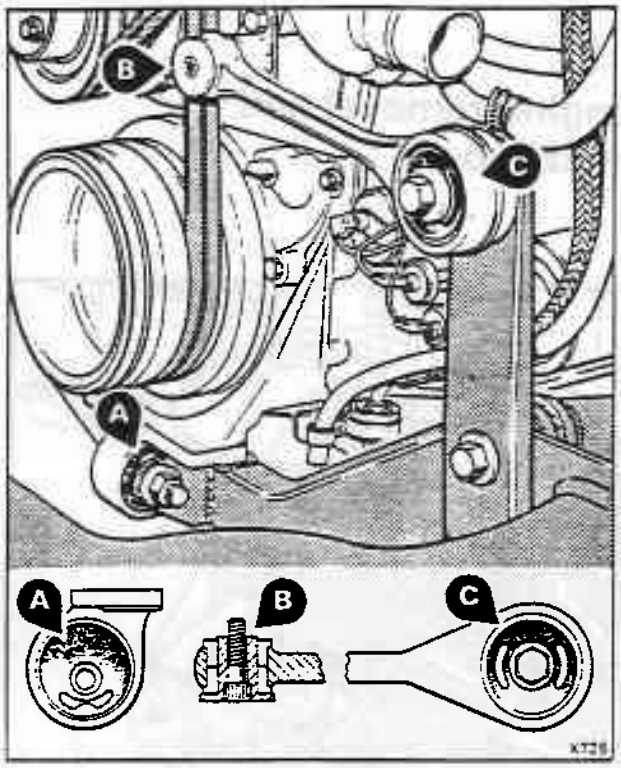


Fig. E12-3 Engine front mount and steady bar

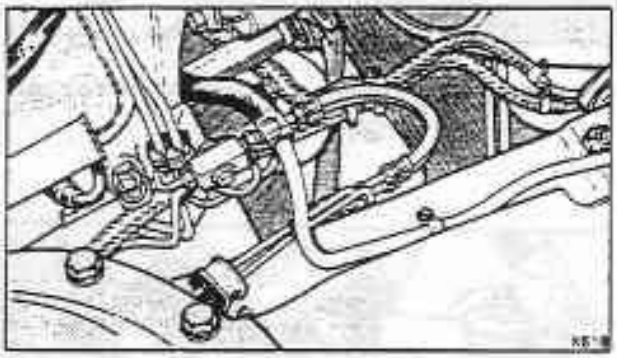

Fig. E12-4 Hydraulic accumulator to body hoses (other than turbocharged engines)

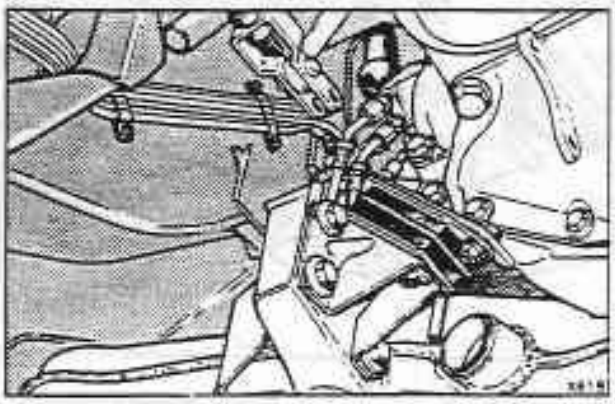

Fig. E12-5 Hydraulic accumulator to body hoses (turbocharged engines)

19. Disconnect and remove the exhaust gas recirculation (EGR) feed pipe (if fitted to the exhaust system balance pipe).
20. Support the weight of the exhaust system under the front silencer/catalytic converter. Remove the exhaust system balance pipe and downtake pipes (see Chapter Q or U).
21. Disconnect the body to the engine fuel hoses.
22. Clamp the hydraulic system reservoir to brake pump hoses to prevent reservoir drainage. Then, disconnect the hoses from the pump inlet pipes.
Fit the blanks to the open connections.
23. Remove the starter motor (see Chapter M).
24. Position a jack under the rear of the engine sump. Place a piece of wood between the head of the jack and the sump. Take the weight of the engine.
25. Remove the torque converter transmission (see Chapter T).
26. On cars fitted with small dampers adjacent to the engine rear mounts, disconnect the top of the dampers from the transmission adapter plate (see figs E12-1 and E12-2).
27. Remove the steady bar (if fitted) from the front of the engine (see fig. E12-3).
28. Disconnect the accumulator to body hoses (see fig. E12-4). On Mulsanne Turbo cars, these hoses are situated on the left-hand side of the engine compartment (see fig. E12-5).
29. Temporarily clamp the two accumulators low pressure return to reservoir hoses. Detach the hoses and suitably blank the open ends. Secure each blank using a hose retaining clip.
30. On Mulsanne Turbo cars, disconnect the two flexible engine oil pipes situated in front of the crankshaft pulley.
31. Disconnect the fuel evaporative hoses (if fitted). Refer to Chapter K or U.
32. Disconnect the vacuum hose to the air blend valve (if fitted).
33. On Mulsanne Turbo cars, disconnect the hose for the vacuum motor.
34. Disconnect the accelerater linkage at the long rod and detach the isolator trapeze from the body.
35. Locate the engine loom where it leaves the engine at the rear of 'A' bank rocker cover. Trace along the loom and free it from the securing clips. Detach the engine loom from its connections below the right-hand blower motor, label each connection to assist identification.

On cars fitted with a fuel injection system, detach the additional connection situated below the left-hand blower motor.

36. Detach the electrical connections to the ignition coil and distributor.

On Mulsanne Turbo cars, disconnect the additional cable from the knock sensor that is fitted towards the rear of the induction manifold on 'B' bank side.

37. To lift the engine fit the slings around the front and rear of the engine. Ensure that the front sling is not positioned under the front pulley. Using an overhead hoist, connect it to the slings using the special lift sling RH 9732.

**Note**
On Mulsanne Turbo cars do not use slings around the front and rear of the engine. Instead, use the special adapter brackets RH 9730 (front) and RH 9731 (rear).
38. Take the weight of the engine.
39. Disconnect the engine front mounting (see fig E12-3). On Corniche, Mulsanne Turbo, and Continental cars refer to figure E12-6.
40. Disconnect the two engine rear mountings.
41. Check to ensure that no wires, cables, pipes, etc., remain connected to the engine.
42. Carefully lift the engine upwards and slightly forwards checking to ensure that it does not foul any point of the engine compartment.
43. Continue to carefully lift the engine out of the vehicle. Once it is clear, lower it down onto a suitable stand and secure it in the upright position.

**Engine - To fit**
Fit the engine by reversing the procedure given for removal, noting the following.
1. When lowering the engine into position, ensure the flywheel assembly and rear of the engine do not become trapped against the rear crossmember of the front sub-frame.

Also ensure that the sump fits into the space between the steering rack pipes and the sub-frame.
2. On Corniche, Mulsanne Turbo, and Continental cars, with the engine front mounting setscrews slack, adjust the position of the engine mounting stop plate so that there is a gap of 1,52 mm (0.060 in) between the bonded rubber strip on the stop plate and crossmember stop bracket (see fig. E12-6). The stop plate has elongated holes to allow adjustment.
3. Connect all pipes, hoses, and cables as described in the relevant chapters.
4. Fill all necessary systems with fluids as described in the relevant chapters.
5. Immediately the engine starts for the first time, inspect for obvious leaks. Whilst the engine is warming up carry out a more detailed inspection of all pipes, hoses, and joints for leaks.
6. After the engine is fully warmed-up check all fluid levels and correct as necessary.
7. Road test the vehicle and make any minor adjustments that are found necessary.

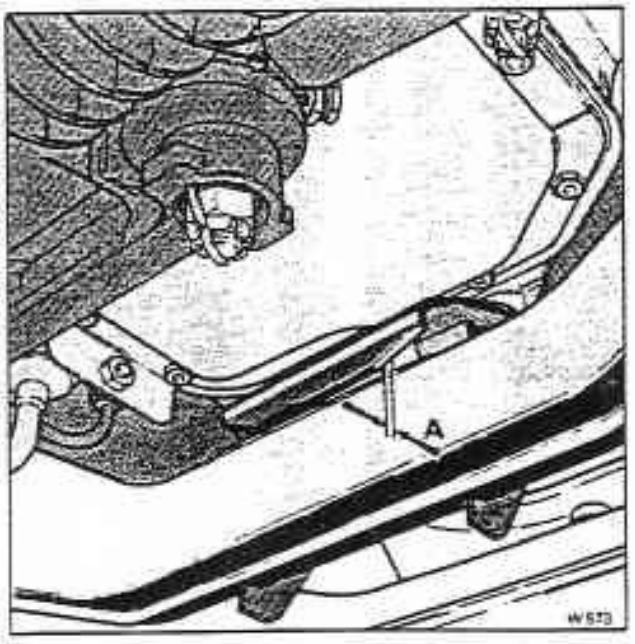


Fig. E12-6 Front engine mount stop plate gap



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# Engine drive belts

Before commencing to adjust the drive belts inspect them for signs of wear or cracking. Any belts found unsatisfactory should be renewed.

If after adjustment, a matched pair of belts have a marked variation in tension, a new pair should be fitted. Always renew both belts in a matched pair, even if only one belt is faulty.

When tensioning the belts two loads are specified; a new belt load for replacement (new) belts and a retensioning load for belts which are satisfactory for further service.

The belt tension must be checked at a point midway between two pulleys by use of a belt tension meter.

Belt dressing must not be applied to prevent belt slip.

On cars produced to the North American and Australian specifications an additional belt is fitted to drive the air injection pump. For details refer to the appropriate section of Chapter U.

**Drive belts - To renew**

1. Release the tension from the particular belt(s) and remove the belt(s) from the pulleys.

Always ensure that the correct approved replacement is obtained and fitted.

2. Inspect the pulleys and pulley grooves.
3. Before fitting the belts always ensure that they are in good condition with no marked variation in size.

## Drive belt tensioning - Cars other than Mulsanne Turbo

**Crankshaft to steering pump/refrigeration compressor**

Load must be applied on the top run of the belts. Each belt to be checked individually.

| | |
|---|---|
| New belt load | |
| Belt tension meter | 40,8 kgf to 45,4 kgf (90 lbf to 100 lbf) |
| Spring balance | 6,3 kgf to 7,7 kgf (14 lbf to 17 lbf) |
| Retensioning load | |
| Belt tension meter | 36,3 kgf to 40,8 kgf (80 lbf to 90 lbf) |
| Spring balance | 4,1 kgf to 6,3 kgf (9 lbf to 14 lbf) |

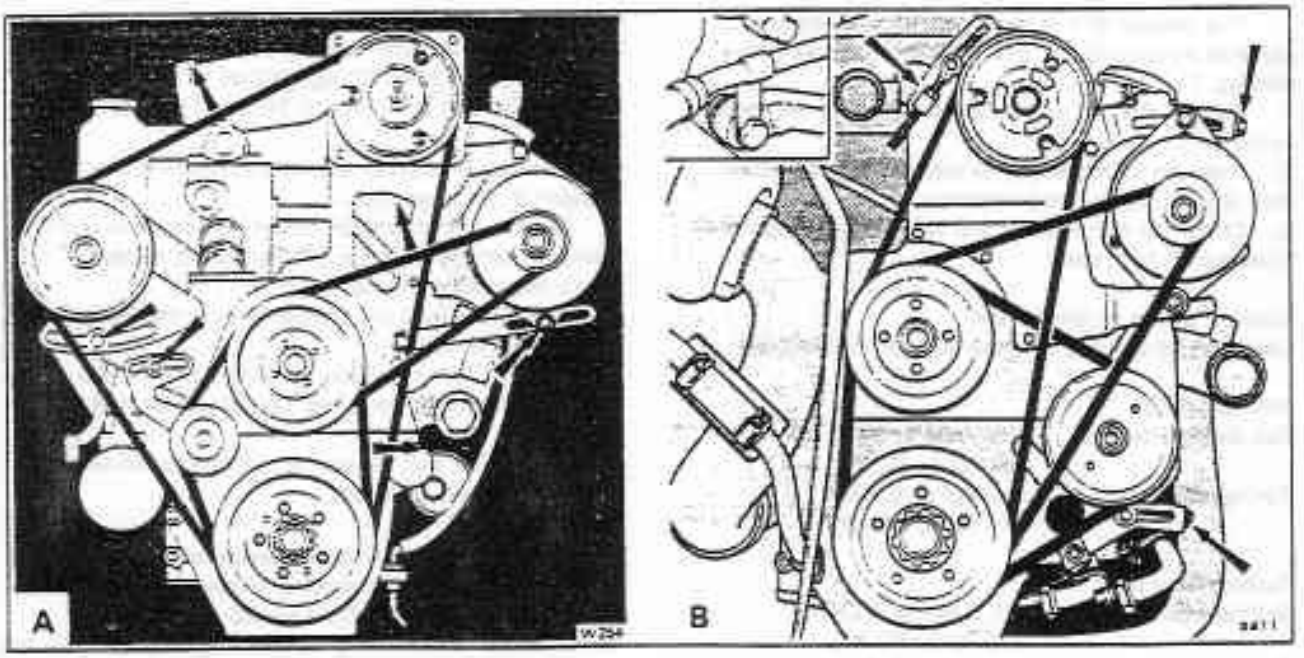


**Fig. E13-1 Engine drive belts arangement**
A Other than Mulsanne Turbo
B Mulsanne Turbo
Inset - Refrigeration compressor rear pivot



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The tension of this matched pair of belts is adjusted by altering the position of the steering pump (see fig. E13-1).
1. Slacken the setscrew in the steering pump mounting bracket slot situated below the pump pulley.
2. Slacken the pump pivot setscrew and the union on the supply hose at the rear of the pump.
3. Pivot the pump to adjust the belt tension then tighten the setscrew in the adjustment slot.
4. Check the belt tension and adjust again if necessary.
5. When the tension is correct tighten the pivot setscrew and again check the belt tension.
6. Finally tighten the supply hose connection ensuring that the hose does not foul on other components.
7. On left-hand drive cars position the hose so that the soft rubber protective sleeve has clearance or minimal contact with the coolant pump to manifold elbow.

**Crankshaft to coolant pump**
Load may be applied on either side of the belt run.

| | |
|---|---|
| New belt load | |
| Belt tension meter | 27,2 kgf to 31,7 kgf (60 lbf to 70 lbf) |
| Spring balance | 7,5 kgf to 8,2 kgf (16.5 lbf to 18 lbf) |
| Retensioning load | |
| Belt tension meter | 22,7 kgf to 27,2 kgf (50 lbf to 60 lbf) |
| Spring balance | 6,8 kgf to 7,5 kgf (15 lbf to 16.5 lbf) |

The tension of this matched pair of belts is adjusted by altering the position of the jockey pulley (see fig. E13-1).
1. Slacken the nut and setscrew securing the jockey pulley arm.
2. Pivot the jockey pulley to adjust the belt tension then tighten the nut and setscrew.
3. Check the belt tension and repeat the adjustment procedure if necessary.

**Coolant pump to alternator**
Load may be applied on either side of the belt run.

| | |
|---|---|
| New belt load | |
| Belt tension meter | 36,3 kgf to 40,8 kgf (80 lbf to 90 lbf) |
| Spring balance | 5,0 kgf to 5,9 kgf (11 lbf to 13 lbf) |
| Retensioning load | |
| Belt tension meter | 31,7 kgf to 36,3 kgf (70 lbf to 80 lbf) |
| Spring balance | 4,1 kgf to 5,0 kgf (9 lbf to 11 lbf) |

The tension of the belt is adjusted by altering the position of the alternator (see fig. E13-1).
1. Slacken the setscrew securing the alternator at the upper mounting point.
2. Slacken the setscrew securing the adjustment strut to the front mounting plate, also the nut and bolt in the adjustment slot.
3. Pivot the alternator to adjust the belt tension then tighten the nut and bolt in the adjustment slot.
4. Check the belt tension and repeat adjustment if necessary.
5. When the tension is correct finally tighten the remaining setscrews and check the tension again.

## Drive belt tensioning - Mulsanne Turbo

**Crankshaft to coolant pump/steering pump**
The belt tension meter reading should be as follows.
New belt 36,3 kgf to 40,8 kgf (80 lbf to 90 lbf).
Retensioned belt 31,7 kgf to 36,3 kgf (70 lbf to 80 lbf).

The tension of this matched pair of belts is adjusted by altering the position of the steering pump.
1. Slacken the setscrew securing the steering pump mounting bracket pivot and the clamping setscrew on the belt tensioner situated below the steering pump (see fig. E13-1).
2. Carefully adjust the tensioner until the correct belt tension is attained.
3. When the belt tension is correct, tighten the tensioner clamp and mounting bracket pivot setscrews.
4. If the alternator belt is to be adjusted the mounting bracket pivot setscrew can remain slack until adjustment has been carried out.
5. Ensure the belt tension is still correct when the steering pump is fully secured.

**Crankshaft to coolant pump/alternator**
The belt tension meter reading should be as follows.
New belt 36,3 kgf to 40 kgf (80 lbf to 90 lbf).
Retensioned belt 31,7 kgf to 36,3 kgf (70 lbf to 80 lbf).

The belt tension is adjusted by altering the position of the alternator.
1. Slacken the alternator mounting setscrew and the clamping setscrew on the belt tensioner situated above the alternator (see fig. E13-1).
2. Carefully adjust the tensioner until the correct belt tension is attained.
3. When the belt tension is correct, tighten the belt tensioner clamping setscrew and alternator mounting setscrew.
4. Ensure the belt tension is still correct when the alternator is fully secured.

**Crankshaft to refrigeration compressor**
The belt tension meter reading should be as follows.
New belt 36,3 kgf to 40,8 kgf (80 lbf to 90 lbf).
Retensioned belt 31,7 kgf to 36,3 kgf (70 lbf to 80 lbf).

The belt tension is adjusted by altering the position of the refrigeration compressor.
1. Slacken the compressor pivot bolts at the front and rear of the compressor and the belt tensioner setscrew (see fig. E13-1).

2. Carefully adjust the tensioner until the correct belt tension is attained.
3. When the belt tension is correct, tighten the belt tensioner clamping setscrew and the compressor pivot bolts.
4. Ensure the belt tension is still correct when the compressor is fully secured.



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# Fault diagnosis

| Symptoms | Possible cause |
|---|---|
| 1. Engine fails to start (starter motor inoperative) | 1. (a) Gear range selector out of 'Neutral' or 'Park' position.<br>(b) Ignition fuse blown.<br>(c) Battery discharged.<br>(d) Break or high resistance in battery connections and starter relay connections.<br>(e) Auxiliary starter relay faulty.<br>(f) Faulty starter motor. |
| 2. Engine fails to start (starter motor operates but fails to turn engine) | 2. (a) Battery discharged.<br>(b) Faulty starter motor circuit (refer to Chapter M).<br>(c) Faulty starter motor.<br>(d) Faulty starter solenoid (refer to Chapter M). |
| 3. Engine fails to fire | 3. (a) No fuel delivered to engine (refer to Chapter K and/or Chapter U).<br>(b) Faulty ignition system (refer to Chapter M).<br>(c) Excess fuel in engine (refer to Chapter K and/or Chapter U).<br>(d) Incorrect metering of fuel (refer to Chapter K and/or Chapter U). |
| 4. Poor engine idling | 4. (a) Incorrect metering of fuel (refer to Chapter K and/or Chapter U).<br>(b) Incorrect ignition timing (refer to Chapter K, Chapter M, and/or Chapter U).<br>(c) Air leaks in induction system (refer to Chapter K and/or Chapter U).<br>(d) Air leaks in exhaust system on engines fitted with a fuel injection system (refer to Chapter U). |
| 5. Incorrect engine idle speed | 5. (a) Incorrect metering of fuel (refer to Chapter K and/or Chapter U).<br>(b) Throttle controls sticking (refer to Chapter K and/or Chapter U).<br>(c) Air leaks in induction system (refer to Chapter K and/or Chapter U). |
| 6. Irregular running | 6. (a) Faulty sparking plug(s) (refer to Chapter M and/or Chapter U).<br>(b) Faulty ignition system (refer to Chapter K, Chapter M, and/or Chapter U).<br>(c) Air leaks in induction system (refer to Chapter K and/or Chapter U).<br>(d) Air leaks in exhaust system on engines fitted with a fuel injection system (refer to Chapter U).<br>(e) Incorrect metering of fuel (refer to Chapter K and/or Chapter U). |



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| Symptoms | Possible cause |
|---|---|
| 6. Irregular running (continued) | (f) Inlet and exhaust valves not seating correctly (refer to Section E8). Examine valve seats and springs.<br>(g) Defective cylinder head gaskets(s) (refer to Section E8). Examine the cylinder head gasket(s). |
| 7. Loss of power | 7. (a) Faulty sparking plug(s) (refer to Chapter M and/or Chapter U).<br>(b) Faulty ignition system (refer to Chapter K, Chapter M, and/or Chapter U).<br>(c) Air leaks in induction system (refer to Chapter K and/or Chapter U).<br>(d) Air leaks in exhaust system on engines fitted with a fuel injection system (refer to Chapter U).<br>(e) Blocked air cleaner filter (refer to Chapter K and/or Chapter U).<br>(f) Incorrect metering of fuel (refer to Chapter K and/or Chapter U).<br>(g) Throttle linkage sticking or incorrectly adjusted (refer to Chapter K and/or Chapter U).<br>(h) Worn or burnt valves. Broken or weak valve springs (refer to Section E8).<br>(i) Defective cylinder head gasket(s) (refer to Section E8). |
| 8. Engine 'spits back' | 8. (a) Incorrect metering of fuel (refer to Chapter K and/or Chapter U).<br>(b) Inlet valves not seating correctly (refer to Section E8).<br>(c) Incorrect grade of fuel.<br>(d) Faulty ignition system (refer to Chapter K, Chapter M, and/or Chapter U).<br>(e) Heavily carboned engine. |
| 9. Engine 'runs on' (diesels) | 9. (a) Engine overheating.<br>(b) Faulty ignition timing.<br>(c) Faulty weakening system<br>(i) Engines fitted with twin SU HIF7 or a Solex 4 A 1 (except Turbo) carburetter(s) refer to Chapter K (Part 1) or Chapter U.<br>(ii) Engines fitted with a fuel injection system refer to Chapter U.<br>(iii) Engines fitted with a turbocharging system refer to Chapter K (Part 2). |
| 10. Detonations in silencer | 10. (a) Incorrect metering of fuel (refer to Chapter K and/or Chapter U.<br>(b) Faulty ignition system (refer to Chapter K, Chapter M, and/or Chapter U).<br>(c) Air leaks in exhaust system (refer to Chapter Q and/or Chapter U).<br>(d) Faulty temperature controlled air intake system (refer to Chapter K and/or Chapter U).<br>(e) Exhaust valve(s) sticking (refer to Section E8). |

| Symptoms | Possible cause |
|---|---|
| 11. Overheating | 11. (a) Loss of coolant.<br>(b) Faulty thermostat.<br>(c) Broken or slipping drive belt.<br>(d) Faulty coolant pump.<br>(e) Weak fuel/air mixture.<br>(f) Inadequate engine lubrication.<br>(g) Faulty ignition system (refer to Chapter K, Chapter M, and/or Chapter U).<br>(h) Blocked cooling system.<br>(i) Restricted air flow through matrix. |
| 12. Low oil pressure | 12. (a) Inadequate oil supply.<br>(b) Low oil level in sump (see Section E10).<br>(c) Defective oil pressure gauge.<br>(d) Worn or defective oil pump (refer to Section E10).<br>(e) Blocked oil pick-up strainer.<br>(f) Defective seal(s) on oil pick-up assembly.<br>(g) Defective seal(s) in main oil galleries (core plugs).<br>(h) Engine overheating. |
| 13. Excessive fuel consumption | 13. (a) Leaks from fuel system.<br>(b) Incorrect metering of fuel (refer to Chapter K and/or Chapter U).<br>(c) Blocked air cleaner filter (refer to Chapter K and/or Chapter U).<br>(d) Faulty ignition system (refer to Chapter K, Chapter M, and/or Chapter U).<br>(e) Loss of engine cylinder compression. |



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# Special torque tightening figures

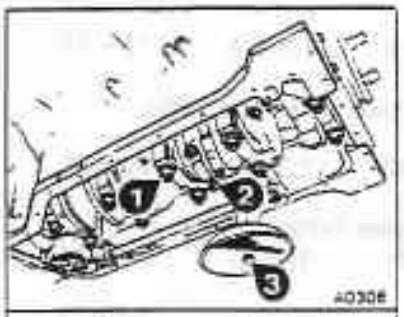
**Introduction**

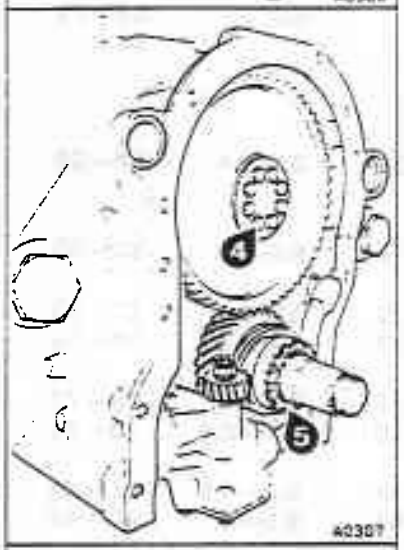
This section contains the special torque tightening figures applicable to Chapter E.

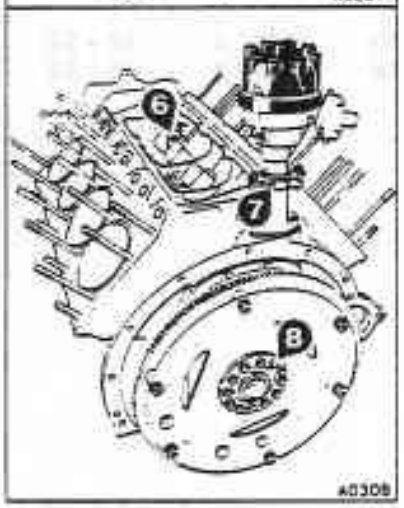
For the standard torque figures refer to Chapter P.

Components used during the manufacture of the vehicle have different thread formations (Metric, UNF, UNC, etc.). Therefore, when fitting nuts, bolts and screws it is important to ensure that the correct type and size of thread formation is used.

**Section E5 to E10**




| Ref. | Component | Nm | kgf m | lbf ft |
|---|---|---|---|---|
| 1 | Nut - Main bearing cap | 79 – 84 | 8,0–8,5 | 58 – 62 |
| 2 | Nut - Big end | | See Section E6 | |
| 3 | Castellated nut - Oil pump intake strainer | 3 | 0,3 | 24 – 30 lbf in |
| 4 | Setscrew - Camshaft gear | 11 – 13 | 1,1–1,4 | 8 – 10 |
| 5 | Serrated nut - Crankshaft pinion (L H thread) | 380 – 434 | 38,7–44,2 | 280 – 320 |
| 6 | Setscrew - Tappet block | 11 – 13 | 1,1–1,4 | 8 – 10 |
| 7 | Bolt - Distributor clamp plate | 6 | 0,6 | 48 – 52 lbf in |
| 8 | Setscrew - Drive plate to crankshaft | 40 – 43 | 4,0–4,4 | 29 – 32 |



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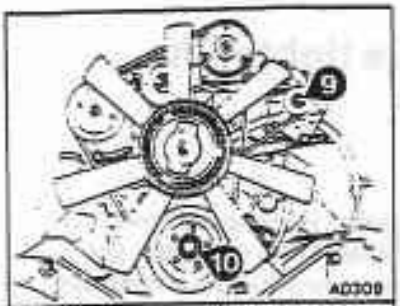
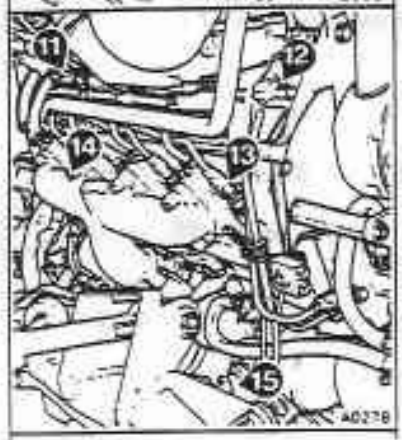
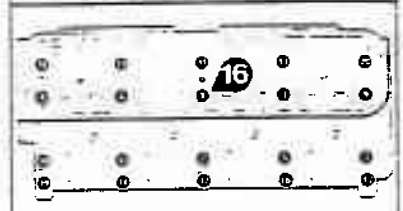
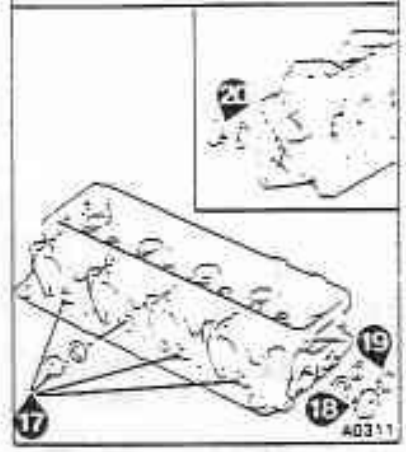



Tightening sequence A0310




| Ref. | Component | Nm | kgf m | lbf ft |
|---|---|---|---|---|
| 9 | Lock-nut - Alternator pulley | 55 – 57 | 5,5–5,8 | 40 – 42 |
| 10 | Serrated nut - Crankshaft damper drive flange | 129 – 203 | 13,1–20,7 | 95 – 150 |
| – | Serrated nut to be initially tightened to 129 Nm (13,1 kgf m, 95 lbf ft), further tightening of the nut to align the castellations with the lock-washer is permissable. However, the final torque figure must not exceed 203 Nm (20,7 kgf m, 150 lbf ft). | | | |
| 11 | Cap nut - Rocker cover | 1 | 0,1 | 10 – 12 lbf in |
| 12 | Setscrew - Rocker shaft pedestal | 11 – 13 | 1,1–1,4 | 8 – 10 |
| 13 | Sparking plug | 18 – 23 | 1,8–2,3 | 13 – 17 |
| 14 | Setscrew - Exhaust | **Other than Mulsanne Turbo** | | |
| | manifold | 31 – 34 | 3,2–3,4 | 23 – 25 |
| | | **Mulsanne Turbo only** | | |
| | | 19 – 21 | 1,9–2,2 | 14 – 16 |
| 15 | Cheesehead screw - Oil level indicator | 2 | 0,2 | 20 – 22 lbf in |
| 16 | Nut - Cylinder head | | | |
| | Stage 1 | | | |
| | Initial tightening | 27 – 34 | 2,7–3,4 | 20 – 25 |
| | Stage 2 | | | |
| | Final tightening | 68 – 74 | 6,9–7,6 | 50 – 55 |
| 17 | Core plug - brass | 37 – 39 | 3,8–4,0 | 27 – 29 |
| | Core plug - aluminium | 41 – 47 | 5,7–6,5 | 30 – 35 |
| 18 | Core plug brass | 93 – 97 | 9,4–9,9 | 68 – 72 |
| | Core plug - aluminium | 95 – 101 | 9,7–10,3 | 70 – 75 |
| 19 | Core plug - brass | 42 – 44 | 4,3 – 4,5 | 31 – 33 |
| | Core plug - aluminium | 55 – 61 | 5,5–6,2 | 40 – 45 |
| 20 | Core plug - brass | 65 – 70 | 6,6–7,1 | 48 – 52 |
| | Core plug - aluminium | 68 – 74 | 6,9–7,6 | 50 – 55 |

# Workshop tools

| Tool Number | Description |
|---|---|
| RH 2684 | Wing cover set |
| RH 2685 | Wing cover liners |
| RH 7094 | Valve spring compressor |
| RH 7095 | Extractor - cylinder liner |
| RH 7110 | Spanner - crankshaft serrated nut (small) |
| RH 7126 | Spanner - cylinder head nuts |
| RH 7131 | Spanner - crankshaft serrated nut (large) |
| RH 7207 | Extraction and Insertion tool - inlet and exhaust valve guides |
| RH 7208 | Extractor - main bearing caps |
| RH 7498 | Extractor attachment - main bearing caps |
| RH 7825 | Reamer - inlet and exhaust valve guides |
| RH 7827 | Tipped reamer - inlet and exhaust valve guides |
| RH 8141 | Extractor - oil pump driven gear |
| RH 9646 | Insertion tool - crankshaft rear seal |
| RH 9655 | Protective sleeve - crankshaft rear seal |
| RH 9730 | Engine lifting bracket - front |
| RH 9731 | Engine lifting bracket - rear |
| RH 9732 | Engine lifting sling |
| RH 9765 | Extractor - front pulley driving flange |



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