ENGINE

SECTION B

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SECTION B—*Index continued*

6 CYLINDER PETROL ENGINE

(KAL MODELS)

DATA

ENGINE

Type	6 cylinder, vertical, overhead valve unit, having an R.A.C. rating of 28·3 h.p.
Bore (grade "B"—nominal)	3·4371/3·4375 in. (87·302/87·313 mm.)
Stroke (nominal)	3·25 in. (82·550 mm.)
Maximum B.H.P. at 3,800 r.p.m.	
—Gross	85
—Nett	79
Maximum torque at 1,400 r.p.m.	147·6 lb. ft. (20·41 kg. m.)
Piston speed per 1,000 r.p.m.	541·8 ft./min. (165·14 m./min.)
Compression ratio	6·5 : 1
Compression pressures	120 to 130 lb./sq. in. (8·44 to 9·14kg./sq. cm.) (see also test conditions, detailed on page B.79)
Displacement	180·9 cu. in. (2,965 c.c.)
Firing order	1 : 5 : 3 : 6 : 2 : 4
Engine mounting	Four point rubber; two at the rear on brackets attached to either side of the clutch housing, and two at the front on extension arms fixed to pads on either side of the crankcase

LUBRICATION SYSTEM

Type of system	Pressure
Type of pump	Submerged Hobourn Eaton
Type of pump intake	Fixed gauze filter
Pump drive	Helical skew gear on camshaft
Normal running pressure (hot)	55 lb./sq. in. (3·87 kg./sq. cm.)
Oil filter	
—Make	AC-Delco
—Type	Full-flow, with renewable element
—Model	AC.1531654 C
—Maker's element number	AC.70
Position of oil filter	Front right hand side of crankcase
Dipstick location	Front left hand side of crankcase, adjacent to the dynamo
Pressure relief valve	
—Type and position	Spring loaded plunger, non-adjustable. Located in the front end of the crankcase, adjacent to the timing cover.
Position of oil filler	Mounted on upper face of the rocker cover, towards the front left hand side
Oil capacity of system	15·75 pint (8·95 litre)

MANUFACTURING DATA

ENGINE

Cylinder Block.

Type	Monobloc, integral with crankcase
Material	Grey cast iron
Water jackets	Full length of bores
Cylinder	Plain bore
Cylinder wall lubrication	Spurt hole in connecting rod big end
Bore size	Grade "B" is nominal size, but is subject to the grading as indicated below. Individual bores in any cylinder block may conform to any of these four grades, i.e., the bores in any one block may not conform to one grade.

	inches	*millimetres*
Grade A	3·4367/3·4371	87·292/87·302
Grade B	3·4371/3·4375	87·302/87·312
Grade C	3·4375/3·4379	87·312/87·323
Grade D	3·4379/3·4383	87·323/87·333

Note: When the letter "T" is stamped as an additional letter to the cylinder bore grading letter, it indicates a production grading system and should be ignored.

Therefore, for service purposes a cylinder bore stamped with the letters "AT" is a grade "A" bore, etc.

The grade letters are stamped on the ledge located in the centre of the right hand wall of the cylinder block at the top, just below the cylinder head gasket.

	inches	*millimetres*
Maximum oversize recommended for reboring (with or without liners)	+·030	+·762
Bore diameter in cylinder block to accommodate liners	3·593/3·594	91·262/91·288
Outer diameter of liner	3·597/3·598	91·364/91·389
Fit of liner in cylinder block	·003 in. to ·005 in. (·076 mm. to ·127 mm.) interference	
Bore diameter of housing for main bearings	2·6462/2·6470 with main bearing cap nuts tightened to the recommended torque wrench reading	67·213/67·234
Main bearing cap bolt size	½ in. U.N.F.	

Cylinder Head.

Material	Grey cast iron
Cylinder head bolt size	$\frac{7}{16}$ in. U.N.F.
Gasket	
—Type	Copper, steel and asbestos composition

	inches	*millimetres*
—Thickness (compressed)	·045	1·143
Valve guide housing diameter	·625/·626	15·875/15·900
Valve seat angle (inlet and exhaust)	45°	

Note: The valve seating must be concentric to the valve guide bore to within ·002 in. (·051 mm.) total indicator reading.

Valve seat inserts available	Std. and +·002/·005/·010 in. (+·051/·127/·254 mm.) oversizes	
Valve throat diameter		
—Inlet	1·397/1·403	35·484/35·636
—Exhaust	1·197/1·203	30·404/30·556
Sparking plug thread size	14 mm. diameter × 1·25 mm. pitch	

Engine—*Data continued*

Valve Guides.

Type	Detachable	
Material	Malleable cast iron	
	inches	*millimetres*
Outer diameter	·6262/·6267	15·905/15·918
Oversize valve guides available	+·001 in. (+·025 mm.) and +·003 in. (+·076 mm.)	
Fit in cylinder head	·0002 in. to ·0017 in. (·005 mm. to ·043 mm.) interference	
Inner diameter	·3437/·3447	8·730/8·755
Overall length		
—Inlet	2·20	55·88
—Exhaust	2·50	63·50
Location in cylinder head	When fitted the upper end face of the valve guides must project, ·61 in. (15·494 mm.) in the case of the inlet valve guides, and ·65 in. (16·510 mm.) in the case of the exhaust valve guides, above the bottom of the valve spring seating. The upper end of each inlet valve guide is marked "TOP" and this end must be located adjacent to the spring seating. The exhaust valve guides are reversible, and may be fitted either way round.	

Valves.

Material		
—Inlet	Steel drop forging	
—Exhaust	Steel extruded forging	
Position and operation	Overhead and operated by push rods and rockers	
	inches	*millimetres*
Rocker clearances (engine hot)		
—Inlet and exhaust	·014	·356
Valve head diameter		
—Inlet	1·546/1·550	39·268/39·370
—Exhaust	1·332/1·336	33·833/33·934
Valve face angle		
—Inlet and exhaust	45°	

Note: The valve face must be concentric to the valve stem to within ·001 in.(·025 mm.) total indicator reading.

Depth of parallel section above face angle		
—Inlet	·05	1·27
—Exhaust	·06	1·52
Valve stem diameter		
—Inlet	·3417/·3422	8·679/8·692
—Exhaust	·3407/·3412	8·654/8·666
Valve stem clearance in guide		
—Inlet	·0015/·0030	·038/·076
—Exhaust	·0025/·0040	·064/·012
Overall length		
—Inlet	4·92	124·97
—Exhaust	4·66 in. (118·36 mm.), plus ·06 in. (1·52 mm.) for the coned head of the valve	
Valve timing		
—Inlet opens	20° B.T.D.C.	For checking these angular positions, set valve clearances to ·021 in. (·533 mm.) (see "Valve Timing", on page B.99)
—Inlet closes	46° A.B.D.C.	
—Exhaust opens	52° B.B.D.C.	
—Exhaust closes	14° A.T.D.C.	

Engine—*Data continued*

Valve Springs.

Type	Single, progressive rating	
Spring retention	Cup and split cotters	
	inches	*millimetres*
Free length	2·11	53·59
Load at fitted length (with valve closed)	75 lb. (34·02 kg.) at 1·65 in. (41·91 mm.)	
Load at compressed length (with valve fully open)	147 lb. to 156 lb. (66·68 kg. to 70·76 kg.) at 1·28 in. (32·51 mm.)	

Rocker Gear.

Rocker shaft	*inches*	*millimetres*
Overall length		
—Inlet and exhaust	12·875	327·025

Note: Shaft to be straight to within ·002 in. (·051 mm.) total indicator reading over its full length.

Outer diameter	·7490/·7495	19·025/19·037
Locating hole diameter at outer end of shaft		
—Inlet	·257	6·528
—Exhaust	·316	8·026
Rocker shaft locating setscrew size		
—Inlet	$\frac{5}{16}$ in. U.N.F.	
—Exhaust	$\frac{3}{8}$ in. U.N.F.	
Rocker bore diameter	·750/·751	19·050/19·075
Rocker shaft standard (all positions)		
Bore diameter	·750/·751	19·050/19·075
Width across boss side faces	1·00	25·40
Centre distance of shaft bores	4·067/4·069	103·302/103·353
Rocker retaining springs		
Free length	1·84	46·736
Load at fitted length	4·6 lb. (2·09 kg.) at 1·275 in. (32·385 mm.)	
Rocker spacing collars		
Thickness	·25	6·35
Push rod		
Overall length (to bottom of socket end)		
—Inlet (nominal)	8·220	208·79
—Exhaust (nominal)	9·700	246·38

Note: Push rod to be straight to within ·008 in. (·203 mm.) total indicator reading over its full length.

Tappet		
Outer diameter	·9988/·9993	25·370/25·382
Diameter of tappet bore in cylinder block	1·0000/1·0010	25·400/25·425

Camshaft.

Location	Right hand side of the cylinder block, and operating in four steel shell, white metal lined type bearings, pressed into the cylinder block
Lubrication	Pressure to the camshaft bearings. Cams dip in an oil well.
End thrust	Taken on the location plate mounted on the front face of the cylinder block

Camshaft—*Data continued*	*inches*	*millimetres*
Thickness of camshaft location plate	·2044/·2054	5·192/5·217
End float	·0033 in. to ·0053 in. (·084 mm. to ·135 mm.)	
Journal diameter —All journals	1·8720/1·8728	47·549/47·569
*Cam base diameter (nominal)	1·225	31·115
*Cam lift (nominal)	·270	6·858
*Diameter of eccentric for fuel lift pump operation	1·495/1·505	37·973/38·227

*The lands of the cams and the fuel lift pump eccentric are taper ground, therefore when checking these dimensions always measure over the foremost edge of the lands, i.e., the larger dimension.

Width of timing wheel key slot on front spigot of camshaft	·187/·188	4·750/4·775
Depth of timing wheel key slot on front spigot of camshaft	·219/·223	5·563/5·664
**Bearing inner diameter (fitted) all bearings		
—Production	1·874/1·875	47·600/47·625
—Service replacements	1·876/1·877	47·650/47·676
**Running clearance of camshaft journals in bearings		
—Production	·0012 in. to ·0030 in. (·030 mm. to ·076 mm.)	
—Service replacements	·0032 in. to ·0050 in. (·081 mm. to ·127 mm.)	

**When checking camshaft bearing diameters and bearing clearances, the following remarks should be observed.

Service replacement camshaft bearings are supplied pre-finished with increased inner bearing diameters to allow for any slight variation in the alignment through the four parent bearing bores in the cylinder block.

Camshaft bearings fitted on production however, are finish line bored in position, allowing closer limits on the bearing inner diameters to be maintained.

Drive	Duplex chain and timing wheels, tensioned by means of a Renolds Automatic Chain Tensioner	
Lubrication of drive	Oil feed through the pad of the chain tensioner	
	inches	*millimetres*
Distributor driving shaft pilot diameter	·8115/·8120	20·612/20·625
Diameter of bore in cylinder block accommodating driving shaft pilot	·8125/·8135	20·637/20·663

Timing Wheels and Chain.

Timing chain		
Type	Renolds Duplex Endless	
Pitch	·375	9·525
Number of pitches	72	
Outer diameter of rollers	·25	6·35
Internal width (to outer end faces of opposing rollers)	·628	15·951
Camshaft timing wheel		
Number of teeth	46	
Pitch of teeth	·375	9·525
Diameter of gear, as taken over ·25 in. (6·35 mm.) diameter pins	5·740/5·745	145·796/145·923
Width of locating key slot	·1875/·1885	4·762/4·788

Timing Wheels—*Data continued*

	inches	*millimetres*
Crankshaft timing wheel		
Number of teeth	23	
Pitch of teeth	·375	9·525
Diameter of gear, as taken over ·25 in. (6·35 mm.) diameter pins	2·993/2·998	76·022/76·149
Width of locating key slot	·250/·251	6·350/6·375

Crankshaft.

Material	Steel drop forging
Balance	Integrally forged counter-weights
Lubrication of crankshaft main and crankpin journals	Pressure
Number and type of main bearings	Four, steel shell, white metal lined, supported in the crankcase and bearing caps
End thrust	Taken on thrust washers flanking the top half only of the rear intermediate main bearing, located between number 4 and 5 cylinders

	inches	*millimetres*
Thickness of thrust washers	·091/·093	2·311/2·362
Oversize thrust washers available	+·005	+·127
End float	·002 in. to ·004 in. (·051 mm. to ·102 mm.)	
Outer diameter of main journal (std.)	2·4990/2·4995	63·475/63·487
Maximum undersize for re-grinding main journals	—·040	—1·016
Inner diameter of main bearing fitted (std.)		
—Front and intermediate	2·5007/2·5022	63·518/63·556
—Rear	2·5002/2·5015	63·505/63·538
Undersize main bearings available	—·020 in. (—·508 mm.) and —·040 in. (—1·016 mm.)	
Running clearance of main journal in bearing		
—Front and intermediate	·0012 in. to ·0032 in. (·030 mm. to ·081 mm.)	
—Rear	·0007 in. to ·0025 in. (·018 mm. to ·064 mm.)	
Width of main journals		
—Front	1·467/1·482	37·262/37·643
—Front intermediate	1·547/1·557	39·294/39·548
—Rear intermediate (std.)	1·555/1·557	39·497/39·548
—Rear	1·90	48·26
Outer diameter of crankpin journals (std.)	2·0005/2·0010	50·813/50·825
Maximum undersize for re-grinding crankpin journals	—·040	—1·016
Width of crankpin journals	1·216/1·218	30·886/30·937
Crankpin throw	1·624/1·626	41·250/41·300
Width of locating key slot for timing wheel	·2495/·2505	6·337/6·363

Connecting Rod.

Material	Steel, "H" section, drop forging	
Distance between centres	5·874/5·876	149·200/149·250
Small end bearing type	Split bush (Vandervell Clevite 10)	
Big end bearing type	Steel shell, white metal lined	

Connecting Rod—*Data continued*

	inches	*millimetres*
Big end		
Bore (less bearing)	2·1460/2·1465 with connecting rod nuts tightened to the recommended torque wrench reading	54·508/54·521
Width	1·206/1·208	30·632/30·683
Side float	·008 in. to ·012 in. (·203 mm. to ·305 mm.)	
Inner diameter of crankpin (big end) bearing fitted (std.)	2·0015/2·0025	50·838/50·864
Undersize crankpin (big end) bearings available	—·020 in. (—·508 mm.) and —·040 in. (—1·016 mm.)	
Running clearance of crankshaft crankpin journal in bearing	·0005 in. to ·0020 in. (·013 mm. to ·051 mm.)	
Bearing cap bolt size	$\frac{3}{8}$ in. U.N.F.	
Small end		
Bore (less bush)	1·0615/1·0625	26·962/26·988
Width	1·206/1·208	30·632/30·683
Inner diameter of bush fitted		
Service replacement connecting rods complete with bushes	·9376/·9379	23·815/23·823
Service replacement bushes, finish honed to size when in position	·9376/·9379	23·815/23·823
Big and small end bores to be parallel in all planes to within	·0005 in. (·0127 mm.) per 1 in. (25·40 mm.) of mandrel length	
Maximum permissible weight variation between any two connecting rod assemblies in a set (less big end bearing)	2 drams (3·55 grm.) each end	

Gudgeon Pin.

	inches	*millimetres*
Type and location	Tubular, fully floating and retained in the piston bosses by circlips	
Finish	Heat treated, ground and lapped	
Overall length	2·803/2·813	71·196/71·450
Outer diameter		
—High grade (colour coded white)	·9376/·9377	23·815/23·818
—Medium grade (colour coded dark green)	·9375/·9376	23·813/23·815
—Low grade (colour coded yellow)	·9374/·9375	23·810/23·813
Oversize gudgeon pins available (colour coded light green)	+·003	+·076
Outer diameter of ·003 in. (·076 mm.) oversize gudgeon pin	·9404/·9407	23·886/23·894

Piston and Piston Ring.

	inches	*millimetres*
Piston		
Type	Slotted skirt and hollow crown	
Material	"Heplex" aluminium alloy, tin plated on the outer diameter	
Form	Taper and oval ground	
Number of rings		
—Compression	2 (top ring, chromium plated—2nd ring, shouldered)	
—Scraper	1 (slotted microland)	
Identification number stamped on piston crown	1,207,146 (6·5 : 1 compression ratio)	
	inches	*millimetres*
Compression height	2·025/2·030	51·435/51·562
Overall length (nominal)	3·4525	87·694

Piston—*Data continued*

	inches	*millimetres*
Upper skirt diameter (after tin plating), as measured directly below the scraper ring groove	Grade "B" is nominal size, but is subject to the following grading:	
Grade A	3·4328/3·4332	87·193/87·203
Grade B	3·4332/3·4336	87·203/87·213
Grade C	3·4336/3·4340	87·213/87·224
Grade D	3·4340/3·4344	87·224/87·234
Grade E	3·4344/3·4348	87·234/87·244

Note: Grade E is for service use only.

When the letter "T" is stamped as an additional letter to the piston grading letter it indicates a production grading system and should be ignored.

Therefore, for service purposes a piston stamped "AT" is a grade "A" piston, etc.

The letter denoting piston skirt diameter grading is stamped on the piston crown.

Clearance in cylinder bore with tin plated piston fitted, as measured directly below the scraper ring groove	·0035 in. to ·0043 in. (·089 mm. to ·109 mm.)	
Oversize pistons available	+·030	+·762
Maximum permissible weight variation between any two pistons in a set	4 drams (7·10 grm.)	
	inches	*millimetres*
Gudgeon pin bore diameter	·9375/·9378	23·813/23·820
Piston ring		
Ring groove width in piston		
—Compression	·080/·081	2·032/2·057
—Scraper	·189/·190	4·801/4·826
Piston ring width		
—Compression	·0771/·0781	1·958/1·984
—Scraper	·1865/·1875	4·737/4·763
Vertical clearance between piston ring and groove		
—Compression	·0019 in. to ·0039 in. (·048 mm. to ·099 mm.)	
—Scraper	·0015 in. to ·0035 in. (·038 mm. to ·089 mm.)	
Piston ring radial thickness		
—Compression	·161/·171	4·089/4·343
—Scraper	·142/·152	3·607/3·861
Piston ring free gap		
—Compression	·457/·587	11·608/14·910
—Scraper	·402/·516	10·211/13·106
Piston ring fitted gap		
—Top compression	·014/·022	·356/·559
—2nd compression and scraper	·010/·015	·254/·381

LUBRICATION SYSTEM

Oil Pump.

	inches	*millimetres*
Body		
Outer driven ring housing diameter	1·6030/1·6040	40·716/40·742
Outer driven ring housing depth (from cover plate mounting face)	1·375/1·376	34·925/34·950
Driving shaft and inner rotor		
Outer diameter of driving shaft	·4980/·4985	12·649/12·662
Driving pinion gear journal diameter	1·2385/1·2390	31·458/31·471
Pinion gear housing diameter (in crankcase)	1·2400/1·2412	31·496/31·526

Oil Pump—*Data continued*

	inches	*millimetres*
Outer driven gear		
Outer diameter	1·5965/1·5975	40·551/40·577
Length	1·3735/1·3740	34·887/34·900
End float between rotor and ring, and cover plate mounting face	·003 in. (·076 mm.) maximum	
Side clearance between tip of inner rotor lobes and outer driven ring	·010 in. (·254 mm.) maximum	
Clearance between outer driven ring and pump body	·008 in. (·203 mm.) maximum	

Pressure Release Valve.

	inches	*millimetres*
Spring		
Free length	3·27	82·60
Outer diameter	·468	11·887
Fitted length	2·98	75·69
Load exerted at checking length	15·3 lb. ± ·5 lb. (6·94 kg. ± ·23 kg.) at 2·625 in. (66·675 mm.)	

TORQUE WRENCH DATA

Cylinder head bolts	65/70 lb. ft. (8·99/9·68 kg. m.)
Main bearing cap bolts	70/75 lb. ft. (9·68/10·37 kg. m.)
Big end cap nuts	35/37 lb. ft. (4·84/5·12 kg. m.)
Flywheel bolts	37/43 lb. ft. (5·12/5·95 kg. m.)

6 CYLINDER PETROL ENGINE

(KAL MODELS)

DESCRIPTION

Examination of the two exploded views, as shown in Figs. B.70 and B.71, will show that the engine is of the six cylinder overhead valve type, with push rod operated valves carried in a detachable cylinder head. The head is located by two dowels pressed into the upper face of the cylinder block, and secured by means of bolts. A gasket of copper, steel and asbestos composition is interposed between the cylinder head and the block to seal this joint. The cylinder block is cast integral with the crankcase. Plain bores are employed in the cylinder block of this engine and maximum life is ensured by employing a chromium plated top compression ring on the pistons.

The engine is rubber mounted in the chassis frame at four points, two at the front on extension legs bolted to pads, one on each side of the crankcase, and two at the rear, by means of brackets attached one on either side of the clutch housing.

The crankshaft is a steel drop forging formed with integral balance weights and is carried in four main bearings of the detachable steel shell, white metal lined type, which are readily renewable. The main bearing upper halves seat in the crankcase, whilst the lower halves seat in the bearing caps, and lips formed on the bearing halves seat in corresponding recesses machined in both the crankcase and bearing caps, thus providing complete location for the bearing shells when assembled. Crankshaft main bearings are obtainable in undersizes of —·020 in. (—·508 mm.) and —·040 in. (—1·016 mm.).

The main bearing caps are located by means of their side faces, which mate with machined registers in the crankcase, the unequal widths of these registers from the crankshaft axis ensure that the caps can only be fitted one way round. However, front and front intermediate main bearing caps are similar and should be identified to their original positions prior to removal. The rear intermediate main bearing cap is wider than the forward pair. The main bearing caps are secured by means of bolts and spring washers.

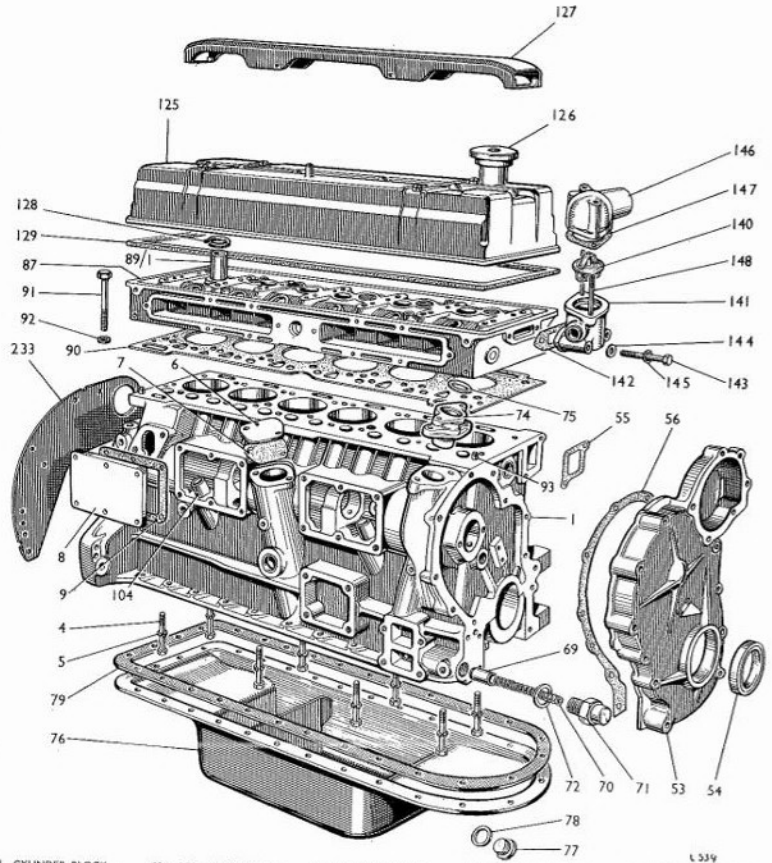
Crankshaft end float is controlled by thrust washer halves fitted to either end face of the rear intermediate bearing housing, and register in recesses provided in the crankcase, or upper half of the bearing only. The two thrust washer halves are prevented from moving radially by the bearing cap, which abuts the end section of the thrust washer halves. Oversize thrust washers are available in +·005 in. (+·127 mm.) thicknesses.

The primary shaft spigot bearing is located in a recess machined in the rear of the shouldered crankshaft flange.

The connecting rods are steel "H" section drop forgings, formed with a closed hub at the upper (small) end, into which is pressed the small end bush. The small end bush is of the split type, having on its internal diameter, oil grooves, which mate with a feed hole in the bush and a hole in the connecting rod small end boss. The lower (big) end of the connecting rod is split at right angles to the axis of the rod and carries detachable steel shell, white metal lined type bearings, which are readily renewable. Locating lips are formed on the bearing halves and register in the recesses machined in both the connecting rod and the big end cap bores. These locating lips provide positive location for the complete bearing shells when assembled. Connecting rod big end bearings are obtainable in undersizes of —·020 in. (—·508 mm.) and —·040 in. (—1·016 mm.). The big end cap is secured to the connecting rod by two "waisted" bolts and self-locking type nuts. An oil squirt hole is drilled in the connecting rod directly above the location slot for the head of the cap bolt, on the thrust side.

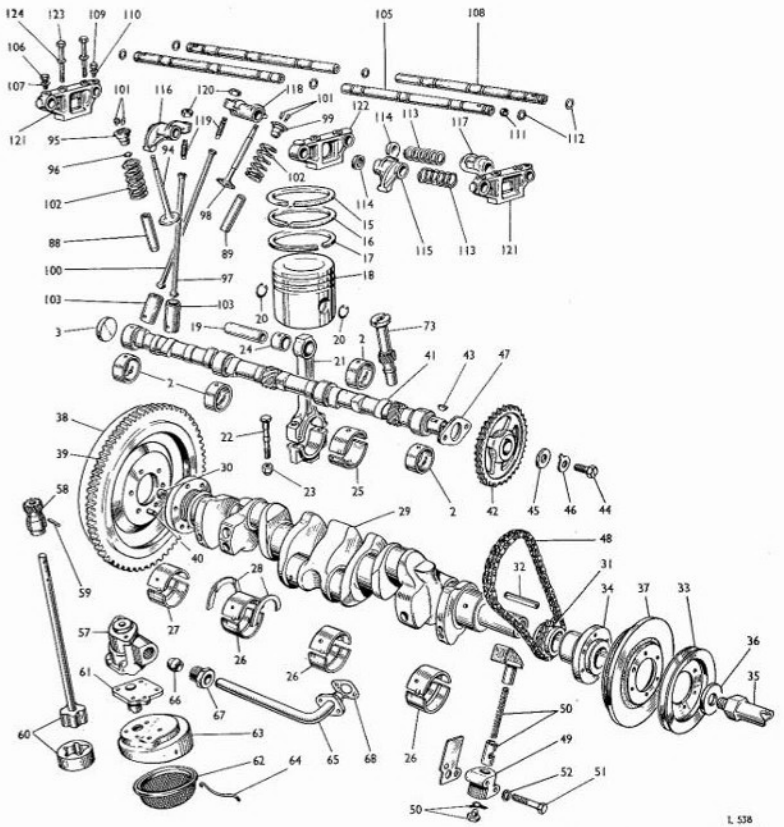
The pistons of "Heplex" aluminium alloy, have a slotted skirt on the opposite side to the thrust, and are attached to the connecting rod small ends by fully floating gudgeon pins. Steel circlips retain the gudgeon pins in the pistons. Standard gudgeon pins are graded high, medium and low on their outer diameters. Gudgeon pins are available in an oversize of +·003 in. (+·076 mm.) for service use. Each piston is oval and taper ground and carries three piston rings located above the gudgeon pin. The top ring is a chromium plated compression ring, the second one a shouldered compression ring, and the third ring a slotted oil control scraper ring. Pistons and rings are available in an oversize of +·030 in. (+·762 mm.).

The camshaft runs in four bearings of the steel shell, white metal lined type, which are readily renewable. The camshaft bearings are pressed into housings on the upper right hand side of the cylinder block. The aperture at the rear of the camshaft rear bearing is closed by means of a pressed disc. A constant oil level is maintained in the camshaft chamber by means of the two diagonally opposed tubes, which also drain surplus oil from the chamber to the sump through their hollow centres. This arrangement provides for the immediate lubrication of the cams and tappets directly the engine is started. Camshaft end float is controlled by a thrust plate bolted to the front face of the cylinder block. The drive to the camshaft is transmitted from the crankshaft by means of an endless duplex chain and two timing wheels, the camshaft running at half crankshaft speed. The crankshaft timing wheel is located by means of a feather key, whilst a Woodruff key radially locates the camshaft timing wheel. Both chain timing wheels are marked with centre dots to facilitate valve timing. The timing chain is tensioned by a Renolds type chain tensioner, which contains a coil spring for auxiliary operation, but utilises oil pressure for tensioning the timing chain once the engine has started.



1 CYLINDER BLOCK
2 CAMSHAFT BEARING
3 CAMSHAFT REAR BEARING SEALING CUP
4 and 5 MAIN BEARING CAP BOLT AND WASHER
6 OIL PUMP DRIVE COVER PLATE
7 COVER PLATE GASKET
8 SIDE COVER PLATE
9 COVER PLATE JOINT
15 TOP COMPRESSION RING
16 SECOND COMPRESSION RING
17 OIL SCRAPER RING
18 PISTON BODY
19 GUDGEON PIN
20 GUDGEON PIN CIRCLIP
21 CONNECTING ROD
22 and 23 CONNECTING ROD BIG END BOLT AND NUT
24 CONNECTING ROD SMALL END BUSH
25 CONNECTING ROD BIG END BEARING
26 CRANKSHAFT FRONT AND INTERMEDIATE MAIN BEARING
27 CRANKSHAFT REAR MAIN BEARING
28 CRANKSHAFT THRUST WASHER
29 CRANKSHAFT
30 PRIMARY SHAFT PILOT BEARING
31 CRANKSHAFT TIMING WHEEL
32 TIMING WHEEL KEY
33 CRANKSHAFT PULLEY
34 CRANKSHAFT PULLEY BOSS
35 and 36 CRANKING HANDLE DOG NUT (WHEN FITTED) AND WASHER
37 DAMPER
38 FLYWHEEL
39 STARTER RING
40 FLYWHEEL DOWEL
41 CAMSHAFT
42 CAMSHAFT TIMING WHEEL
43 TIMING WHEEL KEY
44 TIMING WHEEL SECURING SETSCREW
45 SECURING SETSCREW WASHER
46 SECURING SETSCREW TAB WASHER
47 CAMSHAFT THRUST PLATE
48 TIMING CHAIN
49 CHAIN TENSIONER BODY
50 TENSIONER DETAILS
51 and 52 CHAIN TENSIONER SECURING BOLT AND WASHER
53 TIMING COVER
54 COVER OIL SEAL
55 INLET WATER PASSAGE JOINT
56 TIMING COVER JOINT
57 OIL PUMP BODY
58 PUMP DRIVING PINION
59 DRIVING PINION SECURING PIN
60 PUMP DRIVING SHAFT, ROTOR AND RING ASSEMBLY
61 PUMP COVER PLATE
62 PUMP INTAKE FILTER
63 INTAKE FILTER SHROUD
64 INTAKE FILTER WIRE RETAINER
65 OIL DELIVERY PIPE
66 and 67 DELIVERY PIPE OLIVE AND NUT
68 DELIVERY PIPE JOINT
69 OIL PRESSURE RELIEF VALVE
70 RELIEF VALVE SPRING
71 RELIEF VALVE BODY
72 VALVE BODY SEATING WASHER
73 DISTRIBUTOR DRIVING SHAFT
74 DISTRIBUTOR MOUNTING BRACKET
75 DISTRIBUTOR BODY OIL SEAL
76 SUMP

Fig. B.70. Cylinder block and cylinder head details



77 SUMP DRAIN PLUG
78 PLUG SEALING WASHER
79 SUMP JOINT
87 CYLINDER HEAD
88 INLET VALVE GUIDE
89 EXHAUST VALVE GUIDE
89/1 SPARKING PLUG TUBE
90 CYLINDER HEAD GASKET
91 and 92 CYLINDER HEAD SECURING BOLT AND WASHER
93 CYLINDER HEAD LOCATING DOWEL
94 INLET VALVE
95 INLET VALVE SPRING CUP
96 CUP SEALING RING
97 INLET VALVE PUSH ROD
98 EXHAUST VALVE
99 EXHAUST VALVE SPRING CUP
100 EXHAUST VALVE PUSH ROD
101 VALVE SPRING CUP COTTER
102 VALVE SPRING
103 TAPPET
104 CAMSHAFT CHAMBER OIL LEVEL TUBE
105 INLET ROCKER SHAFT
106 and 107 INLET ROCKER SHAFT LOCATING SETSCREW AND WASHER
108 EXHAUST ROCKER SHAFT
109 and 110 EXHAUST ROCKER SHAFT LOCATING SETSCREW AND WASHER
111 ROCKER SHAFT SEALING PLUG
112 ROCKER SHAFT SEALING RING
113 ROCKER RETAINING SPRING
114 ROCKER DISTANCE PIECE
115 FRONT INLET ROCKER
116 REAR INLET ROCKER
117 FRONT EXHAUST ROCKER
118 REAR EXHAUST ROCKER
119 VALVE CLEARANCE ADJUSTING SCREW
120 ADJUSTING SCREW LOCKNUT
121 FRONT AND REAR ROCKER SHAFT SUPPORT STANDARDS
122 INTERMEDIATE ROCKER SHAFT SUPPORT STANDARD
123 and 124 SUPPORT STANDARD SECURING BOLT AND WASHERS
125 ROCKER COVER
126 OIL FILLER CAP
127 SPARKING PLUG COVER
128 SPARKING PLUG TUBE GROMMET
129 ROCKER COVER JOINT
140 THERMOSTAT
141 THERMOSTAT HOUSING
142 THERMOSTAT HOUSING JOINT
143 to 145 THERMOSTAT HOUSING SECURING BOLT AND WASHERS
146 THERMOSTAT COVER
147 THERMOSTAT COVER JOINT
148 COVER STUD
233 CLUTCH HOUSING COVER PLATE

Fig. B.71. Engine internal details

The slipper pad of the tensioner, which contacts the timing chain is faced with neoprene to promote silent action and reduce the wear on the chain side plates to a minimum. The timing chain and wheels are enclosed by an aluminium alloy cover, which also forms the housing for the water pump assembly. An oil seal pressed into the timing cover, seats around the boss on the crankshaft pulley and provides an oil tight seal at this point. Fitted immediately behind, and bolted with the crankshaft pulley to the pulley boss, a vibration damper ensures smooth running of the engine over the entire speed range. A groove on the rim of the vibration damper and a pointer attached to the front face of the timing cover provides the means of setting the engine to T.D.C., and when the groove is in exact alignment with the pointer, the engine is set at T.D.C. on number 1 and 6 cylinders. Skew gears machined at the centre and the front of the camshaft, drive the oil pump and the distributor respectively, via separate driving shafts. Thus with this layout the oil pump may be removed without affecting the ignition timing. The head of the distributor driving shaft carries an offset slot, which mates with the driving dog on the distributor, therefore these two components can only be coupled in one position, thus the rotation of this offset coupling is carefully timed in relation to the rotation of the camshaft. An eccentric at the rearward end of the camshaft drives the fuel lift pump, which is located on the right hand side of the cylinder block. The tappets operate in diagonally opposed bores in the cylinder block, directly beneath the cylinder head gasket joint, and their withdrawal is facilitated after removal of the cylinder head and gasket, from above. The camshaft chamber is closed by two pressed steel covers secured by setscrews.

The detachable cylinder head carries the valve gear, and the twin shaft, rocker assembly.

The valves are inclined at an angle of 62½° and operate in renewable valve guides pressed into the cylinder head. Valve guides are available in oversizes of +·001in. (+·025 mm.) and +·003 in. (+·076 mm.) on their outer diameter. Hemispherical combustion chambers are provided in the cylinder head, which allows larger valves to be used together with port passageways that give a very free flow of mixture into the cylinders. The valves are fitted with single valve springs having a progressive loading, each of which are retained by a cup and split cotters. On each of the spring cups an internal groove is formed and carries a neoprene "O", or sealing ring.

The rocker shaft assembly consists of two inlet and two exhaust rocker shafts, supported in seven rocker standards, the inner ends of the four hollow shafts meeting in the centre support standard. Owing to the different positions of the valve rockers and therefore the oil feed grooves, the inlet and exhaust rocker shafts are not interchangeable. The hollow rocker shafts are plugged with sealing caps at their outer ends and at this end of each shaft, a groove is also machined to house the neoprene sealing rings, these rings seating in the bores of the front and rear support standards, prevent oil leakage from around the rocker shaft outer ends. Similar sealing rings are fitted between the inner ends of the rocker shafts in the centre support standard. The rocker shafts are secured in the front and rear support standards by dowelled locating setscrews, which differ in size. To ensure correct refitment of the inlet and exhaust rocker shafts to the support standards, these components carry differing size threaded holes, which mate with the locating setscrews. The inlet rocker shaft and its respective boss in the support standard are machined the smaller of the two, accommodating the $\frac{5}{16}$ in. U.N.F. locating setscrew. The bores in the support standards which carry the rocker shafts are offset towards the right hand, or inlet side of the engine. The front and rear rocker support standards are interchangeable and have internal drillings which transfer oil around the rocker shafts, the feed originating at the rear standard from a passage in the cylinder head. The five intermediate support standards are interchangeable with each other, but not with the front and rear standards. The parts of the rocker shafts, on which the rockers operate are induction hardened, and the rockers are retained in position against the end faces of the rocker shaft standards by coil springs. Spacing collars are only fitted between the rockers and the standards in number 2 and 5 cylinder inlet positions, and between the rocker retaining springs and the support standards in number 2 and 5 cylinder exhaust positions.

Rockers are not interchangeable and are handed in sets of three; for ease of identification the arm of the inlet rocker is short and curved, whilst the exhaust rocker arm is longer and only slightly curved. The rocker arm is radiused at its end to contact the tip of the valve stem, and on the opposite side of the rocker boss a lug is forged, which is threaded and carries the adjusting screw and its locknut. The conical end of the adjusting screw seats in the upper socket of the push rod, similarly the lower ball end of the push rod seats in a socket formed in the hollow body of the tappet, thus the movement originating from the tappets contacting the camshaft, is transferred via the push rods, rockers and hence to the valves, which are actuated. The adjusting screws provided at the push rod end of each rocker are for the purpose of valve clearance adjustment. The push rods are diagonally opposed in the cylinder head and as all originate from the tappets above the single camshaft located on the upper right hand side of the cylinder block, the inlet push rods are consequently shorter than the exhaust, and thus are not interchangeable. The whole valve mechanism is enclosed in a pressed steel cover which is sealed around the sparking plug tubes by grommets, and around the edge with a gasket. The cover is retained by four slotted fixing bolts and fibre washers. The internal surfaces of the cylinder head lie below the rocker cover joint face, thus preventing oil accumulating by the rocker cover joint. The sparking plug tubes are pressed into recesses in the cylinder head and sealed with jointing compound.

The cast iron flywheel is spigoted, dowelled and bolted to the rear of the crankshaft flange, with a steel starter ring shrunk on its outer periphery. The flywheel securing bolts are locked by means of tab washers. The clutch is dowelled and bolted to the flywheel rear face and the whole assembly is enclosed by

the clutch housing, which as mentioned previously also provides the means of mounting the rear of the engine, via brackets. The clutch housing is dowelled and bolted to the rear face of the crankcase, and has a pressed steel blanking plate interposed. The blanking plate is also attached to the front face of the clutch housing by means of a setscrew. The bottom aperture of the clutch housing is closed by means of a two piece cover, bolted to the housing.

The twin exhaust manifolds are positioned on the left hand side of the cylinder head, whilst the inlet manifold is located to the right hand side.

The exhaust manifold assembly comprises two separate manifolds joined centrally by a connecting branch. The branch is in turn connected to the flange of the exhaust pipe, by means of studs and nuts. The manifolds are secured to the cylinder head by studs and nuts, and a one-piece gasket is interposed between the mating faces to seal the joint. Separate gaskets are used between the manifolds and the connecting branch, also between the branch and the exhaust pipe flange.

The inlet manifold is "jacketed" to provide for circulation of the engine cooling water, which flows from the cylinder head, via slots in the mating faces, circulates around the manifold ports, and is then drawn to the inlet side of the water pump through the connecting pipe. This feature incorporated in the inlet manifold controls the temperature of the manifold, providing an increased vaporisation of mixture when the engine is

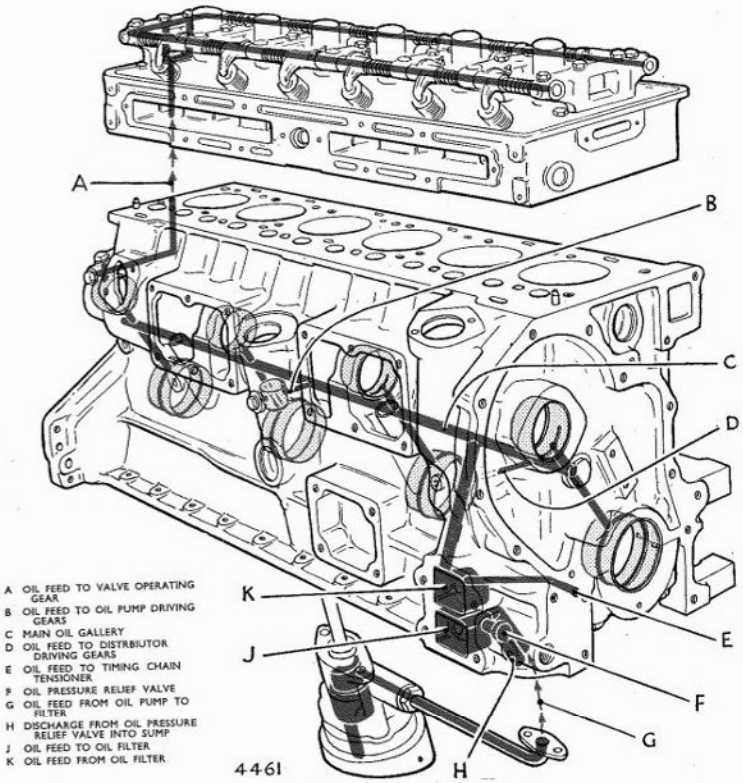


Fig. B.72. Engine unit, showing the oil passage-ways

"warming-up", and a stable temperature within the manifold once the engine has attained normal running temperature. The manifold is secured to the cylinder head by means of bolts, and a gasket is interposed at the mating faces to seal the joint. The carburettor is mounted on the upper face of the manifold via a cast adaptor. A vacuum connection is provided at the rear of the manifold.

Information in respect to the fuel system, the cooling system, the ignition and electrical equipment, and the clutch will be found in the appropriate sections.

ADJUSTMENTS TO THE ENGINE WHILST IN POSITION

To Adjust the Valve Clearances.

Check and if necessary, adjust the valve clearances, while the engine is hot, every 12,000 mile (18,000 km.), adopting the following procedure:

1. Lift the bonnet (hood) and secure in the open position, also release the internal engine cowl from its anchorage.

2. Start the engine and run at a fast idling speed until hot. Switch off the engine once it has attained its operating temperature.

3. Disconnect the breather pipe hose from the rocker cover, and the breather pipe from the moulded branch on the air cleaner to carburettor hose, then lift the pipe and hose clear (see "Fuel System" section).

4. Prise the sparking plug cover clear of the rocker cover and lift away. Disconnect the ignition leads from the sparking plugs by drawing on the lead and casing simultaneously (see "Electrical Equipment" section).

5. Remove the rocker cover, after releasing the four slotted fixing bolts, ensuring that the tube grommets and cover gasket are not damaged as the cover is lifted clear.

6. To check and if necessary, adjust the clearance of an individual valve, proceed as follows, noting that it is most important that the valve clearances are checked and adjusted when the tappets are resting on the back of the cams:

(*a*) Rotate the engine crankshaft until the rocker to be adjusted has opened the valve fully and then turn the engine a further one revolution to bring the tappet on to the back of the cam.

It will be observed that when the tappet is in this position a similar valve on the corresponding cylinder is at full lift. The corresponding cylinders are 1 and 6; 2 and 5; 3 and 4. Thus an alternative method of setting the engine prior to valve clearance adjustment, is to rotate the engine crankshaft until a similar valve on the corresponding cylinder is at full lift, i.e., if it is desired to check number 1 cylinder inlet valve clearance, number 6 cylinder inlet valve must be fully open for the engine to be set correctly.

(*b*) The valves are therefore adjusted in the following order by turning the engine 120° (one third of a turn) between each adjustment:

Inlet Valves.

(i) Number 1 inlet rocker with number 6 inlet valve fully open.

(ii) Number 5 inlet rocker with number 2 inlet valve fully open.

(iii) Number 3 inlet rocker with number 4 inlet valve fully open.

(iv) Number 6 inlet rocker with number 1 inlet valve fully open.

(v) Number 2 inlet rocker with number 5 inlet valve fully open.

(vi) Number 4 inlet rocker with number 3 inlet valve fully open.

Exhaust Valves.

(i) Number 1 exhaust rocker with number 6 exhaust valve fully open.

(ii) Number 5 exhaust rocker with number 2 exhaust valve fully open.

(iii) Number 3 exhaust rocker with number 4 exhaust valve fully open.

(iv) Number 6 exhaust rocker with number 1 exhaust valve fully open.

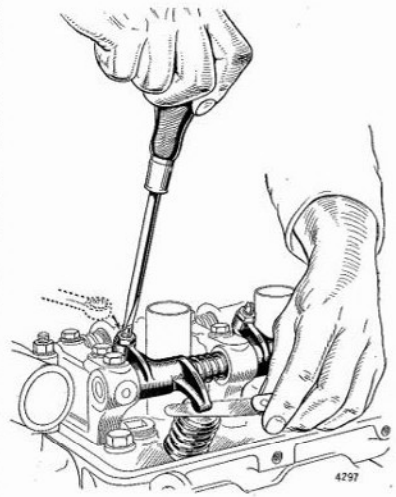


Fig. B.73. Valve clearance adjustment

(v) Number 2 exhaust rocker with number 5 exhaust valve fully open.

(vi) Number 4 exhaust rocker with number 3 exhaust valve fully open.

(*c*) To check the valve clearances, insert a feeler gauge between the valve stem and the rocker foot (see Fig. B.73). Correct clearances with the **engine hot** are: Inlet and exhaust valves ·014 in. (·356 mm.)

(*d*) To adjust the clearance, release the locknut below the adjusting screw head, and then rotate the screw with a screwdriver until a feeler gauge of the correct thickness is lightly gripped between the rocker foot and the valve stem. Tighten the locknut, holding the adjusting screw in position with the screwdriver, and then re-check the clearance with the feeler gauge.

(*e*) Continue the above described procedure until all the valves have been checked. The operation will be simplified if a chalk mark is made on each rocker, after adjustment has been completed.

7. Complete the operation by refitting the components removed, ensuring that the rocker cover gasket is in good condition and the grommets seat correctly around the sparking plug tubes. The breather pipe and hose should be connected securely between the air cleaner hose and the rocker cover. Clip the ignition leads and casings into position, the firing order being 1 : 5 : 3 : 6 : 2 : 4, with number 1 cylinder located at the front. Finally spring the ignition lead cover into position in the recess provided on the rocker cover.

Tightening the Cylinder Head Bolts.

Reference to Fig. B.74 will show that the cylinder head bolts are obscured by the rocker cover and rocker gear. Therefore to effect the operation of tightening the bolts, the rocker cover must be removed as described under "To Adjust the Valve Clearances", paras. 1 to 5 inclusive, and the Churchill "U" Shaped Wrench R.G.274A used in conjunction with a torque wrench. If the Churchill Wrench R.G.274A is not used, the rocker gear must be removed to gain access to the cylinder head bolts. Proceed to tighten the cylinder head bolts, in the following manner:

1. With the engine hot, tighten the bolts in the correct sequence as shown in Fig. B.74, to a torque wrench reading of 65/70 lb. ft. (8·99/9·68 kg. m.).

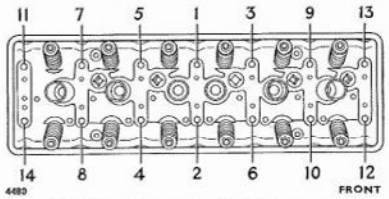


Fig. B.74. Cylinder head bolt tightening sequence

2. Check the valve clearances, as detailed on page B.78.

3. Refit all components removed, by reversing the removal procedure, noting that oil tight joints must result, upon refitting the rocker cover.

COMPRESSION PRESSURES

An engine in a good condition should give compression pressures of between 120 to 130 lb./sq. in. (8·44 to 9·14 kg./sq. cm.). Compression pressures are taken with the engine hot at starter cranking speed, with all sparking plugs removed and the throttle held fully open. It is important to ensure that the valve rocker clearances are correct before making this test (see page B.78).

If the readings obtained are substantially below the given figure, the engine is in need of attention to one, or all of the following:

(*a*) Valves and/or seatings.

(*b*) Pistons, piston rings and/or cylinder bores.

A faulty cylinder head gasket can also cause low, or differing compression readings, and this possibility should not be overlooked.

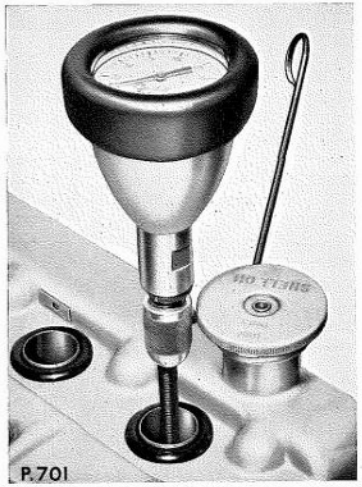


Fig. B.75. Checking the engine compression pressure, using the Churchill Tool 430, in conjunction with adaptor set 430-1

Incorrect valve timing will also give incorrect compression pressures. If the valve timing is early the compression pressures will be higher, and if late, lower than specified. Such compression readings will only be obtained after incorrect assembly of the timing wheels and chain. Check the "Valve Timing", as detailed on page B.99.

It is recommended that the Churchill 430 Cylinder Compression Tester, in conjunction with the Straight Adaptor Tube 430-1 be used for taking pressure readings on this engine.

CYLINDER HEAD MAINTENANCE

Cylinder head maintenance includes removal of the cylinder head, decarbonising, valve refacing, valve seat grinding and the "grinding-in" of the valves. Opportunity should be taken at this time to thoroughly service the carburettor, fuel lift pump filter chamber and the distributor, as detailed under the "Fuel System", and the "Electrical Equipment" sections respectively.

To Remove.

1. Lift the bonnet (hood) and secure in the open position, also release the internal engine cowl from its mounting points.

2. Disconnect the lead from one of the battery terminals.

3. Drain the water from the radiator and the cylinder block (see "Cooling System" section). If an anti-freeze mixture is in use, drain into a clean container for re-use in filling the cooling system upon re-assembly.

4. Disconnect the top water hose and release the lead from the thermometer bulb, located in the water outlet/thermostat housing on the front of the cylinder head. Remove the heater hoses (when fitted), from their adaptors situated in the water pump body and the rear face of the cylinder head.

5. Release the air cleaner to carburettor hose from its locations at either end, similarly the breather pipe hose from its connection on the rocker cover, and then lift the components clear.

6. Remove the carburettor (see "Fuel System" section).

7. Disconnect the fuel pipe (petrol tank to fuel lift pump) from the bracket located on the rear of the cylinder head.

8. Prise the sparking plug cover clear of the rocker cover, and then lift away. Disconnect the ignition leads from the sparking plugs by drawing on the lead and casing simultaneously. Identify the distributor clamp to the mounting bracket, remove the two securing setscrews, and withdraw the distributor complete as a precautionary measure, against accidental damage occurring to the unit during cylinder head removal (see "Electrical Equipment" section).

9. Remove the rocker cover after releasing the four slotted fixing bolts, ensuring that the tube grommets and cover gasket are not damaged as the cover is lifted clear.

10. Release the bolts securing the rocker shaft assembly to the cylinder head, noting that the bolts should be withdrawn evenly so as not to place undue load in any one position. Copper washers are located beneath the bolt heads on the front and rear support standards only, thus sealing the oil passages formed around these bolts. Ensure the copper washers are positioned correctly on re-assembly. Once the bolts are removed the assembly can be lifted clear by supporting the front and rear support standards with the hands, and at the same time exerting pressure inwards so as to prevent the assembly from separating at the centre support standard.

11. Withdraw the push rods from their locations, noting that the exhaust push rods are the longer and pass down those holes, which lie towards the centre of the cylinder head.

12. Remove the twin exhaust manifolds (see page B.115.

13. Release the nuts securing the inlet manifold connecting (water pump by-pass) pipe to the water pump inlet, and to the boss on the manifold, then lift the pipe clear.

14. Disconnect the vacuum pipe (when fitted) from the union on the rear of the inlet manifold.

15. Release the inlet manifold drain tube from its locations.

16. Remove the cylinder head securing bolts, rock the head to effect a break at the gasket, and upon raising the cylinder head to clear the location dowels, it may be tilted and lifted away rearward through the scuttle aperture, complete with the inlet manifold. Two lifting eyes are bolted to the cylinder head, which facilitate the removal operation.

Note: If any water drops into the cylinder bores when the head is lifted away, it should be wiped out immediately to prevent corrosion.

To Dismantle.

Dismantling will be facilitated if the cylinder head is placed with the valve springs uppermost on wooden blocks, one positioned at either end.

1. Remove the inlet manifold (see page B.115).

2. Remove the bolts that secure the water outlet/thermostat housing to the front face of the cylinder head, and withdraw the housing complete.

3. Inlet valves are position marked 1 to 6 from the front of the cylinder head. If required the valve heads of the exhaust valves should be chalk marked with their position reference number, i.e., number the exhaust valves 1 to 6 starting from the front of the cylinder head. Alternatively once removed, locate the valves in a suitable rack, in the same position and sequence as they occupy when fitted to the cylinder head.

To prevent possible damage to the oil sealing ring in the valve spring cup, the cup and spring must not be compressed more than $\frac{3}{16}$ in. (5 mm.) as shown in Fig. B.88. If this distance is exceeded, the sealing ring will be forced over the shoulder on the valve stem causing damage to the ring.

Using a valve spring compressor (Churchill Main Tool R.G.6513, in conjunction with the Compressor Foot R.G.6513-2, as shown in Fig. B.77), compress the valve spring and cup as detailed previously, thus freeing

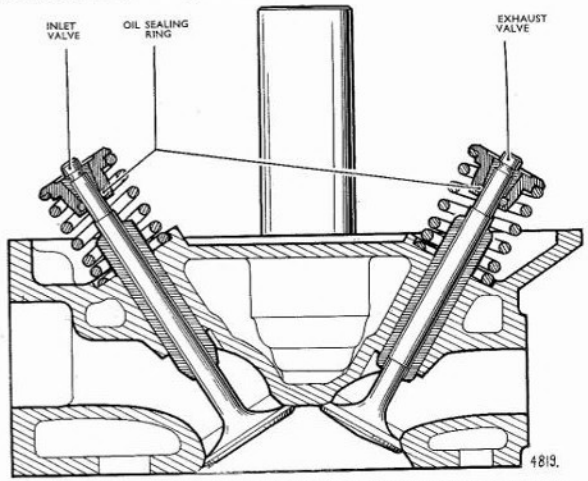


Fig. B.76. Valve gear arrangement, showing the location of the oil sealing ring in the spring cups

the split coned cotters enabling them to be removed. When carrying out this operation ensure that the hardened steel cotters and the spring cups do not damage the valve stems.

4. Release the valve spring compressor and lift off the spring cup and the single valve spring. Remove the sealing ring from each spring cup as it is withdrawn.

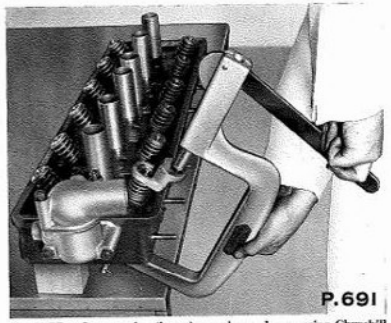


Fig. B.77. Compressing the valve spring and cup, using Churchill Tool R.G.6513, in conjunction with the compressor foot R.G.6513-2

5. Remove the valves. Should a new valve be fitted, identify using similar markings to those observed on the original valve.

Inspection and Overhaul.

Before inspecting any of the components, remove the carbon deposit from the combustion chambers, the valve ports, the valves and inside the valve guides. Suitable wire brushes fitted into a hand drill are recommended for these operations. After cleaning the valve heads, give the stems a polished finish using very fine emery cloth with oil, taking care not to reduce the valve stem diameter over the length which operates in the valve guide (see also "Decarbonising", on page B.87).

Valve Guides.

1. To Inspect. These may be checked for wear by using a new valve as a gauge. The valve stem should be a free sliding fit in the guide without excessive side play. The maximum designed clearance of the valve stem in the guide is as follows:

Inlet	·003 in. (·076 mm.)
Exhaust	·004 in. (·102 mm.)

Whilst making the above checks ensure that the guides are free from carbon and the stems from burrs. All components must be oil free. Renew the guides, if necessary, as detailed in para. 2 below.

Valves guides are available in standard size, and +·001 in. (+·025 mm.) and +·003 in. (+·076 mm.) oversizes on the outer diameter.

2. To Renew. It is seldom necessary to renew the valve guides, but it may be necessary, however, for the purpose of re-grinding the valve seatings where great accuracy is essential to ensure concentricity of the work performed by the stone of the grinder, which operates in conjunction with an expanding pilot inserted in the valve guide.

The guides are an interference fit in the cylinder head and removal and refitment is facilitated by the use of Churchill Main Tool R.G.10A, in conjunction with the Adaptor Sets R.G.10A-5A and R.G.10A-6 (see Fig. B.78). If valve guide renewal is necessary, proceed as follows:

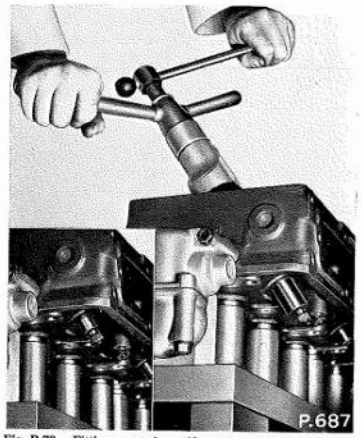


Fig. B.78. Fitting new valve guides, using the Churchill Tool R.G.10A and the adaptor sets R.G.10A-5A and R.G.10A-6 (Inset shows the method of valve guide removal)

(*a*) Screw the centre bar, STN.6658 into the centre screw of the main tool and locate the adaptor, R.G.10A-6, over the centre bar so as to abut the body of the tool. The taper face of the latter adaptor must face away from the tool.

(*b*) To remove a valve guide from the cylinder head, insert the centre bar, STN.6658 down through the combustion chamber and the valve guide bore until it is possible to screw the knurled nut on to the lower end of the centre bar, noting that the taper face of the adaptor, R.G.10A-6 registers squarely on the valve seating (see Fig. B.79). Withdraw the valve guide through the combustion chamber and when clear of its housing remove the main tool complete with valve guide from above. Release the knurled nut and slide off the valve guide from the centre bar of the tool. Repeat this procedure to remove all remaining valve guides.

(*c*) To fit a new valve guide to the cylinder head, utilise again the main tool R.G.10A together with the adaptor sets R.G.10A-5A and R.G.10A-6, maintaining the latter adaptor in the same position on the

Fig. B.79. Correct location of the Churchill Adaptor R.G.10A-6 on the cylinder head valve seating, during valve guide renewal

body of the main tool as it assumed during the removal operations. Insert the centre bar, STN.6658 down through the combustion chamber and the housing for the guide until it protrudes below the cylinder head sufficiently to allow the valve guide, followed by the locating adaptor R.G.10A-5A, Code 1 (inlet valve guide), or R.G.10A-5A, Code 5 (exhaust valve guide) to be fitted over the centre bar of the tool. Finally screw the knurled nut on to the threaded end of the centre bar. Ensure the adaptor, R.G.10A-6, registers squarely on the valve seating (see Fig. B.79). Draw the valve guide into position, noting that when the guide is drawn in to the depth of the locating adaptor it automatically assumes the correct height above the spring seating. Repeat this procedure to refit the remaining valve guides.

Notes:

(i) When fitting the new guides it is important that the prescribed interference fit in the cylinder head of ·0002/·0017 in. (·005/·043 mm.) is maintained.

(ii) The exhaust valve guides are reversible, and may be fitted either way round, **but the inlet valve guides must be located the correct way up** and for this reason the word "TOP" is stamped on one end of the guide. Thus it is important that the inlet guide end, which is marked "TOP", be fitted uppermost, and adjacent to the spring seatings on the top face of the cylinder head.

(iii) It is essential that the guides are fitted to the correct ports, i.e., inlet, or exhaust according to length, to avoid fouling the spring cups. To assist in identification, the inlet guides are ·30 in. (7·62 mm.) shorter in overall length than the exhaust guides.

For additional identification, observe the inlet guides are tapered externally at each end, however the lower (port) end has the acute taper, whilst each end of the exhaust guides are identical to each other, and taper slightly on their external diameter and end faces. The lower (port) end of the inlet guide is the opposite end to the one stamped "TOP".

(iv) Should the Churchill Tool not be available for valve guide removal or refitment, these operations may be accomplished using a suitable piloted drift, noting that upon fitting, the valve guides must project above the bottom of the spring seating by ·61 in. (15·494 mm.) in the case of the inlet guides, and ·65 in. (16·510 mm.) in the case of the exhaust guides.

Valve Seatings.

1. To Inspect. Inspect the cylinder head for cracks, especially in the region of the valve seats.

A cracked head must be renewed, noting that replacement cylinder heads are supplied without sparking plug tubes and a set of six tubes must be obtained with each replacement cylinder head. The tubes in the discarded cylinder head cannot easily be removed as there is no purchase point on the tube, to which an extractor could be fitted. When fitting sparking plug tubes, jointing compound should be painted around the bottom end of each tube before pressing the tube into position in its recess machined in the cylinder head.

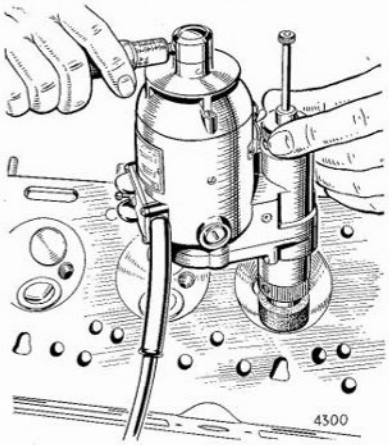


Fig. B.80. Re-grinding the cylinder head valve seatings, using the Hall Eccentric Valve Seat Grinder

Examine the valve seating for excessive pitting or other damage and correct by re-grinding the cylinder head valve seatings, using for this operation the Hall Eccentric Valve Seat Grinder (see para. 2). Light pitting will be corrected by the action of "grinding-in" the valves, but on no account should badly pitted valves and seats be "ground-in" together (see also under "Valve Grinding").

2. To Re-grind. The valve seats in the cylinder head should be re-ground accurately using preferably the Hall Eccentric Valve Seat Grinder, as shown in Fig. B.80, or alternatively, the Churchill Valve Seat Cutters, comprising a Main Tool 316X [Pilot 316-11] and a Cutter Set 317 [317-25 (45° Cutter), and 317G-25 (Glaze Breaker)], may be used as shown in Fig. B.81.

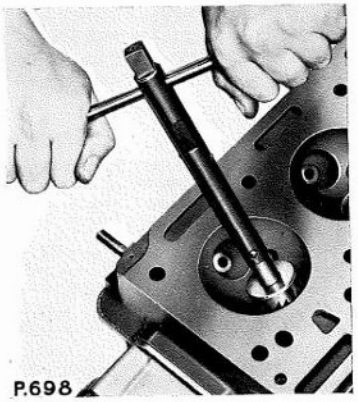


Fig. B.81. Re-cutting the cylinder head valve seatings, using the Churchill Tool 316X and the cutter set 317

It is most important to note that the re-ground valve seat in the cylinder head must be concentric within the required limit of ·002 in. (·051 mm.) total indicator reading with the bore in the valve guide. This degree of accuracy will only be assured if new valve guides are fitted, or alternatively the original guides are within the designed limits and free internally from all carbon deposits, for it cannot be over emphasised that the highest possible degree of concentricity should exist between the valve guide bore and the valve seatings (see also under "Valve Guides"). In order to further maintain accuracy the expanding pilot of the valve seat grinder must be a close fit in the valve guide, being finally expanded when in position to grip and align with the bore of the guide.

With this in mind install the expanding pilot in the valve guide, using the hand wrench provided (see Fig. B.82) expanding the pilot in the guide by means of the the knurled knob on the top of the hand wrench. Release and then withdraw the wrench from the pilot.

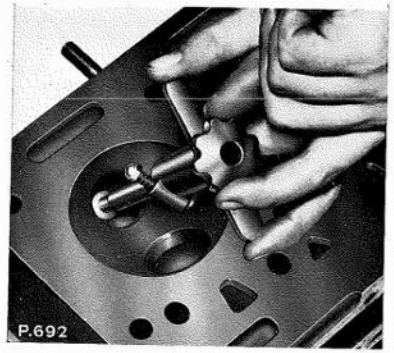


Fig. B.82. Installing the valve seat grinder pilot in the valve guide, using the hand wrench

Dressing the Grinding Wheel. The grinding wheel must be dressed before commencing grinding operations on the valve seatings and this is accomplished using the dressing fixture, on which the grinder seats, via two pilots (see Fig. B.83) and a guide which passes up through the head of the grinder. Set the diamond dressing tool to an angle of 45° as indicated on the scale, energise the motor and dress the grinding wheel.

Operating the Valve Seat Grinder. Locate the grinder over the expanding pilot and release the Allen screw positioned directly above the grinding wheel feed adjusting screw. Push down the depth rod against the top of the pilot (see Fig. B.83) and then lock the Allen screw tightly.

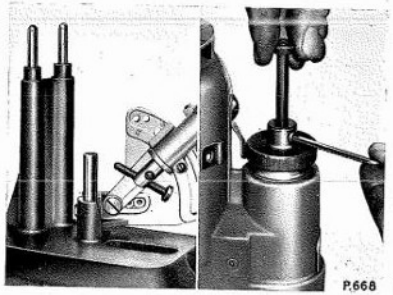


Fig. 83. Valve seat grinder details

Right hand illustration—Setting the depth rod, using an Allen key
Left hand illustration—Dressing fixture, showing the locating pilots and centre guide

Turn the feed adjusting screw until the grinding wheel just clears the valve seating and then balance the grinder by means of the compensating handle (see Fig. B.80).

Start the motor and turn the feed adjusting screw one serration at a time, so feeding the grinding wheel into the valve seating, but only until the wheel is grinding all round the face of the valve seat, noting that before stopping the grinder it is essential to cease the feed on the grinding wheel and allow time for the wheel to grind free. Continue grinding only until all marks have disappeared and a new face is obtained. Turn off the motor at the switch provided, allowing the grinding wheel to stop before lifting the grinder from its pilot.

When the valve seating face has been re-ground satisfactorily, remove the expanding pilot by means of the hand wrench and check that the corresponding valve, which may now be inserted for trial is not brought too low on its seating as a result of excessive re-grinding of the seating in the cylinder head, causing "pocketing" of the valve (see Fig. B.84—lower illustration). If this condition exists and cannot be corrected by the fitting of a new valve, valve seat inserts must be fitted (see "To Fit Valve Seat Inserts").

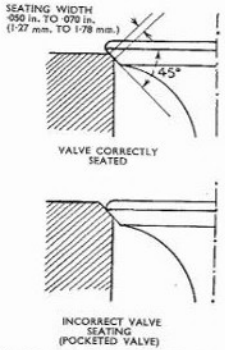


Fig. B.84. Cylinder head valve seatings

Note: "Pocketing" of the valve could result from heavy refacing of the valve itself, and if this condition is confirmed, renew the valve.

Finally examine the face of the newly cut valve seat for width, which must not exceed ·070 in. (1·78 mm.). If the width of the seat exceeds this figure, and owing to the fact that the shape of the combustion chamber restricts the use of a cutter to reduce the top width of the seating, valve seat inserts must be fitted to provide a new seat (see "To Fit Valve Seat Inserts").

3. To Fit Valve Seat Inserts. Inlet and exhaust valve seat inserts are available and should be fitted to the cylinder head when the original valve seats become too wide.

Valve seat inserts are available in standard and +·002/·005/·010 in. (+·051/·127/·254 mm.) oversizes on the outside diameter. Dimensions for machining the cylinder head to take valve seat inserts are given in Fig. B.85, and the dimensions of the valve seat inserts in Fig. B.86. When valve seat inserts are to be used, new valves guides must be fitted to ensure that the work carried out by the cutter is concentric to the bore of the valve guide. The cylinder head should be recessed to the dimensions given in Fig. B.85, using a suitable valve seat insert cutter. The valve insert is an interference fit of ·0025 in. (·063 mm.) to ·0045 in. (·114 mm.) in the cylinder head. The insert must be pressed in perfectly square until it seats on the entire bottom face of the recess, using the Valve Seat Insert Driver, Churchill Tool 6057 and the Pilot 316-11, in conjunction with the Adaptors R.G.6057-8, Code 1 (inlet valve seat inserts) and R.G.6057-8, Code 2 (exhaust valve seat inserts), its top face should then be level with the surrounding metal surface of the combustion chamber. The valve seat on the newly fitted insert should be ground at an angle of 45°, to a width of ·050 in. to ·060 in. (1·27 mm. to 1·52 mm.), and must be concentric to within ·002 in. (·051 mm.) of the valve guide bore. Use the Hall Eccentric Valve Seat Grinder as detailed under "Valve Seatings—To Re-grind".

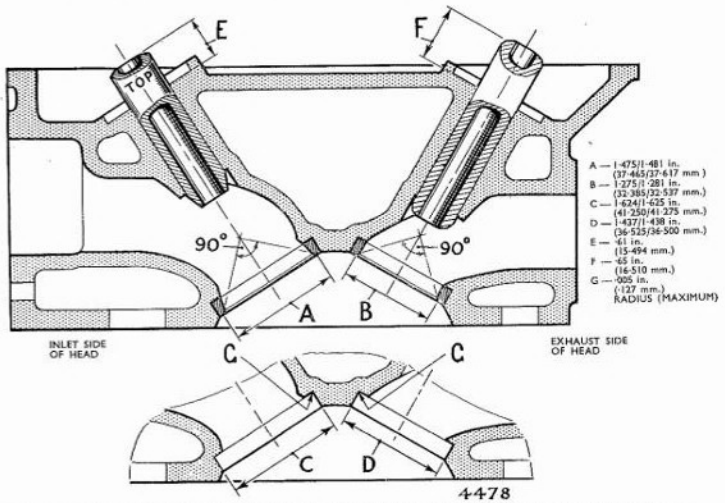


Fig. B.85. Cylinder head machining dimensions to accommodate valve seat inserts, also valve guide pressing dimensions

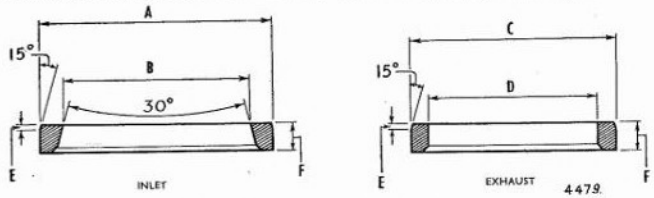


Fig. B.86. Valve seat insert dimensions

Valves.

1. To Inspect. Examine the seating face of the valves for excessive pitting, and the heads for cracks, distortion and burning. If the valve stems are bent, or worn the valves must be renewed even though they may be otherwise sound. Wear on the stems may be checked by means of a micrometer from various angles and positions, as the valve stems do not wear uniform over their length.

The stem diameter of a new valve is:

Inlet	..	·3417/·3422 in. (8·679/8·692 mm.)
Exhaust	..	·3407/·3412 in. (8·654/8·666 mm.)

Should the stems be in reasonable condition, and the valve heads not burnt, or cracked, reface the seats, as detailed in para. 2 below.

2. To Reface. If on examination of the valves it appears unlikely that they would clean up satisfactorily with ordinary "grinding-in", they must be refaced on a suitable valve face grinder. Generally it will be found that the cylinder head valve seatings are better than the valves themselves as regards condition, unless the engine has been in service for a very long time. It is quite practicable to reface the valves and grind them in on the original seatings, if the latter are in good order.

It is always better to renew a badly burnt, or pitted valve, as extended refacing will bring it very low on its seating by reason of the consequent reduction in the effective diameter of the valve face, and "pocketing" of the valve will result (see Fig. B.84—lower illustration). This condition is detrimental to the running of the engine and will cause overheating and loss of power.

When mounting the valve in the grinding machine, perfect concentricity of the valve stem with the chuck, or collet is of the utmost importance, and any "run-out" should be noted and corrected, as necessary, before attempting to grind the valve face. The finished valve face must be concentric to the valve stem within the limit of ·001 in. (·025 mm.) total indicator reading.

The valve face should be ground only until it is just true and clear of marks to an angle of 45° for both the inlet and exhaust valves.

This angle is reckoned from the top face of the valve head, on a line at right angles to the stem axis. Salient dimensions of the valves are given in "Manufacturing Data" at the beginning of this section. It should be noted that inlet and exhaust valves are of a different size.

If after grinding, the parallel portion of the valve head above the seating face is less than $\frac{1}{32}$ in. (·78 mm.) the valve should be renewed.

A valve which has been refaced as described above must be finally "ground-in" to its seating on the cylinder head (see "Valve Grinding"). Valves are position identified during dismantling operations, therefore ensure they are "ground-in" to their respective seating. Very little valve grinding will be required, but it must not be omitted.

Valve Grinding.

1. On no account should badly pitted valves and seats be "ground-in" together as this will give rise to excessively wide seats. When the valve and seats have been re-ground (this is unnecessary if the valves and seats are in good condition) grind them in to give a perfect seating. Care must be taken that the valves are not interchanged, and are located in their original positions, observing position identification made during dismantling operations.

2. To "grind-in" the valves apply a thin coating of fine grinding paste around the valve face, not allowing it to get on the stem, or other parts of the valve. Apply a light smear of oil to the valve stem.

3. Place the valve on its seating and by means of a suction grinding tool, rotate the valve from side to side through a few degrees only, using a light pressure. Frequently raise the valve and move round to a new position on its seating and continue grinding. (On no account should the valve be revolved through complete revolutions when grinding, or rings will be formed on the faces with detrimental affects.)

4. The grinding should be continued in this manner until a continuous, but narrow seating has been obtained both on the valve and the seating.

After thoroughly cleaning off all traces of grinding paste from the valve and seating with a dry cloth, check the valve seat in the following manner:

(*a*) Ensure all traces of grinding paste are removed from the face of the valve and the seat.

(*b*) Smear a thin coat of marking blue on the valve face.

(*c*) Place the valve on its seat and rotate backwards and forwards for approximately $\frac{1}{8}$ in. (3 mm.). Do not rotate more than this amount as an untrue mark will be obtained.

(*d*) To give a good seat, a mark should be obtained that is of equal width over the whole circumference of the seat.

5. When the seat is considered satisfactory, thoroughly clean the valve face and the seat. The resulting valve seat should not be more than ·070 in. (1·78 mm.) in width.

Valve Springs.

1. If possible, the fitted length and load of the springs should be checked. Under test the dimensions obtained should be as follows:

Load at fitted length	..	75 lb. (34·02 kg.) at 1·65 in. (41·91 mm.)

A maximum loss of 10 per cent on used springs is permissible.

2. A quick visual check may be carried out by placing the springs in a straight line on a surface plate, when any spring that is shorter than the others should be renewed, alternatively used valve springs can be checked by comparing them with new springs under pressure as follows. Position the used and new valve springs end

to end on a long bolt and compress them in a press, as shown in Fig. B.87. Any loss will then be apparent as the weaker spring will close up first.

3. Examine the spring coils for cracks.

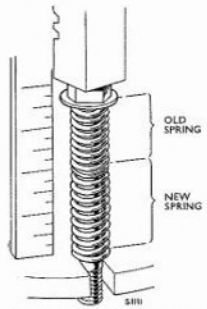


Fig. B.87. Checking valve spring by comparison method, whilst under load

Spring Cups and Cotters.

Examine the spring cups and cotters for cracks, or excessive damage, especially on the mating taper faces, renewing the cups and cotters if necessary. Ensure the 'O', or sealing ring groove on the spring cups are free from burrs.

Decarbonising.

1. The threaded holes in the cylinder block, which accommodate the cylinder head bolts, also the tappet bores, should be suitably protected to prevent the ingress of loose carbon during this process. The cylinder head bolts may be screwed into the cylinder block to prevent carbon falling into the threaded holes. When removing the carbon deposit from each piston crown, it is always advisable to leave a ring of carbon adjacent to the cylinder bore as this helps to preserve a good seal, and to conserve oil. A convenient method of carrying out this operation is to turn the engine until the piston is slightly below the top dead centre position, insert an old piston ring of correct size in the bore, and press down on the piston crown. In this way all the carbon within the old piston ring may be removed, leaving a ring of carbon around the edge.

2. Remove carbon from the tops of the pistons, the combustion chambers in the cylinder head, also from the valve ports (see under "Cylinder Head—Inspection and Overhaul", on page B.82). With a suitable scraper clean out the inside of the twin exhaust manifolds and the connecting branch.

3. Remove all loose carbon, preferably by use of a compressed air line.

4. Care must be taken when decarbonising the tops of the pistons, these being of aluminium alloy, and no pointed instruments, or emery cloth must be used. Do not on any account use abrasives for removing carbon, or damage will result.

5. Having attended to the preceding operations and given the valves and seatings any attention that may be required, the cylinder head may be re-assembled.

To Re-assemble.

Reverse the operations for dismantling, noting the following points:

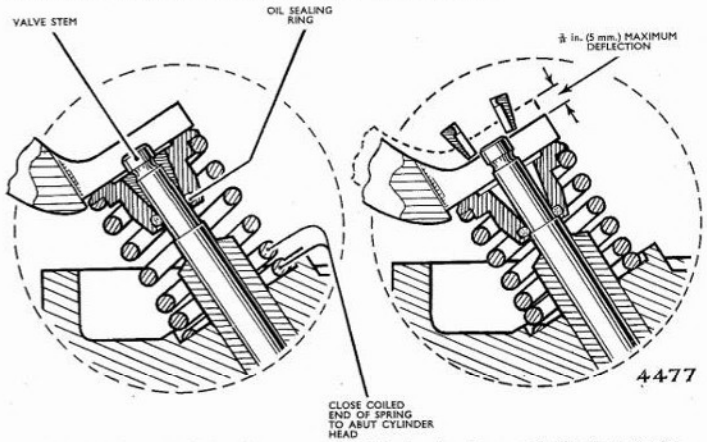


Fig. B.88. Correct use of valve spring compressor when fitting the valve spring, cup and sealing ring to the valve

1. Thoroughly flush out the cylinder head water passages. Ascertain that the interconnecting water passages between the cylinder head and the block, and between the block and the inlet manifolds are clear. Ensure that all parts are clean before re-assembling.

2. Renew the seals in the valve spring cups if damaged in any way and give the valve seats a thin coat of oil. The seals should be a firm push fit on the end of the valve stem when in position in the spring cup.

3. Fit the valve springs into the recesses provided in the cylinder head, with the close coiled end of the spring towards the cylinder head.

4. When fitting the valve spring cups, care must be taken to avoid damage to the sealing ring, or the seal will not be effective and oiling of the sparking plugs may result. Damage can result from over compressing the valve springs, therefore careful note should be made, that the total distance the valve springs are compressed, whilst fitting the split cotters, does not exceed $\frac{3}{16}$ in. (5 mm.), as shown in Fig. B.88.

5. Compress the valve spring and cup, using Churchill Tool R.G.6513 and the Compressor Foot R.G.6513-2, taking care that the cup is compressed only until it is possible to insert the split cotters (refer also to the figure quoted in para. 4).

6. Refit the inlet manifold, ensuring that a new gasket is used (see page B.115).

To Refit.

Before fitting the cylinder head ensure all carbon particles, etc., are removed from the piston crowns, also clean out any foreign matter which may have collected around the cylinder bores. Blow out the threaded holes in the cylinder block, which accommodate the cylinder head bolts.

To install the cylinder head, use a new gasket and reverse the removal procedure, observing the following:

1. Ensure the machined faces of both the head and the block are perfectly clean, and then place the new gasket over the cylinder head locating dowels, noting:

(*a*) Copper, steel and asbestos composition cylinder head gaskets are used, and should be given a coating of "Wellseal" jointing compound on the jointing faces before fitting.

(*b*) All gaskets are marked "TOP" on one side and this side must face uppermost. This ensures that the oil feed hole will be positioned towards the rear of the gasket and align with the respective passage in both the cylinder head and block.

2. The cylinder head bolts should be tightened initially a little at a time in the recommended sequence as shown in Fig. B.74, finally tightening the bolts to a torque wrench reading of 65/70 lb. ft. (8·99/9·68 kg.m.). This should be repeated again when the engine is hot.

Note: In order to obtain the correct torque wrench reading, the bolt threads should be clean and lightly oiled, also the underside of the bolt heads. Dry, dirty, or paraffin wetted bolts will give a false torque wrench reading.

3. When refitting the rocker shaft assembly, refer to the appropriate heading under "Rocker Shaft Assembly, Push Rods and Tappets", on page B.91.

4. Refit the twin exhaust manifold assemblies (see page B.115), also the carburettor as detailed under the "Fuel System" section.

5. Adjust the valve clearances as detailed on page B.78.

Note: Check, and if necessary, adjust the valve clearances, after the cylinder head bolts have been tightened the second time.

6. Renew the rocker cover joint and/or the sparking plug tube grommets if they have deteriorated in any way. Refit the rocker cover, followed by the air cleaner to carburettor hose, and the rocker cover breather pipe and hose. Tighten the hose and pipe clips securely.

7. Clean and adjust the sparking plugs as detailed under the "Electrical Equipment" section.

8. Refit the distributor complete with its mounting clamp, aligning the marks made during removal operations. Clean and adjust the distributor contact breaker points and finally check the ignition timing. (see "Electrical Equipment" section).

ROCKER SHAFT ASSEMBLY, PUSH RODS AND TAPPETS

To Remove.

1. Lift the bonnet hood and secure in the open position, also release the internal engine cowl from its anchorage.

2. Disconnect the breather pipe hose from the rocker cover and the breather pipe from the branch moulding on the air cleaner hose, and then lift the pipe clear (see "Fuel System" section).

3. Prise the sparking plug cover clear of the rocker cover and lift away. Disconnect the ignition leads from the sparking plugs by drawing on the lead and casing simultaneously (see "Electrical Equipment" section).

4. Remove the rocker cover, after releasing the four slotted fixing bolts, ensuring that the tube grommets are not damaged as the cover is lifted clear.

5. Remove the rocker shaft assembly by evenly releasing the securing bolts, thus avoiding undue load in any one position. The rocker shaft assembly should then be lifted off by holding the front and rear support standards between the hands, at the same time applying pressure inwards to prevent the assembly from separating at the centre support standard.

Note: The securing bolts on the front and rear support standards have copper washers under the bolt heads to seal the oil passages.

6. Withdraw the push rods from their locations, noting that the exhaust push rods are the longer and pass down those holes which lie towards the centre of

the cylinder head. Upon removal, locate the push rods in a suitable rack so that they can be refitted to their original positions.

Note: Push rods may be withdrawn without removing the rocker assembly, after slackening off the adjusting screw sufficiently to allow the rocker to be pushed aside against the force exerted by its retaining spring.

7. If it is required to remove the tappets from their locations in the cylinder block, firstly it is necessary to remove the cylinder head (see page B.80), to gain access. It is then possible to withdraw the tappets from their bores. These should be labelled 1 to 12 from the front, to facilitate refitting to their original positions.

Fig. B.89. Withdrawing the tappets from the bores in the upper face of the cylinder block

To Dismantle.

Dismantling the rocker shaft assembly is a straightforward operation involving the separating of the split rocker shafts at the centre support standard, proceeding then as follows:

1. Lift away the centre support standard and remove the "O", or sealing ring located in each of the bores in the support standard.

2. Remove the dowelled locating setscrews from the front and rear support standard, noting that the diameter on the dowelled section of each type differs, as does the thread size, the exhaust one being the larger. The dowelled part of the setscrews match similar diameter drillings in the rocker shafts. Observe that copper washers are situated under the heads of the locating setscrews to prevent oil leakage.

3. Withdraw from the twin rocker shafts, the rockers, rocker retaining springs, support standards and the spacing collars, until only the front and rear support standards remain assembled to the rocker shafts. Remove these shafts in an outward direction so as the whole length of each shaft traverses the support standard boss, thus the "O", or sealing ring will not be trapped in the dowel hole as would be the case if withdrawn inward.

4. Prise the sealing rings from the groove in each of the rocker shafts, using finger pressure only.

Inspection and Overhaul.

1. Examine the internal bore of the rockers and the region of the shafts, on which the rockers operate for wear, which if excessive will necessitate the renewal of the faulty components. Check each rocker foot for indentation and renew if excessive wear is present at this point. The rocker shafts should be straight to within ·002 in. (·051 mm.) total indicator reading over their full length.

2. Check the fit of the dowelled locating setscrews in the rocker shafts, noting that the rocker shafts are drilled ·316 in. (8·026 mm.) diameter in the case of the exhaust shaft, and ·257 in. (6·528 mm.) in the case of the inlet shaft.

3. The cone ended adjusting screws and their locknuts should be removed from the rockers and the following internal passages blown through with compressed air, thus ensuring that no restriction remains, to oppose the free flow of lubricant to the rocker gear:

(*a*) Vertical and horizontal drillings through the front and rear rocker shaft support standards.

(*b*) Drillings through the boss of the rockers.

(*c*) Drilling through the arm of the exhaust rockers only.

Ensure the central drilling and feed holes in the adjusting screws are clear and free from foreign matter.

4. Examine the small drillings in the rocker shaft and if obstructed they may be cleared with a length of thin wire, and then blown through with compressed air. Ensure the central passage in the rocker shaft is clear, and that the sealing plugs at the outer ends of the shafts are in position, and providing oil tight joints. Inspect the grooves in the shafts which locate the sealing rings, ensure they are free of burrs.

5. Check the conical end of the adjusting screws and the mating socket in the push rods for failure of the hardened surfaces, renewing the components, as necessary. Inspect the lower ball of the push rods on the spherical seating and their mating socket in the body of the tappets for failure of the hardened surfaces, renewing the components as necessary. Check the push rods for bend, which if found to be in excess of ·008 in. (·203 mm.) total indicator reading as measured over their overall length, the push rods must be renewed.

6. Check the fit of the tappet body in its respective cylinder block bore and then examine the lower face of the tappet that contacts the camshaft, any evidence of a ridge across this face indicates that the tappet has not rotated freely within its bore. Renew the faulty tappet ensuring that the new tappet is free to revolve in the cylinder block bore, and observe label identification made during the removal operations.

7. Examine the rocker retaining springs for damage and renew, as necessary (see "Manufacturing Data").

8. Renew the rocker shaft sealing rings if damaged in any way, if uncertain renew.

To Re-assemble.

When re-assembling the rocker gear, reference should be made to Fig. B.90, but before actually commencing re-assembly operations the components comprising the rocker gear should be arranged in exploded form, in assembly sequence, with the parts adopting the positions they will ultimately assume when assembled. Salient features of the components to be observed are as follows:

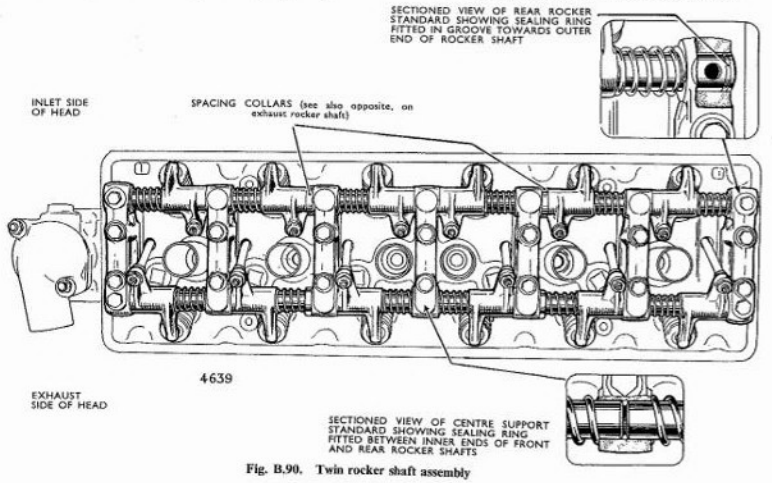


Fig. B.90. Twin rocker shaft assembly

(*a*) The front and rear rocker shaft support standards are distinguished by the extra tapped holes for the locating setscrews, and are interchangeable. The larger threaded hole in the boss of the support standard accommodating the larger threaded locating setscrew must be positioned on the left hand, or exhaust side of the engine. The remaining five intermediate support standards are interchangeable with each other, but not with the front and rear standards. It should be noted that the bosses on the support standards, which house the rocker shafts are offset from the rocker standard securing bolt holes, and the rocker standards must be positioned with this offset towards the right hand, or inlet side of the engine.

(*b*) Four rocker shafts are used, which are plugged at their outer ends, the outer end being the one that is machined to accept the dowelled locating setscrew and the sealing ring. To distinguish between the inlet and exhaust rocker shafts, the former is drilled ·257 in. (6·528 mm.) diameter to accommodate the dowelled locating setscrew, whilst the latter is drilled ·316 in. (8·026 mm.) diameter. A further simple means of recognising the respective shafts, is the length from the inner (unplugged) end to the first groove around the shaft, which is 2 in. (50·80 mm.) for the exhaust rocker shaft, and ·975 in. (24·77 mm.) for the inlet rocker shaft.

(*c*) The rockers are handed on both the inlet and exhaust sides in sets of three, therefore the rockers are not interchangeable, except within their respective sets of three. Components which are retained should be maintained in their original positions. The inlet rocker is distinguished by having a short curved arm, whilst the exhaust rocker has a longer arm slightly curved (see Fig. B.91).

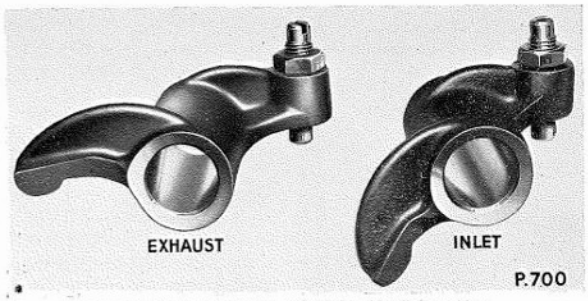
Assemble the rocker gear in accordance with the assembly shown in Fig. B.90, observing the following points:

1. It is important to ensure that a sealing ring is fitted to each rocker shaft at its plugged outer end. This is accomplished by inserting the outer end of the rocker shaft through the boss in the standard until the sealing ring groove is exposed, fitting the sealing ring over the protruding end of the shaft until it seats in the groove, and then finally drawing the shaft and ring back into the boss of the standard. Locate the rocker shaft in the standard by means of the respective size

locating setscrew. Fit the remaining shafts to the standards employing the same procedure. Ensure that the copper washers are in position under the heads of the locating setscrews.

Note: Any attempt to push the rocker shaft with the rubber ring fitted through the standard boss, will result in the rubber ring being damaged as it passes the hole for the shaft locating setscrew.

engine, offer the front and rear support standards up to their locations on the cylinder head, and lightly secure these outer support standards with the securing bolts. Ensure the securing bolts are each fitted with a copper washer beneath the head. Seat the adjusting screw ball ends in the sockets of the push rods and then position the intermediate support standards so as all the remaining securing bolts engage with their locations



Exhaust rocker illustrated is fitted to number 1, 2 and 3 cylinder positions
Inlet rocker illustrated is fitted to number 1, 2 and 3 cylinder positions

Fig. B.91. Rocker identification

2. The sealing ring used between the inner ends of each pair of rocker shafts in the centre support standard, must be fitted before assembling the shafts into this standard.

3. Spacing collars are fitted as shown between number 2 and 5 inlet rockers and the support standards, and between the rocker retaining springs and the support standards in number 2 and 5 exhaust positions.

4. When the complete rocker gear is assembled care should be taken to avoid the two halves of the assembly springing apart at the centre support standard.

To Refit.

1. If withdrawn, it will be necessary firstly to refit the tappets in their original positions, reversing the procedure adopted for removal. If the side cover plates were removed, note when refitting that the setscrew at the bottom centre of each cover is refitted with a copper washer under its head.

2. Insert the push rods through their respective bores in the cylinder head until they locate in the hollow barrels of the tappets, noting that the longer exhaust push rods enter the bores towards the centre of the cylinder head.

3. Slacken all the adjusting screws on the rockers to give maximum clearance, hold the rocker gear by the front and rear support standards and exert slight pressure inwards, ensure that the offset on the rocker shafts is towards the right hand, or inlet side of the in the cylinder head. Tighten the securing bolts evenly.

4. Adjust the valve clearances, as detailed on page B.78. Refit the rocker cover, ensuring that the grommets around the sparking plug tubes and the cover gasket are in good condition. Tighten the slotted fixing bolts evenly.

5. Re-connect the breather pipe and hose between the air cleaner hose and the rocker cover.

6. Clip the ignition leads and casings in position, the firing order being 1 : 5 : 3 : 6 : 2 : 4, with number 1 cylinder located at the front. Finally spring the ignition lead cover into position in the recess provided on the rocker cover.

TIMING COVER

To Remove.

1. Drain the cooling system, disconnect the radiator hoses and remove the radiator (see "Cooling System" section).

2. Remove the nuts securing the inlet manifold coolant pipe to the water pump inlet.

3. Disconnect the heater hose (if fitted) from the union on the water pump body.

4. Remove the water pump from its location on the timing cover, after releasing its securing nuts and bolt.

5. Turn the engine so that the T.D.C. line on the damper periphery aligns with the pointer on the timing

cover. Remove the crankshaft pulley and damper assembly securing bolt.

6. Withdraw the crankshaft pulley and damper assembly using normal hand pressure only. If a heavy interference fit is encountered, the use of Churchill Main Tool 55 and the Adaptor Set R.G.55-8 is recommended (see Fig. B.92), noting that it is first

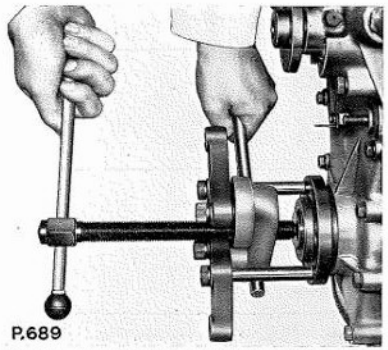


Fig. B.92. Withdrawing the crankshaft pulley boss, using the Churchill Main Tool 55 in conjunction with the adaptor set R.G.55-8

necessary to remove the setscrews securing the crankshaft pulley and the damper to the pulley boss, finally lifting these components clear. Identify the damper to the pulley boss in order that on re-assembly the relationship between the keyway and the T.D.C. line is maintained. It is now possible to apply the adaptor set R.G.55-8 to the flange of the pulley boss.

7. Release the sleeve nut securing the dynamo adjusting arm to the timing cover, and swing the arm clear.

8. Remove the bolts securing the timing cover to the front face of the cylinder block and lift away the cover.

Inspection and Overhaul.

1. Examine the water pump chamber and ensure that the relief hole positioned in the lower edge of the chamber is free from obstruction. Clean with a stiff length of wire, as necessary. Observe the mating hole in the cylinder block and make certain this hole is also clear of obstruction.

2. Inspect the oil seal in the timing cover and should it be damaged, or inefficient in operation, remove by pressing the seal from its bore, in either an inward or outward direction. Press in the new oil seal with its sealing lip pointing inwards towards the cylinder block side, until the inner face of the seal is 1·40 in. (35·56 mm.) from the inner joint face of the timing cover, as shown in Fig. B.93. It should be noted that the spigot on the timing case centraliser, Churchill Tool R.G.221, will also facilitate refitting the oil seal, pressing in to the dimension given previously.

To Refit.

Installation is a reversal of the removal procedure, bearing in mind the following points:

1. The joint faces of the timing cover and the cylinder block must be carefully cleaned and a new joint fitted, which in addition to sealing the timing gear provides the joint in the water relief passage, running from the water pump chamber to the cylinder block water jacket. Also fit a new joint between the timing cover and the cylinder block inlet water passage.

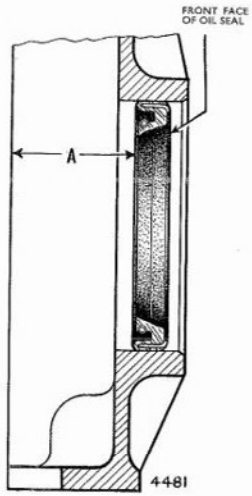
2. Centralise the timing cover over the crankshaft, using Churchill Tool R.G. 221, and then tighten the securing bolts in diagonal sequence.

3. If the damper has been separated from the crankshaft pulley boss, proceed in the following manner:

(*a*) Slide the pulley boss into position along the crankshaft spigot and key. Position the damper so as the marks made during removal operations are coincident.

(*b*) With the crankshaft set to T.D.C. the line on the damper periphery will align exactly with the pointer on the timing cover.

(*c*) With the crankshaft pulley boss and damper held in their original positions, locate the crankshaft pulley over the spigot on the pulley boss and secure the components using setscrews.



A — 1·40 in. (35·56 mm.)

Fig. B.93. Correct location of the oil seal in the timing cover

If however the crankshaft pulley, damper and pulley boss were not separated, refit by sliding home along the crankshaft spigot and key. Secure using the washer and bolt.

4. Refer to the "Cooling System" section and refit the water pump, install the radiator, and finally adjust the fan belt to the correct tension.

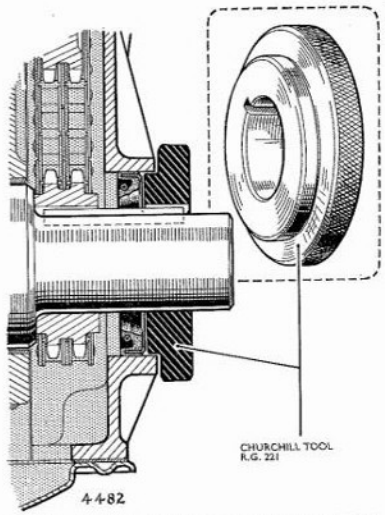


Fig. B.94. Centralising the timing cover, using Churchill Tool R.G.221

TIMING WHEELS AND CHAIN

To Remove.

1. Remove the timing cover (see under "Timing Cover—To Remove", on page B.91).

2. Release the tab washer and remove the bottom plug from the chain tensioner. Insert an Allen key ·125 in. (3·175 mm.) across flats into the hexagonal socket in the bottom of the restraint cylinder and then turn the key in a clockwise direction until the slipper head remains in the retracted position.

3. Turn back the tab washer, and then remove the setscrew, tab washer and plain washer securing the camshaft timing wheel to the front end of the camshaft.

4. To withdraw the timing wheels and chain it is recommended that suitable levers be used behind the timing wheels, applying preferably two levers behind the camshaft timing wheel at diagonally opposite points, and one behind the crankshaft timing wheel. Alternatively the Churchill Universal Puller 6312A applied behind the crankshaft timing wheel will facilitate the removal operation (see Fig. B.95). Lever off both wheels simultaneously, keeping them in line to avoid straining the chain, until the camshaft timing wheel is free of the camshaft spigot. It is now possible to slip the timing chain off the crankshaft timing wheel, thus allowing the wheel and chain to be lifted clear of the engine. Complete the removal of the crankshaft timing wheel.

Note: If a heavy interference fit is encountered when withdrawing the crankshaft timing wheel, the Churchill Universal Puller 6312A must be used. Similarly if a heavy interference fit is encountered when withdrawing the camshaft timing wheel, use Churchill Tool R.G.209.

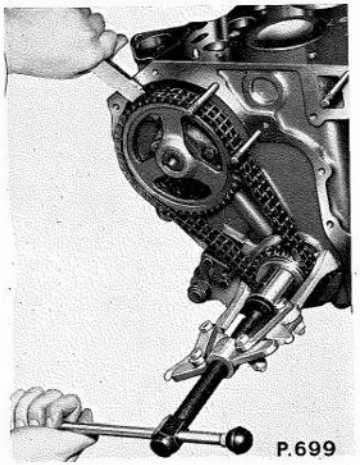


Fig. B.95. Withdrawing the timing wheels and chain, using the Churchill Tool 6312A to facilitate crankshaft timing wheel withdrawal

Inspection.

Thoroughly clean all components in paraffin before inspection. If the timing chain is retained it is important to soak in oil before refitting.

1. Examine the chain for broken rollers, or links, and for stretch.

2. Examine the teeth of the timing chain wheels for wear. A new chain must not be fitted to wheels which are noticeably worn, otherwise the new chain will wear rapidly.

3. Ensure the locating keys are a good fit in the crankshaft and camshaft, and in the keyways of the timing wheels.

4. Make certain that the chain tensioner is operating effectively (see below).

5. Ensure the timing gear oil feed hole in the slipper head of the chain tensioner is not obstructed (see Fig. B.97).

To Refit.

1. Set number 1 and 6 pistons to T.D.C. so that the key on the crankshaft front spigot is exactly to the top.

2. Push the crankshaft timing wheel on to the crankshaft until it is approximately 3·7 in. (94 mm.) from the shaft shoulder.

3. Loop the chain over the crankshaft timing wheel and then enter the camshaft timing wheel into the chain so that the marked tooth on the crankshaft timing wheel is positioned between the two marked teeth on the camshaft timing wheel, and the timing dots fall symmetrically about a line struck through the centres of the crankshaft and camshaft spigots (see Fig. B.96), ensuring that any slack in the timing chain is on the left hand (non-drive) side of the timing wheels when viewed from the front of the engine, i.e., in the position occupied by the chain tensioner (see Fig. B.96).

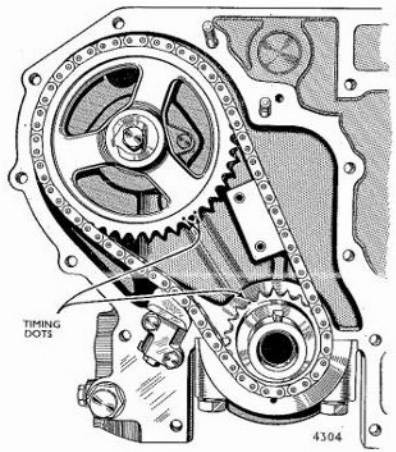


Fig. B.96. Correct positioning of the timing wheel marks, symmetrically about a line through the timing wheel centres

4. Turn the camshaft until the key lines up with the keyway in the camshaft timing wheel and **draw** the wheel on to the camshaft, alternately tapping the crankshaft timing wheel until both wheels are fully home. Check again that the timing dots fall symmetrically about a line struck through the centre of the crankshaft and camshaft spigots (see Fig. B.96), ensuring that any slack in the timing chain is on the left hand (non-drive) side of the timing wheels, when viewed from the front of the engine, i.e., in the position occupied by the chain tensioner.

5. Refit the camshaft timing wheel securing setscrew and plain washer, using a new tab washer. When the setscrew has been securely tightened, turn over the tab washer to lock.

6. Release the chain tensioner, by inserting the Allen key into the socket provided in the restraint cylinder, and turning the key slowly in a clockwise direction until the slipper head moves forward, when a click should be heard. Remove the Allen key. Refit the tab washer, and the bottom plug, securely tightening the plug and turning over the tab to lock.

7. Finally check the setting of the timing wheels, as detailed under "Valve Timing".

8. Refit the timing cover and the remaining components (see under "Timing Cover—To Refit", on page B.92).

AUTOMATIC TIMING CHAIN TENSIONER

Operation.

It will be observed from Figs. B.97 and B.126 that the construction of the chain tensioner is such that oil pressure provides the force to keep the timing chain in

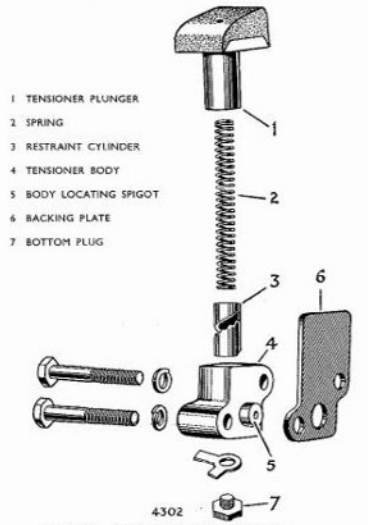


Fig. B.97. Timing chain tensioner details

correct tension and a spring is incorporated for auxiliary operation. A neoprene slipper head is mounted to the platform of the plunger (1), which also encloses the light spring (2), and the restraint cylinder (3), and upon starting the engine, the plunger in combination with oil pressure holds the slipper head against the outside of the timing chain.

Return movement of the slipper head is prevented by a limit peg at the bottom end of the plunger bore engaging the nearest tooth in the helical slot on the restraint cylinder. The oil enters the tensioner body (4), via a small drilling in the locating spigot (5), and a restricted amount passes through the hole in the slipper head to lubricate the chain. The backing plate (6) provides a guide for the slipper head and the timing chain.

To Remove.

1. Remove the timing cover (see page B.91).

2. Release the tab washer and remove the bottom plug from the chain tensioner. Insert an Allen key ·125 in. (3·175 mm.) across flats into the hexagonal socket in the bottom of the restraint cylinder, and then turn the key in a clockwise direction until the slipper head remains in the retracted position.

3. Remove the securing bolts and washers, withdrawing the tensioner complete with the backing plate.

To Dismantle.

1. Lift away the backing plate from the spigot on the tensioner body.

2. Slide out the plunger assembly from the body bore.

3. Using the Allen key withdraw the restraint cylinder from inside the plunger, after turning the key in a clockwise direction.

4. Lift the spring from out of the plunger.

Inspection and Overhaul.

1. The complete tensioner should be renewed if the timing chain has cut deep grooves in the slipper head.

2. The free length of the compression spring should be 2·92 in. (74·168 mm.). It should be renewed if it is considerably less than this dimension and the slipper head is in good condition, i.e., not grooved.

To Re-assemble.

1. Position the spring in the plunger and then locate the restraint cylinder over the exposed end.

2. Insert the Allen key into the socket of the cylinder and turn it clockwise, allowing the limit peg on the plunger to engage the helical slot in the cylinder. Continue to turn until the cylinder is below the limit peg.

3. Slide the plunger assembly into the body and complete the assembly by locating the backing plate in position to abut the rear face of the tensioner body.

To Refit.

1. Offer up the tensioner assembly to its mounting face on the front of the crankcase, locating the spigot in the recess and securing the tensioner with two bolts and washers.

2. Insert the Allen key into the socket in the restraint cylinder and turn slowly in a clockwise direction until the slipper head moves forward and an audible click is heard.

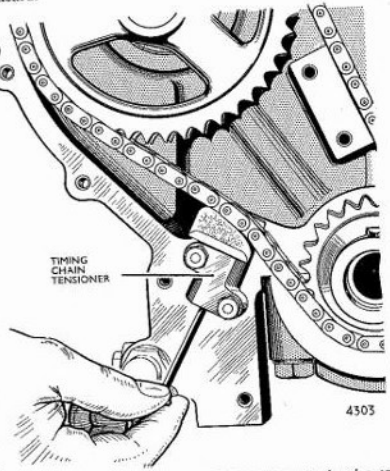


Fig. B.98. Releasing the timing chain tensioner head, using an Allen key

3. Refit the bottom plug and secure by means of the tab washer provided.

4. Complete the refitting operation by installing the timing cover, as detailed on page B.92.

CAMSHAFT

To Remove.

1. Disconnect the lead from one of the battery terminals.

2. Remove the distributor and its mounting clamp and bracket (see "Electrical Equipment" section), noting the number of shims fitted between the bracket and the cylinder block.

3. Screw a suitable length $\frac{7}{16}$ in. × 20 U.N.F. bolt firmly into the centre bore of the distributor driving shaft, and withdraw the shaft.

4. Remove the fuel lift pump, noting the insulating piece, also the number of joints used between the pump flange and the cylinder block pad (see "Fuel System" section).

5. Release the two bottom centre securing setscrews on the two side cover plates, noting that copper washers are used under the heads of these setscrews. Allow the camshaft chamber to drain of oil through these two holes before removing the cover plates, noting that the ignition coil must first be removed (see "Electrical Equipment" section). Once the cover plates are removed access is gained to the camshaft chamber and if necessary the two drain tubes may be withdrawn.

6. Remove the sump after raising the chassis on suitable jacks and supporting on stands. This operation allows the sump to be lowered to clear the oil pump strainer, then moved rearward and finally lifted away. Disconnect the oil delivery pipe, release and then withdraw the oil pump, complete with the strainer (see page B.125).

7. Remove the cylinder head (see page B.80) and withdraw the tappets from the bores in the cylinder block, ensuring that they are suitably identified to their original positions.

8. Remove the radiator grille, complete with side panels and lamps (see "Cab and Body" section), and the radiator (see "Cooling System" section).

9. Remove the water pump and timing cover (see page B.91), followed by the timing wheels and chain, as detailed on page B.93).

Note: Prior to removing the camshaft timing wheel, check the end float of the camshaft with a dial gauge. If the end float exceeds ·0033 in. to ·0053 in. (·084 mm. to ·135 mm.) a new thrust plate must be fitted during installation. (See also para. 4 under "Inspection and Overhaul".)

10. Release the two setscrews securing the camshaft thrust plate to the front of the cylinder block and remove the thrust plate.

11. Withdraw the camshaft carefully, using one hand inserted in the chamber to guide the camshaft through its bearing as it is withdrawn.

Inspection and Overhaul.

1. Wear on the camshaft journals and bearings will under normal conditions be very slight as the bearings are adequately lubricated. Camshaft bearing clearances can be measured by means of a feeler gauge and these clearances are given under "Manufacturing Data". However, if it is necessary to renew the camshaft bearing, proceed as detailed in para. 2.

2. To fit new camshaft bearings, the engine must be first removed from the chassis (see page B.116) and then the following additional components removed; the clutch housing (see under the "Clutch and Propeller Shaft" section), and the sealing disc located at the rear of the rear camshaft bearing. Replacement camshaft bearings are pre-finished to size therefore every care should be taken to avoid damaging the bearing edges.

To facilitate the removal and refitting of the camshaft bearing it is recommended that Churchill Main Tool 32 be used, in conjunction with the Adaptor Set R.G.32-5, proceeding in the following manner:

(*a*) The front intermediate, or rear intermediate camshaft bearing may be removed by employing two Code 3 adaptors, in conjunction with the main tool, using one adaptor as a centraliser in the outer camshaft bearing, and using the other adaptor in the intermediate camshaft bearing as a withdrawal pad. Assemble the main tool and feed the centre screw of the tool through the centraliser and the adaptor until it is possible to assemble the "Cee" washer to the centre screw (see Fig. B.99). Ensure the centre screw remains stationary and turn the wingnut of the main tool until the intermediate camshaft bearing is withdrawn. Dismantle and remove the tool.

(*b*) Using the adaptor, Code 3, in conjunction with the main tool it is possible to remove either the front, or rear camshaft bearing observing that the spigot of the adaptor should be positioned in the bearing to be removed, so as to face outward, i.e., the larger diameter head of the adaptor is innermost. Feed the centre screw of the main tool through the adaptor and assemble the "Cee" washer to the centre screw. Ensure the centre screw remains stationary and turn the wingnut of the main tool, thus withdrawing the bearing. The tool, adaptor and bearing may now be lifted clear complete, and then the components dismantled from one another.

(*c*) To fit a new front, or rear camshaft bearing, use the adaptors Code 1, 2 and 3, in conjunction with the main tool, noting that adaptors Code 1 and 2 act as stop pads. Proceed to fit the new bearings as follows:

(i) In the case of the front camshaft bearing, position the new bearing on the spigot of the adaptor, Code 3, and locate the inner stop pad, Code 2, in the front bearing housing, so as to abut the front crankcase face. Register the outer stop pad, Code 1, over the pad Code 2, and slide home until the outer stop pad contacts the front crankcase face. Assemble the main tool, feed the centre screw of the tool through the stop pads, Codes 1 and 2, and then slide the centre screw into the crankcase until it is visible through the chamber aperture. The body of the main tool registers over the outer stop pad, Code 1.

Insert the front camshaft bearing and the adaptor, Code 3, through the chamber aperture, sliding these components down the centre screw, until it is possible to position the "Cee" washer. Ensure the camshaft bearing is fitted foremost on to the main tool centre screw to abut the housing. Draw on the centre screw and apply hand pressure to the body of the main tool until the adaptors abut, noting that the "Cee" washer is not displaced during this operation.

Refer to the important note on alignment of oil holes given in para. (e) before commencing fitting the new bearing. Ensure the centre screw remains stationary and turn the wingnut of the

main tool, until the camshaft bearing is felt to abut firmly against the inner stop pad, Code 2, which in the latter stages of this operation moves outward with the bearing and finally abuts the outer stop pad, Code 1. Do not apply unnecessary pressure to the wingnut, otherwise damage to the bearing could result when contacting the stop pad. Dismantle and remove the tool.

(ii) To refit the rear camshaft bearing, position the new bearing on the spigot of the adaptor, Code 3, and then register the spigot of the outer stop pad, Code 1, in the rear bearing housing, so as the flange abuts the rear crankcase face. Assemble the main tool, feed the centre screw of the tool through the stop pad, Code 1, and then slide the centre screw into the crankcase until it is visible through the chamber aperture. The body of the main tool abuts the outer face of the stop pad, Code 1.

Insert the rear camshaft bearing and the adaptor, Code 3, through the chamber aperture, sliding these components down the centre screw until it is possible to position the "Cee" washer. The camshaft bearing must be fitted foremost on to the centre screw of the main tool to abut the housing. Draw on the centre screw, and apply hand pressure to the body of the main tool until the adaptors abut, noting that the "Cee" washer is not displaced during this operation.

Refer to the important note on oil hole alignment given in para. (e) before commencing fitting the new bearing. Ensure the centre screw remains stationary and turn the wingnut of the main tool until the camshaft bearing is felt to abut firmly against the outer stop pad, Code 1. Do not apply unnecessary pressure to the wingnut otherwise damage to the bearing could result as it contacts the stop pad. Dismantle and remove the tool.

(*d*) To fit an intermediate camshaft bearing, use three, Code 3 adaptors, in conjunction with the main tool, two of the adaptors acting as centralisers during this operation, whilst the third is located in the bearing and forms a refitting pad. Locate one centraliser, Code 3, in the outer camshaft bearing (front, or rear position according to whether the front, intermediate or rear intermediate bearing respectively is being fitted) positioning as for the removal operations. Locate the second centraliser, Code 3, in the intermediate bearing housing so as the spigot on this centraliser faces in an outward direction toward the main tool.

Assemble the main tool and feed the centre screw of the tool carefully through the centralisers, ensuring they are not displaced, until the centre screw is just protruding from the opposite side of the intermediate bearing housing. Locate the refitting pad, Code 3, into the camshaft bearing, and then enter the two components through the chamber aperture to engage the centre screw of the main tool, the bearing being positioned foremost to abut the housing. Continue feeding the centre screw inwards, until it is possible to position the "Cee" washer on the centre screw. Enter the "Cee" washer into the camshaft chamber through the aperture at the head of the oil pump drive, after removing the cover plate. Draw on the centre screw, and apply hand pressure to the body of the main tool until the adaptors abut, noting that the "Cee" washer and the centralising adaptors are not displaced during this operation.

Refer to the important note on oil hole alignment given in para. (e) before commencing fitting the new bearing. Ensure the centre screw remains stationary and turn the wingnut of the main tool (see Fig. B.99) until the camshaft bearing is flush with the end faces of its housing, finally checking that the oil holes in the bearing are in alignment with the oilways in the housing, correcting if necessary. Dismantle and remove the tool.

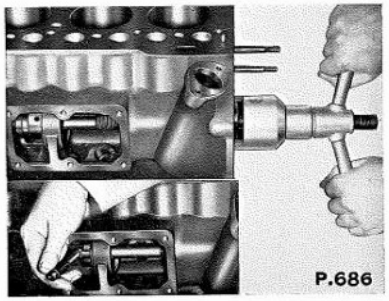


Fig. B.99. Fitting the new front intermediate camshaft bearing, using the Churchill Tool 32 in conjunction with the adaptor set R.G.32-5 (Inset shows the method of bearing removal)

(*e*) It is important to note before drawing the bearing into position, that the oil feed holes in the bearing are in line with the mating oilways in the housing.

(*f*) The camshaft bearings are of the steel backed, white metal lined type and care must be taken not to damage the edges of the white metal during fitting operations. If necessary remove any burrs or sharp edges with a scraper. On completion, it is essential that the new bearings, and the cylinder block, are cleaned out and the oilways re-checked for alignment.

3. Examine the cam lobes, fuel lift pump eccentric and journals for wear, or scores, and teeth of the gears formed at the front and centre of the camshaft for damage. Renew the camshaft, if necessary.

4. Inspect the distributor driving shaft for wear on the pilot diameter and its mating bore in the cylinder block, also check the shaft gear teeth for damage, and renew the driving shaft, as necessary.

5. If the camshaft thrust plate is worn or scored it should be renewed to ensure that the recommended end float figure on the camshaft is maintained.

To Refit.

1. Fit the camshaft to the cylinder block and secure with its thrust plate.

2. Ensure the engine crankshaft is set with numbers 1 and 6 pistons at T.D.C. as given by the feather key in the crankshaft front spigot being exactly at the top.

3. Refit the timing wheels and chain, as detailed on page B.94 and upon installation of the tappets, push rods and rocker assembly (see page B.91), check the valve timing, as detailed on page B.99.

4. Check that the camshaft has retained the recommended end float of ·0033 in. to ·0053 in. (·084 mm. to ·135 mm.), which may be measured by means of a dial gauge, as shown in Fig. B.100.

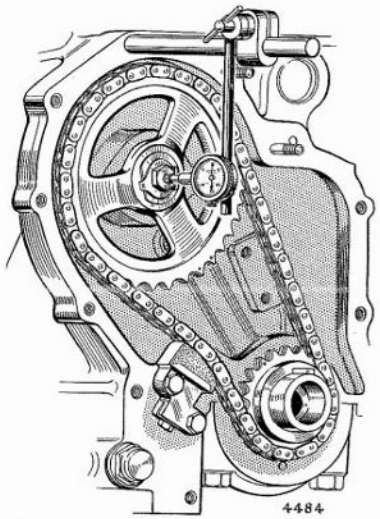


Fig B.100. Checking the camshaft end float, using a dial gauge

5. Set the crankshaft with number 1 and 6 pistons at T.D.C. position with number 1 cylinder firing, as indicated by the valves on number 6 cylinder "rocking". Locate the distributor driving shaft so as the offset slot in the top flange of the shaft assumes the position as shown in Fig. B.101, with the engine set to T.D.C., and firing on number 1 cylinder.

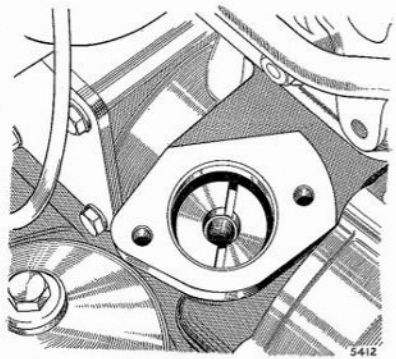


Fig. B.101. Correct location of the offset slot in the distributor driving shaft after fitting, with the engine set at T.D.C. and firing on number 1 cylinder

6. Ensure the same number of shims abut the distributor mounting bracket as on removal. Refit the distributor complete with the clamp and bracket to the block, engaging the distributor dog with the driving shaft flange, noting that if either the bracket or the distributor drive shaft have been renewed, the shaft must be checked for end float, as follows:

(*a*) Identify the distributor clamp to the mounting bracket and remove the distributor and clamp complete. This operation does not apply when a new mounting bracket is used.

(*b*) Ensure the distributor mounting bracket is securely bolted to the crankcase and the mating faces are perfectly clean and free of burrs.

(*c*) Screw a suitable length $\frac{7}{16}$ in. × 20 U.N.F. bolt firmly into the distributor driving shaft and mount a dial gauge to record the end float of the shaft, as the bolt is moved from a maximum upward position, to a maximum downward position. The recorded end float should not exceed ·005 in. (·127 mm.).

(*d*) If the end float on the drive shaft is above the recommended figure, shims should be removed from between the bracket and the cylinder block, until the correct end float results. Alternatively should the end float be found to be below the recommended figure, shims must be added until a correct end float reading is obtained. Shims are available in ·005 in. (·127 mm.) and ·015 in. (·381 mm.) thicknesses.

(*e*) Refit the distributor and clamp to the mounting bracket, aligning the marks made previously. In the case of a new mounting bracket, it will be necessary to reset the distributor, as detailed under the "Electrical Equipment" section. Ensure that the oil seal positioned between the bracket and the distributor clamp is in good condition, and correctly located in the recess provided in the bracket, prior to fitting the distributor.

7. Check the ignition timing as detailed under the "Electrical Equipment" section.

8. Refit the oil pump and the sump (see pages B.126 and B.124 respectively).

9. Install the fuel lift pump, ensuring that the insulating plate is in position and the same number of joints are fitted to the pump flange as found on removal (see "Fuel System" section).

10. Complete the operation by reversing the remaining removal operations.

VALVE TIMING

Providing the timing chain has been correctly assembled on to the timing wheels, the engine valve timing will be correct as shown in Fig. B.102. Should an occasion arise when it is suspected that the valve timing is incorrect through wrongly refitting the timing chain

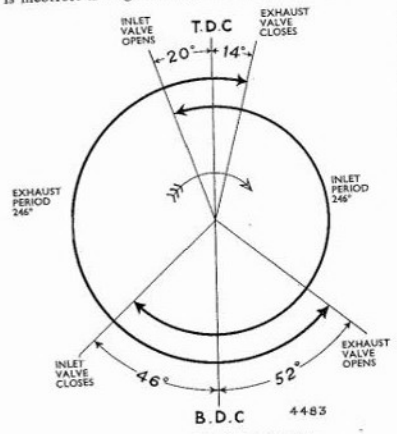


Fig. B.102. Valve timing diagram

and wheels, the following check can be made with the engine either in, or out of the vehicle, providing the timing cover and the crankshaft pulley assembly are in position.

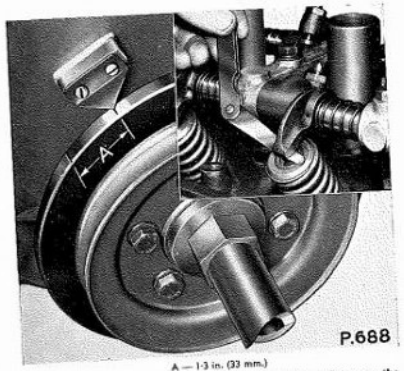
1. Remove the sparking plug cover, the ignition leads and casings from the sparking plugs, and finally remove the rocker cover, after first disconnecting the breather pipe hose. Ensure that the rocker cover joint and the sparking plug tube grommets are not damaged unduly as the cover is lifted clear.

2. Turn the engine so that number 6 cylinder inlet valve is fully open.

3. Set number 1 inlet valve rocker clearance to ·021 in. (·533 mm.). It is most important that this clearance is used and **not** the normal rocker clearance.

4. With number 1 inlet rocker set to this checking clearance the opening point of number 1 inlet valve, which is 20° B.T.D.C. can be checked in the following manner:

(*a*) Clean and chalk the crankshaft damper rim for about 1⅛ in. (38 mm.) in a clockwise direction from the T.D.C. mark on the damper rim.



A — 1·3 in. (33 mm.)

Fig. B.103. Checking the valve timing using the pointer on the timing cover and the groove on the damper rim (Inset shows a ·0015 in. (·038 mm.) feeler gauge just gripped by number 1 cylinder inlet rocker, when dimension "A" is attained)

Note: The cranking handle dog nut illustrated is supplied with the cranking handle kit only.

(*b*) From the damper T.D.C. line, mark off a line with dividers, on the damper rim 1·3 in. (33 mm.) before the T.D.C. position, and pencil a line clearly on to the chalked rim.

(*c*) The 1·3 in. (33 mm.) dimension is the chordal distance and equivalent to the required angle of 20° at the damper rim radius of 3·75 in. (95·25 mm.), and because it is a chordal length, **dividers set to the dimension of 1·3 in. (33 mm.) must be used for marking off.**

5. Turn the engine in a clockwise direction viewed from the front, until number 1 inlet valve just begins to open, and then a further 1¾ turns to bring number 1 cylinder on the exhaust stroke, a quarter of a turn before number 1 inlet valve opens.

6. Now turn the engine very slowly, still in a clockwise direction, until number 1 inlet rocker just grips a ·0015 in. (·038 mm.) feeler. If the valve timing is correct the pencil line made on the damper rim will come exactly opposite to the pointer on the timing case. The timing mark and pointer can be viewed to advantage from the front, towards the right hand side of the engine, and at an angle through the aperture formed between the radiator header tank and the water pump inlet pipe.

Note: The correct valve timing is absolutely dependent upon the correct fitting of the timing wheels. Therefore should the above check prove the valve timing to be incorrect, remove and refit the timing wheels, as detailed on pages B.93 and B.94.

7. Reset number 1 inlet rocker to its normal clearance of ·014 in. (·356 mm.), with number 6 inlet valve fully open.

8. Refit the remaining components by reversing the removal procedure, ensuring that the rocker cover is correctly seated to provide oil tight joints.

PISTON AND CONNECTING ROD ASSEMBLIES

To Remove.

1. Drain the engine oil and remove the sump (oil pan) (see page B.124). Withdraw the dipstick.

2. Disconnect the oil pump outlet pipe, release and then withdraw the oil pump, complete with the strainer (see page B.125).

3. Remove the cylinder head (see page B.80).

4. Release the self-locking nuts securing the big end caps to the connecting rods.

5. Remove the caps and the lower bearing halves. Raise the connecting rods until it is possible to free the upper bearing halves. If the original components are to be used again it is essential that the big end caps be re-assembled to the same rods, from which they were removed and the complete rods refitted to the same crankshaft journal. The bearing shells must be kept paired to their respective connecting rod, also maintaining each bearing half in its original position in the big end bore. For the purpose of identification, the connecting rods and caps are numbered 1 to 6 from the front of the engine, the number being stamped on the outside of the upper and lower halves of the big end on the same side as the oil squirt hole, i.e., to the right hand side of the engine when viewed from the rear.

6. Scrape away the carbon from around the tops of the cylinder bores and slide the piston up the bores. Withdraw the piston and connecting rod assemblies from above, noting the radial location of the piston ring gap in respect to the top chromium plated piston ring only, as each piston is withdrawn. If these piston rings are to be refitted they must assume their original positions in order to avoid unnecessary bedding down, therefore, identify the rings to the cylinder block to assist the location of the rings on re-assembly.

Note: Piston and connecting rod assemblies cannot be withdrawn through the crankcase, as the piston diameter will not pass the main bearing bosses.

7. Refit each connecting rod cap on to the cap bolts and secure with the nuts, until they are finger tight.

To Dismantle.

1. Remove the rings from the pistons, keeping the piston rings to their respective piston in sets, if they are to be used again. Care should be exercised when handling the scraper ring to avoid damaging its thin scraping edges.

2. Scrape away any carbon that has accumulated in the outer ends of the gudgeon pin bore. Remove the circlips retaining the gudgeon pin in the piston with circlip pliers, Churchill Tool 7065A, fitted with type "A" points.

3. As the gudgeon pin is a finger push fit in the piston bosses, excessive heating of the piston is unnecessary to remove the pin, but to facilitate the operation, immerse the piston in hot water before pushing out the gudgeon pin. Separate the pistons and connecting rods. If the original components are being retained, suitably identify the gudgeon pin to its respective piston. The pistons and connecting rods are easily identified as each set of components are numbered 1 to 6 from the front of the engine.

Inspection and Overhaul.

Pistons.

1. Remove any carbon deposits that have formed on the piston crown, the inside faces of the piston and the piston ring grooves. Do not use abrasives for this purpose.

2. Examine the piston body for score marks. A badly scored piston must be renewed. It is recommended that a careful examination of the cylinder, from which the piston was removed be carried out for possible scoring of the bore. If excessive scoring is present it will be necessary to rebore the cylinder block.

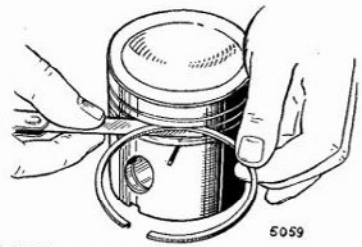


Fig. B.104. Checking piston ring to groove vertical clearance, using a feeler gauge

3. Check the piston rings for vertical clearance all round their respective grooves (see Fig. B.104). The piston rings and/or pistons should be renewed if the vertical clearance is appreciably in excess of the following designed limits:

(*a*) Compression rings ·0019 in. to ·0039 in. (·048 mm. to ·099 mm.).

(*b*) Scraper ring ·0015 in. to ·0035 in. (·038 mm. to ·089 mm.).

4. The pistons and cylinder bores are graded thereby enabling selective fitting of the new components. The grade letters are stamped on the crown of the piston and on the ledge located in the centre of the right hand wall of the cylinder block at the top, just below the cylinder head gasket (see also under "Matching New Pistons to a New Cylinder Block"). If new pistons are to be fitted it must be borne in mind that the maximum weight variation permissible between any two pistons in a set is 4 drams (7·10 grm.).

Note: When fitting new pistons a careful check should be made to ensure that replacement pistons bear similar identification numbers on the crown to the original pistons, i.e., 1,207,146, indicating a compression ratio of 6·5: 1.

Matching New Pistons to a New Cylinder Block (Service Replacements).

1. Every effort is made in the course of manufacture to ensure that pistons and cylinder bores conform to the designed dimensions on the critical machined diameters, however, normal production methods allow for a minute variation on these diameters and so to ensure an ideal working clearance is maintained between pistons and cylinder bores on all engines, these components are classified into different grades. Replacement cylinder block bores are graded A, B, C and D, and the pistons A, B, C, D and E, piston grade E being generally used for service replacements only. The variation in size between each grade letter is ·0004 in. (·010 mm.). Piston and cylinder bore grading tables are given under "Manufacturing Data", and when referring to these tables equivalent diameters for each grade letter in respect of both pistons and cylinder bores are immediately apparent. Always quote the required grade of piston when ordering. It is normal practise to supply cylinder blocks separately, but a set of suitably graded pistons can be supplied to suit any given block. Cylinder blocks complete with pistons are not serviced under one part number.

2. The grading letter stamped on the ledge located in the centre of the right hand wall of the cylinder block, at the top just below the cylinder head gasket, and on the crown of the pistons, should be observed when selectively fitting the pistons to the cylinder bores. Select pistons carrying the same grading letter as the cylinder bores to which they are to be fitted, and then finally check the fit of each new piston in its respective bore, as detailed under "Piston Fitting", on page B.102.

Important: The information given in para. 2 applies to new components being matched for assembly, but it is important to note that this does not apply once the engine has been partly, or fully run-in and in this case to ensure a correct piston clearance is obtained, the piston must be fitted to the cylinder bore as detailed under "Piston Fitting", on page B.102. This latter procedure also applies to rebored cylinder bores (see below).

To Rebore Cylinder Block and Fit Oversize Pistons.

1. Pistons are available in an oversize of +·030 in. (+·762 mm.), always quote this oversize when ordering.

Before reboring the cylinders, the diameters of the oversize pistons should be measured at right angles to the gudgeon pin axis at the top of the piston skirt and as close to the scraper ring groove as possible. The dimensions obtained should be compared with the piston grade diameters given under "Manufacturing Data", and should agree with the grade "B" diameter, plus the oversize dimension stamped on the piston crown.

Note: The pistons are of the split skirt type ground oval with a tapered and barrelled form and thus the piston grade dimensions must be taken at the upper skirt diameter, i.e., just below the scraper ring groove, and not at the bottom of the skirt.

For service use with rebored cylinders, oversize pistons will not be supplied to any particular grade, since grading is incidental to final fitting. As previously mentioned, oversized pistons are based on grade "B" diameter.

2. The cutting tool (or tools) of the boring machine must be set to bore the grade "B" cylinder diameter (see "Manufacturing Data"), plus the oversize dimension stamped on the piston crown. Honing of cylinders to a finish after boring is recommended, and due allowance must be made for this when setting the boring tool. The honed finish must give a cross hatched surface equivalent to 20 to 40 micro inches, i.e., the finish obtained by thoroughly rubbing a used cylinder bore with a piece of worn No. 1 emery cloth to obtain a mat finish. Bores must be produced parallel and round to within ·0004 in. (·010 mm.).

3. After boring and honing the cylinder to size a designed clearance of ·0035 in. to ·0043 in. (·089 mm. to ·109 mm.) will result between the piston upper skirt diameter and the cylinder wall.

4. The use of a cylinder gauge, such as the "Mercer" is recommended for cylinder measurement, after carefully setting the gauge to a "zero" reading in an accurate ring gauge. Alternatively a checked internal micrometer may be used for this measurement. Top, middle and bottom of each bore should be measured, both in line with, and at right angles to, the gudgeon pin axis.

5. It is advisable to re-grind and reset the cutter after completing each cylinder bore.

6. If equipment is not available to measure the oversize piston and cylinder diameters, the cylinders should first be bored out until close proximity of the piston diameter is obtained using the head of the oversize piston as a guide. It is recommended that the measurement of approximately ·001 in (·025 mm.) below the grade "B" cylinder diameter, plus the oversize dimension stamped on the crown be used for guidance at this stage. Now progressively enlarge the cylinders by honing, maintaining the finish previously detailed, until it is possible to fully insert the piston in the cylinder bore with the following clearance present between the bottom of the piston skirt and the cylinder wall.

(*a*) Carefully clean the bore and the outside piston diameter, thoroughly lubricating these surfaces using new engine oil. Wipe off with a dry clean cloth leaving a residual oil film on the bore and piston diameter.

(*b*) Invert the piston and insert it into the bore along with a feeler strip $\frac{1}{2}$ in. (12·7 mm.) wide and ·0015 in. (·038 mm.) thick. The feeler must be interposed between the skirt thrust face (opposite the diagonally slotted face) and the cylinder wall.

(*c*) Push the piston and feeler strip into the bottom of the cylinder bore, and holding the piston stationary, withdraw the feeler strip when a resistance equivalent to 3 to 4 lb. (1·36 to 1·81 kg.) should be apparent, with the piston and cylinder wall wiped dry from an oiled condition.

7. When the oversize piston fits the bore correctly, mark the corresponding bore number on the piston crown.

Measuring Piston Diameter.

1. Pistons are finished ground slightly oval in the plan view, the greater dimension, i.e., major axis, being at 90° to the gudgeon pin hole. In addition to this, the pistons taper slightly from the top to the bottom and have a split skirt. In view of these conditions, measurement of the true piston diameter must be made at the top of the piston skirt, just below the scraper ring groove, and at 90° to the gudgeon pin hole (see Fig. B.105).

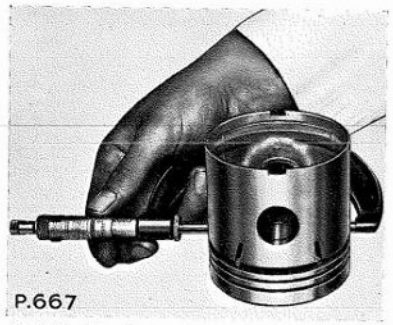


Fig. B.105. Measuring the piston diameter, using a micrometer

2. Measurements should be taken with a micrometer equipped with a vernier scale.

Piston Fitting.

When fitting a new piston, check the clearance in its respective cylinder bore in the following manner:

1. Using a suitable cylinder gauge such as the "Mercer", measure the cylinder bore diameter below the piston ring travel. Before commencing this operation it is essential that the gauge is carefully set to a "zero" reading in an accurate ring gauge. Top, middle and bottom of each bore should be measured both in line with, and at right angles to, the gudgeon pin axis, thus establishing the condition of the cylinder bore. In the case of a new replacement cylinder block this operation is unnecessary. Alternatively a checked internal micrometer may be used for taking these measurements.

2. Compare the measurements obtained in para. 1 with the piston grade diameters given under "Manufacturing Data", and select a piston to fit the cylinder bore with a clearance of ·0035 in. to ·0043 in. (·089 mm. to ·109 mm.) present between the two components. It is important to note that this clearance is calculated between the piston skirt, on the diameter immediately below the scraper ring, at right angles to the gudgeon pin axis, and the cylinder wall.

Example of Piston Fitting.

Cylinder Bore Diameter 3·4377 in. (87·318 mm.).
Mean Piston Clearance ·0039 in. (·099 mm.).
Therefore 3·4377 in.—·0039 in.= 3·4338 in.
(87·318 mm.)—(·099 mm.)=(87·219 mm.).

Thus the piston grade tolerance which incorporates the dimension 3·4338 in. (87·219 mm.) is grade "C", and a grade "C" piston must be fitted.

3. If the cylinder bore has sustained slight damage through seizure, or is slightly tapered it should be honed out to take a larger grade piston, alternatively the cylinder block must be rebored and oversize pistons fitted (see under "To Rebore Cylinder Block and Fit Oversize Pistons").

4. In the absence of suitable piston and cylinder measuring equipment the piston should be selectively fitted to the cylinder bore using a feeler gauge and spring balance as detailed under "To Rebore Cylinder Block and Fit Oversize Pistons", paras. 6 (*a*) to 6 (*c*).

Cylinder Liners.
To Fit.

These instructions apply to engines which are not fitted with liners, those engines which have liners already fitted should be dealt with as described under "Cylinder Liners—To Renew".

If the fitting of liners is to prove really successful a high degree of skill on the part of the operator is required, coupled with first-class precision equipment.

If after considerable mileage, it should be decided to install liners, it is absolutely essential that the procedure laid down in the ensuing paragraphs is rigidly adhered to, as otherwise there is every possibility of the operation proving unsatisfactory.

1. Remove the engine from the chassis and dismantle (see under the appropriate section headings).

2. Measure the external diameter of the liners and check against the figures detailed in para. 4.

3. Measure the diameter of the cylinder bores below the piston ring travel to establish the amount of material to be removed.

4. The outside diameter of the liners is 3·597/3·598 in. (91·364/91·389 mm.), and to accommodate these liners the cylinder block should be bored to a diameter of 3·593/3·594 in. (91·262/91·288 mm.). It is imperative to strictly adhere to the dimensions given, thus the cylinder block will be bored out to suit the liners and the prescribed interference fit of ·003 in. to ·005 in. (·076 mm. to ·127 mm.) will be maintained. Every possible precaution must be taken to ensure concentricity and correct size for the full length of the bore.
Important: Finish boring and honing of the liners must not be attempted until all liners have been fitted.

5. Enter the liner perfectly square into its bore and press in from above. To facilitate fitting, a ·25 in. (6·35 mm.) parallel "lead-in" is provided at the lower end of the liner. When inserting the liner, the load should be released several times during the first inch or so, thus allowing the liner to correct any slight mal-alignment which may be present. Press the liner home so that the upper end is exactly flush with the top of the cylinder block.

6. When each of the liners has been treated as above, they may be finish bored and honed to suit the new standard pistons, allowing for piston clearance as previously described.

To Renew.

The method used to remove liners will depend to a great extent on the facilities available. Liners may be drawn out from the top of the block, or alternatively pressed out from below.

Note: Liners cannot be pressed out from the top of the block as they will not pass the main bearing webs.

1. Check the cylinder block for concentricity and correct size over the full length of the bore after removal of the old liners. If the diameter is in excess of 3·594 in. (91·288 mm.), the correct interference fit will not be obtained.

2. Provided the conditions set out above are fulfilled, press in the new liners. Finally, bore and hone the liners to suit the new standard pistons.

Cylinder Block Sealing Cups (Water Jacket).

To renew the cups used to seal the cylinder block water jacket orifices, proceed as follows:

1. Drill through the existing sealing cup(s) and lever out using a suitable bar, ensuring that the parent bore in the cylinder block is not damaged during this operation.

2. Using a hand scraper, carefully clean around the parent bore, removing any accumulated foreign matter.

3. Examine the new sealing cups, noting that they are tapered on their outer circumference to provide an interference fit when driven fully home in the block.

4. Apply jointing compound to the outside diameter of the cup and the inside diameter of the bore.

5. Enter the minor diameter of the sealing cup into the parent bore, and using a shouldered drift applied to the outer edge of the cup, drive fully home.

Cylinder Block Sealing Plugs (Main Oil Gallery).

To Remove and Refit.

If the sealing plugs are removed for the purpose of cleaning through the main oil gallery, observe that the threads of the rear sealing plug should be coated with sealing compound prior to refitting, in order to provide an effective seal. The front plug is sealed by a copper washer.

Piston Rings.

The following piston rings are fitted to all standard and oversize pistons.

1. Top Compression Ring. This is a cast iron ring, chromium plated on its periphery, which may be fitted either way up in the piston groove. The ring is specially treated on the periphery to assist "bedding-in", and this treatment leaves the surface dull grey and slightly red in colour. It should be noted that these rings require a greater mileage to bed down to their respective bores, and if for any reason the pistons are removed a careful note should be taken of the position of the ring gap as the piston is withdrawn. This will enable the rings to be refitted in exactly the same radial position in their bores, assuming they are in good condition, and ensure that they will again operate in the position into which they were initially "bedded-in".

Where the need arises to fit new chromium plated rings to polished (part worn) bores, it will be necessary first to remove the glaze from the bores as otherwise these rings inserted into polished bores would never bed down properly.

The procedure to adopt in such cases is as follows:

(*a*) Mask off the bottom of the cylinders to prevent any abrasive matter reaching the crankshaft, or crankcase.

(*b*) Make up a wooden dummy piston which will fit snugly into the bore. Wrap a piece of No. 1, or 1½ grade emery paper around the dummy.

(*c*) This dummy piston, with the emery around it, should then be inserted into each cylinder in turn and moved up and down the bore for about 3 minutes (each cylinder) at the same time rotating it first one way and then the other until the entire cylinder wall is covered with criss-crossed abrasions.

(*d*) Wash down the bores thoroughly and dry them out, ensuring that no foreign matter finds its way into the crankcase.

2. Second Compression Ring. To provide more rapid "running-in" and to assist in oil control, a compression ring, shouldered on its lower outer periphery, is fitted in the second groove from the piston crown, on both standard and oversize pistons. It is most important that the piston ring is correctly fitted with the recessed face downwards, that is, with the widest face towards the top of the piston. The wide face is marked "TOP" to indicate that it should be fitted uppermost. Incorrect fitting will result in higher oil consumption.

3. Oil Scraper Ring. A slotted type oil control ring is fitted in the third groove of the piston. Careful fitting is needed to prevent breaking the two very narrow scraping edges of this ring. It is essential that this instruction be borne in mind when fitting the pistons and rings to the cylinder bores, and to obviate damage a ring compressor must be used (see also "Piston and Connecting Rod Assemblies—To Refit", on page B.108).

Fig. B.106. Checking the piston ring gap in the cylinder bore, using a feeler gauge

4. Piston Ring Gaps and Clearances. To check the piston ring gap, fit the piston ring to its respective cylinder bore so that it assumes a position at right angles to the axis of the bore. This is readily attained if the particular piston is inserted in the bore momentarily and the piston ring brought to rest on the crown of the piston, thus ensuring that the ring is square in the bore. Check the piston ring gap by means of a feeler gauge (see Fig. B.106), making sure that the rings checked in number 1 cylinder belong to number 1 piston, etc., and that the respective assembly of piston and rings are fitted to this bore on final installation, a number is carried on each piston crown for the purpose of easy identification. The ring gaps must be within the following limits when fitted to their respective cylinder bores:

(*a*) Top compression ring ·014 in. to ·022 in. (·356 mm. to ·559 mm.).

(*b*) 2nd compressor and scraper rings ·010 in. to ·015 in. (·254 mm. to ·381 mm.).

A nominal gap of ·52 in. (13·21 mm.) for compression rings, and ·46 in. (11·68 mm.) for scraper rings, should be present with the rings free.

With a feeler gauge check the rings for correct vertical clearance all round their respective piston grooves (see Fig. B.104). This clearance should be ·0019 in. to ·0039 in. (·048 mm. to ·099 mm.) for compression rings, and ·0015 in. to ·0035 in .(·038 mm. to ·089 mm.) for scraper rings when new.

Gudgeon Pins and Small End Bushes.

1. Check the gudgeon pins and their respective small end bushes for wear. Also check the fit of the gudgeon pins in their respective piston bosses. The fit of the gudgeon pin at both these points is critical and should be such as to give a finger push fit in the piston bosses, or be such that it is possible to insert the pin in the small end bush by firm hand pressure, both at a room temperature of 70°F. (21·1°C.).

2. Standard replacement gudgeon pins are graded high, medium and low on their external diameter and are identified by a colour coding (see "Manufacturing Data", on page B.69) and should be selectively fitted to the piston bosses and connecting rod small end bushes until the aforementioned fits are obtained. The colour code markings identifying each gudgeon pin are located on the end faces of the pin.

3. If wear is evident, indicated by slackness of the gudgeon pins in the bushes and/or bosses, renew the gudgeon pins and/or the small end bushes (see "Connecting Rods," para. 2 for bush renewal).

4. Alternatively the connecting rod small end bushes and piston bosses (if the original bushings of the connecting rods and pistons are to be retained), can be honed oversize, and the +·003 in. (+·076 mm.) gudgeon pins selectively fitted (see "Connecting Rods", para. 4).

Connecting Rods.

1. Check the connecting rods for correct alignment, using the Churchill Connecting Rod Alignment Jig 335, Master Arbor 336, and the Adaptor R.G.336-3B, ensuring that before any alignment check is carried out, the small end bush is renewed and a new gudgeon pin

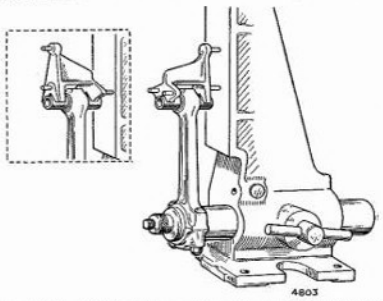


Fig. B.107. Checking the connecting rod for parallelism and twist between the small and big end bores, using the Churchill Tool 335, in conjunction with the adaptor set R.G.336-3B

used as a gauge, or the original small end bush and gudgeon pin are within the designed limits. The small end and big end axes must be parallel to one another and in the same vertical plane to within ·0005 in. (·0127 mm.) per 1 in. (25·40 mm.) of mandrel length. Any rod mis-alignment below ·015 in. (·381 mm.), as measured over the gauge length, can be corrected by re-setting, but rods with errors outside this figure must be renewed.

Proceed using the Churchill Connecting Rod Alignment Jig 335 in the following manner:

(*a*) Position the Master Arbor 336 in the jig body, with the screwed end facing outward.

(*b*) Fit the Adaptor R.G. 336-3B in the big end of the connecting rod (flats on the adaptor to be located parallel with the big end bolts), and clamp securely. Slide the adaptor complete with the connecting rod on to the arbor so that it abuts the shoulder, and secure by means of the knurled nut.

(*c*) Slide the gudgeon pin into the small end of the connecting rod, until it is centrally disposed. Position the connecting rod in relation to the vertical checking surface of the jig body, using the stop bar, so that the end of the gudgeon pin is just clear of the vertical face. Tighten the clamp, thus securing the arbor in the jig body.

(*d*) Place the Sea Lion, 335/G, on to the gudgeon pin. To check for parallelism between the small and big end bores, note whether the pins vertically in line are both in contact with the vertical face. To check for twist between the small and big end bores, note whether the pins horizontally in line are both in contact with the vertical face. If both pairs of pins contact the vertical face of the jig, the connecting rod bores will be in exact alignment in all planes.

(*e*) If the connecting rod is bent, but the bend present does not exceed the stated overall mis-alignment figure from which rods can be safely re-claimed, reset the rod using the Bending Bar 30A, until it is in exact alignment as detailed in para. (*d*).

If new components are to be fitted, it must be borne in mind that the maximum weight variation permissible between any two complete connecting rods (less big end bearings) in a set is 2 drams (3·55 grm.) each end.

2. To Renew Small End Bush. If wear exists in the small end bush such as described under "Gudgeon Pins and Small End Bushes", which indicates bush renewal, and advantage cannot be taken of the oversize gudgeon pins available, i.e., when fitting new pistons and standard gudgeon pins, it will be necessary to renew the small end bush, using Churchill Tool 6201, and the Adaptor Set R.G.6201-1, or alternatively renew with the aid of a suitable spigoted mandrel. Proceed using the Churchill Tool in the following manner:

(*a*) Observe the split across the width of the small end bush and locate this split on the opposite side of the

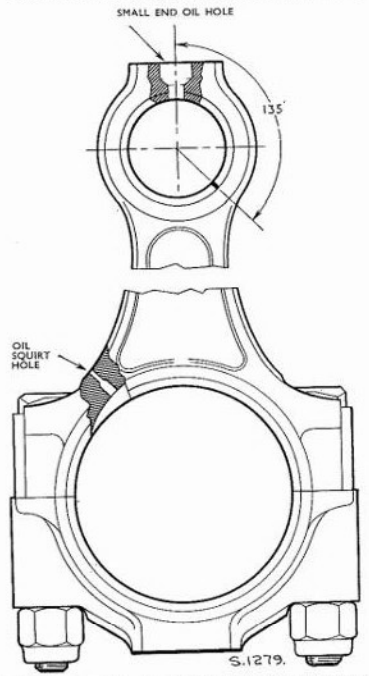


Fig. B.108. Correct location of the split in the connecting rod small end bush in relation to the oil squirt hole

connecting rod to the oil squirt hole, i.e., on the non-thrust side of the rod. Therefore when the two small end oil holes are aligned and the bush fitted, the split will be positioned automatically 135° from the oil hole in the boss of the connecting rod small end, and on the non-thrust side (see Fig. B.108).

(*b*) Slide the new small end bush into position over the adaptor sleeve, Code 4, and then locate the sleeve into the original small end bush, until the two bushes abut, noting that the split in the new bush is located as detailed in para. (*a*). Assemble the ring, STN.6263, to the body of the main tool. Register the ring over the adaptor sleeve, which protrudes from the connecting rod small end on the side opposite the new bush. Engage the centre screw at the same time with the adaptor sleeve.

(*c*) Sight the oil hole in the new small end bush and ensure it is in alignment with the mating hole in the connecting rod small end boss.

(*d*) Grip the adaptor sleeve in a vice by the flats provided, or alternatively hold from turning by means of a spanner similarly applied.

(*e*) Rotate the tommy bar of the tool, thus drawing out the original bush, and simultaneously drawing in the new small end bush. When the new bush is fully home, the head of the adaptor sleeve abuts the connecting rod. Ensure the oil hole in the bush aligns with the oil hole in the connecting rod boss.

(*f*) Dismantle and remove the tool.

(*g*) With compressed air, blow through the oilway and oil squirt hole in the connecting rod, thereby clearing away any obstruction that may be present.

(*h*) The new bush should be honed after fitting and it is of the utmost importance that the maximum bearing area between the gudgeon pin and the bush be obtained. This is accomplished by a very high surface finish on both the gudgeon pin and the bore of the bush, the finish being given to the gudgeon pin during manufacture and to the bush by honing, after fitting.

(*j*) It is recommended that the Delapena Honing Machine be used to hone to size the inner diameter of the small end bush, in conjunction with the following equipment:

(i) Mandrel	SL.900
(ii) Truing Sleeve	ST.900
(iii) Roughing Stones	E—F.3.J
(iv) Finishing Stones	E—F.6.J
(v) Polishing Stones	E—F.8.J
(vi) Connecting Rod Clamp	

Complete and detailed instructions for the operation of the Delapena Honing Machine are given in a booklet issued with each machine.

Note: Honing in this manner ensures a resulting high surface finish in the small end bush, in addition to other essential factors, such as concentricity, an accurate finished diameter and alignment with the big end bore being maintained.

(*k*) Delapena Honing Fluid is recommended and must be applied liberally. To achieve good results, i.e., high surface finish in the bush, it is important to immerse the work frequently in honing fluid, especially if the machine has not its own built-in filtered supply of honing fluid. This process also keeps the work as cool as possible, therefore assisting in maintaining an accurate finished bore. It is recommended that Delapena Standard Honing Fluid be used during honing operations on the small end bush to obtain optimum results.

(*l*) The correct mandrel (SL.900) fitted with the recommended stone, should be used in the honing machine and trued with the appropriate truing sleeve (ST.900) in accordance with the maker's instructions. Approximately ·009 in. to ·013 in. (·229 mm. to ·330 mm.) of material has to be removed from the inner diameter of the bush by honing, until it is possible to insert the selected gudgeon pin by firm hand pressure at a room temperature of 70°F. (21·1°C.) with no lift present (see also under "Gudgeon Pins and Small End Bushes"). When the bush is honed and the gudgeon pin fits the bore correctly, it is important to identify the components as they must be subsequently assembled together.

Note: Oversize gudgeon pins are available and when fitting these gudgeon pins to the pistons and the small end bushes, refer to the instructions given under para. 4.

(*m*) Thoroughly clean the small end bush to remove all foreign matter.

(*n*) Check the connecting rod small and big end alignment as detailed in para. 1.

3. Examine the threads of the cap bolts, and renew the bolts if damaged, or stretching is evident. It is advisable that the nuts be renewed after once being removed.

4. To Fit Oversize Gudgeon Pins. Gudgeon pins are available in an oversize of +·003 in. (+·076 mm.) being identified by a light green colour marking on the end face of each pin.

If wear exists in the piston bosses and connecting rod small end bushes (see under "Gudgeon Pins and Small End Bushes") and the original components are to be retained, it is necessary to fit +·003 in. (+·076 mm.) oversize gudgeon pins, proceeding in the following manner:

(*a*) Use the Delapena Honing Machine in conjunction with the equipment tabulated below for enlarging the gudgeon pin bores in the piston bosses and the connecting rod small end bushes:

(i) Mandrel	SL.900
(ii) Truing Sleeve	ST.900
(iii) Roughing Stones	E—F.3.J
(iv) Finishing Stones	E—F.6.J
(v) Polishing Stones	E—F.8.J

Note: When honing the small end bush, a suitable Connecting Rod Clamp must also be used to afford additional support during actual honing operations.

(*b*) Fit the mandrel (SL.900) in the honing machine and true the stone with the appropriate truing sleeve (ST.900) in accordance with the maker's instructions. First hone the bosses in the piston until the selected oversize gudgeon pin is a finger push fit in the piston bosses at a room temperature of 70°F. (21·1°C.). Similarly hone the small end bush to a finished bore size until it is possible to insert the selected oversize gudgeon pin into the bush by firm hand pressure at a room temperature of 70°F. (21·1°C.). It is important to identify the selected gudgeon pin to the piston and the connecting rod, so as these components are subsequently assembled together.

(*c*) During honing operations, to ensure that accurate bores result, Delapena Honing Fluid must be applied liberally. The work must be immersed frequently in honing fluid during operations to keep it cool and cleanse the honing stone. It is imperative to carry out this instruction faithfully if the machine has not its own built-in filtered supply of fluid. It is recommended that Delapena Standard Honing Fluid be used on the small end bush and the piston bosses to obtain optimum results.

(*d*) Check the connecting rod small and big end alignment as detailed in para. 1.

Big End Bearings.

1. Examine the bearing shells, making sure they are kept to their respective rods. If signs of wear on the bearing halves is evident, such as scoring, or breaking down of the white metal surface, the bearings must be renewed. Check the running clearance of the big end bearings against the figures detailed under "Manufacturing Data".

Important: It must be clearly understood that under no circumstances may the bearing shells, or the big end caps be filed to take up wear.

2. If the big end bearings are renewed, ensure that the replacements are the same size as the originals. Undersize bearings are stamped, according to their size, on the steel shells.

3. Whilst examining the bearing halves for wear the opportunity should be taken to check the crankpin journals for ovality and scoring, which if present must be corrected by re-grinding all crankpin and main journals to the required diameter to suit one of the undersize bearing offered, these being available in —·020 in. (—·508 mm.) and —·040 in. (—1·016 mm.) undersizes (see also under "Crankshaft and Main Bearings", on page B.110 for journal diameters and re-grinding details).

To Re-assemble.

1. To ensure correct relationship results on refitting the components to the engine, position the piston so that the slot in the skirt is on the opposite side of the connecting rod to the oil squirt hole. This will ensure that upon assembly to the engine and the subsequent positioning of the word "Front" stamped on the piston crown, towards the front of the engine, the oil squirt hole in the connecting rod will face towards the thrust, or right hand side of the cylinder block, when viewed from the rear of the engine.

2. Fit a circlip to the groove in one end of the gudgeon pin bore in the piston, using Churchill Circlip Pliers 7065A, fitted with type "A" points. Line up the bore in the piston with the small end bush, then fit the gudgeon pin. Fitting the gudgeon pin to the piston bosses is facilitated by heating the piston in hot water. Insert the circlip in the opposite end of the gudgeon pin bore and ensure that it is firmly located in the groove provided, again using the circlip pliers to facilitate the operation. Make certain the circlips fit correctly in the bottom of their locating grooves.

Note: If the original parts are to be used, the pistons which are numbered 1 to 6 from the front of the engine, must be refitted to the connecting rods, also numbered, from which they were removed. This also applies to the gudgeon pins, although they are not numbered.

3. Re-assemble the three piston rings to each piston, the ring sequence being as follows:

(*a*) Top—Chromium plated compression ring.

(*b*) Second—Shouldered compression ring.

(*c*) Third—Slotted scraper ring.

The chromium plated compression ring can be identified by the word "Vacrom" etched on one of its widest faces. The shouldered compression ring fitted in the second groove from the piston crown must be positioned with the recess downwards, that is, with the widest face towards the top of the piston. This face is marked "TOP" to indicate that it must be fitted uppermost.

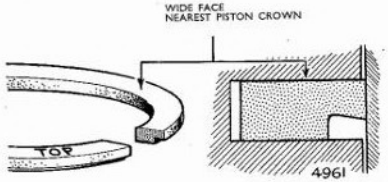


Fig. B.109. Correct assembly of the second compression ring to the piston body

Care must be taken to avoid damage to the two very narrow scraping edges of the scraper ring. To obviate damage a ring compressor must be used when refitting these rings. Smear the piston and rings with lubricant.

4. Fit the rings to the piston in such a way that the ring gaps are equally spaced around the periphery of the piston and not in line with one another. In the case of each top chromium plated piston ring (if the original rings are retained) to obtain satisfactory results initially

upon refitting, it is most important that these rings be re-located in their original radial positions by aligning the marks made during the removal operations, thus avoiding unnecessary bedding down again of the rings.

To Refit.

1. Ensure that all parts are perfectly clean, then fit the big end bearing halves to the connecting rods and the separate bearing caps. Smear the bearing and crankshaft journals with lubricant. Whilst the top and bottom halves of the shell type bearings are interchangeable, it is essential that their locating lips are accurately registered in the recesses formed in the rods and caps. Original bearing halves which are being refitted should maintain their original positioning, i.e., either to the connecting rod, or the bearing cap as applicable. Note also that the oil hole in the upper bearing half is coincident with the groove feeding the oil squirt hole in the connecting rod.

2. To facilitate the fitting of the piston and connecting rod assemblies it is recommended that the Churchill Ring Compressor R.G.203 be used, (see Fig. B.110) this

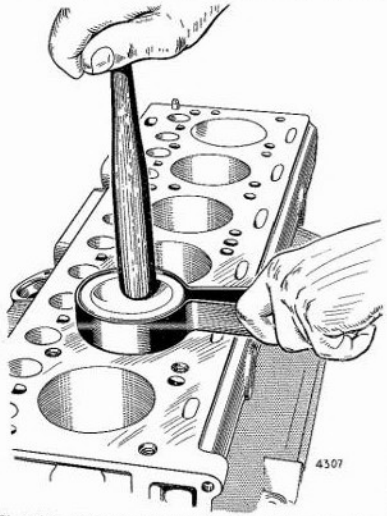


Fig. B.110. Fitting the piston and connecting rod assembly, using the Churchill Tool R.G.203 to compress the piston rings

minimises the risk of breaking the piston rings and damaging the thin scraping edges of the scraper rings, upon refitting to the cylinder bores. If necessary, the tool can be made up from a steel sleeve of approximately the same internal diameter as the piston external diameter, and about 1 in. (25 mm.) in length. Slit the sleeve through its side and slide it over the rings so that they can be compressed to the bore diameter when entering the cylinders.

3. Insert the connecting rod and piston assemblies into the cylinder bores, from the top, ensuring that:

(*a*) The assemblies are fitted into their corresponding bores, i.e., number 1 piston and connecting rod to number 1 bore.

(*b*) The oil squirt hole in the side of the connecting rod is towards the "thrust", or right hand, inlet manifold side of the cylinder block, viewed from the rear.

(*c*) The slotted face of the piston is towards the "non-thrust", or left hand, exhaust manifold side of the cylinder block, viewed from the rear, i.e., the word "Front" stamped on the crown of the piston is towards the front of the engine.

4. Position the connecting rod together with the upper bearing half over the crankpin journal and offer up the bearing cap together with the lower bearing half, so that the stamped figures on the side of the connecting rod and the cap are coincident.

5. Fit the connecting rod cap bolts and secure the caps to the connecting rods with new self-locking nuts. Tighten the nuts to a torque wrench reading of 35/37 lb.ft. (4·84/5·12 kg.m.).

6. Complete the operation by reversing the remaining removal operations, using a new cylinder head gasket, tightening the cylinder head bolts and re-setting the valve clearances, as detailed on pages B.79 and B.78 respectively.

CRANKSHAFT AND MAIN BEARINGS

To Remove Main Bearings and Thrust Washers with Crankshaft in Position.

Removal of the main bearings and thrust washers may be carried out with the crankshaft in position, as detailed in the following:

1. Remove the sump and the oil pump (see pages B.124 and B.125).

2. Release the bolts securing one of the main bearing caps only, and slacken the bolts on the remaining caps. **One bearing cap at a time should be removed and refitted before lowering another cap.** When removing the rear main bearing cap difficulty may be experienced on account of the felt seals, but the use of Churchill Tool R.G.11A and the Adaptor R.G.11A-3 is recommended to overcome this resistance. Secure the adaptor R.G.11A-3 to the lower face of the cap, by means of setscrews and locate the side legs of the main tool on the adjacent flange of the crankcase on either side of the rear main bearing. Holding the tommy bar stationary, rotate the wingnut until the cap is withdrawn.

3. Withdraw the lower bearing half from the cap, and using a suitable metal drift push out the upper bearing half, whilst rotating the crankshaft in the same direction

as that traversed by the drift, noting that the metal drift must be applied to the side opposite the locating lip (see Fig. B.113). If the original bearings are to be refitted, identify each bearing half to its respective position.

4. Remove the thrust washers if inspection, or renewal is necessary, noting that this is accomplished when dealing with the rear intermediate main bearing. Employ a similar method to that used on the bearing halves, i.e., using a thin metal drift applied to one end of the thrust washer half, push on the drift and at the same time rotate the crankshaft, until withdrawal is effected. Identify each thrust washer half to its relative position.

To Fit Main Bearings and Thrust Washers with Crankcase in Position.

1. When fitting replacement bearings ensure they are the same size as the originals. Bearings are stamped according to their size on the steel shells. Upper and lower halves of the bearings are identical, but the rear main bearing is not interchangeable with the three other main bearings, being the wider of the set.

Important: It must be clearly understood that under no circumstances may the bearing shells, or the bearing caps, be filed to take up wear.

2. Refit the lower bearing half to the cap so as the bearing locating lip engages the recess on the cap. Smear the bearing halves and the journals with lubricant. Insert the upper bearing half, plain end foremost until the bearing lip engages the recess in the crankcase. Offer up the bearing cap and lightly secure with the bolts. Due to the offset of the locating registers in the crankcase, main bearing caps can only be fitted one way round.

Note: Particular attention should be paid to the cleanliness of the bearing housing and cap mating faces, the oil thrower on the rear end of the crankshaft, and to the oil thrower recess in the rear main bearing housing and cap.

3. When dealing with the rear intermediate main bearing, it is also necessary to fit the thrust washer halves, lightly coating the halves with lubricant and sliding them into the recesses provided in the crankcase on either side of the rear intermediate bearing housing, with the white metal side containing the oil slots positioned towards the crankshaft. Ensure that the crankcase has retained the recommended end float of ·002 in. to ·004 in. (·051 mm. to ·102 mm.), which can be checked with the aid of feeler gauges. Thrust washers are available in oversizes of +·005 in. (+·127 mm.), which are clearly marked to this effect on the steel backing, and should be fitted as necessary to retain the recommended end float. With the bearing halves positioned correctly offer up the bearing cap and lightly secure with the bolts. Observe the mating surface of the bearing cap, provides for the location of the thrust washer halves.

4. When all the main bearings have been dealt with, tighten the cap bolts to a torque wrench reading of 70/75 lb.ft. (9·68/10·37 kg.m.), starting at the intermediate bearing positions and working outward. After each bearing is finally tightened, turn the crankshaft to ensure that it revolves freely.

5. Pack felt into the grooves in the rear main bearing cap, by cutting the felt into short strips, and then tapping it firmly into the grooves with a suitable rod, until the grooves are full.

6. Complete the refitting procedure by reversing the remaining removal operations (see under "Lubrication System—Oil Pump and Sump", on pages B.126 and B.124 respectively).

To Remove.

To remove the crankshaft and main bearings it will be necessary to remove the engine from the vehicle (see page B.116), and then proceed as follows:

1. Remove the cylinder head and tappets (see pages B.80 and B.88 respectively).

2. Remove the timing cover, timing wheels and chain (see pages B.91 and B.93 respectively).

3. Remove the sump and the oil pump (see pages B.124 and B.125).

4. Remove the piston and connecting rod assemblies (see page B.100).

5. Release the clutch unit (see "Clutch and Propeller Shaft" section), and the flywheel (see page B.112).

6. Remove the main bearing cap bolts, and withdraw the bearing caps. Some difficulty may be experienced in removing the rear bearing cap on account of the felt seals, but the use of Churchill Tool R.G.11A and the

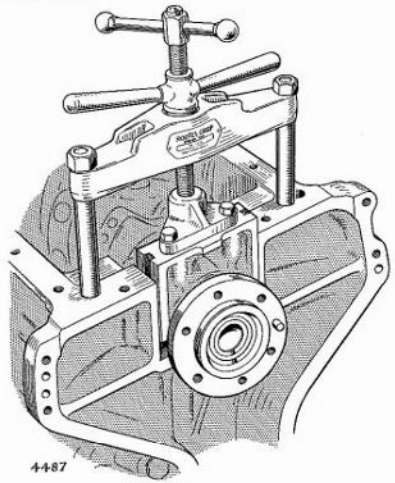
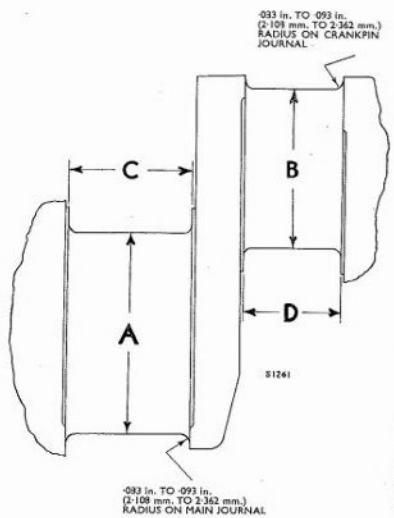


Fig. B.111. Withdrawing the crankshaft rear main bearing cap, using the Churchill Tool R.G. 11A and the adaptor set R.G.11A-3



Adaptor Set R.G.11A-3 is recommended to overcome this resistance. Secure the adaptor R.G.11A-3 to the face of the cap, by means of setscrews and locate the side legs of the main tool on the adjacent flange of the crankcase on either side of the rear main bearing. Holding the tommy bar stationary, rotate the wingnut until the cap is withdrawn. Identify the bearing caps to their respective position to avoid interchanging.

7. Lift out the crankshaft and remove the upper halves of the main bearings and the thrust washers.

To Dismantle the Crankshaft.

1. Withdraw the feather key from the front of the crankshaft.

2. If it is necessary to renew the stem wheel spigot bearing, remove from the recess machined in the rear of the crankshaft flange with an internal withdrawal tool. To facilitate this operation it is recommended that the Churchill Main Tool 7600 be used, in conjunction with the Adaptor Set R.G. 7600-1.

Inspection and Overhaul.

1. Clean the crankshaft thoroughly, paying particular attention to the oilways between the main and crankpin journals. After cleaning, smear the main and crankpin journals with new engine oil to prevent rusting.

CRANKSHAFT JOURNAL WIDTHS AND DIAMETERS

Journal		Main Journal Diameter "A"	Crankpin Journal Diameter "B"	Main Journal Width "C"					Crankpin Journal Width "D"
				Front	Front Intermediate	Rear Intermediate		Rear	
Size	Limit					Standard	Oversize		
Standard	Low	2·4990 in. (63·4746 mm.)	2·0005 in. (50·8127 mm.)	1·467 in. (37·262 mm.)	1·547 in. (39·294 mm.)	1·555 in. (39·497 mm.)	N/A	1·90 in. (48·26 mm.) Nominal	1·216 in. (30·886 mm.)
	High	2·4995 in. (63·4873 mm.)	2·0010 in. (50·8254 mm.)	1·482 in. (37·643 mm.)	1·557 in. (39·548 mm.)	1·557 in. (39·548 mm.)	N/A		1·218 in. (30·937 mm.)
·020 in. undersize	Low	2·4790 in.) (62·9666 mm.)	1·9805 in. (50·3047 mm.)	1·467 in. (37·362 mm.)	1·547 in. (39·294 mm.)	1·555 in. (39·497 mm.)	1·559 in. *(39·599 mm.)	1·90 in. (48·26 mm.) Nominal	1·216 in. (30·886 mm.)
	High	2·4795 in. (62·9793 mm.)	1·9810 in. (50·3174 mm.)	1·482 in. (37·643 mm.)	1·557 in. (39·548 mm.)	1·557 in. (39·548 mm.)	1·561 in. *(39·649 mm.)		1·218 in. (30·937 mm.)
·040 in. undersize	Low	2·4590 in. (62·4586 mm.)	1·9605 in. (49·7967 mm.)	1·467 in. (37·262 mm.)	1·547 in. (39·294 mm.)	1·555 in. (39·497 mm.)	1·559 in. *(39·599 mm.)	1·90 in. (48·26 mm.) Nominal	1·216 in. (30·886 mm.)
	High	2·4595 in. (62·4713 mm.)	1·9610 in. (49·8094 mm.)	1·482 in. (37·643 mm.)	1·557 in. (39·548 mm.)	1·557 in. (39·548 mm.)	1·561 in. *(39·649 mm.)		1·218 in. (30·937 mm.)

* The dimension given under Main Journal Width—Rear Intermediate (Oversize) in this table, is the recommended maximum oversize (low limit components), to clean up the crankshaft journal side faces removing the minimum of material, and then only if damage etc., exists. This dimension could in certain cases be exceeded (high limit components) up to a maximum of 1·565 in. (39·751 mm.), and if it is necessary to take advantage of this additional oversize limit, a dimensional check must first be made to determine the overall width of the housing and oversize thrust washers available, bearing in mind that an end float of ·002 in. to ·004 in. (·051 mm. to ·102 mm.) must result on the crankshaft.

Fig. B.112. Crankshaft re-grinding dimensions

2. Check all journals for ovality, or scores, which if present must be corrected by re-grinding all the main and crankpin journals to one of the undersizes given in Fig. B.112, for which undersize bearings are available. Journals must be re-ground to the limits given according to the undersize decided, as hand scraping of the bearing halves is not permissible. After re-grinding ensure the radius fillets, shown in Fig. B.112 are present at all the crankpin and main journals. Considerable importance is attached to the blending of these radii so that after re-grinding no steps remain. It is also very important to measure the radius fillets with a radius gauge to obtain accurate results. The width dimensions given for the journals in Fig. B.112 must be maintained. The surface finish on all journals must be 12 micro inches as measured by a Profilometer.

3. The bearing halves are stamped on the shell according to their size. Should the main bearings be renewed without re-grinding the crankshaft, ensure that the replacement bearings are the same size as the originals.

Important: It must be clearly understood that under no circumstances may the bearing shells, or the bearing caps be filed to take up wear.

To Re-assemble the Crankshaft.

1. Fit the new stem wheel spigot bearing (sealed end outwards, i.e., towards the clutch), using a suitable shouldered drift in contact with the outer bearing race, tapping the bearing into the recess, until it firmly abuts the locating shoulder in the crankshaft flange.

Note: The bearing should be packed with grease on re-assembly. Do not overfill, or the surplus will be forced past the sealed end and thrown on to the clutch friction faces, causing clutch slip.

2. Refit the key to the front of the crankshaft, ensuring that it enters squarely and is not a loose fit in the keyway.

3. Blow through the crankshaft oilways with compressed air to clear away foreign matter that may be present, prior to refitting the crankshaft.

To Refit.

1. Ensure the main bearing housings are perfectly clean, also the mating faces of the bearing caps. Fit the upper halves of the main bearings to the crankcase, ensuring that each locating lip engages the recess provided on the housings. Smear the bearing surfaces with lubricant.

Note: Undersize bearings are stamped according to their size, and if the crankshaft has been re-ground it is essential that the correct undersize bearings are fitted. The upper and lower halves of the bearings are identical as are the front and intermediate bearings. The rear bearing is wider and is not interchangeable with the front and intermediate bearings and vice versa. If the original bearing halves are retained they must be fitted in their original positions.

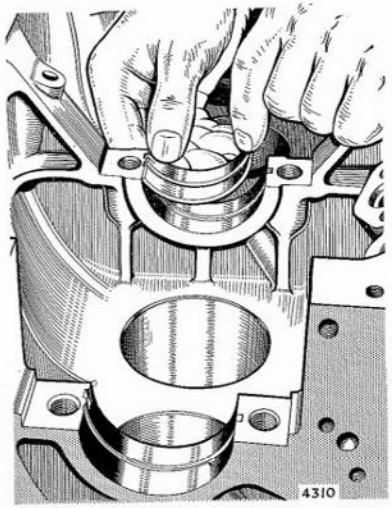


Fig. B.113. Fitting the upper halves of the main bearings to the crankcase

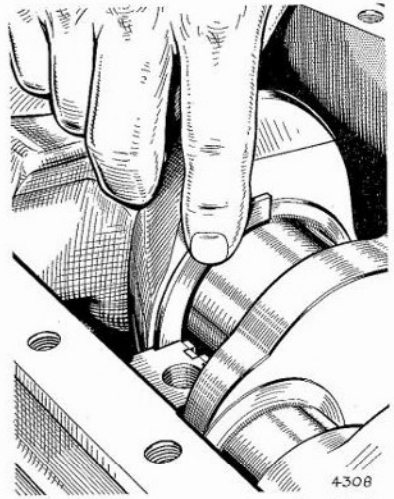


Fig. B.114. Installing the crankshaft thrust washers into the crankcase recesses at the rear intermediate main bearing position

2. Smear the crankshaft journals with lubricant and locate the crankshaft in position in the upper bearing halves. Slide the thrust washer halves, lightly coated with lubricant, into the recesses provided in the crankcase on either side of the rear intermediate main bearing. The white metal face of the thrust washer containing the two oil grooves, must face towards the crankshaft. Check that the recommended end float of between ·002 in. to ·004 in. (·051 mm. to ·102 mm.) is present on the crankshaft, using a feeler gauge as shown in Fig. B.115.

Fig. B.115. Checking the crankshaft end float using a feeler gauge

Note: The thrust washers are available in an oversize of +·005 in. (+·127 mm.) and these should be fitted as necessary to retain the recommended end float. Oversize thrust washers are clearly marked to this effect on the steel backings.

3. Fit the lower halves of the main bearings to the bearing caps and then refit the bearing caps in accordance with the identification marks made during removal, noting that the caps can only be fitted one way round, due to the offset on the locating registers in the crankcase. Refit the main bearing cap bolts and tighten to a torque wrench reading of 70/75 lb.ft. (9·68/10·37 kg.m.), starting at the intermediate bearing positions and working outward. After tightening each bearing in turn, revolve the crankshaft and ensure that it is free.

4. Pack felt into the grooves in the rear main bearing cap, cutting the felt into short strips and tapping them into the grooves tightly with a suitable rod (see Fig. B.116).

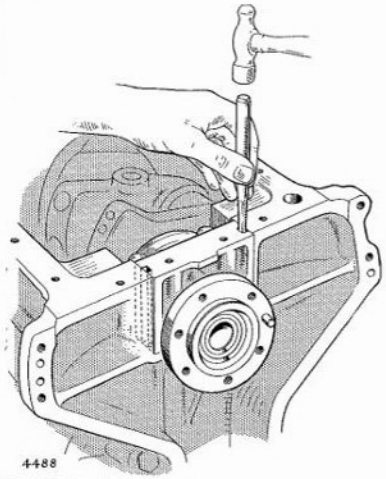


Fig. B.116. Packing the crankshaft rear main bearing cap grooves with felt

5. Re-assemble the engine by reversing the remaining sequence of operations detailed under "Crankshaft and Main Bearings—To Remove", on pages B.108 and B.109.

6. Refit the engine to the chassis. Refill the engine with fresh oil of the recommended grade.

FLYWHEEL AND STARTER RING

To Remove.

1. Remove the gearbox (see "Gearbox" section).

2. Remove the two split halves of the bottom cover from the clutch housing.

3. Remove the clutch (see "Clutch and Propeller Shaft" section).

4. Tap the tabs of the lockwashers clear of the flywheel securing bolts, lock the flywheel to prevent it from turning, and then remove the setbolts securing the flywheel to the crankshaft flange. Carefully lever off the flywheel from the crankshaft spigot.

Note: To facilitate removal, screw a stud of suitable size and length into an upper setbolt hole before levering off the flywheel, thus preventing it from falling accidentally when once clear of the crankshaft spigot, resulting in possible damage to the starter ring.

Inspection and Overhaul.
Flywheel.

1. Examine the friction face on the flywheel, on which the clutch driven plate operates. If this is badly scored the face must be re-ground to restore the original smooth finish, but only until the original marks are removed. When carrying out this operation the whole of the flywheel face must be re-ground and not only the friction area. Reference must be made to Fig. B.117, whilst carrying out this re-grinding operation, for the minimum thickness on the flywheel of 1·345 in. (34·163 mm.) must not be exceeded.

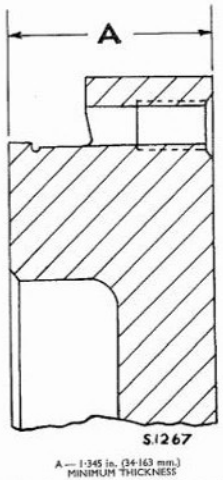


Fig. B.117. Flywheel re-grinding dimension

2. Examine the threads of the securing bolts and if these appear stretched, renew the bolts.

Starter Ring.

1. Examine the starter ring teeth. If these are damaged, or worn excessively, the ring must be renewed.

2. The starter ring is shrunk on to the flywheel and in event of wear developing on the teeth, the complete flywheel and ring should be renewed. However, if suitable equipment is available, the starter ring may be removed and a new one fitted by adopting the following procedure:

(*a*) Immerse the flywheel in a suitable container of clean **cold** water and support the assembly in the water by placing three, or four steel blocks under the starter ring. Arrange the flywheel assembly so that it is partly submerged in the water, starter ring uppermost. The starter ring must be above the water level and it is recommended that approximately $\frac{1}{16}$ in. (5 mm.) clear above the water level, be used as a guide.

(*b*) Heat the starter ring evenly round its circumference (using an oxy-acetylene welding torch) as shown in Fig. B.118, thus expanding the ring which will allow the flywheel itself to drop clear. Remove the flywheel from the water and dry thoroughly.

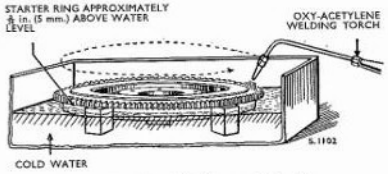


Fig. B.118. Removing the worn starter ring

(*c*) Check the height of the securing lip by means of a straight edge and a feeler gauge. This dimension should be a maximum of ·009 in. (·229 mm.) as shown in Fig. B.119. If the height is greater than

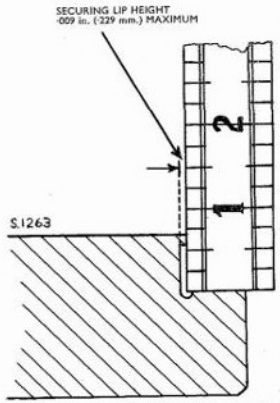


Fig. B.119. Checking the height of the starter ring securing lip

·009 in. (·229 mm.) it must be reduced in a lathe. When carrying out this operation it is most important that the flywheel is located by means of those faces, which register with the crankshaft flange and spigot.

(*d*) Lay the flywheel down on its clutch mounting face, ready to receive the starter ring. Ensure that the registering faces of the flywheel and starter ring are clean and free from burrs.

(*e*) To fit the new starter ring, it must first be pre-heated and this is accomplished by suspending the starter ring from wire hooks in a container of clean engine oil, which has been heated to 392°F. (200°C.), until the ring attains the same temperature as the oil (see Fig. B.120).

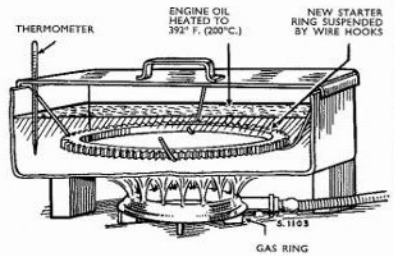


Fig. B.120. Pre-heating the new starter ring prior to fitting

(*f*) To eliminate the possibility of fire whilst heating the oil and the starter ring, keep the container covered by a metal lid to prevent flame from reaching the surface of the oil. Do not allow the starter ring (or thermometer) to rest on the bottom of the container, or a false temperature reading will result.

(*g*) Lift the heated ring from the oil by means of the wire hooks and quickly wipe away surplus oil with a piece of rag.

(*h*) Place the ring in position on the flywheel **with the chamfered sides of the teeth downwards.** Ensure the ring is completely over the securing lip and is square with the flange on the flywheel (see Fig. B.121).

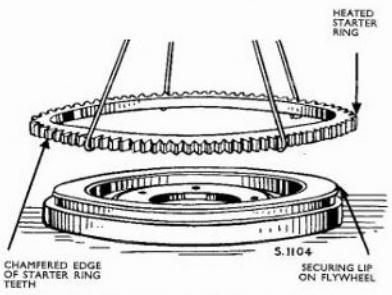


Fig. B.121. Fitting the new starter ring to the flywheel

(*j*) Allow the ring to cool in the atmosphere, when it will contract and thus firmly grip the flywheel diameter.

To Refit.

Reverse the removal procedure, observing the following points:

1. Ensure that the crankshaft flange and spigot, also the mating faces on the flywheel are clean and free from burrs.

2. The locating dowel may have been withdrawn with the flywheel, and should this be the case, tap the dowel from out of the flywheel and refit to the crankshaft flange.

3. Fit the flywheel to the crankshaft spigot and register the dowel in the hole provided. Using new lockwashers on the securing bolts, fit and tighten the bolts in diagonal sequence to a torque wrench reading of 37/43 lb. ft. (5·12/5·95 kg. m.).

4. Check the "run-out" of the flywheel at the outer edge of the driven plate friction face on the flywheel (see Fig. B.122). A total dial gauge reading of ·003 in. (·076 mm.) must not be exceeded. If this figure is

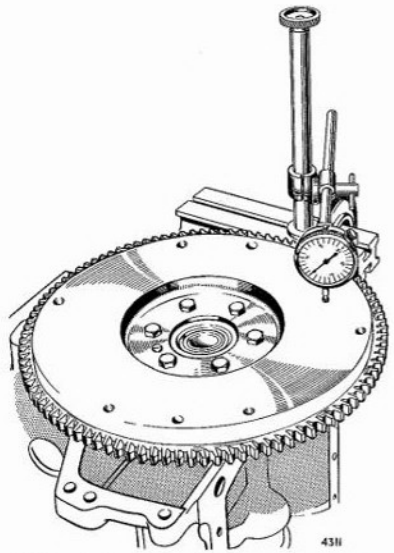


Fig. B.122. Checking the flywheel for "run-out", using a dial gauge

exceeded, it is recommended in the first instance that the flywheel be removed and a careful examination carried out of the mating faces of the flywheel and the crankshaft. Any burrs, or irregularities on these mating surfaces must be removed.

5. If the flywheel "run-out" is within the limits given, lock the setbolts with the new lockwashers.

INLET AND EXHAUST MANIFOLDS

For further information in respect of the exhaust system, refer under the "Chassis Frame, Suspension and Shock Absorbers" section.

To Remove and Refit the Exhaust Manifold.

1. This is a very simple operation requiring the removal of the two exhaust flange nuts and bolts, the front lifting eye bracket, the dipstick tube support, and seven manifold fixing nuts and washers. The use of penetrating oil on the threads, before removal of the nuts, is recommended. On L.H.D. Models the left hand accelerator cross-shaft support bracket must also be released and rotated clear of the exhaust manifold.

2. Remove the four nuts securing the connecting branch to the twin exhaust manifolds and dismantle the components.

3. Loosely assemble the twin manifolds to the connecting branch, i.e., until the securing nuts are finger tight, thus upon fitting the twin manifolds to the cylinder head and tightening the manifold nuts, the manifolds will align. Finally tighten the connecting branch nuts.

4. Refit the exhaust pipe flange to the connecting branch, and secure the dipstick tube to its support.

Note: When refitting, new gaskets should always be fitted and threads lubricated with graphite grease.

5. Refit the remaining components, by reversing the removal procedure.

6. All nuts should be re-tightened after the engine has been run for about an hour.

To Remove and Refit the Inlet Manifold.

1. Disconnect the rocker cover breather pipe and hose from the cover, also the air cleaner hose from the carburettor.

2. Disconnect the fuel feed pipe from the unions on the carburettor and the fuel lift pump.

3. Drain the radiator, taking care to retain any anti-freeze mixture if in use, draining the mixture into a clean container. Disconnect the inlet manifold connecting pipe by removing its securing nuts from the flange studs on the manifold and at the water pump inlet pipe.

4. Remove the distributor cap, low tension lead, vacuum advance pipe, and the two setscrews from the mounting bracket flange on the cylinder block. Lift out the distributor, noting that its offset driving dog ensures that correct refitting results. If required the distributor clamp plate may be separated from the mounting bracket, after first identifying the clamp plate to the bracket thus ensuring correct re-assembly of the components. Note the oil sealing ring between the clamp plate and bracket.

5. Disconnect the vacuum pipe (when fitted) at the union on the rear of the inlet manifold.

6. Remove the carburettor complete, or disconnect the carburettor controls as necessary (see "Fuel System" section).

7. Release the inlet manifold drain tube support clip from the setscrew on the right-hand side of the sump.

8. Remove the securing bolts and washers and lift off the manifold. The anchor plate for the throttle linkage return spring, also the petrol pipe support bracket are secured to the manifold bolts, ensure these components are re-positioned correctly on fitting the manifold.

9. Ensure the interconnecting water passages in the manifold and the cylinder head are clear of obstruction.

10. When refitting the inlet manifold it is recommended that new joints should be used throughout.

11. Refit the manifold by reversing the removal procedure, noting that on refilling the cooling system, no leaks are present at the mating flanges of the manifold.

ENGINE MOUNTINGS

To Remove and Refit.

1. Raise the bonnet (hood) and secure in the open position, also release the internal engine cowl from its anchorage.

2. Disconnect one of the leads from the battery terminals, to prevent short circuits occurring.

3. Drain the cooling system and remove the top and bottom radiator hoses to avoid strain on these components.

4. To remove the front engine mounting rubbers, proceed as follows:

(*a*) Jack up the front of the engine, using a wide wooden block between the jack and the sump (oil pan) until the load is just taken off the front engine mounting rubbers.

Note: Do not under any circumstances jack up the engine higher than is necessary, but only high enough to relieve the load on the mounting rubbers, as raising the engine to an unnecessary height, will place excessive load on the rear engine mountings, and undue strain will be exerted on the engine stabilising tie rod, the exhaust pipe joint at the manifold, and on the various throttle controls.

(*b*) Release the throttle linkage relay bracket from the right hand front engine mounting bracket.

(*c*) Remove the nuts that secure the mounting rubbers to the chassis frame, also the bolts securing the mounting bracket extension legs to the crankcase.

(*d*) Lift away the mounting brackets, complete with the rubbers, and then separate these two components.

5. Refit the front engine mounting rubbers and associated brackets, reversing the procedure given for removal in para. 4. If disconnected, check the operation of the throttle linkage upon refitting the relay bracket, adjusting the linkage if necessary, as detailed under the "Fuel System" section.

6. To release either rear engine mounting rubber, proceed in the following manner, dealing with each side in turn:

(*a*) Jack up the rear of the engine, using a wide wooden block between the jack and the sump (oil pan), until the load is just taken off the rear mounting rubber, on the side receiving attention.

Note: Do not under any circumstances jack up the engine higher than is necessary, but only high enough to relieve the load on the mounting rubber being removed, as raising the engine to an unnecessary height will place excessive load on the other engine mountings, and undue strain will be exerted on the engine stabilising tie rod, the exhaust pipe joint at the manifold, and on the various throttle controls.

(*b*) Unscrew and remove the "Simmonds" nut from the mounting bolt, which passes down through the mounting rubber positioned on the clutch housing bracket (see Fig. B.123). Withdraw the mounting bolt from above, complete with the rebound washer.

(*c*) Release the engine mounting bracket from the clutch housing after removing the four setscrews, and lift it away complete with the mounting rubber.

(*d*) Remove the mounting rubber from the bracket noting that the flange of the mounting rubber is located on the underside of the bracket.

(*e*) Refit the rear engine mounting rubber and associated bracket to the clutch housing by reversing the removal procedure, before dealing with the second rear engine mounting rubber.

(*f*) When refitting, ensure that the earthing wire is re-connected to its original fixing on the rear engine mounting.

(*g*) Remove the second mounting rubber as described previously in paras. 6 (*a*) to 6 (*d*) inclusive.

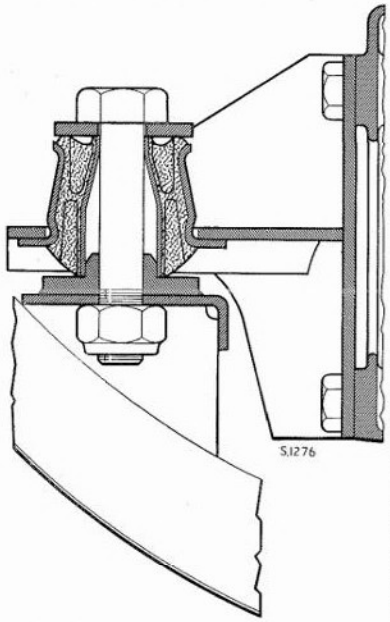


Fig. B.123. Sectional view of the rear engine mounting

7. Refit the second rear engine mounting rubber and bracket to the clutch housing, adopting a similar procedure as used on the first mounting rubber (see para. 6 (*e*)).

8. Locate the rebound washers over the centre bolts, and pass one bolt through each rear mounting rubber and its respective crossmember location, securing the bolts by means of new "Simmonds" nuts, from below. Ensure that the centre sleeve of the mounting rubbers are located over the shouldered pads on the chassis cross-member.

9. Finally complete the operation by reversing the remaining removal operations.

ENGINE REMOVAL

Prior to carrying out this operation, drain the water from the radiator and cylinder block, and the engine oil from the sump (oil pan). It is also advisable to drain the oil from the gearbox, as this unit is removed from the clutch housing to facilitate engine removal.

To remove the engine proceed in the following manner:

1. Raise the bonnet (hood) and secure in the open position, also release the internal engine cowl from its anchorage.

2. Disconnect the leads from the battery terminals. Release the battery retaining strap and then remove the battery, to obtain access to the radiator grille side panel bolts.

3. Release the radiator grille, complete with the side panels and lamps (see "Cab and Body" section).

4. Remove the radiator (see "Cooling System" section), including the front apron tie bar. Remove the radiator baffle panels (see "Cab and Body" section).

5. Release the locknut and unscrew the change speed lever knob. Remove the screws retaining the floor centre panel, and lift off the panel complete, noting that if required the change speed lever bellows may be prised from its seating and pushed through the aperture

in the centre panel, thus leaving the bellows in position as the centre panel is lifted clear. Ensure upon refitting the floor panel, that the panel seals are in good condition.

6. In order to provide increased clearance for the clutch housing during engine removal operations, the centre toe panel may be removed, after releasing the centre panel retaining screws. Slacken the side toe panel retaining screws, in order to permit a rearward withdrawal of the centre panel. Ensure upon refitting the toe panels, that the panel seals are in good condition.

7. Remove the gearbox (see "Gearbox" section), noting that it will be necessary first to remove the gearbox tower and disconnect the propeller shaft at the gearbox driver coupling, moving the propeller shaft to one side, after releasing the centre bearing hub from its split housing.

8. Remove the distributor and carburettor (see the "Electrical Equipment" and "Fuel System" sections respectively). These operations are not essential to the removal of the engine, their purpose being to safeguard the components from damage during the operation of lifting out the engine.

9. Disconnect the following electrical leads:

(*a*) The ignition lead at the coil.

(*b*) The two leads at the dynamo.

(*c*) The lead at the oil pressure switch on the right hand side of the cylinder block.

(*d*) The cable at the starter motor.

10. Release the earth wire from its fixing on the rear engine mounting bracket.

11. Disconnect the lead from the thermometer bulb positioned in the water outlet/thermostat housing on the front of the cylinder head.

12. Remove the heater hoses (when fitted), from their adaptors situated in the water pump body and the rear face of the cylinder head.

13. Disconnect the vacuum pipe (when fitted), at the union on the rear of the inlet manifold.

14. Disconnect the petrol pipe from the tank, at the union positioned at the rear left hand side of the engine.

15. Release the exhaust pipe by withdrawing the two nuts and bolts securing the pipe flange to the manifold connecting branch.

16. Disconnect the engine stabilising tie rod in the following manner:

(*a*) Remove the bolt, plain washers and shakeproof washer securing the tie rod to the clutch housing.

(*b*) If it is required to remove the tie rod from the vehicle, release the locknut, plain nut, neoprene insulator, and plain washer, enabling the complete tie rod to be withdrawn rearward from its cross-member support bracket.

Note: On re-connecting the engine stabilising tie rod, adjust the nuts on the neoprene insulators until a slight tension on the rod is obtained. Do not over tension.

17. Disconnect the throttle link rod (accelerator pedal to relay bracket) from the lever on the relay bracket, the relay bracket being secured to the front engine mounting bracket. On L.H.D. Models release the throttle link rod from the cross-shaft lever. On installing the throttle linkage adjust if necessary, as detailed under the "Fuel System" section.

18. On R.H.D. Models disconnect and remove the clutch operating rod from the lower arm of the clutch pedal, and then withdraw the rod from the clutch withdrawal lever eye.

Note: On L.H.D. Models remove the rod from the relay lever and the clutch withdrawal lever.

19. Disconnect the engine mountings in the following manner:

Front. Remove the nuts which secure the front mounting rubbers to the chassis frame.

Rear. Unscrew and remove the "Simmonds" nut from the mounting bolt, which passes down through the mounting rubber in each clutch housing bracket (see Fig. B.123). Withdraw the bolts from above, complete with the rebound washers. The flange of the mounting rubber is secured by two setscrews and nuts to the underside of each clutch housing bracket. The bracket in turn being secured to the housing by four setscrews.

20. If the rocker cover breather pipe and hose were not withdrawn with the air cleaner hose, remove the pipe and hose at this stage.

21. The engine is withdrawn forward and to enable this to be accomplished a jib crane, or a swan neck crane modified to incorporate a jib and hook must be used. If a swan neck crane is used, it must be counter balanced to take account of the weight of the engine. The approximate weight of the engine, less gearbox is 581 lb. (263·5 kg.).

22. It should be noted that the engine lifting eyes, which are attached to the cylinder head, are only intended to take a vertical lift, using a suitable spreader bar between these points and the hook of the lifting crane. The spreader bar must be positioned as close as possible to the rocker cover, and the jib of the crane positioned as near as possible to the spreader bar, in order to achieve the maximum lift. If the jib is located forward of the cab scuttle panel, increased lift is gained in this way. Position the jib on the spreader bar so that when the engine is being lifted, the front of the engine will be on a higher plane than the rear.

23. Using a locally manufactured support bracket to the dimensions given in Fig. B.124, bolt to the clutch housing, employing the gearbox securing holes. Position a trolley jack and wooden block, or an adjustable height

table under the support bracket and raise to take the weight at the rear of the engine, during the initial stages of engine removal.

24. Take the weight of the engine on both the crane and the jack, and carefully lever the rear mounting rubbers clear of their locations on the chassis cross-member. Then raise the engine on the crane in progressive stages until it clears the front bumper, at the same time sliding the engine forward along on the support bracket bolted to the rear of the clutch housing, until a vertical lift can be achieved on the crane.

25. Lift the engine out of the chassis, ensuring that the clutch housing and the rear mounting brackets do not foul the cab scuttle.

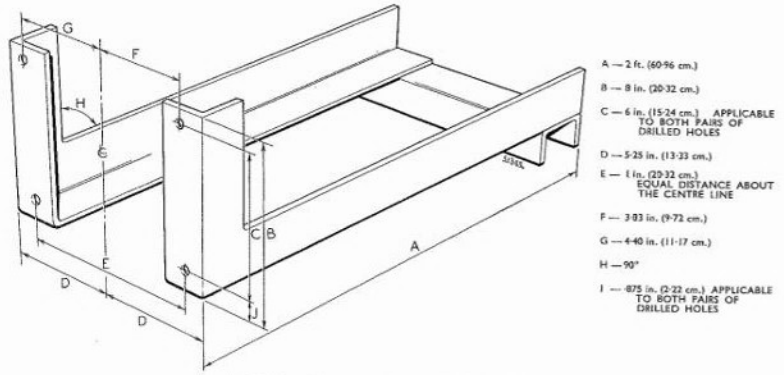


Fig. B.124. Engine removal support bracket dimensions

LUBRICATION SYSTEM

DESCRIPTION AND OPERATION

Reference should be made to Figs. B.125 and B.126, which illustrate the oil passage-ways and the oil flow, the flow being indicated by the black arrows. A more detailed view of the oil passage-ways, particularly in the cylinder block is given in Fig. B.72.

Lubrication of all working parts is effected by a forced feed oil system, in which all the oil passes through a full flow oil filter before reaching the bearings. A Hobourn Eaton oil pump is used and this pump is driven by helical skew gears from the camshaft. The pump draws oil from the sump through a gauze filter fitted to the bottom of the pump, and delivers all the oil through a short internal pipe to the full flow oil filter situated on the front right hand side of the crankcase. From the filter the oil passes into a main oil gallery, drilled in the cylinder block on the same side of the engine as the filter. As the oil pump output is in excess of the quantity of oil that can pass through all the bearings, an oil pressure relief valve is fitted to the front end of the crankcase and is connected to the inlet side of the oil filter, thus preventing excessive build up of oil pressure within the system. Excess oil is discharged into the sump. At all speeds other than idling and fast idling, this relief valve is lifted off its seat against its return spring, which controls the oil pressure to a pre-determined maximum figure. When the engine speed is reduced below that at which the oil pressure relief valve operates, the oil pressure falls until at idling speed it may only be 7 to 10 lb./sq.in. (·49 to ·70 kg./sq.cm.). Normal running oil pressure with the engine hot is 55 lb./sq. in. (3·87 kg./sq. cm.).

Four passages from the main oil gallery provide oil feeds to the top halves of the crankshaft main bearings and to the camshaft bearings. Each camshaft bearing shell has a small diameter hole through which oil is fed to the bearing surfaces. This prevents loss of oil pressure when the camshaft bearing clearances increase after a very high mileage, as the small holes then act as metering holes and control the amount of oil passing to the camshaft bearings. Drillings in the crankshaft, from the main bearing journals to the big end journals, feed to each big end bearing.

The cylinder walls are lubricated by oil splash, supplemented by an oil jet hole in the connecting rod, which squirts oil on the maximum thrust side of the cylinder wall as the connecting rod passes over T.D.C. Oil removed from the cylinder bores by the action of the scraper rings on the pistons is fed back through holes in the piston skirt and hence it gravitates down into the sump. The gudgeon pin is lubricated by oil splash, through holes provided in the small end bush and the piston bosses.

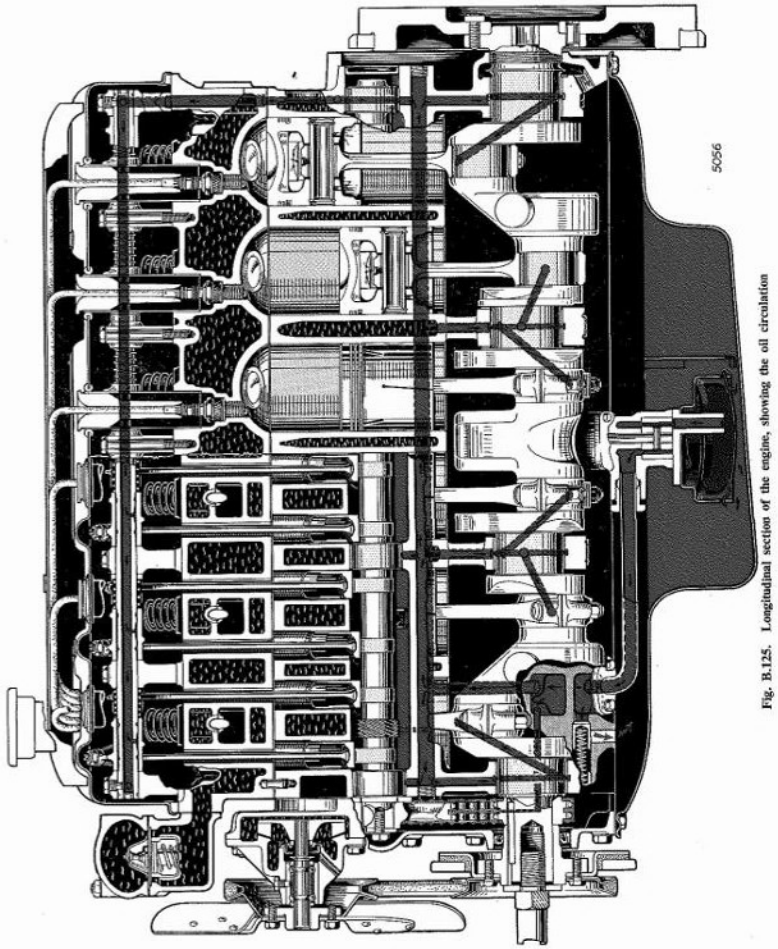


Fig. B.125. Longitudinal section of the engine, showing the oil circulation

The Renolds Timing Chain Tensioner is fed with oil from the outlet side of the oil filter, and maintains the timing chain in correct tension, by means of the oil pressure acting on the plunger. A coil spring is provided for auxiliary operation. The timing chain and wheels are lubricated by oil fed through a hole in the neoprene slipper head of the chain tensioner. Surplus oil from the timing cover drains into the front end of the sump.

Oil fed to the valve rocker gear is taken from the camshaft rear bearing through a drilling in the camshaft rear journal, which acts as a rotary metering device to the oil passing to the rocker gear. The oil flow occurs twice every camshaft revolution, while the journal drilling connects the bearing oil feed hole and the oil hole feeding the rocker gear (see Fig. B.126). By this means a controlled quantity of oil is fed at a lower pressure to a recess in the base of the rear rocker shaft support standard. From this recess the oil flows up to the annular space around the two rear support standard fixing bolts, to a transverse drilling in the standard, which feeds the twin hollow rocker shafts. Copper washers are used under the front and rear, rocker standard fixing bolt heads, and the rocker shaft locating setscrew heads to prevent oil leakage.

Drillings in the rocker shafts face downwards and feed oil to the diagonally machined grooves, whilst the two circular grooves mate with two holes in the rockers, and feed a restricted amount of oil, to the rocker faces in contact with the valve stems, and to the push rod cup ends, including the mating socket in the tappet. The tappets that actuate the push rods are lubricated by oil thrown up by rotation of the cams and by oil running down the push rods, the oil eventually draining from the tappets and supplementing the supply of lubricant in the camshaft chamber.

Oil falling from the rocker gear drains from the cylinder head into the camshaft chamber through drain holes at the front and rear ends of the cylinder head. A sufficient depth of oil is maintained in the camshaft chamber so that the cams dip in oil directly the camshaft rotates. Excess oil drains from the camshaft chamber through two hollow drain tubes, the height of which controls the depth of oil in the chamber.

The full flow oil filter is mounted to the front right hand side of the crankcase, by means of setbolts through the filter body, on to a machined face on the crankcase. The construction of the filter is such that it cannot drain when the engine is stopped. The oil filter comprises, a metal outer container carrying a renewable element, which is secured to the filter body by means of a centre bolt. The element container seats on a gasket recessed into the filter body, whilst the element carries integral sealing rings at either end, which are seated by the action of the locating spring at the top of the container, in conjunction with the element retainer which registers in the top end of the element. The retainer also centralises the element around the centre bolt. A plug is located in the base of the filter body, to facilitate draining the oil from the element container, prior to removal. A gasket located in the recessed cap at the top of the centre bolt seals the bore in the element container, through which the bolt passes. The bottom end of the centre bolt screws into the filter body. Unfiltered oil from the pump flows through the internal pipe and the passageway in the crankcase to the filter body inlet chamber, up through the hollow centre bolt to the element container, circulates within the container and then penetrates the filter element when foreign matter is removed, and the

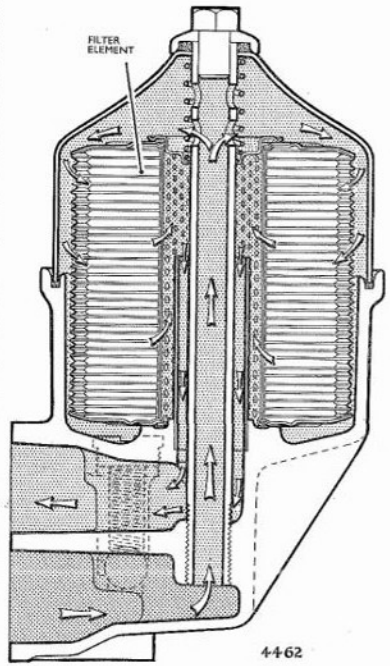


Fig. B.127. Sectional view of the oil filter, showing the oil circulation

clean oil passes to the space around the centre bolt and the outer tube. The bottom end of the outer tube connects with the outlet chamber, thus the filtered oil flows through the outlet chamber and into a passageway in the crankcase, which feeds direct into the main oil gallery.

A spring loaded ball valve connects the inlet to the outlet chamber, and forms a filter by-pass valve. This valve prevents excessive oil pressure build up on the inlet side of the filter, should the filter ever become choked. When the oil filter is operating normally

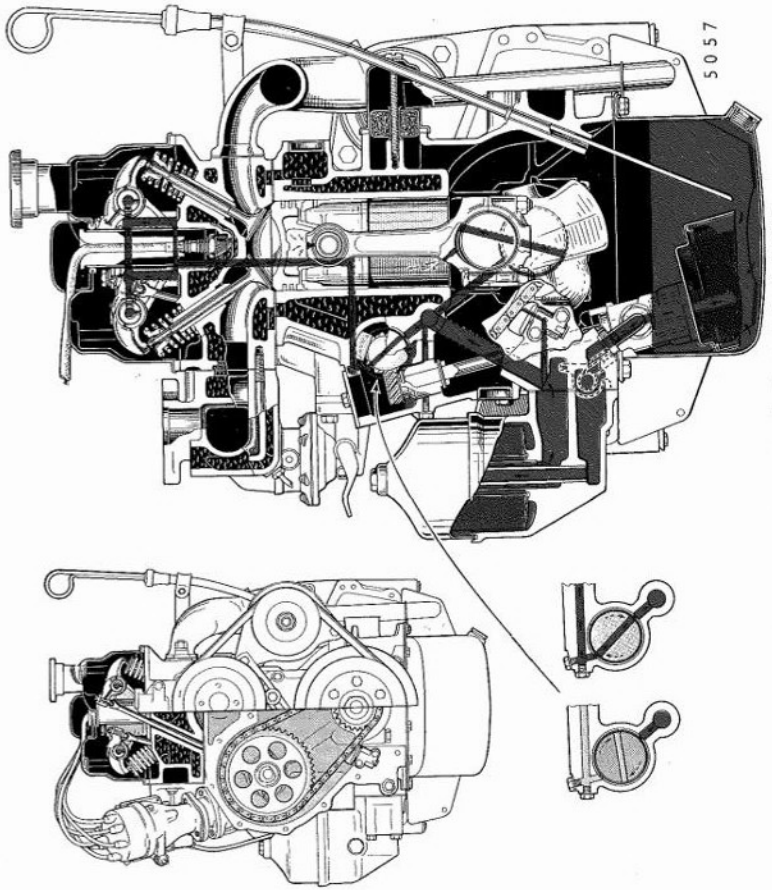


Fig. B.126. Transverse section of engine, showing the oil circulation

(filter not restricted by sludge, due to neglect), the by-pass valve will be closed and the pressure in the inlet and outlet chambers will be equal. If, however, the element does become choked, pressure will increase in the inlet chamber and eventually lift the by-pass valve from its

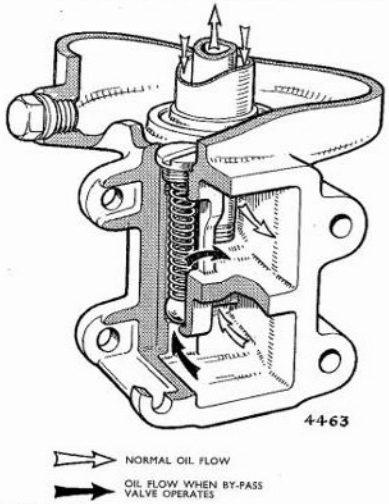


Fig. B.128. Part section view showing the oil filter by-pass valve operation

seating, allowing an unrestricted amount of unfiltered oil to pass to the outlet chamber and hence on to the bearings of the engine. This occurs when the pressure drop across the element exceeds 13 to 17 lb./sq. in. (·91 to 1·20 kg./sq. cm.), thus the importance of renewing the filter element at the recommended periods cannot be over emphasised.

The rotor and ring type oil pump is situated on the right hand underside of the crankcase and is driven from the camshaft through helical skew gears. The pinion gear is pinned to the upper end of the oil pump driving shaft and the integral journal is lubricated by oil, passed via a passage from the main oil gallery. A groove is machined on the journal which allows oil to squirt up on to the gears and into the camshaft chamber, once every revolution of the pump driving shaft, i.e., as the groove passes the oil feed hole in the crankcase. As the distributor is driven by separate helical skew gears from the camshaft, pump removal and refitting does not interfere with the ignition timing. The helical skew gears driving the distributor are lubricated by oil squirt from a hole in the distributor driving shaft upon each revolution of the shaft. The pump construction is such that a four lobe rotor mounted on the main shaft, drives a ring into which are machined five internal lobes. The outer diameter of the ring rotates in a circular bore in the oil pump body, which is offset from the driving shaft. The action of the four lobe rotor on the five lobe ring creates a strong pumping action by progressively increasing and reducing the clearance between each set of lobes. The rotor and ring are enclosed in the pump body by the cover plate, which also carries the inlet pipe. The cover is secured to the pump body by setscrews.

A pressure switch is located on the right hand side of the crankcase and connects with the main oil gallery. The switch works in conjunction with an amber oil warning light located in the combined speedometer instrument on the facia panel.

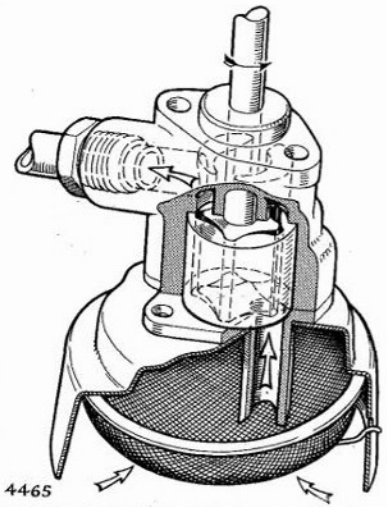


Fig. B.129. Part section view of the oil pump showing the oil flow

CRANKCASE DILUTION

Dilution of the lubricating oil may be brought about by the addition of poor quality oil, or by fuel leaking past pistons and rings. The latter condition may be due to worn cylinder bores, pistons and rings, and is most likely to occur in cold weather.

Symptoms of crankcase dilution are low oil pressure, rapid wear, overheating, loss of power and emulsification of oil. Emulsification of the oil can also be caused by the presence of water due to condensation, a leaking cylinder head gasket, or a cracked cylinder block.

If inspection confirms that dilution has taken place, ascertain and correct the cause of it and drain the sump, oil filter and camshaft chamber. The camshaft chamber is drained by removing the centre bottom fixing setscrew from each of the side cover plates. Draining should be done immediately after a run, while the oil is hot, as it

will then flow more easily. Refill the sump with new oil of the correct grade to the high level mark on the dipstick. After running the engine for a short time, again top up to the high level mark on the dipstick, to account for the initial oil recuperation of the oil filter unit and the camshaft chamber. Oil changes should then be attended to regularly and the correct grade of oil always used.

CRANKCASE BREATHER

The crankcase breather and housing are situated on the left hand side of the crankcase. Every 6,000 miles (9,000 km.) the crankcase breather should be removed, cleaned and re-oiled.

To Clean.

1. Remove the sump setscrew that secures the breather pipe steady bracket.
2. Release the centre bolt retaining the breather housing and withdraw the housing, followed by the filter assembly.
3. Clean the filter gauze in paraffin, or petrol and blow dry with compressed air, or alternatively allow to drain dry.
4. Examine the filter gauze for damage and renew the filter assembly if damage to the gauze exists.
5. Re-oil the filter gauze with clean engine oil and allow the surplus to drain off.
6. Renew the breather housing gasket if it is deteriorated in any way.
7. Refit the filter assembly and the housing, ensuring that the housing is seating squarely on the gasket, as the housing centre bolt is tightened.
8. Secure the breather pipe with the steady bracket to the appropriate sump setscrew.

CYLINDER BLOCK

Main Oil Gallery Sealing Plugs.
To Remove and Refit.

When carrying out this operation, refer to the instructions given under "Piston and Connecting Rod Assemblies", on page B.103.

FULL FLOW OIL FILTER

It is recommended that the oil filter element be renewed every 4,000 mile (6,000 km.).

To Renew the Filter Element.

1. Remove the drain plug situated in the lower front side of the filter body and drain off the oil in the element container.
2. Unscrew the centre bolt and withdraw the container and the element.
3. Separate the element from the container and clean out the container.
4. Fit the new element in the container so that the spring loaded element retainer locates centrally in the end of the element.
5. Fit the new container gasket, supplied with the element, to the filter body and refit the container, securing by means of the centre bolt.
6. Refit the filter drain plug together with its gasket. Once the engine has been run, top up the engine sump to the correct level, thus accounting for the initial oil recuperation of the element container. Finally when running the engine, check for oil leakage at the filter unit.

To Remove.

1. Remove the drain plug in the filter body and drain off the oil in the element container.
2. Withdraw the four bolts that secure the filter body to the cylinder block and remove the filter assembly and the joint.

To Dismantle.

1. Unscrew the centre bolt and withdraw the container and the element.
2. Lift out the element, remove the element retainer and the spring from the centre bolt and withdraw the centre bolt from the container. Remove the seal located in the recess under the centre bolt head.
3. Prise the container gasket from the groove in the filter body.
4. Unscrew the by-pass valve plug and withdraw the spring and ball valve from the filter body.

Inspection and Overhaul.

1. Thoroughly clean all metal components.
2. Renew the element if it has been in use for the specified period.
3. Examine the condition of the seals and renew as necessary.
4. Ensure the ball valve is not indented, or scored and that its seating in the body is in good condition. Renew the components, if necessary.
5. Inspect the by-pass valve spring for weakness and renew as necessary.
6. Ensure the threads on the centre bolt are not damaged in any way. Should damage exist, redress the threads, as necessary.

To Re-assemble.

1. Refit the by-pass ball valve to the filter body, followed by the spring, and secure these components with the plug.
2. Locate the container gasket in the groove on the filter body.

3. Insert the centre bolt in the casing with the small seal located in the recess under the centre bolt head.
4. Slide the spring, and the element retainer (spigoted side facing towards the open end of the casing) in that order, on to the centre bolt inside the container.
5. Position the filter element in the container so that the element retainer locates centrally in the end of the element.
6. Offer up the container and the element to the filter body, ensuring that the container rim seats correctly on its gasket.
7. Secure the container by tightening the centre bolt.
8. Refit the filter drain plug and gasket.

To Refit.

1. Using a new joint, refit the filter to the cylinder block and secure with the four bolts, spring washers and plain washers.
2. Run the engine and check for oil leakage at the filter.
3. Finally top up the engine sump to the correct level to account for the initial oil recuperation of the element container.

OIL SUMP (OIL PAN)

To Remove.

1. Remove the sump drain plug and drain the oil into a suitable container.
2. Raise the chassis on suitable jacks and support on stands, in order to provide the necessary clearance for sump removal.
3. Remove the securing setscrews, allowing the sump to be lowered to clear the oil pump intake filter, then moved rearward and finally lifted away. Observe that the crankcase breather pipe clip is secured to one of the sump setscrews on the left hand side of the crankcase, also the inlet manifold drain tube support clip is secured to a sump setscrew on the right hand side. It is advisable to leave one setscrew in the centre position on each side of the sump, until the weight of the sump can be conveniently taken by the hand, to avoid distortion of the joint faces.

Inspection and Overhaul.

1. Renew the sump joint if it is damaged, or compressed hard.
2. Clean out the sump with paraffin, or petrol and wipe clean with dry lintless rag, or alternatively allow to drain dry.
3. With the sump removed the opportunity should be taken to remove and clean the oil pump intake filter, as detailed on page B.125
4. Inspect the threads of the drain plug and the corresponding threads in the sump for damage and renew the components as necessary.
5. Examine the flange of the sump for distortion between the setscrew holes. Any slight irregularity may be corrected by light hammer blows using a block of steel as a support. Check the sump for damage, or splitting particularly along the flange edge of the sump. Repair, or renew, as necessary.

To Refit.

Reverse the removal procedure, bearing in mind the following:

1. Attach the gasket to the crankcase flange face with a slight smear of grease, and apply a smear of jointing compound to the flange face of the sump only.
2. Refit the sump, securing initially with two setscrews spaced at diagonally opposite positions, and then fit the remaining setscrews. Tighten the setscrews evenly by diagonal selection.
3. Refill the sump to the high level mark on the dipstick. It will be found that 12·75 pint (7·25 litre) of oil are sufficient for refilling, as approximately 3 pint (1·71 litre) of oil remain in the oil passage-ways, filter unit, etc.

Note: Should the refilling of the sump coincide with the fitting of a new oil filter element, allowance must be made for the capacity of the filter unit otherwise a noticeable fall in the sump oil level will take place when the engine has been run, owing to the initial oil recuperation of the filter unit.

OIL PRESSURE RELIEF VALVE

The oil pressure relief valve is positioned on the front crankcase face at the lower right hand side, adjacent to the timing cover, and is of the non-adjustable type. Its setting is carefully pre-set during manufacture and should not require attention. If it is required to examine the valve and its seating in the crankcase, carry out the following sequence of operations, noting that loss of oil pressure may sometimes be traced to the presence of foreign matter between the relief valve face and the valve seating.

To Remove.

Unscrew the hexagon head of the valve body, and withdraw the spring and valve from the crankcase.

Inspection.

1. Examine the sides of the valve for scores and its face for signs of pitting. Renew the valve, if necessary.
2. Renew the valve spring if it is distorted, or if the free length is less than 3·27 in. (82·60 mm.) (see also the dimensions given under "Manufacturing Data").

Important: Never attempt to increase oil pressure by stretching the relief valve spring.

3. Check to ensure that the bore in the valve body is clear of obstruction and that the valve is a free sliding fit.

4. Renew the copper washer if it is damaged.

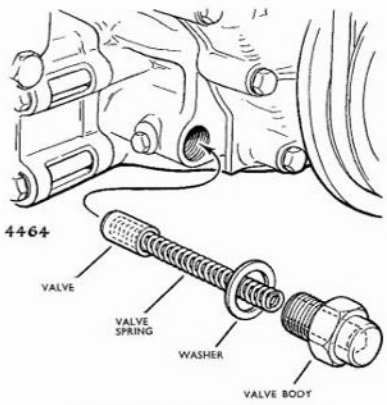


Fig. B.130. Oil pressure relief valve details

To Refit.

When refitting the relief valve, the spring should first be placed in the body, then the valve placed on the projecting end of the spring, and the whole assembly inserted and screwed into the crankcase. Ensure that the copper washer is in position on the body of the relief valve.

Normal Oil Pressure and Reasons for Low Oil Pressure.

Oil pressure may vary considerably according to the engine temperature, grade of lubricant, and condition of engine and oil pump. Normally the running pressure should be 55 lb./sq. in. (3·87 kg./sq. cm.) with the engine hot.

Pressure at idling speed is not critical and the condition of the engine should be judged by its normal running pressure. At normal idling speed an oil pressure of 7 to 10 lb./sq. in. (·49 to ·70 kg./sq. cm.), would be satisfactory with the engine hot.

If abnormally low oil pressure is recorded, it may be due to one of the following reasons:

(*a*) Low oil level in the sump.

(*b*) Oil leaks caused by faulty unions and joints, or by a cracked, or broken internal feed pipe (oil pump to oil filter).

(*c*) Faulty oil pressure warning light and/or pressure switch.

(*d*) Oil pressure relief valve not working properly, due to particles of foreign matter lodged between the valve and its seating.

(*e*) Choked oil pump intake filter.

(*f*) Dilution of the oil in the sump (see under the appropriate heading).

(*g*) Worn main and big end bearings.

(*h*) Worn oil pump rotors and pump body.

OIL PUMP INTAKE FILTER

It is recommended that the oil sump (oil pan) be removed and the oil pump intake filter cleaned at 24,000 mile (36,000 km.) intervals.

To Clean.

1. Remove the sump (see page B.124).

2. The filter gauze is held in position by a spring wire retainer, which when removed, allows the gauze to be withdrawn for cleaning.

3. Clean the gauze in paraffin, or petrol and blow dry with compressed air, or alternatively allow to drain dry.

4. Examine the filter gauze for damage and renew, if necessary.

5. Refit the filter and secure with the wire retainer.

6. Install the sump (see page B.124), and refill with the correct lubricant to the high level mark on the dipstick.

OIL PUMP

To Remove.

1. Drain the engine oil and remove the sump (see page B.124).

2. Disconnect the oil delivery pipe at the union on the pump and at the internal crankcase connection. If it is intended to refit the original pump, the union on the pump body need not be disconnected.

3. Unscrew the setscrew and the bolt in the pump locating flange, and withdraw the pump.

To Dismantle.

1. Invert the oil pump and with the filter facing upwards, withdraw the pump intake filter, after releasing the wire retainer. Remove the four setscrews securing the shroud and the cover plate to the pump body. Remove the shroud and the cover plate.

2. Withdraw the outer driven ring, ensuring that the pump base is maintained uppermost, as it is most essential that the outer driven ring is not allowed to fall accidentally, which would certainly cause the ring to crack. If the oil pump cover plate is removed with the pump in position, care must be taken to withdraw the outer driven ring, noting that it must not fall clear of the pump body accidentally.

3. Drive out the two pins securing the driving pinion to the shaft. Draw off the pinion and withdraw the pump driving shaft complete with the rotor from the pump body.

Inspection and Overhaul.

1. Examine the pump driving pinion for wear, or damage and renew if evident.

2. Check the inner rotor and outer ring clearances as follows, ensuring that all traces of oil are removed from the pump body, also from the rotor and ring before commencing the check:

(*a*) End float between the rotor and ring, and the bottom face of the pump body should not exceed ·003 in. (·076 mm.) when measured with a feeler gauge and straight edge (see Fig. B.131). Providing there is no abnormal wear present, excess end clearance can be removed by lapping the bottom face of the pump body.

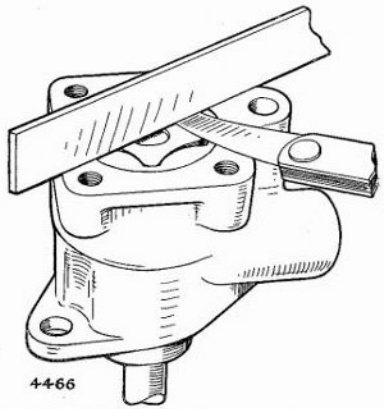


Fig. B.131. Checking end float of the oil pump rotor and ring, using a feeler gauge and straight edge.

(*b*) Side clearance between the tip of the lobes on the inner rotor and the outer ring, as shown at "A", in Fig. B.132, must not exceed a maximum figure of ·010 in. (·254 mm.). New components should be fitted if this clearance is exceeded.

(*c*) Outer driven ring clearance in the pump body, as shown at "B", in Fig. B.132, should not exceed ·008 in. (·203 mm.). If the clearance is found to be in excess of the stated maximum figure, the external diameter of the outer driven ring, also the bore diameter in the pump body should be checked for wear (see "Manufacturing Data"). Any components found outside the designed dimensions, should be renewed.

If wear necessitates the renewal of components, the shaft complete with the inner rotor and the outer driven ring must be renewed as a complete set.

3. Check the fit of the driving shaft in the pump body bushes and renew the components, as necessary.

Note: Factory reconditioned oil pumps are also available in part exchange for the original.

4. Thoroughly clean out the oil delivery pipe, also ensure that the pump intake filter is cleaned before refitting (see page B.125).

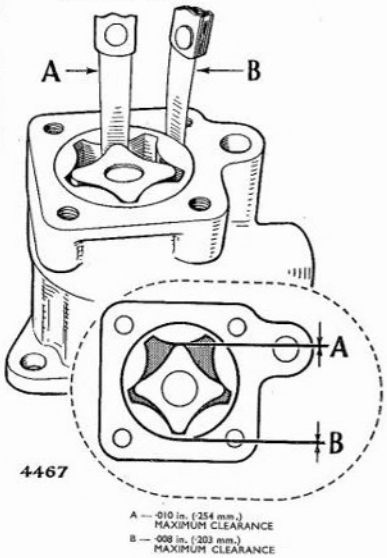


Fig. B.132. Checking side clearances of the oil pump rotor and ring

To Re-assemble.

Re-assembly is a reversal of the dismantling procedure using new pins to secure the pump driving pinion to the shaft.

To Refit.

To refit the oil pump, reverse the removal procedure, observing that it is most important to ensure that the oil delivery pipe is properly fitted.

1. If oil leaks occur from either joint connection at the ends of this pipe, a loss of oil pressure may occur, particularly at low engine speeds. The flanged face of the pipe must be perfectly flat and a new joint should be fitted between the flange face and crankcase.

2. If a replacement oil pump is being fitted, the oil delivery pipe should be annealed before fitting and the union at the pump end tightened as a final operation, after first securing the flanged end of the pipe with its fixing setscrews.

3. Complete the operation by refilling the sump to the correct level with the recommended grade of lubricant.

OIL PRESSURE SWITCH

To Remove and Refit.

1. Disconnect the lead to the switch at the "Lucar" connector provided.

2. Remove the switch unit from the adaptor, using a suitable spanner, applied to the hexagon on the switch. Do not run the engine, whilst this switch is removed, otherwise no warning of oil pressure failure will be given. Temporarily seal the hole in the crankcase adaptor to prevent the entry of dirt, etc.

3. Refit the switch by reversing the removal procedure, fitting a new fibre washer between the adaptor and the crankcase if the original is deteriorated in any way.