

workshop manual for 4.108 4.107 and 4.99 diesel engines

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Peterborough England

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This publication is written for world wide use. In territories where legal requirements govern smoke emission, noise, safety factors etc., then all instructions, data and dimensions given must be applied in such a way that, after servicing (preventive maintenance) or repairing an engine, it does not contravene the local regulations in use.

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FOREWORD

This workshop manual has been compiled for use in conjunction with normal workshop practice. Mention of certain accepted practices therefore, has been purposely omitted in order to avoid repetition.

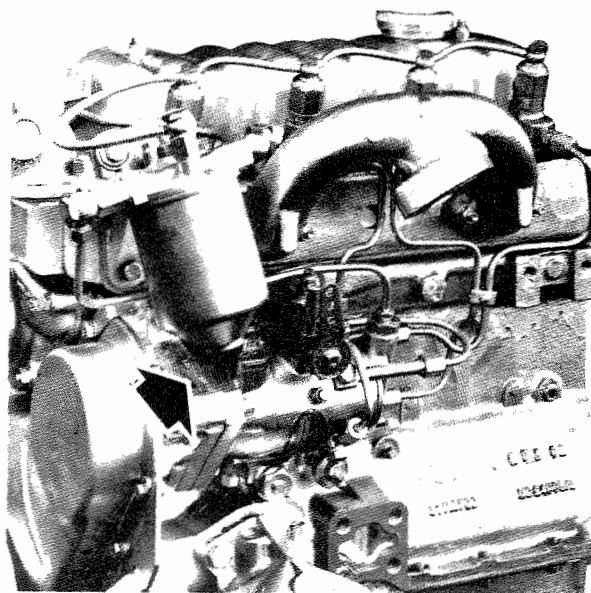
Reference to renewing joints and cleaning off joint faces has to a great extent been omitted from the text, it being understood that this will be carried out where applicable.

Similarly, it is understood that in reassembly and inspection, all parts are to be thoroughly cleaned and where present, burrs and scale are to be removed.

It follows that any open ports of high precision components, e.g., fuel injection equipment, exposed by dismantling, will be blanked off until reassembled, to prevent the ingress of foreign matter.

When setscrews or studs are fitted into holes which are tapped through into the inside of the engine, a suitable sealant must be used on the threads.

Throughout this manual, whenever the "left" or "right" hand side of the engine is referred to, it is that side of the engine as viewed from the flywheel end.



The engine number is stamped on the fuel pump mounting flange as shown in the above illustration.

Three systems of engine numbering have been used.

On very early engines the serial number consisted of seven digits as follows :—

Engine Type	Typical Engine Number
4.108	7300269
4.107	7100399
4.99	7000251

Identification on these engines can be identified by observing the first two figures of the engine number which remain constant depending on engine type.

With later engines, the number consisted of figures and letters :—

Engine Type	Typical Engine Number
4.108	108U251
4.107	107U251
4.99	99U251

The first figures represent the capacity of the engine in cubic inches, the letter "U" signifies that the engine was built in the United Kingdom and the last group of figures comprises the engine serial number.

On current engines, the number can consist of up to fifteen letters and figures, a typical number being ED21512U510256D



Safety precautions

THESE SAFETY PRECAUTIONS ARE IMPORTANT. Reference must also be made to the local regulations in the country of operation.

Do not use these engines in marine applications.

Do not change the specification of the engine.

Do not smoke when you put fuel in the tank.

Clean away any fuel which has fallen and move material which has fuel contamination to a safe place.

Do not put fuel in the tank during engine operation (unless really necessary).

Never clean, lubricate or adjust the engine during operation (unless you have had the correct training when extreme caution must be used to prevent injury).

Do not make any adjustments you do not understand.

Ensure the engine is not in a position to cause a concentration of toxic emissions.

Persons in the area must be kept clear during engine and equipment or vehicle operation.

Do not permit loose clothing or long hair near parts which move.

Keep away from parts which turn during operation. Note that fans can not be seen clearly while the engine is run.

Do not run the engine with any safety guards removed.

Do not remove the radiator cap while the engine is hot and the coolant is under pressure as dangerous hot coolant can be discharged.

Do not use salt water in the cooling system or any other coolant which can cause corrosion.

Keep sparks or fire away from batteries (especially during charge) or combustion can occur. The battery fluid can burn and is also dangerous to the skin and especially the eyes.

Disconnect the battery terminals before you make a repair to the electrical system.

Only one person must be in control of the engine.

Ensure the engine is only operated from the control panel or operators position.

If your skin comes into contact with high pressure fuel, get medical assistance immediately.

Diesel fuel can cause skin damage to some persons. Use protection on the hands (gloves or special skin protection solutions).

Do not move equipment unless the brakes are in good condition.

Ensure that the transmission drive control is in "Out of Drive" position before the engine is started.

Fit only correct Perkins Parts.

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EXAMPLES OF SERVICE FACILITIES

Service

If any problems occur with your engine or the components fitted to it, your Perkins distributor can make the necessary repairs and will ensure that only the correct parts are fitted and that the work is done correctly.

Certain components can be supplied by your Perkins distributor through the Perkins Power exchange system. These will enable you to reduce the cost of some repairs.

Extended Warranty

The engine warranty period can be extended to two years. For details, get in contact with your nearest Perkins distributor.

Service Literature

Users handbooks and other service publications are available from your Perkins distributor at a nominal cost.

Training

Local training on correct engine operation, overhaul and service is available at some Perkins distributors. If special training is needed, your Perkins distributor can give details on how to get this at the Product Education Department, Peterborough, or other main centres.

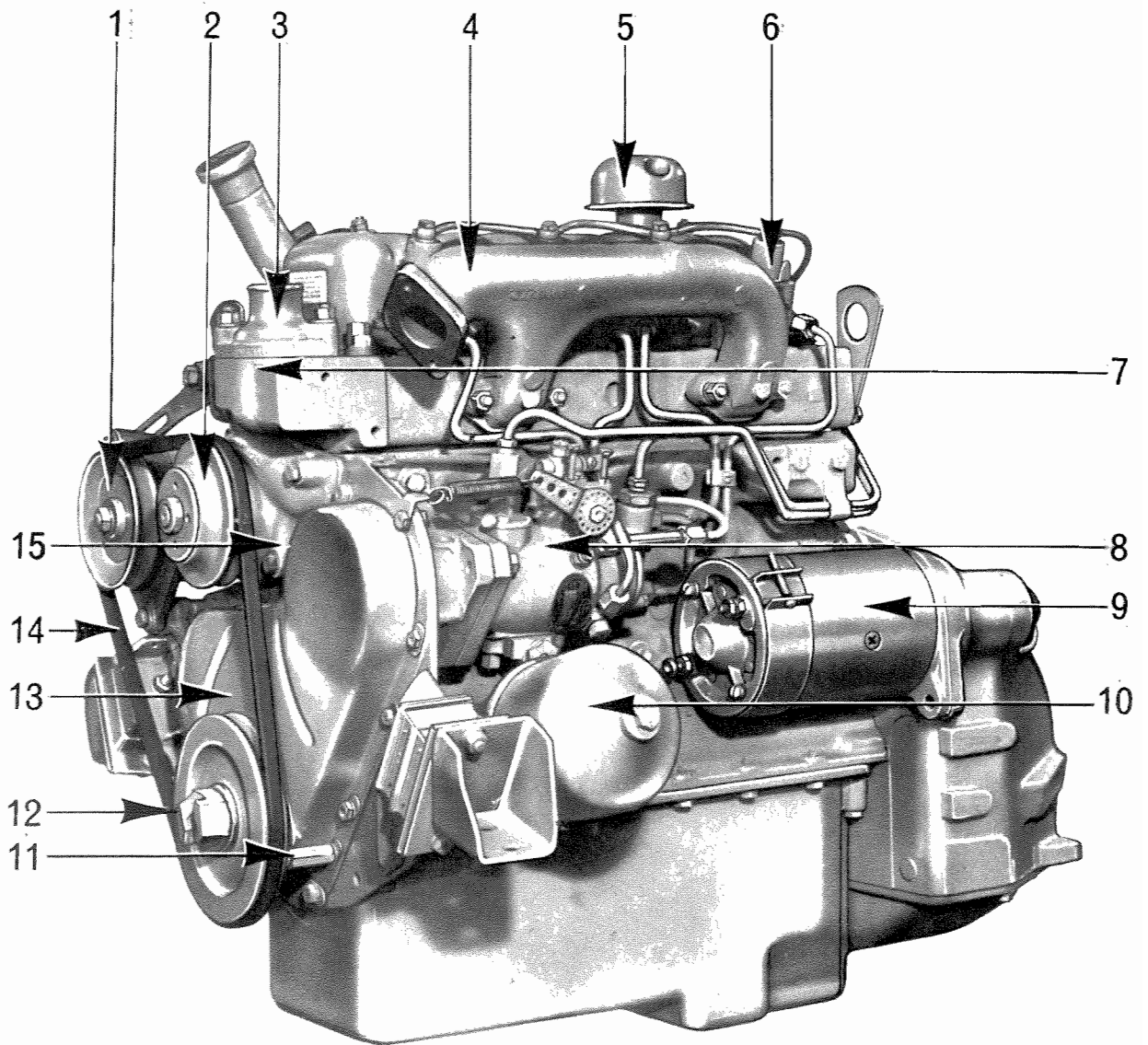
SECTION A

Engine Views



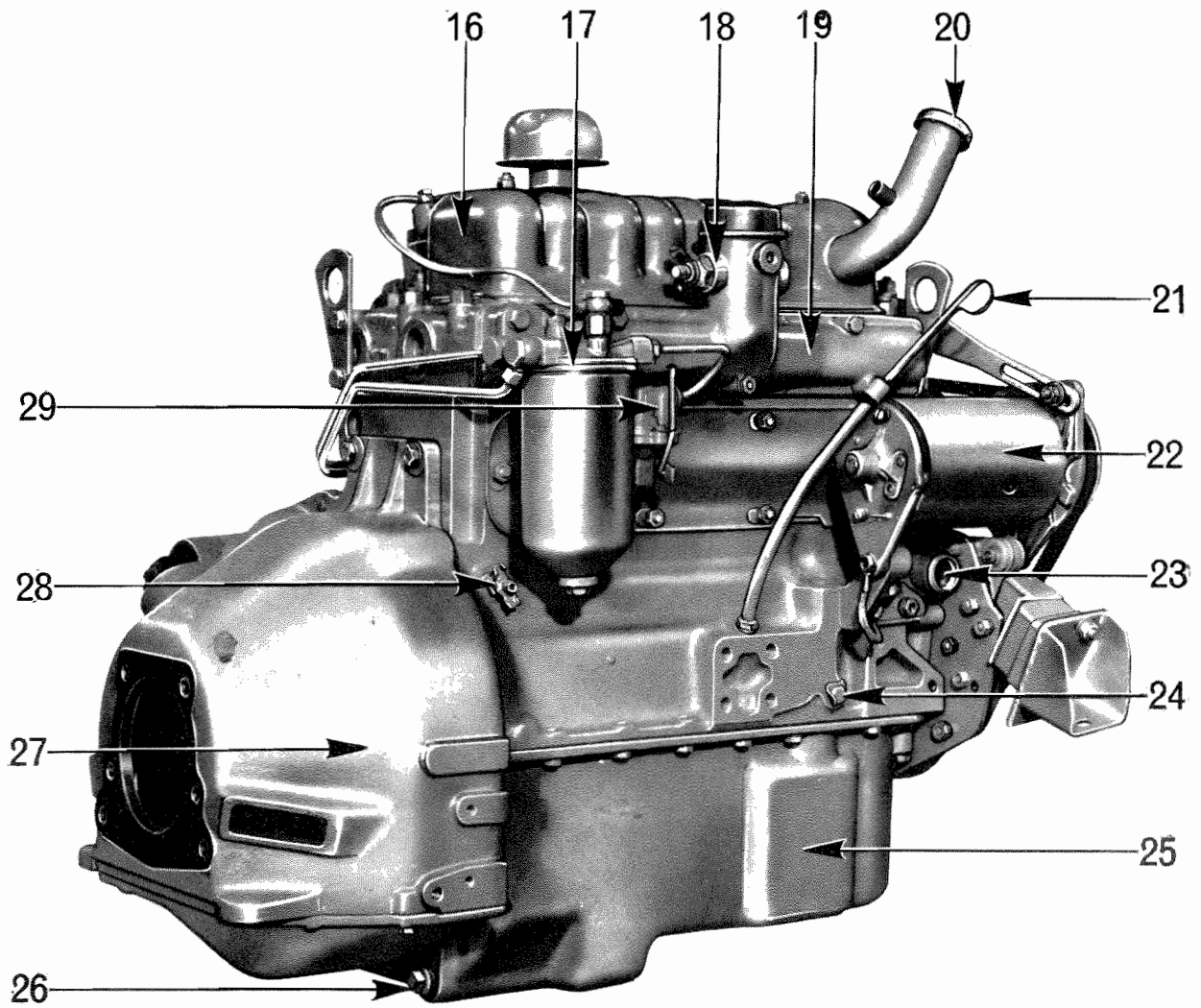
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VIEW OF FUEL PUMP SIDE OF ENGINE

ENGINE VIEWS—A.4



VIEW OF CAMSHAFT SIDE OF ENGINE

SECTION B

Technical Data

Engine Data

				4.108 and 4.107	4.99
Bore (nominal — See Page B.3) ...	...	...	...	3.125 in (79,37 mm)	3.00 in (76,2 mm)
Stroke ...	...	...	...	3.5 in (88,9 mm)	3.5 in (88,9 mm)
No. of Cylinders ...	...	...	...	Four	Four
Cubic Capacity ...	...	...	...	107.4 in ³ (1,760 litre)	99 in ³ (1,621 litre)
Compression Ratio ...	...	...	...	22:1	20:1
Firing Order ...	...	...	...	1, 3, 4, 2.	1, 3, 4, 2.
Cycle ...	...	...	...	Four-Stroke	Four-Stroke
Combustion System ...	...	...	...	Indirect Injection	Indirect Injection
Engine Rotation ...	...	...	...	Clockwise viewed from front	Clockwise viewed from front

Rating Details

	4.99	4.107	4.108
Maximum Gross Rated Output	48 bhp (37 kW) at 4000 rev/min	41 bhp (30,6 kW) at 3000 rev/min	55 bhp (41 kW) at 4000 rev/min
Maximum Gross Torque Output	73 lbf ft (10,1 kgf m) at 2250 rev/min	79 lbf ft (10,9 kgf m) at 1900 rev/min	83 lbf ft (11,5 kgf m) at 2200 rev/min

Engine Weights, Dry

Approx. dry weight, bare engine, i.e. complete with fuel injection equipment, pressed steel oil sump, dynamo, water pump, but not including starter motor, air cleaner, fan, flywheel or flywheel housing: 330 lb (150 kg).

Typical dry weight, engine with all accessories: 450 lb (204 kg).

De-rating for Altitude

Where engines are called upon to operate in rarefied atmospheres occasioned by altitude, such engines should be de-rated.

The following table is given as a general guide, which may be applied on a percentage basis, where specific figures for a particular engine rating are not available.

Altitude	Maximum fuel delivery de-rating*
0— 2,000 feet (600 metre)	No change
2,000— 4,000 feet (1,200 metre)	6%
4,000— 6,000 feet (1,800 metre)	12%
6,000— 8,000 feet (2,400 metre)	18%
8,000—10,000 feet (3,000 metre)	24%
10,000—12,000 feet (3,600 metre)	30%

*Measured at setting speed given in pump setting code.

Any necessary adjustments in this respect to the fuel pump should be carried out by the C.A.V. dealer or Perkins Distributor for the territory concerned.

For any further information apply to Technical Services Department, Perkins Engines Limited, Peterborough or to one of the Perkins Companies listed on Page 2.

TECHNICAL DATA—B.2

Recommended Torque Tensions

The following torque figures will apply with the components lightly oiled before assembly:—

	4.107 and 4.99			4.108		
	lbf ft	kgf m	Nm	lbf ft	kgf m	Nm
Cylinder Head Nuts	42	5,81	57	60	8,3	81
Connecting Rod Setscrews	42	5,81	57	42	5,81	57
*Main Bearing Setscrews	85	11,5	115	85	11,5	115
Flywheel Setscrews	60	8,3	81	60	8,3	81
Idler Gear Hub Setscrews	36	4,98	49	36	4,98	49
Crankshaft Pulley Setscrew — 1.56 in (39,6 mm) long with 1.875 in (47,6 mm) dia. washer	150	20,7	203	150	20,7	203
Crankshaft Pulley Setscrew — 1.68 in (42,7 mm) long with 1.75 in (44,6 mm) dia. washer (Cadmium Plated)				190	26,3	250
Crankshaft Pulley Setscrew (Phosphated)				230	31,5	310
Atomiser Securing Nuts	12	1,7	16	12	1,7	16
High Pressure Fuel Pipe Nuts	15	2,1	20	15	2,1	20
Dynamo Pulley Retaining Nut	20	2,8	27	20	2,8	27
Alternator Pulley Retaining Nut	30	4,1	41	30	4,1	41
Thermostart Unit	10	1,38	13	10	1,38	13
Thermostart Insulating Adaptor	10	1,38	13	10	1,38	13

*The tab and shim washers may be discarded where used on earlier engines, but the setscrews must be tightened to the torque loading indicated.

Service Wear Limits

The following "wear limits" indicate the condition when it is recommended that the respective items should be serviced or replaced.

Cylinder Head Bow	Longitudinal	0.006 in (0,15 mm)
Cylinder Head Bow	Transverse	0.003 in (0,08 mm) concave 0.005 in (0,13 mm) convex
Maximum Bore Wear (when new liners are necessary)		0.006 in (0,15 mm)
Crankshaft Main and Big End Journal	Wear	0.001 in (0,03 mm)
Crankshaft Main and Big End Journal	Ovality	0.0005 in (0,01 mm)
Maximum Crankshaft End Float		0.020 in (0,51 mm)
Valve Stem to Guide Clearance	inlet	0.005 in (0,13 mm)
Valve Stem to Guide Clearance	exhaust	0.006 in (0,15 mm)
Valve Head Thickness at outer edge		0.025 in (0,64 mm)
Rocker Clearance on Shaft		0.005 in (0,13 mm)
Camshaft Journals — Ovality and Wear		0.002 in (0,05 mm)
Camshaft End Float		0.020 in (0,51 mm)
Idler Gear End Float		0.010 in (0,25 mm)
*Valve Head Depth below Head Face—inlet and exhaust		0.048 in (1,22 mm)

*Where vehicle engines have to conform with the smoke density regulation B.S.AU 141a: 1971, then the valve depths must not exceed production limits as given on page B.8.

Manufacturing Data and Dimensions

The data regarding clearances and tolerances are given for personnel engaged upon major overhauls.

Further information can be obtained on request from the Technical Services Department, Perkins Engines Ltd., Peterborough.

CYLINDER BLOCK

Total Height of Cylinder Block		
between Top & Bottom Faces	4.108, 4.107, 4.99	9.936/9.939 in (252,374/252,451 mm)
Parent Bore Dia. for Cylinder Liner	4.108	3.249/3.250 in (82,525/82,550 mm)
Parent Bore Dia. for Cylinder Liner	4.107, 4.99	Wet Liners
Main Bearing Parent Bore	4.108, 4.107, 4.99	2.3950/2.3955 in (60,833/60,846 mm)
Camshaft Bore Dia. No. 1	4.108, 4.107, 4.99	1.794/1.7955 in (45,568/45,606 mm)
Camshaft Bore Dia. No. 2	4.108, 4.107, 4.99	1.784/1.787 in (45,314/45,390 mm)
Camshaft Bore Dia. No. 3	4.108, 4.107, 4.99	1.776/1.778 in (45,110/45,161 mm)
Tappet Bore Dia.	4.108, 4.107, 4.99	0.562/0.56325 in (14,275/14,307 mm)
Fuel Pump Drive Hub Bearing		
Bore Dia.	4.108, 4.107, 4.99	1.8125/1.8141 in (46,037/46,078 mm)

Cylinder Liner 4.108

Type	Cast Iron — Dry — Interference Fit
Interference Fit of Liners	0.003/0.005 in (0,076/0,127 mm)
Inside Dia. of Liner after Finish Boring and Honing ...	3.125/3.126 in (79,375/79,40 mm)
Height of Liner in relation to Cylinder Block Top Face	0.023/0.027 in (0,584/0,686 mm) above
Overall Length of Liner	6.495/6.505 in (164,973/165,227 mm)

Cylinder Liner 4.107 and 4.99

Type	Cast Iron — Wet — Push Fit
Inside Dia. of Liner Pre-Finished	3.00/3.001 in (76,20/76,225 mm)
Inside Dia. of Liner Pre-Finished	3.125/3.126 in (79,374/79,4 mm)
Thickness of Top Flange	0.3125/0.3145 in (7,937/7,988 mm)
Depth of Recess in Block for Liner Flange	0.3115/0.3135 in (7,912/7,963 mm)
Thickness of Top Flange	0.250/0.252 in (6,35/6,4 mm)
Depth of Recess in Block for Liner Flange	0.249/0.251 in (6,325/6,375 mm)
Height of Liner in relation to Cylinder Block Top Face	0.003 in (0,076 mm) Above. 0.001 in (0,025 mm) Below
Liner Flange Outside Dia.	3.618/3.621 in (91,898/91,973 mm)
Cylinder Block Top Bore for Liner Flange	3.625/3.627 in (92,075/92,125 mm)
Clearance Fit of Liner Flange to Block Bore	0.004/0.009 in (0,102/0,229 mm)

Pistons 4.108

Type	Flat Topped
Piston Height in relation to Cylinder Block Top Face ...	0.002/0.006 in (0,051/0,152 mm) Above
Bore Dia. for Gudgeon Pin	1.06255/1.06275 in (26,989/26,994 mm)
Compression Ring Groove Width—Top	0.0805/0.0815 in (2,045/2,070 mm)
Compression Ring Groove Width—2nd	0.0645/0.0655 in (1,638/1,664 mm)
Compression Ring Groove Width—3rd	0.0645/0.0655 in (1,638/1,664 mm)
Oil Control Ring Groove Width—4th	0.126/0.127 in (3,200/3,225 mm)
Oil Control Ring Groove Width—5th	0.190/0.191 in (4,826/4,851 mm)

With engines rated at 3.000 rev/min or below, the fourth ring groove is the same as the fifth ring groove.

Note: There is a Steel Insert fitted above the Top Groove.

Pistons 4.108 (Controlled Expansion)

Type	Flat Topped — Four Ring
Piston Height above Top Face of Cylinder Block ...	0.002/0.006 in (0,05/0,15 mm)
Bore Dia. for Gudgeon Pin	1.0627/1.0629 in (26,992/26,999 mm)
Compression Ring Groove Width, Top	0.0801/0.0821 in (2,035/2,086 mm)
Compression Ring Groove Width, Second and Third ...	0.064/0.065 in (1,64/1,65 mm)
Oil Control Ring Groove Width	0.1887/0.1895 in (4,79/4,81 mm)

Pistons 4.108 (Controlled Expansion)

Type	Flat Topped — Three Ring
Piston Height above Top Face of Cylinder Block ...	0.002/0.006 in (0,05/0,15 mm)
Bore Dia. for Gudgeon Pin	1.0627/1.0629 in (26,992/26,999 mm)
Compression Ring Groove Width, Top	0.080/0.082 in (2,035/2,086 mm)
Compression Ring Groove Width, Second	0.099/0.1005 in (2,53/2,55 mm)
Oil Control Ring Groove Width	0.1890/0.1900 in (4,80/4,826 mm)

Pistons 4.107 and 4.99

Type	Flat Topped
Piston Height in relation to Cylinder Block Top Face ...	0.0085/0.012 in (0,22/0,30 mm) Above
Bore Dia. for Gudgeon Pin later 4.99 and all 4.107 engines	0.93755/0.93775 in (23,81/23,82 mm)
Early 4.99 engines	0.87505/0.87525 in (22,22/22,23 mm)
Compression Ring Groove Width—Top	0.0801/0.0811 in (2,034/2,06 mm)
Compression Ring Grooves Width 2nd and 3rd	0.0645/0.0655 in (1,638/1,664 mm)
Oil Control Ring Grooves 4th and 5th	0.190/0.191 in (4,826/4,851 mm)

TECHNICAL DATA—B.4

Piston Rings 4.108

Top—Compression	...	...	...	Parallel Faced
Second and Third Compression	...	...	...	Internally Stepped
Fourth—Oil Control	...	...	...	Laminated Segment *
Fifth—Oil Control	...	...	...	Slotted Scraper
Top Compression Ring Width	...	...	...	0.0771/0.0781 in (1,958/1,984 mm)
Ring Clearance in Groove	...	...	...	0.0024/0.0044 in (0,061/0,112 mm)
Second and Third Compression Ring Width	...	...	...	0.0615/0.0625 in (1,562/1,587 mm)
Ring Clearance in Groove	...	...	...	0.002/0.004 in (0,051/0,102 mm)
Fifth Scraper Ring Width	...	...	...	0.1865/0.1875 in (4,737/4,762 mm)
Ring Clearance in Groove	...	...	...	0.0025/0.0045 in (0,063/0,114 mm)
Ring Gap—Top Compression	...	...	...	0.009/0.017 in (0,229/0,432 mm)
Ring Gap—Second and Third Compression	...	...	...	0.009/0.017 in (0,229/0,432 mm)
Ring Gap—Fifth Scraper	...	...	...	0.009/0.017 in (0,229/0,432 mm)

* Engines rated at 3,000 rev/min and below have a slotted scraper fitted in the fourth groove which has the same width, clearance and gap as the fifth ring.

Piston Rings 4.108 (Controlled Expansion — Four Ring)

Top Compression	...	...	...	Chrome Insert — Parallel Faced
Second and Third Compression	...	...	...	Internally Stepped
Fourth Oil Control	...	...	...	Spring Loaded Scraper
Top Compression Ring Width	...	...	...	0.077/0.078 in (1,96/1,98 mm)
Ring Clearance in Groove	...	...	...	0.002/0.005 in (0,05/0,13 mm)
Second and Third Compression Ring Width	...	...	...	0.0615/0.0625 in (1,56/1,59 mm)
Ring Clearance in Groove	...	...	...	0.0015/0.0035 in (0,04/0,09 mm)
Oil Control Ring Width	...	...	...	0.186/0.1865 in (4,72/4,74 mm)
Ring Clearance in Groove	...	...	...	0.0022/0.0035 in (0,05/0,09 mm)
Ring Gap, Top	...	...	...	0.012/0.023 in (0,30/0,58 mm)
Ring Gap, Second and Third	...	...	...	0.009/0.020 in (0,23/0,50 mm)
Ring Gap, Oil Control	...	...	...	0.010/0.021 in (0,25/0,53 mm)

Piston Rings 4.108 (Controlled Expansion — Three Ring)

Top Compression	...	...	...	Chrome, Taper Faced
Second Compression	...	...	...	Internally Stepped, Taper Faced
Third Oil Control	...	...	...	Spring Loaded Scraper
Top Compression Ring Width	...	...	...	0.0765/0.0775 in (1,943/1,969 mm)
Clearance in Groove	...	...	...	0.0025/0.0055 in (0,063/0,140 mm)
Second Compression Ring Width	...	...	...	0.097/0.098 in (2,46/2,49 mm)
Clearance in Groove	...	...	...	0.0015/0.0035 in (0,039/0,089 mm)
Oil Control Ring Width	...	...	...	0.1865/0.1875 in (4,737/4,763 mm)
Clearance in Groove	...	...	...	0.0015/0.0035 in (0,039/0,089 mm)
Ring Gap, Top	...	...	...	0.012/0.023 in (0,31/0,59 mm)
Ring Gap, Second	...	...	...	0.009/0.020 in (0,23/0,51 mm)
Ring Gap, Oil Control	...	...	...	0.012/0.023 in (0,31/0,59 mm)

Piston Rings

4.99 Vehicle Engines

Top Compression	...	...	...	Parallel Faced Chrome Plated
Second and Third Compression	...	...	...	Internally Stepped
Fourth and Fifth Oil Control	...	...	...	Slotted Scraper

Piston Rings 4.107 and 4.99

Agricultural and Industrial Engines

Top Compression	...	...	...	Parallel Cast Iron
*Second and Third Compression	...	...	...	Internally Stepped
Fourth—Oil Control	...	...	...	Chrome Plated Spring Loaded Scraper
Fifth—Oil Control	...	...	...	Slotted Scraper

* 4.99 Agricultural engines have taper faced cast iron compression rings fitted in the second and third ring grooves.

Top Compression Ring Width	...	...	...	0.0771/0.0781 in (1,96/1,984 mm)
Ring Clearance in Groove	...	...	...	0.002/0.004 in (0,051/0,102 mm)
Second and Third Compression Ring Width	...	...	...	0.0615/0.0625 in (1,562/1,587 mm)
Ring Clearance in Groove	...	...	...	0.002/0.004 in (0,051/0,102 mm)
Fourth and Fifth Scraper Ring Width	...	...	...	0.1865/0.1875 in (4,737/4,762 mm)
Ring Clearance in Groove	...	...	...	0.0025/0.0045 in (0,064/0,114 mm)
Ring Gap—Compression Rings Chrome Vehicle	...	...	...	0.012/0.020 in (0,30/0,50 mm)
Ring Gap—Oil Control Rings Cast Iron Vehicle	...	...	...	0.009/0.017 in (0,30/0,432 mm)
Ring Gap—Compression Rings Cast Iron Agricultural and Industrial	...	...	...	0.009/0.017 in (0,30/0,432 mm)

Gudgeon Pin 4.108

Type	...	...	...	...	Fully Floating
Outside Dia. of Gudgeon Pin	...	...	...	...	1.0625/1.0627 in (26,987/26,993 mm)
Length of Gudgeon Pin	...	...	...	...	2,673/2,687 in (67,894/68,250 mm)
Fit in Piston Boss	...	...	...	...	Transition

Gudgeon Pin 4.107 and 4.99

Type	...	...	...	...	Fully Floating
Outside Dia. of Gudgeon Pin (Later Engines)	...	...	...	...	0.9375 in/0.9377 in (23,812/23,817 mm)
Outside Dia. of Gudgeon Pin (Earlier Engines)	...	...	...	...	0.875/0.8752 in (22,225/22,23 mm)
Fit in Piston Boss	...	...	...	...	Transition

Small End Bush 4.108

Type	...	...	...	...	Steel Backed, Lead Bronze Lined
Length of Small End Bush	...	...	...	...	0.935/0.955 in (23,749/24,257 mm)
Outside Dia. of Small End Bush	...	...	...	...	1.221/1.222 in (31,013/31,039 mm)
Inside Dia. before Reaming	...	...	...	...	1.0495/1.0545 in (26,657/26,784 mm)
Inside Dia. after Reaming	...	...	...	...	1.06315/1.0632 in (27,004/27,005 mm)
Clearance between Small End Bush and Gudgeon Pin	...	...	...	...	0.00045/0.0007 in (0,0114/0,0178 mm)

Small End Bush 4.107 and 4.99

Type	...	...	...	...	Steel Backed, Lead Bronze Lined
Length of Small End Bush	...	...	...	...	0.865/0.885 in (22,00/22,48 mm)
Outside Dia. of Small End Bush	...	...	...	...
on later 4.99 and all 4.107 engines	...	...	...	...	1.065/1.066 in (27,05/27,08 mm)
Early 4.99 engines	...	...	...	...	1.0025/1.0035 in (25,46/25,49 mm)
Inside Dia. after Reaming on later	...	...	...	...
4.99 and all 4.107 engines	...	...	...	...	0.9382/0.93875 in (23,83/23,84 mm)
Early 4.99 engines	...	...	...	...	0.8757/0.87625 in (22,24/22,26 mm)
Clearance between Small End Bush and Gudgeon Pin	...	...	...	...	0.0005/0.00125 in (0,01/0,03 mm)

Note. Bushes to be reamed to suit respective Gudgeon Pins, and are provided with a reaming allowance.

Connecting Rod 4.108

Type	...	...	...	...	'H' Section
Cap Location to Connecting Rod	...	...	...	...	Serrations, Offset 45° to the Horizontal
Big End Parent Bore Dia.	...	...	...	...	2.146/2.1465 in (54,508/54,521 mm)
Small End Parent Bore Dia.	...	...	...	...	1.21875/1.21975 in (30,956/30,981 mm)
Length from Centre Line of Big End	...	...	...	...
to Centre Line of Small End	...	...	...	...	6.217/6.219 in (157,912/157,963 mm)
Big End Setscrew	...	...	...	...	0.375 in (3/8 in) U.N.F.
Connecting Rod End Float	...	...	...	...	0.0065/0.0105 in (0,165/0,267 mm)

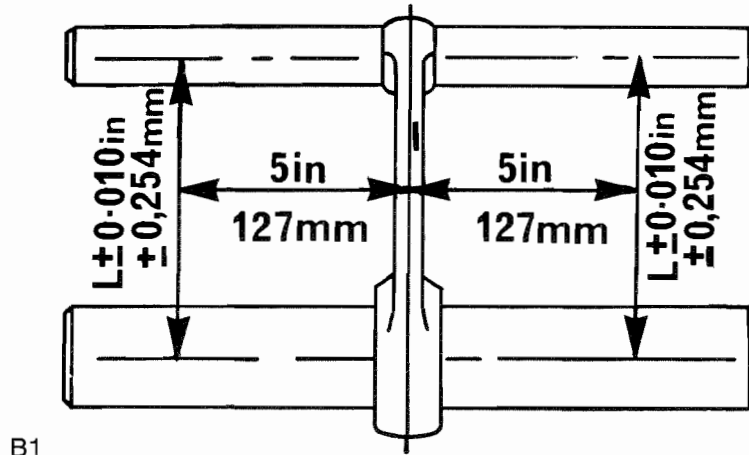
Connecting Rod 4.107 and 4.99

Type	...	...	...	...	'H' Section
Cap Location to Connecting Rod	...	...	...	...	Serrations, Offset 45° to the Horizontal
Big End Parent Bore Dia.	...	...	...	...	2.146/2.1465 in (54,508/54,521 mm)
Small End Parent Bore Dia.	...	...	...	...
on later 4.99 and all 4.107 engines	...	...	...	...	1.0625/1.0635 in (26,99/27,01 mm)
Early 4.99 engines	...	...	...	...	1.00/1.001 in (25,4/25,43 mm)
Length from Centre Line of Big End to Centre Line of	...	...	...	...
Small End	...	...	...	...	6.405/6.407 in (162,69/162,74 mm)
Big End Setscrew	...	...	...	...	0.375 in (3/8 in) U.N.F.
Connecting Rod End Float	...	...	...	...
on later 4.99 and all 4.107 engines	...	...	...	...	0.0065/0.0105 in (0,16/0,27 mm)
Early 4.99 engines	...	...	...	...	0.0075/0.0105 in (0,19/0,27 mm)

TECHNICAL DATA—B.6

Connecting Rod Alignment 4.108, 4.107, 4.99

Large and small end bores must be square and parallel with each other within the limits of ± 0.010 in (0,25 mm) measured 5 in (127 mm) each side of the axis of the rod on test mandrel as shown in Fig. B.1. With the small end bush fitted, the limit of ± 0.010 in (0,25 mm) is reduced to ± 0.0025 in (0,60 mm).



Crankshaft 4.108, 4.107, 4.99

Overall Length	...	...	...	21.125 in (536,575 mm)
Main Journal Dia. Nos. 1 and 2	...	...	...	2.248/2.2485 in (57,099/57,112 mm)
Main Journal Dia. No. 3	...	...	...	2.2475/2.248 in (57,086/57,099 mm)
Main Journal Length No. 1	...	...	...	1.40625 in (35,719 mm)
Main Journal Length No. 2	...	...	...	1.496/1.504 in (37,998/38,202 mm)
Main Journal Length No. 3	...	...	...	1.499/1.502 in (38,075/38,151 mm)
Main Journal Fillet Radii	...	...	...	0.125/0.141 in (3,175/3,581 mm)
Crankpin Dia.	...	...	...	1.9993/2.0001 in (50,78/50,80 mm)
Crankpin Length	...	...	...	1.1875/1.1895 in (30,162/30,213 mm)
Crankpin Fillet Radii	...	...	...	0.15625/0.17187 in (5/32/11/64 in) (3,969/4,366 mm)
Surface Finish—All Journals	...	...	...	8-16 micro-in (0,2 - 0,4 micron)
Main Journal and Crankpin Regrind Undersizes	...	...	...	0.010, 0.020, 0.030 in (0,25, 0,51, 0,76 mm)
Oil Seal Helix Dia.	...	...	...	2.21075/2.21175 in (56,153/56,178 mm)
Oil Seal Helix Width	...	...	...	0.050/0.080 in (1,270/2,032 mm)
Oil Seal Helix Depth	...	...	...	0.004/0.008 in (0,102/0,203 mm)
Flange Dia.	...	...	...	3.9985/3.9995 in (101,562/101,587 mm)
Flange Width	...	...	...	0.500 in (12,700 mm)
Spigot Bearing Recess Depth	...	...	...	0.875 in (22,225 mm)
Spigot Bearing Recess Bore	...	...	...	1.250 in (31,750 mm)
Crankshaft End Float	...	...	...	0.002/0.015 in (0,0508/0,381 mm)

Crankshaft Thrust Washers 4.108, 4.107, 4.99

Type	...	...	...	Steel Backed—Lead Bronze Faced
Position in Engine	...	...	...	Rear Main Bearing
Thrust Washer Thickness (STD)	...	...	...	0.089/0.091 in (2,261/2,311 mm)
Thrust Washer Thickness (O/S)	...	...	...	0.0965/0.1005 in (2,451/2,553 mm)
Thrust Washer Outside Dia.	...	...	...	3.245/3.255 in (82,423/82,677 mm)
Thrust Washer Inside Dia.	...	...	...	2.590/2.600 in (65,786/66,040 mm)

Main Bearings 4.108, 4.107, 4.99

Type	...	...	...	Pre-finished, Steel Backed, Aluminium Tin Lined
Shell Width	...	...	...	1.245/1.255 in (31,623/31,877 mm)
Outside Dia. of Main Bearing	...	...	...	2.3955 in (60,846 mm)
Inside Dia. of Main Bearing	...	...	...	2.2505/2.2515 in (57,163/57,188 mm)
Running Clearance—Nos. 1 and 2	...	...	...	0.002/0.0035 in (0,051/0,089 mm)
Running Clearance—No. 3	...	...	...	0.0025/0.004 in (0,063/0,102 mm)
Steel Thickness	...	...	...	0.060 in (1,524 mm) Max.
Aluminium Thickness	...	...	...	0.012/0.01225 in (0,305/0,311 mm)

Connecting Rod Bearings 4.108, 4.107, 4.99

Type	Pre-finished, Steel Backed, Aluminium Tin Lined
Shell Width	0.870/0.880 in (22,098/22,325 mm)
Outside Dia. of Con. Rod Bearing	2.1465 in (54,521 mm)
Inside Dia. of Con. Rod Bearing	2.0015/2.0025 in (50,838/50,863 mm)
Running Clearance	0.0014/0.0032 in (0,036/0,081 mm)
Steel Thickness	0.060 in (1,524 mm) Max.
Aluminium Thickness	0.012/0.01225 in (0,305/0,311 mm)

Camshaft 4.108, 4.107, 4.99

No. 1 Journal Length	1.347/1.351 in (34,214/34,315 mm)
No. 1 Journal Dia.	1.791/1.792 in (45,491/45,517 mm)
No. 1 Cylinder Block Camshaft Bore Dia.	1.794/1.7955 in (45,568/45,606 mm)
No. 1 Journal Running Clearance	0.002/0.0045 in (0,051/0,114 mm)
No. 2 Journal Length	1,250 in (31,750 mm)
No. 2 Journal Dia.	1.781/1.782 in (45,237/45,263 mm)
No. 2 Cylinder Block Camshaft Bore Dia.	1,784/1,787 in (45,314/45,390 mm)
No. 2 Journal Running Clearance	0.002/0.006 in (0,051/0,152 mm)
No. 3 Journal Length	1.000 in (25,400 mm)
No. 3 Journal Dia.	1.773/1.774 in (45,034/45,060 mm)
No. 3 Cylinder Block Camshaft Bore Dia.	1.776/1.778 in (45,110/45,161 mm)
No. 3 Journal Running Clearance	0.002/0.005 in (0,051/0,127 mm)
Cam Lift	0.2592/0.2622 in (6,58/6,66 mm)
Oilways for Rocker Shaft Lubrication	No. 2 Journal

Camshaft Thrust Plates 4.108, 4.107, 4.99

Type	180° Oil Impregnated Sintered Iron
Thrust Plate Outside Dia.	2.555/2.557 in (64,897/64,948 mm)
Cylinder Block Recess Dia. for Thrust Plate	2.5585/2.5685 in (64,986/65,240 mm)
Clearance Fit of Thrust Plate in Recess	0.0015/0.013 in (0,038/0,330 mm)
Thrust Plate Inside Dia.	1.500 in (38,100 mm)
Thrust Plate Thickness	0.160/0.162 in (4,060/4,115 mm)
Cylinder Block Recess Depth for Thrust Plate	0.158/0.164 in (4,009/4,166 mm)
Thrust Plate Height in relation to Cylinder Block Face	0.004 in (0,102 mm) above or below
Camshaft End Float	0.003/0.009 in (0,076/0,228 mm)

Valve and Fuel Pump Timing

Refer to later section on timing (page K.1).

CYLINDER HEAD 4.108, 4.107, 4.99

Overall Length of Cylinder Head	20.000 in (508,000 mm)
Overall Depth of Cylinder Head	2.617/2.633 in (66,472/66,878 mm)
Skimming Allowance on Cylinder Head Face	NIL—On no account can the cylinder head face be skimmed
Pressure for Water Leakage Test	20 lbf/in ² (1,4 kgf/cm ²) — 138 kN/m ²
Valve Seat Angle	45°
Bore in Cylinder Head for Guide	0.4995/0.5005 in (12,687/12,713 mm)
Bore in Cylinder Head for Combustion Chamber Inserts	1.250/1.252 in (31,750/31,801 mm)
Depth of Bore in Cylinder Head for Combustion Chamber Inserts	0.373/0.376 in (9,474/9,550 mm)

Combustion Chamber Inserts 4.108, 4.107, 4.99

Outside Dia. of Insert	1.248/1.249 in (31,699/31,724 mm)
Depth of Insert	0.374/0.375 in (9,499/9,525 mm)
Height of Insert in relation to Cylinder Head Face	0.002 in (0,051 mm) above or below
Clearance Fit of Insert in Cylinder Head Bore	0.001/0.004 in (0,025/0,102 mm)
Method of Location in Cylinder Head	By Cylinder Block Face and Expansion Washer

Valve Guides (Inlet) 4.108, 4.107, 4.99

Inside Dia.	0.3141/0.3155 in (7,978/8,014 mm)
Outside Dia.	0.5021/0.5026 in (12,753/12,766 mm)
Interference fit of Guide in Cylinder Head Bore	0.0016/0.0031 in (0,041/0,079 mm)
Overall length of Guide	2.130 in (54,102 mm)
Guide Protrusion Above Top Face of Cylinder Head	0.800/0.815 in (20,320/20,701 mm)

TECHNICAL DATA—B.8

Valve Guides (Exhaust) 4.108, 4.107, 4.99

Inside Dia.	0.3141/0.3155 in (7,978/8,014 mm)
Outside Dia.	0.5021/0.5026 in (12,753/12,766 mm)
Interference fit of Guide in Cylinder Head Bore ...	0.0016/0.0031 in (0,041/0,079 mm)
Depth of Counterbore	0.380 in (9,650 mm)
Overall Length of Guide	2.440 in (61,980 mm)
Guide Protrusion above Top Face of Cylinder Head ...	0.800/0.815 in (20,320/20,701 mm)

Valves (Inlet) 4.108, 4.107, 4.99

Valve Stem Dia.	0.312/0.313 in (7,925/7,950 mm)
Clearance fit of Valve Stem in Guide	0.0011/0.0035 in (0,028/0,089 mm)
Valve Head Dia.	1.410/1.414 in (35,814/35,916 mm)
Valve Face Angle	45°
Valve Head Depth Below Cylinder Head Face ...	0.028/0.039 in (0,711/0,991 mm)
Overall Length of Valve	4.592/4.608 in (116,637/117,043 mm)
Sealing Arrangement	Rubber Oil Seal

Valve (Exhaust) 4.108, 4.107, 4.99

Valve Stem Dia.	0.3115/0.3125 in (7,912/7,937 mm)
Clearance Fit of Valve Stem in Guide	0.0016/0.004 in (0,041/0,102 mm)
Valve Head Dia.	1.191/1.195 in (30,251/30,353 mm)
Valve Face Angle	45°
Valve Head Depth Below Cylinder Head Face ...	0.021/0.032 in (0,533/0,813 mm)
Overall Length of Valve	4.600/4.616 in (116,840/117,246 mm)
Sealing Arrangement	No Seal fitted to Exhaust Valve

Inner Valve Springs (where fitted)

Fitted Length	1.530 in (38,862 mm)
Load at Fitted Length	28.6 lbf ± 2 lbf (13,0 kgf ± 0,91 kgf)
Fitted Position	Damper Coil to Cylinder Head

Outer Valve Springs 4.108, 4.107, 4.99

Fitted Length	1.780 in (45,212 mm)
Load at Fitted Length	56.0 lbf ± 2.8 lbf (25,4 kgf ± 1,27 kgf)
Fitted Position	Damper Coil to Cylinder Head

Rocker Levers 4.108, 4.107, 4.99

Length between Centre Line of Adjusting Screw and Centre Line of Rocker Shaft	1.042/1.058 in (26,467/26,873 mm)
Length between Centre Line of Rocker Lever Pad and Centre Line of Rocker Shaft	1.567/1.583 in (39,802/40,208 mm)
Inside Dia. of Rocker Lever Bore	0.71825/0.71950 in (18,243/18,275 mm)
Outside Dia. of Rocker Lever Bush	0.7205/0.7215 in (18,301/18,326 mm)
Interference Fit of Bush in Rocker Lever	0.001/0.00325 in (0,025/0,082 mm)
Finished Inside Dia. of Rocker Lever Bush	0.6245/0.62575 in (15,862/15,894 mm)
Clearance of Rocker Lever Bush on Rocker Shaft ...	0.00075/0.0035 in (0,019/0,089 mm)

Valve Clearances 4.108, 4.107, 4.99

Clearance between Valve Stem Tip and Rocker Lever	0.012 in (0,30 mm) Cold
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Rocker Shaft 4.108, 4.107, 4.99

Overall Length of Shaft	14.5625 in (369,887 mm)
Outside Dia. of Shaft	0.62225/0.62375 in (15,805/15,843 mm)
Lubrication	Oil Feed from Cylinder Head through Central Passage to Individual Rocker Levers

Push Rods 4.108, 4.107, 4.99

Overall Length	8.527/8.560 in (216,58/217,42 mm)
Outside Dia.	0.250 in (6,350 mm)

Tappets 4.108, 4.107, 4.99

Overall Length	2.250 in (57,150 mm)
Outside Dia. of Tappet Shank	0.560/0.561 in (14,224/14,249 mm)
Cylinder Block Tappet Bore Dia.	0.562/0.56325 in (14,275/14,307 mm)
Tappet Running Clearance in Cylinder Block Bore	0.001/0.00325 in (0,025/0,082 mm)
Outside Dia. of Tappet Foot	1.245/1.255 in (31,623/31,877 mm)

TIMING GEARS 4.108, 4.107, 4.99

Note: Some engines are fitted with spur gears instead of helical gears, in which case the number of teeth on each gear are given in brackets.

Camshaft Gear

Number of Teeth	48 (50)
Inside Dia. of Gear Boss	1.750/1.7514 in (44,450/44,486 mm)
Outside Dia. of Camshaft Hub	1.7496/1.7509 in (44,430/44,473 mm)
Transition Fit of Gear and Hub	0.0009/0.0018 in (0,023/0,046 mm)

Fuel Pump Gear

Number of Teeth	48 (50)
Inside Dia. of Cylinder Block Bore for Fuel Pump Drive Hub Bearing	1.8125/1.8141 in (46,037/46,078 mm)
Outside Dia. of Fuel Pump Drive Hub Bearing Interference Fit of Drive Hub Bearing in Cylinder Block Bore	1.8145/1.8152 in (46,088/46,106 mm)
Inside Dia. of Fuel Pump Drive Hub Bearing	0.0004/0.0027 in (0,010/0,069 mm)
Outside Dia. of Fuel Pump Gear Drive Hub	1.3125/1.3135 in (33,34/33,78 mm)
Running Clearance of Drive Hub in Bearing	1.3105/1.3115 in (33,287/33,312 mm)
Drive Hub End Float	0.0031/0.0051 in (0,079/0,129 mm)
	0.002/0.010 in (0,051/0,254 mm)

Idler Gear and Hub

Number of Teeth	57 (42)
Inside Dia. of Gear Boss	1.7187/1.7197 in (43,655/43,680 mm)
Inside Dia. of Gear Boss with Bush Fitted	1.5625/1.5641 in (39,687/39,728 mm)
Outside Dia. of Gear Hub	1.5612/1.5619 in (39,654/39,668 mm)
Running Clearance of Gear on Hub	0.0003/0.0016 in (0,008/0,041 mm)
Idler Gear Width	1.3105/1.3135 in (33,287/33,363 mm)
Hub Width	1.3165/1.3195 in (33,439/33,52 mm)
Idler Gear End Float	0.003/0.008 in (0,076/0,208 mm)

Crankshaft Gear

Number of Teeth	24 (25)
Inside Dia. of Gear	1.250/1.2512 in (31,750/31,780 mm)
Crankshaft Dia. for Gear	1.250/1.2506 in (31,750/31,756 mm)
Transition Fit of Gear on Crankshaft	0.0006/0.0012 in (0,015/0,030 mm)

Timing Gear Backlash

Clearance between Crankshaft/Idler and Camshaft/Idler Gear	0.0015/0.0025 in (0,038/0,064 mm)
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LUBRICATING SYSTEM 4.108, 4.107, 4.99

Lubricating Oil Pressure	30/60 lbf/in ² (2,1/4,2 kgf/cm ²) — 207/414 kN/m ² at maximum engine speed and normal working temperature.
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Sump

Dipstick Position	Camshaft side of engine opposite No. 2 cylinder
Strainer Location	End of suction pipe to lubricating oil pump.

Typical Sump Capacities

Refill Capacities—Engine Level	Imp. pt	U.S. pt	Litre
Standard Sump	7.0	8.4	4.0
Vauxhall Motors	9.0	10.8	5.1
Chrysler Cars	8.6	10.3	4.9
Ford Motor Co.	8.75	10.5	5.0

Note: The above sump capacities are intended to be used as a guide and actual capacities should be governed by the level indicated on the dipstick.

When refilling the engine after an overhaul has been carried out a further 2 imp. pints, 2½ U.S. pints or 1 litre approximately should be added to the capacities quoted, to allow for filling the pipes, oilways, filter assembly, etc.

TECHNICAL DATA—B.10

Lubricating Oil Pump

Type	...	...	...	...	...	Rotor Type	Three or Four
Number of Lobes—Inner Rotor	...	...	...	...	...	Four or Five	
Number of Lobes—Outer Rotor	...	...	...	...	...	By Spiral Gears from the Camshaft	
Method of Drive	...	...	...	...	...

Pump Clearances

Inner Rotor to Outer Rotor	...	...	...	...	0.0005/0.0025 in (0,013/0,063 mm)
Outer Rotor to Pump Body	...	...	...	...	0.011/0.013 in (0,28/0,33 mm)
Inner Rotor End Clearance	...	...	...	...	0.0015/0.003 in (0,038/0,076 mm)
Outer Rotor End Clearance	...	...	...	...	0.0005/0.0025 in (0,013/0,063 mm)
Inside Dia. of Bore for Pump Shaft	...	...	...	...	0.500/0.501 in (12,700/12,725 mm)
Outside Dia. of Pump Shaft	...	...	...	...	0.4983/0.4986 in (12,655/12,664 mm)
Running Clearance, Shaft in Bore	...	...	...	...	0.0014/0.0027 in (0,036/0,069 mm)

Lubricating Oil Pump Drive Gear

Number of Teeth	...	...	...	...	12
Inside Dia. of Gear Bore	...	...	...	...	0.4965/0.4970 in (12,611/12,624 mm)
Outside Dia. of Oil Pump Drive Shaft	...	...	...	...	0.4983/0.4986 in (12,655/12,664 mm)
Interference Fit of Gear on Shaft	...	...	...	...	0.0013/0.0021 in (0,033/0,053 mm)
Lubricating Oil Pump Drive Gear Backlash	...	...	...	...	0.0155/0.019 in (0,394/0,483 mm)

Relief Valve

Type	...	...	...	...	...	Spring Loaded Plunger
Pressure Setting	...	...	...	...	...	50/65 lbf/in ² (3,5/4,6 kgf/cm ²) — 344/448 kN/m ²
Length of Plunger	...	...	...	...	...	0.9375 in (23,813 mm)
Outside Dia. of Plunger	...	...	...	...	...	0.5585/0.5595 in (14,19/14,21 mm)
Inside Dia. of Valve Housing Bore	...	...	...	...	...	0.5605/0.5625 in (14,24/14,29 mm)
Clearance of Plunger in Bore	...	...	...	...	...	0.001/0.004 in (0,025/0,102 mm)
Outside Dia. of Spring	...	...	...	...	...	0.368/0.377 in (9,347/9,576 mm)
Spring—Free Length	...	...	...	...	...	1.5 in (38,10 mm)

Lubricating Oil Filter

Type	...	...	...	...	...	Full Flow
Element Type	...	...	...	...	...	Paper or Canister
By-Pass Valve Setting	...	...	...	...	...	Open between 13-17 lbf/in ² (0,91-1,2 kgf/cm ²) — 90-117 kN/m ² pressure differential

COOLING SYSTEM 4.108, 4.107, 4.99

Type	...	...	...	...	...	Water Cooled
Cylinder Block and Head	...	...	...	...	...	Thermo-Syphon Impeller Assisted
Engine Water Capacity (Less Radiator)	...	...	...	...	...	6 Imp. pt (7.2 U.S. pt or 3,4 Litre)

Thermostat

Type	...	...	...	...	...	Wax Capsule
Opening Temperature	...	...	...	...	...	175-182° F (79,5-83,5° C)
Fully open at	...	...	...	...	...	200-205° F (93,5-96° C)
Minimum Travel at Fully Open Temp.	...	...	...	...	...	0.3125 in (7,94 mm)

Water Pump

Type	...	...	...	...	...	Centrifugal—Belt driven from Crankshaft
Outside Dia. of Shaft for Pulley (Separate Bearing Pump)	...	...	...	...	...	0.5905/0.5908 in (14,999/15,006 mm)
Inside Dia. of Pulley Bore (Separate Bearing Pump)	...	...	...	...	...	0.588/0.589 in (14,935/14,961 mm)
Outside Dia. of Shaft for Pulley (Combined Bearing and Shaft)	...	...	...	...	...	0.6262/0.6267 in (15,808/15,920 mm)
Inside Dia. of Pulley Bore (Combined Bearing and Shaft Pump)	...	...	...	...	...	0.6239/0.6247 in (15,849/15,869 mm)
Interference Fit of Pulley on Shaft	...	...	...	...	...	0.0015/0.0028 in (0,038/0,071 mm)
Outside Dia. of Shaft for Impeller	...	...	...	...	...	0.498/0.499 in (12,649/12,675 mm)
Inside Dia. of Impeller Bore	...	...	...	...	...	0.497/0.4975 in (12,624/12,636 mm)
Interference Fit of Impeller on Shaft	...	...	...	...	...	0.0005/0.002 in (0,013/0,051 mm)

Outside Dia. of Impeller	3.094/3.125 in (78,588/79,375 mm)
Water Pump Seal Type	Synthetic Rubber—Carbon Faced

FUEL SYSTEM 4.108, 4.107, 4.99

Approved Fuel Oil Specification

United Kingdom	BS.2869:1967	Class A.1 or A.2
United States	VV-F-800a	Grades DF-A, or DF-2.
	A.S.T.M./D975-66T	Nos. 1-D or 2-D.
France	(J.O. 14/9/57)	Gas Oil or Fuel Domestique
India	IS: 1460/1968	Grade Special or Grade A
Germany	DIN-51601 (1967)	—
Italy	CUNA-Gas Oil NC-630-01 (1957)	—
Sweden	SIS. 15 54 32 (1969)	—
Switzerland	Federal Military Spec. 9140-335-1404 (1965)	—

Fuel oils available in territories other than those listed above which are to an equivalent specification may be used.

Fuel Lift Pump

Type	AC Delco Diaphragm 'YJ' Series
Spring Colour Code	Green
Method of Drive	From Eccentric on Camshaft via Push rod
Total Stroke of Operating Lever	0.192 in (4,877 mm)
Static Pressure—No Delivery	4-7 lbf/in ² (0,28-0,49 kgf/cm ²) — 28-48 kN/m ²
Pump to Distance Piece Gasket Thickness	0.018/0.022 in (0,457/0,559 mm)
Distance Piece—Lift Pump to Tappet Inspection Cover	0.256 in (6,502 mm)

Final Fuel Filter

Element Type	Paper
Overflow Valve Type	Gravity Ball Check Valve
Valve in Fuel Pump Drain Connection	Spring Loaded Non-Return Valve set at 0.71-1.25 lbf/in ² (0,0522-0,0875 kgf/cm ²) — 5-9 kN/m ²

Fuel Injection Pump

Make	C.A.V.
Type	D.P.A.
Rotation	Clockwise (Viewed from Drive End)
Plunger Dia.	6 mm

Hydraulically Governed

	4.108	4.107	4.99
Timing Letter	A		A
No. 1 Cylinder Outlet	W		W

Mechanically Governed

Timing Letter	C	C	C
No. 1 Cylinder Outlet	W	W	W

TECHNICAL DATA—B.12

Static Timing Position

The static timing position varies according to application, but can be obtained by referring to the first group of letters and digits of the fuel pump setting code (stamped on the fuel pump identification plate).

On the latest 4.108 engines the setting codes start with the fuel pump part number followed by the two code letters. Only the two code letters are used in the table for identification purposes.

(USING TIMING TOOL MS67B) ALTERNATIVE DROP VALVE METHOD					
First Group of Fuel Pump Code	Engine Checking Angle (Degrees)	Fuel Pump Marking Angle (Degrees)	Static Timing (Degrees) BTDC	Piston Displacement in (mm) BTDC	
4.99					
AH28	282	295	26	0.226 (5,74)	
BH26	287	300	26	0.226 (5,74)	
CH35	280½	290	19	0.120 (3,05)	
DH19	287	300	26	0.226 (5,74)	
LH20 } LH26 }	282	292	20	0.134 (3,40)	
LH29	281	292	22	0.160 (4,06)	
MH26	281	290	18	0.110 (2,79)	
4.107					
CH35	280½	290	19	0.120 (3,05)	
LH23 } LH28 } LH29 }	282	292	20	0.134 (3,40)	
LH31 } (exceptions below)					
LH31/900/2/2770 } LH31/900/2/3130 }	281	292	22	0.160 (4,06)	
LH31/900/9/1880 }					
MH27 } PH28 } PH30 }	281	290	18	0.110 (2,79)	
PH34	280	290	20	0.134 (3,40)	
4.108					
EH } EH34E } EH39 }	281	290	18	0.110 (2,79)	
LH30	281	292	22	0.160 (4,06)	
PH } PH23E (exceptions below) PH25E	281	290	18	0.110 (2,79)	
PH25E500/5/2450 } PH25E500/9/1990 }	279½	290	21	0.150 (3,81)	
PH25E500/9/2090 }					
PH27 } PH28 } (exceptions below) PH30 }	281	290	18	0.110 (2,79)	
PH30/500/5/2450 } PH30/500/6/1570 }	279½	290	21	0.150 (3,81)	
PH30/500/9/1990 } PH30/500/9/2090 }					
RH } RH30E } SH33E }	279½	290	21	0.150 (3,81)	
TH } TH23E }	281	291	20	0.134 (3,40)	

Note: For 4.107 and 4.99 mechanically governed engines rated above 3,000 and 2,500 rev/min respectively, the static timing is altered to 22° B.T.C.D. - piston displacement 0.160 in (4,06 mm). For 4.108 engines prior to engine numbers 108U15973 and 108UD20214, the static timing was 19° B.T.C.D. - piston displacement 0.120 in (3,05 mm). When re-setting these pumps, it is advisable to set at the figures quoted in above table.

For 4.107 industrial engines having a fuel pump coding of PH30 and an idling speed of 1,000 rev/min, the static timing is 21° B.T.C.D. and a piston displacement of 0.147 in (3,73 mm).

Atomisers

4.108 Veh., M., Ind., Comb.

4.107 M., Ind., TA

Make	...	...	...	...	...	C.A.V.
Holder Type	...	...	...	...	...	BKB40SD5224
Nozzle Type	...	...	...	...	...	BDN12SD6236
Code Letter	...	...	...	...	...	BG
Min. Working Pressure	...	...	...	...	...	135 atm (2000 lbf/in ² or 140 kgf/cm ²)
Setting Pressure	...	...	...	...	...	150 atm (2200 lbf/in ² or 155 kgf/cm ²)

4.108M, Ind., Comb.

Make	...	...	...	...	...	C.A.V.
Holder Type	...	...	...	...	...	BKB40SD5224
Nozzle Type	...	...	...	...	...	BDN4SD6769
Code Letter	...	...	...	...	...	GY
Min. Working Pressure	...	...	...	...	...	135 atm (2000 lbf/in ² or 140 kgf/cm ²)
Setting Pressure	...	...	...	...	...	150 atm (2200 lbf/in ² or 155 kgf/cm ²)

Note: Earlier atomisers bearing the identification code letter 'J' had a setting pressure of 140 atm. When servicing of these atomisers is carried out, they should be reset in accordance with the settings quoted above.

	4.99 Veh	4.99 Veh	4.99 Ind. & 4.107 Ind.
Make	...	...	...
Holder Type	...	...	...
Nozzle Type	...	...	...
Code Letter	...	...	...
Min. Working Pressure	...	...	...
Setting Pressure	...	...	...
	C.A.V.	C.A.V.	C.A.V.
	BKB40S5223	BKB40S5224	BKB40S5224
	BDN12SD6236	BDN12SD6236	BDN4S6157
	BK	BL	BE
	120	125	130
	130	130	135

Starting Aid

Make	...	...	...	...	...	C.A.V.
Type	...	...	...	...	...	Thermostart
Voltage	...	...	...	...	...	12 Volt
Maximum Current Consumption	...	...	...	...	...	12.9 Amperes at 11.5 Volts
Fuel Flow Rate through Unit	...	...	...	...	...	4.3-4.9 cm ³ min at 70°F (21°C)
Height of Reservoir (where fitted) above Centre of Thermostart	...	...	...	...	...	4.5-10 in (11,4-25,4 cm)

Electrical System

Dynamo

Make	...	...	...	...	...	Lucas
Type	...	...	...	...	...	C40
Max. Output	...	...	...	...	...	11A

Alternator

Make	...	...	...	...	...	Lucas or C.A.V.
Type	...	...	...	...	...	AC5 (12V or 24V), 11AC (12V or 24V), 15ACR (12V) and 17ACR (12V)

Max. Output (hot)

AC5 (12V)	...	...	...	...	...	53A
AC5 (24V)	...	...	...	...	...	30A
11AC (12V)	...	...	...	...	...	43A
11AC (24V)	...	...	...	...	...	23A
15ACR	...	...	...	...	...	28A
17ACR	...	...	...	...	...	36A

Starter Motor

Make	...	...	...	...	...	Lucas
Type	...	...	...	...	...	MG45 or 2M113
Max. Current	...	...	...	...	...	900A
Starter Cable Resistance	...	...	...	...	...	0.0017 ohms (Max.)
No. of Teeth on Pinion	...	...	...	...	...	10



SECTION C

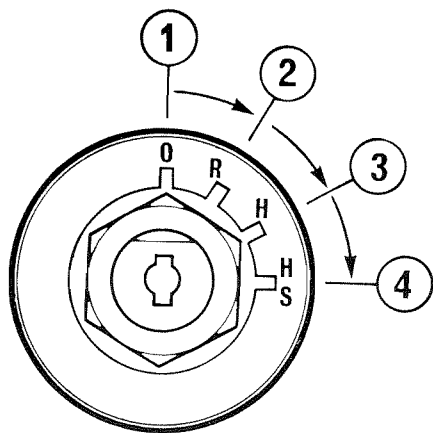
Operating and Maintenance

Starting the Engine

If the weather is warm or the engine has only been stopped for a little while, place the accelerator in the fully open position and engage the starter motor by turning the starter switch in a clockwise direction to the "HS" position (See Fig. C.1).

If the battery is well up, enough to turn the starter motor quickly, the engine should start.

Always be sure that the starter pinion and flywheel have stopped revolving before re-engaging the starter, otherwise the ring or pinion may be damaged.



C1

1. Off Position
2. Run Position
3. Heat Position
4. Heat and Start Position

To Operate the Starting Aid

In cold weather the procedure for the use of this equipment is as follows:—

Ensure that the engine stop control is in the "run" position.

Turn on the fuel supply tap of the starting aid reservoir, where fitted.

Turn start switch in direction to "H" position for fifteen to twenty seconds.

With accelerator in the fully open position, turn the switch a further clockwise movement to the "HS" position thereby engaging the starter motor.

If the engine does not start after fifteen seconds, return switch to "H" position for ten seconds and then re-engage the starter motor.

As soon as the engine starts, the switch should be returned to the "R" position, and the tap on the starting reservoir, when fitted, turned off.

NOTE: The above procedure is not necessary when the engine is hot. To re-start, turn the switch in a clockwise direction to the "HS" position which will engage the starter motor.

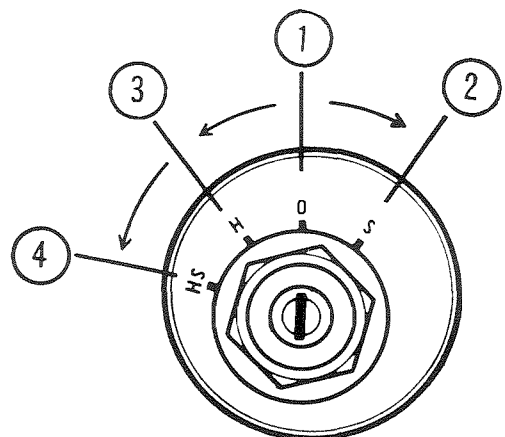
Earlier Heat Start Switch

The cold start switch fitted to earlier engines is shown in Fig. C.2.

With this switch, starting a warm engine is effected by turning the switch in a clockwise direction to the "S" position.

In cold weather, the switch should be turned to the "H" position for fifteen to twenty seconds and then to the "HS" position in order to engage the starter motor. As soon as the engine starts, the switch should be returned to the "O" position.

Where this type of switch is used, it was customary to have a separate switch for the electrical circuits and this should be turned on before starting the engine and turned off after stopping the engine.



C2

1. Off Position
2. Start Position
3. Heat Position
4. Heat and Start Position

OPERATING AND MAINTENANCE—C.2

Alternative Method

With some engines, a different starter switch is provided and the cold start aid is operated by means of a separate push button switch.

The cold starting procedure is the same i.e. Switch on by turning the starter switch in a clockwise direction to the first position.

Press the heater button for fifteen to twenty seconds and then, with the heater button still pressed, turn the starter switch in a further clockwise direction to engage the starter motor. As soon as the engine starts, release switch and heater button.

Glow Plugs

Glow plugs are sometimes fitted to engines in applications such as refrigeration units, fork lift trucks and other certain 4.108 mechanically governed engines rated at 3,000 rev/min and below. As the buss bar connecting these glow plugs may not be insulated, extreme care must be exercised to keep pipes, clips or other metal objects well clear as the consequences of a direct short of this buss bar to earth when energised are obvious.

It must be noted that in no circumstances should either or any other unauthorised starting aids be used at the same time as glow plugs.

To operate, use the following procedure :—

Before operating the starter motor, press the "Heat" button for 20 to 30 seconds.

With the "Heat" button still pressed, engage the starter motor until the engine starts.

Continue to press the "Heat" button for a few seconds after the engine has started until even running has been obtained.

If the engine does not start, disengage the starter motor, but keep the "Heat" button pressed for a further 10 to 15 seconds, when a further attempt should be made to start the engine, keeping the glow plugs energised whilst starting and for a few seconds after the engine has fired until even running is obtained.

Points to Note

Ensure that the electrical connection to the starting aid is correctly made.

Always ensure that the reservoir feeding fuel to the starting aid is fully primed and is not leaking. With some later engines, this fuel reservoir has been deleted, the cold start aid being fed direct from the fuel filter through a non-return valve.

Extended use of the cold starting equipment above the time periods already stated should be avoided, otherwise the starting aid in the induction manifold may be damaged also continuous flaming will starve the engine of oxygen.

In the event of difficult starting, check that fuel is reaching the starting aid in the induction manifold by unscrewing the inlet fuel connection. If fuel is reaching it satisfactorily, then it may be that the starting aid itself is not working correctly. This can be checked by removing the air cleaner and watching the starting aid whilst the equipment is used. When the starting switch

is turned to the "heat" position, the element should become red hot, and upon engagement of the starter motor ignition of the fuel should take place.

4.108, 4.107 and 4.99 engines are fitted with efficient starting equipment and no responsibility can be accepted for any damage caused by unauthorised starting aids.

To prevent thermostart damage, it is essential that the thermostart is not operated **DRY**. After any operation which allows fuel to drain from the the thermostart feed pipe, the pipe must be disconnected at the thermostart and all air bled from the pipe before the thermostart is operated.

Where a thermostart starting aid has to be replaced, care must be taken not to exceed the torque figure quoted on Page B.2. Excessive torque loading can crack the insulator adaptor causing an electrical short and hard starting characteristics.

Stopping the Engine

A spring loaded stop control is located near the normal engine controls and functions by cutting off the fuel at the fuel injection pump.

To operate, pull the knob and hold in this position until the engine ceases to rotate. Ensure that the control returns to the "run" position, otherwise difficulty may be experienced in re-starting the engine.

Return latest cold start switch to the "O" position.

Some engines may have an electric solenoid stop control on the fuel injection pump operated by a switch on the control panel.

Running In Procedure

It is not necessary to gradually run-in a new or factory rebuilt engine and any prolonged light load running during the early life of the engine can in fact prove harmful to the bedding in of piston rings and liners.

Full load can be applied on a new or factory rebuilt engine as soon as the engine is used, **provided that the engine is first allowed to reach a temperature of at least 140°F (60°C).**

PREVENTIVE MAINTENANCE

These preventive maintenance periods are general in application. Check the periods given by the manufacturer of the equipment in which the engine is installed and, where necessary, use the shorter periods. These periods and procedures must also be adapted to ensure correct operation for any local machine regulations.

It is good maintenance to check for leakage and loose fasteners at each service interval.

These maintenance periods are only for engines that are operated with fuel and lubricating oil to the specifications given in this manual.

The schedules which follow must be applied at the interval (miles, kilometres, hours or months) which occurs first.

- | On stop start low mileage work, the hours run are more applicable than the mileage covered.

Daily or every 8 hours

Check coolant level.
 Check sump oil level.
 Check oil pressure (where gauge is fitted).
 In extreme dust conditions, clean oil bath air cleaner and empty dust bowl on dry type air cleaner.

**Every 4,000 miles (6,000 km),
 150 hours or 3 months**

- † Drain and renew lubricating oil (see list of approved lubricating oils Appendix).
- † Renew lubricating oil filter element or canister.
 Clean oil bath air cleaner.
 Empty dust bowl on dry type air cleaner.
 *Check drive belt tension.
 Clean water trap.
 Lubricate dynamo rear bush (where applicable).

**Every 12,000 miles (18,000 km)
 450 hours or 12 months**

- † Renew final fuel filter element — agricultural and industrial applications.
 Clean element of dry type air cleaner or renew (if not indicated earlier).

Every 24,000 miles (36,000 km) or 900 hours

Renew final fuel filter element — vehicle applications.

Every 72,000 miles (108,000 km) or 2,700 hours

Arrange for examination and service of proprietary equipment, i.e., compressor, exhauster, starter, dynamo etc.
 Service atomisers.
 Check and adjust valve clearance.

- †| Refrigeration unit engines have a larger capacity sump and larger lubricating oil filter canister, therefore the lubricating oil and filter change can be extended to 1000 hours. Also with a primary fuel oil filter fitted, the main fuel filter element change period can be extended to 1000 hours.

*The drive belt tension should be checked monthly on engines rated above 3,000 rev/min.

POST DELIVERY CHECKOVER

After a customer has taken delivery of his Perkins Diesel engine, it is advisable, in his own interest, that a general checkover of the engine be carried out after

the first 500/1000 miles (800/1600 km) or 25/50 hours in service.

It is also recommended that the following procedure be adopted where an engine has been laid up for a considerable period before it is again put into service. With the engine thoroughly warmed through, this checkover should comprise the following points.

1. Drain lubricating oil sump. Renew lubricating oil filter element or canister. (Refer to Page L.5 or L.6).
2. Remove the rocker assembly, check that the cylinder head nuts are to the correct torque. (Refer to Page B.2).
3. Refit rocker assembly and set valve clearances. (Refer to Page B.8).
4. Refill lubricating oil sump with clean new oil to the correct level. (Do not overfill).
5. Check fan belt tension. (Refer to Page M.1).
6. Check coolant level in radiator, inspect for any coolant leaks.
7. Check security of all external nuts, setscrews, hose clips, mountings, etc.
8. Start engine and check for any fuel or lubricating oil leaks.
9. Carry out test to check general performance of engine.

Thereafter routine maintenance should be in accordance with Periodical Attentions which are given on previous Page.

NOTE: If the cylinder head is removed for any reason e.g. top overhaul, then it is recommended that the cylinder head nuts are retorqued as shown in Fig. E.23 after 500/1000 miles (800/1600 km) or 25/50 hours with the engine hot, to the setting given on Page B.2. It is assumed that electrical equipment will have already been checked for such points as dynamo rate of charge, effectiveness of connections and circuits, etc.

Protection of an engine not in service

The recommendations given below are to ensure that damage is prevented when an engine is removed from service for an extended period. Use these procedures immediately the engine is removed from service. The instructions for the use of POWERPART products are given on the outside of each container.

1. Thoroughly clean the outside of the engine.
2. Where a preservative fuel is to be used, drain the fuel system and fill with the preservative fuel. **POWERPART Lay-Up 1** can be added to the normal fuel to change it to a preservative fuel. If preservative fuel is not used, the system can be kept charged with normal fuel but this will have to be drained and discharged at the end of the period together with the fuel filter.
3. Run the engine until it is warm. Correct any fuel, lubricating oil or air leakage. Stop the engine and drain the lubricating oil sump.
4. Renew the lubricating oil filter canister.
5. Fill the sump to the full mark on the dipstick with clean new lubricating oil or with a correct preservative fluid. **POWERPART Lay-Up 2** can be added to the lubricating oil to give protection against corrosion during the period in storage. If a preservative fluid is used, this must be drained and normal lubricating oil used when the engine is returned to service.

OPERATING AND MAINTENANCE—C.4

6. Drain the cooling system, see below. To give protection against corrosion, it is better to fill the cooling system with a coolant that has a corrosion inhibitor, see 'Engine Coolant' below. If frost protection is needed, use an antifreeze mixture. If no frost protection is needed, use water with an approved corrosion inhibitor mixture.
7. Run the engine for a short period to send the lubricating oil and coolant around the engine.
8. Clean out the engine breather pipe and seal the end of the pipe.
9. Remove the atomisers and spray **POWERPART Lay-Up 2** into each cylinder bore. If this is not available, clean engine lubricating oil will give a degree of protection. Spray into the cylinder bores 140 ml ($\frac{1}{4}$ pint) of lubricating oil divided evenly between the four cylinders.
10. Slowly turn the crankshaft one revolution and then install the atomisers complete with new seat washers.
11. Remove the air filter and any pipe installed between the air filter and induction manifold. Spray **POWERPART Lay-Up 2** into the induction manifold. Seal the manifold with waterproof tape.
12. Remove the exhaust pipe. Spray **POWERPART Lay-Up 2** into the exhaust manifold. Seal the manifold with waterproof tape.
13. Remove the lubricating oil filler cap. Spray **POWERPART Lay-Up 2** around the rocker shaft assembly. Fit the filler cap. Where the oil filler cap is not on the cylinder head cover, remove the cover to spray the rocker shaft assembly.
14. Disconnect the battery and put it into safe storage in a fully charged condition. Before the battery is put into storage, give the battery terminals a protection against corrosion. **POWERPART Lay-Up 3** can be used on the terminals.
15. Seal the vent pipe of the fuel tank or the fuel filler cap with waterproof tape.
16. Remove the fan belt and put it into storage.
17. To prevent corrosion, spray the engine with **POWERPART Lay-Up 3**. Do not spray inside the alternator cooling fan area.

NOTE: Before the engine is started after a period in storage, operate the starter motor with the engine stop control in the 'off' position until oil pressure shows on the oil pressure gauge or the oil warning light goes out. If a solenoid stop control is used, this will have to be disconnected for this operation.

If the engine protection is done correctly according to the above recommendations, no corrosion damage will normally occur. Perkins Engines Ltd. are not responsible for any damage that occurs in relation to a service storage period.

Engine Coolant

The quality of the coolant used can have a large effect on the efficiency and life of the cooling system. The recommendations given below can be of assistance in the maintenance of a good cooling system with frost and/or corrosion protection.

1. Where possible, use clean soft water.
2. If an antifreeze mixture, other than Perkins **POWERPART**, is used to prevent frost damage,

it must have an ethanediol (ethylene glycol) base with a corrosion inhibitor. It is recommended that the corrosion inhibitor is of the sodium nitrate/benzoate type. The antifreeze mixture must provide cooling/corrosion protection at least as good as the requirements of the standards below:

UK: BS.6580: 1985: "Specification for corrosion inhibiting, engine coolant concentrate (antifreeze)".

U.S.A. ASTM D3306-74 'Ethylene Glycol Base Engine Coolant'.

Australia AS 2108-1977 'Antifreeze Compounds and Corrosion Inhibitors for Engine Cooling Systems'.

When Perkins **POWERPART** antifreeze is used, the correct mixtures of antifreeze and water are as given below. Perkins **POWERPART** Antifreeze fully passes the above standards.

Lowest Temperature of Protection Needed	%Volume of POWERPART Antifreeze	Mixture Ratio by Volume POWERPART Antifreeze:Water
-12°C (10°F)	25	1:3
-18°C (0°F)	33	1:2
-25°C (-13°F)	40	1:1.5
-37°C (-34°F)	50	1:1

The quality of the antifreeze coolant must be checked at least once a year, for example, at the start of the cold period.

3. When frost protection is not necessary, it is still an advantage to use an approved antifreeze mixture as this gives a protection against corrosion and also raises the boiling point of the coolant. A minimum concentration of 25% by volume of antifreeze is necessary, but it is our recommendation that 33% concentration by volume is used.

If an antifreeze is not used, add a correct corrosion inhibitor mixture to the water.

Change the water/corrosion inhibitor mixture every six months or check according to the inhibitors manufacturer's recommendations.

Note: Some corrosion inhibitor mixtures contain soluble oil which can have an adverse effect on some types of water hose.

If the correct procedures are not used, Perkins Engines Ltd., can not be held responsible for any frost or corrosion damage.

To Drain the Cooling System

1. Ensure that the vehicle or machine is on level ground.
2. Remove the radiator filler cap.
3. Remove the drain plug from the side of the cylinder block (see engine views) to drain the engine. Ensure that the drain hole does not have any restriction.
4. Open the tap or remove the drain plug at the bottom to drain the radiator. If a tap or plug is not fitted to the radiator, disconnect the bottom radiator hose.
5. Where necessary, flush the system with clean water.
6. Fit the drain plugs and radiator cap. Where necessary, close the radiator tap or connect the radiator hose.

SECTION D

Fault Diagnosis

Fault	Possible Cause
Low cranking speed	1, 2, 3, 4.
Will not start	5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 31, 32, 33.
Difficult starting	5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19, 20, 21, 22, 24, 29, 31, 32, 33.
Lack of power	8, 9, 10, 11, 12, 13, 14, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 31, 32, 33.
Misfiring	8, 9, 10, 12, 13, 14, 16, 18, 19, 20, 25, 26, 28, 29, 30, 32.
Excessive fuel consumption	11, 13, 14, 16, 18, 19, 20, 22, 23, 24, 25, 27, 28, 29, 31, 32, 33.
Black exhaust	11, 13, 14, 16, 18, 19, 20, 22, 24, 25, 27, 28, 29, 31, 32, 33.
Blue/white exhaust	4, 16, 18, 19, 20, 25, 27, 31, 33, 34, 35, 45, 56.
Low oil pressure	4, 36, 37, 38, 39, 40, 42, 43, 44, 58.
Knocking	9, 14, 16, 18, 19, 22, 26, 28, 29, 31, 33, 35, 36, 45, 46, 59.
Erratic running	7, 8, 9, 10, 11, 12, 13, 14, 16, 20, 21, 23, 26, 28, 29, 30, 33, 35, 45, 59.
Vibration	13, 14, 20, 23, 25, 26, 29, 30, 33, 45, 47, 48, 49.
High oil pressure	4, 38, 41.
Overheating	11, 13, 14, 16, 18, 19, 24, 25, 45, 50, 51, 52, 53, 54, 57.
Excessive crankcase pressure	25, 31, 33, 34, 45, 55, 60.
Poor compression	11, 19, 25, 28, 29, 31, 32, 33, 34, 46, 59.
Starts and stops	10, 11, 12.

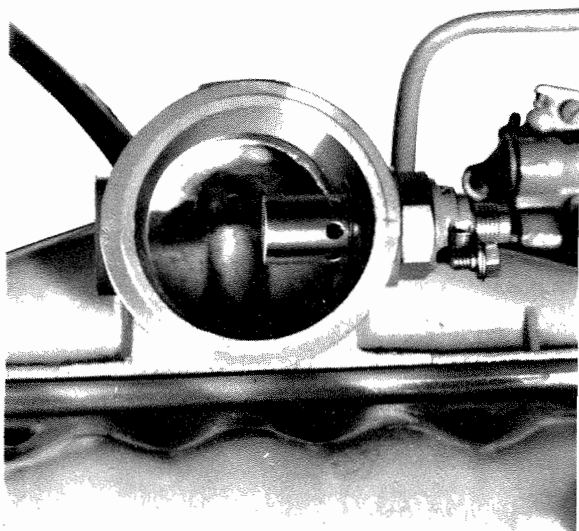
Key to Fault Finding Chart

- | | |
|--|---|
| <ol style="list-style-type: none"> 1. Battery capacity low. 2. Bad electrical connections. 3. Faulty starter motor. 4. Incorrect grade of lubricating oil. 5. Low cranking speed. 6. Fuel tank empty. 7. Faulty stop control operation. 8. Blocked fuel feed pipe. 9. Faulty fuel lift pump. 10. Choked fuel filter. 11. Restriction in air cleaner or induction system. 12. Air in fuel system. 13. Faulty fuel injection pump. 14. Faulty atomisers or incorrect type. 15. Incorrect use of cold start equipment. 16. Faulty cold starting equipment. 17. Broken fuel injection pump drive. 18. Incorrect fuel pump timing. 19. Incorrect valve timing. 20. Poor compression. 21. Blocked fuel tank vent. 22. Incorrect type or grade of fuel. 23. Sticking throttle or restricted movement. 24. Exhaust pipe restriction. 25. Cylinder head gasket leaking. 26. Overheating. 27. Cold running. 28. Incorrect tappet adjustment. 29. Sticking valves. 30. Incorrect high pressure pipes. | <ol style="list-style-type: none"> 31. Worn cylinder bores. 32. Pitted valves and seats. 33. Broken, worn or sticking piston ring/s. 34. Worn valve stems and guides. 35. Overfull air cleaner or use of incorrect grade of oil. 36. Worn or damaged bearings. 37. Insufficient oil in sump. 38. Inaccurate gauge. 39. Oil pump worn. 40. Pressure relief valve sticking open. 41. Pressure relief valve sticking closed. 42. Broken relief valve spring. 43. Faulty suction pipe. 44. Choked oil filter. 45. Piston seizure/pick up. 46. Incorrect piston height. 47. Damaged fan. 48. Faulty engine mounting (Housing). 49. Incorrectly aligned flywheel housing, or flywheel. 50. Faulty thermostat. 51. Restriction in water jacket. 52. Loose fan belt. 53. Choked radiator. 54. Faulty water pump. 55. Choked breather pipe. 56. Damaged valve stem oil deflectors (if fitted). 57. Coolant level too low. 58. Blocked sump strainer. 59. Broken valve spring. 60. Defective exhauster/leaking vacuum pipe. |
|--|---|



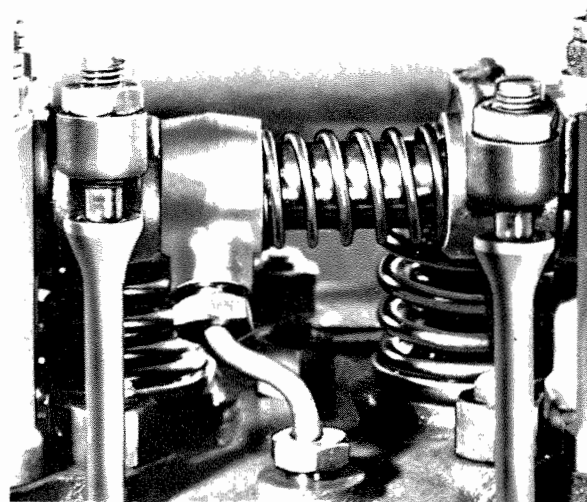
SECTION E

Cylinder Head



E1

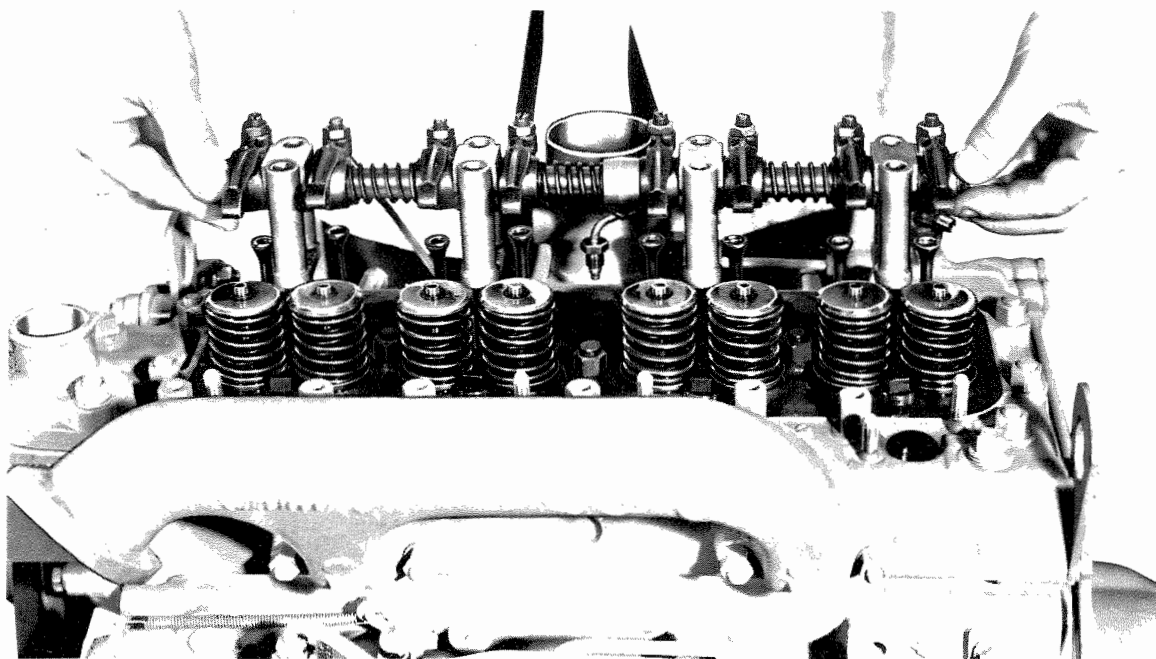
Before commencing to overhaul the cylinder head ensure that all joints, gaskets and any other parts expected to be required are available. Remove any external components from the vicinity of the cylinder head cover, atomisers and fuel pump.



E2

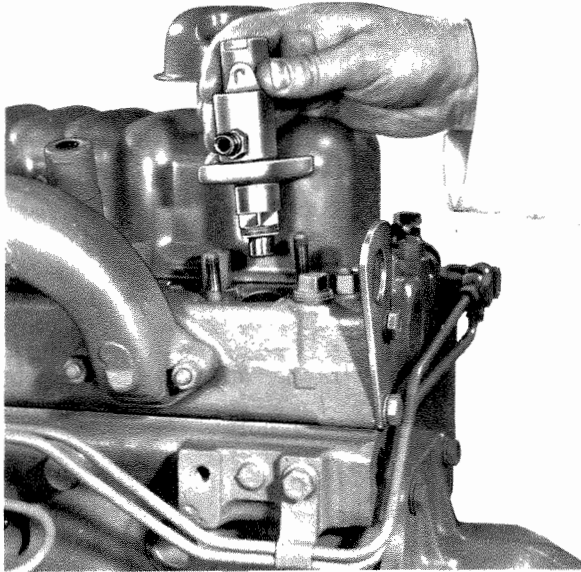
To Remove the Cylinder Head

1. Completely drain the cooling system.
2. Disconnect the battery terminals.
3. Remove the securing nuts and detach the exhaust pipe from the exhaust manifold. Blank off the end of the exhaust pipe to prevent entry of any foreign matter.



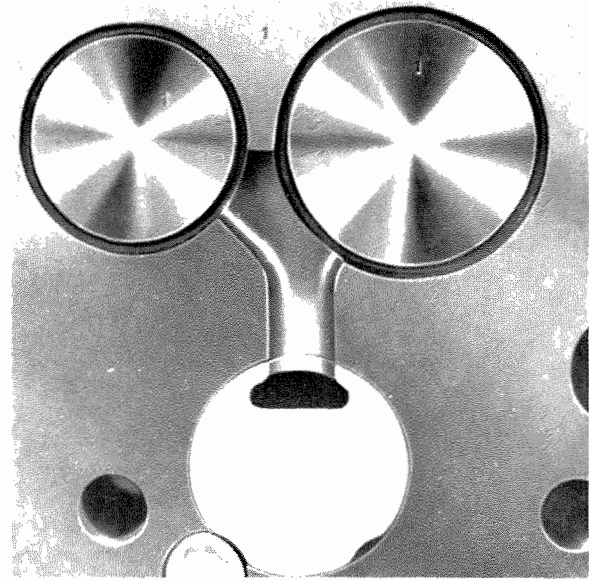
E3

CYLINDER HEAD—E.2



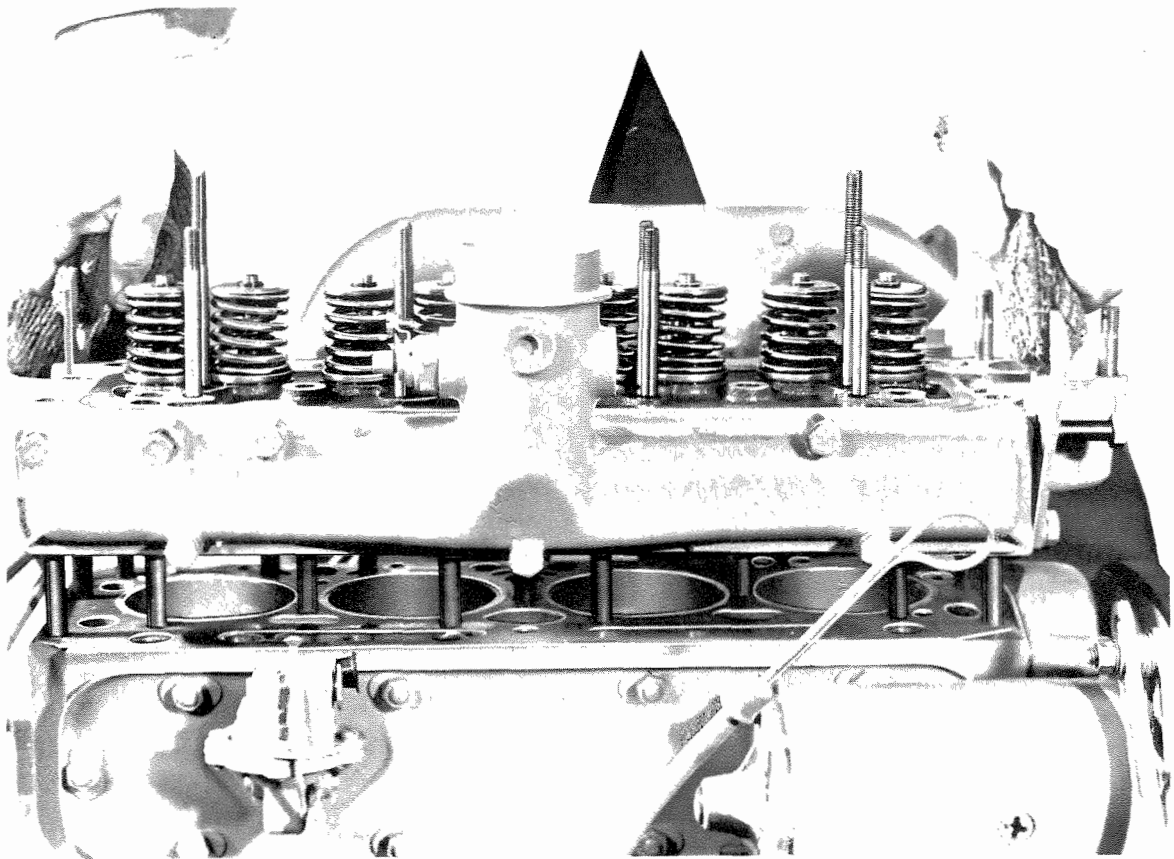
E4

4. Uncouple the water outlet connection on the front of the cylinder head.
5. Remove the air cleaner and place somewhere level ready for servicing.
6. Disconnect the fuel pipe and electrical connection to the starting aid located in the induction manifold. (Refer to Fig. E.1).

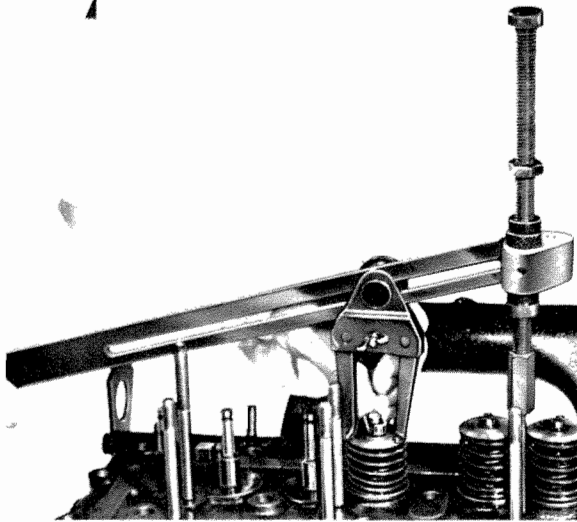


E6

7. Remove the cylinder head cover together with the breather pipe.
8. Unscrew the oil feed pipe to the rocker shaft at the cylinder head end. (Refer to Fig. E.2 for its location).
9. Remove the eight rocker shaft bracket securing nuts **evenly** and remove the rocker shaft complete with the oil feed pipe. (Refer to Fig. E.3).

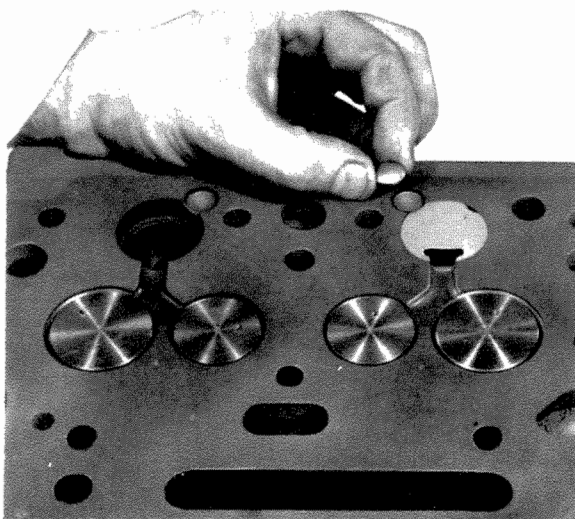


E5

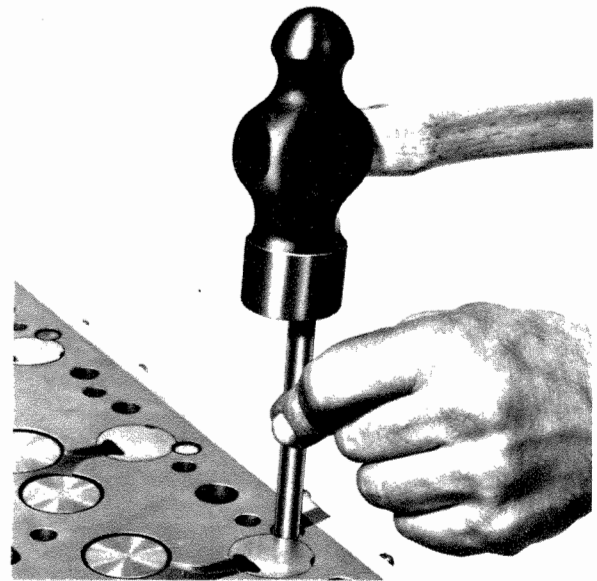


E7

10. Remove the eight push rods and place somewhere safe (possibly in the cylinder head cover) to avoid the possibility of any being accidentally bent.
11. Unscrew the small banjo bolts on the tops of the atomisers and remove the leak-off pipe by unscrewing the union on top of the fuel filter.
12. Remove the low pressure fuel pipes between the fuel filter and the fuel pump, remove the fuel filter after disconnecting the feed pipe from the lift pump, blank off all pipes and ports to prevent ingress of foreign particles.
13. Remove the four high pressure fuel pipes from the fuel pump to the atomisers. Blank off fuel pump outlet ports.
14. Remove the atomiser securing nuts and carefully remove the atomisers. (Refer to Fig. E.4). Blank off the exposed ports on the atomisers.
15. Uncouple the dynamo or alternator adjusting link.



E8



E9

16. Remove the cylinder head securing nuts and lift off the cylinder head complete with the inlet and exhaust manifolds. (Refer to Fig. E.5).

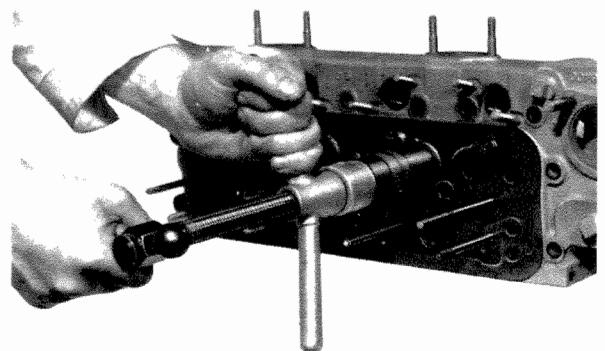
NOTE: On 4.99 and 4.107 engines, to prevent liner movement should the engine be turned with the cylinder head removed, it is suggested that the liners are held in position by suitable tubing placed over two of the cylinder head studs and locked with nuts and washers.

To Remove the Valves

With earlier engines, the valves were numbered and the cylinder head was marked with corresponding numbers (see fig. E.6).

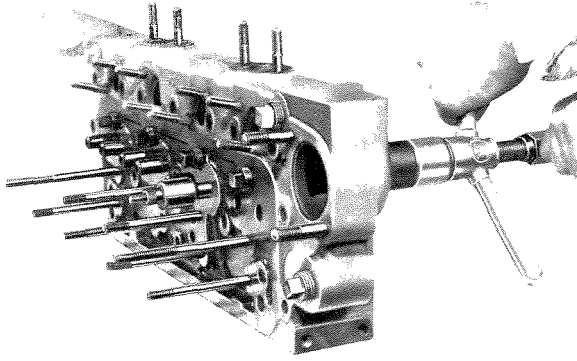
With current engines, the valves and seats are not numbered and where a valve is to be used again, it should be suitably identified to ensure it is replaced in its original position.

1. Remove collets by compressing the valve springs as shown in Fig. E.7.
2. Remove the spring caps, springs, seals (where fitted) and spring seats. Remove valves.



E10

CYLINDER HEAD—E.4



E11

COMBUSTION CHAMBER INSERTS

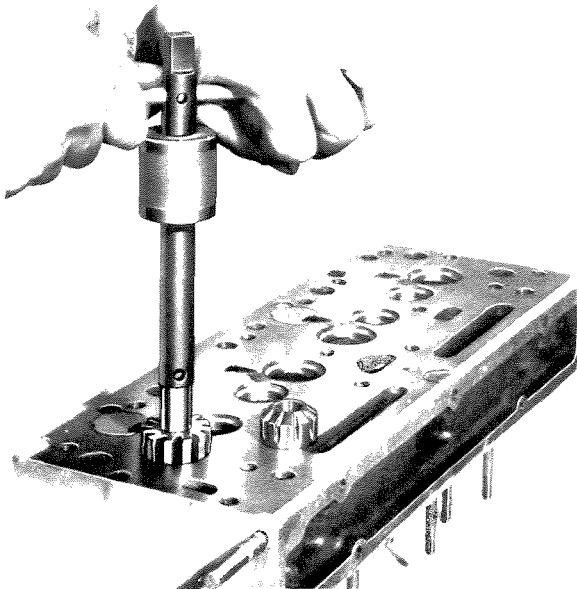
These can be gently tapped out of their locations by means of a short length of curved bar through the atomiser bore. When refitting they must be located by means of expansion washers in the recesses provided, as shown in Figs. E.8 and E.9.

Cleaning

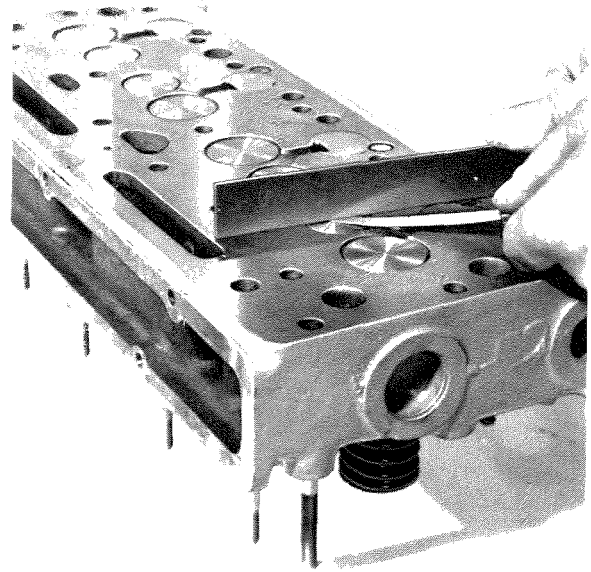
Remove any carbon from the cylinder head. If the water jacket within the cylinder head shows signs of excessive scale, then a proprietary brand of descaling solution may be used, if possible the cylinder head should be tested for water leakage after such treatment at the pressure given on Page B.7.

VALVE SPRINGS

It is advisable to fit new valve springs whenever the engine undergoes a major overhaul. Where a top overhaul only is being carried out the springs should be examined, paying particular attention to squareness of ends and pressures developed at specific lengths, the details of which can be found on Page B.8.



E12



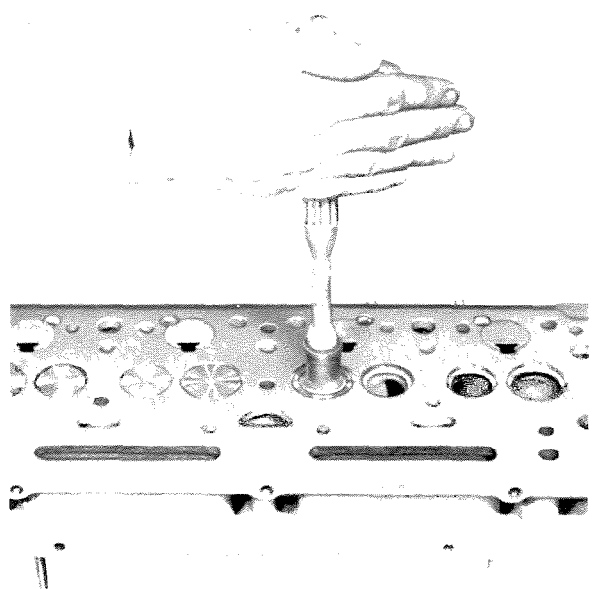
E13

VALVE GUIDES

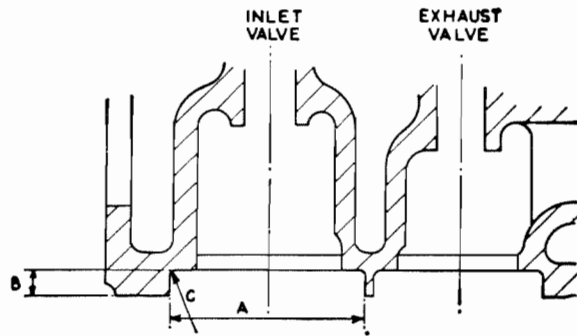
The worn guides should be removed either by means of a press and a suitable "dolly" or the valve guide removal tool shown in Fig. E.10.

Before fitting the new guides remove any burrs from the cylinder head parent bores, then smear the bores with clean oil and either press in the new guides or pull them in by means of the tool shown in Fig. E.11, until the guide protrusion above the head top face is that quoted on Page B.7.

NOTE: Special care should be exercised during this operation as the guides, being made of cast iron, are therefore comparatively brittle.



E14



E15

Inlet

- A—1.530 in to 1.531 in
- B—0.3125 in to 0.3175 in
- C—0.015 in chamfer at 45° (Max.)

Exhaust

- A—1.296 in to 1.297 in
- B—0.3125 in to 0.3175 in
- C—0.015 in chamfer at 45° (Max.)

VALVES AND VALVE SEATS

The valves should be checked in their respective guides for wear and replaced if wear has taken place, (ensure that the wear is in fact on the valve stem and not in the guide bore before replacing the valve).

The valve and valve seat faces should be reconditioned in the normal way using specialised equipment or with grinding compound, according to their condition. A valve seat (hand operated) cutting tool is shown in Fig. E.12. Valves should always be refitted to their original seats and any new valve fitted should be suitably marked to identify its position if removed at a later date. (Refer to Fig. E.6 for illustration of valve numbering).

Before refitting the valves it should be ascertained whether the valve head depth relative to the cylinder head face is within the limits given on Page B.2. This depth can be checked, as shown in Fig. E.13, by placing a straight edge across the face of the cylinder head, then by careful selection of feeler gauges measuring the distance between the straight edge and the head of the valve.

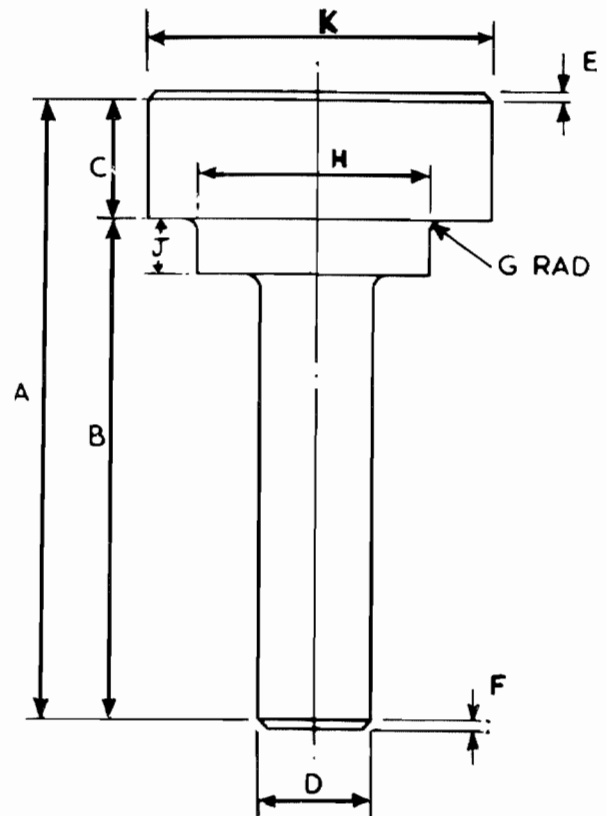
Where vehicle engines have to conform with the smoke density regulation B.S.AU 141a: 1971, then valve depths must not exceed production limits as given on page B.8.

Where this depth exceeds the maximum limit and even the fitting of a new valve does not reduce this depth below the maximum limit, then the remedy is to fit a valve seat insert as detailed later.

When refacing valves or valve seats care should be taken to see that only the minimum amount of metal necessary to obtain a satisfactory seat is removed, and that as narrow a valve seat as possible is maintained.

Hand Grinding

When grinding or lapping-in valves make certain that all signs of pitting are removed from the seats.



E16

Material EN32A Case Hardened and Ground

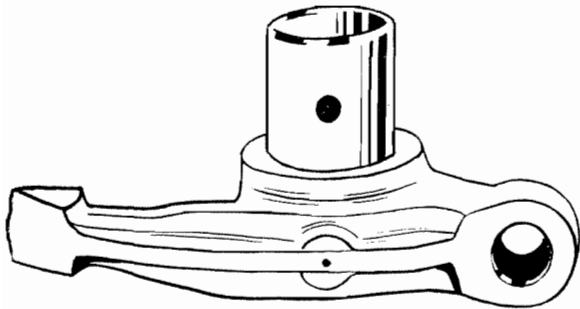
Inlet Dimensions

- A—2.75 in
- B—2 in
- C—0.75 in
- D—0.309 in to 0.310 in
- E—1/16 in at 45°
- F—1/16 in at 45°
- G—1/32 in Radius
- H—1.238 in to 1.239 in
- J—0.222 in to 0.225 in
- K—1.523 in to 1.533 in

Exhaust Dimensions

- A—2.75 in
- B—2 in
- C—0.75 in
- D—0.309 in to 0.310 in
- E—1/16 in at 45°
- F—1/16 in at 45°
- G—1/32 in Radius
- H—1.018 in to 1.019 in
- J—0.222 in to 0.225 in
- K—1.287 in to 1.297 in

After all the valves have been lapped in the valve head depths relative to the cylinder head face should be checked to ensure that they are within the limits given on Page B.8.



E17

VALVE SEAT INSERTS

Valve seat inserts are not fitted to production engines, but may be fitted in service.

When fitting inserts ensure that only genuine Perkins parts are used.

In order to fit these inserts proceed as follows:

1. Fit new valve guides as described on Page E.4.
2. Using the new valve guide bore as a pilot, machine the insert recess in the cylinder head face to the dimensions shown in Fig. E.15.

3. Remove all machining swarf and thoroughly clean the insert recess (removing any burrs which may be present).

4. Using the valve guide bore as a pilot once again press the insert home with the inserting tool, this tool is shown fully dimensioned in Fig. E.16.

NOTE: The insert must not under any circumstances be hammered in, neither should any lubrication be used.

5. Visually inspect to ensure that the insert has been pressed fully home, i.e. is flush with the bottom of the recess.

6. Recut the valve seat at an included angle of 90° (which will give the normal 45° seat) until the valve head depth reaches the minimum limit which is given on Page B.8. Lightly lap the valve to its new seat.

To Dismantle the Rocker Shaft Assembly

1. Remove the retaining circlips from each end of the rocker shaft.
2. Withdraw the rocker levers, springs and support brackets from the rocker shaft.
3. Unscrew the oil feed pipe from the banjo and remove the banjo. (When refitting this feed pipe it should be noted that the end of the pipe locates the banjo position on the shaft).

Examine the rocker bushes and shaft for wear. The rocker levers should be an easy fit on the rocker shaft without excessive side play.

New rocker levers are supplied complete with bush fitted and reamed to size.

NOTE: When fitting new bushes ensure that the oil feed holes are in alignment before pressing home; and when pressed fully home that the holes coincide. (Refer to Fig. E.17).

To Re-Assemble the Rocker Shaft Assembly

1. Refit the oil feed banjo and locate with the feed pipe.
2. Refit the rocker levers, springs and support brackets in the opposite order to which they were removed. Lightly oil the components during re-assembly and ensure that each rocker lever does not bind on the shaft. The assembly should now be as shown in Fig. E.18.

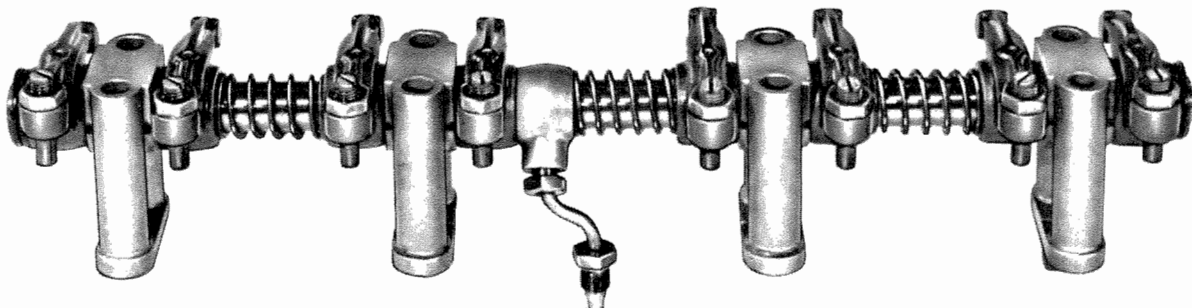
PUSH RODS

Check the push rods for straightness, if any are bent then fit new replacements.

To Refit the Valves

Lightly oil the valve stems to provide the initial lubrication.

Replace valves, springs, spring plates, washers, collars and collets, taking care that the numbers on the valves correspond to the numbers stamped adjacent to the valve seat (see Fig. E.6).



E18

CYLINDER HEAD—E.7

NOTE: Valve springs incorporate a damper coil and care should be taken to ensure that this damper coil is to the bottom of the spring i.e., nearest the cylinder head when fitted.

Inner valve springs are not required for engines rated at 3,000 rev/min and below.

4.108 engines and 4.99 vehicle engines are fitted with rubber sealing rings on inlet valves only.

All latest 4.107 and 4.99 agricultural and industrial engines incorporate oil deflectors on both inlet and exhaust valves.

In the case of earlier 4.107 and 4.99 agricultural and industrial engines which incorporate rubber sealing rings on the inlet valves only, oil deflectors should be fitted to both inlet and exhaust valves after the valve assembly has been dismantled. With this arrangement, a different valve spring seating washer is required for exhaust valves.

Where a groove is cut on the inlet valve stem, a rubber sealing washer should be fitted in addition to the deflector to stop the later from becoming canted on the stem.

Oil deflectors should not be fitted to 4.99 vehicles and some 4.108 engines.

CYLINDER HEAD GASKET

Always use a new cylinder head gasket. Ensure that the correct type is used.

4.108 Engines

With this engine, the gasket is made of a black composite material and is known as the Klinger type. It MUST be fitted DRY and on no account should jointing compound be used.

It is very important that the gasket is placed correctly, otherwise the steel beading may be nipped between the cylinder head face and the top of the liner.

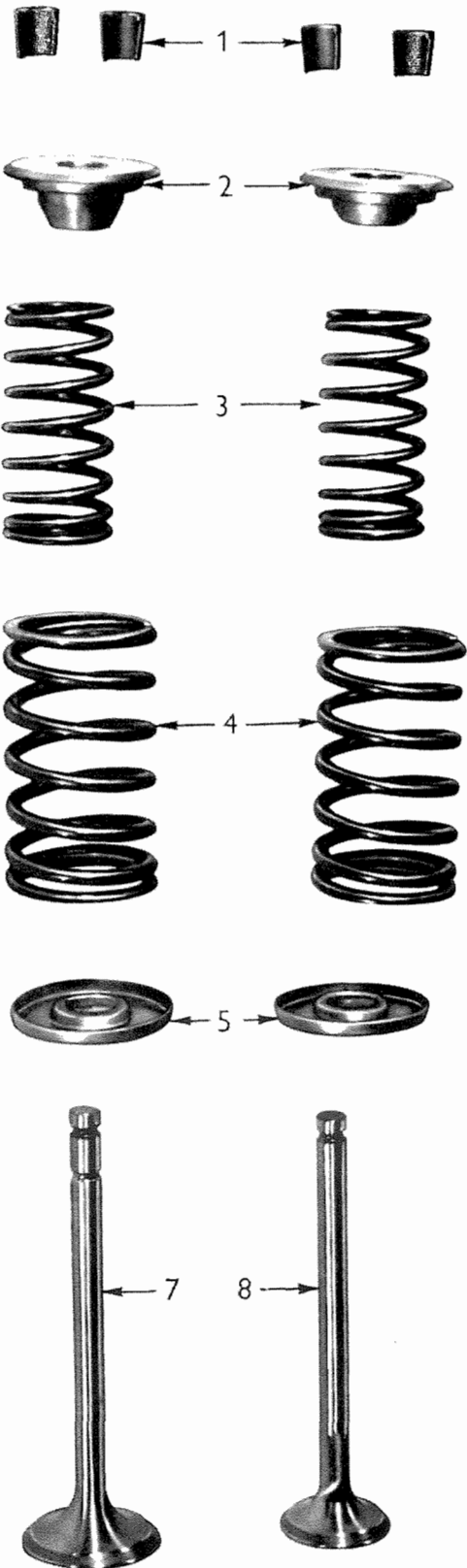
4.107 and 4.99 Engines

These engines use a copper and asbestos or a copper, steel and asbestos gasket. These gaskets should be fitted with a light coating of Perkins (Hylomar) jointing compound on both sides.

To Refit Cylinder Head

1. Place the cylinder head gasket carefully in position on the cylinder block face (the gasket is marked "TOP FRONT" to indicate how it should be fitted). (Refer to Fig. E.22).
2. Lower the cylinder head into position on top of the gasket ensuring that it lays perfectly level.
3. Lightly lubricate both cylinder head studs and nuts with engine oil, then tighten the nuts progressively in three stages in the sequence shown in Fig. E.23 to the torque given on page B.2. This final torque tightening stage should be repeated to ensure that no loss of tension has taken place on any studs earlier in the sequence.

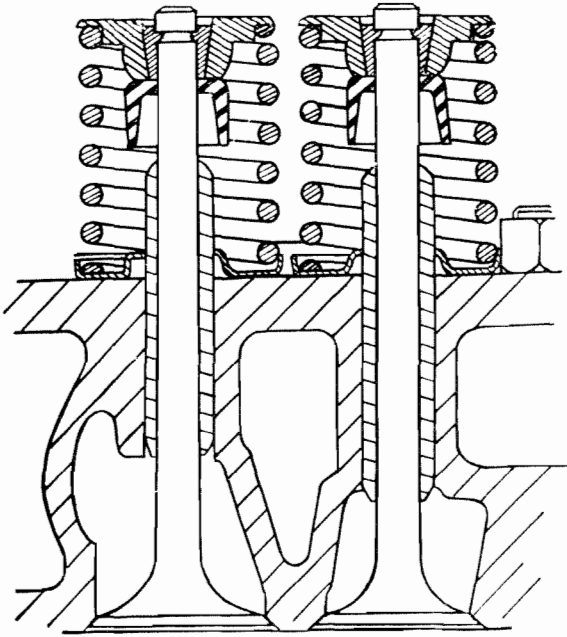
With current engines, washers are fitted under the cylinder head nuts which necessitates longer cylinder head studs. The cylinder head tightening torque remains unaltered.



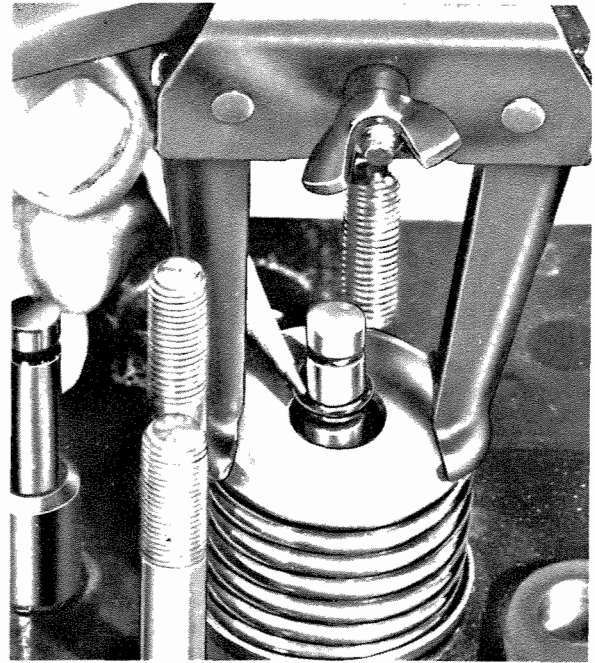
E19

1. Retaining Collets
2. Spring Caps
3. Inner Valve Springs
4. Outer Valve Springs
5. Spring Seating Washers
6. 'O' Sealing Ring (Inlet Valves only)
7. Inlet Valves
8. Exhaust Valve

CYLINDER HEAD—E.8



E20

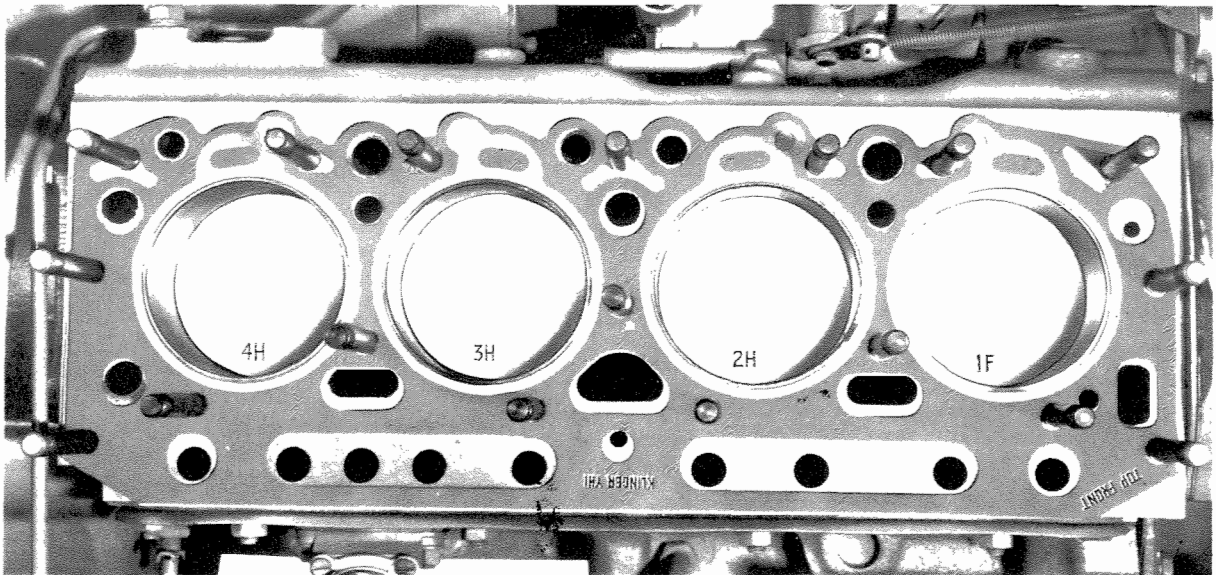


E21

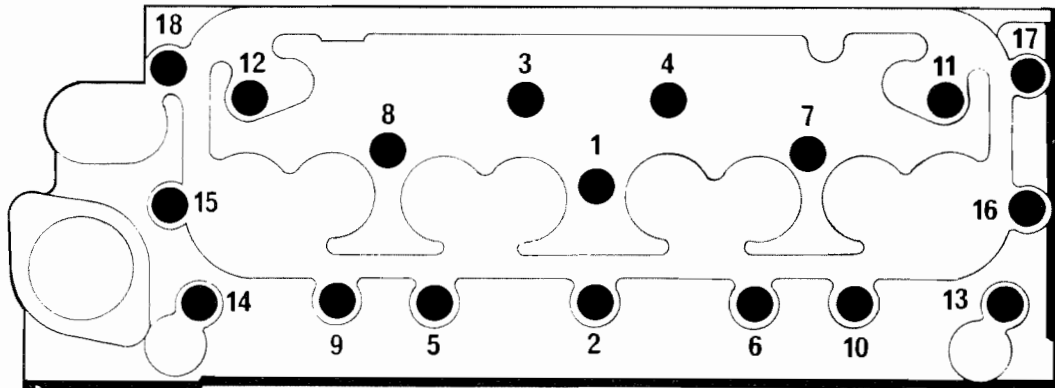
4. Fit the push rods in their locations then carefully fit the rocker shaft assembly, noting that the valve adjusting screw ends locate in their respective push rod cups and the oil feed to the rocker shaft is located correctly.
5. Locate the oil feed pipe nut just finger tight at this stage, then evenly tighten the rocker shaft bracket securing nuts to a torque of 12 - 15 lbf ft (1.7 - 2 kgf m) now tighten the oil feed pipe nut. When correctly located the oil feed pipe will be as shown in Fig. E.2.

NOTE: If the oil feed pipe nut is tightened before the rocker shaft bracket securing nuts, the pipe will either be strained or the olive pulled off the feed pipe.

6. Adjust the valve clearances to 0.012 in (0.3 mm) as follows:—
Turn the engine so that the valves of No. 1 cylinder are in the position of 'valve overlap', i.e. the period between the opening of the inlet valve and the closing of the exhaust valve. In this position, adjust the clearances of No. 4 cylinder valves: similarly with the valves of No. 3 cylinder in the overlap position, adjust the valves of No. 2 cylinder. With valves of No. 4 in the overlap position, adjust the valves of No. 1 cylinder and finally with valves of No. 2 cylinder in overlap position, adjust valves on No. 3 cylinder.
7. Replace the dynamo or alternator adjusting link and tension the fan belt (Refer to Page M.1).



E22



E23

8. Replace the atomisers (Refer to Page N.10) but do not tighten the securing nuts.
9. Replace the leak off pipe assembly and four high pressure fuel pipes to the atomisers. Tighten the atomiser securing nuts.
NOTE : The correct tightening torque for high pressure fuel pipe nuts is 15 lbf ft (2,1 kgf m) or 20 Nm and for the atomiser securing nuts is 12 lbf ft (1,7 kgf m) or 16 Nm.
10. Replace the fuel oil filter and the low pressure fuel pipes between filter and lift pump and filter and fuel pump.
11. Reconnect the electrical and fuel supplies to the starting aid.
12. Reconnect the exhaust pipe to the manifold.
13. Reconnect the water outlet connection at the front of the cylinder head.
14. Fill the cooling system with clean water ensuring the drain taps are turned off. Check for water leaks
15. Bleed the air from the fuel system as decribed on Page N.11.
16. Reconnect the battery.

10 positions again to ensure that they are still to the correct torque. During this last check, do not loosen the nuts.

Replace the rocker shaft as previously described and set the valve clearances to 0.012 in (0,30 mm) COLD. Start engine and check oil flow to rocker levers, if satisfactory refit cylinder head cover and air cleaner. Finally check for oil leaks and rectify immediately if any are visible.

It is important that the cylinder head nuts are re-tightened to the correct torque, in the correct sequence, after the engine has completed between 500/1000 miles (800/1600 km) or 25/50 hours.

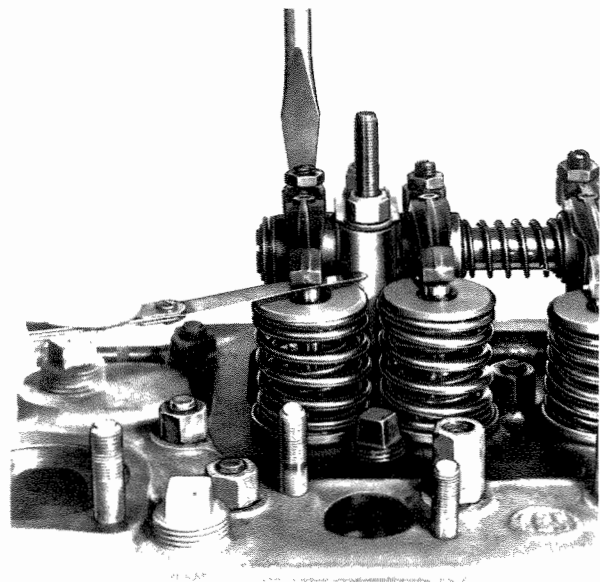
Starting the Engine

Proceed as instructed on Page C.1, with the engine running at a fast idle check that the oil pressure is satisfactory and that the oil reaches the rocker assembly and oozes gently from the rocker levers at this speed.

With the coolant outlet temperature higher than 170°F (77°C), tighten the cylinder head nuts in the order given in Fig. E23 and to the torque given on Page B.2. If a nut moves when checked, tighten it to the correct torque.

If a nut does not move before the correct torque is reached, loosen the nut by 1/12 to 1/6 (30° to 60°) of a turn and then tighten to the correct torque.

After all the nuts have been tightened, check the first

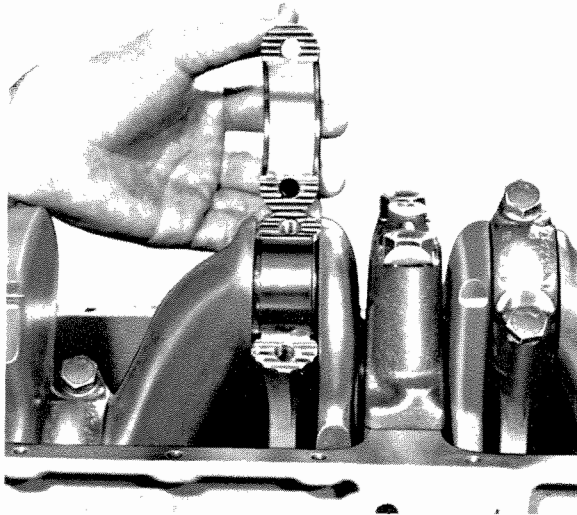


E24

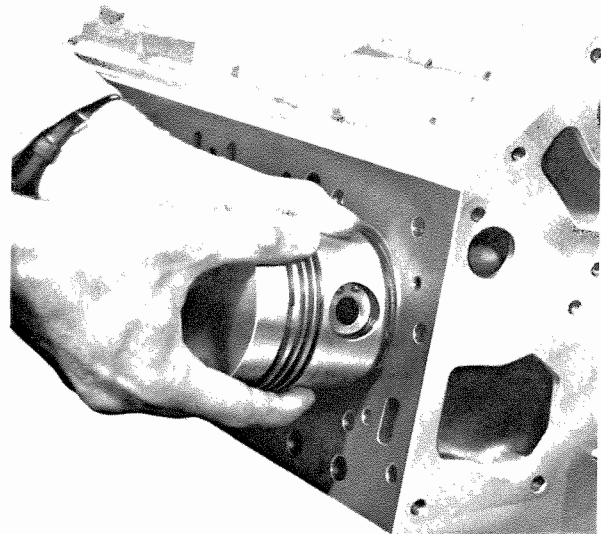


SECTION F

Pistons and Connecting Rods



F1



F2

To Remove Pistons and Connecting Rods

1. Remove the cylinder head assembly. (Refer to Page E.1).
2. Remove the oil sump. (Refer to Page L.1).
NOTE: Any ridges or carbon deposits around the top of the cylinder bore should be removed with a suitable scraper before piston removal is attempted.
3. Rotate the crankshaft until one pair of big ends are at bottom dead centre, then remove their respective connecting rod cap securing bolts.
4. Remove the connecting rod caps and bearing shells. (Refer to Fig. F.1).
NOTE: If the bearing shells are serviceable, they should be suitably marked to identify them to their original locations.
5. Push the pistons and connecting rods carefully out through the top of the block and remove as shown in Fig. F.2.
6. Rotate the crankshaft through 180° to bring the remaining pair of big ends to bottom dead centre and repeat removal operations.

When piston removal has been carried out keep each piston and rod assembly separate, each to each as marked. Mark the pistons on the crown (before removing the gudgeon pin) to indicate the 'FRONT' in relation to the 'FRONT' marking cast on the connecting rods.

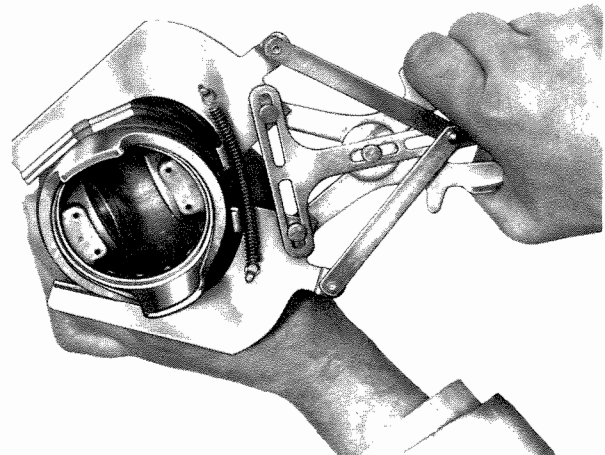
To Remove Pistons and Rings from the Connecting Rods

1. Remove the piston rings from each piston, using a suitable piston ring tool, such a tool is shown in Fig. F.3.
NOTE: The laminated segments or spring loaded rings fitted in the fourth ring groove should be removed by hand.

With 4.108 pistons there is a steel insert rolled into the top ring groove during piston manufacture. It should be regarded as an integral part of the piston and no attempt should be made to remove it from its location.

2. Remove the circlip retaining the gudgeon pin and push out the gudgeon pin to release the connecting rod.

NOTE: Should difficulty be experienced in removing the gudgeon pin, warm the piston in a suitable clean liquid (usually water) to a temperature of 100—120°F, (40—50°C), this will then enable the pin to be pushed out quite easily.



F3

PISTONS AND CONNECTING RODS—F.2

Inspection

1. Examine the pistons for scoring and any signs of groove damage.
2. Check the clearance of the piston rings in their respective grooves by placing the ring outer face into the groove and a suitable sized feeler between the ring and groove face.
NOTE: All ring gaps, ring groove clearances etc., are given in the Technical Data Section on Page B.4.
3. Check the fitted gaps of the piston rings, bearing in mind that in worn cylinder bores these gaps should be checked at the **bottom** of the bore.
4. Check the fit of the gudgeon pin in the small end bush, if excessive, replace the small end bush.
5. To renew the small end bush, remove the old one by means of a suitable press and 'dolly'. Press in the new bush, ensuring that the oil holes coincide when fitted. Ream out the new bush to suit the gudgeon pin, then check the rod for parallelism and twist. (Refer Page B.5).
6. Examine the big end bearing shells for any signs of wear or pitting.

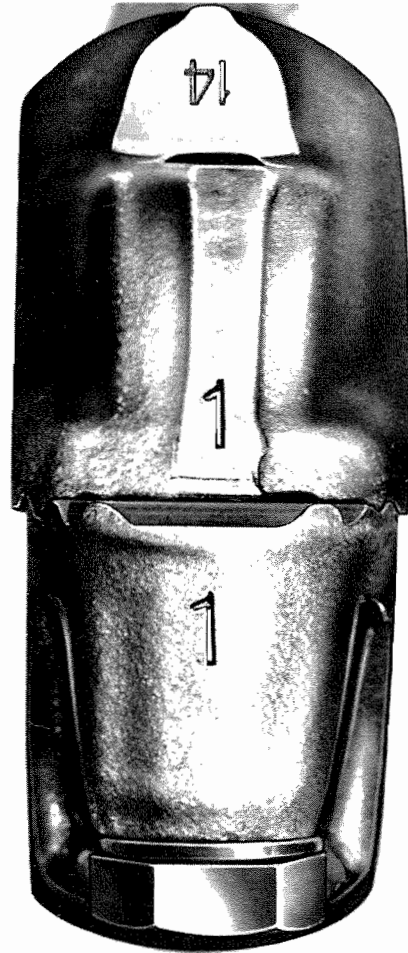
To Refit the Pistons to the Connecting Rods

If the original pistons are to be refitted they must be re-assembled to the same connecting rods, i.e. No. 1 piston to No. 1 connecting rod assembly. Refer to Figs. F.4 and F.5 for location of piston and rod numbering. Any new components fitted should be numbered the same as those which they replace.

Note: Where controlled expansion pistons are fitted, these have a 0.020 in (0.51 mm) off-set gudgeon pin towards the camshaft side of the engine and when replacing these pistons, they must be fitted the correct way round, i.e., the word "FRONT" or arrow on the piston crown to the front of the engine. If these marks have been removed by machining the crown, then the small round recess in the gudgeon pin bore 'A' Fig. F.6, must face the front of the engine.

Where controlled expansion pistons with off-set pins are fitted, the latest phosphated crankshaft pulley setscrew must be used.

1. Warm the piston in a suitable clean liquid to a temperature of 100 — 120°F (40 — 50°C) which will enable the gudgeon pin to be easily pushed into the piston bore when the piston and rod have been correctly aligned

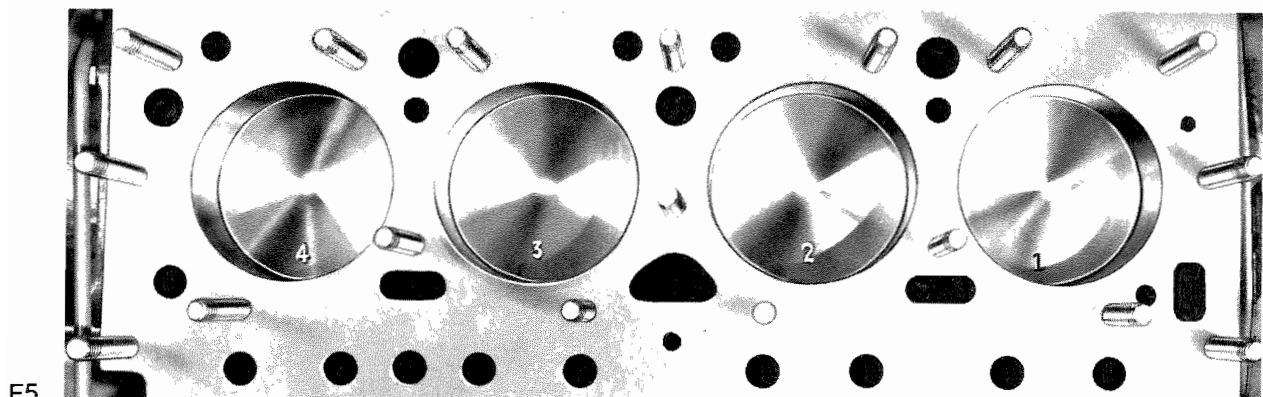


F4

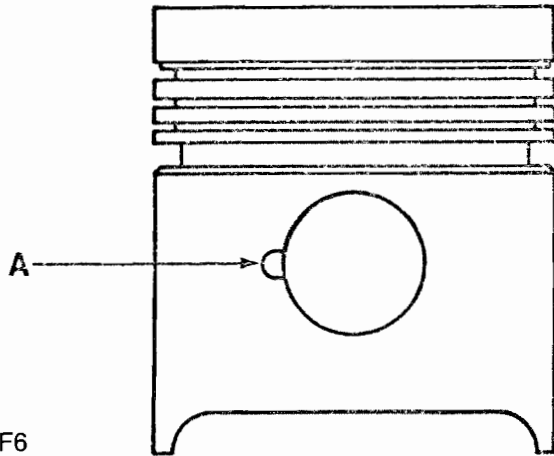
2. Place No. 1 piston onto its head, noting the position of the mark previously made to indicate the "FRONT".
3. Hold No. 1 connecting rod with the small end between the gudgeon pin bores so that the word "FRONT" cast on the rod is towards the same side.
4. Push the gudgeon pin into the piston thus locating the connecting rod in position.
5. Fit the two retaining circlips ensuring that they locate correctly in their recesses. (Refer to Fig. F.7).

NOTE: If the engine has been in service for some considerable time it is advisable to fit new circlips, even if the old ones do not appear to be strained or damaged.

6. Repeat this procedure for the three remaining pistons and connecting rods.



F5



F6

Fitting the Piston Rings

Fit piston rings to the piston. Rings vary according to engine type and application as follows: reading from the top of the piston.

4.108 Engines

Standard Pistons

- 1. Plain parallel faced compression
- 2. Internally stepped compression
- 3. Internally stepped compression
- 4. Laminated segment oil control*
- 5. Slotted scraper

* Engines rated at 3,000 rev/min and below have a slotted scraper fitted in the fourth groove which has the same width, clearance and gap as the fifth piston ring.

Controlled Expansion Pistons

These have either four or three rings per piston as follows:

- 1. Chrome insert parallel faced
- 2. Internally stepped
- 3. Internally stepped
- 4. Spring loaded scraper

- 1. Chrome taper faced
- 2. Internally stepped taper faced
- 3. Spring loaded scraper



F7



F8

4.99 Vehicle Engines

- 1. Chrome parallel faced compression.
- 2. Internally stepped compression.
- 3. Internally stepped compression.
- 4. Slotted scraper.
- 5. Slotted scraper.

4.107 and 4.99 Agricultural and Industrial Engines

- 1. Plain parallel faced compression.
- 2. Internally stepped compression.*
- 3. Internally stepped compression.*
- 4. Chrome spring loaded scraper.
- 5. Slotted scraper.

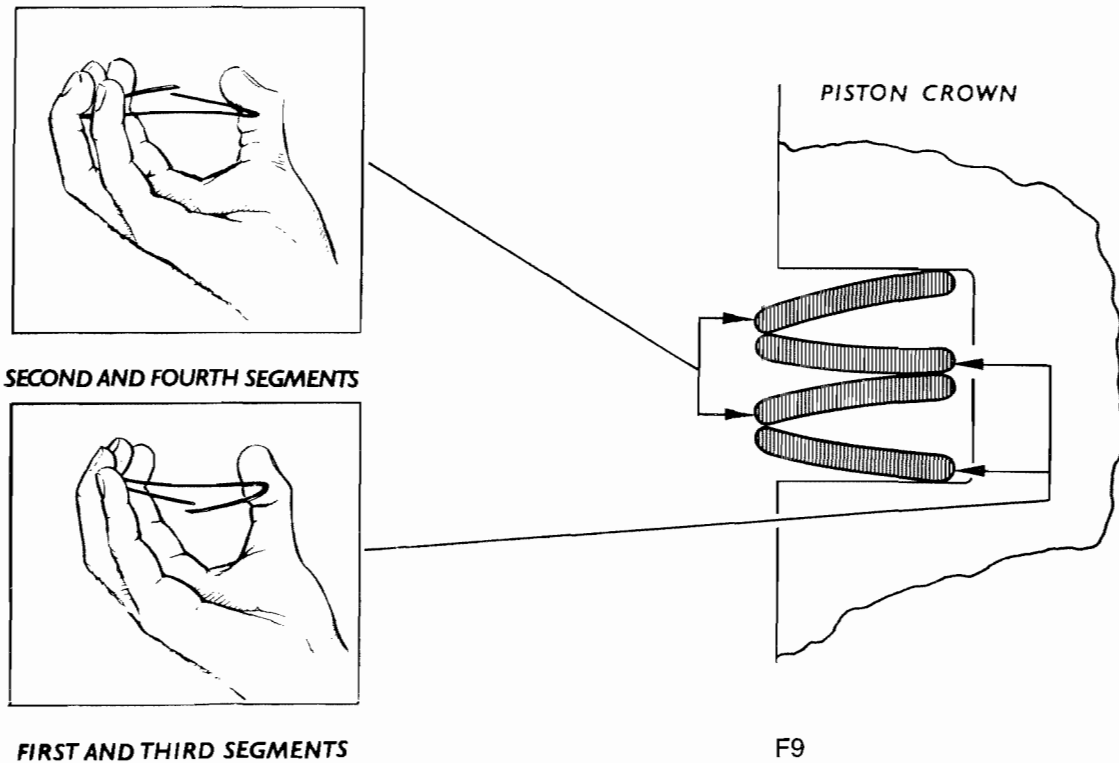
*4.99 agricultural engines have taper faced cast iron compression rings fitted in the 2nd and 3rd ring grooves.

After an appropriate period of service, when indications of piston ring and/or cylinder bore wear may become apparent, a replacement ring pack has been made available for fitting exclusively to 4.99 service engines and includes a taper faced ring for fitting in the top ring groove.

NOTE: All the rings quoted above except the laminated and spring loaded type may be fitted by means of an

PISTONS AND CONNECTING RODS—F.4

expanding tool of the type shown in Fig. F.3. These rings, being made of cast iron are therefore comparatively brittle, so when fitting care should be taken not to expand any ring more than is necessary to just clear the piston.



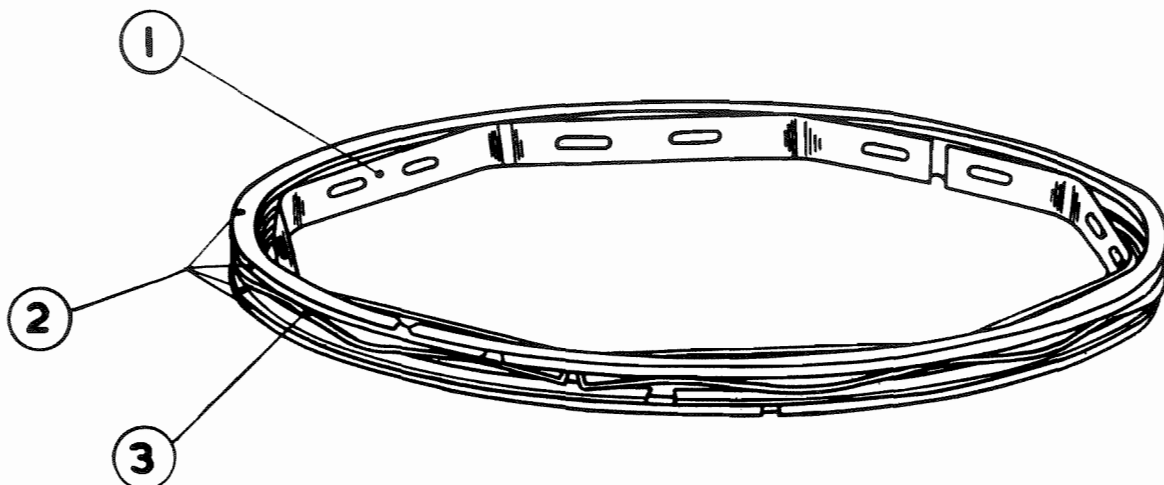
Laminated Segment Rings

The procedure for fitting the laminated type is different, in as much as the ring comprises four separate segments, these may be fitted by hand in the following sequence with the piston crown uppermost:—

1. Fit the first segment to the piston so that when held horizontally between the thumb and fingers and radially compressed the ring ends point downwards (see Fig. F.9).

Place this ring on the bottom face of the fourth ring groove with the gap over the gudgeon pin bore.

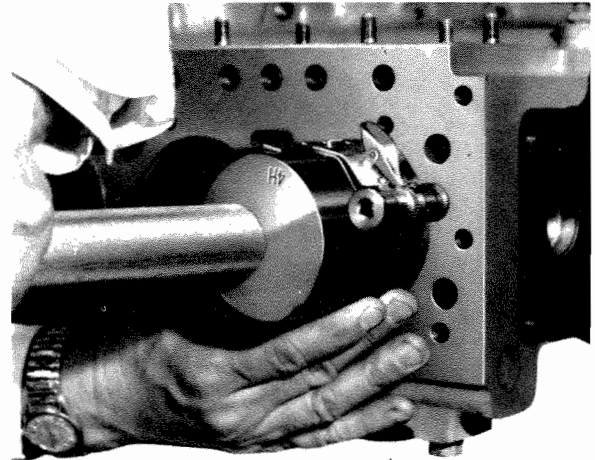
2. Fit the second segment on top of the first, so that when compressed as described above the ends point upwards. Position the gap at 180° to that of the first segment.
3. Fit the third segment as in (1) above with the gap immediately above the gap of the first segment.
4. Fit the fourth segment as in (2) above with the gap immediately above the gap of the second segment. If all the segments have been fitted correctly then they will be positioned as shown above.



F10

The gaps of the remaining rings should be staggered alternately along the gudgeon pin axis. Liberally lubricate the rings in their grooves and see that they can move freely in their locations, this does not apply to the laminated type in the fourth groove, which if correctly fitted should **not** move freely due to the outward pressure of the top and bottom segments on the ring groove walls. When all the rings have been fitted, they should be shown in Fig. F.9.

Always ensure that internally stepped or taper faced rings are correctly fitted. They are marked TOP or BTM (bottom) to ensure correct replacement. The top compression and slotted oil control rings may be fitted either way up.



F11

Spring Loaded Scraper Ring

When fitting the chrome plated spring loaded scraper ring. (see Fig. F.10), the following procedure should be adopted :—

1. Fit internal expander (1).
2. Fit two rail rings (2) at the bottom of the groove.
3. Fit spiral ring (3).
4. Fit two top rail rings (2).

When fitting rail rings, the gaps should be staggered.

To Fit Piston and Connecting Rod Assemblies

Before fitting the piston and connecting rod assemblies to their respective cylinder bores, thoroughly clean and liberally coat each bore with clean engine oil.

1. Turn the engine until the crankpins of numbers 1 and 4 cylinders are at the bottom dead centre.
2. Using a suitable ring clamp of the type shown in Fig. F.11, carefully compress the rings of No. 1 piston and hold in this position.
3. With the word 'FRONT' on the connecting rod facing the front of the engine, insert the rod carefully into No. 1 cylinder bore.

NOTE: The cylinders are numbered 1, 2, 3, 4 starting from the front (water pump) end of the engine. It is extremely important that these components (marked as shown in Figs. F.4 and F.5), are returned to their original locations.

4. The piston head may be gently tapped with the shaft of a hammer as shown in Fig. F.11 until all the rings have entered the cylinder bore.
5. Draw the rod towards the crankpin, place the top half bearing shell in position locating the tag in the machined slot and liberally oil, draw the rod onto the crankpin.
6. Fit the lower half bearing shell to the connecting rod cap, locating the tag in the machined slot, liberally oil and fit the cap to the crankpin, ensuring that the numbers on the rod and cap coincide as shown in Fig. F.4.

7. Fit the two connecting rod securing setscrews and tighten evenly to the torque quoted on Page B.2.
NOTE: Locking tabs are not fitted to these setscrews.
8. Repeat this procedure for No. 4 piston and connecting rod assembly.
9. Rotate the crankshaft to bring numbers 2 and 3 crankpins to bottom dead centre.
10. Repeat procedures 2 — 7 to fit the two remaining assemblies.
11. Refit the lubricating oil sump. (Refer Page L.4).
12. Refit the cylinder head assembly. (Refer Page E.7).

Fitting New Pistons

With new 4.108 and 4.107 pistons a machining allowance is provided on the crown of the piston to enable the necessary material to be removed by means of a lathe so that when fitted the piston height above the cylinder block top face will be within the limits quoted on Page B.3.

To determine the exact amount to be removed from the piston crown, the piston, connecting rod and bearing assembly will have to be fitted to its respective cylinder bore as previously described, and the piston height above the cylinder block top face measured with the particular piston at top dead centre. This piston height can be measured by means of a piston height gauge of the type shown in Fig. F.12. Repeat for each new piston to be fitted and mark each piston with the number of the cylinder bore it will belong to, (not on the top as any marking here will be removed by the machining). When each piston has been skimmed it should be checked again when finally refitted to ensure that any new piston fitted is now within the limits quoted. Once the piston height is correct mark any such piston on the crown with the number of its respective bore. (Refer to Fig. F.5).

Pretopped pistons are available for fitting to 4.108 vehicle engines and all 4.99 engines and are available in three grades (see separate tables). For identification purposes, the grade letter is stamped on the piston crown.

PISTONS AND CONNECTING RODS—F.6

Where pretopped pistons are used, then the piston height can be slightly lower than the limits given.

It is important to note that where vehicle engines have to conform to the smoke density regulation B.S.AU 141a: 1971, then the piston height production limits must be maintained.

It will of course be appreciated that grade F pistons are suitable for topping to give other grades where these are not to hand.

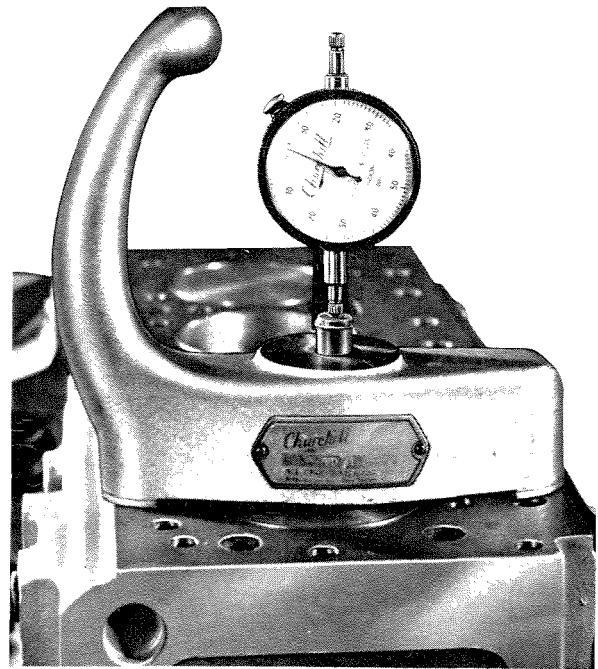
After fitting pre-topped pistons, the distance between the cylinder block face and piston crowns should be checked to ensure the limit is as already quoted (See Fig. F.12).

4.108 Vehicle Engines

Production Grade	Equivalent Service Grade
A to F	F
G to L	L
M to P	P

4.99 Engines

Production Grade	Equivalent Service Grade
B, D, & F	F
H, J, & L	L
N & P	P



F12

SECTION G

Cylinder Block and Liners

CYLINDER LINERS (4.108 ENGINES)

The cylinder liners fitted to the 4.108 series engines are centrifugally cast alloy iron, they are an interference fit in the cylinder block parent bore and of the thinwall dry type.

Reboring of these liners is not possible and new liners should be fitted when a rebore would normally be considered necessary.

The exception is 4.108 refrigeration unit engines which can be rebored to 0.020 in (0,51 mm) oversize. It must be noted that the oversize pistons for these engines are only suitable for this type of application due to the special operating conditions.

Dimensional checks of the cylinder bore are carried out by means of the gauge tool shown in Fig. G.1. When checking liners each one should be measured in three positions — top, centre and bottom; the readings being taken parallel and at right angles to the centre line of the cylinder block giving six readings for each cylinder bore.

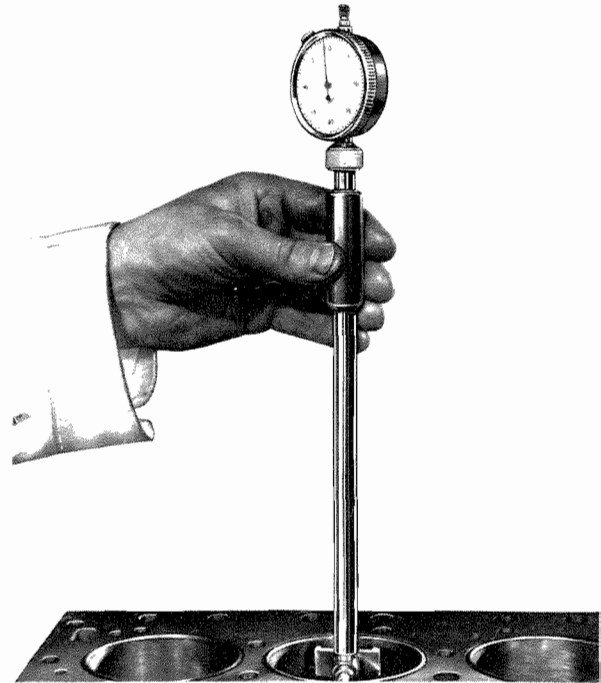
When checking the fitted internal bore of a new thin-wall liner it is advisable to allow a period of time to elapse for the liner to settle.

To Renew Cylinder Liners

1. Remove all the various components from the cylinder block. (Refer to the appropriate sections for details of their removal).
2. Using a shouldered metal disc slightly smaller on the outside diameter than the parent bore diameter and a suitable press, press the liners carefully out through the top of the cylinder block.
NOTE: Support the block locally in the area of the top of the liner.
3. Lightly lubricate the outside of the liner with clean engine oil ready for fitting.
4. As the liner must protrude above the cylinder block top face and not be pressed fully home when fitted correctly, a solid stop washer should be available designed to give the correct liner protrusion.
NOTE: The limits for liner protrusion are given on page B.3 and may be checked as shown in Fig. G.2.
5. Press the liner into the bore progressively until it reaches the solid stop washer.
6. Bore and finish hone the liners to the dimension quoted on Page B.3.
NOTE: Where boring equipment is mounted on the top face of the cylinder block fit a parallel plate between the boring bar and cylinder block face. Such a plate should be thicker than 0.027 in (0,686 mm).
7. Re-assemble the engine components to the cylinder block. (Refer to the appropriate sections for assembly of these).

CYLINDER LINERS (4.107 and 4.99)

Cylinder liners fitted to 4.107 and 4.99 engines are of the centrifugal cast iron wet type. They have flanges at the top and are sealed at the bottom by means of two rubber sealing rings which fit in machined recesses in the cylinder block.

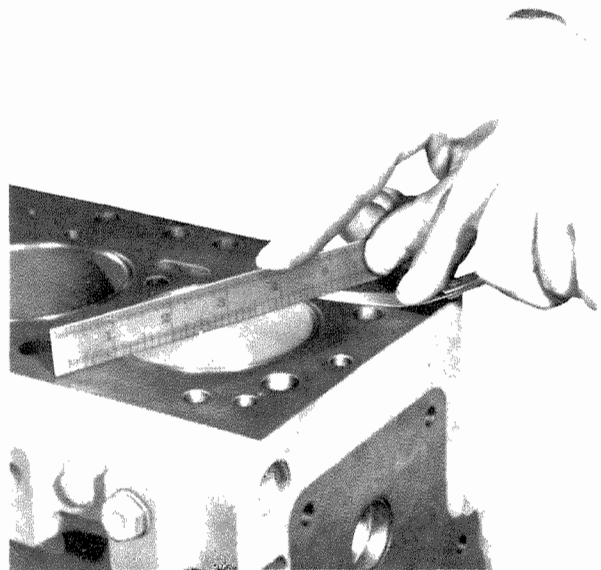


G1

Earlier 4.99 engines had only one seating ring at the bottom of the liner (see Fig. G.3).

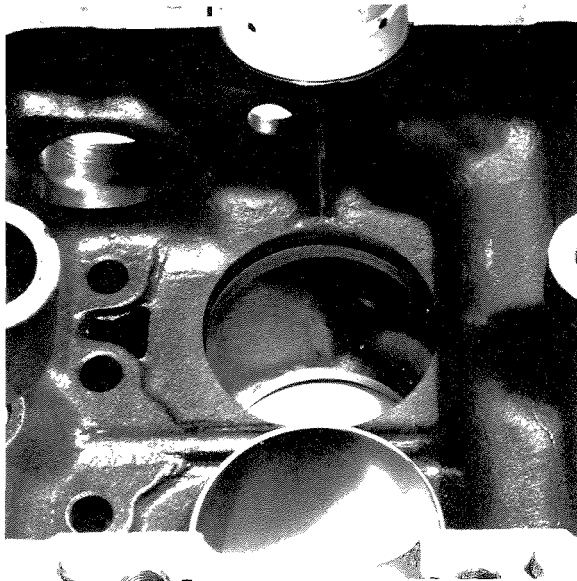
4.107 and 4.99 cylinder liners have pre-finished bores. Under normal circumstances, the liner would only need to be renewed during major overhaul, but should it be necessary to remove the liner for any other reason, this can be carried out without removal of the crankshaft.

If at any time, the cylinder liners are removed and these same liners are to be refitted, then before they are removed from the cylinder block, they should be



G2

CYLINDER BLOCK AND LINERS—G.2



G3

suitably marked so that they may be refitted to their original parent bore and in the same position in that bore, that is, thrust side of the liner to the thrust side of the cylinder block.

To Renew Cylinder Liners

Remove all components from cylinder block.

Remove liners using a suitable liner removing tool (see Fig. G.4).

Once the liner has cleared the rubber sealing rings in the cylinder block, the liner can be removed by hand. Remove any corrosion and burrs which may be present at the inner ends of the landings.

Renew the rubber sealing rings in the grooves at the bottom lands.

To ease fitting of the liners when the rings have been placed in position, smear the liners with soft soap or soapy water.

Place liner in position and press home by hand, ensuring that the rubber sealing rings remain in their grooves (see Fig. G.5).

The liners are a push fit and no force is required.

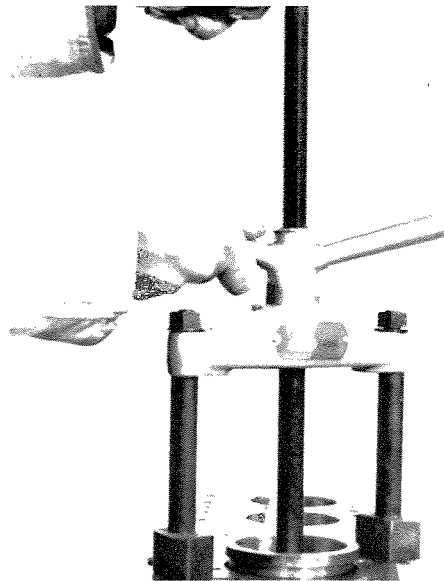
After fitting the liners, the cylinder block should be water tested at a pressure of 20 lbf/in² (1,4 kgf/cm²).

Re-assemble engine as required and to instructions given for the various components.

Note: If engine is overheated, it could have an adverse affect on the liner sealing rings.

All 4.107 and later 4.99 engines have four small holes drilled along the fuel pump side of the cylinder block, each one breaking through into the area between the two sealing rings at the bottom of each cylinder liner. These holes permit any coolant which may have leaked past the upper sealing ring to escape thus relieving the bottom sealing ring of any pressure above it and preventing coolant from entering the engine sump.

In the case of a new engine, or where cylinder liners and/or sealing rings have been fitted, it is possible that a slight leakage of coolant could occur from these holes. This should ease as the liners and sealing rings settle down after the initial period of running, but



G4

where difficulty is experienced, then the use of BARSEAL in the cooling system (in accordance with the manufacturers instructions) is approved.

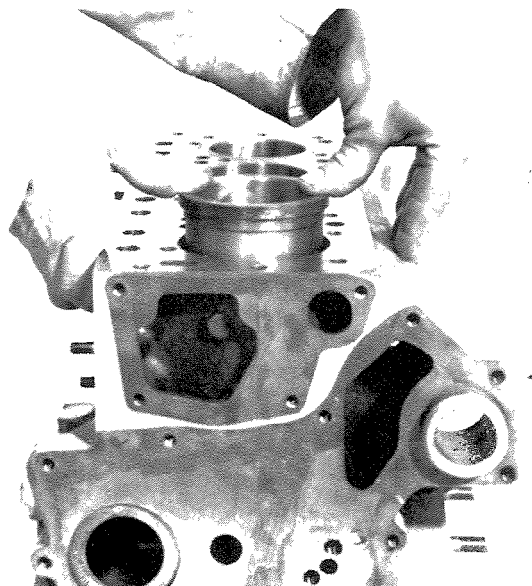
Oversize Cylinder Liners

Oversize outside diameter cylinder liners are available for service use on 4.108 engines, if the standard parent bore has been made larger to remove damage.

Oversize **Description**

0.010 in (0,25 mm) Cast Iron Flangeless—Bore & hone
Where a parent bore is made larger in service, it should be machined to the dimension by adding 0.010 in (0,25 mm) to the standard parent bore diameter given on Page B.3. A chamfer must be machined at the top of the new parent bore.

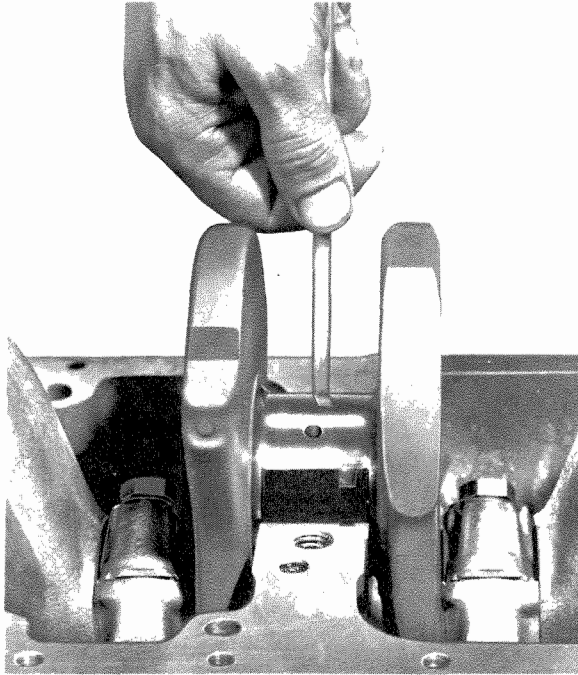
When oversize liners are fitted at the factory, the liner oversize is stamped on the top face of the cylinder block between the liner and the edge of the cylinder block.



G5

SECTION H

Crankshaft and Main Bearings



H1

Description

The crankshaft runs in three pre-finished replaceable thinwall, steel backed, aluminium tin lined bearings. Crankshaft end float is controlled by thrust washers located either side of the rear main bearing. 0.0075 in

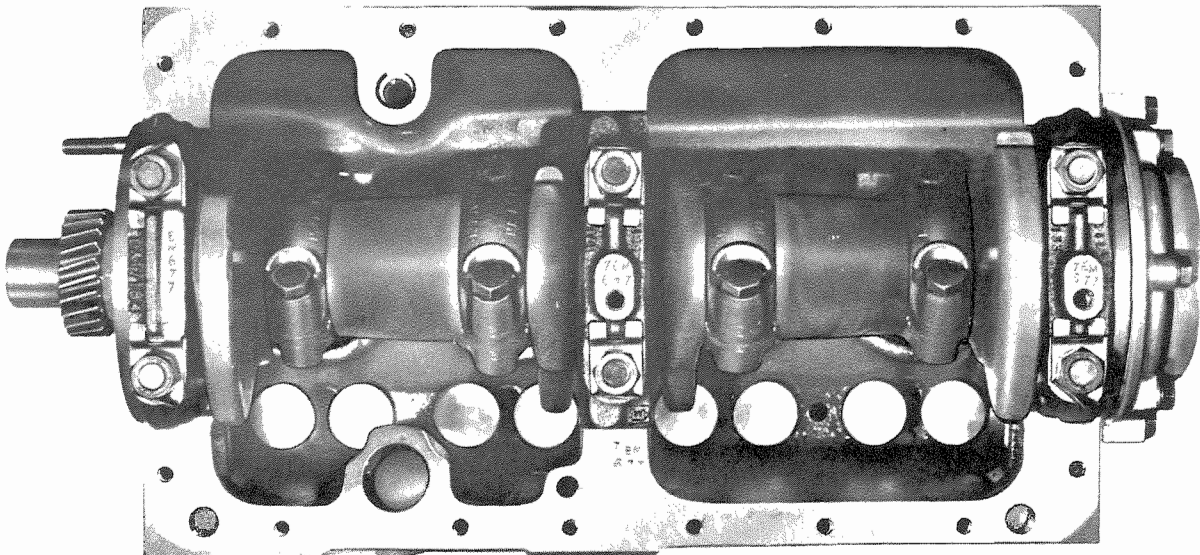
(0.19 mm oversize) thrust washers are available which if used on one side of the rear main bearing only will reduce crankshaft end float by 0.0075 in (0.19 mm) and by 0.015 in (0.38 mm) if used on both sides. The limits for the crankshaft end float are given on Page B.6.

The main bearing caps are numbered and are not interchangeable. The main bearing shells are located by means of tabs which locate in slots in the bearing housings.

NOTE: Before renewal of the main bearings is attempted make absolutely certain that the correct replacements are available, reference to the relevant parts list will ensure this, but for identification purposes the new bearings should have an annular groove machined in the inner (bearing) face along the centre line of the feed holes, when the bearings are correctly located these feed holes will correspond exactly with those machined in the cylinder block.

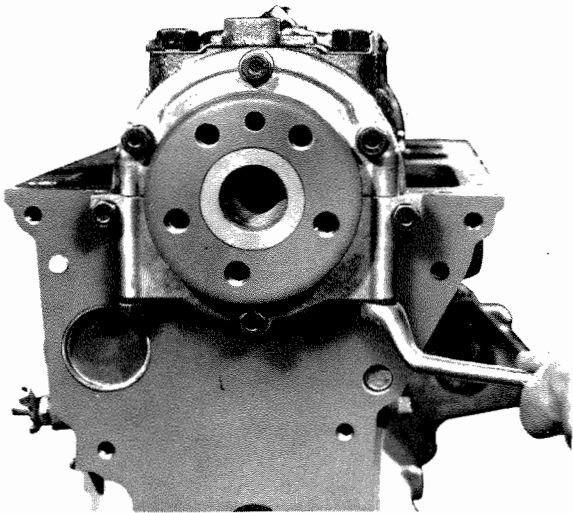
On later 4.107 and 4.99 engines, the annular oil groove in the main bearing parent bore (cylinder block and bearing cap) has been deleted. Adequate lubrication is maintained by repositioning the oil feed holes radially in the shell bearings and continuing to machine the annular groove in the bearing on the centre line of these feed holes.

These later type shell bearings may be used on both early and later type engines, whereas the early type of shell bearings must NOT on any account, be fitted to later engines where the annular groove in the main bearing parent bore has been deleted.

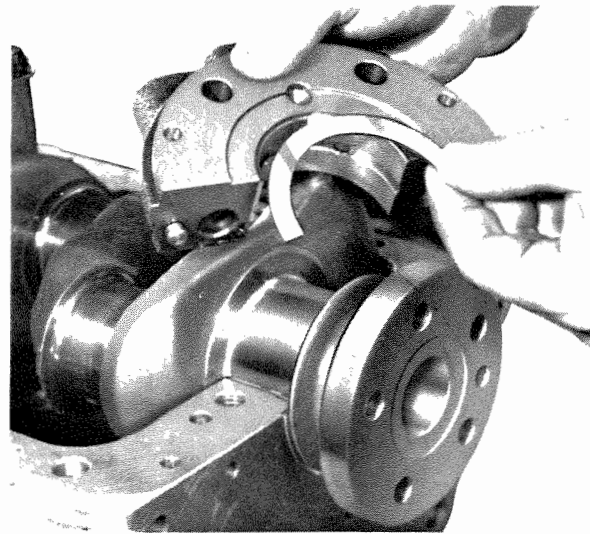


H2

CRANKSHAFT AND MAIN BEARINGS—H.2



H3



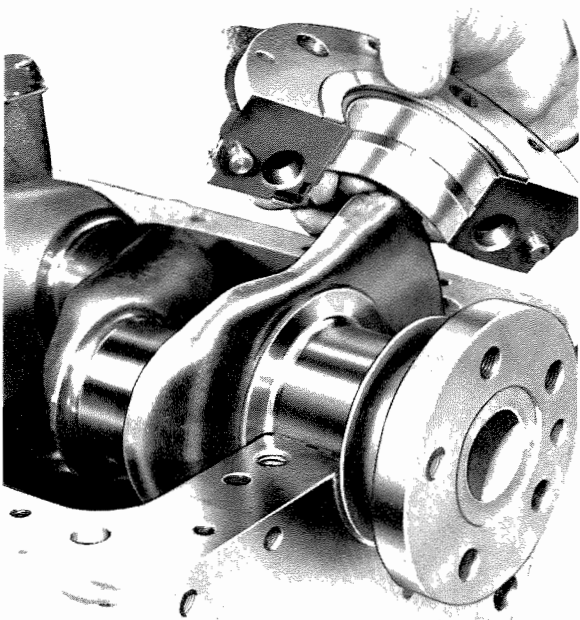
H4

To Renew Main Bearings and Thrust Washers

Removal of the main bearings and thrust washers can be carried out without removing the crankshaft by the following procedure:—

1. Remove the engine from its application.
2. Remove the sump and suction pipe assembly.
3. Slacken the setscrews which secure the main bearing caps.
4. Remove completely one of the main bearing caps and remove the bearing shell from the cap.
5. Remove the top half of the bearing shell by pushing it, on the opposite side to the one having the locating tag, with a suitable strip of wood and rotating it on the crankshaft as shown in Fig. H.1.
6. Inspect the bearing shells and if replacements are necessary continue by lightly lubricating and inserting the new top half bearing shell, plain end first, into the side having the tag location.
7. Rotate the bearing shell on the crankshaft until it locates correctly with the tag in the machined slot.
8. Locate the lower half bearing shell in the main bearing cap, liberally lubricate and refit.
9. Tighten the two securing setscrews to positively locate the bearing shells then slacken a turn or two.
10. Repeat items 3—8 for the remaining two bearings. NOTE: To enable the rear main bearing cap to be removed, first remove the two oil seal housing setscrews as shown in Fig. H.3.
11. Finally tighten the main bearings to the torque given on Page B.2.

Renewal of the thrust washers is accomplished by carrying out the following procedure:—



H5

1. Remove the two setscrews securing the two rear main bearing oil seal half housing as shown in Fig. H.3 and remove the half housing from the bearing cap.
2. Remove the rear main bearing cap securing setscrews.
3. Remove the rear main bearing cap and from it the two lower half thrust washers. (Refer Fig. H.4).
4. The single upper half thrust washer is removed by rotating it with a thin piece of wood until it can be lifted out of its recess. NOTE: The new thrust washers should be lightly lubricated before fitting. The steel faces of the lower thrust washers should face inwards towards the bearing cap, (Refer Fig. H.5), the steel face of the upper thrust washer should also face inwards.
5. Locate the upper thrust washer half as shown in Fig. H.6, place the lower halves either side of the rear main bearing cap as described and refit the cap.
6. Tighten the setscrews evenly and finally to the torque given on Page B.2.

7. Check that the crankshaft end float is within the limits given on Page B.6 by means of feeler gauges as shown in Fig. H.7. If incorrect, oversize thrust washers are available to give an overall reduction of 0.015 in (0,38 mm). (Refer to Page H.1).
8. Refit the rear main oil seal half housing.
NOTE: If any leakage of oil is apparent from this seal then new seals should be fitted to the half housing as described under the heading "Crankshaft Rear End Oil Seal" or fit a new assembly.
9. Refit the suction pipe assembly and sump.

To Remove the Crankshaft

To remove the crankshaft it will be necessary to remove the engine from the vehicle or application.

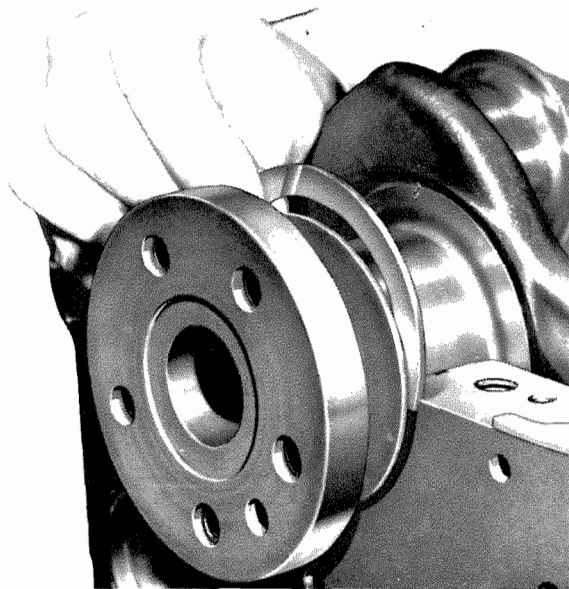
1. Remove the starter motor, flywheel and flywheel housing. (Refer to Page P.1 for details of flywheel and flywheel housing removal).
2. Remove the crankshaft front pulley, timing case cover, timing gears and fuel pump drive hub. (Refer to Page J.1 for details of their removal).
3. Remove the timing case back plate.
4. Remove the sump and lubricating oil pump complete with suction and delivery pipes. (Refer to Page L.1 for removal of these).
5. Remove all the connecting rod setscrews, connecting rod caps and bearing shells. (Refer to Page F.1).

NOTE: All the bearing shells should be marked to indicate "top" or "bottom" and number of the rod assembly.

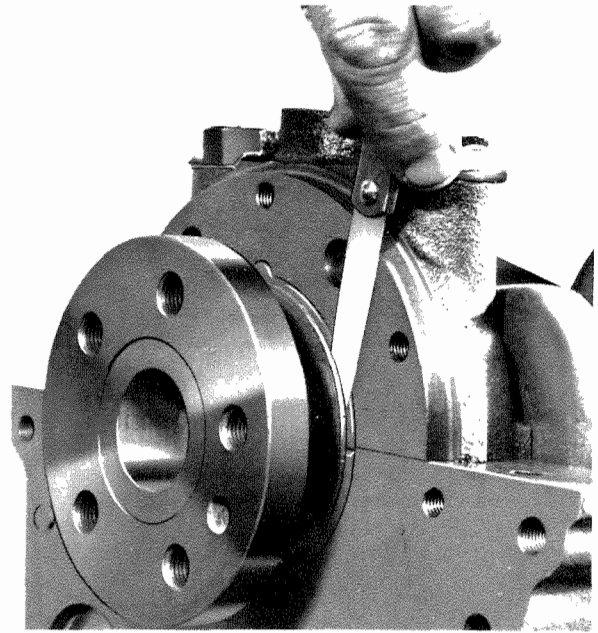
6. Unscrew the main bearing cap setscrews.

NOTE: The rear seal half housing securing setscrews will require removal to enable the rear main bearing cap to be removed. (Refer to Fig. H.3).

7. Lift out the crankshaft and place where it is not likely to be damaged ready for inspection.
8. Remove the top half main bearing shells.
9. Finally, remove the top half oil seal housing.



H6



H7

Crankshaft Regrinding

The crankshafts fitted to most 4.108 and some 4.107 engines are Tufftrided and these crankshafts must be re-hardened after regrinding. If facilities are not available for Tufftriding, the crankshaft can be re-hardened by the 20 hour nitriding process but if this cannot be carried out, then a replacement crankshaft should be fitted. The Tufftrided crankshafts can be recognised by the part number that is stamped on the crankshaft nose or No. 1 web. The part numbers of the Tufftrided crankshafts are 31315741, 31315827, 31315828, 31315829, 31315831, 31315836, 31315838, 31316111, 31316112, 31316113, 31316114, 31316122, 31316128 and 31316121.

The crankshafts fitted to 4.99 and most 4.107 and some 4.108 engines are induction hardened and do not require re-hardening after regrinding.

The crankpin and main journal diameters can be reground to 0.010 in (0,25 mm), 0.020 in (0,51 mm) or 0.030 in (0,76 mm) undersize. For crankshaft regrind data, see Page H.5.

When regrinding, only very light cuts should be used and adequate cooling must be maintained, especially around the fillet radii. The crankshaft should be crack detected and de-magnetised before and after regrinding and the fillet radii and the surface finish must be maintained to within the limits given on Page B.6. After regrinding and before polishing and where necessary, rehardening, the oil holes should be chamfered 0.020/0.060 in (0,51/1,52 mm) at 45° to blend smoothly into the crankpin and main journal diameters.

To Refit the Crankshaft

1. First ensure that crankshaft oilways are clear.
2. Place the three top bearing shells in position then oil liberally with clean engine oil.

NOTE: Unless a new set of main bearings is being fitted, those removed must be returned to their original locations.

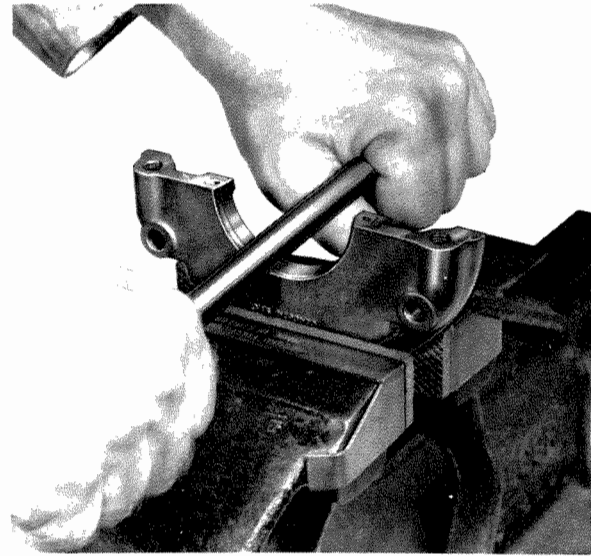
CRANKSHAFT AND MAIN BEARINGS—H.4

- Place the crankshaft in position.
- Locate the upper thrust washer in position as shown in Fig. H.6.
- Fit the three lower bearing shells, oil, and fit the three main bearing caps in their respective locations.
NOTE: Ensure at this stage that the two lower thrust washer halves are positioned correctly either side of the rear main bearing cap when it is fitted.
- Check the main bearing setscrews prior to fitting for signs of stretch or thread damage. Where damage or any doubt exists fit new replacements.
- Fit the setscrews then tighten evenly to the torque tension given on Page B.2.
- Check that the crankshaft can be rotated freely, if satisfactory check the crankshaft end float by means of feeler gauges as shown in Fig. H.7. Should it not be within the limits quoted on Page B.6, then oversize thrust washers are available to give the necessary adjustment. (Refer to Page H.1).
- Fit new sealing strips to the rear main bearing oil seal housings and refit the housings as described under the heading "Crankshaft Rear End Oil Seal" below.
- Liberal oil the crankpins, locate the connecting rod bearing shells, again ensuring their correct relative positions, then fit the connecting rod caps as described on Page F.5. The crankcase should now be as shown in Fig. H.2.
- Refit the lubricating oil pump complete with suction and delivery pipes. (Refer to Page L.4).
- Refit the sump using new seals and joints. (Refer to Page L.1).
- Refit the timing case back plate, fuel pump drive hub, timing gears, timing cover and crankshaft front pulley. (Refer to later text commencing on Page J.1 for their reassembly).
- Refit and correctly align the flywheel housing as described on Page P.2.
- Refit the flywheel and starter motor.

CRANKSHAFT REAR END OIL SEAL

This sealing arrangement consists of two half housings bolted around the rear of the crankshaft. The bore of these housings is machined to accommodate a rubber cored asbestos strip which, in conjunction with a right hand helix machined between the thrust collar and the flywheel mounting flange to the dimensions given on Page B.6, acts to return the surplus oil reaching the seal. The two half housings fit over this helix and the contact of the sealing strips with the crankshaft prevents leakage beyond this point.

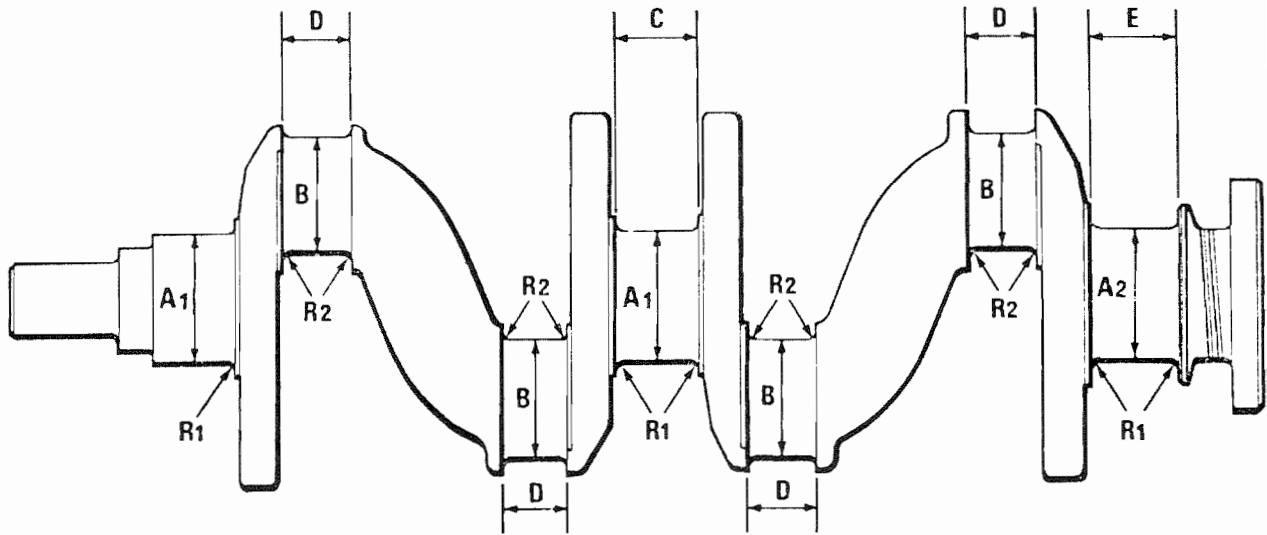
NOTE: When traces of oil become apparent from behind the flywheel and a faulty rear oil seal is suspected, first ensure that the crankcase is breathing normally. Any build up in crankcase pressure could cause oil to be forced past the rear sealing arrangement. If crankcase pressure is normal and new seals require to be fitted the following procedure should be adopted with the crankshaft in position.



H8

- Set up a half housing in the vice with the seal recess uppermost.
- Settle approximately 1 in (25 mm) of the strip, at each end, into the ends of the groove ensuring that each end of the strip projects 0.010/0.020 in (0,25/0,50 mm) beyond the half housing joint face.
- With the thumb or finger press the remainder of the strip into the groove, working from the centre, then use any convenient round bar to further bed in the strip by rolling and pressing its inner diameter as shown in Fig. H.8. This procedure takes advantage of the friction between the strip and the groove at the ends to compact the rope, whilst ensuring that the projections of the end faces of the rope remain as set.
- Fit the sealing strip to the other half housing in a similar manner.
- Remove all traces of the old joint from the cylinder block rear face and fit a new joint treated with a suitable jointing compound.
- Lightly coat the faces of the housing with a suitable jointing compound.
- Spread a film of graphite grease over the exposed inside diameter surface of the strip.
- Assemble the half housings around the crankshaft rear journal and fasten together by the two setscrews (See Fig. H.3).
- Swivel the complete seal housing on the shaft to bed in the strips, and to establish that the assembly turns on the crankshaft.
- Bolt the seal housing in position on the block and the rear main bearing cap then finally tighten the securing setscrews.

CRANKSHAFT AND MAIN BEARINGS—H.5



Crankshaft Regrinding Data

	0.010 in (0,25 mm)	0.20 in (0,51 mm)
	Undersize	Undersize
	Undersize	2.228/2.2285 in
A1	2.238/2.2385 in	(56,59/56,60 mm)
	(56,85/56,86 mm)	2.2275/2.228 in
A2	2.2375/2.238 in	(56,58/56,59 mm)
	(56,83/56,85 mm)	1.9793/1.9801 in
B	1.9893/1.9901 in	(50,27/50,29 mm)
	(50,53/50,55 mm)	0.030 in (0,76 mm)
C	1.509 in (38,33 mm) maximum	Undersize
D	1.1945 in (30,34 mm) maximum	2.218/2.2185 in
E	1.516 in (38,51 mm) maximum	(56,34/56,35 mm)
R1	0.125/0.141 in (3,17/3,58 mm) all journals	2.2175/2.218 in
R2	0.156/0.172 in (3,96/4,37 mm) all crankpins	(56,32/56,34 mm)
		1.9693/1.9701 in
		(50,02/50,04 mm)

Surface finish of crankpins and journals 16 micro inches (0,4 microns) C.L.A. Maximum.

Surface finish of fillet radii 50 micro inches (1,3 microns)

Magnetic crack detection D.C. Flow — 2 amps A.C. Current — 1000 amps

Limits of taper and out of round for pins and journals :

Taper	0.00035 in	Out of Round	0.0004 in
	(0,009 mm)		(0,010 mm)

Maximum Run-out with crankshaft mounted on the end main journals

Independent readings :

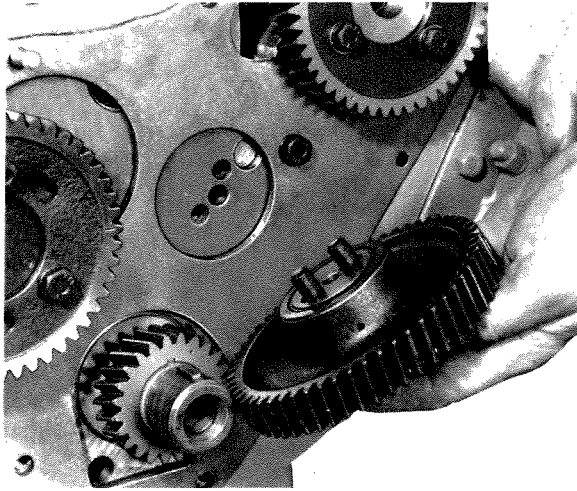
Crankshaft Pulley	Rear Oil Seal	Flywheel Flange
Diameter T.I.R.	Diameter T.I.R.	Diameter T.I.R.
0.002 in (0,05 mm)	0.002 in (0,05 mm)	0.002 in (0,05 mm)
Journals T.I.R.		
Number 1.	Number 2.	Number 3.
Mounting	0.003 in (0,08 mm)	Mounting

—



SECTION J

Timing Case and Drive



J1

Note: There are a few engines fitted with spur gears instead of helical gears shown in this section. These spur gears have a different number of teeth, but fitting and timing is the same as given.

To carry out the following procedure it is assumed that either working space exists with the engine 'in situ' or it is removed from the vehicle or application.

To Remove the Timing Case Cover

1. Slacken the generator mounting bolts, release the adjusting arm setscrew and remove the generator drive belt.
2. Remove the crankshaft pulley retaining setscrew or dognut and withdraw the pulley which is a keyed or splined fit on the crankshaft.
3. Remove the securing setscrews and nuts from the timing case and carefully remove the cover, taking care not to catch the rubber lip of the oil seal on the crankshaft pulley locating key or splines.

To Renew the Crankshaft Front Oil Seal

Oil seals which have a series of windback grooves on the face of the main lip and a shaft direction arrow on the front face of the seal have the oil thrower removed and a spacer fitted in its place. Crankshaft pulleys which have a wear ring use a seal with a larger internal diameter.

1. Using a suitable dolly and press, push the oil seal out through the front of the timing case cover. If a centralising tool is to be used to align a timing gear cover of pressed steel, then the seal should not be fitted until the timing gear cover has been fitted.
2. Locate the new seal in position so that the garter spring faces inwards. Where the timing gear case is of pressed steel, push the seal into the seal housing until it butts against the seal retaining lip, giving local support to the cover as the seal is pressed home. Where the timing gear

case is of aluminium and the seal housing is 19,0 mm (0.75 in) deep there is a production and a service position for the seal. The production position is 6,3 mm (0.248 in) and the service position is 9,3 mm (0.366 in) from the flat front face of the seal to the front of the seal housing. The production position may be used again if there is no wear on the pulley. If the seal has a protruding dust lip ensure that the fitting tool has a suitable recess for the lip.

To Refit the Timing Case Cover

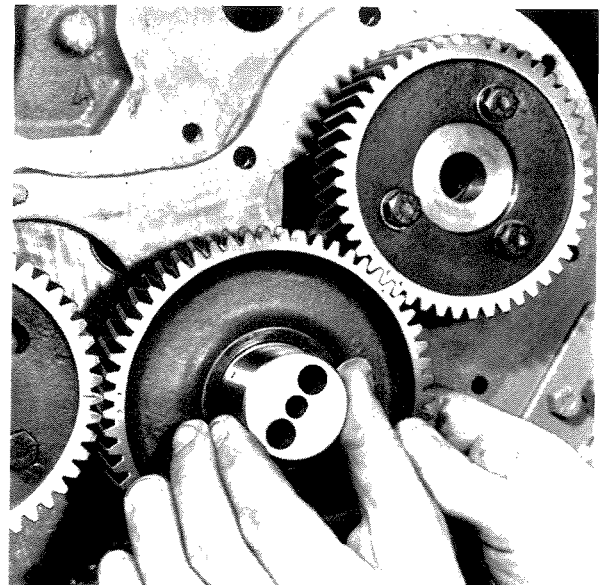
1. Using a new joint, lightly coated with a suitable jointing compound, place the front cover in position taking care not to damage the rubber lip of the oil seal on the crankshaft pulley key.
2. Fit the timing case cover to the timing case back plate by the use of two opposite setscrews loosely tightened. Ensure that the cover is correctly aligned by the use of centralising tool PD.160 on the crankshaft and in the seal housing and lightly tighten the assembly by the crankshaft pulley setscrew and washer. Tighten all the timing case cover setscrews and nuts and remove the tool. If a centralising tool is not available, the crankshaft pulley can be used to align the cover.

Note: Where a centralising tool is used with a pressed steel cover, the crankshaft front oil seal has to be fitted after the cover is fitted.

3. Fit the crankshaft pulley retaining setscrew or dognut and tighten to the torque given on Page B.2.
4. Refit the fan belt and tension as described on Page M.1.

To Remove the Idler Gear and Hub

1. Remove the timing case front cover as previously described in this section.



J2

TIMING CASE AND DRIVE—J.2

2. Tap back the locking tabs and unscrew the two idler hub securing setscrews.
3. The setscrews, idler gear and hub may now be removed together as shown in Fig. J.1.
4. Clean and thoroughly examine the gear and hub for signs of excessive wear, cracks, pitting, etc.

To Refit the Idler Gear and Hub

1. After ensuring that the oilways in the hub and gear are clear, hold the gear in position with the timing marks correctly aligned.

NOTE: If the cylinder head assembly has not been disturbed, then the cylinder head cover and rocker shaft should be removed in order to allow the camshaft to be turned to facilitate the aligning of the timing marks.

2. Insert the hub as shown in Fig. J.2 so that the holes in the hub and the cylinder block are in alignment and secure with the two setscrews.

NOTE: Clearance is provided in the setscrew holes of the idler gear hub, to provide the necessary backlash adjustment for the timing gears. Backlash should be set at the tightest point.

3. Using the adjustable idler gear, backlash between both crankshaft gear/idler gear and camshaft gear/idler gear should be set within the range given on Page B.9 with the gears held together in order to take up the effect of bearing clearance. Backlash may be checked by the use of feeler gauges as shown in Fig. J.3.
4. When the backlash has been correctly set, finally tighten the idler gear hub securing setscrews to the torque given on Page B.2.
5. Check the idler gear end float as shown in Fig. J.4 the limits are given on Page B.9.
6. Lock the idler gear hub securing setscrews with the tabwashers.

NOTE: The timing gears when correctly set should appear as shown in Fig. K.1.

7. Refit the timing case front cover, etc., as previously detailed in this section.

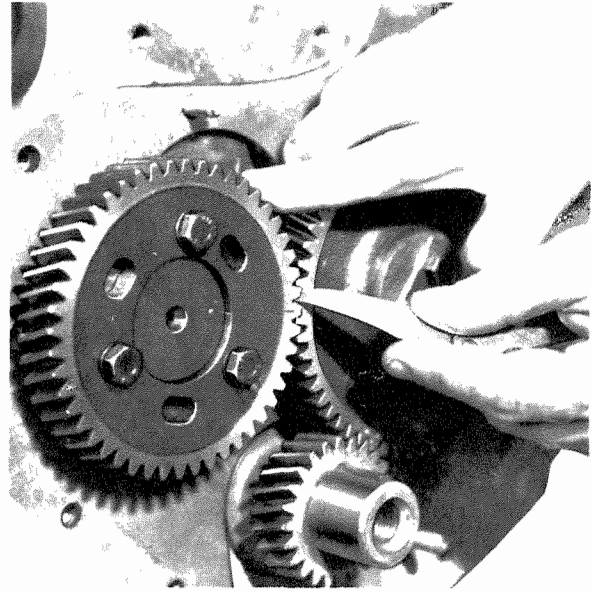
Hydraulic Pump Gears

Where a hydraulic pump is fitted to the timing case, always ensure that a minimum of 0.003 in (0.08 mm) backlash between the gears is established when fitting the pump.

This can be obtained by the fitting of necessary joints, up to a maximum of three, between the timing case and hydraulic pump housing as indicated at "Y" in Fig. J.5.

To Remove the Camshaft Gear

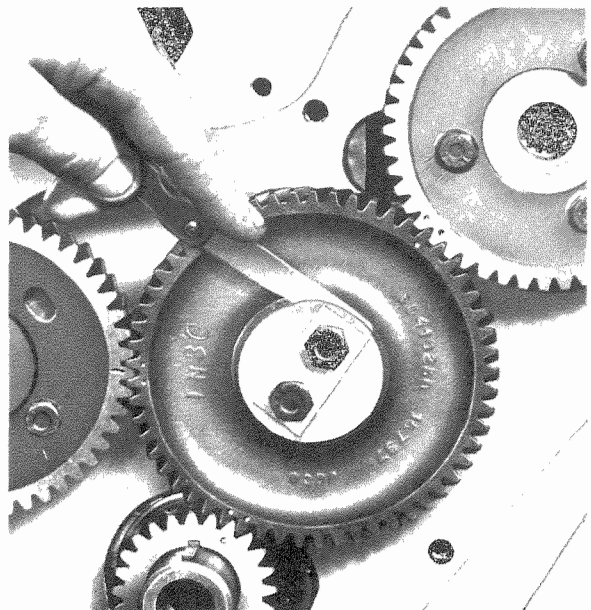
1. Remove the timing case front cover.
2. Remove the three securing setscrews and ease the gear away from its location.
3. Examine the gear for signs of excessive wear, cracks, pitting, etc.



J3

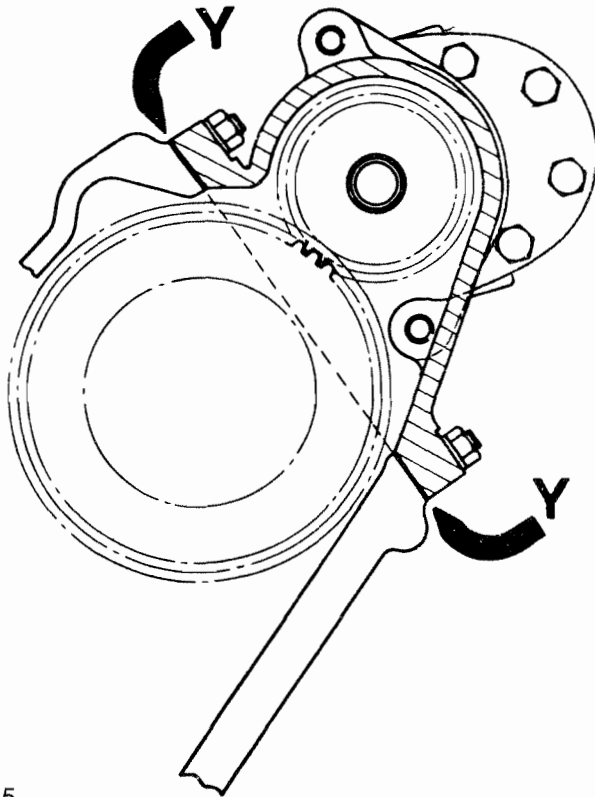
To Refit the Camshaft Gear

1. Remove the idler gear and hub, cylinder head cover and rocker shaft (if not previously removed).
2. Refit the gear to the camshaft ensuring that the 'D' marks on the gear and camshaft hub respectively align as shown in Fig. J.6.
3. Refit the three securing setscrews and tighten to a torque of 19—21 lbf ft (2.6—2.9 kgf m).
NOTE: Only the plain (non-slotted) holes in the camshaft gear are to be used and these will align with the tapped holes on the camshaft hub when the 'D' marks are in alignment.
4. Refit the idler hub and gear, timing case front cover, etc., as previously detailed in this section.

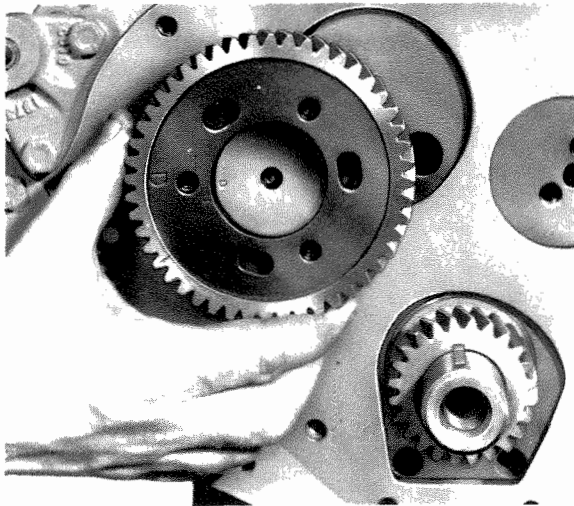


J4

TIMING CASE AND DRIVE—J.3



J5



J6

To Remove the Fuel Pump Gear

1. Remove the timing case front cover.
2. Remove the idler gear and hub.
3. Remove the three securing setscrews and ease the gear from its location on the fuel pump driving hub.
4. Examine the gear for signs of excessive wear, cracks, pitting, etc.

To Refit the Fuel Pump Gear

1. Refit the fuel pump gear so that the timing marks on the gear and hub respectively are in alignment as shown in Fig. J.7.

2. Refit the three securing setscrews, and tighten to a torque of 19—21 lbf ft (2,6—2,9 kgf m).
3. Refit the idler gear and hub, timing case front cover, etc.

To Fit New Fuel Pump Gear

In the event of a new fuel pump gear being required, this will be supplied without timing marks and to ensure correct fitment of the gear and timing of the fuel injection pump, the following procedure should be adopted:—

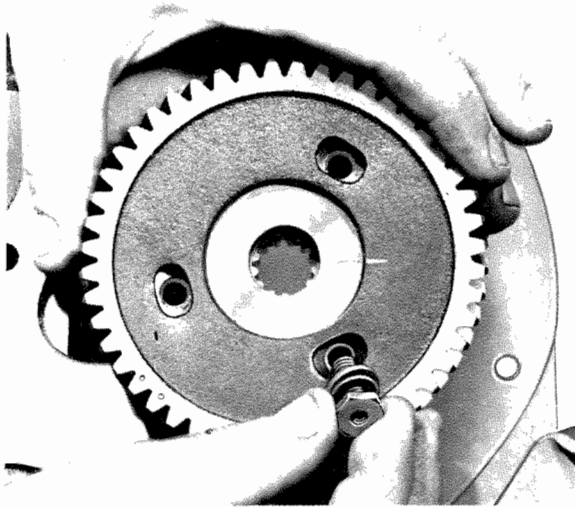
Using Special Tool MS67B (see Fig. N.12)

1. Turn crankshaft until Nos. 1 and 4 pistons are at T.D.C., No. 1 piston being on compression stroke.
2. Remove fuel pump gear.
3. Ensure that the timing marks on crankshaft gear, idler gear and camshaft coincide.
4. Remove fuel pump.
5. Set special tool MS67B to the correct checking angle (see Page B.12).
6. Fit special tool in place of fuel pump and line up the slotted pointer with the timing mark on the fuel pump mounting flange.
7. Fit the new fuel pump gear, holding gear against the direction of rotation to take up backlash. Tighten the retaining setscrews.
8. Mark the new fuel pump gear with a scribed line to coincide with the scribed line on the fuel pump driving hub. Also stamp two dots on the new gear to coincide with the single dot on the idler gear (see Fig. K.1).
9. Check backlash of timing gears and adjust within the limits as detailed on Page J.2.

Where the special tool is not available, the following method should be adopted.

1. Turn crankshaft until Nos. 1 and 4 pistons are at T.D.C., Nos. 1 piston being on compression stroke.
2. Remove fuel pump gear and idler gear.
3. Replace idler gear ensuring that timing marks on crankshaft gear, idler gear and camshaft gear coincide.
4. Turn crankshaft in opposite direction to normal direction for about a quarter of a revolution. Then turn in normal direction until No. 1 piston is at its static timing point (see Page N.7).
5. Remove fuel pump inspection plate (mechanically governed pumps) or plate embodying fuel return connection (hydraulically governed pumps) enabling the fuel pump rotor to be seen.
6. Then turn fuel pump driving hub until scribed line on the rotor marked "A" or "C" (for hydraulically governed and mechanically governed pumps respectively) coincides with the square end of the fuel pump timing circlip.
7. Ensuring timing gears and fuel pump shaft do not move, fit fuel injection pump gear and secure with three setscrews.
8. Turn crankshaft back slightly and then forward again to No. 1 piston on static timing point to check that fuel pump timing is correct.

TIMING CASE AND DRIVE—J.4

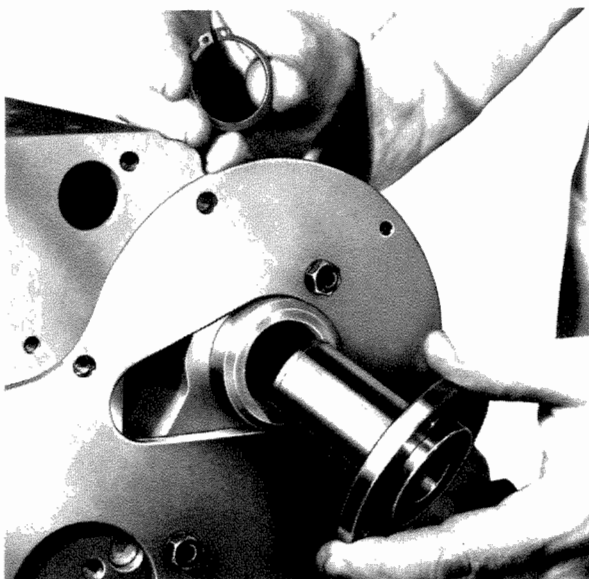


J7

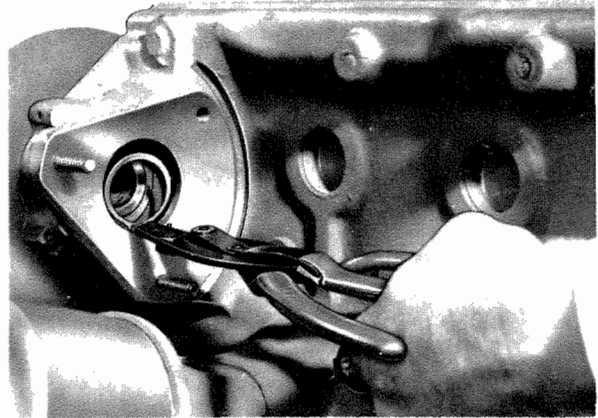
9. Bring crankshaft up to T.D.C. for Nos. 1 and 4 pistons, No. 1 piston being on its compression stroke and mark new fuel pump gear with a scribed line to coincide with the scribed line on the fuel pump driving hub: also stamp two dots on the new gear to coincide with the single dot on the idler gear.
10. When replacing a fuel pump, it will be necessary to adjust the timing gear backlash to within the limits prescribed on Page J.2.

To Remove the Fuel Pump Drive Hub

1. Remove the timing case front cover and fuel pump gear.
2. Remove the low and high pressure fuel pipes from the fuel (injection) pump.
3. Remove the fuel pump securing setscrews and withdraw the pump.
4. Remove the drive hub locating circlip and withdraw the drive hub from its bearing (Refer Fig. J.8).



J8



J9

5. Examine the drive hub also the bearing in which it runs for signs of excessive wear, surface cracks, pitting etc.

NOTE: The bearing is an interference fit in the cylinder block and replacement is carried out by means of a suitable dolly and puller or press if the block is completely stripped, the new one being fitted in the reverse manner.

The earlier bronze service bearing had a 0.010 in (0,25 mm) allowance for machining in situ. The current steel bearing is fitted with 2 pre-finished wrapped bushes.

To Refit the Fuel Pump Drive Hub

1. Replace the drive hub in the bearing and locate with the circlip as shown in Fig. J.9.
2. Check the drive hub end float by means of feeler gauges placed between the front face of the bearing and the rear face of the drive hub. The end float limits are given on Page B.9.
3. Refit the fuel pump as detailed on Page N.6.
4. Refit the low and high pressure fuel pipes to the fuel pump.
5. Refit the fuel pump drive gear, idler gear and hub, timing case front cover etc.

To Remove the Timing Case Back Plate

1. Remove the timing case front cover and timing gears.
2. Remove the fuel pump and drive hub.
3. Remove the securing setscrews and studs (where fitted).
4. Lift the timing case back plate clear from the camshaft and crankshaft gear.

NOTE: The crankshaft gear is an interference fit on the crankshaft. Should its removal become necessary, then this can be accomplished by the use of a suitable puller.

To Refit the Timing Case Back Plate

1. Fit the timing case back plate to the cylinder block using a new joint and suitable jointing compound.
2. Refit any studs removed and secure with the setscrews.
3. Refit the fuel pump drive hub and fuel pump.
4. Refit the timing gears, timing case front cover etc.

To Remove the Camshaft and Tappets

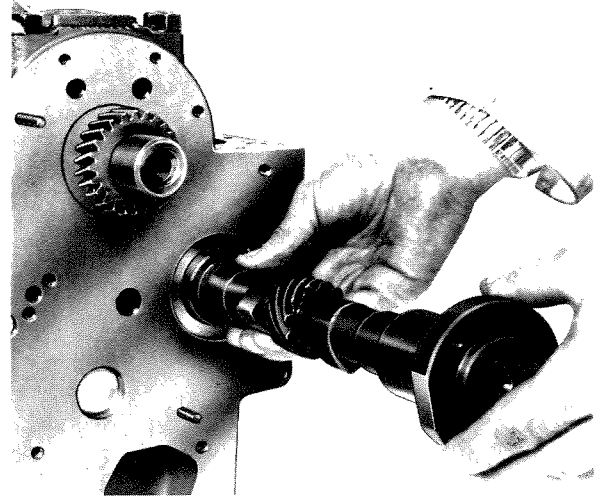
To remove the camshaft it may be necessary to remove the engine from the vehicle or application and place in a suitable dismantling stand where it can be turned upside down. The purpose of this is to prevent the tappets from falling out of their locations when the camshaft is removed. If however, it is not possible to turn the engine over in this manner, then this problem may be overcome by attaching suitable clips (when the tappet inspection cover has been removed) to each tappet to hold them in their locations when the camshaft is withdrawn from the block.

1. Remove the engine from the vehicle or application and mount in a suitable dismantling stand (where available) correct way up.
2. Remove the cylinder head cover, rocker shaft and push rods.
3. Remove the timing case front cover and timing gears.
4. Remove the fuel lift pump, tappet inspection cover and fuel pump operating push rod.
5. Turn the engine over so that the sump is now uppermost.

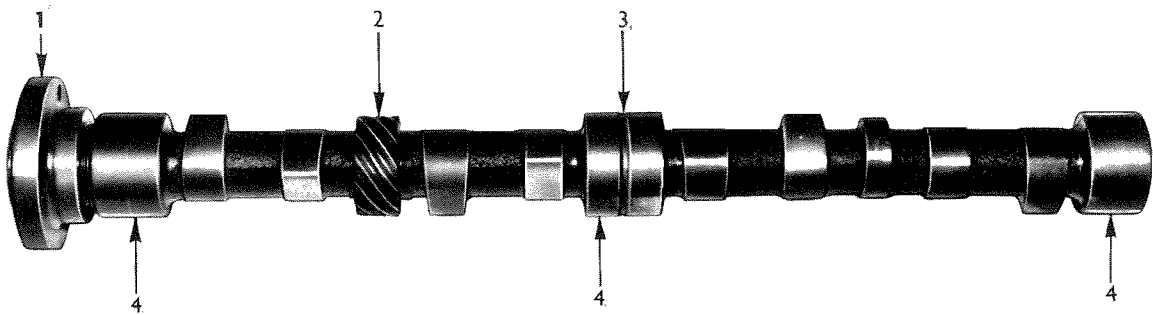
NOTE: At this stage if it is not possible to turn the engine over then the tappets should be lifted to the top of their locations and secure with suitable clips.

6. Remove the sump and lubricating oil pump assembly. (Refer to Page L.1 for details of their removal).
7. Remove the timing cover back plate as previously detailed this will show the camshaft and thrust

8. plates as illustrated in Fig. J.14.
8. Ease the camshaft out from the back and catch the two thrust plates as they come out of their recess in the cylinder block.
9. Withdraw the camshaft as shown in Fig. J.10 taking care to ensure that the cams and journals are not damaged during this operation.
10. The tappets may now be removed by lifting them out of their locations (Refer to Fig. J.12) or by removal of the retaining clips if the engine is still the normal way up.
11. Examine camshaft and tappets for signs of excessive wear, surface cracks, pitting etc.



J10



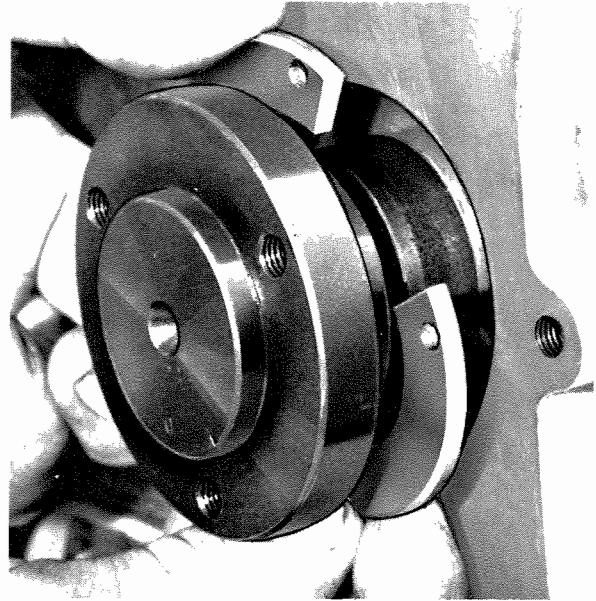
1. Drive Hub
2. Lubricating Oil Pump Drive Gear
3. Groove for reduced oil pressure feed to Rocker Shaft
4. Bearing Journals

J11

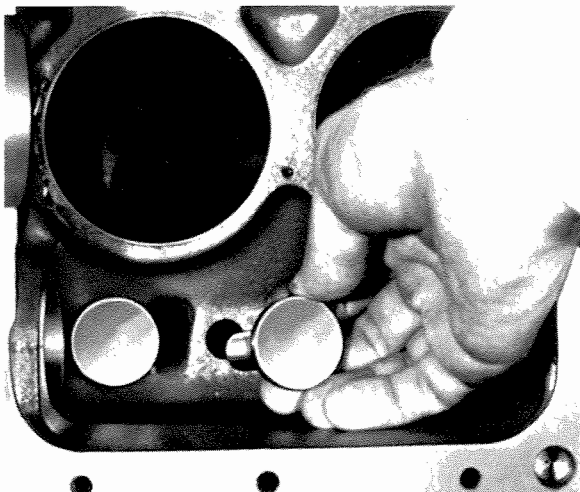
TIMING CASE AND DRIVE—J.6

To Refit the Tappets and Camshaft

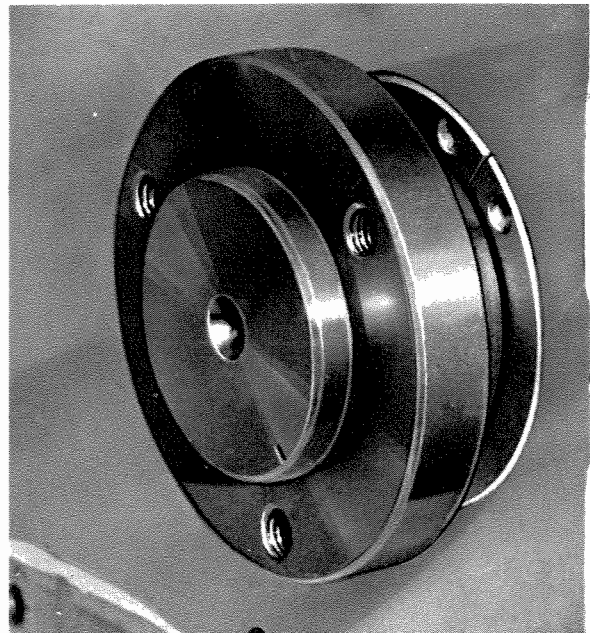
1. If the tappets have been removed liberally lubricate them with clean engine oil and return to their respective locations. Secure with clips (if applicable).
2. Carefully refit the camshaft into the cylinder block exercising the same care as used during its removal.
3. Before the camshaft is pushed fully home locate the two thrust plates (Refer to Fig. J.13) (one of which locates on the dowel in the recess) in position, either side of the camshaft hub, when correctly located the camshaft can be pushed fully home and will appear as in Fig. J.14.
4. Refit the timing case back plate as previously described.
5. Refit the lubricating oil pump assembly and sump as described on Pages L.1 and L.4.
6. Turn the engine over so the cylinder block top face or cylinder head (if fitted) is uppermost.
7. Refit the timing gears, timing case front cover etc., as previously detailed.
8. Refit the fuel lift pump operating push rod (Refer to Fig. J.15), tappet inspection cover, (after removing any retaining clips) and fuel lift pump. Refer to Fig. N.9.
9. Re-assemble the remainder of the engine components in accordance with the instructions given for each in the relevant part of this section.
10. With later engines having a splined crankshaft nose with no master serration, the crankshaft pulley is marked with a centre punch mark which must be aligned with the scribed line on the crankshaft nose (see Fig. J.16).



J13

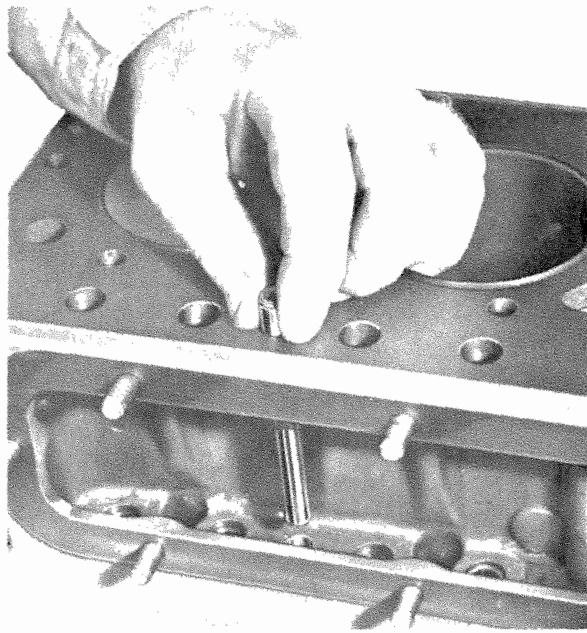


J12

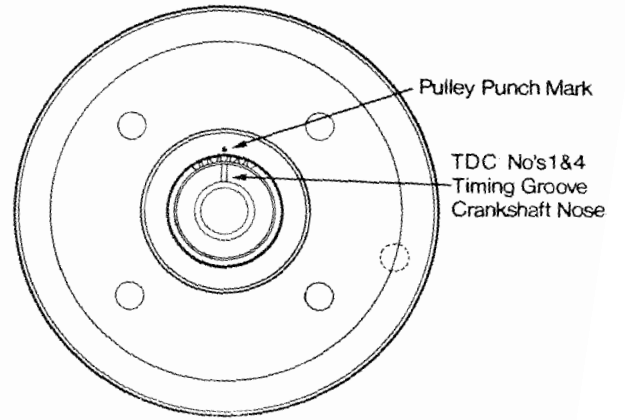


J14

TIMING CASE AND DRIVE—J.7



J15

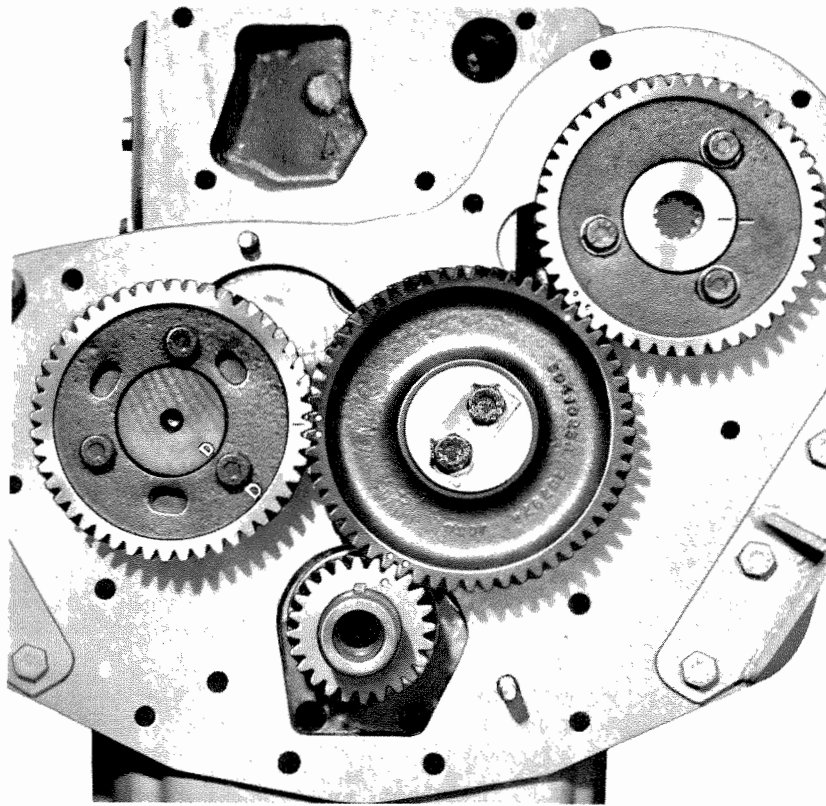


J16



SECTION K

Timing



K1

General

As timing gears are employed, the factory setting remains constant. It is also worth remembering that the removal of the cylinder head in no way effects either the fuel pump or the valve timing.

TIMING MARKS

When the engine is originally timed at the factory, certain marks are stamped on the gears, so that if for any reason the engine timing has to be disturbed, then to reset to the original timing is quite straight forward.

To Reset the Engine to the Original Timing

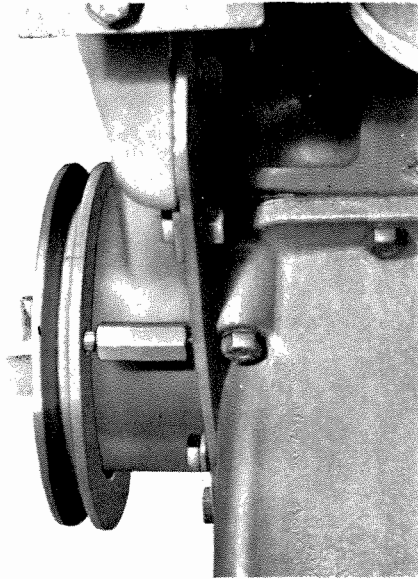
Before commencing the retiming procedure it is assumed that (a) the camshaft, fuel pump and idler gears have all been removed, and (b) the camshaft is free to turn by hand. (If the cylinder head assembly is still in position, it is advisable to remove the atomisers and rocker shaft to facilitate the retiming operations).

1. Turn the engine until the keyway in the front of the

crankshaft is uppermost as shown in Fig. K.1. (This will bring Nos. 1 and 4 pistons to T.D.C.)

2. Fit the camshaft gear to its hub ensuring that the 'D' marks are correctly aligned. (Refer to Fig. J.5). Secure with the three setscrews.
3. Similarly, fit the fuel pump gear to the fuel pump drive hub ensuring that the stamped timing marks align as shown in Fig. J.6. Secure with the three setscrews.
4. Replace the idler gear so that the double dots on the idler gear are matched to the single dot on the crankshaft gear and single line (or dot) on the camshaft gear, whilst the single dot on the idler gear matches with the double dots on the fuel pump gear. These timing marks when correctly positioned will appear as shown in Fig. K.1.
5. Locate the idler gear with the hub and the two securing setscrews using a new tabwasher.
6. Backlash adjustment should be carried out as described under the heading 'To Refit the Idler Gear and Hub. (See Page J.1).

TIMING—K.2



K2

NOTE: When the timing has been reset, great care should be exercised when first turning the engine, for should the timing be incorrectly set, even by only one tooth, there is the possibility that a valve head will strike the piston crown.

TIMING PIN

A timing pin is fitted at the bottom of the timing case cover on the left hand side. When it is unscrewed it locates in a hole machined in the rear face of the crankshaft pulley (as shown in Fig. K.2), when Nos. 1 and 4 pistons are at T.D.C.

With some applications, two holes are provided in the rear face of the crankshaft pulley, i.e., one for the

T.D.C. position and the other for the static fuel pump timing position.

Always return this pin to its normal location immediately T.D.C. has been determined and before any attempt is made to turn or start the engine.

Checking Fuel Pump Timing—See Page N.6

Checking Valve Timing

To check the valve timing proceed as follows:

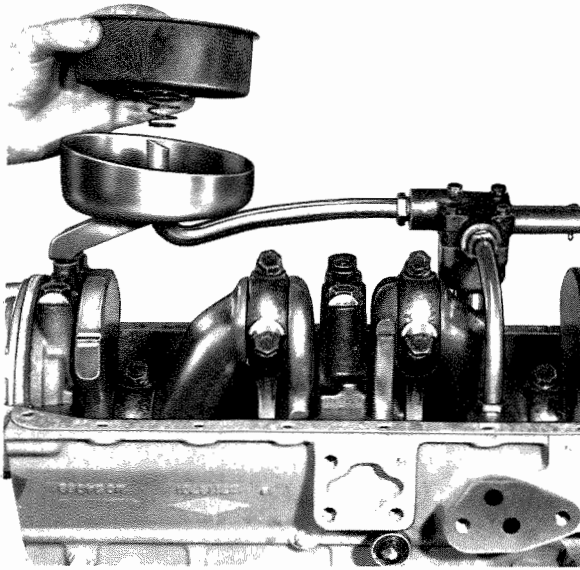
1. Turn the crankshaft until the valves of No. 4 cylinder are 'on overlap'.
2. In this position set the valve clearance of No. 1 inlet valve to 0.039 in (1 mm).
3. Turn the engine slowly in the normal direction of rotation until the clearance No. 1 inlet valve is just taken up. (In this condition it will just be possible to rotate No. 1 inlet valve push rod between the thumb and the forefinger).
4. Nos. 1 and 4 pistons will now be at T.D.C. if the timing has been correctly set.

NOTE: No adjustment is provided for valve timing, should the timing be incorrect and the camshaft gear has been correctly fitted to the camshaft hub, the error will probably be due to incorrect alignment of the original timing marks on the drive gears. Recheck as detailed on Page K.1.

When valve timing is originally set and checked during production a timing tolerance of plus or minus $2\frac{1}{2}$ (flywheel) degrees is allowed for item (4) above. When the timing has been correctly set, do not forget to reset No. 1 inlet valve clearance to the correct figure also to return the timing pin to its correct location if it has been used to check T.D.C.

SECTION L

Lubrication System



L1

The importance of correct and clean lubrication cannot be stressed too highly and all references to engine oil should be taken to mean lubricating oil which falls within the specification given in the appendix. Care should be taken to ensure that the oil chosen is that specified for the climatic conditions under which the engine is operated.

THE LUBRICATING OIL PUMP

The oil pump fits into a machined bore in the cylinder block and is located by means of a screw locked by a tab washer. (Refer to No. 24 "Index to Engine Photographs" for its location).

The oil pump is driven through spiral gears from the camshaft, on the other end of the drive shaft is pressed and pinned a four lobed rotor. This rotor meshes with and drives a five lobed rotor which is free to rotate within the cast iron pump body.

To Remove the Sump

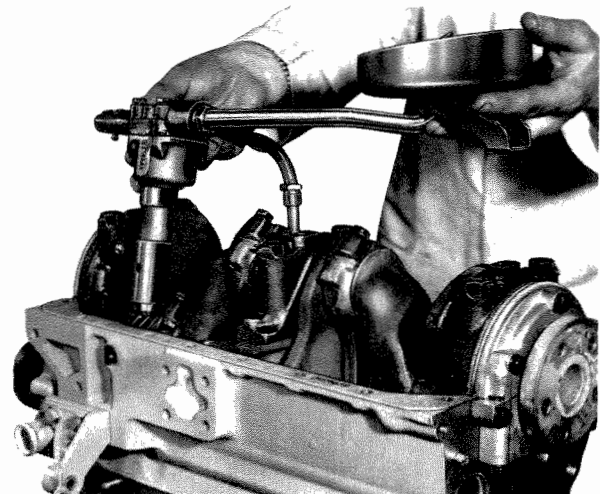
1. Remove the sump drain plug and drain the oil.
2. Remove the dipstick, sump securing setscrews and remove the sump.

To Refit the Sump

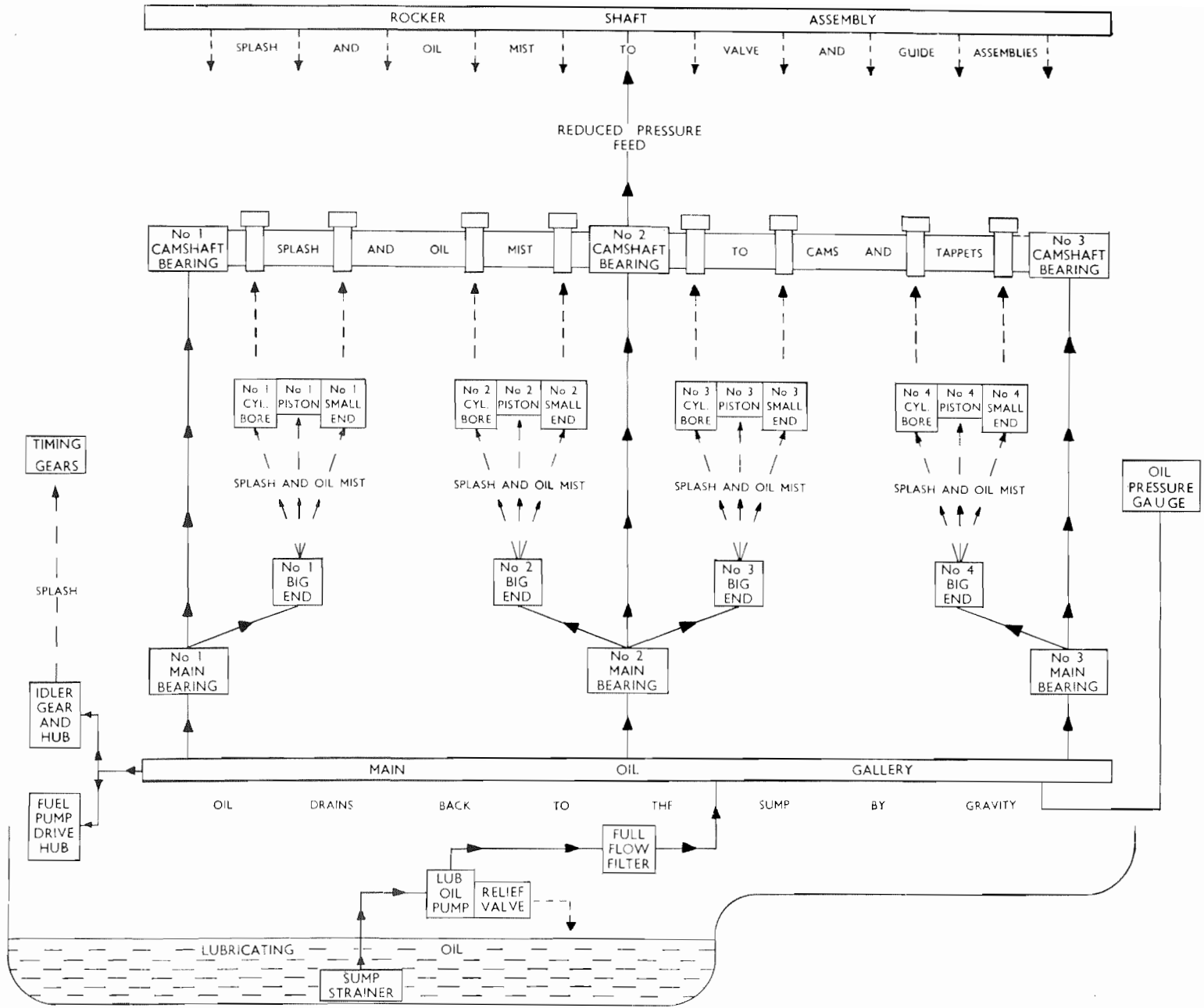
1. Lightly apply a coating of a suitable jointing compound to the crankcase and sump faces, position the joints so that all the holes align.
NOTE: When the joints are being placed in position it is important that the mitred ends go right up into the recesses in the front and rear main bearing caps.
2. Lightly apply a coating of jointing compound to the cork strips, then press these strips into the grooves provided in the main bearing caps.
3. Place the sump in position and fit all the retaining setscrews, tighten evenly.
4. Replace the dipstick and sump drain plug, then refill with clean new oil of an approved grade to the correct level. Do not overfill.

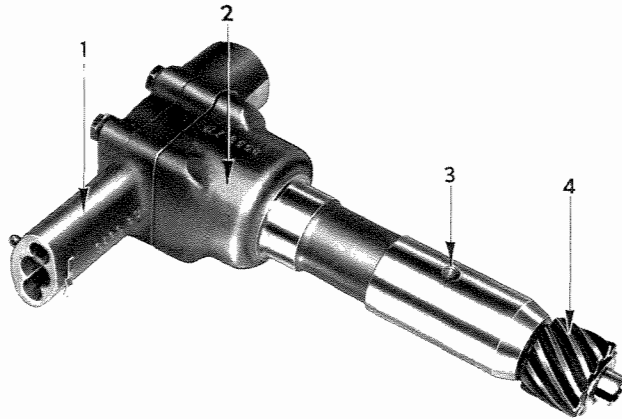
To Remove the Oil Pump

1. Drain the engine oil and remove sump.
2. Remove the strainer from the end of the lubricating oil suction pipe. (Refer to Fig. L.1).
3. Unscrew the delivery pipe securing nut to the cylinder block and the setscrew securing the suction pipe assembly to the rear main bearing cap.



L2





L4

1. Relief Valve Housing
 2. Rotor Housing
 3. Hole for Locating Screw
 4. Pump Drive Gear
4. Tap back the tab washer locking the location screw and support the lubricating oil pump assembly (if the engine is the normal way up), whilst the location screw is removed.
 5. Remove the lubricating oil pump assembly from the cylinder block as shown in Fig. L.2.

To Dismantle the Oil Pump

1. Remove the delivery and suction pipes. The pump will now be as shown in Fig. L.4.
2. Withdraw the drive gear by means of a suitable puller.
3. With the pump suitably held in a vice, (using protective clamps) remove the four securing set-screws and remove the end cover assembly. N.B. This end cover assembly also incorporates the pressure relief valve housing.
4. Withdraw the drive shaft complete with inner rotor. N.B. It is advisable not to remove this inner rotor from the shaft as this item is not available as a separate part (See later note).
5. Withdraw the outer rotor.

Inspection

1. Inspect for signs of wear, cracks, pitting, etc.



L5

2. Install the drive shaft complete with inner rotor, then the outer (driven) rotor ensuring that the face which carries the chamfered edge enters the pump body first (Refer Fig. L.5), now carry out the three following dimensional checks.
 - (a) Check the clearance between the inner and outer rotors. (Refer Fig. L.6).
 - (b) Check the clearance between the outer rotor and the pump body (Refer Fig. L.7).
 - (c) Check the clearance between the rotors and the end cover assembly using a straight edge and feeler gauges (Refer Fig. L.8).



L6

LUBRICATION SYSTEM—L.4



L7

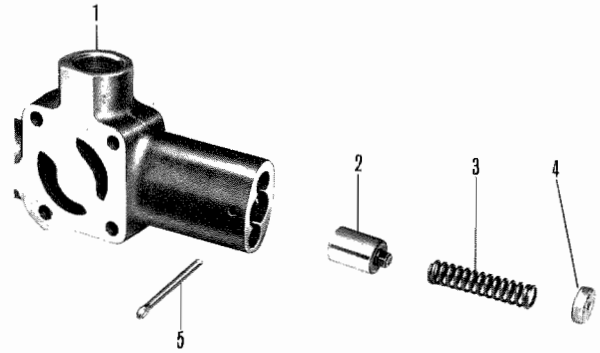
NOTE: The relevant clearances for these dimensional checks are given on Page B.10, they are the clearances applicable to a new pump and are intended to be used as a guide. Should a lubricating oil pump be worn to such an extent that it adversely affects the working oil pressure, then a replacement pump should be obtained.

To Re-Assemble the Oil Pump

1. Insert the outer rotor ensuring that the face which carries the chamfered edge enters the pump body first. (Refer Fig. L.5).



L8



L9

1. Outlet to Main Oil Filter
2. Relief Valve Plunger
3. Plunger Spring
4. Spring Cap
5. Retaining Splitpin

2. Insert the drive shaft complete with inner rotor into the pump body.
3. Replace the end cover assembly and fit the four securing setscrews. Ensure correct positioning so that the suction and delivery pipes will locate correctly.
4. Press the oil pump drive gear onto the shaft.
5. Finally rotate the pump by hand to ensure that it turns quite freely.

To Refit the Oil Pump

1. Prime the lubricating oil pump with clean lubricating oil.
2. Refit the suction and delivery pipes, do not tighten the pipes at this stage.
3. Place the lubricating oil pump assembly in position, locate with the securing screw and lock it with the tab washer.
4. Tighten the delivery pipe at both ends, refit the setscrew securing the suction pipe assembly.
5. Tighten the suction pipe at the pump end then refit the strainer on the end of the suction pipe.
NOTE: The strainer which fits on the end of the suction pipe should be thoroughly cleaned in a suitable cleaning fluid before being refitted. It is good practice to remove this strainer and clean it thoroughly on every occasion when the sump is removed.
6. Replace the sump as previously detailed and secure with the setscrews.
7. Fill the sump to the correct level with clean oil of an approved grade.

NOTE: Caution should be exercised when restarting the engine, as it will take a moment or two for the oil pump and pipes to prime, therefore the engine speed should be kept to a minimum until either gauge shows satisfactory pressure (where fitted) or the oil pressure warning light is extinguished.

The most satisfactory way to prime the lubricating oil system is to motor the engine for approximately 10/20 seconds with the stop control in the "no fuel" position until oil pressure is indicated before any attempt is made to start the engine.

OIL PRESSURE RELIEF VALVE

The oil pressure relief valve is contained in a housing integral with the oil pump end cover, which is secured to the rotor housing by four setscrews. This relief valve controls the maximum oil pressure by allowing a spring loaded plunger to move and by-pass excess oil back to the sump when the pre-determined spring pressure given on page B.10 is exceeded.

To Dismantle the Oil Pressure Relief Valve

1. Drain the engine oil from the sump.
2. Remove the sump securing setscrews and carefully remove the sump.
3. Continue as for removing the oil pump as previously detailed.
4. Remove suction and delivery pipes.
5. Remove the four securing setscrews and remove the end cover assembly.
6. Remove the split pin from the end of the housing and withdraw the spring cap, spring and plunger. An exploded view of the assembly is shown in Fig. L.9.
7. Thoroughly clean the parts, inspect for wear or damage and renew if necessary.

To Re-Assemble the Oil Pressure Relief Valve

1. Replace the plunger, spring and spring cap then secure with the split pin.
2. Secure to the lubricating oil pump body by means of the four setscrews.
3. Continue as detailed for refitting the lubricating oil pump.

OIL PRESSURE

Always ensure that with the engine running, oil pressure is registering on the gauge or the oil pressure warning light is extinguished.

Pressures do vary according to climatic conditions and even between individual engines, but the oil pressure range at normal working speed and temperature is given on Page B.9. The pressure will drop whilst the engine is idling and also a slight drop will be experienced when the oil is hot, this is quite normal. If, however, the oil pressure is suspected of being too high or too low then reference to the possible faults listed under these headings given on Page D.1, may prove helpful.

LUBRICATING OIL FILTERS

To ensure cleanliness of the lubricating oil a sump strainer and a main full flow type of oil filter are fitted. The sump strainer consists of a gauze wire container which is fitted over the end of the lubrication oil pump suction pipe. All oil must pass through this strainer before it reaches the oil pump.

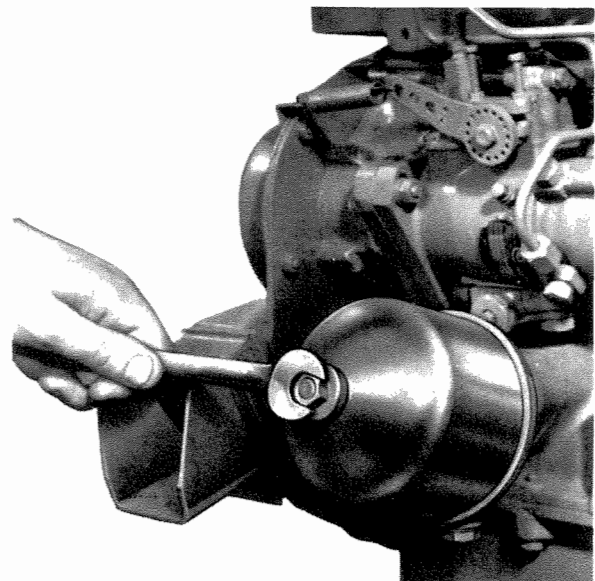
The main full flow type oil filter is mounted externally on the side of the cylinder block. All the oil passes through this filter after it leaves the pump, but before it reaches the bearings.

The full flow filter may incorporate a paper element in a bowl or a screw on canister in which the element is an integral part of the canister. At the appropriate time, as given on Page C.2, the paper element or the canister should be renewed as detailed below.

To Renew the Paper Filter Element

1. Unscrew the filter bowl securing setscrew as shown in Fig. L.10.
2. Withdraw the filter bowl (Fig. L.11), remove the element and discard.
3. Clean the bowl in a suitable cleaning fluid.
4. Renew the sealing ring in the filter head, where necessary.
5. Place the new element centrally in the bowl, position the bowl and element assembly squarely and centrally on the filter head and tighten the bowl securing setscrew.
6. As the filter element will normally be changed at the same time as the engine lubricating oil, refill the sump with oil, run the engine and check for oil leaks. Recheck the oil level after running the engine and top up as necessary.

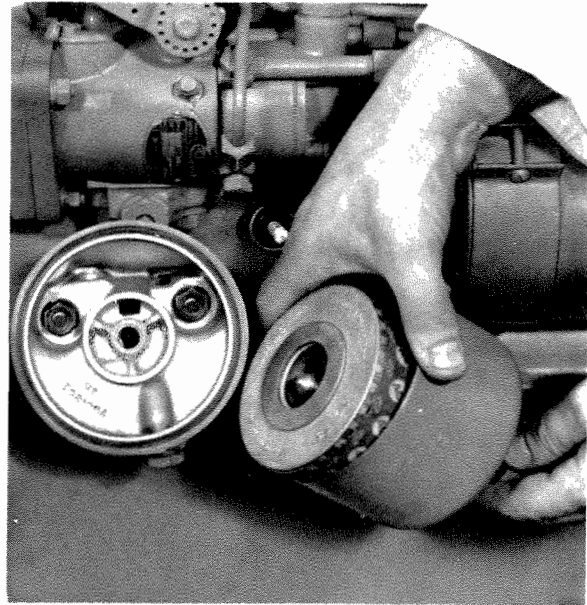
The filter bowl securing setscrew should be checked for tightness after 1000 miles (1500 km) or 24 hours running following a filter element change.



LUBRICATION SYSTEM—L.6

To Renew the Filter Canister

1. Unscrew the canister from the filter head (see Fig. L.12).
2. Check that the threaded adaptor is secure in the filter head and discard the old canister. Clean the filter head.
3. Using clean engine lubricating oil, lightly oil the top seal of the new canister.
4. Prime the canister with lubricating oil allowing time for the oil to filter through the element.
5. Screw the new canister on to the filter head until the canister seal just touches the head and then tighten by hand as detailed in the instructions on the canister. Where a tool is available, tighten to 15 lbf ft (2,07 kgf m).
6. As the filter canister will normally be changed at the same time as the engine lubricating oil, refill the sump with oil, run the engine and check for oil leaks. Recheck the oil level after running the engine and top up as necessary.



L11

Oil Filter Assembly

In some instances the setscrews securing the filter head to the cylinder block are enclosed within the filter head and bowl assembly as shown in Fig. L.11. With this arrangement, the filter bowl has to be removed before the filter head can be detached from the block.

When fitting the filter head joint, ensure that the holes in the joint line up with the corresponding drillings in the cylinder block.

By-Pass Valve

Should the lubricating oil filter element be allowed to become contaminated to the extent where the lubricating oil has difficulty in passing through the element, then a pressure difference will build up between the inlet and outlet sides of the filter assembly. When this pressure reaches the figure given on Page B.10, a ball valve will open in the filter head casting and allow unfiltered oil to by-pass the filter element to prevent the engine being starved of oil.



L12

COOLING SYSTEM—M.2

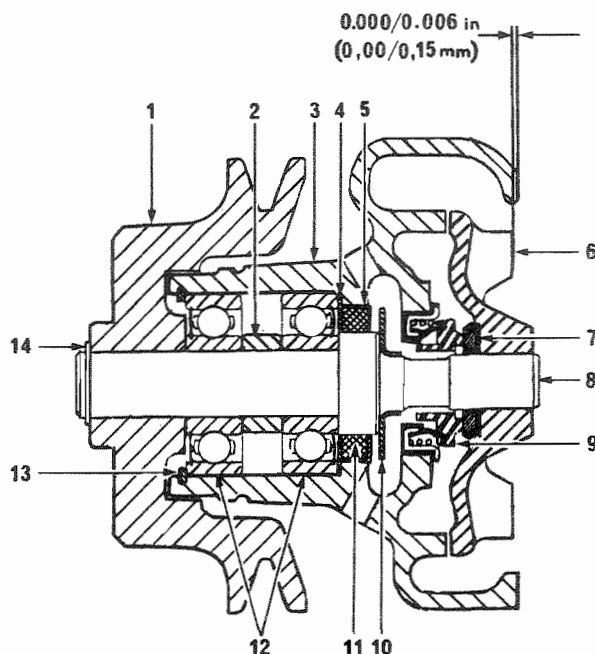


M2

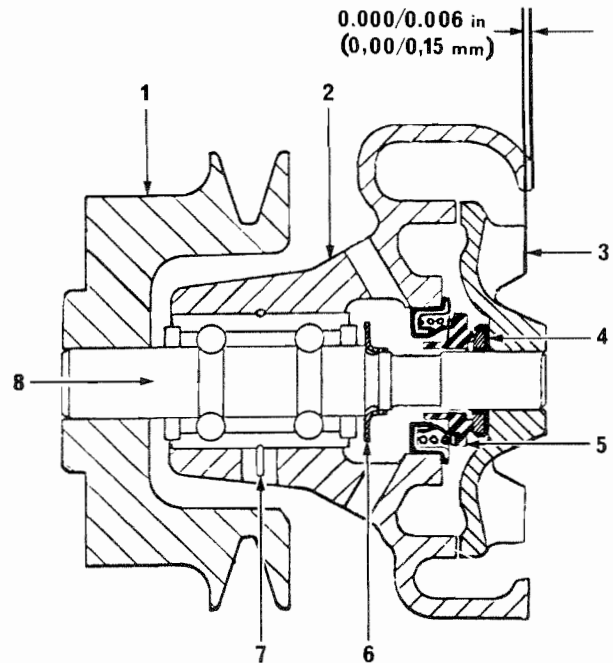
To Dismantle the Separate Bearing Type Pump (Fig. M.3)

NOTE: On later pumps items 4, 5, 10 and 11 are no longer fitted and a longer distance piece has been introduced to accommodate the removal of the seal retaining flange (4).

1. Where necessary remove the pulley circlip (14) and using a suitable puller, remove the pulley (1) as shown in Fig. M.2. Make a note of the position of any pump securing setscrew that has been trapped in its location by the pulley.
2. Using a suitable adaptor that will pass through the



M3



M4

- bearings, press out the shaft (8) through the rear of the pump complete with the impeller (6) counterface (7), seal (9) and thrower (10).
3. Press the impeller from the shaft and remove the counterface, seal and thrower.
 4. Remove the bearing circlip (13) and using a suitable adaptor, press the bearings (12) and distance piece (2) out through the front of the body (3).
 5. Remove the seal retaining flange (4), felt seal (11) and seal retainer (5).

To Dismantle the Combined Bearing and Shaft Type Pump (Fig. M.4)

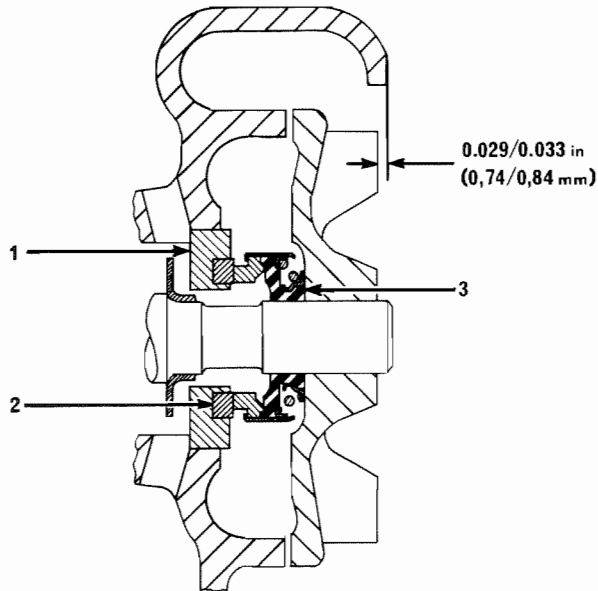
1. Using a suitable puller, remove the pulley (1), as shown in Fig. M.2. Make a note of the position of any pump securing setscrew that has been trapped in its location by the pulley.
2. Remove the clip (7) through the aperture in the pump body (2).
3. Press the bearing and shaft assembly (8) out through the rear of the pump complete with the impeller (3), counterface (4), seal (5) and thrower (6).
4. Press the impeller from the shaft and remove the counterface, seal and thrower.

To Dismantle Earlier Type Pumps (Fig. M.5)

This is the same as for the later types detailed above except that the insert (1) will be pressed out with the shaft and impeller.

Inspection

1. Examine the pump body for cracks, corrosion or any other damage. Check that the seal housing bore is not damaged. Renew where necessary.
2. Examine the shaft and bearing assembly for wear or corrosion. Renew where necessary.
3. Examine the water thrower flange for damage or corrosion. Renew where necessary.



M5

4. Examine the water pump seal, counterface or insert for excessive wear, scoring or cracks on the sealing faces. Renew where necessary.
5. Remove rust and scale from the impeller and examine for excessive corrosion or other damage. Renew where necessary.
6. Examine the pump pulley for signs of cracks, corrosion or any other damage. Renew where necessary.

To Assemble the Separate Bearing Type Pump (Fig. M.3)

NOTE: On later pumps items 4, 5, 10 and 11 are no longer fitted and a longer distance piece has been introduced to accommodate the removal of the seal retaining flange (4).

1. Position the thrower (10) in its compartment in the pump body (3) with the central protrusion of the thrower towards the rear.
2. Insert the seal retainer (5) and position the felt seal (11) and seal retaining flange (4) with the dish of the flange towards the felt seal.
3. Press the bearings (12) and distance piece (2) on to the shaft (8) with the shielded faces of the bearings facing outwards to the front and rear ends of the shaft and three quarters fill the bearings and space between the bearings with high melting point grease.
4. Press the bearings and shaft assembly into the body, ensuring that the shaft passes through the thrower. Fit the retaining circlip (13).
5. Press the thrower into its position on the shaft.
6. Locate any pump securing setscrews that cannot be fitted after the pulley (1) is in position.
7. Press the pulley on to the shaft until it abuts the front bearing and where applicable, fit the pulley circlip (4). When the pulley is fitted during production, a pressure of $2\frac{1}{2}$ — 3 tonf/in² (3,94/4,73 kgf/mm²) is required. If a substantially reduced

pressure will press the pulley on the shaft, a replacement pulley and/or shaft should be fitted.

8. Ensure that the carbon sealing face of the seal (9) is clean and fit the seal squarely in its housing.
9. Check that the sealing face of the counterface (7) is clean and position the counterface, by hand only, with the sealing insert registering with the carbon face of the seal.
10. With the pump resting on the front end of the shaft and the pump body unsupported, press on the impeller (6) until the rear face of the impeller vanes is 0.000/0.006 in (0,00/0,15 mm) below the rear face of the body.

To Assemble the Combined Bearing and Shaft Type Pump (Fig. M.4)

1. Press the bearing and shaft assembly (8) into the pump body (2), with the smaller diameter end towards the rear, until the retaining clip grooves of the bearing and body align. Fit the retaining clip (7).
2. Locate any pump securing setscrews that cannot be fitted after the pulley (1) is in position and press the pulley on to the shaft until the front end of the pulley is flush with the front end of the shaft.
3. Press the thrower (6) into its position on the shaft.
4. Ensure that the carbon face of the seal (5) is clean and fit the seal squarely into its housing.
5. Check that the sealing face of the counterface (4) is clean and position the counterface (4) with the sealing insert registering with the carbon face of the seal.
6. With the pump resting on the front end of the shaft and the pump body unsupported, press on the impeller (3) until the rear face of the impeller vanes is 0.000/0.006in (0,00/0,15 mm) below the rear face of the pump body.

To Assemble Earlier Type Pumps (Fig. M.5)

This is the same procedure as for the later types detailed above except for the following points.

Before assembly, thoroughly clean the insert recess and drain hole in the body with cleaning spirit or Locquic 'Q'.

After fitting the bearings and shaft assembly and the thrower, lightly coat the locating diameter of the insert (1) and the inner diameter of the insert recess with grade 'AVV' Loctite. Ensure that the counterface (2) is clean and press the insert home with the counterface to the rear of the pump. Clean off any surplus Loctite. When pressing in the insert, ensure that the sealing face of the counterface is not damaged. Check that the carbon face of the seal (3) is clean and position the seal with this face registering on the counterface.

With the pump resting on the front end of the shaft and the body unsupported, press on the impeller until the rear face of the impeller vanes is 0.029/0.033 in (0,74/0,84 mm) below the rear face of the pump. On earlier pumps where the seal face registers directly on to the insert with no counterface fitted, the impeller should be pressed on to the shaft until the clearance between the front face of the impeller and the water pump body is 0.005/0.010 in (0,12/0,25 mm). This can be checked by means of a feeler gauge through the outlet channel of the pump body.

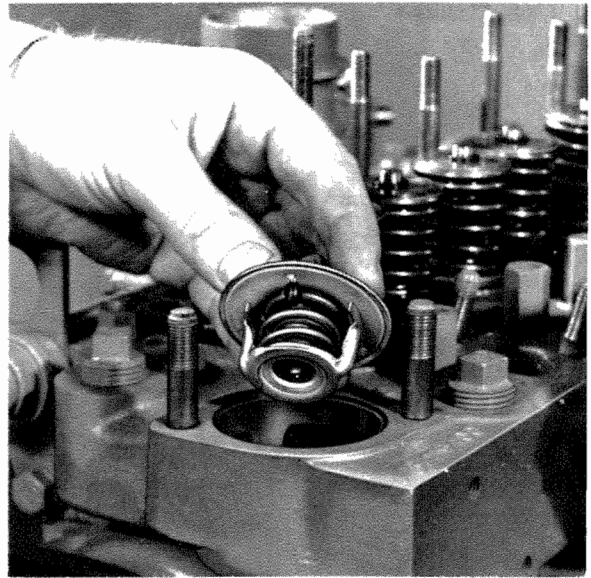
COOLING SYSTEM—M.4

To Refit the Water Pump

1. Fit the backplate followed by the water pump to the cylinder block, using new joints lightly coated with suitable jointing compound.
2. Secure the water pump assembly to the cylinder block with the four setscrews.
3. Refit the fan belt and adjust to the correct tension.
4. Refit the fan using new lockwashers.

Water Pump Seals

Where ceramic counter face water pump seals are fitted, if the engine is run without coolant, even for a few seconds, the heat build-up between the carbon seal and ceramic counter face is very rapid, resulting in the cracking of the ceramic. This often creates the misunderstanding that the cause of leakage is due to the incorrect assembly of the sealing arrangement of the water pump.



M6

THERMOSTAT

To Remove the Thermostat

1. Drain the coolant from the radiator.
2. Remove the water hose from the engine water outlet connection at the front of the cylinder head.
3. Remove the two nuts and washers securing the outlet connection to the thermostat housing.
4. Remove the outlet connection and joint.
5. Lift out the thermostat as shown in Fig. M.6.

be as stamped on the unit by the manufacturers.

3. If the unit does not function properly then a replacement thermostat will be required, as no adjustment of these units is possible.

Certain engine applications have an external bypass which incorporates a thermostat with a bypass blanking valve. This valve closes the bypass port as the thermostat opens directing the coolant through the radiator. (see Fig. M.7). When replacing a thermostat, the correct type must be fitted. Failure to fit the correct thermostat may result in the engine overheating.

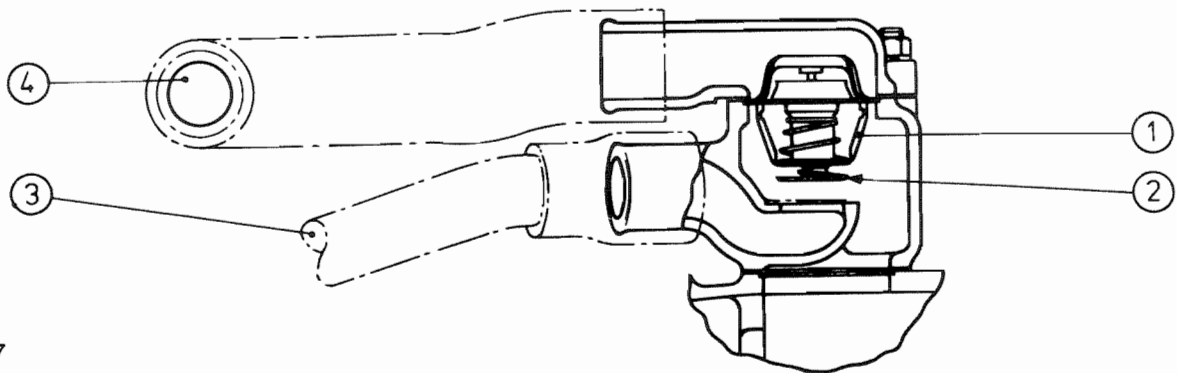
To Test the Thermostat

1. Immerse the thermostat in a suitable container of water and slowly heat. An accurate thermometer should be available to check the temperature of the water as it rises.
2. Note the temperature at which the valve in the unit commences to open. This temperature should

To Replace the Thermostat

Replacing the thermostat is a reversal of the removal procedure. A new joint should be fitted between the thermostat housing and the water outlet connection.

When the radiator has been refilled with coolant, check that no leaks are visible.



M7

1. Thermostat
2. Thermostat Bypass Valve
3. Bypass Outlet
4. Outlet to Radiator

SECTION N

Air Cleaners and Fuel System

AIR CLEANERS

Operating conditions play an important part in deciding how frequently it is necessary to service the air cleaner. If you are working in dusty conditions then the air cleaner should be attended to every day, as indicated under "Preventive Maintenance".

If not already fitted, you should consider the fitting of an 18 in water gauge RESTRICTION INDICATOR in the air trunking between the air cleaner and the engine induction manifold. It indicates by means of a visual signal when the air cleaner element needs servicing. A means of visual signalling for the "Rotopamic" type air cleaner failure is the use of the "DUST SIGHT". A window in this device becomes cloudy when the system has failed; but this type of indicator is usually only used with the two stage extreme heavy duty cleaners.

The type of air cleaner fitted to your vehicle or machine depends upon the manufacturer of your equipment. Usually, guidance for the method of servicing is shown on the body of the air cleaner, but the following advice will also help.

Dry Type Two Stage "Cyclopac" See Fig. N.1

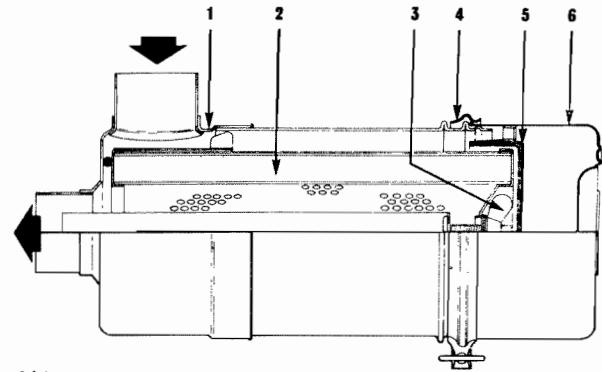
The dust bowl collects the heavier particles which are thrown out by the centrifuge path of the air. This dust enters the bowl by the slot in the baffle plate. The level of dust in the bowl must not be allowed to reach to within half an inch of the slot in the baffle plate.

For cleaning purposes the assembly should be removed from the engine. With horizontal installations the slot in the baffle is located at the top.

Remove the dust bowl by releasing the pinch screwed clamp. Remove the baffle from the interior of the dust cup by lifting it out, which gives access to the dust for removal. The element can be removed by releasing the wing nut.

Renew the element or clean by back flow air pressure no more than 100 lbf/in² or washing in a non foaming detergent as recommended by the air cleaner manufacturers. Allow the element to soak for at least ten minutes and then gently agitate. Rinse the element with clean water and allow to dry. Do not use oven heat.

WARNING: There is a danger that some of the dust remaining in the element after it is washed will be pulled through into the engine if the element is replaced in a wet condition. The reason for this is that the water acts as carrier for the dust.



N1

1. Body Assembly
2. Element Assembly
3. Nut and Gasket Assembly
4. Clamp Assembly
5. Baffle Skirt
6. Cup Assembly

Inspect the element by placing a bright light in its centre. Any pin holes, thin spots or ruptures render the element unfit for further use. This cleaning procedure reduces the effective life of the element.

With all dry type elements, they should be renewed after six cleanings and at least once a year, whichever occurs first.

Never use petrol (gasoline) for cleaning.

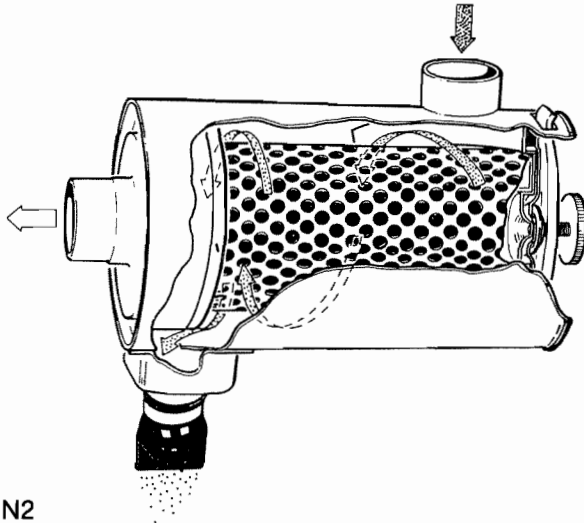
Dry Type Two Stage "Cyclone" See Fig. N.2

The AUTOMATIC DUST EJECTOR should always be kept clean and the lips of the rubber ejector checked to see that they close but do not adhere together.

To service the element, unscrew the clamping screw and remove the element retaining strip. Remove the seal plate (if fitted) and element.

If the element is contaminated by dry dust, clean by carefully tapping by hand or by directing low pressure compressed air on to the clean side of the element. If the element is contaminated by oil or soot, it can be cleaned by washing in a suitable non-foaming detergent. After washing, rinse out thoroughly by directing clean water to clean air side of element and allow to dry — do not oven dry.

AIR CLEANERS AND FUEL SYSTEM—N.2



N2

Inspect cleaned element by placing a bright light inside and looking through element. Any thin spots, pin holes or other damage will render the element unfit for further use.

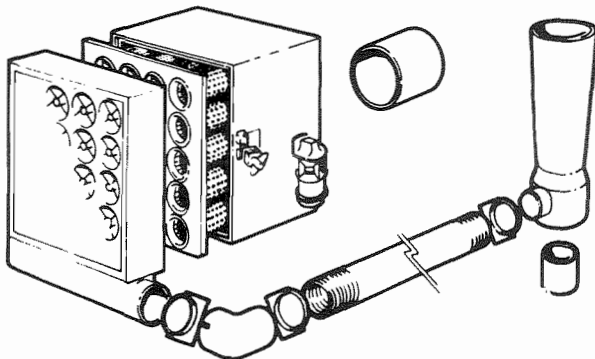
The element should be renewed after six detergent washes or annually, whichever occurs first. Clean the inside of the element body and dry thoroughly. Inspect joints, hoses and clips and renew where necessary.

Re-assemble cleaner ensuring that all joints are leak proof.

Extreme Heavy Duty Two Stage, with Multiple Elements "Rotopamic" — See Fig. N.3

The "Rotopamic" type air cleaner may be fitted where the application is designed to work in heavy concentrations of dust and a restriction indicator must be fitted.

The air cleaner elements are replaceable and no attempt should be made to clean or re-use dirty elements or cartridges.



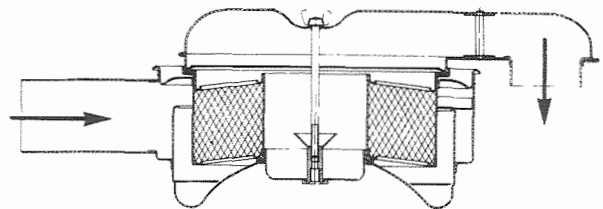
N3

For cartridge replacement, unclamp and remove the moisture eliminator or pre-cleaner panel, pull out the dirty cartridges and insert the new ones. Refit the pre-cleaner.

Never use petrol (gasoline) for cleaning any of the air induction system.

Oil Bath Air Cleaners — See Fig. N.4

To service the oil bath type cleaner, the lid should be removed and the element lifted out. The oil in the container should be drained out and the dirt and sludge thoroughly cleaned out with a proprietary cleaning fluid or Kerosene. Refill the container with clean new engine lubricating oil, to the indicated level. The woven filter element should be cleaned in a bath of Kerosene. Do not use petrol (gasoline) as this highly volatile fuel could cause explosive damage within the engine. The indicated filling mark level should never be exceeded, otherwise oil can be drawn up into the engine which could lead to uncontrolled engine speeds, and excessive engine wear.



N4

The heavy duty oil bath air cleaners are usually fitted with a centrifugal pre-cleaner mounted on top of the main cleaner, this should be removed and the air inlet vanes in the bottom plate of the assembly, the ejection slots on the side of the cone and the vanes in the outlet tube, cleaned of dust and dirt. The detachable element is accessible by lowering the oil container which may be attached by clips or a pinch screwed clamp.

Thoroughly clean the container and refill to the indicated level with new engine lubricating oil. The separate element should be cleaned in a Kerosene bath.

The upper element which is permanently attached inside the body should be periodically cleaned by washing in a Kerosene bath. Drain the element thoroughly before reassembly and do not use petrol (gasoline) for cleaning purposes.

FUEL OIL FILTERS

The element in this filter is of the paper type and therefore no attempt should be made to clean it. Its life will be governed by the quality and condition of the fuel passing through it, but under average conditions the element should be renewed in accordance with the recommended Periodical Attentions given on Page C.2. This period would naturally be reduced if it was apparent from the condition of the element if removed and inspected, that conditions warranted it.

On early engines the filter element is contained inside a filter bowl, (Fig. N5). On later engines the filter element is situated between the filter head and the bottom cover, (Fig. N6).

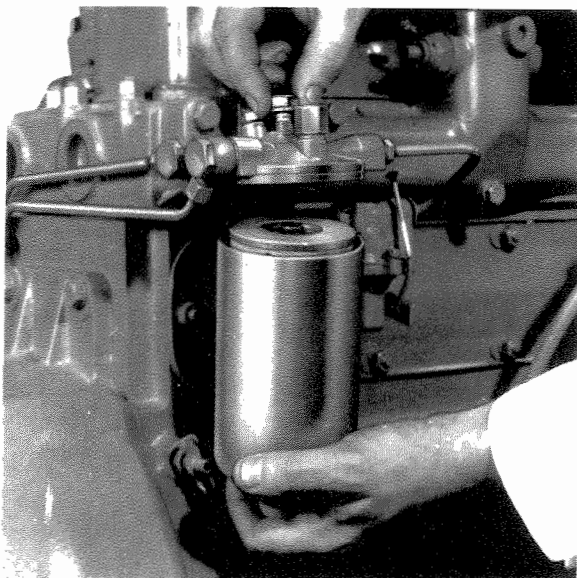
To Renew the Filter Element

1. Clean the outside of the filter.
2. Release the setscrew in the centre of the filter head.
3. Lower the filter bowl, (Fig. N5) or the bottom cover, (Fig. N6) depending on which type of filter is used and discard any fuel together with the used filter element.
4. Clean the inside of the filter head and the inside of the filter bowl or bottom cover.
5. Inspect the seals and renew them if they are damaged.
6. Place the new filter element inside the bowl or put the bottom cover on the bottom of the new filter element. Offer up the filter bowl or element assembly to fit centrally on the seal in the filter head.
7. Hold in this position whilst the securing setscrew is located and tightened. Do not overtighten.
8. Prime the fuel system as detailed in page N.11.

FUEL LIFT PUMP

Testing the Pump in Position

1. Disconnect the outlet pipe (lift pump to filter) leaving a free outlet from the pump.



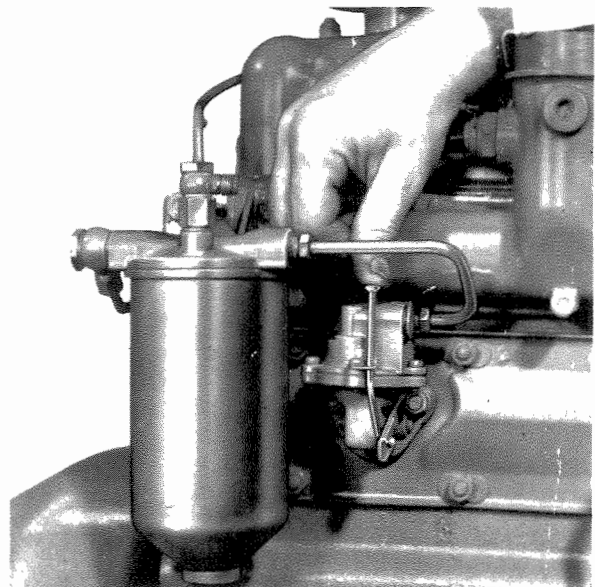
N5



N6

2. Rotate the engine and note if there is a well defined spurt of fuel from the outlet port once every two engine revolutions.

NOTE: As an alternative the pump may be operated by means of the hand primer as shown in Fig. N.7, which should give the same result every time the priming lever is operated. However should the engine happen to have stopped in such a position that the eccentric operating the lift pump is in the maximum lift position, then it will not be possible to operate the hand primer properly. If such a condition arises the remedy is to rotate the engine one complete revolution.



N7

AIR CLEANERS AND FUEL SYSTEM—N.4

Pressure Checking of Fuel Lift Pump in Position

Fit a 0-10 lbf/in² (0-0,7 kgf/cm²) or 0-70 kN/m² pressure gauge to the outlet of the pump. Ensure that there are no leaks at the connections between pump and gauge. Crank the engine for 10 seconds and note the maximum reading on the gauge. If the pressure recorded is less than 75% of the minimum production static pressure shown below, then rectify the pump. Also observe the rate at which the pressure drops to half the maximum figure obtained when cranking has ceased. If less than 30 seconds, rectify the pump.

	Minimum Production Static Pressure		Minimum Test Pressure (75% of Minimum Production Pressure)			
	lbf/in ²	kgf/cm ²	kN/m ²	lbf/in ²	kgf/cm ²	kN/m ²
4 bolt type	6	0,42	41	4,5	0,31	31
2 bolt type	6	0,42	41	4,5	0,31	31

To Remove the Lift Pump

1. Disconnect the pipes from the inlet and outlet ports. Seal the ends of the pipes to prevent the entry of foreign matter.
2. Remove the two nuts and washers holding the pump to the tappet inspection cover. Withdraw the pump, distance piece and joints.

To Dismantle the Lift Pump

1. Before dismantling, make a file mark across the flanges for location purposes when the pump is being re-assembled.
2. Remove the five cover screws and separate the two main castings, then remove the diaphragm assembly from the lower half by turning the diaphragm through 90° in either direction.

NOTE: The diaphragm and pull rod assembly is a permanent assembly and no attempt should be made to separate the parts.

3. Remove the retaining clip from one side of the pump body and push out the rocker arm retaining pin. Withdraw the rocker arm, etc., from the body.
4. Prise out the valves with a screwdriver or other suitable tool.

Inspection

1. Check the diaphragm assembly and renew if the material is split or cracked, or if serious wear is apparent in the link engagement slot.
2. The diaphragm spring should be replaced if faulty or corroded. A new spring should have the same colour identification (Refer to Page B.11).
3. Replace the valves unless they appear to be in perfect condition.

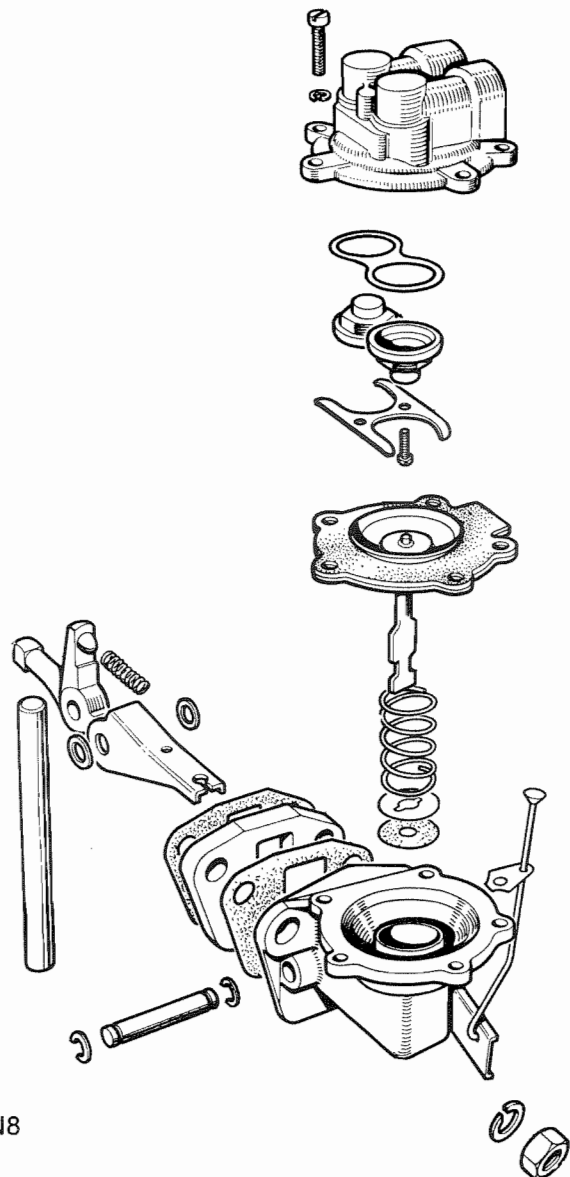
4. Examine the rocker arm, operating lever, rocker arm retaining pin and rocker arm return spring for wear. Replace any parts where necessary.
5. Replace all joints, seals and washers as routine procedure.
6. Examine upper and lower castings for wear or distortion. Slight distortion of flanges can be remedied by grinding the flange face to restore flatness.

To Re-Assemble the Lift Pump

Examine the casting and ensure that there is sufficient material to provide a sound staking when new valves are fitted.

Clean the valves recesses to allow the new valves to be correctly fitted.

1. Insert a new valve gasket in each valve recess.
2. Place the new valves in the recesses. The valve in the inlet port should be fitted with the spring outwards (i.e., towards the diaphragm flange) and



the valve in the outlet port fitted in the reverse position.

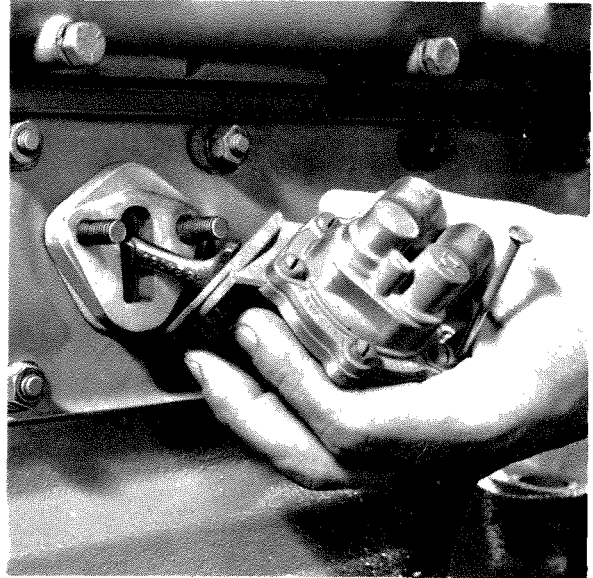
3. Press the valves home with a suitable piece of tubing, approximately 9/16 in (14,29 mm) inside diameter and 3/4 in (19,05 mm) outside diameter.
4. Stake the casting in six places (between the original stakings) round each valve, with a suitable punch.

NOTE: Valves fitted to earlier lift pumps were held in position with a retaining plate and two screws. On no account should attempts be made to stake the valves of this earlier type pump.

5. Place the rocker arm retaining pin in the appropriate hole in the lower casting and push through until it protrudes slightly inside.
6. Fit one packing washer and the link into the casting moving the pin in slightly to retain them.
7. Fit the rocker arm and return spring and retain by moving the pin in further, ensuring that the spring seats correctly.
8. Fit the remaining packing washer, then push the rocker arm retaining pin through the link, washer and casting until the ends protrude equally beyond the outside of the casting.
9. Retain by securing with the two clips.
10. Insert the new rubber sealing washer followed by the steel seating washer and diaphragm return spring.
11. Place the diaphragm assembly over the spring with the pull rod downwards, locating the top of the spring in the diaphragm protector washer.
12. Now position the pull rod so that the flat notched blade has one of its thin edges facing the rocker arm. Press downwards on the diaphragm assembly and twist it through 90° in either direction, this action will engage and retain the pull rod in the fork of the link.
13. Operate the rocker arm against the diaphragm spring pressure until the diaphragm is level with the body flange.
14. Place the cover assembly in position and line up the file marks made on the flanges prior to dismantling.
15. Still holding the diaphragm level with the body flanges, fit the five flange securing screws, tighten evenly and securely.

To Refit the Fuel Lift Pump

1. Fit the distance piece using a joint on either side.
2. Enter the pump operating lever into the recess in the tappet inspection cover as shown on Fig. N.9 and secure with the two nuts and washers.
3. Reconnect the low pressure fuel pipes to the inlet and outlet ports.



N9

FUEL INJECTION PUMP

Description

The fuel injection pump is of the D.P.A. distributor type. It is a precision built unit incorporating a simple hydraulic governor or alternatively one of the mechanical flyweight type depending upon the application to which the engine is fitted.

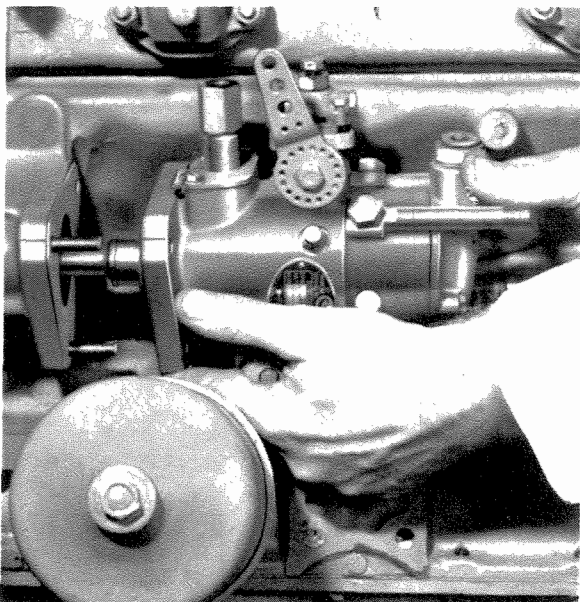
To Remove the Fuel Injection Pump

1. Remove the four high pressure pipes between the pump and the atomisers and blank off all ports to prevent the ingress of foreign particles.
2. Remove the low pressure fuel pipes from the inlet and outlet connections and blank off all ports.
3. Disconnect the stop and throttle controls and their return springs.
4. Remove the two nuts and the socket headed set-screw which secure the fuel pump to the mounting flange together with their spring and plain washers.
5. Carefully withdraw the fuel pump from its mounting.

AIR CLEANERS AND FUEL SYSTEM—N.6

To Refit the Fuel Injection Pump

1. Replace the fuel pump mounting flange joint (where necessary).
2. Offer up the pump as shown in Fig. N.10 ensuring that the master spline on its quill shaft is correctly positioned to engage with the female splines within the fuel pump drive hub.
NOTE: This master spline ensures that the pump will only locate in the drive hub in one position for timing purposes.
3. When the splines are in correct alignment the pump can be pushed in until the mounting flanges meet and the securing nuts and setscrew with their washers can be fitted.
4. Before tightening, align the timing marks scribed on the fuel pump mounting flanges as shown in Fig. N.11. Tighten the setscrew and nuts.
5. Refit the low pressure pipes to the inlet and outlet connections.
6. Refit the high pressure fuel pipes.
7. Reconnect the throttle and stop controls together with their return springs.
8. Prime the fuel system with fuel oil as detailed on Page N.10.
9. Fuel pump timing can be checked as detailed in the following text.

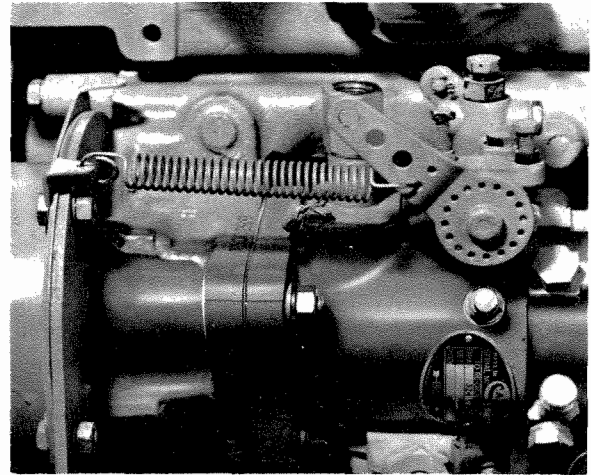


N10

The checking of the scribed line on the fuel pump and drive housing mounting flanges can be checked by means of special tool MS67B (see Fig. N.12) as follows:—

To Check Engine Marking Angle on Fuel Pump Drive Housing

1. Turning engine in normal direction of rotation, position No. 1 piston at T.D.C. compression stroke by means of the timing pin or pointer.
2. Remove fuel injection pump.

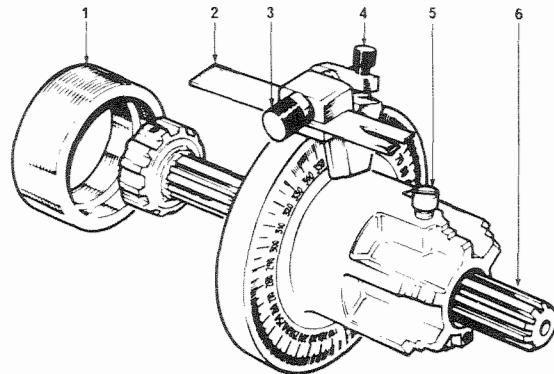


N11

FUEL INJECTION PUMP TIMING

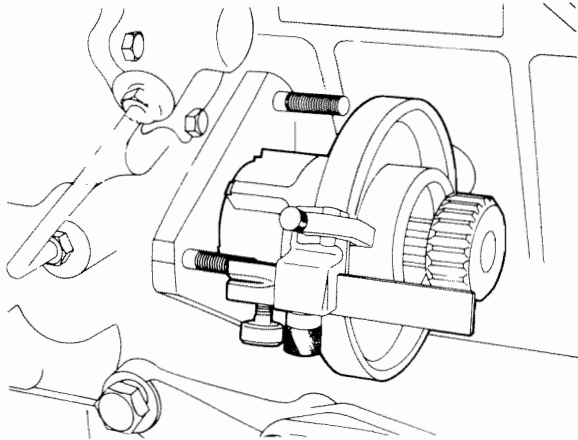
Reference should be made to the details given on Page K.1 covering engine timing. If this timing sequence has been followed regarding the timing gears and the timing marks on the mounting flanges are correctly aligned as shown in Fig. N.11, then the fuel pump timing should be correct.

3. Release screw (5, Fig. N.12) and position splined shaft (6) in tool so that relevant spline is to front of tool.
4. Ensure that slotted pointer (2) is positioned with slot to front of tool and chamfered sides of slot outwards. At this stage, slotted ends of pointer should be kept well back from front of body. Ensure that flat in washer fitted behind pointer securing screw (3) is located over pointer.
5. Release bracket screw (4) and set bracket so that the chamfered edge is in line with the relevant engine checking angle (see Page B.12).



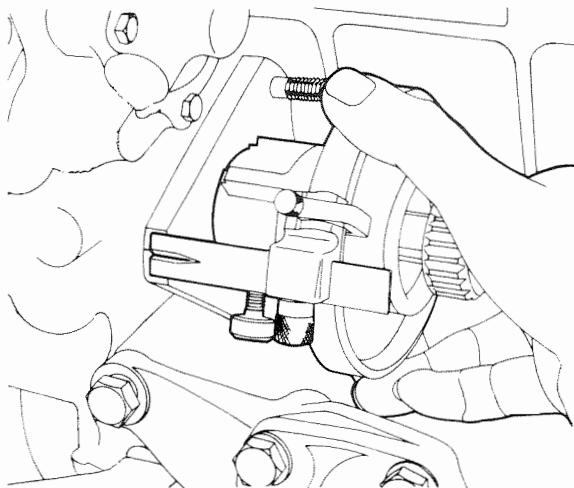
N12

6. Fit timing tool to engine in fuel pump position ensuring firstly that splined shaft with master spline is fully located in pump drive shaft and then that register of tool is seated in fuel pump locating aperture (see Fig. N.13). Lock splined shaft in tool. If pointer is 180° from timing mark, engine is probably on wrong stroke in which case, remove tool and set engine on correct stroke.
7. Slide slotted pointer forward so that slot is half way over mounting flange.



N13

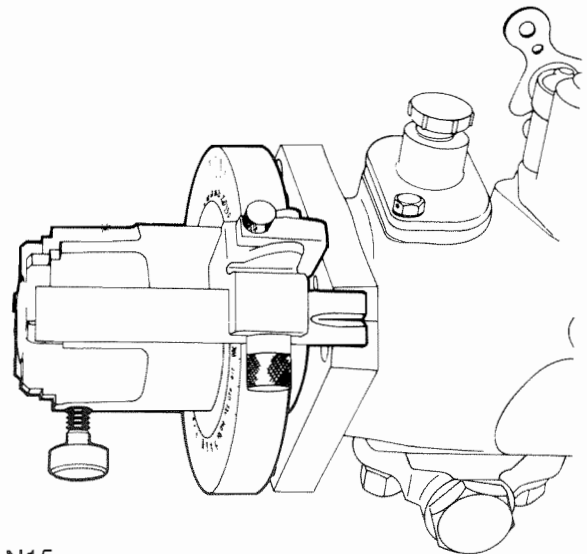
8. Turn timing tool by hand in opposite direction to pump rotation (shown on pump nameplate) to take up backlash and check that timing mark on mounting flange is central in slot of pointer (see Fig. N.14).
9. If timing mark is not central, position of fuel pump drive gear should be altered as detailed on Page J.3 so that the mark is central in slot with backlash taken up.
10. When engine timing is correct, remove tool.
11. Refit fuel pump in engine with timing marks in line.



N14

To check Marking Angle of Fuel Injection Pump

1. Release screw (5, Fig. N.12) and remove splined shaft (6).
2. Ensure that slotted pointer (2) is positioned with slot to rear of tool and chamfered side of slot outwards. At this stage, slotted end of pointer should be kept well back towards body of tool. Ensure that flat in washer fitted behind pointer securing screw (3) is located over side of pointer.
3. Connect No. 1 outlet of pump body to an atomiser test rig and pump up to a maximum pressure of 30 atm (31 kgf/cm²) or 440 lbf/in².
4. Release bracket screw (4) and set bracket so that chamfered edge is in line with relevant marking angle as given on Page B.12.
5. Position timing tool on pump drive shaft with master splines engaged and tool locating on spigot (see Fig. N.15).



N15

6. Turn pump in normal direction of rotation as shown on nameplate until pump locks.
7. In this position, slide pointer forward until it is halfway over pump flange and check that tool timing mark is central to slot in pointer.

Alternative Method where No Tool is Available

A further check is possible and utilises the internal timing marks within the pump body. To be able to see these marks necessitates the removal of the inspection cover.

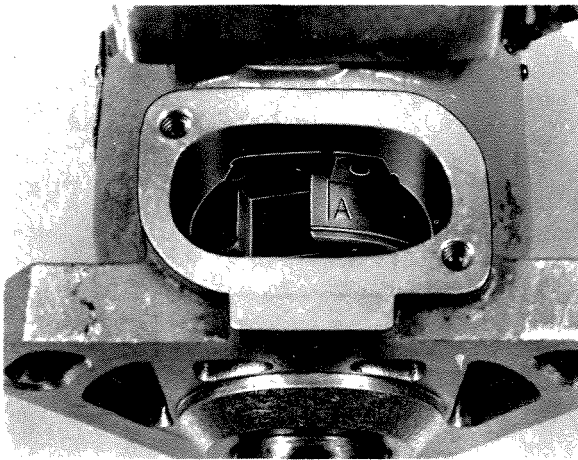
On the fuel pump rotor inside the fuel pump, are a number of scribed lines, each one bearing an individual letter. A timing circlip, one end of which has a straight edge is positioned inside the pump body and has to be preset so that when the appropriate scribed line on the fuel pump rotor aligns with the straight end

AIR CLEANERS AND FUEL SYSTEM—N.8

of the circlip, it denotes commencement of injection (static timing) see Fig. N.16.

To set the timing circlip, it is necessary to remove the pump from the engine and fix the position of the circlip by connecting No. 1 cylinder outlet connection (marked W) to an atomiser tester and pump up to 30 atm (31 kgf/cm²) or 440 lbf/in². Turn the pump by hand in the normal direction of rotation until it "locks up". The squared end of the circlip should now be lined up with the letter A (for hydraulically governed pumps) or C (for mechanically governed pumps) on the pump rotor.

NOTE: On earlier pumps, the timing circlip had a scribed line on one end and on these pumps, the scribed line on the fuel pump rotor should be aligned with the scribed line on the circlip.



N16

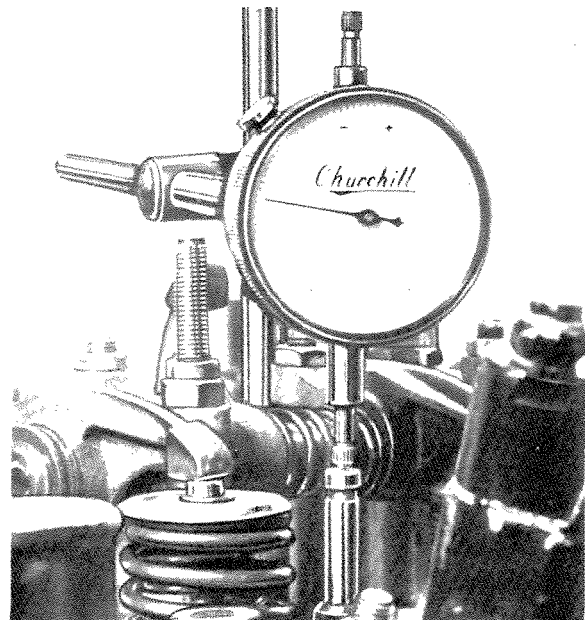
1. Ensure the pump circlip is correctly positioned as previously described and that the fuel pump is correctly fitted to the engine with the scribed line on the mounting flange aligning with the adjacent mounting flange on the cylinder block (see Fig. N.11).
2. Position the crankshaft so that No. 1 piston is at T.D.C. on its compression stroke.
3. Remove the cylinder head cover.
4. Slacken the valve adjusting screw No. 1 exhaust valve sufficiently to allow the rocker lever to be moved to one side and the push rod removed, rotate the rocker lever on the shaft so that the valve spring cap is accessible for using the valve spring compressor.
5. Remove the collets, spring cap and springs from No. 1 exhaust valve and allow the valve to rest on the top of the piston. A suitable ring should be fitted to the valve stem to prevent the valve falling completely into the cylinder.
6. With the aid of a clock gauge in contact with the end of the valve now resting on No. 1 piston, it will be necessary to position the crankshaft so that the piston will be 0.108 in (2.75 mm) B.T.D.C. this being the equivalent of 18° on the engine flywheel. Refer Fig. N.17.

To do this, zero the gauge to piston T.D.C. and then turn the crankshaft in the opposite direction to normal rotation, approximately an eighth of a

turn and then forward until the required position is registered on the clock gauge. This enables the backlash in the timing gears to be taken up.

NOTE: The above setting is for 4.108 vehicle engines. For other applications and engines see Page B.12.

7. Remove the inspection plate on the fuel pump enabling the rotor to be seen. (Fig. N.16).
8. With No. 1 piston at the static timing point on its compression stroke, the scribed line on the rotor marked 'A' (for hydraulically governed engines) or 'C' (for mechanically governed engines) should align with the straight edge or scribed line on the timing circlip.
9. If the timing is incorrect proceed by either:—
 - (a) making any necessary adjustments by means of the holes in the fuel pump gear, they are slotted enabling the drive shaft to be turned relative to the gear when the securing set-screws are slackened. (Refer to Fig. J.6) or
 - (b) by slackening the two nuts and socket headed setscrew which secure the fuel pump to the mounting flange and turning the pump body in the direction required.
10. When the fuel pump timing has been set, turn the engine against the normal direction of rotation once again to the appropriate piston displacement to check that the squared end of the circlip is now aligned with the line on the rotor.
11. When the fuel pump timing has been correctly set, slowly turn the engine to T.D.C. in the normal direction of rotation, remove the clock gauge and refit the valve springs.
12. Refit the push rod and reset the valve clearance.



N17

**Maximum Speed Setting
(Refer to Figs. N.18 and N.19)**

The maximum speed screw (5) is set and sealed by the manufacturers and must not be altered or tampered with in any way, unless factory authority is first obtained and any adjustments necessary are carried out by experienced personnel. As with all seals on the pump unauthorised removal may render the guarantee void.

The maximum no load speed may vary according to the vehicle or application to which it is fitted, reference may be made to the code number stamped on the fuel pump data plate. The last four numbers in the code indicate the maximum no load engine speed, therefore in the case of the following example it would be 4480 rev/min. Code Example EH39/1200/0/4480.

NOTE: If the fuel pump data plate is damaged or defaced so as to make it impossible to read accurately, or if there is no code stamped on the plate you are advised to contact your nearest C.A.V. Distributor, or alternatively, Service Department, Perkins Engines Ltd., Peterborough, to obtain the required information.

NOTE: The engine must not be allowed to operate at a speed in excess of that specified or severe damage may occur.

IDLING SPEED ADJUSTMENT

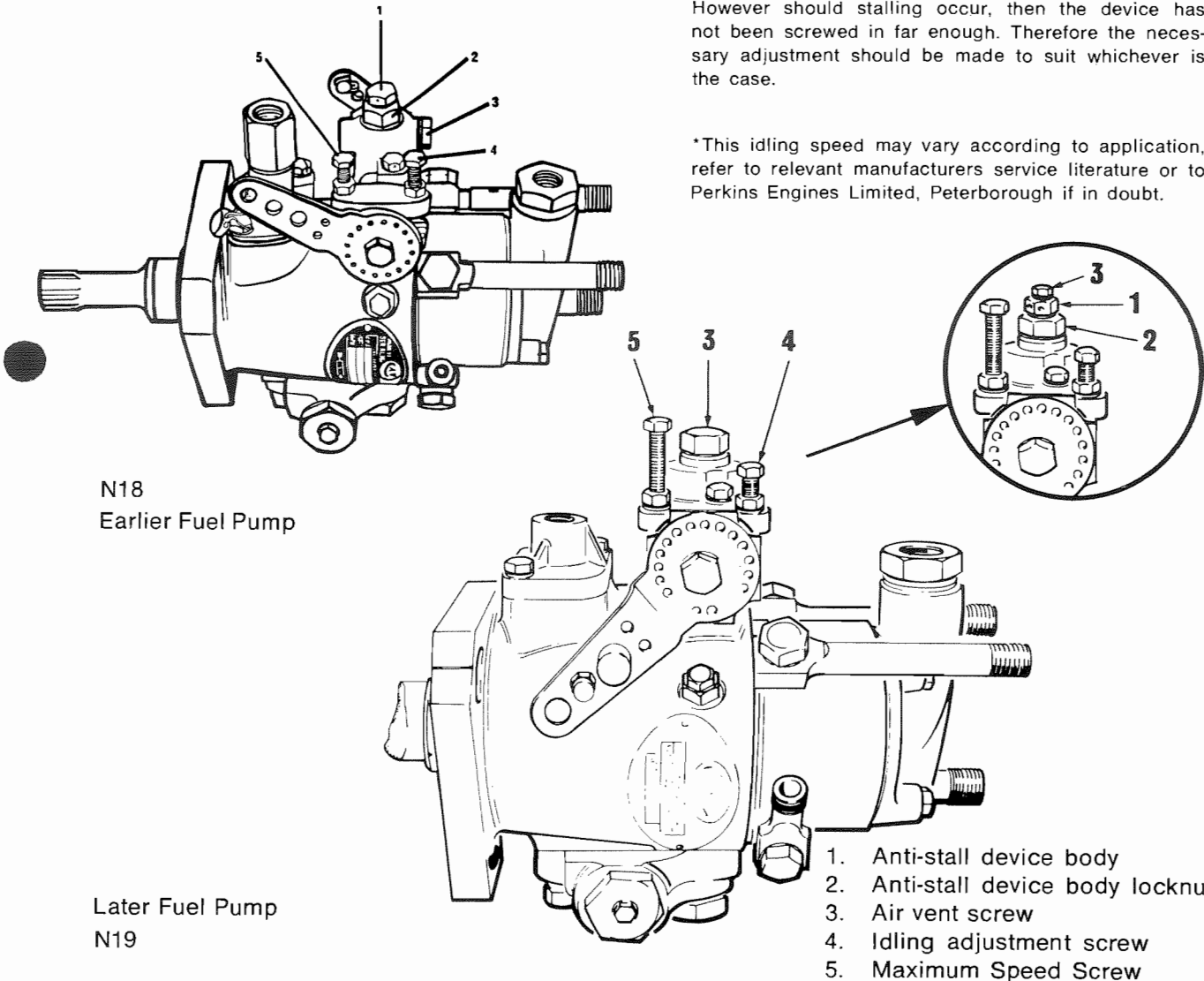
This adjustment is carried out by means of the idling adjustments screw (4), it is carried out in conjunction with the setting of the anti-stall device with the engine warmed through as detailed in the following text.

**Anti-Stall Device
(Refer to Figs. N.18 and N.19)**

- (a) Slacken the locknut (2) sufficiently to enable the anti-stall device body (1) to be unscrewed two complete turns.
- (b) Adjust idling speed to 625 rev/min* with the idling adjustment screw (4).
- (c) Now screw down the anti-stall device body (1) until there is a very slight increase in engine speed, bring back half a turn and lock with the lock nut (2).
- (d) Accelerate the engine to maximum no load rev/min and immediately return to idling. Should the period of return from maximum rev/min to idling exceed three seconds the device has been screwed in too far.

However should stalling occur, then the device has not been screwed in far enough. Therefore the necessary adjustment should be made to suit whichever is the case.

*This idling speed may vary according to application, refer to relevant manufacturers service literature or to Perkins Engines Limited, Peterborough if in doubt.



N18
Earlier Fuel Pump

Later Fuel Pump
N19

1. Anti-stall device body
2. Anti-stall device body locknut
3. Air vent screw
4. Idling adjustment screw
5. Maximum Speed Screw

AIR CLEANERS AND FUEL SYSTEM—N.10

ATOMISERS

General

When replacing atomisers in the cylinder head, it is essential that a new, correct type copper washer is fitted between the nozzle body and cylinder head.

The correct torque for the atomiser securing nuts is 12 lbf ft (1,7 kgf m) or 16 Nm.

The first symptoms of atomiser trouble usually come under one or more of the following headings:—

1. Misfiring.
2. Knocking in one (or more) cylinders.
3. Engine overheating.
4. Loss of power.
5. Smoky exhaust (black).
6. Increased fuel consumption.

Testing for Faulty Atomiser

If an atomiser is suspected of being faulty, try this method to isolate it.

Slacken the union nut at the atomiser end of the high pressure fuel pipe. If each atomiser is isolated in turn in this way, (with the engine running at approximately 1.000 rev/min) tightening each union nut firmly before proceeding to the next, then the faulty atomiser, when isolated in this manner, will have little or no effect on the running.

Warning

Great care should be taken to prevent the hands or face from getting into contact with the spray, as the working pressure will cause the oil to penetrate the skin with ease.

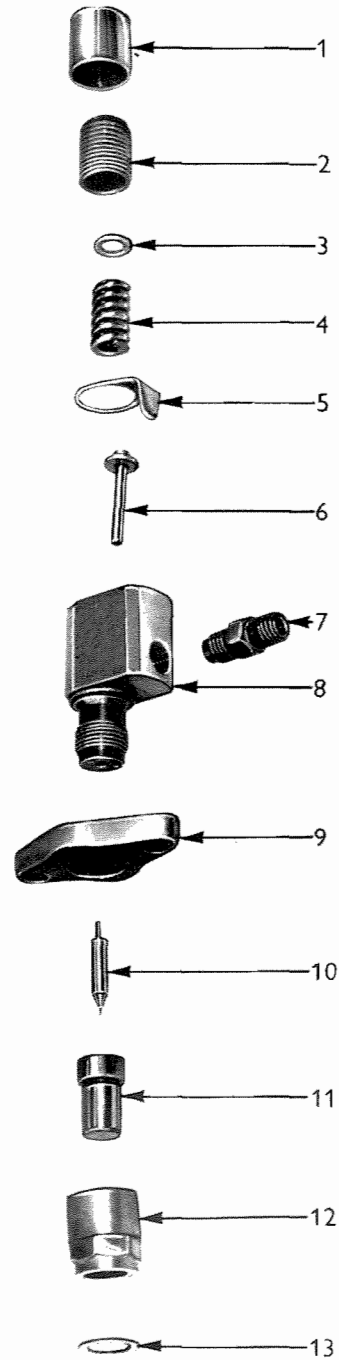
Atomiser Pressures

Details of holders and nozzle types together with pressure settings are given on Page B.12.

NO ATTEMPT SHOULD BE MADE TO ADJUST THE INJECTION PRESSURE WITHOUT AN ATOMISER TESTING PUMP. IT IS QUITE IMPOSSIBLE TO ADJUST THE SETTING OF ATOMISERS WITH ANY DEGREE OF ACCURACY WITHOUT PROPER EQUIPMENT.

Atomiser Identification

Atomisers can be identified by code letters stamped on a tab washer fitted under the spring cap nut (see Fig. N.20) or alternatively, the code is stamped on the atomiser body. Details of codings can be found on Page B.12.



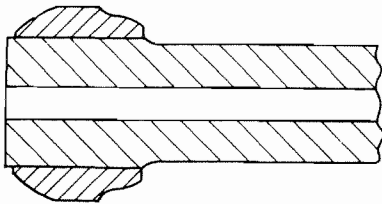
1. Capnut
2. Spring cap
3. Shim washer
4. Nozzle spring
5. Identification tab washer
6. Spindle
7. Fuel inlet union
8. Nozzle holder body
9. Securing flange
10. Nozzle needle
11. Nozzle body
12. Nozzle capnut
13. Copper sealing washer

N20

Fuel Pipes (High Pressure)

When replacing the fuel pipes it should be noted that no two pipes are the same, each is formed to suit an individual atomiser position. This is important when ordering a replacement pipe, as each one has a different part number.

High pressure fuel pipes are now supplied with formed ends instead of olives. The earlier pipes supplied with olives were fitted as shown in Fig. N.21. Originally the olives were fitted in the reverse position, but both positions are satisfactory if undamaged.



N21

The pipes should be clean, (wash in clean fuel oil and blow through the fine bore with compressed air if there is any doubt), the olives at each end should not be split or unduly compressed, otherwise leakage will result and a new pipe will be needed.

Ensure when fitting, that the pipe fits squarely at both ends and that the union nuts are tightened firmly but not over-tightened.

The correct tightening torque for high pressure fuel pipe nuts is 15 lbf ft (2,1 kgf m) or 20 Nm.

When changing an atomiser always remove the pipe completely.

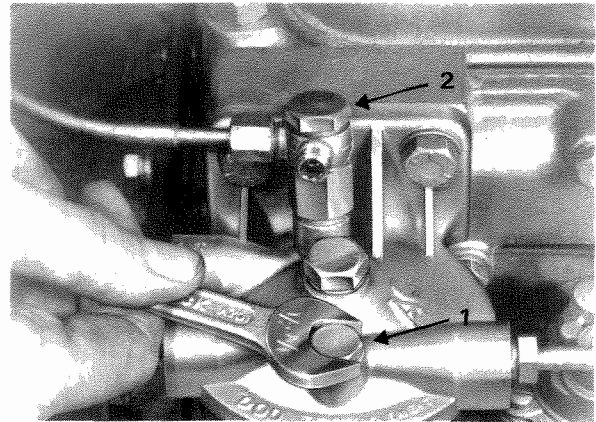
Priming the Fuel System

The air must be vented from the fuel system whenever any part of the system between the fuel tank and injection pump has been disconnected for any reason, or when the system has been emptied of fuel.

No attempt must be made to start the engine until the injection pump has been filled and primed as serious damage can be caused to the pump due to lack of lubrication.

The method of priming detailed below, ensures that only fuel which has passed through the paper filter element can reach the interior of the pump.

1. Loosen the vent screw (1, Fig. N22) on top of the filter. Where a vent screw is not fitted, loosen the return to tank banjo bolt (2) on top of the filter.
2. Operate the priming lever on the fuel lift pump (see Fig. N7) and when fuel, free of air, flows from the vent or banjo connection, tighten the vent screw or banjo bolt. If the drive cam of the fuel lift pump is at maximum lift it will not be possible to operate the lift pump and the crankshaft must be turned through one revolution.



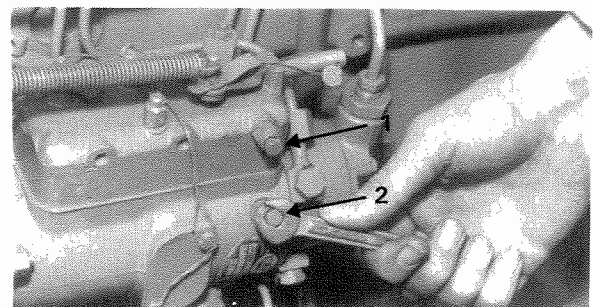
N22

3. Ensure that the stop control is in the 'run' position. if an electric solenoid stop control is used, turn the key of the start switch to the 'R' position. Set the throttle to fully open.
4. Loosen the vent screw on top of the control gear housing, on hydraulically governed fuel pumps (see Fig. N19) or on the rear of the governor housing on mechanically governed fuel pumps, (1, Fig. N23). Loosen the vent screw in the locking bolt of the hydraulic head, (2, Fig. N23), for both types of fuel pump.

Operate the priming lever on the fuel lift pump until fuel, free of air, flows from the vents. Tighten the vent screw in the locking bolt of the hydraulic head and then the vent screw on the governor housing or control gear housing.

5. Where a Thermostart cold starting aid is fitted and the fuel pipe has been drained, loosen the pipe connection at the starting aid. Operate the priming lever of the lift pump until fuel, free of air, flows from the connection and tighten the connection.
6. Loosen the high pressure pipe connections at two of the atomisers. Ensure that the manual stop control, if fitted, is in the run position. Operate the starter motor until fuel, free of air, comes from the pipe connections, tighten the high pressure pipe connections. The engine is now ready to start.

If after priming the fuel system, the engine starts, runs satisfactorily for a few minutes and then loses power, misfires or stops and when checked the system is found to be full of air, then a leak on the suction side is indicated.



N23



SECTION P

Flywheel and Flywheel Housing

To Remove the Flywheel

1. Remove the gearbox, clutch assembly and any linkage as detailed in the service literature applicable to the particular vehicle or application.
2. Knock back the locking tabs from the flywheel securing setscrews.
3. Remove the securing setscrews and carefully remove the flywheel from the crankshaft flange.

To Renew the Flywheel Ring Gear

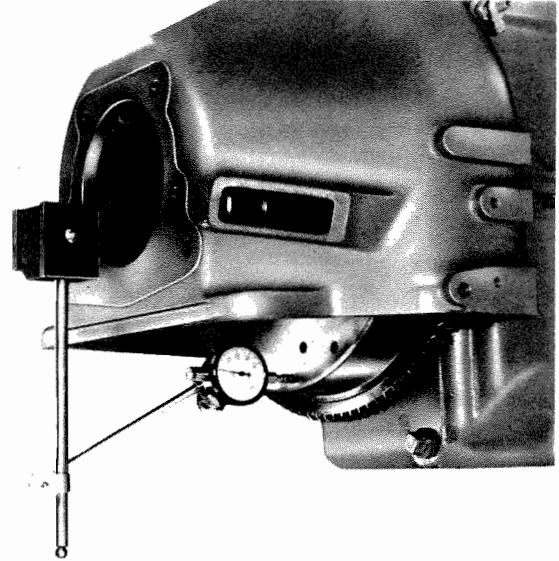
1. The flywheel ring gear is a shrunk fit on the flywheel, its removal is carried out by partially cutting through the gear and chisel cutting it from the flywheel. An alternative method is to apply localised heat to the ring gear to expand it sufficiently to enable it to be tapped evenly from the flywheel.
2. The locating faces of the flywheel should be thoroughly cleaned to ensure a positive location when the new ring gear is fitted.
3. Clean, then heat the new ring gear to a temperature not exceeding 480°F (250°C).
4. Fit the ring gear over the flywheel with the lead on the teeth facing uppermost, i.e., facing away from the engine when the flywheel is fitted. Rotate the gear quickly on its location immediately it is fitted to ensure it is laying flat, then allow to cool.

To Refit the Flywheel

It is most essential to ensure that the crankshaft flange face and periphery are perfectly clean and free from burrs, similarly the mating face of the flywheel itself before refitting of the flywheel is attempted. Failure to ensure this may make it impossible to fit the flywheel satisfactory within the various limits quoted hereafter. It will be noted that there is a sixth (untapped) hole in the crankshaft flange which will be at B.D.C. when Nos. 1 and 4 pistons are at T.D.C.

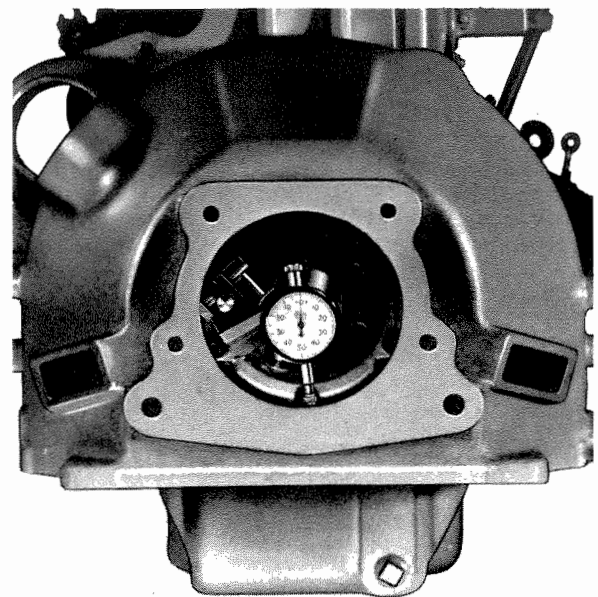
The flywheel can only be fitted in one position due to the irregular spacing of the setscrew holes.

1. It is advisable to screw a short stud into the crankshaft flange just finger tight, so that when the flywheel is offered up this stud can take the weight of the flywheel whilst the securing setscrews are fitted, this stud can then be removed and replaced by the fifth setscrew.
2. Tighten the securing setscrews to the torque given on Page B.2 but do not lock with the tab washers at this stage.



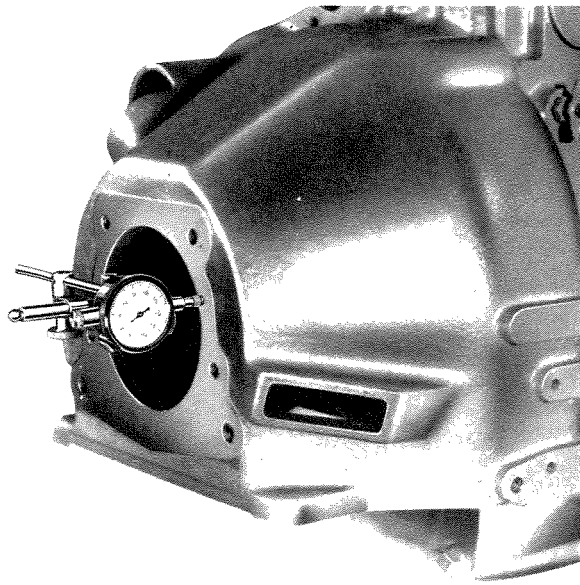
P1

3. Set up a dial test indicator (clock) gauge with the base secured against the rear face of the flywheel housing and the gauge stylus at right angles to the periphery of the flywheel. Turn the crankshaft and check the run out, the flywheel should run truly within 0.012 in (0,30 mm) total indicator reading



P2

FLYWHEEL AND FLYWHEEL HOUSING—P.2



P3

4. Check the alignment of the flywheel face by positioning the gauge as shown in Fig. P.1. Turn the crankshaft and the total indicator reading for the flywheel being truly at right angles to the crankshaft axis should not exceed 0.001 in (0,025 mm) for every inch (25 mm) the gauge stylus is reading from the centre of the flywheel, i.e. if the flywheel has a diameter of approx. 20 in (500 mm) then the stylus will be approx. 10 in (250 mm) from its centre, therefore the total indicator reading should not exceed 0.010 in (0,25 mm).
5. When the flywheel is correctly aligned, lock the securing setscrews with the tabwashers.

To Remove the Flywheel Housing

1. Remove the flywheel (Refer to previous text).
2. Remove the starter motor.
3. Unscrew the securing setscrews and carefully tap the housing clear of the locating dowels.

4. Carefully examine the housing for any signs of cracks, fretting or other damage.

To Refit the Flywheel Housing

1. Ensure that the rear face of the cylinder block and the mating face of the flywheel housing are perfectly clean and free from burrs, etc.
2. Locate the flywheel housing carefully on the two dowels and refit the securing setscrews.
3. Mount a dial test indicator (clock) gauge with the base on the crankshaft flange and the gauge stylus on and perpendicular with the inner face of the housing aperture as shown in Fig. P.2. Rotate the crankshaft, the inner bore should be truly central with the crankshaft within the limits listed towards the end of this section.
4. With the gauge base still mounted in the same position adjust the stylus so that it is at right angles to the vertically machined rear face of the flywheel housing as shown in Fig. P.3. Turn the crankshaft and check that this face is at right angles to the crankshaft axis to within the following limits.
Check dowel location in block and housing, ream and fit oversize dowels where necessary.

Diameter of Housing Bore	Max. Allowance (total indicator reading)
Up to 14 $\frac{1}{4}$ in (362 mm)	0.006 in (0,15 mm)
14 $\frac{1}{4}$ to 20 $\frac{1}{8}$ in (362 to 511 mm)	0.008 in (0,20 mm)
20 $\frac{1}{8}$ to 25 $\frac{1}{2}$ in (511 to 648 mm)	0.010 in (0,25 mm)
25 $\frac{1}{2}$ to 31 in (648 to 787 mm)	0.012 in (0,30 mm)

NOTE: Any adjustments which may be necessary to bring the flywheel housing within the limits quoted must be carried out on the housing, under no circumstances may the rear face of the cylinder block be interfered with.

5. When the housing is correctly aligned finally tighten the securing setscrews.
6. Refit the flywheel as previously discribed on Page P.1.

SECTION Q

Electrical Equipment

ALTERNATOR

Models AC5, 11AC, 15ACR and 17 ACR

1. Precautions

The diodes in the alternator function as one-way valves and the transistors in the regulator/control box operate as fast switches. Both are accurate and sensitive.

They do not wear out and seldom require adjustment, but because they are sensitive to voltage changes and high temperature, the following precautions are vital to prevent them from being destroyed.

- (a) DO NOT disconnect the battery whilst the engine is running. This will cause a voltage surge in the alternator charging system that will immediately ruin the diodes or transistors.
- (b) DO NOT disconnect a lead without first stopping the engine and turning all electrical switches to the off position.
- (c) DO NOT cause a short circuit by connecting leads to incorrect terminals. Always identify a lead to its correct terminal. A short circuit or wrong connection giving reverse polarity will immediately and permanently ruin transistors or diodes.
- (d) DO NOT connect a battery into the system without checking for correct polarity and voltage.
- (e) DO NOT "flash" connections to check for current flow. No matter how brief the contact the transistors may be ruined.

2. Maintenance

The alternator charging system will normally require very little attention, but it should be kept free from build-up of dirt, and a check made if it fails to keep the battery charged.

- (a) Regularly inspect the driving belts for wear and correct tension. It is important to ensure that all belts on a multiple belt drive have equal tension and are each carrying their share of the load. Slack belts will wear rapidly and cause slip which will not drive the alternator at the required speed. Drive belts which are too tight impose severe side thrust on the alternator bearings and shorten their life. Periodically ensure that the alternator is correctly aligned to the drive.
- (b) Do not replace faulty belts individually in a multi-belt system. A complete matched set of drive belts must always be used.
- (c) Keep the alternator clean with a cloth moistened in kerosene or cleaning fluids. Ensure that ventilation slots and air spaces are clear and unobstructed.

- (d) Remove any dirt accumulated on the regulator/control box housing, and ensure that cooling air can pass freely over the casing.

3. Fault Finding on AC5

The AC 5 alternator is so designed that a flow of current indicated either by the extinguishing of the warning light, or as shown on the ammeter, is sufficient evidence that the system is in proper working order. Therefore, no open circuit, voltage or current output checks should be performed in the installation UNLESS:—

- (a) The warning light fails to illuminate when the generator is stationary, and the switch is closed OR fails to become extinguished when the alternator is running.
- (b) No charging current is shown on ammeter.
- (c) The battery is flat.
- (d) The battery is "boiling", indicating loss of voltage control.

If any of the above symptoms occur, the procedure indicated below should be followed.

- (a) Connect a good quality moving coil voltmeter 0—50 volts range across the battery or regulator negative terminal, and one of the three positive terminals marked LO, MED, HI. Disconnect alternator output terminal. Fit a good quality moving coil 0 — 100 amp ammeter in series with the alternator terminal and output lead. **The battery should be in a charged condition.**
- (b) Close the warning light switch (master electric switch on dashboard) when the warning lamp should light up.
- (c) Switch on a 10—15 amperes load such as lights, etc. for fifteen minutes.
- (d) Start engine and run at fast idle speed with fans, etc. for fifteen minutes.
 1. The warning light should go out.
 2. The ammeter records a small charge dependant on engine speed.
- (e) Increase engine speed momentarily to maximum speed, when the charging current should be about 30 Amperes for 24 Volt, and 53 Amperes for 12 volt systems.
- (f) With the alternator running at approximately half speed, (engine speed about 1,500 rev/min) switch off electrical load. Depending on the connection selected for the positive sensing wire LO, MED or HI, the voltage should rise to between 26 and 28 volts on 24 volt systems and 13—14 volts on 12 volt systems and then remain constant. At the same time the current reading should drop appreciably.

ELECTRICAL EQUIPMENT—Q.2

Any variance in the above data could indicate a fault and the following procedure should be adopted before disconnecting any components.

The regulator is a sealed unit and is non-repairable and if found to be faulty it must be replaced.

Warning Lamp does not light when switched "On".

Check the bulb.

If no fault

Check all wiring connections at regulator, alternator and battery.

If no fault

Switch off, disconnect 'F' lead at regulator and connect it to the negative terminal.

Switch on. If warning lamp lights up, the regulator is faulty. If lamp fails to light up, the alternator is faulty.

Warning Lamp does not go out and Ammeter shows no output when running.

Check all regulator, alternator and battery connections.

If no fault

Switch off, disconnect 'F' lead at regulator and connect to regulator negative terminal.

Switch on, and run at fast idle.

If no output, alternator is faulty.

If output appears, regulator is faulty.

Warning Lamp does not go out when running and Ammeter shows reduced output with full output only at maximum speed or Warning Lamp goes out but Alternator delivers reduced output. Full output only at maximum speed.

Alternator faulty. Remove from installation and apply open circuit diode check.

Warning Lamp flashes intermittently and Ammeter needle oscillates when Battery is fully charged and no loads are switched in.

Check for excessive resistance in regulator negative sensing lead.

If no fault, regulator is faulty.

Batteries overcharging and Ammeter indicates high or full output all the time.

Check regulator positive sensing lead and its connection at regulator.

If no fault, regulator is faulty.

4. Fault Finding on 11 AC

If the alternator does not produce its rated output of 43 amperes for 12 volt and 23 amperes for 24 volt circuit, the failure may be due to any unit or the associated wiring, and the following procedure should be followed.

TEST 1

Checking the Field Isolating Relay

Disconnect the earthed battery terminal and the cable from the alternator main output terminal. Connect a 0—60 DC ammeter between the terminal and disconnected cable. Link terminals 'C1' and 'C2' on the field relay. Reconnect the battery cable. Close the master switch and start engine and run at charging speed. If ammeter shows a charge the relay is faulty, or its wiring and connections.

If ammeter shows no charge, carry on with Test 2.

TEST 2

Checking the Alternator and Control Box

Leave the test ammeter connected, and disconnect cables 'F' and '—' from control unit and join them together. Remove link from field relay terminals and ensure they are connected to 'C1' and 'C2'. Start engine and run at charging speed.

Ammeter should indicate current values at 35 amps or more for 12 volt circuit or 22 amps or more for 24 volt circuit. A zero or low reading indicates a faulty alternator.

If satisfactory output is recorded, a faulty control unit is indicated.

TEST 3

Checking or Adjusting the Voltage Setting

The regulator of the 4 TR control unit must be set on CLOSED CIRCUIT, when the alternator is under load. Also, the system must be stabilised before checking or resetting is carried out, and the battery must be in a well charged condition. Check the battery to control unit wiring, to ensure that the resistance of the complete circuit does not exceed 0.1 ohm. Any high resistance must be traced and remedied. Connect a test DC voltmeter (suppressed zero type) scale 12 — 15 volts for 12 volt installations or 24—30 volts for 24 volt installations, between the battery terminals, and note the reading with no electrical load. Disconnect battery earth cable and connect test ammeter between alternator main terminal and disconnected cable. Reconnect battery earth cable, and switch on an electrical load of approximately two amps, such as, side and tail lights. Start engine and run at about 2000 rev/min for at least eight minutes. If the charging current is still greater than 10 amps, continue to run engine until this figure is reached. Then compare the voltmeter reading with the appropriate setting limits, as specified for the particular control unit as follows.

12 V (37423)/(37449)	13.9 — 14.3 volts
24 V (37444)/(37502)	27.9 — 28.3 volts
12 V (37429)	13.7 — 14.1 volts

(Part no. marked on upper edge of the moulded cover of Control Unit).

If reading obtained is stable but outside the appropriate limits the unit can be adjusted as follows.

ADJUSTMENT OF VOLTAGE SETTING

Stop the engine and remove the control unit from its mounting. At the back of the unit is a sealed potentiometer adjuster. Carefully scrape away the sealing compound. Then start the engine, and while running the alternator at charging speed, turn the adjuster slot — CLOCKWISE to INCREASE the setting or ANTI-CLOCKWISE to DECREASE it — until the required setting is obtained.

Recheck the setting by stopping the engine, then start again and slowly "run-up" to charging speed. If setting is now correct, remount the control unit, disconnect test meters and restore original wiring connections. If, after adjustment, the voltmeter reading remains unchanged, or increases in an uncontrolled manner, then the control unit is faulty and a replacement must be fitted.

TEST 4

Check Alternator Output

Disconnect battery earth cable, and connect test ammeter between the alternator main terminal and disconnected cables. Reconnect battery earth cable, and switch on the vehicles full electrical load and leave on for 3 or 4 minutes. Leave load on and start engine and run at approximately 2000 rev/min. The alternator output should balance the load, and at the same time show a charge to the battery.

Check Warning Light Control

If warning light does not function either by remaining "on" or "off", but the system is charging satisfactorily, connect voltmeter between the alternator "AL" terminal and earth. Reading should be 7.0—7.5 max (12 volt alternator) or 14.0—15.0 (24 volt alternator). Connect leads 'E' and 'WL' together. If warning lamp lights the warning light control is faulty and should be replaced.

5. Fault Diagnosis Procedure for 11 AC

Alternator Fails to Charge

- (a) Check driving belt for correct tension and wear.
- (b) Apply Tests 1 and 2.

Low-Unsteady Charging Rate

- (a) Check driving belt for correct tension and wear.
- (b) Check for high resistance at battery terminals and in the circuit wiring and connection.
- (c) Check all connections made to earth.
- (d) Apply Test 2.

Flat Battery or Low State of Charge

- (a) CHECK condition of battery with hydrometer and high rate discharge tester.
- (b) Check driving belt for correct tension and wear.
- (c) Check that the field isolating relay contacts open when master switch is off, otherwise battery will discharge through rotor winding.
- (d) Check that flat or low battery is not caused by insufficient alternator output caused by abnormal electrical loads by applying Test 4.

Excessive Charge Rate to a Fully Charged Battery

- (a) Apply Test 3.

Noisy Alternator

- (a) Alternator loose in mounting brackets.
- (b) Worn frayed or loose drive belt.
- (c) Worn bearings, fully out of alignment.
- (d) Rotor damage or pulley fan loose on shaft.
- (e) Open circuited, or short circuited rectified diodes, or stator winding open-circuit.
- (f) Loose pulley.

6. Testing the 15ACR and 17ACR Alternator in Position

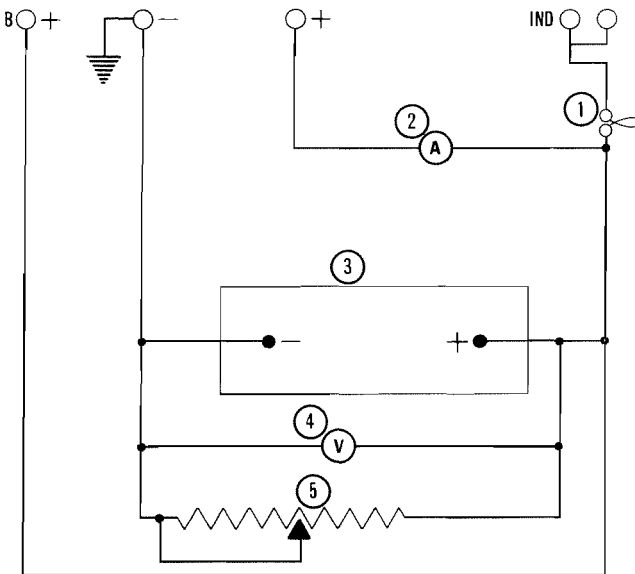
First check the driving belt for condition and tension. The nominal hot outputs at 6,000 rev/min (alternator speed) are 28 amps and 36 amps for 15ACR and 17ACR alternator respectively. These figures may be exceeded slightly when the alternator is running cold. To avoid misleading results, the following test procedure should therefore be carried out with the alternator running as near as possible to its normal operating temperature.

ELECTRICAL EQUIPMENT—Q.4

Alternator Output Test with Regulator Inoperative

Withdraw the two-part connector from the alternator, remove the moulded cover (secured by two screws) and link together regulator terminals 'F' and '—'.

Connect an external test circuit to the alternator output terminals as shown in Fig. Q.1.



Q1

1. 12 volt 2.2 watt Bulb
2. 0-40 or 0-60 Ammeter
3. 12 volt Battery
4. 0-20 Voltmeter
5. 0-15 ohm 35 amp Variable Resistor

Observe carefully the polarity of battery and alternator terminals — reversed connections will damage the alternator diodes.

The variable resistor across the battery terminals must not be left connected for longer than is necessary to carry out the following test.

Start the engine. At 1,500 rev/min (alternator speed), the test circuit bulb should be extinguished. Increase engine speed until the alternator is running at 6,000 rev/min approximately, and adjust the variable resistance until the voltmeter reads 14.0 volts. The ammeter reading should then be approximately equal to the rated output (See previous paragraph). Any appreciable deviation from this figure will necessitate the alternator being removed from the engine for further examination.

Failure of one or more of the diodes will be indicated in the above test by effect on alternator output, and also in some instances by abnormally high alternator temperature and noise level.

Regulator Test

The following test assumes the alternator to have been tested and found satisfactory.

Disconnect the variable resistor and remove the link bridging regulator terminals 'F' and '—'.

With the remainder of the test circuit connected as for the alternator output test, start the engine and again run the alternator up to 6,000 rev/min until the ammeter shows an output current of less than 10 amperes. The voltmeter should then give a reading of 14.0 — 14.4 volts. Any appreciable deviation from this (regulating) voltage means that the regulator is not functioning properly and must be replaced.

If the foregoing tests show the alternator and regulator to be satisfactorily performing, disconnect the test circuit and reconnect the alternator terminal connector. Now connect a low-range voltmeter between the positive terminal of the alternator (the moulded terminal connector is open-ended to facilitate this) and the positive terminal of the battery. Switch on battery load (headlights etc.), start the engine and increase speed until the alternator runs at approximately 6,000 rev/min. Note the voltmeter reading.

Transfer the voltmeter connections to the negative terminals of alternator and battery and again note the meter reading.

If the reading exceeds 0.5 volt on the positive side or 0.25 volt on the negative side, there is a high resistance in the charging circuit which must be traced and remedied.

DYNAMO

The following information is concerned with the Lucas C40-1 model. Should information be required in connection with any other type of dynamo then the relevant manufacturer should be contacted.

The C40-1 is of extruded yoke construction and is a ventilated type. Holes in each end bracket allow a pulley mounted fan to draw cooling air through the dynamo.

Description

It is a shunt wound, two pole, two brush machine designed to work in conjunction with a compensated voltage control regulator unit. A ball bearing supports the armature at the driving end and a porous bronze bush at the rear supports the commutator end.

The output of the dynamo is controlled by the regulator unit and is dependent on the state of charge of the battery and the loading of the electrical equipment in use. When the battery is in a low state of charge, the dynamo gives a high output, whereas if the battery is fully charged, the dynamo gives only sufficient output to keep the battery in good condition without any possibility of overcharging. An increase in output is given to balance the current taken by lamps and other accessories when in use.

When fitting a new control box, it is important to use only an authorised replacement. An incorrect replacement can result in damage to the dynamo.

2. Routine Maintenance

(a) Lubrication

Every 4,000 miles (6,000 km) or 150 running hours, inject a few drops of high quality S.A.E.30 engine oil into the hole marked "OIL" at the commutator end bearing housing (Refer to Fig. Q.2).

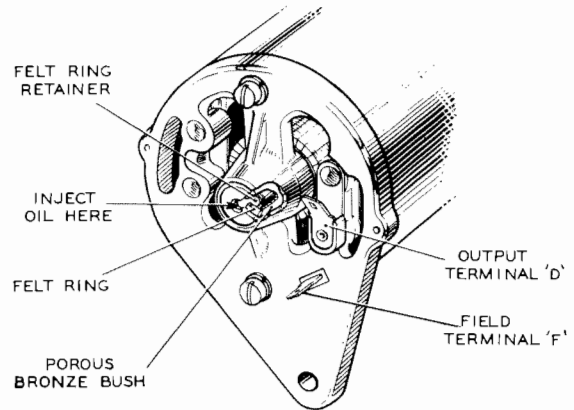
(b) Inspection of Brushgear

Every 72,000 miles (108,000 km) or 2,700 running hours, the dynamo should be removed from the engine and the brushgear inspected by a competent electrician.

(c) Belt Adjustment

Every 4,000 miles (6,000 km) or 150 running hours, inspect the dynamo driving belt, and if necessary, adjust to take up any slackness by turning the dynamo on its mounting. Care should be taken to avoid overtightening the belt (see Page M.1).

LUBRICATOR IN COMMUTATOR END BRACKET



Q2

3. Performance Data

The cutting in and maximum output speeds quoted below are production test figures and refer to cold machines with brushes only partly bedded.

Model C40-1.

Cutting-in Speed.

1450 rev/min (Max.) at 13.0 dynamo volts.

Maximum Output.

22 amp at 2250 rev/min (Max.) at 13.5 dynamo volts and a resistance load of 0.61 ohms.

Field Resistance.

6.0 ohms.

4. Start the engine and set to run at normal idling speed.
5. Clip the negative lead of a moving coil type voltmeter, (calibrated 0-20 volts) to one dynamo terminal and the positive lead to a good earthing point on the yoke.
6. Gradually increase the engine speed, when the voltmeter reading should rise rapidly and without fluctuation. Do not allow the volt meter reading to reach 20 volts, and do not race the engine in an attempt to increase the voltage. It is sufficient to run the dynamo up to a speed of 1,000 rev/min. If the voltage does not rise rapidly and without fluctuation the unit must be dismantled for internal examination.

Excessive sparking at the commutator in the above test indicates a defective armature which should be replaced.

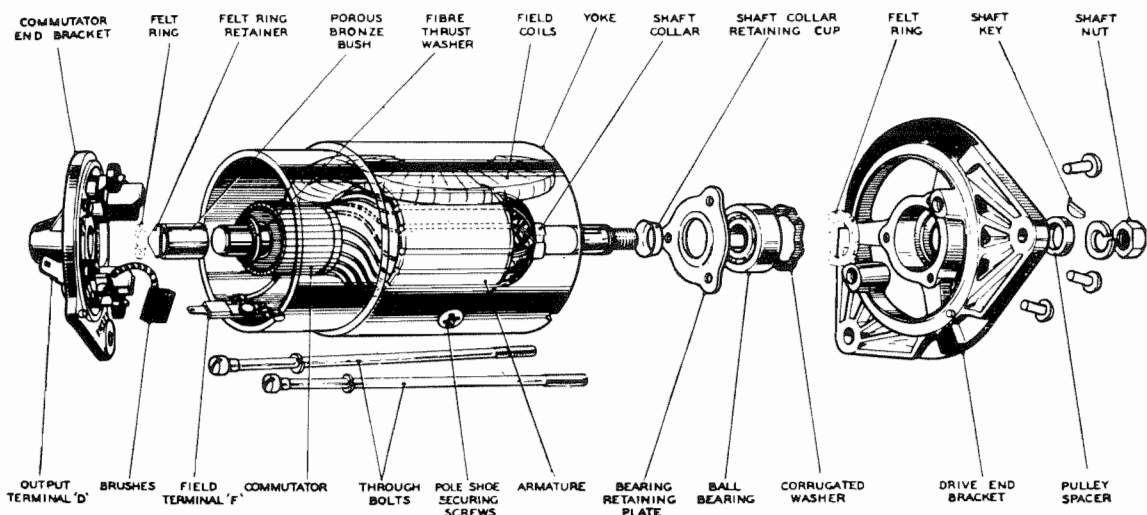
NOTE: If a radio suppression capacitor is fitted between the output terminal and earth, disconnect this capacitor and re-test the dynamo before dismantling. If a reading is now given on the voltmeter, then the capacitor is defective and must be replaced. If the dynamo is in good order,

4. Servicing

Testing in Position

1. Inspect the driving belt and adjust if necessary. (Refer to Page M.1).
2. Check the connection on the commutator end bracket. The larger connector carries the main dynamo output, the smaller connector the field current.
3. Switch off all lights and accessories, take off the cables from the terminals of the dynamo and connect the two terminals with a short length of wire.

MODEL C40-1 GENERATOR DISMANTLED



Q3

ELECTRICAL EQUIPMENT—Q.6

remove the link from between the terminals and restore the original connections.

STARTER MOTORS

General

The following information is concerned with the M45G starter motor. Two types of drive are available and both are covered fully in the following section. Should information be required in connection with any other type of starter motor then the relevant manufacturer should be contacted.

STARTER MOTORS

Run-off Helix Drive (See Fig. Q.4)

1. Description—Model M45G Type RF 17

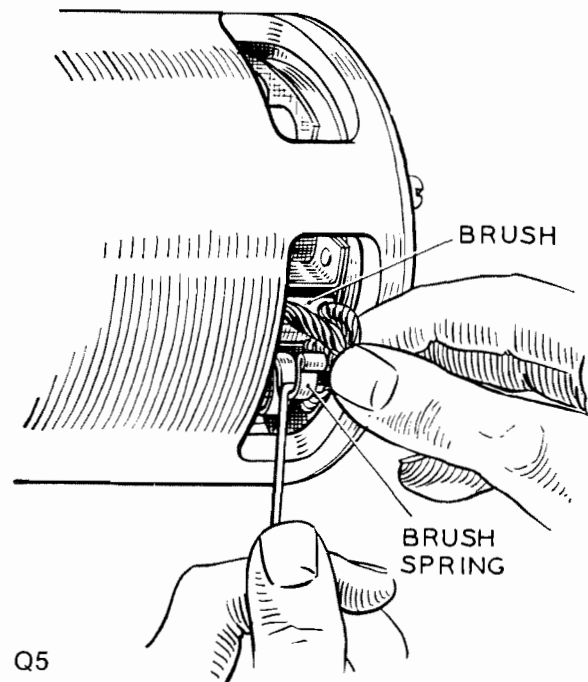
This electric starter motor is a four-pole four-brush machine having an extended shaft which carries the engagement gear, or starter drive as it is more generally known.

The starter motor is of a similar construction to the dynamo except that heavier copper wire is used in the construction of the armature and field coils. The field coils are series-parallel connected between the field terminal and the insulated pair of brushes.

The armature has 23 winding slots. The drive portion incorporates a special overload protective device known as the Run-off Helix.

2. Routine Maintenance

- (a) The starter motor requires no routine maintenance beyond the occasional inspection of the electrical connection which must be clean and tight, the brush gear, and the commutator.
 - (b) After the starter motor has been in service for some time remove the starter motor from the engine and submit it to a thorough bench inspection.
1. Check that the brushes move freely in their holders by holding back the brush springs and pulling

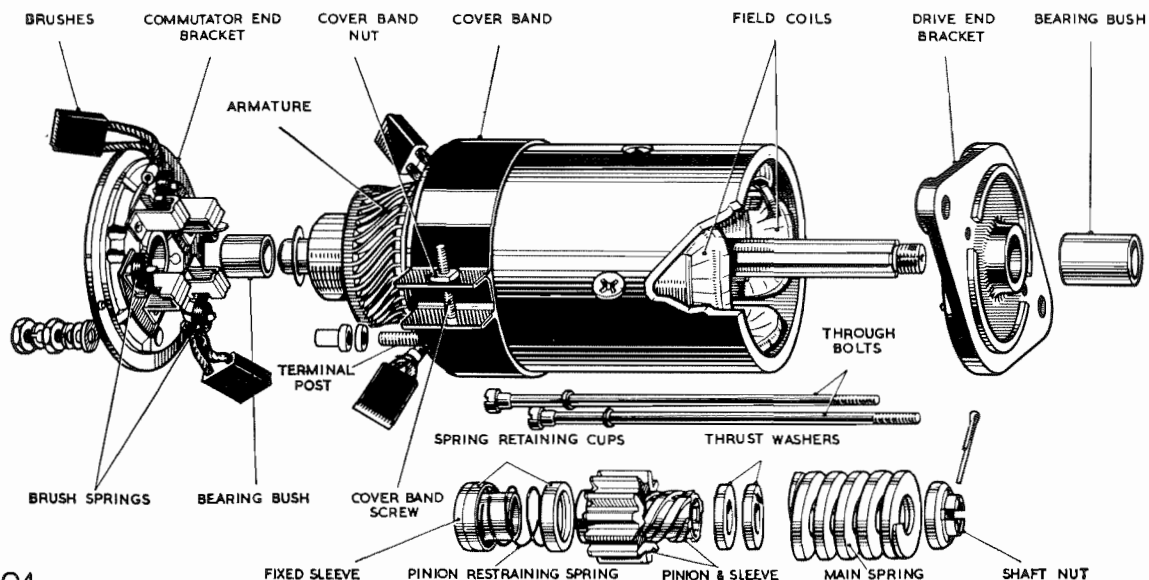


gently on the flexible connectors (Refer to Fig. Q.5). If movement is sluggish, remove the brush from its holder and clean its sides with a fluffless petrol moistened cloth. Replace the brush in its original position. Brushes which are worn to less than 9/16 in (14 mm) long must be renewed.

NOTE: This is the length when half the available wearing length has worn away. The time taken to reach this stage normally extends well beyond that to reach the point of major engine overhaul. After this time, the rate of wear accelerates due to reducing spring pressure.

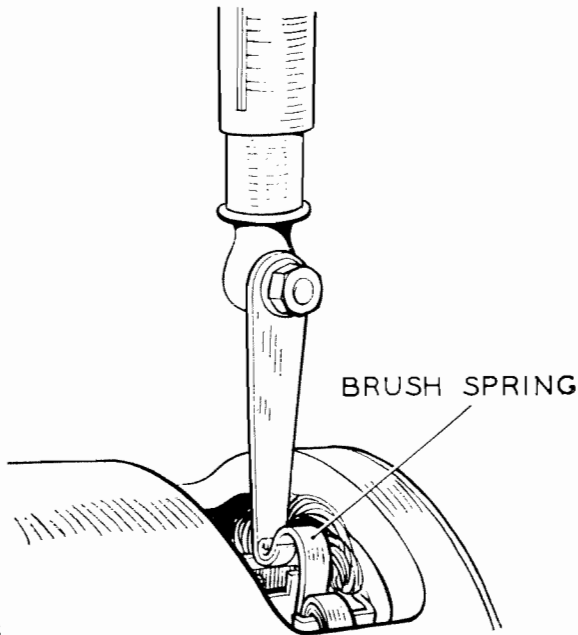
2. Check the tension of the brush springs using a spring scale. (Refer to Fig. Q.6). The minimum tension is 43 ozf (0,61 kgf). New springs should be fitted if the tension is low.

MODEL M45G TYPE RF 17



NOTE: This is applicable to a brush when half the available wearing length has been worn away.

3. The commutator must be clean and have a polished appearance. If necessary, clean it by pressing a fine dry cloth against it whilst the armature is turned by hand. If the commutator is very dirty, moisten the cloth with petrol.
4. Keep all the electrical connections clean and tight. Any which have become dirty should be cleaned and the contacting surfaces lightly smeared with petroleum jelly.



Q6

3. Servicing

(a) Testing in Position

If the starter motor does not operate or fails to crank the engine when the starting button is used, switch on the headlamps. When these are not fitted connect a good quality 0—20 voltmeter across the battery terminals, operate the starter button and watch for the following symptoms:

1. The headlamps dim (or the voltmeter reading falls appreciably) but the motor does not crank the engine.

This may be caused by the starter drive pinion being jammed in mesh with the engine flywheel. The pinion can usually be freed by engaging a low gear and gently rocking the engine. It is advisable to remove the starter motor from the engine and inspect the starter drive as described later in this section.

Sluggish action of the starter motor may be due to a discharged battery, check this by disconnecting the existing cables and reconnecting the motor to a battery known to be fully charged. If the starter motor now functions normally then the battery must be examined. Should the starter motor still not function normally then it should be removed from the engine and examined.

2. The headlamps do not dim (or the voltmeter reading remain unaffected) and the motor does not crank the engine.

Check first that the circuit up to the supply terminal on the starter motor is in order.

If no voltage is indicated, check the circuit from the battery to the motor via the starter switch. Ensure that all the connections are clean and tight. If the switch is found to be faulty fit a serviceable replacement.

A normal voltage supply reaching the starter motor terminal indicates that the starter motor has an internal fault and must be removed for examination. If the starter motor operates but does not crank the engine, the starter drive may require cleaning or may have developed some other fault. In either case the starter motor requires removal from the engine for a full examination.

'S' TYPE STARTER DRIVE ASSEMBLY

(a) Operation

This drive incorporates a protective feature known as the 'Run-off Helix'. The purpose of this feature is to prevent possible damage occurring to the starter motor through excessive torque being applied while the pinion is in engagement, as would arise for example in the event of an engine back-fire during starting.

Under normal conditions of engagement, axial movement of the pinion is arrested when, in the one direction, the first cup washer has fully compressed the restraining spring and is abutted hard against the second cup washer and, in the opposite direction, the helically screwed sleeve is pressing the thrust washer hard against the main spring.

In the 'Run-off Helix' drive, the main spring is capable of greater compression than is the equivalent standard 'S' pattern drive spring. In addition, the trailing faces of the pinion and helically screwed sleeve are machined to form indented ratchet recesses.

In the event of a back-fire occurring during starting, the pinion (being able to rotate but incapable of further axial movement) forces the helically screwed sleeve along the straight-splines of the starter shaft. This further compresses the main spring and permits axial movement of the screwed sleeve to continue until it is clear of the interior of the pinion. At this stage, axial movement of the screwed sleeve ceases and the pinion, now jointly supported by the fixed sleeve and the recessed end of the screwed sleeve, is free to be rotated by the engine ring gear. In this way, excessive torque is harmlessly dissipated by the ratcheting action of the pinion and screwed sleeve against the reaction pressure of the main spring.

The operation of a 'Run-off Helix' drive can be checked by securing the armature and drive assembly in a vice (using wooden vice-clamps) and applying a torque wrench to the pinion. The ratchet action must occur at a torque of not less than 36 lbf ft (5 kgf m).

(b) Routine Maintenance

If any difficulty is experienced with the starter motor not meshing correctly with the flywheel, it may be that the drive requires cleaning.

The pinion should move freely on the screwed sleeve; if there is any dirty or other foreign matter on the sleeve it must be washed off with paraffin.

ELECTRICAL EQUIPMENT—Q.8

STARTER MOTOR—PRE-ENGAGED DRIVE (See Fig. Q.7)

1. Description—Model M45G or 2M113 with Model 7S Solenoid.

This starter motor is a four-pole, four-brush earth return machine with series-parallel connected field coils. A solenoid-operated pre-engaged drive assembly is carried on an extension of the armature shaft.

The main features of this type of drive are as follows:

- Positive pinion engagement preventing the pinion being thrown out of mesh whilst starting.
- Dual-purpose plate clutch incorporated in the drive assembly giving over-speed and over-load protection.
- Self-indexing pinion to ensure smooth engagement between the pinion and the flywheel teeth before the starter motor begins to rotate.
- Armature braking system to ensure rapid return to rest when the starter button is released.

2. Routine Maintenance

- The starter motor requires no routine maintenance beyond the occasional inspection of the electrical connection which must be clean and tight, the brush gear, and the commutator.
 - After the starter motor has been in service for some time, remove the starter motor from the engine and submit it to a thorough bench inspection.
- Brush wear (this is a fair indication of the amount of work done). Renew brushes worn to, or approaching, 5/16 in (7,9 mm) in length.
 - Brush spring tension. Correct tension is 30 - 40 ozf (0,85-1,13 kgf). Renew springs if tension has dropped below 25 ozf (0,71 kgf).
 - Skim commutator if it is pitted or badly worn.

- Check bearings for excessive side play of armature shaft.
- Check pinion movement.
- Clean and lubricate the indented bearing inside the pinion sleeve using a bentonite based grease for this purpose.
- Clean and lubricate the indented bronze bearing in the intermediate bracket. Use Ragosine 'Molypad' Molybdenised non-creep oil for this purpose.

3. Servicing

(a) Testing in Position

Switch on the lamps. If the vehicle is not equipped with lighting, then connect a 0-20 voltmeter across the battery terminals before proceeding. Operate the starter control and watch for the following symptoms:—

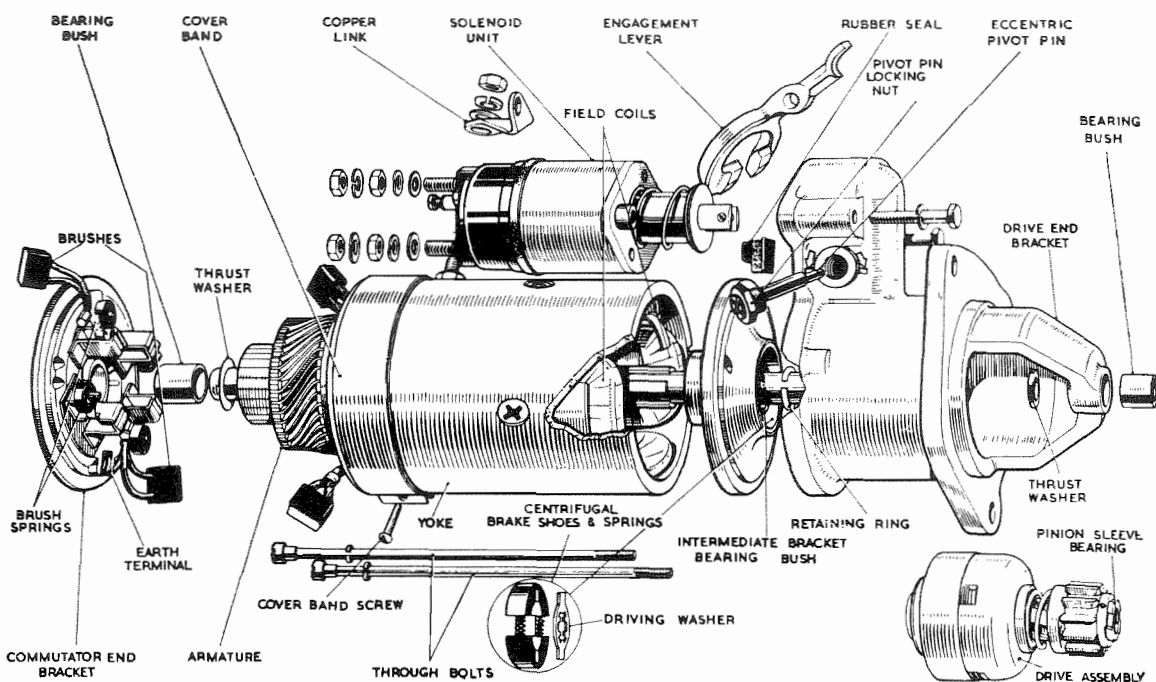
- The lamps dim or voltmeter reading drops to about 6 volts, and the motor does not crank the engine. Check battery (must be at least half-charged) and battery lugs. (clean and a good earth connection). Check by hand that engine turns freely.
- The lamps do not dim, the voltmeter reading remains steady at about 12 volts, and the motor does not crank the engine. Connect voltmeter from solenoid terminal 'BAT', and starter yoke, operate starter:—

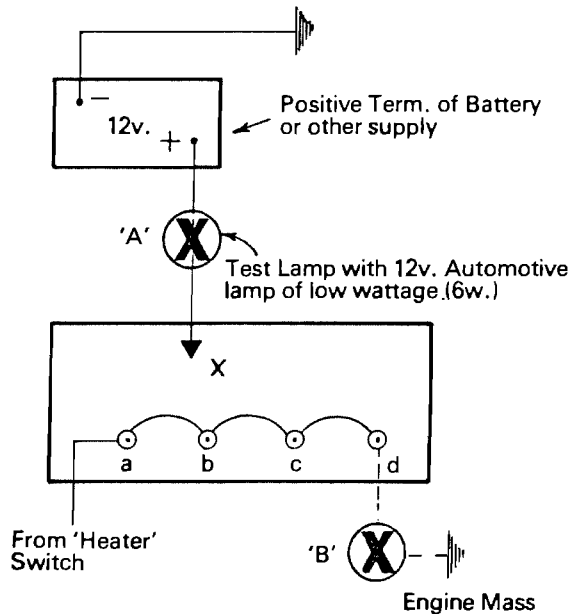
No volts indicated

- Poor lug connections at battery.
- Bad earth connection.
- Broken starter lead, battery to starter.

Full volts i.e., 12-14 volts indicated.

- Faulty solenoid switch.
- Open circuit in starter—check brushes.



CHECKING GLOW PLUGS**Glow Plugs**

Where glow plugs are used as a starting aid, the bus bar connecting the four plugs is electrically energised when the equipment is used.

As this bus bar is not insulated, extreme care must be exercised in as much as all pipes, clips and other metal objects must be kept well clear.

The consequences of a direct short of this bus bar to earth when energised are obvious.

On early engines the glow plugs are screwed into adaptors which are fitted to the cylinder head. On later engines the adaptors are removed and glow plugs are screwed directly into the cylinder head. The latest engines have the holes in the cylinder head for the tip of the glow plugs increased to accept glow plugs with a larger tip diameter.

To Check for Continuity of Glow Plugs

- (a) Remove leads from glow plugs.
- (b) Connect test lamp (A) as shown, to live (+ VE) terminal.
- (c) Check operation of lamp by earthing end (X) to engine head.
- (d) Connect test point "X" to each glow plug terminal in turn, lamp will light on 'good' glow plugs and will not light on open circuit (faulty) glow plugs.

To Check Supply to Glow Plugs

Connect test lamp (B) between point 'd' and earth (engine mass).

When heater switch is operated the lamp should light.

Checking Glow Plus Using a Voltmeter

1. Disconnect glow plug interconnecting links and main feed wire.
2. To check each glow plug individually connect a 30-0-30 ammeter in series with main feed cable and glow plug terminal.
3. Connect a 0-20 voltmeter from Glow Plug terminal to earth.
4. Press heater button and observe ammeter and voltmeter readings. A current of about 9 amps will be seen when the voltage is in the region of 11 to 12 volts. Energise plugs for about 20 to 30 seconds.
5. If the reading is low, or non existent, plug should be replaced.
6. If no volt-meter reading is observed, a defective feed cable or switch is the probable cause.



SECTION R

Engines for Refrigeration Units

4.108 engines supplied for the driving of refrigeration units are similar to those engines described in this 4.108 workshop manual and in the main, can be serviced in accordance with the instructions given in this publication. The following differences should however, be noted:—

Cold Starting Procedure (Refer Figs. R.1, R.2)

Glow plugs are fitted in the cylinder head to assist starting under cold conditions (see Page C.2).

On early engines the glowplugs are screwed into adaptors which are fitted to the cylinder head. Later engines have the glowplugs screwed directly into the cylinder head. For further information refer to page Q.9.

Cylinder Liners

The cylinder liners fitted to 4.108 refrigeration unit engines can be rebored 0.020 in (0,51 mm) oversize to the standard bore dimensions given on Page B.3.

Lubricating System

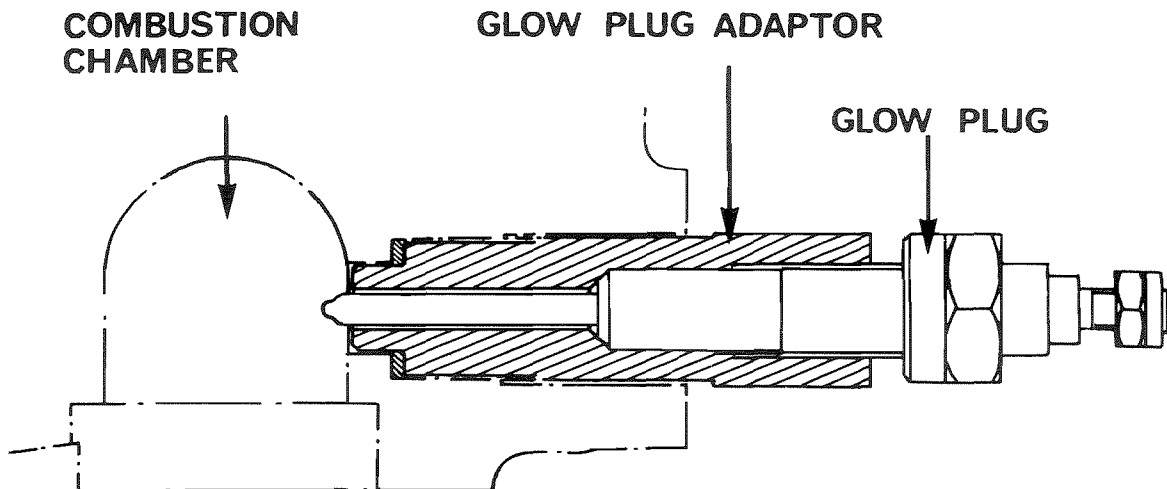
Due to the fact that the lubricating oil sump capacity has been increased to 28 pints and a much larger full flow lubricating oil filter is used, also the addition of a by-pass lubricating oil filter, the lubricating oil and filter element change period is extended to 1,000 hours.

Fuel System

A mechanically governed fuel injection pump is fitted. The fuel pump rotor timing letter is "C", No. 1 outlet is W and static timing is 21° B.T.D.C. or 0.150 in (3,81mm) displacement B.T.D.C.

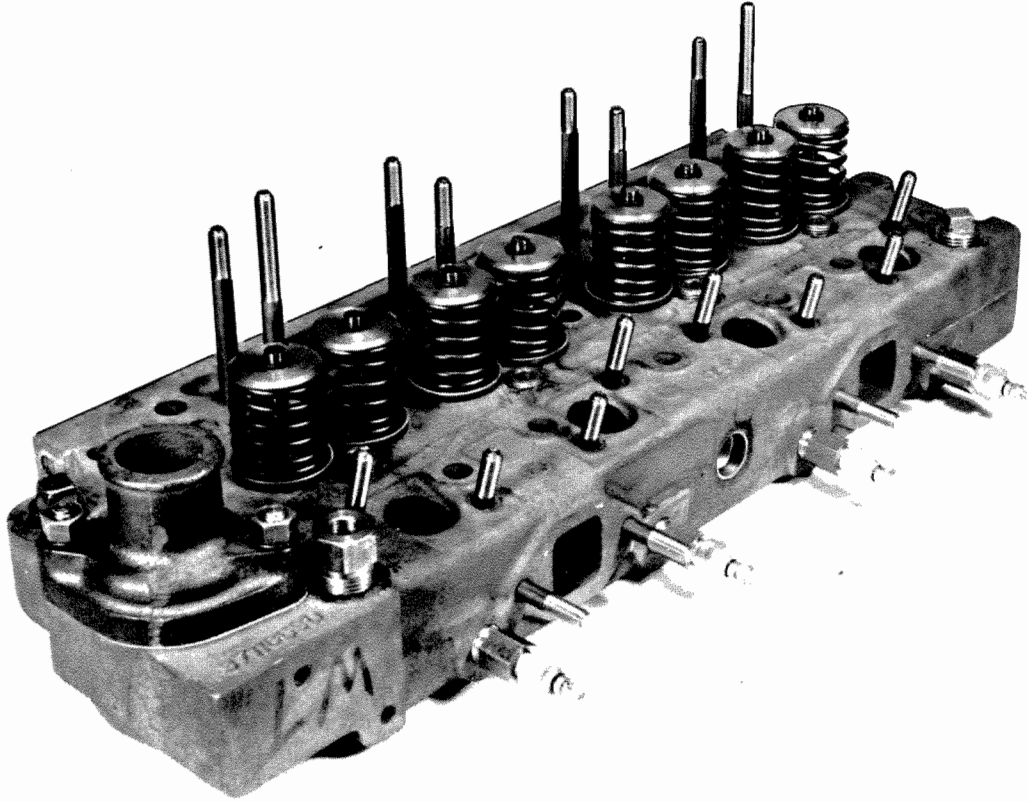
Two timing holes are provided in the rear of the crankshaft pulley, which when engaged with the timing pin, denote T.D.C. and 21° B.T.D.C. (static timing point).

When this method of timing the fuel injection pump is used, ensure that the fuel pump circlip is correctly set. For how to set the circlip, refer to the first part of "Alternative method where no tool is available," page N.7.



R1

ENGINES FOR REFRIGERATION UNITS—R.2



R2

General

The following major differences between the standard 4.108 vehicle engine and the 4.108 refrigeration unit engine may be of interest:—

	4.108 (V)	4.108 for Refrigeration Units
Crankshaft	Tufftrided	Non-tufftrided
Cylinder head	No glow plug bosses	Glow plugs in combustion chambers
Piston ring, top	Plain cast iron	Chrome plated o. Chrome Inserted
Piston ring, 2nd and 3rd	Internally stepped	Internally stepped
Piston ring, 4th	Cords	Microland
Piston ring, 5th	Maxigroove	Microland or spring loaded
Piston	Narrow 4th groove for cords rings	Wide 4th groove for Microland ring
Inlet valve seal	Fitted	Fitted
Exhaust valve seal	None fitted	Fitted
Valve spring inner	Fitted	None fitted
Fuel pump	Hydraulically governed D.P.A.	Mechanically governed D.P.A.
Lubricating oil system	—	Much increased oil and filter capacity as detailed on previous page

Timing Gear Cover and Oil Seal

Early engines use a black nitrile or a red silicone seal in a timing gear cover of pressed steel. An oil thrower is used with a nitrile seal, but a spacer is used in place of the oil thrower with the silicone seal. The silicone seal has a series of spiral grooves set into the front face of the main lip and a shaft rotation arrow marked on the front face of the seal. This type of seal is known as a 'Spiroseal'. There is also a dust lip forward of the main lip.

Later engines use a red or brown silicone 'Spiroseal' in a timing gear cover of cast aluminium which is dowelled to ensure centralisation of the seal. The crankshaft pulley has been lengthened and the oil thrower or spacer has been removed.

The latest engines have a wear ring fitted to the crankshaft pulley and use a black viton seal which has a larger internal diameter. The latest viton seal is a 'Spiroseal' with a protruding dust lip. For information on fitting the oil seal and timing gear cover refer to page J.I.

A later controlled expansion piston with a 0.020 in (0,50 mm) off-set gudgeon pin has been introduced and details of these are given on Pages B3, B.4, F.2 and F.3.

A controlled expansion piston has been introduced into the 4.108 refrigeration specification engine. These pistons have a closer tolerance to the cylinder bore, therefore extreme care must be taken during handling, storing and refitting as any distortion or damage to the piston skirt could lead to a seizure.

An interim controlled expansion piston was introduced from Engine No. 108U113592 and a final specification piston from Engine No. 108U119423. The final specification piston will be the only one supplied as a spare part, and when used as a replacement for the interim or the older type five ring piston, they should only be fitted in complete engine sets using the correct piston ring pack.

Details of the controlled expansion pistons and their respective ring layouts are as follows: —

Piston

Type	...	...	...	...	...
Piston Height in Relation to Cylinder Block Top Face	...	...	...	...	...
Bore Dia. for Gudgeon Pin	...	...	...	...	...
Compression Ring Groove Width — Top	...	...	...	...	...
Compression Ring Groove Width — 2nd & 3rd	...	...	...	...	...
Oil Control Ring Groove — 4th	...	...	...	...	...

Flat Topped — Controlled Expansion	0.002/0.006 in (0,05/0,15 mm) above
	1.0627/1.0629 in (26,994/26,999 mm)
	0.080/0.083 in (2,03/2,10 mm)
	0.064/0.065 in (1,64/1,65 mm)
	0.188/1.189 in (4,79/4,81 mm)

Piston Rings

Top Compression (marked 'TOP')	...	...	...
Second and Third Compression (marked 'BTM')	...	...	...
Fourth Oil Control	...	...	...
Top Compression Ring Width	...	...	...
Ring Clearance in Groove	...	...	...
Second and Third Compression Ring Width	...	...	...
Ring Clearance in Groove	...	...	...
Fourth Scraper Ring Width	...	...	...
Ring Clearance in Groove	...	...	...
Ring Gap Top Compression	...	...	...
Ring Gap Second and Third Compression	...	...	...
Ring Gap Fourth Scraper	...	...	...

Chrome Plated Taper Faced	
Internally Stepped	
Spring Loaded Scraper	
	0.077/0.078 in (1,96/1,98 mm)
	0.003/0.005 in (0,08/0,13 mm)
	0.0615/0.0625 in (1,56/1,59 mm)
	0.0015/0.0035 in (0,04/0,09 mm)
	0.186/0.1865 in (4,72/4,74 mm)
	0.002/0.0035 in (0,05/0,09 mm)
	0.012/0.020 in (0,30/0,50 mm)
	0.009/0.017 in (0,23/0,43 mm)
	0.010/0.018 in (0,25/0,46 mm)



Lubricating Oils

Lubricating oils should meet the requirements of the U.S. Ordnance Specifications MIL-L-46152 or MIL-L-2104C. The lubricating oils for use in Perkins Diesel engines should have a **minimum** Viscosity Index of 80.

Note : Operators are advised not to use a lubricating oil to the MIL-L-2104C specification for the first 500/1,000 miles (800/1600 km) or 25/50 hours of operation.

Some of these oils are listed below and on the following page. Any other oils which meet these specifications are also suitable.

MIL-L-46152 OILS

Company	Brand	S.A.E. Designation		
		0°F (-18°C) to 30°F (-1°C)	30°F (-1°C) to 80°F (27°C)	Over 80°F (27°C)
B.P. Ltd.	Vanellus M	10W	20W	30
	Vanellus M		20W/50	20W/50
Castrol Ltd.	Castrol/Deusol CRX	10W	20	30
	Castrol/Deusol CRX	10W/30	10W/30	10W/30
	Castrol/Deusol CRX		20W/50	20W/50
	Deusol RX Super		20W/40	20W/40
A. Duckham & Co. Ltd.	Fleetol HDX	10	20	30
	Fleetol Multi V		20W/50	20W/50
	Fleetol Multilite	10W/30	10W/30	10W/30
	Farmadcol HDX		20	30
	Hypergrade		15W/50	15W/50
	Fleetmaster		15W/40	15W/40
Esso Petroleum Co. Ltd.	Essolube XD-3	10W	20W	30
	Essolube XD-3		15W/40	10W/30
Mobil Oil Co. Ltd.	Delvac 1200 Series	1210	1220	1230
	Delvac Special	10W/30	10W/30	10W/30
Shell	Rimula X	10W	20W/20	30
	Rimula X	10W/30	10W/30	10W/30
	Rimula X		15W/40	15W/40
	Rimula X		20W/40	20W/40
	Rotella TX	10W	20W/20	30
	Rotella TX		20W/40	20W/40
Total Oil Co. Ltd.	Total Super HD		20W/20	30
	Total HD2-M	10W/30	20W/40	20W/50
	Total HD3-C (Rubia S)	10W	20W/20	30
	Total HD3-C (Rubia TM)		15W/40	15W/40
	Total Universal Tractor Oil (Multagri)		20W/30	20W/30
	Total Super Universal Tractor Oil (Multagri TM)		20W/30	20W/30

MIL-L-2104C OILS

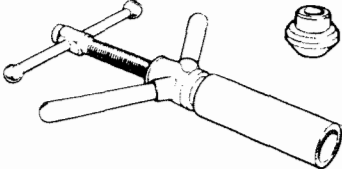
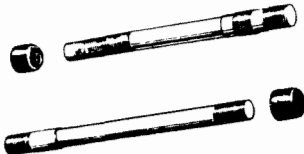

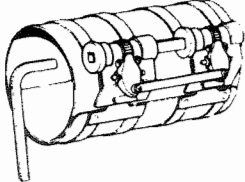
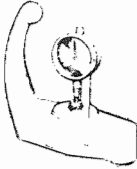
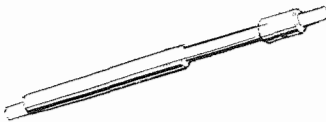
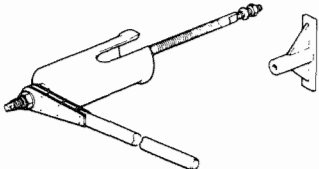
Company	Brand	S.A.E. Designation		
		0°F (-18°C) to 30°F (-1°C)	30°F (-1°C) to 80°F (27°C)	Over 80°F (27°C)
B.P. Ltd.	Vanellus C3	10W	20W/20	30
Castrol Ltd.	Castrol/Deusol CRD	10W	20	30
	Deusol RX Super		20W/40	20W/40
	Agricastrol HDD	10W	20	30
	Agricastrol MP		20W/30	20W/30
	Agricastrol MP		20W/40	20W/40
A. Duckham & Co. Ltd.	Fleetol 3	3/10	3/20	3/30
	Farmadcol 3	3/10	3/20	3/30
	Hypergrade		15W/50	15W/50
	Fleetmaster		15W/40	15W/40
Esso Petroleum Co. Ltd.	Essolube D-3HP	10W	20W	30
	Essolube XD-3	10W	20W	30
	Essolube XD-3		15W/40	15W/40
Mobil Oil Co. Ltd.	Delvac 1300 Series	1310	1320	1330
Shell	Rimula CT	10W	20W/20	30
	Rimula X	10W	20W/20	30
	Rimula X	10W/30	10W/30	10W/30
	Rimula X		15W/40	15W/40
	Rimula X		20W/40	20W/40
	Rotella TX	10W	20W/20	30
	Rotella TX		20W/40	20W/40
Total Oil Co. Ltd.	Total HD3-C (Rubia S)	10W	20W/20	30
	Total HD3-C (Rubia TM)		15W/40	15W/40
	Total Super Universal Tractor Oil (Multagri TM)		20W/30	20W/30

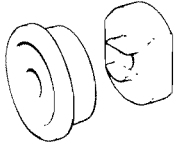
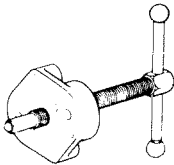
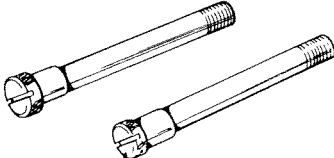
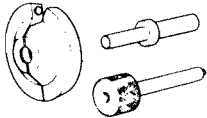
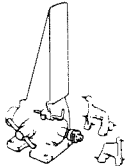
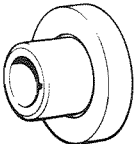
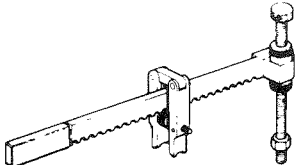
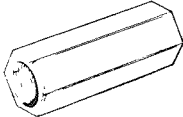
Lubricating oils for use in Perkins Diesel engines should have a minimum viscosity index of 80.

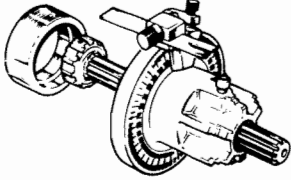
The above specifications are subject to alteration without notice.

Approved Service Tools

Available from V. L. Churchill & Co. Ltd., Daventry, Northamptonshire, NN11 4NF, England.

Tool No.	Description
PD.1D	VALVE GUIDE REMOVER AND REPLACER (MAIN TOOL)
	
PD.1D-1A	ADAPTOR FOR PD.1D A pair of puller bars fitted with knurled nuts. Suitable for $\frac{5}{16}$ " and $\frac{3}{8}$ " guides. The necessary distance piece from the adaptors below should also be used.
	
PD.1D-2	ADAPTOR FOR PD.1D A 20.5 mm ($\frac{13}{16}$ ") distance piece used to replace valve guides to a set height.
	
No. 8	PISTON RING SQUEEZER
	
PD.41B	PISTON HEIGHT AND VALVE DEPTH GAUGE A simple method of quickly checking piston height.
	
PD.130A	FUEL PUMP ALLEN SCREW KEY Assists access to the otherwise inaccessible screws on D.P.A. pump.
	
PD.150A	CYLINDER LINER REMOVER/ REPLACER (MAIN TOOL) For Field Service replacement of single liners. Not advised for complete overhaul. For this work use adaptors with a hydraulic ram unit.
	

Tool No.	Description
	PD.150-5 ADAPTORS FOR PD.150 Suitable for cylinders of 3.125" dia. Removal and replacement.
	155B BASIC PULLER The cruciform head with multiple holes at different centres is used with adaptors listed below.
	PD.155-1 ADAPTORS FOR PD.155A Used to remove water pump pulleys.
	MF.200-26 WATER PUMP OVERHAUL KIT Used with 370 Taper Base and Press.
	355 CON ROD JIG & 336 MASTER ARBOR
	336-101 ARBOR ADAPTOR Used with 335.
	6118B VALVE SPRING COMPRESSOR
	PD.6118-1 ADAPTOR FOR 6118B

Tool No.	Description
	TOOL FOR CHECKING FUEL INJECTION PUMP TIMING
MS.73	ADJUSTABLE VALVE SEAT CUTTERS (for 45° seats)
PD.160	TIMING TOOL COVER CENTRALISING TOOL



POWERPART Consumable Products

To give assistance in the correct operation, service and maintenance of your engine and machine, Perkins Engines Ltd. have made available the products shown below.

The instructions for the use of each product are given on the outside of each container.

These products are available from your Perkins distributor.

POWERPART Antifreeze

Gives corrosion protection and also a more efficient coolant in hot conditions. See Page C4.

POWERPART Lay-Up 1

A diesel fuel additive for protection against corrosion. See Page C.3.

POWERPART Lay-Up 2

Gives inside protection to the engine and other closed systems. See Page C.3.

POWERPART Lay-Up 3

Gives outside protection to any metal parts. See Page C.4.

POWERPART De-Icer

To remove frost.

POWERPART Silent Spray

Silicone lubrication to lubricate and prevent noise from hinges, slide doors, etc.

POWERPART Damp Displacer

To make damp electrical equipment dry and give future protection.

POWERPART Hylomar

Universal sealing compound to seal joints.

POWERPART Hylosil

Silicone rubber sealant to prevent leakage.

POWERPART Impact Adhesive

To keep joints in position during installation and other general attachment purposes.

POWERPART Solvent

To thoroughly clean metal faces before assembly.

POWERPART Locking Agent

Used to securely install fasteners, sleeves, etc.



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TO ENSURE YOU OBTAIN THE BEST RESULTS FROM YOUR ENGINE AND TO SAFEGUARD YOUR OWN GUARANTEE, FIT ONLY GENUINE PERKINS PARTS. THESE ARE READILY OBTAINABLE THROUGHOUT THE WORLD.