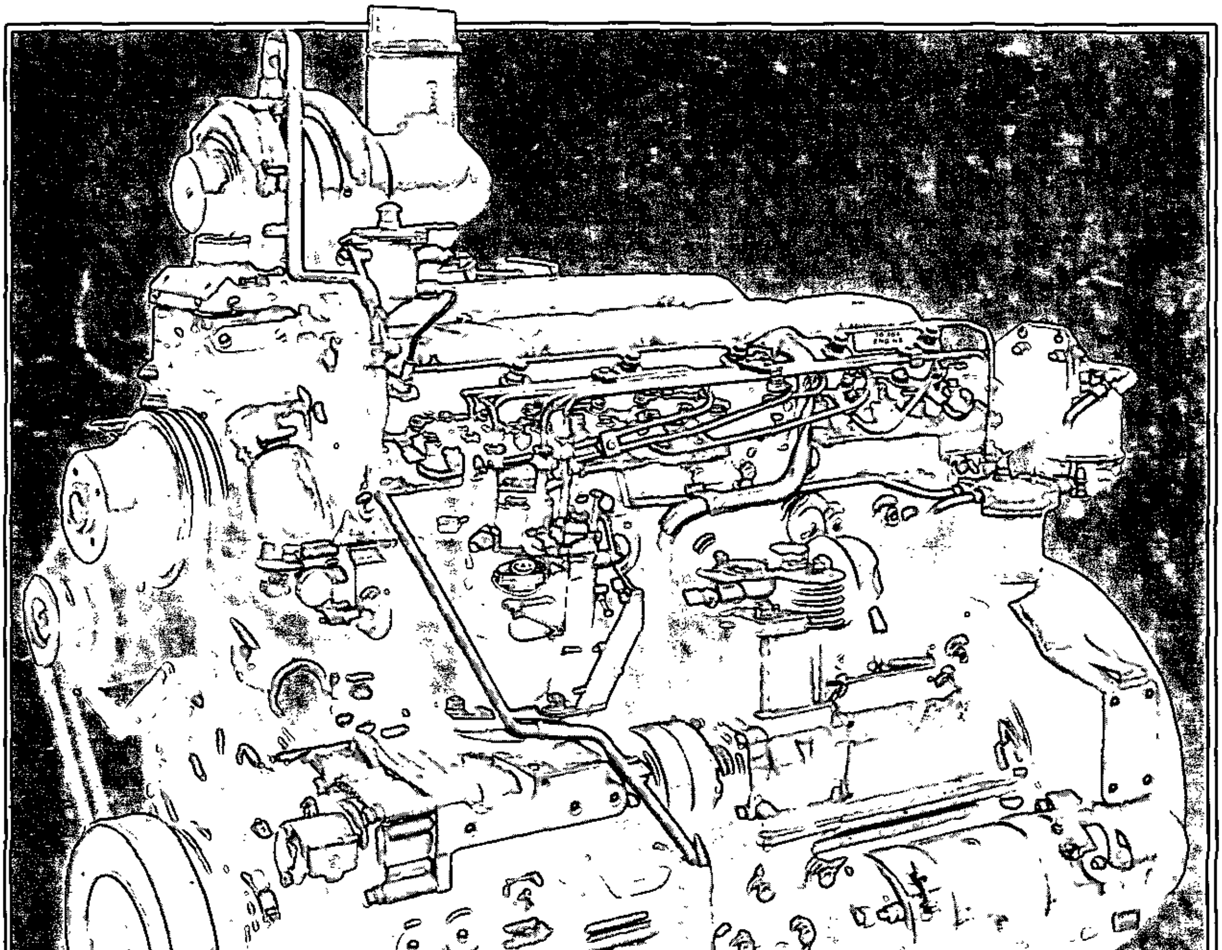
Perkins WORKSHOP MANUAL

6.354 SERIES



Perkins engines

workshop manual for 6.354, T6.354, 6.3542 and 6.372 diesel engines

Perkins Engines Limited

Peterborough England
1981

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This publication is written for world wide use. In territories where legal requirements govern engine 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 when in use.

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In addition to the above, there are Perkins Distributors in the majority of countries. For further details, apply to Perkins Engines Ltd., Peterborough or to one of the above companies.

CONTENTS

Unified Threads and Engine No. Location

All threads used on the 6.354 engine, excepting for proprietary equipment, are Unified Series and American Pipe Series.

Unified threads are not interchangeable with B.S.F. threads and although B.S.W. have the same number of threads per inch as Unified Coarse, interchanging is not recommended, due to a difference in thread form.

The engine number is stamped on the side of the auxiliary drive housing. This number should be quoted when requesting information or ordering parts.

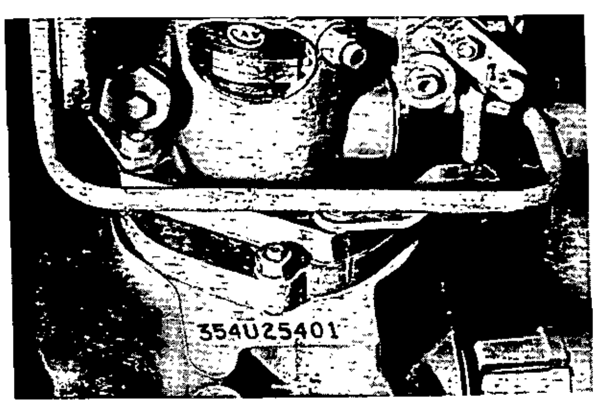
With early engines, the number consists of seven digits commencing with the figure "8".

Later engines had a number consisting of numbers and letters, e.g., 354U25401.

With current engines, the number consists of fifteen letters and numbers and a typical number is TB20102U510123D.

In all cases the engine number should be quoted **in full**.

Throughout this manual where it is considered necessary to use abbreviations, they are in accordance with those recommended by the British Standards Institute.



Engine Number Location

⚠ SAFETY PRECAUTIONS ⚠

THESE SAFETY PRECAUTIONS ARE IMPORTANT. Refer also to the local and government regulations applicable in your jurisdiction.

Do not use these engines in marine applications.

Do not modify the engine.

Do not smoke when refuelling.

Always remove spilt fuel and soaked clothing to a safe place.

Do not refuel whilst the engine is running (unless absolutely necessary).

Never clean, lubricate or adjust the engine whilst it is running (unless qualified to do so, in which case, extreme care should be taken to avoid injury).

Do not attempt any adjustments you do not understand.

Ensure the engine is positioned so as to prevent a build-up of toxic emissions.

Warn persons in the area to keep well clear during engine and equipment or vehicle operation.

Do not wear loose clothing or allow long hair near moving machinery.

Keep well clear of rotating parts or machinery in operation. Note that fans are not clearly visible whilst the engine is running.

Do not run the engine with any safety guards removed.

Do not remove the radiator cap whilst the engine is hot and coolant is under pressure as scalding can result.

On no account should sea water or any other electrolytic or corrosive medium be used in the cooling system.

Keep sparks or flames away from batteries as the gases from the electrolyte (especially whilst the battery is under charge) are highly inflammable. This acid is also dangerous to the skin especially the eyes.

Always disconnect the battery terminals before repairing or interfering with the electrical system.

Only one person should be in control of the engine.

Always operate the engine from the control panel or operators seat.

If your skin comes into contact with high pressure fuel, seek medical attention immediately.

Diesel fuel can cause skin infections to some people. Use protective gloves or hand cream.

Do not move mobile equipment without first ensuring the brakes are in good working order.

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

Fit in genuine Perkins Parts.

SAFETY IS SENSE. USE IT

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.

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

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 fitting setscrews or studs into holes which are tapped through into the interior of the engine, a suitable sealant should be used.

Users of Turbocharged engines should read the contents of Section "P" BEFORE STARTING their engine. Particular reference should be made to Sections 5 and 6.

Engine Designation

Different types of 6.354 Engines are available, i.e., Turbocharged and Normally Aspirated. Turbocharged engines have the letter "T" prefixed to the engine designation, i.e. T6.354, and Normally Aspirated engines are known as 6.354 engines.

Vertical and Horizontal engines are also available, Horizontal engines have the letter "H" prefixed to the engine designation, e.g., H6.354.

Extra heavy duty engines are designated 6.3542.

Engines of increased capacity (due to a larger cylinder bore diameter are designated 6.372.

Engines built for Massey Ferguson applications are designated AT6.354, A6.3541, A6.354 and A6.372. The appropriate engine designation is given where peculiar information relates to Massey Ferguson engines, otherwise the information is the same as listed under standard engine types.

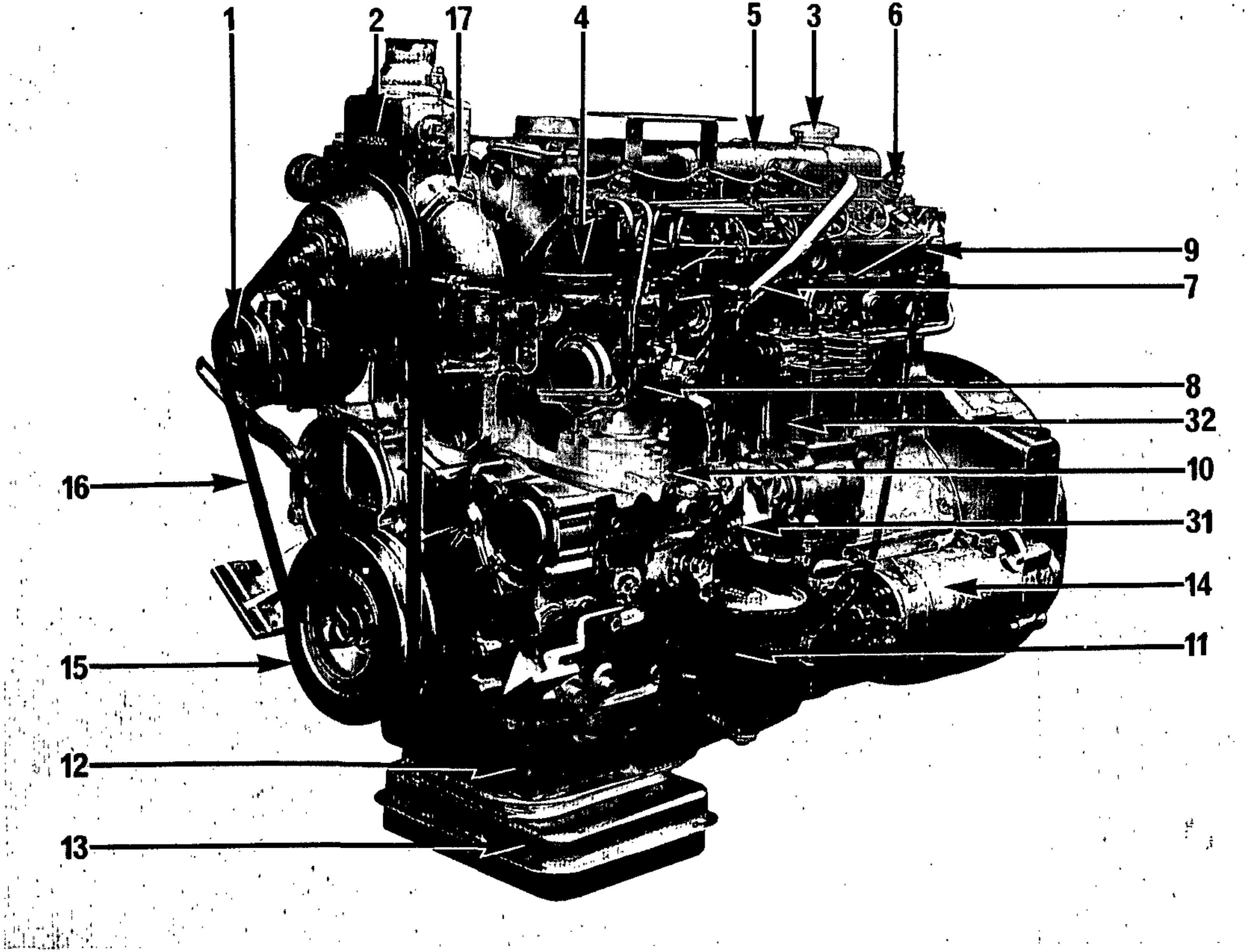
All references to 6.354 engines in this Workshop Manual may be taken to refer to all types unless otherwise stated.

SECTION A
Engine Photographs

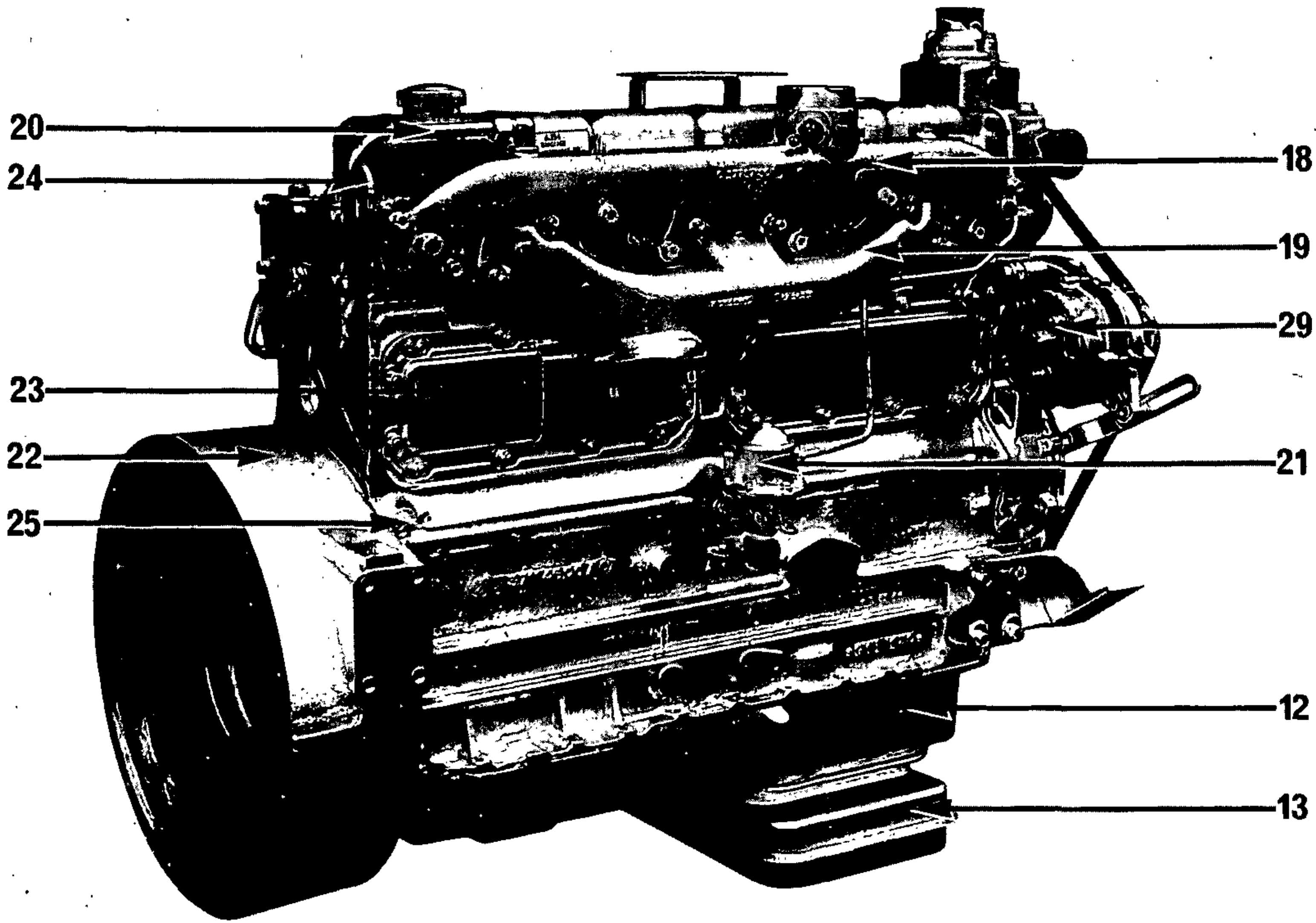
Perkins Engines are built to individual requirements to suit the applications for which they are intended and the following engine views do not necessarily typify any particular specification.

Index to Engine Photographs

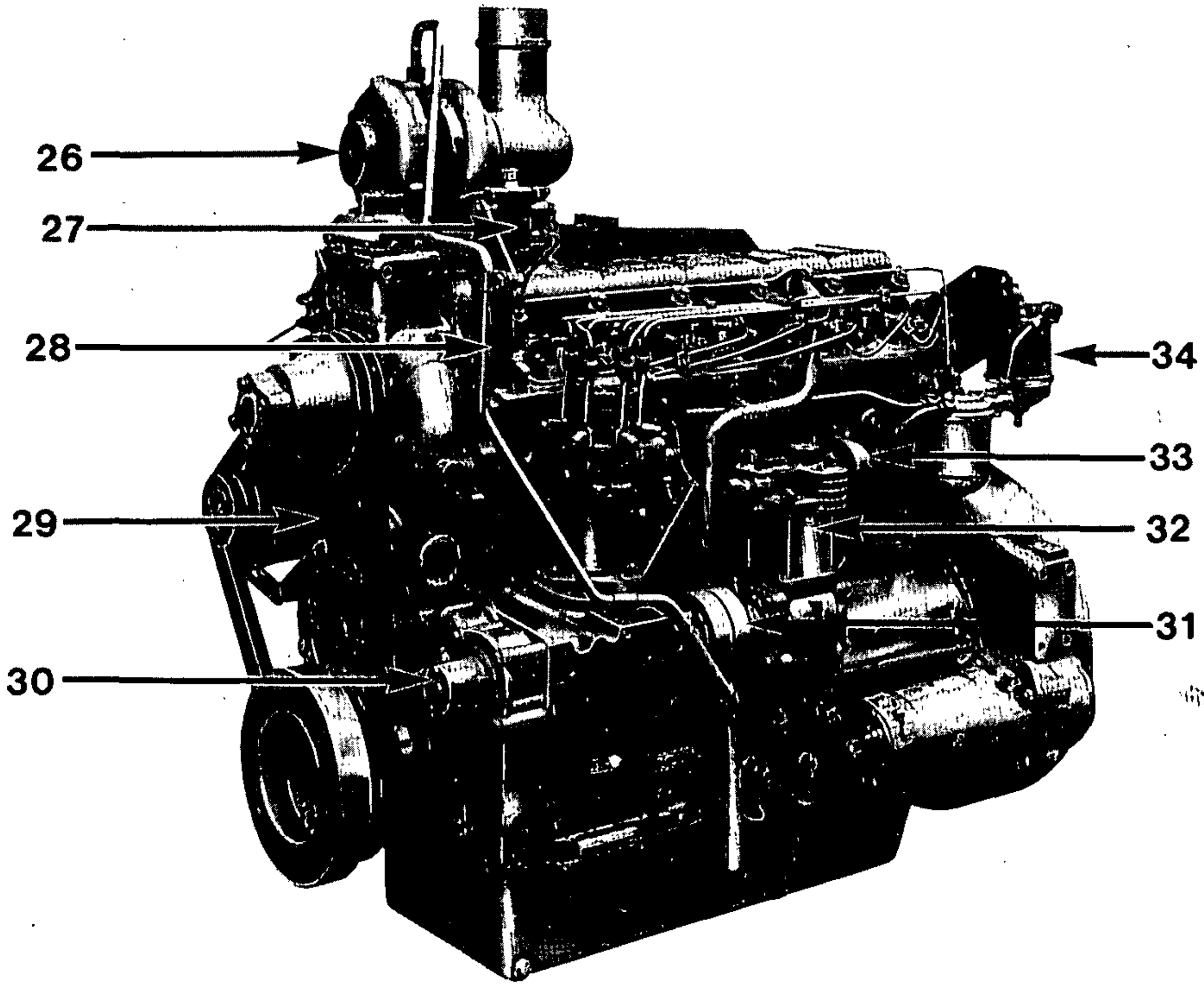
1. Alternator Pulley
2. Water Pump Outlet (incorporating thermostat).
3. Lubricating Oil Filler.
4. Fuel Oil Filter.
5. Cylinder Head Cover.
6. Atomiser.
7. Breather Pipe.
8. Fuel Injection Pump
9. Dipstick.
10. Engine Number Location.
11. Lubricating Oil Filter.
12. Sump.
13. Sump Well.
14. Starter Motor.
15. Vibration Damper/Crankshaft Pulley.
16. Fan Belt.
17. Water Pump.
18. Induction Manifold.
19. Exhaust Manifold.
20. Air Feed Pipe to Compressor.
21. Fuel Lift Pump.
22. Flywheel Housing.
23. Push Rod Inspection Cover.
24. Rear Lifting Bracket.
25. Cylinder Block Drain Tap.
26. Turbocharger.
27. Thermostart Reservoir.
28. Lubricating Oil Feed Pipe to Turbocharger.
29. Alternator.
30. Hour Meter.
31. Compressor Coupling.
32. Compressor.
33. Compressor Breather.
34. Primary Fuel Oil Filter incorporating a water trap.



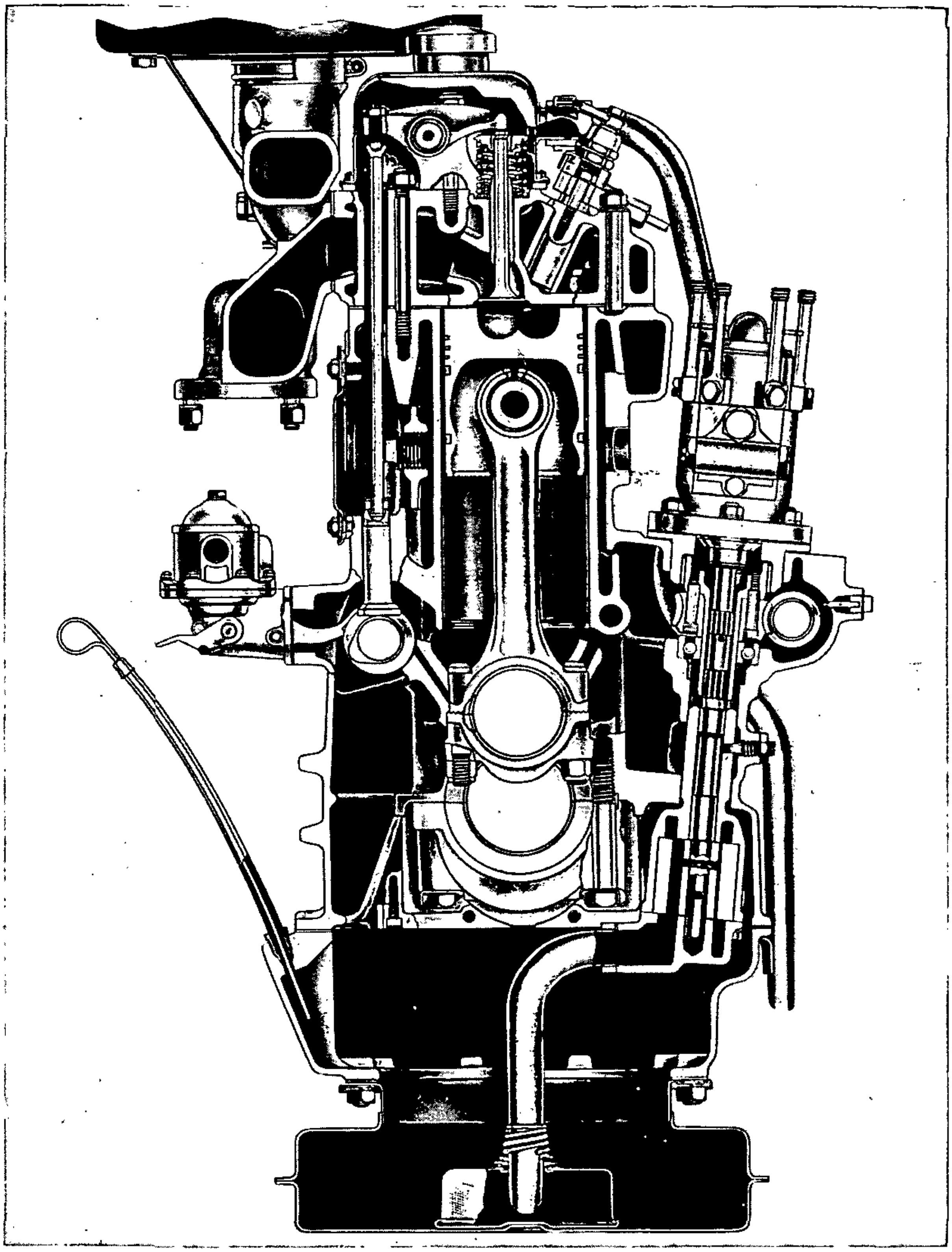
Near-side View of the 6.354 Engine.



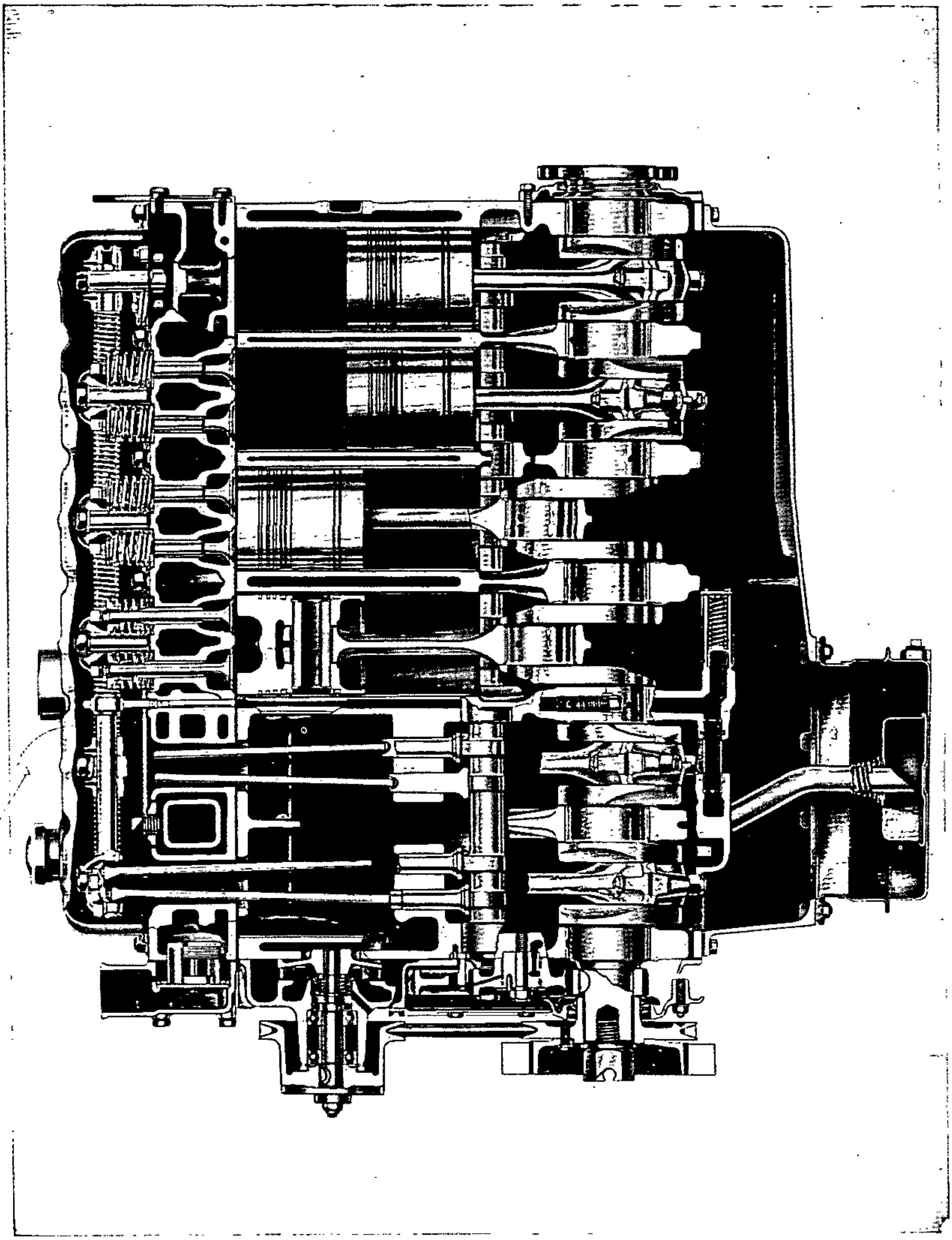
Off-side View of the 6.354 Engine.



Near-side View of a Typical Industrial Turbocharged 6.354 Engine



Cross Sectional View — 6.354 Engine.



Longitudinal Sectional View — 6.354 Engine.

SECTION B
Technical Data

Bore (6.372)	3.975 in (100 mm)*
Bore (6.3542, T6.354 and 6.354)	3.875 in (98,4 mm)*
Stroke	5 in (127 mm)
No. of Cylinders	Six
Cubic Capacity (6.372)	372 in³ (6,1 litres)
Cubic Capacity (6.3542, T6.354 and 6.354) ...	354 in³ (5,8 litres)
Compression Ratio	16 : 1
Firing Order	1,5,3,6,2,4,.
Combustion System	Direct Injection
Valve Clearance (cold)	0.012 in (0,30 mm)

*Nominal—for actual bore size, see pages B.3 and B.4.

DETAILS OF RATINGS

6.372 Engines

Industrial and Agricultural	121 bhp (90 kw) at 2,500 rev/min 292 lbf ft (40,4 kgf m)

6.3542, T6.354 and 6.354 Engines

Vehicle	120 bhp (89 kW) at 2,800 rev/min
(alternative rating)	112 bhp (85 kW) at 2,800 rev/min
Maximum Torque	260 lbf ft (36 kgf m)
Agricultural	104 bhp (78 kW) at 2,400 rev/min
Maximum Torque	266 lbf ft (36,8 kgf m)
*Industrial (Turbocharged)	117 bhp (87 kW) at 2250 rev/min
Maximum Torque	305 lbf ft (42,4 kgf m)
Industrial (Normally Aspirated — Mech. Gov.) ...	90 bhp (67 kW) at 2,250 rev/min
Maximum Torque	238 lbf ft (32,9 kgf m)
†Industrial (Normally Aspirated—Hyd. Gov.) ...	112 bhp (85 kW) at 2,800 rev/min
Maximum Torque	260 lbf ft (36 kgf m)

*Continuous Rating. †Intermittent Rating.

Note : All the above ratings are maximum and can vary according to application. For details of individual ratings, apply to your nearest Perkins Distributor.

Engine Weights

Basic Weight—Minus Flywheel or Backplate

(a) Vehicle type with exhauster	836 lb (380 kg)
(b) Agricultural type and Industrial with basic alloy oil sump.	825 lb (375 kg)

Typical Installed Weight—Basic plus flywheel, housing, starter motor, air cleaner, fan and filters.

(a) Vehicle type	1020 lb (464 kg)
(b) Agricultural and Industrial with alloy sump and medium weight flywheel	1040 lb (472 kg)

Recommended Torque Tensions

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

Component	Screw Size U.N.F.	lbf ft	kgf m	Nm
Cylinder Head Nuts (and/or Setscrews)	$\frac{1}{2}$	100	13,8	136
Cylinder Head Nuts	$\frac{7}{16}$ in	60	8,3	81
Big End Nuts (Cadmium Plated) see Page F.5 ...	$\frac{1}{2}$ in	75	10,4	102
Big End Nuts (Phosphated) see Page F.5	$\frac{1}{2}$ in	95	13,1	129
Filter Bowl Retaining Setscrew		10	1,38	13,6
Main Bearing Setscrew (see Page H.1)	$\frac{5}{8}$	150	20,7	203
Main Bearing Setscrew (see Page H.1)	$\frac{5}{8}$	180	24,9	244
Idler Gear Hub Nuts (early)	$\frac{7}{16}$ in	50	6,9	68
Idler Gear Hub Nuts (current)	$\frac{1}{2}$ in	65	9,0	88
Idler Gear Hub Nuts (heavy duty)	$\frac{3}{8}$ in	24	3,3	32
Sump to Cylinder Block Setscrews	$\frac{5}{16}$ in	15	2,1	20
Flywheel Setscrews	$\frac{1}{2}$ in	80	11,1	108
Camshaft Gear Retaining Setscrew	$\frac{1}{2}$ in	50	6,9	68
Crankshaft Pulley Setscrew (with $\frac{3}{8}$ in washer) ...	$\frac{7}{8}$ in	300	41,5	406
Crankshaft Pulley Setscrew (with $\frac{1}{4}$ in washer) ...	$\frac{7}{8}$ in	250	34,5	339
Crankshaft Damper Setscrews	$\frac{5}{16}$ in	15	2,1	20
Atomiser Securing Nuts	$\frac{5}{16}$ in	12	1,7	16
Dynamo Pulley Nut	$\frac{7}{16}$ in	20	2,7	27
Dynamo Pulley Nut	$\frac{5}{8}$ in	25	3,5	34
Alternator Pulley Nut	$\frac{7}{16}$ in	30	4,1	41
Alternator Pulley Nut	$\frac{9}{16}$ in	30	4,1	41
Alternator Pulley Nut	$\frac{5}{8}$ in	42	5,8	57
Induction Manifold Setscrews (with corrugated joints) (See Page E.9)		24	3,3	32
High Pressure Fuel Pipe Nuts		15	2,1	20
Thermostart Insulation Adaptor	$1\frac{1}{4}$ in	10	1,38	13,6
Thermostart Unit	$\frac{7}{8}$	10	1,38	13,6

Note : Connecting rod nuts shold be replaced whenever the big ends are disturbed.

$\frac{1}{2}$ in cylinder head nuts were fitted as from Engine No. 8060000.

Rocker Cover Joint (Black Plastic VITON) ... Torque on cover fixings must not exceed 8 lbf ft (1,1 kgf m) — 11 Nm.

De-Rating For Altitude

Where engines operate at high altitudes they should be de-rated.
The following table is given as a general guide, to be applied on a percentage basis, where specific figures for a particular engine rating are not available.

Altitude	Maximum fuel delivery de-rating*
0/ 2000 ft (600 metre)	No change
2000/ 4000 ft (1200 metre)	6%
4000/ 6000 ft (1800 metre)	12%
6000/ 8000 ft (2400 metre)	18%
8000/10000 ft (3000 metre)	24%
10000/12000 ft (3600 metre)	30%

*Measured at setting speed given on pump setting code.

It should be noted that the above information only applies to **normally aspirated engines.**

MANUFACTURING DATA AND DIMENSIONS

The data regarding clearances and tolerances is given for personnel engaged upon major overhauls. Further information can be obtained on request from your nearest Perkins Distributor.

Cylinder Block

Height between Top Face and C/L of Crankshaft ...	13.869/13.873 in (352,27/352,37 mm)
Parent Bore Diameter for Cast Iron Flangless Cylinder Liner	4.0615/4.0625 in (103,16/103,19 mm)
Parent Bore Diameter for Cast Iron Flanged Cylinder Liner 6.3542, T6.354 and 6.354	4.0625/4.0635 in (103,19/103,22 mm)
Parent Bore Diameter for Flanged Cast Iron Cylinder Liner — 6.372	4.1025/4.1035 in (104,20/104,23 mm)
Parent Bore Diameter for Cylinder Liner (Chrome) Thin Wall	3.9625/3.9635 in (100,65/100,67 mm)
Parent Bore Diameter for Cylinder Liner (Chrome) Thick Wall	4.0625/4.0635 in (103,19/103,21 mm)
Main Bearing Parent Bore Diameter	3.166/3.167 in (80,42/80,44 mm)
Camshaft Parent Bore Diameter No. 1	2.000/2.001 in (50,8/50,83 mm)
Camshaft Parent Bore Diameter No. 2	1.990/1.992 in (50,55/50,6 mm)
Camshaft Parent Bore Diameter No. 3	1.980/1.982 in (50,29/50,34 mm)
Camshaft Parent Bore Diameter No. 4	1.970/1.972 in (50,04/50,09 mm)
Recess Dia. for Cylinder Liner Flange — 6.3542, T6.354 and 6.354	4.205/4.210 in (106,73/106,93 mm)
Recess Diameter for Cylinder Liner Flange — 6.372	4.245/4.250 in (107,82/107,95 mm)
Recess Depth for Cylinder Liner Flange	0.150/0.154 in (3,81/3,91 mm)

Cylinder Liners (Cast Iron — Flangeless) — 6.3542,T6.354 and 6.354

Type	Dry—Interference Fit
Interference Fit of Liner	0.003/0.005 in (0,076/0,127 mm)
Inside Diameter of Liner after Finish Honing ...	3.877/3.878 in (98,48/98,50 mm)
Depth of Liner in relationship to Cylinder Block Top Face (Early Type) — T6.354 and 6.354 ...	0.005/0.013 in (0,13/0,33 mm)
Height of Liner in relationship to Cylinder Block Top Face (Later Type)	0.028/0.035 in (0,71/0,89 mm) Above
Maximum Oversize (Rebore)	+0.030 in (+0,76 mm)
Overall Length of Liner (Early Type)	8.963/8.973 in (227,7/227,9 mm)
Overall Length of Liner (Later Type)	9.005/9.015 in (228,7/229 mm)

Cylinder Liners (Cast Iron — Flangeless) — 6.372

Type	Dry — Interference Fit
Interference Fit of Liner	0.003/0.005 in (0,08/0,13 mm)
Inside Diameter of Liner after Finish Honing ...	3,9785/3,9795 in (101,05/101,08 mm)
Height of Liner in relationship to Cylinder Block Top Face	0.028/0.035 in (0,71/0,89 mm) Above
Overall Length of Liner	8.805/8.815 in (223,65/223,90 mm)
Reboring	Not Permissible

Cylinder Liners (Cast Iron-Flanged)

Type	Dry—Interference Fit (Production)—Transition Fit (Service)
Interference Fit of Liner (Production)	0.002/0.004 in (0,05/0,10 mm)
Inside Diameter of Production Liner after Finish Honing — 6.3542, T6.354 and 6.354 ...	3.877/3.878 in (98,48/98,50 mm)
Inside Diameter of Production Liner after Finish Honing — 6.372	3.9785/3.9795 in (101,05/101,07 mm)

Fit of Liner (Service) ...	—0.001/+0.001 in (—0,025/+0,025 mm)
Inside Diameter of Service Liner after Fitting — 6.3542, T6.354 and 6.354 ...	3.877/3.8795 in (98,48/98,54 mm)
Inside Diameter of Service Liner after Fitting — 6.372 ...	3.980/3.981 in (101,09/101,12 mm)
Flange Thickness (Early) ...	0.144/0.146 in (3,66/3,71 mm)
Flange Thickness (Current) ...	0.150/0.152 in (3,81/3,86 mm)
Height of Liner above Cylinder Block Top Face ...	0.028/0.035 in (0,71/0,89 mm)
Depth of Liner Flange below Top Face of Cylinder Block (Early) ...	0.004/0.010 in (0,10/0,25 mm)
Relationship of Liner Flange to Top Face of Cylinder Block (Current) ...	0.002 in (0,05 mm) ABOVE to 0.004 in (0,10 mm) BELOW
Overall Length of Liner ...	8.941/8.954 in (227,1/227,43 mm)

Cylinder Liners (Chrome Plated)

Type ...	Dry—Transition Fit
Inside Diameter after Fitting—Thin Wall ...	3.8765/3.879 in (98,46/98,53 mm)
Depth of Liner below Cylinder Block Top Face (Early Type) Thin Wall ...	0.001/0.009 in (0,025/0,23 mm)
Depth of Liner below Cylinder Block Top Face (Later Type) Thin Wall ...	0.004/0.008 in (0,1/0,2 mm)
Flange Thickness (Early Type) Thin Wall ...	0.040/0.045 in (1,016/1,143 mm)
Flange Thickness (Later Type) Thin Wall ...	0.043/0.045 in (1,092/1,143 mm)
Overall Length of Liner (Both Types) Thin Wall ...	8.92125/8.89125 in (226,6/225,84 mm)
Inside Diameter after Fitting—Thick Wall ...	3.877/3.8795 in (98,48/98,54 mm)
Height of Liner above Cylinder Block Top Face ...	0.028/0.035 in (0,71/0,89 mm)
Depth of Liner Flange below Cylinder Block Top Face—Thick Wall ...	0.004/0.008 in (0,1/0,2 mm)
Flange Thickness—Thick Wall ...	0.144/0.146 in (3,66/3,71 mm)
Overall Length of Liner—Thick Wall ...	8.939/8.954 in (227,05/227,43 mm)

Pistons

Note: The piston heights quoted are production limits. Where service pre-topped pistons are used, then the piston heights can be lower than that quoted. Piston heights should never be above these limits. Where engines have to conform to the smoke density regulation B.S. AU 141a : 1971, then piston heights must conform to production limits. This is achieved by using untopped pistons and machining to suit.

6.3542 Engines

Type ...	Toroidal Cavity in Crown
Piston height in relation to Cylinder Block ...	0.0026/0.0103 in (0,07/0,26 mm) Above
Bore Diameter for Gudgeon Pin ...	1.37485/1.37505 in (34,92/34,93 mm)
Compression Ring Groove Width No. 1 ...	0.1275/0.1285 in (3,24/3,27 mm)
Compression Ring Groove Width Nos. 2 and 3 ...	0.0957/0.0967 in (2,43/2,46 mm)
Scraper Ring Groove Width ...	0.2525/0.2535 in (6,41/6,44 mm)

6.372, T6.354 and 6.354 engines

Type ...	Toroidal Cavity in Crown
Piston Height in relation to Cylinder block (Turbocharged) ...	0.000/0.005 in (0,00/0,127 mm) Below
Piston Height in relation to Cylinder Block (Normally Asp.) ...	0.0026/0.0103 in (0,07/0,26 mm) Above
Bore Diameter for Gudgeon Pin (Turbocharged) ...	1.49985/1.50005 in (38,096/38,101 mm)
Bore Diameter for Gudgeon Pin (Normally Asp.) ...	1.37485/1.37505 in (34,92/34,93 mm)
Compression Ring Groove Width No. 1 (Turbocharged) ...	0.127/0.128 in (3,23/3,25 mm)
Compression Ring Groove Width Nos. 2 and 3 (Turbocharged) ...	0.0957/0.0967 in (2,43/2,46 mm)
Compression Ring Groove Width (Normally Asp.)	0.0957/0.0967 in (2,43/2,46 mm)
Scraper Ring Groove Width ...	0.2525/0.2535 in (6,41/6,44 mm)

Piston Rings

Ring gaps given are for when checking in an unworn portion of the cylinder bore.

Turbocharged Engines

Compression Ring Width—Top Ring	0.124/0.125 in (3,15/3,175 mm)
Compression Ring Width—2nd and 3rd Rings ...	0.0928/0.0938 in (2,36/2,38 mm)
Scraper Ring Width	0.2485/0.250 in (6,32/6,35 mm)
Top Ring Clearance in Groove	0.002/0.004 in (0,051/0,1 mm)
2nd and 3rd Ring Clearance in Groove	0.0019/0.0039 in (0,05/0,1 mm)
Scraper Ring Clearance in Groove	0.0025/0.005 in (0,06/0,13 mm)
Piston Ring Gap (chrome)	0.016/0.034 in (0,41/0,86 mm)
Piston Ring Gap (cast iron)	0.012/0.030 in (0,30/0,76 mm)

Normally Aspirated 6.372 and 6.354 Engines

Compression Ring Width	0.0928/0.0938 in (2,36/2,38 mm)
Scraper Ring Width	0.249/0.250 in (6,33/6,35 mm)
Compression Ring Clearance in Groove	0.0019/0.0039 in (0,05/0,1 mm)
Scraper Ring Clearance in Groove	0.0025/0.0045 in (0,06/0,11 mm)
Piston Ring Gap (chrome)	0.016/0.034 in (0,41/0,86 mm)
Piston Ring Gap (cast iron)	0.012/0.030 in (0,30/0,76 mm)
Scraper Ring Gap (6.372) — varies according to application	0.014/0.028 in (0,36/0,71 mm)

6.3542 Engines

Compression Ring Width—Top Ring	0.124/0.125 in (3,15/3,17 mm)
Compression Ring Width—2nd and 3rd Rings ...	0.0927/0.0937 in (2,36/2,38 mm)
Scraper Ring Width	0.249/0.250 in (6,33/6,35 mm)
Top Ring Clearance in Groove	0.0025/0.0045 in (0,06/0,11 mm)
2nd and 3rd Ring Clearance in Groove	0.002/0.004 in (0,05/0,10 mm)
Scraper Ring Clearance in Groove	0.0025/0.0045 in (0,06/0,11 mm)
Nos. 1, 2, 3 and 4 Ring Gap	0.016/0.034 in (0,41/0,86 mm)
No. 5 Ring Gap	0.012/0.030 in (0,30/0,76 mm)

Small End Bush

Type	Steel Backed, Lead Bronze Lined.
Outside Diameter (Normally Asp.)	1.535/1.536 in (38,99/39,01 mm)
Outside Diameter (Turbocharged)	1.660/1.661 in (42,16/42,19 mm)
Length	1.316/1.336 in (33,43/33,93 mm)
Inside Diameter before Reaming (Normally Asp.) ...	1.359/1.363 in (34,52/34,62 mm)
Inside Diameter before Reaming (Turbocharged) ...	1.489/1.493 in (37,82/37,92 mm)
Inside Diameter after Reaming (Normally Asp.) ...	1.3765/1.37575 in (34,96/34,94 mm)
Inside Diameter after Reaming (Turbocharged) ...	1.5015/1.50075 in (38,14/38,12 mm)
Clearance Between Small End Bush and Gudgeon Pin	0.0017/0.00075 in (0,038/0,024 mm)

Gudgeon Pin

Type	Fully Floating
Outside Diameter (Normally Asp.)	1.3748/1.375 in (34,92/34,93 mm)
Outside Diameter (Turbocharged)	1.4998/1.500 in (38,09/38,1 mm)
Length (Normally Asp.)	3.297/3.312 in (83,74/84,12 mm)
Length (Turbocharged)	3.250/3.2599 in (82,55/82,8 mm)
Fit in Piston Boss	Transition

Connecting Rod

Type	"H" Section
Cap Location to Connecting Rod	Serrations
Big End Parent Bore Diameter	2.646/2.6465 in (67,21/67,22 mm)
Small End Parent Bore Diameter (Normally Asp.) ...	1.53125/1.53225 in (38,9/38,92 mm)
Small End Parent Bore Diameter (Turbocharged) ...	1.65625/1.65725 in (42,07/42,09 mm)
Length from C/L of Big End to C/L of Small End	8.624/8.626 in (219,05/219,1 mm)
Connecting Rod Side Play	0.0095/0.0145 in (0,24/0,36 mm)

Connecting Rod Alignment

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 (0,06 mm).

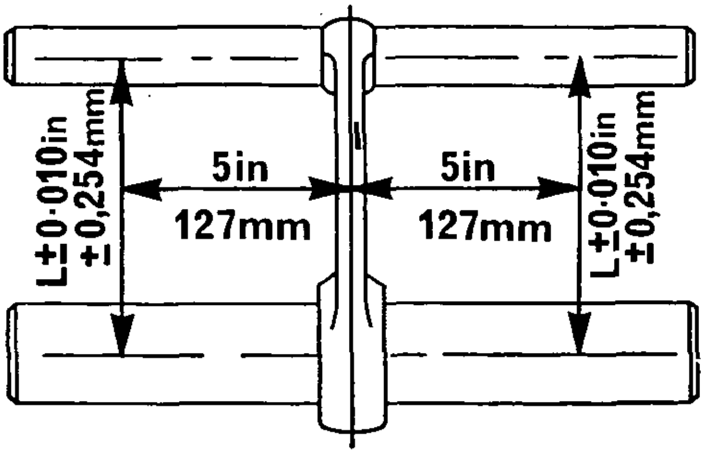


Fig. B.1.

Crankshaft

Overall Length	33.83375/33.85375 in (859,38/859,89 mm)
Main Journal Diameter	2.9984/2.9996 in (76,16/76,19 mm)
Main Journal Length—No. 1	1.454/1.484 in (36,91/37,69 mm)
Main Journal Length—Nos. 2, 3, 5, 6 and 7 ...	1.545/1.549 in (39,24/39,34 mm)
*Main Journal Length—No. 4	1.738/1.741 in (44,15/44,22 mm)
*Fillet Radius—Main Journals	0.145/0.156 in (3,68/3,96 mm)
Crankpin Diameter	2.4988/2.4998 in (63,47/63,49 mm)
*Crankpin Length	1.5885/1.5915 in (40,35/40,42 mm)
*Fillet Radius—Crankpins	0.145/0.156 in (3,68/3,96 mm)
Surface Finish—All pins and journals	16 micro-inches (0,4 microns) maximum
Main Journal and Crankpin—Regrind Undersizes ...	—0.010, 0.020 & 0.030 in (—0,25, 0,51 & 0,76 mm)
Oil Seal Helix Diameter (rope seal only)	3.124/3.125 in (79,35/79,38 mm)
Oil Seal Helix Width	0.050/0.080 in (1,27/2,03 mm)
Oil Seal Helix Depth	0.004/0.008 in (0,1/0,2 mm)
Flange Diameter	5.248/5.250 in (133,3/133,35 mm)
Flange Width (rope seal)	0.500 in (12,7 mm)
Flange Width (lip seal)...	1.200 in (30,48 mm)
Spigot Bearing Recess (Depth)	0.781 in (19,84 mm)
Spigot Bearing Recess (Bore)	1.849/1.850 in (46,96/47,0 mm)
Crankshaft End Float	0.002/0.015 in (0,05/0,38 mm)

*Fillet radius and surface finish must be maintained during crankshaft regrinding. Length of No. 4 main journal not to exceed 1.759 in (44,68 mm) after regrinding ; where necessary use oversize thrust washers to suit. Length of crankpins not to exceed 1.5965 in (40,55 mm) after regrinding.

Important Note: See remarks on Page H.2 concerning the regrinding of Nitrided and Tufftrided crankshafts.

Crankshaft Thrust Washers

Type	Steel Backed, Lead Bronze Faced
Position in Engine	Centre Main Bearing
Thrust Washer Thickness (Standard)	0.089/0.091 in (2,26/2,31 mm)
Thrust Washer Thickness (Oversize)	0.0965/0.0985 in (2,45/2,51 mm)
Thrust Washer Outside Diameter	4.088/4.098 in (103,84/104,09 mm)
Thrust Washer Inside Diameter	3.42/3.43 in (86,87/87,12 mm)

Main Bearings

Type	Pre-finished, Steel Backed, Aluminium Silicon Faced.
Shell Width—Nos. 1, 2, 3, 5, 6 and 7	1.245/1.255 in (31,62/31,88 mm)
Shell Width—No. 4	1.435/1.445 in (36,45/36,7 mm)
Outside Diameter of Main Bearing	3.166/3.167 in (80,42/80,44 mm)
Inside Diameter of Main Bearing	3.0015/3.003 in (76,24/76,28 mm)
Main Bearing Running Clearance	0.0019/0.0046 in (0,05/ 0,12 mm)
Shell Thickness	0.082/0.08225 in (2,08/2,09 mm)

Connecting Rod Bearings

Type	Pre-finished, Steel Backed, Aluminium Silicon Faced
Shell Width	1.245/1.255 in (31,62/31,88 mm)
Outside Diameter of Con-Rod Bearing	2.646/2.6465 in (67,21/67,22 mm)
Inside Diameter of Con-Rod Bearing	2.501/2.502 in (63,53/63,55 mm)
Con-Rod Bearing Running Clearance	0.0012/0.0032 in (0,03/0,08 mm)
Shell Thickness	0.07225/0.0725 in (1,83/1,84 mm)

Camshaft

No. 1 Journal Length	1.148 in (29,16 mm)
No. 1 Journal Diameter	1.9965/1.9975 in (50,71/50,74 mm)
No. 1 Journal Running Clearance	0.0025/0.0045 in (0,064/0,11 mm)
No. 2 Journal Length	1.375 in (34,93 mm)
No. 2 Journal Diameter	1.9865/1.9875 in (50,46/50,48 mm)
No. 2 Journal Running Clearance	0.0025/0.0055 in (0,064/0,14 mm)
No. 3 Journal Length	1.375 in (34,93 mm)
No. 3 Journal Diameter	1.9765/1.9775 in (50,20/50,23 mm)
No. 3 Journal Running Clearance	0.0025/0.0055 in (0,064/0,14 mm)
No. 4 Journal Length	1.125 in (28,58 mm)
No. 4 Journal Diameter	1.9665/1.9675 in (49,95/49,97 mm)
No. 4 Journal Running Clearance	0.0025/0.0055 in (0,064/0,14 mm)
Cam Lift	0.3035 in (7,71 mm)
Oilways for Rocker Shaft Lubrication	No. 2 Journal
Width of Spigot for Thrust Washer	0.222/0.232 in (5,638/5,892 mm)
Camshaft End Float	0.004/0.016 in (0,1/0,41 mm)

Camshaft Thrust Washer

Type	360°
Thrust Washer Outside Diameter	2.872/2.874 in (72,95/73,0 mm)
Cylinder Block Recess Diameter for Thrust Washer	2.875/2.885 in (73,03/73,28 mm)
Clearance Fit of Washer in Recess	0.001/0.013 in (0,025/0,33 mm)
Thrust Washer Internal Diameter	1.75 in (44,45 mm)
Thrust Washer Thickness	0.216/0.218 in (5,49/5,54 mm)
Cylinder Block Recess Depth for Thrust Washer (Early Engines)	0.154/0.156 in (3,86/3,91 mm)
Cylinder Block Recess Depth for Thrust Washer (Later Engines)	0.213/0.216 in (5,41/5,49 mm)
Protrusion of Thrust Washer above Cylinder Block Front Face (Early Engines)	0.062/0.066 in (1,53/1,68 mm)
Protrusion of Thrust Washer above Cylinder Block Front Face (Later Engines)	0.000/0.005 in (0,00/0,13 mm)

Cylinder Head

Cylinder Head Length	29.28125 in (743,74 mm)
Cylinder Head Depth	3.235/3.265 in (82,17/82,93 mm)
Skimming Allowance on Cylinder Head Face ...	0.012 in (0,30 mm)*
Leak Test Pressure	30 lbf/in^2 (2,11 kgf/cm^2) — 207 kN/m^2
Valve Seat Angle	45°
Valve Guide Bore in Cylinder Head	0.6247/0.6257 in (15,87/15,89 mm)

*Providing the nozzle protrusion does not exceed 0.144 in (3,66 mm) after skimming.
With earlier engines, nozzle protrusion should not exceed 0.224 in (5,69 mm) after skimming.

Valve Guides

Internal Diameter	0.3743/0.3757 in (9,51/9,54 mm)
Outside Diameter	0.6268/0.6273 in (15,92/15,93 mm)
Internal Diameter of Counterbore (Exhaust Valve Guide Only)	0.421/0.441 in (10,69/11,20 mm)
Depth of Counterbore (Exhaust Valve Guide Only)	0.40625 in (10,32 mm)
Interference Fit of Guide in Cylinder Head Bore ...	0.0011/0.0026 in (0,03/0,07 mm)
Overall Length of Guide (Inlet)	2.281 in (57,94 mm)
Overall Length of Guide (Exhaust)	2.406 in (61,11 mm)
Overall Protrusion above bottom face of Valve Spring Recess	0.594 in (15,08 mm)

Inlet Valves

Valve Stem Diameter	0.3725/0.3735 in (9,46/9,49 mm)
Clearance Fit of Valve in Guide	0.0008/0.0032 in (0,02/0,08 mm)
Valve Head Diameter	1.736/1.746 in (44,09/44,35 mm)
Valve Face Angle	45°
Valve Head depth below Cylinder Head Face— Production Limits	0.029/0.039 in (0,74/0,99 mm)
Overall Length	4.830/4.845 in (122,68/123,06 mm)
Sealing Arrangement	Rubber Deflector

Exhaust Valves

Valve Stem Diameter ...	0.372/0.373 in (9,45/9,47 mm)
Clearance Fit of Valve in Guide	0.0013/0.0037 in (0,03/0,09 mm)
Valve Head Diameter ...	1.438/1.442 in (36,54/36,64 mm)
Valve Face Angle	45°
Valve Head Depth below Cylinder Head Face— Production Limits ...	0.029/0.039 in (0,74/0,99 mm)
Overall Length	4.845/4.862 in (123,03/123,54 mm)

Inner Valve Springs

T6.354 and 6.354 Engines

Fitted Length	1.5625 in (39,7 mm)
Load at Fitted Length ...	15.4 lb ± 0.77 lb (7 kg ± 0,35 kg)
No. of Active Coils	9
No. of Damper Coils	2
Coiled	R.H.—Damper Coils to Cylinder Head

6.372 and 6.3542 Engines

Fitted Length	1.340 in (34,02 mm)
Load at Fitted Length ...	20.1/23.3 lb (9,1/10,5 kg)
No. of Active Coils	4.9
No. of Damper Coils ...	1
Coiled	R.H. — Damper coil to cylinder head

Outer Valve Springs

T6.354 and 6.354 Engines

Fitted Length	1.780 in (45,21 mm)
Load at Fitted Length ...	38/42 lb (17,24/19,05 kg)
No. of Active Coils	7.5
No. of Damper Coils ...	2
Coiled	L.H.—Damper Coils to Cylinder Head

6.372 and 6.3542 Engines

Fitted Length	1.410 in (35,81 mm)
Load at Fitted Length ...	39.5/43.7 lb (17,9/19,8 kg)
No. of Active Coils	3.625
No. of Damper Coils ...	1
Coiled	L.H.—Damper coil to cylinder head

Tappets

Overall Length	2.96875 in (75,41 mm)
Tappet Shank Diameter	0.7475/0.7485 in (18,99/19,01 mm)
Cylinder Block Tappet Bore Diameter	0.750/0.75125 in (19,05/19,08 mm)
Running Clearance of Tappet in Bore	0.0015/0.00375 in (0,04/0,09 mm)
Outside Diameter of Tappet Foot	1.1875 in (30,16 mm)

Rocker Shaft

Overall Length	26.3125 in (668,38 mm)
Outside Diameter of Shaft	0.7485/0.7495 in (19,01/19,04 mm)

Rocker Levers (Unbushed)

Internal Diameter of Rocker Lever Bore ...	0.7505/0.752 in (19,06/19,1 mm)
Clearance of Rocker Lever to Rocker Shaft	0.001/0.0035 in (0,025/0,09 mm)

Rocker Levers (Bushed)

Internal Bore Diameter of Rocker Lever for Bush ...	0.875/0.8762 in 22,22/22,25 mm)
Outside Diameter of Bush	0.877/0.8785 in (22,27/22,34 mm)
Interference Fit of Bush in Rocker Lever ...	0.0008/0.0035 in (0,02/0,09 mm)
Internal Diameter of Bush (after reaming in situ) ...	0.7505/0.7520 in (19,06/19,1 mm)
Clearance of Bush to Rocker Shaft	0.001/0.0035 in (0,03/0,09 mm)

Push Rods

Length of Push Rod	10.456/10.540 in (256,6/267,7 mm)
Shank Diameter	0.310/0.312 in (7,87/7,93 mm)

TIMING GEARS

Camshaft Gear

Number of Teeth	56
Inside Diameter of Gear Boss	1.375/1.376 in (34,93/34,95 mm)
Outside Diameter of Camshaft Hub	1.3751/1.3757 in (34,93/34,94 mm)
Transition Fit of Gear to Hub	—0.0007/+0.0009 in (—0,018/+0,023 mm)

Auxiliary Drive Gear

Number of Teeth	28
Internal Diameter of Gear Bore	1.000/1.001 in (25,4/25,43 mm)
Maximum Adjustment in Slotted Locating Holes ...	10°

Crankshaft Gear

Number of Teeth	28
Internal Diameter of Crankshaft Gear Bore ...	1.875/1.876 in (47,63/47,65 mm)
Crankshaft Diameter for Gear	1.875/1.8755 in (47,63/47,64 mm)
Fit of crankshaft gear to crankshaft	—0.0005/+0.001 in (—0,012/+0,025 mm)

Idler Gears and Hubs (Standard)

Number of Teeth	37
Inside Diameter of Gear	1.53125/1.53225 in (38,89/38,92 mm)
Outside Diameter of Bush	1.53375/1.53575 in (38,96/39,01 mm)
Inside Diameter of Bush	1.3755/1.3771 in (34,94/34,98 mm)
Outside Diameter of Hub	1.374/1.3745 in (34,90/34,91 mm)
Fit of Hub inside Bush	0.001/0.003 in (0,025/0,076 mm) clearance
Diameter of Oil Hole Drilling in Gear	0.073 in (1,85 mm)
End Float of Gears	0.002/0.012 in (0,05/0,305 mm)

Idler Gears and Hubs (Heavy Duty)

Number of Teeth	37
Inside Diameter of Gear	1.937/1.9385 in (49,2/49,24 mm)
Outside Diameter of Bush	1.9415/1.9435 in (49,31/49,36 mm)
Inside Diameter of Bush	1.6248/1.6257 in (41,37/41,39 mm)
Outside Diameter of Hub	1.621/1.622 in (41,17/41,3 mm)
Fit of Hub inside Bush	0.0028/0.0047 in (0,07/0,12 mm) clearance
End Float of Gears	0.002/0.004 in (0,05/0,10 mm)

Idler Gears and Hubs (Heavy Duty for Power Take-Off)

Number of Teeth	37
Inside Diameter of Gear	2.0625/2.0643 in (52,38/52,44 mm)
Outside Diameter of Bush	2.06625/2.06825 in (52,43/52,49 mm)
Inside Diameter of Bush	1.875/1.8778 in (47,63/47,69 mm)
Outside Diameter of Hub	1.8714/1.8730 in (47,54/47,58 mm)
Fit of Hub inside Bush	0.002/0.0064 in (0,05/0,16 mm) clearance
End Float of Gears	0.0015/0.004 in (0,04/0,10 mm)

Timing Gear Backlash

All Gears	0.003 in (0,076 mm) minimum

Auxiliary Drive Shaft Assembly

Drive Shaft—Overall Length	10.25 in (260,35 mm)
Number of Teeth on Worm	11
Outside Diameter of Worm—Early	1.619/1.624 in (41,12/41,25 mm)
—Current	1.870 in (47,5 mm)
Diameter of Front Journal—Early	1.748/1.749 in (44,4/44,42 mm)
—Current	1.9355/1.9365 in (49,16/49,19 mm)
Diameter of Rear Journal	1.248/1.249 in (31,7/31,72 mm)

Drive Shaft Bush — Front

Outside Diameter of Bush—Early	1.9375/1.9385 in (49,21/49,24 mm)
—Current	2.1283/2.1303 in (54,06/54,11 mm)
Housing, Bore	2.125/2.1264 in (53,98/54,0 mm)
Interference fit of bush	0.0021/0.0053 in (0,05/0,13 mm)
Inside Diameter of Bush—Fitted—Early	1.750/1.7516 in (44,45/44,49 mm)
—Current	1.9375/1.9397 in (49,21/49,27 mm)
Running Clearance of Shaft in Bush—Early	0.001/0.0036 in (0,025/0,09 mm)
—Current	0.001/0.0042 in (0,025/0,11 mm)

Drive Shaft Bush — Rear

Outside Diameter of Bush	1.4086/1.4105 in (35,78/35,83 mm)
Housing Diameter for Bush	1.4063/1.4076 in (35,73/35,75 mm)
Interference Fit in Housing	0.001/0.0042 in (0,03/0,11 mm)
Internal Diameter of Bush—Fitted	1.25/1.2519 in (31,75/31,79 mm)
Running Clearance of Shaft in Bush	0.001/0.0036 in (0,025/0,09 mm)

Auxiliary Drive Thrust Washers

Thickness	0.1875/0.1905 in (4,76/4,84 mm)
Cylinder Block Recess Depth for Thrust Washer	0.184/0.187 in (4,67/4,75 mm)
Outside Diameter	2.806/2.812 in (71,27/71,42 mm)
Groove Width on Drive Shaft	0.193/0.1965 in (4,9/4,99 mm)
Groove to Washer Clearance	0.0025/0.009 in (0,064/0,23 mm)

Fuel Pump Drive Shaft (early engines)

Overall Length	3.875 in (98,43 mm)
Outside Diameter of Shaft for Wormwheel	1.0002/1.0006 in (25,4/25,42 mm)
Outside Diameter of Shaft for Adaptor Plate	2.3095/2.3115 in (58,66/58,71 mm)

Wormwheel (early engines)

Number of Teeth	22
Internal Diameter	1.000/1.0008 in (25,4/25,42 mm)
Transition Fit of Wormwheel to Drive Shaft	—0.0006/+0.0006 in (—0,015/+0,015 mm)
Distance between Centres—Wormwheel to Auxiliary Drive Shaft	1.95 in (49,53 mm)—Early 2.375 in (60.33 mm)—Current

Fuel Pump Adaptor Plate Bush (early engines)

Internal Diameter of Plate for Bush	2.50/2.5012 in (63,5/63,53 mm)
Internal Diameter of Plate for Fuel Pump	1.8141/1.8125 in (46,08/46,04 mm)
Width of Datum Slot	0.121/0.129 in (3,07/3,28 mm)
Outside Diameter of Bush	2.5053 in (63,63 mm)
Internal Diameter of Bush (requires boring in situ)	2.3125/2.3143 in (58,74/58,78 mm)
Running Clearance of Fuel Pump Drive Shaft in Bush	0.001/0.0048 in (0,02/0,122 mm)

Hydraulically Loaded Wormwheel (later engines)

Bore Dia. in Cylinder Block for Fuel Pump Adaptor Plate and Upper Thrust Collar ...	3.500/3.5014 in (88,90/88,94 mm)
Fuel Pump Adaptor Plate Dia.	3.4986/3.4995 in (88,86/88,89 mm)
Fit of Adaptor Plate in Cylinder Block	0.0005/0.0028 in (0,01/0,07 mm)
Outer Dia. of Upper Thrust Collar	3.496/3.498 in (88,80/88,85 mm)
Clearance of Upper Thrust Collar in Cylinder Block	0.002/0.0054 in (0,05/0,14 mm)
Fuel Pump Adaptor Plate — Parent Bore Dia. for Bush	2.0625/2.0643 in (52,34/52,43 mm)
Outer Dia. of Bush	2.06625/2.06825 in (52,48/52,53 mm)
Interference Fit of Bush in Adaptor Plate	0.00195/0.00575 in (0,05/0,15 mm)
Width of Groove in Upper Thrust Collar	0.0957/0.0967 in (2,43/2,46 mm)
Upper Thrust Collar Sealing Ring Thickness ...	0.0928/0.0938 in (2,36/2,38 mm)
Clearance of Sealing Ring in Groove	0.0019/0.0039 in (0,05/0,10 mm)
Inner Dia. of Bush in Fuel Pump Adaptor Plate ...	1.8750/1.8766 in (47,63/47,67 mm)
Upper Dia. of Fuel Pump Drive Shaft	1.8714/1.8730 in (47,53/47,57 mm)
Clearance of Drive Shaft in Adaptor Plate Bush ...	0.002/0.0052 in (0,05/0,13 mm)
Inner Dia. of Upper Thrust Collar	1.886/1.890 in (47,90/48,01 mm)
Clearance of Drive Shaft in Upper Thrust Collar ...	0.013/0.0186 in (0,33/0,47 mm)
Inner Dia. of Bush in Lower Thrust Collar ...	1.6255/1.6266 in (41,29/41,32 mm)
Lower Dia. of Fuel Pump Drive Shaft	1.6214/1.6224 in (41,18/41,21 mm)
Clearance of Drive Shaft in Bush	0.0031/0.0052 in (0,08/0,12 mm)
Inside Dia. of Lower Thrust Collar	1.7812/1.7828 in (45,24/45,28 mm)
Outside Dia. of Lower Thrust Collar Bush ...	1.7843/1.7857 in (45,32/45,36 mm)
Interference Fit of Bush in Lower Thrust Collar ...	0.0015/0.0045 in (0,04/0,11 mm)

LUBRICATION SYSTEM

Normal Lubricating Oil Pressure at Maximum Engine Speed and Normal Working Temperature	30/60 lbf/in² (2,11/4,22 kgf/cm²) — 207/414 kN/m²

Sump

Sump Capacity	24 Imperial Pints (13,6 Litres) (vehicle only)*

*Other sump capacities vary according to application.

Oil Pump

Type of Pump	Rotor Type
No. of Lobes—Inner Rotor	Four or Three
No. of Lobes—Outer Rotor	Five or Four

Pump Part No. 41314044 (Hobourn Eaton) and 41314096 (Concentric or Hobourn Eaton)

Inner rotor to outer rotor	0.001/0.006 in (0,02/0,15 mm)
Outer rotor to pump body	0.0055/0.010 in (0,14/0,25 mm)
Inner and outer rotor end clearance	0.001/0.005 in (0,02/0,13 mm)

Pump Part No. 41314053 (Concentric)

Inner rotor to outer rotor	0.001/0.0035 in (0,02/0,09 mm)

Pump Part No. 41314058 (Concentric)

Inner Rotor to Outer Rotor	0.003/0.005 in (0,08/0,13 mm)

Pump Part No. 41314062 and 41314067 (Concentric High Capacity)

Inner rotor to outer rotor	0.001/0.005 in (0,02/0,13 mm)

Pump Part Nos. 41314053 and 41314058 (Concentric)

Pump Part Nos. 41314062 and 41314067 (Concentric High Capacity)

Outer rotor to pump body	0.006/0.013 in (0,15/0,33 mm)

Inner rotor end clearance	0.0015/0.003 in (0,04/0,08 mm)
Outer rotor end clearance	0.0005/0.0025 in (0,01/0,06 mm)

Note: For replacement purposes the whole pump assembly must be replaced.

Relief Valve

Pressure Setting I	50/60 lbf/in² (3,52/4,22 kgf/cm²) — 345/414 kN/m²
Pressure Setting II (Identified by a distance piece under split pin)	60/70 lbf/in² (4,22/4,92 kgf/cm²) — 414/483 kN/m²
Length of Plunger	0.875 in (22,23 mm)
Outside Diameter of Plunger	0.747/0.749 in (18,91/18,96 mm)
Inside Diameter of Valve Housing Bore	0.750/0.751 in (19,05/19,08 mm)
Clearance of Plunger in Bore	0.001/0.004 in (0,025/0,1 mm)
Outside Diameter of Spring	0.679/0.695 in (17,25/17,65 mm)
Solid Length	1.56 in (39,62 mm)
Fitted Length (Normally Asp.)	2.0625 in (52,39 mm)
Fitted Length (Turbocharged)	2.0625 in (52,39 mm)
Fitted Load (Normally Asp.)	13.33 lb ± 5½ oz (6,05 kg ± 155 grammes)
Fitted Load (Turbocharged)	18.4 lb ± 8½ oz (8,37 kg ± 240 grammes)
Load at 1 13/16 in (46 mm) Spring Length (Normally Asp.)	21.47 lb ± 9½ oz (9,75 kg ± 270 grammes)
Load at 1 13/16 in (46 mm) Spring Length (Turbocharged)	26.6 lb±12½ oz (12,0 kg±355 grammes)

Lubricating Oil Filter

Type of Filter	Full Flow
Element Type	Paper or Replaceable Cannister
By-Pass Valve Setting	8/12 lbf/in² (0,56/0,84 kgf/cm²) — 55/82 kN/m²
Type of Valve	Pressure Differential Spring Loaded Ball (paper type only)

COOLING SYSTEM

Type of Cooling System

Cylinder Head	Water Pump Circulation
Cylinder Block	Thermo-Syphon
Engine Water Capacity (Less Radiator)	20 Imperial Pints (11,4 Litres)

Thermostat

Type	Bellows or Wax
Opening Temperature	170/182°F (77/83°C)
Fully Open at	202°F (94°C)
Valve Lift	0.312/0.469 in (7,92/11,91 mm)

Water Pump

Type	Centrifugal
Outside Diameter of Shaft for Pulley	0.7492/0.7497 in (19,03/19,04 mm)
Inside Diameter of Pulley Bore	0.7500/0.7508 in (19,05/19,07 mm)
Clearance Fit of Pulley on Shaft	0.0003/0.0016 in (0,01/0,05 mm)
Outside Diameter of Shaft for Impeller	0.6262/0.6267 in (15,9/15,92 mm)
Diameter of Impeller Bore	0.6249/0.6257 in (15,87/15,89 mm)
Interference Fit of Impeller on Shaft	0.0005/0.0018 in (0,013/0,046 mm)
Impeller Blade to Body Clearance	0.012/0.035 in (0,3/0,89 mm)

FUEL SYSTEM

Fuel Oil Specification	
United Kingdom	BS.2869: 1967 — Class A1 and A2.
United States	A.S.T.M/D.975 — 66T — Nos. 1-D and 2-D Federal Specification VV — F — 800: Grades DF-A, DF-1 and DF-2 (according to operating ambient temperature).

TECHNICAL DATA—B.14

Germany	DIN-51601 (1967)
France	J.O. 14/9/57 Gas Oil.
Italy	CUNA — Gas Oil NC-630-01 (1957).
India	IS: 1460/1968—Grade Special and Grade A.
Switzerland	Federal Military Specification 9140-335-1404 (1965).

Fuel Lift Pump

Type of Pump	A.C. Delco—U.F. Series
Method of Drive (Vertical Engines)	Eccentric on Camshaft
Method of Drive (Horizontal Engines)	Eccentric on Auxiliary Drive Shaft
Delivery Pressure	5/8 lbf/in^2 (0,35/0,56 kgf/cm^2)
Diaphragm Spring Colour	Blue

Fuel Filter

Element Type	Paper Element
Pressure Valve	Gravity Vent Valve

Fuel Injection Pump

Make	C.A.V.
Type	D.P.A.
Pump Rotation	Anti-Clockwise viewed from drive shaft end.
Timing Letter (Hydraulic)	'H'
Timing Letter (Mechanical)	'F'
No. 1 Cylinder Outlet	'X'

ATOMISERS

Make C.A.V.

Code	Holder	Nozzle	Setting Pressure	Working Pressure
X	BKBL67S5100	BDLL150S6225	175 atm (181 kgf/cm^2) 2570 lbf/in^2	170 atm (176 kgf/cm^2) 2500 lbf/in^2
Y	BKBL67S5151	BDLL150S6329	175 atm (181 kgf/cm^2) 2570 lbf/in^2	170 atm (176 kgf/cm^2) 2500 lbf/in^2
CM	BKBL67S5299	BDLL150S6472	195 atm (201 kgf/cm^2) 2870 lbf/in^2	180 atm (186 kgf/cm^2) 2650 lbf/in^2
CN	BKBL67S5299	BDLL150S6329	195 atm (201 kgf/cm^2) 2870 lbf/in^2	180 atm (186 kgf/cm^2) 2650 lbf/in^2
CP	BKBL67S5299	BDLL150S6435	195 atm (201 kgf/cm^2) 2870 lbf/in^2	180 atm (186 kgf/cm^2) 2650 lbf/in^2
DW	BKBL67S5299	BDLL150S6382	210 atm (217 kgf/cm^2) 3090 lbf/in^2	195 atm (201 kgf/cm^2) 2870 lbf/in^2
ZZ	BKBL67S5151	BDLL150S6395	175 atm (181 kgf/cm^2) 2570 lbf/in^2	170 atm (176 kgf/cm^2) 2500 lbf/in^2
CL	BKBL67S5299	BDLL150S6507	210 atm (217 kgf/cm^2) 3090 lbf/in^2	195 atm (201 kgf/cm^2) 2870 lbf/in^2
FC	BKBL67S5299	BDLL150S6649	210 atm (217 kgf/cm^2) 3090 lbf/in	195 atm (201 kgf/cm^2) 2870 lbf/in^2
AF	BKBL67S5100	BDLL150S6435	175 atm (181 kgf/cm^2) 2570 lbf/in^2	170 atm (176 kgf/cm^2) 2500 lbf/in^2
AN	BKBL67S5151	BDLL150S6472	175 atm (181 kgf/cm^2) 2570 lbf/in^2	170 atm (176 kgf/cm^2) 2500 lbf/in^2
AT	BKBL67S5238	BDLL150S6472	205 atm (212 kgf/cm^2) 3010 lbf/in^2	190 atm (196 kgf/cm^2) 2790 lbf/in^2
DV	BKBL67S5299	BDLL150S6576C	215 atm (222 kgf/cm^2) 3160 lbf/in^2	200 atm (207 kgf/cm^2) 2940 lbf/in^2
DL	BKBL67S5299	BDLL150SY6545	210 atm (217 kgf/cm^2) 3090 lbf/in^2	195 atm (201 kgf/cm^2) 2870 lbf/in^2
EG	BKBL67S5299	BDLL150S6600	210 atm (217 kgf/cm^2) 3090 lbf/in^2	195 atm (201 kgf/cm^2) 2870 lbf/in^2
FL	BKBL67S5299	BDLL150S6673	215 atm (222 kgf/cm^2) 3160 lbf/in^2	200 atm (207 kgf/cm^2) 2940 lbf/in^2

Engine Checking and Fuel Pump Marking Angles, Static Timing

The correct marking angles and static timing can be found by reference to the prefix letters and figures of the setting code adjacent to the word "Set" on the fuel pump identification plate. Engine checking and fuel pump marking angles are for use with timing tool MS67B.

Prefix Letters 6.354 & 6.3542	Engine Checking Angle (Degrees) (with engine at TDC compression)	Fuel Pump Marking Angle (Degrees)	Static Timing (BTDC—Degrees)	Piston Displacement BTDC
A50E	154	143	22	0.230 in (5,84 mm)
AX53, AX58, AX60	159	146	26	0.325 in (8,26 mm)
AY58E	159	145	28	0.372 in (9,45 mm)
AY59	160	146	28	0.372 in (9,45 mm)
AY62E	150	146	28	0.372 in (9,45 mm)
BX64	160	144	32	0.485 in (12,32 mm)
BY57E	160	146	28	0.372 in (9,45 mm)
CR52, CR55, CR62, ER42, ER45, ER47, ER51, ER54, ER57	158	144	28	0.372 in (9,45 mm)
EX42E	155	146	18	0.155 in (3,94 mm)
EX51E, EX53E	160	146	28	0.372 in (9,45 mm)
EX56	159	146	26	0.325 in (8,26 mm)
EX56E, FX46E	160	146	28	0.372 in (9,45 mm)
GX52E	156	144	24	0.275 in (6,98 mm)
HX51E	160	146	28	0.372 in (9,45 mm)
KX46E, KX47E	154	143	22	0.230 in (5,84 mm)
LR52, LR54, LR58	155	142	26	0.325 in (8,26 mm)
MR52, MR56	161	147	28	0.372 in (9,45 mm)
MR62, MR66, MR69, MR72	158	144	28	0.372 in (9,45 mm)
MX49E	161	146	30	0.426 in (10.82 mm)
MX53E, MX56, MX56E	160	146	28	0.372 in (9,45 mm)
PR62, PR63	158	142	32	0.485 in (12,32 mm)
PX53E, PX56E	160	146	28	0.372 in (9,45 mm)
RR62, RR63, RR67	158	144	28	0.372 in (9,45 mm)

Prefix Letters	Engine Checking Angle (Degrees) (with engine at TDC compression)	Fuel Pump Marking Angle (Degrees)	Static Timing (BTDC—Degrees)	Piston Displacement BTDC
SR55, SR58, SR63, SR64, SR67	154	143	22	0.230 in (5,84 mm)
WR51E	160	146	28	0.372 in (9,45 mm)
WR57	159	145	28	0.372 in (9,45 mm)
WX48E	157	144	26	0.325 in (8,26 mm)
XR55, XR60, XR63, YR56, YR58, YR62, YR70	154	143	22	0.230 in (5,84 mm)
ZR61	160	146	28	0.372 in (9,45 mm)
T6.354				
BX84, CX75	160	144	32	0.485 in (12,32 mm)
CY106E	153	145	16	0.125 in (3,18 mm)
DR69, DR82, DR88	156	143	26	0.325 in (8,26 mm)
DR91	154	143	22	0.230 in (5,84 mm)
DX92, DX96	161	146	30	0.426 in (10,82 mm)
DY80E	160	144	32	0.485 in (12,32 mm)
ET69	160	144	32	0.485 in (12,32 mm)
JR91	154	143	22	0.230 in (5,84 mm)
JR105	158	143	30	0.426 in (10,82 mm)
KR70, KR70E	160	146	28	0.372 in (9,45 mm)
KR79/600/9/2450	162	146	32	0.485 in (12,32 mm)
KR79/750/6/2380	160	146	28	0.372 in (9,45 mm)
KR69/750/6/2520	162	146	32	0.485 in (12,32 mm)
KR79/750/9/2300	162	146	32	0.485 in (12,32 mm)
KR79/750/9/2350	160	146	28	0.372 in (9,45 mm)
KR79/750/9/2430, KR79/750/9/2450	162	146	32	0.485 in (12,32 mm)
KR79E	162	146	32	0.485 in (12.32 mm)
KR82, KR82E	160	146	28	0.372 in (9,45 mm)
KR85	162	146	32	0.485 in (12,32 mm)
LX61E, LX69E, LX71E	159	144	30	0.426 in (10,82 mm)
TR71, TR84	158	144	28	0.372 in (9,45 mm)
TX71E, TX76E	159	144	30	0.426 in (10,82 mm)
UR88	158	142	32	0.485 in (12,32 mm)

Prefix Letters	Engine Checking Angle (Degrees) (with engine at TDC compression)	Fuel Pump Marking Angle (Degrees)	Static Timing (BTDC—Degrees)	Piston Displacement BTDC
VR72, VR74, VR76E, VR82, VR88, VR90	159	144	30	0.426 in (10,82 mm)
XX69E, XX75E	159	144	30	0.426 in (10,82 mm)
YR73	156	143	26	0.325 in (8,26 mm)
YX84E, YX90E	160	144	32	0.485 in (12,32 mm)
ZX59E	158	146	24	0.275 in (6,98 mm)
6.372				
HR65, HR67	158	144	28	0.372 in (9,45 mm)
SX59E	158	146	24	0.275 in (6,98 mm)

ELECTRICAL SYSTEM

Alternator

Make	C.A.V. or Lucas
Type	AC5, 11AC, 15ACR, 17 ACR or 18ACR
Maximum output AC5 12 volt (hot)	55A
Maximum output AC5 24 volt (hot)	31A
Maximum output 11AC 12 volt (hot)	43A
Maximum output 15ACR (hot)	28A
Maximum output 17ACR (hot)	36A
Maximum output derated 17ACR (hot)	25A
Maximum output 18ACR (hot)	45A

Dynamo

Make	Lucas
Type	C40L—2 Brush Shunt Wound
Rotation	Clockwise
Maximum Output	25 amps
Cut-In Speed	630/744 rev/min

Starter Motor

Make	Lucas or C.A.V.
Type	M45G CA45 or M50
Maximum Current	1150 amps
Starter Cable Resistance	0.0017 ohms max.
No. of Teeth on Pinion	10

Note : The above data is general and can vary with individual applications.

Starting Aid

Make	C.A.V.
Voltage	12 (24 volt systems have resistor in circuit)
Maximum Current Consumption	12.5 — 13.5 A at 11.5V
Flow Rate through Thermostart	3.5 — 5.0 ml/min
Height of Reservoir above centre of Thermostart ...	4½/10 in (114,3/254 mm)

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	Transverse	0.005 in (0,13 mm)
	Longitudinal	0.010 in (0,25 mm)
Maximum Bore Wear (when reboring or new liners are necessary) ...		0.008 in (0,2 mm)
Crankshaft Main and Big End Journal Wear, Ovality		0.0015 in (0,04 mm)
Maximum Crankshaft End Float		0.015 in (0,38 mm)
Valve Stem to Bore/Guide Clearance	Inlet	0.005 in (0,13 mm)
	Exhaust	0.006 in (0,15 mm)
Valve Head Thickness between run-out of valve seat and face of valve		1/32 in (0,79 mm)
Valve Head Depth below Cylinder Head Face—Service Maximum		0.060 in (1,52 mm)
Rocker Clearance on Rocker 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 (heavy duty)		0.010 in (0,25 mm)
Idler Gear End Float (standard)		0.012 in (0,30 mm)

SECTION C
Operating and Maintenance

STARTING THE ENGINE

Turn starter switch to position "R" (see Fig. C.1) and ensure that the engine stop control is in the run position (i.e., pushed fully home).

Place engine speed control in maximum speed position.

If the engine or weather is warm, turn starter switch in a clockwise direction to the "HS" position.

As soon as the engine starts release the switch to the "R" position.

Be sure that the starter pinion and engine have stopped rotating before re-engaging the starter motor otherwise damage may result.

If weather is cold, turn starter switch to the "H" position and hold it there for fifteen to twenty seconds.

Then turn the starter switch to the "HS" position, thereby engaging the starter motor.

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

As soon as the engine starts, release the switch to the "R" position.

Earlier Heat Start Switch

The cold start switch supplied with 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 sometimes 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.

Starting the Engine (Alternative Method)

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

The cold starting procedure is however 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 both starter switch and heater button.

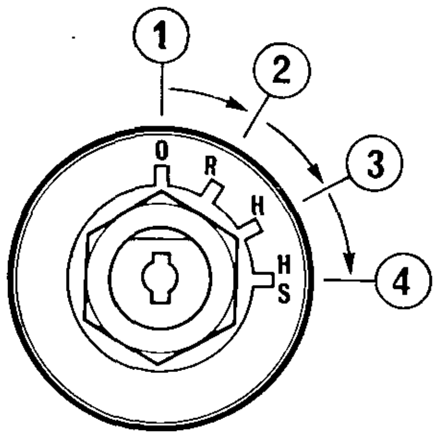


Fig. C.1.

Combined Heat/Start Switch.

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

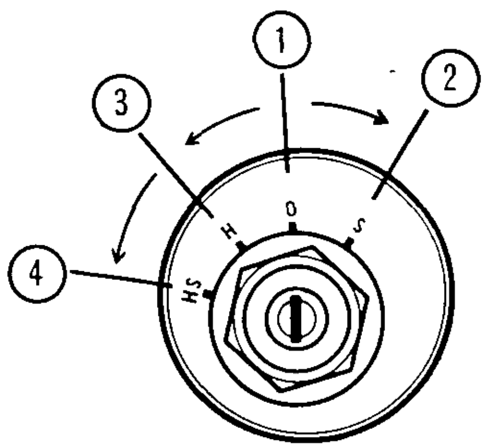


Fig. C.2.

Earlier Combined Heat/Start Switch.

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

To Stop the Engine

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

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

Turn the start switch to the "O" position.

Things to Note

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

In the event of difficult starting, check that fuel is reaching the cold starting aid in the induction manifold by unscrewing the inlet fuel connection. If fuel is reaching it satisfactorily, then it may be that the cold starting aid itself is not working correctly. This can be checked by removing the air cleaner and watching the cold starting aid whilst the equipment is used. When the starting switch is turned to the "heat" position, the element should become red hot, and on engagement of the starter motor, it should burst into flame.

The 6.354 engine is fitted with efficient cold starting equipment and no responsibility can be accepted for any damage caused by unauthorised starting aids.

Running In

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 coolant is first allowed to reach a temperature of at least 140°F (60°C).**

PREVENTIVE MAINTENANCE

The following "Periods" are general in their application. The operator should compare the Routine Maintenance for his particular engine with the schedules as laid down by the manufacturer of the particular machine or vehicle into which his Perkins engine has been installed, and he should adopt the shorter period, where relevant.

Whilst we have given specific periods for preventive maintenance, you should have due regard for the local regulations concerning your vehicle or machine and ensure that the engine is operating within those regulations.

The maintenance periods should be reduced to suit any exceptional operating conditions, such as stop-start, low mileage work, where the hours or engine running time are more applicable than the mileage run, or continuous sustained high speeds or temperatures.

The cleaning and replenishing of the oil bath air cleaner, or the replacement of the paper element filter should be done far more often than the periods quoted above if extremely dusty conditions are prevalent.

It is good engineering practice to check for water, fuel and lubricating oil leaks and the tightness of nuts, setscrews and hose clips at each servicing period.

It should be noted that the maintenance periods given are on the assumption that the fuel and lubricating oils are to the specifications given in this manual.

Daily or Every 8 hours (whichever occurs first)

Check coolant level.

Check sump oil level.

Check oil pressures (where gauge fitted).

In extreme dust conditions, clean oil bath air cleaner and empty dust bowl on dry type air cleaner.

Every 5,000 Miles (7,500 km), 250 Hours or 4 Months (whichever occurs first)

Drain and renew engine lubricating oil (see lubricating oils.

Renew lubricating oil filter element or canister.

Check drive belt tension.

Clean oil bath air cleaner.

Empty dust bowl on dry type air cleaner.

Clean compressor air cleaner (if fitted).

Clean water trap.

Lubricate dynamo rear bush (where fitted).

Turbocharged Engines. Renew turbocharger lubricating oil filter element (where fitted).

Every 10,000 Miles (15,000 km), 500 Hours or 12 Months (whichever occurs first)

Clean lift pump gauze strainer.

Renew final fuel filter element — T.A., and Industrial applications.

Check hoses and clips.

Every 20,000 Miles (30,000 km), 1,000 Hours

Renew final fuel filter element — Vehicle engines.

Decarbonise compressor cylinder head.

Clean element of dry type air cleaner or renew.

Turbocharged Engines. Clean turbocharger impeller, diffuser and oil drain pipe.

Every 60,000 Miles (90,000 km), 2,500 Hours

Arrange for examination and service of proprietary equipment, i.e., compressor/exhauster, starter motor, dynamo, etc.

Service atomisers.

Check and adjust valve clearance (see Page E.8).

POST DELIVERY CHECKOVER

After a customer has taken delivery of his Perkins Diesel engine, a general checkover of the engine must be carried out after the first 500/1000 miles (800/1600 km) or 25/50 hours in service.

The checkover should comprise the following points :—

1. Drain lubricating oil sump and refill to full mark on dipstick with new oil. Remove and clean sump strainer where possible. Change lubricating oil filter element or canister.
2. Remove rocker assembly and check cylinder head nuts are to correct torque (See Page B.2) (not necessary with turbocharged engines, 6.372 and 6.3542 engines).
   The correct procedure for retightening of cylinder head nuts is given on Page E.9.
3. Refit rocker assembly and set valve clearance to 0.012 in (0,30 mm) cold.
4. Check coolant level in radiator and inspect for leaks.
5. Check external nuts, setscrews, hose clips, mountings etc., for tightness.
6. Check belt tension.
7. Check electrical equipment and connections.
8. Check for lubricating and fuel oil leaks.
9. Check general performance of engine.

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 discarded at the end of the storage 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.
6. Drain the cooling system, see Page C.4. To give protection against corrosion, it is better to fill the cooling system with a coolant that has a corrosion inhibitor, see Page C.4. 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 (¼ 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.
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 maintenace of a good cooling system with frost and/or corrosion protection.

1. Where possible, use clean soft water.
2. When frost protection is not necessary, it is still an advantage to use an approved antifreeze mixture (see 3 below) 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. The mixture of additives given below has been found to give good results.
   Sodium Benzoate 10-15 gramme/litre
   Sodium Nitrite 1-2 gramme/litre
   Benzatriazole 0.5 gramme/litre
   pH (acid/alkaline) Control Additive
   Change the water/corrosion inhibitor mixture every six months or check according to the inhibitor manufacturer's recommendations.
   NOTE : Some corrosion inhibitor mixtures contain soluble oil which can have an adverse effect on some types of water hose.
3. If an antifreeze mixture is used to prevent frost damage, it must have an ethylene glycol (ethanediol) base. An antifreeze that is to one of the standards given below or to an equal standard is acceptable if the pH value is kept within the range of 7.0-8.5 when diluted.

U.K. BS 3151:1959
'Ethanediol Antifreeze Type B with Sodium Benzoate and Sodium Nitrite Inhibitors'.
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. Perking POWERPART Antifreeze fully passes the above standards.

Lowest Temp. of Protection Needed	% Volume of POWERPART Antifreeze	Mixture Ratio by Vol. 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
–60°C (–76°F)	66	2:1

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

If the correct precedures 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 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 of the radiator 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.
7. If the cooling system is left drained, it is advisable to further safeguard the oil cooler (where fitted) by inserting ½ pint (0,28 litre) of undiluted antifreeze into the cooler to prevent freezing of any water that may drain into the cooler if the machine is moved.

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, 60, 62, 63.
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, 63.
Black exhaust	11, 13, 14, 16, 18, 19, 20, 22, 24, 25, 27, 28, 29, 31, 32, 33, 60.
Blue/white exhaust	4, 16, 18, 19, 20, 25, 27, 31, 33, 34, 35, 45, 56, 61.
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, 64.
Poor compression	11, 19, 25, 28, 29, 31, 32, 33, 34, 46, 59.
Starts and stops	10, 11, 12.

KEY TO FAULT FINDING CHART

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.
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 water pump drive belts.
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. Damaged or dirty turbocharger impeller.
61. Leaking turbocharger oil seals.
62. Leaking boost control pipe.
63. Leaking induction system.
64. Defective exhauster/leaking vacuum pipe.

SECTION E
Cylinder Head

NOTE: Cylinder heads for 6.3542 and 6.372 have special coring for improved coolant flow and are not interchangeable with normal 6.354 cylinder heads.

Special bushed rockers, high load valve springs with associated valve spring caps are also fitted to the 6.3542 engine to provide overspeed protection.

To Remove the Cylinder Head

1. Drain the cooling system.
2. Uncouple all connections to the turbocharger (if fitted) and remove.
3. Remove air cleaner and any connecting hose.
4. Disconnect battery terminals.
5. Release the electrical connection to the water temperature gauge (if fitted) and release the water outlet hose.
6. Release electrical connection to the thermostart, feed and return fuel pipes to the thermostart unit and container.
7. Detach the exhaust pipe and remove the exhaust and induction manifolds.
8. Remove the fuel pipe from fuel lift pump to fuel filter.
9. Disconnect breather pipe from rocker cover.
10. Remove fuel pipes connecting fuel filter and fuel injection pump. Remove fuel filter from bracket.
11. Remove high pressure pipes and atomiser leak off pipe assembly.
12. Remove atomisers.
13. Remove the rocker cover and rocker shaft assembly (Fig. E.2). The push rods may stick to the rockers and if they drop off they can drop through to the sump. To avoid this, lift the rocker shaft assembly a small amount and pull each push rod down to its seat in the tappet, then the rocker shaft can be lifted straight off. Remove push rods.
14. Remove cylinder head nuts in reverse order of tightening sequence (Fig. E.13).
15. Remove cylinder head.

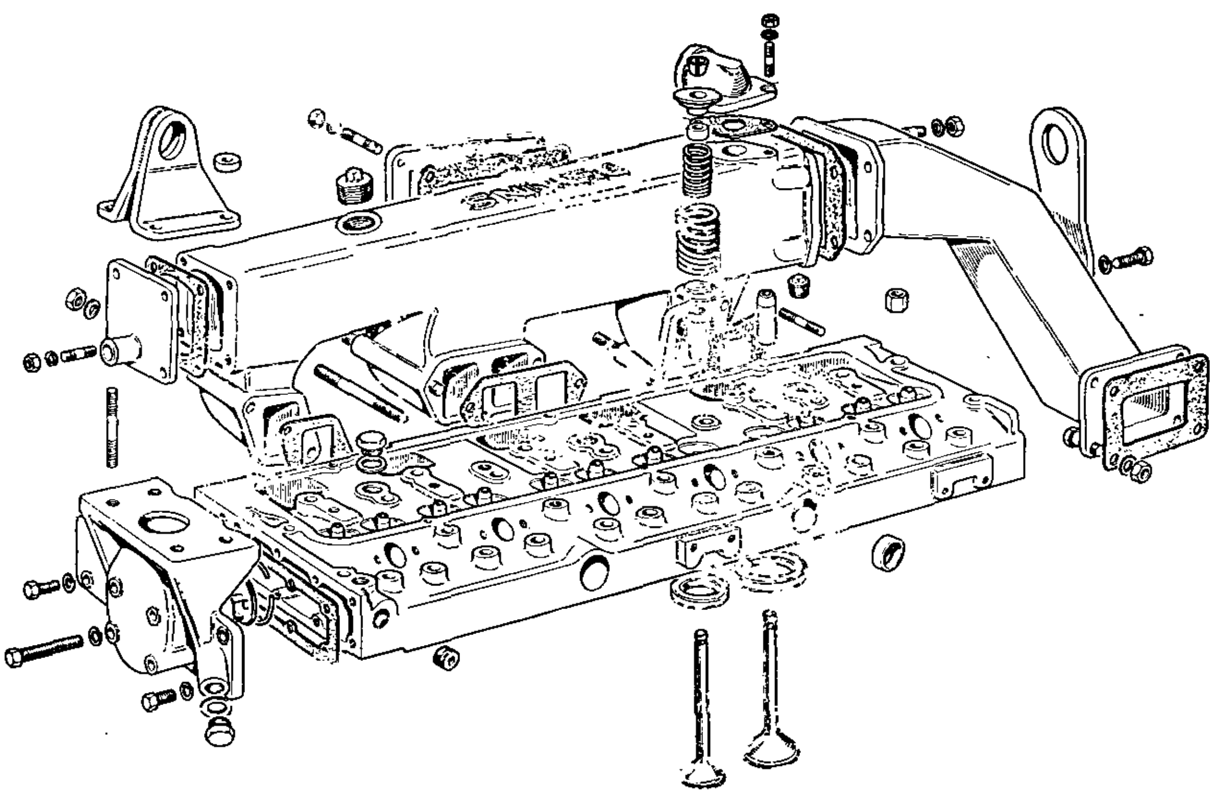


Fig. E.1. Exploded view of Cylinder Head Assembly.

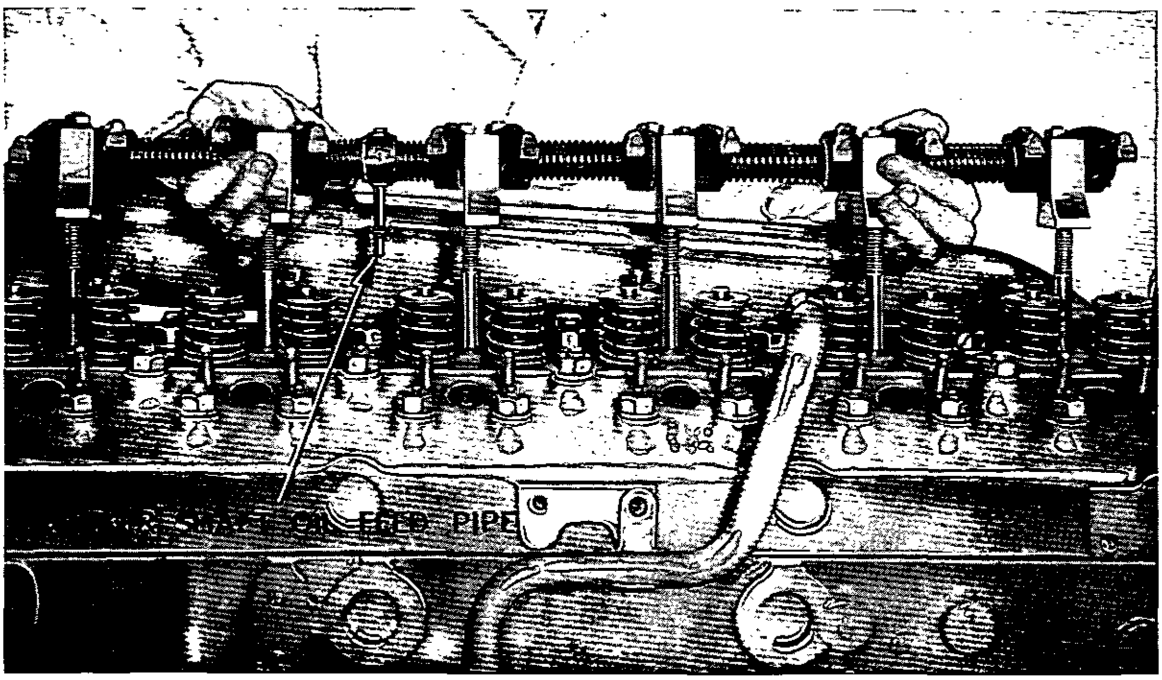


Fig. E.2. Removing Rocker Shaft Assembly.

With earlier engines, the valves are marked 1 and 1, 2 and 2 etc., commencing at the front of the engine. On very early engines, valves are numbered 1 to 12 commencing at the front of the engine. The cylinder head is marked with corresponding numbers opposite the valve seats.

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

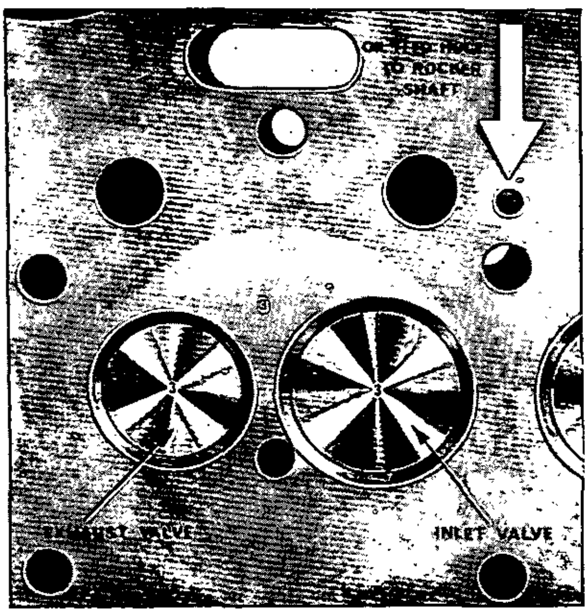


Fig. E.3. Valve Numbering.
(Earlier engines only)

An exploded view of the valve assemblies is shown in Fig. E.10.

1. Compress spring caps and springs (Fig. E.4) and remove the two half conical collets.
2. Remove spring caps, springs and rubber oil deflectors from valve stems. Remove valves.

Cleaning

1. Clean cylinder head.
2. If the water jacket of the cylinder head shows signs of scale, a proprietary brand of descaling solution should be used.
3. Blank off rocker oil feed between Nos. 2 and 3 cylinders and remove carbon from pistons and cylinder block face.
4. After valve seat machining and valve grinding operations have been carried out, all parts should be washed in cleaning fluid.

Valve Guides

Examine valve guides for wear and, if necessary, renew.

To fit new guides, smear the outer surface with clean oil and using a suitable press, drive home until 0.594 in (15,08 mm) of the guide is protruding above the bottom face of the valve spring recess.

(Figs. E.6 and E.7 show the guides being removed and replaced by a special service tool).

Valves and Valve Seats

Examine valves for cracks. Check wear of valve stems and their fit in the valve guides.

When fitting new valves in production, the clearance between the valve head and cylinder head bottom face is not less than 0.029 in (0,74 mm) for inlet and exhaust and not greater than 0.039 in (0,99 mm).

In service, the maximum clearance for both inlet and exhaust valves should not exceed 0.050 in (1,27 mm) for cylinder heads with three exhaust ports or 0.060 in (1,52 mm) for cylinder heads having four exhaust ports. Valve seat inserts can be fitted (Page E.4).

Where engines have to conform with the smoke density regulation B.S. AU 141a : 1971, then the valve depths must not exceed the production limits as given on Pages B.8 and B.9.

The valve seats in the cylinder head should be reconditioned, by means of valve seat cutters or specialised grinding equipment at an angle of 45°

As narrow a seat as possible should always be maintained.

Hand Grinding

When grinding in valves, it is essential that no signs of pitting are left on the seatings. At the same time care should be taken to avoid unnecessary grinding away of the seat.

After grinding operations have been completed, check the valve head depths relative to the cylinder head face, and wash the cylinder head.

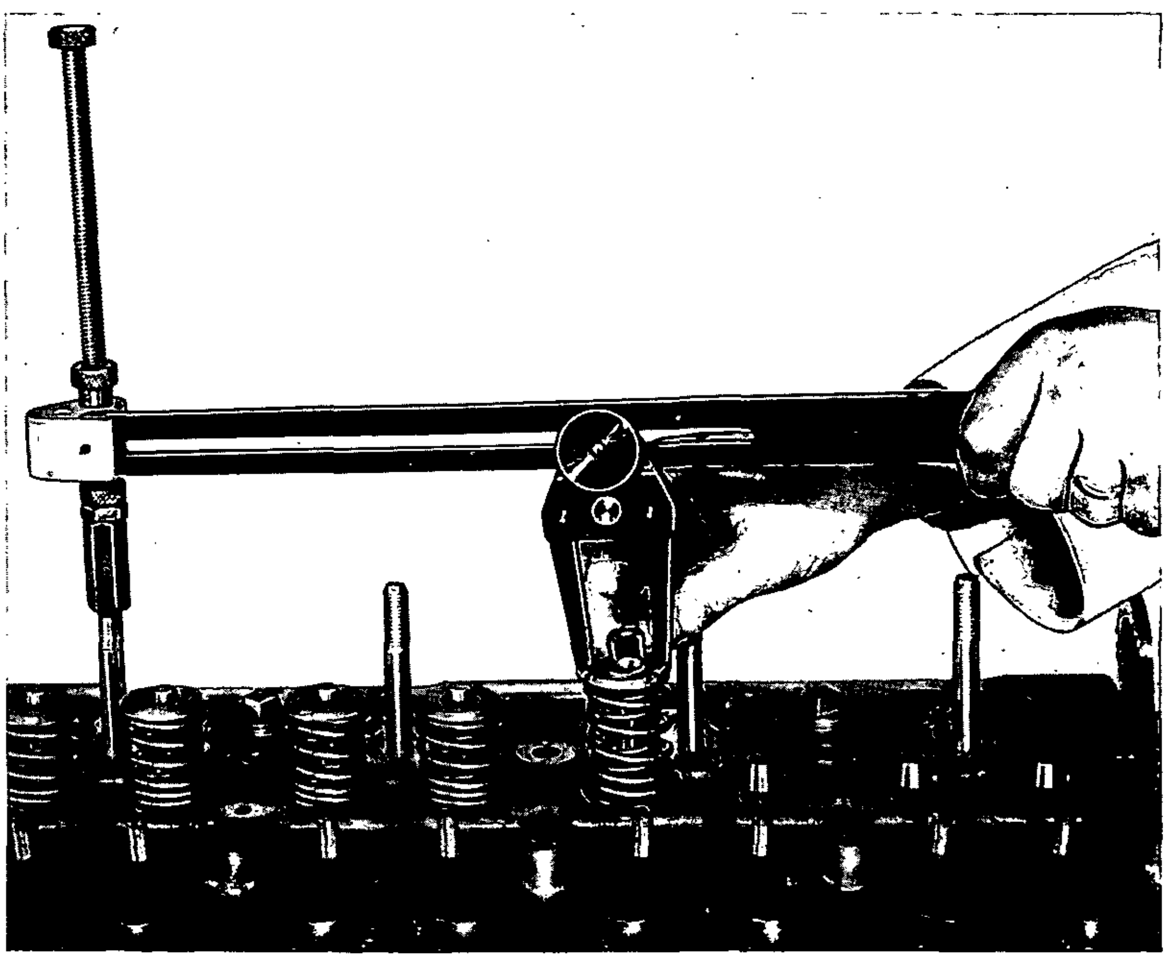


Fig. E.4. Removing Valve Assembly.

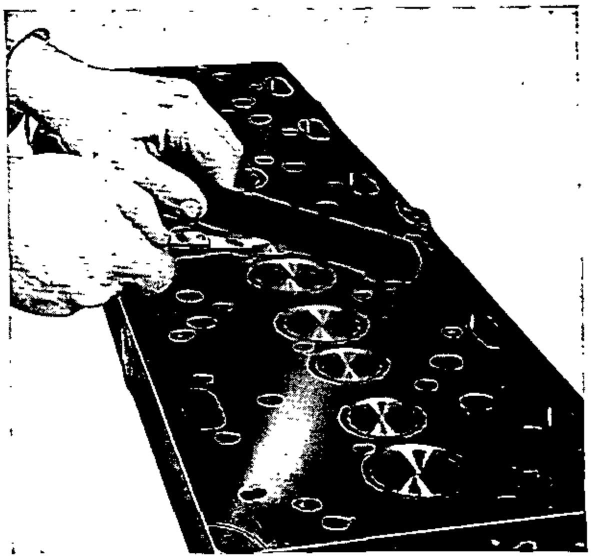


Fig. E.5. Checking Valve Depth.

Valve Seat Inserts

Valve seat inserts are not fitted to normally aspirated 6.354 production engines. They are fitted to turbocharged engines.

In the case of the 6.354 engine inserts can be fitted.

When fitting inserts, ensure that genuine Perkins Parts are used and proceed as follows :—

1. Press out the existing guide and clean the parent bore.
2. Press in new guide.
3. Using the valve guide bore as a pilot, machine the recess in the cylinder head to the dimensions in Fig. E.8.

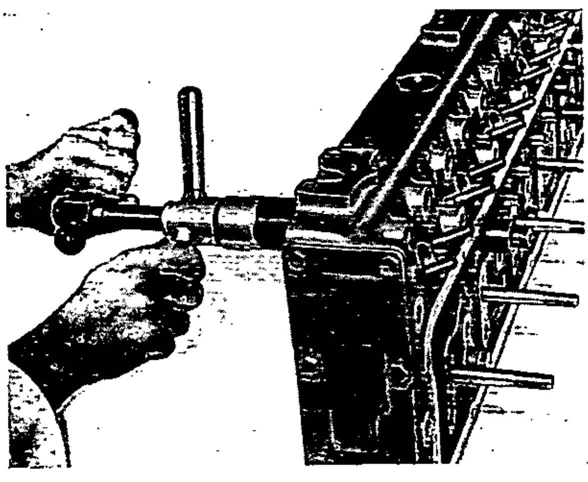


Fig. E.6. Replacing Valve Guides.

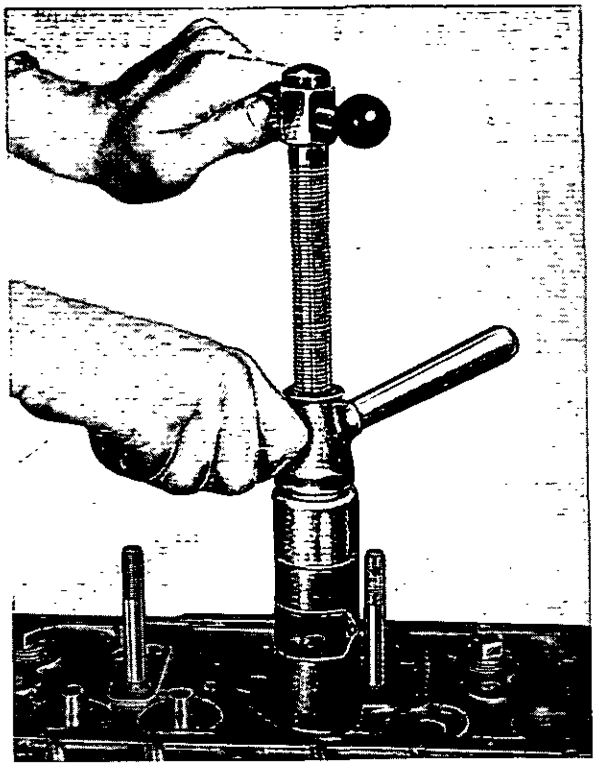


Fig. E.7. Removing Valve Guides.

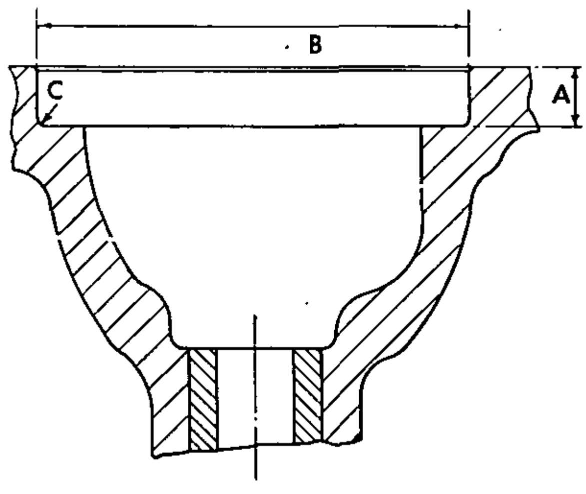


Fig. E.8.
Valve Seat. Cutting Dimensions.

Inlet

A—0.283/0.288 in (7,19/7,31 mm)
B—2.0165/2.0175 in (51,22/51,24 mm)
C—Radius 0.015 in (0,38 mm) Max.

Exhaust

A—0.375/0.380 in (9,52/9,65 mm)
B—1.678/1.679 in (42,62/42,64 mm)
C—Radius 0.015 in (0,38 mm) Max.

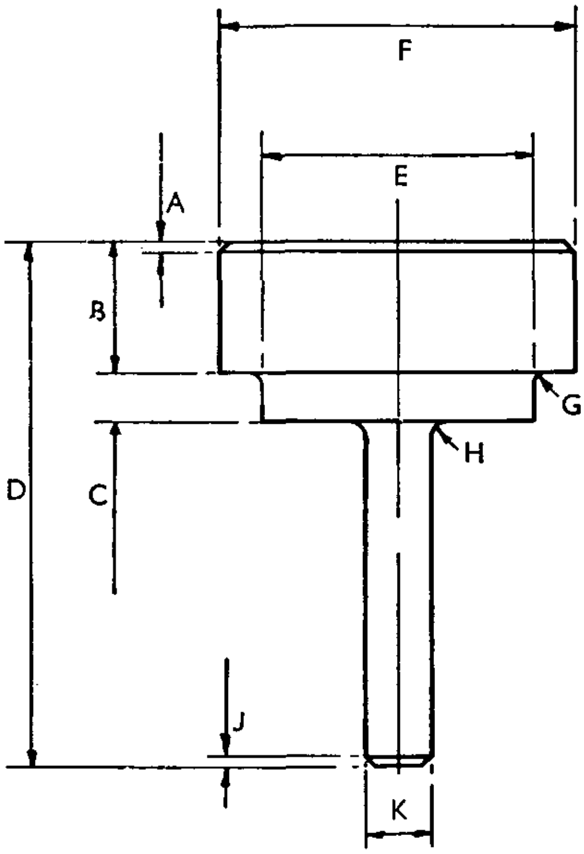


Fig. E.9. Press Tool for Valve Seat Inserts.

Key to Fig. E.9.

Inlet

A—$\frac{1}{16}$ in (1,59 mm) at 45°

B—$\frac{3}{4}$ in (19,05 mm)

C—0.250 in (6,35 mm)

D—3 in (76,20 mm)

E—1.582/1.583 in (40,18/40,21 mm)

F—2.009/2.019 in (51,03/51,28 mm)

G—$\frac{1}{32}$ in (0,79 mm) radius

H—$\frac{1}{16}$ in (1,59 mm) radius

J—$\frac{1}{16}$ in (1,59 mm) at 45°

K—0.372/0.373 in (9,45/9,47 mm)

Exhaust

A—$\frac{1}{16}$ in (1,59 mm) at 45°

B—$\frac{3}{4}$ in (19,05 mm)

C—0.312 in (7,92 mm)

D—3 in (76,20 mm)

E—1.248/1.249 in (31,70/31,72 mm)

F—1.670/1.680 in (43,42/43,67 mm)

G—$\frac{1}{32}$ in (0,79 mm) radius

H—$\frac{1}{16}$ in (1,59 mm) radius

J—$\frac{1}{16}$ in (1,59 mm) at 45°

K—0.372/0.373 in (9,45/9,47 mm)

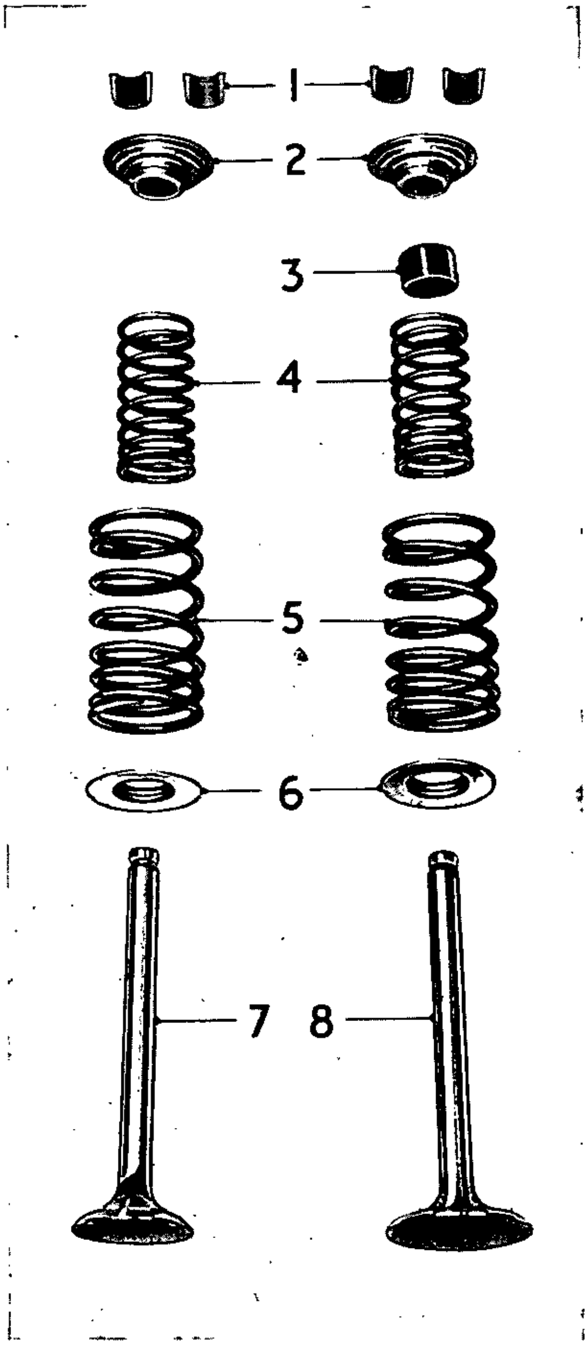


Fig. E.10.
Exploded view of Valve Assemblies.

1. Collets.
2. Valve Spring Cap.
3. Oil Deflector.
4. Inner Valve Spring.
5. Outer Valve Spring.
6. Valve Spring Seat.
7. Exhaust Valve.
8. Inlet Valve.

4. Remove all machining swarf and clean the insert recess. Using the valve guide bore as a pilot, press the insert home with the inserting tool (Fig. E.9). Under no circumstances should the insert be hammered in, neither should lubrication be used during pressing in.
5. Inspect to ensure that the insert has been pressed fully home and is flush with the bottom of the recess.
6. For inlet valve inserts, machine the "flare" to the dimensions given in Fig. E.11 using the valve guide bore as a pilot.
7. Remove all machining swarf and burrs.
8. Cut the valve seat at an included angle of 90° so that the valve head depth below the cylinder head face is within the production limits of 0.029/0.039 in (0,74/0,99 mm).

Note: Work as closely as possible to the minimum figure to allow for re-seating at a later date. When re-facing a valve the included angle of the contact face is 90°.

If the cylinder head face has been skimmed since the fitting of valve seat inserts, then the following is allowed:

(a) Machine to the dimensions given in Fig. E.11 and continue as in stages 7 and 8.

(b) If the insert is damaged or unserviceable through wear, it must be removed and replaced with a new one. Before fitting, however, the back of the insert should be surface ground, removing sufficient material to give a flush fitting. Do not forget to re-chamfer the insert as it was prior to grinding, i.e. 0.020/0.030 in (0,508/0,762 mm) at 45°. Then proceed as in stages 4 — 8.

Skimming of Cylinder Head

A maximum of 0.012 in (0,30 mm) may be removed from the cylinder head providing the nozzle protrusion does not exceed 0.144 in (3,66 mm). This applies as from the following engine numbers:—

354UA 14129TL
354UA 50474L
354US 18830
354U 329416L
354UX 4278HTL
3542U 12924L
372UA 6030L
372U 2802L

Prior to these engine numbers, the maximum nozzle protrusion was 0.224 in (5,69 mm).

Nozzle protrusion must not be obtained by the use of additional atomiser washers.

Valve Springs

A new set of valve springs should always be fitted at every major overhaul.

For engines rated at high speeds, two springs per valve are provided.. Engines rated at lower speeds, have only the outer spring fitted.

Examine the valve springs with regard to squareness of ends and pressures developed at specified lengths, details of which can be found in "Manufacturing Data and Dimensions." Each spring incorporates damper coils at one end and these must be towards the cylinder head.

Rocker Shaft Assembly (Fig. E.12)

To Dismantle:

1. Remove circlips and washers from each end of the rocker shaft.
2. Withdraw the rocker levers, springs and support brackets.

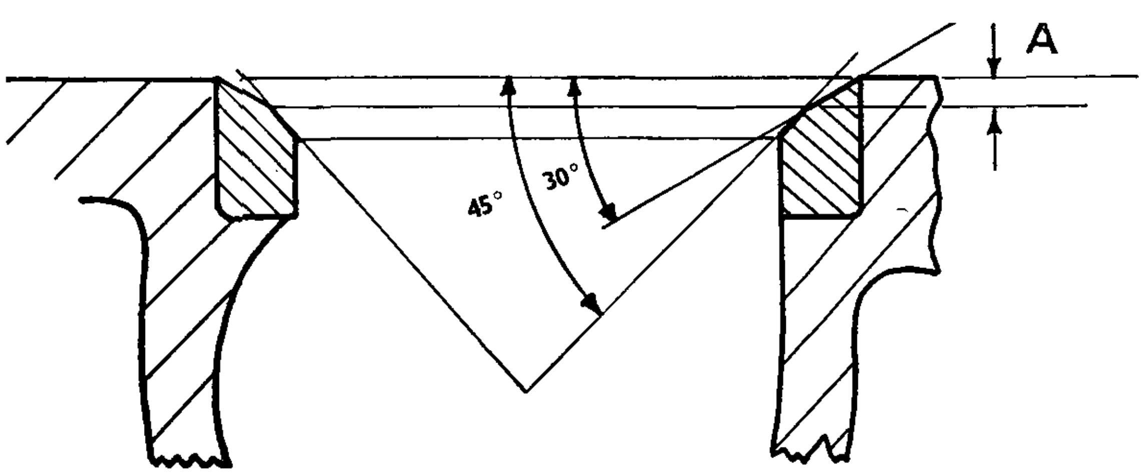


Fig. E.11. Showing Flare to be cut at 30°.   Dimension A—0.094/0.099 in (2,39/2,52 mm).

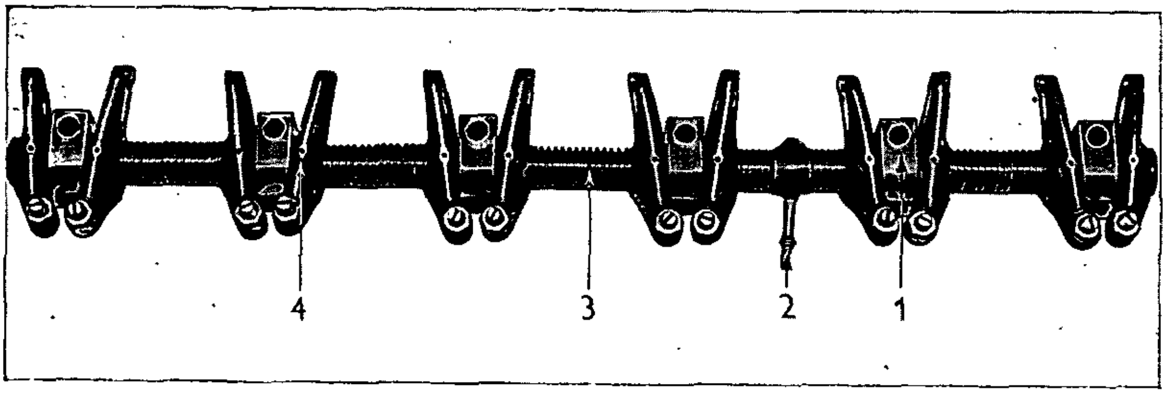


Fig. E.12. Rocker Shaft Assembly.
1. Rocker Shaft Bracket. 3. Spring.
2. Oil Feed Connection. 4. Rocker Arm.

3. Remove the locating screw from the rocker oil feed connection and withdraw the connection. Examine the rocker lever bores and shaft for wear. Rockers should be an easy fit on the shaft without excessive side play.

To Re-assemble :

1. Fit oil feed connection to rocker shaft and secure with the locating screw, ensuring that the screw enters the locating hole in the shaft.
2. Refit the support brackets, springs and rocker levers in the correct order (Fig. E.12).
3. Fit securing washer and circlip to each end of the shaft.

Bushed Rockers

Where rocker levers are fitted with bushes, the bushes can be replaced by pressing out the old one with the new one. Ensure the oil hole in the bush aligns with the oil hole in the rocker, After fitting a new bush, ream out to the dimensions given on page B.10.

Push Rods

Check push rods for straightness. If any are bent, fit replacements.

Valve Stem Oil Seals

All hydraulically governed engines and certain mechanically governed engines have rubber oil deflectors fitted to inlet valve stems only. (see Fig. E.10). When fitting these deflectors, the open end should be towards the cylinder head.

With the majority of mechanically governed engines, oil seals are fitted to both inlet and exhaust valves. Earlier engines had a shallow rubber oil deflector fitted to the valve stems and positioned above the conical valve spring seating collar, the open end of the deflector being fitted towards the cylinder head. Later engines have a rubber oil seal which fits over the valve guide protrusion. In some cases, this latter seal has a nylon insert.

On some engines, the seals have a garter spring fitted around their outer circumference.

In manufacturing, some engines have a red coloured material for inlet valves seals and black for exhaust seals. The red seal may only be fitted over the inlet valve, it is unsuitable for exhaust valves, but the black seal may be fitted to either exhaust or inlet.

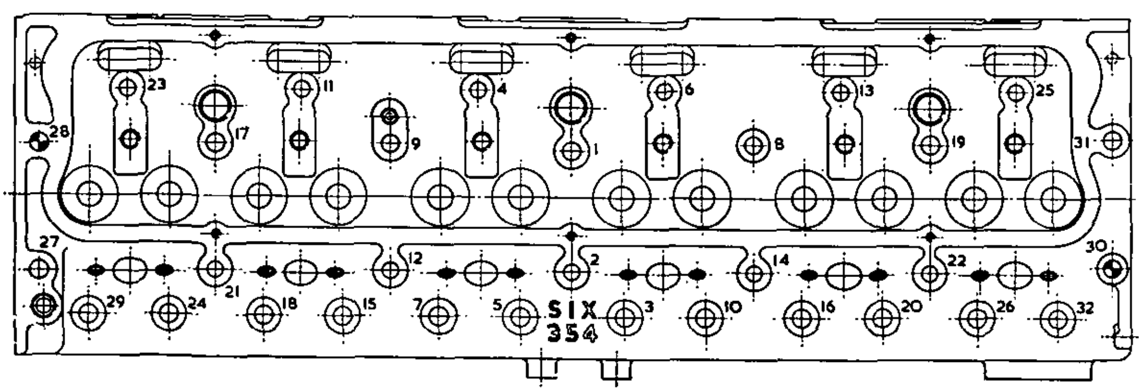


Fig. E.13. Cylinder Head Tightening Sequence.

To Re-Assemble the Cylinder Head

1. Lightly oil valve stems.
2. Fit valve to its correct guide.
3. Locate spring washers.
4. Fit valve stem oil seals.
5. Fit valve springs and spring caps in position.
6. Compress each valve spring and fit the valve collets.

Cylinder Head Gasket

As two types of liners are fitted, i.e. cast iron and chrome plated, with different fitting methods (Page G.1), and there are two sizes of cylinder head studs, i.e., $\frac{7}{16}$ in and $\frac{1}{2}$ in, this has necessitated a number of different cylinder head gaskets. It is **very important** therefore to refer to the Parts List, making sure the correct engine number is applied, in order to select the correct cylinder head gasket. A special cylinder head gasket is used on 6.372 and 6.3542 engines and is not interchangeable with other gaskets.

All gaskets are marked "Top Front."

To Replace the Cylinder Head

The recess in the top face of the cylinder block around each liner must be clean. To clean the top face of the cylinder block, remove the cylinder head studs. Clean the studs. Studs and nuts should be examined for damaged threads. Ensure that the rocker assembly oil feed passage in the cylinder head is clean.

1. KLINGER, VICTOR or COOPER type cylinder head gaskets should be fitted DRY. Jointing compound must not be used with these gaskets. The earlier copper/asbestos gasket should have both sides lightly coated with non-hardening jointing compound. Position the beading of the gasket in the recess around the cylinder liner.

   Where steel laminated cylinder gaskets are used, both sides of the gasket should be coated with Perkins Hylomar jointing compound.

2. Fit cylinder head to cylinder block. Lightly oil nuts and studs before fitting. Tighten cylinder head nuts progressively in three stages in the order as shown in Fig. E.13, until a torque as given on page B.2 is achieved. The final stage should be repeated. $\frac{1}{2}$ in cylinder head studs were introduced as from Engine No. 8060000.

   Studs and setscrews are used on 6.3542 engines, for securing the cylinder head.

3. Refit the push rods and the rocker shaft assembly. The rocker assembly securing nuts or setscrews should be tightened down progressively from the centre outwards to a torque of 32 lbf ft (4,43 kgf m) — 43 Nm for nuts and 55 lbf ft (7,6 kgf m) or 75 Nm for setscrews. A new seal must be used when refitting the rocker oil feed connection. The seal is a square section and should be lightly oiled on its inner and outer surfaces and placed in the appropriate oil feed drilling. On inserting the pipe assembly which has a lead in (Fig. E.14), the seal will butt against the single convolution.

   On the earlier arrangement, the seal which has an "O" section and which must also be renewed, is positioned on the pipe assembly which has two convolutions and no lead in (Fig. E.15). The seal is placed immediately below the lower convolution, and when fitting, the ring seal will roll over the lower convolution and locate correctly between the two.

4. Adjust the valve clearance to 0.012 in (0,30 mm) with engine cold (Fig. E.16).

   When setting valve clearances, the following procedure should be adopted :—

   (a) With valves rocking on No. 6 cylinder (i.e., the period between the opening of

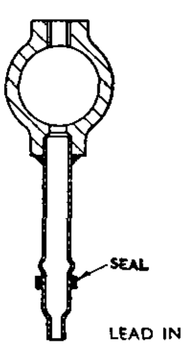


Fig. E.14

Seal in fitted position
Current Arrangement

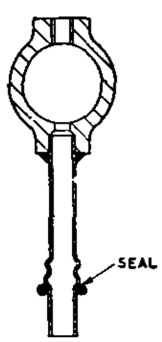


Fig. E.15

Location of seal prior to inserting pipe in position.
Previous arrangement.

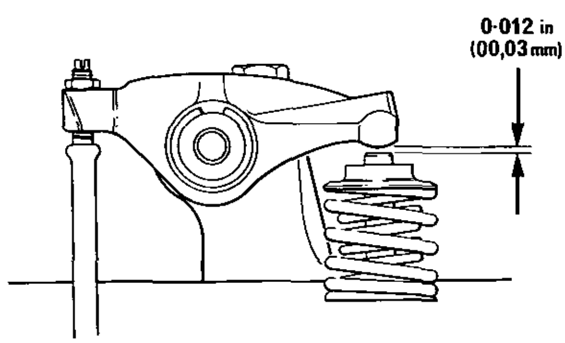


Fig. E.16. Adjusting Valve Clearance.

the inlet valve and the closing of the exhaust valve), set the valve clearance on No. 1 cylinder.

(b) With the valves rocking on No. 2 cylinder, set the valve clearances on No. 5 cylinder.

(c) With the valves rocking on No. 4 cylinder, set the valve clearances on No. 3 cylinder.

(d) With the valves rocking on No. 1 cylinder, set the valve clearances on No. 6 cylinder.

(e) With the valves rocking on No. 5 cylinder, set the valve clearances on No. 2 cylinder.

(f) With the valves rocking on No. 3 cylinder, set the valve clearances on No. 4 cylinder.

5. Refit atomisers with new copper sealing washers ensuring that they seat squarely. Atomiser dust seals are fitted to current engines. Refit the high pressure fuel pipes (see Pages M.10 and M.11).

6. Refit the fuel filter. Refit the pipe connecting the fuel lift pump and fuel filter.

7. Reconnect the fuel pipes to the fuel injection pump and fuel filter. Refit the atomiser leak off assembly.

8. Refit the induction and exhaust manifolds, turbocharger and connections (where fitted) and connect the exhaust pipe.

   Corrugated inlet manifold joints should always be fitted DRY with the notches to the top and tightened to a torque of 24 lbf ft (3,3 kgf m) — 32 Nm.

   After at least 10 minutes following fitting, retorque the setscrews to the original figure. THIS IS IMPORTANT.

9. Refit the air cleaner and connections.

10. Connect the electrical lead, fuel feed and return pipes to the thermostart unit and container.

11. Connect the electrical lead to the water temperature gauge, also the water outlet hose.

12. Connect the battery terminals.

13. Refill the cooling system.

14. Bleed the fuel system of air as described on Page M.11, and start the engine.

15. Check the oil flow to the rocker shaft assembly and allow the engine to warm up.

16. After warming through, the engine should be shut down and the cylinder head nuts again tightened to the correct torque and in the correct sequence, as shown in Fig. E.13.

   Note: When retightening cylinder head nuts, the engine coolant outlet temperature should not be less than 170°F (77°C).

   If the nut moves when retightening, then tighten up to the torque quoted on Page B.2.

   If the nut does not move before the correct torque is achieved, then slacken off 1/12 to 1/6 of a turn (30° to 60°) and retighten to the correct figure.

   After retightening all the nuts, the first 10 positions should be rechecked without further slackening off to ascertain they are still tightened to the torque quoted.

17. Reset the valve clearance to 0.012 in (0,30 mm) cold (Fig. E.16). Fit the rocker cover.

   Where the rocker cover joint is manufactured from black plastic VITON, the rocker cover fixings should not be tightened in excess of 8 lbf ft (1,1 kgf m) — 11 Nm.

   Note: It is most important that the cylinder head be tightened down to the correct torque in the correct sequence after the vehicle or machine has completed 500 miles (800 km) or 25 hours service. This procedure is not necessary where a steel laminated gasket is fitted.

   See above for correct retightening procedure.

SECTION F
Pistons and Connecting Rods

NOTE: Special pistons are used with the 6.3542 engine, having a protection insert in the top ring groove.

6.3542 pistons and standard 6.354 pistons are not interchangeable.

To Remove Piston and Connecting Rod Assemblies

1. Remove the cylinder head, page E.1.
2. Drain and remove the sump, page K.2.
3. Remove the nuts from the big end bolts.
4. Remove the big end caps, bearing shells and bolts (Fig. F.1).

   Note: If the bearings removed are serviceable, mark them for refitting in their original positions.
5. Push pistons and connecting rods out of the top of the cylinders (Fig. F.2).

   Note: Keep each piston and connecting rod assembly separate, each to each as marked.

To Remove Pistons from the Connecting Rods

An exploded view of a piston and connecting rod assembly is shown in Fig. F.3.

1. Remove the rings from each piston.
2. Remove the circlips and withdraw the gudgeon pin. If the gudgeon pin is tight in the

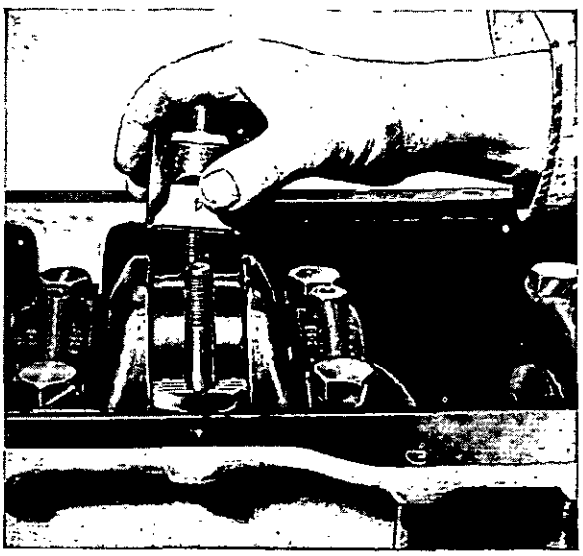


Fig. F.1 Big End Cap Removal.

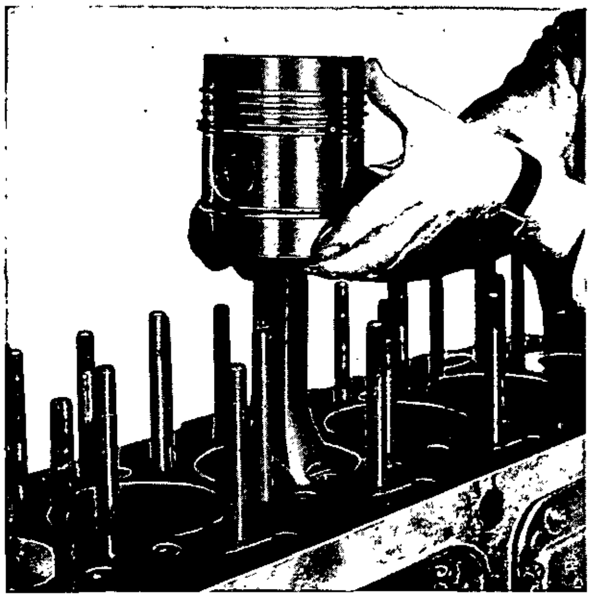


Fig. F.2.

Removing Piston and Connecting Rod Assembly from Cylinder Bore.

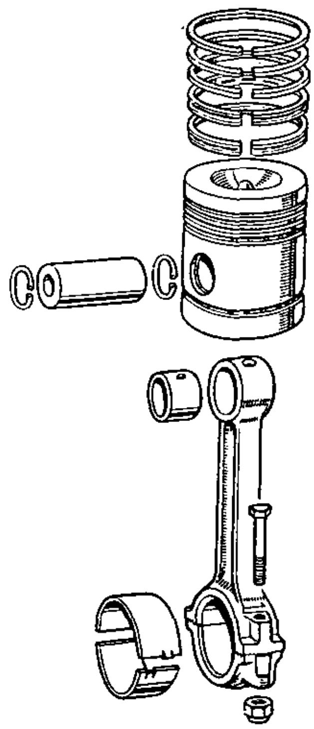


Fig. F.3.

Exploded view of Piston and Connecting Rod Assembly.

piston bore, warm the piston in clean liquid to a temperature of 100/120°F (38/49°C).

Inspection

1. Examine the pistons for scoring and clean carbon from the ring grooves. Check the clearance of the new piston rings in their respective grooves, (see "Manufacturing Data and Dimensions"). If, with a new ring fitted the vertical groove clearance is in excess of 0.008 in (0,2 mm), new pistons must be fitted.
2. Check the fitted gap of the rings in the unworn portion at the top of the cylinder bore. For details of ring gap dimensions, see "Technical Data" (Page B.5). Ring gaps for conformable rings are with the spring fitted.
3. When renewing a small end bush, ensure that the oil hole in the bush aligns with the hole in the connecting rod. Ream out to suit the gudgeon pin and check the connecting rod for parallelism, Page B.6.
4. Examine the big end bearings for wear and scoring. Also examine the crankpins for wear and ovality. For crankshaft details see Page B.6.

To Assemble the Pistons to the Connecting Rods

If the original pistons are being used they must be assembled to the original connecting rods. Pistons are stamped with a number on the top face.

1. With the stamped mark "FRONT" on the piston crown away from you and toroidal cavity towards the left hand side (Fig. F.4), place the connecting rod in position taking care to note that the number on the rod is to the left hand side. Insert gudgeon pin into position and fit new circlips, warming the piston if necessary.
2. Fit the rings in the following order :—

(a) 6.354 Engines fitted with Cast Iron Liners

Slotted Scraper—
below the gudgeon pin.
Slotted Scraper—
above the gudgeon pin.
Internally Stepped Compression—
third groove.
Internally Stepped Compression—
second groove.
Chrome Inserted Cast Iron Compression—
(Certain Agricultural and Industrial Engines have a plain C.I. ring).
top groove.

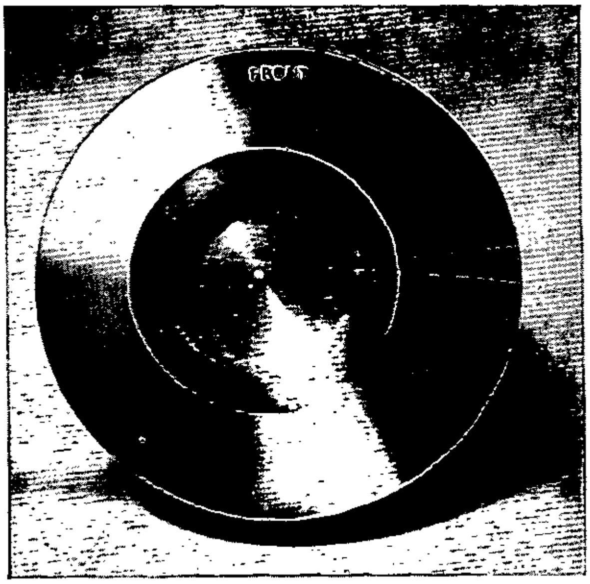


Fig. F.4. View of Piston Top Face.

With later 6.354 combine engines, the bottom scraper ring is omitted.

(b) Engines fitted with Chrome Liners

Slotted Scraper—
below the gudgeon pin.
Slotted Scraper—
above the gudgeon pin.
Laminated Compression—
third groove.
Internally Stepped Compression—
second groove.
Cast Iron Compression—
top groove.

(c) 6.3542 Engines

C.I. Slotted Scraper—
below gudgeon pin
*Conformable Chrome Plated Spring Loaded Scraper—
above gudgeon pin
Internally Stepped Copper Flashed Chrome Plated Compression—
third groove
*Internally Stepped Copper Flashed Chrome Plated Compression—
second groove
Barrel Faced Chrome Plated Compression—
top groove

*Early engines had a slotted scraper above the gudgeon pin and the internally stepped ring was not copper flashed.

(d) Turbocharged Engines
4 Ring Piston

Conformable Chrome Spring Loaded Scraper above the gudgeon pin.
Internally Stepped Compression—third groove.
Internally Stepped Compression—second groove.
Chrome Plated Compression—top groove.

(e) 5 Ring Piston

Slotted Scraper—below gudgeon pin
Slotted Scraper—above gudgeon pin
Internally Stepped Compression—third groove
Internally Stepped Compression—second groove
Cast Iron Compression—top groove

(f) 6.372 Engines

Conformable Chrome Spring Loaded Scraper above gudgeon pin
Chrome Internally Stepped Compression third groove
Chrome Internally Stepped Compression second groove
Chrome Inlaid Compression—top groove

Later 6.372 engines have three rings per piston, only one internally stepped compression being used.

If the original cylinder liners are satisfactory (see Page B.18), the service ring kit should be fitted.

Internally stepped rings are marked "TOP" or "BTM" (bottom) to ensure correct fitting.

When fitting conformable spring loaded scraper rings, ensure that the latch pin enters both ends of the spring. With the ring gap diametrically opposite to the latch pin, position oil control ring over spring with spring correctly located in annular groove of ring, i.e., between the oil control ring and the bottom of the ring grooves in the piston.

Piston rings should always be arranged so that their gaps are equally spaced around the piston.

When fitting the laminated compression ring, fit the first segment to the piston so that when held horizontally in the palm of the hand and radially compressed, the ring ends point downwards. (see Fig. F.5). Position this ring at the bottom of the groove with the gap over the gudgeon pin bore.

NOTE: Never fit chrome plated rings to engines having chrome plated cylinder liners.

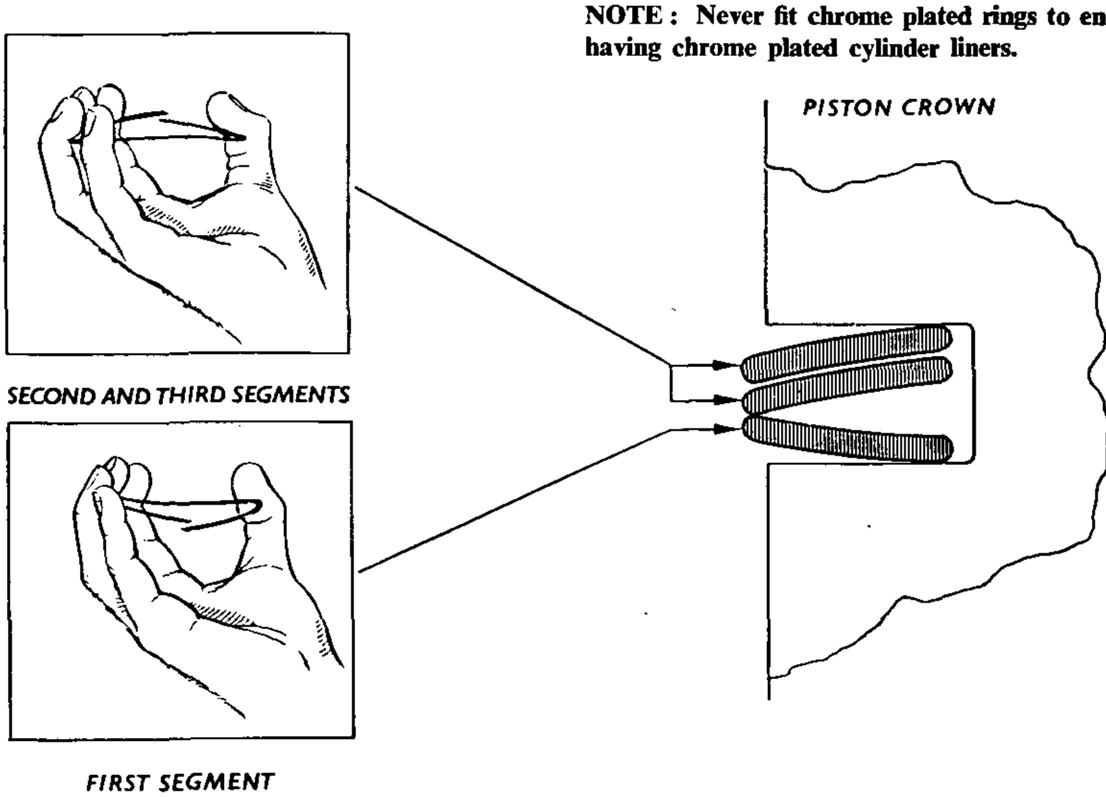


Fig. F.5.
Diagrammatic Method of Fitting Laminated Piston Ring—Three Segments Type.

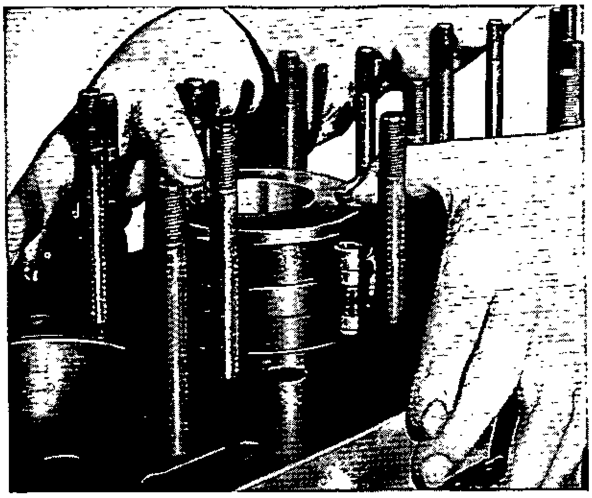


Fig. F.6.

Piston fitting with the aid of a Ring Guide.

Fit the second segment on top of the first so that when held compressed as described above, the ring ends point upwards. Position the gap at 180° to the first segment gap.

The third segment should be fitted on top of the second so that when held and compressed as described, the ring ends point upwards. Position the gap immediately above that of the first segment.

To Fit the Piston and Connecting Rod Assemblies

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

2. Using a ring guide, insert each assembly into the top of the respective cylinder bore (Fig. F.6). The piston and rod number must relate to the cylinder into which it is being fitted and the rod identification number must be opposite to the camshaft. The word "Front" marked on the piston crown must be towards the front of the engine.

3. Fit the bearing shells and cap with the numbers on the same side of the rod and cap (Fig. F.7). On turbocharged engines the top half bearing is grooved and drilled.

4. Refit the two securing bolts so that the flat on the head of each bolt is located against the shoulder on the rod. Secure with two new

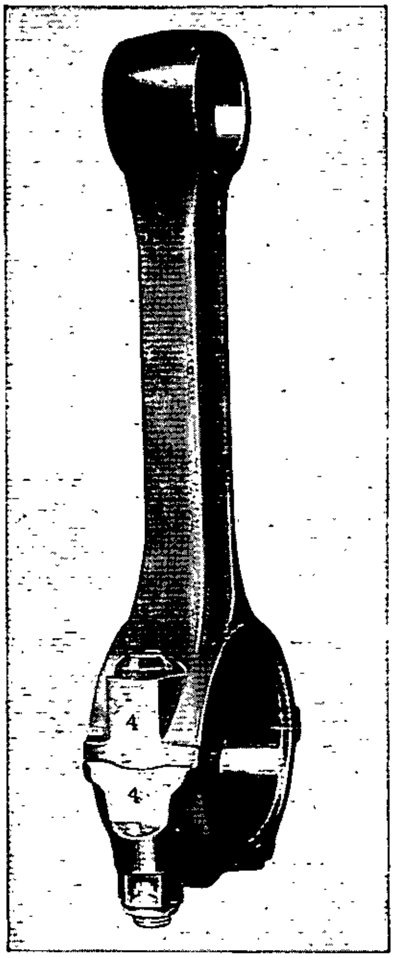


Fig. F.7.
Numbering of Connecting Rods and Caps.

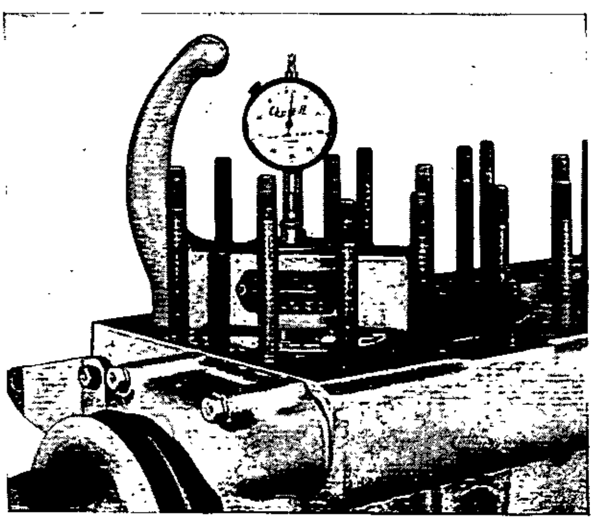


Fig. F.8.
Checking Height of Piston.

nuts to a torque of 75 lbf ft (10,4 kgf m) — 102 Nm for Cadmium plated nuts or 95 lbf ft (13,1 kgf m) — 129 Nm for Phosphated nuts.

Cadmium plated nuts can be identified by their bright finish and Phosphated nuts by their dull black finish.

5. Refit the lubricating oil pump and sump and fill with oil (Page K.4).

6. Replace the cylinder head (Page E.7).

Fitting New Pistons

Pistons, fitted on production, will not be less than 0.003 in (0,07 mm) or more than 0.010 in (0,25 mm) above the top face of the cylinder block.

In the case of turbocharged engines, the piston crown will be 0.000 in (0,00 mm) to 0.005 in (0,13 mm) below the top face of the cylinder block.

When using service pre-topped pistons it may be found that the piston height is lower than that quoted. Piston height should not be above these limits.

Where engines have to conform to the smoke density regulation B.S. AU 141a : 1971, the piston heights must conform to the production limits. This is achieved by using untopped pistons and topping to suit.

When using untopped pistons, then these will require topping to bring them within the dimensions quoted.

The piston height can be measured by using a height gauge as shown in Fig. F.8 or by the use of feelers and a straight edge across the top of the liner, providing the height of liner protrusion is taken into consideration.

SECTION G
Cylinder Block and Liners

An exploded view of the cylinder block assembly is shown in Fig. G.1.

NOTE: Cylinder blocks for 6.3542 and 6.372 engines have special coring for improved coolant flow and are not interchangeable with normal 6.354 cylinder blocks.

Four types of cylinder liner are fitted to the 6.354 engine, these being either, cast iron plain, cast iron flanged, thin-wall chrome-plated steel, or thick-wall chrome plated steel. All liners are of the dry renewable type and are not interchangeable (see "Manufacturing Data and Dimensions").

A chrome linered engine can be identified by the letters "CL" stamped adjacent to the engine number on the cylinder block or a letter "C" contained in the engine number, after the digits.

Flangeless cast iron liners may be rebored to +0.030 in (0,76 mm) oversize on 6.354 engines or, alternatively new liners fitted, which must be bored and honed to size when fitted. Reboring is not permissible with 6.372 engines.

In production the cast iron flanged liner has an interference fit of 0.001/0.003 in (0,025/0,076 mm) and is bored and honed in situ. They cannot be rebored oversize. For service, a pre-finished liner is available, having a transition fit of +0.001 in (0,025 mm) to —0.001 in (0,025 mm).

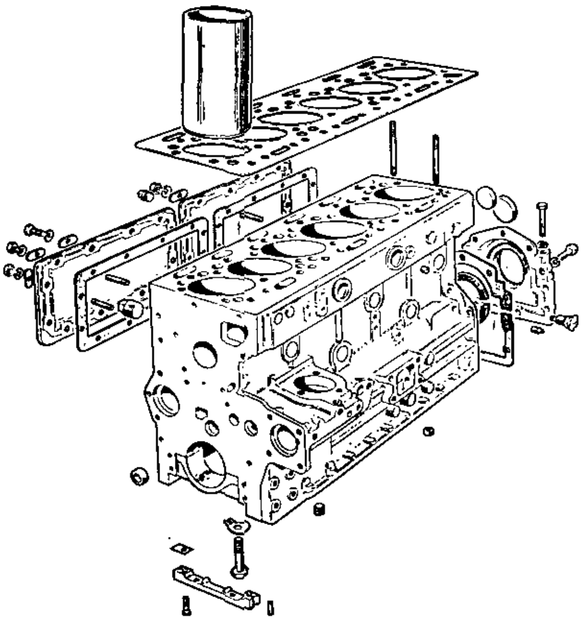


Fig. G1. Exploded View of Cylinder Block Assembly.

Pre-finished chrome plated liners must be renewed when worn.

To Renew Cylinder Liners (Cast Iron Flangeless)

1. Remove all components from the cylinder block.
2. Remove the cylinder head studs.
3. Press out the liners from the bottom.
4. With 6.354 engines lubricate the outside diameter of the liners with clean oil and press them in. When inserting new liners, the load should be released several times during the first inch, so as to allow the liner to centralise itself in the parent bore. The liner should be pressed in until 0.028/0.035 in (0,71/0,89 mm) of the liner is protruding above the cylinder block face (Fig. G.3). Shim washers or a solid stop washer, 0.028/0.035 in (0,71/0,89 mm) thick should be used to give the correct protrusion.

Important Note:
Earlier liners should be fitted 0.005/0.013 in (0,125/0,33 mm) below the cylinder block top face.

Earlier liners can be identified by their length which is 8.963/8.973 in (227,7/227,9 mm) compared with 9.005/9.015 in (228,7/229 mm) for the current type. The correct cylinder

Fig. G.2.
Checking Cylinder Liner Protrusion above top face of Cylinder Block.

head gasket must be used. Earlier type gaskets are only suitable for the earlier liners, but the latest type gasket is suitable for both types of liner. The earlier liner must not be fitted to give a protrusion of 0.028/0.035 in (0,71/0,89 mm) as the bottom piston ring may clear the bottom of the liner when the piston is at bottom dead centre.

With 6.372 engines, ensure that the cylinder liners are perfectly clean and free from grease. Apply a 1 in band of Loctite Retaining Compound No. 75 half way down the cylinder liner parent bores and a further 1 in band around the top of the parent bores. Press in the liners until they protrude 0.028/0.035 in (0,71/0,89 mm) above the top face of the cylinder block. Allow 8 hours for the loctite to cure before machining liners to finished size.

5. Bore and hone finish the liners to the dimensions given in "Manufacturing Data and Dimensions."

   When using a boring bar on the top face of the cylinder block, fit a parallel plate between the boring bar and cylinder block face.

6.372 and 6.3542 Engines

To ensure rapid bedding in, a super honed finish should be obtained as follows:—

Bores should be diamond honed to the following specification :—

1. Cross hatch angle 30° to 35° (horizontal included angle).
2. Uniformly cut in both directions throughout the length of the liner.
3. Clean cut and free of torn or folded metal.
4. Micro average 25 or 40 micro inch (0,63 to 1,0 micrometre) C.L.A. No single reading must be greater than 50 micro inch (1,25 micrometre) or less than 20 micro inch (0,50 micrometre).
5. Plateau area to be half to two thirds of surface measured by visual assessment of fax film and micro section.
6. Finished surface to be free of burnish or glaze.
7. Finished surface to be thoroughly cleaned and free of embedded particles, this preferably being achieved by scrubbing with a nylon brush.
8. No burrs or sharp edges to be present at top or bottom of liner after honing.

To Renew Cylinder Liners (Chrome Plated)

1. Remove all components from the cylinder block.

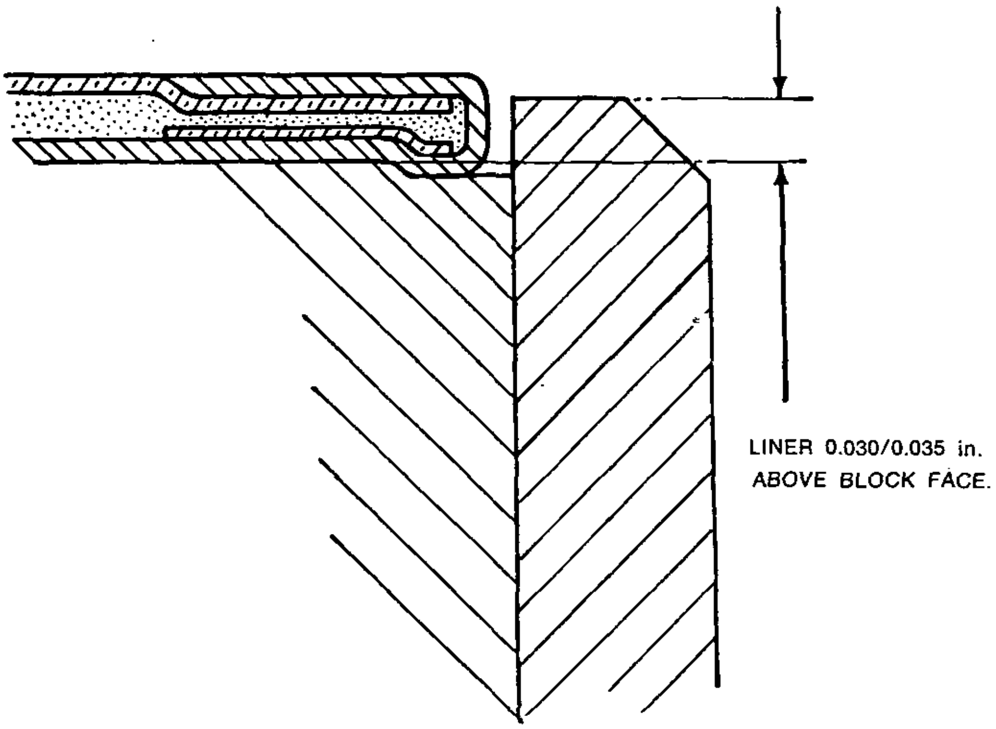


Fig. G.3.
Showing protrusion of Cylinder Liner.
(Later Types only).

2. Remove the cylinder head studs.
3. Press out the liners from the bottom.
   Great care must be taken in handling, transit and storage of new chrome plated liners, as the slightest burr or damage is sufficient to cause local distortion of the bore when fitted.

   Note: From Engine No. 8064469 the chrome liner and cylinder block were altered slightly to allow the fitment of the Klinger or Victor type cylinder head gasket to cast iron linered engines. The Klinger or Victor gasket must not be fitted to chrome linered engines prior to the above number.
4. Lubricate the outside diameter of the liners with clean oil.
5. Press in the new liners so that the flanges at the top of the liners do not foul the counterbore at the top of the parent bore. When fully home, the top face of the liner flange should be between 0.001/0.009 in (0,025/0,23 mm) below the top face of the cylinder block, for the earlier liner and between 0.004/0.008 in (0,1/0,2 mm) for the later liner.
6. It is advisable to allow a settling in period to elapse before checking the fitted internal bore diameter of the liner. The acceptable limit is 3.8765/3.879 in (98,463/98,527 mm). Each new liner should be checked in three positions — top, centre and bottom; the readings being taken transversely and parallel to the centre line of the cylinder block.

Some later engines are fitted with a thick wall chrome plated liner. When these liners are replaced, the top face of the liner must protrude above the cylinder block by 0.028/0.035 in (0,71/0,89 mm).

The fitted internal bore of the liner should be 3.877/3.8795 in (98,48/98,54 mm).

To Renew Cylinder Liners (Cast Iron Flanged)

1. Remove all components from the cylinder block.
2. Remove the cylinder head studs.
3. The liners should be pressed out from the bottom.
4. Lubricate the outside diameter of the liner with clean oil.
5. Press in the new liners, fully home. The top face of the liner should protrude above the cylinder block by 0.028/0.035 in (0,71/0,89 mm).
6. It is advisable to allow a settling period to elapse before checking the fitted internal bore diameter of the liner. The acceptable limit is 3.877/3.8795 in (98,476/98,539 mm) for 6.3542, T6.354 and 6.354 engines and 3.980/3.981 in (101,09/101,12 mm) for 6.372 engines.

SECTION H
Crankshaft & Main Bearings

An exploded view of the crankshaft and main bearings is shown in Fig. H.1.

The crankshaft runs in seven pre-finished replaceable shell bearings lined with copper lead or alternatively aluminium silicon.

End float of the crankshaft is controlled by four thrust washers which are located on both sides of the centre main bearing housing. 0.0075 in (0,19 mm) oversize thrust washers are available which may be combined with standard thrust washers to give an adjustment of 0.0075 in (0,19 mm). or when used on both sides of the bearing housing give an adjustment of 0.015 in (0,38 mm).

Crankshafts fitted to 6.3542 engines are nitrided and have provision for 12 bolt flywheel fixing.

Other engines may also have 12 bolt flywheel fixing.

To Renew the Thrust Washers

Renewal of the thrust washers can be carried out without the removal of the crankshaft, as follows :—

1. Remove the sump, sump strainer and the oil pump suction pipe (page K.2).
2. Remove the centre main bearing cap (No. 4) and the two bottom half thrust washers. The two top half thrust washers can now be removed by sliding them round the crankshaft and out of the recesses machined in the cylinder block main bearing housing.
3. When fitting new or refitting thrust washers, liberally oil the two upper halves and slide them into the recesses on either side of the centre main bearing housing. The steel side of the thrust washers should be towards the bearing housing and the cap. Refit the cap with the lower half bearing, secure with the setscrews tightened to 150 lbf ft (20,7 kgf m) — 203 Nm for engines preceeding the following engine numbers :—

Engine Type	Cut-in Eng. No.
6.372	372U709
6.372 (Claas)	372UC818
A6.372	372UA879
6.3542	3542U2657
T6.354/6.354	354U175383
6.354 (Claas)	354UC15247
6.354 (International Harvester)	354UH13537
6.354 S.O.S.	354US10294 (approx.)
AT6.354	354UA7800T
A6.354	354UA32041
HT6.354/H6.354	354UX3141HT

As from the above engine numbers, the torque for the main bearing cap setscrews is 180 lbf ft (24,9 kgf m) — 244 Nm.

Early 6.3542 engines were numbered 354U200000 to 354U201892 before commencing at 3542U251 and onwards. Main bearing cap setscrews on the above engine numbers should only be tightened to 150 lbf ft (10,7 kgf m) — 203 Nm and NOT to the higher torque of 180 lbf ft (24,9 kgf m) — 244 Nm, otherwise damage to the main bearing caps could result.

Note: Later type thrust washers are non reversible and are not interchangeable with the earlier type. Replacement thrust washers must be of the same pattern as the originals.

4. Check the crankshaft end float for a clearance of 0.002/0.015 in (0,05/0,38 mm). Fig. H.3.
5. Replace the oil pump suction pipe, sump strainer and sump (Page K.2).

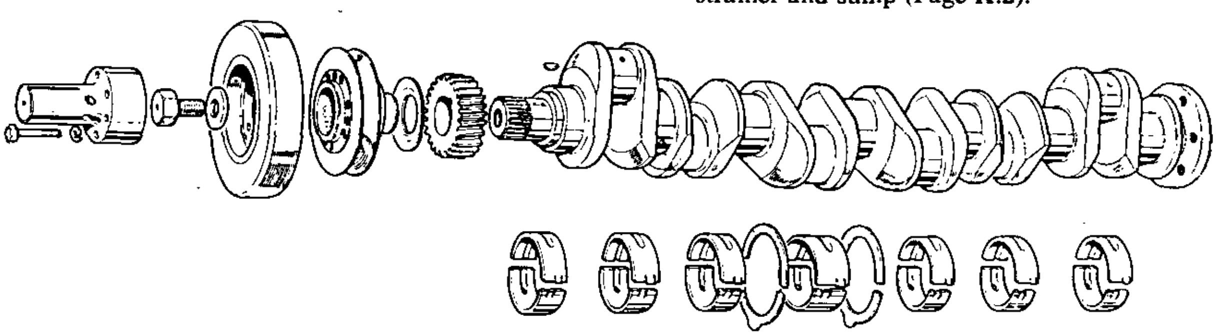


Fig. H.1. Exploded view of Crankshaft and Main Bearings.

To Remove the Crankshaft

It will be necessary to remove the engine from its vehicle or machine.

1. Remove the sump, sump strainer and the oil pump suction pipe.
2. Remove the crankshaft pulley.
3. Remove the camshaft gear, auxiliary drive gear and timing case (Page J.1).
4. Remove the flywheel and flywheel housing. (See Section N).
5. Remove the rear main oil seal housing.
6. Remove the front and rear bridge pieces from the cylinder block bottom face.
7. Remove the connecting rod caps and big end bearings.
8. Remove the main bearing caps and half bearings.
9. Lift out the crankshaft and remove the upper half bearings.

Regrinding the Crankshaft

20 hour Nitrided crankshafts cannot be reground to 0.010 in (0,25 mm) 0.020 in (0,51 mm) or 0.030 in (0,76 mm) undersize without re-Nitriding for a 20 hour period after each regrinding operation.

60 hour Nitrided crankshafts may be reground to 0.010 in (0,25 mm) undersize without re-Nitriding. Subsequent regrinding to 0.020 in (0,51 mm) or 0.030 in (0,76 mm) undersize calls for re-Nitriding for a 60 hour period after each regrinding operation.

If a 60 hour Nitrided crankshaft is found to be suitable for further service, but necessary to regrind down to 0.020 in (0,51 mm) or 0.030 in (0,76 mm) undersize, grind down to 0.0015/0.002 in (0,04/0,05 mm) above finished size leaving an allowance to grind off the white compound layer formed by the 60 hour Nitriding process.

When regrinding, the operation calls for specialised equipment and great care.

Using a Prince type grinder with a Universal Grinding Wheel Company wheel to Grade WA-80 JE (or equivalent), remove the white compound layer formed by the Nitriding process to achieve finished size. The collar faces of the crankshaft should be lightly flashed but not be ground at this operation and the fillet radii should be maintained within 0.156/0.162 in (3,96/4,12 mm). This will leave the compound layer in the radii and collars. When removing the compound layer, a grinding wheel speed of 880 rev/min and a crankshaft working speed of 16 rev/min for main journals and 8 rev/min for pins should be observed and a hand feed of approximately 0.0005 in (0,01 mm) per revolution of crankshaft. An adequate supply of coolant (Walker Century A305) should be used.

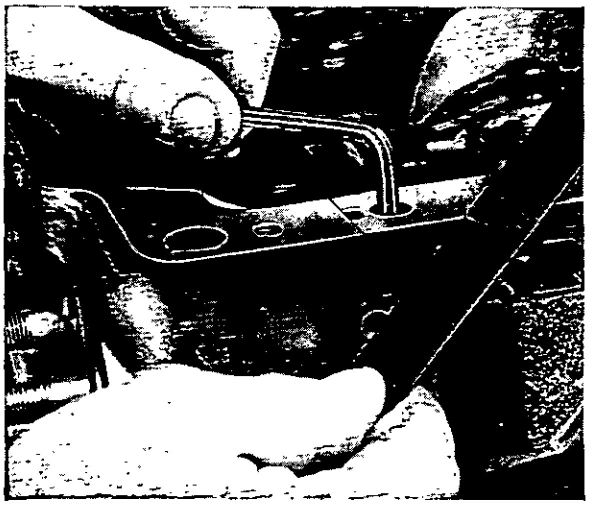


Fig. H.2. Aligning Bridge Piece to Block Face.

Tufftrided crankshafts must be re-Tufftrided after each regrinding operation. If facilities for Tufftriding are not available, then the crankshaft may be re-Nitrided by the 20 hour process.

Where facilities for re-Nitriding or re-Tufftriding are not available, then a factory replacement crankshaft should be fitted.

Tufftrided and Nitrided shafts cannot be straightened.

Four different hardening techniques are used in respect of crankshafts.

Induction hardened crankshafts can be reground without any subsequent re-hardening.

Nitrided and Tufftrided crankshafts can be identified by the part number which will be found on the nose of the crankshaft or stamped on No. 1 web. In some cases, only the last three figures will be found.

Generally speaking, Nitrided or Tufftrided crankshafts are fitted to turbocharged engines and Nitrided crankshafts are fitted to 6.3542 engines.

20 Hour Nitrided Crankshafts

31322317	31325016
31322321	31325022
31322322	31325023
31322421	31325042
31323207	31325036
31323251	31325028
31322351	31325025
31323202	31325019

31323254	31325032
31322422	31325041

60 Hour Nitrided Crankshafts

31322318	31325017
31323201	31325024
	31325041
	31325032
31323204	31325033
31323203	31325037
31322363	31325006
31322372	31325007
31322381	31325004
31322362	31325045
31322393	31325201
31322392	31325202
31322391	31325211
31322306	31325221
31322307	31325222
31322371	31325223
31323264	31325304
31323266	31325306
31323281	31325311
31323282	31325312
31323301	31325321
31323302	31325322
31323331	31325331

Tufftrided Crankshafts

31322314	31325013
31322315	31325014
31322373	31325008
31322364	31325009
31322365	31325011
31323262	31325046
31322309	31325047
31322311	31325203
31323284	31325302
31322312	31325305
31323265	31325314
31323303	31325323

Before regrinding the crankshaft it should be crack detected. Demagnetise after crack detecting.

Data for Crankshaft Regrinding is given on Page H.8.

After regrinding, the sharp corners on the oil holes should be removed and the crankshaft crack detected and de-magnetised.

Note: It is most important that the radii on the main journals and crankpins are maintained.

To Refit the Crankshaft

1. The oilways in the cylinder block and crankshaft must be free from obstruction.
2. Check the main bearing setscrews for stretch or damage. Only setscrews supplied by the engine manufacturers should be used as they are of a special heat treated high grade steel.
3. Clean the bearing housings, place the top half bearings in position and liberally oil.
4. Position the crankshaft.
5. Oil the two upper thrust washers and slide into the recesses on either side of the centre main bearing housing.
6. Liberally oil and fit the lower halves of the main bearings to the bearing caps. Fit the caps to their respective positions so that the lower halves of the thrust washers are correctly positioned on either side of the centre main bearing cap. The main bearing caps are numbered, No. 1 commencing at the front of the engine. Each cap is also marked with a serial number as stamped on the cylinder block bottom face. These should read in line.
7. Fit the setscrews.
   NOTE: On earlier engines the main bearing cap setscrews were locked with tabwashers. *It is not necessary to replace these after removal.* Shim washers fitted between the setscrew head and the main bearing cap have also been deleted.
8. Tighten the main bearing setscrews to the torque given on page H.1.
9. Check the crankshaft end float for a clearance of 0.002/0.014 in (0,05/0,36 mm) (Fig. H.3). Oversize thrust washers may be fitted.
10. Refit the connecting rod caps and big end bearings.

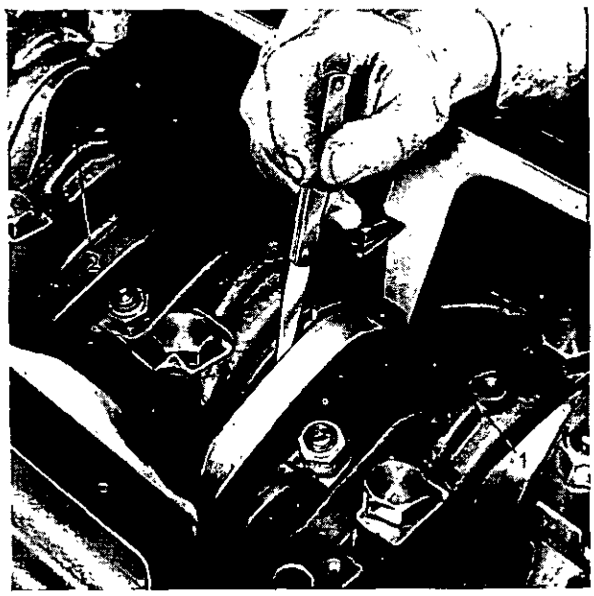


Fig. H.3. Checking Crankshaft End Float.
1. Main Bearing Cap.
2. Crankshaft.

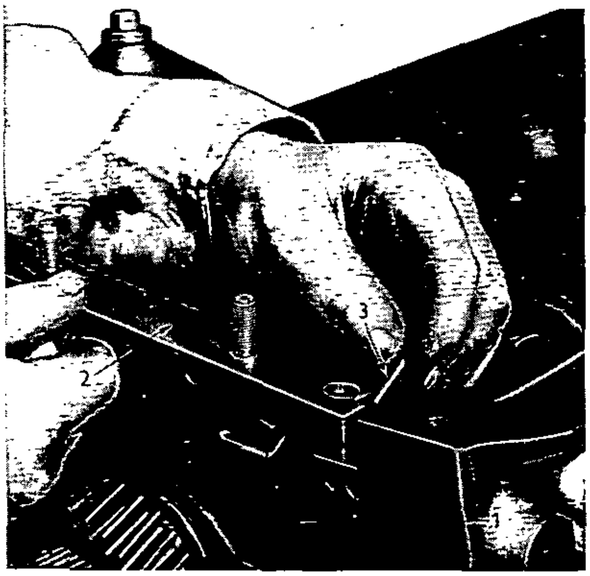


Fig. H.4. Fitting Main Bearing Bridge Piece Oil Seal.

1. Front Main Bearing Cap.
2. Bearing Bridge Piece.
3. Bearing Bridge Piece Oil Seal.

11. Refit the front and rear bridge pieces to the cylinder block (Fig. H.4). Check that the end faces of the bridge pieces are flush with the end faces of the cylinder block (Fig. H.2).

12. Fit new seals in the rear main oil seal housings and refit the housings, as described in "Crankshaft Rear End Oil Seal."

13. Refit and correctly align the flywheel housing and flywheel (Page N.1).

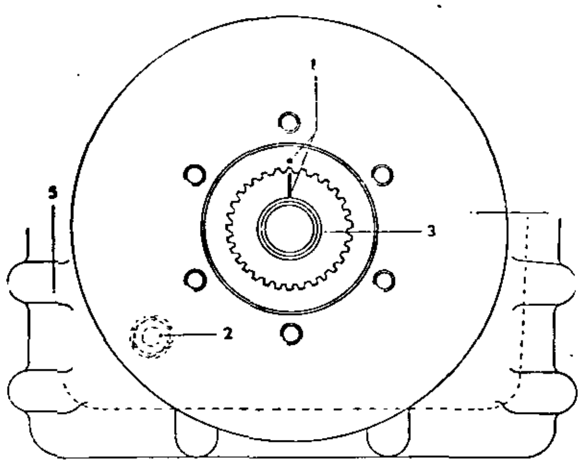


Fig. H.5.

1. T.D.C. Marks on Pulley and Crankshaft.
2. Timing Pin.
3. Crankshaft.

14. Refit the timing case, camshaft gear and auxiliary drive gear.

15. Replace the crankshaft pulley, so that the punch mark on the inside face of the pulley is in line with the scribed line on the end face of the crankshaft (Fig. H.5).
When fitting the pulley it is recommended that "Loctite" be used, in the following manner.
   (a) Thoroughly clean the crankshaft and pulley serrations, removing all traces of dirt and oil. Locquic 'Q' Activator, supplied in a pressurised aerosol may be used for this purpose and its use will considerably reduce the curing time.
   (b) When using Locquic 'Q,' spray over the serrations of both crankshaft and pulley, then wipe clean. Spray again with Locquic 'Q' and allow to dry. Locquic as well as being an activator, is a mild degreasing agent, capable of dissolving light oil films. Should the crankshaft or pulley be particularly greasy, they should be brushed with Loquic on the first application. Complete absence of grease and oil is essential. For best results the second application of Locquic must be allowed to dry completely. Evaporation is complete when the surfaces are free of odour.
   (c) Apply Loctite, grade "CVE" Blue to the serrations and fit the pulley, split retainer, washer and dognut or setscrew.
   (d) Two types of washer are in service, varying in thickness. Where a $\frac{1}{4}$ in (6,35 mm) washer is used, the dognut or setscrew should be tightened to a torque of 250 lbf ft (34,6 kgf m) — 339 Nm whilst a torque of 300 lbf ft (41,5 kgf m) — 406 Nm should be applied where a $\frac{3}{8}$ in (9,53 mm) washer is used.

With combine engines using multigroove overhanging pulleys, the retaining setscrew should be tightened to a torque of 300 lbf ft (41,5 kgf m) — 406 Nm and re-checked after a test run.

IMPORTANT

Where Loquic "Q" Activator has been used, as in (b) above, a curing period of one hour at room temperature is necessary before the engine is run.
If Licquic Activator has not been used, the curing period is 24 hours.

16. Replace the oil pump suction pipe, sump strainer and sump.

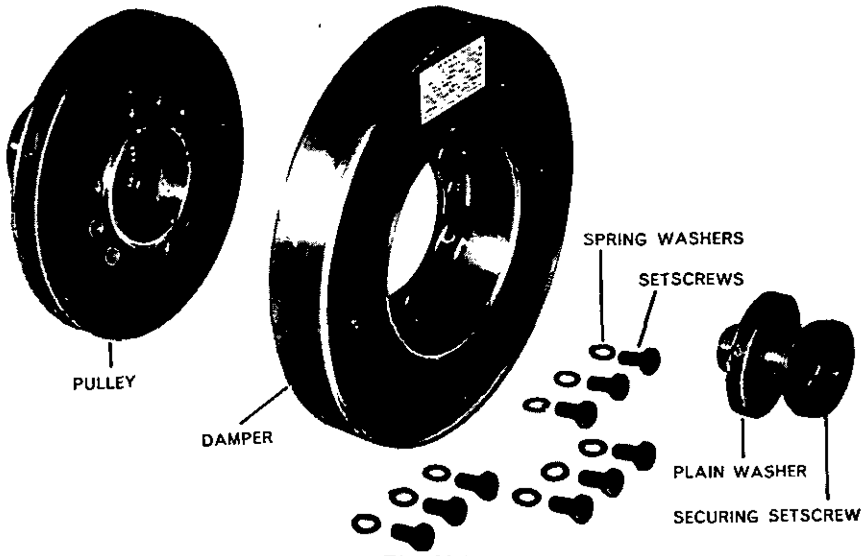


Fig. H.6.
Viscous Type Crankshaft Damper.

CRANKSHAFT DAMPER

The viscous (oil filled) crankshaft damper fitted to certain applications has been superseded by one which is rubber bonded.

The viscous damper is secured to the crankshaft pulley with nine setscrews. The rubber bonded damper is part of the pulley itself and is not detachable.

The method used to secure the rubber bonded damper/pulley assembly (Fig. H.7) differs to that used in the viscous type (Fig. H.6).

The viscous type is secured by a plain washer and setscrew directly to the crankshaft but the internal bore of the rubber bonded type has a tapered recess at the outer end to allow for a clamping ring which is fitted before the plain washer and setscrew. The clamping ring being externally tapered must be fitted with the tapered end entering the recess in the damper/pulley assembly.

This clamping ring can split when the securing setscrew is tightened. This is perfectly satisfactory and the clamping ring can be replaced in a split condition.

The latest type of viscous damper now incorporates a clamping ring as in the rubber bonded damper.

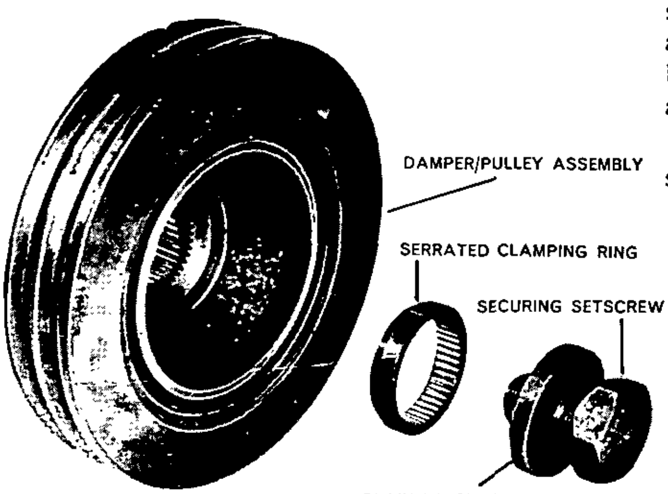


Fig. H.7.
Rubber Bonded Type Crankshaft Damper.

ROPE TYPE CRANKSHAFT REAR END OIL SEAL

The housing consists of two halves bolted around the rear of the crankshaft which has a shallow spiral oil return groove machined in it to a depth of 0.004/0.008 in (0,10/0,20 mm). The bore of the housing accommodates a rubber cored asbestos strip, comprising two sections.

When fitting the seal the following procedure should be adopted :

1. Set up a half housing in the vice with the seal recess uppermost and settle approximately 1 in (25 mm) of the strip, at each end, into the ends of the groove, so that each end of the strip protrudes 0.010/0.20 in (0,25/0,5 mm) beyond the half housing joint face.
2. With the thumb or finger press the remainder of the strip into the groove working from the centre. Use a round bar to further bed in the strip by rolling and pressing its inner diameter (Fig. H.8).

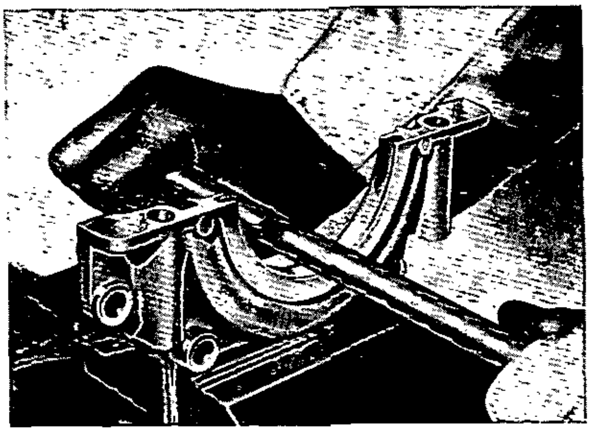


Fig. H.8. Rolling in Rear Main Oil Seal.

3. Fit the sealing strip to the other half housing in a similar manner.
4. Fit a new joint using jointing compound applied both sides.
5. Spread a film of graphite grease over the exposed inside diameter of the strip.
6. Assemble the half housings to the cylinder block and tighten setscrews and housing clamping setscrews finger tight only.
7. Tighten clamping setscrews to a torque of 6 lbf ft (0,83 kgf m) — 8 Nm.
8. Tighten setscrews in cylinder block to a torque of 12 lbf ft (1,66 kgf m) — 16 Nm.
9. Finally tighten the clamping setscrews to a torque of 12 lbf ft (1,66 kgf m) — 16 Nm.

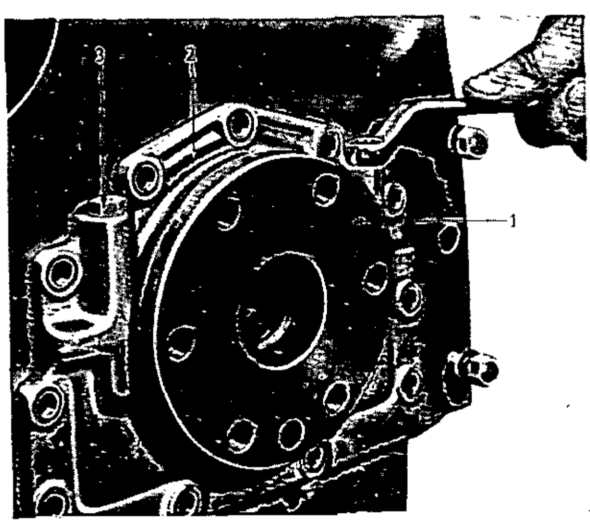


Fig. H.9. Tightening Oil Seal Housing Setscrew.
1. Crankshaft.
2. Oil Seal Housing.
3. Oil Seal Housing Setscrew.

LIP TYPE CRANKSHAFT REAR END OIL SEAL

On some engines, a circular, spring loaded, lip seal is fitted, which locates on the periphery of the flange of the crankshaft. On production, this seal is fitted with its rear face flush with the rear face of the single piece housing.

This type of seal is easily damaged and extreme care should be taken when handling and fitting it to its housing or to the crankshaft. Any visual damage across the lip of a new seal will cause leakage and prevent bedding in of the new seal.

The seal is designed to function correctly with the direction of rotation of the engine and for identification purposes, the seal is marked with an arrow.

On production the seal is fitted with its rear face flush with the rear face of the housing. In service, when a new seal is to be fitted to a worn crankshaft, it should be pressed further into the housing, in the first instance to $\frac{1}{8}$ in (3,2 mm) or, if this position has been used, to $\frac{1}{4}$ in (6,4 mm) from the rear face of the housing — see Fig. H.10. If all three positions have been used, it may be possible to machine the worn sealing area of the crankshaft flange, but not the spigot area on which the flywheel locates — see Fig. H.11. When a new seal is fitted to a new or reconditioned crankshaft, it should be fitted with its rear face flush with the housing.

Before fitting the seal in the housing, carefully examine the seal for damage, especially on the lip and outside diameter.

Using clean engine lubricating oil, lubricate the outside diameter of the seal and the inside diameter of the housing.

Press the seal into the housing to the required position, taking care that the seal is entered and pressed in squarely, otherwise damage to the outside diameter of the seal may occur, or if it is not square in the housing when fitted to the engine, it may leak.

The seal and housing should be fitted, using seal guide PD 145 (Churchill Tool) as follows :—

Clean the faces of the cylinder block and oil seal housing, and the outside diameter of the crankshaft flange.

Check that the seal and the outside diameter of the crankshaft flange are not damaged. Where a new seal has been fitted, check that it is in the correct position as previously detailed.

Ensure that the two dowels are fitted in the cylinder block. Coat both sides of the housing with Perkins Hylomar jointing compound and position the joint over the dowels in the block.

The lip type seal assembly and its counterpart crankshaft are not interchangeable with previous types.

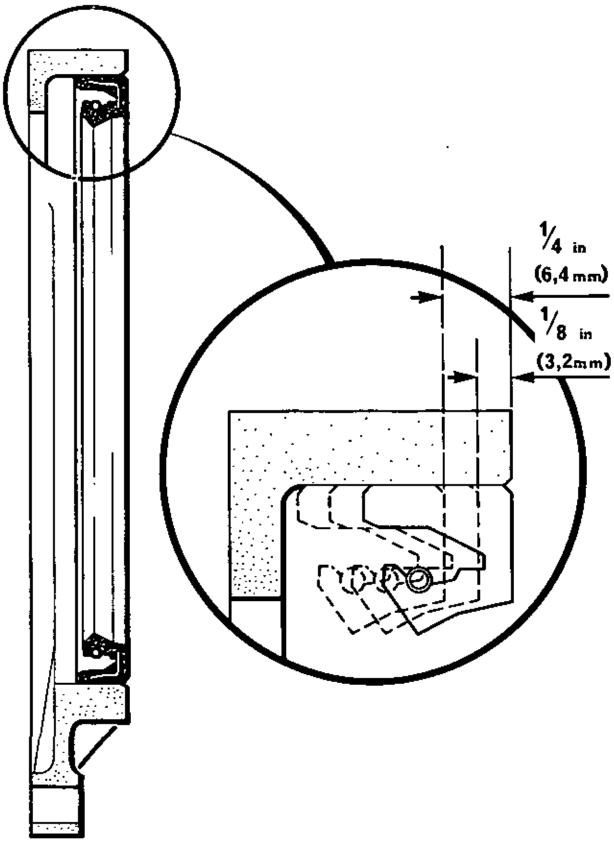


Fig. H.10
Three Positions for Seal.

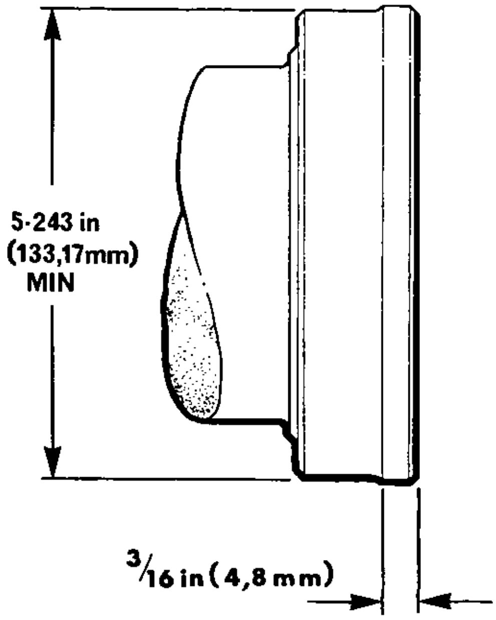


Fig. H.11
Grinding of Crankshaft Flange.

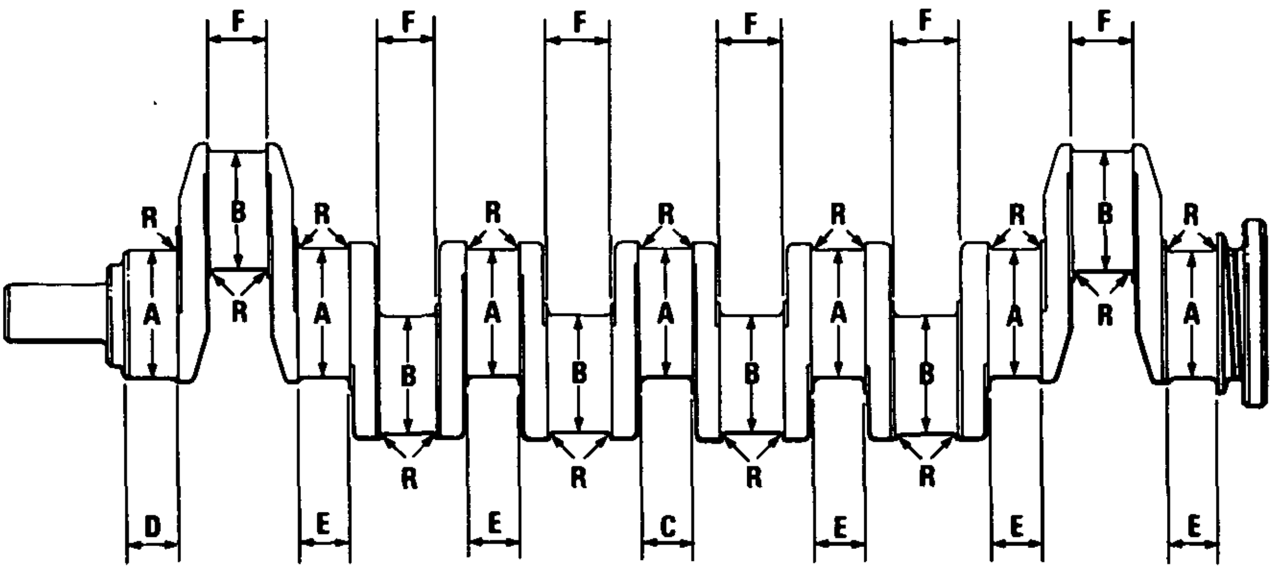
Using clean engine lubricating oil, lubricate the crankshaft flange, the seal and the seal guide. The lubrication of the seal is necessary to prevent damage that may be caused by initial dry running.

Position the seal and housing on the seal guide, locate the guide on the crankshaft flange and gently press the seal and its housing into position on the flange, locating the housing on its dowels.

Withdraw the guide and secure the housing with setscrews and washers.

CRANKSHAFT AND MAIN BEARINGS—H.8

Crankshaft Regrind Data



A	2.9884/2.9896 in (75,91/75,94 mm)	2.9784/2.9796 in (75,65/75,68 mm)	2.9684/2.9696 in (75,40/75,43 mm)
B	2.4888/2.4898 in (63,22/63,24 mm)	2.4788/2.4798 in (62,96/62,99 mm)	2.4688/2.4698 in (62,70/62,73 mm)

C 1.759 in (44,68 mm) maximum

D 1.489 in (37,82 mm) maximum

E 1.554 in (39,47 mm) maximum

F 1.5965 in (40,55 mm) maximum

R 0.145/0.156 in (3,68/3,96 mm) all journals and crankpins

R (60 hour Nitrided only) 0.156/0.162 in (3,96/4,12 mm) all journals and crankpins

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

Magnetic crack detection D.C. Flow — 4 amps A.C. Current — 1600 amps

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

Taper 0.00035 in (0,008 mm) Out of Round 0.0004 in (0,010 mm)

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

Independent Readings :—

Crankshaft Pulley Diameter T.I.R.	Rear Oil Seal Diameter T.I.R.	Flywheel Flange 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. — Run-out must not be opposed :—

Number 1. Mounting	Number 2. 0.004 in (0,10 mm)	Number 3. 0.008 in (0,20 mm)	Number 4. 0.010 in (0,25 mm)
Number 5. 0.008 in (0,20 mm)	Number 6. 0.004 in (0,10 mm)	Number 7. Mounting	

The difference in Run-out between any two adjacent bearings must not be greater than 0.004 in (0,10 mm).

SECTION J
Timing Case and Drive

An exploded view of the timing case and drive is shown in Fig. J.1.

To Remove the Timing Case, Camshaft Gear and Auxiliary Drive Gear

1. Slacken the dynamo/alternator mounting bolts and remove the drive belt.
2. Where necessary, remove water pump.
3. Remove the crankshaft pulley.
4. Remove the camshaft gear cover and auxiliary drive gear cover.
5. Remove the camshaft gear securing setscrew and washers and extract the gear from the camshaft (Fig. J.2).
6. Remove the retaining plate securing the auxiliary drive gear to the auxiliary drive shaft hub and withdraw the gear (Fig. J.3).
7. Remove the timing case and oil thrower.

To Renew the Crankshaft Front Oil Seal

1. Using a press and dolly, remove the oil seal from the timing case.
2. Press the new seal into position from the front until the front face is ¼ in (6,35 mm) below the front face of the timing case (Fig. J.4).

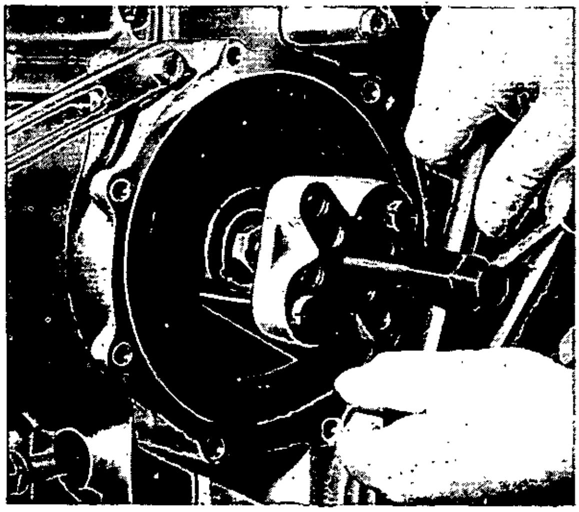


Fig. J.2. Removal of Camshaft Gear.

On certain engines, the seal is designed to function correctly with the direction of rotation of the engine and for identification purposes the seal is marked with an arrow.

Earlier engines were fitted with a black nitrile seal and a crankshaft oil thrower.

The current seal is a red silicone type and the oil thrower is replaced with a distance piece. Under no circumstances should the latest red seal be fitted with an oil thrower.

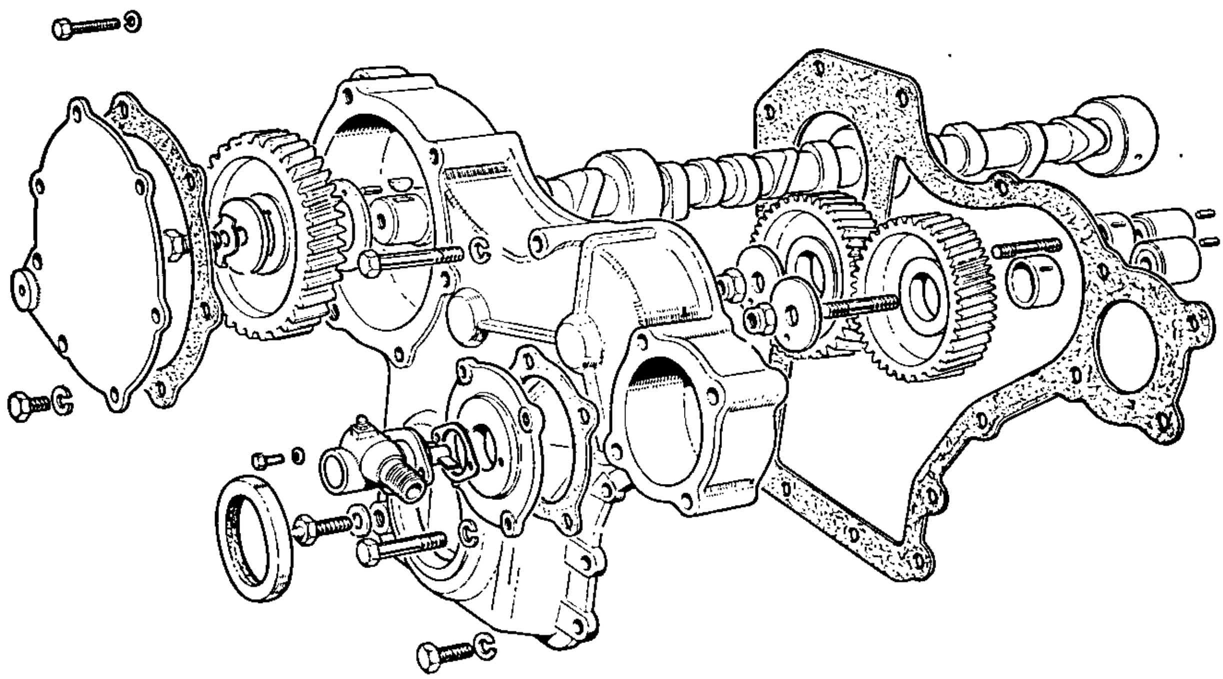


Fig. J.1. Exploded view of Timing Case and Drive.

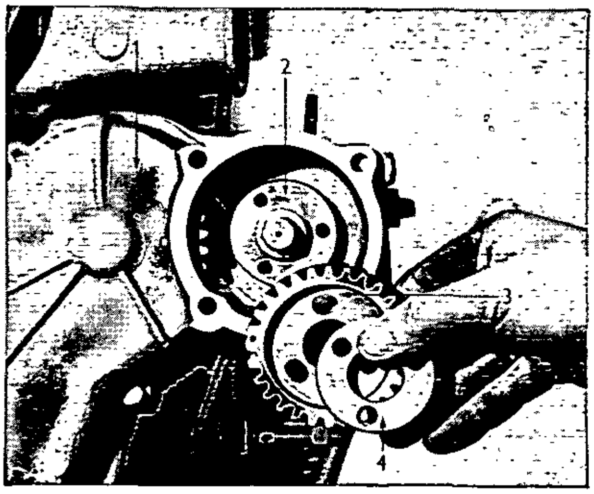


Fig. J.3. Removing Auxiliary Drive Gear.
1. Timing Case. 3. Fuel Pump Drive Gear.
2. Auxiliary Drive Shaft. 4. Retaining Plate.

To Refit the Timing Case, Camshaft Gear and Auxiliary Drive Gear

1. Remove the rocker cover and release the rocker shaft.
2. Turn the crankshaft until Nos. 1 and 6 pistons are at T.D.C., i.e. with the keyway in the crankshaft gear at 12 o'clock.
3. If the double dot mark on the lower idler gear is not in line with the single dot on the crankshaft gear, remove the idler gear and replace with the marks in line.
4. Replace the crankshaft oil thrower (where fitted) with the dished face outwards.
5. Position the timing case with a new joint on the cylinder block by means of two opposite setscrews fitted loosely. Centralise the case by locating the centralising tool PD.162 on the crankshaft and in the seal housing and tighten the assembly by means of the crankshaft pulley setscrew and washer — do not overtighten. Tighten all the timing case setscrews and remove the tool. If the centralising tool is not available, the crankshaft pulley can be used to centralise the case, but as this method utilises the inside diameter of the seal, the case may not be truly central and leaks may occur.
6. Align the keyway in the camshaft gear with the key in the camshaft, align the double dot timing mark on the camshaft gear teeth with the single dot on the lower idler gear. Draw the gear onto the camshaft by fitting the gear retaining washer, tabwasher, shimwasher and setscrew. Tighten the setscrew to a torque of 45/50 lbf ft (6.2/6.9 kgf m) — 61/68 Nm, and lock with the tabwasher.
7. Replace the camshaft gear cover plate.
8. Remove the fuel injection pump (Page M.6). Turn the auxiliary drive shaft until the slot in the vertical fuel pump drive hub aligns with the slot in the fuel pump adaptor plate (Fig. M.13). With the engine set in this position, fit the auxiliary drive gear so that the holes in the auxiliary drive shaft are central within the three slots of the auxiliary drive gear. Secure the gear with the retaining plate and setscrews and replace the auxiliary drive gear cover plate.

Where timing tool MS67B is available, then the auxiliary drive shaft and gear can be fitted in accordance with the details given on Page M.8.

NOTE : Steel auxiliary drive shaft gears are fitted to later engines and should be fitted to earlier engines where the gear needs replacing.

6.354.2 engines have a hardened steel auxiliary drive shaft gear with a steel centred thrust washer.

9. Refit the fuel injection pump (Page M.6). Tighten down the rocker assembly and adjust the valve clearances to 0.012 in (0,30 mm) cold.

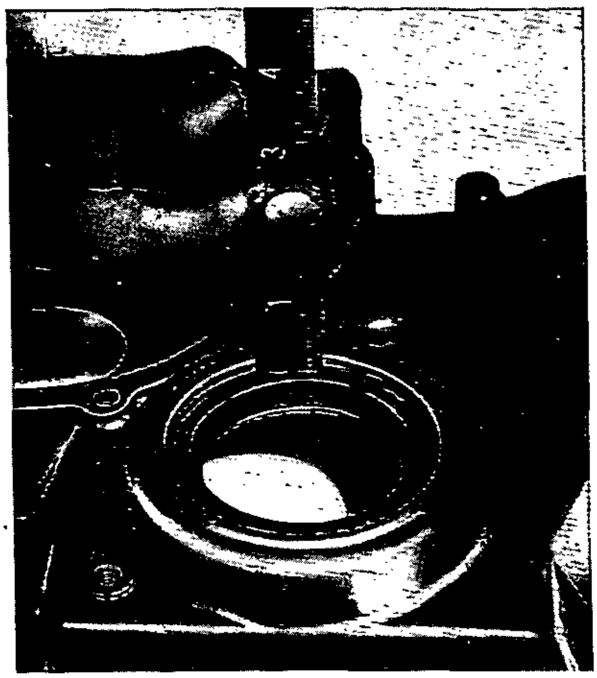


Fig. J.4. Checking Depth of Front Oil Seal.

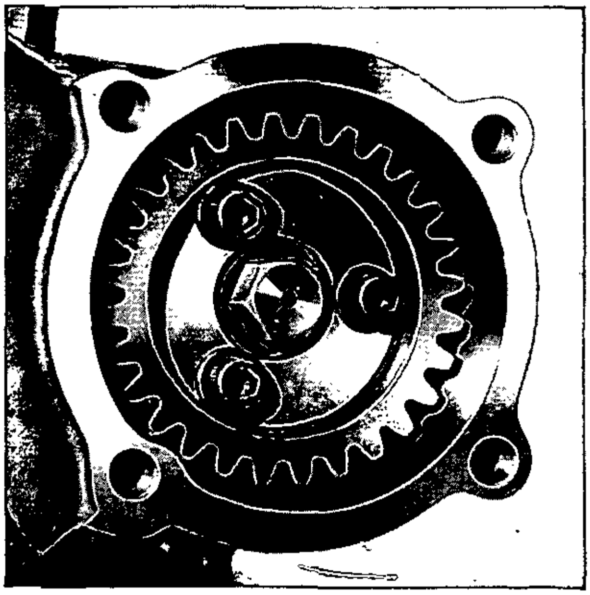


Fig. J.5. Auxiliary Drive Gear.

10. Replace the crankshaft pulley (Page H.4). so that the dot on the inside of the pulley is in line with the scribed line on the end of the crankshaft. Lubricate nose of pulley with engine oil before fitting. Replace the split retainer, washer and pulley retaining setscrew and tighten to the correct torque (Page B.2).
11. Fit the drive belt and retighten the dynamo/alternator (Page L.1).

To Remove Idler Gears and Hubs

1. Remove the timing case.
2. Remove the self locking nut securing each idler gear.
   Note: Certain agricultural applications have a two stud fixing for each idler gear.
3. Withdraw the retaining plate and the idler gears (Fig. J.6). Withdraw the hubs (Fig. J.7).
4. Examine the gear and hub for wear, cracks and pitting, etc. The oilways in the hubs and gears must be clean.

To Replace Idler Gears and Hubs

1. Remove the rocker cover and slacken off the rocker assembly securing nuts.
2. Turn the crankshaft to T.D.C. on Nos. 1 and 6 pistons.

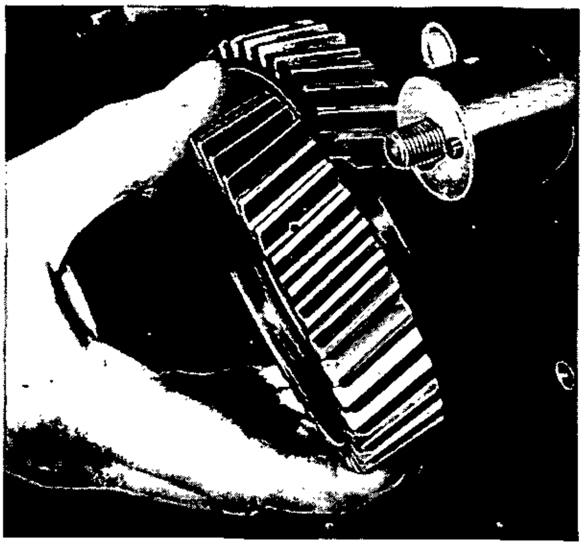


Fig. J.6. Removing Idler Gear.

3. Remove the fuel injection pump (Page M.6) and turn the auxiliary drive shaft until the slot in the vertical fuel pump drive hub aligns with the slot in the fuel pump adaptor plate.
4. Refit the idler gear hubs.
5. Refit the idler gears and retaining plates, so that the timing marks on the lower idler gear align with the timing marks on the

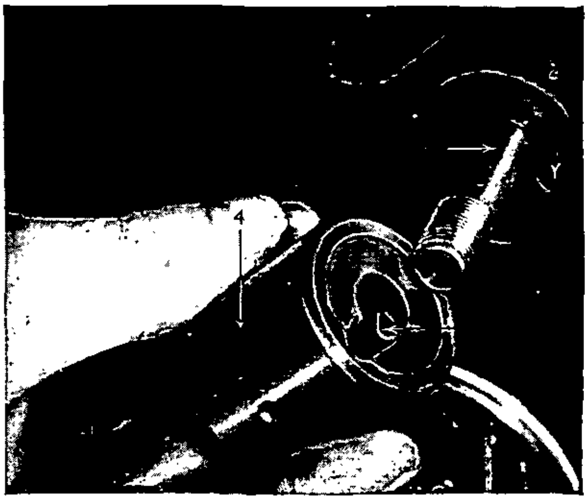


Fig. J.7. Removing Idler Gear Hub.
1. Idler Gear Hub Retaining Stud.
2. Oil Passage.
3. Hollow Dowel.
4. Idler Gear Hub.

crankshaft gear. Using new self locking nuts, secure the gears to a torque of 45/50 lbf ft (6,2/6,9 kgf m) — 61/68 Nm for $\frac{7}{16}$ in (11,11 mm) studs, and to a torque of 60/65 lbf ft (8,3/9,0 kgf m) — 82/89 Nm for $\frac{1}{2}$ in (12,70 mm) studs.

6. Refit the timing case, camshaft gear and auxiliary drive gear.
7. Replace the fuel pump (Page M.6).
8. Tighten down the rocker assembly, adjust the valve clearance to 0.012 in (0,30 mm) cold and refit the rocker cover.

Note: On certain industrial and agricultural applications a heavy duty timing gear train is fitted. The camshaft gear remains the same as for other applications, but the crankshaft gear, idler gear and bushes and the auxiliary drive gear are of different dimensions (see "Manufacturing Data and Dimensions") and material specification.

The idler gears for these applications are attached by a two stud fixing. When re-assembling the idler gears a torque of 20/24 lbf ft (2,8/3,3 kgf m) — 27/32 Nm must be applied to the nuts.

Attached to each idler gear retaining plate is a spray tube which directs oil onto the teeth of the idler gears.

The lower idler gear spray tube bends round to fix in a small hole in the cylinder block, whilst the upper idler gear spray tube bends to fix in a small hole in the inside back face of the timing case; before the timing case can be removed, the upper idler gear spray tube must first be detached.

Important: The heavy duty timing gears must not be fitted to a standard engine, as there is a danger of interference with the crankshaft oil thrower.

To Remove the Camshaft and Tappets

1. Remove the timing case.
2. Remove the rocker cover, and rocker assembly. Withdraw the push rods.
3. Release the connections to the fuel lift pump and remove the pump.

   Note: Before removing the camshaft, it is advisable to lay the engine on its side to prevent the tappets from falling out.

4. Remove the sump.
5. Withdraw the camshaft (Fig. J.8) and its thrust ring (Fig. J.9). The tappets can now be withdrawn.

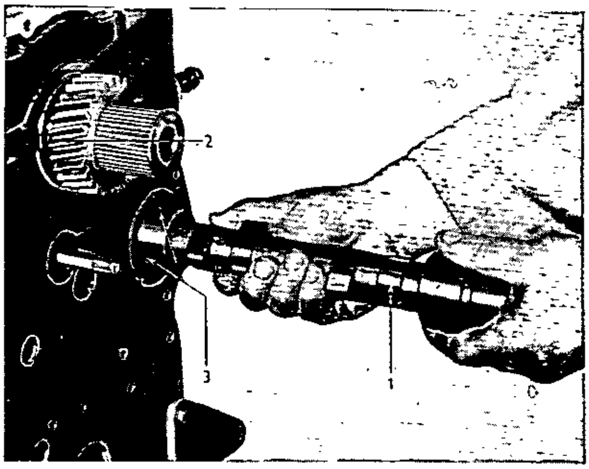


Fig. J.8. Camshaft Removal.
1. Camshaft. 2. Crankshaft Gear.
3. Camshaft Oil Reducer Drillings.

To Replace the Camshaft

1. Refit the tappets (Fig. J.10).
2. Refit the camshaft.
3. Refit the sump.
4. Fit the camshaft thrust ring so that it is correctly positioned on the dowel (Fig. J.9). Check the protrusion beyond the front face of the cylinder block. This should be within the limits quoted on Page B.8.
5. Refit the fuel lift pump. Attach the connections.

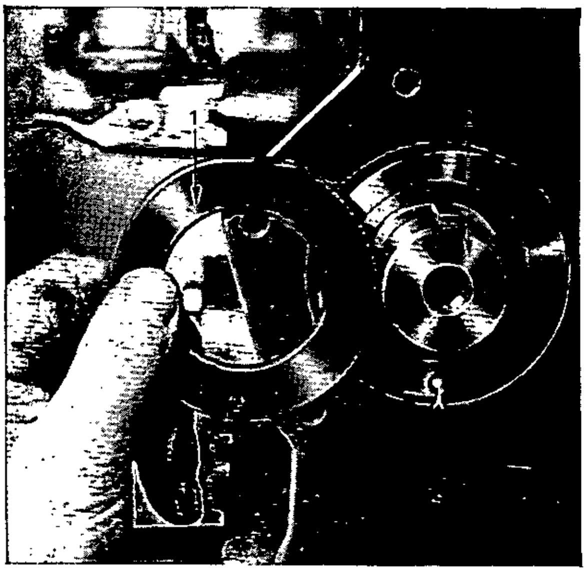


Fig. J.9. Removing Camshaft Thrust Washer.
1. Camshaft Thrust Washer.
2. Camshaft.
3. Thrust Washer Dowe .Pin.

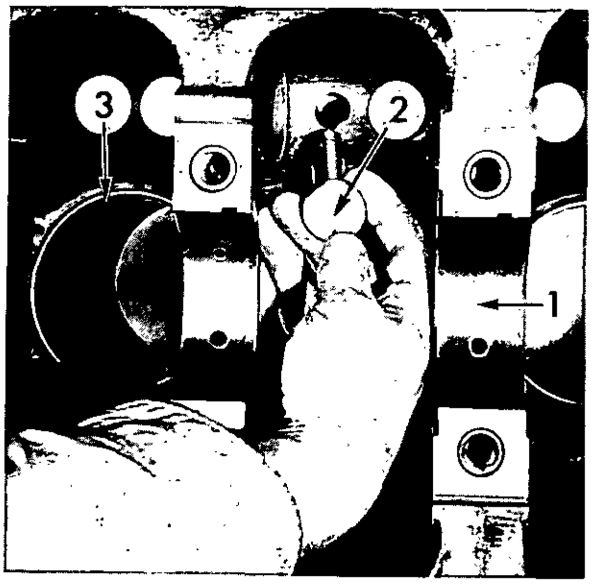


Fig. J.10. Removing Tappets.
1. Main Bearing Housing. 2. Tappet.
3. Cylinder Liner.

6. Replace the timing case and refit the timing gears.
7. Refit the push rods and rocker assembly. Adjust the valve clearances to 0.012 in (0,30 mm) cold. Refit the rocker cover.

To Remove the Auxiliary Drive Shaft and Fuel Pump Drive Shaft

1. Remove the timing case.
2. Remove the exhauster or compressor (if fitted) and coupling from the rear of the auxiliary drive shaft.
3. Remove the fuel pump.
4. Withdraw the auxiliary drive shaft (Fig. J.11), with a twisting motion, and the two 180° half thrust washers.
5. Remove the fuel pump adaptor plate.
6. Remove the sump and oil pump (Page K.2) and tap the fuel pump drive shaft up out of the crankcase. Remove any shims that may be present at the bottom of the bearing recess. An exploded view of the fuel pump drive assembly is shown in Figs. J.12 and J.13.
7. All parts should be examined for damage and wear. If the bronze worm gear requires renewing on early types, remove the bearing from the fuel pump drive shaft and the gear by removing four cap screws. The four cap screws should be coated with a film of "Loctite" Grade "C" before refitting.

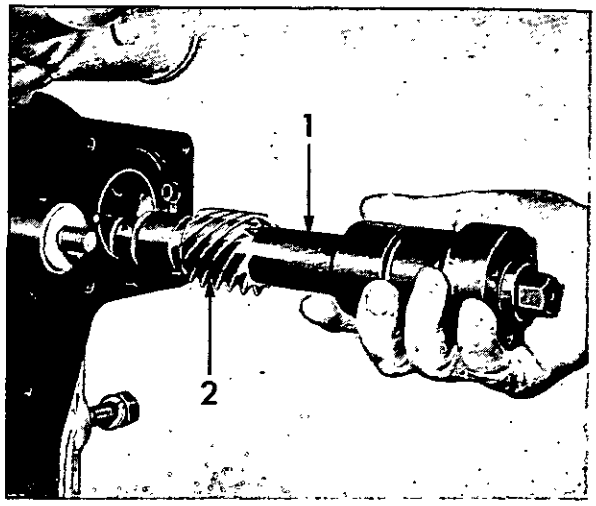


Fig. J.11. Removing Auxiliary Drive Shaft.
1. Auxiliary Drive Shaft.
2. Fuel Pump Drive Gear.

With later type of fuel pump drive shaft, the whole assembly should be renewed if necessary.

Where necessary, renew auxiliary drive shaft front and rear bushes in cylinder block. It is advisable that these be drawn into the block by means of a suitable threaded bar and adaptors.

To Replace the Auxiliary Drive Shaft and Fuel Pump Drive Shaft

1. On early engines adjacent to the engine number, on the auxiliary drive housing, is stamped the amount of shimming required to be placed at the bottom of the fuel pump drive shaft bearing recess. The amount of shimming may vary from 0.002/0.008 in (0,05/0,2 mm) and 0.002 in (0,05 mm) shims are available. If there is no stamping, shims are not required.

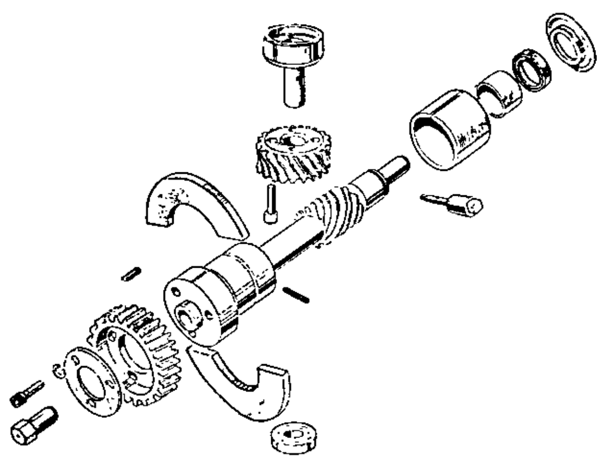


Fig. J.12.
Exploded View of Auxiliary Drive Assembly (Early).

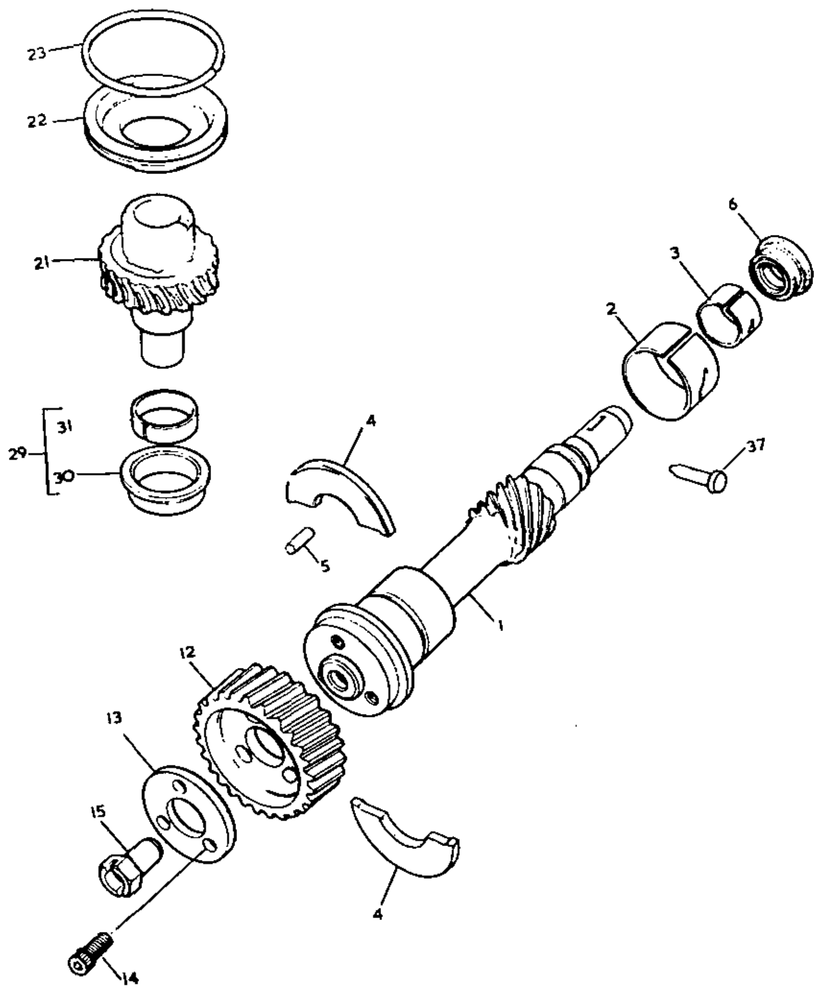


Fig. J.13
Exploded View of Auxiliary Drive Assembly (Later).

The lower thrust bearing for the fuel pump drive shaft (assembly 29) differs on current engines (see Fig. J.18).

2. Replace the fuel pump drive shaft assembly, bearing end first, into the crankcase and press into position.
3. Replace the lubricating oil pump and sump (Page K.2).
4. Replace the fuel pump adaptor plate, so that the timing mark scribed on the periphery is adjacent to the outside securing stud.
5. Slide the auxiliary drive shaft into position in the cylinder block, until the two halves of the thrust washer, fitted in the groove around the drive shaft, seat in the recess in the cylinder block and the butt faces are located by the dowel. End float of the drive shaft is controlled by the clearance between the thrust washers (held in position by the timing case) and the groove in the drive shaft. This clearance is between 0.0025/0.009 in (0,064/0,23 mm).
6. Replace the timing case, timing gears (Page J.1) and fuel pump (Page M.6).
7. Refit the exhauster or compressor so that there is a clearance of 0.020/0.025 in (0,5/0,64 mm) between the rubber and the body of the drive coupling.

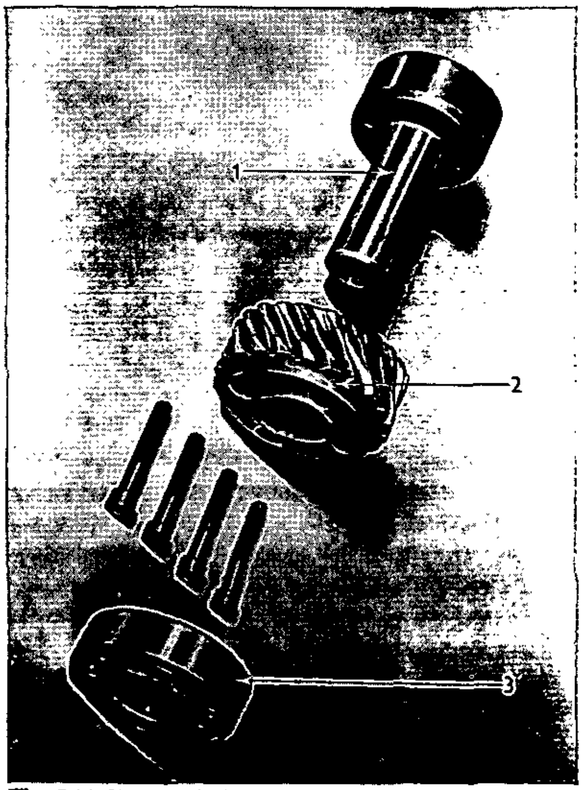


Fig. J.14. Exploded view of early type Fuel Pump Drive.
1. Drive Shaft.
2. Bronze Gear.
3. Ball Race.

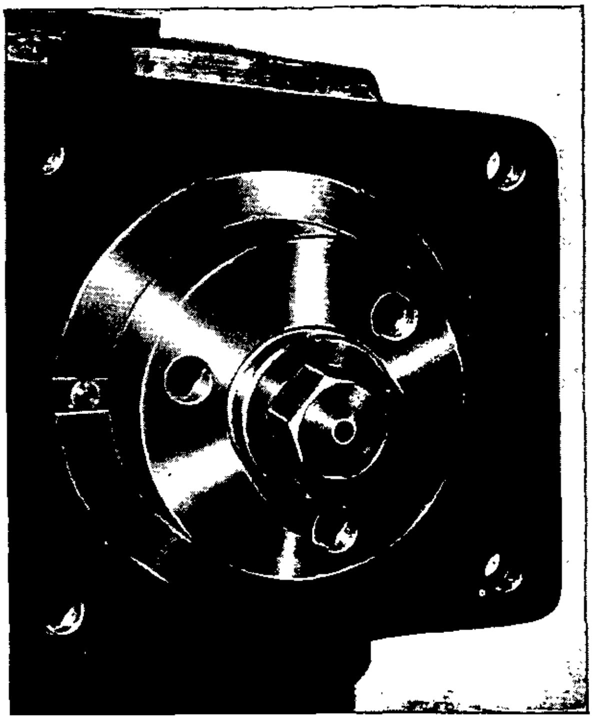


Fig. J.15.
Showing method of Auxiliary Drive Shaft Thrust Washer Location.

Note : As from engine No. 8020251 (Vertical, General), 8220251 (Vertical for Gebr. Claas) and 8420251 (Horizontal), wider gear centres have been provided between the fuel pump worm drive and wormhead. This has necessitated a larger diameter for the auxiliary drive shaft front bearing. It should be noted that with this alteration, the following parts are not interchangeable — cylinder block, auxiliary drive shaft, auxiliary drive shaft front bush, thrust washers and the lubricating oil pump and fuel pump drive shaft assembly.

Hydraulic Wormwheel Assembly

Later engines are fitted with a hydraulically loaded wormwheel assembly. Removal and replacement can be carried out in the following manner.

To Remove the Auxiliary Drive Shaft and Wormwheel Drive Assembly

1. Remove the timing case.
2. Remove the compressor (if fitted) and coupling from the rear of the auxiliary drive shaft.
3. Remove the fuel pump.
4. With a twisting motion, withdraw the auxiliary drive shaft and two half (180°) thrust washers.

5. Remove the fuel pump adaptor plate.
6. The wormwheel and fuel pump drive shaft assembly can now be pulled up and out, bringing with it, the thrust sleeve and piston ring seal.
7. The thrust collar assembly will remain in its location in the cylinder block and can be removed by means of a special tool.

All parts should be examined for damage and wear. If the bronze worm gear requires renewing, remove the four cap screws securing the gear to the drive shaft and withdraw the gear. The four cap screws and the shaft should be coated with a film of Loctite Grade RC. Fit a new gear so that the oil groove is in line with the slot in the shaft and tighten the screws. Latest gears are shrunk on and punch peened to the drive shaft. In the event of the gear requiring renewal, the gear and shaft assembly should be replaced. If the bush in the thrust collar requires renewing, press out the old bush and refit a new one. The new bush will require boring out after fitting, to a diameter of 1.6255/1.6266 in (41,29/41,32 mm). The piston ring seal will not normally require renewing unless it is damaged.

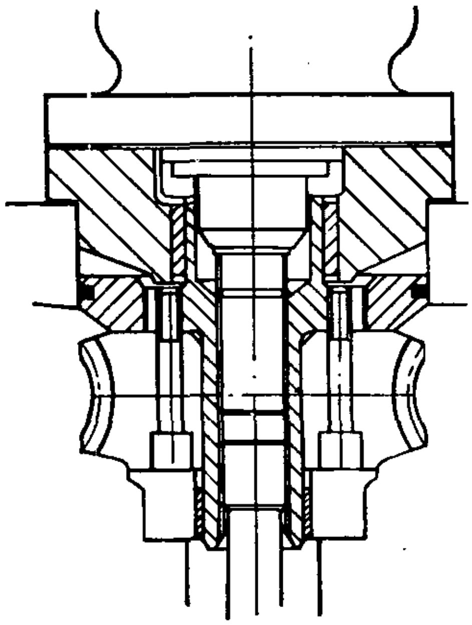


Fig. J.16

Section View of Hydraulically Loaded Wormwheel Assembly.

NOTE: The hydraulic wormwheel calls for a lubricating oil pump with an oil drain channel in the drive end of the body casting. It is important to note that lubricating oil pumps without this drain channel must not be used to replace those with the drain channel as this will prevent the drain of oil from the hydraulic loading within the auxiliary drive housing.

Auxiliary Drive Spray Tube

The auxiliary drive gears are lubricated by oil directed on to them by a spray tube in the auxiliary drive housing (See Fig. J.17). With early engine, this spray tube was screwed into the cylinder block, but with current engines, it is a push fit sealed with a "D" type plug.

This spray tube should be removed and cleaned during engine overhaul. Spares blocks are not fitted with this spray tube, therefore when replacing a block, always ensure that the tube is transferred from the old block to the new one.

PART SIDE VIEW ON AUX. DRIVE HOUSING

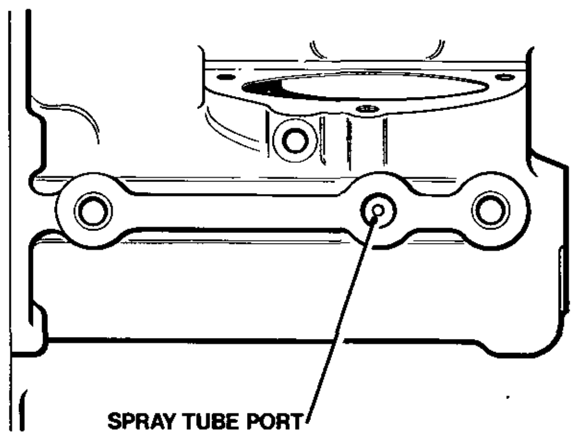


Fig. J. 17

To Replace the Auxiliary Drive Shaft and Wormwheel Drive Assembly

1. Replace the thrust collar assembly and press into position.
2. The wormwheel and fuel pump drive assembly can now be replaced.
   NOTE: With current engines, a design improvement has been made to the fuel pump drive shaft assembly and lower thrust collar. The contact area between the lower thrust collar and bronze gear has been increased and the material specification of the lower thrust collar has been changed to sintered material and originally did not carry a bush, the fuel pump drive shaft running directly in the thrust collar. However, current engines do have a bush and this should be finish bored as previously described.
   A small slot has been machined in the underside of the bronze gear (see Fig. J.18). This slot connects the oil flutes in the thrust collar to the crankcase as the gear turns,

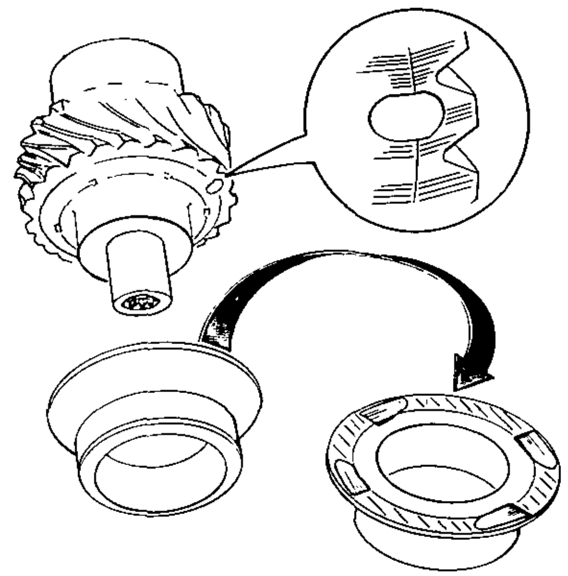


Fig. J.18.
Current Fuel Pump Drive Shaft
Assembly and Lower Thrust Collar.

allowing an intermittent flow of oil across the thrust face of the collar improving lubrication.

The new bronze gear and lower thrust washer are interchangeable as an assembly, but not as individual items.

3. With the piston ring seal assembled on the thrust sleeve, replace the assembly.
4. Replace the oil pump and sump.
5. Replace the fuel pump adaptor plate, so that the timing mark scribed on the periphery is adjacent to the outside securing stud.
   Note: Current engines have a joint between the adaptor plate and cylinder block. With earlier engines, it is suggested that this joint be fitted as it could prevent an oil leak should oil pass the adaptor plate "O" ring".
6. Slide the auxiliary drive shaft into position in the cylinder block, until the two halves of the thrust washer, fitted in the groove around the drive shaft, seat in the recess in the cylinder block and the butt faces are located by the dowels. End float of the drive shaft is controlled by the clearance between the thrust washers (held in position by the timing case) and the groove in the drive shaft. This clearance is between 0.0025 to 0.009 in (0,064/0,23 mm).
7. Replace the timing case, timing gears and fuel pump.

Auxiliary Drive Shaft (current engines)

An improved sealing arrangement has been introduced for the rear end of the auxiliary drive shaft.

The new arrangement removes the integral oil thrower "X" (Fig. J.19) from the shaft and introduces a "wind back" silicone rubber oil seal at the rear end of the shaft. The seal fitted prior to this alteration was either a plain black nitrile rubber seal or a plain red silicone rubber seal.

The black nitrile rubber seal must not be fitted to the new shaft without the thrower as it would not cope with the increased flow of oil.

The plain red silicone rubber seal can be fitted with either type of shaft.

The new "wind back" seal must not be fitted to the old shaft with the integral oil thrower as this seal requires a greater supply of oil for cooling purposes. This seal has a shaft rotation arrow formed on its rear face (see Fig. J.20). As the inner lip of these seals is very flexible, take care that this lip is not curled back as the seal is fitted to the shaft.

Before fitting a new seal, check the type of shaft fitted by looking into the rear aperture of the drive shaft housing with the old seal removed. If the new shaft is fitted, the rear bearing journal and rear edge of the bush will be clearly visible. If the old shaft is fitted, the oil thrower projection will be seen to the rear of the bearing journal and this will partly obscure the edge of the bush when viewed at an angle.

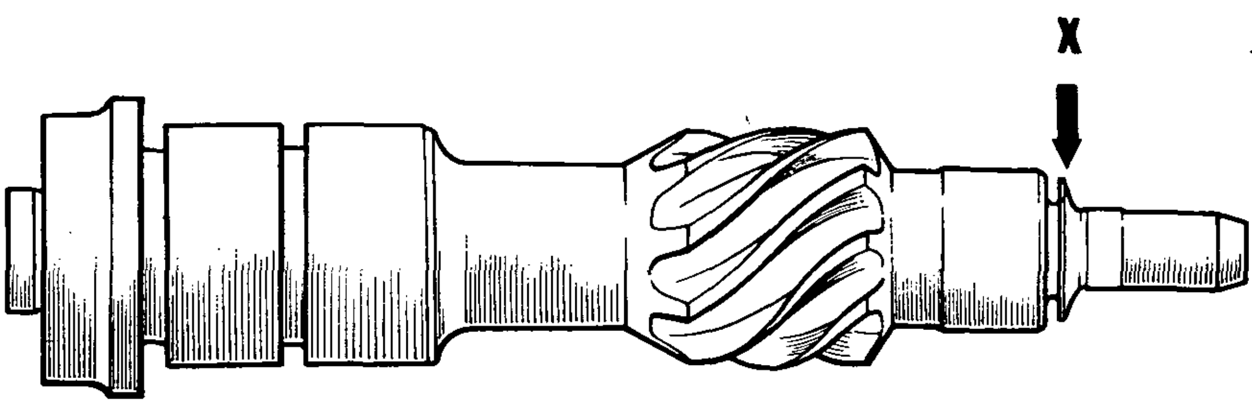


Fig. J.19.

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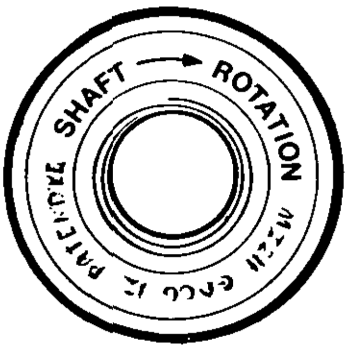


Fig. J.20.

Checking the Timing Gear Backlash

1. Remove the camshaft gear and auxiliary drive gear covers.

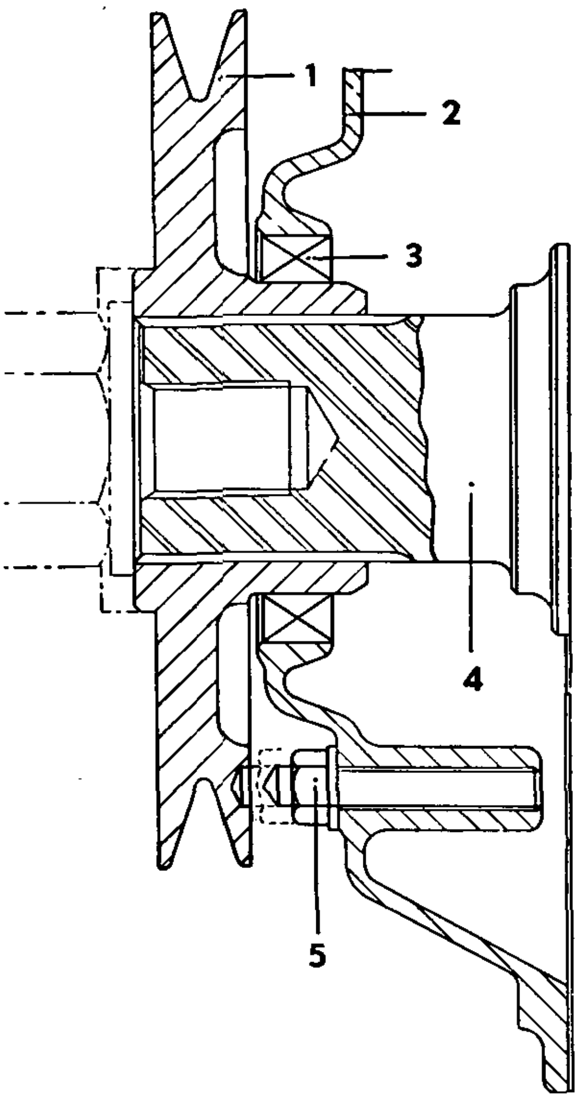


Fig. J.21

1. Crankshaft Pulley.
2. Timing Case.
3. Timing Case Seal.
4. Crankshaft.
5. Timing Pin (not fitted to current engines).

2. Check the backlash between the timing gears using a clock gauge or feeler gauges. The minimum back lash should be 0.003 in (0,08 mm).

CHECKING VALVE TIMING

1. Turn the crankshaft until the valves on No. 6 cylinder are rocking. Set the clearance on No. 1 inlet valve to the figure quoted on Page J.11.
2. Turn the crankshaft in the normal direction of rotation until the push rod of No. 1 inlet valve just tightens.
3. Check that Nos. 1 and 6 pistons are at T.D.C. either on the flywheel or by unscrewing the timing pin, in the lower half of the timing case, until it locates in the hole in the rear of the crankshaft pulley (see Figs. J.21 and J.22). On current engines, a pointer is provided in place of the timing pin which when aligned with a mark on the periphery of the crankshaft pulley, indicates T.D.C. The valve timing tolerance is plus or minus $2\frac{1}{2}°$.
4. When the valve timing is found to be correct, release the timing pin in the crankshaft pulley and reset valve clearance to 0.012 in (0,30 mm) cold.

Note: The only error possible is in the fitting of the timing gears.

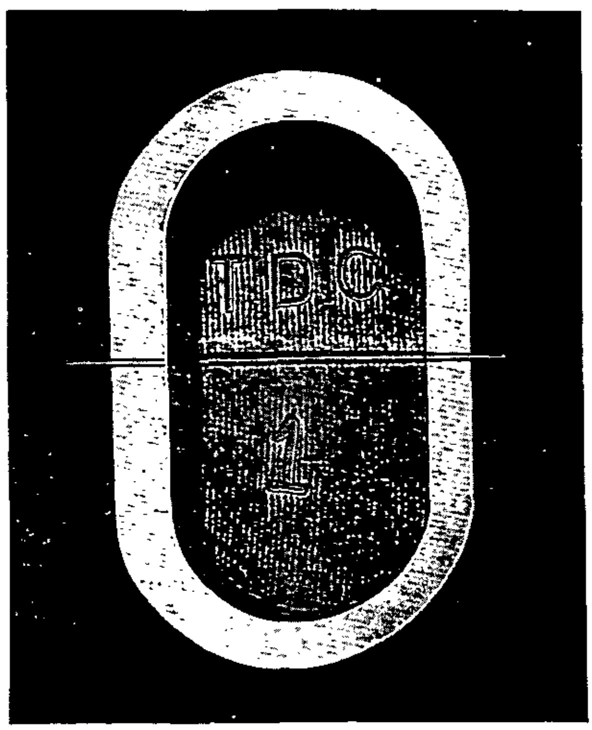


Fig. J.22. T.D.C. Mark on Flywheel.

NORMALLY ASPIRATED ENGINES

No. 1 Inlet Valve Clearances for Valve Timing Purposes

Early 6.354 Engines :

All engines up to engine numbers quoted below ...		0.034 in (0,86 mm)

Current 6.354 Engines rated above 2,250 rev/min :

Engine No. and Type		
8070878	General	0.047 in (1,19 mm)
8131276	International Harvester Co. Ltd. ...	
8230756	Gebr. Claas	
8430101	Horizontal — General	

Current 6.354 Engines rated below 2,250 rev/min :

Engine No. and Type		
8072773	General	0.021 in (0,53 mm)
8231057	Gebr. Claas	

6.372 and 6.3542 Engines:

All Types	0.047 in (1,19 mm)

TURBOCHARGED ENGINES

Early engines rated up to 2,250 rev/min ...	0.021 in (0,53 mm)
Early engines rated above 2,250 rev/min ...	0.047 in (1,19 mm)
Current engines (all ratings)	0.047 in (1,19 mm)

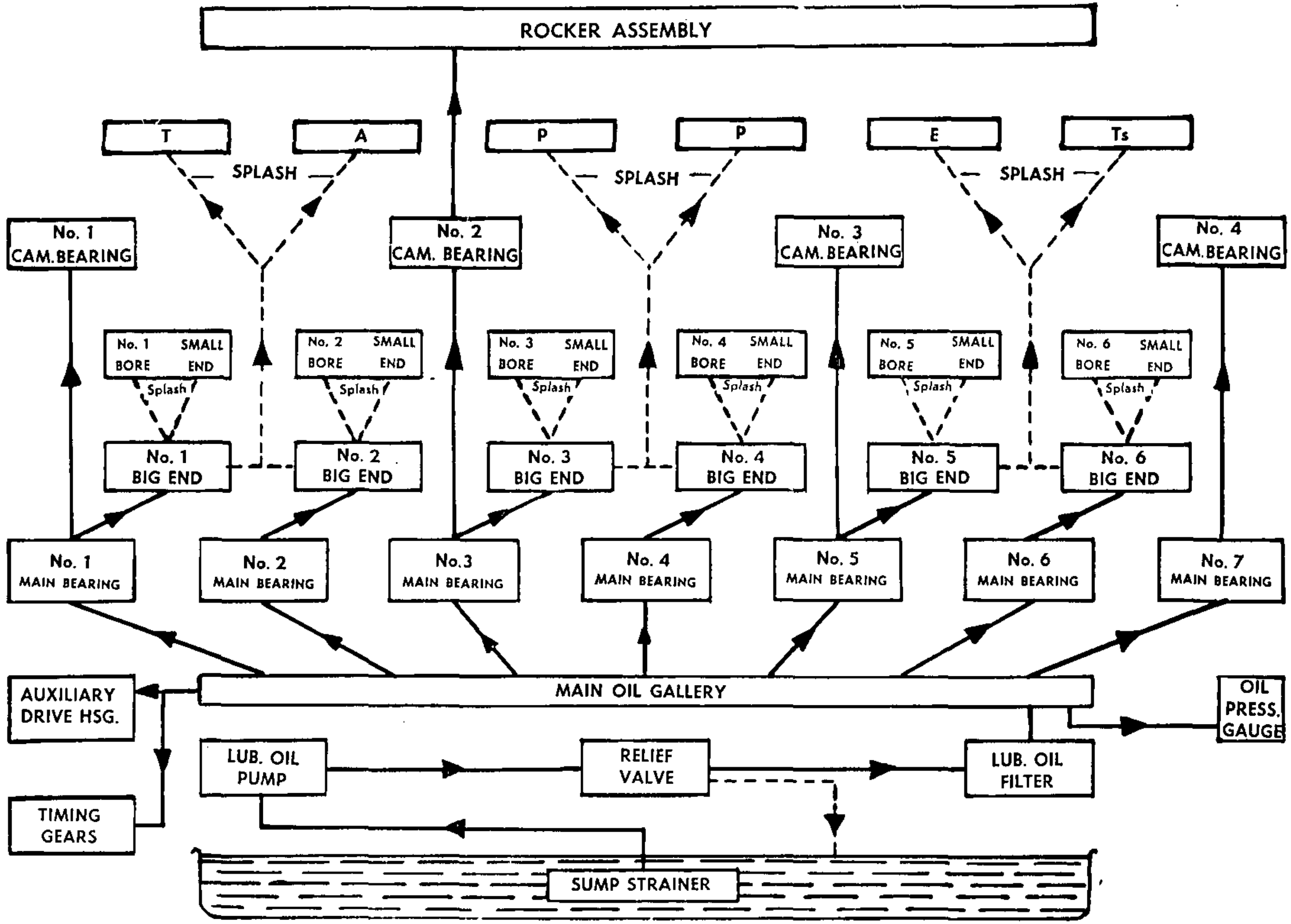


Fig. K.1. Lubricating Diagram.

SECTION K
Lubricating System

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

Oil Circulation

The oil pump draws oil through the sump strainer and delivers it through a short tube to the oil delivery housing. From the housing oil passes through a drilling to the oil filter. The oil passes through the filter to the pressure rail drilled the length of the cylinder block.

Holes in the crankcase webs feed oil from the pressure rail to the main bearings and holes in the crankshaft carry oil to the big-end bearings. A seal prevents oil leaking along the crankshaft at the rear end.

The small end bushes are lubricated by splash and oil mist. On T6.354 engines the small end bushes are also pressure fed through the shank of the connecting rod.

Through drillings in Nos. 1, 3, 5 and 7 crankcase webs, oil passes from the main bearings to lubricate the camshaft bearings.

No. 2 camshaft bearing supplies a controlled feed of oil, to the rocker shaft assembly. This is achieved by allowing oil to be forced to the rocker shaft only when the oilways in the camshaft journal and No. 2 camshaft bearing are in line. Oil from the rocker shaft escapes through a small bleed hole in each rocker lever and lubricates the valves and springs.

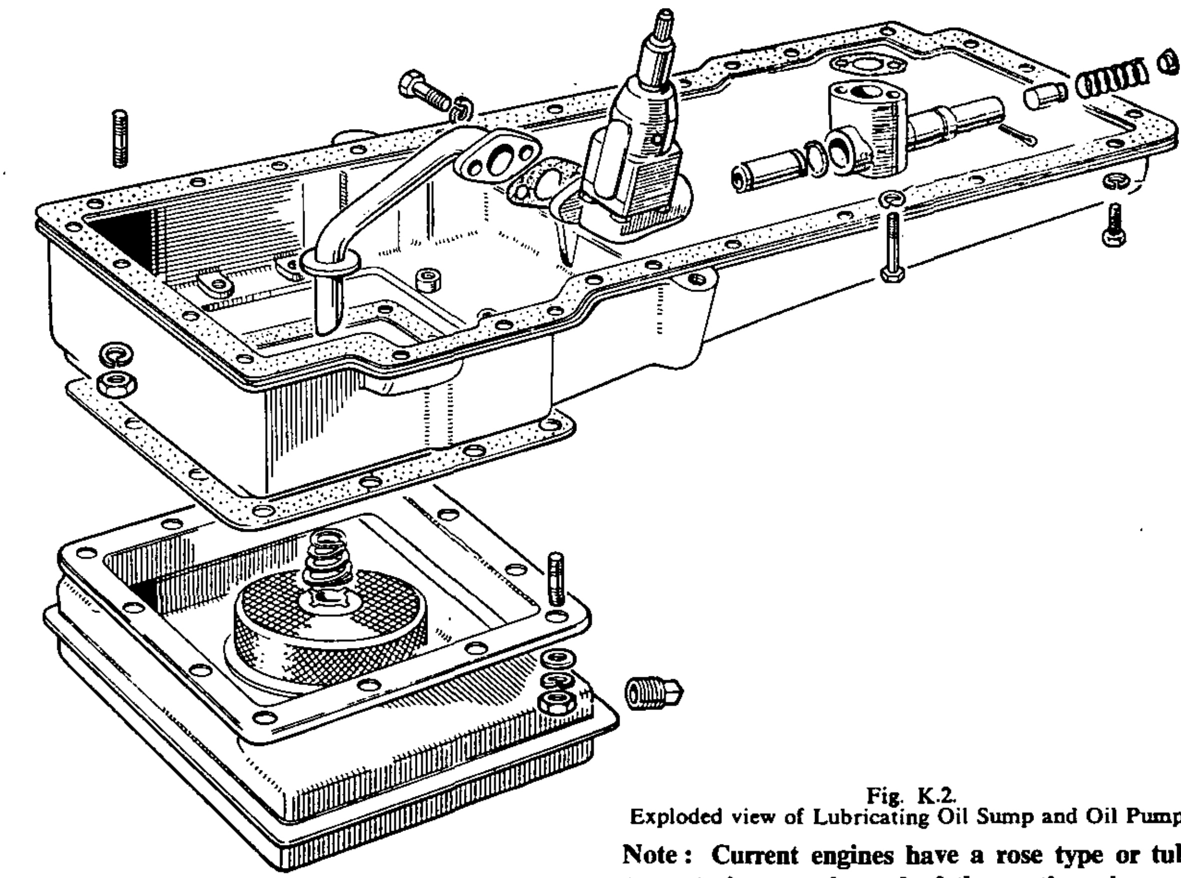


Fig. K.2.
Exploded view of Lubricating Oil Sump and Oil Pump.

Note: Current engines have a rose type or tube type strainer on the end of the suction pipe.

Lubrication for the timing gears is taken from the oil passages connecting the pressure rail with the front main bearing and auxiliary drive. The two idler gear hubs intersect these drillings and oil is passed through the hubs to lubricate the teeth of the gear train.

The auxiliary drive shaft bearings are lubricated by a drilling from the pressure rail to the front auxiliary drive shaft bearing. The oil then passes around a groove in the bearing journal and through a further drilling along the outer side of the auxiliary drive housing to the rear auxiliary drive shaft bearing. Lubricant for the upper fuel pump drive bearing is also taken from this drilling. Also connected with the outer drilling is a small spray tube, which directs oil onto the wormwheel and worm gear.

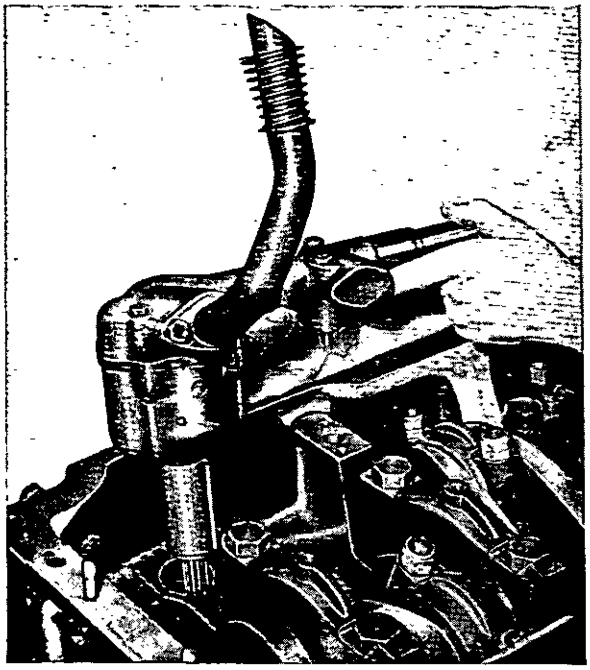


Fig. K.3. Lubricating Oil Pump Removal.

SUMP

An exploded view of the lubricating oil sump and pump is shown in Fig. K.2.

To Remove the Sump

Lower the sump by releasing all flange setscrews.

To Replace the Sump

1. Screw two guide studs in the cylinder block, one on each side.
2. Place the sump in position and insert the screws. Remove the guide studs.
3. Tighten the screws evenly to a torque 9/10 lbf ft (1.2/1.4 kgf m) — 12/14 Nm.

OIL PUMP

To Remove the Oil Pump and Oil Pump Delivery Housing

1. Remove the sump and strainer.
2. Remove the two setscrews securing the oil delivery housing to the cylinder block.
3. Unscrew the lubricating oil pump locating setscrew situated on the outside of the cylinder block.
4. The oil pump and oil delivery housing can now be removed (Fig. K.3).
5. The two parts of this assembly are connected by a short pipe which is a push fit in each compartment. A rubber 'O' ring is recessed into the bore of both the lubricating oil pump and the delivery housing and to separate, pull the components apart.

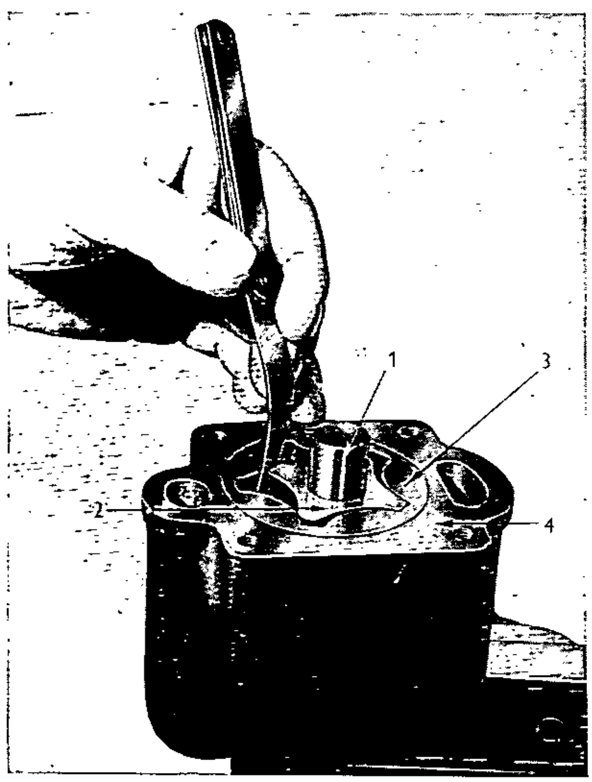


Fig. K.4. Checking Clearance between Inner and Outer Rotor.

1. Shaft.
2. Inner Rotor.
3. Outer Rotor.
4. Pump Body.

To Dismantle the Oil Pump

1. Remove the suction pipe.
2. Remove the bottom cover from the pump.
3. The shaft, inner and outer rotors can now be removed.

Inspection of the Oil Pump

1. Inspect the rotors for cracks or scores.
2. Install the drive and driven rotors in the pump body. The chamfered edge of the outer rotor enters the pump body first.
3. Check clearances between inner and outer rotors (Fig. K.4), rotor end float (Fig. K.5) and clearance between outer rotor and pump body (Fig. K.6).

Note: The clearances for these dimensional checks are given on Page B.12. These are clearances applicable to a new pump and are intended to be used as a guide. If the pump is considered faulty, then it must be replaced by a complete unit as parts are not supplied individually.

The hydraulic wormwheel assembly as described on page J.6 calls for a lubricating oil pump with a drain channel in the drive end of the body casting. It is important to note that lubricating oil pumps without this drain channel must not be used to replace pumps with a drain channel as this will prevent the drain of oil from the hydraulic loading within the auxiliary drive housing.

NOTE: A high capacity lubricating oil pump is fitted to 6.3542 engines. It is not interchangeable with the standard lubricating oil pump.

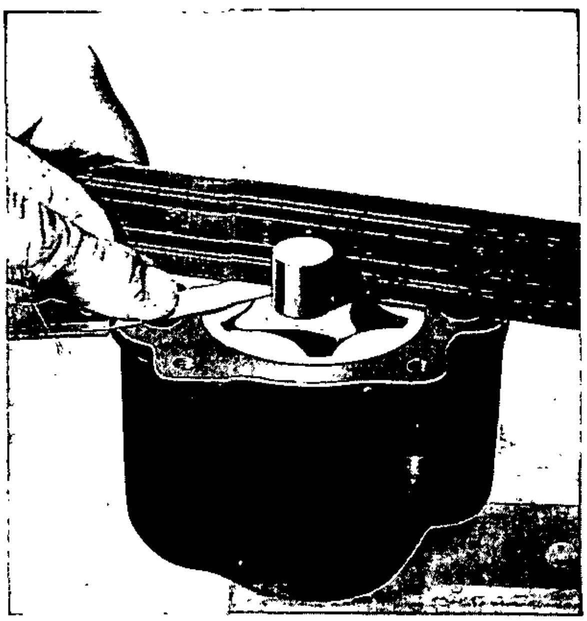


Fig. K.5. Checking End Float of Rotors.

Fig. K.6.
Checking Clearance between Outer Rotor and Pump Body.

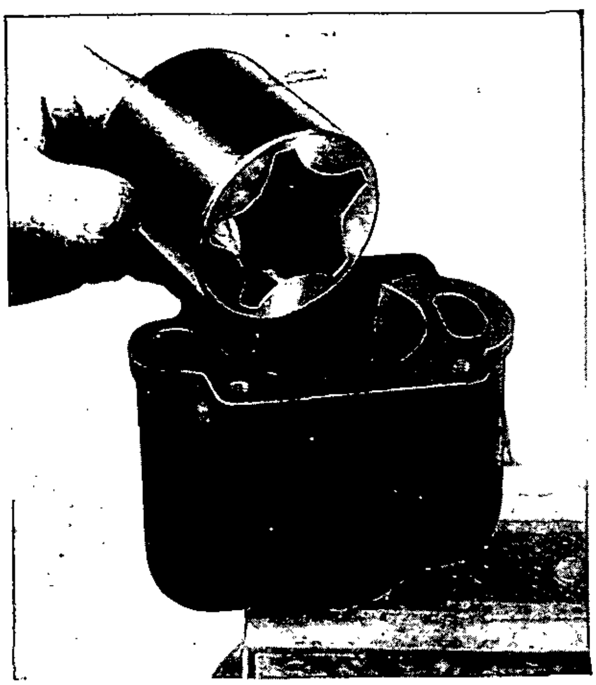


Fig. K.7. Replacing Outer Rotor.

To Refit the Oil Pump

1. Fit the outer rotor, entering the chamfered end first (Fig. K.7).
2. Fit the inner rotor and drive shaft (Fig. K.8).
3. Using a new "O" ring refit the end cover and suction pipe.
4. Refit the oil delivery housing to the oil pump (Fig. K.9).
5. Fit the assembly and replace the oil pump locating screw.
6. Tighten down the oil delivery housing.
7. Replace the sump strainer and sump.

The oil pump should be primed with lubricating oil prior to fitting.

NOTE:

On earlier engines, a 1/32 in (0,794 mm) joint was used between the lubricating oil delivery housing and the cylinder block. When replacing this joint only, torque to 12/15 lbf ft (1,66/2,07 kgf m) — 16/20 Nm. As an interim measure, before the current 0.010 in (0,254 mm) thick joint was used, an aluminium joint was incorporated. In both these cases the setscrews are to be tightened to a torque of 19/21 lbf ft (2,63/2,90 kgf m) — 26/28 Nm, using a plain washer under the spring washer.

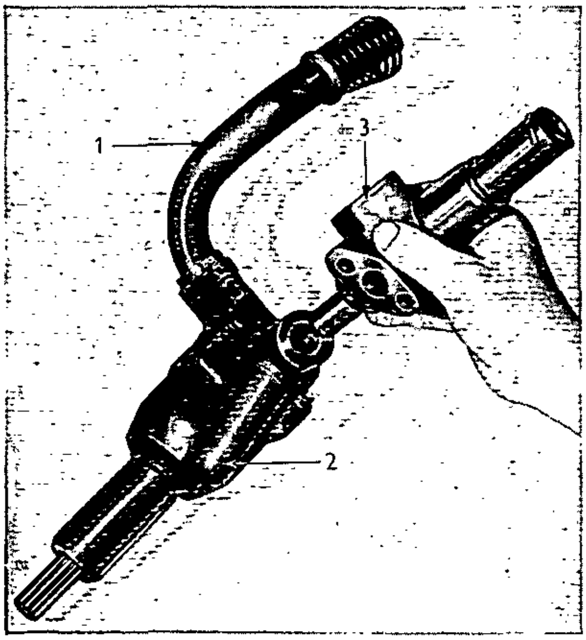


Fig. K.9. Oil Pump and Oil Delivery Housing Assembly.
1. Suction Pipe.
2. Lubricating Oil Pump.
3. Oil Delivery Housing.

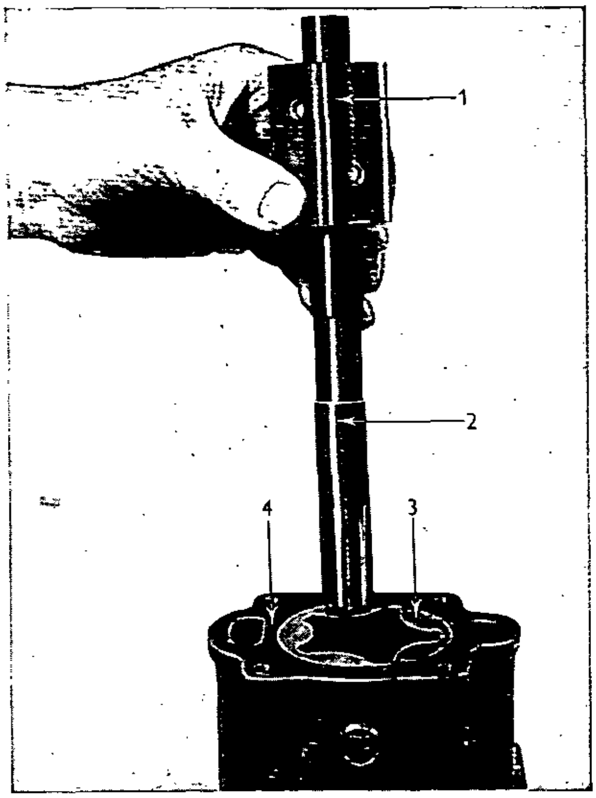


Fig. K.8. Replacing Oil Pump Drive Shaft.
1. Inner Rotor.
2. Shaft.
3. Outer Rotor.
4. Pump Body.

OIL PRESSURE RELIEF VALVE

The oil pressure relief valve is incorporated in the oil delivery housing bolted to the bottom of the cylinder block and is set to operate at pressures given on Page B.13.

To Remove and Dismantle the Relief Valve Assembly

1. Remove the sump.
2. The delivery housing and oil pump are connected by a short tube which is a push fit. Remove the oil delivery housing by pulling it away from the connecting tube.
3. Remove the splitpin from the end of the relief valve housing and withdraw the cap, spring and plunger.
4. Inspect all parts for wear or damage.

To Assemble and Refit the Relief Valve Assembly

1. Fit the plunger, spring and cap to the relief valve housing and secure with the split pin.

2. If possible, check the pressure setting of the relief valve as quoted above. If not, extreme caution is advised when starting the engine, until it is certain that the pressure relief valve is working properly.

3. Refit the relief valve assembly to the cylinder block. When refitting, the oil seals around the connecting tube should be renewed.

4. Refit the sump.

Oil Pressure

The pressure may vary with individual engines and under different operating conditions, but should be 30 lbf/in² (2,1 kgf cm²) — 207 kN/m² minimum at working temperature and maximum running speed.

If the oil pressure is below normal, check the following in the order given below.

1. Dipstick. Check there is sufficient oil in the sump.

2. Oil Pressure Gauge. Check for accuracy with a master gauge.

3. Lubricating Oil Filter. May be choked, renew element.

4. Sump Strainer. This may be choked, remove, clean and replace.

5. Lubricating Oil Pump. Check that the suction pipe and oil delivery housing joints are tight.

6. Oil Pressure Relief Valve may be stuck open.

LUBRICATING OIL FILTERS

A sump strainer and full flow main oil filter are fitted. For early T6.354 engines a turbocharger filter is fitted in tandem with the engine filter.

The sump strainer consists of a gauze wire container which fits over the suction pipe of the lubricating oil pump. The sump strainer must be thoroughly cleaned each time the sump is removed.

The main oil filter is mounted on the side of the cylinder block. The canister or paper element should be renewed every 5,000 miles (7,500 km) or 200 hours.

To Change the Filter Element (Paper Type)

1. To dismantle the filter, see Figs. K.10 and K.11.
2. Remove the old element (Fig. K.12 and clean out the container.
3. Part fill the container with new oil and fit the new element so that it locates correctly on the spring loaded guide in the base of the container.
4. Fit a new container seal in the filter head.
5. Offer up the container and element assembly to the filter head and secure.

To Refit the Oil Filter to the Engine

1. Secure the filter to the cylinder block. Between the joint and filter bracket, a hard setting jointing compound should be used, as

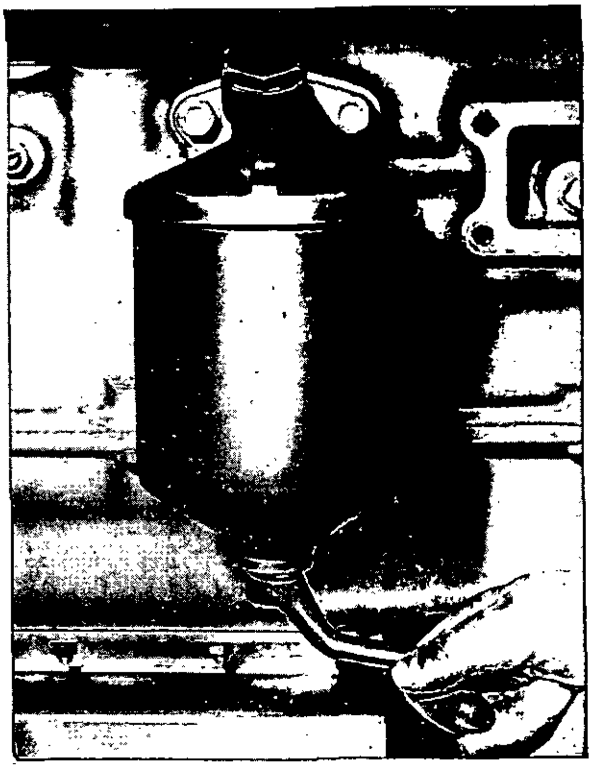


Fig. K.10. Unscrewing Filter Bowl Securing Bolt.

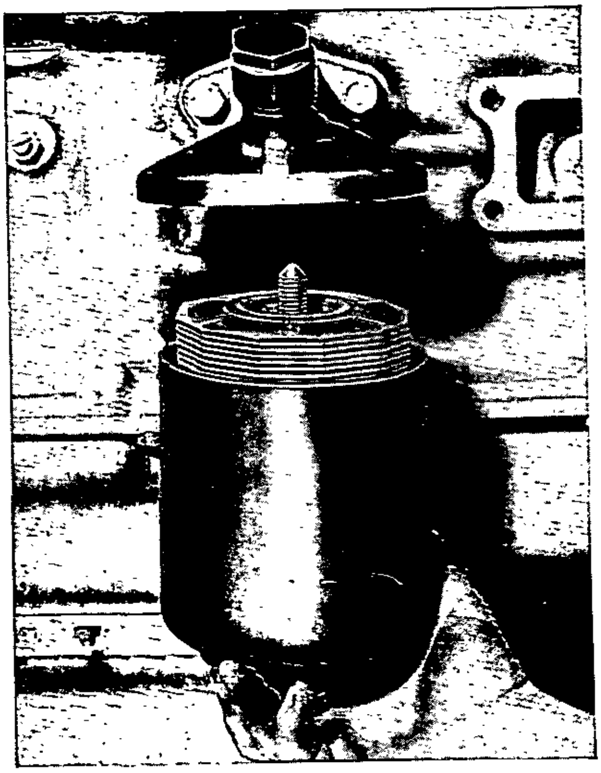


Fig. K.11. Dismantling Lubricating Oil Filter.

opposed to a non-setting jointing compound on the reverse side. The setscrews should be tightened to a torque of 30 lbf ft (4,2 kgf m) — 41 Nm.

2. Check the sump level after running the engine and top up as necessary.

Spin-on Type Oil Filter

Later engines employ a spin-on type oil filter. The canister consists of a combined casing and element. With early canisters, a standpipe was screwed into the element and the standpipe was threaded at its lower end which screwed into the filter head. With current type canisters, the standpipe is an integral part of the canister and a threaded adaptor secures the canister to the filter head.

The later type spin-on filter canister will fit over the standpipe which was designed for the earlier canister, making the two canisters interchangeable in this respect.

Under no circumstances may an earlier spin-on canister without an integral standpipe, be fitted in an inverted position on an engine without a standpipe, as this would allow the oil to drain from the filter when the engine is a rest. If there is no standpipe fitted to the filter head casting, then you must always fit the later type canister with the inbuilt standpipe.

The earlier type canister can be identified by a number of small holes which can be seen on the inside of the element within the canister, whilst on the later canister, the integral standpipe can be seen.

Always fit the correct Perkins filter canister as the following features are incorporated in current canisters which may not be included in other types.

1. A filter by-pass valve set to a pressure to suit the applicable engine type.
2. An integral standpipe to prevent drainage of the filter through the engine bearings.
3. A rubber flap valve to prevent drainage of the filter through the oil pump.

To Renew Spin-on Type Oil Filter Canister

1. Unscrew filter canister from filter head (see Fig. K.13).
2. Discard old canister.
3. Clean filter head.
4. Using clean engine oil, liberally oil top seal of replacement canister.
5. Fill the new canister with clean lubricating oil allowing time for the oil to filter through the element.
6. Screw replacement canister onto filter head until seal just touches head and then tighten

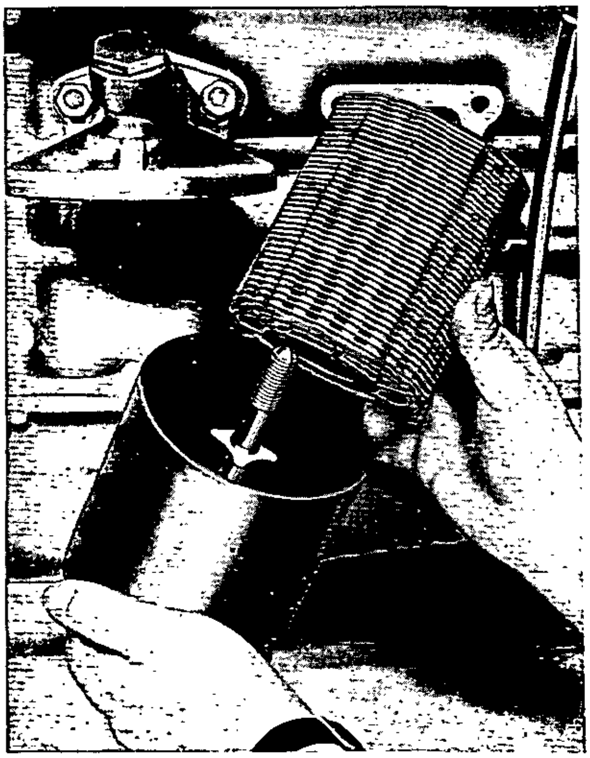


Fig. K.12. Removing Lubricating Oil Filter Element.

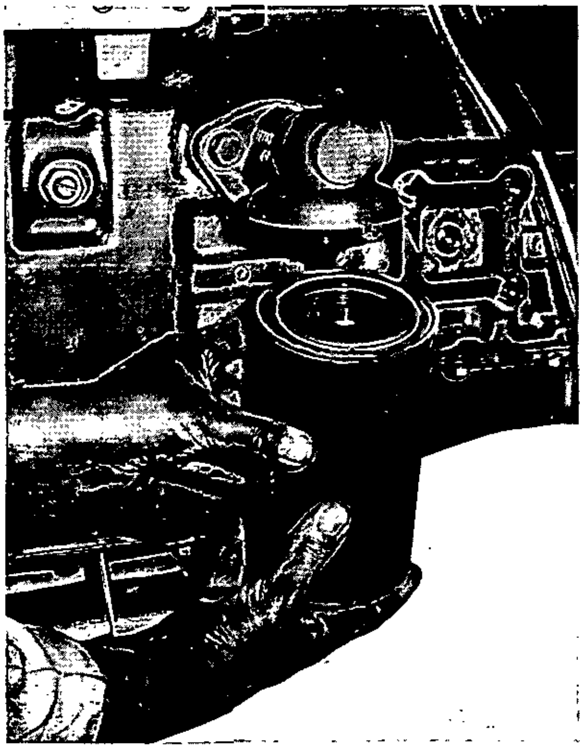


Fig. K.13. Removing Spin-on Lubricating Oil Filter Canister.

by hand as per instructions on canister. Where a tool is available, tighten to 15 lbf ft (2.07 kgf m) — 20 Nm.

7. Run engine and check for leaks.

HORIZONTAL ENGINES

Whilst the oil circulation on the horizontal engine is similar to that employed for vertical engines, it can differ by a 'dry sump' system being employed.

The lubricating oil is contained in a separate well mounted on the side of the sump, the oil being drawn from the well by the oil pump. When the oil drains back to the sump, it is pumped to the sump well by means of a scavenge pump mounted on the front main bearing cap and gear driven from the front of the crankshaft. Two drain plugs are provided, one for the sump and one for the sump well.

Due to the variance in delivery of the oil pump and scavenge pump the following procedure is recommended when renewing the lubricating oil.

1. Fill engine sump well to full mark on the dipstick.
2. Run the engine until normal operating temperature is obtained, then idle for two minutes and shut down.
3. Top up the sump well to full mark on the dipstick.

For routine oil level checks, the engine should be idled for two minutes and then shut down before reading the dipstick.

The oil level should not be checked with the engine running at speeds in excess of 1000 rev/min or if the engine has been shut down from speeds in excess of 1000 rev/min without the two minute idling period.

To Remove Sump Well and Strainer

1. Remove the dynamo complete with its bracket.
2. Uncouple the oil pipes from the oil filter and remove the filter complete with its bracket.
3. Remove the oil filler body.
4. Remove the dipstick.
5. Remove the sump well. The sump strainer can now be removed.

To Remove the Sump

1. Remove the sump well.
2. Lower the sump by releasing all flange setscrews.

To Remove the Scavenge Pump

1. Remove the sump well and sump.
2. Remove the timing case.
3. Remove the oil pipes from the scavenge pump.
4. Remove the scavenge pump idler gear.
5. Remove the scavenge pump from the front main bearing cap (K.14).

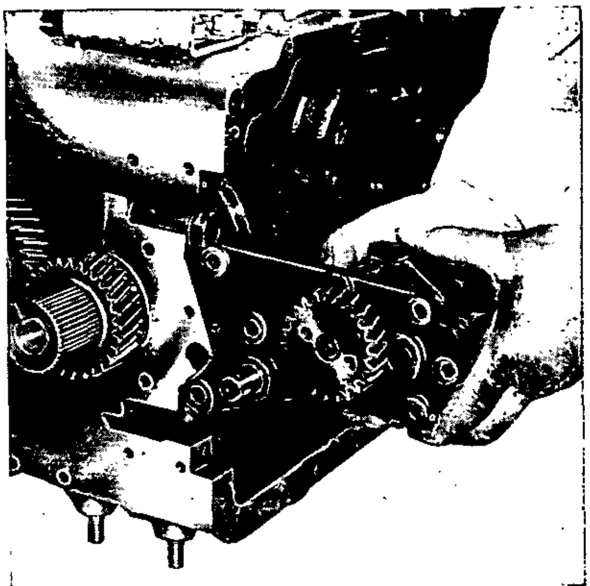


Fig. K.14.
Removing Scavenge Pump.
(Horizontal Engines only).

Dismantling the Scavenge Pump

1. Remove the end plate.
2. The pump may now be completely dismantled by removing the drive gear and pump body from the mounting bracket. Two extractor holes are provided in the scavenge pump drive gear to facilitate easy removal.
3. Reassembly of the scavenge pump may be effected by reversing the sequence of dismantling.
4. Check that the pump turns freely before refitting it.

To Replace the Sump and Sump Well

The replacement of these items may be effected by reversing the order of dismantling.

Easy replacement of the sump may be facilitated by using two guide studs screwed into each side of the crankcase which will ensure correct positioning of the sump and joints. These studs should be removed and replaced by setscrews once the sump has been secured to the crankcase.

When replacing the sump it should be ascertained that the oil pump suction pipe correctly enters the grommet in the wall dividing the sump from the sump well. It should also be ascertained that this grommet is not damaged.

SECTION L
Cooling System

Circulation of the engine coolant is provided by an impeller type pump driven by a 'V' belt from the crankshaft pulley. Provision is made to mount a fan on the water pump pulley.

A high or low position water pump may be fitted on the front face of the cylinder block.

The water pump bearings are pre-packed with a special grease during assembly and do not require attention in service.

A thermostat is fitted in the water outlet connection.

Twin by-pass blanking thermostats are used in the A6.3541 and 6.372 cooling system which blank off the by-pass ports when the thermostats are fully open. This system is also used with 6.3542 engines employing high level water pumps.

FAN BELT

Thumb pressure on the belt on the longest run between any two pullies should allow a ⅜ in deflection either way from the mean position.

Correct tension of the fan and generator belt should be maintained by periodical checking and adjustment every 5,000 miles (7,500 km) or 250 hours.

Belt adjustment is obtained by altering the position of the generator with an adjustable link.

Note: Re-check the adjustment of new belts after a short running in period.

WATER PUMP

An exploded view of a typical low position type water pump is shown in Fig. L.1, and a fitted high position water pump in Fig. L.2.

To Remove and Refit the Water Pump — High and Low Position Types

1. Remove the fan and belt.
2. Disconnect connections to water pump.

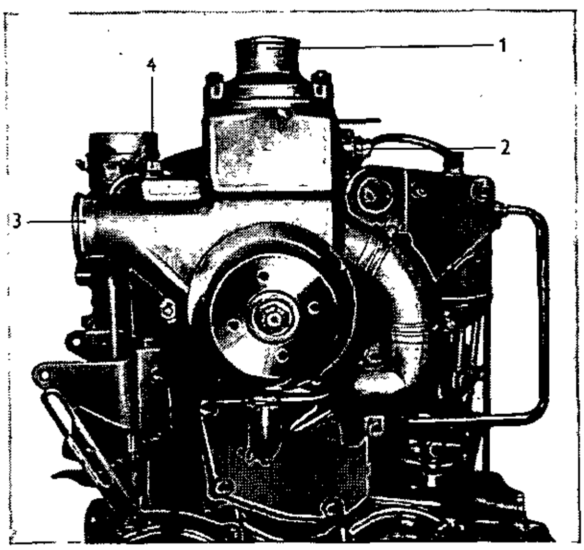


Fig. L.2. High Position Water Pump.
1. Water Outlet Connection.
2. Cab Heater Outlet Connection.
3. Water Inlet Connection.
4. Cab Heater Return Connection.

3. Remove the pump.
4. Refit pump in reverse sequence.

NOTE:

On 6.354 and T6.354 engines commencing with serial number 354U59084 incorporating a high position water pump which is fitted to the cylinder head, the pump body, joint and backplate upper two setscrew holes securing the backplate to the water pump body, have been repositioned radially to provide easier accessibility to the cylinder head securing nuts.

For identification purposes, the associated part numbers have been changed.

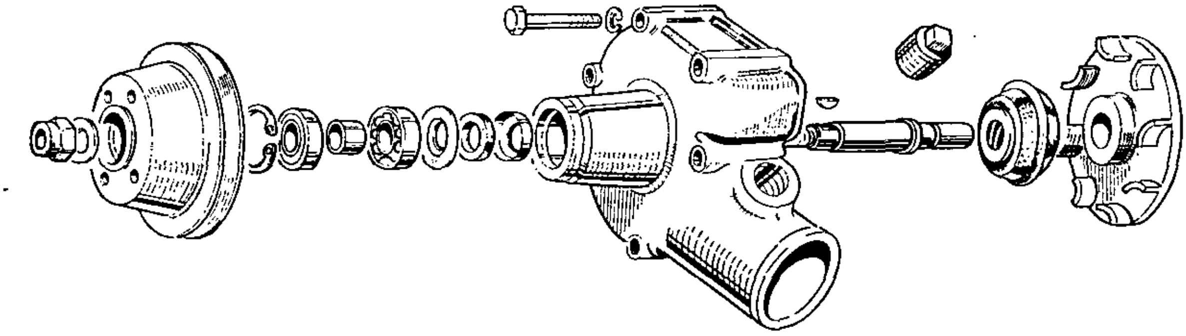


Fig. L.1.
Exploded view of low position water pump.

The later combination of water pump body, joint and backplate may be fitted in service, but individually they are not interchangeable.

The earlier combination will continue to be available.

Service kits will continue to be available for all pumps.

To Dismantle the Water Pump — Both Types

1. Remove the nut and washer securing the water pump pulley and withdraw the pulley from the shaft (Fig. L.3), also the driving key.
2. Press water pump shaft complete with impeller out of the body, from the front (Fig. L.4).
3. Press the impeller from the shaft (Fig. L.6).
4. Remove the rear seal from the shaft.
5. Remove the bearing retaining circlip (Fig. L.5).
6. Press out the two bearings, distance piece and flange.
7. Remove the front seal and seal retainer.

Inspection

1. Examine the body for cracks, damage or corrosion.

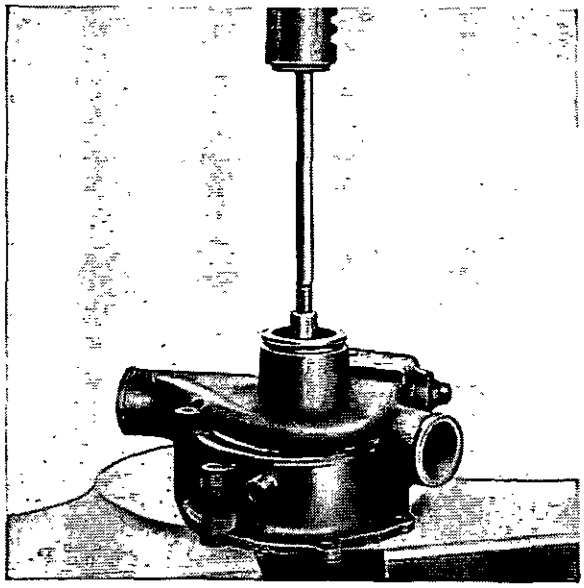


Fig. L.4.
Removing Water Pump Shaft.
(High Position Type Water Pump).

2. Examine the drive shaft for wear ensuring inner diameter of the bearings are a perfect fit on the shaft. The shaft should be renewed if the inner races rotate on the shaft.
3. Remove rust and scale from impeller and inspect for cracks or damage. Examine im-

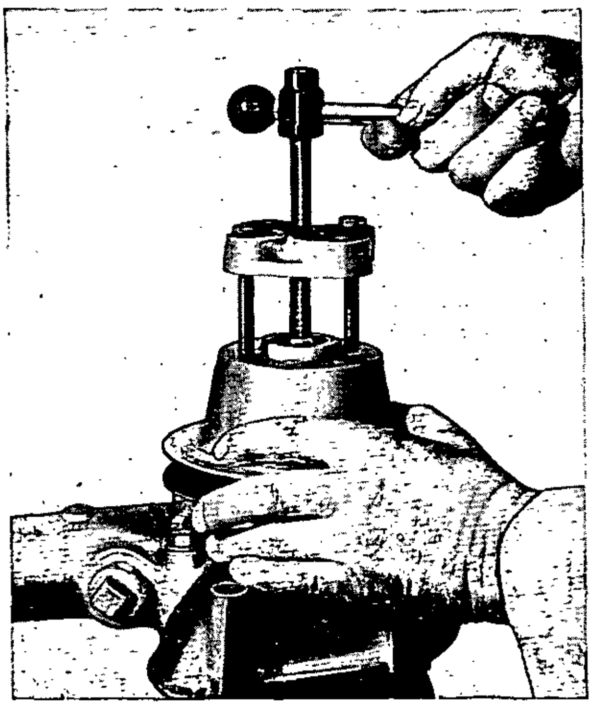


Fig. L.3. Removing Water Pump Pulley (Low Position Type Water Pump).

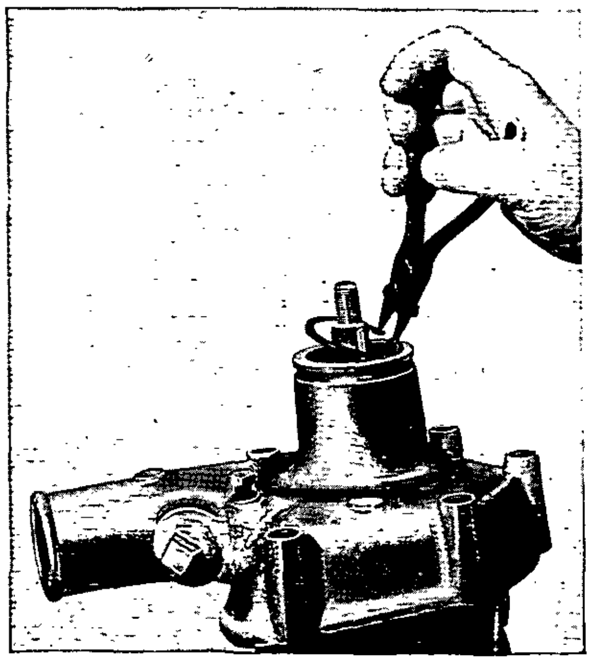


Fig. L.5. Removing Bearing Retaining Circlip. (Low Position Type Water Pump).

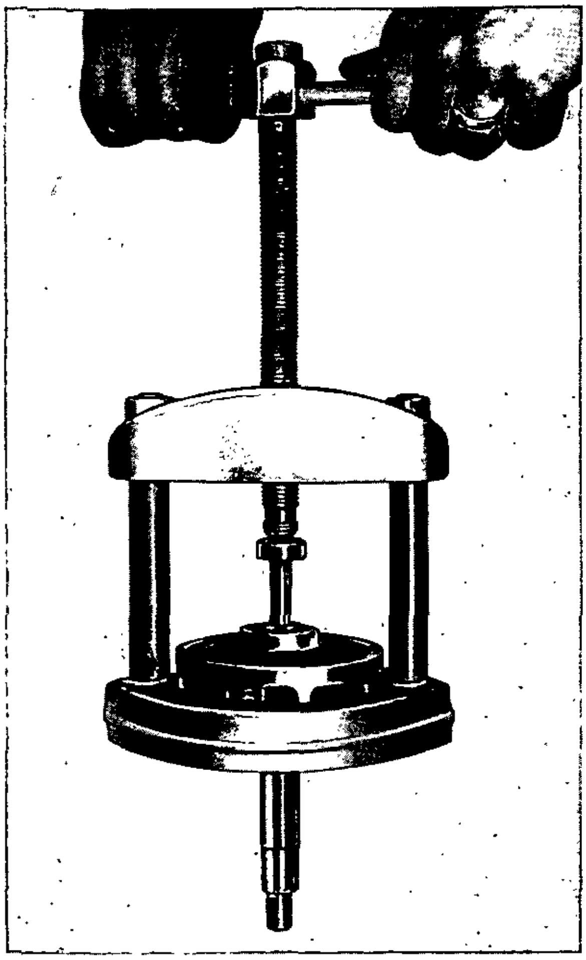


Fig. L.6.
Removing Impeller from Water Pump Shaft.

peller hub sealing face for excessive wear or scoring.

4. Examine water seal for damage.
5. Inspect bearings for pitting, corrosion or wear.

To Reassemble the Water Pump — Both Types

1. Press rear bearing onto the shaft, fit distance piece and then press on front bearing. When fitting bearings to the shaft, ensure the shielded face of each bearing faces outwards, towards the front and rear ends of shaft.
2. Fit grease seal retaining plate in position against back face of the rear bearing. This retaining plate is dished and when in position, the centre of the plate must not be in contact with the bearing.
3. Fit felt seal and seal retaining housing so that these bear on the retaining plate.
4. Half fill space between the two bearings with high melting point grease and press complete bearing and shaft assembly into pump body from the front end. Position the retaining circlip in the recess of pump housing immediately forward of front bearing.
5. Fit the water seal with carbon face towards rear.
6. At this stage, the shaft should be turned by hand to check for undue resistance.
7. Fit pulley driving key and press on pulley making sure there is no rearward movement of the shaft.
8. Press impeller onto shaft, so that a clearance of 0.012/0.035 in (0,30/0,89 mm) is maintained between impeller vanes and pump body (Fig. L.7).
9. Refit washer and nut, tightening to a torque of 55 lbf ft (7,6 kgf m) — 75 Nm.

Note: **The earlier water pump was modified to incorporate a seal with a brass outer casing, which is a press fit in the pump body, and the pump bearings are sealed. The front felt seal has also been changed in favour of one which has been soaked in Shell Ensis 20 oil.**

All current engines have a ceramic counter face for the seal between the impeller and the spring loaded carbon faced seal. Care should be taken to ensure that the ceramic face of the seal bears against the carbon face of the spring loaded seal. There is a special repair kit for this pump.

The A6.3541 and 6.3542 water pump is not interchangeable with the pump fitted to standard T6.354 and 6.354 engines.

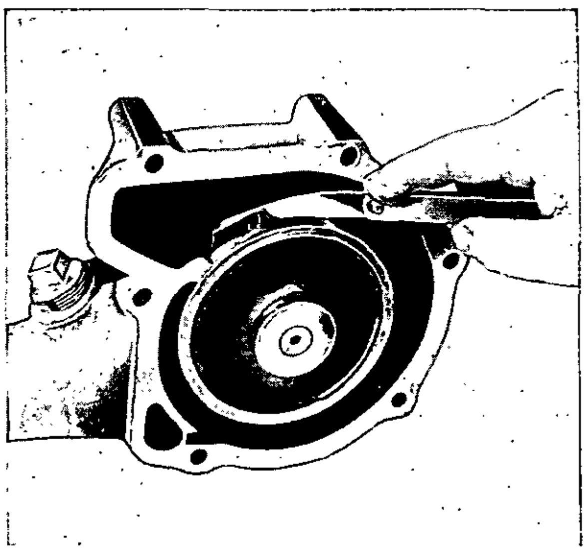


Fig. L.7.
Checking Clearance between Impeller and Pump Body. (Low Position Type Water Pump).

It is recommended that, where an early type pump requires attention or replacement, it should be exchanged for one of the current type.

Should this not be possible, however, it is possible to fit all later parts to an earlier type pump, but the following must be observed.

1. The sealed bearings must be fitted with the seals towards the outside of the pump.
2. The space between the fitted bearings must be half to two thirds filled with Shell Alvania 2 grease.
3. When fitting the rear seal, the brass portion of the seal and the recess in the pump body should be cleaned and a good quality jointing compound used before pressing the seal home. The contact face of the seal must be kept clean.

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.

THERMOSTAT

A thermostat is incorporated in the cooling system to allow the engine to reach the most efficient working temperature quickly.

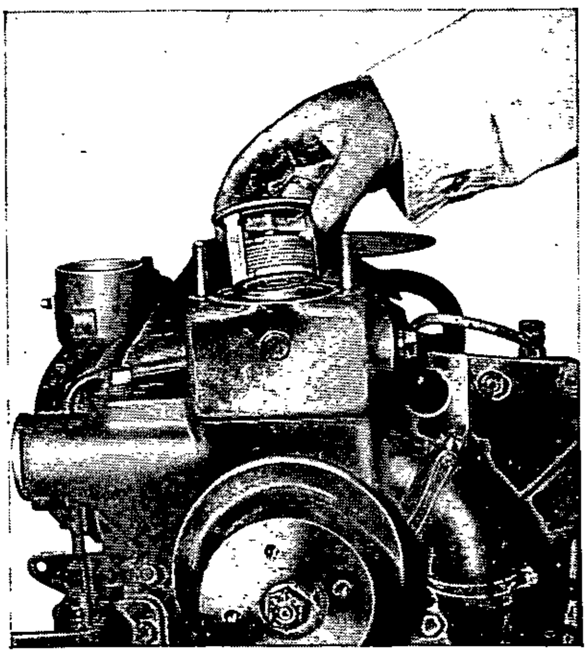


Fig. L.8.
Removing Thermostat (6.354 High Position Type Water Pump).

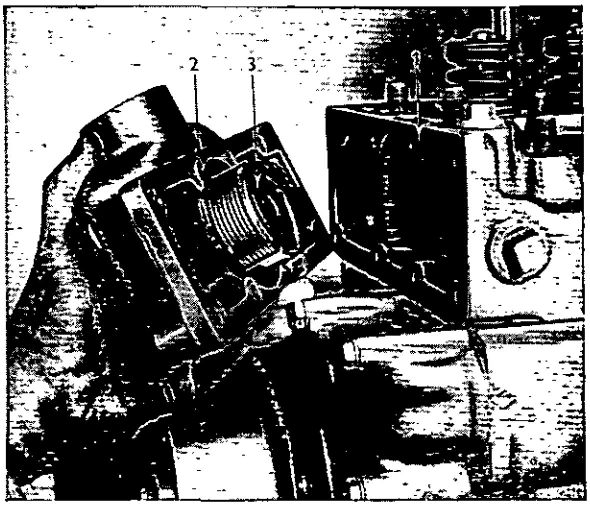


Fig. L.9. Removing Thermostat.
(6.354 Low Position Type Water Pump).
1. Cylinder Head.
2. Water Outlet Plate.
3. Thermostat.

With the high position pump, the thermostat is fitted in the top of the pump (Fig. L.8).

With the low position pump, the thermostat is fitted in the water outlet body situated on the front of the cylinder head (Fig. L.9). It is retained by a circlip (Fig. L.10).

With 6.372 engines, twin by-pass blanking thermostats are fitted in the water outlet body at the front of the cylinder head.

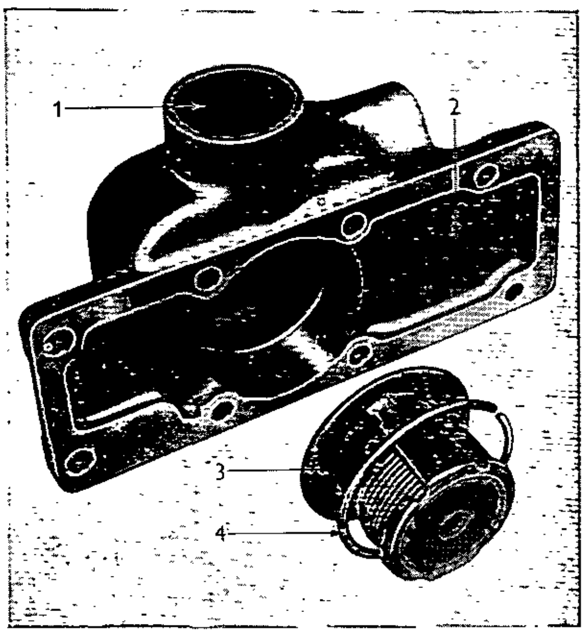


Fig. L.10. Exploded view of Thermostat and Water Outlet Connection
(6.354 Low Position Type Water Pump).
1. Water Outlet Connection.
2. Water Outlet Plate.
3. Thermostat.
4. Circlip.

To allow air to escape when filling the engine with coolant, a jiggle pin is incorporated with the thermostat. High position water pumps have the jiggle pin fitted in the top of the thermostat, whilst low position pumps have the jiggle pin fitted in the thermostat housing, or alternatively a small bleed hole is drilled in the housing in place of the jiggle pin. It is **most important** that the correct type of thermostat is fitted to the engine; i.e. thermostat with jiggle pin in the top for high position and plain top thermostat for low position water pump See Note on Page D.3.

NOTE: If overheating of the water coolant is experienced on engines fitted with a low position water pump, following a period in which the system had been drained and allowed to stand for a couple of days, it may be due to the jiggle pin being clogged which will not allow the escape of trapped air and the cooling system will appear to be full, when in fact it is not. Reference to the vehicle, tractor or plant manufacturers handbook will reveal the total capacity of the cooling system, it will therefore be possible to ascertain whether *the system is fully charged.*

If a discrepancy is found, the temperature gauge sender or blanking plug whichever is fitted should be removed from the top front of the cylinder head, on the fuel pump side and coolant added to the radiator until it emerges from the hole. Re*place the temperature gauge sender or blanking* plug and top up the radiator. Run the engine for a few minutes and top up the radiator again if necessary.

The above procedure is recommended because the location of the jiggle pin in the water outlet body varies according to the application, and it is not always accessible.

To Remove the Thermostat

1. Drain off the coolant and remove the hose between radiator header tank and water outlet connection, or water pump.
2. For low position pumps, remove water outlet body and circlip in the body securing the *thermostat. Remove thermostat (Fig. L.9).*
3. In the case of the high position pump, remove water outlet connection adaptor; lift out thermostat (Fig. L.8).

Testing the Thermostat

If it is suspected that the thermostat is not operating correctly it should be tested as follows:

Immerse thermostat in water and gradually heat. Check water temperature at frequent intervals with accurate thermometer. The valve should commence to open at temperature stamped on top face of thermostat adjacent to valve seat.

Thermostats are NOT repairable.

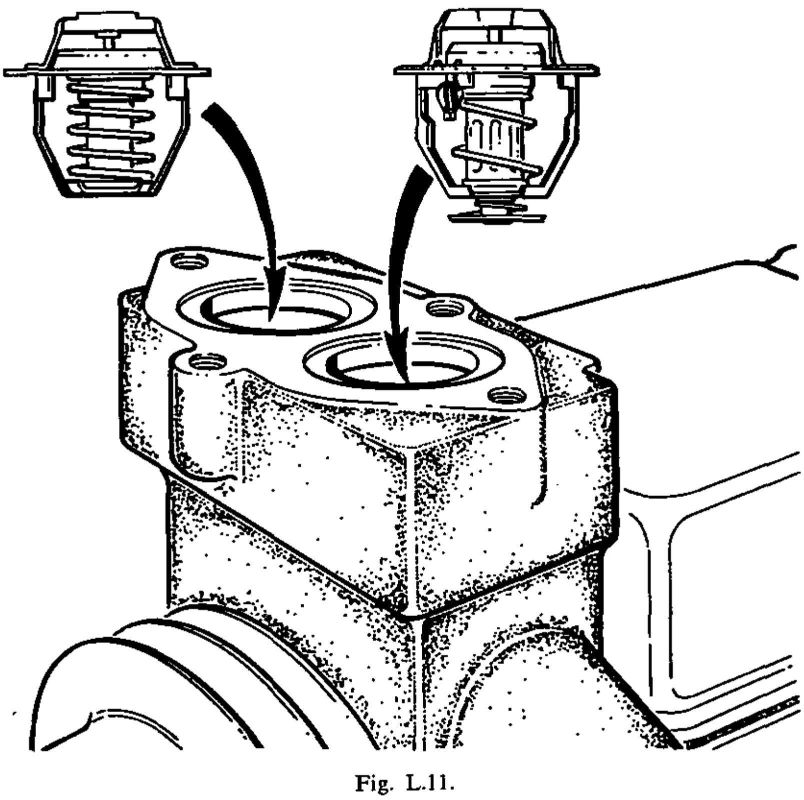


Fig. L.11.

SECTION M
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 a 22 in water gauge RESTRICTION INDICATOR (18 in water gauge for turbocharged engines) in the air trunking between the air cleaner and the engine manifold. It indicates by means of a visual signal when the air cleaner 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. M.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/in^2 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 it that the water acts as a carrier for the dust.

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.

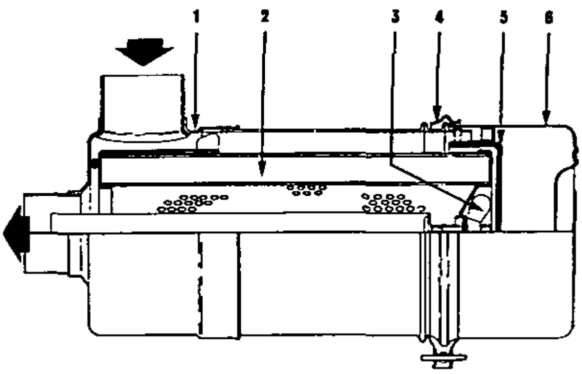


Fig. M.1.
Dry Type Two Stage Air Cleaner.

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

Dry Type Two Stage "Cyclone" See Fig. M.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.

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 cleaner body and dry thoroughly. Inspect joints, hoses and clips and renew where necessary.

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

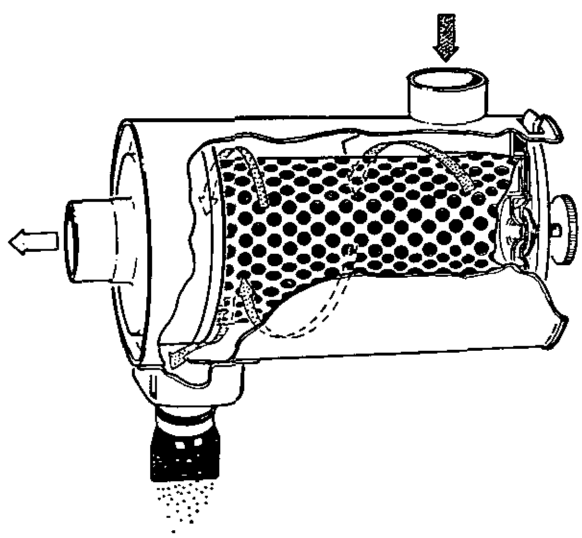


Fig. M.2.
Dry Type Two Stage Air Cleaner.

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

The "Rotopamic" type air filter 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.

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. M.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

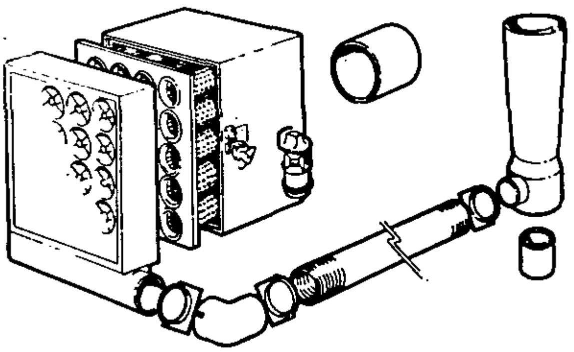


Fig. M.3.
Heavy Duty, Multiple Element Air Cleaner.

with a proprietary cleaning fluid or Kerosene. Refill the container with clean new engine lubricating oil, grade SAE 40 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.

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.

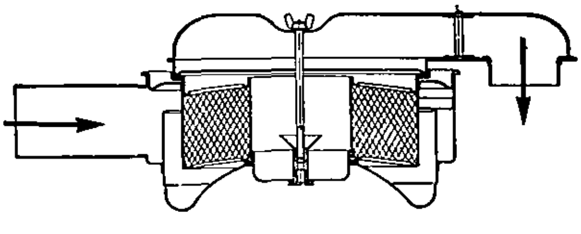


Fig. M.4.
Oil Bath Air Cleaner.

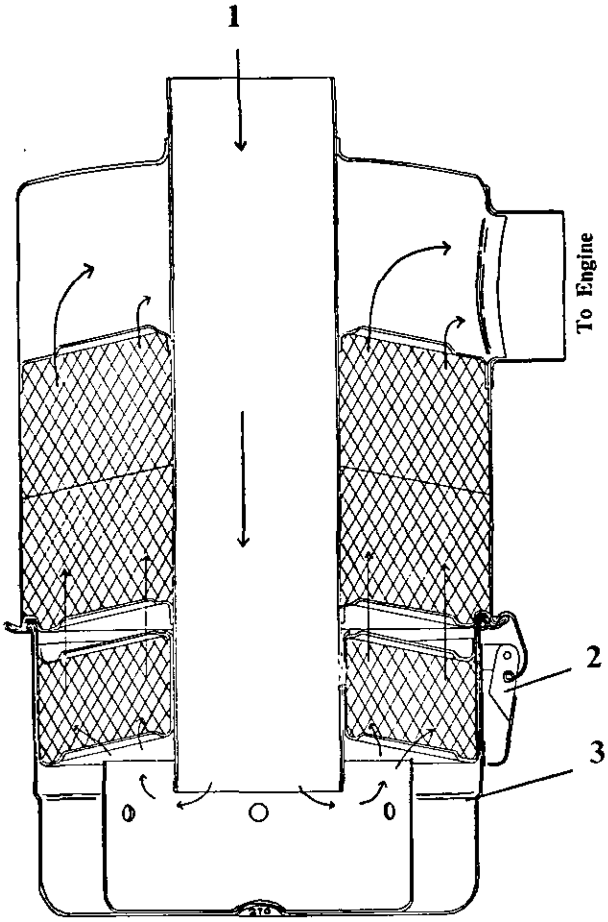


Fig. M.5:
Diagram showing direction of air flow.
1. Air Inlet. 2. Clip. 3 Oil Level.

Tractor Type Air Cleaner (Fig. M.5)

The air cleaner container should be removed, cleaned and recharged with S.A.E. 50 oil to the level mark every 200 hours. The lower gauze filter should also be removed and cleaned. The larger gauze in the main body of the cleaner should also be cleaned.

Under extremely dirty conditions attention to the cleaner should be given more frequently. It is important to note that the cleaner oil container must never be filled above the indicated level.

FUEL FILTER

Fuel oil filters are provided as well as a dirt trap in the fuel tank.

The first filter is a gauze trap in the filler of the fuel tank. This must not be removed when fuel is being poured into the tank. It should be periodically cleaned.

If there is no filter in the filler, the fuel should be poured through a fine gauze strainer when filling the tank.

The second filter is a gauze type fitted in the fuel lift pump. It should be removed, by unscrewing the bolt securing the domed cover on top of the fuel lift pump, and cleaned every 10,000 miles (15000 km) or 400 hours, unless condition of the fuel calls for more regular attention.

Reassemble, so that a good joint is made between the cover and the fuel lift pump body.

The third and final filter is a paper element type, fitted between the top and bottom covers of the filter. It is not possible to clean the element; it should be renewed in accordance with Preventive Maintenance, Page C.1.

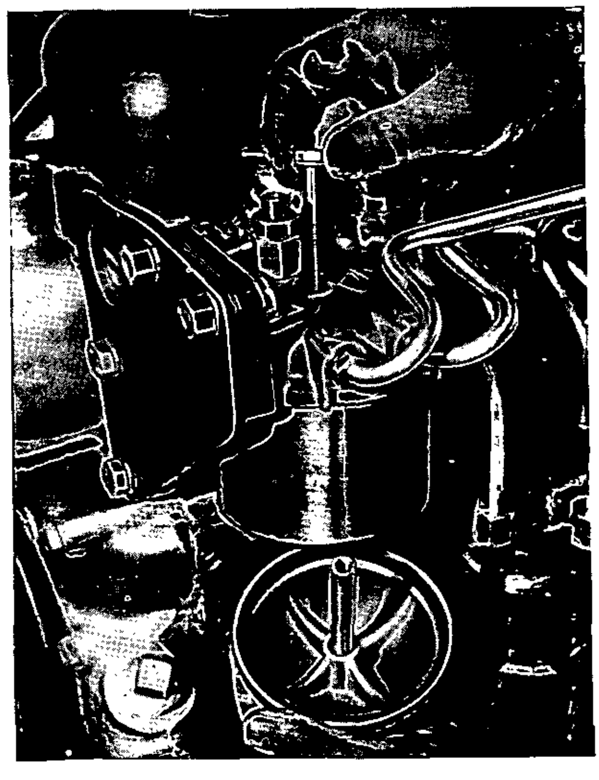


Fig. M.6. Dismantling Fuel Filter.

To Renew the Fuel Filter Element

1. Remove filter element as in figs. M.6 and M.7.
2. Discard the element.
3. Clean the filter top and bottom cover.

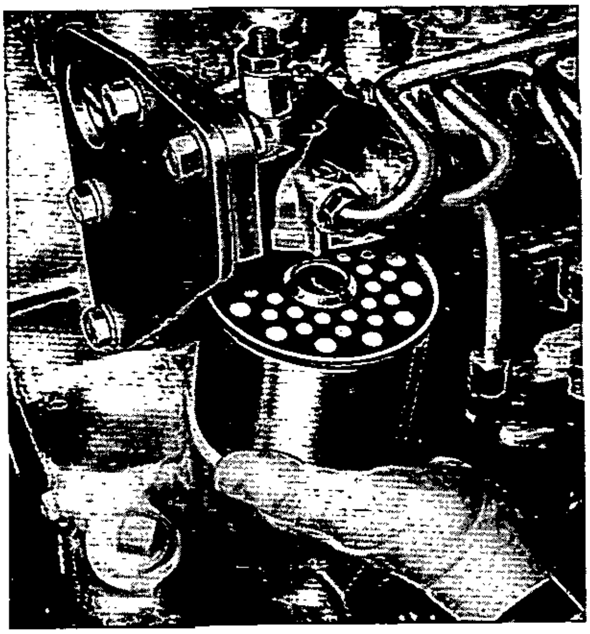


Fig. M.7. Removing Fuel Filter Element.

4. Reassemble the filter and vent the fuel system as on Page M.11.

FUEL LIFT PUMP (Fig. M.9)

The diaphragm type fuel lift pump is operated by an eccentric on the camshaft and is mounted on the right hand side of the cylinder block. It is fitted with a hand priming lever.

With horizontal engines, the fuel lift pump is mounted on the auxiliary drive housing, driven by an eccentric on the auxiliary drive shaft.

Pressure Checking of Fuel Lift Pump

Fit a 0/10 lbf/in^2 (0/0,7 kgf/cm^2) — 0/70 kN/m^2 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 pressure on 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.

	Min. Production Static Pressure			Min. Test Pressure (75% Min. Prod. Pres.)		
	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	5	0,35	34	3.75	0,26	26

To Remove the Pump from the Engine

1. Disconnect the pipes.
2. Remove the pump and joint (Fig. M.8).

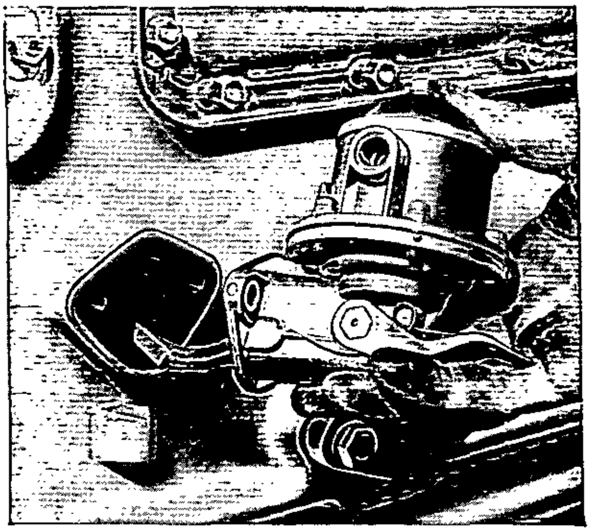


Fig. M.8. Removing Fuel Lift Pump.

Dismantling the Pump

Remove the domed cover from the top of the lift pump, also the gasket and gauze filter.

Make a file mark across the two flanges for guidance in reassembly.

Separate the two halves of the pump.

Turn the diaphragm assembly through 90° and lift the diaphragm and pull rod assembly from the body. The diaphragm and rod are serviced as an assembly and no attempt should be made to separate the layers of the diaphragm.

If any of the diaphragm layers are stuck together or appear cracked, replace the unit. It must also be replaced if there appears to be undue wear in the link engagement slot of the pull rod.

The diaphragm spring should be replaced by one of the same identifying colour if it is corroded or distorted.

The rocker arm pin, spring and washers, together with the rocker arm and connecting link may now be removed.

Prise out the valves with a screwdriver or other suitable tool.

Cleaning and Inspection of Parts

Upper and lower pump castings should be examined for cracks or damage and where the diaphragm or engine mounting flanges are distorted these should be lightly linished to restore their original flatness.

Re-assembly

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

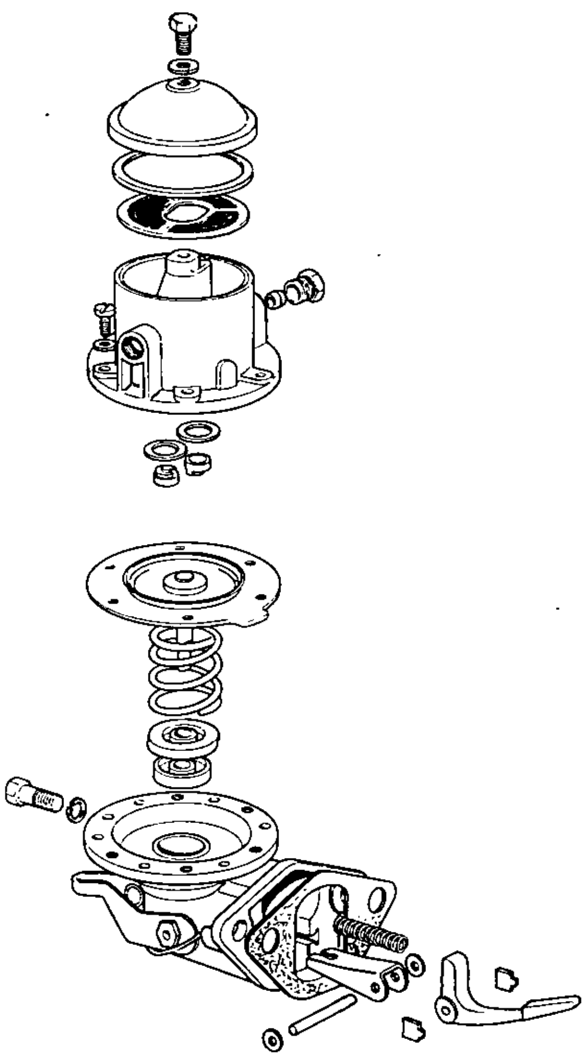


Fig. M.9. Exploded view of Fuel Lift Pump.
Note : Later lift pumps have four bolt fixings.

Clean the valve recesses to allow the new valves to be correctly seated.

Insert a new valve gasket in each valve recess.

Place 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.

Press the valves home with a suitable piece of steel tubing, approximately $\frac{9}{16}$ in (14,29 mm) inside diameter and $\frac{3}{4}$ in (19,05 mm) outside diameter.

Stake the casting in six places (between the original stakings) round each valve, with a suitable punch.

NOTE: The 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.

Replace the filter gauze, gasket and domed cover, to the top of the upper casting.

Assemble the link, packing washers, rocker arm and rocker arm spring, insert the rocker arm pin and place the assembly into the pump body.

Place the rocker arm retainers in position on each end of the pin and tap them into the pump body. Renew the diaphragm seal if worn. Place the seal retainer in position.

Replace the diaphragm spring and the diaphragm assembly over the spring (the pull rod being downwards) and centre the upper end of the spring in the lower protector washer.

When fitting the diaphragm assembly, the small locating tabs should be at position 'A' as shown in Fig. M.10. The diaphragm assembly should then be pushed down until the flattened end of the pull rod enters the slot in the link and then turned a quarter of a turn to the left until the diaphragm locating tabs are at position 'B' (Fig. M.10) and then they will be in line with the locating mark cast on the pump body. The sub-assemblies are now ready for fitting together.

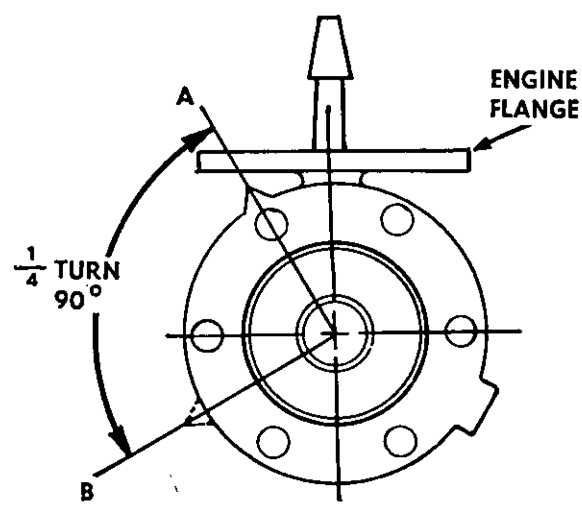


Fig. M.10.
Diaphragm Locating Tab Positions for Reassembly.

Push the rocker arm towards the pump until the diaphragm is level with the body flanges. Place the upper half of the pump into position, as shown by the mark made on the flanges. Install the screws and washers and tighten until the heads just engage the washers.

Before tightening the screws, the rocker must be held at its inward position. Sufficient pressure must be exerted to draw the diaphragm inwards until its edges no longer protrude beyond the pump flanges.

While the rocker arm is so held, the cover screws should be securely tightened, working from side to side so as to keep the pressure even.

To Refit the Lift Pump to the Engine

1. Refit the pump to the cylinder block.
2. Reconnect the fuel lines and vent the system of air as detailed on Page M.11.

FUEL INJECTION PUMP

Description

The fuel injection pump is of the D.P.A. distributor type, vertically mounted on the auxiliary drive housing and is spline-coupled to the auxiliary drive wormgear.

The pump is a compact, oil tight unit, lubricated throughout by fuel oil and requiring no separate lubrication system.

Sensitive speed control is maintained by a governor of either the mechanical or hydraulic operated type and automatic variation of the commencement of injection is obtained with an automatic advance unit.

Note: Unless proper test equipment and the relevant Test Plan for the fuel pump is available, adjustment or maintenance of the fuel pump should not be contemplated.

To Remove the Fuel Pump

1. Disconnect the stop and throttle controls from the pump and remove the return springs.
2. Remove the high and low pressure fuel pipes from the fuel pump.
3. Remove the fuel pump (Fig. M.11).

To Refit the Fuel Pump

1. Replace the fuel pump ensuring that the master spline on its quill shaft will enter the female spline within the vertical drive shaft.
2. Position the fuel pump so that the scribed line on the fuel pump flange aligns with the mark on the fuel pump adaptor plate (Fig. M.12). Secure the pump to the adaptor plate.
3. Refit the high and low pressure pipes to the fuel pump.
4. Reconnect the throttle and stop lever controls and attach the return springs.

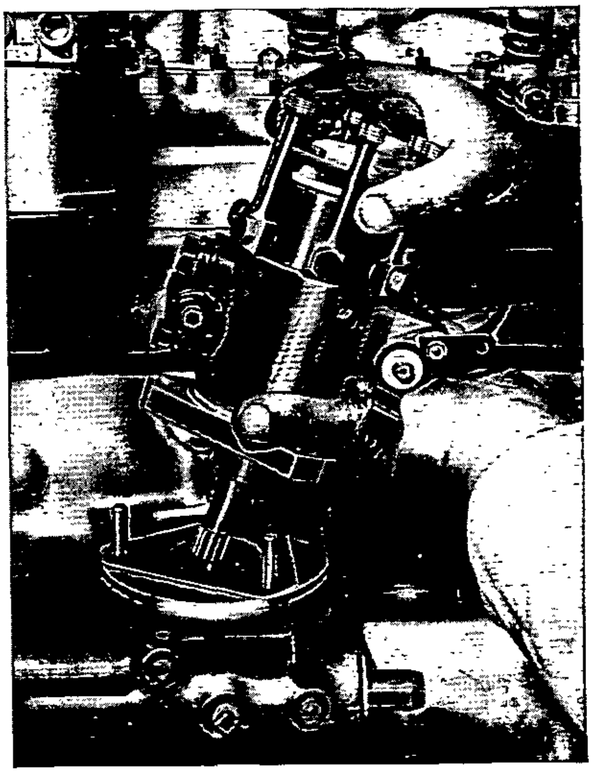


Fig. M.11. Removing Fuel Pump.

5. Vent the fuel system of air (Page M.11).
6. Adjust the maximum and idling speeds (Pages M.9 and M.10).

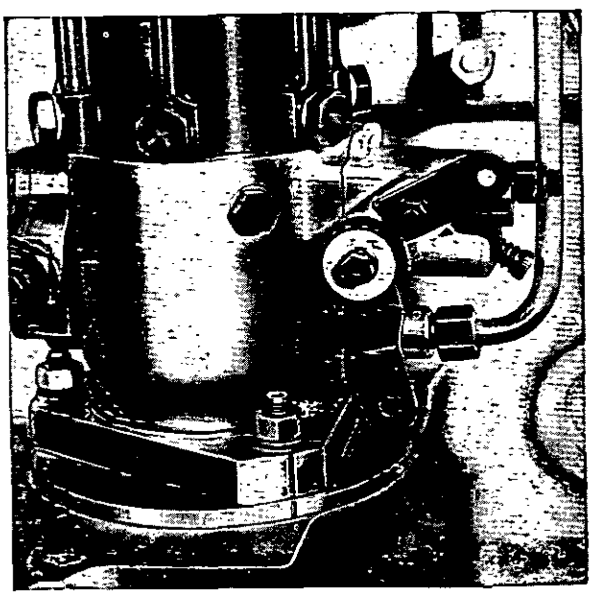


Fig. M.12.
Scribed Line on Fuel Pump and Adaptor Plate

Fuel Pump Timing

There are a number of timing marks appertaining to the fuel pump, which when aligned in the correct manner, ensure the fuel pump is timed correctly.

With No. 1 piston at T.D.C. on compression and with the fuel pump removed, the slot in the fuel pump drive hub should be aligned with the slot in the fuel pump adaptor plate, see Fig. M.13. If these slots are not in line, remove the auxiliary drive gear cover plate from the front of the timing case, release the three securing setscrews of the gear and turn the auxiliary drive shaft by means of the hexagon plug in the front end of the shaft.

On the fuel pump rotor, inside the fuel pump, are a number of scribed lines, each one bearing an individual letter. A timing circlip also bearing a scribed line is positioned inside the pump body **which has to be set** so that when the appropriate scribed line on the fuel pump rotor aligns with the scribed line on the circlip, it denotes commencement of injection (static timing), Fig. M.14.

Note: On later engines the scribed line on the circlip has been deleted. On these engines the scribed line on the rotor should be aligned with the end of the circlip which has a straight edge (Fig. M.15).

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 on the pump to an atomiser tester and pump up to 30 ats (31 kgf/cm² or

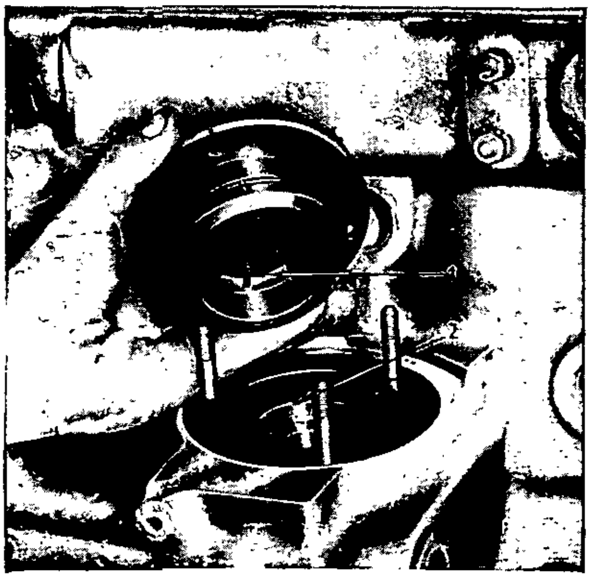


Fig. M.13
1. Timing Slot on Fuel Pump Adaptor Plate.
2. Timing Slot on Fuel Pump Drive Hub.

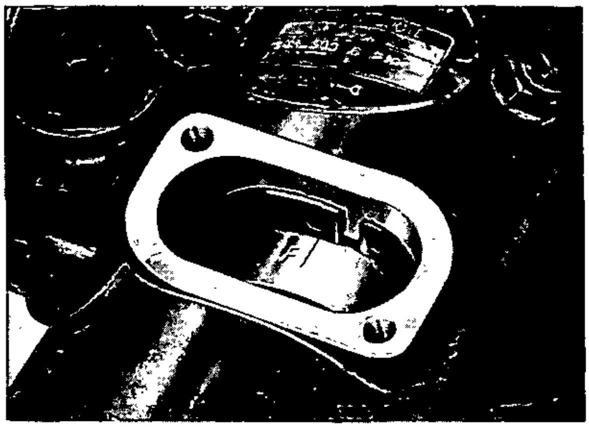


Fig. M.14. Static Timing Mark—Early Fuel Pumps.

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 adjusted until it lines up with the relative letter on the pump rotor.

A line is scribed on the fuel pump mounting flange and another on the fuel pump adaptor plate. When the fuel pump is fitted to the engine, before tightening the securing nuts, these two scribed lines should be aligned.

Checking Fuel Pump Timing

1. Ensure fuel pump timing circlip is correctly positioned as described previously.
2. Ensure the fuel pump is correctly fitted with the scribed line on the mounting flange aligning with the mark on the fuel pump adaptor plate.
3. Position the crankshaft so that No. 1 piston is at T.D.C. on its compression stroke.
4. Remove the rocker cover.
5. Remove the collets, spring cap and springs from No. 1 inlet valve and allow the valve to rest on top of the piston.

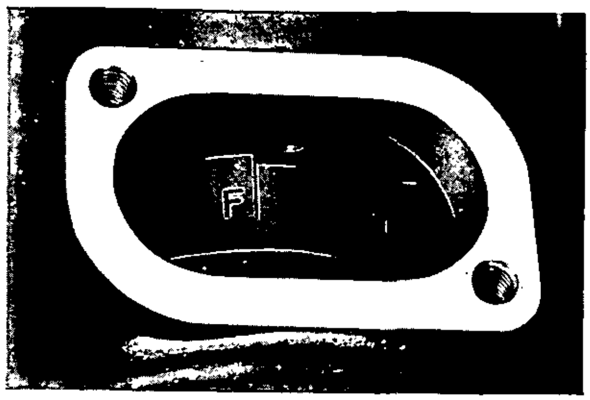


Fig. M.15. Static Timing Mark—Later Fuel Pumps.

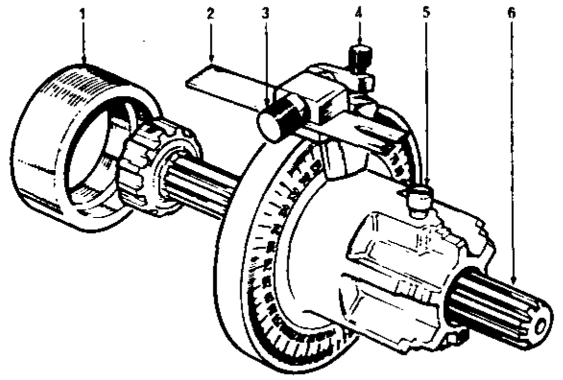


Fig. M.16.
Timing Tool MS67B.

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 0.372 in (9,45 mm) B.T.D.C., this being an equivalent of 28° B.T.D.C. on the flywheel.

   To do this, 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: This setting is for basic normally aspirated vehicle engines. For other applications see Pages B.15 and B.16.

7. Remove the inspection plate on the fuel pump enabling the rotor to be seen (Figs. M.14 and M.15).

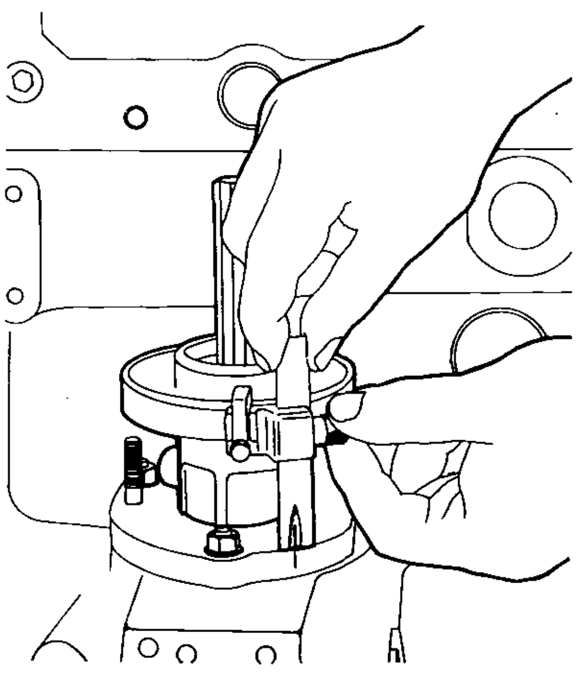


Fig. M.17.
Checking Marking Angle on Fuel Pump Adaptor Plate.

8. With No. 1 piston at the static timing point on its compression stroke, the scribed line on the rotor marked 'H' (for hydraulically governed engines) or 'F' (for mechanically governed engines) should align with the scribed line or straight edge on the timing circlip.
9. If it does not, release the three nuts securing the fuel pump and twist the pump body until the marks align. Further adjustment can be made by turning the auxiliary drive shaft, after first releasing the auxiliary drive gear securing setscrews.
10. If after both these adjustments, the timing marks do not align, it could mean the auxiliary drive gear has been fitted incorrectly; see Page J.1 for correct fitting.

CHECKING FUEL PUMP TIMING USING TOOL MS67B

Checking Timing Scribed Line on Fuel Pump Adaptor Plate

1. Turn engine in normal direction of rotation and position No. 1 piston at T.D.C. compression stroke as detailed on Page J.10.
2. Remove fuel injection pump.
3. Release screw (5) of timing tool (MS67B — Fig. M.16) and position splined shaft (6) in tool so that the relevant spline is to the front of the tool. In the case of some engines using the large heavy duty fuel pump drive, the larger splined adaptor must be used, even though the smaller splined shaft will fit.
4. Ensure that the slotted pointer (2) is positioned with slot to front of tool and chamfered sides of slot outwards. At this stage, slotted end 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. This angle can be obtained by reference to the fuel pump setting code as given on Pages B.15 or B.16.
6. Fit timing tool to engine in fuel pump position ensuring firstly that the splined shaft with master spline is fully located in fuel pump drive shaft and then that register of tool is seated in fuel pump locating aperture. Lock splined shaft in tool. If pointer is 180° from

timing mark, engine is probably on wrong stroke in which case remove the tool and set the engine on correct stroke.

7. Slide slotted pointer downwards so that end of pointer abuts or passes over the fuel pump adaptor plate (see Fig. M.17).
8. Turn timing tool by hand in opposite direction to pump rotation (shown on pump nameplate) to take up backlash and check that scribed line on pump adaptor plate is in line with slot in pointer.
9. If timing mark is not in line, the position of the auxiliary drive shaft relative to its drive gear should be altered as detailed in Section J so that mark is in line with slot when backlash is taken up.
10. Remove tool from fuel pump drive gear and fit fuel pump as detailed on Page M.6.

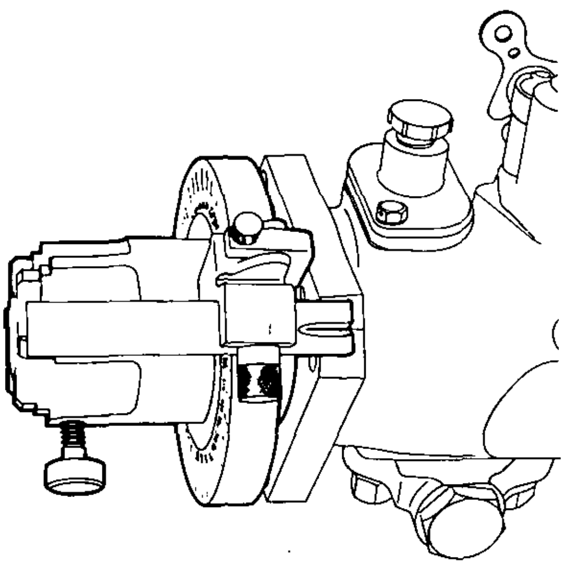


Fig. M.18.
Checking Marking Angle on Fuel Pump Flange.

Checking Marking Angle of Fuel Injection Pump

1. Release screw (5) of timing tool MS67B (see Fig. M.16) and remove splined shaft (6).
2. Ensure that slotted pointer (2) is positioned with slot to rear of tool and chamfered sides 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

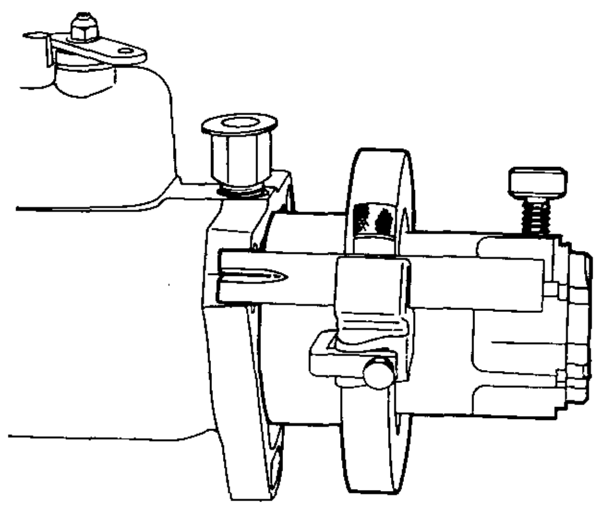


Fig. M.19.
Checking Marking Angle on Fuel Pump Flange using Adaptor MS67B/8.

pressure of 30 atm (31 kgf/cm^2) or 440 lbf/in^2. If pressurising valve is fitted, this must be removed.

4. Release bracket screw (4) and set bracket so that the chamfered edge is in line with relevant marking angle detailed on Pages B.15 or B.16.
5. Position timing tool on pump drive shaft with master splines engaged and tool located on spigot (see Fig. M.18). Adaptor MS67B/8 (1 — Fig. M.16) will be needed on some pumps using the large splined drive (see Fig. M.19).
6. Turn pump in normal direction of rotation as shown in nameplate until pump locks.
7. In this position, slide pointer forward until it is half-way over pump flange and check that timing mark is central to slot in pointer.

Maximum Speed Setting

IMPORTANT NOTE:

The maximum speed screw seal of original fuel pumps must not be broken or tampered with in any way unless factory authority is first obtained. Failure to do so may result in the guarantee becoming void.

When fitting a replacement pump, or in the event of the maximum speed screw having been moved, the maximum no load speed must be checked and reset as necessary.

The maximum no load speed will vary according to application. For details, reference should be made to the code stamped on the fuel pump data plate. The last four numbers in the code indicate the speed required and in the case of the example below, this would be 3130 rev/min.

Code Example: CR62/900/0/3130.

Note: If the fuel pump data plate is damaged or defaced so as to make it impossible to read the code, or if the code is not stamped on the plate, it is advised that the nearest Perkins Distributer or C.A.V. Dealer be contacted, or alternatively, Service Division, Perkins Engines Ltd., Peterborough, to obtain the correct setting.

Important: Under no circumstances should the engine be allowed to operate at higher rev/min than specified or severe damage to the engine may result.

Idling Speed Setting

The engine idling speed is adjusted by the idling screw.

With the engine warm, turn the screw clockwise to increase the engine speed or anti-clockwise to decrease.

The idling speed will vary, according to application. For details, apply to the nearest Perkins Distributor or C.A.V. Dealer, alternatively, Service Division, Perkins Engines Limited, Peterborough.

ATOMISERS

General

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

The atomiser securing nuts should be tightened evenly to 12 lbf ft (1,7 kgf m) — 16 Nm.

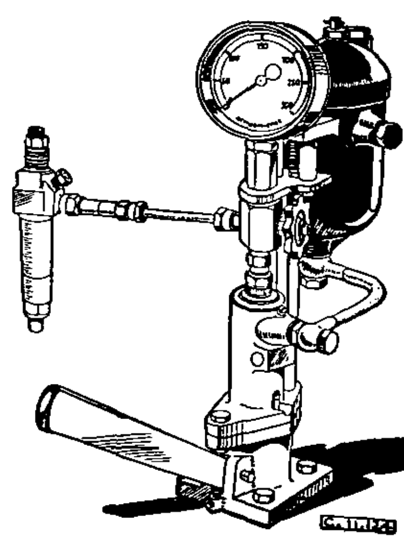


Fig. M.20. Atomiser Testing Pump.

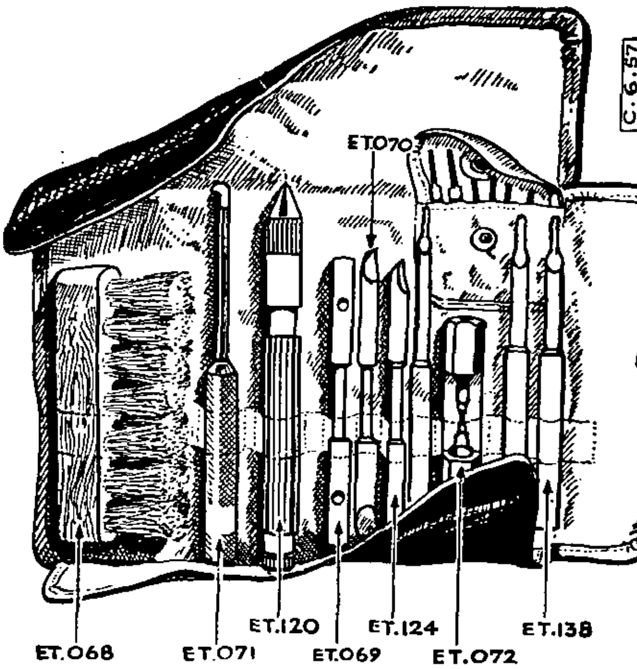


Fig. M. 21.
Complete Kit of Tools for use when cleaning and overhauling atomisers.

Troubles in Service

The first symptoms of atomiser troubles usually fall in 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.

The particular faulty atomiser or atomisers may be determined by releasing the pipe union nut on each atomiser in turn, with the engine running at a fast "tick-over." If after slackening a pipe union nut the engine revolutions remain constant, this denotes a faulty atomiser. The complete unit should be withdrawn from the cylinder head and inverted, atomiser nozzle outwards and the

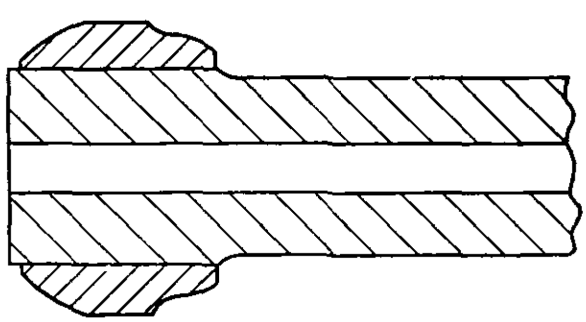


Fig. M.22. High Pressure Fuel Pipe Olive.

unions retightened. After slackening the unions of the other atomiser pipes (to avoid the possibility of the engine starting), the engine should be turned until the nozzle sprays into the air, when it will be seen if the spray is in order. If the spray is unduly "wet" or "streaky" or obviously to one side, or the nozzle "dribbles" it may only be necessary to probe the nozzle holes to remove carbon.

Note: **Care should be exercised to prevent the hands or face from coming into contact with the spray, as the working pressure will cause the fuel oil to penetrate the skin.**

Maintenance

For detailed times refer to periodical maintenance, Section C.

NO ATTEMPT SHOULD BE MADE TO ADJUST THE INJECTION PRESSURE WITHOUT A PROPER TESTING PUMP AND PRESSURE GAUGE AS DESCRIBED AND ILLUSTRATED. IT IS QUITE IMPOSSIBLE TO ADJUST THE SETTING OF ATOMISERS WITH ANY DEGREE OF ACCURACY WITHOUT PROPER EQUIPMENT.

A perfect atomiser, when tested by pumping fuel through it in the open air gives a short "pinging" sound as the fuel emerges from the holes. After the atomiser has been in service for some time, the "pinging" changes to a crackling sound. It is not until the atomiser sounds "dead" that its condition is likely to affect the running of the engine.

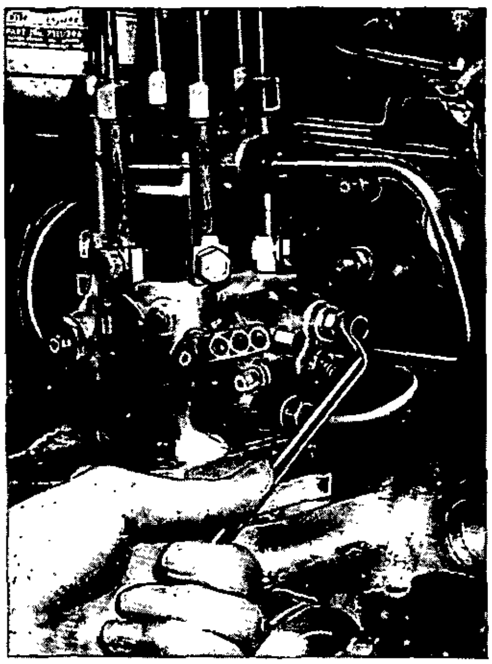


Fig. M.23.
Slackening Bleed Screw on Governor Housing.
(Hydraulic Governor).

Fig. M.24.
Slackening Bleed Screw on Governor Housing.
(Mechanical Governor).

FUEL PIPES

Current high pressure fuel pipes are now supplied with formed ends in place of olives. Earlier pipes supplied with olives were fitted as shown in Fig. M.22. Originally the olives were fitted in the reversed position and both are still satisfactory if undamaged.

No two of the pressure pipes, from the fuel pump to the atomisers are alike.

If the union nuts have been overtightened there is a risk that the olives will have cracked or been unduly compressed, when leakage will result.

The working pressure which these joints must sustain is several thousand pounds per sq. in.

If the union is tightened excessively the olive may collapse and split. The same danger exists if the pipe is not square to and central with the union.

High pressure fuel pipe nuts should be tightened to 15 lbf ft (2,1 kgf m) — 20 Nm.

When changing an atomiser always remove the pipe entirely. Never bend the pipe.

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.

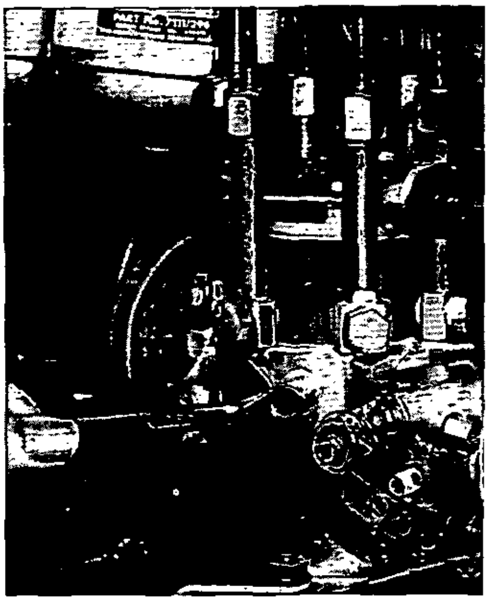


Fig. M.25.
Slackening Bleed Screw at Hydraulic Head Locking Screw.

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.

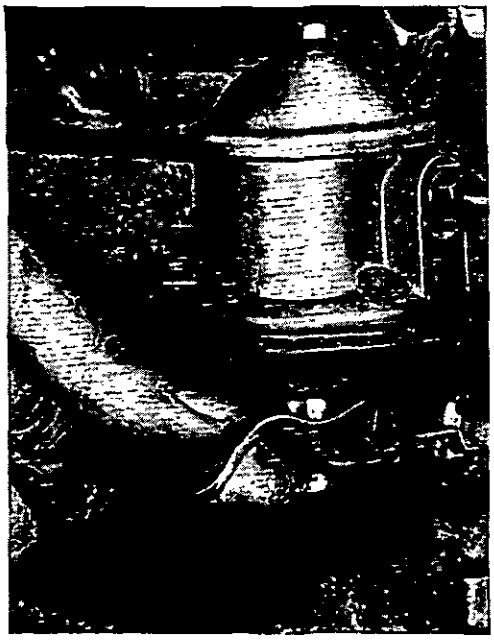


Fig. M.26.
Operating Fuel Lift Pump.

1. Slacken the air vent valve on the side of the control gear housing (hydraulic governor) Fig. M.23, or on the top of the governor control cover (mechanical governor) Fig. M.24.
2. Slacken the vent valve fitted on the hydraulic head locking screw Fig. M.25.
3. Operate the priming lever on the fuel feed pump and when fuel, free from air bubbles,

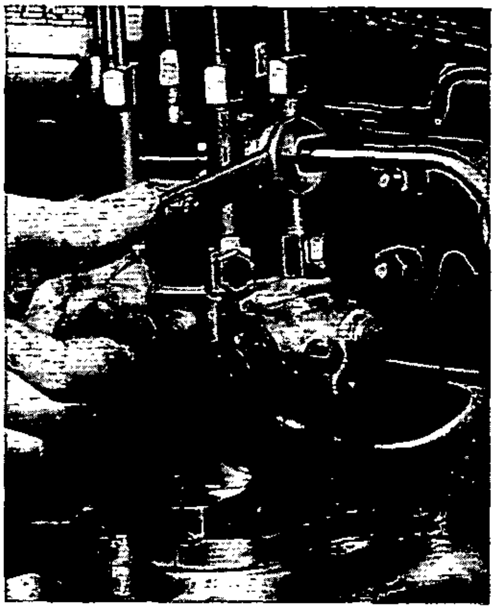


Fig. M.27.
Slackening Inlet Pipe Union Nut.

issues from each venting point, tighten the screws in the following order :—
(a) Head locking screw vent valve Fig. M.25.
(b) Governor cover vent valve Figs. M.23 or M.24.
4. Slacken the union nut at the pump inlet Fig. M.27, operate the priming device and re-tighten when oil, free from air bubbles issues from around the threads.
5. Slacken the unions at the atomiser ends of two of the high pressure pipes.
6. Set the accelerator at the fully open position and ensure that the "stop" control is in the "run" position.
7. Turn the engine until fuel oil, free from air, issues from both fuel pipes.
8. Tighten the unions in both fuel pipes.
9. Slacken the union at the thermostart cold start aid and again turn the engine until fuel free from air issues from this connection. Tighten the union.

The engine is then ready for starting.

SECTION N
Flywheel & Flywheel Housing

FLYWHEEL AND FLYWHEEL HOUSING

To Remove the Flywheel

1. Remove the gearbox and bell housing.
2. Remove clutch assembly.
3. Remove the flywheel. To facilitate safe removal, it is recommended that two diametrically opposed setscrews are removed and in their place, fit two suitably sized studs, finger tight only. The remaining setscrews can now be removed and the flywheel withdrawn under control.
4. Remove the clutch pilot bearing if fitted.

To Renew the Flywheel Ring Gear

1. Place the flywheel in a suitable container of clean cold water and support it by positioning four metal blocks under the ring gear. Arrange the flywheel assembly so that, when submerged in the water, the ring gear is uppermost and clear of the water line by approximately ¼ in (6,5 mm). Heat the ring gear evenly, around its circumference, thus expanding it. This will allow the flywheel to drop away from the ring gear.

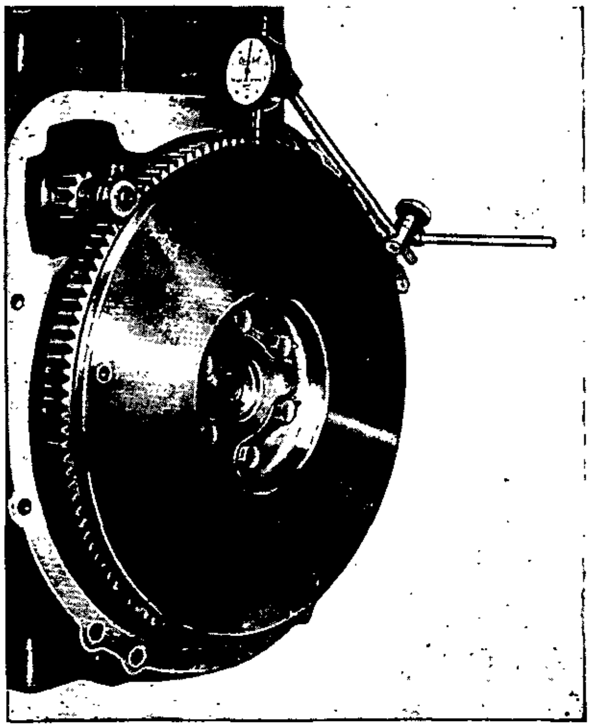


Fig. N.1. Checking Flywheel Run-out.

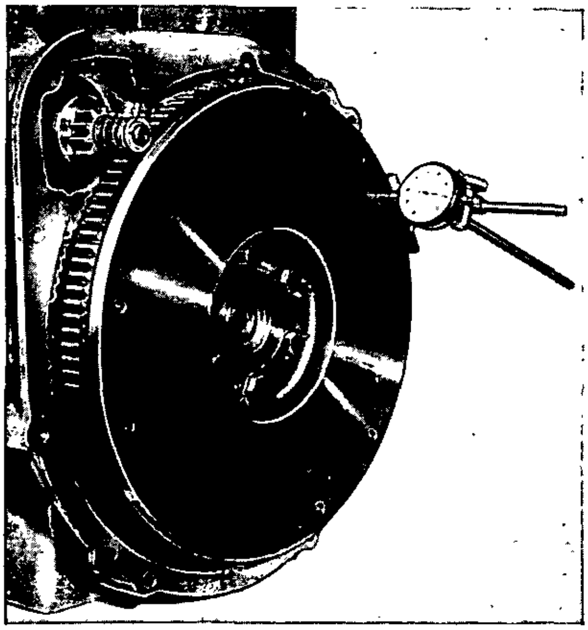


Fig. N.2. Checking Flywheel Face.

2. Heat the new ring gear to an approximate temperature of 475°F (246°C). Fit the gear over the flywheel with the lead-in on the teeth facing towards the front of the flywheel and allow the ring to cool.

Sealed Back Ends

Certain engines have a sealed back end arrangement consisting of a spring loaded rubber seal fitted in the engine backplate which locates around a spigot on the front face of the flywheel.

When fitting this seal, always ensure that the lip of the seal is towards the flywheel side of the backplate and fitted flush with the front side of the backplate.

To Refit the Flywheel

1. Mount the flywheel to the crankshaft flange so that the untapped hole in the flange is in line with the seventh unused smaller hole in the flywheel.

To facilitate easy fitting of the flywheel, it is advisable to fit four studs as a temporary measure, to the crankshaft flange.

2. Engage the six securing setscrews with new locking washers and tighten to a torque of 80 lbf ft (11,06 kgf m) — 108 Nm.

3. Set up an indicator clock gauge with the base secured to the flywheel housing or cylinder block and adjust the clock so that the stylus is contacting the flywheel periphery. Turn the crankshaft and check total reading. The flywheel should run true within 0.012 in (0,30 mm) total indicator reading (Fig. N.1).

4. Now adjust the clock gauge so that the plunger is at right angles to the crankshaft flange and rests on the vertical machined face of the flywheel, at the outermost point of the face. Press the crankshaft one way, to take up the end float, and turn the flywheel. The run-out on the flywheel face should be within 0.001 in (0,025 mm) per inch (25,4 mm) of flywheel radius from the crankshaft axis to the clock gauge stylus (Fig. N.2). If not, remove flywheel and check mating faces for burrs and dirt.

5. Lock the setscrews with the tabwashers (where applicable).

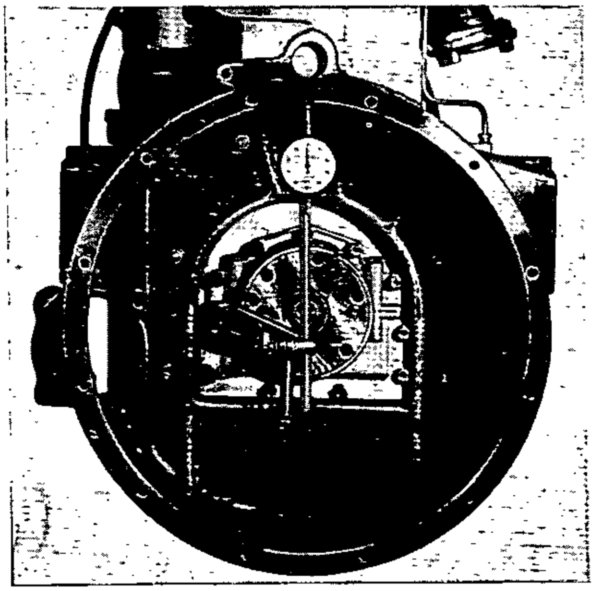


Fig. N.3.
Checking Alignment of Flywheel Housing Bore.

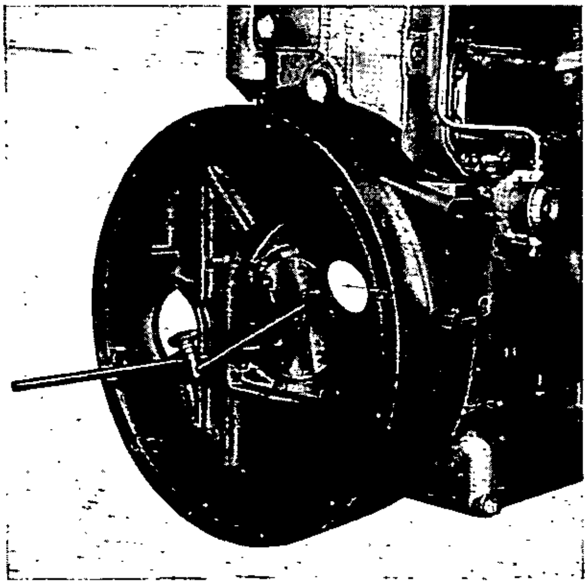


Fig. N.4.
Checking Alignment of Flywheel Housing Face.

6. Refit the clutch and gearbox, etc.

To Remove the Flywheel Housing

1. Remove the starter motor.
2. Remove the flywheel using two guide studs in the crankshaft flange.
3. Unscrew securing setscrews and tap flywheel housing off rear face of cylinder block.

To Refit the Flywheel Housing

1. Fit the housing to the cylinder block.
2. Refit the securing nuts or setscrews.
3. Check concentricity (Fig. N.3). The inner bore of the flywheel housing must be central within the limits listed on Page N.3.
4. Check perpendicular alignment (Fig. N.4). This facing should be within the limits listed on Page N.3.
5. All adjustments to bring the flywheel housing within these limits must be carried out on the flywheel housing and under NO CONDITIONS must the rear face of the cylinder block be interfered with.
6. When the housing is properly aligned, tighten the securing setscrews evenly.
7. Refit the flywheel, etc.

Alignment Limits — Flywheel Housing Bore and Face

Diameter of Housing	Limits
Up to 14.25 in (362 mm)	0.006 in (0,15 mm) Total Indicator Reading
14.25 to 20.125 in (362 to 511 mm)	0.008 in (0,20 mm) Total Indicator Reading
20.125 to 25.5 in (511 to 648 mm)	0.010 in (0,25 mm) Total Indicator Reading
25.5 to 31.0 in (648 to 787 mm)	0.012 in (0,30 mm) Total Indicator Reading

SECTION P
Turbochargers

CONTENTS

These instructions are issued for the general guidance of those concerned with the turbocharged 6.354 diesel engine. Please read carefully BEFORE starting a turbocharged engine.

In all correspondence or communications dealing with a turbocharger of this type, the date and serial number to be found on the body of the unit must be quoted clearly and fully.

In the event of an accident causing damage to the turbocharger, the unit must be removed, carefully packed and returned to the nearest Perkins Industrial Distributor or Overseas Company, where a replacement unit should be obtained. If this is impossible the instructions given in section 9 should be carefully followed.

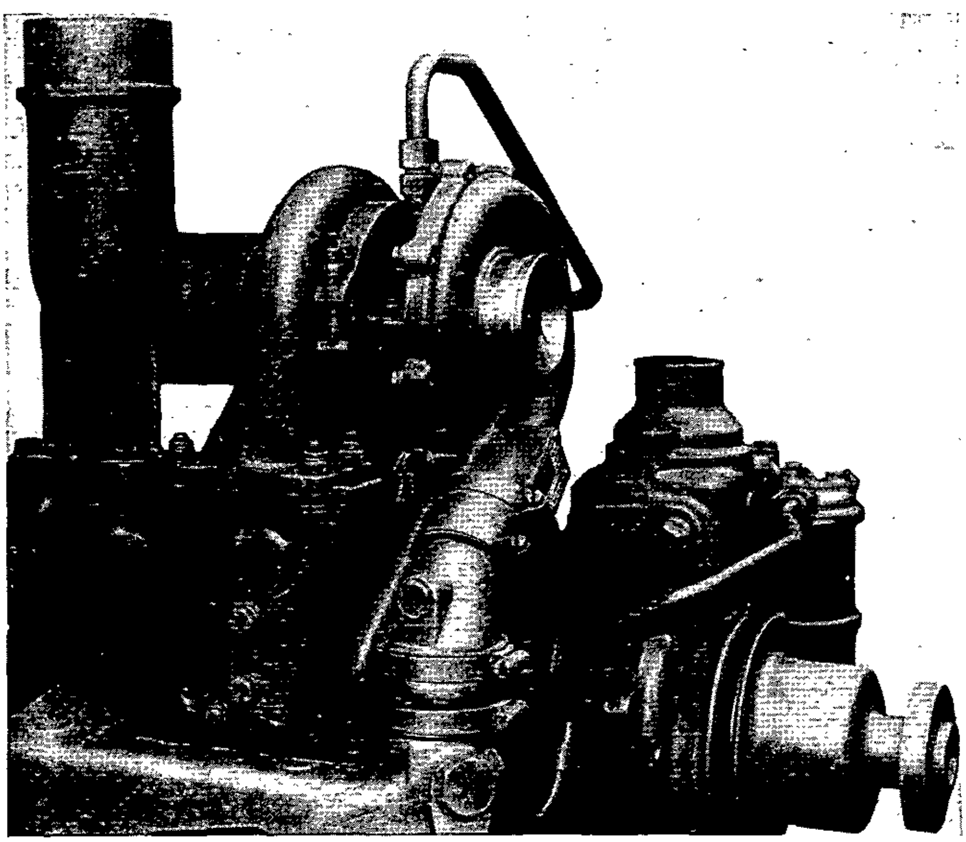
It is not permissible to fit a Turbocharger unit to a normally aspirated engine.

DO'S AND DON'TS

TO BE OBSERVED DURING THE OPERATION OF THE TURBOCHARGER

1. **DO** read these instructions carefully before starting the engine.
2. **DO** check the oil pressure each time the engine is started.
3. **DO** change the oil filter element where fitted every **5,000** miles (7,500 km) or **250** hours.
4. **DO** check the maximum boost at least every **5,000** miles (7,500 km) or **250** hours when gauge is fitted.
5. **DO** keep the installation clean by checking leaky unions and replacing damaged pipes.

1. **DON'T** run the turbocharger without oil pressure.
2. **DON'T** run with a dirty oil filter element.
3. **DON'T** run with a dirty air cleaner or damaged air intake pipe.
4. **DON'T** *continue to run if the boost pressure* does not reach its normal value.
5. **DON'T** shut the engine down rapidly from full throttle.



Typical Holset Model 3LD Turbocharger Installation.

SECTION 1

General Information

General Information

On early production Perkins Turbocharged Engines, three types of Mk. 1/5 turbochargers were fitted, namely the Mk. 1/5N, Mk. 1/5Q and Mk. 1/5R. Currently, the Holset 3LD model turbocharger is fitted in production to industrial, and agricultural type engines and the Airesearch T-04B is fitted to certain agricultural engines.

All the turbochargers fitted to Perkins engines are self-contained units mounted directly, or by an adaptor, to the exhaust manifold and consist of a gas turbine and a centrifugal compressor fitted to a common shaft with the necessary surrounding casings. The exhaust gas from the diesel engine is directed through manifolding to the turbine, which utilises some of the energy in the exhaust gas to drive the compressor. The air required by the engine is supplied at a pressure above atmospheric through the conventional air intake manifold, and enables a higher output to be obtained from the engine.

No control over the turbocharger is necessary, the speed and output varying automatically with changes in load and speed of the engine.

Whilst all three Mk. 1/5 turbochargers are similar in design it should be noted that the rotating assemblies and certain individual parts are not interchangeable due to internal design changes. These main internal differences are as follows :—

Mk. 1/5N

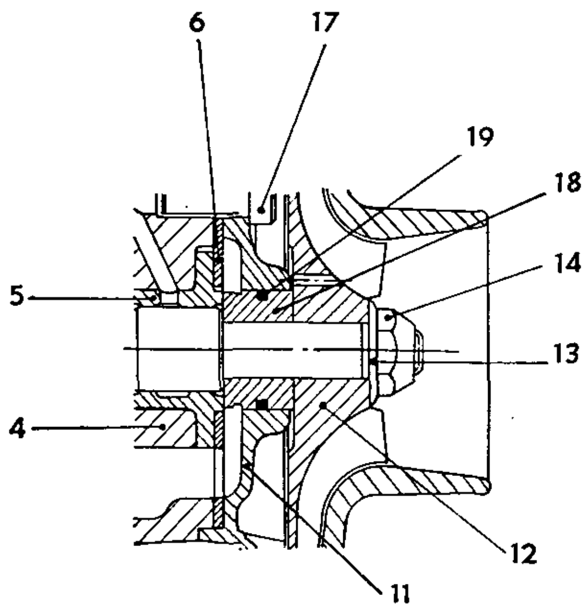
This turbocharger was manufactured by Engineering Productions (Clevedon) Ltd., and has a labyrinth oil seal at the impeller end of the rotor shaft as shown in Fig. 4. The turbine nozzle unit has 23 blades. It can be identified by the marking "1/5N" on the casing.

Mk. 1/5Q

This turbocharger was originally manufactured by Engineering Productions (Clevedon) Ltd., and later by Simms Motor Units Ltd. It has a piston ring oil seal at the impeller end of the rotor shaft as shown in Fig. P.1. The turbine nozzle unit has 14 blades. Those manufactured by Engineering Productions (Clevedon) Ltd., can be identified by the marking "1/5Q" on the casing. Those manufactured by Simms Motor Units Ltd. can be identified by the figures "1501" on the casing.

Mk. 1/5R

This turbocharger which is manufactured by Simms Motor Units Ltd. is identical to the Mk. 1/5Q with the exception of the turbine nozzle unit which has 23 blades. It can be identified by the figures "1502" on the casing.



Sectional View of Mk. 1/5Q and Mk. 1/5R Turbocharger showing Piston Ring Oil Seal.

Fig. P.1.

4. Centre Casing
5. Bearing
6. Retaining Plate
11. Plain Diffuser
12. Impeller
13. Washer
14. Nut
17. Cap Screw
18. Compressor Seal Sleeve
19. Piston Ring Seal

Holset 3LD

The Holset 3LD turbocharger can be identified by the 'V' clamp securing the bearing housing to the turbine housing and by the manufacturers plate attached to the compressor cover.

Interchangeability

The Mk. 1/5N and 1/5Q turbochargers were fitted to marine engines rated at or below 135 shp and the Mk. 1/5Q only to Industrial engines.

The Mk. 1/5R turbocharger was used on Marine engine of all ratings.

The Holset 3LD model turbocharger is used on all current 6.354 production Turbocharged engines and may be used as a service replacement for all the three Mk. 1/5 turbochargers mentioned above, as these are no longer available as replacement items.

Replacement of Mk. 1/5 Turbochargers with the Holset 3LD Model

When it is necessary to replace in service a Mk. 1/5N, Q or R model turbocharger with the Holset 3LD, it will be necessary to obtain the appropriate conversion kit which includes conversion instructions. The kit and turbocharger type will vary according to the installation.

Airesearch T-04B

This replaces the Holset 3LD on certain agricultural engines, but is not interchangeable as a unit.

SECTION 2

Details of Construction

Mk. 1/5 Turbocharger

(Numbers in brackets refer to numbers in Fig. P.4).

The engine exhaust manifold conducts the exhaust gases to the turbine casing (1). Clamped to the turbine casing is the nozzle unit (2), which contains guide vanes and these direct the exhaust gases to the turbine rotor (3).

The centre casing (4) is bolted to the turbine casing and houses the one piece bearing (5) which is restrained by the retaining plate (6).

The bearing lubricating oil is directed through oil seal (7) which is integral with the rotor shaft (8) and the removable seal (9).

The compressor casing (10) bolts directly on to the centre casing and contains a plain diffuser (11) bolted to the centre casing. Air enters the compressor casing axially and after passing through the impeller (12) is discharged tangentially to the engine induction piping.

The complete rotating assembly, which is dynamically balanced as one unit, consists of the rotor (3) which is integral with the rotor shaft (8), the oil seals (9) and the impeller (12) which is secured by a washer (13) and nut (14).

Holset 3LD Turbocharger

(Numbers in brackets refer to numbers in Fig. P.6).

The engine exhaust manifold conducts the exhaust gases to the turbine housing (8).

The bearing housing (14) is secured to the turbine housing by a 'V' clamp (7) and locknut (6) and houses the one piece bearing (11) which is restrained by the thrust plate (5).

The compressor insert (19), spacer sleeve (16), oil deflector (13) and thrust ring (12), are retained in the centre bearing housing (14) by a large retaining ring (20). The compressor wheel (18) is secured to the rotor shaft (10) by a locknut (17).

The compressor cover (21) bolts directly on to the centre bearing housing (14). Air enters the compressor cover axially and after passing through the compressor wheel (18) is discharged tangentially to the engine induction piping.

The shaft and turbine wheel assembly (10) and the compressor wheel (18) rotate as one assembly and are as one unit dynamically balanced.

Airesearch T-04B Turbocharger

The turbocharger consists of radial inward flow turbine, a centrifugal compressor wheel, a centre housing which serves to support the rotating assembly, bearing and seals, a turbine housing and compressor housing.

Engine oil is fed under pressure through passages in the centre housing. The oil is directed to journal bearings and thrust bearings through passages in the centre housing.

Oil is sealed from the compressor and turbine by seal arrangements at both ends of the centre housing. Oil drains by gravity back to the engine sump.

SECTION 3

Lubrication System

Lubrication System

The turbocharger bearing is lubricated with oil taken from the engine lubricating oil system.

The oil is piped to the oil inlet connection located at the top of the centre bearing housing and through a drilling in the casing to the bearing.

On some installations, the bottom end of the oil feed pipe is attached to a separate full flow filter which is mounted adjacent to the main engine oil filter. No by-pass valve is incorporated in the turbocharger filter.

Alternatively, the bottom end of the oil feed pipe is attached to the cylinder block, at the opposite end of the cross-drilling to which the engine lubricating oil filter is located.

The oil return flow to the engine is by way of a drain pipe attached to the outlet connection in the bottom of the centre bearing housing of the turbocharger. Oil is returned either to the tappet inspection cover or the engine sump.

SECTION 4

Installation

When the turbocharger is despatched either as a separate unit or mounted to an engine, the openings are plugged to prevent entrance of dirt and the exposed surfaces are protected against rust. No dismantling is necessary before installation.

Before removing seals, clean with suitable cleaning compound. Care must be taken to prevent the solvent entering the openings of the turbocharger.

The unit is mounted on to the engine by bolting the turbine inlet flange directly on to the engine exhaust manifold with a jointing gasket or, in some cases, to an adaptor secured to the manifold by four studs, nuts and washers and two appropriate gaskets, after which the following connections should be made :—

(1) Turbine Outlet.

(2) Compressor Inlet.

(3) Compressor Outlet.

(4) Lubricating Oil System (see notes in Section 3).

The following general points should be observed :—

Exhaust System

If the turbocharged engine is being fitted in place of a normally aspirated engine it is highly improbable that the existing silencing system will be adequate, even if the difference in pipe diameter is remedied by a local modification at the turbocharger exhaust connection.

In order to get the best and most efficient service out of the turbocharger it is very important that the exhaust system should be free of restrictions and large enough to cope with the increased gas flows. Rather than making an unsatisfactory job out of existing piping, it is strongly recommended that a completely new pipe is made up incorporating the following suggestions.

It is very important that the exhaust pipe should not impart any strain on the turbocharger exhaust outlet. In order to ensure this, the exhaust pipe should be firmly fixed by a suitable bracket to the lower part of the engine in the region of the sump and between this bracket and the turbocharger outlet a length of flexible pipe at least one foot long should be introduced.

On installations using long exhaust systems it is advisable to fit an additional piece of flexible piping between the above mentioned fixing bracket on the engine and the silencer.

The Mk. 1/5 turbocharger only is fitted with an exhaust box incorporating an exhaust outlet connection which fits onto the turbine exhaust flange. This is arranged so that it can be fitted in a number of different positions in the same plane, thus enabling the exhaust pipe to be led away at different angles to suit the particular installation.

The pipe should be made up so that the turbine outlet box just fits onto the turbocharger exhaust flange without any forcing when the pipe is clamped in position by the lower bracket. This will ensure that no strain is imparted to the turbocharger.

The exhaust pipes from either the Mk. 1/5 or Holset 3LD turbocharger should have the minimum of restrictions due to bends, small diameter piping, inadequate silencers and right angle bends are to be avoided. A pipe size of 3 in. diameter is recommended, and if this is a reasonable length, i.e. about 12 feet or more, the operator may find that he can dispense with a silencer in certain overseas countries. A short exhaust system will of course require a suitable silencer.

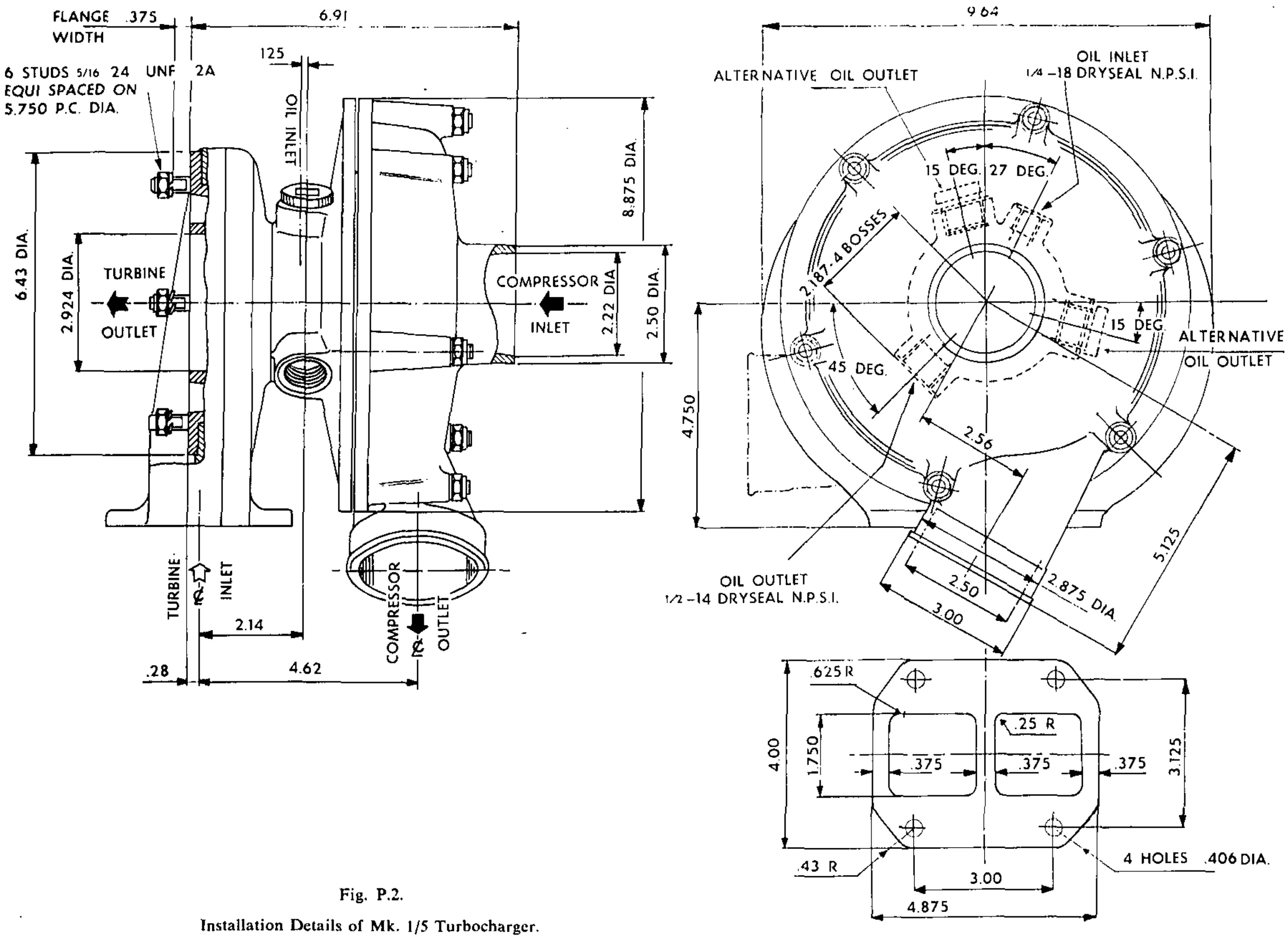
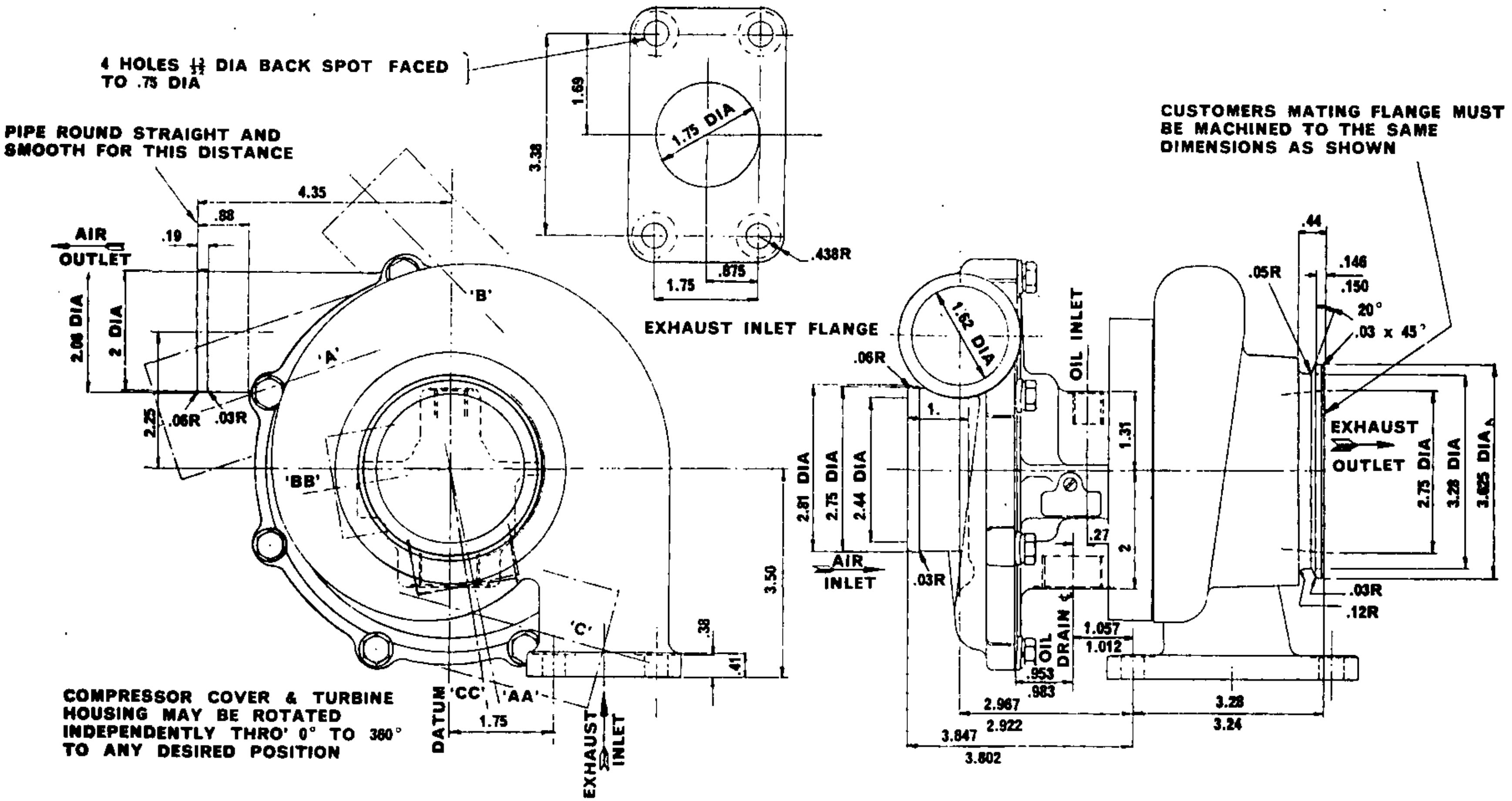


Fig. P.2.

Installation Details of Mk. 1/5 Turbocharger.
All dimensions are in inches.



Compressor Position	Angle Anti-clock	Oil Drain Position	Angle Anti-clock
A	289°	AA	12°
B	225°	BB	280°
C	75°	CC	9½°

Fig. P.3.

Installation Details of Holset 2LD Turbocharger.
All dimensions are in inches.

The back pressure in the exhaust system should not be more than 20 in water at maximum rated full load speed. If this is to be measured, a tapping should be made as close to the turbine outlet as possible.

The pipe layout should be such that it does not run close to the fuel filter or fuel pump, as this will lead to unnecessary heating of the fuel and injection equipment. If this is unavoidable, a suitable anti-radiation shield should be fitted between the exhaust pipe and the injection equipment such as a steel plate lagged with asbestos.

When the exhaust system is finally fitted to the engine, the compressor rotor should be spun with the finger to see that it turns freely.

Intake System (Industrial Applications)

The air intake system should be fitted as close to the compressor inlet as possible but preferably not within metal sheeting surrounding the engine. If there is no alternative to the enclosed position, a suitable arrangement should be made to duct fresh air to the cleaner.

For normal applications a medium duty air cleaner is supplied, and in order to connect up the larger diameter opening on the cleaner with the smaller diameter of the compressor inlet a funnel is available. If this funnel is made up locally the reduction in diameter should not be made in less than one foot overall length.

The pipe from the cleaner to the compressor inlet should be kept as straight as possible and of appropriate dimensions according to the type of turbocharger fitted (see figures 2 and 3). If flexible piping is used great care should be taken to secure it properly to avoid holes being rubbed in it by contact with the tin-work or other piping.

A heavy duty air-cleaner is also available for this engine but it requires a different intake pipe arrangement. This is a centrifugal oil bath cleaner which has an outlet of 5 in diameter and a suitable funnel to connect the 5 in diameter piping to the compressor inlet is available.

(a) The appropriate high temperature gaskets should be used on the exhaust gas inlet and outlet flanges and the threads of studs and cap screws coated with graphite paste to facilitate dismantling.

(b) Low temperature gaskets are suitable for the compressor connections.

(c) The lubricating oil piping from the filter or cylinder block to the turbocharger must be flushed out to remove any dirt or chips before fitting to the appropriate connections.

(d) The nameplate, listing the serial number of the unit and other relevant data is attached directly to the centre casing of the Mk. 1/5 turbocharger and to the compressor cover of the Holset 3LD model.

SECTION 5

Starting Instructions. From New Installation.

(1) Slacken the lubricating oil feed pipe union at the centre casing of the turbocharger, or the plug in the banjo bolt if fitted. Turn the engine over on the battery with the fuel control off until oil leaks from the union; re-tighten the union and then start the engine.

(2) Start the engine and operate at idling or light load conditions. A minimum oil pressure of 10 lbf/in² (0,7 kgf/cm²) — 69 kN/m² is required during idling conditions and if this pressure does not show on the pressure gauge in 12 to 15 seconds, shut down and check for the cause.
Note : The engine should not be run at more than 1,000 r.p.m. no load speed until the oil pressure has reached 20 lbf/in² (1,4 kgf/cm²) — 138 kN/m².

(3) Operate the engine at a fast idling speed (1,200 rev/min no load), for 10 minutes checking the lubricating oil pressure in the engine system. When normal engine oil pressure has been developed, the oil pressure to the turbocharger must be a minimum of 30 lbf/in². If this is not achieved, shut down and investigate.

(4) The unit should be checked during the 10 minutes of operation to make certain that no oil, water and exhaust gas leaks have developed.

(5) After the above steps have been taken, the turbocharger is ready for continuous operation.

It is advisable NOT to run up to maximum speed and boost during the first 500 miles or 25 hours of running.

NOTE : The power output of the turbocharged engine should never be increased beyond its manufactured rating as this will create an overload condition, increased exhaust temperatures and high turbocharger speed which may lead to failure.

SECTION 6

Service Operation

Performance of the turbocharger should be checked at every oil filter change (See paragraph 3 below).

1. Oil Pressure

Lubricating oil pressure should be a minimum 30 lbf/in² (2,11 kgf/cm²) — 207 kN/m² at normal engine working speeds. Check this pressure regularly.

2. Oil Temperature

As the turbocharger has been designed to operate satisfactorily when lubricated within the normal range of engine oil temperature, no additional gauge is necessary.

3. Boost Pressure

The maximum boost pressure when the engine is running at maximum speed at full load will vary according to the type of turbocharger fitted as shown below.

Mk. 1/5	10—13 lbf/in² (0,7 —0,91 kgf/cm²)
Holset 3LD	11—15 lbf/in² (0,77—1,05 kgf/cm²)
Airesearch T-04B	11—13 lbf/in² (0,77/0,91 kgf/cm²)

With some applications where is not possible to fully load the engine, the boost pressure will be somewhat lower.

4. Turbocharger Speed

No attention need be paid to the speed of the turbocharger since this varies automatically with the speed and load of the engine.

5. Vibration

Ensure that excessive vibration from the engine mountings does not cause damage to the turbocharger connections.

6. Oil Drainage

The oil drain pipe should be inspected after 20,000 miles (30,000 km) or 1,000 hours. A partially blocked drain will restrict the flow of oil from the bearing housing, causing it to flood through the seals into the compressor and turbine casings. This will result in excessively dirty exhaust smoke, and loss of power.

7. Emergency Operation

Should an accident or damage occur to some part of the turbocharger preventing operation of the unit, the engine can operate slowly with a small throttle opening for a short period with care.

8. Smoke

Excessive exhaust smoke may be caused by the following :—

(1) Air cleaner choked.
(2) Turbocharger not operating correctly due to dirt build-up on the compressor.
(3) Restriction in the pipe from air cleaner to compressor inlet.
(4) Fuel pump incorrectly calibrated.
(5) Excessive back pressure in the exhaust system.

9. Stopping the engine

Do not shut the engine down rapidly from full throttle.

SECTION 7

Maintenance Instructions

NOTE: The only maintenance necessary, providing the foregoing instructions have been adhered to, is the cleaning of the impeller and, in case of the Mk. 1/5 turbocharger, the diffuser, and also the replacement of the element when a separate turbocharger oil filter is provided.

1. Mk. 1/5 Turbocharger

(Numbers in brackets refer to numbers on the Sectional Drawing, Fig. P.4).

The impeller (12) and diffuser (11) may require cleaning every 20,000 miles (30,000 km) or 1,000 hours. This can be achieved without removing the turbocharger from the engine.

Disconnect the blower discharger piping and remove the nuts (15) holding the compressor casing (10) to the centre casing (4). The compressor can then be carefully pulled out along the rotational axis of the unit, care being taken to avoid damaging the impeller blades. The impeller, diffuser and compressor casing should then be cleaned with a suitable solvent such as trichloroethylene to remove any dirt, grease or carbon deposits. Never use a caustic solution, wire brush or scraper on these parts. Visually examine all components, before reassembling in the reverse order.

2. Holset 3LD Turbocharger

The impeller and impeller cover may be cleaned without removing the turbocharger from the engine if the following instructions are carried out.

(Numbers in brackets refer to Numbers on the Sectional Drawing, Fig. P.6).

(1) Mark relative positions of turbine housing (8), bearing housing (14), compressor cover (21) and "V" clamp (7).

(2) Remove the eight bolts (3) and associated lockwashers (2) fastening compressor cover (21) to bearing housing (14) and lift off cover (21).

(3) Remove the "V" clamp locknut and spring the "V" clamp (7) back onto the bearing housing (14). Lift the core assembly clear of the turbine housing (8).

(4) Holding the turbine wheel at the hub, remove the compressor locknut (17).

(5) Slide compressor wheel (18) off the shaft.

The compressor wheel and cover may be washed in non-caustic cleaning fluid. A non-metallic brush or plastic scraper blade should be used to avoid scoring these parts.

Following cleaning, the parts removed should be examined and if found to be in a satisfactory condition, should be re-assembled in reverse order of the stripping sequence outlined above.

Airesearch T-04B Turbocharger

Remove the air inlet duct and compressor housing and check for dirt or dust build-up.

Remove all foreign matter — determine and correct cause of build-up.

Use soft brush on compressor wheel as uneven deposits can affect rotor balance and cause bearing failure.

With the compressor housing removed, push the compressor wheel towards the turbine wheel end and turn rotating assembly by hand: check for binding and rubbing. Listen carefully for unusual noises. If binding or rubbing is evident, remove the turbocharger for disassembly and inspection.

3. Replacement of Oil Filter Element

The element of the separate oil filter (where fitted) which feeds the turbocharger must be renewed every 5,000 miles (7,500 km) or 250 hours. Unlike the engine lubricating oil filter, the turbocharger oil filter does not incorporate a by-pass valve and care must be taken to ensure that this filter is always kept clean, otherwise the turbocharger will be starved of lubricating oil. When replacing this filter element take care to prevent dirt and metal particles entering the filter casing. Fill the casing with clean engine oil before replacing. Bleed as Section 5, paragraph (1).

SECTION 8

Fault Diagnosis

If the performance of the turbocharger is suspect, check the installation for the following faults :—

Excessive air inlet depression.

Low or high air delivery pressure

Low oil pressure and/or low oil flow

Restricted exhaust from turbine

Fuel pump or injection faults

Check and rectify in accordance with the procedure given in the following paragraphs:

(1) Excessive air inlet depression : The air depression at the entry to the compressor, that is, in the ducting after the air filter and immediately before the compressor cover, should not exceed a 20 in (500 mm) head of water.

If the depression is excessive, the cause will be due to a restriction of inlet air by dirty air filters.

Service air filters.

(2) Low or high air delivery pressure : The pressure will vary according to engine rating, speed and load.

If the pressure is low, the probable cause is a dirty or damaged compressor, incorrect fuelling of the engine pump, or leaking manifold joints.

Check that the injection pump fuelling has not been disturbed and if satisfactory, remove the turbocharger from the engine for inspection.

A high reading may also indicate incorrect injection pump fuelling but may be due to fouling or damage to the turbine.

Action as for low pressure.

(3) Low oil pressure and/or oil flow : The oil delivery pressure should not be less than 30 lbf/in^2 (2,1 kgf/cm^2) — 207 kN/m^2 under normal conditions of load.

If the oil pressure is low refer to Section K for action, check engine oil filter (and turbocharger filter if fitted), clean the bores of the feed and return pipes and check the connections for obstruction. Ensure that the oil drain pipe when assembled has a continuous slope downwards to the inlet on the engine.

Restricted exhaust from the turbine : A restriction of the exhaust from the turbine will affect engine performance. If the back pressure is more than 20 in (500 mm) head of water, check the exhaust system for obstruction and rectify as necessary.

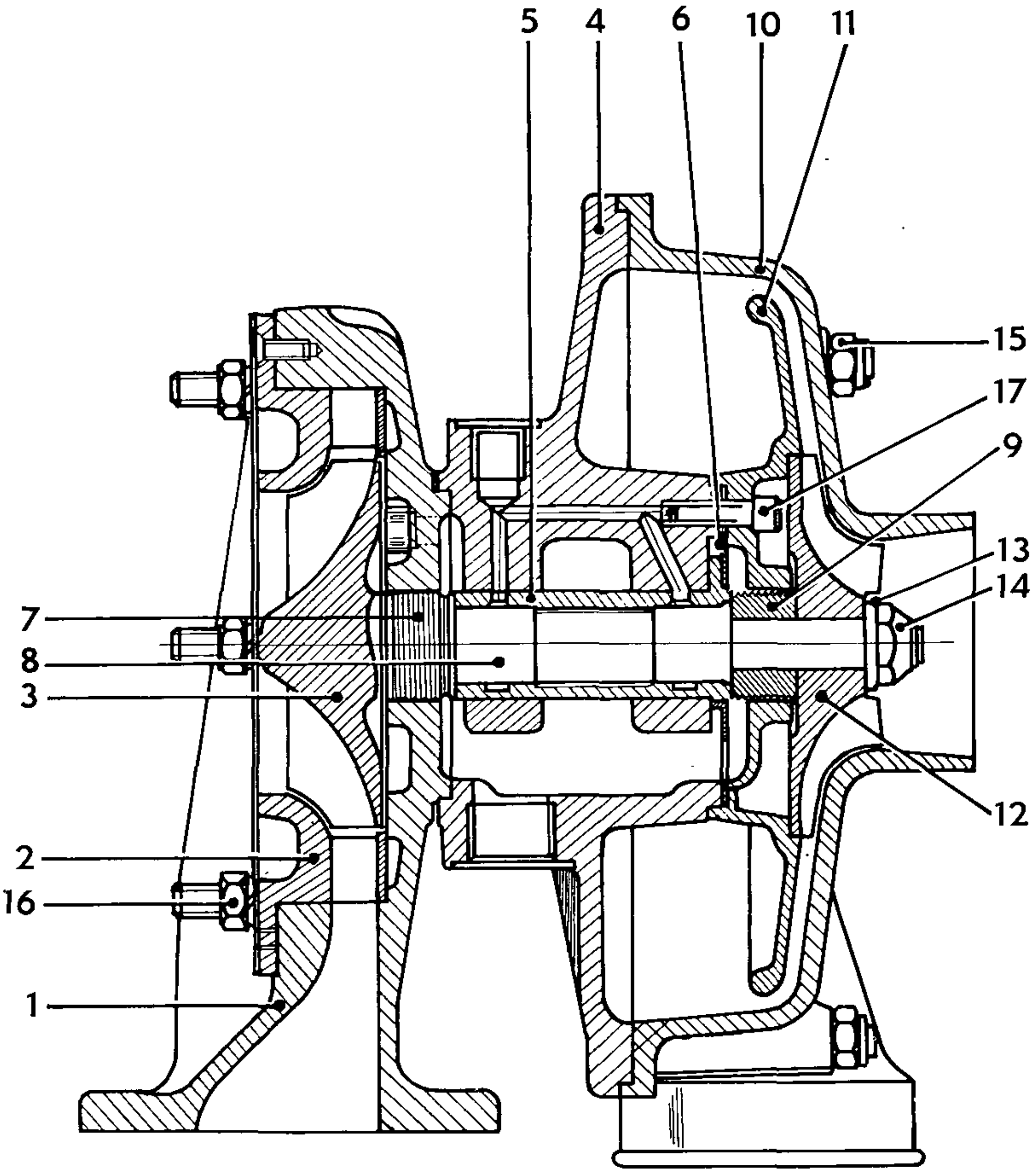


Fig. P.4
Sectional view of Mk. 1/5 Turbocharger

1. Turbine Casing.
2. Nozzle Unit.
3. Turbine Rotor.
4. Centre Casing.
5. Bearing.
6. Retaining Plate.
7. Shaft Oil Seal.
8. Rotor Shaft.
9. Removable Oil Seal. (Types 1/5N).
10. Compressor Casing
11. Plain Diffuser.
12. Impeller.
13. Washer.
14. Nut.
15. Compressor Nuts.
16. Nozzle Unit Nuts
17. Cap Screws.

SECTION 9

Reconditioning Instructions

Important

(1) When a turbocharger is removed from an engine, it is imperative that all terminations of oil connections are sealed immediately, to prevent the entry of dirt.

(2) During all stages of turbocharger dismantling, examination and rebuilding, care must be taken to ensure that no damage is caused to components. In the case of the Mk. 1/5 turbocharger, this applies especially to the rotor and impeller blades which, if damaged, will necessitate replacement and re-balancing of the complete rotating assembly. No attempt should be made to correct damage to components of the rotating assembly.

Mk. 1/5 Turbocharger

(Numbers in brackets refer to Numbers on the Sectional Drawing, Fig. P.4).

Dismantling

(1) Clamp unit upright in vice on turbine inlet flange.

(2) Remove the compressor casing nuts (15) fastening compressor casing (10) to centre casing (4) and lift off casing (10).

(3) Remove the nozzle unit nuts (16) and then, by means of jacking screws, withdraw the nozzle unit (2) axially.

(4) Remove the impeller (12) by standing the centre assembly, with the shaft vertical, and resting the centre assembly on a locating tool (see fig. 5), the pegs of which must locate in the scallops of the turbine rotor and be in good condition, otherwise they will slip out of the rotor scallops and cause damage to the blades. Slacken the impeller nut (14) keeping a steady downward pressure on the assembly; remove impeller nut and washer (13).

(5) Place the centre casing (4) on its side, and withdraw the shaft and rotor (3) from the turbine end. (After removal of the shaft, it is adviseable to protect the journals by wrapping them with tape).

(6) Remove the compressor oil seleeve (9) from the diffuser (11).

(7) Remove the cap screws (17) from the diffuser (11) — the bearing retaining plate will then be exposed and this should be removed.

(8) Remove the bearing (5).

Cleaning Procedure

(1) Use a commercially approved cleaner only. Caustic solutions will damage certain parts and should NOT be used.

(2) Soak parts in cleaner until all deposits have been loosened.

(3) Use a plastic scraper or bristle type brush on aluminium parts. Vapour blast may also be used providing the shaft and other bearing surfaces are protected.

(4) Clean all drilled passages with compressed air jet.

(5) Make certain that surfaces adjacent to wheels on stationary housings are free of deposits and are clean and smooth.

Internal Parts Inspection

(1) Shaft and Turbine Rotor Assembly (3).
   (a) Inspect bearing journals for excessive scratches, pitting and wear. Minor scratches may be tolerated.
   (b) Check carefully for cracked or damaged blades, **but do not attempt to straighten blades.**

(2) Bearing (5).
Replace bearing if excessively scratched or worn.

(3) Centre Casing (4).
Replace casing if bearing bore is excessively scratched or worn.

(4) Retaining plate (6).
Inspect for excessive wear on bearing face.

(5) Compressor Impeller (12).
Check carefully for cracked, bent or damaged blades, **but do not attempt to straighten blades.**

(6) Nozzle Unit (2).
Examine for distortion of the side plate and damage to the blades.

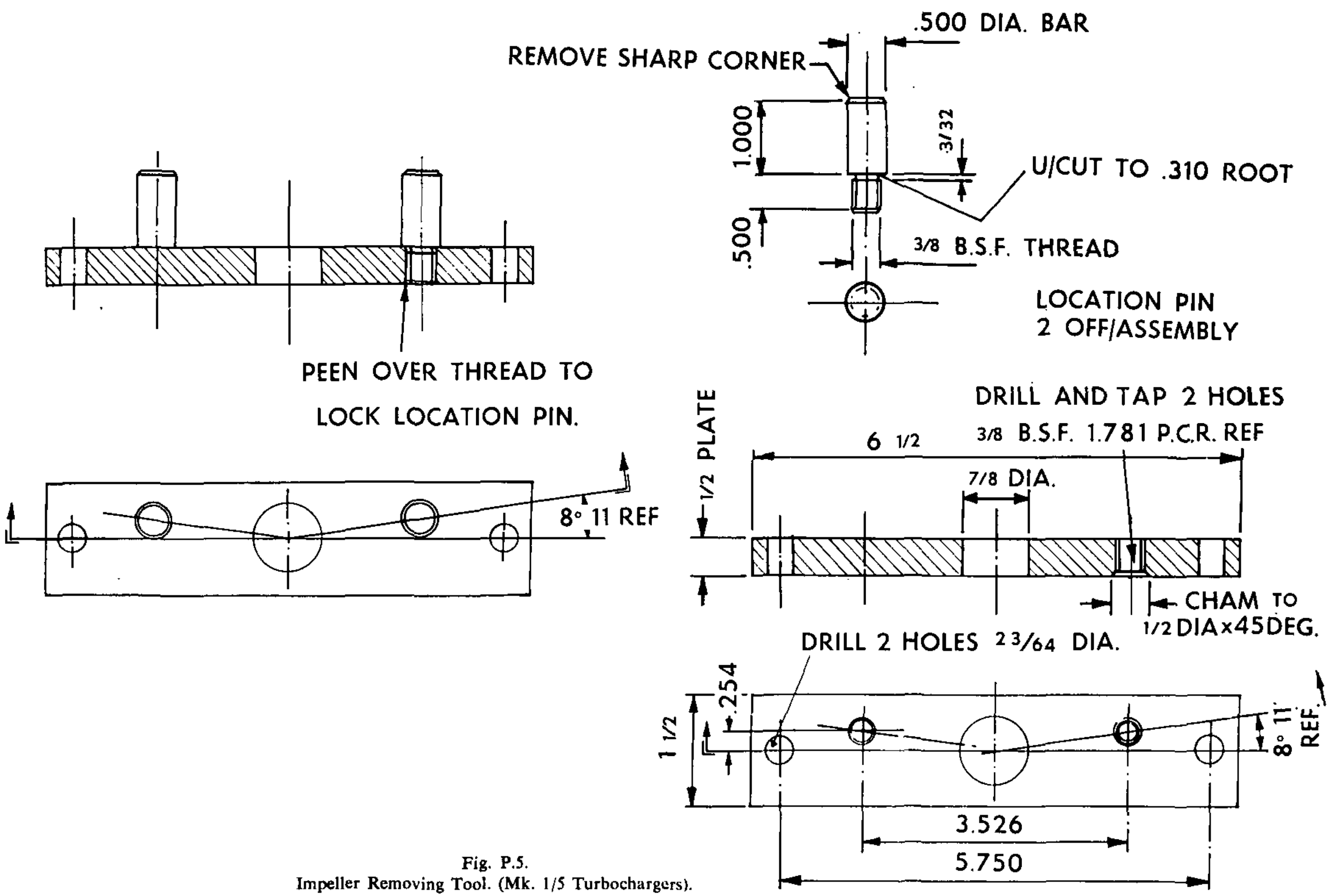


Fig. P.5.
Impeller Removing Tool. (Mk. 1/5 Turbochargers).
All dimensions are in inches.

Re-assembly

When the turbocharger has been thoroughly cleaned, inspected, passages blown out with air and any damaged parts replaced, re-assembly can commence.

NOTE: If during inspection, any part of the rotating assembly is found to be damaged, a replacement assembly which has been dynamically balanced must be obtained and fitted.

Before a replacement rotating assembly is installed, it should be dismantled, examined and cleaned as necessary. The assembly will consist of a rotor and shaft (3), bearing (5), removable oil seal (9), impeller (12), washer (13) and nut (14).

To rebuild a turbocharger which has been dismantled, using either the original or a replacement rotating assembly, the following procedure should be followed :

(1) Lightly oil the bearing and shaft, and fit the bearing into the centre casing; then slide the shaft carefully into the bearing.

(2) Place the unit with the shaft vertical with the turbine rotor underneath, resting it on the tool previously used for dismantling. Fit the retaining plate (6) and the diffuser (7) coating the mating surfaces with a suitable jointing compound, and then secure the latter with the cap screws (17) which should be lightly coated with locking liquid. Fit the seal (9) impeller (12) and washer, taking care that the location marks on all three correspond with the location mark on the shaft. Finally coat the thread on the end of the shaft with locking liquid, fit the nut and tighten to a torque of 310 lbf/in (3,6 kgf m) — 35 Nm.

(3) Fit the compressor casing (10), tighten the securing nuts.

(4) Turn the assembly over so that the rotor is uppermost. Fit the nozzle unit. The mating flanges should close easily if they fail to close, remove and rectify. **Do not** attempt to pull them together by tightening the securing nuts (16).

(5) Tighten the turbine casing nuts (16) and check that the rotating assembly turns easily.

The unit is now ready for fitting to the engine. If it is not intended to mount the turbocharger on the engine immediately after assembly, then the oil and gas passages must be sealed off to prevent entry of dirt.

Holset 3LD Turbocharger

(Numbers in brackets refer to numbers on Sectional Drawing, Fig. P.6).

Dismantling

(1) Clamp unit upright in vice on turbine inlet flange.

(2) Mark relative positions of turbine housing (8), bearing housing (14), compressor cover (21) and "V" clamp (7).

(3) Remove the eight bolts (3) and associated lockwashers (2) fastening compressor cover (21) to bearing housing (14) and lift off cover (21).

(4) Remove the "V" clamp locknut and spring "V" clamp (7) back onto the bearing housing (14). Lift the core assembly clear of the turbine housing (8).

(5) Holding the turbine wheel at the hub, remove the compressor locknut (17).

(6) Slide compressor wheel (18) off the shaft.

(7) Using circlip pliers, remove the large retaining ring (20) which retains compressor insert (19). Two screw drivers should be used to lift insert (19) from bearing housing (14). Remove "O" ring (4) from insert (19).

(8) The individual parts of the thrust assembly can now be lifted out.

- (a) Spacer sleeve (16) which can be gently pushed out of the insert (19).
- (b) Oil deflector (13) positioned by two groove pins.
- (c) Thrust ring (12).
- (d) Thrust plate (5).

Note. The groove pins are a press fit in the bearing housing (14) and should not be removed.

(9) Remove shaft and turbine wheel assembly (10) together with its piston rings (9) and (15).

(10) Insert fingertip into bore of bearing (11) and remove.

(11) Carefully expand and remove piston rings (9) and (15) from both the spacer sleeve and turbine wheel and shaft assembly.

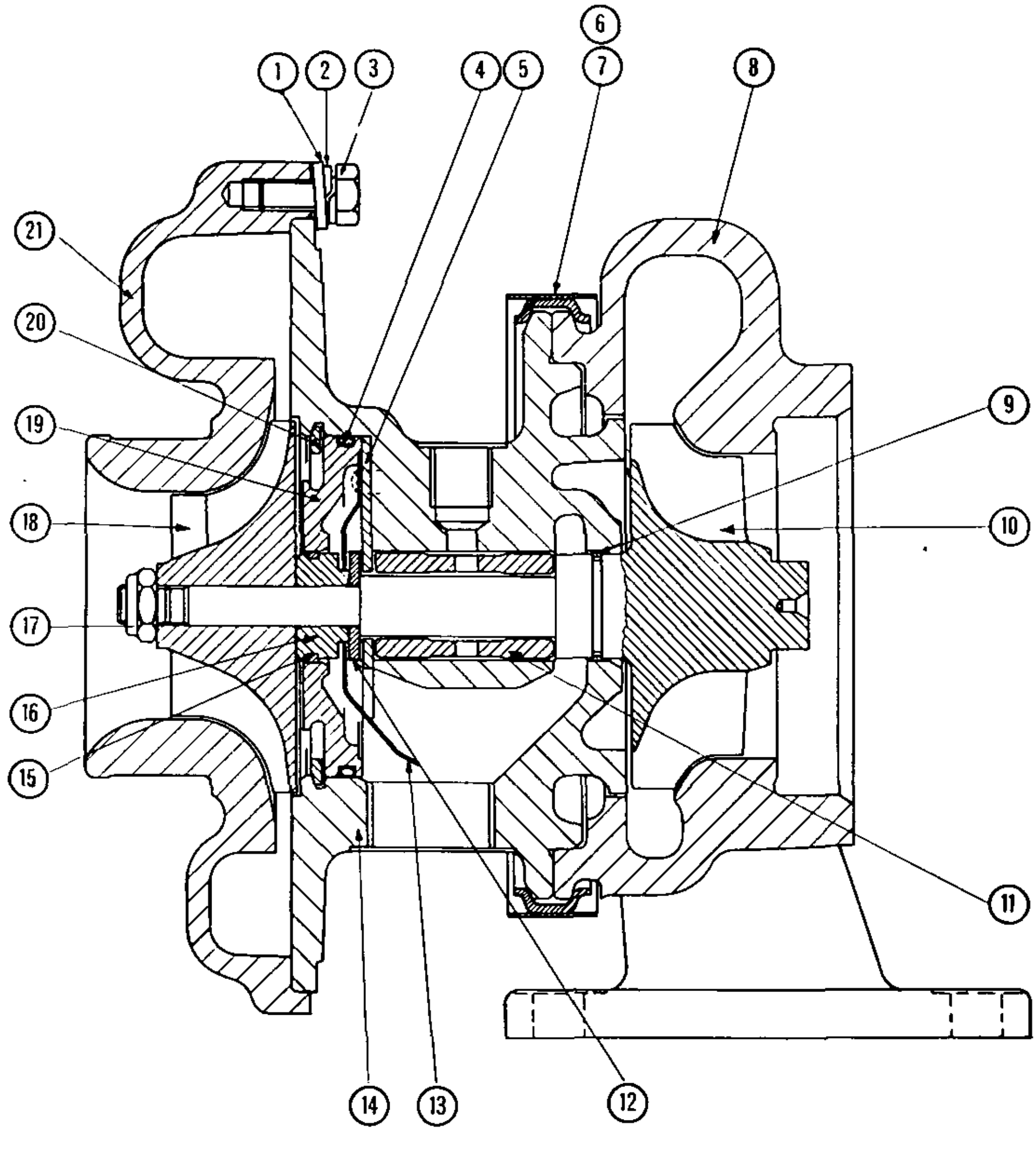


Fig. P.6.

Sectional View of Typical Holset Model 3LD Turbocharger.

1. Washer.
2. Lockwasher.
3. Bolt.
4. 'O' Ring.
5. Thrust Plate.
6. 'V' Clamp Locknut
7. 'V' Clamp.
8. Turbine Housing.
9. Piston Ring.
10. Shaft and Turbine Wheel Assembly.
11. Bearing.
12. Thrust Ring.
13. Oil Deflector.
14. Bearing Housing.
15. Piston Ring.
16. Spacer Sleeve.
17. Compressor Locknut.
18. Compressor Wheel.
19. Compressor Insert
20. Retaining Ring.
21. Compressor Cover.

Caution. Over expansion of piston ring will cause a permanent set or break the ring.

Cleaning Procedure

(1) Use a commercially approved cleaner only. Caustic solutions will damage certain parts and should NOT be used.

(2) Soak parts in cleaner until all deposits have been loosened.

(3) Use a plastic scraper or bristle type brush on aluminium parts. Vapour blast may also be used providing the shaft and other bearing surfaces are protected.

(4) Clean all drilled passages with compressed air jet.

(5) Make certain that surfaces adjacent to wheels on stationary housing are free of deposits and are clean and smooth.

Internal Parts Inspection

(1) Shaft and turbine wheel assembly (10).
   (a) Inspect bearing journals for excessive scratches and wear. Minor scratches may be tolerated.
   (b) Inspect piston ring groove walls for scoring. Minor scratches are acceptable.
   (c) Check carefully for cracked, bent or damaged blades, but **do not attempt to straighten blades.**

(2) Bearing (11).
Replace bearings if excessively scratched or worn.

(3) Bearing Housing (14).
Replace housing if bearing or piston ring bores are excessively scratched or worn.

(4) Spacer sleeve (16).
Replace if piston ring groove or spacer are damaged.

(5) Thrust ring (12) : thrust plate (5).
   (a) Replace if thrust faces are damaged. Minor scratches are acceptable.
   (b) Replace thrust plate (5) if faces are worn excessively, unevenly, severely scratched or otherwise damaged.
   (c) The small feed grooves in the thrust plate (5), must be clean and free from obstruction.

(6) Compressor wheel (18).
Check carefully for cracked, bent or damaged blades, but **do not attempt to straighten blades.**

(7) 'O' ring (4).
Replace if Section through ring has taken a permanent set, indicated by flats on the sides of the ring.

A schedule of tolerances which includes allowable dimensions after service, is given on Page P.23.

Re-assembly

When the turbocharger has been thoroughly cleaned, inspected and any damaged parts replaced, assembly can commence.

Assembly of the unit is the reverse of dismantling, but the following points should be noted :

(a) Lubricate bearings, thrust assembly, piston rings and rotor shaft, with clean engine oil.

(b) When replacing turbine wheel and shaft (10) into bearing housing (14), and spacer sleeve (16) into insert (19), do not force piston rings into bore, as an off-centred ring will fracture, causing the shaft to bind.

(c) The large retaining ring (20) should have bevelled side facing outwards.

(d) Torque locknut (17) to 13 lbf ft (1,8 kgf m) — 17 Nm bolt (3) to 5 lbf ft (0,7 kgf m) — 6,8 Nm and "V" clamp locknut (6) to 10 lbf ft (1,4 kgf m) — 14 Nm.

(e) On completion spin shaft to ensure that it rotates freely.

NOTE: If during the dismantling of the turbocharger the lubricating oil feed and drain pipe adaptors were removed from the bearing housing, these should, on re-assembly, be torqued to 25/30 lbf ft (3,46/4,15 kgf m) — 34/41 Nm and 60/65 lbf ft (8,3/8,99 kgf m) — 81/88 Nm respectively.

The unit is now ready for fitting to the engine. If it is not intended to mount the turbocharger on the engine immediately after assembly, then the gas and oil connections must be sealed off to prevent the entry of dirt.

Airesearch T-04B Turbocharger

Dismantling

Clean the exterior with a pressure spray of a non-caustic cleaning solvent before dismantling. Dismantle only as required to make necessary inspection or repairs. As each part is removed, place it in a clean container to prevent loss or damage.

Remove the bolts, clamps and lockplates which hold the compressor and turbine housings to the centre housing group. Tap the housings with a soft faced hammer if force is needed for removal.

NOTE : Exercise caution when removing housings to prevent damage to compressor or turbine wheel. Once damaged, they cannot be repaired. Never attempt to straighten bent compressor or turbine blades — replace the faulty component.

Place the centre housing group in a suitable holding fixture which will prevent the turbine wheel from turning.

Use a T-handled wrench when removing the compressor wheel locknut to avoid possible bending of the shaft.

Lift the compressor wheel off the shaft. Remove the shaft wheel from the centre housing keeping shaft central with bearings until clear of the centre housing.

NOTE : The turbine wheel shroud is not retained to the centre housing and will fall free when the shaft wheel is removed.

Remove lockplates and bolts from back plate.

Tap backplate with soft mallet to remove from recess in centre housing.

Remove thrust collar and thrust bearing from centre housing.

Remove bearings and retainers from centre housing. Discard rubber sealing ring.

Cleaning

Before cleaning, inspect all parts for signs of rubbing, burning or other damage which might not be evident after cleaning.

Soak all parts in clean non-caustic carbon solvent. After soaking, use a stiff bristle brush and remove all dirt particles. Dry parts thoroughly.

NOTE : Normally, a light accumulation of carbon deposits will not affect turbine operation.

Internal Parts Inspection

Parts must not show signs of damage, corrosion or deterioration. Threads must not be nicked, crossed or stripped.

The turbine wheel must show no signs of rubbing and vanes must not be torn or worn to a feather edge. The shaft must show little signs of scoring, scratches or seizure with the bearings.

The compressor must show no signs of rubbing or damage from foreign matter. It must be completely free of dirt or other foreign matter. The compressor wheel bore must not be chafed.

Seal parts must show no signs of rubbing or scoring of the running faces. Housings must show no signs of contact with rotating parts. Oil and air passages must be clean and free from obstructions.

Burnish or polish out minor surface damage. Use silicon carbide abrasive cloth for aluminium parts and crocus abrasive cloth for the steel parts. Thoroughly clean parts before re-assembly.

Replace any parts which do not meet requirements.

Replace the following parts : seal ring, lockplates, piston rings, turbine housing bolts, journal bearings, bearing retaining rings and compressor wheel locknut.

If thrust bearing and thrust collar show signs of nicks, scores, varnish deposits or foreign matter embedments — replace. Also, a close inspection of bearing bores in the centre housing should be made and if any of the above conditions exist — replace the centre housing.

Re-assembly

Check each part prior to installation to ensure cleanliness. Exercise care to prevent entry of foreign matter during assembly.

Check thrust collar piston ring groove for nicks or burns.

Assemble in the following manner :

Install inboard bearing retainers. Lubricate bearings with clean engine oil. Fit bearings and outer bearing retainers.

Place turbine wheel upright. Gently guide shaft through shroud and centre housing bearings. Place thrust bearing over thrust collar.

Fit piston ring on thrust collar. Place thrust collar over shaft so that thrust bearing is flat against the centre housing and engages the centre housing anti-rotating pins.

Install seal ring in groove in centre housing.

Ensure that thrust spring is installed in back plate. Align mounting holes of centre housing and backplate and install over shaft and thrust collar. Use care not to break piston ring when engaging seal into back plate bore. Back plate is easily installed if open end position of piston is engaged into back plate bore first.

Install compressor backplate bolts and lockplate. Tighten to 75/90 lbf in (86/104 kgf cm) — 9/11 Nm and secure lockplates.

Fit compressor wheel. The larger face of the locknut and the front face of the impeller must be smooth and clean. Lightly oil threads and face of nut and tighten to 18/20 lbf in (21/23 kgf cm) — 2/2.4 Nm. Then continue to tighten until length of shaft increases by 0.0055/0.0065 in (0,14/0,16 mm). Tighten nut using T-handled wrench to avoid side load which may cause shaft to bend. Check axial end play for 0.001/0.004 in (0,03/0,10 mm) travel. If equipment is not available to measure shaft stretch, this alternative method may be used: after installing impeller nut and tightening to 18/20 lbf in (21/23 kgf cm) — 2/2.4 Nm, continue to tighten through an angle of 90°.

Check fore clearance between wheel shroud and turbine wheel.

Orientate compressor housing to centre housing. Fit the six bolts and three lockplates. Tighten bolts to 100/130 lbf in (115/150 kgf cm) — 12/16 Nm.

Orientate turbine housing to centre housing. Coat bolt threads with a high temperature thread lubricant. Install bolts, clamps and lockplates. Tighten bolts to 100/130 lbf in (115/150 kgf cm) — 12/16 Nm. Bend up lockplates.

After assembly, push the rotating assembly as far as possible from the turbine end and check for binding. Repeat check, pushing from compressor end.

If the unit is to be stored, lubricate internally and install protective covers on all openings.

NOTE: The turbocharger does not require testing after overhaul.

INSTALLATION CHECK LIST
Mk 1/5, Holset 3LD and Airesearch Turbochargers

(1) Inspect the air intake system and the exhaust manifold for cleanliness and foreign matter.

(2) Inspect the oil drain line and make sure it is not clogged.

(3) Inspect the oil supply line for clogging, deterioration or possibility of leaking under pressure.

(4) Inspect the turbocharger mounting pad on the manifold to make certain that all of the old gasket has been removed. On some applications, an adaptor is fitted between the turbocharger and exhaust manifold assembly. The adaptor is secured to the manifold by four studs, nuts and washers and it should be ascertained that all traces of the old gasket have been removed from it.

(5) Install a new gasket between the turbocharger and exhaust manifold. In cases where an adaptor is fitted, it will be necessary to install a gasket between the adaptor and the manifold assembly before placing the turbocharger gasket over the four turbocharger locating studs fitted into the adaptor. Ensure that the gaskets do not protrude into the openings of the manifold (and adaptor when fitted). The opening(s) in the gaskets should be preferably 1/16 in (1,6 mm) away from the edge of the openings in the manifold and adaptor.

(6) Install turbocharger and tighten mounting bolts or securing nuts.

(7) Connect the oil supply line but leave the oil drain line disconnected.

(8) Connect the compressor inlet and outlet piping. Check all joints for possible leaks. Make certain that the piping is not exerting a strain on the compressor cover. Connect exhaust pipe.

(9) Motor the engine without firing (i.e. by operating stop control), until a steady flow of oil comes from the oil drain line.

(10) Stop motoring and connect oil drain pipe connection.

HOLSET 3LD TURBOCHARGER

SCHEDULE OF TOLERANCES

	Manufactured Dimensions		Allowable Dimensions after Service	Remarks
Total turbine wheel clearance	0.047/0.057 in	(1,19/1,45 mm)	0.024 in (0,61 mm) min.	
Back turbine wheel clearance	0.015/0.0027 in	(0,38/0,68 mm)	As Manufactured	Wheel pushed to compressor end.
Front turbine wheel clearance	0.024/0.038 in	(0,61/0,96 mm)	0.024 in (0,61 mm) min.	
Total compressor wheel clearance	0.049/0.062 in	(1,24/1,57 mm)	As Manufactured	
Back compressor wheel clearance	0.026/0.043 in	(0,66/1,09 mm)	As Manufactured	Wheel pushed to turbine end.
Thrust clearance	0.004/0.008 in	(0,10/0,20 mm)	As Manufactured	
Radial float at compressor wheel hub	0.015/0.021 in	(0,38/0,53 mm)	0.024 in (0,61 mm) max.	
Bearing outside diameter	0.8714/0.8719 in	(22,13/22,14 mm)	As Manufactured	
Bearing inside diameter	0.4815/0.4818 in	(12,23/12,24 mm)	As Manufactured	
Thrust bearing width	0.105/0.107 in	(2,67/2,72 mm)	0.104 in (2,64 mm) min.	
Squareness of back face of turbine wheel	0.002 in T.I.R.	(0,05 mm T.I.R.)	As Manufactured	On Vee block at 1.375 in radius.
Eccentricity of small diameter of shaft	0.0006 in T.I.R.	(0,01 mm T.I.R.)	As Manufactured	
Piston ring grooves on shaft	0.066/0.068 in	(1,68/1,73 mm)	0.066/0.070 in (1,68/1,79 mm)	
Piston ring groove on spacer sleeve	0.066/0.068 in	(1,68/1,73 mm)	0.066/0.070 in (1,68/1,79 mm)	
Piston ring width at turbine end	0.062/0.063 in	(1,57/1,60 mm)		Replace at each service.
Piston ring width at compressor end	0.062/0.063 in	(1,57/1,60 mm)		Replace at each service.
Bearing housing bore for piston ring	0.8750/0.8755 in	(22,22/22,24 mm)	0.877 in (22,28 mm) max.	
Compressor insert bore	0.875/0.876 in	(22,22/22,25 mm)	0.877 in (22,28 mm) max.	
Bearing housing bore at bearing	0.8750/0.8755 in	(22,22/22,24 mm)	As Manufactured	
Turbine wheel outside diameter	2.977/2.975 in	(75,62/75,56 mm)	2.980 in (75,69 mm) max.	
Shaft diameter at bearing	0.4803/0.4800 in	(12,20/12,19 mm)	0.4799 in (12,19 mm) min.	

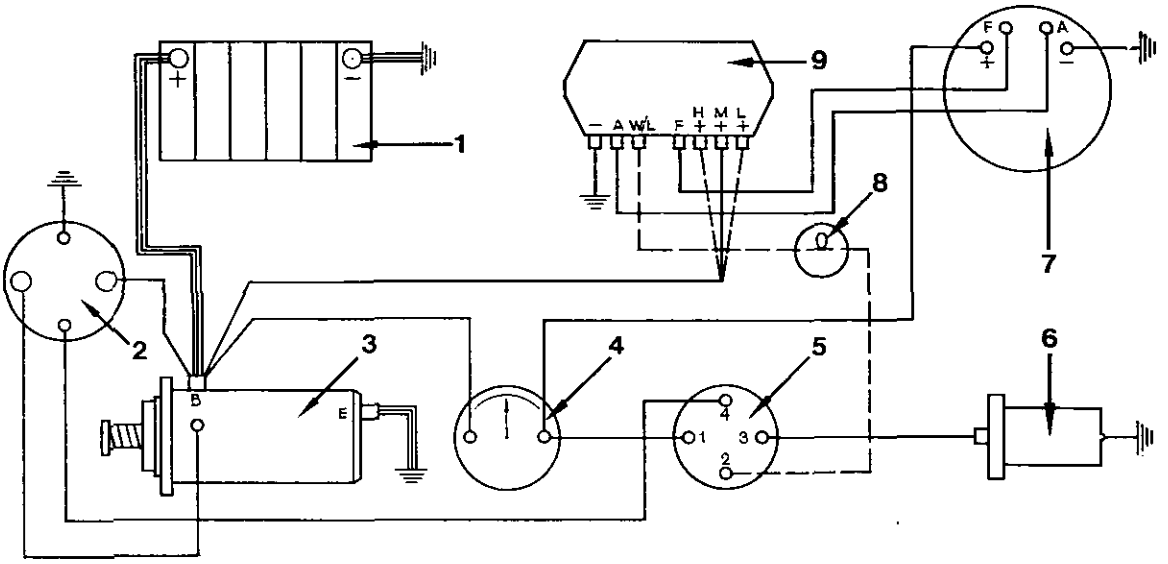


Fig. Q.1.
Typical Wiring Diagram incorporating a AC5 Alternator.

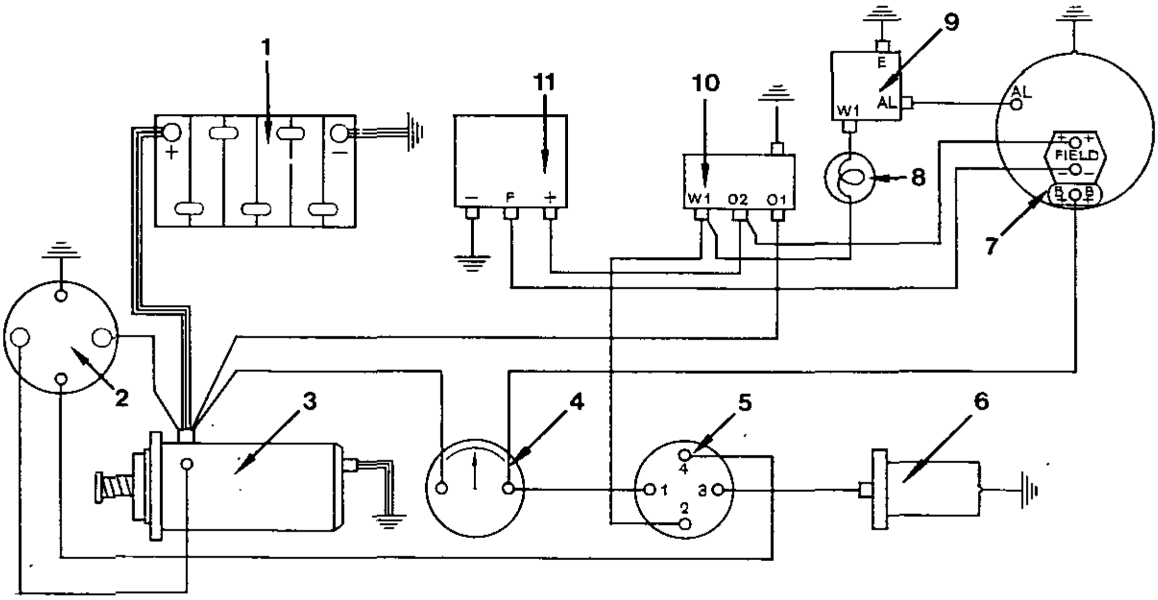


Fig. Q.2.
Typical Wiring Diagram incorporating a 11AC Alternator.

AC5 Various Components.

1. 12 Volt Battery.
2. Starter Relay.
3. Starter Motor.
4. Ammeter.
5. Auxiliary Heat/Start Switch.
6. Thermostart.
7. AC5 Alternator.
8. Alternator Warning Lamp.
9. 440 Regulator.

11AC Various Components

1. 12 Volt Battery.
2. Starter Relay
3. Starter Motor.
4. Ammeter.
5. Auxiliary Heat/Start Switch.
6. Thermostart.
7. 11AC Alternator.
8. Alternator Warning Lamp.
9. 3AW Warning Light Unit.
10. Field Isolating Relay.
11. 4TR Control Unit.

SECTION Q

Alternator Dynamo and Starter Motor

ALTERNATOR

MODELS AC5, 11AC, 15ACR, 17ACR and 18ACR

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 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 on 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. 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, fans, etc., for fifteen minutes.

(d) Start engine and run at fast idle speed when

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.

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 up 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 11AC

If the alternator does not produce its rated output of 43 amps for 12 volt and 23 amps 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.

Check 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

Check 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 of 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 ex ceed 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 ten 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 uncon-rolled manner, then the control unit is faulty and a replacement must be fitted.

TEST 4

Check of 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 11AC

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. Check all connections made to earth.

(c) Apply Test 2.

Flat Battery or Low State of Charge

(a) CHECK condition of battery with hydrometer and high rate discharge tester.

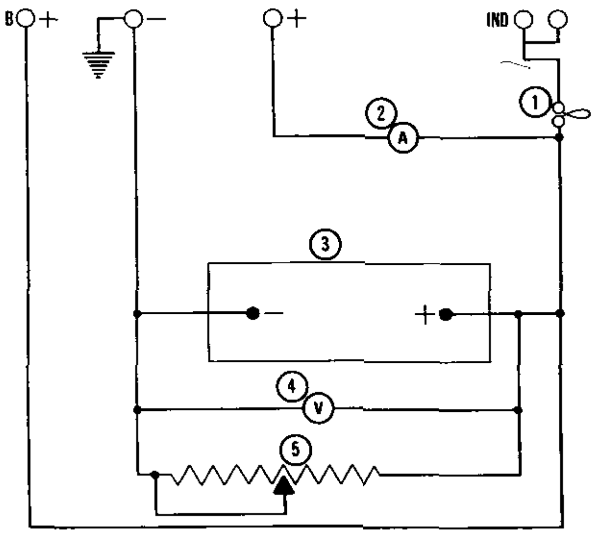


Fig. Q.3.
Test Circuit for 15ACR and 17 ACR Alternators.
Standard terminations, battery-sensed.

(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 damaged 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, 17ACR and 18ACR 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, 36 amps and 45 amps for 15ACR, 17ACR and 18ACR 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.

NOTE : De-rated 17ACR alternators, giving a hot output of 25 amps may be fitted to combine harvesters and similar applications where the engine is operating in dusty conditions.

Alternator Output Test with Regulator Inoperative

Withdraw the cable connector(s) from the alternator, remove the moulded cover (secured by

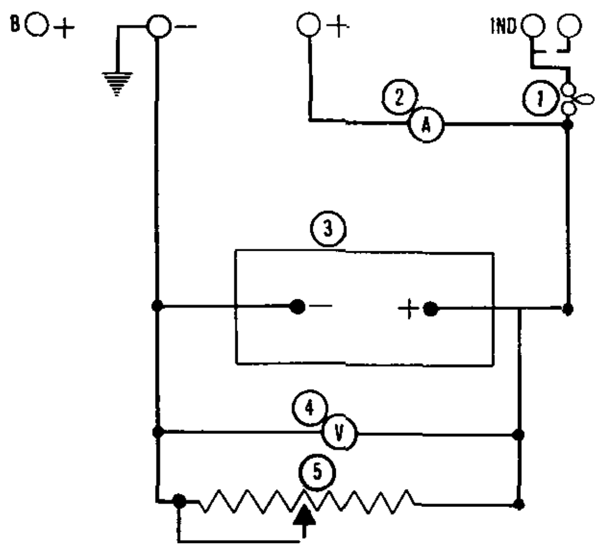


Fig. Q.4
Test Circuit for 15ACR and 17ACR alternators with standard terminals and two piece connection plug (machine-sensed).

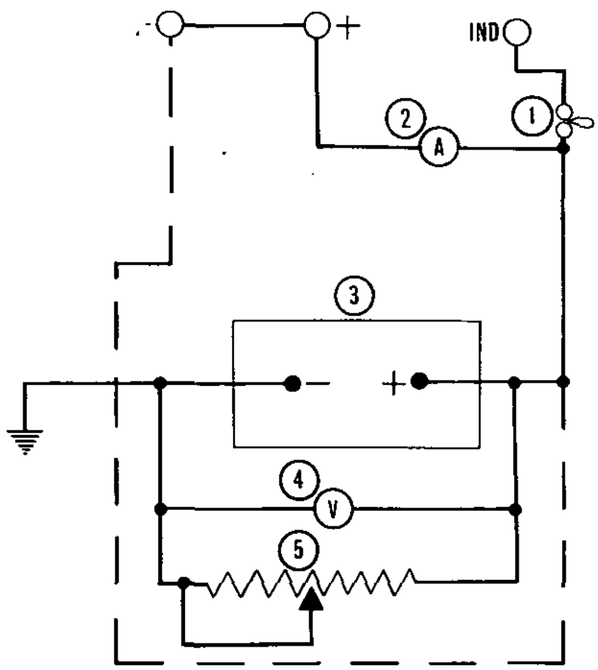


Fig. Q.5
Test Circuit for 15ACR, 17ACR and 18ACR alternators with European terminations and single 3 terminal connector plug (machine-sensed). Broken line cable connection applies to battery-sensed, in which case, the connections between the two '+' terminals will not apply and the broken line terminal will be marked "S" instead of "+".

two screws) and earth the regulator green lead or connector strip to frame.

Connect an external test circuit to the alternator output terminals as shown in Fig. Q.3, Q.4 or Q.5.

Value of components in Figs. Q.3, Q.4 and Q.5 are as follows :—

1. 12 volt 2.2 watt bulb.
2. 0 — 60 ammeter
3. 12 volt battery
4. 0 — 20 moving coil 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 13.6 volts. The ammeter reading should then be approximately equal to the rated output (see previous heading). 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 earth connection from the regulator green lead or connector strip to frame.

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 13,6 — 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 the 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
Models C40A and C40L

1. General

The following information concerns the two types of dynamo fitted as standard equipment to the 6.354 engine, namely, the Lucas C40A and C40L models. If information concerning another type of dynamo is required, the relevant manufacturer should be contacted.

The C40A is a non-ventilated unit. It will be found fitted to applications such as agricultural machines, which operate under exposed service conditions. The C40L is a ventilated dynamo and will be found on applications such as road vehicles, which operate under cleaner and more normal conditions.

Both types are shunt-wound two-pole two-brush machines arranged 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 5,000 miles (7,500 km) or 250 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 (see Fig. Q.6).

(b) Inspection of Brush Gear

Every 20,000 miles (30,000 km) or 1,000 running hours, the dynamo should be removed from the engine and the brushgear inspected by a competent electrician.

(c) Belt Adjustment

Occasionally 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 L.1). At the same time check the dynamo pulley securing nut tightness. Pull to a torque of 15/20 lbf ft (2,1/2,7 kgf m).

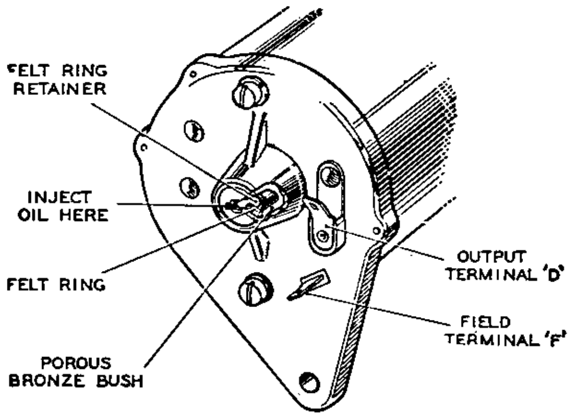


Fig. Q.6. Lubricator in Commutator End Bracket.

3. Servicing
Testing in Position to Locate Fault in Charging Circuit

1. Inspect the driving belt and adjust if necessary.
2. Check the connections 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.
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.

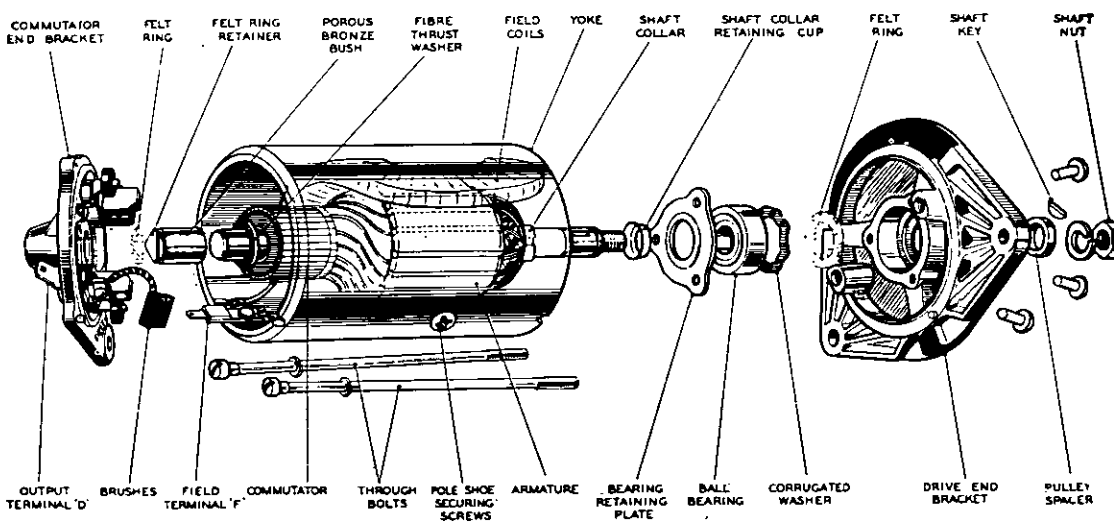


Fig. Q.7. Dynamo Dismantled.

STARTER MOTOR
Model M45G

1. GENERAL

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 :—

(a) Positive pinion engagement preventing the pinion being thrown out of mesh whilst starting.

(b) Dual-purpose plate-clutch incorporated in the drive assembly giving over-speed and overload protection.

(c) Self-indexing pinion to ensure smooth engagement between the pinion and the flywheel teeth before the starter motor begins to rotate.

(d) Armature braking system to ensure rapid return to rest when the starter button is released.

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. Brush wear (this is a fair indication of the amount of work done). Renew brushes worn to, or approaching, $\frac{5}{16}$ in (7,9 mm) in length.
2. Brush spring tension. Correct tension is 30/40 oz (0,85/1,13 kg.) Renew springs if tension has dropped below 25 oz (0,71 kg.)
3. Skim commutator if it is pitted or badly worn.
4. Check bearings for excessive side play of armature shaft.
5. Check pinion movement.
6. Clean and lubricate the indented bearing inside the pinion sleeve using Shell SB2628 for temperate and cold climates or Shell Retinex for hot climates, for this purpose.
7. Clean and lubricate the indented bronze bearing in the intermediate bracket. Use Ragosine 'Molypad' Molybdenised non-creep oil for this purpose.

3. SERVICING

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

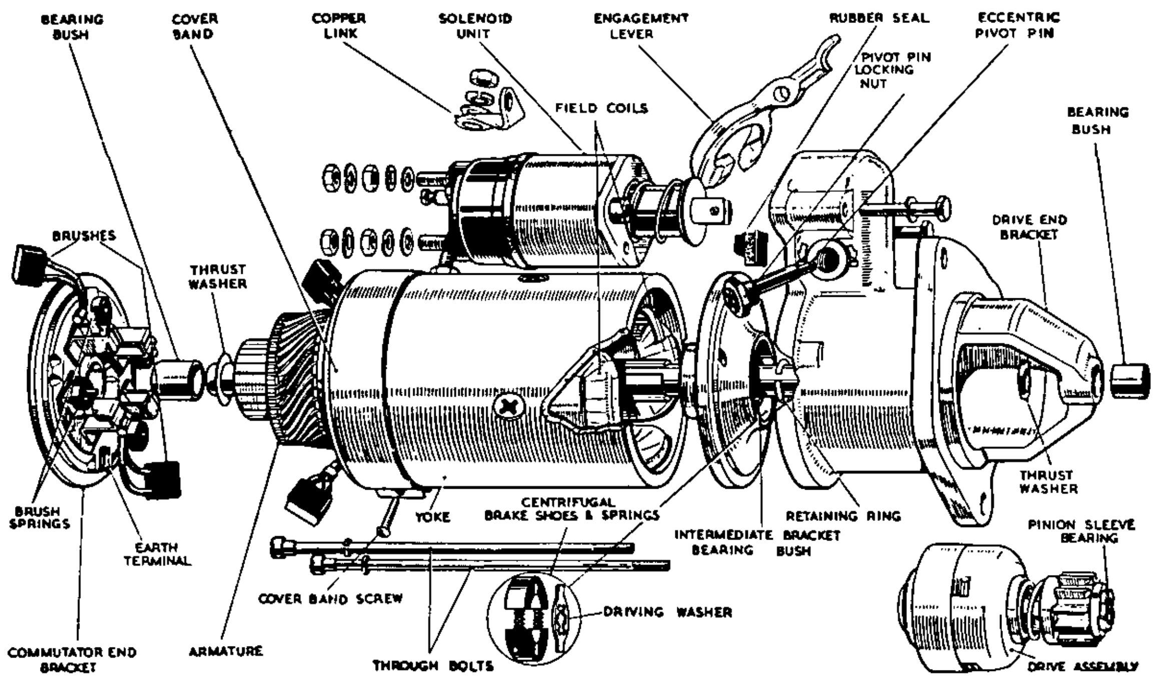


Fig. Q.8. M45G Starter Motor Dismantled.

proceeding. Operate the starter control and watch for the following symptoms :—

1. 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).
2. 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.
   (a) Poor lug connections at battery.
   (b) Bad earth connection.
   (c) Broken starter lead, battery to starter.
   Full volts i.e., 12/14 volts indicated.
   (a) Faulty solenoid switch.
   (b) Open circuit in starter — check brushes.

STARTER MOTOR

Model — CA45

GENERAL DESCRIPTION

Designed for flange mounting, the C.A.45 starter motor has a uniform cylindrical shape with no surface protrusions. This is because the solenoid and main switch assemblies are housed within the drive end-shield, around (i.e., co-axially with) the armature shaft.

The essential feature of the co-axial starter is that, **the Pinion alone** moves axially to engage the engine flywheel. There is no longitudinal movement of the whole armature assembly, as in the axial types.

Smooth engagement of the pinion with the engine flywheel is constantly ensured by using two-stage operation of the solenoid and switch mechanisms. Thus the risk of damage to both pinion and flywheel, through faulty meshing, is practically eliminated.

In construction, the starter consists of three main sections, into which it can be easily dismantled.

1. The solenoid switch-gear and pinion assembly housed in the drive end-shield.
2. The armature, shaft and commutator assembly.
3. The yoke, pole-piece and field-coil assembly.

Ready access is possible therefore, to those parts most likely to require adjustment, such as the switchgear and commutator assemblies.

Testing on the Vehicle

Ensure that the battery is in a charged condition.

Switch on the lamps and operate the starter button. If the starter fails to function, but the lights maintain full brilliance, check the switch and battery connections to the starter and all external leads. Sluggish action of the starter can be caused by a poor or faulty connection.

Difficulty in smooth engagement between starter and engine flywheel is probably due to dirt on the starter-shaft helices preventing free pinion movement. The shaft should be thoroughly cleaned with cleaning fluid followed by the application of a small quantity of Acro Shell 6B or Shell SB2628 for temperate and cold climates or Shell Retinex for hot climates.

MAINTENANCE

Brush Gear and Commutator

Inspect the brushes at intervals to ensure that they are free in their guides and that the leads are quite free for movement, by easing back the brush springs and pulling gently on the flexible connections. If a brush is inclined to stick, remove it from its holder and clean the sides with a petrol moistened cloth.

Be sure to refit the brushes in their original positions to retain the "bedding." The brushes should be well bedded (i.e. worn to the commutator periphery) but if not, wrap a strip of very fine glass or carborundum paper firmly around the commutator with the abrasive side outwards. With the brushes in position, rotate the armature by hand in the normal working direction of rotation ; until the correct brush shape is obtained. If the brushes are worn down so that the springs are no longer providing effective pressure, they should be renewed. Check the brush spring pressure by hooking a spring balance under the spring lip. The correct tension is 30/40 ozf (0,85/1,13 kgf).

It is essential that replacement brushes are the same grade as those originally fitted. Genuine spares should always be used. To remove the brushes, unscrew the four fixing screws, one to each brush. In re-assembling care must be taken to re-connect the field coil and interconnector leads, held by two of the fixing screws. Before inserting brushes in their holders, it is advisable to blow through the holders with compressed air or clean them with a cloth moistened with petrol.

The commutator should be clean, entirely free from oil or dirt. Any trace of such should be removed by pressing a clean dry **fluffless cloth** against it, while armature is hand rotated.

If the commutator is dirty or discoloured, tilt the brushes and wrap a strip of fine glass or carborundum paper (not emery cloth) round the commutator, with the abrasive side inwards. Rotate the armature by hand until the surface is even. Clean with a petrol moistened cloth.

If repair is necessary to the commutator or switch gear etc. *the starter must be exchanged or* repaired by an authorised agent.

STARTER MOTOR

MODEL M50

General Description

The model M50 starter motor is a four pole machine of 5 in (127,0 mm) nominal yoke diameter, and has a 21 slot armature.

The drive is of pre-engaged, solenoid operated, push screw type, incorporating a five roller clutch.

The function of the clutch is to prevent the armature being rotated at high speeds in the event of the engaged position being held after the engine has started. The solenoid incorporates a two-stage switching arrangement which ensures that the motor develops its maximum torque only when full pinion-flywheel engagement has been achieved.

Testing on the Vehicle

Ensure that the battery is in a charged condition.

Switch on the lamps and operate the starter button. If the starter fails to function, but the lights maintain full brilliance, check the switch and battery connections to the starter and all external leads. Sluggish action of the starter can be caused by a poor or faulty connection.

Difficulty in smooth engagement between starter and engine flywheel is probably due to dirt on the starter-shaft helices preventing free pinion movement. The shaft should be thoroughly cleaned with cleaning fluid followed by the application of a small quantity of Acro Shell 6B or Shell SB2628 for temperate and cold climates or Shell Retinex for hot climates.

MAINTENANCE

Brush Gear and Commutator

Inspect the brushes at intervals to ensure that they are free in their guides and that the leads are quite free for movement, by easing back the brush springs and pulling gently on the flexible connections. If a brush is inclined to stick, remove it from its holder and clean the sides with a petrol moistened cloth.

Be sure to refit the brushes in their original positions to retain the "bedding". The brushes should be well bedded (i.e. worn to the commutator periphery) but if not, wrap a strip of very fine glass or carborundum paper firmly around the commutator with the abrasive side outwards. With the brushes in position, rotate the armature by hand in the normal working direction of rotation; until the correct brush shape is obtained. If the brushes are worn down so that the springs are no longer providing effective pressure, they should be renewed. Check the brush spring pressure by hooking a spring balance under the spring lip. The correct tension is 30/40 ozf (0,85/1,13 kgf).

It is essential that replacement brushes are the same grade as those originally fitted. Genuine spares should always be used. To remove the brushes, unscrew the four fixing screws, one to each brush. In re-assembling care must be taken to reconnect the field coil and interconnector leads, held by two of the fixing screws. Before inserting brushes in their holders, it is advisable to blow through the holders with compressed air or clean them with a cloth moistened with petrol.

The commutator should be clean, entirely free from oil or dirt. Any trace of such should be removed by pressing a clean dry fluffless cloth against it, while armature is hand rotated.

If the commutator is dirty or discoloured, tilt the brushes and wrap a strip of fine glass or carborundum paper (not emery cloth) round the commutator, with the abrasive side inwards. Rotate the armature by hand until the surface is even. Clean with a petrol moistened cloth.

If repair is necessary to the commutator or switch gear etc., the starter must be exchanged or repaired by an authorised agent.

SECTION R
Compressors

S.C.6. COMPRESSOR

Introduction

The S.C.6. compressor is a single cylinder unit which is bracket mounted on the cylinder block and driven from the auxiliary drive.

The compressor draws air through the engine induction system. The air is then compressed and fed to the air reservoir. The compressor cylinder head incorporates an unloader device which is operated by air pressure and controlled by a governor valve connected to the reservoir and the compressor by a small bore pipe.

PREVENTIVE MAINTENANCE

Every 5,000 Miles (7,500 km) or 250 Hours

Remove the compressor air cleaner and wash out with clean paraffin or diesel oil. Soak the gauze element in engine lubricating oil and allow to drain off before replacing.

Make a visual check of all joints, unions, etc., for leakage or looseness and rectify where necessary. If the cylinder head has recently been removed, check that the cylinder head nuts are fully tightened down to a torque of 9/10 lbf ft (1,24/ 1,38 kgf m) — 12/13 Nm.

Check compressor mounting and couplings for alignment.

Every 20,000 Miles (30,000 km) or 1,000 Hours

Clean the oil supply line to the compressor.

Remove delivery valve cap and delivery valve seat retaining spring and check for presence of excessive carbon. Withdraw and check condition of delivery valve. If excessive carbon is found, remove and clean the cylinder head ; also check compressor discharge line for carbon and clean or replace the line if necessary.

Every 60,000 Miles (90,000 km) or 2,500 Hours

Dismantle compressor, thoroughly clean all parts and inspect for wear and damage. Repair or replace all worn or damaged parts or replace the compressor with a Factory Reconditioned Unit.

SERVICE CHECK

INSPECTION

Ensure that the air cleaner or filter is clean and correctly installed.

With compressor running, check for noisy operation and oil leaks.

Reduce the pressure in the reservoir by operating the brakes and check that governor and unloader mechanisms are functioning at correct pressure. (If possible the vehicle gauge should be replaced during the test by a master gauge).

Check to be sure compressor mounting bolts are secure.

OPERATING TESTS

If leakage in the remainder of the system is not excessive, failure of the compressor to maintain the normal air pressure in the system usually denotes loss of efficiency due to wear. Another sign of wear is excessive oil passing through to the reservoir. If either condition develops, and inspection shows the remainder of the air brake equipment to be in good condition, the compressor must be overhauled or replaced with a Factory Reconditioned Unit.

AIR LEAKAGE TESTS

Excessive leakage past the delivery valve can be detected by charging the air system to just below the governor cut-out setting, and then with the engine stopped, carefully listening at the compressor for the sound of escaping air. If this test is satisfactory, fully charge the system and again stop the engine. Check once more for audible leaks, which if present indicate leakage at the unloader plunger.

Leakage at the delivery valve can be remedied by cleaning, lapping or replacing the valve and/or valve seat. Unloader plunger leakage can be remedied by replacing the plunger seal or valve plunger.

TO REMOVE COMPRESSOR

Release all air pressure from the system.

Disconnect oil pipe and air pipes at the compressor.

Remove the compressor mounting bolts and detach the compressor from the engine.

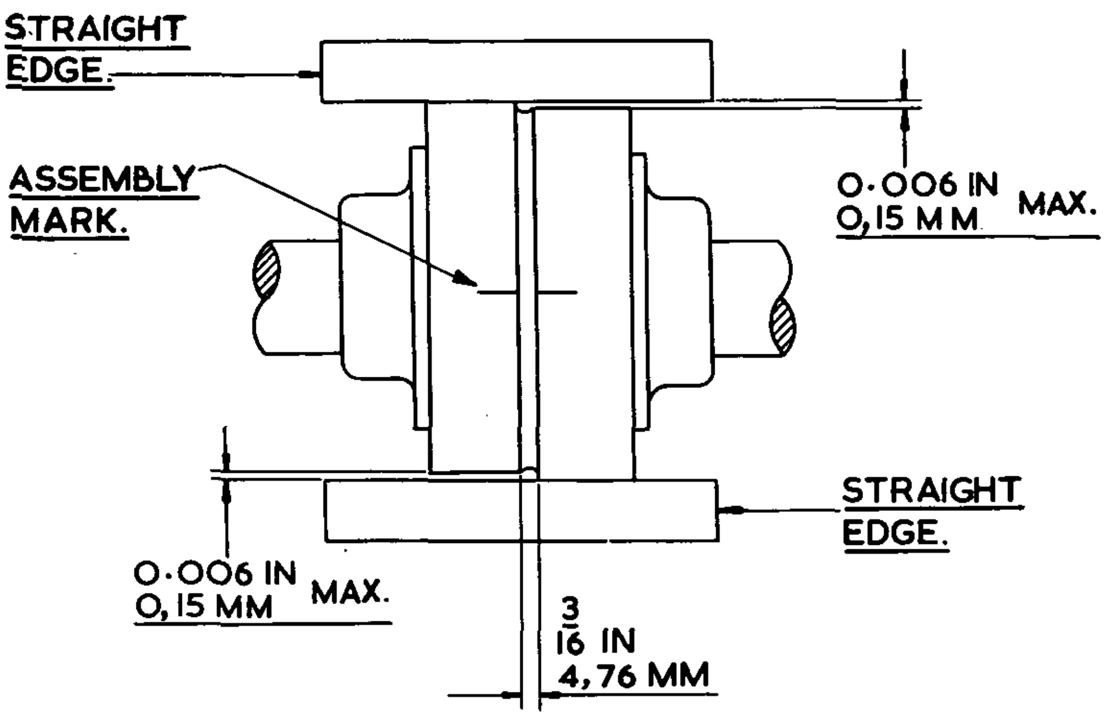
Remove coupling from compressor crankshaft.

NOTE : When reassembling the later type coupling with the rubber insert, it is important that the two moulded halves are assembled in their original position, by ensuring that the marks on the machined periphery of the couplings are adjacent. It may be found however, that some couplings are not marked, and if this is the case, it will be necessary to mark before dismantling.

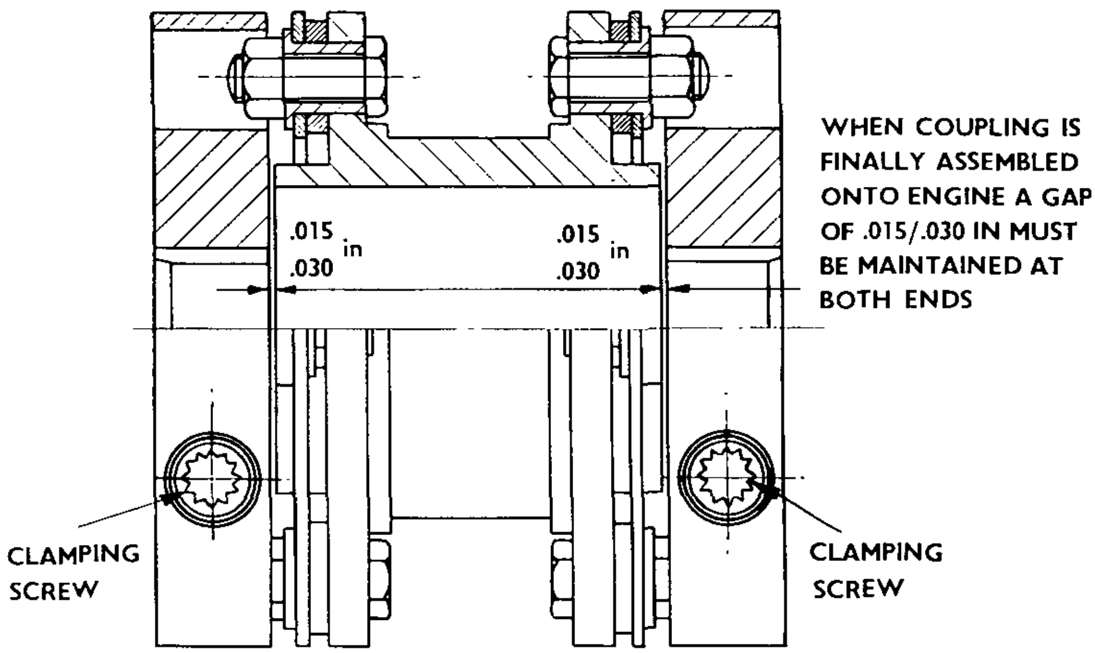
TO REPLACE COMPRESSOR

Fitted with later type coupling

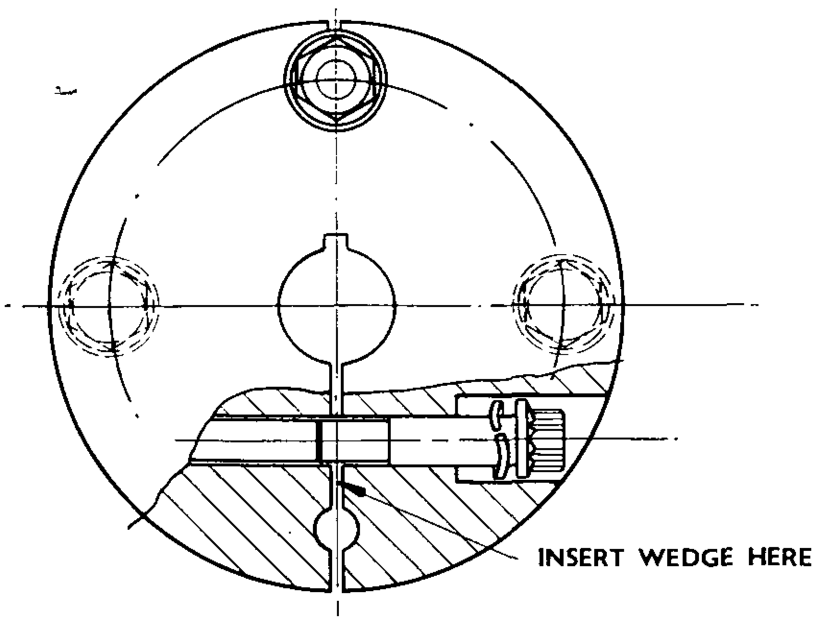
1. Slacken the four clamping setscrews.
2. Fit one half coupling, together with the rubber insert, to the auxiliary drive shaft and, with approximately $\frac{1}{8}$ in (3,17 mm) clearance between the drive shaft seal and the coupling half, tighten the two securing setscrews.
3. Fit tne other half coupling to the compressor *shaft but do not tighten the clamping setscrews.*
4. Fit the compressor to the engine by lightly tightening two securing setscrews and at the same time ensure that the coupling halves are correctly mated, as shown by the adjacent markings (Fig. R.1).
5. Using a straight edge and feeler gauges on the machined diameters of the coupling halves. set the horizontal alignment of the auxiliary drive and compressor shafts. Due to machining tolerances on the outer diameters, it is necessary to check the alignment at both top and bottom of the diameters. Adjust the compressor on its mounting until the coupling halves are concentric within 0.012 in (0,30 mm), total indicator reading. This means that by using feeler gauges with the straight edge positioned as shown in Fig. R.1, the maximum clearance must not exceed 0.006 in (0,15 mm) in either position, as illustrated.
6. Tighten the four setscrews which secure the compressor to the cylinder block. According to the application concerned, different diameter setscrews will be encountered. Where these are $\frac{3}{8}$ in U.N.F., they should be tightened to a torque of 19/21 lbf ft (2,63/2,90 kgf m) — 26/28 Nm and where they are $\frac{7}{16}$ in U.N.F., they should be tightened to a torque of 40/45 lbf ft (5,53/6,22 kgf m) — 54/61 Nm.
7. Adjust the compressor coupling half to give a clearance of $\frac{3}{16}$ in (4,76 mm).
8. Tighten the four coupling setscrews to a torque of 24/26 lbf ft (3,32/3,60 kgf m) — 32/35 Nm and lock the tab washers.
9. Recheck the coupling alignment and the clearance as set in (7).



Later type coupling.
Compressor Coupling Alignment
Fig. R.1.



SECTION THROUGH COUPLING



END VIEW SHOWING WEDGE POSITION

Fig. R.2.

Note

There is an angular tolerance on the coupling of 1° and providing the correct procedure is carried out when setting the horizontal alignment, the angular alignment will be within this limit.

Failure to fit the coupling in the recommended manner may well result in damage to the engine and/or compressor.

Clean the oil supply line to the compressor and run the engine for a few seconds to be sure the oil supply is running freely.

Connect oil and/or air pipes, ensuring that the air cleaner or filter is clean and properly installed.

TO REPLACE COMPRESSOR

Fitted with early type coupling

Fit the coupling to the compressor crankshaft. To assist the entering of the shafts into the ends of the coupling, two short wedges should be made, suitable for driving into the split line at each end of the coupling, thus providing temporary relief in the bore. The wedges should be driven in from the face and not the periphery of the coupling (Fig. R.2.)

1. Slacken the two clamping screws (one at each end of the coupling).
2. Inspect the keys and keyways of each shaft for the presence of burrs, and relieve as necessary. On no account should the bore of the coupling be relieved.
3. Drive the wedges laterally into the split line of each end of the coupling assembly and fit the coupling onto the compressor shaft with the key correctly positioned in its keyway.

Check that the oil return passage in the mounting is clean and clear for oil to return to the engine crankcase. Replace the compressor, renewing the gasket or packing shims where fitted. Ensure that any oil hole in the gasket is correctly positioned and continue as follows :—

1. Offer up the compressor with the coupling to the auxiliary drive shaft with the key in position.
2. Centralise the coupling so that there is approximately $\frac{3}{16}$ in (4,76 mm) of shaft protruding from each end, remove the wedge from the tighten the clamping screw at this end of the coupling to a torque of 20/25 lbf ft (2,77/3,46 kgf m) — 27/34 Nm.
3. Before tightening the remaining clamping screw, it is necessary to set the clearance between the centre spacer and the end clamping pieces as shown in Fig. R.2, and to align the compressor.

   This is done by inserting four feeler gauges of identical thickness between the clamping pieces and the protruding bosses of the centre spacer at both ends. The feelers should be inserted at four equidistant positions around the coupling, i.e. two above and two below the shafts.

   The clearance between the centre spacer and the clamping pieces, should be between 0.015 in and 0.030 in (0,38 mm and 0,76mm), Fig. R.2. Careful adjustment of the compressor on its securing studs must be made to achieve an equal clearance at various points around the coupling.
4. Remove the wedge from the compressor end of the coupling, tighten the clamping screw at this end to the torque figure quoted in (2) above and secure the compressor. A final check should be made for clearance around the coupling to ensure final alignment before re-entry into service.

IMPORTANT

On no account should any of the coupling screws other than the clamping screws be loosened.

Clean the oil supply line to the compressor and run the engine for a few seconds to be sure the oil supply is flowing freely.

Connect oil and/or air pipes, ensuring that the air cleaner or filter is clean and properly installed.

CHECK AFTER INSTALLATION

With the compressor running, check for noisy operation and oil and air leaks.

DISMANTLING

Marking before dismantling

The compressor should have the following items marked to show the correct relationship prior to dismantling.

1. Position of cylinder head in relation to cylinder and crankcase.
2. Position of end-cover(s) in relation to crankcase.
3. Position of crankshaft in relation to crankcase.

Removing and Dismantling Cylinder Head and Cylinder

Remove the unloader cap and copper washer and withdraw the unloader plunger assembly and spring.

Remove the delivery valve cap and copper washer, and remove delivery valve spring and seat retaining spring.

Unscrew the four nuts and washers from cylinder head studs and lift off cylinder head. Remove the joint.

Remove the delivery valve and screw out the valve seat.

Withdraw inlet valve spring guide. (A simple extractor can be made from two ¼ in U.N.F. bolts and a strip of metal formed to bridge the guide). Remove the inlet valve spring, inlet valve and valve seat.

Withdraw cylinder and remove the joint.

Removing and Dismantling Piston and Connecting Rod Assemblies

Remove the compressor mounting bracket and joint.

Turn the crankshaft to B.D.C. position and release the tabs of the locking strap. Unscrew the two bolts and remove the connecting rod cap. With draw piston assembly and replace connecting rod cap.

Remove the piston rings from the piston. If the piston is to be detached from the connecting rod, release one gudgeon pin retaining circlip and press the gudgeon pin from the piston and connecting rod.

Removing Crankshaft

Remove drive key from crankshaft.

Unscrew the four setscrews or nuts together with washers securing the rear end-cover to crankcase. Withdraw the end-cover, plain bearing, thrust washer (where fitted) and joint.

Unscrew the four setscrews or nuts securing the drive end-cover, and withdraw the end-cover complete with crankshaft and joint. Tap crankshaft with bearing from drive end-cover.

CLEANING

Ensure that all carbon is removed from the cylinder head. Check that the air passages in the head and the oilways in the crankcase, where applicable, rear end-cover and crankshaft are clear and clean.

Clean inlet and discharge valves, not damaged or worn excessively, by lapping them on a sheet of crocus cloth held on a flat surface.

INSPECTION OF PARTS

Cylinder

Check cylinder bore for excessive wear, out-of-round or scoring. If scored or out-of-round more than 0.002 in (0,05 mm) or tapered more than 0.003 in (0,08 mm) cylinder should be rebored. The original cylinder bore is to the limits 2.6255/2.6265 in (66,69/66,71 mm) and the clearance for the piston is 0.002/0.003 in (0,05/0,08 mm). Check for wear in cylinder bore and rectify in accordance with following table :

Wear in bore	Remedy
+0.005 in (0,13 mm)	Fit new standard rings.
+0.005/0.010 in (0,13/0,25 mm)	Bore out to +0.010 in (0,25 mm) and fit 0.010 in (0,25 mm) oversize piston and rings.
+0.015 in (0,38 mm)	Fit new 0.010 in (0,25 mm) oversize rings.
+0.015/0.020 in (0,38/0,51 mm)	Bore out to +0.020 in (0,51 mm) and fit 0.020 in (0,51 mm) oversize piston and rings.
+0.025 in (0,63 mm)	Fit new 0.020 in (0,51 mm) oversize rings.

Piston and Connecting Rod

Inspect piston for scores, cracks or damage of any kind. Check fit of rings in ring grooves, clearance should be 0.0005/0.0025 in (0,01/0,06 mm). Install rings in cylinder and check that gaps are 0.003/0.007 in (0,08/0,18 mm). Check fit of gudgeon pin in piston and connecting rod. Gudgeon pin should be a light press fit in piston and clearance in the connecting rod bush should not exceed 0.0015 in (0,04 mm).

Inspect connecting rod bearing for correct fit on crankshaft journal. Clearance between rod journal and bearing must not be less than 0.001 in (0,02 mm) and not more than 0.003 in (0,08 mm). Check connecting rod for cracks or damage.

Crankshaft and Bearings

Examine ball bearings for discoloration, pitting wear and cracked races. Rotate slowly to check for roughness. Defective bearings should be removed, using a well-fitting extracting tool. Press new bearing on to crankshaft, using a suitable length of tube, until it contacts shoulder.

Inspect crankshaft for wear and check threads, shaft ends, keyways and drive keys for damage. The crank pin diameter should be within the limits 0.874/0.8735 in (22,20/22,19 mm).

Crankshaft and End-covers

Inspect oil seal carefully, ensuring that sealing edge is intact and sharp. If an oil leak has been observed at the crankshaft end, a new seal must be fitted. Lip of seal should face inwards.

Examine crankcase, end-cover and mounting bracket for damage and cracks. Check bearing bores for wear. The ball race should be a light press fit in end-cover and the crankshaft should be a neat sliding fit in the plain bearing. Inspect crankshaft thrust washer for wear (where fitted).

Cylinder Head

Inspect cylinder head for cracks and unloader plunger guide bush for wear. Check that unloader plunger is a neat sliding fit in the guide. If it is necessary to replace the unloader piston guide, this will be found to have an undersized bore, and will require reaming in situ to 0.3745/0.3755 in (9,51/9,54 mm). Ensure that the bore is machined square to the underside of the cylinder head. The maximum finish of the guide bore should be 25 micro inches (0,6 microns). A chamfer is also required at the top of the guide bore to an angle of

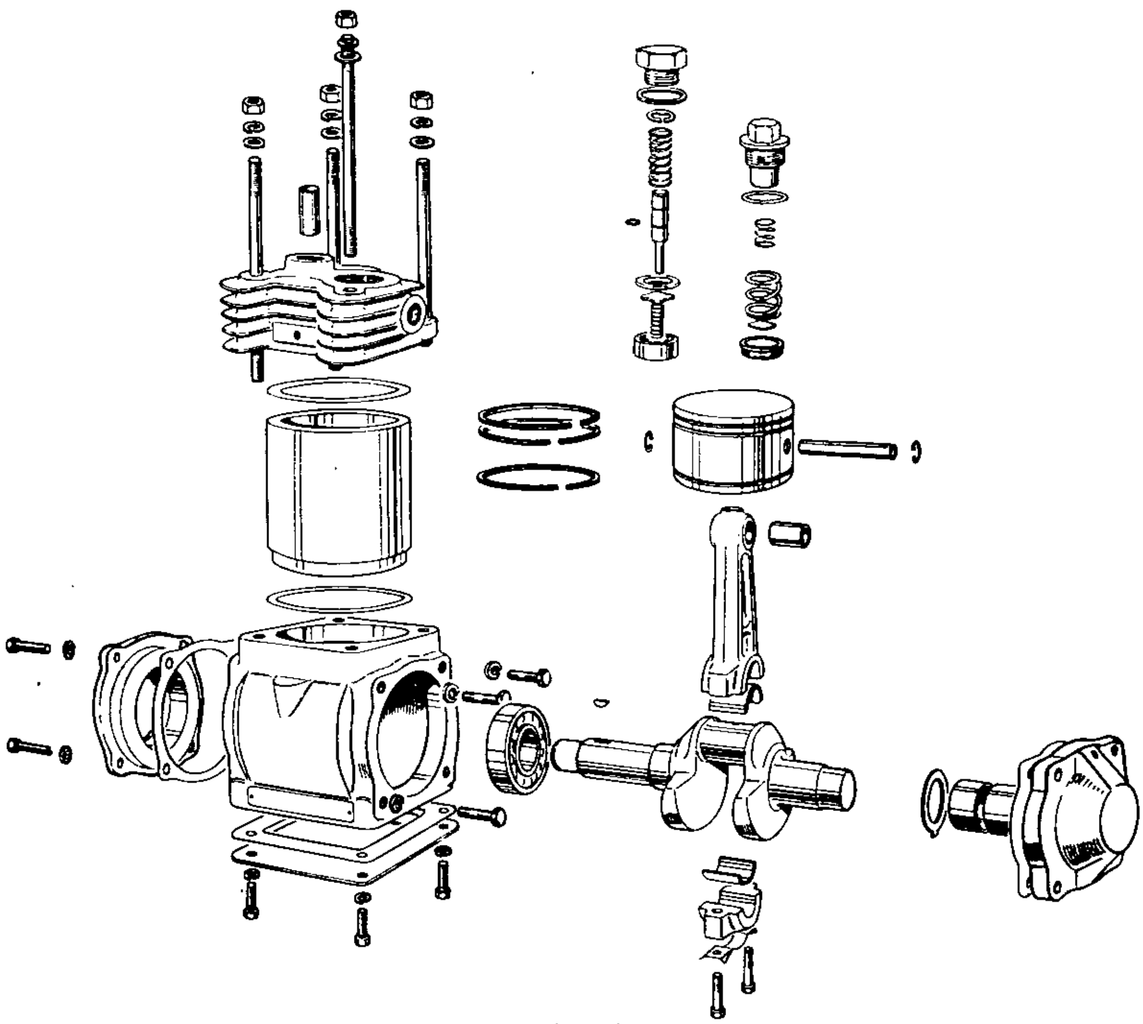


Fig. R.3.
Exploded view of typical Single Cylinder Air Compressor.

15° and to a depth of 0.102 in (2,59 mm). Make sure that the guide and chamfer angle are free from burrs. Examine unloader plunger seal ring for wear. Inspect inlet and delivery valves and seats. If valves are grooved deeper than 0.003 in (0,08 mm) where they contact the seat, they should be replaced. If not badly grooved they can be refaced by lapping on crocus cloth. Valve seats, if showing slight scratches, may be reclaimed by lapping with fine grinding paste. If badly pitted or scratched, use a seating reamer before lapping.

Renew delivery valve spring and check remaining springs for corrosion, fatigue or permanent set.

REASSEMBLY

Lubricate all internal parts with clean engine oil to prevent possible damage until the oil supply is functioning.

Install the crankshaft, complete with bearing, into the drive end-cover. Insert the crankshaft into the crankcase and secure the drive end-cover, ensuring that the joint is correctly positioned over the oil drain ports.

Position the thrust washer in the rear end-cover, with the steel face towards the plain bearing and the tab located in the slot. Assemble the rear end-cover with joint and secure. Check the crankshaft to ensure free rotation and then tighten end-cover nuts or bolts. Fit the drive key to the crankshaft.

Refit the piston rings, ensuring that sides marked 'Top' are uppermost, and assemble the piston to the connecting rod. Assemble the connecting rod on the crankshaft, tighten the bolts to a torque of 3.75/4 lbf ft (0,51/0,55 Kgf m), and turn up the tabs of the locking strap. Space the piston ring gaps and assemble the cylinder, with joint, over the piston.

Assemble the cylinder head. Lightly smear the outside diameters of the inlet valve seat and spring guide with 'Loctite,' or equivalent, sealing compound. Insert the inlet valve seat, inlet valve and valve spring and press the spring guide into position. Screw in the delivery valve seat, using a wrench inserted in the hexagonal hole through the centre of the fitting, and tighten securely. Place the delivery valve on the seat and position the springs. Screw in the valve cap together with the copper washer. Lightly smear the unloader plunger with MS200 (Midland Silicone) grease, and insert the spring and plunger complete with the spring circlip. Screw in the unloader cap together with copper washer.

Place the joint on the cylinder and correctly position the cylinder head on the studs. Tighten nuts progressively to a torque of 9/10 lbf ft (1,24/1,38 kgf m) — 12/14 Nm.

Invert the compressor and apply clean engine oil over the crankshaft and on the cylinder wall. Assemble the mounting bracket and joint.

FAULT FINDING

Compressor Fails to Maintain Adequate Pressure in the System

Dirty air cleaner or filter.
Excessive carbon in cylinder head or discharge line.
Delivery valve leaking.
Excessive wear in compressor.
Inlet valve or unloader plunger stuck open.
Excessive leakage at inlet valve.

Compressor Passes Excessive Oil

Excessive wear.
Dirty air cleaner or filter.
Excessive oil pressure.
Oil return to engine crankcase obstructed.
Back pressure from engine crankcase.
Piston rings incorrectly installed.

Noisy Operation

Excessive wear.
Excessive carbon in cylinder head.

Compressor does Not Unload

Defective unloader plunger seal.
Unloader plunger sticking or binding.
Passage in cylinder head obstructed.

COMPRESSOR MOUNTING PAD

There are two types of mounting pad on the 6.354 cylinder block, the studs of which have different centres (Fig. R.4). The type of compressor does not govern the mounting pad to which it is fitted and both S.C.4 and S.C.6 compressors may be found fitted to both types of pad. When replacing a cylinder block or fitting a service replacement engine, it will be necessary to ensure *that the mounting pad on the replacement is* dimensionally identical to that of the displaced cylinder block, or it will not be possible to refit the compressor to the engine.

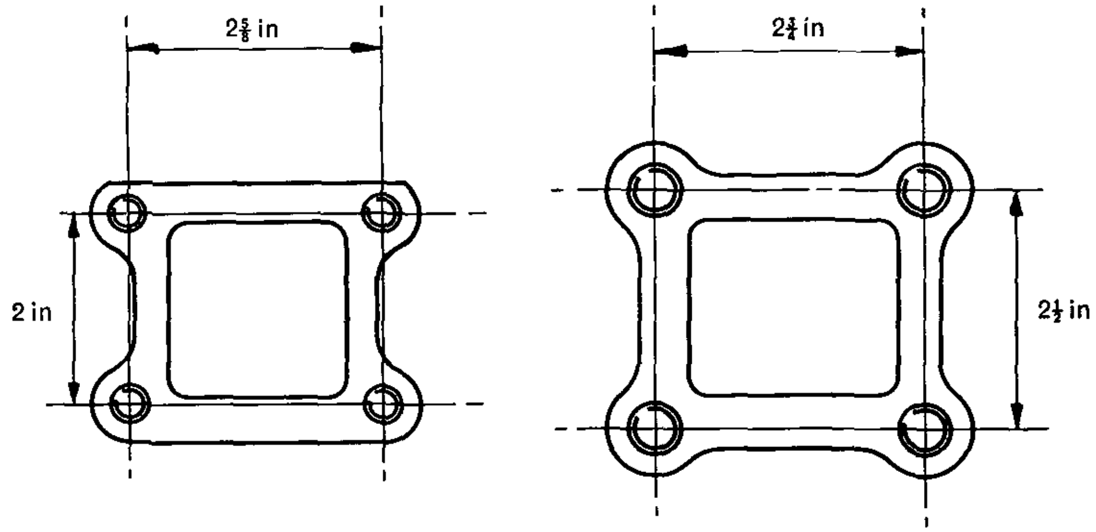


Fig. R.4.
Compressor and Exhauster Block Mounting Pads.

S.C.4 COMPRESSOR

INTRODUCTION

The S.C.4. air compressor is a single cylinder unit which is bracket mounted on the cylinder block and driven from the auxiliary drive. The compressor draws air from the engine induction system, the air being compressed and fed to the air reservoir integral with the servo unit. The compressor unloader mechanism is built into the compressor and is operated by reservoir pressure fed back to the compressor governor through a small-bore pipe. An air pressure gauge is incorporated in the system and a safety valve is mounted on the compressor head.

PREVENTIVE MAINTENANCE

Every 5,000 Miles (7,500 km) or 250 Hours

Remove the compressor air cleaner and wash out with clean paraffin or diesel oil. Soak the gauze element in engine lubricating oil and allow to drain off before replacing.

Make a visual check of all joints, unions, etc., for leakage or looseness and rectify where necessary. If the cylinder head has recently been removed, check that the cylinder head nuts are fully tightened down to a torque of 15/17 lbf ft (2,07/2,35 kgf m) — 20/30 Nm.

Check compressor mounting and couplings for alignment.

Every 20,000 Miles (30,000 km) or 1,000 Hours

Clean oil supply line to compressor.

Remove the governor assembly from the side of the cylinder head. Dismantle and clean all parts; ensure that the items are in perfect condition and the ball valve is free from pitting. Clean the small filter in the governor body by blowing through with compressed air. Avoid disturbing the setting of the governor adjuster and locknut.

Remove delivery valve cap and delivery valve seat retaining spring and check for presence of excessive carbon. Withdraw and check condition of delivery valve. If excessive carbon is found, remove and clean the cylinder head; also check compressor discharge line for carbon and clean or replace the line if necessary.

Every 60,000 Miles (90,000 km) or 2,500 Hours

Dismantle compressor, thoroughly clean all parts and inspect for wear and damage. Repair or replace all worn or damaged parts or replace the compressor with a Factory Reconditioned Unit.

SERVICE CHECK

INSPECTION

Ensure that the air cleaner or filter is clean and correctly installed.

With compressor running, check for noisy operation and oil leaks.

Reduce the pressure in the reservoir by operating the brakes and check that governor and unloader mechanisms are functioning at correct pressure. (If possible the vehicle gauge should be replaced during the test by a master gauge).

Should the Governor Unit be found to be defective it is recommended that the complete Unit be replaced.

Check to be sure compressor mounting bolts and/or nuts are secure.

OPERATING TESTS

If leakage in the remainder of the system is not excessive, failure of the compressor to maintain the normal air pressure in the system usually denotes loss of efficiency due to wear. Another sign of wear is excessive oil passing through to the reservoir. If either condition develops, and inspection shows the remainder of the air brake equipment to be in good condition, the compressor must be overhauled or replaced with a Factory Reconditioned Unit.

AIR LEAKAGE TESTS

Excessive leakage past the delivery valve can be detected by charging the air system to just below the governor cut out setting, and then with the engine stopped, carefully listening at the compressor for the sound of escaping air. If this test is satisfactory, fully charge the system and again stop the engine. Check once more for audible leaks, which if present indicate leaking at the unloader valve piston.

Leakage at the delivery valve can be remedied by cleaning, lapping or replacing the valve and/or valve seat. Unloader valve leakage can be remedied by replacing the piston seal or valve piston.

TO REMOVE COMPRESSOR

Release all air pressure from the system.

Disconnect air and oil pipes at the compressor.

Remove compressor mounting bolts and detach compressor from engine.

Remove coupling from compressor crankshaft.

TO REPLACE COMPRESSOR

Clean oil supply line to compressor and run engine for a few seconds to be sure oil supply is flowing freely.

Check that oil return passage in the mounting is clean and clear for oil to return to engine crankcase.

Fit the coupling to the compressor crankshaft.

Replace the compressor renewing the gasket or packing shims where fitted. Ensure that any oil hole in gasket is correctly positioned.

Check the clearance between the rubber insert and the forward half-coupling at the position shown (Fig. R.5). This should be 0.020/0.025 in (0,51/0,63 mm). Should the clearance be incorrect, the half-coupling can be moved on the shaft until the correct clearance is obtained.

Connect air and oil pipes, ensuring that air cleaner or filter is clean and properly installed.

CHECK AFTER INSTALLATION

With compressor running, check for noisy operation and oil and air leaks.

DISMANTLING

Marking Before Dismantling

The compressor should have the following items marked to show the correct relationship prior to dismantling.

1. Position of cylinder head in relation to cylinder and crankcase.
2. Position of end-covers in relation to crankcase.
3. Position of crankshaft in relation to crankcase.

Removing and Dismantling Cylinder Head and Cylinder

Unscrew the two setscrews together with washers and remove the governor assembly from the cylinder head.

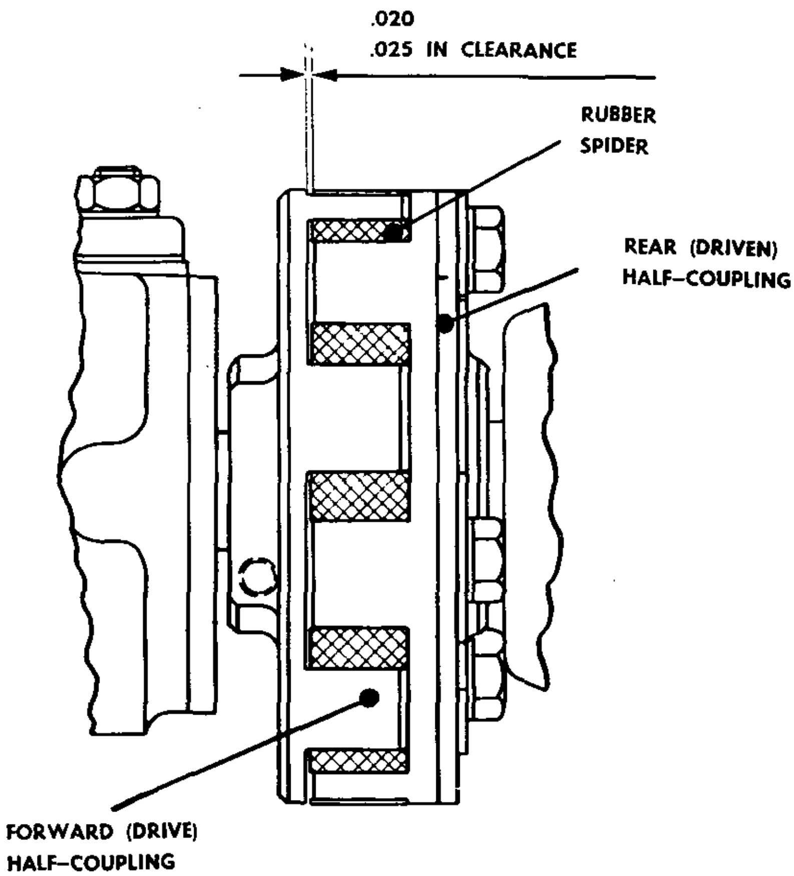


Fig. R.5.
SC4 Compressor Coupling.

Unscrew the inlet connection and safety valve elbow from the head.

Remove the unloader valve cap and copper washer and withdraw the unloader valve piston assembly and spring.

Remove the delivery valve cap and copper washer, and remove delivery valve spring and seat retaining spring.

Remove the four nuts and washers from cylinder head studs and lift off cylinder head. Retain the copper joint.

Remove the delivery valve and press out the valve seat. Discard the seat sealing ring.

Withdraw inlet valve spring guide. (A simple extractor can be made from two ¼ in U.N.F. bolts and a strip of metal formed to bridge the guide). Remove the inlet valve spring, inlet valve and valve seat.

Withdraw cylinder and retain the copper joint.

Dismantling the Governor

The adjuster and locknut should not be disturbed, otherwise it will be necessary to re-set the governor adjustment after assembly.

Unscrew the cap from the body, and remove the brass shim, ball valve, valve seat, ball-valve guide, ball, spring and spring seats.

Carefully remove the filter retainer and gently press out the filter.

Removing and Dismantling Piston and Connecting Rod Assemblies

Remove the compressor mounting bracket and joint.

Turn the crankshaft to B.D.C. position and release the tabs of the locking strap. Unscrew the two bolts and remove the connecting rod cap. Withdraw piston assembly and replace connecting rod cap.

Remove the piston rings from the piston. If the piston is to be detached from the connecting rod, release one gudgeon pin retaining circlip and press the gudgeon pin from the piston and connecting rod.

Removing Crankshaft

Remove drive key from end of crankshaft.

Unscrew the four setscrews together with washers securing the rear end cover to crankcase. Withdraw the end cover complete with bush, joint and thrust washer (where fitted).

Unscrew the four setscrews or nuts and washers securing drive-end cover. Withdraw end cover complete with crankshaft.

Tap crankshaft with bearings from drive-end cover.

CLEANING

Ensure that all carbon is removed from the cylinder head. Check that passages in head, governor, rear-end cover and crankshaft are clear and clean.

Clean inlet and discharge valves, not damaged or worn excessively, by lapping them on a sheet of crocus cloth held on a flat surface.

INSPECTION OF PARTS

Cylinder: Check cylinder bore for excessive wear, out-of-round or scoring. If scored or out-of-round more than 0.002 in (0,05 mm) or tapered more than 0.003 in (0,08 mm), cylinder should be rebored. The original cylinder bore is to the limits 2.1255/2.1260 in (53,99/54,00 mm) and the clearance for the piston is 0.002/0.003 in (0,05/0,08 mm). Check for wear in cylinder bore and rectify in accordance with following table :

Wear in bore	**Remedy**
+0.005 in (0,13 mm)	Fit new standard rings.
+0.005/0.010 in (0,13/0,25 mm)	Bore out to +0.010 in (0,25 mm) and fit 0.010 in (0,25 mm) oversize piston and rings.
+0.015 in (0,38 mm)	Fit new 0.010 (0,25 mm) oversize rings.
+0.015/0.020 in (0,38/0,51 mm)	Bore out to+ 0.020 in (0,51 mm) and fit 0.020 in (0,51 mm) oversize piston and rings.
+0.025 in (0,63 mm)	Fit new 0.020 in (0,51 mm) oversize rings.

Piston and Connecting Rod : Inspect piston for scores, cracks or damage of any kind. Check fit of rings in ring grooves, clearance should be 0.0005/ 0.0025 in (0,01/0,06 mm). Install rings in cylinder and check that gaps are 0.002/0.006 in (0,05/0,15 mm).

Check fit of gudgeon pin in piston and connecting rod. Gudgeon pin should be a light press fit in piston and clearance in the connecting rod bush should not exceed 0.0015 in (0,04 mm).

Inspect connecting rod bearing for correct fit on crankshaft journal. Clearance between rod journal and bearing must not be less than 0.001 in (0,02 mm) and not more than 0.003 in (0,08 mm). Check connecting rod for cracks or damage.

Crankshaft and Bearings : Examine ball bearing for discolouration, pitting, wear and cracked races. Rotate slowly to check for roughness. Defective bearings should be removed, using a well-fitting extracting tool. Press new bearing on to crankshaft, using a suitable length of tube, until it contacts shoulder.

Inspect crankshaft for wear and check threads, taper ends, keyways and drive keys for damage. The crankpin diameter should be within the limits 0.874/0.8735 in (22,20/22,19 mm).

Crankcase and End Covers : Inspect oil seal carefully, ensuring that sealing edge is intact and sharp. If an oil leak has been observed at the crankshaft end, a new seal must be fitted. Lip of seal should face inwards.

Examine crankcase, end covers and mounting bracket for damage and cracks. Check bearing bores for wear. Ball race should be a light press fit in end cover and the crankshaft should be a neat sliding fit in the rear end cover bush. Inspect crankshaft thrust washer (where fitted) for wear.

Cylinder Head : Inspect cylinder head for cracks and unloader valve guide bush for wear. Check that unloader piston is a neat sliding fit in the guide. If it is necessary to replace the unloader piston guide, this will be found to have an undersized bore, and will require reaming in situ to 0.3745/0.3755 in (9,51/9,54 mm). Ensure that the bore is machined square to the underside of the cylinder head. The maximum finish of the guide bore should be 25 micro inches (0,6 microns). A chamfer is also required at the top of the guide bore to an angle of 15° and to a depth of 0.102 in (2,59 mm). Make sure that the guide and chamfer angle are free from burrs. Examine unloader piston seal ring for wear. Inspect inlet and delivery valves and seats. If valves are grooved deeper than 0.003 in (0,08 mm) where they contact the seat, they should be replaced. If not badly grooved they can be refaced by lapping on crocus cloth. Valve seats, if showing slight scratches, may be reclaimed by lapping with fine grinding paste. If badly pitted or scratched, use a seating reamer before lapping.

Renew delivery valve spring and check remaining springs for corrosion, fatigue or permanent set.

Governor : Inspect the component parts of the governor for damage, cracks or wear. Examine the filter. Check the ball valve for scratches and discolouration. Inspect the ball valve seats. Inspect the spring for corrosion and permanent set.

If the ball and/or valve seats are found to be defective, the complete Governor Assembly should be replaced. If it is not possible a new body, ball and valve seat must be fitted. It is important that the correct clearance be maintained, and the following procedure is recommended :–

Insert ball and seat into body without brass shim.

Compress the ball and seat in the body (a half inch B.S.P. steel union nut screwed on to the body thread may be used for this operation) until the flange of the valve seat contacts the end of the body.

Unscrew the nut, extract valve seat and ball and remove any surplus metal.

REASSEMBLY

Lubricate all internal parts with clean engine oil to prevent possible damage until the oil supply is functioning.

Install crankshaft into drive end cover. Insert crankshaft into the crankcase and secure the end cover, ensuring that the joint is correctly positioned over the oil drain ports. Position thrust-washer on end-cover with tab located in slot. Assemble rear end cover with joint and secure. Check crankshaft to ensure free rotation and then tighten end cover. Fit the drive key to the crankshaft.

Refit the piston rings and assemble the piston to the connecting rod. Assemble the connecting rod on the crankshaft, tighten the bolts to a torque of 3.75/4 lbf ft (0,51/0,55 kgf m) — 5/5,4 Nm, and turn up the tabs of the locking strap. Space the piston-ring gaps and assemble the cylinder, with copper joint, over the piston.

Assemble the cylinder head. Insert the inlet valve seat, inlet valve and valve spring and press the spring guide into position. Insert the delivery valve seat and sealing ring. Place the delivery valve in position and assemble the seat retaining spring. Insert the delivery valve spring into the valve cap and screw in the cap, with the copper washer. Insert the unloader spring and unloader

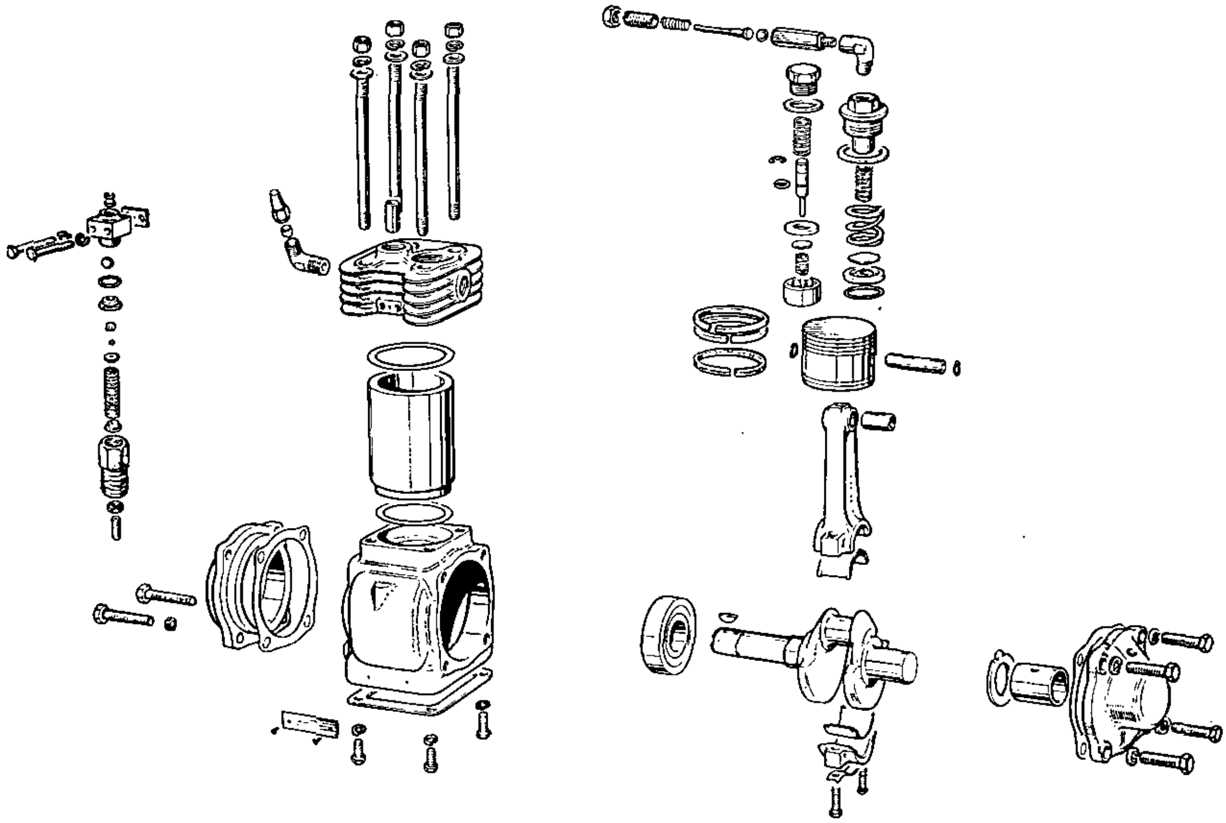


Fig. R.6.
Exploded view of typical "S.C.4" Air Compressor.

valve piston with the spring circlip. Screw in the unloader valve cap, with copper washer.

Place the copper washer on the cylinder and correctly position the cylinder head on the studs. Tighten nuts progressively to a torque of 15/17 lbf ft (2,07/2,35 kgf m) — 20/23 Nm.

Fit inlet and safety valve elbows and safety valve.

Safety Valve

Assemble governor valve, ensuring that the brass shim is fitted between the valve seat and the body. Mount the governor valve, with joint on the cylinder head and tighten the bolts.

Invert the compressor and apply clean engine oil over the crankshaft and on the cylinder wall. Assemble the mounting bracket and joint.

The safety valve protects the air brake system against air pressure in excess of 150 lbf/in^2 (10,55 kgf/cm^2) — 1034 kN/m^2. It consists of a spring-loaded ball check valve which lifts and permits air to release to atmosphere, should the pressure in the reservoir line rise above its setting.

Operating Test

The safety valve may be tested to be sure it is operative by pulling the exposed end of the valve stem when the compressor is charging the reservoir. This removes the spring load from the ball and permits the valve to release. If the safety valve does not 'blow off' the valve must be stuck on its seat. In these circumstances the complete valve should be removed and dismantled for cleaning.

Leakage Test

With the compressor charging, coat the release port with soap suds. Leakage at the release port in the valve body should not exceed a one inch soap bubble in five seconds at 90 lbf/in^2 (6,33 kgf/cm^2) — 620 kN/m^2.

DISMANTLING

1. Release the locknut and unscrew the adjusting screw.
2. Withdraw the release pin valve spring and ball valve.

CLEANING AND INSPECTION

Clean all parts in cleaning solvent.

Examine the ball valve for signs of pitting or scratches. Inspect the ball valve seat.

Check the body for cracks and the spring for distortion and fatigue.

REASSEMBLY

Re assemble the safety valve and set the adjuster in conjunction with an accurate gauge in an air line. The pressure setting of 150 lbf/in² (10,55 Kgf/cm²) has a tolerance of 5 lbf/in² (0,35 Kgf/cm²).

FAULT FINDING

Compressor Fails to Maintain Adequate Pressure in the System

Dirty air cleaner or filter.

Excessive carbon in cylinder head or discharge line.

Delivery valve leaking.

Excessive wear in compressor.

Inlet, unloader or governor valve stuck open.

Excessive leakage at inlet valve.

Compressor Passes Excessive Oil

Excessive wear.

Dirty air cleaner or filter.

Excessive oil pressure.

Oil return to engine crankcase obstructed.

Back pressure from engine crankcase.

Piston rings incorrectly installed.

Noisy Operation

Excessive wear.

Excessive carbon in cylinder head.

Compressor Does not Unload

Defective unloader piston seal.

Unloader piston sticking or binding.

Filter in governor valve blocked.

Passage in cylinder head or governor body obstructed.

Ball in governor stuck on body seat.

Damaged or obstructed air line between governor and reservoir.

Safety Valve 'Blows off'

Safety Valve out of adjustment.

Air pressure in the air brake system above normal.

Compressor mounting pad (See Page R.8).

BENDIX WESTINGHOUSE TWIN 9 COMPRESSOR

To Dismantle Compressor

Remove filter assembly, filter element and adaptor plate.

Remove top cover and cylinder head/valve plate assembly.

Remove valve plate from cylinder head. Mark valves, springs and valve cages to identify position.

Mark connecting rods and caps to identify position.

Release big end securing bolts and remove piston/connecting rod assembly. (Note it is important to release big end bolts before the bolts securing the end cover.

Remove gudgeon pins to release pistons from connecting rods.

Remove piston rings.

Remove end cover.

Remove plastic cover from non-drive end of compressor (if fitted).

Remove crankshaft with thrust washer.

Remove all seals, "O" rings and gaskets.

Reconditioning

All gaskets, seals and "O" rings should be renewed.

The cylinder head and associated parts, and the pistons should be cleaned of any carbon present. The valve discs, springs and valve guides should be renewed. The valve seats may be lapped with a fine grinding paste, but if there is any appreciable wear, the valve plate should be renewed.

The unloading pistons must be a neat sliding fit in the guide bushes. If wear is apparent, renew the pistons or bushes as necessary.

The maximum permissible worn diameter of the cylinder bores is 2.257 in (57,33 mm).

The clearance of the compression rings in the piston grooves is 0.0005/0.002 in (0,012/0,051 mm) and that of the scraper rings is 0.0005/0.0025 in (0,012/0,063 mm). The gap of the compression and scraper rings in the cylinder is 0.003/0.007 in (0,07/0,18 mm).

If the piston rings are being refitted and are bedded for more than the 30% of the width, or if new rings are being fitted, the glaze on the cylinder bores must be broken.

The clearance of the crankshaft in the main bearings should not exceed 0.0035 in (0,09 mm), whilst the clearance of the crankpins in the big end bearings should not exceed 0.003 in (0,08 mm).

The end float of the crankshaft is 0.004/0.012 in (0,10/0,30 mm).

The gudgeon pin should be a light press fit in the piston and the clearance of the pin in the small end of the connecting rod should not exceed 0.0015 in (0,038 mm). Renew gudgeon pin circlips if necessary.

To Re-assemble Compressor

Clean all parts, remove all jointing compound and gaskets. Ensure that all oilways and water passages are clean and free from obstruction. Lightly oil all bearing surfaces, journals and thrust washer faces.

Fit oil seals to crankcase and end cover.

Fit crankshaft to crankcase ensuring that oil seal is not damaged by the edges of the slot in the crankshaft.

Fit thrust washer to crankshaft.

Coat joint face of end cover with sealing compound and fit end cover to crankcase securing with setscrews and spring washers.

Tighten setscrews to 7/9 lbf ft (0.97/1.24 kgf m) — 9.4/12.2 Nm.

Ensure that end float of crankshaft is correct.

Fit connecting rod to piston. Fit gudgeon pin and secure with circlip.

Fit piston rings to piston ensuring that the ring gaps are equally spaced around the piston. The two compression rings on each piston must be fitted with the internal steps or chamfers towards the piston crown. Rings are usually marked with the word "top" or "bottom" on the appropriate face to aid correct fitting.

Lubricate piston rings and cylinder bores thoroughly with clean engine oil before fitting pistons in cylinders.

Fit piston/connecting rod assemblies in crankcase, ensuring that they are fitted with the tooling hole in the connecting rod facing inwards towards the centre line of the compressor.

Fit big end caps and secure with bolts and tabwashers. Tighten bolts to 8/9 lbf ft (1.11/1.24 kgf m) — 11/12 Nm and lock tabwashers.

Ensure compressor has free rotation.

Fit "O" rings to unloader pistons, lubricating assemblies with Silicone Fluid MS200. Fit unloader piston assemblies to crankcase. Fit spring and saddle. Ensure that unloader pistons have free movement.

Fit inlet and exhaust valves, springs and valve guides to cylinder head. Fit valve plate to cylinder head with gasket and secure with countersunk screw. Tighten screw to 45/50 lbf in (0,52/0,57 kgf m) — 5.5/6.1 Nm.

Ensure valves have free movement after assembly.

Fit cylinder head/valve plate assembly with gasket to crankcase. Fit top cover with gasket to cylinder head. Secure with nuts and spring washers where studs are fitted and with bolts and spring washers at tapped hole positions. Tighten nuts and bolts to 15/17 lbf ft (2.07/2.35 kgf m) — 20/23 Nm progressively.

Fit mounting bracket with gasket to base of compressor with bolts and spring washers. Tighten bolts to 15/17 lbf ft (2.07/2.35 kgf m) — 20/23 Nm progressively.

Where required, fit plastic cover to non drive end of compressor and crankshaft.

Coat joint face of filter adaptor with sealing compound and fit plate to crankcase. Secure with countersunk screws tightened to 40/50 lbf in (0.46/0.58 kgf m) — 4.9/6.1 Nm.

Fit new filter element to filter body. Fit retaining plate and retain with bolts and spring washers.

Fit filter assembly to adaptor plate and secure with nuts and spring washers tightening to a torque of 7/9 lbf ft (0.97/1.24 kgf m) — 9.4/ 12.2 Nm.

Fit key to drive end of crankshaft.

Finally protect all ports to prevent ingress of foreign matter.

Data and Dimensions for Bendix Westinghouse Twin 9 Compressor

Cylinder bore diameter	2.250/2.251 in (57.15/57.18 mm)
Max. permissible worn bore diameter	2.257 in (57.33 mm)
Clearance of piston skirt in bore	0.0023/0.0043 in (0.06/0.11 mm)
Clearance of compression rings in piston grooves	0.0005/0.002 in (0.012/0.051 mm)
Clearance of scraper rings in piston grooves ...	0.0005/0.0025 in (0.012/0.063 mm)
Compression ring gap in cylinder	0.003/0.007 in (0.08/0.18 mm)
Scraper ring gap in cylinder	0.003/0.007 in (0.08/0.18 mm)
Crankpin diameter	1.2495/1.250 in (31.74/31.75 mm)
Big end running clearance	0.0005/0.0015 in (0.012/0.038 mm)
Max. permissible worn big end bearing running clearance	0.003 in (0.076 mm)
Main journal diameter	1.2482/1.2491 in (31.70/31.73 mm)
Main bearing running clearance	0.0009/0.0028 in (0.02/0.07 mm)
Max. permissible worn main bearing running clearance	0.0035 in (0.09 mm)

Crankshaft end float	0.004/0.012 in (0,10/0,30 mm)
Max. permissible end float on worn compressor ...	0.017 in (0,43 mm)

Recommended Torques

Cylinder head bolts/nuts	15/17 lbf ft (2,07/2,35 kgf m) — 20/23 Nm
End cover bolts	7/9 lbf ft (0,97/1,24 kgf m — 9.4/12.2 Nm
Mounting bracket bolts	15/17 lbf ft (2,07/2,35 kgf m) — 20/23 Nm
Strainer mounting bolts	7/9 lbf ft (0,97/1,24 kgf m) — 9.4/12.2 Nm
Strainer adaptor screws	40/50 lbf in (0,46/0,58 mm) — 4.9/6.1 Nm
Big end bolts	8/9 lbf ft (1,11/1,24 kgf m) — 11/12 Nm

RECONDITIONING CLAYTON DEWANDRE TWIN 10 COMPRESSOR

Cylinder Head

Mark the cylinder head in relation to the cylinders.

Remove the cylinder head nuts and setscrews and break the joint with a hide hammer.

Remove delivery valve details. Delivery valve springs are accessible after removing the delivery cap or safety valve. Delivery valve seats are either screwed into the head from the top (R.H. thread) or pressed in from the bottom. Screwed in seats can be identified by a square or hexagonal hole through the seat.

The inlet valve details are retained by screwed or pressed in keepers staked by the cylinder head. Both types look similar, but pressed in types embody one to two holes through the keeper tapped B.S.F. or U.N.F. to accept withdrawal bolts. Screwed keepers can be removed by a peg spanner. After removing the keeper, take out spring, valve guide (if fitted), valve disc and seat. The valve seat may have been fitted with loctite on assembly and may require tapping to free the bond.

Thoroughly clean out the water passages of the cylinder head, removing plugs as necessary. Remove all carbon, the piston crown can also be de-carbonised if necessary. Inspect all threads for damage.

Before re-assembling, replace all plugs and ensure complete cleanliness. Insert inlet valve seat, flat side first so that the seating portion faces outwards towards the bottom of the head, valve disc and spring. Screw or press the keeper fully in. Tighten screwed keepers to a torque of 30/35 lbf ft (4,15/4,84 kgf m) — 41/47 Nm.

Stake the face of the cylinder head in three places around the keeper. Screwed types of delivery valve seats with the sealing ring (if fitted) should be inserted down the valve cap bore and screwed in fully to a torque of 5/8 lbf ft (0,69/1,11 kgf m) — 6.7/10.8 Nm. Pressed in type delivery valve seats should have the valve discs located in the seat before the seat is pressed in. Place the delivery valve springs on the valves and sealing washers on the delivery valve caps or cap and safety valve, and screw in to a torque of 65 lbf ft (8,99 kgf m) — 88 Nm.

Place the cylinder head joint on the cylinders and locate the marks made before dismantling : fit and tighten the cylinder head nuts and setscrews to a torque of 16 lbf ft (2,21 kgf m) — 22 Nm.

Pistons and Cylinders

Remove cylinder head as previously detailed.

Remove mounting bracket from compressor crankcase.

Mark each big end cap and connecting rod to ensure re-assembly. Remove bolts and locking strips and detach the cap and bearing. Push the connecting rod up the bore and ease out the piston. Remove piston rings and remove carbon from the ring grooves.

Remove the glaze from the cylinder bores.

Check bores for excessive wear, ovality or scores. If bores are scored, more than 0.002 in (0,06 mm) oval or if wear exceeds 0.005 in (0,127 mm), then the cylinders or liners must be replaced.

Check gudgeon pin clearance in small end bush. Limit is 0.0015 in (0,04 mm). If new bush has to be fitted, mark piston and gudgeon pin in relation to connecting rod before dismantling. Drill oil hole(s) through the bush from the top of the connecting rod before reaming.

Check new piston rings in cylinder bore. Compression ring gap should be 0.003/0.015 in (0,08/0,38 mm). Scraper ring gap should be 0.010/0.022 in (0,25/0,56 mm). Fit rings to piston ensuring that the internal recesses (or the word "TOP") face towards the piston crown.

Assemble pistons to connecting rods and with ring gaps spaced at 120° to each other, fit piston/connecting rod assemblies to cylinder block.

Fit new big end bearings, replace big end caps and tighten big end bolts to a torque of 10/12 lbf ft (1,38/1,66 kgf m) — 13/16 Nm.

Refit compressor mounting bracket and tighten setscrews to 10 lbf ft (1,38 kgf m) — 13 Nm.

Refit cylinder head as previously detailed.

Major Overhaul

Overhaul of the cylinder head and pistons/cylinders is covered separately under previous headings to complete overhaul :—

Remove end cover from cylinder block.

Tap crankshaft at end opposite to cover to remove crankshaft and bearings. Renew oil seals where necessary.

Refit crankshaft bearings. Check end float of crankshaft — limit is 0.003/0.033 in (0,08/0,83 mm).

Refit crankshaft end cover.

Refit piston/connecting rod assemblies and cylinder head as previously described.

SECTION S

Exhausters

DESCRIPTION

The A.350 type exhauster is a rotary sliding vane pump, with an eccentrically mounted rotor.

The unit is bolted directly against the side of the engine crankcase and is driven through a flexible coupling, by a shaft which is connected to the timing gears and also drives the fuel pump. The exhauster body and end covers are of cast iron, and house an aluminium rotor die-cast on to a steel shaft. The rotor has four equi-spaced slots to accommodate fibre blades. The shaft runs in sintered bronze plain bearings fitted in the end cover, which, if bored straight through, also contain seals to prevent the ingress of air and dirt and the leakage of oil from the exhauster. The drive end of the shaft is machined to accept a Woodruff key, thus ensuring non-slip drive. The intake port in the exhauster is pipe-connected to the vacuum reservoir, and the outlet port formed in the base of the exhauster aligns with an aperture in the engine crankcase.

Lubrication is by engine pressure feed, oil entering through a connection in the rear end cover to an annular groove in the bearing housing, from which it passes through a hole in the bearing to oilways in the rotor shaft, communicating with the slots in the rotor. The plain bearing fitted in the drive end cover receives oil through an extension of the main oil way in the rotor shaft, a passage in the drive end cover to the vacuum side of the pump relieving oil pressure on the seal.

OPERATION

At all speeds the rotor blades are kept in contact with the bore of the body by centrifugal force, assisted by the hydraulic action of the oil beneath the blades. When the rotor turns, the spaces between the blades vary, because of the eccentric mounting of the rotor in the exhauster body. As a blade passes the inlet port the space between it and the following blade increases and air is drawn from the vacuum reservoir. This air is then compressed and expelled with the lubricating oil through the outlet port to the engine crankcase.

SERVICING EXHAUSTER

Periodic Inspection and Preventive Maintenance
Weekly or every 5,000 miles

Examine the vacuum lines and fittings. Vacuum leakage may occur through the line or reservoir mounted non-return valve, if the valve seat is dirty or pitted. Should leakage occur, the exhauster will pressurise the engine crankcase, resulting in oil leakage at the crankshaft seals and other joints. Examine the exhauster for evidence of oil leakage, particularly at the end cover joints and at the shaft oil level. Check the oil supply line for leaks at fittings and connections.

Every 10,000 miles

Check the mounting setscrews and end cover retaining socket screws for tightness.

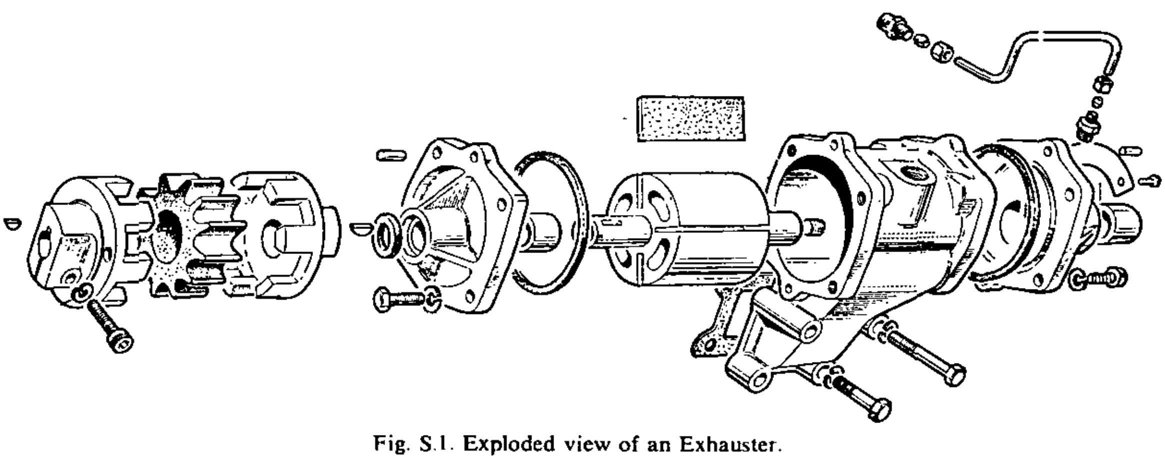


Fig. S.1. Exploded view of an Exhauster.

Every 60,000 miles

Remove and dismantle the exhauster, thoroughly clean all parts and inspect them for wear and damage. If the exhauster is well worn it will be advisable to return it to Perkins Engines Ltd., in exchange for a factory reconditioned unit.

To Remove the Exhauster

Disconnect the oil vacuum pipes at the exhauster and plug the open unions to prevent the entry of foreign matter. Release the driving coupling from the end of the rotor shaft. Unscrew the setscrews which secure the exhauster to the crankcase, and remove the unit from the engine.

Dismantling

Mark the end covers in relation to the body to ensure correct location on re-assembly. Unscrew the four socket-headed screws and remove the rear end cover with the rubber sealing ring. Mark the blades in relation to the rotor and withdraw the rotor complete with blades from the body. Unscrew the four socket-headed screws and remove the drive end cover with its rubber sealing ring.

CLEANING AND INSPECTION

Cleaning

Wash all the components in cleaning solvent and clear the rotor and drive end cover oil ways with compressed air.

Inspection of Parts

Examine the bushes for excessive wear. To renew them see "Overhaul" section. Inspect the rotor and shaft for cracks and damage, check the fit of the fibre blades in the rotor slots and replace any worn or damaged blades. Examine the seals carefully to see that the sealing edges are pliable, intact and sharp. Seals rendered ineffective (usually by dirty oil and grit) should be renewed as prescribed in the section headed "Overhaul." Examine the body for cracks and damage and the bore for longitudinal ripples or lines. If these are only slight the body is still serviceable, if excessive the body should be renewed. Examine the end covers, and renew them if they are cracked or scored.

OVERHAUL

To Renew End Cover Bearings and Seals

Drive End Cover

Extract the seal from the drive end cover and press in the new one until the steel seal holder abuts against the shoulder in the cover. With the seal removed, press the worn plain bearing out of the cover using a bar or tube $1\frac{1}{16}$ in diameter. Press the new bearing into the cover until it is $\frac{1}{8}$ in below the cover face.

Rear End Cover

Blank end covers are not fitted with seals. The bearing should be extracted or machined out taking care not to damage the housing, or in an emergency it may be removed by cutting a groove along the bearing, using a narrow half round chisel. Inspect the housing, remove any burrs and press the new bush fully into the cover. Where the

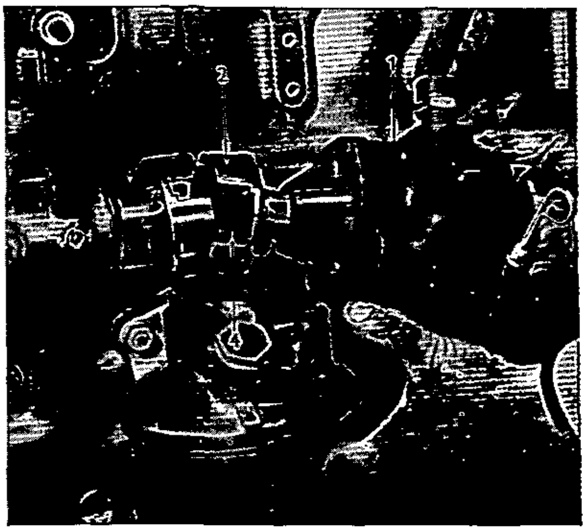


Fig. S.2. Removing Exhauster.
1. Exhauster.
2. Exhauster Coupling (Driven Half).
3. Exhauster Coupling (Drive Half).
4. Rubber Coupling.

rear end cover has been bored straight through and blanked off, the circlip should be removed followed by the blanking disc and 'O' ring, which acts as a seal. The bush may then be pressed out of the cover, using a bar or tube, $1\frac{1}{16}$ in diameter. When replacing these components it is advisable to fit the circlip in its groove and then refit the blanking disc followed by a new 'O' ring. The new bush should be pressed into the cover until it slightly compresses the 'O' ring against the blanking disc, the resulting reduction in internal diameter of the 'O' ring ensuring an effective seal on the shaft. The large rubber 'O' rings which seal the gaps between the exhauster body and the end covers, should be renewed if they appear to be in any way compressed or damaged.

Re-assembly

Lubricate all moving parts with clean engine oil.

Carefully insert the shaft into the drive end cover, avoiding damage to the seal.

With the large rubber 'O' ring fitted in its groove in the cover, assemble the latter to the body, locating the dowels in their respective holes.

Hold the body, drive end downwards, and replace the blades in the rotor slots, making sure that the marks made during dismantling correspond.

Install the rear end cover with its rubber 'O ring on to the body (ensuring that the dowels locate in their respective holes) and tighten the socket-headed screws.

Turn the rotor by hand to make sure that it revolves freely.

Installation

Replace the joint and remount the exhauster securely to the engine crankcase, with the coupling halves fitted loosely on the shafts. Tighten the coupling halves to their respective shafts, so that there is a nominal clearance of 3/64 in (1,19 mm) between the rubber spider and each coupling half.

NOTE: This clearance is necessary, as no end loading on the rotor shaft is permissible.

Reconnect the oil feed and vacuum pipes.

EXHAUSTER MOUNTING PAD

There are two types of mounting pad on the 6.354 cylinder block, the studs of which have different centres, (Fig. R.4). The type of exhauster does not govern the mounting pad to which it is fitted, and different types may be fitted to both types of pad. When replacing a cylinder block or fitting a service replacement engine, it will be necessary to ensure that the mounting pad on the replacement is dimensionally identical to that of the displaced cylinder block, or it will not be possible to refit the exhauster to the engine.

LUBRICATING OILS

Lubricating oils for normally aspirated engines should meet the requirements of the U.S. Ordnance Specification MIL-L-46152 or MIL-L-2104C. Lubricating oils for turbocharged engines and engines installed in Heavy Duty Earthmoving Equipment should meet the U.S. Ordnance Specification MIL-L-2104C.

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
	Q Motor Oil		20W/50	20W/50
	Farmadcol HDX		20	30
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
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

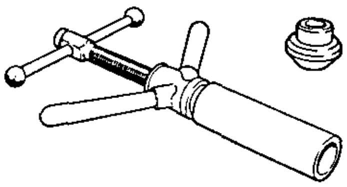
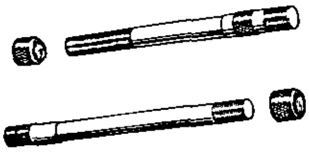
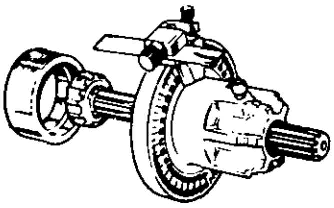
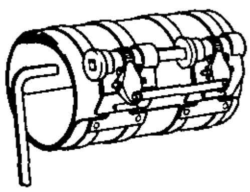
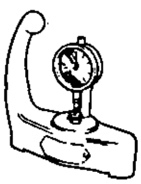
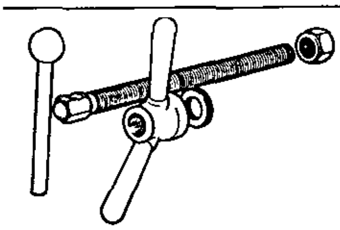
Where oils to the MIL-L-46152 or MIL-L-2104C specification are not available, then oils to the previous specification MIL-L-2104B for normally aspirated engines and MIL-L-45199B or Series 3 specification for turbocharged engines may continue to be used providing they give satisfactory service.

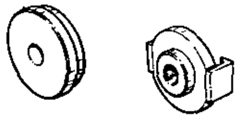
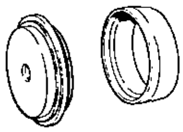
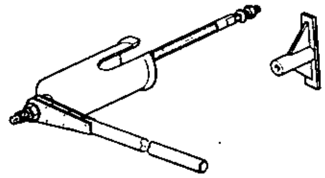
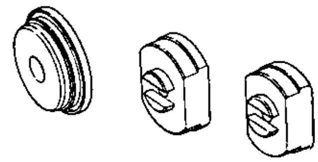
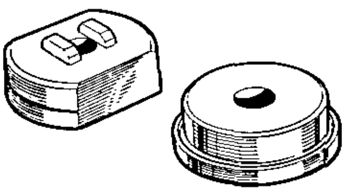
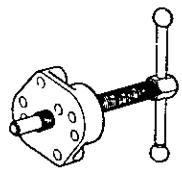
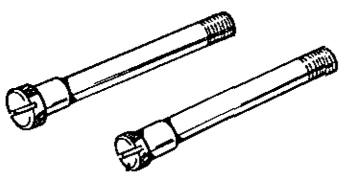
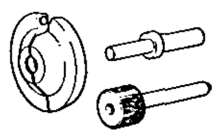
Lubricating oils for use in Perkins Diesel engines should have a minimum viscosity index of 80.

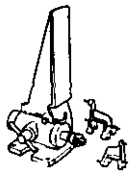
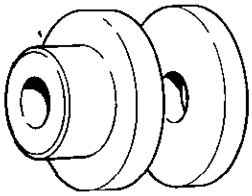
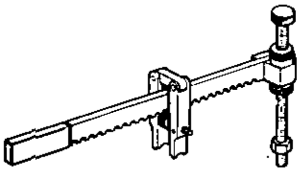
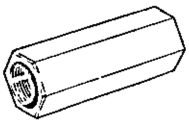
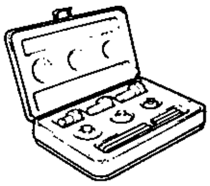
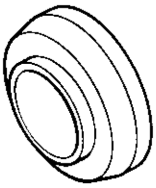
The above specifications are subject to alteration without notice.

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.
	PD.1D-6	ADAPTOR FOR PD.1D A 15 mm (19/32") distance piece used to replace valve guides to a set height.
	MS.67B	TIMING TOOL WITH ADAPTOR MS67B/8 Used for setting and checking Fuel Pump Timing
	No.8	*PISTON RING SQUEEZER*
	PD.41B	PISTON HEIGHT AND VALVE DEPTH GAUGE A simple method of quickly checking piston height.
	*PD.140*	*CAMSHAFT BUSH REMOVER/ REPLACER*

	Tool No.	Description
	PD.140-2	FUEL PUMP THRUST COLLAR REMOVER/REPLACER ADAPTORS
	PD.145	CRANKSHAFT REAR OIL SEAL REPLACER ADAPTOR (LIP TYPE SEAL)
	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.
	PD.150-1B	ADAPTORS FOR PD.150 Suitable for cylinders of 3.6" dia. and 3.87" dia. Removal and replacement.
	PD.150-7A	ADAPTORS FOR PD.150 Suitable for cylinders of 3.97" 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. Also suitable to remove Camshaft Gears.
	MF.200-26	WATER PUMP OVERHAUL KIT Used with 370 Taper Base and Press.

	Tool No.	Description
	335	CON ROD JIG & 336 MASTER ARBOR
	336-102	ARBOR ADAPTOR Used with 335.
	6118B	VALVE SPRING COMPRESSOR
	PD.6118-4	ADAPTOR FOR 6118B
	MS.73	ADJUSTABLE VALVE SEAT CUTTERS
	PD.162	TIMING CASE 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 C.4.

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.3.

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 to 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 fastners, sleeves, etc.

INDEX

INDEX (Continued)

EXAMPLES OF SERVICE FACILITIES

Service Publications

The following Service Literature may be purchased through your local Perkins Distributor.

Workshop Manuals
Operators Handbooks
Crankshaft Regrinding
Fault Finding Guide
Engine Brake Testing Data
Installation and Maintenance Guide for Static Standby Engines
Etcetera

Service Instruction

PETERBOROUGH

Apply to Product Department for details.

This publication is published by the Service Publications Department of Perkins Engines Limited and every endeavour is made to ensure that the information contained in this Manual is correct at the date of publication but, due to continuous developments, the manufacturers reserve the right to make alterations without notice.

USE ONLY
GENUINE
PERKINS PARTS

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.