

# PERKINS

## diesel engines



# workshop manual for 6.354 turbocharged and normally aspirated diesel engines

**(includes 6.354.2 engines)**

---


Perkins Engines Limited

Peterborough England

---

'Phone : Peterborough 67474

Cables : Perkoil Peterborough

Telex : 32132



Publication No. 601 SER 1020

RE-ISSUED JANUARY 1970

Printed in England

# Perkins Engines Limited

## *Overseas Companies and Manufacturing Licensees*

| | |
|---|---|
| **ARGENTINA** | PERKINS ARGENTINA S.A.I.C.<br>Bolivar 368, BUENOS AIRES.<br>Cables : Perkinsa, Baires. Telephone : 30-7002/30-6978/30-6981.<br>Telex : B A 102. |
| **AUSTRALIA** | PERKINS ENGINES (PTY.) LTD.<br>P.O. Box 156, DANDENONG, Victoria, Australia.<br>Cables : Perkoil, Dandenong. Telephone : Dandenong 20431. |
| **BRAZIL** | MOTORES PERKINS S.A.<br>Caixa Postal 5720, Estado de Sao Paulo, SAO PAULO, Brazil.<br>Cables : Perkoil, Sao Paulo. Telephone : 43 - 1499. Telex : Sao Paulo 427. |
| **CANADA** | PERKINS ENGINES CANADA LTD.<br>7 Meridian Road, Rexdale, Ontario, Canada.<br>Tel : 416/677/4960 |
| **FRANCE** | MOTEURS PERKINS S.A.<br>55 Boulevard Ornano, SAINT-DENIS (Seine), France.<br>Cables : Perkoil, Paris. Telephone : 243.04-40. Telex : 62251. |
| **GERMANY** | PERKINS MOTOREN G.M.B.H.<br>8752 Kleinostheim, Autobahnausfahrt Aschaffenburg-West, Germany.<br>Telephone : (06027)-291. Telex : 4-188869. |
| **INDIA** | SIMPSON & CO. LTD.<br>P.O. Box 303, 202-203 Mount Road, MADRAS.<br>Cables : Simpsons, Madras. Telephone : 83021 (8 lines). |
| **ITALY** | MOTORI PERKINS S.P.A.<br>Via Pasquale Paoli, 9/A, COMO—CAMERLATA, Italy.<br>Cables : Perkoil, Camerlata. Telephone : Como, Camerlata 504886-7-8. |
| **JAPAN** | TOYO KOGYO CO. LTD.<br>6047 Fucho-Machi, Aki-gun, HIROSHIMA.<br>Telephone : Hiroshima 62-1111 Telex : Japan 652-333 |
| **MEXICO** | MOTORES PERKINS S.A.<br>Tiber 68. 1er Piso. MEXICO 5, D.F. Telephone : 286167<br>Cables through Automex : Famsamex 0177721 |
| **SOUTH AFRICA** | PERKINS ENGINES (PTY.) LTD.<br>P.O. Box 9951, 4 Simmonds Southway, Park Central, JOHANNESBURG, South Africa.<br>Cables : Perkoil, Johannesburg. Telephone : Johannesburg 835-6071/2/3. |
| **SPAIN** | MOTOR IBERICA, S.A.<br>Division Perkins, Avenida de Aragon, 130 MADRID (17).<br>Telephone : Madrid 205 00 40 1-2-3 & 205 09 95. Telex : 07324 |
| **U.S.A.** | PERKINS ENGINES INC.<br>27575 Wixom Road, P.O. Box 500, Wixom, Michigan 48096, U.S.A.<br>Cables : Perkoil, Wixom. Telephone : Detroit 349.4100. |

# CONTENTS


| | |
|---|---|
| ENGINE PHOTOGRAPHS | Section |
| ENGINE DESCRIPTION | A |
| TECHNICAL DATA | B |
| PERIODICAL ATTENTIONS | C |
| FAULT DIAGNOSIS | D |
| CYLINDER HEAD | E |
| PISTONS AND CONNECTING RODS | F |
| CYLINDER BLOCK AND LINERS | G |
| CRANKSHAFT AND MAIN BEARINGS | H |
| TIMING CASE AND DRIVE | J |
| LUBRICATING SYSTEM | K |
| COOLING SYSTEM | L |
| AIR FILTERS AND FUEL SYSTEM | M |
| FLYWHEEL AND HOUSING | N |
| TURBOCHARGER | P |
| ALTERNATOR, DYNAMO AND STARTER MOTOR | Q |
| COMPRESSOR | R |
| EXHAUSTER | S |
| GLOSSARY OF TERMS — INDEX | Appendix |
| APPROVED SERVICE TOOLS | „ |
| APPROVED LUBRICATING OILS | „ |
| SERVICE FACILITIES | „ |

# 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 current engines, the engine number consists of figures and letters, e.g. 354U251. In this instance the first three figures represent the cubic capacity, i.e. 354 $in^3$ (6,354 engine), the letter "U" signifies that the engine was built in the United Kingdom and the last group of figures comprises the engine serial number.

Other letters may follow the serial number denoting specific information, e.g. a letter "C" indicates an engine fitted with chrome plated cylinder liners, a letter "H" indicates a horizontal engine, whilst a letter "T" indicates a turbocharged engine.

With 6.354.2 engines, the Eng. No. commences at 354U200000.

Earlier engines had serial numbers consisting of seven digits, commencing with the figure eight " 8," situated in the same place as the present series.

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. A Glossary of Terms for reference purposes is included at the back of this publication.

# Engine Designation

Two types of 6.354 Engines are available, i.e., Turbo-charged 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.

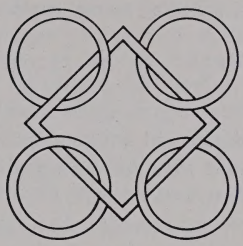
Vertical and Horizontal engines are also available, Horizontal engines have the letter "H" prefixed to the engine designation, e.g., H6.354.

Extra heavy duty engines are designated 6.354.2.

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

This publication is produced 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.

**PERKINS Parts**



**for**

**PERKINS Products**

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.

# *Brief History of Company Development*

The Perkins organisation, as we know it today, was founded by the late Mr. Frank Perkins in 1932.

The first 'factory' was a tiny workshop in Queen Street, Peterborough, the employees numbered only four and they produced engines with such colourful names as Vixen, Fox, Wolf and Leopard.

In 1937 the company produced the 'P6' which turned out to be the forerunner of a line of engines designed to operate in vehicles, agricultural machines, industrial plant and boats all over the world.

During World War II Perkins concentrated on producing essential power units for the armed services, including marine engines for the Royal Air Force in their air sea rescue launches.

After the war, company progress gathered momentum, overseas companies were set up to provide marketing and servicing facilities for Perkins products ; in many instances these companies have their own production plants. Perkins engines are also produced by other firms under licence, this all amounts to many thousands of additional units being produced outside the United Kingdom, which supplements the Peterborough output and helps to meet the world demand.

This illustrates the outstanding rate of growth of the Perkins Group of Companies, for in a little over thirty years the Group has grown from a small firm in a provincial back street into an international organisation, which is the world's largest producer of diesel engines and whose engines operate in no less than one hundred and sixty countries or territories.

In February 1959, Perkins became part of the world wide Massey-Ferguson organisation but continued to operate as an independent unit. A new subsidiary company, Perkins Engines Limited was formed to handle sales and servicing of Perkins engines throughout the world.

The present production plant, situated at Eastfield (on the outskirts of the City of Peterborough), covers more than a million square feet on a site of one hundred and twenty acres. A new factory extension was recently opened, it houses a completely self contained manufacturing plant, which has been described as the most highly automated diesel engine plant in the world, and is also the headquarters of the research, development and service departments, whose efforts are directed towards bringing Perkins customers, wherever they operate, all that is best in the field of diesel engineering.

# Foreword

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

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

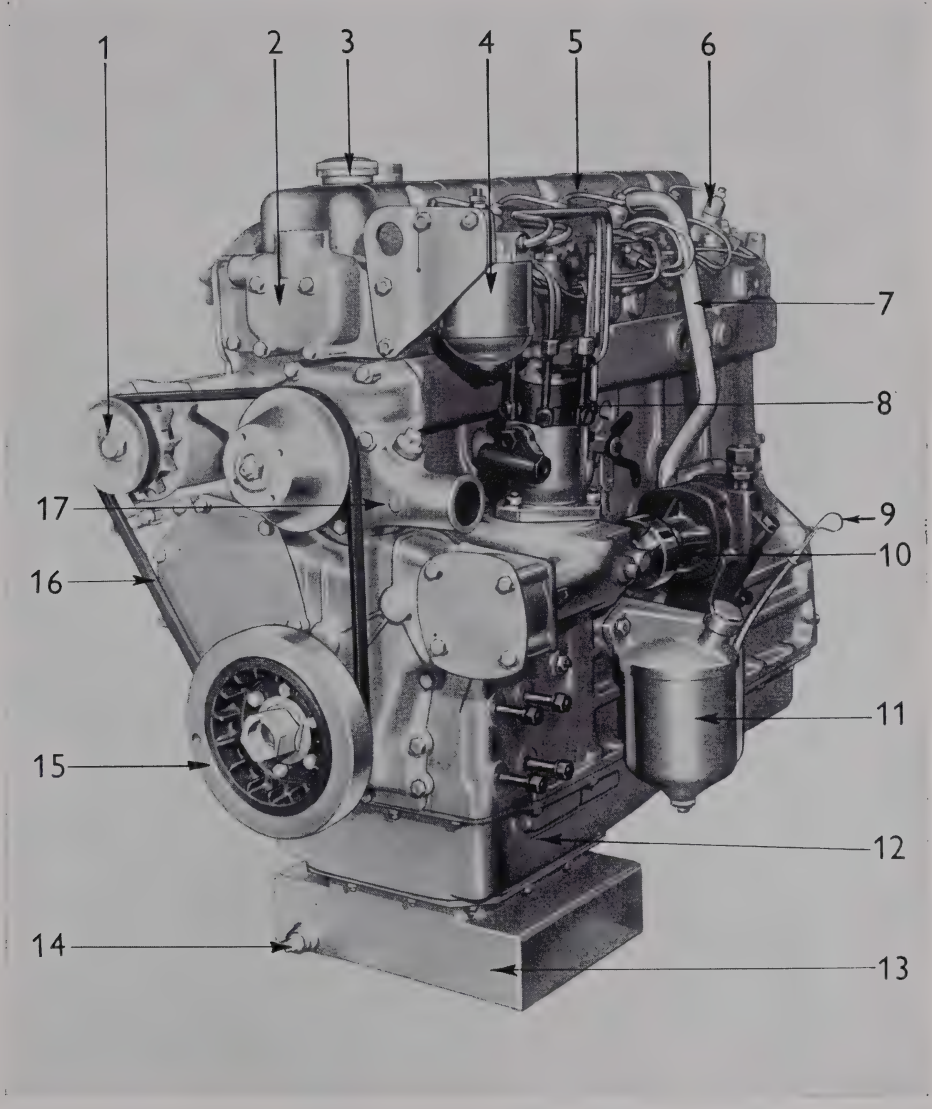
Similarly, it is understood that in reassembly and inspection, all parts are to be thoroughly cleaned, and where present, burrs and scale are to be removed.

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

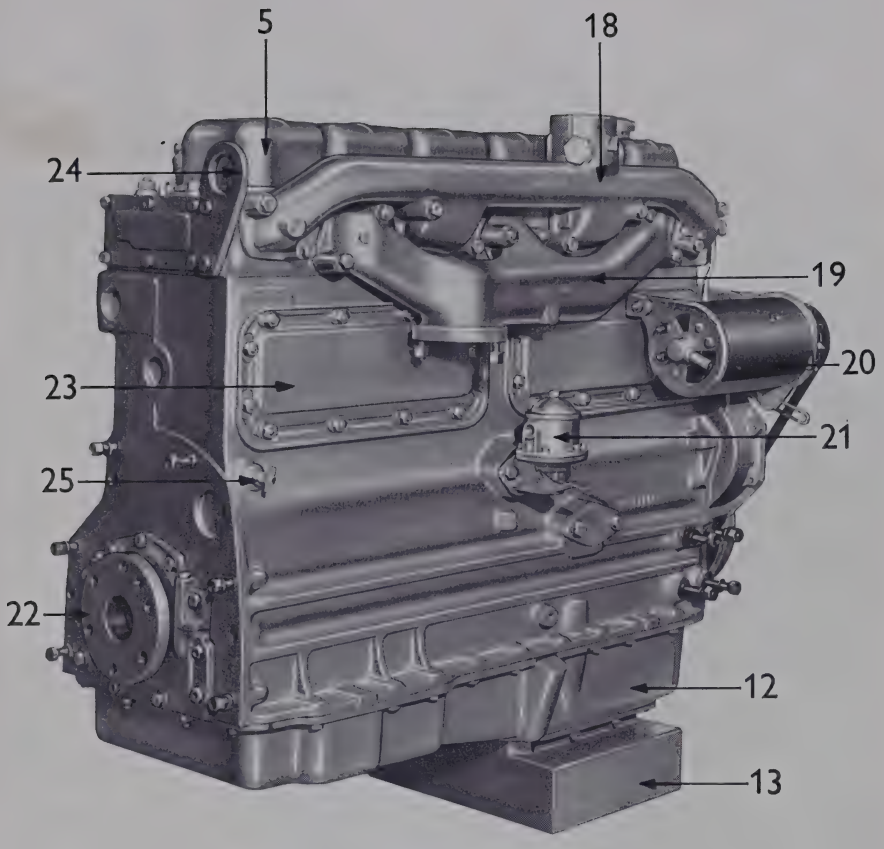
Users of Turbocharged engines should read the contents of Section "P" BEFORE STARTING their engine. Particular reference should be made to Sections 5 and 6.

# INDEX TO ENGINE PHOTOGRAPHS

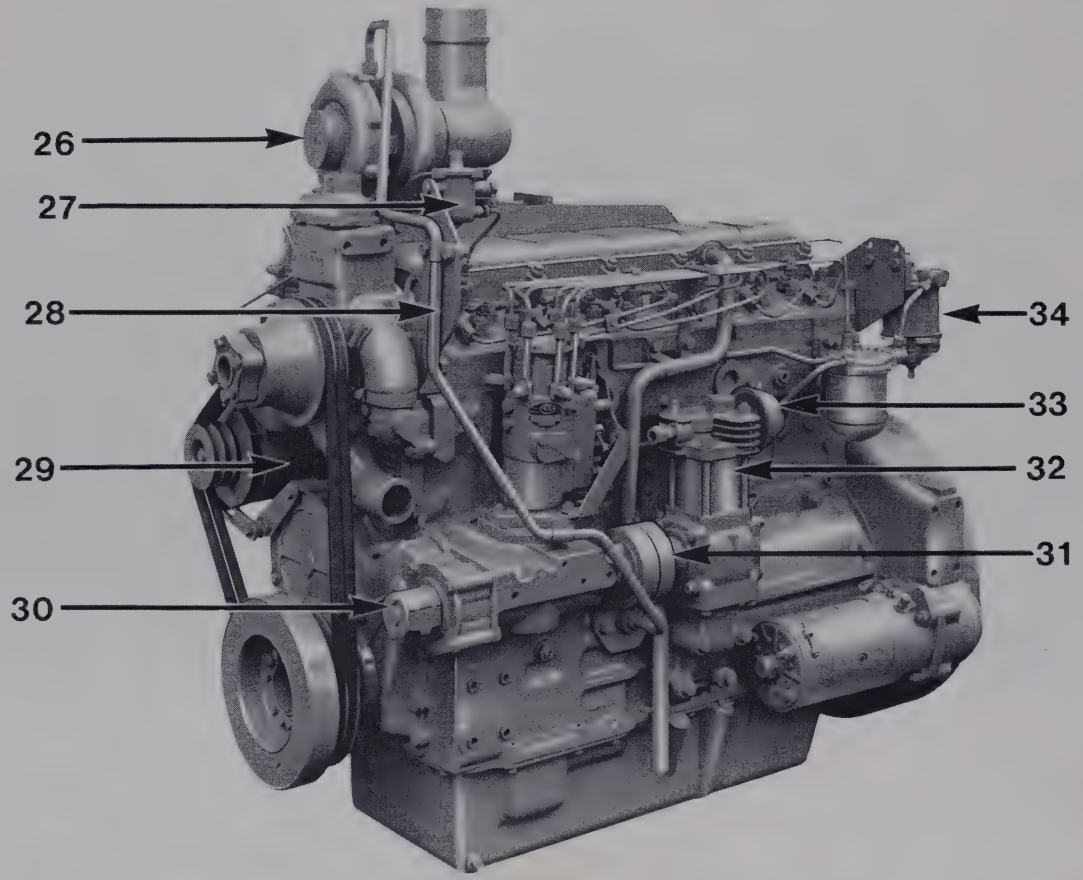
1. Dynamo Pulley.
2. Thermostat Housing.
3. Lubricating Oil Filler.
4. Fuel Oil Filter.
5. Cylinder Head Cover.
6. Atomiser.
7. Breather Pipe.
8. Fuel Injection Pump.
9. Dipstick.
10. Exhauster.
11. Lubricating Oil Filter.
12. Sump.
13. Sump Well.
14. Drain Plug.
15. Vibration Damper.
16. Fan Belt.
17. Water Pump.
18. Induction Manifold.
19. Exhaust Manifold.
20. Dynamo.
21. Fuel Lift Pump.
22. Crankshaft.
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.



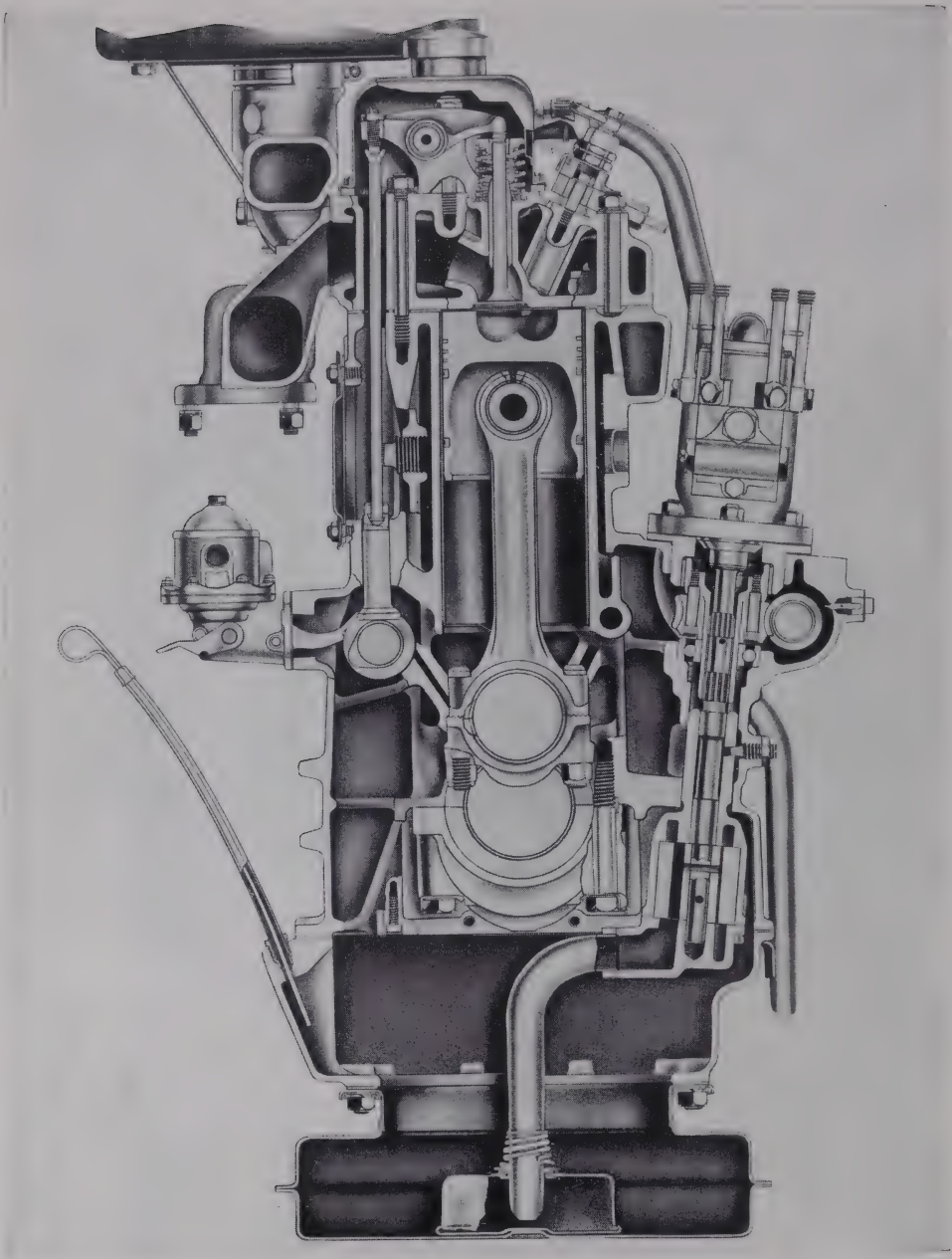

**Near Side View of the 6.354 Engine.**



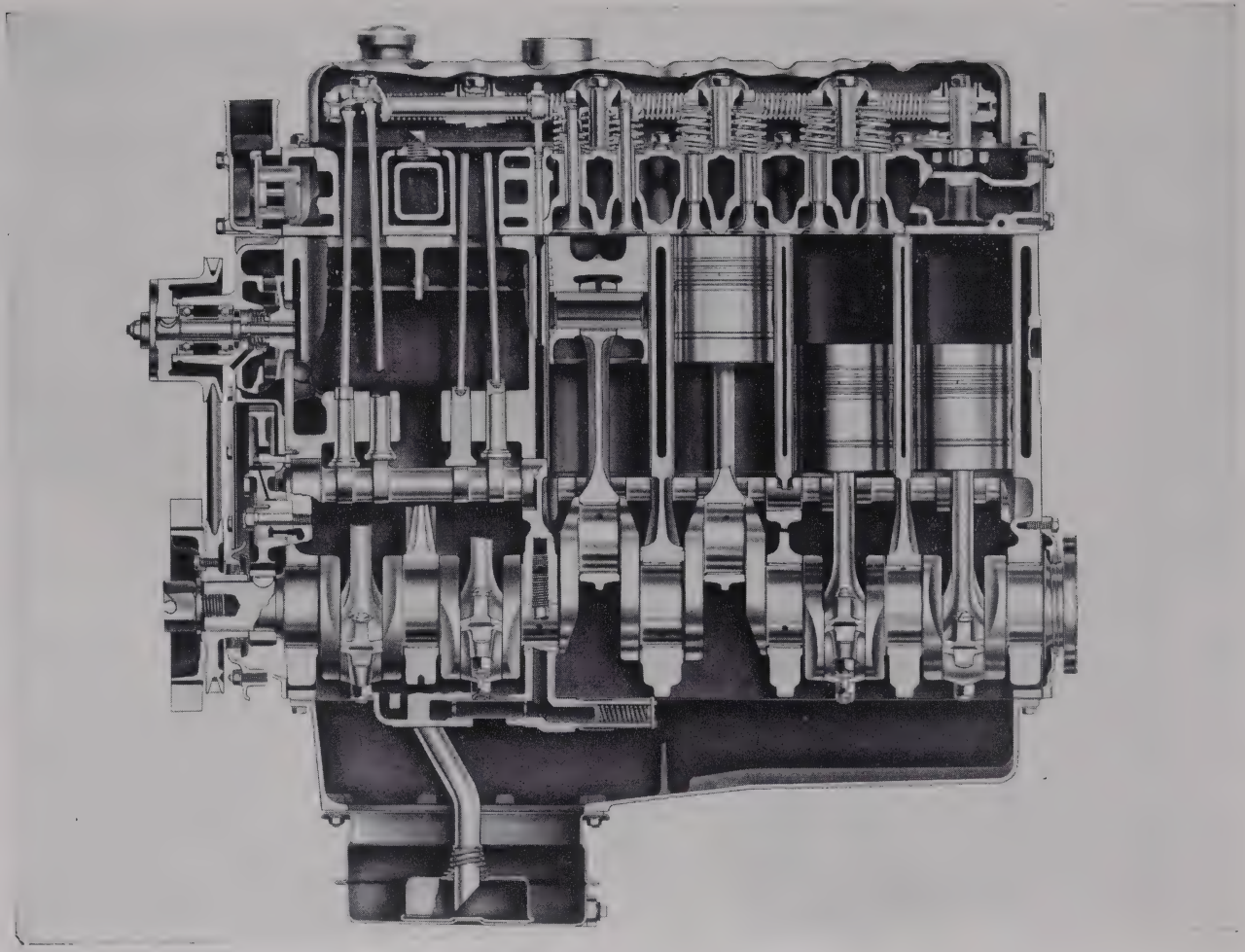

**Off-side View of 6.354 Engine.**




Near-side View of a Typical Industrial Turbocharged 6.354 Engine.



**Cross Sectional View — 6.354 Engine.**



Longitudinal Sectional View — 6.354 Engine.

# Section "A"
# Engine Description

The Perkins 6.354 Diesel Engine is a six cylinder, four stroke, direct injection power unit, having a bore of $3\frac{7}{8}$ in (98,4 mm) and a stroke of 5 in (127 mm).

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

### Cylinder Block and Crankcase

The cylinder block is cast integrally with the crankcase, the sides of the cylinder block extending below the crankshaft axis to form a stiffening skirt.

Cylinder blocks applicable to 6.354.2 engines are designed to give improved water circulation.

Normally, dry type renewable, pressed in cast iron liners are fitted, but some applications do have renewable chromium plated liners fitted.

Liners fitted to 6.354.2 engines have super-honed bores for rapid bed-in.

### Cylinder Head and Valves

The cylinder head is secured to the cylinder block by steel studs and nuts, the joint being made by a Klinger or Victor type gasket.

Cylinder heads for 6.354.2 engines are designed to give improved water circulation and a steel laminated cylinder head gasket is employed.

Two valves per cylinder operate in unshouldered cast iron guides fitted into the cylinder head, two springs (inner and outer) are provided for each valve. Certain mechanically governed engines with a lower maximum speed range have only one spring per valve, the inner valve spring being deleted.

### Combustion System

Being a direct injection engine, the combustion chamber is formed in the crown of the piston.

The atomisers are fitted into the left hand side of the cylinder head and are cooled by jets of water directed onto the nozzle bosses and valves through cored deflectors cast in the cylinder head. These deflectors are in direct communication with the water rail on the side of the cylinder block. The fuel is injected by means of multi-hole nozzles.

### Valve Assembly

The valves are operated by cast iron mushroom type tappets with chill hardened tappet faces, located in guides machined in the cylinder block, through push rods with hardened ends to cast iron rocker levers.

High load valve springs and associated caps are fitted to 6.354.2 engines to provide overspeed protection.

The rockers and valve assembly are lubricated by an intermittent feed, taken from the second camshaft bearing via a drilled oil way in the cylinder block and head to the hardened hollow rocker shaft.

### Crankshaft

The crankshaft is forged steel. The rear of the shaft is machined to provide an oil thrower and oil return scroll.

6.354.2 crankshafts are nitrided and have twelve bolt flywheel fixing.

Crankshaft end float is controlled by four thrust washers, located on both sides of the centre main bearing housing and centre main bearing cap.

Oil seals are provided at the front and rear of the crankshaft. The front seal is a synthetic rubber lip seal, fitting into the timing case cover ; the rear main oil seal is a rubber core, woven asbestos rope, retained in a split housing.

### Main Bearings and Bearing Caps

Seven main bearings are provided, lined with aluminium tin. Each half bearing is located by a tab which fits into a slot in the bearing housing.

The main bearing caps are secured to the crankcase by two setscrews and located by ring dowels.

### Camshaft

The camshaft is mounted in a low position on the right hand side of the cylinder block, supported in four bearings machined directly in the cylinder block, all the bearings being lubricated by a full pressure feed.

### Connecting Rods

The connecting rods are fitted with small end bushes and with pre-finished big end bearings. The big end bearing caps are located by serrations on the big end faces, at right angles to the rod axis.

### Timing Drive

The camshaft and auxiliary drive shaft are driven from the front end of the crankshaft through a train of gears. The timing gears are enclosed by a cover secured to the front face of the cylinder block.

The auxiliary drive gear used on 6.354.2 engines is of hardened steel with a steel centred thrust washer and the idler gear has larger retaining studs.

The camshaft is located axially by a collar locating in a groove at the front end of the camshaft. The timing gears are lubricated by an intermittent feed from the idler gear hubs.

### Pistons and Gudgeon Pins

The aluminium pistons have a toroidal cavity in their crown. Each piston is fitted with five rings, three compression rings and one scraper ring above the gudgeon pin and one scraper ring below. On T6.354 engines, the bottom scraper ring is deleted.

On 6.354.2 engines, all piston rings fitted above the gudgeon pin are chrome plated and the piston has a cast iron insert in the top groove.

The gudgeon pins are fully floating and are located axially in the pistons by circlips.

### Lubricating System

The rotary oil pump, secured to the cylinder block is driven through a serrated extension of the fuel pump worm gear.

The oil pump used for 6.354.2 engines has a 16% higher capacity which assists in lowering oil temperature.

The oil is delivered by the pump through a full flow filter, to the main oil gallery, lengthwise through the crankcase.

Holes through the main bearing housings carry oil from the main gallery to the main bearings, through the crankshaft to the big end bearings.

The camshaft bearings are lubricated from Nos. 1, 3, 5 and 7 main bearings.

The cylinder bores, small end bushes and gudgeon pins are lubricated by splash from the big end bearings. On T6.354 engines, the small end bushes are pressure fed from the big end bearings.

### Lubricating Oil Sump

A reversible aluminium sump is fitted for vehicle type engines and a cast iron sump for industrial and agricultural use.

### Cooling System

An impeller type water pump is fitted to the front of the cylinder block and is driven by a Vee belt from the front of the engine crankshaft.

Water pumps fitted to 6.354.2 engines have a ceramic faced water pump seal.

The cooling system is thermostatically controlled.

### Crankcase Ventilation

The crankcase and cylinder head cover is vented to the atmosphere by a breather pipe on the left hand side of cylinder head cover.

### Fuel Injection Equipment

The fuel injection pump is of the distributor type, mounted vertically on the left hand side of the engine, driven via a worm gear from the auxiliary drive shaft.

An extension of the auxiliary drive shaft can be used to drive ancilliary equipment.

The fuel pump can incorporate an automatic advance and retard mechanism. Engine speed is controlled by an hydraulic or mechanical governor in the fuel pump.

A fuel lift pump of the diaphragm type, equipped for hand priming is mounted on the cylinder block, operated by an eccentric on the camshaft.

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

### Induction and Exhaust Manifold

The induction manifold in aluminium has provision for an electrical cold starting aid. Both the induction manifold and exhaust manifold are located on the right hand side of the engine.

### Electrical Equipment

A 12 volt and 24 volt electrical system is used. The dynamo or alternator is mounted on the right hand side of the engine, belt driven from the front of the crankshaft. Belt tension is adjusted by a slotted link.

# Technical Data (B)

| | |
|---|---|
| Bore (Nominal—see page B.3). ... .. ... | 3.875 in (98,4 mm) |
| Stroke ... ... ... ... ... | 5 in (127 mm) |
| No. of Cylinders ... ... ... ... | Six |
| Cubic Capacity ... ... ... ... | 354 in³ (5,8 litres) |
| Compression Ratio ... ... ... ... | 16 : 1 |
| Firing Order ... ... ... ... ... | 1,5,3,6,2,4,. |
| Combustion System ... ... ... ... | Direct Injection |
| Valve Clearance (Hot) ... ... ... | 0.010 in (0,25 mm) |

## DETAILS OF RATINGS

| | |
|---|---|
| Vehicle ... ... ... ... ... | 120 bhp at 2800 rev/min |
| (alternative rating) ... ... ... ... | 112 bhp at 2800 rev/min |
| Maximum Torque ... ... ... ... | 260 lbf ft (36 kgf m) |
| Agricultural ... ... ... ... ... | 104 bhp at 2400 rev/min |
| Maximum Torque ... ... ... ... | 266 lbf ft (36,8 kgf m) |
| *Industrial (Turbocharged) ... ... ... | 117 bhp at 2250 rev/min |
| Maximum Torque ... ... ... ... | 305 lbf ft (42,4 kgf m) |
| Industrial (Normally Aspirated—Mech. Gov.) ... | 90 bhp at 2250 rev/min |
| Maximum Torque ... ... ... ... | 238 lbf ft (32,9 kgf m) |
| †Industrial (Normally Aspirated—Hyd. Gov.) ... | 112 bhp at 2800 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 Technical Service Department, Perkins Engines Ltd., Peterborough.

### 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 |
|---|---|---|---|
| *Cylinder Head Nuts (or setscrews—6.354.2 engine) | $\frac{1}{2}$ in | 80/ 85 | 11,1 /11,7 |
| Cylinder Head Nuts ... ... ... ... | $\frac{7}{16}$ in | 55/ 60 | 7,6 / 8,3 |
| Big End Nuts (Cadmium Plated) ... ... | $\frac{1}{2}$ in | 65/ 70 | 9,0 / 9,7 |
| Big End Nuts (Plain) ... ... ... ... | $\frac{1}{2}$ in | 85/ 90 | 11,7 /12,4 |
| Main Bearing Setscrews ... ... ... | $\frac{5}{8}$ in | 140/150 | 19,3 /20,7 |
| Idler Gear Hub Nuts ... ... ... ... | $\frac{7}{16}$ in | 45/ 50 | 6,2 / 6,9 |
| Idler Gear Hub Nuts ... ... ... ... | $\frac{1}{2}$ in | 60/ 65 | 8,3 / 9,0 |
| Idler Gear Hub Nuts ... ... ... ... | $\frac{3}{8}$ in | 20/ 24 | 2,7 / 3,3 |
| Sump to Cylinder Block Setscrews ... ... | $\frac{5}{16}$ in | 9/ 10 | 1,3 / 1,4 |
| Flywheel Setscrews ... ... ... ... | $\frac{1}{2}$ in | 74/ 80 | 10,2 /11,1 |
| Camshaft Gear Retaining Setscrew ... ... | $\frac{1}{2}$ in | 45/ 50 | 6,2 / 6,9 |
| Crankshaft Pulley Setscrew (with $\frac{3}{8}$ in washer) ... | $\frac{7}{8}$ in | 270/300 | 37,3 /41,5 |
| Crankshaft Pulley Setscrew (with $\frac{1}{4}$ in washer) ... | $\frac{7}{8}$ in | 200/250 | 27,6 /34,5 |
| Crankshaft Damper Setscrews ... ... ... | $\frac{5}{16}$ in | 18/ 19 | 2,51/ 2,6 |
| Atomiser Securing Nuts ... ... ... | $\frac{5}{16}$ in | 10/ 12 | 1,4 / 1,7 |
| Dynamo Pulley Nut ... ... ... ... | $\frac{7}{16}$ in | 15/ 20 | 2,1 / 2,7 |

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

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

### 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 measured at 800 rev/min pump speed. |
|---|---|
| 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% |

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

In the case of turbocharged engines, where these are required to operate at altitudes over 4,000 feet, de-rating data in each individual case should be obtained from the Technical Service Department, Perkins Engines Ltd., Peterborough, England.

When requesting such information, details should be supplied concerning engine number, rating and machine's operating requirements.

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

For any further information apply to Technical Service Department, Perkins Engines Limited, Peterborough, or to those Overseas Companies listed on Page 2.

# 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 the Technical Service Department, Perkins Engines Ltd., Peterborough.

### 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 Cylinder Liner (Cast Iron) | 4.0625/4.0635 in (103,19/103,21 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) |
| Cylinder Block Dowel Bore Diameter ... ... | 0.8125/0.8135 in (20,64/20,66 mm) |

### Cylinder Liners (Cast Iron — Plain)

| | |
|---|---|
| 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) ... ... ... | 0.005/0.013 in (0,125/0,33 mm) Below |
| Height of Liner in relationship to Cylinder Block Top Face (Later Type) ... ... ... | 0.030/0.035 in (0,76/0,89 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 (228,7/229,0 mm) |

### Cylinder Liners (Cast Iron-Flanged)

| | |
|---|---|
| Type ... ... ... ... ... | Dry—Interference Fit (Production)—Transition Fit (Service) |
| Interference Fit of Liner (Production) ... ... | 0.001/0.003 in (0,025/0,076 mm) |
| Inside Diameter of Production Liner after Finish Honing ... ... ... ... ... | 3.877/3.878 in (98,48/98,50 mm) |
| Fit of Liner (Service) ... ... ... ... | —0.001/+0.001 in (—0,025/+0,025 mm) |
| Inside Diameter of Service Liner after Fitting ... | 3.877/3.8795 in (98,48/98,54 mm) |
| Flange Thickness ... ... ... ... | 0.144/0.146 in (3,66/3,71 mm) |
| Height of Liner above Cylinder Block Top Face ... | 0.030/0.035 in (0,76/0,89 mm) |
| Depth of Liner Flange below Top Face of Cylinder Block ... ... ... ... ... | 0.004/0.008 in (0,1/0,2 mm) |
| 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

| | |
|---|---|
| Type ... ... ... ... ... | Toroidal Cavity in Crown |
| Overall Height—Skirt to Crown (Turbocharged) ... | 4.7596 in (120,89 mm) |
| Overall Height—Skirt to Crown (Normally Asp.) ... | 4.767 in (121,08 mm) |
| Piston Skirt Diameter (Across Thrust) ... ... | 3.8699/3.8707 in (98,3/98,32 mm) |
| Piston Crown Diameter (Across Thrust) ... ... | 3.8508/3.8528 in (97,8/97,85 mm) |
| 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 Nos. 1, 2 and 3 (Normally Asp.) ... ... ... ... | 0.0957/0.0967 in (2,43/2,46 mm) |
| Scraper Ring Groove Width Nos. 4 and 5 ... | 0.2525/0.2535 in (6,41/6,44 mm) |

### Piston Rings

**Piston Ring Gaps quoted for both Turbocharged and Normally Aspirated engines are measured in a Ring Gauge of 3.877 in (98,48 mm) Bore. In practice, for every 0.001 in (0,0254 mm) difference in Cylinder Bore Diameter from Gauge size, 0.003 in (0,0762 mm) should be allowed.**

#### Turbocharged Engines

| | |
|---|---|
| Compression Ring Width—Top Ring ... ... | 0.124/0.125 in (3,15/3,175 mm) |
| Compression Ring Width—2nd and 3rd Rings ... | 0.0928/0.00938 in (2,36/2,38 mm) |
| Scraper Ring Width ... ... ... ... | 0.249/0.250 in (6,33/6,35 mm) |
| Top Ring Clearance in Groove ... ... | 0.002/0.004 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 ... ... | 0.0025/0.0045 in (0,06/0,11 mm) |
| Piston Ring Gap ... ... ... ... | 0.016/0.021 in (0,41/0,53 mm) |

#### Normally Aspirated Engines

| | |
|---|---|
| Compression Ring Width—1st, 2nd and 3rd Rings ... | 0.0928/0.0938 in (2,36/2,38 mm) |
| Scraper Ring Width—4th and 5th Rings ... ... | 0.249/0.250 in (6,33/6,35 mm) |
| 1st, 2nd and 3rd Ring Clearance in Groove ... | 0.0019/0.0039 in (0,05/0,1 mm) |
| 4th and 5th Ring Clearance in Groove ... ... | 0.0025/0.0045 in (0,06/0,11 mm) |
| Piston Ring Gap ... ... ... ... | 0.016/0.021 in (0,41/0,53 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 ... ... ... ... ... | 1.339/1.349 in (34,01/34,26 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) |
| Type of Big End Nut ... ... ... ... | Self Locking |

### 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).

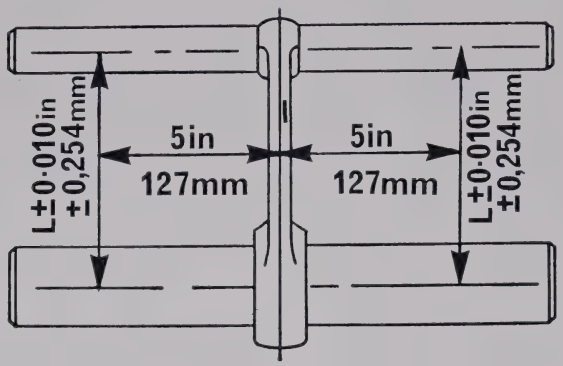



Fig. B.1.

### Crankshaft

| | |
|---|---|
| Overall Length ... ... ... ... | 33.83375/33.85375 in (859,38/859,89 mm) |
| Main Journal Diameter ... ... ... | 2.9985/2.999 in (76,16/76,18 mm) |
| Main Journal Length—No. 1 ... ... ... | 1.453/1.473 in (36,91/37,4 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 ... ... ... ... | 2.499/2.4995 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) |
| Main Journal and Crankpin—Regrind Undersizes ... | —0.010, 0.020 & 0.030 in (—0,25, 0,51 & 0,76 mm) |
| Oil Seal Helix Diameter ... ... ... | 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 ... ... ... ... | 0.500 in (12,7 mm) |
| Spigot Bearing Recess (Depth) ... ... ... | 0.781 in (19,84 mm) |
| Spigot Bearing Recess (Bore) ... ... ... | 1.8497/1.8502 in (46,98/47,0 mm) |
| Crankshaft End Float ... . . ... ... | 0.002/0.014 in (0,05/0,36 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 ot crankpins not to exceed 1.635 in (41,53 mm) after regrinding.

### Crankshaft Thrust Washers

| | |
|---|---|
| Type | Steel Backed, Lead Bronze Faced |
| Position in Engine | Centre Main Bearing |
| Thrust Washer Thickness (Standard) | 0.089/0.093 in (2,26/2,36 mm) |
| Thrust Washer Thickness (Oversize) | 0.0965/0.1005 in (2,45/2,55 mm) |
| Thrust Washer Outside Diameter | 4.088/4.098 in (103,84/104,9 mm) |
| Thrust Washer Inside Diameter | 3.42/3.43 in (86,87/87,12 mm) |

### Main Bearings

| | |
|---|---|
| Type | Pre-finished, Steel Backed, Aluminium Tin 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 (80,41/80,44 mm) |
| Inside Diameter of Main Bearing | 3.0015/3.003 in (76,24/76,28 mm) |
| Main Bearing Running Clearance | 0.0025/0.0045 in (0,064/0,11 mm) |
| Steel Thickness | 0.070 in (1,78 mm) |
| Facing Thickness | 0.012/0.0125 (0,30/0,32 mm) |

### Connecting Rod Bearings

| | |
|---|---|
| Type | Pre-finished, Steel Backed, Aluminium Tin Faced |
| Shell Width | 1.245/1.255 in (31,62/31,88 mm) |
| Outside Diameter of Con-Rod Bearing | 2.646/2.6465 in (67,21/67,23 mm) |
| Inside Diameter of Con-Rod Bearing | 2.501/2.502 in (63,53/63,55 mm) |
| Con-Rod Bearing Running Clearance | 0.0015/0.003 in (0,038/0,076 mm) |
| Steel Thickness | 0.050 in (1,27 mm) |
| Facing Thickness | 0.02225/0.0225 in (0,56/0,57 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 Groove 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/in² (2,11 kgf/cm²) |
| Valve Seat Angle | 45° |
| Valve Guide Bore in Cylinder Head | 0.625/0.6255 in (15,87/15,88 mm) |

*Providing the nozzle protrusion does not exceed 0.224 in (5,69 mm) after skimming.

### Valve Guides

| | |
|---|---|
| Internal Diameter | 0.375/0.376 in (9,53/9,55 mm) |
| Outside Diameter | 0.626/0.6265 in (15,9/15,91 mm) |
| Internal Diameter of Counterbore (Exhaust Valve Guide Only) | 0.422 in (10,72 mm) |
| Depth of Counterbore (Exhaust Valve Guide Only) | 0.40625 in (10,32 mm) |
| Interference Fit of Guide in Cylinder Head Bore | 0.0005/0.0015 in (0,013/0,038 mm) |
| Overall Length of Guide (Inlet) | 2.281 in (57,94 mm) |
| Overall Length of Guide (Exhaust) | 2.406 in (61,12 mm) |
| Overall Protrusion above Cylinder Head Top Face | 0.594 in (15,08 mm) |

### Inlet Valves

| | |
|---|---|
| Valve Stem Diameter | 0.3725/0.3735 in (9,46/9,48 mm) |
| Clearance Fit of Valve in Guide | 0.0015/0.0035 in (0,04/0,09 mm) |
| Valve Head Diameter | 1.736/1.746 in (44,09/44,36 mm) |
| Valve Face Angle | 45° |
| Valve Head depth below Cylinder Head Face—Production Limits | 0.029/0.039 in (0,74/0,99 mm) |
| Valve Head Depth below Cylinder Head Face—Max. Permissible after servicing | 0.050 in (1,27 mm) Three Exhaust Port Head<br>0.060 in (1,52 mm) Four Exhaust Port Head |
| Overall Length | 4.830/4.845 in (122,9/123,03 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 | 0.002/0.004 in (0,051/0,1 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) |
| Valve Head Depth below Cylinder Head Face Max. Permissible after servicing | 0.050 in (1,27 mm) Three Exhaust Port Head<br>0.060 in (1,52 mm) Four Exhaust Port Head |
| Overall Length | 4.845/4.862 in (123,03/123,54 mm) |

### Inner Valve Springs

| | |
|---|---|
| Fitted Length | 1.5625 in (39,7 mm) |
| Solid Length | 0.940 in (23,88 mm) |
| Load at Fitted Length | 15.4 lb ± 2 lb (7 kg ± 0,91 kg) |
| No. of Active Coils | 9 |
| No. of Damper Coils | 2 |
| Coiled | R.H.—Damper Coils to Cylinder Head |

### Outer Valve Springs

| | |
|---|---|
| Fitted Length | 1.78 in (45,22 mm) |
| Solid Length | 1.08 in (27,43 mm) |
| Load at Fitted Length | 40 lb ± 2 lb (18,1 kg ± 0,91 kg) |
| No. of Active Coils | 7.5 |
| No. of Damper Coils | 2 |
| Coiled | L.H.—Damper Coils 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

| | |
|---|---|
| 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) |

### Push Rods

| | |
|---|---|
| Gauge Length of Push Rod | 10.648/10.708 in (270,46/271,98 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 | —0.0007/+0.0009 in (—0,018/+0,023 mm) |
| Outside Diameter of Camshaft Hub | 1.375/1.376 in (34,93/34,95 mm) |
| Transition Fit of Gear to Hub | 1.3751/1.3757 in (34,93/34,94 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 | 1.53125/1.53225 in (38,89/38,92 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) |

### Timing Gear Backlash

| | |
|---|---|
| All Gears | 0.003/0.006 in (0,076/0,15 mm) |

### 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 | 2.125/2.1262 in (53,98/54,0 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 | 1.4105 in (35,87 mm) |
| Housing Diameter for Bush | 1.40625/1.40725 in (35,72/35,74 mm) |
| Interference Fit in Housing | 0.00325/0.00425 in (0,08/0,11 mm) |
| Internal Diameter of Bush—Fitted | 1.25/1.2516 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 | 0.188/0.191 in (4,77/4,85 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<br>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) |
| 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 (45,76/45,80 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 | 1.625/1.6266 in (41,28/41,32 mm) |
| Lower Dia. of Fuel Pump Drive Shaft | 1.6214/1.6230 in (41,18/41,22 mm) |
| Clearance of Drive Shaft in Bush | 0.002/0.0052 in (0,05/0,12 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) |

### Sump

| | |
|---|---|
| Sump Capacity | 24 Imperial Pints (13,6 Litres) (vehicle only) |
| Strainer Position | On suction pipe of Lubricating Oil Pump |

### Oil Pump

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

### Oil Pump Clearances

| | |
|---|---|
| Pump Part No. 41314044 (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) |
| 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) |
| Pump Part Nos. 41314058, 41314062, 41314067, 41314096 (Concentric—High Capacity) | |
| Inner rotor to outer rotor | 0.001/0.005 in (0,02/0,13 mm) |
| 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) |
| Pressure Setting II | 60/70 lbf/in² (4,22/4,92 kgf/cm²) |
| Identified by a distance piece under split pin. | |
| 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 $1\frac{3}{16}$ in (45,04 mm) Spring Length (Normally Asp.) | 21.47 lb ± 9½ oz (9,75 kg ± 270 grammes) |
| Load at $1\frac{3}{16}$ in (45,04 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 |
| By-Pass Valve Setting | 8/12 lbf/in² (0,56/0,84 kgf/cm²) |
| Type of Valve | Pressure Differential Spring Loaded Ball |
| Torque Tension for Filter Bowl Retaining Setscrew | 10 lbf ft (1,38 kgf m) |

## 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 | 168/176°F (75/80°C) |
| Fully Open at | 189/195°F (87/90°C) |
| Valve Lift | 0.312/0.469 in (7,92/11,91 mm) |

### Water Pump

| | |
|---|---|
| Type | Centrifugal |
| Outside Diameter of Shaft for Pulley | 0.7501/0.7506 in (19,052/19,065 mm) |
| Inside Diameter of Pulley Bore | 0.7500/0.7508 in (19,05/19,07 mm) |
| Transition Fit of Pulley on Shaft | —0.0006/+0.0007 in (—0,015/+0,018 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 (15,85/15,88 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). |
| **Germany** | DIN-51601 (1959). |
| **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/in² (0,35/0,56 kgf/cm²) |
| 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 |
| Timing Letter (Hydraulic) ... ... ... | 'H' |
| Timing Letter (Mechanical) ... ... ... | 'F' |
| No. 1 Cylinder Outlet ... ... ... ... | 'X' |

### ATOMISERS

Make C.A.V.

| Engine Type | Code | Holder | Nozzle | Setting Pressure | Working Pressure |
|---|---|---|---|---|---|
| Vehicle (112 bhp) | X | BKBL67S5100 | BDLL150S6225 | 175 atm (181 kgf/cm²) 2600 lbf/in² | 170 atm (176 kgf/cm²) 2500 lbf/in² |
| Industrial | Y | BKBL67S5151 | BDLL150S6329 | 175 atm (181 kgf/cm²) 2600 lbf/in² | 170 atm (176 kgf/cm²) 2500 lbf/in² |
| Combine | CM | BKBL67S5299 | BDLL150S6472 | 180 atm (186 kgf/cm²) 2645 lbf/in² | 195 atm (210 kgf/cm²) 2868 lbf/in² |
| | CN | BKBL67S5299 | BDLL150S6329 | 180 atm (186 kgf/cm²) 2645 lbf/in² | 195 atm (210 kgf/cm²) 2868 lbf/in² |
| | CP | BKBL67S5299 | BDLL150S6435 | 180 atm (186 kgf/cm²) 2645 lbf/in² | 195 atm (210 kgf/cm²) 2868 lbf/in² |
| Vehicle (120 bhp) | ZZ | BKBL67S5151 | BDLL150S6395 | 175 atm (181 kgf/cm²) 2600 lbf/in² | 170 atm (176 kgf/cm²) 2500 lbf/in² |
| T.A. | AF | BKBL67S5100 | BDLL150S6435 | 175 atm (181 kgf/cm²) 2600 lbf/in² | 170 atm (176 kgf/cm²) 2500 lbf/in² |
| T.A. (Chamberlain Tractor) | AN | BKBL67S5151 | BDLL150S6472 | 175 atm (181 kgf/cm²) 2600 lbf/in² | 170 atm (176 kgf/cm²) 2500 lbf/in² |
| Turbocharged Industrial | AT | BKBL67S5238 | BDLL150S6472 | 205 atm (212 kgf/cm²) 3000 lbf/in² | 190 atm (197 kgf/cm²) 2800 lbf/in² |

### STATIC TIMING POSITION

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

| First Group of Fuel Pump Code | Static Timing B.T.D.C. | Piston Displacement B.T.D.C. |
|---|---|---|
| SR55, SR63, SR67, XR63 | 22° | 0.230 in (5,84 mm) |
| DR69, DR82, DR88, LR58, WR57 | 26° | 0.325 in (8,26 mm) |

## STATIC TIMING POSITION continued

| | | |
|---|---|---|
| CR52, ER51, ER57, MR56, MR62, MR66, MR72, RR63, RR67, TR71, TR84 | 28° | 0.372 in (9,45 mm) |
| VR72, VR82 | 30° | 0.426 in (10,82 mm) |
| PR63 | 32° | 0.485 in (12,32 mm) |

## ELECTRICAL SYSTEM

### Alternator

| | |
|---|---|
| Make | C.A.V. or Lucas |
| Type | AC5 or 11AC |
| Maximum output AC5 12 volt (hot) | 55A at 13.5 volts |
| Maximum output AC5 24 volt (hot) | 31A at 27.5 volts |
| Maximum output 11AC 12 volt (hot) | 43A at 13.5 volts |
| Cutting in speed 12 and 24 volts AC5 | 1125 rev/min |
| Cutting in speed 11AC | 1000 rev/min |

### 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 or CA45 |
| Maximum Current | 1150 amps |
| Starter Cable Resistance | 0.0017 ohms |
| 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 or 24 Volt |
| Maximum Current Consumption | 15 amps (12V) or 7.5 amps (24V) |
| Flow Rate through Thermostart | 9 $cm^3$/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 ... ... | | 0.014 in (0,35 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) |
| 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 ... ... ... ... | | 0.010 in (0,25 mm) |

# Periodical Attentions

**Daily**

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), 200 Hours or 4 Months**

Drain and renew engine lubricating oil.
Renew lubricating oil filter element.
Check drive belt tension.
Clean oil bath air cleaner.
Empty dust bowl on dry type air cleaner.
Clean water trap.
Check engine for leakage of oil and water.
Lubricate dynamo rear bush (where fitted).
Turbocharged Engines. Renew turbocharger lubricating oil filter element (where fitted).

**Every 10,000 Miles (15,000 km), 400 Hours or 12 months**

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), 800 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), 2,400 Hours**

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

**NOTE :**

The "Periods" quoted 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.

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.

## 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.
2. Remove rocker assembly and check cylinder head nuts are to correct torque (See Page B.2)
3. Refit rocker assembly and set valve clearance to 0.010 in (0,25 mm) hot.
4. Check coolant level in radiator and inspect for leaks.
5. Check external nuts, setscrews, mountings etc., for tightness.
6. Check belt tension.
7. Check electrical equipment and connections.
8. Check for lubricating and fuel oil leaks.
9. Check slow running speed.
10. Check general performance of engine.

## PRESERVATION OF LAID-UP ENGINES

Where an application is to be laid up for several months it must be protected as follows :—

1. Clean all external parts.
2. Run engine until warm. Stop and drain the lubricating oil sump.

3. Throw away paper element in the lubricating oil filter, clean bowl and fit a new element. Part fill bowl with new oil of an approved grade, a list of which appears in the Appendix..

4. Clean out breather pipe.

5. Fill lubricating oil sump to correct level with new oil of an approved grade.

6. Drain all fuel oil from fuel tanks and filters. Put into the fuel tank at least one gallon of one of the oils listed under "Recommended Oils for the Fuel System." If because of the construction of the fuel tank, this quantity of oil is inadequate, break the fuel feed line before the first filter and connect a small capacity auxiliary tank.

7. Prime the system as detailed on page M.12.

8. Start engine and run it at half speed for 15 minutes when the oil will have circulated through the injection pump, pipes and injectors.

9. Seal the air vent in the tank or filler cap with waterproof adhesive tape.

10. Drain water by opening all drain taps. To ensure complete draining, remove the drain taps and check that the holes are not blocked by scale.
    Cylinder block drain plugs are fitted to later engines.

11. Remove the atomisers, and spray into the cylinder bores $\frac{1}{4}$ pint (0,14 litre) of lubricating oil, divided between all cylinders.
    Rotate the crankshaft one complete revolution and replace atomisers.

12. Remove the air cleaner and any piping. Seal the air intake with water proofed adhesive tape.

13. Remove the exhaust pipe and seal the manifold port.

14. Remove cylinder head cover, lubricate the rocker assembly and replace the cover.

15. Remove fan and water pump driving belt.

16. **Batteries**

    (a) Remove the battery and top up the cells with distilled water.

    (b) Recharge.

    (c) Clean terminals and lightly smear with petroleum jelly.

    (d) Store in a cool, dry, dust free place. Avoid freezing risk.

    (e) Recharge once a month.

17. **Starters and Generators**

    Clean terminals and lightly smear with petroleum jelly. If vehicle or machine is to stand in the open, the generator, starter and control board must be protected against rain.

## RECOMMENDED OILS FOR THE FUEL SYSTEM*

| | Lowest Temperature during Lay-Up |
|---|---|
| Esso IL815 | 25°F (— 4°C) |
| Esso IL1047 | 0°F (—18°C) |
| Shell Calibration Fluid "C" (U.K.) | 0°F (—18°C) |
| Shell Calibration Fluid "B" (Overseas) | —70°F (—57°C) |
| Shell Fusus "A" | —15°F (—26°C) |
| Shell Fusus "A" R1476 (Old Type) | 25°F (— 4°C) |

No attempt should be made to restart the engine until the temperature has been at least 15°F (9°C) above that shown in the table for not less than 24 hours, otherwise there may be difficulty in obtaining a free flow of fuel.

*The proprietary brands of oils listed are recommended for the purpose by the oil companies. They may not be available in all parts of the world, but suitable oils may be obtained by reference to the oil companies. The specification should include the following :—

Viscosity : Should not be greater than 22 centistokes at the lowest ambient temperature likely to be experienced on re-starting.

Pour Point : Must be at least 15°F (9°C) lower than the lowest ambient temperature to be experienced on restarting and should be lower than the lowest temperature likely to be met during the lay-up period.

The oils selected are not necessarily suitable for calibrating or testing pumps.

## PREPARING THE ENGINE FOR RETURN TO SERVICE

When the engine is to be returned to service, the following procedure must be observed :—

1. Thoroughly clean all external parts.

2. Remove adhesive tape from the fuel tank vent or filler cap.
3. Drain fuel tank to remove any remaining oil and condensed water and refill the tank with fuel oil.
4. Fit new filter element and vent the filter.
5. Vent and prime the fuel injection pump (See Page M.12).
6. Close the cylinder block and radiator drain taps and fill the system with clean coolant. Check for leaks. See Note on Page D.3.
7. Rotate fan by hand to ensure freedom of water pump seals.
8. Refit water pump and fan driving belt.
9. Remove the rocker cover, lubricate rocker assembly with engine oil and replace cover.
10. Remove adhesive tape from the air intake, refit the air cleaner and any air intake pipe. Clean the gauze and if it is the oil bath type, fill with engine oil to the correct level.
11. Remove adhesive tape from the exhaust manifold port and refit exhaust pipe.
12. Connect the battery.
13. **Starter and Dynamo**

    Wipe the grease from the terminals and check that all connections are sound. If the starter is fitted with a Bendix type of drive, lubricate with a little light engine oil. CA45 co-axial starters, except where they are fitted with dust covers, should be given the same treatment.
14. Check the level and condition of the oil in the sump. Change the oil if necessary.
15. Start the engine in the normal manner, checking for oil pressure and dynamo charge. Whilst the engine is reaching normal running temperature check that it is free from water and fuel leaks.

**Note :**

If the foregoing instructions are observed, the laying up and returning to service should be carried out efficiently and without adverse affect on the engine. Perkins Engines Ltd., however, cannot accept liability for direct or consequential damage that might arise following periods of laying-up.

## FROST PRECAUTIONS

Precautions against damage by frost should be taken if the engine is to be left exposed, either by draining the water system or, where this is not convenient, an anti-freeze of reputable make and incorporating a suitable corrosion inhibitor may be used.

Should it be necessary to use anti-freeze it should conform to British Standard 3151.

After an anti-freeze solution has been used, the cooling system should be thoroughly flushed in accordance with the anti-freeze manufacturers instructions before refilling with normal coolant. If the foregoing action is taken, no harmful effects should be experienced, but Perkins Engines Ltd., cannot be held responsible for any frost damage or corrosion which may be incurred.

# Fault Diagnosis

| POSSIBLE CAUSE | REMEDY |
|---|---|
| **ENGINE WILL NOT START** | |
| **1. No Fuel at Atomisers:—** | |
| (a) Stop control in "no fuel" position. | Move control to "run" position. |
| (b) Insufficient fuel in tank, air has been drawn into the system. | Replenish fuel tank, then "bleed" system as detailed on Page M.12. |
| (c) Fuel lift pump inoperative. | Remove lift pump and rectify or fit replacement pump. |
| (d) Fuel filters choked or fuel feed pipe blocked. | Check fuel feed to fuel pump and filters. |
| (e) Fuel pump not delivering fuel to the atomisers. | Remove pump for attention of specialised workshop and fit replacement. Check fuel pump drive. |
| **Fuel at Atomisers:—** | |
| (a) Atomisers require servicing. | Service or fit replacement set. |
| (b) Wrong type of Thermostart unit fitted. | Fit correct type. |
| (c) Thermostart unit inoperative. | Visually check unit as detailed on Page M.14, fit new unit if unserviceable. |
| (d) Valve and/or Pump timing incorrect. | Check and reset. |
| **2. Cranking speed too low** | |
| (a) Battery discharged. | Fit fully charged replacement. |
| (b) Incorrect grade of lubricating oil. | Check oil viscosity against Approved Lists in Appendix for temperature range. |
| (c) Poor electrical connections between battery and starter motor, and between battery and earth. | Check and tighten or remake connections where necessary. |
| (d) Starter motor faulty. | Replace or repair. |
| **3. Poor Compression** | |
| With poor compression, starting may be difficult in warm weather, but in cold weather the engine may refuse to start. The causes are numerous, worn liners, piston rings, leaking valves, etc. | A top overhaul or a complete overhaul is indicated.<br>A Service ring pack is available for cast iron liners and for chromed liners. |
| **ENGINE STARTS, RUNS FOR A FEW MOMENTS THEN STOPS:—** | |
| (a) Partially choked fuel feed pipe or filter. | Trace and rectify. |
| (b) Fuel lift pump not giving adequate delivery. | Check output of lift pump and rectify or replace. |
| (c) Fuel tank vent hole blocked. | Unblock. |
| (d) Restriction in induction or exhaust systems. | Check and clear restrictions. |
| (e) Air leaking into fuel pipes. | Trace and rectify. |

## ENGINE MISFIRING OR RUNNING ERRATICALLY:—

| | |
|---|---|
| (a) Atomiser(s) require attention. | Isolate, remove and test. |
| (b) Air in fuel system. | Trace and rectify. |
| (c) Water in fuel pump. | Trace and rectify. |
| (d) Valve and/or pump timing incorrect. | Reset. |
| (e) Valve clearances incorrect. | Reset. |
| (f) Fuel leaking from high pressure pipe. | Replace pipe. |
| (g) Faulty Fuel Pump. | Replace for comparison. |
| (h) Mis-matching of the fuel injection equipment. | Check parts list for correct parts. |

## ENGINE RUNS EVENLY BUT SUFFERS FROM LOSS OF POWER:—

| | |
|---|---|
| (a) Atomisers require servicing. | Service or fit a replacement set. |
| (b) Loss of compression. | Top or Major Overhaul. |
| (c) Fuel Injection Pump not delivering sufficient quantity of fuel. | Check throttle linkage travel.<br>Replace pump for comparison. |
| (d) Air cleaner restriction. | Service air cleaner. |
| (e) Fuel pump timing incorrect. | Check and reset. |
| (f) Brakes binding causing excessive load on engine and apparent loss of power. | Check brake drum(s) for over-heating. |
| (g) Exhaust pipe damaged. | Repair. |

## ENGINE RUNS BUT WITH A SMOKEY EXHAUST:—

| | |
|---|---|
| (a) Incorrect air/fuel ratio. | Check for restriction to air flow. Check fuel pump by replacement for comparison. |
| (b) Cold starting aid (Thermostart) valve leaking. | Fit new unit. |
| (c) Valve and/or fuel pump timing incorrect. | Check and reset. |
| (d) Atomiser(s) require servicing. | Service or fit a replacement set. |
| (e) Excessive oil consumption. | New rings not bedded.<br>Poor compression and long engine life, workshop examination required. Use Service ring pack. |
| (f) Vehicle over-loaded. | Check that the loading is consistent with the manufacturers load classification. |
| (g) Compressor Valve faulty. | Test and repair. |

## ENGINE KNOCKING:—

| | |
|---|---|
| (a) Faulty atomiser (nozzle needle sticking). | Replace. |
| (b) Fuel pump timing too far advanced. | Reset. |
| (c) Piston striking a valve. | Check valve timing, piston topping and valve head depth relative to cylinder head face. |
| (d) Incorrect fuel. | Check that the tank has been filled with diesel fuel and not gasoline. |
| (e) Worn or damaged bearings, etc. | Overhaul engine. |
| (f) Piston slap—worn bores or rings. | Rebore and/or re-ring. |

**ENGINE OVERHEATING:—**

| | |
|---|---|
| (a) Coolant level too low. | Replenish and check if leakage is taking place. |
| (b) Radiator or system blocked (See Note below). | Flush system to remove sediment or scale. |
| (c) Blockage or restriction due to ice formation. | Thaw. |
| (d) Fan belt slipping or incorrect type of fan fitted. | Check belt tension (See Page L.1) and fan type. |
| (e) Valve and/or fuel pump timing incorrect. | Check and reset. |
| (f) Thermostat stuck in the closed position. | Replace. |
| (g) Cylinder Head Gasket failure. | Check bow of head and block. Fit new gasket. |

**LOW OIL PRESSURE:—**

| | |
|---|---|
| (a) Oil level in sump too low. | Rectify. |
| (b) Incorrect grade or inferior oil being used. | Change to Approved Grade. |
| (c) Oil leaking externally from engine. | Rectify. |
| (d) Pressure gauge, or oil warning light switch inaccurate. | Check with master unit. |
| (e) Oil pump worn or pressure relief valve sticking open. | Replace. |
| (f) Suction pipe to oil pump damaged allowing air to be drawn in. | Rectify. |
| (g) Worn main or big end bearings. | Overhaul engine. |

**HIGH OIL PRESSURE**

| | |
|---|---|
| (a) Incorrect grade of oil being used. | Change to Approved Grade. |
| (b) Pressure gauge inaccurate. | Check with master unit. |
| (c) Pressure relief valve sticking closed. | Rectify. |

**EXCESSIVE CRANKCASE PRESSURE:—**

| | |
|---|---|
| (a) Partially choked breather pipe. | Remove and clean. |
| (b) Worn or sticking piston rings. | Examine. |
| (c) Pipework or tank on vacuum side of exhauster allowing entry of air into the system. | Check system for leaks. |

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 number 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. Replace 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 is not always accessible.

# Cylinder Head (E)

NOTE: Cylinder heads for 6.354.2 engines 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 6.354.2 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.

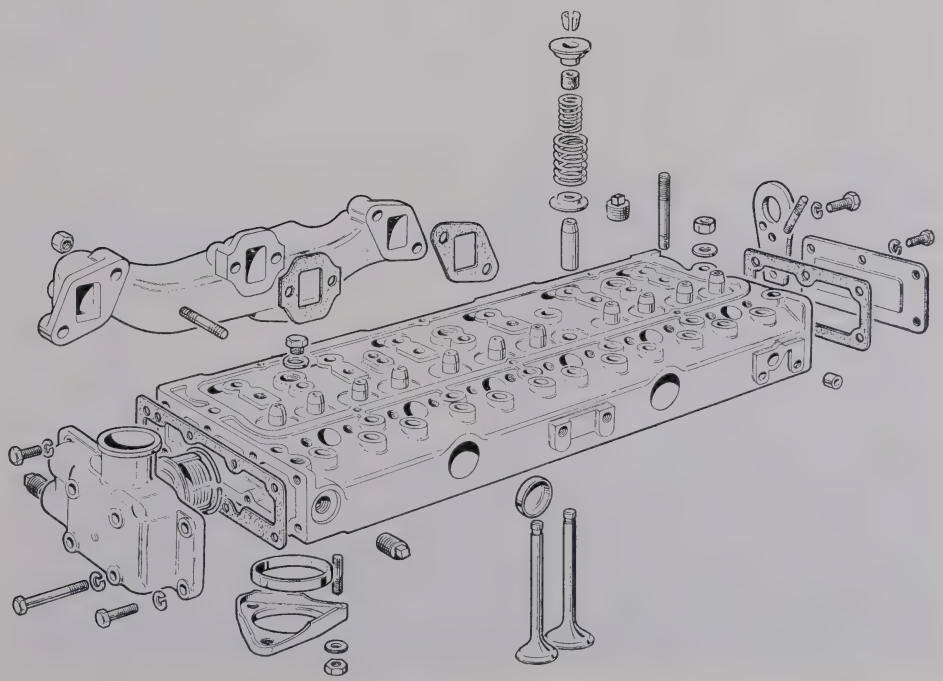


Fig. E.1. Exploded view of Cylinder Head Assembly.

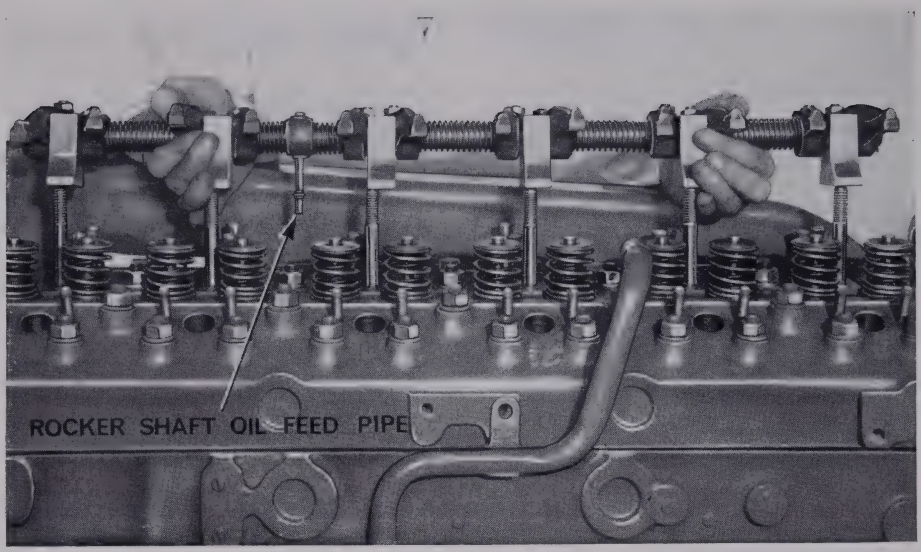



Fig. E.2. Removing Rocker Shaft Assembly.

Valves are marked 1 and 1, 2 and 2, etc. commencing at the front of the engine (Fig. E.3). On earlier 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.

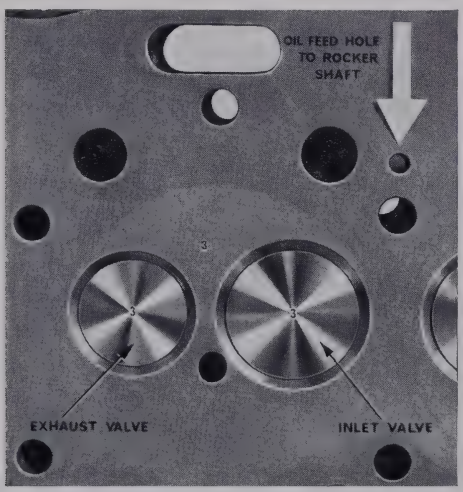



Fig. E.3. Valve Numbering.

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 cylinder head top face.

(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.

Number all new valves to correspond with the numbering of the old valves. 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).

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.

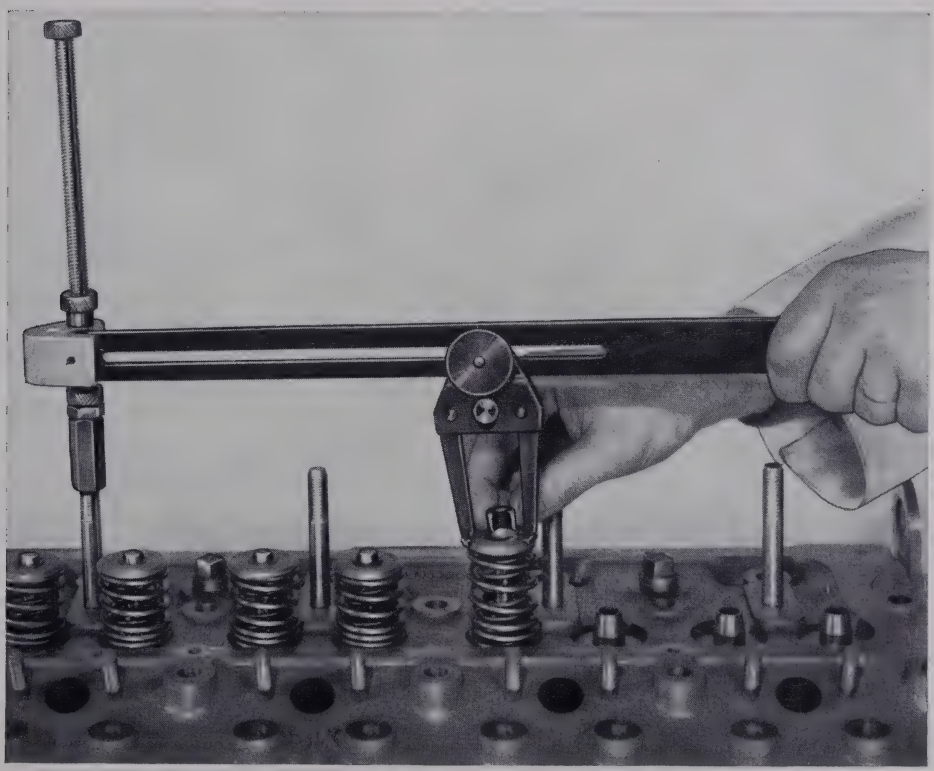


Fig. E.4. Removing Valve Assembly.



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.

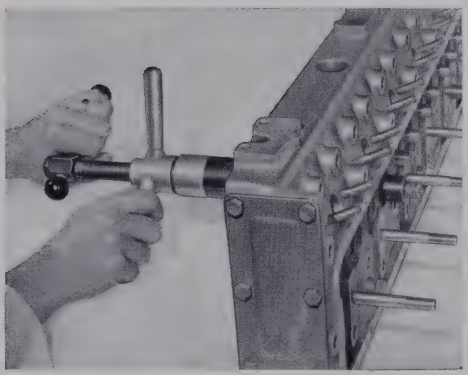


Fig. E.6. Replacing Valve Guides.

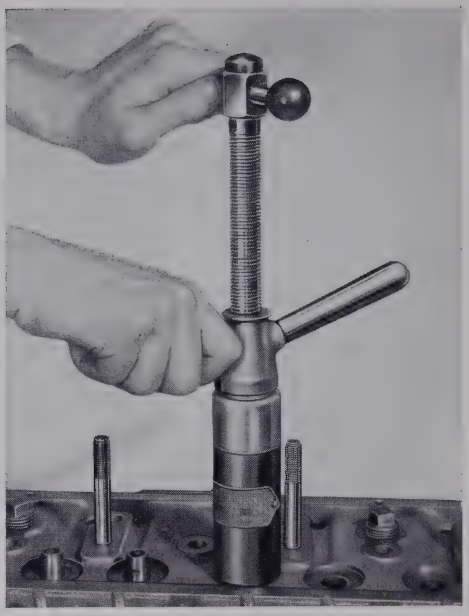


Fig. E.7. Removing Valve Guides.

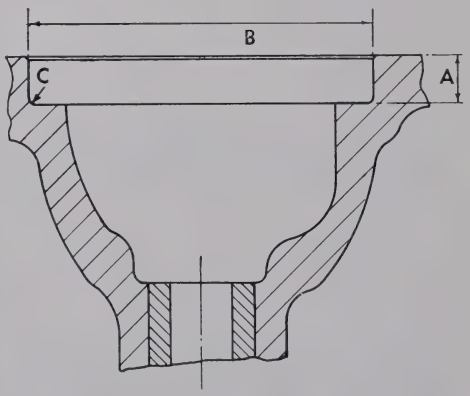



Fig. E.8.
Valve Seat Cutting Dimensions

**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.

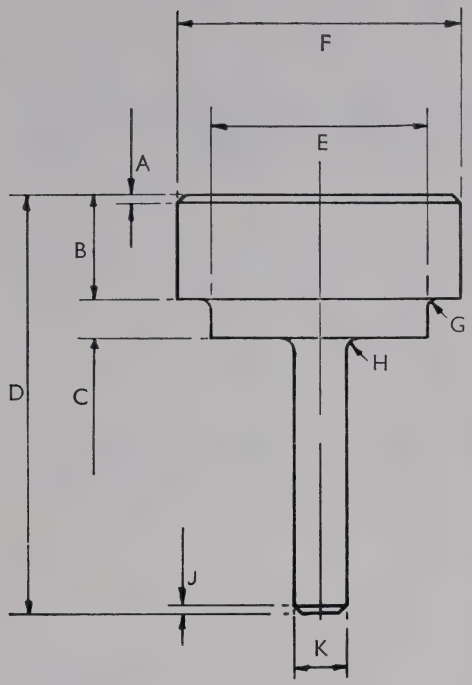



Fig. E.9. Press Tool for Valve Seat Inserts.

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)

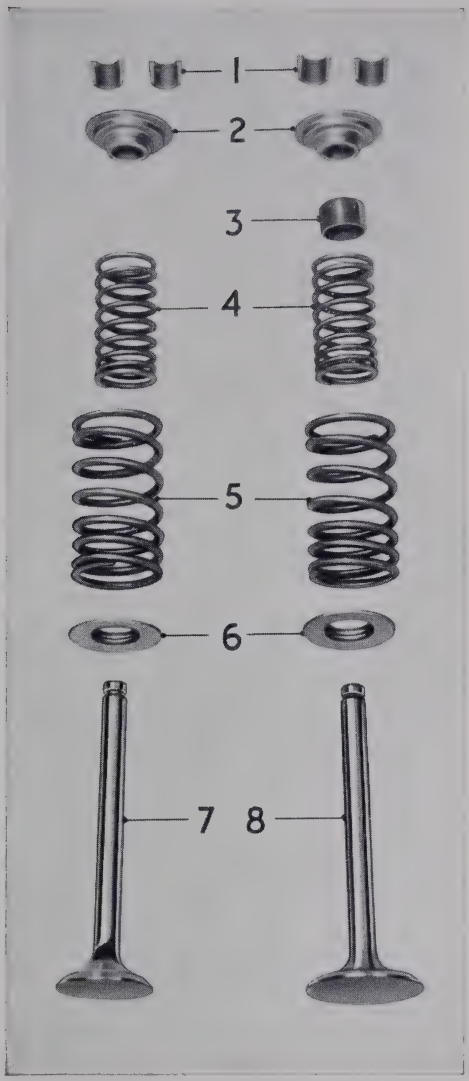



Fig. E.10.
Exploded view of Valve Assemblies.

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. Using the valve guide bore as a pilot, machine the "flare" to the dimensions in Fig. E.11.
7. Remove all machining swarf and burrs.
8. Re-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 (0,3 mm) may be removed providing the nozzle protrusion is not greater than 0.224 in (5,69 mm). This figure must not be obtained by the use of additional washers to the atomisers as these may be removed at a later date and result in loss of power.

### 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.
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.

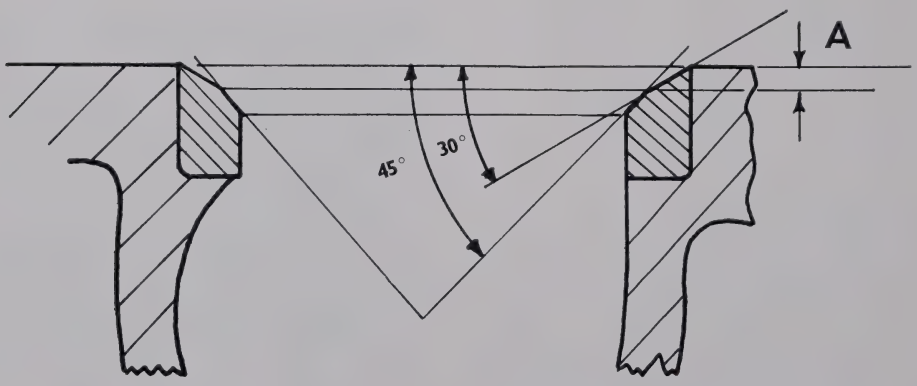



Fig. E.11. Showing Flare to be cut at 30°.

Dimension A—0.094/0.099 in (2,39/2,52 mm).

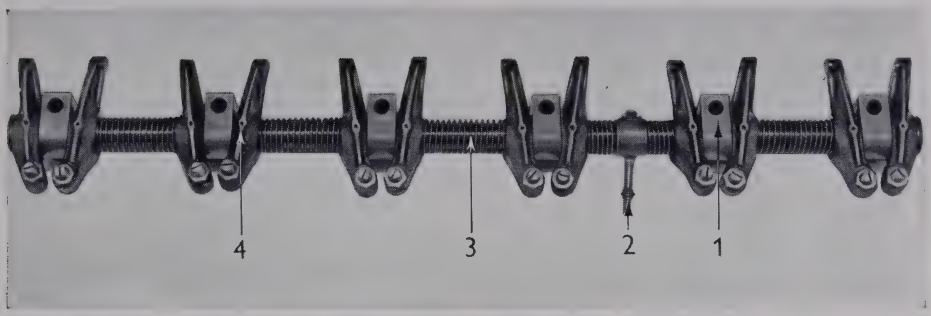



Fig. E.12. Rocker Shaft Assembly.
1. Rocker Shaft Bracket. 3. Spring.
2. Oil Feed Connection. 4. Rocker Arm.

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.

### Push Rods

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

### To Re-Assemble the Cylinder Head

1. Lightly oil valve stems.
2. Fit valve to its correct guide.
3. Locate spring washers.
4. Fit the inlet valve oil deflector rubbers with open end towards cylinder head.
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 "Coopercor" cylinder head gasket is used on 6.354.2 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 COOPERCOR 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.

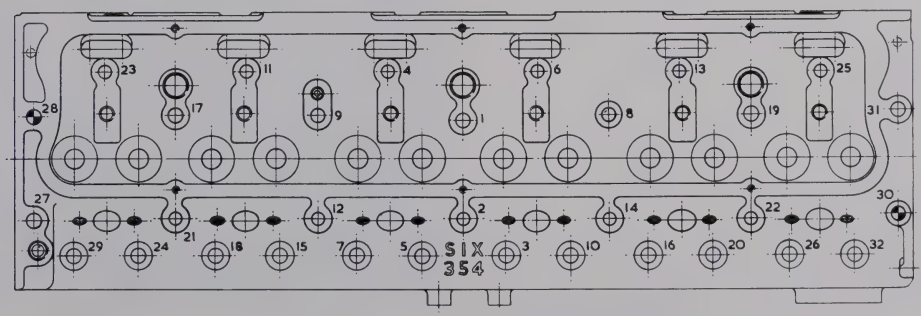



Fig. E.13. Cylinder Head Tightening Sequence.

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 of 60 lbf ft (8,30 kgf m) for $\frac{7}{16}$ in studs or 85 lbf ft (11,75 kgf m) for $\frac{1}{2}$ in studs is achieved. The final stage should be repeated.
   $\frac{1}{2}$ in cylinder head studs were introduced as from Engine No. 8060000.

3. Refit the push rods and the rocker shaft assembly. The rocker assembly securing nuts should be tightened down progressively from the centre outwards to a torque of 28/32 lbf ft 3.87/4,43 kgf m). 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.15).

5. Refit atomisers with new copper sealing washers ensuring that they seat squarely. Refit the high pressure fuel pipes.

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.

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.12, and start the engine.

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

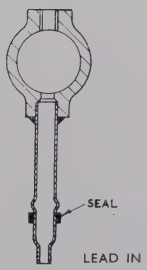



Fig. E.14

Seal in fitted position
Current Arrangement

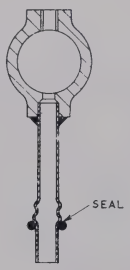



Fig. E.15

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

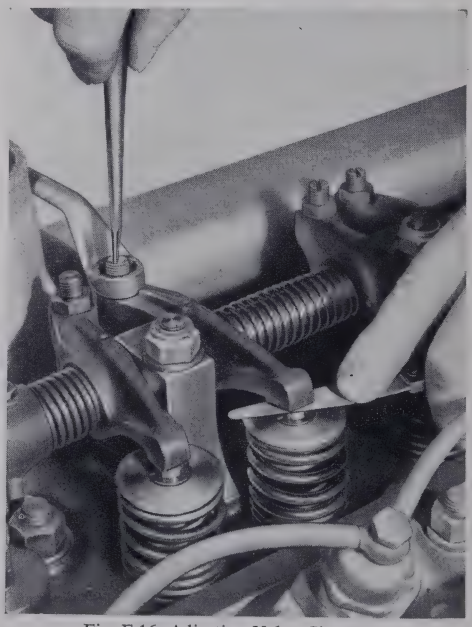


Fig. E.16. Adjusting Valve Clearance.

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.
17. Reset the valve clearance to 0.010 in (0,25 mm) hot (Fig. E.16). Fit the rocker cover.

**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.

# Pistons & Connecting Rods (F)

NOTE: Special pistons are used with the 6.354.2 engine, having a protection insert in the top ring groove.

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

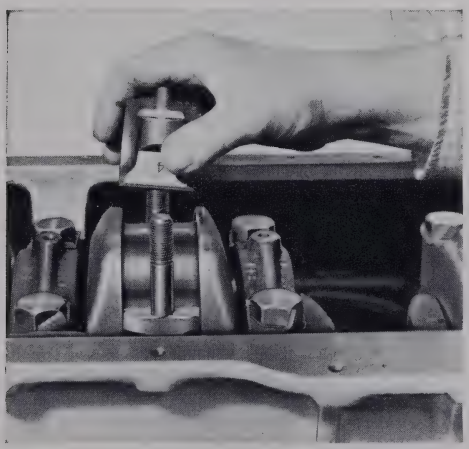


Fig. F.1 Big End Cap Removal.

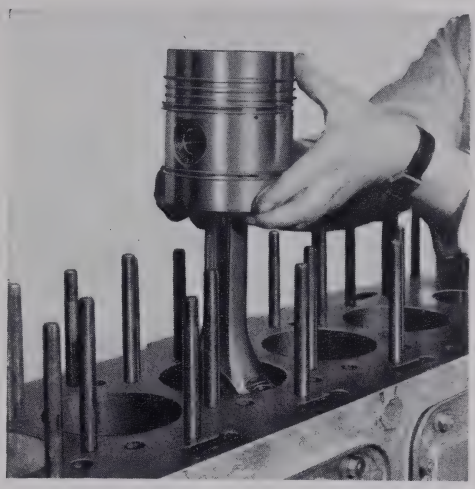


Fig. F.2.

Removing Piston and Connecting Rod Assembly from Cylinder Bore.

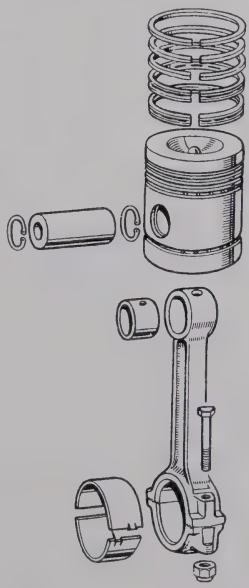


Fig. F.3.

Exploded view of Piston and Connecting Rod Assembly.

### 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. Ring gap dimensions given in "Manufacturing Data and Dimensions" on page B.5. are for nominal bore of 3.876 in (98,45 mm). For every 0.001 in (0,0254 mm) above nominal the gap will increase by 0.003 in (0,0762 mm) approximately.
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. If replacement connecting rods are fitted the finished weight of all six rods should be within 2 oz (57 grammes) of each other. A code number is etched on every rod, adjacent to the bolt hole, on the opposite side to the one carrying the rod and cap numbers. A table of code numbers and related weights are included in "Manufacturing Data and Dimensions." The correct weight of rod must always be fitted to match the engine set.
5. 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) 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.

**(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.

3. **(c) 6.354.2 Engines**

Slotted Scraper—
below gudgeon pin
Slotted Scraper—
above gudgeon pin
Chrome Plated Compression—
third groove
Chrome Plated Compression—
second groove
Chrome Plated Compression—
top groove

**(d) Turbocharged Engines**
**4 Ring Piston**

Tapered Rail 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

**Note:** The internally stepped rings are marked "BTM" (bottom) to ensure correct fitting. Never fit chrome plated rings to engines having chrome plated liners. Piston rings should be arranged so that their gaps are equally spaced around the piston. **If the original liners are satisfactory, the service ring kit should be fitted.**

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.

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.

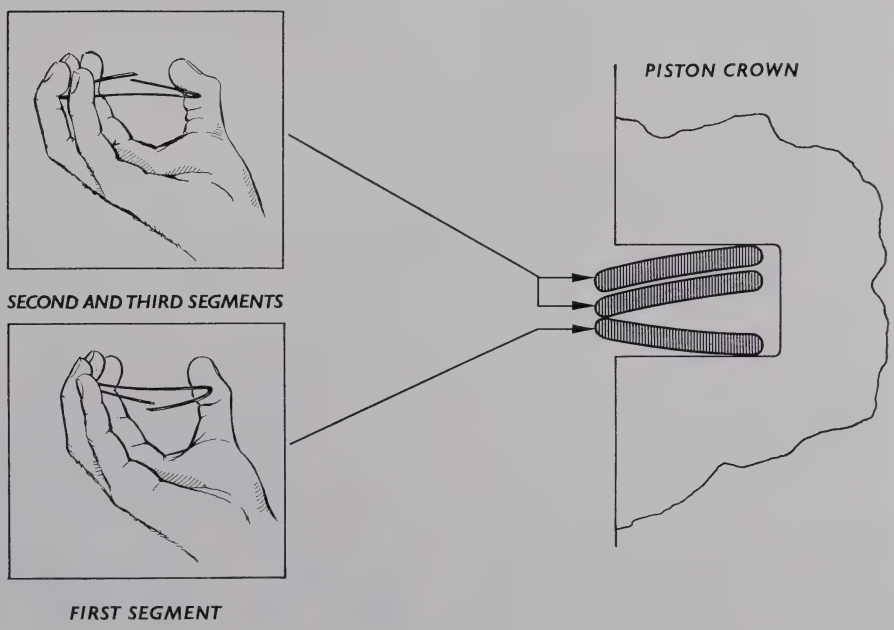



Fig. F.5.
Diagrammatic Method of Fitting Laminated Piston Ring—Three Segments Type.

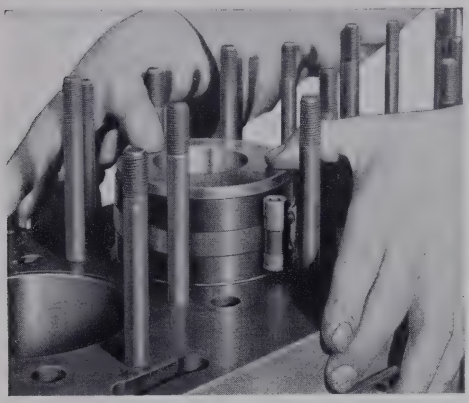


Fig. F.6.
Piston fitting with the aid of a Ring Guide.

### 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 nuts to the torque given on Page B.2.
5. Refit the lubricating oil pump and sump and fill with oil (Page K.3).
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




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

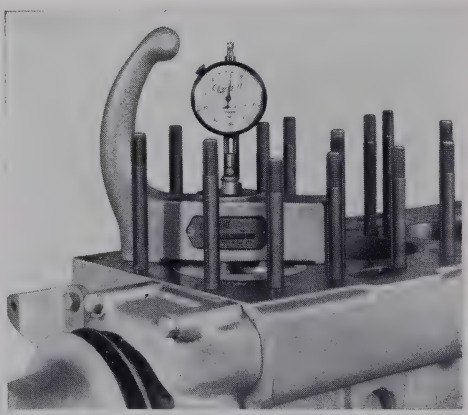


Fig. F.8.
Checking Height of Piston.

(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 slightly lower than that quoted. This is satisfactory, but the piston height should not be above these limits.

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.

### Service Ring Pack

When there are indications of excessive exhaust smoke and/or lubricating oil consumption, then the fitting of Service ring packs may be the cure. There is one available for cast iron liners and another for chromed liners.

# Cylinder Block and Liners (G)

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

NOTE: Cylinder blocks for 6.354.2 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.

Flangless cast iron liners may be rebored to +0.030 in (0,76 mm) oversize, or, alternatively new liners fitted, which must be bored and honed to size when fitted.

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).

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

### To Remove Cylinder Liners (Cast Iron Plain)

1. Remove all components from the cylinder block.
2. Remove the cylinder head studs.
3. Press out the liners from the bottom.
4. 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 0.030/0.035 in (0,76/0,89 mm) of the liner is protruding above the cylinder block face (Fig. G.3). Shim washers or a solid stop washer, 0.030/0.035 in (0,76/0,89 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 head

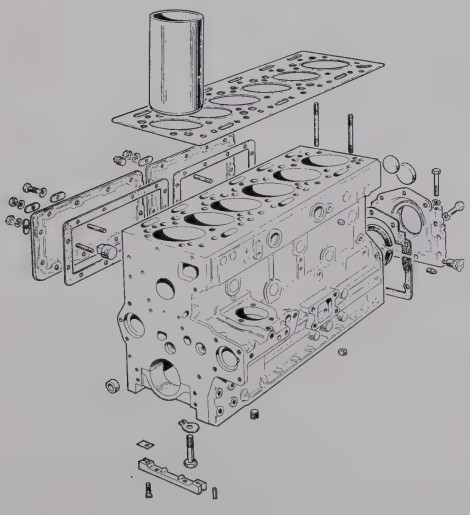


Fig. G.1. Exploded view of Cylinder Block Assembly.



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

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 0.030/0.035 in (0,76/0,89 mm) as the bottom piston ring may clear the bottom of the liner when the piston is at bottom dead centre.

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.

### To Renew Cylinder Liners (Chrome Plated)

1. Remove all components from the cylinder block.
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 re-

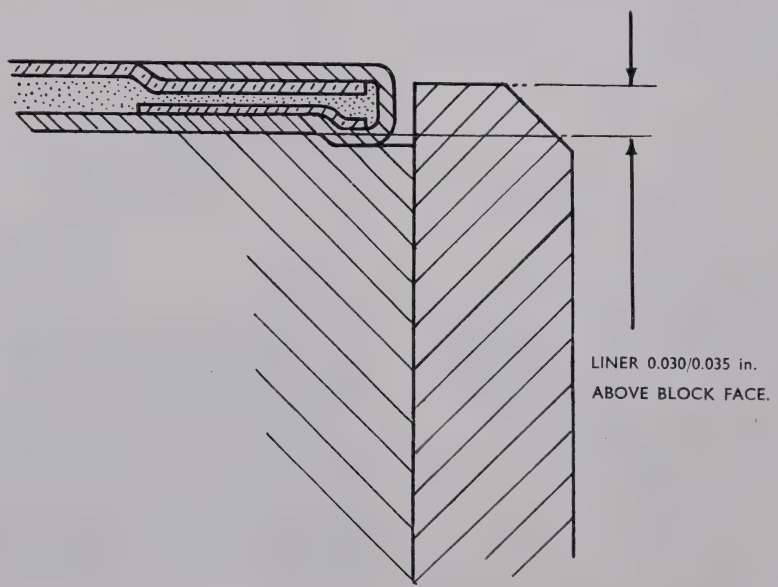



Fig. G.3.
Showing protrusion of Cylinder Liner.
(Later Types only).

placed, 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 0.030/0.035 in (0,76/0,89 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).

### 6.354.2 Engines

These engines are fitted with flangeless cast iron cylinder liners which can be rebored to +0.030 in (0,76 mm) oversize or fitted with new liners and then bored to standard size.

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

Bores should be:

1. Diamond honed followed by plateau hone.
2. Diamond cross hatch to be 30° to 35° (horizontally included angle).
3. Uniformly cut in both directions throughout length of liner.
4. Clean cut and free of torn and folded metal.
5. Micro average 50 - 60 C.L.A. in the range 45 - 65 C.L.A. after diamond honing.
   Micro average 35 - 45 C.L.A. in the range 32 - 48 C.L.A. after plateau honing.
6. Plateau area to be $\frac{1}{3}$ to $\frac{1}{2}$ of surface measured by visual assessment of fax film and micro section.
7. Free of burnish or glaze.
8. Thoroughly clean and free from embedded particles.

# Crankshaft & Main Bearings (H)

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 tin.

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 6.354.2 engines are nitrided and have provision for 12 bolt flywheel fixing.

### To Renew Main Bearings and Thrust Washers

Renewal of the main bearings and 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 front and rear bridge pieces from the base of the cylinder block. The front bridge piece is attached to the timing case and the rear bridge piece is attached to the rear main oil seal housing. Two recessed setscrews also secure the bridge pieces to the cylinder block. Take care to retrieve the rubber oil seals.
3. Slacken the setscrews on the main bearing caps.
4. Remove one main bearing cap. Only one cap should be removed at any time.
5. Remove the lower half of the main bearing from the bearing cap. The top half of the bearing may be removed by pushing it out with a piece of wood, applied the opposite side to the locating lip (Fig. H.2) then rotating the bearing on the crankshaft. The locating lips are on the camshaft side of the engine.
   **Note :** If the original bearings are to be refitted, identify each bearing to its respective position.
6. Replace a new half bearing in the bearing cap, locating the lip in its slot. Liberally oil the other half of the bearing, insert it plain end first and slide it around the crankshaft until the locating lip locates in its slot. Oil the cap half bearing and refit the cap lightly using new shim washers. On earlier engines, the main bearing setscrews were locked with tabwashers. These need not be replaced.

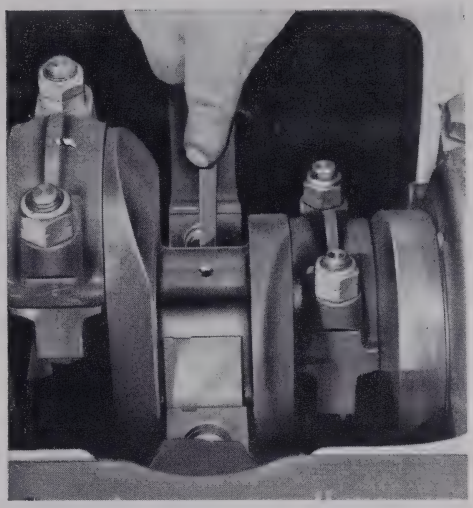


Fig. H.2. Removing a Main Bearing Shell.

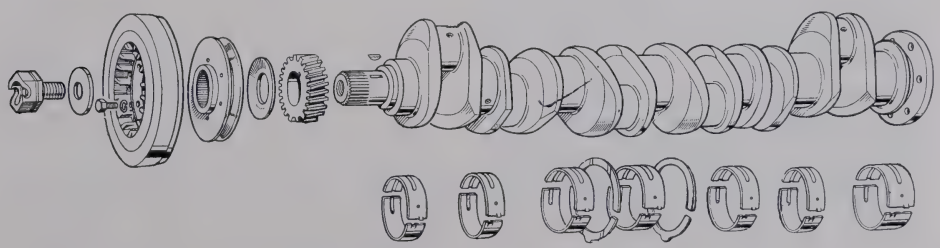


Fig. H.1. Exploded view of Crankshaft and Main Bearings.

7. Repeat as in 6 for all main bearings to be renewed.

   **Note :** Make sure that the bearing caps are fitted to their original positions. Each cap is numbered to correspond with its engine position commencing with No. 1 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.

8. If the thrust washers require examination and/or renewal, it is necessary to remove the centre main bearing cap (No. 4). Remove 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. If the thrust washers are to be used again, identify each of them to its relative position.

9. 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 bearings, secure with the setscrews tightened to 140/150 lbf ft (19,35/20,74 kgf m).

   **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.

10. Check the crankshaft end float for a clearance of 0.002/0.014 in (0,05/0,36 mm).

11. Refit the front and rear bridge pieces (Fig. H.5) using jointing compound between the bridge piece and the cylinder block at the setscrew holes. Secure the bridge pieces to the cylinder block, also to the timing case and rear main oil seal respectively. Ensure the end faces of the bridge pieces are flush with the end faces of the cylinder block (Fig. H.3).

12. Replace the oil pump suction pipe, sump strainer and sump (Page K.2).

### 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.



Fig. H.3. Aligning Bridge Piece to Block Face.

3. Remove the camshaft gear, auxiliary drive gear and timing case (Page J.1).
4. Remove the flywheel and flywheel housing.
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

**Important Note :** Crankshafts fitted to early turbocharged engines and all 6.354.2 engines are Nitrided. These crankshafts can be reground —0.010 in (—0,25 mm) undersize without re-nitriding. If facilities for nitriding after regrinding below —.010 in (—,025 mm) are not available then a factory replacement crankshaft should be obtained.

Later turbocharged engines are fitted with Tufftrided crankshafts which must be re-tufftrided after any regrinding operation or a replacement crankshaft fitted. A Tufftrided crankshaft may be used as a replacement where a Nitrided crankshaft was originally fitted to turbocharged engines.

In order to identify crankshafts, reference should be made to the part number which will be found stamped at the front end, usually on the No. 1 web. Nitrided crankshafts will be numbered either 31322306 or 31322307 and Tufftrided crankshafts will be numbered either 31322309 or 31322311.

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

The main journal and crankpin diameters should be checked to ascertain the next size to which the crankshaft can be ground, i.e. —0.010 in (0,25 mm), —0.020 in (0,51 mm) or —0.030 in (0,76 mm). If it requires to be reground below 0.030 in (0,76 mm), a new crankshaft must be fitted. See "Manufacturing Data and Dimensions" for crankshaft regrind data.

The dimensions given in "Manufacturing Data and Dimensions" for the crankpin width apply only to a standard crankshaft. This dimension may increase as the crankpins are reground, but must not exceed 1.635 in (41,53 mm).

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 a new shim washer to each main bearing setscrew and fit the setscrews. The shim washer is fitted between the setscrew head and the main bearing cap.
   NOTE : On earlier engines the main bearing cap setscrews were locked with tabwashers. It is not necessary to replace these after removal.
8. Tighten the main bearing setscrews to a torque of 140/150 lbf ft (19,35/20,74 kgf m).
9. Check the crankshaft end float for a clearance of 0.002/0.014 in (0,05/0,36 mm) (Fig. H.4). Oversize thrust washers may be fitted.
10. Refit the connecting rod caps and big end bearings.
11. Refit the front and rear bridge pieces to the cylinder block (Fig. H.5). Check that the end faces of the bridge pieces are flush with the end faces of the cylinder block (Fig. H.3).




Fig. H.4. Checking Crankshaft End Float.
1. Main Bearing Cap.
2. Crankshaft.

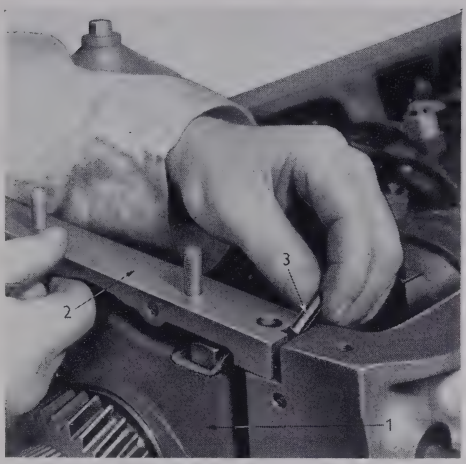



Fig. H.5. Fitting Main Bearing Bridge Piece Oil Seal.

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

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).

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

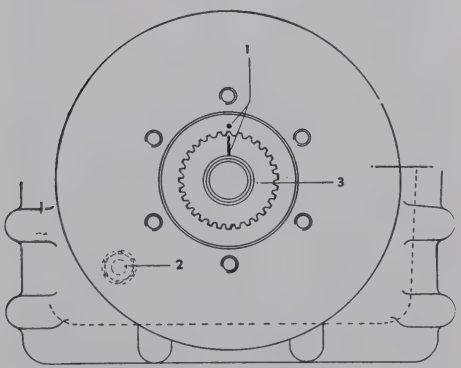



Fig. H.6.

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

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.6).
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 'AVV' 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 200/250 lbf ft (27,7/34,6 kgf m), whilst a torque of 270/300 lbf ft (37,3/41,5 kgf m) should be applied where a $\frac{3}{8}$ in (9,53 mm) washer is used.

**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 Locquic Activator has not been used, the curing period is 24 hours.

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

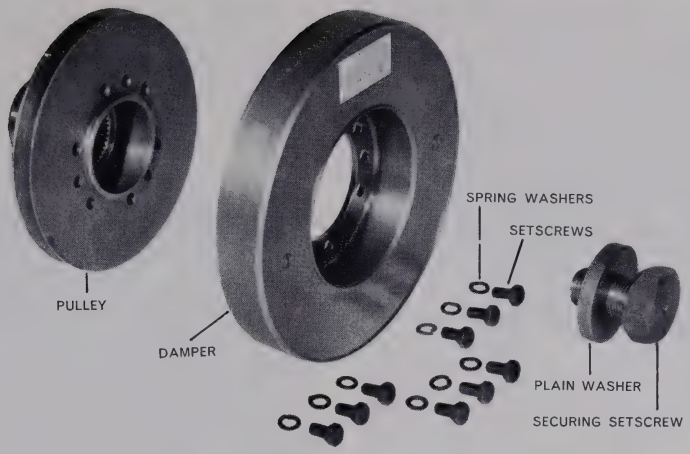



Fig. H.7.
Viscous Type Crankshaft Damper.

## 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.8) differs to that used in the viscous type (Fig. H.7).

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 an internally serrated 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.

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

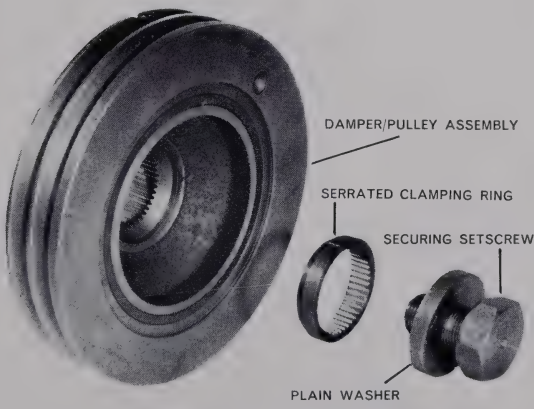



Fig. H.8.
Rubber Bonded Type Crankshaft Damper.

## 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.9).

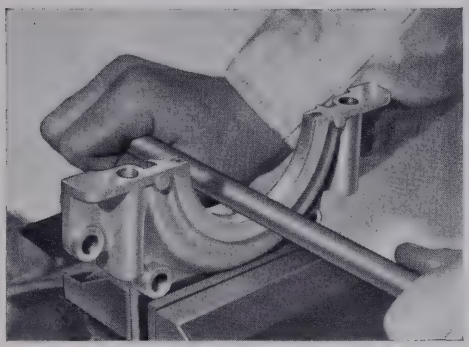


Fig. H.9. Rolling in Rear Main Oil Seal.

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 4/6 lbf ft (0,55/0,83 kgf m).
8. Tighten setscrews in cylinder block to a torque of 12 lbf ft (1,66 kgf m).
9. Finally tighten the clamping setscrews to a torque of 12 lbf ft (1,66 kgf m).

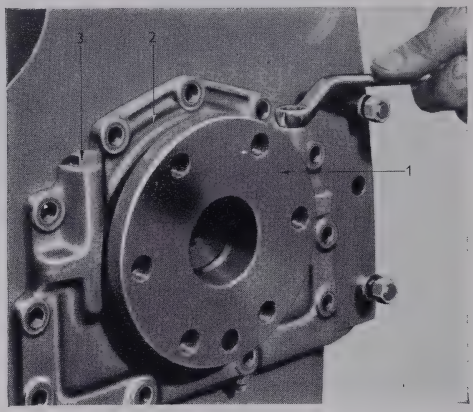



Fig. H.10. Tightening Oil Seal Housing Setscrew.
1 Crankshaft.
2. Oil Seal Housing.
3. Oil Seal Housing Setscrew.

# Timing Case and Drive (J)

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 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.

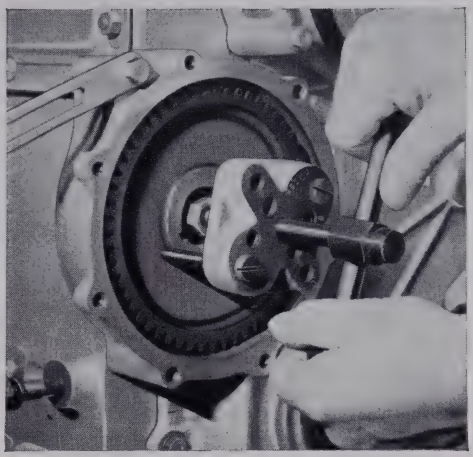


Fig. J.2. Removal of Camshaft Gear.

### To Renew the Crankshaft Front Oil Seal

1. Using a press, remove the oil seal from the timing case. Alternatively, the seal may be tapped out (Fig. J.4).
2. Press the new seal into position from the front until the front face is 3/32 in (2,38 mm) below the front face of the timing case (Fig. J.5). Churchill Tool No. P.D. 141 may be used.

### 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.

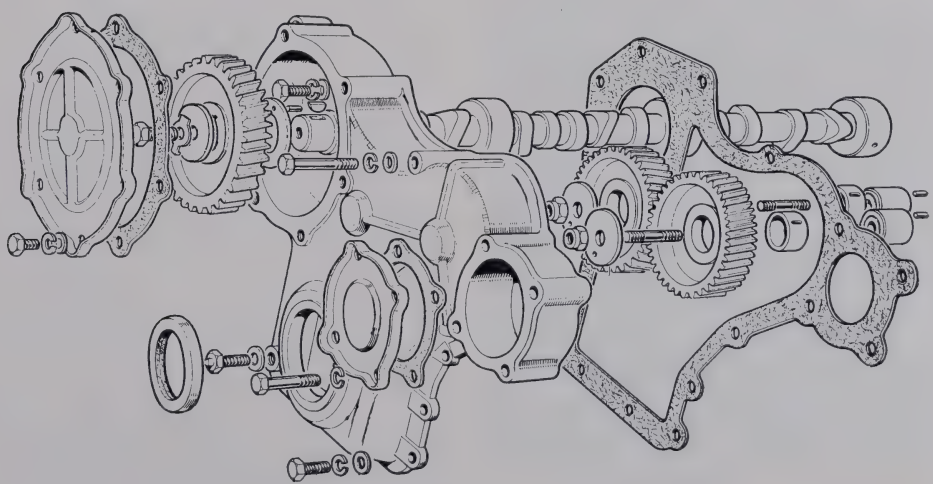


Fig. J.1. Exploded view of Timing Case and Drive.

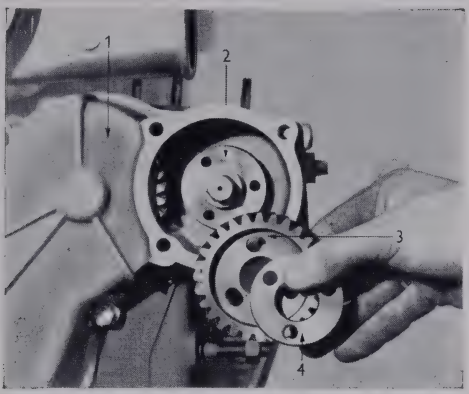



Fig. J.3. Removing Auxiliary Drive Gear.
1. Timing Case.
2. Auxiliary Drive Shaft.
3. Fuel Pump Drive Gear.
4. Retaining Plate.

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 with the dished face outwards.

5. Refit the timing case and slide the crankshaft pulley into position thus centralising the case. Tighten all exposed setscrews and then remove the pulley to gain access to the nuts at the bottom of the timing case. Evenly tighten all the securing setscrews.

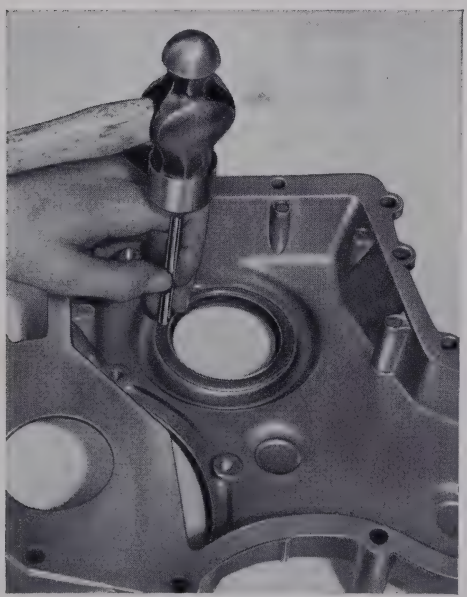


Fig. J.4.
Removing Crankshaft Front Oil Seal.

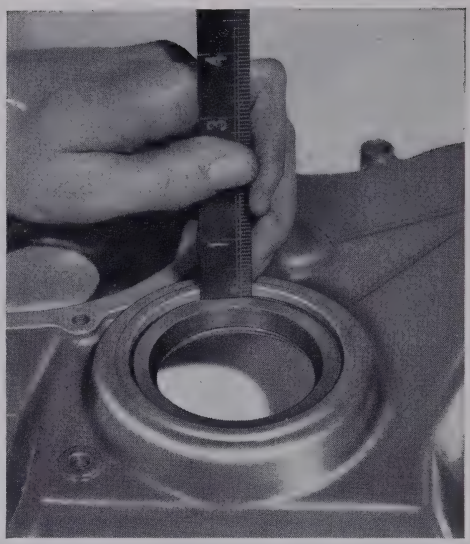


Fig. J.5. Checking Depth of Front Oil Seal.

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), and lock with the tabwasher.

7. Replace the camshaft gear cover plate.

8. Remove the fuel injection pump (Page M.8). 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.16). 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.

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.

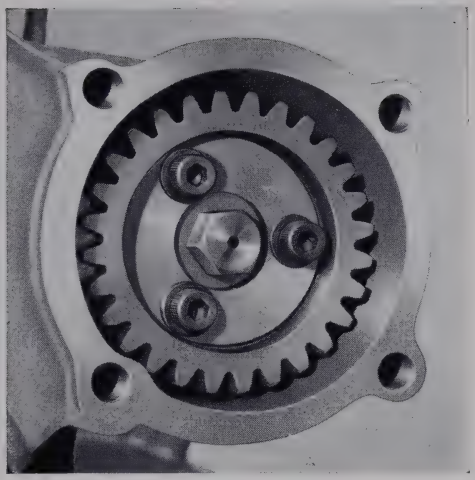


Fig. J.6. Auxiliary Drive Gear.

9. Refit the fuel injection pump (Page M.8), Tighten down the rocker assembly and adjust the valve clearances to 0.012 in (0,30 mm) cold.
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. 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 (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.7). Withdraw the hubs (Fig. J.8).
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.

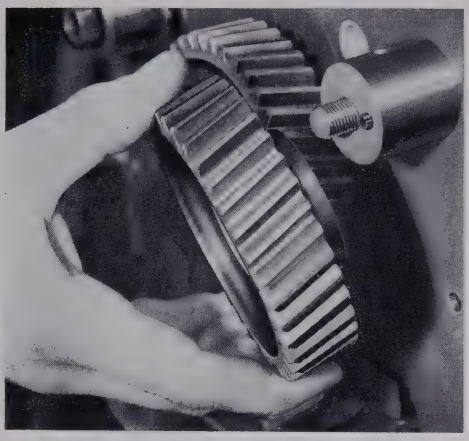


Fig. J.7. Removing Idler Gear.

2. Turn the crankshaft to T.D.C. on Nos. 1 and 6 pistons.
3. Remove the fuel injection pump (Page M.8), 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

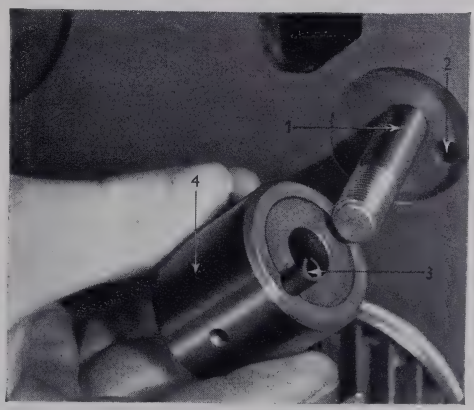



Fig. J.8. Removing Idler Gear Hub.
1. Idler Gear Hub Retaining Stud.
2. Oil Passage.
3. Hollow Dowel.
4. Idler Gear Hub.

crankshaft gear. Using new self locking nuts, secure the gears to a torque of 45/50 lbf ft (6,2/6,9 kgf m) for 7/16 in (11,11 mm) studs, and to a torque of 60/65 lbf ft (8,3/9,0 kgf m) 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.8).
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) 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.

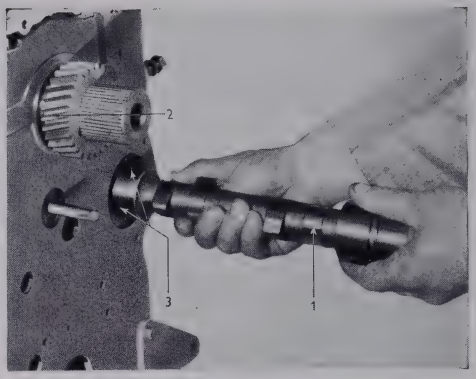
**Important:** The heavy duty timing gears must not be fitted to a standard engine, as there is a danger of interference with the crankshaft oil thrower.

### 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 being displaced.

4. Remove the sump.
5. Withdraw the camshaft (Fig. J.9) and its thrust ring (Fig. J.10). The tappets can now be withdrawn.




Fng. J.9. Camshaft Removal.
1. Camshaft. 2. Crankshaft Gear.
3. Camshaft Oil Reducer Drillings.

### To Replace the Camshaft

1. Refit the tappets (Fig. J.11).
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.10). 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.

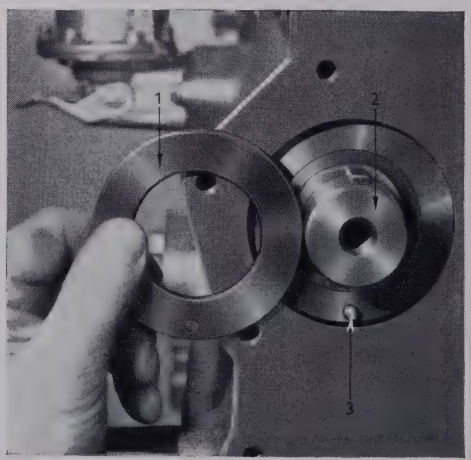



Fig. J.10 Removing Camshaft Thrust Washer.
1. Camshaft Thrust Washer.
2. Camshaft.
3. Thrust Washer Dowel Pin.

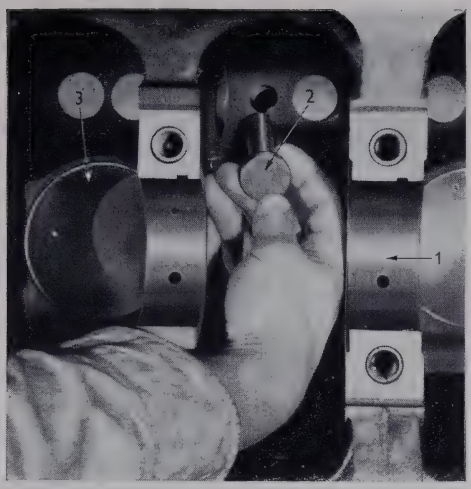



Fig. J.11. Removing Tappets.
1. Main Bearing Housing. 2. Tappet.
3. Cylinder Liner.

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.12), 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 Fig. J.13.

7. All parts should be examined for damage and wear. If the bronze worm gear requires renewing, remove the bearing from the fuel pump drive shaft by removing four cap screws. The four cap screws should be coated with a film of "Loctite" Grade "C" before refitting.

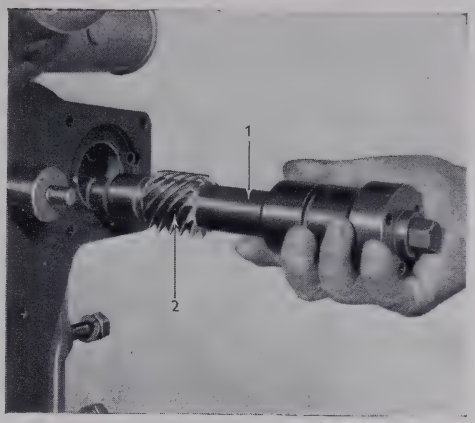



Fig. J.12. Removing Auxiliary Drive Shaft.
1. Auxiliary Drive Shaft.
2. Fuel Pump Drive Gear.

### To Replace the Auxiliary Drive Shaft and Fuel Pump Drive Shaft

1. 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.

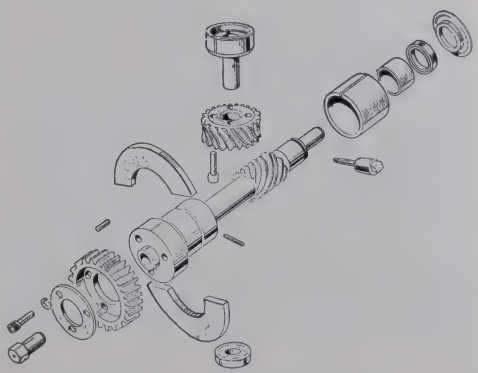


Fig. J.13.
Exploded view of Fuel Pump Drive Assembly.

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.8).
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.

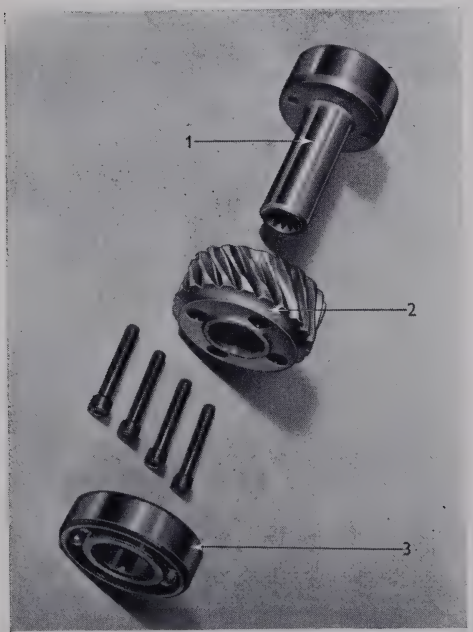



Fig. J.14. Exploded view of Fuel Pump Drive.
1. Drive Shaft.
2. Bronze Gear.
3. Ball Race.

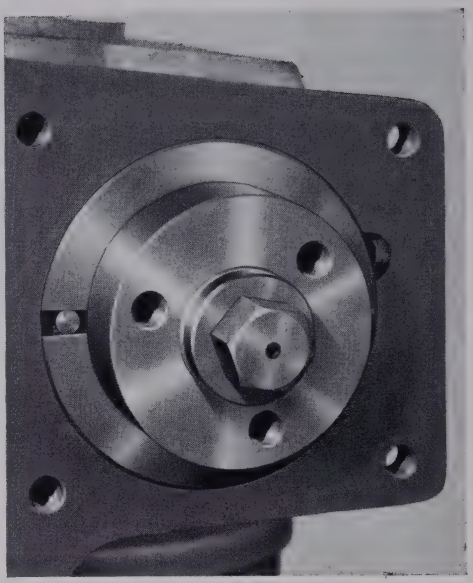


Fig. J.15.
Showing method of Auxiliary Drive Shaft Thrust Washer Location.

**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 hydraulic 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 removing the sump and oil pump and tapping the collar up out of the crankcase.

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

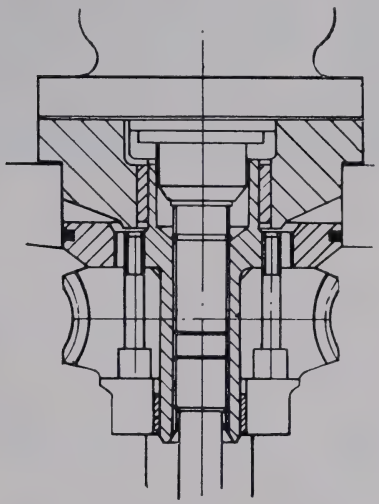


Fig. J.16.
Section View of Hydraulic Wormwheel Assembly.

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 1.625/1.6266 in (41,28/41,32 mm). The piston ring seal will not normally require renewing unless it is damaged.

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.

### 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.
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.

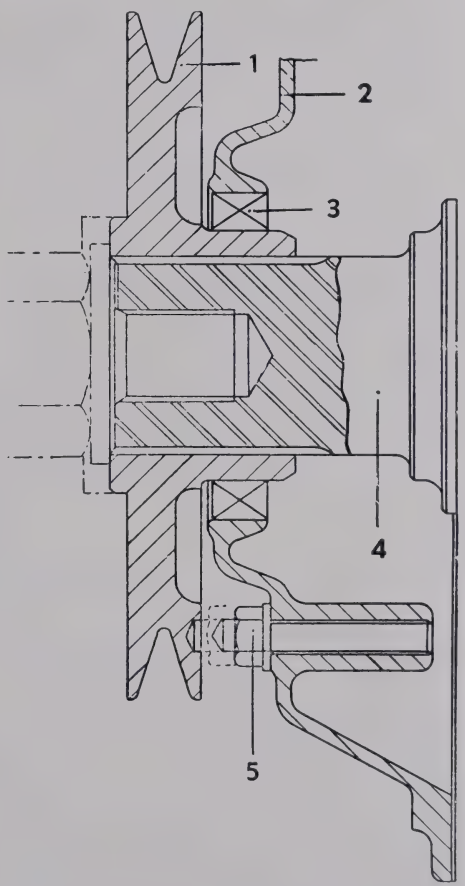



Fig. J.17.
1. Crankshaft Pulley.
2. Timing Case.
3. Timing Case Seal.
4. Crankshaft.
5. Timing Pin.

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.

### Checking the Timing Gear Backlash

1. Remove the camshaft gear and auxiliary drive gear covers.
2. Check the backlash between the timing gears using a clock gauge or feeler gauges. The back lash should be between 0.003/0.006 in (0,08/0,15 mm) if not, replace the gears affected.

### 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 below.
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. On some 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 0.010 in (0,25 mm) hot.

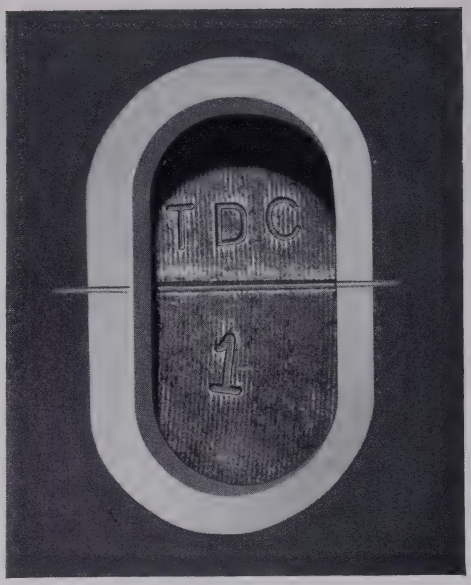



Fig. J.18. T.D.C. Mark on Flywheel.

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

**No. 1 Inlet Valve Clearances for Valve Timing Purposes**

**Early Engines :**

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

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

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

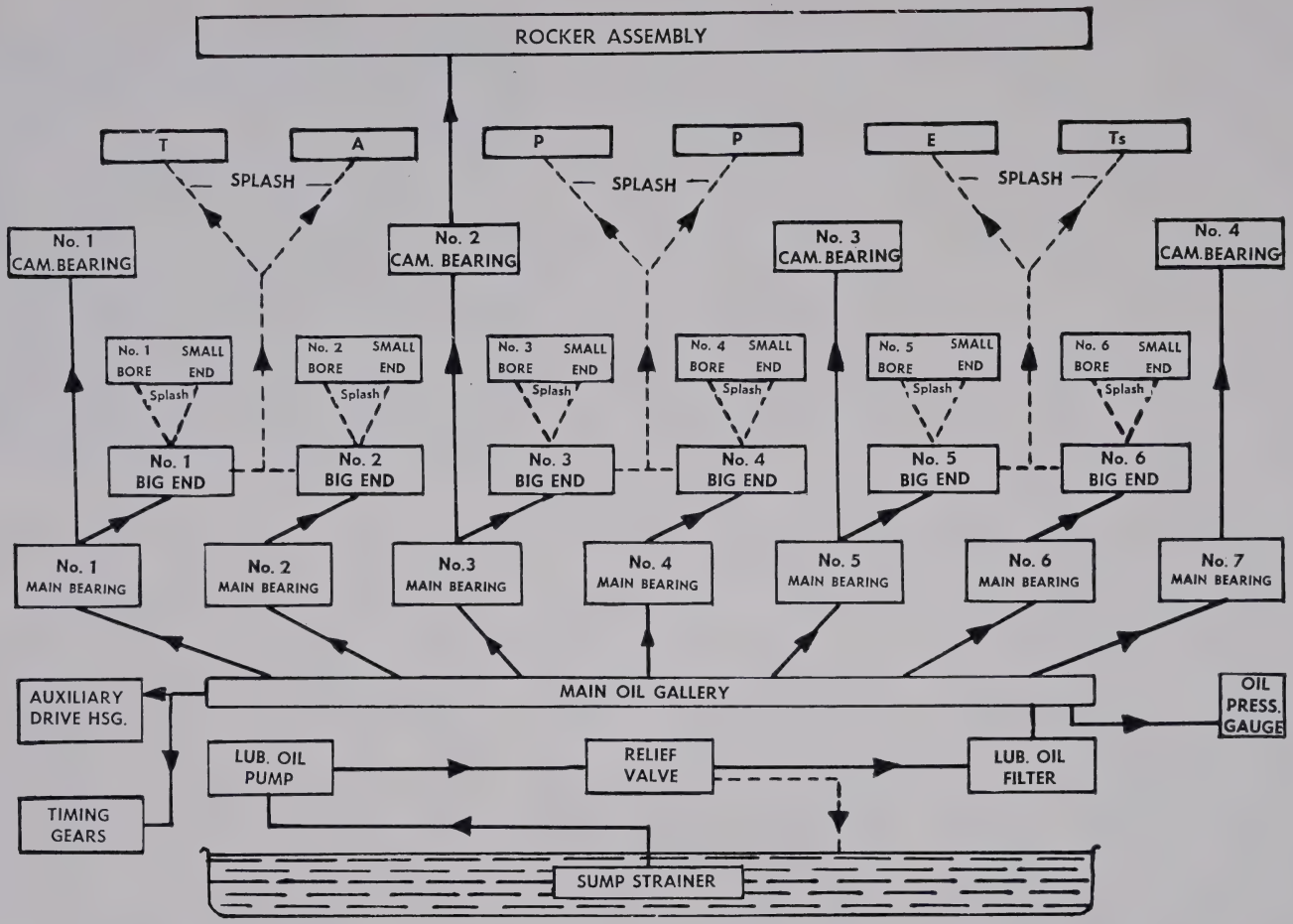



Fig. K.1. Lubricating Diagram.

# Lubricating System (K)

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.

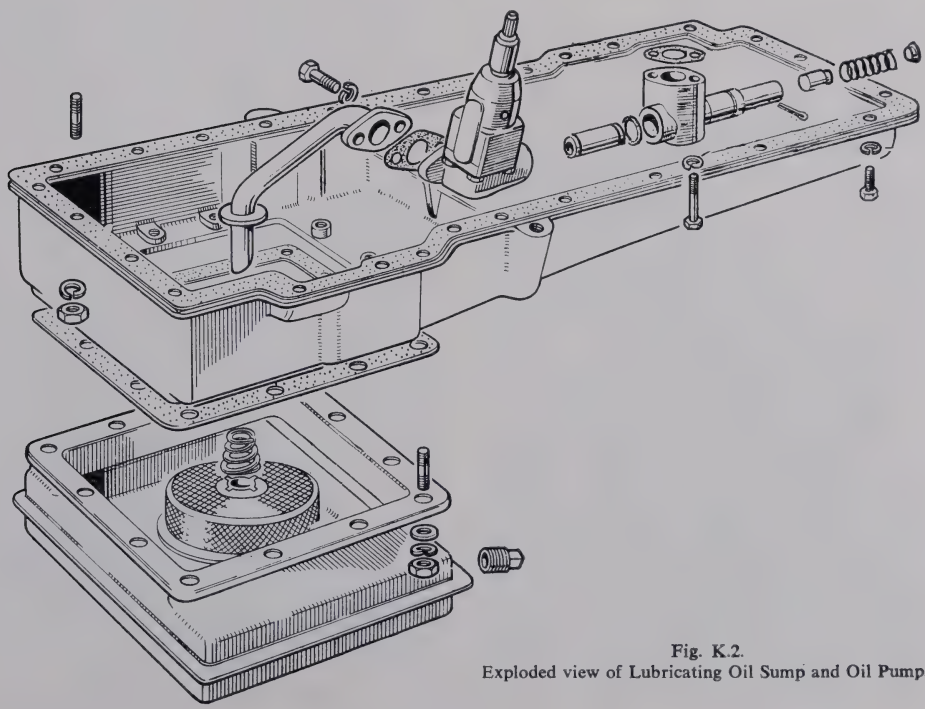


Fig. K.2.
Exploded view of Lubricating Oil Sump and Oil Pump.

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 radial drillings in the idler gears 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.

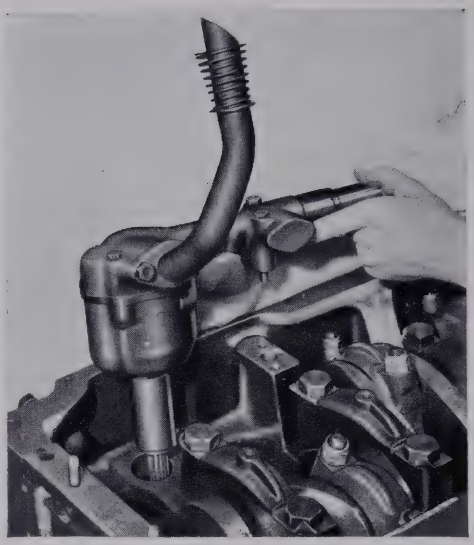


Fig. K.3. Lubricating Oil Pump Removal.

## 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 set-screws.

### 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).

## 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.

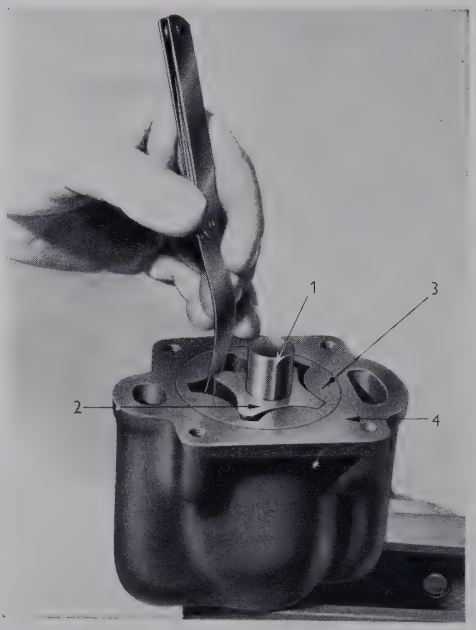



Fig. K.4. Checking Clearance between Inner and Outer Rotor.

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: An increased capacity lubricating oil pump is fitted to 6.354.2 engines to provide a lower oil temperature.

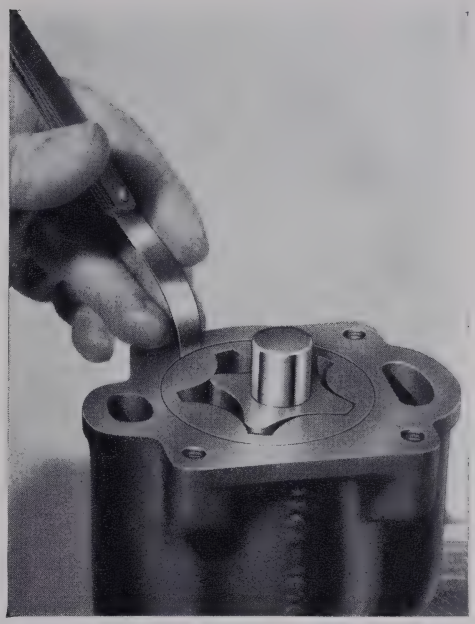


Fig. K.6.
Checking Clearance between Outer Rotor and Pump Body.

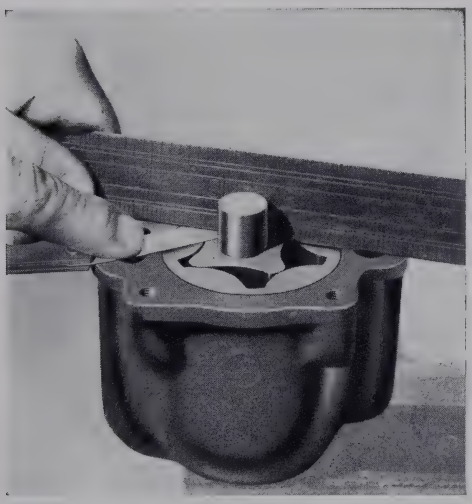


Fig. K.5. Checking End Float of Rotors.

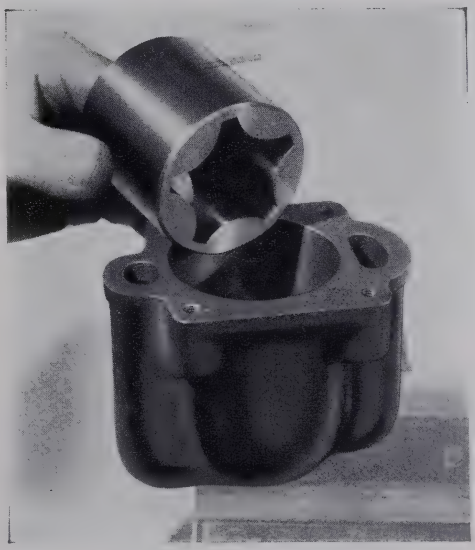


Fig. K.7. Replacing Outer Rotor.

### 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.

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). 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), using a plain washer under the spring washer.

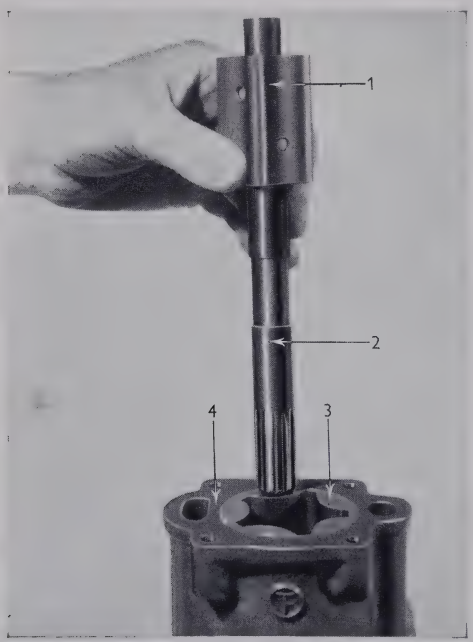



Fig. K.8. Replacing Oil Pump Drive Shaft.
1. Inner Rotor.
2. Shaft.
3. Outer Rotor.
4. Pump Body.

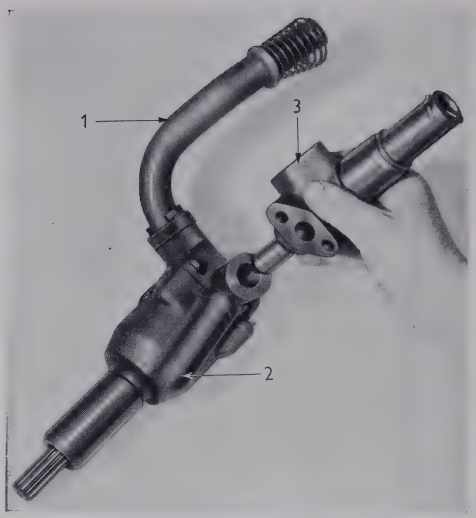



Fig. K.9. Oil Pump and Oil Delivery Housing Assembly.
1. Suction Pipe.
2. Lubricating Oil Pump.
3. Oil Delivery Housing.

## 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 40/50 lbf/in² (2,8/3,5 kgf/cm²). For T6.354 engines, this setting is 50/60 lbf/in² (3,5/4,2 kgf/cm²).

### 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) 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 T6.354 engines a turbocharger filter is fitted in tandem with the engine filter.



Fig. K.10. Sump Strainer location in Sump.

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 paper element should be renewed every 5,000 miles (7,500 km) or 200 hours.

### To Change the Filter Element

1. To dismantle the filter, see Figs. K.11 and K.12.
2. Remove the old element (Fig. K.13), 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

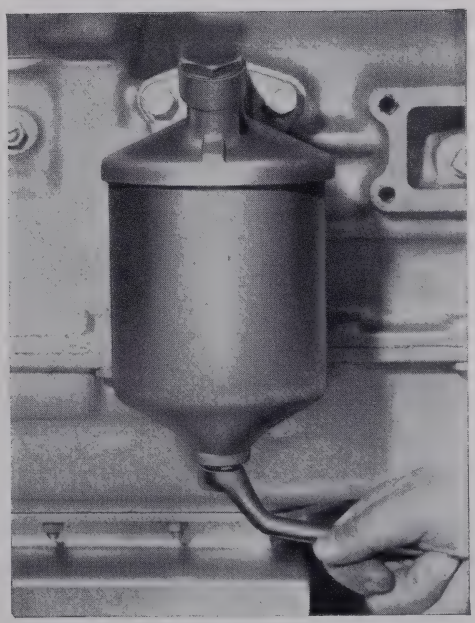


Fig. K.11. Unscrewing Filter Bowl Securing Bolt.

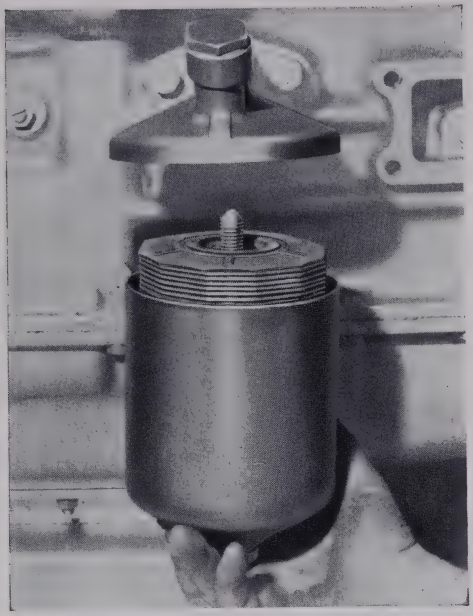


Fig. K.12. Dismantling Lubricating Oil Filter.

opposed to a non-setting jointing compound on the reverse side. The setscrews should be tightened to a torque of 26/30 lbf ft (3,6/4,2 kgf m).

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

### Screw Type Oil Filter

Certain applications employ a screw type oil filter. This filter is a combined casing and filter element into which is screwed a standpipe. The standpipe is threaded at its lower end which screws into the filter head.

### To Renew Screw Type Oil Filter

1. Unscrew the filter from the filter head complete with standpipe.
2. Remove the standpipe from the filter and discard the filter.
3. Clean the standpipe and fit it to the new filter.
4. Refit the filter assembly to the filter head.
5. Run the engine for a few seconds at idling speed, to enable the filter to fill before increasing speed.

## 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.

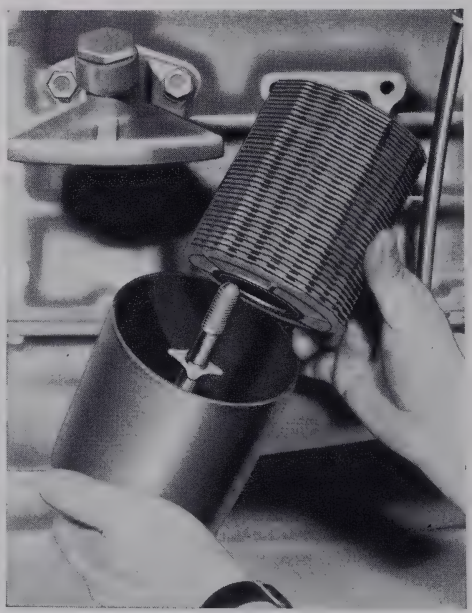


Fig. K.13. Removing Lubricating Oil Filter Element.

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 (Fig. K.14).

### 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.

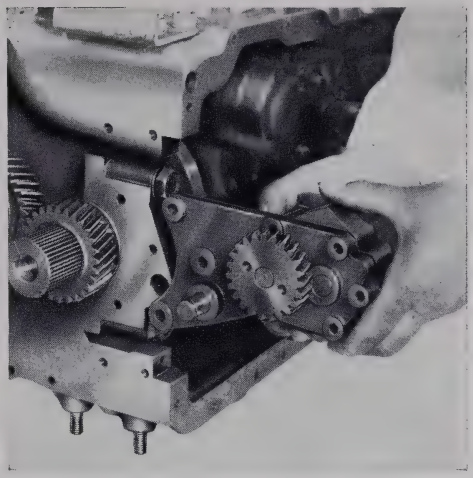


Fig. K.14.
Removing Scavenge Pump.
(Horizontal Engines only).

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.

### Lubricating oil consumption

When there are indications of excessive oil consumption and the liners are not excessively worn, say, beyond 0.006 in (0,152 mm) above original size, then service ring packs may assist in curing this complaint.

# Cooling System (L)

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.

## FAN BELT

Thumb pressure on the belt between the crankshaft and water pump pulley should allow a $\frac{3}{8}$ in deflection either way from the mean position.

Correct tension of the fan and dynamo belt should be maintained by periodical checking and adjustment every 5,000 miles (7,500 km) or 200 hours.

Belt adjustment is obtained by altering the position of the dynamo 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.

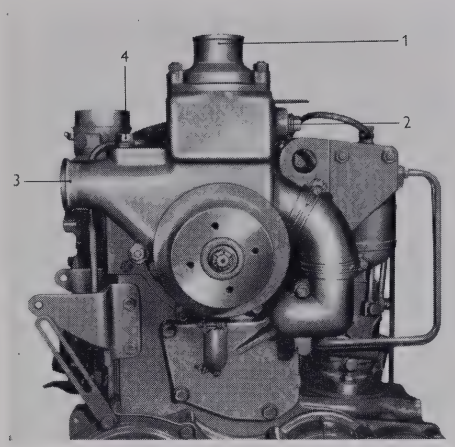



Fig. L.2. High Position Water Pump.
1. Water Outlet Connection.
2. Cab Heater Outlet Connection.
3. Water Inlet Connection.
4. Cab Heater Return Connection.

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.

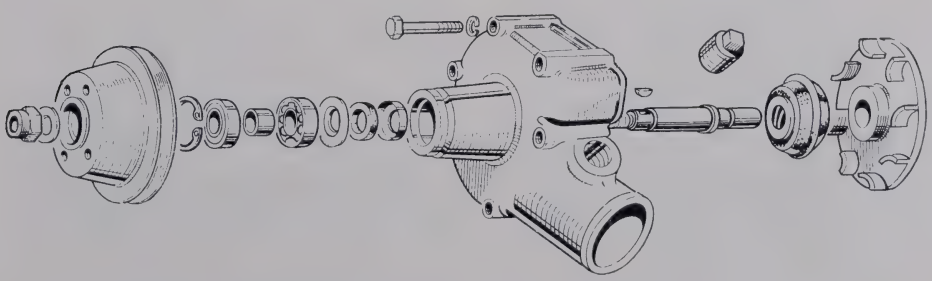


Fig. L.1.
Exploded view of low position water pump.

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 self locking nut and plain 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.

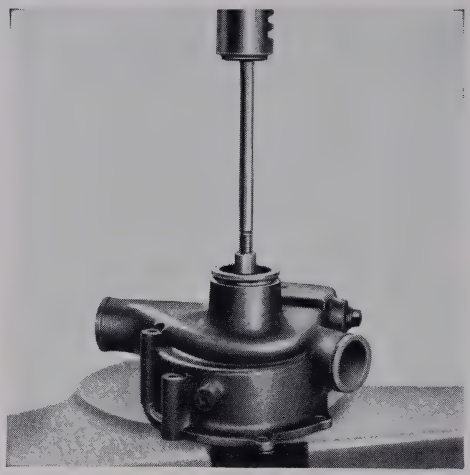


Fig. L.4.
Removing Water Pump Shaft.
(High Position Type Water Pump).

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).

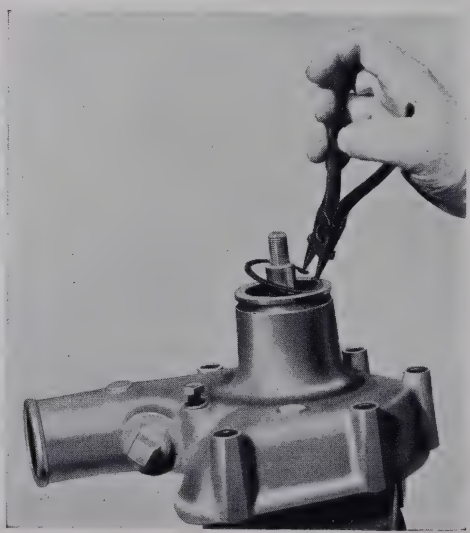


Fig. L.5. Removing Bearing Retaining Circlip.
(Low Position Type Water Pump).

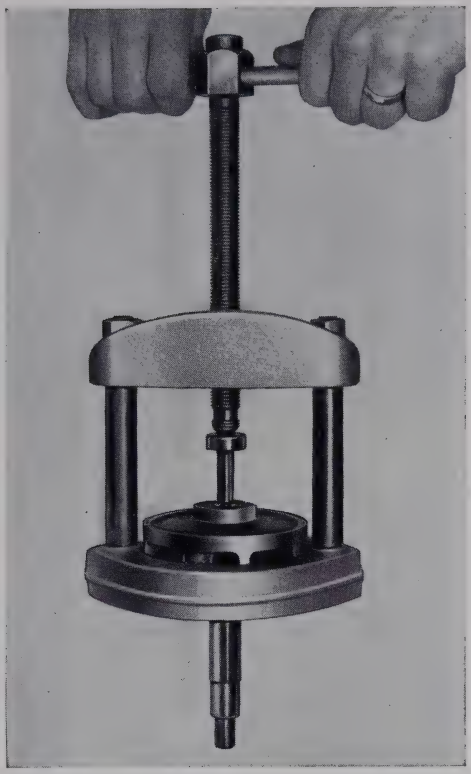


Fig. L.6.
Removing Impeller from Water Pump Shaft.

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 plain washer and self locking nut, tightening to a torque of 50/55 lbf ft (6,9/7,6 kgf m).

**Note :** The current water pump has been 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.

6.354.2 engines and latest 6.354 engines also have a ceramic faced 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.

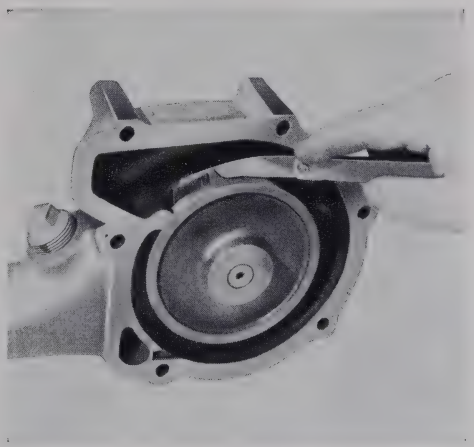


Fig. L.7.
Checking Clearance between Impeller and Pump Body. (Low Position Type Water Pump).

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.

## THERMOSTAT

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

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).

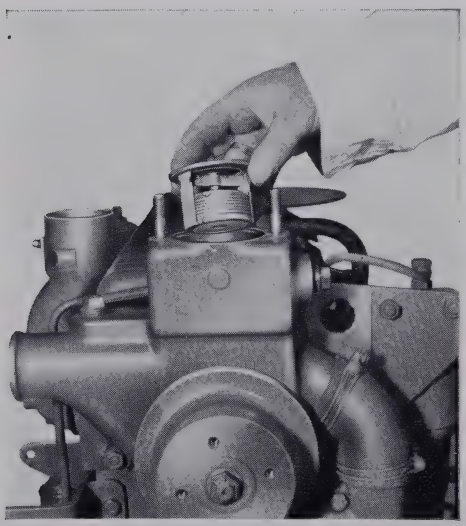


Fig. L.8.
Removing Thermostat (High Position Type Water Pump).

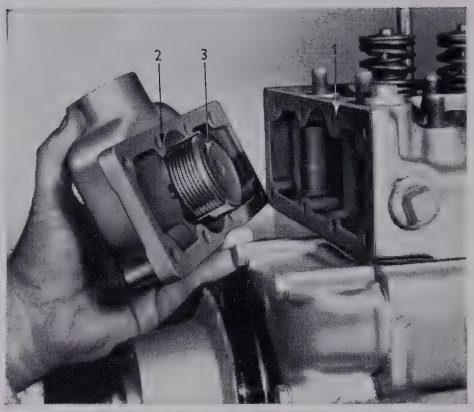



Fig. L.9. Removing Thermostat.

(Low Position Type Water Pump).
1. Cylinder Head.
2 Water Outlet Plate.
3. Thermostat.

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 alter-

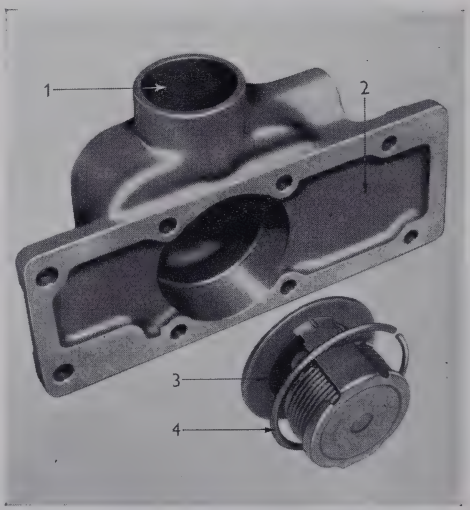



Fig. L.10. Exploded view of Thermostat and Water Outlet Connection
(Low Position Type Water Pump).
1. Water Outlet Connection.
2. Water Outlet Plate.
3. Thermostat.
4. Circlip.

natively 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. Replace 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.

# Air Filters and Fuel System (M)

### Introduction

Air drawn into the engine through the induction manifold, is filtered by an oil bath or dry element type air cleaner.

## AIR FILTERS

The time period for cleaning the air filter or renewing the paper element depends upon operating conditions. Under extremely dusty conditions, the time limits recommended should be decreased.

### Dry Type Air Filter (Fig. M.1)

This type of filter incorporates a paper element which should be renewed every 20,000 miles (30,000 km) or 800 hours.

Periodically the filter should be dismantled and any dirt removed.

To renew element, unscrew the winged nut and lift off the cover.

### Oil Bath Air Filter (Fig. M.2)

Every 5,000 miles (7,500 km) or 200 hours, remove, dismantle and clean the filter as follows :

1. Remove the top cover.
2. Lift out the wire element and clean the gauze.
3. Empty the oil from the filter casing. Wash out and dry the casing.
4. Examine the large cork ring in the top cover and the smaller cork ring between the under side of the element and the rim of the vertical pipe in the casing. When fitting a new large cork ring, coat the side of the ring towards the top cover with a jointing compound and press firmly into the rim of the top cover.
5. Replenish the filter casing with S.A.E. 30 oil to the correct level.
6. Refit the element and top cover.

**NOTE :** For high speed vehicle engines, with the encased type oil bath air cleaner, an S.A.E. 50 grade oil should be used.

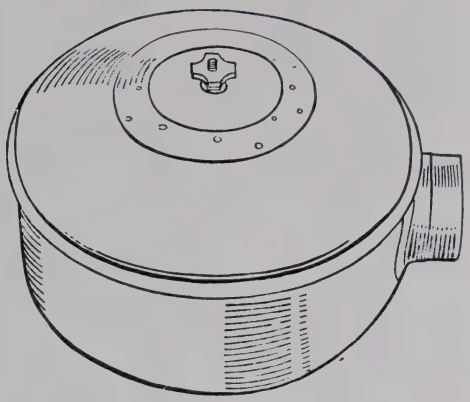


Fig. M.2. Oil Bath Air Cleaner.

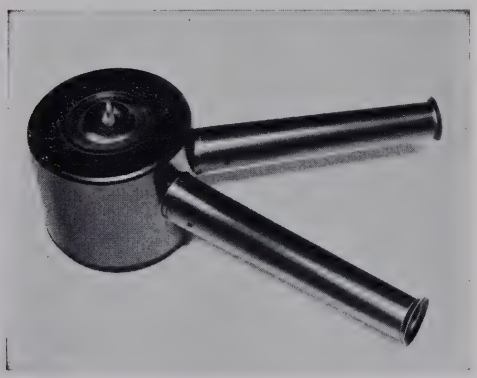


Fig. M.1. Dry type Air Cleaner.

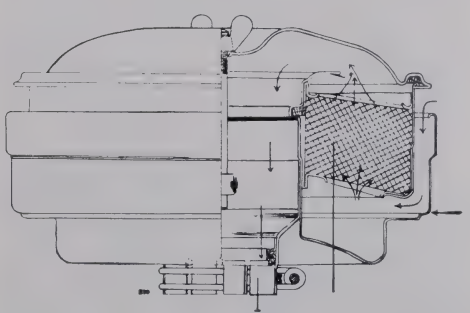


Fig. M.3.
Showing direction of air flow through the Oil Bath Air Cleaner.

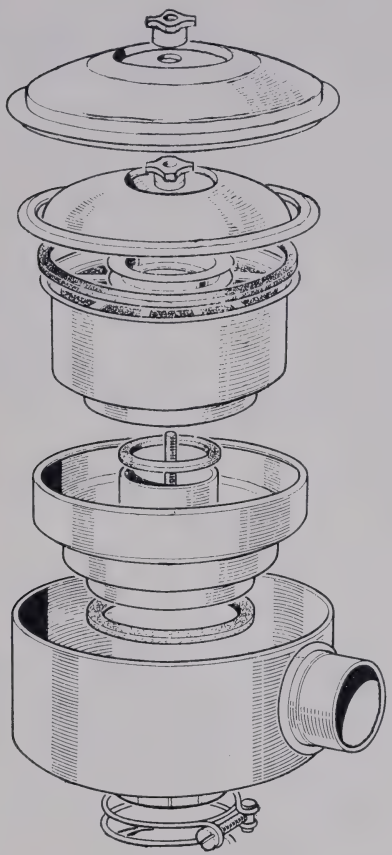


Fig. M.4. Exploded view of Oil Bath Air Cleaner.

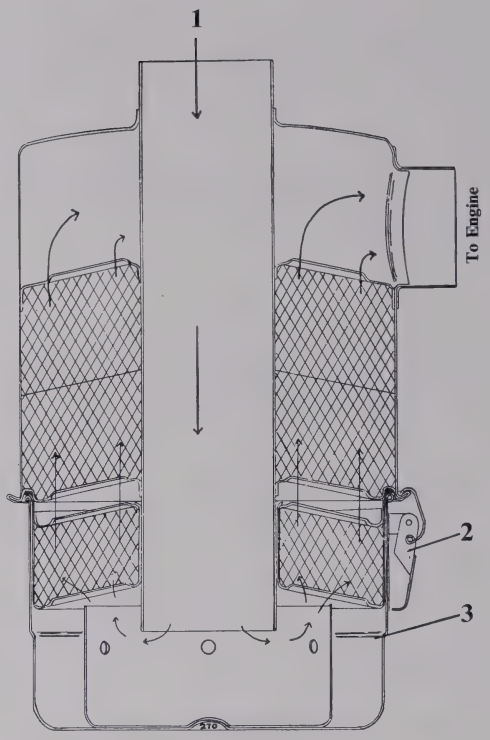



Fig. M.5.
Diagram showing direction of air flow.
1. Air Inlet. 2. Clip. 3. Oil Level.

### Tractor Type Air Filter (Fig. M.5)

The air filter 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 filter should also be cleaned.

Under extremely dirty conditions attention to the filter should be given more frequently. It is important to note that the filter 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 Periodical Attentions, Page C.1.

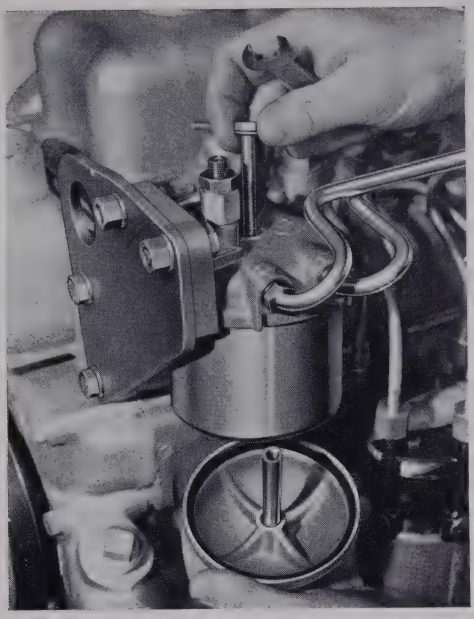


Fig. M.6. Dismantling Fuel Filter.

### 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.12.

## 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.

### To Remove the Pump from the Engine

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

### 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.

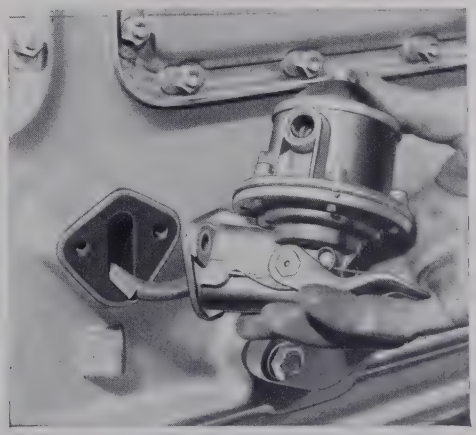


Fig. M.8. Removing Fuel Lift Pump.

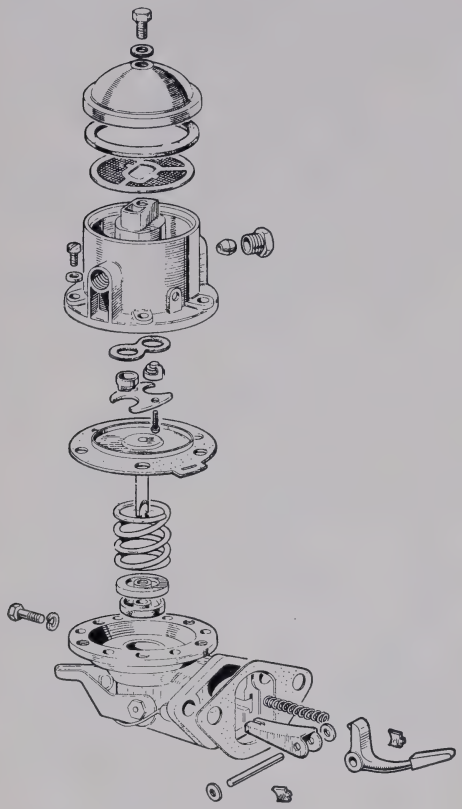


Fig. M.9. Exploded view of Fuel Lift Pump.

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.

Withdraw the valve retainer screws from inside the upper casting and remove the retainer plate valve assemblies and valve retainer gaskets.

### 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.

### Reassembly

Fit the valve retainer gasket and valve retainer.

Valves are retained by a retaining plate or alternatively by staking in six places with a suitable punch.

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.

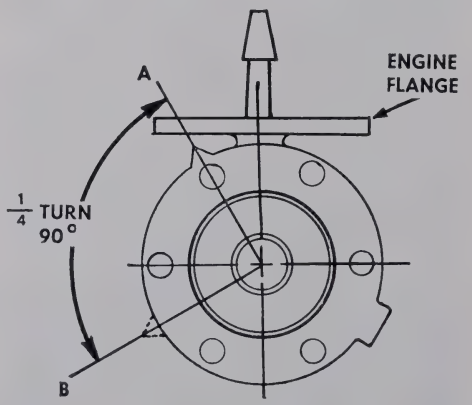



Fig. M.10.

Diaphragm Locating Tab Positions for Reassembly.

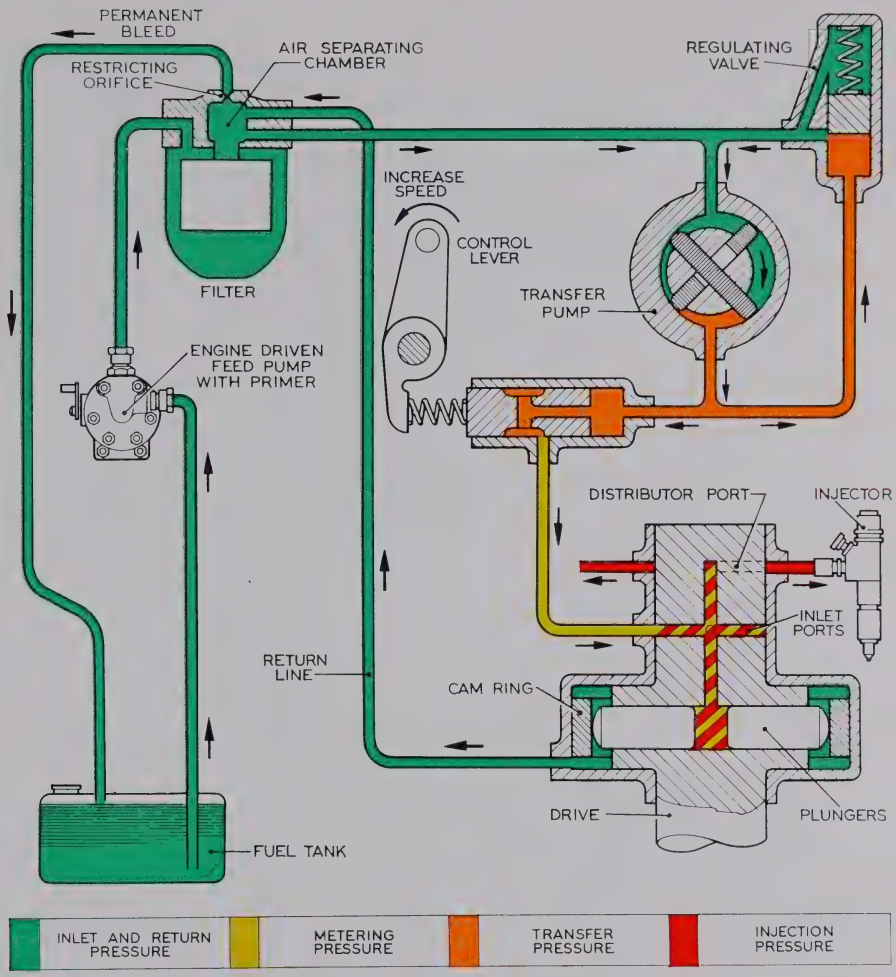



Fig. M.11.
Typical fuel system with DPA pump and hydraulic governor.

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.

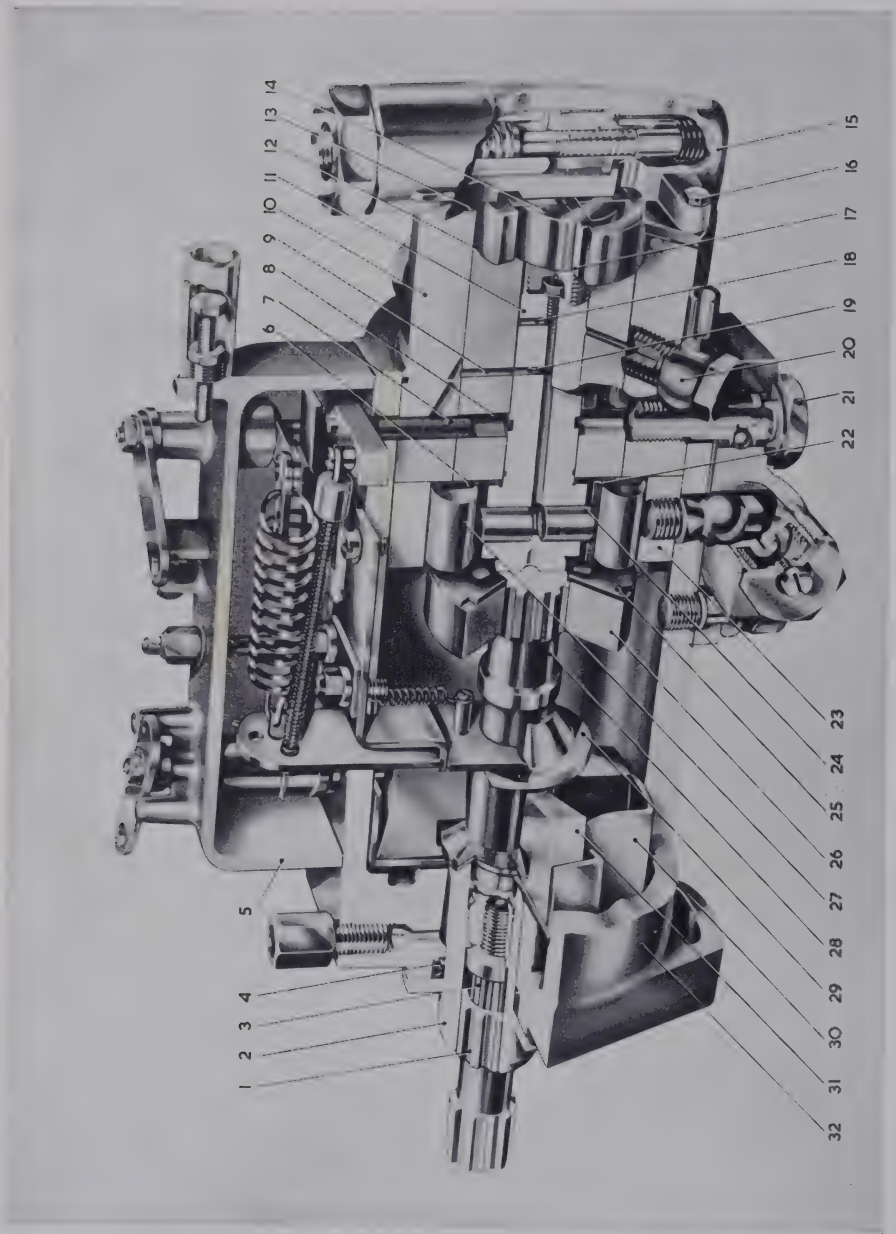



Fig. M.12.
Pump with mechanical governor and advance device.

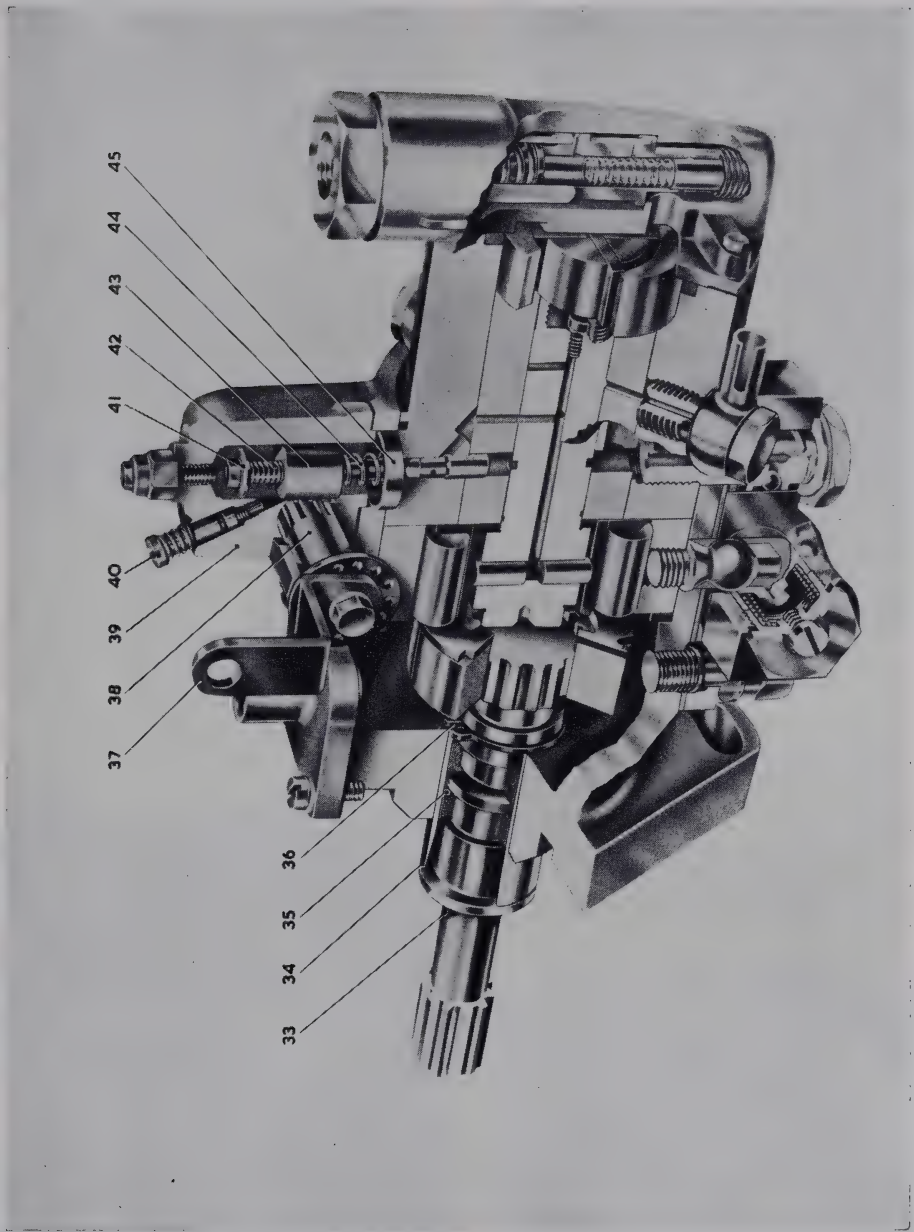



Fig. M.13.
Pump with hydraulic governor and advance device

### 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.12.

## FUEL INJECTION PUMP (Figs. M.12 & M.13)

### 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 maintainance 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.14).

### 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.15). 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.

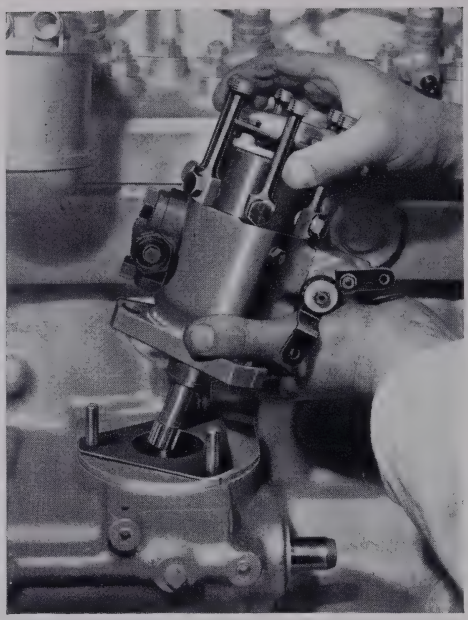


Fig. M.14. Removing Fuel Pump.

5. Vent the fuel system of air (Page M.12).
6. Adjust the maximum and idling speeds (Page M.10).

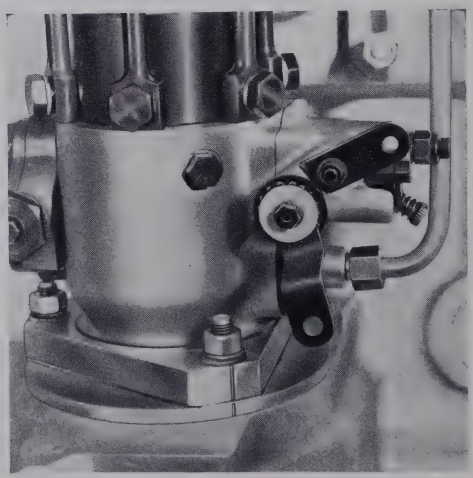


Fig. M.15.
Scribed Line on Fuel Pump and Adaptor Plate

### 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.16. 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 and is preset 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.17.

**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.18).

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.

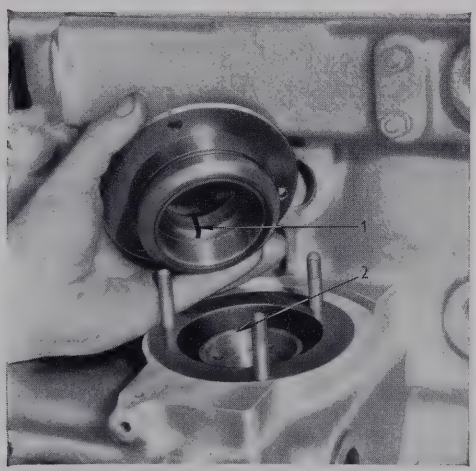



Fig. M.16.
1. Timing Slot on Fuel Pump Adaptor Plate.
2. Timing Slot on Fuel Pump Drive Hub.

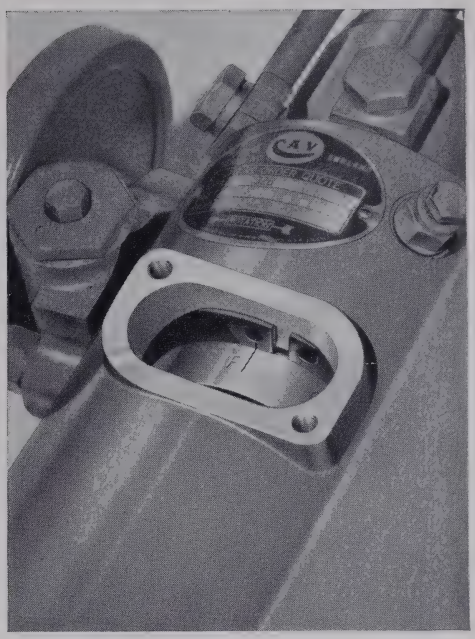


Fig. M.17. Static Timing Mark—Early Engines.

### Checking Fuel Pump Timing

1. 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.
2. Position the crankshaft so that No. 1 piston is at T.D.C. on its compression stroke.
3. Remove the rocker cover.
4. Remove the collets, spring cap and springs from No. 1 inlet valve and allow the valve to rest on top of the piston.

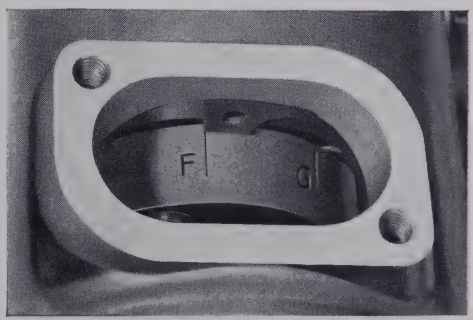



Fig. M.18. Static Timing Mark—Later Engines.

5. 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 Page B.14.
6. Remove the inspection plate on the fuel pump enabling the rotor to be seen (Figs. M.17 and M.18).
7. 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.
8. 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.
9. 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.

### 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.

### 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 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.

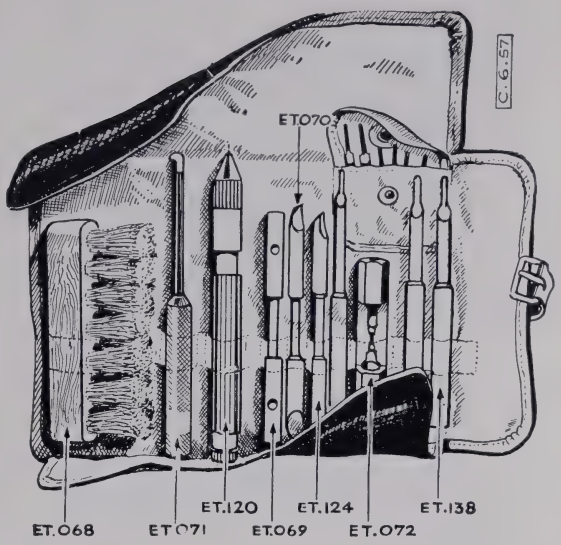



Fig. M.20.
Complete Kit of Tools for use when cleaning and overhauling atomisers.

### 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.

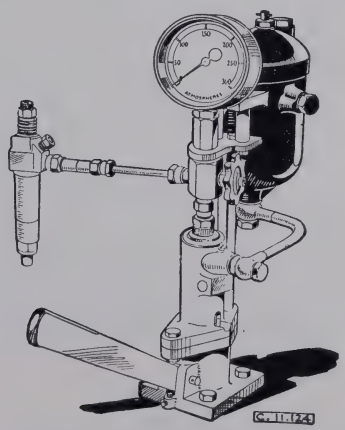



Fig. M.19. Atomiser Testing Pump.

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.

## FUEL PIPES

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.

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.

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.

A typical fuel system, incorporating the DPA fuel pump and hydraulic governor is shown in Fig. M.11.

1. Slacken the air vent valve on the top of the control gear housing (hydraulic governor) Fig. M.21, or on the front side of the governor control cover (mechanical governor) Fig. M.22.
2. Slacken the vent valve fitted on the hydraulic head locking screw Fig. M.23.
3. Operate the priming lever on the fuel feed pump and when fuel, free from air bubbles, issues from each venting point, tighten the screws in the following order :—

   (a) Head locking screw vent valve Fig. M.23.

   (b) Governor cover vent valve Figs. M.21 or M.22.
4. Slacken the union nut at the pump inlet Fig. M.25, operate the priming device and retighten when oil, free from air bubbles issues from around the threads.
5. Slacken the unions at the atomiser ends of tow 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 on both fuel pipes, and the engine is ready for starting.

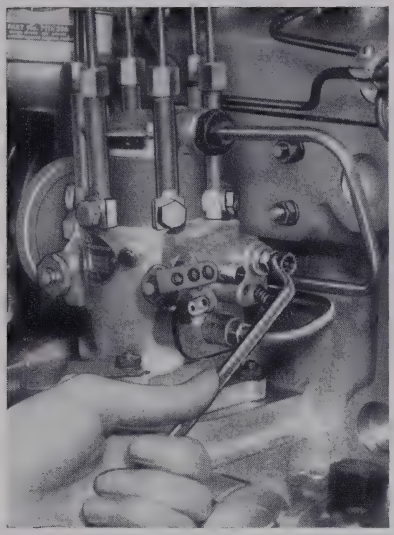


Fig. M.21.

Slackening Bleed Screw on Governor Housing. (Hydraulic Governor).

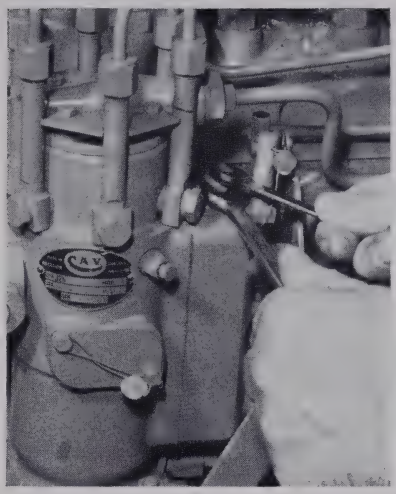



Fig. M.22.

Slackening Bleed Screw on Governor Housing. (Mechanical Governor).

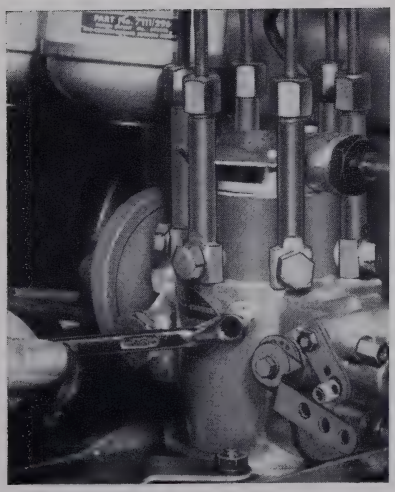


Fig. M.23.

Slackening Bleed Screw at Hydraulic Head Locking Screw.

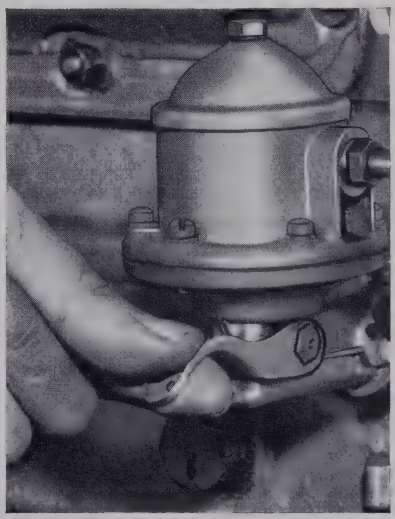


Fig. M.24.

Operating Fuel Lift Pump.

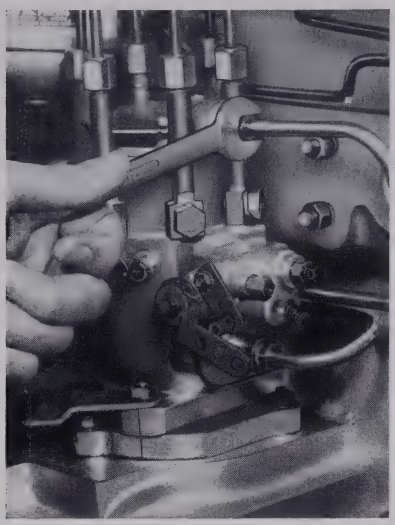


Fig. M.25.
Slackening Inlet Pipe Union Nut.

## STARTING THE ENGINE

Turn starter switch to position "R" (see Fig. M.26) 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,** ensure cold start aid reservoir contains fuel oil. Turn on tap between reservoir and cold start aid.

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 and turn off the tap on the cold start reservoir.

### Earlier Heat Start Switch

The cold start switch supplied with earlier engines is shown in Fig. M.27.

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.

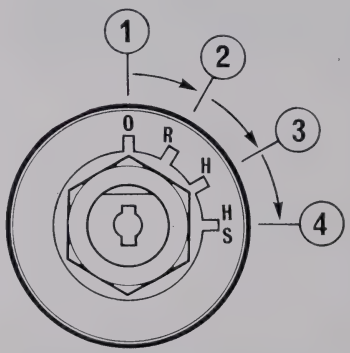



Fig. M.26
Combined Heat/Start Switch.
1. Off Position.
2. Run Position.
3. Heat Position.
4. Heat and Start Position.

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

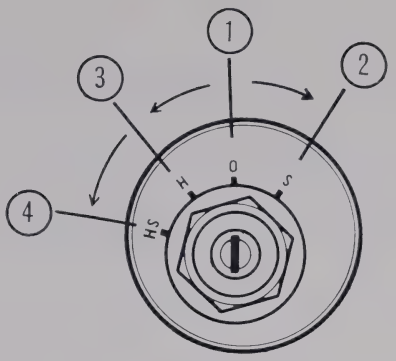



Fig. M.27.
Earlier Combined Heat/Start Switch.

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

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.

### 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.

Turn the start switch to the "O" position.

### Things to Note

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

Always ensure that the reservoir feeding fuel to the cold starting aid is fully primed and is not leaking.

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.

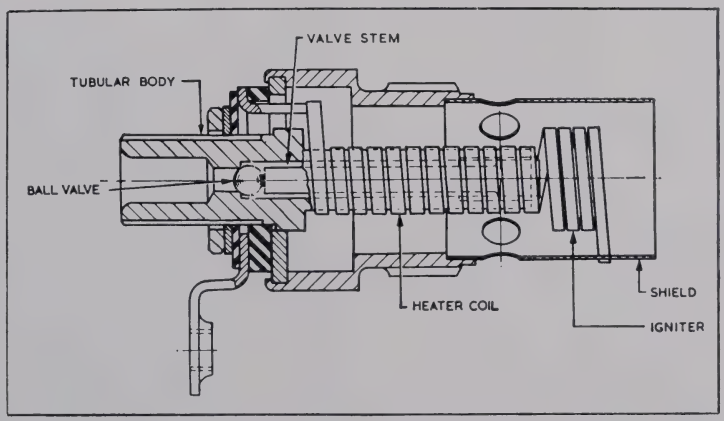



Fig. M.28. Cold Start Aid.

### Running In Procedure

**To ensure the future efficiency and life of the engine, careful treatment during the early life should be exercised.**

**To obtain the best results from your new or replacement 6.354 engine, it should be operated within reasonable limits and not at maximum rev/min for the first 500 miles (750 km) or 25 hours.**

# Flywheel & Flywheel Housing (N)

## FLYWHEEL AND FLYWHEEL HOUSING

### To Remove the Flywheel

1. Remove the gearbox and bell housing.
2. Remove clutch assembly.
3. Remove the flywheel.
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 $\frac{1}{4}$ 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.
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.

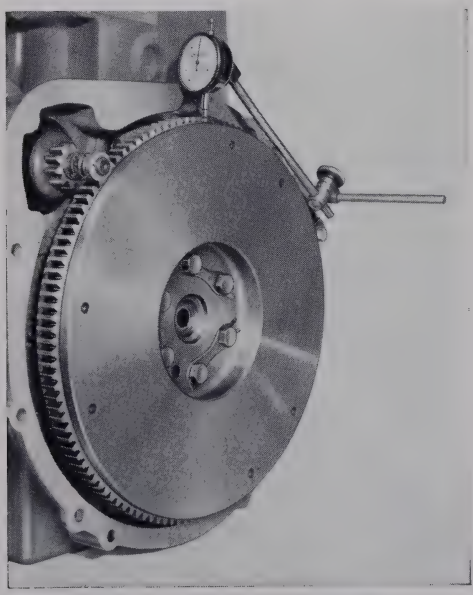


Fig. N.1. Checking Flywheel Run-out.

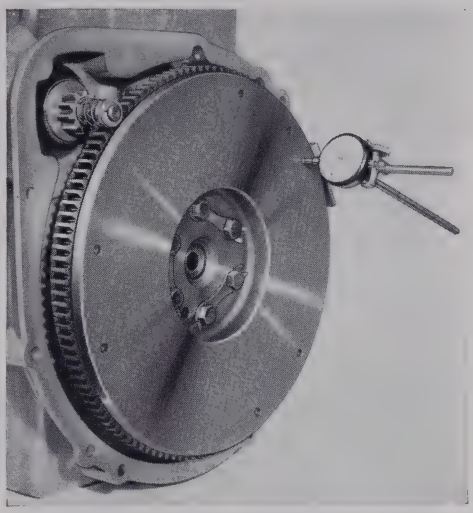


Fig. N.2. Checking Flywheel Face.

### 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.
2. Engage the six securing setscrews with new locking washers and tighten to a torque of 74/80 lbf ft (10,3/11,06 kgf m).
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,

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).
6. Refit the clutch and gearbox, etc.

### To Remove the Flywheel Housing

1. Remove the flywheel.
2. Unscrew the nuts or setscrews securing the flywheel housing to the cylinder block and tap the housing clear of the locating dowels.
3. Examine the housing for cracks and damage, etc.

### 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 below.
4. Check perpendicular alignment (Fig. N.4). This facing should be within the limits listed below.

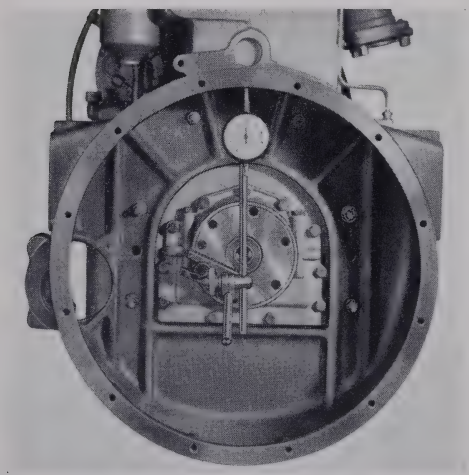


Fig. N.3.
Checking Alignment of Flywheel Housing Bore.

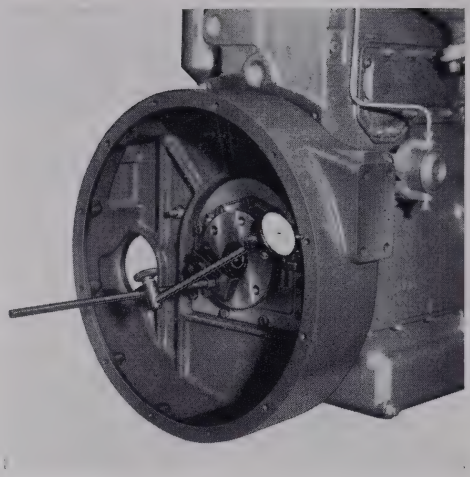


Fig. N.4.
Checking Alignment of Flywheel Housing Face.

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 nuts evenly.
7. Refit the flywheel, etc.

### Alignment Limits —
### Flywheel Housing Bore and Face

| Diameter of Housing | Limits |
|---|---|
| Up to 14.25 in | 0.006 in T.I.R. |
| (362 mm) | (0,15 mm) |
| 14.25 to 20.125 in | 0.008 in T.I.R. |
| (362 to 511 mm) | (0,20 mm) |
| 20.125 to 25.5 in | 0.010 in T.I.R. |
| (511 to 648 mm) | (0,25 mm) |
| 25.5 to 31.0 in | 0.012 in T.I.R. |
| (648 to 787 mm) | (0,30 mm) |

# Turbochargers (P)

## CONTENTS

Section 1 — General Information ... ... ... ... Page P.3

Section 2 — Details of Construction ... ... ... ... Page P.6

Section 3 — Lubricating System ... ... ... ... Page P.7

Section 4 — Installation ... ... ... ... ... Page P.8

Section 5 — Starting Instructions ... ... ... ... Page P.12

Section 6 — Service Operation ... ... ... ... ... Page P.13

Section 7 — Maintenance Instructions ... ... ... ... Page P.14

Section 8 — Fault Diagnosis ... ... ... ... ... Page P.15

Section 9 — Reconditioning Instructions including Schedule of Tolerances ... ... ... ... Page P.17

These instructions are issued for the general guidance of operators using the turbocharged 6.354 diesel engine. Please read carefully BEFORE starting your 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 Signholder or Overseas Company, where a replacement unit should be obtained. If this is impossible the instructions given in section 9 should be carefully followed.

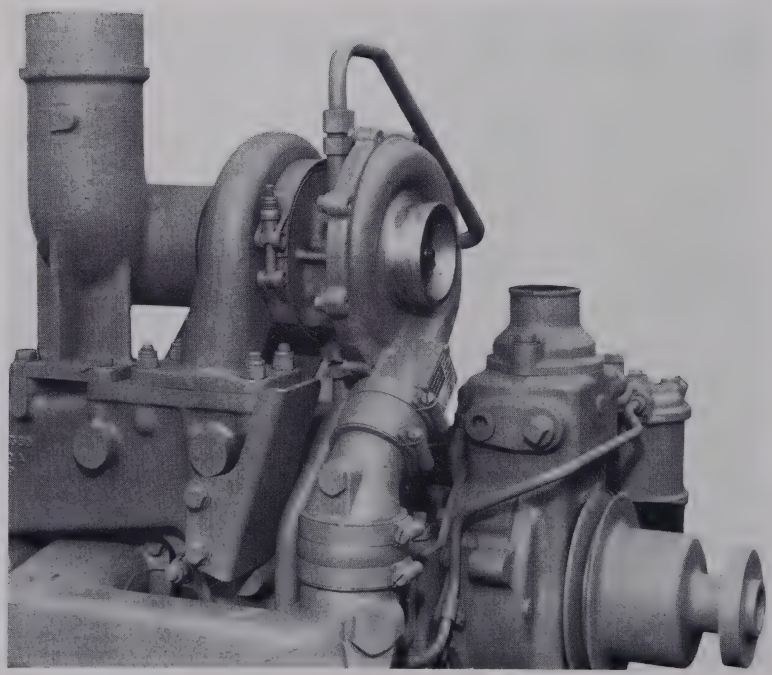
It is not permissible to fit a Turbocharger unit to a normally aspirated engine.

# 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 **200** hours.
4. **DO** check the maximum boost at least every **5,000** miles (7,500 km) or **200** 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, agricultural and marine type 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

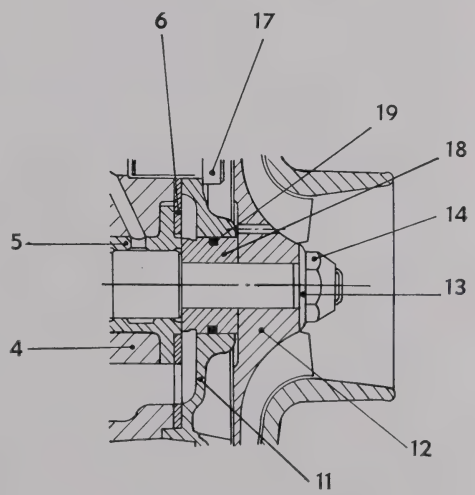
This turbocharger was manufactured by Engineering Productions (Clevedon) Ltd., and has a labyrinth oil seal at the impeller end of the rotor shaft as shown in Fig. 4. The turbine nozzle unit has 23 blades. It can be identified by the marking "1/5N" on the casing.

### 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 | 13. | Washer |
| 5. | Bearing | 14. | Nut |
| 6. | Retaining Plate | 17. | Cap Screw |
| 11. | Plain Diffuser | 18. | Compressor Seal Sleeve |
| 12. | Impeller | 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.

# 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.

# 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 shipped 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 tow 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.

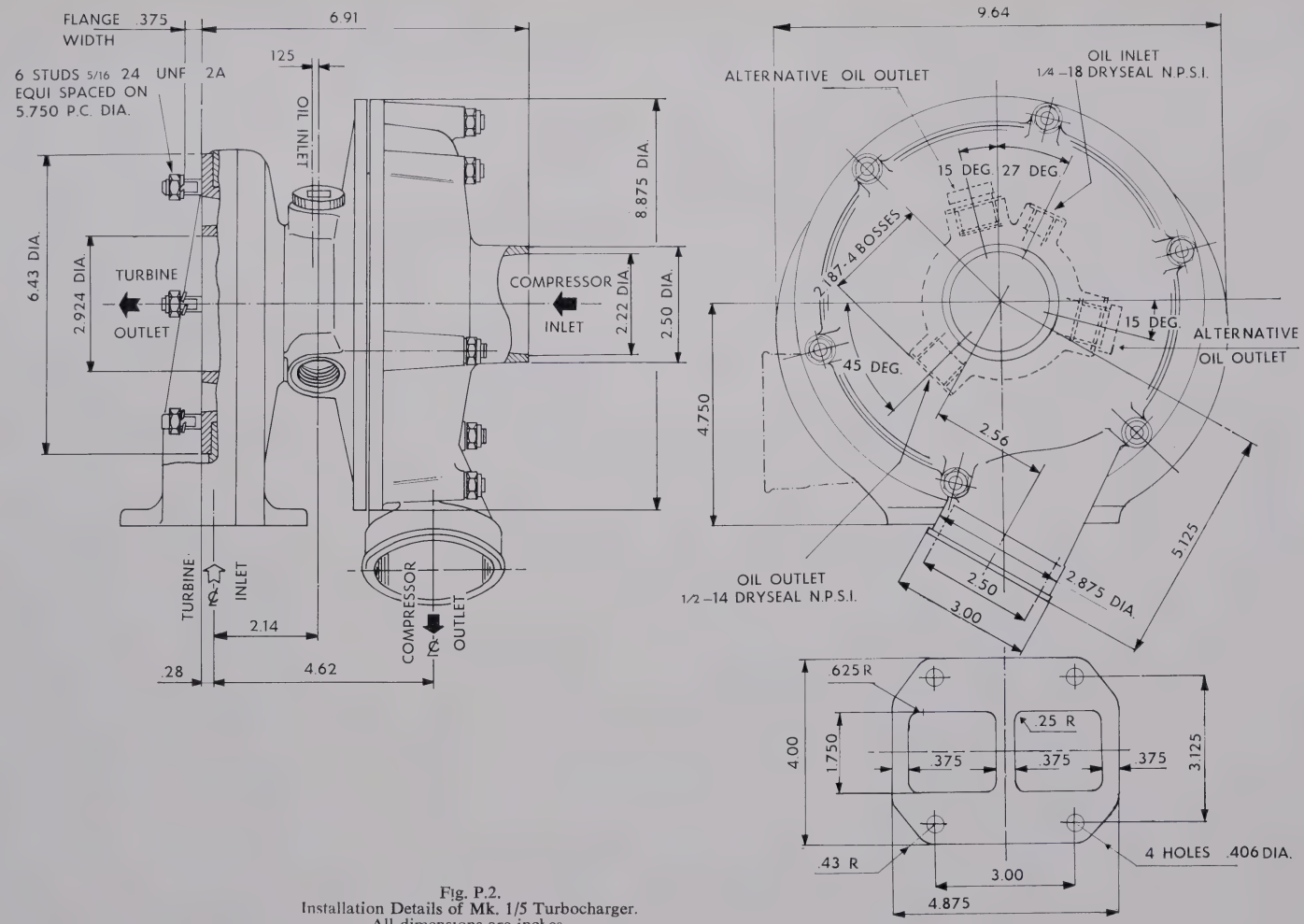
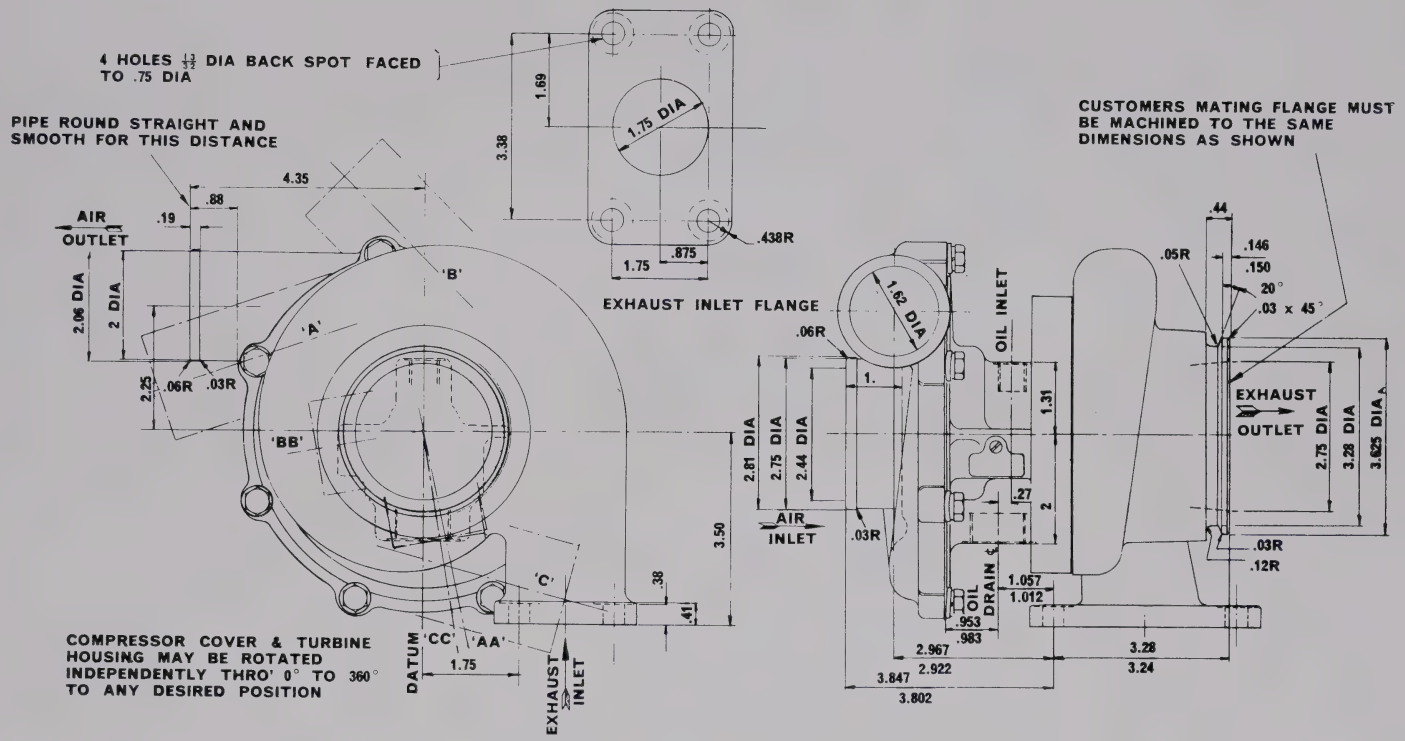



Fig. P.2.
Installation Details of Mk. 1/5 Turbocharger.
All dimensions are inches.




| 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 3LD Turbocharger.
All dimensions are in inches.

The back pressure in the exhaust system should not be more than 15 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/in$^2$ 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/in$^2$.

(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/in$^2$. 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/in$^2$ 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

Boost pressure should be checked every 5,000 miles (7,500 km) or 200 hours. 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/in$^2$ |
| Holset 3LD | 11—15 lbf/in$^2$ |

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 800 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 800 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.

### 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 200 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$^2$) under normal conditions of load.

If the oil pressure is low refer to the engine Workshop Manual 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.

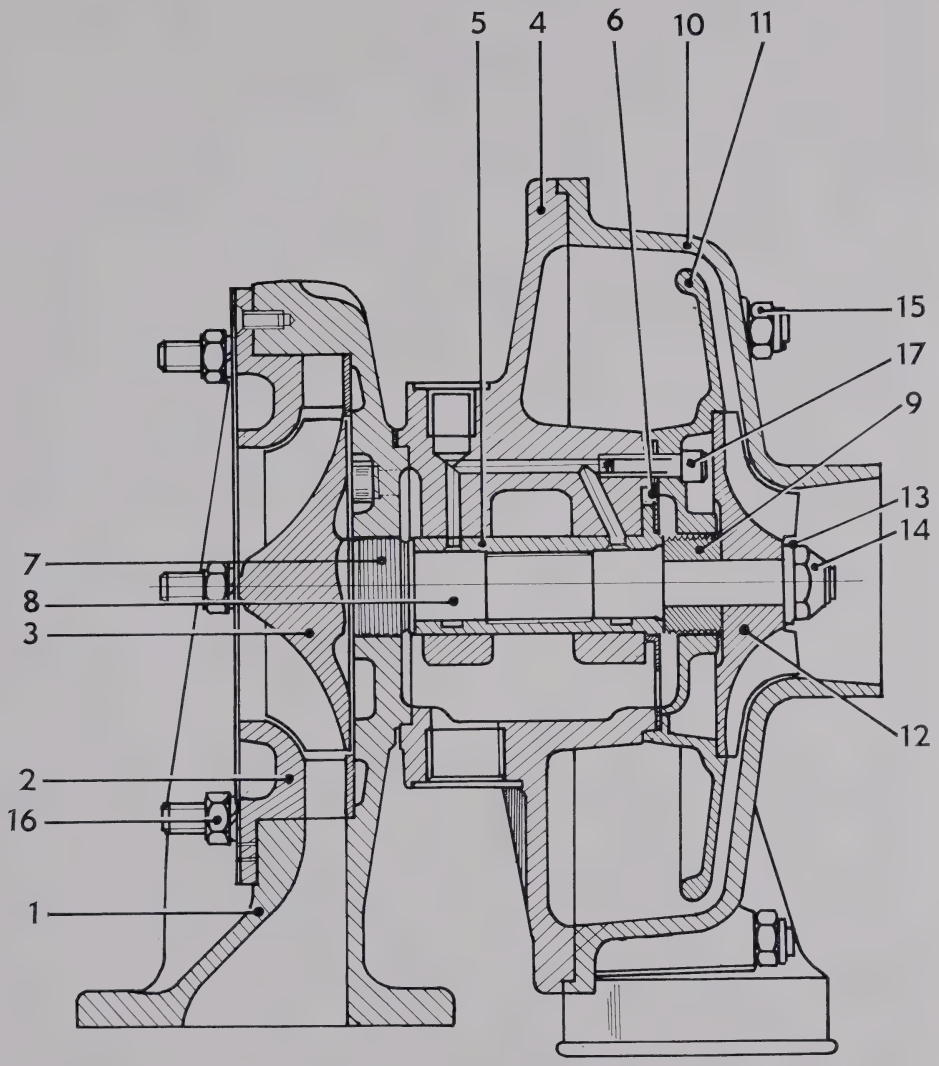



Fig. P.4
Sectional view of Mk. 1/5 Turbocharger.

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.

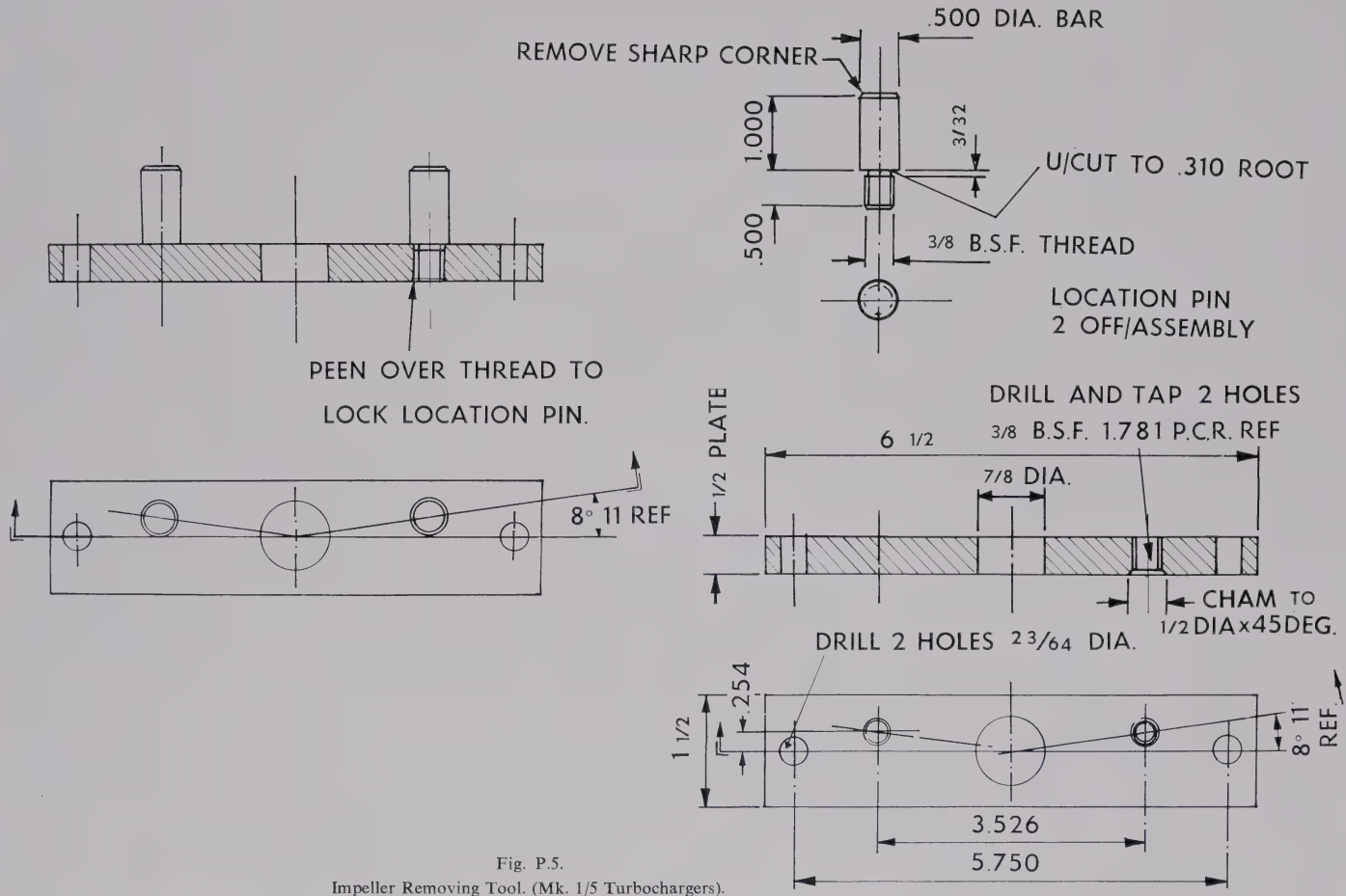



Fig. P.5.
Impeller Removing Tool. (Mk. 1/5 Turbochargers).
All dimensions are in inches.

### 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) 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.

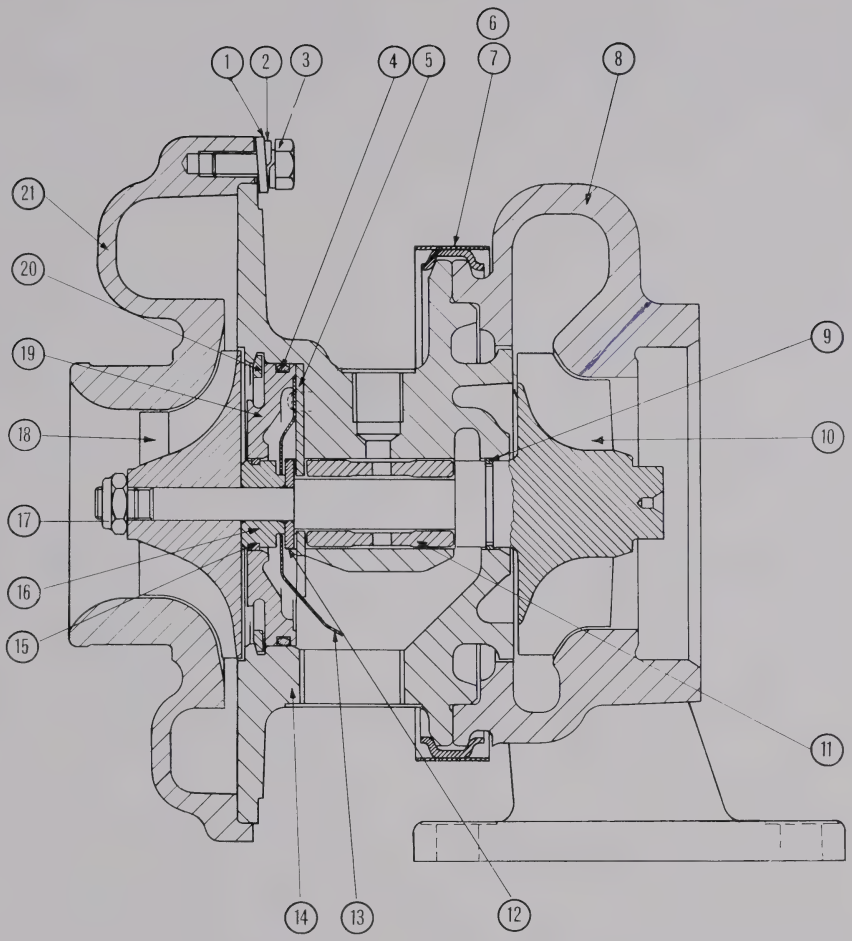



Fig. P.6.

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.22.

### 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), bolt (3) to 5 lbf ft (0,7 kgf m) and "V" clamp locknut (6) to 10 lbf ft (1,4 kgf m).
  (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) and 60—65 lbf ft (8,3—8,99 kgf m) 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.

### Installation Check List

#### Mk. 1/5 and Holset 3LD 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.

(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.

NOTE : When the turbocharger is put into service it must be "run-in" in accordance with the instructions given in Section 5.

# 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. | |

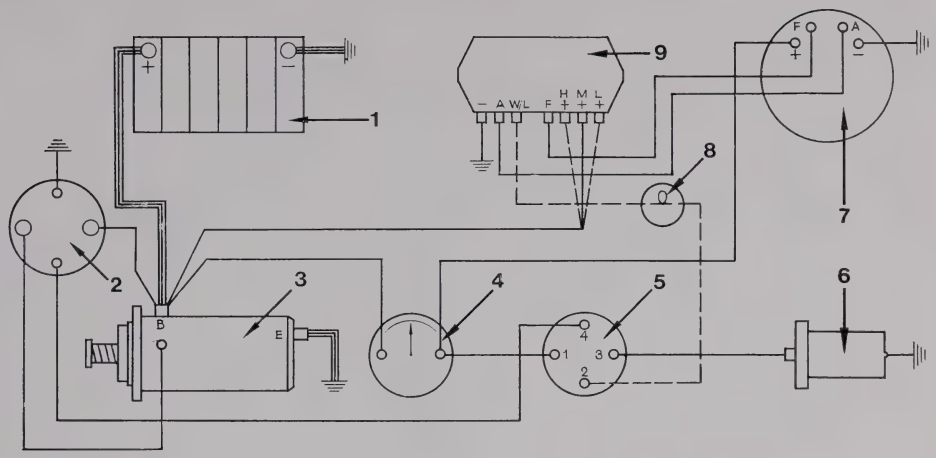



Fig. Q.1.
Typical Wiring Diagram incorporating a AC5 Alternator.

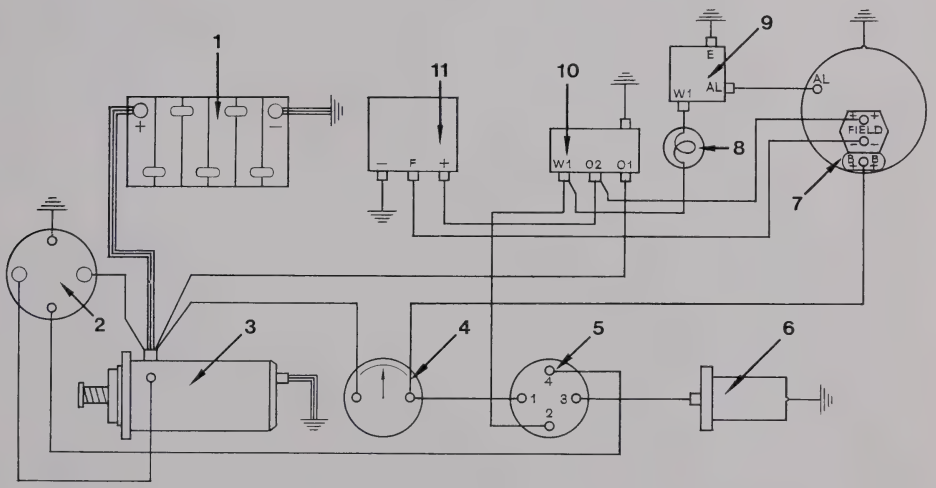



Fig. Q.2.
Typical Wiring Diagram incorporating a 11AC Alternator.

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.

## HI-LIFE SOFT & MOIST DOG FOOD




Twelve packets of beef flavor dog food. Equals as many meals as 12 - 1 Lb. Cans.
REG. FLEET PRICE ..... $1.99
WHILE QUANTITIES LAST!




**FOR YOUR SHOPPING CONVENIENCE**
Quality Farm & Fleet stores honor Master Charge and VISA.




QUALITY FARM & FLEET INC.®

**HERE'S THE QUALITY FARM & FLEET NEAREST YOU**

## QUALITY FARM & FLEET

1651 South Main Street, Route 68
Bellefontaine, OH 43311
Phone 513/592-2045

### STORE HOURS

Monday thru Friday 8:00 A.M. to 8:00 P.M.
Saturday 8:00 A.M. to 5:00 P.M.
Sunday 12:00 Noon to 5:00 P.M.

Bulk Rate
U.S. Postage
PAID
Permit No. 494
St. Cloud, Minn.

R.R. BOXHOLDER PATRON
P.O. BOXHOLDER PATRON

We reserve the right to limit quantities and correct printing errors.

# QUALITY FARM & FLEET

## Take the chill out of winter with these

# Red Hot Values!

## Fleet Special Prices Good Feb. 8-19!



### 4 LB. POPCORN

FLEET Special **69¢**

Enjoy hot popcorn! Delicious, nutritious and economical.
4 Lb. Bag.
REG. FLEET PRICE..... $1.19
WHILE QUANTITIES LAST!

### HI-LIFE SOFT & MOIST DOG FOOD




FLEET Special **1.47**

Twelve packets of beef flavor dog food. Equals as many meals as 12 - 1 Lb. Cans.
REG. FLEET PRICE ..... $1.99
WHILE QUANTITIES LAST!



### 5 TON HYDRAULIC JACK

FLEET Special **12.77**

Heavy-duty performance for lifting or pushing in any position: vertical, angle or horizontal. Lift Range: 7⅛" - 15¼". No. HJ-50.
REG. FLEET PRICE..... $17.84

FOXCRAFT™

**FOR YOUR SHOPPING CONVENIENCE**
Quality Farm & Fleet stores honor Master Charge and VISA.

VISA

QUALITY FARM & FLEET INC.®

**HERE'S THE QUALITY FARM & FLEET NEAREST YOU**

**QUALITY FARM & FLEET**
1651 South Main Street, Route 68
Bellefontaine, OH 43311
Phone 513/592-2045

**STORE HOURS**
Monday thru Friday 8:00 A.M. to 8:00 P.M.
Saturday 8:00 A.M. to 5:00 P.M.
Sunday 12:00 Noon to 5:00 P.M.

Bulk Rate
U.S. Postage
PAID
Permit No. 494
St. Cloud, Minn.

R.R. BOXHOLDER PATRON
P.O. BOXHOLDER PATRON

We reserve the right to limit quantities and correct printing errors.

# SHOP Q.F.F. FOR THE BEST SPRAYER VALUE



NEW AT QUALITY FARM & FLEET

## 700 GALLON LONG TRAILER SPRAYER

- Rugged Heavy-Duty Frame Of Strong 4" Square Tubing
- High Crop Clearance
- Baffled Fiberglass Tank

Tank saddles built into the frame for strength. 16" x 8 bolt rims. Centrifugal hose kit and agitator system. Includes front jack stand and 10 row boom with 20 gallon tips. Pump and tires not included.

REG. FLEET PRICE ..... $1,729.00

EARLY BIRD SPECIAL ..... **$1,608.00**

PRICED KNOCKED DOWN - LESS PUMP & TIRES

**Available from but not stocked in all stores.**

## 1000 GALLON LONG TRAILER SPRAYER

- Heavy Commercial Boom
- Cat Walk With Step
- Adjustable, Oscillating Axles

Adjustable axles will accomodate 11L x 15 flotation tires to decrease soil compaction. ¾" feeder lines for maximum application rates. Includes 10 row commercial boom, four jet agitators and all hardware, less pump and tires.

REG. FLEET PRICE ..... $2,594.00

EARLY BIRD SPECIAL ..... **$2,412.00**

PRICED KNOCKED DOWN - LESS PUMP & TIRES

**Available from but not stocked in all stores.**



NEW AT QUALITY FARM & FLEET



NEW AT QUALITY FARM & FLEET

## "VERTICAL" SIDE MOUNT SPRAYERS

### 300 GAL. — 400 GAL. — 520 GAL.

- Designed For Close Coupled Tractors
- Heavy-Duty Reinforced Mounting Brackets
- Narrow Tanks For Easier Mounting

Includes chemical resistant hose, separate agitation system in each tank, quick acting shut-off valve, nylon strainer and shut-off valves for each tank. Pump not included.

300 Gal. Capacity - REG. FLEET PRICE ..... $598.00

EARLY BIRD SPECIAL **$556.00**

400 Gal. Capacity - REG. FLEET PRICE ..... $618.00

EARLY BIRD SPECIAL **$575.00**

520 Gal. Capacity - REG. FLEET PRICE ..... $674.00

EARLY BIRD SPECIAL **$628.00**

PRICED KNOCKED DOWN - LESS PUMP



## 300, 400 & 500 GALLON LONG TRAILER SPRAYERS

- Long Trailer Gives Better View And Stability
- Convertable Bolt-On Saddles
- Heavy-Duty Adjustable Axle W/6 Bolt Flotation Rims

300 GAL. - 8 Row Boom with plumbing for centrifugal pump.
REG. FLEET PRICE ..... $ 809.00

EARLY BIRD SPECIAL **$ 753.00**

300 GAL. - 10 Row Boom with plumbing for centrifugal pump.
REG. FLEET PRICE ..... $ 878.00

EARLY BIRD SPECIAL **$ 818.00**

400 GAL. - 8 Row Boom with plumbing for centrifugal pump.
REG. FLEET PRICE ..... $ 884.00

EARLY BIRD SPECIAL **$ 822.00**

400 GAL. - 10 Row Boom with plumbing for centrifugal pump.
REG. FLEET PRICE ..... $ 953.00

EARLY BIRD SPECIAL **$ 886.00**

500 GAL. - 10 Row Boom with front jack stand.
REG. FLEET PRICE ..... $1174.00

EARLY BIRD SPECIAL **$1036.00**

2 Row Extension Kit to convert 10 Row to 12 Row.
FLEET PRICE ..... $ 36.00

PRICED KNOCKED DOWN - LESS PUMP & TIRES

## SELF-PRIMING PORTABLE PUMP

A versatile centrifugal pump. Can be used for draining of sumps, cellars, excavations, liquid fertilizer, filling tanks, marine bilge service, livestock watering, irrigation and many other applications. Pump made of non-corrosive thermo polyester with neoprene wear plate. 2" inlet/outlet.
REG. FLEET PRICE..$158.83



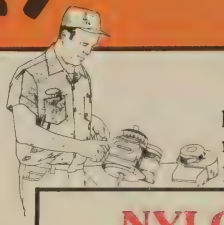
FLEET Special **129.00**

## TRANSFER PUMP

A superior portable pump, self-priming and powered by famous 3 H.P. Briggs & Stratton Engine. 2" inlet/outlet, 7200 GPH capacity. Build for longer life, easier servicing, extra thrifty operation.
REG. FLEET PRICE..... $158.83



FLEET Special **129.00**



Every **QUALITY FARM & FLEET** has a REPAIR SHOP, right at the Store, with repair kits or parts and service for transfer pumps, hydraulic pumps and motors.

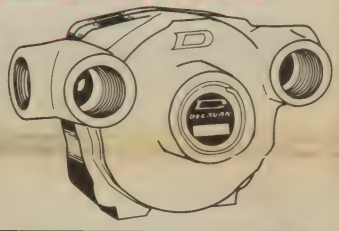


## ACE QUICK COUPLER PTO DRIVEN CENTRIFUGAL PUMP

Designed for direct mounting on 1⅜" 600 rpm PTO shaft. 0-60 PSI. Extra long life and maintenance-free performance. Belt driven. Includes Positive Splined PTO Coupler.
**For 540 RPM.**
No. PTOC-600-10-QC.
FLEET PRICE.....**$121.75**

## NYLON ROLLER PUMPS

Delavan pumps feature cast iron case, hard chromed steel sleeves, precision molded, weighted and balanced nylon rollers, Shielded ball bearings, rubber compound cartridge type seals and precision ground stainless steel shaft.



| Description | FLEET PRICE |
|---|---|
| 6 Roller Case W/Coupler | $36.48 |
| 7 Roller Case W/Coupler | 44.80 |
| 7 Roler Ni-Resist | 70.21 |

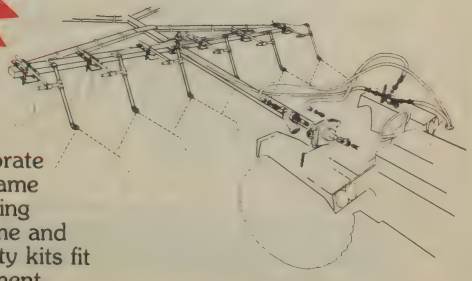


## ACE HYDRAULIC CENTRIFUGAL PUMP

A centrifugal pump with hydraulic motor coupled to the pump. An ideal solution to free the PTO. Mounts right on your sprayer trailer, nurse tank or tractor in any position . . . even upside down. Also popular for side mount application. No. FMC-HYD 204.
FLEET PRICE.....**$129.00**

NEW AT QUALITY FARM & FLEET!

## DISC BOOM KIT

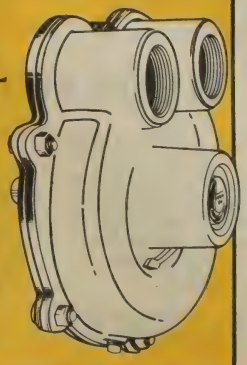


Add to your disc harrow to apply and incorporate herbicides at the same time the soil is being worked. Saves time and energy. Heavy-duty kits fit most large equipment.

FLEET PRICE
No. 36270-1, for 9' thru 15' discs. **$ 99.78**
No. 36270-2, for 16' thru 22' discs. **$144.87**

## DELAVAN TURBO 90™ CENTRIFUGAL PUMP

Workhorse Turbo 90™ turbine pump has high capacity (up to 60 GPM at 30 PSI), handles wettable powders and suspensions with less clogging and wear because of self-flushing seal cavities. Flow range capacity of up to 90 GPM. Complete w/coupler for 1000 RPM tractors.
REG. FLEET PRICE..... $88.40



# When you think hydraulics, think Quality Farm & Fleet!

## 4 IN ONE CONVERTA VALVE




Operates as 4-way for double acting cylinders or 2-way for control of hydraulic motors. Can easily be converted to 3-way operation for single acting cylinders or 1-way operation of motors. No. SCV.
REG. FLEET PRICE ..... $33.11

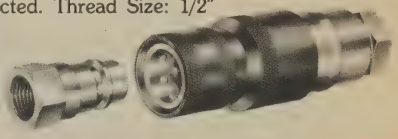
## HYDRAULIC COUPLER

Two-way sleeve allows connection/disconnection by moving the sleeve in either direction. Interchangeable with most popular brands of hydraulic couplers. Thread Size: ½" NPTF. No. S40-4.
REG. FLEET PRICE ..... $6.74




## FULL PRESSURE HYDRAULIC COUPLER

Hand connect your hydraulic systems without relieving pressure. Completely safe under all conditions. Automatically seals when disconnected. Thread Size: 1/2" NPTF. No. S60-4.
FLEET PRICE.. $13.83



## CROSS HYDRAULIC CYLINDERS

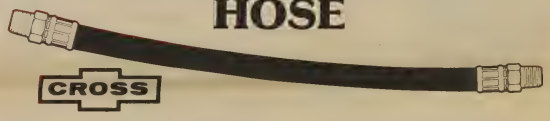



Cross Cylinders are designed for modern farm applications. Rugged construction for long life. Double ported base - single port on rod end for mounting ports in line. Positive-lock clamp-on rod clevis standard.

| Bore & Stroke | PSI | FLEET PRICE |
|---|---|---|
| 2" x 8" | 2500 | $34.89 |
| 3" x 8" | 2500 | 43.25 |
| 3½" x 8" | 2500 | 50.75 |
| 4" x 8" | 2500 | 67.97 |

Cylinders W/Stroke Control Available — $8.00 Extra.

## HYDRAULIC HOSE




Cross precision fittings and pressure controlled swedging assure maximum quality in finished hose assemblies. Meet or exceed SAE Specifications. ½" N.P.T. Male Ends.

| ⅜" 2 WIRE BRAID | | ½" 2 WIRE BRAID | |
|---|---|---|---|
| Length | FLEET PRICE | Length | FLEET PRICE |
| 15" | $ 3.19 | 15" | $ 3.42 |
| 24" | 4.13 | 24" | 4.50 |
| 36" | 5.38 | 36" | 5.84 |
| 48" | 6.64 | 48" | 7.39 |
| 60" | 7.92 | 60" | 8.83 |
| 72" | 9.22 | 72" | 10.30 |
| 84" | 10.43 | 84" | 11.75 |
| 96" | 11.70 | 96" | 13.20 |
| 108" | 12.95 | 108" | 14.62 |
| 120" | 14.20 | 120" | 15.85 |
| | | 144" | 18.78 |
| | | 168" | 21.45 |
| | | 192" | 24.97 |

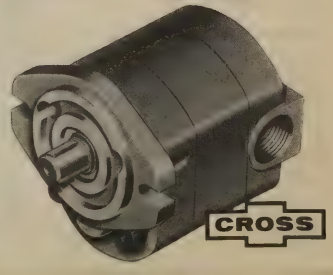



- 100% Brazilian Sisal
- 9,000 Ft. Per Bale
- 325 Lb. Tensil Strength
- Knotless and Uniform
- Treated to Resist Rodents, Insects, Rot and Mildew

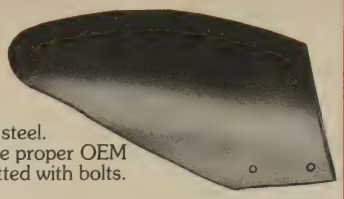
No. 9000-37
FLEET PRICE ..... $12.95

## HYDRAULIC PUMP

Rated to 15 GPM @ 3000 PSI. Pressure balanced loading plates Integral gear and shaft. Bi-rotational for conversion to pump or motor. ⅞" Keyed Shaft. Ideal for log splitters.
No. 40M005.
FLEET PRICE..... $60.87



# MOLDBOARDS
## FOR BLADE TYPE PLOWS



Made from C1080 solid grade plow steel. Individually ground by hand to insure proper OEM specifications. All moldboards are fitted with bolts.

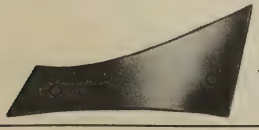
| Repl. No. | To Fit | Plow Series | FLEET PRICE |
|---|---|---|---|
| 326070 | AC 16" | 333-363 | $29.62 |
| 347966 | AC 14" & 16" | 387 | 34.59 |
| EX16 | Case 16" | EX | 29.59 |
| HS314 | Deere 14" | HS | 25.58 |
| HS316 | Deere 16" | HS | 32.98 |
| AA14885 | Deere NU 16" | NU | 42.40 |
| 104409 & 104425 | Ford 14" | GP | 30.69 |
| 104412 & 104426 | Ford 16" | GP | 34.38 |
| 462313 | IHC 14" | HS | 30.69 |
| 462314 | IHC 16" | HS | 31.59 |
| 522328 | IHC 14" S.C. | GP | 27.28 |
| 522329 | IHC 16" S.C. | GP | 30.79 |
| 515710 | IHC 14" P.C. | PC | 26.89 |
| 520194 | IHC 16" P.C. | PC | 29.62 |
| NC219-14 | Oliver 14" | 219 | 30.69 |
| NC219-16 | OLiver 16" | 219 | 34.55 |
| R419-14 | Oliver 14" | 419-619 | 30.69 |
| R419-16 | Oliver 16" | 419-619 | 34.55 |
| R919-16 | Oliver 16" | 919 | 34.55 |

# LANDSLIDES WITH BOLTS



## FOR BLADE-TYPE PLOWS

| Repl. No. | To Fit | Plow Series | FLEET PRICE |
|---|---|---|---|
| 342942 | AC Front | 333-363 | $ 5.65 |
| 337422 | AC 387 | 387 | 4.12 |
| T10856 | Case Rear (fits front) | EX | 6.32 |
| AA15611 | Deere | HS-NU | 9.49 |
| AA15262 | Deere Wear Plate (for above) | | 4.53 |
| 107980 | Ford Front | GP | 5.67 |
| 104356 & 100600 | Ford Front | GP | 7.65 |
| 660002 | MF | H | 8.07 |
| 522342 | IHC S.C. Front | SC | 9.07 |
| 522343 | IHC S.C. Rear | SC | 12.58 |
| 515658 | IHC P.C. Front | PC | 5.46 |
| 515661 | IHC P.C. Rear W/Wheel | PC | 13.12 |
| EP8154 & 217194 | Oliver Front | 219 | 7.74 |
| 218270B | Oliver-Both-Offset | 419-619 | 8.97 |



# SHINS WITH BOLTS

| Repl. No. | To Fit | Plow Series | FLEET PRICE |
|---|---|---|---|
| 324940 | AC 14" & 16" | 333-363 | $ 5.54 |
| 347649 | AC387 14" & 16" | 387 | 5.54 |
| E16 | Case 16" | EX | 5.87 |
| 8195A | Deere 14" | HS | 5.75 |
| 8196A | Deere 16" | HS | 5.87 |
| AA14883 | Deere NU 16" | NU | 6.15 |
| 104403 & 104428 | Ford 12"-14"-16" | GP | 6.12 |
| 660020 | MF 12"-14"-16" | N | 6.12 |
| 522325 | IHC S.C. 14"-16" | SC | 6.27 |
| 515680 | IHC P.C. 12"-14"-16" | PC | 6.12 |
| EP7490 | Oliver 12"-14"-16" | 219-419-619 | 5.27 |

# ADAMS Hard-Facing Company PLOW SHARES

*GUARANTEED AGAINST BREAKAGE

## SAVE FUEL
WITH EASY-PULLING SELF-SHARPENING ADAMS ROCK SHARES



## ADAMS HARDFACED ROCK SHARES

Constructed of exclusive high impact steel with Famous Adams hardfaced process covering the nose and cutting edge. Designed to stay sharp and pull easy to minimize fuel consumption.



## ADAMS SUPER ROCK SHARES

Heaviest share on the market. Made from high strength, heat treated plow steel. Designed to penetrate easy and stay in the ground.

| Plow Make | Share Length | No. of Holes | FLEET PRICE Regular Rock Shares | FLEET PRICE Hardfaced Rock Shares |
|---|---|---|---|---|
| *Allis 387* | *16"* | *4* | ***$6.95*** | ***$16.99*** |
| Allis 387 | 18" | 4 | 8.38 | — |
| Case EX | 14" | 4 | 6.91 | 17.57 |
| Case EX | 16" | 4 | 7.56 | 17.99 |
| Ford GP | 14" | 4 | 5.91 | 15.69 |
| Ford GP | 16" | 4 | 6.38 | 16.99 |
| Ford GP | 18" | 5 | 7.56 | — |
| IHC S.C. | 14" | 3 | 5.91 | — |
| IHC S.C. | 14" | 4 | 5.91 | 15.69 |
| IHC S.C. | 16" | 4 | 6.38 | 16.99 |
| IHC S.C. | 18" | 4 | 7.56 | 18.99 |
| J. Deere HS | 14" | 3 | 5.91 | — |
| J. Deere HS-NU | 14" | 4 | 5.91 | 15.69 |
| J. Deere HS | 16" | 3 | 6.38 | — |
| J. Deere HS-NU | 16" | 4 | 6.38 | 16.99 |
| J. Deere NU | 18" | 5 | 7.56 | 18.99 |
| MF N | 14" | 4 | 5.91 | 15.69 |
| MF N | 16" | 4 | 6.38 | 16.99 |
| Oliver | 14" | 4 | 5.91 | 15.69 |
| Oliver | 16" | 4 | 6.38 | 16.99 |
| Oliver | 18" | 5 | 7.56 | 18.99 |

***ADAMS TILLAGE GUARANTEE**
**"If You Break It, We Replace It!"**

Adams Rock Shares are 100% guaranteed against breakage while in use on the tillage machine for which it was designed. This guarantee is good as long as the share has a usable cutting edge.

## 3 PT. UTILITY BLADES

Indexes full 360° on the tractor; reversible ½" x 6" cutting edge; side tilt by offsetting hitch pins; moldboard 15" high 12" offset feature for 24" total adjustment.

FLEET Special 6' BLADE **123.00**

SOME ASSEMBLY REQUIRED

6' blade, 40 H.P. capacity.
REG. FLEET PRICE..... $138.00

7' blade, 40 H.P. capacity.
REG. FLEET PRICE..... $154.75

FLEET Special 7' BLADE **138.11**

aq-tronic inc. the manufacture progress

## 8 H.P. PORTABLE ELECTRIC GENERATOR

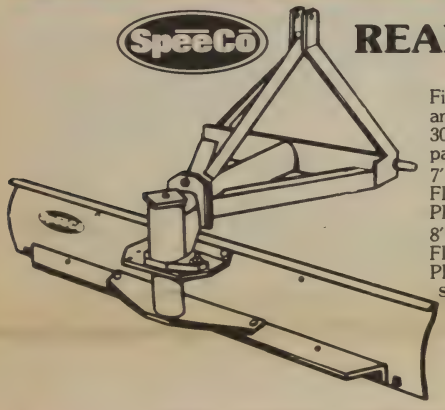
NEW AT QUALITY FARM & FLEET!



For protection against costly power outages, and for electric power where power lines don't go. Briggs & Stratton Industrial Type 8 H.P. Engine. Two outlets give 3000 watt output at 120 volts/25 amps and 240 volt/13 amp. Rotary field design for greater motor starting capacity and longer life. Will provide power for 1/3 H.P. furnace fan, deep freeze, refrigerator, 300 watt lighting, sump pump, and television set all at the same time. No. A3.
FLEET PRICE..... **$599.00**

## REAR BLADES

SpeeCo



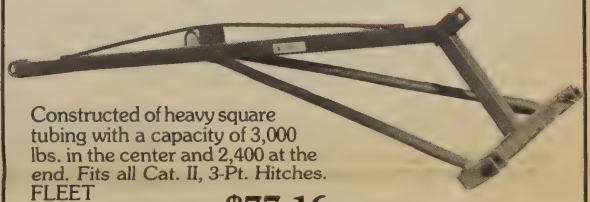
Five forward and five reverse angle adjustments. Blade tilts 30° for ditching. 60 H.P. capacity.

7' Blade, No. RB27172.
FLEET PRICE.... **$267.00**

8' Blade, No. RB27182.
FLEET PRICE.... **$289.00**

SOME ASSEMBLY REQUIRED

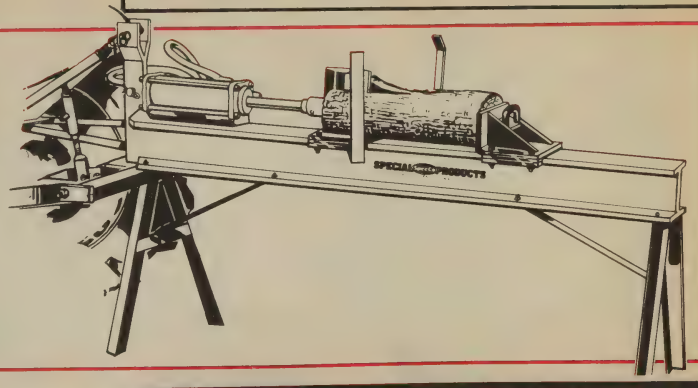
## HEAVY DUTY 3 PT. BOOM



Constructed of heavy square tubing with a capacity of 3,000 lbs. in the center and 2,400 at the end. Fits all Cat. II, 3-Pt. Hitches.
FLEET PRICE..... **$77.16**

SpeeCo

## 3 PT. LOG SPLITTER



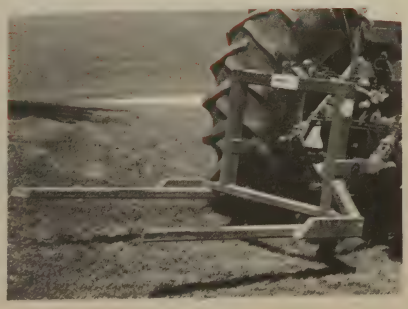
Constructed with high strength wide flange steel I-beam. Standard 3-point A-frame for Category I - 26 inch and Category II - 32 inch lift arm spacing. Exclusive Quick Adjust Splitting Wedge allows use of 8 inch stroke cylinder. (Cylinder, legs and valve not included.) No. LS400103.
FLEET PRICE..... **$149.00**

Legs, No. LS400104.
FLEET PRICE..... **$22.80**

3½" x 8" Cylinder. No. 3508DB.
FLEET PRICE..... **$50.75**

4 in 1 Converta Valve, No. SCV.
FLEET SPECIAL..... **$23.88**

## BALE MOVER



Designed to carry 800 and 1,500 lb. bales. Constructed of 3" x 2" and 3" x 3" square tubing for maximum strength. Wide tine spacing for easier bale loading. No. E-510.
FLEET PRICE. **$166.00**

## CANVAS TARPS

All tarps have double stitched seams, double reinforced corners and rot resisting thread.

FLEET Special



| Cut Size | Approximate Finished Size | Fabric Weight | Regular Fleet Price | FLEET Special |
|---|---|---|---|---|
| 8' x 10' | 7'1" x 9'5" | 10 Oz. | $17.65 | $14.87 |
| 8' x 12' | 7'1" x 11'5" | 10 Oz. | 18.85 | 15.91 |
| 10' x 14' | 9'1" x 13'4" | 12 Oz. | 33.54 | 27.97 |
| 12' x 16' | 11'2" x 15'4" | 12 Oz. | 44.87 | 37.88 |

# Tractor Parts & Accessories

## TRACTOR MUFFLERS



Made of 16 ga. aluminized steel for superior heat resistance and longer life. Free-flow design for better engine performance.

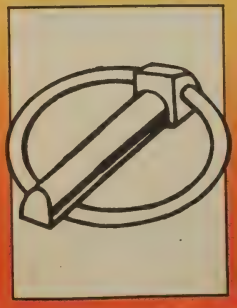
| No. | Description | FLEET PRICE |
|---|---|---|
| AC-4 | Allis WD-45, D-17 | $ 7.75 |
| AC-5 | IHC A 100, 200, 300 | 7.47 |
| CA-1 | Case C, D, 400, 700 | 8.78 |
| CA-3 | Case S & SC | 7.68 |
| CA-7 | Case 530, 630 | 8.68 |
| FO-3 | Ford 9N, 8N, 2N Horizontal | 6.87 |
| FO-4 | Ford NAA 600 thru 900 | 4.86 |
| FO-9 | Ford 9N, 8N, 2N Vertical | 8.96 |
| IH-4 | IHC H, Super H, 300, 350 | 7.27 |
| IH-9 | Farmall 460, IHC 460, 560, 606, 660, G & D | 9.20 |
| IH-10 | IHC 300, 350, Utility, H, HV, Super H & HV Super W-4, W-6, WD-6, 400, 450, W-400, W-450, Super M-TA, Super M, 340, Diesel, Utility, 460 Utility, 560, 460 Super MV, Super MD, Super MDV, Super W-6, Super W-6, Super WG-TA, Super WD-6, Diesel | 7.29 |
| IH-14 | IHC 706G, 806 G & D | 10.30 |
| IH-21 | IHC 1456, 1026 (Case & Diesel) 1466, 1066 Diesel Vertical | 28.95 |
| JD-1 | Deere A, 60, 70, 620, 720 | 6.97 |
| JD-4 | Deere 8 50, 520, 530 | 5.88 |
| JD-21 | Deere 3010 G & LP, 3010 D to 1T6643. 3020 G & LP, 4010 G, LP & 4010 D to 2T7026, 4020 G & LP | 11.87 |
| JD-22 | Deere 4010 Diesel 217026 UP, 4020 D | 12.98 |
| MF-15 | Massey Harris 33, 44, 44D | 6.67 |
| MF-16 | Ferguson T020, T030 | 8.47 |
| OL-6 | Oliver 770, 870, 1600, 1650 | 7.95 |
| OL-7 | Oliver 1650D, 1800, 1850, G, D, & LP | 11.87 |
| OL-11 | Oliver 1755D, 1750D, 1655D, 1650G, 1850D, 1855 Gas | 32.78 |

## 6 VOLT OR 12 VOLT TRACTOR LIGHTS



4½" sealed beam utility lamp. Includes adjustable bracket. No. 203400, 6 Volt; No. 203600, 12 Volt.
FLEET PRICE..... $5.87

## SpeeCo LINCH PINS

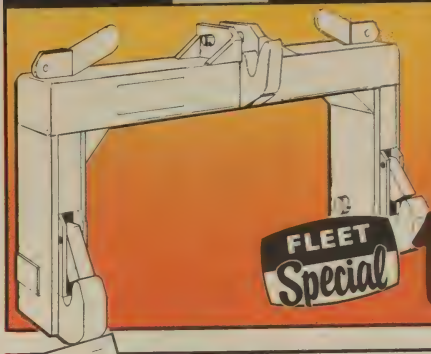


7/16" Linch Pins.
REG. FLEET PRICE ... 25¢ Ea.

FLEET Special

8/88¢

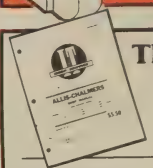
## FLEETLAND QUICK HITCH



Hook up to, release from 3 pt. equipment in seconds rather than minutes. Easily mounts on Cat. 2 tractors. Engineered and built to take the punishing treatment of hard work.
Cat. 2 Quick Hitch
REG. FLEET PRICE.....$169.00

FLEET Special 139.00

## TRACTOR REPAIR MANUALS



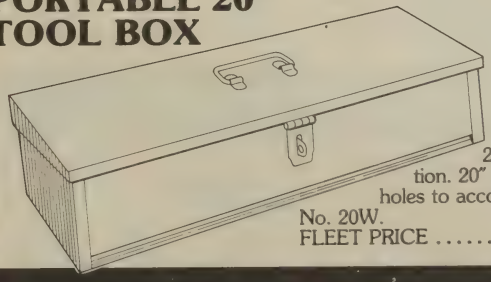


Illustrated in exact detail to cover almost every repair job that could happen. Explains how to find the problem and details how to fix it. Includes Gas, LP & Diesel engines.

| For Tractor Model | Book Number | FLEET PRICE |
|---|---|---|
| **INTERNATIONAL HARVESTER** | | |
| Super & Non-Super Series A, B, C Cub Prior 1957, H, M, MTA, 4, 6, W6TA, 9 | IH-8 | $4.64 |
| Series 300, 300 Utility, 350, 350 Utility, 400, W400, 450, W450 | IH-10 | 4.64 |
| Series 460, 560, 660, 606, 2606 | IH-25 | 4.97 |
| Series 706, 756, 806, 856, 1206, 1256, 1456, 2706, 2756, 2806, 2856, 21206, 21256, 21456 | IH-32 | 4.97 |
| **MASSEY FERGUSON** | | |
| Models TE20, T020, T030 | FE-2 | 3.84 |
| Models T035, F40, MH50, MHF202 MF35, MF50, MF202, MF204 | MF-14 | 4.64 |
| Models MF135, MF150, MF165 | MF-27 | 4.97 |
| **OLIVER & COCKSHUTT** | | |
| Super & Non-Super 66, 77, 88, 770, 880 | O-10 | 7.68 |
| Series 1750, 1800, 1850, 1900, 1950, 1950-T | O-21 | 6.87 |
| Series 1550, 1555, 1600, 1650, 1655 | O-23 | 6.10 |
| Series 1755, 1855, 1955 | O-24 | 4.23 |
| **ALLIS-CHALMERS** | | |
| Models, B, C, CA, G, RC, WC, WD, WD45, WD45 Diesel, WF | AC-11 | 4.97 |

| For Tractor Model | Book Number | FLEET PRICE |
|---|---|---|
| **ALLIS-CHALMERS Continued** | | |
| Models D-14, D-15, D-15 Series II, D-17, D-17 Series III, D-17 Series VI | AC-17 | $4.97 |
| Model D-19 | AC-23 | 4.23 |
| **J.I. CASE** | | |
| Series 400, 700B, 800B | C-9 | 4.64 |
| Series 500, 600, 900B | C-10 | 4.23 |
| Series 730, 830, 930, 1030 | C-21 | 5.39 |
| Series 770, 870, 970, 1070, 1090, 1170, 1175 | C-28 | 4.64 |
| **JOHN DEERE** | | |
| Series A, B, D, G, H, M, MT | JD-4 | 4.64 |
| Models 50, 60, 70 | JD-10 | 4.23 |
| Models 720 Diesel, 730 Diesel | JD-11 | 4.64 |
| Series 520, 530, 620, 630, 720, 730 Series 1010, 2010 | JD-16 JD-21 | 4.64 3.97 |
| Series 3010, 3020, 4010, 4020, 5010, 5020 | JD-29 | 4.64 |
| Series 4320, 4520, 4620 | JD-34 | 4.23 |
| Series 4030, 4230, 4430, 4630 | JD-35 | 4.64 |
| **FORD** | | |
| Series 2N, 8N, 9N | FO-4 | 3.84 |
| Model NAA | FO-19 | 3.84 |
| Series 501, 600, 601, 700, 701, 800, 801, 900, 901, 1801, 2000 (4-cyl.), 4000 (4-cyl.) | FO-20 | 6.10 |

## PORTABLE 20" TOOL BOX



Mounting brackets designed to fit most tractors. 20 ga. steel construction. 20" x 6" x 5". Knockout holes to accomodate grease gun.
No. 20W.
FLEET PRICE ..... $7.63

## QUALITY BUCKET CUSHION



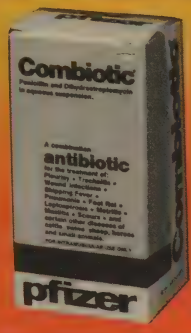
Foam filled cushion for all bucket-type tractor and implement seats.
No. 505.
REG. FLEET PRICE ..... $5.43

FLEET Special 3.99

# COMBIOTIC®

Anti-bacterial agent combining penicillin with dihydrostreptomycin sulfate for wider coverage of protection. 100 cc. No. 3849.
REG. FLEET PRICE ..... $4.75

FLEET Special **3.19**







# KENDALL MASTITIS FORMULA

Broad spectrum formula for acute and chronic mastitis. One 10 cc syringe. No. D-834.
FLEET PRICE..... 56¢ Ea.




# KENDALL MILK FILTERS

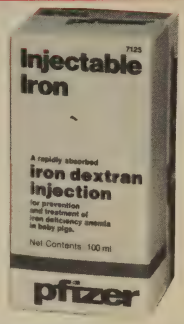
Kendall non-gauze discs and socks stop more sediment, filter faster, and cost less.

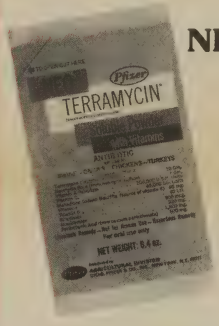



| No. | Description | Size | FLEET PRICE |
|---|---|---|---|
| D-107 | Filter Discs | 6" | $1.47 |
| D-109 | Filter Discs | 6½" | 1.55 |
| D-558 | Super Socks | 2" x 24" | 7.19 |
| D-559 | Super Socks | 2 -3/16" x 24" | 7.75 |
| D-576 | Break-Proof Socks | 2" x 24" | 8.36 |
| D-577 | Break-Proof Socks | 2 -3/16" x 24" | 8.98 |

# pfizer INJECTABLE IRON

Prevents baby pig anemia. 100 ml rubber-stoppered vial. No. 7125.
FLEET PRICE..... $5.77




# NEO-TERRAMYCIN® SOLUBLE POWDER

Fights scours, respiratory infections, and enteric disease in cattle. Mix with water. 6.4 Oz. Bag. No. 7485.
FLEET PRICE..... $2.89

# PENICILLIN "G" PROCAINE

An injectable anti-bacterial agent effective against a wide variety of diseases. 100 ml. No. 1690.
FLEET PRICE..... $3.98

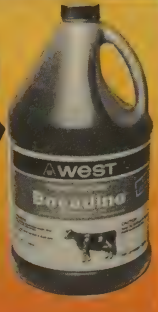



# DAIRY SPECIALS

## BOVADINE TEAT DIP

"Tamed Iodine" sanitizing teat dip for use after each milking to keep mastitis producing bacteria from entering the teat canal. 1 Gal. No. 12390.
REG. FLEET PRICE ..... $6.38

FLEET Special **4.77**




FLEET Special **5.88**

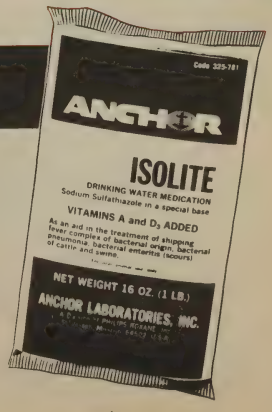



## IOSAN GERMICIDE CLEANER

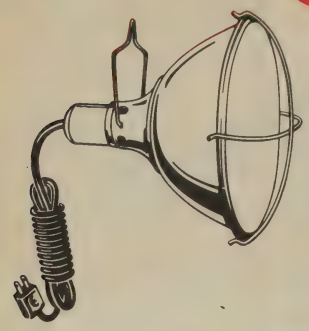
With "Tamed Iodine" to clean utensils after each milking to kill bacteria and to keep cows from becoming infected. 1 Gal. No. 12460.
REG. FLEET PRICE ..... $7.67

# ANCHOR ISOLITE

Mix with feed or water to treat pneumonia and scours. Effective on controlling shipping fever in newly shipped cattle. 1 Lb. Bag. No. 325-781.
FLEET PRICE..... $6.08



# Livestock Supplies



## BROODER LAMP

Stainless reflector with porcelain socket. No. 165M.
FLEET PRICE..... $3.19

## BROODER BULBS

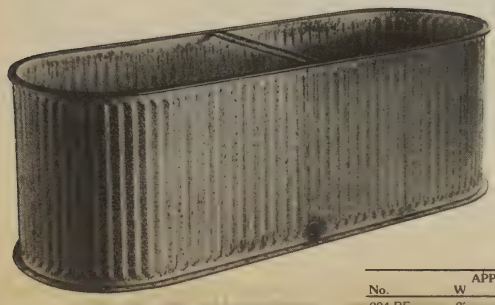
250 Watt Infra-Red Heat Bulb, White.
No. 06858.
REG. FLEET PRICE ..... $1.19 Ea.

FLEET Special

89¢

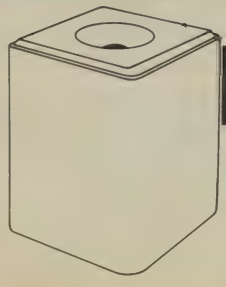



## GALVANIZED STOCK TANKS



Constructed of 20 gauge corrugated steel. Top flange is rolled to produce triple thicknesses of hydraulically welded steel. ¾" drain flange.

| No. | APPROX. W | H | L | FLEET PRICE |
|---|---|---|---|---|
| 224-RE | 2′ | 2′ | 4′ | $30.95 |
| 225-RE | 2′ | 2′ | 5′ | 37.20 |
| 226-RE | 2′ | 2′ | 6′ | 45.85 |
| 227-RE | 2′ | 2′ | 7′ | 53.85 |
| 2528-RE | 2½′ | 2′ | 8′ | 61.80 |



## DIAMOND SALT BLOCK

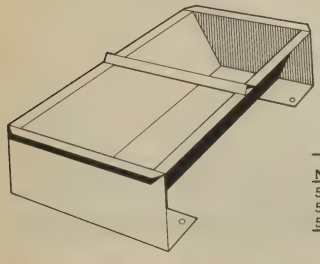
50 Lb. Block.
Check your local Quality Farm & Fleet Store for everyday low Fleet Prices.

## QUIK-CALF MILK REPLACER

Not less than 25% crude protein, not less than 10% crude fat and not more than 1% crude fiber. For fast, healthy growth of calves several days old. 50 Lb. Bag. No. FM-2.
FLEET PRICE..... $12.98

QUIK-CALF SUPER FORMULA
50 Lb. Bag
FLEET PRICE..... $17.48



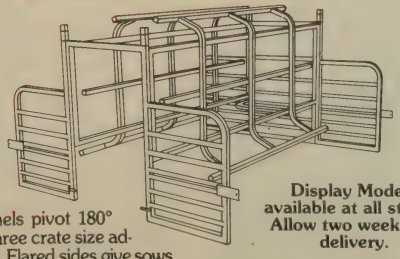



## HOG TROUGH

Crafted of welded 14 gauge steel to make them leak-proof. Protected with non-toxic paint.

| No. | Length | FLEET PRICE |
|---|---|---|
| 550013 | 2′ | $ 9.26 |
| 550015 | 4′ | 13.10 |
| 550017 | 6′ | 18.16 |

## ADJUSTABLE FARROWING CRATE

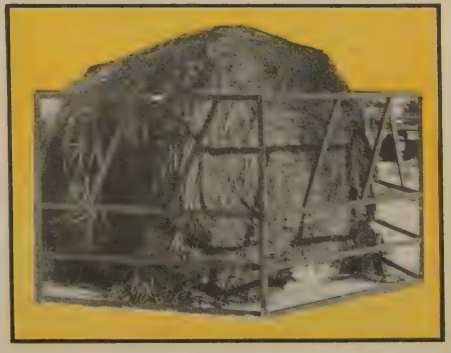


Side panels pivot 180° to give three crate size adjustment. Flared sides give sows more room for nursing. 1¼" square tubing. No. 1.
FLEET PRICE ..... $137.50

**Display Models available at all stores. Allow two weeks for delivery.**

## ROUND BALE HAY FEEDERS

Made in three sections that bolt together to form six-sided feeder. Slant bars save more hay. 1¼" sq. tubing. 48" high, 8½′ diameter. No. 644-S.
FLEET PRICE.. $136.50



# POLYESTER CORD TIRES




- Full 4 Ply Polyester Cord Construction
- 12/32" Tread Depth
- Whitewall

A78-13 LOW AS **22.95** Plus $1.72 Excise Tax

| No. | FLEET PRICE | F.E.T. |
|---|---|---|
| A78-13 | $22.95 | $1.72 |
| C78-13 | 25.75 | 1.97 |
| C78-14 | 26.44 | 2.01 |
| E78-14 | 28.02 | 2.23 |
| F78-14 | 29.29 | 2.37 |
| G78-14 | 30.05 | 2.53 |
| H78-14 | 32.49 | 2.73 |
| G78-15 | 31.57 | 2.59 |
| H78-15 | 33.10 | 2.79 |
| J78-15 | 33.84 | 2.96 |
| L78-15 | 34.74 | 3.09 |

# FREE

## VALVE STEMS
For your safety and protection, free valve stems installed with all tubeless passenger tires purchased and mounted at Quality Farm & Fleet.

## MOUNTING
All passenger tires except front wheel drive, sport wheels and split rims.




# DOUBLE DUTY HIGHWAY TRUCK TIRES




- Strong Nylon Cord
- Massive Tread and Shoulder Design

7.00-15, 6 PLY RATING LOW AS **33.53** Plus $2.85 Excise Tax

| Size | Ply Rtg. | FLEET PRICE | F.E.T. |
|---|---|---|---|
| **TUBE TYPE** | | | |
| G78-15 | 6 | $ 35.03 | $3.04 |
| H78-15 | 6 | 37.71 | 3.25 |
| H78-15 | 8 | 39.70 | 3.30 |
| L78-16 | 8 | 47.28 | 3.88 |
| 7.00-15 | 6 | 33.53 | 2.85 |
| 7.00-15 | 8 | 35.55 | 3.02 |
| 7.50-16 | 8 | 42.09 | 3.68 |
| 8.25-20 | 10 | 90.23 | 6.20 |
| 9.00-20 | 10 | 105.56 | 7.28 |
| 10.00-20 | 12 | 134.90 | 8.97 |
| 10.00-22 | 12 | 144.09 | 9.65 |
| **TUBELESS** | | | |
| G78-15 | 6 | 38.55 | 3.27 |
| H78-15 | 6 | 42.05 | 3.50 |
| 8.00-16.5 | 8 | 41.84 | 3.45 |
| 8.75-16.5 | 8 | 51.68 | 3.94 |
| 9.50-16.5 | 8 | 55.39 | 4.48 |
| 10.00-16.5 | 8 | 56.04 | 4.54 |
| 12.00-16.5 | 8 | 72.48 | 5.58 |

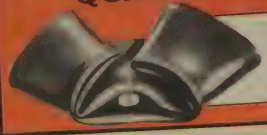
NO TRADE-IN REQUIRED!

# TIRE SERVICE CENTER AT EVERY STORE!




- Tire Repairs
- Spin Or Bubble Balancing

## QUALITY FARM & FLEET



TRUCK & FARM TUBES AVAILABLE

# TRACTOR FRONTS




- 3 Rib Design
- Nylon Cord Construction

| Size | Ply Rtg. | FLEET PRICE | F.E.T. |
|---|---|---|---|
| **TUBE TYPE** | | | |
| 4.00-15 | 4 | $15.74 | $ .53 |
| 4.00-19 | 4 | 20.43 | .66 |
| 5.00-15 | 4 | 17.40 | .69 |
| 5.50-16 | 6 | 21.23 | .96 |
| 6.00-16 | 6 | 23.13 | 1.05 |
| 6.50-16 | 6 | 24.92 | 1.24 |
| 7.50-16 | 6 | 30.22 | 1.65 |
| 7.50-18 | 6 | 34.22 | 1.84 |
| **TUBELESS** | | | |
| 11L-15 | 6 | 73.16 | 2.77 |
| 10.00-16 | 6 | 77.86 | 2.88 |

# Truck & Tractor Needs

## DURA-START BATTERIES







### 6-VOLT TRUCK/TRACTOR

Q.F.F. 6-volt batteries are suitable for use in any older model tractor, truck, or car requiring 6-volt starting power. 24 and 36 month.

### 12-VOLT TRUCK/TRACTOR

24 month batteries suitable for all late model trucks and tractors requiring 12-volt starting power.

### 6-VOLT TRUCK & TRACTOR

| No. | Cold Cranking Power | Mo. Guar. | Total Plates | FLEET PRICE |
|---|---|---|---|---|
| 1DT24 | 460 | 24 | 45 | $23.24 |
| 1DT36 | 560 | 36 | 51 | 27.90 |
| 2DT36 | 590 | 36 | 57 | 28.96 |
| 3DT36 | 660 | 36 | 63 | 35.69 |
| 4DT36 | 720 | 36 | 69 | 38.90 |
| 3EH-DT24 | 663 | 24 | 75 | 39.84 |
| 4EH-DT24 | 800 | 24 | 87 | 49.94 |
| 5D24 | 830 | 24 | 75 | 46.67 |
| 7D24 | 940 | 24 | 87 | 55.22 |

### 12-VOLT TRUCK & TRACTOR

| No. | Cold Cranking Power | Mo. Guar. | Total Plates | FLEET PRICE |
|---|---|---|---|---|
| 3ETDT24 | 370 | 24 | 78 | $37.78 |
| 3EEDT24 | 300 | 24 | 54 | 28.98 |
| 30HDT24 | 520 | 24 | 90 | 47.89 |
| FDTDT24 | 480 | 24 | 90 | 63.92 |
| 17TF24 | 460 | 24 | 102 | 49.87 |
| 4DLT24 | 575 | 24 | 150 | 65.76 |

## OIL FILTERS




| No. | Applications | Regular Fleet Price | FLEET Special |
|---|---|---|---|
| PM-1 | Ford - AC Chrysler | $1.89 | $1.39 |
| PM-4 | GM - Chevy | 1.89 | 1.39 |
| PM-9 | GM - Chevy | 1.89 | 1.39 |
| PM-3 | Buick - Pontiac | 1.89 | 1.39 |
| PM-5 | Compacts | 1.89 | 1.39 |
| PM-3P | MF - IHC - AC | 1.33 | .99 |
| PM-X40 | AC | 1.21 | .99 |
| PM-IH-10 | IHC | 1.03 | .89 |
| PM-294 | John Deere | 1.09 | .89 |
| PM-IH-15 | IHC | 1.03 | .89 |

## PENNZOIL
### — the "Ask For" Motor Oil

100% pure Pennsylvania oil with Z-7 for maximum protection against rust, corrosion, varnish, sludge and acid.

| Weight | QUART PRICE | 24 QUART CASE PRICE |
|---|---|---|
| 20W/30W | 58¢ | $13.40 |
| 10W30 | 65¢ | 14.83 |
| 10W40 | 68¢ | 15.30 |




## QUAKER STATE

Quaker State your cars and trucks to keep them running young. Keeps engines free and clean from harmful sludge and varnish deposits.

| Weight | QUART PRICE | 24 QUART CASE PRICE |
|---|---|---|
| 20W/30W | 58¢ | $13.40 |
| 10W30 | 65¢ | 14.83 |
| 10W40 | 68¢ | 15.30 |



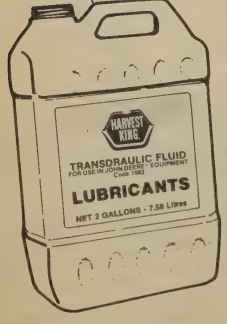




## ALL SEASON LITH-FLEX GREASE

Multi-purpose lithium base grease. For wheel bearings, chassis, water pumps, and other grease lubricated bearings.

| Description | FLEET PRICE |
|---|---|
| Cartridge, 14½ Oz. | $ .43 |
| Case of 50 | 19.93 |




## TRANSDRAULIC FLUIDS

Transmission-hydraulic fluids meet requirements of leading tractor manufacturers. 2 Gallon.

| No. | Make | FLEET PRICE |
|---|---|---|
| 1681 | Universal | $5.87 |
| 1682 | John Deere | 5.87 |
| 1688 | Ford | 5.43 |
| 1692 | IHC | 5.69 |




## HEAVY DUTY XHD-72

Meets all current car makers "SE" engine warranty requirements. Detergent motor oil in 20W, 30W and 40W.

| Grade | QUART PRICE | 2 GAL. PRICE | 24 QUART CASE PRICE |
|---|---|---|---|
| 20-20W | 59¢ | $4.80 | $13.68 |
| 30W | 59¢ | 4.80 | 13.68 |
| 40W | 59¢ | 4.80 | 13.68 |

## ALL-SEASON 10W30

Gives the same outstanding performance as HD XHD-72, but with the added advantages of multi-grade oil.

| Grade | QUART PRICE | 2 GAL. PRICE | 24 QUART CASE PRICE |
|---|---|---|---|
| 10W30 | 60¢ | $4.99 | $13.97 |







## NON DETERGENT

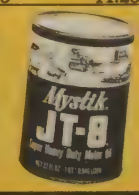
In individual SAE grades 10W, 20-20W, 30 and 40.

| Grade | QUART PRICE | 2 GAL. PRICE | 24 QUART CASE PRICE |
|---|---|---|---|
| 10W | 49¢ | $3.95 | $11.28 |
| 20-20W | 49¢ | 3.95 | 11.28 |
| 30W | 49¢ | 3.95 | 11.28 |
| 40W | 49¢ | 3.95 | 11.28 |

## JT8 10W40-20W50

Designed to surpass most requirements of automobile, truck, tractor & stationary engine manufacturers.

| Grade | QUART PRICE | 2 GAL. PRICE | 24 QUART CASE PRICE |
|---|---|---|---|
| 10W40 | 69¢ | $5.78 | $15.97 |
| 20W50 | 69¢ | 5.78 | 15.97 |



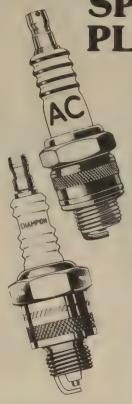
## MECHANICS CREEPER

Constructed of top quality hardwood. 35" overall length. 1¾" side rails with 4 cross-members. Sponge rubber headrest with vinyl covering. 2¾" nylon casters. No. 111.
REG. FLEET PRICE ..... $7.75

FLEET Special **4.93**



## AC OR CHAMPION SPARK PLUGS



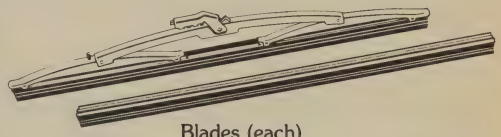

Brand name spark plugs at everyday low Fleet Prices.
Non-Resistor Plugs
FLEET PRICE... **75¢** Ea.
Resistor Plugs
FLEET PRICE... **95¢** Ea.

## PISTOL-GRIP GREASE GUN



Zinc plated - loads three ways. (Cartridge, Suction or Barrel Pump) No. 610.
FLEET PRICE... **$5.89**

ROBERT live edge™



## WIPER BLADES & Refills

Ice shedding, smoothly contoured shape. Non-glare finish. Refills will fit Trico and Anco.

Blades (each)
FLEET PRICE..... **$1.98**
Refills (per pair)
FLEET PRICE..... **$1.98**

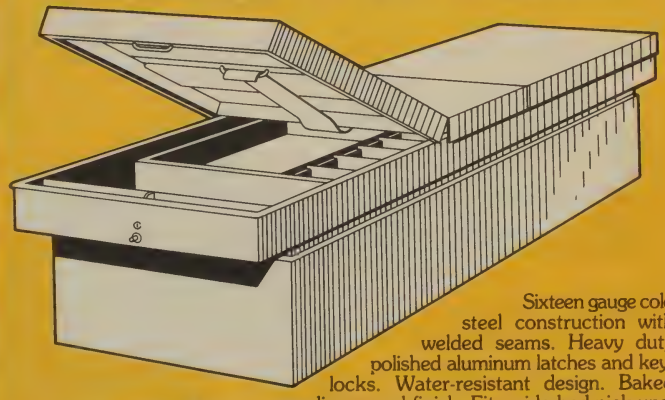
FOXCRAFT ADJUSTABLE
## JACK STAND

Full 1½ ton capacity. Heavy duty tubular steel construction. Three position adjustment from 11½" to 16½". Heavy duty steel support pin. No. JS-15.
FLEET PRICE..... **$2.93** Ea.



# Truck Accessories

## PICK-UP UTILITY BOX



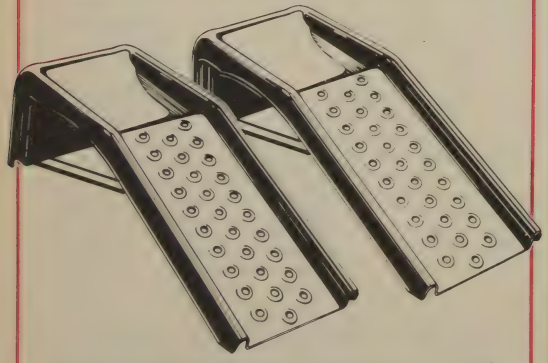
Sixteen gauge cold steel construction with welded seams. Heavy duty polished aluminum latches and key-locks. Water-resistant design. Baked acrylic enamel finish. Fits wide bed pick-ups. No. 1.
FLEET PRICE..... **$89.95**




## MUD FLAPS

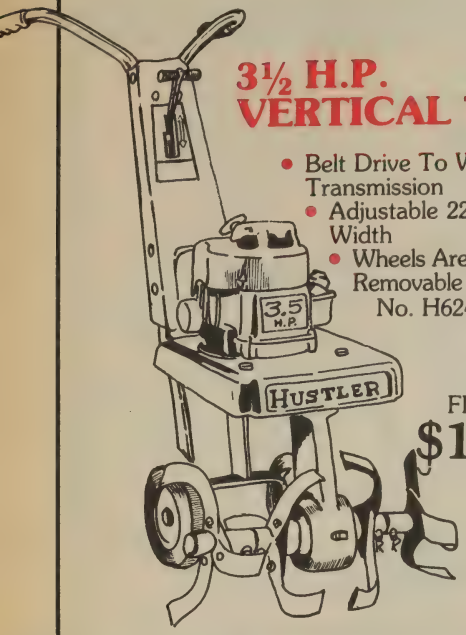
24" x 36". Made of rubber reinforced with nylon and rayon tire cord.
FLEET PRICE..... **$3.25** Ea.

FOXCRAFT
## AUTO RAMPS



Rugged steel construction. Supports up to 5,000 pounds in pairs.
No. CR-75.
FLEET PRICE..... **$19.88**

## 3½ H.P. VERTICAL TILLER

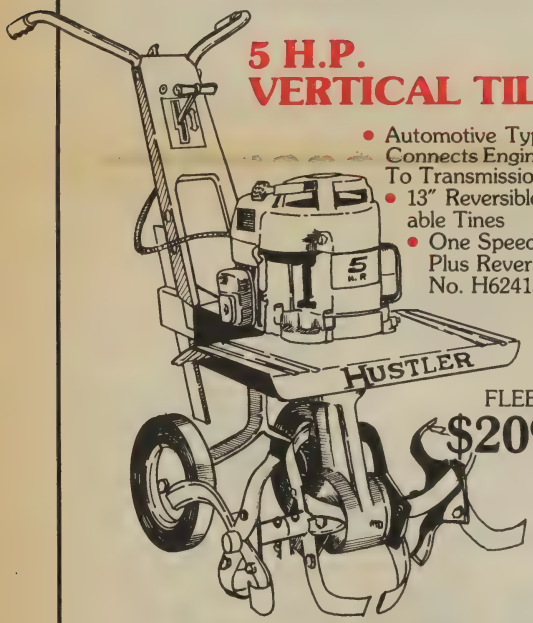



- Belt Drive To Worm Gear Transmission
- Adjustable 22" To 24" Tilling Width
- Wheels Are Adjustable And Removable

No. H62413

FLEET PRICE
**$167.75**

## 5 H.P. VERTICAL TILLER




- Automotive Type Clutch Connects Engine Directly To Transmission
- 13" Reversible/Expandable Tines
- One Speed Forward Plus Reverse

No. H62415

FLEET PRICE
**$209.00**



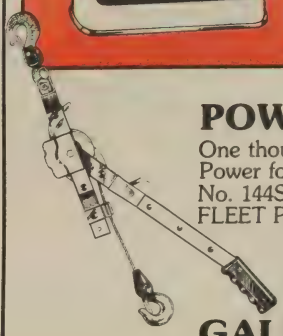
Every
**QUALITY FARM & FLEET**
has a full time REPAIR SHOP with parts and service for your gas-powered tiller, mower or garden tractor.

## FRUIT TREE SPRAY




A highly refined miscible, odorless oil for control of scale and mite eggs on roses, shrubs, shade and fruit trees.

| No. | Size | Regular Fleet Price | FLEET Special |
|---|---|---|---|
| 25-150 | Qt. | $2.67 | $1.77 |
| 25-200 | Gal. | 6.77 | 4.77 |



## POW'R-PULL

One thousand pound capacity winch hoist. Power for pulling, lifting and stretching.
No. 144S-6.
FLEET PRICE ..... **$25.50**

## 20 GALLON GALVANIZED GARBAGE CAN




Corrugated can w/double seamed bottom. Drop side handles.
*No. 920.*
FLEET PRICE ..... **$5.89**

Your Choice




**12¢** Per Pack

Choose your garden seeds early from our wide variety of flower and vegetable seed packages.
**While Quantities Last!**

## WILD BIRD FOOD




Twenty pound bag Regular Mixture with 10% Sunflower Seed.
FLEET PRICE ... **$2.88**
**While Quantities Last!**



**ASSORTED GRADE 2**
## NUTS, BOLTS & WASHERS

Your Choice!
**75¢**
Per Pound

# FLEETCREST COLORWORLD * PAINT SYSTEM *




OUR FINEST
ACRYLIC LATEX
**FLAT WALL PAINT**

FLEET Special **6.47**

Applies easily and dries quickly. Fully scrub washable. Most surfaces require only one coat. Soap and water clean-up. No's. 608-00, White; 608-49, Pastel Base; 608-50, Medium Base.
REG. FLEET PRICE $8.49

**"Our No Questions Asked" PAINT GUARANTEE**

**If you are not completely satisfied with the quality of Fleetcrest Paint, return the unused portion with your sales receipt for a full refund of the purchase price or replacement of a comparable paint.**

OUR BEST
ACRYLIC LATEX
**SEMI-GLOSS**

FLEET Special **7.88**

Combines the ease of application of latex with the durability of semi-gloss to give a smooth washable finish. One coat covers most surfaces. Soap and water clean-up. No's. 468-00, White; 468-49, Pastel Base; 468-50, Medium Base.
REG. FLEET PRICE $9.92




**Our Fleetcrest fine quality paints are equal to or better than any national brand or nationally advertised private label brand you can buy, plus, we save you money with Fleetcrest Paints because they are priced for savings over the nationally advertised brands at everyday low Fleet Prices.**

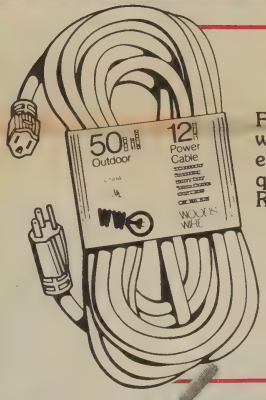
**Deep Tone Colors available at slightly higher prices.**

## RUST PREVENTIVE TRUCK, TRACTOR & IMPLEMENT ENAMEL

Quick drying, high gloss finish is ideal for interior and exterior wood and metal surfaces. A durable, tough finish with rust inhibitor. Available in popular colors.

Gallon FLEET PRICE ..... **$10.46**
Quart FLEET PRICE ..... **$ 3.11**
12 Oz. Spray Can FLEET PRICE ..... **$ 1.28**




## POWER CABLE

Fifty foot grounded outdoor cable. Twelve gauge wire with orange vinyl cover — remains flexible in extremely cold temperatures. Meets OSHA requirements. No. 529.
REG. FLEET PRICE ..... $16.76

FLEET Special **10.97**

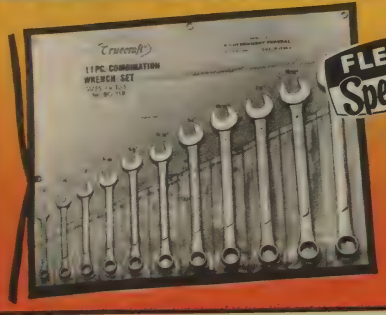


## UTILITY CHAIN BINDER

11" closed length. 2000 lb. stress load, 700 lb. leverage load. Handles chain up to ¼". No. 98.
REG. FLEET PRICE ..... $4.99

FLEET Special **2.97**

## 11 PIECE COMBINATION WRENCH SET

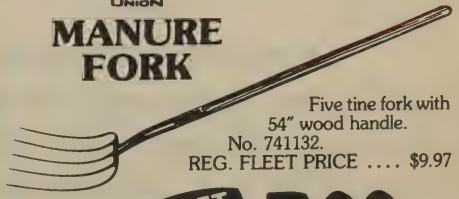



FLEET Special **17.88**

⅜" to 1" combination wrenches in a heavy vinyl roll. No. B011R.
REG. FLEET PRICE ..... $24.59

UNION

## MANURE FORK



Five tine fork with 54" wood handle. No. 741132.
REG. FLEET PRICE .... $9.97

FLEET Special **7.88**

# WOMEN'S CASUAL WEAR

## WOMEN'S SHIRTS

Long-sleeve Madras Plaids, Permanent Press. No. 44241 and No. 44252.
REG. FLEET PRICE ..... $9.97
WHILE QUANTITIES LAST!

FLEET Special **6.99** YOUR CHOICE

## WOMEN'S JEANS

100% cotton denim, western style jeans. Sizes 7-15. No. 33353.
REG. FLEET PRICE ..... $12.97

FLEET Special **8.99**




# We Have Casual & Work Clothing For Your Entire Family!

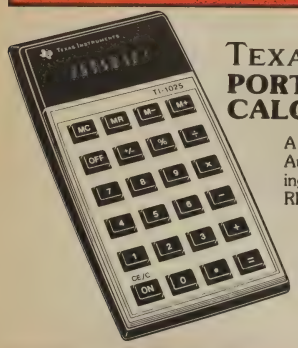
# MEN'S WORKWEAR



## key STRIPED COVERALLS

Ten ounce pre-shrunk fabric. Two-way zipper. Two breast pockets, two front pockets, two back pockets. Button collar and sleeves. Sizes: 34-46. No's. 990-08 or 971-18.
REG. FLEET PRICE ..... $17.49
(NOT EXACTLY AS SHOWN)

FLEET Special **12.88**




## TEXAS INSTRUMENTS PORTABLE ELECTRONIC CALCULATOR W/MEMORY

A functional calculator with versatile memory. Automatic constant with four functions, floating decimal. No. T1-1025.
REG. FLEET PRICE ..... $10.67

FLEET Special **8.67**



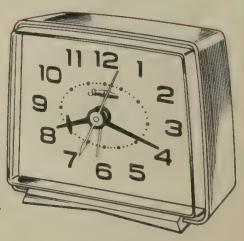
walker
## 8" LOGGER BOOT

Black wateproofed leather uppers. Full leather mid-sole with shaped logger heel. Non-marking composition sole. Goodyear Welt. No. 1255D & EE.
REG. FLEET PRICE ..... $24.49

FLEET Special **16.87**

*Sunbeam*
## ALARM CLOCK

Dependable electric alarm clock with easy-to-read white dial with black numerals and hands. No. 80-11.
REG. FLEET PRICE ..... $2.97




FLEET Special **1.99**

# QUALITY FARM & FLEET

## Take the chill out of winter with these

# Red Hot Values!

## Fleet Special Prices Good Feb. 8-19!



### 4 LB. POPCORN

FLEET Special **69¢**

Enjoy hot popcorn! Delicious, nutritious and economical.
4 Lb. Bag.
REG. FLEET PRICE..... $1.19
WHILE QUANTITIES LAST!



### 5 TON HYDRAULIC JACK

FLEET Special **12.77**

Heavy-duty performance for lifting or pushing in any position: vertical, angle or horizontal. Lift Range: 7⅞" - 15¼". No. HJ-50.

# Alternator Dynamo and Starter Motor (Q)

## ALTERNATOR

### MODELS AC5 AND 11AC

#### 1. General

At the time of writing there are two types of alternator fitted to the 6.354 engine, namely the AC 5 with its associated 440 regulator, and the 11 AC with the 4 TR Control Box.

These are driven by the engine in the same manner as a D.C. Generator, namely, belt driven from the crankshaft pulley, but the advantage lies in their ability to provide higher maximum output at lower speeds, to cope with increased electrical load demanded by modern equipment and decreased road speeds owing to increased density of traffic, especially in built up areas. They are also much lighter in weight, output for output.

As opposed to the DC Generator in which the armature windings rotate inside a stationary field system, the alternator has a rotating field system inside a stationary generating winding. When the rotor rotates inside the stator, the output produced is alternating current (AC) This is unsuitable for charging the battery which requires direct current (DC), so it is rectified by means of diodes which converts it to uni-directional flow to the battery.

The alternator voltage output is maintained within close limits by means of a control box which is fully transistorised and functions as fast switches.

#### 2. Precautions

As previously described 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.

#### 3. 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.

# QUALITY FARM & FLEET

## Take the chill out of winter with these

# Red Hot Values!

## Fleet Special Prices Good Feb. 8-19!

### PRE-SEASON LAYAWAYS

Order now and just 10% down will guarantee the price and assure availability by May 1st, and you save from $20 to $40. We will notify you when your order arrives for pick-up by May 1, 1978.

FLOOR SAMPLES AVAILABLE FOR INSPECTION.

**Save $20-$40**

VISA

### 11 H.P. LAWN MOWER

**You Save $40.00**



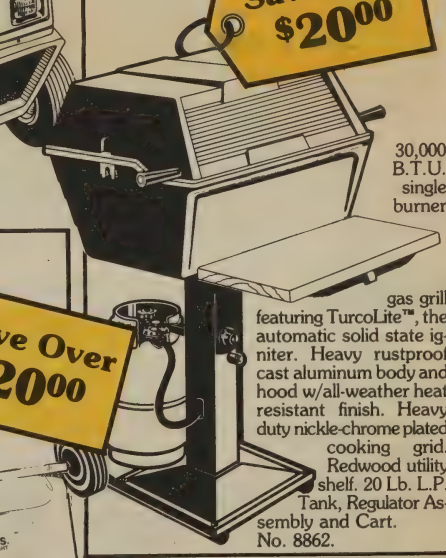
- Briggs & Stratton Engine
- 3 Speed Transaxle
- Disc Brakes
- Chrome Hub Caps
- Electric Start
- 38" Full Floating Deck
- Sealed Beam Headlights
- Brilliant Red Finish
- Fully Assembled

No. 138-497-205
REG. FLEET PRICE 767.00
PRE-SEASON SPECIAL ..... $727.00

### Turco MANUFACTURING COMPANY GAS GRILL

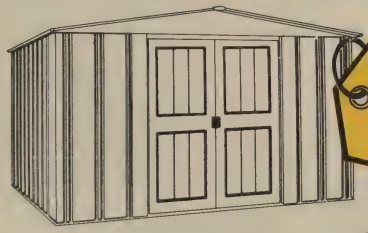
REG. FLEET PRICE ..... $149.95
PRE-SEASON PRICE ..... $128.88

**Save Over $20.00**



30,000 B.T.U. single burner gas grill featuring TurcoLite™, the automatic solid state igniter. Heavy rustproof cast aluminum body and hood w/all-weather heat resistant finish. Heavy duty nickle-chrome plated cooking grid. Redwood utility shelf. 20 Lb. L.P. Tank, Regulator Assembly and Cart. No. 8862.

### ARROW The Northport 10' x 9' STORAGE SHED



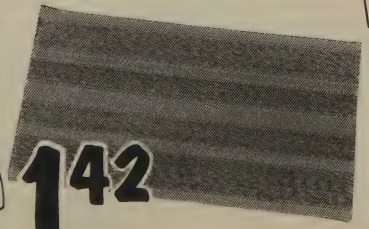
Fully galvanized PERMA-PLATE weather resistant finish. Easy assembly — all parts numbered, step by step illustrated assembly guide.
REG. FLEET PRICE ..... $139.75
PRE-SEASON PRICE ..... $119.00

**Save Over $20.00**

### 24" x 45" YARN RUG

Washable, reversible woven rugs. Made from modern carpet yarn for durability. Assorted colors. No. 300.
REG. FLEET PRICE $2.19

FLEET Special **1.42**






### CONCENTRATED DOG FOOD

A complete dog food with 21% protein. 50 Lb. Bag.
FLEET PRICE ..... $7.38

HI-LIFE SOFT & MOIST
DOG FOOD

FLEET Special
147

Twelve packets of beef flavor dog food. Equals as many meals as 12 - 1 Lb. Cans.
REG. FLEET PRICE ..... $1.99
WHILE QUANTITIES LAST!

PRICE ..... $17.84

FOR YOUR SHOPPING CONVENIENCE
Quality Farm & Fleet stores honor Master Charge and VISA.

HERE'S THE QUALITY FARM & FLEET NEAREST YOU

QUALITY FARM & FLEET
1651 South Main Street, Route 68
Bellefontaine, OH 43311
Phone 513/592-2045
STORE HOURS
Monday thru Friday 8:00 A.M. to 8:00 P.M.
Saturday 8:00 A.M. to 5:00 P.M.
Sunday 12:00 Noon to 5:00 P.M.

QUALITY FARM & FLEET INC.

Bulk Rate
U.S. Postage
PAID
Permit No. 494
St. Cloud, Minn.

R.R. BOXHOLDER PATRON
P.O. BOXHOLDER PATRON

We reserve the right to limit quantities and correct printing errors.



# Alternator Dynamo and Starter Motor (Q)

## ALTERNATOR

### MODELS AC5 AND 11AC

#### 1. General

At the time of writing there are two types of alternator fitted to the 6.354 engine, namely the AC 5 with its associated 440 regulator, and the 11 AC with the 4 TR Control Box.

These are driven by the engine in the same manner as a D.C. Generator, namely, belt driven from the crankshaft pulley, but the advantage lies in their ability to provide higher maximum output at lower speeds, to cope with increased electrical load demanded by modern equipment and decreased road speeds owing to increased density of traffic, especially in built up areas. They are also much lighter in weight, output for output.

As opposed to the DC Generator in which the armature windings rotate inside a stationary field system, the alternator has a rotating field system inside a stationary generating winding. When the rotor rotates inside the stator, the output produced is alternating current (AC) This is unsuitable for charging the battery which requires direct current (DC), so it is rectified by means of diodes which converts it to uni-directional flow to the battery.

The alternator voltage output is maintained within close limits by means of a control box which is fully transistorised and functions as fast switches.

#### 2. Precautions

As previously described 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.

#### 3. 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.

### 4. 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, HI. If an ammeter is not part of the applications circuit, fit a good quality moving coil 0—100 amp ammeter in the alternator to battery positive line. **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.

(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.

## 5. Fault Finding on 11 AC

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 exceed 0.1 ohm. Any high resistance must be traced and remedied. Connect a test DC voltmeter (suppressed zero type) scale 12—15 volts for 12 volt installations or 24—30 volts for 24 volt installations, between the battery terminals, and note the reading with no electrical load. Disconnect battery earth cable and connect test ammeter between alternator main terminal and disconnected cable. Reconnect battery earth cable, and switch on an electrical load of approximately two amps, such as, side and tail lights. Start engine and run at about 2000 rev/min. for at least eight minutes. If the charging current is still greater than 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 uncontrolled 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.

## 6. Fault Diagnosis Procedure for 11 AC

**Alternator Fails to Charge**

(a) Check driving belt for correct tension and wear.

(b) Apply Tests 2 and 3.

**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 4.

**Flat Battery or Low State of Charge**

(a) CHECK condition of battery with hydrometer and high rate discharge tester.

(b) Check driving belt for correct tension and wear.

(c) Check that the field isolating relay contacts open when master switch is off, otherwise battery will discharge through rotor winding.

(d) Check that flat or low battery is not caused by insufficient alternator output caused by abnormal electrical loads by applying Tests 4 and 3.

**Excessive Charge Rate to a Fully Charged Battery**

(a) Apply Test 5.

**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.

## 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 200 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.

#### (b) Inspection of Brush Gear

Every 20,000 miles (30,000 km) or 800 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).

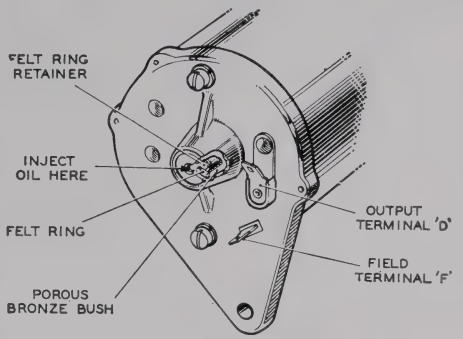



Fig. Q.3. Lubricator in Commutator End Bracket.

### 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.

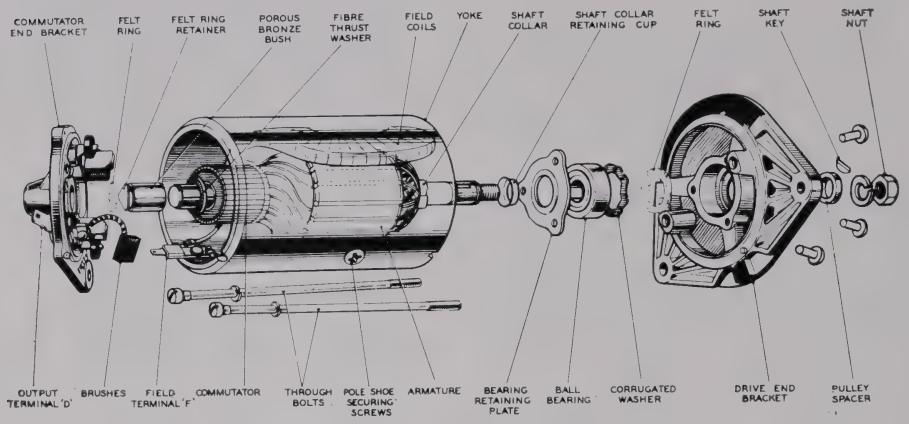



Fig. Q.4. Dynamo Dismantled.

## 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 a bentonite based grease 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 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). Check by hand-cranking that the engine is not abnormally stiff.

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.

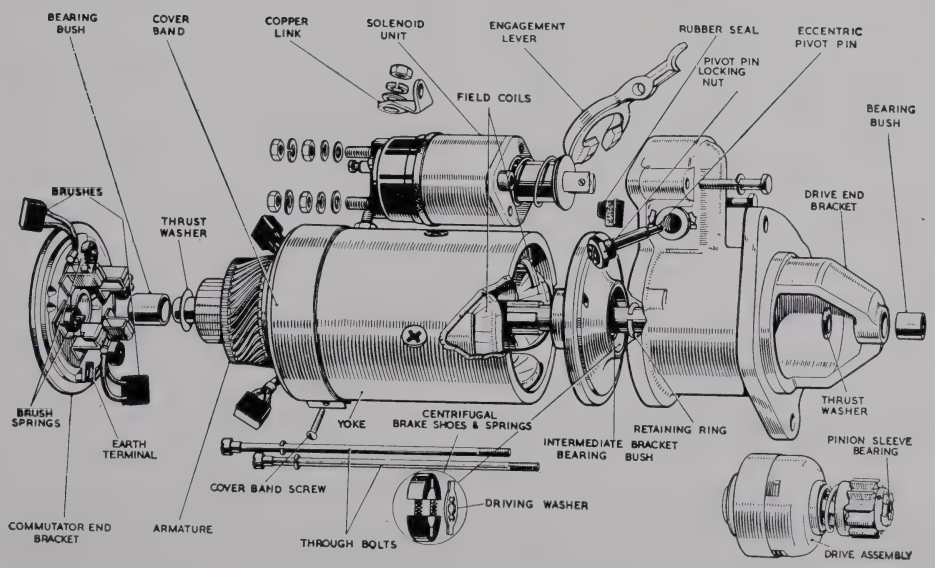



Fig. Q.11. M45G Starter Motor Dismantled.

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 its equivalent.

## 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.

# Compressors (R)

## 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.

### PERIODICAL ATTENTION

**Every 5,000 Miles (7,500 km) or 200 Hours**

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).

Check compressor mounting and couplings for alignment.

**Every 20,000 Miles (30,000 km) or 800 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 2,400 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 mach-

ined 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 the 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) 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).
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) and lock the tab washers.
9. Recheck the coupling alignment and the clearance as set in (7).

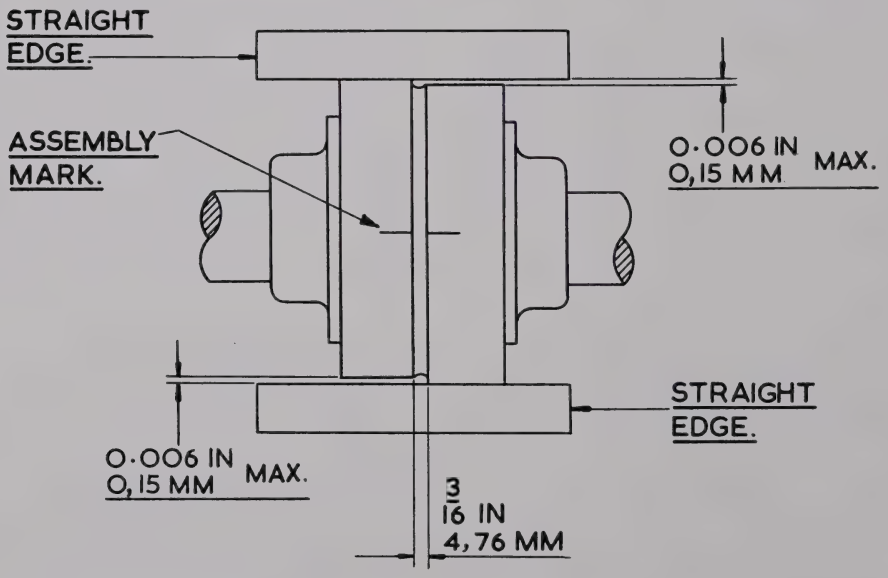
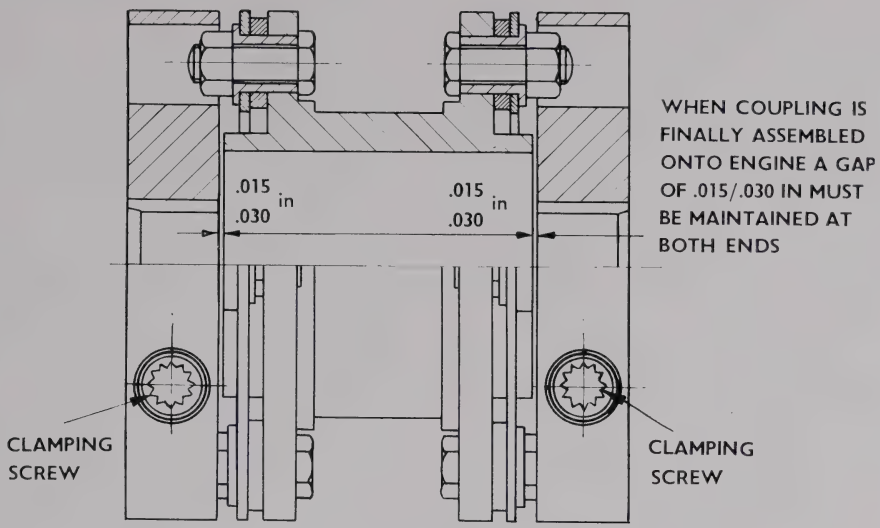
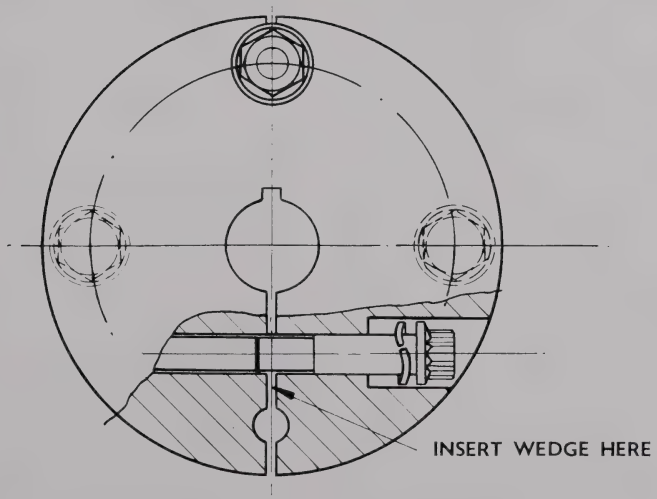



Fig. R.1.
Compressor Coupling Alignment
Later type coupling.




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 auxiliary drive end of the coupling and tighten the clamping screw at this end of the coupling to a torque of 20/25 lbf ft (2,77/3,46 Kgf m).
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 0,76 mm), 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 $\frac{1}{4}$ 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 2.6255/2.620 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

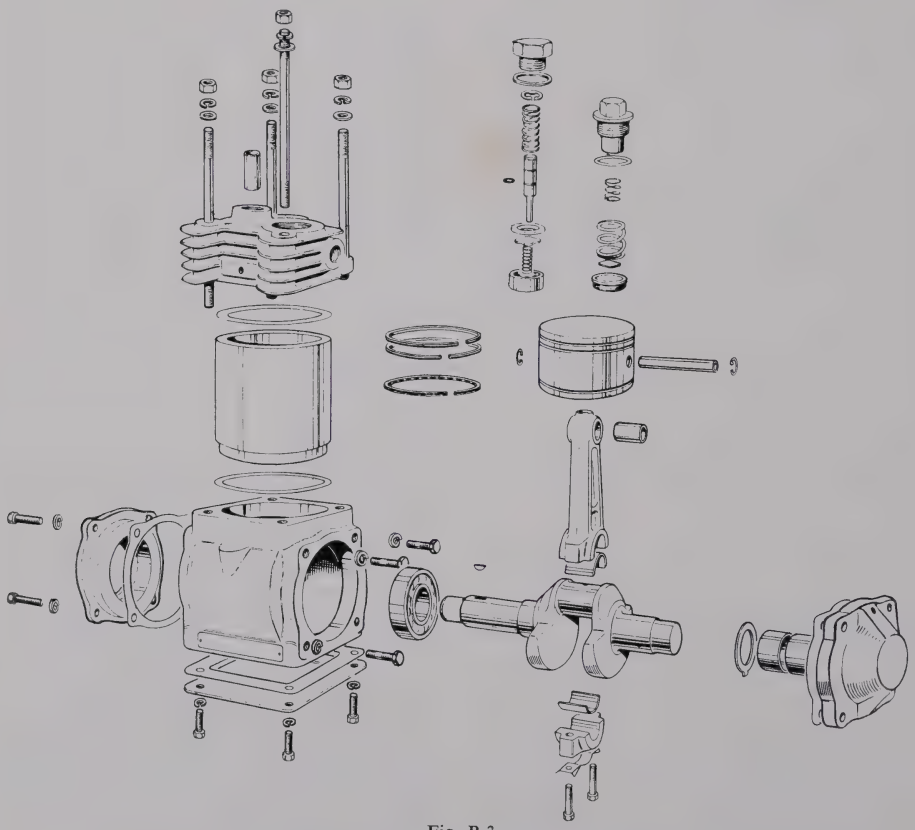


Fig. R.3.
Exploded view of typical Single Cylinder Air Compressor.

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 re-faced 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 'Dow-Corning' 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).

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.

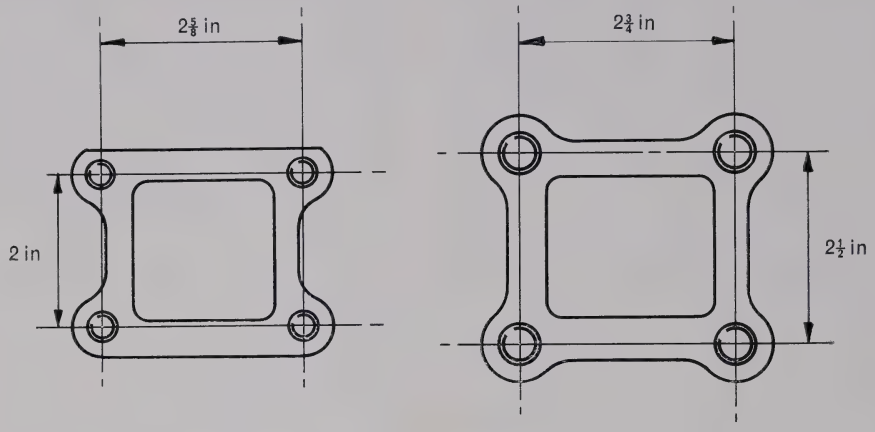



Fig. R.4.
Compressor and Exhauster Block Mounting Pads.

# 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.

## PERIODICAL ATTENTION

### Every 5,000 Miles (7,500 km) or 200 Hours

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).

Check compressor mounting and couplings for alignment.

### Every 20,000 Miles (30,000 km) or 800 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 2,400 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.

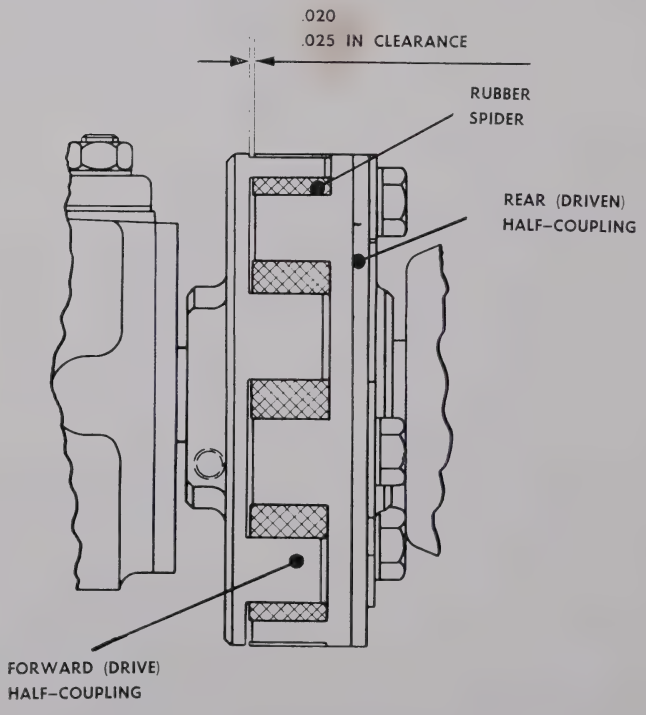



Fig. R.5.
SC4 Compressor Coupling.

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 $\frac{1}{4}$ 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 to 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 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

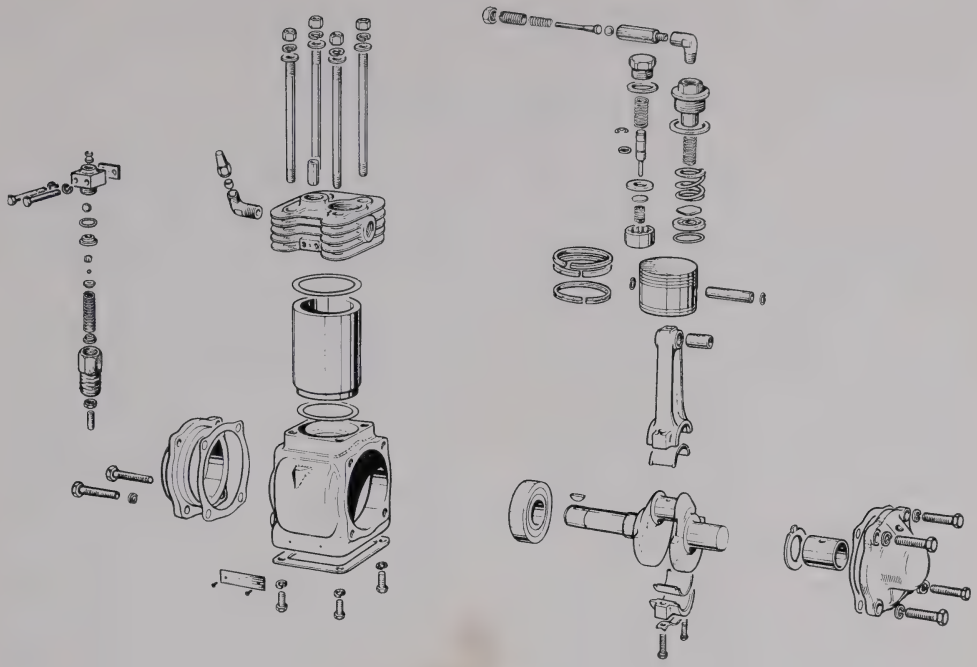


Fig. R.6.
Exploded view of typical "S.C.4" Air Compressor.

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).

Fit inlet and safety valve elbows and 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$^2$). 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$^2$).

## 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/in$^2$ (10,55 Kgf/cm$^2$) has a tolerance of 5 lbf/in$^2$ (0,35 Kgf/cm$^2$).

## 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).

# Exhausters (S)

## 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.

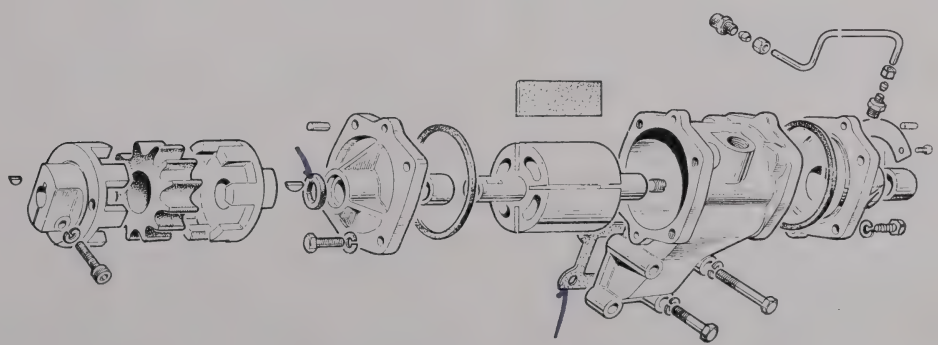


Fig. S.1. Exploded view of an Exhauster.

### 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

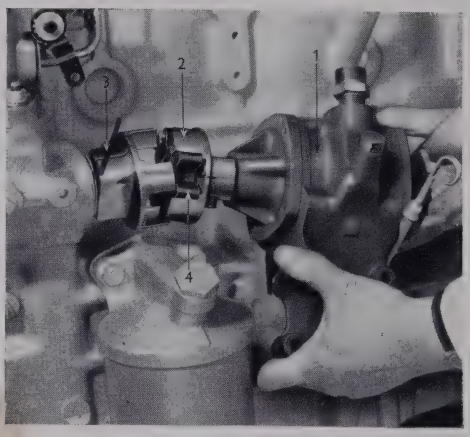



Fig. S.2. Removing Exhauster.
1. Exhauster.
2. Exhauster Coupling (Driven Half).
3. Exhauster Coupling (Drive Half).
4. Rubber Coupling.

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.

# INDEX


Alternator AC5 and 11AC Q.1
Precautions Q.1
Maintenance Q.1
Fault Finding AC5 Q.2
Fault Finding 11AC Q.3
Fault Diagnosis Procedure 11AC Q.4
Data B.14
Altitude, De-rating B.2
Atomisers, M.10
Data B.14
General M.10
Maintenance M.11
Periodical Attention C.1
Pressure Setting B.14
Troubles in Service M.10

Battery, Periodical Attention C.1
Belt, Fan, Adjustment L.1
Belt, Fan, Periodical Attention C.1
Bearing, Main, Data B.7
Bearing, Main, Description A.1
Bearing, Main, To Renew H.1
Block, Cylinder, Data B.3
Bush, Auxiliary Drive Shaft Front, Data B.10
Bush, Auxiliary Drive Shaft Rear, Data B.11
Bush, Connecting Rod, Small End, Data B.5
Bush, Connecting Rod, To Renew F.2
Bush, Dynamo Rear, Periodical Attention C.1
Bush, Fuel Injection Pump Adaptor Plate, Data B.11

Case, Timing, To Remove J.1
Case, Timing, To Replace J.1
Camshaft, Data B.7
Camshaft, Description A.1
Camshaft, To Remove J.4
Camshaft, To Replace J.4
Club, Perkins Drivers Appendix
Cold Starting Aid, Data B.15
Cold Starting Aid, Operation M.14
Companies, Overseas page 2
Compressor S.C.6
Periodical Attention R.1
Service Check R.1
Inspection R.1
To Remove R.1
To Replace, later type coupling R.2
To Replace, early type coupling R.4
Dismantling R.4
Reassembly R.7
Fault Finding R.7
Mounting Pad R.8
Compressor S.C.4.
Periodical Attention R.9
Service Check R.9
Inspection R.9
To Remove R.9
To Replace R.10
Dismantling R.10
Reassembly R.12
Fault Finding R.14
Cooling System, Data B.13
Cooling System, Description A.2
Cover, Cylinder Head Tightening Periodical Attention C.1
Crankshaft,
Data B.6
Description A.1
To Regrind H.2
To Remove H.2
To Replace H.3

Data and Dimensions B.3
Data, Engine B.1
Damper, Crankshaft, To Replace H.5
Description, Engine A.1
Designation, Engine page 4
Drive, Timing, Description A.1
Dynamo, Data B.15
Dynamo, Periodical Attention C.1
Dynamo C40A & C40L Q.5
General Q.5
Routine Maintenance Q.5
Testing in Position Q.5
Electrical Equipment, Description A.2
Exhaust Smoky, Fault Diagnosis D.2
Exhauster, S.1
Cleaning and Inspection S.2
Description S.1
Mounting Pad S.3
Operation S.1
Overhaul S.2
Periodical Attention C.1
Servicing S.1

Fault Diagnosis D.1
Film Library Appendix
Filter,
Air, Dry Type M.1
Air, General M.1
Air, Oil Bath Type M.1
Air, Tractor Type M.2
Fuel, Data B.13
Fuel, To Renew M.2
Fuel, Periodical Attention C.1
Lubricating Oil, Data B.13
Lubricating Oil, Description K.5
Lubricating Oil, Periodical Attention C.1
Lubricating Oil, To Remove K.5
Lubricating Oil, To Replace K.5
Lubricating Oil, Screw Type K.6
Foreword page 7
Flywheel, To Remove N.1
Flywheel, To Replace N.1
Frost Precautions C.3
Fuel Injection System, Description A.2
Fuel Oil Specification B.13
Fuel System, Priming M.11

Gauze, Fuel Lift Pump, Periodical Attention C.1
Gasket, Cylinder Head E.7
Gear,
Auxiliary Drive Shaft, Data B.10
Auxiliary Drive Shaft, To Remove J.1
Auxiliary Drive Shaft, To Replace J.1
Camshaft, Data B.9
Camshaft, To Remove J.1
Camshaft, To Replace J.1
Crankshaft, Data B.10
Flywheel Ring, To Renew N.1
Heavy Duty Idler, Data B.10
Heavy Duty Idler, General J.4
Standard Idler, Data B.10

## INDEX (Continued)


Standard Idler, To Remove J.3
Standard Idler, To Replace J.3
Timing, Backlash B.10
Timing, Backlash, Checking J.8
Guide, Valve, Data B.8
Guide, Valve, To Renew E.2

Head, Cylinder,
Data B.8
Description A.1
To Clean E.2
To Remove E.1
To Re-assemble E.7
To Replace E.7
Skimming E.6
Housing, Flywheel, Alignment Limits N.2
Housing, Flywheel, To Remove N.1
Housing, Flywheel, To Replace N.1
Hub, Heavy Duty Idler Gear, Data B.10
Hub, Heavy Duty Idler Gear, General J.4
Hub, Standard Idler Gear, Data B.10
Hub, Standard Idler Gear, To Remove J.3
Hub, Standard Idler Gear, To Replace J.3

Insert, Valve Seat, Fitting E.4
Insert, Valve Seat, To Replace E.6

Laying-Up, Engine Preservation C.1
Liner, Cylinder,
Cast Iron flanged, Data B.3
Cast Iron Plain, Data B.3
Chrome Plated, Data B.4
Cast Iron Flanged, To Renew G.3
Cast Iron Plain, To Renew G.1
Chrome Plated, To Renew G.2
Description G.1
Lubricating Oil,
Approved Grades Appendix
Operating Pressure B.12
High Pressure, Fault Diagnosis D.3
Level, Periodical Attention C.1
Low Pressure, Fault Diagnosis D.3
Renewal, Periodical Attention C.1
System K.1
Lubrication, Engine K.1
Lubrication, Horizontal Engine K.6
Lubrication, Valves, Periodical Attention C.1

Misfire, Engine, Fault Diagnosis D.2
Manifold, Exhaust, Description A.2
Manifold, Induction, Description A.2

Number, Engine Location page 4

Overheating, Engine, Fault Diagnosis D.3

Periodical Attentions C.1
Pipes, Fuel Injection High Pressure M.11
Pin, Gudgeon, Data B.5
Piston,
To Assemble F.2
Data B.4
Description A.2
To Dismantle F.1
Fitting F.3
Inspection F.2
To Remove F.1
To Replace F.3
Plan, Perkins Perpetuity Appendix
Post Delivery Checkover C.1
Power, Loss, Fault Diagnosis D.2
Pressure, Crankcase, Fault Diagnosis D.3
Pressure, Lubricating Oil, General K.5
Pulley, Crankshaft, To Replace H.4
Pump, Fuel Injection, M.8
Idling Speed Setting M.10
Maximum Speed Setting M.10
Data B.14
Description M.8
To Remove M.8
To Replace M.8
Pump, Fuel Lift,
Cleaning and Inspection M.4
Data B.13
Dismantling M.3
Re-assembly M.4
To Remove M.3
To Replace M.8
Pump, Lubricating Oil,
Clearances B.12
Data B.12
Delivery Housing, To Remove K.2
Inspection K.3
To Dismantle K.3
To Re-assemble K.3
To Remove K.2
To Replace K.4
Pump, Lubricating Oil, Scavenge, K.6
Dismantling K.7
To Assemble K.7
To Remove K.7
Pump, Water, High Position, To Remove L.1
Pump, Water, High Position, To Replace L.1
Pump, Water, Low Position, To Remove L.1
Pump, Water, Low Position, To Replace L.1
Pump, Water L.1
Data B.13
To Dismantle L.2
Inspection L.2
To Re-assemble L.3
Push Rod, Data B.9
Push Rod, Inspection E.7
Push Rod, Replacement E.8

Radiator, Flushing, Periodical Attention C.1
Rating, Details B.1
Rings, Piston, Turbocharged Engines, Data B.5
Rings, Piston, Normally Aspirated Engines, Data B.5
Rings, Piston, Types F.2
Rockers, Data B.9
Rod, Connecting
Bearings B.7
Data B.5
Description A.1
Inspection F.2
To Remove F.1
To Replace F.3

Seal, Crankshaft Front End Oil, To Renew J.1
Seal, Crankshaft Rear End Oil, To Renew H.5
Seal, Rocker Shaft Oil Feed Connection, Fitting E.8

Service, Engine Return Preparation C.2
Service Instruction Appendix
Service Wear Limits B.16
Shaft, Auxiliary Drive, To Remove J.5
Shaft, Auxiliary Drive, To Replace J.5
Shaft, Fuel Injection Pump Drive, Data B.11
Shaft, Fuel Injection Pump Drive, To Remove J.5
Shaft, Fuel Injection Pump Drive, To Replace J.5
Shaft, Rocker, Data B.9
Shaft, Rocker, Dismantling E.6
Shaft, Rocker, Re-assembly E.6
Shims, Fuel Pump Drive Shaft Bearing J.5
Spring, Inner Valve, Data B.9
Spring, Outer Valve, Data B.9
Springs, Valve, Fitting E.7
Springs, Valve, Inspection E.6
Starter Motor, Data B.15
Starter Motor CA45 Q.7
- General Q.7
- Routine Maintenance Q.8

Starter Motor, M45G Q.6
- General Q.6
- Routine Maintenance Q.6
- Testing in Position Q.7

Starting, Difficulty, Fault Diagnosis D.1
Sump,
- Data B.12
- Horizontal Engine, To Remove K.7
- To Remove K.2
- To Replace K.2

Sump Well & Strainer, Horizontal Engine,
- To Remove K.7

Sump Well & Strainer, Horizontal Engine,
- To Replace K.7

Tank, Fuel, Periodical Attention C.1
Tappets, Data B.9
Tappets, To Remove J.4
Tappets, To Replace J.4
Terms, Glossary Appendix
Thermostat, L.4
- Data B.13
- Testing L.5
- To Remove L.5
- Types L.4

Threads, Types Page 4
Timing, Fuel Injection, Checking M.9
Timing, Fuel Injection, General M.9
Timing Fuel Injection Static, Position B.14
Timing, Valve, Checking J.8
Tools, Approved Service Appendix
Torque, Recommended Tensions B.2
Turbocharger, Contents P.1
- Cleaning Mk. 1/5 P.17
- Cleaning 3LD P.21
- Details of Construction P.6
- Dismantling Mk. 1/5 P.17
- Dismantling 3LD P.19
- Do's and Don'ts P.2
- Exhaust System P.8
- Fault Diagnosis P.15
- General Information Mk. 1/5 P.3
- General Information 3LD P.4
- Inspection Mk. 1/5 P.17
- Inspection 3LD P.21
- Installation P.8
- Intake System P.11
- Impeller & Diffuser Cleaning P.14
- Lubrication System P.7
- Maintenance Instructions P.14
- Re-assembly Mk. 1/5 P.19
- Re-assembly 3LD P.21
- Reconditioning Mk. 1/5 P.17
- Reconditioning 3LD P.19
- Replacing Oil Filter Element P.14
- Service Operations P.13
- Starting Instructions P.12

Valves,
- Clearances E.8
- Clearances, Periodical Attention C.1
- Exhaust, Data B.9
- Hand Grinding E.3
- Inlet, Data B.8
- Inspection E.3
- Seats, Inspection E.3
- To Remove E.2

Valve, Oil Pressure Relief,
- Removal and Dismantling K.4
- Re-assembly and Refitting K.4
- Setting K.4
- Data B.12

Ventilation, Crankcase, Description A.2

Washers, Auxiliary Drive Thrust, Data B.11
Washer, Camshaft Thrust, Data B.8
Washer, Crankshaft Thrust, Data B.7
Washer, Crankshaft Thrust, To Renew H.2
Water Level, Periodical Attention C.1
Weights, Engine B.1

**Abbreviations of Technical Terms Applicable to Service Literature**

Where it is found necessary to use abbreviations in Service Literature the units and symbols adopted are those laid down in British Standards Publications 1991.

A glossary of such terms with their British Standard equivalent is given below for reference purposes.

## GLOSSARY OF TERMS

| TERM | BRITISH STANDARD | REMARKS |
|---|---|---|
| ampere | A | or ampere if confusion may arise |
| atmosphere | atm | |
| brake horse power | b h p | |
| British Thermal Unit | B t u | |
| centimetre | cm | |
| Cubic centimetre | $cm^3$ | similarly for millimetre, etc. |
| cubic inch | $in^3$ | similarly for foot, etc. |
| foot | ft | |
| foot pounds per minute (work) | ft lbf/min | |
| gallon | gal | |
| gallons per minute | gal/min | similarly for pint, litre, etc. |
| gramme | g | when referring to gramme mass. |
| gramme | gf | when referring to gramme force. |
| hour | h | |
| inch | in | or inch if confusion may arise. |
| kilogramme | kg | |
| kilogramme metre (torque) | kgf m | |
| kilogrammes per square centimetre | $kgf/cm^2$ | similarly for gramme, etc. |
| kilometre | km | |
| litre | l | or litre if confusion may arise. |
| mile | mile | |
| millimetre | mm | |
| miles per gallon | mile/gal | similarly for pint, litre, etc. |
| miles per hour | mile/h | similarly for kilometre, etc. |
| minute | min | |
| ounce | oz | |
| pint | pt | |
| pound | lb | when referring to pound mass. |
| pound | lbf | when referring to pound force. |
| pounds feet (torque) | lbf ft | |
| pounds per square inch | $lbf/in^2$ | similarly for ton, etc. |
| revolutions per minute | rev/min | |
| second (time) | s | |
| shaft horse power | s h p | |
| square centimetre | $cm^2$ | similarly for millimetre, etc |
| square inch | $in^2$ | similarly for foot, yard, etc. |
| ton | ton | |
| tonne (1000 kg) | t | |
| volt | V | |
| yard | yd | |

# APPROVED SERVICE TOOLS

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

**PD 1C Valve Guide Remover and Replacer**

Engine Type : All
With this tool, all valve guides can be removed and replaced provided puller bars are available.

**PD 1C-1 Puller Bars**

Engine Type : All
Two bars are supplied for use with PD 1C to suit $\frac{5}{16}$ in and $\frac{3}{8}$ in i/d valve guide bores.

**PD 1C-2 Valve Guide Replacing Stop**

Engine Type : 4.99 4.107 4.108
When the valve guide is replaced using one of these stops, it will ensure that the guide protrudes the correct amount above the top face of the cylinder head.

**PD 1C-3 Valve Guide Replacing Stop**

Engine Type : 6.354 4.236
Remarks : See PD 1C-2

**PD 1C-4 Valve Guide Replacing Stop**

Engine Type :
P3 P3.144 B3.152 3.152 4.192 4.203
P4 P6 6.288 6.305
Remarks : See PD 1C-2

**38 U3 Piston Assembly Ring**

Engine Type : All
This is an expandable piston assembly ring for Std. and oversize pistons on all engine types.

**PD 41B Piston Height and Valve Depth Gauge**

Engine Type : All
For checking piston heights and valve depths.

**PD 155A Small Adjustable Puller**

Engine Type : All
Can be used with suitable adaptors to remove water pump pulley, oil pump drive gears and camshaft gear.

**PD 155A-1 Small Adjustable Puller Adaptors**

Engine Type :
R6 P3.144 3.152 B3.152 4.192 4.203
Removes water pump pulley only on
6.305 L4 4.270 4.99 4.107 4.108
Removes water pump pulley and camshaft gear on
6.354

**PD 155A-2 Small Adjustable Puller Adaptors**

Engine Type : P3 P4 P6
To remove low position water pump pulley.

**PD 155A-4 Small Adjustable Puller Adaptor**

Engine Type :
P3.144 3.152 B3.152 4.192 4.203
Removal of oil pump gear.

**No. 3 Tension Wrench**

Engine Type : All
$\frac{1}{2}$ in square drive 25 to 170 lbf ft.

**PD 150 Cylinder Liner Remover and Replacer**

Engine Type :
6.354 4.236 3.152 D3.152 4.203 D4.203
6.305

**PD 150-1 Cylinder Liner Remover/Replacer Pads**

Engine Type :
6.354 4.236 3.152 D3.152 4.203 D4.203
6.305
For use with PD 150.

**PD150-3A**

Engine Type: 4.99
For use with PD 150.

**PD150-5**

Engine Type:
4.107 4.108
For use with PD 150.

**316X Valve Seat Cutter Handle**

Engine Type : All
This tool is required for the operation of all cutters and pilots.

**316-10 Valve Seat Cutter Pilot**

Engine Type :
P3 P3.144 3.152 B3.152 4.107 4.99 4.108
4.192 4.203 P4 P6 6.288 6.305
This pilot is suitable for all guides that have a nominal $\frac{5}{16}$ in i/d bore.

**316-12 Valve Seat Cutter Pilot**

Engine Type :
L4 4.270 R6 F340 S6 4.236 6.354
This pilot is suitable for all guides having a nominal $\frac{3}{8}$ in i/d bore.

**316-125 Valve Seat Cutter Pilot**
Engine Type : 4.236 (0.015 in oversize)
This pilot is for valve bores which have been reamed 0.015 in oversize.

**316-13 Valve Seat Cutter Pilot**
Engine Type : 4.236 (0.030 in oversize)
This pilot is for valve bores which have been reamed 0.030 in oversize.

**PD 137 Valve Bore Reamer (0.015 in oversize)**
EngineType : 4.236
This reamer is only suitable for guideless cylinder heads.

**PD 138 Valve Bore Reamer (0.030 in oversize)**
Engine Type : 4.236
This reamer is only suitable for guideless cylinder heads.

**PD 317-23 Valve Seat Cutter Exhaust**

**PD 317-26 Valve Seat Cutter Inlet**

**317-G22 Glaze Breaker Exhaust**

**317-G25 Glaze Breaker Inlet**
Engine Type :
P3 P3.144 B3.152 3.152 4.192 4.203 P4 P6 6.288 6.305
The above cutters have been designed to cut seats to the correct angle and at the same time reduce seat width. It is strongly recommended that the glaze breakers be used first as this will greatly reduce the chattering of the cutters.

**PD 317-25 Valve Seat Cutter Exhaust**

**PD 317-29 Valve Seat Cutter Inlet**

**317-G30 Glaze Breaker Exhaust and Inlet**
Engine Type :
L4 4.270 R6 F340
Remarks : See PD 317-23

**317-30 Valve Seat Cutter Inlet**
Engine Type :
4.236 4.248 6.354 D4.203 D3.152
Remarks : See PD317-23

**317-30 Valve Seat Cutter Exhaust**
Engine Type :
D4.203 D3.152
Remarks : See PD317-23

**317G-30 Glaze Breaker Exhaust and Inlet**
Engine Type :
6.354 4.236 4.248 D4.203 D3.152
Remarks : See PD317-23

**PD 317-18 Valve Seat Cutter Exhaust**

**PD 317-22 Valve Seat Cutter Inlet**

**317-G19 Glaze Breaker Exhaust and Inlet**
Engine Type :
4.99 4.107 4.108
Remarks : See PD 317-23

**PD317-22 Valve Seat Cutter Exhaust**
Engine Type :
6.354 4.236 4.248
Remarks : See PD317-23

**FC9900 Atomiser Tester**
Engine Type : All
This is a portable tester fitted with a paper filter element.

**7066 Circlip Pliers**
Engine Type : All
Two types of points are available. $\frac{1}{2}$ in shaft size, $\frac{1}{2}$ in — 1 in "B" shaft size 1 in — 3 in.

**355 Connecting Rod Alignment Jig**
Engine Type : All
Enables a quick check to be made on the alignment of connecting rods — various adaptors are required as follows :—

**336 Multi-Purpose Con. Rod Arbor**
Engine Type : All
Required with the above tool.

**PD 336-1 Adaptor**
Engine Type :
P3 P3.144 B3.152 3.152 4.192 4.203 P4 P6 6.288 6.305
This adaptor is fitted into the big end bore when checking alignment. (Thin wall bearings only).

**PD 336-3 Adaptor**
Engine Type : L4 4.270
Remarks : See PD 336-1

**PD 336-5 Adaptor**
Engine Type : 4.99 4.107 4.108
Remarks : See PD 336-1

**PD 336-6 Adaptor**
Engine Type : 6.354 4.236
Remarks : See PD 336-1

**6118 Valve Spring Compressor**
Engine Type : All
This valve spring compressor has been designed to remove valve springs without removing the cylinder head, providing the adaptors are available.

**PD 6118-1 Valve Spring Compressor Adaptor**
Engine Type : 4.99 4.107 4.108
The adaptor is fitted to the rocker shaft securing studs.

**PD 6118-2 Valve Spring Compressor Adaptor**
Engine Type :
P3 P4 P6 6.288 6.305 S6
Remarks : See PD 6118-1

**PD 6118-3 Valve Spring Compressor Adaptor**
Engine Type :
P3.144 B3.152 3.152 4.192 4.203 L4 4.270 R6 F340
Remarks : See PD 6118-1

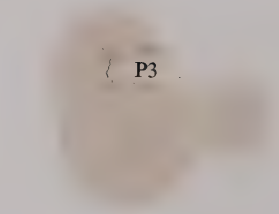
**PD 6118-4 Valve Spring Compressor Adaptor**
Engine Type : 6.354 4.236
Remarks : See PD 6118-1

**PD 130 Fuel Pump Allen Screw Wrench**
Engine Type : 4.192 4.203 4.99 4.107 4.108
Used to remove the Allen Screw securing the fuel Injection pump.

**PD 141 Timing Case Oil Seal Fitting Tool**
Engine Type 6.354 V8.510

**6400 Crankshaft Fillet Radii Rolling Tool**
Engine Types :
P4 4.192 4.203 P6 6.288 6.305 4.270
For cold rolling of fillet radii on certain crankshaft main journals.

**6400-1 Adaptor Set**
For use with the above.


P3

# APPROVED LUBRICATING OILS

Lubricating oils for normally aspirated engines should meet the requirements of the U.S. Ordanance Specification MIL-L-2104B and below, we give a list of some of these oils. Any other oils which also conform to this specification, but we are not here are, of course, also suitable.

Turbocharged engines should be operated on Series 3 lubricating oils or those conforming to the MIL-L-45199A specification. However, should such oils not be available then MIL-L-2104B oils may be used **providing** the oil change period as used for Series 3 oils is halved.

The **minimum** requirement for turbocharged engines is the MIL-L-2104B specification, at more frequent change periods, that is, halved. Normally aspirated engines must not be operated on Series 3 oils unless they also meet the MIL-L-2104B specification.

The lubricating oils for use in Perkins Diesel engines should have a **minimum** Viscosity Index of 80.

| 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) |
| **H. G. Allcard & Co. Ltd.** | Cyldol DX | 10 | 20 | 30 |
| **Amoco (UK) Ltd.** | Amoco 200 Series | 10W | 20W/20 | 30 |
| **B. P. Ltd.** | B.P. Vanel' | 10W | 20W/20 | 30 |
| | B.P. Van. | 10W/30 | 10W/30 | 10W/30 |
| | B.P. Vanellus S3 | 10W | 20W/20 | 30 |
| **Castrol Ltd.** | Castrol Deusol C.R.B. | 10W | 20W/20 | 30 |
| | Castrol Deusol C.R.D. | 10W | 20W/20 | 30 |
| **Chevron Oil (UK) Ltd.** | RPM DELO Multi-Service | 10W | 20W/20 | 30 |
| **A. Duckham & Co. Ltd.** | Fleetol HDX | 10W | 20 | 30 |
| **Esso Petroleum Co. Ltd.** | Essolube HDX | 10W | 20 | 30 |
| **Filtrate Ltd.** | Filtrate HDX | 10W | 20/20W | 30 |
| **Germ Lubricants Ltd.** | Super Germol | 10 | 20 | 30 |
| **Gulf Oil Group of Companies & British/American Company** | Gulflube Motor Oil XHD | 10W | 20W/20 | 30 |
| | B-A Endurance Motor Oil | 10W | 20W/20 | 30 |
| **Mobil Oil Co. Ltd.** | Delvac 1100 Series | 1110 | 1120 | 1130 |
| **Petrofina Group of Companies** | Fina Delta | 10W | 20W/20 | 30 |
| | Fina Solna B | 10W | 20W/20 | 30 |
| **Regent / Texaco Ltd.** | Ursa Oil Extra Duty | 10W | 20W/20 | 30 |
| **Shell** | Shell Rotella T. | 10W | 20W/20 | 30 |
| | Shell Rimula CT. | 10W | 20W/20 | 30 |
| **Snowdrift Lubricants Ltd.** | Royal Snowdrift Andes | 10W | 20W | 30 |
| | Royal Snowdrift Sterling | 10W | 20W/20 | 30 |
| **Sternol Ltd.** | Sternol Elixir | 10W | 20W/20 | 30 |
| **Total Group of Companies** | Total HD 1 | 10W | 20W/20 | 30 |

**The above specifications are subject to alteration without notice**

# EXAMPLES OF SERVICE FACILITIES

## *Service Instruction*

AT PETERBOROUGH

*Apply to Product Education Department for details.*

## *Film Library*

*Apply for catalogue.*

## *Perkins Perpetuity Plan*

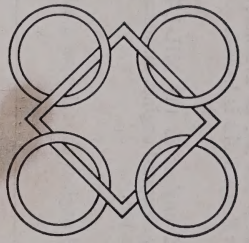
FULLY GUARANTEED Factory Replacement Engines and Parts at Pre-determined Charges.

*Apply to your local Perkins Distributor.*

## *Perkins Drivers' Club*

*All drivers and operators are eligible for membership of this club. Apply for Enrolment Form and full particulars.*

**PERKINS Parts**



**for**

**PERKINS Products**

*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.*

*Enquire at your local Perkins Distributor or direct to Perkins Engines Ltd., Service Department, Peterborough for further information*