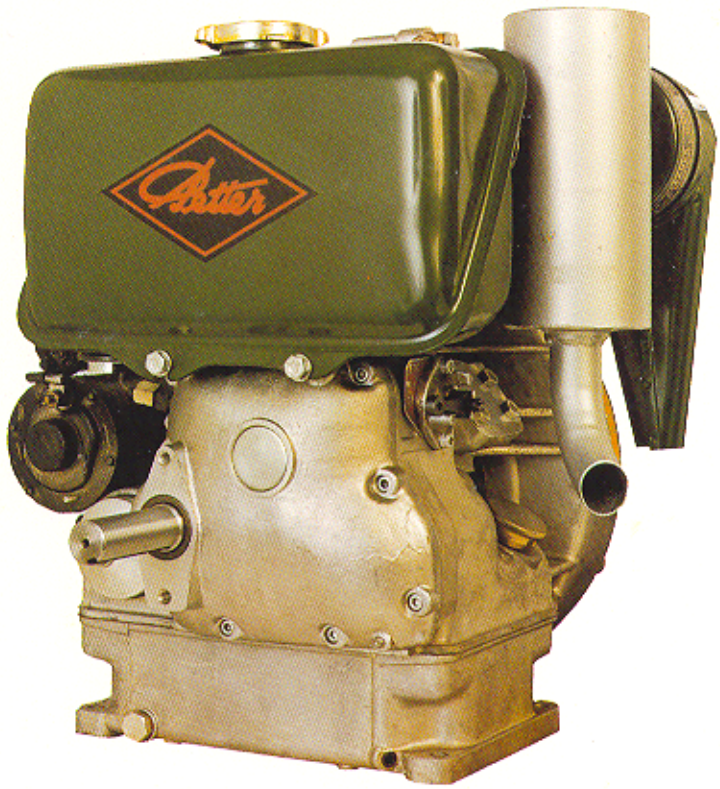
# WORKSHOP MANUAL

## 'A' Range



HAWKER SIDDELEY

**PETTER PARTS & SERVICE**

PETTERS LIMITED HAMBLE, SOUTHAMPTON SO3 5NJ, ENGLAND Telephone (0703) 452061 Telex No. 47626 Cables PETTER HAMBLE

PUBLICATION
FIRST EDITION


# 'A' RANGE
# WORKSHOP MANUAL

# 'A' RANGE WORKSHOP MANUAL

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## HEALTH AND SAFETY

TO PROMOTE SAFETY AND TO AVOID RISK TO HEALTH, USERS OF PETTER DIESEL ENGINES SHOULD OBSERVE THE FOLLOWING PRECAUTIONS.

ENSURE THAT THE ENGINE IS CORRECTLY INSTALLED, OPERATED AND MAINTAINED. ALWAYS FOLLOW MAKERS' INSTRUCTIONS.

BEFORE STARTING THE ENGINE, REMOVE AS MUCH OF THE LOAD AS POSSIBLE.

WHEN USING A STARTING ROPE, DO NOT WIND THE ROPE ROUND HAND OR WRIST. MAKE SURE THE ROPE IS NOT TANGLED OR FRAYED.

WHEN USING A STARTING HANDLE, HOLD THE HANDLE FIRMLY WITH THE THUMB ON TOP OF THE GRIP AND NOT ROUND IT. KEEP THE HANDLE AND SHAFT CLEAN AND LUBRICATED TO ENSURE EASY WITHDRAWAL OF HANDLE.

DO NOT REMOVE GUARDS.

KEEP CLEAR OF HOT, MOVING OR ELECTRICAL PARTS.

IF THE ENGINE IS INSTALLED IN AN ENCLOSED SPACE, VENT THE EXHAUST FUMES TO ATMOSPHERE.

WHEN TESTING FUEL INJECTORS, DO NOT DIRECT THE SPRAY AT ANY EXPOSED PART OF THE BODY — IT CAN PENETRATE THE SKIN.

LIFTING EYES ARE PROVIDED ON THE TOP OF THE ENGINE FOR LIFTING THE ENGINE ONLY AND MUST NOT BE USED TO LIFT COMPLETE INSTALLATIONS.

## FOREWORD

This Workshop Manual covers the operation of the Petter 'A' range of air and water cooled diesel engines. The Manual is divided into two parts which are in turn divided into sections. Part 1 covers the operation and maintenance of the air cooled engines (AA1, AB1, AC1, AC1Z, AC1ZS and AC2) and Part 2 the maintenance of the water cooled engines (AB1W, AC1W, AC2W). The common details of both types of engines are covered in Part 1.

The advanced design of Petter 'A' range engines has resulted in a compact unit which can be relied upon to operate for very long periods, withstanding the rigours of various climatic and operational conditions. Efficient maintenance, however, prolongs the life of any engine and this manual will enable the operator to achieve this objective.

The information, specifications and illustrations in this manual are correct at the time of going to print, Petter's policy is one of continuous product improvement and the right is reserved to alter information in this manual without prior notice.

## ENQUIRIES

Enquiries for Sales, Parts and Service for Petter air and water cooled diesel engines should be made to the following:—

### Petter Parts and Service Headquarters

Hamble
Southampton
Hampshire
SO3 5NJ
England.

*Telephone* 0703 452061
*Telex* 47626 Petter G

### For New Engine Enquiries and Orders

Petters Limited
Causeway Works
Staines
Surrey
TW18 3AR
England.

*Telephone* 0784 51333
*Telex* 23871 Petter G

### Overseas

*Enquiries should be directed to the local Petters Limited Representative. Lists of Representatives are available from Petters Limited on request.*

## ASSOCIATED PUBLICATIONS

| | |
|---|---|
| **AA1 and AB1** | Operators Handbook |
| **AB1W** | Operators Handbook |
| **AC1 and AC2** | Operators Handbook |
| **AC1W and AC2W** | Operators Handbook |
| **AC1Z** | Operators Handbook |
| **AC1ZS** | Operators Handbook |
| **AA1** | Petters Parts Interpretation Manual |
| **AB1** | Petters Parts Interpretation Manual |
| **AB1W** | Petters Parts Interpretation Manual |
| **AC1** | Petters Parts Interpretation Manual |
| **AC1W** | Petters Parts Interpretation Manual |
| **AC1Z–AC1ZS** | Petters Parts Interpretation Manual |
| **AC2** | Petters Parts Interpretation Manual |
| **AC2W** | Petters Parts Interpretation Manual |
| **AC1 WM** | Petters Parts Interpretation Manual |
| **AC2 WM** | Petters Parts Interpretation Manual |
| **'A' Range** | Service Hints |
| **GE** | General Engineering Service Hints |

## IMPORTANT

When purchasing parts or giving instructions for repairs, customers should state the engine type and serial number or spares identification number, reference number of the part, the quantity required and in their own interest, always specify:

### GENUINE PETTER PARTS

Parts that have not been supplied by the Petter organisation cannot be relied upon for correct materials, dimensions or finish. Petters cannot, therefore, be responsible for any damage arising from the use of such parts and the guarantee will be invalidated.

In your own interest, therefore, specify:

**GENUINE PETTER PARTS**

**CAUTION**
**Petter parts in the 'A' Range of air and water cooled engines are similar but not identical and must not be fitted to any engine than that specified in the Petter Parts Interpretation Manual.**

***PLEASE REMEMBER ...***

***... an engine needs fuel —***
Keep fuel, tank, filter and piping, clean.

***... an engine needs lubricating oil —***
Use the correct grade and quality of oil. Keep oil level topped up.

***... an engine needs air —***
Keep air cleaner clean. Keep air inlet manifold and entire exhaust system free of carbon and any other restriction.

***... an engine needs cooling —***
Keep cooling system free from obstruction.

# TECHNICAL DATA 'A' RANGE

## AA1 ENGINE (Model Build After Engine Serial Number 160000)

Bore (nominal) **69.85 mm (2.75 in.)**
Stroke **57.15 mm (2.25 in.)**

Power and Speed per cylinder (continuous rating):

**1.15 kW (1.5 bhp) at 1500 r/min**
**1.35 kW (1.8 bhp) at 1800 r/min**
**1.55 kW (2.1 bhp) at 2100 r/min**
**1.85 kW (2.5 bhp) at 2500 r/min**
**2.25 kW (3.0 bhp) at 3000 r/min**
**2.6 kW (3.5 bhp) at 3600 r/min**

Cubic capacity per cylinder **0.219 litres (13.4 in.$^3$)**

Compression ratio **17:1**

Lubricating oil pressure (minimum) **2.4 bar (35 lbf/in.$^2$)**

**FUEL TANK CAPACITY** (standard engine mounted): **3.8 litres (6.5 pints)**

**OIL CAPACITY: 1.9 litres (3.25 pints)**

**LUBRICATING OIL:** to MIL-L-46152-B
formerly MIL-L-2104B (now obsolete)

**FUEL:** A high grade light distillate diesel fuel in accordance with B.S. Specification No. 2869: 1970 Class A1 or A2

**STARTER MOTOR BATTERY:** 12 Volts 57 Ampere Hours (min)
NEGATIVE EARTH

**FUEL INJECTION RELEASE PRESSURE: 162/183 bar (2350/2650 lbf in.$^2$)**

**FUEL INJECTION TIMING (BY SPILL): FIXED AND VARIABLE SPEED**

All fixed speeds and two speeds
**24° before TDC (up to 2200 r/min)**
**27° before TDC (2201 to 3000 r/min)**
**27° before TDC (3001 to 3300 r/min)**
**33° before TDC (3301 to 3600 r/min)**

All variable speeds **33° before TDC**

**VALVE TIMING**

Inlet valve opens **16° before TDC**
Inlet valve closes **36° after BDC**
Exhaust valve opens **44° before BDC**
Exhaust valve closes **8° after TDC**

**TOLERANCES**

Lubricating oil pump:

| | |
|---|---|
| Rotor end clearance (new) | **0.025/0.064 mm (0.001/0.0025 in.)** |
| Rotor end clearance (not to exceed) | **0.127 mm (0.005 in.)** |
| Rotor form clearance (new) | **0.051/0.127 mm (0.002/0.005 in.)** |
| Rotor form clearance (not to exceed) | **0.203 mm (0.008 in.)** |
| Shaft/bore clearance (new) | **0.038/0.076 mm (0.0015/0.003 in.)** |
| Shaft/bore clearance (not to exceed) | **0.127 mm (0.005 in.)** |
| Rotor shaft diameter (new) | **15.032/15.044 mm (0.5918/0.5923 in.)** |
| Camshaft end float | **0.08/0.25 mm (0.003/0.010 in.)** |
| Crankshaft end float | **0.076/0.609 mm (0.003/0.024 in.)** |
| Crankpin ovality (not to exceed) | **0.063 mm (0.0025 in.)** |
| Cylinder bore wear (not to exceed) | **0.25 mm (0.010 in.)** |
| Piston ring gap (new) | **0.28/0.41 mm (0.011/0.016 in.)** |
| Piston ring gap (not to exceed) | **1.14 mm (0.045 in.)** |

## TECHNICAL DATA 'A' RANGE (continued)

### TOLERANCES (continued)

| | |
|---|---|
| Piston ring side clearance (not to exceed) | 0.25 mm (0.010 in.) |
| Exhaust valve lift by decompressor (maximum) | 0.38 mm (0.015 in.) |
| Bumping clearance | 0.56/0.66 mm (0.022/0.026 in.) |
| Valve rocker clearance (cold) | 0.10 mm (0.004 in.) |
| Flame face to valve head dimension | |
| Up to Engine Serial No. 141926 | |
| New | 0.99/1.45 mm (0.039/0.057 in.) |
| Not to exceed | 1.65 mm (0.065 in.) |
| Engine Serial No. 141927 onwards | |
| New | 0.63/1.06 mm (0.025/0.042 in.) |
| Not to exceed | 1.27 mm (0.050 in.) |
| Main bearing clearance (new) | 0.033/0.076 mm (0.0013/0.003 in.) |
| Large end bearing clearance (new) | 0.025/0.09 mm (0.0010/0.0035 in.) |
| Drive shaft diameter (Std) | 25.38/25.40 mm (0.9995/1.000 in.) |
| Drive shaft keyway width | 6.32/6.38 mm (0.249/0.251 in.) |
| Small end bush diameter (fitted) | 22.233/22.243 mm (0.8753/0.8757 in.) |
| Reduction gear power take off shaft end float | 0.05/0.13 mm (0.002/0.005 in.) |

### CYLINDER REBORING DIAMETERS

| | |
|---|---|
| Standard | 69.850/69.875 mm (2.7500/2.7510 in.) |
| Oversize 0.5 mm (0.020 in.) | 70.358/70.388 mm (2.7700/2.7710 in.) |
| 1.0 mm (0.040 in.) | 70.866/70.891 mm (2.7900/2.7910 in.) |

### CRANKSHAFT REGRINDING DIAMETERS

| | |
|---|---|
| Standard | 41.275/41.262 mm (1.6250/1.6245 in.) |
| Undersize 0.25 mm (0.010 in.) | 41.021/41.008 mm (1.6150/1.6145 in.) |
| 0.50 mm (0.020 in.) | 40.767/40.754 mm (1.6050/1.6045 in.) |

### TORQUE SPANNER SETTINGS

| | |
|---|---|
| Large end bolt | 34 Nm (25 lbf ft.) |
| Cylinder head nut | 27 Nm (20 lbf ft.) |
| Injector stud nut | 18 Nm (13 lbf ft.) |
| Flywheel nut | 210 Nm (155 lbf ft.) |
| Flywheel extension or gearwheel bolt | 36 Nm (27 lbf ft.) |
| Lubricating oil pump screw | 14 Nm (10 lbf ft.) |
| Lubricating oil filter centre bolt | 14 Nm (10 lbf ft.) |
| Fuel pump delivery union body | 41 Nm (30 lbf ft.) |
| Fuel injection pump nuts | 18 Nm (13 lbf ft.) |
| Crankshaft and camshaft extension shaft screw | 19 Nm (14 lbf ft.) |
| Crankshaft gearwheel retaining screw | 36 Nm (27 lbf ft.) |
| Camshaft gearwheel retaining screw | 36 Nm (27 lbf ft.) |
| Raised hand start (starting handle shaft retaining screw) | 34 Nm (25 lbf ft.) |
| Mounting plate screw (4:1 hand starting) (F/W/E) | 24 Nm (18 lbf ft.) |
| Sliding plate locating screw (4:1 hand starting) (F/W/E) | 24 Nm (18 lbf ft.) |
| Sliding plate top screw (4:1 hand starting) (F/W/E) | 16 Nm (12 lbf ft.) |

## TECHNICAL DATA 'A' RANGE (continued)

### TORQUE SPANNER SETTINGS (continued)

| | |
|---|---|
| Gearwheel retaining clip screw (4:1 hand starting) (F/W/E) | **16 Nm (12 lbf ft.)** |
| Pinion bolt (4:1 hand starting) (F/W/E) | **33/41 Nm (25/30 lbf ft.)** |
| Rope start pulley retaining bolt (G/E) | **18 Nm (13 lbf ft.)** |
| Air cell plug | **95 Nm (70 lbf ft.)** |
| Breather base to crankcase | **5 Nm (4 lbf ft.)** |
| Gear cover cap screw | **12 Nm (9 lbf ft.)** |
| Sump cap screw | **12 Nm (9 lbf ft.)** |
| 1/8 in. BSP oil gallery plug | **14 Nm (10 lbf ft.)** |

## TECHNICAL DATA 'A' RANGE (continued)

### AB1 ENGINE (Model Build After Engine Serial Number 55000)

Bore (nominal) **76.2 mm (3 in.)**
Stroke **57.15 mm (2.25 in.)**

Power and Speed per cylinder (continuous rating):

**1.7 kW (2.3 bhp) at 1500 r/min**
**2.0 kW (2.7 bhp) at 1800 r/min**
**2.4 kW (3.2 bhp) at 2100 r/min**
**2.85 kW (3.8 bhp) at 2500 r/min**
**3.35 kW (4.5 bhp) at 3000 r/min**
**3.7 kW (5.0 bhp) at 3600 r/min**

| | |
|---|---|
| Cubic capacity per cylinder | **0.261 litres (15.9 in.$^3$)** |
| Compression ratio | **16.25:1** |
| Lubricating oil pressure (minimum) | **2.4 bar (35 lbf/in.$^2$)** |

**FUEL TANK CAPACITY** (standard engine mounted): **5.13 litres (9 pints)**

**OIL CAPACITY: 1.9 litres (3.25 pints)**

| | |
|---|---|
| **LUBRICATING OIL:** | to MIL-L-46152-B<br>formerly MIL-L-2104B (now obsolete) |
| **FUEL:** | A high grade light distillate diesel fuel in accordance with B.S. Specification No. 2869: 1970 Class A1 or A2 |
| **STARTER MOTOR BATTERY:** | 12 Volts 57 Ampere Hours (min)<br>NEGATIVE EARTH |
| **FUEL INJECTION RELEASE PRESSURE:** | **162/183 bar (2350/2650 lbf in.$^2$)** |

### FUEL INJECTION TIMING (BY SPILL): FIXED AND VARIABLE SPEED

| | |
|---|---|
| All fixed speeds and two speeds up to 3000 r/min | **23° before TDC (up to 2200 r/min)**<br>**26° before TDC (2201 to 2700 r/min)**<br>**30° before TDC (2701 to 3000 r/min)** |
| Fixed speed and two speed 3001 to 3600 r/min | **30° before TDC** |
| All variable speeds | **30° before TDC** |

### VALVE TIMING

| | |
|---|---|
| Inlet valve opens | **13° before TDC** |
| Inlet valve closes | **38° after BDC** |
| Exhaust valve opens | **38° before BDC** |
| Exhaust valve closes | **13° after TDC** |

### TOLERANCES

Lubricating oil pump:

| | |
|---|---|
| Rotor end clearance (new) | **0.025/0.064 mm (0.001/0.0025 in.)** |
| Rotor end clearance (not to exceed) | **0.127 mm (0.005 in.)** |
| Rotor form clearance (new) | **0.051/0.127 mm (0.002/0.005 in.)** |
| Rotor form clearance (not to exceed) | **0.203 mm (0.008 in.)** |
| Shaft/bore clearance (new) | **0.038/0.076 mm (0.0015/0.003 in.)** |
| Shaft/bore clearance (not to exceed) | **0.127 mm (0.005 in.)** |
| Rotor shaft diameter (new) | **15.032/15.044 mm (0.5918/0.5923 in.)** |
| Camshaft end float | **0.08/0.25 mm (0.003/0.010 in.)** |
| Crankshaft end float | **0.076/0.609 mm (0.003/0.024 in.)** |
| Crankpin ovality (not to exceed) | **0.063 mm (0.0025 in.)** |
| Cylinder bore wear (not to exceed) | **0.25 mm (0.010 in.)** |
| Piston ring gap (new) | **0.3/0.43 mm (0.012/0.017 in.)** |
| Piston ring gap (not to exceed) | **1.14 mm (0.045 in.)** |

## TECHNICAL DATA 'A' RANGE (continued)

### TOLERANCES (continued)

| | |
|---|---|
| Piston ring side clearance (not to exceed) | **0.25 mm (0.010 in.)** |
| Exhaust valve lift by decompressor (maximum) | **0.38 mm (0.015 in.)** |
| Bumping clearance | **0.56/0.66 mm (0.022/0.026 in.)** |
| Valve rocker clearance (cold) | **0.10 mm (0.004 in.)** |
| Flame face to valve head dimension (new) | **1.29/1.72 mm (0.051/0.068 in.)** |
| Flame face to valve head dimension (not to exceed) | **1.93 mm (0.076 in.)** |
| Main bearing clearance (new) | **0.033/0.076 mm (0.0013/0.0030 in.)** |
| Large end bearing clearance (new) | **0.025/0.090 mm (0.0010/0.0035 in.)** |
| Drive shaft diameter (Std) | **25.38/25.40 mm (0.9995/1.000 in.)** |
| Drive shaft keyway width | **6.32/6.38 mm (0.249/0.251 in.)** |
| Small end bush diameter (fitted) | **22.233/22.243 mm (0.8753/0.8757 in.)** |

### CYLINDER REBORING DIAMETERS

| | | |
|---|---|---|
| Standard | | **76.20/76.23 mm (3.000/3.001 in.)** |
| Oversize | 0.50 mm (0.020 in.) | **76.71/76.73 mm (3.020/3.021 in.)** |
| | 1.0 mm (0.040 in.) | **77.22/77.24 mm (3.040/3.041 in.)** |

### CRANKSHAFT REGRINDING DIAMETERS

| | | |
|---|---|---|
| Standard | | **41.275/41.262 mm (1.6250/1.6245 in.)** |
| Undersize | 0.25 mm (0.010 in.) | **41.021/41.008 mm (1.6150/1.6145 in.)** |
| | 0.50 mm (0.020 in.) | **40.767/40.754 mm (1.6050/1.6045 in.)** |

### TORQUE SPANNER SETTINGS

| | |
|---|---|
| Large end bolt | **34 Nm (25 lbf ft.)** |
| Cylinder head nut | **27 Nm (20 lbf ft.)** |
| Injector stud nut | **18 Nm (13 lbf ft.)** |
| Flywheel nut | **210 Nm (155 lbf ft.)** |
| Flywheel extension or gearwheel bolt | **36 Nm (27 lbf ft.)** |
| Lubricating oil pump screw | **14 Nm (10 lbf ft.)** |
| Lubricating oil filter centre bolt | **14 Nm (10 lbf ft.)** |
| Fuel pump delivery union body | **41 Nm (30 lbf ft.)** |
| Crankshaft and camshaft extension shaft screw | **19 Nm (14 lbf ft.)** |
| Crankshaft gearwheel retaining screw | **36 Nm (27 lbf ft.)** |
| Camshaft gearwheel retaining screw | **36 Nm (27 lbf ft.)** |
| Raised hand start (starting handle shaft retaining screw) | **34 Nm (25 lbf ft.)** |
| Mounting plate screw (4:1 hand starting) (F/W/E) | **24 Nm (18 lbf ft.)** |
| Sliding plate locating screw (4:1 hand starting) (F/W/E) | **24 Nm (18 lbf ft.)** |
| Sliding plate stop screw (4:1 hand starting) (F/W/E) | **16 Nm (12 lbf ft.)** |
| Gearwheel retaining clip screw (4:1 hand starting) (F/W/E) | **16 Nm (12 lbf ft.)** |
| Pinion bolt (4:1 hand starting) (F/W/E) | **33/41 Nm (25/30 lbf ft.)** |
| Rope start pulley retaining bolt (G/E) | **18 Nm (13 lbf ft.)** |
| Air cell plug | **95 Nm (70 lbf ft.)** |

## TECHNICAL DATA 'A' RANGE (continued)

### TORQUE SPANNER SETTINGS (continued)

| | | |
|---|---|---|
| Breather base to crankcase | **5 Nm** | **(4 lbf ft.)** |
| Gear cover cap screw | **12 Nm** | **(9 lbf ft.)** |
| Sump cap screw | **12 Nm** | **(9 lbf ft.)** |
| Fuel injection pump nut | **18 Nm** | **(13 lbf ft.)** |
| 1/8 in. BSP oil gallery plug | **14 Nm** | **(10 lbf ft.)** |

## TECHNICAL DATA 'A' RANGE (continued)

### AC1 ENGINE (Model Build After Engine Serial Number 60000)

Bore (nominal) **76.2 mm (3 in.)**
Stroke **66.67 mm (2.625 in.)**

Power and Speed per cylinder (continuous rating):

**2.0 kW (2.7 bhp) at 1500 r/min**
**2.45 kW (3.3 bhp) at 1800 r/min**
**3 kW (4.0 bhp) at 2100 r/min**
**3.7 kW (5.0 bhp) at 2500 r/min**
**4.45 kW (6.0 bhp) at 3000 r/min**
**4.8 kW (6.5 bhp) at 3600 r/min**

Cubic capacity per cylinder **0.304 litres (18.5 in.$^3$)**

Compression ratio **17:1**

Lubricating oil pressure (minimum) **2.4 bar (35 lbf/in.$^2$)**

**FUEL TANK CAPACITY** (standard engine mounted): **5.13 litres (9 pints)**

**OIL CAPACITY: 2.7 litres (4.75 pints)**

**LUBRICATING OIL:** to MIL-L-46152-B
formerly MIL-L-2104B (now obsolete)

**FUEL:** A high grade light distillate diesel fuel in accordance with B.S. Specification No. 2869: 1970 Class A1 or A2

**STARTER MOTOR BATTERY:** 12 Volts 57 Ampere Hours (min)
NEGATIVE EARTH

**FUEL INJECTION RELEASE PRESSURE: 162/183 bar (2350/2650 lbf in.$^2$)**

### FUEL INJECTION TIMING (BY SPILL): FIXED AND VARIABLE SPEED

All fixed speed and two speeds
**26° before TDC (up to 2200 r/min)**
**28° before TDC (2201 to 2800 r/min)**
**30° before TDC (2801 to 3300 r/min)**
**33° before TDC (3301 to 3600 r/min)**

All variable speeds **30° before TDC**

### VALVE TIMING

*Up to Engine Serial No. 46518*

Inlet valve opens **13°** before TDC
Inlet valve closes **38°** after BDC
Exhaust valve opens **38°** before BDC
Exhaust valve closes **13°** after TDC

*Engine Serial No. 46519 to 61896*

Inlet valve opens **53.5°** before TDC
Inlet valve closes **78.5°** after BDC
Exhaust valve opens **78.5°** before BDC
Exhaust valve closes **53.5°** after TDC

*With engine cold and valve rocker clearance set at* **0.10 mm (0.004 in.)**

*Engine Serial No. 61897 onwards*

Inlet valve opens **45.5°** before TDC
Inlet valve closes **70.5°** after BDC
Exhaust valve opens **78.5°** before BDC
Exhaust valve closes **53.5°** after TDC

*With engine cold and valve rocker clearance set at* **0.10 mm (0.004 in.)**

### TOLERANCES

Lubricating oil pump:

| | |
|---|---|
| Rotor end clearance (new) | **0.025/0.064 mm (0.001/0.0025 in.)** |
| Rotor end clearance (not to exceed) | **0.127 mm (0.005 in.)** |
| Rotor form clearance (new) | **0.051/0.127 mm (0.002/0.005 in.)** |
| Rotor form clearance (not to exceed) | **0.203 mm (0.008 in.)** |

## TECHNICAL DATA 'A' RANGE (continued)

### TOLERANCES (continued)

| | |
|---|---|
| Shaft/bore clearance (new) | 0.038/0.076 mm (0.0015/0.003 in.) |
| Shaft/bore clearance (not to exceed) | 0.127 mm (0.005 in.) |
| Rotor shaft diameter (new) | 15.032/15.044 mm (0.5918/0.5923 in.) |
| Camshaft end float | 0.08/0.25 mm (0.003/0.010 in.) |
| Crankshaft end float | 0.076/0.609 mm (0.003/0.024 in.) |
| Crankpin ovality (not to exceed) | 0.063 mm (0.0025 in.) |
| Cylinder bore wear (not to exceed) | 0.25 mm (0.010 in.) |
| Piston ring gap (new): top and second ring | 0.30/0.43 mm (0.012/0.017 in.) |
| Piston ring gap (new): oil control ring | 0.23/0.36mm (0.009/0.014in) |
| Piston ring gap (not to exceed) | 1.14 mm (0.045 in.) |
| Piston ring side clearance (not to exceed) | 0.25 mm (0.010 in.) |
| Exhaust valve lift by decompressor (maximum) | 0.38 mm (0.015 in.) |
| Bumping clearance | 0.56/0.66 mm (0.022/0.026 in.) |
| Valve rocker clearance (cold) | 0.10 mm (0.004 in.) |
| Flame face to valve head dimension (new) | 1.29/1.72 mm (0.051/0.068 in.) |
| Flame face to valve head dimension (not to exceed) | 1.93 mm (0.076 in.) |
| Main bearing clearance (new) | 0.033/0.076 mm (0.0013/0.0030 in.) |
| Large end bearing clearance (new) | 0.025/0.090 mm (0.0010/0.0035 in.) |
| Drive shaft diameter (Std) | 25.38/25.40 mm (0.9995/1.000 in.) |
| Drive shaft keyway width | 6.32/6.38 mm (0.249/0.251 in.) |
| Small end bush diameter (fitted) | 22.233/22.243 mm (0.8753/0.8757 in.) |

### CYLINDER REBORING DIAMETERS

| | | |
|---|---|---|
| Standard | | 76.20/76.23 mm (3.000/3.001 in.) |
| Oversize | 0.5 mm (0.020 in.) | 76.71/76.73 mm (3.020/3.021 in.) |
| | 1.0 mm (0.040 in.) | 77.22/77.24 mm (3.040/3.041 in.) |

### CRANKSHAFT REGRINDING DIAMETERS

| | | |
|---|---|---|
| Standard | | 41.275/41.262 mm (1.6250/1.6245 in.) |
| Undersize | 0.25 mm (0.010 in.) | 41.021/41.008 mm (1.6150/1.6145 in.) |
| | 0.50 mm (0.020 in.) | 40.767/40.754 mm (1.6050/1.6045 in.) |

### TORQUE SPANNER SETTINGS

| | |
|---|---|
| Large end bolt | 34 Nm (25 lbf ft.) |
| Cylinder head nut | 27 Nm (20 lbf ft.) |
| Injector stud nut | 18 Nm (13 lbf ft.) |
| Flywheel nut | 210 Nm (155 lbf ft.) |
| Flywheel extension or gearwheel bolt | 36 Nm (27 lbf ft.) |
| Lubricating oil pump screw | 14 Nm (10 lbf ft.) |
| Lubricating oil filter centre bolt | 14 Nm (10 lbf ft.) |
| Fuel pump delivery union body | 41 Nm (30 lbf ft.) |
| Crankshaft and camshaft extension shaft screw | 19 Nm (14 lbf ft.) |
| Crankshaft gearwheel retaining screw | 36 Nm (27 lbf ft.) |
| Camshaft gearwheel retaining screw | 36 Nm (27 lbf ft.) |
| Raised hand start (starting handle shaft retaining screw) | 36 Nm (27 lbf ft.) |

## TORQUE SPANNER SETTINGS (continued)

| | |
|---|---|
| Mounting plate screw (4:1 hand starting) (F/W/E) | **24 Nm (18 lbf ft.)** |
| Sliding plate locating screw (4:1 hand starting) (F/W/E) | **24 Nm (18 lbf ft.)** |
| Sliding plate stop screw (4:1 hand starting) (F/W/E) | **16 Nm (12 lbf ft.)** |
| Gearwheel retaining clip screw (4:1 hand starting) (F/W/E) | **16 Nm (12 lbf ft.)** |
| Pinion bolt (4:1 hand starting) (F/W/E) | **33/41 Nm (25/30 lbf ft.)** |
| Rope start pulley retaining bolt (G/E) | **18 Nm (13 lbf ft.)** |
| Air cell plug | **95 Nm (70 lbf ft.)** |
| Breather base to crankcase | **5 Nm (4 lbf ft.)** |
| Top fuel tank bracket set screw (H.D.P. fuel tank only) | **11 Nm (8 lbf ft.)** |
| Bottom fuel tank bracket set screw (H.D.P. fuel tank only) | **11 Nm (8 lbf ft.)** |
| Gear cover cap screw | **12 Nm (9 lbf ft.)** |
| Fuel lift pump cover set screw | **18 Nm (13 lbf ft.)** |
| Sump cap screw | **12 Nm (9 lbf ft.)** |
| Fuel injection pump nut | **18 Nm (13 lbf ft.)** |
| 1/8 in. BSP oil gallery plug | **14 Nm (10 lbf ft.)** |

## TECHNICAL DATA 'A' RANGE (continued)

### AC1Z ENGINE (Model Build After Engine Serial Number 20000)

Bore (nominal) **76.2 mm (3 in.)**
Stroke **66.68 mm (2.625 in.)**

Power and Speed per cylinder (continuous rating):
**1.65 kW (2.2 bhp) at 1500 r/min to 4.45 kW (6.0 bhp) at 3000 r/min**

Cubic capacity per cylinder **0.304 litres (18.6 in.$^3$)**

Compression ratio **17:1**

Lubricating oil pressure (minimum) **2.4 bar (35 lbf/in.$^2$)**

**FUEL TANK CAPACITY** (standard engine mounted): **5.13 litres (9 pints)**

**OIL CAPACITY: 2.7 litres (4.75 pints)**

**LUBRICATING OIL:** to MIL-L-46152-B
formerly MIL-L-2104B (now obsolete)

**FUEL:** A high grade light distillate diesel fuel in accordance with B.S. Specification No. 2869: 1970 Class A1 or A2

**FUEL INJECTION RELEASE PRESSURE: 162/183 bar (2350/2650 lbf in.$^2$)**

### FUEL INJECTION TIMING (BY SPILL): FIXED AND VARIABLE SPEED

All speeds **32° before TDC (up to Engine No. 14649)**
**30° before TDC (Engine No. 14650 onwards)**

### VALVE TIMING

*Up to Engine Serial No. 12647*

Inlet valve opens **13°** before TDC
Inlet valve closes **38°** after BDC
Exhaust valve opens **38°** before BDC
Exhaust valve closes **13°** after TDC

*Engine Serial No. 12648 to 19999*

Inlet valve opens **53.5°** before TDC
Inlet valve closes **78.5°** after BDC
*With engine cold and valve rocker clearance set at* **0.10 mm (0.004 in.)**
Exhaust valve opens **78.5°** before BDC
Exhaust valve closes **53.5°** after TDC

*Engine Serial No. 20000 onwards*

Inlet valve opens **45.5°** before TDC
Inlet valve closes **70.5°** after BDC
*With engine cold and valve rocker clearance set at* **0.10 mm (0.004 in.)**
Exhaust valve opens **78.5°** before BDC
Exhaust valve closes **53.5°** after TDC

### TOLERANCES

Lubricating oil pump:

| | |
|---|---|
| Rotor end clearance (new) | **0.025/0.064 mm (0.001/0.0025 in.)** |
| Rotor end clearance (not to exceed) | **0.127 mm (0.005 in.)** |
| Rotor form clearance (new) | **0.051/0.127 mm (0.002/0.005 in.)** |
| Rotor form clearance (not to exceed) | **0.203 mm (0.008 in.)** |
| Shaft/bore clearance (new) | **0.038/0.076 mm (0.0015/0.003 in.)** |
| Shaft/bore clearance (not to exceed) | **0.127 mm (0.005 in.)** |
| Rotor shaft diameter (new) | **15.032/15.044 mm (0.5918/0.5923 in.)** |
| Camshaft end float | **0.08/0.25 mm (0.003/0.010 in.)** |
| Crankshaft end float | **0.016/0.609 mm (0.003/0.024 in.)** |
| Crankpin ovality (not to exceed) | **0.063 mm (0.0025 in.)** |
| Cylinder bore wear (not to exceed) | **0.25 mm (0.010 in.)** |

## TECHNICAL DATA 'A' RANGE (continued)

### TOLERANCES (continued)

| | |
|---|---|
| Piston ring gap (new): top and second ring | 0.3/0.43 mm (0.012/0.017 in.) |
| Piston ring gap (new): oil control ring | 0.23/0.36 mm (0.009/0.014 in.) |
| Piston ring gap (not to exceed) | 1.14 mm (0.045 in.) |
| Piston ring side clearance (not to exceed) | 0.25 mm (0.010 in.) |
| Exhaust valve lift by decompressor (maximum) | 0.38 mm (0.015 in.) |
| Bumping clearance | 0.56/0.66 mm (0.022/0.026 in.) |
| Valve rocker clearance (cold) | 0.10 mm (0.004 in.) |
| Flame face to valve head dimension (new) | 1.29/1.72 mm (0.051/0.068 in.) |
| Flame face to valve head dimension (not to exceed) | 1.93 mm (0.076 in.) |
| Main bearing clearance (new) | 0.033/0.076 mm (0.0013/0.003 in.) |
| Large end bearing clearance (new) | 0.025/0.09 mm (0.0010/0.0035 in.) |
| Drive shaft diameter | 25.38/25.40 mm (0.9995/1.000 in.) |
| Drive shaft keyway width | 6.32/6.38 mm (0.249/0.251 in.) |
| Small end bush diameter (fitted) | 22.233/22.243 mm (0.8753/0.8757 in.) |

### CYLINDER REBORING DIAMETERS

| | | |
|---|---|---|
| Standard | | 76.20/76.23 mm (3.000/3.001 in.) |
| Oversize | 0.5 mm (0.020 in.) | 76.71/76.73 mm (3.020/3.021 in.) |
| | 1.0 mm (0.040 in.) | 77.22/77.24 mm (3.040/3.041 in.) |

### CRANKSHAFT REGRINDING DIAMETERS (Main journal and crankpin)

| | | |
|---|---|---|
| Standard | | 41.275/41.262 mm (1.6250/1.6245 in.) |
| Undersize | 0.25 mm (0.010 in.) | 41.021/41.008 mm (1.6150/1.6145 in.) |
| | 0.50 mm (0.020 in.) | 40.767/40.754 mm (1.6050/1.6045 in.) |

### TORQUE SPANNER SETTINGS

| | |
|---|---|
| Large end bolt | 34 Nm (25 lbf ft.) |
| Cylinder head nut | 27 Nm (20 lbf ft.) |
| Injector stud nut | 18 Nm (13 lbf ft.) |
| Flywheel nut | 210 Nm (155 lbf ft.) |
| Flywheel extension shaft bolt | 33/41 Nm (25/30 lbf ft.) |
| Lubricating oil pump screw | 14 Nm (10 lbf ft.) |
| Lubricating oil filter centre bolt | 14 Nm (10 lbf ft.) |
| Fuel pump delivery union body | 41 Nm (30 lbf ft.) |
| Crankshaft gearwheel retaining screw | 36 Nm (27 lbf ft.) |
| Air cell plug | 95 Nm (70 lbf ft.) |
| Breather base to crankcase | 5 Nm (4 lbf ft.) |
| Camshaft gear and starting handle dog retaining cap screw | 27 Nm (20 lbf ft.) |
| Gear cover cap screw | 12 Nm (9 lbf ft.) |
| Sump cap screw | 12 Nm (9 lbf ft.) |
| Fuel injection pump nut | 18 Nm (13 lbf ft.) |
| 1/8 in. BSP oil gallery plug | 14 Nm (10 lbf ft.) |

## TECHNICAL DATA 'A' RANGE (continued)

### AC1ZS ENGINE (Model Build After Engine Serial Number 10000)

Bore (nominal) **76.2 mm (3 in.)**
Stroke **66.68 mm (2.625 in.)**

Power and Speed per cylinder (continuous rating):

**1.15 kW (1.5 bhp) at 1000 r/min**
**1.5 kW (2.0 bhp) at 1250 r/min**
**1.85 kW (2.5 bhp) at 1500 r/min**
**2.25 kW (3.0 bhp) at 1800 r/min**

| | |
|---|---|
| Cubic capacity per cylinder | **0.305 litres (18.6 in.$^3$)** |
| Compression ratio | **17:1** |
| Lubricating oil pressure (minimum) | **2.06 bar (30 lbf/in.$^2$) at 1250 r/min**<br>**2.4 bar (35 lbf/in.$^2$) at 1800 r/min** |

**FUEL TANK CAPACITY** (standard engine mounted): **5.13 litres (9 pints)**

**OIL CAPACITY:** **2.7 litres (4.75 pints)**

**LUBRICATING OIL:** to MIL-L-46152-B
formerly MIL-L-2104B (now obsolete)

**FUEL:** A high grade light distillate diesel fuel in accordance with B.S. Specification No. 2869: 1970 Class A1 or A2

**FUEL INJECTION RELEASE PRESSURE:** **162/183 bar (2350/2650 lbf in.$^2$)**

**FUEL INJECTION TIMING (BY SPILL): FIXED AND VARIABLE SPEED**

**20°** before TDC (1000 to 1250 r/min)
**25°** before TDC (1251 to 1800 r/min)

### VALVE TIMING

*Up to Engine Serial No. 9999*

| | |
|---|---|
| Inlet valve opens | **13°** before TDC |
| Inlet valve closes | **38°** after BDC |
| Exhaust valve opens | **38°** before BDC |
| Exhaust valve closes | **13°** after TDC |

*Engine Serial No. 10000 onwards*

| | | |
|---|---|---|
| Inlet valve opens | **45.5°** before TDC | ) |
| Inlet valve closes | **70.5°** after BDC | ) *With engine cold and valve rocker clearance set at* |
| Exhaust valve opens | **38°** before BDC | ) **0.10 mm (0.004 in.)** |
| Exhaust valve closes | **13°** after TDC | ) |

### TOLERANCES

| | |
|---|---|
| Lubricating oil pump: | |
| Rotor end clearance (new) | **0.025/0.064 mm (0.001/0.0025 in.)** |
| Rotor end clearance (not to exceed) | **0.127 mm (0.005 in.)** |
| Rotor form clearance (new) | **0.051/0.127 mm (0.002/0.005 in.)** |
| Rotor form clearance (not to exceed) | **0.203 mm (0.008 in.)** |
| Shaft/bore clearance (new) | **0.038/0.076 mm (0.0015/0.003 in.)** |
| Shaft/bore clearance (not to exceed) | **0.127 mm (0.005 in.)** |
| Rotor shaft diameter (new) | **15.032/15.044 mm (0.5918/0.5923 in.)** |
| Camshaft end float | **0.08/0.25 mm (0.003/0.010 in.)** |
| Crankshaft end float | **0.076/0.609 mm (0.003/0.024 in.)** |
| Crankpin ovality (not to exceed) | **0.063 mm (0.0025 in.)** |
| Cylinder bore wear (not to exceed) | **0.25 mm (0.010 in.)** |
| Piston ring gap (new): top and second ring | **0.3/0.43 mm (0.012/0.017 in.)** |
| Piston ring gap (new): oil control ring | **0.23/0.36 mm (0.009/0.014 in.)** |

## TECHNICAL DATA 'A' RANGE (continued)

### TOLERANCES (continued)

| | |
|---|---|
| Piston ring gap (new) | 0.28/0.41 mm (0.011/0.016 in.) |
| Piston ring gap (not to exceed) | 1.14 mm (0.045 in.) |
| Piston ring side clearance (not to exceed) | 0.25 mm (0.010 in.) |
| Exhaust valve lift by decompressor (maximum) | 0.38 mm (0.015 in.) |
| Bumping clearance | 0.56/0.66 mm (0.022/0.026 in.) |
| Valve rocker clearance (cold) | 0.10 mm (0.004 in.) |
| Flame face to valve head dimension (new) | 1.29/1.72 mm (0.051/0.068 in.) |
| Flame face to valve head dimension (not to exceed) | 1.93 mm (0.76 in.) |
| Main bearing clearance (new) | 0.033/0.076 mm (0.0013/0.0030 in.) |
| Large end bearing clearance (new) | 0.025/0.09 mm (0.0010/0.0035 in.) |
| Drive shaft diameter | 25.38/25.40 mm (0.9995/1.000 in.) |
| Drive shaft keyway width | 6.32/6.38 mm (0.249/0.251 in.) |
| Small end bush diameter (fitted) | 22.233/22.243 mm (0.8753/0.8757 in.) |

### CYLINDER REBORING DIAMETERS

| | | |
|---|---|---|
| Standard | | 76.20/76.23 mm (3.000/3.001 in.) |
| Oversize | 0.5 mm (0.020 in.) | 76.71/76.73 mm (3.020/3.021 in.) |
| | 1.0 mm (0.040 in.) | 77.22/77.24 mm (3.040/3.041 in.) |

### CRANKSHAFT REGRINDING DIAMETERS (Main journal and crankpin)

| | | |
|---|---|---|
| Standard | | 41.275/41.262 mm (1.6250/1.6245 in.) |
| Undersize | 0.25 mm (0.010 in.) | 41.021/41.008 mm (1.6150/1.6145 in.) |
| | 0.50 mm (0.020 in.) | 40.767/40.754 mm (1.6050/1.6045 in.) |

### TORQUE SPANNER SETTINGS

| | |
|---|---|
| Large end bolt | 34 Nm (25 lbf ft.) |
| Cylinder head nut | 27 Nm (20 lbf ft.) |
| Injector stud nut | 18 Nm (13 lbf ft.) |
| Flywheel nut | 210 Nm (155 lbf ft.) |
| Flywheel extension shaft bolt | 33/41 Nm (25/30 lbf ft.) |
| Lubricating oil pump screw | 14 Nm (10 lbf ft.) |
| Lubricating oil filter centre bolt | 14 Nm (10 lbf ft.) |
| Fuel pump delivery union body | 41 Nm (30 lbf ft.) |
| Crankshaft gearwheel retaining screw | 36 Nm (27 lbf ft.) |
| Air cell plug | 95 Nm (70 lbf ft.) |
| Breather base to crankcase | 5 Nm (4 lbf ft.) |
| Camshaft gear and starting handle dog retaining cap screw | 27 Nm (20 lbf ft.) |
| Gear cover cap screw | 12 Nm (9 lbf ft.) |
| Sump cap screw | 12 Nm (9 lbf ft.) |
| Fuel injection pump nut | 18 Nm (13 lbf ft.) |
| 1/8 in. BSP oil gallery plug | 14 Nm (10 lbf ft.) |

## TECHNICAL DATA 'A' RANGE (continued)

### AC2 ENGINE

Bore (nominal) **76.2 mm (3 in.)**
Stroke **66.68 mm (2.625 in.)**

Power and Speed (continuous rating):

**6.7 kW (9.0 bhp) at 2500 r/min**
**8.2 kW (11.0 bhp) at 3000 r/min**
**8.95 kW (12.0 bhp) at 3600 r/min**

Cubic capacity per cylinder **0.304 litres (18.5 in.$^3$)**

Compression ratio **17:1**

Lubricating oil pressure (minimum) **2.4 bar (35 lbf/in.$^2$)**

**FUEL TANK CAPACITY** (standard engine mounted): **5.13 litres (9 pints)**

**OIL CAPACITY: 3.7 litres (6.5 pints)**

**LUBRICATING OIL:** to MIL-L-46152-B
formerly MIL-L-2104B (now obsolete)

**FUEL:** A high grade light distillate diesel fuel in accordance with B.S. Specification No. 2869: 1970 Class A1 or A2

**STARTER MOTOR ASSEMBLY:** 12 Volts 58 Ampere Hours (min)
NEGATIVE EARTH

**FUEL INJECTION RELEASE PRESSURE: 162/183 bar (2350/2650 lbf in.$^2$)**

**FUEL INJECTION TIMING (BY SPILL): FIXED AND VARIABLE SPEED**

All fixed speeds
**30° before TDC (2201 to 2800 r/min)**
**32° before TDC (2801 to 3200 r/min)**
**34° before TDC (3201 to 3600 r/min)**

All variable speeds **32° before TDC**

### VALVE TIMING

*Up to Engine Serial No. 8098*

Inlet valve opens **13°** before TDC
Inlet valve closes **38°** after BDC

Exhaust valve opens **38°** before BDC
Exhaust valve closes **13°** after TDC

*Engine Serial No. 8099 onwards*

Inlet valve opens **53.5°** before TDC
Inlet valve closes **78.5°** after BDC
*With engine cold and valve rocker clearance set at* **0.10 mm (0.004 in.)**
Exhaust valve opens **78.5°** before BDC
Exhaust valve closes **53.5°** after TDC

### TOLERANCES

Lubricating oil pump:

| | |
|---|---|
| Rotor end clearance (new) | **0.025/0.064 mm (0.001/0.0025 in.)** |
| Rotor end clearance (not to exceed) | **0.127 mm (0.005 in.)** |
| Rotor form clearance (new) | **0.051/0.127 mm (0.002/0.005 in.)** |
| Rotor form clearance (not to exceed) | **0.203 mm (0.008 in.)** |
| Shaft/bore clearance (new) | **0.038/0.076 mm (0.0015/0.003 in.)** |
| Shaft/bore clearance (not to exceed) | **0.127 mm (0.005 in.)** |
| Rotor shaft diameter (new) | **15.032/15.044 mm (0.5918/0.5923 in.)** |
| Camshaft end float | **0.08/0.25 mm (0.003/0.010 in.)** |
| Crankshaft end float | **0.076/0.609 mm (0.003/0.024 in.)** |
| Crankpin ovality (not to exceed) | **0.063 mm (0.0025 in.)** |
| Cylinder bore wear (not to exceed) | **0.25 mm (0.010 in.)** |

## TECHNICAL DATA 'A' RANGE (continued)

### TOLERANCES (continued)

| | |
|---|---|
| Piston ring gap (new): top and second ring | 0.30/0.43 mm (0.012/0.017 in.) |
| Piston ring gap (new): oil control ring | 0.23/0.36 mm (0.009/0.014 in.) |
| Piston ring gap (not to exceed) | 1.14 mm (0.045 in.) |
| Piston ring side clearance (not to exceed) | 0.25 mm (0.010 in.) |
| Exhaust valve lift by decompressor (maximum) | 0.38 mm (0.015 in.) |
| Bumping clearance | 0.56/0.66 mm /0.022/0.026 in.) |
| Valve rocker clearance (cold) | 0.10 mm (0.004 in.) |
| Flame face to valve head dimension (new) | 1.29/1.72 mm (0.051/0.068 in.) |
| Flame face to valve head dimension (not to exceed) | 1.93 mm (0.076 in.) |
| Main bearing clearance gear end (new) | 0.05/0.088 mm (0.0021/0.0036 in.) |
| Main bearing clearance flywheel end (new) | 0.04/0.078 mm (0.0016/0.0031 in.) |
| Main bearing clearance intermediate (new) | 0.093/0.137 mm (0.0037/0.0054 in.) |
| Large end bearing clearance (new) | 0.025/0.090 mm (0.0010/0.0035 in.) |
| Drive shaft diameter (F/W/E) | 34.900/34.915 mm (1.374/1.375 in.) |
| Drive shaft keyway width | 9.50/9.52 mm (0.374/0.375 in.) |
| Small end bush diameter (fitted) | 22.233/22.243 mm (0.8753/0.8757 in.) |

### CYLINDER REBORING DIAMETERS

| | | |
|---|---|---|
| Standard | | 76.20/76.23 mm (3.000/3.001 in.) |
| Oversize | 0.5 mm (0.020 in.) | 76.71/76.73 mm (3.020/3.021 in.) |
| | 1.0 mm (0.040 in.) | 77.22/77.24 mm (3.040/3.041 in.) |

### CRANKSHAFT REGRINDING DIAMETERS (Main, Intermediate journal and crankpin)

| | | |
|---|---|---|
| Standard | | 41.275/41.262 mm (1.6250/1.6245 in.) |
| Undersize | 0.25 mm (0.010 in.) | 41.021/41.008 mm (1.6150/1.6145 in.) |
| | 0.50 mm (0.020 in.) | 40.767/40.754 mm (1.6050/1.6045 in.) |

### TORQUE SPANNER SETTINGS

| | |
|---|---|
| Large end bolt | 34 Nm (25 lbf ft.) |
| Cylinder head nut | 27 Nm (20 lbf ft.) |
| Injector stud nut | 18 Nm (13 lbf ft.) |
| Flywheel nut | 210 Nm (155 lbf ft.) |
| Flywheel extension or gearwheel bolt | 36 Nm (27 lbf ft.) |
| Lubricating oil pump screw | 14 Nm (10 lbf ft.) |
| Lubricating oil filter centre bolt | 14 Nm (10 lbf ft.) |
| Fuel pump delivery union body | 41 Nm (30 lbf ft.) |
| Injector pump nuts | 18 Nm (13 lbf ft.) |
| Crankshaft and camshaft extension shaft screw | 19 Nm (14 lbf ft.) |
| Crankshaft gearwheel retaining screw | 36 Nm (27 lbf ft.) |
| Camshaft gearwheel retaining screw | 36 Nm (27 lbf ft.) |
| Air cell plug | 95 Nm (70 lbf ft.) |
| Breather base to crankcase | 5 Nm (4 lbf ft.) |
| Intermediate bearing housing retaining bolt | 41 Nm (30 lbf ft.) |
| Camshaft pinion screw | 27 Nm (20 lbf ft.) |

## TECHNICAL DATA 'A' RANGE (continued)

### TORQUE SPANNER SETTINGS (continued)

| | | |
|---|---|---|
| Gear cover cap screw | **12 Nm** | **(9 lbf ft.)** |
| Fuel lift pump cover set screw | **18 Nm** | **(13 lbf ft.)** |
| Sump cap screw | **12 Nm** | **(9 lbf ft.)** |
| Fuel injection pump nut | **18 Nm** | **(13 lbf ft.)** |
| 1/8 in. BSP oil gallery plug | **14 Nm** | **(10 lbf ft.)** |

## TECHNICAL DATA 'A' RANGE (continued)

### AB1W ENGINE

Bore (nominal) **76.2 mm (3 in.)**
Stroke **57.15 mm (2.25 in.)**

Power and Speed per cylinder (continuous rating):

**1.8 kW (2.4 bhp) at 1500 r/min**
**2.25 kW (3.0 bhp) at 1800 r/min**
**2.6 kW (3.5 bhp) at 2100 r/min**
**3.15 kW (4.2 bhp) at 2500 r/min**
**3.35 kW (5.0 bhp) at 3000 r/min**
**3.7 kW (5.5 bhp) at 3600 r/min**

Cubic capacity per cylinder **0.261 litres (15.9 in.$^3$)**

Compression ratio **16.25:1**

Lubricating oil pressure (minimum) **2.4 bar (35 lbf/in.$^2$)**

**FUEL TANK CAPACITY** (standard engine mounted): **5.13 litres (9 pints)**

**OIL CAPACITY: 1.9 litres (3.25 pints)**

**LUBRICATING OIL:** to MIL-L-46152-B
formerly MIL-L-2104B (now obsolete)

**FUEL:** A high grade light distillate diesel fuel in accordance with B.S. Specification No. 2869: 1970 Class A1 or A2

**STARTER MOTOR BATTERY:** 12 Volts 57 Ampere Hours (min)
NEGATIVE EARTH

**FUEL INJECTION RELEASE PRESSURE: 162/183 bar (2350/2650 lbf in.$^2$)**

**FUEL INJECTION TIMING (BY SPILL): FIXED AND VARIABLE SPEED**

| | |
|---|---|
| Fixed speed and two speeds up to 3000 r/min | **29**° before TDC |
| Fixed speed and two speed 3001 to 3600 r/min | **29**° before TDC (3001 to 3300 r/min)<br>**34**° before TDC (3301 to 3600 r/min) |
| All variable speeds | **29**° before TDC |

### VALVE TIMING

| | |
|---|---|
| Inlet valve opens | **13**° before TDC |
| Inlet valve closes | **38**° after BDC |
| Exhaust valve opens | **38**° before BDC |
| Exhaust valve closes | **13**° after TDC |

### TOLERANCES

Lubricating oil pump:

| | |
|---|---|
| Rotor end clearance (new) | **0.025/0.064 mm (0.001/0.0025 in.)** |
| Rotor end clearance (not to exceed) | **0.127 mm (0.005 in.)** |
| Rotor form clearance (new) | **0.051/0.127 mm (0.002/0.005 in.)** |
| Rotor form clearance (not to exceed) | **0.203 mm (0.008 in.)** |
| Shaft/bore clearance (new) | **0.038/0.076 mm (0.0015/0.003 in.)** |
| Shaft/bore clearance (not to exceed) | **0.127 mm (0.005 in.)** |
| Rotor shaft diameter (new) | **15.032/15.044 mm (0.5918/0.5923 in.)** |
| Camshaft end float | **0.08/0.25 mm (0.003/0.010 in.)** |
| Crankshaft end float | **0.076/0.609 mm (0.003/0.024 in.)** |
| Crankpin ovality (not to exceed) | **0.063 mm (0.0025 in.)** |
| Cylinder bore wear (not to exceed) | **0.25 mm (0.010 in.)** |
| Piston ring gap (new) | **0.3/0.43 mm (0.012/0.017 in.)** |
| Piston ring gap (not to exceed) | **1.14 mm (0.045 in.)** |

## TECHNICAL DATA 'A' RANGE (continued)

### TOLERANCES (continued)

| | |
|---|---|
| Piston ring side clearance (not to exceed) | 0.25 mm (0.010 in.) |
| Exhaust valve lift by decompressor (maximum) | 0.038 mm (0.015 in.) |
| Bumping clearance with REINZ head gasket | 0.56/0.66 mm (0.022/0.026 in.) |
| Valve rocker clearance (cold) | 0.10 mm (0.004 in.) |
| Flame face to valve head dimension (new) | 1.29/1.72 mm (0.051/0.068 in.) |
| Flame face to valve head dimension (not to exceed) | 1.93 mm (0.076 in.) |
| Main bearing clearance (new) | 0.033/0.076 mm (0.0013/0.003 in.) |
| Large end bearing clearance (new) | 0.025/0.090 mm (0.0010/0.0035 in.) |
| Drive shaft diameter (Std) | 25.38/25.40 mm (0.9995/1.000 in.) |
| Drive shaft keyway width | 6.32/6.38 mm (0.249/0.251 in.) |
| Small end bush diameter (fitted) | 22.233/22.243 mm (0.8753/0.8757 in.) |

### CYLINDER REBORING DIAMETERS

| | | |
|---|---|---|
| Standard | | 76.20/76.23 mm (3.000/3.001 in.) |
| Oversize | 0.5 mm (0.020 in.) | 76.71/76.73 mm (3.020/3.021 in.) |
| | 1.0 mm (0.040 in.) | 77.22/77.24 mm (3.040/3.041 in.) |

### CRANKSHAFT REGRINDING DIAMETERS (Main journal and crankpin)

| | | |
|---|---|---|
| Standard | | 41.275/41.262 mm (1.6250/1.6245 in.) |
| Undersize | 0.25 mm (0.010 in.) | 41.021/41.008 mm (1.6150/1.6145 in.) |
| | 0.50 mm (0.020 in.) | 40.767/40.754 mm (1.6050/1.6045 in.) |

### TORQUE SPANNER SETTINGS

| | |
|---|---|
| Large end bolt | 34 Nm (25 lbf ft.) |
| Cylinder head nut | 30 Nm (22 lbf ft.) |
| Cylinder head rocker support nut | 32.5 Nm (24 lbf ft.) |
| Injector stud nut | 18 Nm (13 lbf ft.) |
| Flywheel nut | 210 Nm (155 lbf ft.) |
| Flywheel extension or gearwheel bolt | 36 Nm (27 lbf ft.) |
| Lubricating oil pump screw | 14 Nm (10 lbf ft.) |
| Lubricating oil filter centre bolt | 14 Nm (10 lbf ft.) |
| Fuel pump delivery union body | 41 Nm (30 lbf ft.) |
| Crankshaft and camshaft extension shaft screw | 19 Nm (14 lbf ft.) |
| Crankshaft gearwheel retaining screw | 36 Nm (27 lbf ft.) |
| Camshaft gearwheel retaining screw | 36 Nm (27 lbf ft.) |
| Raised hand start (starting handle shaft retaining screw) | 36 Nm (27 lbf ft.) |
| Mounting plate screw (4:1 hand starting) (F/W/E) | 24 Nm (18 lbf ft.) |
| Sliding plate locating screw (4:1 hand starting) (F/W/E) | 24 Nm (18 lbf ft.) |
| Sliding plate stop screw (4:1 hand starting) (F/W/E) | 16 Nm (12 lbf ft.) |
| Gearwheel retaining clip screw (4:1 hand starting) (F/W/E) | 16 Nm (12 lbf ft.) |
| Pinion bolt (4:1 hand starting) (F/W/E) | 33/41 Nm (25/30 lbf ft.) |

## TECHNICAL DATA 'A' RANGE (continued)

### TORQUE SPANNER SETTINGS (continued)

| | | |
|---|---|---|
| Rope start pulley retaining bolt (G/E) | **18 Nm** | **(13 lbf ft.)** |
| Air cell plug | **95 Nm** | **(70 lbf ft.)** |
| Breather base to crankcase | **5 Nm** | **(4 lbf ft.)** |
| Gear cover cap screw | **12 Nm** | **(9 lbf ft.)** |
| Fuel lift pump cover set screw | **18 Nm** | **(13 lbf ft.)** |
| Sump cap screw | **12 Nm** | **(9 lbf ft.)** |
| Fuel injection pump nut | **18 Nm** | **(13 lbf ft.)** |
| 1/8 in. BSP oil gallery plug | **14 Nm** | **(10 lbf ft.)** |

## TECHNICAL DATA 'A' RANGE (continued)

### AC1W ENGINE (Model Build After Engine Serial Number 6000)

Bore (nominal) **76.2 mm (3 in.)**
Stroke **66.68 mm (2.625 in.)**

Power and Speed per cylinder (continuous rating):

**3.7 kW (5.0 bhp) at 2500 r/min**
**4.45 kW (6.0 bhp) at 3000 r/min**
**4.8 kW (6.5 bhp) at 3600 r/min**

Cubic capacity per cylinder **0.304 litres (18.5 in.$^3$)**

Compression ratio **17:1**

Lubricating oil pressure (minimum) **2.4 bar (35 lbf/in.$^2$)**

**FUEL TANK CAPACITY** (standard engine mounted): **5.13 litres (9 pints)**

**OIL CAPACITY:** **2.7 litres (4.75 pints)**

**LUBRICATING OIL:** to MIL-L-46152-B
formerly MIL-L-2104B (now obsolete)

**FUEL:** A high grade light distillate diesel fuel in accordance with B.S. Specification No. 2869: 1970 Class A1 or A2

**STARTER MOTOR BATTERY:** 12 Volts 57 Ampere Hours (min)
NEGATIVE EARTH

**FUEL INJECTION RELEASE PRESSURE:** **162/183 bar (2350/2650 lbf in.$^2$)**

### FUEL INJECTION TIMING (BY SPILL): FIXED AND VARIABLE SPEED

All fixed speeds and two speed
**26°** before TDC (up to 2200 r/min)
**28°** before TDC (2201 to 2800 r/min)
**30°** before TDC (2801 to 3300 r/min)
**33°** before TDC (3301 to 3600 r/min)

All variable speeds **30°** before TDC

### VALVE TIMING

*Up to Engine Serial No. 4856*

Inlet valve opens **13°** before TDC
Inlet valve closes **38°** after BDC
Exhaust valve opens **38°** before BDC
Exhaust valve closes **13°** after TDC

*Engine Serial No. 4857 to 6047*

Inlet valve opens **53.5°** before TDC
Inlet valve closes **78.5°** after BDC
Exhaust valve opens **78.5°** before BDC
Exhaust valve closes **53.5°** after TDC

*With engine cold and valve rocker clearance set at* **0.10 mm (0.004 in.)**

*Engine Serial No. 6048 onwards*

Inlet valve opens **45.5°** before TDC
Inlet valve closes **70.5°** after BDC
Exhaust valve opens **78.5°** before BDC
Exhaust valve closes **53.5°** after TDC

*With engine cold and valve rocker clearance set at* **0.10 mm (0.004 in.)**

### TOLERANCES

Lubricating oil pump:

| | |
|---|---|
| Rotor end clearance (new) | **0.025/0.064 mm (0.001/0.0025 in.)** |
| Rotor end clearance (not to exceed) | **0.127 mm (0.005 in.)** |
| Rotor form clearance (new) | **0.051/0.127 mm (0.002/0.005 in.)** |
| Rotor form clearance (not to exceed) | **0.203 mm (0.008 in.)** |
| Shaft/bore clearance (new) | **0.038/0.076 mm (0.0015/0.003 in.)** |

## TECHNICAL DATA 'A' RANGE (continued)

### TOLERANCES (continued)

| | |
|---|---|
| Shaft/bore clearance (not to exceed) | 0.127 mm (0.005 in.) |
| Rotor shaft diameter (new) | 15.032/15.044 mm (0.5918/0.5923 in.) |
| Camshaft end float | 0.08/0.25 mm (0.003/0.010 in.) |
| Crankshaft end float | 0.076/0.609 mm (0.008/0.024 in.) |
| Crankpin ovality (not to exceed) | 0.063 mm (0.0025 in.) |
| Cylinder bore wear (not to exceed) | 0.25 mm (0.010 in.) |
| Piston ring gap (new): top and second ring | 0.3/0.43 mm (0.012/0.017 in.) |
| Piston ring gap (new): oil control ring | 0.23/0.36 mm (0.009/0.014 in.) |
| Piston ring gap (not to exceed) | 1.14 mm (0.045 in.) |
| Piston ring side clearance (not to exceed) | 0.25 mm (0.010 in.) |
| Exhaust valve lift by decompressor (maximum) | 0.38 mm (0.015 in.) |
| Bumping clearance with REINZ head gasket | 0.56/0.66 mm (0.022/0.026 in.) |
| Bumping clearance with GOETZE head gasket | 0.66/0.76 mm (0.026/0.030 in.) |
| Valve rocker clearance (cold) | 0.10 mm (0.004 in.) |
| Flame face to valve head dimension (new) | 1.29/1.72 mm (0.051/0.068 in.) |
| Flame face to valve head dimension (not to exceed) | 1.93 mm (0.076 in.) |
| Main bearing clearance (new) | 0.033/0.076 mm (0.0013/0.003 in.) |
| Large end bearing clearance (new) | 0.025/0.090 mm (0.010/0.0035 in.) |
| Drive shaft diameter (Std) | 25.38/25.40 mm (0.9995/1.000 in.) |
| Drive shaft keyway width | 6.32/6.38 mm (0.249/0.251 in.) |
| Small end bush diameter (fitted) | 22.233/22.243 mm (0.8753/0.8757 in.) |

### CYLINDER REBORING DIAMETERS

| | |
|---|---|
| Standard | 76.20/76.23 mm (3.000/3.001 in.) |
| Oversize 0.5 mm (0.020 in.) | 76.71/76.73 mm (3.020/3.021 in.) |
| 1.0 mm (0.040 in.) | 77.22/77.24 mm (3.040/3.041 in.) |

### CRANKSHAFT REGRINDING DIAMETERS (Main journal and crankpin)

| | |
|---|---|
| Standard | 41.275/41.262 mm (1.6250/1.6245 in.) |
| Undersize 0.25 mm (0.010 in.) | 41.021/41.008 mm (1.6150/1.6145 in.) |
| 0.50 mm (0.020 in.) | 40.767/40.754 mm (1.6050/1.6045 in.) |

### TORQUE SPANNER SETTINGS

| | |
|---|---|
| Large end bolt | 34 Nm (25 lbf ft.) |
| Cylinder head nut | 30 Nm (22 lbf ft.) |
| Cylinder head nut (rocker support) | 32.5 Nm (24 lbf ft.) |
| Injector stud nut | 18 Nm (13 lbf ft.) |
| Flywheel nut | 210 Nm (155 lbf ft.) |
| Flywheel extension or gearwheel bolt | 36 Nm (27 lbf ft.) |
| Lubricating oil pump screw | 14 Nm (10 lbf ft.) |
| Lubricating oil filter centre bolt | 14 Nm (10 lbf ft.) |
| Fuel pump delivery union body | 41 Nm (30 lbf ft.) |
| Injector pump nuts | 18 Nm (13 lbf ft.) |
| Crankshaft and camshaft extension shaft screw | 19 Nm (14 lbf ft.) |

## TECHNICAL DATA 'A' RANGE (continued)

### TORQUE SPANNER SETTINGS (continued)

| | |
|---|---|
| Crankshaft gearwheel retaining screw | **36 Nm (27 lbf ft.)** |
| Camshaft gearwheel retaining screw | **36 Nm (27 lbf ft.)** |
| Raised hand start (starting handle shaft retaining screw) | **36 Nm (27 lbf ft.)** |
| Mounting plate screw (4:1 hand starting) (F/W/E) | **24 Nm (18 lbf ft.)** |
| Sliding plate locating screw (4:1 hand starting) (F/W/E) | **24 Nm (18 lbf ft.)** |
| Sliding plate stop screw (4:1 hand starting) (F/W/E) | **16 Nm (12 lbf ft.)** |
| Gearwheel retaining clip screw (4:1 hand starting) (F/W/E) | **16 Nm (12 lbf ft.)** |
| Pinion bolt (4:1 hand starting) (F/W/E) | **33/41 Nm (25/30 lbf ft.)** |
| Rope start pulley retaining bolt (G/E) | **18 Nm (13 lbf ft.)** |
| Air cell plug | **95 Nm (70 lbf ft.)** |
| Breather base to crankcase | **5 Nm (4 lbf ft.)** |
| Top fuel tank bracket set screw (H.D.P. fuel tank only) | **11 Nm (8 lbf ft.)** |
| Bottom fuel tank bracket set screw (H.D.P. fuel tank only) | **11 Nm (8 lbf ft.)** |
| Gear cover cap screw | **12 Nm (9 lbf ft.)** |
| Fuel lift pump cover set screw | **18 Nm (13 lbf ft.)** |
| Sump cap screw | **12 Nm (9 lbf ft.)** |
| Fuel injection pump nut | **18 Nm (13 lbf ft.)** |
| 1/8 in. BSP oil gallery plug | **14 Nm (10 lbf ft.)** |

## TECHNICAL DATA 'A' RANGE (continued)

### AC2W ENGINE

Bore (nominal) **76.2 mm (3 in.)**
Stroke **66.68 mm (2.625 in.)**

Power and Speed (continuous rating):

**6.7 kW (9.0 bhp) at 2500 r/min**
**8.2 kW (11.0 bhp) at 3000 r/min**
**8.95 kW (12.0 bhp) at 3600 r/min**

Cubic capacity per cylinder **304 $cm^3$ (18.5 $in.^3$)**
Compression ratio **17:1**
Lubricating oil pressure (minimum) **2.4 bar (35 $lbf/in.^2$)**

**FUEL TANK CAPACITY** (standard engine mounted): **5.13 litres (9 pints)**

**OIL CAPACITY: 3.7 litres (6.5 pints)**

**LUBRICATING OIL:** to MIL-L-46152-B
formerly MIL-L-2104B (now obsolete)

**FUEL:** A high grade light distillate diesel fuel in accordance with B.S. Specification No. 2869: 1970 Class A1 or A2

**STARTER MOTOR BATTERY:** 12 Volts 58 Ampere Hours (min)
NEGATIVE EARTH

**FUEL INJECTION RELEASE PRESSURE: 162/183 bar (2350/2650 $lbf\ in.^2$)**

### FUEL INJECTION TIMING (BY SPILL): FIXED AND VARIABLE SPEED

Fixed speed and two speeds
**30°** before TDC (2201 to 2800 r/min)
**32°** before TDC (2801 to 3200 r/min)
**34°** before TDC (3201 to 3600 r/min)

All variable speeds **32°** before TDC

### VALVE TIMING

*Up to Engine Serial No. 2118*

Inlet valve opens **13°** before TDC
Inlet valve closes **38°** after BDC
Exhaust valve opens **38°** before BDC
Exhaust valve closes **13°** after TDC

*Engine Serial No. 2119 onwards*

Inlet valve opens **53.5°** before TDC
Inlet valve closes **78.5°** after BDC
Exhaust valve opens **78.5°** before BDC
Exhaust valve closes **53.5°** after TDC

*With engine cold and valve rocker clearance set at* **0.10 mm (0.004 in.)**

### TOLERANCES

Lubricating oil pump:

| | |
|---|---|
| Rotor end clearance (new) | **0.025/0.064 mm (0.001/0.0025 in.)** |
| Rotor end clearance (not to exceed) | **0.127 mm (0.005 in.)** |
| Rotor form clearance (new) | **0.051/0.127 mm (0.002/0.005 in.)** |
| Rotor form clearance (not to exceed) | **0.203 mm (0.008 in.)** |
| Shaft/bore clearance (new) | **0.038/0.076 mm (0.0015/0.003 in.)** |
| Shaft/bore clearance (not to exceed) | **0.127 mm (0.005 in.)** |
| Rotor shaft diameter (new) | **15.032/15.044 mm (0.5918/0.5923 in.)** |
| Camshaft end float | **0.08/0.25 mm (0.003/0.010 in.)** |
| Crankshaft end float | **0.076/0.609 mm (0.003/0.024 in.)** |
| Crankshaft end float (not to exceed) | **0.51 mm (0.020 in.)** |
| Crankpin ovality (not to exceed) | **0.063 mm (0.0025 in.)** |
| Cylinder bore wear (not to exceed) | **0.25 mm (0.010 in.)** |

## TECHNICAL DATA 'A' RANGE (continued)

### TOLERANCES (continued)

| | |
|---|---|
| Piston ring gap (new): top and second ring | 0.30/0.43 mm (0.012/0.017 in.) |
| Piston ring gap (new): oil control ring | 0.23/0.36 mm (0.009/0.014 in.) |
| Piston ring gap (not to exceed) | 1.14 mm (0.045 in.) |
| Piston ring side clearance (not to exceed) | 0.25 mm (0.010 in.) |
| Exhaust valve lift by decompressor (maximum) | 0.38 mm (0.015 in.) |
| Bumping clearance with REINZ head gasket | 0.56/0.66 mm (0.022/0.026 in.) |
| Bumping clearance with GOETZE head gasket | 0.66/0.76 mm (0.026/0.030 in.) |
| Valve rocker clearance (cold) | 0.10 mm (0.004 in.) |
| Flame face to valve head dimension (new) | 1.29/1.72 mm (0.051/0.068 in.) |
| Flame face to valve head dimension (not to exceed) | 1.93 mm (0.076 in.) |
| Main bearing clearance gear end (new) | 0.05/0.088 mm (0.0021/0.0036 in.) |
| Main bearing clearance flywheel end (new) | 0.04/0.078 mm (0.0016/0.0031 in.) |
| Main bearing clearance intermediate (new) | 0.093/0.137 mm (0.0037/0.0054 in.) |
| Large end bearing clearance (new) | 0.025/0.090 mm (0.0010/0.0035 in.) |
| Drive shaft diameter (F/W/E) | 34.900/34.915 mm (1.374/1.375 in.) |
| Drive shaft keyway width | 9.50/9.52 mm (0.374/0.375 in.) |
| Small end bush diameter (fitted) | 22.233/22.243 mm (0.8753/0.8757 in.) |

### CYLINDER REBORING DIAMETERS

| | | |
|---|---|---|
| Standard | | 76.20/76.23 mm (3.000/3.001 in.) |
| Oversize | 0.5 mm (0.020 in.) | 76.71/76.73 mm (3.020/3.021 in.) |
| | 1.0 mm (0.040 in.) | 77.22/77.24 mm (3.040/3.041 in.) |

### CRANKSHAFT REGRINDING DIAMETERS (Main, Intermediate journal and crankpin)

| | | |
|---|---|---|
| Standard | | 41.275/41.262 mm (1.6250/1.6245 in.) |
| Undersize | 0.25 mm (0.010 in.) | 41.021/41.008 mm (1.6150/1.6145 in.) |
| | 0.50 mm (0.020 in.) | 40.767/40.754 mm (1.6050/1.6045 in.) |

### TORQUE SPANNER SETTINGS

| | |
|---|---|
| Large end bolt | 34 Nm (25 lbf ft.) |
| Cylinder head nut | 30 Nm (22 lbf ft.) |
| Cylinder head nut rocker support | 32.5 Nm (24 lbf ft.) |
| Injector stud nut | 18 Nm (13 lbf ft.) |
| Flywheel nut | 210 Nm (155 lbf ft.) |
| Flywheel extension or gearwheel bolt | 36 Nm (27 lbf ft.) |
| Lubricating oil pump screw | 14 Nm (10 lbf ft.) |
| Lubricating oil filter centre bolt | 14 Nm (10 lbf ft.) |
| Fuel pump delivery union body | 41 Nm (30 lbf ft.) |
| Injector pump nuts | 18 Nm (13 lbf ft.) |
| Crankshaft and camshaft extension shaft screw | 19 Nm (14 lbf ft.) |
| Crankshaft gearwheel retaining screw | 36 Nm (27 lbf ft.) |
| Camshaft gearwheel retaining screw | 36 Nm (27 lbf ft.) |
| Air cell plug | 95 Nm (70 lbf ft.) |

## TECHNICAL DATA 'A' RANGE (continued)

### TORQUE SPANNER SETTINGS (continued)

| | | |
|---|---|---|
| Breather base to crankcase | **5 Nm** | **(4 lbf ft.)** |
| Intermediate bearing housing retaining bolt | **41 Nm** | **(30 lbf ft.)** |
| Camshaft pinion screw | **27 Nm** | **(20 lbf ft.)** |
| Gear cover cap screw | **12 Nm** | **(9 lbf ft.)** |
| Fuel lift pump cover set screw | **18 Nm** | **(13 lbf ft.)** |
| Sump cap screw | **12 Nm** | **(9 lbf ft.)** |
| Fuel injection pump nut | **18 Nm** | **(13 lbf ft.)** |
| 1/8 in. BSP oil gallery plug | **14 Nm** | **(10 lbf ft.)** |

## FUEL CONSUMPTION CHARTS

The fuel consumptions quoted are for engines running on full load. The no-load fuel consumption is approximately 25% of the full load consumption at the same speed.

| ENGINE TYPE | CONTINUOUS POWER AND SPEED | | | FUEL USED g/kWh |
|---|---|---|---|---|
| | kW | bhp | r/min | |
| AA1 | 1.15 | 1.5 | 1500 | 329 |
| | 1.35 | 1.8 | 1800 | 329 |
| | 1.55 | 2.1 | 2100 | 317 |
| | 1.85 | 2.5 | 2500 | 311 |
| | 2.25 | 3.0 | 3000 | 317 |
| | 2.6 | 3.5 | 3600 | 329 |
| AB1 | 1.7 | 2.3 | 1500 | 323 |
| | 2.0 | 2.7 | 1800 | 310 |
| | 2.4 | 3.2 | 2100 | 286 |
| | 2.85 | 3.8 | 2500 | 298 |
| | 3.35 | 4.5 | 3000 | 310 |
| | 3.7 | 5.0 | 3600 | 310 |
| AC1 | 2 | 2.8 | 1500 | 317 |
| | 2.45 | 3.3 | 1800 | 310 |
| | 3 | 4.0 | 2100 | 310 |
| | 3.7 | 5.0 | 2500 | 305 |
| | 4.45 | 6.0 | 3000 | 298 |
| | 4.8 | 6.5 | 3600 | 310 |
| AC2 | 6.7 | 9.0 | 2500 | 280 |
| | 8.2 | 11.0 | 3000 | 274 |
| | 8.95 | 12.0 | 3600 | 280 |
| AC1Z | 4.45 | 6.0 | 3000 | 290 |
| AC1ZS | 1.15 | 1.5 | 1000 | 336 |
| | 1.5 | 2.0 | 1250 | 319 |
| | 1.85 | 2.5 | 1500 | 316 |
| | 2.25 | 3.0 | 1800 | 322 |
| AB1W | 1.8 | 2.4 | 1500 | 335 |
| | 2.25 | 3.0 | 1800 | 335 |
| | 2.6 | 3.5 | 2100 | 310 |
| | 3.15 | 4.2 | 2500 | 316 |
| | 3.35 | 5.0 | 3000 | 328 |
| | 3.7 | 5.5 | 3600 | 298 |
| AC1W | 3.7 | 5.0 | 2500 | 262 |
| | 4.45 | 6.0 | 3000 | 268 |
| | 4.8 | 6.5 | 3600 | 274 |
| AC2W | 6.7 | 9.0 | 2500 | 280 |
| | 8.2 | 11.0 | 3000 | 274 |
| | 8.95 | 12.0 | 3600 | 280 |

## ENGINE DE-RATING TABLES

Petter diesel engines are rated in accordance with B.S. 5514/1 (I.S.O. 3046/1) which has standard reference conditions as follows:—

TOTAL BAROMETRIC PRESSURE
— 100 kN/m² (750.1 mm HG)

AIR INLET TEMPERATURES
— 300°K (27°C)

RELATIVE HUMIDITY
— 60% (16 mm HG)

For non-standard site conditions engine power should be adjusted in accordance with B.S. 5514/1 (I.S.O. 3046/1). When exact site service powers are required they should be calculated by using the following formulae:

(1) Site service power = Engine power under standard reference conditions X$\alpha$

(2) $\alpha = k - 0.7(1-k)\left(\frac{1}{\eta m} - 1\right)$

(3) $k = \left(\frac{Px - PVx}{Pr - PVr}\right)\left(\frac{Tr}{Tx}\right)^{.75}$

Where P = total barometric pressure
PV = water vapour pressure
T = absolute temperature
r = reference conditions
x = site conditions
$\eta m$ = mechanical efficiency

Approximate site service powers can be obtained by using the correction factors shown below. The figures obtained will usually be suitable for selecting the engine required for an application and can be considered accurate to 1% for de-rating up to 10% and 2.5% for de-rating up to 20%. Where exact figures are required, formulae (1), (2) and (3) above should be used.

ALTITUDE:
6.5% per 500 m above 150 m.

TEMPERATURE:
3% per 10°K (10°C) above 300°K (27°C).

All Petter engines can be de-rated using these formulae and tables for altitudes up to 2500 m and ambient temperatures up to 52°C. For operation above these figures consult Petters Limited for accurate de-rate values and engine selection advice.

The tables given can be used when approximate de-rating is sufficient.

*TABLE 1*
*PERCENTAGE DE-RATING FOR ALTITUDE*

| Altitude | | De-rating |
|---|---|---|
| Metres | Feet | % |
| 150 | 492 | 0 |
| 200 | 656 | 0.6 |
| 300 | 984 | 1.9 |
| 400 | 1312 | 3.2 |
| 500 | 1640 | 4.5 |
| 600 | 1969 | 5.8 |
| 700 | 2297 | 7.1 |
| 800 | 2625 | 8.4 |
| 900 | 2953 | 9.7 |
| 1000 | 3281 | 11.0 |
| 1100 | 3600 | 12.3 |
| 1200 | 3932 | 13.6 |
| 1300 | 4265 | 14.9 |
| 1400 | 4593 | 16.2 |
| 1500 | 4921 | 17.5 |
| 1600 | 5249 | 18.8 |
| 1700 | 5577 | 20.1 |
| 1800 | 5906 | 21.4 |
| 1900 | 6233 | 22.7 |
| 2000 | 6562 | 24.0 |
| 2100 | 6890 | 25.3 |
| 2200 | 7218 | 26.6 |
| 2300 | 7546 | 27.9 |
| 2400 | 7674 | 29.2 |
| 2500 | 8202 | 30.5 |

*TABLE 2*
*PERCENTAGE DE-RATING FOR AMBIENT TEMPERATURE*

| Temperature | | De-rating |
|---|---|---|
| °C | °F | % |
| 27 | 81 | 0 |
| 30 | 86 | 0.9 |
| 32 | 90 | 1.5 |
| 34 | 93 | 2.1 |
| 36 | 97 | 2.7 |
| 38 | 100 | 3.3 |
| 40 | 104 | 3.9 |
| 42 | 108 | 4.5 |
| 44 | 111 | 5.1 |
| 46 | 115 | 5.7 |
| 48 | 118 | 6.3 |
| 50 | 122 | 6.9 |
| 52 | 126 | 7.5 |

*TABLE 3*
*PERCENTAGE DE-RATING FOR ATMOSPHERIC HUMIDITY AT VARIOUS TEMPERATURES*

| Ambient Temp. | | Percentage Humidity | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| °C | °F | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| 27 | 81 | – | – | – | – | – | – | 0.5 | 1.1 | 1.5 | 1.9 |
| 30 | 86 | – | – | – | – | – | 0.5 | 1.1 | 1.7 | 2.2 | 2.7 |
| 32 | 90 | – | – | – | – | 0.3 | 0.9 | 1.5 | 2.2 | 2.8 | 3.4 |
| 34 | 93 | – | – | – | – | 0.7 | 1.3 | 2.0 | 2.7 | 3.4 | 4.1 |
| 36 | 97 | – | – | – | 0.3 | 1.1 | 1.8 | 2.6 | 3.4 | 4.1 | 4.9 |
| 38 | 100 | – | – | – | 0.7 | 1.5 | 2.3 | 3.2 | 4.0 | 4.9 | 5.7 |
| 40 | 104 | – | – | 0.1 | 1.1 | 2.0 | 2.9 | 3.8 | 4.7 | 5.7 | 6.7 |
| 42 | 108 | – | – | 0.5 | 1.5 | 2.5 | 3.5 | 4.5 | 5.5 | 6.6 | 7.7 |
| 44 | 111 | – | – | 0.9 | 1.9 | 3.0 | 4.2 | 5.4 | 6.5 | 7.7 | |
| 46 | 115 | – | – | 1.2 | 2.4 | 3.7 | 5.0 | 6.3 | 7.6 | | |
| 48 | 118 | – | 0.1 | 1.5 | 2.9 | 4.3 | 5.7 | 7.2 | | | |
| 50 | 122 | – | 0.5 | 2.0 | 3.5 | 5.0 | 6.7 | | | | |
| 52 | 126 | – | 0.9 | 2.5 | 4.2 | 6.0 | 7.7 | | | | |

***NOTE:*** *In any part of the world, de-rating for humidity rarely exceeds 6%.*

EXAMPLE:
The continuous power of engine is 7.5 BHP at B.S. 5514 standard reference conditions. What will be the site service power at 700 m, 40°C and 70% humidity?

*From the tables above the following % de-rate figures are obtained*

Altitude = **7.1%**
Temperature = **3.9%**
Humidity = **3.8%**
Total = **14.8%**

$$\text{Site service power} = 7.5 \times \frac{100 - 14.8}{100}$$

$$= 7.5 \times .852$$

$$= 6.39 \text{ BHP}$$

## TOOL LIST

This list details the recommended tools (or equivalents) required to maintain a basic build 'A' range Petter diesel engine with no variants fitted.

| *DESCRIPTION* | *SIZE* | *QUANTITY* |
|---|---|---|
| Open end spanner | 7/16 in. AF | 1 |
| Open end spanner | 1/2 in. AF | 1 |
| Open end spanner | 9/16 in. AF | 1 |
| Open end spanner | 5/8 in. AF | 1 |
| Open end spanner | 16 mm | 1 |
| Open end spanner | 19 mm | 1 |
| Open end spanner | 1/4 in. BSF | 1 |
| Open end spanner | 3/8 in. BSF | 1 |
| Ring spanner | 7/16 in. AF | 1 |
| Ring spanner | 1/2 in. AF | 1 |
| Ring spanner | 9/16 in. AF | 1 |
| Ring spanner | 7/16 in. BSF | 1 |
| Allen key | 7/32 in. AF | 1 |
| Allen key | 3/16 in. AF | 1 |
| Allen key | 3 mm | 1 |
| Tee bar | 1/2 in. square drive | 1 |
| 5 in. extension bar | 1/2 in. square drive | 1 |
| Socket | 1/2 in. AF | 1 |
| Socket | 1/2 in. AF (deep) | 1 |
| Socket | 9/16 in. AF | 1 |
| Socket | 7/8 in. BSF | 1 |
| Socket | 5/8 in. BSF | 1 |
| Socket | 9/16 in. BSF | 1 |
| Pin Punch | 3 mm dia. (1/8 in. dia.) | 1 |
| External Micrometer(s) | 0 to 51 mm (0 to 2 in.) | 1 |
| Internal Micrometer(s) | 51 to 102 mm (2 to 4 in.) | 1 |
| Lead Wire | | **As required** |
| Circlip Pliers (internal) | | **1 Pair** |
| Circlip Pliers (external) | | **1 Pair** |
| Torque Wrench(es) | 0 to 271 Nm (0 to 200 lbf ft.) | 1 |
| Feeler Gauges | | 1 |
| Screwdriver | | 1 |
| Flat File | | 1 |
| Pliers | | **1 Pair** |
| Oil Can | | 1 |
| Oil Pressure Test Gauge | | 1 |
| Tachometer | | 1 |
| Dial Test Indicator | | 1 |

## SPECIAL TOOLS

These lists detail the special tools required to maintain an 'A' Range Petter diesel engine. These tools can be obtained from Petters Limited or their representatives.

### BASIC BUILD

| *DESCRIPTION* | *QTY.* | *FIG. NO.* |
|---|---|---|
| Flywheel and Gear Puller | 1 | 1 |
| Injector Test Rig | 1 | 2 |
| Oil Seal Sleeve (Gear End) | 1 | 3 |
| Flywheel Locking Plate | 1 | 4 |
| Valve Collet Extractor | 1 | 5 |
| Valve Guide Removal Tool | 1 | 6 |
| Crankshaft Gear Extractor AC1Z and AC1ZS | 1 | 7 |
| Socket 1 7/8 in. AF (Flywheel Nut) | 1 | 8 |

### ADDITIONAL SPECIAL TOOLS FOR MODEL BUILD ENGINES

| *DESCRIPTION* | *QTY.* | *FIG. NO.* |
|---|---|---|
| Oil Seal Insertion Dolly (Raised Hand Start Adaptor Plate) | 1 | 9 |
| Oil Seal Insertion Dolly (Mk 1 Drive) | 1 | 10 |
| Oil Seal Insertion Dolly (2:1 Hand Start) | 1 | 11 |
| Bush Insertion Dolly (Mk 1 Drive) | 1 | 12 |
| Core Plug Fitting Tool (Roller Clutch Start) | 1 | 13 |
| Oil Seal Sleeve (Raised Hand Start and Mk 1 Drive AA1, AB1, AC1 and AC1W | 1 | 14 |
| Oil Seal Sleeve (Mk 1 Drive) | 1 | 15 |
| Oil Seal Sleeve (2:1 Hand Start) | 1 | 16 |
| Oil Seal Sleeve (Basic Crank Gear) | 1 | 17 |

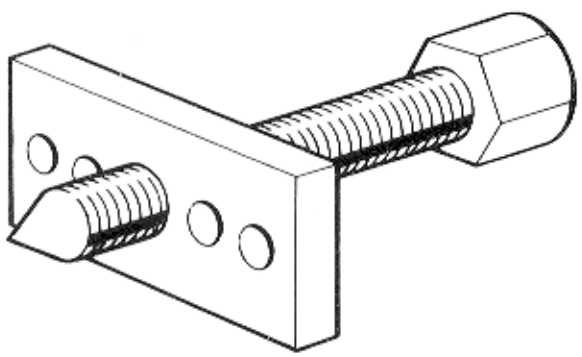


*Figure 1 Flywheel and Gear Puller*

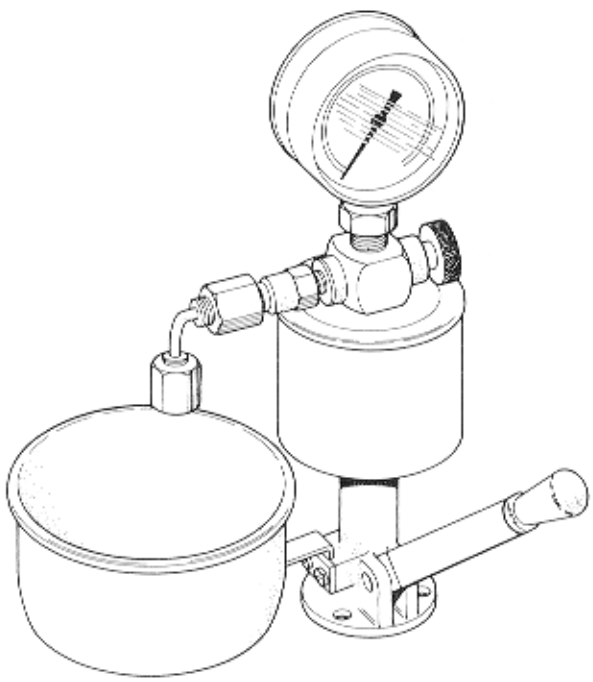


*Figure 2 Injector Test Rig*

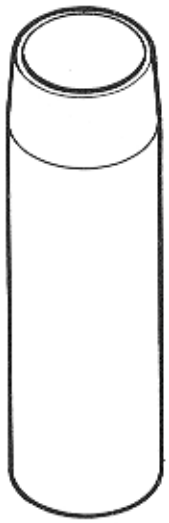


Figure 3 Oil Seal Sleeve : Gear End

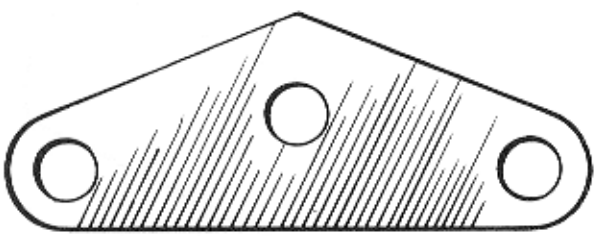


Figure 4 Flywheel Locking Plate

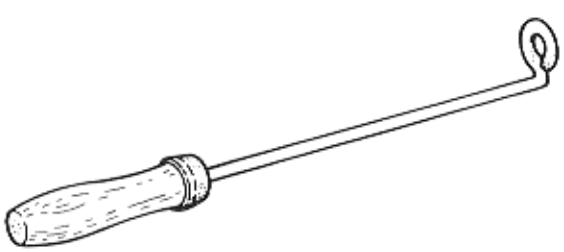


Figure 5 Valve Collet Extractor

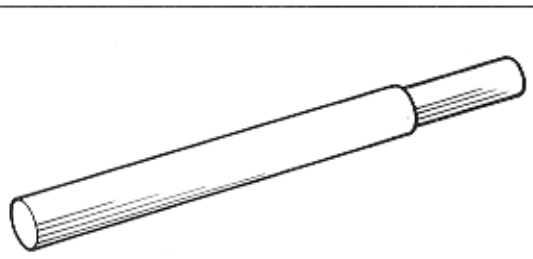


Figure 6 Valve Guide Removal Tool

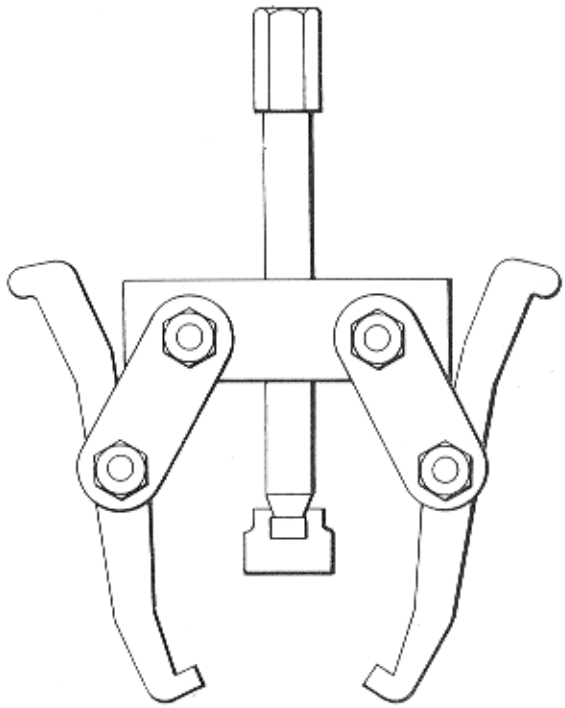


Figure 7 Crankshaft Gear Extractor
AC1Z and AC1ZS

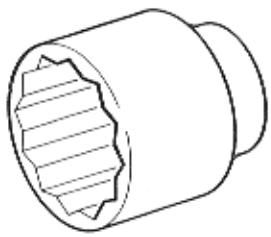


Figure 8 Socket 1 7/8 in. AF (Flywheel Nut)
AA1, AB1, AB1W and AC1

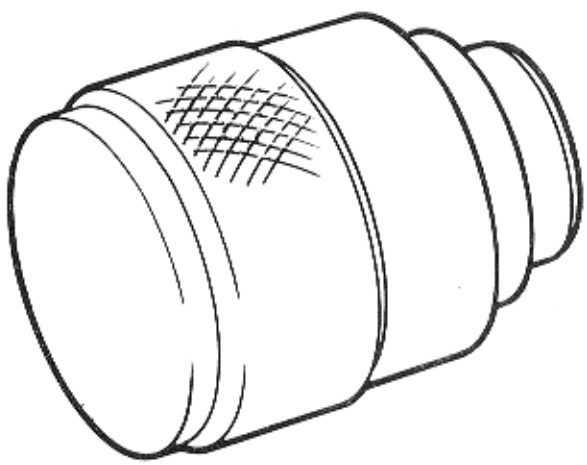


Figure 9 Oil Seal Insertion Dolly
(Raised Hand Start Adaptor Plate)

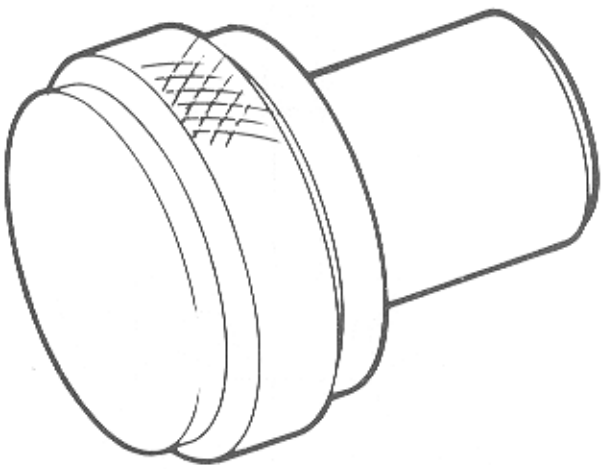


Figure 10 Oil Seal Insertion Dolly
(Mk. 1 Drive)

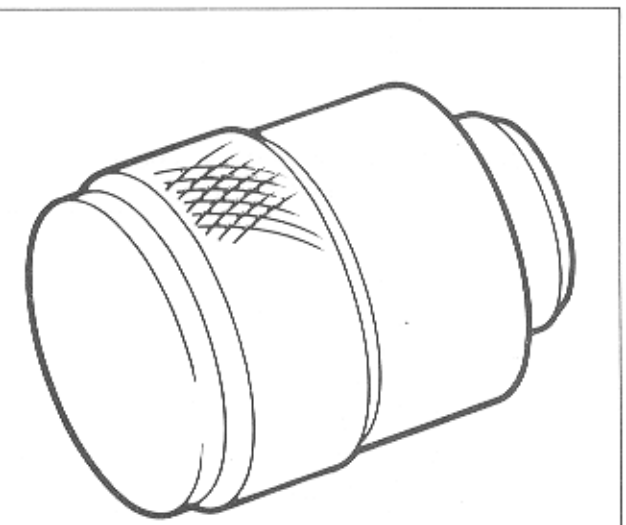


Figure 11 Oil Seal Insertion Dolly
(2:1 Hand Start)

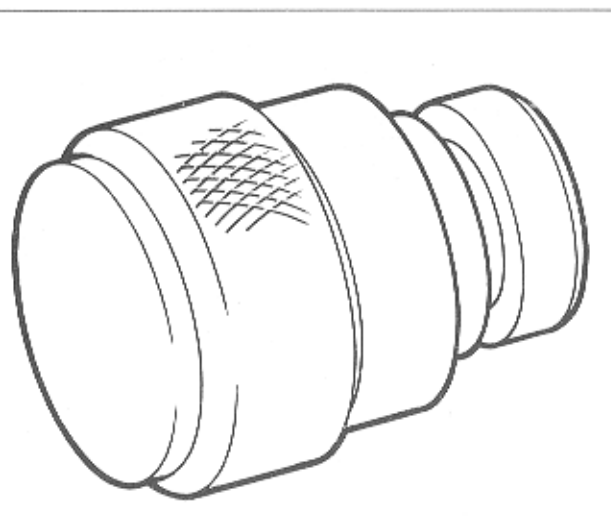


Figure 12 Bush Insertion Dolly
(Mk. 1 Drive)

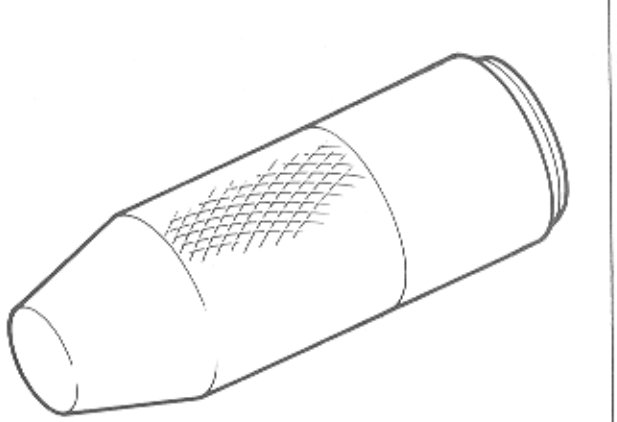


Figure 13 Core Plug Fitting Tool
(Roller Clutch Start)

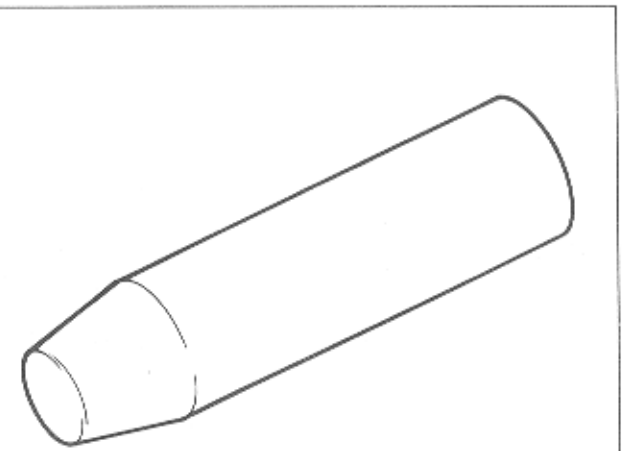


Figure 14 Oil Seal Sleeve
(Raised Hand Start and Mk. 1 Drive
AA1, AB1, AC1 and AC1W)

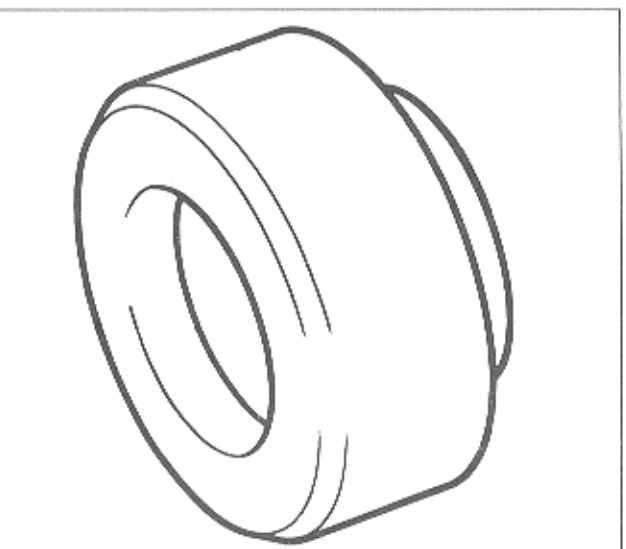


Figure 15 Oil Seal Sleeve (Mk. 1 Drive)

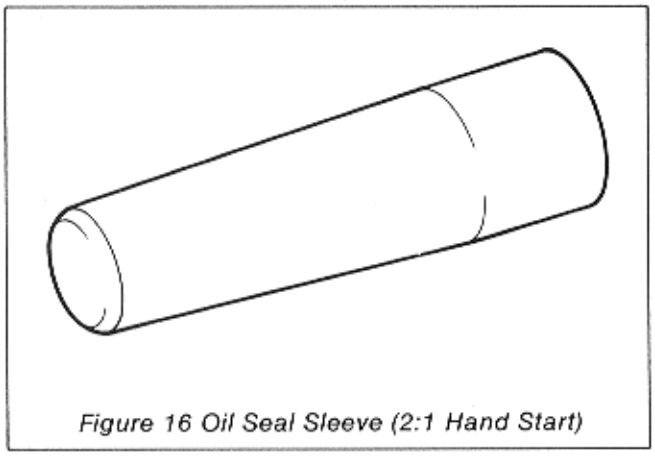


*Figure 16 Oil Seal Sleeve (2:1 Hand Start)*

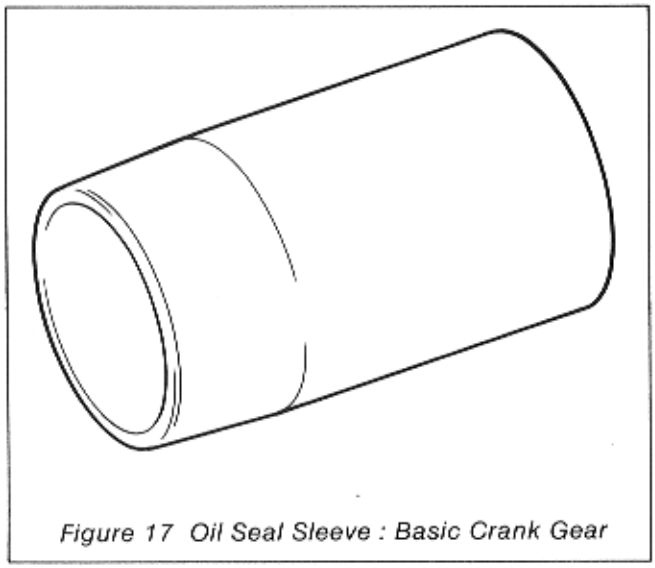
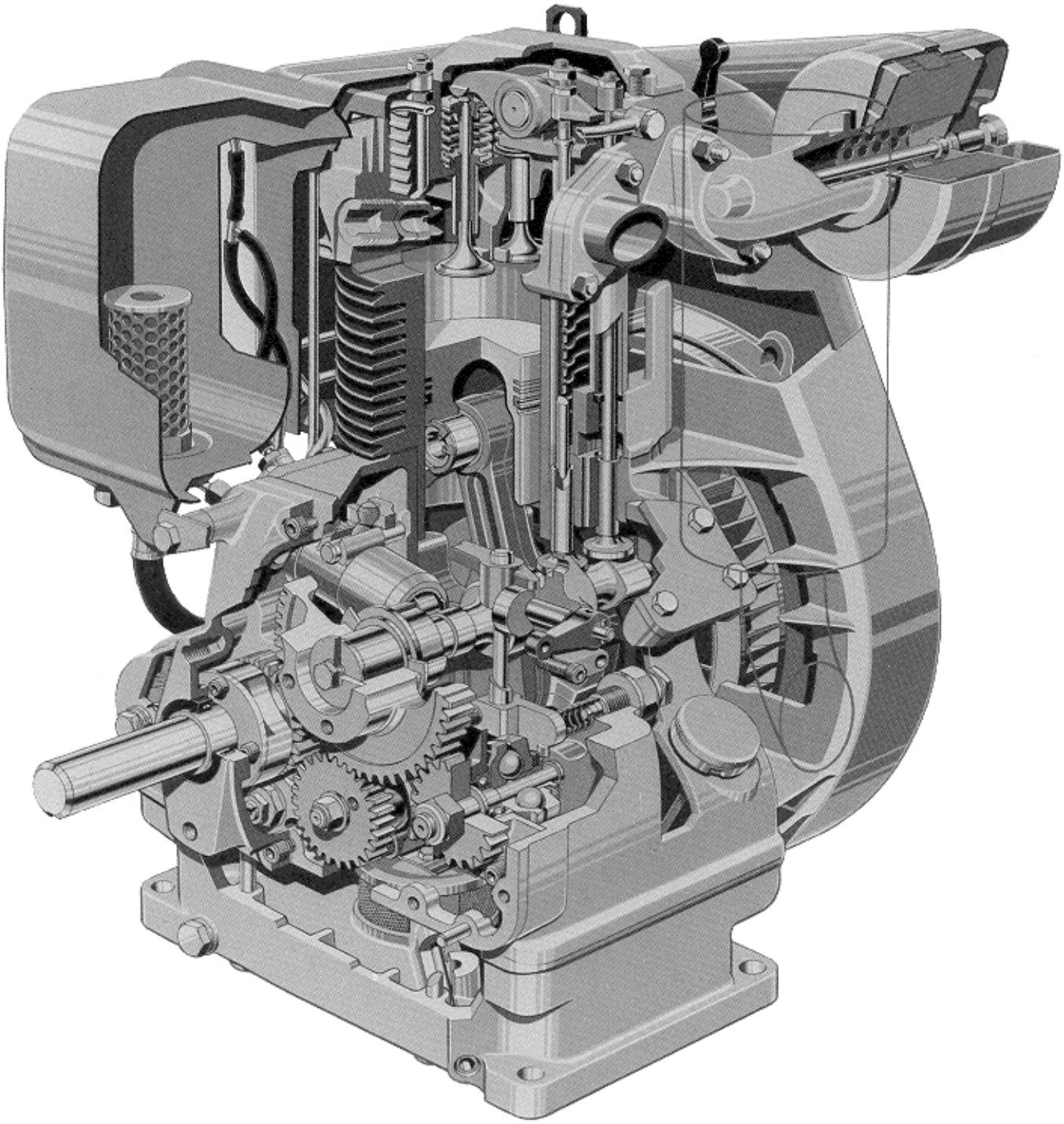


*Figure 17 Oil Seal Sleeve : Basic Crank Gear*

PART 1

# 'A' RANGE AIR COOLED DIESEL ENGINES



PART 1

# 'A' RANGE AIR COOLED DIESEL ENGINES AA1, AB1, AC1, AC1Z, AC1ZS AND AC2

INDEX

## SECTION 1 — GENERAL INFORMATION



## SECTION 2 — LUBRICATION SYSTEM



## SECTION 3 — FUEL SYSTEM

## SECTION 4 — AIR FILTRATION



## SECTION 5 — ENGINE GENERAL MAINTENANCE



## SECTION 6 — COMMON VARIANTS AND ACCESSORIES

# SECTION 1
# GENERAL INFORMATION

## INSTALLATION

### INTRODUCTION

**1.1** It is essential that an air cooled diesel engine is installed correctly to obtain the maximum performance and reliability. Users are advised that installation drawings are obtainable from Petters Limited or their representatives. Petters Limited or their representatives should also be consulted in the following cases:

(1) Before proceeding with any new form of installation.

(2) Where the use of anti-vibration mountings is contemplated.

### ENGINE MOUNTING

**WARNING**

**LIFTING EYES ARE PROVIDED ON THE TOP OF THE ENGINE FOR LIFTING THE ENGINE ONLY AND MUST NOT BE USED FOR LIFTING COMPLETE INSTALLATIONS.**

#### Solid Mounting

**1.2** The engine and driven unit must be mounted on a rigid framework of sufficient strength to resist twisting. Twisted frames can lead to misalignment which could in extreme cases result in bearing wear, fracture of mounting feet or crankcase. Good quality holding down bolts or studs must be used. Do not use setscrews.

**CAUTION**

**It is important that the engine is not used to hold the frame together by being one of the members itself. Petter engines must be supported on their mounting feet. They must not be overhung.**

#### Flexible Mounting

**1.3** Petters Limited or their representatives work in conjunction with an anti-vibration mounting manufacturer and should be consulted before attempting to install anti-vibration mountings.

### ACCESS

**1.4** Before installing any engine suitable provision must be made to allow access for the following:

(1) Lubricating oil dipstick removal.

(2) Lubricating oil filler cap removal, lubricating oil filling and topping-up.

(3) Oil filter maintenance.

(4) Fuel filter maintenance.

(5) Air cleaner maintenance.

(6) Starting handle operation and withdrawal (if used).

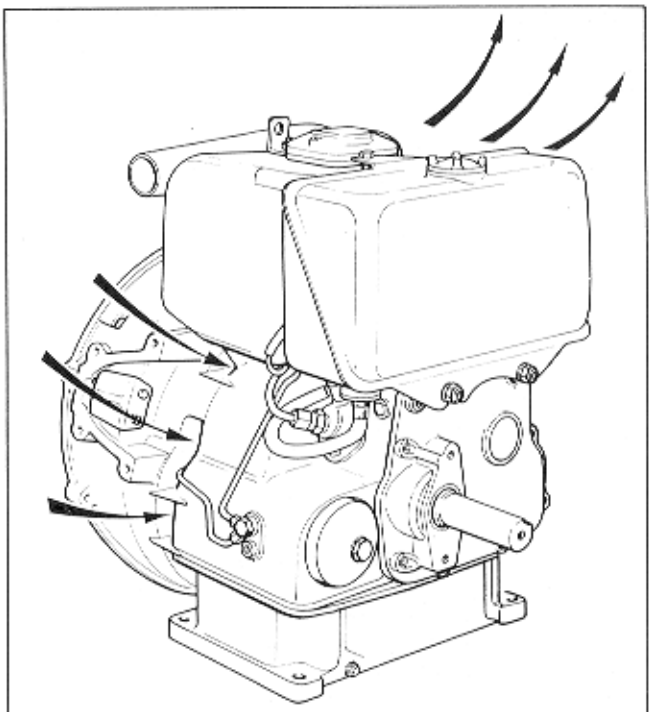
(7) Rope starting (if used).

(8) Operation of controls.

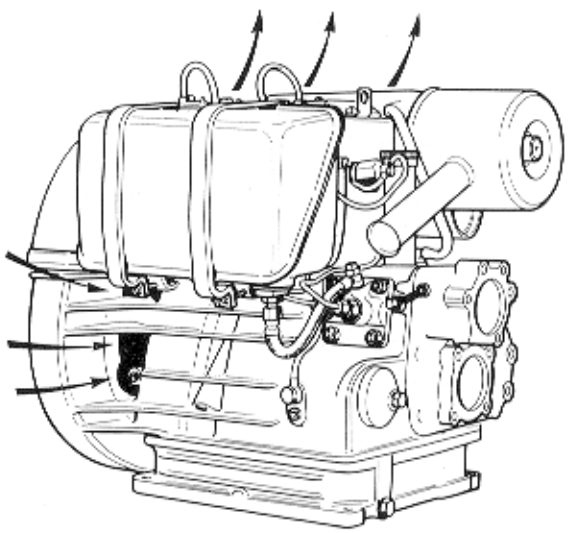
### AIR COOLING (Figure 1.1)

**1.5** Before installing any engine suitable consideration must be given to the fact that it is vital for air cooled engines to be supplied with sufficient air for cooling and combustion to avoid overheating and overloading.

**1.6** Cooling air is supplied by the flywheel fan and care must be taken to ensure that the fan cowling air intake is unobstructed. Engines mounted inside housings or confined spaces must be provided with sufficient vents to give a free circulation of air.



(1) Single Cylinder Engine



(2) Two Cylinder Engine

*Figure 1.1 Cooling Air Flow*

### FOUNDATIONS

**1.7** To mount engines on a concrete base, if required, foundations must be prepared and surfaces should finish about 25 mm (1 in.) below the finished dimension to allow for grouting up. Foundation bolts can be supplied to special order only.

#### Concrete

**1.8** The concrete should be made up of one part best portland cement, two parts clean sharp sand and four parts washed ballast or hard broken stone of a size that will pass through a 25 mm (1 in.) diameter ring.

## Grouting

**1.9** The grouting should be made up of one part best portland cement and two parts fine sand.

**1.10** The final surfaces of the foundation block must be checked to ensure that they are flat, level and at the correct relative heights for engine and driven units. A small allowance (3 mm – 0.125 in. approximately) should be made in the finished height for thin metal strips to be placed under the mounting feet on either side of, and as close as possible to the holding down bolts. Shimming should then be used in conjunction with these strips to ensure an equal bearing load and prevent distortion of the engine mounting feet when finally grouting in and tightening down the foundation bolts.

## COUPLINGS

**1.11** Selection of the correct coupling to suit the requirements of a particular application is of vital importance and should be made on torsional performance and technical suitability rather than on a commercial and dimensional basis.

**1.12** Water pumps and generating sets are the most common application requiring some form of coupling. In the smaller range many applications are of the single bearing type and require support at the engine end. For these, two types of connection are normally used. One is a tapered shaft locating directly into the application and the other is a steel disc coupling, which, like the tapered shaft contains little torsional flexibility and rigidly connects the application to the engine flywheel face.

**1.13** In the larger range with multi-bearing applications a flexible coupling is essential with the stiffness of the rubber being critical. Whilst, theoretically, to avoid critical resonant conditions a full torsional vibration analysis should be carried out on the complete application, a simple two mass calculation can often indicate the range of coupling stiffness required. Other aspects to be considered when selecting a coupling are engine power, torque capacity and ease of fitment. Petters Limited or their representatives should be consulted when in doubt.

### Close Coupling (tapered shaft)

**1.14** To fit a tapered extension shaft close coupling, proceed as follows:

(1) Place the engine with the coupling end uppermost.

(2) Fit the extension shaft to the flywheel or crankshaft gear (as appropriate) ensuring that mating surfaces are clean and free from burrs.

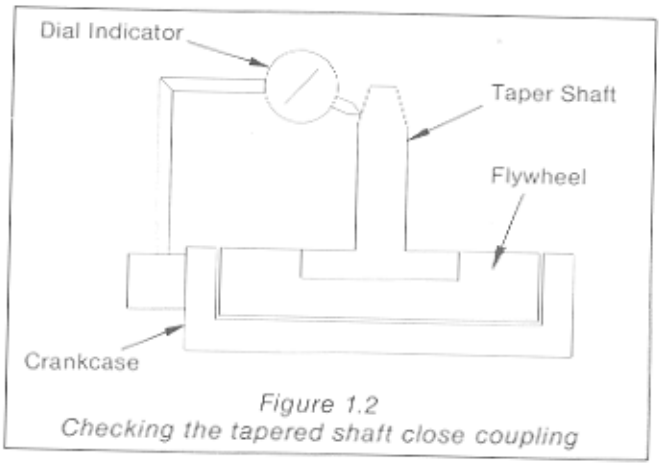



*Figure 1.2*
*Checking the tapered shaft close coupling*

(3) Mount a dial indicator on the crankcase with the pointer against the extension shaft as shown in Figure 1.2.

(4) Rotate the shaft through 360° the indicator reading run out should not exceed 0.13 mm (0.005 in.) total.

(5) Fit the driven unit in position and secure.

### Direct Coupling

#### Alignment

**1.15** Accurate alignment is necessary between the engine drive shaft and the driven unit even with a flexible coupling fitted, as poor alignment shortens coupling life, can cause bearing wear and produce excessive vibration. Two principal types of misalignment can occur; parallel and angular or there can be a combination of these two. Parallel misalignment is when the shaft driven unit is parallel to, but not in line with, the engine drive shaft. Angular misalignment is when the axis of the two shafts meet at the correct point but the shafts are at an angle to each other. The two types of misalignment are shown in Figure 1.3 To check the alignment the following procedure should be carried out:

(1) Fit the coupling halves to the respective engine drive shaft and the driven unit shaft. Shafts should protrude slightly past the inner faces (Figure 1.4).

(2) Position the driven unit on its base frame so that the coupling halves are apart by the same amount as that of the thickness of the coupling middle section.

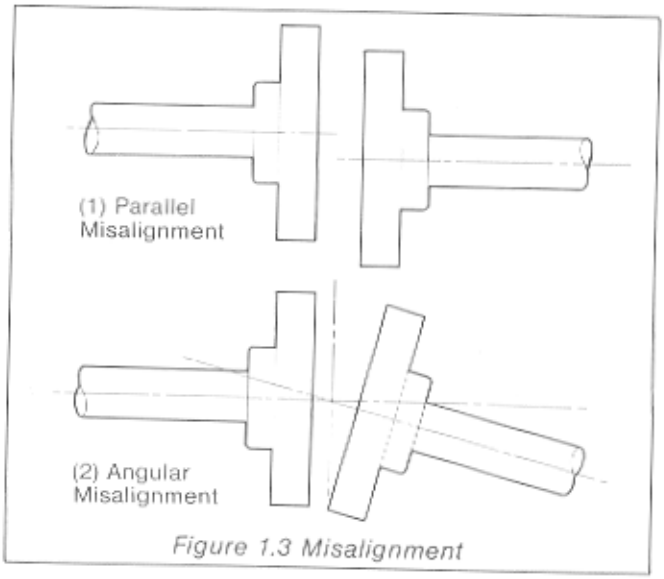
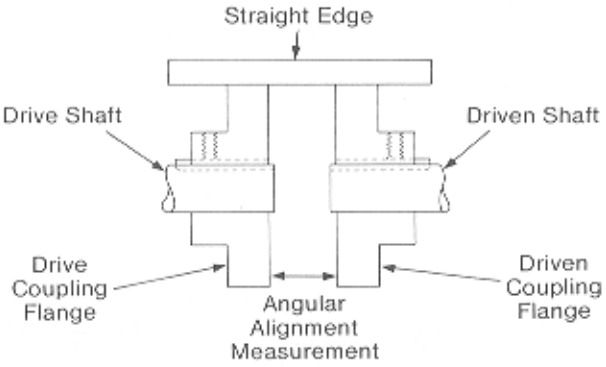



*Figure 1.3 Misalignment*

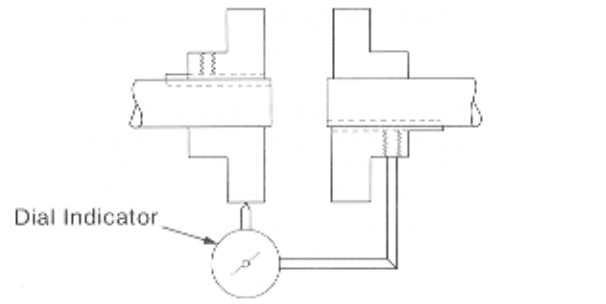
(3) Check the parallel alignment by laying a straight edge across the coupling flanges at several positions around the circumference. An alternative method using a dial indicator can be used. Both these methods are shown in Figure 1.4(1) and (2) respectively.

(4) Using a suitable measuring tool check the angular alignment by measuring the gap between the coupling halves at several positions around the circumference of the coupling as shown in Figure 1.4(1).

(5) If the measurements made are in excess of 0.13 mm (0.005 in.) adjust the parallel alignment by placing shims, as necessary, under the supports of the driven unit and adjust the angular alignment by altering the position of the driven unit on its frame.




(1) Parallel and angular alignment checks




(2) Parallel alignment checks using a Dial Indicator

*Figure 1.4 Checking Misalignment*

(6) Secure the driven unit to its frame.

(7) Fit and secure the middle flexible section of the coupling making sure that no strain is applied to the flanges; if necessary with the middle section secured gently tap the flanges towards each other at the flange bases.

**CAUTION**
**Ensure that when the coupling is secured the end float of the engine shaft and the driven unit is as specified.**

(8) Tighten the grub screws or bolts securing the flanges to the shafts.

## AIR INTAKE CLEANERS

**1.16** It is important that the air drawn into the inlet manifold is clean and free from contaminants as these can find their way into the engine and cause abnormal wear and consequent damage. To combat this, an efficient air cleaner must be installed and correctly maintained. Varying types of air cleaners and filters for differing conditions and specially engineered to meet individual engine requirements, are available. Any doubt in requirements, consult Petters Limited or their representatives. The air cleaners are of two basic types, dry paper element and oil bath.

### Paper Element

**1.17** The paper element is a dry type air filter manufactured from a special high quality, resin-impregnated filter paper. The pleated construction of the element allows a large filtering area to be contained within a comparatively small volume. The efficiency of this type of element is high and remains so at all air flows. In operation the air passes through the element from the outside to the inside and the dust is collected on the outer surfaces of the pleats.

### Cyclonic Air Cleaners

**1.18** For extreme dust conditions it is recommended that a Cyclonic air cleaner is used. Air is drawn into a pre-cleaner where axial vanes impart a cyclonic twist to the air. This spins out the larger contaminants against the wall of the cleaner where they are expelled through a vacuator valve. The pre-cleaned air is then fed via a paper element to the engine.

### Installation of the Cyclonic Air Cleaner

**1.19** The cyclonic air cleaner must be mounted on a vibration free part of the engine installation and not on the engine itself. It is important to ensure that a good seal exists between the pipes connecting the air cleaner to the inlet manifold. The number of joints must be kept to a minimum. The length of connecting pipe used must not exceed 1 m (3.2 ft) and should be of smooth bore, re-inforced hose suitable for use in a fuel and lubricating oil environment. It must be routed away from exhaust pipes and kept free from sharp bends and supported clear of other components to prevent chafing. Ideally a moulded hose should be used to suit the particular application. If it is necessary to accomodate different diameter fittings a moulded adaptor should be fitted to the inlet manifold. Worm drive hose clips should be used to fix the pipes and should be check tightened after the first eight hours of operation. It is recommended that the depression in the inlet manifold should be checked on each different application to ensure that the maximum depression of 8 in. $H_2O$ is not exceeded and thus degrade the performance of the engine. Although pressure differential devices are available from the air cleaner manufacturer to indicate when the air filter element is restricted and requires changing they must not be fitted as the current pressure settings are unsuitable for Petter engines.

### Oil Bath

**1.20** The oil bath type of cleaner allows the combustion air to impinge upon oil in an oil cup before passing through a wire gauze filter. The oil cup removes the larger particles of dust and the incoming air carries the oil up to wash the filter. The dust particles extracted from the air are then carried back to the oil cup by the circulation of the oil around the filter. to cope with more ardous conditions, heavy duty air cleaners are available which have a pre-cleaner fitted to the air intake. This pre-cleaner is designed to impart a swirl to the air, the centrifugal action set up by the air throws the larger particles of dust to the side of the pre-cleaner. In addition, the heavy duty air cleaners have a removable wire element between the oil cup and the fixed element.

### Servicing

**1.21** The servicing periods recommended for air cleaners are based on the engine being used in normal environmental conditions. It will therefore be necessary to increase the frequency of air cleaner servicing where the engine is being used in dusty conditions (see Section 4).

## EXHAUSTS

**1.22** When fitting an exhaust system to a Petter engine it is important to observe the following guidelines:

(1) The exhaust pipe should be uniform in diameter and length used as short as possible. The number of bends should be restricted to the minimum and the use of elbows is not recommended.

(2) Exhaust pipes should be installed with a

flange connection in preference to a nipple to facilitate periodic dismantling, so that carbon adhering to the inside of the pipe can be removed. A flanged exhaust outlet manifold with threaded adaptor is available for all Petter engines.

(3) Where possible, exhaust pipes must slope down away from the engine. If there is a possibility of condensate draining back into the engine, a suitable water trap with a drain cock must be fitted. This cock should be left open when the engine is idle.

(4) The weight of the exhaust pipe should not be taken by the engine manifold. Brackets which allow for expansion of the pipes should be fitted and a length of flexible pipe fitted between the engine and pipe run to absorb vibration.

(5) The exhaust pipe should be lagged where it is liable to obstruct the carrying out of maintenance or operation of controls. Total lagging of the exhaust pipe assists in preventing internal condensation and helps to lower engine room or housing temperature.

## Calculating Exhaust Pipe Sizes

**1.23** The use of sharp bends and elbows restricts the flow of exhaust gases and is not recommended. The number of bends should be kept to a minimum, as when the exhaust gas has to pass through a bend the restriction to flow is equivalent to that caused by a much longer piece of pipe. For example a 1 in. BSP pipe bend has the same restriction as 300mm length of pipe, whilst a 2 in. BSP bend has the equivalent restriction of 610mm of straight pipe. As the exhaust pipe size is calculated using the relationship between length and diameter it is therefore necessary to make allowances for the number of bends. This is achieved by calculating a theoretical pipe length corresponding to the number of bends and adding this to the pipe length already determined. In order to establish the exhaust pipe size for a particular installation proceed as follows:

(1) Accurately measure and note the total proposed exhaust pipe length.

(2) Using Table 1.1 determine the pipe size.

(3) Note the number of bends required.

(4) Using Table 1.2 determine the theoretical pipe length corresponding to the number of bends and add to the pipe length noted in Paragraph 1.23(1).

(5) Using this calculated length and Table 1.1 determine the pipe size.

**1.24** Two examples of calculating exhaust pipe sizes are as follows:

(1) Example 1 – No Bends

Actual length 2m

With reference to Table 1.1 – Exhaust pipe size 1.5 in. BSP.

(2) Example 2 – Three Bends

Actual length 2m

With reference to Table 1.1 – Exhaust pipe size 1.5 in. BSP.

With reference to Table 1.2

Three bends = 3 x 460mm = 1.38m

Calculated length = 2m (actual length) + 1.38m (allowance) = 3.38m

With reference to Table 1.1

Exhaust pipe length 3.38m (calculated) = 2 in. BSP

Therefore exhaust pipe size is 2 in. BSP x 2m long.

*TABLE 1.1*
*EXHAUST PIPE LENGTH AND SIZE (BSP) RELATIONSHIP*

| *AA1, AB1* | |
|---|---|
| *Exhaust pipe length* | *Exhaust pipe size BSP* |
| **460 mm to 3 m (18 in. to 10 ft.)**<br>**3 m to 6 m (10 ft. to 20 ft.)** | **1.5 in.**<br>**2 in.** |
| **Note**<br>*For lengths up to 460 mm (18 in.) use the 1 in. BSP threaded exhaust flange adaptor. For lengths in excess of this fit an expansion nipple to the adaptor and use the appropriate exhaust pipe as detailed.* | |
| *AC1, AC2, AC1Z, AC1ZS* | |
| *Exhaust pipe length* | *Exhaust pipe size BSP* |
| **460 mm to 1.8 m (18 in. to 6 ft.)**<br>**1.8 m to 6 m (6 ft. to 20 ft.)** | **1.5 in.**<br>**2 in.** |
| **Note**<br>*For lengths up to 1.8 m (6 ft) use the 1.5 in. BSP threaded exhaust flange adaptor. For lengths in excess of this fit an expansion nipple to the adaptor and use the appropriate exhaust pipe as detailed.* | |

*TABLE 1.2*
*PIPE LENGTH ALLOWANCES FOR BENDING*

| *Pipe size BSP* | *Add for each bend* |
|---|---|
| **1 in.**<br>**1.5 in.**<br>**2 in.** | **300 mm (1 ft)**<br>**460 mm (1.5 ft)**<br>**610 mm (2 ft)** |

**Note**
*For bends with a radius greater than six times the pipe diameter no extra allowance is necessary.*

## SILENCERS

**1.25** A simple "pepper pot" type silencer which is supplied as standard equipment on most Petter industrial engines is adequate for general silencing. This may also be fitted to the open end of an exhaust pipe if required, but if the pipe length used demands an increase in diameter an appropriate size of silencer must be fitted.

**1.26** Where a higher degree of silencing is required, a piped exhaust system including an acoustic silencer should be fitted. This type of silencer must be positioned at the open end of the pipe and the size must conform to the size of piping. For maximum efficiency a tail pipe should be fitted to this silencer, the length of which should be ten times the diameter of the exhaust pipe, that is a tail pipe 510 mm (20 in.) long must be fitted to a 2 in. BSP silencer and pipe. For maximum silencing it is necessary to include an expansion silencer, fitted close to the engine exhaust manifold, in addition to the acoustic silencer and tail pipe.

### Spark Arrestor

**1.27** Spark arrestors with replaceable elements can be obtained from Petters Limited or their representatives and are for use with the acoustic silencer only. The arrestors should be installed as high as possible and at the open end of the exhaust pipe. Regular inspection and servicing are essential.

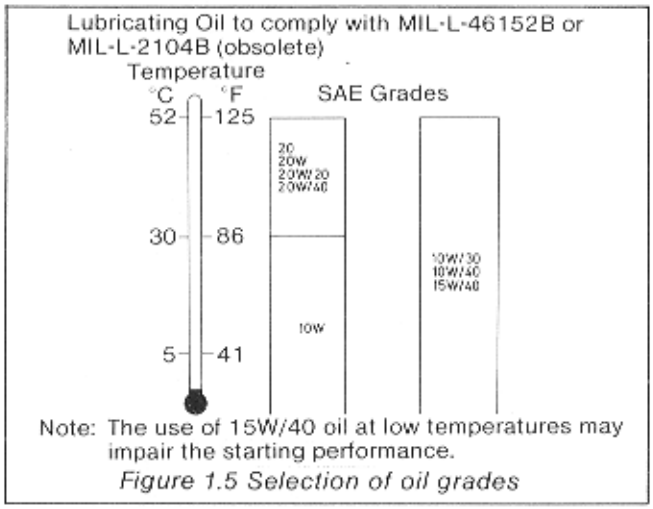
**Note**
*This type of arrestor is not a flame trap.*

## LUBRICATION

### LUBRICATING OILS

**1.28** The engine lubrication oils used in Petter engines are heavy duty oils which must conform to the minimum performance level as specified by the U.S. Department of Defence Standard MIL-L46152-B which supersedes MIL-L-2104B (now obsolete). Other suitable heavy duty engine oils may be recommended by a local distributor, but the performance level must be as specified by MIL-L-46152-B. Petters Limited or their representatives must be consulted if doubt arises regarding the selection of engine oil.

**CAUTION**
**Series 3 or MIL-L-2104C Lubricating oils inhibit the running in of new or overhauled engines. They are not suitable for engines running at light load in low ambient temperatures. Their use must be restricted to the combination of high loads, speeds and ambient temperatures.**




Note: The use of 15W/40 oil at low temperatures may impair the starting performance.

*Figure 1.5 Selection of oil grades*

### Selection of Viscosity (Grade)

**1.29** The correct selection of oil viscosity to be used at various temperatures is given in the chart shown in Figure 1.5 Although different viscosities of oil are recommended for differing temperatures it is not always practical to change oils where engines are operating in various temperature conditions. Under these circumstances it is recommended that an approved multi-grade be used, if this is not available then the oil used should be of viscosity (grade) suitable for the coldest temperature likely to be encountered. This recommendation is made with ease of hand starting as first consideration.

## FUEL

### STORAGE

**1.30** The storage of diesel fuel is subject to local regulations, but generally, is permitted above ground using containers or tanks of authorised construction and capacity. In order to keep the engine fuel system functioning correctly it is important to ensure that the fuel is clean and free from water.

**CAUTION**
**Do not use galvanised containers or the zinc coating will react with the fuel and damage the fuel injection equipment.**

**1.31** Provision must be made at the base of storage tanks to drain off water which may accumulate at the base of the tank. Water absorbed by the fuel can be kept to the minimum by keeping storage tanks as full as possible and ensuring that filler caps and inspection covers are effectively sealed.

### HANDLING

**1.32** The following points must be observed in order to ensure a supply of clean and efficient fuel.

(1) The fuel used must be a high grade light diesel fuel, gas oil or DERV fuel and comply with BS2869:1970 Classes A1 and A2 an extract of which is given in Table 1.3. It is not advisable to use an inferior fuel.

(2) Fuel should be allowed to settle for sufficient time to allow sludge or water to accumulate at the bottom of the container or tank.

(3) Fuel from storage tanks should be taken from a short distance above the base, enabling clean fuel to be withdrawn without disturbing water or sediment.

*TABLE 1.3 EXTRACT FROM BS2869 : 1970*

| *Detail* | *Class A1 Automotive Use* | *Class A2 General Purpose Use* |
|---|---|---|
| Cetene number (minimum) | 50 | 45 |
| Viscosity (kinematic) at 37.8°C (100°F) | 1.5 to 5.5 cSt | 1.5 to 5.5 cSt |
| Carbon residue. Ramsbottom percent by Mass on 10% residue (maximum) | 0.2% | 0.2% |
| Distillation recovered at 357°C (675°F) : by volume | 90% | 90% |
| Flash point (closed) | 55°C (130°F) | 55°C (130°F) |
| Water : by volume (maximum) | 0.05% | 0.05% |
| Sediment : by weight (maximum) | 0.01% | 0.01% |
| Ash : by weight (maximum) | 0.01% | 0.01% |
| Sulphur : by weight (maximum) | 0.3% | 0.5% |

(4) Funnels or cans used for fuel must be kept absolutely clean and dry and only used for fuel.

(5) The engine fuel tank must always be filled through a strainer. The tank should occasionally be drained and cleaned by flushing out with kerosene.

(6) The engine fuel tank should be kept full when the engine is not in use to prevent condensation.

## GRADES

**1.33** Diesel fuels are graded for use under varying temperature conditions and the fuel grade used should be suitable for the prevailing temperature. Diesel fuels available for use in low temperatures are classified as Cold Start Reference Fuels. Although different grades of fuel are recommended for different temperatures it is not always practical to change grades when operating under constantly changing conditions. Under these circumstances the fuel suitable for the coldest condition likely to be met should be used.

**1.34** Some diesel fuels not suitable for low temperatures may form wax under these conditions. If it is suspected that wax has formed, the whole engine should be gently warmed throughout and the fuel tank, pipes, injector and fuel injection pump then completely drained and flushed with the correct fuel. The system should be then filled with the correct fuel, bled and primed before attempting to start.

## GOVERNING

**1.35** The governor maintains a constant predetermined engine speed irrespective of load conditions and in the case of variable speed engines prevents the maximum permitted speed being exceeded. The governor system consists of steel balls housed in a case which with the application of centrifugal force operates a sliding cone. The movement of the cone is transmitted via a bracket, shaft and lever to the fuel injection pump where it controls the amount of fuel delivered to the fuel injectors.

# DRIVE ARRANGEMENTS

## CLASSIFICATION

**1.36** Petter engine drives are varied and are dependent upon application. They are classified by Mark (Mk) Numbers as shown in Figure 1.6 and are as follows:

(1) Mk1 – Drive at half engine speed, gear end. Rope starting on flywheel.

(2) Mk2 – Drive at engine speed, gear end. Rope starting on flywheel.

(3) Mk4 – Drive at engine speed through flywheel end clutch. Half speed start, gear end.

(4) Mk5 – Drive at engine speed, flywheel end. Half speed start, gear end.

(5) Mk6 – Drive at engine speed, flywheel end. Rope starting on gear end.

**Note**
*Mk3 is not used on 'A' range.*

**1.37** Power can be taken from more than one shaft at the same time provided that the total power absorbed is not greater than the rated power of the engine.

*TABLE 1.4*
*MARK APPLICABILITY*

| ENGINE | MARK | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| AA1 | ✓ | ✓ | X | X | X | ✓ |
| AB1 | ✓ | ✓ | X | X | X | ✓ |
| AC1 | ✓ | ✓ | X | ✓ | ✓ | ✓ |
| AC1Z | X | X | X | X | ✓ | X |
| AC1ZS | X | X | X | X | ✓ | X |
| AC2 | X | X | X | X | ✓ | X |

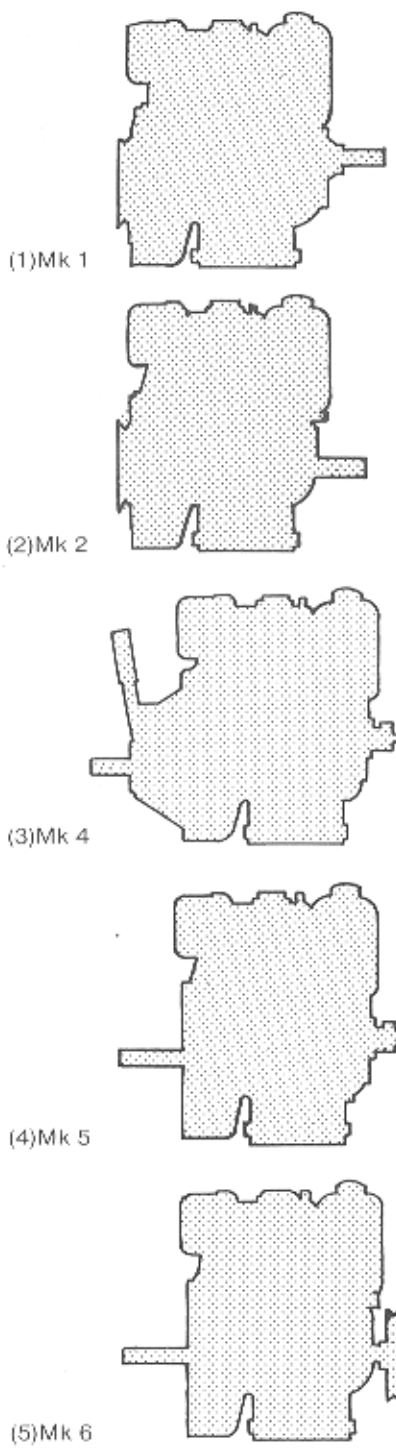



*Figure 1.6 Engine Drive Arrangements*

## PULLEY DRIVE

**1.38** When belt drives are used the belts should be as close to the engine as possible. When fixed and loose pulleys are fitted, the fixed drive must be nearest the engine.

**1.39** To prevent damage to the new vee belts when fitting, the distance between the centre of the engine pulley and the driven pulley as shown in Figure 1.7 must be capable of a reduction from the designed running position. Provision must also be made for an increase of at least 5% over the designed running position to provide adjustment for belt stretch and wear during the life of the belts. Multiple belts should always be renewed in matched sets.

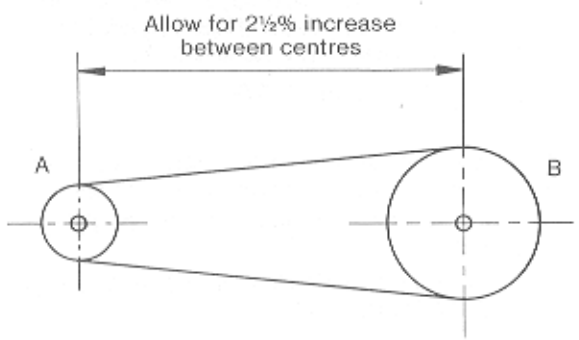



*Figure 1.7 Adjustment of Drive Belts.*

## ROTATION

**1.40** Engine rotation is viewed from the flywheel end. Rotation for the various types of engines in the air cooled 'A' range is given in Table 1.5.

*TABLE 1.5*
*ENGINE ROTATION*

| *Engine Type* | *Rotation* |
|---|---|
| **AA1** | Clockwise |
| **AB1** | Clockwise |
| **AC1** | Clockwise |
| **AC1Z** | Counter-clockwise |
| **AC1ZS** | Clockwise |
| **AC2** | Counter-clockwise |

# OPERATING INSTRUCTIONS

## NEW OR OVERHAULED ENGINE

### Preparation for Starting (Figure 1.10)

**1.41** To prepare a new or overhauled engine for starting proceed as follows:

(1) Check that the cooling fan air intake is free from obstruction.

(2) Remove the oil filler cap and, with the engine level fill with lubricating oil which conforms to specification MIL-L-46152-B (Paragraph 1.28) and of the correct grade (Paragraph 1.29) to the high level mark on the dipstick. To ensure a correct reading, the dipstick should be withdrawn while the oil is being added. It should be submerged for at least five seconds before being removed for reading. Wipe the dipstick each time it is replaced for further readings. Replace the cap when oil level is at the high mark on the dipstick.

(3) If the engine is fitted with an oil bath type air cleaner fill the bowl with oil to the indicated level.

(4) Move the STOP/RUN **(3)** lever to the STOP position.

(5) Lift the decompressor lever(s) **(1)** and turn the engine about fifteen times to circulate the oil.

(6) Fill the fuel tank with the appropriate type and grade of fuel (Paragraph 1.32 and Paragraph 1.33).

(7) Bleed the fuel system as detailed in Paragraph 1.42 if required.

**Note**
*Most 'A' range engines are fitted with a self-bleeding pipe assembly in place of the fuel pump vent screw (Figure 1.9) and require no action.*

(8) Lightly lubricate the control linkages.

### Bleeding the Fuel System

**1.42** If the engine is not fitted with a self bleeding fuel system, or a separately mounted fuel filter is fitted the procedures detailed must be followed. With a separately mounted fuel tank employing a fuel lift pump the pump priming lever must be operated to bleed all fuel systems.

#### Fuel Filter

**1.43** If a separately mounted fuel filter is fitted loosen the two vent screws (Figure 1.8) on the top of the filter and when air free fuel flows out tighten the vent screws.

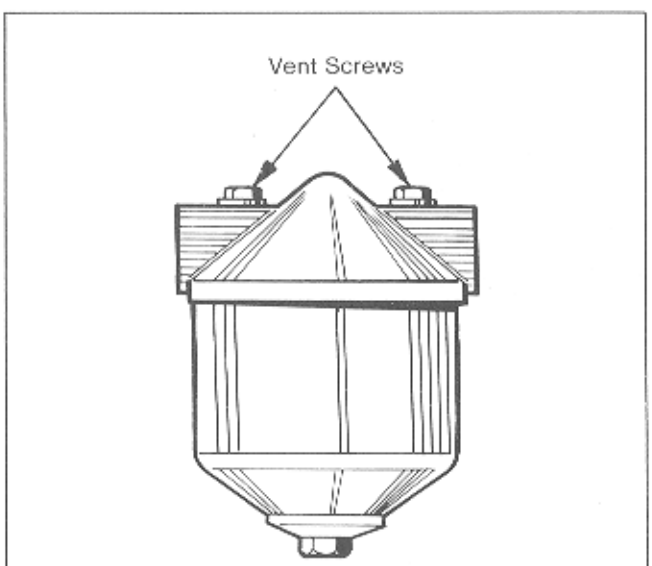



*Figure 1.8 Separately Mounted Fuel Filter: Vent Screws*

#### Fuel System

**1.44** On engines not fitted with a self-bleeding fuel system, move the STOP/RUN **(3)** lever to the RUN position, that is horizontal. Loosen the vent screw (Figure 1.9) on the fuel injection pump. When clean air free fuel flows out tighten the vent screw.

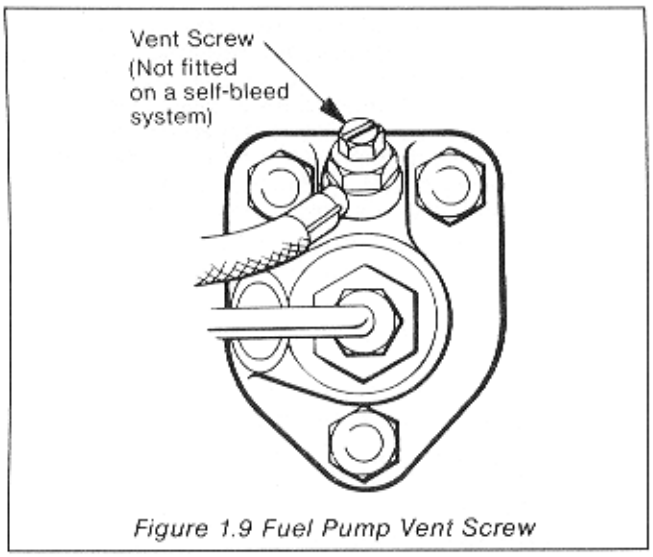



*Figure 1.9 Fuel Pump Vent Screw*

### Engine Running In

**1.45** To avoid excessive oil consumption the following running in procedure must be carried out on new or overhauled engines:

(1) Run for 2 minutes on no load, and ensure that there are no oil leaks.

**Note**

*After the initial few minutes running stop the engine and check the oil level, top up as required. The level of engine oil usually falls slightly after the initial circulation.*

(2) Run for 10 minutes at approximately half load.

(3) Run for a further minimum of 8 hours or longer, if possible on full load.

**CAUTION**

**Initial running at idling speed for long periods of a new or overhauled engine causes glazed bores and thus excessive oil consumption.**

## STARTING

**WARNING**

**(1) WHEN USING A STARTING ROPE, DO NOT WIND THE ROPE AROUND HAND OR WRIST MAKE SURE THAT THE ROPE IS NOT TANGLED OR FRAYED AND OF THE CORRECT LENGTH.**

**(2) ENSURE THAT THE STARTING HANDLE (IF USED) IS CLEAN, LIGHTLY LUBRICATED AND IN GOOD CONDITION TO ALLOW IT TO EASILY AND SAFELY ENGAGE AND DISENGAGE.**

**(3) MAKE SURE THAT AFTER INSERTING THE STARTING HANDLE THAT THE LOCATING PIN, WHERE APPLICABLE, IS SECURELY LOCATED IN THE SLOT IN THE HOUSING IN THE CAPTIVE POSITION.**

**(4) THE STARTING HANDLE SHOULD BE HELD FIRMLY WITH THE THUMB ON TOP OF THE GRIP NOT ROUND IT.**

### Normal Start (Figure 1.10)

#### Preliminaries

**1.46** To start an engine under normal conditions carry out the following preliminary operations:

(1) Remove as much load from the engine as possible.

(2) Move the STOP/RUN lever **(3)** to the RUN position (horizontal).

(3) If a variable speed control is fitted set to full speed using the knurled adjusting nut or control lever.

(4) If a two speed lever is fitted set to the full speed position.

(5) Push down and release the overload stop lever **(4)** located on the fuel pump side of the engine.

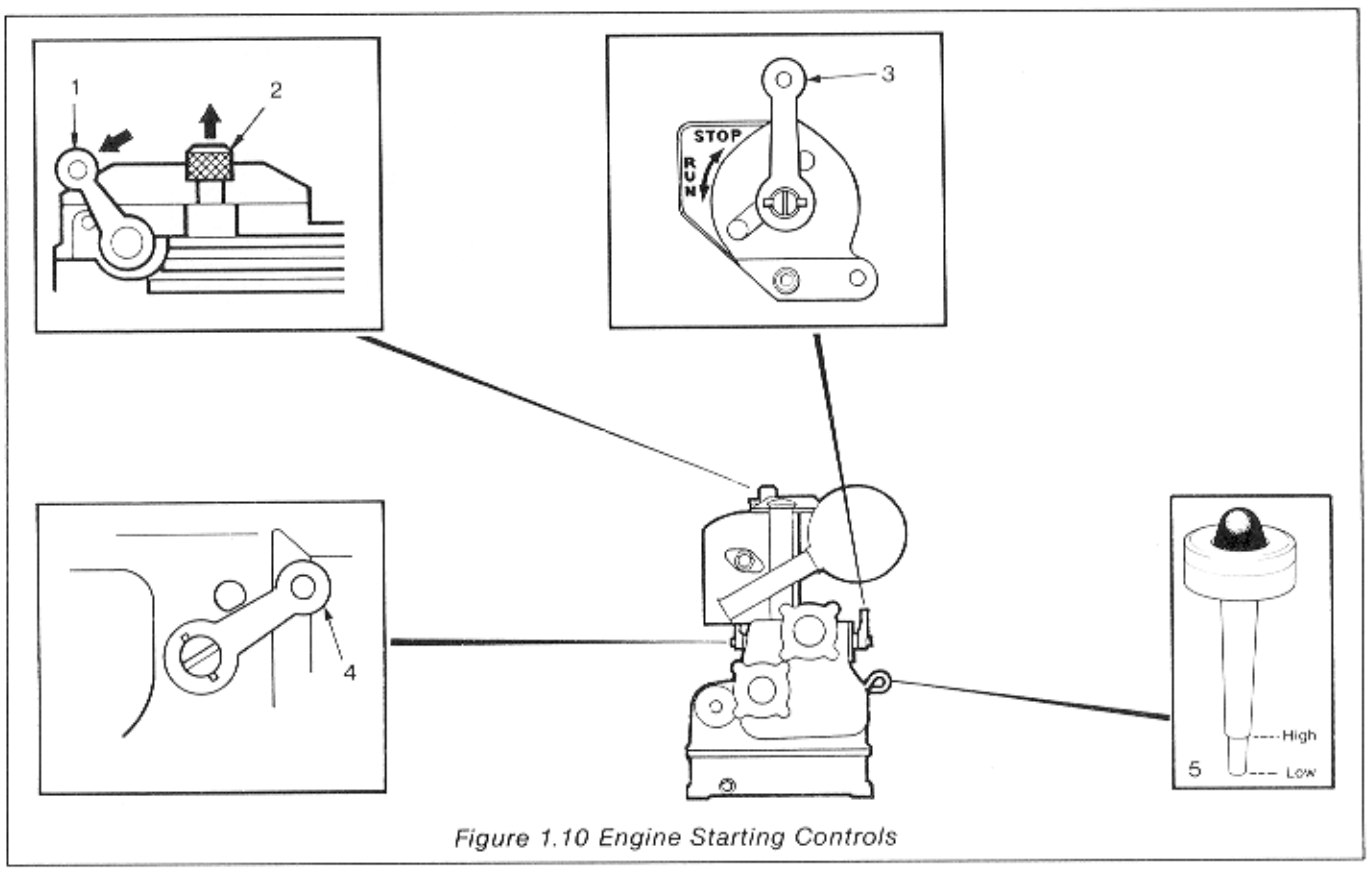



*Figure 1.10 Engine Starting Controls*

### Rope Starting

**1.47** To rope start proceed as follows:

(1) Turn the starting pulley in the opposite direction of rotation until a resistance is felt.

(2) Bounce the pulley vigorously against the resistance, until the injector has squeaked a few times (this is not necessary with a warm engine).

(3) Wind the rope two turns around the starting pulley in the direction of rotation.

**WARNING**
**DO NOT WIND THE ROPE AROUND THE HAND OR WRIST.**

(4) Ensure that the decompressor lever **(1)** is down and pull the rope sharply until it unwinds completely.

**Note**
*Rope starting is not recommended at temperatures below –4°C (25°F).*

### 4:1 Hand Starting

**1.48** To carry out 4:1 hand starting proceed as follows:

(1) Lift the starting gear.

(2) Engage the starting handle in the starting gear. The handle will not fully engage unless the starting gear has been lifted.

(3) Lift and hold the decompressor lever **(1)** against its stop. Turn the starting handle slowly and when the injector is heard to squeak, turn the handle as fast as possible and lower the decompressor lever while still turning. When the engine fires, remove the starting handle.

### Hand Starting

**1.49** To carry out all other forms of hand starting proceed as follows:

(1) Lift and hold the decompressor lever(s) **(1)** against its stop.

(2) Engage the starting handle and turn the handle slowly until the injector is heard to squeak.

(3) Turn the starting handle as fast as possible and at the same time lower the decompressor lever. On two cylinder engines lower one decompressor lever only and as soon as the engine fires lower the other lever.

(4) When the engine starts remove the starting handle.

### Electric Starting

**1.50** Make sure the decompressor lever(s) **(1)** is down before operating the starter switch or button. When the engine starts release the switch or button. Do not operate the starter switch or button for more than 20 seconds at a time.

## Cold Starting (Figure 1.10)

### Engine Without Heater Plugs

**1.51** At temperatures below 13°C (55°F), (0°C (32°F) ACIZS only) it is essential to carry out the following procedure:

(1) Remove the priming plunger(s) **(2)** located in the top of the cylinder head.

(2) Fill the priming chamber with engine oil – not fuel. This should be done using the priming facility on the dipstick **(5)** if fitted. The priming dipstick has a neoprene bulb, which when pressed and then released in position will fill with oil from the engine sump. The dipstick can then be removed and oil injected into the priming chamber. Replace the dipstick after use.

(3) Replace the priming plunger(s) and press down. With the exception of AC1ZS engines, if the temperature is below 0°C (32°F) prime the engine twice.

**CAUTION**
**Do not over prime.**

(4) Start the engine in the normal manner. Should the engine fire and then stop, prime again and release the overload stop lever (if fitted) before attempting a further start. If under cold conditions the engine does not run up to its rated speed after starting operate the priming plunger again while the engine is still running.

### Engines With Heater Plugs

**1.52** For engines with electric starting and heater plugs, operate the heater plugs for 20 seconds and then switch immediately to start.

## Cold Starting Pump (If Fitted)

**1.53** On a new or overhauled engine remove the rocker cover and fill the reservoir with clean approved engine oil. At temperatures below 13°C(55°F), (0°C(32°F) ACIZS only) it is essential to prime the engine. To prime the engine withdraw the plunger fully, allow a few seconds and push fully inwards. Repeat the operation two more times and then start the engine in the normal way. If under extreme cold conditions the engine does not run up to its rated speed after starting, withdraw and press in the plunger while the engine is running.

**CAUTION**
**Do not over prime**

**1.54** When the engine is running normally leave the priming plunger fully inwards.

## Cold Starting Aids

**1.55** When the operating temperatures are below –4°C (25°F) a cold starting aid may be required. Below –9°C (16°F) consult Petters Limited or their representatives for starting instructions, information on cold starting aids may also be obtained.

## STOPPING

**1.56** Before stopping it is advisable to run the engine on a light load for a few minutes. To stop the engine move the STOP/RUN lever to the STOP position (vertical) and hold in this position until the engine stops.

**CAUTION**
**Do not turn off the fuel supply or use the decompressor lever(s) to stop the engine.**

## OPERATING PRECAUTIONS

**1.57** The following points should be noted when operating Petter diesel engines:

(1) Do not stop the engine by lifting the decompressor lever(s). This will damage valve seats.

(2) Do not allow the engine fuel tank to run low. This could allow sediment or water to be drawn into the fuel system.

(3) Do not remove or alter the setting of the overload stop or operate the overload stop lever when the engine is running. This will

cause overheating, excessive wear and possible piston seizure.

(4) Prolonged running at idling speed and/or light load causes glazed bores and thus excessive oil consumption.

## ROUTINE MAINTENANCE

### INTRODUCTION

**1.58** The routine servicing and maintenance instructions given in this manual are based on average operating conditions and cover the minimum requirements to keep an engine running at peak performance with trouble free operation. Under very dusty conditions, air cleaners, lubricating oil and fuel filters will require more frequent attention. Decarbonising may be required more frequently when engines are running on light loads for long periods.

***Please remember***

***... an engine needs fuel –***
*Keep fuel, tank, filter and piping clean.*

***... an engine needs lubricating oil –***
*Use correct grade and type of oil. Keep oil level topped up.*

***... an engine needs air –***
*Keep air cleaner clean. Keep air inlet manifold and entire exhaust system free of carbon and any other obstruction.*

***... an engine needs cooling –***
*Keep air intakes clean and provide adequate ventilation.*

### INITIAL CHECKS ON NEW OR OVERHAULED ENGINES

#### 20 Hours Initial Running

**1.59** After approximately 20 hours initial running of a new or overhauled engine carry out the following procedure:

(1) Check the tightness of all nuts, bolts, securing screws and clips. Re-torque the cylinder head nuts in accordance with the procedure detailed in Section 5.

**CAUTION**
**Checking the tightness of nuts, bolts and securing screws must be carried out with the engine cold.**

(2) Check valve clearance (Section 5).

(3) Drain the lubricating oil from sump, fit a new oil filter and fill with clean oil (Section 2).

(4) Check fuel filter (Section 3).

### DAILY CHECKS

**1.60** Carry out the following procedure:

(1) Check and top up the fuel tank with the correct type and grade of fuel.

(2) Check the oil level on the dipstick, if necessary top up the engine at the oil filler with the correct type and grade of lubricating oil

(3) Check that the cooling fan intake is free from obstructions.

(4) Visually check the engine for signs of oil or fuel leaks.

### EVERY 50 RUNNING HOURS

**1.61** Clean the oil bath type air cleaner, if fitted. (Section 4). Refill with clean lubricating oil to the indicated level. Examine the alternator or dynamo driving belt (if fitted) and adjust the tension if necessary. The belt should be tighter than a conventional V-belt but not tight enough to damage the bearings.

### EVERY 250 RUNNING HOURS

**1.62** Carry out the following procedure:

(1) Check the tightness of all nuts (excluding cylinder head), bolts, securing screws and clips.

**CAUTION**
**Checking the tightness of nuts, bolts and securing screws must be carried out with the engine cold.**

(2) Check that the fuel tank filler cap vent hole is clear, and clean if necessary.

(3) Clean the air cleaner paper element, if fitted.

(4) Check the exhaust system for damage, corrosion and holes, clean out deposits of carbon.

(5) Clean the fuel tank strainer, if fitted.

(6) Drain the oil sump and refill with new lubricating oil of the correct type and grade. (Section 2). Fit a new oil filter element and gasket.

**Note**
*The oil level should be checked after initial run when the oil filter element has been changed.*

(7) Check the valve clearance (Section 5) and adjust, if necessary.

(8) Lightly lubricate the control linkage.

(9) Remove the fuel injector(s) and test spray. If in order fit a new sealing washer, replace without further maintenance. (Section 3).

**CAUTION**
**Whenever an injector is removed a new sealing washer must be fitted.**

(10) Carry out the maintenance procedure as detailed in Section 6 on the 4:1 hand start and raised hand start (if fitted).

### EVERY 500 RUNNING HOURS

**1.63** Carry out the following procedure:

(1) Fit a new air cleaner element (paper type) if fitted.

(2) Fit a new filter element to remote fuel filter (separate tank).

### EVERY 1000 RUNNING HOURS

**1.64** Carry out the following procedure:

(1) Drain and clean out the engine fuel tank.

(2) Fit a new fuel tank filter element (Section 3).

### EVERY 2000 RUNNING HOURS

**1.65** Carry out the following procedure:

(1) Decarbonise the piston(s) and cylinder head(s) in accordance with the procedure detailed in Section 5.

(2) Check the crankshaft bearings and renew, if worn (Section 5).

(3) Clean the oil pump strainer (Section 2).

(4) Examine the breather valve (if fitted) and renew, if worn.

# SECTION 2
# LUBRICATING SYSTEM

## LUBRICATING SYSTEM

**2.1** The 'A' range diesel engines are lubricated by a rotary pump type lubricating oil system. The pump is mounted at the gear end of the engine and is driven by a gear from the camshaft. The oil is drawn via a strainer from the sump and pumped via a pressure relief valve to the filter from where it is distributed via oilways in the crankcase or external pipes to the crankshaft bearings. An external pipe feeds oil through a restrictor to the valve rockers. The cylinder, small end bearings and camshaft are splash lubricated. The lubricating oil is drained by removing either one of two plugs located at the bottom of the sump.

## ROTARY OIL PUMP

### Removal

**2.2** To remove the oil pump carry out the following procedure:

(1) Drain the oil from the sump by removing an oil drain plug.

(2) Remove any ancillary equipment attached to the gear cover.

(3) Remove the eight 1/4 in. UNC socket head cap screws securing the gear cover to the crankcase.

(4) Loosen the 3/8 in. UNF self-locking nut retaining the oil pump gearwheel.

(5) Remove the camshaft gearwheel. (Section 5).

(6) Remove the oil pump gearwheel retaining nut and washer and remove the gearwheel. The gearwheel is keyed to the shaft.

(7) Remove the three 1/4 in. UNC capscrews and washers securing the pump and withdraw the pump assembly.

(8) The backplate (if fitted) is dowelled to the body.

### Dismantling

**2.3** To dismantle the rotary oil pump proceed as follows:

(1) Remove the backplate (if fitted) from the oil pump body.

(2) Withdraw the inner and outer rotors.

### Maintenance

**2.4** Clean all components and check the rotors for signs of wear. If worn renew the pump assembly.

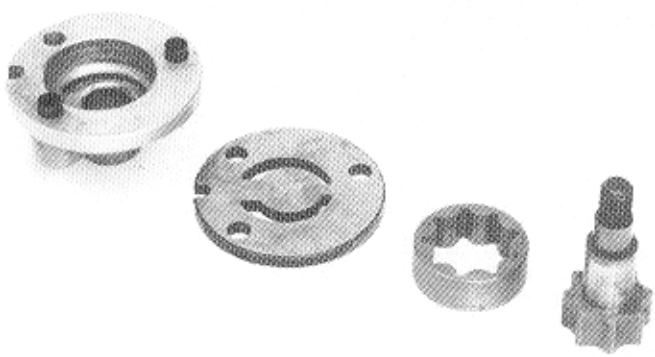


*Figure 2.1 Dismantled Rotary Oil Pump Single-Cylinder Engines*

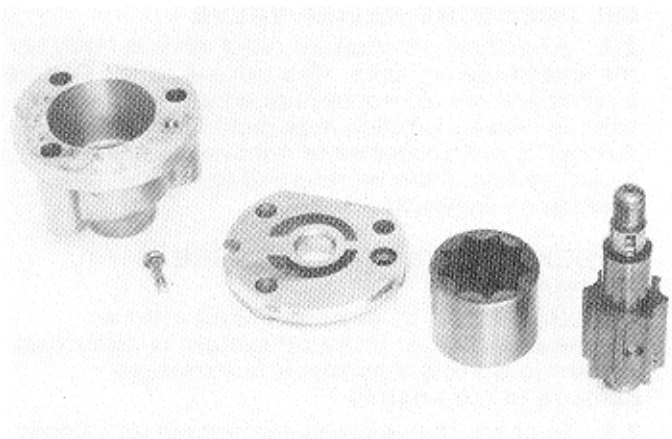


*Figure 2.2 Dismantled Rotary Oil Pump Two-Cylinder Engines*

### Assembly

**2.5** To assemble the rotary oil pump proceed as follows:

(1) Fit the rotors into the pump body. Ensure that the outer rotor chamfered edge is entered into the pump body.

(2) Locate the backplate (if fitted) on the two dowels with the cutaway on its outer edge in line with the cutaway on the pump body.

### Replacement

**2.6** To replace the rotary oil pump proceed as follows:

(1) Pour a small quantity of lubricating oil into the pump through the ports before fitting the pump to the engine.

(2) Align the pump assembly with the offset capscrew thread holes.

(3) Fit the three 1/4 in. UNC capscrews and washers and tighten to a torque loading of 13.6 Nm (10 lbf ft.)

(4) Fit the oil pump gearwheel, keying it to the shaft.

(5) Fit the 3/8 in. UNF self-locking nut and washer retaining the oil pump gearwheel.

(6) Replace the camshaft gearwheel (Section 5).

(7) Tighten the oil pump gear retaining nut.

(8) Fit a new gasket and assemble the gear cover to the crankcase.

(9) Fit any ancillary equipment as required to the gear cover.

## OIL FILTER

**2.7** The oil filter consists of a detachable cover containing a filter element which is secured by a centre bolt to the crankcase. To change the filter element proceed as follows:

(1) Unscrew the centre bolt and withdraw the filter cover and element.

(2) Clean the cover and chamber.

(3) Renew the filter element and sealing ring. These items are obtainable from Petters Limited or their representatives. Do not attempt to clean the element.

(4) Fit the element, sealing ring and cover.

(5) Tighten the centre bolt to a torque of 13.6 Nm (10 lbf ft).

**CAUTION**
**Do not over torque the centre bolt.**

## OIL PRESSURE RELIEF VALVE

**2.8** A ball type oil pressure relief valve is fitted at the side of the oil pump. The valve is set by Petters Limited and should not require adjustment. If the valve is dismantled then note must be made of the number of turns required to remove the adjusting screw, so that it can be returned to its original position on assembly.

## CHECKING THE OIL PRESSURE

**CAUTION**
**The oil pressure must be checked after an engine overhaul or if the oil system is disturbed. Failure to do this may result in extensive damage to the engine.**

**2.9** To check the oil pressure proceed as follows:

(1) Locate and remove the blanking plug from below the rocker oil supply pipe union on the right hand side of the crankcase when viewed from the flywheel end of the engine.

(2) Fit a 1/8 in. BSP union, capillary pipe and pressure gauge.

(3) Start the engine and ensure that the oil pressure builds up.

(4) Run the engine at the r/min indicated on the engine nameplate and check with the engine hot that the oil pressure is not lower than 2.4 bar (35 lbf/in$^2$). On ACIZS engines which are rated at 1250 r/min the oil pressure must be no lower than 2.06 bar (30 lbf/in$^2$).

## OIL PUMP STRAINER (SINGLE CYLINDER ENGINES)

### Removal

**2.10** To remove the oil pump strainer carry out the following procedure:

(1) Drain the oil from the sump.

(2) Remove the eight capscrews retaining the sump and discard the sump gasket.

(3) Remove the centre bolt and strainer clip and remove the strainer.

### Maintenance

**2.11** Clean the strainer using clean kerosene.

### Replacement

**2.12** To replace the strainer carry out the following procedure:

(1) Locate the strainer in the sump making sure it is correctly seated.

(2) Fit the strainer clip and centre bolt, making sure that the concave side of the clip holds the strainer.

(3) Renew the sump gasket and fit the sump.

(4) Fill the oil system with the approved type and grade of oil.

## OIL PUMP STRAINER (AC2 ENGINES)

### Removal

**2.13** To remove the oil pump strainer carry out the following procedure:

(1) Drain the oil from the sump

(2) Remove the ten sump capscrews retaining the sump and sump gasket. Discard the sump gasket.

(3) Remove the two 1/4 in. UNC retaining screws, strainer assembly and flange gasket.

### Maintenance

**2.14** Clean the strainer using clean kerosene.

### Replacement

**2.15** To replace the strainer carry out the following procedure:

(1) Fit a new flange gasket.

(2) Locate the strainer flange and two retaining screws to the crankcase.

(3) Tighten the two retaining screws evenly.

(4) Renew the sump gasket and fit the sump.

(5) Fill the oil system with the approved type and grade of oil.

# SECTION 3
# FUEL SYSTEM

## INTRODUCTION

**3.1** The fuel injection equipment is manufactured to very fine limits and requires extreme care and absolute cleanliness in handling. Any part of the fuel system including pipes removed from an engine must be placed in a clean container containing clean fuel.

## FUEL INJECTION EQUIPMENT IDENTIFICATION

**3.2** The fuel injection equipment fitted to 'A' range engines although similar in construction and operation varies between engine types. To assist in identification and to show interchangeability between types the fuel injection equipment details are listed in Tables 3.1, 3.2 and 3.3.

### Fuel Injection Pumps

**3.3** Identification of a fuel injection pump is achieved by reading the type code from the name plate on the pump body. Compatible pumps are shown in Table 3.1.

### Fuel Injectors

**3.4** The fuel injector(s) fitted to air cooled 'A' range engines can be one of three types: the Bryce Early, the Bryce Late or the I.E.S.A. type. The Bryce injectors have interchangeable nozzles and the Bryce Late injector is interchangeable with the I.E.S.A. injector, but the Bryce and I.E.S.A. nozzle tips are not interchangeable. The Bryce Early type injector is not interchangeable with the Bryce Late or I.E.S.A. injector. See Table 3.2.

*TABLE 3.2 FUEL INJECTORS*

| *Engine Type* | *Fuel Injector* | *Nozzle Code* |
|---|---|---|
| AA1 – Engine No 101 to 93723<br>AB1 Engine No 101 to 29188<br>AC1 Engine No 101 to 3866 | **Bryce Early Type** | PIS 4S 437 |
| All other Engines | **Bryce Late Type** | PIS 4S 437 |
| | **or I.E.S.A. Type** | OGD 10 4S437 |

### High Pressure Injector Pipes

**3.5** It is important that the correct bore diameter and length of pipe is fitted to obtain the correct engine performance and details are given in Table 3.3.

## DESCRIPTION

**3.6** The fuel system comprises a fuel tank, fuel filter and a fuel injection pump and an injector(s). Fuel is supplied from the tank via a filter to the pump through flexible fuel pipes and by rigid pipe(s) from the pump to the injector(s). The leak-off from the injector(s) is fed via an external pipe back to the tank or to the inlet side of the filter when the system is fitted with a remote tank.

*TABLE 3.1 FUEL INJECTION PUMPS*

| *Engine Type* | *Engine Speed* | *Fuel Injection Pump* | |
|---|---|---|---|
| | | *Make* | *Pump Code* |
| AA1, AB1 | **Fixed Speed and Two Speed up to 3000 r/min** | Bryce 'B' Series | FAOARO55BO301 |
| | | Bryce 'B' Series | FAOARO55BO486 |
| | | Bryce 'E' Series | FAOARO55E0613 |
| | | I.E.S.A. | EMYW13755 sgrvi |
| AA1, AB1 | **Fixed Speed and Two Speed 3001 to 3600 r/min** | Bryce 'B' Series | FAOARO55BO404 |
| | | Bryce 'B' Series | FAOARO55BO487 |
| | | Bryce 'E' Series | FAOARO55E0614 |
| AA1, AB1 | **All Variable Speeds** | Bryce 'B' Series | FAOARO55BO402 |
| | | Bryce 'B' Series | FAOARO55BO488 |
| | | Bryce 'B' Series | FAOARO55BO486 |
| | | Bryce 'E' Series | FAOARO55E0614 |
| AC1 | **Fixed Speed and Two Speed up to 3000 r/min** | Bryce 'B' Series | FAOARO55BO301 |
| | | Bryce 'B' Series | FAOARO55BO486 |
| | | Bryce 'E' Series | FAOARO55E0613 |
| | | I.E.S.A. | EMYW13755 sgrvi |
| AC1 | **Fixed Speed and Two Speed 3001 to 3600 r/min and all Variable Speeds** | Bryce 'B' Series | FAOARO55BO523 |
| | | Bryce 'E' Series | FAOARO55E0615 |
| AC1Z, AC1ZS | **All Speeds** | Bryce 'B' Series | FAOARO55BO486 |
| | | Bryce 'E' Series | FAOARO55E0613 |
| | | I.E.S.A. | EMYW13755 sgrvi |
| AC2 | **All Speeds** | Bryce 'A' Series | FAOBRO55A0567 |
| | | Bryce 'A' Series | FAOBR055A0568 |
| | | Bryce 'E' Series | FAOBRO55E0617 |

TABLE 3.3
HIGH PRESSURE INJECTOR PIPES

| Engine Type | Speed | Bore Diameter | Length |
|---|---|---|---|
| AA1 | Fixed Speed | **2mm (0.08in.)** | **356mm (14in.)** |
| AA1 | Variable Speed | **1mm (0.04in.)** | **356mm (14in.)** |
| AB1 | All Speeds | **1.5mm (0.06in.)** | **270mm (10.6in.)** |
| AC1 | All Speeds | **2mm (0.08in.)** | **270mm (10.6in.)** |
| AC1Z | All Speeds | **2mm (0.08in.)** | **270mm (10.6in.)** |
| AC1ZS | All Speeds | **2mm (0.08in.)** | **270mm (10.6in.)** |
| AC2 | All Speeds | **2mm (0.08in.)** | **430mm (17in.)** |

## FUEL TANK

**3.7** The fuel tank is either of steel or High Density Polyethylene (HDP) construction and is secured to the gear end of the engine, with the exception of the AC2 model which is secured on the right-hand side of the engine when viewed from the flywheel end. Engine mounted tanks contain an integral fuel filter element. Engines can also be used with a remote fuel tank and separate fuel filter arrangement. The fuel tank capacity can vary according to requirements. Engines fitted with 9 litre (16 pints) capacity tanks are fitted with a separate filter attached to the engine.

### Steel Tank (Single Cylinder)

#### Removal

**3.8** To remove the fuel tank proceed as follows:

(1) Unlock the tab washers on the two bottom set screws or nuts and loosen the set screws or nuts.

(2) Remove the self-locking nut and plain washer securing the top tank bracket.

(3) Carefully lift the tank clear of the mounting studs; stand the tank on its end with the tank-to-injection pump pipe connection at the top.

**CAUTION**
**Extreme care must be taken to avoid straining or distorting the fuel pipes**

(4) Disconnect the fuel pipe at the tank, lift the tank clear and drain the fuel.

#### Maintenance

**3.9** Remove the sediment from the tank, if necessary flush the tank with clean kerosene and allow to drain. Check the tank and mounting lugs for damage. If necessary change the fuel filter element.

#### Replacement (Figure 3.1)

**3.10** To replace the fuel tank proceed as follows:

(1) Check that all the correct set screws or studs, nuts washers and spacers (9 pint only) are available.

(2) Check the fuel tank mounting bosses on the gear cover for damage. Fit the two studs if applicable.

(3) Loosely fit the two bottom fixing set screws or nuts to the gear cover, complete with a new tab washer and spacers.

(4) With the tank clear of the mounting studs connect the tank-to-injection pump pipe to the tank. Do not strain or distort the pipe.

(5) On a 9 pint tanks only fit the top spacer in position as shown in Figure 3.1.

(6) Fit the top fuel tank lug over the cylinder head stud at the same time locating the bottom fuel tank lugs over the two set screws or studs. On 9 pint tanks only ensure that the bottom spacers are behind the fuel tank lugs as shown in Figure 3.1. Check that the tank is squarely in position.

(7) Tighten the bottom set screws checking that the tank top mounting bracket does not spring upwards. If it does remove the tank and carefully bend the top bracket downwards sufficiently to eliminate any pre-stressing.

(8) When the bottom mounting is fully secured the top mounting bracket should be square on the cylinder cowling or spacer (where applicable). Tighten the top self-locking nut and bend the tabs to lock the bottom set screws or nuts (where applicable).

(9) Fill with the correct grade of fuel.

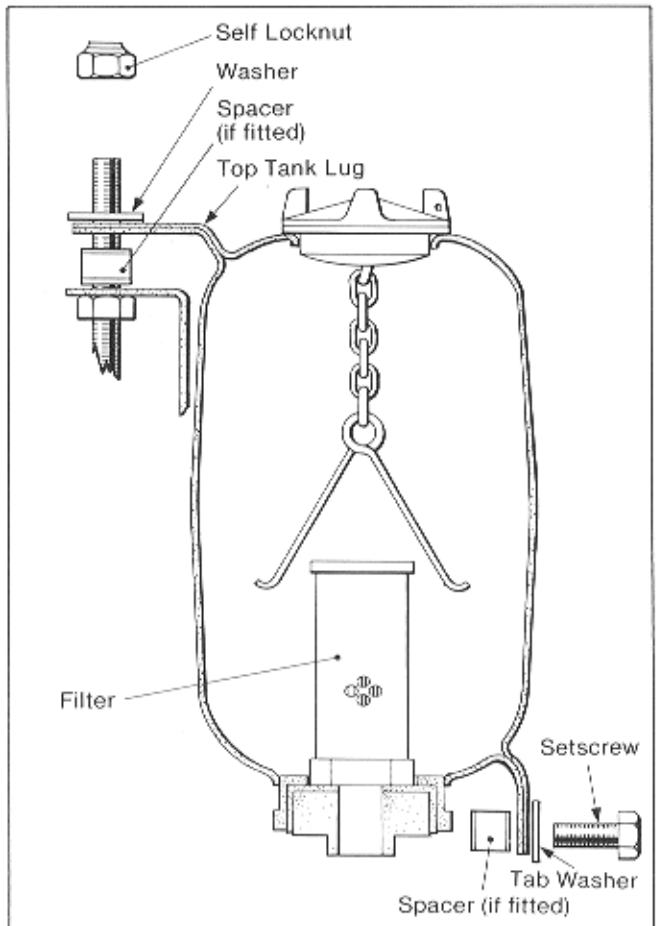



*Figure 3.1. Steel Fuel Tank Single Cylinder: Installation.*

## Steel Tank (AC2 Engines)

### Removal

**3.11** To remove and drain the fuel tank proceed as follows:

(1) Disconnect the tank to injection pump pipe at the tank and drain the fuel.

(2) Disconnect the leak-off pipe.

(3) Slacken the two strap set screws sufficiently to allow strap removal and lift the tank off. Retain the packing and spacers.

(4) To remove the mounting bracket (if required) unscrew the two 5/16 in. UNF screws and washers securing the top of the mounting bracket.

(5) Unlock the tabwasher on the bottom 1/4 in. UNC set screws and slacken the screws sufficiently to lift the bracket clear.

### Maintenance

**3.12** Check the tank for damage and remove any sediment, if necessary change the filter element. Check the spacer and strap packings for deterioration, renew if necessary.

### Replacement

**3.13** To replace the fuel tank and mounting bracket proceed as follows:

(1) Loosely fit the two bottom fixing 1/4 in. UNC set screws, complete with a new tabwasher.

(2) Locate the lugs on the bottom of the mounting bracket on the screws and fit the two top 5/16 in. UNF screws. Gradually tighten the securing screws. Bend the tabs to lock the bottom set screws.

(3) Locate the tank in the mounting ensuring that the spacer is in position.

(4) Fit the fuel tank straps in position complete with packing.

(5) Tighten the two strap set screws.

(6) Connect the fuel pipes and fill the tank with the correct grade of fuel.

## H.D.P. Tank (5.1 Litres)

### Removal

**3.14** To remove the fuel tank proceed as follows:

(1) Drain the tank by disconnecting the fuel pipe.

(2) Unlock the tab washers from the two bottom set screws securing the bottom bracket of the fuel tank. Remove set screws.

(3) Remove the cowling nut and washer from the long cylinder stud.

(4) Remove the fuel tank and brackets. Retain the spacer.

### Maintenance

**3.15** Check the tank for damage and remove any sediment, if necessary change the filter element.

### Replacement (Figure 3.2)

**3.16** The mounting brackets are not normally removed from the tank, but if removed they must be fitted as follows:

(1) Position the collars in each slot of the top bracket and secure the bracket to the tank using the two washers and setscrews. Torque load the setscrews to 11Nm (8lbf ft.). Note with the setscrews fully torqued there is sufficient movement of the bracket for positioning the tank assembly when fitting it to the engine.

(2) Fit the pressure plate, bottom bracket, setscrews and nuts to the lower mounting flange of the tank. Torque load the setscrews and nuts to 11Nm (8lbf ft).

**3.17** To fit the tank assembly to the engine proceed as follows:

(1) Fit the spacer on the cylinder head stud. (Figure 3.3)

(2) Locate the top bracket of the fuel tank over the cylinder head stud.

(3) Fit the bottom bracket retaining setscrews complete with a new tabwasher. Tighten the setscrews and bend the tabwasher to lock in position.

(4) Fit the top bracket self-locking nut and plain washer.

(5) Connect the fuel pipes and fill the tank with the correct grade of fuel.

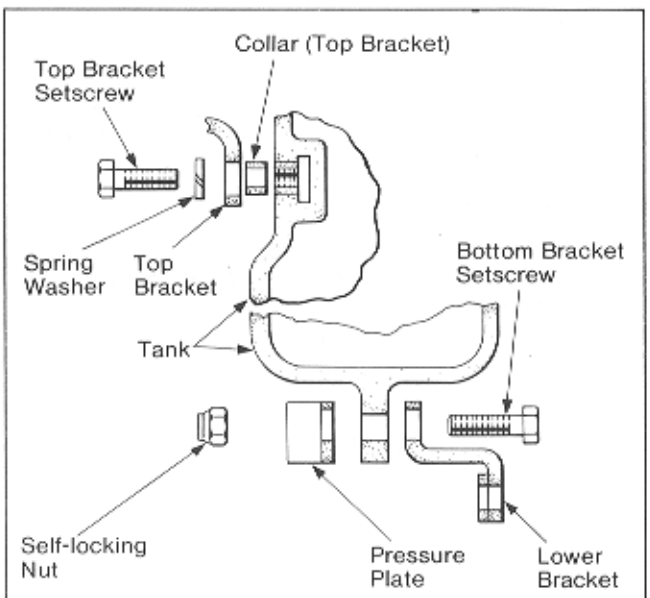



*Figure 3.2 H.D.P. Fuel Tank Single Cylinder Mounting Brackets Installation*

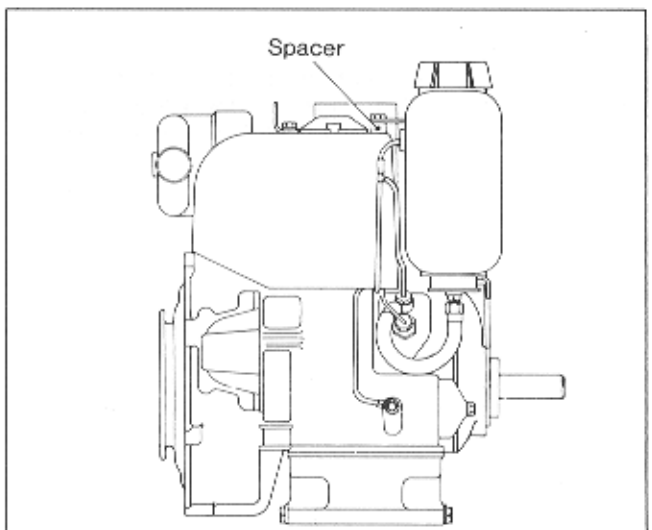



*Figure 3.3 H.D.P. Fuel Tank Single Cylinder Location of Spacer*

## FILTER-FUEL TANK

### Removal

#### Early Type

**3.18** To remove the early type fuel filter element proceed as follows:

(1) Drain the fuel tank by disconnecting the tank-to-pump flexible pipe at the tank

(2) Remove the fuel tank filler cap.

(3) Remove the element retainer and element assembly from the tank.

#### Late Type

**3.19** To remove the late type fuel filter element proceed as follows:

(1) Drain the fuel tank by disconnecting the tank-to-pump flexible pipe at the tank.

(2) Unscrew the fuel filter plug at the base of the tank.

(3) Unscrew the filter element from the plug and remove the washer.

### Maintenance

**3.20** If the element shows a large deposit of sediment, remove the tank and clean using kerosene or fuel. Do not attempt to clean the element but fit a new one, obtainable from Petters Limited or their representatives.

### Replacement

#### Early Type

**3.21** To fit the early type fuel filter element proceed as follows:

(1) Locate the element in the element retainer.

(2) Fit the element retainer assembly into the fuel tank.

(3) Connect the fuel pipes.

(4) Fill the tank with the approved grade of fuel.

#### Late Type

**3.22** To fit the late type fuel filter element proceed as follows:

(1) Fit the element complete with a new sealing washer to the plug.

(2) Screw the plug assembly into the base of the tank. On H.D.P. tanks torque load to 11 Nm (8lbf ft).

**CAUTION**
**Some plug assemblies have a fine thread and care must be taken to avoid cross-threading when fitting this type of assembly into the base of the tank.**

(3) Connect the tank-to-pump flexible fuel pipe.

(4) Fill the tank with the approved grade of fuel.

## FILTER-SEPARATELY MOUNTED

**3.23** The separately mounted fuel filter assembly consists of a detachable bowl, containing the filter element, which is secured by a centre bolt to a filter head. The filter head has two screws to allow the fuel system to be bled free of air. The filter assembly is mounted on a bracket.

### To Clean Fuel Filter (Figure 3.4)

**3.24** To clean the fuel filter proceed as follows:

(1) Isolate the fuel supply.

(2) Unscrew the bolt **(1)** at the centre of the filter bowl and withdraw the bowl complete with the element.

(3) Clean out the bowl **(2)**.

(4) Visually check the element for sediment. If the element is contaminated it must be renewed.

**CAUTION**
**Do not attempt to clean the element.**

### Assembly (Figure 3.4)

**3.25** To assemble the fuel filter proceed as follows:

(1) If the same element is being re-used check that the seals **(3)**, **(4)**, **(5)** and **(8)** are in good condition. If damaged in any way renew. If an element is being renewed the bowl seal **(3)** and the element joint washer **(4)** supplied with a new element must be fitted.

**CAUTION**
**When assembling the filter the internal components must be fitted as shown in Figure 3.4. If assembled incorrectly fuel will bypass the filter element and be fed directly to the fuel injection pump and injector, possibly damaging these components.**

(2) Fit the centre bolt lower seal **(5)** to the centre bolt and push down to fit at the head of the bolt.

(3) Place the centre bolt through the hole in the filter bowl.

(4) Fit the spring **(6)** followed by the plain washer **(7)** and the upper seal **(8)** on the centre bolt inside the filter bowl.

(5) Fit the element in the bowl locating it on upper seal **(8)**.

(6) Fit the element joint washer **(4)** and the filter bowl seal **(3)** in the head.

(7) Locate the filter bowl assembly squarely on the sealing ring **(3)** and tighten the centre bolt just sufficiently to prevent leaks.

**CAUTION**
**After changing or inspecting the filter element it is advisable to check for leaks on initial start up.**

(8) Bleed the fuel system of air as detailed in Section 1.

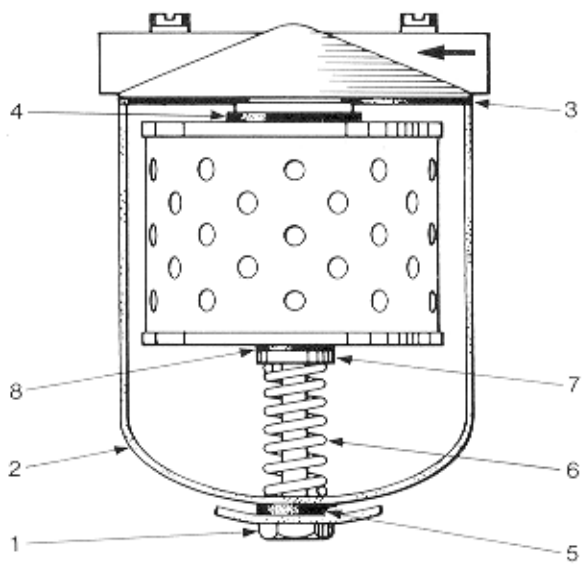



*Figure 3.4*
*Fuel Filter Assembly Separately Mounted*

## FUEL INJECTION PUMP

**3.26** The fuel injection pump is mounted on the right-hand side of the crankcase near the gear cover, when viewed from the flywheel end of the engine and is operated directly from the camshaft.

**3.27** The fuel injection pump fitted to AC2 engines has two pumping elements housed in a single body; each element is operated by an associated cam on the camshaft. The types of pumps fitted are given in Table 3.1.

### Removal (Figure 3.5)

**3.28** To remove the fuel injection pump proceed as follows:

(1) Isolate the fuel supply and remove the fuel tank, if fitted.

(2) Remove the air cowling.

(3) Disconnect and remove the fuel pipes. It is advisable to fit blanking caps on all pipes and connectors to prevent the ingress of dirt.

(4) Remove the oil supply pipe to the rockers.

(5) Set the engine to TDC on the exhaust stroke (No. 1 cylinder on AC2 engines).

(6) Remove the three 5/16 in. UNF nuts and spring washers retaining the fuel pump (four on AC2 engines).

(7) Align the fuel pump rack ball with the cut-away in the crankcase by positioning the STOP/RUN lever approximately 10° before the vertical position.

(8) Remove the fuel injection pump and retain the timing shims. Do not force the pump from the crankcase, if difficulty is experienced when withdrawing the pump, remove the gear cover and visually position the rack ball to clear the crankcase cut-away.

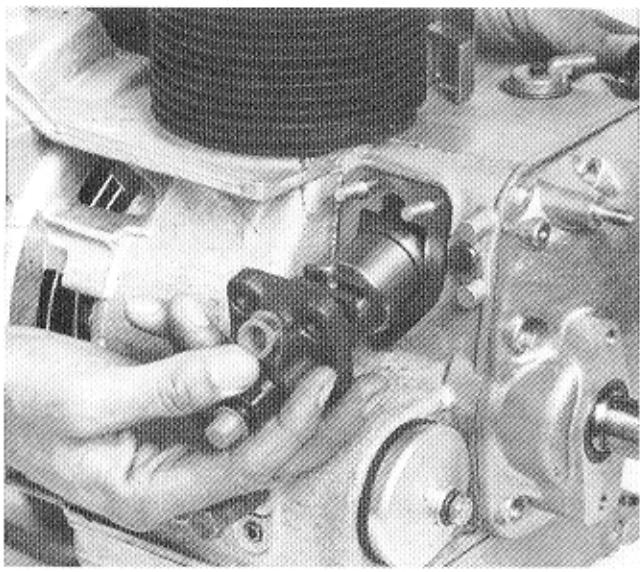


*Figure 3.5 Fuel Injector Pump Removal*

### Dismantling (Figure 3.6)

**CAUTION**

**(1) If adequate workshop facilities or skills are not available it is advisable not to attempt to service a faulty pump, it is recommended that a replacement pump is fitted.**

**(2) Fuel injection pumps are subject to special calibration by the manufacturers and only the delivery side of the pump may be dismantled.**

**3.29** To dismantle the delivery side of a fuel injection pump proceed as follows:

(1) Ensure that the work area is clean.

(2) Clean the exterior of the pump.

(3) Unscrew the union body **(1)** and lift out the spring peg **(2)** (excluding early type 'B' series), spring **(3)** 'O' ring seal **(4)**, high pressure seal **(5)** and delivery valve assembly **(6)** and **(7)**.

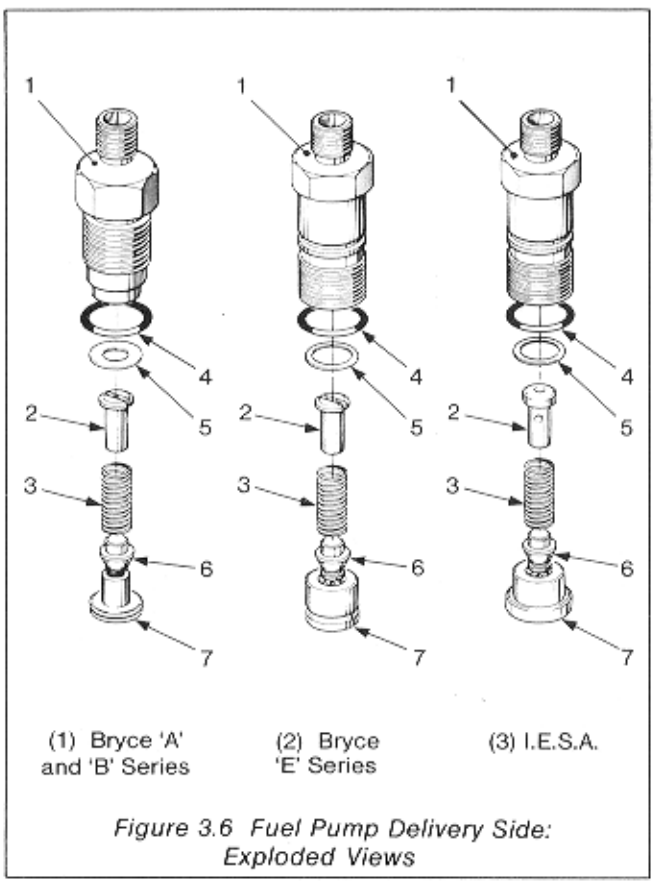



*Figure 3.6 Fuel Pump Delivery Side: Exploded Views*

### Maintenance

**3.30** Carry out the following procedure:

(1) Ensure that the valve is free in its seat.

(2) Check the valve and seat for damage and renew if faulty.

(3) Check the 'O' ring and high pressure seals for damage and renew if necessary.

### Assembly (Figure 3.6)

**3.31** Before assembly ensure that all component parts are clean and wetted with clean fuel. To assemble the delivery side of a fuel injection pump proceed as follows:

(1) Fit the delivery valve assembly **(6)**, **(7)** and seal **(5)**.

(2) Fit the spring **(3)** and spring peg **(2)**, (if applicable).

(3) Locate the 'O' ring seal **(4)** into its correct position.

(4) Screw the union body **(1)** into the pump body and torque load to 41 Nm (30lbf ft.)

**Note**

*If the pump requires timing just screw the union body in finger-tight.*

(5) Fuel pumps not required for immediate use must be sealed to prevent ingress of dirt and moisture.

### Replacement

**3.32** To replace the fuel injection pump proceed as follows:

(1) Set the engine to TDC on the exhaust stroke (No 1 cylinder on AC2 engines).

(2) Position the fuel pump operating lever forked end in line with the cut-away in the crankcase. This can be achieved by moving the stop/run lever approximately 10° before the vertical position.

(3) Fit the fuel pump timing shims retained in Paragraph 3.28.

(4) Fit the fuel pump, making sure that the fuel pump rack ball has engaged correctly with the operating lever fork.

(5) Tighten the three 5/16in. UNF nuts (four on AC2 engines) to a torque load of 18Nm (13lbf ft.).

(6) Remove the blanking caps from the pipe ends and connectors. Connect the fuel pipes and the self-bleed pipe where applicable. Fit the oil supply pipe to the rockers.

(7) Time the fuel injection pump as detailed in Paragraph 3.33.

(8) Fit the air cowling.

(9) Fit the fuel tank.

## FUEL INJECTION PUMP TIMING

### AA1 and AB1 Engines (Figure 3.6)

**3.33** On fixed speed and two speed engines running at speeds above 3000 r/min and on all variable speed engines, move the STOP/RUN lever towards the STOP position, that is vertical, and fix it at approximately 10° before the vertical position. On variable speed engines move the speed control to the full speed position. Do not operate the overload stop lever.

**3.34** On fixed speed and two speed engines running at 3000 r/min and below, move the STOP/RUN lever to the RUN position that is horizontal. Carry out the following procedure.

(1) Isolate the fuel supply and remove the pump-to-injector fuel pipe.

(2) Unscrew the delivery union body **(1)** and remove, ensure that the 'O' ring seal **(4)** is also withdrawn.

(3) Lift out the spring peg **(2)** (excluding early type 'B' series), and spring **(3)**.

(4) Carefully lift out the delivery valve **(6)** do not disturb the seat **(7)** or seal **(5)**. Place the spring peg, spring and delivery valve in a container of clean fuel.

(5) Locate the 'O' ring seal **(4)** on the lower diameter of the Bryce 'A' and 'B' series union body and ensure that the 'O' ring seal is in position on the union body of the Bryce 'E' and IESA pumps. Screw the union body into the pump.

(6) Fit a suitable spill pipe (as shown in Figure 3.7).

(7) Turn the engine flywheel until the engine is a quarter of a turn before TDC with the piston on compression stroke.

(8) Connect the fuel supply and bleed the separately mounted fuel filter (if fitted). Fuel should flow from the spill pipe.

**Note**
*If a fuel lift pump is fitted fuel will not flow unless the hand priming lever is operated.*

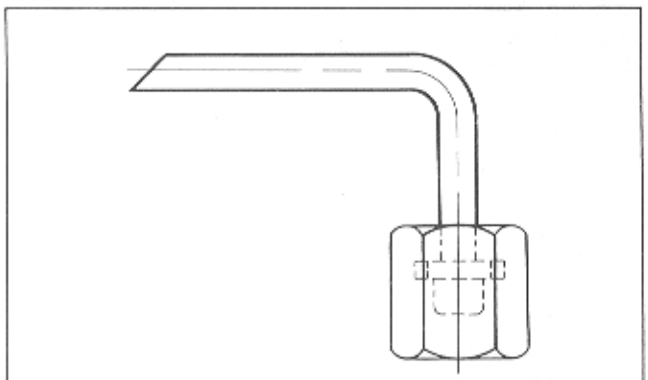


*Figure 3.7 Typical Spill Pipe*

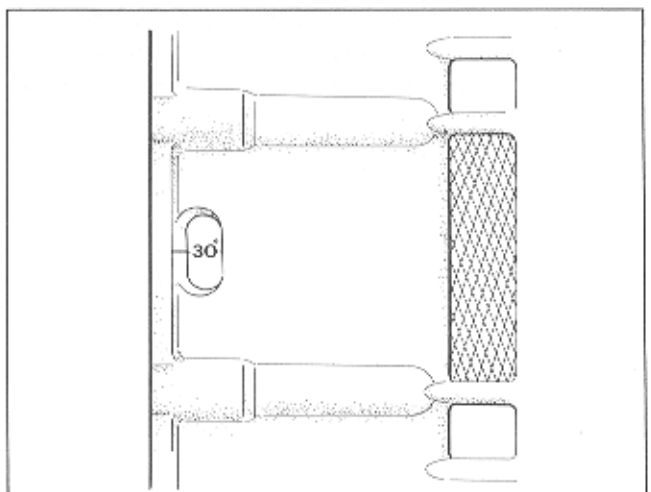



*Figure 3.8 Flywheel Timing Marks*

(9) Turn the flywheel slowly by hand in the direction of rotation until the fuel flow from the spill pipe stops. This position is known as the spill point. To ensure that the position noted is correct it is advisable to repeat the operation a number of times.

(10) Read off the angle through the timing hole in the bell housing (Figure 3.8). Check with the figures detailed in Table 3.4. If the angle is too large, shims must be added between the pump and the crankcase, if too small, shims must be removed. To calculate the thickness of shims required 1 degree is equal to 0.1mm (0.004in.).

(11) When the correct timing angle has been obtained remove the spill pipe, unscrew and remove the union body **(1)** with the 'O' ring seal **(4)**.

(12) Replace the delivery valve **(6)**, spring **(3)** and spring peg **(2)** if fitted.

(13) Locate the 'O' ring seal **(4)** on the lower diameter of the Bryce 'A' and 'B' series union body and ensure that the 'O' ring seal is in position on the union body of the Bryce 'E' and IESA pumps. Screw the union body into the pump and torque load to 41Nm (30lbf ft.).

(14) Connect the fuel pipes.

(15) Fill the fuel tank with the approved fuel and bleed the fuel system where applicable as detailed in Section 1.

TABLE 3.4 FUEL INJECTION TIMING (BY SPILL) AA1 AND AB1 ENGINES

| Engine | Speed | r/min | Flywheel Setting Angle BTDC |
|---|---|---|---|
| AA1 | Fixed Speed and Two Speed | Up to 2200 | 24° |
| AA1 | Fixed Speed and Two Speed | 2201 to 3000 | 27° |
| AA1 | Fixed Speed and Two Speed | 3001 to 3300 | 27° |
| AA1 | Fixed Speed and Two Speed | 3301 to 3600 | 33° |
| AA1 | All Variable Speeds | — | 33° |
| AB1 | Fixed Speed and Two Speed | Up to 2200 | 23° |
| AB1 | Fixed Speed and Two Speed | 2201 to 2700 | 26° |
| AB1 | Fixed Speed and Two Speed | 2701 to 3000 | 30° |
| AB1 | Fixed Speed and Two Speed | 3001 to 3600 | 30° |
| AB1 | All Variable Speeds | — | 30° |

TABLE 3.5 FUEL INJECTION (BY SPILL) AC1, AC1Z AND AC1ZS ENGINES

| Engine | Speed | r/min | Flywheel Setting Angle BTDC |
|---|---|---|---|
| AC1 | Fixed Speed and Two Speeds | Up to 2200 | 26° |
| AC1 | Fixed Speed and Two Speeds | 2201 to 2800 | 28° |
| AC1 | Fixed Speed and Two Speeds | 2801 to 3300 | 30° |
| AC1 | Fixed Speed and Two Speeds | 3301 to 3600 | 33° |
| AC1 | All Variable Speeds | | 30° |
| AC1Z | All Speeds, Fixed or Variable | — | 32° (up to Engine No 14649) |
| AC1Z | All Speeds, Fixed or Variable | — | 30° (Engine No 14650 onwards) |
| AC1ZS | All Speeds, Fixed or Variable | 1000 to 1250 | 20° |
| AC1ZS | All Speeds, Fixed or Variable | 1251 to 1800 | 25° |

## AC1, AC1Z and AC1ZS Engines

**3.35** Move the STOP/RUN lever to the RUN position, that is horizontal. On variable speed engines move the speed control to the full speed position, do not operate the overload stop lever, if fitted.

**3.36** Carry out the procedure detailed in Paragraph 3.33 using Table 3.5. On AC1Z and AC1ZS engines the timing marks are located on the outer edge of the flywheel with a pointer on the flywheel cowling.

## AC2 Engines

**3.37** Move the STOP/RUN lever midway between the STOP and RUN position. On variable speed engines move the speed control to the full speed position. Do not operate the overload stop lever. Number 1 cylinder (gear end), which is used when timing the injection pump, is fed from the gear end side of the pump. Ensure that the flywheel marks refer to No 1 cylinder. Carry out the procedure detailed in Paragraph 3.34 using Table 3.6, removing the delivery valve from the gear end side of the pump.

TABLE 3.6
FUEL INJECTION TIMING (BY SPILL) AC2 ENGINES

| Speed | r/min | Flywheel Setting Angle No 1 Cylinder BTDC |
|---|---|---|
| All Fixed Speeds | 2201 to 2800 | 30° |
| | 2801 to 3200 | 32° |
| | 3201 to 3600 | 34° |
| All Variable Speeds | — | 32° |

## FUEL INJECTOR

**3.38** The fuel injector is located in the cylinder head and comprises two main assemblies: a nozzle holder and nozzle. Fuel is pumped under pressure through the fuel inlet and down the nozzle holder body to the nozzle. The fuel pressure lifts the

needle valve and fuel is sprayed out of the hole in the nozzle. The opening pressure of the needle valve is controlled by the injector spring. The spring pressure is set by an adjusting screw. The fuel injector provides a fine mist spray of fuel to the cylinder.

### Removal

**3.39** To remove the fuel injector proceed as follows:

(1) Remove the air cleaner assembly, cylinder cowling and engine mounted fuel tank, if applicable.

(2) Disconnect at the injector the fuel pipe from the pump and the injector leak-off pipe.

(3) Remove the two 5/16 in. UNF nuts and spring washers securing the injector flange.

(4) Carefully ease out the injector from the cylinder head.

(5) Remove the fuel injector sealing washer.

### Testing (Without a Test Rig).

**3.40** To test the fuel injector without a test rig proceed as follows:

(1) Connect the injector to the pump-to-injector fuel pipe in such a manner that the injector nozzle points away from the engine. (Figure 3.9).

**WARNING**
**WHEN TESTING ENSURE THAT THE SPRAY IS NOT DIRECTED AT ANY EXPOSED PART OF THE BODY. THE SPRAY WILL PENETRATE THE SKIN.**

(2) With the STOP/RUN lever in the RUN position, turn the engine over in the direction of rotation. The fuel should squirt out suddenly in a fine mist spray and should then stop just as suddenly. If the nozzle fails to spray or give a solid squirt of fuel, or dribbles after the spray has stopped fit a new nozzle.

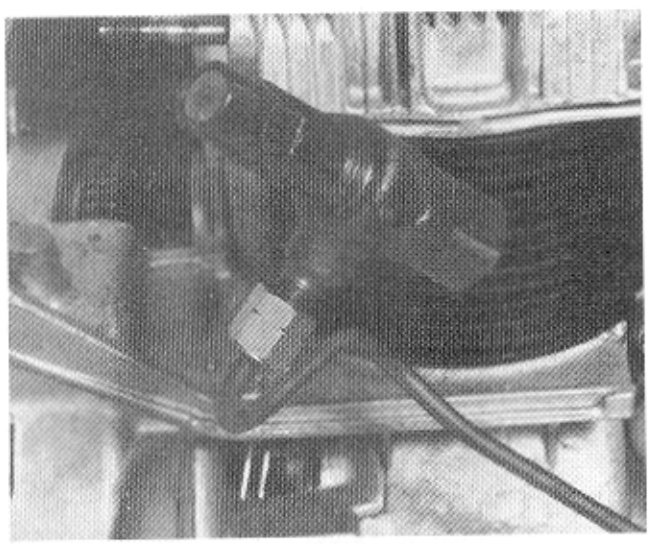


*Figure 3.9 Testing the Fuel Injector Without a Test Rig.*

### Dismantling (Figure 3.10)

**CAUTION**
**If adequate workshop facilities or skills are not available it is advisable not to attempt to service a faulty fuel injector, it is recommended that a replacement fuel injector is fitted.**

**3.41** Before dismantling clean the injector and remove carbon deposits from the nozzle taking care not to damage the nozzle tip or end face.

**3.42** Carry out the following procedure:

(1) Remove the cap nut **(1)** and adjusting screw **(2)**.

(2) Remove the spring pad **(3)**, the spring **(4)** and the spring pressure rod **(5)**.

(3) Unscrew the nozzle nut **(6)** and remove the nozzle assembly **(7)** taking care to avoid dropping the needle **(8)**. It may be necessary to push the nozzle out of the nut by means of a copper or brass tubular drift. The nozzle must not be driven out by striking the nozzle end face or tip.

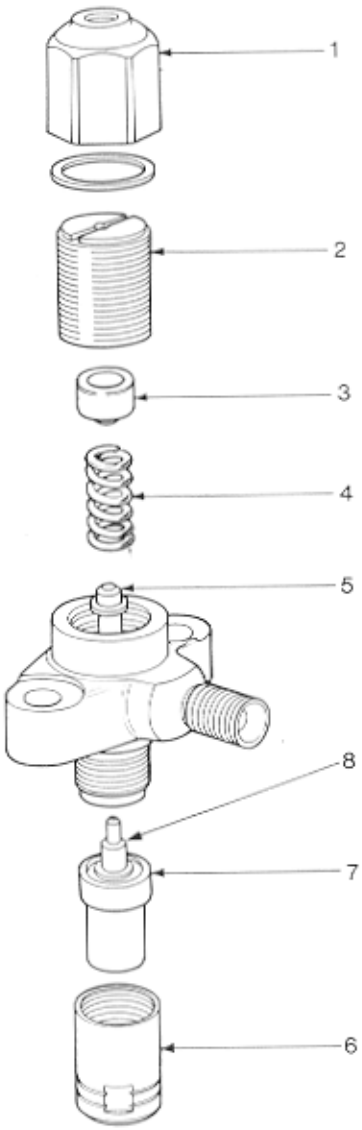



*Figure 3.10 Fuel Injector: Exploded View*

### Maintenance (Figure 3.11)

**3.43** The sealing faces between the nozzle holder and nozzle body must be clean, flat and smooth.

**3.44** Immerse the nozzle body and needle in clean fuel oil. The needle should be lightly brushed with a brass wire brush. Note that the nozzle bodies and needles are mated pairs and must not be interchanged. (It is advisable to deal with one injector at a time). Check that the guide surface of the needle is clean with an even, mirror-like finish. There should be no scratched or dull patches, very bright spots or any discolouration on or above the needle seat.

**3.45** Inspect the nozzle joint face for scratches or damage. Clean the fuel feed hole **(1)** by pushing a suitable probe **(2)** (wire or twist drill) down into the fuel chamber **(3)**. Take care not to damage the joint face. Using a special fuel chamber scraper **(4)** clean the deposits from the fuel chamber. Clean, using a seat cleaning tool, the nozzle body seat making sure that all traces of foreign matter have been removed.

**3.46** Clean the nozzle spray hole using a spray hole cleaner **(5)**.

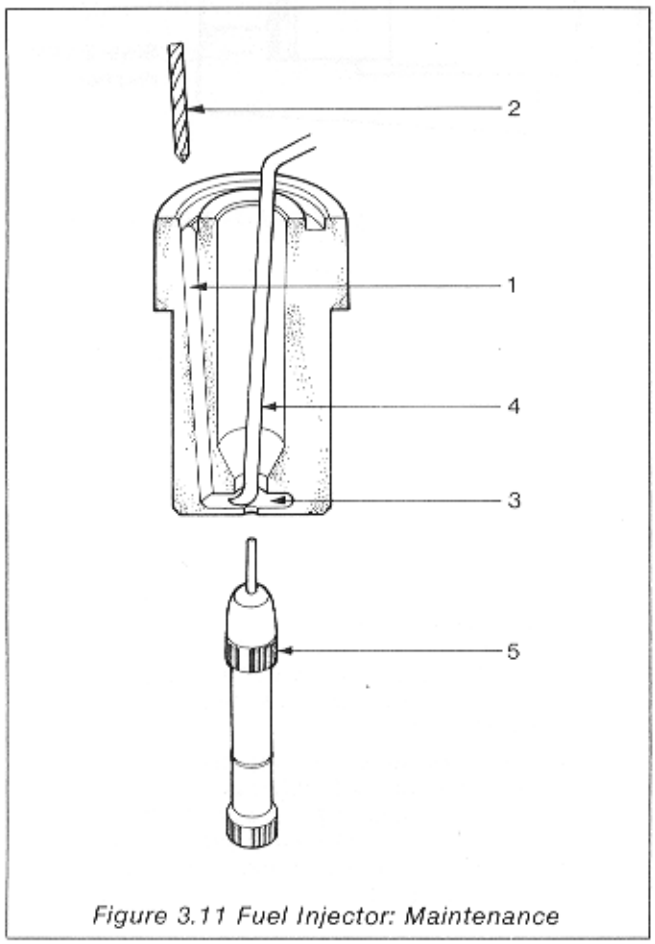



*Figure 3.11 Fuel Injector: Maintenance*

## Assembly (Figure 3.10)

**3.47** Carry out the following procedure washing all component parts in clean fuel oil as they are assembled.

(1) Fit the needle **(8)** into the nozzle.

(2) Fit the nozzle assembly **(7)** to the nozzle holder **(6)**, holding it hard against the pressure face and tighten the nozzle nut.

(3) Replace the spindle assembly and spring.

(4) Replace the adjusting screw.

(5) Set the fuel injection release pressure as detailed in Paragraph 3.48.

## Testing and Setting up (Using a Test Rig)

**3.48** Using the test rig (Figure 3.12) test and set up the fuel injector as follows:

(1) Connect the assembled injector to the test rig by a length of high pressure pipe.

(2) Fill the test rig oil reservoir with test oil (Shell Calibration Fluid C or B).

**WARNING**
**TAKE CARE TO DIRECT THE INJECTOR NOZZLE AWAY FROM THE BODY AS THE SPRAY CAN PENETRATE THE SKIN.**

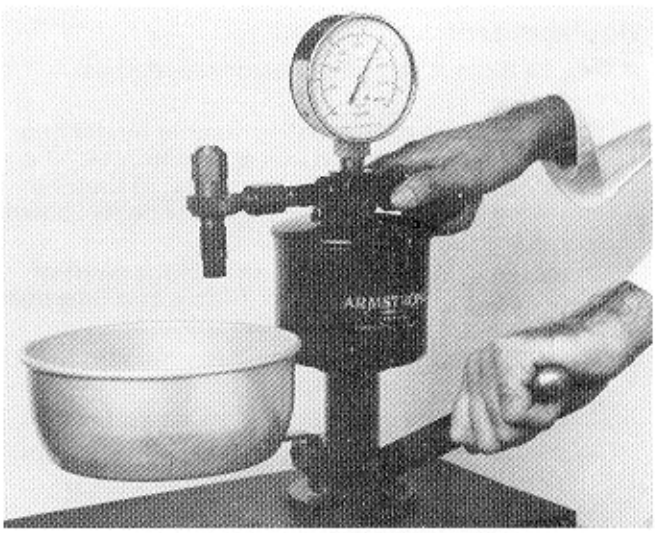


*Figure 3.12 Testing the Fuel Injector using a Test Rig*

### Seat Leakage

**3.49** Carry out the following procedure:

(1) Operate the test-rig pump until oil is discharged from the injector.

(2) Open the test-rig gauge cock. Continue pumping and adjust the nozzle opening pressure as detailed in Table 3.7. Turn the adjusting screw in (clockwise) to increase pressure and out (counter-clockwise) to decrease the pressure. Discharge the nozzle and wipe dry.

(3) Raise the pressure to approximately 10 bar (150 lbf/in$^2$) below opening pressure, and maintain this pressure for 10 seconds.

(4) After this period check that the leakage on the nozzle body is insufficient to form a continuous film on the finger tip.

*TABLE 3.7*
*FUEL INJECTOR PRESSURE SETTING*

| *Engine r/min* | *Pressure* |
|---|---|
| All speeds | **162 to 183 bar (2350 to 2650 lbf/in$^2$** |

### Chatter Test

**3.50** At the nozzle opening pressure, and with the gauge cock closed operate the pump lever at approximately six strokes every ten seconds. Under these conditions the nozzle should discharge with a sharp and crisp chattering action.

### Spray Form

**3.51** Check that the spray from the nozzle hole is atomized, of regular form and free from ragged edges.

### Back Leakage

**3.52** Set the nozzle opening pressure to 162 to 172 bar (2350 to 2500 lbf/in$^2$). Raise the pump pressure to 152 bar (2200 lbf/in$^2$). Measure the time taken for the pressure to drop to 101 bar (1470 lbf/in$^2$) this must exceed six seconds.

**3.53** Set the correct nozzle opening pressure as detailed in Table 3.7. Replace and tighten the cap nut. Operate the hand pump a few times with the gauge cock closed to ensure that all components have settled and then, recheck the pressure.

**Note**
*Injectors not required for immediate use must be sealed to prevent ingress of dirt and moisture.*

### Replacement

**3.54** To replace the fuel injector proceed as follows:

(1) Fit a new injector sealing washer as defined in Table 3.8 and Figures 3.13 and 3.14. If a steel shield washer is fitted ensure that the dimple (apex) is towards the nozzle as shown.

**CAUTION**
**Extreme care must be taken in replacement of the fuel injector, as incorrect fitting can damage the connecting pipe and/or the injector.**

(2) Fit the injector and sealing washer into the cylinder head.

(3) Fit the spring washers and securing nuts.

(4) Fit the pump-to-injector fuel pipe and tighten the union nuts finger-tight.

(5) Tighten the union nuts a further third of a turn with a spanner.

(6) Tighten the injector flange nuts evenly, to a torque of 18Nm (13 lbf ft).

(7) Connect the leak-off pipe.

(8) Refit cylinder cowling air filter assembly and engine mounted fuel tank, if applicable.

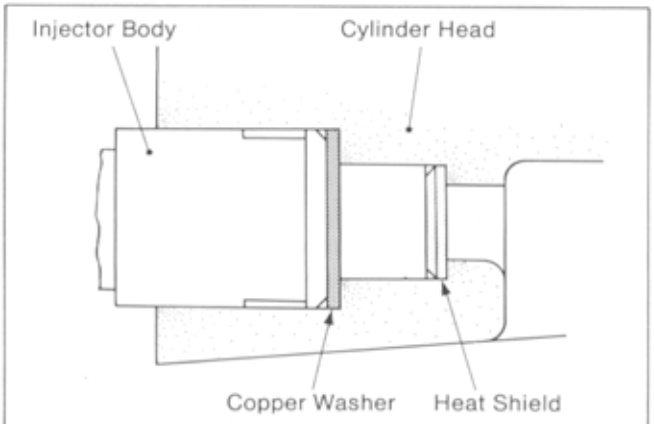



*Figure 3.13*
*Fitting a Copper Washer and Heatshield*

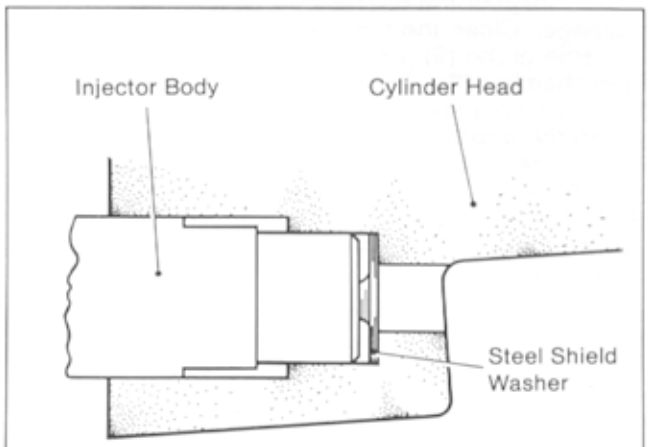



*Figure 3.14 Fitting a Steel Dimpled Washer*

## HIGH PRESSURE FUEL PIPES

**3.55** High pressure fuel pipes must be correctly clamped to avoid pipe failure through excessive vibration. It is therefore essential that pipe clamps are properly installed and maintained as follows:

(1) The pipe(s) must be firmly gripped by the clip. On AC2 engines the gear end high pressure pipe (No. 1 cylinder) damper block must be firmly held against the crankcase.

(2) The clip or blocks must be replaced if the material shows any signs of deterioration. The olive ends of the high pressure pipes should be checked before fitting to see that each end has not been deformed by overtightening. Restriction can cause excessive pumping pressure and abnormal leakage.

(3) Do not overtighten proprietary compression type fittings as high spanner torques are not required to make a satisfactory joint. The use of unnecessary force can damage the pipe end or the threaded connection on the pipe, injector or pump.

*TABLE 3.8 INJECTOR SEALING WASHERS*

| *Engine* | *Engine Serial No* | | *Sealing Washer* |
|---|---|---|---|
| | *From* | *To* | |
| AA1 | **Initial** | **93723** | Copper* |
| | **93724** | **Current** | Steel Dimpled |
| | | | **Note** *A copper washer is used in place of the steel dimpled washer on special build AA1 engines from after serial No 93724 which run at 1500 r/min and below on light load applications.* |
| AB1 | **Initial** | **29188** | Copper* |
| | **29189** | **Current** | Steel Dimpled |
| AC1 | **Initial** | **3866** | Copper with heatshield |
| | **3867** | **Current** | Steel Dimpled |
| AC1Z | **Initial** | **149** | Copper* |
| | **150** | **Current** | Steel Dimpled |
| AC1ZS | **Initial** | **631** | Steel Dimpled |
| | **632** | **Current** | Copper* |
| AC2 | **Initial** | **Current** | Steel Dimpled |
| | | | **Note** *Washers marked with an asterisk* are not interchangeable.* |

(4) The high pressure pipe must be pre-formed to the correct shape before fitting. In particular the pipe ends must align with the pump and injector fittings, without strain.

(5) Reference should be made to Table 3.3 for the size of high pressure pipes as applicable to engine type.

## SPEED CONTROL ADJUSTMENT

### Speed Control

**3.56** The centrifugal forces on the governor balls are transmitted to the fuel pump rack. These forces, which vary with the speed of the engine are balanced by an adjustable speeder spring. This adjustment allows a set range of speed. To adjust the engine speed outside this range a different fuel pump and spring may be required and these are obtainable from Petters Limited or their representatives. However, if the setting is disturbed, or a different speed is required within the set range adjustments can be carried out as detailed in the following paragraphs.

### Fixed Speed (Figure 3.15)

**3.57** To set the fixed speed control proceed as follows:

(1) Slacken the locknut **(1)** on the dipstick side of the engine and screw in the adjuster **(2)** to increase the speed or out to decrease it.

(2) Tighten the locknut. The engine speed should be set at 4% above the rated speed as shown on the engine nameplate when running off load.

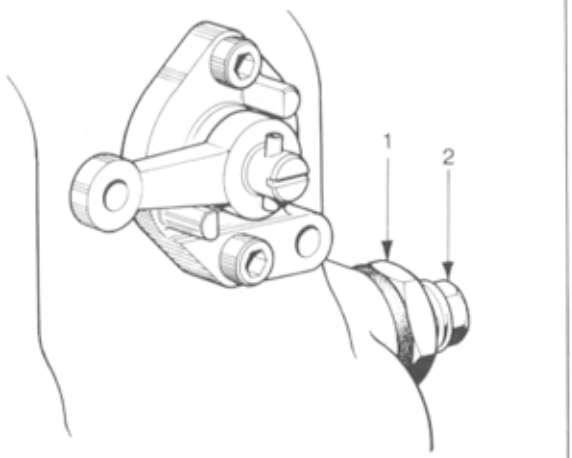



*Figure 3.15 Fixed Speed Control: Adjustment*

### Variable Speed Control (Type 1) (Figure 3.16)

**3.58** To set the variable speed control proceed as follows:

(1) Set the speed control to the idling position.

(2) Slacket the locknut **(1)** and adjust the idling speed to approximately 1200 r/min by screwing in adjuster **(2)** to increase speed or out to decrease it.

(3) Tighten the lock nut **(1)**.

(4) Set the speed control to the full speed position.

(5) Slacket the locknut **(3)** and adjust the full speed to 8% above the rated speed, as shown on the engine nameplate when running without load, by screwing the adjusting screw **(4)** in (clockwise) to increase speed or out (counter-clockwise) to decrease it.

(6) Fit new lead seal and locking wire.

(7) To adjust the control cable, push the control rod **(5)** firmly in the direction of the arrow as shown. Screw in the cable adjuster **(6)** until there is a small amount of slack in the inner cable, that is the speed control lever can just be moved before the inner cable starts to move the speed control.

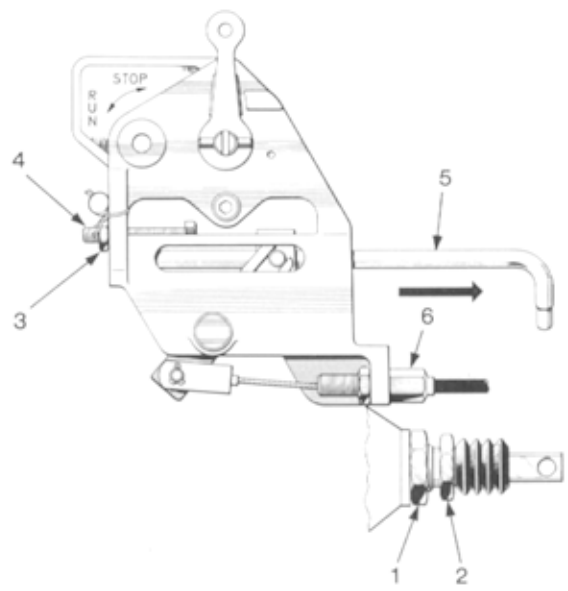



*Figure 3.16 Variable Speed Control (Type 1): Adjustment*

### Variable Speed Control (Type 2) (Figure 3.17)

**3.59** To set the variable and two speed control type 1 proceed as follows:

(1) Set the speed control in the idling position, that is with the plunger **(1)** fully in the direction of the arrow.

(2) Slacken the locknut **(2)** and adjust the idling speed to approximately 1200 r/min by screwing in the adjuster **(3)** to increase the speed or out to decrease it. Tighten the locknut.

(3) Set the speed control in the full speed position or RUN position on a two-speed control.

(4) Loosen the locknut **(4)** and adjust to full speed or speed required by screwing the adjusting screw **(5)** out (counter-clockwise) to increase the speed or in (clockwise) to decrease it. The speed should be set at 8% above the rated speed as shown on the engine nameplate when running off load. Tighten the locknut and fit a new seal and locking wire.

(5) Recheck the idling speed and adjust, if necessary.

(6) To adjust the control cable, set the speed control in the idling position. Screw in the cable adjuster **(6)** until there is a small amount of slack in the inner cable, that is the control lever can just be moved before the inner cable begins to move the plunger.

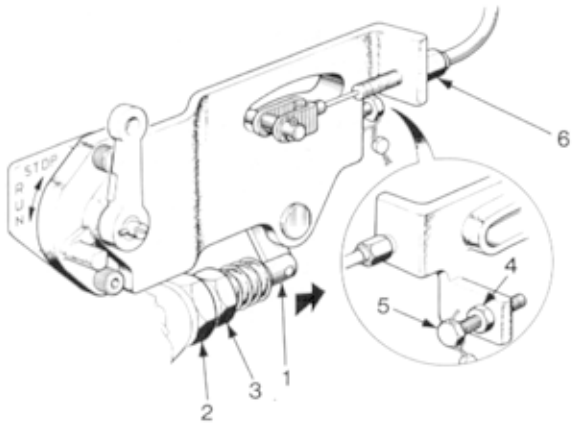



*Figure 3.17 Variable Speed Control (Type 2): Adjustment*

## Two Speed Control (Figure 3.18)

**3.60** To set the two speed control proceed as follows:

(1) Set the control arm **(1)** to the idle position as shown.

(2) Slacken the locknut **(2)** and adjust the idling speed to approximately 1200 r/min by screwing in the adjuster **(3)** to increase the speed or out to decrease it. Tighten the locknut.

(3) Slacken locknut **(4)** and unscrew the setscrew **(5)** sufficiently to allow full movement of the control arm **(1)**.

(4) Lift the control arm **(1)** upwards and over the bracket **(6)** and position the control arm such that the speed adjusting nut **(7)** is against the bracket.

(5) Slacken the lock nut **(8)** and adjust the full speed to 8% above the rated speed, as shown on the engine nameplate when running off load, by turning the adjuster nut **(7)** such that the control arm moves in the direction of arrow 'A' to decrease speed or in the direction of arrow 'B' to increase speed.

(6) Tighten locknut **(8)**.

(7) With the control arm in the full speed position screw setscrew **(5)** in so that it just touches the operating arm **(9)**. Screw out setscrew **(5)** just sufficiently to allow movement of the control arm from the full speed to the idle position. Tighten locknut **(4)** against the bracket and wire lock.

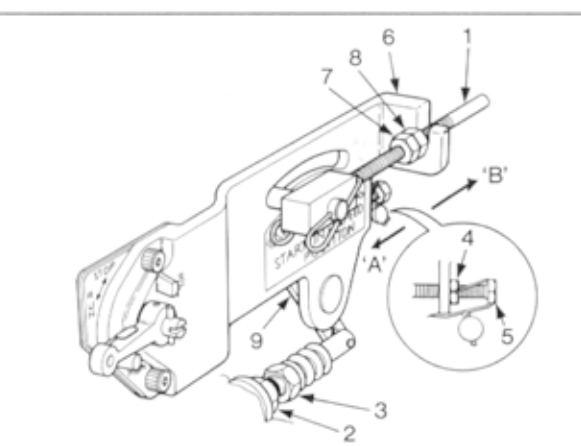



*Figure 3.18 Two Speed Control: Adjustment*

## Variable and Two Speed Control (Figure 3.19)

**3.61** To set the variable and two speed control proceed as follows:

(1) Set the variable speed lever **(1)** or two speed control knob **(2)** in the idling position

(2) Loosen the grub screw **(3)** on the idling stop **(4)** and adjust the idling speed to approximately 1200 r/min by moving the control rod **(5)** in the direction of the arrow to increase the speed or away from it to decrease the speed.

(3) Set the idling stop **(4)** against the bracket **(9)** and tighten the grubscrew.

(4) **Variable Speed:** Set the speed control to the full speed position.

(5) **Two-Speed:** Set the control knob to the RUN position.

(6) Slacken the locknuts **(6)** and adjust to full speed or the speed required by screwing in the adjusting screw **(7)** to increase the speed or out to decrease it. The speed should be set at 8% above the rated speed shown on the engine nameplate when running off load. Tighten the locknuts and fit a new seal and locking wire.

(7) To adjust the control cable, set the speed control in the idling position. Screw in the cable adjuster **(8)** until there is a small amount of slack in the inner cable, that is the control lever can just be moved before the inner cable begins to move the plunger.

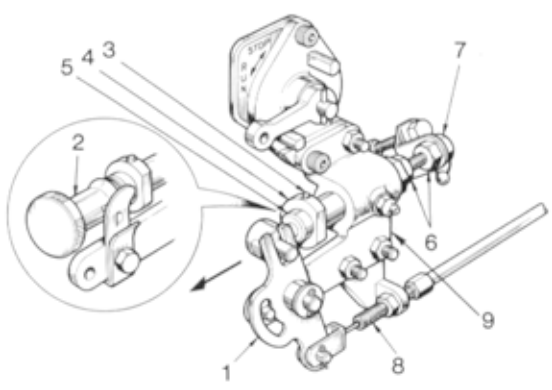



*Figure 3.19*
*Variable and Two Speed Control Adjustment*

## Idler Control (Two Speed) (Figure 3.20)

**3.62** To set the idler control proceed as follows:

(1) Move the locknut **(1)** and the nut **(2)** to the end of the control rod **(3)**.

(2) Set the control lever **(4)** to the idling position, that is upwards.

(3) Slacken the locknut **(5)** and adjust the idling speed to approximately 1200 r/min by screwing in the adjuster **(6)** to increase speed, or out to decrease it. Tighten the locknut.

(4) Slacken to locknut **(7)**. Move the control rod in the direction of the arrow so that the nut **(8)** is hard against the bracket **(9)**.

(5) Maintain the nut **(8)** hard against the bracket and adjust the full speed by turning the nut **(8)** counter-clockwise to increase speed or

clockwise to decrease it. The speed should be set at 8% above the rated speed as shown on the engine nameplate when running off load.

(6) Tighten the locknut **(7)**.

(7) Set the control lever **(4)** to the full speed position that is downwards.

(8) Turn the nut **(2)** clockwise until nut **(8)** is lightly touching the bracket **(9)**.

(9) Tighten the locknut **(1)**.

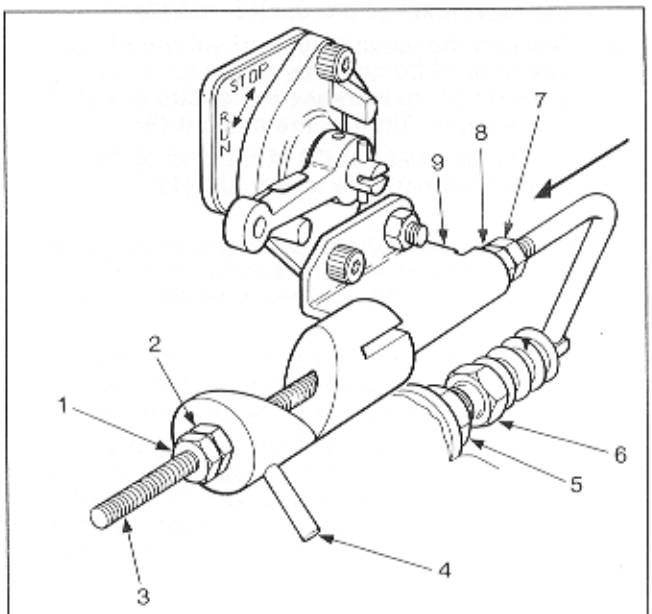



*Figure 3.20 Idler Control (Two Speed)*

## Variable Speed Control (Cable or Adjusting Nut)

### Cable Operated (Figure 3.21)

**3.63** To set the cable operated variable speed control, proceed as follows:

(1) Move the lock nut(s) **(1)** and knurled adjusting nut **(2)** to the end of the control rod **(9)**.

(2) Slacken the lock nut **(3)** and adjust the idling speed to 1200 r/min by screwing in the adjuster **(4)** to increase the speed or out to decrease it. Tighten the lock nut **(3)**.

(3) Lock the knurled adjusting nut **(2)** at the end of the control rod **(9)** with locknut(s) **(1)**.

**Note**

*If the minimum speed required is above the idling speed turn the knurled adjusting nut towards the bracket* **(7)** *until the required speed is obtained. Lock the adjusting nut in position.*

(4) Slacken lock nut **(5)**. Move the control rod in the direction of the arrow so that the nut **(6)** is hard against the bracket **(7)**.

(5) Maintain the nut **(6)** hard against the bracket and adjust the full speed by turning the nut **(6)** counter-clockwise to increase the speed or clockwise to decrease it. The speed should be set at 8% above the rated speed as shown on the engine nameplate when running off load.

(6) Position the plate **(8)** against nut **(6)** where required and tighten the locknut **(5)**.

(7) Fit the control cable so that it is capable of moving the control rod from the minimum speed to full speed position.

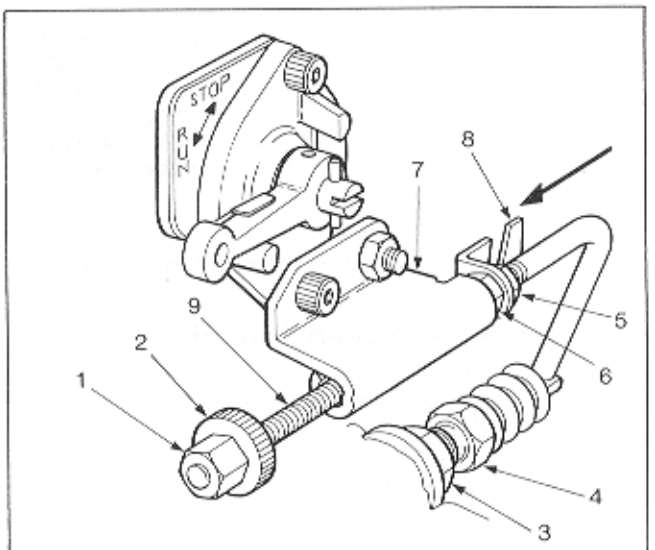



*Figure 3.21 Variable Speed Control: Cable Operated Adjustment*

### Knurled Nut Operated (Figure 3.22)

**3.64** To set the variable speed knurled nut operated control proceed as follows:

(1) Move the lock nut(s) **(1)** and knurled nut **(2)** back to the end of the control rod **(8)**.

(2) Slacken the lock nut **(3)** and adjust the idling speed to 1200 r/min by screwing in the adjuster **(4)** to increase the speed or out to decrease it. Tighten the lock nut **(3)**.

(3) Position the lock nut(s) **(1)** at the end of the control rod **(8)** and secure. Do not lock the knurled nut as this has to be free to vary the engine speed.

**Note**

*If the minimum speed required is above the idling speed turn the knurled nut* **(2)** *clockwise towards the bracket* **(7)** *until the required minimum speed is obtained. Bring the lock nut(s)* **(1)** *up to the knurled nut and lock in position. Do not lock the knurled nut.*

(4) Slacken lock nut **(5)**. Move the control rod in the direction of the arrow so that the nut **(6)** is against the bracket **(7)**.

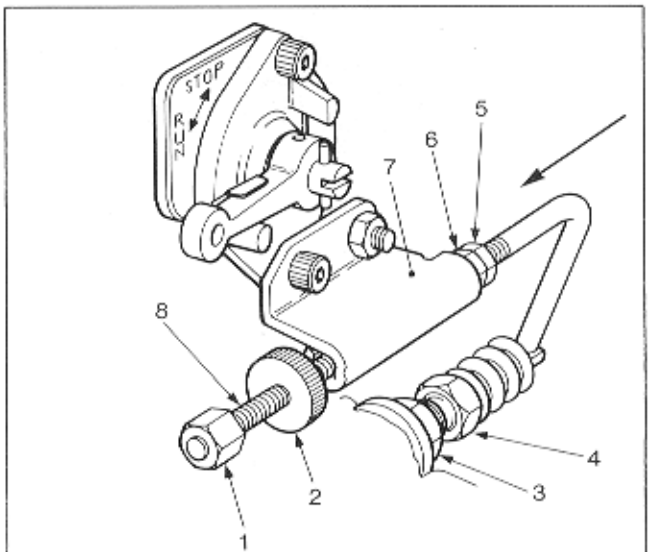



*Figure 3.22 Variable Speed Knurled Nut Operated : Adjustment*

(5) Maintain the nut **(6)** hard against the bracket and adjust the full speed by turning the nut **(6)** counter-clockwise to increase the speed or clockwise to decrease it. The speed should be set at 8% above the rated speed as shown on the engine nameplate when running off load.

(6) Tighten locknut **(5)**.

(7) Set the engine speed as required by using the knurled nut **(2)**.

## Adjustable Fixed Speed Control (Figure 3.23)

**3.65** To set the adjustable fixed speed control proceed as follows:

(1) Move the lock nut(s) **(1)** and knurled adjusting nut **(2)** to the end of the control rod **(8)**.

(2) Slacken the lock nut **(3)** and adjust the idling speed to approximately 1200 r/min by screwing in the adjuster **(4)** to increase the speed or out to decrease it. Tighten the lock nut **(3)**.

(3) Slacken the lock nut **(5)**. Move the control rod in the direction of the arrow so that the nut **(6)** is hard against the bracket **(7)**.

(4) Maintain the nut **(6)** hard against the bracket and adjust the full speed by turning the nut **(6)** counter-clockwise to increase the speed or clockwise to decrease it. The speed should be set at 8% above the rated speed as shown on the engine nameplate when running off load.

(5) Tighten the locknut **(5)**.

(6) Set the required operating speed by turning the knurled adjusting nut **(2)** clockwise towards and against the bracket **(7)**.

(7) When the required speed is obtained lock the adjusting nut in position with the lock nut(s) **(1)**.

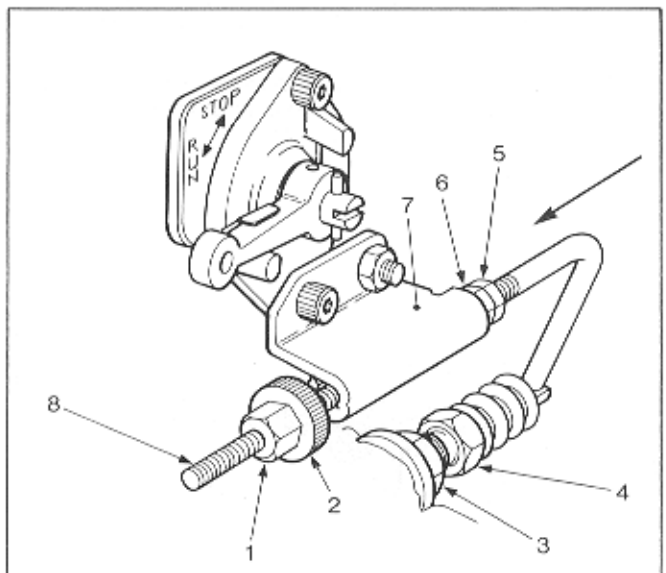



*Figure 3.23 Adjustable Fixed Speed Control: Adjustment*

## Variable Speed Control – Spring Assisted Cable Operated (Figure 3.24)

**3.66** To set the spring assisted, cable operated variable speed control proceed as follows:

(1) Move the lock nut(s) **(1)** and knurled nut **(2)** to the end of the control rod **(3)**.

(2) Set the control lever to the minimum speed position.

(3) Slacken the locknut **(4)** and set the adjuster **(5)** so that the control cable does not limit the movement of the control rod **(3)**.

(4) Slacken the locknut **(6)** and set the idling speed to 1200 r/min by screwing in the adjuster **(7)** to increase the speed or out to decrease it. Tighten the locknut **(6)**.

(5) Fix the knurled nut **(2)** at the end of the control rod with the lock nut(s) **(1)**.

**Note**
*If the minimum operating speed required is greater than the idling speed turn the knurled nut* **(2)** *towards the bracket* **(8)** *until the required speed is obtained.*

(6) Slacken the locknut **(9)** move the control rod in the direction of the arrow so that the nut **(10)** bears hard against the bracket **(8)**.

(7) Maintain the nut **(10)** hard against the bracket and adjust the full speed by turning the nut **(10)** counter-clockwise to increase the speed or clockwise to decrease it. The speed should be set at 8% above the rated speed as shown on the engine nameplate when running off load.

(8) Position the plate **(11)** as shown against the nut **(10)** and tighten the locknut **(9)**.

(9) By means of the control cable adjuster **(5)** and nuts **(4)** set the control cable so that the engine control lever is capable of moving the speed control from the minimum speed to the full speed position.

(10) Tighten the cable adjuster nuts **(4)** in position.

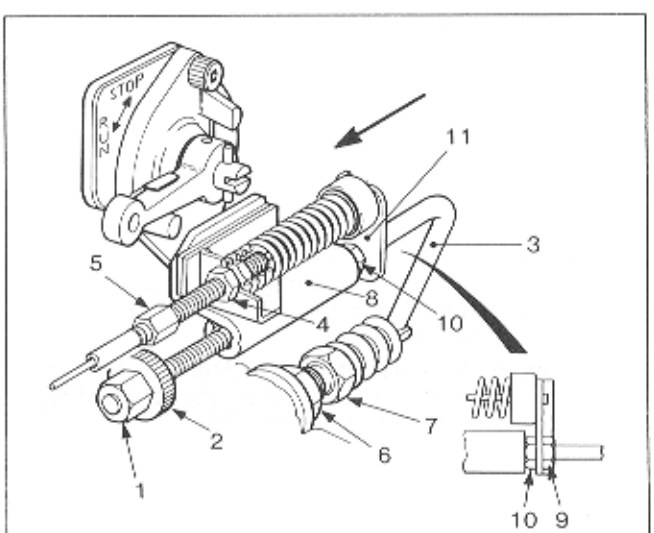



*Figure 3.24 Variable Speed Control – Spring Assisted Cable Operated: Adjustment*

# SECTION 4
# AIR FILTRATION

## INTRODUCTION

**4.1** The operating conditions that are met in service play an important part in the selection of air cleaners the various types being given in Section 1.

Table 4.1 shows the typical dust concentrations against site conditions and the typical paper element replacement frequency.

*TABLE 4.1*
*OPERATING CONDITIONS*

| *DUST CONCENTRATION* | *mg/m³* | *ELEMENT REPLACEMENT* | *TYPICAL OPERATING CONDITIONS* |
|---|---|---|---|
| Light | **up to 175** | **Every 500 Hrs** | Metalled Roads<br>Machine Shops<br>Ship Auxiliaries |
| medium | **175 to 350** | **Every 250 Hrs** | Sand Pits<br>Unmetalled Roads |
| Heavy | **350 to 700** | **Every 50 Hrs** | Ploughing Dry Soil<br>Temporary Air Strip<br>Road Working Equipment<br>Building Sites |
| Very Heavy | **700 to 1400** | **Every 10 Hrs** | China Clay Pits<br>Cement Works<br>Stone Crushers |
| Exceptionally Heavy | **Above 1400** | | Dust Storms |

**4.2** The need for regular attention to maintenance cannot be over-emphasised and where operating conditions are dusty 90% of engine breakdowns are due to the dust entering the engine through lack of attention to the air cleaner or its fitting. a badly made air filter connection on an engine operating in dust cloud can cause noticeable wear after 15 hours operation. A further 10 hours can make it impossible to start the engine due to worn piston rings and cylinder bores.

**CAUTION**
**Neglect of the air filtration system can lead to rapid wear of major engine components.**

## AIR CLEANER PAPER ELEMENT

### Removal

**4.3** Unscrew the nut retaining the front cover, remove cover. Remove element clamping plate (where applicable). Remove element and rear cover. Retain the air cleaner seal.

### Maintenance

**4.4** Clean the element by blowing from the inside to the outside with low pressure air. A strong light directed into the inside of an element and viewed from the outside will reveal any damage to the paper corrugations. If the element is damaged or shows a large deposit of dirt, fit a new element obtainable from Petters Limited or their representatives. Ensure all sealing surface areas are not damaged. Replace any defective parts. Also ensure that the air cleaner seal is serviceable, that is capable of giving a perfect airtight seal. If an interconnecting flexible pipe is used between the cleaner and intake manifold check for any cracks or holes. Replace if defective. Failure to observe these points could result in rapid engine wear. (Paragraph 4.2).

### Assembly

**4.5** Replace air cleaner seal, rear cover, element, element clamping plate (where applicable) and front cover.

## AIR CLEANER OIL BATH TYPE

### Standard

#### Removal

**4.6** Unscrew the wing nut and remove the top half of the cleaner. Slacken the retaining clip and remove the bottom cup of the cleaner.

#### Maintenance

**4.7** Wash all parts in clean kerosene and allow to drain.

#### Assembly

**4.8** Fit the bottom cup and fill with clean engine oil to the indicated level; re-assemble the cleaner.

### Heavy Duty

#### Removal

**4.9** Disconnect the breather pipe (if applicable) and remove the air cleaner assembly from the engine.

#### Maintenance

**4.10** Carry out the following procedure:

(1) Unclip the bottom cup and remove it from the main body.

(2) If a removable top is fitted, unscrew the centre wing-nut and lift off the top.

(4) Wash all parts in clean kerosene and allow to drain.

**Assembly**

**4.11** Assemble the air cleaner as follows:

(1) Ensure that the mating faces of the cleaner and manifold are clean and fit a new gasket (where applicable).

(2) Fit the main body of the air cleaner to the engine.

(3) Fit the breather pipe (if applicable).

(4) Fit the removable top (if fitted) and tighten the centre wing nut.

(5) Fill the bottom cup with clean engine oil to the indicated level and fit the cup to the main body.

**Note**

*If flexible interconnected pipes are fitted between the air cleaner and intake manifold, ensure that they air air tight and are not cracked or damaged.*

## CYCLONIC AIR CLEANERS

**4.12** In engine installations where a cyclonic air cleaner is fitted servicing of the cleaner must be carried out in accordance with the manufacturers instructions.

# SECTION 5
# ENGINE GENERAL MAINTENANCE

## INTRODUCTION

**5.1** This section contains fitting and servicing instructions for major repairs and maintenance of the 'A' Range diesel engine. Major servicing should be carried out by qualified personnel in a workshop environment. It is important that all component parts should be kept clean.

## DECARBONISING

**5.2** A carbon deposit forms on piston and cylinder heads and the presence of an excessive carbon deposit is usually indicated by a loss of power. Decarbonising necessitates the removal of the cylinder head, followed by the removal of all carbon and the grinding in of the valves.

### Cylinder Head Removal (Figure 5.1)

5.3 To remove the cylinder head proceed as follows:

(1) Remove the fuel tank as detailed in Section 3.

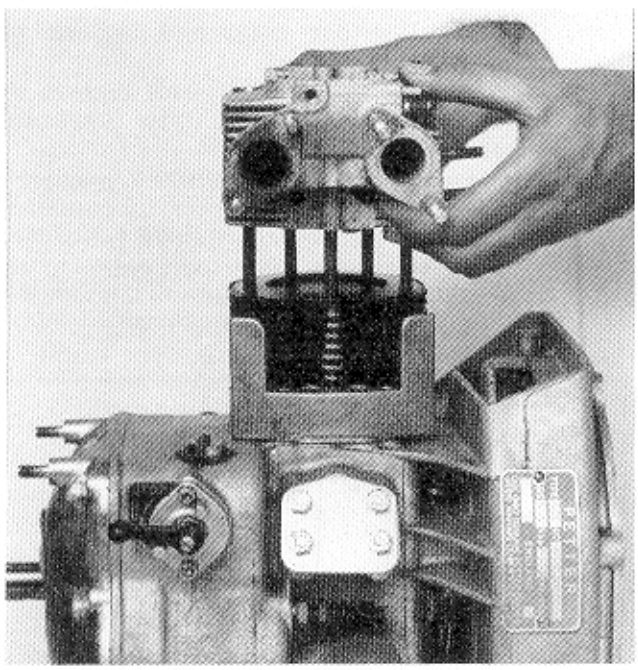


*Figure 5.1 Cylinder Head Removal*

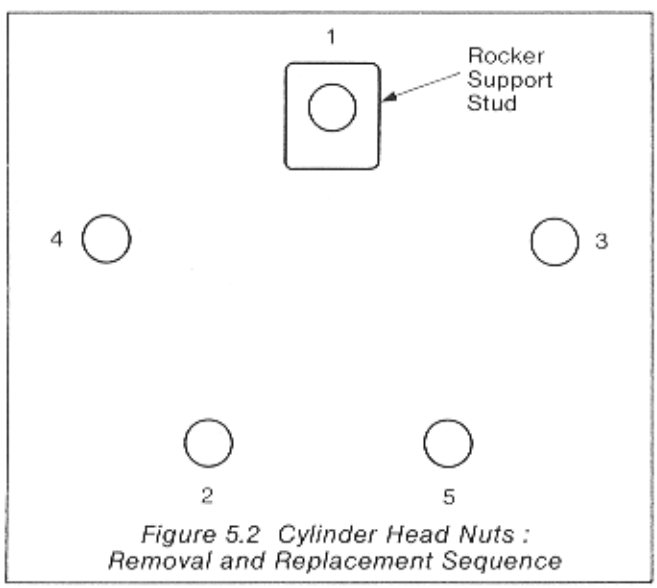



*Figure 5.2 Cylinder Head Nuts : Removal and Replacement Sequence*

(2) **AC2 Engines Only.** Remove the fuel tank bracket.

(3) Remove the exhaust silencer and the air cleaner.

(4) Remove the cylinder cowling.

(5) Remove the fuel pump to injector pipe(s) and leak-off pipe.

(6) Remove the manifold(s).

(7) Remove the crankcase-to-cylinder head oil pipe.

(8) Remove the rocker box cover(s).

(9) Remove the priming plunger(s).

(10) Remove the two 5/16 in. UNF nuts and spring washers retaining the injector.

(11) Remove the injector(s) assembly and the injector nozzle seal washer(s).

(12) Gradually slacken the 5/16 in. UNF cylinder head retaining nuts in sequence diagonally as shown in Figure 5.2. Note their positions and remove the nuts and washers.

(13) Remove the rocker assembly.

(14) Note the position of the push rods and remove the push rods.

**Note**

*It is important that the push rods are refitted in the same position on assembly.*

(15) Lift off the cylinder head and remove the push rod tubes.

### Valve Removal (Figure 5.3)

**5.4** Place the cylinder head on a flat surface. Using the special tool, as shown, press down the valve spring cap and remove the split collets from the valve stems. Withdraw the valves, springs, spring plates and caps noting their positions.

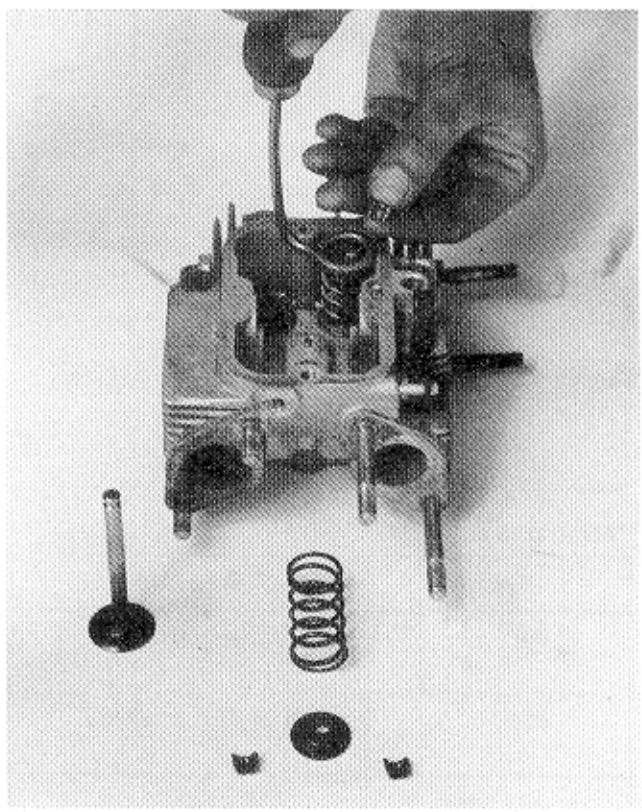


*Figure 5.3 Valve Removal*

## Carbon Removal

**5.5** To remove the carbon proceed as follows:

(1) Turn the crankshaft until the piston is at the top of its stroke.

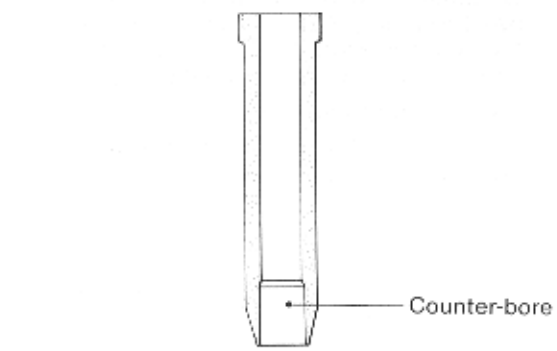
(2) Remove the carbon deposit from the cylinder head and the top of the piston using a blunt tool. It is important not to damage the top of the piston. Do not allow carbon particles to fall between the piston and the cylinder bore.

**Note**

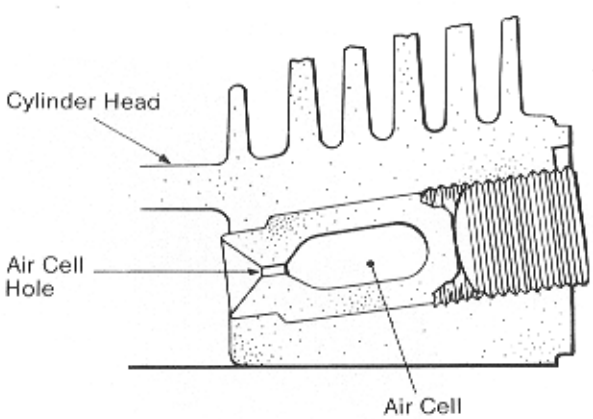
*At this stage it is recommended that the cylinder be removed to inspect the piston, piston rings and cylinder bore for wear and damage (See Paragraph 5.14).*

(3) Do not remove the air cell from the cylinder head. If a carbon deposit has formed in the air cell hole it may be removed using a piece of soft wire. (Figure 5.4)

(4) Clean injector bore and seating face.




(1) Valve Guide




(2) Air Cell

*Figure 5.4 Carbon Removal*

**CAUTION**

**Do not use emery cloth.**

(5) Clean the carbon from the counter-bore at the valve head end of the valve guide bore (Figure 5.4). Check the valve guides for wear, if worn renew the guides as detailed in Paragraphs 5.9 and 5.10.

(6) Clean the valves and check the valve seats. If the valves are badly pitted or distorted fit new valves. Grind the valves in as detailed in Paragraph 5.8. If the valve seats are pocketed carry out the procedure detailed in Paragraph 5.6.

## Valve Seats

**5.6** If the valve seats are badly pocketed and cutting the valve seats back will exceed the flame face – to valve head clearance (Figure 5.5), valve seat inserts must be fitted. Suitable valve seat inserts as defined in Figure 5.6 are available and reference must be made to the three schemes to determine the insert part number required. The maximum limits are detailed in Table 5.1.

**5.7** To fit the valve seat inserts proceed as follows:

(1) Strip the cylinder head and remove the damaged inserts.

(2) Machine each valve seat insert bore to the dimensions detailed on the applicable scheme shown in Figure 5.6.

(3) Heat the cylinder head to 150°C and press the valve seat inserts at ambient temperature into the cylinder head (chamfered edge first).

(4) Machine the valve seats concentric to the valve guide bore to the dimensions detailed on the applicable scheme shown in Figure 5.6.

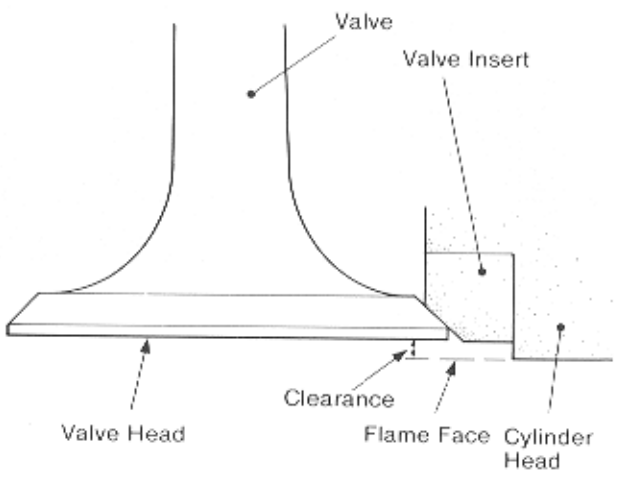
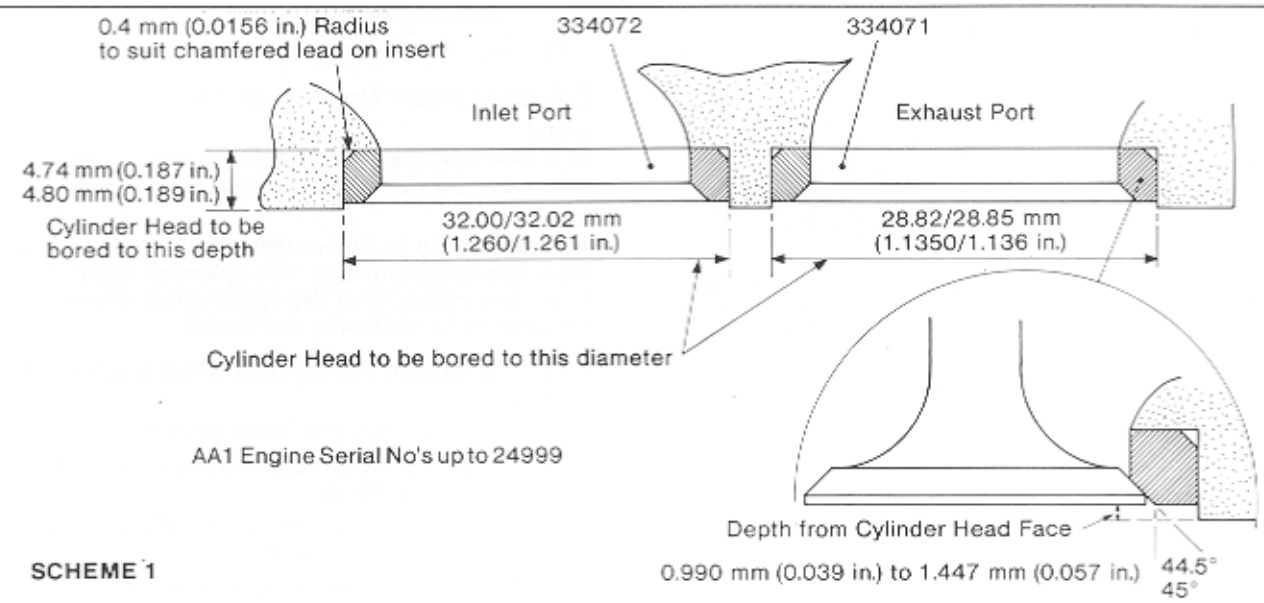


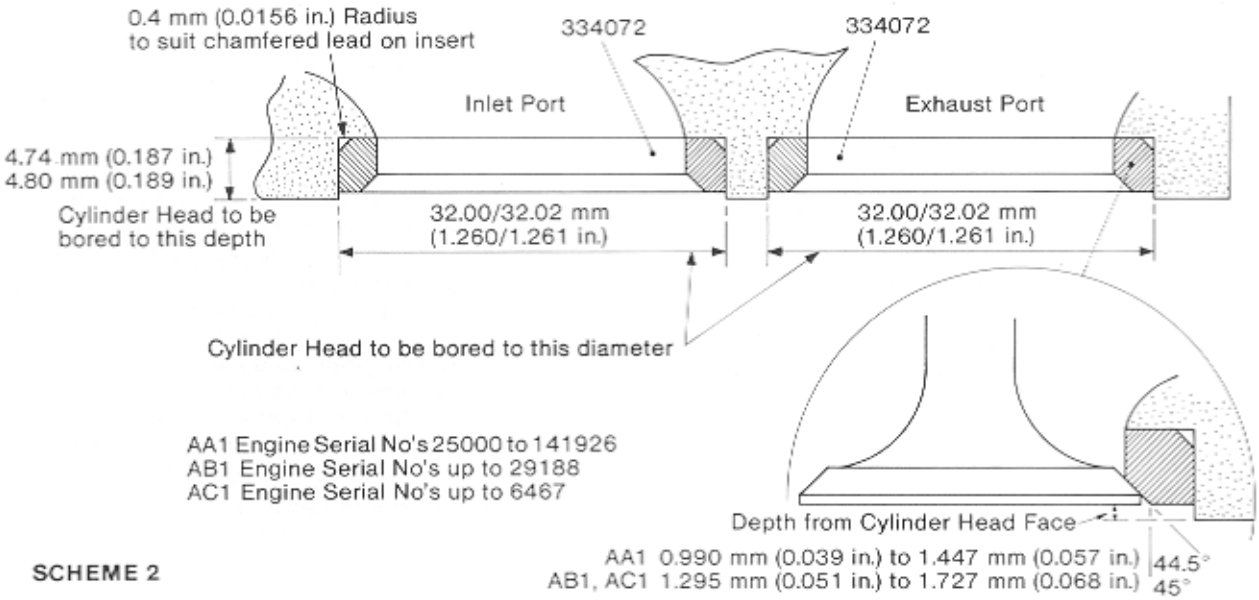

*Figure 5.5 Flame Face-to-Valve Head Clearance*

*TABLE 5.1 FLAME FACE-TO-VALVE HEAD CLEARANCE*

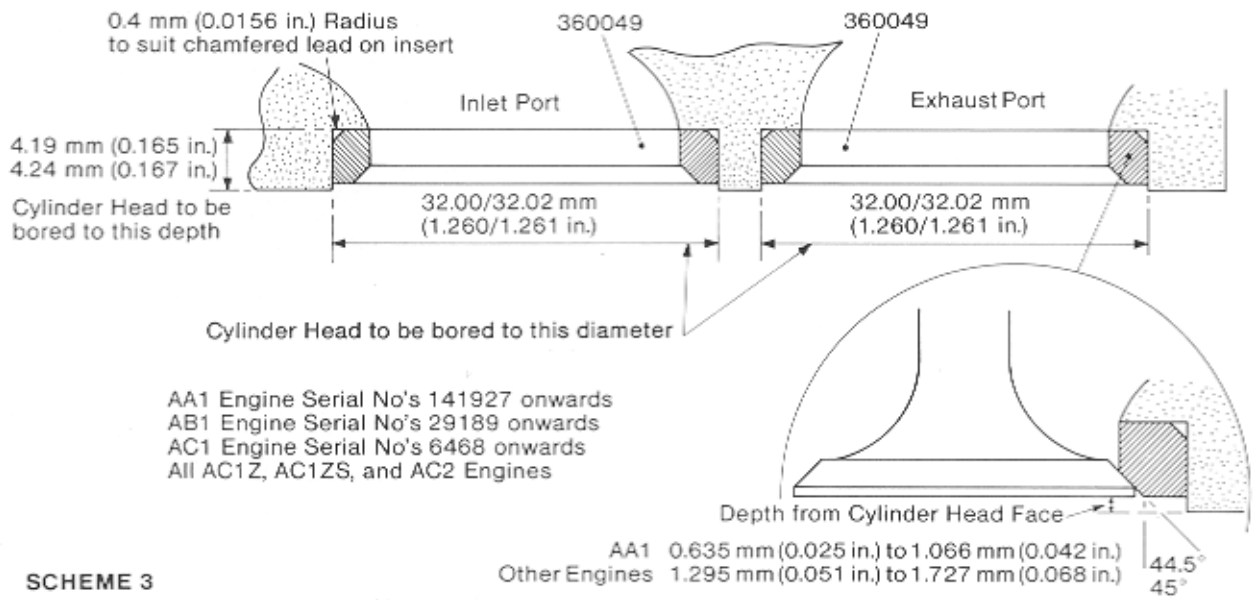
| *Engine* | *Serial No* | *Clearance (new)* | *Not to Exceed* |
|---|---|---|---|
| AA1 | Up to 141926 | **0.99 to 1.45 mm (0.039 to 0.057 in.)** | **1.65mm (0.065 in.)** |
| AA1 | 141927 onwards | **0.63 to 1.06mm (0.025 to 0.042 in.)** | **1.27mm (0.050 in.)** |
| All Other | 'A' Range | **1.29 to 1.72mm (0.051 to 0.068 in.)** | **1.93mm (0.076 in.)** |




**SCHEME 1**




**SCHEME 2**




**SCHEME 3**

Valve seats to be machined to $\overset{32}{\nabla}$ before lapping to give finished dimension from the valve head to flame face as detailed in the insets.

*Figure 5.6 Valve Inserts: Machining Dimensions*

## Valves: Grinding In

**5.8** To grind in valves proceed as follows:

(1) Lightly lubricate the valve stem with engine oil.

(2) Place a very small quantity of grinding paste evenly around the valve face and insert the valve in the correct valve guide. Partially rotate the valve backwards and forwards on its seating, exerting a gentle but firm pressure.

(3) Periodically lift the valve from its seating and rotate it through approximately 120°. It is unnecessary to continue grinding once the faces of the valve and its seating have a clean, even matt-surfaced appearance.

(4) Remove all traces of grinding paste.

(5) Replace the valves and rotate them backwards and forwards a few times. If the valves have been correctly ground a thin polished line will appear all round the mating surfaces.

## Valve Guides

**CAUTION**

**Extreme care must be taken when removing and replacing valve guides; do not use excessive force, if necessary, reheat the cylinder head if heavy resistance is encountered. Care must be taken to avoid damaging the bores as this will affect the fitting of the new valve guides.**

### Removal

**5.9** To remove the valve guides carry out the following procedure:

(1) Clean the cylinder head using kerosene and ensure that all carbon, oil and dirt is removed.

(2) Heat the cylinder head by placing it in boiling water for two minutes.

(3) Support the head on wood blocks at least 13 mm (0.5 in.) thick to prevent the valve guides bottoming. Press out the guides using a special tool available from Petters Limited or their representatives. If heavy resistance is encountered do not use excessive force, but replace the cylinder head in boiling water for a further two minutes.

### Replacement

**5.10** To fit new valve guides proceed as follows:

(1) Ensure that the bores in the cylinder head and the body of the guides are clean.

(2) Heat the cylinder head by placing it in boiling water for two minutes.

(3) Enter the guides squarely in the cylinder head bores from the rocker box side and press home to the shoulder.

**CAUTION**

**The valve guides must not be reamed.**

(4) Grind in the valves as detailed in Paragraph 5.8.

## Cylinder Head Assembly

**5.11** To assemble the cylinder head proceed as follows:

(1) If new valves, guides, or valve seat inserts are fitted the valves must be ground in according with the instructions given in Paragraph 5.8. Before assembling lightly oil the valve stems with engine lubricating oil.

(2) Assemble the valve spring plate, spring(s) and valve cup to their appropriate valve.

(3) Depress the valve spring(s) and fit the collets.

## Cylinder Head Replacement

**Note**

*Fit a new cylinder head gasket, rocker support seal and push rod seals when replacing the cylinder head.*

**CAUTION**

**As the engine is fitted with long through studs from the crankcase to the cylinder head it is most important that the tightening down procedure is correctly followed.**

**5.12** To replace the cylinder head proceed as follows:

(1) Fit a new cylinder head gasket.

(2) Fit the cylinder head and push rod tubes using new seals.

(3) Lightly lubricate the push rods and place in their noted positions.

(4) Fit a new rocker support seal, the rocker support and rockers.

(5) Locate the self-locking 5/16 in. UNF nut on the rocker support stud; fit the 5/16 in. UNF nuts and washers in the positions noted in Paragraph 5.3 (12) to the remaining four studs and screw down finger-tight. Tighten the self-locking nut sufficiently to just contact the rocker support ensuring that the support is level and touching the cylinder head.

(6) With reference to Figure 5.2 tighten each nut a quarter of a turn at a time in the sequence shown. the nuts must be finally tightened to a torque loading 27Nm (20 lbf ft). On two cylinder engines, ensure that the manifold bolting faces are parallel with each other. Check with a straight edge before tightening down the cylinder head nuts as shown in Figure 5.7, or by bolting on a manifold.

(7) After 20 hours running check the torque loading of the cylinder head nuts as detailed in Paragraph 5.13.

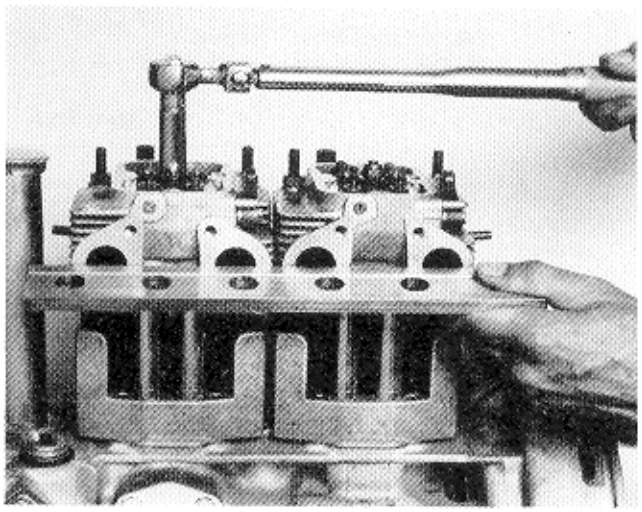


*Figure 5.7 Checking the Manifold Alignment AC2 Engines*

### Re-Torque Loading After 20 hours

**5.13** After 20 running hours the torque loading of the cylinder head must be checked by slackening each nut, in turn (in the sequence shown in Figure 5.2) a quarter of a turn and re-torque loading to 27Nm (20 lbf ft).

## Valve Rockers Adjustment (Figure 5.8)

**5.14** Set up the valve rockers on each cylinder in turn as follows:

(1) Set the engine at TDC on the firing stroke (both valves closed).

(2) Slacken the locknut **(1)** and using a screw driver set the rocker adjusting screw **(2)** to give the correct clearance using a feeler gauge **(3)**. When the correct clearance of 0.10 mm (0.004 in.) is obtained with the engine cold tighten the locknut.

(3) Recheck the clearance.

**Note**

*Because of the close confines of the rocker box difficulty in obtaining an accurate adjustment with a standard feeler gauge will be experienced. It is recommended that a feeler gauge be made up as shown in Figure 5.8 (1) to overcome this difficulty. It is important to have accurate adjustment of the tappet clearances in order to maintain reliability and full engine power.*

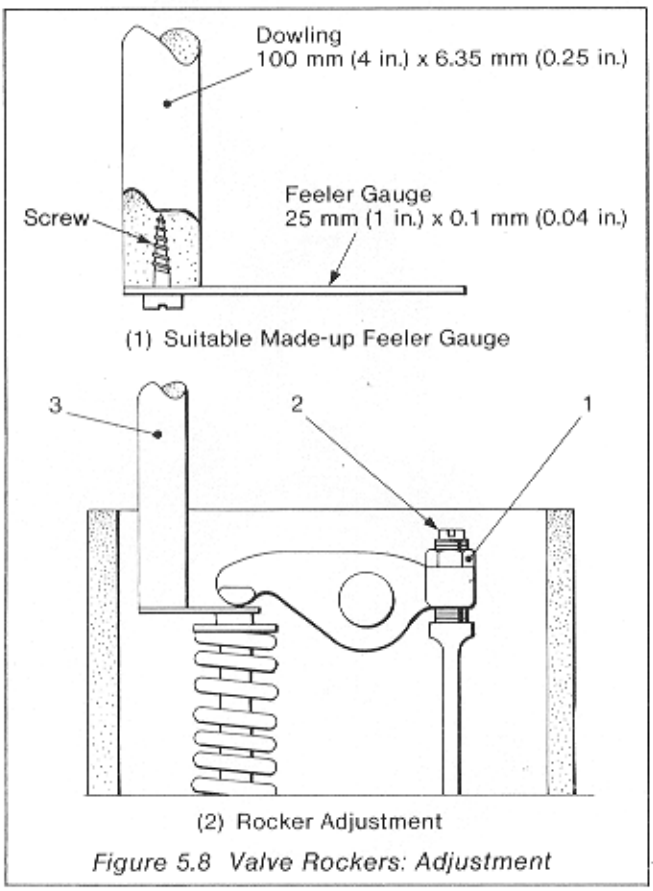



*Figure 5.8 Valve Rockers: Adjustment*

## Setting the Decompressor Lever (Figure 5.9)

**5.15** To set the decompressor lever proceed as follows:

(1) Set the engine so that the exhaust valve is fully closed.

(2) Check that with the decompressor lever **(1)** in the vertical position the spindle **(2)** moves the rocker arm just sufficiently to take up the valve clearance.

(3) If adjustment is necessary, hold the decompressor lever **(1)** in the vertical position and back off the spindle **(2)** from the exhaust valve rocker by turning it clockwise using a screwdriver in the spindle slot **(3)**. Then turn the spindle counter-clockwise until it moves the exhaust valve rocker just sufficiently to take up the valve clearance.

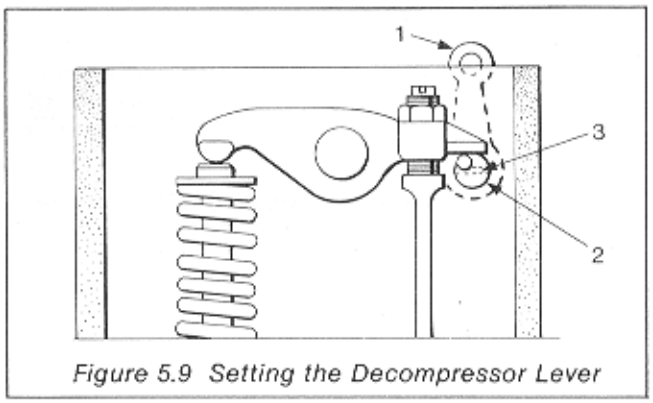



*Figure 5.9 Setting the Decompressor Lever*

## CYLINDER, PISTON AND CONNECTING ROD (Figure 5.10)

### Removal

**5.16** Carry out the following procedure:

(1) Remove the cylinder head as detailed in Paragraph 5.3.

(2) Drain the oil from the sump by removing an oil drain plug.

(3) Remove the sump capscrews retaining the sump and gasket.

(4) Note the position of the large end bearing cap, mated sides are numbered for identification.

(5) Remove the large end bolts and bearing cap. Set the piston at TDC.

(6) Lift off the cylinder complete with piston and connecting rod. Retain the shims fitted between the cylinder and crankcase. These control the bumping clearance.

(7) Withdraw the piston and connecting rod assembly from the cylinder barrel.

(8) Using circlip pliers remove one of the gudgeon pin circlips.

(9) Remove the gudgeon pin. If the gudgeon pin is a tight fit soak the piston in hot water for sufficient time to allow the pin to be removed.

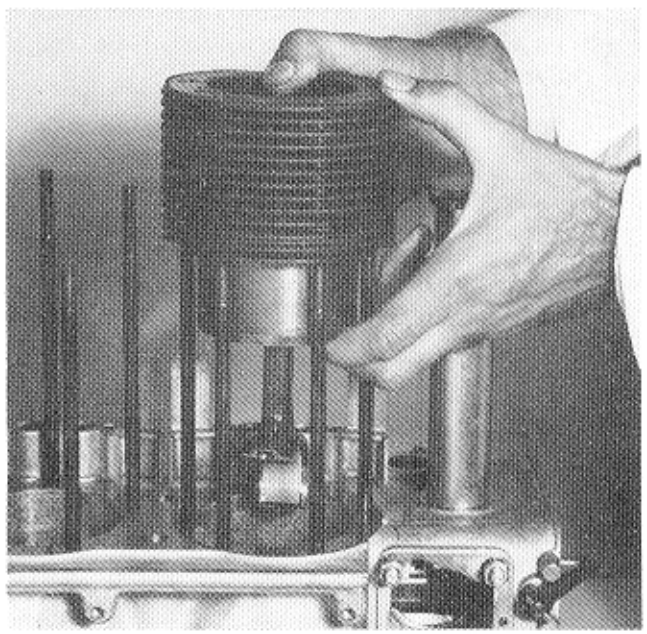


*Figure 5.10 Cylinder, Piston and Connecting Rod Removal*

## Cylinder Maintenance

**5.17** Check the cylinder bore wear, if this has reached the maximum 0.25 mm (0.010 in.) the cylinder must be rebored and an oversize piston and rings fitted. The cylinder should be bored and honed to the sizes listed in Table 5.2 for AA1 range and Table 5.3 for AB1, AC1, AC2, AC1Z and AC1ZS ranges.

*TABLE 5.2 CYLINDER REBORING DIAMETERS AA1*

| Cylinder | Bore |
|---|---|
| Standard | **69.850 to 69.875 mm (2.750 to 2.751 in.)** |
| 1st Oversize 0.508mm (0.020 in.) | **70.358 to 70.388 mm (2.770 to 2.771 in.)** |
| 2nd Oversize 1.016mm (0.040 in.) | **70.866 to 70.891 mm (2.790 to 2.791 in.)** |

*TABLE 5.3 CYLINDER REBORING DIAMETERS AB1, AC1, AC2, AC1Z AND AC1ZS*

| Cylinder | Bore |
|---|---|
| Standard | **76.20 to 76.23 mm (3.000 to 3.001 in.)** |
| 1st Oversize 0.508 mm (0.020 in.) | **76.71 to 76.73 mm (3.020 to 3.020 in.)** |
| 2nd Oversize 1.016 mm (0.040 in.) | **77.22 to 77.24 mm (3.040 to 3.041 in.)** |

## Piston Maintenance

**5.18** Excessive lubricating oil consumption, loss of compression and knocking are signs that a piston needs attention. To check the piston rings carry out the following procedure:

(1) Remove the rings from the piston as shown in Figure 5.11 noting the order of assembly and which ring face is uppermost.

(2) Remove all the carbon deposit from the rings and ring grooves. The small holes in the piston should receive attention as their purpose is to return excess oil to the sump.

(3) Insert the piston into the cylinder bore with the crown towards the bottom end of the bore and about 13 mm (0.5 in.) from the bottom edge. Insert the rings one at a time, pushing each ring hard up against the piston crown to ensure that it is level in the cylinder bore. Withdraw the piston sufficiently to allow the gap to be measured with a feeler gauge. The piston ring gap must not exceed 1.14 mm (0.045 in.) If necessary the rings must be renewed. Check the piston ring side clearances are as detailed in the appropriate Engine Technical Data.

(4) Assemble the rings on the piston in the correct order with the correct face uppermost as shown in Figure 5.12. Rings should not be slack or stuck fast in the groove.

(5) When the engine has been fully run in, the bore will have a highly polished and very hard surface. If new piston rings are fitted without the cylinder being rebored, the new rings will not bed in satisfactorily. Under these conditions the hard polished bore must be lightly roughened using a medium grade carborundum cloth. The roughening should be carried out radially by hand and should be sufficient only to produce a matt surface on the bore. Alternatively, a suitably sized de-glazing tool of the rotary brush type with silicone-carbide tips may be used provided method used is in accordance with manufacturers instructions. After this treatment the cylinder must be thoroughly washed in kerosene to remove all traces of carborundum.

**Note**
*Pistons fitted to AA1 range of engines may have a second oil scraper ring groove machined below the gudgeon pin. This groove is not fitted with a ring.*

*Figure 5.11 Piston Ring Removal*

## Initial Running

**5.19** To allow the piston rings to bed in satisfactorily carry out the initial running procedure:

(1) Run for 2 minutes on no load.

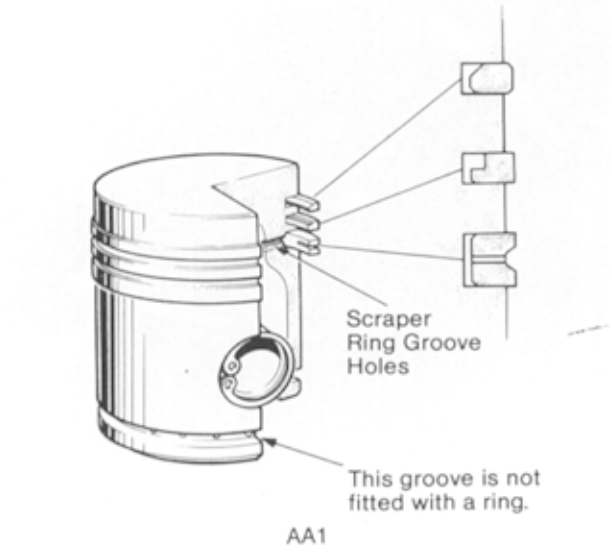
(2) Run for 10 minutes on half load.

(3) Run for a further minimum of 8 hours or longer on full load.

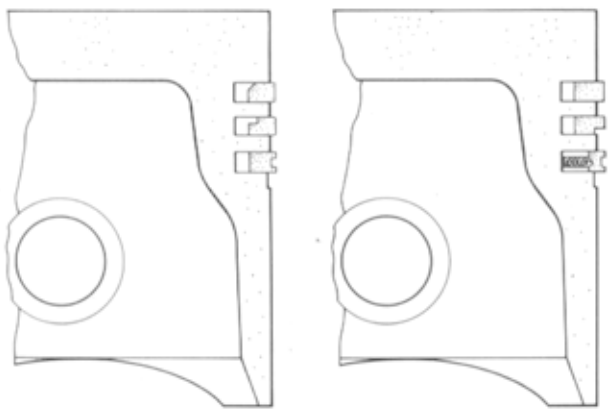
## Connecting Rod Maintenance

### Small End Bush

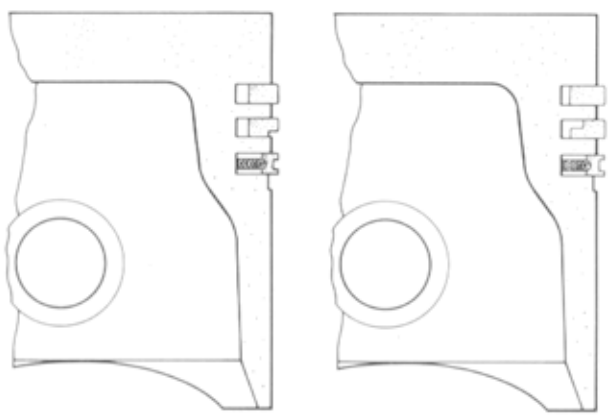
**5.20** When fitting a small end bush take care that the oil hole coincides with the hole in the connecting rod. Ensure that the bush enters the connecting rod squarely.




AA1



AB1 AC1 and AC2



AC1Z AC1ZS

*Figure 5.12 Piston Rings Arrangements*

### Large End Bearings

**5.21** Large end bearings are of the precision thin wall steel backed type and consist of two half shells lined with bearing metal. They should be replaced in their original positions. New bearings are machined to give the required fit when in position and should not be scraped or bedded in, neither should shims of any description be fitted. If the faces of the connection rod or its cap are filed the rod becomes useless regarding replacement bearing shells. When fitting make sure that the connecting rod bore and the outside of shells and their split faces are clean. Connecting rods and caps are stamped with an assembly serial number and care must be taken that these numbers match and are assembled on the same side.

**Note**
*Undersize bearings are obtainable from Petters Limited or their representatives.*

### Replacement

**5.22** Before fitting the piston on to the connecting rod soak the piston in hot water to allow the gudgeon pin to slide freely. Replace the cylinder, piston and connecting rod as follows:

(1) Fit the piston to the connecting rod.

(2) Secure the gudgeon pin by replacing the circlips. Ensure that the circlips fit correctly in their grooves.

(3) Distribute the piston ring gaps around the piston circumference so that the gaps are not in line.

(4) Lightly lubricate with engine oil the cylinder bore, the piston and piston rings.

(5) Using a piston ring clamp compress the rings and fit the piston and connecting rod assembly into the cylinder.

(6) Replace the shims retained in paragraph 5.16 (6) between the cylinder and crankcase. These shims control the bumping clearance between the piston and the cylinder head at TDC.

(7) Check that the bearings and crankpin are clean. Lightly lubricate the crankpin and bearing face.

(8) Place the cylinder over the long through studs.

(9) Assemble the connecting rod to the crankshaft making sure that the numbers on the connecting rod are towards the camshaft side of the engine. Fit the connecting rod cap ensuring that the numbers on the cap and rod assembly are correctly matched and are on the same side.

(10) Tighten the large end bolts to a torque of 34Nm (25 lbf ft).

### Bumping Clearance (Figure 5.13)

**5.23** Check the bumping clearance as follows:

(1) Set the piston to 6.35 mm (0.25 in.) before TDC.

(2) Place three pieces of soft lead wire or soft solder equidistant on the top of the piston. Ensure that the wire pieces are not aligned with the valve heads and/or combustion chamber.

(3) Replace the cylinder head as detailed in Paragraph 5.12 and turn the engine over TDC.

(4) Remove the cylinder head and measure the

thickness of the flattened wire with a micrometer. This should be 0.56 to 0.66 mm (0.022 to 0.026 in.) for an average of three readings. If necessary adjust the clearance by re-shimming. (Paragraph 5.22 (6)).

(5) Replace the cylinder head as detailed in Paragraph 5.12.

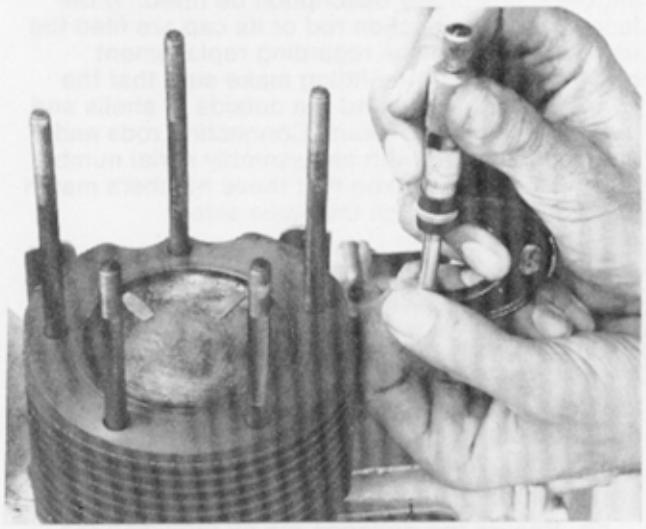


*Figure 5.13 Checking the Bumping Clearance*

## FLYWHEEL REMOVAL

**5.24** To remove the flywheel proceed as follows:

(1) Remove any fittings from the bell housing and flywheel.

(2) **AA1, AB1, AC1 and AC2 Ranges.** Prevent the flywheel from turning by using a special locking plate (obtainable from Petters Limited or their representatives) or inserting a suitable steel rod through the timing hole in the bell housing into the hole in the flywheel periphery.

(3) **AC1Z and AC1ZS Ranges.** Prevent the flywheel from turning by removing the sump and positioning a block of hard wood in such a manner to hold the crankshaft.

(4) Bend back the tabwasher on the flyweel retaining nut and remove the flywheel nut and tabwasher.

(5) Using a suitable extractor (obtainable from Petters Limited or their representatives) loosen the flywheel from its tapered shaft. Remove the flywheel locking device and withdraw the flywheel taking care not to damage the plastic cooling fan. Remove the flywheel key.

## FLYWHEEL REPLACEMENT

**5.25** To fit the flywheel proceed as follows:

(1) Fit the flywheel key.

(2) Align the flywheel keyway with the key on the shaft and push the flywheel on the shaft as far as possible.

(3) Prevent the flywheel from turning as detailed in Paragraph 5.24(2).

(4) Fit a new tabwasher.

(5) Fit the retaining nut and tighten to a torque loading of 210Nm (155 lbf ft).

(6) Bend up the tabwasher to lock the retaining nut.

(7) Remove the flywheel locking device.

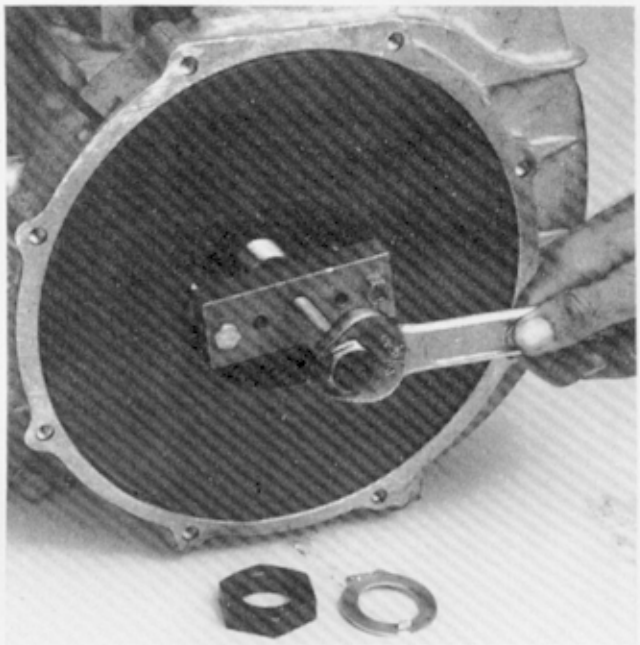


*Figure 5.14 Flywheel Removal*

## CRANKSHAFT

### Removal

**5.26** To remove the crankshaft proceed as follows:

(1) Remove the cylinder head(s) as detailed in Paragraph 5.3.

(2) Remove the flywheel and key as detailed in Paragraph 5.24.

(3) Remove the extension shaft on the crankshaft gearwheel (if fitted).

(4) Remove the eight 1/4 in. UNC socket head capscrews securing the gear-cover to the crankcase. The cover is dowelled to the crankcase and care should be taken to avoid damage.

**Note**

*The order in which the gear cover or extension shaft are removed will depend on the engine build.*

(5) Remove the crankshaft gearwheel retaining bolt and plate. Replace the retaining bolt to prevent damage to the shaft thread when removing the gearwheel.

(6) Using a suitable gearwheel puller (obtainable from Petters Limited or their representatives) remove the gearwheel. (Figure 5.15)

(7) Drain the oil from the sump and remove the sump (Section 2).

(8) On AC2 engines only remove the oil suction pipe and strainer (Section 2).

(9) Remove the cylinder(s), piston(s) and connecting rod(s) as detailed in Paragraph 5.16.

(10) On two cylinder engines remove the two bolts that hold the intermediate main bearing housing in position. Note the positions of the two bearing housing halves and remove.

(11) Remove the six 5/16 in. UNF self-locking nuts and washers retaining the flywheel end main bearing housing and guard.

(12) Remove the flywheel guard and housing assembly.

(13) Withdraw the crankshaft by pulling towards the flywheel end of the engine and remove the crankshaft thrust washers.

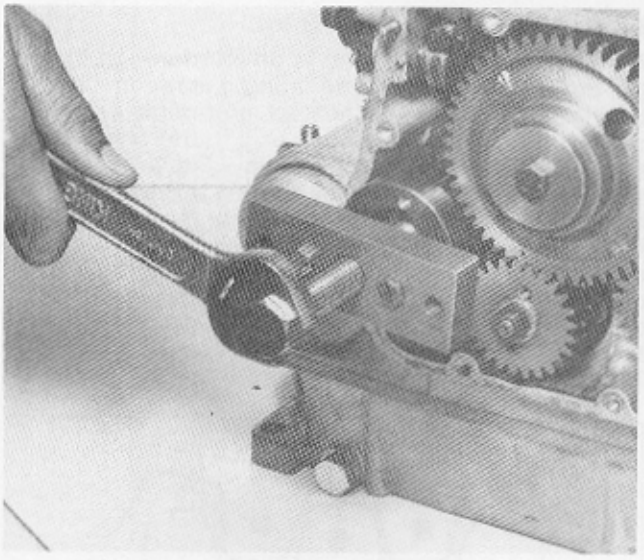


*Figure 5.15 Crankshaft Gearwheel Removal Using Gearwheel Puller*

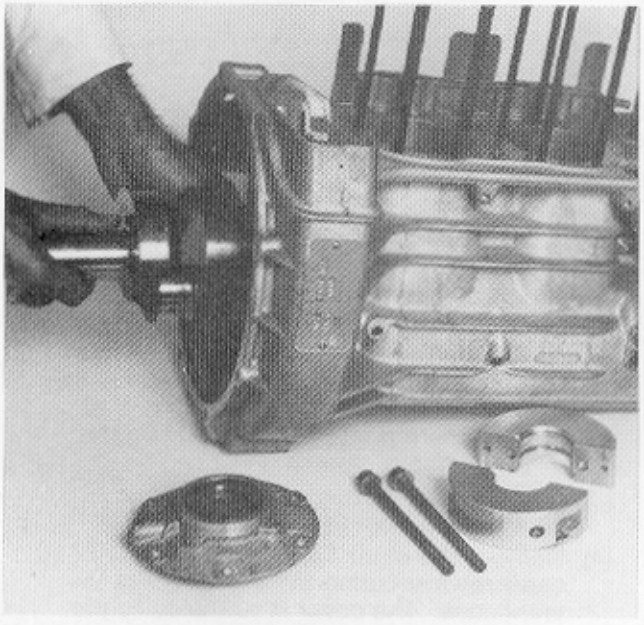


*Figure 5.16 Crankshaft Removal AC2 Engines*

## Crankshaft Maintenance

**5.27** Examine the bearing journals and crankpins for scoremarks and ovality. The ovality should not exceed the maximum of 0.063 mm (0.0025 in.). If the ovality exceeds the maximum tolerance the crankshaft must be reground to the diameter shown in Table 5.4 and undersize bearings fitted. Before refitting the crankshaft clean out the oil holes and ensure that they have radiused edges.

*TABLE 5.4 CRANKSHAFT REGRINDING DIAMETERS (ALL TYPES)*

| *Crankshaft* | *Main and Intermediate Journal and Crankpin* |
|---|---|
| *Standard* | **41.275 to 41.262 mm (1.6250 to 1.6245 in.)** |
| *Undersize 0.254 mm (0.010 in.)* | **41.021 to 41.008 mm (1.6150 to 1.6145 in.)** |
| *Undersize 0.508 mm 0.020 in.)* | **40.767 to 40.754 mm (1.6050 to 1.6045 in.)** |

## Main Bearing Maintenance

**5.28** The main bearings are of the precision thin wall, steel backed, sleeve type lined with a bearing metal. To renew these bearings a suitable mandrel must be used to press or drive the bearings out of their housings. Before fitting new bearings ensure that the crankcase/housing oil holes are clean. Ensure that the surface around the part numbers stamped on the bearing outer face is not raised, if so this should be removed before fitting.

## Gear End and Flywheel End Bearing Removal

**5.29** When removing a gear end bearing from the crankcase or a flywheel end bearing from its housing heat the crankcase or bearing housing in boiling water before pressing out the bearing.

## Gear End and Flywheel End Bearing Replacement

**5.30** To ease the fitting of a gear end or flywheel end bearing, heat the crankcase or bearing housing in boiling water; at the same time freeze the bearing (domestic refrigerator) before fitting. When replacing a bearing ensure that it enters the bearing housing or crankcase squarely and that the oil holes in the bearing and the crankcase housing are in line. Check that the bearing split is above the horizontal.

**Note**
*New bearings are machined to give the required fit when in position and should not be scraped or bedded in, neither should shims of any description be fitted.*

## Flywheel End Oil Seal

**5.31** When fitting the flywheel end oil seal ensure that it is fitted squarely in the housing before pressing or driving in. The seal face must be flush with the outer face of the bearing housing.

**Note**
*Before fitting a new oil seal it is important that the recess in the seal is filled with Shell Alvania R2 Grease. This is a Lithium Grease to NLG1 No 2 consistancy. In the event of non-availability of the grease soak the seal in engine lubricating oil at ambient temperature for 24 hours.*

## Crankshaft Replacement

**5.32** Before fitting the crankshaft ensure that the journal bearing surfaces and oil holes are clean. Place a small quantity of lubricating oil in the gear end bearing and on the crankshaft journals. To fit the crankshaft proceed as follows:

(1) Fit the gear end thrust washer on the locating dowels in the crankcase, making sure that the grooved side is away from the crankcase and the tongue is located in its groove. (Figure 5.17).

(2) Insert the crankshaft into the gear end bearing taking care not to damage the bearing surface.

(3) On AC2 engines, replace the top half of the intermediate bearing and housing. Ensure that the oilway cross hole is towards the flywheel end of the engine. Line up the matching numbers on both halves of the bearing housing and fit the bottom half. Fit the intermediate bearing bolts and washers and torque load the bolts to 41 Nm (30 lbf ft).

(4) Fit the flywheel end thrust washer on the locating dowels in the flywheel end main

bearing housing, making sure that the grooved side is away from the housing and the tongue located in its groove. (Figure 5.17).

(5) Fit the flywheel end main bearing housing together with gasket and flywheel guard. Tighten the six nuts diagonally.

**CAUTION**
**As the crankshaft is tapered it is not necessary to use an oil seal sleeve when fitting the flywheel end bearing and housing, but care must be taken to avoid damaging the seal on the keyway edges.**

(6) Check the crankshaft endfloat (Figure 5.18) by using a feeler inserted between the thrust washer face and the crankshaft. The endfloat should be between 0.076 to 0.609 mm (0.003 to 0.024 in.).

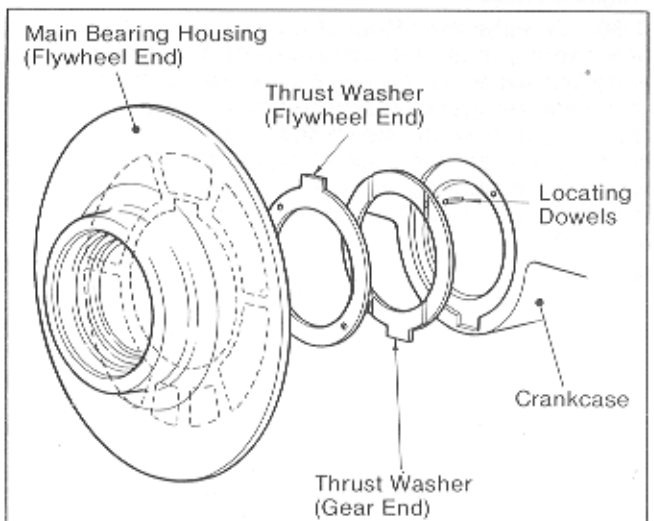



*Figure 5.17 Crankshaft Thrust Washers: Location*

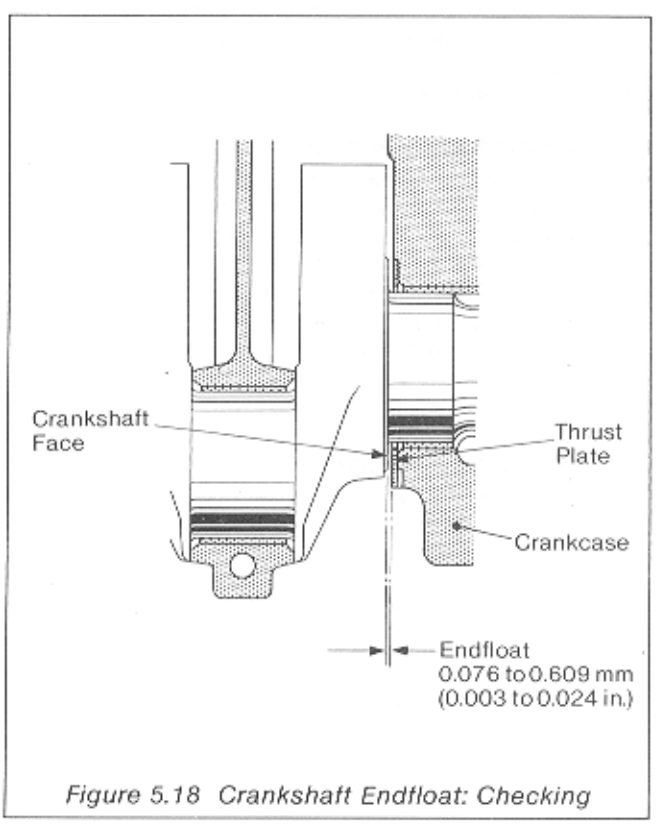



*Figure 5.18 Crankshaft Endfloat: Checking*

## Fitting the Crankshaft Gear

**5.33** The crankshaft gear is an interference fit on the crankshaft and to ease fitting it is recommended that the gear should be heated, preferably using an oil bath, before attempting to fit it to the crankshaft. If an alternative source of heat is used, ensure that the gearwheel is not overheated as this may effect the hardness. Before driving the gearwheel on to the shaft, ensure that the keyway is in line with the crankshaft key and the shaft is lightly oiled. If the camshaft is fitted ensure that the teeth marked with dots are in their relative positions (Figure 5.19). Fit the gearwheel retaining plate and securing screw. Tighten the screw to a torque 36.6 Nm (27 lbf ft).

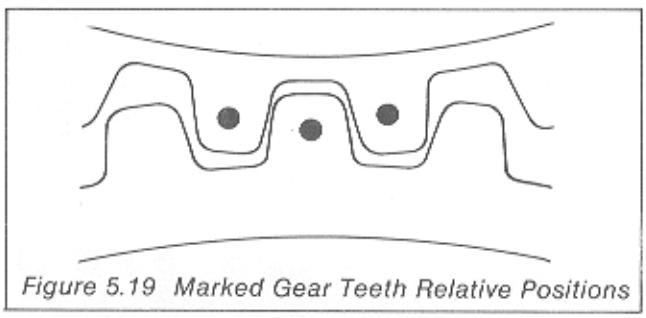


*Figure 5.19 Marked Gear Teeth Relative Positions*

## CAMSHAFT

**5.34** To remove the camshaft proceed as follows:

**Note**
*It is necessary on Model Build Engines (see Technical Data for Engine Serial Numbers) to remove the crankshaft gear as detailed in Paragraph 5.26.*

(1) Drain the oil from the sump.

(2) Drain and remove the fuel tank (Section 3). Remove the fuel pipes between injection pump and injector(s). Blank off all disconnected pipes and connections to prevent the ingress of dirt. Remove the injection pump. (Section 3).

(3) Remove any starting arrangement or accessories from the gear cover.

(4) Remove the eight 1/4 in. UNC socket head capscrews securing the gearcover to the crankcase. The cover is dowelled to the crankcase and care should be taken to avoid damage.

(5) Remove the rocker cover(s), rocker support(s) complete with rocker arms and withdraw the push rods noting their positions.

**Note**
*It is important that the push rods are returned to the same position on assembly.*

(6) Remove the fuel feed pump, gasket and operating push rod, if fitted.

(7) Stand the engine on its flywheel end and remove the sump.

(8) Remove the camshaft thrust plate retaining screws, these are accessible through holes in the gearwheel as shown in Figure 5.20. (see note).

**Note**
*Camshaft end float on AC1Z and AC1ZS engines before engine serial numbers 20000 and 10000, respectively, is controlled by the machined face of the crankcase and the inner face of the gear cover and therefore a thrust plate is not fitted.*

(9) Withdraw the camshaft from the gear end of the engine. Remove the cam followers noting their positions.

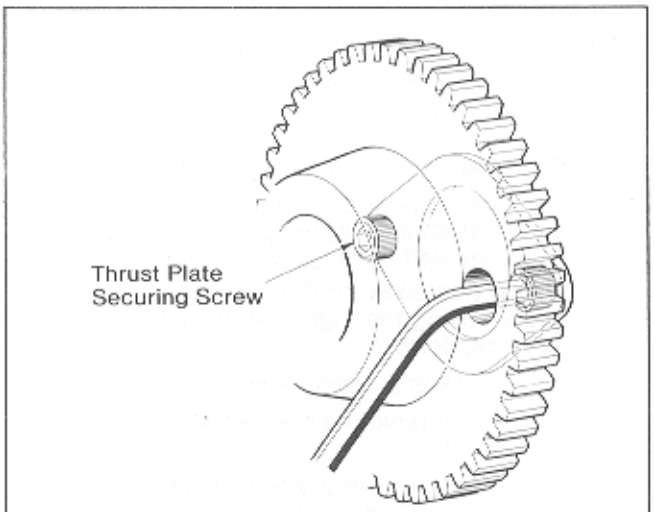



*Figure 5.20 Camshaft Thrust Plate Removal*

## Camshaft Gearwheel

**5.35** The camshaft gearwheel is a press fit on the camshaft. To fit a new thrust-plate or gearwheel, remove extension shaft, pinion, or starter dog (as fitted, dependant on engine). Remove the gearwheel retaining set screw and washer (if still fitted) and press the shaft from the gearwheel. The gearwheel is keyed to the shaft. A suitable extractor is obtainable from Petters Limited or their representatives.

## Camshaft Maintenance

**5.36** Check the camshaft cam lobes and cam followers for wear or damage. If worn or damaged it will be necessary to fit new parts. Check the camshaft core plug for security or leaks. If necessary fit a new core plug from the inside of the crankcase the cup bottom being entered first.

**5.37** Before fitting the camshaft check the camshaft bearings and thrustplate (where applicable) for damage or wear and renew, if necessary.

## Camshaft Replacement

**5.38** To fit the camshaft proceed as follows:

(1) To fit the camshaft gearwheel it is recommended that the gear should be heated, preferably using an oil bath, before attempting to fit it to the camshaft. If an alternative source of heat is used ensure that the gearwheel is not overheated as this may effect the hardness. Before pressing the gearwheel on to the shaft, ensure the thrust plate (where applicable) is fitted, the keyway is in line with the camshaft key and the shaft is lightly oiled. Fit the retaining washer and screw, fit starter dog or pinion, if applicable. Tighten the gearwheel securing screw to a torque loading of 36.6 Nm (27 lbf ft). Fit the extension shaft, if applicable.

(2) Check that the camshaft bearing surfaces are clean and lightly lubricated.

(3) Fit the camshaft followers in their noted positions.

(4) Insert the camshaft in position, if the crankshaft gear is fitted make sure that the marked teeth on the gearwheels are in their relative positions as shown in Figure 5.19.

(5) Align the thrust plate in position and tighten the retaining screws. (If applicable).

(6) With the exception of AC1Z and AC1ZS engines prior to engine serial numbers 20000 and 10000, respectively, check the camshaft end float using a dial indicator as shown in Figure 5.21. The end float should be between 0.08 to 0.25mm (0.003 to 0.010 in.).

(7) Secure the gear cover to the crankcase.

(8) On AC1Z and AC1ZS engines prior to engine serial numbers 20000 and 10000, respectively, check the camshaft end float by using a dial indicator on the face of the start dog which protrudes through the cover. The end float should be between 0.08 to 0.25mm (0.003 to 0.010 in.).

(9) Refit the sump using a new gasket and stand the engine on its base.

(10) Fit the push rods in their noted positions and assemble the rocker support and rocker arms; check the valve clearances as detailed in Paragraph 5.14.

(11) Fit the fuel feed pump, gasket and operating push rod, if fitted.

(12) Fit the fuel injection pump and pipes; time the fuel injection pump (Section 3).

(13) Fit the fuel tank (Section 3).

(14) Fill the engine sump with the correct type and grade of lubricating oil.

(15) Fit any starting arrangements or accessories.

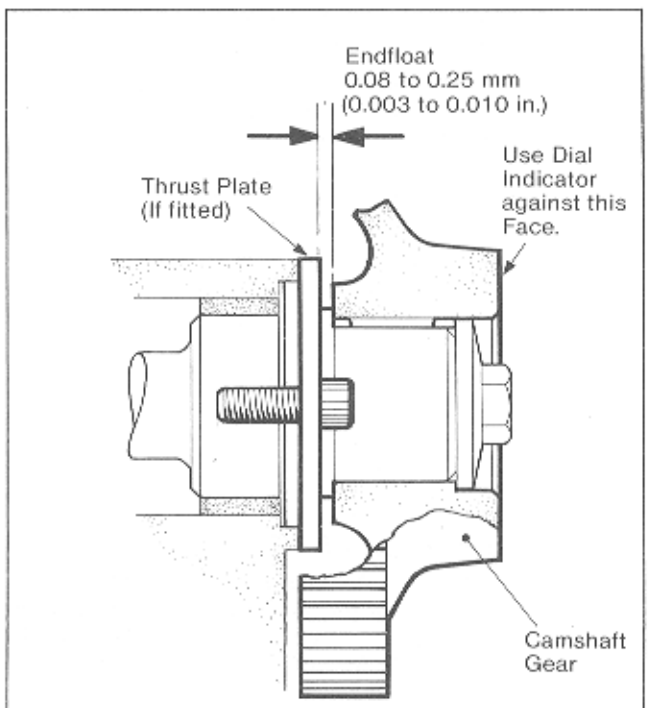



*Figure 5.21 Checking the Camshaft Endfloat*

## GOVERNOR AND LINKAGE

**5.39** The governor maintains a constant predetermined engine speed irrespective of load conditions and in the case of variable speed engines prevents the maximum permitted speed being exceeded. The governor system consists of steel balls housed in a cage which, with the application of centrifugal force operates a sliding cone. The movement of the cone is transmitted via a bracket, shaft and lever to the fuel pump where it controls the amount of fuel delivered to the fuel injector(s).

### Operation

**5.40** As the governor rotates, centrifugal force causes the steel balls to be thrown outwards moving the cone along the governor spindle. This in turn moves the governor bracket which is connected by a down shaft to the fuel pump rack operating lever. The centrifugal forces acting on the governor bracket are balanced by an adjustable speeder spring, which is located behind the governor bracket. The engine speed can be set (within a narrow range) by adjusting the pressure of the speeder spring. Adjustment outside this range can be achieved by fitting an alternative speeder spring. Petters Limited or their representatives should be consulted if this is required.

**5.41** Initially the spring brings the fuel pump rack into the starting position and as the engine starts and runs up to speed a balanced position between the centrifugal force of the governor assembly and the spring tension is achieved; the fuel supplied holds the engine at a steady speed. An increase in load reduces the speed and consequently the centrifugal force decreases allowing the fuel pump rack to open further to increase the fuel delivery. The engine speed recovers and a balance of forces is again achieved. Conversely if the load is removed the action is reversed and the fuel delivery is reduced.

## GOVERNOR

### Removal

**5.42** To remove the governor proceed as follows:

(1) Drain the oil from the sump.

(2) Drain and remove the fuel tank (Section 3). Blank off all disconnected pipes and connections to prevent ingress of dirt.

(3) Remove any starting arrangement or accessories from the gear cover.

(4) Remove the eight 1/4 in. UNC socket head capscrews securing the gear cover to the crankcase. The cover is dowelled to the crankcase and care should be taken on removal to avoid damage.

(5) Remove the governor gear wheel and retain the key.

(6) Remove the three 1/4 in. UNC capscrews securing the governor and withdraw the assembly.

### Maintenance (Figure 5.22)

**5.43** Clean the governor assembly in kerosene. Check the bearings, governor balls and sliding cone for wear or damage. If any parts of the governor are worn or damaged the governor must be renewed.

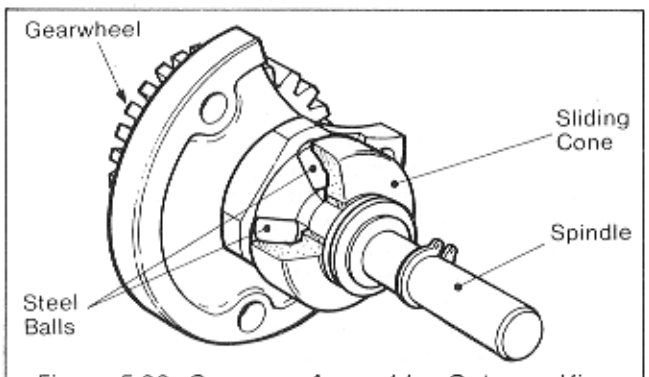



*Figure 5.22 Governor Assembly : Cutaway View Showing the Steel Balls*

### Replacement

**5.44** To fit the governor proceed as follows:

(1) Fit the governor assembly in position and secure using the three ¼ in. UNC capscrews.

(2) Fit the key in the governor shaft keyway.

(3) Align the keyway on the gearwheel to the key on the shaft and fit the gearwheel. Secure using the self-locking nut.

(4) Fit the gearcover to the crankcase and secure using the eight 1/4 in. UNC socket head capscrews.

(5) Fit any starting arrangements or accessories.

(6) Fit the fuel tank and connect the fuel pipes (Section 3).

(7) Fill the engine sump with the correct grade and type of lubricating oil.

## GOVERNOR LINKAGE

### Removal (Figure 5.23)

**5.45** To remove the governor linkage proceed as follows:

(1) Remove the governor assembly as detailed in Paragraph 5.42. It is not necessary to remove the governor gearwheel unless it is required to carry out maintenance on the governor assembly.

**Note**

*It is necessary on Model Build Engines (See Technical Data for Engine Serial Numbers) to remove the crankshaft gear (Paragraph 5.26) to remove the camshaft gearwheel.*

(2) Remove the camshaft gearwheel retaining bolt and washer. Refit the bolt and remove the gearwheel using an extractor, retaining the key. A suitable extractor is obtainable from Petters Limited or their representatives. Remove the bolt.

(3) Unscrew the governor speeder spring adjuster and remove the speeder spring (Figure 5.24).

(4) Remove the two 1/4 in. UNC capscrews **(2)** retaining the STOP/RUN lever assembly and remove the assembly.

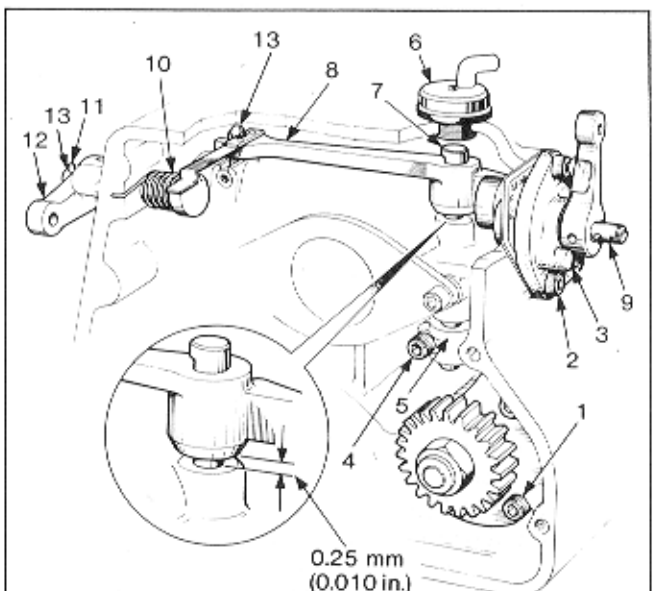



*Figure 5.23 Governor Linkage Assembly*

(5) Slacken the 1/4 in. UNF governor bracket capscrew **(4)** and remove the bracket **(5)**.

(6) Remove the breather assembly **(6)** or blanking plug (as applicable) from the top of the crankcase.

(7) Remove the operating lever **(8)** by lifting the shaft **(7)** and placing a suitable hard wood block at the base as shown in Figure 5.25. Place a short tubular drift over the top of the operating lever **(8)** and shaft. Drive the operating lever downwards allowing the shaft to pass up through the lever. Increase the thickness of the hard wood block in stages until the operating shaft **(7)** is clear of the operating lever **(8)**.

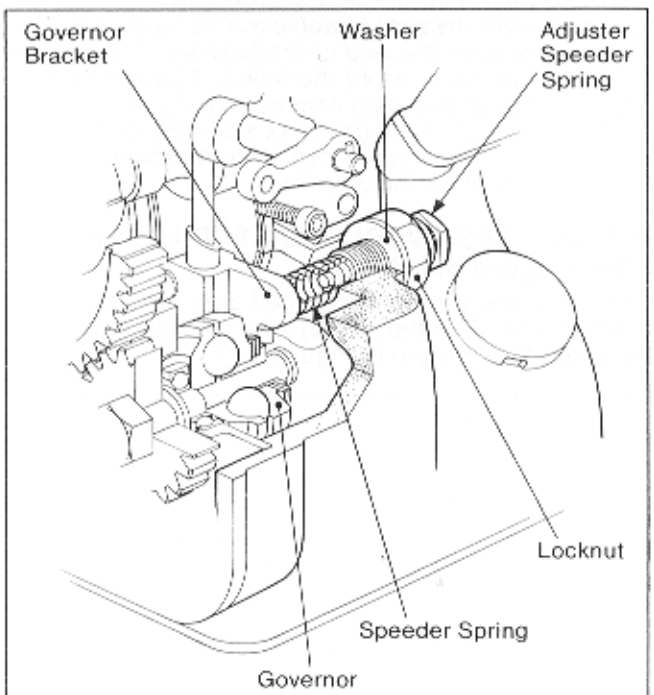



*Figure 5.24 Governor Speeder Spring Location*

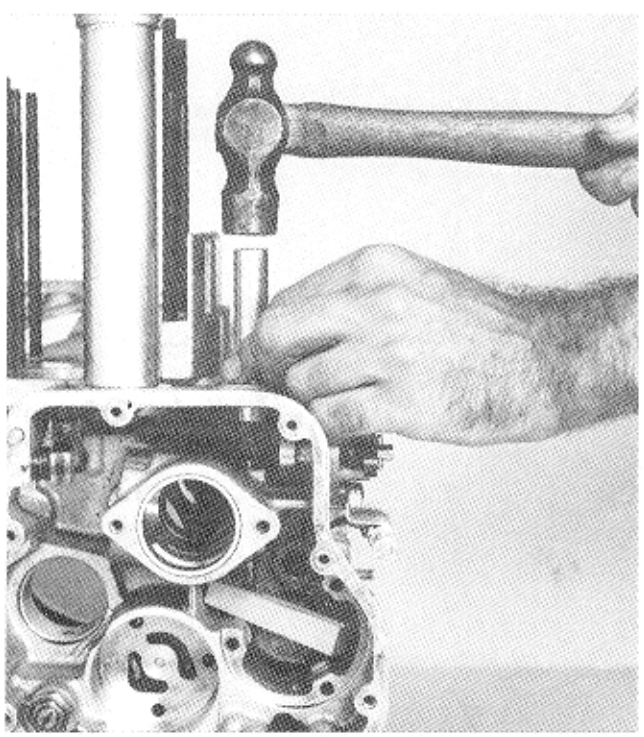


*Figure 5.25 Governor Shaft Removal*

## Maintenance

**5.46** Clean all component parts in kerosene and examine for signs of wear. Renew worn parts.

## Assembly (Figure 5.23)

**5.47** To fit the governor linkage proceed as follows:

(1) Position the fuel pump operating lever **(8)** in the crankcase and gently tap the operating shaft **(7)** into the lever until it comes to a stop.

(2) Fit the governor bracket **(5)** tighten the securing screw **(4)** sufficiently to ensure that the bracket will not fall off.

(3) Fit the governor assembly and fully tighten the three securing capscrews.

(4) Fit the speeder spring and adjuster (final adjustment to be carried out with the engine running) (Section 3).

## Setting the Governor Linkage (Figure 5.23)

**5.48** If the engine is fitted with a variable speed or two speed control set in the maximum speed position and proceed as follows:

**Note**
*To set the governor linkage the fuel injection pump must be fitted (Section 3).*

(1) Slacken the governor bracket capscrew **(4)**. The governor bracket should be hard against the governor, with its sliding cone and rotating housing together. This should be achieved by the action of the speeder spring.

(2) Operate the overload stop (if fitted) and push the fuel injection pump operating lever **(8)** in as far as possible into the crankcase, that is the maximum fuel position.

(3) With reference to the inset shown in Figure 5.23 set the distance between the fuel pump operating lever and the top of the governor shaft bush using a feeler gauge to 0.25 mm (0.010 in.). This adjustment is achieved by moving the governor bracket up or down the shaft.

(4) Tighten the governor bracket capscrew. Fit the STOP/RUN lever assembly and tighten down the two retaining capscrews.

(5) Set the overload stop if necessary (early type) as detailed in Paragraph 5.50.

(6) Fit the breather assembly or blanking plug.

(7) Fit the camshaft gear.

(8) Fit the gear cover and accessories (if fitted).

(9) Fill the engine sump with the correct grade and type of lubricating oil.

(10) Fit the fuel tank and connect the fuel pipes.

## OVERLOAD STOP (IF FITTED) (Figure 5.23)

**Note**
*The overload stop is set by Petters Limited and should not be disturbed. On early types do not loosen the clamping screw when removing the overload stop.*

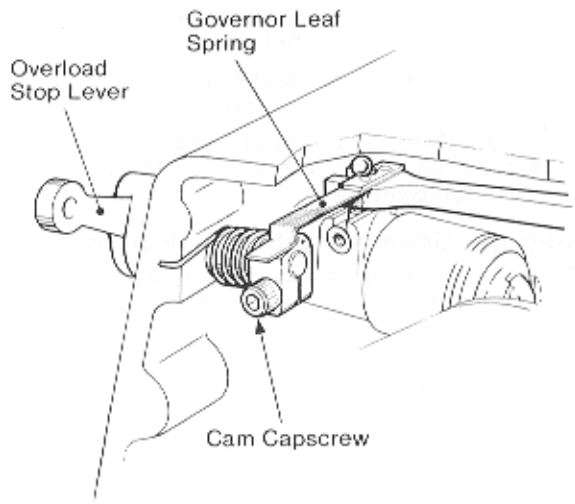
**5.49** If oil is leaking from around the spindle **(13)** or the overload stop return spring **(10)** is damaged remove the pin **(11)** securing the overstop lever **(12)** and remove the lever. Withdraw the spindle and spring from inside the crankcase. On completion it will be necessary to set the overload stop.

## SETTING THE OVERLOAD STOP EARLY TYPE (Figure 5.26)

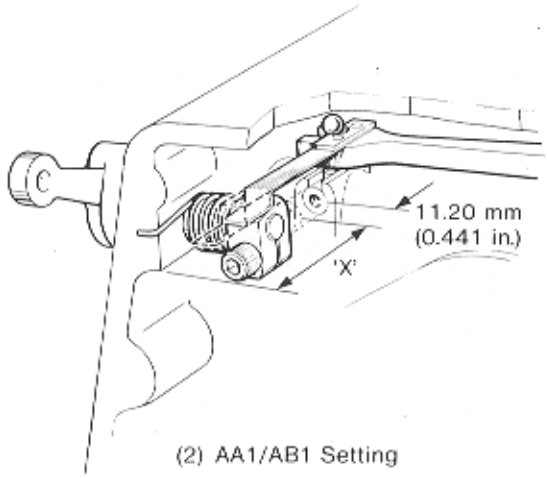
**Note**

*It is important to set the overload stop accurately as it can not be adjusted with the engine assembled.*

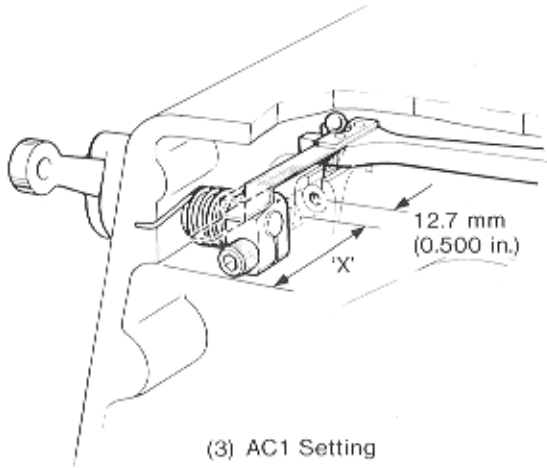
**5.50** Set the STOP/RUN lever fully to the STOP position and measure the distance between the end of the fuel pump rack and the gear cover face. Note this measurement 'X'.




(1) Overload Stop




(2) AA1/AB1 Setting




(3) AC1 Setting

*Figure 5.26 Overload Stop Early Type : Setting-up*

### AA1/AB1 Engine (Figure 5.26(2))

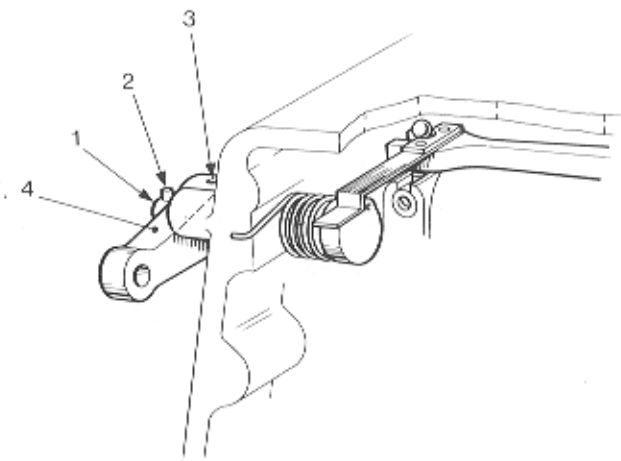
**5.51** Set the STOP/RUN lever to the RUN position. Add 11.20 mm (0.441 in.) to the distance 'X' measured in Paragraph 5.50 and move the operating lever inwards to achieve this calculated distance between the end of the fuel pump rack and the gear cover face. Hold the rack in this position and set the overload stop cam so that it just touches the step of the governor leaf spring. To move the cam slacken the securing capscrew to allow it to rotate on the spindle.

### AC1 Engine (Figure 5.26(3))

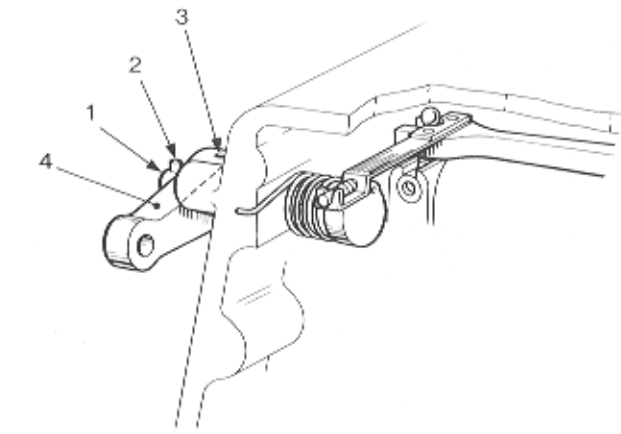
**5.52** Set the STOP/RUN lever to the RUN position. Add 12.70 mm (0.500 in.) to the distance 'X' measured in Paragraph 5.50 and move the operating lever inwards to achieve this calculated distance between the end of the fuel pump rack and the gear cover face. Hold the rack in this position and set the overload stop cam so that it just touches the step of the governor leaf spring. To move the cam slacken the securing capscrew to allow it to rotate on the spindle.

## SETTING THE OVERLOAD STOP LATER TYPE (Figure 5.27)

**5.53** To initially set the overload stop turn the spindle **(1)** to align the pin **(2)** with the hole **(3)** in the lever **(4)** as shown in Figure 5.27.




(1) AA1, AB1, AC1, AC1Z and AC2 (fixed speed only) Engines




(2) AC2 (variable speed only) Engines

*Figure 5.27 Initial Setting of Overload Stop Later Type*

## CHECKING THE OVERLOAD STOP SETTING

**5.54** To check the overload stop setting, the engine has to be accelerated from idle to full speed as quickly as possible with no load and the level of exhaust smoke checked. When set correctly the exhaust should be a barely visable haze.

### Fixed Speed Engines

**5.55** To check the overload stop setting on a fixed speed engine proceed as follows:

(1) Run the engine on load until the engine reaches its normal working temperature.

(2) Remove the load from the engine.

(3) Adjust the speed control to give full rated speed as detailed in Section 3.

(4) Move the STOP/RUN lever towards the STOP position to decrease the engine speed. Obtain an idle speed and allow it to stabilise for a few seconds; move the lever sharply to the run position to accelerate the engine. Turn the overload stop spindle **(2)** counter-clockwise in small amounts until black smoke is emitted from the exhaust when the engine is accelerated. It may be necessary to repeat the procedure several times until this is achieved.

(5) When black smoke is emitted from the exhaust turn the spindle **(2)** clockwise by a small amount and accelerate the engine. Repeat the procedure turning the spindle by a small amount at a time until the black smoke just clears and barely visible haze is emitted.

### Variable Speed Engines

**5.56** To check the overload stop setting on a variable speed engine proceed as follows:

(1) Run the engine on load until the engine reaches it normal working temperature.

(2) Remove the load from the engine.

(3) Adjust the speed control to give full rated speed as detailed in Section 3.

(4) Obtain an idle speed and allow it to stabilise for a few seconds; accelerate the engine to full speed using the variable control. Turn the overload stop spindle **(1)** counter-clockwise in small amounts until black smoke is emitted from the exhaust when the engine is accelerated. It may be necessary to repeat this several times until this is achieved.

(5) When black smoke is emitted from the exhaust turn the spindle **(1)** clockwise by a small amount at a time until the black smoke just clears and barely visible haze is emitted.

## EXTENSION SHAFT/STARTING SHAFT

### Bearing Maintenance (if fitted)

**5.57** Should it be necessary to renew the support bearing(s) it is recommended to place the housings in a container of boiling water for a few minutes. This will ease removal and replacement. Fitting procedure is as described for the main bearings.

### Oil Seals (if fitted)

**5.58** Ensure that when replacing an oil seal it is fitted squarely into the housing, and when fitting the housing assembly over the shaft care is taken not to damage oil seal lip. Failure to observe these precautions will result in oil leaks.

# SECTION 6
# COMMON VARIANTS AND ACCESSORIES

## 4:1 HAND STARTING-GEAR END (FIGURE 6.1)

### Removal

**6.1** To remove the 4:1 hand starting gear end proceed as follows:

(1) Remove the three screws securing the starting gear guard **(1)** and remove the guard.

**Note**
*Normal servicing can be carried out with the guard removed. The gearwheels should be lubricated with a proprietary gear spray and the sliding plate assembly, locating screws and starting handle shaft recess lightly oiled.*

(2) Remove the starting gearwheel retaining spring clip assembly **(2)**, circlip **(3)** and the gearwheel **(4)**.

(3) Remove the crankshaft extension shaft gearwheel retaining screw **(5)** and plate **(6)**. Remove the gearwheel **(17)** which is keyed to the shaft **(12)**.

(4) Remove the two shouldered screws **(7)** securing the sliding plate **(8)** to the mounting plate **(9)**.

(5) Remove the sliding plate.

(6) Remove the screws securing the mounting plate and remove the mounting plate and guard **(11)** from the engine gear cover.

### Maintenance

**6.2** Clean and inspect all parts paying particular attention to the gears and bushes. Replace all worn or damaged parts.

### Assembly

**6.3** To assemble the 4:1 hand starting (gear end) proceed as follows:–

(1) Position the sliding plate **(8)** on top of the mounting plate **(9)** and insert the return spring **(10)** in the pilot hole on the sliding plate and in the smallest hole on the mounting plate.

(2) Secure the sliding plate to the mounting plate using the two shouldered screws **(7)**. One through the bottom hole and one through the slot. Torque load the screws to 24 Nm (18 lbf ft).

(3) Place the starting gear guard (inner) **(11)** in position over the crankshaft extension shaft **(12)** and attach the mounting plate and sliding plate assembly to the gear cover through the backplate. Use the longer shouldered set screw **(13)** through the slot, the shorter set screw and washer **(14)** in the counter-bored hole and the longer set screw, washer and collar **(15)** through the centre of the return spring. Torque load the screws to 24 Nm (18 lbf ft).

(4) Insert the key in the crankshaft extension **(12)** and fit the extension shaft gearwheel **(17)**. Fit the retaining washer **(6)** and set screw **(5)**. Torque load the set screw to 24 Nm (18 lbf ft).

(5) Press the bearing **(16)** into the starting gearwheel **(4)** and fit the assembly onto the sliding plate shaft. Retain with the circlip **(3)**.

(6) Fit the retaining spring clip assembly **(2)** to the inner starting gear guard using two cap screws, nuts and washers.

(7) Attach the outer starting gear guard using the three screws.

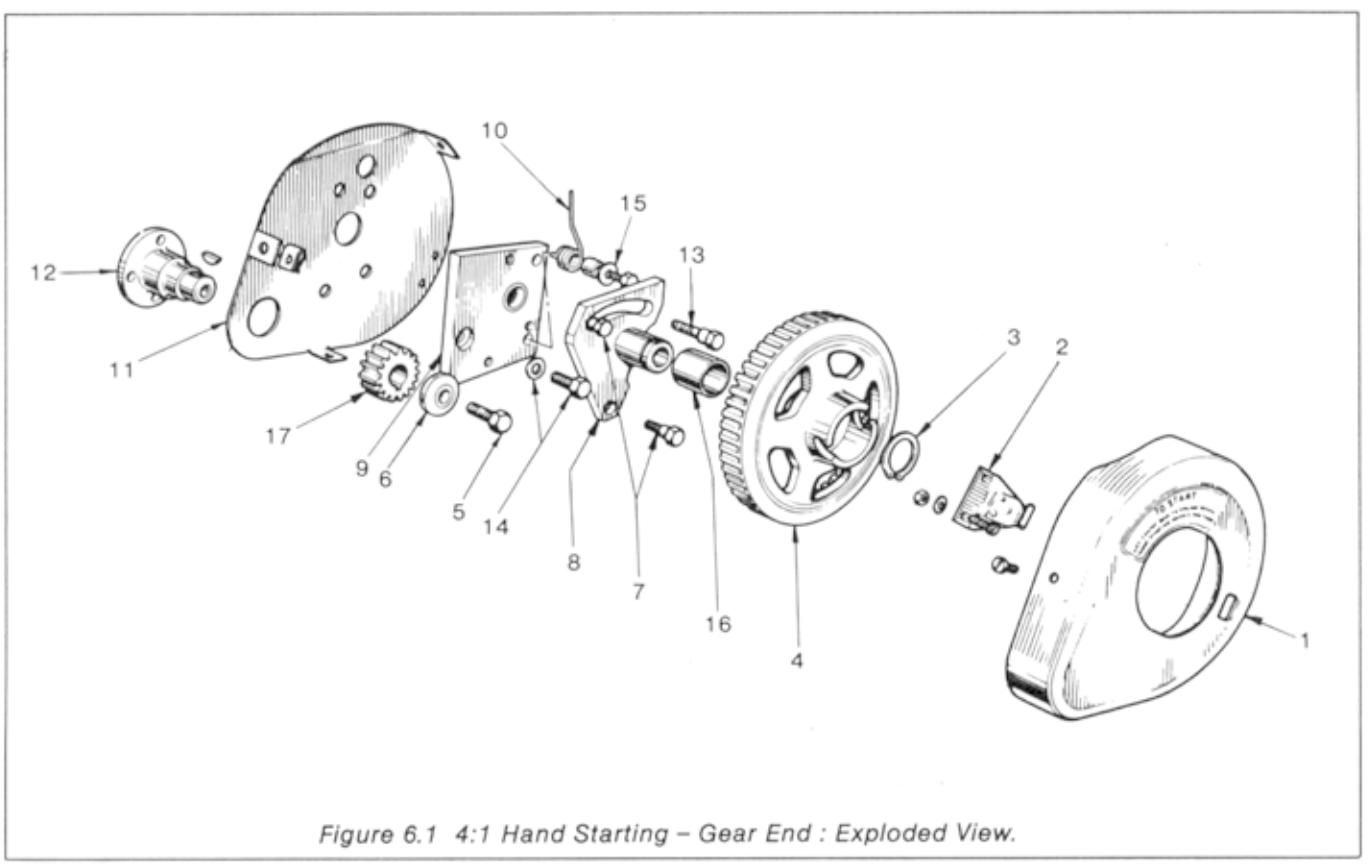



*Figure 6.1 4:1 Hand Starting – Gear End : Exploded View.*

## 4:1 HAND STARTING – FLYWHEEL END (FIGURE 6.2)

### Removal

**6.4** To remove the 4:1 hand starting flywheel end proceed as follows:

(1) Remove the four screws securing the starting gear guard **(1)** and remove the guard.

**Note**

*Normal servicing can be carried out with the guard removed. The gearwheels should be lubricated with a proprietary gear spray and the sliding plate assembly, locating screws and starting handle shaft recess lightly oiled.*

(2) Remove the starting gearwheel retaining spring clip assembly **(2)** by removing the two capscrews.

(3) Remove the circlip **(3)** and withdraw the gearwheel **(13)** and bearing **(12)** from the sliding plate shaft.

(4) Remove the three shouldered set screws **(4)** securing the sliding plate assembly **(5)** to the mounting plate **(6)**. Remove the two setscrews and washers **(11)** securing the sliding plate stops **(7)**. Remove the stops and spring **(8)**.

(5) Remove the four screws securing the mounting plate to the engine bell housing face and remove the mounting plate.

(6) Remove the four bolts **(9)** securing the pinion **(10)** to the flywheel and remove the pinion.

### Maintenance

**6.5** Clean and inspect all parts. Replace all worn or damaged parts. Renew the spring **(8)** and clip **(2)**.

### Assembly

**6.6** To assemble the 4:1 hand starting (flywheel end) proceed as follows:

(1) Fit the pinion **(10)** to the flywheel centre recess and secure with the four bolts **(9)**. Torque load the bolts to 34 to 41 Nm (25 to 30 lbf ft).

(2) Fit the mounting plate **(6)** vertically to the engine bell housing face with the bushed hole uppermost. Secure with the four screws torque loaded to 24 Nm (18 lbf ft).

(3) Fit the sliding plate stops **(7)** to the mounting plate using the two set screws and washers **(11)**. Torque load to 16 Nm (12 lbf ft).

(4) Loosely attach the sliding plate assembly **(5)** to the mounting plate, with the single slot uppermost, position by means of the two shouldered set screws **(4)** located in the lower slots. Insert a new spring **(8)** and fit the third shouldered set screw **(4)**. Torque load the three screws to 24 Nm (18 lbf ft).

(5) Press the starting gearwheel bearing **(12)** into the gearwheel **(13)** and position the gearwheel assembly onto the sliding plate shaft. Fit the retaining circlip **(3)**.

(6) Fit a new spring clip assembly **(2)** to the mounting plate with the cap screws, using the two holes below the gearwheel in the mounting plate. Torque load the screws to 16 Nm (12 lbf ft).

(7) Check that the load required to lift the gear out of the spring clip is between 10.8 to 12.7 Kg (24 to 28 lb). Adjustment is achieved by altering the set of the spring clip assembly.

(8) Attach the guard using the four set screws to the bell housing face.

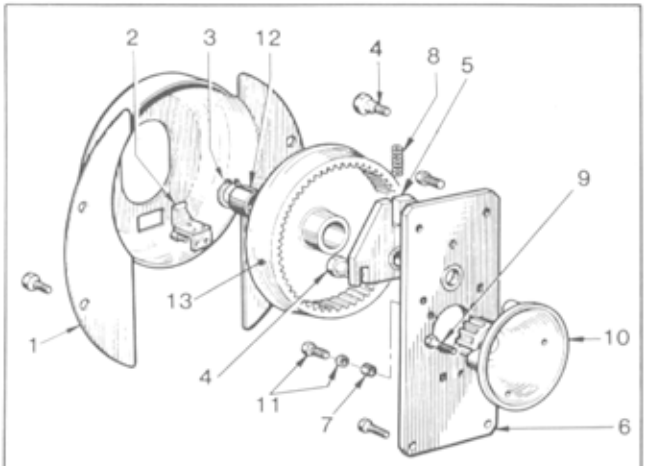



*Figure 6.2 4:1 Hand Starting – Flywheel End : Exploded View*

## RAISED HAND STARTING (FIGURE 6.3)

**6.7** To remove the raised hand starting proceed as follows:

(1) Loosen the starting handle shaft retaining screw **(1)** but do not remove it.

(2) Remove the circlip **(2)** from the starting handle shaft **(3)** and take off the washers **(4)**.

(3) Remove the five 5/16 in. UNC screws **(5)** retaining the outer chain housing and draw it off the dowels.

(4) Remove the starting handle shaft retaining screw **(1)** remove the shaft, upper chainwheel **(6)**, shaft retaining collar **(7)** and chain **(8)**.

(5) Remove the outer circlip **(9)** and washer **(10)** from the extension shaft **(11)** and gently slide the lower chainwheel **(12)** and clutch assembly **(13)** off the shaft.

(6) Remove the washer **(19)** and inner circlip **(14)**.

(7) Remove the two 5/16 in. UNC cap screws **(15)** from the back of the inner chain housing **(16)** and remove the housing.

### Maintenance

**6.8** Clean and inspect all parts paying particular attention to wear on the bushes **(17)**, clutch **(13)** and oil seal **(18)** renew defective parts.

### Assembly

**6.9** Before assembly immerse the chain in oil and lubricate the chainwheels using Shell Ensis 20 oil, or equivalent, and pack the clutch with water resistant grease. To assemble the raised hand starting proceed as follows:

(1) Fit the inner chain housing to the gear cover and retain using the two 5/16 in. UNC cap screws **(15)**.

(2) Fit the inner circlip **(14)** and washer **(19)** to the extension shaft.

(3) Fit the lower chainwheel **(12)** and clutch assembly **(13)** to the extension shaft. Ensure that the chainwheel and clutch are fitted the correct way round, that is when turned clockwise the clutch grips and when turned counter-clockwise the clutch is free. Fit the washer **(10)** and outer circlip **(9)**.

(4) Fit the chain **(8)**, upper chain wheel **(6)**, shaft

retaining collar **(7)** and shaft **(3)** and secure with the retaining screw **(1)**.

(5) Fit the outer chain cover to the dowels and secure using the five 5/16 in. UNC screws.

(6) Fit the three washers **(4)**, ensuring that the felt washer is sandwiched between the two steel washers. Fit the circlip **(2)** to the starting handle shaft **(3)**.

(7) Torque load the starting handle shaft retaining screw **(1)** to 36 Nm (27 lbf ft).

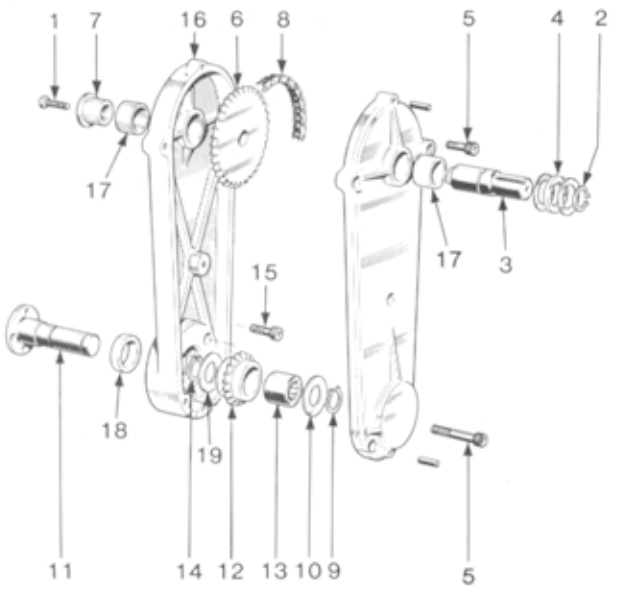



*Figure 6.3 Raised Hand Starting : Exploded View*

## 3.5:1 HANDSTART ROLLER CLUTCH FLYWHEEL END (FIGURE 6.4)

### Removal

**6.10** To remove the 3.5:1 flywheel end handstart proceed as follows:

(1) Remove the three retaining screws and washers from the starting gear cover and remove the cover **(1)**.

(2) Remove the retaining circlip **(2)** and gearwheel **(3)**.

(3) Remove the four set screws and washers retaining the mounting plate assembly **(4)** to the engine bell housing. Withdraw the assembly.

(4) Prevent the flywheel from turning, unscrew the four bolts **(5)** and remove the shaft and pinion assembly **(8)** **(9)** from the flywheel.

### Roller Clutch Dismantling

**6.11** To dismantle the roller clutch remove the retaining screw **(6)** and washer **(7)**. Withdraw the roller clutch and pinion **(8)** from the extension shaft **(9)**. Drain the lubricating oil from the shaft.

### Maintenance

**6.12** Clean and inspect all parts for damage, renew as necessary.

### Roller Clutch Assembly

**6.13** To assemble the roller clutch proceed as follows:

(1) Fit the roller clutch and pinion **(8)** to the extension shaft **(9)**. Ensure that it is fitted so as to grip when rotated clockwise as viewed from shaft end.

(2) Using a syringe fill the small oil reservoir in the shaft via the shaft retaining screw hole with 7cc of SAE 20W/20 lubricating oil.

(3) Fit the retaining washer **(7)** and screw **(6)** and torque load to 8 Nm (6 lbf ft). Lock using Loctite 87AV (or suitable equivalent).

### Assembly

**6.14** To assemble the flywheel end handstart proceed as follows:

(1) Fit the shaft and pinion assembly **(8)** **(9)** to the flywheel and torque the four securing bolts **(5)** to 34 Nm (25 lbf ft).

(2) Fit the mounting plate **(4)** to the crankcase.

(3) Lubricate the gear wheel bush, fit the gearwheel **(3)** and retaining circlip **(2)**.

(4) Fit the gear cover using the three retaining screws and washers.

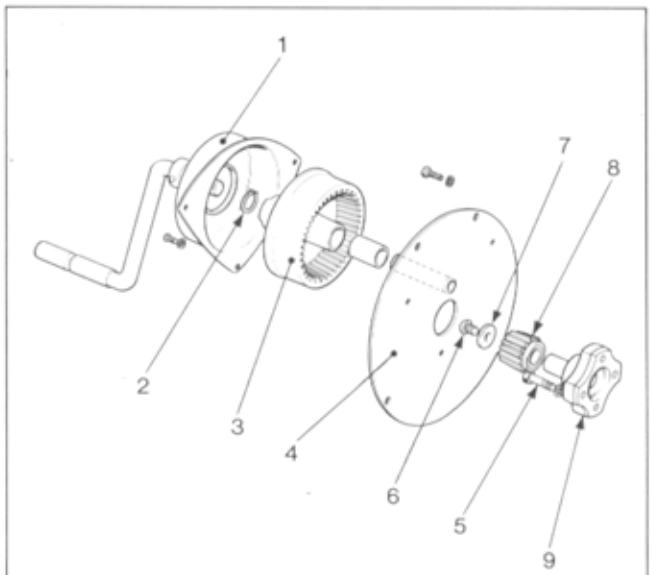



*Figure 6.4 3.5:1 Handstart Roller Clutch Flywheel End : Exploded View*

## 3.5:1 HANDSTART ROLLER CLUTCH GEAR END (FIGURE 6.5)

### Removal

**6.15** To remove the 3.5:1 handstart gear end proceed as follows:

(1) Remove the three retaining screws and washers from the gearwheel guard. Remove the guard **(1)**.

(2) Remove the retaining circlip **(2)** and the gearwheel **(3)**.

(3) Remove the three set screws and washers securing the backplate **(4)** and mounting bracket **(5)** to the adaptor **(6)**.

(4) Remove the pinion retaining circlip **(7)** and washer **(8)**, slide off pinion complete with roller clutch **(9)** from extension shaft **(10)**)

(5) Remove the gear cover and extension shaft.

**Note**
*On the latest engines it is not necessary to remove the gear cover as access is available to the extension shaft bolts.*

(6) Remove the plug from the end of the extension shaft and drain the lubricating oil from the shaft.

### Maintenance

**6.16** Clean and inspect all parts for damage, renew as necessary.

### Assembly

**6.17** To assemble the gear end hand start proceed as follows:

(1) Fit the extension shaft and torque load the four retaining screws to 19 Nm (14 lbf ft). Secure the gearcover to the crankcase (if removed).

(2) Fit the backplate **(5)** and mounting plate **(4)**.

(3) Slide the roller clutch and pinion assembly onto the extension shaft. Ensure that the clutch grips when rotated in a counter-clockwise direction as viewed from shaft end. Fit the retaining washer **(8)**and circlip **(7)**.

(4) Using a syringe fill the small oil reservoir in the shaft with 7cc of SAE20W/20 lubricating oil.

(5) Screw the plug in the extension shaft and torque load to 8 Nm (6 lbf ft). Lock the plug using Loctite 87AV (or suitable equivalent).

(6) Lightly lubricate the gearwheel bush, fit the gearwheel **(3)** and circlip **(2)**.

(7) Fit the gearwheel guard **(1)**.

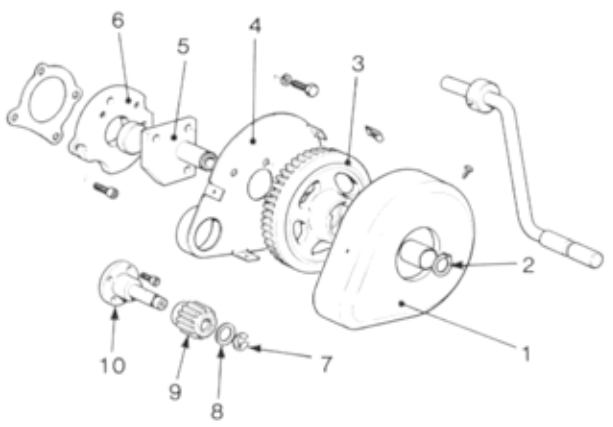



*Figure 6.5 3.5:1 Handstart Roller Clutch Gear End : Exploded View*

## CLUTCH SINGLE PLATE (FIGURE 6.6)

### Removal

**6.18** To remove the single plate clutch proceed as follows:

(1) Remove the eight 5/16 in. UNC capscrews **(1)** securing the clutch housing **(2)** to the crankcase and withdraw the housing complete with operating lever and shaft.

(2) Slacken the six 5/16 in. UNF screws **(3)**, securing the clutch to the flywheel, half a turn at a time working diagonally across the clutch until the clutch spring pressure is released. Remove the screws.

(3) Remove the clutch cover assembly **(4)** and clutch disc from the flywheel; the clutch cover assembly is dowelled to the flywheel.

### Maintenance

**6.19** Carry out the following procedure:

(1) Check the clutch cover assembly **(4)**, thrust bearing **(6)** and the clutch linings for wear, the surfaces should have a clean

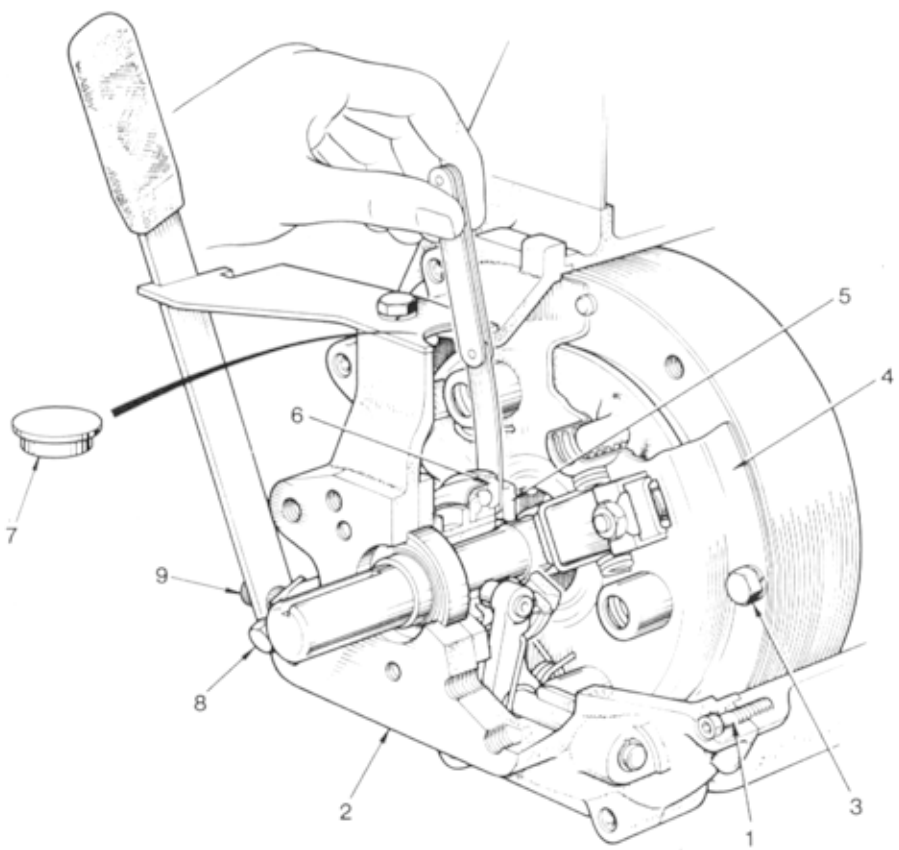



*Figure 6.6 Clutch Single Plate : Cutaway View*

appearance. If the surfaces have a glazed or varnished appearance ensure that oil is not penetrating to the clutch housing from the engine.

(2) Check the clutch disc and splines for wear. If worn fit new parts.

### Replacement

**6.20** Ensure that the clutch disc is centralized and is fitted with the longer end of the splined hub away from the flyheel. Fit the clutch as follows:

(1) Fit the clutch cover assembly to the flywheel locating it on the dowels. Secure to the flywheel using the six 5/16 in. UNF screws. Working diagonally tighten the screws half a turn at a time.

(2) Fit the clutch housing complete with operating lever and shaft. Secure the housing using the eight 5/16 in. UNC cap screws.

### Adjustment

**6.21** Remove the plug **(7)** from the top of the clutch housing and check the clearance between the thrust plate **(5)** and the thrust bearing **(6)** using a feeler gauge as shown in Figure 6.6. The clearance should be between 2.5 to 2.8 mm (0.10 to 0.15 in). If necessary the clearance can be adjusted by loosening the operating lever pinch bolt **(8)** and with the lever in the engaged position as shown alter the position of the shaft **(9)** relative to the operating lever by turning the shaft against the spring pressure until the feeler gauge is just gripped between the thrust bearing and the thrust plate. Tighten the pinch bolt. Check the clearance and fit the plug.

## CENTRIFUGAL CLUTCH

### Removal

**6.22** Remove the clutch retaining screw and withdraw the clutch. The clutch is keyed to the shaft.

### Maintenance

**6.23** The centrifugal clutch manufacturer's servicing instructions should be carried out as appropriate.

### Replacement

**Caution**

**Ensure that the clutch is a hand push fit on the shaft to avoid internal engine damage.**

**6.24** Locate the clutch on the shaft, lining up the keyway tighten the clutch retaining screw.

## REDUCTION GEAR (FIGURE 6.7)

### Removal

**6.25** To remove the reduction gear carry out the following procedure:

(1) Drain and remove the fuel tank (Section 3).

(2) Remove the oil drain plug **(1)** from the reduction gear housing and drain the oil.

(3) Remove the six 1/4 in. UNC screws **(2)** securing the bearing housing **(3)** to the reduction gear housing **(4)**.

(4) Remove the housing complete with the power take-off shaft **(5)** and the driven gearwheel **(6)**. Retain the shims **(7)**.

(5) Remove the eight 1/4 in. UNC screws securing the reduction gear housing and remove the housing.

(6) Remove the four 1/4 in. UNF nuts **(8)** and washers or capscrews (2:1 ratio) securing the driving gearwheel **(9)**.

### Maintenance

**6.26** Check the bearings and gearwheels for wear and damage, renew if necessary. If renewing the taper roller bearings the housings should be placed in boiling water before attempting to remove or fit the bearing tracks. After a few minutes sufficient expansion will have taken place, to ease removal or replacement.

### Replacement

**6.27** To replace the reduction gear proceed as follows:

(1) Fit a new oil seal **(11)** ensuring that it is fitted squarely with its outer face flush with the bearing housing **(3)**.

(2) Fit the driving gearwheel **(9)** to the camshaft and secure using the four 1/4 in. UNF nuts and washers, or capscrews (2:1 ratio).

(3) Fit the reduction gear housing and secure using the eight 1/4 in. UNC screws.

(4) Assemble the outer bearing housing **(3)** over the power take-off shaft assembly using an oil seal sleeve (obtainable from Petters Limited or their representatives).

**Note**

*The endfloat is achieved by using shims of varying thickness fitted between the inner and outer bearing housings. Initially it is advisable to fit sufficient shims to give excessive endfloat and then correct back.*

(5) Fit the shims retained in paragraph 6.25 (4).

**Caution**

**If the outer bearing housing is fully tightened down with insufficient shims (no endfloat) it could result in cracked housings.**

(6) Fit the outer bearing housing and shaft assembly.

(7) Using a dial test indicator check the endfloat of the power take-off shaft is 0.05 to .127mm (0.002 to 0.005 in.) Adjust if necessary by means of the shims.

(8) Tighten the outer bearing housing securing bolts.

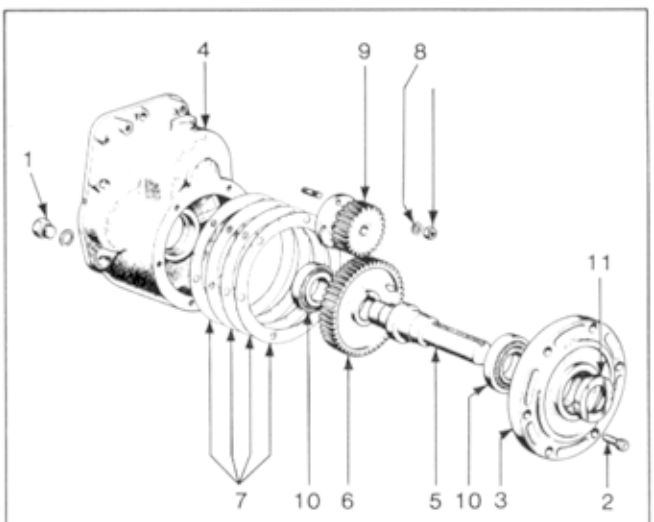



*Figure 6.7 Reduction Gear : Exploded View*

## COLD STARTING PRIMING PUMP (FIGURE 6.8)

**6.28** This priming device consists of an oil reservoir from which a plunger is used to pump a small quantity of engine oil into the inlet port(s) to assist engine starting in cold weather. The reservoir level is maintained via an external oil feed pipe.

### Removal

**6.29** To remove the cold starting priming pump proceed as follows:

(1) Disconnect the external oil feed pipe **(1)**.

(2) Remove the rocker cover and reservoir securing bolts **(2)**.

(3) Lift off the cover gasket **(3)** and anti-surge shim **(4)**.

(4) Remove the reservoir and plunger assembly **(5)**.

### Maintenance

**6.30** Carry out the following procedure:

(1) Pull out the priming plunger assembly **(6)**.

(2) Clean and inspect all parts.

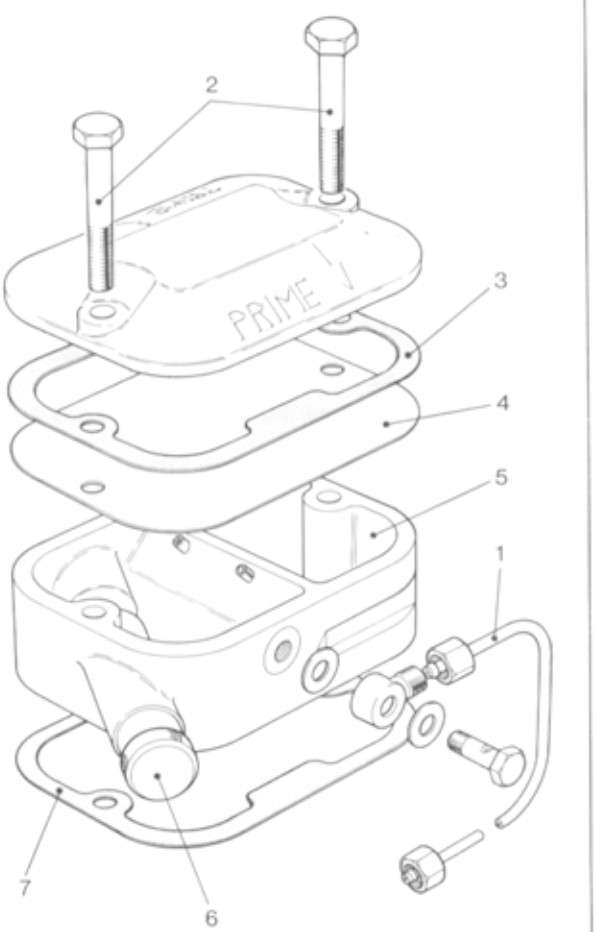



*Figure 6.8 Cold Starting Priming Pump*

### Replacement

**6.31** Renew all 'O' ring seals and proceed as follows:

(1) Fit the reservoir and plunger assembly to the cylinder head with a new gasket **(7)**. Ensure that the priming pump oil outlet and its associated 'O' ring is located fully into the cylinder head.

(2) Align the priming plunger so that the flat portion enables the retaining bolt to be screwed into the cylinder head. This bolt, when in place, prevents the plunger from being fully withdrawn.

(3) Fit the anti-surge shim **(4)**.

(4) Fit a new gasket **(3)** and secure the rocker cover and reservoir using the two bolts **(2)**.

(5) Fit and secure the external oil feed pipe.

## FUEL LIFT PUMP

**6.32** A fuel lift pump is normally fitted to an engine using a separately mounted fuel tank. The fuel lift pump is mounted on a flange on the left-hand side of the crankcase, as viewed from the flywheel end and is operated via a push rod by the camshaft. A hand priming lever allows the fuel to be pumped through the filter to the injection pump.

### Removal

**6.33** To remove the fuel lift pump proceed as follows:

(1) Isolate the fuel supply.

(2) Disconnect the inlet and outlet fuel pipes at the pump.

(3) Remove the two or four capscrews (depending on engine type) securing the pump to the crankcase and withdraw the pump.

### Dismantling

**6.34** Carry out the following procedure:

(1) Mark across the two flanges of the fuel pump body. (This is to assist in assembly of the pump to ensure that the two halves of the body are returned to their original positions).

(2) Remove the set screws and separate the two halves of the pump body.

(3) Turn the diaphram and pull rod assembly clockwise through 90° and lift out.

### Maintenance

**6.35** Carry out the following procedure:

(1) Clean all the components in kerosene and blow dry, paying particular attention to the passages in the pump body.

(2) Examine the diaphragm and renew if it shows signs of cracking or hardening.

(3) Examine the suction and delivery valves for proper seating.

(4) Check pump linkage for wear and flanges for distortion.

### Assembly

**6.36** To assemble the fuel lift pump proceed as follows:

(1) With reference to Figure 6.9 place the diaphragm and pull rod assembly over the spring with the locating tab in the 12 O'clock position. Press down on the diaphragm against the spring pressure and turn counter clockwise through 90°. This allows the pull rod to engage in the fork of the linkage. The tab should now be in the 9 O'clock position.

(3) Assemble the two halves of the pump ensuring that they are in their original positions as marked (Paragraph 6.34(1)).

### Replacement

**6.37** To fit the fuel lift pump proceed as follows:

(1) Ensure that the mating surfaces are clean.

(2) Fit a new fuel lift pump gasket.

(3) Ensure that the fuel pump operating push rod is in position in its guide bore.

(4) Fit the fuel lift pump to the crankcase flange and tighten the cap screws.

(5) Connect the fuel pipes and bleed the fuel system as detailed in Section 1 Operating Instructions.

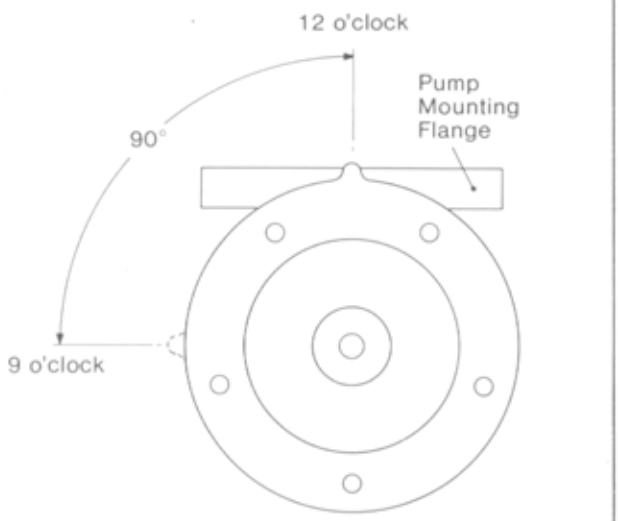



*Figure 6.9 Fuel Lift Pump Diaphragm Location*

## HYDRAULIC PUMP (AC1 and AC2 Engines)

### Installation

**6.38** A hydraulic pump can be fitted in one of two positions:

(1) Flywheel end : engine speed

(2) Gear end : engine speed (AC2 engine only).

### Fitting or Replacement

#### Flywheel End (Figure 6.10)

**6.39** When a hydraulic pump is fitted, or replaced after engine overhaul it is necessary to check the coupling clearance. To obtain the correct coupling clearance proceed as follows:

(1) Fit the engine coupling half and tighten the four securing cap screws to a torque of 34 Nm (25 lbf ft).

(2) Fit the spigot ring and hydraulic pump to the adaptor plate and secure.

(3) Fit the pump half of the coupling to the hydraulic pump drive shaft. Do not tighten the socket screw.

(4) Fit the coupling centre.

(5) Fit the hydraulic pump and adaptor plate leaving out the shim between the adaptor plate and crankcase. This will push the coupling on the drive shaft so that with the shim fitted there will be sufficient clearance.

(6) Remove the pump and adaptor plate taking care not to move the coupling half.

(7) Tighten the socket grub screw to secure the coupling half on the pump drive shaft.

(8) Fit the shim and replace the adaptor plate and pump unit.

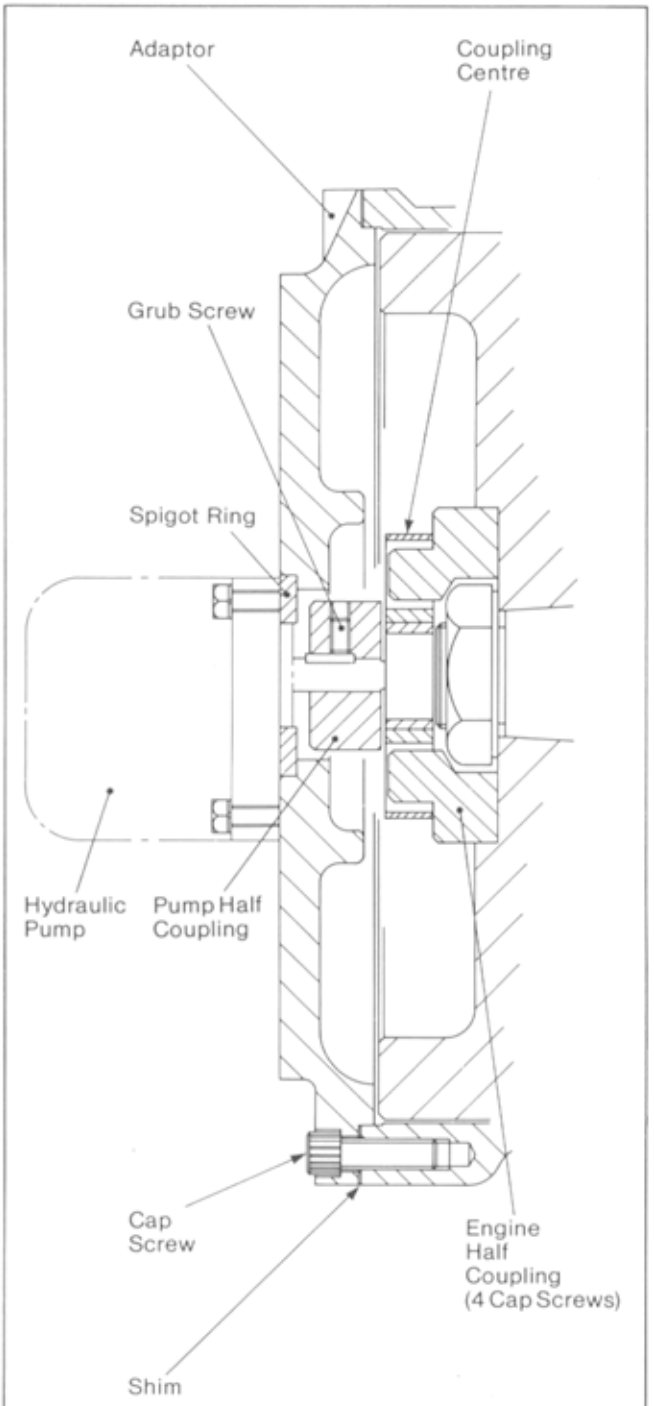



*Figure 6.10 Hydraulic Pump Coupling-Flywheel End : Sectional View*

#### Gear End Drive AC2 Engine Only (Figure 6.11)

**6.40** To fit a hydraulic pump to the gear end drive proceed as follows:

(1) Fit the engine coupling half and tighten the four retaining cap screws to a torque of 19 Nm (14 lbf ft).

(2) Fit the adaptor plate to the hydraulic pump.

(3) Fit the pump half of the coupling to the pump tapered drive shaft. Due to the tapered shaft it is not necessary to check coupling clearance.

(4) Fit the coupling centre.

(5) Fit the adaptor plate and hydraulic pump unit. Tighten the four securing nuts to a torque of 17.6 Nm (12 lbf ft).

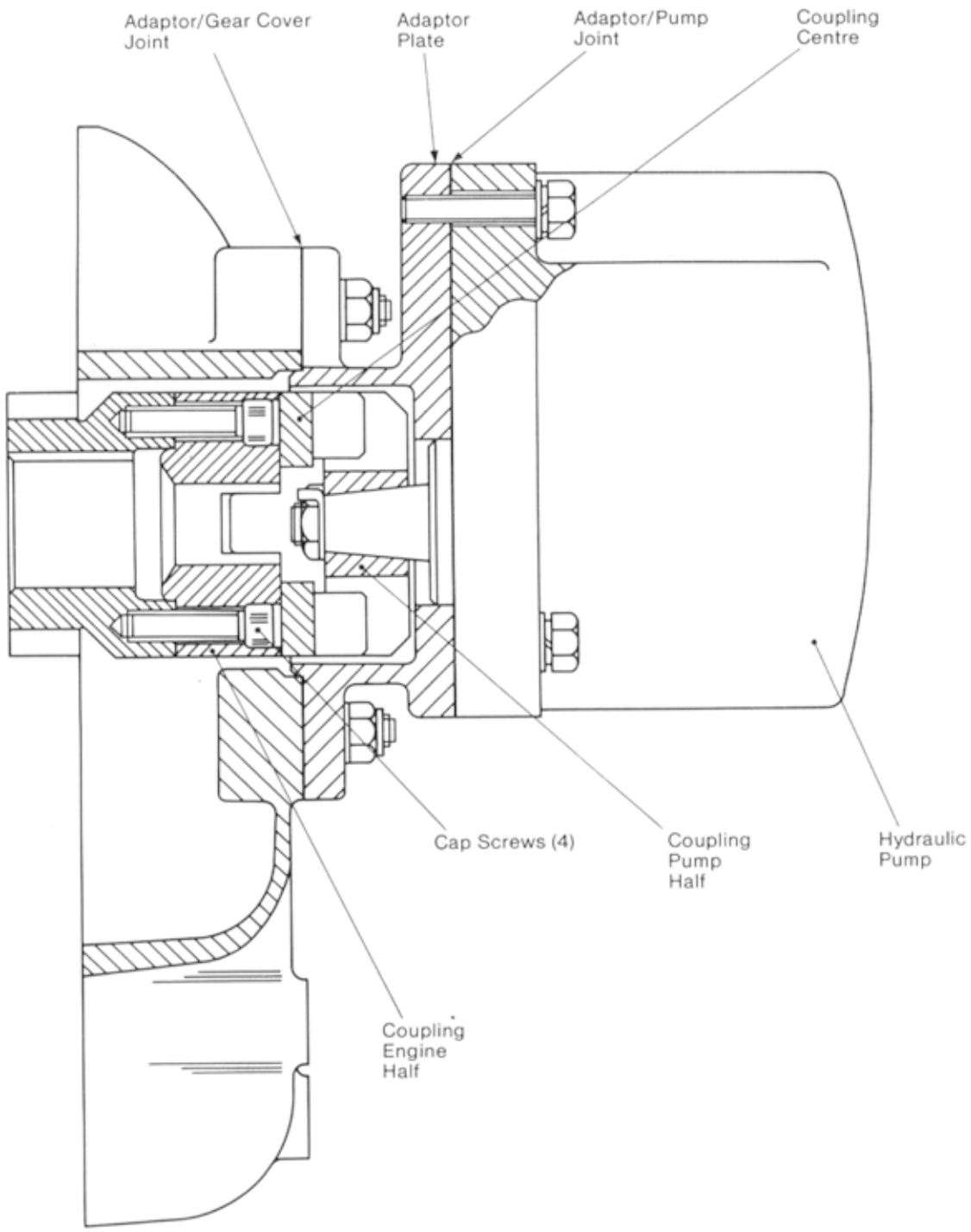



*Figure 6.11 Hydraulic Pump Coupling-Gear End : Sectional View.*

# SECTION 7
# ELECTRICS

## INTRODUCTION

**7.1** This section gives servicing information and wiring diagrams for basic electric starting systems that can be used on the 'A' range diesel engines. Further information can be obtained from Petters Limited or their representatives.

## STARTING SYSTEMS

### Battery Operated Starter Motor

**7.2** This consists of a battery-operated starter motor engaging with a gear ring on the flywheel, a dynamo or alternator for battery charging, a regulator, ammeter and starter switch. Operating the starter switch energises a solenoid on the starter, which in turn engages the motor pinion with the flywheel gear ring. When the pinion is fully engaged the solenoid completes the circuit to turn the starter motor. The pinion remains engaged until the starter switch is released, but a free-wheel prevents the motor from being driven when the engine fires.

### Battery Operated Dynastart

**7.3** The Dynastart system includes starter/dynamo and switch assembly box. The box which includes a starter solenoid, cut-out and automatic voltage control unit is a sealed assembly and must be returned to the manufacturers for repairs or adjustment. When starting the engine the Dynastart operates as a series motor and is controlled by a push button which operates the solenoid. When the Dynastart is driven by the engine the shunt windings are excited and it operates as a dynamo. Initially the generated voltage increases with engine speed and as soon as the rated level voltage is achieved the cut-out closes to charge the battery. When running the voltage output is maintained by the automatic voltage control unit.

## STARTER MOTOR (FIGURE 7.1 AND 7.2)

**7.4** The starter is a pre-engaged, four pole, four-brush motor with a solenoid-operated roller clutch drive. The starter provides a positive drive engagement as full battery voltage is not connected to the starter until the pinion is completely meshed with the engine drive. This also prevents premature ejection of the drive during isolated firing strokes. The clutch drive transmits the torque developed by the starter and runs free when the engine starts. The solenoid has two windings connected in parallel, a closing coil (low resistance) and a hold-on coil (high resistance). When the starter switch is closed the solenoid is energised and draws the plunger into the solenoid core which in turn via the operating lever, brings the pinion into mesh with the engine drive. The solenoid contacts close and bypasses the closing winding. Current flows from the battery to the starter setting the armature in motion. The solenoid is held in position by the hold-on coil. When the starter switch is released the hold-on coil is de-energised and the plunger returning to its normal position withdraws the pinion from the engine drive. At the same time the solenoid contacts open and the starter is disconnected from the battery. On occasions of tooth-to-tooth abutment (when the pinion does not slide into mesh with the engine drive) the solenoid energises normally and the forked operating lever causes the operating plate to compress the engagement spring. As the solenoid plunger has full travel the solenoid contacts close, the starter motor rotates and the pinion slips into mesh under pressure from the compressed engagement spring. A spring (lost motion) located around the solenoid plunger stirrup assembly ensures that the contacts open before the pinion is extracted on starter switch release.

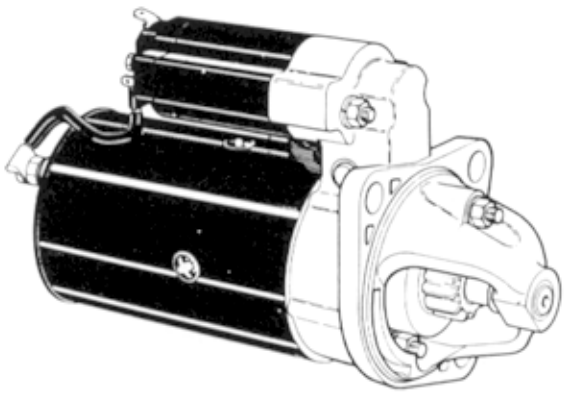


*Figure 7.1 Typical Starter Motor*

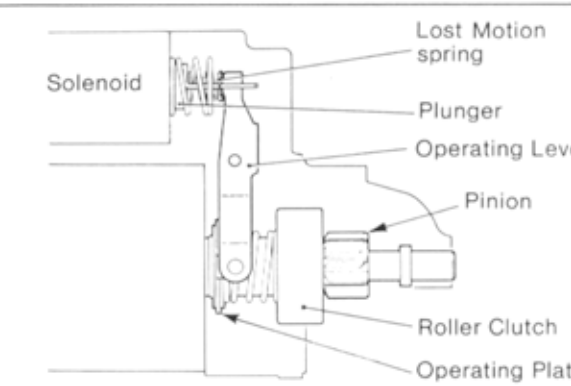



*Figure 7.2 Starter Motor Drive Mechanism*

### Roller Clutch (Figure 7.3)

**7.5** The roller clutch consists of a driving and driven member and a number of cylindrical rollers running in cam tracks in the clutch outer member. These rollers are spring-loaded and according to the direction of the drive they are either free-running or wedge-locked between the driving and driven member.

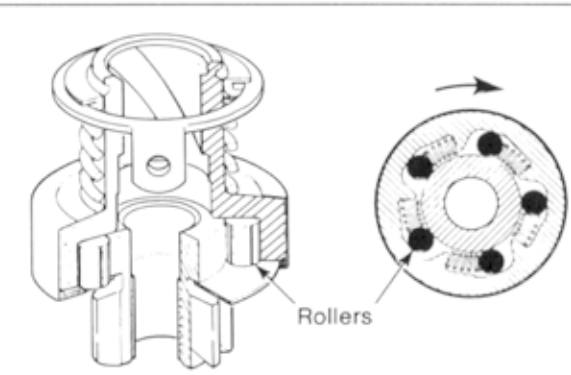



*Figure 7.3 Roller Clutch Drive Assembly*

### Removal

**WARNING**
**DISCONNECT THE BATTERY BEFORE CARRYING OUT ANY MAINTENANCE ON THE STARTER MOTOR.**

**7.6** Carry out the following procedure:

(1) Disconnect the battery.
(2) Disconnect the starter.
(3) Unscrew the three 3/8 in. UNC securing bolts and remove the starter.

### Maintenance

**7.7** When dismantling for periodical overhaul the brush gear and commutator surfaces should be checked as follows:

(1) Check that the brushes move freely in their respective holders. A sticking brush can be freed by cleaning both the brush and holder with a petrol-moistened lint-free cloth.
(2) Check the brushes for wear and renew when worn to or approaching 7.94 mm (5/16 in.) in length.
(3) Check the commutator is burnished and free from pits or burned spots. If necessary clean the surface with a petrol moistened cloth. If the surface is badly worn it is advisable to fit a replacement motor.

**7.8** Check the roller clutch drive as follows:

(1) Check that the clutch provides instantaneous drive take-up in one direction and rotates freely and smoothly in the other direction.
(2) Check that the roller clutch drive moves round and along the shaft splines without roughness or a tendency to bind.
(3) Lubricate all moving parts with Shell SB2628 grease.

**Note**
*If the roller clutch drive fails to operate correctly it must be replaced.*

### Replacement

**7.9** To fit the starter proceed as follows:

(1) Check the four mounting bracket 5/16 in. UNF nuts for tightness.
(2) Fit the starter and secure using the three 3/8 in. UNC bolts.
(3) Connect the starter ensuring that terminals are clean.
(4) Connect the battery.

## STARTER MOTOR TESTING

**7.10** The following paragraphs detail tests that can be carried out on the starter motor to assist locating faults in the starting system. A voltmeter with a range of 0 to 20V is required. Before carrying out any tests on the starting system it is important to ascertain that the battery is capable of supplying sufficient current to operate the starter motor and that the battery connections are clean and tight. Tests should be carried out in the order detailed.

**WARNING**
**WHEN CARRYING OUT STARTER MOTOR TESTS CARE MUST BE TAKEN TO AVOID ANY MOVING MACHINERY.**

### Test 1 Battery Terminal Voltage Under Load

**7.11** Connect the voltmeter across the battery terminals as shown in Figure 7.4 and operate the starter switch. The voltage reading depends on the engine load and battery size (Ah). A typical figure is about 9.0V. A low voltage reading would indicate excessive current flow in the circuit and the starter should be removed.

**7.12** Carry out Test 2.

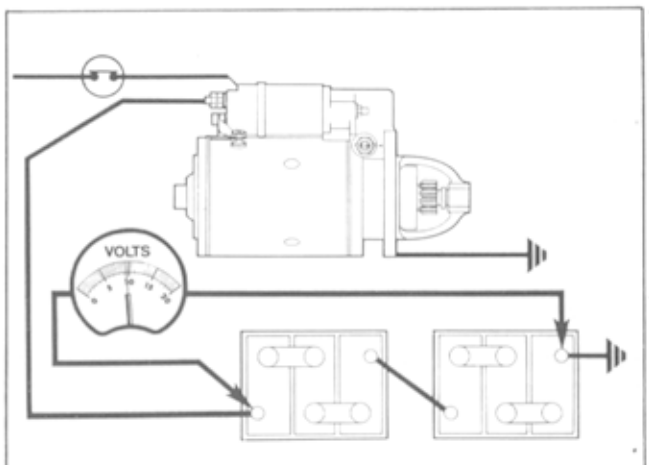



*Figure 7.4 Battery Terminal Voltage Under Load : Test 1 Connections*

### Test 2 Starter Terminal Voltage Under Load

**7.13** Connect the voltmeter between the starter input terminal and earth (commutator end bracket) as shown in Figure 7.5 and operate the starting switch. The voltage reading should not be more than 0.5V below the voltage measured across the battery terminals (Test 1). If the voltage reading is within this limit the starter circuit is satisfactory. If the voltage reading is low (battery voltage correct) it indicates a high resistance in the cable or at the starter contacts. This could be bad or dirty connections.

**7.14** Carry out Test 3.

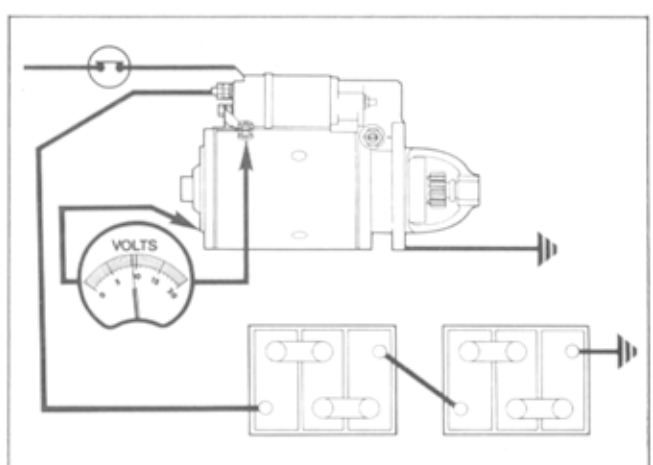



*Figure 7.5 Starter Terminal Voltage Under Load : Test 2 Connections*

### Test 3 Voltage Drop On the Insulated Line

**7.15** Connect the voltmeter between the starter input terminal and the insulated battery terminal as shown in Figure 7.6. With the starter switch open, the voltmeter should read the battery voltage. When the starter switch is operated the voltmeter reading should be practically zero. A high voltmeter reading indicates a high resistance in the starter

circuit and all insulated connections at the battery, solenoid and starter should be checked.

**7.16** Carry out Test 4.

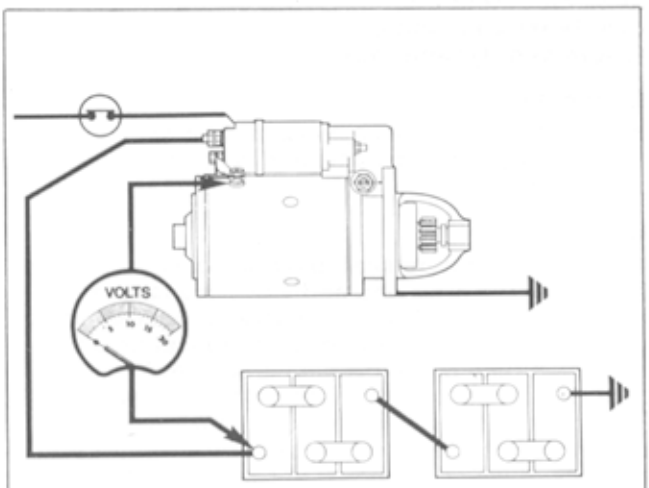



*Figure 7.6 Voltage drop on Insulated Line : Test 3 Connections*

### Test 4 Voltage Drop Across the Solenoid Contacts

**7.17** Connect the voltmeter across the two main solenoid contacts as shown in Figure 7.7. With the starter switch open the voltmeter should read battery voltage. When the starter switch is operated the voltmeter should read zero volts or a fractional value.

**7.18** A zero or fractional reading on the voltmeter indicates that if a high resistance is deduced in Test 3 a fault is due to bad or dirty connections. A high reading (similar to Test 3) indicates a faulty solenoid or connections.

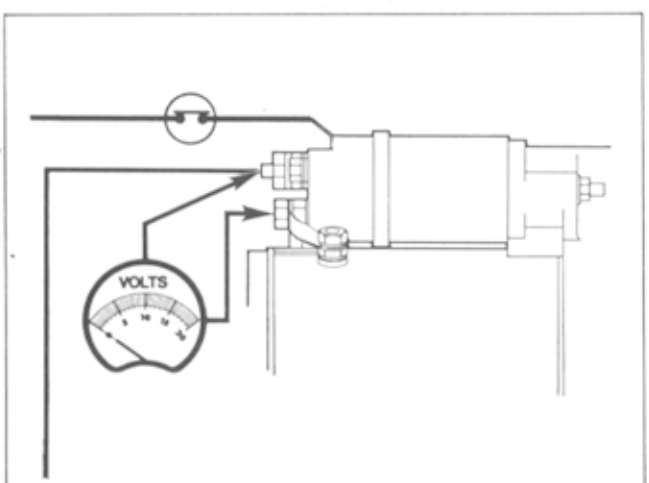



*Figure 7.7 Voltage Drop Across the Solenoid Contacts : Test 4 Connections*

### Test 5 Voltage Drop on Earth Line

**7.19** Connect the voltmeter between the battery earth terminal and the starter (commutator end bracket) as shown in Figure 7.8. Operate the starter switch and check that the voltmeter reads practically zero.

**Note**
*The total voltage drop in the starting circuit insulated line (Test 3) and earth line must not exceed 0.5V.*

**7.19** If the meter reading is high, clean and tighten all earth connections and bonding straps.

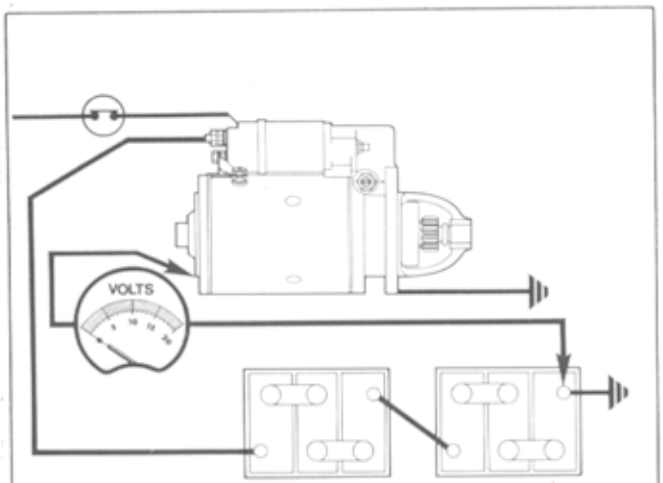



*Figure 7.8 Voltage Drop on Earth Line : Test 5 Connections*

### DYNAMO (Figure 7.9)

**7.21** The dynamo is a non-ventilated earth-return two-pole, two-brush, shunt connected model, with a maximum output of 11A. To protect the dynamo against overload and the battery against overcharge a control box is fitted. Dynamos or control boxes may be replaced separately, but if either item is changed both units should be checked and/or set-up by an electrical engineer.

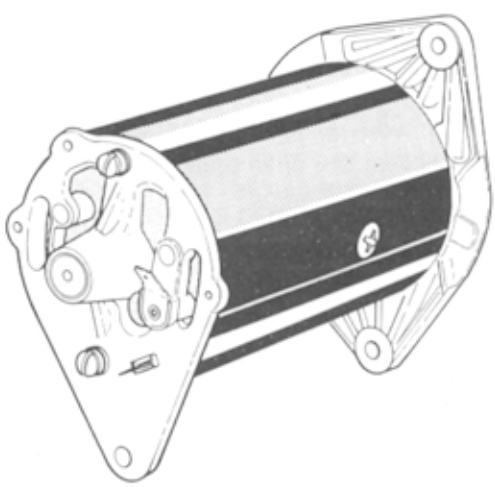


*Figure 7.9 Typical Dynamo*

**CAUTION**
**Check that the dynamo rotation as marked by an arrow is correct when related to the engine. A reverse rotation dynamo is available from Petters Limited or their representatives.**

## Polarisation (Figure 7.10)

**7.22** Whenever a new, replacement or repaired dynamo is fitted it is essential that it is polarised to suit the engine installation. To polarise the dynamo proceed as follows:

(1) Fit the dynamo to the engine installation. Do not connect the 'D' and 'F' leads.

(2) Ensure that the battery earth is connected.

(3) Connect a jumper lead to the battery insulated terminal and touch the free end to the dynamo 'F' terminal for a few seconds.

(4) Remove the jumper lead and connect the 'D' and 'F' leads.

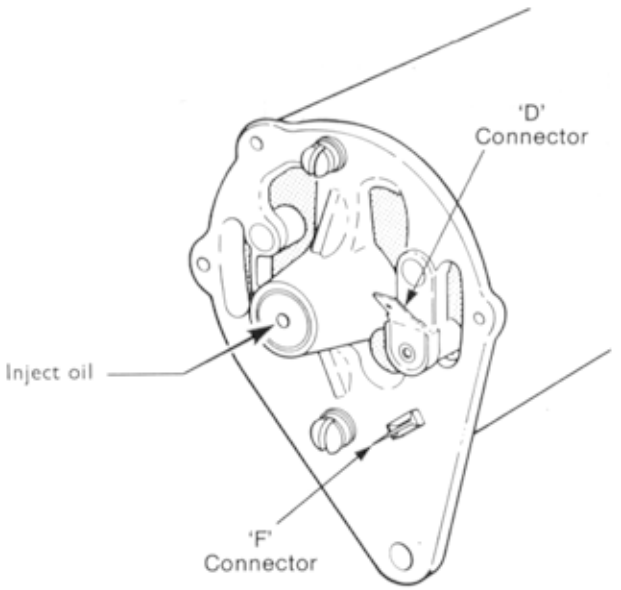



*Figure 7.10 Commutator End Bracket*

## Maintenance

### Driving Belt

**7.23** Carry out the following procedure:

(1) Check the general condition of the driving belt, if worn or damaged renew.

(2) Check that the driving and dynamo pulleys are in line and parallel with each other to within 0.5 mm (0.020 in.). Pulley alignment may be checked by placing a straight edge across the pulley faces. The distance between pulley centres to allow for belt removal and replacement should be 279 mm (11 in.). A further 17.5 mm (0.6875 in.) is required for tensioning the belt. If further adjustment is required the belt must be renewed.

(3) Check the belt tension is sufficient to ensure that the slack side does not sag, fluctuate or bulge away from the pulley when the engine is running. To set belt tension, stop the engine, slacken the two dynamo securing bolts and the bolt on the slotted adjustment strap. Pull the dynamo outwards to increase the tension. Belt tension is correct when moderate hand pressure applied at the centre of the belt between the pulleys gives a deflection of approximately 6 mm (1/4 in.) Tighten the adjusting strap bolt while the belt tension is maintained, then tighten the two securing bolts.

**CAUTION**
**An under tensioned belt overheats, causes low dynamo output and may work off the pulleys. An over tensioned belt causes premature belt failure and dynamo bearing wear.**

### Connections

**7.24** Check for broken, loose and/or dirty connections at the dynamo and control box. Rectify any faults.

### Lubrication

**7.25** The armature shaft bearings consist of a ball bearing at the drive end and a bearing bush at the commutator end. The ball bearing is packed with grease which provides adequate lubrication until a major overhaul of the dynamo is required. The bearing bush, however needs lubrication every 6 months or 700 running hours. To lubricate the bearing use a force-feed oil can and inject a small quantity of clean engine oil in small hole marked OIL on the end-face of the bearing bush housing of the commutator-end bracket as shown in Figure 7.10.

### Armature Voltage Check

**7.26** To check the armature voltage proceed as follows:

(1) Disconnect the 'D' and 'F' leads at the commutator end bracket (Figure 7.10).

(2) Connect a voltmeter between 'D' terminal and earth.

(3) Run the engine and check that the voltmeter reads 1.5V to 3.0V.

### Field Circuit Check (Figure 7.11)

**7.27** To check the field circuit proceed as follows:

(1) Disconnect the 'D' and 'F' leads at the commutator end bracket.

(2) Connect a voltmeter between 'D' terminal and earth.

(3) Connect an ammeter between 'D' and 'F'.

(4) Run the engine.

(5) Check that the voltmeter reads a nominal 12V and the ammeter approximately 2A.

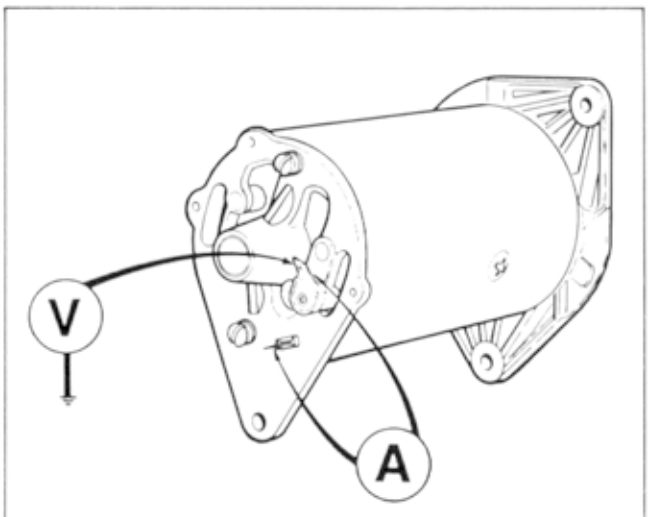



*Figure 7.11 Testing the Field Circuit*

### Dynamo Leads Check (Figure 7.12)

**7.28** If the correct readings are obtained on the tests at the dynamo, check the dynamo cables as follows:

(1) Ensure that 'D' and 'F' leads are connected at the dynamo.

(2) Disconnect the 'D' and 'F' leads at the control box.

(3) Connect one lead of the voltmeter to the 'D' lead and the other to earth and run the engine.

(4) Check that the voltmeter reads 1.5V to 3V. No reading indicates a faulty 'D' lead, a high reading indicates a short between the 'D' and 'F' leads.

(5) If the reading is correct, leave the voltmeter in position and short 'F' lead to 'D' lead. Voltage should rise. If the reading increases only slightly, an open circuit 'F' lead is indicated. A zero reading indicates 'F' lead shorted to earth.

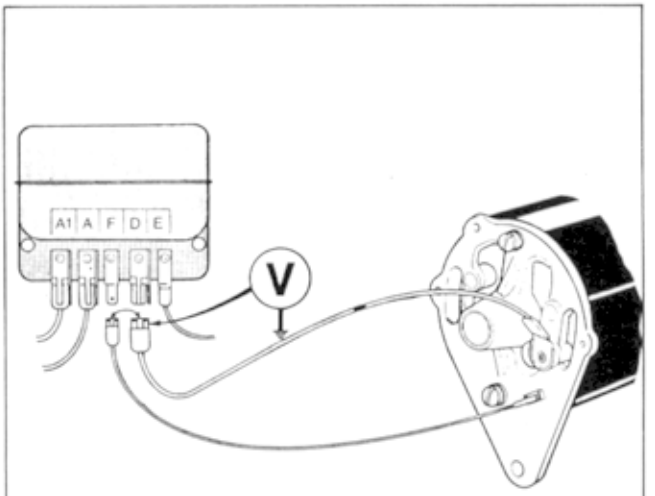



*Figure 7.12 Checking the Dynamo Leads*

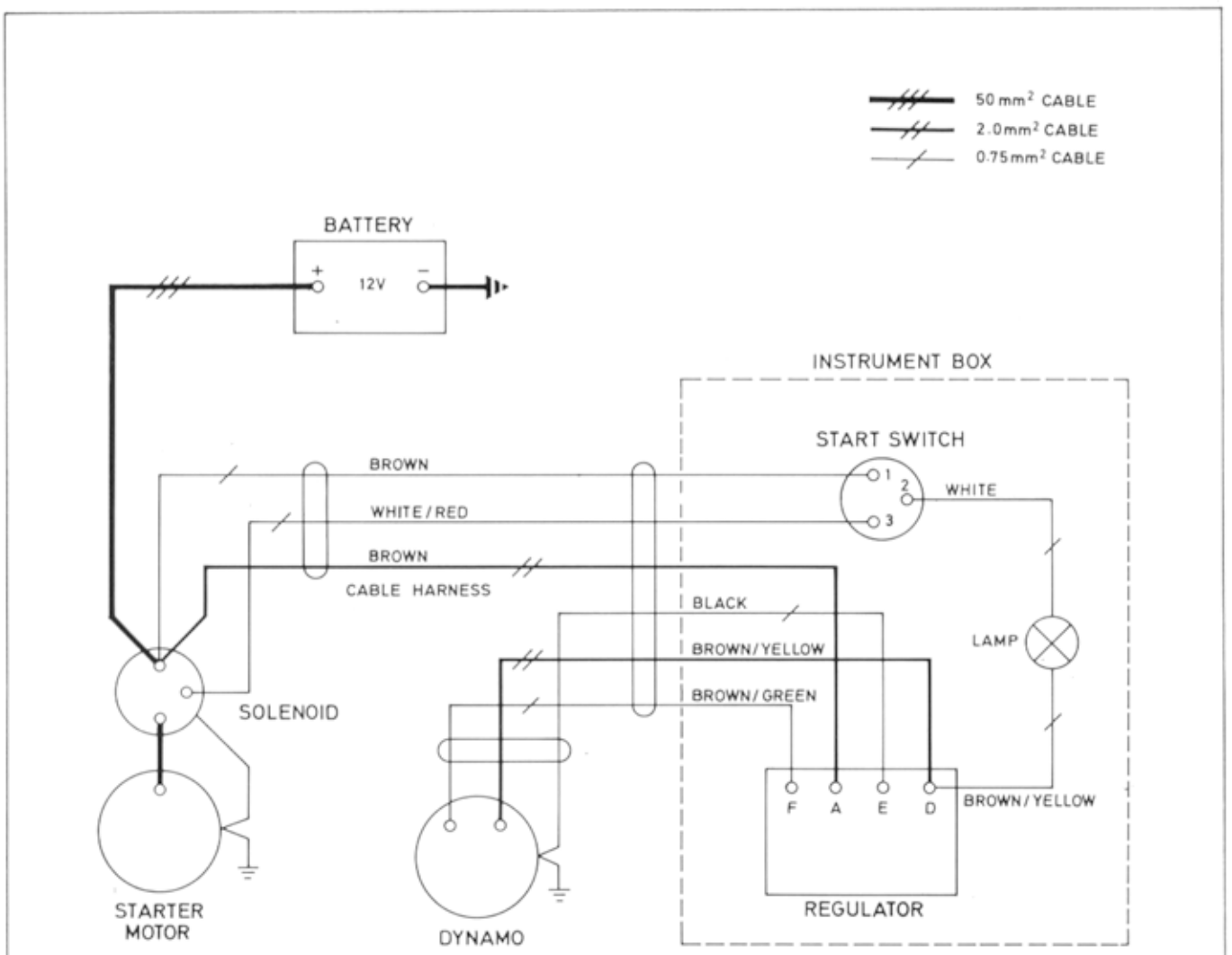



*Figure 7.13 Electrical system; Dynamo*

## ACR ALTERNATOR (Figure 7.14)

**7.29** The ACR alternator produces alternating current which is converted to direct current suitable for a 12V battery starter system. The output of the alternator is controlled by an electronic voltage regulator which is more reliable and stable than the conventional type of mechanical regulators used with a dynamo. The cut-out is not required with this type of control since the semi-conductor devices prevent reverse currents from flowing. Also the self-regulating properties of the alternator limit the output current to a safe value so that there is no need for a current regulator.

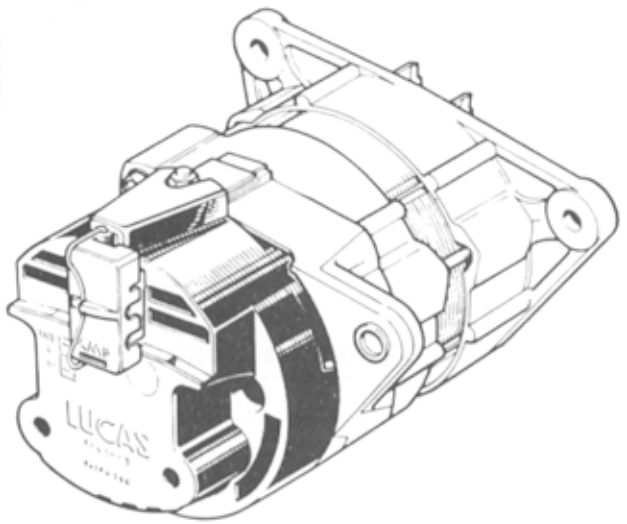



*Figure 7.14 Typical ACR Alternator*

**7.30** A typical ACR alternator as shown in Figure 7.15 consists of:

(1) A laminated stator pack on which is wound a 3-phase star connected output winding.

(2) A 12-pole rotor carrying the field winding. Each end of the rotor shaft runs on ball-race bearings. These bearings are pre-packed with grease for life.

(3) A rectifier pack for converting the A.C. output of the stator to D.C.

(4) A built-in voltage regulator.

**7.31** Rectification of the alternator output is achieved by six silicon diodes housed in a rectifier pack. The pack also contains three diodes to provide self-excitation of the rotor field winding.

**7.32** The voltage regulator is a modular pack and is an integral part of the alternator.

**7.33** The electrical connections to the external circuits are brought out to Lucar connector blades, which are grouped so as to accept a non-reversible socket to prevent damage to the semi-conductor devices through connections of the wrong polarity.

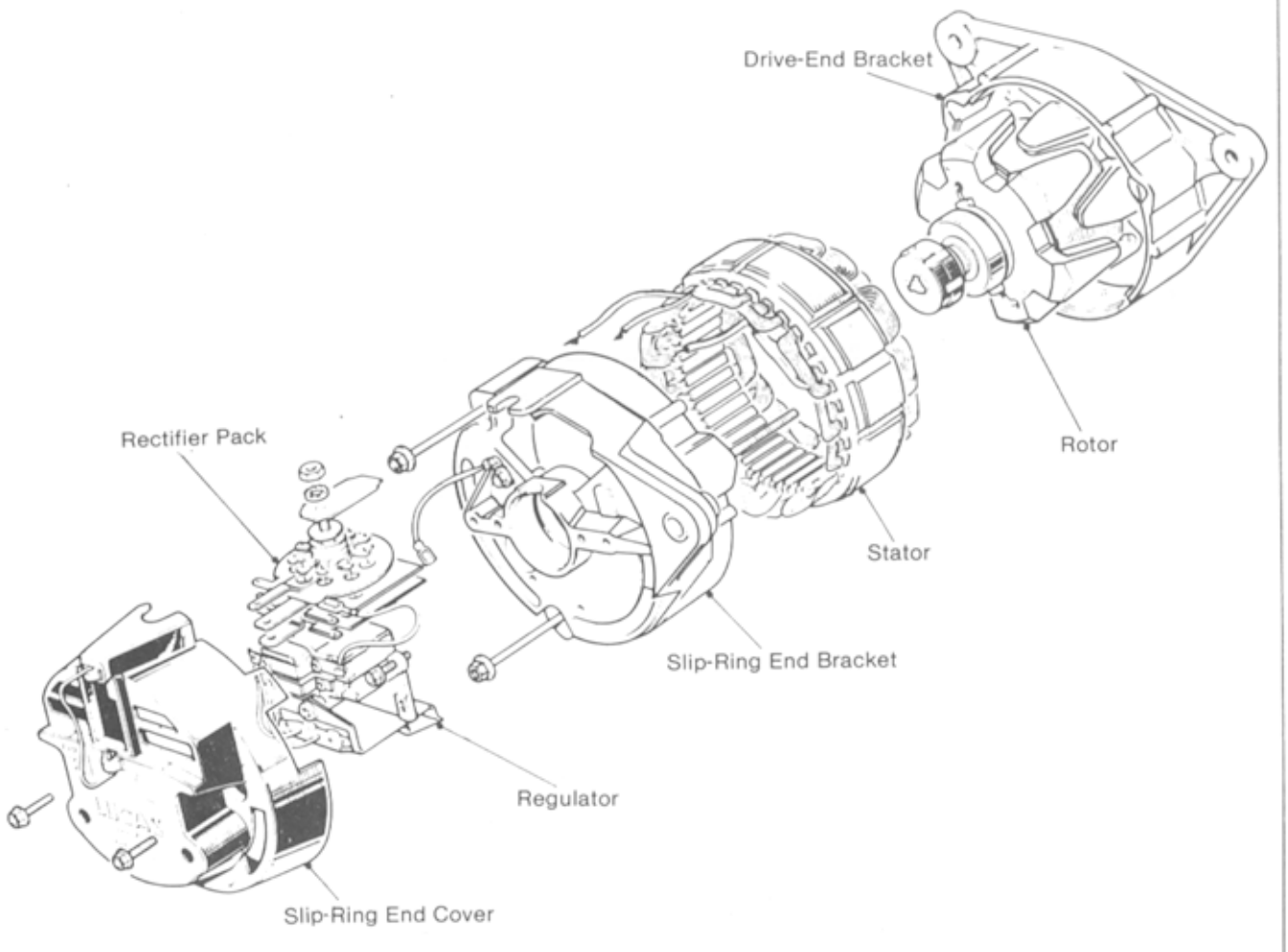



*Figure 7.15 Typical ACR Alternator – Exploded View*

## Connections

**7.34** Figure 7.16 shows the alternator (European Termination) connections. It consists of two large '+' Lucar connections and a small 'IND' connector. The negative connection is made through the alternator body. The two Lucar '+' connectors give a better mechanical grip for the socket, but there is only a single cable to the battery.

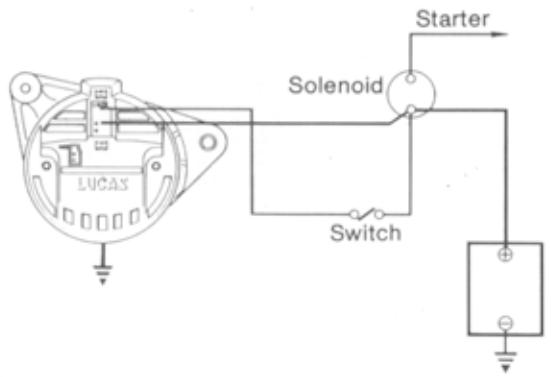



*Figure 7.16 ACR Alternator Simplified Circuit*

## Maintenance

**CAUTION**
**It is important that the following precautions should be observed to avoid extensive damage to the alternator system.**

**(1) Do not disconnect the battery whilst the alternator is running.**

**(2) Do not disconnect any lead unless the alternator is stopped and all switches are in the OFF position.**

**(3) Always ensure that all leads are connected to their correct terminals.**

**(4) Do not connect a battery into the system without ensuring that the voltage and polarity are correct.**

**(5) Do not 'flash' the connections to check current flow.**

**(6) Do not experiment with adjustments or repairs to the system.**

**7.35** The alternator requires minimum maintenance in service the only items subject to wear being the brushes and bearings. Brushes should be examined after 2000 hours running and renewed if necessary. The bearings are pre-packed with grease for life.

### Belt Tension

**7.36** Check the belt tension is sufficient to ensure that the slack side does not sag, fluctuate or bulge away from the pulley when the engine is running. To set the belt tension, stop the engine slacken the alternator pivot bolts and the bolt on the slotted adjustment strap. Pull the alternator out to increase tension. Belt tension is correct when moderate hand pressure applied at the centre of the belt between the pulleys gives a deflection of approximately 6mm (¼ in). Tighten the adjusting strap bolt while the belt tension is maintained, then tighten the two pivot bolts.

**CAUTION**
**An under tensioned belt overheats and may work off the drive pulleys. An over tensioned belt causes premature belt failure and alternator bearing wear.**

### Voltage Drop in Charging Circuit (Figure 7.17)

**7.37** To check for a high resistance in the charging circuit proceed as follows:

(1) Connect a voltmeter between the battery insulated terminal and the alternator main output terminal.

(2) Start and run the engine at approximately 3000 r/min the voltmeter (V1) reading should not exceed 0.5V.

(3) Transfer the voltmeter connections to the battery earth and alternator body and run the engine as before. The voltmeter (V2) reading should not exceed 0.25V. If the readings are higher than the figures given in Paragraph 7.37 (2) or 7.37 (3), then there is a high resistance in the circuit which must be located and rectified.

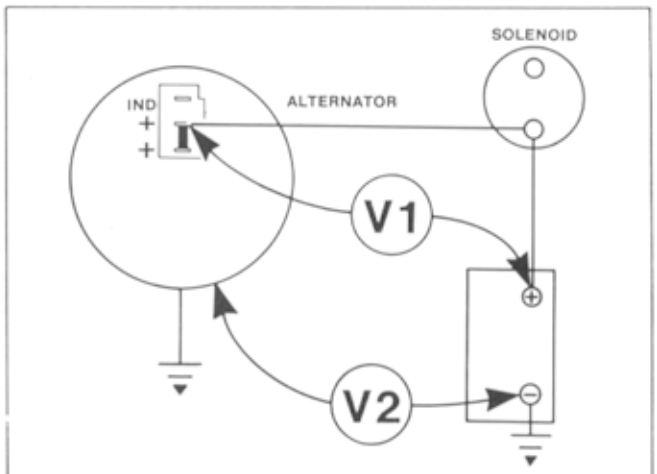



*Figure 7.17 Checking the Voltage Drop in the Charging Circuit*

### Voltage Output (Figure 7.18)

**7.38** To check the voltage output ensure that the battery is fully charged then proceed as follows:

(1) Disconnect the battery earth cable.

(2) Connect an ammeter between the starter solenoid terminal and the alternator main output cable.

(3) Connect a voltmeter across the battery terminals.

(4) Reconnect the battery earth cable.

(5) Start the engine and run at approximately 3000 r/min. When the ammeter is reading less than 10A the voltmeter reading should be within the limits 13.6 to 14.4V. If the reading is unstable or outside the specified limits, the alternator is faulty.

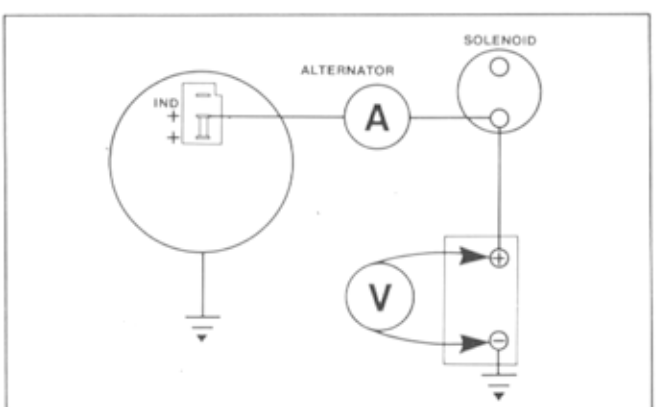



*Figure 7.18 Checking the Voltage Output*

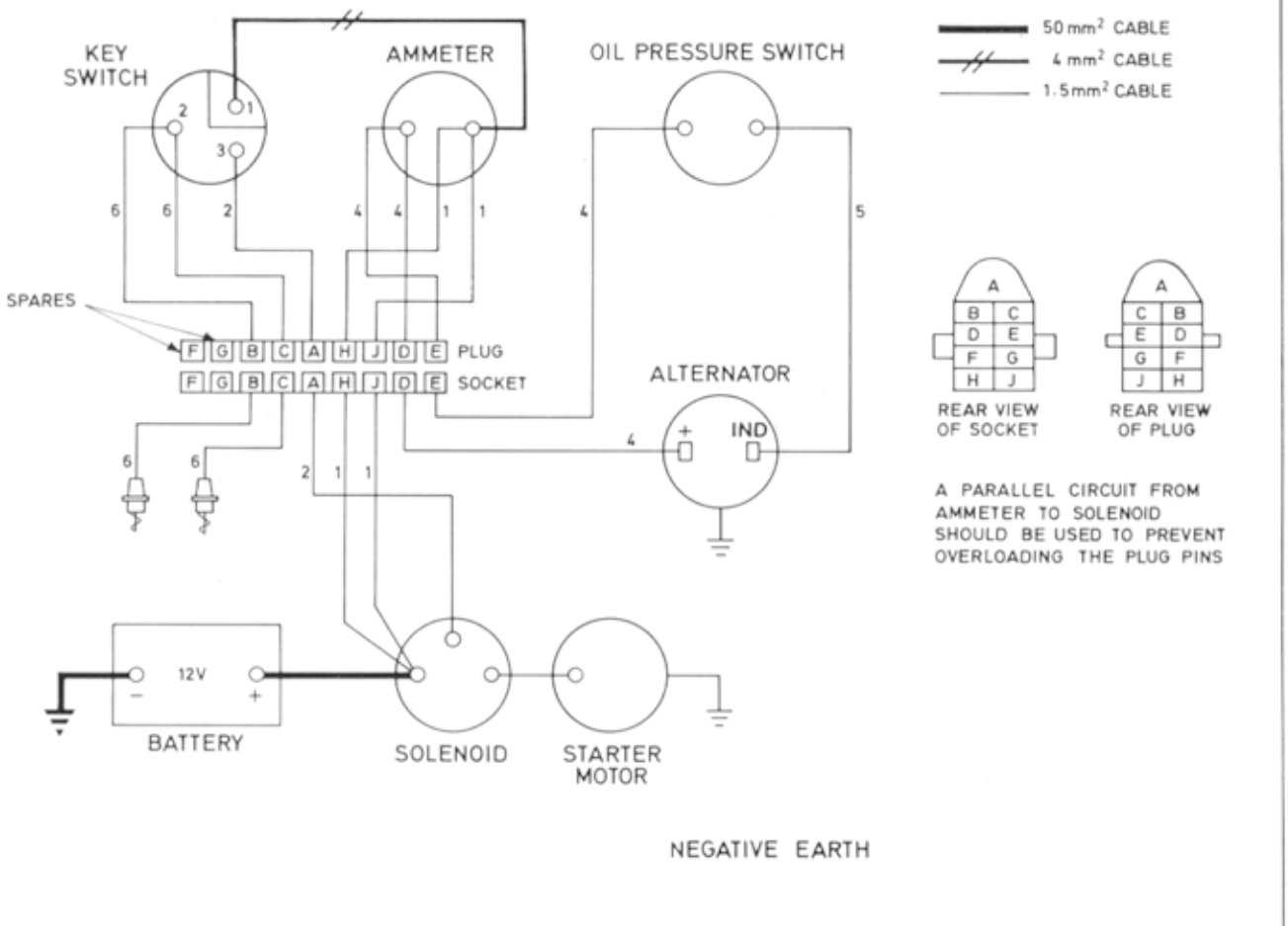



*Figure 7.19 Electrical System Alternator*

## DYNASTART

**7.39** The dynastart unit is of a four pole design, two poles carrying the series windings for starting and two shunt windings for generation.

### Maintenance

**7.40** Carry out the following procedure:

(1) Check the dynastart engine mountings for tightness.

(2) Check the belt tension is sufficient to ensure that the slack side does not sag, fluctuate or bulge away from the pulley when the engine is running. To set the belt tension, stop the engine slacken the dynastart pivot bolts and the bolt on the slotted adjustment strap. Pull the dynastart out to increase tension. Belt tension is correct when moderate hand pressure applied at the centre of the belt between the pulleys gives a deflection of approximately 6mm (¼ in). Tighten the adjusting strap bolt while the belt tension is maintained, then tighten the two pivot bolts.

**CAUTION**
**An under tensioned belt overheats and may work off the drive pulleys. An over tensioned belt causes premature belt failure and dynastart bearing wear.**

(3) Check the terminals and circuit connections for tightness and that the terminals are clean.

(4) Remove the brush gear cover and inspect the brushes and commutator. Brushes should move freely in their slides with the brush springs sitting squarely on the brushes. The brushes and commutator should be clean and contact surfaces smooth and uniform in colour. Brushes must be replaced when worn to 6mm (0.25 in.) in length. The insulated brush is replaced by unsoldering the old brush and soldering the new one in position; ensure that the short wire link between the brush connection and the D+ terminal is secure and that no loose solder remains in the dynastart. Remove the two rivets securing the earthed brush holder to the commutator end bracket and fit a new brush. After fitting new brushes, check the insulation between terminal A and the yoke and ensure no earth fault; ensure that continuity exists between terminals A, D+ and DF.

### Charging Test

**7.41** To check the dynastart run the engine at operating speed and check that a charge is registering on the ammeter. If not disconnect lead DF from the switch assembly box and connect it to earth. If the ammeter then indicates a charge the fault is in the voltage regulator, or the switch assembly box is not earthed correctly. Should this check prove negative, disconnect the ammeter from terminal 61D+ and connect it via a 30A fuse to terminal 51/30; if a charge reading is obtained there is a fault in the switch assembly box. If no charge is indicated the Dynastart is faulty.

### Switch Assembly Box

**7.42** Adjustment should not be made other than by an electrical engineer.

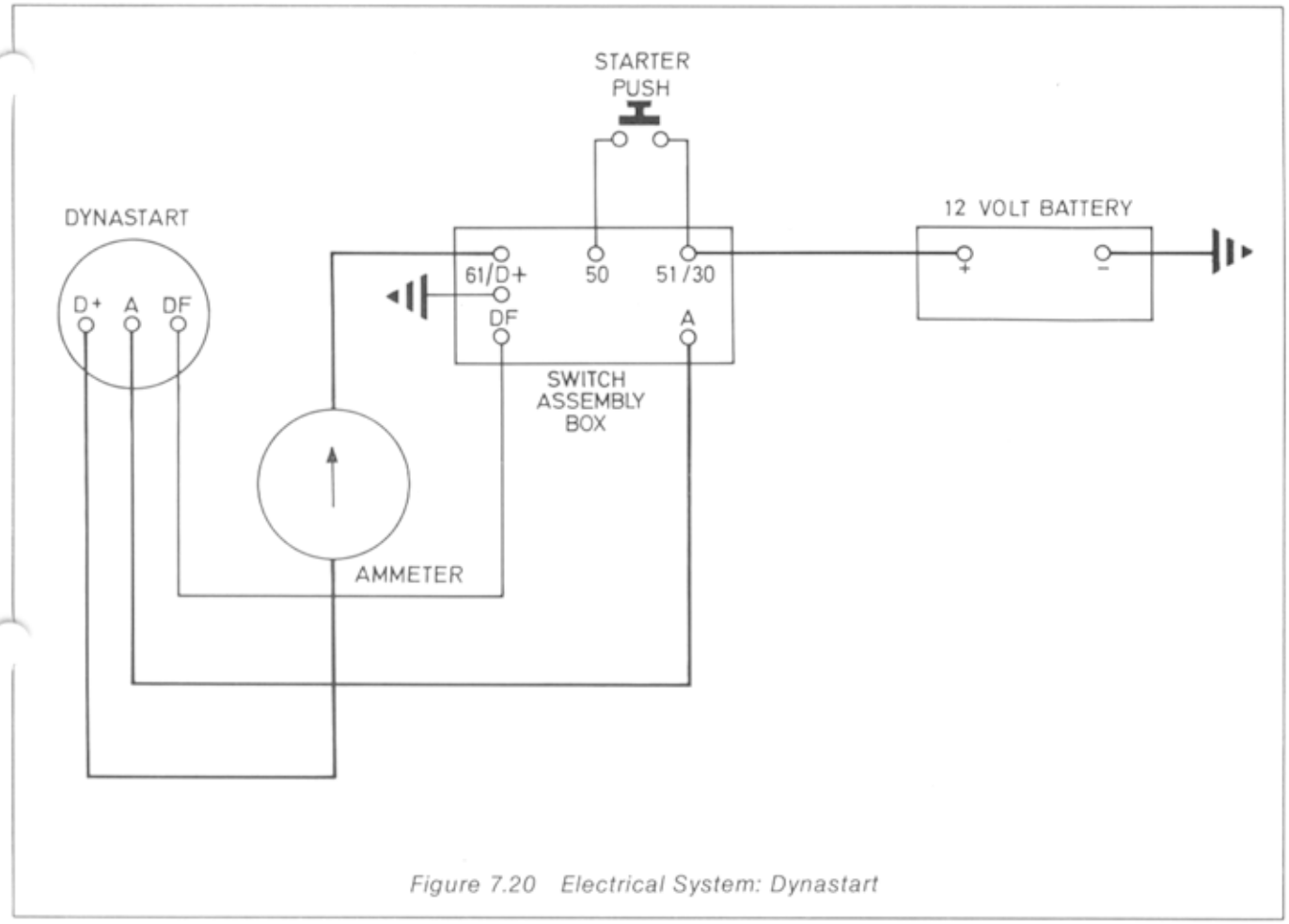



*Figure 7.20 Electrical System: Dynastart*

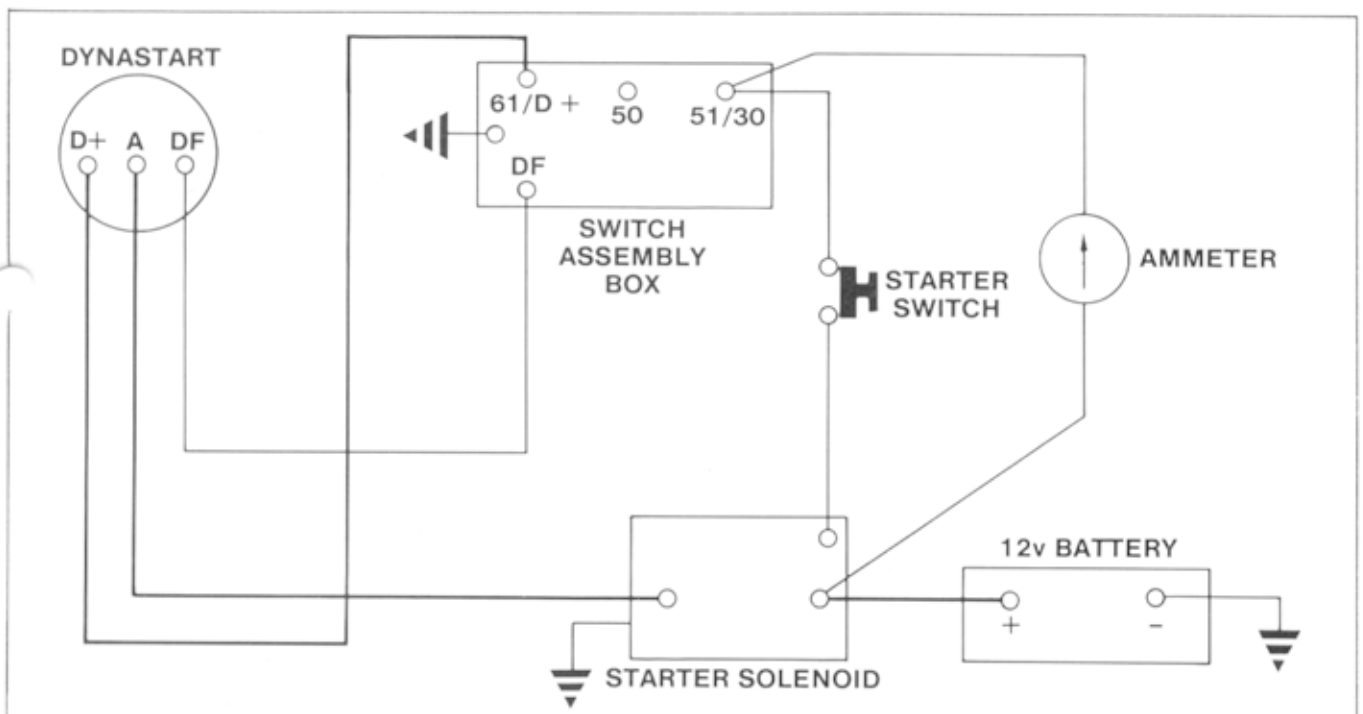



*Figure 7.21 Electrical System: Dynastart With Starter Solenoid*

# SECTION 8
# PROTECTION AND PRESERVATION

## PROTECTION

**8.1** To increase the life of the engine it is advisable to protect the engine as much as possible from environmental damage. When not in use engines must be protected by a dust and waterproof cover. Under tropical conditions a permanent awning should be provided.

### Intermittent Use

**8.2** When not in regular use, engines should be run on load at normal operating temperatures each month to lubricate internal parts and remove condensation. External unpainted parts should be wiped clean and lightly sprayed with a proprietary de-wetting agent.

## PRESERVATION

**8.3** Engines remaining idle for more than a month may corrode resulting in serious damage. In order to prevent this it is recommended that the following preservation procedure is carried out:

(1) Carry out a 500 hours service as detailed in Section 1.

(2) Drain the sump, flush out with flushing oil and refil with the correct grade of lubricating oil. Alternatively a lubricating oil with preservation properties may be used as recommended by Petters Limited or their representatives.

(3) Drain the fuel tank and filter and refill with 1.41 litres (2 pints) of Shell Fusus Oil or Calibration Fluid C. Bleed and prime the fuel system (Section 1) and run the engine on a light load for five minutes.

(4) If prolonged storage is envisaged remove the injector and apply a small quantity of preservative oil to the cylinder and piston while turning the engine by hand. Replace the injector, fitting a new sealing washer.

(5) Remove air inlet and exhaust fittings and with each cylinder on the compression stroke in turn (inlet and exhaust valves closed) apply preservative oil to both inlet and exhaust ports to protect the valve seats. The manifolds should then be sealed to prevent ingress of moisture.

(6) If electric starting is fitted, the battery must be removed and the terminals cleaned and greased. To maintain the battery in good condition it should be trickle charged at regular intervals.

(7) Clean and dry the engine, repaint where necessary and wipe all unpainted parts with an oil rag. All pivot points and external controls should be clean and sprayed with a proprietary de-wetting agent.

**8.4** Protected engines should be periodically examined to check the preservation effectiveness. Rectification of the protection should be carried out, if necessary.

## PREPARATION FOR USE

**8.5** After an engine has been preserved the following procedure must be carried out to return it to its operating condition:

(1) Remove all protective coverings.

(2) Check and top up the fuel tank with the correct type and grade of fuel (Section 1).

(3) Check the oil level on the dipstick and ensure that the engine is filled with the correct type and grade of oil.

(4) Re-connect the battery, if fitted.

(5) Check the air cleaner oil bath, if fitted (Section 4).

(6) Check the tension of the alternator or dynamo drive belt (if fitted) and adjust if necessary (Section 7).

(7) Check the exhaust system for damage and security of joints.

(8) Lubricate the 4:1 or raised hand starting, if fitted (Section 6).

(9) Clean and lightly lubricate the speed control linkage.

(10) Bleed the fuel system, if necessary. (Section 1).

(11) Check the tightness of all nuts (excluding cylinder head), bolts and hose clips.

**8.6** After an initial engine run check the oil level and visually check the system for leaks.

# SECTION 9
# FAULT FINDING

## INTRODUCTION

**9.1** This section is a guide to assist in the location of a fault that may occur on a 'A' range engine. Information on causes and suggested remedies are also given.

*TABLE 9.1 ENGINE WILL NOT START*

| *Reason* | *Cause* | *Suggested Remedy* | *Reference* |
|---|---|---|---|
| | Incorrect starting procedure | Adopt correct procedure | Sect. 1 |
| Temperature below 14°C (55°F) | Failure to prime | Prime with lubrication oil | Sect. 1 |
| Incorrect lubrication oil | Too high viscosity oil causing excessive drag | Drain the sump and fill with correct oil | Sect. 2<br>Sect. 1 |
| Contaminated fuel | Water, dirt or unsuitable fuel in system | Drain and flush fuel system and fill with correct fuel | Sect. 3<br>Sect. 1 |
| Excessive load | Excessive drag from driven machine | Remove all load during starting | |
| Fuel supply failure check by cranking the engine and listen for the characteristic squeak of the injector | No fuel | Fill with correct fuel | Sect. 1 |
| | Air in system | Bleed the fuel system | Sect. 1 |
| | Fuel filter blocked | Fit new element | Sect. 3 |
| | Faulty injector nozzle | Replace the nozzle or fit replacement fuel injector | Sect. 3 |
| | Injection pump failure | Fit a replacement injection pump | Sect. 3 |
| Poor compression | Valves sticking or not seating properly | Decarbonise and grind in valves | Sect. 5 |
| | Cylinder head gasket blown | Fit a new gasket | Sect. 5 |
| | Piston rings stuck in piston grooves | Clean piston and fit new rings | Sect. 5 |
| | Worn cylinder and piston | Replace cylinder, piston and piston rings | Sect. 5 |
| | Incorrect bumping clearance | Check large end bearing and reset bumping clearance | Sect. 5 |
| | Broken or weak valve springs | Renew valve springs | Sect. 5 |
| | Incorrect valve clearances | Adjust valve clearances | Sect. 5 |
| | Injector seal washer leaking | Clean orifice and fit new washer | Sect. 3 |

*TABLE 9.1 Continued*

| *Reason* | *Cause* | *Suggested Remedy* | *Reference* |
|---|---|---|---|
| Starter motor will not crank engine | Flat battery | Charge battery or replace | |
| | Flat battery due to faulty charging equipment | Isolate fault and repair | Sect. 7 |
| | Dirty or loose terminals | Clean and tighten | Sect. 7 |
| | Broken wire | Replace | Sect. 7 |
| | Faulty starter switch | Replace switch | |
| | Faulty starter motor or solenoid | Repair or replace | Sect. 7 |
| | Engine seized | Overhaul engine | Sect. 5 |
| Heater plug inoperative | Flat battery | Charge battery or replace | Sect. 7 |
| | Dirty or loose terminals | Clean and retighten | Sect. 7 |
| | Broken wire | Replace | Sect. 7 |
| | Faulty heater plug switch | Replace | Sect. 7 |
| | Heater plug element broken or burned out | Replace heater plug | Sect. 7 |

*TABLE 9.2 ENGINE STARTS BUT FIRES INTERMITTENTLY OR SOON STOPS*

| *Reason* | *Cause* | *Suggested Remedy* | *Reference* |
|---|---|---|---|
| Faulty fuel supply | Water in the fuel | Drain and flush the fuel system and fill with clean fuel | Sect. 3<br>Sect. 1 |
| | Sticking injector needle | Fit a new nozzle or a replacement injector | Sect. 3 |
| | Partially blocked fuel filter | Renew fuel filter element | Sect. 3 |
| | Air in system | Bleed fuel system | Sect. 1 |
| Restricted air intake | Dirty air cleaner | Clean air cleaner and/ or fit new element | Sect. 4 |
| Faulty compression | Valves sticking or not seating correctly | Decarbonise and grind in valves | Sect. 5 |
| | Cylinder head gasket blown | Fit a new gasket | Sect. 5 |
| | Piston rings stuck in piston grooves | Clean piston and fit new piston rings | Sect. 5 |
| | Worn cylinder and piston | Replace cylinder, piston and piston rings | Sect. 5 |
| | Incorrect bumping clearance | Check large end bearings and reset bumping clearance | Sect. 5 |
| High exhaust back pressure | Blocked exhaust pipe or silencer, incorrect exhaust | Clean or replace | Sect. 1 |
| Overloaded | Excessive drag from driven machine | Reduce the load | |

TABLE 9.3 ENGINE LACKS POWER AND/OR SHOWS A DIRTY EXHAUST GAS

| Reason | Cause | Suggested Remedy | Reference |
|---|---|---|---|
| Faulty fuel supply | Air in fuel system | Bleed the fuel system | Sect. 1 |
| | Incorrect fuel | Drain and flush the fuel system and fill with the correct fuel | Sect. 3 Sect. 1 |
| | Fuel leaks | Check tighten pipe connectors, renew or repair fuel lines | Sect. 3 |
| | Faulty injector | Fit a new nozzle or a replacement injector | Sect. 3 |
| | Incorrect fuel pump timing | Time the injection pump | Sect. 3 |
| | Faulty injector pump | Renew pump | Sect. 3 |
| | Incorrect injector pipe | Fit correct pipe | Sect. 3 |
| | Kinked flexible fuel pipes | Fit new pipe | |
| | Partically blocked fuel filter | Renew filter element | Sect. 3 |
| Restricted air intake | Dirty air cleaner | Clean and/or refit a new element | Sect. 4 |
| Running at an incorrect speed | Worn or incorrectly adjusted variable speed control | Renew or adjust | Sect. 3 |
| Faulty compression | Valves sticking or not seating correctly | Decarbonise and grind in valves | Sect. 5 |
| | Cylinder head gasket blown | Fit a new gasket | Sect. 5 |
| | Piston rings stuck in piston grooves | Clean piston and fit new piston rings | Sect. 5 |
| | Worn cylinder and piston | Replace cylinder, piston and piston rings | Sect. 5 |
| | Incorrect bumping clearance | Check large end bearings and reset bumping clearance | Sect. 5 |
| High exhaust back pressure | Blocked exhaust pipe or silencer, incorrect exhaust | Clean or replace | Sect. 1 |
| Extended periods of running off load or with a light load | Glazed cylinder bore | De-glaze cylinder bore and fit new piston rings | Sect. 5 |
| Excessive carbon formation | Blocked air cell | Clean air cell orifice | Sect. 5 |
| Overloaded | Load requirement in excess of engine power rating | Reduce load | Preliminaries |

*TABLE 9.4 FAULTY RUNNING*

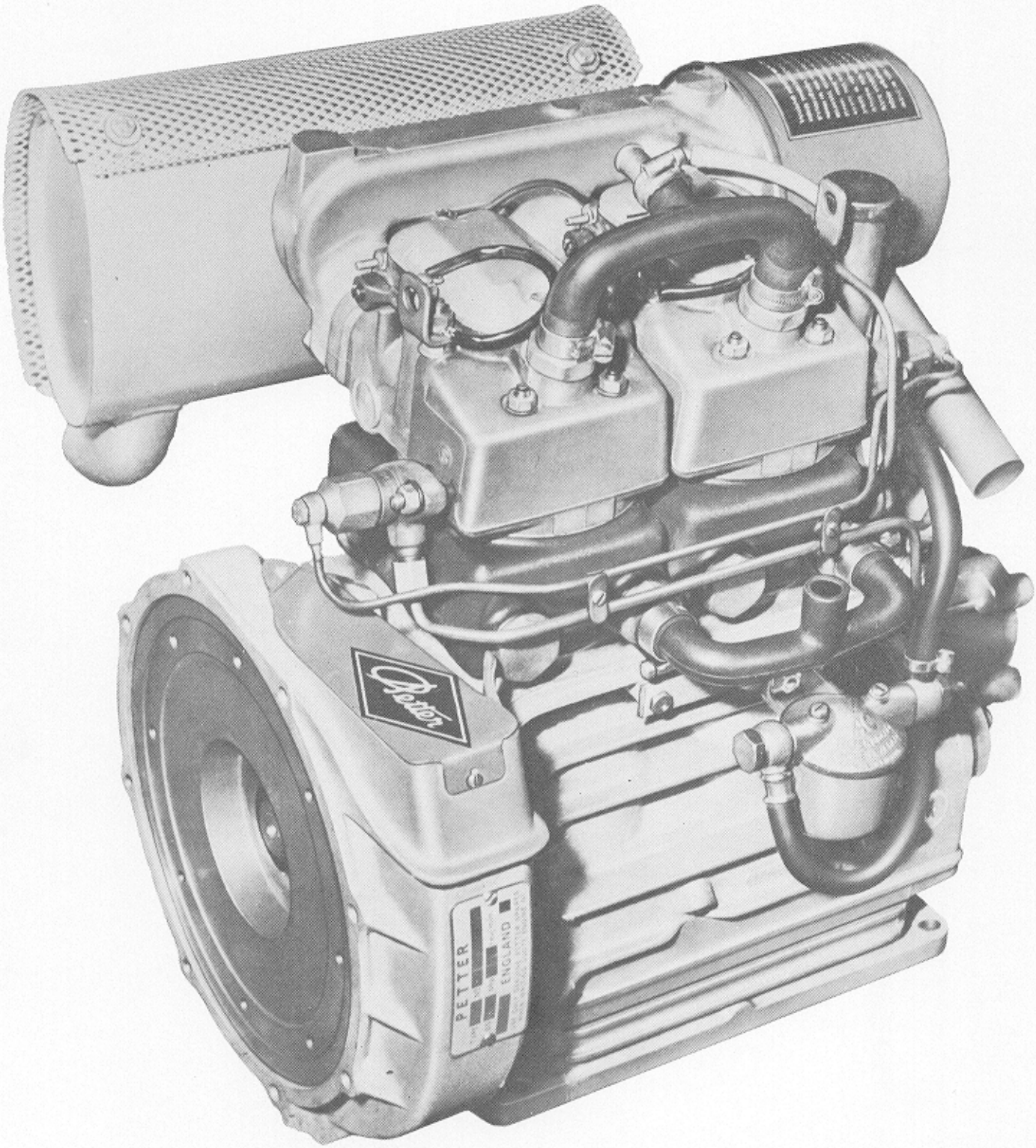
| *Reason* | *Cause* | *Suggested Remedy* | *Reference* |
|---|---|---|---|
| Knocking | Excessive carbon formation | Decarbonise | Sect. 5 |
| | Air in fuel system | Bleed fuel system | Sect. 1 |
| | Low oil supply | Replenish oil system | Sect. 1<br>Sect. 2 |
| | Diluted or incorrect oil | Drain and refil sump with correct grade and type of oil | Sect. 1<br>Sect. 2 |
| | Injector needle sticking or release pressure incorrect | Fit new nozzle or a replacement injector | Sect. 3 |
| | Injection pump timing too far advanced | Adjust timing | Sect. 3 |
| | Broken piston ring | Examine piston and cylinder for damage and repair as necessary | Sect. 5 |
| | Slack piston | Check piston and cylinder for wear and renew as necessary | Sect. 5 |
| | Worn large end bearing | Check crankpin for damage renew as necessary check lubrication system | Sect. 5<br>Sect. 2 |
| | Worn small end bearing | Renew small end bearing and check gudgeon pin | Sect. 5 |
| | Loose flywheel | Refit | Sect. 5 |
| Overheating | Cooling system failure | Check that the cooling system is in order and air flow is not obstructed | Sect. 1 |
| | Overloaded | Reduce load to conform with engine power rating | Preliminaries |
| | Excessive valve clearances | Adjust valve clearances | Sect. 5 |
| | Incorrect lubrication oil or level | Drain and refil sump with correct grade and type of oil or drain to the correct level | Sect. 1<br>Sect. 2 |
| | Injection pump timing incorrect | Adjust timing | Sect. 3 |
| Speed surges | Over heating | See overheating | |
| | Air in fuel system | Bleed the fuel system | Sect. 1 |
| | Injector release pressure incorrect | Fit a replacement injector | Sect. 3 |
| | Injector pump rack sticking | Fit a replacement pump | Sect. 3 |
| | Governor sticking or worn | Free or fit a new governor | Sect. 5 |

TABLE 9.4 Continued

| Reason | Cause | Suggested Remedy | Reference |
|---|---|---|---|
| Sudden stop | Empty fuel tank | Fill fuel tank and bleed fuel system | Sect. 1 |
| | Blocked or stuck injector | Fit a replacement injector | Sect. 3 |
| | Broken fuel pipe | Repair or renew | Sect. 3 |
| | Engine seized | Overhaul engine | Sect. 5 |
| Heavy vibration | Loose flywheel | Refit | Sect. 5 |
| | Faulty installation | Check holding down bolts flexible mountings and couplings | Sect. 1 |
| Engine overspeeds | Lubrication oil overfilled | Drain down to correct level | Sect. 1 |
| | Lubrication oil diluted or incorrect grade | Rectify cause of dilution drain and refil with correct grade of oil | Sect. 1 |
| | Injection fuel pump stuck in full fuel position | Replace injection pump | Sect. 3 |
| | Governor faulty | Fit new governor | Sect. 5 |
| Excessive oil consumption | Oil leaks | Rectify leaks | |
| | Worn valve guides, piston rings, or cylinder | Renew as necessary | Sect. 5 |
| | Incorrect type or grade of oil | Drain and fill with correct type and grade of oil | Sect. 1 |
| | Extended periods of running off load or with a light load | De-glaze cylinder bore and fit new piston rings | Sect. 5 |
| | Excess oil in sump | Drain oil to correct level | Sect. 1 |
| | Overheating | See overheating | |
| Lubrication oil dilution | Leaking lift pump diaphragm | Fit new diaphragm | Sect. 6 |
| | Leaking injection pump element | Fit replacement pump | Sect. 3 |
| | Faulty injector | Fit a replacement injector | Sect. 3 |

PART 2

# WATER COOLED DIESEL ENGINES
# AB1W, AC1W and AC2W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PART 2

# WATER COOLED DIESEL ENGINES AB1W, AC1W AND AC2W

*INDEX*

## SECTION 9 — FAULT FINDING



## TABLES

# SECTION 1
# GENERAL INFORMATION

## INSTALLATION

### INTRODUCTION

**1.1** It is essential that a water cooled diesel engine is installed correctly to obtain the maximum performance and reliability. Users are advised that installation drawings are obtainable from Petters Limited or their representatives, who should also be consulted in the following cases:

(1) Before proceeding with any new form of installation.

(2) Where the use of anti-vibration mountings is contemplated.

### ENGINE MOUNTING

**1.2** The engine mounting procedure is common to all 'A' range engines and reference should be made to Part 1, Section 1.

### ACCESS

**1.3** Before installing any engine suitable provision must be made to allow access for the following:

(1) Lubricating oil dipstick removal.

(2) Lubricating oil filler cap removal, lubricating oil filling and topping up.

(3) Lubricating oil filter maintenance.

(4) Fuel filter maintenance.

(5) Cooling system topping up, coolant draining and filling.

(6) Air cleaner maintenance.

(7) Starting handle operation and withdrawal.

(8) Operation of controls.

### AIR INTAKE

**1.4** Before installing any engine ensure that sufficient air supply is available and that the air intake is unobstructed. Engines mounted inside housings or confined spaces must be provided with ample openings for the free circulation of air.

### FOUNDATIONS

**1.5** Foundation preparation is identical to all 'A' range engines and reference should be made to Part 1, Section 1.

### COOLING SYSTEMS

#### Open System

**CAUTION**

**(1) Sea water must not be used except in engines equipped to withstand the harmful effects of corrosion.**

**(2) Ensure that no brass or copper pipes, or fittings contact the light alloy parts of the engine.**

**1.6** The following points must be taken into account when installing a cooling system.

(1) The cooling system must not be connected directly to a main water pressure supply unless a control valve is fitted in the inlet side of the system. The control valve must at all times prevent the system being pressurised.

(2) The cooling system must be arranged so that water remains in the engine cooling jacket when the engine is shut down or the water flow is interrupted.

(3) If a water pump is fitted the vertical distance between the pump and the water supply must not be more than 610 mm (2 ft.). By fitting a small reservoir and supplying water through a hose of no more than 9.5 mm (0.375 in.) bore the distance may be increased to 3 m (10 ft.).

(4) For correct circulation, the cooling water inlet must be fitted to the side of the cylinder head on AB1W engines and to the bottom of the cylinder(s) on AC1W and AC2W engines; the outlet is taken from the top of the cylinder head(s).

#### Cooling Tanks — Thermosyphon (Figure 1.1)

**1.7** The following points should be noted when installing cooling tanks:

(1) Coolant connections to and from the engine are by means of 19.05 mm (0.75 in.) bore pipes on one-cylinder engines or 25 mm (1 in.) bore pipes on two-cylinder engines.

(2) Coolant pipe **(1)** should go to the top of the cooling tank **(2)** in a steady incline. The bottom of the cooling tank should be level with, or slightly below the bottom of the cylinder. Pipes should be as short as possible with a minimum of bends.

(3) The coolant level **(7)** must not fall below the top connection.

(4) If two or more cooling tanks are installed to achieve the correct water capacity, they should be connected by 2 in. BSP pipes **(3)**, one below the level of pipe **(1)** and the other about 50 mm (2 in.) from the base.

(5) A tap or cock **(5)** should be fitted to the pipe **(4)** for maintenance purposes. The outlet temperature of the coolant should not exceed 95°C (203°F) and not be less than 75°C (167°F). A thermostatic valve **(6)** should be installed in the outlet pipe **(1)** as near as possible to the engine to maintain this temperature.

**1.8** Under low temperature conditions it is advisable to use an anti-freeze coolant. The anti-freeze should be in accordance with B.S.3161 to ensure that it contains the correct corrosion inhibitor. Do not mix different grades of coolant and always top up with a mixture of the same strength. Make sure that the coolant is suitable for the coldest conditions likely to be encountered.

*TABLE 1.1 WATER CAPACITY COOLING TANK(S)*

| *Engine* | *Cooling Tank(s) Capacity* | |
|---|---|---|
| | *Temperate* | *Tropical* |
| AB1W | **273 litres (60 gallons)** | **568 litres (125 gallons)** |
| AC1W | **273 litres (60 gallons)** | **568 litres (125 gallons)** |
| AC2W | **500 litres (110 gallons)** | **1023 litres (225 gallons)** |

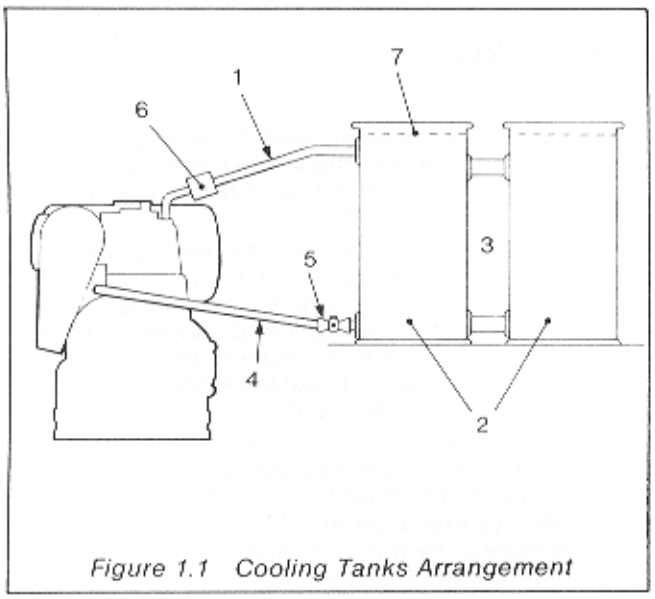



*Figure 1.1 Cooling Tanks Arrangement*

## ALIGNMENT

**1.9** The alignment procedure is as detailed in Part 1, Section 1.

## AIR INTAKE CLEANERS

**1.10** Air intake cleaners are common to all 'A' range engines and is as described in Part 1, Section 1.

## EXHAUSTS AND SILENCERS

**1.11** Exhaust and silencer fitting is common to all 'A' range engines and is as described in Part 1, Section 1.

## LUBRICATION

**1.12** Lubrication systems are identical on all 'A' range engines and reference should be made to Part 1, Section 1.

## FUEL

**1.13** Fuel systems are identical on all 'A' range engines and reference should be made to Part 1, Section 1.

## DRIVE ARRANGEMENTS

**1.14** The classification of the Petter engine drives is given in Part 1, Section 1, and the Mark applicability is given in Table 1.2.

*TABLE 1.2 MARK APPLICABILITY*

| ENGINE | MARK | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| **AB1W** | ✓ | ✓ | X | X | X | ✓ |
| **AC1W** | ✓ | ✓ | X | ✓ | ✓ | ✓ |
| **AC2W** | X | X | X | X | ✓ | X |

## PULLEY DRIVES

**1.15** The pulley drives are identical on all 'A' range engines and reference should be made to Part 1, Section 1.

## ROTATION

**1.16** Engine rotation is viewed from the flywheel end. Rotation for the various types of engines in the water cooled 'A' range is given in Table 1.3.

*TABLE 1.3 ENGINE ROTATION*

| Engine Type | Rotation |
|---|---|
| **AB1W** | Clockwise |
| **AC1W** | Clockwise |
| **AC2W** | Counter-Clockwise |

# OPERATING INSTRUCTIONS

## NEW OR OVERHAULED ENGINE

### Preparation for Starting

**1.17** To prepare a new or overhauled engine for starting proceed as follows:

(1) Check that the cooling system is in order and is unobstructed.

(2) Remove the oil filler cap and, with the engine level fill with lubricating oil which conforms to specification MIL-L-46152-B (Part 1, Section 1, Paragraph 1.28) and of the correct grade (Part 1, Section 1, Paragraph 1.29) to the high level mark on the dipstick. To ensure a correct reading, the dipstick should be withdrawn while the oil is being added. It should be submerged for at least five seconds before being removed for reading. Wipe the dipstick each time it is replaced for further readings. Replace the cap when oil level is at the high mark on the dipstick.

(3) Fill the oil bath cleaner (if fitted) with oil to the indicated level.

(4) Lift the decompressor lever(s) and turn the engine about fifteen times to circulate the oil.

(5) Fill the fuel tank with the appropriate type and grade of fuel (Part 1, Section 1, Paragraphs 1.32 and 1.33).

(6) Bleed the fuel system as detailed in Part 1, Section 1, Paragraph 1.42 if required (see Note).

**Note**

*Most 'A' range engines are fitted with a self-bleeding pipe assembly in place of the fuel pump vent screw (Part 1, Section 1, Figure 1.9) and require no action.*

(7) Lightly lubricate the control linkages.

**Note**

*After initial running check the oil level and top up, as required. The level of oil usually falls slightly after initial circulation.*

### Engine Running In

**1.18** To avoid excessive oil consumption the running in procedure must be carried out on new or overhauled engines as detailed in Paragraph 1.34.

**CAUTION**

**Initial running at idling speed for long periods of a new or overhauled engine causes glazed bores and thus excessive oil consumption.**

## STARTING

**WARNING**

**(1) ENSURE THAT THE STARTING HANDLE IS CLEAN, LIGHTLY LUBRICATED AND IN GOOD CONDITION TO ALLOW IT TO EASILY AND SAFELY ENGAGE AND DISENGAGE.**

**(2) MAKE SURE THAT AFTER INSERTING THE STARTING HANDLE THAT THE LOCATION PIN WHERE APPLICABLE IS SECURELY LOCATED IN THE SLOT IN THE HOUSING IN THE CAPTIVE POSITION.**

**(3) THE STARTING HANDLE SHOULD BE HELD FIRMLY WITH THE THUMB ON TOP OF THE GRIP NOT ROUND IT.**

**(4) WHEN USING A STARTING ROPE, DO NOT WIND THE ROPE AROUND HAND OR WRIST, MAKE SURE THE ROPE IS NOT TANGLED OR FRAYED AND IS OF THE CORRECT LENGTH.**

## Normal Start (Figure 1.2)

### Preliminaries

**1.19** To start an engine under normal conditions carry out the following preliminary operations:

(1) Check the coolant level in the cooling tank(s). If a water pump reservoir is fitted ensure that it is full and the cap is in position.

(2) Remove as much load from the engine as possible.

(3) Move the STOP/RUN lever **(3)** to the RUN position (horizontal).

(4) If a two speed control is fitted set the control in the relevant RUN position, or if a variable speed control is fitted set to the full speed position.

(5) Push down and release the overload stop lever **(4)** located on the fuel pump side of the engine (where applicable).

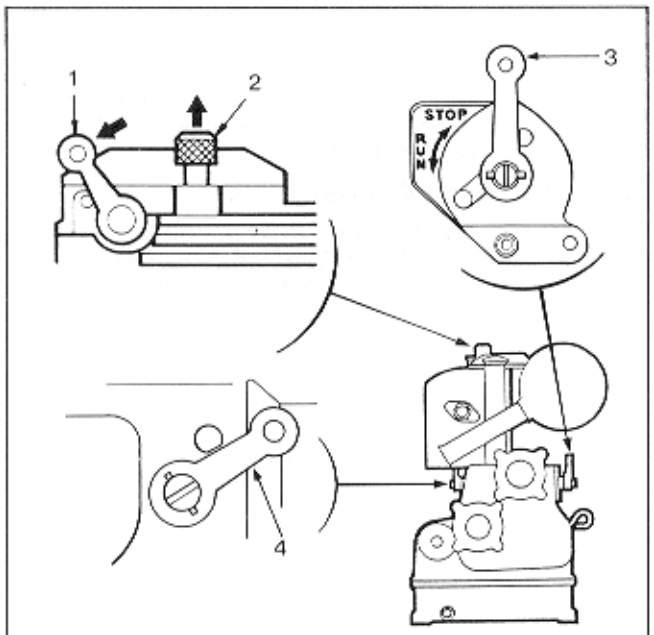



*Figure 1.2 Engine Starting Controls*

### Rope Starting

**1.20** To rope start proceed as follows:

(1) Turn the starting pulley in the opposite direction of rotation until a resistance is felt.

(2) Bounce the pulley vigorously against the resistance, until the injector has squeaked a few times (this is not necessary with a warm engine).

(3) Wind the rope two turns around the starting pulley in the direction of rotation.

**WARNING**
**DO NOT WIND THE ROPE AROUND THE HAND OR WRIST.**

(4) Ensure that the decompressor lever **(1)** is down and pull the rope sharply until it unwinds completely.

**Note**
*Rope starting is not recommended at temperatures below –4°C (25°F).*

### 4:1 Hand Starting

**1.21** To carry out 4:1 hand starting proceed as follows:

(1) Lift the centre boss of starting gear.

(2) Insert the starting handle in the starting gear. The handle will not fully engage unless the starting gear has been lifted.

(3) Lift and hold the decompressor lever **(1)** against its stop. Turn the starting handle slowly and when the injector is heard to squeak, turn the handle as fast as possible and lower the decompressor lever while still turning. When the engine fires, remove the starting handle.

### Hand Starting

**1.22** To carry out all other forms of hand starting proceed as follows:

(1) Lift and hold the decompressor lever(s) **(1)** against its stop.

(2) Engage the starting handle and turn the handle slowly until the injector is heard to squeak.

(3) Turn the starting handle as fast as possible and at the same time lower the decompressor lever. On two cylinder engines lower one decompressor lever only and as soon as the engine fires lower the other lever.

(4) When the engine starts remove the starting handle.

### Electric Starting

**1.23** Make sure the decompressor lever(s) **(1)** is down before operating the starter switch or button. When the engine starts release the switch or button. Do not operate the starter switch or button for more than 20 seconds at a time.

## COLD STARTING (ALL ENGINES)

**1.24** At temperatures below 13°C (55°F), it is essential to prime the engine as follows:

(1) Remove the priming plunger(s).

(2) Fill the priming chamber(s) with engine oil – not fuel. Use the priming facility on the dipstick, if fitted (Part 1, Section 1, Figure 1.10). The priming dipstick has a neoprene bulb, which when pressed and then released in position will fill with oil from the engine sump. The dipstick can then be removed and oil injected into the priming chamber. Replace the dipstick after use.

(3) Replace the priming plunger(s) and press down. If the temperature is below 0°C (32°F) prime the engine twice.

(4) Start the engine in the normal manner.

**1.25** Should the engine fire and then stop, prime again and release the overload stop lever (if fitted) before attempting a further start. If under cold conditions the engine does not run up to its rated speed after starting operate the priming plunger(s). again while the engine is still running.

**1.26** It is advisable to keep the engine under cover (if possible) when not in use.

## COLD STARTING PRIMING PUMP (IF FITTED)

**1.27** On a new or overhauled engine remove the rocker cover and fill the reservoir with clean approved engine oil. At temperatures below 13°C (55°F), it is essential to prime the engine. To prime the engine withdraw the plunger fully, allow a few seconds and push fully inwards. Repeat the operation two more times and then start the engine in the normal way. If under extreme cold conditions the engine does not run up to its rated speed after starting, withdraw and press in the plunger while the engine is running.

**CAUTION**
**Do not over prime**

**1.28** When the engine is running normally leave the priming plunger fully inwards.

### Cold Starting Aids

**1.29** When the operating temperatures are below –4°C (25°F) a cold starting aid may be required. Below –9°C (16°F) consult Petters Limited or their representatives for starting instructions, information on cold starting aids may also be obtained.

## STOPPING

**1.30** Before stopping it is advisable to run the engine on a light load for a few minutes. To stop the engine move the STOP/RUN lever to the STOP position (vertical) and hold in this position until the engine stops.

**CAUTION**
**Do not turn off the fuel supply or use the decompressor lever(s) to stop the engine.**

## OPERATING PRECAUTIONS

**1.31** The following points should be noted when operating Petter diesel engines:

(1) Do not stop the engine by lifting the decompressor lever(s). This will damage valve seats.

(2) Do not allow the engine fuel tank to run low. This could allow sediment or water to be drawn into the fuel system.

(3) Do not remove or alter the setting of the overload stop or operate the overload stop lever when the engine is running. This will cause overheating, excessive wear and possible piston seizure.

(4) Prolonged running at idling speed and/or running on a light load causes glazed bores and thus excessive oil consumption.

# ROUTINE MAINTENANCE

## INTRODUCTION

**1.32** The routine servicing and maintenance instructions given in this manual cover the minimum requirements to keep an engine running at peak performance and give trouble free operation, based on average operating conditions. Under very dusty conditions, air cleaners, lubricating oil and fuel filters will require more frequent attention. Decarbonising may be required more frequently when engines are running on light loads for long periods.

***PLEASE REMEMBER***

***... an engine needs fuel —***
Keep fuel, tank, filter and piping clean.

***... an engine needs lubricating oil —***
Use correct grade and type of oil. Keep oil level topped up.

***... an engine needs air —***
Keep air cleaner clean. Keep air inlet manifold and entire exhaust system free of carbon and any other obstruction.

***... an engine needs cooling —***
Keep coolant level topped up and provide adequate ventilation.

## INITIAL CHECKS ON NEW OR OVERHAULED ENGINES

### Initial Start

**1.33** To allow the piston rings to bed in satisfactory carry out the following procedure:

(1) Run the engine for two minutes on no load.

(2) Run the engine for ten minutes on half load.

(3) Run the engine on full load for one hour.

### After an Initial Run of One Hour on Full Load

**1.34** After an initial run of one hour on full load stop the engine and allow it to cool. When the engine is cold re-torque the cylinder head nuts. This is achieved by slackening each nut in turn in the sequence shown in Section 5, Figure 5.1 a quarter of a turn and re-torque loading to 32.5 Nm (24 lbf ft.) for the rocker support stud nut and 29.8 Nm (22 lbf ft.) for the remaining cylinder head nuts. Reset the valve rocker clearance to 0.10 mm (0.004 in.) as detailed in Section 5.

**1.35** After completion of the re-torque loading procedure a further eight hours engine running on full load must be carried out.

### 20 Hours Initial Running

**1.36** After approximately 20 hours initial running of a new or overhauled engine carry out the following procedure with the engine cold:

(1) Check the tightness of all nuts (excluding the cylinder head), bolts, securing screws and hose clips.

(2) Drain the lubricating oil from the sump, fit a new filter element and sealing ring. Fill the sump with new lubricating oil of the correct type and grade. (Part 1, Section 2).

**Note**
*When renewing the oil filter element check the oil level after the initial engine run.*

(3) Check the fuel filter (Part 1, Section 3).

### 50 Hours Initial Running or Three Months (Marine Engines Only)

**1.37** Protection against electrolytic corrosion is provided by zinc anode(s) fitted in the cylinder block(s) or cylinder head(s) (early engines). These anodes should be checked at regular intervals especially in the case of engines where direct sea water (raw water) cooling is used. Due to the varied environmental conditions that exist it is not possible to specify a uniform period when these anodes should be checked. Initially it is recommended that the anodes should be checked after 50 hours running or no later than three months from the date of ownership (excluding any period where the engine is not in use with the cooling system drained). Depending on the condition of the anodes at this time determines a suitable servicing frequency for the future.

## DAILY CHECKS

**1.38** Carry out the following procedure:

(1) Check and top up the fuel tank with the correct type and grade of fuel.

(2) Check the oil level on the dipstick, if necessary top up at the engine oil filler with the correct type and grade of lubricating oil.

(3) Check the coolant level in the cooling tank(s) and if a water pump reservoir is fitted, ensure that it is full and the cap is in position.

(4) Visually check the engine for signs of oil, fuel and coolant leaks.

## EVERY 50 RUNNING HOURS

**1.39** Carry out the following procedure:

(1) Clean the oil bath type air cleaner, if fitted. (Part 1, Section 4).

(2) Check the tension of the alternator or dynamo drive belt (if fitted) and adjust, if necessary. (Part 1, Section 7).

## EVERY 250 RUNNING HOURS

**1.40** Carry out the following procedure:

(1) Clean the fuel filter. (Part 1, Section 3).

(2) Check the tightness of all nuts (excluding cylinder head), bolts, securing screws and hose clips. (Engine cold).

(3) Check that the fuel tank filler cap vent hole is clear, and clean if necessary.

(4) Clean the air cleaner paper element, if fitted. (Part 1, Section 4).

(5) Check the exhaust system for damage, corrosion and holes, clean out deposits of carbon.

(6) Clean the fuel tank strainer, if fitted.

(7) Drain the oil sump, fit a new oil filter element and sealing ring. Fill the sump with new lubricating oil of the correct type and grade. (Part 1, Section 2).

(8) Clean the fuel lift pump filter gauze (if applicable).

**Note**
*When renewing the oil filter element check the oil level after the initial engine run.*

(9) Visually check the fuel system for leaks.

(10) Remove the fuel injector(s) and test spray. (Part 1, Section 3).

**Note**
*Whenever a fuel injector is removed a new nozzle sealing washer must be fitted.*

(11) Lubricate the 4:1 or raised hand starting, if fitted. (Part 1, Section 6).

(12) Check valve clearance (Section 5) and adjust, if necessary.

(13) Lightly lubricate the speed control linkage.

(14) Check the water pump and seal (if fitted) for damage and renew, if required. (Section 4).

## EVERY 500 RUNNING HOURS

**1.41** Carry out the following procedure:

(1) If a separately mounted fuel filter is fitted to the engine installation renew the filter element.

(2) Drain the cooling system and flush with clean fresh water. Refill the system with coolant.

## EVERY 1000 RUNNING HOURS

**1.42** Carry out the following procedure:

(1) Clean out fuel tank.

(2) Fit a new fuel filter element (fuel tank mounted).

## EVERY 2000 RUNNING HOURS

**1.43** Carry out the following procedure:

(1) Decarbonise the piston(s) and cylinder head(s) in accordance with the procedure detailed in Section 5.

(2) Check the connecting rod bearings. (Section 5).

(3) Clean the oil pump strainer. (Part 1, Section 2).

# SECTION 2
# LUBRICATING SYSTEM

## INTRODUCTION

**2.1** The lubricating system is common to all 'A' range engines and is as described in Part 1, Section 2.

# SECTION 3
# FUEL SYSTEM

## INTRODUCTION

**3.1** The fuel injection equipment is manufactured to very fine limits and requires extreme care and absolute cleanliness in handling. Any part of the fuel system including pipes removed from an engine must be placed in a clean container containing clean fuel.

## FUEL INJECTION EQUIPMENT IDENTIFICATION

**3.2** The fuel injection equipment fitted to 'A' range water cooled engines although similar in construction and operation varies between engine types. To assist in identification and to show interchangeability between types the fuel injection equipment details are listed in Tables 3.1, 3.2 and 3.3.

### Fuel Injection Pumps

**3.3** Identification of a fuel injection pump is achieved by reading the type code from the name plate on the pump body. Compatible pumps are shown in Table 3.1.

### Fuel Injectors

**3.4** The fuel injector(s) fitted to water cooled 'A' range engines can be one of three types: the Bryce Early, the Bryce Late or the I.E.S.A. type. The Bryce injectors have interchangeable nozzles and the Bryce Late injector is interchangeable with the I.E.S.A. injector, but the Bryce and I.E.S.A. nozzle types are not interchangeable. The Bryce Early type injector is not interchangeable with the Bryce Late or I.E.S.A. injector. See Table 3.2. The Bryce Early type injector is fitted using a copper type sealing washer. All other injectors use a steel dimpled sealing washer.

*TABLE 3.2 FUEL INJECTORS*

| *Engine Type* | *Fuel Injector* | *Nozzle Code* |
|---|---|---|
| AB1W<br>Engine No. 101 to 3254 | **Bryce Early Type** | PIS 4S437 |
| AB1W<br>Engine No. 3255 onwards<br>AC1W<br>AC2W | **Bryce Late Type<br>or<br>I.E.S.A. Type** | PIS 4S437<br><br><br>OGD 10.4S437 |

### High Pressure Injector Pipes

**3.5** It is important that the correct bore diameter and length of pipe is fitted to obtain the correct engine performance and details are given in Table 3.3.

*TABLE 3.1 FUEL INJECTION PUMPS*

| *Engine Type* | *Engine Speed* | *Fuel Injection Pump* | |
|---|---|---|---|
| | | *Make* | *Pump Code* |
| AB1W | **Fixed Speed and Two Speed up to 3000 r/min** | Bryce 'B' Series<br>Bryce 'B' Series<br>Bryce 'E' Series<br>I.E.S.A. | FAOARO55B0301<br>FAOARO55B0486<br>FAOARO55E0613<br>EMYW13755 sgrvi |
| AB1W | **Fixed Speed and Two Speed 3001 to 3600 r/min** | Bryce 'B' Series<br>Bryce 'B' Series<br>Bryce 'E' Series | FAOARO55B0404<br>FAOARO55B0487<br>FAOARO55E0614 |
| AB1W | **All Variable Speeds** | Bryce 'B' Series<br>Bryce 'B' Series<br>Bryce 'B' Series<br>Bryce 'E' Series | FAOARO55B0402<br>FAOARO55B0488<br>FAOARO55B0486<br>FAOARO55E0614 |
| AC1W | **Fixed Speed and Two Speed up to 3000 r/min** | Bryce 'B' Series<br>Bryce 'B' Series<br>Bryce 'E' Series<br>I.E.S.A. | FAOARO55B0301<br>FAOARO55B0486<br>FAOARO55E0613<br>EMYW13755 sgrvi |
| AC1W | **Fixed Speed and Two Speed 3001 to 3600 r/min and all Variable Speeds** | Bryce 'B' Series<br>Bryce 'E' Series | FAOARO55B0523<br>FAOARO55E0615 |
| AC2W | **All Speeds** | Bryce 'A' Series<br>Bryce 'A' Series<br>Bryce 'E' Series | FAOBRO55A0567<br>FAOBRO55A0568<br>FAOBRO55E0617 |

*TABLE 3.3 HIGH PRESSURE INJECTOR PIPES*

| Engine Type | Speed | Bore Diameter | Length |
|---|---|---|---|
| AB1W | All Speeds | **1.5 mm (0.06 in.)** | **270 mm (10.6 in.)** |
| AC1W | All Speeds | **2 mm (0.08 in.)** | **270 mm (10.6 in.)** |
| AC2W | All Speeds | **2 mm (0.08 in.)** | **430 mm (17 in.)** |

## FUEL SYSTEM

**3.6** The fuel system as described in Part 1, Section 3 is identical to the water cooled 'A' range engines with the exception of the fuel injection pump timing.

## FUEL INJECTION PUMP TIMING

### AB1W Engine (Figure 3.1)

**3.7** On fixed speed and two speed engines running at speeds above 3000 r/min and on all variable speed engines, move the STOP/RUN lever towards the STOP position, that is vertical, and fix it at approximately 10° before the vertical position. On variable speed engines move the speed control to the full speed position. Do not operate the overload stop lever.

**3.8** On fixed speed and two speed engines running at 3000 r/min and below, move the STOP/RUN lever to the RUN position that is horizontal.

**3.9** Carry out the following procedure:

(1) Isolate the fuel supply and remove the pump-to-injector fuel pipe.

(2) Unscrew the delivery union body **(1)** and remove, ensure that the 'O' ring seal **(4)** is also withdrawn.

(3) Lift out the spring peg **(2)** (excluding early type 'B' series), and spring **(3)**.

(4) Carefully lift out the delivery valve **(6)**. Do not disturb the seal seat **(7)** or seal **(5)**. Place the spring peg, spring and delivery valve in a container of clean fuel.

(5) Locate the 'O' ring seal **(4)** on the lower diameter of the Bryce 'A' and 'B' series union body and ensure that the 'O' ring seal is in position on the union body of the Bryce 'E' and IESA pumps. Screw the union body into the pump.

(6) Fit a suitable spill pipe (as shown in Figure 3.2).

(7) Turn the engine flywheel until the engine is a quarter of a turn before TDC with the piston on compression stroke.

(8) Connect the fuel supply and bleed the separately mounted fuel filter (if fitted). Fuel should flow from the spill pipe.

**Note**
*If a fuel lift pump is fitted fuel will not flow unless the hand priming lever is operated.*

(9) Turn the flywheel slowly by hand in the direction of rotation until the fuel flow from the spill pipe stops. This position is known as the spill point. To ensure that the position noted is correct it is advisable to repeat this operation a number of times.

(10) Read off the angle through the timing hole in the bell housing (Figure 3.3). Check with the figures detailed in Table 3.4. If the angle is too large, shims must be added between the pump and the crankcase. If too small, shims must be removed. To calculate the thickness of shims required 1 degree is equal to 0.1 mm (0.004 in.).

(11) When the correct timing angle has been obtained remove the spill pipe, unscrew and remove the union body **(1)** with the 'O' ring seal **(4)**.

(12) Replace the delivery valve **(6)**, spring **(3)** and spring peg **(2)** if fitted.

(13) Locate the 'O' ring seal **(4)** on the lower diameter of the Bryce 'A' and 'B' series union body and ensure that the 'O' ring seal is in position on the union body of the Bryce 'E' and IESA pumps. Screw the union body into the pump and torque load to 41 Nm (30 lbf ft.).

(14) Connect the fuel pipes.

(15) Fill the fuel tank with the approved fuel and bleed the fuel system, where applicable, as detailed in Part 1, Section 1.

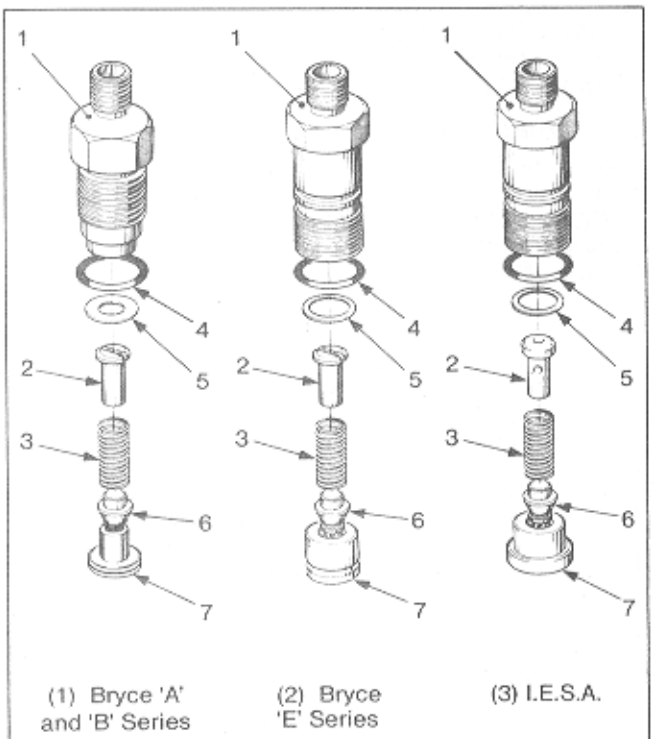



*Figure 3.1 Fuel Pumps Delivery Side: Exploded Views*

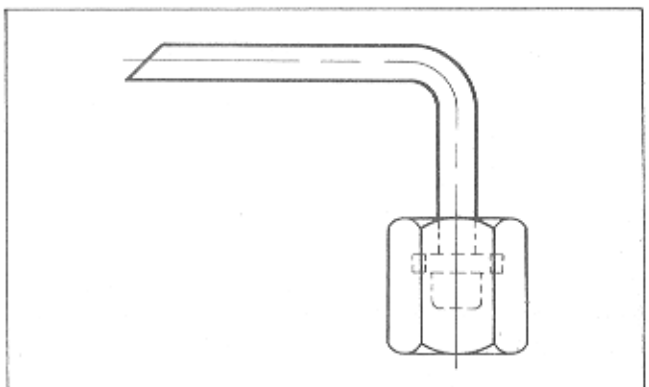


*Figure 3.2 Typical Spill Pipe*

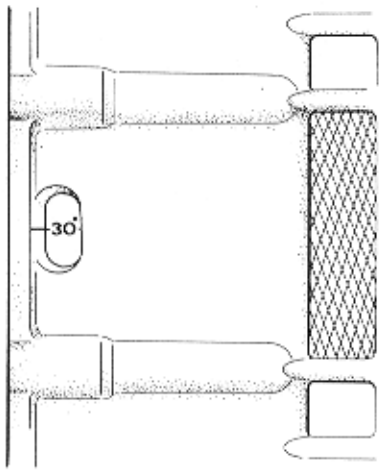



*Figure 3.3 Flywheel Timing Marks*

*TABLE 3.4 FUEL INJECTION TIMING (BY SPILL) AB1W ENGINES*

| *Speed* | *r/min* | *Flywheel Setting Angle BTDC* |
|---|---|---|
| Fixed Speed and Two Speeds | **Up to 3000** | **29°** |
| Fixed Speed and Two Speeds | **3001 to 3300** | **29°** |
| Fixed Speed and Two Speeds | **3301 to 3600** | **34°** |
| All Variable Speeds | | **29°** |

## AC1W Engines

**3.10** Move the STOP/RUN lever to the RUN position, that is horizontal. On variable speed engines move the speed control to the full speed position, do not operate the overload stop lever, if fitted.

**3.11** Carry out the procedure detailed in Paragraph 3.9 using Table 3.5.

*TABLE 3.5 FUEL INJECTION (BY SPILL) AC1W ENGINES*

| *Speed* | *r/min* | *Flywheel Setting Angle BTDC* |
|---|---|---|
| Fixed Speed and Two Speeds | **Up to 2200** | **26°** |
| Fixed Speed and Two Speeds | **2201 to 2800** | **28°** |
| Fixed Speed and Two Speeds | **2801 to 3300** | **30°** |
| Fixed Speed and Two Speeds | **3301 to 3600** | **33°** |
| All Variable Speeds | | **30°** |

## AC2W Engines

**3.12** Move the STOP/RUN lever midway between the STOP and RUN position. On variable speed engines move the speed control to the full speed position. Do not operate the overload stop lever. The injection pump is timed on No. 1 cylinder (gear end) which is fed from the gear end side of the pump. Ensure that the flywheel marks refer to No. 1 cylinder. Carry out the procedure detailed in Paragraph 3.9 using Table 3.6.

*TABLE 3.6 FUEL INJECTION TIMING (BY SPILL) AC2W ENGINES*

| *Speed* | *r/min* | *Flywheel Setting Angle No. 1 Cylinder BTDC* |
|---|---|---|
| All Fixed Speeds | **2201 to 2800** | **30°** |
| | **2801 to 3200** | **32°** |
| | **3201 to 3600** | **34°** |
| All Variable Speeds | — | **32°** |

# SECTION 4
# AIR FILTRATION AND ENGINE COOLING

## AIR FILTRATION

**4.1** Air filtration is common to all 'A' range engines and reference should be made to Part 1, Section 4.

## ENGINE COOLING

### Cooling Tanks

**4.2** Maintenance of cooling tanks is limited to checking for leaks, damage to pipes and, if necessary, changing the coolant and flushing the system with clean water.

### Draining

**4.3** To drain the cooling system proceed as follows:

(1) Remove the plug(s) from the cylinder(s).

(2) Loosen the water pump cover if fitted and drain the coolant from pump and the hoses.

### Flushing

**4.4** To flush the cooling system carry out the following procedure:

(1) Drain the engine as detailed in Paragraph 4.3.

(2) Insert a piece of wire or suitable tool through each orifice in the cylinder and rake out any deposit. This operation should be carried out whilst flushing with fresh water, preferably under pressure. It may be necessary to flush the system out frequently if water with a high silt content is used.

(3) Replace the cylinder plug(s) and pipe fittings.

(4) Fill the system with the appropriate coolant.

(5) Check the system for leaks during initial run after flushing.

## WATER PUMP — FLANGE MOUNTED (Figure 4.1)

### Removal

**4.5** To remove the water pump proceed as follows:

(1) Isolate the water supply and drain cooling system.

(2) Disconnect the water pipes at the pump.

(3) Remove the four No. 10 UNF nuts and washers securing the pump.

(4) Carefully slide off the pump assembly from the pump drive shaft.

(5) Remove the pump adaptor plate **(1)**, adaptor shims **(2)**, pump shaft washer **(3)** and water thrower **(4)**.

### Dismantling

**4.6** To dismantle the water pump proceed as follows:

(1) Remove the three screws securing the front cover and remove the cover **(5)** and gasket **(6)**.

(2) Remove the water pump impellor **(7)** and water pump seal **(8)**.

### Maintenance

**4.7** Carry out the following procedure:

(1) Clean all component parts and check for wear or damage. Examine the rubber seal **(8)**, water thrower **(4)** and impellor **(7)** for cracking or hardening.

**Note**
*It is not necessary to remove the camplate from the inside of the pump body.*

(2) Check the water pump drive shaft for wear or damage.

### Replacement

**4.8** Carry out the following procedure:

(1) Lightly lubricate the water pump seal **(8)** with water pump grease. Insert the seal with the lip facing towards the impellor.

(2) Fit the water pump adaptor plate **(1)** and adaptor shim **(2)** on to the locating studs.

(3) Fit the pump shaft washer **(3)** in to the adaptor plate recess. Fit the water thrower **(4)** leaving a gap between it and the pump shaft washer.

(4) Slide the water pump body onto the shaft with the cam securing screw uppermost. Fit and tighten the four securing washers and nuts.

(5) Check that the shaft does not protrude beyond the outer face of the water pump body. This can be checked by using a straight edge or the pump cover. If the shaft does protrude extra shims must be added.

(6) Fit the impellor **(7)** on the shaft and fit the cover **(5)** and gasket **(6)**. The gasket must be positioned so as to cover the camplate.

**CAUTION**
**The correct gasket must be used as this gasket affects the pump performance.**

(6) Connect the water pipes. The pump inlet is on the right side when viewed from the front (impellor end).

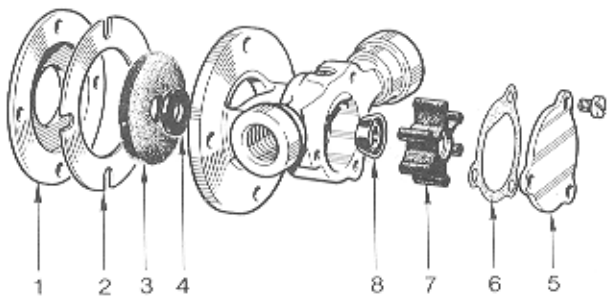



*Figure 4.1 Water Pump Flange Mounted: Exploded View*

## WATER PUMP — PEDESTAL MOUNTED (Figure 4.2)

### Removal

**4.9** To remove the water pump proceed as follows:

(1) Isolate the water supply and drain the cooling system.

(2) Disconnect the water pipes at the pump.

(3) Remove the drive belt and pulley.

(4) Remove the two securing bolts, nuts and washers and lift off the pump assembly from the mounting plate.

### Dismantling

**4.10** To dismantle the pump proceed as follows:

(1) Remove the six screws from the front cover.

(2) Remove the cover **(1)**, gasket **(2)** and impellor **(3)**. Should difficulty be experienced in removing the impellor it may be necessary to prise it out using suitable blunt instruments.

(3) Remove the cam screw and cam **(4)**. Lift out wear plate **(5)**.

(4) Using a suitable hooked piece of wire, remove the seal **(6)** and 'O' ring **(7)**.

(5) Remove the outer bearing seal **(8)** and circlip **(9)**.

(6) Heat the pump body in hot water and remove the shaft and bearing assembly **(10)** by applying pressure at the impellor end of the shaft. Remove the inner bearing seal **(11)** and water thrower **(12)**.

### Maintenance

**4.11** Clean all parts and check for wear or damage.

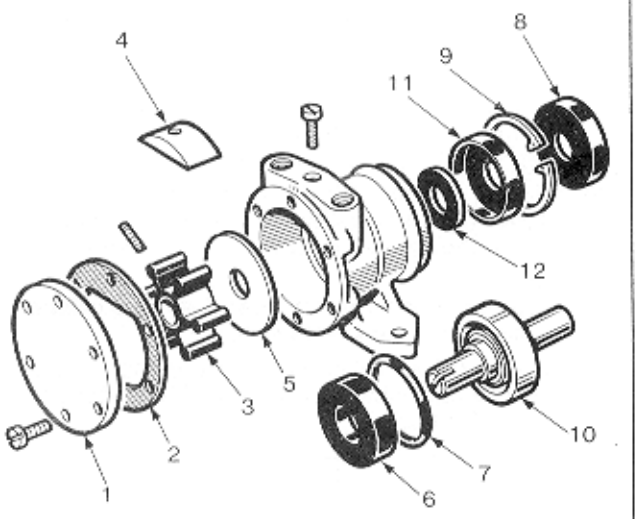



*Figure 4.2 Water Pump Pedestal Mounted: Exploded View*

### Assembly

**4.12** To assemble the water pump proceed as follows:

(1) Lubricate the inner bearing seal **(11)** with water pump grease and press in position with the outer lip facing towards the impellor bore.

(2) Position the water thrower **(12)** in the drain area of the pump body, insert the slotted end of the shaft and bearing assembly **(10)** through the inner seal and water thrower.

(3) Heat the water pump body in hot water and press the shaft into position.

(4) Fit the circlip **(9)** with the flat side facing the bearing.

(5) Lubricate the outer bearing seal **(8)** with grease and fit with the outer lip facing towards the bearing. The outer face of the seal should be flush with the pump body.

(6) Lightly lubricate and fit the 'O' ring seal **(7)**.

(7) Lubricate the outside diameter and lip of seal **(6)** with grease and fit with the lip facing towards the impellor bore.

(8) Insert the wear plate **(5)** with the dimple facing the impellor bore and in-line with the cam screw.

(9) Lightly smear the top and inner edge of the cam **(4)** with a non-setting jointing compound. Fit the cam ensuring that the groove on the inner edge of the cam is located over the dimple on the wear plate. Fit the cam retaining screw. Non-setting jointing compound should also be used on the securing screw.

(10) Lightly lubricate the impellor bore. Fit the impellor **(3)** using a twisting motion until the impellor drive screw engages with the slot in the shaft.

(11) Fit the cover plate **(1)** and gasket **(2)**. Ensure that the joint covers the cam. Ensure that the correct gasket is used as a gasket of incorrect thickness will effect the performance of the pump.

## ZINC ANODES — MARINE ENGINES

**4.13** Protection against electrolytic corrosion is given by zinc anode(s) fitted in the cylinder block(s) or head(s) (early engines). These anodes must be checked at regular intervals paying particular attention where direct sea water (raw water) cooling is used. (See Section 1 Initial Checks). If the anode is found to be 75% worn (eroded) it must be renewed. Do not use any type of insulating material on the threads of the anode holder(s) or adaptor(s) as this will effect the electrical continuity of the anode.

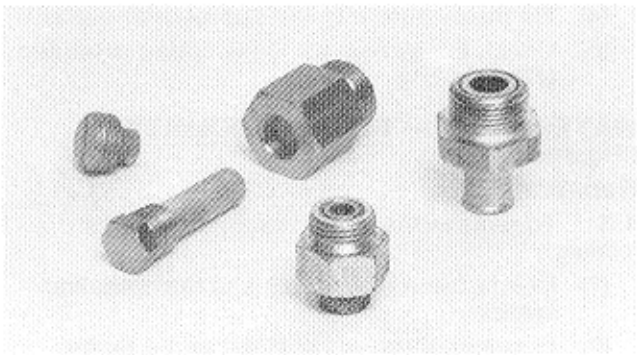


*Figure 4.3 Types of Zinc Anodes*

# SECTION 5
# ENGINE GENERAL MAINTENANCE

## INTRODUCTION

**5.1** This section contains fitting and servicing instructions for major repairs of the water cooled 'A' range engines. Servicing which is common to all 'A' range engines is referenced to Part 1. Major servicing should be carried out by qualified personnel in a workshop environment. It is important that all component parts are kept clean.

## DECARBONISING

**5.2** A carbon deposit forms on piston and cylinder heads and the presence of an excessive carbon deposit is usually indicated by a loss of power. Decarbonising necessitates the removal of the cylinder head, followed by the removal of all carbon and the grinding in of the valves.

### Cylinder Head Removal

**5.3** To remove a cylinder head proceed as follows:

(1) Drain off the cooling system as detailed in Section 4.

(2) Remove the cooling pipe connections.

(3) If applicable remove the fuel tank and fuel pipes (Part 1, Section 3).

(4) Remove the exhaust silencer, air cleaner and manifolds.

(5) Remove the crankcase to rocker box oil pipe.

(6) Remove the fuel injector(s) as detailed in Part 1, Section 3.

(7) Remove the rocker cover(s) and priming plunger(s).

(8) Gradually slacken the 5/16 in. UNF cylinder head retaining nuts in sequence diagonally as shown in Figure 5.2. Note their positions and remove the nuts and washers.

(9) Remove the rocker assembly.

(10) Note the positions of the push rods and remove.

**Note**
*It is important that the push rods are refitted in the same position on assembly.*

(11) Lift off the cylinder head(s).

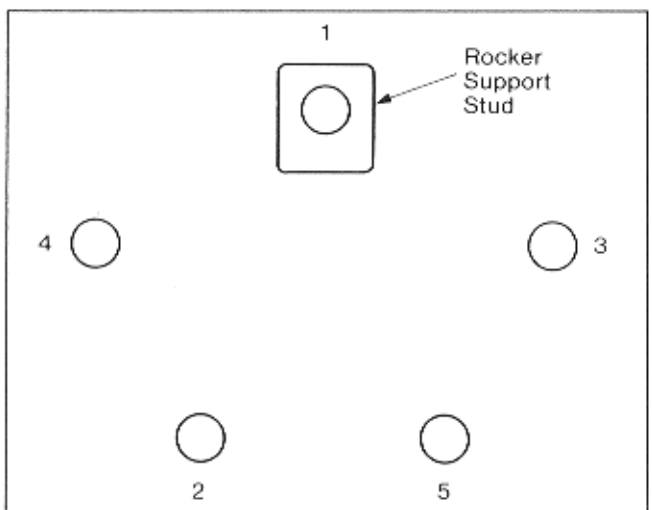



*Figure 5.1 Cylinder Head Nuts Removal and Replacement Sequence*

### Cylinder Head Dismantling

**5.4** Dismantle the cylinder head as detailed in Part 1, Section 5.

### Valve Removal

**5.5** Remove the valves as detailed in Part 1, Section 5.

### Carbon Removal

**5.6** Remove the carbon as detailed in Part 1, Section 5.

### Valve Seats

**5.7** Check the valve seats in accordance with the procedure detailed in Part 1, Section 5, AB1W, AC1W and AC2W procedures are identical to AB1, AC1 and AC2 respectively.

### Valves Grinding In

**5.8** Grind the valves in as detailed in Part 1, Section 5.

### Valve Guides

**5.9** Carry out the procedure detailed in Part 1, Section 5.

### Cylinder Head Assembly

**5.10** Assemble the cylinder head as detailed in Part 1, Section 5.

### Cylinder Head Replacement

**5.11** When replacing the cylinder head(s) a new cylinder head gasket, and rocker support seal(s) must be fitted. Failure to renew these items may lead to oil leaks.

**CAUTION**
**As the engine is fitted with long through studs from the crankcase to the cylinder head it is most important that the tightening down procedure is correctly followed.**

**5.12** To replace the cylinder head(s) proceed as follows:

(1) Fit a new cylinder head gasket ensuring that the gasket faces are clean and dry. (See Paragraph 5.21 and Figures 5.3 and 5.4 to identify the type of gasket).

(2) Fit the cylinder head.

(3) Lightly lubricate the push rods and place in their noted positions.

(4) Fit the rocker support seal, rocker support and rockers.

(5) Locate the self-locking 5/16 in. UNF nut on the rocker support stud; fit the 5/16 in. UNF nuts and washers in the positions noted in Paragraph 5.3 **(8)** to the remaining four studs and screw down finger-tight. Tighten the self-locking nut sufficiently to just contact the rocker support, ensuring that the support is level and touching the cylinder head. With reference to Figure 5.1 tighten each nut a quarter of a turn at a time. Finally torque load the rocker support nut to 32.5 Nm (24 lbf ft.) and the remaining cylinder head nuts to 29.8 Nm (22 lbf ft.).

**Note**
*On two cylinder engines, ensure that the manifold bolting faces are parallel with each other. Check*

*with a straight edge before tightening down the cylinder head nuts or bolt on a manifold.*

### Valve Rockers Adjustment (Part 1, Section 5, Figure 5.8)

**5.13** Set up the valve rockers on each cylinder in turn as follows:

**CAUTION**
**The cylinder head and rocker support nuts must be tightened down before rocker clearance is adjusted.**

(1) Set the engine at TDC of the firing stroke (both valves closed).

(2) Slacken the locknut **(1)** and using a screwdriver set the rocker adjusting screw **(2)** to give the correct clearance **(3)** using a feeler gauge. When the correct clearance of 0.10 mm (0.004 in.) is obtained with the engine cold tighten the locknut.

(3) Re-check the clearance.

**CAUTION**
**It is important that the cylinder head nuts be re-torqued to the specified torque and the tappet clearance be reset to 0.10 mm (0.004 in.) with the engine cold after an initial run of one hour on full load. (See Section 1).**

### Setting the Decompressor Lever

**5.14** Set the decompressor lever as detailed in Part 1, Section 5.

## CYLINDER, PISTON AND CONNECTING ROD

### Removal

**5.15** Carry out the following procedure:

(1) Remove the cylinder head as detailed in Paragraph 5.3.

(2) Drain the oil from the sump by removing an oil drain plug.

(3) Remove the sump capscrews retaining the sump and gasket.

(4) Note the position of the large end bolts and bearing cap(s), mated sides are numbered for identification. Remove the large end bolts and bearing cap(s).

(5) Set the piston at TDC.

(6) Lift off the cylinder complete with piston and connecting rod. Retain the shims fitted between the cylinder and crankcase, these control the bumping clearance.

(7) Withdraw the piston and connecting rod assembly from the cylinder barrel.

(8) Using circlip pliers remove one of the gudgeon pin circlips.

(9) Remove the gudgeon pin. If the gudgeon pin is a tight fit soak the piston in hot water for sufficient time to allow the pin to be removed.

### Cylinder Maintenance

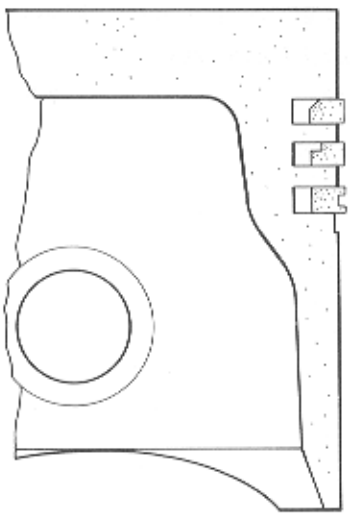
**5.16** Check the cylinder bore wear, if this has reached the maximum 0.25 mm (0.010 in.) the cylinder must be rebored and an oversize piston and rings fitted. The cylinder should be bored and honed to the sizes listed in Table 5.1.

### Piston Maintenance

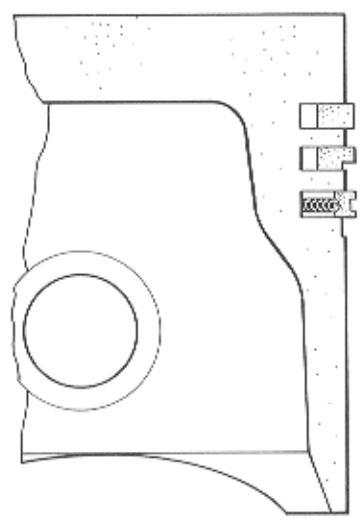
**5.17** Excessive lubricating oil consumption, loss of compression and knocking are signs that a piston needs attention. To check the piston rings carry out the following procedure:

(1) Remove the rings from the piston as shown in Part 1, Section 5, Figure 5.11 noting the order of assembly and which ring face is uppermost.

(2) Remove all the carbon deposit from the rings and ring grooves. The small holes in the piston should receive attention as their purpose is to return excess oil to the sump.



(1) AB1W



(2) AC1W and AC2W

*Figure 5.2 Piston Rings Arrangement*

*TABLE 5.1 CYLINDER REBORING DIAMETERS (ALL WATER COOLED ENGINES)*

| *Cylinder* | *Bore* |
|---|---|
| **Standard** | **76.20 to 76.23 mm (3.000 to 3.001 in.)** |
| **1st Oversize 0.508 mm (0.020 in.)** | **76.71 to 76.73 mm (3.020 to 3.021 in.)** |
| **2nd Oversize 1.016 mm (0.040 in.)** | **77.22 to 77.24 mm (3.040 to 3.041 in.)** |

(3) Insert the piston into the cylinder bore with the crown towards the bottom end of the bore and about 13 mm (0.5 in.) from the bottom edge. Insert the rings one at a time, pushing each ring hard up against the piston crown to ensure that it is level in the cylinder bore. Withdraw the piston sufficiently to allow the gap to be measured with a feeler gauge. The piston ring gap must not exceed 1.14 mm (0.045 in.). If necessary the rings must be renewed. Check the piston ring side clearances are as detailed in the appropriate Engine Technical Data.

(4) Assemble the rings on the piston in the correct order with the correct face uppermost as shown in Figure 5.2. Rings should not be slack or stuck fast in the groove.

(5) When the engine has been fully run in, the bore will have a highly polished and very hard surface. If new piston rings are fitted without the cylinder being rebored, the new rings will not bed in satisfactorily. Under these conditions the hard polished bore must be lightly roughened using a medium grade carborundum cloth. The roughening should be carried out radially by hand and should be sufficient only to produce a matt surface on the bore. Alternatively, a suitably sized de-glazing tool of the rotary brush type with silicone-carbide tips may be used provided method used is in accordance with manufacturers instructions. After this treatment the cylinder must be thoroughly washed in kerosene to remove all traces of carborundum.

### Initial Running

**5.18** To allow the piston rings to bed in satisfactorily carry out the initial running procedure:

(1) Run for 2 minutes on no load.

(2) Run for 10 minutes on half load.

(3) Run for a further minimum of 8 hours or longer on full load.

## Connecting Rod Maintenance

**5.19** Carry out the connecting rod maintenance as detailed in Part 1, Section 5.

## Replacement

**5.20** Before fitting the piston on to the connecting rod soak the piston in hot water to allow the gudgeon pin to slide freely. Replace the cylinder, piston and connecting rod as follows:

(1) Fit the piston to the connecting rod.

(2) Secure the gudgeon pin by replacing the circlips. Ensure that the circlips fit correctly in their grooves.

(3) Distribute the piston ring gaps around the piston circumference so that the gaps are not in line.

(4) Lightly lubricate with engine oil the cylinder bore, the piston and piston rings.

(5) Using a piston ring clamp compress the rings and fit the piston and connecting rod assembly into the cylinder.

(6) Replace the shims retained in Paragraph 5.15 (6) between the cylinder and crankcase. These shims control the bumping clearance between the piston and the cylinder head at TDC.

(7) Check that the bearings and crankpin are clean. Lightly lubricate the crankpin and bearing.

(8) Place the cylinder(s) over the long through studs.

(9) Assemble the connecting rod to the crankshaft making sure that the numbers on the connecting rod are towards the camshaft side of the engine. Fit the connecting rod cap ensuring that the numbers on the cap and rod assembly are correctly matched and are on the same side.

(10) Tighten the large end bolts to a torque of 34 Nm (25 lbf ft.).

## Bumping Clearance

**5.21** Check the bumping clearance as follows:

(1) Set the piston to 6.35 mm (0.25 in.) before TDC.

(2) Place three pieces of soft lead wire or soft solder equidistant on top of the piston. Ensure that the wire pieces are not aligned with the valve heads and/or combustion chamber.

(3) Replace the cylinder head as detailed in Paragraph 5.11 and turn the engine over TDC.

(4) Remove the cylinder head and measure the thickness of the flattened wire with a micrometer. This should be as detailed in Table 5.2 for an average of three readings. If necessary adjust the clearance by re-shimming (Paragraph 5.20 (6)).

(5) Replace the cylinder head as detailed in Paragraph 5.11.

*TABLE 5.2*
*BUMPING CLEARANCE WATER COOLED ENGINES*

| *Cylinder Head Gasket (see note)* | *Bumping Clearance* |
|---|---|
| Reinz Type | **0.56 to 0.66 mm (0.022 to 0.026 in.)** |
| Goetze Type | **0.66 to 0.76 mm (0.026 to 0.030 in.)** |

**Note**
*The cylinder head gasket is identified as follows:*

*(1)* ***Reinz Head Gasket*** *(Figure 5.3). Grey in colour with the word Reinz written all over the upper face.*

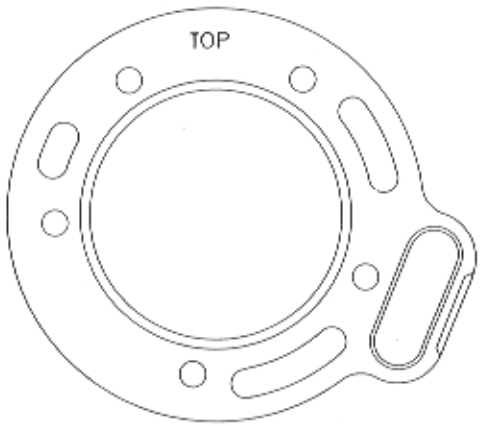



*Figure 5.3 Reinz Head Gasket*

(2) ***Goetze Head Gasket*** *(Figure 5.4). Brown in colour with the word Goetze stamped on the upper face adjacent to a stud hole.*

**CAUTION**
**If a Goetze gasket is to replace a Reinz gasket and the cylinder block is not changed, 0.51 mm (0.020 in.) must be machined from the top of the block in order to achieve the bumping clearance of 0.66 mm to 0.76 mm (0.026 in. to 0.030 in.). This is due to the fact that a Goetze gasket is 0.51 mm (0.020 in.) thicker than a Reinz gasket.**

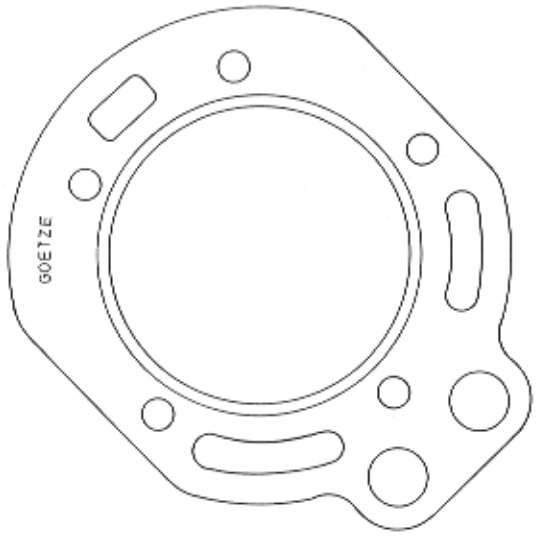



*Figure 5.4 Goetze Head Gasket*

## FLYWHEEL

### Removal

**5.22** To remove the flywheel proceed as follows:

(1) Remove any fittings from the bell housing and flywheel.

(2) Prevent the flywheel from turning by using a special locking plate (obtainable from Petters Limited or their representatives), or inserting a suitable steel rod through the timing hole in the bell housing and into a hole in the flywheel periphery.

(3) Bend back the tabwasher on the flywheel retaining nut and remove the flywheel nut and tabwasher.

(4) Using a suitable extractor (obtainable from Petters Limited or their representatives), loosen the flywheel from its tapered shaft. Remove the flywheel locking device and withdraw the flywheel.

(5) Remove the flywheel key.

### Replacement

**5.23** To fit the flywheel proceed as follows:

(1) Fit the flywheel key.

(2) Align the flywheel keyway with the key on the shaft and push the flywheel on the shaft as far as possible.

(3) Prevent the flywheel from turning as detailed in Paragraph 5.22 (2).

(4) Fit a new tabwasher.

(5) Fit the retaining nut and tighten to a torque loading of 210 Nm (155 lbf ft.).

(6) Bend up the tabwasher to lock the retaining nut.

(7) Remove the flywheel locking device.

(8) Replace any fittings removed from the bell housing and flywheel.

## CRANKSHAFT

**5.24** The crankshaft maintenance procedure is as detailed in Part 1, Section 5, AB1W, AC1W and AC2W water-cooled engines being identical to AB1, AC1 and AC2 air-cooled engines, respectively.

## CAMSHAFT

**5.25** The camshaft maintenance procedure is as detailed in Part 1, Section 5, AB1W, AC1W and AC2W water-cooled engines being identical to AB1, AC1 and AC2 air-cooled engines, respectively.

## GOVERNOR AND LINKAGE

**5.26** The governor and linkage is identical on all 'A' range engines and is detailed in Part 1, Section 5.

## SETTING THE OVERLOAD STOP

**5.27** To set the overload stop carry out the procedure as detailed in Part 1, Section 5, AB1W, AC1W and AC2W water-cooled engines being identical to AB1, AC1 and AC2 air-cooled engines, respectively.

## CHECKING THE OVERLOAD STOP

**5.28** The procedure for checking the overload stop is identical on all 'A' range engines and is as detailed in Part 1, Section 5.

# SECTION 6
# VARIANTS AND ACCESSORIES

## INTRODUCTION

**6.1** The variants and accessories described in Part 1, Section 6 are common to all 'A' range engines.

# SECTION 7
# ELECTRICS

## INTRODUCTION

**7.1** The electrical systems are common to all 'A' range engines and are as described in Part 1, Section 7.

# SECTION 8
# PROTECTION AND PRESERVATION

## PROTECTION

**8.1** To increase the life of the engine it is advisable to protect the engine as much as possible from environmental damage. When not in use engines must be protected by a dust and waterproof cover. Coolant systems must be kept fully topped up or completely drained, anti-freeze must be added when operating in temperatures below 0°C (32°F). Under tropical conditions a permanent awning should be provided. It is important that the engine is kept clean and where necessary any damaged paintwork repaired.

### Intermittent Use

**8.2** When not in regular use, engines should be run on load at normal operating temperatures each month to lubricate internal parts and remove condensation. External unpainted parts should be wiped clean and lightly sprayed with a proprietary de-wetting agent.

## PRESERVATION

**8.3** Engines remaining idle for more than a month may corrode resulting in serious damage. In order to prevent this it is recommended that the following preservation procedure is carried out:

(1) Carry out a 500 hours service as detailed in Section 1.

(2) Drain the sump, flush out with flushing oil and refill with the correct grade of lubricating oil. Alternatively a lubricating oil with preservation properties may be used as recommended by Petters Limited or their representatives.

(3) Ensure that the coolant system is fully topped up or completely drained. If the coolant system is full it is advisable to include an inhibiting agent and if the temperature is liable to fall below 0°C (32°F) anti-freeze must be added.

(4) Drain the fuel tank and filter and refill with 0.57 litres (1 pint) of Shell Fusus Oil or Calibration Fluid C. Bleed and prime the fuel system (Section 1) and run the engine on a light load for five minutes.

(5) If prolonged storage is envisaged remove the injector and apply a small quantity of preservative oil to the cylinder and piston while turning the engine by hand. Replace the injector, fitting a new sealing washer.

(6) Remove air inlet and exhaust fittings and with each cylinder on the compression stroke in turn (inlet and exhaust valve closed) apply preservative oil to both inlet and exhaust ports to protect the valve seats. The manifolds should then be sealed to prevent the ingress of moisture.

(7) If electric starting is fitted, the battery must be removed and the terminals cleaned and greased. To maintain the battery in good condition it should be trickle charged at regular intervals.

(8) Clean and dry the engine, repaint where necessary and wipe all unpainted parts with an oil rag. All pivot points and external controls should be clean and sprayed with a proprietary de-wetting agent.

**8.4** Protected engines should be periodically examined to check the preservation effectiveness. Rectification of the protection should be carried out, if necessary.

## PREPARATION FOR USE

**8.5** After an engine has been preserved the following procedure must be carried out to return it to its operating condition:

(1) Remove all protective coverings.

(2) Check and top up the fuel tank with the correct type and grade of fuel (Section 1).

(3) Check the oil level on the dipstick and ensure that the engine is filled with the correct type and grade of oil.

(4) Check the coolant level in the cooling tank(s) and if a water pump reservoir is fitted, ensure that it is full and the cap is in position.

(5) Re-connect the battery, if fitted.

(6) Check the air cleaner oil bath, if fitted (Part 1, Section 4).

(7) Check the tension of the alternator or dynamo drive belt (if fitted) and adjust if necessary (Part 1, Section 7).

(8) Check the exhaust system for damage and security of joints.

(9) Lubricate the 4:1 or raised hand starting, if fitted (Part 1, Section 6).

(10) Clean and lightly lubricate the speed control linkage.

(11) Bleed the fuel system, if necessary (Section 1).

(12) Check the tightness of all nuts (excluding cylinder head), bolts and hose clips.

**8.6** After an initial engine run check the oil and coolant levels and visually check the system for leaks.

# SECTION 9
# FAULT FINDING

## INTRODUCTION

**9.1** This section is a guide to assist in the location of a fault that may occur on an 'A' range water-cooled engine. Information on causes and suggested remedies are also given.

*TABLE 9.1 ENGINE WILL NOT START*

| *Reason* | *Cause* | *Suggested Remedy* | *Reference* |
|---|---|---|---|
| | Incorrect starting procedure | Adopt correct procedure | Sect. 1 |
| Temperature below 14°C (55°F) | Failure to prime | Prime with lubrication oil | Sect. 1 |
| Incorrect lubrication oil | Too high viscosity oil causing excessive drag | Drain the sump<br>Fill with correct oil | Part 1, Sect. 2<br>Part 1, Sect. 1 |
| Contaminated fuel | Water, dirt or unsuitable fuel in system | Drain and flush fuel system<br>Fill with correct fuel | Part 1, Sect. 3<br>Part 1, Sect. 1 |
| Excessive load | Excessive drag from driven machine | Remove all load during starting | |
| Fuel supply failure<br>Check by cranking the engine and listen for the characteristic squeak of the injector | No fuel | Fill with correct fuel | Part 1, Sect. 1 |
| | Air in system | Bleed the fuel system | Part 1, Sect. 1 |
| | Fuel filter blocked | Fit new element | Part 1, Sect. 3 |
| | Faulty injector nozzle | Replace the nozzle or fit replacement fuel injector | Sect. 3 |
| | Injection pump failure | Fit a replacement injection pump | Sect. 3 |
| Poor compression | Valves sticking or not seating properly | Decarbonise and grind in valves | Sect. 5 |
| | Cylinder head gasket blown | Fit a new gasket | Sect. 5 |
| | Piston rings stuck in piston grooves | Clean piston and fit new rings | Sect. 5 |
| | Worn cylinder and piston | Replace cylinder, piston and piston rings | Sect. 5 |
| | Incorrect bumping clearance | Check large end bearing and reset bumping clearance | Sect. 5 |
| | Broken or weak valve springs | Renew valve springs | Sect. 5 |
| | Incorrect valve clearances | Adjust valve clearances | Sect. 5 |
| | Injector seal washer leaking | Clean orifice and fit new washer | Part 1, Sect. 3 |
| Starter motor will not crank engine | Flat battery | Charge battery or replace | |
| | Flat battery due to faulty charging equipment | Isolate fault and repair | Part 1, Sect. 7 |
| | Dirty or loose terminals | Clean and tighten | Part 1, Sect. 7 |

*TABLE 9.1 continued*

| *Reason* | *Cause* | *Suggested Remedy* | *Reference* |
|---|---|---|---|
| | Broken wire | Replace | Part 1, Sect. 7 |
| | Faulty starter switch | Replace switch | |
| | Faulty starter motor or solenoid | Repair or replace | Part 1, Sect. 7 |
| | Engine seized | Overhaul engine | Sect. 5 |
| Heater plug inoperative | Flat battery | Charge battery or replace | Part 1, Sect. 7 |
| | Dirty or loose terminals | Clean and retighten | Part 1, Sect. 7 |
| | Broken wire | Replace | Part 1, Sect. 7 |
| | Faulty heater plug switch | Replace | Part 1, Sect. 7 |
| | Heater plug element broken or burned out | Replace heater plug | Part 1, Sect. 7 |

*TABLE 9.2 ENGINE STARTS BUT FIRES INTERMITTENTLY OR SOON STOPS*

| *Reason* | *Cause* | *Suggested Remedy* | *Reference* |
|---|---|---|---|
| Faulty fuel supply | Water in the fuel | Drain and flush the fuel system and fill with clean fuel | Part 1, Sect. 3<br>Part 1, Sect. 1 |
| | Sticking injector needle | Fit a new nozzle or a replacement injector | Sect. 3 |
| | Partially blocked fuel filter | Renew fuel filter element | Part 1, Sect. 3 |
| | Air in system | Bleed fuel system | Part 1, Sect. 1 |
| Restricted air intake | Dirty air cleaner | Clean air cleaner and/ or fit new element | Part 1, Sect. 4 |
| Faulty compression | Valves sticking or not seating correctly | Decarbonise and grind in valves | Sect. 5 |
| | Cylinder head gasket blown | Fit a new gasket | Sect. 5 |
| | Piston rings stuck in piston grooves | Clean piston and fit new piston rings | Sect. 5 |
| | Worn cylinder and piston | Replace cylinder, piston and piston rings | Sect. 5 |
| | Incorrect bumping clearance | Check large end bearings and reset bumping clearance | Sect. 5 |
| High exhaust back pressure | Blocked exhaust pipe or silencer, incorrect exhaust | Clean or replace | Part 1, Sect. 1 |
| Overloaded | Excessive drag from driven machine | Reduce the load | |

*TABLE 9.3 ENGINE LACKS POWER AND/OR SHOWS A DIRTY EXHAUST GAS*

| *Reason* | *Cause* | *Suggested Remedy* | *Reference* |
|---|---|---|---|
| Faulty fuel supply | Air in fuel system | Bleed the fuel system | Part 1, Sect. 1 |
| | Incorrect fuel | Drain and flush the fuel system and fill with the correct fuel | Part 1, Sect. 3 |
| | Fuel leaks | Check tighten pipe connectors, renew or repair fuel lines | Sect. 3 |
| | Faulty injector | Fit a new nozzle or a replacement injector | Sect. 3 |
| | Incorrect fuel pump timing | Time the injection pump | Sect. 3 |
| | Faulty injector pump | Renew pump | Sect. 3 |
| | Incorrect injector pipe | Fit correct pipe | Sect. 3 |
| | Kinked flexible fuel pipes | Fit new pipe | |
| | Partially blocked fuel filter | Renew filter element | Part 1, Sect. 3 |
| Restricted air intake | Dirty air cleaner | Clean and/or refit a new element | Part 1, Sect. 4 |
| Running at an incorrect speed | Worn or incorrectly adjusted variable speed control | Renew or adjust | Part 1, Sect. 3 |
| Faulty compression | Valves sticking or not seating correctly | Decarbonise and grind in valves | Sect. 5 |
| | Cylinder head gasket blown | Fit a new gasket | Sect. 5 |
| | Piston rings stuck in piston grooves | Clean piston and fit new piston rings | Sect. 5 |
| | Worn cylinder and piston | Replace cylinder, piston and piston rings | Sect. 5 |
| | Incorrect bumping clearance | Check large end bearings and reset bumping clearance | Sect. 5 |
| High exhaust back pressure | Blocked exhaust pipe or silencer, incorrect exhaust | Clean or replace | Part 1, Sect. 1 |
| Extended periods of running off load or with a light load | Glazed cylinder bore | De-glaze cylinder bore and fit new piston rings | Sect. 5 |
| Excessive carbon formation | Blocked air cell | Clean air cell orifice | Sect. 5 |
| Overloaded | Load requirement in excess of engine power rating | Reduce load | Preliminaries |

*TABLE 9.4 FAULTY RUNNING*

| *Reason* | *Cause* | *Suggested Remedy* | *Reference* |
|---|---|---|---|
| Knocking | Excessive carbon formation | Decarbonise | Sect. 5 |
| | Air in fuel system | Bleed fuel system | Part 1, Sect. 1 |
| | Low oil supply | Replenish oil system | Part 1, Sect. 1<br>Part 1, Sect. 2 |
| | Diluted or incorrect oil | Drain and refill sump with correct grade and type of oil. Rectify cause of oil dilution | Part 1, Sect. 1<br>Part 1, Sect. 1<br>See oil dilution |
| | Injector needle sticking or release pressure incorrect | Fit new nozzle or a replacement injector | Sect. 3 |
| | Injection pump timing too far advanced | Adjust timing | Sect. 3 |
| | Broken piston ring | Examine piston and cylinder for damage and repair as necessary | Sect. 5 |
| | Slack piston | Check piston and cylinder for wear and renew as necessary | Sect. 5 |
| | Worn large end bearing | Check crankpin for damage<br>Renew as necessary<br>Check lubrication system | Sect. 5<br><br>Part 1, Sect. 2 |
| | Worn small end bearing | Renew small end bearing and check gudgeon pin | Sect. 5 |
| | Loose flywheel | Refit | Sect. 5 |
| Overheating | Cooling system failure | Check that the cooling system is in order | Sect. 1 |
| | Overloaded | Reduce load to conform with engine power rating | Preliminaries |
| | Excessive valve clearances | Adjust valve clearances | Sect. 5 |
| | Incorrect lubrication oil or level | Drain and refill sump with correct grade and type of oil or drain to the correct level | Part 1, Sect. 1<br>Part 1, Sect. 2 |
| | Injection pump timing incorrect | Adjust timing | Sect. 3 |
| Speed surges | Overheating | See overheating | |
| | Air in fuel system | Bleed the fuel system | Part 1, Sect. 1 |
| | Injector release pressure incorrect | Fit a replacement injector | Sect. 3 |
| | Injector pump rack sticking | Fit a replacement pump | Sect. 3 |
| | Governor sticking or worn | Free or fit a new governor | Sect. 5 |

*TABLE 9.4 continued*

| *Reason* | *Cause* | *Suggested Remedy* | *Reference* |
|---|---|---|---|
| Sudden stop | Empty fuel tank | Fill fuel tank and bleed fuel system | Part 1, Sect. 1 |
| | Blocked or stuck injector | Fit a replacement injector | Sect. 3 |
| | Broken fuel pipe | Repair or renew | Sect. 3 |
| | Engine seized* | Overhaul engine | Sect. 5 |
| Heavy vibration | Loose flywheel | Refit | Sect. 5 |
| | Faulty installation | Check, holding down bolts, flexible mountings and couplings | Part 1, Sect. 1 |
| Engine overspeeds | Lubrication oil overfilled | Drain down to correct level | Part 1, Sect. 1 |
| | Lubrication oil diluted or incorrect grade | Rectify cause of dilution, drain and refill with correct grade of oil | Part 1, Sect. 1 See oil dilution |
| | Injection fuel pump stuck in full fuel position | Replace injection pump | Sect. 3 |
| | Governor faulty | Fit new governor | Sect. 3 |
| Excessive oil consumption | Oil leaks | Rectify leaks | |
| | Worn valve guides, piston rings, or cylinder | Renew as necessary | Sect. 5 |
| | Incorrect type or grade of oil | Drain and fill with correct type and grade of oil | Part 1, Sect. 1 |
| | Extended periods of running off load or with a light load | De-glaze cylinder bore and fit new piston rings | Sect. 5 |
| | Excess oil in sump | Drain oil to correct level | Part 1, Sect. 1 |
| | Overheating | See overheating | |
| Lubrication oil dilution | Leaking lift pump diaphragm | Fit new diaphragm | Part 1, Sect. 6 |
| | Leaking injection pump element | Fit replacement pump | Sect. 3 |
| | Faulty injector | Fit a replacement injector | Sect. 3 |