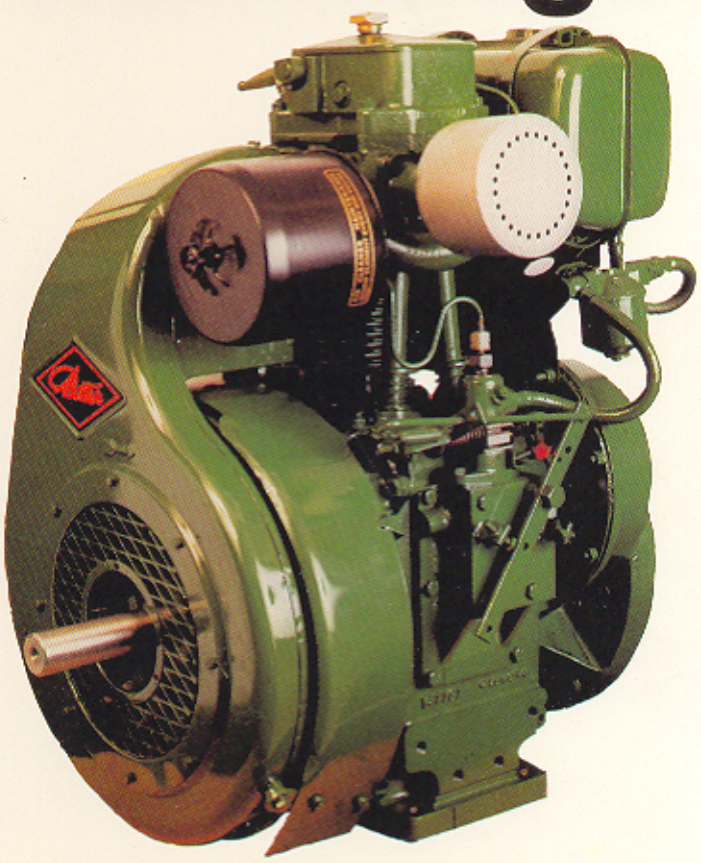
WORKSHOP MANUAL

PH Range



HAWKER SIDDELEY

PETTER PARTS & SERVICE

PETTERS LIMITED HAMBLE, SOUTHAMPTON SO3 5NJ, ENGLAND Telephone HAMBLE 2061 Telex No. 47626 Cables PETTER HAMBLE

PUBLICATION
FIRST EDITION

PH RANGE
WORKSHOP MANUAL

PH 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 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.

FOREWORD

This Workshop Manual covers the operation and maintenance of the Petter PH 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 (PH) and Part 2 the maintenance of the water cooled engines (PHW). The common parts of both types of engines are covered in Part 1.

Due to the robust construction and simplicity of design of Petter PH range of engines they can be relied to operate for very long periods under the most adverse 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:–

Parts and Service Headquarters

Petters Limited
Hamble
Southampton
Hampshire
SO3 5NJ
England.

Telephone 042122 2061
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

PH	Operators Handbook
PHW	Operators Handbook
PH1	Petter Parts Interpretation Manual
PH2	Petter Parts Interpretation Manual
PHW1	Petter Parts Interpretation Manual
PHW2	Petter Parts Interpretation Manual
PH	Service Hints
GE	General Service Hints

IMPORTANT

When purchasing parts or giving instructions for repairs, customers should state the engine type and serial number, part number or 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

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 PH RANGE

ENGINE

Bore (nominal) **87.3 mm (3.4375 in.)**
Stroke **100 mm (4.33 in.)**

Power and Speed per cylinder (continuous rating):

3.0kW	**(4.0 bhp)**	**at**	**1000**	**r/min**
3.7kW	**(5.0 bhp)**	**at**	**1200**	**r/min**
4.7kW	**(6.3 bhp)**	**at**	**1500**	**r/min**
5.05kW	**(6.8 bhp)**	**at**	**1650**	**r/min**
5.6kW	**(7.5 bhp)**	**at**	**1800**	**r/min**
6.15kW	**(8.2 bhp)**	**at**	**2000**	**r/min**
6.7kW	**(9.0 bhp)**	**at**	**2200**	**r/min**

Cubic capacity per cylinder **0.659 litre (40.2 in^3)**

Compression ratio **16.5 : 1**

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

FUEL TANK CAPACITY (standard engine mounted) **6.8 litre (12 pints).**

OIL CAPACITY:

Engine (one cylinder)		**2.84 litres (5 pints)**
Engine (one cylinder)	*with filter*	**3.41 litres (6 pints)**
Engine (two cylinder)		**5.68 litres (10 pints)**
Engine (two cylinder)	*with filter*	**6.53 litres (11.5 pints)**
Clutch		**0.3 litres (0.5 pints)**
Speed Increasing Gear		**0.3 litres (0.5 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	*Volts*	*Ampere Hours*
One cylinder engine	**12**	**50**
Two cylinder engine	**12**	**65**

FUEL INJECTION RELEASE PRESSURE

900 to 1099 r/min **137/152 bar (1995/2205 lbf/in^2)**
1100 to 2200 r/min **197/217 bar (2850/3150 lbf/in^2)**

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

Up to 1650 r/min **24° BTDC**
1651 to 2200 r/min **28° BTDC**

VALVE TIMING

For engines up to 2000 r/min prior to and including engine numbers:

153501 PH1 (Standard rotation).
153337 PH1R (Reverse rotation).
110727 PH2 and R (Standard and Reverse rotation).

Inlet valve opens	**4.5°**	before TDC	*Angle readings obtained when valve rocker clearance is* **0.18 mm (0.007 in.)** *with hot engine*
Inlet valve closes	**35.5°**	after BDC	
Exhaust valve opens	**35.5°**	before BDC	
Exhaust valve closes	**4.5°**	after TDC	

TECHNICAL DATA PH RANGE (CONTINUED)

For all engines running up to 2200 r/min. From engine numbers:

153502 PH1 (Standard rotation) and onwards
153338 PH1R (Reverse rotation) and onwards
119728 PH2 and R (Standard and Reverse rotation) and onwards

Inlet valve opens	**13.5°** before TDC	*Angle readings obtained when valve rocker clearance is* **0.25 mm (0.010 in.)** *with hot engine*
Inlet valve closes	**38.5°** after BDC	
Exhaust valve opens	**38.5°** before BDC	
Engine valve closes	**13.5°** after TDC	

TOLERANCES

Camshaft end float	**0.10 to 0.38 mm (0.004 to 0.015 in.)**
Crankshaft end float (new)	**0.20 to 0.50 mm (0.008 to 0.020 in.)**
Crankshaft end float (not to exceed)	**0.63 mm (0.025 in.)**
Crankpin ovality (not to exceed)	**0.08 mm (0.003 in.)**
Cylinder bore wear (not to exceed)	**0.25 mm (0.010 in.)**
Piston ring side clearance (new)	
Compression ring	**0.08 to 0.13 mm (0.0033 to 0.0053 in.)**
Scraper ring	**0.06 to 0.11 mm (0.0025 to 0.0045 in.)**
Piston ring side clearance (not to exceed)	
Compression ring	**0.25mm (0.010 in.)**
Scraper ring	**0.25mm (0.010 in.)**
Piston ring gap (new)	**0.74 to 0.94 mm (0.029 to 0.037 in.)**
Piston ring gap (not to exceed)	**1.52 mm (0.060 in.)**
Exhaust valve lift by decompressor (max)	**0.63 mm (0.025 in.)**
Bumping clearance	**0.91 to 1.07 mm (0.036 to 0.042 in.)**
Valve rocker clearance (cold)	**0.10 mm (0.004 in.)**
Valve depth from cylinder head face (new)	**0.81 to 1.17 mm (0.032 to 0.046 in.)**
Main bearing clearance (new)	**0.051 to 0.114 mm (0.0020 to 0.0045 in.)**
Large end bearing clearance (new)	**0.051 to 0.089 mm (0.0020 to 0.0035 in.)**
Drive shaft diameter	**38.090 to 38.012 mm (1.4996 to 1.4989 in.)**
Drive shaft keyway width	**9.50 to 9.52 mm (0.374 to 0.375 in.)**
Small end bush diameter (fitted)	**30.035 to 30.048 mm (1.1825 to 1.1830 in.)**

CYLINDER REBORING DIAMETERS:

Standard	**87.465 to 87.491 mm (3.4435 to 3.4445 in.)**
Oversize 0.5 mm (0.020 in.)	**87.973 to 87.998 mm (3.4635 to 3.4645 in.)**
1.00 mm (0.040 in.)	**88.481 to 88.516 mm (3.4835 to 3.4845 in.)**

TECHNICAL DATA PH RANGE (CONTINUED)

CRANKSHAFT REGRINDING DIAMETERS:

	Main Journal	*Crankpin & Intermediate Journal*
Standard	**60.287 to 60.274 mm (2.3735 to 2.3730 in.)**	**63.325 to 60.312 mm (2.3750 to 2.3745 in.)**
Undersize 0.25 mm (0.010 in.)	**60.031 to 60.020 mm (2.3635 to 2.3630 in.)**	**60.071 to 60.058 mm (2.3650 to 2.3645 in.)**
0.50 mm (0.020 in.)	**59.779 to 59.766 mm (2.3535 to 2.3530 in.)**	**59.817 to 59.804 mm (2.3550 to 2.3545 in.)**
0.75 mm (0.030 in.)	**59.525 to 59.512 mm (2.3435 to 2.3430 in.)**	**59.563 to 59.550 mm (2.3450 to 2.3445 in.)**
1.00 mm (0,040 in.)	**59.271 to 59.258 mm (2.3335 to 2.3330 in.)**	**59.309 to 59.296 mm (2.3350 to 2.3345 in.)**

TORQUE SPANNER SETTINGS:

Large end bolt	**77 Nm (57 lbf ft)**
Cylinder head nut	**81 Nm (60 lbf ft)**
Fuel pump union body	**54 Nm (40 lbf ft)**
Balance weight bolt PH1	**159 Nm (117 lbf ft)**
PH2	**267 Nm (197 lbf ft)**
Extension shaft setscrew	**32 NM (24 lbf ft)**
Intermediate main bearing housing nut	**34 Nm (25 lbf ft)**
Cylinder nut	**81 Nm (60 lbf ft)**
Cylinder crankcase studs	**37 Nm (24 lbf ft)**
Fuel injector nuts	**20 Nm (15 lbf ft)**
Intermediate main bearing	**30 to 38 Nm (22 to 28 lbf ft)**
Inspection cover bolts	**22 to 23 Nm (16 to 17 lbf ft)**
Crankshaft gear retaining screw	**62 Nm (46 lbf ft)**

TECHNICAL DATA PHW RANGE

ENGINE

Bore (nominal) **87.3 mm (3.4375 in.)**
Stroke **100 mm (4.33 in.)**

Power and Speed per cylinder (continuous rating):

3.0kW	**(4.0 bhp) at 1000 r/min**
3.7kW	**(5.0 bhp) at 1200 r/min**
4.7kW	**(6.3 bhp) at 1500 r/min**
5.05kW	**(6.8 bhp) at 1650 r/min**
5.6kW	**(7.5 bhp) at 1800 r/min**
6.15kW	**(8.2 bhp) at 2000 r/min**

Cubic capacity per cylinder **0.659 litre (40.2 in^3)**
Compression ratio **16.5 : 1**

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

FUEL TANK CAPACITY (standard engine mounted) **6.8 litre (12 pints).**

OIL CAPACITY:

Engine (one cylinder)		**2.84 litres (5 pints)**
Engine (one cylinder)	*with filter*	**3.41 litres (6 pints)**
Engine (two cylinder)		**5.68 litres (10 pints)**
Engine (two cylinder)	*with filter*	**6.53 litres (11.5 pints)**
Clutch		**0.3 litres (0.5 pints)**
Speed Increasing Gear		**0.3 litres (0.5 pints)**

LUBRICATING OIL: to MIL-L-46152B or 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	*Volts*	*Ampere Hours*
One cylinder engine	**12**	**50**
Two cylinder engine	**12**	**65**

FUEL INJECTION RELEASE PRESSURE

900 to 1099 r/min **137/152 bar (1995/2205 lbf/in^2)**
1100 to 2000 r/min **197/217 bar (2850/315 lbf/in^2)**

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

Up to 1650 rev/min **24° BTDC**
1651 to 2000 rev/min **28° BTDC**

VALVE TIMING

For engines up to 2000 r/min. Prior to and including engine numbers:

35853 PH1W (Standard rotation).
37352 PH1W (Standard rotation).
16473 PH1W and R (Standard and Reverse rotation).

Inlet valve opens	**4.5°**	before TDC	) *Angle readings obtained*
Inlet valve closes	**35.5°**	after BDC	) *when valve rocker clearance is* **0.18 mm**
Exhaust valve opens	**35.5°**	before BDC	) **(0.007 in.)** *with hot*
Exhaust valve closes	**4.5°**	after TDC	) *engine*

TECHNICAL DATA PHW RANGE (CONTINUED)

For all engines running up to 2000 r/min. Including engine numbers:

35854 PH1W and onwards
16474 PH2W and R (Standard and Reverse rotations) and onwards.

Inlet valve opens	**13.5°**	before TDC	*Angle readings obtained when valve rocker clearance is* **0.25 mm (0.010 in.)** *with hot engine*
Inlet valve closes	**38.5°**	after BDC	
Exhaust valve opens	**38.5°**	before BDC	
Exhaust valve closes	**13.5°**	after TDC	

TOLERANCES

Camshaft end float	**0.10 to 0.38 mm (0.004 to 0.015 in.)**
Crankshaft end float (new)	**0.20 to 0.50 mm (0.008 to 0.020 in.)**
Crankshaft end float (not to exceed)	**0.63 mm (0.025 in.)**
Crankpin ovality (not to exceed)	**0.08 mm (0.003 in.)**
Cylinder bore wear (not to exceed)	**0.25 mm (0.010 in.)**
Piston ring gap (not to exceed)	**1.52 mm (0.060 in.)**
Piston ring gap (new)	**0.25 to 0.48 mm (0.010 to 0.019 in.)**
Piston ring side clearance (new)	
Compression ring	**0.08 to 0.13 mm (0.0033 to 0.0053 in.)**
Scraper ring	**0.06 to 0.11 mm (0.0025 to 0.0045 in.)**
Piston ring side clearance (not to exceed)	
Compression ring	**0.25 mm (0.010 in.)**
Scraper ring	**0.25 mm (0.010 in.)**
Exhaust valve lift by decompressor (max)	**0.63 mm (0.025 in.)**
Bumping clearance	**0.76 to 0.91 mm (0.030 to 0.036 in.)**
Valve rocker clearance (cold)	**0.25 mm (0.010 in.)**
Valve depth from cylinder head (new)	**0.91 to 1.17 mm (0.32 to 0.046 in.)**
Main bearing clearance (new)	**0.051 to 0.114 mm (0.0020 to 0.0045 in.)**
Large end bearing clearance (new)	**0.051 to 0.089 mm (0.0020 to 0.0035 in.)**
Drive shaft diameter	**38.090 to 38.012 mm (1.4886 to 1.4989 in.)**
Drive shaft keyway width	**9.50 to 9.52 mm (0.374 to 0.375 in.)**
Small end bush diameter (fitted)	**30.035 to 39.948 mm (1.1825 to 1.1830 in.)**

CYLINDER REBORING DIAMETERS:

Standard		**87.465 to 87.491 mm (3.4435 to 3.4445 in.)**
Oversize	0.5 mm (0.020 in.)	**87.973 to 87.998 mm (3.4635 to 3.4645 in.)**
	1.00 mm (0.040 in.)	**88.481 to 88.516 mm (3.4735 to 3.4845 in.)**

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 & SPEED			FUEL USED PER HOUR		RUNNING TIME ON FULL TANK
	kw	bhp	r/min	litres	pints	h.min
PH1/PH1W	3.00	4.0	1000	1.02	1.8	6.40
	3.75	5.0	1200	1.19	2.1	5.43
	4.70	6.3	1500	1.48	2.6	4.37
	5.05	6.7	1650	1.59	2.8	4.17
	5.60	7.5	1800	1.76	3.1	3.52
	6.15	8.2	2000	2.05	3.6	3.20
PH1 ONLY	6.70	9.0	2200	2.33	4.1	2.55
PH2/PH2W	6.00	8.0	1000	1.88	3.3	3.38
	7.50	10.0	1200	2.22	3.9	3.05
	9.40	12.5	1500	2.73	4.8	2.30
	10.10	13.5	1650	2.90	5.1	2.21
	11.20	15.0	1800	3.36	5.9	2.02
	12.30	16.4	2000	3.81	6.7	1.47
PH2 ONLY	13.40	18.0	2200	4.29	7.6	1.35

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/m^2 (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 $X \propto$

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

(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
ηm = 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 derating up to 10% and 2.5% for derating 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 derated 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 derate values and engine selection advice.

The tables given can be used when approximate derating 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	4765	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 BS 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 % derate 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 PH/PHW Petter diesel engine with no variants fitted.

DESCRIPTION	*SIZE*	*QUANTITY*
Open end spanner	3/16 in. BSF	**2**
Ring spanner	7/16 in. BSF	**1**
Ring spanner	1/2 in. BSF	**1**
Ring spanner	9/16 in. BSF	**1**
Ring spanner	3/4 in. BSF	**1**
Open end/ring spanner	1/4 in. BSF	**1**
Open end/ring spanner	5/16 in. BSF	**1**
Open end/ring spanner	3/8 in. BSF	**1**
Open end spanner	1/4 in. AF	**1**
Open end spanner	1.1/16 in. AF	**1**
Ring spanner	9/16 in. AF	**1**
Tee bar	1/2 in. Drive	**1**
5 in. extension	1/2 in. Drive	**1**
Socket	5/16 in. BSF	**1**
Socket	9/16 in. BSF	**1**
Socket	5/8 in. BSF	**1**
Socket	11/16 in. BSF	**1**
Socket	1.1/16 in. BSF	**1**
Open end spanner	16 mm	**1**
Socket	21 mm	**1**
Socket adaptor	3/8 in. x 1/2 in.	**1**
Extension (10 in. long)	3/8 in. Drive	**1**
Socket	7/16 in. BSF (3/8 in. Drive)	**1**
Crow foot wrench	15 mm (3/8 in. Drive)	**1**
Pin Punch	1/8 in.	**1**
Micrometer(s) external	0 to 100 mm (0 to 4 in.)	**1**
Micrometer(s) internal	0 to 100 mm (0 to 4 in.)	**1**
Lead wire	1.524 mm (0.060 in.) thick	As required
Circlip pliers internal		**1 Pair**
Circlip pliers external		**1 Pair**
Torque wrench(s)	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 guage	6.76B (0-100 psi)	**1**
Tachometer		**1**
Injector cleaning kit		**1**

SPECIAL TOOLS

This list details the special tools required to maintain a basic build PH/PHW Petter diesel engine. These tools can be obtained from Petters Limited or their representatives.

DESCRIPTION	*QTY.*	*FIG NO.*
Crankshaft Gear Puller	**1**	*1*
Injector Test Rig	**1**	*2*
Oil Seal Sleeve (Extension Shaft)	**1**	*3*
Oil Seal Sleeve (Bell Housing)	**1**	*3*
Valve Collet Extractor	**1**	*4*
Fuel Pump Rack Gauge 1/2 in.	**1**	*5*
Fuel Pump Rack Gauge 13/16 in.	**1**	*5*
Flywheel Key Extractor Box Type	**1**	*6*
Flywheel Key Extractor Taper Drift	**1**	*6*
Engine Lifting Attachment	**1**	*7*

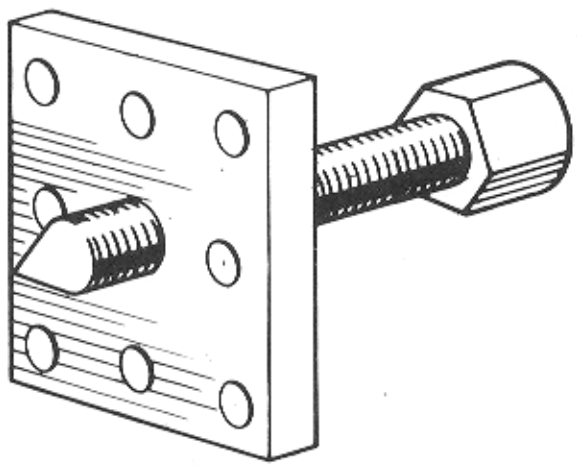


Figure 1 Crankshaft Gear Puller

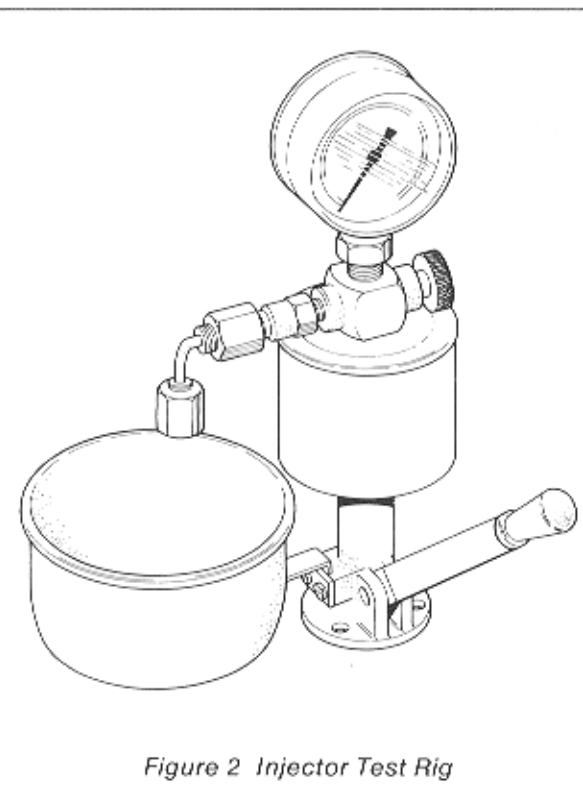


Figure 2 Injector Test Rig

(1) Extension Shaft

(2) Bell Housing

Figure 3 Oil Seal Sleeves

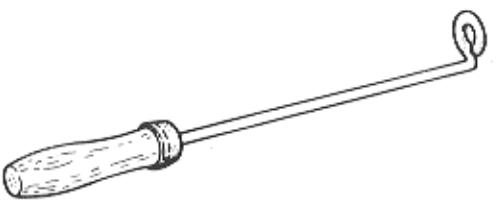
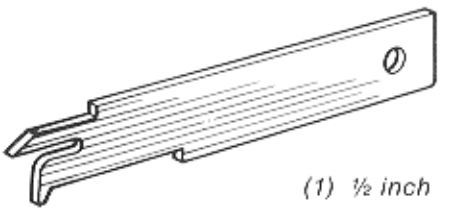
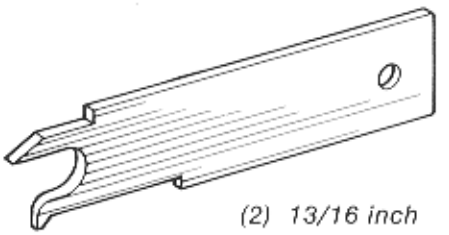


Figure 4 Valve Collet Extractor



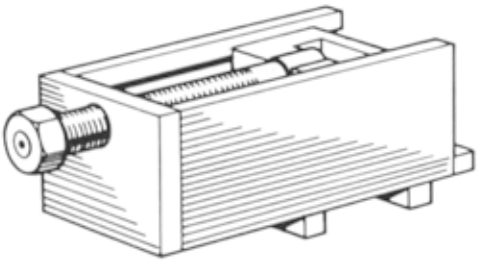
(1) ½ inch



(2) 13/16 inch

Figure 5 Fuel Pump Rack Gauges

(1) Taper Drift



(2) Box Type

Figure 6 Flywheel Key Extractors

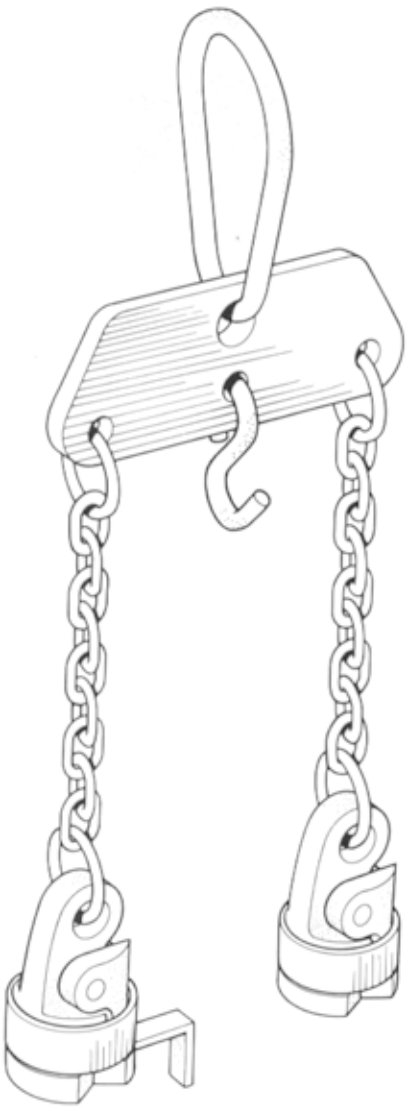
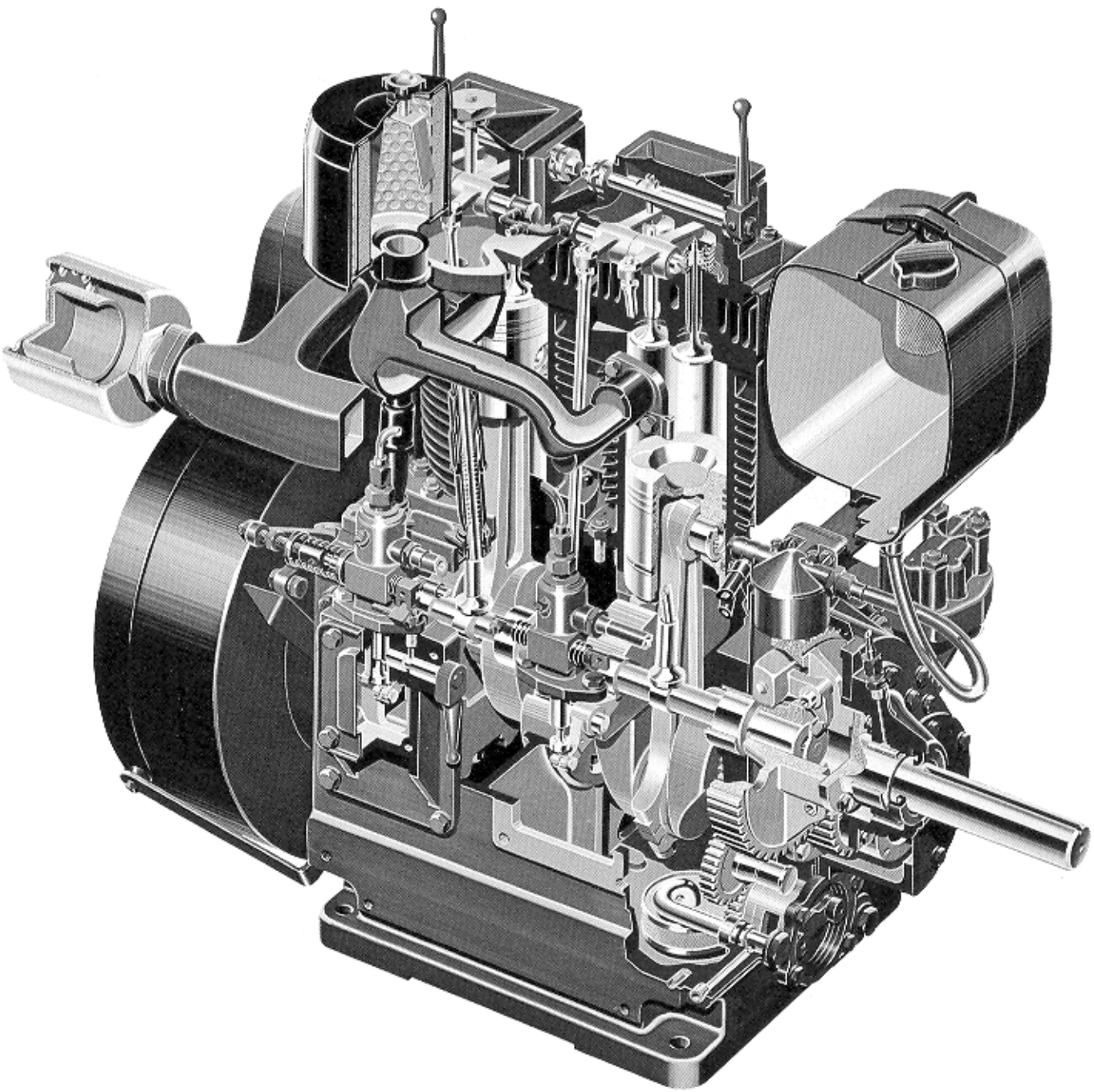


Figure 7 Engine Lifting Attachment

PART 1

AIR COOLED DIESEL ENGINES
PH1 and PH2



PART 1

AIR COOLED DIESEL ENGINES PH1 AND PH2

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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

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 work in conjunction with an anti-vibration manufacturer and should be consulted before attempting to install an engine on 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.

(7) 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.

CAUTION

Under no circumstances may an engine be run without fan cowlings in position

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 intakes to give a free circulation of air.

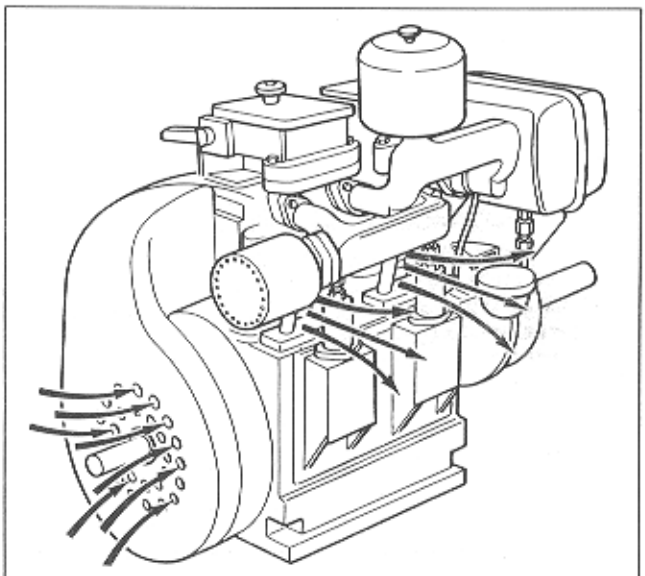


Figure 1.1 Cooling Air Flow

CLUTCH

1.7 If a Petter clutch is fitted and the final drive is through a belt or chain, a bearer must be fitted to the base pad of the clutch housing.

FOUNDATIONS

1.8 To mount engines on a concrete base, foundations must be prepared as shown in Figure 1.2. The dimensions shown are for normal site conditions with solid subsoil and should be enlarged upon or a raft constructed, if a soft or made up ground condition exists. Surfaces should finish about 25mm (1 in.) below the dimensions given to allow for grouting up. Foundation bolts can be supplied to special order only.

Concrete

1.9 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

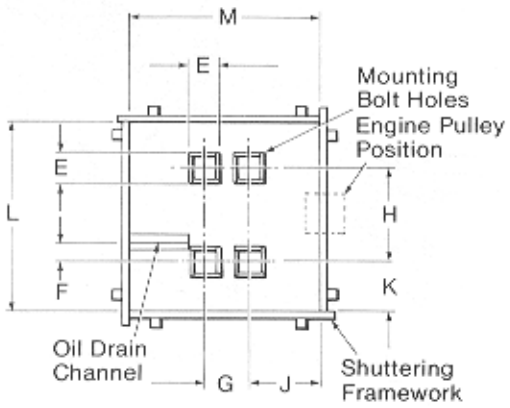
1.10 The grouting should be made up of one part best portland cement and two parts fine sand.

Note...

Owing to the varying nature of ground conditions, Petters Limited cannot accept responsibility for ensuring that foundations are satisfactory.

1.11 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 (3mm – 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.

	SINGLE CYL.			TWIN CYL.	
	mm	ins		mm	ins
A	225	10	A	255	10
B	255	10	B	255	10
C	150	6	C	150	6
D	355	14	D	365	14
E	75	3	E	75	3
F	65	2½	F	65	2½
G	140	5½	G	295	11⅝
H	290	11½	H	290	11½
J	230	9	J	230	9
K	150	6	K	150	6
L	610	24	L	610	24
M	610	24	M	766	30⅛



Layout of Engine Foundation

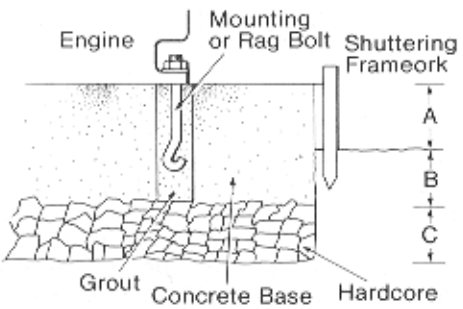


Figure 1.2 Foundations

COUPLINGS

1.12 Selection of the correct flexible coupling for an installation is dependant on application, engine power and torque capacity. Petters Limited or their representatives should be consulted when in doubt.

ALIGNMENT

1.13 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, causes bearing wear and produces 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 couplings middle section.

(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 0.05 mm (0.002 in.) adjust the parallel alignment by placing shims, as necessary, under the supports of the driven unit and the conical alignment by adjusting position of the driven unit on its frame.

(6) Secure the driven unit to its frame.

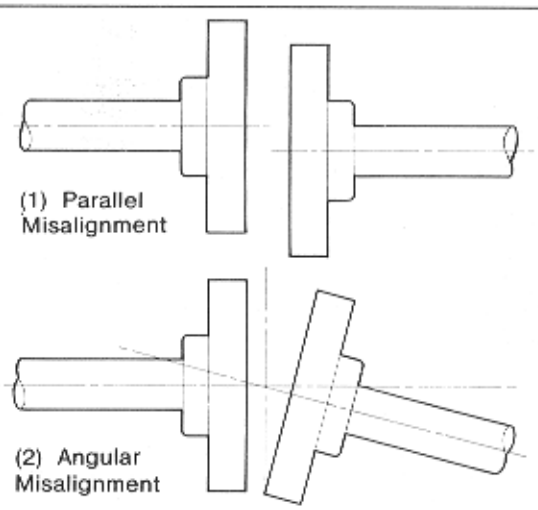
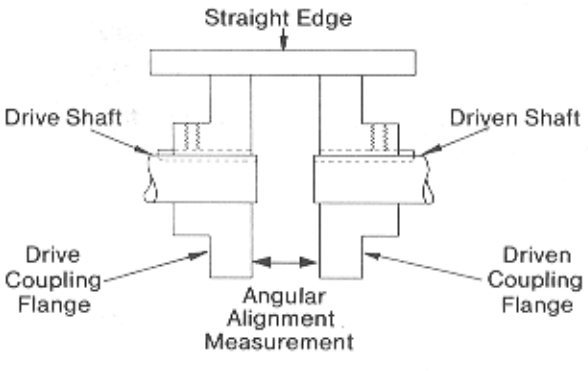
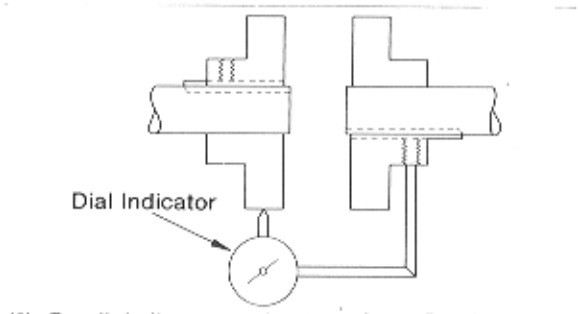


Figure 1.3 Misalignment



(1) Parallel and angular alignment checks



(2) Parallel alignment checks using a Dial Indicator

Figure 1.4 Checking Misalignment

(7) Fit and secure the middle flexible section of the coupling making sure tha 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 shaft.

AIR INTAKE CLEANERS

1.14 It is important that the air drawn into the air manifold inlet 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

1.15 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 surface of the pleats.

Cyclonic Air Cleaners

1.16 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

1.17 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 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 clamps should be used to fix the pipes and should be check tightened after the first eight hours of operation.

1.18 It is recommended that the depression in the inlet manifold should be checked on each different application to check 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 that can be supplied are unsuitable for Petter engines.

Oil Bath

1.19 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 through the filter. To cope with more arduous 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, this 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 element between the oil cup and the fixed element.

Servicing

1.20 Whilst it is policy to recommend air cleaner element change periods under normal environmental conditions it will be necessary to increase frequency of element changes where the engine is being used in dusty conditions (see Section 4).

EXHAUSTS

1.21 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 the length used as short as possible. The relationship between length and exhaust size (BSP) is given in Table 1.1. For pipes lengths in excess of 30 m (100 ft) consult Petters Limited or their representatives.

(2) The use of elbows is not recommended and the number of bends should be restricted to a minimum. When calculating pipe sizes an allowance for the increased resistance of each bend must be made by adding to the actual length as detailed in Table 1.2.

(3) Exhaust pipes should be installed with a flange connection in preference to nipples 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.

(4) Where possible, exhaust pipes must slope down away from the engine. It 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.

(5) 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.

(6) 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.

TABLE 1.1
EXHAUST PIPE LENGTH AND SIZES (BSP) RELATIONSHIP

Exhaust pipe length	Exhaust pipe size (BSP)	
	PH1	PH2
6 m to 12 m (20 ft to 40 ft)	1.5 in.	2 in.
12 m to 18 m (40 ft to 60 ft)	2.5 in.	3 in.
18 m to 30 m (60 ft to 100 ft)	3.5 in.	4 in.

Note
For lengths up to 6 m (20 ft) use the 1 in. BSP or 1.5 in. BSP threaded exhaust flange adaptor for the PH1 or PH2 respectively. 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.	300 mm (1 ft)
1.5 in.	460 mm (1.5 ft)
2 in.	610 mm (2 ft)
2.5 in.	760 mm (2.5 ft)
3 in.	910 mm (3 ft)
3.5 in.	1.1 m (3.5 ft)
4 in.	1.2 m (4 ft)

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

SILENCERS

1.22 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.

1.23 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.

1.24 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

1.25 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

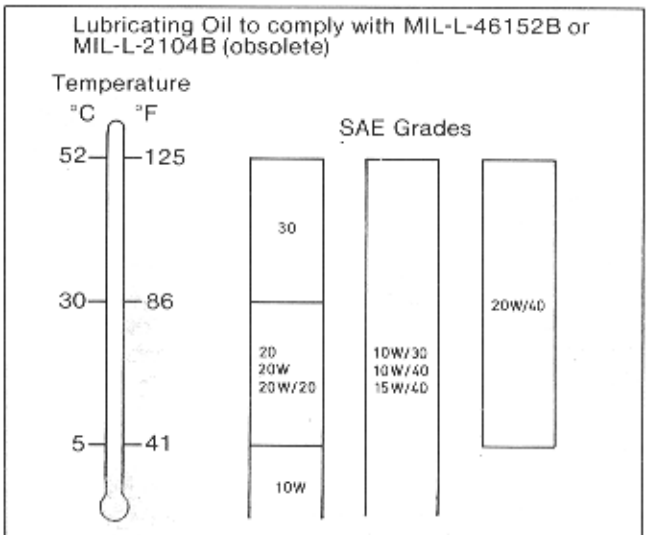
1.26 The engine lubrication oils used in Petter engines are heavy duty oils which must conform to the minimum performance level as specified by the U.S. Department of Defence Standard MIL-L46152-B which supersedes MIL-L-2104B (now obsolete). Other suitable heavy duty engine oils may be recommended by 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.

Selection of Viscosity (Grade)

1.27 The correct selection of oil viscosity to be used at various temperatures is given in the chart shown in Figure 1.5 Although difference viscosities of oil are recommended for differing temperatures it is not always practical to change oils where engines are operating in various temperature conditions (marine auxiliary installations). 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.



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

Figure 1.5 Selection of oil grades

FUEL

STORAGE

1.28 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 used 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.

1.29 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

1.30 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 Class A1 or A2 : 1970 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.

(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

1.31 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 (that is marine auxiliary engines). Under these circumstances the fuel suitable for the coldest condition likely to be met should be used.

1.32 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

1.33 The governor controls the engine at a predetermined speed irrespective of load variations.

1.34 The governor weights are fitted to the camshaft and their action is transmitted by push rods in the camshaft to the fuel pump rack which governs the fuel available to the engine. The centrifugal forces on the governor weights are balanced out by an adjustable speeder spring. By varying the speeder spring pressure the speed of the engine can be altered.

1.35 The overload stop is set by Petters Limited and should not be disturbed. Interference with the setting may result in the engine being overloaded or not delivering its rated power. Excessive load must be avoided and this will be indicated by the engine running below its rated speed and/or dirty exhaust.

DRIVE ARRANGEMENTS

CLASSIFICATION

1.36 Petter engines 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 at end remote from the flywheel (gear end). Starting handle at flywheel end.

(2) MK2 – Drive at engine speed at end remote from the flywheel (gear end). Starting handle at flywheel end.

(3) MK3 – Drive at half engine speed at end remote from the flywheel (gear end) through a clutch drive. Starting handle at flywheel end.

TABLE 1.3
EXTRACT FROM BS2849 : 1970

Detail	*Class A1 Automotive Use*	*Class A2 General Purpose Use*
Cetane 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) MK4 – Drive at engine speed at end remote from the flywheel (gear end) through a clutch drive. Starting handle at flywheel end.

(5) MK5 – Drive at engine speed at flywheel end. Starting handle at half speed at end remote from flywheel (gear end).

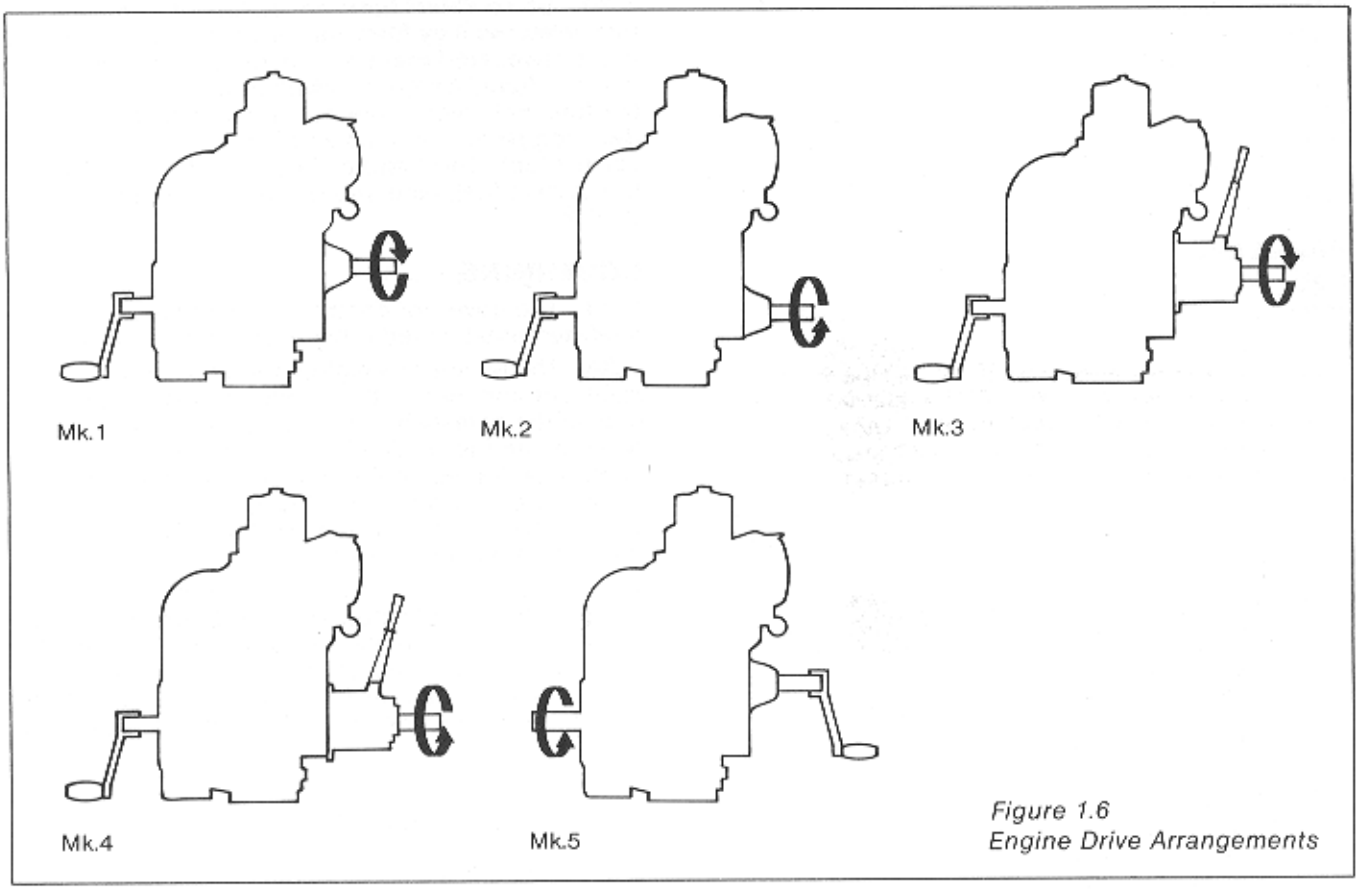


Figure 1.6
Engine Drive Arrangements

PULLEY DRIVE

1.37 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.

1.38 To prevent damage to 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 2.5% 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.

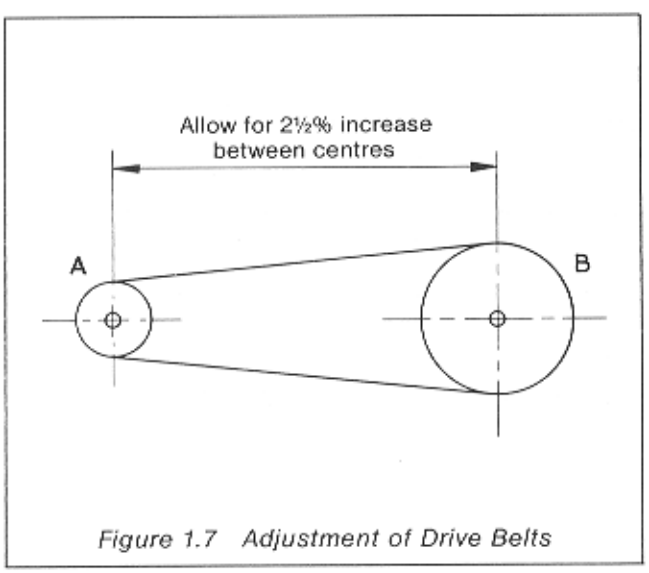


Figure 1.7 Adjustment of Drive Belts

ROTATION

1.39 Standard engine rotation is clockwise when viewed from the flywheel end. Engines with counter-clockwise rotation, that is with rotation reverse-to-standard are identified by a letter 'R' following the engine serial number.

STARTING HANDLE

1.40 The starting handle can be arranged for either clockwise or counter-clockwise rotation of the starting shaft as shown in Figure 1.8. Check that the pawl is correctly assembled. The pawl may be fitted at the top or bottom to give alternative starting positions.

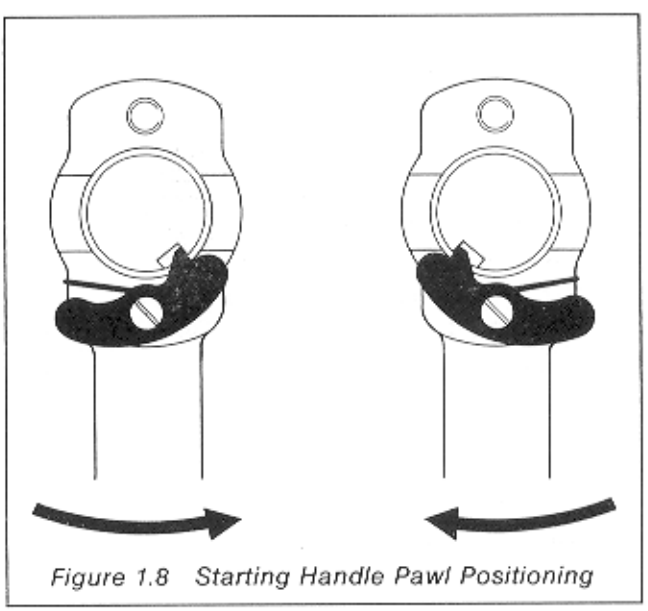


Figure 1.8 Starting Handle Pawl Positioning

OPERATING INSTRUCTIONS

NEW OR OVERHAULED ENGINE

Preparation for Starting

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 and that the fan cowlings are secured.

CAUTION

Under no circumstances attempt to start an engine without the fan cowlings in position.

(2) Remove the oil filler cap and, with the engine level fill with lubricating oil which conforms to specification MIL-L-46152-B (Paragraph 1.26) and of the correct grade (Paragraph 1.27) 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 a Petter clutch is fitted remove the cover plate and pour 0.3 litres (0.5 pints) of engine lubricating oil into the clutch housing. The clutch is a positive action type and must not be slipped when operating. The lever must be smartly engaged and disengaged.

(4) Lift the decompression 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 (Paragraph 1.30 and Paragraph 1.31)

(6) Bleed and prime the fuel system as detailed in Paragraph 1.42.

Bleeding and Priming the Fuel System

1.42 To bleed and prime the fuel system, each cylinder (in the case of multi-cylinder engines) must be done in turn. The flywheel TDC mark must be set for the appropriate cylinder about half a revolution away from the pointer before top dead centre. If a fuel lift pump is fitted fuel will not flow unless the lift pump priming lever is operated. With reference to Figure 1.9 carry out the following procedure:

(1) Slacken the two vent screws **(1)** on top of the fuel filter, when clean, air free fuel leaks out tighten the two vent screws.

(2) Slacken the vent screw **(2)** on the fuel pump, until air free fuel is expelled. Tighten the vent screw.

(3) Unscrew the delivery pipe connection **(4)** from the fuel injector. Operate the priming lever **(3)** until air free fuel is expelled. Re-connect the delivery pipe.

(4) Repeat the pumping action on the priming lever **(3)** until the injector is heard to squeak.

(5) Repeat operations **(2)** to **(4)** on the each subsequent cylinder, if appropriate re-aligning the flywheel mark.

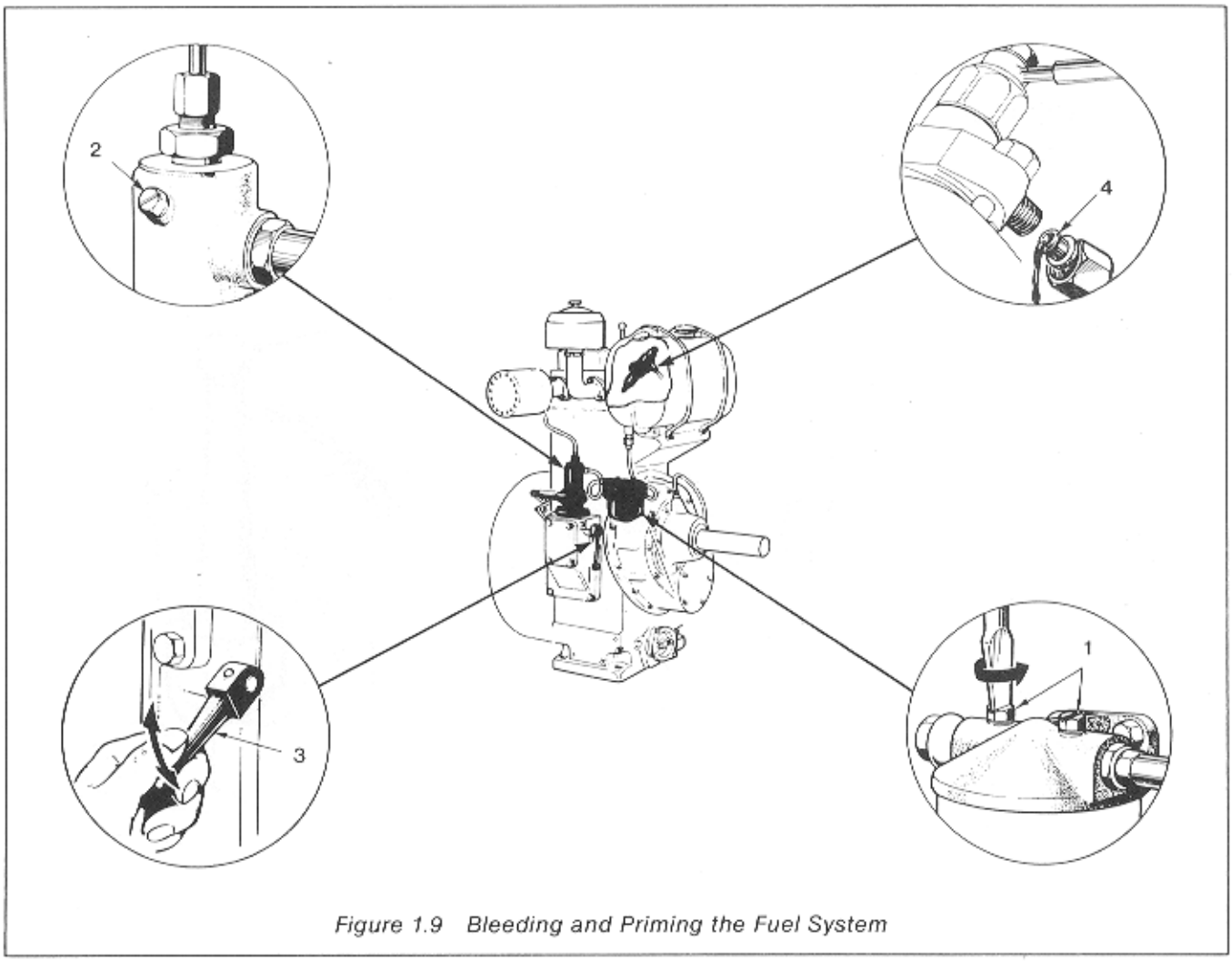


Figure 1.9 Bleeding and Priming the Fuel System

Engine Running In

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

(1) Run for 2 minutes; check oil pressure 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) 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 LOCATING 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.

Normal Start (Figure 1.10)

1.44 To start an engine under normal operating conditions using the starting handle proceed as follows:

(1) If a variable speed control is fitted, set the control lever to the full speed position.

(2) Lift the red painted overload stop **(1)** and allow the fuel pump rack(s) to move into the fully open position.

(3) Operate the fuel pump priming lever for each cylinder about six times to prime the cylinder. (This operation is not required if the engine is warm).

(4) Lift the decompression lever(s) **(2)** and turn the engine by hand as fast as possible. When the engine is turning over at a good speed, knock down the decompression lever. The engine should now fire. On two cylinder engines fitted with separate decompressors, knock down one lever and then as soon as the engine fires, knock down the other lever.

(5) If the engine does not fire, lift the decompression lever(s) and slowly turn the engine a few times before attempting to start again.

1.45 When using a starter motor to turn the engine the decompression lever(s) are not raised. Do not operate the starter motor for more than 20 seconds at a time.

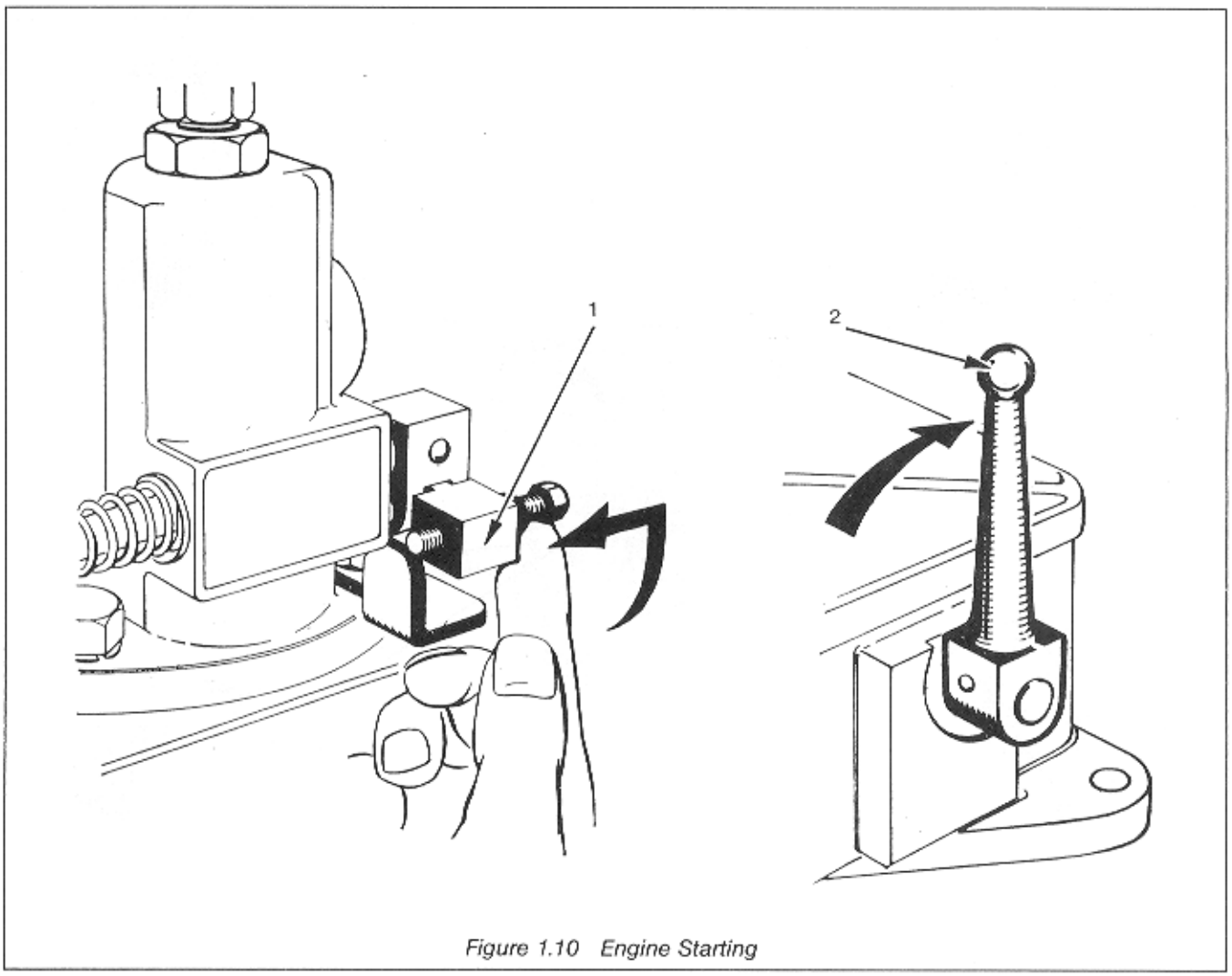


Figure 1.10 Engine Starting

Cold Start

1.46 When operating in low temperature conditions it may be necessary to use a cold starting aid, details of which can be obtained from Petters Limited or their representatives. This aid may be in the form of an auxiliary fuel introduced into the combustion system during starting, through a permanently fitted equipment spraying directly into the inlet manifold. Care must be used when using a cold starting aid as indiscriminate use may cause damage to the engine. Petters Limited or their representatives must be consulted if doubt arises regarding the use of such aid.

1.47 Temperatures below which a cold starting aid may be required depends on the installation and the condition of the engine and are as in Table 1.4.

TABLE 1.4
COLD STARTING AID TEMPERATURES FOR HAND STARTING (BARE ENGINES)

Installation	*PH1 engine*	*PH2 engine*
On half-speed extension shaft	**–13°C (9°F)**	**–12°C (10°F)**
On full-speed extension shaft	**–10°C (14°F)**	**–5°C (23°F)**

Hot Start

PH1 Engines

1.48 Carry out the following procedure:

(1) Raise the fuel pump priming lever to the vertical position.
(2) Lift the decompressor lever.
(3) Turn the engine to clear the cylinder of hot air and fuel.
(4) Lower the priming lever.
(5) Turn the engine as fast as possible or operate the starter motor. When the engine is turning at a good speed knock down the decompression lever. The engine should now fire.

PH2 engines

1.49 Carry out the following procedure:

(1) Raise the fuel pump priming levers to the vertical position.
(2) Lift the decompressor levers.
(3) Turn the engine to clear the cylinders of hot air and fuel.
(4) Lower the priming levers.
(5) Turn the engine as fast as possible. When the engine is turning at a good speed knock down the decompression lever. On two cylinder engines fitted with separate decompressors knock down one lever and then as soon as the engine fires knock down the other lever.

STOPPING

1.50 Before stopping the engine it is advisable to run it on a light load for a few minutes. To stop the engine raise the fuel pump priming levers to the vertical position, or push the governor fulcrum lever towards to the fuel pump until the engine stops.

CAUTION
Do not turn off the fuel supply or use the decompression levers to stop the engine.

OPERATING PRECAUTIONS

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

(1) Do not stop the engine by lifting the decompression lever(s). This will damage valve seats and cylinder head joints.
(2) Do not allow the engine fuel tank to run dry. This means that sediment or water could be drawn into the fuel lines thus necessitating bleeding and priming of the fuel system.
(3) Do not remove or alter the setting of the overload stop.

ROUTINE MAINTENANCE

INTRODUCTION

1.52 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 and are 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 of oil and quality. 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

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

(1) Check valve clearance (Section 5).
(2) Drain lubricating oil from sump, change the filter element (if applicable) and fill with clean oil (Section 2).
(3) Check fuel filter (Section 3).
(4) Check the tightness of all nuts, bolts, securing screws and hose clips.

DAILY CHECKS

1.54 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

1.55 Carry out the following procedure:

(1) Clean the oil bath type air cleaner, if fitted (Section 4).

(2) Check the alternator/dynamo drive belt, if fitted.

EVERY 250 RUNNING HOURS

1.56 Carry out the following procedure:

(1) Clean the fuel filter (Section 3).

(2) Check the tightness of all nuts, bolts, securing screws and clips.

(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.

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

(6) Clean the fuel tank strainer.

(7) Drain the oil sump and refill with new lubricating oil of the correct type and grade. (Section 2).

(8) Fit a new lubricating oil filter element and joint ring (where fitted).

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

(9) Visually check the fuel system for leaks.

(10) Remove the fuel injector(s) (Section 3) and test spray. If in order replace.

(11) Check valve clearance (Section 5) and adjust if necessary.

(12) Clean the lubricating oil feed restrictor to rockers (Section 2).

(13) Lightly lubricate the speed control linkage.

(14) Clean the fuel lift pump strainer, if fitted. (Section 6)

EVERY 500 RUNNING HOURS

1.57 Carry out the following

(1) Fit a new fuel filter element (Section 3).

(2) Fit a new air cleaner element (if fitted).

EVERY 2000 RUNNING HOURS

1.58 Carry out the following:

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

(2) Clean out piston oil return holes.

(3) Check piston rings for wear (Section 5).

(4) Check each cylinder bore wear (Section 5).

(5) Check the connecting rod bearings. (Section 5).

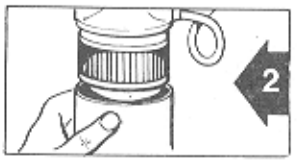
(6) Drain and clean out the engine fuel tank.

(7) Fit a new plunger pin (Section 2) on the plunger pump type oil system (if fitted).

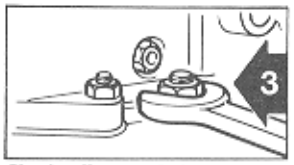
DAILY

Check the lubricating oil level on the dipstick and top up if necessary.

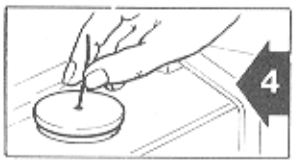
250 HOURS



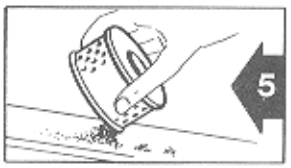
Clean the fuel filter bowl.



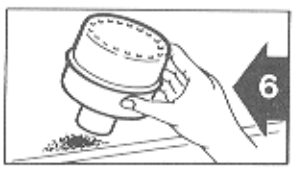
Check all nuts, bolts, etc. for tightness.



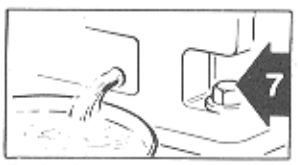
Make sure the fuel tank filler cap vent hole is clear.



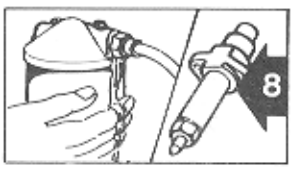
Clean the air cleaner element. (In very dusty conditions this must be done more frequently.)



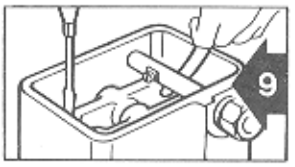
Clean out deposit from exhaust system.



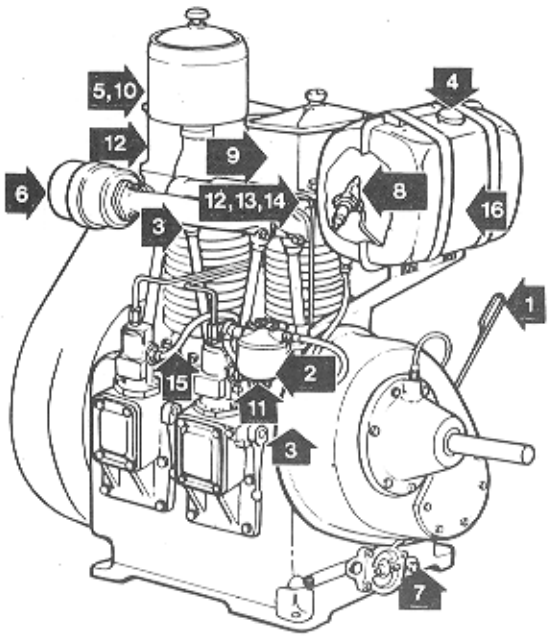
Drain the sump, flush out with flushing oil and refill with new oil. Clean the strainer.



Test the fuel system for leaks. Remove the fuel injectors and test spray.

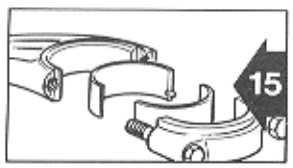


Check the valve clearance and adjust if necessary.



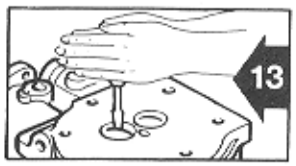
2,000 HOURS

Clean out the fuel tank thoroughly.



Examine the crankshaft bearings and renew if clearance is excessive.

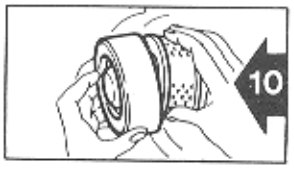
Clean the piston oil return holes. Check cylinder bore wear.



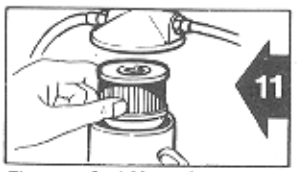
Examine the valves and grind if necessary.

Remove cylinder head and decarbonise.

500 HOURS



Fit new air cleaner element.



Fit new fuel filter element.

Figure 1.11 Maintenance Chart

SECTION 2
LUBRICATING SYSTEM

INTRODUCTION

2.1 Two types of lubricating oil systems are used on PH engines, these differ in the type of oil pump used and are as follows:

(1) Rotary pump oil system, fitted on PH1 engine number 3101, 3102, 3228 and onwards.

(2) Plunger pump oil system prior to the above.

ROTARY PUMP LUBRICATING OIL SYSTEM

2.2 The lubricating oil system using a rotary type pump is shown in Figure 2.1. The pump **(1)** is mounted at the gear end of the crankcase and is driven via an idler gear **(2)** by a gear fitted on the crankshaft. Lubricating oil is drawn from the sump **(3)** via a strainer **(4)** by the rotary oil pump **(1)**. The oil is then pumped via an adjustable pressure relief valve **(5)** to a full flow oil filter **(6)** (if fitted) and thence via an oil distribution bracket to the crankcase oilways. Oil from the oilways is fed to the gear end and flywheel end main bearings, and thence via drillings in the crankshaft to the large end bearings and in the case of two cylinder engines to the main intermediate bearing. Additionally oil is fed from the oil distribution bracket via a restrictor **(7)** and a banjo bolt, through an external pipe **(8)** to the valve rockers **(9)** and through a second external pipe **(10)** to the extension shaft bearing **(11)**. The cylinder, small end bearings and camshaft are splash lubricated. The sump is drained by removing the drain plug **(12)** which is located at the bottom front of the crankcase adjacent to the oil pump.

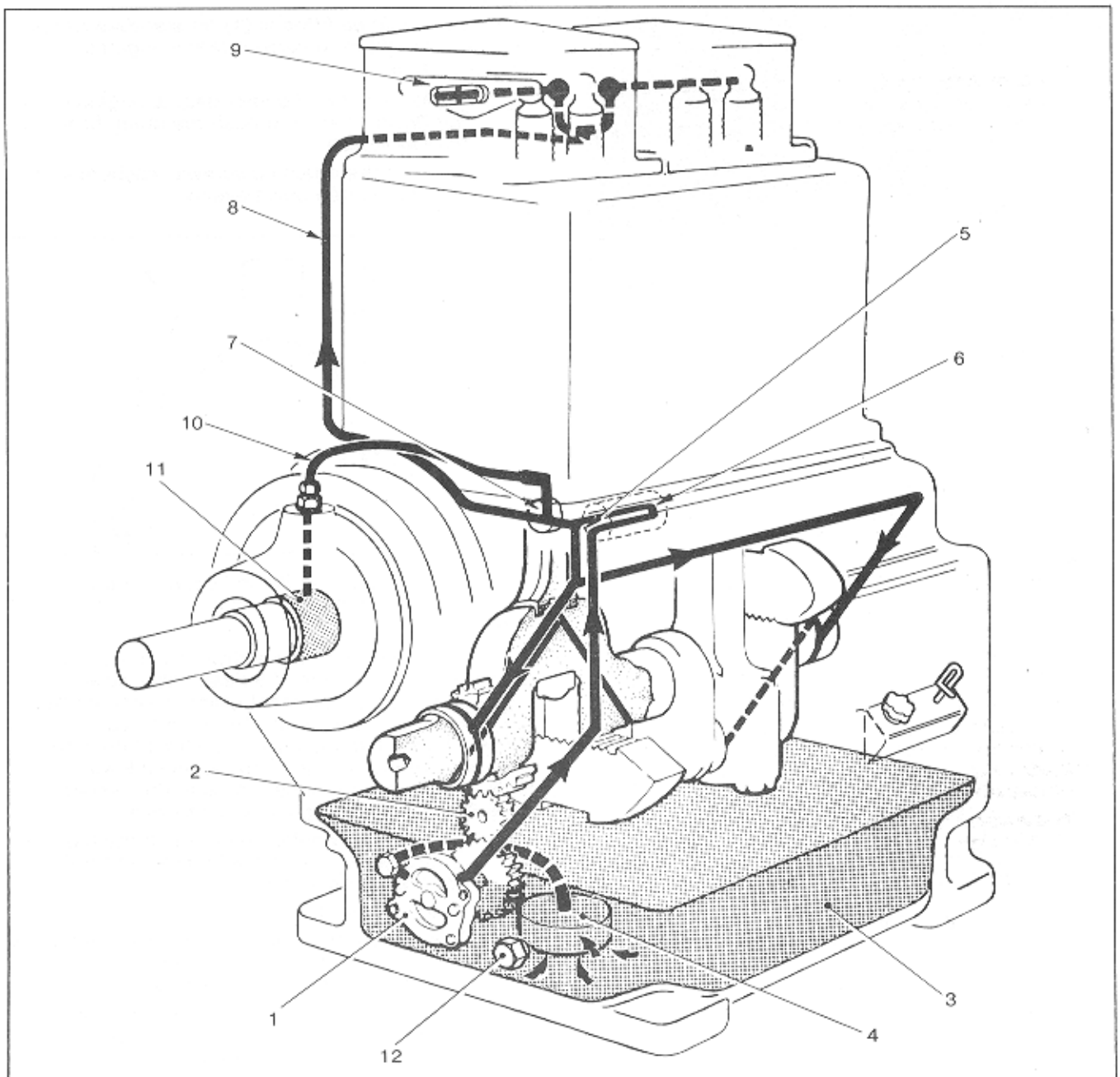


Figure 2.1 Rotary Pump Lubricating Oil System

Rotary Oil Pump

Removal

2.3 To remove the oil pump carry out the following procedure:

(1) Drain the oil from the sump by removing the oil drain plug from the bottom front of the crankcase to the oil pump.

(2) Remove the three 5/16 in. BSF bolts and washers and the ¼ in. BSF nut and washer retaining the pump.

(3) Screw two 5/16 in. BSF bolts into the holes provided in the pump and exert an even pull on both bolts as shown in Figure 2.2.

Note

The idler gear is on a spigot located in the crankcase by the gear cover plate. The gear is retained by a washer and circlip and is accessible through the crankcase inspection cover.

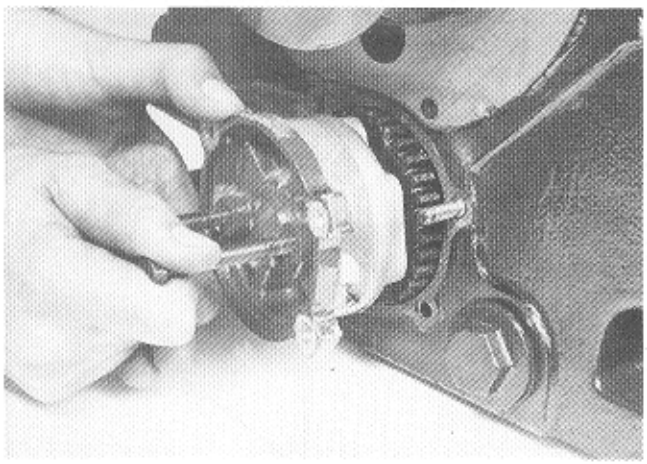


Figure 2.2 Removal of Rotary Oil Pump

Dismantling (Figure 2.3)

2.4 To dismantle the rotary oil pump proceed as follows:

(1) Tap out the retaining pin from the driving gear hub.

(2) Remove the driving gear.

(3) Remove the three screws retaining the oil pump cover and remove the cover.

Note

The cover is dowelled to the body of the oil pump.

(4) Withdraw the inner and outer rotor.

Maintenance

2.5 Clean all components and examine for signs of scoring or wear. If worn fit new parts.

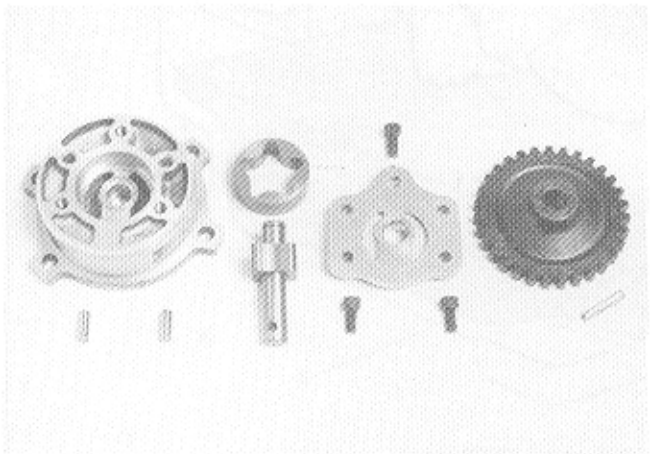


Figure 2.3 Dismantled Rotary Oil Pump

Assembly

2.6 To assemble the rotary oil pump proceed as follows:

(1) Fit the inner and outer rotors into the pump body. Ensure that the outer rotor chamfered edge is entered into the pump body and is not adjacent to the cover.

(2) Fit the cover, locating it on the dowels in the pump body.

(3) Secure the cover with the three screws.

(4) Fit the driving gear to the rotor shaft, align the hole in the shaft to the hole in the gear and replace pin.

Replacement

2.7 To fit the rotary oil pump to the engine proceed as follows:

(1) Fit a new joint washer.

(2) Locate the pump on the stepped stud, ensuring that the stud is in the correct position as shown in Figure 2.4.

Note

The stud should be fitted at **(1)** *for standard rotation engines or at* **(2)** *for reverse rotation engines. See Sect. 1.39*

(3) Make sure that the idler gear is engaged with the driving gear and push the pump fully into the crankcase.

(4) Replace the retaining screws, washers and nut and tighten down evenly.

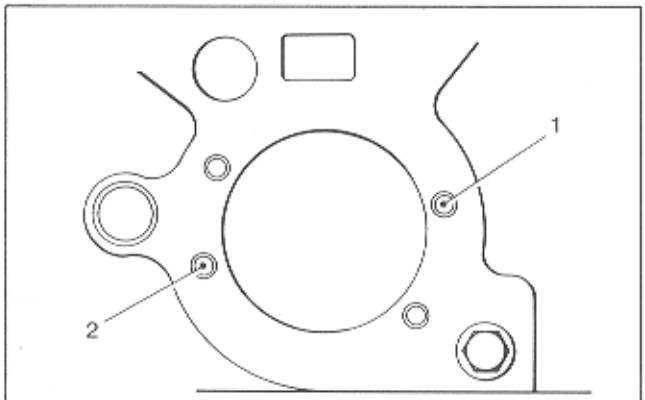


Figure 2.4 Oil Pump Locating Stud

Filter

2.8 The full flow oil filter is fitted as an option. The 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 incorporates a bypass valve that should the filter become blocked the valve opens and allows unfiltered oil to be pumped through the system. To change filter element proceed as follows:

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

(2) Clean the bowl.

(3) Check the centre bolt seal and the seal at the bottom of the bowl (bottom sump seal) for deterioration, replace as necessary.

(4) To replace the seals remove the centre bolt circlip, element guide, centre bolt seal, centre bolt washer, centre bolt spring and remove centre bolt collar and seal. Replace the seals as required and assemble in reverse order.

(5) Fit a new top seal between the bowl and filter head.

(6) Fit a new element, obtainable from Petters Limited or their representatives.

(7) Locate the centre bolt and tighten down, ensuring that the filter bowl fits correctly into the filter head.

Oil Pressure Relief Valve

2.9 The oil pressure relief valve is fitted either in the head of the filter (if fitted) or in a relief valve adaptor mounted on the oil distribution bracket. The valve is set by Petters Limited. If the oil pressure relief valve is dismantled, note the number of turns when removing the adjusting screw so that it can be returned to its original position on assembly.

2.10 Oil pressure must be checked and adjusted finally when the engine has been completely rebuilt, initially started and running. Oil pressure must be set when the engine is hot as detailed in Paragraph 2.30.

Oil Restrictor (Figure 2.5 and 2.6)

2.11 The oil restrictor consists of a plunger **(1)** and a spring **(2)** in a barrel housing **(3)** located at the top of the oil distribution bracket. The plunger and the spring are retained by a banjo bolt **(4).** The oil from the restrictor is then fed via an external pipe from the banjo connection to the rocker box. This supplies metered oil for the rocker bushes.

Operation

2.12 Oil from the pump is forced under pressure through two drilled holes in the barrel **(5),** around a recess in the plunger body, out through a centre drilling to the barrel outlet **(6)** and via the banjo bolt and external pipe to the rocker box. Oil flow is further restricted by the limited clearance of the rocker bushes and this in turn is felt as a back pressure against the front face of the plunger. This moves the plunger away from the banjo bolt against the pressure of the spring misaligning the plunger recess to the barrel supply holes to still further restrict the oil flow. The back pressure in the supply line is thus reduced and this allows the spring to return the plunger towards the banjo bolt and increase the oil flow, to repeat the cycle. Hydraulic locking of the plunger is prevented by allowing excess oil to pass between plunger and barrel and through the open end of the barrel back to the crankcase.

Removal

2.13 Disconnect the external pipe by unscrewing and removing the banjo bolt. Remove the barrel housing complete with restrictor and spring.

Maintenance

2.14 Remove the plunger and spring, clean the barrel assembly and replace the plunger and spring. Ensure that the plunger slides freely in the barrel.

Replacement

2.15 To replace the oil restrictor proceed as follows:

(1) Loosen the oil distribution bracket assembly by slackening the three 5/16 in. bolts and the 5/16 in. screw.

(2) Locate the oil restrictor barrel housing and tighten down finger tight.

(3) Tighten the oil restrictor and bracket securing bolts gradually and diagonally.

(4) Connect the external pipe by replacing and tightening the banjo bolt.

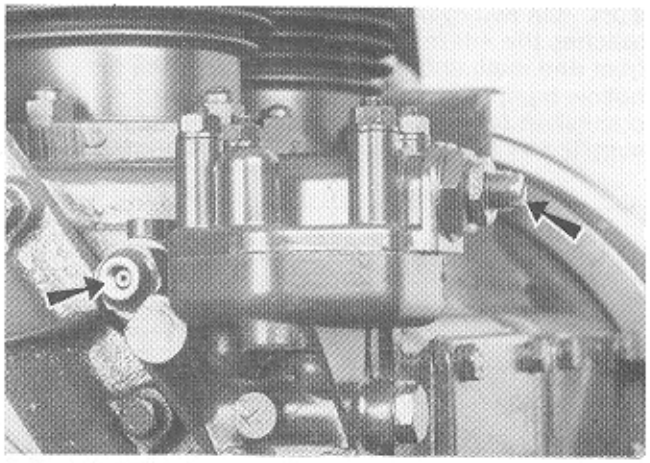


Figure 2.5 Oil Restrictor Location showing Restrictor (arrowed left) and Relief Valve (arrowed right).

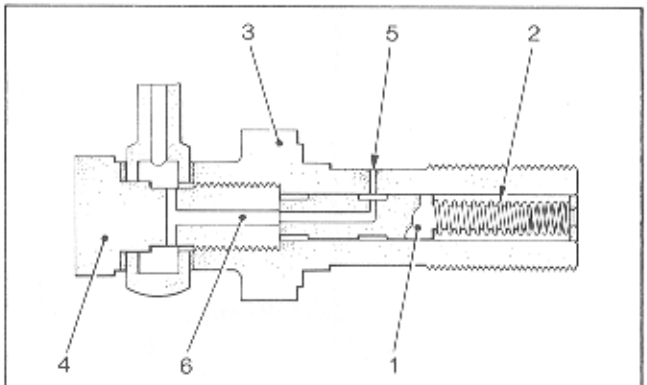


Figure 2.6 Oil Restrictor Sectional View

Oil Pump Strainer

Removal

2.16 To remove the oil pump strainer carry out the following procedure:

(1) Drain the oil from the sump by removing the oil drain plug at the bottom of the crankcase.

(2) Remove the crankcase inspection cover.

(3) Remove the banjo bolt securing the strainer to the crankcase and remove the strainer.

Maintenance

2.17 Wash the strainer in clean kerosene.

Replacement

2.18 Carry out the following procedure:

(1) Locate the strainer in the crankcase making sure that the oil seal and joint washer are in position.

(2) Replace and tighten the banjo bolt at the same time holding the strainer in position to prevent it twisting and being damaged.

PLUNGER PUMP OIL SYSTEM

2.19 The lubricating oil system using a plunger type pump is shown in Figure 2.7. Lubricating oil is drawn from the sump via a strainer by the plunger pump **(1)** which is submerged in the oil at the gear end of the crankcase sump. The pump is operated by an eccentric **(2)** on the crankshaft.

2.20 On single cylinder engines oil under pressure is pumped to the large end bearing and the gear end main bearing via the hollow pump plunger **(3)**

and holes drilled in the crankshaft **(4)**. The flywheel end main bearing is supplied by an external pipe **(5)**.

2.21 On two cylinder engines, oil under pressure reaches the intermediate main bearing, also the gear end main and large end bearings, via the hollow pump plunger **(3)** and holes drilled in the crankshaft **(4)**. The flywheel end main bearing is supplied by an external pipe **(5)**. The large end bearing at the flywheel end is supplied from the flywheel end mainbearing via holes drilled in the crankshaft.

2.22 An external pipe **(6)** feeds oil via a reducing valve **(7)** to the valve rockers. An adjustable oil pressure valve **(8)** is fitted to control the oil pressure. The cylinders, small end bearings and camshaft are splash lubricated.

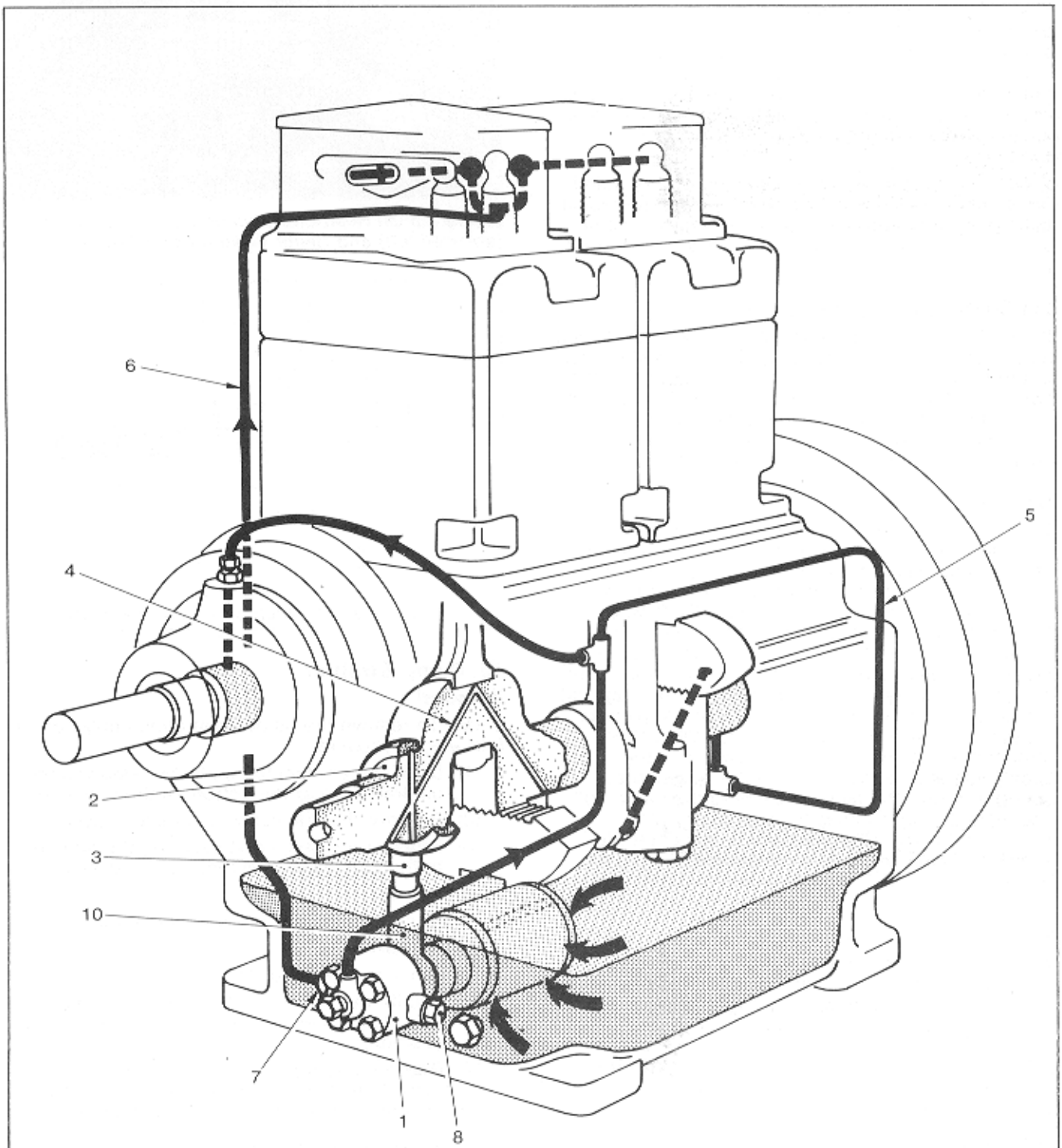


Figure 2.7 Plunger Pump Lubricating Oil System

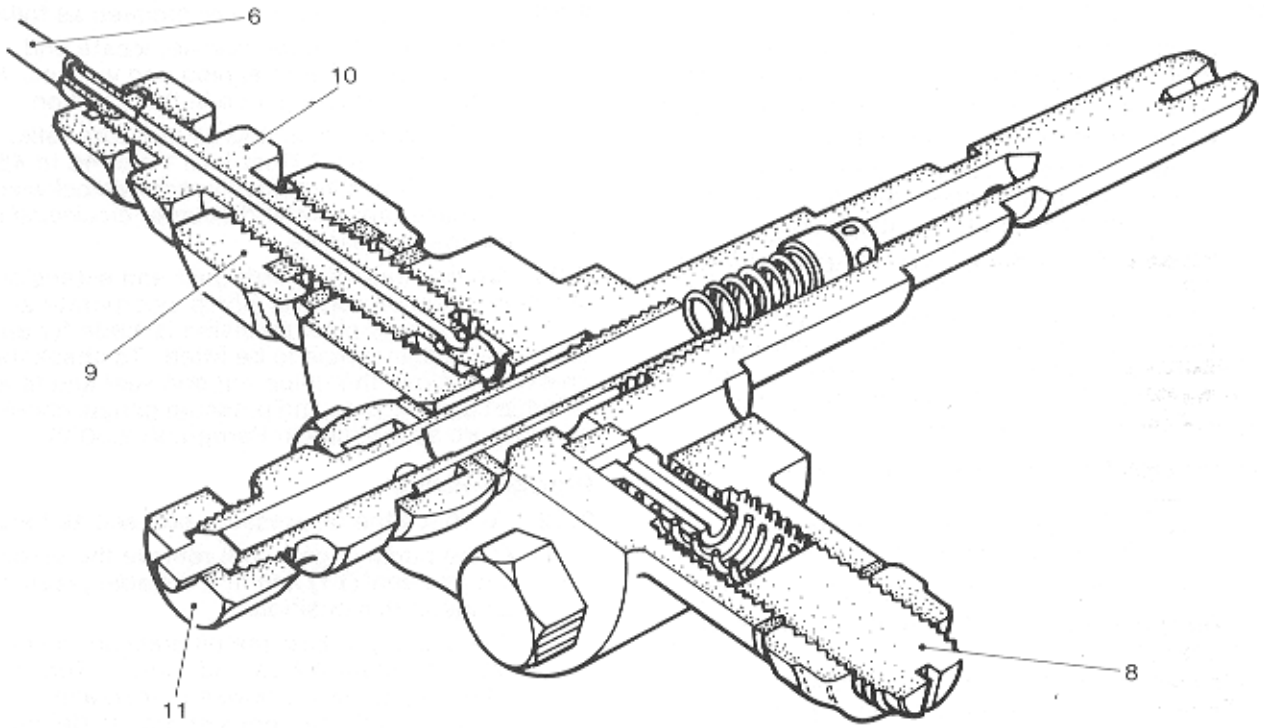


Figure 2.8 Plunger Oil Pump: Reducing and Pressure Relief Valves

Plunger Oil Pump

Removal

2.23 To remove the oil pump carry out the following procedure:

(1) Drain the oil from the sump by removing the oil drain plug at the front of the sump.

(2) Remove the crankcase inspection cover(s).

(3) Slacken the oil strainer clamp ring and remove the oil strainer.

(4) Disconnect the oil pipes from the pump and flywheel end main bearing.

(5) Remove the crankshaft in accordance with Section 5.

(6) Withdraw the pump body by pulling gently towards the flywheel end.

CAUTION

Take care not to damage the pump plunger and strap.

(7) Unscrew the four bolts retaining the fulcrum pin and remove the fulcrum pin and relief valve assembly. Retain the mitre valve and spring.

(8) Slacken the rocker oil feed valve locknut and unscrew the valve.

(9) Slacken the pressure relief valve locknut half a turn and unscrew the adjusting screw to remove the relief valve plunger and spring. By slackening the locknut half a turn only, the adjusting screw will give approximately the right oil pressure when reassembled.

Maintenance

2.24 Carry out the following procedure:

(1) Clean all parts in kerosene.

(2) Check the plunger and pump body for signs of wear or scoring. If worn or scored fit new parts.

(3) Check the mitre valve and the pressure relief valve plunger for wear, paying particular attention to the valve seats. If worn or damaged fit new parts.

(4) Fit a new plunger pin (Figure 2.9) and check the plunger internal valve seats for wear.

CAUTION

It is important that the plunger pin should be renewed as considerable damage could be caused to the engine in the event of pin failure.

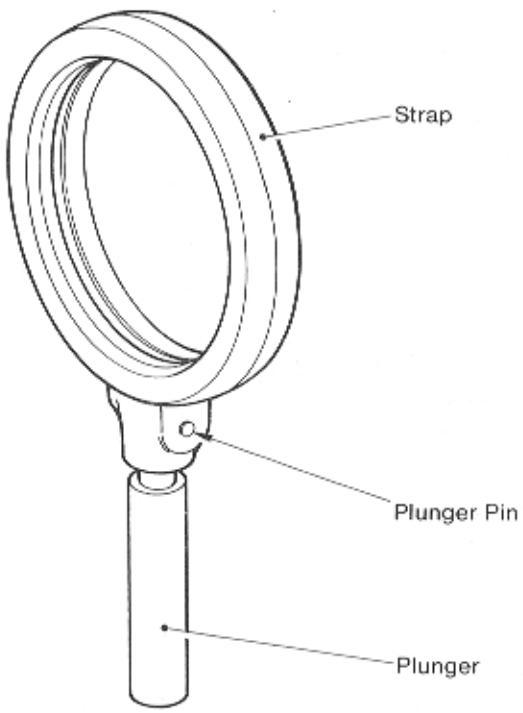


Figure 2.9
Strap and Plunger, Showing Plunger Pin

Replacement

2.25 Carry out the following procedure:

(1) Before assembling clean out the oilways, especially the small holes in the mitre valve.

(2) Lubricate the pump plunger with engine oil before insertion into the pump body.

(3) Replace the relief valve plunger and spring. Turn the adjusting screw to within half a turn of the locknut and tighten the locknut.

(4) Replace the rocker oil feed valve and tighten locknut.

(5) Fit the new fulcrum pin and relief valve assembly. Ensure that the mitre valve and spring are in the correct position. Tighten the four bolts retaining the fulcrum pin.

(6) Assemble the pump body.

(7) Replace the crankshaft in accordance with Section 5.

(8) Connect the oil pipes to the pump and flywheel end main bearing.

(9) Replace the oil strainer and tighten clamps.

(10) Refill the sump with the approved grade of lubricating oil.

(11) Check the oil pressure (Paragraph 2.32) Oil pressure must be set with the engine hot.

(12) Set the oil feed to the valve rockers (Paragraph 2.26).

Setting of Valve Rocker Oil Feed

2.26 To set the oil feed to the valve rockers refer to Figure 2.8 and proceed as follows:

(1) Slacken the union nut securing oil pipe **(6).**

(2) Slacken the oil feed valve locknut **(9).**

(3) Turn fully in the oil feed valve **(10).**

(4) Turn the oil feed valve **(10)** out one-sixth of a turn.

(5) Tighten down the locknut **(9)** ensuring that the valve does not turn.

(6) Tighten the union nut securing the oil pipe.

Oil Pump Strainer

Removal

2.27 To remove the oil pump strainer carry out the following procedure:

(1) Drain the oil from the sump by removing the oil drain plug at the bottom of the crankcase.

(2) Remove the crankcase inspection cover.

(3) Slacken the worm clip drive securing the strainer to the oil pump.

(4) Remove the strainer by gently pulling towards the flywheel.

Maintenance

2.28 Wash the strainer in clean kerosene.

Assembly

2.29 Replace the strainer in position and tighten the worm drive clip. Replace the crankcase inspection cover and fill the sump with approved lubricating oil.

CHECKING THE OIL PRESSURE

CAUTION

The engine oil pressure must be checked with the engine hot and running at its rated speed and reset if necessary after engine overhaul or if the oil system is disturbed. Failure to do this may result in extensive damage to the engine.

Rotary Pump

2.30 To check the oil pressure proceed as follows:

(1) At the oil distribution bracket locate and remove the hexagonal plug and washer. Fit a suitable pressure gauge in this position.

(2) If necessary, adjust the oil pressure relief valve to obtain 2.7 bar to 3.1 bar (40 to 45 lb/in^2). Turn the adjusting screw clockwise to increase pressure and counter-clockwise to decrease pressure.

2.31 On engines fitted with gear end extension shafts or common variants which incorporate an external oil supply pipe, provision is made for an additional capillary pipe to be fitted. To check the oil pressure remove the union nut and seal and fit a suitable capillary pipe and pressure gauge, check the oil pressure as detailed in Paragraph 2.30(2).

Plunger Pump

2.32 To check the oil pressure proceed as follows:

(1) At the pump (Figure 2.8) remove the union nut and seal **(11)** and fit a suitable pressure gauge in this position.

(2) If necessary, adjust the oil pressure relief valve to obtain 2.4 bar (35 lb/in.^{2}). Turn the adjusting screw clockwise to increase pressure and counter-clockwise to decrease pressure.

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.

CAUTION

No filing, grinding, scraping or sawing must be carried out adjacent to dismantled fuel equipment. No rag, cloth or waste should be used for cleaning purposes.

DESCRIPTION (Figure 3.1)

3.2 The fuel system comprises a fuel tank, fuel filter and a fuel injection pump(s) and an injector(s). Fuel is supplied from the tank via a filter to the pump(s) through flexible fuel pipes and by rigid pipe(s) from the pump(s) to the injectors. 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.

FUEL TANK

3.3 The fuel tank can be either a 6.8 litre (1.5 gal) or 18 litre (4 gal) tank strapped to a mounting bracket on the engine. Located inside the filler neck is a strainer. Engines can also be used with a separately mounted fuel tank.

FUEL FILTER

3.4 The 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 attached to the top two gear cover retaining bolts.

To Clean Fuel Filter (Figure 3.2)

3.5 To clean the fuel filter proceed as follows:

(1) Isolate the fuel supply.

(2) Unscrew the clamp 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 deposits of dirt. If the element has a deposit of dirt it must be renewed.

CAUTION

Do not attempt to clean the element.

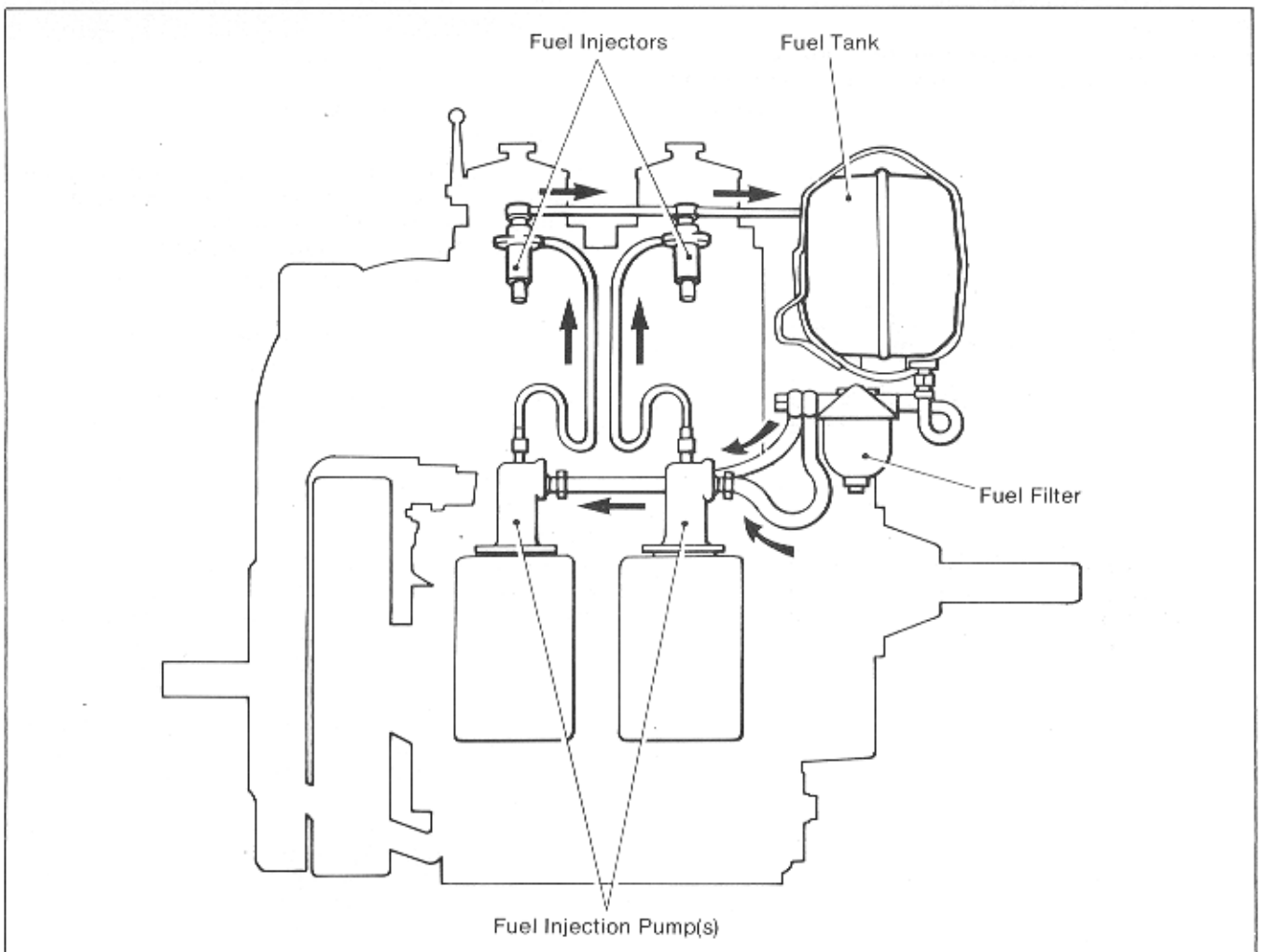


Figure 3.1 Fuel System

Assembly (Figure 3.2)

3.6 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 a new element is being fitted the bowl seal **(3)** and the element joint washer **(4)** are supplied with a new element and should be fitted.

CAUTION

When assembling the filter the internal components must be fitted as shown in Figure 3.2. If assembled incorrectly fuel will bypass the filter element and be fed directly to the fuel 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 centre bolt spring **(6)** followed by the plain washer **(7)** and the centre bolt 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 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.

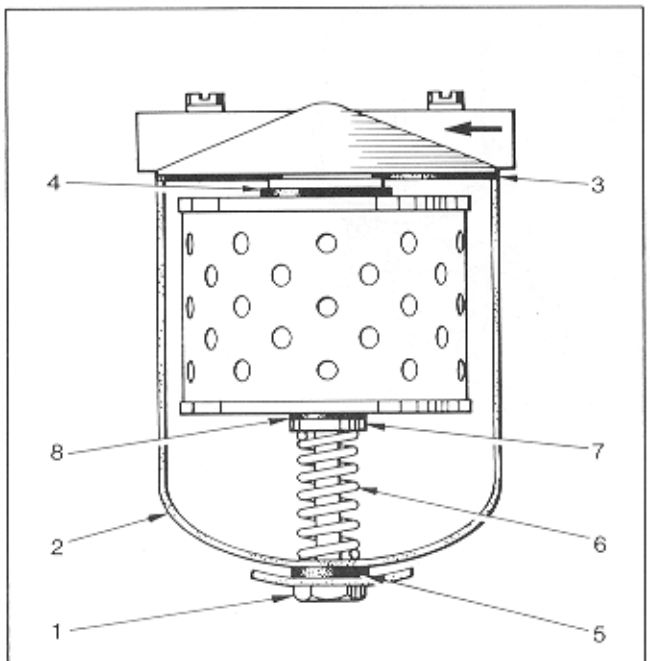


Figure 3.2 Fuel Filter Assembly

FUEL INJECTION PUMP

3.7 A separate fuel pump is fitted for each cylinder. The pump is mounted on a bracket which in turn is mounted on the crankcase. The pump is driven by a rocker arm which is actuated by the camshaft. An external handle allows the pump to be hand operated for priming and bleeding.

Removal (Figure 3.3)

3.8 To remove a fuel injection pump proceed as follows:

(1) Isolate the fuel supply.

(2) Disconnect the pipe from the pump to the injector and from the filter to the pump.

(3) On variable speed engines remove the connecting spring between the governor fulcrum arm and fuel pump rack extension (flywheel end pump only).

(4) Multi-cylinder engines only – disconnect pump linkage.

(5) Remove the two 5/16 in BSF retaining screws and remove the pump by lifting it from its mounting bracket.

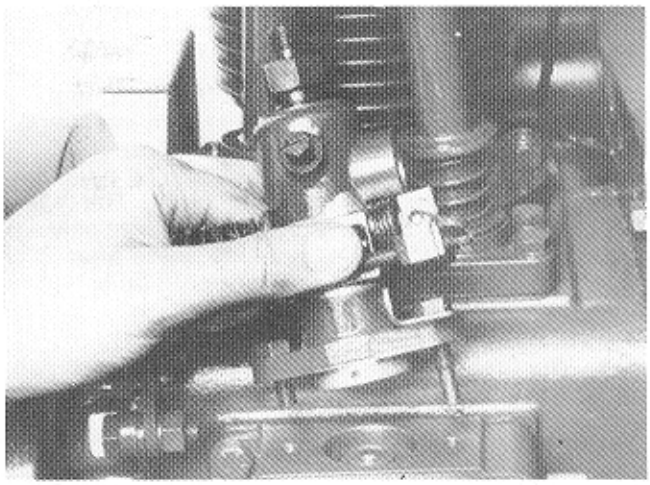


Figure 3.3 Removing the Fuel Injection Pump

Dismantling (Figure 3.4)

CAUTION

If adequate workshop facilities or skills are not available it is advisable to return faulty fuel pumps to Petters Limited or their representatives for repair or replacement.

3.9 To dismantle 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 delivery valve spring **(2)** and the delivery valve **(3).**

(4) Withdraw the delivery valve seat **(4)** and the joint **(5).**

Note

For Bryce pumps a special tool for this purpose can be obtained from Petters Limited or their representatives. On CAV pumps the delivery valve seat can be pushed out with the element as described in Paragraph 3.8(7). This also applies to Bryce pumps if the special tool is not available.

(5) Press in the tappet **(6)** and remove the circlip **(7).** During this operation the tappet may be held in by a pin inserted through a hole in the pump body.

(6) Remove the tappet, the lower spring plate **(8),** the plunger **(9)** and plunger spring **(10),** the upper spring plate **(11)** and the pinion **(12).** Note the assembly marks on the pinion and rack **(13).** On Bryce pumps the upper spring plate and pinion are retained by a circlip **(14).**

(7) Remove the element locating screw **(15)** and push out the element **(16)** through the top of the pump.

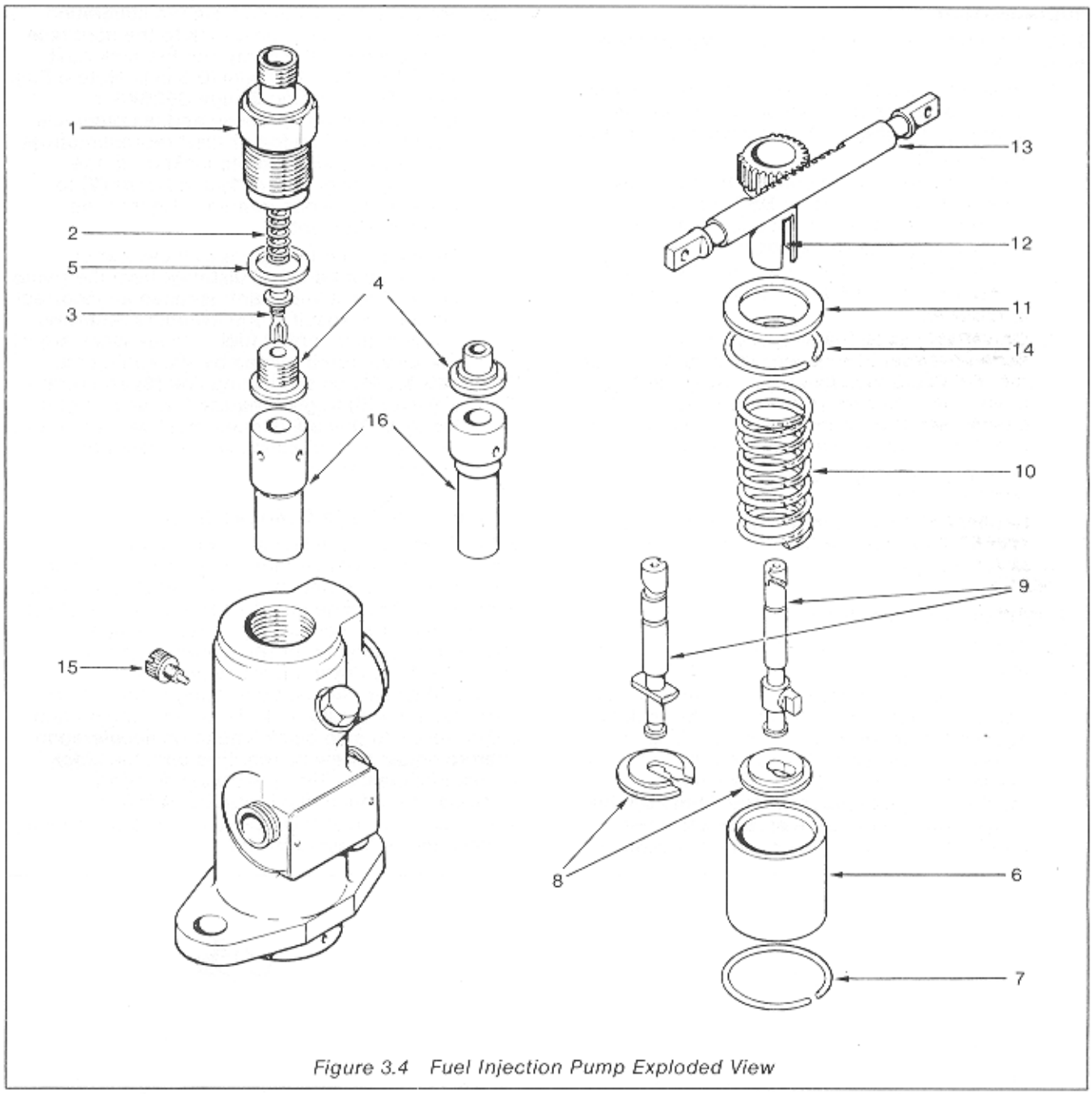


Figure 3.4 Fuel Injection Pump Exploded View

Maintenance (Figure 3.4)

CAUTION

Each plunger of a pump assembly is mated to one element only and must never be used in another.

3.10 Carry out the following procedure:

(1) Clean all parts in clean fuel.

(2) Check that the delivery valve joint is not cracked or scored.

(3) Check the valve seat for damage.

(4) Make sure the rack is free throughout its travel.

Assembly (Figure 3.4)

3.11 Carry out the following procedure:

Note

All parts must be assembled fuel wet.

(1) Replace the element **(16)** in the top of the pump and replace the element locating screw **(15).** Make sure the element can move up and down slightly when the locating screw is tightened.

(2) Assemble the rack and pinion ensuring that the marked teeth are in their relative positions.

(3) Replace the upper spring plate **(11)** plunger spring **(10)** the plunger **(9)** and the lower spring plate **(8)** and tappet **(6).** On Bryce pumps fit the upper spring plate and pinion retaining circlip **(14).**

(4) Press in the tappet and fit retaining circlip **(7).**

(5) Replace the delivery valve seat **(4).**

(6) Fit the delivery valve **(3)** and spring **(2).**

(7) Fit the joint **(5)** and assemble the union body.

(8) Tighten the union body to 54 Nm (40 lbf ft). Do not overtighten.

Note

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

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

Replacement

3.12 To replace the fuel injection pump proceed as follows:

(1) Rotate the engine to position the rocker arm such that the tappet plunger will be at the bottom of its stroke. This allows easier fitting of the pump.

(2) Fit the pump to the mounting bracket making sure that the two 5/16 in BSF screws are fitted in their correct positions. That is the screw with the extended plain shank is fitted in the right-hand position. This screw locates into a groove in the priming shaft to retain it in position.

(3) On variable speed engines connect the spring between the governer fulcrum arm and the fuel pump rack extension (flywheel end pump only). Ensure that there is no clearance between the governer fulcrum arm and the end of the fuel pump rack extension.

(4) Multi-cylinder engines only – connect the pump linkage.

(5) Reconnect the pipe from the pump to the injector and from the filter to the pump.

(6) Bleed the fuel system.

Adjustment (Figure 3.5)

3.13 On multi-cylinder engines start at the flywheel end pump, and carry out the following procedure:

(1) Set the fuel pump rack to the maximum fuel position. That is with the end of the rack held against the governor fulcrum arm adjusting screw and pushed as far as possible forwards the flywheel. For engines fitted with an overload stop this necessitates lifting up the hinged lower part of the stop to allow the rack to move into the maximum fuel position.

(2) Measure the distance from the calibration mark on the fuel pump rack to the spot face on the side of the pump not the rack bush. This should be 12.7 mm (0.5 in.). Note a Fuel Pump Rack Setting Gauge 392645 is available for this purpose and is obtainable from Petters Limited or their representatives. If necessary slacken the locknut on the governor lever screw **(1)** and adjust **(2)** to achieve this measurement. Tighten the locknut when set.

(3) On multi-cylinder engines all calibration marks must be equal distance from the pump body. This is important because an incorrect setting will result in the cylinders receiving unequal amounts of fuel. If necessary, adjust the subsequent pumps by slackening the locknut **(4)** on the joining link **(3)** and rotate adjustor **(5)** to give required setting. Tighten locknut. This adjustment must be carried out on subsequent pumps without disturbing previous setting.

Engines fitted with Overload Stop

3.14 With the adjusting screw held against the stop plate the measurement from the calibration mark on the fuel pump rack to the spot face on the pump side should be initially set to 20.6 mm (13/16 in.). Note a Fuel Pump Rack Setting Gauge 3926346 is available for this purpose and is obainable from Petters Limited or their representatives. Adjust by rotating screw. After pump timing (Paragraph 3.15) run the engine and adjust screw to give black smoke on acceleration. Then re-adjust screw as required until the black smoke just clears. Turn the adjusting screw clockwise to reduce black smoke. It may be necessary to repeat this operation several times to achieve the optimum position.

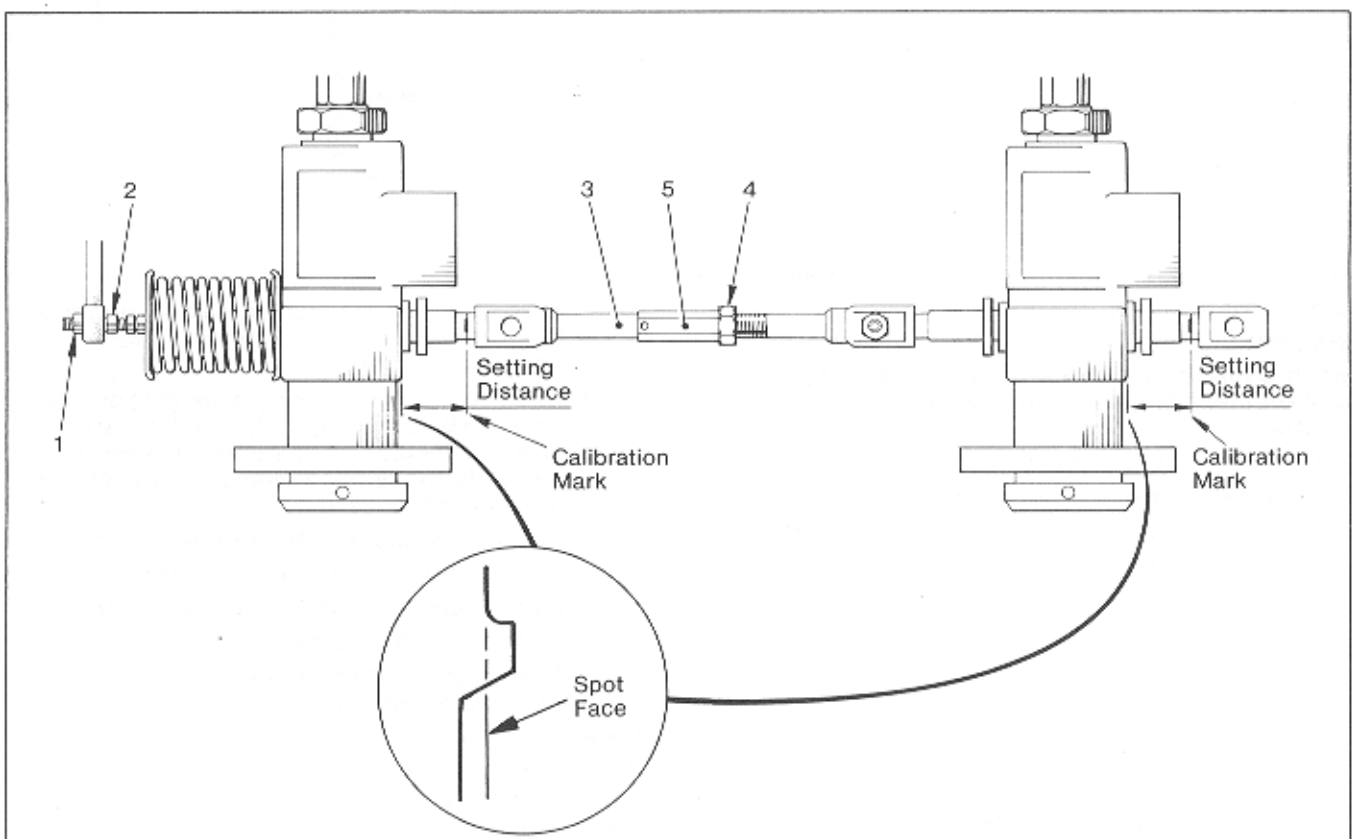


Figure 3.5 Fuel Injection Pump(s): Adjustment

Timing (Figure 3.7)

3.15 To time the fuel injection pump (in the case of multi-cylinder engines) carry out the following procedure on one cylinder at a time:

(1) Remove the four 5/16 in BSF bolts and spring washer retaining the fuel pump bracket cover. Take extra care when removing the cover on which a speed control is mounted.

(2) Secure the fuel injection pump rack with the calibration mark (Figure 3.5) 20.6 mm (13/16 in) from the spot face on the pump body, not the rack bush.

(3) Remove the pump-to-injector pipe and unscrew the union body (Figure 3.4 **(1)**) from the pump. Lift out the delivery valve and place in clean fuel. Do not disturb the delivery valve seat. Replace the union body, leaving out the delivery valve. Fit a spill swan neck pipe (Figure 3.6) to the pump union body.

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

(5) With reference to Figure 3.7 slacken the pump rocker pinch bolt **(1).** Unscrew the adjusting screw **(2)** until the pump is at the bottom of its stroke. Allow the fuel to flow from the pump. If a fuel lift pump is fitted fuel will not flow unless the feed pump lever is operated.

(6) Turn the flywheel until the appropriate timing mark (refer to Table 3.1) preceding the TDC mark is opposite the pointer.

TABLE 3.1
FUEL INJECTION TIMING (BY SPILL)
FIXED AND VARIABLE SPEED

Engine Speed	*Flywheel Setting*
Up to 1650 r/min	**24° before TDC**
1650 to 2200 r/min	**28° before TDC**

(7) Screw up the rocker adjusting screw until the fuel flow just stops. Set the screw at the exact position where the fuel flow stops. This position is known as the spill point.

(8) Tighten the rocker pinch bolt taking care not to alter the setting.

(9) Remove the swan neck pipe.

(10) Remove the union body and replace the delivery valve. Replace the union body. Tighten the union body to a torque loading of 54 Nm (40 lbf ft).

(11) Reconnect the injector-to-pump pipe.

(12) Refit the fuel injection pump bracket cover.

(13) Bleed the fuel system (Section 1).

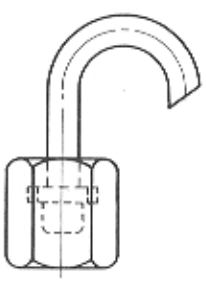


Figure 3.6 Swan Neck Pipe

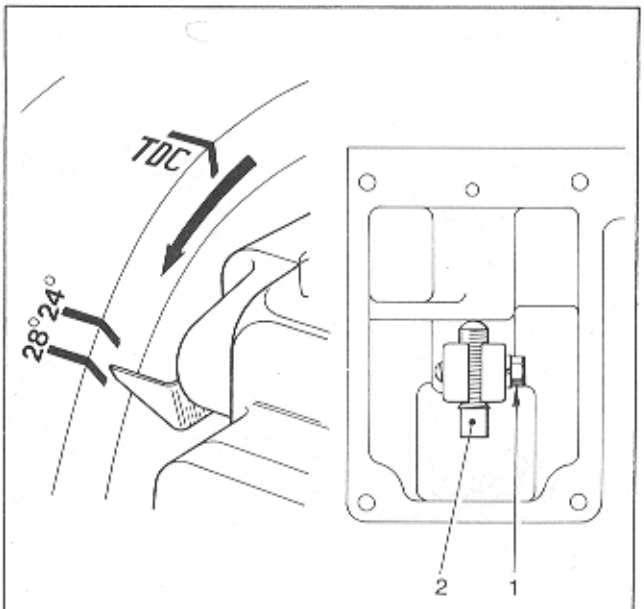


Figure 3.7 Fuel Injector Pump Timing

FUEL INJECTOR

3.16 The fuel injector is located in the cylinder head and comprising 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 and fuel is sprayed out via holes in the nozzle. The opening pressure of the needle is controlled by the injector spring. The spring pressure is set by an adjusting screw. The fuel injector provides three fine mist sprays of fuel to the cylinder.

Removal

3.17 To remove the fuel injector proceed as follows:

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

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

(3) Carefully ease out the injector from the injector cooling sleeve. The cooling sleeve is a tight fit in the cylinder head and must not be removed.

Testing (Without a Test Rig).

3.18 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 3.8).

WARNING

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

(2) Operate the fuel pump priming lever. The fuel should squirt out suddenly in three fine mist sprays, these should then stop just as suddenly. If the nozzle fails to spray, or gives solid squirts of fuel, or dribbles after the sprays have stopped, fit a new nozzle.

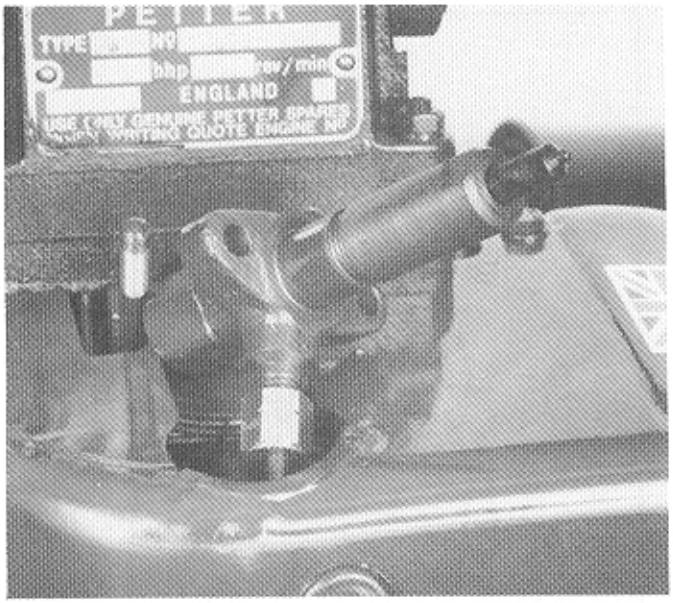


Figure 3.8
Testing the Fuel Injector without a Test Rig.

Dismantling (Figure 3.9)

CAUTION

If adequate workshop facilities or skills are not available it is advisable to return faulty fuel injectors to Petters Limited or their representatives for repair or replacement.

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

3.20 Carry out the following procedure:

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

(2) Remove the spring **(3)** and spindle assembly **(4).** The lower spring plate **(5)** is integral with the spindle.

(3) Unscrew the nozzle nut **(6)** and taking care to avoid dropping the needle valve **(8)** remove the nozzle **(7)** from the holder. 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.

Maintenance (Figure 3.9)

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

3.22 Immerse the nozzle body and needle valve in clean fuel oil. The needle valve stem and seat should be lightly brushed with a brass wire brush. Note that nozzle bodies and needle valves 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 valve is clean with an even, mirror-like finish. There should be no scratched or dull patches, very bright spots or any discoloration on or above the needle seat.

3.23 Inspect the nozzle body joint face for scratches or damage. Clean the fuel feed holes **(4)** by pushing a suitable probe **(10)** (wire or twist drill) down into the fuel chamber **(11).** Take care not to damage the joint face. Using a special fuel chamber scraper **(12)** 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.

3.24 Clean the nozzle spray holes using a spray hole cleaner **(14).**

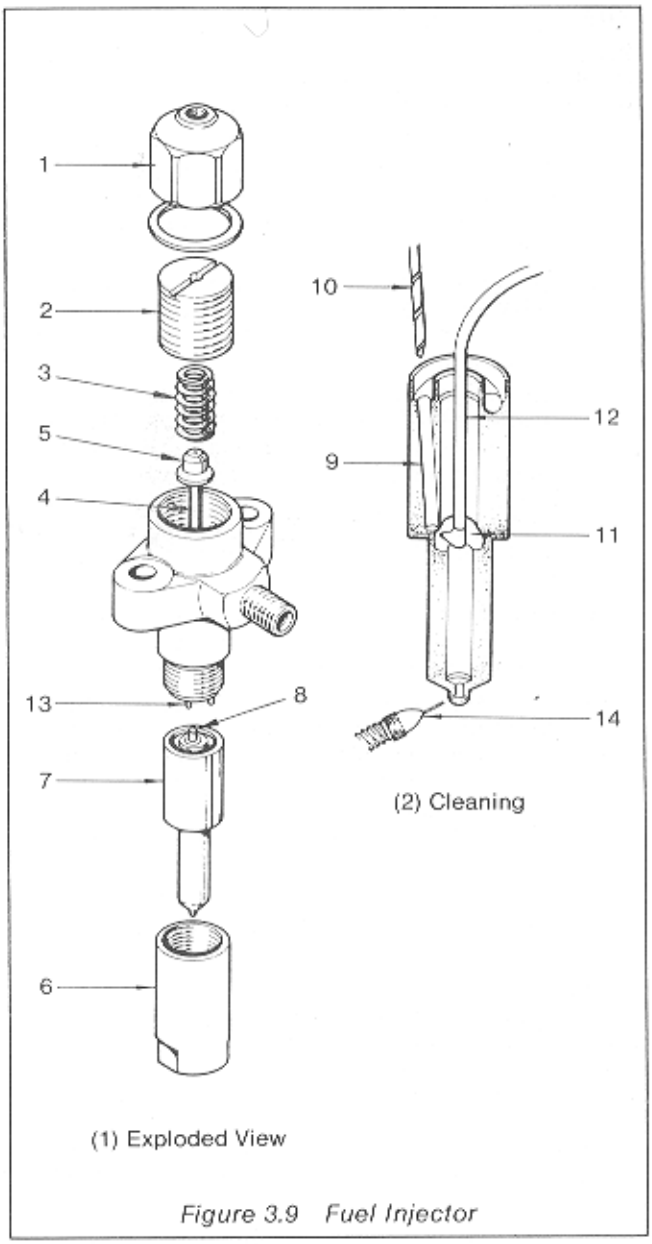


Figure 3.9 Fuel Injector

Assembly (Figure 3.9)

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

(1) Fit the needle valve into the nozzle.

(2) Fit the nozzle assembly to the nozzle holder, holding it hard against the pressure face in the position determined by the dowels **(13)** 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 3.26.

Testing and Setting Up (Using a Test Rig)

3.26 Using the test rig (Figure 3.10) 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 fuel oil or 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.

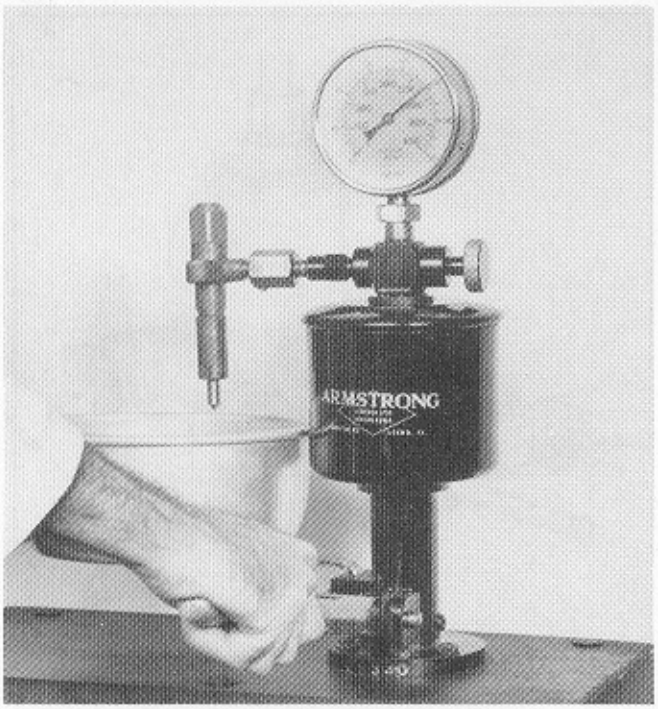


Figure 3.10
Testing the Fuel Injector using a Test Rig

Seat Leakage

3.27 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 to the pressure as detailed in Table 3.2. 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 3.2
FUEL INJECTOR PRESSURE SETTING

Engine Speed	*Pressure*
900 to 1099 r/min	**137/152 bar (1995/2205 lbf/in^2)**
1100 to 2200 r/min	**197/217 bar (2850/3150 lbf/in^2)**

Chatter Test

3.28 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.

Note

A few types of nozzle do not chatter under hand test conditions but will operate satisfactorily when fitted in the engine.

Spray Form

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

Back Leakage

3.30 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. Oil temperature should be 15.6°C (60°F) during this test.

3.31 Set the correct nozzle opening pressure as detailed in Table 3.2. 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 (Figure 3.11)

3.32 To replace the fuel injector proceed as follows:

(1) Slide the injector into the finned cooling sleeve.

CAUTION

(1) **The engine must not be run without a cooling sleeve around the injector.**

(2) **Extreme care must be taken in replacement of the injector as incorrect fitting can damage the connecting pipe and/or the injector.**

(3) **There is no sealing washer fitted to injectors on air cooled engines.**

(2) Fit the spring washers and loosely tighten the securing nuts.

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

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

(5) Tighten the injector flange nuts evenly.

(6) Connect the leak-off pipe.

(7) Bleed the fuel injector.

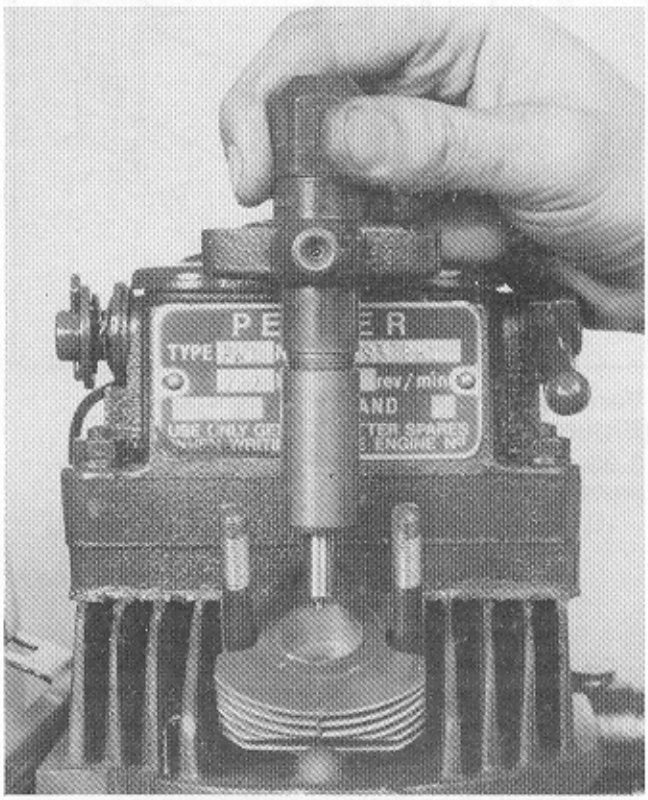


Figure 3.11 Fitting Fuel Injector

SPEED CONTROL ADJUSTMENT

Speed Control (Figure 3.12)

3.33 The centrifugal forces on the governor weights are transmitted to the fuel pump rack. These forces, which vary with the speed of the engine are balanced by an adjustable speeder spring **(1)**. This adjustment allows a set range of speed. To adjust the speed outside this range a different spring and flywheel may be required and these are obtainable from Petters Limited or their representatives. The adjusting screw **(2)** is set by Petters Limited and should not require adjustment; any further adjustment may result in the engine overspeeding when the load is suddenly removed. However, if the setting is disturbed on fixed and variable speed engines, or a different speed is required on variable fixed speed engines adjustments are carried out as detailed in the following paragraphs.

Fixed Speed (Figure 3.12)

3.34 To set the fixed speed control proceed as follows:

(1) Slacken the locknut **(3)**.

(2) Adjust the nut **(4)** against the spring (clockwise) to increase the speed, or away from the spring (counter-clockwise) to decrease the speed. The speed should be set at 4.5% above the rated speed as shown on the engine nameplate, when running without load.

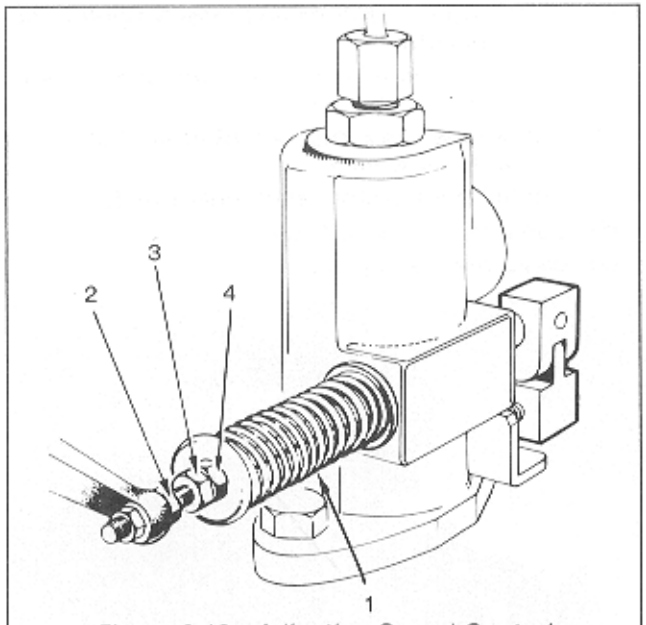


Figure 3.12 Adjusting Speed Control

Variable Fixed Speed – Early Type (Figure 3.13)

3.35 To set the adjustable fixed speed control proceed as follows:

(1) To decrease speed slacken the locknut **(1)** and nut **(2)** and turn nut **(3)** towards the flywheel until the required speed is obtained. Tighten nut **(2)** against the bracket **(4)**. Tighten the locknut **(1)**.

(2) To increase speed. Slacken the locknut **(1)** and nut **(3)**. Turn nut **(2)** away from the flywheel until the required speed is obtained. Tighten nut **(3)** against the bracket **(4)**. Tighten locknut **(1)**.

(3) Check the spill timing as detailed in Paragraph 3.15 and adjust, if necessary.

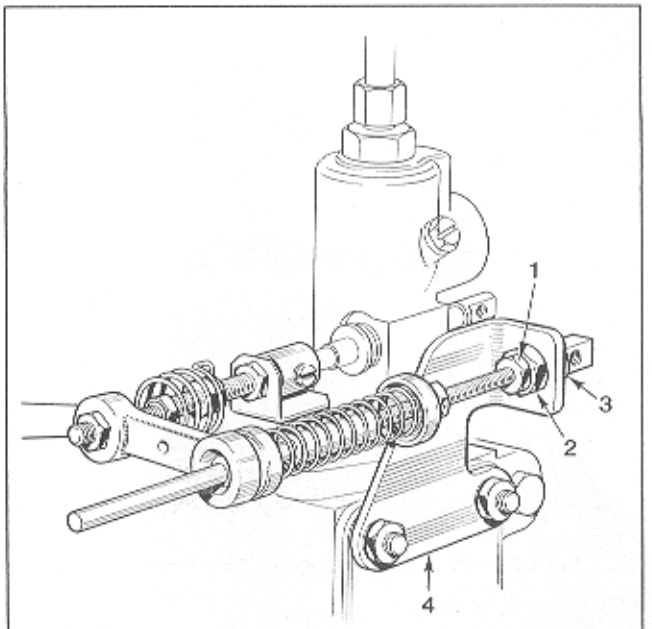


Figure 3.13 Adjustable Fixed Speed Control – Early Type Adjustment

Variable Speed Control (Figure 3.14)

3.36 To set the variable speed control proceed as follows:

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

(2) Slacken the locknut **(1)** and adjust the idling speed to 950 to 1000 r/min by screwing the adjustment **(2)** up to decrease or down to increase the speed. Tighten the locknut **(1)**.

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

(4) Slacken the locknut **(3)** and adjust the full speed by screwing in the adjustment **(4)** to increase the speed or out to decrease it. The maximum speed should be set to 8% above the rated speed as shown on the engine nameplate, when running off load.

(5) Tighten locknut **(3)** and wire lock and seal the adjustment.

(6) The fuel injector pump rack stop should be adjusted so that the rack(s) are held 1.5 mm (1/16 in.) away from their fully closed position.

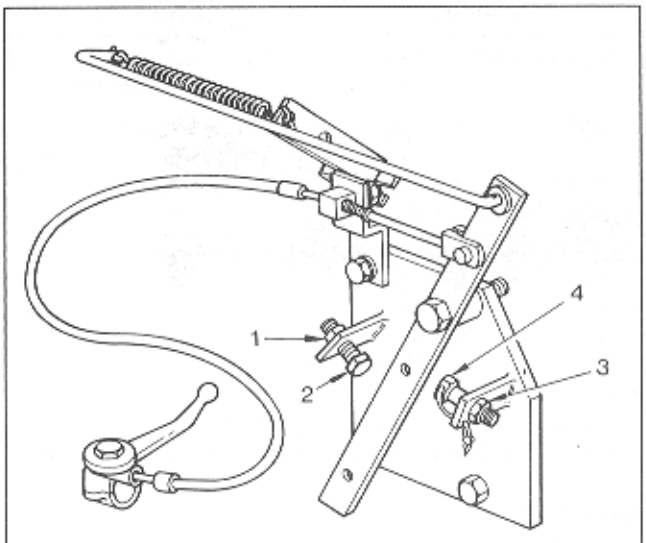


Figure 3.14 Variable Speed Control : Adjustment

Variable Speed Control – Early Type (Figure 3.15)

3.37 To set the variable speed control proceed as follows:

(1) Set the control speed control lever in the idling position.

(2) Slacken the locknut **(1)** and set the idling speed to 500 to 600 r/min by adjusting screw **(2)** in or out to increase or decrease the speed, respectively. Tighten locknut **(1).** Check that there is sufficient slack in the control cable to allow the control arm to bear hard against the stop. If not adjust the cable by slackening locknut **(6)** and screw in the adjuster **(7)** until there is a small amount of slack in the inner cable. That is the cable control lever can be moved before the inner cable begins to move the control. Tighten locknut **(6).**

(3) Set the speed control lever to the full speed position.

(4) Slacken the locknut **(4)** and set the full speed to 8% above the rated speed as shown on the engine nameplate, when running off load. That is 2160 for 2000 r/min engines. Adjust screw **(3)** in to decrease speed and out to increase speed. Tighten locknut **(4)** and wire lock and seal the adjusting screw.

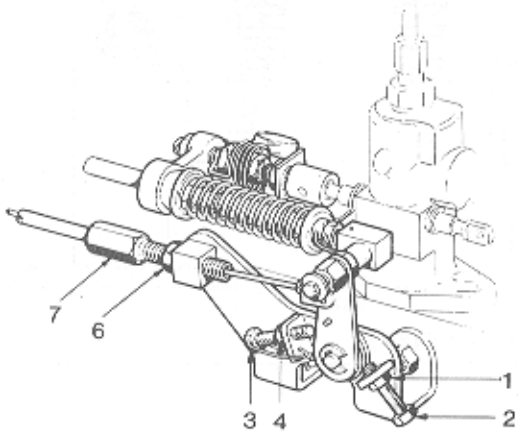


Figure 3.15 Variable Speed Control – Early Type : Adjustment

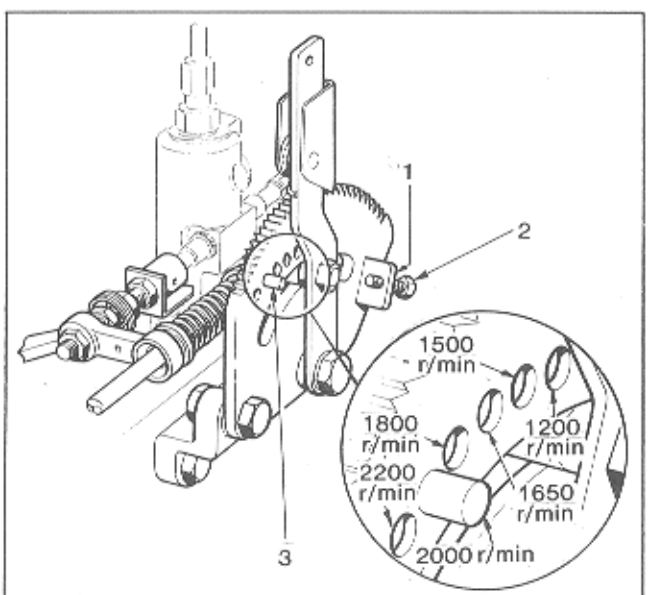


Figure 3.16 Variable Speed Ratchet Control : Adjustment

Variable Speed Ratchet Control (Figure 3.16)

3.38 To set the variable speed control proceed as follows:

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

(2) Slacken the locknut **(1)** and set the idling speed to 500 to 600 r/min by adjusting screw **(2)** in or out to increase or decrease the speed, respectively. Tighten locknut **(1).**

(3) Set the full speed stop **(3)** to the appropriate full speed position (See inset).

Adjustable Fixed Speed (Figure 3.17)

3.39 To set the adjustable fixed speed control proceed as follows:

(1) Ensure that the maximum speed stop **(1)** is set to give the maximum rated speed of 2200 r/min plus 8% and the bottom end of the lever **(2)** corresponds with the 2200 r/min graduation on the speed scale **(3).** If not slacken the locknuts **(4), (5)** and **(6).** Turn the adjusting screw assembly **(7)** in conjunction with the maximum speed stop until the maximum speed is obtained.

(2) Tighten the locknut **(4)** and secure the stop with wire and a lead seal.

(3) If the operating speed required is below 2200 r/min turn the adjusting rod until the bottom edge of the lever **(2)** corresponds with the speed required on the speed scale. Tighten the locknuts **(5)** and **(6).**

(4) Check the spill timing as detailed in Paragraph 3.15.

Note

*In some instances it may be found that during the setting of the maximum rated speed the lever **(2)** does not correspond exactly with the 2200 graduation on the scale although the engine running speed is correct. In this case it is necessary to adjust the speeder spring tension as well as the adjusting rod until the exact speed setting and graduation alignment is achieved.*

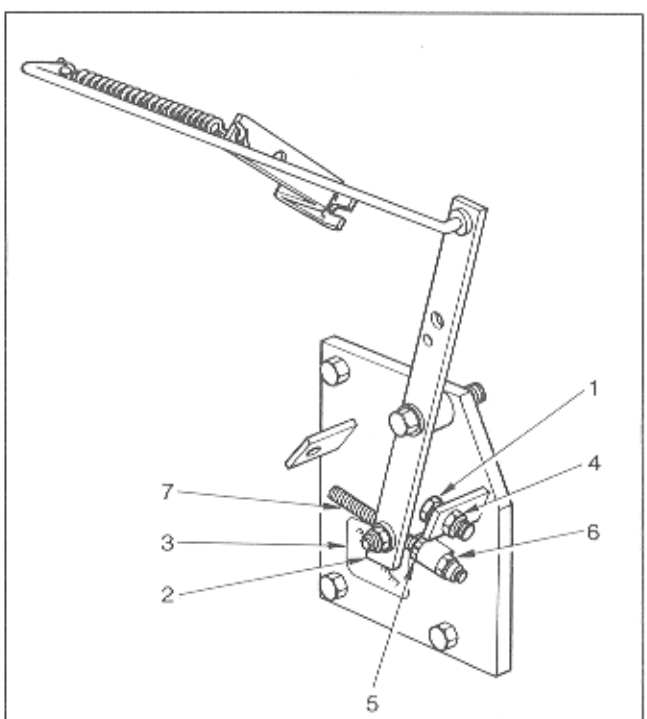


Figure 3.17 Adjustable Fixed Speed : Adjustment

HIGH PRESSURE FUEL PIPES

3.40 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 metal clip (single cylinder engines) or the fibre damper blocks on multi-cylinder engines.

(2) The clip or blocks must be replaced if the material shows any signs of deterioration. The swaged ends of the high pressure pipes should be checked periodically 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.

(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.

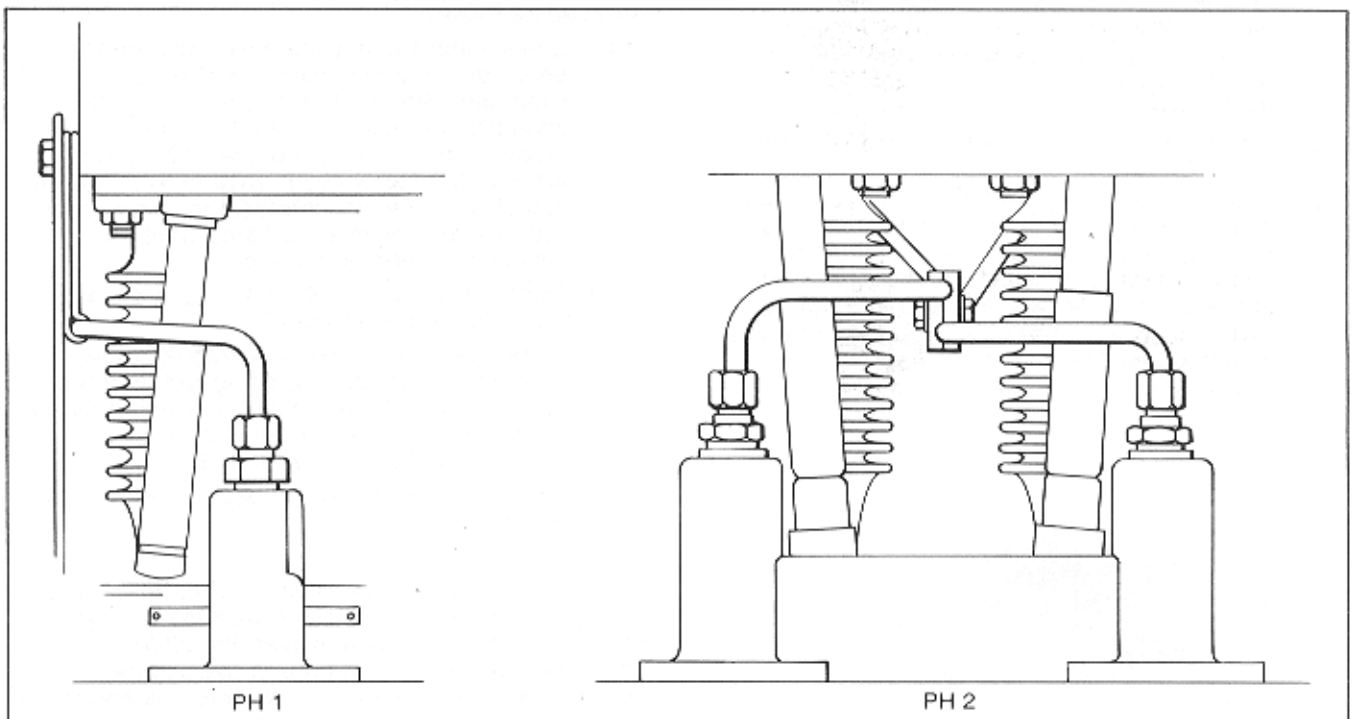


Figure 3.18 High Pressure Fuel Pipe Clamps

SECTION 4
AIR FILTRATION

INTRODUCTION

Operating Conditions

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 Machine Shops Ship Auxilaries
Medium	**175 to 350**	**Every 250 Hrs**	Sand Pits Unmetalled Roads
Heavy	**350 to 700**	**Every 50 Hrs**	Ploughing Dry Soil Temporary Air Strip Road Working Equipment Building Sites
Very Heavy	**700 to 1400**	**Every 10 Hrs**	China Clay Pits Cement Works Stone Crushers

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 a 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 air filtration system can lead to rapid wear of major engine components.

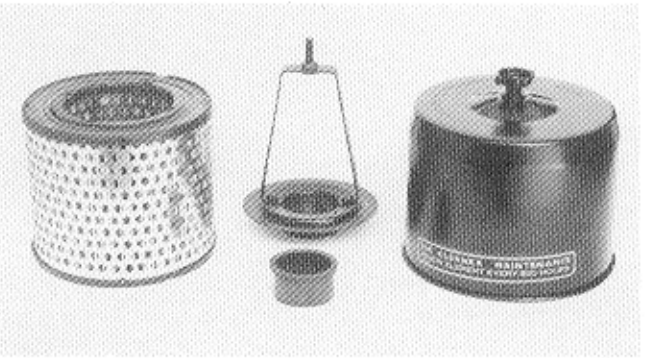


Figure 4.1 Air Cleaner Paper Element Type

AIR CLEANER PAPER ELEMENT TYPE

Removal

4.3 Unscrew the cover retaining nut remove the cover and element.

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.

Assembly

4.5 Replace the element and fit the cover. Ensure that the sealing surface on both cover and cleaner base are undamaged and that the element sealing faces are intact. Check the interconnecting flexible pipes (if fitted) between the cleaner and intake manifold are not cracked or holed.

AIR CLEANER OIL BATH TYPE

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 out the top half of the cleaner in clean kerosene and allow to drain. Clean out the sediment in the bottom using a clean lint-free rag. Check the rubber seal for damage or deterioration.

CAUTION

Avoid kerosene coming in contact with the rubber seal.

Assembly

4.8 Fit the bottom cup and fill with clean engine oil to the indicated level and fit the top half of the cleaner. Check that the two halves of the cleaner are correctly mated. Check that the interconnecting flexible pipes (if fitted) between the cleaner and intake manifold are not cracked or holed.

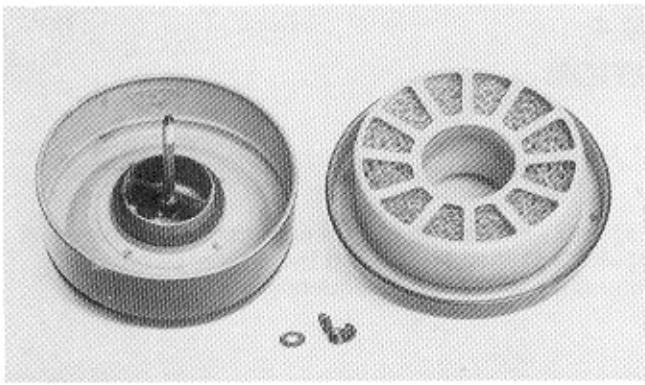


Figure 4.2 Air Cleaner Oil Bath Type

AIR CLEANER OIL BATH TYPE WITH PRE-CLEANER

Removal

4.9 Remove the bottom cup and top half of the cleaner.

Maintenance

4.10 Clean out the sediment from the bottom half of the cleaner. Invert the top half of the cleaner and wash out in kerosene and allow to drain.

Assembly

4.11 Fit the top of half of the cleaner and fill the bottom cup with engine oil to the indicated level. Refit the cup. Check that the two halves of the cleaner are correctly mated. Check that the interconnecting flexible pipes (if fitted) between the cleaner and intake manifold are not cracked or holed.

SECTION 5
ENGINE GENERAL MAINTENANCE

INTRODUCTION

5.1 This section contains fitting and servicing instructions for major repairs and maintenance of the PH 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 black exhaust gas accompanied 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 a cylinder head proceed as follows:

(1) Remove the cylinder cowling.

(2) Remove the inlet and exhaust manifolds by unscrewing the 5/16 in. BSF retaining bolts.

(3) Remove the fuel injector as detailed in Section 3.

(4) Disconnect the oil pipe from the end of the rocker shaft, and remove the restrictor valve (if fitted).

(5) Remove the four 5/16 in. BSF nuts and spring washers securing the rocker box and remove the rocker box.

(6) 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

(7) Remove the push rod tubes.

(8) Gradually slacken the cylinder head nuts diagonally and remove the six nuts. Lift off the cylinder head.

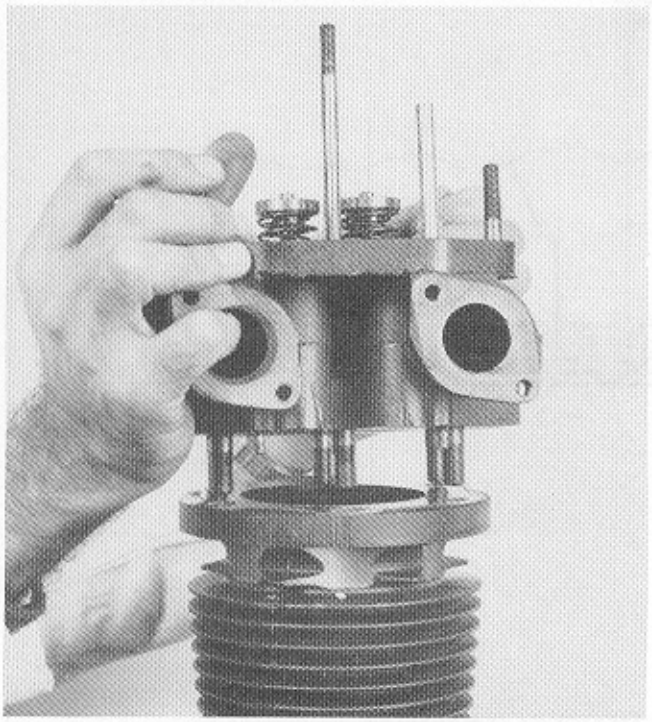


Figure 5.1 Cylinder Head Removal

Rocker Box Dismantling

5.4 To dismantle the rocker box proceed as follows:

(1) Remove the decompressor shaft split pin and slide off the washers noting the order of removal.

(2) Slacken off the decompressor pin locknut, remove the pin and withdraw the decompressor shaft.

(3) Drive out the rocker shaft using a copper drift or piece of hard wood.

Cylinder Head Dismantling

Valves Removal (Figure 5.2)

5.5 To remove the valves, place the cylinder head on a block of wood as shown in Figure 5.2. Using the special tool as shown, press down the valve spring and remove the split collets from the valve stems. Withdraw the valves and springs noting their positions, that is inlet and exhaust.

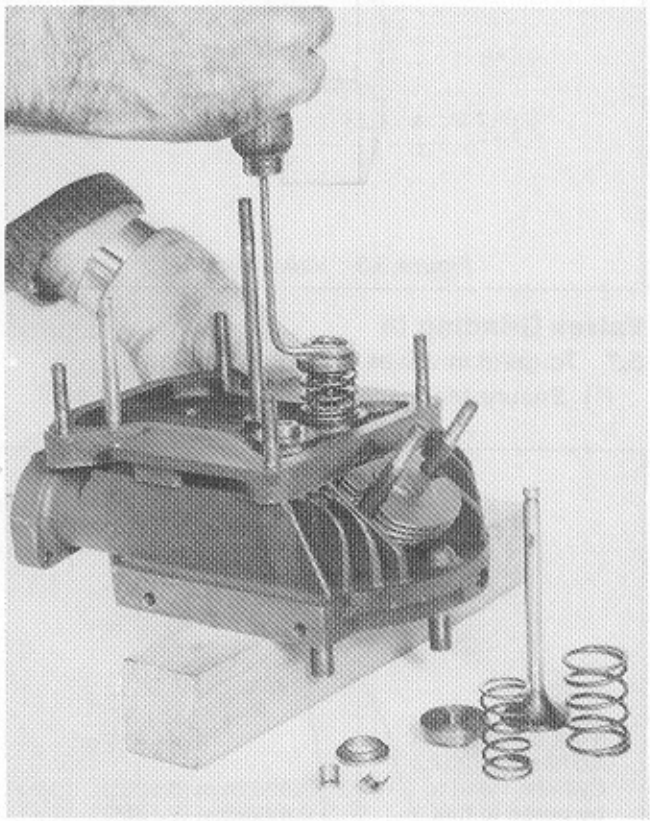


Figure 5.2 Valve Removal

Carbon Removal

5.6 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.

CAUTION

Do not use emery cloth

(3) Ensure that the recesses at the valve head end of the valve guide bores are free from carbon.

(4) 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 5.7. If the valves seats are pocketed carry out the procedure detailed in Paragraph 5.8.

(5) Insert the valves in their correct positions and check that they are seating properly.

(6) Check that the breather tube, which is located to one side of the inlet port, is clear.

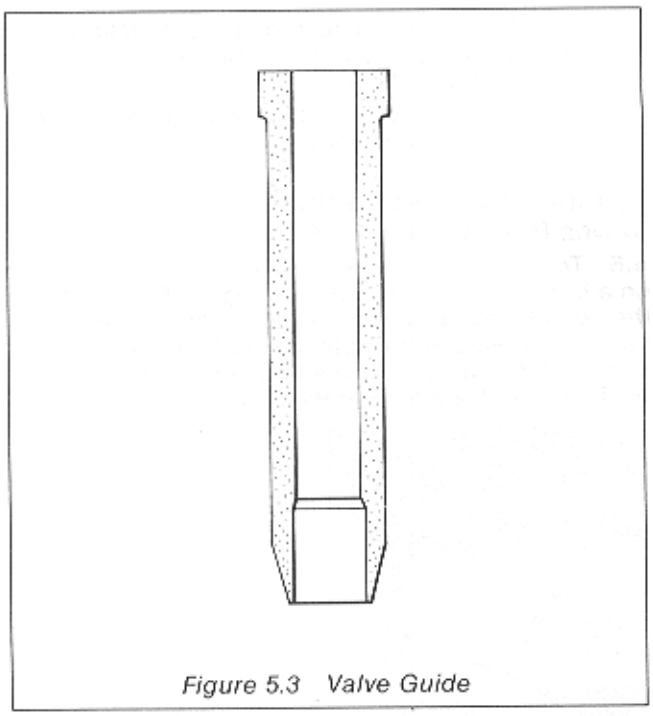


Figure 5.3 Valve Guide

Valves Grinding In

5.7 To grind in valves proceed as follows:

(1) Ensure that each valve is in its correct seat.

(2) Place a very small quantity of grinding paste evenly around the valve seat and insert the valve. 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 give it a half turn, thus ensuring that the grinding paste is evenly spread. It is unnecessary to continue grinding once the faces of the valve and its seating have a clean, even, matt-surfaced appearance. A polished surface must not be expected and is unnecessary.

(4) Wash out the ports thoroughly with kerosene making sure that all traces of grinding paste are removed from the valves and guides.

(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 seat.

Valve Seats

5.8 If the exhaust and inlet valve seats are badly pocketed and cutting the valve seats back with a valve seat cutter will exceed the flame face-to-valve head clearance of 0.7 mm to 1.05 mm (0.28 in. to 0.42 in.) it is advisable to fit valve inserts. Suitable valve seat inserts can be supplied and are fitted in the following manner:

(1) Strip the cylinder head and bore each valve port to the dimension shown in Figure 5.4. It is essential not to machine the head beyond the dimension shown, particularly in the case of the inlet port. This is specially shaped to create turbulence of the air entering the engine.

(2) Press the valve seat inserts into the cylinder head (chamfered end first).

(3) Machine the valve seats to the dimensions shown in Figure 5.4.

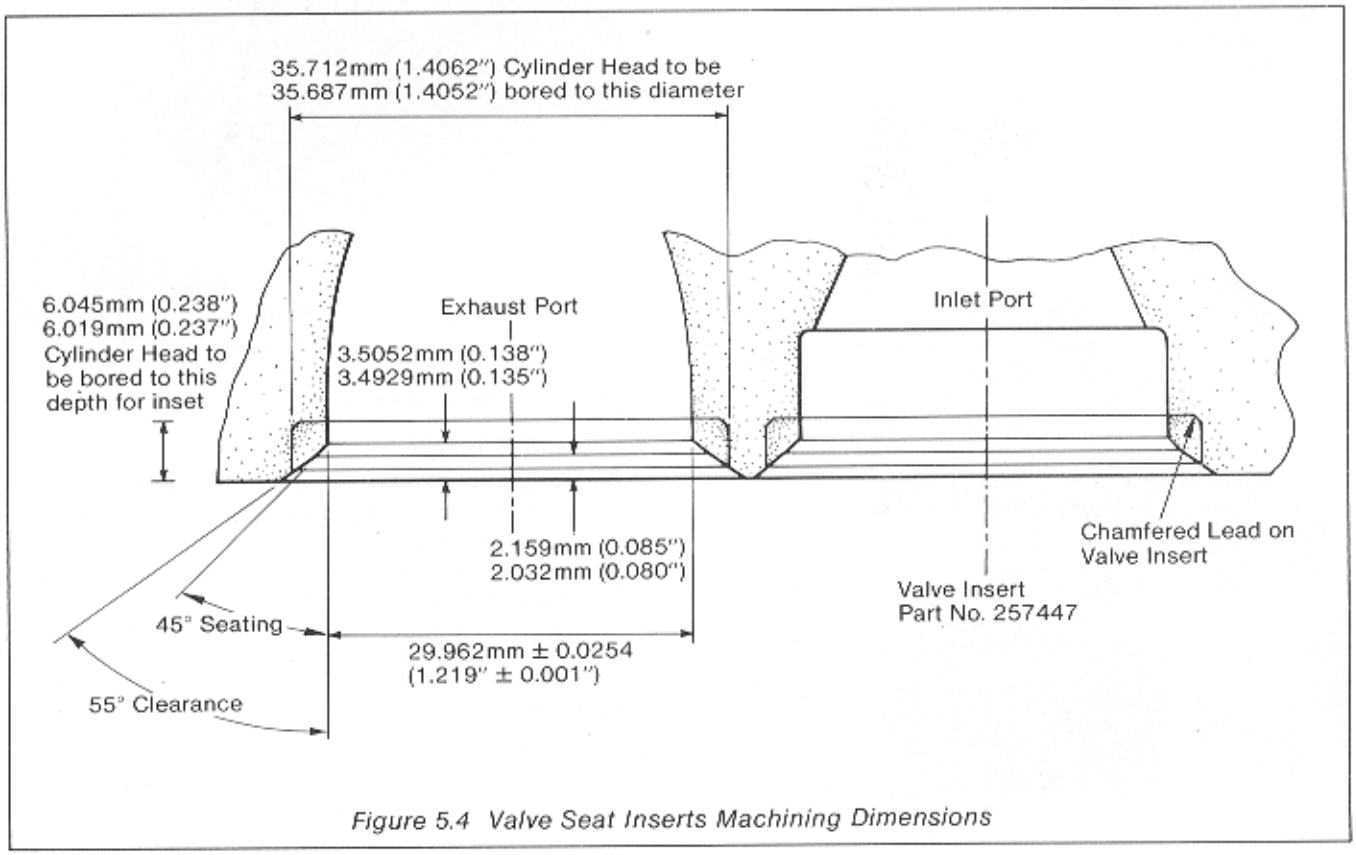


Figure 5.4 Valve Seat Inserts Machining Dimensions

Note

If any dirt or grit passes the air cleaner it will cause the inlet valve seat to wear excessively. Therefore, it is essential to maintain the air cleaner properly in order to keep valve seat wear at a minimum. This is especially important where the engine is working in dusty conditions.

Cylinder Head Assembly

5.9 To assemble the cylinder head proceed as follows:

(1) If new valves, guides, or valve seats are fitted the valves must be ground in according with the instructions given in Paragraph 5.7. Before assembling lightly oil the valve stems with engine lubricating oil. If using the original valves ensure that the exhaust valves and inlet valves are returned to their correct positions.

(2) Assemble the valve spring plate, inner and outer springs and valve cup to their appropriate valves.

(3) Depress the valve springs and fit the collets.

Rocker Box Assembly

5.10 To assemble the rocker box proceed as follows:

(1) Replace the rocker shaft.

(2) Insert the decompressor shaft and replace the pin and locknut.

(3) Fit the washers in the order noted in Paragraph 5.4(1). Ensure that the composite oil sealing washer is fitted next to the rocker box.

(4) Fit the decompressor shaft split pin.

Cylinder Head Replacement

Note

Fit a new gasket every time a cylinder head is removed.

5.11 To replace the cylinder head proceed as follows:

(1) Fit the cylinder head gasket, with TOP mark facing up. If the gasket is not marked the metal fold should face upwards. Fit the cylinder head.

(2) Replace the cylinder head nuts and tighten finger-tight. On two cylinder engines, ensure that the manifold bolting faces are square and parallel with each other. Check with a straight edge before tightening the cylinder head nuts as shown in Figure 5.5, or by bolting on the manifold.

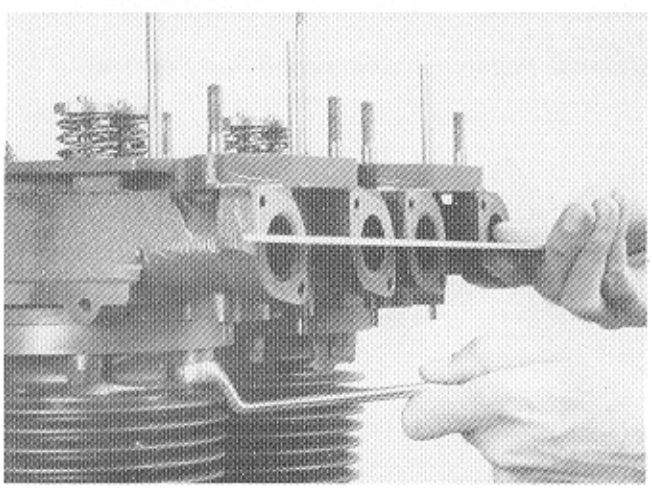


Figure 5.5 Checking Cylinder Head Alignment

(3) It is important that the cylinder head nuts are tightened in the correct sequence (Figure 5.6) and to the correct torque. Tighten down each cylinder head nut in turn a quarter of a turn working diagonally across the cylinder head. Tighten to a torque loading of 81 Nm (60 lbf ft.).

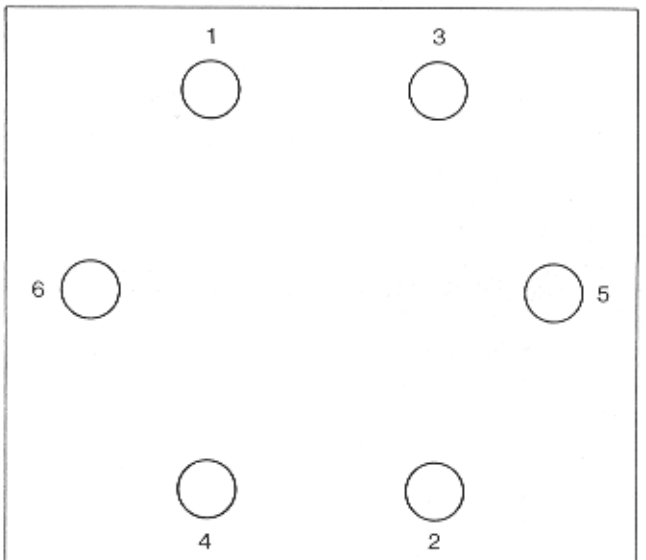


Figure 5.6
Cylinder Head Nut Tightening Sequence

(4) With reference to Figure 5.7 assemble the push rod tube assembly by ensuring that the stepped portion of the assembly is at the bottom and that the oil seals and the joint washer/'O' rings are in good condition and seating properly. Check that the push rod tube covers (where applicable) are fitted with the ends folded inwards to form a dust and oil tight seal.

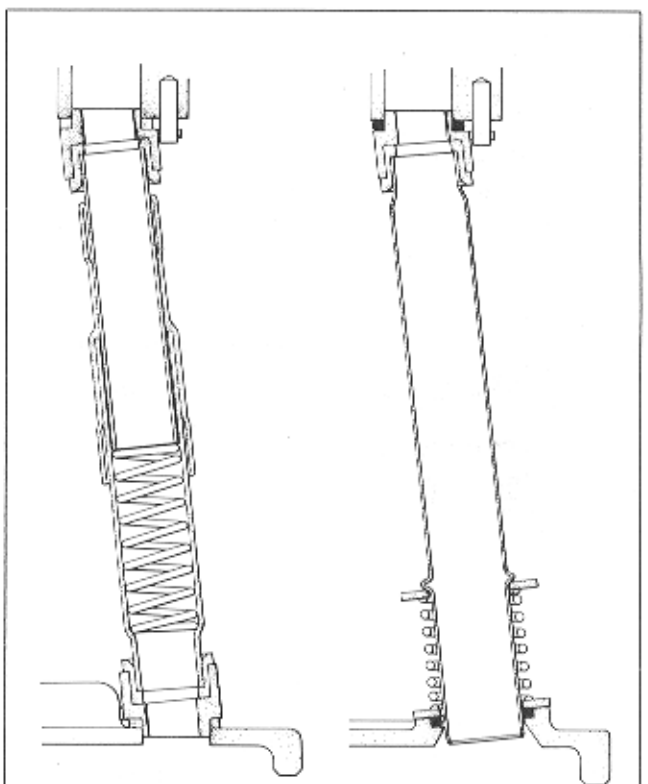


Figure 5.7 Push Rod Tubes (Both Types)

(5) Lightly lubricate the push rods and insert them in the noted positions.

(6) Fit the rocker box joint washer (renew if damaged).

(7) Fit the rocker box and secure with the four 5.16 in. BSF nuts and spring washers.

(8) Fit the restrictor valve (if fitted) and connect the oil pipe to the end of the rocker shaft.

(9) Fit the fuel injector (Section 3).

(10) Fit the inlet and exhaust manifolds.

Valve Rockers Adjustment (Figure 5.8)

5.12 Set up the valve rockers on each cylinder in turn as follows:

CAUTION

The cylinder head and rocker box nuts must be tightened down before rocker clearance is adjusted with the engine cold.

(1) Set the engine at TDC of the firing stroke (both valves closed).

Note

Due to the close confines of the rocker box a suitable feeler gauge as shown in Figure 5.8 should be used to set the valve clearances.

(2) Slacken the locknut and using a screwdriver set the rocker adjusting screw to give the correct valve clearance with a feeler gauge and when the correct setting of 0.10mm (0.004 in.) is obtained (cold) tighten the locknut.

(3) Recheck the clearance.

Setting the Decompressor Lever (Figure 5.8)

5.13 The exhaust valve must be lifted the correct amount by movement of the decompressor lever from the horizontal to the vertical position. To set the movement carry out the following procedure:

(1) Set the cylinder on compression stroke TDC.

(2) Set the decompressor lever to the vertical position.

(3) Slacken the decompressor pin locknut.

(4) Adjust the decompressor pin so that it just touches the valve rocker.

(5) Turn the pin a further half a turn in to lower the valve the required amount.

(6) Tighten the decompressor pin locknut.

CAUTION

The valve must not be lifted more than 0.63 mm (0.025 in.) or it will cause serious damage by hitting the piston.

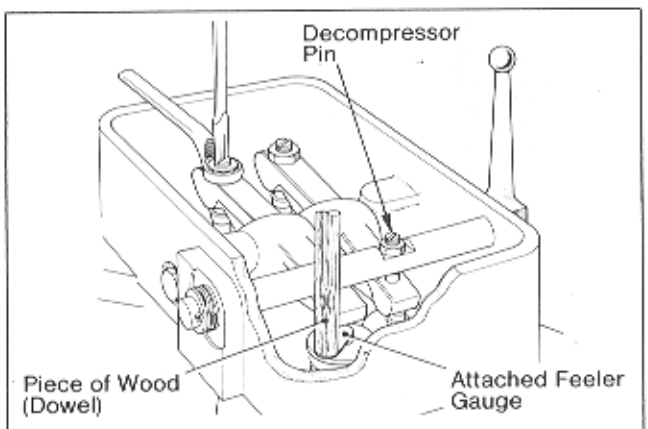


Figure 5.8 Setting the Valve Clearances

CYLINDER, PISTON AND CONNECTING ROD

Removal

5.14 Carry out the following procedure:

(1) Remove the cylinder head as detailed in Paragraph 5.3.

(2) Remove the crankcase inspection cover.

(3) If parallel connecting rods are fitted, lift the fuel pump lever and remove the fuel injection pump together with the pump bracket (six 5/16 in. bolts and spring washers).

(4) Set the piston in the TDC position.

(5) Note the position of the large end bearing caps, mated sides are numbered for identification.

(6) Remove the large end bolts (or bolts and nuts if applicable).

(7) Mark the cylinder and crankcase to ensure that the cylinder is fitted in its original position.

(8) Remove the six nuts securing the cylinder to the crankcase.

(9) Lift off the cylinder complete with piston and connecting rod. Ensure that the shims fitted between the cylinder and crankcase are not disturbed. These control the bumping clearance.

(10) Withdraw the piston and connecting rod assembly from the cylinder barrel.

(11) Using circlip pliers remove one of the gudgeon pin circlips.

(12) Remove the gudgeon pin. If the gudgeon pin is a tight fit soak the piston in hot water. After a few minutes the piston will have expanded sufficiently to allow the pin to be removed.

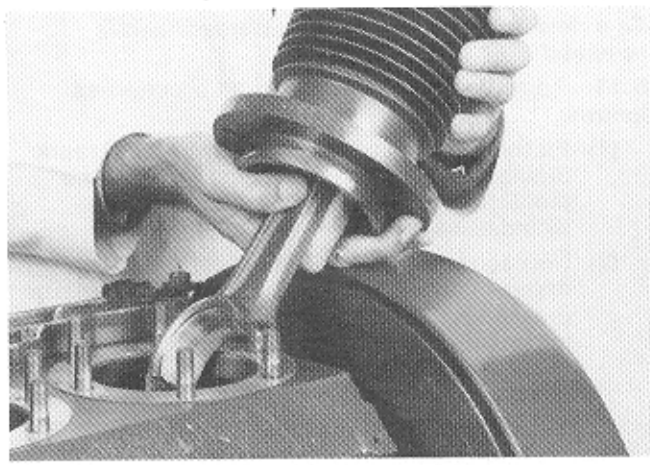


Figure 5.9
Cylinder, Piston and Connecting Rod Removal.

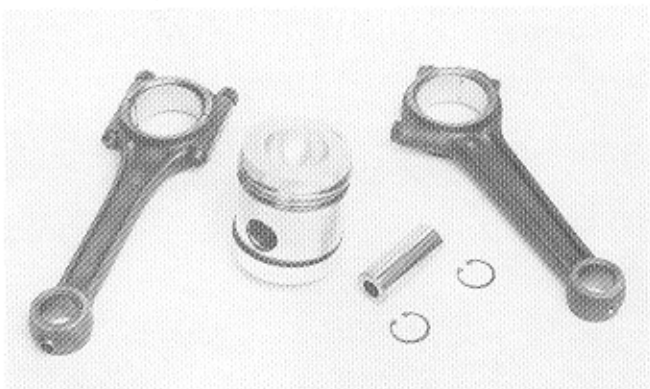


Figure 5.10 Piston and Connectng Rod (Both Types)

Cylinder Maintenance

5.15 Check the cylinder bore wear, if this has reached the maximum 0.25 mm (0.10 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.

TABLE 5.1 CYLINDER REBORING DIAMETERS

Cylinder	*Size*
Standard **1st Oversize 0.508 mm (0.020 in.)** **2nd Oversize 1.016 mm (0.040 in.)**	**87.465 to 87.491 mm (3.4435 to 3.445 in.)** **87..973 to 87.998 mm (3.4635 to 3.4545 in.)** **88.481 to 88.516 mm (3.4835 to 3.4845 in.)**

CAUTION
Cylinder barrels must not be rebored beyond the maximum oversize diameter 1.016 mm (0.040 in.) as recommended by Petters Limited. Sleeves must also not be fitted. These practices could result in cylinder base fracture. Any cylinder worn beyond the maximum limit must be replaced.

Piston Maintenance

5.16 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 scraper ring grooves 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 1.52 mm (0.060 in.). If necessary the rings must be renewed.

(4) Assemble the rings on the piston in the correct order with the correct face uppermost.

CAUTION
Ensure that the scraper ring is fitted with the chamfered side uppermost as shown in Figure 5.12.

(5) Rings should not be slack or stuck fast in the groove.

(6) When the engine has been fully run in, the bore will have a highly polished and very hard surface. It 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
To allow the piston rings to bed in satisfactory carry out the initial running procedure:

(1) Run for 2 minutes with no load.
(2) Run for 10 minutes at half load.
(3) Run for a further minimum of 8 hours or longer on full load.

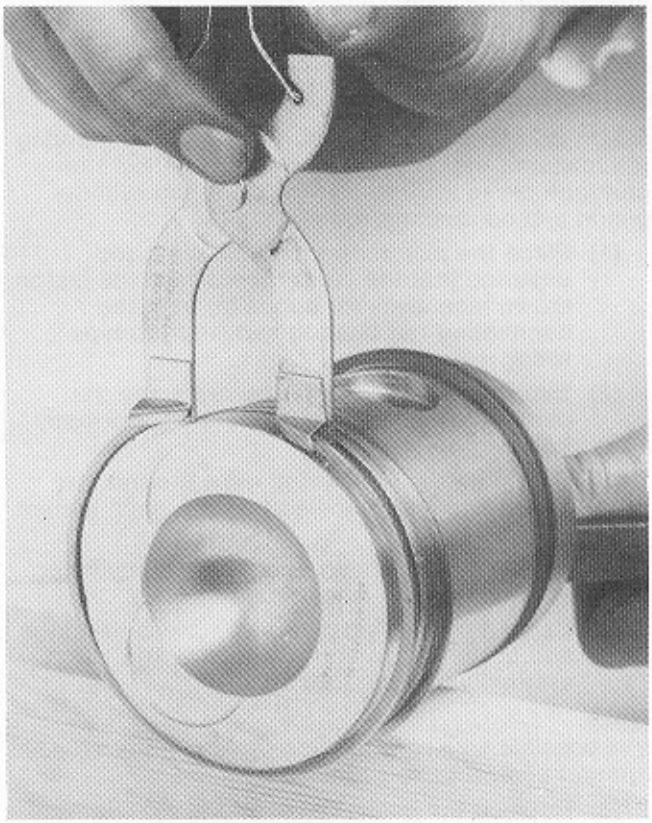


Figure 5.11 Piston Ring removal

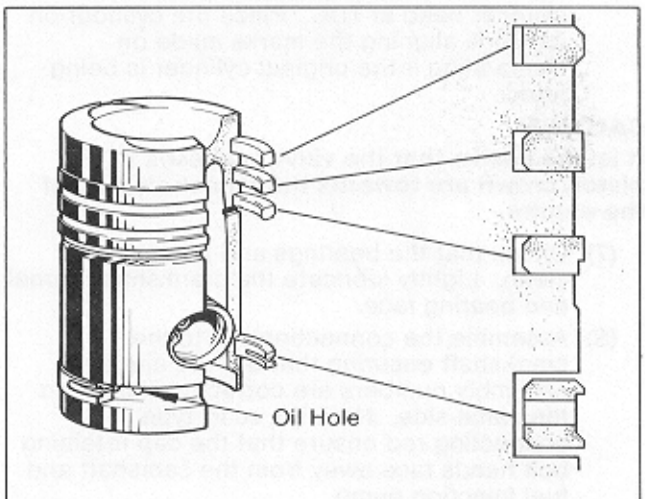


Figure 5.12 Piston Rings Arrangement

Connecting Rod Maintenance

Small End Bush

5.17 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.

Large End Bearings

5.18 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 connecting 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 numbers are correctly assembled and on the same side.

5.19 Undersize bearings are obtainable from Petters Limited or their representatives.

Replacement

5.20 Before fitting the piston on to the connecting rod immerse the piston in hot water to allow the gudgeon pin to slide freely. Replace the cylinder, piston and connecting rod as follows:

(1) Place the piston on the connecting rod ensuring that the valve recesses in the piston crown face away (or opposite) from the connecting rod bearing cap (scarfed type rods).

(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.

Note

It is possible with care to slide the piston into the cylinder compressing the rings by hand.

(6) Replace the shims between the cylinder and crankcase. These shims control the bumping clearance between the piston and the cylinder head at TDC. Place the cylinder on its studs aligning the marks made on dismantling if the original cylinder is being fitted.

CAUTION

It is imperative that the valve recesses in the piston crown are towards the camshaft side of the engine.

(7) Check that the bearings and journal are clean. Lightly lubricate the crankshaft journal and bearing face.

(8) Assemble the connecting rod to the crankshaft ensuring that the rod and cap assembly numbers are correctly aligned on the same side. Note if a scarf type connecting rod ensure that the cap retaining bolt heads face away from the camshaft and fuel injection pump.

(9) Tighten the bolts or nuts to a torque of 77 Nm (57 lbf ft).

(10) Tighten the six cylinder base nuts diagonally and evenly and torque load to 81 Nm (60 lbf ft).

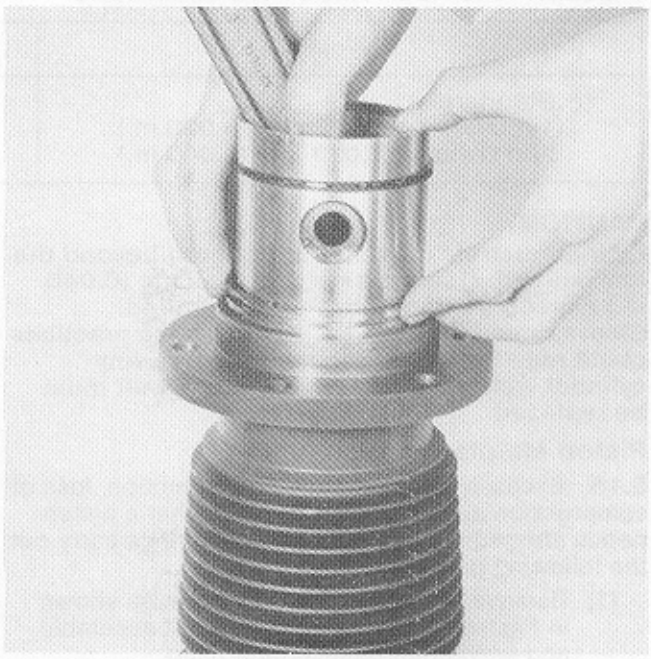


Figure 5.13 Piston Fitting Into Cylinder

Bumping Clearance (Figure 5.14)

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 lead wire on top of the piston as shown.

(3) Replace the cylinder head (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. It should be 0.91 to 1.017 mm (0.036 to 0.042 in.) for an average of the three readings. If necessary adjust the clearance by re-shimming. (Paragraph 5.20(6)).

(5) Replace the cylinder head as detailed in Paragraph 5.10.

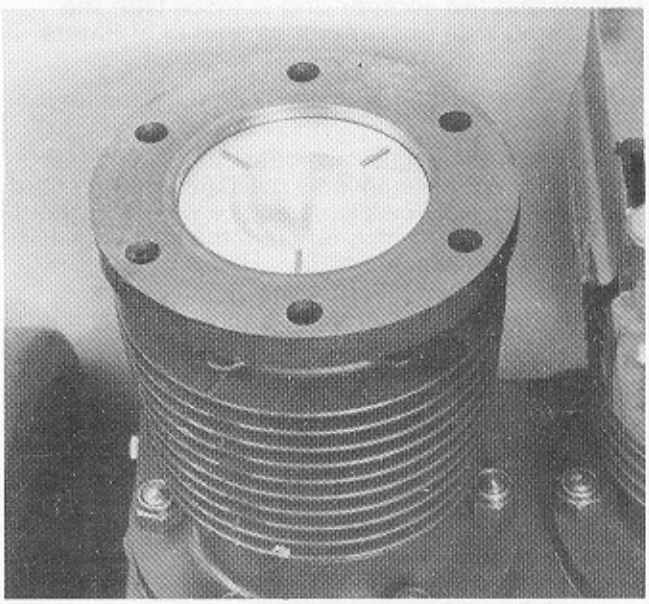


Figure 5.14 Bumping Clearance

FLYWHEEL

Removal

5.22 Withdraw the flywheel key with a tapered key drift (Figure 5.15) or special extractor (Figure 5.16), both of which are obtainable from Petter Limited or their representatives. It is advisable to support the head of the key by placing a spacer in the key way of the reduced portion of the crankshaft during removal. This stops the key from bending and digging into the crankshaft on removal.

5.23 In some instances it may be found that the flywheel is tight on the crankshaft due to dirt or corrosion. Clean the exposed portion of the crankshaft and lubricate with penetrating oil. Position a block of wood through the crankcase in such a manner so that the crankshaft will only partially turn. Turn the flywheel sharply in either direction so that the crankshaft strikes the wood block. The inertia of the flywheel will break its hold on the shaft allowing removal in a screw like manner.

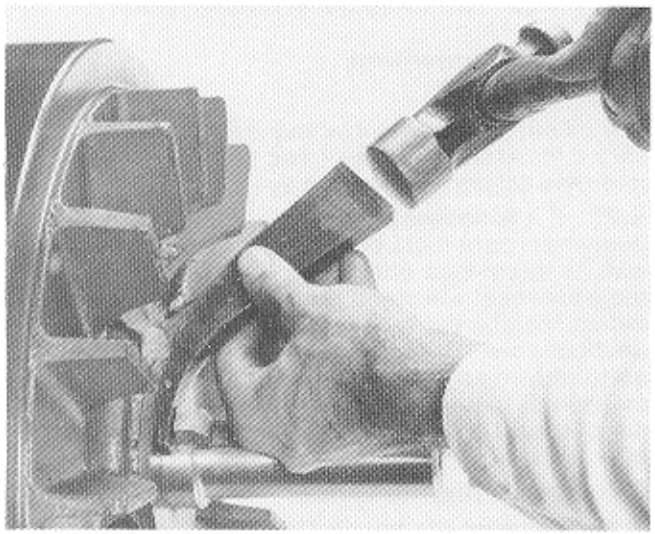


Figure 5.15
Removal of Flywheel Key using a Tapered Key Drift

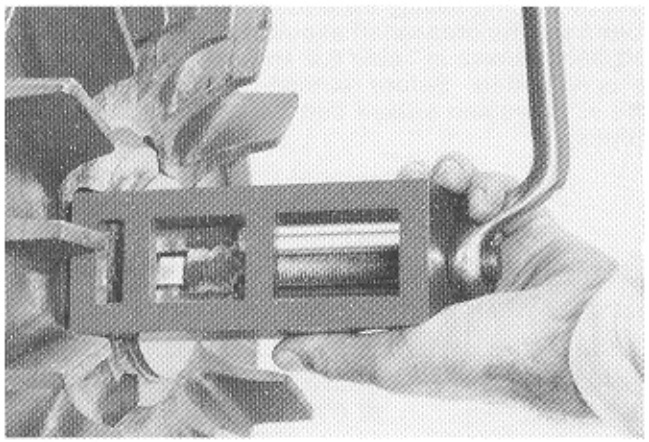


Figure 5.16
Removal of Flywheel Key using Special Extractor

Replacement

5.24 Apply a small quantity of grease or oil to the crankshaft and push the flywheel on the shaft. Ensure that the flywheel is fully up to the shoulder on the crankshaft.

5.25 Note when fitting the flywheel a new key must be used and should be fitted as follows.

(1) File a chamfer on all four corners of the key to prevent any possibility of the corners binding in the keyways corners.

(2) Push the key by hand as far as possible into the keyway. Measure the distance between the flywheel boss and keyhead, as shown in Figure 5.17, this should be 23.8 mm (15/16 in.). If it is more, remove metal from the bottom of the key to obtain this measurement.

CAUTION

Do not remove metal from the tapered surface of the key.

(3) Knock the key further into the flywheel until a measurement of 11.1 mm (7/16 in.) is attained between the flywheel boss and the keyhead.

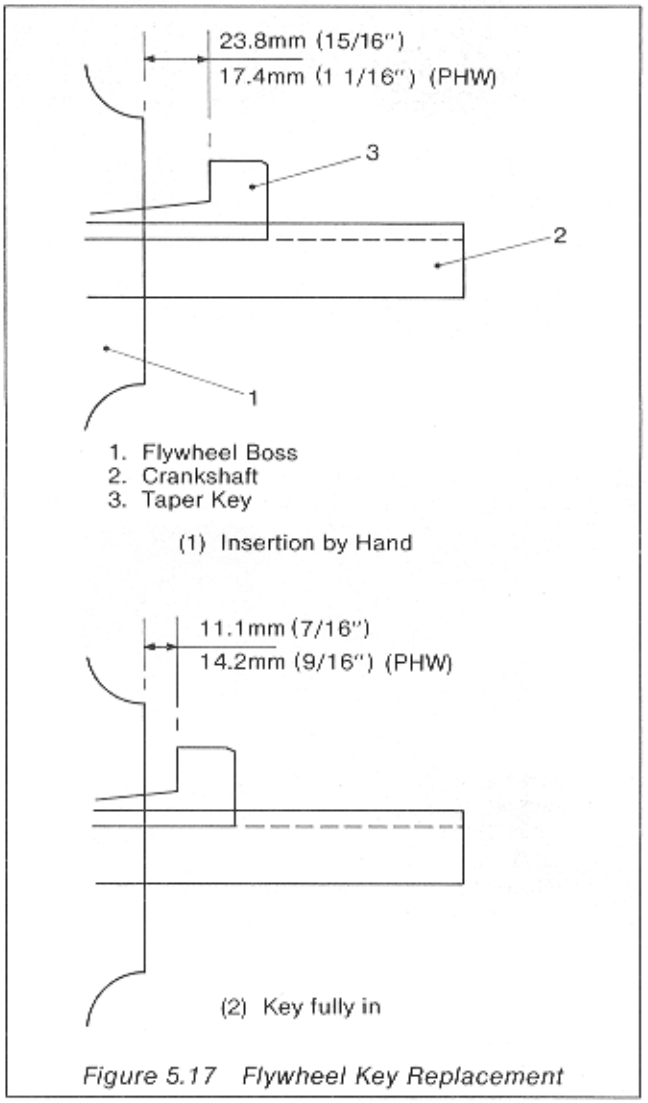


Figure 5.17 Flywheel Key Replacement

CRANKSHAFT

Removal

5.26 To remove the crankshaft proceed as follows:

(1) Remove the cylinder head (Paragraph 5.3), cylinder and connecting rod (paragraph 5.14).

(2) Remove the flywheel (Paragraph 5.22).

(3) Remove the gear cover. The gear cover is dowelled to the crankcase.

(4) Remove the bolt and gearwheel retaining plate from the gear end of the crankshaft. Replace the bolt in the end of the crankshaft to prevent damage to the threads; withdraw the gearwheel using an extractor. (Figure 5.16). A special tool for this purpose can be obtained from Petters Limited or their representatives.

(5) On the PH2 engine remove the intermediate main bearing housing locking screw (Figure 5.19) holding the housing in position.

(6) Mark the balance weights to identify the assembly positions. Unscrew the bolts and remove the balance weights and washers.

(7) Remove the bolts securing the flywheel end main bearing housing, and withdraw the housing.

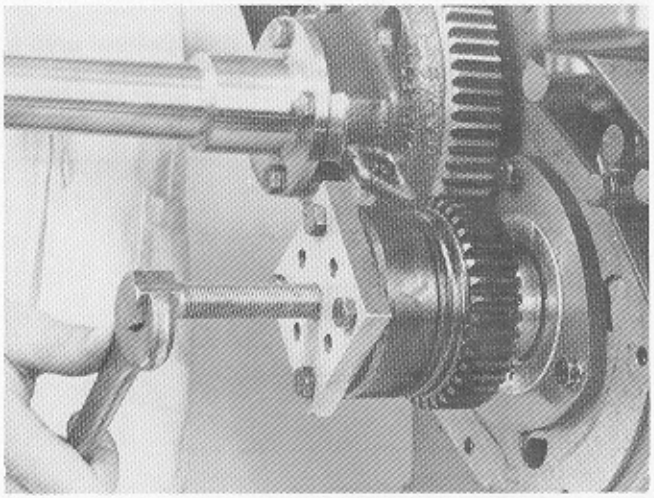


Figure 5.18
Withdrawing the Gearwheel using an Extractor

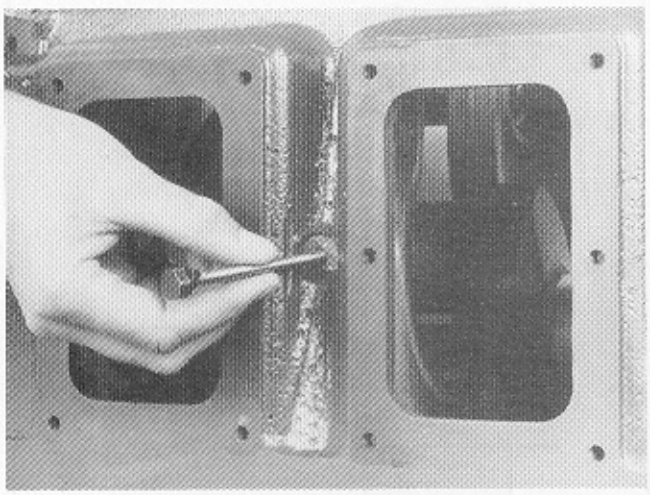


Figure 5.19 Removing the Intermediate Bearing Housing Locking Screw (PH2)

(8) Remove the crankshaft by pulling towards the flywheel end.

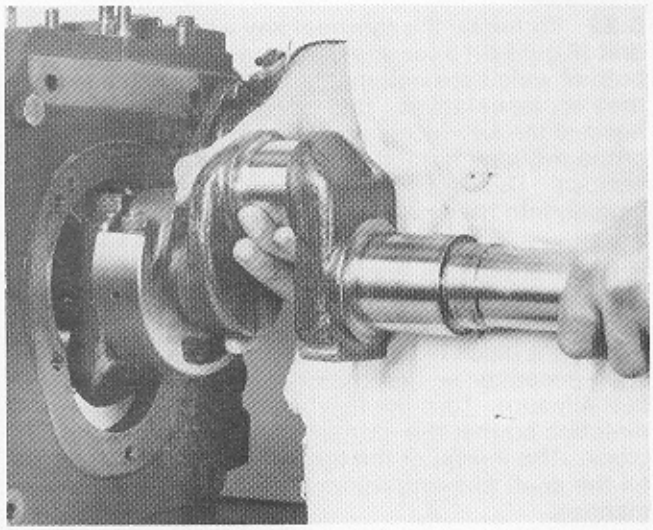


Figure 5.20 Removing the PH2 Crankshaft

Oil Pump Gearwheel

Note

The oil pump gearwheel (where applicable) is a shrink fit on the crankshaft and should not be removed unless worn or damaged.

5.27 If it is necessary to renew the oil pump gearwheel care must be taken to fit the gearwheel with its thrust face outermost. If fitted incorrectly the gearwheel will stand proud of the crankshaft radius, making the crankshaft endfloat unobtainable. The gearwheel should be heated preferably in an oil bath before fitting to the crankshaft. If using any other method of heating do not overheat or the gearwheel's hardness may be effected.

Crankshaft Maintenance

5.28 Examine the bearing journals and crankpins for scoremarks and ovality. The ovality should not exceed the maximum of 0.08 mm (0.003 in.) If the journals or the ovality exceeds the maximum tolerance the crankshaft should be reground to the diameter shown in Table 5.2 and undersize bearings fitted. Before refitting carefully clean out the oil holes and ensure that they have radiused edges.

TABLE 5.2 CRANKSHAFT REGRINDING DIAMETERS

Crankshaft	*Main Journal*	*Crankpin and Intermediate Journal*
Standard	**60.287 to 60.274 mm (2.3735 to 2.3730 in.)**	**63.325 to 60.312 mm (2.3750 to 2.3745 in.)**
Undersize 0.254 mm (0.010 in.)	**60.031 to 60.020 mm (2.3635 to 2.3630 in.)**	**60.071 to 60.058 mm (2.3630 to 2.3645 in.)**
Undersize 0.508 mm (0.020 in.)	**59.779 to 59.766 mm (2.3535 to 2.3530 in.)**	**59.817 to 59.804 mm (2.3550 to 2.3545 in.)**
Undersize 0.762 mm (0.030 in.)	**59.525 to 59.512 mm (2.3435 to 2.3430 in.)**	**59.563 to 59.550 mm (2.3450 to 2.3445 in.)**
Undersize 1.016 mm (0.40 in.)	**59.271 to 59.285 mm 2.3335 to 2.3330 in.)**	**59.309 to 59.296 mm (2.3350 to 2.3345 in.)**

Main Bearing Maintenance

5.29 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.

5.30 When replacing a bearing ensure that it enters the bearing housing or crankcase squarely and that the oil holes in the bearing and the housing are in line. Check that the bearing split is slightly above the horizontal.

5.31 Note that 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.

5.32 Ensure that the bearing bush at the gear end protrudes between 1.27 to 1.52 mm (0.05 to 0.06 in.) as shown in Figure 5.21(1). This assists in the correct positioning of the outer thrust washer when the crankshaft gearwheel is fitted. Do not exceed the maximum protrusion.

CAUTION

Excess protrusion can affect crankshaft end float.

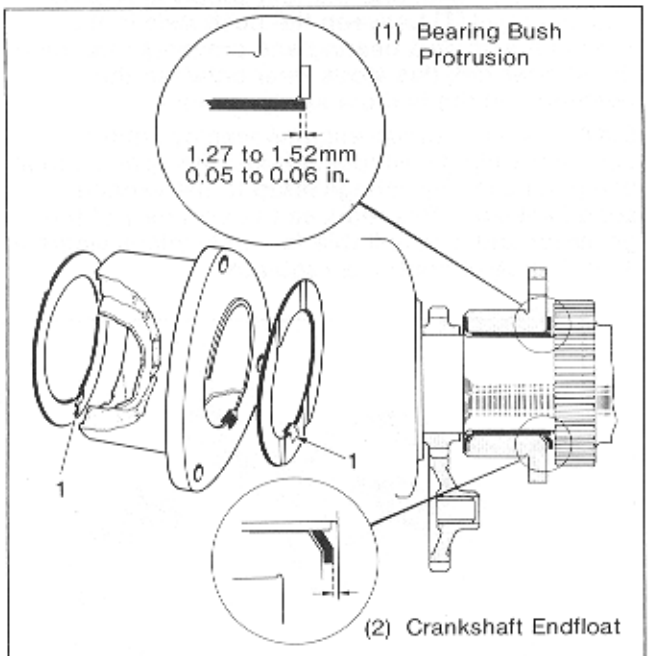


Figure 5.21 Bearing and Thrust Washer Assembly

Flywheel End Oilseal

5.33 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.

Replacement

5.34 To replace the crankshaft carry out the following procedure:

(1) Fit timing cover backplate (if removed).

(2) Fit the gear end main bearing housing making sure the oil hole is in line with the oil hole in the crankcase. This is simplified by aligning the small cut-away on the bearing housings outer flange with the raised dimple on the timing cover back plate.

(3) Fit the crankshaft thrust washer making sure that the grooved sides are away from the bearing housing and their tongues located in their respective grooves Figure 5.21 (1). Place a light smear of grease on the back of the thrust washer to hold it in position.

(4) Check that the crankshaft journal bearing surfaces and oil holes are clean. Place a small quantity of lubricating oil in the gear end bearing and on the crankshaft journal and insert the crankshaft. Take care not to damage the bearing surface whilst entering the shaft. On the PH2 engine ensure that the intermediate main bearing housing is correctly assembled on the crankshaft with the side marked TOP towards the flywheel end.

(5) Apply a small quantity of lubricating oil to the flywheel end main bearing and crankshaft journal and fit the main bearing housing assembly. Fit an oil seal sleeve to avoid damage to the oil seal when entering over the crankshaft. Tighten down the five securing bolts diagonally.

(6) With a SAE5 bellhousing fitted, ensure that the oil seal and its bearing face are serviceable. Fit a new gearwheel retaining plate seal and a new sealing washer to the retaining plate bolt.

(7) Replace the balance weights in their original positions as noted in Paragraph 5.24(6) and torque load the weight securing bolts to 159Nm (117 lbf ft.) for PH1 and 267Nm (197 lbf ft.) for PH2. If new weights are fitted they must be balanced to within 7g (0.25 oz) for PH1 and 14g (0.5 oz) for PH2.

(8) Fit the intermediate main bearing housing locking screw on the PH2 engine and tighten down.

Fitting the Crankshaft Gear

5.35 The crankshaft gear is a 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.

5.36 It is important that the crankshaft is held firmly against the inner thrust washer during the fitting of the gear.

CAUTION

Under no circumstances should a wedge be used to hold the crankshaft. Failure to observe this caution may cause extensive damage to the crankshaft, balance weights and crankcase.

5.37 The crankshaft can be held in position by a hard wood block supported by additional weight as required. After fitting the gearwheel check that the thrust washer is still in position by rotating the crankshaft by hand. Fit the gearwheel retaining plate and securing bolt.

Crankshaft Endfloat

5.38 Using a set of feeler gauges check the crankshaft endfloat by measuring between the thrust washer and inner face of the gear as shown in Figure 5.21(2). The endfloat should not exceed 0.63 mm (0.025 in.). The endfloat when new should be 0.20 to 0.050 mm (0.008 to 0.020 in.).

CAMSHAFT (Figure 5.22)

Removal

5.39 To remove the camshaft carry out the following:

(1) Remove the gear cover. The gear cover is dowelled to the crankcase.

(2) Disconnect the fuel pipes and remove the fuel pump bracket assembly (Section 2).

(3) Remove the rocker box, push rod and tubes (Paragraph 5.3).

(4) Wind a rubber band or piece of string **(1)** around the shanks of the valve tappets to prevent their falling into the sump when the camshaft is withdrawn.

(5) A camshaft thrustplate **(2)** is located between the camshaft gearwheel and the crankcase, with two vertical slots for holding screws **(3).** Slacken these screws which are accessible through holes in the gearwheel and thrust plate will drop about 13 mm (0.5 in.).

(6) Withdraw the camshaft assembly which includes the governor, from the gear end of the engine.

(7) When an SAE5 bellhousing is fitted, the crankshaft gearwheel and oil thrower assembly must be removed before withdrawing the camshaft.

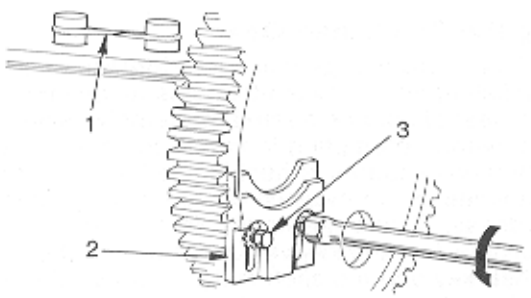


Figure 5.22 Camshaft Removal

Governor (Figure 5.23)

5.40 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 weights housed in the camshaft gearwheel which, with the application of centrifugal force operates a push rod located within the hollow camshaft. The movement of the push rod is transmitted via a fulcrum arm to the fuel pump(s) where it controls the amount of fuel delivered to the fuel injectors which in turn controls the engine speed. The push rod is in two parts separated by a steel ball.

Operation

5.41 As the camshaft and consequently the governor weights **(1)** rotate, centrifugal force causes the weights to be thrown outwards pivoting about their retaining pins **(2).** The heel of the weights move the push rods **(3)** which in turn move the fulcrum arm **(4)** mounted on the crankcase at the rear of the camshaft. The fulcrum arm moves the fuel pump(s) rack(s) thus controlling the fuel.

5.42 The centrifugal forces acting on the governor weights are balanced by three springs, two **(5)** are fitted to the weights (governor weight springs) and are fixed and the third **(6)** (speeder spring) which is adjustable is fitted to the fuel pump rack extension. 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 varying the speeder spring and in some cases fitting different tension springs on the governor weights. Petters Limited or their representatives should be consulted if this is required.

5.43 Initially the springs bring the fuel pump rack(s) into the starting position, that is maximum fuel, and as the engine starts and runs up to speed a balance position between the centrifugal force of the governor weights and the springs is achieved and the fuel supplied holds the engine at a steady speed. An increase in load will reduce speed and consequently the centrifugal force of the weights and thus the spring pressure opens the fuel pump rack further to increase fuel. The engine speed recovers and a balance of forces is again achieved. Conversely if the load is removed the opposite action takes place and the fuel supply is reduced. The steel ball **(7)** between the push rods in the camshaft acts as a bearing and prevents rotation of the shorter rod, this stops wear between the pushrod and the fulcrum arm inner face.

5.44 Variable speed engines employ lighter governor weights without springs, the spring action being supplied by springs fitted to the variable speed linkage. This reduces the accuracy of the governor and is unsuitable for applications where a high degree of control is required.

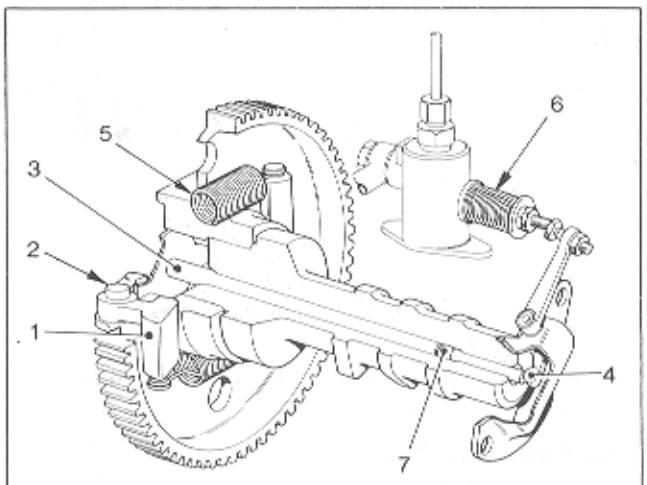


Figure 5.23 Engine Governing System

Camshaft and Governor Maintenance

5.45 Examine the cam faces, if worn or damaged it is necessary to fit a new camshaft. Any damage to the camshaft gearwheel will also necessitate fitting a new camshaft as the gearwheel is shrunk on the camshaft and cannot be removed.

5.46 Remove the governor push rods, the push rod at the flywheel end can be easily withdrawn but at the flywheel end it is necessary to remove the governor weights. The push rods are separated by a steel ball. Clean the push rods and the hole

through the camshaft with kerosene. Since any stickiness of the push rods will affect the speed control.

5.47 Assemble the governor by replacing the steel ball and long push rod in the camshaft. Fit the governor weights using new pins (Figure 5.23).

Note

The governor weights are fitted in pairs and are balanced within 1g (0.035 oz).

5.48 Ensure that the contact surfaces of the fuel pump rack operating lever adjusting screw and fuel pump rack extension are smooth and lubricated.

5.49 Examine the governor fulcrum lever assembly. Check that the internal lever face is not worn and the down shaft freely swivels in its body.

Note

Excessive wear on the down shaft or body will cause oil leakage.

5.50 Check the camshaft bush for wear or damage and if necessary to renew the bush ensure that it does not protrude beyond the timing cover backplate.

Note

There is no bush on the flywheel end bearing journal.

Replacement

5.51 To replace the camshaft proceed as follows:

(1) Ensure that all bearing surfaces are clean and lubricated before inserting the camshaft and governor assembly.

(2) Fit the valve tappets and hold in position using a rubber band or string (Figure 5.22).

(3) Fit the camshaft making sure that the marked teeth on the gearwheels are in their relative positions as shown in Figure 5.24.

(4) With the shaft in position lift up the thrust plate as shown in Figure 5.25, ensuring that the upper edge of the thrust plate locates in the machined groove in the camshaft. Tighten the two holding screws which are accessible through holes in the gearwheel.

(5) Check the camshaft end float is 0.10 to 0.38 mm (0.004 to 0.015 in.). The measurement is checked by inserting a feeler gauge between boss and thrust plate, as shown in Figure 5.26.

(6) Fit the timing cover locating it on the aligning dowels.

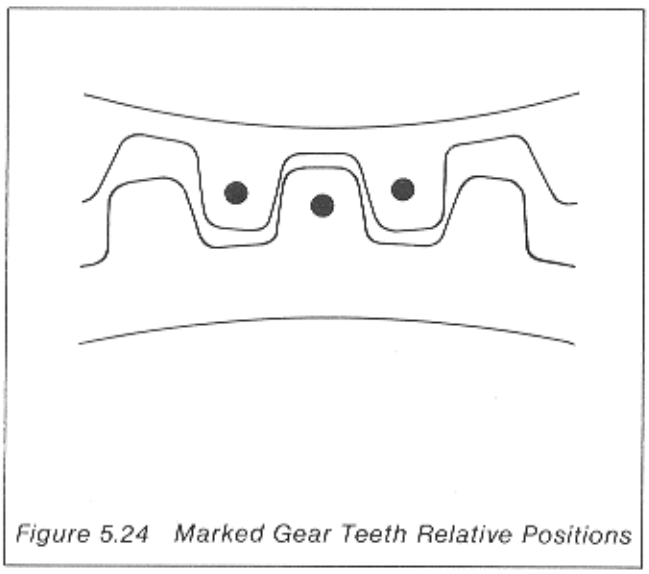


Figure 5.24 Marked Gear Teeth Relative Positions

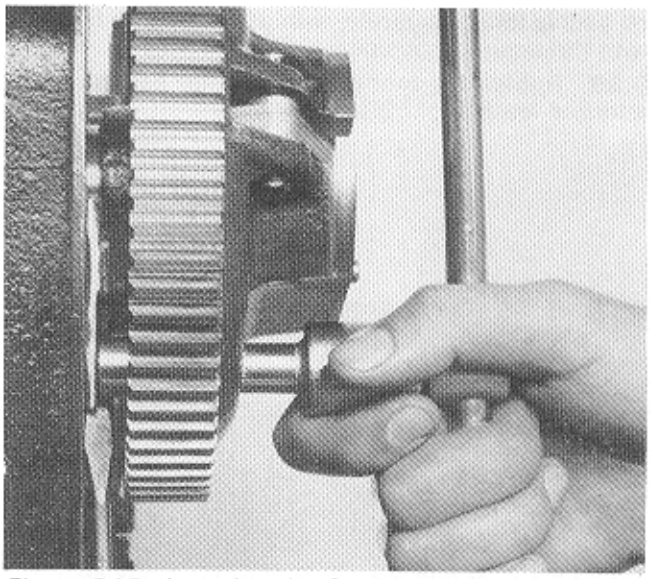


Figure 5.25 Locating the Camshaft Thrustplate

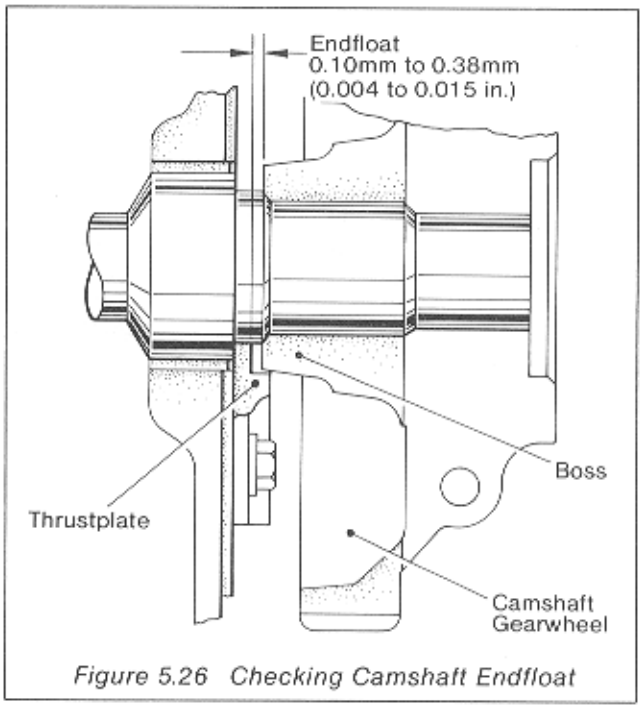


Figure 5.26 Checking Camshaft Endfloat

Extension Shaft Bearing Maintenance

5.52 Should it be necessary to renew the extension shaft support bearing it is recommended that the bearing housing be placed in a container of boiling water for five minutes. This will enable easier removal or replacement of the bearing.

5.53 A suitable mandrel must be used to press or drive the bearing out of its housing. Before fitting a new bearing ensure that the housing oil hole is clean and that the surface around the part numbers stamped on the bearing outer face is not raised, if so this should be removed before fitment.

5.54 When replacing the bearing ensure that it enters the bearing housing squarely, that the oil holes in the bearing and housing are in line. New bearings are machined to the required fit and should not be scraped.

5.55 When fitting the housing assembly over the extension shaft it is advisable to use an oil seal protection sleeve as shown in Figure 5.27. This prevents damage to the oil seal lip. A special tool for this purpose can be obtained from Petters Limited or their representatives. Make sure that the

oil seal is fitting squarely, with its outer face flush with the bearing housing.

5.56 Tighten the four extension shaft setscrews to a torque loading of 32Nm (27 lbf ft).

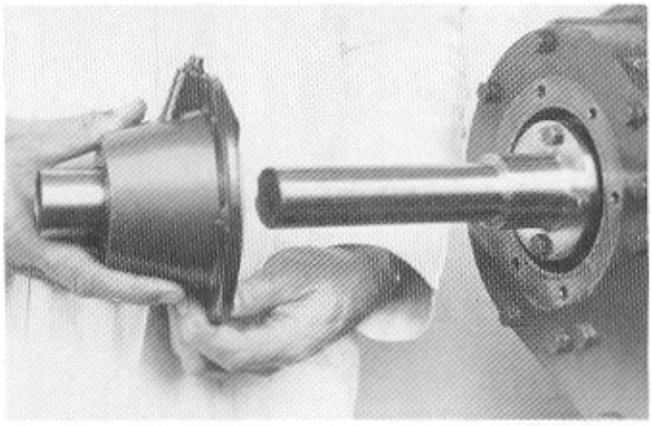


Figure 5.27 Fitting the Oil Seal using a Sleeve

SECTION 6
COMMON VARIANTS AND ACCESSORIES

CLUTCH

Introduction

6.1 All the Petter clutches used on PH engines are multiple-plate, hand-operated and fitted to the gear end of the engine, that is the opposite end to the flywheel. The clutch consists of a number of metal plates sandwiched together, enclosed in an oil filled housing. Alternate plates are driven by the engine and the intermediate plates are connected to the drive shaft. The plates are held together when engaged and the friction between the plates transmits the drive.

6.2 The clutch is initially set by Petters Limited but adjustment may be necessary after a running-in period, dependant on the frequency of operation, or when slip is indicated by a reduced resistance to the movement of the operating lever from the disengaged position. The clutch is lubricated by engine oil fed via an external pipe and a restrictor. The restrictor is painted red and is located in a banjo bolt mounted in the top of the clutch housing.

Adjustment (Figure 6.1)

6.3 To adjust the clutch proceed as follows:

(1) Remove the four 5/16 in. B.S.F. bolts and spring washers securing the clutch housing cover **(1)**. Remove the housing cover and joint washer **(2).**

(2) Slacken the locknut on the adjusting ring grubscrew **(3).**

(3) Using a tommy bar turn the adjusting ring **(4)** until the operating lever **(5)** can be pushed into the fully engaged position without undue strain.

CAUTION

Do not over adjust as this may cause damage

(4) Tighten the grubscrew and locknut.

(5) Fit the cover joint washer and housing cover.

Oil Flow Adjustment

6.4 To adjust the oil flow to the clutch proceed as follows:

(1) Locate the red painted restrictor on the top of the clutch housing.

(2) Slacken the restrictor locknut and screw the restrictor fully in.

(3) Screw the restrictor out a quarter of a turn.

(4) Tighten the locknut taking care not to move the restrictor.

Removal (Figure 6.1)

6.5 To remove the clutch proceed as follows:

(1) Set the clutch operating lever to the disengaged position.

(2) Disconnect the oil pipe by removing the restrictor assembly banjo bolt.

(3) Remove the eight 5/16 in. B.S.F. bolts securing the clutch housing to the engine gear cover and withdraw the clutch assembly.

(4) Remove the lead seals and the four 5/16 in. B.S.F. cap screws securing the driving flange (6). Withdraw the driving flange.

(5) Remove the clutch spigot plate **(7)** from the engine gear cover.

Dismantling (Figure 6.1)

6.6 To dismantle the clutch proceed as follows:

(1) Remove the four 5/16 in. B.S.F. bolts and spring washers and remove the clutch housing cover **(1)** and joint washer.

(2) Remove the two 1/4 in. B.S.F. pinch bolts **(9)** from the clutch yoke **(10).** Withdraw the operating lever and yoke shaft, leaving the yoke in the housing.

(3) Remove the five 3/8 in. B.S.F. bolts and spring washers securing the oil seal housing **(11).** Remove the oil seal housing and joint washer **(12).**

(4) Remove the external circlip **(13).**

(5) Carefully push out the clutch shaft and plate assembly from the driving end. Remove the circlip from the clutch shaft.

(6) Slacken the adjusting ring grubscrew locknut and loosen the grubscrew.

(7) Screw the adjusting ring towards the driving end of the shaft until the sliding sleeve **(14)** can be removed.

(8) Remove the sliding sleeve and thrust ring assembly **(15).**

(9) Remove the adjusting ring.

(10) Remove the clutch plates noting the order of assembly.

Assembly (Figure 6.1)

6.7 To assemble the clutch proceed as follows:

(1) Fit the clutch plates in the order as noted in Paragraph 6.5.

(2) Fit the adjusting ring by just screwing on the shaft sufficiently to allow the toggles **(18)** to engage the sliding sleeve. Fit the sliding sleeve and thrust ring assembly and tighten the adjusting ring. Note if the two halves of the thrust ring have been separated assemble the halves with the serial numbers on the same side. The halves of each thrust ring are machined as a pair and must not be interchanged with a part of another assembly.

(3) Replace the clutch yoke on the thrust ring ensuring that the pinch bolt bosses face away from the ball bearing. Fit the circlip.

(4) Insert the clutch shaft and plate assembly into the clutch housing bearing.

(5) Fit the external circlip **(13).**

(6) Fit the oil seal housing **(11)** and joint washer **(12)** taking care not to damage the seal.

(7) Fit the operating lever and yoke shaft with key to the housing and yoke.

(8) Fit the two 1/4 in. B.S.F. pinch bolts and locking tabwasher **(17).** Tighten the bolts and bend up the tab washers to lock the bolts.

Replacement (Figure 6.1)

6.8 To fit the clutch to the engine proceed as follows:

(1) Fit the clutch spigot plate **(7)** to the engine gear cover **(8)** using four 5/16 in. B.S.F. screws. These counter-sunk screws must be screwed tight and centre-popped for locking purposes.

(2) Fit the driving flange using the four 5/16 in. B.S.F. cap screws. Lock using lead seals.
(3) Fit the clutch housing to the engine gear cover using the eight 5/16 in. B.S.F. bolts.
(4) Connect the oil pipe to the clutch housing.
(5) Adjust the oil flow as detailed in Paragraph 6.4.
(6) Adjust the clutch as detailed in Paragraph 6.3

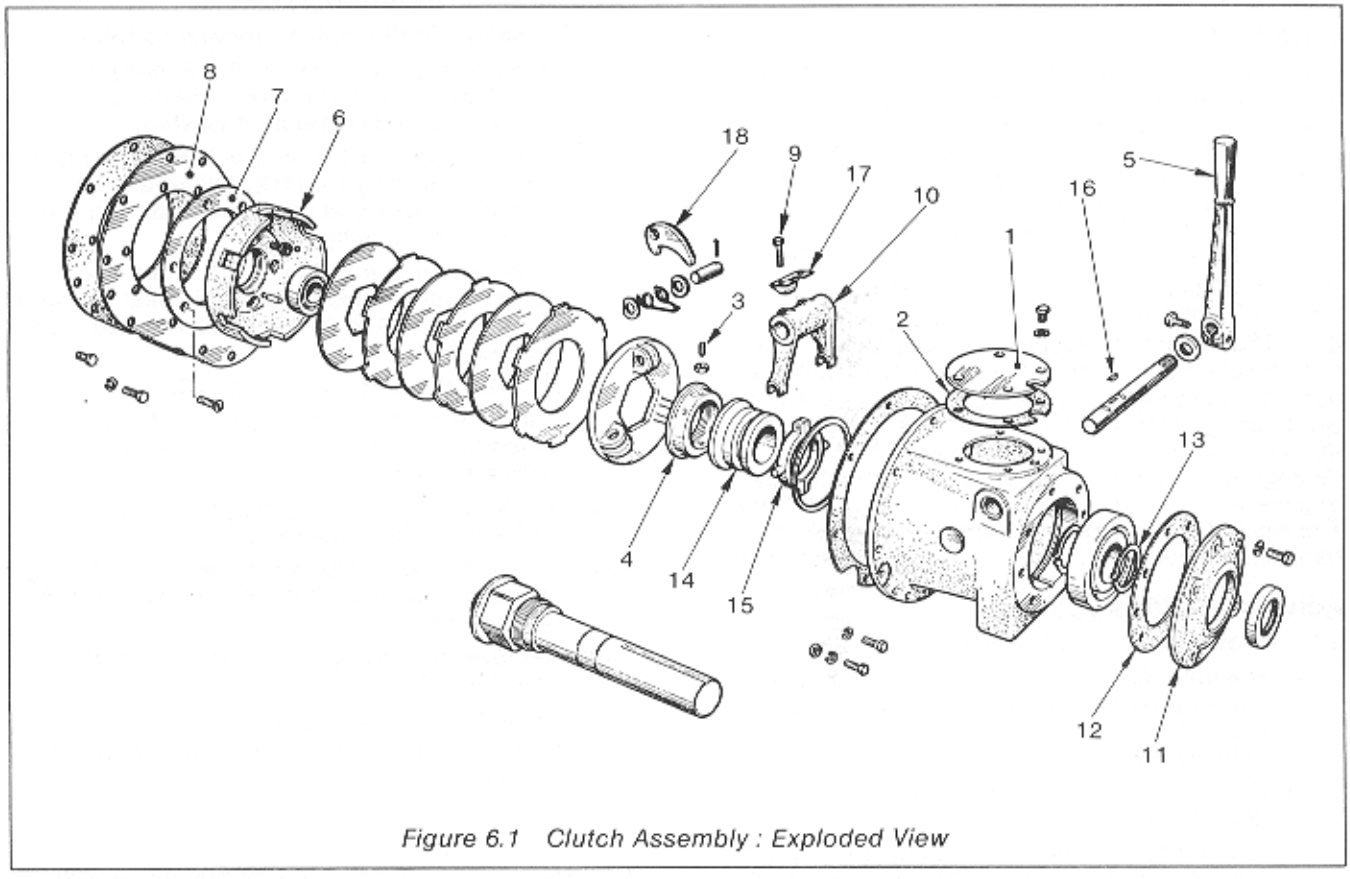


Figure 6.1 Clutch Assembly : Exploded View

SPEED INCREASING GEAR

Description

6.9 The speed increasing gear is a cast iron assembly consisting of a rear housing and cover. The rear housing has a mounting flange which is bolted to the engine gear cover and located by removable dowels. The cover is also bolted and dowelled to the housing, the mating faces having thin paper joints between them. A driving gear is keyed to the input shaft between the crankshaft gear and the outer bronze bearing. Ball and roller bearings support the output shaft into which the driven gear is keyed. Lubrication is provided from the engine oil pump. The plain bearing for the input shaft has a special pressure feed. The oil forms an oil bath in the lower half of the unit and excess oil flows back into the engine sump. Both gears and shaft bearings are lubricated by the oil bath. An oil seal is fitted on the output shaft.

Speed Increasing Gear Ratio

6.10 Two speed increasing gear ratios are available 1.61:1 and 1.86:1 either ratio is accommodated in the same housing; it is only necessary to change the gears and output shaft.

Rotation

6.11 Speed increasing gears are suitable for both standard and reverse rotation engines.

TABLE 6.1 SPEED INCREASING GEAR RATIOS

Engine Type		*Ratio*			
		1.61:1		1.86:1	
PH1 BHP	PH2 BHP	Engine Speed r/min	Output Shaft Speed r/min	Engine Speed r/min	Output Shaft Speed r/min
4	**8**	**995**	**1600**	**995**	**1850**
5	**10**	**1215**	**1950**	**1210**	**2250**
6.25	**12.5**	**1490**	**2400**	**1510**	**2800**
6.75	**13.5**	**1645**	**2650**	**1645**	**3050**
7.5	**15**	**1805**	**2900**	**1805**	**3350**
8.2	**16.4**	**1990**	**3200**	**1990**	**3700**

Removal (Figure 6.2)

6.12 To remove the speed increasing gear proceed as follows:

(1) Disconnect the external oil pipe at the top of the cover **(1)** and drain the oil by removing the drain plug.

(2) Remove the eight 5/16 in. B.S.F. bolts **(2)** securing the two halves of the housing.

(3) Withdraw the four hexagon-headed dowels **(3)** locating the two halves of the housing. The dowels may be removed with a spanner on edge.

(4) Withdraw the cover half of the housing together with the power take-off shaft **(4)** and driven-gear assembly **(5).** Care must be taken not to damage the inner ring of the pilot bearing which is now exposed on the end of the shaft.

(5) Remove the four 5/16 in. B.S.F. nuts and washers **(6)** securing the oil seal housing **(7)** and withdraw the housing taking care not to damage the seal **(8).**

(6) Slacken the locking screw **(9)** on the ball bearing locknut **(10)** and remove the latter. Withdraw the shaft from the bearing. Note on the 1.86:1 ratio gear release the circlip **(11)** to remove the inner ring of the pilot bearing and driven gear.

(7) Loosen the locking screw **(12)** from the driving gearwheel locknut **(13),** remove the locknut and gearwheel **(14).**

(8) Remove the four setscrews **(15)** securing the extension shaft **(16)** to the crankshaft gearwheel.

(9) Remove the four 5/16 in. B.S.F. nuts and washers securing the engine-half housing to the gear cover. From the inside of the housing remove the 5/16 in. B.S.F. bolt and tap washer **(19)** and the 5/16 in. B.S.F. socket-headed screw **(20).**

Replacement

6.13 To fit a speed increasing gear lightly oil all parts and proceed as follows:

(1) Fit the extension shaft using the four setscrews, making sure that the extension shaft dowel **(18)** is in position. Ensure that the end faces of the crankshaft gearwheel and the extension shaft are clean and undamaged. Check that the concentricity of the extension shaft with the crankshaft axis is within 0.05mm (0.002 in.) throughout its full length.

(2) Check the concentricity of the gear cover bore with the crankshaft. If the eccentricity (that is half the total indicator reading) is in excess of 0.13 mm (0.005 in.) remove the gear cover and the gear cover dowels. Refit the gear cover without the dowels the gear cover set screws must be tightened sufficiently to hold the cover in position but at the same time allow movement when the cover is gently tapped on its side. Gently tap the cover until the eccentricity is within tolerance. Tighten down the setscrews and re-check. Ream the dowel holes to 8.33 mm (21/64 in.) and fit oversize dowels.

(3) Fit the engine-half studs (if necessary) to the gear cover and fit the engine-half housing with joint. Renew the joint if damaged.

(4) Fit the 5/16 in. B.S.F. bolt and tabwasher **(19)** and the 5/16 in. B.S.F. socket-headed screw **(20).** Bend up the tabwasher to lock the bolt and lock the screw by caulking the seal against the serrated screw head.

(5) Fit the track of small roller bearing to the engine half housing.

(6) Fit the driving gearwheel **(14)** to the crankshaft extension shaft. The gearwheel is keyed to the shaft and the large chamfer in the bore of the gearwheel is placed against the extension shaft shoulder.

(7) Fit and tighten the locknut and lock with locking screw.

(8) **1.86 to 1 Ratio**

1. Fit the driven gearwheel to the power take-off shaft. The gearwheel is keyed to the shaft, and the shouldered face is towards the roller bearing end of the shaft.
2. Fit the inner ring of the roller bearing to the power take-off shaft and fit the circlip **(11).**

(9) **1.61 to 1 Ratio**

1. Fit the driven gearwheel to the power take-off shaft. The gearwheel is keyed to the shaft and the plain face is towards the roller bearing end of the shaft.
2. Fit the collar **(21)** to the power take-off shaft.
3. Fit the inner ring of the roller bearing to the power take-off shaft.

(10) Fit the ball bearing to the power take-off shaft. Fit and tighten the locknut **(10)** and lock with locking screw **(9).**

(11) Fit the crankshaft extension bush to the power take-off half-housing **(1).** Ensure that the oil hole in the bush is aligned with the housing oilway and that the bush is flush with the inside of the housing.

(12) Fit the power take-off shaft assembly to the cover housing ensuring that the ball bearing is pressed fully into the housing.

(13) Fit the oil seal **(8)** to the seal housing **(7)** and lightly oil the power take-off shaft. Fit the oil seal joint **(23),** shim(s) **(24)** and oil seal housing. Make sure that the oil seal is not damaged when fitting it over the end of the shaft.

(14) Fit and tighten the four 5/16 in. B.S.F. nuts and washers **(6)** retaining the oil seal housing to the cover **(1).** Check the end float of the ball bearing, this should not exceed 0.10 mm (0.004 in.). Normally two shims **(24)** are fitted to ensure free rotation of the output shaft without dragging and also give the required end float, but more or less shims can be added to achieve the required conditions as necessary.

(15) Fit the cover half assembly to the engine half assembly ensuring that the joint **(25)** is undamaged. Fit the eight 5/16 in. B.S.F. bolts and the four hexagon-headed dowels. Tighten the bolts.

(16) Connect the oil lubricating pipe.

(17) Fit the oil drain plug **(26).**

(18) Lightly smear the counter-bore of the crankshaft extension shaft bush with jointing compound and fit a core plug **(27).** Spread the core plug by giving the centre of the plug a sharp blow to form an oil tight fit in the housing.

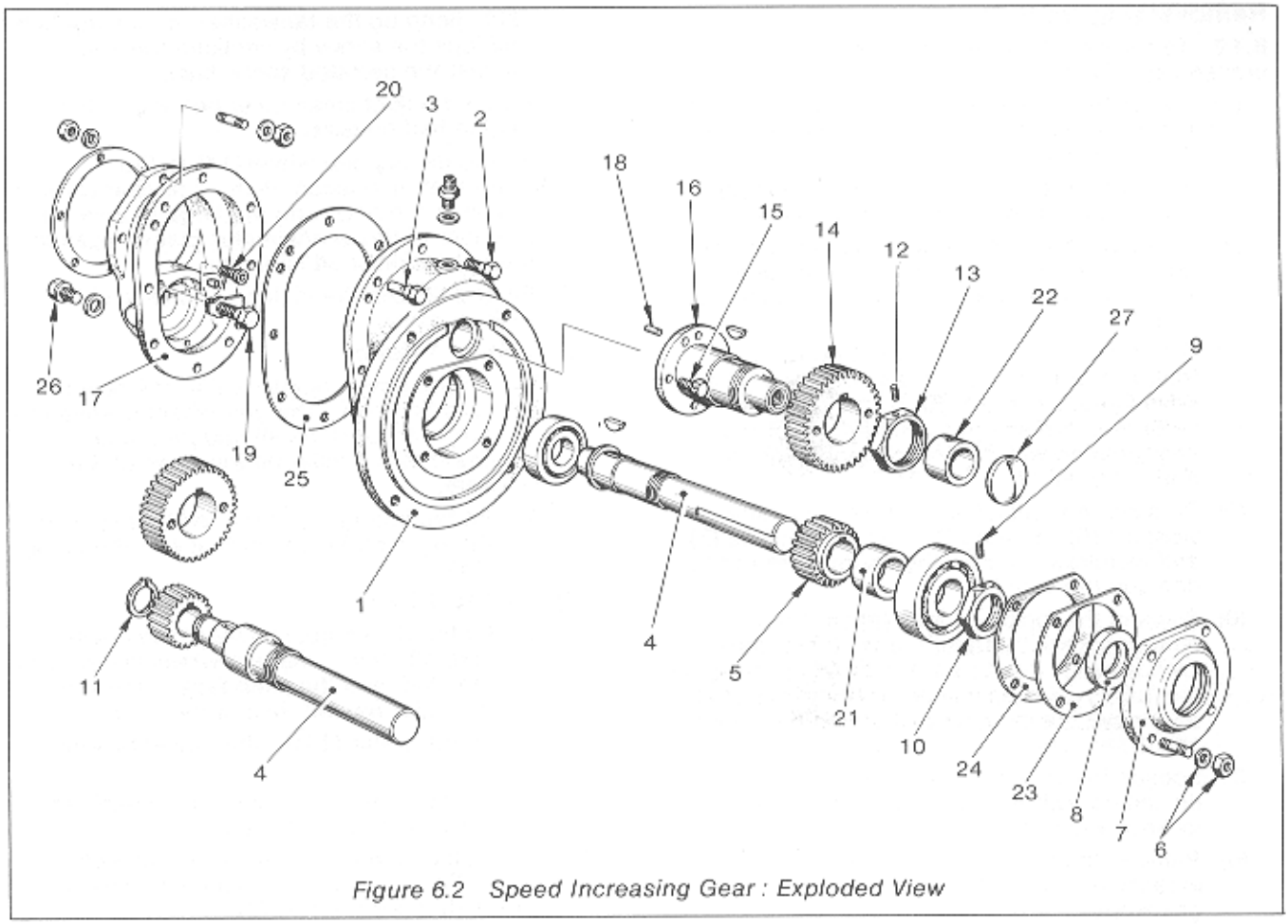


Figure 6.2 Speed Increasing Gear : Exploded View

FUEL LIFT PUMP

6.14 An engine fuel lift pump is normally fitted in an engine installation using a separately mounted fuel tank. The fuel lift pump is mounted on the right-hand side of the engine when viewed from the flywheel end. The pump is operated by a push rod which is in turn operated by a roller attached to the fuel injection pump operating rocker. A hand priming lever allows a supply of fuel to be pumped through the fuel filter to the injection pump(s) for bleeding the fuel system.

Removal

6.15 To remove the fuel lift pump proceed as follows:

(1) Isolate the fuel supply.

(2) Disconnect the two fuel pipes from the pump.

(3) Unscrew the two set bolts securing the pump to the fuel injection pump support bracket and withdraw the pump, shims and joint.

Dismantling

6.16 To dismantle the fuel lift pump proceed as follows:

(1) Remove the domed cover and joint ring from the top half of the pump body.

(2) Lift out the gauze filter.

(3) Make a mark across the two flanges of the body (this is for guidance on assembly).

(4) Remove the setscrews and separate the two halves of the pump body.

(5) Remove the diaphragm and pull rod assembly by turning clockwise through 90° and lift out.

(6) Remove (where applicable) the suction and delivery valves from the top half of the pump body.

Maintenance

6.17 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 cranking or hardening.

(3) Examine the suction and delivery valves (where possible) for proper seating.

(4) Check all pump linkage for wear and pump flanges for distortion.

Assembly

6.18 To assemble the fuel lift pumps proceed as follows:

(1) Fit (where applicable) the suction and delivery valves.

(2) With reference to Figure 6.3 assemble the diaphragm and pull rod by setting the locating tab on the periphery of the diaphragm at the 11 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 the fork in the linkage. The tab should now be in the 8 o'clock position.

(3) Assemble the two halves of the pump ensuring that they are in their original positions as marked (Paragraph 6.16(3)).

(4) Fit the gauze filter.

(5) Fit the domed cover and joint ring and tighten the setscrew just sufficiently to make a fuel tight joint.

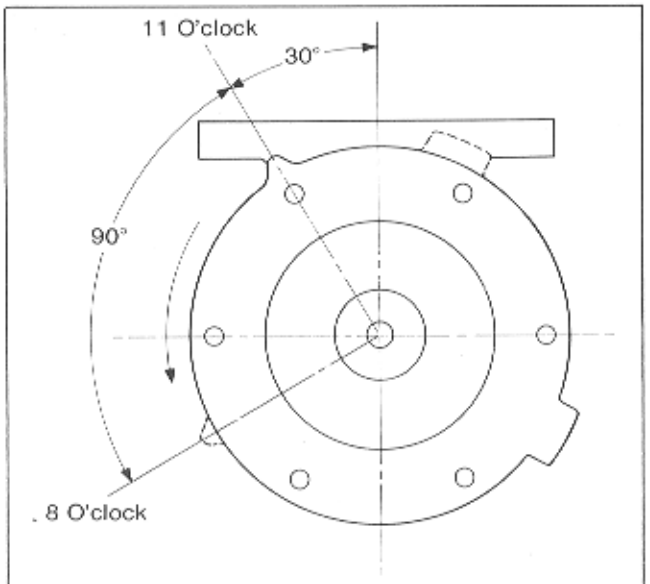


Figure 6.3 Fitting the Fuel Lift Pump Diaphragm

CAUTION

Do not overtighten the domed cover setscrew

Checking the Push Rod Protrusion

6.19 Before fitting the fuel lift pump to the engine it is important to check the protrusion of the push rod as follows:

(1) Turn the engine until the push rod is in the maximum lift position.

(2) Fit the fuel lift pump joint.

(3) With reference to Figure 6.4 measure the maximum protrusion of the push rod, this should be 3.81 mm (0.15 in.). If necessary adjust the protrusion by means of shims fitted under the mounting flange of the pump to achieve this figure. Shims (0.015 in. thick) can be obtained from Petters Limited Part No. 334143.

Replacement

6.20 Fit the fuel pump to the support bracket and tighten the two set bolts. Connect the fuel pipes and bleed the fuel system as detailed in Section 1.

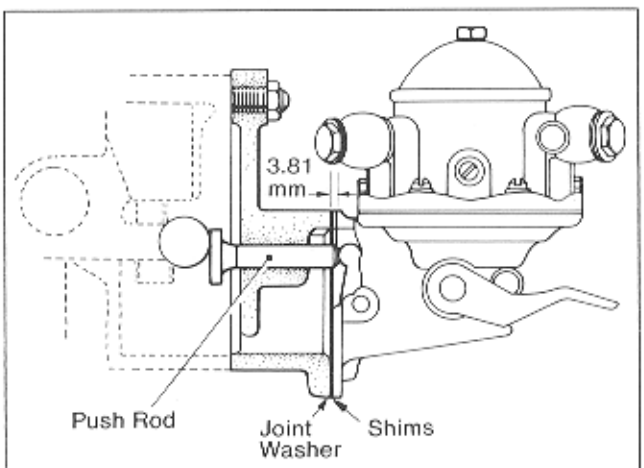


Figure 6.4 Fuel Lift Pump : Checking the Push Rod Protrusion

HYDRAULIC PUMPS

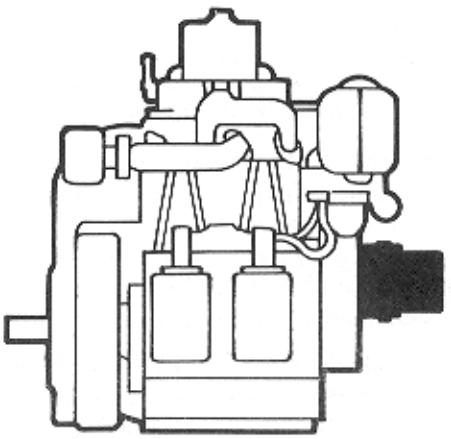
Drive Positions (Figure 6.5)

6.21 A hydraulic pump can be fitted to a PH engine in one of three positions.

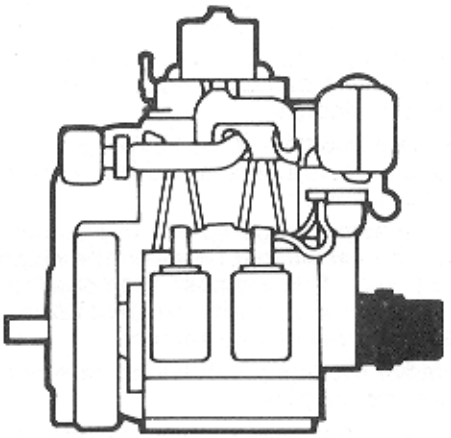
(1) Half engine speed gear end.

(2) Engine speed gear end.

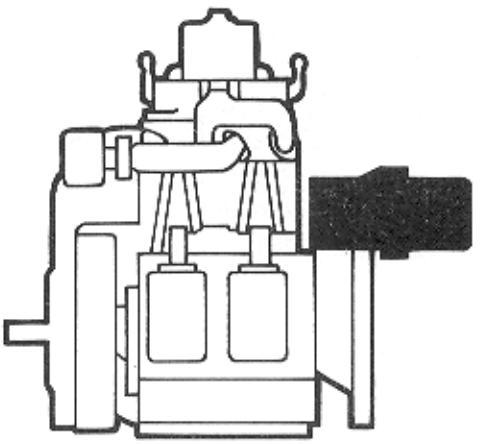
(3) Engine speed gear end (raised) with an SAE5 Bellhousing.



(1) Half Engine Speed Gear End



(2) Engine Speed Gear End



(3) Engine Speed Gear End (Raised) with an SAE 5 Bellhousing

Figure 6.5 Hydraulic Pump Drive Positions

Installation Checks

6.22 When the hydraulic pump is installed or replaced after engine overhaul it is necessary to check various clearance depending on drive positions.

Half or Engine Speed Gear End

6.23 To obtain the correct clearance of the coupling proceed as follows:

(1) Fit the pump half of the coupling to the hydraulic pump drive shaft. Do not tighten the socket screw.

(2) Fit the hydraulic pump unit in position leaving out the joint washer between the adaptor and pump. This will push the coupling on the drive shaft so that with the joint fitted the clearance will be satisfactory.

(3) Remove the pump unit taking care not to move the coupling.

(4) Tighten the socket screw to secure the coupling on the drive shaft.

(5) Fit joint washer and replace pump unit.

Engine Speed Gear Eng (SAE5 Bellhousing)

6.24 To obtain the correct clearances when fitting a hydraulic pump to the engine speed gear end (raised) using a SAE5 Bellhousing proceed as follows):

(1) Check the backlash between the camshaft gear and pump drive gear is 0.10 mm (0.004 in.) to 0.15 mm (0.006 in.). If necessary this can be adjusted by using different thickness shims between the bellhousing flange and the drive housing.

(2) Fit the pump half of the coupling to the hydraulic pump drive shaft, Do not tighten the socket screw.

(3) Fit the hydraulic pump unit in position leaving out the joint washer between the spigot plate and pump. This will push the coupling on the drive shaft so that with the joint fitted the clearance will be satisfactory.

(4) Remove the pump unit taking care not to move the coupling.

(5) Tighten the socket screw to secure the coupling on the drive shaft.

(6) Fit joint and replace pump unit.

MARINE ENGINES

6.21 Petter PH engines which are built for marine use are identical in construction to the normal PH engine but are fitted with certain modified components built to withstand the corrosive effects of the marine environment. These components are:

(1) Valve springs (Inner and outer).

(2) Fuel injection pump(s).

(3) Speeder spring(s).

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 PH range diesel engines. Further information can be obtained from Petters Limited or their representatives.

ELECTRIC STARTING EQUIPMENT

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.

STARTER MOTOR

Maintenance

7.3 Carry out the following procedure:

(1) Check the motor 3/8 in. B.S.F. securing nuts for tightness.

(2) Check the motor terminal nuts for tightness and that the terminals are clean.

(3) 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.

CAUTION

Disconnect the battery before carrying out maintenance on the solenoid.

(4) The solenoid should move freely and its contact faces should be clean and free from damage.

Note

The starter motor bearings are lubricated on assembly and require no attention between overhaul periods.

DYNAMO

Maintenance

7.4 Carry out the following procedure:

(1) Check the driving belt for wear or damage, if necessary renew.

(2) Check the driving belt tension, the belt should have 13 mm (0.5 in.) movement when pressure is applied to the centre of the belt. To adjust the tension slacken the dynamo pivot and strap bolts just sufficient to allow movement of the dynamo. After adjustment ensure that the bolts are tightened.

(3) Inspect the brushes and commutator. Brushes should move freely in the slides with the brush springs sitting squarely on the brushes. The brushes and commutators should be clean and contact surface smooth and uniform in colour.

(4) Check that the main terminals and circuit connections are secure and clean.

Note

The dynamo bearings are lubricated on assembly and require no attention between overhaul periods.

REGULATOR

7.5 Adjustments and servicing should be made by an electrical engineer.

ALTERNATOR

Maintenance

7.6 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. The driving belt should have 13 mm (0.5 in.) movement when pressure is applied to the centre of the belt and tension can be adjusted by slackening the pivot and strap bolts just sufficiently to allow movement of the alternator. After adjustment ensure that the bolts are tightened.

CAUTION

It is important that the following precautions should be observed to avoid extensive damage to 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.**

Note

The oil pressure switch is incorporated in the alternator circuit to prevent battery drain when the engine is stopped.

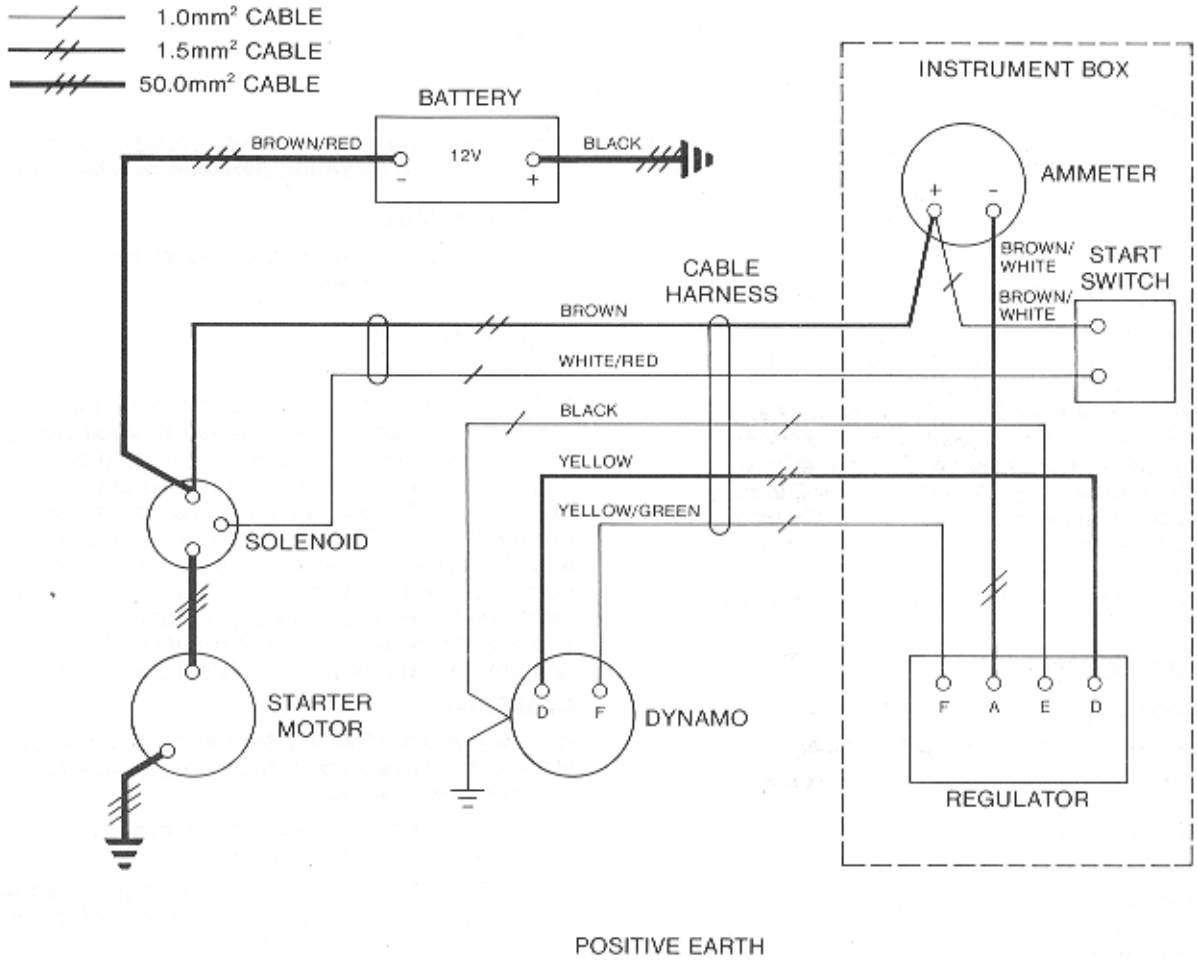


Figure 7.1 Electrical System – Dynamo

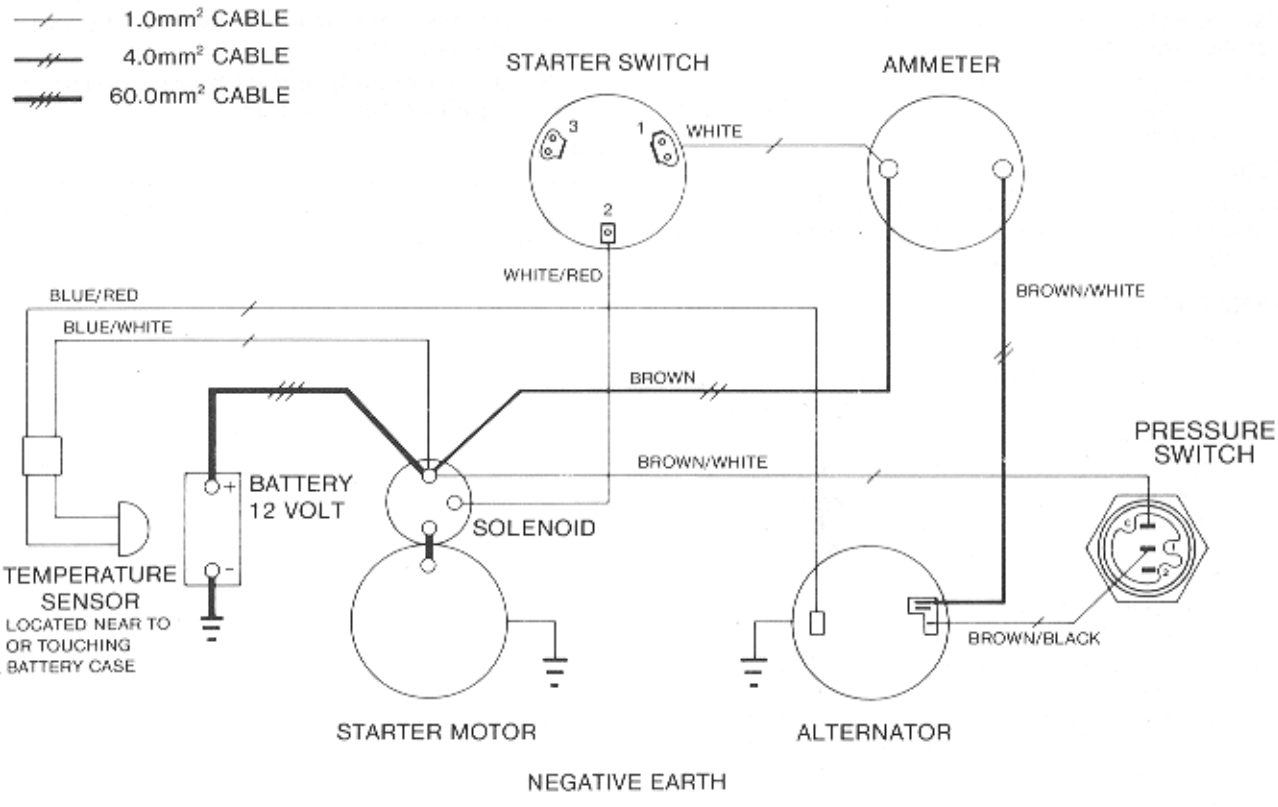


Figure 7.2 Electrical System – Alternator

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.

Dust

8.2 In a dust laden atmosphere lubricating oil filters and heavy duty air filters should be fitted.

Covers

8.3 When not in use engines should be protected by a waterproof cover. Under tropical conditions a permanent awning should be provided.

Intermittent Use

8.4 When not in regular use, engines should be run for a thirty minute period each week to lubricate internal parts and remove condensation. External unpainted parts should be wiped clean and lightly oiled. External controls should be lubricated where necessary.

Storage

8.5 Engines despatched from Petters Limited are preserved for storage and should not be disturbed until required for use.

PRESERVATION

8.6 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 hour 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) 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.

(5) Remove air inlet and exhaust manifold 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 be sealed to prevent the ingress of moisture.

(6) If electric starting is fitted, the battery should 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 lubricated and shafts greased.

8.7 Protected engines need no attention while in storage other than to ensure that they are kept dry. Before use ensure that all protective coverings are removed and the engine is prepared for use by carrying out the instructions detailed in Section 1 Paragraph 1.41.

SECTION 9
FAULT FINDING

INTRODUCTION

9.1 This section is a guide to the location of faults that may occur on a PH engine. Information on causes and suggested remedies are also given.

TABLE 9.1 ENGINE WILL NOT START

Reason	*Causes*	*Suggested Remedy*	*Reference*
Fuel Supply failure	No fuel in tank	Fill tank and bleed the fuel system	Sect. 1
Check by operating the fuel pump priming lever and listen for the characteristic squeak in the injector	Air in the pipe line Broken fuel pipe or leaking connection	Bleed the system Repair or renew the pipe and tighten the connection	Sect. 1
	Fuel filter choked	Fit new filter element	Sect. 3
	Faulty injector nozzle	Fit new nozzle	Sect. 3
	Fuel pump plunger sticking	Fit new pump	Sect. 3
	Fuel pump tappet sticking	Free and clean the tappet	Sect. 3
	Valves sticking Cylinder head loose Cylinder head gasket blown	Free the valves Tighten all nuts Fit new gasket	Sect. 5
Poor Compression	Piston rings stuck in grooves	Check rings and clean the piston	Sect. 5
	Worn cylinder and piston	Overhaul the engine	Sect. 5
	Valves not seating properly	Check valve springs Grind in if necessary Check valve clearance	Sect. 5
Incorrect lubricating oil	Too high a viscosity oil causing excessive engine drag	Drain the sump and fill with correct oil	Sect. 2

TABLE 9.2 ENGINE STARTS BUT FIRES INTERMITTENTLY OR SOON STOPS

Reason	*Causes*	*Suggested Remedy*	*Reference*
Faulty fuel supply	Air in fuel lines	Bleed the system	Sect. 1
	Water in the fuel	Drain fuel system and fill with clean fuel	Sect. 3
	Faulty injector nozzle	Fit new nozzle	Sect. 3
	Fuel filter choked	Fit new filter element	Sect. 3
Faulty compression	Broken valve spring	Fit new spring	
	Sticking valve	Free the valve	Sect. 5
	Pitted valve	Grind or renew	
Dirty exhaust	Blocked exhaust pipe or similar	Clean out	

TABLE 9.3 ENGINE LACKS POWER AND SHOWS DIRTY EXHAUST

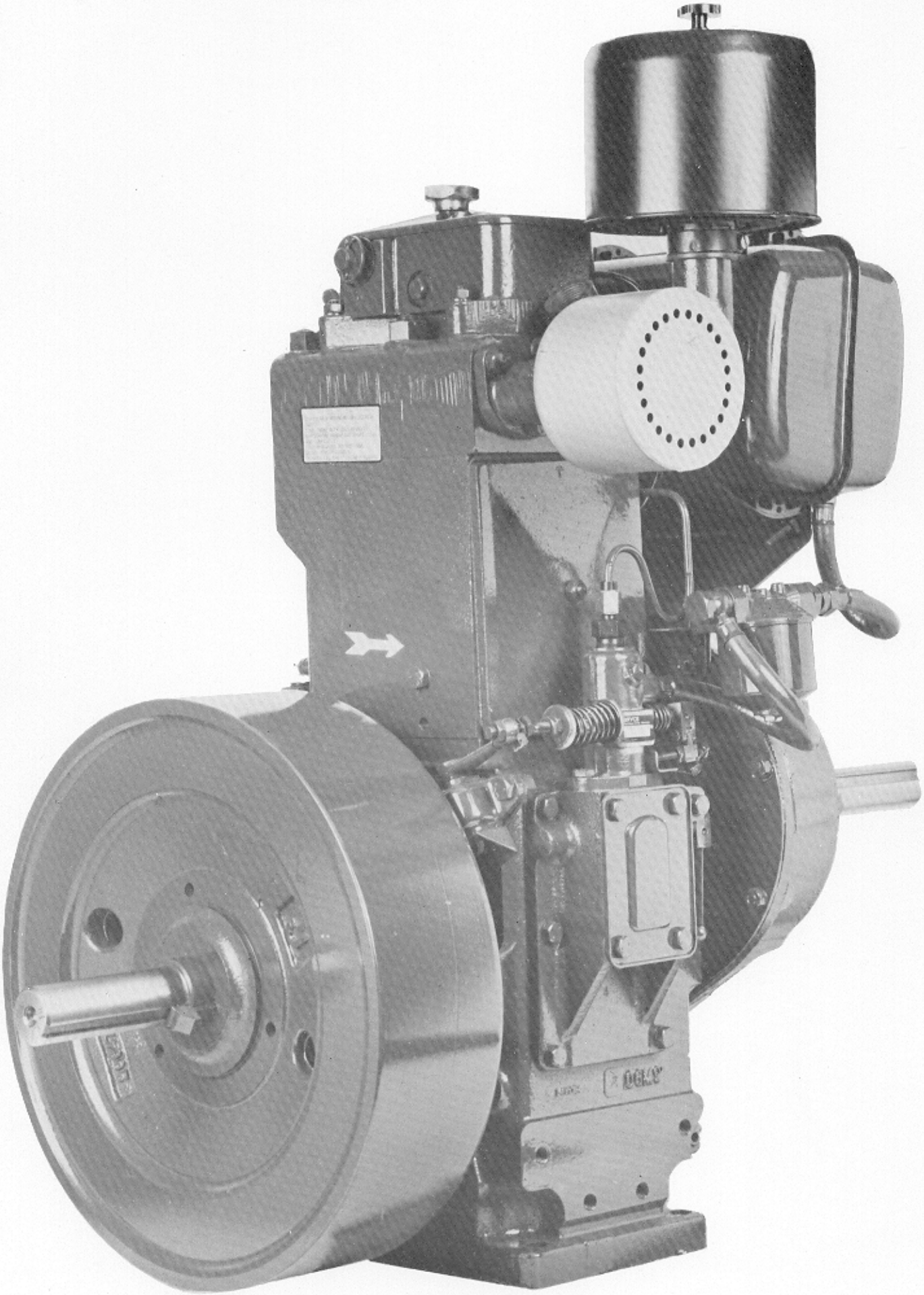
Reason	*Causes*	*Suggested Remedy*	*Reference*
Faulty fuel supply	Faulty fuel pump	Fit new pump	Sect. 3
	Faulty injector nozzle	Fit new nozzle	Sect. 3
	Unsuitable fuel	Drain the fuel system and fill with correct fuel	Sect. 3
Out of adjustment	Valve clearance incorrect	Adjust	Sect. 5
	Fuel timing incorrect	Adjust	Sect. 3
	Blocked exhaust pipe or similar	Clean out	
	Dirty air cleaner	Clean out	Sect. 4
Dirty engine	Faulty piston ring	Fit new ring	Sect. 5
	Excessive carbon on piston and cylinder head	Decarbonise	Sect. 5
	Worn cylinder and piston	Overhaul the engine	Sect. 5

TABLE 9.4 FAULTY RUNNING

Reason	Causes	Suggested Remedy	Reference
Knocking	Carbon on piston crown	Decarbonise	Sect. 5
	Injector needle sticking	Fit new nozzle	Sect. 3
	Fuel timing too far advanced	Adjust timing	Sect. 3
	Broken piston ring	Fit new ring	Sect. 5
	Slack piston	Fit new piston ring	Sect. 5
	Worn large end bearing	Renew and check lubrication	Sect. 5
	Loose flywheel	Refit	Sect. 5
	Worn main bearing	Renew and check lubrication	Sect. 5
Overheating	Overload	Reduce the load	
	Lubricating oil failure	Fill the sump and check system	Sect. 2
	Cylinder giving unequal power	Check and adjust fuel pump setting	Sect. 3
	Excessive valve clearance	Adjust	Sect. 5
	Cooling system failure	Check that the cooling system is in order and free from obstruction	
Speed surges	Overheating	See above	
	Air in fuel pipes	Bleed the system	Sect. 1
	Governor sticking	Free the governor	Sect. 5
Sudden stop	Empty fuel tank	Fill tank and bleed the fuel system	Sect. 1
	Choked injector	Fit new nozzle	Sect. 3
	Fuel pipe broken	Repair or renew	Sect. 3
	Seized piston	Fit new piston or, in an emergency, stone down	Sect. 5
	Seized crankshaft	Check bearings	Sect. 5
Heavy vibration	Faulty installation	Check holding down bolts, coupling and alignment.	Sect. 1

PART 2

WATER COOLED DIESEL ENGINES
PH1W AND PH2W



PART 2

WATER COOLED DIESEL ENGINES PH1W AND PH2W

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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. 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 mounting is contemplated.

(3) When a portable installation is contemplated.

ENGINE MOUNTING

1.2 The engine mounting procedure is common to all PH series 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 COOLING

1.4 Before installing any engine ensure that sufficient air supply is available for the radiator fan and that the fan air intake is unobstructed. Engines mounted inside housings or confined spaces must be provided with ample openings for the free circulation of air. Hot air from the radiator must not be allowed to recirculate to the fan.

CLUTCH

1.5 If a Petter clutch is fitted and the final drive is through a belt or chain, a bearer must be fitted to the base pad of the clutch housing.

FOUNDATIONS

1.6 Foundation preparation is identical to all PH series engines and reference should be made to Part 1 Section 1.

COOLING SYSTEMS

CAUTION

Sea water must not be used except in engines equipped to withstand the harmful effects of corrosion.

1.7 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 from 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.

Cooling Tanks (Figure 1.1)

1.8 The following points should be noted when installing cooling tanks:

(1) Coolant connections to and from the engine are by means of a 3/4 in. BSP pipes on one-cylinder engines or 1 in. BSP pipes on two-cylinder engines.

(2) Collant 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 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 should be fitted to the pipe **(4)** to control the temperature. The outlet temperature of the coolant should not exceed 82°C (180°F) and not be less than 60°C (140°F). Pipes should be too hot to hold but the coolant should not boil.

TABLE 1.1
WATER CAPACITY COOLING TANK(S)

Engine	*Cooling Tank(s) Capacity*	
	Temperate	**Tropical**
PH1W	**218 litres (48 gal)**	**545 litres (120 gal)**
PH2W	**545 litres (120 gal)**	**1090 litres (240 gal)**

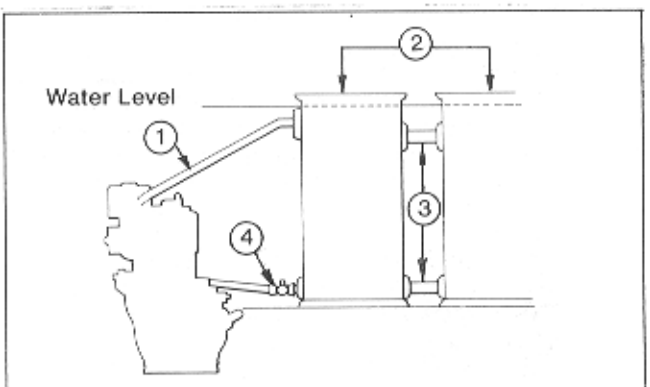


Figure 1.1 Cooling Tanks Arrangement

Radiator Cooling

1.9 Cooling air is supplied by the radiator fan and care must be taken to ensure that the air flow is unobstructed.

1.10 Under low temperature conditions it is advisable to use an anti-freeze coolant. The anti-freeze should be in accordance with B.S.3151 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 1.2

COOLANT CAPACITY RADIATORS

Engine	*Radiator Capacity*	
	Temperate	**Tropical**
PH1W	**5.1litres (9 pints)**	**9.1 litres (16 pints)**
PH2W	**7.1litres (12.5 pints)**	**9.1 litres (16 pints)**

ALIGNMENT

1.11 The alignment procedure is as detailed in Part 1 Section 1.

AIR INTAKE CLEANERS

1.12 Air intake cleaners are common to all PH series engines and is as described in Part 1, Section 1.

EXHAUSTS AND SILENCERS

1.13 Exhaust and silencer fitting is common to all PH series engines and is as described in Part 1, Section 1.

LUBRICATION

1.14 Lubrication systems are identical on all PH series engines and reference should be made to Part 1, Section 1.

FUEL

1.15 Fuel systems are identical on all PH series engines and reference should be made to Part 1, Section.

DRIVE ARRANGEMENTS

1.16 The engine drive arrangements are common to all PH series engines and reference should be made to Part 1, Section 1.

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 that the radiator fan 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 1.26) and of the correct grade (Part 1, Section 1 Paragraph 1.27) 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 a Petter clutch is fitted remove cover plate and pour 0.3 litres (0.5 pints) of engine lubricating oil into the clutch housing. The clutch is a positive action type and must not be slipped when operating. The lever must be smartly engaged and disengaged.

(4) Lift the decompression 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 Paragraph 1.30 and 1.31).

(6) Bleed and prime the fuel system as detailed in Paragraph 1.18.

Bleeding and Priming the Fuel System

1.18 To bleed and prime the fuel system, each cylinder (in the case of two cylinder engines) must be done in turn. The flywheel TDC mark must be set for the appropriate cylinder about half a revolution away from the pointer before top dead centre. If a fuel lift pump is fitted fuel will not flow unless the fuel lift pump priming lever is operated. With reference to Figure 1.2 carry out the following procedure:

(1) Slacken the two vent screws **(1)** on top of the fuel filter, when clean, air free fuel leaks out tighten the two vent screws.

(2) Slacken the vent screw **(2)** on the fuel pump until air free fuel is expelled. Tighten the vent screw.

(3) Unscrew the delivery pipe connection **(4)** from the fuel injector. Operate the priming lever **(3)** until air free fuel is expelled. Reconnect the delivery pipe.

(4) Repeat the pumping action on the priming lever **(3)** until the injector is heard to squeak.

(5) Repeat operations **(2)** to **(4)** on the second cylinder, if appropriate, re-aligning the flywheel mark.

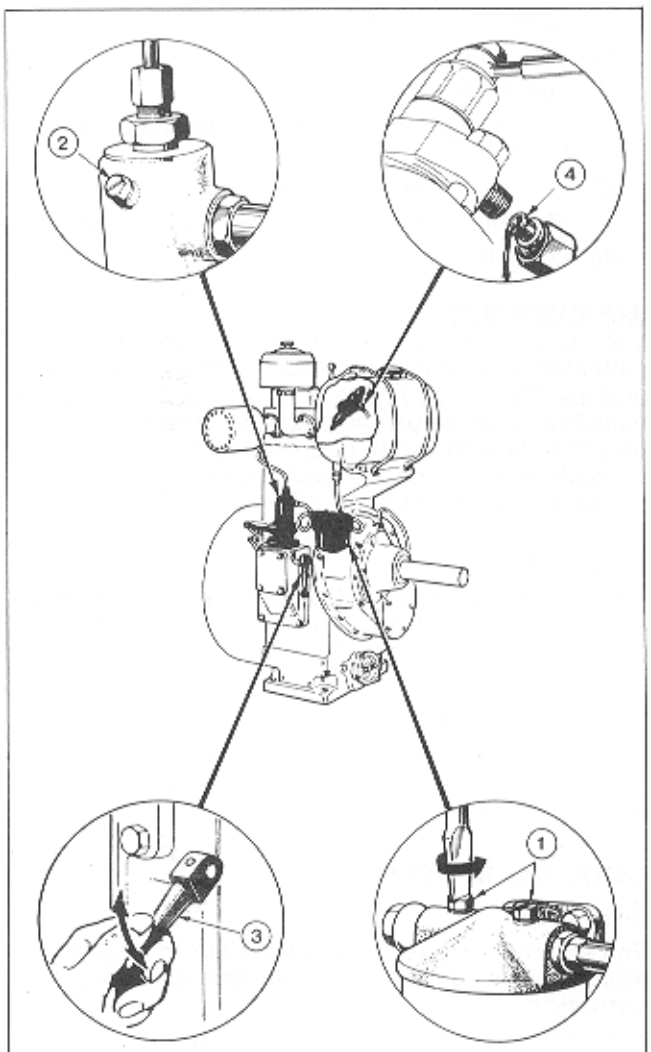


Figure 1.2 Bleeding and Priming the Fuel System

Engine Running In

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

(1) Run for 2 minutes; check oil pressure and ensure that there are no oil leaks.

(2) Check that there are no coolant 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.

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

(4) 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) 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

Normal Start (Figure 1.3)

1.20 To start an engine under normal operating conditions using the starting handle proceed as follows:

(1) If a variable speed control is fitted, set the control lever to the full speed position.

(2) Lift the red painted overload stop **(1)** and allow the fuel pump rack(s) to move into the fully open position.

(3) Operate the fuel pump priming lever for each cylinder about six times to prime the cylinder. (This operation is not required if the engine is warm).

(4) Lift the decompression lever(s) **(2)** and turn the engine by hand as fast as possible. When the engine is turning over at a good speed, knock down one decompression lever. The engine should now fire, then knock down the other lever.

(5) If the engine does not fire, lift the decompression lever(s) and slowly turn the engine a few times before attempting to start again.

1.21 When using a starter motor to turn the engine the decompression lever(s) are not raised. Do not operate the starter motor for more than 20 seconds at a time.

Cold Start

1.22 When operating in low temperature conditions it may be necessary to use a cold starting aid, details of which can be obtained from Petters Limited or their representatives. This aid may be in the form of an auxiliary fuel introduced into the combustion system during starting, through a permanently fitted equipment spraying directly into the inlet manifold. Care must be used when using a cold starting aid as indiscriminate use may cause damage to the engine. Petters Limited or their representatives must be consulted if doubt arises regarding the use of such aid.

1.23 Temperatures below which a cold starting aid may be required depends on the installation and the condition of the engine and are as in Table 1.3.

TABLE 1.3

COLD STARTING AID TEMPERATURES FOR HAND STARTING

Installation	*PH1W engine*	*PH2W engine*
On half-speed extension shaft	**–13°C (9°F)**	**–12°C (10°F)**
On full-speed extension shaft	**–10°C (14°F)**	**–5°C (23°F)**

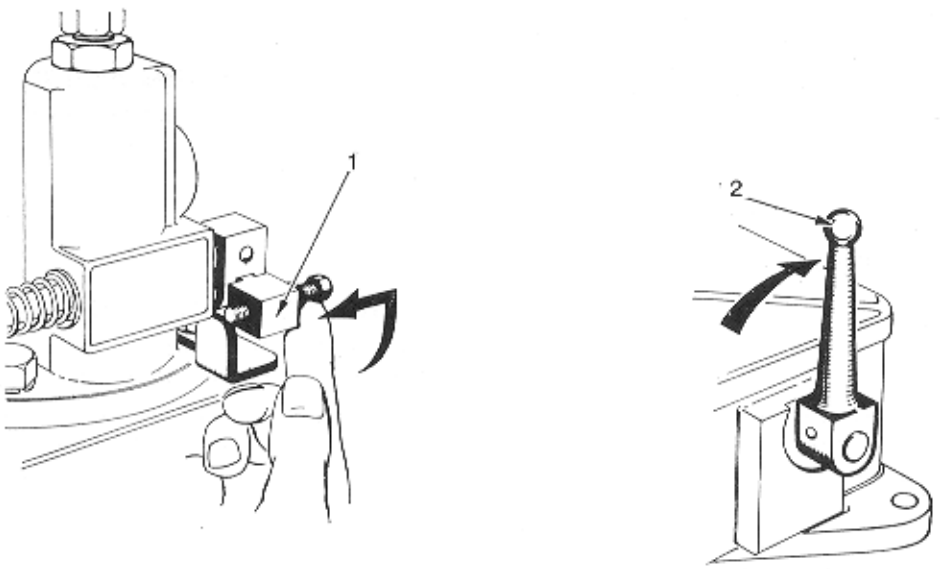


Fig 1.3 Engine Starting

Hot Start

PH1W Engines

1.24 Carry out the following procedure:

(1) Raise the fuel pump priming lever to the vertical position.

(2) Lift the decompressor lever.

(3) Turn the engine to clear the cylinder of hot air and fuel.

(4) Lower the priming lever.

(5) Turn the engine as fast as possible or operate the starter motor. When the engine is turning at a good speed knock down the decompression lever. The engine should now fire.

PH2W engines

1.25 Carry out the following procedure:

(1) Raise the fuel pump priming levers to the vertical position.

(2) Lift the decompressor levers.

(3) Turn the engine to clear the cylinders of hot air and fuel.

(4) Lower the priming levers.

(5) Turn the engine as fast as possible. When the engine is turning at a good speed knock down the decompression lever. On two cylinder engines fitted with separate decompressors knock down one lever and then as soon as the engine fires knock down the other lever.

STOPPING

1.26 Before stopping the engine it is advisable to run on a light load for a few minutes. To stop the engine raise the fuel pump priming levers to the vertical position, or push the governor fulcrum lever towards the fuel pump until the engine stops.

CAUTION

Do not turn off the fuel supply or use the decompression levers to stop engine.

OPERATING PRECAUTIONS

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

(1) Do not stop the engine by lifting the decompression lever(s). This will damage valve seats and cylinder head joints.

(2) Do not allow the engine fuel tank to run dry. This means that sediment or water could be drawn into the fuel system and also air will be drawn into the fuel lines thus necessitating bleeding and priming of the fuel system.

(3) Do not remove or alter the setting of the overload stop.

ROUTINE MAINTENANCE

INTRODUCTION

1.28 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, and are 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 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 obstruction.

...an engine needs cooling
Keep air intakes clean and provide adequate ventilation.
Keep coolant level topped up.

INITIAL CHECKS ON NEW OR OVERHAULED ENGINES

20 Hours Initial Running

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

(1) Check the torque loading of the cylinder head and rocker box retaining nuts (see Technical Data PHW Range).

(2) Check the tightness of all nuts, bolts, securing screws and hose clips.

(3) Check the valve clearances (Section 5).

(4) Drain the lubricating oil from the sump, check the filter (if fitted) and fill with clean oil (Part 1 Section 2).

(5) Check the fuel filter (Part 1 Section 3).

DAILY CHECKS

1.30 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 of grade of lubricating oil.

(3) Check coolant level in the radiator or cooling tank and top up if necessary. Check fan belt tension. Check that the radiator is not obstructed.

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

EVERY 50 RUNNING HOURS

1.31 Carry out the following procedure:

(1) Clean the oil bath type air cleaner, if fitted. (Part 1 Section 4).

(2) Check the alternator/dynamo drive belt, if fitted.

EVERY 250 RUNNING HOURS

1.32 Carry out the following procedure:

(1) Clean the fuel filter (Part 1, Section 3)

(2) Check the tightness of all nuts, bolts, securing screws and hose clips.

(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.

(7) Drain the oil sump and refill with new lubricating oil of the correct type and grade (Part 1 Section 2).

(8) Lubricate radiator cooling fan shaft (if applicable).

(9) Clean fuel lift pump filter gauze (if applicable).

(10) Fit a new lubricating oil filter element and joint ring (where fitted).

Note

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

(11) Visually check the fuel system for leaks.

(12) Remove the fuel injector(s) (Section 3) and test spray. If in order replace.

(13) Check valve clearance (Section 5) and adjust if necessary.

(14) Clean the lubricating oil feed restrictor to rockers (Part 1 Section 2).

(15) Lightly lubricate the speed control linkage.

EVERY 500 RUNNING HOURS

1.33 Carry out the following:

(1) Fit a new fuel filter element (Part 1 Section 3).

(2) Fit a new air cleaner element (if fitted).

EVERY 1000 RUNNING HOURS

1.34 Drain the cooling system and flush with clean fresh water. Refill the system with coolant.

EVERY 2000 RUNNING HOURS

1.35 Carry out the following:

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

(2) Clean out piston oil return holes.

(3) Check piston rings for wear (Section 5).

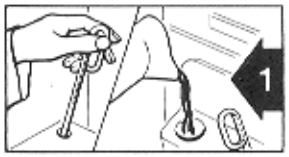
(4) Check each cylinder bore wear (Section 5).

(5) Check the connecting rod bearings. (Section 5).

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

(7) Fit a new plunger pin. (Part 1 Section 2) on the plunger pump type oil system (if fitted).

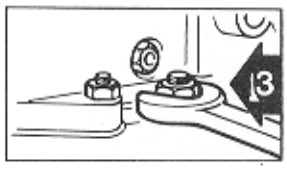
DAILY



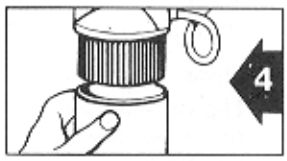
Check the lubricating oil level on the dipstick and top up if necessary.

Check the water level in the radiator or cooling tank and top up if necessary. Check fan belt tension.

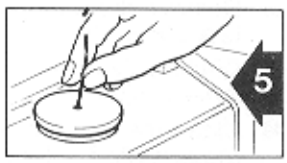
250 HOURS



Check all nuts, bolts, etc. for tightness.

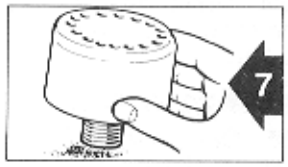


Clean the fuel filter bowl.



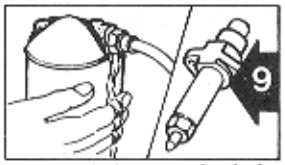
Make sure the fuel tank filter cap vent hole is clear.

Clean the air cleaner element. (In very dusty conditions this must be done more frequently.)

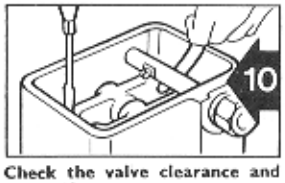


Clean out deposit from exhaust system.

Drain the sump, flush out with flushing oil and refill with new oil. Clean the strainer.



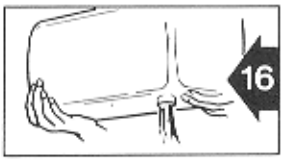
Test the fuel system for leaks. Remove the fuel injectors and test spray.



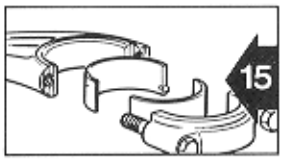
Check the valve clearance and adjust if necessary.

2,000 HOURS

Clean out water spaces in cylinder head, cylinder-block and radiator.

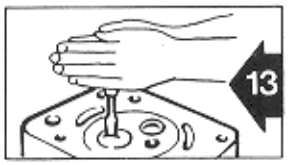


Clean out the fuel tank thoroughly.

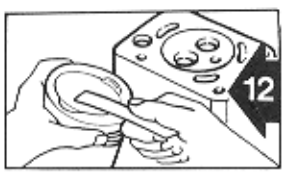


Examine the crankshaft bearings and renew if clearance is excessive.

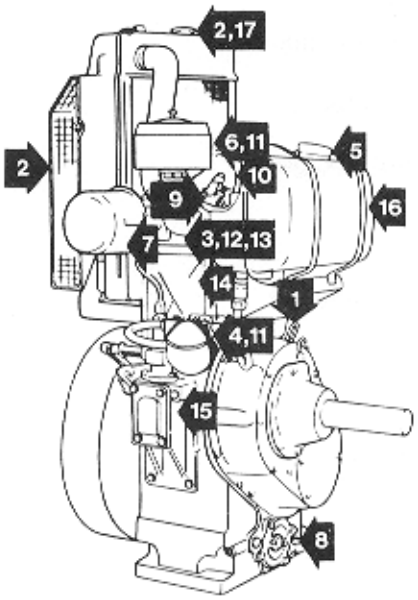
Clean the piston oil return holes. Check cylinder bore wear.



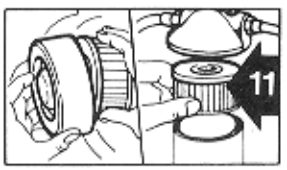
Examine the valves and grind if necessary.



Remove cylinder head and decarbonise.



500 HOURS



Fit new air cleaner element.
Fit new fuel filter element.

Figure 1.4 Maintenance Chart

SECTION 2
LUBRICATING SYSTEM

INTRODUCTION

2.1 Two types of lubricating oil systems are used on PH engines these differ in the type of oil pump used and are as follows:

(1) Rotary pump oil system, fitted on PH1W engine number 303 and onwards and PH2W engine numbers 661 and 716 onwards.

(2) Plunger pump oil system.

2.2 The lubricating systems are common to all PH series engines and are described in Part 1, Section 2.

SECTION 3
FUEL SYSTEM

INTRODUCTION

3.1 The fuel system used on the PHW series engine is almost identical to the PH and is described in Part 1, Section 3. The exception is the fuel injector which is fitted with a sealing washer and the method of securing the high pressure pipes.

FUEL INJECTOR

Removal

3.2 To remove the fuel injector proceed as follows:

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

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

(3) Carefully lever out the injector complete with the sealing washer.

Testing (Without a Test Rig)

3.3 Test the fuel injector as detailed in Part 1, Section 3.

Dismantling

3.4 Dismantle the fuel injector as detailed in Part 1, Section 3.

Maintenance

3.5 Service the injector as detailed in Part 1, Section 3.

Assembly

3.6 Assemble the injector as detailed in Part 1, Section 3.

Testing and Setting-Up (Using a Test Rig)

3.7 Test and set up the injector as detailed in Part 1, Section 3.

Replacement (Figure 3.)

3.8 To replace the fuel injector proceed as follows:

(1) Fit a new sealing washer on the injector with the concave side facing upwards as shown in Figure 3.1.

CAUTION

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

(2) Fit the injector and sealing washer into the engine.

(3) Fit the spring washers and the flange 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 flange nuts evenly.

(7) Connect the leak-off pipe.

(8) Bleed the fuel injector.

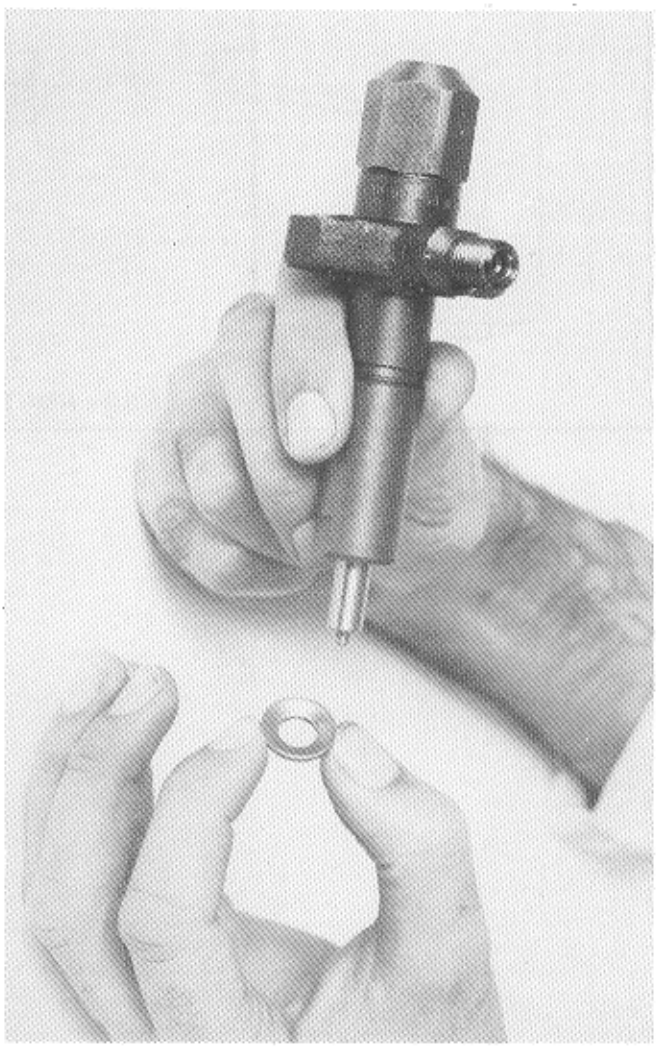


Figure 3.1 Fitting the Sealing Washer

HIGH PRESSURE FUEL PIPES

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

(1) The pipe(s) must be firmly gripped by the rubber damper block(s) and the rubber damper blocks must be firmly held against the cylinder block.

(2) The blocks must be replaced if the material shows any signs of deterioration. The swaged ends of the high pressure pipes should be checked periodically 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.

(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.

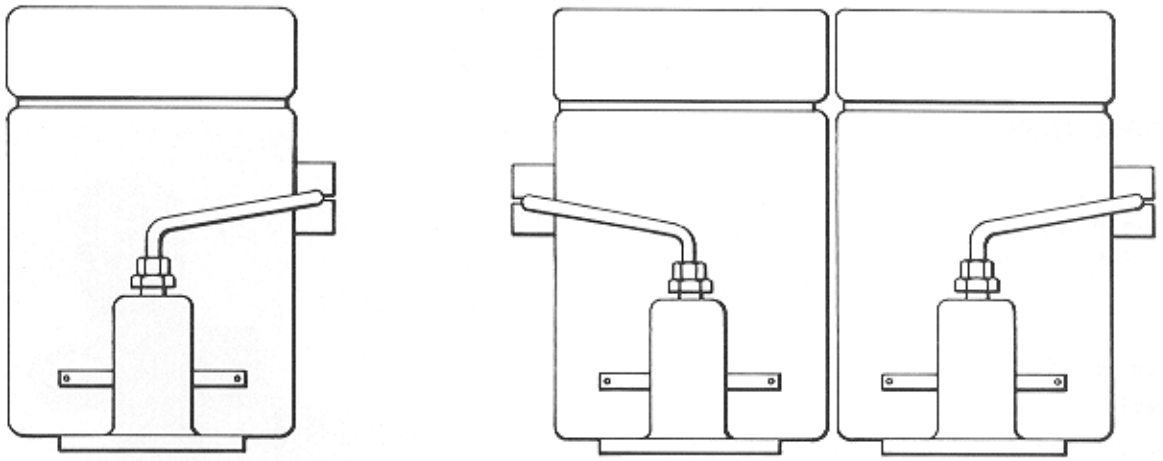


Figure 3.2 High Pressure Fuel Pipe Clamps

SECTION 4
AIR FILTRATION AND ENGINE COOLING

AIR FILTRATION

4.1 Air filtration is common to all PH series 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.

Radiators

Draining

4.3 To drain the cooling system proceed as follows:

(1) Drain the radiator by removing the drain plug.

(2) On PH1W engines remove the plug from the cylinder, and on PH2W engines open the tap on the manifold water inlet, to allow coolant to drain from the engines.

Flushing

4.4 To flush the cooling system carry out the following procedure:

(1) Drain the radiator and engine as detailed in Paragraph 4.3.

(2) Remove the water inlet and outlet manifolds.

(3) Insert a piece of wire or suitable tool through each orifice in the cylinder and cylinder head 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.

(4) Replace the water manifolds, and cylinder plug with its washer.

(5) Fill the system with the appropriate coolant.

(6) Check the system for leaks during initial run after flushing.

To adjust the Fan Belt

4.5 To adjust the fan belt proceed as follows:

(1) Loosen the locknut on the pulley support and slide the pulley support assembly upwards to increase belt tension or downwards to decrease it.

(2) The fan belt tension is checked by applying pressure on the fan belt as shown in Figure 4.2. The belt should have about 6.35 mm (0.25 in.) of movement.

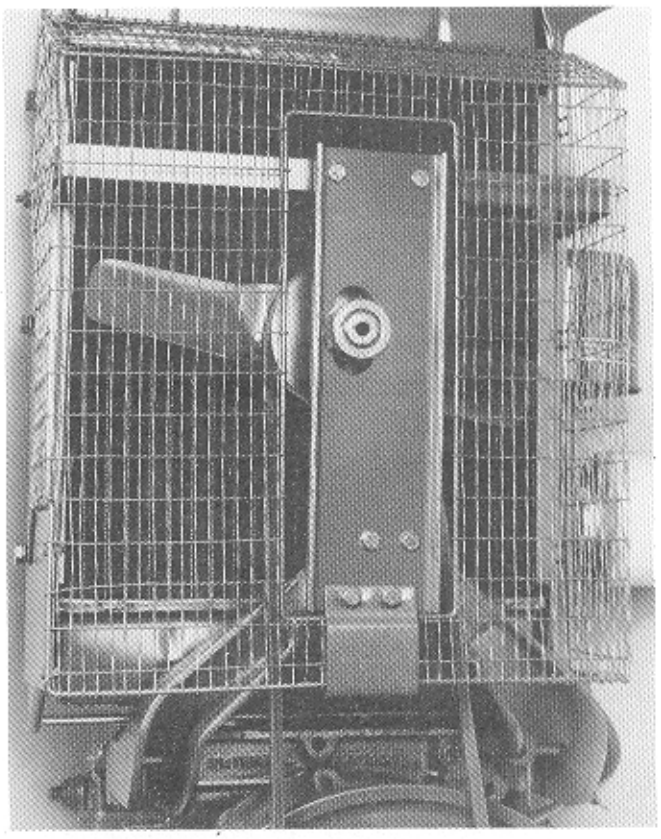


Fig 4.1 Fan Belt Adjustment Locknut

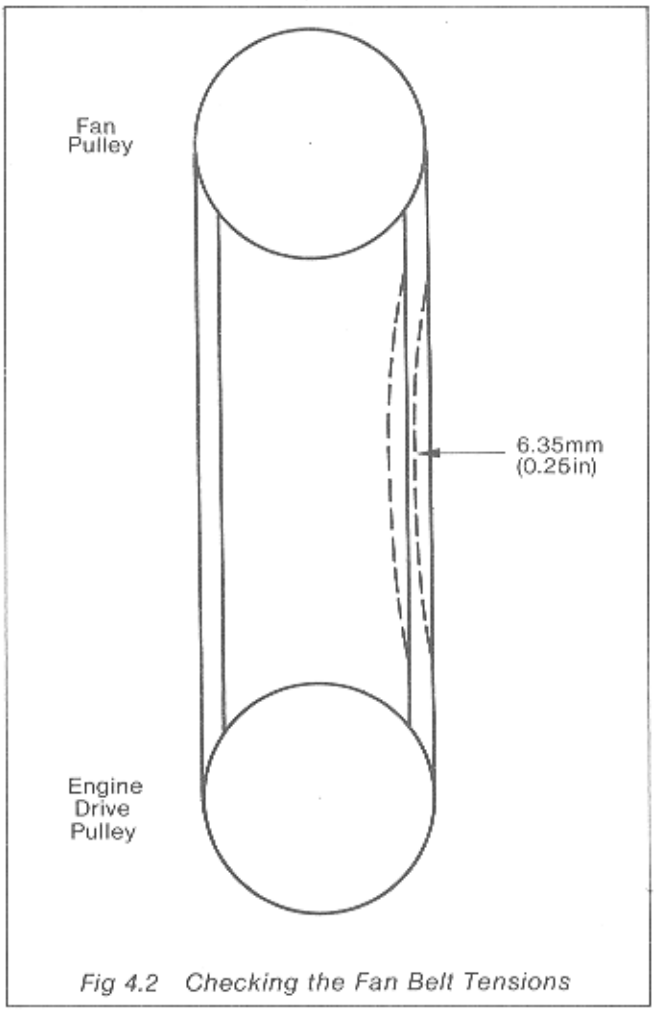


Fig 4.2 Checking the Fan Belt Tensions

SECTION 5
ENGINE GENERAL MAINTENANCE

INTRODUCTION

5.1 This section contains fitting and servicing instructions for major repairs and maintenance of the PHW diesel engine. Servicing which is common to all PH series 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 desposit 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) Remove cooling outlet manifold.
(4) Remove the inlet and exhaust manifolds by unscrewing the 5/16 in. BSF retaining bolts.
(5) Remove the fuel injector as detailed in Part 1 Section 3.
(6) Disconnect the oil pipe(s) from the end of the rocker shaft(s), and remove the restrictor valve (if fitted).
(7) Remove the four 5/16 in. BSF nuts and spring washers securing the rocker box and remove the rocker box.
(8) 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.

(9) Remove the push rod cover.
(10) Gradually slacken the cylinder head nuts diagonally and remove the four nuts.

Rocker Box and Cylinder Head Dismantling

5.4 Dismantle the rocker box and 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.

Valves Grinding In

5.7 Grind the valves in as detailed in Part 1, Section 5.

Valve Seats

5.8 Check the valve seats in accordance with the procedure detailed in Part 1, Section 5.

Rocker Box and Cylinder Head Assembly

5.9 Assemble the rocker box and cylinder head as detailed in Part 1, Section 5.

Cylinder Head Replacement

5.10 It is advisable to fit a new gasket every time a cylinder head is removed.

5.11 To replace the cylinder head proceed as follows:

(1) Fit the cylinder head gasket ensuring that the face marked TOP is uppermost. If the gasket is not marked the metal fold should face uppermost. Fit the cylinder head.
(2) Replace the cylinder head nuts and tighten finger-tight. On two cylinder engines, ensure that the manifold bolting faces are parallel with each other. Check with a straight edge before tightening the cylinder head nuts as shown in Part 1, Section 5 Figure 5.5, or by bolting on the manifold.
(3) It is important that the cylinder head nuts are tightened in the correct sequence and to the correct torque. Tighten down each cylinder head nut, in turn, a quarter of a turn working diagonally across the cylinder head. Tighten to a torque loading of 169Nm (125 lbf ft).
(4) Lightly lubricate the push rods and insert them in the noted positions.
(5) Fit the push rod cover and joint.
(6) Fit the rocker box joint washer (renew if damaged).
(7) Fit the rocker box and secure with the four 5/16 in. BSF nuts and spring washer.
(8) Fit the restrictor valve (if fitted) and connect the oil pipe(s) to the end of the rocker shaft(s).
(9) Fit the fuel injector (Section 3).
(10) Fit the inlet and exhaust manifold.
(11) Fit the cooling outlet manifold.

Valve Rockers Adjustment (Part 1, Section 5, Figure 5.8)

5.12 Set up the valve rockers on each cylinder in turn as follows:

CAUTION

The cylinder head and rocker box nuts must be tightened down before rocker clearances are adjusted.

(1) Set the engine at TDC of the firing stroke (both valves closed).
(2) Slacken the locknut and using a screwdriver set the rocker adjusting screw to give the initial valve tappet clearance of 0.38 mm (0.015 in.) (cold) using a feeler gauge. Tighten the locknut.
(3) Recheck 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 0.25 mm (0.010 in.) with the engine cold after an initial run of one hour on full load.

Setting the Decompression Lever

5.13 Set the decompression lever as detailed in Part 1, Section 5.

CYLINDER, PISTON AND CONNECTING ROD

Removal

5.14 Carry out the following procedure:

(1) Remove the cylinder head as detailed in Paragraph 5.3.

(2) Remove the crankcase inspection cover.

(3) If parallel connecting rods are fitted, lift the fuel pump lever and remove the fuel injection pump together with the pump bracket (six 5/16 in. bolts and spring washers).

(4) Set the piston in the TDC position.

(5) Note the position of the large end bearing caps, mated sides are numbered for identification.

(6) Remove the large end bolts (or bolts and nuts if applicable).

(7) Note the positions of the cylinder blocks (PH2W) to ensure that each cylinder is returned to its original position.

(8) Remove the coolant inlet manifold.

(9) Remove the push rod cover.

(10) Remove the four 5/8 in. BSF nuts and spring washers securing the cylinder block and liner assembly to the crankcase.

(11) Lift off the cylinder block complete with piston and connecting rod. Ensure the shims fitted between the cylinder and crankcase are not disturbed. These control the bumping clearance.

(12) Withdraw the piston and connecting rod assembly from the cylinder barrel.

(13) Using circlip pliers remove one of the gudgeon pin circlips.

(14) Remove the gudgeon pin. If the gudgeon pin is a tight fit soak the piston in hot water. After a few minutes the piston will have expanded sufficiently to allow the pin to be removed.

To Remove the Cylinder Liner (Figure 5.1)

5.15 To remove the cylinder liner invert the cylinder block and place on two blocks of wood. Place a piece of wood across the bottom of the liner and gently tap the liner out.

Cylinder Liner Maintenance

5.16 Check the cylinder liner bore wear, if this has reached the maximum the cylinder liner 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.

Replacement of Cylinder Liner

5.17 Replace the cylinder liner as follows:

(1) Clean all joint faces ensuring that the liner register in the top of the cylinder block is clean and undamaged.

(2) Stand the cylinder block on two pieces of wood, making sure they are clear of the bore.

(3) Check the cylinder liner bore joint ring groove for damage.

(4) Lightly lubricate a new joint ring and place it in the groove in the liner.

(5) Push the liner into the cylinder by hand. Ensure that the liner enters the block squarely to avoid damage to the ring.

(6) Check that the liner stands proud of the top face of the cylinder block by 0.051 to 0.178 mm (0.002 to 0.007 in.). the protrusion should be checked in various positions around the blocks upper face, as shown in Figure 5.2. If necessary skim the cylinder block to achieve this figure.

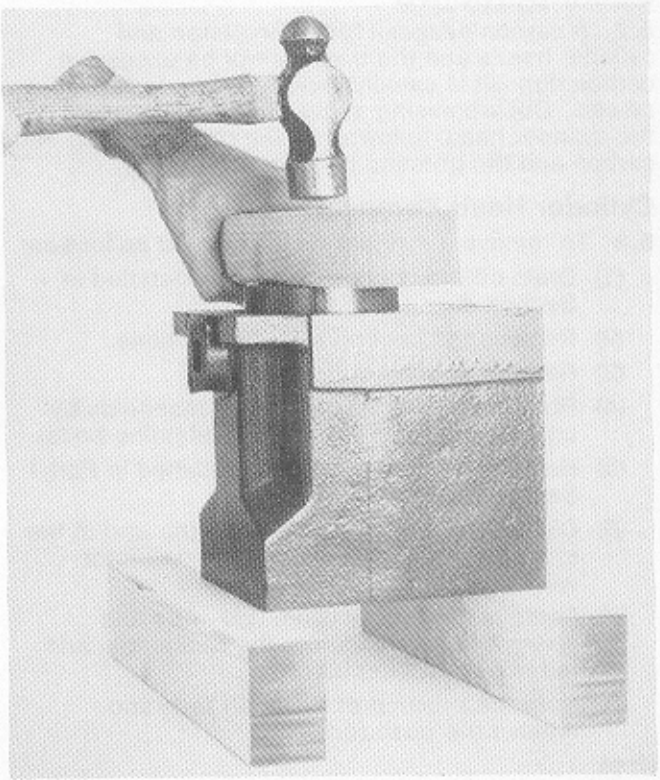


Figure 5.1 Removal of Cylinder Liner

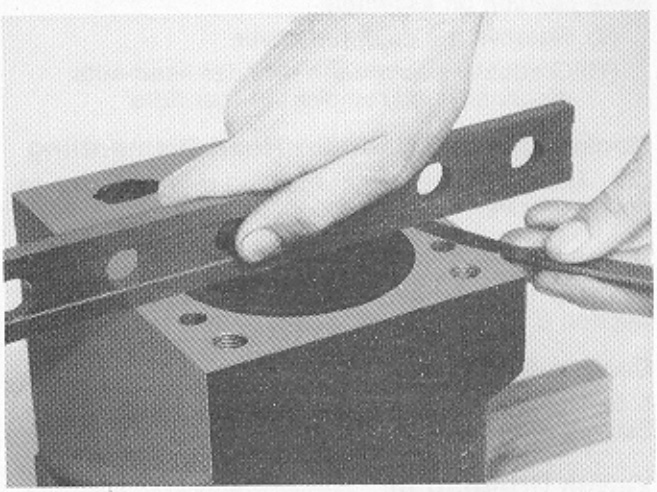


Figure 5.2 Checking the Cylinder Liner Protrusion

TABLE 5.1
CYLINDER REBORING DIAMETERS

Cylinder	*Size*
Standard	**87.312 to 87.348 mm (3.4375 to 3.4389 in.)**
1st oversize 0.508 mm (0.020 in.)	**87.820 to 87.856 mm (3.4575 to 3.4589 in.)**
2nd oversize 1.016 mm (0.040 in.)	**88.328 to 88.363 mm (3.4775 to 3.4789 in.)**

Piston Maintenance

5.18 Carry out the piston maintenance as detailed in Part 1, Section 5.

Connecting Rod Maintenance

5.19 Carry out the procedure as detailed in Part 1, Section 5.

Replacement

5.20 Before fitting the piston on to the connecting rod immerse the piston in hot water to allow the gudgeon pin to slide freely. Replace the cylinder piston and connecting rod as follows:

(1) Place the piston on the connecting rod ensuring that the valve recesses in the piston crown face away (or opposite) from the connecting rod bearing cap (scarfed type rods).

(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.

Note

It is possible with care to slide the piston into the cylinder compressing the rings by hand.

(6) Ensure that the shims are still in place between the cylinder and crankcase. These shims control the bumping clearance between the piston and the cylinder head at TDC. Place the cylinder on its studs aligning the marks made on dismantling if the original cylinder is being fitted.

CAUTION

It is imperative that the valve recesses in the piston crown are towards the camshaft side of the engine.

(7) Check that the bearings and journal are clean. Lightly lubricate the crankshaft journal and bearing face.

(8) Assemble the connecting rod to the crankshaft ensuring that the rod and cap assembly numbers are correctly aligned on the same side. Note with a scarfed type connecting rod ensure that the cap retaining bolt heads face away from the camshaft and fuel injection pump.

(9) Tighten the bolts or nuts to a torque of 77Nm (57 lbf ft). or the bolts (scarfed type) to 81 Nm (60 lbf ft).

(10) Tighten the four cylinder base nuts diagonally and evenly and torque load to 149Nm (110 lbf ft).

Bumping Clearance (Part 1, Section 5, Figure 5.14)

5.21 Check the bumping clearance as follows:

(1) Set the piston to about 6 mm (0.25 in.) before TDC.

(2) Place three pieces of lead wire on top of the piston as shown.

(3) Replace the cylinder head (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. It should be 0.76 to 0.9mm (0.030 to 0.036 in.) for an average of the three readings. If necessary adjust the clearance by re-shimming. (Paragraph 5.20(6)).

(5) Replace the cylinder head as detailed in Paragraph 5.10.

FLYWHEEL

Removal

5.22 Withdraw the flywheel key with a tapered key drift (Part 1, Section 5, Figure 5.15) or special extractor (Part 1, Section 5, Figure 5.16), both of which are obtainable from Petter Limited or their representatives. It is advisable to support the head of the key by placing a spacer in the key way of the reduced portion of the crankshaft during removal. This stops the key from bending and digging into the crankshaft on removal.

5.23 In some instances it may be found that the flywheel is tight on the crankshaft due to dirt or corrosion. Clean the exposed portion of the crankshaft and lubricate with penetrating oil. Position a block of wood through the crankcase in such a manner so that the crankshaft will only partially turn. Turn the flywheel sharply in either direction so that the crankshaft strikes the wood block. The inertia of the flywheel will break its hold on the shaft allowing removal in a screw like manner.

Replacement

5.24 Apply a small quantity of grease or oil to the crankshaft and push the flywheel on the shaft. Ensure that the flywheel is fully up to the shoulder on the crankshaft.

5.25 Note when fitting the flywheel a new key must be used and should be fitted as follows:

(1) File a chamfer on all four corners of the key to prevent any possibility of the corners binding in the keyway corners.

(2) Push the key by hand as far as possible into the keyway. Measure the distance between the flywheel boss and keyhead, as shown in Part 1, Section 5, Figure 5.17, this should be 27 mm (1.1/16 in.). If it is more, remove metal from the bottom of the key to obtain this measurement.

CAUTION

Do not remove metal from the tapered surface of the key.

(3) Knock the key further into the flywheel until a measurement of 14.3 mm (9/16 in.) is attained between the flywheel boss and the keyhead.

CRANKSHAFT

Removal

5.26 To remove the crankshaft proceed as follows:

(1) Remove the cylinder head (Paragraph 5.3) and connecting rod (Paragraph 5.14).

(2) Remove the flywheel as detailed in Paragraph 5.22.

(3) Remove the gear cover. The gear cover is dowelled to the crankcase.

(4) Remove the bolt and gearwheel retaining plate from the gear end of the crankshaft. Replace the bolt in the end of the crankshaft to prevent damage to the threads when using

an extractor. Withdraw the gearwheel using the extractor. The extractor used for this purpose can be obtained from Petters Limited or their representatives.

(5) On the PH2W engine remove the intermediate main bearing housing locking screw (Part 1, Section 5, Figure 5.19) holding the housing in position.

(6) Mark the balance weights to identify the assembly positions. Unscrew the bolts and remove the balance weights and washers.

(7) Remove the bolts securing the flywheel end main bearing housing and withdraw the housing.

(8) Remove the crankshaft by pulling towards the flywheel end.

Oil Pump Gearwheel

Note

The oil pump gearwheel (where applicable) is a shrink fit on the crankshaft and should not be removed unless worn or damaged.

5.27 If it is necessary to renew the oil pump gearwheel care must be taken to fit the gearwheel with its thrust face outermost. If fitted incorrectly the gearwheel will stand proud of the crankshaft radius, making crankshaft endfloat unobtainable. The gearwheel should be heated preferably in an oil bath before fitting to the crankshaft. If using any other method of heating do not overheat or the gearwheel's hardness may be effected.

Crankshaft Maintenance

5.28 Carry out the procedure detailed in Part 1 Section 5.

Main Bearing Maintenance

5.29 Carry out the procedure detailed in Part 1 Section 5.

Flywheel End Oilseal

5.30 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.

Replacement

5.31 To replace the crankshaft carry out the procedure detailed in Part 1 Section 5.

Fitting the Crankshaft Gear

5.32 Fit the crankshaft gear as detailed in Part 1 Section 5.

Crankshaft Endfloat

5.33 Check the crankshaft endfloat, this should not exceed 0.63mm (0.025 in.). The endfloat when new should be 0.13 to 0.38 mm (0.005 to 0.015 in.).

CAMSHAFT

5.34 Refer to Part 1 Section 1.

SECTION 6
COMMON VARIANTS AND ACCESSORIES

INTRODUCTION

6.1 The common variants and accessories including the clutch, speed increasing gear, fuel lift pump and hydraulic pump mounting are identical to all the PH series of engines and are described in Part 1, Section 6. The variant of the water-cooled engine used for marine purposes is described in this section.

MARINE ENGINES

6.2 Petter PHW engines which are built for marine use are identical in construction to the normal PHW engine but are fitted with certain modified components built to withstand the corrosive effects of the marine environment. These components are:

(1) Valve springs (Inner and outer).

(2) Cylinder head core plugs.

(3) Fuel injection pump(s).

(4) Speeder spring(s).

(5) Zinc anodes (corrosion preventatives).

6.3 Protection against electrolytic corrosion is given by hollow zinc anode(s) fitted between the water inlet manifold and cylinder block(s), and these anodes should be checked at regular intervals paying particular attention to engines where direct sea water (raw water) cooling is used. Due to the varied conditions that can exist which effects corrosion, it is not possible to specify a uniform period when the zinc anodes should be checked. Initially it is recommended that the zinc anodes should be checked no later than after six months of vessel ownership, (excluding any period where the vessel is out of the water). Depending on the condition of the anode(s) at this time determines a suitable servicing frequency for the future.

6.4 The cylinder(s) and cylinder head(s) must be flushed out every 1000 operating hours or yearly, depending on which comes first, as follows:

(1) Drain the coolant from the cylinder(s) and cylinder head(s).

(2) Remove the water manifold, joints and zinc anodes.

(3) Insert a suitable piece of wire through the various orifices in the cylinder(s) and cylinder head(s) and rake out any deposit. This operation should be carried out whilst flushing with clean fresh water, preferably under pressure. The use of a suitable descaling agent will assist in removing any inaccessible or stubborn deposits.

(4) Replace the inlet manifold ensuring that the tube portion of the zinc anode(s) are inserted into the inlet water ports of the cylinder(s), not the manifold.

Note

If may be necessary to flush the cooling system at more frequent intervals depending on operating conditions.

SECTION 7
ELECTRICS

7.1 The electrical systems are common to all PH series engines and are 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.

Dust

8.2 In a dust laden atmosphere lubricating oil filters and heavy duty air filters should be fitted.

Covers

8.3 When not in use engines should be protected by a waterproof cover. Under tropical conditions a permanent awning should be provided.

Intermittent Use

8.4 When not in regular use, engines should be run for a thirty minute period each month to lubricate internal parts and remove condensation. External unpainted parts should be wiped clean and lightly oiled. External controls should be lubricated where necessary.

Storage

8.5 Engines despatched from Petters Limited are preserved for storage and should not be disturbed until required for use.

PRESERVATION

8.6 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 1000 hour 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) 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.

(5) Remove air inlet and exhaust manifold 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 be sealed to prevent the ingress of moisture.

(6) If electric starting is fitted, the battery should 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 lubricated and shafts greased.

8.7 Protected engines need no attention while in storage other than to ensure that they are kept dry. Before use ensure that all protective coverings are removed and the engine is prepared for use by carrying out the instructions detailed in Section 1 Paragraph 1.17.

SECTION 9
FAULT FINDING

INTRODUCTION

9.1 This section is a guide to the location of faults that may occur on a PHW engine. Information on causes and suggested remedies are also given.

TABLE 9.1
ENGINE WILL NOT START

Reason	*Causes*	*Suggested Remedy*	*Reference*
Fuel supply failure	No fuel in tank	Fill tank and bleed the fuel system	Sect. 1
Check by operating the fuel pump priming lever and listen for the characteristic squeak in the injector	Air in the pipe line	Bleed the system	Sect. 1
	Broken fuel pipe or leaking connection	Repair or renew the Pipe and tighten the connection	
	Fuel filter choked	Fit new filter element	Part 1 Sect. 3
	Faulty injector nozzle	Fit new nozzle	
	Fuel pump plunger sticking	Fit new pump	Part 1 Sect. 3
	Fuel pump tappet sticking	Free and clean the tappet	Part 1 Sect. 3
	Valves sticking	Free the valves	Sect. 5
	Cylinder head loose	Tighten all nuts	Sect. 5
	Cylinder head gasket blown	Fit new gasket	Sect. 5
Poor Compression	Piston rings stuck in grooves	Check rings and clean the piston	Sect. 5
	Worn cylinder and piston	Overhaul the engine	Sect. 5
	Valves not seating properly	Check valve springs	Sect. 5
		Grind in if necessary	Sect. 5
		Check valve clearance	Sect. 5
Incorrect lubricating oil	Too High a viscosity oil causing excessive engine drag	Drain the sump and fill with correct oil	Part 1 Sect. 2

TABLE 9.2
ENGINE STARTS BUT FIRES INTERMITTENTLY OR SOON STOPS

Reason	*Causes*	*Suggested Remedy*	*Reference*
Faulty fuel supply	Air in fuel lines	Bleed the system	Sect. 1 1
	Water in the fuel	Drain fuel system and fill with clean fuel	Sect. 3
	Faulty injector nozzle	Fit new nozzle	Sect. 3
	Fuel filter choked	Fit new filter element	Part 1 Sect. 3
Faulty compression	Broken valve spring	Fit new spring	Sect. 5
	Sticking valve	Free the valve	
	Pitted valve	Grind or renew	
Dirty exhaust	Blocked exhaust pipe or similar	Clean out	

TABLE 9.3
ENGINE LACKS POWER AND SHOWS DIRTY EXHAUST

Reason	*Causes*	*Suggested Remedy*	*Reference*
Faulty fuel supply	Faulty fuel pump	Fit new pump	Part 1 Sect. 3
	Faulty injector nozzle	Fit new nozzle	Sect. 3
	Unsuitable fuel	Drain the fuel system and fill with correct fuel	Part 1 Sect. 3
Out of adjustment	Valve clearance incorrect	Adjust	Sect. 5
	Fuel timing incorrect	Adjust	Part 1 Sect. 3
	Blocked exhaust pipe or similar	Clean out	
	Dirty air cleaner	Clean out	Part 1 Sect. 4
Dirty engine	Faulty piston ring	Fit new ring	Sect. 5
	Excessive carbon on piston and cylinder head	Decarbonise	Sect. 5
	Worn cylinder and piston	Overhaul the engine	

TABLE 9.4
FAULTY RUNING

Reason	*Causes*	*Suggested Remedy*	*Reference*
Knocking	Carbon on piston crown	Decarbonise	Sect. 5
	Injector needle sticking	Fit new nozzle	Sect. 3
	Fuel timing too far advanced	Adjust timing	Part 1 Sect. 3
	Broken piston ring	Fit new ring	Sect. 5
	Slack piston	Fit new piston ring	Sect. 5
	Worn large end bearing	Renew and check lubrication	Sect. 5
	Loose flywheel	Refit	Sect. 5
	Worn main bearing	Renew and check lubrication	Sect. 5
Overheating	Overload	Reduce the load	
	Lubricating oil failure	Fill the sump and check system	Part 1 Sect. 2
	Cylinder giving unequal power	Check and adjust fuel pump setting	Part 1 Sect. 3
	Excessive valve clearance	Adjust	Sect. 5
	Cooling system failure	Check that the cooling system is in order and free from obstruction	Sect. 4
Speed surges	Overheating	See above	
	Air in fuel pipes	Bleed the system	Sect. 1
	Governor sticking	Free the governor	Part 1 Sect. 5
Sudden stop	Empty fuel tank	Fill tank and bleed the fuel system	Sect. 1
	Choked injector	Fit new nozzle	Sect. 3
	Fuel pipe broken	Repair or renew	
	Seized piston	Fit new piston or, in an emergency, stone down	Sect. 5
	Seized crankshaft	Check bearings	Sect. 5
Heavy vibration	Faulty installation	Check holding down bolts, coupling and alignment.	Part 1 Sect. 1