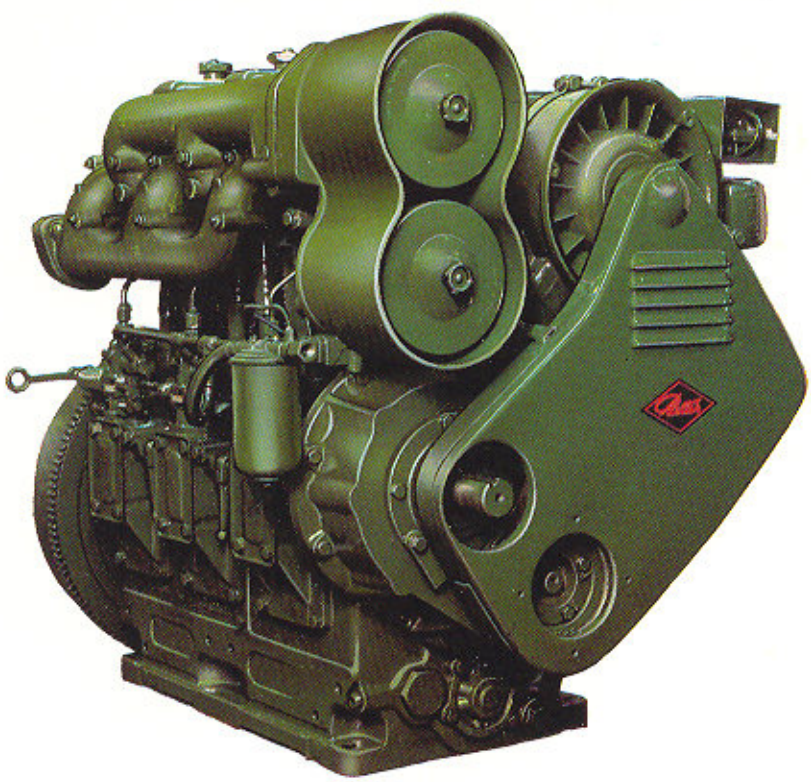
WORKSHOP MANUAL

'PJ' Range



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PETTER PARTS & SERVICE

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PUBLICATION
FIRST EDITION

PJ RANGE
WORKSHOP MANUAL

'PJ' 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 MAKER'S 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 PJ 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 (PJ) and Part 2 the maintenance of the water cooled engines (PJW). The common details of both types of engines are covered in Part 1.

Due to the robust construction and simplicity of design of Petter PJ range of engines they can be relied on 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 0703 452061
Telex 47626 Petter G

For New Engine Enquiries and Orders

Petters Limited
Causeway Works
Staines
Surrey
TW18 3AR
England.

Telephone 0784 51333
Telex 23871 Petter G

Overseas

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

ASSOCIATED PUBLICATIONS

PJ1/2	Operators Handbook
PJ1W/2W	Operators Handbook
PJ3/4	Operators Handbook
PJ3W/4W	Operators Handbook
PJZ/PJWZ	Operators Handbook
PJ1	Petters Parts Interpretation Manual
PJ1W	Petters Parts Interpretation Manual
PJ1Z	Petters Parts Interpretation Manual
PJ1WZ	Petters Parts Interpretation Manual
PJ2	Petters Parts Interpretation Manual
PJ2W	Petters Parts Interpretation Manual
PJ2Z	Petters Parts Interpretation Manual
PJ2WZ	Petters Parts Interpretation Manual
PJ3	Petters Parts Interpretation Manual
PJ3W	Petters Parts Interpretation Manual
PJ4	Petters Parts Interpretation Manual
PJ4W	Petters Parts Interpretation Manual
PJ	Service Hints 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 PJ RANGE

ENGINE

Bore (nominal)	**96.8 mm (3.8125 in.)**
Stroke	**110 mm (4.33 in.)**

Power and Speed per cylinder (continuous rating):

3.7 kW (5 bhp) at 1000 r/min
4.77 kW (6.4 bhp) at 1200 r/min
6.3 kW (8.5 bhp) at 1500 r/min
7.5 kW (10.0 bhp) at 1800 r/min
8.4 kW (11.3 bhp) at 2000 r/min

Cubic capacity per cylinder	**0.810 litres (49.4 in^3)**
Compression ratio	**17.5:1**
Lubricating oil pressure (minimum)	**2.76 bar (40 lbf in^2)**

FUEL TANK CAPACITY (standard engine mounted, one and two cylinder engines only) **9.1 litres (2 gals)**

OIL CAPACITY

PJ1 Engine including filter	**3.4 litres (6 pints)**
PJ1Z Engine	**2.85 litres (5 pints)**
PJ2 Engine including filter	**6.53 litres (11.5 pints)**
PJ2Z Engine	**5.7 litres (10 pints)**
PJ3 Engine including filter	**7.67 litres (13.5 pints)**
PJ4 Engine including filter	**9.94 litres (17.5 pints)**
Clutch (PJ1 and PJ2 only)	**0.3 litres (0.5 pints)**
Speed Increasing Gear (PJ1 and PJ2 only)	**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:

PJ1	**12V**	**50Ah**
PJ2	**12V**	**65Ah**
PJ3	**12V**	**120Ah**
PJ4	**12V**	**120Ah**

FUEL INJECTION RELEASE PRESSURE: 197 to 217 bar (2850 to 3150 lbf in^2)

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

PJ1, PJ2, PJ3 and PJ4

Fixed speed	
Up to 1650 r/min	**23° before TDC**
1651 to 2000 r/min	**26° before TDC**
Variable and two speed	**23° before TDC**
PJ1Z and PJ2Z	
All speeds	**23° before TDC**

FIRING ORDER (FROM GEAR END)

Three cylinder	1, 3, 2	Standard Rotation	1, 2, 3	Reverse	Rotation
Four cylinder	1, 3, 4, 2	Standard Rotation	1, 2, 4, 3	Reverse	Rotation

VALVE TIMING

	Early	Late
Inlet valve opens	**4.5° before TDC**	**13.5° before TDC**
Inlet valve closes	**35.5° after TDC**	**38.5° after TDC**
Exhaust valve opens	**35.5° before TDC**	**38.5° before TDC**
Exhaust valve closes	**4.5° after TDC**	**13.5° after TDC**

TOLERANCES

Camshaft end float:

PJ	**0.13 to 0.71 mm (0.005 to 0.028 in.)**
PJZ	**0.13 to 0.38 mm (0.005 to 0.015 in.)**

TECHNICAL DATA PJ RANGE (continued)

TOLERANCES (continued)

Crankshaft end float (new)	0.203 to 0.508 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 (new)	0.69 to 0.89 mm (0.027 to 0.035 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)	0.68 to 1.09 mm (0.027 to 0.043 in.)
Small end bush diameter (fitted)	30.035 to 30.048 mm (1.1825 to 1.183 in.)
Drive shaft diameter:	
PJ1 and PJ2 engines	47.615 to 47.597 mm (1.8746 to 1.8739 in.)
PJ3 and PJ4 engines	53.964 to 53.944 mm (2.1246 to 2.1238 in.)
PJ1Z and PJ2Z engines	38.05 to 38.07 mm (1.499 to 1.4999 in.)
Clutch (PJ1 and PJ2 engines only)	38.09 to 38.072 mm (1.4996 to 1.4989 in.)
Drive shaft keyway width:	
PJ1 and PJ2 engines	12.67 to 12.7 mm (0.499 to 0.500 in.)
PJ3 and PJ4 engines	15.85 to 15.87 mm (0.624 to 0.625 in.)
Clutch (PJ1 and PJ2 engines only)	9.50 to 9.53 mm (0.374 to 0.375 in.)
PJ1Z and PJ2Z engines	9.50 to 9.53 mm (0.374 to 0.375 in.)
Bearing clearance (new) PJ1, PJ2, PJ3 and PJ4	
Flywheel end main bearing	0.080 to 0.135 mm (0.00275 to 0.00525 in.)
Gear end main bearing	0.051 to 0.115 mm (0.0020 to 0.0045 in.)
Intermediate main bearing	0.064 to 0.102 mm (0.0025 to 0.0040 in.)
Large end bearing	0.051 to 0.089 mm (0.002 to 0.0035 in.)
Bearing clearances (new) PJ1Z and PJ2Z	
Main bearings	0.051 to 0.114 mm (0.002 to 0.0045 in.)
Large end bearing	0.051 to 0.089 mm (0.002 to 0.0035 in.)

CYLINDER REBORING DIAMETERS

Standard	96.965 to 96.99 mm (3.8175 to 3.8185 in.)
Oversize 0.5 mm (0.020 in.)	97.478 to 97.498 mm (3.8375 to 3.8385 in.)
1.0 mm (0.040 in.)	97.981 to 98.006 mm (3.8575 to 3.8585 in.)

TECHNICAL DATA PJ RANGE (continued)

CRANKSHAFT REGRINDING DIAMETERS

PJ1, PJ2, PJ3 and PJ4

	Main journal (gear end)	Main journal (flywheel end)	Intermediate journal and crankpin
Standard	60.287 to 60.274 (2.3735 to 2.3730 in.)	104.673 to 104.661 mm (4.121 to 4.1205 in.)	60.325 to 60.312 mm (2.375 to 2.3745 in.)
Undersize			
0.25mm (0.010 in.)	60.033 to 60.020 mm (2.3635 to 2.3630 in.)	104.419 to 104.407 mm (4.111 to 4.1105 in.)	60.071 to 60.058 mm (2.365 to 2.3645 in.)
0.508 mm (0.020 in.)	59.779 to 59.766 mm (2.3535 to 2.3530 in.)	104.165 to 104.153 mm (4.101 to 4.1005 in.)	59.817 to 59.804 mm (2.355 to 2.3545 in.)
0.762 mm (0.030 in.)	59.525 to 59.512 mm (2.3435 to 2.343 in.)	103.911 to 103.899 mm (4.091 to 4.0905 in.)	59.563 to 59.55 mm (2.345 to 2.3445 in.)
(1.016 mm) (0.040 in.)	59.271 to 59.258 mm (2.3335 to 2.333 in.)	103.657 to 106.643 mm (4.081 to 4.0805 in.)	59.309 to 59.296 mm (2.335 to 2.3345 in.)

PJ1Z and PJ2Z

	Main journal	Intermediate journal and crankpin
Standard	60.287 to 60.274 mm (2.3735 to 2.3730 in.)	63.325 to 60.312 mm (2.375 to 2.3745 in.)
Undersize		
0.25 mm (0.010 in.)	60.031 to 60.02 mm (2.3635 to 2.363 in.)	60.071 to 60.058 mm (2.365 to 2.3645 in.)
0.508 mm (0.020 in.)	59.779 to 59.766 mm (2.3535 to 2.353 in.)	59.817 to 59.804 (2.355 to 2.3545 in.)
0.762 mm (0.030 in.)	59.525 to 59.512 mm (2.3435 to 2.343 in.)	59.563 to 59.55 mm (2.345 to 2.3445 in.)
1.016 mm (0.040 in.)	59.271 to 59.258 mm 2.3335 to 2.333 in.)	59.309 to 59.296 mm (2.335 to 2.3345 in.)

TORQUE SPANNER SETTINGS

Large end bolts	77 Nm (57 lbf ft)
Cylinder head nuts	75 to 88 Nm (55 to 65 lbf ft)
Cylinder crankcase studs	34 to 41 Nm (25 to 30 lbf ft)
Cylinder head rocker support:	
Large nut	88 Nm (65 lbf ft)
Small nut	43 Nm (32 lbf ft)
Gear end extension shaft bolts	30 to 34 Nm (22 to 25 lbf ft)
Flywheel extension shaft bolts:	
PJ1 and PJ2	41 to 47 Nm (30 to 35 lbf ft)
PJ3 and PJ4	61 to 68 Nm (45 to 50 lbf ft)
Flywheel securing bolts PJ1, PJ2	64 Nm (47 lbf ft)
PJ3 and PJ4 only	
Fuel pump high pressure union	54 Nm (40 lbf ft)
Fuel injector nuts	20 Nm (15 lbf ft)
Intermediate main bearing cap:	
PJ2 and PJ2Z	34 Nm (25 lbf ft)
PJ3 and PJ4	54 Nm (40 lbf ft)
Inspection cover bolts	22 Nm (16 lbf ft)
Crankshaft gear retaining bolt	62 Nm (46 lbf ft)
Balance weight bolt	156 to 163 Nm (115 to 120 lbf ft)

TECHNICAL DATA PJW RANGE

ENGINE

Bore (nominal) **96.8 mm (3.8125 in.)**
Stroke **110 mm (4.33 in.)**

Power and Speed per cylinder (continuous rating)

3.7 kW (5 bhp)	**at 1000 r/min**
4.77 kW (6.4 bhp)	**at 1200 r/min**
6.3 kW (8.5 bhp)	**at 1500 r/min**
7.5 kW (10.0 bhp)	**at 1800 r/min**
8.4 kW (11.3 bhp)	**at 2000 r/min**

Cubic capacity per cylinder **0.810 litres (49.4 in^3)**

Compression ratio **17.5:1**

Lubricating oil pressure (minimum) **2.76 bar (40 lbf in^2)**

FUEL TANK CAPACITY (standard engine mounted, one and two cylinder engines only) **9.1 litres (2 gals)**

OIL CAPACITY:

PJ1W Engine including filter	**3.4 litres (6 pints)**
PJ1WZ Engine	**2.85 litres (5 pints)**
PJ2W Engine including filter	**6.53 litres (11.5 pints)**
PJ2WZ Engine	**5.7 litres (10 pints)**
PJ3W Engine including filter	**7.67 litres (13.5 pints)**
PJ4W Engine including filter	**9.94 litres (17.5 pints)**
Clutch (PJ1W and PJ2W only)	**0.3 litres (0.5 pints)**
Speed Increasing Gear (PJ1W and PJ2W only)	**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:

PJ1W	**12V**	**50Ah**
PJ2W	**12V**	**65Ah**
PJ3W	**12V**	**120Ah**
PJ4W	**12V**	**120Ah**

FUEL INJECTION RELEASE PRESSURE: 197 to 217 bar (2850 to 3150 lbf in^2)

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

PJ1W, PJ2W, PJ3W and PJ4W

Fixed speed Up to 1650 r/min	**23° before TDC**
1651 to 2000 r/min	**26° before TDC**
Variable and two speed	**23° before TDC**

PJ1WZ and PJ2WZ

All speeds	**23° before TDC**

FIRING ORDER (FROM GEAR END)

Three cylinder	1, 3, 2	Standard Rotation	1, 2, 3	Reverse Rotation
Four cylinder	1, 3, 4, 2	Standard Rotation	1, 2, 4, 3	Reverse Rotation

VALVE TIMING

	Early	Late
Inlet valve opens	**4.5° before TDC**	**13.5° before TDC**
Inlet valve closes	**35.5° after TDC**	**38.5° after TDC**
Exhaust valve opens	**35.5° before TDC**	**38.5° before TDC**
Exhaust valve closes	**4.5° after TDC**	**13.5° after TDC**

TECHNICAL DATA PJW RANGE (continued)

WATER CAPACITY (RADIATOR)

	Temperate	Tropical
PJ1W engine	5.7 litres (10 pints)	6.8 litres (12 pints)
PJ2W engine	8.5 litres (15 pints)	8.5 litres (15 pints)
PJ3W engine		10.2 litres (18 pints)
PJ4W engine		12.2 litres (22 pints)

WATER CAPACITY (COOLING TANK)

	Temperate	Tropical
PJ1W and PJ1WZ	545 litres (120 gals)	1090 litres (240 gals)
PJ2W and PJ2WZ	1090 litres (240 gals)	2180 litres (480 gals)
PJ3W	1640 litres (360 gals)	3280 litres (720 gals)
PJ4W	2090 litres (460 gals)	4180 litres (920 gals)
Run through water per bhph	13.6 litres (3 gals)	

TOLERANCES

Camshaft end float	
PJW	0.13 to 0.71 mm (0.005 to 0.028 in.)
PJWZ	0.13 to 0.38 mm (0.005 to 0.015 in.)
Crankshaft end float (new)	0.13 to 0.43 mm (0.008 to 0.020 in.)
Crankshaft end float (not to exceed)	0.62 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 (new)	0.25 to 0.41 mm (0.016 to 0.024 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)	0.25 mm (0.010 in.)
Valve depth from cylinder head face (new)	0.68 to 1.09 mm (0.027 to 0.043 in.)
Small end bush diameter (fitted)	30.035 to 30.048 mm (1.1825 to 1.183 in.)
Drive shaft diameter:	1.52 mm (0.060 in.)
PJ1W and PJ2W engines	47.615 to 47.597 mm (1.8746 to 1.8739 in.)
PJ3W and PJ4W engines	53.964 to 53.944 mm (2.1246 to 2.1238 in.)
PJ1WZ and PJ2WZ engines	38.05 to 38.07 mm (1.499 to 1.4999 in.)
Clutch (PJ1W and PJ2W engines only)	38.09 to 38.072 mm (1.4996 to 1.4989 in.)
Drive shaft keyway width:	
PJ1W and PJ2W engines	12.67 to 12.7 mm (0.499 to 0.500 in.)
PJ3W and PJ4W engines	15.85 to 15.87 mm (0.624 to 0.625 in.)
Clutch (PJ1W and PJ2W engines only)	9.50 to 9.53 mm (0.74 to 0.375 in.)
PJ1WZ and PJ2WZ engines	9.50 to 9.53 mm (0.374 to 0.375 in.)
Bearing clearances (new) PJ1W, PJ2W, PJ3W and PJ4W	
Flywheel end main bearing	0.080 to 0.135 mm (0.00275 to 0.00525 in.)
Gear end main bearing	0.051 to 0.115 mm (0.0020 to 0.0045 in.)
Intermediate main bearing	0.064 to 0.102 mm (0.0025 to 0.0040 in.)
Large end bearing	0.051 to 0.089 mm (0.002 to 0.0035 in.)

TECHNICAL DATA PJW RANGE (continued)

TOLERANCES (continued)

Bearing clearances (new)
PJ1WZ and PJ2WZ

Main bearings	0.051 to 0.114 mm (0.002 to 0.0045 in.)
Large end bearing	0.051 to 0.089 mm (0.002 to 0.0035 in.)

CYLINDER REBORING DIAMETERS

Standard	96.876 to 96.901 mm (3.8140 to 3.8150 in.)
Oversize 0.5 mm (0.020 in.)	97.384 to 97.409 mm (3.8340 to 3.8350 in.)
1.0 mm (0.040 in.)	97.892 to 97.917 mm (3.8540 to 3.8550 in.)

CRANKSHAFT REGRINDING DIAMETERS

PJ1W, PJ2W, PJ3W and PJ4W

	Main journal (gear end)	Main journal (flywheel end)	Intermediate journal and crankpin
Standard	60.287 to 60.274 mm (2.3735 to 2.3730 in.)	104.673 to 104.661 mm (4.121 to 4.1205 in.)	60.325 to 60.312 mm (2.375 to 2.3745 in.)
Undersize			
0.25 mm (0.010 in.)	60.033 to 60.02 mm (2.3635 to 2.363 in.)	104.419 to 104.407 mm (4.111 to 4.1105 in.)	60.071 to 60.058 mm (2.365 to 2.3645 in.)
0.508 mm (0.020 in.)	59.779 to 59.766 mm (2.3535 to 2.353 in.)	104. 165 to 104.153 mm (4.101 to 4.1005 in.)	59.817 to 59.804 mm (2.355 to 2.3545 in.)
0.762 mm (0.030 in.)	59.525 to 59.512 mm (2.3435 to 2.343 in.)	103.911 to 103.899 mm (4.091 to 4.0905 in.)	59.563 to 59.55 mm (2.345 to 2.3445 in.)
1.016 mm (0.040 in.)	59.271 to 59.258 mm (2.3335 to 2.333 in.)	103.657 to 106.643 mm (4.081 to 4.0805 in.)	59.309 to 59.296 mm (2.335 to 2.3345 in.)

PJ1WZ and PJ2WZ

	Main journal	Intermediate journal and crankpin
Standard	60.287 to 60.274 (2.3735 to 2.3730 in.)	63.325 to 60.312 mm (2.375 to 2.3745 in.)
Undersize		
0.25 mm (0.010 in.)	60.033 to 60.020 mm (2.3635 to 2.3630 in.)	60.071 to 60.058 mm (2.365 to 2.3645 in.)
0.508 mm (0.020 in.)	59.779 to 59.766 (2.3535 to 2.3530 in.)	59.817 to 59.804 (2.355 to 2.3545 in.)
0.762 mm (0.030 in.)	59.525 to 59.512 mm (2.3435 to 2.343 in.)	59.563 to 59.55 mm (2.345 to 2.3445 in.)
(1.016 mm) (0.040 in.)	59.271 to 59.258 mm (2.3335 to 2.333 in)	59.309 to 59.296 mm (2.335 to 2.3345 in.)

TORQUE SPANNER SETTINGS

Large end bolts	77 Nm (57 lbf ft)
Cylinder head nuts	84 Nm (62 lbf ft)
Cylinder block nuts	176 Nm (130 lbf ft)
Cylinder block crankcase studs	34 to 41 Nm (25 to 30 lbf ft)
Cylinder head rocker support:	
Large nut	88 Nm (65 lbf ft)
Small nut	43 Nm (32 lbf ft)
Gear end extension shaft bolts	30 to 34 Nm (22 to 25 lbf ft)
Flywheel extension shaft bolts:	
PJ1W and PJ2W	41 to 47 Nm (30 to 35 lbf ft)
PJ3W and PJ4W	61 to 68 Nm (45 to 50 lbf ft)
Flywheel securing bolts PJ1W, PJ2W, PJ3W and PJ4W only	64 Nm (47 lbf ft)
Fuel pump high pressure union	54 Nm (40 lbf ft)

TECHNICAL DATA PJW RANGE (continued)

TORQUE SPANNER SETTINGS (continued)

Fuel injector nuts	**20 Nm (15 lbf ft)**
Intermediate main bearing cap:	
PJ2W and PJ2WZ	**34 Nm (25 lbf ft)**
PJ3W and PJ4W	**54 Nm (40 lbf ft)**
Inspection cover bolts	**22 Nm (16 lbf ft)**
Crankshaft gear retaining bolt	**62 Nm (46 lbf ft)**
Balance weight bolt	**56 to 163 Nm (115 to 120 lbf ft)**

FUEL CONSUMPTION CHARTS

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

ENGINE TYPE	Continuous Power & Speed			Fuel Used	
	kW	BHP	r/min	Litres/kW h	Gallons/kW h
PJ1/PJ1W PJ1Z/PJ1WZ	3.70	5.0	1000	.215	.978
	6.30	8.5	1500	.196	.891
	7.5	10.0	1800	.203	.992
	8.4	11.3	2000	.205	.931
PJ2/PJ2W PJ2Z/PJ2WZ	7.5	10.0	1000	.215	.978
	12.7	17.0	1500	.196	.891
	14.90	20.0	1800	.203	.922
	16.8	22.5	2000	.205	.931
PJ3/PJ3W	19.00	25.5	1500	.199	.904
	22.4	30.0	1800	.20	.909
	25.2	33.8	2000	.204	.927
PJ4/PJ4W	25.4	34.0	1500	.199	.904
	29.8	40.0	1800	.20	.909
	33.6	45.0	2000	.204	.927

ENGINE DE-RATING TABLES

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

TOTAL BAROMETRIC PRESSURE
- 100 kN/m² (750.1 mm Hg)

AIR INLET TEMPERATURES
- 300°K (27°C)

RELATIVE HUMIDITY
- 60% (16 mm Hg)

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

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

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

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

Where P = total barometric pressure
PV = water vapour pressure
T = absolute temperature
r = reference conditions
x = site conditions
ηm = mechanical efficiency

Approximate site service powers can be obtained by using the correction factors shown . 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) should be used.

ALTITUDE:
6.5% per 500 m above 150 m.

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

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

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

TABLE 1
PERCENTAGE DE-RATING FOR ALTITUDE

Altitude		De-Rating
Metres	Feet	%
150	492	0
200	656	0.6
300	984	1.9
400	1312	3.2
500	1640	4.5
600	1969	5.8
700	2297	7.1
800	2625	8.4
900	2953	9.7
1000	3281	11.0
1100	3600	12.3
1200	3932	13.6
1300	4265	14.9
1400	4593	16.2
1500	4921	17.5
1600	5249	18.8
1700	5577	20.1
1800	5906	21.4
1900	6233	22.7
2000	6562	24.0
2100	6890	25.3
2200	7218	26.6
2300	7546	27.9
2400	7874	29.2
2500	8202	30.5

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	
	kW	BHP	r/min	Litres/kW h	Gallons/kW h
PJ1/PJ1W PJ1Z/PJ1WZ	3.70	5.0	1000	.215	.978
	6.30	8.5	1500	.196	.891
	7.5	10.0	1800	.203	.992
	8.4	11.3	2000	.205	.931
PJ2/PJ2W PJ2Z/PJ2WZ	7.5	10.0	1000	.215	.978
	12.7	17.0	1500	.196	.891
	14.90	20.0	1800	.203	.922
	16.8	22.5	2000	.205	.931
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(1) Site service power = Engine power under standard reference conditions $\times \alpha$

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

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

Where P = total barometric pressure
PV = water vapour pressure
T = absolute temperature
r = reference conditions
x = site conditions
ηm = mechanical efficiency

Approximate site service powers can be obtained by using the correction factors shown . 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) should be used.

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2100	6890	25.3
2200	7218	26.6
2300	7546	27.9
2400	7874	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	6.0
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%**

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

$$= 7.5 \times .852$$

$$= \mathbf{6.39\ BHP}$$

TOOL LIST

This list details the recommended tools (or equivalents) required to maintain a basic built PJ/PJW Petter diesel engine with no variants fitted.

DESCRIPTION	*SIZE*	*QUANTITY*
Open end spanner	3/16 in. BSF	2
Open end spanner	5/8 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
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 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
Extension (5 in. long)	1/2 in. Drive	1
Socket	5/16 in. BSF	1
Socket	7/16 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
Pin Punch	1/8 in.	1
Micrometer(s) external	0 to 125 mm (0 to 5 in.)	1
Micrometer(s) internal	0 to 100 mm (0 to 4 in.)	
Lead Wire	1.524 mm (0.060 in) thick	As required
Circlip pliers internal		1 pair
Circlip pliers external		1 pair
Torque wrench(es)	0 to 203 Nm (0 to 150 lbf ft)	1
Feeler Gauges		1 set
Screwdriver		1
Flat file		1
Pliers		1 pair
Oil can		1
Grease gun		1
Oil pressure test gauge	0 to 6.76 Bar (0-100 psi)	1
Tachometer		1
Injector cleaning kit		1

SPECIAL TOOLS

This list details the special tools required to maintain a basic build PJ and PJW 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: Crankshaft – Flywheel End PJ1, PJ1W, PJ1Z, PJ2, PJ2W and PJWZ	1	3
Oil Seal Sleeve: Crankshaft – Flywheel end PJ3, PJ3W, PJ4 and PJ4W	1	4
Oil Seal Sleeve (Extension Shaft)	1	5
Valve Collet Extractor	1	6
Fuel Pump Rack Gauge 12.7 mm (0.5 in.)	1	7
Fuel Pump Rack Gauge 20.6 mm (0.8125 in.)	1	7
Flywheel Key Extractor Taper Drift PJZ & PJWZ	1	8
Engine Lifting Attachments (2 sets required for 3 and 4 cylinder engines)	2	9

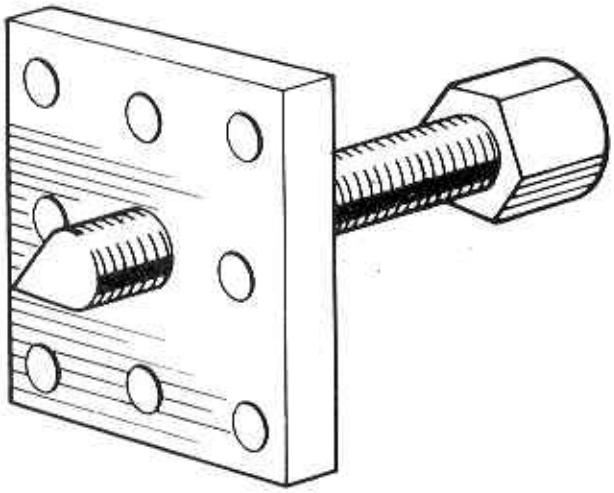

Figure 1 Crankshaft Gear Puller

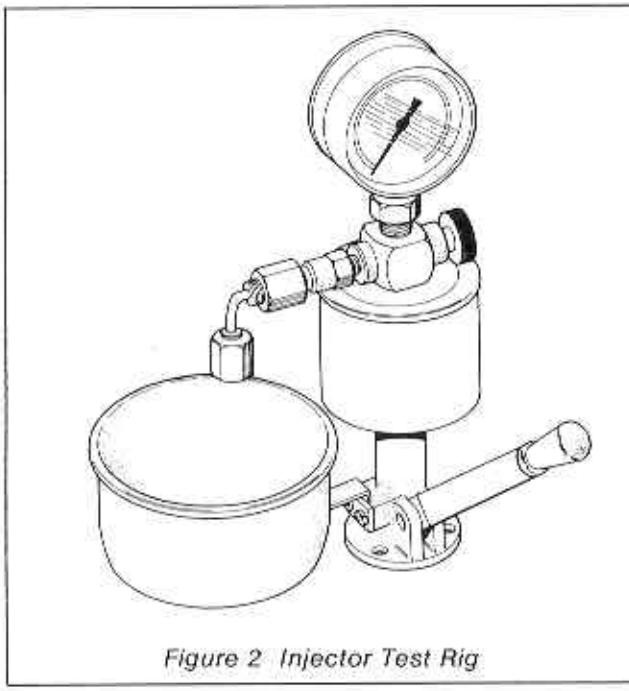

Figure 2 Injector Test Rig

Figure 3 Oil Seal Sleeve Crankshaft Flywheel End PJ1, PJ1W, PJ1Z, PJ2, PJ2W and PJ2WZ

Figure 4 Oil Seal Sleeve Crankshaft – Flywheel End PJ3, PJ3W, PJ4 and PJ4W

Figure 5 Oil Seal Sleeve (Extension Shaft)

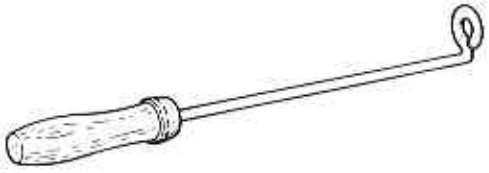

Figure 6 Valve Collet Extractor

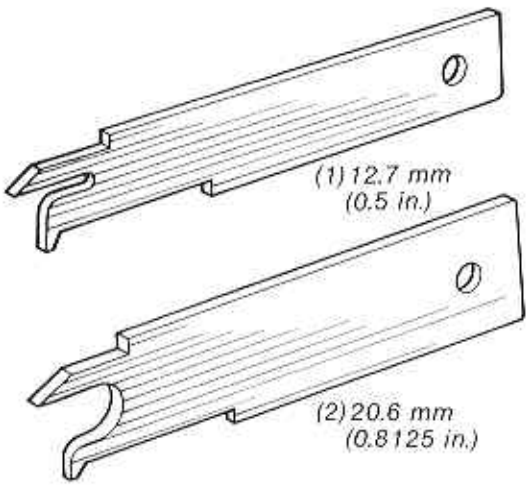

Figure 7 Fuel Pump Rack Gauges

Figure 8 Flywheel Key Extractor Taper Drift PJZ and PJZW

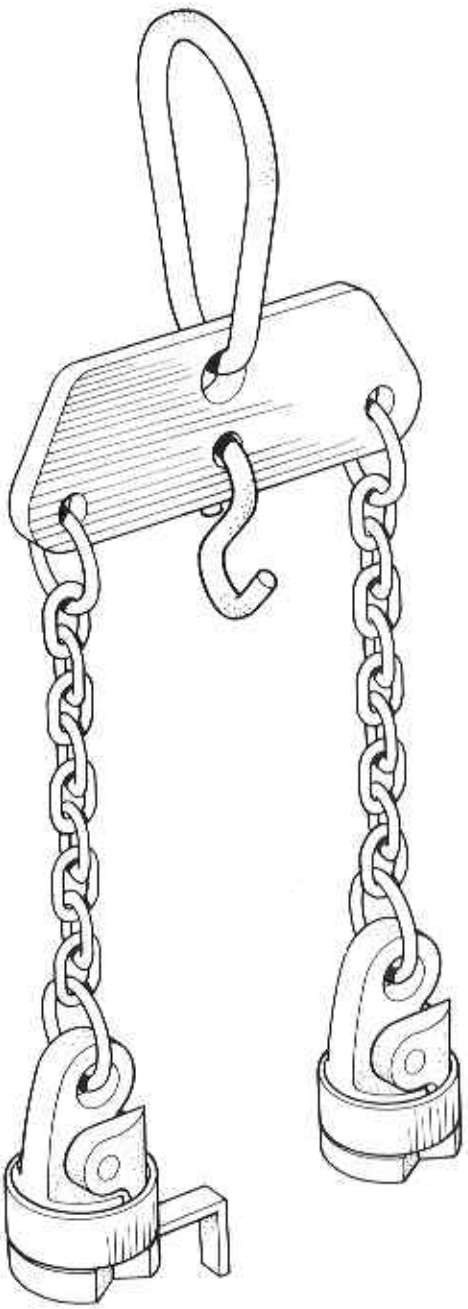

Figure 9 Engine Lifting Attachment

PART 1

AIR COOLED DIESEL ENGINES
PJ1, PJ1Z, PJ2, PJ2Z, PJ3 AND PJ4

PART 1

AIR COOLED ENGINES
PJ1, PJ1Z, PJ2, PJ2Z, PJ3 AND PJ4

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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.

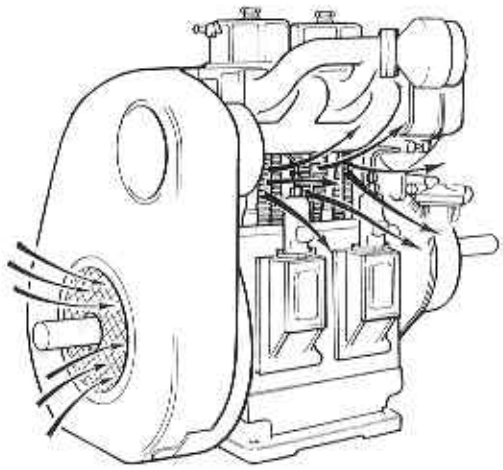
AIR COOLING (Figure 1.1)

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.

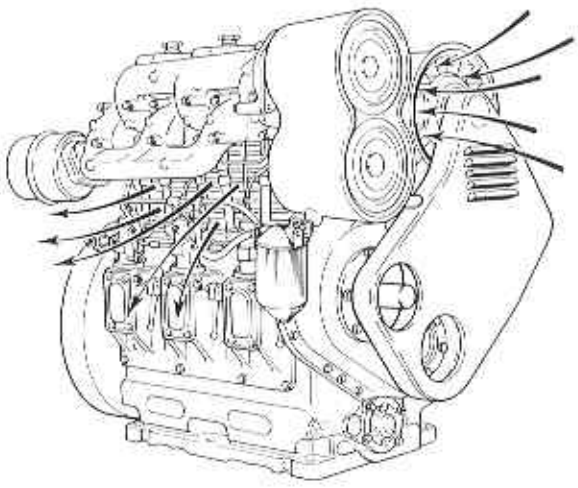
CAUTION

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

1.6 Cooling air is supplied by a centrifugal, flywheel mounted, fan (PJ1 and PJ2) or belt driven axial cooling fan (PJ3 and PJ4) and care must be taken to ensure that the cooling air intake is unobstructed. Engines mounted inside housings or confined spaces must be provided with sufficient correctly placed apertures to give a free flow of air.



(1) One and Two Cylinder



(2) Three and Four Cylinder

Figure 1.1 Cooling Air Flow

CLUTCH (PJ1 and PJ2 only)

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 25 mm (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.

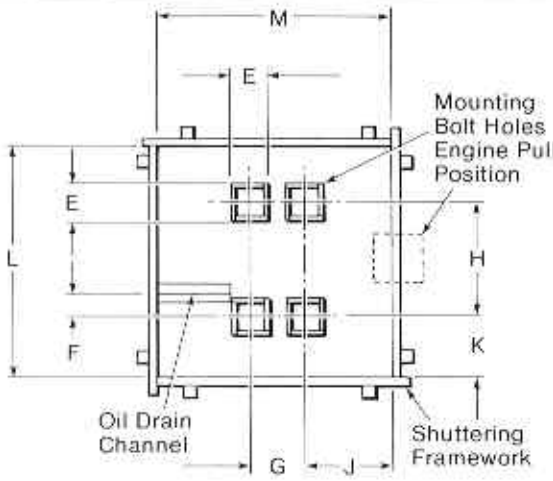
Grouting

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

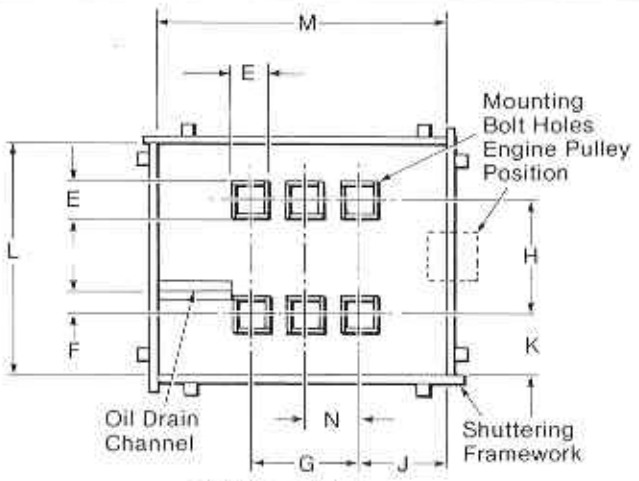
Note

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

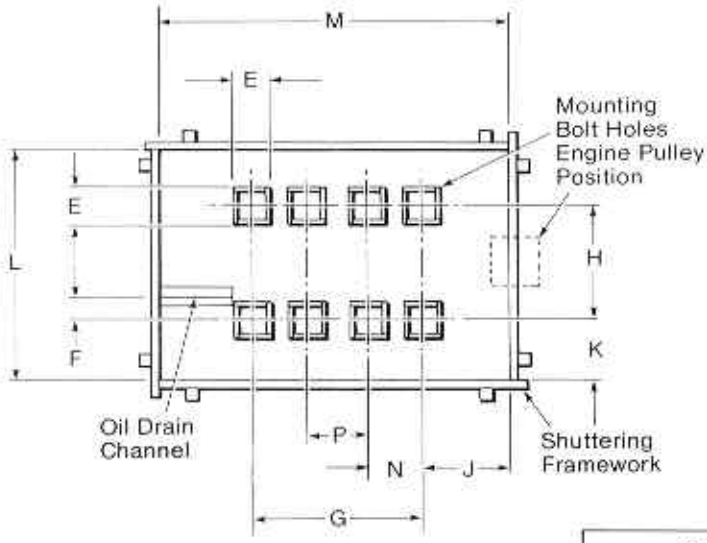
1.11 The final surfaces of the foundation block must be checked to ensure that they are flat, level and at the correct relative heights for engine and driven units. A small allowance (3 mm — 0.125 in. approximately) should be made in the finished height for thin metal strips to be placed under the mounting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



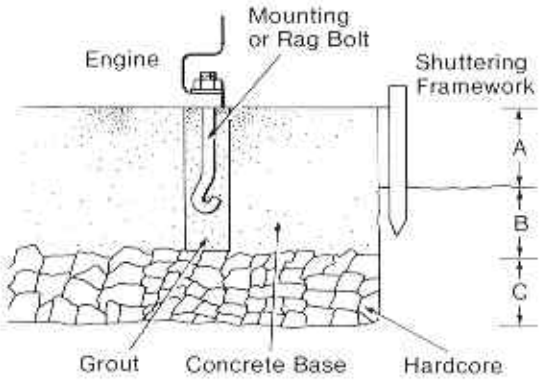
(1) Single and Twin Cylinder



(2) Three Cylinder



(3) Four Cylinder



(4) Fixing Bolts

	Single Cylinder		Twin Cylinder		Three Cylinder		Four Cylinder	
	mm	ins	mm	ins	mm	ins	mm	ins
A	255	10	225	10	225	10	255	10
B	255	10	255	10	255	10	255	10
C	150	6	150	6	150	6	150	6
D	355	14	355	14	355	14	355	14
E	75	3	75	3	75	3	75	3
F	65	2½	65	2½	65	2½	65	2½
G	140	5½	295	11⅝	464	18¼	632	24⅞
H	290	11½	290	11½	290	11½	290	11½
J	230	9	230	9	230	9	230	9
K	150	6	150	6	150	6	150	6
L	610	24	610	24	610	24	610	24
M	610	24	766	30⅛	933	36¾	1107	43⅝
N	–	–	–	–	216	8½	216	8½
P	–	–	–	–	–	–	168	6½

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.

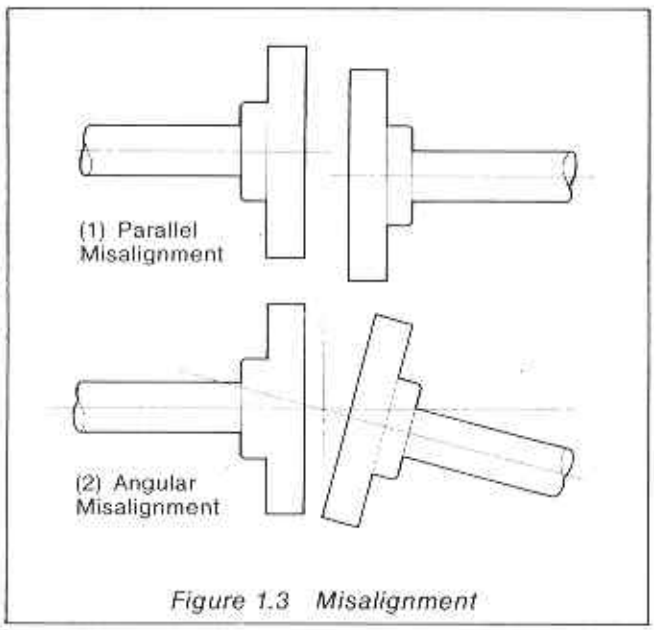
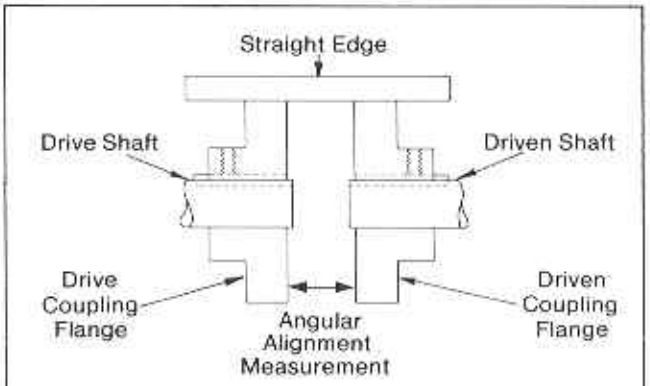
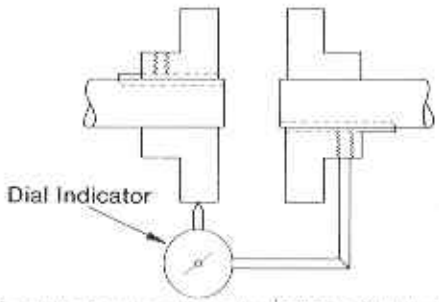


Figure 1.3 Misalignment



(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 that no strain is applied to the flanges, if necessary with the middle section secured gently tap the flanges towards each other at the flange bases.

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

(8) Tighten the grub screws or bolts securing the flanges to the 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 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 accommodate 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 length used as short as possible. The number of bends should be restricted to the minimum and the use of elbows is not recommended.

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

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

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

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

Calculating Exhaust Pipe Sizes

1.22 The use of sharp bends and elbows restricts the flow of exhaust gases and is not recommended. The number of bends should be kept to a minimum, as when the exhaust gas has to pass through a bend the restriction to flow is equivalent to that caused by a much longer piece of pipe. For example a 1 in. BSP pipe bend has the same restriction to flow as a 300 mm (12 in.) length of pipe, whilst a 2 in. BSP bend has the equivalent restriction of 610 mm (24 in.) of straight pipe. As the exhaust pipe size is calculated using the relationship between length and diameter it is therefore necessary to make allowances for the number of bends. This is achieved by calculating a theoretical pipe length corresponding to the number of bends and adding this to the pipe length already determined. In order to establish the exhaust pipe size for a particular installation proceed as follows:

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

(2) Using Table 1.1 determine the pipe size.

(3) Note the number of bends required.

(4) Using Table 1.2 determine the theoretical pipe length corresponding to the number of bends and add to the pipe length noted in paragraph 1.22(1).

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

1.23 Two examples of calculating exhaust pipe sizes are as follows:

(1) **Example 1 — Two Cylinder No Bends**

Actual length 10 m

With reference to Table 1.1 — Exhaust pipe size 2.5 in. BSP.

(2) **Example 2 — Four Cylinder Three Bends**

Actual length 10 m

With reference to Table 1.1 — Exhaust pipe size 3.5 in. BSP

With reference to Table 1.2

Three bends = 3 × 1.1 m = 3.3 m

Calculated length = 10 m (actual length) + 3.3 m (allowance) = 13.3 m

With reference to Table 1.1

Exhaust pipe length 13.3 m (calculated) = 4.5 in. BSP

Therefore exhaust pipe size 4.5 in. BSP × 10 m long.

TABLE 1.1
EXHAUST PIPE LENGTH AND SIZES (BSP) RELATIONSHIP

Exhaust pipe length	*Exhaust pipe size BSP*	
	PJ1, PJ1Z PJ2, PJ2Z	*PJ3, PJ4*
Up to 6 m (20 ft.)	**2 in.**	**2.5 in.**
6 m to 12 m (20 ft. to 40 ft.)	**2.5 in.**	**3.5 in.**
12 m to 18 m (40 ft. to 60 ft.)	**3.5 in.**	**4.5 in.**
18 m to 30 m (60 ft. to 100 ft.)	**4.5 in.**	**5.5 in.**

Note
The 1.5 in. BSP and the 2 in. BSP threaded adaptor fitted to the PJ1, PJ1Z, PJ2, PJ2Z and PJ3, PJ4 engines respectively, is only suitable for fitting the standard "pepper pot" type silencer. If an exhaust pipe of any length is required an expansion nipple must be fitted to the adaptor and the appropriate size of exhaust pipe used as detailed.

TABLE 1.2
PIPE LENGTH ALLOWANCES FOR BENDING

Pipe size	*Add for each bend*
2 in.	**610 mm (2 ft.)**
2.5 in.	**760 mm (2.5 ft.)**
3.5 in.	**1.1 m (3.5 ft.)**
4.5 in.	**1.4 m (4.5 ft.)**
5.5 in.	**1.7 m (5.5 ft.)**

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

SILENCERS

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

Spark Arrestor

1.25 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

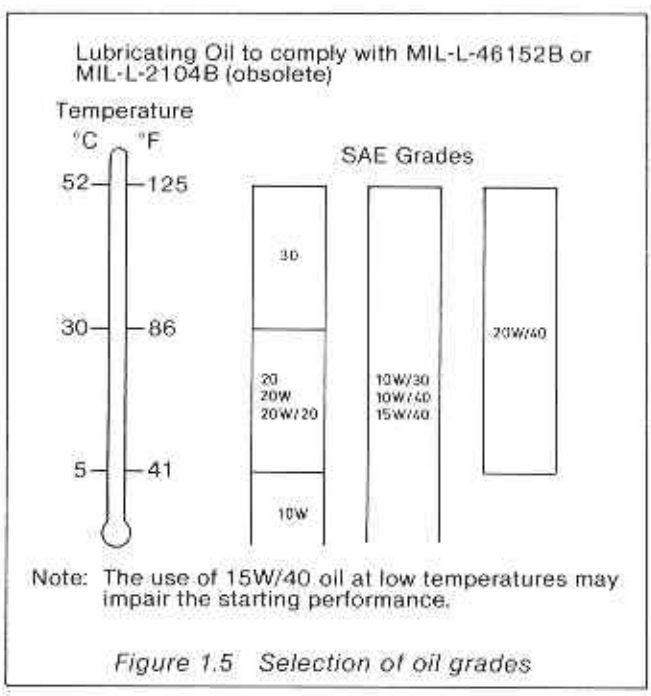
LUBRICATING OILS

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-L-46152-B which supersedes MIL-L-2104-B (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-2104-C 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 : 1970 Class A1 or A2 an extract of which is given in Table 1.3. It is not advisable to use an inferior fuel.

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

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

(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.

TABLE 1.3 EXTRACT FROM BS2869 : 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%**

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

PJ1, PJ2 (Figure 1.6 (1))

1.36 Engine drives for PJ1 and PJ2 are varied and are dependant 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.

(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).

PJ1Z, PJ2Z (Figure 1.6 (2))

1.37 Engine drive for PJ1Z and PJ2Z is at engine speed, flywheel end. Half speed start at end remote from the flywheel (gear end).

PJ3, PJ4 (Figure 1.6 (3))

1.38 The alternative drives available for PJ3 and PJ4 engines are as follows:

(1) Drive at engine speed flywheel end. Half speed start at end remote from the flywheel (gear end).

(2) Main drive at engine speed, flywheel end. Auxiliary drive (up to 22 BHP) at half engine speed at end remote from flywheel. Electrical or mechanical starting.

(3) Drive at engine speed through flywheel end clutch. Half speed start at end remote flywheel (gear end).

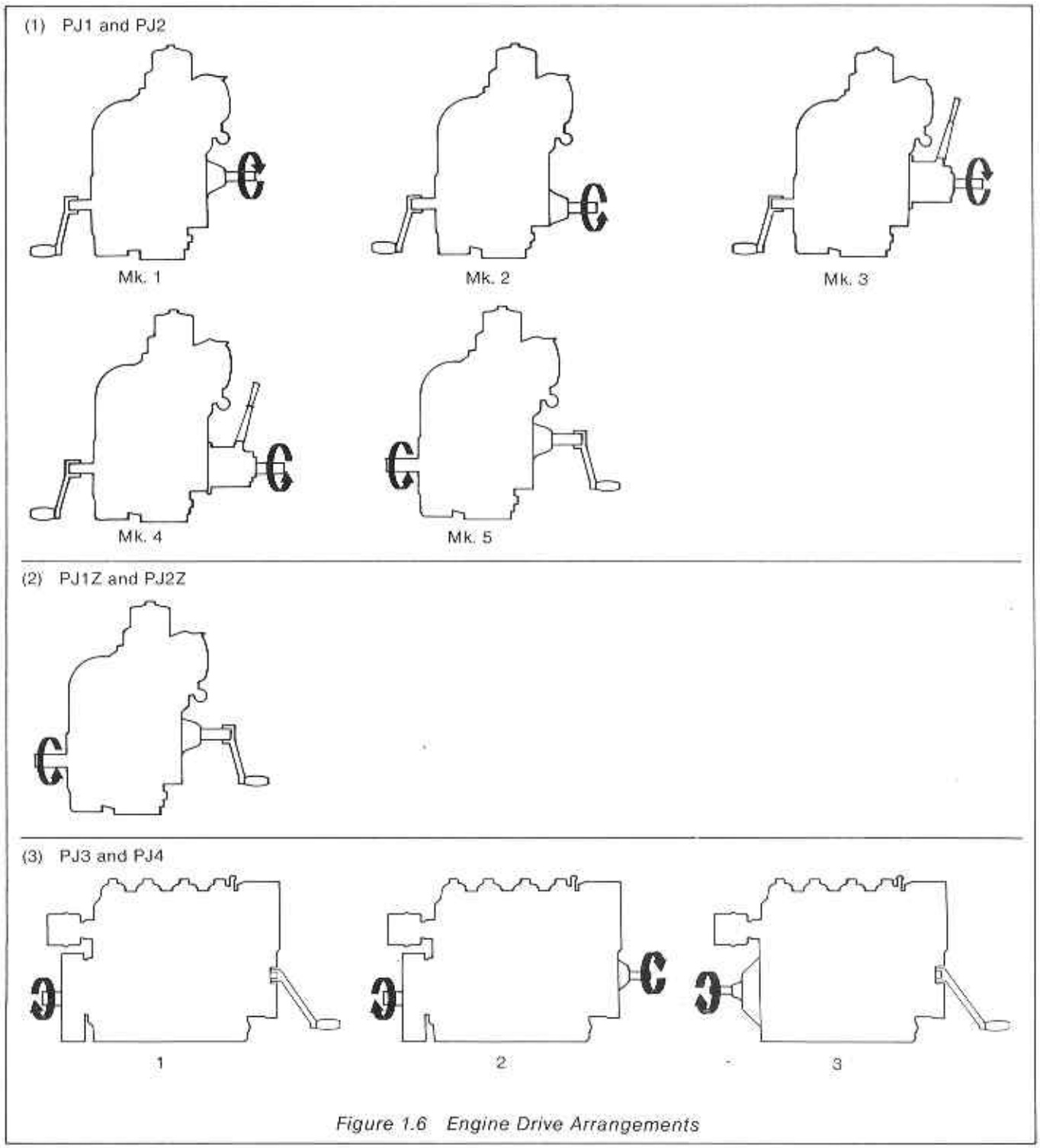


Figure 1.6 Engine Drive Arrangements

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.

PULLEY DRIVE

1.40 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.

1.41 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.

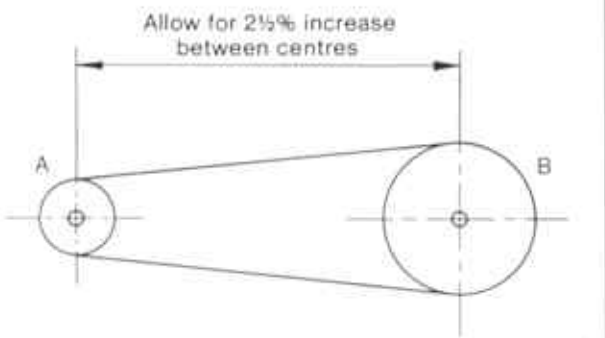


Figure 1.7 Adjustment of Drive Belts

STARTING HANDLE

1.42 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.

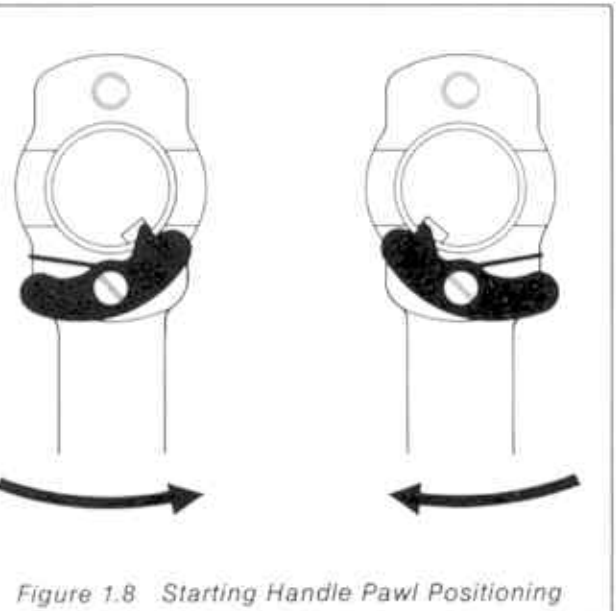


Figure 1.8 Starting Handle Pawl Positioning

OPERATING INSTRUCTIONS

NEW OR OVERHAULED ENGINE

Preparation for Starting

1.43 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 decompressor lever(s) and turn the engine about fifteen times to circulate the oil.

(5) Fill the fuel tank with the appropriate type and grade of fuel (paragraph 1.30 and paragraph 1.31).

(6) Bleed and prime the fuel system as detailed in paragraph 1.44.

Bleeding and Priming the Fuel System

1.44 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, when 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 each subsequent cylinder, if appropriate re-aligning the flywheel mark.

Engine Running In

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

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

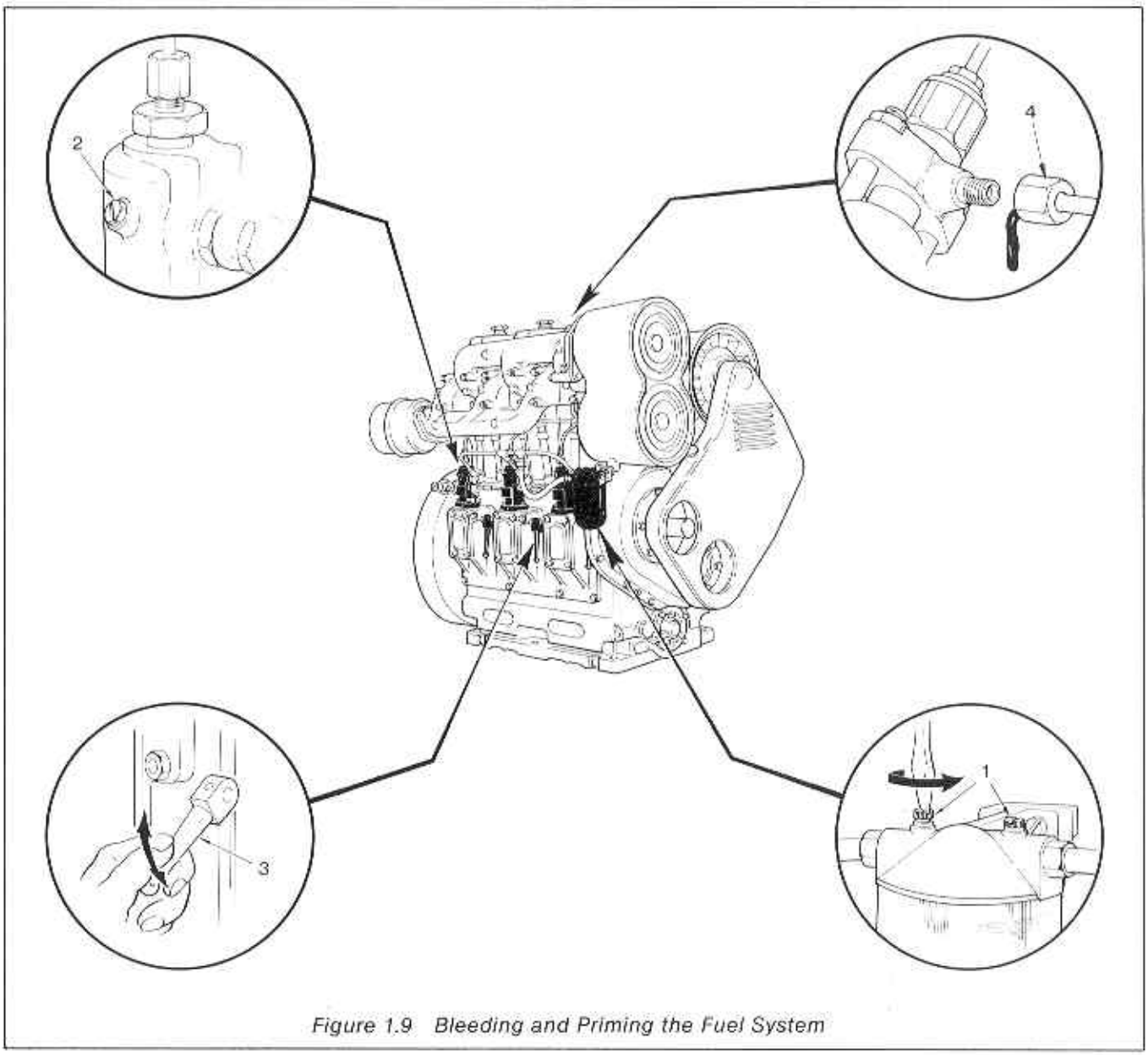


Figure 1.9 Bleeding and Priming the Fuel System

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 for long periods at idling speed 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)

1.46 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 decompressor 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 decompressor lever. The engine should now fire. On multi cylinder engines fitted with separate decompressors, knock down one lever and then as soon as the engine fires, knock down the other lever(s).

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

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

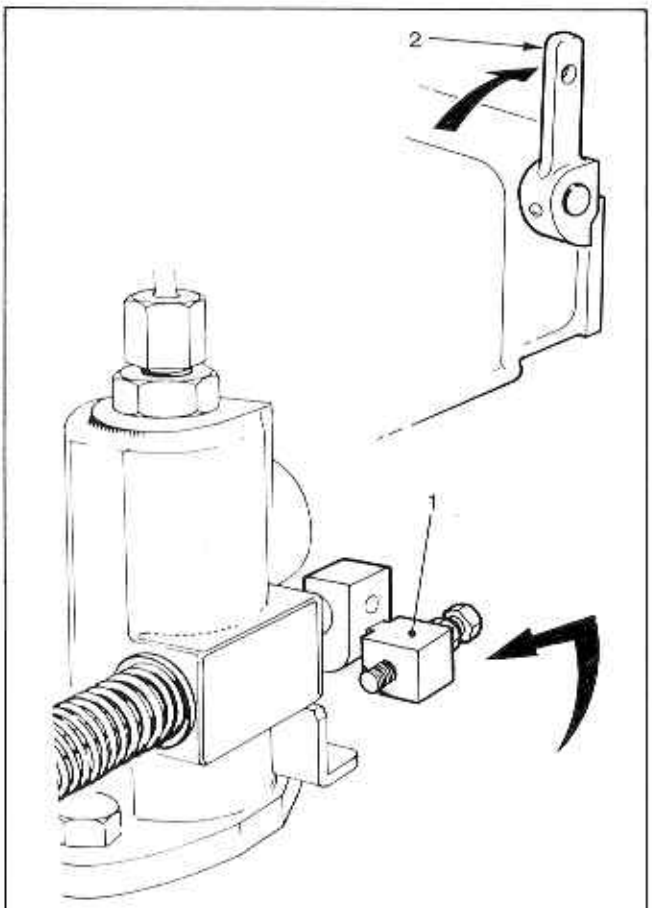


Figure 1.10 Engine Starting Controls

Cold Start

1.48 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.

1.49 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.

Hot Start

1.50 Carry out the following procedure:

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

(2) Lift the decompressor lever(s).

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

(4) Lower the priming lever(s).

(5) Turn the engine as fast as possible. When the engine is turning at a good speed knock down the decompressor lever. The engine should now fire. On multi-cylinder engines, knock down one lever and then as soon as the engine fires, knock down the remaining lever(s).

STOPPING

CAUTION

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

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

OPERATING PRECAUTIONS

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

(1) Do not stop the engine by lifting the decompressor lever(s).

(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

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

PLEASE REMEMBER

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

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

Installation	*Engine Type*		
	PJ1 and PJ2	*PJ3 and PJ4*	*PJ1Z and PJ2Z*
On half-speed extension shaft — Hand Start	**-8°C (17°F)**	**-6°C (21°F)**	**-8°C (17°F)**
On full-speed extension shaft — Hand Start	**5°C (41°F)**	**5°C (41°F)**	—
Electric Start	**-16°C (3°F)**	**-16°C (3°F)**	—

...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

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

(1) With the engine cold, re-torque the cylinder head nuts as detailed in Section 5.
(2) Check the valve clearance.
(3) Drain the lubricating oil from the sump, change the filter element (if applicable) and fill with clean oil (Section 2).
(4) Check the fuel filter (Section 3).
(5) Check the tightness of all nuts (excluding the cylinder head) bolts, securing screws and hose clips.
(6) Check any belt drives.

DAILY CHECKS

1.55 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.
(5) **PJ3 and PJ4:** On the fan belt idler pulley housing, screw the grease cap clockwise half a turn (inwards).

EVERY 50 RUNNING HOURS

1.56 Carry out the following:

(1) **PJ1 and PJ2:** Check the alternator or dynamo drive belt tension, if applicable.
(2) Clean the oil bath type air cleaner, if fitted (Section 4).
(3) **PJ3 and PJ4:** Check the fan belt tension.

EVERY 250 RUNNING HOURS

1.57 Carry out the following procedure:

(1) Clean the fuel filter (Section 3).
(2) Check the tightness of all nuts (excluding the cylinder head), 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).
(15) **PJ3 and PJ4:** Grease the fan bearings as detailed in Section 5.

EVERY 500 RUNNING HOURS

1.58 Carry out the following:

(1) Fit a new fuel filter element (Section 3).
(2) Fit a new air cleaner element(s) (if fitted).

EVERY 2000 RUNNING HOURS

1.59 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.

SECTION 2
LUBRICATING OIL SYSTEM

INTRODUCTION

2.1 The lubricating oil system used on PJ engines incorporates a rotary type oil pump. With the exception of the PJZ type an oil filter is fitted as standard.

DESCRIPTION

2.2 The lubricating oil system 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 pump and then pumped via an adjustable pressure relief valve **(5)** to a full flow oil filter **(6)**. The oil is then fed via a 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 multi-cylinder engines to the intermediate main bearing(s). 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)**. The cylinders, small end bearings and camshaft are splash lubricated. The sump is drained by removing the drain plug **(10)** which is located at the bottom front of the crankcase adjacent to the oil pump. On PJ1, PJ2, PJZ1 and PJZ2 engines only, a second external pipe **(11)** from the distribution bracket feeds oil to the extension shaft bearing.

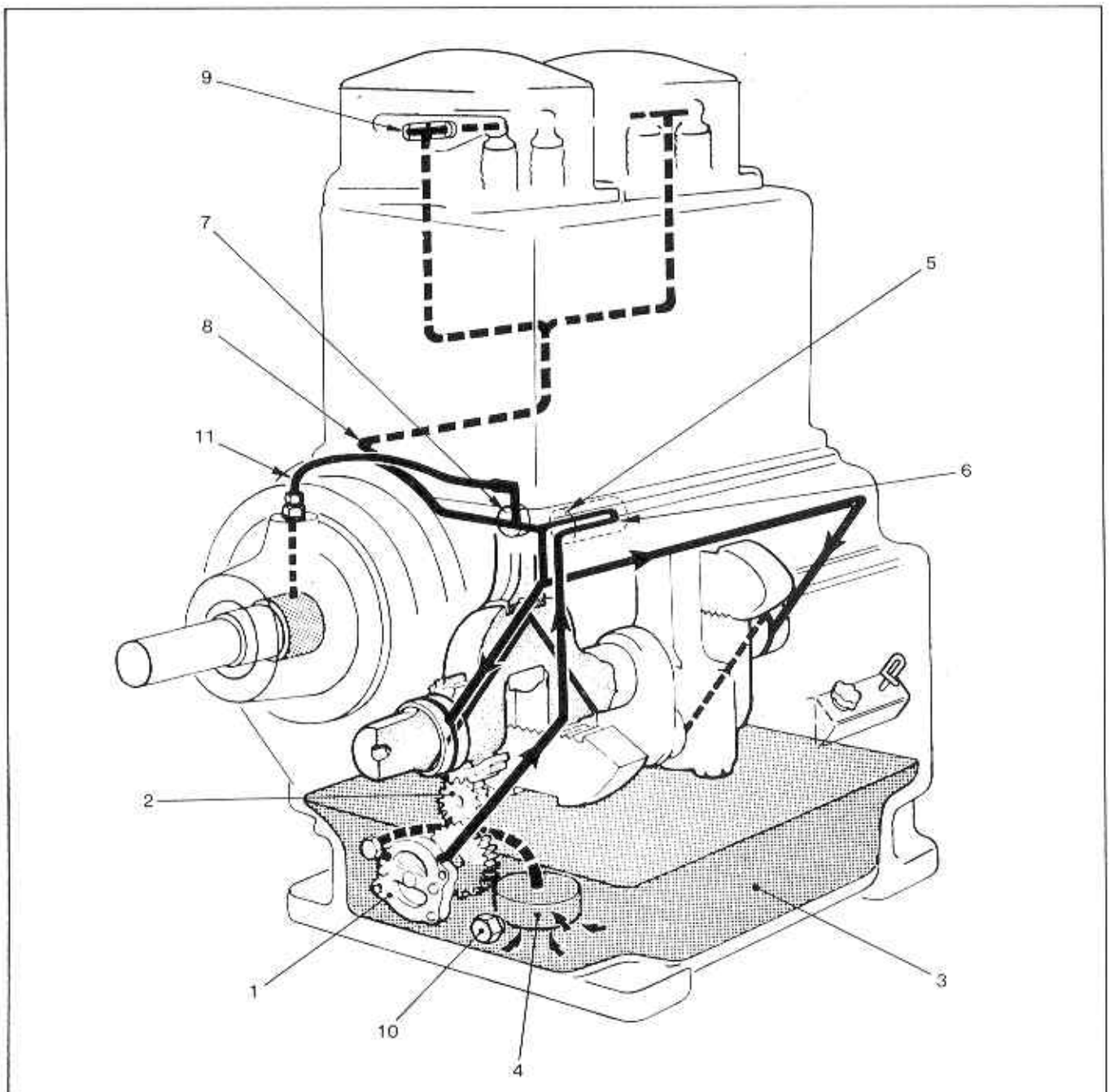


Figure 2.1 Typical Lubricating Oil System

ROTARY OIL PUMP

Removal (Figure 2.2)

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 1/4 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.

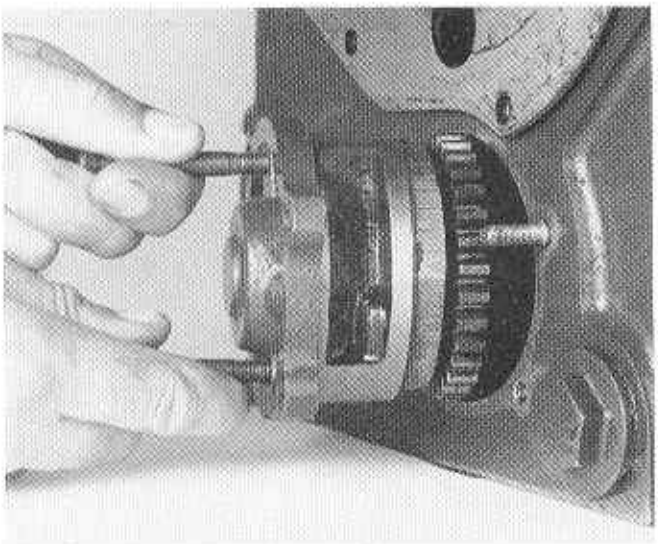


Figure 2.2 Removal of Rotary Oil Pump

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 of wear. If worn fit new parts.

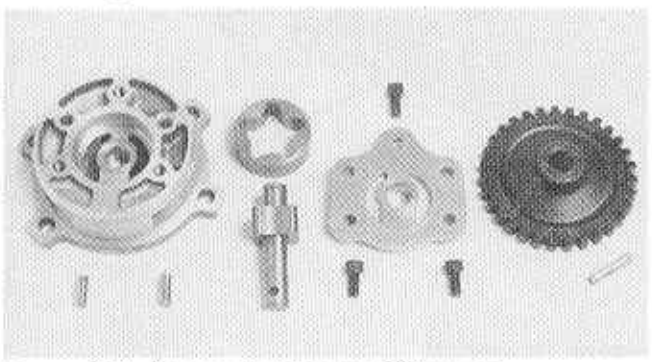


Figure 2.3 Dismantled Rotary Oil Pump

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 Section 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.

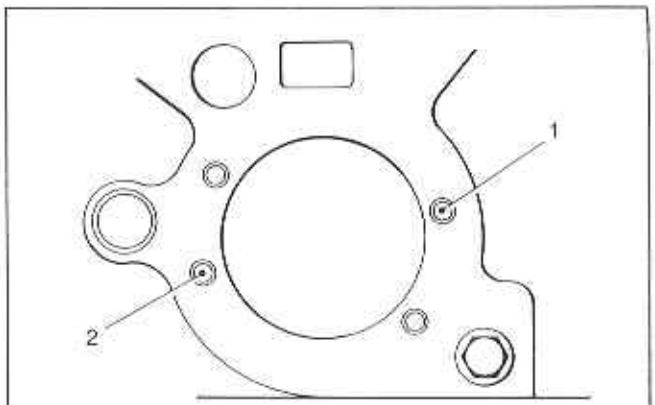


Figure 2.4 Oil Pump Locating Stud

FILTER

2.8 The 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 in the head of the filter. 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 2.24.

OIL RESTRICTOR (Figure 2.5 and 2.6)

Description

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.

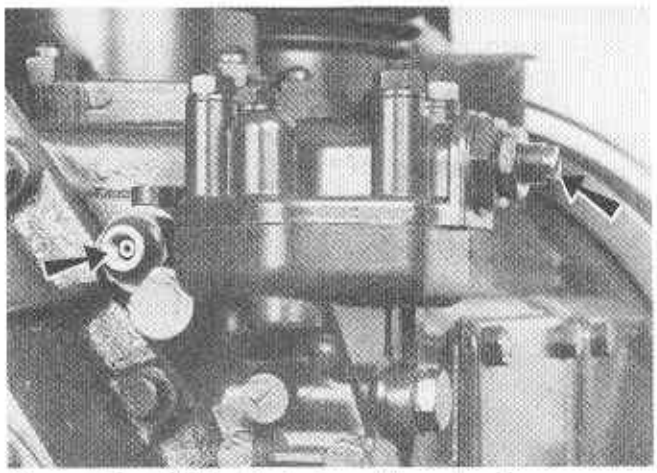


Figure 2.5 Oil Restrictor Location showing Restrictor (arrowed left) and Relief Valve (arrowed right)

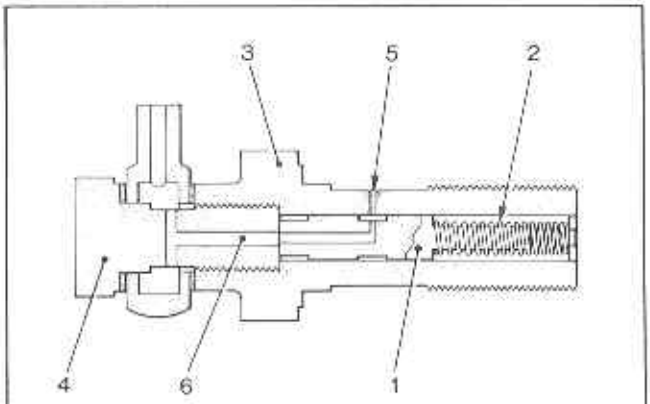


Figure 2.6 Oil Restrictor Sectional View

OIL PUMP STRAINER

Removal

2.16 Drain the oil from the sump by removing the oil drain plug at the bottom of the crankcase.

PJ1, PJ2, PJ1Z and PJ2Z Engines

2.17 Carry out the following procedure:

(1) Remove the crankcase inspection cover.

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

PJ3 and PJ4 Engines

2.18 Carry out the following procedure:

(1) Remove the No. 2 cylinder fuel pump bracket complete with injection pump to allow access to the strainer pipe support bracket. Unfasten the nut, bolt and copper washer securing the support bracket to the crankcase.

(2) Remove the banjo bolt securing the strainer pipe to the crankcase.

(3) Push the strainer pipe end inwards so that the pipe end releases from the crankcase. The pipe can then be moved, as required, allowing the strainer to be separately removed.

Maintenance

2.19 Wash the strainer in clean kerosene.

Replacement

PJ1, PJ2, PJ1Z and PJ2Z Engines

2.20 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 turning and being damaged.

PJ3 and PJ4 Engines

2.21 Carry out the following procedure:

(1) Fit the oil seal in position on the grooved end of the strainer pipe.

(2) Enter the strainer pipe and strainer into the crankcase separately.

(3) Fit the oil pipe into the strainer and then locate the other end in position in the crankcase wall.

(4) Fit the screw retaining the support bracket to the crankcase and secure using the copper washer and self-locking nut.

(5) Fit the joint washer to the banjo bolt. Fit and tighten the banjo bolt.

2.23 Fit the oil drain plug and fill the engine with the approved type and grade of oil (Section 1.26).

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.

2.24 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.

2.25 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 2.24(2).

SECTION 3
FUEL SYSTEM

INTRODUCTION

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

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

PJ1, PJ2, PJZ1 and PJZ2 Engines

3.3 The fuel tank can be either a 9 litre (2 gal.), 18 litre (4 gal.) or a 27 litre (6 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 remote fuel tank.

PJ3 and PJ4 Engines

3.4 The fuel tank mounted on the engine is of a 45 litre (9.9 gal.) capacity. Engines can also be used with a remote fuel tank.

FUEL FILTER

3.5 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)

3.6 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.

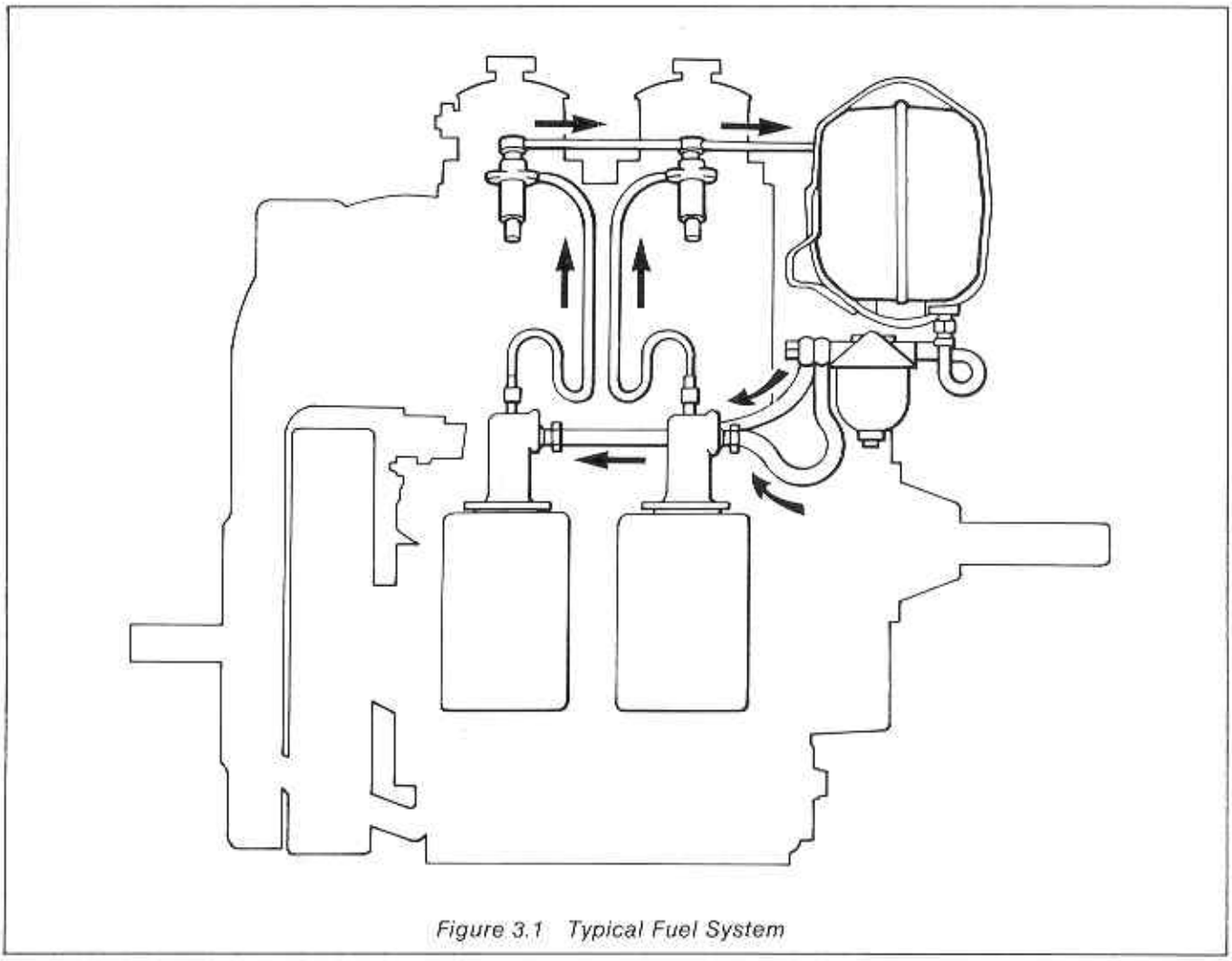


Figure 3.1 Typical Fuel System

Assembly (Figure 3.2)

3.7 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 fit the internal components 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.

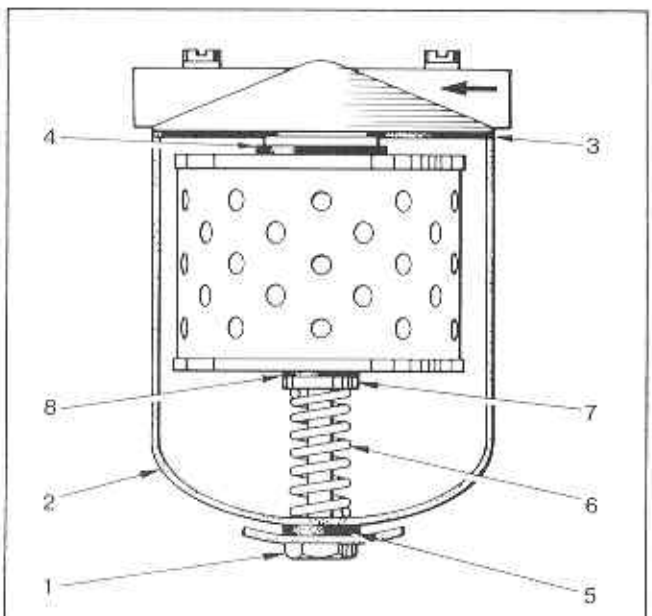


Figure 3.2 Typical Fuel Filter Assembly

FUEL INJECTION PUMP

3.8 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)

3.9 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.

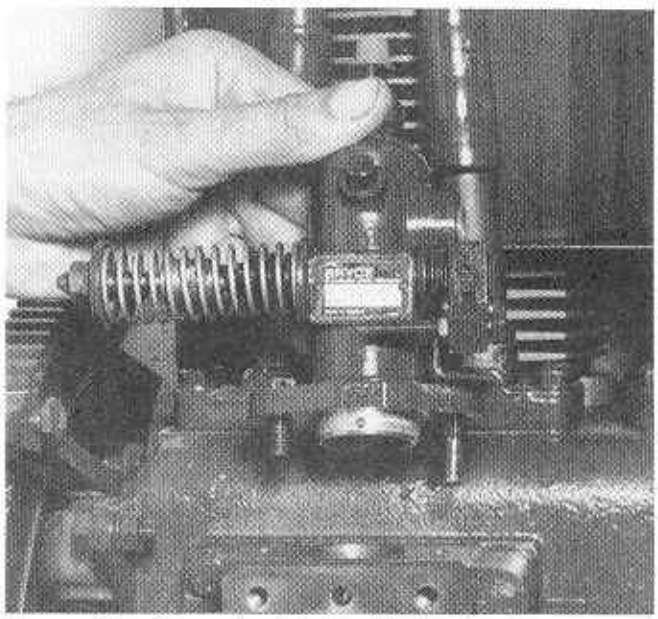


Figure 3.3 Removing the Fuel Injection Pump

Dismantling (Figure 3.4)

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

3.10 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 3.10 (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

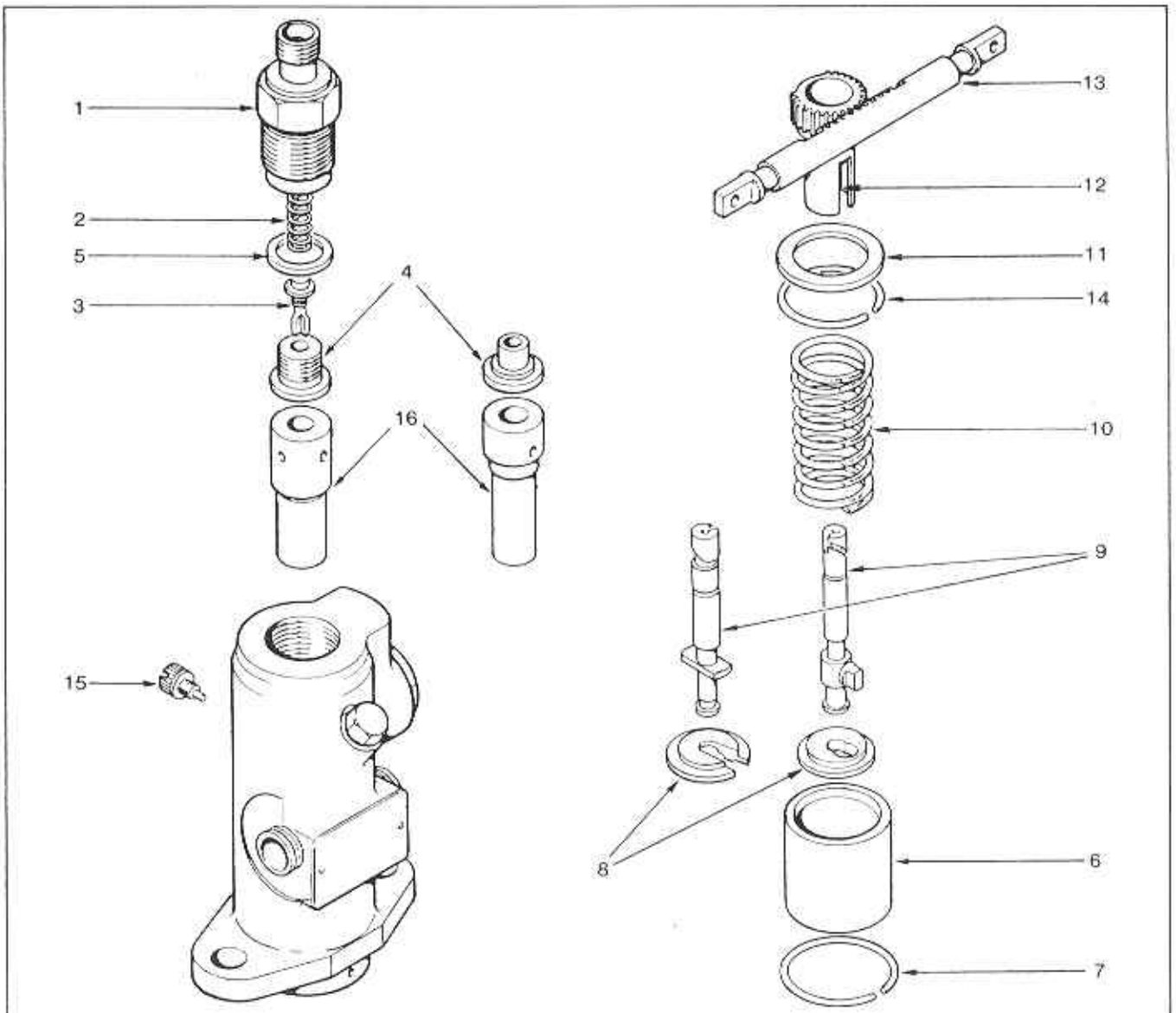


Figure 3.4 Fuel Injection Pump Exploded View

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.

Maintenance (Figure 3.4)

CAUTION

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

3.11 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)

3.12 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

3.13 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 governor fulcrum arm and the fuel pump rack extension (flywheel end pump only). Ensure that there is no clearance between the governor 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)

3.14 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 towards 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

3.15 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 392646 is available for this purpose and is obtainable from Petters Limited or their representatives. Adjust by rotating screw. After pump timing (paragraph 3.16) 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.

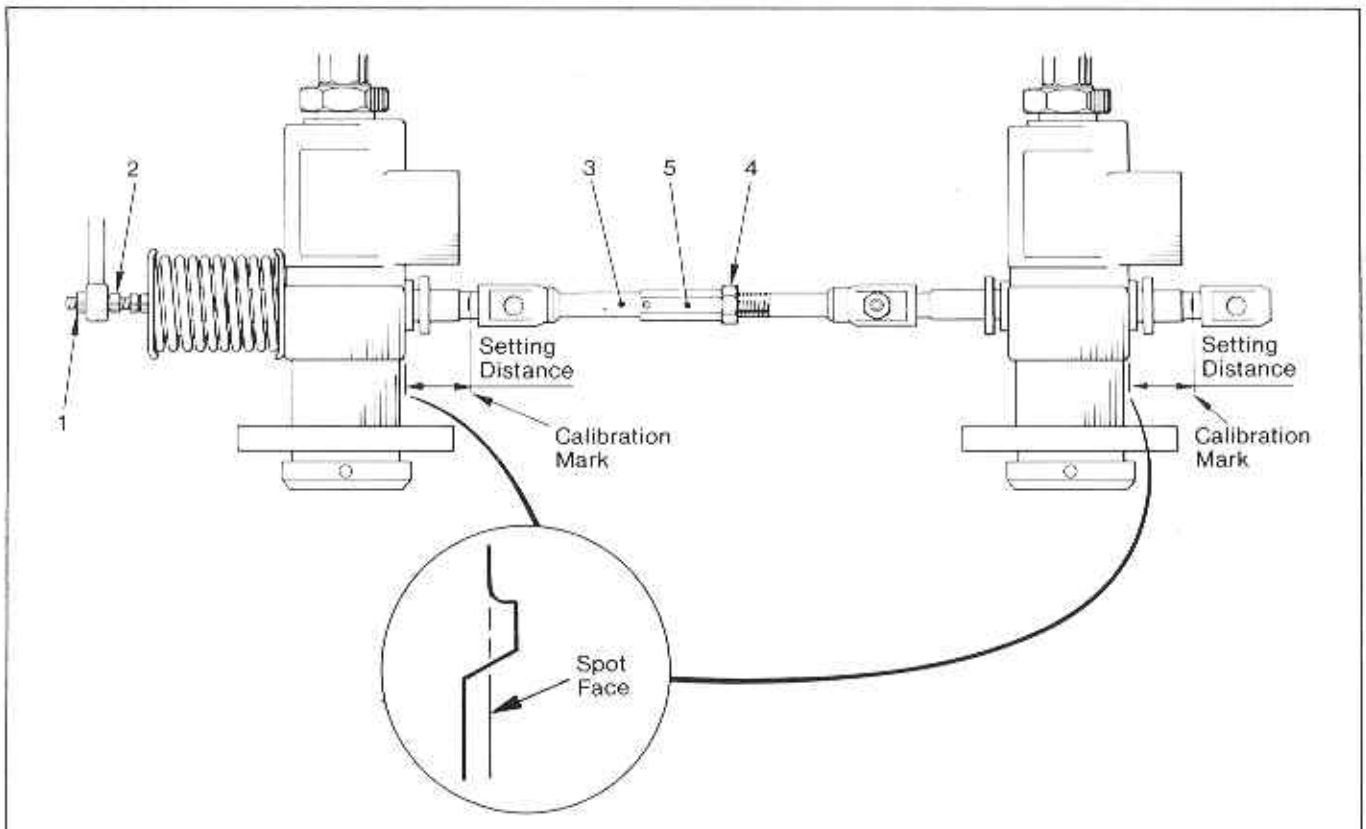


Figure 3.5 Fuel Injection Pump(s): Adjustment

Timing (Figure 3.7)

3.16 To time the fuel injection pump carry out the following procedure on one cylinder at a time:

(1) Remove the four 5/16 in. BSF bolts and spring washers 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 flywheel until the appropriate timing mark (refer to Table 3.1) preceding the TDC mark is opposite the pointer.

(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.

TABLE 3.1 FUEL INJECTION TIMING (BY SPILL)

Engine Speed	*Flywheel Setting*
PJ fixed speed up to 1650 r/min.	**23° BTDC**
1651 to 2000 r/min.	**26° BTDC**
Variable and two speed	**23° BTDC**
PJZ all speeds	**23° BTDC**

(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.).

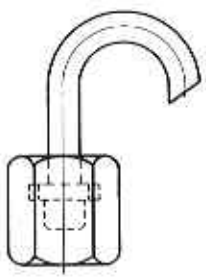


Figure 3.6 Swan Neck Pipe

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

(12) Refit the fuel injection pump bracket cover.

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

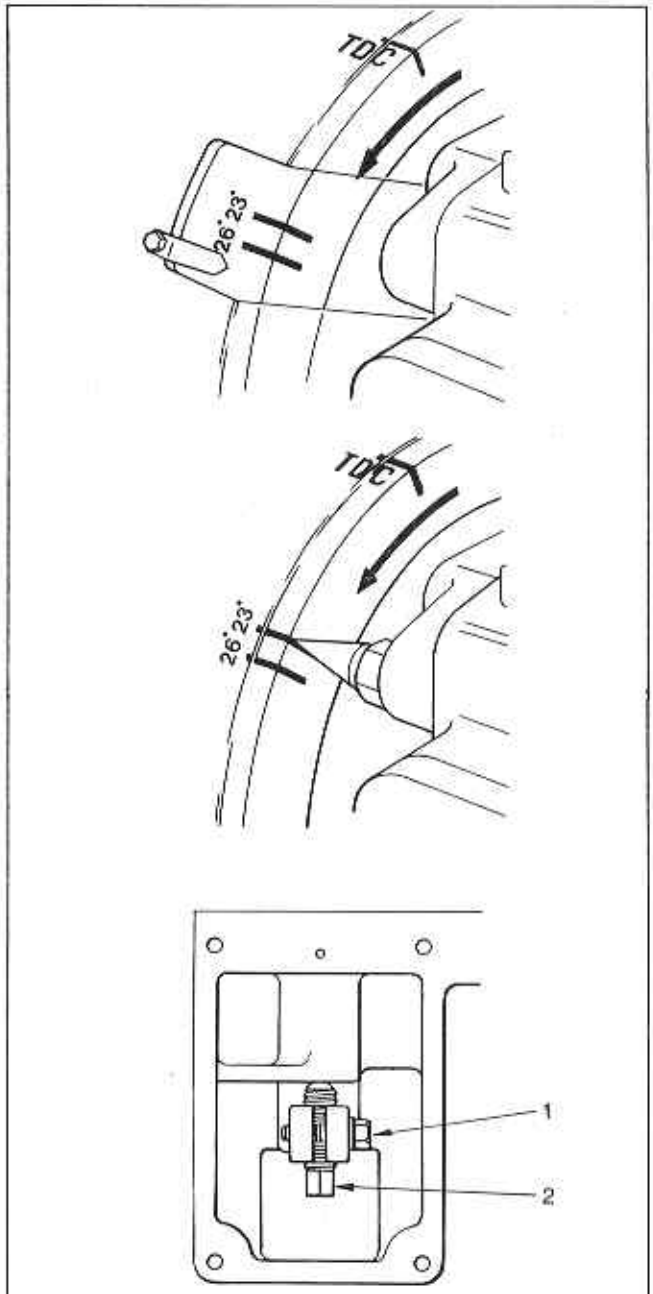


Figure 3.7 Fuel Injector Pump Timing

FUEL INJECTOR

3.17 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 four fine mist sprays of fuel to the cylinder.

Removal

3.18 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. Withdraw the injector cooling sleeve and sealing washer. Ensure that the sealing washer which fits between the cylinder head and cooling sleeve is retained.

Testing (Without a Test Rig)

3.19 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 four 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.

Dismantling (Figure 3.8)

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

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

3.21 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 3.8)

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

3.23 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 discolouration on or above the needle seat.

3.24 Inspect the nozzle body joint face for scratches or damage. Clean the fuel feed holes **(9)** 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.

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

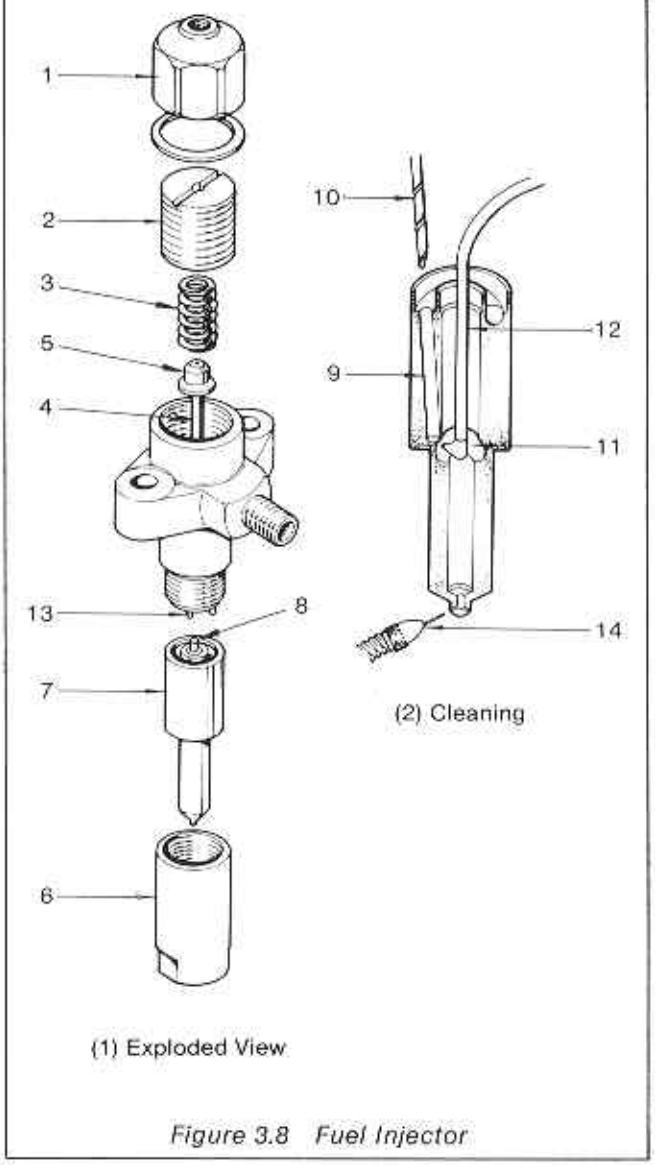


Figure 3.8 Fuel Injector

Assembly (Figure 3.8)

3.26 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 3.27.

Testing and Setting Up (Using a Test Rig)

3.27 Using the test rig (Figure 3.9) 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.

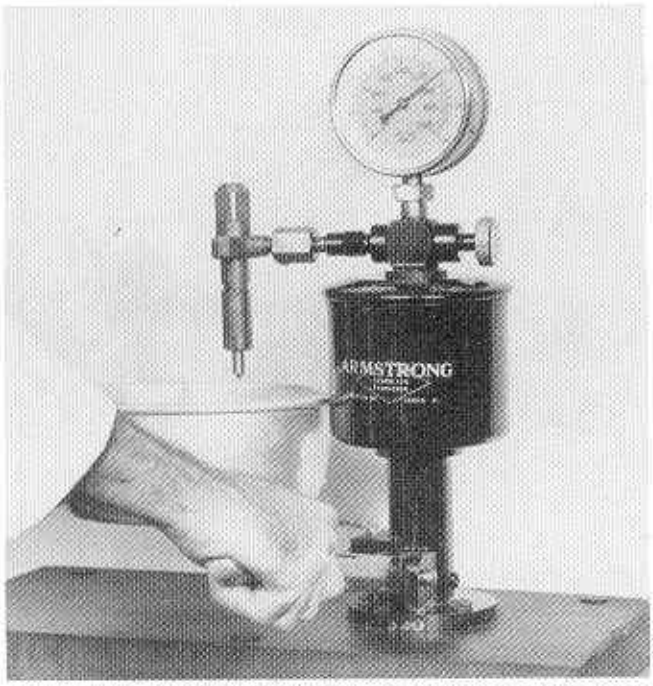


Figure 3.9 Testing the Fuel Injector using a Test Rig

Seat Leakage

3.28 Carry out the following procedure:

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

(2) Continue pumping and adjust the nozzle opening pressure to 197 to 217 bar (2850 to 3150 lbf/in.^{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.

Chatter Test

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

Spray Form

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

Back Leakage

3.31 Set the nozzle opening pressure to 162 to 172 bar (2350 to 2500 lbf/in.^{2}). Raise the pump pressure to 162 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.

3.32 Set the correct nozzle opening pressure to 197 to 217 bar (2850 to 3150 lbf/in.^{2}). Replace and tighten the cap nut. Operate the hand pump a few times with the gauge-cock closed to ensure that all the components have settled and then recheck the pressure.

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

Replacement

3.33 To replace the fuel injector proceed as follows:

(1) Fit a new insulating washer into the cylinder head.

(2) Fit the cooling sleeve into the cylinder head.

(3) Slide the injector into the cooling sleeve.

CAUTION

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

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

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

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

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

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

(7) Tighten the injector flange nuts evenly.

(8) Connect the leak-off pipe.

(9) Bleed the fuel injector.

HIGH PRESSURE FUEL PIPES

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

(1) The pipe(s) must be firmly gripped by the metal clip.

(2) The clip 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.

(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.

SPEED CONTROL ADJUSTMENT

Speed Control (Figure 3.10)

3.35 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 may be required and is 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 3.10)

3.36 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.

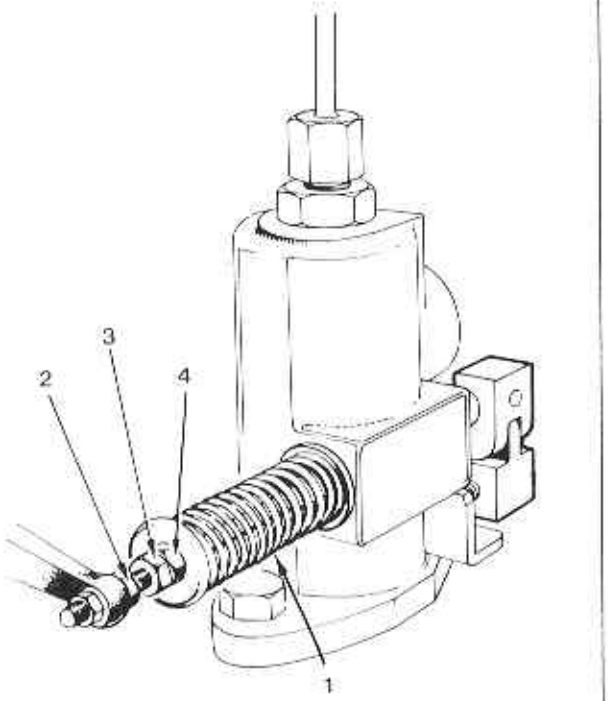


Figure 3.10 Adjusting Speed Control

Adjustable Fixed Speed — Early Type (Figure 3.11)

3.37 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 3.16 and adjust, if necessary.

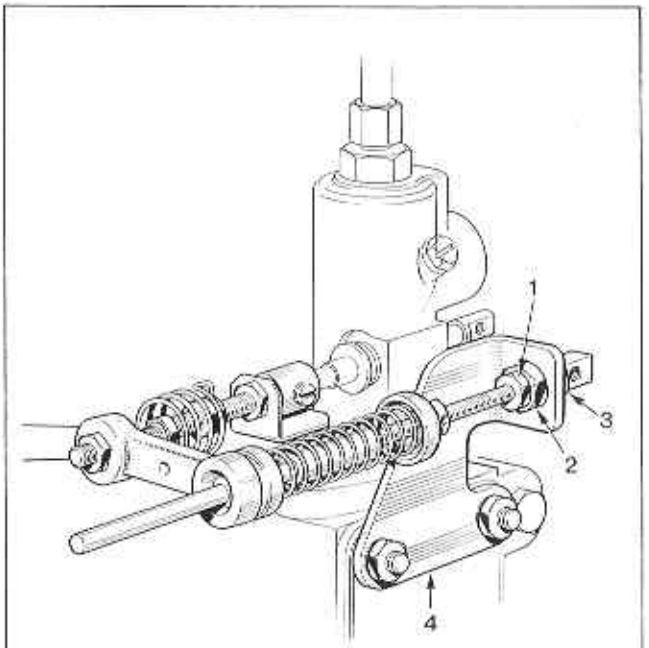


Figure 3.11 Adjustable Fixed Speed Control — Early Type: Adjustment

Variable Speed Control (Figure 3.12)

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 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.

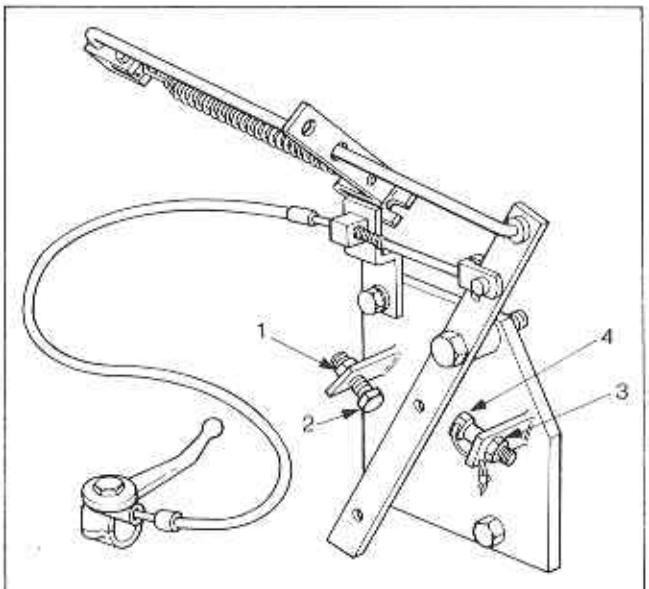


Figure 3.12 Variable Speed Control: Adjustment

Variable Speed Control — Early Type (Figure 3.13)

3.39 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 **(5)** and screw in the adjuster **(6)** 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 **(5)**.

(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.

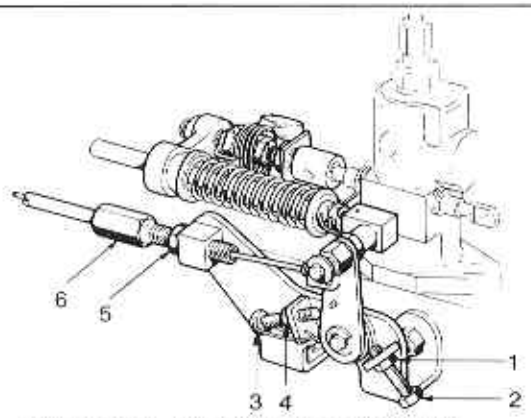


Figure 3.13 Variable Speed Control — Early Type: Adjustment

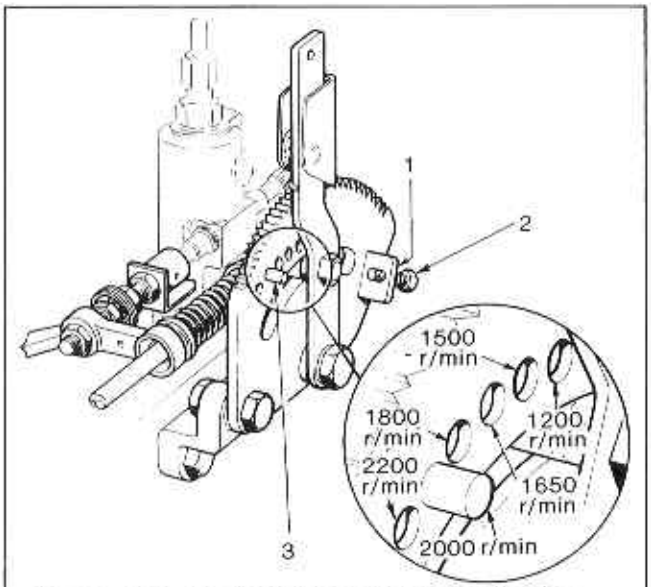


Figure 3.14 Variable Speed Ratchet Control — Adjustment

Variable Speed Ratchet Control (Figure 3.14)

3.40 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 3.15)

3.41 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 **(1)** until the maximum speed is obtained.

(2) Tighten the locknut **(4)** and secure the top 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 3.16.

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.*

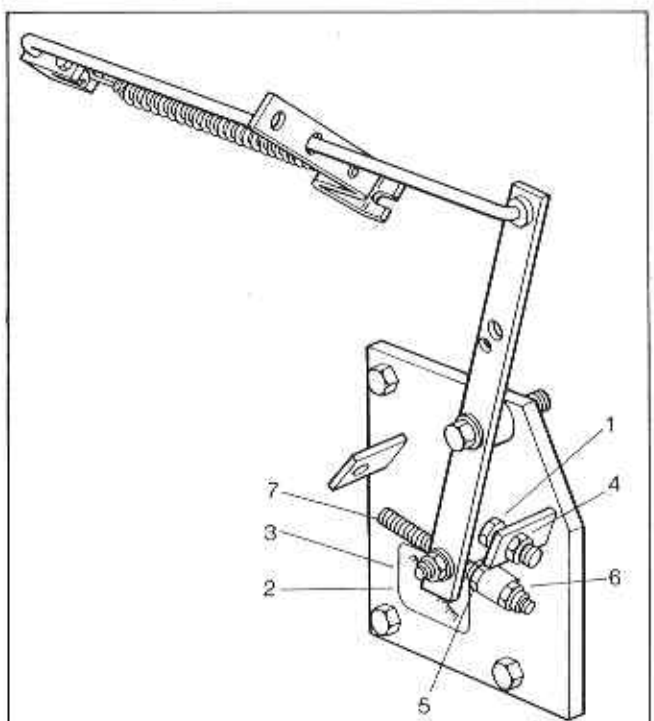


Figure 3.15 Adjustable Fixed Speed: Adjustment

SECTION 4
AIR FILTRATION

INTRODUCTION

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

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

TABLE 4.1 OPERATING CONDITIONS

Dust Concentration	*mg/m³*	*Element Replacement*	*Typical Operating Conditions*
Light	**up to 175**	**Every 500 Hours**	Metalled Roads Machine Shops Ship Auxilaries
Medium	**175 to 350**	**Every 250 Hours**	Sand Pits Unmetalled Roads
Heavy	**350 to 700**	**Every 50 Hours**	Ploughing Dry Soil Temporary Air Strip Road Working Equipment Building Sites
Very Heavy	**700 to 1400**	**Every 10 Hours**	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 an air filtration system can lead to rapid wear of major engine components.

AIR CLEANER PAPER ELEMENT TYPE

Removal

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

Note
PJ3 and PJ4 engines have two covers and two elements fitted.

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 WITH PRE-CLEANER

Removal

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

Maintenance

4.7 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

4.8 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 PJ diesel engine. Major servicing should be carried out by qualified personnel in a workshop environment. It is important that all component parts should be kept clean.

DECARBONISING

5.2 A carbon deposit forms on piston and cylinder heads and the presence of an excessive carbon deposit is usually indicated by a loss of power. Decarbonising necessitates the removal of the cylinder head, followed by the removal of all carbon and the grinding in of the valves.

Cylinder Head Removal (Figure 5.1)

5.3 To remove a cylinder head proceed as follows:

(1) Remove the cylinder cowlings.

(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 lubrication oil feed pipe to the rockers.

(5) Remove the rocker box by unscrewing the large centre nut and lifting the box off.

(6) Unscrew rocker support post nuts and remove the rocker assembly complete with its support and withdraw the push rods noting their position.

Note

It is important that the push rods are refitted in the same position on assembly.

(7) Remove the push rod tubes and note the position of the push rod tube adaptors.

(8) Gradually slacken the cylinder head self-locking retaining nuts in sequence as shown in Figure 5.2

(9) Remove the nuts and lift off the cylinder head.

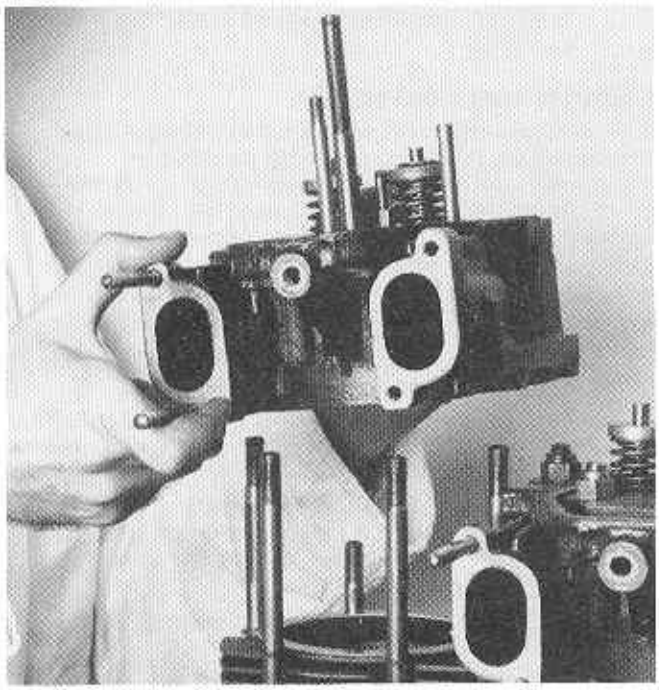


Figure 5.1 Cylinder Head Removal

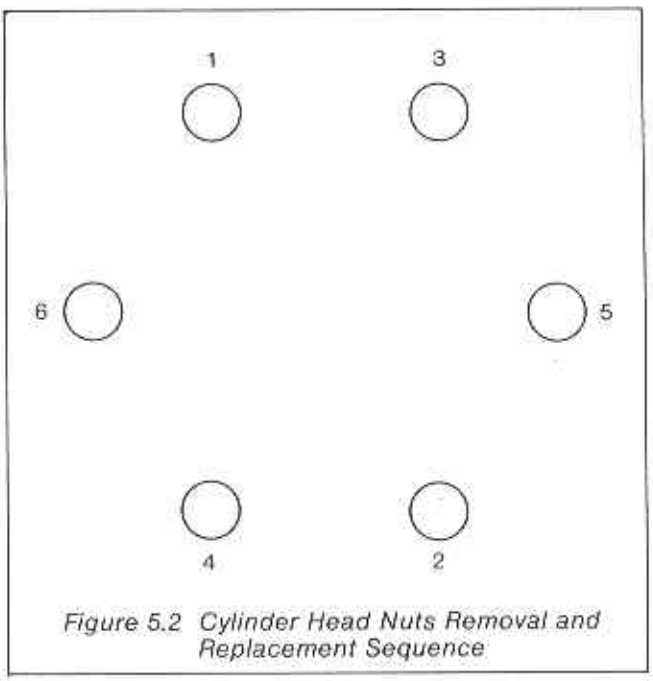


Figure 5.2 Cylinder Head Nuts Removal and Replacement Sequence

Rocker Box Dismantling

5.4 Remove the pin retaining the decompressor shaft. Noting the positions of the washers and oil seal slide them off the shaft. Remove the rocker box plate, decompressor screw and withdraw the shaft.

Cylinder Head Dismantling (Figure 5.3)

5.5 Carry out the following procedure:

(1) Place the cylinder head as shown.

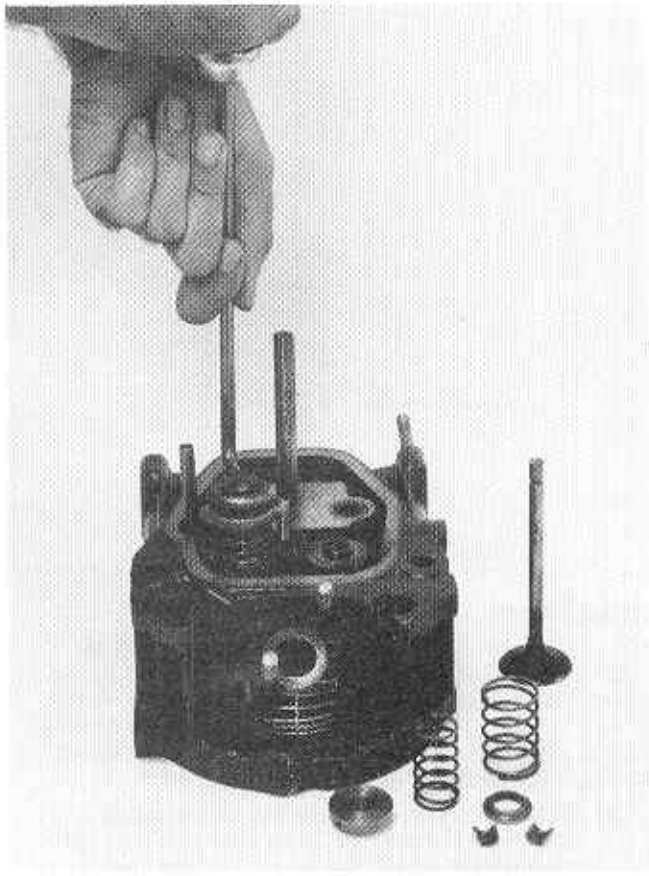


Figure 5.3 Valve Removal

(2) Remove and retain the valve stem caps noting their positions.

(3) On the inlet valve(s) withdraw and disgard the split pin from the top of the valve stem.

(4) Using the special tool, as shown, depress the valve and remove the split collets from the valve stem.

(5) Remove the valve caps and springs noting their positions.

(6) Withdraw the valves, noting their positions.

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) Clean the carbon from the counter-bore at the valve head end of the valve guide bore. (Figure 5.3). Check the valve guides for wear if worn renew the guides.

(4) Clean the valves and check the valve seats. If the valves are badly pitted or distorted it will be necessary to fit new valves. Grind the valves in as detailed in Paragraph 5.8.

(5) If the valve seats are pocketed carry out the procedure detailed in Paragraph 5.7.

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

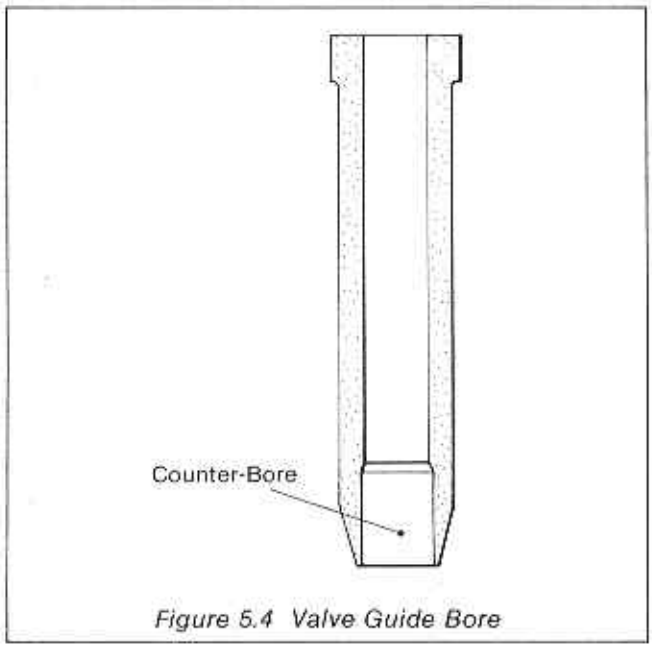


Figure 5.4 Valve Guide Bore

Valve Seats

5.7 If the valve seats are badly pocketed and cutting the valve seats back will exceed the flame face-to-valve head clearance 0.68 mm to 1.09 mm (0.027 in. to 0.043 in.) as shown in Figure 5.5 valve inserts must be fitted. Suitable valve seat inserts can be supplied and are fitted as follows:

(1) Bore each valve port to the dimensions shown in Figure 5.6. It is essential not to machine the cylinder head beyond the dimensions shown.

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

(3) Machine the valve seats concentric to the valve guide bore to the dimensions shown in Figure 5.6.

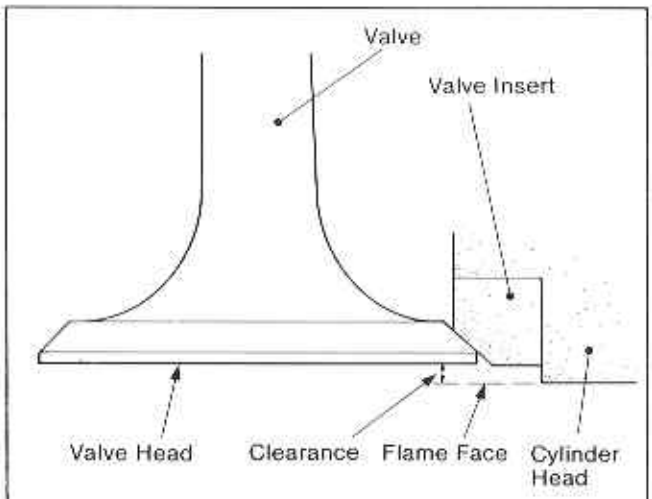


Figure 5.5 Flame Face-to-Valve Head Clearance

Valves: Grinding In

5.8 To grind the valves in proceed as follows

(1) Lightly lubricate the valve stem with engine oil.

(2) Place a very small quantity of grinding paste evenly around the valve face and insert the valve in its correct seat. Partially rotate the valve backwards and forwards on its seating, exerting a gentle but firm pressure.

(3) Periodically lift the valve from its seating and rotate it through approximately 120°. It is unnecessary to continue grinding once the faces of the valve and its seating have a clean, even matt-surfaced appearance.

(4) Remove all traces of grinding paste.

(5) Replace the valves and rotate them backwards and forwards a few times. If the valves have been correctly ground a thin polished line will appear all round the mating surfaces.

Cylinder Head Assembly

5.9 If new valves, or valve seat inserts are fitted the valves must be ground in as detailed in Paragraph 5.8. Before assembling lightly oil the valve stems with engine lubricating oil. If the original valves are being refitted ensure that the exhaust and inlet valves are returned to their correct positions as noted in Paragraph 5.5(6).

5.10 To assemble the cylinder head proceed as follows:

(1) Locate the valves in the valve guides.

(2) Assemble the valve spring plate, springs and valve cup to the appropriate valve, as noted in Paragraph 5.5(4).

(3) Using the special tool depress the valve springs and fit the collects, ensure that the inlet guide spring cap is correctly located on its guide pin.

(4) Fit a new split pin in the top stem of each inlet valve.

(5) Fit the valve stem caps as noted in Paragraph 5.5 (2).

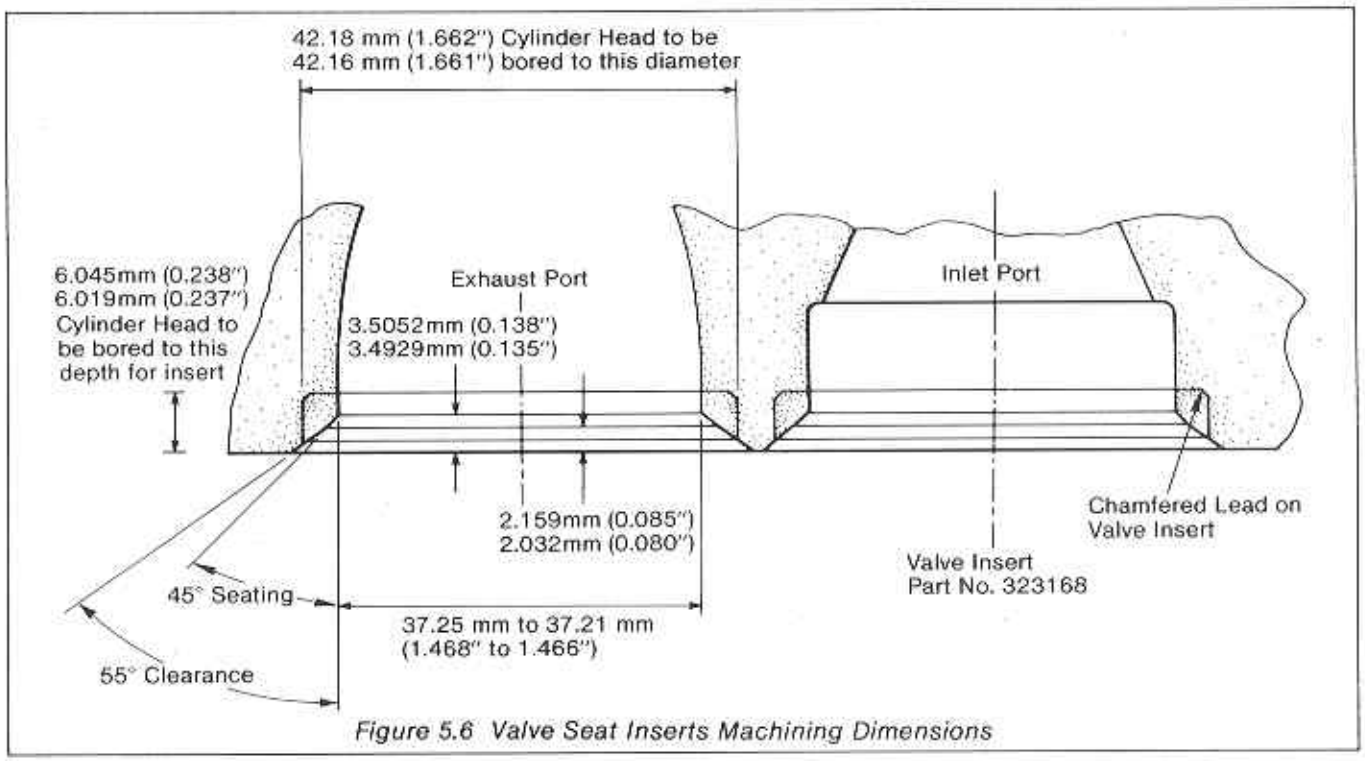


Figure 5.6 Valve Seat Inserts Machining Dimensions

Rocker Box Assembly

5.11 To assemble the rocker box proceed as follows:

(1) Replace the decompressor shaft.
(2) Fit the washers and oil seal in the order noted in Paragraph 5.4.
(3) Fit the decompressor shaft split pin.
(4) Fit the decompressor screw.

Cylinder Head Replacement

5.12 To replace the cylinder head proceed as follows:

(1) Fit a new cylinder head gasket and lower the head over the studs into position.
(2) On multi-cylinder engines ensure that the manifold bolting faces are parallel with each other. Check with a straight edge as shown in Figure 5.7, or by bolting on a manifold.
(3) Fit the cylinder head nuts. Tighten each nut in turn sufficiently to touch the cylinder head. Do not compress the cylinder head gasket.
(4) With reference to Figure 5.2 tighten each nut a quarter of a turn at a time in the sequence shown. Each nut must be finally tightened to a torque loading of 81 Nm (60 lbf ft).
(5) Assemble the push rod tube as shown in Figure 5.8 ensuring that the oil seals and washer/'O' rings are in good condition and seating correctly. Where push rod tube covers are fitted ensure that the ends are folded inwards to form a dust and oil tight seal. Ensure that the push rod tube adaptors are fitted in position as noted in Paragraph 5.3(8).
(6) Lightly lubricate the push rods with engine oil and fit in the positions noted in Paragraph 5.3(6).
(7) Fit the rocker support and secure using the two self-locking nuts.
(8) Connect the rocker lubrication oil feed pipe.
(9) Fit the fuel injector (Section 3).
(10) Fit the inlet and exhaust manifolds.

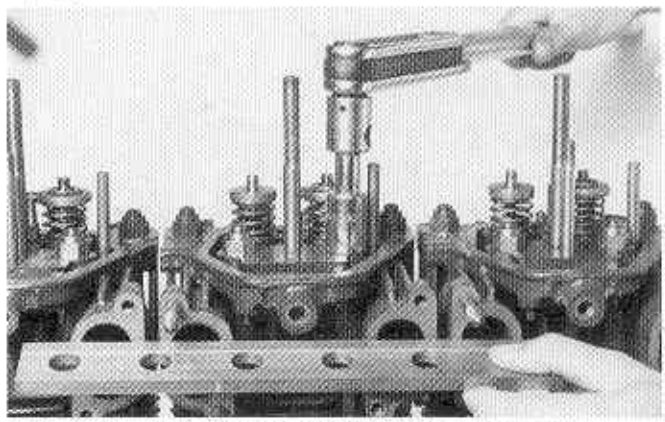


Figure 5.7 Checking Cylinder Head Alignment

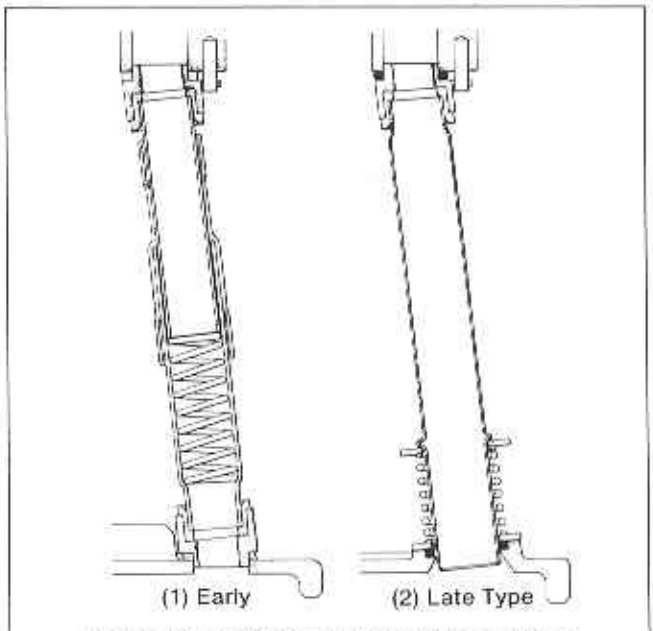


Figure 5.8 Push Rod Tubes (Both Types)

Valve Rockers Adjustment (Figure 5.9)

5.13 Set up the valve clearances on each cylinder in turn with the engine cold as follows:

CAUTION
The cylinder head and rocker support post nuts must be tightened down before the rocker clearance is adjusted.

(1) Set the piston at TDC on the firing stroke (both valves closed).

(2) Slacken the locknut **(1)** and using a screwdriver set the rocker adjusting screw **(2)** to give the correct valve clearance with a feeler gauge as shown. When the correct setting of 0.10mm (0.004in.), is obtained tighten the locknut.

(3) After tightening the locknut re-check the clearance.

Rocker Box Replacement

5.14 To fit the rocker box proceed as follows:

(1) Fit the rocker box gasket.

(2) Fit the rocker box and secure, using the large nut and special washer, to the rocker box stud.

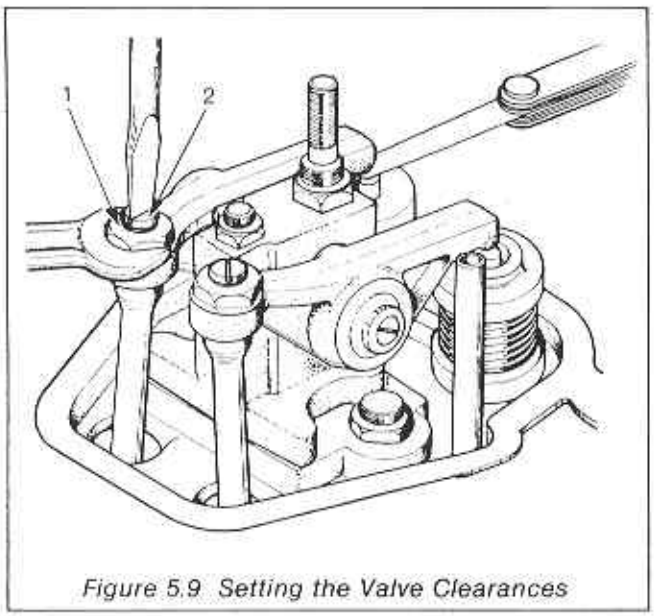


Figure 5.9 Setting the Valve Clearances

Setting the Decompressor Lever

5.15 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) Remove the two screws and spring washers securing the rocker box plate to the rocker box cover. Remove the plate and gasket.

(3) Set the compressor lever to the vertical position.

(4) Using a suitable spanner through the access hole in the rocker box cover loosen the decompressor locknut.

(5) Using a screwdriver set the decompressor pin so that it just touches the valve rocker taking up the valve clearance.

(6) Turn the pin clockwise a further two thirds of a turn in, this will lower the valve the required amount.

(7) Prevent the pin from turning and tighten the locknut.

(8) Fit the rocker box plate and gasket.

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

CYLINDER, PISTON AND CONNECTING ROD

Removal

5.16 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 5/16in. 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) Lift off the cylinder complete with piston and connecting rod. Retain the shims fitted between the cylinder and crankcase these control the bumping clearance.

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

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

(11) 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.

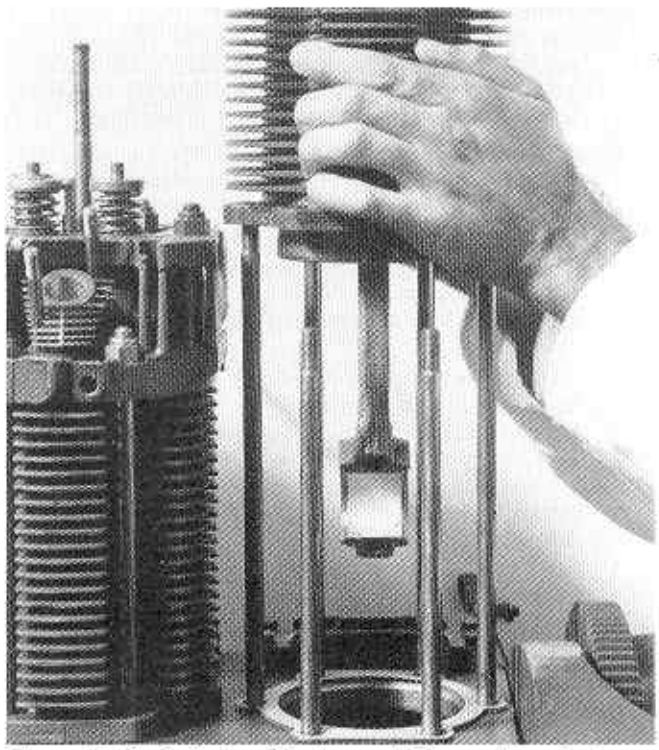


Figure 5.10 Cylinder, Piston and Connecting Rod Removal

Figure 5.11 Piston and Connecting Rod (Both Types)

Cylinder Maintenance

5.17 Check the cylinder bore wear, if this has reached the maximum 0.25mm (0.010in.) the cylinder must be rebored and an oversize piston and rings fitted. The cylinder only should be bored and honed to the sizes listed in Table 5.1

TABLE 5.1 CYLINDER REBORING DIAMETERS

Cylinder	*Size*
Standard	**96.965 to 96.990 mm (3.8175 to 3.8185 in.)**
1st Oversize 0.508 mm (0.020 in.)	**97.478 to 97.498 mm (3.8375 to 3.8385 in.)**
2nd Oversize 1.016 mm (0.040 in.)	**97.981 to 98.006 mm (3.8575 to 3.8585 in.)**

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

Piston Maintenance

5.18 Excessive lubricating oil consumption, loss of compression and knocking are signs that a piston needs attention. To check the piston rings carry out the following procedure:

(1) Remove the rings from the piston as shown in Figure 5.12 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 (0.5in.) 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 1.52mm (0.060in.). If necessary the rings must be renewed.

(4) Assemble the rings on the piston in the correct order with the correct face uppermost, as shown in Figure 5.13. rings should not be slack or stuck fast in the groove.

(5) When the engine has been fully run in, the bore will have a highly polished and very hard surface. If new piston rings are fitted without the cylinder being rebored, the new rings will not bed in satisfactorily. Under these conditions the hard polished bore must be lightly roughened using a medium grade carborundum cloth. The roughening should be carried out radially by hand and should be sufficient only to produce a matt surface on the bore Alternatively, a suitably sized de-glazing tool of the rotary brush type with silicone-carbide tips may be used provided method used is in accordance with manufacturers instructions. After this treatment the cylinder must be thoroughly washed in kerosene to remove all traces of carborundum.

Note
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 6 hours or longer on full load.

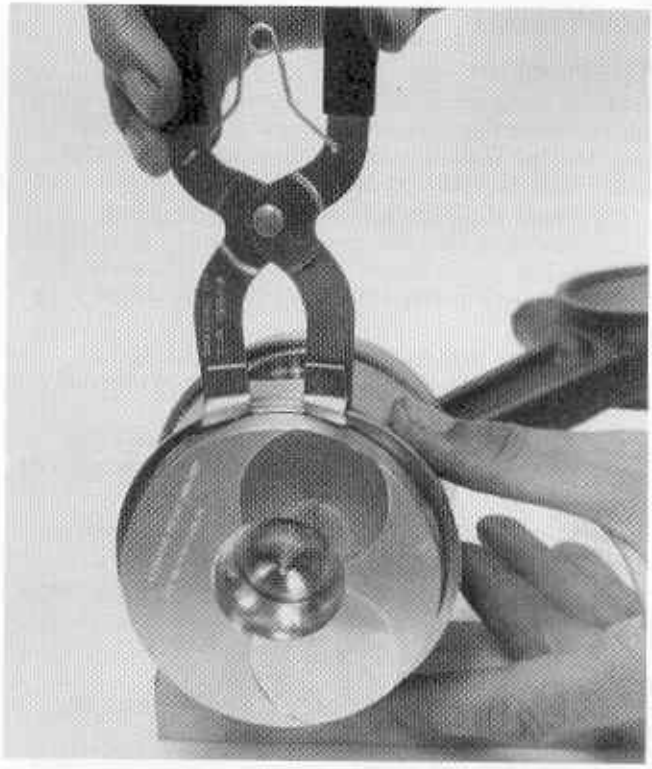


Figure 5.12 Piston Ring Removal

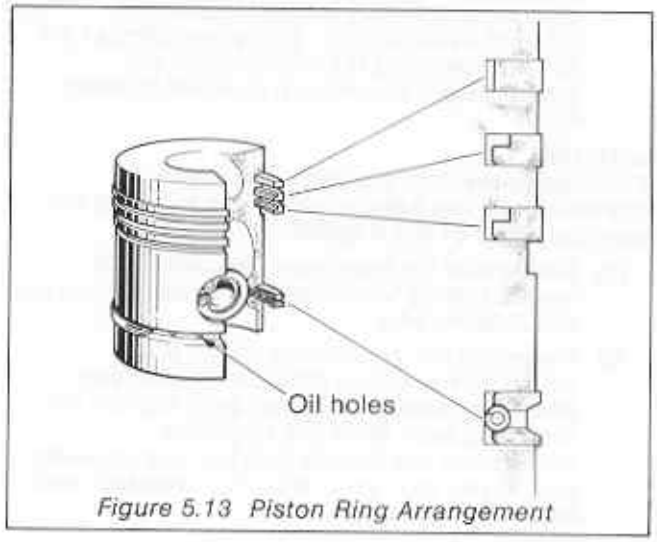


Figure 5.13 Piston Ring Arrangement

Connecting Rod Maintenance

Small End Bush

5.19 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

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

Replacement

5.21 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 (if applicable) 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 (if applicable) 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.)

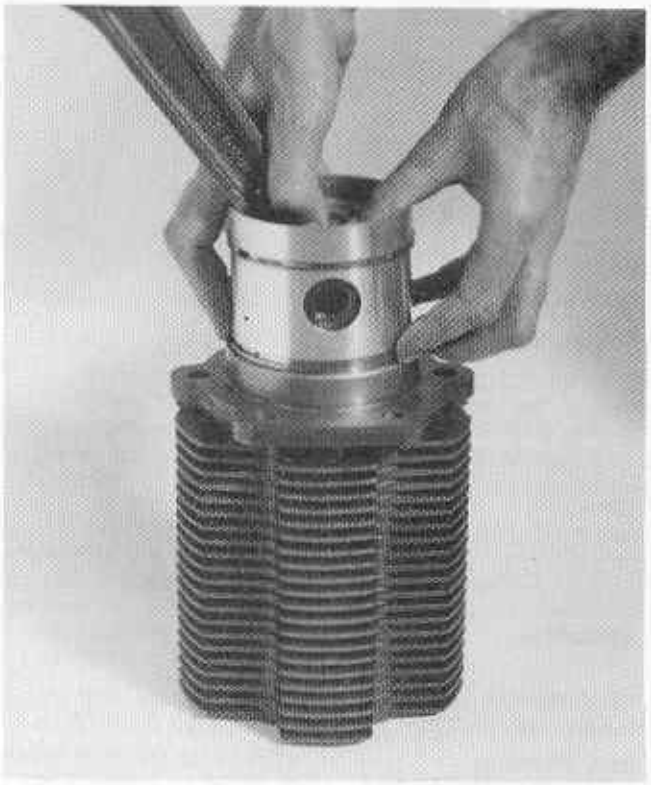


Figure 5.14 Piston Fitting into Cylinder

Bumping Clearance (Figure 5.15)

5.22 Check the bumping clearance as follows:

(1) Set the piston to 6.35mm (0.25in.) before TDC.

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

(3) Replace the cylinder head (Paragraph 5.12) and turn the engine over TDC.

(4) Remove the cylinder head and measure the thickness of the flattened wire with a micrometer. It should be 0.91 to 1.017mm (0.036 to 0.042in.) for an average of the three readings. If necessary adjust the clearance by re-shimming. (Paragraph 5.21(6)).

(5) Replace the cylinder head.

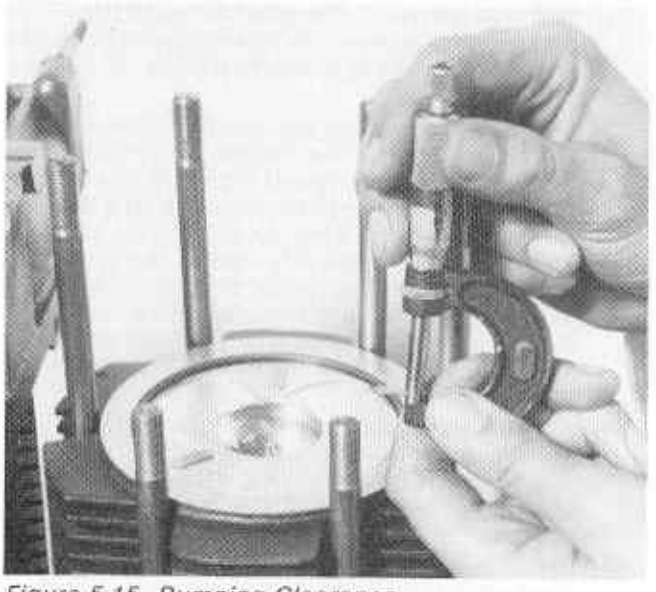


Figure 5.15 Bumping Clearance

FLYWHEEL

Removal

PJ1, PJ2, PJ3 and PJ4 Engines

5.23 To remove the flywheel proceed as follows:

(1) Remove the flywheel cowling and brackets (PJ1 and PJ2 only).

(2) Unlock the flywheel bolts by bending back the tab washers.

(3) Remove any two diagonally opposite bolts and fit two identical threaded studs that protrude approximately 38mm (1.5in.) out of the flywheel. (These studs act as guides and take the weight of the flywheel).

(4) Remove the remaining bolts and pull off the flywheel and extension shaft along the two fitted studs. Retain the locating dowels.

CAUTION
On single and two cylinder engines when removing the flywheel take care not to damage the plastic flywheel cooling fan (if fitted).

PJ1Z and PJ2Z Engines

5.24 To remove the flywheel proceed as follows:

(1) Remove the six retaining screws and lift off the cooling fan.

(2) Withdraw the flywheel key with a tapered key drift (Figure 5.16) which is obtainable from Petters 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.

(3) 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.

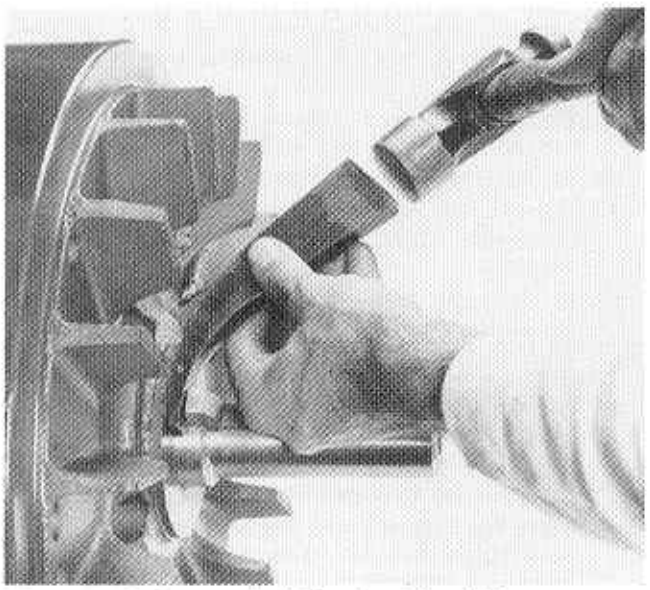


Figure 5.16 Removal of Flywheel Key Using a Tapered Key Drift.

Replacement

PJ1, PJ2, PJ3 and PJ4 Engines

5.25 To replace the flywheel proceed as follows:

(1) Screw the two guide studs used for removal into two diagonally opposite holes in the crankshaft. Ensure that the locating dowels are in position.

(2) Align and slide the flywheel onto the two studs as far as possible.

(3) Fit the extension shaft (if applicable) and four flywheel bolts.

(4) Remove the two guide studs and fit the two remaining flywheel bolts.

(5) Tighten all bolts gradually in turn working diagonally; finally torque load PJ1 and PJ2 engines to 43 Nm (32 lbf ft.) or PJ3 and PJ4 engines to 63.5 Nm (47 lbf. ft).

PJ1Z and PJ2Z Engines

5.26 Before fitting the flywheel apply a small quantity of grease or oil to the crankshaft. Push the flywheel on the shaft ensuring that it is fully against the shoulder on the crankshaft.

5.27 Fit a new flywheel key 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.

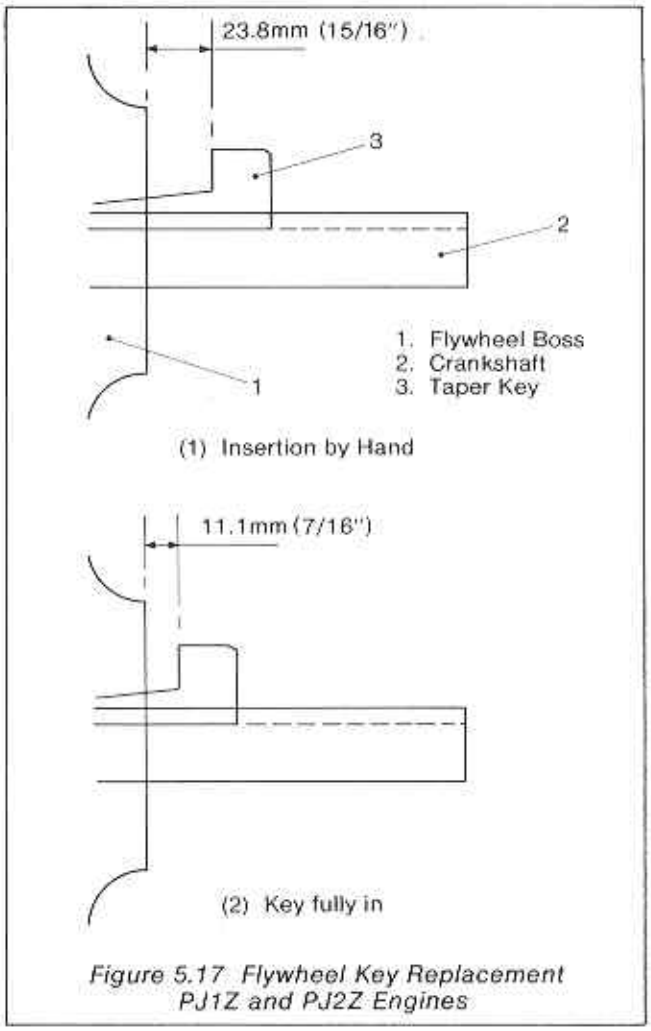


Figure 5.17 Flywheel Key Replacement PJ1Z and PJ2Z Engines

(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 23.8mm (15/16in.). If it is more, remove metal from

the botton 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 11.1mm (7/16in.) is attained between the flywheel boss and the keyhead.

(4) Refit cooling fan and tighten screws diagonally.

CRANKSHAFT

Removal

Single and Two Cylinder Engines

5.28 To remove the crankshaft proceed as follows:

(1) Remove the cylinder head(s) (Paragraph 5.3), cylinder(s) and connecting rod(s) (Paragraph 5.16).

(2) Remove the flywheel (Paragraph 5.24).

(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 5.18). A special tool for this purpose can be obtained from Petters Limited or their representatives.

(5) On the PJ2 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.

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

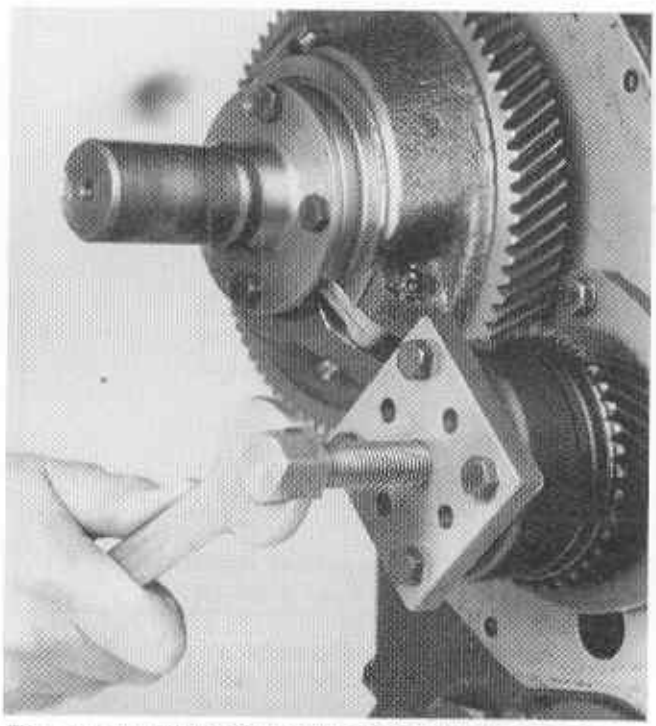


Figure 5.18 Withdrawing the Gearwheel using an Extractor

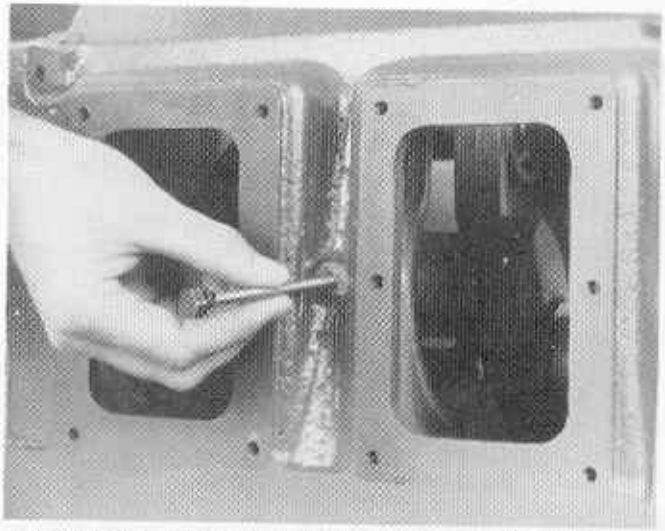


Figure 5.19 Removing the Intermediate Bearing Housing Locking Screw (PJ2)

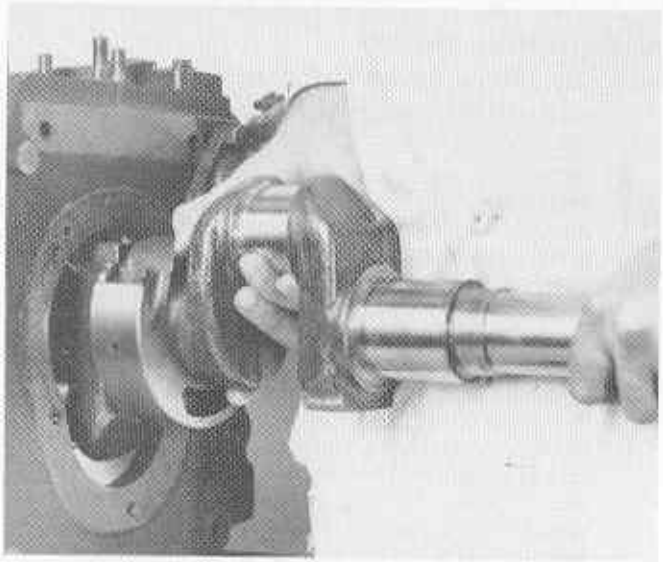


Figure 5.20 Removing the Crankshaft

PJ3 and PJ4 Engines

5.29 To remove the crankshaft proceed as follows:

(1) Remove the cylinder heads (Paragraph 5.3), cylinders and connecting rods (Paragraph 5.16).

(2) Remove the front fan belt guard. Slacken the idler pulley, dynamo or alternator sufficiently to remove the fan belt.

(3) Remove the set screws securing the crankshaft pulley and withdraw the pulley.

(4) Remove the rear fan belt guard

(5) Remove the gear cover and fan assembly complete. The gearcover is dowelled to the crancase.

(6) Remove the bolt and retaining plate from inside the crankshaft gearwheel, replace the bolt in the end of the crankshaft to prevent damage to the threads and using an extractor withdraw the gearwheel (Figure 5.18). A special tool for this purpose can be obtained from Petters Limited or their representatives.

(7) Remove the flywheel (Paragraph 5.24).

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

(9) Remove the intermediate main bearing housing locking screw(s) (Figure 5.19).

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

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

(12) Mark the halves of the intermediate main bearing housings to identify the assembly positions and remove the housings. The halves of each housing are machined as an assembly and must not be mixed with those of another housing assembly.

Oil Pump Gearwheel

Note

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

5.30 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

5.31 Examine the bearing journals and crankpins for scoremarks and ovality. The ovality should not exceed the maximum of 0.8mm (0.003in.) If the journals or the ovality exceeds the maximum tolerance the crankshaft should be reground to the diameter shown in Table 5.2 (PJ) or Table 5.3 (PJZ) and undersize bearings fitted. Before refitting carefully clean out the oil holes and ensure that they have radiused edges.

Main Bearing Maintenance

5.32 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.

5.33 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.

5.34 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.

5.35 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.

TABLE 5.2 CRANKSHAFT REGRINDING DIAMETERS PJ ENGINES

Crankshaft	*Main Journal Gear End*	*Main Journal Flywheel End*	*Crankpin and Intermediate Journal*
Standard	**60.287 to 60.274 mm (2.3735 to 2.3730 in.)**	**104.673 to 104.661 mm (4.1210 to 4.1205 in.)**	**63.325 to 60.312 mm (2.3750 to 23745 in.)**
Undersize 0.254 mm (0.010 in.)	**60.031 to 60.020 mm (2.3635 to 2.3630 in.)**	**104.419 to 104.407 mm (4.1110 to 4.1105 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.)**	**104.165 to 104.153 mm (4.1010 to 4.1005 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.)**	**103.911 to 103.899 mm (4.0910 to 4.0905 in.)**	**59.563 to 59.550 mm (2.3450 to 2.3445 in.)**
Undersize 1.016 mm (0.040 in.)	**59.271 to 59.285 mm (2.3335 to 2.3330 in.)**	**103.657 to 103.643 mm (4.0810 to 4.0805 in.)**	**59.309 to 59.296 mm (2.3350 to 2.3345 in.)**

TABLE 5.3 CRANKSHAFT REGRINDING DIAMETERS PJZ ENGINES

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 (0.040 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.)**

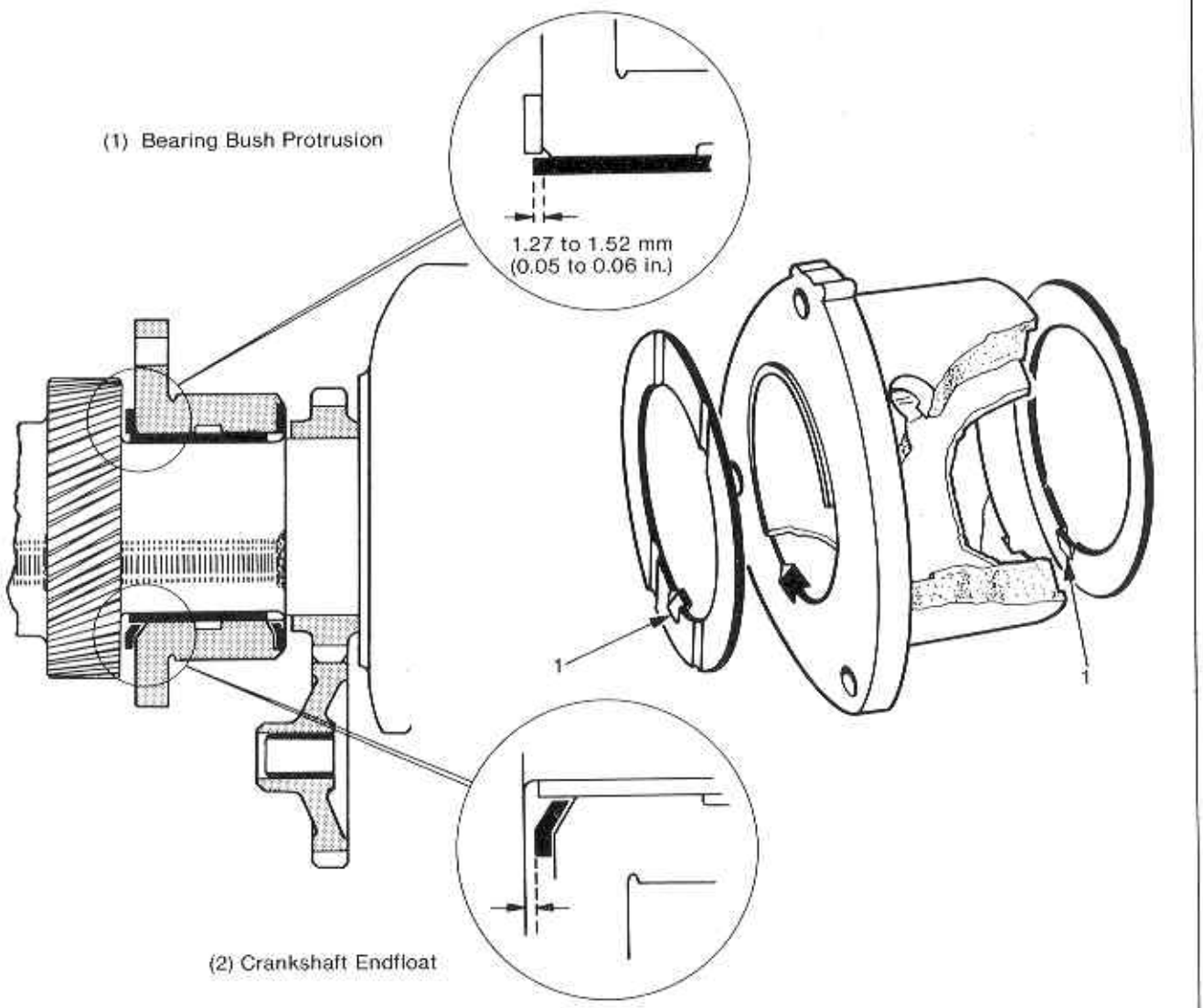


Figure 5.21 Bearing and Thrust Washer Assembly

Flywheel End Oilseal

5.36 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

5.37 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 washers 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 each 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 engine lubricating oil on the crankshaft journal and bearing surfaces.

(5) **Two Cylinder Engines** On two cylinder engines make sure that the intermediate main bearing housing is correctly assembled on the crankshaft with the sides marked TOP towards the flywheel end. Tighten the cap nuts to a torque of 34 Nm (25 lbf. ft).

(6) **Three and Four Cylinder Engines** (Figure 5.22). On three and four cylinder engines make sure that the intermediate bearing housings are correctly fitted with the oil hole **(1)** and locking screw hole **(2)** in their relative positions. Make sure the dowels **(3)** are correctly fitted and tighten the capscrews to a torque of 54 Nm (40 lbf. ft).

(7) Insert the crankshaft into the gear end bearing, taking care not to damage the bearing surface.

(8) Apply a small quantity of engine 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 three securing bolts evenly.

(9) With the 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.

(10) Fit the intermediate main bearing housing locking screw(s) on the multi-cylinder engines taking care that the screw(s) enters the correct hole in the bearing housings.

(11) Fit the balance weights in their original positions as noted and torque load the weight securing bolts to 159Nm (117 lbf ft). If new weights are fitted they must be balanced to within 7g (0.25oz).

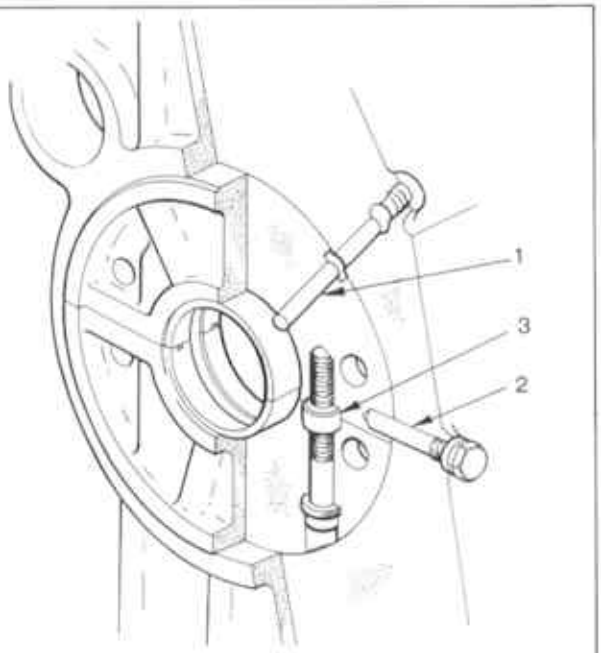


Figure 5.22 Fitting the Intermediate Bearing Housing PJ3 and PJ4

Fitting the Crankshaft Gear

5.38 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. 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.

5.39 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

5.40 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 0.2 to 0.5 mm (0.008 to 0.020 in.).

CAMSHAFT

Removal

PJ1, PJ2, PJ3 and PJ4 Engines

5.41 To remove the camshaft carry out the following procedure:

(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 around the shanks of the valve tappets to prevent their falling into the sump when the camshaft is withdrawn.

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

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

PJ1Z and PJ2Z Engines (Figure 5.23)

5.42 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 thrust plate **(2)** is located between the camshaft gearwheel and the crankcase, with two vertical slots for holding screws which are accessible through holes in the gearwheel. The 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.

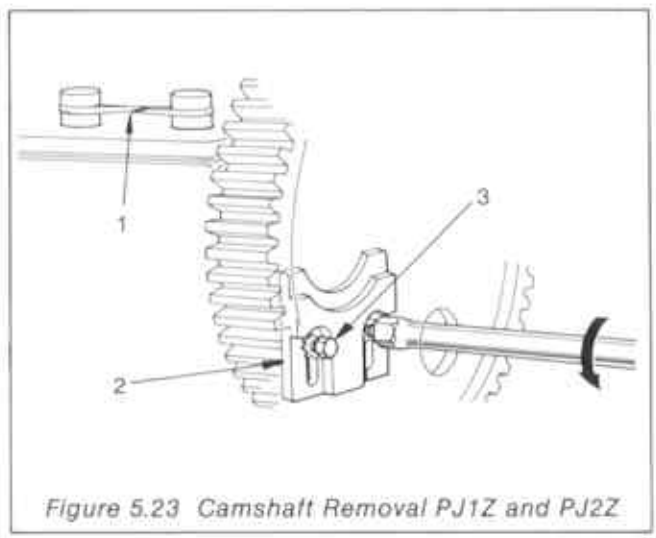


Figure 5.23 Camshaft Removal PJ1Z and PJ2Z

Governor (Figure 5.24)

5.43 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

5.44 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.

5.45 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.

5.46 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.

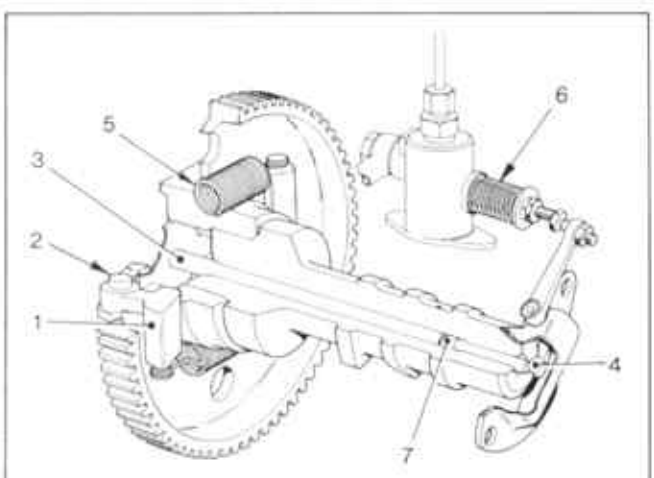


Figure 5.24 Engine Governing System

5.47 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.

Camshaft and Governor Maintenance

5.48 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.

5.49 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. Any stickiness of the push rods will affect the speed control.

5.50 Assemble the governor by replacing the steel ball and long push rod in the camshaft. Fit the governor weights using new pins.

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

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

5.52 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.

5.53 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

PJ1, PJ2, PJ3 and PJ4 Engines

5.54 To replace the camshaft carry out the following procedure:

(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.

(3) Ensure that the two thrust washers are securely located in position. One thrust washer **(1)** is located behind the camshaft gearwheel the other **(2)** to the inside of the gear cover. Both thrust washers are held in position by securing pins **(3)** (Figure 5.25).

(4) Fit the camshaft making sure that the marked teeth on the gearwheels are in their relative positions as shown in Figure 5.26.

(5) Fit the gear cover and gasket locating it on the aligning dowels. Ensure that the correct gasket is fitted between the gear cover and the extension shaft housing or blanking plate. The thickness of the gasket will effect the camshaft end float.

(6) Check the camshaft end float is between 0.13 mm to 0.71 mm (0.005 to 0.028 in.) as

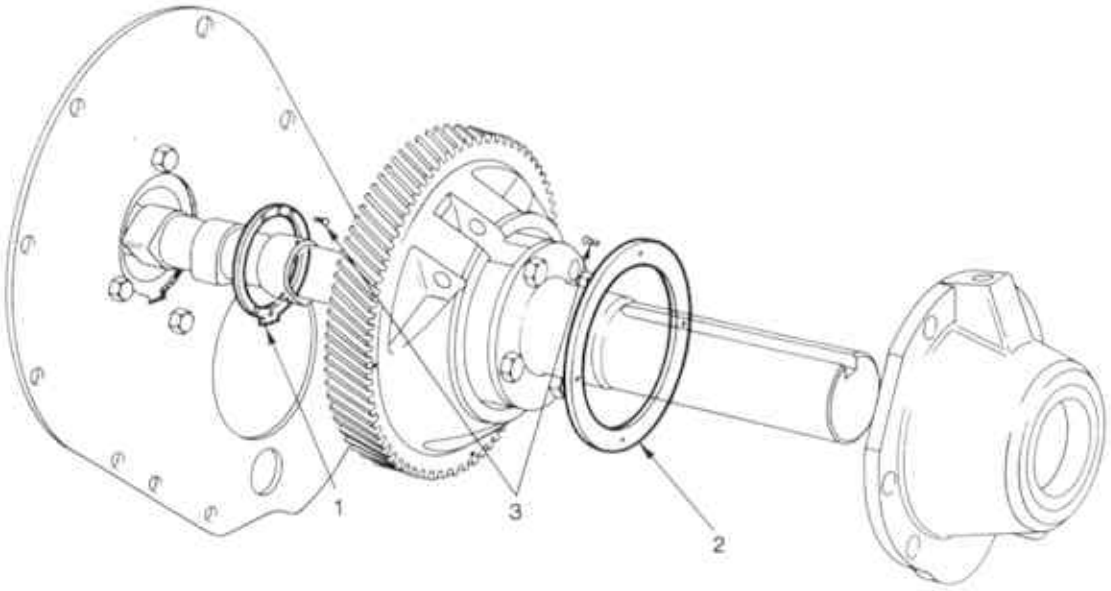


Figure 5.25 Camshaft Showing the Positions of the Thrust Washers

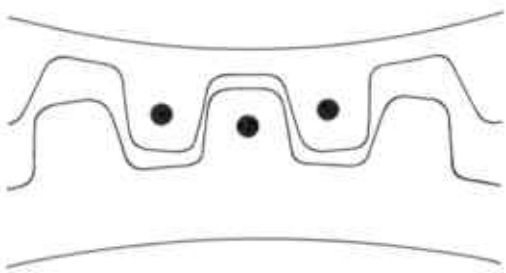


Figure 5.26 Marked Gear Teeth Showing Relative Positions

shown in Figure 5.27. The float can only be checked with the extension shaft housing or blanking plate in position. If an extension shaft is fitted check the end float by mounting a dial test indicator on the timing cover with the pointer against the end of the shaft. If a blanking plate is fitted check the end float by mounting the dial test indicator on the fuel pump side of the crankcase with the pointer against the side of one of the cam profiles.

(7) If the endfloat is excessive fit new thrust washers. When fitting new thrust washers, ensure that the grooved side of the inner thrust washer is against the thrust face of the camshaft and that the tongue is located in the recess. Secure the thrust washers in position using new pins (Figure 5.25).

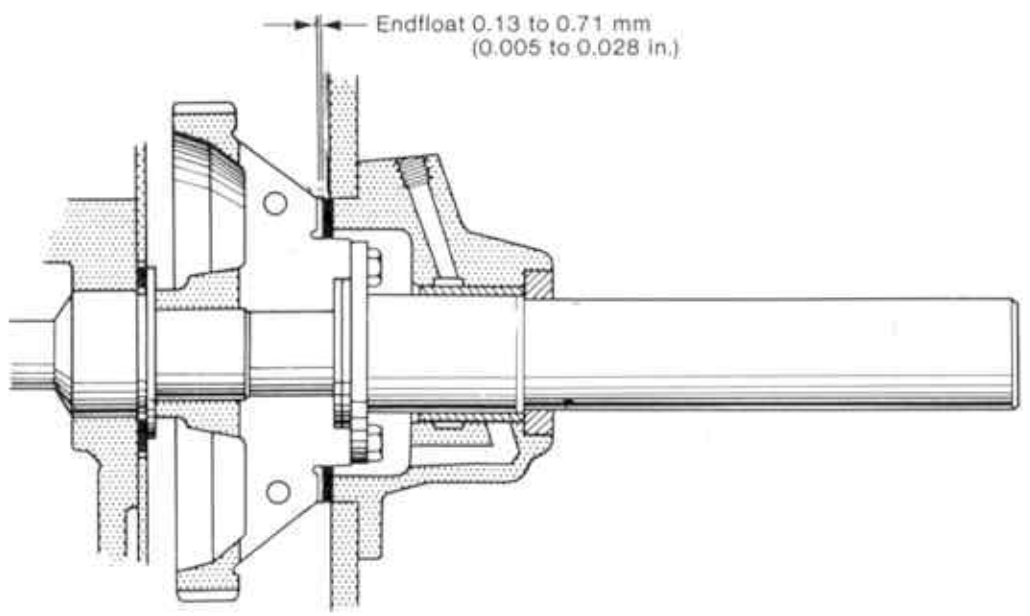


Figure 5.27 Check the Camshaft Endfloat

(2) Remove the four securing setscrews and withdraw the fan from the shaft.

(3) Remove the drive pulley key and washer. Pull out the distance sleeve.

(4) Taking care not to damage the thread, gently tap out the shaft from the pulley end.

(5) Remove the two oil seals from the housing.

(6) Remove the two circlips.

(7) Place the housing in boiling water for sufficient time to allow easier removal of the bearings.

Maintenance

5.63 Clean and inspect all parts for wear or damage and renew where necessary.

Assembly

5.64 To assemble the cooling fan proceed as follows:

(1) Place the housing in boiling water for sufficient time to allow easier fitment of the bearings.

(2) Pack the bearings with a suitable high melting point grease. Fit the roller bearing at the drive pulley end of the housing and the ball bearing at the end nearest the fan.

(3) Fit the distance sleeves and retaining circlips.

(4) Fit the two oil seals ensuring that they are fitted squarely into the housing. Failure to do this will result in a loss of lubricant and ingress of dirt.

(5) Fit the fan shaft, distance sleeve, washer and pulley key.

(6) Fit the drive pulley and washer. Fit and tighten the retaining nut.

Replacement

5.65 To replace the fan proceed as follows:

(1) Fit the fan housing to the gear cover. Secure using the four setscrews and spring washer.

(2) Pump a suitable high melting point grease through the grease nipple until the relief valve is seen to rise.

(3) Secure the strap holding the cylinder cowling to the fan housing.

Fan Drive Belt Adjustment

5.66 To adjust the fan drive belt proceed as follows:

(1) Remove the fan belt guard.

(2) Slacken the idler, dynamo or alternator hinge bolts and the clamping set screw.

(3) Press the idler, dynamo or alternator drive pulley against the belt until all slackness is removed without the belt being stretched, tighten the clamping setscrew.

(4) Measure the outside length of the belt and note this measurement.

(5) Slacken the clamping setscrew and increase the pressure on the drive pulley sufficiently to increase the measured length noted by 6 mm (0.25 in.). Tighten the clamping setscrew and pivot bolts.

(6) Fit the fan belt guard.

SECTION 6
COMMON VARIANTS AND ACCESSORIES

CLUTCH PJ1 AND PJ2 ENGINES

Introduction

6.1 All the Petter clutches used on PJ1 and PJ2 engines are multi-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 The 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 and 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 The 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)**. Withdrawn the driving flange.

(5) Remove the clutch adaptor plate **(7)** and gasket **(8)**.

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.

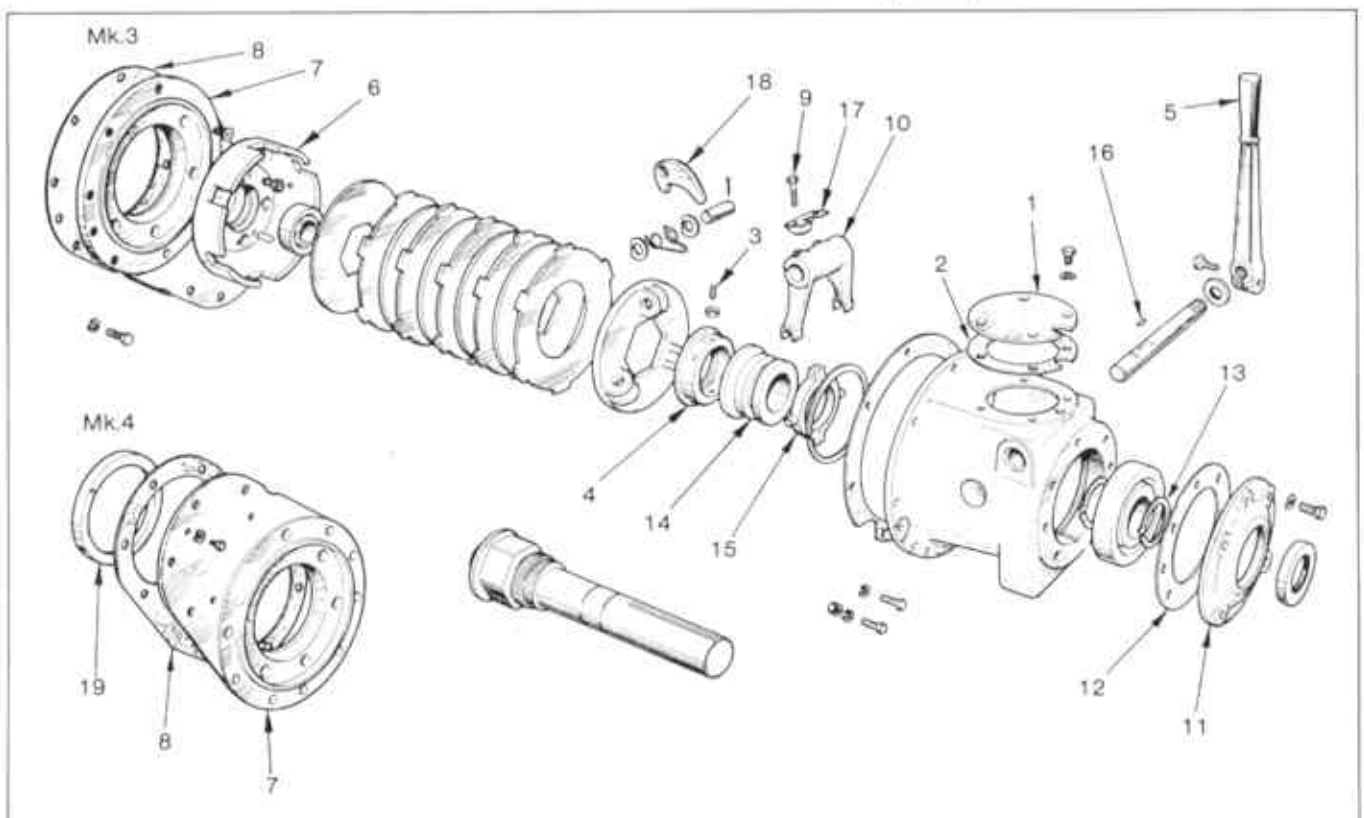


Figure 6.1 Clutch Assembly: Exploded View

(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 orders 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) On the Mk 4 engines ensure that the front camshaft thrust washer **(19)** is in position. Fit the clutch adaptor **(7)** and a new gasket **(8)** to the engine using six 5/16 in. B.S.F. screws. These counter sunk screws must be locked by centre-popping.

(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.

SPEED INCREASING GEAR PJ1 and PJ2 ENGINES

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.

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.

TABLE 6.1 SPEED INCREASING GEAR RATIOS

Engine Type				*Ratio*			
PJ 1		PJ 2		1.61:1		1.86:1	
kW	BHP	kW	BHP	Engine Speed r/min	Output Shaft Speed r/min	Engine Speed r/min	Output Shaft Speed r/min
3.70	5	7.5	10	1000	1610	1000	1860
6.3	8.5	12.7	17	1500	2415	1500	2790
7.5	10	14.9	20	1800	2898	1800	3348
8.4	11.3	16.8	22.5	2000	3220	2000	3720

(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 gear-wheel.

(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 tabwasher **(19)** and the 5/16 in. B.S.F. socket-head 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 set-screws, 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 0.05 mm (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.

(2) 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-

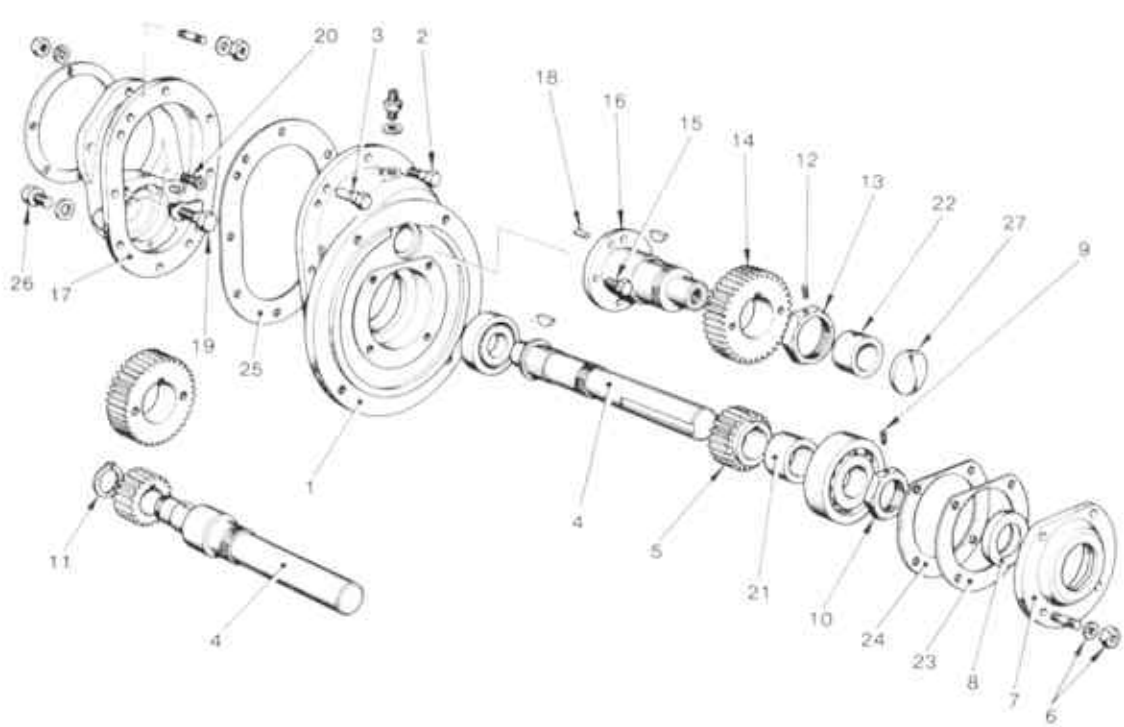


Figure 6.2 Speed Increasing Gear : Exploded View

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.

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.

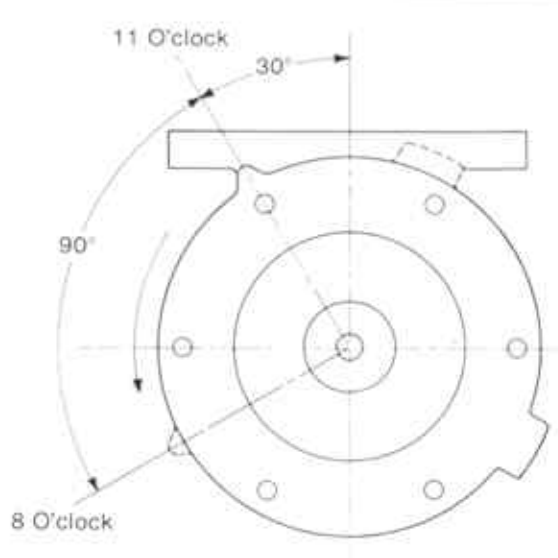


Figure 6.3 Fitting the Fuel Lift Pump Diaphragm

(3) Assemble the two halves of the pump ensuring that they are in their original positions as marked (paragraph 6.16 (3)). Holding the priming lever fully against the spring secure the two halves together using the six setscrews.

(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.

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.

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.

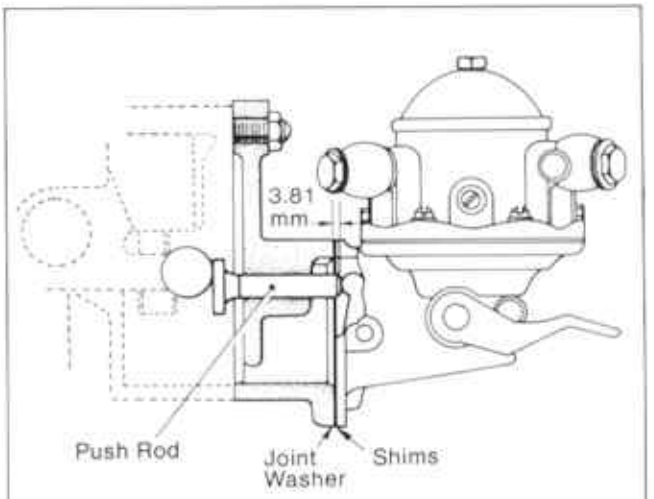


Figure 6.4 Fuel Lift Pump: Checking the Push Rod Protrusion

HYDRAULIC PUMPS

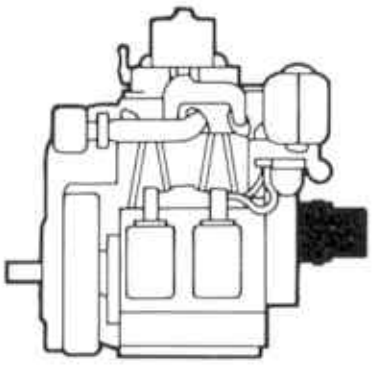
Drive Positions (Figure 6.5)

6.21 A hydraulic pump can be fitted to a PJ engine in one of three positions:

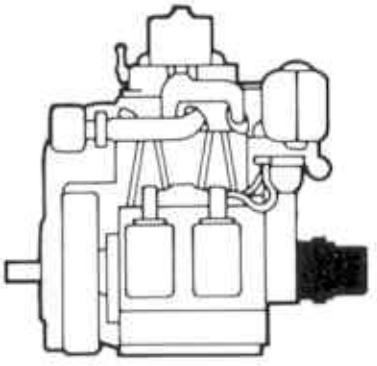
(1) Half engine speed, gear end.

(2) Engine speed, gear end.

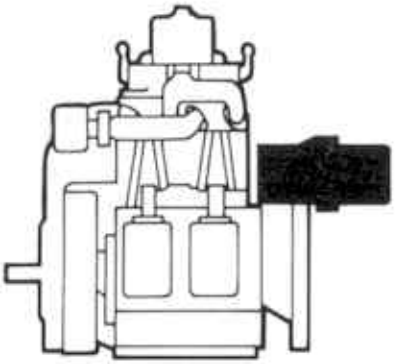
(3) Engine speed, gear end (raised).



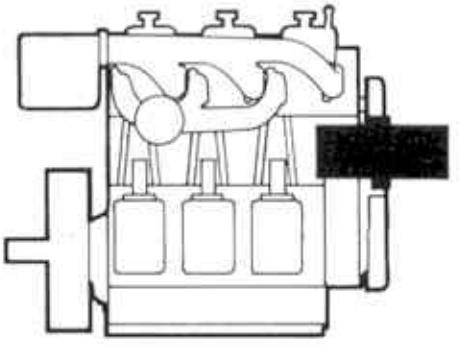
(1) Half Engine Speed Gear End



(2) Engine Speed Gear End



(3) Engine Speed Gear End (Raised) with SAE5 Bellhousing



(4) Engine Speed Gear End (Raised) PJ3 and PJ4 (power requirement must not exceed 16.4 kW (22 bhp)

Figure 6.5 Hydraulic Pump Drive Positions

6.22 An hydraulic pump can be fitted to any of the three positions on PJ1 and PJ2 engines but it can only be fitted at the engine speed gear end (raised) on PJ3 and PJ4 engines. When fitted to a PJ3 or PJ4 engine the power requirement must not exceed 16.4 kW (22 bhp).

Installation Checks

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

Half or Engine Speed Gear End

6.24 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 gasket between the adaptor and the pump. This will push the coupling on the drive shaft so that with the gasket 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 the gasket and replace the pump unit.

Engine Speed Gear End (Raised)

6.25 To obtain the correct clearances when fitting a hydraulic pump to the engine speed gear end (raised).

(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 gear cover flange or 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 gasket between the spigot plate and pump. This will push the coupling on the drive shaft so that with the gasket 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 the gasket and replace the pump unit.

MARINE ENGINES

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

(1) Valve spring (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 eletrical starting systems that can be used on the PJ range diesel engines. Further information can be obtained from Petters Limited or their representatives.

ELECTIC 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 (Figure 7.1 and 7.2)

7.3 The starter is a pre-engaged, four pole,four-brush motor with a solenoid-operated roller clutch drive. The starter provides a positive drive engagement as full battery voltage is not connected to the starter until the pinion is completely meshed with the engine drive. This also prevents premature ejection of the drive during isolated firing strokes. The clutch drive transmits the torque developed by the starter and runs free when the engine starts. The solenoid has two windings connected in parallel, a closing coil (low resistance) and a hold-on coil (high resistance). When the starter switch is closed the solenoid is energised and draws the plunger into the solenoid core which in turn via the operating lever, brings the pinion into mesh with the engine drive. The solenoid contacts close and bypasses the closing winding. Current flows from the battery to the starter setting the armature in motion. The solenoid is held in position by the hold-on coil. When the starter switch is released the hold-on coil is de-energised and the plunger returning to its normal position withdraws the pinion from the engine drive. At the same time the solenoid contacts open and the starter is disconnected from the battery. On occasions of tooth-to-tooth abutment (when the pinion does not slide into mesh with the engine drive) the solenoid energises normally and the forked operating lever causes the operating plate to compress the engagement spring. As the solenoid plunger has full travel the solenoid contacts close, the starter motor rotates and the pinion slips into mesh under pressure from the compressed engagement spring. A spring (lost motion) located around the solenoid plunger stirrup assembly ensures that the contacts open before the pinion is extracted on starter switch release.

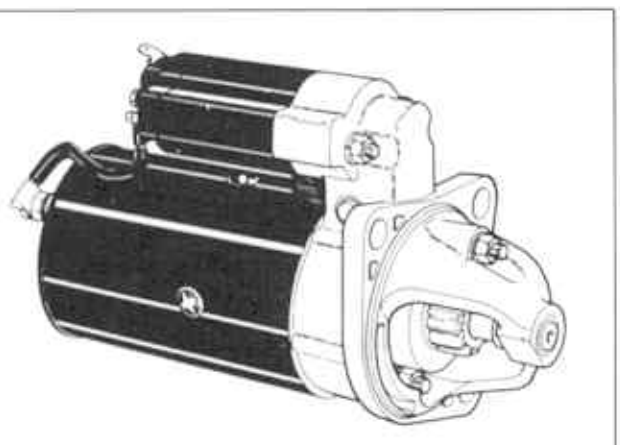


Figure 7.1 Typical Starter Motor

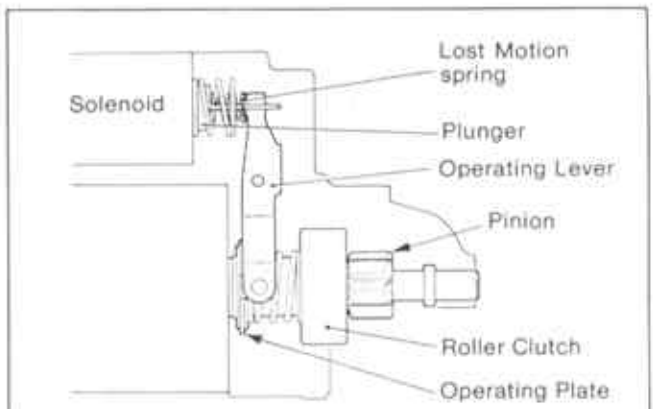


Figure 7.2 Starter Motor Drive Mechanism

Roller clutch (Figure 7.3)

7.4 The roller clutch consists of a driving and driven member and a number of cylindrical rollers running in cam tracks in the clutch outer member. These rollers are spring-loaded and according to the direction of the drive they are either free-running or wedge-locked between the driving and driven member.

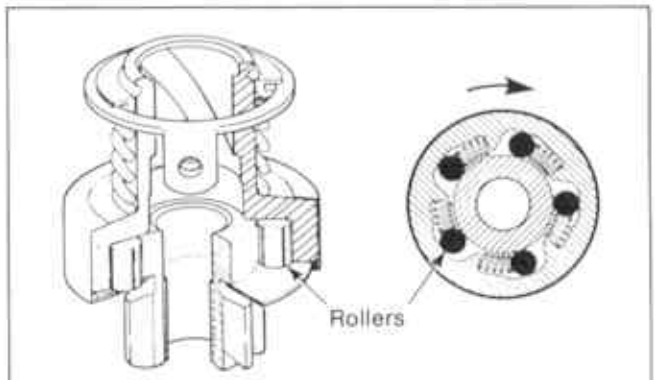


Figure 7.3 Roller Clutch Drive Assembly

Removal

WARNING
DISCONNECT THE BATTERY BEFORE CARRYING OUT ANY MAINTENANCE ON THE STARTER MOTOR.

7.5 Carry out the following procedure:

(1) Disconnect the battery.
(2) Disconnect the starter.
(3) Unscrew the three 3/8 in. UNC securing bolts and remove the starter.

Maintenance

7.6 When dismantling for periodical overhaul the brush gear and commutator surfaces should be checked as follows:

(1) Check that the brushes move freely in their respective holders. A sticking brush can be freed by cleaning both the brush and holder with a petrol-moistened lint-free cloth.

(2) Check the brushes for wear and renew when worn to or approaching 7.94 mm (5/16 in.) in length.

(3) Check the commutator is burnished and free from pits or burned spots. If necessary clean the surface with a petrol moistened cloth. If the surface is badly worn it is advisable to fit a replacement motor.

7.7 Check the roller clutch drive as follows:

(1) Check that the clutch provides instantaneous drive take-up in one direction and rotates freely and smoothly in the other direction.

(2) Check that the roller clutch drives moves round and along the shaft splines without roughness or a tendency to bind.

(3) Lubricate all moving parts with Shell SB2628 grease.

Note
If the roller clutch drive fails to operate correctly it must be replaced.

Replacement

7.8 To fit the starter proceed as follows:

(1) Fit the starter and secure using the three 3/8 in. UNC bolts.

(2) Connect the starter ensuring that terminals are clean.

(3) Connect the battery.

STARTER MOTOR TESTING

7.9 The following paragraphs detail tests that can be carried out on the starter motor to assist locating faults in the starting system. A voltmeter with a range of 0 to 20V in required. Before carrying out any tests on the starting system it is important to ascertain that the battery is capable of supplying sufficient current to operate the starter motor and that the battery connections are clean and tight. Tests should be carried out in the order detailed.

WARNING
WHEN CARRYING OUT STARTER MOTOR TESTS CARE MUST BE TAKEN TO AVOID ANY MOVING MACHINERY.

Test 1 Battery Terminal Voltage Under Load

7.10 Connect the voltmeter across the battery terminals as shown in Figure 7.4 and operate the starter switch. The voltage reading depends on the engine load and battery size (Ah). A typical figure is about 9.0V. A low voltage reading would indicate excessive current flow in the circuit and the starter should be removed.

7.11 Carry out Test 2.

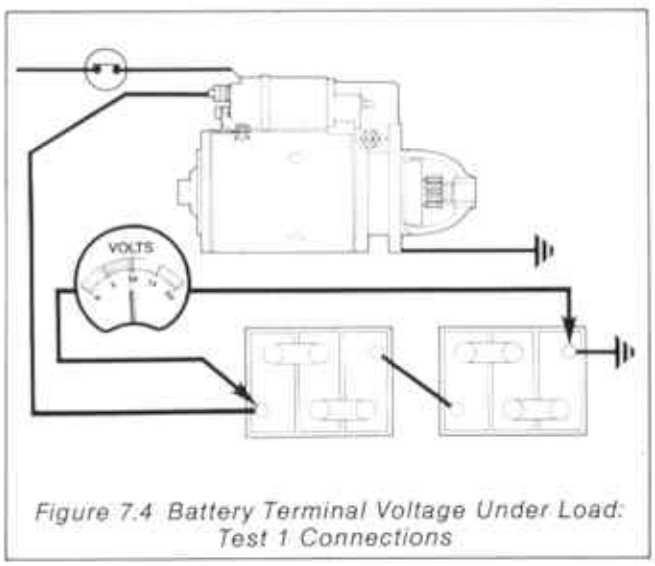


Figure 7.4 Battery Terminal Voltage Under Load: Test 1 Connections

Test 2 Starter Terminal Voltage Under Load

7.12 Connect the voltmeter between the starter input terminal and earth (commutator end bracket) as shown in Figure 7.5 and operate the starting switch. The voltage reading should not be more than 0.5V below the voltage measured across the battery terminals (Test 1). If the voltage reading is within this limit the starter circuit is satisfactory. If the voltage reading is low (battery voltage correct) it indicates a high resistance in the cable or at the starter contacts. This could be bad or dirty connections.

7.13 Carry out Test 3.

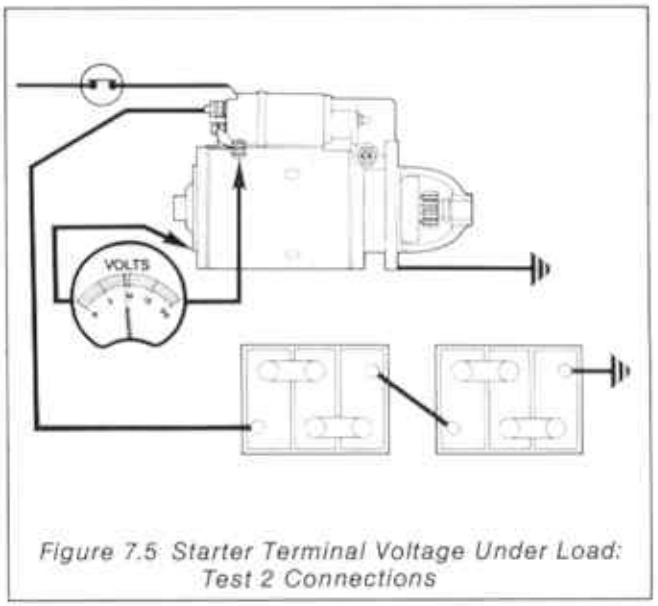


Figure 7.5 Starter Terminal Voltage Under Load: Test 2 Connections

Test 3 Voltage Drop On the Insulated Line

7.14 Connect the voltmeter between the starter input terminal and the insulated battery terminal as shown in Figure 7.6. With the starter switch open, the voltmeter should read the battery voltage. When the starter switch is operated the voltmeter reading should be practically zero. A high voltmeter reading indicates a high resistance in the starter circuit and all insulated connections at the battery, solenoid and starter should be checked.

7.15 Carry out Test 4.

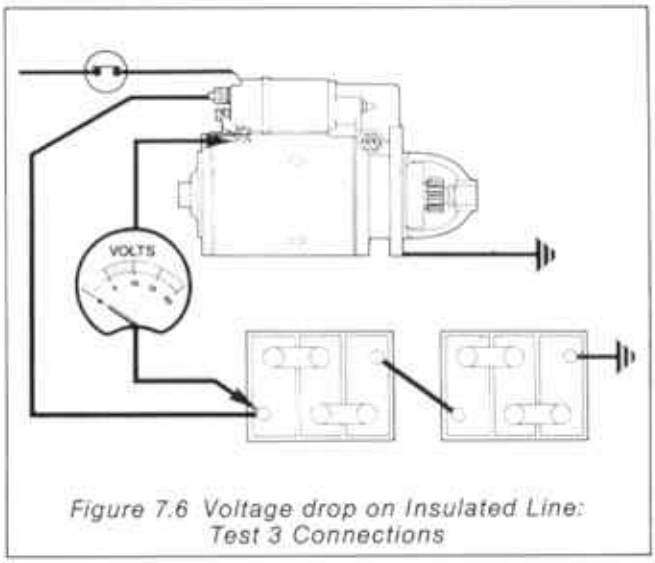


Figure 7.6 Voltage drop on Insulated Line: Test 3 Connections

Test 4 Voltage Drop Across the Solenoid Contacts

7.16 Connect the voltmeter across the two main solenoid contacts as shown in Figure 7.7. With the starter switch open the voltmeter should read battery voltage. When the starter switch is operated the voltmeter should read zero volts or a fractional value.

7.17 A zero or fractional reading on the voltmeter indicates that if a high resistance is deduced in Test 3 a fault is due to bad or dirty connections. A high reading (similar to Test 3) indicates a faulty solenoid or connections.

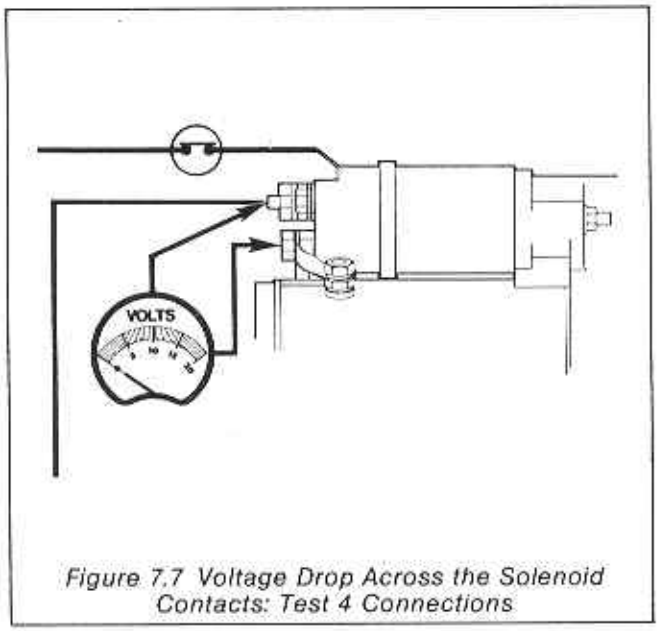


Figure 7.7 Voltage Drop Across the Solenoid Contacts: Test 4 Connections

Test 5 Voltage Drop on Earth Line

7.18 Connect the voltmeter between the battery earth terminal and the starter (commutator end bracket) as shown in Figure 7.8. Operate the starter switch and check that the voltmeter reads practically zero.

Note
The total voltage drop in the starting circuit insulated line (Test 3) and earth line must not exceed 0.5V.

7.19 If the meter reading is high, clean and tighten all earth connections and bonding straps.

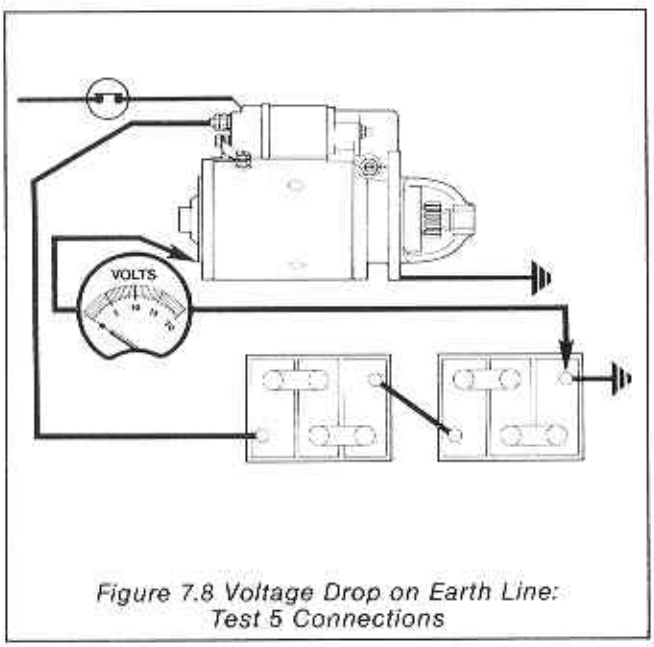


Figure 7.8 Voltage Drop on Earth Line: Test 5 Connections

DYNAMO (Figure 7.9)

7.20 The dynamo is a non-ventilated earth-return two-pole, two-brush, shunt connected model, with a maximum output of 11A. To protect the dynamo against overload and the battery against overcharge a control box is fitted. Dynamos or control boxes may be replaced separately, but if either item is changed both units should be checked and/or set-up by an electrical engineer.

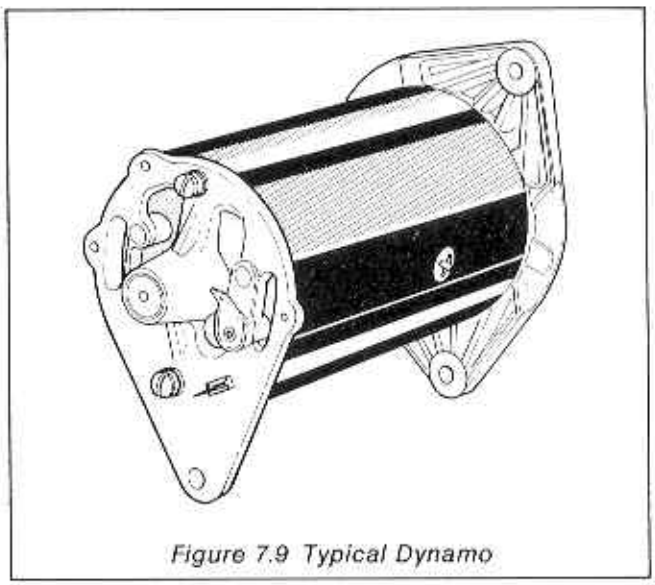


Figure 7.9 Typical Dynamo

CAUTION
Check that the dynamo rotation as marked by an arrow is correct when related to the engine. A reverse rotation dynamo is available from Petters Limited or their representatives.

Polarisation (Figure 7.10)

7.21 Whenever a new, replacement or repaired dynamo is fitted it is essential that it is polarised to suit the engine installation. To polarise the dynamo proceed as follows:

(1) Fit the dynamo to the engine installation. Do not connect the 'D' and 'F' leads.
(2) Ensure that the battery earth is connected.
(3) Connect a jumper lead to the battery insulated terminal and touch the free end to the dynamo 'F' terminal for a few seconds.
(4) Remove the jumper lead and connect the 'D' and 'F' leads.

Maintenance

Driving Belt

7.22 Carry out the following procedure

(1) Check the general condition of the driving belt, if worn or damaged renew.
(2) Check that the driving and dynamo pulleys are in line and parallel with each other to within 0.5 mm (0.020 in.) Pulley alignment may be checked by placing a straight edge across the pulley faces.
(3) Check the belt tension is sufficient to ensure that the slack side does not sag, fluctuate or bulge away from the pulley when the engine is running.

CAUTION
An under tensioned belt overheats, causes low dynamo output and may work off the pulleys. An over tensioned belt causes premature belt failure and dynamo bearing wear.

Belt Tension – PJ1 and PJ2 Engines

7.23 Belt tension is correct when moderate hand pressure applied at the centre of the belt between the pulleys gives a deflection of approximately 13 mm (0.5 in.). To adjust the tension slacken the two dynamo pivot bolts and the bolt on the slotted adjustment straps. Pull the dynamo outwards to increase the tension. Maintain the correct tension and tighten the adjusting strap bolt, then tighten the pivot bolts.

Belt Tension – PJ3 and PJ4 Engines

7.24 To adjust the belt tension on PJ3 and PJ4 engines proceed as follows

(1) Remove the belt guard

(2) Slacken the dynamo pivot bolts and the clamping setscrew.

(3) Set the dynamo drive pulley so that the belt is not slack but not stretched. Tighten the clamping setscrew.

(4) Measure the outside length of the belt and note this measurement.

(5) Slacken the clamping setscrew and increase the pressure on the drive pulley sufficiently to increase the measured length noted by 6 mm (0.25 in.). Tighten the clamping setscrew and pivot bolts.

(6) Fit the fan belt guard.

Connections

7.25 Check for broken, loose and/or dirty connections at the dynamo and control box. Rectify any faults.

Lubrication

7.26 The armature shaft bearings consist of a ball bearing at the drive end and a bearing bush at the commutator end. The ball bearing is packed with grease which provides adequate lubrication until a major overhaul of the dynamo is required. The bearing bush, however needs lubrication every 6 months or 700 running hours. To lubricate the bearing use a force-feed oil can and inject a small quantity of clean engine lubricating oil in the hole marked OIL on the end-face of the bearing bush housing of the commutator-end bracket as shown in Figure 7.10.

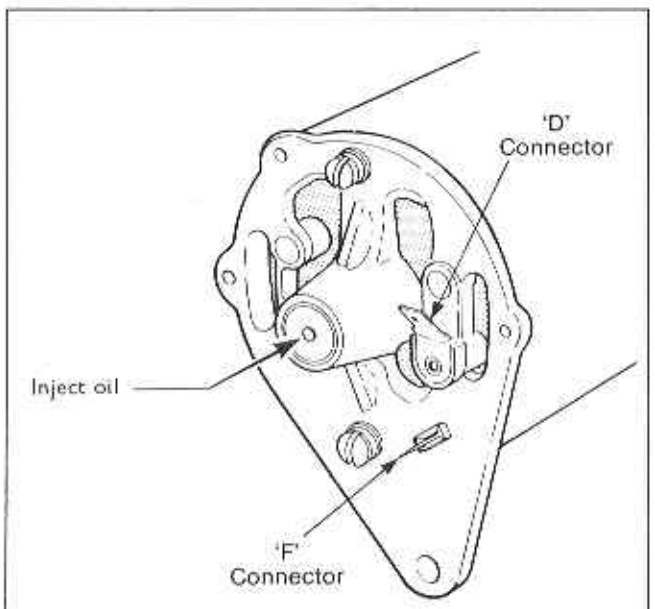


Figure 7.10 Commutator End Bracket

Armature Voltage Check

7.27 To check the armature voltage proceed as follows:

(1) Disconnect the 'D' and 'F' leads at the commutator end bracket (Figure 7.10).

(2) Connect a voltmeter between 'D' terminal and earth.

(3) Run the engine and check that the voltmeter reads 1.5V to 3.0V.

Field Circuit Check (Figure 7.11)

7.28 To check the field circuit proceed as follows:

(1) Disconnect the 'D' and 'F' leads at the commutator end bracket.

(2) Connect a voltmeter between 'D' terminal and earth.

(3) Connect an ammeter between 'D' and 'F'.

(4) Run the engine.

(5) Check that the voltmeter reads a nominal 12V and the ammeter approximately 2A.

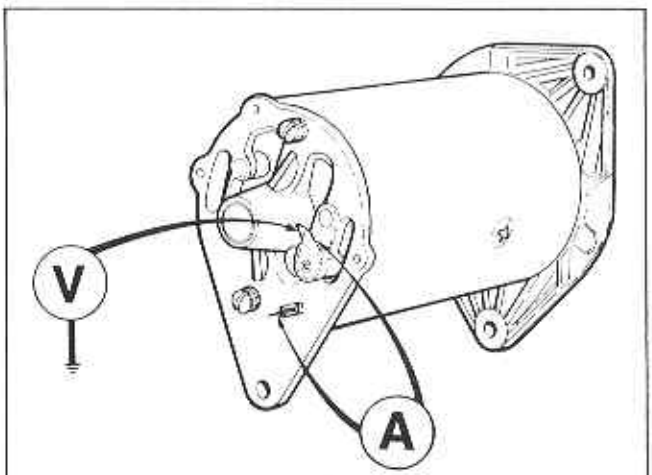


Figure 7.11 Testing the Field Circuit

Dynamo Leads Check (Figure 7.12)

7.29 If the correct readings are obtained on the tests at the dynamo, check the dynamo cables as follows:

(1) Ensure that 'D' and 'F' leads are connected at the dynamo.

(2) Disconnect the 'D' and 'F' leads at the control box.

(3) Connect one lead of the voltmeter to the 'D' lead and the other to earth and run the engine.

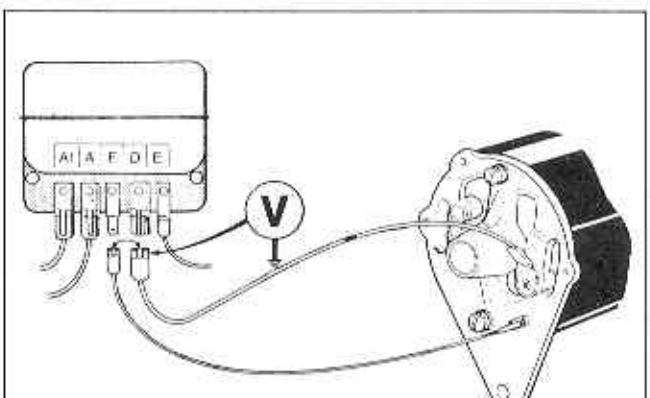


Figure 7.12 Checking the Dynamo Leads

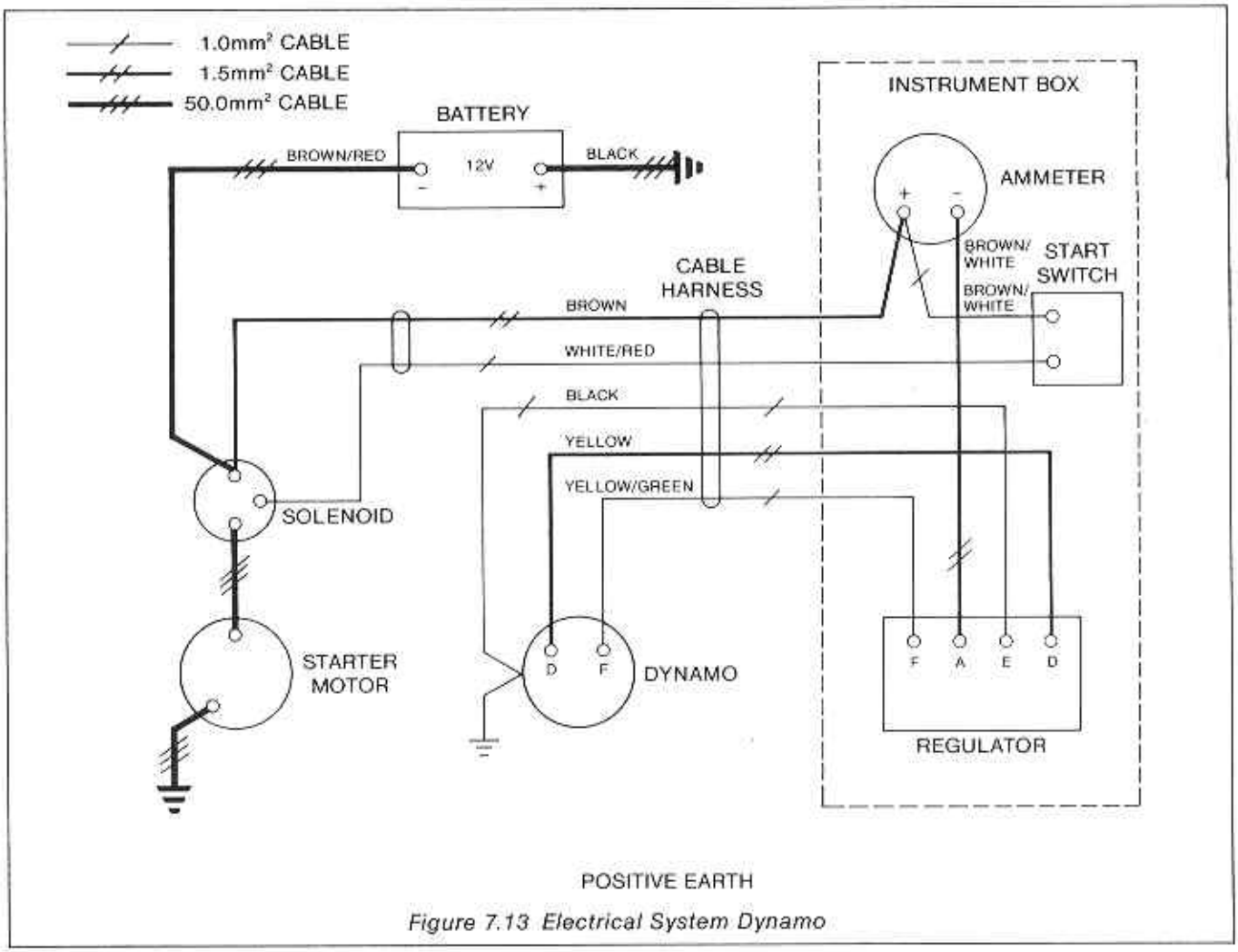


Figure 7.13 Electrical System Dynamo

(4) Check that the voltmeter reads 1.5V to 3V. No reading indicates a faulty 'D' lead, a high reading indicates a short between the 'D' and 'F' leads.

(5) If the reading is correct, leave the voltmeter in position and short 'F' lead to 'D' lead. Voltage should rise. If the reading increases only slightly, an open circuit 'F' lead is indicated. A zero reading indicates 'F' lead shorted to earth.

ACR ALTERNATOR (Figure 7.14)

7.30 The ACR alternator produces alternating current which is converted to direct current suitable for a 12V battery starter system. The output of the alternator is controlled by an electronic voltage regulator which is more reliable and stable than the conventional type of mechanical regulators used with a dynamo. The cut-out is not required with this type of control since the semi-conductor devices prevent reverse currents from flowing. Also the self-regulating properties of the alternator limit the output current to a safe value so that there is no need for a current regulator.

7.31 A typical ACR alternator as shown in Figure 7.15 consists of:

(1) A laminated stator pack on which is wound a 3-phase star connected output winding.

(2) A 12-pole rotor carrying the field winding. Each end of the rotor shaft runs on ball-race bearings. These bearings are pre-packed with grease for life.

(3) A rectifier pack for converting the A.C. output of the stator to D.C.

(4) A built-in voltage regulator.

7.32 Rectification of the alternator output is achieved by six silicon diodes housed in a rectifier pack. The pack also contains three diodes to provide self-excitation of the rotor field winding.

7.33 The voltage regulator is a modular pack and is an integral part of the alternator.

7.34 The electrical connections to the external circuits are brought out to Lucar connector blades, which are grouped so as to accept a non-reversible socket to prevent damage to the semi-conductor devices through connections of the wrong polarity.

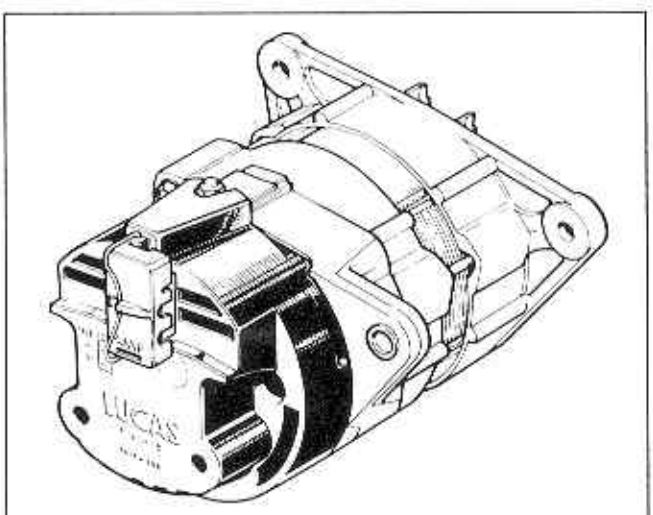


Figure 7.14 Typical ACR Alternator

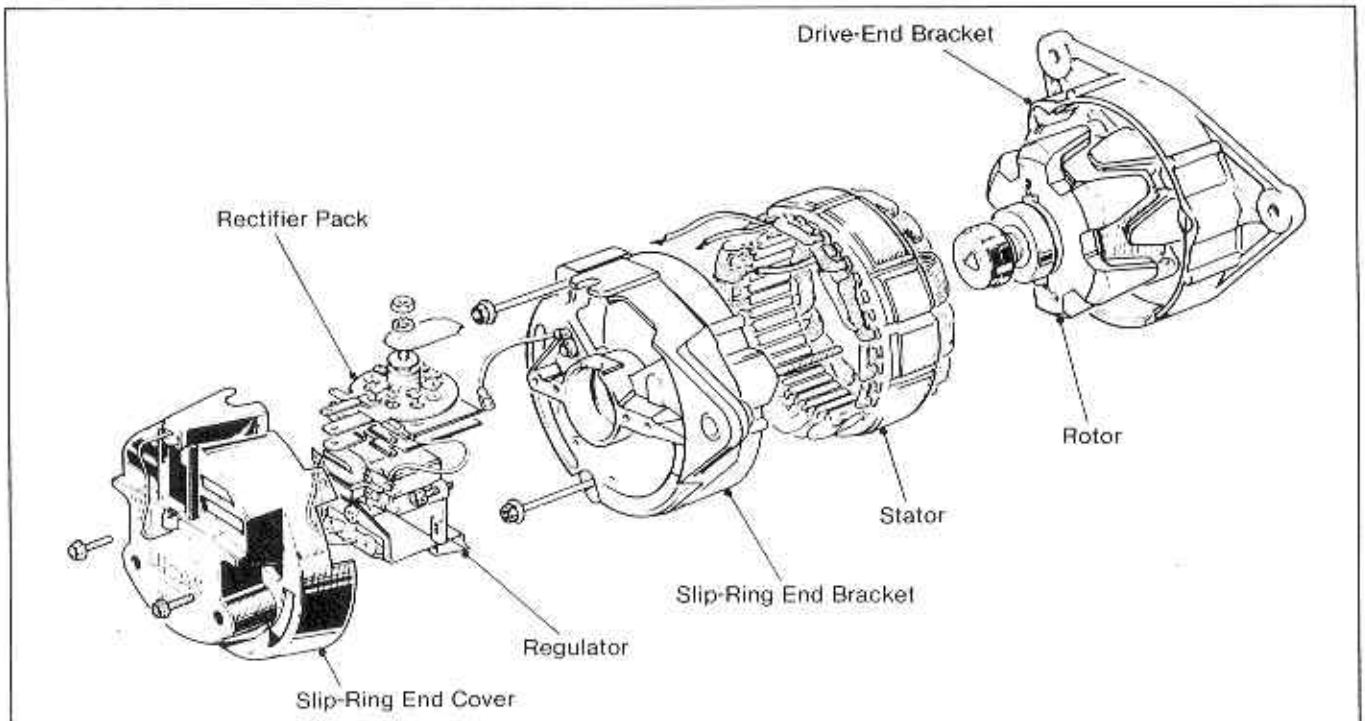


Figure 7.15 Typical ACR Alternator — Exploded View

Connections

7.35 Figure 7.16 shows the alternator (European Termination) connections. It consists of two large '+' Lucar connections and a small 'IND' connector. The negative connection is made through the alternator body. The two Lucar '+' connectors give a better mechanical grip for the socket, but there is only a single cable to the battery.

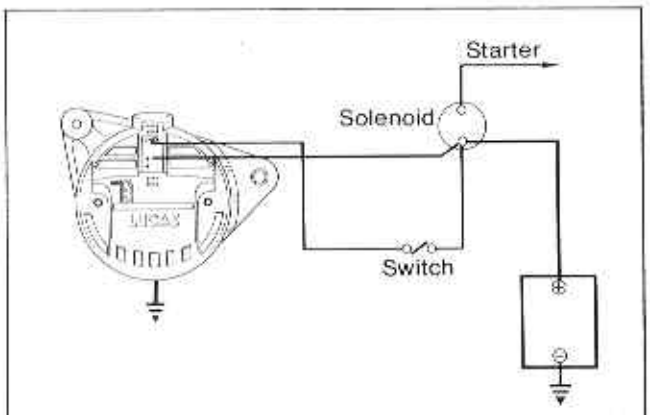


Figure 7.16 ACR Alternator Simplified Circuit

Maintenance

CAUTION

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

(1) Do not disconnect the battery whilst the alternator is running

(2) Do not disconnect any lead unless the alternator is stopped and all switches are in the OFF position.

(3) Always ensure that all leads are connected to their correct terminals.

(4) Do not connect a battery into the system without ensuring that the voltage and polarity are correct.

(5) Do not 'flash' the connections to check current flow.

(6) Do not experiment with adjustments or repairs to the system.

7.36 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.

Voltage Drop in Charging Circuit (Figure 7.17)

7.37 To check for a high resistance in the charging proceed as follows:

(1) Connect a voltmeter between the battery insulated terminal and the alternator main output terminal.

(2) Start and run the engine at approximately rated speed. the voltmeter (V1) reading should not exceed 0.5V.

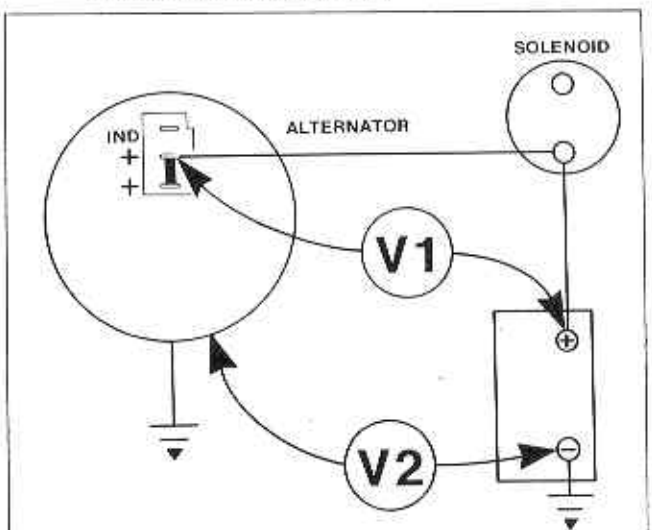


Figure 7.17 Checking the Voltage Drop in the Charging Circuit

(3) Transfer the voltmeter connections to the battery earth and alternator body and run the engine as before. The voltmeter (V2) reading should not exceed 0.25V. If the readings are higher than the figures given in Paragraph 7.37(2) or 7.37(3), then there is a high resistance in the circuit which must be located and rectified.

Voltage Output (Figure 7.18)

7.38 To check the voltage output ensure that the battery is fully charged then proceed as follows:

(1) Disconnect the battery earth cable.

(2) Connect an ammeter between the starter solenoid terminal and the alternator main output cable.

(3) Connect a voltmeter across the battery terminals.

(4) Reconnect the battery earth cable.

(5) Start the engine and run at approximately rated speed. When the ammeter is reading less than 10A the voltmeter reading should be within the limits 13.6 to 14.4V. If the reading is unstable or outside the specified limits the alternator is faulty.

Driving Belt

7.39 Carry out the following procedure

(1) Check the general condition of the driving belt, if worn or damaged renew.

(2) Check that the driving and alternator pulleys are in line and parallel with each other to within 0.5 mm (0.020 in.) Pulley alignment may be checked by placing a straight edge across the pulley faces.

(3) Check the belt tension is sufficient to ensure that the slack side does not sag, fluctuate or bulge away from the pulley when the engine is running.

CAUTION
An under tensioned belt overheats, causes low dynamo output and may work off the pulley. An over tensioned belt causes premature belt failure and dynamo bearing wear

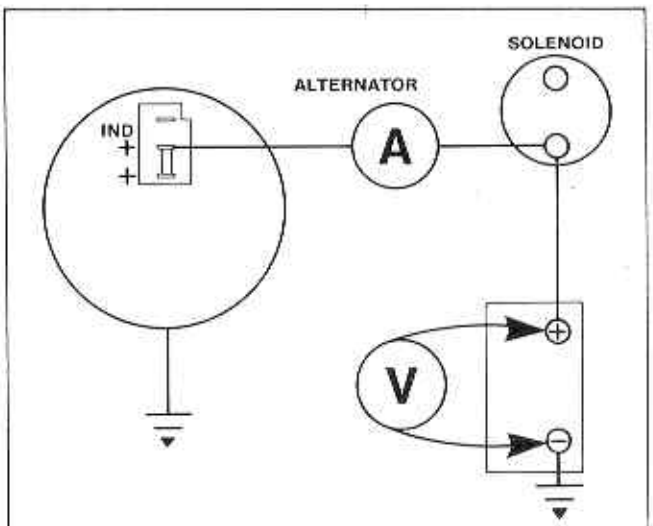


Figure 7.18 Checking the Voltage Output.

Belt Tension – PJ1 and PJ2 Engines

7.40 Belt tension is correct when moderate hand pressure applied at the centre of the belt between the pulleys gives a deflection of approximately 13 mm (0.5 in.). To adjust the tension slacken the two alternator pivot bolts and the bolt on the slotted adjustment

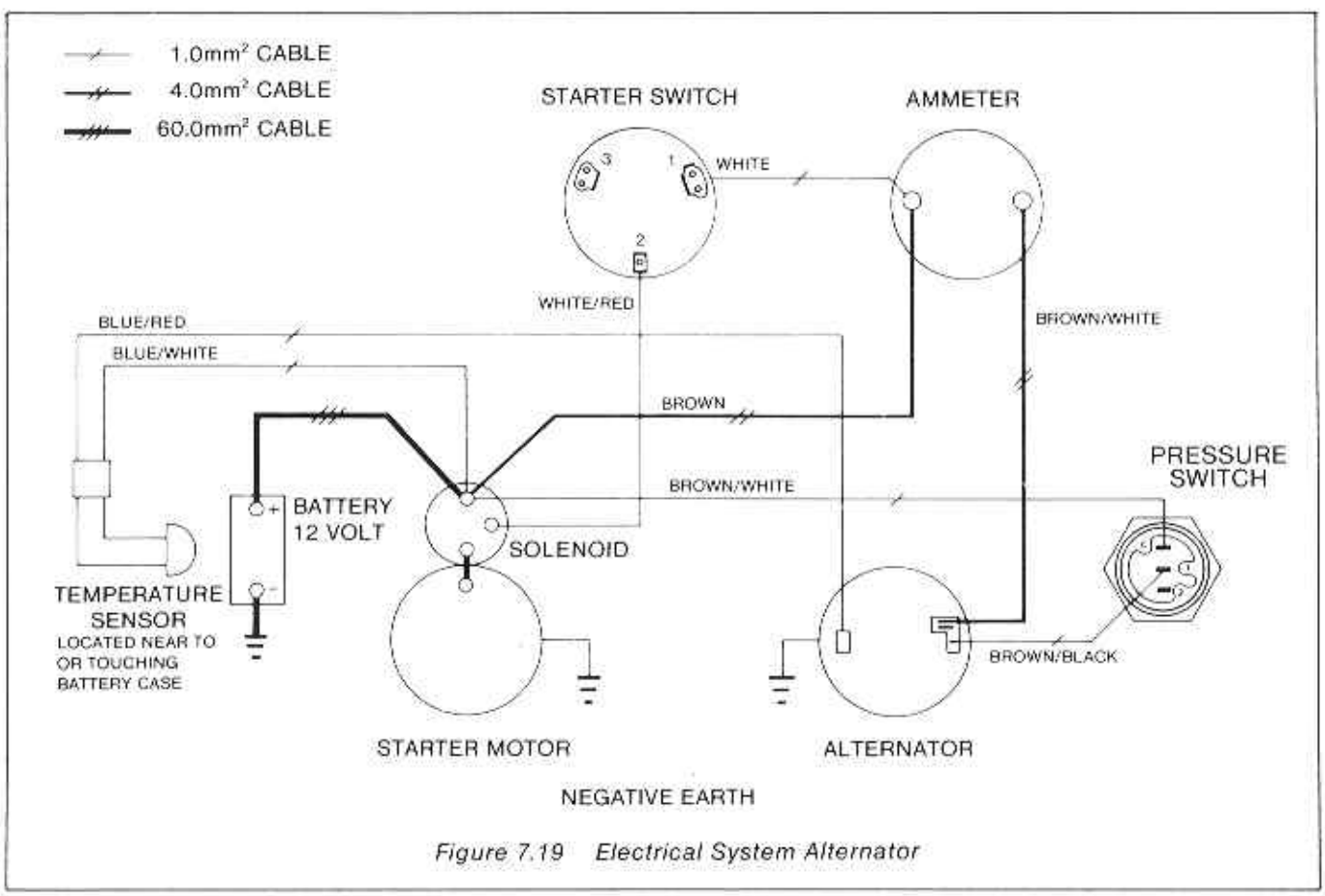


Figure 7.19 Electrical System Alternator

strap. Pull the alternator outwards to increase the tension. Maintain the correct tension and tighten the adjusting strap bolt, then tighten the pivot bolts.

Belt Tension PJ3 and PJ4 Engines

7.41 To adjust the belt tension on PJ3 and PJ4 engines proceed as follows

(1) Remove the belt guard

(2) Slacken the alternator pivot bolts and the clamping setscrew.

(3) Set the alternator drive pulley so that the belt is not slack but not stretched. Tighten the clamping setscrew.

(4) Measure the outside length of the belt and note this measurement.

(5) Slacken the clamping setscrew and increase the pressure on the drive pulley sufficiently to increase the measured length noted by 6 mm (0.25 in.). Tighten the clamping setscrew and pivot bolts.

(6) Fit the fan belt guard.

SECTION 8
PROTECTION AND PRESERVATION

PROTECTION

8.1 To increase the life of the engine it is advisable to protect the engine as much as possible from environmental damage. When not in use engines must be protected by a dust and waterproof cover. Under tropical conditions a permanent awning should be provided.

Intermittent Use

8.2 When not is regular use, engines should be run on load at normal operating temperature each month to lubricate internal parts and remove condensation. External unpainted parts should be wiped clean and lightly sprayed with a proprietary de-wetting agent.

PRESERVATION

8.3 Engines remaining idle for more than a month may corrode resulting in serious damage. In order to prevent this it is recommended that the following preservation procedure is carried out.

(1) Carry out a 500 hours service as detailed in Section 1.

(2) Drain the sump, flush out with flushing oil and refil with the correct grade of lubricating oil. Alternatively a lubricating oil with preservation properties may be used as recommended by Petters Limited or their representatives.

(3) Drain the fuel tank and filter and refill with 0.57 litres (1 pint) of Shell Fuses Oil or Calibration Fluid C. Bleed and prime the fuel system (Section 1) and run the engine on a light load for five minutes.

(4) If prolonged storage is envisaged remove the injector and apply a small quantity of preservative oil to the cylinder and piston while turning the engine by hand. Replace the injector, fitting a new sealing washer.

(5) Remove air inlet and exhaust fittings and with each cylinder on the compression stroke in turn (inlet and exhaust valves closed) apply preservative oil to both inlet and exhaust ports to protect the valve seats. The manifolds should then be sealed to prevent ingree of moisture.

(6) If electric starting is fitted the battery must be removed and the terminals cleaned and greased. To maintain the battery in good condition it should be trickle charged at regular intervals.

(7) Clean and dry the engine, repaint where necessary and wipe all unpainted parts with an oil rag. All pivot paints and external controls should be cleaned and sprayed with a proprietary de-wetting agent.

8.4 Protected engines should be periodically examined to check the preservation effectiveness. Rectification of the protection should be carried out if necessary.

PREPARATION FOR USE

8.5 After an engine has been preserved the following procedure must be carried out to return it to its operating condition.

(1) Remove all protective coverings.

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

(3) Check the oil level on the dipstick and ensure that the engine is filled with the correct type and grade of oil. (Section 1).

(4) Re-connect the battery, if fitted.

(5) Check the air cleaner oil bath, if fitted (Section 4).

(6) Check the tension of the drive belt (if fitted) and adjust if necessary.

(7) Check the exhaust system for damage and security of joints.

(8) Clean and lightly lubricate the speed control linkage.

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

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

8.6 After an initial run check the oil level and visually check for leaks.

SECTION 9
FAULT FINDING

INTRODUCTION

9.1 This section is a guide to assist in the location of a fault that may occur on a 'PJ' range engine. Information or causes and suggested remedies are also given.

TABLE 9.1 ENGINE WILL NOT START

Reason	*Cause*	*Suggested Remedy*	*Reference*
	Incorrect starting procedure	Adopt correct procedure	Sect. 1
	Low temperature	Starting aid may be required	Sect. 1
Incorrect lubrication oil	Too high viscosity oil causing excessive drag	Drain the sump and fill with correct oil	Sect. 2 Sect. 1
Contaminated fuel	Water, dirt or unsuitable fuel in system	Drain and flush fuel system and fill with correct fuel	Sect. 3 Sect. 1
Excessive load	Excessive drag from driven machine	Remove all load during starting	
Fuel supply failure check by cranking the engine and listen for the characteristic squeak of the injector	No fuel	Fill with correct fuel	Sect. 1
	Air in system	Bleed the fuel system	Sect. 1
	Fuel filter blocked	Fit new element	Sect. 3
	Faulty injector nozzle	Replace the nozzle or fit replacement fuel injector	Sect. 3
	Injection pump failure	Fit a replacement injection pump	Sect. 3
Poor compression	Valves sticking or not seating properly	Decarbonise and grind in valves	Sect. 5
	Cylinder head gasket blown	Fit a new gasket	Sect. 5
	Piston rings stuck in piston grooves	Clean piston and fit new rings	Sect. 5
	Worn cylinder and piston	Replace cylinder, piston and piston rings	Sect. 5
	Incorrect bumping clearance	Check large end bearing and reset bumping clearance	Sect. 5
	Broken or weak valve springs	Renew valve springs	Sect. 5
	Incorrect valve clearances	Adjust valve clearances	Sect. 5

TABLE 9.1 Continued

Reason	*Cause*	*Suggested Remedy*	*Reference*
Starter motor will not crank engine	Flat battery	Charge battery or replace	
	Flat battery due to faulty charging equipment	Isolate fault and repair	Sect. 7
	Dirty or loose terminals	Clean and tighten	Sect. 7
	Broken wire	Replace	Sect. 7
	Faulty starter switch	Replace switch	
	Faulty starter motor or solenoid	Repair or replace	Sect. 7
	Engine seized	Overhaul engine	Sect. 5

TABLE 9.2 ENGINE STARTS BUT FIRES INTERMITTENTLY OR SOON STOPS

Reason	*Cause*	*Suggested Remedy*	*Reference*
Faulty fuel supply	Water in the fuel	Drain and flush the fuel system and fill with clean fuel	Sect. 3 Sect. 1
	Sticking injector needle	Fit a new nozzle or a replacement injector	Sect. 3
	Partially blocked fuel filter	Renew fuel filter element	Sect. 3
	Air in system	Bleed fuel system	Sect. 1
Restricted air intake	Dirty air cleaner	Clean air cleaner and/ or fit new element	Sect. 4
Faulty compression	Valves sticking or not seating correctly	Decarbonise and grind in valves	Sect. 5
	Cylinder head gasket blown	Fit a new gasket	Sect. 5
	Piston rings stuck in piston grooves	Clean piston and fit new piston rings	Sect. 5
	Worn cylinder and piston	Replace cylinder, piston and piston rings	Sect. 5
	Incorrect bumping clearance	Check large end bearings and reset bumping clearance	Sect. 5
High exhaust back pressure	Blocked exhaust pipe or silencer, incorrect exhaust	Clean or replace	Sect. 1
Overloaded	Excessive drag from driven machine	Remove the load during starting	

TABLE 9.3 ENGINE LACKS POWER AND/OR SHOWS A DIRTY EXHAUST GAS

Reason	*Cause*	*Suggested Remedy*	*Reference*
Faulty fuel supply	Air in fuel system	Bleed the fuel system	Sect. 1
	Incorrect fuel	Drain and flush the fuel system and fill with the correct fuel	Sect. 3 Sect. 1
	Fuel leaks	Check tighten pipe connectors, renew or repair fuel lines	Sect. 3
	Faulty injector	Fit a new nozzle or a replacement injector	Sect. 3
	Incorrect fuel pump timing	Time the injection pump	Sect. 3
	Faulty injector pump	Renew pump	Sect. 3
	Incorrect injector pipe	Fit correct pipe	Sect. 3
	Kinked flexible fuel pipes	Fit new pipe	
	Partially blocked fuel filter	Renew filter element	Sect. 3
Restricted air intake	Dirty air cleaner	Clean and/or refit a new element	Sect. 4
Running at an incorrect speed	Worn or incorrectly adjusted speed control	Renew or adjust	Sect. 3
Faulty compression	Valves sticking or not seating correctly	Decarbonise and grind in valves	Sect. 5
	Cylinder head gasket blown	Fit a new gasket	Sect. 5
	Piston rings stuck in piston grooves	Clean piston and fit new piston rings	Sect. 5
	Worn cylinder and piston	Replace cylinder, piston and piston rings	Sect. 5
	Incorrect bumping clearance	Check large end bearings and reset bumping clearance	Sect. 5
High exhaust back pressure	Blocked exhaust pipe or silencer, incorrect exhaust	Clean or replace	Sect. 1
Extended periods of running off load or with a light load	Glazed cylinder bore	De-glaze cylinder bore and fit new piston rings	Sect. 5
Overloaded	Load requirement in excess of engine power rating	Reduce load	Preliminaries

TABLE 9.4 FAULTY RUNNING

Reason	*Cause*	*Suggested Remedy*	*Reference*
Knocking	Excessive carbon formation	Decarbonise	Sect. 5
	Air in fuel system	Bleed fuel system	Sect. 1
	Low oil supply	Replenish oil system	Sect. 1 Sect. 2
	Diluted or incorrect oil	Drain and refil sump with correct grade and type of oil	Sect. 1 Sect. 2
	Injector needle sticking or release pressure incorrect	Fit new nozzle or a replacement injector	Sect. 3
	Injection pump timing too far advanced	Adjust timing	Sect. 3
	Broken piston ring	Examine piston and cylinder for damage and repair as necessary	Sect. 5
	Slack piston	Check piston and cylinder for wear and renew as necessary	Sect. 5
	Worn large end bearing	Check crankpin for damage renew as necessary check lubrication system	Sect. 5 Sect. 2
	Worn small end bearing	Renew small end bearing and check gudgeon pin	Sect. 5
	Loose flywheel	Refit	Sect. 5
Overheating	Cooling system failure	Check that the cooling system is in order and air flow is not obstructed	Sect. 1
	Overloaded	Reduce load to conform with engine power rating	Preliminaries
	Excessive valve clearances	Adjust valve clearances	Sect. 5
	Incorrect lubrication oil or level	Drain and refil sump with correct grade and type of oil or drain to the correct level	Sect. 1 Sect. 2
	Injection pump timing incorrect	Adjust timing	Sect. 3
Speed surges	Over heating	See overheating	
	Air in fuel system	Bleed the fuel system	Sect. 1
	Injector release pressure incorrect	Fit a replacement injector	Sect. 3
	Injector pump rack sticking	Fit a replacement pump	Sect. 3
	Governor sticking or worn	Free or fit a new governor components	Sect. 5

TABLE 9.4 Continued

Reason	Cause	Suggested Remedy	Reference
Sudden stop	Empty fuel tank	Fill fuel tank and bleed fuel system	Sect. 1
	Blocked or stuck injector	Fit a replacement injector	Sect. 3
	Broken fuel pipe	Repair or renew	Sect. 3
	Engine seized	Overhaul engine	Sect. 5
Heavy vibration	Loose flywheel	Refit	Sect. 5
	Faulty installation	Check holding down bolts flexible mountings and couplings	Sect. 1
Engine overspeeds	Lubrication oil overfilled	Drain down to correct level	Sect. 1
	Lubrication oil diluted or incorrect grade	Rectify cause of dilution drain and refil with correct grade of oil	Sect. 1
	Injection fuel pump stuck in full fuel position	Replace injection pump	Sect. 3
	Governor faulty	Fit new governor	Sect. 5
Excessive oil consumption	Oil leaks	Rectify leaks	
	Worn valve guides, piston rings, or cylinder	Renew as necessary	Sect. 5
	Incorrect type or grade of oil	Drain and fill with correct type and grade of oil	Sect. 1
	Extended periods of running off load or with a light load	De-glaze cylinder bore and fit new piston rings	Sect. 5
	Excess oil in sump	Drain oil to correct level	Sect. 1
	Overheating	See overheating	
Lubrication oil dilution	Leaking lift pump diaphragm	Fit new diaphragm	Sect. 6
	Leaking injection pump element	Fit replacement pump	Sect. 3
	Faulty injector	Fit a replacement injector	Sect. 3

PART 2

WATER COOLED DIESEL ENGINES
PJ1W, PJ1WZ, PJ2W, PJ2WZ, PJ3W AND PJ4W

PART 2

WATER COOLED DIESEL ENGINES
PJ1W, PJ1WZ, PJ2W, PJ2WZ, PJ3W AND PJ4W

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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 PJ 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 (PJW1 and PJW2 only)

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 PJ 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 35 mm (1.375 in.) bore pipes.

(2) Coolant pipe **(1)** should go to the top of the cooling tank **(2)** in a steady incline. The bottom of the cooling tank should be level with or slightly below the bottom of the cylinder. Pipes should be as short as possible with a minimum of bends.

(3) The coolant level 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 50 mm (2 in.) bore pipes **(3)**, one below the level of pipe **(1)** and the other about 50 mm (2 in.) from the base.

(5) A tap or cock **(5)** should be fitted to the pipe **(4)** for maintenance purposes. The outlet temperature of the coolant should not exceed 95°C (203°F) and not be less than 75°C (167°F). A thermostatic valve **(6)** should be installed in pipe **(1)** to maintain this temperature.

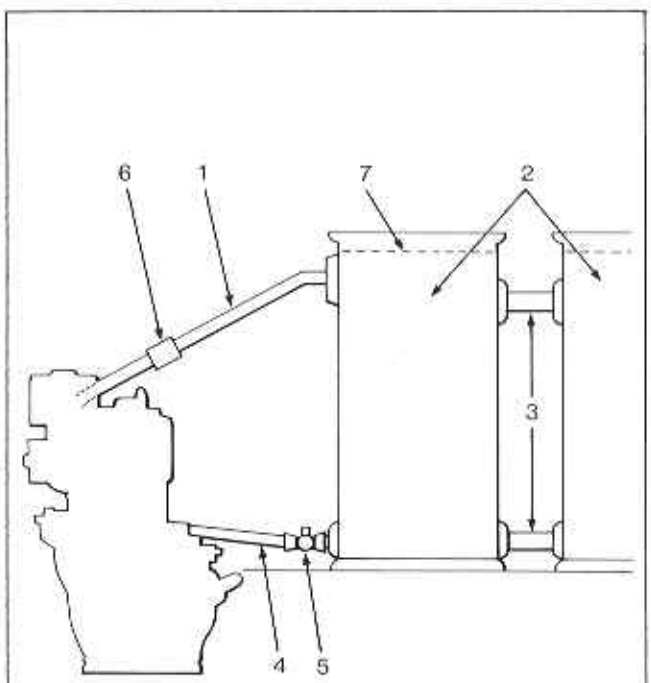


Figure 1.1 Cooling Tanks Arrangement

TABLE 1.1 WATER CAPACITY COOLING TANK(S)

Engine	Cooling Tank(s) Capacity	
	Temperate	Tropical
PJ1W	**545 litres (120 gal)**	**1090 litres (240 gal)**
PJ1WZ	**545 litres (120 gal)**	**1090 litres (240 gal)**
PJ2W	**1090 litres (240 gal)**	**2180 litres (480 gal)**
PJ2WZ	**1090 litres (240 gal)**	**2180 litres (480 gal)**
PJ3W	**1640 litres (360 gal)**	**3280 litres (720 gal)**
PJ4W	**2090 litres (460 gal)**	**4180 litres (920 gal)**

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.

TABLE 1.2 RADIATOR COOLANT CAPACITY

Engine	Radiator Capacity	
	Temperate	Tropical
PJ1W	**5.7 litres (10 pints)**	**6.8 litres (12 pints)**
PJ2W	**8.5 litres (15 pints)**	**8.5 litres (15 pints)**
PJ3W	**10.2 litres (18 pints)**	**10.2 litres (18 pints)**
PJ4W	**12.5 litres (22 pints)**	**12.5 litres (22 pints)**

Anti-freeze

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.

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 PJ series engines and is as described in Part 1, Section 1.

EXHAUSTS AND SILENCERS

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

LUBRICATION

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

FUEL

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

DRIVE ARRANGEMENTS

1.16 The engine drive arrangements are common to all PJ 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 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 decompressor lever(s) and turn the engine about fifteen times to circulate the oil.

(5) Fill the fuel tank with the appropriate type and grade of fuel (Part 1, Section 1, 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 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 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) and (4) on each subsequent cylinder, if appropriate, re-aligning the flywheel mark.

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 on no load and ensure that there are no oil leaks.

(2) Check that there are no coolant leaks.

Note

After the initial run 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 one hour on full load, and carry out the procedure detailed in Paragraph 1.28.

(5) Run for a further minimum of 8 hours or longer, 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.

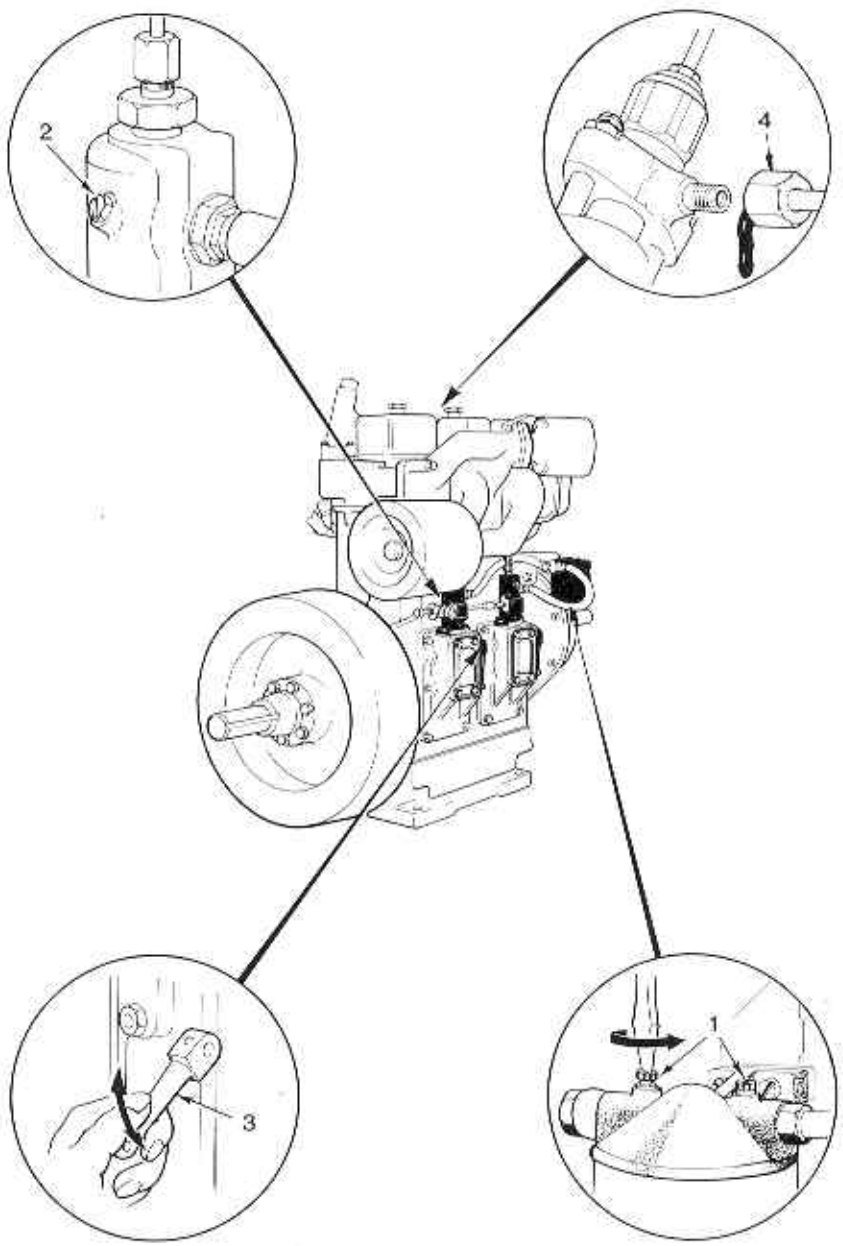


Figure 1.2 Bleeding and Priming the Fuel System

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 decompressor 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 decompressor lever. The engine should now fire, then knock down the other lever(s).

(5) If the engine does not fire, lift the decompressor 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 decompressor 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 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.

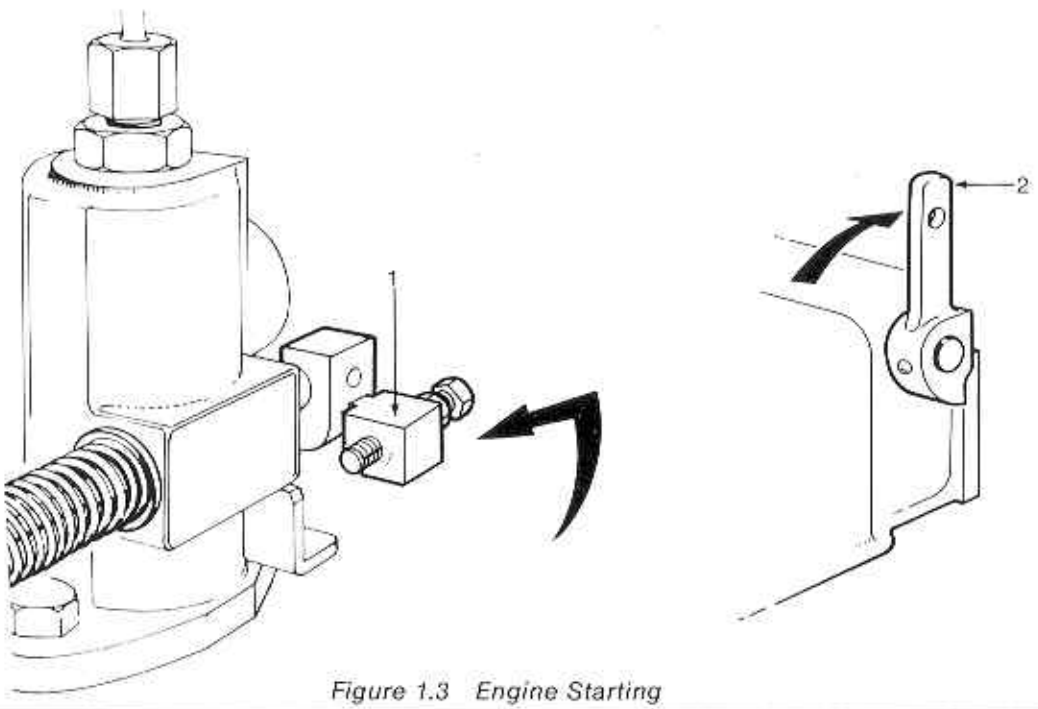


Figure 1.3 Engine Starting

TABLE 1.3 COLD STARTING AID TEMPERATURES FOR STARTING (BARE ENGINES)

Installation	*Engine Type*					
	PJ1W	*PJ1WZ*	*PJ2W*	*PJ2WZ*	*PJ3W*	*PJ4W*
On half-speed extension shaft (Hand)	**−8°C (17°F)**	**−8°C (17°F)**	**−8°C (17°F)**	**−8°C (17°F)**	**−6°C (21°F)**	**−6°C (21°F)**
On full-speed extension shaft (Hand)	**5°C (41°F)**	—	**5°C (41°F)**	—	**5°C (41°F)**	**5°C (41°F)**
Electric	**−16°C (3°F)**	—	**−16°C (3°F)**	—	**−16°C (3°F)**	**−16°C (3°F)**

Hot Start

1.24 Carry out the following procedure:

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

(2) Lift the decompressor lever(s).

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

(4) Lower the priming lever(s).

(5) Turn the engine as fast as possible. When the engine is turning at a good speed knock down one decompressor lever. The engine should now fire. On multi-cylinder engines knock down the remaining decompressor lever(s). On engines with a starter motor lower the decompressor lever(s). Do not operate the starter motor for more than 20 seconds at a time.

STOPPING

1.25 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 decompressor levers to stop the engine.

OPERATING PRECAUTIONS

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

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

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

Please remember

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

... an engine needs lubricating oil
Use correct grade and 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

After an Initial Run of One Hour on Full Load

1.28 After an initial run of one hour on full load and with the engine cold re-torque the cylinder head and block nuts. To achieve this slacken and tighten each cylinder head nut in turn a quarter of a turn and re-torque load to 84 Nm (62 lbf ft.). Slacken each cylinder block nut a quarter of a turn and re-torque to 176 Nm (130 lbf ft.). Reset the tappet clearance to 0.25 mm (0.010 in.).

20 Hours Initial Running

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

(1) Drain the lubricating oil from the sump, change the filter element (if applicable) and fill with clean oil (Section 2).

(2) Check the fuel filter (Section 3).

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

(4) Check any belt drives.

50 Hours Initial Running or Three Months

Marine Engines Only

1.30 Protection against electrolytic corrosion is provided by a zinc anode fitted at the hose connection end of the water inlet manifold. This anode should be checked at regular intervals especially in the case of engines where direct sea water (raw water) cooling is used. Due to the varied environmental conditions that exist it is not possible to specify a uniform period when the anode should be checked. Initially it is recommended that the anode should be checked after 50 hours running or no later than three months from the date of ownership (excluding any period where the engine is not in use with the cooling system drained). Depending on the condition of the anode at this time determines a suitable servicing frequency for the future.

DAILY CHECKS

1.31 Carry out the following procedure:

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

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

(3) Check 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

1.32 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

1.33 Carry out the following procedure:

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

(2) Check the tightness of all nuts (excluding the cylinder head and block), 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

1.34 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

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

EVERY 2000 RUNNING HOURS

1.36 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 for wear (Section 5).

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

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

SECTION 2
LUBRICATING SYSTEM

INTRODUCTION

2.1 The lubricating system is identical to the PJ air cooled engine and is as described in Part 1, Section 2.

SECTION 3
FUEL SYSTEM

INTRODUCTION

3.1 The fuel system used on the PJ water cooled series engine is almost identical to the air cooled, described in Part 1, Section 3, the exception is the fuel injector which is fitted with a sealing washer.

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 3.1)

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 cylinder head.

(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.

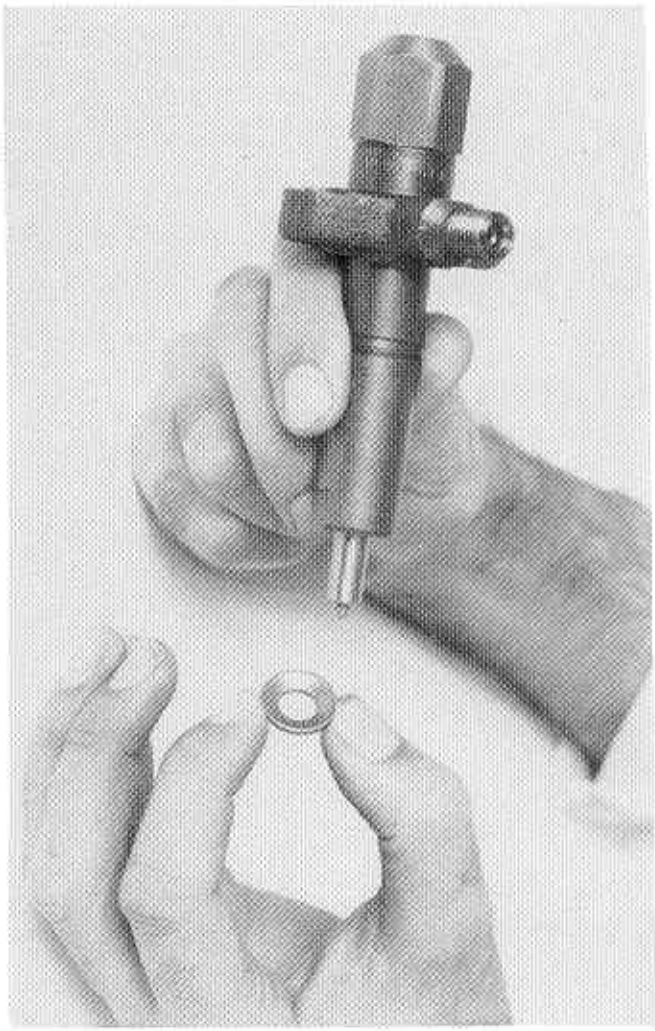


Figure 3.1 Fitting the Sealing Washer

SECTION 4
AIR FILTRATION AND ENGINE COOLING

AIR FILTRATION

4.1 Air filtration is common to all PJ 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) Remove the plug(s) from the cylinder(s) and open the tap on the manifold water inlet to allow the coolant to drain from the engine.

Flushing

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

(1) Isolate the cooling tanks or drain the radiator.

(2) Remove the plug(s) from the cylinder(s) and open the tap on the manifold water inlet to allow the coolant to drain from the engine.

(3) Remove the water inlet and outlet manifolds.

(4) 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.

(5) Replace the water manifolds and cylinder plug(s) with its washer(s).

(6) Fill the system with the appropriate coolant.

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

Adjusting the Radiator Fan Belt

4.5 To adjust the fan belt proceed as follows:

(1) Loosen the locknut on the fan pulley support.

(2) Loosen the six fan guard securing bolts.

(3) Slide the pulley support assembly upwards to increase the belt tension or downwards to decrease it.

(4) The fan belt tension is checked by applying pressure on the belt as shown in Figure 4.1 The belt should have about 6.35 mm , (0.25 in.) movement.

(5) Tighten the fan pulley support locknut.

(6) Centralize the fan guard so that it is completely clear of the fan blades when rotated and tighten the six securing bolts.

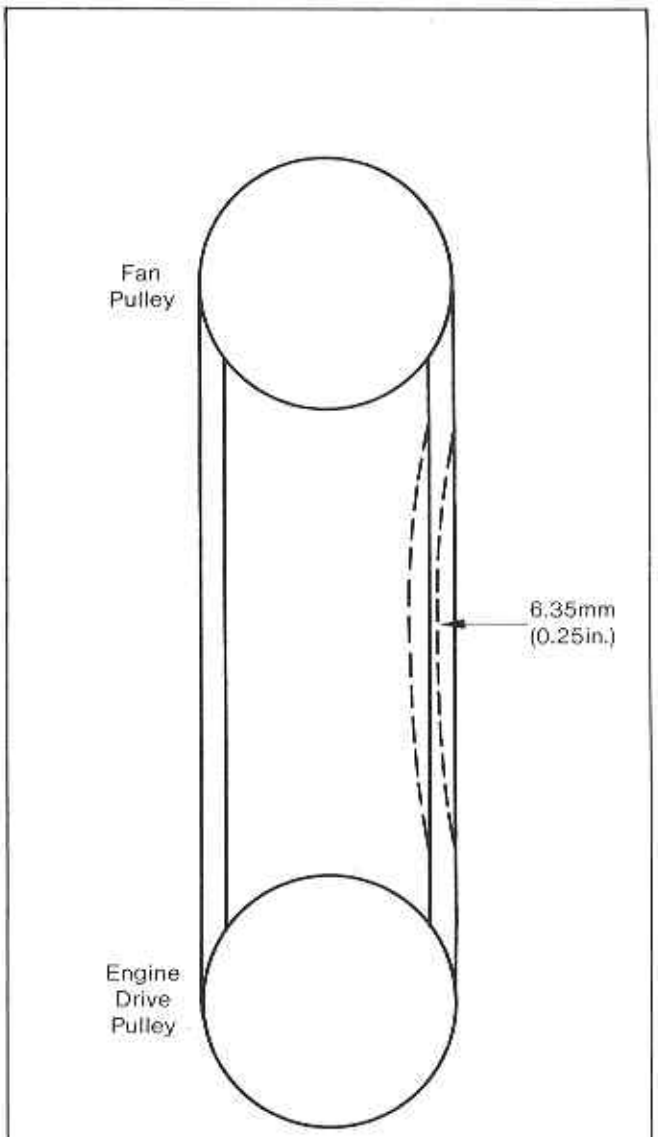


Figure 4.1 Checking the Fan Belt Tension

Radiator Fan Spindle Lubrication (Early Type)

4.6 The spindle runs in an oil impregnated bush and should be oiled when the engine is overhauled as follows:

(1) Remove the round-headed screw and washers retaining the fan pulley.

(2) Using a syringe fill the small reservoir in the shaft with SAE 20W/20 lubricating oil.

(3) Fit the washer and retaining screw.

Water Pump (Belt Driven) (Figure 4.2)

Removal

4.7 To remove the water pump from the engine proceed as follows:

(1) Drain the cooling water.

(2) Disconnect the inlet and outlet pipes at the pump.

(3) Remove the four setscrews **(1)** securing the fan **(2)** and fan plate **(3)** to the water pump pulley **(4)**.

(4) Slacken the idler pulley or dynamo/alternator pivot bolts and clamping setscrew. Remove the drive belt.

(5) Remove the setscrews securing the pump bracket **(5)**.

Dismantling

4.8 To dismantle the water pump proceed as follows:

(1) Separate the pump body **(6)** from the bracket **(5)** by removing the bolts **(7)**.

(2) Using suitable screws in the tapped holes of the impeller **(8)** as an extractor remove it from the shaft **(9)**.

(3) Remove the water pump seal **(10)**.

(4) Remove the circlip **(11)** from the shaft and withdraw the pulley and shaft assembly from the pump body.

Maintenance

4.9 Carry out the following:

(1) Clean all parts and check for wear or damage.

(2) Replace any defective parts.

Assembly

4.10 To assemble the water pump proceed as follows:

(1) Insert the shaft **(9)** into the pump body **(6)** and fit the circlip **(11)**.

(2) Fit the seal **(10)**.

(3) Press the impeller onto the shaft.

(4) Fit a new gasket and bolt the pump body **(6)** to the bracket **(5)**.

Replacement

4.11 To replace the water pump on the engine proceed as follows:

(1) Position the water pump bracket and secure.

(2) Fit the drive belt.

(3) Connect the water pipes to the pump connections.

(4) Fill the system with coolant and check for leaks.

(5) Adjust the belt tension as detailed in Paragraph 4.12.

Water Pump Belt Drive Tension

4.12 The belt tension must be set correctly as a slack belt overheats and gives a low dynamo/alternator output if fitted. An over-tensioned belt causes premature belt and bearing wear. To adjust a bramer the belt tension proceed as follows:

(1) Slacken the clamping setscrew.

(2) Set the pulley so that the belt is not slack but not stretched. Tighten the clamping setscrew.

(3) Measure the outside length of the belt and note this measurement.

(4) Slacken the clamping setscrew and increase the pressure on the pulley sufficiently to increase the measured length noted by 6 mm (0.25 in.). Tighten the clamping setscrew and pivot bolts.

(5) Fit the guard.

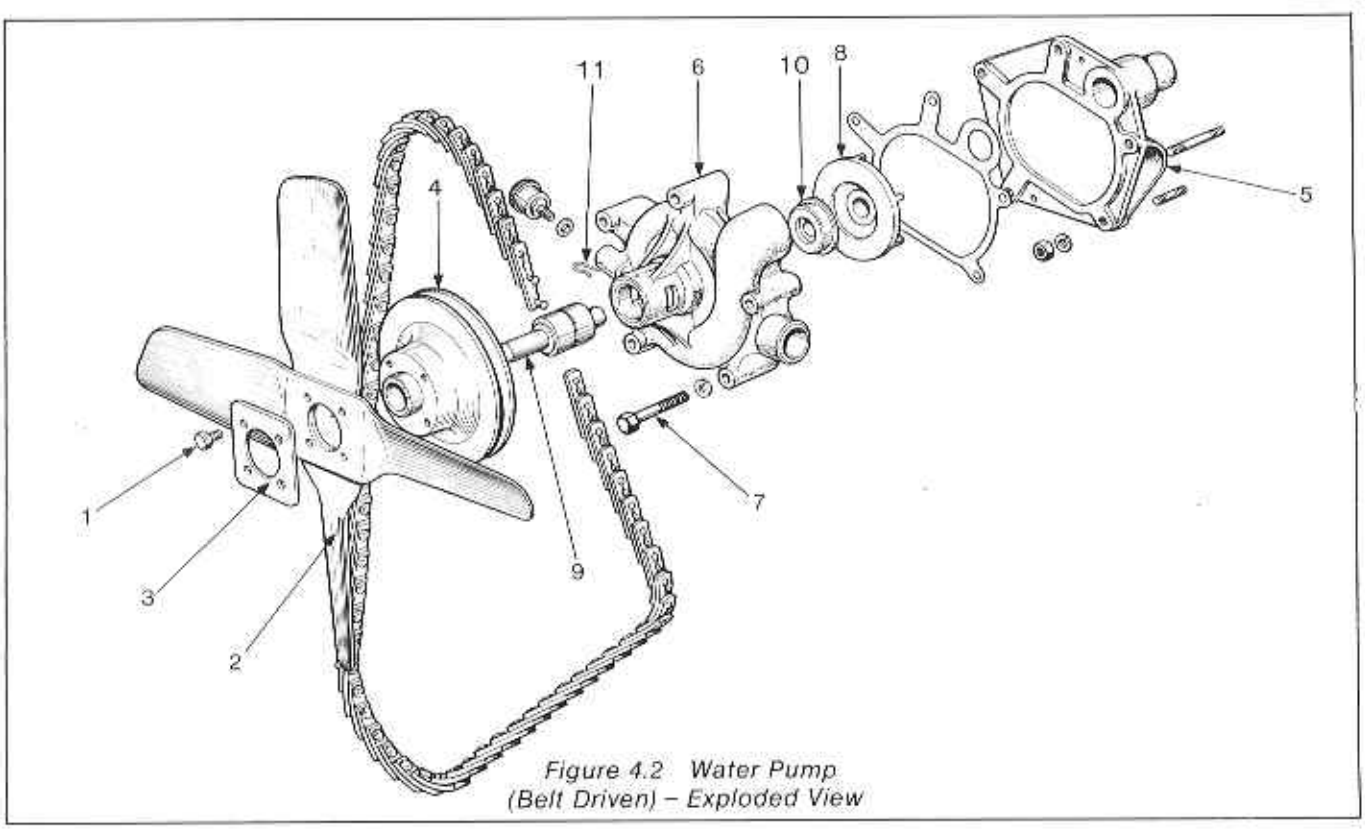


Figure 4.2 Water Pump (Belt Driven) – Exploded View

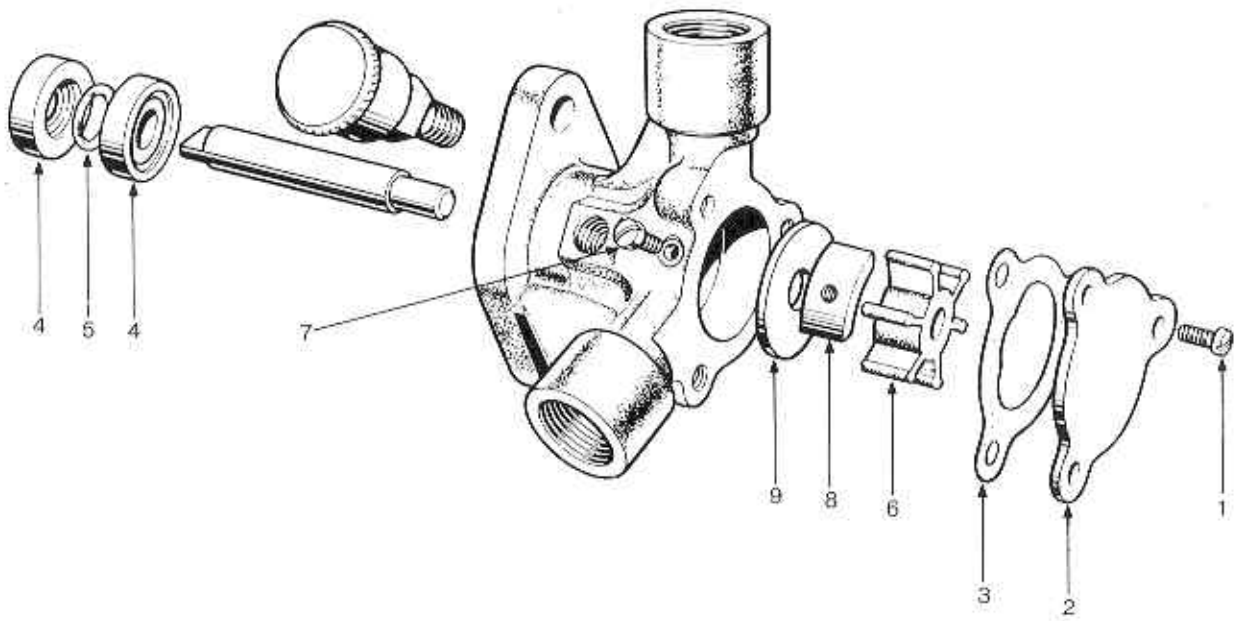


Fig 4.3. Water Pump (Shaft Driven) : Exploded View

Water Pump (Shaft Driven) (Figure 4.3)

Removal

4.13 To remove the water pump from the engine proceed as follows:

(1) Isolate the coolant supply; drain the coolant if necessary. Disconnect the pipes at the pump body.

(2) Remove the two nuts securing the pump to the gear cover.

(3) Remove the pump and gasket.

Dismantling

4.14 To dismantle the water pump proceed as follows:

(1) Remove the three screws **(1)** securing the cover **(2)** and remove the cover and gasket **(3)**.

(2) Remove the impeller and shaft assembly by pressing the drive end of the shaft.

(3) Remove the seal(s) **(4)** and 'O' ring **(5)** (if applicable).

(4) Remove the impeller **(6)**.

(5) Remove the cam screw, **(7)** cam **(8)** and wear plate **(9)** (if fitted).

Maintenance

4.15 Carry out the following procedure:

(1) Clean and inspect all parts for wear or damage and renew any defective parts.

(2) Check that the drain hole in the pump body is not blocked.

Assembly

4.16 To assemble the water pump proceed as follows:

(1) Insert the wear plate **(9)** (if fitted) with the dimple facing outward and in line with the cam locating screw hole.

(2) Apply a suitable sealing compound to the top surface of the cam **(8)**.

(3) Fit the cam **(8)** and screw **(7)** ensuring that the groove on the inner edge locates with the dimple on the wear plate.

(4) Press in the seal **(4)** with its lip towards the impeller.

(5) Fit the impeller onto the shaft.

(6) Insert the shaft into the pump body carefully so as not to damage the seal or impeller blades.

(7) Fit the 'O' ring seal **(5)** and the outer seal with its lip towards the driving tongue and its edge flush with the pump body face.

(8) Fit the gasket **(3)** and cover plate **(2)** using the three screws **(1)**.

Replacement

4.17 To replace the pump on the engine proceed as follows:

(1) Fit the gasket over the studs in the gear cover.

(2) Locate the pump over the studs engaging the drive.

(3) Fit and tighten the nuts.

SECTION 5
ENGINE GENERAL MAINTENANCE

INTRODUCTION

5.1 This section contains fitting and servicing instructions for major repairs and maintenance of the PJ water cooled diesel engines. Servicing which is common to all PJ 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 deposit forms on piston and cylinder heads and the presence of an excessive carbon deposit is usually indicated by a loss of power. Decarbonising necessitates the removal of the cylinder head, followed by the removal of all carbon and the grinding in of the valves.

Cylinder Head Removal

5.3 To remove a cylinder head proceed as follows:

(1) Drain off the cooling system as detailed in Section 4.

(2) Remove the cooling pipe connections.

(3) 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 lubricating oil feed pipe to the rockers.

(7) Remove the rocker box by unscrewing the large centre nut and lifting the box off.

(8) Unscrew the rocker support post nuts and remove the rocker assembly complete. Withdraw the push rods noting their position.

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 self-locking retaining nuts diagonally in sequence as shown in Figure 5.2.

(11) Remove the nuts and lift off the cylinder head.

Cylinder Head Dismantling

5.4 Dismantle the cylinder head as detailed in Part 1, Section 5.

Valve Removal

5.5 Remove the valves as detailed in Part 1, Section 5.

Carbon Removal

5.6 Remove the carbon as detailed in Part 1, Section 5.

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.

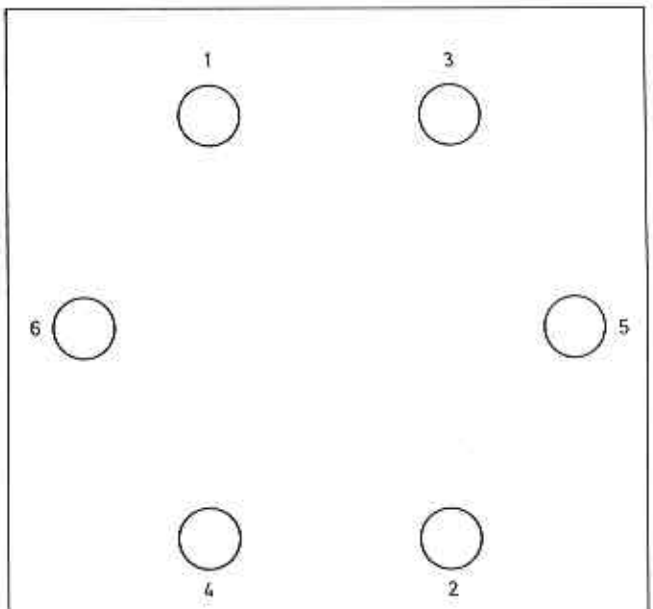


Figure 5.1 Cylinder Head Nuts: Removal and Replacement Sequence

Cylinder Head Assembly

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

Cylinder Head Replacement

5.10 To fit the cylinder head proceed as follows:

(1) Fit a new cylinder head gasket ensuring that the face marked TOP is uppermost. If the gasket is not marked the metal fold should face uppermost. Lower the cylinder head over the studs into position. Locate the exhaust port heat shield.

(2) Fit the cylinder head nuts and tighten finger-tight. On multi-cylinder engines, ensure that the manifold bolting faces are parallel with each other. Check with a straight edge as shown in Part 1, Section 5, or by bolting on a manifold.

(3) With reference to Figure 5.1 tighten each nut a quarter of a turn at a time in the sequence shown. Each nut must be finally tightened to a torque loading of 84 Nm (62 lbf ft.).

(4) Lightly lubricate the push rods with engine oil and fit in the positions noted in Paragraph 5.3 (8).

(5) Fit the push rod cover and gasket.

(6) Fit the valve caps.

(7) Fit the rocker support and secure using the two self-locking nuts.

(8) Connect the rocker lubrication oil feed pipe.

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

(10) Fit the inlet and exhaust manifold.

Valve Rockers Adjustment (Figure 5.2)

5.11 Set up the valve clearances on each cylinder in turn with the engine cold as follows:

CAUTION
The cylinder head and rocker support post nuts must be fully tightened down before the rocker clearance is adjusted.

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

(2) Slacken the locknut **(1)** and using a screwdriver set the rocker adjusting screw **(2)** to give the correct valve clearance with a feeler gauge as shown. When the correct setting of 0.25 mm (0.010 in.) is obtained tighten the locknut.

(3) After tightening the locknut re-check the clearance.

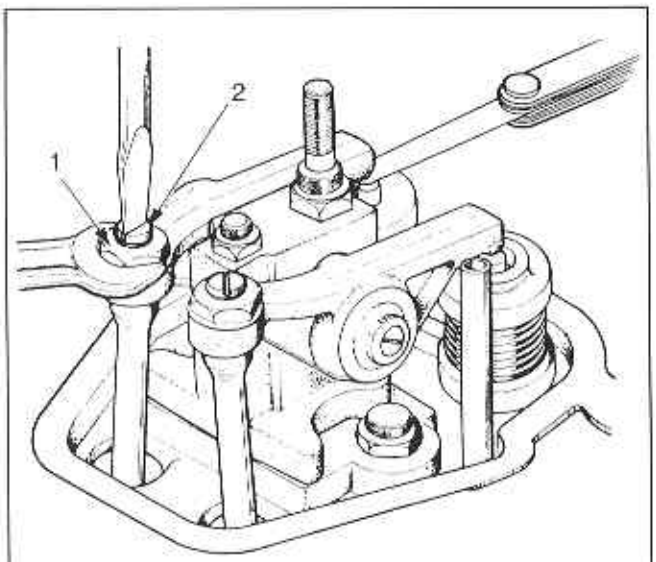


Figure 5.2 Setting the Valve Clearances

CAUTION
It is important that the cylinder head nuts are re-torqued to the specified torque and the tappet clearance reset with the engine cold after an initial run of one hour on full load. (Section 1)

Rocker Box Cover Replacement

5.12 Replace the rocker box cover as detailed in Part 1, Section 5.

Setting the Decompressor Lever

5.13 Set the decompressor 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) On multi-cylinder engines note the position of each cylinder block to ensure that it 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. Retain the shims fitted between the cylinder block and crank-case. These control the bumping clearance.

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

(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 for sufficient time to allow the pin to be removed.

Cylinder Liner Removal (Figure 5.3)

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.

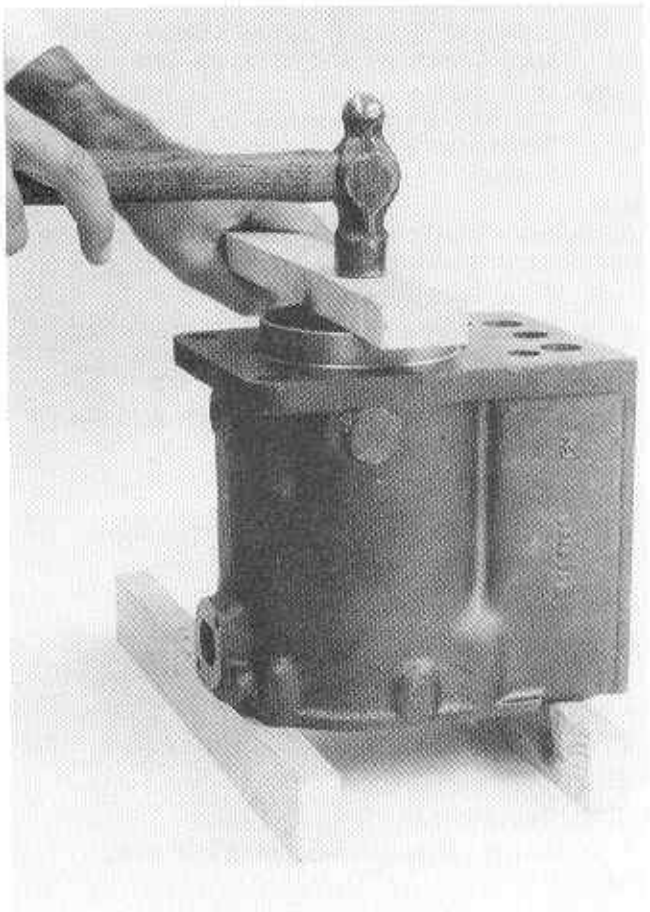


Figure 5.3 Removal of Cylinder Liner

Cylinder Liner Maintenance

5.16 Check the cylinder liner bore wear if this has reached the maximum of 0.25 mm (0.010 in.) the liner must be rebored and an oversize piston and rings fitted. The cylinder liner should be bored and honed to the sizes listed in Table 5.1. Check the liner joint ring groove for damage.

TABLE 5.1 CYLINDER LINER REBORING DIAMETERS

Cylinder Liner	*Size*
Standard	**96.876 to 96.901 mm (3.814 to 3.815 in.)**
1st oversize 0.508 mm (0.020 in.)	**97.384 to 97.409 mm (3.834 to 3.835 in.)**
2nd oversize 1.016 mm (0.040 in.)	**97.892 to 97.917 mm (3.854 to 3.855 in.)**

Cylinder Liner Replacement

5.17 To replace the cylinder liner proceed 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) Lightly lubricate a new joint ring and place it in the groove in the liner.

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

(5) Check the liner stands proud of the top face of the cylinder block by 0.267 to 0.394 mm (0.0105 to 0.0155 in.). The protrusion should be checked in various positions around the upper face of the block as shown in Figure 5.4. If necessary skim the cylinder block to achieve this figure.

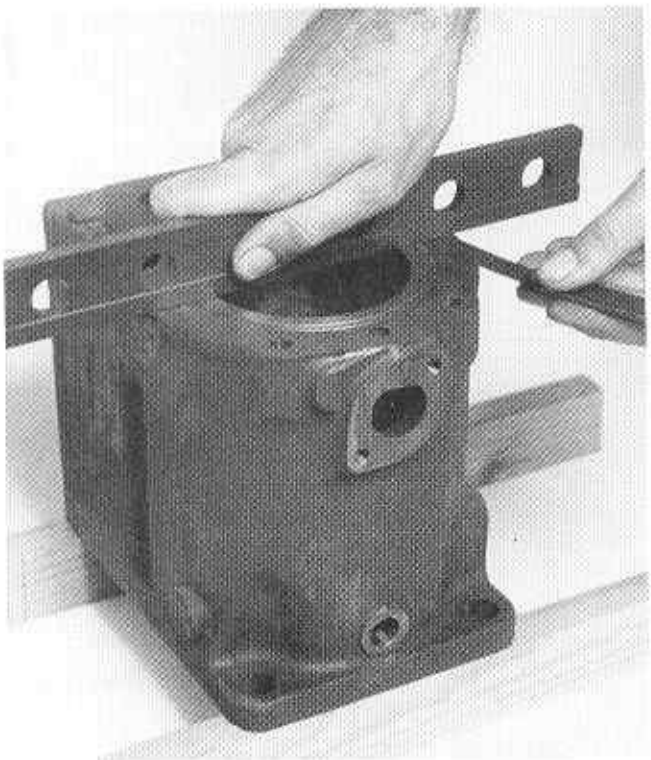


Figure 5.4 Checking the Cylinder Liner Protrusion

Piston Maintenance

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

Connecting Rod Maintenance

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

Replacement

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

(1) Place the piston on the connecting rod ensuring that the valve recesses (if applicable) 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 liner 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 block and crankcase. These shims control the bumping clearance between the piston and the cylinder head at TDC. Place the cylinder block on its studs aligning the marks made on dismantling if the original cylinder is being fitted.

CAUTION
It is imperative that the valve recesses (if applicable) 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 connecting rod bolts or nuts to a torque of 77 Nm (57 lbf ft.).

(10) Tighten the four cylinder block nuts diagonally and evenly. Finally torque load the nuts to 176 Nm (130 lbf. ft.).

Bumping Clearance (Part 1, Section 5, Figure 5.15)

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 5.10) 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 1.07 mm (0.036 to 0.042 in.) for an average of three readings. If necessary adjust the clearance by re-shimming (Paragraph 5.20 (6)).

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

FLYWHEEL

Removal

PJ1W, PJ2W, PJ3W and PJ4W Engines

5.22 To remove the flywheel proceed as follows:

(1) Unlock the flywheel bolts by bending back the tab washers.

(2) Remove any two diagonally opposite bolts and fit two identical threaded studs. These studs should protrude approximately 38 mm (1.5 in.) out of the flywheel.

(3) Remove the remaining bolts and pull off the flywheel and extension shaft along the two fitted studs. Retain the locating dowels.

PJ1WZ and PJ2WZ Engines

5.23 Withdraw the flywheel key with a tapered key drift (Part 1, Section 5, Figure 5.16) which is obtainable from Petters 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.

5.24 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

PJ1W, PJ2W, PJ3W and PJ4W Engines

5.25 To replace the flywheel proceed as follows:

(1) Screw the two studs used for removal into two diagonally opposite holes in the crankshaft. Ensure that the locating dowels are in position.

(2) Align and slide the flywheel onto the two studs as far as possible.

(3) Fit the extension shaft (if applicable) and four flywheel bolts.

(4) Remove the two studs and fit the two remaining flywheel bolts.

(5) Tighten all bolts gradually in turn working diagonally around the flywheel. Finally torque load PJ1W and PJ2W engines to 43 Nm (32 lbf ft.) or PJ3W and PJ4W engines to 63.5 Nm (47 lbf ft.).

PJ1WZ and PJ2WZ Engines

5.26 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.

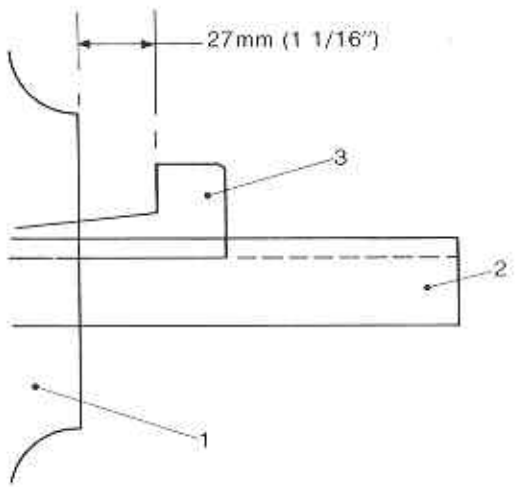
5.27 Note when fitting the flywheel a new key must be used and should be fitted as follows:

(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 Figure 5.5, 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.

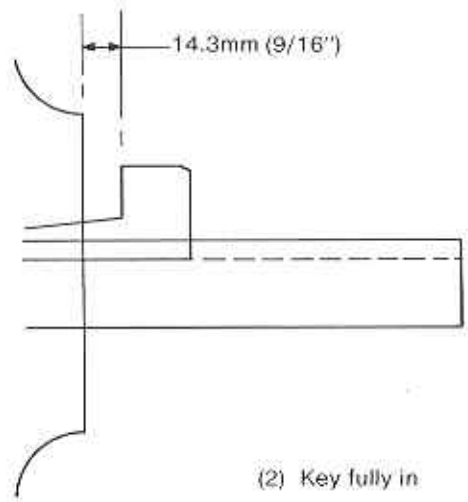
CAUTION
Do not remove metal from the tapered surface of the key.

(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.



1. Flywheel Boss
2. Crankshaft
3. Taper Key

(1) Insertion by Hand



(2) Key fully in

Figure 5.5 Flywheel Key Replacement

CRANKSHAFT

Removal

5.28 To remove the crankshaft proceed as follows:

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

(2) Remove the flywheel.

(3) On engines fitted with a flywheel bellhousing, remove the bellhousing.

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

(5) 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.

(6) On multi-cylinder engines remove the intermediate main bearing housing locking screw(s) (Part 1, Section 5, Figure 5.19) holding the housing(s) in position.

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

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

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

(10) On three and four cylinder engines mark the halves of the intermediate main bearing housings to identify the assembly positions and remove the housings from the crankshaft.

CAUTION
The halves of each bearing housing are machined as an assembly and must not be interchanged between assemblies.

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.

5.29 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

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

Main Bearing Maintenance

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

Flywheel End Oil Seal

5.32 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

5.33 To replace the crankshaft carry out the procedure detailed in Part 1, Section 5.

Fitting the Crankshaft Gear

5.34 Fit the crankshaft gear as detailed in Part 1, Section 5.

Crankshaft End Float

5.35 Check the crankshaft end float, this should not exceed 0.63 mm (0.025 in.). The end float when new should be 0.13 to 0.38 mm (0.005 to 0.015 in.).

CAMSHAFT

5.36 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 PJ 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 PJW engines which are built for marine use are identical in construction to the normal PJW 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 a hollow zinc anode fitted at the hose connection end of the water inlet manifold, and this anode 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 anode should be checked. Initially it is recommended that the zinc anode should be checked no later than after three months of vessel ownership (excluding any period where the vessel is out of the water). Depending on the condition of the anode 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(s) and gaskets.
(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 manifold(s).

Note
It may be necessary to flush the cooling system at more frequent intervals depending on operating conditions.

SECTION 7
ELECTRICS

INTRODUCTION

7.1 The electrical systems are common to all PJ 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. When not in use engines must be protected by a dust and waterproof cover. Coolant systems must be kept fully topped up or completely drained, anti-freeze must be added when operating in temperatures below 0°C (32°F). Under tropical conditions a permanent awning should be provided. It is important that the engine is kept clean and where necessary any damaged paintwork repaired.

Intermittent Use

8.2 When not in regular use, engines should be run on load at normal operating temperatures each month to lubricate internal parts and remove condensation. External unpainted parts should be wiped clean and lightly sprayed with a proprietary de-wetting agent.

PRESERVATION

8.3 Engines remaining idle for more than a month may corrode resulting in serious damage. In order to prevent this it is recommended that the following preservation procedure is carried out.

(1) Drain the coolant system and flush the system with clean fresh water. Ensure that the system is fully topped up or completely drained. If the system is to be filled it is advisable to include an inhibiting agent and if the temperature is liable to fall below 0°C (32°F) a suitable anti-freeze must be added.

(2) Drain the oil sump, flush out with flushing oil and refill with the correct grade of lubricating oil. Alternatively refill with a lubricating oil with preservation properties as recommended by Petters Limited or their representatives.

(3) Drain the fuel tank and filter and refill with 0.57 litres (1 pint) of Shell Fusus Oil or Calibration Fluid C. Bleed and prime the fuel system (Section 1) and run the engine on a light load for five minutes.

(4) If prolonged storage is envisaged remove the injector(s) and apply a small quantity of preservative oil to the cylinder(s) and piston(s) while cranking the engine by hand. Replace the injector(s) fitting new sealing washer(s).

(5) Remove air inlet and exhaust fittings and with each cylinder on the compression stroke (inlet and exhaust valve closed) apply preservative oil to both inlet and exhaust ports to protect the valve seats. The manifolds should be replaced and then sealed to prevent the ingress of water and dirt.

(6) If electric starting is fitted, the battery must be removed and the terminals cleaned and greased. To maintain the battery in good condition it should be trickle charged at regular intervals.

(7) Clean and dry the engine, repaint where necessary and wipe all unpainted parts with an oil rag. All pivot points and external controls should be cleaned and sprayed with a proprietary de-wetting agent.

(8) Apply protective coverings.

8.4 Protected engines should be periodically examined to check the preservation effectiveness. Rectification of the protection should be carried out, if necessary.

PREPARATION FOR USE

8.5 After an engine has been preserved the following procedure must be carried out:

(1) Remove the protective coverings.

(2) Drain the fuel tank and refill with the correct type and grade of fuel (Section 1).

(3) Check the oil level on the dipstick and ensure that the engine is filled with the correct type and grade of oil.

(4) Check the coolant level, top-up or fill the system as required.

(5) Re-connect the battery, if fitted.

(6) Check the air cleaner, clean or renew the element (paper). If an oil bath type air cleaner is fitted check the oil level.

(7) Check the tension of the drive belt (if fitted) and adjust if necessary.

(8) Check the exhaust system for damage and security.

(9) Clean and lightly lubricate the controls and linkage.

(10) Bleed the fuel system.

(11) Check the tightness of all nuts (excluding cylinder head and block) bolts and hose clips.

8.6 After an initial run check the oil and coolant levels and visually check the system for leaks.

SECTION 9
FAULT FINDING

INTRODUCTION

9.1 This section is a guide to assist in the location of a fault that may occur on a PJ range water-cooled engine. Information on causes and suggested remedies are also given.

TABLE 9.1 ENGINE WILL NOT START

Reason	*Cause*	*Suggested Remedy*	*Reference*
	Incorrect starting procedure	Adopt correct procedure	Sect. 1
	Low temperature	Starting aid may be required	Sect. 1
Incorrect lubrication oil	Too high viscosity oil causing excessive drag	Drain the sump Fill with correct oil	Part 1, Sect. 2 Part 1, Sect. 1
Contaminated fuel	Water, dirt or unsuitable fuel in system	Drain and flush fuel system Fill with correct fuel	Part 1, Sect. 3 Part 1, Sect. 1
Excessive load	Excessive drag from driven machine	Remove all load during starting	
Fuel supply failure Check by cranking the engine and listen for the characteristic squeak of the injector	No fuel	Fill with correct fuel	Part 1, Sect. 1
	Air in system	Bleed the fuel system	Part 1, Sect. 1
	Fuel filter blocked	Fit new element	Part 1, Sect. 3
	Faulty injector nozzle	Replace the nozzle or fit replacement fuel injector	Sect. 3
	Injection pump failure	Fit a replacement injection pump	Sect. 3
Poor compression	Valves sticking or not seating properly	Decarbonise and grind in valves	Sect. 5
	Cylinder head gasket blown	Fit a new gasket	Sect. 5
	Piston rings stuck in piston grooves	Clean piston and fit new rings	Sect. 5
	Worn cylinder and piston	Replace cylinder, piston and piston rings	Sect. 5
	Incorrect bumping clearance	Check large end bearing and reset bumping clearance	Sect. 5
	Broken or weak valve springs	Renew valve springs	Sect. 5
	Incorrect valve clearances	Adjust valve clearances	Sect. 5
	Injector seal washer leaking	Clean orifice and fit new washer	Part 1, Sect. 3
Starter motor will not crank engine	Flat battery	Charge battery or replace	
	Flat battery due to faulty charging equipment	Isolate fault and repair	Part 1, Sect. 7

TABLE 9.1 continued

Reason	Cause	Suggested Remedy	Reference
	Dirty or loose terminals	Clean and tighten	Part 1, Sect. 7
	Broken wire	Replace	Part 1, Sect. 7
	Faulty starter switch	Replace switch	
	Faulty starter motor or solenoid	Repair or replace	Part 1, Sect. 7
	Engine seized	Overhaul engine	Sect. 5

TABLE 9.2 ENGINE STARTS BUT FIRES INTERMITTENTLY OR SOON STOPS

Reason	Cause	Suggested Remedy	Reference
Faulty fuel supply	Water in the fuel	Drain and flush the fuel system and fill with clean fuel	Part 1, Sect. 3 Part 1, Sect. 1
	Sticking injector needle	Fit a new nozzle or a replacement injector	Sect. 3
	Partially blocked fuel filter	Renew fuel filter element	Part 1, Sect. 3
	Air in system	Bleed fuel system	Part 1, Sect. 1
Restricted air intake	Dirty air cleaner	Clean air cleaner and/ or fit new element	Part 1, Sect. 4
Faulty compression	Valves sticking or not seating correctly	Decarbonise and grind in valves	Sect. 5
	Cylinder head gasket blown	Fit a new gasket	Sect. 5
	Piston rings stuck in piston grooves	Clean piston and fit new piston rings	Sect. 5
	Worn cylinder and piston	Replace cylinder, piston and piston rings	Sect. 5
	Incorrect bumping clearance	Check large end bearings and reset bumping clearance	Sect. 5
High exhaust back pressure	Blocked exhaust pipe or silencer, incorrect exhaust	Clean or replace	Part 1, Sect. 1
Overloaded	Excessive drag from driven machine	Reduce the load	

TABLE 9.3 ENGINE LACKS POWER AND/OR SHOWS A DIRTY EXHAUST GAS

Reason	*Cause*	*Suggested Remedy*	*Reference*
Faulty fuel supply	Air in fuel system	Bleed the fuel system	Part 1, Sect. 1
	Incorrect fuel	Drain and flush the fuel system and fill with the correct fuel	Part 1, Sect. 3
	Fuel leaks	Check tighten pipe connectors, renew or repair fuel lines	Sect. 3
	Faulty injector	Fit a new nozzle or a replacement injector	Sect. 3
	Incorrect fuel pump timing	Time the injection pump	Sect. 3
	Faulty injector pump	Renew pump	Sect. 3
	Incorrect injector pipe	Fit correct pipe	Sect. 3
	Kinked flexible fuel pipes	Fit new pipe	
	Partially blocked fuel filter	Renew filter element	Part 1, Sect. 3
Restricted air intake	Dirty air cleaner	Clean and/or refit a new element	Part 1, Sect. 4
Running at an incorrect speed	Worn or incorrectly adjusted speed control	Renew or adjust	Part 1, Sect. 3
Faulty compression	Valves sticking or not seating correctly	Decarbonise and grind in valves	Sect. 5
	Cylinder head gasket blown	Fit a new gasket	Sect. 5
	Piston rings stuck in piston grooves	Clean piston and fit new piston rings	Sect. 5
	Worn cylinder and piston	Replace cylinder, piston and piston rings	Sect. 5
	Incorrect bumping clearance	Check large end bearings and reset bumping clearance	Sect. 5
High exhaust back pressure	Blocked exhaust pipe or silencer, incorrect exhaust	Clean or replace	Part 1, Sect. 1
Extended periods of running off load or with a light load	Glazed cylinder bore	De-glaze cylinder bore and fit new piston rings	Sect. 5
Excessive carbon formation	Prolonged use	De-carbonise	Sect. 5
Overloaded	Load requirement in excess of engine power rating	Reduce load	Preliminaries

TABLE 9.4 FAULTY RUNNING

Reason	Cause	Suggested Remedy	Reference
Knocking	Excessive carbon formation	Decarbonise	Sect. 5
	Air in fuel system	Bleed fuel system	Part 1, Sect. 1
	Low oil supply	Replenish oil system	Part 1, Sect. 1 Part 1, Sect. 2
	Diluted or incorrect oil	Drain and refill sump with correct grade and type of oil. Rectify cause of oil dilution	Part 1, Sect. 1 Part 1, Sect. 1 See oil dilution
	Injector needle sticking or release pressure incorrect	Fit new nozzle or a replacement injector	Sect. 3
	Injection pump timing too far advanced	Adjust timing	Sect. 3
	Broken piston ring	Examine piston and cylinder for damage and repair as necessary	Sect. 5
	Slack piston	Check piston and cylinder for wear and renew as necessary	Sect. 5
	Worn large end bearing	Check crankpin for damage Renew as necessary Check lubrication system	Sect. 5 Part 1, Sect. 2
	Worn small end bearing	Renew small end bearing and check gudgeon pin	Sect. 5
	Loose flywheel	Refit	Sect. 5
Overheating	Cooling system failure	Check that the cooling system is in order and air flow is not obstructed	Sect. 1
	Overloaded	Reduce load to conform with engine power rating	Preliminaries
	Excessive valve clearances	Adjust valve clearances	Sect. 5
	Incorrect lubrication oil or level	Drain and refill sump with correct grade and type of oil or drain to the correct level	Part 1, Sect. 1 Part 1, Sect. 2
	Injection pump timing incorrect	Adjust timing	Sect. 3
Speed surges	Overheating	See overheating	
	Air in fuel system	Bleed the fuel system	Part 1, Sect. 1
	Injector release pressure incorrect	Fit a replacement injector	Sect. 3
	Injector pump rack sticking	Fit a replacement pump	Sect. 3
	Governor sticking or worn	Free or fit new component governor components	Sect. 5

TABLE 9.4 continued

Reason	Cause	Suggested Remedy	Reference
Sudden stop	Empty fuel tank	Fill fuel tank and bleed fuel system	Part 1, Sect. 1
	Blocked or stuck injector	Fit a replacement injector	Sect. 3
	Broken fuel pipe	Repair or renew	Sect. 3
	Engine seized	Overhaul engine	Sect. 5
Heavy vibration	Loose flywheel	Refit	Sect. 5
	Faulty installation	Check, holding down bolts, flexible mountings and couplings	Part 1, Sect. 1
Engine overspeeds	Lubrication oil overfilled	Drain down to correct level	Part 1, Sect. 1
	Lubrication oil diluted or incorrect grade	Rectify cause of dilution, drain and refill with correct grade of oil	Part 1, Sect. 1 See oil dilution
	Injection fuel pump stuck in full fuel position	Replace injection pump	Sect. 3
	Governor faulty	Fit new governor components	Sect. 3
Excessive oil consumption	Oil leaks	Rectify leaks	
	Worn valve guides, piston rings, or cylinder	Renew as necessary	Sect. 5
	Incorrect type or grade of oil	Drain and fill with correct type and grade of oil	Part 1, Sect. 1
	Extended periods of running off load or with a light load	De-glaze cylinder bore and fit new piston rings	Sect. 5
	Excess oil in sump	Drain oil to correct level	Part 1, Sect. 1
	Overheating	See overheating	
Lubrication oil dilution	Leaking lift pump diaphragm	Fit new diaphragm	Part 1, Sect. 6
	Leaking injection pump element	Fit replacement pump	Sect. 3
	Faulty injector	Fit a replacement injector	Sect. 3