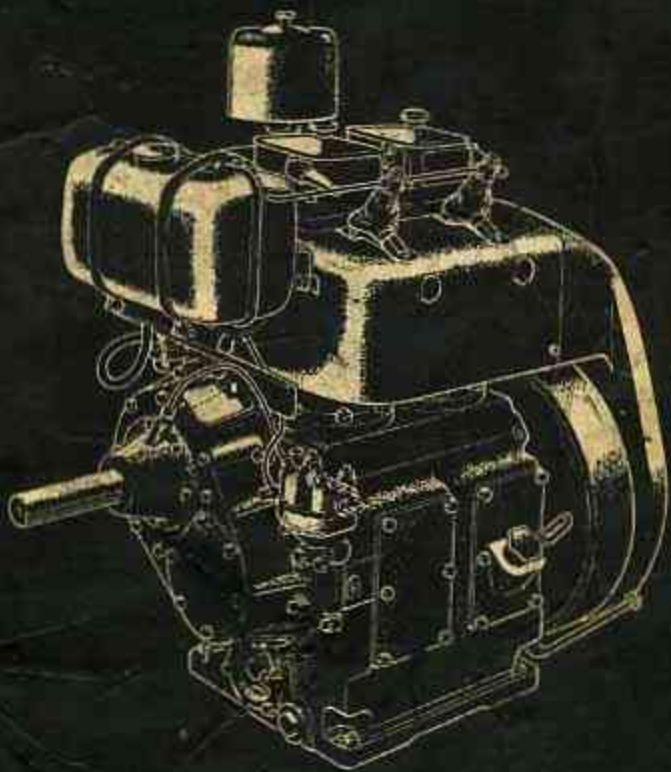
PETTER

DIESEL ENGINES



PH
OPERATORS HANDBOOK

ISSUE 17

Publication No. 340967

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Petter Diesel Engines

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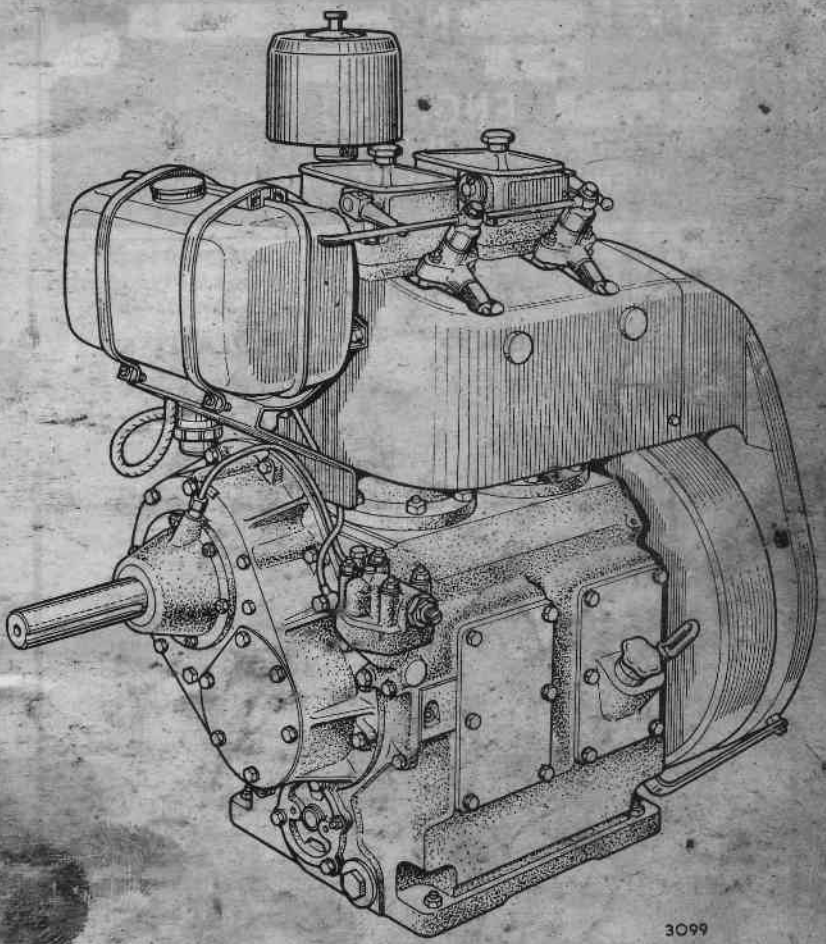

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This book will help the user to get the best results from the engine. No engine will run without care, but it will give good service if given the attention described in this book.

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Please record details of engine and installation in the spaces below

Copy details from engine label

ENGINE INSTALLATION **PLANT No.**

.....p .....

Important

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

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Please remember . . .

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

. . . **an engine needs lubricating oil—**
Use the correct grade 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.

●

After approximately 20 hours initial running of a new or overhauled engine the following points should receive attention:

(*a*) Check valve clearance.
(*b*) Drain lubricating oil from sump and refill with clean oil.
(*c*) Check fuel filter.
(*d*) Check all nuts, bolts, etc., for tightness.

●

Requests for parts and service should be directed to:

Overseas
The appointed Petter agent or dealer in the territory.

United Kingdom

Petters Ltd. Service Division,
Hamble,
Southampton
SO3 5NJ

Phone: Hamble 2061
Telex: 47626
Telegrams:
Petter Hamble Telex

or Service Depots at

Petters Ltd. Service Depot,
Broomhill Industrial Estate,
Kirkintilloch,
Dunbartonshire

Kirkintilloch 041-776 2316/7/8
Telex: 778204

Petters Ltd. Service Depot,
Limewood Road, Seacroft, Leeds, LS14 1LS

Leeds 649101

Petters Ltd. Service Depot,
Cliff Works, Burton-on-the-Wolds,
Loughborough, Leics.

Wymeswold 880333

Petters Ltd. Service Depot,
Bridge Works, Staines, Mddx. TW18 3AR

Staines 51333

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a technical data

Bore (nominal)	3·437in (87·3mm)
Stroke	4·33in (110mm)
Power and Speed per cylinder (B.S. continuous rating):	4 bhp at 1000 rev/min 5 bhp at 1200 rev/min 6·25 bhp at 1500 rev/min 6·75 bhp at 1650 rev/min 7·5 bhp at 1800 rev/min 8·2 bhp at 2000 rev/min
Cubic capacity per cylinder	659 cm³ (40·2 in³)
Compression ratio	16·5:1
Lubricating oil pressure (min.)	35 lbf/in² (2·46 kgf/cm²)
Fuel injection release pressure:	
900 to 1099 rev/min	1955/2250 lbf/in² (140/158 kgf/cm²)
1100 to 2000 rev/min	2850/3150 lbf/in² (200/221 kgf/cm²)
Fuel injection timing (by spill):	
Up to 1650 rev/min	24° before TDC
1651 to 2000 rev/min	28° before TDC
Inlet valve opens	4½° before TDC
Inlet valve closes	35½° after BDC
Exhaust valve opens	35½° before BDC
Exhaust valve closes	4½° after TDC

With valve rockers set at 0·007in (0·18mm) hot clearance

Fuel tank capacity (engine mounted)	1½ gal (6·8 litres)
Oil capacity:	
Engine (one-cylinder)	5 pints (2·84 litres)
Engine (one-cylinder) (with filter)	6 pints (3·41 litres)
Engine (two-cylinder)	10 pints (5·68 litres)
Engine (two-cylinder) (with filter)	11·5 pints (6·53 litres)
Clutch	½ pint (0·3 litre)
Lubricating oil	See approved list
Fuel	A high grade light distillate diesel fuel in accordance with B.S. Specification No. 2869: 1967 Class A1 or A2

Starter motor battery:	Volts	Ampere hour
One-cylinder engine	12	50
Two-cylinder engine	12	65

NOTE: Oil capacities, etc., are based on the Imperial (U.K.) gallon

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Camshaft end float	0·004/0·015in (0·10/0·38mm)
Crankshaft end float (new)	0·005/0·015in (0·13/0·38mm)
Crankshaft end float (not to exceed)	0·025in (0·63mm)
Crankpin ovality (not to exceed)	0·003in (0·08mm)
Cylinder bore wear (not to exceed)	0·010in (0.25mm)
Piston ring gap (new)	0·029/0·037in (0·74/0·94mm)
Piston ring gap (not to exceed)	0·060in (1·52mm)
Exhaust valve lift by decompressor (max)	0·025in (0·63mm)
Bumping clearance	0·036/0·042in (0·91/1·07mm)
Valve rocker clearance (cold)	0·004in (0·10mm)
Valve depth from cylinder head face (new)	0·028/0·042in (0·071/1·07mm)
Main bearing clearance (new)	0·0020/0·0045in (0·051/0·114mm)
Large end bearing clearance (new)	0·0020/0·0035in (0·051/0·089mm)
Drive shaft diameter	1·4996/1·4989in (38·090/38·072mm)
Drive shaft keyway width	0·374/0·375in (9·50/9·52mm)
Small end bush diameter (fitted)	1·1825/1·1830in (30·035/30·048mm)

Cylinder reboring diameters:

Standard	3·4435/3·4445in (87·465/87·491mm)
Oversize:	
0·020in	3·4635/3·4645in (87·973/87·998mm)
0·040in	3·4835/3·4845in (88·481/88·516mm)

Crankshaft regrinding diameters:

	Main journal	Crankpin and Intermediate journal
Standard	2·3735/2·3730in (60·287/60·274mm)	2·3750/2·3745in (63·325/60·312mm)
Undersize:		
0·010in	2·3635/2·3630in (60·031/60·020mm)	2·3650/2·3645in (60·071/60·058mm)
0·020in	2·3535/2·3530in (59·779/59·766mm)	2·3550/2·3545in (59·817/59·804mm)
0·030in	2·3435/2·3430in (59·525/59·512mm)	2·3450/2·3445in (59·563/59·550mm)
0·040in	2·3335/2·3330in (59·271/59·258mm)	2·3350/2·3345in (59·309/59·296mm)

Torque spanner settings:

Large end bolt	57 lbf ft (7·88 kgf m)
Cylinder head nut	60 lbf ft (8·30 kgf m)
Fuel pump union body	40 lbf ft (5·53 kgf m)
Balance weight bolt PH1	117 lbf ft (16·18 kgf m)
PH2	197 lbf ft (27·24 kgf m)
Extension shaft setscrew	27 lbf ft (3·73 kgf m)
Intermediate main bearing housing nut	25 lbf ft (3·46 kgf m)

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APPROVED LUBRICANTS

Supplier	U.K. Winter *Below 5°C (41°F)	U.K. Summer From 5°C to 30°C (41°F to 86°F)	Tropical Above 30°C (86°F)
Shell Oil Co. Ltd.	Rotella SX 10W Rotella TX 10W Rotella TX 10W/30 Talona 10W X-100 10W	Rotella SX 20/20W Rotella TX 20/20W Rotella SX 20W/40 Rotella TX 20W/40 Super Oil Tractor Oil Universal	Rotella SX 30 Rotella TX 30 Rotella SX 20W/40 Rotella TX 20W/40 Super Oil Tractor Oil Universal
Mobil Oil Co. Ltd.	Delvac 1210 Delvac Special 10W/30 Mobiloil Super	Delvac 1220 Delvac Special 10W/30 Mobiloil Super Mobiland Universal Mobilgard 212	Delvac 1230 Delvac Special 10W/30 Mobiloil Super Mobiland Universal Mobilgard 312
B.P. Companies	Vanellus 10W Super Visco-Static 10W/40	Vanellus 20W Vanellus Multigrade 20W/30 Energol IC-D20 Motor Oil 20W Super Visco-Static 20W/50 Energol IC-M20W Tractor Oil Universal 20W/30	Vanellus 30 Vanellus Multigrade 20W/30 Energol IC-D30 Motor Oil 30 Super Visco-Static 20W/50 Energol IC-M30 Tractor Oil Universal 20W/30
Castrol Ltd.	Deusol CR1 10 Deusol CRB 10 Deusol CRB 10W/30 Castrol CR1 10 Castrol CRB 10 Agricastrol Multi-Use 10W/30	Deusol CR1 20 Deusol CRB 20 Deusol CRB 10W/30 Castrol CRB 20 Castrol 210 MX Agricastrol Multi-Use 10W/30	Deusol CR1 30 Deusol CRB 10W/30 Deusol CRM Castrol CRB 30 Castrol 215 MX Agricastrol Multi-Use 20W/30

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APPROVED LUBRICANTS—contd.

Supplier	U.K. Winter *Below 5°C (41°F)	U.K. Summer From 5°C to 30°C (41°F to 86°F)	Tropical Above 30°C (86°F)
Esso Petroleum Co. Ltd.	Essolube HD 10W Essolube HDX 10W Essolube D-3HP 10W Essolube D-3 10 Motor Oil 10W Essolube HDX 10W/30	Essolube HD 20W Essolube HDX 20W Essolube D-3HP 20W Essolube D-3 20W Motor Oil 20W Essolube HDX 10W/30	Essolube HD 30 Essolube HDX 30 Essolube D-3HP 30 Essolube D-3 30 Motor Oil 30 Essolube HDX 10W/30
Caltex (U.K.) Ltd.	Supreme Five Star 10W/30 Custom Five Star 10W/30 Custom Five Star 10 Five Star 10W RPM Delo 200 10W/30 RPM Delo 200 10W RPM Delo 100 10W	Supreme Five Star 10W/30 Custom Five Star 10W/30 Custom Five Star 20/20W Five Star 20/20W RPM Delo 200 10W/30 RPM Delo 200 20/20W RPM Delo 100 20/20W	Supreme Five Star 10W/30 Custom Five Star 10W/30 Custom Five Star 30 Five Star 30 RPM Delo 200 10W/30 RPM Delo 200-30 RPM Delo 100-30
Texaco Ltd.	Ursa Extra Duty 10W Ursa Extra Duty 10W/30 Havoline 10W Havoline 10W/40	Ursa Extra Duty 20W Ursa Extra Duty 10W/30 Havoline 20/20W Havoline 10W/40	Ursa Extra Duty 30 Ursa Extra Duty 10W/30 Havoline 30 Havoline 10W/40
Gulf Oil (G.B.) Ltd.	Gulflube XHD 10W Gulflube XHD 10W/30 Multi-G 10W/30	Gulflube XHD 20 20W Gulflube XHD 10W/30 Multi-G 10W/30 Superfleet 20W/30	Gulflube XHD 30 Gulflube XHD 10W/30 Multi-G 10W/30 Superfleet 20W/30
Chevron International Oil Co. Ltd.	Delo Special 10W Delo 200 10W	Delo Special 20/20W Delo 200 20/20W Delo 200 20W/30	Delo Special 30 Delo 200-30 Delo 200 20W/30

* Below −7°C (20°F) it is advisable to use an SAE 5W or 5W/30 oil. Where an approved oil of this viscosity is not available, consult *Petters Ltd or their agents.*

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TROUBLE LOCATING CHART

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

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TROUBLE LOCATING CHART—contd.

Trouble	Reason	Causes	Suggested Remedy
Engine starts but fires intermittently or soon stops	Faulty fuel supply	Air in the fuel lines Water in the fuel Faulty injector nozzle Fuel filter choked	Bleed the system Drain fuel system and fill with clean fuel Fit new nozzle Fit new filter element
	Faulty compression	Broken valve spring Sticking valve Pitted valve	Fit new spring Free the valve Grind or renew
	Dirty exhaust	Blocked exhaust pipe or similar	Clean out
Engine lacks power and/or shows dirty exhaust	Faulty fuel supply	Faulty fuel pump Faulty injector nozzle Unsuitable fuel	Fit new pump Fit new nozzle Drain the fuel system and fill with correct fuel
	Out of adjustment	Valve clearance incorrect Fuel timing incorrect	Adjust Adjust
	Dirty engine	Blocked exhaust pipe or similar Dirty air cleaner Faulty piston ring Excessive carbon on piston and cylinder head Worn cylinder and piston	Clean out Clean out Fit new ring Decarbonise Overhaul the engine

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TROUBLE LOCATING CHART—contd.

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

b installation

1. Engine bearers

Engine mounting bearers or framework must be of rigid construction and neither deflect nor twist when subjected to the weight of the engine and any ancillary equipment or their operation.

2. Erection

(a) Installation drawings are obtainable from *Petters Ltd or their agents.*

(b) Provision must be made for:
- (i) Dipstick withdrawal, oil filler cap removal and oil draining.
- (ii) Fuel and oil filter and air cleaner maintenance.
- (iii) Starting handle withdrawal and operation of controls.

(c) Only good quality holding down bolts or studs may be used. Setscrews must NOT be used.

(d) *Petters Ltd or their agents* should be consulted in the following cases:
- (i) Before proceeding with any new form of installation.
- (ii) Where the use of anti-vibration mountings is contemplated. (An unsuitable choice can be dangerous.)
- (iii) Where a portable installation is contemplated. In this instance a *Petter* engineer should be present when the initial installation is made.

(e) On direct driven sets, the driving and driven units must be lined up and a flexible coupling fitted.

(f) If a *Petter* clutch is fitted and the final drive is through belt or chain, a bearer should be fitted to the base pad of the clutch housing.

3. Exhaust

(a) On one cylinder engines the exhaust manifold has a 1in BSP thread. On two-cylinder engines the exhaust manifold has a 1½in BSP thread.

(b) Exhaust piping up to 20ft (6m) must be 1in BSP for one-cylinder engines or 1½in BSP for two-cylinder engines. For lengths in excess of 20ft (6m), consult *Petters Ltd or their agents.*

(c) The 'pepper-pot' type of silencer supplied with the engine may be screwed directly into the exhaust manifold or used with exhaust pipes up to 20ft (6m) in length. When an

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exhaust pipe in excess of 20ft (6 m) is used, a larger silencer with a thread size the same as the exhaust pipe must be used.

(*d*) An acoustic type silencer is obtainable from *Petters Ltd or their agents* and the thread size of the silencer must be the same as that of the exhaust pipe. A tail-pipe must be fitted to this type of silencer and the length of the tail-pipe must be ten times the inside diameter of the exhaust pipe, i.e. a tail-pipe 10in (254mm) long must be fitted to a 1in BSP acoustic silencer.

(*e*) The exhaust system should be as short as possible and with a minimum of bends, otherwise a serious reduction of power will result.

(*f*) A short length of flexible exhaust pipe should be included between the engine and main run of piping.

4. Air intake

Air is taken in through an air cleaner.
Engine installed in confined spaces require good ventilation to ensure a plentiful supply of cool, clean air.

5. Cooling (Fig. 1)

(*a*) Cooling air is supplied by the flywheel fan and care must be taken to ensure that the fan cowling air intake is unobstructed.

(*b*) Engines mounted inside housings or confined spaces must be provided with ample openings for the free circulation of air.

(*c*) UNDER NO CIRCUMSTANCES MAY ENGINES BE RUN WITHOUT FAN COWLINGS IN POSITION.

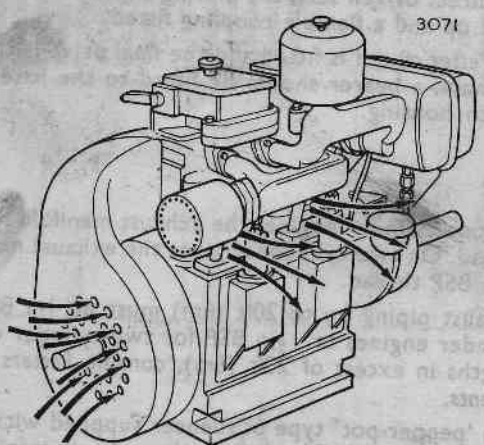

Fig. 1

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6. Lubrication

(a) The engine oils listed under Approved Lubricants are heavy duty oils with a minimum performance level as specified by:
British Defence Specification No. 2101D
or
U.S. Specification MIL/L/2104B

(b) Suitable additional heavy duty engine oils will be recommended by a local oil distributor but a minimum performance level as above must be specified.

(c) *Petters Ltd or their agents* should be consulted if doubt arises regarding the selection of an engine oil.

(d) MARINE AUXILIARY INSTALLATIONS. Although three viscosities of oil are recommended for differing climatic conditions, it is not always practical to change oils as the engine passes from one climate to another. Under these circumstances, for engines operating fire pumps or other equipment required to operate IN AN EMERGENCY, it is recommended that the oil selected should be of a viscosity suitable for the coldest climate likely to be encountered. It should be noted that this recommendation is made with ease of hand starting as a first consideration where an approved multi-grade oil is not available.

7. Fuel

(a) The bulk storage of diesel fuel is subject to official regulations, but generally, storage is permitted above ground provided containers of authorised construction and capacity are used. Do not use galvanised containers or the zinc coating will react with the fuel and damage the fuel injection equipment.

(b) To prevent the harmful effects of moisture absorbed by fuel, provision must be made for draining off water which may accumulate at the base of the storage tank. The amount of water absorbed by fuel can be minimised by keeping storage tanks as full as possible and ensuring that filler caps, inspection covers, etc., have effective sealings.

(c) Tank cocks for withdrawing fuel should be fitted a short distance above the base, enabling clean fuel to be withdrawn without disturbing water or sediment.

(d) To ensure proper working of the fuel system the fuel must always be CLEAN.

(e) Fuel should be allowed to settle before use. Sludge or water at the bottom of the container must not be used. Due to increased engine repair costs, a cheap fuel may prove very expensive in the long run.

(f) Funnels or cans used for fuel should not be used for anything else and must be kept absolutely clean. They should be thoroughly dried before use.

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(g) The fuel tank should always be filled through a strainer. Occasionally the tank should be flushed out with petrol or paraffin.

(h) The fuel used should be high grade light diesel fuel, gas oil or DERV fuel. It should comply with B.S.2869: 1967 Class A1 or A2, an extract of which is as follows:

	Class A1	Class A2
Cetane number (min.) ...	50	45
Viscosity (kinematic) at 37·8°C (100°F)	1·6 to 6·0 cSt	1·6 to 6·0 cSt
Carbon residue. Conradson on 10% residue (by weight) (max)	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) (max)	0·05%	0·05%
Sediment (by weight) (max)	0·01%	0·01%
Ash (by weight) (max) ...	0·01%	0·01%
Sulphur (by weight) (max)	0·5%	1·0%

Class A1 fuel is intended primarily for automotive use. Class A2 is a general purpose fuel.

(j) Winter and summer grades of diesel fuels are marketed during the appropriate seasons and are also graded for that part of the world in which they are intended to be used. Diesel fuels available for use in low temperature climates are classified as 'Cold Start Reference Fuels'. Make sure that the fuel being used is suitable for the prevailing temperature conditions.

(k) Fuels for marine auxiliary engines required to operate under constantly differing climatic conditions should be suitable for the coldest condition likely to be encountered. This is particularly important when considering fire pumps, etc., required to operate in an emergency.

(l) 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. Refill the fuel system with the correct fuel and bleed and prime before attempting to start.

8. Governing

The governor controls the engine at a predetermined speed irrespective of load variations between idling and full rated speed.

The governor weights are fitted to the camshaft and their action is transmitted by push rods in the camshaft to the fuel

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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.

The overload stop is set by *Petters Ltd* 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.

C drive arrangements

9. Engine marks

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

Drive and starting arrangements are as follows:

MARK I Drive at half engine speed on camshaft extension at end remote from flywheel. Starting handle at flywheel end.

MARK II Drive at engine speed on crankshaft extension at end remote from flywheel. Starting handle at flywheel end.

MARK III Clutch drive at half engine speed on camshaft extension at end remote from flywheel. Starting handle at flywheel end.

MARK IV Clutch drive at engine speed on crankshaft extension at end remote from flywheel. Starting handle at flywheel end.

MARK V Drive at engine speed on crankshaft at flywheel end. Starting handle on half speed extension at end remote from flywheel.

10. Pulley drive (Fig. 2)

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

To prevent damage to new vee belts when fitting, the distance between the centre of the engine pulley (A) and the driven pulley (B) must be capable of a reduction from the designed running position.

Provision must also be made for an increase of at least 2½% 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.

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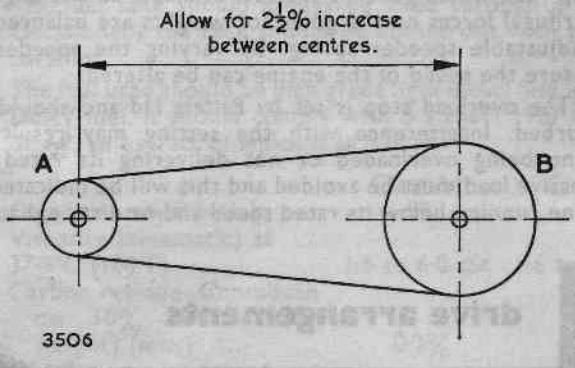

Fig. 2

11. Rotation

Standard engine rotation is clockwise when viewed from the flywheel end.

Engines with rotation reverse to standard are identified by a letter 'R' following the engine serial number.

12. Starting handle (Fig. 3)

The starting handle assembly can be arranged for either clockwise or anti-clockwise rotation of the starting shaft. (Check that the pawl is correctly assembled.)

The pawl may be fitted at the top or bottom to give alternative starting positions.

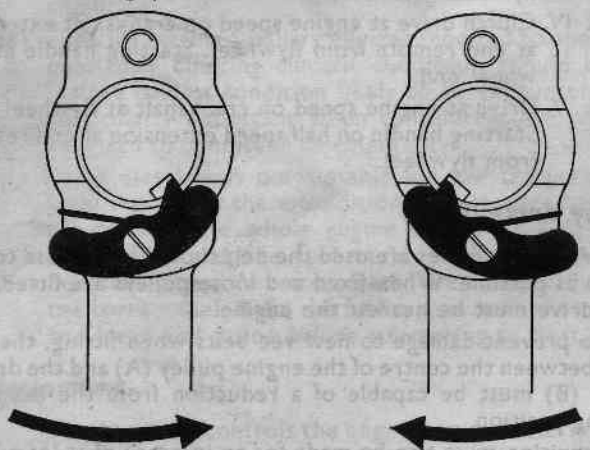

Fig. 3

The starting handle and shaft should be kept clean, lubricated and in good condition. When starting the engine always ensure that the thumb is positioned on top of the starting handle grip and not round it.

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13. To prepare a new or overhauled engine for starting (Fig. 4)

(a) Check that the cooling system is in order and free from obstruction.

(b) Remove the oil filler cap and, with the engine level, fill with lubricating oil to the high level mark on the dipstick. To ensure a correct reading, the dipstick should remain withdrawn while oil is being added and wiped before replacement. It should be submerged for at least five seconds between readings. Replace cap. (After a few minutes running, stop the engine and top up the oil, as the level always falls slightly after the initial circulation.)

(c) If a *Petter* clutch is fitted, pour $\frac{1}{2}$ pint (0·3 litre) of engine lubricating oil into the clutch housing. (The clutch is a positive action type and must on no account be slipped when operating. The lever should be smartly engaged and disengaged.)

(d) Lift the decompressor lever and turn the engine fifteen times to help circulate the oil.

(e) Fill the fuel tank. Bleed and prime the fuel system.

14. To bleed and prime the fuel system (Fig. 4)

(a) Loosen the two vent screws (A) on top of the fuel filter and keep loose until clean, bubble-free fuel leaks out. Retighten screws.

(b) Loosen the vent screw (B) at the side of the fuel pump. Work the priming lever (C) with a slow, pumping action until clean, bubble-free fuel leaks out. Retighten screw.

(c) Unscrew the delivery pipe connection (D) from the fuel injector. Operate the priming lever until bubble-free fuel leaks out. Replace pipe connection.

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

(e) The operation of bleeding the fuel line and priming the injector should be carried out on one cylinder at a time. During this operation, be sure that the flywheel mark 'TDC' for the cylinder receiving attention is about half a revolution away from the pointer. If a fuel feed pump is fitted fuel will not flow unless the fuel feed pump lever is operated.

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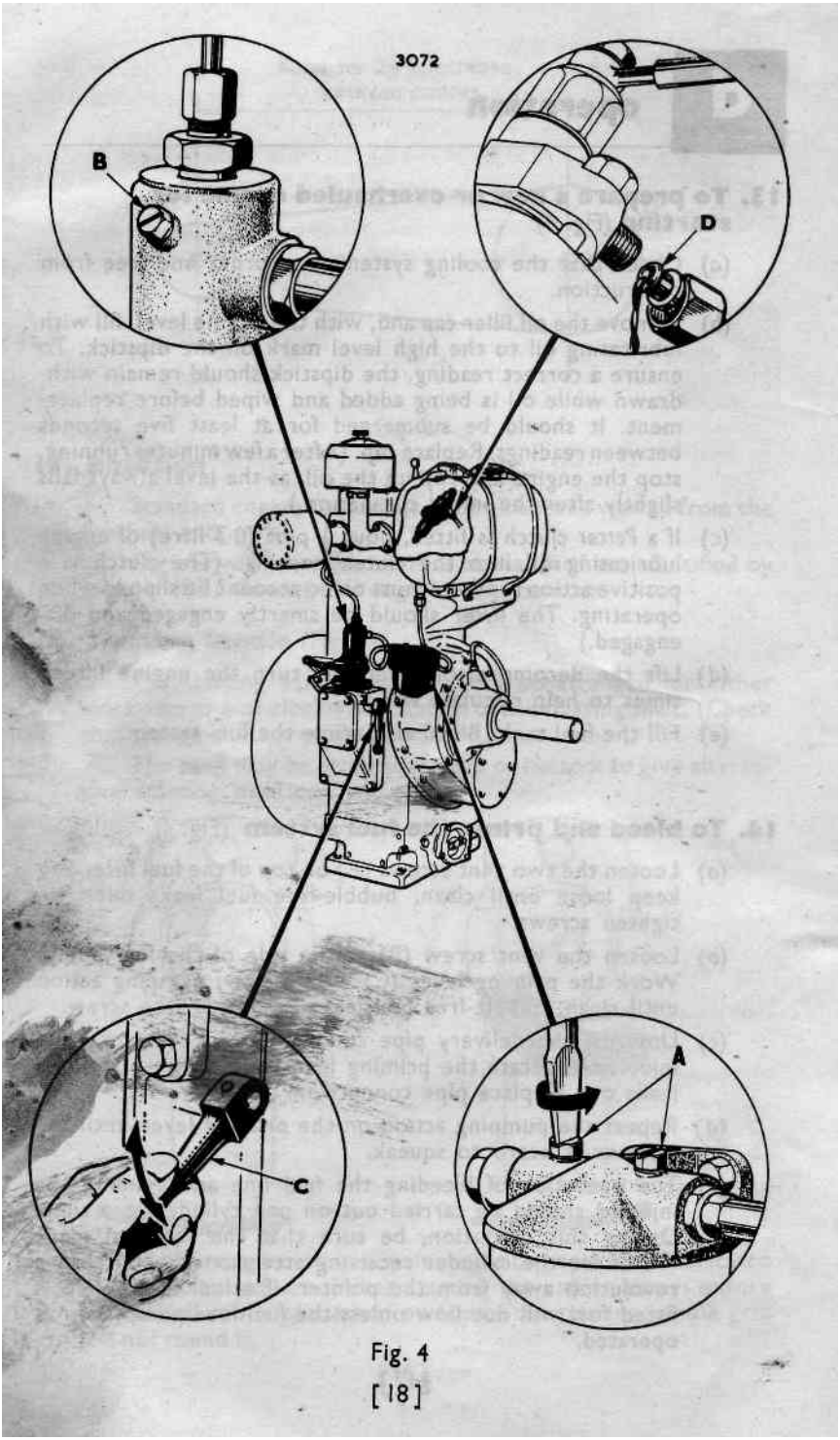

Fig. 4

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15. To start (Fig. 5)

(a) Lift the red painted overload stop (A) and allow the fuel pump racks to move into the fully open position.

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

(c) Give each cylinder half a dozen priming strokes. (This is unnecessary with a warm engine.)

(d) Lift the decompressor lever (B) and turn the engine as fast as possible or operate the starter motor. When it is turning at a good speed, knock down the lever. The engine should now fire. On two-cylinder engines fitted with a separate decompressor lever on each cylinder, knock down one lever and then, as soon as the engine fires, knock down the other lever.

(e) If the engine does not fire, lift the decompressor lever and slowly turn the engine a few times before attempting to start again. Do not operate the starter motor for more than 20 seconds at a time.

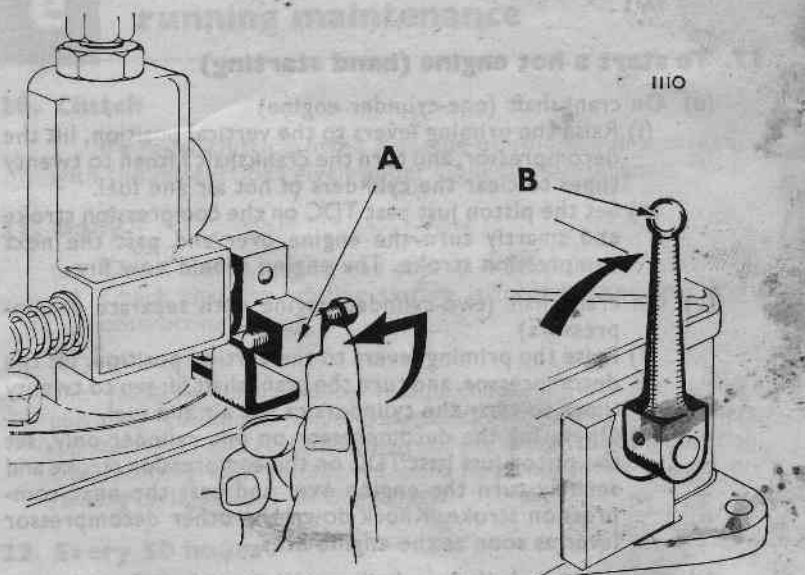

Fig. 5

16. Cold starting

(a) Under low temperature conditions it may be necessary to use a cold starting aid and details of these are obtainable from *Petters Ltd or their agents.*
These aids may be in the form of auxiliary fuels introduced into the combustion system during starting, either from a

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hand held aerosol can spraying into the air cleaner (with the element removed) or through permanently fitted equipment spraying directly into the inlet manifold.
Indiscriminate use of this type of cold starting aid may cause damage. *Petters Ltd or their agents* should be consulted if doubt arises regarding the use of such aids.
Temperatures below which a cold starting aid may be required will depend upon the installation and the condition of the engine and these are approximately as follows:

Hand starting:
One-cylinder engine
On half speed extension shaft —15°C (5°F)
On full speed shaft —12°C (10°F)

Two-cylinder engine
On half speed extension shaft —14°C (7°F)
On full speed extension shaft —10°C (14°F)

Under low temperature conditions make sure that an SAE 10 viscosity engine oil is used (see Approved Lubricants).

17. To start a hot engine (hand starting)

(*a*) On crankshaft (one-cylinder engine)
(i) Raise the priming levers to the vertical position, lift the decompressor, and turn the crankshaft fifteen to twenty times to clear the cylinders of hot air and fuel.
(ii) Set the piston just past TDC on the compression stroke and smartly turn the engine over and past the next compression stroke. The engine should now fire.

(*b*) On crankshaft (two-cylinder engine with separate decompressors)
(i) Raise the priming levers to the vertical position, lift the decompressor, and turn the crankshaft fifteen to twenty times to clear the cylinders of hot air and fuel.
(ii) Operating the decompressor on one cylinder only, set the piston just past TDC on the compression stroke and smartly turn the engine over and past the next compression stroke. Knock down the other decompressor lever as soon as the engine fires.

(*c*) On crankshaft (two-cylinder engine with linked decompressors)
(i) Raise the priming levers to the vertical position, lift the decompressor, and turn the crankshaft fifteen to twenty times to clear the cylinders of hot air and fuel.
(ii) Set the engine with the piston of the second firing cylinder just past TDC on the firing stroke and then smartly turn the engine over and past the next compression stroke. The engine should now fire.

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18. To stop

(a) It is advisable to run on light load for a few minutes before stopping.

(b) Raise the priming levers to the vertical position or push the governor lever towards the fuel pump until engine stops.

19. Important don'ts

(a) DON'T stop the engine by means of the decompressor. This will lead to damaged valve seats and cylinder head joints.

(b) DON'T stop the engine by allowing the tank to run dry. This will let air into the fuel lines and make it necessary to bleed and prime the system.

(c) DON'T remove or alter the setting of the overload stop.

(d) DON'T forget to grease the starting handle shaft. Make sure the starting handle can be freely withdrawn.

e running maintenance

20. Clutch

If a *Petter* clutch is fitted it should be adjusted in accordance with the instructions given under General Maintenance.

21. Daily

(a) Check lubricating oil and top up if necessary.

(b) Check that the cooling system is in order and free from obstruction.

NOTE:
The following maintenance recommendations are for average operating conditions. Under very dusty conditions, air cleaners, lubricating oil and fuel filters will require more frequent attention. Decarbonising may be required more frequently when engines are running on light loads for long periods.

22. Every 50 hours

(a) Clean the air cleaner (oil bath type).

23. Every 250 hours

(a) Clean the fuel filter.

(b) Check all nuts, bolts, etc. for tightness.

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

(d) Clean the air cleaner (paper element type).

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(e) Clean out deposit from exhaust system.
(f) Clean the fuel feed pump strainer.
(g) Drain the sump, flush out with flushing oil and refill with new oil. Clean the strainer. (Paraffin may be used if flushing oil is unobtainable but the engine must not be run with paraffin in the sump.)
(h) Test the fuel system for leaks.
(j) Remove the fuel injectors and test spray. If in order replace without further interference.
(k) Check the valve clearance and adjust if necessary.
(l) Clean the lubricating oil feed restrictor to rockers.
(m) Fit new lubricating oil filter element and joint ring (where fitted)
(n) Lubricate the speed control linkage.

24. Every 500 hours

(a) Fit new fuel filter element.
(b) Fit new air cleaner element.

25. Every 2000 hours

(a) Decarbonise.
(b) Clean out piston oil return holes. Check cylinder bore wear.
(c) Examine the crankshaft bearings and renew if clearance is excessive.
(d) Clean out the fuel tank thoroughly.
(e) Wash out lubricating oil system.

f general maintenance

26. Decarbonising

A carbon deposit forms on piston and cylinder heads and the presence of an excessive carbon deposit is usually indicated by a dirty exhaust and a falling off of power.

Decarbonising necessitates the removal of the cylinder head, followed by the removal of all carbon and the grinding in of the valves. These operations are described in subsequent paragraphs.

Sets of joints are obtainable from *Petters Ltd or their agents*.

27. To remove cylinder head

(a) Remove the cylinder cowling.
(b) Remove the air inlet and exhaust manifolds.
(c) Remove the fuel injector.
(d) Disconnect the lubricating oil pipe from the end of the rocker shaft.
(e) Remove the rocker box.
(f) Remove the push rods and push rod tubes.
(g) Remove the cylinder head and cylinder head gasket.

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28. To dismantle cylinder head

(a) Remove the decompressor shaft split pin and slide off washers and spring washers.

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

(c) Drive out rocker shaft with a soft metal drift or piece of wood.

(d) To remove the valves, place the cylinder head on a bench. Press down the valve spring cups and remove the split collets from the valve stems. Valves and springs can now be withdrawn.

29. To remove carbon

(a) Turn crankshaft until piston is at top of its stroke.

(b) Scrape carbon from the cylinder head and top of piston. An old screwdriver or other blunt tool may be used. Emery cloth must NOT be used. Do not allow carbon dust to fall between the piston and the cylinder bore.

(c) Thoroughly clean out the exhaust and inlet ports and manifolds.

(d) IT IS IMPORTANT that the recesses at the end of valve guide bores are free from carbon.

(e) Thoroughly clean the valves and examine the valve seats. If these show signs of pitting, they should be ground in.

(f) Make sure the valves are seating properly. Leaking valves cause loss of compression and difficult starting.

30. To grind in valves

(a) Care must be taken that the valves are returned to their correct seatings for this operation.

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

(c) Periodically lift the valve from its seating and give it a half turn, thus ensuring that the grinding paste is evenly spread.

(d) It is unnecessary to continue grinding once the faces of the valve and its seating have a clean, even, matt-surfaced appearance. A polished surface must not be expected and is unnecessary.

(e) Wash out the ports thoroughly with petrol or paraffin, making sure that all traces of grinding paste are removed from the valves and guides.

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

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31. To replace cylinder head (Fig. 6)

(*a*) Generally reverse the instructions for removal and dismantling.

(*b*) It is IMPORTANT that the exhaust and inlet valves be returned to their correct positions.

(*c*) If the valves are distorted or very badly pitted, fit new ones.

(*d*) If new valves or guides are fitted, the valves must be ground in.

(*e*) A new cylinder head gasket must be fitted if the old one shows any sign of damage. It is a wise policy to fit a new gasket every time a cylinder head is removed.

(*f*) On two-cylinder engines, make sure the manifold bolting faces are square and parallel with each other. Check with a straight edge before tightening the cylinder head nuts.

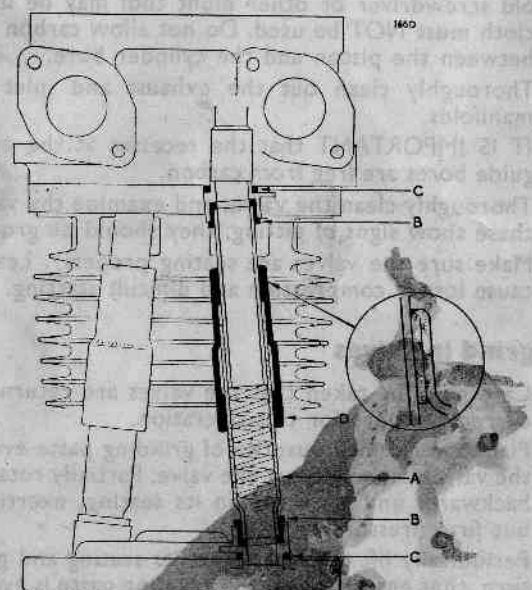

Fig. 6

(*g*) When replacing the push rod tubes make sure that the stepped portion (A) of the assembly is fitted at the bottom and that the oil seals (B) and joint washers (C) are in good condition and seating properly. Make sure that the push rod tube covers (D) are correctly fitted with the ends folded inward to form a dust-proof and oil-tight seal. Failure to observe these precautions may lead to oil leaks.

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(*h*) It is MOST IMPORTANT that the cylinder head nuts are correctly tightened and in the right sequence. Tighten the cylinder head nuts using a torque spanner set to the figure shown under Technical Data. Proceed as follows:

(i) Screw down each cylinder head nut until finger tight.

(ii) Tighten each nut a quarter of a turn at a time working diagonally across the cylinder head until all nuts are tight.

(iii) After approximately 20 hours running check again for tightness.

32. To adjust valve rockers (Fig. 7)

(*a*) To adjust the clearance, set the engine with valves closed (TDC of firing stroke), loosen the locknut (A) and turn the rocker adjusting screw (B) with a screwdriver. Measure the gap with a feeler gauge, and when the correct setting is obtained (see Technical Data) retighten the locknut. Recheck the gap.

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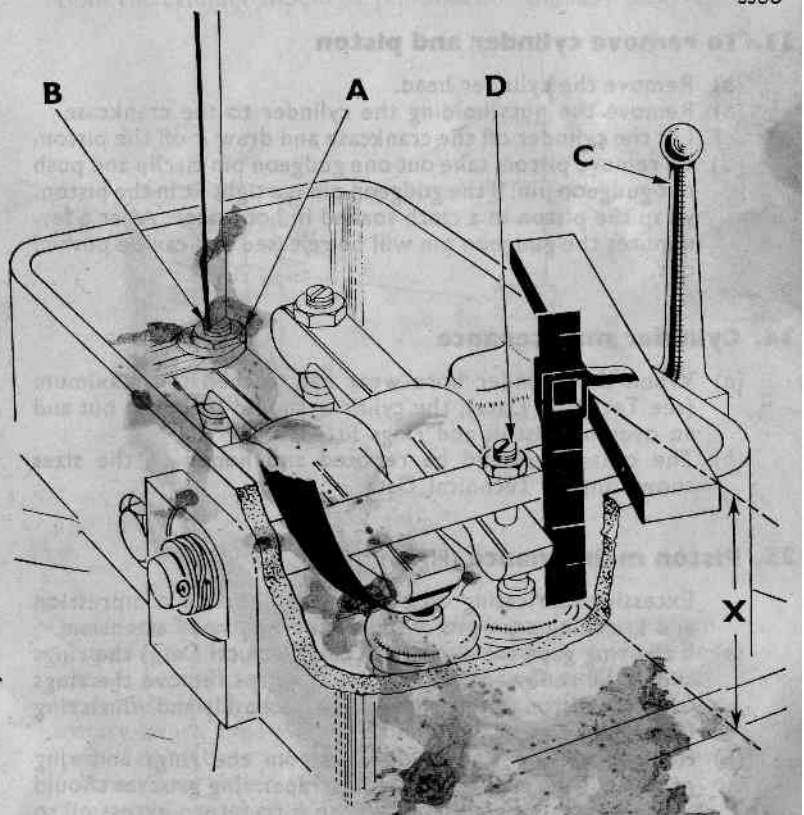

Fig. 7

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(*b*) The exhaust valve should be lifted the correct amount by the movement of the decompressor lever (C) from the horizontal to the vertical position. If a depth gauge is not available, approximate settings may be obtained as follows:
(i) Turn decompressor lever to the vertical position.
(ii) Slacken locknut and turn the decompressor pin (D) until it just touches the valve rocker. A further half turn will lower the valve the required amount.
NOTE: The valve should not be lifted more than the specified amount (see Technical Data) as measured at X, or it will cause serious damage by hitting the piston. When the decompressor is in operation, air is allowed to escape from the cylinder through the slightly opened exhaust valve. Compression cannot therefore build up and the engine will turn easily and will not fire.

(*c*) IMPORTANT. The cylinder head and rocker box must be firmly bolted in position, with nuts finally tightened, before the rocker clearances are adjusted.

33. To remove cylinder and piston

(*a*) Remove the cylinder head.
(*b*) Remove the nuts holding the cylinder to the crankcase.
(*c*) Lift the cylinder off the crankcase and draw it off the piston.
(*d*) To remove piston, take out one gudgeon pin circlip and push out gudgeon pin. If the gudgeon pin is a tight fit in the piston, wrap the piston in a cloth soaked in hot water. After a few minutes the gudgeon pin will be released and can be pushed out.

34. Cylinder maintenance

(*a*) When the cylinder bore wear has reached the maximum (see Technical Data), the cylinder should be bored out and an oversize piston and rings fitted.
(*b*) The cylinder should be rebored and honed to the sizes shown under Technical Data.

35. Piston maintenance (Fig. 8)

Excessive lubricating oil consumption, loss of compression and knocking are signs that a piston may need attention.

(*a*) If the ring gaps are excessive (see Technical Data) the rings should be renewed. To measure the gaps remove the rings from the piston noting the order of assembly and which ring face is uppermost.

(*b*) Remove all the carbon deposit from the rings and ring grooves. The small holes (A) in the scraper ring grooves should receive attention as their purpose is to return excess oil to the sump.

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(c) Insert the piston into the cylinder bore with the crown towards the bottom end of the bore and about $\frac{1}{2}$in (13mm) 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.

(d) Assemble the rings on the piston in the correct order with the correct face uppermost. Special attention must be paid to the scraper ring, which MUST be fitted with the CHAMFERED SIDE UPPERMOST. Rings should not be slack or stuck fast in the groove. With the piston held in a horizontal position the rings should not fall downwards unless the piston is shaken. This applies only to a piston and rings free from grease or oil.

(e) 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 or resleeved, the new rings will not bed in satisfactorily. Under these conditions the cylinder should be removed and the hard polished

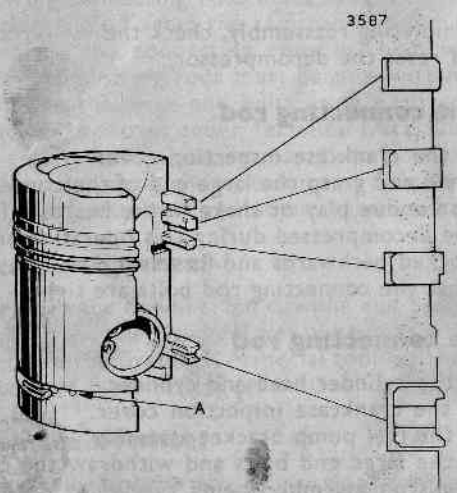

Fig. 8

bore lightly roughened using a medium grade emery 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 suitable 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 petrol or paraffin to remove all traces of carborundum.

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(*f*) To allow the piston rings to bed in satisfactorily, it is recommended that the engine be run on half load whenever possible after overhaul.

36. To replace cylinder and piston

(*a*) When replacing the piston see that the two valve recesses in the crown are at the side nearest to the camshaft.
(*b*) Take care that the piston ring gaps are not in line but well distributed around the piston circumference.
(*c*) Replace the shims between the cylinder and the crankcase. The thickness of the shims controls the bumping clearance between the pistons and the cylinder head at TDC.
(*d*) Before completing reassembly, check the bumping clearance (see Technical Data) as follows:
Place two pieces of lead wire on top of the piston roughly at right angles to the gudgeon pin. Replace the cylinder head gasket and cylinder head and bolt down firmly. Turn the engine over TDC, remove the cylinder head and measure the thickness of the now flattened lead wire with a micrometer.
(*e*) After completing reassembly, check the valve rocker clearance and reset the decompressor.

37. To examine connecting rod

(*a*) Remove the crankcase inspection cover.
(*b*) Insert hand and grasp the large end of the connecting rod. Check for undue play or shake in the bearing. The engine should be decompressed during this operation and the flywheel rocked backwards and forwards.
(*c*) Check that the connecting rod bolts are tight.

38. To remove connecting rod

(*a*) Remove the cylinder head and cylinder.
(*b*) Remove the crankcase inspection cover.
(*c*) Remove the fuel pump bracket assembly.
(*d*) Remove the large end bolts and withdraw the connecting rod and piston assembly, being careful to note in which position the bearing halves are fitted. Note the crankshaft assembly positions.

39. Connecting rod maintenance

(*a*) When fitting a small end bush take care that the oil hole coincides with that in the connecting rod and that the bush enters the connecting rod squarely. In the absence of a press a block of wood and mallet may be used for driving it home.
(*b*) New small end bushes are supplied with a reaming allowance and after fitting, must be reamed to the size shown under Technical Data.

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(c) 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.

(d) 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.

(e) 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.

(f) Undersize bearings are obtainable from *Petters Ltd or their agents.*

40. To replace connecting rod

(a) Generally reverse the instructions for removal. When replacing connecting rods make sure that the bolt heads are facing AWAY from the camshaft and fuel injection pumps.

(b) Replace the connecting rods in their original positions. New connecting rods must balance within $\frac{1}{4}$oz (7g).

(c) Tighten the large end bolts using a torque spanner set to the figure shown under Technical Data. Do not overtighten the bolts or the bearing may distort.

(d) When replacing the cylinder and cylinder head check the bumping clearance and adjust valve rocker clearance.

41. To remove flywheel

(a) Remove the flywheel fan cowling and brackets.

(b) Withdraw the flywheel key with a tapered key drift and remove the flywheel. A special tool for this purpose can be obtained from *Petters Ltd or their agents.*

42. To replace flywheel

(a) Generally reverse the instructions for removal.

(b) Ensure that the flywheel is pushed firmly onto the crankshaft before replacing the flywheel key firmly in position.

43. To remove crankshaft

(a) Remove the cylinder head, cylinder and connecting rod.

(b) Remove the flywheel.

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

(d) Remove the bolt and gearwheel retaining plate from the gear end of the crankshaft and withdraw the gearwheel with a simple extractor. A special tool for this purpose can be obtained from *Petters Ltd or their agents.*

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(e) On two-cylinder engines, remove the setscrew at the side of the crankcase that holds the intermediate main bearing housing in position.
(f) Mark the balance weights to identify the assembly positions. Unscrew the bolts and remove balance weights and washers.
(g) Remove the flywheel end main bearing housing.
(h) Withdraw the crankshaft by pulling towards the flywheel end. The oil pump gearwheel is a forced fit on the crankshaft and should not be removed.

44. Crankshaft maintenance

(a) Carefully examine the bearing journals and crankpins. They should be free from score marks and ovality should not exceed the maximum (see Technical Data).
(b) If these defects are present the crankshaft should be re-ground to the diameter shown under Technical Data and undersize bearings fitted.
(c) Carefully clean out the oil holes and make sure they have radiused edges.

45. Main bearing maintenance

(a) Intermediate main 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. The two halves of the intermediate bearing housing are stamped with an assembly serial number and care must be taken that numbers are correctly assembled and on the same side.
(b) Main bearings are of the precision thin wall steel backed sleeve type lined with bearing metal. When replacing a bearing take care that it enters the bearing housing squarely, that the oil holes in the bearing and the housing are in line, and that the bearing split is slightly above the horizontal.
(c) 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.
(d) Undersize bearings are obtainable from *Petters Ltd or their agents*.

46. To replace crankshaft and time engines (Fig. 9 & 13)

(a) Generally reverse the instructions for removal. The crankshaft gearwheel is a tight fit on the crankshaft and it may be necessary to heat the gearwheel before fitting to the crankshaft. Do not overheat the gearwheel or its hardness may be affected.
(b) Fit new bearings if the old ones have excessive clearance or show signs of the metal having run. Make sure that the bearing shell at the gear end does not protrude beyond the limits shown in the illustration.

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(c) If the main bearing housing at the gear end has been removed, make sure it is correctly fitted with the oil hole in line with the oil hole in the crankcase.

(d) On two-cylinder engines make sure that the intermediate main bearing housing is correctly assembled on the crankshaft with the side marked 'TOP' toward the flywheel end.

(e) When replacing the thrust washers, be sure that the grooved sides are away from the bearing housing and the tongues (C) located in their respective recesses.

(f) Before completing the assembly, check the end float (Y) and if excessive fit new thrust washers (see Technical Data). The outer thrust washer is located by the bearing shell which protrudes slightly from the housing and the inner one by a recess in the housing. They should be replaced in their original positions.

(g) Replace the balance weights in their original positions. New balance weights must be balanced within $\frac{1}{4}$oz (7g) (one-cylinder engine) or $\frac{1}{2}$oz (14g) (two-cylinder engine).

(h) When assembling the gearwheels make sure that the teeth marked with dots are in their relative positions.

(j) When an SAE 5 bellhousing is fitted, ensure that the oil seal and its bearing face are in good order. Fit a new seal to the gearwheel retaining plate and a new sealing washer to the retaining plate bolt. Failure to observe these precautions may lead to oil leaks.

(k) Fit new locking wire to extension shaft setscrews.

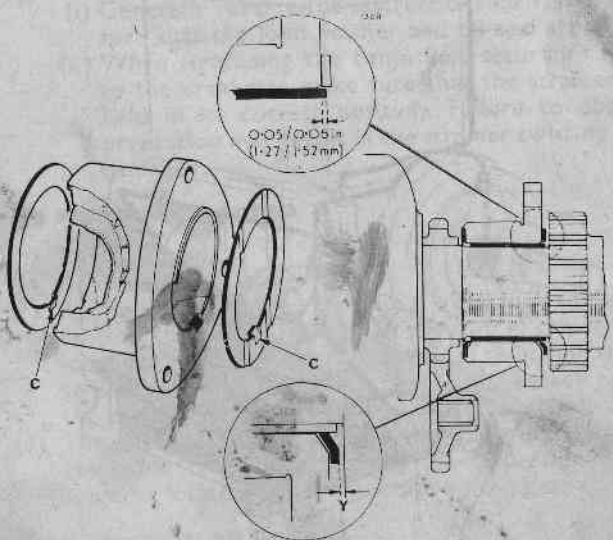

Fig. 9

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47. Lubricating oil system (Fig. 10)

(*a*) The lubricating oil system is as follows:

(i) A rotary oil pump (A) is mounted on the crankcase at the gear end. The pump is driven by a gear and idler gear from the crankshaft.

(ii) Oil is drawn through a strainer (B) and fed via oilways in the crankcase to the main bearings.

(iii) The large end bearings are supplied with oil from the main bearings via holes in the crankshaft.

(iv) The valve rockers (C) are supplied with oil by an external pipe (D) through a restrictor (E).

(v) An adjustable pressure relief valve is incorporated to control the oil pressure.

(*b*) The cylinders, small end bearings and camshaft are splash lubricated.

(*c*) The sump can be drained by removing the plug at the bottom of the crankcase.

(*d*) Oil must always be CLEAN and containers, funnels, etc., must be kept in a spotless condition. Use only approved oil. Cheap, unsuitable or dirty oil will cause trouble.

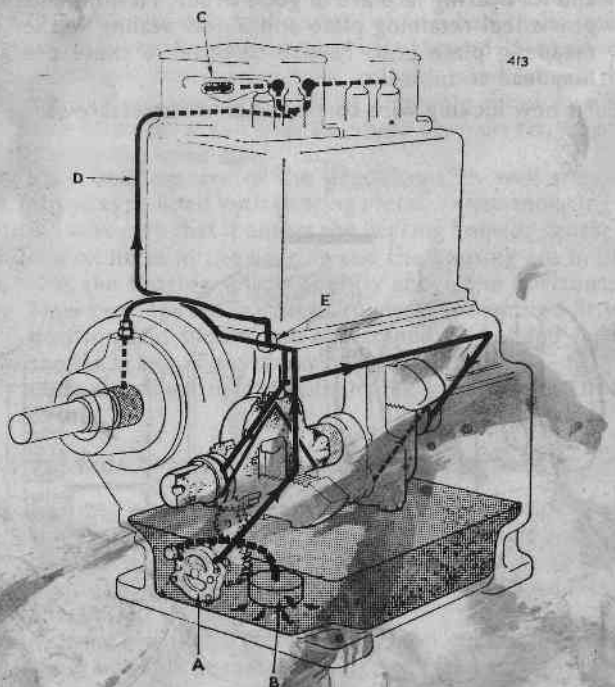

Fig. 10

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48. Oil filter maintenance

(a) The filter incorporates an adjustable pressure relief valve to control the oil pressure. This valve is set by *Petters Ltd* and should not require further adjustment.

(b) Should the filter become blocked with dirt, the element bypass valve will open and unfiltered oil will flow directly from the pump to the bearings, etc. Make sure that the by-pass valve is seating correctly but do not dismantle the valve.

(c) To change element

(i) Unscrew the clamp bolt at the centre of the filter bowl and withdraw the bowl complete with element.

(ii) Thoroughly clean out the bowl and examine the joint ring.

(iii) If the element shows a large deposit of dirt, fit a new element, obtainable from *Petters Ltd or their agents*. Do not attempt to clean the element.

(iv) Fit the new joint ring supplied with each element.

49. Oil pump strainer

(a) To remove

(i) Drain the oil.

(ii) Remove the crankcase inspection cover.

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

(b) To clean

(i) Wash the strainer in clean paraffin or fuel.

(c) To replace

(i) Generally reverse the instructions for removal, making sure that the joint washer and oil seal are in position.

(ii) When tightening the banjo bolt securing the strainer to the crankcase make sure that the strainer is firmly held in its correct position. Failure to observe this precaution may result in the strainer twisting and being damaged.

50. To remove oil pump

(a) Drain the oil.

(b) Remove the oil strainer.

(c) Remove the setscrews and nut retaining the pump and remove the pump, noting the position of the stepped stud locating the pump. The easiest way of removing the pump is to screw two $\frac{5}{16}$in BSF bolts into the threads provided in the pump and to exert an even pull on both bolts.

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

51. To dismantle oil pump

(a) Tap the pin out of the driving gear hub and pull off the gear.

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(*b*) Remove the screws retaining the cover and remove the cover.
NOTE: The cover is dowelled to the body.
(*c*) Withdraw the rotor and stator components.

52. Oil pump maintenance

(*a*) Thoroughly clean all parts.
(*b*) Carefully examine the rotor and stator. If they are scored or show signs of wear fit new parts.

53. To replace oil pump (Fig. 11)

(*a*) Generally reverse the instructions for removal and dismantling.
(*b*) Make sure the stepped stud locating the pump is in the correct position. The stud should be fitted at (A) for standard rotation engines or at (B) for reverse rotation engines.

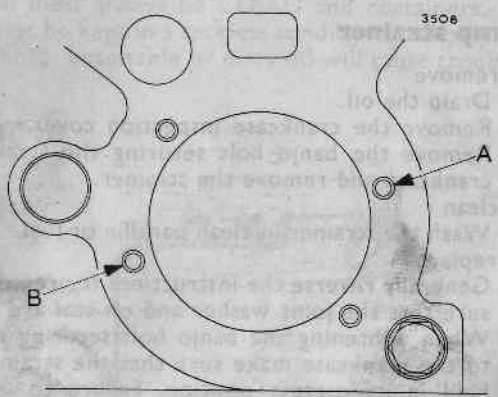

Fig. 11

54. To remove camshaft (Fig. 12)

(*a*) Remove the gear cover.
(*b*) Disconnect fuel pipes and remove the fuel pump bracket assembly.
(*c*) Remove the rocker box, push rods and tubes.
(*d*) Wind a rubber band or piece of string (A) round the shanks of the valve tappets to prevent their falling into the sump when the camshaft is withdrawn.
(*e*) A camshaft thrust plate (B) is located between the camshaft gearwheel and the crankcase, with two vertical slots for the holding screws (C). Loosen these screws, which are accessible through holes in the gearwheel, and the thrust plate will drop about $\frac{1}{2}$in (13mm).
(*f*) Withdraw the camshaft assembly, which includes the governor, from the gear end of the engine.

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(g) When an SAE 5 bellhousing is fitted, the crankshaft gearwheel and oil thrower assembly must be removed before withdrawing the camshaft.

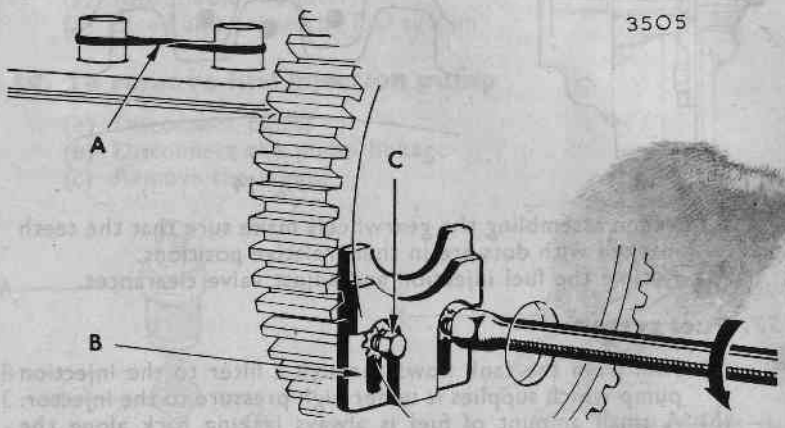

Fig. 12

55. Camshaft and governor maintenance

(a) Carefully examine the faces of the cams. If these are worn or chipped it will be necessary to fit a new camshaft.
(b) The camshaft gearwheel is shrunk on the camshaft and cannot be removed.
(c) The governor weights are fitted to the camshaft gearwheel and their action is transmitted by push rods in the camshaft. The push rod at the flywheel end can easily be withdrawn but at the gear end it is necessary to remove the governor weights. The push rods are separated by a steel ball. New governor weights should be fitted in pairs balanced within $\frac{1}{32}$oz (1g).
(d) After removal, thoroughly clean the push rods and the hole through the camshaft with paraffin. Any stickiness of the push rods will affect the speed control.
(e) Make sure that the contact surfaces of the fuel pump rack operating lever adjusting screw and the fuel pump rack extension are smooth and lubricated.

56. To replace camshaft and time engine (Fig. 13 & 14)

(a) Generally reverse the instructions for removal.
(b) Check the camshaft end float (Y) and if excessive fit a new thrust plate (see Technical Data).

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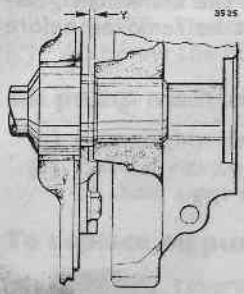

Fig. 13

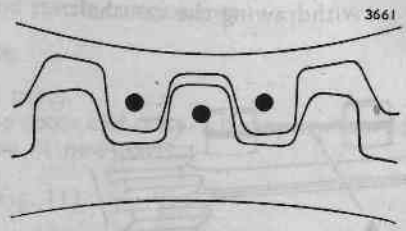

Fig. 14

(c) When assembling the gearwheels make sure that the teeth marked with dots are in their relative positions.
(d) Retime the fuel injection and adjust valve clearances.

57. Fuel system

(a) Fuel from the tank flows through a filter to the injection pump which supplies it under high pressure to the injector.
(b) A small amount of fuel is always leaking back along the injector nozzle needle and this is returned to the fuel system by a pipe.
(c) The quantity of fuel injected during each cycle is very small and the fuel injection equipment is manufactured to very fine limits. IT REQUIRES EXTREME CARE AND ABSOLUTE CLEANLINESS IN HANDLING.
(d) Should any part of the fuel system, including pipes, be removed from the engine, it should be placed in a clean container which is filled with clean fuel. NO FILING, GRINDING, SCRAPING OR SAWING SHOULD BE CARRIED OUT WITHIN A FEW YARDS OF DISMANTLED FUEL INJECTION EQUIPMENT.
(e) Replace the equipment wet. No rag, cloth or waste should touch it.
(f) Unless the user has been trained in the care and repair of fuel injection equipment, he should not dismantle it in any way other than as described in subsequent paragraphs.
(g) Fuel pump and injectors should be returned to *Petters Ltd or their agents* for repair or replacement. Users are advised to keep a nozzle in their spares kit so that a faulty one can be renewed immediately.
(h) If the exhaust becomes dirty, it is an indication that either the engine is being overloaded or the fuel injection system requires servicing.

58. To clean fuel filter

(a) Unscrew the clamp bolt at the centre of the filter bowl and withdraw the bowl complete with element.

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(*b*) Thoroughly clean out the bowl and examine the joint ring.
(*c*) If the element shows a large deposit of dirt, fit a new element, obtainable from *Petters Ltd or their agents*. Do not attempt to clean the element.
(*d*) It is advisable to fit a new joint ring when the element is changed.
(*e*) Reassemble the filter.
(*f*) Bleed and prime the fuel system.

59. To remove fuel injection pump

(*a*) Disconnect pipes.
(*b*) Disconnect the pump linkage
(*c*) Remove the pump.

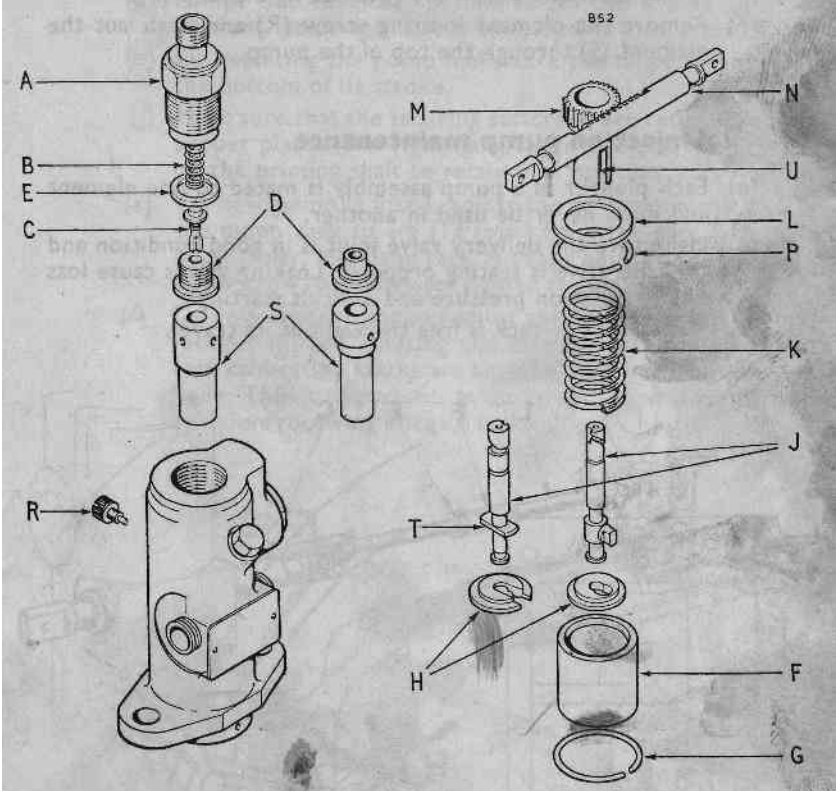

Fig. 15

60. To dismantle fuel injection pump (Fig. 15)

(*a*) Thoroughly clean the exterior of the pump.
(*b*) Unscrew the union body (A) and lift out the delivery valve spring (B) and the delivery valve (C).

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(c) Withdraw the delivery valve seat (D) and the joint (E). For *Bryce* pumps a special tool for this purpose can be obtained from *Petters Ltd or their agents*. On CAV pumps the delivery valve seat can be pushed out with the element as described in (*f*) below. This also applies to *Bryce* pumps if the special tool is not available.

(*d*) Press down the tapped (F) and remove the circlip (G). During this operation the tappet may be held down by a pin inserted through the hole in the pump body.

(e) Remove the tappet, the lower spring plate (H), the plunger (J) and plunger spring (K), the upper spring plate (L) and the pinion (M). Note the assembly marks on the teeth of the pinion and the rack (N). On *Bryce* pumps the upper spring plate and pinion are retained by a circlip (P).

(*f*) Remove the element locating screw (R) and push out the element (S) through the top of the pump.

61. Fuel injection pump maintenance

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

(*b*) Make sure the delivery valve joint is in good condition and that the valve is seating properly. Leaking valves cause loss of fuel injection pressure and difficult starting.

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

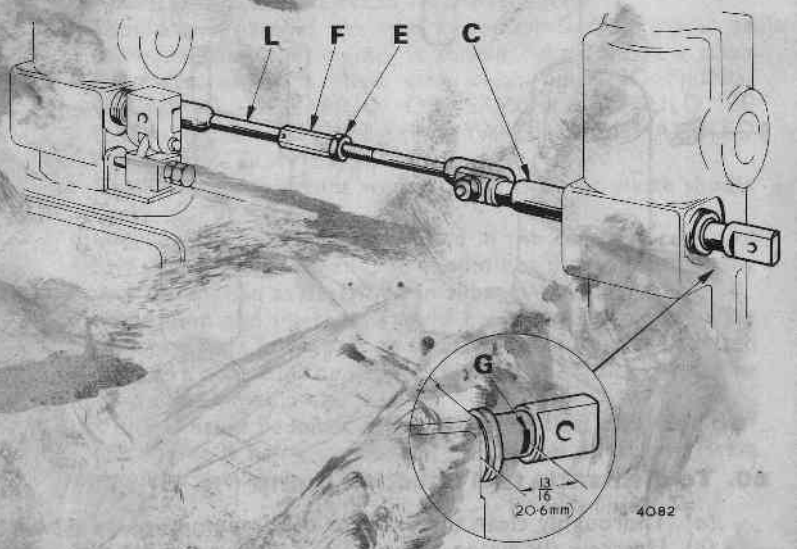

Fig. 16

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62. To replace fuel injection pump (Fig. 15, 16 & 19)

(a) Generally reverse the instructions for removal and dismantling.

(b) Thoroughly clean all parts in clean fuel and assemble wet.

(c) When assembling the rack and pinion make sure that the marked teeth are in their relative positions.

(d) Make sure the elements can move up and down slightly when the locating screw is tightened. Lock the locating screw by caulking the pump body against the screw serrations or slot.

(e) On *CAV* pumps make sure the plunger location arms (T) are correctly assembled in the pinion slots.

(f) Do not over-tighten union body.

(g) Pumps not required for immediate use should have connections sealed against the admission of dirt, etc.

(h) On replacing the pump make sure the tappet plunger is at the bottom of its stroke.

(j) Make sure that the securing setscrews are returned to their proper places. The right-hand screw projects into a groove on the priming shaft to retain it in position.

(k) If a new pump is fitted, adjust the calibration mark (G) on the pump rack to $\frac{1}{2}$in (12·7mm) from the spot face on the pump body, NOT the rack bush, by adjusting the governor lever screw (B). When set tighten the locknut.

(l) On two-cylinder engines adjust the link (L) by loosening the locknut (E) and rotating the adjuster (F) until both pump rack calibration marks are an equal distance from the pump body. This is important, as faulty setting will result in the cylinders receiving unequal fuel.

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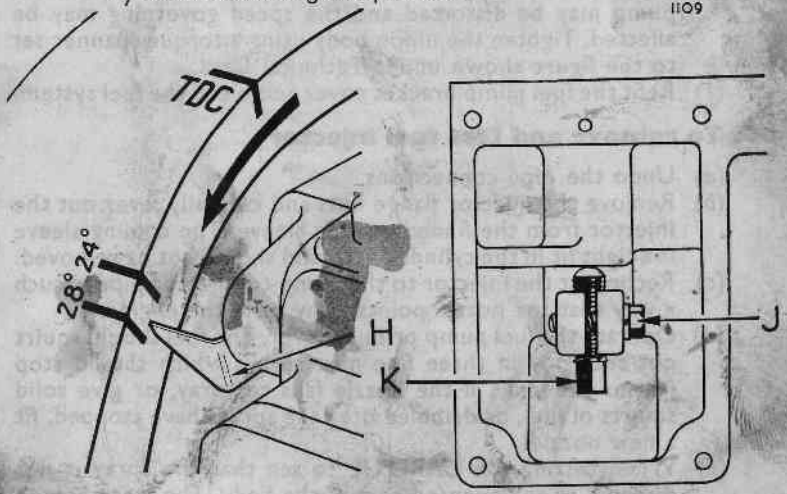

Fig. 17

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63. To time fuel injection pump (Fig. 16 & 17)

Perform the timing operation on one cylinder at a time. Remove the cover from the fuel pump bracket. Take extra care when removing a cover on which a speed control is mounted.

(*a*) Secure the fuel pump rack with the calibration mark (G) $\frac{13}{16}$in (20·6mm) from the spot face on the pump body, NOT the rack bush.

(*b*) Remove the pump-to-injector pipe and unscrew the union body from the pump. Lift out the delivery valve assembly and place it in clean fuel. Do not disturb the delivery valve seat. Replace the union body, leaving out the delivery valve.

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

(*d*) Loosen the fuel pump rocker pinch bolt (J) and unscrew the adjusting screw (K) until the pump is at the bottom of its stroke. Allow the fuel to flow from the pump. If a fuel feed pump is fitted fuel will not flow unless the feed pump lever is operated.

(*e*) Turn the flywheel until the appropriate timing mark preceding the TDC mark on the flywheel is opposite the pointer (H). For timing figures see Technical Data.

(*f*) Screw up the rocker adjusting screw until the fuel stream just stops. Adjust the screw until the EXACT position where the fuel flow stops. This position is known as the spill point.

(*g*) When the spill point is correctly adjusted, tighten the rocker pinch bolt taking care not to alter the setting.

(*h*) Reassemble the fuel injection equipment including the fuel delivery valve. Do not overtighten the union body or the pump may be distorted and the speed governing may be affected. Tighten the union body using a torque spanner set to the figure shown under Technical Data.

(*j*) Refit the fuel pump bracket cover and bleed the fuel system.

64. To remove and test fuel injector

(*a*) Undo the pipe connections.

(*b*) Remove the injector flange nuts and carefully lever out the injector from the finned cooling sleeve. The cooling sleeve is a tight fit in the cylinder head and should not be removed.

(*c*) Reconnect the injector to the pump-to-injector pipe in such a way that the nozzle points away from the engine.

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

(*e*) When testing, BE CAREFUL to see that the spray is not directed at any exposed part of the body. The force behind the spray will cause it to penetrate the skin.

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65. Fuel injector maintenance (Fig. 18)

An injector servicing kit consisting of brass wire brush, nozzle scraper and spray hole cleaner is obtainable from *Petters Ltd or their agents.*

(*a*) Thoroughly clean the exterior of the injector.

(*b*) Remove the nozzle holder cap nut (A) and the adjusting screw (B).

(*c*) Remove the nozzle nut (C) and the nozzle assembly (D). Each needle of a nozzle assembly is mated to one nozzle body and must never be used in another.

(*d*) To ensure a thorough cleaning of all parts they should be left in a bath of clean fuel. After this treatment, any remaining carbon can be scraped off with the brass wire brush or a piece of clean wood or brass.

(e) The nozzle holder and nozzle joint faces must be clean with a mirror-like appearance. The nozzle and nozzle nut clamping shoulders must be clean.

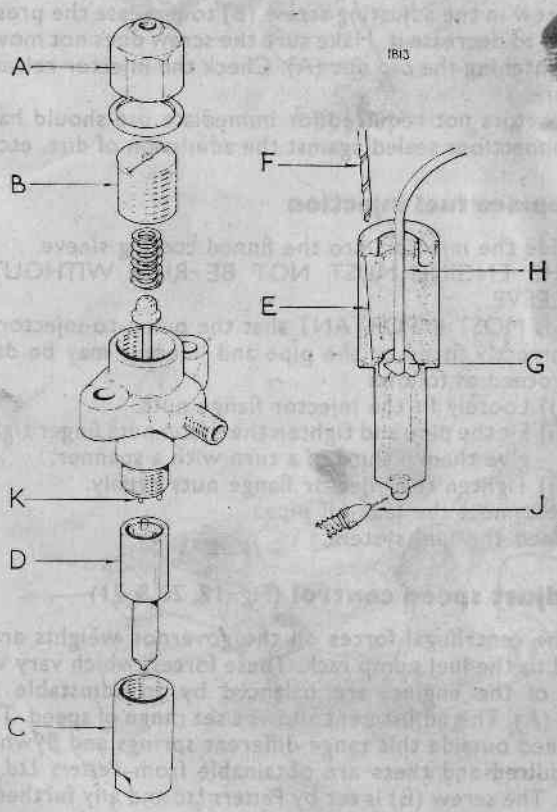

Fig. 18

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(*f*) The nozzle body fuel feed holes (E) should be cleaned by pushing a wire or twist drill (F) down to the fuel chamber (G) being careful not to scratch the joint face.

(*g*) Insert the nozzle scraper (H) down into the fuel chamber, press sideways and rotate to remove carbon, etc.

(*h*) Soft carbon can be removed from the spray holes with the spray hole cleaner (J). Care must be taken that the wire is not broken off in the spray hole.

(*j*) Wash the nozzle body and needle in clean fuel and assemble wet.

(*k*) To fit a nozzle assembly to the nozzle holder body, hold it hard against the pressure face in the position determined by the dowels (K) and tighten the nozzle nut.

(*l*) To complete the assembly of the injector, grease the spring assembly and replace it, together with the adjusting screw.

(*m*) The fuel injection release pressure will require adjustment and it must be reset to the figure shown under Technical Data. A test pump for this purpose can be obtained from *Petters Ltd or their agents*. To adjust the release pressure, screw in the adjusting screw (B) to increase the pressure or out to decrease it. Make sure the screw does not move while tightening the cap nut (A). Check the injector release pressure.

(*n*) Injectors not required for immediate use should have pipe connections sealed against the admission of dirt, etc.

66. To replace fuel injection

(*a*) Slide the injector into the finned cooling sleeve. THE ENGINE MUST NOT BE RUN WITHOUT THIS SLEEVE.

(*b*) It is MOST IMPORTANT that the pump-to-injector pipe is correctly fitted or the pipe and injector may be damaged. Proceed as follows

(i) Loosely fit the injector flange nuts.

(ii) Fit the pipe and tighten the union nuts finger tight, then give them a third of a turn with a spanner.

(iii) Tighten the injector flange nuts evenly.

(*c*) Reconnect the leak-off pipe.

(*d*) Bleed the fuel system.

67. To adjust speed control (Fig. 19, 20 & 21)

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 (A). This adjustment allows a set range of speed. To adjust the speed outside this range different springs and flywheel may be required and these are obtainable from *Petters Ltd or their agents*. The screw (B) is set by *Petters Ltd* and any further adjustment may result in the engine overspeeding when the load is

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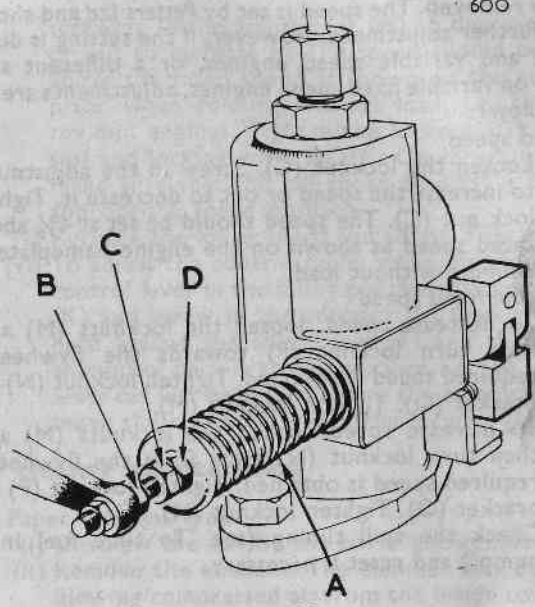

Fig. 19

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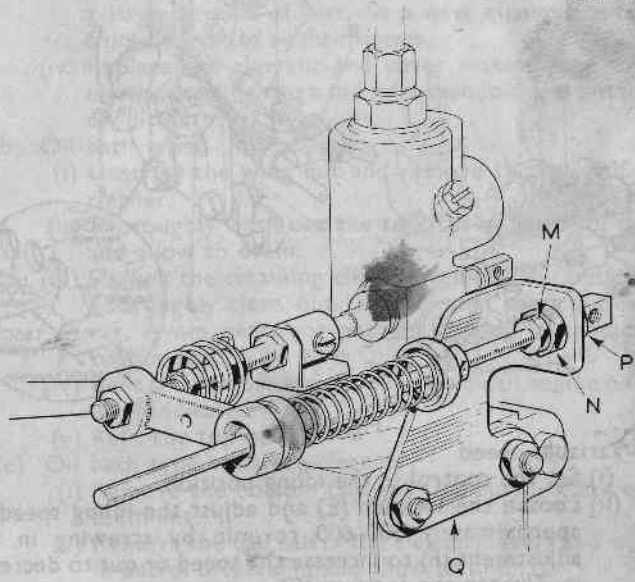

Fig. 20

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suddenly removed. The speed is set by *Petters Ltd* and should not require further adjustment. 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 follows:

(*a*) Fixed speed

(i) Loosen the locknut (C). Screw in the adjustment (D) to increase the speed or out to decrease it. Tighten the lock nut (C). The speed should be set at 4% above the rated speed as shown on the engine nameplate, when running without load.

(*b*) Variable fixed speed

(i) To decrease speed, loosen the locknuts (M) and (N) then turn locknut (P) towards the flywheel until required speed is obtained. Tighten locknut (N) against bracket (Q). Tighten locknut (M).

(ii) To increase speed, loosen the locknuts (M) and (P) then turn locknut (N) away from the flywheel until required speed is obtained. Tighten locknut (P) against bracket (Q). Tighten locknut (M).

(iii) Check the spill timing (see 'To time fuel injection pump') and reset if necessary.

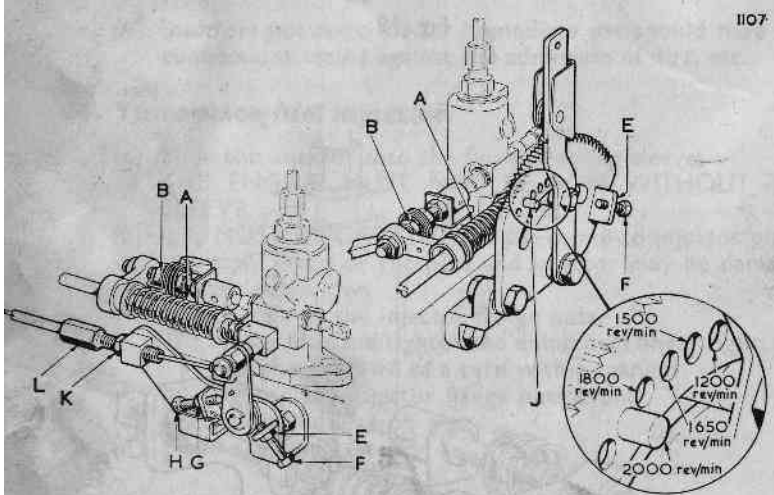

Fig. 21

(*c*) Variable speed

(i) Set the control in the idling position.

(ii) Loosen the locknut (E) and adjust the idling speed to approximately 500–600 rev/min by screwing in the adjustment (F) to increase the speed or out to decrease it. Tighten the locknut (E).

(iii) Set the control in the full speed position.

(iv) Loosen the locknut (G) and adjust the full speed by

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screwing in the adjustment (H) to decrease the speed or out to increase it. The speed should be set at 8% above the rated speed as shown on the engine name-plate, when running without load, i.e. 2160 for 2000 rev/min engines. Tighten the locknut (G) and fit new seal and locking wire. NOTE: On rachet type control, make sure that the full speed stop (J) is fitted in the appropriate speed position.

(v) Recheck the idling speed and adjust if not correct.

(vi) To adjust the control cable, when fitted, set the cable control lever in the idling position. Slacken the locknut (K) and screw in the adjuster (L) until the control is hard against the adjustment (F) and there is a small amount of slack in the inner cable, i.e. the cable control lever can just be moved before the inner cable begins to move the control. Tighten the locknut (K).

68. Air cleaner maintenance

(*a*) Paper element type

(i) Unscrew the nut on the cover and remove the cover.

(ii) Remove the element. The element may be cleaned by blowing compressed air from the inside to the outside.

(iii) 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 Ltd or their agents*.

(iv) Replace the element and cover making sure that the element sealing rings and inlet manifold seal are in good condition.

(*b*) Oil bath type

(i) Unscrew the wing nut and remove the top half of the cleaner.

(ii) Thoroughly wash out the top half in petrol or paraffin and allow to drain.

(iii) Slacken the retaining clip and remove the bottom cup. Thoroughly clean out the sediment using a clean oily rag. Avoid petrol or paraffin coming in contact with rubber seal.

(iv) Refit the bottom cup and fill with clean engine oil to the level indicated.

(v) Refit the top half.

(*c*) Oil bath type with pre-cleaner

(i) Remove the bottom cup and thoroughly clean out the sediment.

(ii) Remove the top half of the cleaner, invert and wash out in petrol or paraffin and allow to drain.

(iii) Refit the cleaner and fill the cup with clean engine oil to the level indicated.

(iv) Refit the cup.

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69. Clutch

The clutch is adjusted by *Petters Ltd* but further adjustment may be necessary after an initial running-in period, dependent 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 to the fully engaged position.

The clutch is lubricated from the engine via a red painted restrictor which should pass 45 to 65 cm^3 of oil per $\frac{1}{4}$ hour.

(*a*) To adjust clutch
- (i) Remove the housing cover.
- (ii) Loosen the adjusting ring grubscrew and locknut. Turn the adjusting ring with a tommy bar until the operating lever can be pushed into the full engaged position without undue strain. DO NOT OVER-ADJUST. THIS MAY CAUSE DAMAGE.
- (iii) Tighten the grubscrew and locknut and replace the housing cover.

(*b*) To adjust oil flow to clutch
- (i) Loosen the restrictor locknut.
- (ii) Screw the restrictor in to reduce the oil flow or out to increase it.
- (iii) Tighten locknut, taking care not to move the restrictor.

(*c*) To remove clutch
- (i) Set the operating lever in the disengaged position.
- (ii) Disconnect the oil pipe.
- (iii) Remove the bolts holding the clutch housing to the engine gear cover and withdraw the clutch assembly.
- (iv) Remove the lead seals and screws securing the driving flange and withdraw the flange.
- (v) Remove the clutch spigot plate from the engine gear cover.

(*d*) To dismantle clutch
- (i) Remove the housing cover.
- (ii) Remove the pinch bolts from the clutch yoke and withdraw the operating lever and yoke shaft, leaving the yoke in the housing.
- (iii) Remove the oil seal housing and the adjoining circlip.
- (iv) Carefully push out the clutch shaft and plate assembly from the driving end.
- (v) Slacken the adjusting ring grubscrew and locknut and screw the ring towards the driving end of the shaft until the sliding sleeve can be removed.
- (vi) Remove the sliding sleeve and thrust ring assembly.
- (vii) Take off the adjusting ring and the clutch plates, noting the order of assembly.

(*e*) To replace clutch

Generally reverse the instructions for removal and dismantling, paying particular attention to the following points:

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(i) The countersunk screws attaching the spigot plate to the engine gear cover should be screwed tight and centre-popped for locking purposes.
(ii) The driving flange capscrews should be locked with lead seals.
(iii) Clutch plates should be refitted in the same order and position as when dismantled.
(iv) The clutch yoke must be replaced with the pinch bolt bosses facing the engine.
(v) If the halves of the thrust ring have been separated, make sure that the halves have been assembled with the serial numbers on the same side. The halves of each thrust ring are machined as an assembly and must not be mixed with those of another thrust ring assembly.

70. Speed increasing gear

(*a*) Lubrication
(i) By means of an external oil pipe.
(*b*) To dismantle
(i) Remove oil pipe and drain oil by removing drain plug.
(ii) Remove bolts securing the two halves of the housing. The hexagon-headed dowels may be removed with a spanner on edge.
(iii) Draw off the power take-off half of the housing, together with the power take-off shaft and driven gear assembly. Care must be taken not to damage the inner ring of the pilot bearing now exposed on the end of the shaft.
(iv) Remove the oil seal housing and draw it off the shaft, taking care not to damage the oil seal.
(v) Remove the locking screw from the ball bearing locknut and remove the latter. The shaft can now be withdrawn from the bearing. On the 1·86:1 ratio gear it will be necessary to release the circlip to remove the inner ring of the pilot bearing and the driven gear.
(vi) To expose the crankshaft gearwheel loosen the locking screw from the driving gearwheel locknut and remove locknut and gearwheel. The crankshaft extension shaft can now be removed by unscrewing the setscrews attaching it to the crankshaft gearwheel.
(*c*) To replace
(i) Generally reverse instructions for dismantling, making sure all parts are well oiled.

71. Electric starting equipment (Fig. 22)

This consists of a battery-operated starter motor engaging with a gear ring on the flywheel, a dynamo for battery charging, a regulator, ammeter and switch. Operating the switch energises a solenoid which engages a motor pinion with the gear ring.

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The pinion remains engaged until the switch is released, but a free-wheel prevents overspeeding the motor when the engine fires.

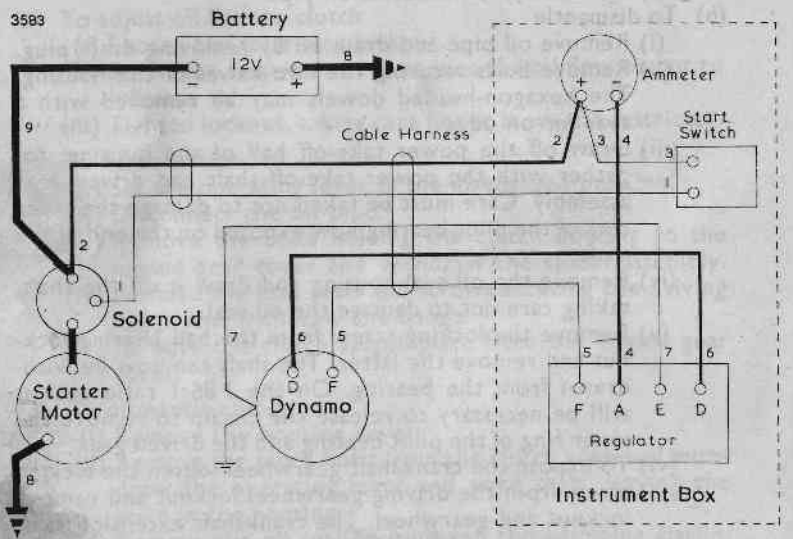
Starter motor

(*a*) Mounting
Make sure the motor is securely mounted on the engine.

(*b*) Lubrication
Bearings are lubricated on assembly and require no attention between overhaul periods.

(*c*) Terminals
Main terminals and all circuit connections must be clean and tight. Terminal shrouds should be in position.

(*d*) Brush gear
Remove the cover and inspect the brushes and commutator. Brushes should be free in their slides. Springs should seat squarely on the brushes. See that the insulation is in good condition. The brushes and commutator should be free



1 White/Red 14/0·012in (32/0·20mm 1·0 mm²)
2 Brown 28/0·012in (30/0·25mm 1·5 mm²)
3 Brown/White 14/0·012in (32/0·20mm 1·0 mm²)
4 Brown/White 28/0·012in (30/0·25mm 1·5 mm²)
5 Yellow/Green 14/0·012in (32/0·20mm 1·0 mm²)
6 Yellow 28/0·012in (30/0·25mm 1·5 mm²)
7 Black 14/0·012in (32/0·20mm 1·0 mm²)
8 Black 61/0·044in (19/1·78mm 50 mm²)
9 Brown/Red 61/0·044in (19/1·78mm 50 mm²)

Fig. 22

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from dust and grease and contact surfaces clean, smooth and uniform in colour.

(e) Solenoid
The solenoid should move freely and contact faces be clean and unburnt. Do not attempt to clean the solenoid without disconnecting the battery.

Dynamo

(a) Mounting
The belt tension should be checked carefully. A slack belt overheats and causes low dynamo output. A tight belt overloads the dynamo bearings and leads to early belt and bearing failure.
Belt slackness should not be more than $\frac{1}{2}$in (13mm). To adjust the tension, loosen the dynamo pivots and adjusting strap. Make sure the pivots and strap are tightened after adjustment.

(b) Lubrication
Bearings are lubricated on assembly and require no attention between overhaul periods.

(c) Brush gear
Remove the cover and inspect the brushes and commutator. Brushes should be free in their slides. Springs should seat squarely on the brushes. See that the insulation is in good condition. The brushes and commutator should be free from dust and grease and contact surfaces clean, smooth and uniform in colour.

(d) Terminals
Main terminals and all circuit connections must be clean and tight. Terminal shrouds should be in position.

Regulator

Adjustments should not be made other than by an electrical engineer.

72. Protection and preservation

(a) Dust protection
In a dust laden atmosphere lubricating oil filters and fuel pump rack covers should be fitted.

(b) Covers
When not in use engines should be protected by a waterproof cover. Under tropical conditions a permanent awning should be provided.

(c) Storage
Before despatch from the factory engines are preserved for storage and should not be disturbed until required for use.

(d) Intermittent use
When not in regular use, engines should be run for a thirty-minute period each week to lubricate internal parts and boil off any condensation that has formed. External unpainted parts should be wiped with an oil rag, and external controls, etc., lubricated.

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(e) Preservation

Engines remaining idle for more than a month may corrode, and as serious damage may result it is recommended that they be preserved as follows:

(i) Carry out a 500-hour service.

(ii) Drain the sump, flush out with flushing oil and refill with the appropriate grade of *Shell* lubricating oil which will provide internal protection. (Alternatively, a lubricating oil with preservative properties will be recommended by a local oil distributor.)

(iii) Drain the fuel tank and filter and refill with approximately 2 pints (1·14 litres) of *Shell Fusus* oil or *Calibration Fluid C*. Bleed and prime the fuel system and run the engine on light load for five minutes. The fuel system is now adequately protected.

(iv) If prolonged storage is envisaged, the injector should be removed and a small quantity of preservative oil applied to the cylinder and piston while cranking the engine. Replace the injector, fitting a new washer if applicable.

(v) Air inlet and exhaust fittings should be removed and with the inlet and exhaust valves closed, i.e. engine on compression, preservative oil should be applied to both the inlet and exhaust ports to protect the valve seats. The manifolds should be sealed against the ingress of moisture.

(vi) If electric starting is fitted, the battery should be removed and the terminals cleaned and greased. To maintain the battery in peak efficiency it should be trickle charged at regular intervals.

(vii) Ensure that the engine is clean and dry. Repaint where necessary and wipe all unpainted parts with an oil rag. All pivot points, external controls, etc., should be lubricated and shafts greased.

(viii) Protected engines need no attention while in storage other than to ensure that they remain dry. Before use, ensure that all sealing tape is removed and the instructions under 'To prepare a new or overhauled engine for starting' are followed.

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