Perkins®

TSL4184E
May 1998

User's Handbook

Perkins 4006 and 4008 Diesel

4006
4008

WARNING 

READ AND UNDERSTAND ALL SAFETY PRECAUTIONS AND WARNINGS MENTIONED IN THIS MANUAL.

IMPROPER OPERATION OR MAINTENANCE PROCEDURES COULD RESULT IN A SERIOUS ACCIDENT OR DAMAGE TO THE EQUIPMENT CAUSING INJURY OR DEATH.

NON-COMPLIANCE WITH THESE INSTRUCTIONS AND THOSE INCLUDED IN THE INSTALLATION MANUAL TSL4068 MAY INVALIDATE THE WARRANTY OFFERED WITH THE ENGINE.

MAKE QUITE CERTAIN THAT THE ENGINE CANNOT BE STARTED IN ANY WAY BEFORE UNDERTAKING ANY MAINTENANCE, PARTICULARLY IN THE CASE OF AUTOMATICALLY STARTING GENERATING SETS.

The purpose of this Manual is to enable the operator to carry out routine servicing of the engine.
Before undertaking any work on the engine the appropriate section in the **Workshop Manual** should be read fully and completely understood prior to starting work.
The information contained within the manual is based on such information as was available at the time of going to print. In line with Perkins Engines (Stafford) Limited policy of continual development and improvement that information may change at any time without notice. The engine user should therefore ensure that he has the latest information before starting work.
The instructions contained in this manual will, provided that they are correctly carried out, ensure the safe operation of the equipment.
Users are respectfully advised that it is their responsibility to employ competent persons to operate, maintain and service the equipment in the interest of safety.
Certain overhaul operations are impracticable without the use of special tools, and those operators who are not equipped to undertake major repairs are urged to consult their Perkins distributor.
When not working on the engine, ensure that all covers, blank flanges, doors, etc., are refitted to openings to prevent the ingress of dirt, etc.
Please quote the engine type and serial number with all your enquiries. This will help us to help you. The type and serial number are on a plate fitted to the crankcase.
If any doubt exists regarding the installation, use or application of the engine, the Installation Manual should be consulted for further advice contact Applications Department at Perkins Engines (Stafford) Ltd.
Oil change intervals may be changed according to operating experience by agreement with Perkins Engines (Stafford) Limited and subject to oil analysis being carried out at regular intervals.
Please note that this 4000 Series manual also covers SE engines dispatched from the factory from 1 March 1996. A table of equivalent engine designations is given on **page 2**.

PERKINS COMPANIES

Perkins Group of Companies
Perkins Engines (Peterborough) Ltd.
Frank Perkins Way, Eastfield,
Peterborough, PE1 5NA, England.
Tel.: (01733) 67474
Telex: 32501 PERKEN G
Fax: (01733) 583000

Perkins Engines (Shrewsbury) Ltd.
Lancaster Road, Shrewsbury,
SY1 3NX, England.
Tel.: (01743) 212000
Telex: 35171/2 PESL G
Fax: (01743) 212700

Perkins Engines (Stafford) Ltd.
Tixall Road, Stafford, ST16 3UB, England.
Tel.: (01785) 223141
Telex: 36156 PERKEN G
Fax: (01785) 215110

Perkins Powerpart Distribution Centre
Frank Perkins Way,
Northbank Industrial Park, Irlam,
Manchester, M44 5PP, England.
Tel.: (0161) 776 5000
Specifications Help Desk
Tel.: (0161) 776 5151
Fax: (0161) 776 5200
Specifications Help Desk
Tel.: (0161) 776 5100
Telex: 32501 PERKEN G

Perkins International - North America
12025 Tech Center Drive,
Livonia, Michigan 48150,
U.S.A.
Tel.: 313 266 5427
Fax: 313 266 2700

Perkins Engines Latin America Inc
999 Ponce de Leon Boulevard,
Suite 710, Coral Gables,
Florida 33134, U.S.A.
Tel.: (305) 442 7413
Telex: 32501 PERKEN G
Fax: (305) 442 7419

Perkins Engines Australia Pty Ltd
Suite 2, 364 Main Street, Mornington
3931, Victoria, Australie.
Tel.: (059) 75 1877
Telex: 30816
Fax: (059) 75 1305

Motori Perkins SpA
Via Socrate. 8,22070 Casnate
Con Bernate (Como), Italie.
Tel.: 031 56 46 25 / 031 56 46 33
Telex: 380658 PERKIT I
Fax: 031 24 90 92 / 031 56 41 45

Perkins Motoren GmbH
D-63801 Kleinostheim,
Saalackerstrasse 4, Allemagne.
Tel.: (49) (6027) 5010
Fax: (49) (6027) 501130

Moteurs Perkins SA
Parc de Reflets - Paris Nord II,
165 Avenue du Bois de la Pie, BP 40064,
95913 Roissy CDG Cedex, France
Tel.: 00 33 149 90 71 72
Fax: 00 33 149 90 71 90

Perkins Engines (Far East) Pte Ltd.
39 Tuas Avenue 13,
Singapour 638999.
Tel.: (65) 861 1318
Fax: (65) 861 6252

In addition to the above companies, there are Perkins Distributors in most countries. Perkins Engies (Peterborough) Limited or one of the above companies can provide distributor handbooks Publication No. 1407/4/97

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PERKINS ENGINES (STAFFORD) ENGINE DESIGNATIONS 4000 SERIES AND SE SERIES EQUIVALENT TERMS	
4000 SERIES	**SE SERIES**
4006TG	6SET
4006TWG	6SETCR
4006TWG3	6SETCR3
4006TAG1	6SETCA1
4006TAG2	6SETCA2
4006TAG3	6SETCA3
4006TEG	6SETCW
4008TWG2	8SETCR2
4008TAG	8SETCA
4008TAG1	8SETCA1
4008TAG2	8SETCA2

PAGE

4006TWG3

4006TG

4006TAG3

4008TAG2

4006TG	6 cylinder, inline, water cooled, 4 stroke, turbocharged diesel engine, with jacket water cooled oil cooler in engine cooling circuit.
4006TWG	6 cylinder, inline, water cooled, 4 stroke, turbocharged diesel engine, with jacket water cooled oil cooler and charge air cooler in engine cooling circuit.
4006TWG3	Up-rated version of the 4006TWG. 6 cylinder, inline, water cooled, 4 stroke, turbocharged diesel engine, with jacket water cooled oil cooler and charge air cooler in engine cooling circuit.
4006TAG1	6 cylinder, inline, water cooled, 4 stroke, turbocharged diesel engine, with jacket water cooled oil cooler in engine cooling circuit and air cooled charge air cooler in radiator.
4006TAG2	Up-rated version of the 4006TAG1. 6 cylinder, inline, water cooled, 4 stroke, turbocharged diesel engine, with jacket water cooled oil cooler in engine cooling circuit and air cooled charge air cooler in radiator.
4006TAG3	Up-rated version of the 4006TAG2. 6 cylinder, inline, water cooled, 4 stroke, turbocharged diesel engine, with jacket water cooled oil cooler in engine cooling circuit, and air cooled charge air cooler in radiator.
4006TEG	6 cylinder, inline, water cooled, 4 stroke, turbocharged diesel engine, with jacket water cooled oil cooler in engine cooling circuit, and water cooled charge air cooler with raw water pump in separate cooling circuit.
4008TWG2	8 cylinder, inline, water cooled, 4 stroke, turbocharged diesel engine, with jacket water cooled oil cooler and charge air cooler in engine cooling circuit.
4008TAG	8 cylinder, inline, water cooled, 4 stroke, turbocharged diesel engine, with jacket water cooled oil cooler in engine cooling circuit and air cooled charge air cooler in radiator.
4008TAG1	Up-rated version of the 4008TAG. 8 cylinder, inline, water cooled, 4 stroke, turbocharged diesel engine, with jacket water cooled oil cooler in engine cooling circuit and air cooled charge air cooler in radiator.
4008TAG2	Up-rated version of the 4008TAG1. 8 cylinder, inline, water cooled, 4 stroke, turbocharged diesel engine, with jacket water cooled oil cooler in engine cooling circuit and air cooled charge air cooler in radiator.

SAFETY

Engine lift equipment

Use only the lift equipment which is designed for the engine.

Use lift equipment or obtain assistance to lift heavy engine components such as the cylinder block, cylinder head, flywheel housing, crankshaft and flywheel.

Check the engine lift brackets for security before the engine is lifted.

Fig. 1 1085.2

Asbestos joints

Some joints and gaskets contain compressed asbestos fibres see **Warning label Fig. 1** in a rubber compound or in a metal outer cover. The 'white' asbestos (Chrysotile) which is used is a safer type of asbestos and the danger of damage to health is extremely small.

Contact with asbestos particles normally occurs at joint edges or where a joint is damaged during removal, or where a joint is removed by an abrasive method.

To ensure that the risk is kept to a minimum, the procedures given below must be followed when an engine which has asbestos joints is dismantled or assembled.

- Work in an area with good ventilation.
- Do NOT smoke.
- Use a hand scraper to remove the joints - do NOT use a rotary wire brush.
- Ensure that the joint to be removed is wet with oil or water to contain any loose particles.
- Spray all asbestos debris with water and place it in a closed container which can be sealed for safe disposal.

Dangers from used engine oils

Prolonged and repeated contact with mineral oil will result in the removal of natural oils from the skin, leading to dryness, irritation and dermatitis. The oil also contains potentially harmful contaminants which may result in skin cancer.

Adequate means of skin protection and washing facilities should be readily available.

The following is a list of 'Health Protection Precautions', suggested to minimise the risk of contamination.

1. Avoid prolonged and repeated contact with used engine oils.
2. Wear protective clothing, including impervious gloves where applicable.
3. Do not put oily rags into pockets.
4. Avoid contaminating clothes, particularly underwear, with oil.
5. Overalls must be cleaned regularly. Discard unwashable clothing and oil impregnated footwear.
6. First aid treatment should be obtained immediately for open cuts and wounds.
7. Apply barrier creams before each period of work to aid the removal of mineral oil from the skin.
8. Wash with soap and hot water, or alternatively use a skin cleanser and a nail brush, to ensure that all oil is removed from the skin. Preparations containing lanolin will help replace the natural skin oils which have been removed.
9. Do NOT use petrol, kerosene, diesel fuel, gas oil, thinners or solvents for washing the skin.
10. If skin disorder appears, medical advice must be taken.
11. Degrease components before handling if practicable.
12. Where there is the possibility of a risk to the eyes, goggles or a face shield should be worn. An eye wash facility should be readily available.

Environmental protection

There is legislation to protect the environment from the incorrect disposal of used lubricating oil. To ensure that the environment is protected, consult your Local Authority who can give advice.

Viton seals

Some seals used in engines and in components fitted to engines are made from Viton.

Viton is used by many manufacturers and is a safe material under normal conditions of operation.

If Viton is burned, a product of this burnt material is an acid which is extremely dangerous. Never allow this burnt material to come into contact with the skin or with the eyes.

If it is necessary to come into contact with components which have been burnt, ensure that the precautions which follow are used:

- Ensure that the components have cooled.
- Use Neoprene gloves and discard the gloves safely after use.
- Wash the area with a calcium hydroxide solution and then with clean water.
- Disposal of gloves and components which are contaminated, must be in accordance with local regulations.

If there is contamination of the skin or eyes, wash the affected area with a continuous supply of clean water or with a calcium hydroxide solution for 15-60 minutes. Obtain immediate medical attention.

California Proposition 65 Warning

Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm. Battery posts, terminals and related accessories contain lead and lead compounds. **Wash hands after handling**.

Practical Information

To clean components

It is important that the work area is kept clean and that the components are protected from dirt and other debris. Ensure that dirt does not contaminate the fuel system.

Before a component is removed from the engine, clean around the component and ensure that all openings, disconnected hoses and pipes are sealed.

Remove, clean and inspect each component carefully. If it is usable, put it in a clean dry place until needed. Ball and roller bearings must be cleaned thoroughly and inspected. If the bearings are usable, they must be flushed in low viscosity oil and protected with clean paper until needed.

Before the components are assembled, ensure that the area is free from dust and dirt as possible. Inspect each component immediately before it is fitted, wash all pipes and ports and pass dry compressed air through them before connections are made.

Use suitable gloves for protection when components are degreased or cleaned with trichloroethylene, white spirit, etc. Degreasing solutions which are basically trichloroethane are not recommended

For full technical data please refer to the **Product Information Manual**.
Type: Water-cooled, turbocharged, charge cooled, industrial diesel engine.

RANGE	**4006**	**4008**
Cycle	4 stroke	
No. of cylinders	6	8
Configuration	In-Line	
Bore	160 mm	
Stroke	190 mm	
Total swept volume	22.92 litres	30.561 litres
Compression ratio	13.6:1	
Rotation	Anti-clockwise looking on flywheel end	
Firing order	1-5-3-6-2-4	1-4-7-6-8-5-2-3
Cylinder numbering	Cylinder 1 furthest from flywheel	
Valve clearances Inlet and exhaust (cold)	0,40 mm (0.016”)	
Valve dia (mm) Inlet and exhaust	48 (early engine) 52 (later and uprate engines)	
Valve setting	See **Page 43**	
Valve timing	See **Workshop Manual Section U**	
Injection timing	See **Engine Number plate**	
Piston speeds	Engine r/min 1000 1200 1500 1800	m/s (ft/min) 6.33 (1247) 7.60 (1496) 9.50 (1870) 11.40 (2244)

TYPICAL COOLING SYSTEM

Approved coolants	See **Page 17**	
Water capacity (block only)	36 litres (8 gal)	48 litres (10.5 gal)

Total water capacity	**Litres**	**Gals**	**Spec**	**Litres**	**Gals**	**Spec.**
Engine with tropical radiator	106	23.3	TG	135	29.7	TAG
	110	24.2	TAG1	145	31.9	TAG1
	110	24.2	TAG2	145	31.9	TAG2
	125	27.5	TAG3	48	10.6	TWG2*
	106	23.3	TWG			
	130	28.6	TWG3			
	46	10.1	TEG**			

* Engine only
** Engine with heat exchanger

Engine shut down temperature	96°C
Max water temperature into engine	To be determined from heat dissipated & water flow through each particular engine model
Thermostat opening temperature	71°C
System pressure	0.5 to 0.7 bar

FUEL SYSTEM

	4006	4008
Approved fuels	See **page 18**	
Relief valve setting	276 kPa (40 lb/in²)	
Injector nozzle pressure	225-235 atm	
Injection equipment	Lucas-Bryce unit injector	
Filtre/water separator	Spin-on expendable canister(s)	
Fuel lift pump	Maximum suction lift 2 metres	
Fuel flow	13.4 litres/min. (3 gpm) @ 1800 r/min	

GOVERNORS

Type	Electronic	Electronic
Type	Hydraulic	Hydraulic

LUBRICATION SYSTEM

Recommended oil	See **page 15**	
Type of system	Wet sump, external engine mounted oil pump	
Total oil capacity (oil cooler and filter)	122.7 litres (27 gal)	165.5 litres (36.5 gal)
Sump capacity (dipstick) Min.	90.7 litres (20 gal)	127 litres (27.9 gal)
Sump capacity (dipstick) Max.	113.4 litres (25 gal)	154 litres (33.9 gal)
Min. oil pressure (rated speed) to bearings	200 kPa (28 lb/in²)	
Crankcase pressure	25 mm water gauge	
Max. oil temperature to bearings	105°C	
Lubricating oil filter	disposable canister type	

INDUCTION SYSTEM

Air cleaner	Single air cleaner	Twin air cleaners
	Twin air cleaners (Uprate)	
Type (paper element)	S551A	
Max. Air intake depression	381 mm H_2O (28 mm Hg)	
Air restriction Indicator setting	380 mm H_2O	
Turbocharger	Garrett (x1) (x2 uprate only)	(x2)

EXHAUST SYSTEM

	4006	4008
Manifold type	Dry	Dry
Exhaust outlet flange (non uprate)	Vertical (single)	Vertical (single) Option
(uprate)	Vertical (single) Option Vertical (twin)	Vertical (twin)
Mating flange (non uprate)	1 x 8" Table "D" BS4	1 x 10" Table "D"
(uprate)	1 x 10" Table "D" 2 x 6" Table "D" Option	2 x 6" Table "D"
Max. exhaust back pressure	See **Product Information Manual**	
Max. exhaust temperature	See **Product Information Manual**	

FLYWHEEL

SAE size	14"	18"

FLYWHEEL HOUSING

SAE size	0	0

CRANKSHAFT

Max. overhung weight on rear bearing	1000 kg	
Tuning plate	1 x 14.6"	-
T.V. damper (non uprate)	1 x 14"	2 x 20"
(uprate)	1 x 18"	

NOTE: Subject to a torsional vibration investigation different T.V. dampers may be fitted

TYPICAL DRY WEIGHT

	4006	4008
Dry weight (engine)	2295 kg 4006TG	3120 kg 4008TAG
	2320 kg 4006TAG1/2	3250 kg 4008TAG1/2
	2340 kg 4006TWG	3325 kg 4008TWG2
	2420 kg 4006TEG	
	2400 kg 4006TAG3	
	2340 kg 4006TWG3	
Dry weight (engine and tropical radiator)	2636 kg 4006TG	3730 kg 4008TAG
	2761 kg 4006TAG1/2	4360 kg 4008TAG1/2
	2477 kg 4006TWG1/2	
	3010 kg 4006TAG3	
	2790 kg 4006TWG3	
Dry weight (engine and heat exchanger)	2560 kg 4006TEG	3462 kg 4008TWG2

HOLDING DOWN BOLT HOLES

Bolt size (engine feet)	20 mm
No. off	6

ELECTRICAL SYSTEM

Voltage	24	
Alternator type	PRESTOLITE (BUTEC) A3024 with internal regulator	
Alternator output (amps)	30 at a stabilised output of 28 volts	
Starter motor type	PRESTOLITE/BUTEC MS1/105	MS7/3A
No. of teeth (gear ring)	190	
No. of teeth (starter motor)	12	
Battery capacity cold cranking amps to IEC Standard at 0°C (32°F)	540 (each battery)	600 (each battery)
Battery (lead acid) 24 V	(2 x 12V) Total 143 Ah	(2 x 12V) Total 178 Ah

PROTECTION EQUIPMENT

Before resetting protection equipment, it must be established whether special settings (for that individual engine) have been specified in the engine sales contract. This is particularly important with ALL high water temperature settings.
Standard settings for protection equipment are as follows:

	4006	4008
Shutdown switches	**Alarm**	**Shutdown**
High Oil temperature	105°C	110°C
Low oil pressure	2.06 bar (30 lb/in²)	1.93 bar (28 lb/in²)
Hight water temperature		
71°C Thermostat	91°C	96°C

Caution: The above standard settings do not supersede any settings specified in the engine sales contract.

Overspeed	15% (on 1500 rev/min) 7% (on 1800 rev/min)

AIR STARTING

Air starter pressure	30 bar
Compressed air supply	17 bar
Type	Ingersoll-Rand Type SS350
Type	GALI A25

INSTRUMENT PANEL (ENGINE MOUNTED)

	Normal Operation
Oil pressure	Between 300-560 kPa (42.6-80 lb/in²)
Oil temperature	Between 80-90°C (176-194°F)
Water temperature	Between 65-85°C (149-185°F)
Exhaust temperature	See **Product Information Manual**
Boost pressure	See Test Certificate

COOLANT JACKET HEATING

Heater	1 x 2 kW	1 x 4 kW

WARNING IT IS ESSENTIAL THAT THE CORRECT LENGTH OF SCREW OR BOLT IS USED. INSUFFICIENT LENGTH MAY RESULT IN THE THREAD BEING STRIPPED, WHEREAS TOO LONG A THREAD MAY RESULT IN BOTTOMING IN A BLIND HOLE, OR CATCHING ON ADJACENT COMPONENTS.

NOTE: * Bolt and threads must be lubricated with clean engine oil.

** Cylinder head bolts to be lubricated under the heads, under the washers and on the threads with P.B.C. (Poly-Butyl-Cuprysil) grease. **Important:** See **Section R10 in the Workshop Manual** before fitting. All other bolt threads only to be lubricated with clean engine oil. Care must be taken not to oil the heads and faces.

TORQUE SETTINGS

CYLINDER HEAD GROUP	**lbf.ft**		**Nm**
Cylinder head bolt ** (early type)	M24	550	750
Cylinder head bolt ** (later (waisted) type)	M24	530	723
Rocker shaft bolt/nut	M16	90	120
Rocker adjuster nut inlet/exhaust	M12	35	50
Rocker adjuster nut pump/injector	M14	50	70
Rocker box bolt	M10	35	50
Air manifold bolt	M10	35	50
Exhaust manifold bolt	M10	50	70
Turbocharger V-band clamp nuts	M8	8	11

CRANKCASE AND CRANKSHAFT GROUPS			
* Main bearing bolt	M24	580	783
Side bolts (main bearing caps)	M16	124	168
Bolts sump to crankcase	M10	40	57
* Connecting rod bolt	M16	210	285
Viscous damper botls (4006/8 series)	M12	120	160
Flywheel bolts	M16	250	340
Front drive adaptor bolts	M16	250	340
Balance weight bolt	M16	250	340
Front crankshaft pulley bolt	M16	250	340
Piston cooling jet bolt	M10	7	10
Flywheel housing bolt	M10	35	50
Crankcase side bolts	M16	200	270

		lbf.ft	Nm
LUBRICATING OIL PUMP			
Bolts, pump housing to gearcase plate	M10	35	50
Thin nut, gear to drive shaft	M24	175	237
CAMSHAFT GROUP			
Camshaft gear bolt	M12	110	150
Camshaft thrust plate bolt	M10	35	50
Camshaft follower housing bolt	M10	35	50
Idler gear hub bolts	M10	35	50
WATER PUMP			
Water pump gear nut	M24	170	230
Water header to oil cooler bolts	M10	35	50
Water header to gearcase bolts	M10	35	50
Raw water pump gear securing nut, **dry thread**	M35	18	244
ENGINE FEET			
Engine feet to base frame bolts	M20	350	475
Engine feet to cushion feet bolts	M16	160	215
Engine feet to gearcase and suspension plate bolt	M10	35	50
GOVERNOR			
Control shaft mounting plate bolt	M10	35	50
FAN DRIVE			
Fan driven pulley taper lock bush screws	$^{1}/_{2}$" BSW	35	50
Fan driven pulley taper lock bush screws	$^{5}/_{8}$" BSW	65	90
ALTERNATOR			
Drive pulley taper lock bush nuts	$^{3}/_{8}$" BSW	15	20
FUEL PUMP/INJECTORS			
Injector capscrew clamp to cylinder head, early engines	M10	50	70
Injector capscrew clamp to cylinder head, later engines	M12	70	95
Injector nozzle nut to holder	M27	150	203
Fuel pump control linkage screw	2BA	6	8
Unit injector control lever capscrews	M5	6	8
FLEXIBLE COUPLING (HOLSET)			
Flexible coupling cover screw	M12 or $^{1}/_{2}$" UNC	90	129
Coupling driving flange screws (coupling size 2.15)	M12 or $^{1}/_{2}$" UNC	90	129

GENERAL TORQUE LOADINGS

The following torque loadings are general for metric coarse threads for grade 8.8 steel and do not supersede the figures quotes above.

Thread size (mm)	lbf.ft	Nm
8	18	25
10	35	50

General Note:

M10-12.9 steel	50	70

These are based to BS 3692.

QUANTITY OF OIL

Sump capacity dipstick	4006	4008
Minimum	90.7 litre (20 gal)	127.4 litre (28 gal)
Maximum	113.4 litre (25 gal)	154 litre (34 gal)

TYPE OF OIL

The industrial diesel engine should be lubricated with a good quality oil conforming to API CD or CCMC D4 specifications. All the major oil companies formulate oils to the above specifications.

VISCOSITY

Use oil of:

SAE10W/30 in starting temperatures below -15°C (without sump heater)
SAE15W/40 in starting temperatures from -15°C to 0°C
SAE30 in starting temperatures from 0°C to 32°C } or Mobil Delvac
SAE40 in starting temperatures above 32°C } 1300 SAE 15W/40

OIL CHANGE PERIODS

For normal operation of the engine the oil should be changed every 250 hours or annually whichever is the sooner.

Under certain circumstances where a centrifugal oil filter is fitted to the engine and an oil analysis programme has been carried out with the oil supplier over a period of 1000 hours of engine operation, it may be possible to extend the oil change period up to maximum of 350 hours.

To achieve this extended oil change period, a centrifugal oil filter must be fitted and cleaned every 250 hours between routine oil changes, and at every oil change point i.e. 350 hours maximum.

As the oil deteriorates it is essential that the following parameters must not be exceeded at the oil change point:

1. The viscosity of the oil must not increase by more than 10cSt at 100°C.
2. The total base number of the oil should not reduce to less than 50% of the value of new oil.
3. The flash point of the oil should exceed 180°C.
4. The water content of the oil must not exceed 1%.
5. The fuel content of the oil must not exceed 1%.
6. Oil samples should be taken from the mean sump oil level of the engine.

ENGINE OPERATION

Excessive periods of idling or repeated cold starts should be avoided, as they will cause excessive dilution of the oil by fuel, requiring more frequent oil changes and dangerously lowering the flash point of the oil.

Should there be a lubricating oil supply problem, or if the fuel being used contains more than 0.5% sulphur, Perkins Engines (Stafford) Limited must be consulted to give advice in selecting a suitable grade.

The following list gives details of some of the oils that meet the required specifications. Note that the brand names may change as oils are upgraded or reformulated.

An up-to-date list is maintained by Perkins Engines (Stafford) Limited of major oil companies products and information, which can be obtained from Perkins Engines (Stafford) Service Department.

WARNING  FAILURE TO COMPLY WITH THESE INSTRUCTIONS WILL INVALIDATE THE WARRANTY OFFERED WITH THE ENGINE, AS IT MAY RESULT IN ENGINE DAMAGE.

APPROVED INDUSTRIAL OIL A1 SPECIFICATIONS BSEN 590

(Suitable for fuel to Class A2 specifications BS2869 Part 2)

Oil Company	Type
CASTROL	CRH/RX Super
ELF	Multiperfo XC
KUWAIT OIL Co	Q8 T400
MOBIL	Delvac 13
MOBIL	Delvac Super 1300 (15W/40)
SHELL	Rimula X
ESSO	Essolube XD 3+
TEXACO	Ursa Super LA

WARNING ALWAYS STOP THE ENGINE AND ALLOW THE PRESSURISED SYSTEM TO COOL BEFORE REMOVING FILLER CAP. AVOID SKIN CONTACT WITH ANTIFREEZE BY WEARING HAND PROTECTION.

ENGINE COOLING SYSTEM

To protect the engine cooling system against corrosion it is essential that the engine coolant contains suitable additives which will give the necessary protection.
Caution: untreated water is not suitable.

WATER QUALITY

The water to be mixed with the additive must have the following characteristics:
Chloride less than 80 PPMV (PPMV = parts per million by volume)
Sulphates less than 80 PPMV
Total hardness less than 200 PPMV pH of water between 7 to 7.5 (neutral to slightly alkaline)

ADDITIVES TO WATER

Due to the complexity of the cooling system it is necessary to use an additive that contains a balanced package of corrosion inhibitors.
To achieve the required solution a 50/50 mix of Shell Safe Premium antifreeze with water should be used at all times, even in areas where frost is unlikely.
This mixture will give frost protection down to -35°C. In areas where Shell anti-freeze is unobtainable contact Perkins Engines (Stafford) Ltd for advice.
Under no circumstances should an additive containing nitrites, borates, phosphates, chromates, nitrates or silicates be used, as these materials are not compatible with the materials used in the cooling system.

When mixing the antifreeze with the water always follow the manufacturer's recommendation which is to add the anti-freeze to water and mix thoroughly before adding the mixture to the engine cooling system.
Mixing water to the anti-freeze can lead to the formation of gel in the mixture, due to over concentration, and this can lead to blockage of water passages and subsequent loss of water flow causing overheating.

MAINTENANCE OF COOLANT

The water/anti-freeze mixture should be replaced in operating engines at least once a year.
It is essential to maintain the coolant at the correct alkalinity level i.e. the pH should not increase above 7.5. A hydrometer only shows the proportion of ethylene glycol. **This is not a measure of protection against corrosion**.

WARNING FAILURE TO FOLLOW THE ABOVE RECOMMENDATIONS MAY RESULT IN ENGINE DAMAGE AND WILL INVALIDATE THE ENGINE WARRANTY.

FUEL SPECIFICATION

Fuel should be wholly hydrocarbon oil derived from petroleum, with which small quantities of additives may be incorporated for the improvement of ignition or other characteristics and should conform to British Standard Specification 2869. Class A1 or A2.
If fuels other than the above classes are considered, the operator must consult Perkins Engines (Stafford) Limited, and ensure that a suitable grade of lubricating oil is used.

BS2869 REQUIREMENTS FOR ENGINE FUEL

Property		Class A1	Class A2
Viscosity, Kinematic at 40°C, cSt *			
Min.		1.5	1.5
Max.		5.0	5.5
Cetane number, min.		50	45
Carbon residue, Ramsbottom on 10% residue, % (m/m), max.		0.20	0.20
Distillation, recovery at 350°C, % (V/V), min.		56°C	56°C
Water content, % (V/V), max.		0.05	0.05
Sediment, % (m/m), max.		0.01	0.01
Ash, % (m/m), max.		0.01	0.01
Sulphur content, % (m/m), max.		0.30++	0.50++
Copper corrosion test, max.		1	1
Cold filter plugging point °C, max.			
Summer (March/September inclusive)	Northern Hemisphere	-4	-4
Winter (October/February inclusive)	Northern Hemisphere	-15	-12

* cSt = 1 mm^2/s.

++This limit is set in accordance with the legislative requirements for gas oil of the 'Council Directive (75/716/EEC of the European Economic Community) on the approximation of the laws of Member States relating to the sulphur content of certain liquid fuels'.
In countries where this legislation does not apply, it is permissible to run 4000 Series engines on fuels with up to 1.0% sulphur.

ENGINE FUELS

1 The two classes of fuel specified in the table are marketed specifically as oil engine fuels. Class A1 is of higher quality and is intended primarily as an automotive diesel fuel, whilst Class A2 is intended as a general purpose diesel fuel. Classes A1 and A2 are distillate grades and are so specified as to prevent the inclusion of residuum.
2 The specifications for Classes A1 and A2 include limits for cold filter plugging point chosen to cover seasonal requirements in the United Kingdom.
3 Ignition quality is specified in terms of cetane number, but the calculated cetane index is referred to as an alternative for routine purposes with fuels not containing ignition improver additives.

NOTE: If local supply problems dictate that fuels which fall outside the above specification are to be used, our Service Department must be consulted prior to use.

PREPARATION FOR INITIAL START BATTERIES (PERKINS BATTERIES ARE SUPPLIED DRY CHARGED. SEE INSTALLATION MANUAL TL4068)

WARNING HAND PROTECTION MUST BE WORN WHEN CHECKING ELECTROLYTE LEVEL IN THE BATTERY.
INFLAMMABLE GAS IS GIVEN OFF BY THE BATTERY. DO NOT CHECK WITH A NAKED FLAME.

Check the level of electrolyte in each of the battery cells; it should be 8-16 mm above the plates. Using a hydrometer, check that the batteries are fully charged. A fully charged battery will have a specific gravity of 1.27 to 1.285, assuming the air temperature is below 32°C. For higher temperatures the specific gravity will be 1.24 to 1.255. When topping up the batteries always use pure distilled water and always replace the plugs after filling.

WARNING NEVER CONNECT A BATTERY INTO THE SYSTEM WITHOUT FIRST CHECKING THE POLARITY AND VOLTAGE.
NEVER DISCONNECT THE BATTERY WHILST THE ENGINE IS RUNNING.
NEVER FLASH CONNECTIONS TO CHECK FOR CURRENT FLOW.

FILLING THE ENGINE WITH OIL

Remove the drain plug to ensure sump is clean and empty, refit and tighten the plug. Remove the oil filler plug situated on the left hand side of the gearcase by rotating T-bar anti-clockwise and pulling see **Fig. 2**. Fill the sump to maximum mark on the dipstick see **Fig. 3** with the appropriate grade and quality of oil specified, see **Pages 15 - 16** and replace the plug, rotating the T-bar to tighten and seal it.

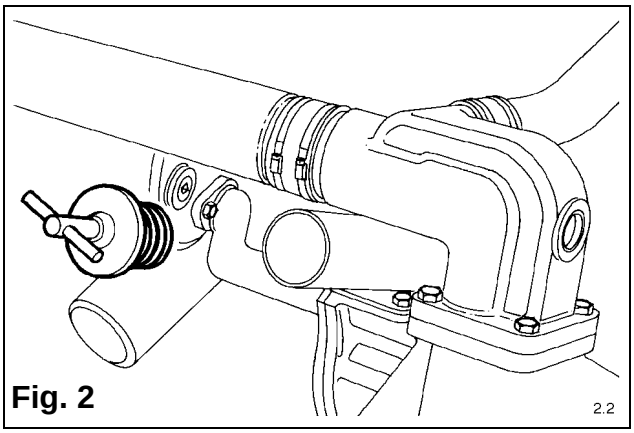

Fig. 2

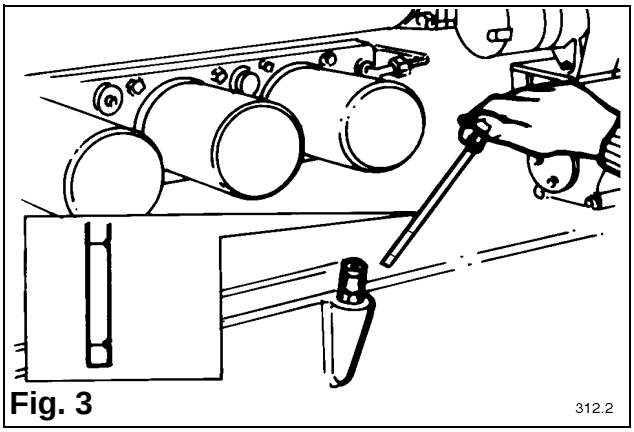

Fig. 3

PRIMING THE LUBRICATION SYSTEM

Before starting the engine for the first time, or if it has stood idle for more than three months the crankshaft and turbocharger bearings should be primed.

To prime the lubrication system the engine needs to be motored over on the starter. In order that the engine does not run up to speed when operating the key switch (i.e. energising the stop solenoids) it will be necessary to hold the governor lever in the stop position (see **Fig. 4**).

Prime the lubricating system through the oil filters until approximately 0.3 bar (5lb/in²) is indicated on the oil pressure gauge. Continue pumping for a further 10 seconds to ensure that oil has reached the turbocharger.

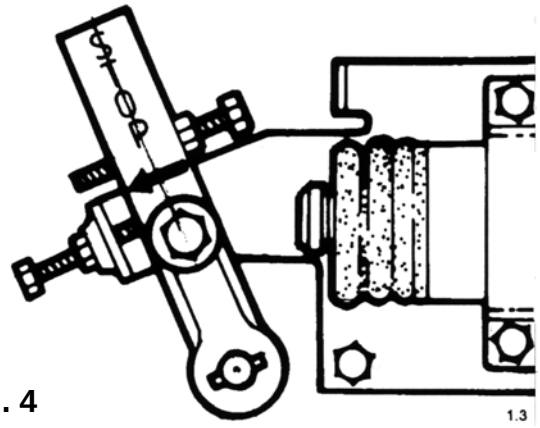

Fig. 4

FILLING THE COOLING SYSTEM

WARNING THE COOLING SYSTEM IS PRESSURISED - DO NOT REMOVE THE FILLER CAP FROM THE RADIATOR WHILST THE ENGINE IS HOT. HAND PROTECTION MUST BE WORN.

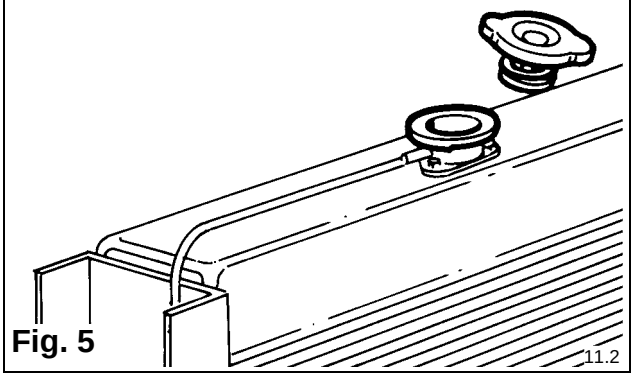

Fig. 5

The use of plain drinking water is not recommended owing to chemical reactions which can result in corrosion and furring-up of the cooling system. A solution of either water and universal anti-freeze or water and corrosion preventative must be used. Refer to **page 17**.

After installation and before the first start remove the radiator cap **Fig. 5** by rotating it anti-clockwise. Fill the cooling system with the required coolant. Should the engine be fitted with water cooled exhaust manifolds then these may need bleeding (see **Workshop Manual Section F8**). Run the engine off-load for one minute to ensure that the system is completely filled, then stop the engine and top up the system to 25 mm (1") below the top of the filter neck then replace the cap.

PREPARATION FOR INITIAL START
PRIMING THE FUEL SYSTEM

Turn on the fuel feed from the day tank, loosen the union on the tee-piece (1) **Fig. 6** then operate the priming pump by repeatedly pressing the rubber button (2) until air free fuel flows from the union, re-tighten the union.

Fuel flow circuit Fig. 6

A. Combined fuel filter/water separator

Normal fuel flow

Priming circuit

Loosen the union on the fuel feed pipe (3) **Fig. 7** at the flywheel end of the fuel rail. Operate the priming pump until air free fuel flows and re-tighten the union, continue this operation at the fuel feed union (4) and the fuel return union (5) at this point one cylinder will be primed and a considerable amount of fuel will have reached other cylinders the engine will run in this condition if a little unevenly until air is fully vented from the system.

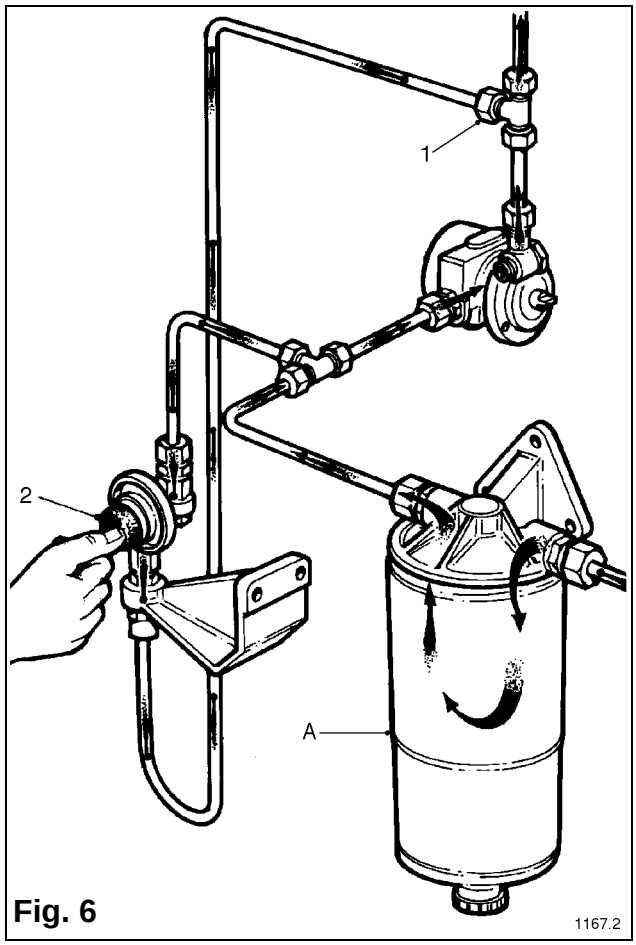

Fig. 6 1167.2

OPTIONAL CHANGE OVER FILTER

On engines fitted with a change over filter system prime the system as described above but prime the filter on the engine feed side union (6) **Fig. 8** before priming the fuel rail.

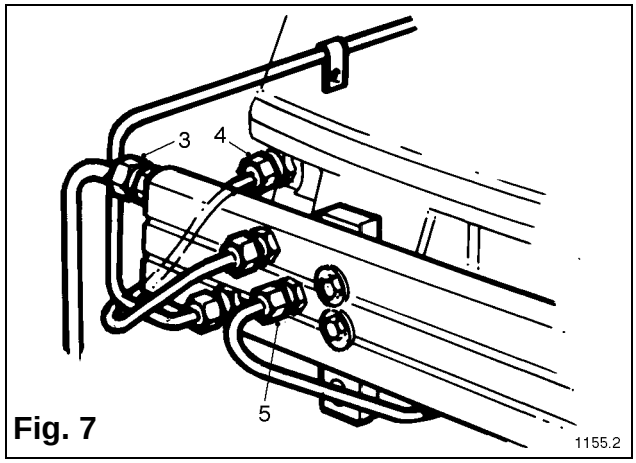

Fig. 7 1155.2

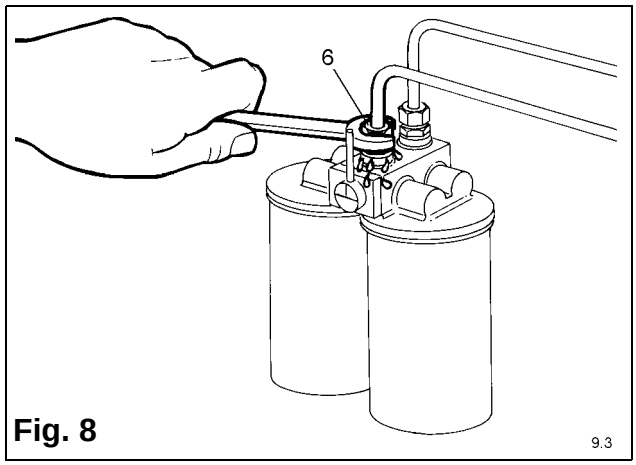

Fig. 8 9.3

DESCRIPTION

The instrument panel is flexibly mounted on the engine on the left hand side of the engine, between the air manifold mating flanges (see **Fig. 9**). The basic engine mounted panel includes the instruments associated with the engine only, which show the readings for the following conditions:

(1) Cooling water temperature
(2) Lubricating oil temperature
(3) Lubricating oil pressure
(4) Battery charging rate
(5) Speed and hours run
(6) Keyswitch
(7) Fuse holder
(8) Exhaust temperature gauge (when fitted)

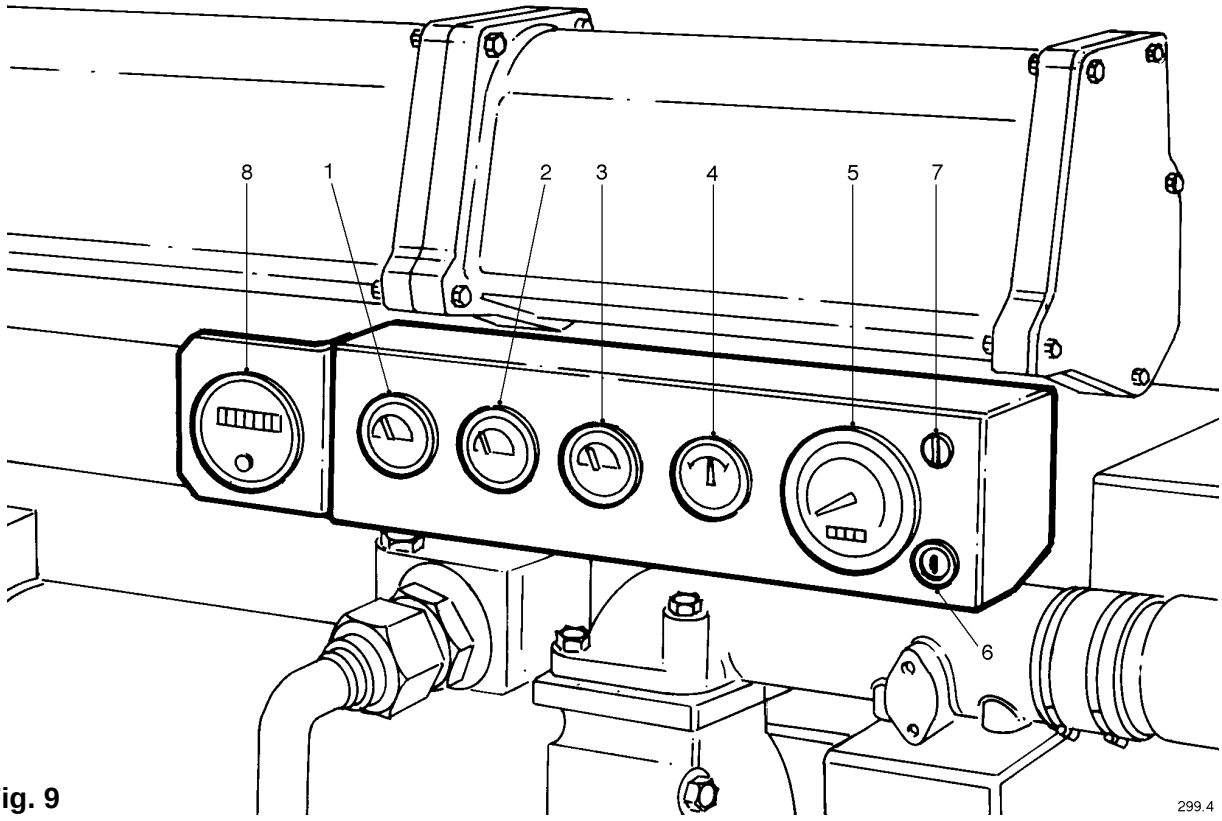

Fig. 9

Engine water temperature gauge
(Fahrenheit/Centigrade) **Fig. 10**
The coolant temperature during normal operation should be between 65°C - 85°C (149°F - 185°F). If the temperature should rise above 93°C (200°F) for a prolonged period of time, stop the engine and investigate the cause. The engine should, on the other hand, not be run at too low a temperature for long periods either.

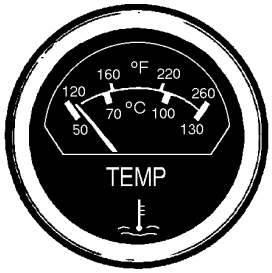

Fig. 10 300.2

Engine oil temperature gauge (Engine mounted)
(Fahrenheit/Centigrade) **Fig. 11**
The lubricating oil temperature should be between 80°C - 90°C (176°F - 194°F) when the engine is hot. If the temperature should rise above 115°C (240°F), stop the engine immediately and investigate the cause.

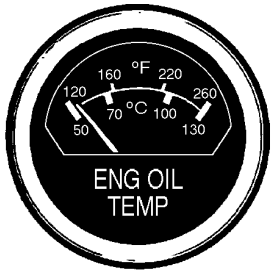

Fig. 11 301.2

Engine oil pressure gauge Fig. 12
(pounds per square inch/kiloPascal x 100)
The lubricating oil pressure should be between 300 - 350 kPa (45 - 50 lb/in²) when the engine is hot. If the pressure should drop below 200 kPa (30 lb/in²) at higher engine speeds than idling, stop the engine immediately and investigate the cause.

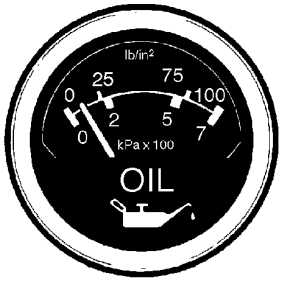

Fig. 12 302.2

Ammeter (Ampere) Fig. 13
The ammeter indicates at what charging current the battery is being charged by the alternator, or to what extent current is taken from the battery without the battery being recharged.

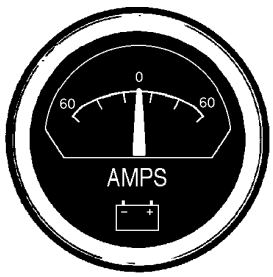

Fig. 13 303.2

Engine tachometer and hour counter
(revolutions per minute x 1000 and hours) **Fig. 14**.
The electrically operated tachometer/hour counter shows the speed of the engine in r/min. and the actual operating hours the engine has run. The tachometer/hour counter starts operating from an alternator voltage of 12 V onwards, which has already been reached at engine idling speed.

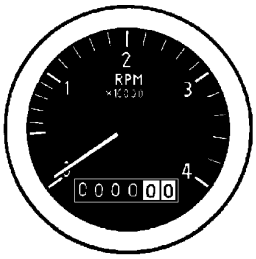

Fig. 14 304.2

Exhaust temperature gauge
Temperature range -20 +800°C
The gauge shows readings of turbine outlet temperature **Fig. 15**.

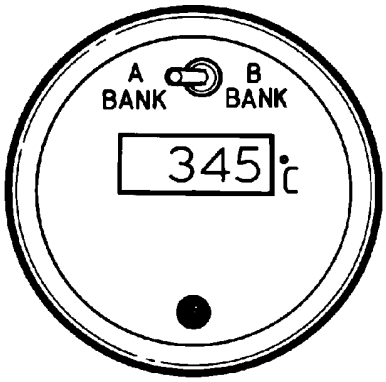

Fig. 15 307.2

Key switch (3 position) (Off/run/start)
The hand operated keyswitch with switch lock is moved by a separate key to the positions shown, (see **Fig. 16**) viewed from front of switch.

Fuse holder
To protect the instrument panel a 2 amp fuse is fitted to remove the fuse (1) unscrew its holder (2) (see **Fig. 17**).

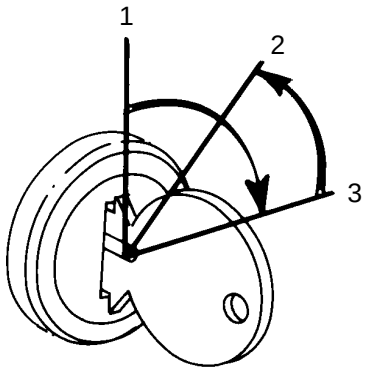

Fig. 16 1018.2

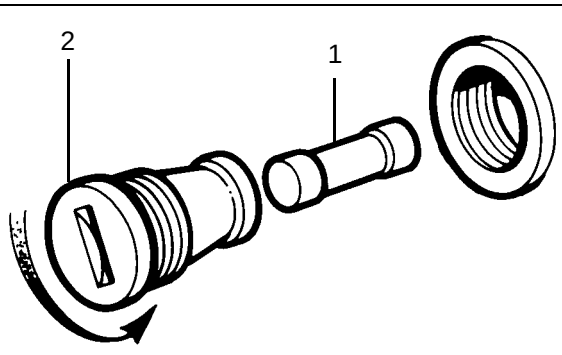

Fig. 17 1066.2

NORMAL STARTING PROCEDURE

Ensure any engine control switch is set to the run position, with the load disengaged. Manually set the air shut-off valve (if fitted) to the run position (see **Fig. 18**). Turn the keyswitch to the start position, which will energise the solenoid allowing the engine to crank over for a few seconds then start.

Check the instrument panel is showing normal running oil pressure, and the ammeter for charge to the engine batteries (see **pages 22-25**).

Allow the engine to run for five minutes checking the instruments are reading correctly. Stop the engine and check the oil and coolant levels, replenish if necessary (see **pages 19-20**).

Key
(Fig. 18)

1. Position - closed
2. Position - open

WARNING THE COOLING SYSTEM IS PRESSURISED - DO NOT REMOVE THE FILLER CAP FROM THE RADIATOR WHILST THE ENGINE IS HOT. HAND PROTECTION MUST BE WORN.

ENGINE SHUTDOWN

The engine is normally stopped by operating an electric stop control via a key switch. In this case it is only necessary to turn the key in an anti-clockwise direction which de-energises the stop solenoid to stop the engine. The solenoide remains de-energised until the engine is started up again.

With the manual system the stop control must be held in the stop position until the engine stops. Manual stopping can be used to override the electrical system if necessary.

Should the engine stop due to the air shut-off valves being operated, it is imperative that the cause of the fault be investigated immediately.

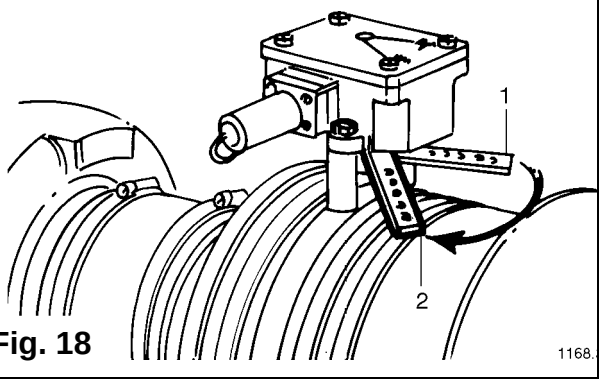

Fig. 18

It is essential to allow the engine to run at no load for 3-5 minutes before stopping to allow the circulating lubricating oil to take the heat away from the bearings and shafts, etc. This is especially important with turbocharged engines where extremely high temperatures are experienced within the turbocharger. Heat rise by suddenly stopping the engine on load can cause seizure of bearings and damage to oil seals.

WARNING DO NOT RUN THE ENGINE EXCESSIVELY AT LOW SPEEDS OR LOADS. IF THE ENGINE IS NOT BEING USED SHUT IT DOWN.

NOTE: Excessive idling of the engine will result in only partial burning of the fuel, causing high carbon build-up on injector nozzles, valves, piston rings, etc. Also unburnt fuel will tend to wash the lubricating oil from cylinder bores and dilute the oil in the sump. This can eventually cause inefficient lubrication of bearings and result in seizure.

If an engine is operated on a load less than 25-30% of its rated outout, certain symptoms will be observed which may give cause for concern.

The usual results of this operation are heavier than normal lubricating oil consumption, and oil leaks from the air and exhaust manifolds. This condition is particularly evident on standby generator set applications, where a weekly exercise on no load is common practice.

These phenomena are due to the fact that:

1. Turbocharger oil seals are not fully effective on light load, which results in oil being delivered together with the air into the engine air manifolds.
2. The cylinder temperatures are too low to ensure complete burning of all the fuel delivered.
   This results in an unsightly drip from the exhaust manifold junction glands.

A further result is that of abnormal carbon build-up on the valves, piston crowns and exhaust ports. Thus the normal service interval of see **Maintenance Schedules** between top overhauls may be reduced. Fuel dilution of the lubricating oil will also occur.

It is therefore recommended that the following precaution are observed:

1) Running on light load should be avoided or reduced to the minimum period. If weekly exercising on no load is carried out, the running period should be kept down to say, 10 minutes, or until the battery charging rate returns to normal
2) Every year the engine or generator set should be run on full load for four hours, to burn off accumulations of carbon in the engine and exhaust system. This may require the use of a ‘dummy load’. The load should be built up gradually from zero over the four hour run.
   On standby sets, air cleaner elements should be changed annually. Oil and fuel filter elements should be changed every six months. The fuel injectors should be checked every **2** years.

There is absolutely no danger of failure or breakdown resulting from light load operation, providing the above recommendations are followed, in addition to the normal procedures laid down in this manual.

Towards the rear of this section there is a check list sheet for continuous duty generator sets which is to be used as a guide for operators and maintenance personnel.
The following schedule details some of the maintenance to be carried out as in the maintenance check lists, however not all are detailed. In these cases please refer to the **Workshop Manual**.
The schedule within this section will be perfectly suitable for an engine working under average conditions. If your engine is working under particularly dirty or dusty conditions, more frequent servicing will be necessary particularly in respect of the lubricating oil and air cleaners. Correct and regular maintenance will help prolong engine life.

WARNING MAKE QUITE CERTAIN THE ENGINE CANNOT BE STARTED BEFORE UNDERTAKING ANY MAINTENANCE, PARTICULARLY IN THE CASE OF AUTOMATICALLY STARTING GENERATING SETS OR REMOTE STARTING ENGINES.

DAILY INSPECTION

LUBRICATING OIL LEVEL

With the engine stopped for at least 5 minutes:-

i) Withdraw the dipstick and wipe clean.
ii) Re-insert the dipstick fully into the sump.
iii) Wait for at least 5 seconds, withdraw and check the oil level in relation to the two marks on the dipstick.
iv) Repeat operation (i) (ii) (iii) at least twice, until identical readings are observed.

If the oil level is below the top mark add sufficient of the same grade as that already in the engine to bring the oil level up to the top mark.
Always replace the filler plug immediately replenishment is completed.

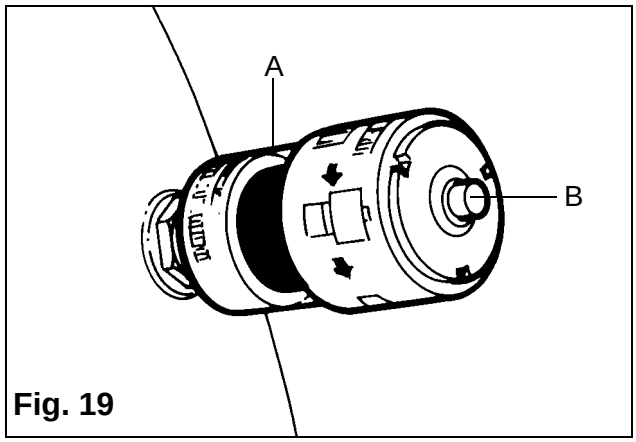

Fig. 19

COOLANT LEVEL

WARNING THE COOLING SYSTEM IS PRESSURISED - DO NOT REMOVE THE FILLER CAP WHEN THE ENGINE IS HOT. HAND PROTECTION MUST BE WORN.

With the engine stopped remove the radiator cap; the coolant should be 25 mm (1") below the top of the filler neck. If the level is low top up with a solution of water and inhibitor or water and anti-freeze similar to that already in the engine. Refer to **Engine Data section pages 7 to 10**.

LEAKS

Visually check the engine for gas, oil, coolant and exhaust leaks, repairing where necessary.

WEEKLY INSPECTION

Deal with items under DAILY INSPECTION.

AIR CLEANER RESTRICTION INDICATOR

The middle section of the restriction indicator 'A' will remain clear while the air cleaner is in a serviceable condition. When the filter reaches its contamination limit the restriction indicator will sense the change in manifold pressure and middle section 'A' will change to red. At this point the air filter must be changed (see **page 40**). When the air filters have been changed reset the indicator by pressing button 'B'. (See **Fig. 19**).

BATTERIES

WARNING HAND PROTECTION MUST BE WORN WHEN CHECKING ELECTROLYTE LEVEL IN THE BATTERY.
INFLAMMABLE GAS IS GIVEN OFF BY THE BATTERY. DO NOT CHECK WITH A NAKED FLAME.

Remove the plugs or 'quick fill' covers and check the level of electrolyte. It should be approximately 3 mm above the top of the plates. If it is low, top-up with pure distilled water. Replace the plugs and wipe the top of the battery clean and dry (see **page 25** for fuller information).
NOTE: Check the specific gravity (see **Maintenance Schedules**).

RADIATOR

If the engine is working in dirty or dusty conditions check that the air passages in the radiator are not becoming choked. They can be cleaned out by blowing compressed air in the direction opposite to that of the normal air flow.

FENNER TAPER LOCK BUSHES MAINTENANCE INSTRUCTIONS

Experience has shown that taper lock bushes as fitted in the fan pulleys and battery alternator driven pulley can work loose shortly after being put into service. Check using a hexagon wrench to tighten screws (1) gradually and alternately until all are tightened to the required torque (see **Torque Settings** on **pages 12 - 14**) full details of taper lock pulley see **Section B2 and D1 of the Workshop Manual**. Replace any guards removed before running the engine (see **Fig. 20**).

NEW OR REBUILT ENGINES

It is essential to carry out the following maintenance procedure after the initial 100 hours.

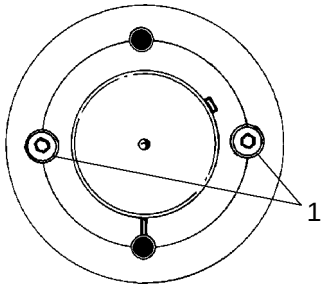

Fig. 20

FLANGES AND FASTENERS

Check the torque on all external fasteners including the exhaust manifold and turbocharger flanges. Tighten all hose clips and pipe unions.

EQUALISE BRIGDE PIECES AND CHECK VALVE CLEARANCES

(see **page 44**).

TURBOCHARGERS

If the engine has been overhauled and a filter joint fitted to the turbocharger oil feed, this should now be removed and replaced with the standard joint. See **Service Bulletin 301 (Revised) and 1**.

ENGINE OIL AND SPIN-ON FILTERS, ALSO CENTRIFUGAL OIL FILTER (WHERE FITTED)

Change engine oil and disposable filters (see **page 36**) clean centrifugal filter (see **page 34**)

DRAINING THE WATER TRAP/ SEDIMENTER (WHERE FITTED)

There are no moving parts or elements to service, however daily open the drain plug to remove collected water and sediment. The plug is self retaining, unscrew until loose. Leave open until clean fuel is seen. Screw back in (see **Fig. 21**).

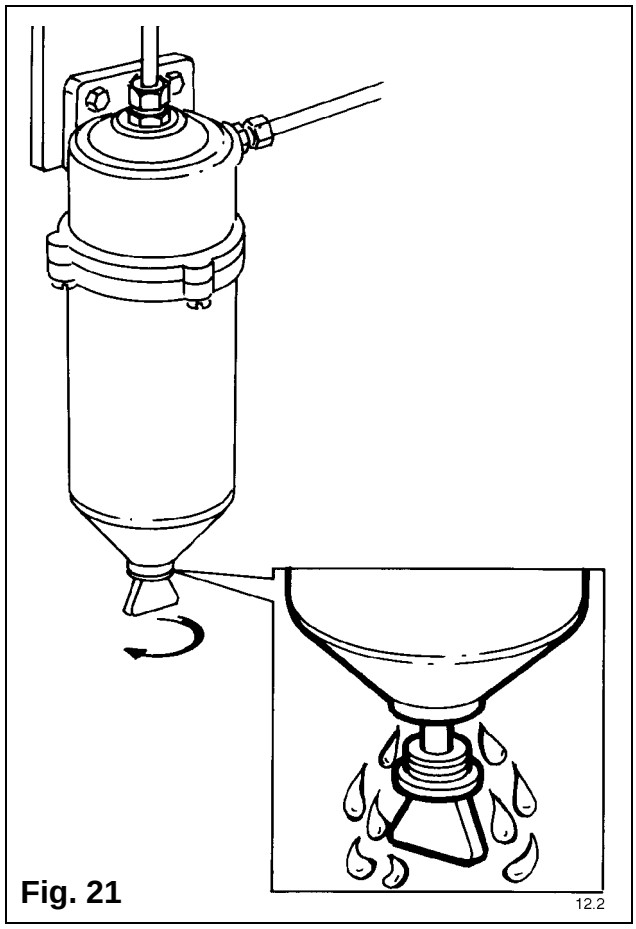

Fig. 21

ENGINE ALTERNATOR DRIVE BELT

WARNING DISCONNECTING BATTERIES OR ANY OTHER MEANS OF STARTING.

Remove the small mesh guard (1) around the alternator. The toothed belt used to drive the alternator relies on tooth engagement to transmit to load. It does not require preloading, however a slight initial tension to ensure that the belt fits snugly round the pulleys is desirable. Using light pressure midway between the two pulleys a total deflection of 1.5 mm ($^{1}/_{16}$") is satisfactory (see **Fig. 22**). Refit the guard.

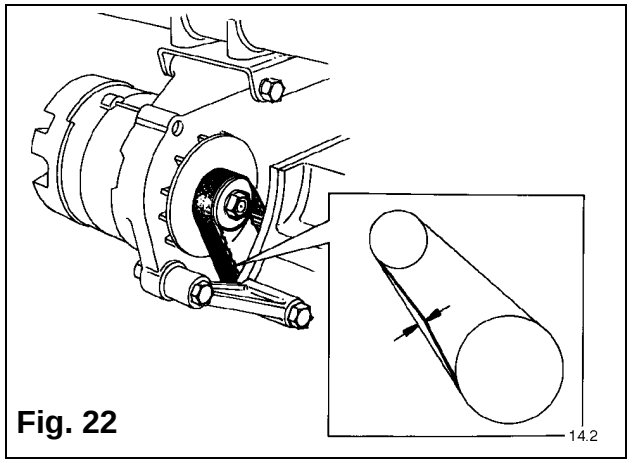

Fig. 22

FAN BEARINGS AND BELTS

WARNING DISCONNECT BATTERIES OR ANY OTHER MEANS OF STARTING.

Remove the mesh guard around the fan belts, grease the fan and jockey pulley bearings **Fig. 23** using high melting point lithium based grease (e.g. Shell Alvania R.A.)

Check the tension and condition of the fan belts. Using a spring balance and rule, or a belt tension indicator, check that the force compares with the kgf (lbf) values shown below for the correct belt deflection. See **Fig. 23**.

Deflection	kg Force	lb Force
11 mm	3 - 4.3	6.67 - 9.47

Fan belts if worn, should be replaced as a complete, matching set. Individual belts should NOT be replaced.

To adjust slacken the jockey pulley pivot and adjuster bolts, and operate the jockey pulley lever.

Moving the jockey pulley lever outwards will tension the belts and inwards will slacken the belts.

The correct tension is obtained by measuring the deflection at the mid point between the fan pulley and the crankshaft pulley when the above force is applied.

To apply the force place a rule across the outside width of the belts and attach spring balance as shown **Fig. 23** pull on the spring balance until the required force is reached and measure the belt deflection.

Adjust the position of the jockey pulley lever until the force on the spring balance and the belt deflection agree with the figures given above.

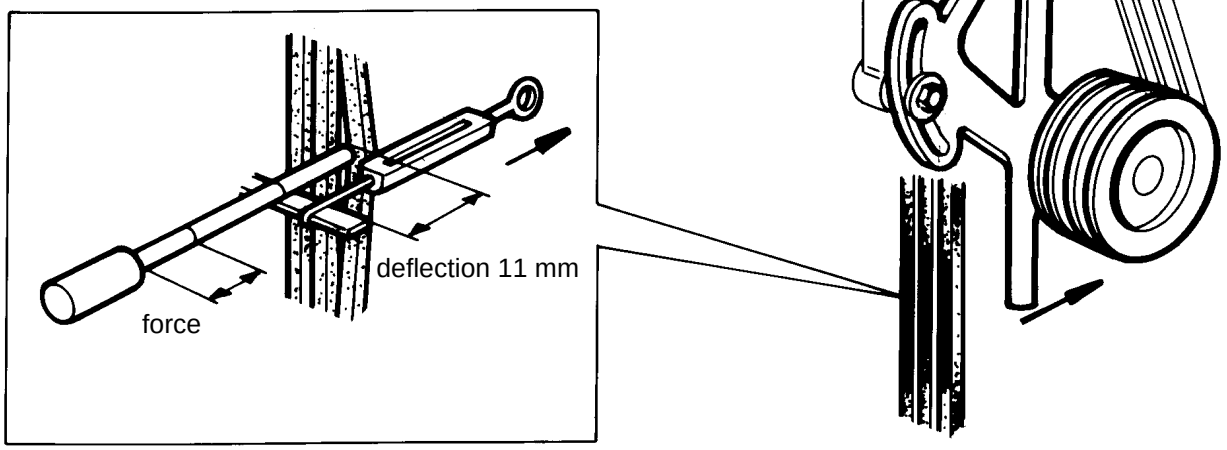

Fig. 23

15.2

When using a belt tension indicator position the indicator on top of a belt at the mid centre distance and apply a force at right angles to the belt deflecting it to the point where the lower marker is level with the top of the adjacent belt. Read off the force value indicated by the top edge of the upper marker.
Having set the tension on the belts, tighten the adjuster and pivot bolts.
Refit the fan belt guard.
NOTE: If the measured force falls within the values given, the drive should be satisfactory, if it is below the lower value under tensioning is indicated.
A new drive should be tensioned to the higher value to allow for the normal drop in tension during the running-in period.
After the drive has been running for 30 minutes, the tension should be checked and re-adjusted to the higher value.

FAULT TRACING

a) Small cracks on V-Belt Side and Base
Generally caused by lack of belt tension but excessive heat and/or chemical fumes can also lead to similar failure.

b) V-Belt swelling and softening
Caused by excessive contamination by oil, certain cutting fluids or rubber solvents.

c) Whipping during running
Usually caused by incorrect tensioning principally on long centre drives. If a slightly higher (or lower) tension does not cure the problem there may be a critical vibration frequency in the system which requires re-design or a banded belt (2 belts banded together to make a W belt).

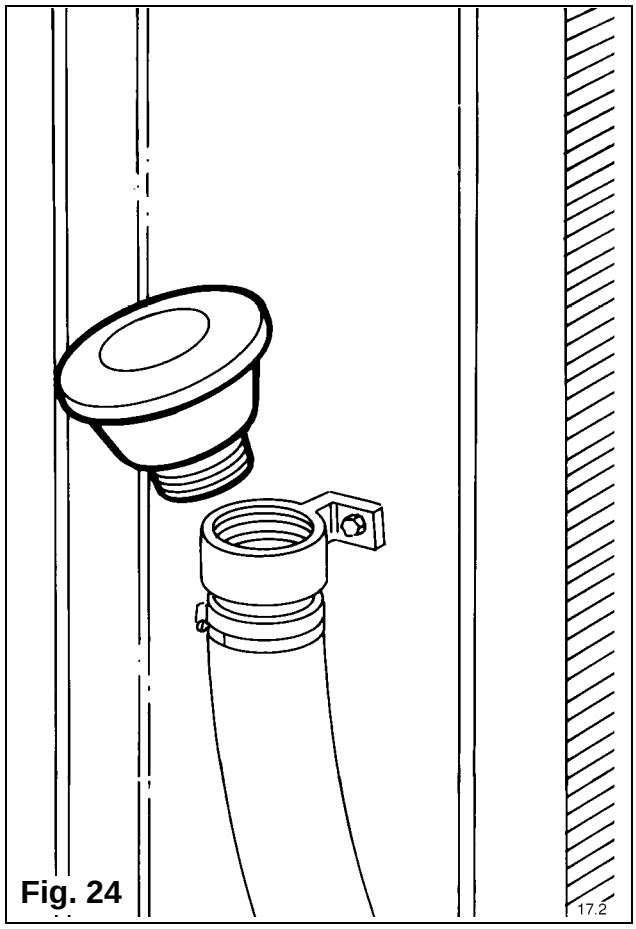

Fig. 24

CRANKCASE BREATHING (SEE MAINTENANCE SCHEDULES)

WARNING DISCONNECT BATTERIES OR ANY OTHER MEANS OF STARTING. WHEN USING COMPRESSED AIR OR CLEANING AGENTS ALWAYS WEAR EYE PROTECTION, AND PROTECTIVE GLOVES.

CRANKCASE BREATHER ON EARLIER ENGINES (RADIATOR COOLED)

The crankcase breather is mounted on the side of the radiator **Fig. 24** and is connected to an elbow mounted on the gearcase by a flexible pipe **Fig. 26**.

CRANKCASE BREATHER ON EARLIER ENGINES (HEAT EXCHANGER COOLED)

The crankcase breather is mounted on the side of the thermostat housing **Fig. 25** and is connected to a breather body mounted on the gearcase by a flexible extension pipe **Fig. 26**.

Unscrew the breather by turning it anti-clockwise, wash thoroughly using a suitable cleaning agent, shake as dry as possible, finally blow dry with compressed air then screw the breather firmly back into position.

Key
(Fig. 26)

1. Position of breather when engine is fitted with a radiator
2. Position of breather when engine is fitted with heat exchanger
3. Flexible pipe
4. Elbow

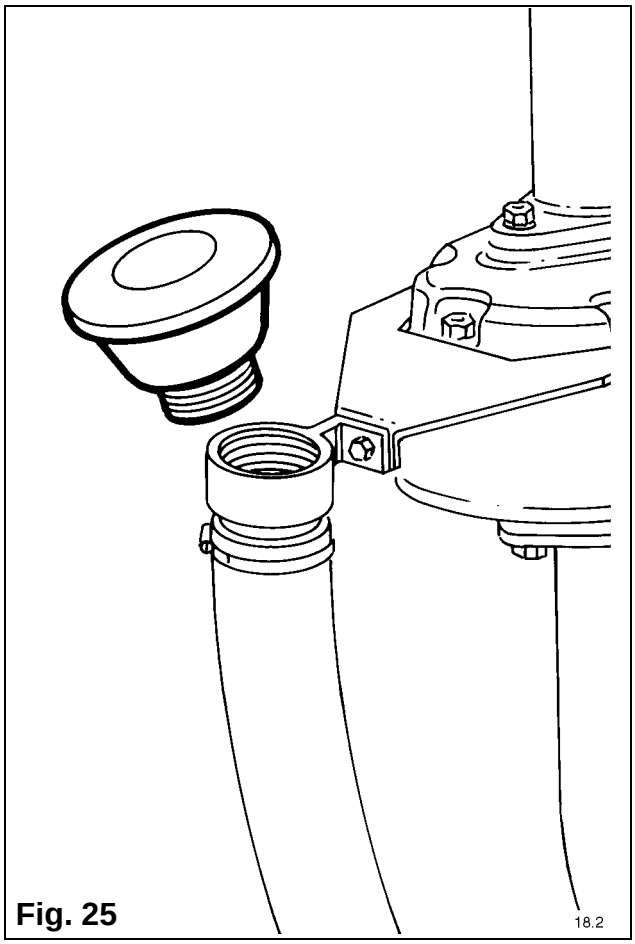

Fig. 25 18.2

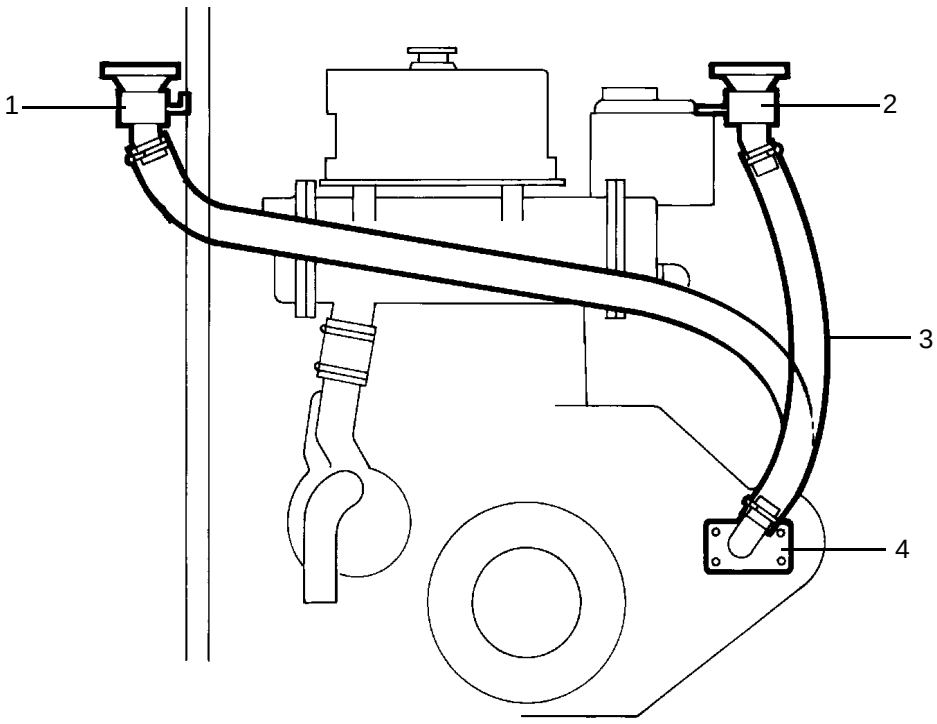

Fig. 26 19.2

WARNING DISCONNECT BATTERIES OR ANY OTHER MEANS OF STARTING. WHEN USING COMPRESSED AIR OR CLEANING AGENTS ALWAYS WEAR EYE PROTECTION, AND PROTECTIVE GLOVES.

CRANKCASE BREATHER (IMPROVED DESIGN) FITTED TO LATER ENGINES

The crankcase breather is mounted on the side of the thermostat housing **Fig. 27** and is connected to the engine via a flexible pipe and elbow fitted on the front of the gearcase (see **Fig. 28**).

To clean the breather remove the top cover and withdraw the two wire mesh elements and wash thoroughly using a suitable cleaning agent. Shake as dry as possible, finally blow dry with an compressed air. Refit the elements into the breather body, and fit the top cover firmly. (See **Fig. 26**).

NOTE: When replacing the cover check the sealing gasket is in good condition and the cover has located on its dowel.

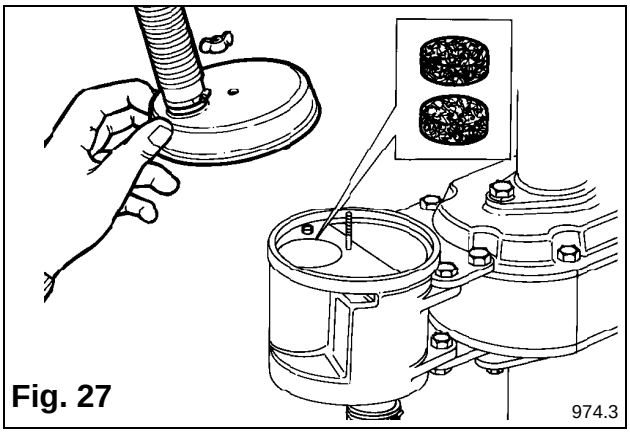

Fig. 27 974.3

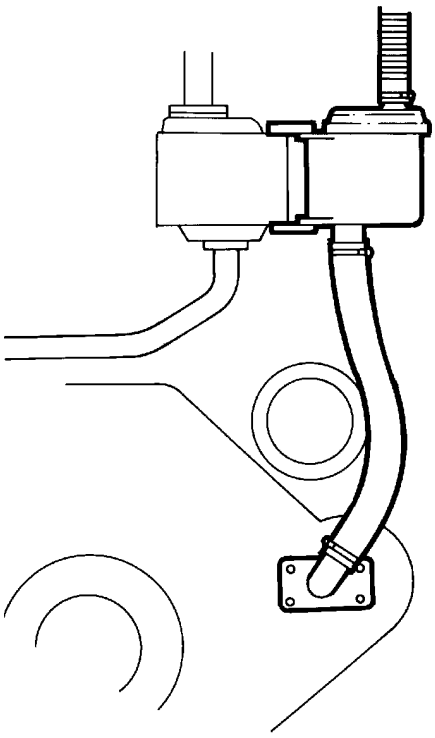

Fig. 28 976.3

WARNING DISCONNECT BATTERIES OR ANY OTHER MEANS OF STARTING. ALWAYS WEAR PROTECTIVE GLOVES.

CLEANING THE CENTRIFUGAL LUBRICATING OIL FILTER SEE FIG. 29 REFER TO MAINTENANCE SCHEDULE

Stop the engine, and allow time for lubricating oil to drain back to sump.

(1) Unscrew the cover nut and lift off the filter body cover.

(2) Examine 'O' ring for damage, renew if necessary.

(3) Withdraw rotor assembly from spindle and allow oil to drain from nozzle before removing from filter body. Hold rotor body and remove rotor knurled nut. Separate the rotor cover from the rotor body. Remove central stand tube.

(4) Remove sludge from the inside of the rotor cover by means of a wooden spatula or suitably shaped piece of wood and wipe clean.

(5) Clean and wash out the central stand tube using a suitable solvent ensuring that the strainer holes are not blocked.

(6) Clean out nozzles with brass wire to ensure free passage of oil. Examine top and bottom bearings in rotor body to ensure that they are free from damage or excessive wear. Examine 'O' ring for damage renew if necessary.

(7) Re-assemble rotor complete, tighten cover nut to 9.5 Nm - 10.8 Nm (7-8 lbft.).

(8) Examine spindle journals to ensure that they are free from damage or excessive wear, remove cut-off valve plug from filters only and remove cut-off valve assembly.
Check that the spring and shuttle are undamaged and free to move. Examine gasket for damage. Renew if necessary.

(9) Re-assemble cut-off valve assembly.

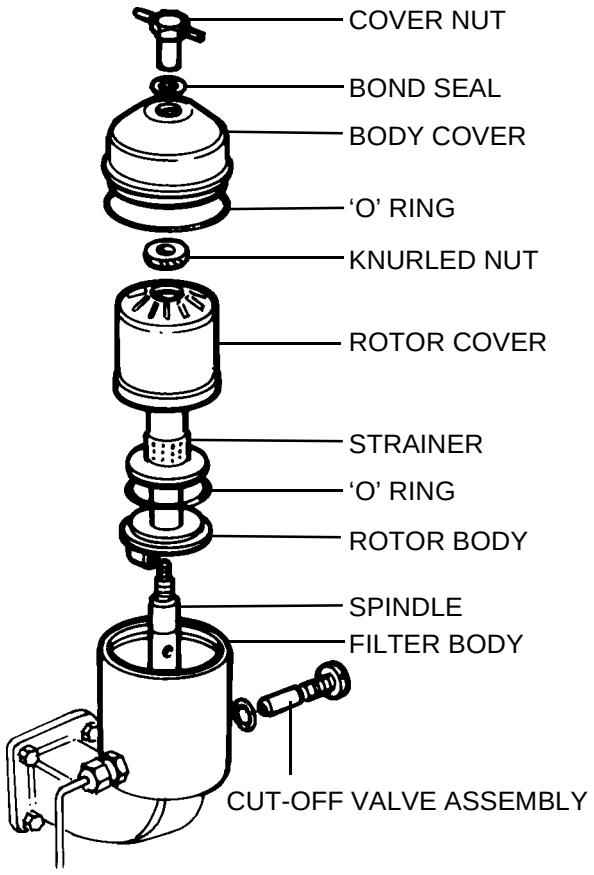

Fig. 29 315.2

(10) Re-assemble filter complete, checking that the rotor assembly is free to rotate then replace filter cover and tighten cover nut by hand until full resistance is felt.

(11) With the engine running check all connections and joints for leakage.

CHANGING ENGINE OIL AND STANDARD SPIN-ON TYPE LUBRICATING OIL FILTERS

WARNING DISCONNECT BATTERIES OR ANY OTHER MEANS OF STARTING. ALWAYS WEAR PROTECTIVE GLOVES.

With the engine stopped, place a suitable container of at least 148 litres (32.5 gal) beneath the drain plug. Remove the drain plug and allow the oil to drain. This operation is best carried out while the engine is still warm as the thinner oil will drain more efficiently. While the oil is draining remove the three oil filters turning them anti-clockwise with a strap wrench **Fig. 30**.

NOTE: Removal of oil filters will allow an escape of oil from the filter header. It is therefore recommended that a suitable container of at least 5 litres (1 gal) capacity is positioned under each filter prior to removal. Wipe clean the sealing faces and threaded bosses of the oil header. Smear engine oil on the captive rubber sealing ring and carefully screw each new filter up to the oil header using firm hand pressure only.

Use only genuine Perkins oil filters. The use of other filters may cause serious damage to the engine.

Refit the drain plug and fill the engine with the appropriate grade of new oil (see **pages 15 - 16**). (If fitted) manually set the air shut off valves to the run position, hold the stop lever in the stop position. Turn the keyswitch to the start position, and crank the engine over until the oil pressure gauge registers 0.4 kg/cm² (5lb/in²).

Continue cranking for a further 10 seconds which will ensure that oil has reached the turbocharger bearings.

Stop cranking the engine and visually check the engine for oil leaks, top up the oil level.

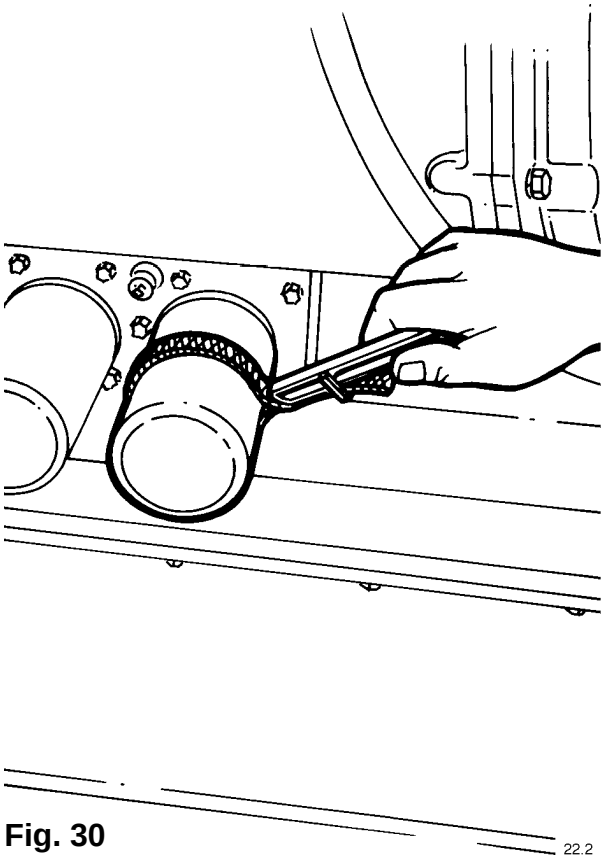

Fig. 30

WARNING DISCONNECT BATTERIES OR ANY OTHER MEANS OF STARTING. ALWAYS WEAR PROTECTIVE GLOVES.

CHANGING THE OPTIONAL CHANGE-OVER LUBRICATING OIL FILTERS

These special duplex filters are normally intended for use on long running engines, or where a servicing requirement may occur when it is impractical to stop the engine. For this reason they are fitted with a three way change-over valve in the head which enables the elements to be changed, one at a time, whilst the engine continues to run. They are normally mounted on the engine, but may be remotely mounted, and connected to the engine by means of flexible pipes.

NOTE: If the flexible connections to the filter are removed for any reason, it is essential that they are reconnected correctly to avoid unfiltered oil getting into the engine. See **Fig. 31**. Failure to change filters when due can also lead to trouble from unfiltered oil.

CHANGING THE FILTER ELEMENTS WHEN THE ENGINE IS STOPPED

All that is necessary is to unscrew the canisters with a strap wrench as shown in **Fig. 31**, without moving the change-over valve, as there is no pressure in the system when the engine is stationary. The underside of the header is then wiped clean, and a smear of oil applied to the sealing rings on the new canisters, before screwing them up by hand and tightening them by no more than three quarters of a turn after the seals contact the header. Check the filter for leaks after the engine is restarted.

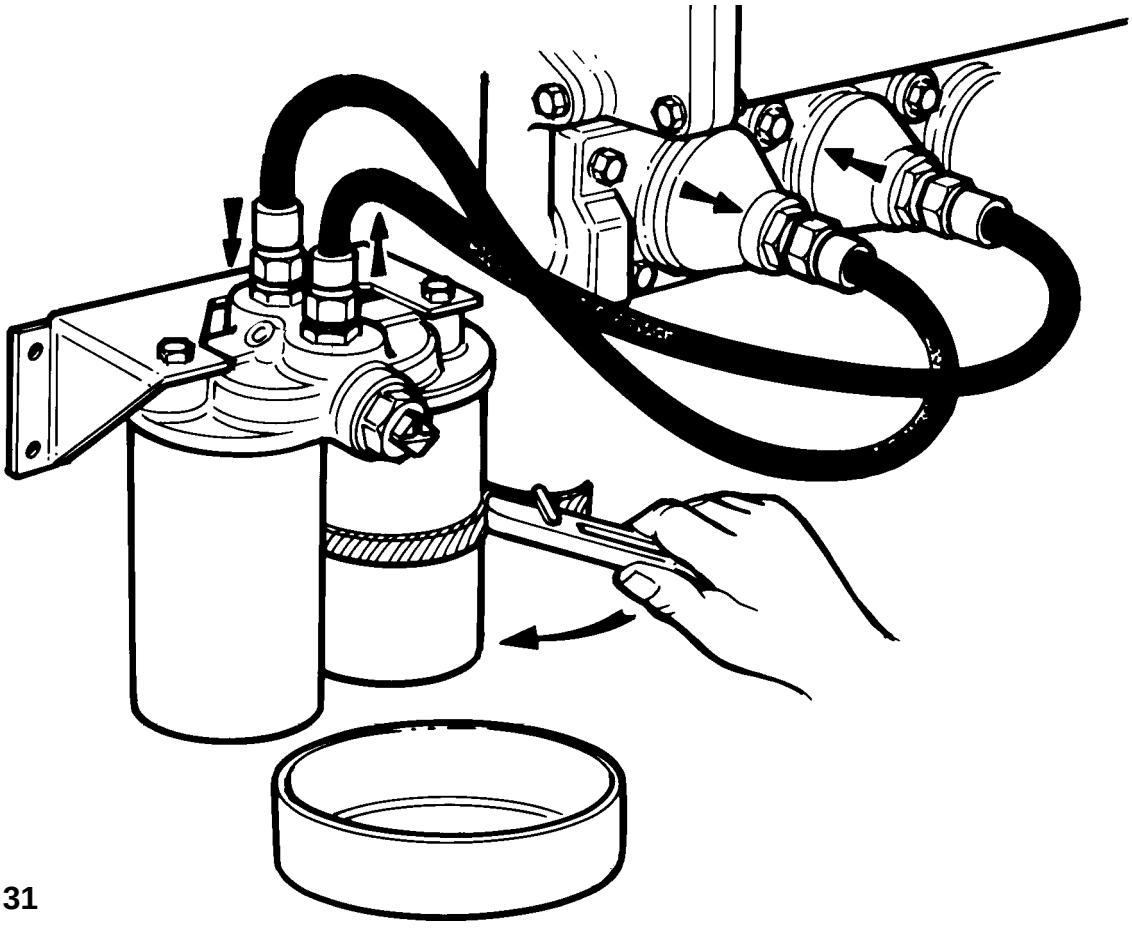

Fig. 31

1108.2

WARNING REDUCE ENGINE SPEED TO IDLING IF CHANGING THE FILTERS WHILST THE ENGINE IS RUNNING.

CHANGING THE FILTER ELEMENTS WITHOUT STOPPING THE ENGINE

The normal position of the change-over valve is with marking on the valve spindle for the spanner showing the leg of the inverted T pointing upwards when both filter elements are in circuit. Turning the valve with the spanner provided so that the leg of the T points to the left, puts the right hand filter out of service, so that it may be exchanged for a new one, **fill the new filter with clean oil before fitting**. Turning the valve so that the leg points to the right, puts the left hand filter out of service, so that this one can now be exchanged for a new filter canister. The valve is then returned to its original position, so that both elements of the filter are back in service. Check for oil leaks.

NOTE: Prepare for a small spillage of oil from the filter as each canister is removed, by placing a container of about 5 litres or 1 gallon capacity under the filter.

Note the piston jet filters which can only be changed with the engine stopped.

(Fig. 32)

1. Change right filter
2. Normal running position
3. Change left filter
4. Dirty oil into filter
5. Clean oil into engine

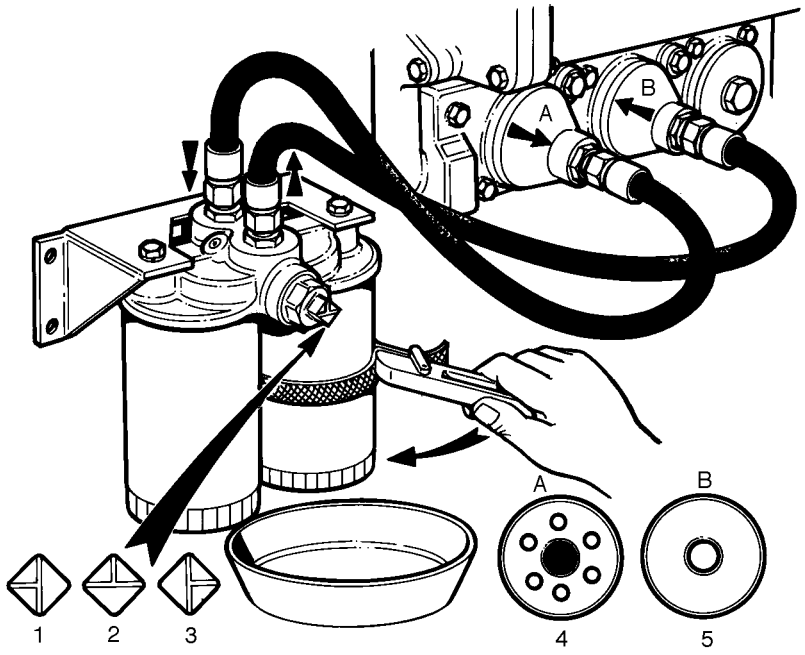

Fig. 32

80.3

CHANGING THE COMBINED FUEL FILTER WATER SEPARATOR

Remove the filter separator canister using a strap wrench see **Fig. 33** fill the new filter/ separator with clean engine oil to the rubber seal, then screw the canister onto the housing using firm hand pressure. Bleed air from the system follow the procedure on **page 21**.

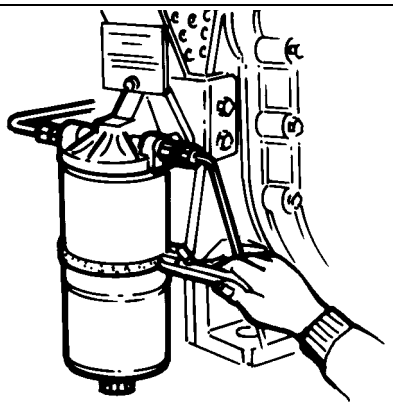

Fig. 33

CHANGING THE CHANGE OVER FUEL FILTER ELEMENTS WHEN THE ENGINE IS STOPPED

All that is necessary is to unscrew the canisters with a strap wrench as shown in **Fig. 34**, leaving the change-over lever in the vertical position as there is no pressure in the fuel system with the engine stationary. The replacement canisters are screwed on by hand, after applying a smear of clean engine oil to the rubber seals, and tightening by firm hand pressure only. Bleed the air from the new filters by slackening the vent screw (2) and operating the priming pump. Check for leaks when the engine is restarted.

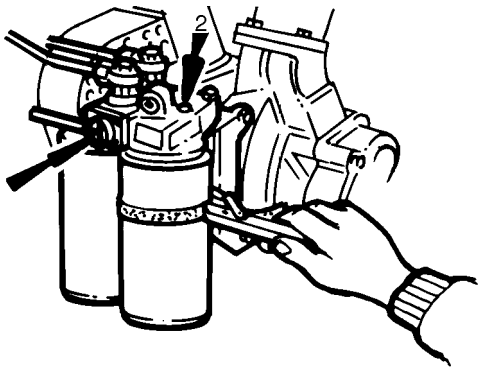

Fig. 34

1156.2

NOTE: Prepare for some spillage of fuel by placing a bowl of about 5 litres or 1 gallon capacity under the filter when changing the capacities.

WARNING REDUCE ENGINE SPEED TO IDLING IF CHANGING THE FILTERS WHILST THE ENGINE IS RUNNING.

CHANGING THE CHANGE OVER FUEL FILTER ELEMENTS WHEN THE ENGINE IS RUNNING

Both filters are in use with the change over lever in the vertical position. Moving the lever to the left puts the right hand filter out of service (1) see **Fig. 35 and Fig. 36** and moving it to the right for the left hand filter.

With the lever positioned remove the appropriate filter canister using a strap wrench see **Fig. 35** fill the new filter with fuel apply a smear of engine oil to the rubber seal, then screw the canister onto the housing using firm hand pressure. Air must be vented from each new filter slacken the vent screw (2) **Fig. 33** slowly raise the lever toward the vertical position stop when fuel flows from vent screw, when air free fuel flows tighten the vent screw return the lever to the vertical position and repeat the operation on the second filter. Wipe any spilled fuel from the filter unit, check for leaks at idling and normal running speed.

NOTE: Prepare for some spillage of fuel by placing a bowl of about 5 litres or 1 gallon capacity under the filter when changing the capacities.

Key
(Fig. 35)

1. Both filters in use (Normal Running Position)
2. Change right hand filter
3. Change left hand filter

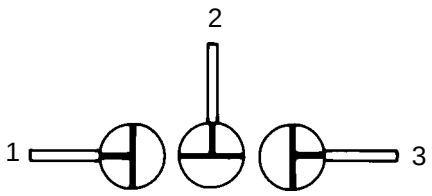

Fig. 35 1157.2

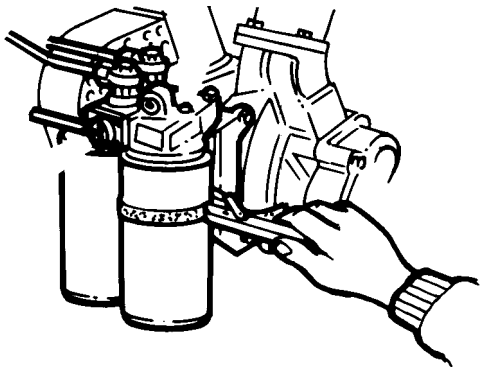

Fig. 36 1156.3

WARNING DISCONNECT BATTERIES OR ANY OTHER MEANS OF STARTING ENGINE.

CHANGING AIR FILTER (SEE SECTION A1 IN THE MAINTENANCE MANUAL)

STANDARD

Remove the end cover (3) of the air filter housing, after unscrewing the retaining wing nut, carefully lift out the paper air filter element (1). For servicing the element see **General Servicing Instructions** below. When all servicing procedures are completed, fit the new or cleaned element into the housing. When fitting the end cover ensure it has seated fully in the housing before tightening the wing nut. Inspect and tighten all air filter connection before resuming equipment operation (see **Fig. 37**).

HEAVY DUTY

The heavy duty air filter incorporates a cyclone unit (4) fitted to the air intake of the filter (replacing the mesh guard (2)). To clean the cyclone unit remove it from the air filter and blow out any foreign matter within the unit. Changing the paper air filter element the procedure is the same as for the standard air filter above.

GENERAL SERVICING INSTRUCTIONS

Servicing procedures include cleaning or replacing the filter element, cleaning the filter housing, and assuring that all piping and hose connection from the filter outlet to the turbocharger intake are sealed airtight.

FILTER ELEMENT SERVICE

Clean the exterior of the filter housing and then carefully remove the element. Inspect the "clean air side" of the element and the outlet side of the filter housing for any unusual dust accumulations.

(a) Dust accumulations on the clean air side of the element usually indicates a rupture in the filter medium. Immediate replacement of the element is necessary.

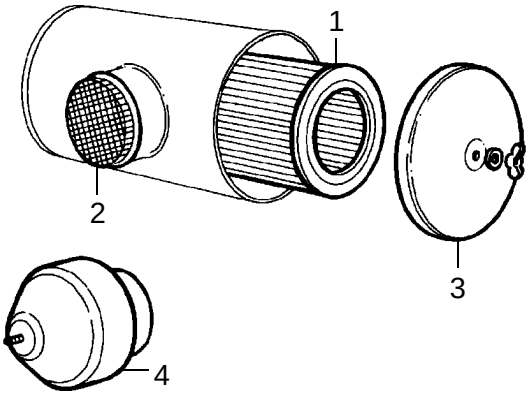

Fig. 37

(b) Dust accumulation on the inlet side of the housing is usually caused by leaking gaskets and/or damaged gasket surfaces. If this condition exists, leaking gaskets should be replaced and damaged gasket surfaces should be repaired before placing the unit back into service.

WARNING REPLACE ANY ELEMENT WHICH IS DAMAGED.
NEVER "BLOW" DIRT OUT OF THE FILTER HOUSING. THIS MAY INTRODUCE DUST INTO THE ENGINE. INSTEAD, USE A CLEAN, DAMP, CLOTH, DO NOT OIL THE ELEMENT.
WHEN USING COMPRESSED AIR ALWAYS WEAR EYE PROTECTION.

ELEMENT CLEANING

If the filter element is in good condition with light dust contamination on its outer surface and the air flow restriction indicator (see **Page 27**) has not been triggered, the element can be cleaned using a vacuum cleaner or compressed air.

CLOSED CIRCUIT BREATHER SYSTEM

The closed circuit breather separator is mounted on the right hand side of the gearcase and is connected to the air inlet system between the air cleaner and turbocharger via the breather valve (see **Fig. 38**).

It consists of a filter separator (1) and two breather valves (2) with a pipe feeding into the air inlet system (between the air cleaner and turbocharger).

To clean the breather valves release the pipe clips (A) and pull away the breather valves and the valve manifold from the engine. Release the clamp (3) see **Fig. 39** and remove the breather valves from the valve manifold. Wash the breathers thoroughly in a suitable solvent paying particular attention to any deposits on the internal area of the breather. Shake as dry as possible and blow dry with compressed air.

Before refitting ensure that the cup at the base of the two breather valves are full of clean engine oil and the 'O' ring at the base of the breather valve is in tact. (See **Fig. 39**).

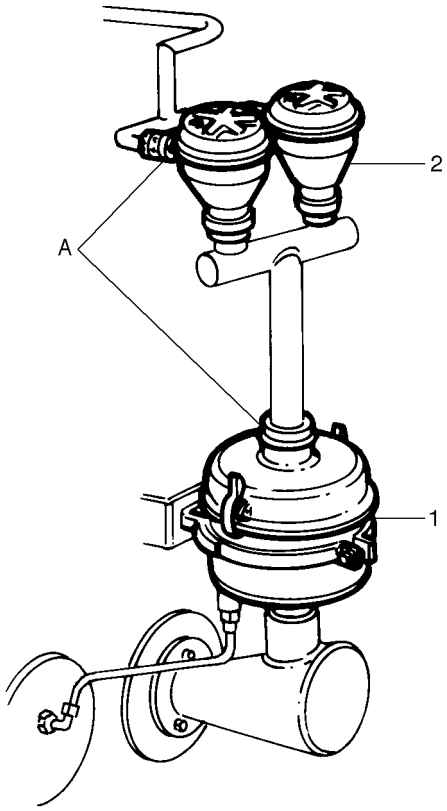

Fig. 38 966.3

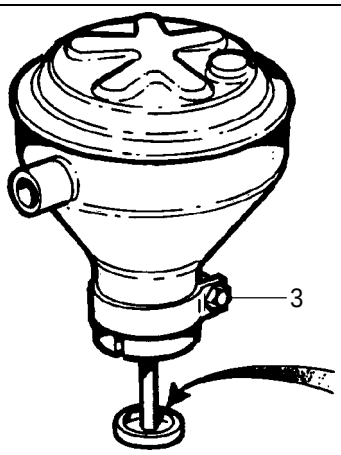

Fig. 39 1005.3

CLOSED CIRCUIT BREATHER SYSTEM

Release the retaining clips and remove the top cover (1) see **Fig. 40** from the filter separator body (2) remove the foam element (3) and the gauze strainer (4) check it for oil sludge saturation wash thoroughly in a suitable solvent, shake off excess solvent and blow dry with compressed air. Clean any oil sludge deposits from the filter body re-assemble and fit to engine.

NOTE: Cleaning agents must not enter the engine via the breather system as oil dilution may occur causing engine damage.

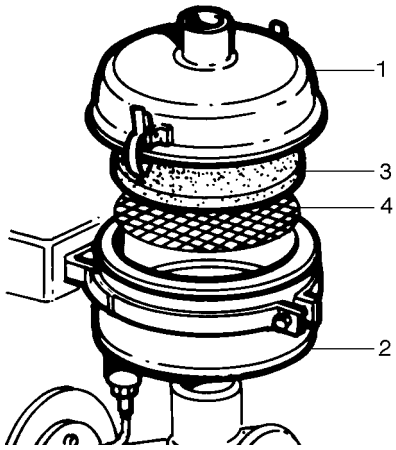

Fig. 40

EQUALISING ROCKER BRIDGES AND SETTING VALVE CLEARANCES

NOTE: The bridge pieces must be set before attempting to set the valve clearances.

WARNING DISCONNECT BATTERIES AND ALL OTHER MEANS OF STARTING THE ENGINE.

Remove the 4 screws (1) from each rocker cover (2), lift off the covers and peel off and throw away the old gaskets **Fig. 41**.

To equalise the bridge pieces the appropriate valves must be rocking, use the table on **page 44**.

In order that the engine may be rotated while the batteries are disconnected a special cranking device (SE253) can be fitted to a starter motor hole in the flywheel housing see **Fig. 42**. The flywheel housing has an inspection hole directly below the turbocharger through which the flywheel markings may be seen to line up with the pointer set in the flywheel housing **Fig. 43**.

Using a socket and ratchet wrench press against the spring loaded bolt head until the pinion engages with the flywheel gear then crank the engine to the desired position.

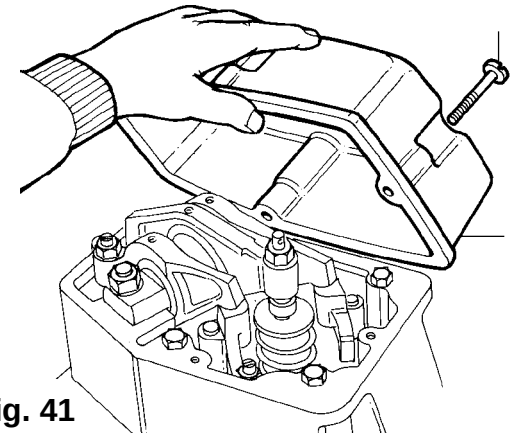

Fig. 41

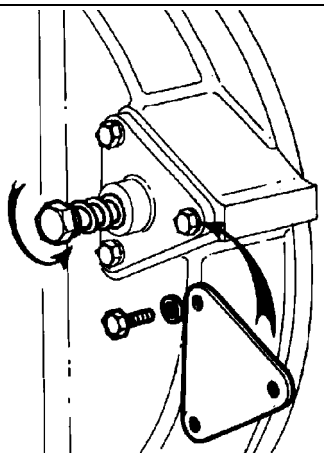

Fig. 42

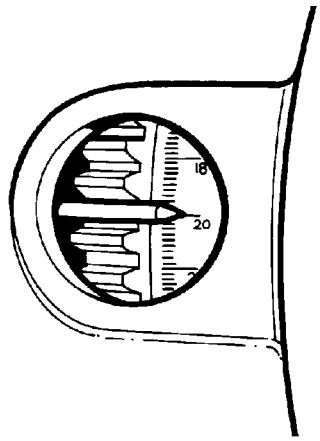

Fig. 43

118.2

EQUALISING THE BRIDGE PIECES

WARNING DISCONNECT BATTERIES OR ANY OTHER MEANS OF STARTING THE ENGINE.

Having rotated the engine to the correct position, check that the inlet and exhaust rockers have clearance before continuing with the next operation. Loosen the lock nut (1) on each bridge piece, screw the adjuster (2) out until the fixed side of the bridge piece rests on its valve, hold the top edge down with one hand, then screw the adjuster down until you feel it touch the valve, thereby equalising valve lift. Tighten the lock nut without moving the adjuster (see **Fig. 44**).

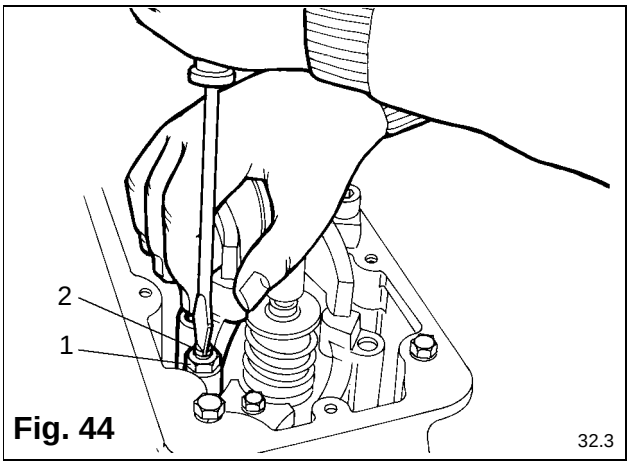

Fig. 44

SETTING VALVE CLEARANCES

With both bridge pieces equalised check the valve clearance of 0.4 mm (0.016") inlet and exhaust using a feeler gauge (1). If adjustment is required loosen the lock nut (2) and using the adjuster screw (3) set the clearance (see **Fig. 45**). Tighten the lock nut without moving the adjuster. The feeler gauge should be a slide fit between the rocker and bridge piece thereby giving the correct clearance. Refit the rocker cover with a new gasket.

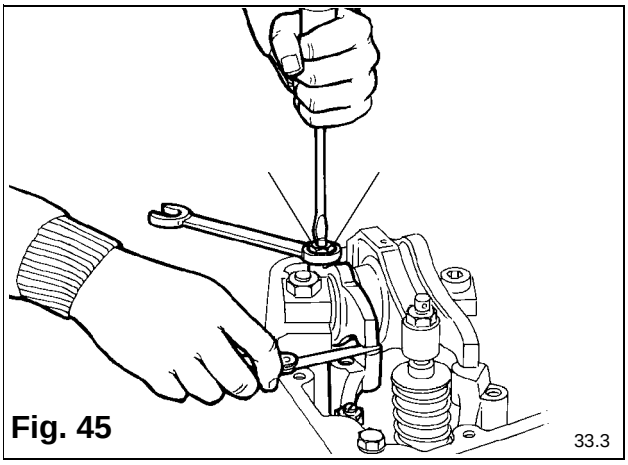

Fig. 45

Engine 4006 T.D.C.	Valves Rocking on Cylinder No.	Set Bridge Piece and Valve Clearance on Cylinder No.
1 and 6	6	1
2 and 5	2	5
3 and 4	4	3
1 and 6	1	6
2 and 5	5	2
3 and 4	3	4

Engine 4008 T.D.C.	Valves Rocking on Cylinder No.	Set Bridge Piece and Valve Clearance on Cylinder No.
1 and 8	8	1
4 and 5	5	4
2 and 7	2	7
3 and 6	3	6
1 and 8	1	8
4 and 5	4	5
2 and 7	7	2
3 and 6	6	3

SCHEDULE FOR ENGINES IN STAND-BY DUTY

For engines which are in use for a total of less than 400 hours in every twelve months, the schedule below must be used:
The preventive maintenance operations must be applied at the interval (hours or months) which occurs first.

A - Monthly
B - 3 Months
C - Every 200 hours or 6 months
D - Every 1,000 hours or 12 months

A	B	C	D	Operation
●				Check the amount of coolant
●				Check the lubricating oil level
●				Check the restriction indicators for the air filters and, when necessary, renew the filter elements
	●			Start and run the engine on load until normal temperature of operation is reached
●				Drain any water/sediment from the primary fuel filter
			●	Check the condition and the tension of all drive belts
			●	Check the specific gravity and the pH value of the coolant
		●		Renew the lubricating oil and filter
			●	Check radiator air restriction (visual)
		●		Clean centrifugal oil filter
		●		Renew the canister of the main fuel filter
			●	Ensure that the fuel injectors are checked and corrected or renewed, if necessary*
			●	Equalise bridge pieces and check valve clearances

NOTE: All bolts, hose clips, terminal connections, pipes and joints must be checked for tightness and leaks every 3 months unless stated otherwise.

* By a person who has had the correct training.

SCHEDULE FOR ENGINES IN CONTINUOUS DUTY

The preventive maintenance operations must be applied at the interval (hours or months) which occurs first.

A - Daily
B - Every 250 hours or 6 months
C - Every 2500 hours or 12 months

A	B	C	Operation
●			Check the coolant level
●			Check the lubricating oil level
●			Check the restriction indicators for the air filters and, when necessary, renew the filter elements
●			Drain any water/sediment from the primary fuel filter
	●		Check the condition and the tension of all drive belts
	●		Check the specific gravity and the pH value of the coolant
	●		Renew the lubricating oil and filter
	●		Visually check for radiator air restriction
	●		Clean centrifugal oil filter
	●		Renew the canister of the main fuel filter
	●		Clean the water trap sedimenter
	●		Equalise bridge pieces and check valve clearances
	●		Check that the air charge cooler and the radiator are clean and free from debris
		●	Drain and flush the coolant system and renew coolant mixture
		●	Ensure that the fuel injectors are checked and corrected or renewed, if necessary *

* By a person who has had the correct training.

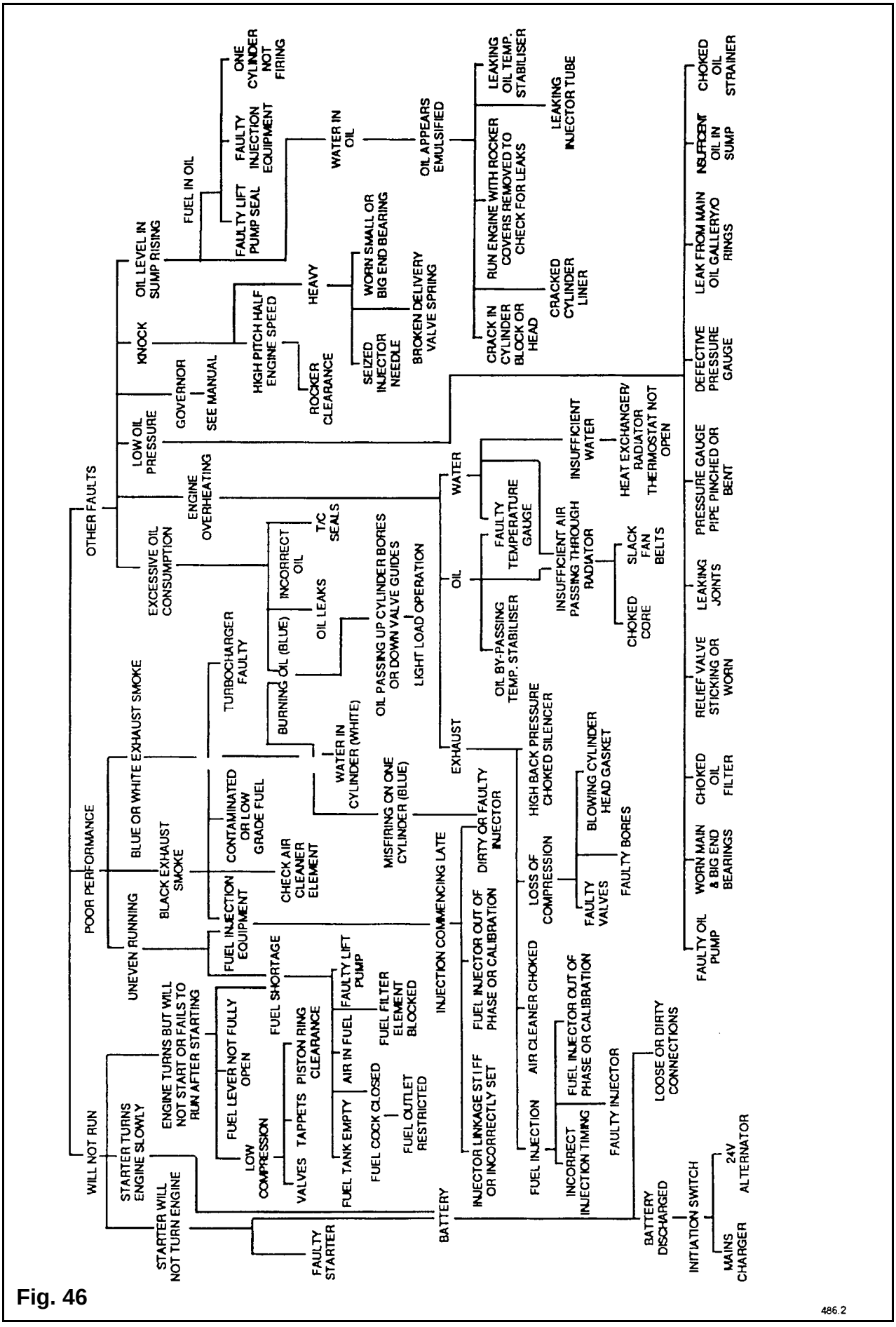
WILL NOT RUN
STARTER WILL NOT TURN ENGINE
STARTER TURNS ENGINE SLOWLY
BATTERY
BATTERY DISCHARGED
LOOSE OR DIRTY CONNECTIONS
INITIATION SWITCH
MAINS CHARGER
24V ALTERNATOR
FAULTY STARTER
ENGINE TURNS BUT WILL NOT START OR FAILS TO RUN AFTER STARTING
FUEL LEVER NOT FULLY OPEN
FUEL SHORTAGE
FUEL TANK EMPTY
AIR IN FUEL
FAULTY LIFT PUMP
FUEL COCK CLOSED
FUEL FILTER ELEMENT BLOCKED
FUEL OUTLET RESTRICTED
LOW COMPRESSION
VALVES
TAPPETS
PISTON RING CLEARANCE
INJECTION COMMENCING LATE
INJECTOR LINKAGE STIFF OR INCORRECTLY SET
FUEL INJECTION INCORRECT INJECTION TIMING
FUEL INJECTOR OUT OF PHASE OR CALIBRATION
AIR CLEANER CHOKED
FAULTY INJECTOR
FUEL INJECTOR OUT OF PHASE OR CALIBRATION
DIRTY OR FAULTY INJECTOR
UNEVEN RUNNING
FUEL INJECTION EQUIPMENT
LOSS OF COMPRESSION
FAULTY VALVES
FAULTY OIL PUMP
WORN MAIN & BIG END BEARINGS
FAULTY BORES
POOR PERFORMANCE
BLACK EXHAUST SMOKE
CONTAMINATED OR LOW GRADE FUEL
CHECK AIR CLEANER ELEMENT
HIGH BACK PRESSURE CHOKED SILENCER
BLOWING CYLINDER HEAD GASKET
CHOKED OIL FILTER
BLUE OR WHITE EXHAUST SMOKE
TURBOCHARGER FAULTY
BURNING OIL (BLUE)
OIL LEAKS
INCORRECT OIL
T/C SEALS
WATER IN CYLINDER (WHITE)
MISFIRING ON ONE CYLINDER (BLUE)
OIL PASSING UP CYLINDER BORES OR DOWN VALVE GUIDES
LIGHT LOAD OPERATION
EXCESSIVE OIL CONSUMPTION
ENGINE OVERHEATING
OTHER FAULTS
LOW OIL PRESSURE
GOVERNOR
SEE MANUAL
KNOCK
OIL LEVEL IN SUMP RISING
FUEL IN OIL
FAULTY LIFT PUMP SEAL
FAULTY INJECTION EQUIPMENT
ONE CYLINDER NOT FIRING
HIGH PITCH HALF ENGINE SPEED
ROCKER CLEARANCE
HEAVY
WORN SMALL OR BIG END BEARING
SEIZED INJECTOR NEEDLE
BROKEN DELIVERY VALVE SPRING
WATER IN OIL
OIL APPEARS EMULSIFIED
OIL
WATER
EXHAUST
OIL BY-PASSING TEMP. STABILISER
FAULTY TEMPERATURE GAUGE
INSUFFICIENT AIR PASSING THROUGH RADIATOR
CHOKED CORE
SLACK FAN BELTS
INSUFFICIENT WATER
HEAT EXCHANGER/ RADIATOR THERMOSTAT NOT OPEN
LEAKING JOINTS
RELIEF VALVE STICKING OR WORN
PRESSURE GAUGE PIPE PINCHED OR BENT
DEFECTIVE PRESSURE GAUGE
CRACK IN CYLINDER BLOCK OR HEAD
RUN ENGINE WITH ROCKER COVERS REMOVED TO CHECK FOR LEAKS
LEAKING OIL TEMP. STABILISER
LEAKING INJECTOR TUBE
CRACKED CYLINDER LINER
LEAK FROM MAIN OIL GALLERY/O RINGS
INSUFFICIENT OIL IN SUMP
CHOKED OIL STRAINER
486.2

Fig. 46

Key
(Fig. 47)

1. Repeater relay
2. 24 volt starting batteries
3. CAV Starter motor
4. Start relay
5. Fuel stop solenoid
   35.0 Amps inrush
   0.75 Amps holding
   Energised to run
6. **NOTE:** Aux terminal gives a battery negative signal when solenoid is fully energised. To enable engine to run immediately on depressing start button F.P.S. must be fed positive +ve
7. Fuel stop solenoid relay
8. Start button

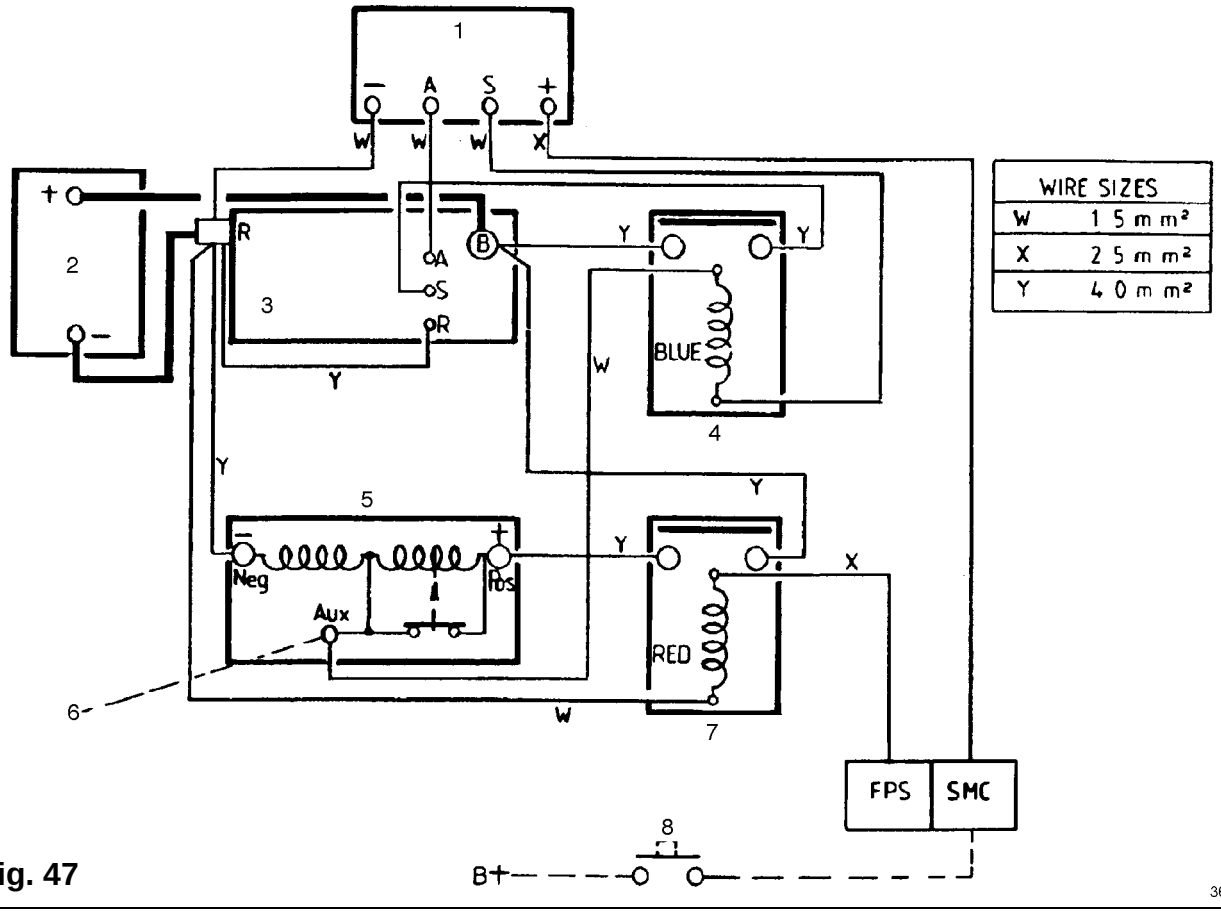

Fig. 47

Key
(Fig. 48)

1. 24 volt starting batteries
2. CAV Starter motor
3. Start relay
4. Fuel stop solenoid
   35.0 Amps inrush
   0.75 Amps holding
   Energised to run
5. Fuel stop solenoid relays
6. **NOTE:** Aux terminal gives a battery negative signal when solenoid is fully energised. To enable engine to run immediately on depressing start button F.P.S. must be fed positive +ve
7. Start button

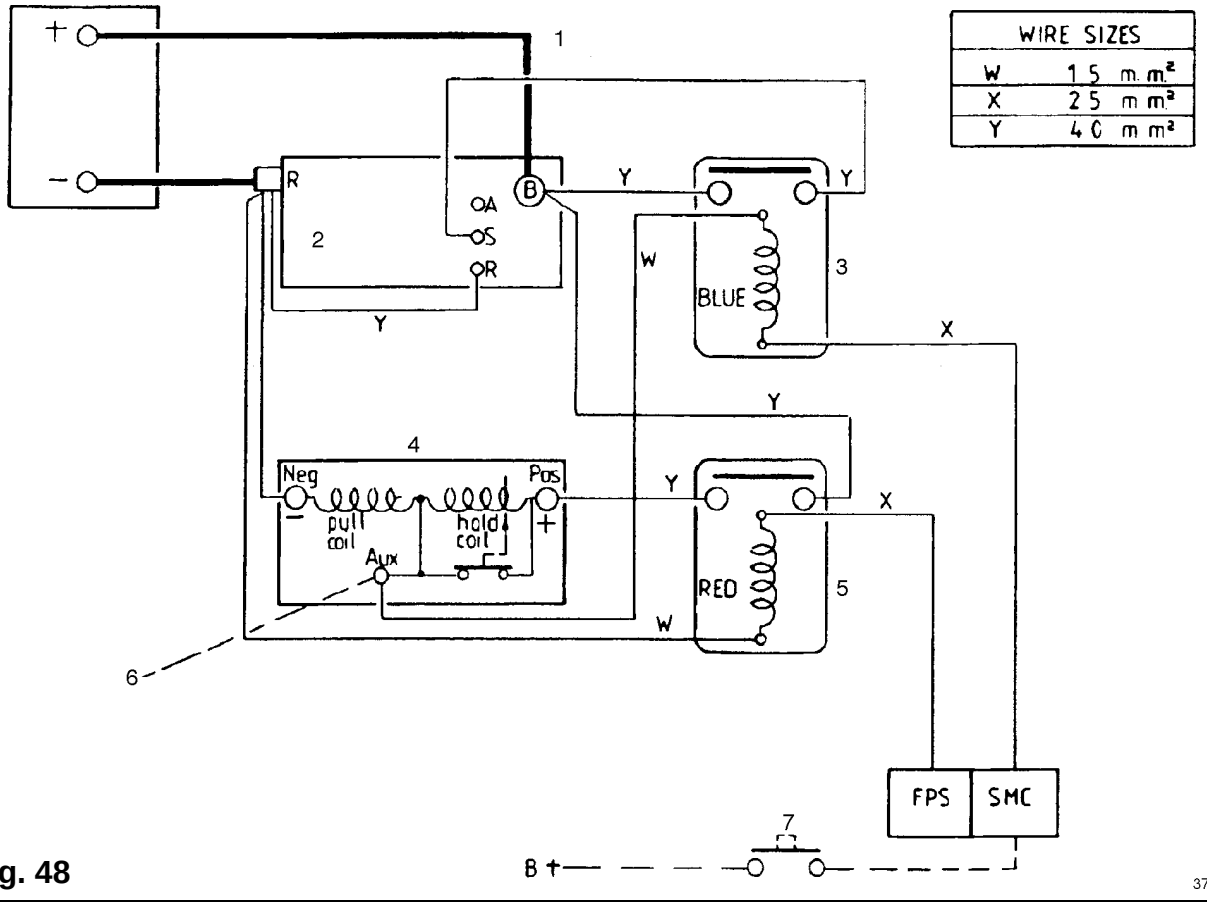

Fig. 48

Key
(Fig. 49)

1. Charge alternator
2. Oil pressure switch
3. Resistor
4. Water temperature gauge
5. Oil temperature gauge
6. Oil pressure gauge
7. Ammeter
8. Tachometer
9. Fuse
10. Governor actuator
11. Repeator relay
12. Aux terminal gives a battery negative signal fully energised
13. Water temperatur sender
14. Oil temperature sender
15. Oil pressure sender
16. Oil pressure sender
17. Key switch if required
18. Starter motor
19. Start relay
20. Fuel solenoid relay
21. Fuel solenoid energised to run
    45.0 Amps inrush
    0.75 Amps holding
22. Combined engine faults switch
23. Water temperature
24. Oil pressure
25. Magnetic pick-up
26. Engine flywheel
27. 24 volt starting batteries
28. Typical terminal block
29. Two switch speed unit
30. Switch 2 overspeed
31. Switch 1 speed ref
32. To enable engine to run immediately on depressing start button both FPS and GOV+ must be fed 24 volt +ve. To stop break thus +ve supply
33. Speed trim pot
34. If speed trim pot is not required remove and connect thus
35. Wire sizes

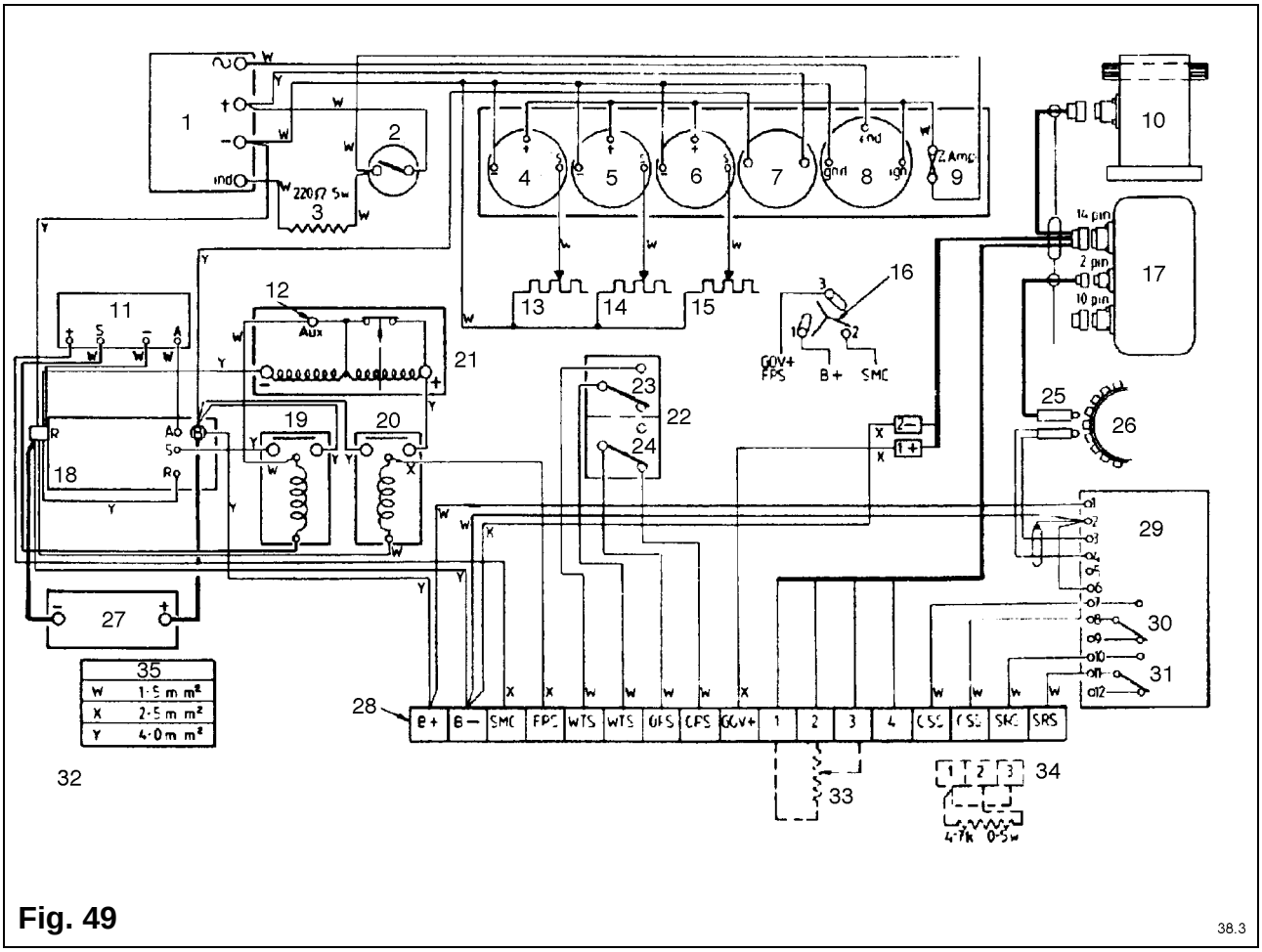

Fig. 49

38.3

Key
(Fig. 50)

1. Charging alternator
2. Oil pressure switch
3. Resistor
4. Water temperature gauge
5. Oil temperature gauge
6. Oil pressure gauge
7. Ammeter
8. Tachometer
9. 2 Amp fuse
10. Governor actuator
11. Aux terminal gives a battery negative signal fully energised
12. Fuel solenoid energised to run
    45.0 Amps inrush
    0.75 Amps holding
13. Combined engine fault switch
14. Water temperature
15. Oil pressure
16. Key switch if required
17. Governor control box
18. Magnetic pick-ups
19. Engine flywheel
20. Starter motor
21. Starter relay
22. Fuel solenoid relay
23. 24 volt starting relay
24. Typical terminal block
25. Two switch speed box
26. Switch 2 overspeed
27. Switch 1 speed ref
28. Wire sizes
29. To enable engine to run immediately on depressing start button both GOV and FPS must be fed 24 volt +ve to stop break +ve supply
30. Speed trim pot
31. If speed trim pot is not required remove and connect thus

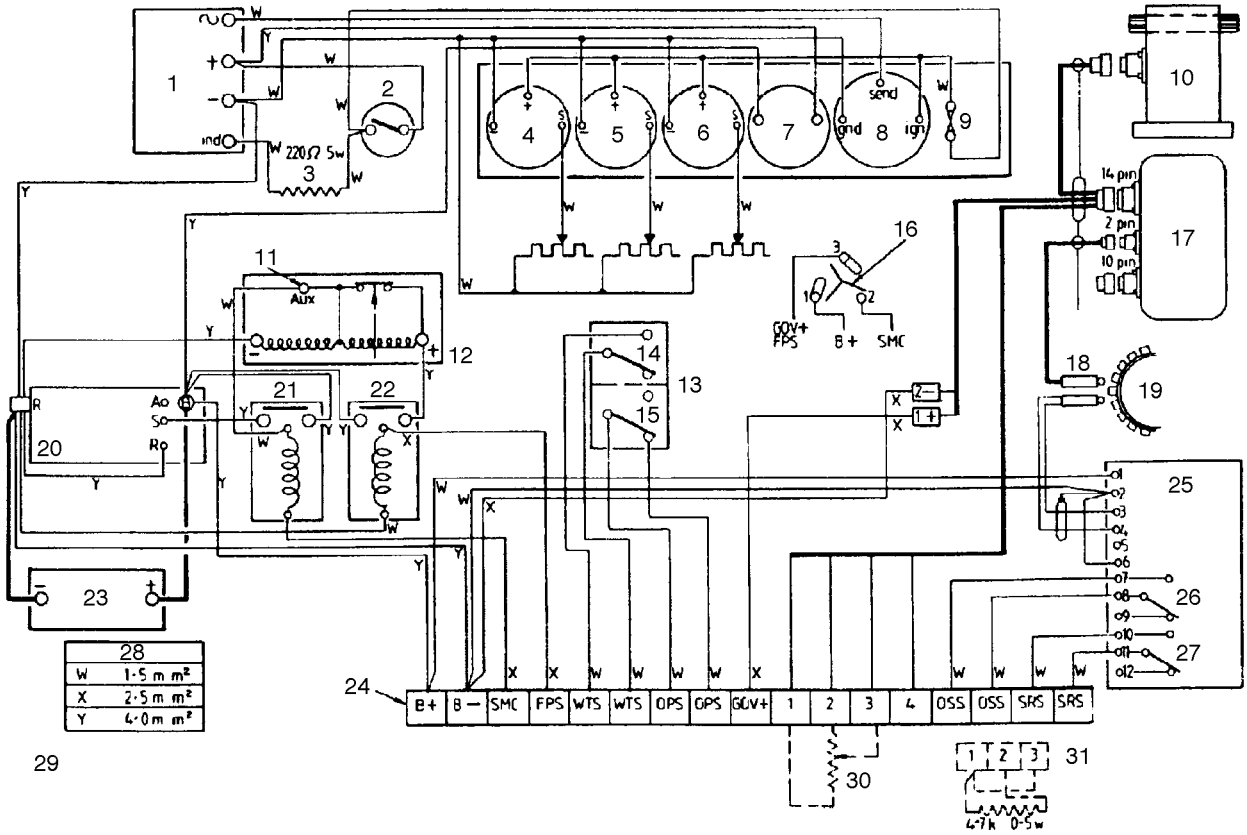

Fig. 50

39.3

Key
(Fig. 51)

1. Charging alternator
2. Signal for tacho
3. Ammeter
4. Oil pressure switch
5. Resistor
6. 24 volt starting batteries
7. Starter motor
8. Starter relay
9. Fuel solenoid relay
10. Repeat start unit
11. Fuel stop solenoid energised to stop
    45.0 Amps inrush
    0.75 Amps holding
12. Start button
13. To stop

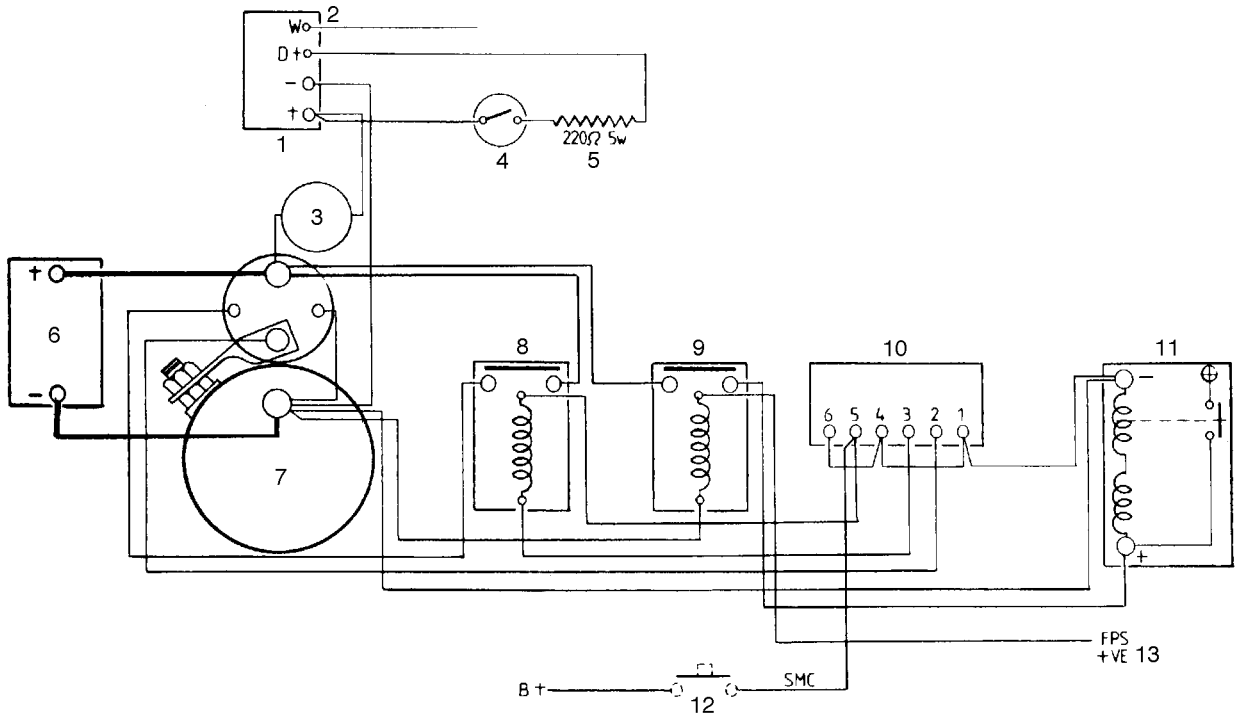

Fig. 51

40.3

Key
(Fig. 52)

1. Charging alternator
2. Signal for tacho
3. Oil pressure switch
4. Resistor
5. Ammeter
6. 24 volt starting batteries
7. Starter motor
8. Starter relay
9. Relay to allow fuel solenoid to energise before crank
10. Fuel stop solenoid energised to stop
    45 Amps inrush
11. Start button
12. Must be +ve immediately on start

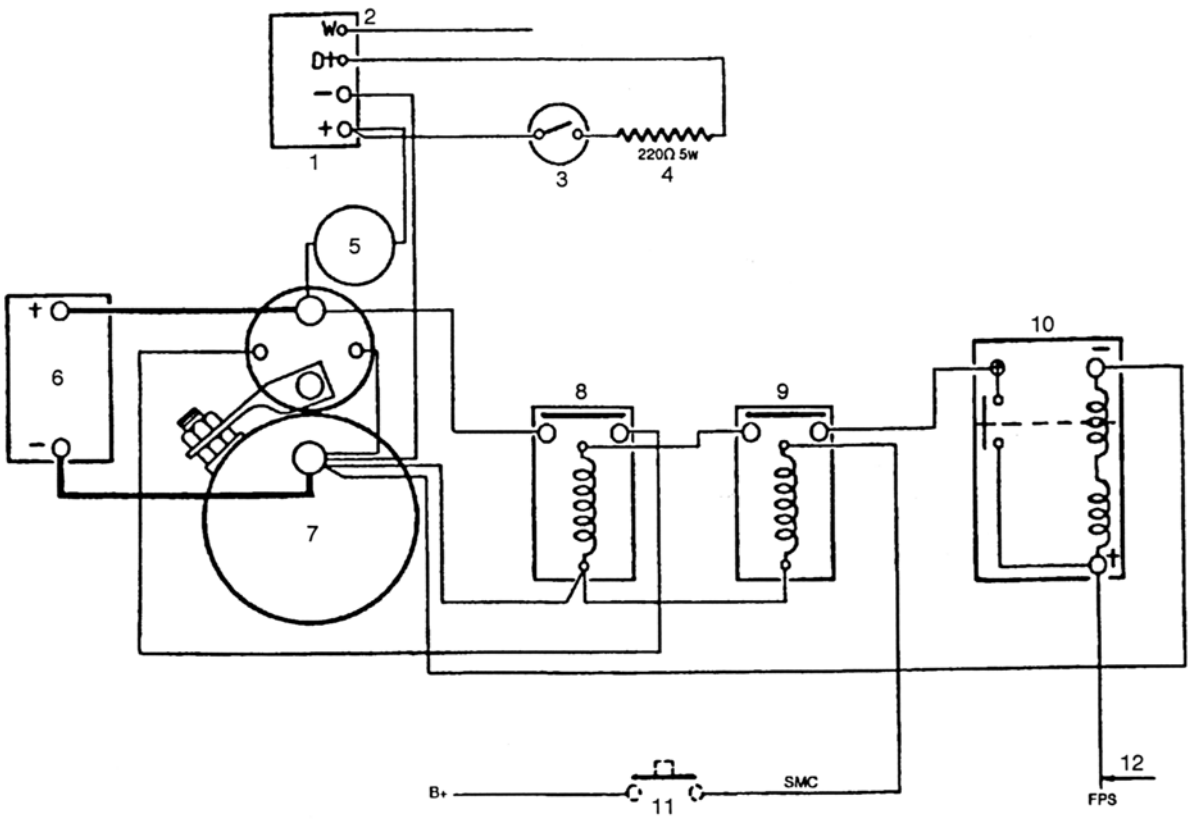

Fig. 52

Key
(Fig. 53)

1. Charge alternator (CAV)
1A. Charge alternator (BUTEC)
2. Oil pressure switch
3. Water temperature gauge
4. Oil temperature gauge
5. Oil pressure gauge
6. Ammeter
7. Tachometer
8. Fuse
9. Key switch if required
10. Governor actuator
11. Resistor
12. Sender water temperature
13. Sender oil temperature
14. Sender oil pressure
15. Governor control box
16. Fuel solenoid energised to run
17. Magnetic pick-up
18. Engine flywheel
19. 24 volt starting batteries
20. Starter motor
21. Start relay
22. Fuel solenoid relay
23. Combined engine faults switch
24. Water temperature
25. Oil pressure
26. Two switch speed unit
27. Switch 2 overspeed
28. Switch 1 speed ref
29. Wire sizes
30. To enable engine to run immediately on depressing start button both FPS and GOV+ must be fed 24 volt +ve. To stop break thus +ve supply
31. Typical terminal block
32. Speed trim pot
33. If speed trim pot is not required remove and connect thus

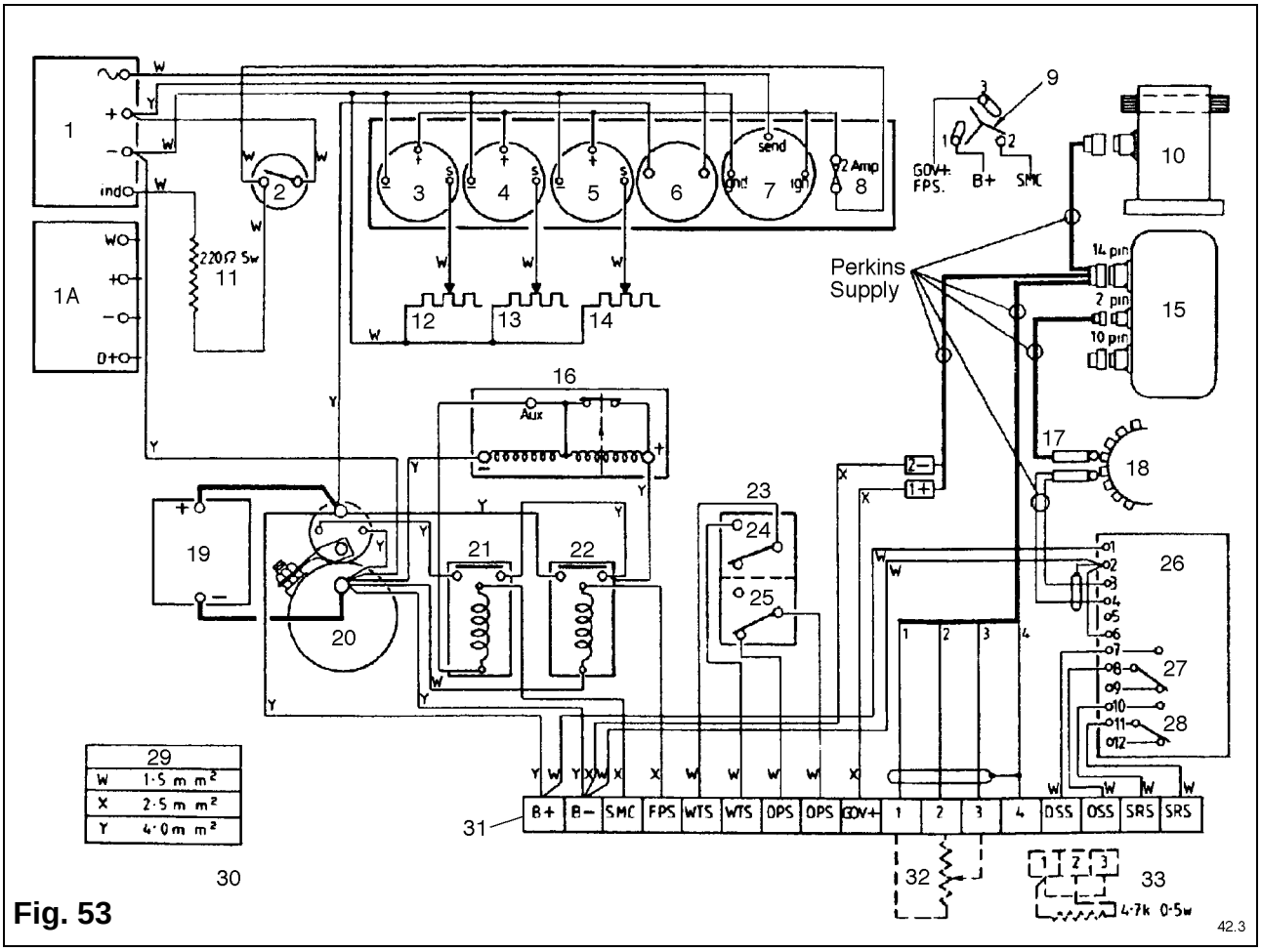

Fig. 53