Perkins®

TSL4186E, Issue 1
February 1998

User's Handbook

4000 Series Diesel

4016 TAG1
4016 TAG2

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 Operators Handbook 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 this Operators Handbook 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 Operators Handbook 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**.

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In addition to the above companies, there are Perkins distributors in most countries. Perkins Engines (Peterborough) Limited or one of the above companies can provide details.

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PERKINS ENGINES (STAFFORD) ENGINE DESIGNATIONS 4000 SERIES AND SE SERIES EQUIVALENT TERMS	
4000 SERIES	**SE SERIES**
4012TWG	12SETCR
4012TAG	12SETCR2
4012TAG1	12SETCA
4012TA2	12SETCA1
4012TEG	12SETCA2
4012TEG2	12SETCW
4016TWG	12SETCW2
4016TWG2	16SETCR
4016TAG	16SETCR2
4016TAG1	16SETCA
4016TAG2	16SETCA2
4016TEG	16SETCW
4016TEG2	16SETCW2

4012 TAG

4012 TAG

4016 TAG

4016 TAG

4012TWG 12 cylinder "V" form diesel engine, water cooled, turbocharged (twin turbochargers), jacket water cooled charge air coolers and oil coolers in engine cooling circuit. Earlier engines with vertical air cleaners, later engines with horizontal air cleaners.

4012TWG2 Up rated version of the 4012TWG 12 cylinder "V" form diesel engine, water cooled, turbocharged (twin turbochargers) jacket water cooled charge air coolers in engine cooling circuit. Horizontal air cleaners.

4012TAG 12 cylinder "V" form diesel engine, water cooled, turbocharged (twin turbochargers), air cooled charge air intercooler in radiator. Oil coolers in engine cooling circuit. Earlier engines with vertical air cleaners, later engines with horizontal air cleaners.

4012TAG1 Up rated version of the 4012TAG 12 cylinder "V" form diesel engine, water cooled, turbocharged (twin turbochargers) air cooled charge air intercooler in radiator. Oil coolers in engine cooling circuit. Horizontal air cleaners.

4012TAG2 Up rated version of the 4012TAG1 12 cylinder "V" form diesel engine, water cooled, turbocharged (twin turbochargers), air cooled charge air intercooler in radiator. Oil coolers in engine cooling circuit. Horizontal air cleaners.

4012TEG 12 cylinder "V" form diesel engine, water cooled, turbocharged (twin turbochargers), raw water cooled charge air coolers with raw water pump and separate cooling circuit. Oil coolers in engine cooling circuit. Earlier engines with vertical air cleaners, later engines with horizontal air cleaners.

4012TEG2 12 cylinder "V" form diesel engine, water cooled, turbocharged (twin turbochargers), raw water cooled charge air coolers with raw water pump and separate cooling circuit. Oil coolers in engine cooling circuit. Horizontal air cleaners.

4016TWG 16 cylinder "V" form diesel engine, water cooled, turbocharged (twin turbochargers), jacket water cooled air coolers and oil coolers in engine cooling circuit. Horizontal air cleaners.

4016TWG2 Up rated version of the 4016TWG 16 cylinder "V" form diesel engine, water cooled, turbocharged (four turbochargers), jacket water cooled charge air coolers and oil coolers in engine cooling circuit. Horizontal air cleaners.

4016TAG 16 cylinder "V" form diesel engine, water cooled, turbocharged (twin turbochargers), air cooled charge air intercooler in radiator. Oil coolers in engine cooling circuit. Earlier engines with vertical air cleaners, later engines with horizontal air cleaners.

4016TAG1 Up rated version of the 4016TAG 16 cylinder "V" form diesel engine, water cooled, turbocharged (four turbochargers) air cooled charge air intercooler in radiator. Oil coolers in engine cooling circuit. Horizontal air cleaners.

4016TAG2 Up rated version of the 4016TAG1 16 cylinder "V" form diesel engine, water cooled, turbocharged (four turbochargers) air cooled charge air intercooler in radiator. Oil coolers in engine cooling circuit. Horizontal air cleaners.

4016TEG 16 cylinder "V" form diesel engine, water cooled turbocharged (twin turbochargers) raw water cooled charge air coolers with raw water pump and separate cooling circuit. Oil coolers in engine cooling circuit. Earlier engines with vertical air cleaners, later engines with horizontal air cleaners.

4016TEG1 AND 4016TEG2 Uprated versions of the 4016TEG 16 cylinder "V" form diesel engine, water cooled, turbocharged (four turbochargers), raw water cooled charge air coolers with raw water pump and separate cooling circuit. Oil coolers in engine cooling circuit. Horizontal air cleaners.

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. A 1085.2

Asbestos joints

Some joints and gaskets contain compressed asbestos fibres see **Warning label Fig. A** 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.

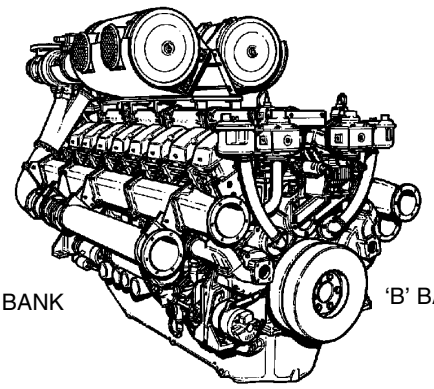

Fig. B

For full technical data please refer to the **Product Information Manual**.

Type: Water-cooled, turbocharged, charge cooled, industrial diesel engine.

RANGE	**4012**	**4016**
Cycle	4 stroke	4 stroke
No. of cylinders	12	16
Configuration	V-form	V-form
Bore	160 mm	160 mm
Stroke	190 mm	190 mm
Total swept volume	45,84 litres	61,123 litres
Compression ratio	13,6:1	13,6:1
Rotation	Anti-clockwise looking on flywheel end	
Firing order	1A-6B-5A-2B-3A-4B- 6A-1B-2A-5B-4A-3B	1A-1B-3A-3B-7A-7B-5A-5B- 8A-8B-6A-6B-2A-2B-4A-4B
Valve Timing	inlet valve opens 60° BTDC inlet valve closes 46° ABDC	exh valve opens 46° BBDC exh valve closes 60° ATDC
Cylinder numbering	Cylinder 1 furthest from flywheel	
Cylinders designated A are on the right hand side of the engine, when viewed from the fly-wheel end and cylinders designated B are on the left hand side of the engine.		
Valve Clearances	exhaust	0,40 mm (0,016")
(Engine cold)	inlet	0,40 mm (0,016")
Valve dia. (mm) inlet and exhaust	48	48
	(52 on 4012TAG1/2 AND 4016TAG1/2)	
Valve Timing	See **Workshop Manual Sections U4 and U5**	
Injection Timing	See engine nameplate	
Piston Speeds	Engine r/min	m/s (ft/min)
	1000	6,33 (1247)
	1200	7,60 (1496)
	1500	9,50 (1870)
	1800	11,40 (2244)

TYPICAL COOLING SYSTEM

	4006	4008
Approved Coolants)	See page 21	

Total water capacity	Ltrs	Gals	Spec	Ltrs	Gals	Spec
	200	44	TAG	255	56.1	TAG
	232	51	TAG1	316	70	TAG1
	232	51	TAG2	316	70	TAG2
	185	40	TWG	95	21	TWG*
	205	45	TWG2	95	21	TWG2*
	82	18	TEG**	108	23.7	TEG**

* Engine only
** Engine with heat exchanger

Max radiator top tank temperature	93°C
Max water temperature into engine	80°C
Thermostat opening temperature	71°C
System pressure	0.5 to 0.7 bar

FUEL SYSTEM

	4012	4016
Approved fuels	See page 20	
Minimum size fuel tank	14000 litres (3000 gal.)	18000 litres (4000 gal.)
Relief valve setting	310 kPA (45 psi)	
Inferior nozzle pressure	225-235 atm	
Injection equipment	Lucas-Bryce unit injector	
Filter/water separator	Spin-on expandable canister(s)	
Fuel lift pump	Maximum suction lift 1 metre	
Fuel flow	20.457 litre/min. (4.5 gpm) @ 1800 r/min	

GOVERNORS

	4012	4016
Type	Electronic	Electronic
Type	Hydraulic	Hydraulic

LUBRICATION SYSTEM

	4012	4016
Recommended oil	See **pages 19 and 20**	
Type of system	Wet sump, external engine mounted oil pump	
Total oil capacity (including cooler and filter)	178 litre (39.2 gal)	238 litre (53 gal)
Sump capacity (dipstick)		
Min.	136 litre (30 gal)	147 litre (33 gal)
Max.	159 litre (35 gal)	214 litre (47 gal)
Crankcase pressure (max)	25 mm (1") water gauge	
Lubricating oil temperature max. to bearings	105°C	
Lubricating oil pressure at 80°C temp. to bearings	0.34 mPa	
Max. oil temperature in sump	115°C	
Min. oil pressure (1500 rpm)(at filter head)	200 kPa (30 lb/in²)	
Oil filter	Disposable canister type	
Oil pump location	'A' Bank	

INDUCTION SYSTEM

	4012	4016
Air cleaners (earlier) (current)	Twin vertical air cleaners Twin horizontal air cleaners	
Type	Paper element	
Air restriction indicator setting	380 mm H_20	
Turbochargers	x2 off	x4 off

EXHAUST SYSTEM

	4012	4016
Manifold Type	Dry or water cooled	
Exhaust outlet flange	Vertical (Twin)	
Mating flange	See **Installation Manual**	
Max. exhaust back pressure	See **Product Information Manual**	
Max. exhaust temperature		

FLYWHEEL

	4012	4016
Drive size	SAE 18"	
	SAE 21" Optional	

FLYWHEEL HOUSING

	4012	4016
SAE size	00	

TYPICAL DRY WEIGHT

	4012	4016
Dry weight (engine)	4360 kg 4012TAG	5500 kg 4016TAG
	4360 kg 4012TAG1	5750 kg 4016TAG1
	4400 kg 4012TAG2	5750 kg 4016TAG2
	4975 kg 4012TWG	5940 kg 4016TWG/2
	5315 kg 4012TWG2	5820 kg 4016TEG
	4680 kg 4012TEG2	
Dry weight engine & tropical radiator	5280 kg 4012TAG	6900 kg 4016TAG
	5760 kg 4012TAG1	8010 kg 4016TAG1
	5800 kg 4012TAG2	8010 kg 4016TAG2
	4995 kg 4012TWG	
	5315 kg 4012TWG/2	
Dry weight engine & heat exchanger	4860 kg 4012TEG	6000 kg 4016TEG

HOLDING DOWN BOLT HOLES

	4012	4016
Hole dia. (Engine feet)	22 mm	
No. off	8	
Hole dia. (Radiator feet)	18 mm x 6 4012TAG	22 mm x 6 4016TAG/2
Turbochargers	22 mm x 6 4012TAG2	
	22 mm x 6 4012TWG/1	

ELECTRICAL SYSTEM

	4012	4016
Voltage	24V	
Alternator	Belt Driven	
Alternator output	30A	
Starter motor	Single CAV (Earlier Engines) Twin Prestolite (Current Engines)	Twin Prestolite
No. of teeth (gear ring)	144 (Early Engines) 156 (Current Engines)	156
No. of teeth (starter pinion)	12	
Battery (lead acid)	24V DC (2 x 12V)	
Capacity down to 0°C (32°F)	286 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, and ALL Cogen applications.

Standard settings for protection equipment are as follows:-

	Alarm	Shutdown
High Oil temperature (in sump)	110°C	115°C
Low oil pressure	2.06 bar (30 lb/in²)	1.93 bar (28 lb/in²)
High water temperature		
71°C Thermostat	91°C	96°C
85°C Thermostat	96°C	101°C
96°C Thermostat	100°C	105°C

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

Overspeed	15% above max. running speed (Except 1800 r/min which is 7%)

AIR STARTING

	4012	4016
Air starter	See **Installation Manual**	
Air starter pressure	150 lb/in^2 (10.34 bar)	
Compressed air supply	170 lb/in^2 (11.72 bar)	

INSTRUMENT PANEL (ENGINE MOUNTED)

	Normal Operation
Oil pressure	Between 276-413 kPa (40-60 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**

COOLANT JACKET HEATING

	4012	4016
Heater	2 x 4 kW	
Voltage	210-250V ac	

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 heads 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 PBC (Poly-Butyl-Cuprysil) grease. **Important:** See **Workshop Manual Section R11** before fitting. However, **dry threads** are required for connecting rod bolts and the raw water pump shaft nut, but all other threads only to be lubricated with clean engine oil and care must be taken **NOT** to oil the heads or 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	720
Rocker shaft capscrew/nut	M16	90	120
Rocker adjuster nuts inlet/exhaust	M12	35	50
Rocker adjuster nuts pump injectors	M14	50	70
Injector clamp capscrews	M12	70	95
Bridge piece adjuster nuts	M10	25	35
Injector clamp to cylinder head capscrews	M12	70	95
Rocker box bolts	M10	35	50
Air manifold bolt	M10	35	50
Exhaust manifold bolts	M10	50	70
Exhaust bellows to exhaust manifold (16 cyl only) prevailing torque bolts / nuts	M10	45	60
Exhaust Y piece (16 cyl only) prevailing torque bolts	M10	38	50
Schwitzer turbocharger 'V'-band clamp nuts	M8	8	11
Sandwich plate retaining capscrews	M10	35	50

CRANKCASE AND CRANKSHAFT GROUPS			
Main bearing bolts * (See **Section W4** for sequence)	M24	580	786
Lateral capscrews, main bearing caps (See **Section W4** for sequence)	M16	124	168
Bolts sump to crankcase	M10	40	54
New connecting rod bolts (must be fitted with dry threads)	M16	210	285
Inspection covers	M10	35	50
Viscous damper bolts	M16	250	340
Flywheel bolts See **Section X3** for sequence	M16	250	340
Front drive adaptor bolts (12 cylinder engines only)	M16	250	340
Front drive adaptor bolts (16 cylinder engines only)	M20	380	520
Balance weight bolts	M16	250	340
Crankshaft pulley bolts	M16	250	340
Piston cooling jet screws	M10	20	27
Flywheel housing bolts	M10	35	50
Lifting bracket Durlock screws	M10	50	70

LUBRICATING OIL PUMP		lbf.ft	Nm
Bolts, pump housing to gearcase plate	M10	35	50
Thin nut, gear to drive shaft	M30	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 pump to gearcase bolts	M10	35	50
Raw water pump gear securing nut, dry thread	M35	180	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	M12	70	95
GOVERNOR			
Control shaft mounting plate bolt	M10	35	50
FAN			
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 screw	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			
Flexible coupling cover screw	M12 or 1/2" UNC	47	64
Coupling driving flange screws (coupling size 2.15)	M12 or 1/2" UNC	47	64
Coupling driving flange screws (coupling size 3.86)	M16 or 5/8" UNC	114	155

GENERAL TORQUE LOADINGS

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

THREAD	lbf ft	Nm
M5	5	7
M6	9	12
M8	21	28
M10	41	56
M12	72	98
M16	180	244
M20	351	476
M24	606	822

GENERAL NOTE:

M10 - 12.9 Steel	50	70

TIGHTENING TORQUES

These are based on 85% of the proof loads designated in BS3692.

QUANTITY OF OIL

Sump Capacity Dipstick	4012	4016
Minimum	136 litre(30 gal)	147 litre (33 gal)
Maximum	159 litre (35 gal)	214 litre (47 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 OF OIL

Use oil of:

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

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
	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, ETC.

ENGINE COOLING SYSTEM

The cooling system of an engine contains many different materials e.g. cast iron, aluminium, copper, solder, rubber (various types). To prevent deterioration of these materials, it is essential to use a very good quality coolant. **Untreated water is not suitable.** It is essential that the water is treated with an additive that gives the necessary protection.

WATER QUALITY

The water to be mixed with the additive must have the following characteristics:

Chlorides 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.**

The 50/50 mixture will give frost protection down to -35°C. In areas where Shell Safe Premium is not available contact Perkins Engines (Stafford) Limited for advice on a recommended alternative.

Under no circumstances should an additive containing nitrites, borates, phosphates, chromates, nitrates, or silicates be used, as they are not compatible with the materials used in the cooling system.

When mixing the antifreeze with the water always follow the manufacturer's recommendation to add the antifreeze in the correct proportion before introducing it into the engine cooling system. Adding water to antifreeze can lead to the formation of a gel in the mixture, which can cause blockage of the water passages and subsequent local overheating.

MAINTENANCE OF COOLANT

The water/antifreeze mixture should be regularly replaced in operating engines at least once a year.

In engines used for standby duty it is essential to maintain the water/antifreeze mixture at the correct alkalinity level i.e. the pH should not increase above 7.5. A hydrometer only shows the proportion of ethylene glycol, not the degree of corrosion protection.

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

4012TWG2 only to this rule is when two section radiators are used in conjunction with charge air coolers under tropical conditions. It may be necessary to reduce the antifreeze content of the coolant from 50% to 10% to achieve an adequate heat transfer coefficient.

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
Sulphur 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)	-4	-4
Winter (October/February inclusive)	-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. (See **page 20 "Engine Operation"**).

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.

PREPARING FOR INITIAL START
FILLING THE ENGINE WITH OIL

WARNING NEVER OPERATE THE ENGINE WHEN THE OIL LEVEL IS BELOW THE MINIMUM MARK OR ABOVE THE MAXIMUM. ALWAYS WEAR PROTECTIVE GLOVES WHEN HANDLING ENGINE OIL.

Remove the drain plug to ensure that the sump is clean and empty. Refit and tighten the plug. Remove the oil filler situated on the left hand side of the crankcase, by rotating the T-bar anti-clockwise and pulling up (**Fig. 1**). Fill the sump to the maximum mark on the dipstick with the appropriate grade and quantity of oil (see **page 19 & 20**).

NOTE: If the engine has been overhauled ensure that, with the governor in the stop position, the pump injectors are set in the 'NO FUEL' position.

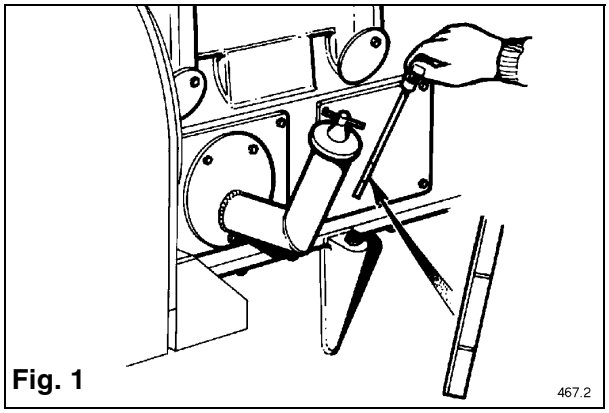

Fig. 1 467.2

PRIMING THE TURBOCHARGERS ON ENGINES FITTED WITH THE ELECTRONIC GOVERNOR

Before starting the engine for the first time, or if it has stood idle for more than three months, the turbocharger bearings should be primed. To prime the turbocharger, 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. 13**) but ensure that the air shut-off valves have been manually set to the run position (see **Fig. 12**).

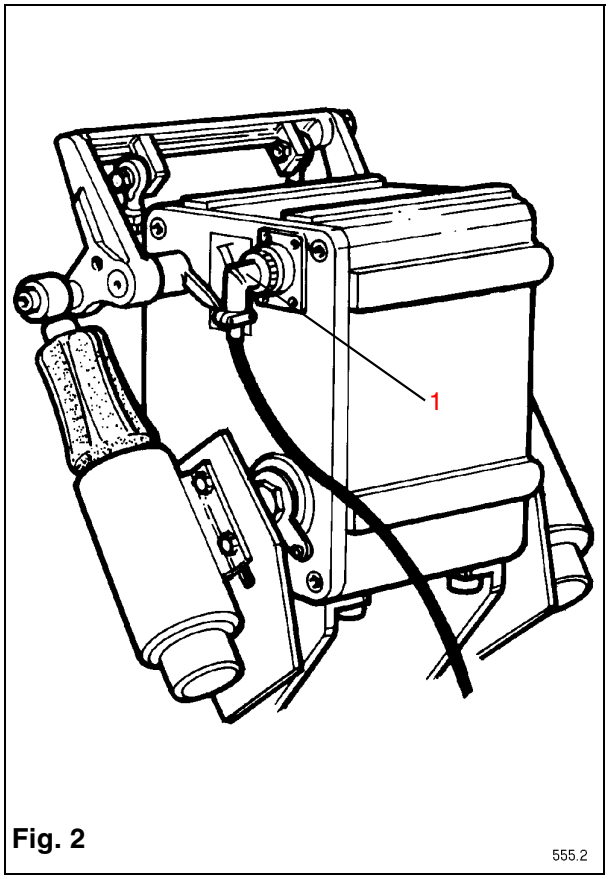

Fig. 2 555.2

Key

(Fig. 2 & Fig. 3)

1. Electronic plug

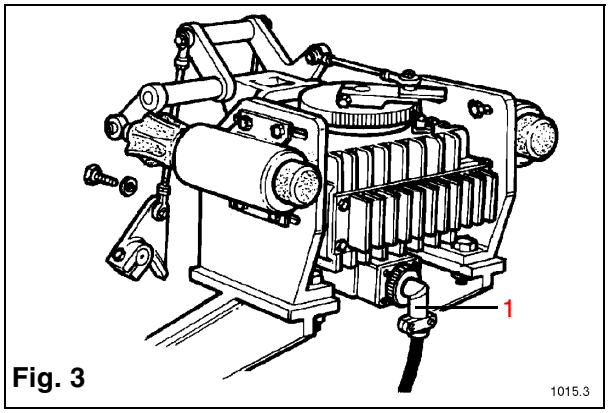

Fig. 3 1015.3

For earlier engines not fitted with a stop lever, disconnect the battery leads and remove the electric plug from the governor by unscrewing the locking collar and pulling the plug out of its socket. (See **Fig. 2 & Fig. 3**).

Operate the starting control or key switch and motor the engine over on the starter until an oil pressure of approximately 40 kPa (5 lb/in^2) is indicated on the pressure gauge. Continue for a further 10 seconds to ensure that the oil has reached the turbochargers, and stop the engine by releasing the start control. Disconnect the battery leads and reconnect the electric plug in the actuator. Reconnect the battery leads.

PRIMING THE TURBOCHARGERS ON ENGINES FITTED WITH REGULATEURS EUROPA OR HYDRAULIC GOVERNORS

Let the engine run without load for about 5 minutes ensuring the lubricating oil has reached the turbochargers.

PRIMING THE TURBOCHARGERS ON ENGINES FITTED WITH A WOODWARD TYPE UG10 OR 3161 HYDRAULIC GOVERNOR

WARNING ⚠ THE OPERATOR MUST BE IN A TO PRESS THE EMERGENCY STOP BUTTON IN THE EVENT OF A PROTECTION EQUIPMENT FAILURE.

NOTE: It is recommended that for initial starting of new or overhauled engines, that the load is disengaged, with the governor speed control lever in the minimum speed position, the shutdown solenoid in the STOP position and the air shut-off valves manually set to the run position **(see Fig. 4 and Fig. 11).**

Check the oil level by means of the sight gauge. If necessary, add new SAE 30 or SAE15W/40 engine oil (after lifting the filler cap) to bring the oil up to the correct level (see **Fig. 2**). Ensure that the fuel supply to the engine is turned off.

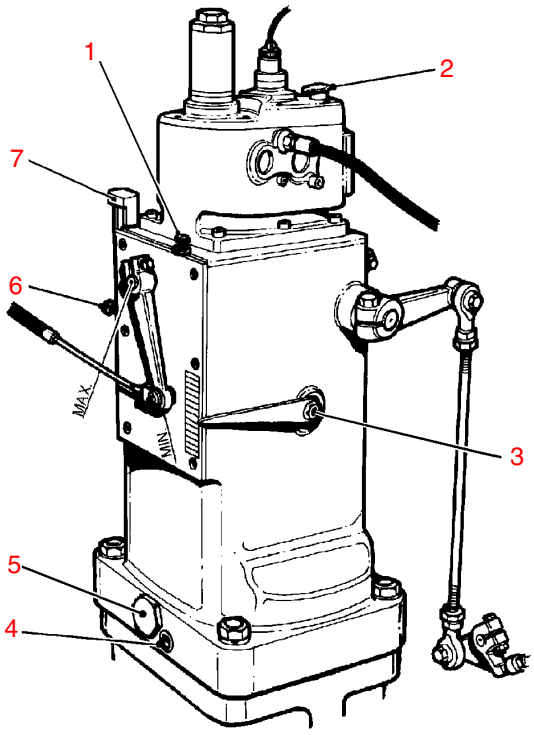

Fig. 4

Key
(Fig. 4)

1 Low speed stop
2 Oil filler
3 Compensation adjustment
4 Oil drain plug
5 Compensating needle valve
6 High speed stop
7 Oil level gauge

With the speed control unit set in the idling position, (for generator duty the governor minimum and maximum speed stops are factory set) ensure that the governor speed lever is in the minimum speed position. Turn the key in the instrument panel from the stop position to the start position and motor the engine over on the starter until the oil pressure gauge registers approximately 40 kPa (5 lb/in^2). Continue cranking for a further 10 seconds to ensure that the oil has reached the turbochargers.

BATTERIES (SUPPLIED DRY CHARGED)
See Installation Manual

WARNING HAND PROTECTION MUST BE WORN WHEN CHECKING THE BATTERY ELECTROLYTE. NEVER CHECK WITH A NAKED FLAME.

Check the level of electrolyte in each battery cell which should be approximately 8 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.

PRIMING AND VENTING THE FUEL SYSTEM AS FITTED ON THE EARLIER 12 & 16 CYLINDER ENGINES.

Loosen the union nut on the fuel feed pipe from the fuel filter, **Fig. 5**.

Operate the priming pump by pressing the rubber button **Fig. 6**. Continue priming until air free fuel flows from the union. Re-tighten the union nut.

Then slacken off the vent plugs located at the opposite to flywheel end of 'A' and 'B' bank fuel return rails, **Fig. 7** and continue priming until air free fuel flows. Tighten the vent plugs.

When priming a fuel system fitted with changeover fuel filters, undo the left hand bleed screws '**L**' (see **Fig. 8**). Operate the priming pump by pressing the rubber button (see **Fig. 6**), until air free fuel flows from the bleed screws. Retighten the left bleed screws '**L**'. Repeat the above operation with the right hand bleed screws '**R**' until all four filters have been primed with fuel.

Slacken off the vent plugs located at the front end of both fuel return rails (see **Fig. 7**) and continue priming until air free fuel flows. Retighten the vent plugs.

Key

(Fig. 6 & Fig. 7)

1 Priming pump

2 Strainer

3 Vent plug

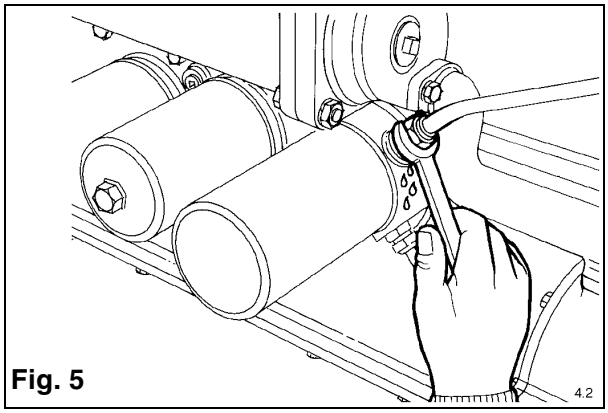

Fig. 5

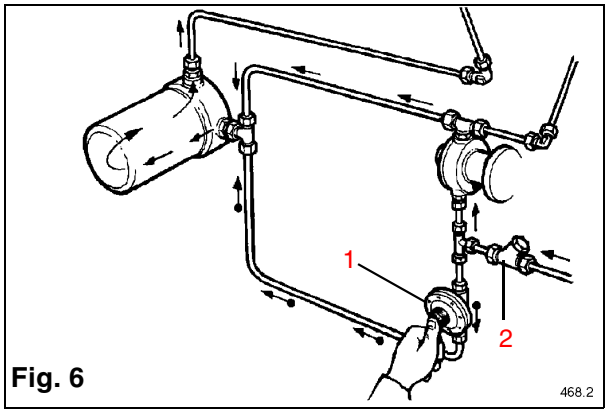

Fig. 6

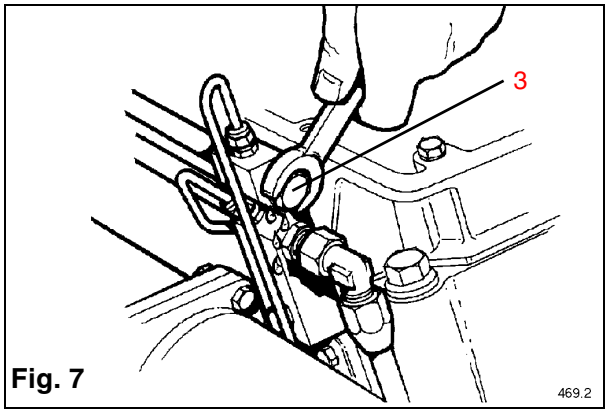

Fig. 7

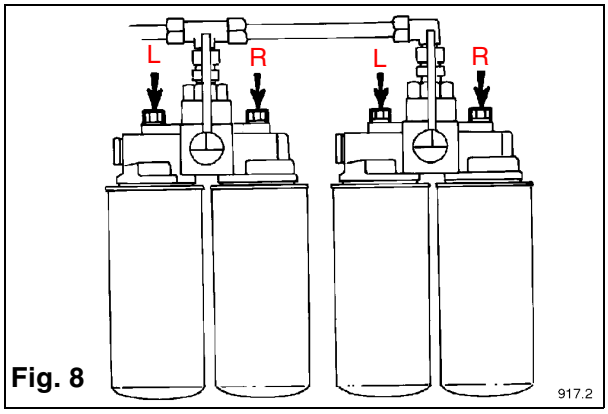

Fig. 8

PRIMING AND VENTING THE FUEL SYSTEM AS FITTED ON LATER 12 & 16 CYLINDER ENGINES

Loosen the union nut on the fuel feed pipe to the front cylinder head on the fuel rail **Fig. 9**.

NOTE: The fuel system should not be bled from the water trap/sedimenter filter (if fitted), since this is on the suction side of the lift pump. **Fig. 10**. However, it is important to drain the water from this unit periodically. Do not operate the priming pump but unscrew the valve at the bottom of the filter about 4 turns until it drops down about 25 mm (1 inch). Allow the water to drain out and then screw the valve back in until it is hand tight.

Operate the priming pump by pressing the rubber button **Fig. 10**. Continue priming until air free fuel flows from the union. Re-tighten the union nut.

FILLING THE COOLING SYSTEMS

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

The use of non-inhibited water is not recommended owing to chemical reactions which can result in corrosion and furring-up of the cooling system. A solution of either universal anti-freeze or corrosion preventative and water must be used. Refer to **page 21**.

After installation and before the first start remove the radiator cap, see **Fig. 11**. Fill the cooling system and run the engine off-load for one minute to ensure that the system is completely filled. Stop the engine and top up the system to within 25 mm (1") of the top of the filler neck then replace the cap. Should the engine be fitted with water cooled exhaust manifolds, these will need bleeding. (Older engines without vent pipes only). (See **Workshop Manual Section Q3**).

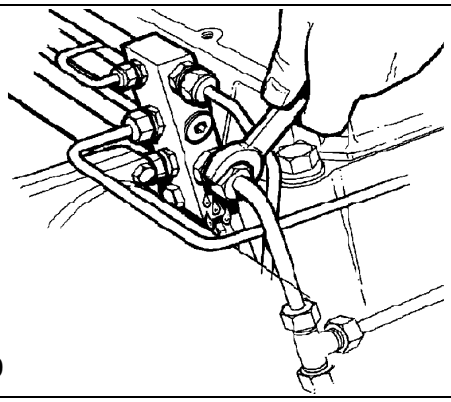

Fig. 9

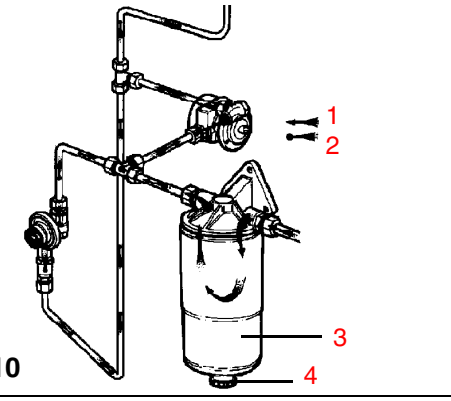

Fig. 10

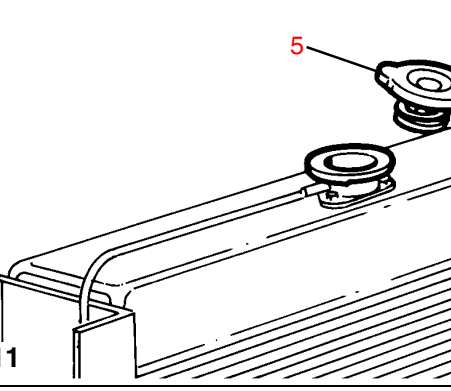

Fig. 11

Key
(Fig. 10 & Fig. 11)

1 Normal fuel flow
2 Priming circuit
3 Water trap/sedimenter
4 Drain valve - DO NOT open when engine running
5 Radiator cap

WARNING ALWAYS BE IN A POSITION TO MANUALLY STOP THE ENGINE IN THE EVENT OF A MALFUNCTION BY OPERATING THE EMERGENCY STOP BUTTON.

INITIAL STARTING OF THE ENGINE WHEN FITTED WITH THE ELECTRONIC GOVERNOR

With the load disengaged, ensure that the stop control on engine/panel is in the 'stop' position, and that the air shut-off valves have been manually set to the 'run' position (see **Fig. 12**) typical installation.

EARLIER ENGINES NOT FITTED WITH AN ENGINE STOP LEVER

Disconnect the battery leads and remove the electric plug from the Heinzmann actuator by unscrewing the locking collar and pulling the plug out of its socket.

Press the emergency stop button to de-energise the stop solenoids, to prevent the governor levers moving into the 'run' position.

Reconnect the battery leads.

LATER ENGINES FITTED WITH AN ENGINE STOP LEVER

In order to prevent the engine running up to its rated speed when operating the key switch, it will be necessary to hold the stop lever in the 'stop' position. **Fig. 13**.

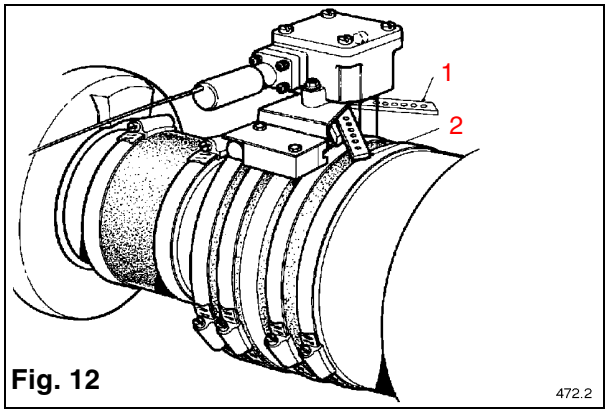

Fig. 12 472.2

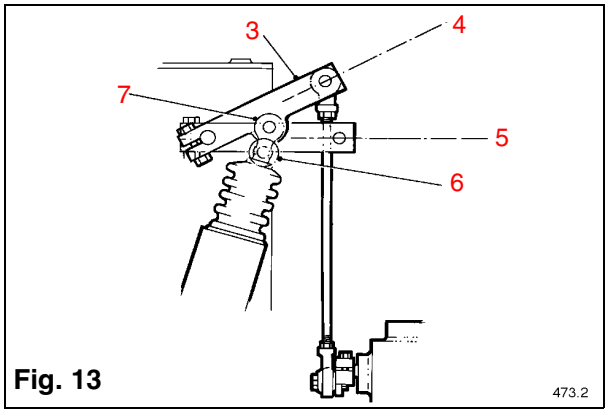

Fig. 13 473.2

Key
(Fig. 12 & Fig. 13)

1 Closed (stop)
2 Latched in (run)
3 Governor lever
4 Stop position
5 Run position
6 Solenoid energised
7 Solenoid de-energised

INITIAL STARTING OF THE ENGINE WHEN FITTED WITH THE REGULATEURS EUROPA 2100 HYDRAULIC GOVERNOR

NOTE: It is recommended that for initial starting of new or overhauled engines, any automatic starting or control systems are by-passed and the engine is controlled manually with the load disengaged, but with the air shut-off valves manually set to the 'run' position (see **Fig. 12**).

Remove the filler plug from the top face of the governor and fill with oil to the line in the sight glass (see **Fig. 14**). Refer to **Workshop Manual, Section AA41** for the correct grade of oil. Replace the plug. Ensure that the fuel supply to the engine is turned off.

Rotate the engine using the cranking device, as described on **page 55**, in the correct direction of rotation for two revolutions to ensure that all working parts are free.

Disengage or remove the cranking device immediately after use.

NOTE: When the engine is fitted with **three** starter motors i.e. two electric and maybe one air starter then on early engines one of the starters may need to be removed to enable the cranking device to be fitted.

WARNING UNDER NORMAL CONDITIONS GENERATING SETS MUST NOT BE RUN AT LESS THAN THEIR NORMAL OPERATING SPEED. OPERATION BELOW THIS SPEED WILL DAMAGE THE AUTOMATIC VOLTAGE REGULATOR (AVR) THEREFORE ISOLATE THE AVR BEFORE REDUCING THE ENGINE SPEED.

The minimum and maximum speed stops are factory set. Reduce the governor speed setting by turning the hand wheel clockwise until there is no further movement of the output levers.

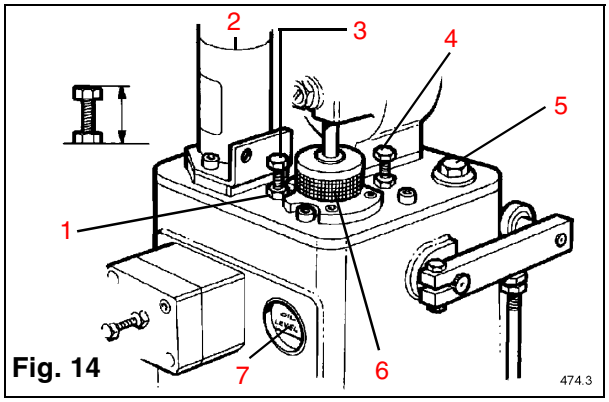

Fig. 14

Key
(Fig. 14)

1 Locknut
2 Solenoid energised to stop
3 Minimum speed stop screw
4 Maximum speed stop screw
5 Oil filler plug
6 Hand control wheel
7 Oil level sight glass

Ensure the starting batteries are fully charged. Energise the shutdown solenoid ('stop' position) and motor the engine over on the starter until the oil pressure gauge registers approximately 40 kPa (5 lb/in²). Continue cranking for a further 10 seconds, to ensure that the oil has reached the turbochargers. Stop the engine by releasing the start control and visually check the engine for fuel or oil leaks, rectifying where necessary. Turn on the fuel supply and bleed the fuel system. Ensuring that the shutdown solenoid is de-energised ('run' position) crank the engine on the starter. The engine should start and run up to the minimum speed setting. Increase the engine speed by turning the hand wheel anti-clockwise until there is no further movement of the output levers. With the engine running up to the maximum speed setting, adjust the hand wheel to obtain the desired operating speed.

Check the engine for fuel and oil leaks. Apply load.

NORMAL STARTING PROCEDURE WHEN FITTED WITH THE REGULATEURS EUROPA 2100 GOVERNOR AND A WOODWARD TYPE UG10 OR 3161

Ensure that where possible the load is off. Set the engine switch to the 'run' position and press the starter button, the engine should start immediately and run up to full speed.

If the engine does not start within a few seconds, do not keep the starter engaged, let the engine come to rest and begin again. Allow 15 seconds between start attempts. If the engine fails to start after several attempts, do not persist in motoring the engine but investigate the cause. Check oil pressure, for fuel and oil leaks and that the ammeter in the instrument panel is showing charge to the engine batteries. Allow the engine to run for 5 minutes. Check instruments are reading correctly. Apply load.

NORMAL STARTING PROCEDURE WHEN FITTED WITH THE HEINZMANN E16 AND WOODWARD PROACT II ELECTRONIC GOVERNOR

Operate the start control, which will energise the solenoid and allow the governor lever to move to the 'run' position **Fig. 11**, the engine should then start immediately. Again check the oil pressure, for any fuel or oil leaks, and that the ammeter in the instrument panel is showing charge to the engine batteries. Allow the engine to run for five minutes, checking that instruments are reading correctly. Apply load.

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 solenoids to stop the engine. The solenoids remain de-energised until the engine is started up again.

NOTE: For engines fitted with Regulateurs Europa 2100, Woodward UG 10 or 3161 hydraulic governors, the 'stop' solenoids are built into the governors and they are energised to stop (ETS) the engine and de-energised shortly after the engine stops.

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.

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 an engine on load can cause seizure of bearings and damage to oil seals.

WARNING DO NOT RUN THE ENGINE 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 output, 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 stand-by generator set applications where a weekly exercise on no load is the usual 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 junctions. A further result is that of abnormal carbon build-up on the valves, piston crowns and exhaust ports, thus the normal service interval of 2500 hours between top overhauls may have to be **reduced**. Fuel dilution of the lubricating oil will also occur.

To alleviate this condition the following recommendations are made:-

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. Periodically site load should be applied (min 25%) through the year.

2 Every year the engine or generator set should be run for four hours, to burn off accumulations of carbon in the engine and exhaust system. This **will** require the use of a '**dummy load**', which should be built up gradually from zero to the maximum over a four hour run.

On standby sets, air cleaner elements should be changed annually. Lubricating oil and fuel filter elements should be changed every six months. The fuel pump injectors should be checked every **2** years.

DESCRIPTION

The instrument panel is flexibly mounted on the engine (see **Fig. 15**). 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	**4**	Battery charging rate	**7**	Fuse holder
2	Lubricating oil temperature	**5**	Speed and hours run	**8**	Exhaust temperature gauge (when fitted)
3	Lubricating oil pressure	**6**	Keyswitch		

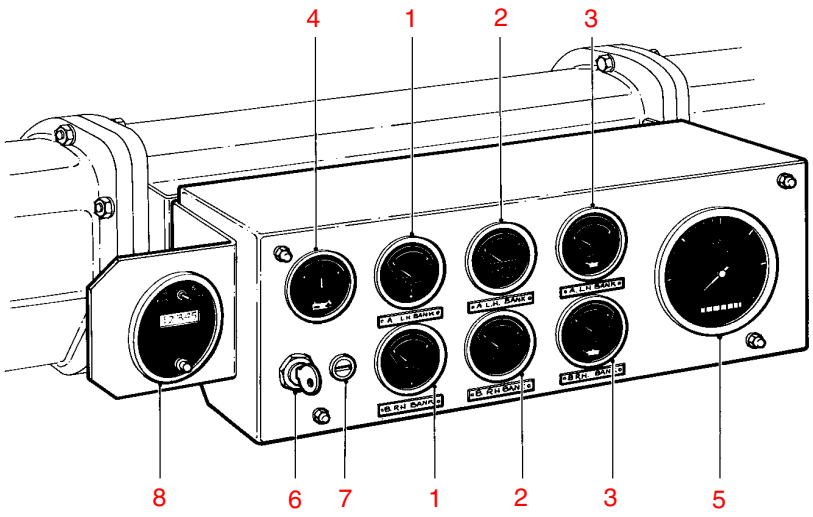

Fig.15

577.2

1 Engine water temperature gauge (Fahrenheit/Centigrade) **Fig. 16**

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.

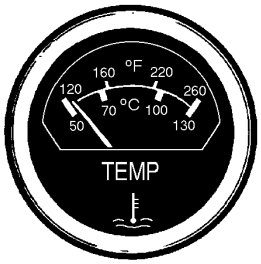

Fig. 16 300.2

2 Engine oil temperature gauge (Fahrenheit/Centigrade) **Fig. 17**

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.

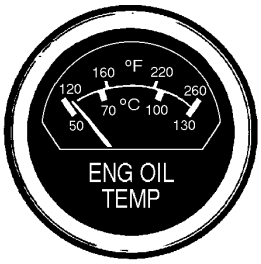

Fig. 17 301.2

3 Engine oil pressure gauge Fig. 18 (pounds per square inch/kiloPascal x 100)

The lubricating oil pressure should be between 276 - 413 kPa (40 - 60 lb/in^2) when the engine is hot. If the pressure should drop below 200 kPa (30 lb/in^2) at higher engine speeds than idling, stop the engine immediately and investigate the cause.

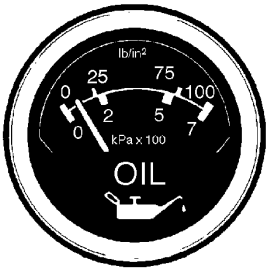

Fig.18 302.2

4 Ammeter (Ampere) Fig. 19

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.

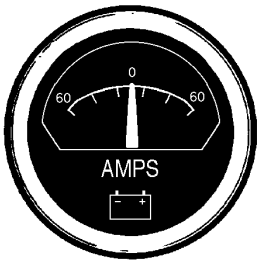

Fig. 19 303.2

5 Engine tachometer and hour counter (revolutions per minute x 1000 and hours) **Fig. 20**

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.

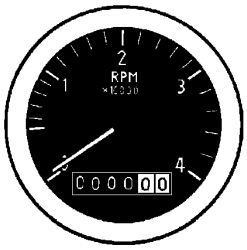

Fig. 20 304.2

6 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. 21**) viewed from front of switch.

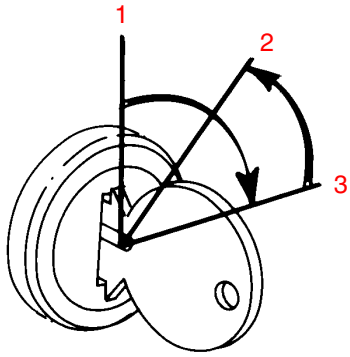

Fig. 21 1018.2

7 Fuse holder

To protect the instrument panel a 2 amp fuse is fitted to remove the fuse (**1**) unscrew its holder (**2**) (see **Fig. 21.1**).

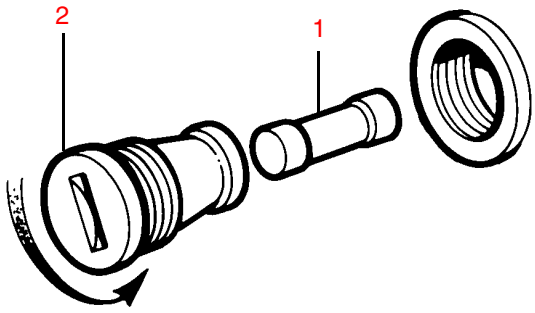

Fig. 21.1 1066.2

Key

(Fig. 21)

1 Off

2 Run

3 Start

DESCRIPTION

All exhaust temperature gauges are of the high accuracy type with digital LCD display, and are powered by the engine 24 volt system.

A two-point gauge may be fitted to these engines, measuring the exhaust temperature of both banks after the turbocharger (see **Fig. 22**, **Fig. 23** and **Fig 24**).

NOTE: These gauges are wired with 'A' bank defined as 'the left hand bank as viewed from the **FRONT** (free end) of the engine'.

Key

(Fig. 22)

1 Red terminal
2 Compensating cables
3 Red terminal
4 Locknuts
5 Mounting bracket
6 Exhaust temperature gauge
7 Mounting bracket
8 Nylon connector
9 Armour braided cable
10 Exhaust bend
11 Thermocouple
12 Probe

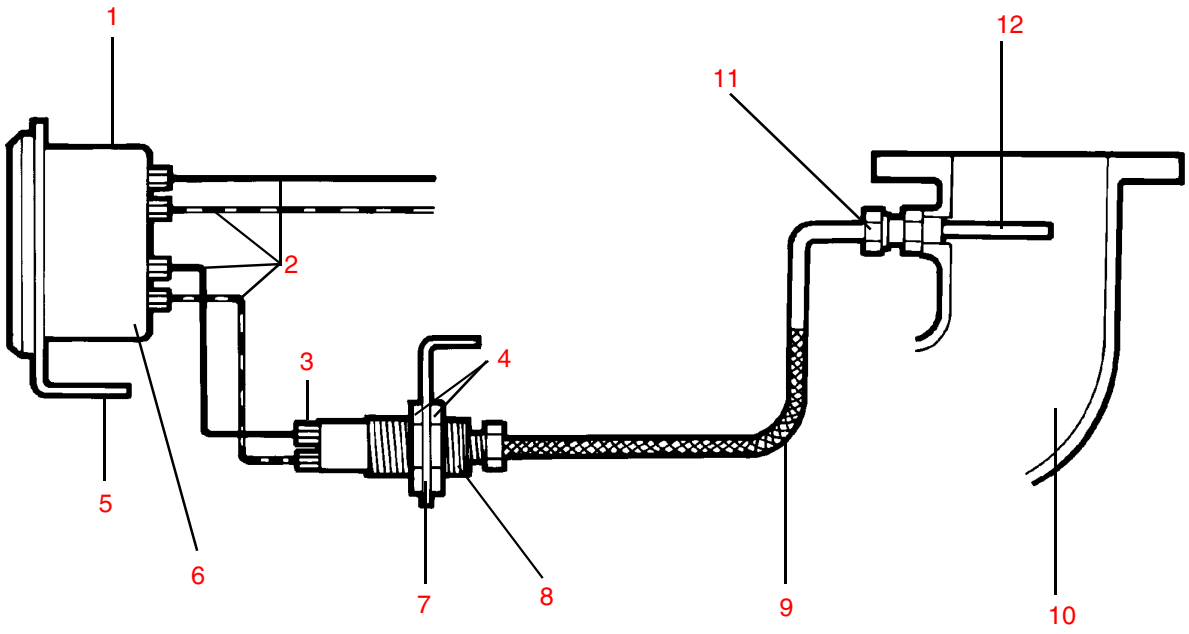

Fig. 22

920.2

SPECIFICATION

Temperature range	-20/+800°C
Resolution	1°C
Accuracy	+ 0.5% F.S.D.
Probe fitting	3/8" BSP
Terminal size	to suit 4BA eyelet connector
Cable size	2 core 7 strand 0.1 mm dia.
Type of cable	Compensating type K i.e. nickel/chrome or nickel/alumel to British Standard 4937 alternatively copper/constantan
Supply battery	24V DC or PP3 lithium (earlier engines)

Key

(Fig. 23)

1 Push button to read (battery powered only)

2 Switch

(Fig. 24)

1 24V DC Supply

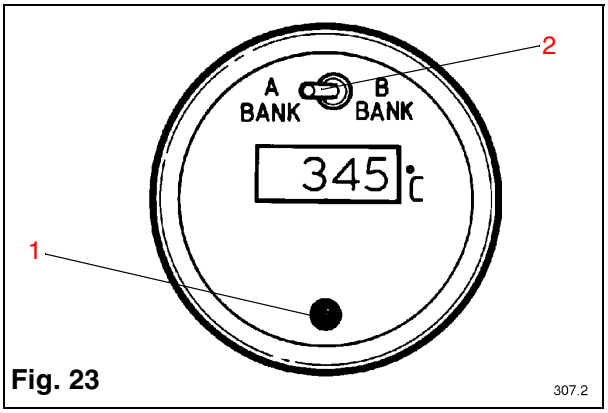

Fig. 23 307.2

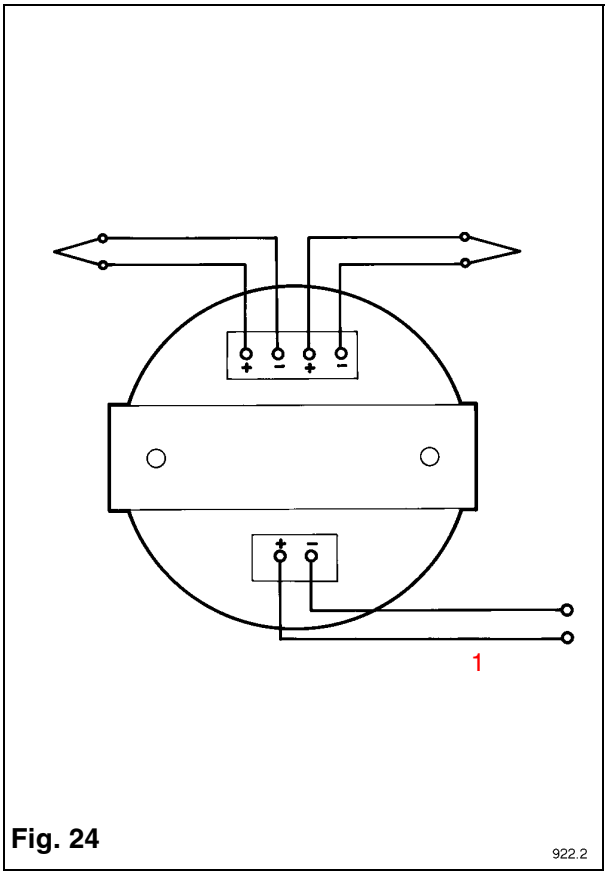

Fig. 24 922.2

EXHAUST TEMPERATURE GAUGE (OPTIONAL)

A four point gauge may also be fitted which measures the exhaust temperature of both banks before as well as after the turbocharger (see **Fig. 25** and **Fig. 26**).

NOTE: These gauges are wired with 'A' bank defined as 'the left hand bank as viewed from the FRONT (free end) of the engine'.

With both the above gauges, a thermocouple is inserted into each exhaust at the point to be measured, and is connected via armour braided cable to a nylon terminal connector. Type K compensating cables are used to connect the nylon terminal connector to the gauge. (see **Fig. 22**).

Wiring is quite straightforward, with the positive (red) terminal on the nylon terminal connector, connected to its corresponding positive (red) terminal at the back of the gauge (see **Figs. 22, 24 and 26**).

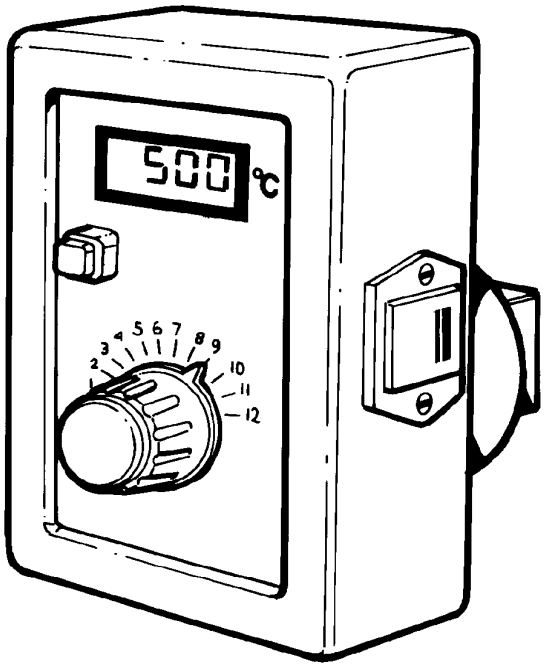

Fig. 25 921.2

Key

(Fig. 26)

1 24V DC Suppy

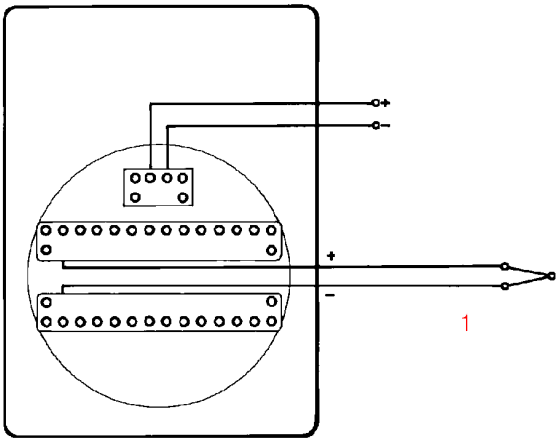

Fig. 26 923.2

Towards the rear of this section are two check sheets, one for continuous duty sets and one for standby duty sets, which are 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 arduous, dirty or dusty conditions, it will be necessary to undertake more frequent servicing, particularly in respect of the lubricating oil, fuel systems and air cleaners. Correct and regular maintenance will help prolong the life of your engine.

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

The periods referred to throughout this maintenance section are true engine running hours as indicated on the hour recorder fitted in the instrument panel.

DAILY INSPECTION

LUBRICATING OIL LEVEL

With the engine stopped for at least 5 minutes withdraw the dipstick, wipe clean and re-insert into the sump. After waiting 5 - 10 seconds for the oil level to stabilise, withdraw and check the oil level in relation to the two marks on the dipstick. If the level is below the top mark, remove the oil filler cap and add the correct grade of oil to bring the level up to the top mark. Always replace the filler cap immediately replenishment is completed.

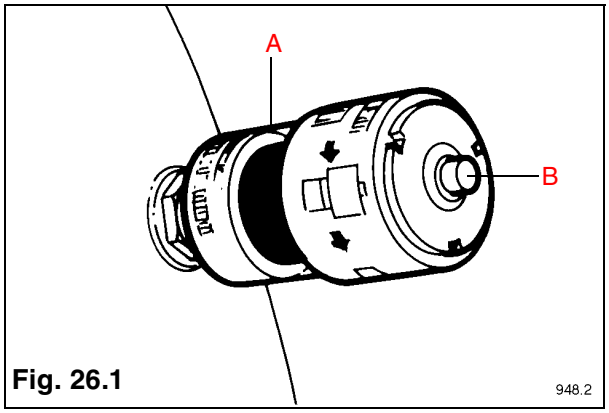

Fig. 26.1 948.2

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 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 **page 21**.

LEAKS

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

AIR FILTER MAINTENANCE

(See **Section A4 Maintenance Manual**)

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. When the air filters have been changed reset the indicator by pressing button '**B**'. (See **Fig. 26.1**). Check this signal daily.

AIR FILTER MAINTENANCE

GENERAL SERVICING INSTRUCTIONS

Servicing procedures include replacing the filter element, cleaning the filter housing, and assuring that all piping and hose connections from the filter outlet to the turbocharger intake are sealed and airtight. (See **Fig. 27**).

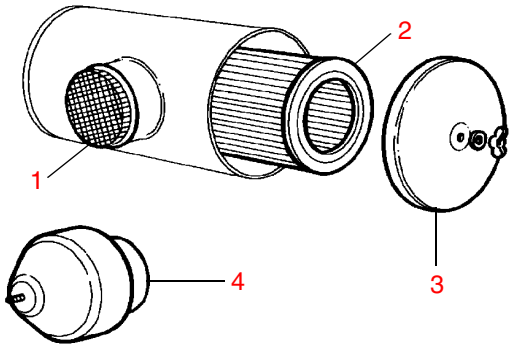

Fig. 27

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

WARNING DISCONNECT BATTERIES OR ANY OTHER MEANS OF STARTING ENGINE.

Key

(Fig. 27)

1 Mesh guard

2 Element

3 End cover

4 Pre-cleaner (Cyclone unit) (Optional)

DAILY INSPECTION

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

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. 28**).

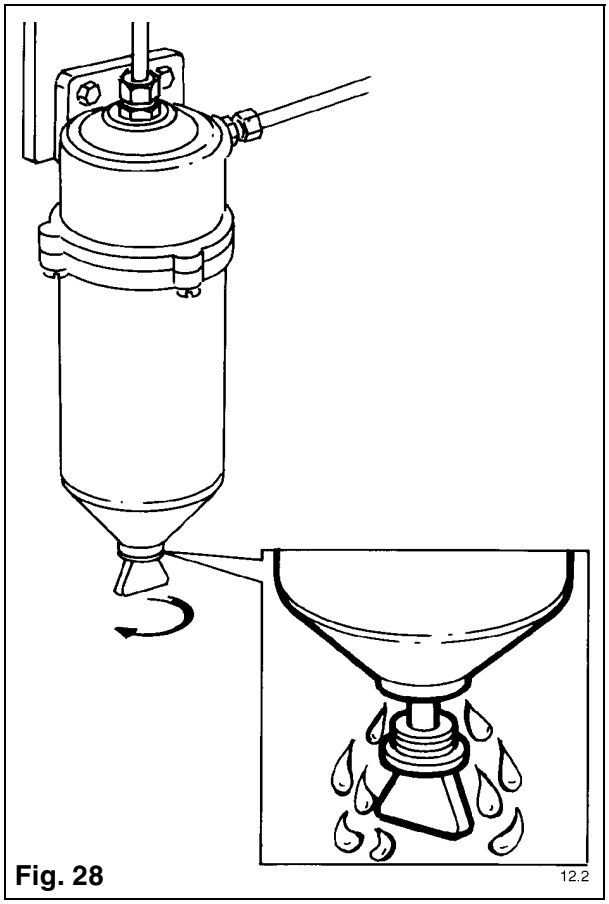

Fig. 28 12.2

AFTER FIRST 50 HOURS ONLY

FENNER TAPER LOCK BUSHES

Maintenance Instructions

Experience has shown that taper lock bushes, as fitted in the fan and alternator driven pulleys, can work loose shortly after being put into service. After a bush has been run for the first 50 hours, check the tightness of the screws. Tighten the screws gradually and alternately until tightened to the required torque (see **Torque Settings**). Replace any guards removed before running the engine (see **Fig. 29**).

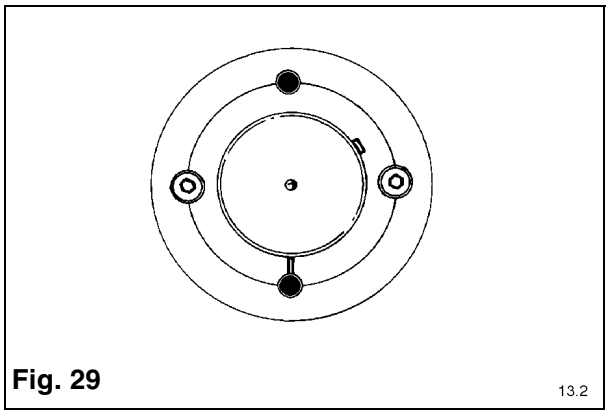

Fig. 29 13.2

AFTER FIRST 100 HOURS

NEW OR REBUILT ENGINES

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

Equalise bridge pieces and check valve clearances (see **pages 55-58**).

EVERY 250 HOURS OR EVERY 6 MONTHS

ENGINE OIL AND FILTERS

Change engine oil and filter (see **page 48**).

Equalise bridge pieces and check valve clearances (see **pages 55-58**).

Key

(Fig. 29)

1 Locating screw

EVERY 250 HOURS OR 6 MONTHS

CENTRIFUGAL OIL FILTER (IF FITTED)

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

Stop the engine, and allow time for the oil to drain back to the sump. **Refer to Fig. 30**.

1 Slacken safety clamp (**1**) unscrew cover nut and lift off cover.

2 Lift off rotor assembly (**2**) having allowed oil to drain from nozzles. The rotor should be removed and replaced on the spindle with extreme care in order to ensure that bearings are not damaged.

3 Secure rotor in dismantling tool **T6253/292**. Unscrew rotor cover nut (**3**) and separate rotor cover from body.

4 Remove standtube (**4**) using extraction tool **T6253/293** and clean.

5 Remove sludge from inside the rotor by means of a spatula and wipe clean. Ensure that all rotor components are thoroughly cleaned and free from deposits of dirt before reassembling the rotor. Failure to do so could cause an out-of-balance condition which will accelerate bearing spindle wear.

6 Clean nozzle with brass wire. Examine 'O'-ring (**5**) and renew if damaged.

7 Reassemble rotor completely and tighten top nut.

IMPORTANT: Ensure that rotor cover and rotor body are always matched by balance reference number and pin location.

DO NOT INTERCHANGE ROTOR COVERS.

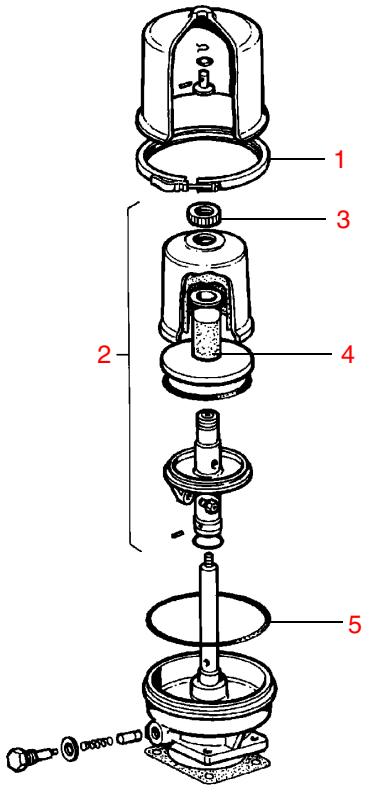

Fig. 30 700.3

8 Examine spindle journals, if damaged or worn replace with body assembly complete.

9 Reassemble filter completely, checking that rotor revolves freely, then replace filter body cover. Tighten cover nut and secure safety clamp. The clamp ring should be securely fitted at all times and the filter should not be run without the clamp ring fitted.

10 With engine running check all joints for leakage. Check for excessive vibration.

See **page 19** for oil change periods.

EVERY 250 HOURS OR EVERY 6 MONTHS

ALTERNATOR DRIVE BELT

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

Remove the small mesh guard around the alternator. The toothed belt used to drive the alternator relies on tooth engagement to transmit load. It does not require pre-loading, 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. 31**). Refit the guard.

Key

(Fig. 31)

1 Pulley guard

2 Tensioning arm

3 Drive guard

4 Pivot bracket and bolt

MAINTENANCE OF COOLANT

COOLING SYSTEM

Check the specific gravity and the pH value of the coolant (see **page 25 of the Workshop Manual**). Visually check the radiator core for debris causing air restriction.

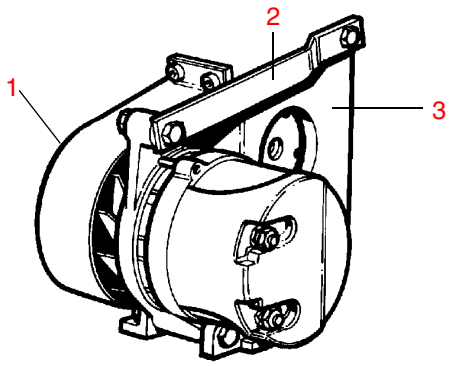

Fig. 31 475.2

FAN BELTS

Fan belts should be checked for wear and condition, particularly the following faults:

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 give same failure.

b 'V'-belt swelling or softening.

Caused by excessive contamination by oil, certain cutting fluids or rubber solvent.

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 the use of a banded belt.

EVERY 250 HOURS OR EVERY 6 MONTHS BEARINGS AND BELTS (COVRAD RADIATOR)

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

Remove the mesh guard around the fan belts, grease the fan bearings (**2**) and jockey pulley bearings (**4**) **Fig. 32**, using high melting point lithium LM grease at greasing points (**5**).

Check the tension and wear of the fan belts. Using moderate thumb pressure midway between the crankshaft and fan pulley, a total deflection of 12.5 mm (1/2") is satisfactory.

If the fan belts are worn, the complete set should be replaced and the fan pulley to crankshaft pulley alignment checked.

If adjustment is found necessary, slacken the two adjusting screws (**3**) and using a tube extension (**6**) fitted over either the fan or jockey pulley adjusting tag (**1**), move outwards to tension the belts and inwards to slacken the belts. Having set the tension of the belts, tighten the adjusting screws (**3**) and refit the fan belt guard.

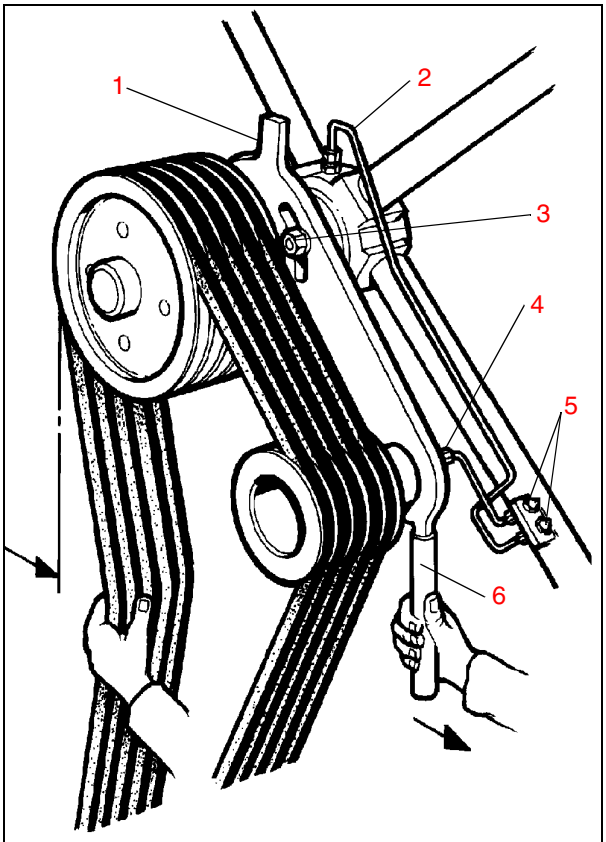

Fig. 32 476.3

FAN BEARINGS AND BELTS (BEARWARD RADIATOR)

Remove the mesh guard around the fan belts. The fan bearings (**1**) and jockey pulley bearings (**2**) do not need greasing as these are of the pre-packed type.

Check the tension and wear of the fan belts. Using moderate thumb pressure midway between the crankshaft and fan pulley (**1**), a total deflection of 12.5 mm (1/2") is satisfactory (see **Fig. 33**). If one or more fan belts are faulty, **a complete set must always be fitted**, and the fan pulley to crankshaft pulley alignment checked. If adjustment is found necessary slacken the locking bolts (**3**) and adjust nut (**4**) either way retighten locking bolts (**3**) and adjusting nut (**4**).

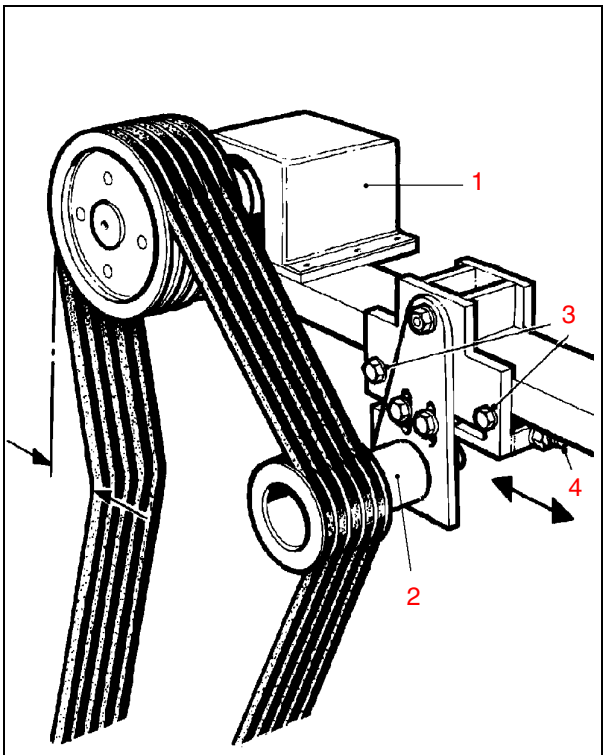

Fig. 33 477.3

EVERY 250 HOURS OR EVERY 6 MONTHS

CRANKCASE BREATHER, EARLIER ENGINES (RADIATOR COOLED)

WARNING DISCONNECT BATTERIES OR ANY OTHER MEANS OF STARTING. ALWAYS WEAR EYE PROTECTION AND PROTECTIVE GLOVES WHEN CLEANING BREATHER.

An extension pipe runs from both sides of the engine gearcase to the engine breathers, which are mounted on each side of the radiator **Fig. 34 and Fig. 35**. Unscrew each breather by turning it anti-clockwise. Wash it thoroughly. Shake it as dry as possible, finally blow it dry with compressed air and screw the breather firmly back into position.

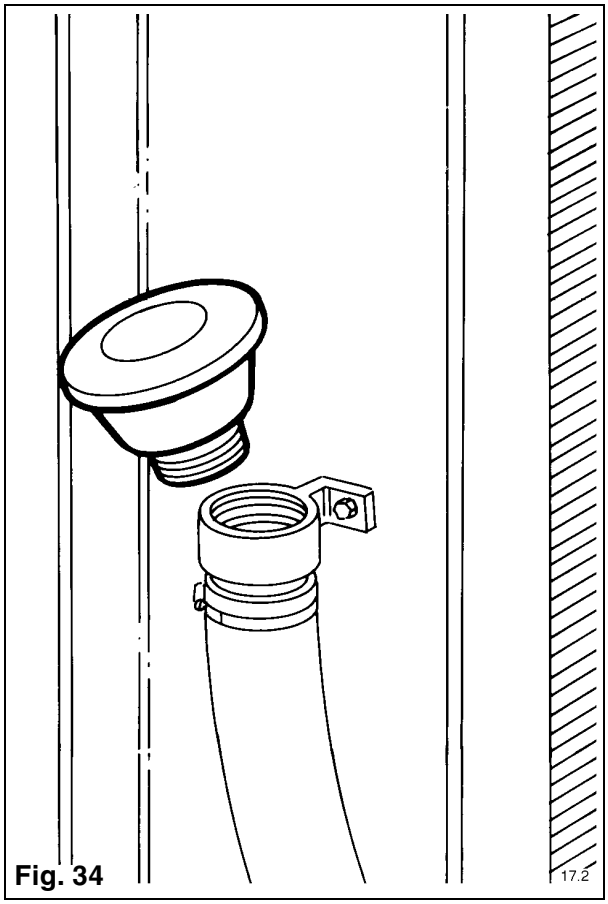

Fig. 34

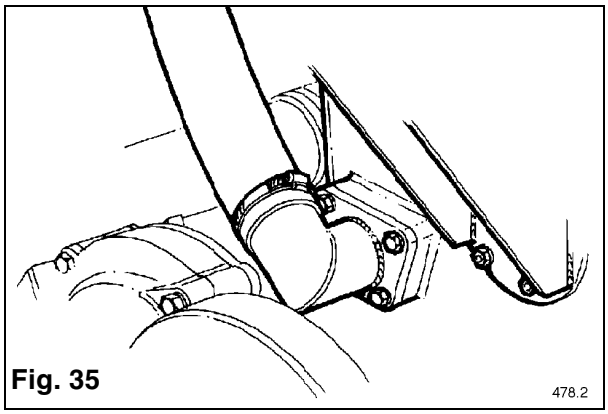

Fig. 35

EVERY 250 HOURS OR EVERY 6 MONTHS

CRANKCASE BREATHER (HEAT EXCHANGER COOLED ENGINES)

The crankcase breathers are mounted on the side of each thermostat housing and are connected to the engine via an extension pipe and bend fitted on each side of the gearcase (see **Fig. 37**). To clean a breather, unscrew the cap see **Fig. 36** by turning anti-clockwise and wash it thoroughly. Shake it as dry as possible, blow dry with compressed air and screw it firmly back into position.

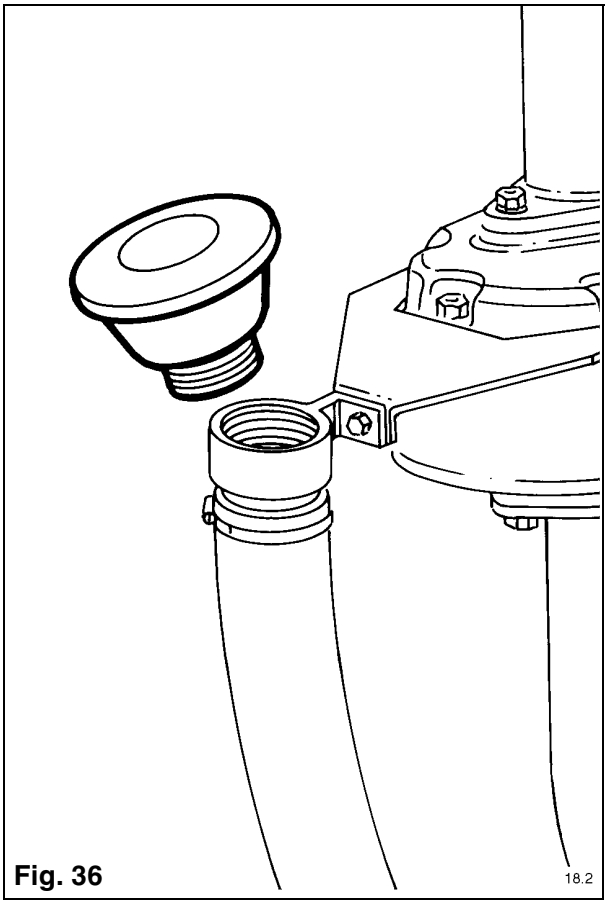

Fig. 36 18.2

AS FITTED ON 4012 (EARLIER ENGINES)

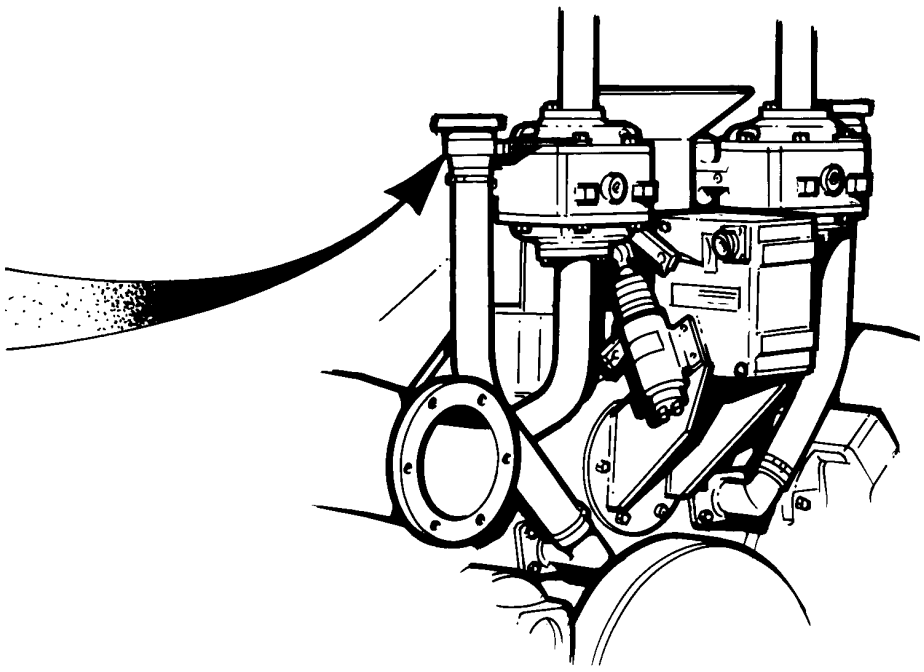

Fig. 37 479.2

EARLY 250 HOURS OR 6 MONTHS

CRANKCASE BREATHER (RADIATOR OR HEAT LATEST EXCHANGER COOLED ENGINES)

The crankcase breathers are mounted on the side of the thermostat housings and are connected to the engine via an extension pipe and bend fitted on each side of the gearcase (see **Fig. 39**). To clean the breather remove the top cover see **Fig. 38** and withdraw the two wire mesh elements and wash thoroughly. Shake as dry as possible, finally blow dry with an air line. Refit the elements into the breather body, and fit the top cover firmly back into position.

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

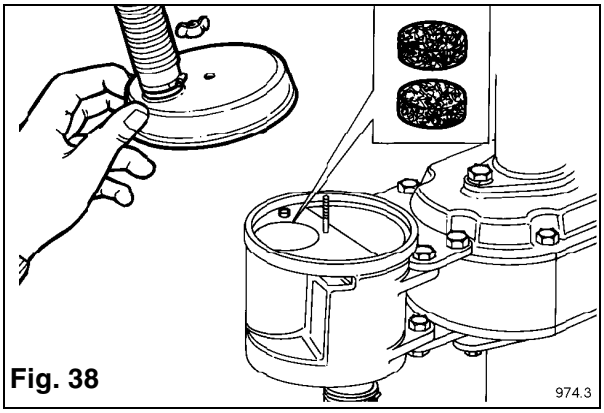

Fig. 38 974.3

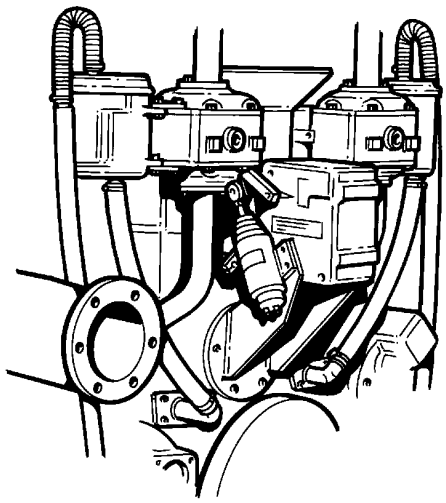

Fig. 39 975.2

AS FITTED ON ALL 4016 ENGINES AND 4012 (CURRENT ENGINES)

EVERY 250 HOURS OR EVERY 6 MONTHS

CLOSED CIRCUIT BREATHER SYSTEM (IF FITTED)

The closed circuit separators are mounted just behind the thermostat housing via an expansion pipe and hose bend which is fitted on each side of the gearcase and is connected to the air inlet via the breather valve see **Fig. 41**.

To clean the breather separator remove the complete unit from the engine remove the top cover and withdraw the foam element (see **Fig. 40**), check for oil saturation wash thoroughly (with a suitable detergent), shake as dry as possible and finally blow dry with compressed air. Check the lower body for sludge contamination build up and clean as above. Finally refit in reverse order.

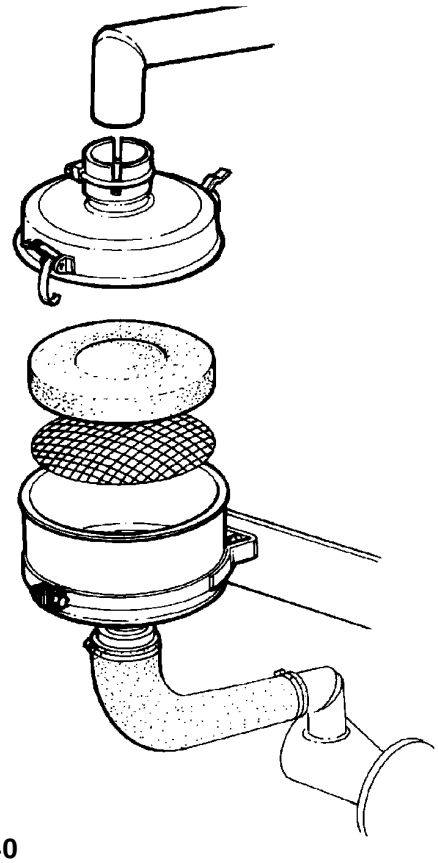

Fig. 40 1002.2

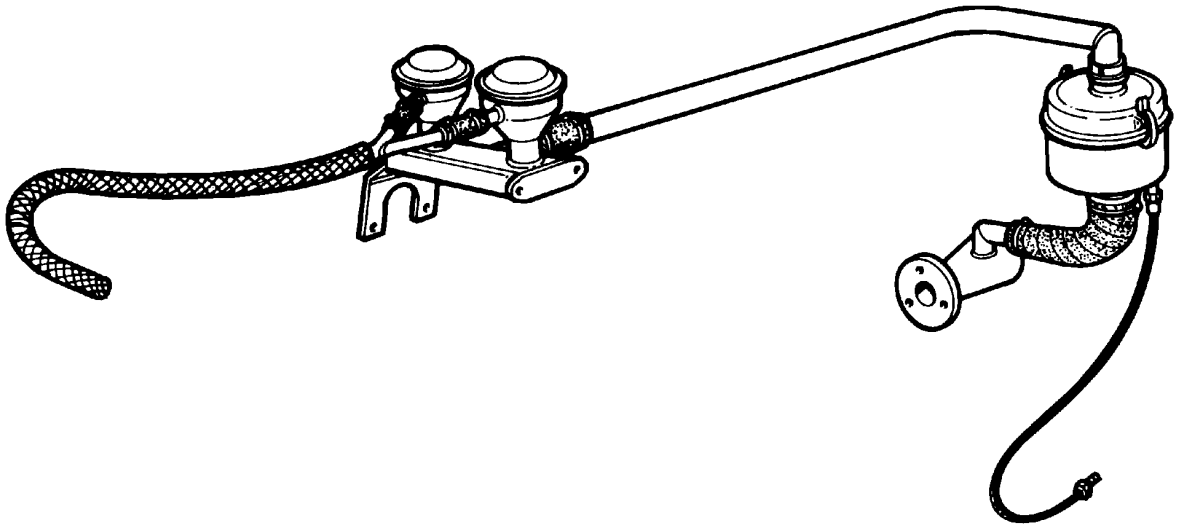

Fig. 41 1006.2

EVERY 250 HOURS OR EVERY 6 MONTHS

Two breather valves are mounted in the circuit. To remove release the pipe clips and pull away from the valve manifold. Wash the breather thoroughly (with a suitable detergent) 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 (see **Fig. 42**).

Key

(Fig. 42)

1 Breather valve

2 Fill with clean engine oil

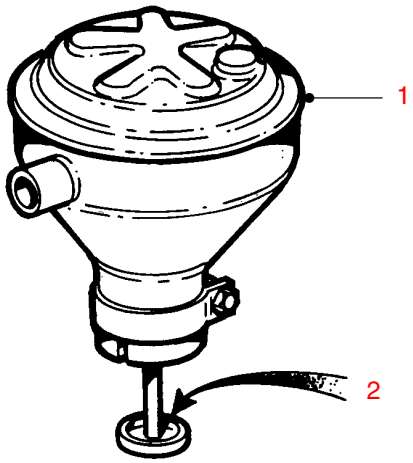

Fig. 42 1005.2

EVERY 250 HOURS OR EVERY 6 MONTHS

CHANGING ENGINE OIL AND OIL FILTERS (STANDARD HORIZONTAL TYPE)

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

With the engine stopped, place a suitable container of at least 214 litres (47 gal) beneath the drain plug (which is situated on the bottom edge of the sump directly under the dipstick). 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 quickly. While the oil is draining remove all three oil filters per bank, two on the main header supplying the bearings and one on the single header supplying the piston jets, by turning them anti-clockwise with a strap wrench **Fig. 43**).

NOTE: Removal of the oil filters will allow an escape of oil from the filter headers. It is therefore recommended that a suitable container of at least 5 litres (1 gal) capacity is positioned under each header prior to filter removal as the oil filters are of the disposable canister type they must be thrown away. Fill the oil filters with clean engine oil prior to fitting. Wipe clean the sealing faces and threaded bosses of the 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.

Having drained the engine oil, refit the drain plug and fill the engine with the appropriate grade of new oil (see **pages 19** & **20**). Ensure that the switch on the control panel and fuel stop lever on the engine are both in their respective 'stop' positions, and that the air shut-off valves have been manually set to the 'run' position (see **Fig. 2**). Then motor the engine over on the starter until a pressure of approximately 40 kPa (5lb/in2) is indicated on the pressure gauge, thus ensuring that the oil filters are full and the turbocharger bearings are primed (see **page 23**). Check the dipstick and add more oil if necessary.

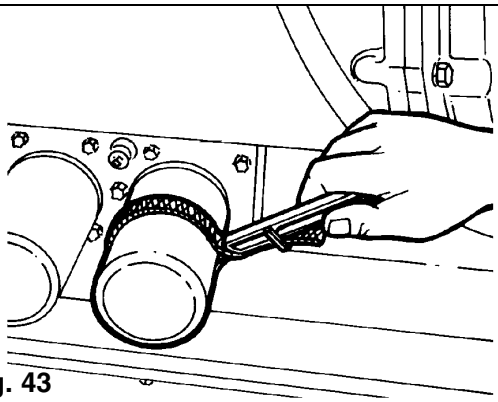

Fig. 43 22.3

WARNING IT IS ESSENTIAL TO PRIME THE SYSTEM AFTER AN OIL AND FILTER CHANGE TO AVOID OIL STARVATION PROBLEMS, WITH AUTOMATICALLY STARTING GENERATOR SETS, WHICH TAKE FULL LOAD IMMEDIATELY AFTER STARTING.

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 impossible to stop the engine to change the filters. 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 they may also 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. 44**. Failure to change filters when due can also lead to trouble from unfiltered oil.

Always fill a replacement filter with clean engine oil before fitting.

EVERY 250 HOURS OR 6 MONTHS

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. 44**, 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 clean 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 for leaks after the engine is restarted.

Key

(Fig. 44)

1 Change right filter

2 Normal running

3 Change left filter

Early Engines (optional)

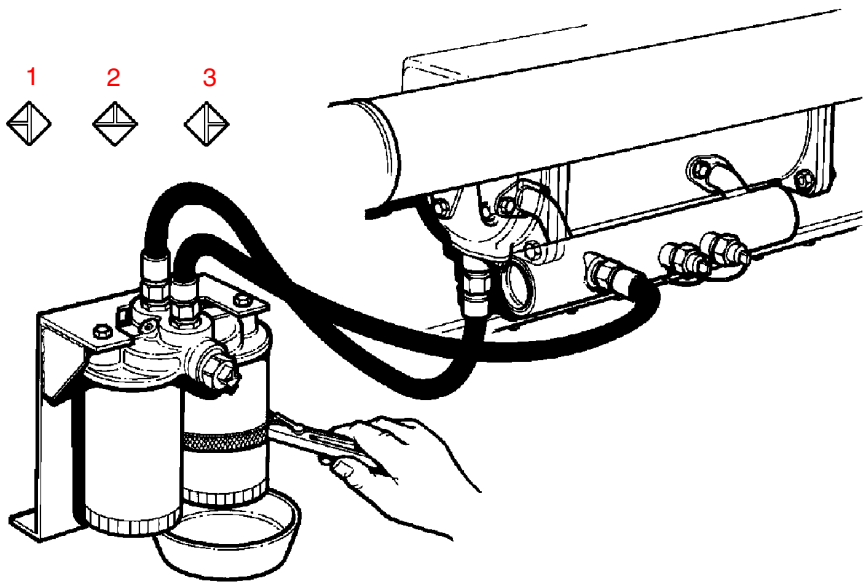

Fig. 44

482.2

EVERY 250 HOURS OR 6 MONTHS

CHANGING THE CHANGE OVER FILTER ELEMENTS WITHOUT STOPPING THE ENGINE

If the filters must be changed without stopping the engine. The normal position of the change-over valve is with the leg of the '**T**' mark pointing upwards, see **Fig. 44 or 45**, when both filter elements are in circuit. Turning the valve 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 which should be filled with new oil before screwing the canister into position using firm hand pressure only. Turning the valve so that the leg of the '**T**' points to the right puts the left hand filter out of service, so that this one can now be exchanged for a new canister also primed with oil as before. The valve is then returned to its original position, so that both elements of the filter are back in service. Check for leaks before leaving the engine and increasing its speed.

NOTE: Prepare for some spillage of oil as each canister is removed, by placing a bowl of about 5 litres or 1 gallon capacity under the filters.

NOTE: If the pipes connecting the change-over oil filters to the engine are removed for any reason, it is essential that they be reconnected correctly to avoid unfiltered oil getting into the system. See **Fig. 44 or 45**.

Left hand side pipe (**A**) fitted to the oil cooler header fits to the front of the oil filter header.

Right hand side pipe (**B**) fitted to the oil cooler header fits to the rear of the filter header.

Key

(Fig. 45)

1 Change right filter

2 Normal running

3 Change left filter

Later Engines (Optional)

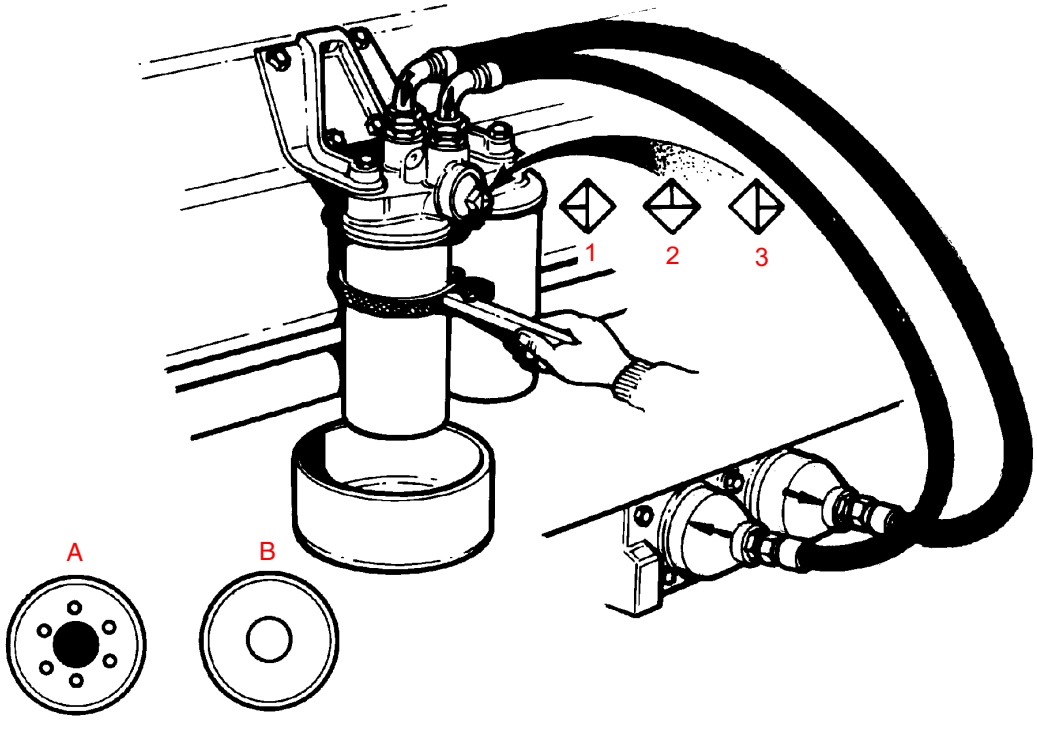

Fig. 45

928.3

EVERY 250 HOURS OR EVERY 6 MONTHS

CHANGING FUEL FILTER ELEMENTS

NOTE: Ensure complete cleanliness is adhered to.

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

HORIZONTAL FUEL FILTER (EARLY ENGINES)

First turn off the fuel on installations having an overhead supply, drain the sediment trap or pre-fuel filter (if fitted) before filter removal.

Remove the two fuel filters (one filter on each bank) located at the opposite end of the engine to the flywheel, by turning them anti-clockwise with a strap wrench **Fig. 46**.

NOTE: Removal of the filters will allow an escape of fuel from the filter housings and pipes, it is therefore recommended that a suitable container of at least 5 litres (1 gal) capacity is positioned under each housing prior to filter removal.

As the fuel filters are of the non-serviceable canister type they must be thrown away. Wipe clean the sealing faces and threaded bosses of the housings. Smear clean engine oil on the captive rubber sealing ring and carefully screw the new canister up to the housing using firm hand pressure only.

Turn on the fuel supply (if applicable) and vent the fuel system (refer to **pages 25-26**).

the filters for leaks with the engine running.

Key

(Fig. 46)

1 Oil filters

FUEL FILTER AND WATER SEPARATOR (FITTED TO 4012 ENGINES ONLY)

First turn off the fuel supply, drain the sediment trap or pre-fuel filter (if fitted) before filter renewal. Remove the fuel filter canister, which is located on the side of the gearcase, by unscrewing from the filter header with a strap wrench (**Fig. 47**).

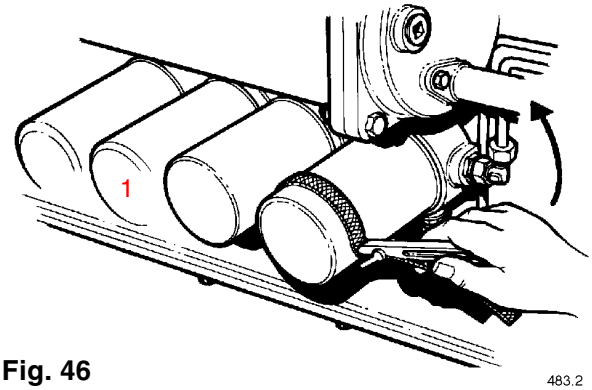

Fig. 46 483.2

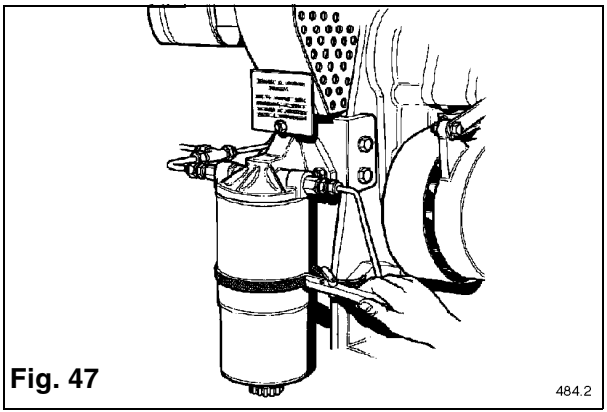

Fig. 47 484.2

STRAINER (FITTED TO 4016 ENGINES ONLY)

The screen inside the strainer body should be removed for cleaning (using a suitable cleaning agent) at the same time that the filter elements are replaced. To remove the screen, unscrew the cap nut under the body and withdraw it, catching any spillage of fuel in a 5 litre (1 gal) container.

EVERY 250 HOURS OR EVERY 6 MONTHS

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. 48**, 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 screws and operating the priming pump. Check for leaks when the engine is restarted.

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

The normal position of the change-over valve lever is vertically upwards, when both filters are in circuit. Turning the lever to the left, puts the right hand filter out of service, so that the right hand canister may be exchanged for a new one, smearing the seal with clean engine oil and tightening by firm hand pressure only. Bleed the air from the new filter by means of the vent screw as the lever is returned to the vertical position. Turning the lever so that it points the right, puts the left hand filter out of service so that it can then be exchanged for a new one, as before. Again bleed the air from the new filter as the lever is returned to its normal vertical position, so that both elements are back in circuit, and check for leaks before leaving the engine.

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.

CLEANING WATER TRAP/SEDIMENTER (WHERE FITTED)

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

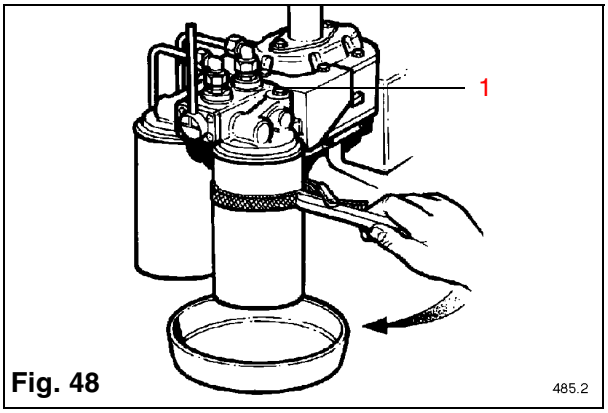

Fig. 48

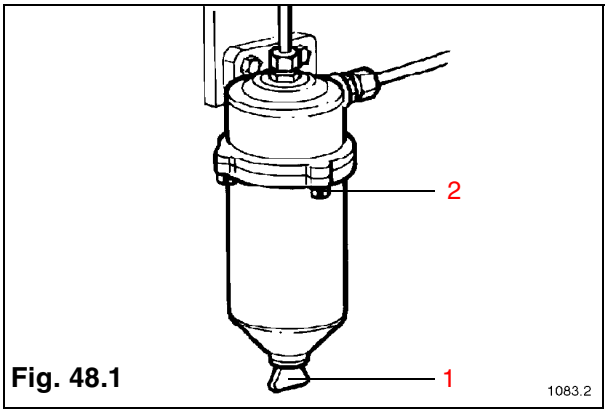

Fig. 48.1

Open drain plug (**1**) to remove collected water and sediment. The plug is self retaining, leave open until clean fuel is seen then screw back in see **page 41**. Remove the bowl by unscrewing three screws (**2**). Clean thoroughly all components and dry with compressed air. Replace joint washer if damaged.

FUEL SUPPLY AND PRIMING CIRCUITS MAINTENANCE INSTRUCTIONS

FUEL LIFT PUMP

For information on the lift pump see **Section KK1 of the Workshop Manual**.

HAND PRIMING PUMP (OPTIONAL)

The pump requires no maintenance but should it fail to operate a replacement unit is required.

EVERY 250 HOURS OR 6 MONTHS

EQUALISE ROCKER BRIDGES AND SETTING VALVE CLEARANCES

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

WARNING DISCONNECT BATTERIES AND OTHER MEANS OF STARTING THE ENGINE.

Remove the 4 slot headed screws from each rocker cover, lift off the covers and peel off and throw away the old gaskets **Fig. 49**.

To set the valve clearances and bridge pieces the appropriate valves must be rocking, use the table on **page 56**.

NOTE: For cylinder designation see **Data Data on page 11**.

In order that the engine may be rotated while the batteries are disconnected an engine rotating device can be fitted to a spare starter motor hole in the flywheel housing **Fig. 50**. This is fitted with a cover which is removed by unscrewing the retaining screw. Then using a socket and ratchet wrench press against the spring loaded bolt head until the pinion engages with the flywheel gear and rotate the engine to the desired position by turning in the direction of the arrow. When the engine is fitted with three starters, one of them may need to be removed to enable the above device to be fitted.

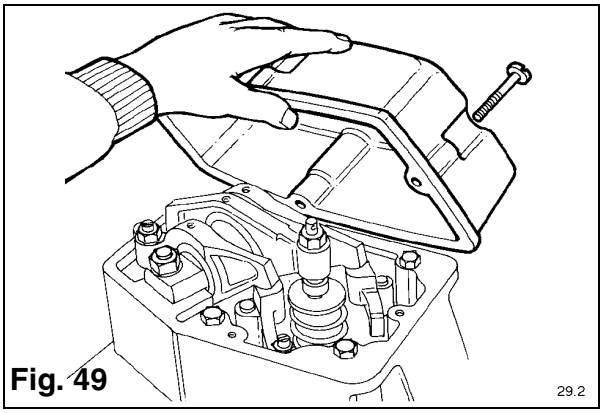

Fig. 49

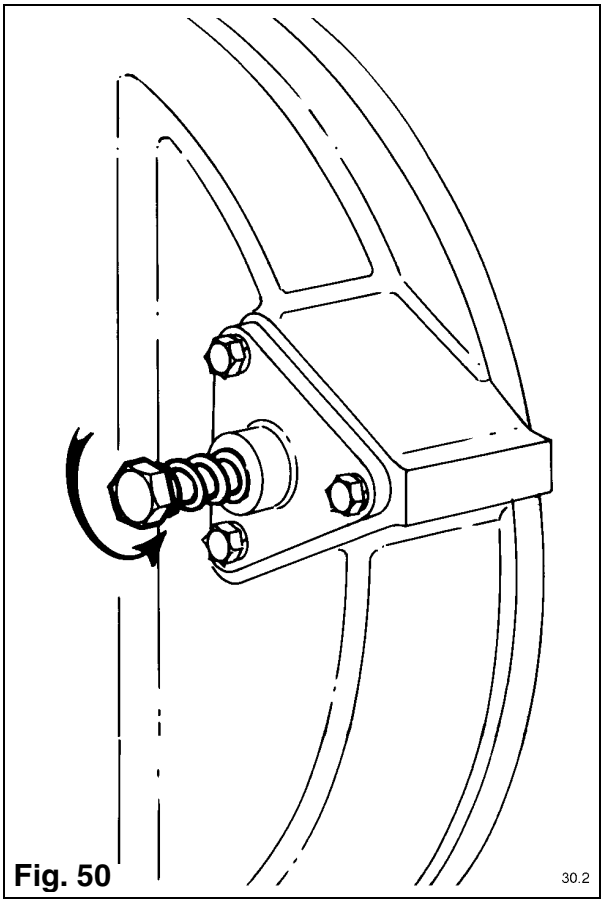

Fig. 50

Engine 4012 T.D.C.	Valves Rocking on Cylinder No.	Set Bridge Pieces and Valve Clearances on Cylinder no.
A1 & A6	A6	A1
B1 & B6	B1	B6
A2 & A5	A2	A5
B2 & B5	B5	B2
A3 & A4	A4	A3
B3 & B4	B3	B4
A1 & A6	A1	A6
B1 & B6	B6	B1
A2 & A5	A5	A2
B2 & B5	B2	B5
A3 & A4	A3	A4
B3 & B4	B4	B3

Engine 4016 T.D.C.	Valves Rocking on Cylinder No.	Set Bridge Pieces and Valve Clearances on Cylinder no.
A1 & A8	A8	A1
B1 & B8	B8	B1
A3 & A6	A6	A3
B3 & B6	B6	B3
A7 & A2	A2	A7
B7 & B2	B2	B7
A5 & A4	A4	A5
B5 & B4	B4	B5
A1 & A8	A1	A8
B1 & B8	B1	B8
A3 & A6	A3	A6
B3 & B6	B3	B6
A7 & A2	A7	A2
B7 & B2	B7	B2
A5 & A4	A5	A4
B5 & B4	B5	B4

EVERY 250 HOURS OR EVERY 6 MONTHS

If the valves required to be rocking are closed, rotate the engine one revolution, which will bring these valves to the rocking position.

The flywheel housing has an inspection hole directly below the 'B' bank turbocharger(s) through which the flywheel markings may be seen to line up with the pointer set in the flywheel housing **Fig. 51**.

The flywheel is marked as follows:-

4012		**4016**	
T.D.C.	A1-A6	T.D.C.	A1-A8
	A5-A2		A3-A6
	A3-A4		A7-A2
	B1-B6		A5-A4
	B5-B2		B1-B8
	B3-B4		B3-B6
			B7-B2
			B5-B4

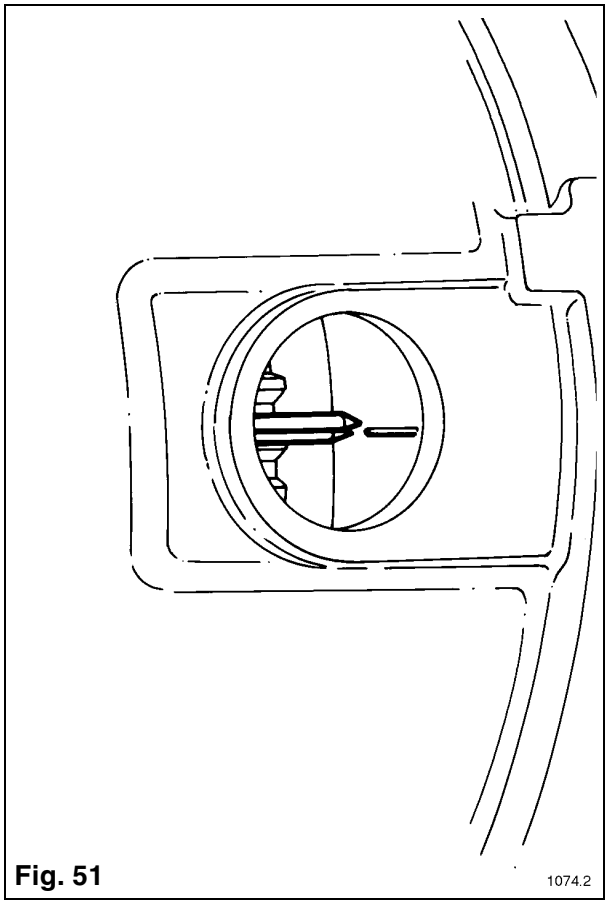

Fig. 51 1074.2

EQUALISING THE BRIDGE PIECES

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

Having rotated the engine to the correct position see the table on **page 56**, check that the inlet and exhaust rockers to be adjusted have clearance before continuing with the next operation. Loosen the locknut on each bridge piece adjuster, screw the adjuster out until the fixed side of the bridge piece rests on its valve, hold the top edge of the bridge piece down with one hand **Fig. 52**, then screw the adjuster down until you feel it touch the valve, thereby equalising valve lift. Tighten the lock nut without moving the adjuster.

EVERY 250 HOURS OR EVERY 6 MONTHS

WARNING FAILURE TO EQUALISE A BRIDGE PIECE MAY RESULT IN ENGINE DAMAGE. ALWAYS CHECK THAT THE PARTS FIT TOGETHER AND MOVE FREELY, BEFORE ASSEMBLY.

E.g. to adjust valves and bridge pieces on No. A1 cylinder set No. A6 cylinder valves rocking for the 4012 engine and No. A8 for the 4016 engine.

RESETTING THE VALVE CLEARANCES WITH ENGINE COLD

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

With both bridge pieces equalised, check and adjust the valve clearance using a 0.4 mm (0.016") feeler gauge for both the exhaust and inlet valve set between each rocker and bridge piece **Fig. 53**. If required screw the adjuster until the rocker is bearing lightly on the feeler gauge. Tighten the lock nut without moving the adjuster. (See **Torque Settings page 16**). 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.

For further instructions on maintenance please refer to the **Maintenance Section of the Workshop Manual**.

LINKAGE FROM THE GOVERNOR TO THE CONTROL SHAFTS

Check the freedom of operation of these important linkages, which are vital to the proper running of the engine.

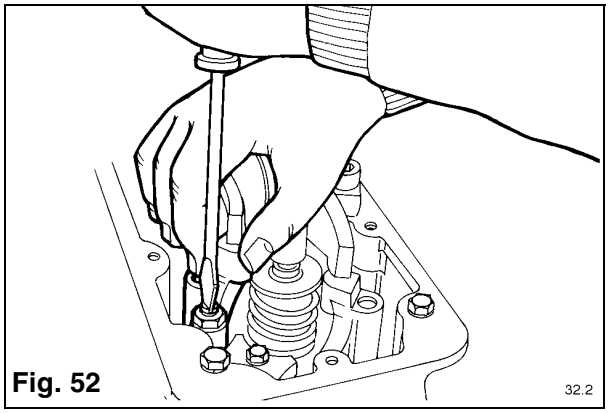

Fig. 52

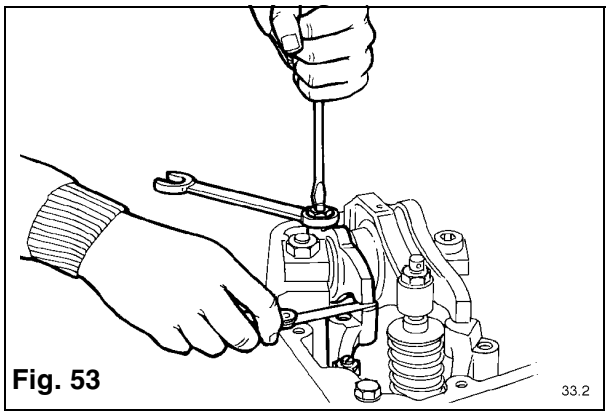

Fig. 53

OVERHAUL PERIODS

The intervals at which routine overhauls are required, to keep an engine in good operating condition, will vary considerably depending upon operating conditions, the quality of lubricating oil and fuels used, and the engine operating speed.

The frequency required for top overhaul will depend upon the condition of valve seats, and in the case of prolonged light load operation, the amount of carbon accumulated around the valves and on the piston crowns.

A major influence on valve condition is tappet clearance and the importance of checking tappet clearances every **250** hours cannot be overstressed.

After the **FIRST 2500 HOURS** operation of a new engine it is good practice to remove the unit injectors and check their condition, carry out a compression test, and an endoscopic (borescope) examination of liner and valve condition. If there are any problems, then remove **TWO** cylinder heads to **assess** the condition of the valves, cylinder bores and fuel injectors.

If all components are in good condition, clean the parts and reassemble the engine leaving the other cylinders alone.

This inspection will enable maintenance engineers to decide upon the required frequency of top overhaul to suit the particular application.

EVERY 2500 HOURS (TOP OVERHAUL IF NECESSARY)

A top overhaul may involve some or all of the following operations depending upon the hours run, the engine application and the duty cycle.

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

CYLINDER HEAD

NOTE: Service exchange cylinder heads are available.

Remove the cylinder heads from the engine and remove the inlet and exhaust valves. Soak the cylinder head in a carbon removing fluid or remove all deposits by use of a scraper and wire brush.

Check for cracks especially between valve ports and the injector hole. Check core plugs and replace if leaking or corroded.

When handling, always protect the bottom machined face from accidental damage.

Examine the injector tubes for leaks. Check the nozzle seating face.

Prior o refitting the valves, wash the head thoroughly and blow off with compressed air. If new core plugs or injector tubes have been fitted a hydraulic pressure test to 6.9 bar (100 lb/in^2) for leaks should be carried out using hot water at 70-90°C (158-194°F) .

WARNING WHEN USING COMPRESSED AIR ALWAYS WEAR EYE PROTECTION.

VALVE GUIDES

Inspect the bores of the guides for wear and check the fit of a new valve. Check for pick-up or scoring. Replace if necessary.

VALVES

Remove carbon and scale by soaking in a water based solvent or by use of a scraper and wire brush. Polish with fine emery cloth. Examine the valve heads for cracks. Inspect valve seats and true up by grinding to the correct angle if required. Check the valve stem tip for wear and reface by grinding if necessary. (To a maximum limit of 0.4 mm (0.015").

Check the valve stems for wear or scoring.

Check valve heads for distortion by rolling the stems on a surface table. Scrap any bent valves. Replace any worn collets and valve spring retainers. Check valve protrusion after refitting into head.

EVERY 2500 HOURS OR 12 MONTHS IF NECESSARY

VALVE SEAT INSERTS

Examine the valve seats for pitting and wear. If necessary reface them using a planetary grinder and then hand lap the valves into their seats using grinding paste. In cases of extreme wear or burning, fit new inserts, (see **Section R4 in the Workshop Manual**).

VALVE SPRINGS

Measure the free length. Compare with a new spring (See **page 41 in Workshop Manual Schedule of Wear and Renewal Limits**). Reject any spring which may have a permanent set.

Check the ends of the springs for squareness.

ROCKERS AND ROCKER BRIDGES

Inspect the bridge pieces and their guide also each rocker on its shaft for wear and replace where necessary.

INJECTOR TUBES

These do not require replacing unless they are leaking.

PISTONS AND LINERS

Using a blunt scraper, remove excessive carbon from the piston crown and the liner flange face. Do not use emery cloth. Do not allow any carbon to find its way down between the piston and liner. Rotate the engine as required. Wipe the bores clean and lubricate before refitting the cylinder heads.

EVERY 2500 HOURS OR 12 MONTHS

COOLING SYSTEM

Drain off the coolant in the fresh water system using the drain plug fitted in the oil cooler end covers. Refill the system as described on **page 27**.

GENERAL ATTENTION

Also carry out all checks and fit replacement parts as listed for each service period in the Maintenance Schedule.

EVERY 12 MONTHS CHANGE THE WOODWARD GOVERNOR OIL

WARNING DISCONNECT BATTERIES AND ALL OTHER MEANS OF STARTING. ALWAYS WEAR PROTECTIVE GLOVES AND GOGGLES.

Remove the drain plug from the front of the governor whilst the engine is still warm and collect the 1/2 gallon / 2 litres of oil in a suitable container. Refit the plug and refill with a similar quantity of diesel fuel. Reconnect the batteries, start the engine and run it at a low speed. Cycle the governor by opening the needle valve by two or three turns. Let the governor hunt for a minute or two, then stop the engine and drain the governor. Repeat this flushing operation and then replace the diesel fuel with new SAE30 or SAE15W/40 engine oil.

Restart the engine and reset the compensation adjustment and needle valve setting. (See **Sections AA54-AA75 in the Workshop Manual** for UG10 and 3161 governors).

FIRST MAJOR OVERHAUL

If service schedules are adhered to major overhauls may not be required until 20,000 hours of operation have been completed.

The charge air cooler and heat exchanger will also need to be inspected at 10,000 hours for internal cleaning of the inside and outside of the tubes, and the maintenance period determined for future overhauls.

The **FIRST** assessment of engine condition will enable maintenance engineers to plan the time of major overhauls i.e. **10,000** and **20,000** hours to be carried out at convenient times e.g. to coincide with annual refits or factory shut-downs.

The oil change intervals may be altered according to operating experience over 1000 hours by agreement with Perkins Engines (Stafford) Limited and subject to oil analyses being carried out on a regular basis, see **pages 19 & 20**.

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 lad 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

For 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.

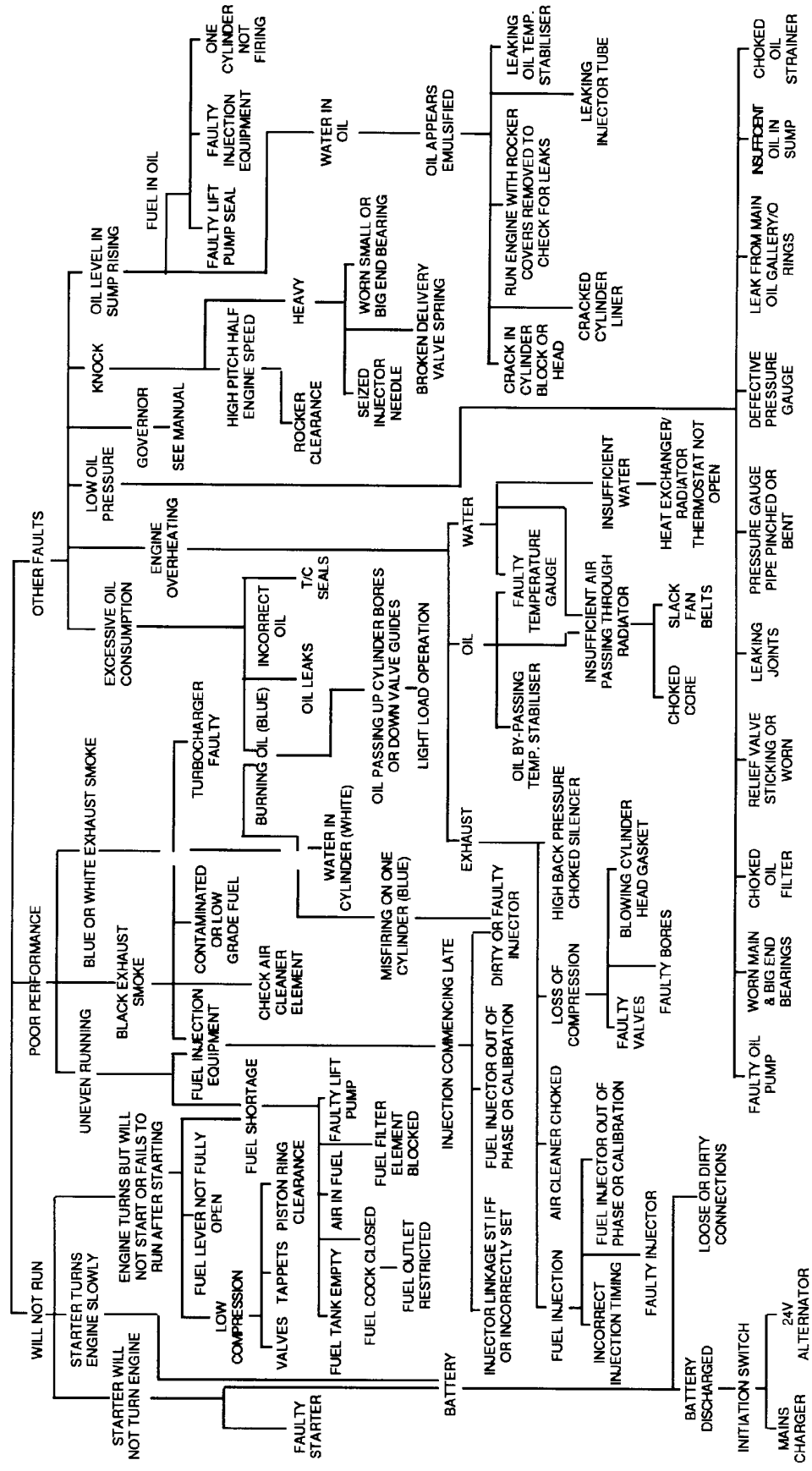
WILL NOT RUN
STARTER TURNS ENGINE SLOWLY
STARTER WILL NOT TURN ENGINE
FAULTY STARTER
BATTERY DISCHARGED
MAINS CHARGER
24V ALTERNATOR
INITIATION SWITCH
ENGINE TURNS BUT WILL NOT START OR FAILS TO RUN AFTER STARTING
LOW COMPRESSION
FUEL LEVER NOT FULLY OPEN
VALVES
TAPPETS
PISTON RING CLEARANCE
FUEL SHORTAGE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

Fig. 54

Starting circuit for 4012 engine range, read in conjunction with wiring diagram **Fig. 57**.

Key

(Fig. 55)

1 Terminal box
2 Starter
3 Repeater relay
4 Emergency stop
5 Starter motor
6 Start relay
7 Start inhibit relays
8 Fuel stop solenoids (energised to run)
9 Wire sizes
10 Magnetic pick-ups
11 Engine flywheel
12 Electronic governor control box
13 Electronic governor actuator

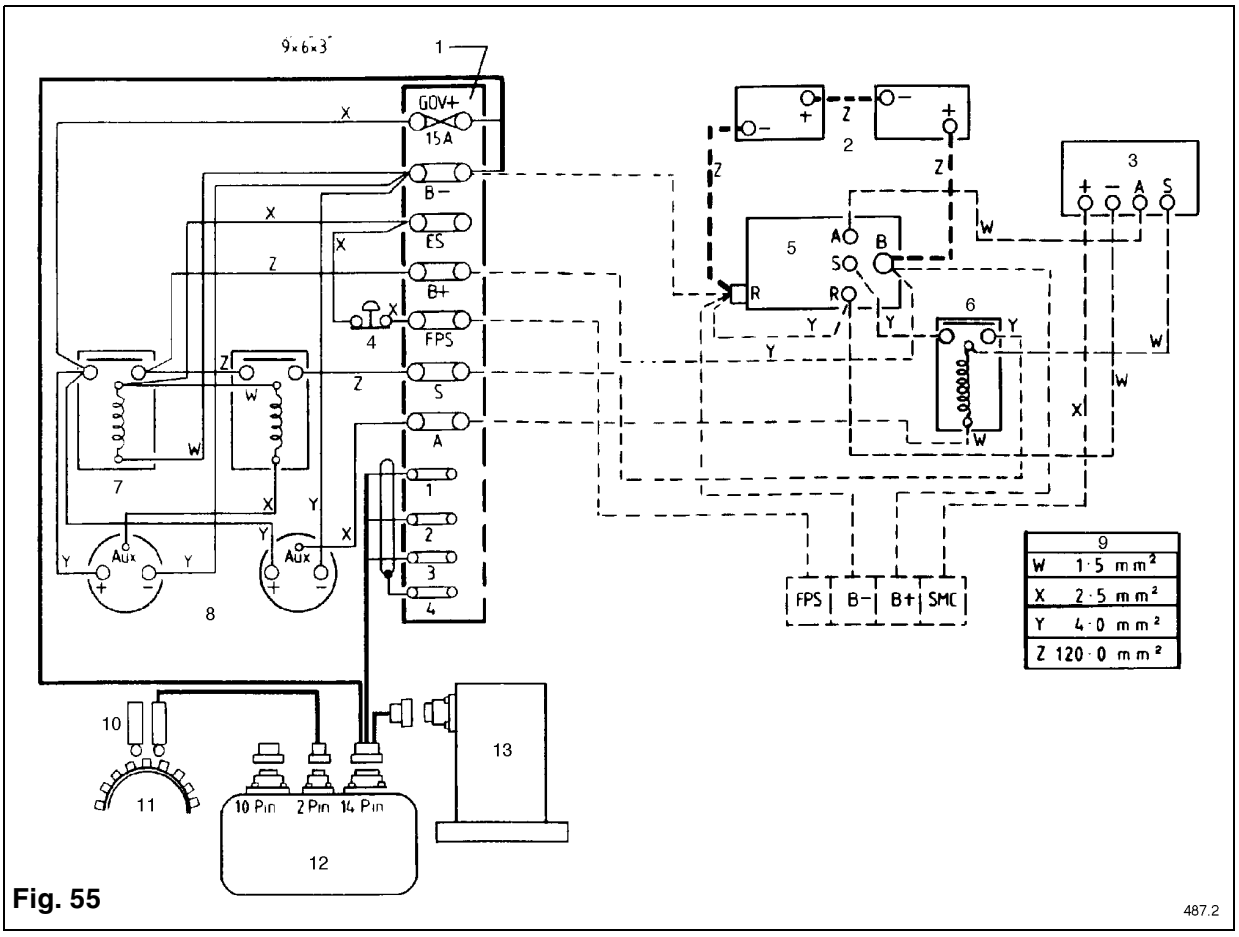

Fig. 55

487.2

Starting circuit for 4012 engine range, read in conjunction with wiring diagram **Fig. 57**.

Key

(Fig. 56)

1 Terminal box
2 Starter motor 1
3 Starter motor 2
4 24 v Starting batteries
5 Emergency stop switch
6 Start relays
7 Start inhibit relays
8 Fuel stop solenoids (energised to run)
9 Wire sizes
10 Magnetic pick-ups
11 Engine flywheel
12 Electronic governor control box
13 Electronic governor actuator

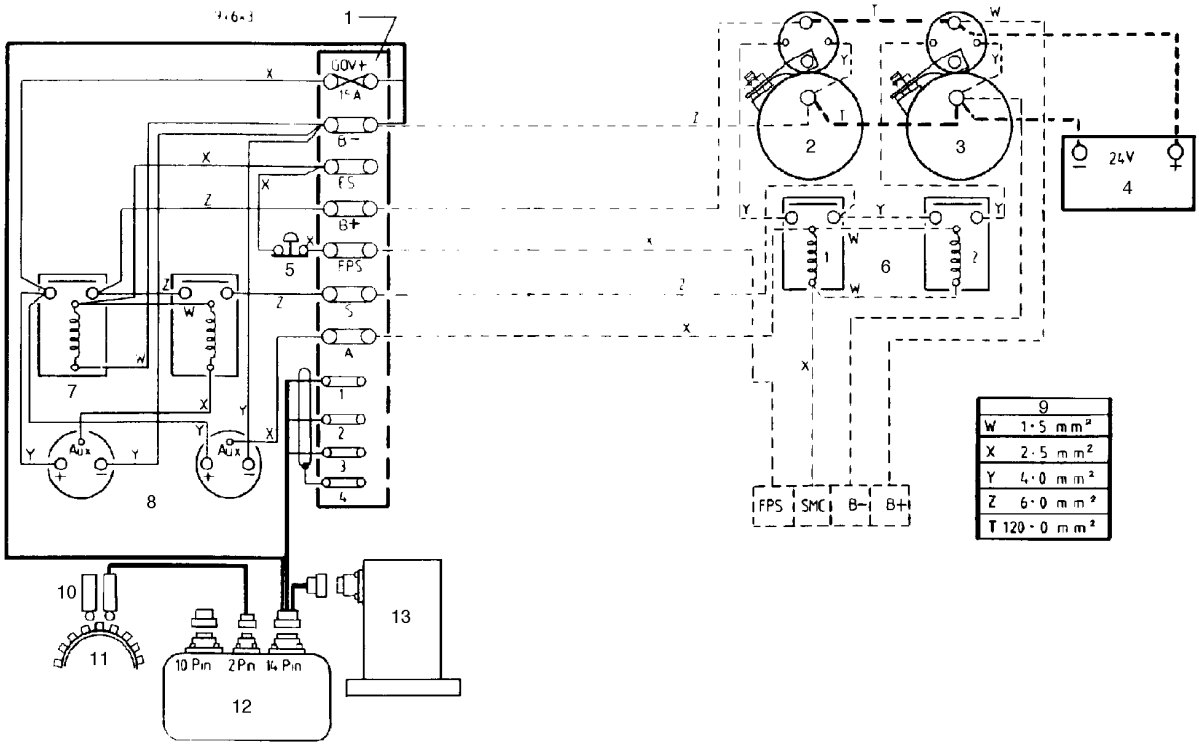

Fig. 56

488.2

NOTES:

1 To enable to run immediately on depressing start button 'FPS' must be fed 24 volt +ve. To stop break this +ve supply, on overspeed stopping energise air shutoff valves also.

2 All switches shown engine at rest. (Close on a fault).

3 Start inhibit relays allow fuel stop solenoids to energise before cranking.

Key (Fig. 57)

1 Wiring by Perkins
2 Start batteries
3 Repeater relay
4 Engine instrument panel
5 Senders
6 Oil temperature
7 Oil pressure
8 Water temperature
9 Oil temperature
10 Oil pressure
11 Water temperature
12 Tachometer
13 Ammeter
14 Starter motor
15 Starter relay
16 Emergency stop switch
17 Wire sizes
18 Oil pressure switch
19 Charging alternator
20 Starter inhibit relays
21 Air shutoff solenoid valves energised to stop, on overspeed fault only. Not continuously rated. Must be manually reset.
22 Fuel stop solenoids energised to run
23 Two switch speed unit
24 Switch 2 overspeed
25 Switch 1 speed 600 rpm
26 Micro switches
27 Engine fault switches left/right/banks
28A Water temp. right
28B Water temp. left
29A Oil pressure right
29B Oil pressure left
30 Magnetic pick-ups
31 Engine flywheel
32 Electronic governor control unit
33 Electronic governor actuator
34 Speed trim pot
35 If speed trim pot is not required remove and connect thus
36 Typical terminal block

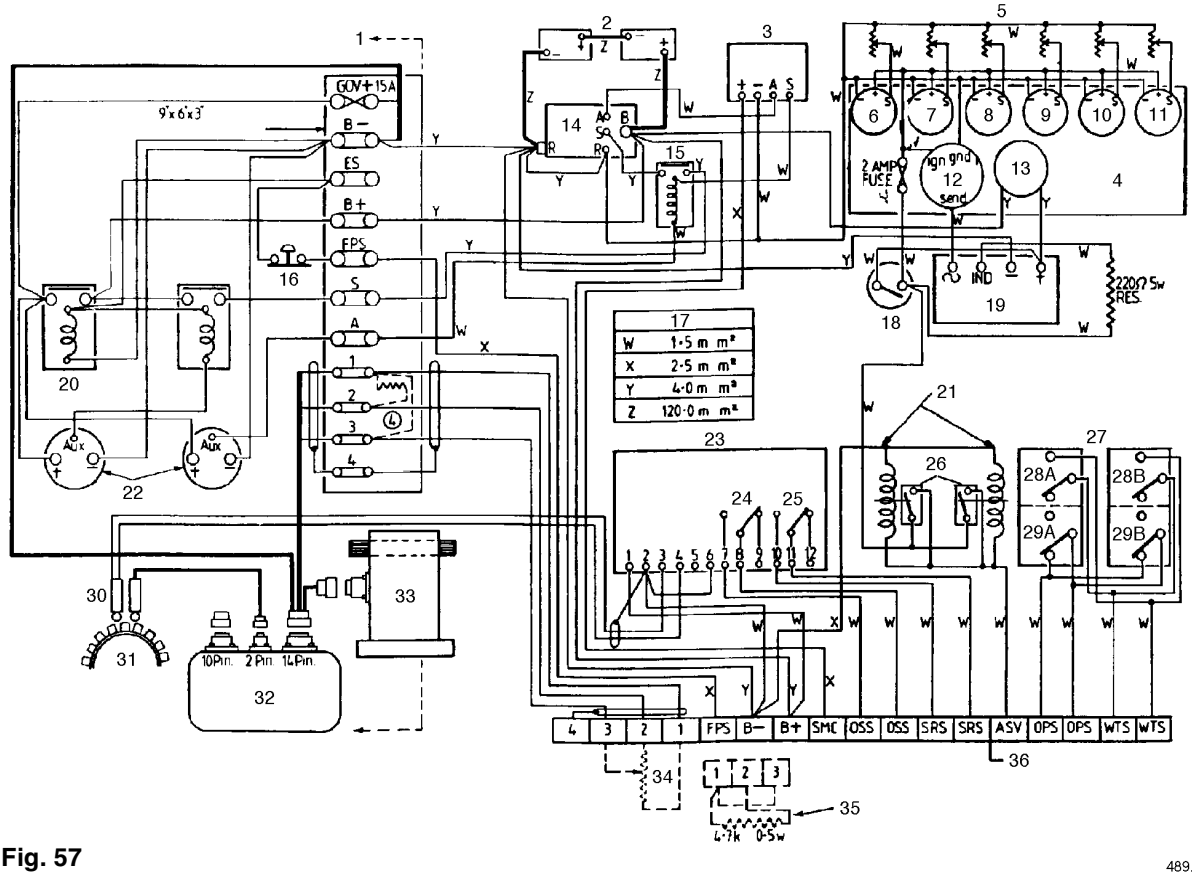

Fig. 57

489.2

NOTE: To enable engine to run immediately on depressing start button FPS must be fed 24 volt +ve. To stop break this +ve supply. On overspeed stopping energise air shutoff valves also.
All switches shown engine at rest (close on a fault).
Startinhibit relays allow fuel stop solenoids to energise before cranking.
Air shutoff solenoid valves micro switches ensure one valve alone cannot operate (+ve signal from oil pressure switch).

Key (Fig. 58)

1 Terminal box Perkins supply
2 Starter motor 1
3 Starter motor 2
4 Engine instrument panel
5 Oil temperature
6 Oil pressure
7 Water temperature
8 Oil temperature
9 Oil pressure
10 Water temperature
11 Fuse 2 amp
12 Tachometer
13 Ammeter
14 Emergency stop
15 Start relays
16 Oil pressure switch
17 Charging alternator
18 Start inhibit relays
19 Air shutoff solenoid valves. Energised to stop on overspeed fault only. Not continuously rated. Must be manually reset.
20 Engine fault switches left/right banks
21A Water temp. left
21B Water temp. right
22A Oil pressure left
22B Oil pressure right
23 Fuel stop solenoids (energised to run)
24 Two switch speed unit
25 Switch 2 overspeed
26 Switch 1 700 rpm
27 Magnetic pick-up
28 Engine flywheel
29 Electronic governor control box
30 Electronic governor actuator
31 Speed trim
32 If speed trim pot is not required remove and correct thus.
33 Typical terminal box
34 Wire sizes

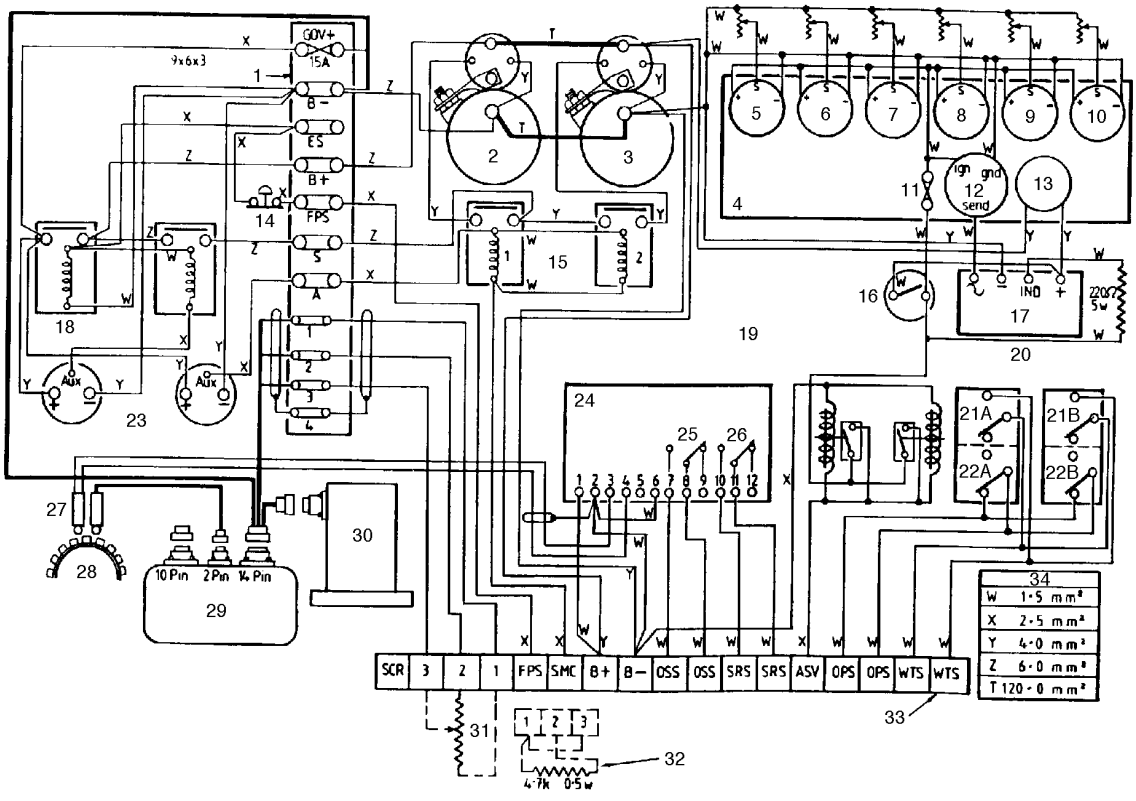

Fig. 58

490.2

4012/16 WIRING DIAGRAM, SINGLE STARTER AND HYDRAULIC GOVERNOR (EARLY ENGINES)

Engine fitted with regulators Europa hydraulic governor

NOTE: All switches shown engine at rest

Key
(Fig. 59)

1 Engine instrument panel
2 Oil temperature gauge
3 Oil pressure gauge
4 Water temperature gauge
5 Oil temperature gauge
6 Oil pressure gauge
7 Water temperature
8 2 Amp fuse
9 Tachometer
10 Ammeter
11 24 volt start batteries
12 Charging alternator
13 Resistor
14 Oil pressure switch
15 Repeater relay
16 Starter motor
17 Starter relay
18 Solenoid
19 Engine fault switches left/right bank
20A Water temperature
20B Water temperature
21A Oil pressure
21B Oil pressure
22 Two switch speed unit
23 Switch 1 700 rpm
24 Switch 2 1725 rpm
25 Engine flywheel
26 Air shutoff solenoid valves. Energised to stop on overspeed fault only. Not continuously rated. Must be manually reset.
27 Governor speeder motor
28 Connections in main alternator for remote volts trimmer
29 Fitted terminal box
30 Customers 16 core 2.5mm2 to control panel

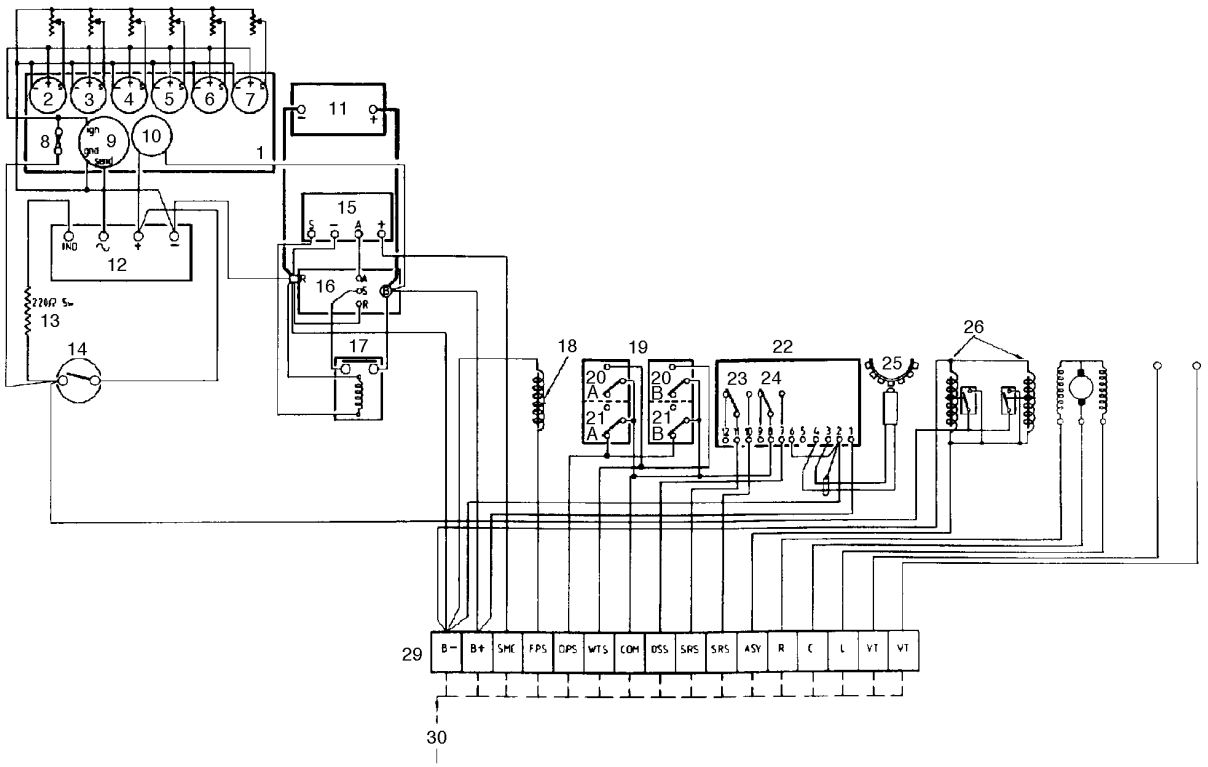

Fig. 59

491.2

Key
(Fig. 60)

1 Terminal box
2 Starter motor 1
3 Starter motor 2
4 Engine instrument panel
5 Oil temperature gauge
6 Oil pressure gauge
7 Water temperature gauge
8 Oil temperature gauge
9 Oil pressure gauge
10 Water temperature gauge
11 Tachometer
12 Ammeter
13 Emergency start
14 Start relay
15 Oil pressure switch
16 Battery charging alternator
17 Start inhibit relays
18 Fuel stop solenoids (energised to run)
19 Air shutoff solenoid valves. Energised to stop on overspeed fault only. Not continuously rated. Must be manually reset.
20 Two switch speed unit
21 Switch 2 overspeed
22 Switch 1 speed 700 rpm
23 Micro switches
24 Engine fault switches left/right bank
25A Water temperature switch
25B Water temperature switch
26A Oil pressure switch
26B Oil pressure switch
27 Engine flywheel
28 Magnetic pick-ups
29 Heinzmann Control box
30 Heinzmann actuator
31 Fitted terminal box

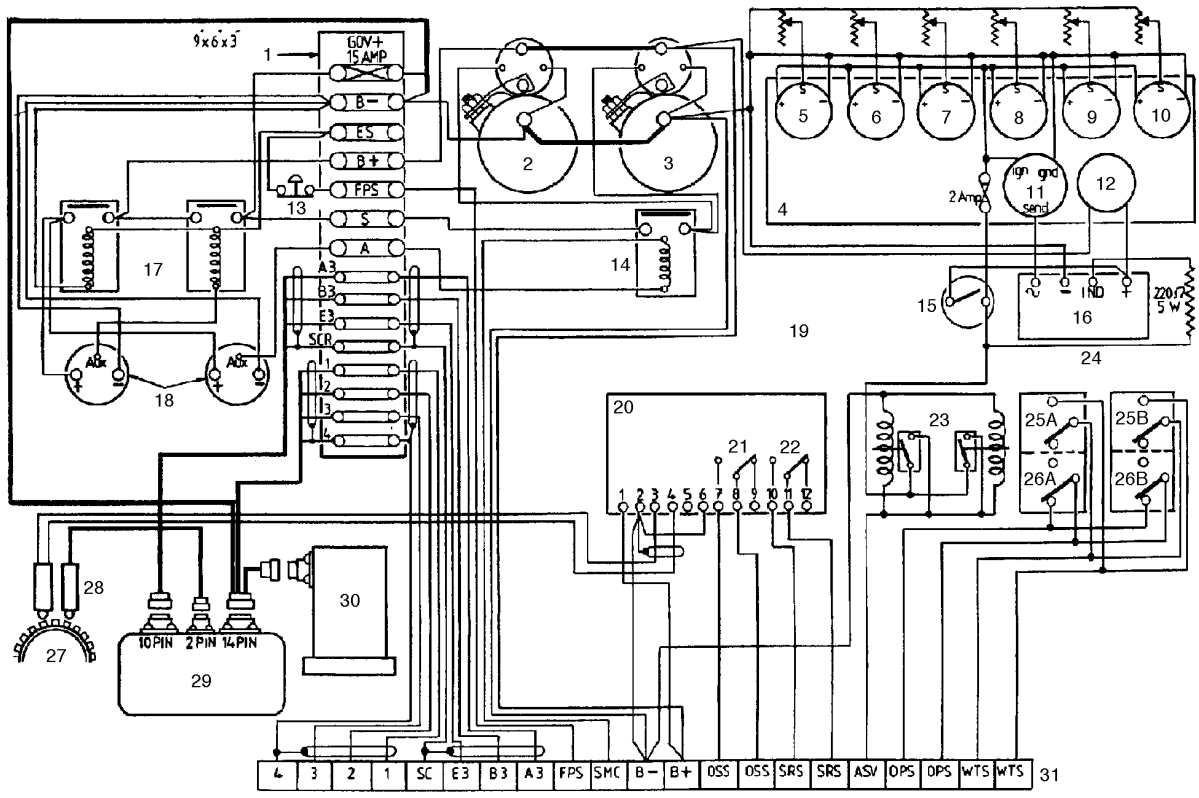

Fig. 60

Z12480.2

Engine engine wiring to engine fitted terminal box on diesel engines.

Key
(Fig. 61)

1 Engine fitted terminal box
2 Starter motor 1
3 Starter motor 2
4 Emergency stop
5 Start inhibit relays
6 Start relay
7 Fuel stop solenoids (energised to run)
8 Magnetic pick-ups
9 Engine flywheel
10 Electronic governor control box
11 Electronic governor actuator
12 Permanent battery positive supply for engine to run. Remove this positive supply to stop
13 Start engine
14 Battery positive

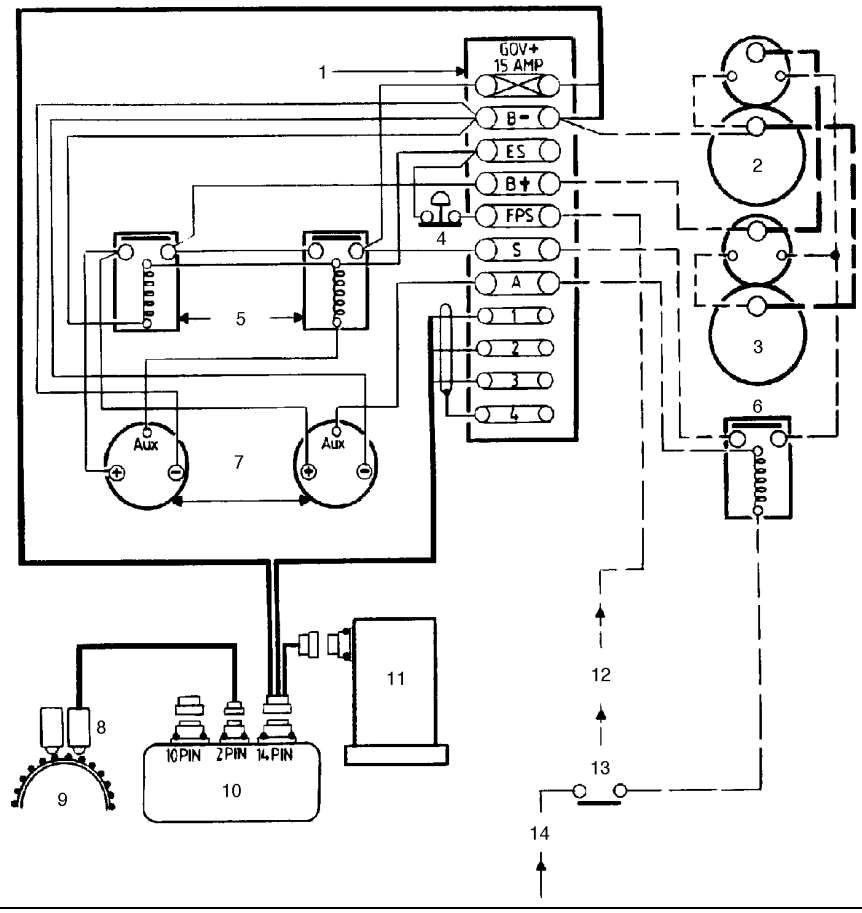

Fig. 61

Key
(Fig. 62)

1 Engine fitted terminal box
2 Two off air shutoff solenoid valves energise to stop. To operate only in conjunction with overspeed fault.
3 Emergency stop
4 Starter motor 1
5 Starter motor 2
6 Start relay
7 Battery charging alternator
8 Oil pressure switch
9 Start inhibit relay
10 Fuel stop solenoids (energised to run)
11 Two switch speed unit
12 Overspeed
13 Speed reference 600 rpm
14 Engine fault switches
15 'A' bank
16 'B' bank
17A Water temperature
17B Water temperature
18A Oil pressure
18B Oil pressure
19 Magnetic pick-ups
20 Engine flywheel
21 Electronic governor control box
22 Electronic governor actuator
23 **NOTE:** All switches are shown with the engine at rest
24 Typical linking box to controller

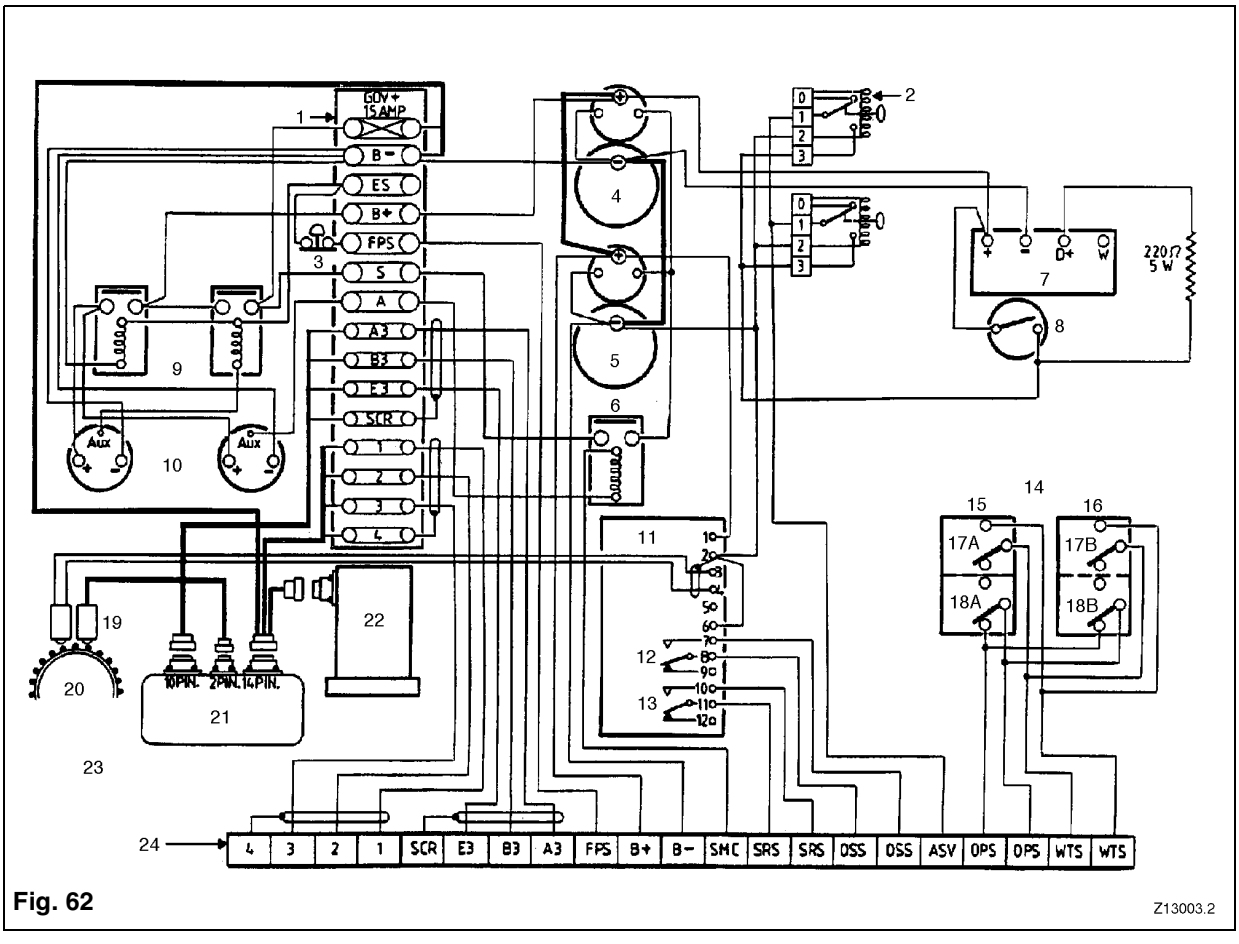

Fig. 62

Z13003.2

Key
(Fig. 63)

1 Engine fitted terminal box
2 Four off air shutoff solenoid valves energised to stop. To operate only in conjunction with overspeed fault.
3 Emergency stop
4 Starter motor 1
5 Starter motor 2
6 Start relay
7 Battery charging alternator
8 Oil pressure switch
9 Start inhibit relay
10 Fuel stop solenoids (energised to run)
11 Two switch speed unit
12 Overspeed
13 Speed reference 600 rpm
14 Engine fault switches
15 'A' bank
16 'B' bank
17A Water temperature
17B Water temperature
18A Oil pressure
18B Oil pressure
19 Magnetic pick-ups
20 Engine flywheel
21 Electronic governor control box
22 Electronic governor actuator
23 **NOTE:** All switches are shown with the engine at rest
24 Typical linking box to controller

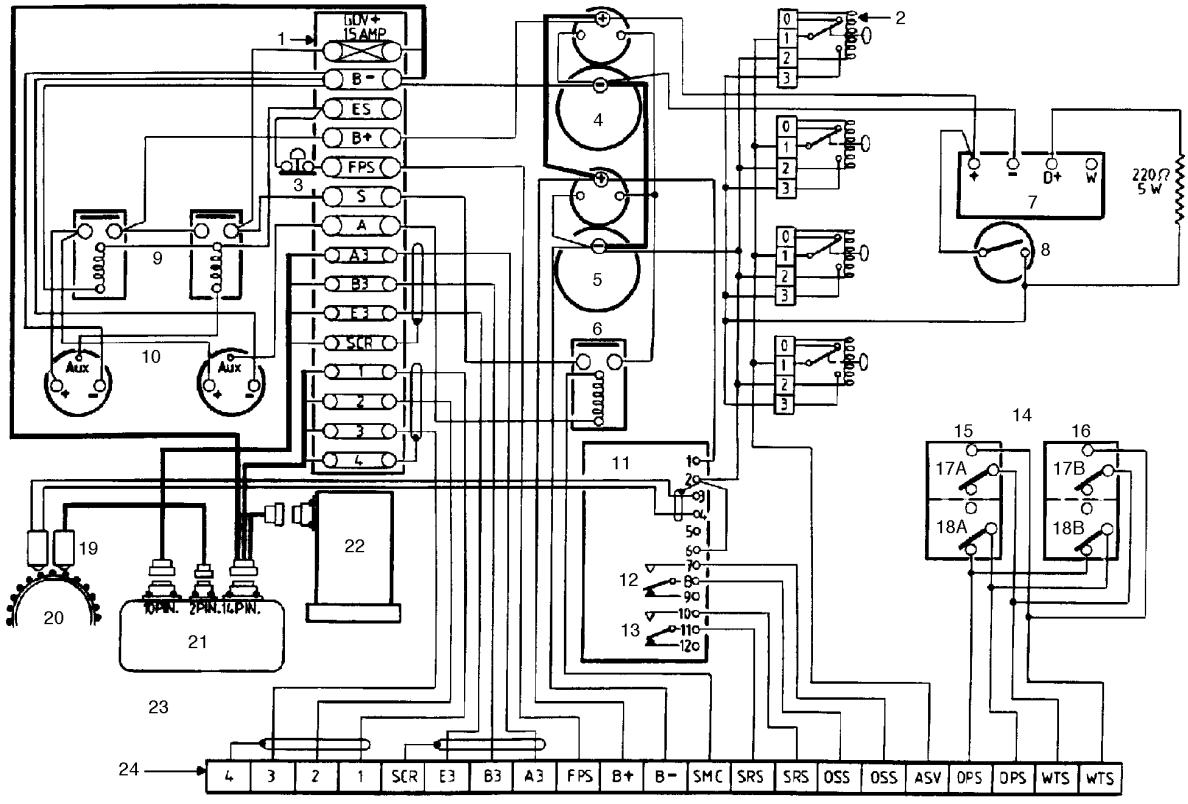

Fig. 63 Z13002.2

Key
(Fig. 64)

1 Engine fitted terminal box
2 Oil pressure switch
3 Starter motor 1
4 Starter motor 2
5 Battery charging alternator
6 Start inhibit relay
7 Emergency stop switch
8 Starter relay
9 Two air shutoff solenoid valves energise to stop. To operate only in conjunction with overspeed fault. Must be manually reset after operating.
10 Fuel stop solenoids energised to run
11 Two switch speed unit
12 Speed ref.
13 Overspeed
14 'A' bank engine fault switches
15 'B' bank engine fault switches
16A Water temperature
16B Water temperature
17A Oil pressure
17B Oil pressure
18 Magnetic pick-ups
19 Engine flywheel
20 Electronic governor control box
21 Electronic governor actuator
22 **NOTE:** All switches are shown with the engine at rest
23 Typical linking box to controller

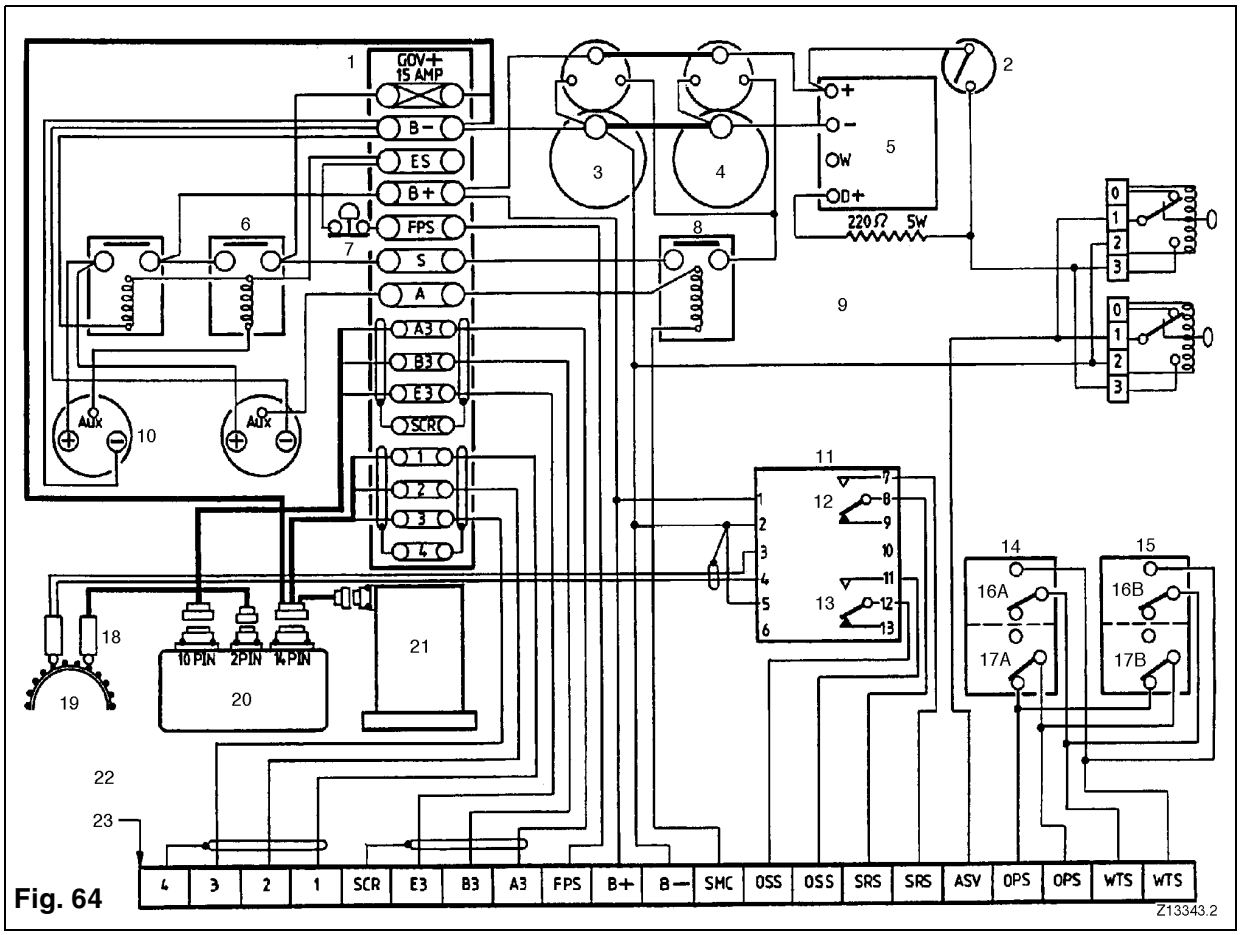

Fig. 64

4016 WIRING DIAGRAM, TWIN STARTERS, ELECTRONIC GOVERNOR (CURRENT ENGINES)

Key
(Fig. 65)

1 Engine fitted terminal box
2 Oil pressure switch
3 Starter motor 1
4 Starter motor 2
5 Battery charging alternator
6 Start inhibit relays
7 Emergency stop switch
8 Starter relay
9 Four air shutoff solenoid valves energised to stop. To operate only in conjunction with over speed fault. Must be manually reset after operating.
10 Fuel stop solenoids energised to run
11 Two switch speed unit
12 Speed ref.
13 Overspeed
14 Magnetic pick-ups
15 Engine flywheel
16 Electronic governor control box
17 Electronic governor actuator
18 'A' Bank
19 'B' Bank
20A Water temperature
20B Water temperature
21A Oil pressure
21B Oil pressure
22 All switches shown engine at rest
23 Typical linking box to controller

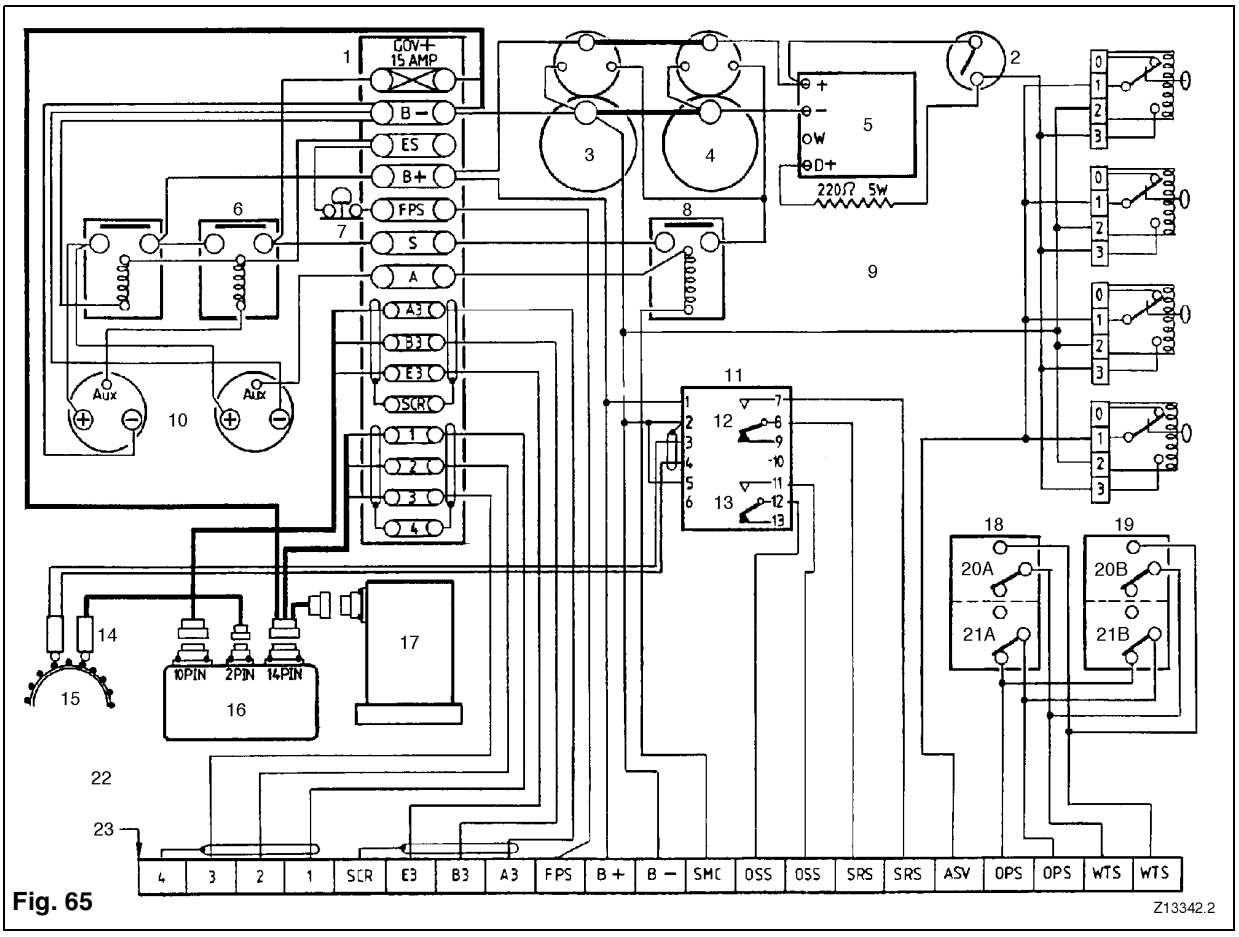

Fig. 65

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**.