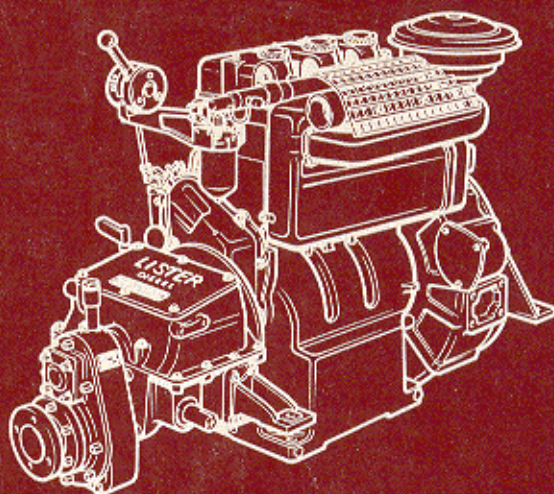
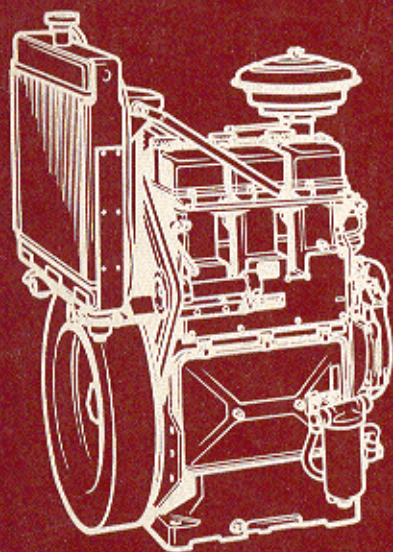
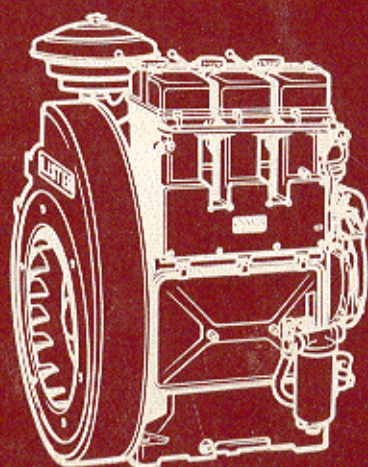
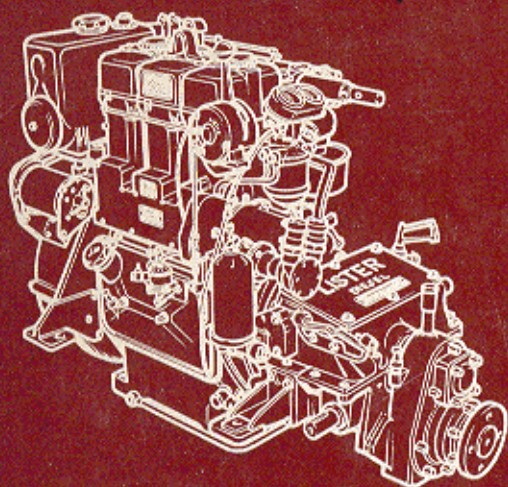


LISTER

HR & HRW Industrial - Marine Diesel Engines (2 and 3 Cylinder)

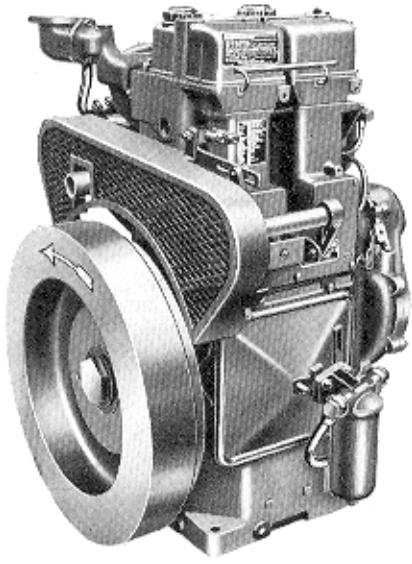


Workshop Manual

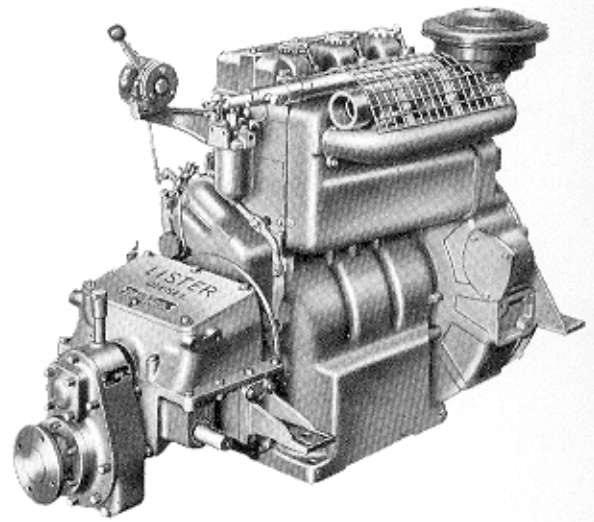
**HR and HRW
2 & 3 CYLINDER
DIESEL ENGINES**

FOR
INDUSTRIAL
MARINE AUXILIARY
AND
MARINE PROPULSION
APPLICATIONS

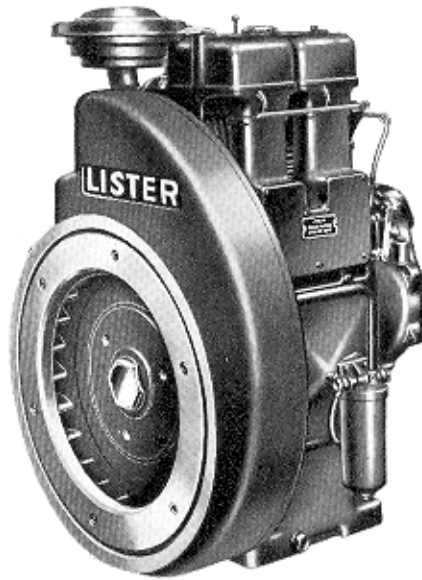
RECEIVED JC
LIBRARY 24 OCT 1978
F11



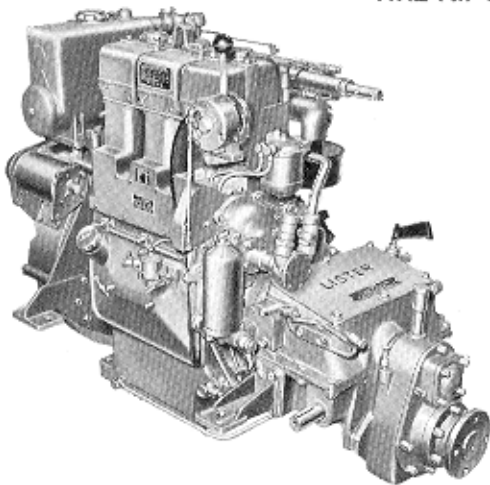
HRW2 Tank Cooled Engine



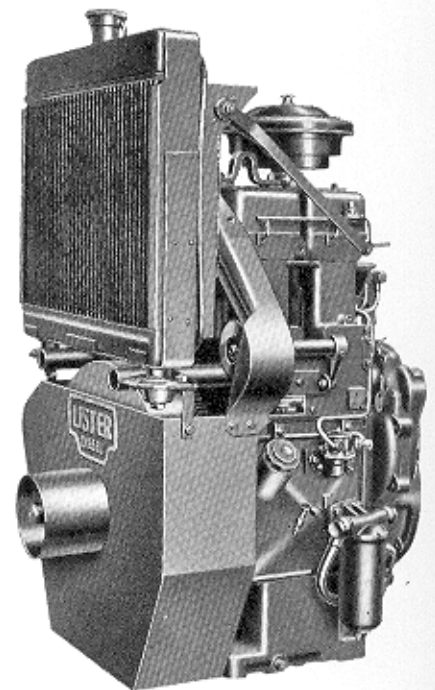
HR3M Air Cooled Marine Propulsion Engine



HR2 Air Cooled Industrial Engine



HRW3M Water Cooled Marine Propulsion Engine



HRW2 Radiator Cooled Engine

Lister HR and HRW (2 and 3 Cylinder) Engines

LISTER

HR and HRW 2 & 3 CYLINDER DIESEL ENGINES

Workshop Manual

R. A. LISTER & CO. LTD.

DURSLEY

GLOUCESTERSHIRE, GL11 4HS

ENGLAND

Telephone: DURSLEY (0453) 4141

Telex: 43261

Telegrams & Cables (Industrial): Machinery, Dursley

Telegrams & Cables (Marine): Power, Dursley

PUBLICATION 2003

FIRST EDITION

COPYRIGHT 1976

Publications for HR and HRW2/3 Engines

Workshop Manual

Industrial and Marine

Book 2003

Operators Handbooks

Industrial and Marine Auxiliary

Book 1443

Marine Propulsion

Book 1444

Parts Lists

Industrial and Marine Auxiliary—HR2/3

Book 1443PL(HR)

Industrial and Marine Auxiliary—HRW2/3

Book 1443PL(HRW)

Marine Propulsion—HR2/3M

Book 1444PL(HR)

Marine Propulsion—HRW2/3M

Book 1444PL(HRW)

Generating Sets

A list of books containing information and parts lists for generating sets which may be fitted to HR and HRW2/3 engines can be found in Section Eight.

Note: Every engine supplied by R. A. Lister is consigned with the appropriate Operators Handbook and Parts List.

ENQUIRIES

Industrial Engines

R. A. Lister and Co. Ltd.,

Marine Auxiliary and Marine Propulsion

R. A. Lister, Marine Division

DURSLEY, GLOUCESTERSHIRE, GL11 4HS, ENGLAND

Telephone: DURSLEY (0453) 4141.

Generating Sets supplied by Lister

R. A. Lister, Power Plant Ltd.

THRUPP, GLOUCESTERSHIRE, GL5 2BW, ENGLAND.

Telephone: BRIMSCOMBE (045-388) 5166.

OR YOUR NEAREST LISTER DISTRIBUTOR

FOREWORD

This Manual covers the operation and servicing of Lister HR and HRW two and three cylinder Engines used in Industrial and Marine applications.

The Manual is divided into sections as listed in the index which are arranged to show the complete strip and assembly sequence for each component part of the engine and its accessories. Section Four which deals with the basic engine is in two parts. Part 1 covers the servicing of the air cooled engines (HR) and Part 2 the servicing of water cooled engines (HRW). All the salient external features of the basic engine can be identified by reference to the photographs on pages 40 and 41 (HR) and pages 60 and 61 (HRW).

The use of genuine Lister replacement parts will assure the correct material, dimension and high standard of quality associated with the original engine components. When ordering replacement parts, always quote the engine serial number which will be found on the plate on the fuel pump housing door, or the air outlet duct.

The information, specifications and illustrations in this publication are correct at the time of going to print. Our policy is one of continued development and we therefore reserve the right to amend any of the information contained in this book without prior notice.

IMPORTANT

When purchasing parts or giving instructions for repairs, customers should in their own interest, always specify:

GENUINE LISTER PARTS

Parts that have not been supplied by the Lister organisation cannot be relied upon for correct material, dimensions or finish. R. A. LISTER & CO. LTD. cannot therefore be responsible for any damage arising from the use of such parts and the guarantee will be invalidated. In your own interest, therefore, specify

GENUINE LISTER PARTS

INDEX

	Page No.		Page No.
SECTION ONE—GENERAL INFORMATION		SECTION FOUR, PART 1—HR ENGINES	
Technical Data	4	Main Features	40
Installation Information	6	Main Features—Marine Propulsion	
Installation Information — Marine		Engines	41
Engines	13	Lubrication on Assembly	42
Operating Instructions	17	Air Cleaner	42
Routine Maintenance	19	Air Shields	48
		Breather	43
		Camshaft	52
		To Remove	52
		Changing Bushes	53
		Timing	53
SECTION TWO—LUBRICATING SYSTEM		Connecting Rod	48
Specification	21	Big End Bearings	49
Operation	21	Cooling Fins	59
Strainer	22	Crankshaft and Main Bearings	55
Oil Pump	22	To Remove	55
Oil Filter	23	To Refit	56
Oil Seals	24	Checking End Float	56
Oil Pipes	25	Cylinder Barrels	49
Dipsticks and Capacities	27	Cylinder Heads	45
		To Remove	46
		To Refit	47
		Checking Clearance	47
		Cylinder Head Covers	43
		Decarbonising	59
SECTION THREE—FUEL SYSTEM		Decompressor—Adjustment	44
Specification	29	End Cover	50
Description	29	Fanshroud	54
Servicing	29	Flywheel	54
Fuel Tanks	31	Fuel Pump Housing	52
Fuel Filter	30	Fuel Pump Tappet and Guide	52
Changing the Element	30	Gear Train	51
Priming System	30	Governor	51
Fuel Pumps	31	Gudgeon Pin	48
Fuel Pump and Governor Setting	32	Jointing Compounds	57
Fuel Pump Timing	34	Laying Up Procedure	59
Injectors	35	Main Bearing Housing	55
Testing	36	Manifolds	43
Governor	37	Pistons	48
Changing Governor Weights and		Piston Rings	48
Springs	38	Silencers	43
		Torque Spanner Settings	58
		Valve Clearance	44
		Valves and Valve Guides	46
		Valve Rocker Lever	47

INDEX—continued

	Page No.		Page No.
SECTION FOUR, PART 2—HRW ENGINES		SECTION FIVE—ACCESSORIES	
Main Features	60	Air Cleaners	80
Main Features—Marine Propulsion Engines	61	Air Outlet Duct	85
Lubrication on Assembly	62	Clutch	83
Air Cleaners	63	Coupled Decompressors	85
Belts	66	Duplex Fuel Filters	92
Breather	64	Flexible Couplings	82
Camshaft	52	Flywheel Shaft Extension	81
Connecting Rod	74	Fuel Lift Pump	93
Big End Bearings	74	Fuel Tanks	91
Crankshaft and Main Bearings	55	Gauges	88
Cylinder Blocks	74	Guards	86
Cylinder Heads	71	Hydraulic Pump Mounting	86
To Remove	72	Jockey Pulley	94
To Refit	73	Oil Cooler	95
Checking Clearance	73	Raised Hand Start	95
Cylinder Head Covers	64	Reduction Gear	
Decarbonising	59	Industrial Engines	84
Decompressor—Adjustment	65	Marine Propulsion Engines	100
End Cover	77	Reverse Gear—Marine	
Flywheel	78	Borg Warner—Hydraulic	100
Fuel Pump Housing	52	Lister—Mechanical	96
Gear Train	77	Running Hour Recorders	94
Governor	77	S.A.E. Adaptors	81
Gudgeon Pin	74	Silencers and Flexible Exhaust	88
Heat Exchanger	69	Sump Pump	95
Jabsco Pump	70	Tachometer	94
Jointing Compounds	57	Variable Speed Controls	89
Laying Up Procedure	59	Other Accessories—Marine	100
Main Bearing Housing	55		
Manifolds	63	SECTION SIX—FAULT DIAGNOSIS	101
Pistons	74		
Piston Rings	74	SECTION SEVEN—SERVICE TOOLS	
Radiator and Fan	68	Main Bearing Assembly and With-	
Silencer	63	drawal Tool	106
Tank Cooled Engine—Guard	68	End Cover Oil Seal Assembly Tool	107
Thermostat	64	Flywheel Withdrawal Tool	107
Torque Spanner Settings	58		
Valve Clearance	65	SECTION EIGHT—ELECTRICAL	
Valves and Valve Guides	72	EQUIPMENT	
Valve Rocker Lever	72	Starting Procedure	108
Water Pump	66	Location of Components	109
		Dynamo Servicing	110
		Instructions for Making Connections	110
		Notes on Alternators	112
		Wiring Diagrams	112
		Generating Sets—Reference Books	115
TABLE OF CLEARANCES AND DIMENSIONS OF WEARING PARTS			116

Section One

GENERAL INFORMATION

TECHNICAL DATA

HR2—AIR COOLED ENGINE

HRW2—WATER COOLED ENGINE

Engine

Type	Four stroke, vertical two cylinder with direct injection Diesel engine.
Bore and Stroke	107.95 mm. x 114.3 mm. (4.25 in. x 4.5 in.)
Cylinder Capacity (2 cyls.)	2.09 litres (127.5 in. ³).
*BHP/kW (to BS:649) continuous	29.5/22.0 at 2200 rev/min. 27.5/20.5 at 2000 rev/min. 25.0/18.6 at 1800 rev/min. 21.5/16.0 at 1500 rev/min. 17.0/12.7 at 1200 rev/min.
B.M.E.P.	6.13 bar (88.9 lbf. in. ²) at 1500 rev/min.
Weight (Basic Engine)	HR2—281 kg. (620 lb.) HRW2—286 kg. (630 lb.)

No. 1 Cylinder is at opposite end to flywheel.

Lubricating System

Oil Pressure	2.1/3.2 kgf.cm. ² (30/45 lbf.in. ²)
Oil Pump	Rotary type driven through a gear train from the crankshaft.
Relief Valve	Fitted to main oil feed pipe from filter to engine.
Oil Filter	A.C. Delco purolator, secured on or near crankcase door.
Oil Consumption	Less than 0.75% of full load fuel consumption.
Sump Capacity (engine level)	10.8 litres (19 pints). See also page 27.

Fuel System

Fuel Pumps	Bryce Berger (2)
Fuel Filter	C.A.V.
Injectors	Bryce Berger (2)
Injector Pressure	170 atmospheres
†Fuel Consumption (approx.)	
lb/bhp/h—g/bhp/h—kg/kW/h	0.455—202—0.271 at 2200 rev/min.
(at full load subject to	0.432—196—0.263 at 2000 rev/min.
5% B.S. tolerance)	0.414—188—0.252 at 1800 rev/min.
	0.398—180—0.243 at 1500 and 1200 rev/min.

*Rating

This is the bhp which the engine is capable of delivering continuously at a stated crankshaft speed in accordance with the conditions specified in British Standard 649:1958. The engine shall be capable of satisfactorily providing an output 10% in excess of the BS rating at the same speed for one hour in any period of twelve hours consecutive running unless driving centrifugal water pumps, fans and other similar equipment.

†Fuel Consumption

The fuel consumption figures apply to fully run-in, non de-rated, bare engines without power absorbing optional accessories, transmissions, marine gearboxes etc.

Rotation is anti-clockwise or clockwise looking on flywheel.

**TECHNICAL DATA HR3—AIR COOLED ENGINE
HRW3—WATER COOLED ENGINE**

Engine	
Type	Four stroke, vertical three cylinder, with direct injection Diesel engine.
Bore and Stroke	107.95 mm. x 114.3 mm. (4.25 in. x 4.5 in.)
Cylinder Capacity (3 cyls.)	3.14 litres (191.5 in. ³)
*BHP/kW (to BS:649) continuous	44.25/33.0 at 2200 rev/min. 41.25/30.8 at 2000 rev/min. 37.5/28.0 at 1800 rev/min. 32.25/24.1 at 1500 rev/min. 25.5/19.0 at 1200 rev/min.
B.M.E.P.	6.13 bar (88.9 lbf. in. ²) at 1500 rev/min.
Weight (Basic Engine)	HR3—372 kg. (820 lb.) HRW3—399 kg. (880 lb.)
Firing Order	1—3—2

No. 1 cylinder is at opposite end to the flywheel.

Lubricating System

Oil Pressure	2.1/3.2 kgf.cm. ² (30/45 lbf.in. ²)
Oil Pump	Rotary type driven through a gear train from the crankshaft.
Relief Valve	Fitted to main oil feed pipe from filter to engine.
Oil Filter	A.C. Delco purolator, secured on or near crankcase door.
Oil Consumption	Less than 0.75% of full load fuel consumption.
Sump Capacity (engine level)	14.8 litres (26 pints). See also page 27.

Fuel System

Fuel Pumps	Bryce Berger (3)
Fuel Filter	C.A.V.
Injectors	Bryce Berger (3)
Injector Pressure	170 atmospheres
†Fuel Consumption (approx.) lb/bhp/h—g/bhp/h—kg/kW/h (at full load subject to 5% B.S. tolerance)	0.435—197—0.264 at 2200 rev/min. 0.415—188—0.252 at 2000 rev/min. 0.400—181—0.243 at 1800 rev/min. 0.392—178—0.238 at 1500 and 1200 rev/min.

***Rating**

This is the bhp which the engine is capable of delivering continuously at a stated crankshaft speed in accordance with the conditions specified in British Standard 649:1958. The engine shall be capable of satisfactorily providing an output 10% in excess of the BS rating at the same speed for one hour in any period of twelve hours consecutive running unless driving centrifugal water pumps, fans and other similar equipment.

†Fuel Consumption

The fuel consumption figures apply to fully run-in, non de-rated, bare engines without power absorbing optional accessories, transmissions, marine gearboxes etc.

Rotation is anti-clockwise or clockwise looking on flywheel.

INSTALLATION INFORMATION

—INDUSTRIAL ENGINES

The engine should be secured in a level position. Where the engine has to be installed on an incline, for example mobile plants, the angle of inclination must not exceed 15° flywheel up or down.

IMPORTANT:—See diagrams on following pages showing methods of installation to ensure satisfactory cooling.

Too much emphasis cannot be placed on the need for care at every stage of the installation procedure. Correct installation and alignment are essential if the engine is to give long trouble-free service.

LIGHTING

A portable electric light for inspection purposes is recommended in addition to the fixed lighting of the engine room.

ROTATION

Normal rotation is anti-clockwise looking on the **flywheel end** of the engine. A special stub shaft extension is available for bolting to the flywheel to permit starting opposite rotation engines and for pulley drives. Clockwise rotation engines are available.

EXHAUST PIPING

If it is necessary to fit a longer exhaust pipe than standard, it should at no point slope upwards away from the engine unless a suitable condensate trap is fitted at the lowest part of the system.

Piping should be as short and straight as possible.

The exhaust pipe internal diameter must be increased according to the length of pipe as follows:—

- Up to 4.5 m. (15 ft.) 2 in.
- 4.5 m. (15 ft.) to 11 m. (36 ft.) ...2½ in.
- 11 m. (36 ft.) to 22 m. (71 ft.) ...3 in.
- Above 22 m. (71 ft.) 4 in.

Bends should have a radius of about 4 diameters and each bend must be allowed for by adding one foot to the total effective length of exhaust pipe.

A back pressure of about 1½ lbf. in.² (40" water gauge) (3" mercury) at the point where the exhaust pipe joins the exhaust manifold must not be exceeded.

COOLING—HRW ENGINES

Cooling can be either by tank or radiator, in both cases a thermostat is fitted. Water circulation in each case is pump assisted, the centrifugal pump being a standard fitting. On hand started engines a jockey pulley is fitted to allow for adjustment of the pump driving belts while on electric start engines the dynamo replaces the jockey pulley.

The operating temperature should be between 75°C (167°F) and 90°C (194°F).

COOLING—HR Engines

A fan impeller is secured to the flywheel and air is drawn into the impeller and discharged through shrouding to the fins of the cylinder and cylinder head.

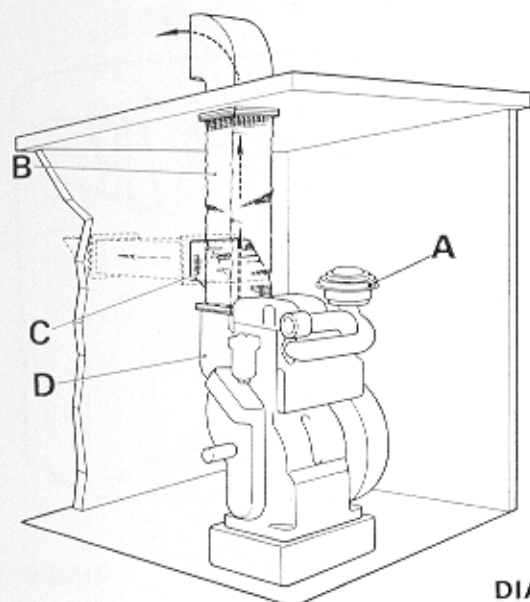
If the engine is enclosed in a housing, openings must be provided opposite the cooling air intake and outlet. It is important that the hot air is ejected from the housing and not recirculated to the air intake as this will cause the engine to overheat. The inlet and outlet openings must have a clear area of at least 520 cm.² (80 in.²) for the 2 cylinder engine and 780 cm.² (120 in.²) for the 3 cylinder engine.

If they are covered with mesh the area taken by it must be allowed for. The use of simple ducting and deflectors inside the housing may be advisable in some cases. Air outlet trunking is available for cases where the hot air must be ducted away from the engine room.

Wherever possible the approval of R. A. Lister should be obtained in the case of engines installed in small housings. The ingress of dirt, sawdust, chaff, etc., into the cooling air intake must be prevented by the provision of suitable shields or by placing the engine in a sheltered place.

A rotary screen for fitting to the flywheel can be supplied in cases where hair, straw, etc., are likely to enter the cooling air intake.

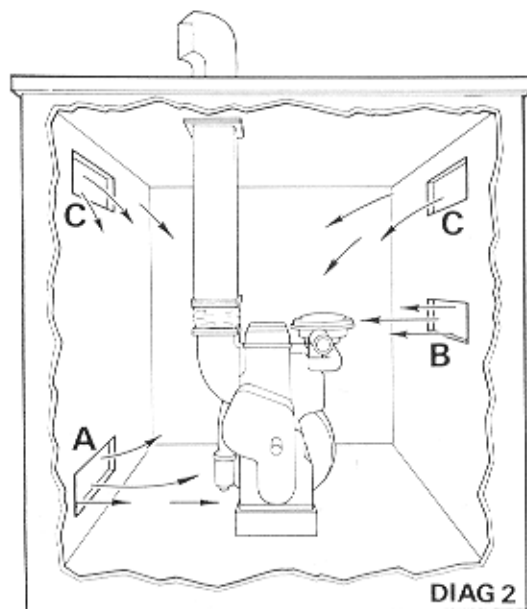
COOLING AIR CONSIDERATIONS (HR)



DIAG 1

Diag. 1 Method of leading out the hot cooling air in small enclosed compartments.

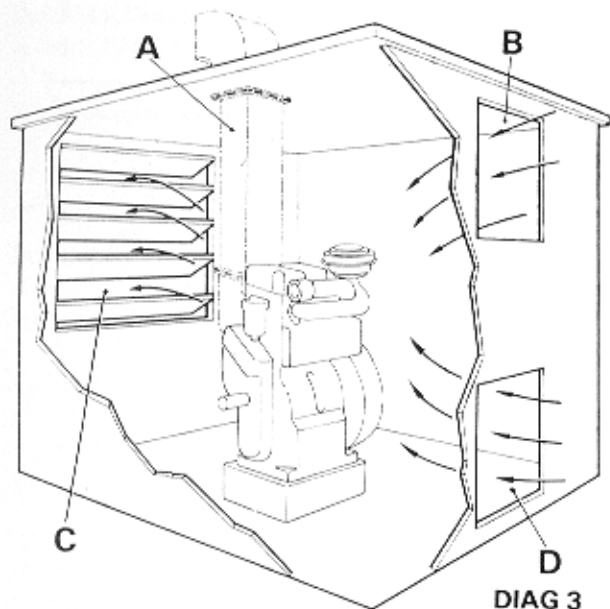
- A It is absolutely essential that the hot cooling air discharge does not find its way to the cooling air inlet and become recirculated.
- B Flexible trunking of canvas, rubberised canvas or heat resisting rubber.
- C One of these alternative methods must be used.
- D Ducting as shown can be supplied if ordered. Ducting is fully detachable for servicing and the trunking must be attached so that it does not impair the quick removal of the ducting. The extension on ducting, the trunking and the cowl to be supplied by the customer. For lengths of trunking up to 1.5 m. (5 ft.) the minimum inside areas are to be:—
 450 cm.² (70 in.²) for two cylinder engines;
 650 cm.² (100 in.²) for three cylinder engines:
 1.5 to 3 m. (5 ft. to 10 ft.) multiply by 1.4
 3 to 7.5 m. (10 ft. to 25 ft.) multiply by 2.25
 7.5 to 15 m. (25 ft. to 50 ft.) multiply by 3.5.



DIAG 2

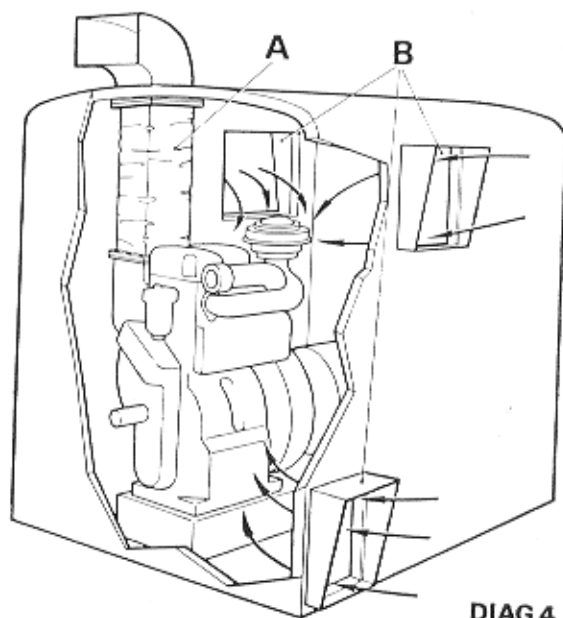
Diag. 2 Notes on air intakes.

- A One of the cooling air intake holes must be near the bottom of the engine room to bring cool air in and also to strike the engine sump to assist cooling the lubricating oil.
- B Another intake hole must be opposite the air filter to ensure a good supply of cool combustion air.
- C One or two cooling air intake holes must be near the top of the engine room to prevent an accumulation of hot air above the engine. Generally it is not desirable to place an air intake hole opposite the engine cooling fan, because the rest of the engine room will not be ventilated, except where the ambient temperature exceeds 49°C (120°F) as it is essential for the engine to be as cool as possible under these conditions.



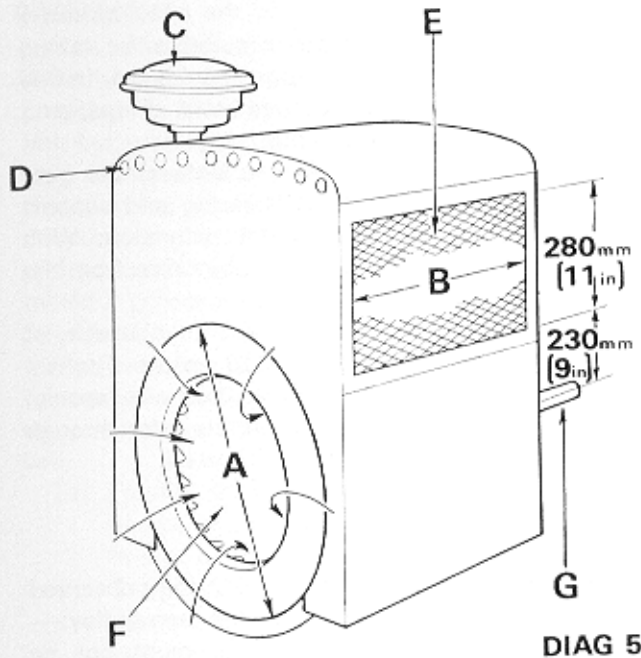
Diag. 3 Installation in moderate size engine house 3 x 1.8 m. (10 ft. x 6 ft.)

- A Engine ducting trunking and cowl to be used in tropical climates and also in other climates when a cool engine house is required.
- B Window 0.6 x 0.6 m. (2 ft. x 2 ft.) near the roof and opposite the main window, capable of being fully opened.
- C Large window opposite the engine air outlet capable of being fully opened or if louvred slats to be 102 mm. (4 in.) apart as shown. (Not required if ducting is fitted.)
- D Window 0.6 x 0.6 m (2 ft. x 2 ft.) near the floor and opposite the main window, or in the wall nearest the engine fuel filter, capable of being fully opened.



Diag. 4 Installation in confined space where air intake holes have to be as small as possible.

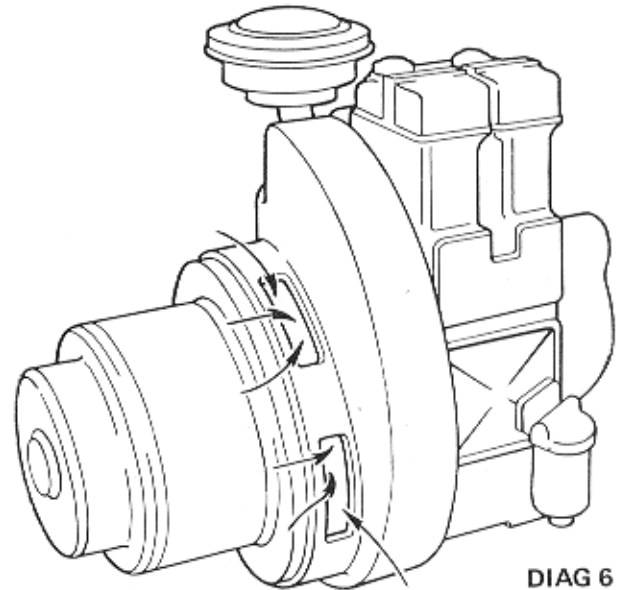
- A Area of trunk and cowl to be as given in Diag. 3.
- B Air intake holes to be in positions shown and all the same size to ensure even air intakes. Minimum area of intakes:
3 holes—each 19 cm.² (30 in.²) for two cylinder engine;
3 holes—each 322 cm.² (50 in.²) for three cylinder engine.



DIAG 5

Diag. 5 Engine installed in a housing which itself is in the open with unobstructed air all round.

- A 508 mm. (20 in.) minimum diameter hole opposite flywheel air intake.
- B 495 mm. (19½ in.) for two cylinder engine; 635 mm. (25 in.) for three cylinder engine.
- C Combustion air intake brought outside.
- D At least 10 ventilating holes each end 25.4 mm. (1 in.) diameter.
- E Open mesh grille opposite hot air side of engine. Free area through grille:
520 cm.² (80 in.²) (minimum) for two cylinder engine;
780 cm.² (120 in.²) (minimum) for three cylinder engine.
- F Flywheel air intake to be against this end.
- G Crankshaft extension for starting handle.



DIAG 6

Diag. 6 Engine close coupled to a driven machine.

Air intake holes in adaptor. The absolute minimum area of intakes must be:
450 cm.² (70 in.²) for two cylinder engine;
650 cm.² (100 in.²) for three cylinder engine.
A larger area is preferred.

Any coupling or clutch driving member at the flywheel end must not obstruct the air flow through the fan and the above free areas must be maintained at this point and through the fan. The area taken by mesh or guards over the air intake openings must be allowed for when calculating the above areas.

FOUNDATIONS

For engines solidly mounted on concrete, the foundations should be prepared in accordance with the drawing which can be supplied on request.

The dimensions quoted on the foundation drawing are the minimum for good solid sub-soil conditions, and must be increased at the customer's discretion where the sub-soil bearing capacity is known to be poor.

NOTE:—Owing to the varying nature of ground conditions R. A. Lister & Co. cannot accept responsibility for ensuring that foundations are satisfactory.

The final surfaces of the foundation block must be checked to ensure that they are flat, level and at the correct relative heights for the engine and driven unit(s). A small allowance (approx. 3 mm— $\frac{1}{8}$ in.) must be made in the finished height for thin metal strips to be placed under the mounting feet on either side of, and as close as possible to, the holding-down bolts. Shimming should then be used in conjunction with these strips to ensure an equal bearing load and absence of distortion when finally grouting in and tightening down the foundation bolts.

For engines mounted on fabricated structures or in portable equipment particular attention must be paid to the supporting members being of adequate rigidity—preferably constructed in box section form. **No strain must be imposed on the engine mounting feet either by distortion during installation (feet not correctly shimmed), or by deflection of the structure in operation.**

SHAFT EXTENSIONS

A 50.8 mm (2 in.) shaft extension can be provided at the flywheel end of the engine and this is suitable for taking the full power of the engine by flat belts, chains, vee belts, or in-line couplings. The starting shaft extension at the gear end of the engine (fuel filter end) is 38.1 mm (1½ in.) diameter and two lengths are available, the longer one being used when a pulley as well as the starting handle is to be used on it. This shaft extension is suitable, in the 2 cylinder engine, for taking the full power of the engine with vee belt drives, chains and also for in-line couplings, but it is essential that the sprocket or pulley is within 25.4 mm (1 in.)

of the engine end cover. In the case of the 3 cylinder engine the shaft is suitable for taking the full power of the engine with an in-line coupling. Side drives, such as belts, chains, etc., must be limited to 20 h.p.

A special end cover is available at the gear end to carry an additional bearing and support and 50.8 mm. (2 in.) shaft extension. With this arrangement any drive can be taken from the engines.

Up to 25.4 cm (10 in.) outside diameter of any type of pulley can be used on the flywheel end of the engines but above this size special slotted pulleys allowing the air to enter through the centre of the bore must be used.

PULLEY DRIVES

The following points must be strictly observed in all cases where the user fits his own pulley:—

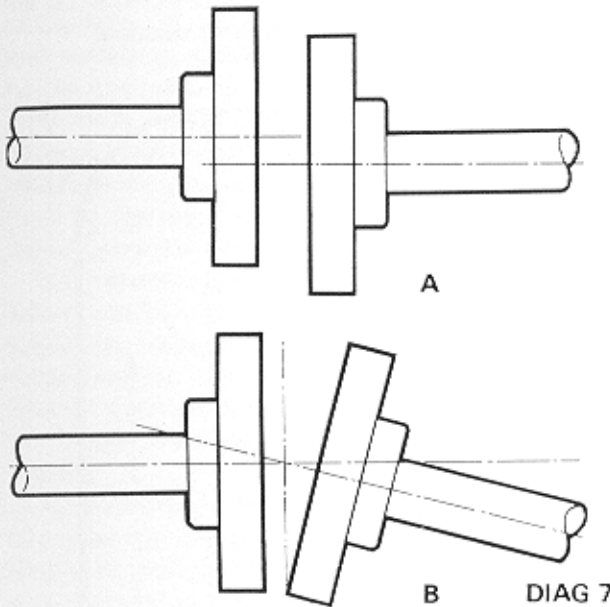
- (1) Cooling Air Intake—This must not be restricted by the pulley and must have a clear minimum area of 450 cm.² (70 in.²) for HR2 and 645 cm.² (100 in.²) for HR3.
- (2) Driving Pulley Sizes—Pulleys of smaller diameters than those listed in 1443PL must NOT be used without special approval from R. A. Lister & Co. Ltd. With flat belt pulleys the edge of the belt must be within 12.7 mm. ($\frac{1}{2}$ in.) of the fan-shroud.
- (3) Overhang—the maximum amount of overhang for any flat belt pulley must NOT exceed 187.3 mm (7½ in.) (146 mm. (5¾ in.) for Vee belt measured from the outer face of the fan shroud to the outer edge of the pulley.
- (4) Pedestal Bearings—These must be used in each of the following cases:—
 - (a) Where air flow would be restricted.
 - (b) Where wider pulleys are required.
 - (c) Where very heavy belt pulls are expected.
- (5) Belt Tension—Normal belt tension only should be applied to all pulley drives recommended in the foregoing notes. Excessive tightening of the belt is harmful and unnecessary.
- (6) Driving belts must be run as close up to the engine as possible to avoid undue strain on the bearings.

ALIGNMENT

It is often thought that little attention need be paid to accurate alignment when a "flexible coupling" is fitted between the engine and driven unit but such optimism is seldom justified in practice. Irrespective of the type of coupling used, the coupling life will be longer, the chance of coupling or shaft failure will be greatly reduced, and vibration of the combined set will be minimized if proper attention is paid to the alignment problem.

Two principal types of misalignment can occur—parallel misalignment and conical misalignment, or there can be a combination of these two.

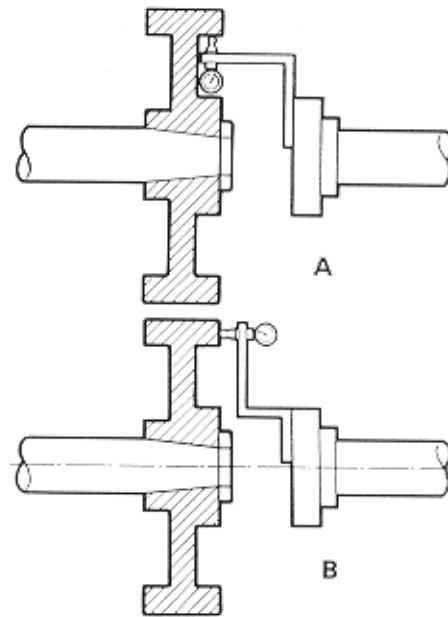
- (a) Parallel Misalignment—when the shaft of the driven unit is parallel to, but not in line with, the engine output shaft.
- (b) Conical Misalignment—when the axes of the two shafts meet at the correct points, but the shafts are not parallel to each other.



Diag. 7 Misalignment

Each type of misalignment is checked individually by having a bracket or clock gauge bolted to the flange of the driven unit and rotated through 360° to check the clearance to (a) the inside (or outside) of the flywheel rim for parallel misalignment, and (b) the clearance to the flywheel face for conical misalignment. Readings should not vary by more than 0.005" throughout one revolution.

Alternatively conical alignment can be checked by measuring with feelers, at 90° intervals, the gap between the coupling faces. If the coupling flanges are machined round the circumference a check for parallel alignment can be made with a straight edge across both faces at 90° intervals.



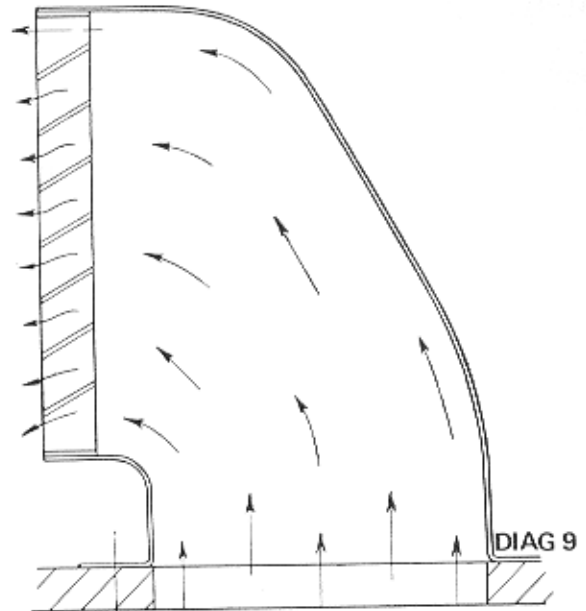
DIAG 8

Diag. 8 Checking Alignment

TEMPERATURES

From the aspect of engine performance, the temperature of the air entering the engine is the only criterion of ambient temperature. The power developed by the engine depends on the temperature of the combustion air, measured at the air manifold inlet (or the air cleaner), and the temperature of the cooling air as measured at the fan inlet. The higher of these two temperatures is taken as being the "Ambient Temperature" as far as engine ratings are concerned.

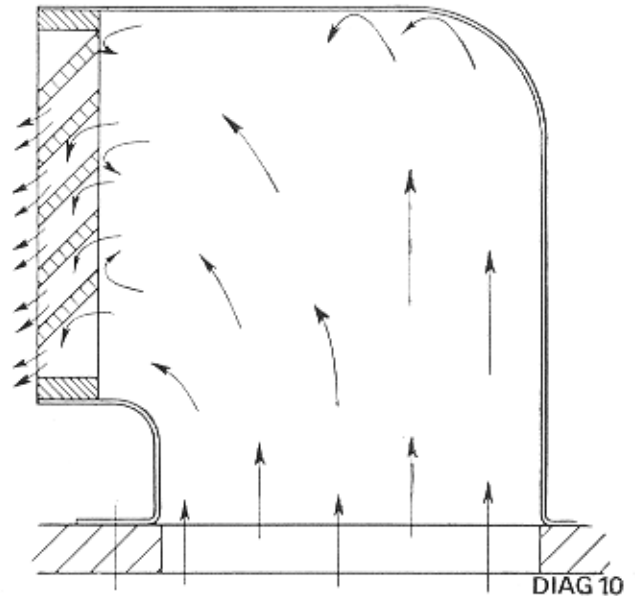
The engines are able to run satisfactorily at Ambient temperatures up to 29.4°C (85°F) without derating. Above this temperature the rated brake horsepower must be reduced by 1 per cent for every 2.78°C (5°F). The maximum temperature is 52°C (125°F), and if it is desired to run at higher temperatures, R. A. Lister & Co. Ltd., or their Distributors must be consulted.



Diag. 9 Cowl

CORRECT

Area through louvers or grille is at least 25 per cent greater than area of ducting.



Diag. 10 Cowl

WRONG

Louvers or grille obstructs air flow. Area through louvers is smaller than area of ducting.

AIR FLOW

Grilles, wire mesh or louvers placed in the air stream are obstructions and must be allowed for. The free flow area of these must be calculated to ensure it is at least 25 per cent greater than that specified for the inlet and outlet passages.

INSTALLATION INFORMATION—MARINE

GENERAL

Before arranging your installation, it is imperative that careful consideration be given to the general layout of the machinery and to the cooling of the engine; the guidance notes on the arrangement drawings must be followed.

Careful consideration should be given to ensure accessibility and ease of maintenance, any housing must be constructed so that the sides and forward portion can be dismantled for servicing without disturbing the controls or instruments. The housing should not be connected directly to the engine bearers but fastened to a coaming on the deck or cockpit floor.

COOLING—HR ENGINES

Unless an adequate supply of air is allowed to circulate around the engine and means are taken to prevent the same air re-circulating, the engine will lose power due to overheating.

Provision is made on the engine to take the customer's air outlet ducting. Sizes of air inlets and outlets as specified are minimum and must not be obstructed in any way. If wooden slats, or wire mesh having not less than $\frac{1}{4}$ " x $\frac{1}{4}$ " mesh between the wires, are fitted as protective measures over openings, the area of the openings must be increased to compensate for same, thus maintaining the net specified area.

It is recommended that the portion of ducting which attaches to the outlet port on the engine should be made of fire resistant material and be made readily detachable. When engines are flexibly mounted due allowance must be made in the length of ducting between engine and fixed ducting.

An unrestricted flow of cold air to the engine fan must be maintained, inlets for cooling air should be designed to give not less, and preferably more, than the sectional area specified.

To ensure efficient engine operation the combustion air filter must receive an adequate supply of cold air. To ensure this the filter may, if found necessary, be removed from the engine and fitted in a protected position on deck or at engine bearer level, the connection between engine and filter being by flexible pipe.

Where hot air is led away by trunking, this hot

air can be utilised to heat accommodation and ventilate cupboards, etc., but the recirculation of this air back to the engine compartment must be prevented and, further shutters or similar fittings used to control the air to the accommodation must operate in the heating trunk—not in the engine discharge trunking.

Heat radiated from the engine must be expelled from the engine case or compartment. Where an engine is installed in a case, a series of one inch diameter holes near the top will give adequate top ventilation. When fitted in a compartment, cowl ventilators opening just below the top of the compartment, will dispel the heat; extractor fans installed in the ventilators will obviously improve this arrangement.

COOLING—HRW ENGINES

The cooling system is of the closed circuit fresh water type which consists of a combined heat exchanger and header tank mounted on the engine at the forward end. Sea water is circulated by means of a pump, which is direct driven from the engine gear train, whilst the fresh water is circulated by a centrifugal pump mounted at the forward end and driven by two V belts. Keel cooling can be used instead of heat exchanger cooling.

Depending on the ambient temperature and the load factor, the engine may be operated up to 95°C (203°F). Consult Lister Marine for further information.

The system is pressurised to 6 lbf. in² (0.42 kgf. cm²) and care must be taken if the filler cap is removed when the engine is hot.

EXHAUST SYSTEM

Pipes should slope gradually away from the engine down to the outlet on ship's side or transom and be kept as straight and short as possible, the minimum radius in any bend being not less than 4 times the pipe bore. Adjacent wood structure must be protected from exhaust heat by adequate clearance and lagging.

If it is found necessary to fit a swan neck in the exhaust pipe to prevent the ingress of water, a small ($\frac{1}{32}$ " diameter) hole must be drilled in the top of same to break the vacuum and a drain plug or cock should be fitted at the lowest point in the pipe. Information on back pressure can be found on page 6.

ENGINE MOUNTING (Diag.11)

To provide a rigid bed free from alignment troubles it is essential in the case of wooden hulls to ensure that the engine bearers extend as far forward and aft as possible, and are made of well seasoned wood of liberal size so arranged that they are an integral part of the ship's hull. In addition a steel plate should be placed along the top of the bearer the length of the engine base to prevent the engine feet biting into the bearers. Bearers must be adequately supported by athwartship members secured to the hull structure. See also page 16.

Since NO PROVISION is made in the engine design to take END THRUST, a thrust block must be provided for all propulsion installations.

LISTER reverse and reverse/reduction gears are provided with thrust bearings.

On propulsion units when a flexible coupling is fitted, a plummer block must be fitted to the tailshaft if the stern tube forward bearing is more than 9" from the edge of the tailshaft coupling.

Propellers must run in adequate apertures and never behind heavy square ended body posts. These should be tapered off to an inclusive angle of about 40°. The distance between the outboard gland and the propeller boss should not be greater than the diameter of the shaft.

FLEXIBLE MOUNTINGS

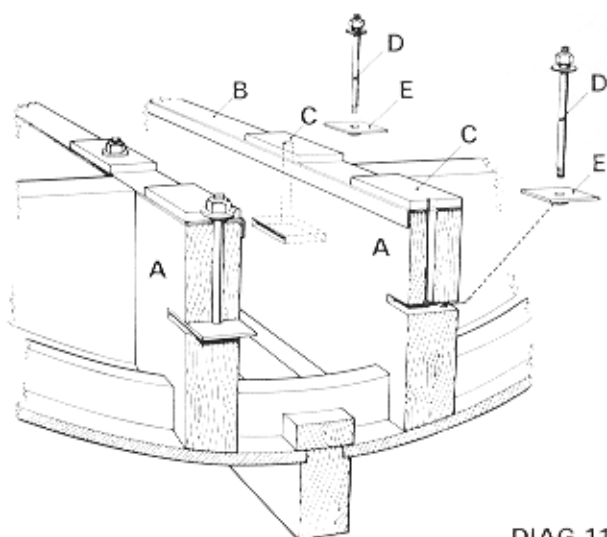
Allowance must be made for the engine to clear bearers by at least $\frac{1}{2}$ ", and to clear any casing, including air ducts or deflectors which might be fitted, by 1" to allow for engine movement.

INCLINATION

The maximum angle of inclination at which engines may be run is 15° flywheel up or down. See page 27.

ROTATION

Engine rotation is anti-clockwise when looking on **flywheel end** of engine. When a Lister reverse and reduction gear is fitted rotation of the output coupling is clockwise—when no reduction gear is fitted, rotation of output coupling is anti-clockwise.



DIAG 11

- A—Engine Bearers.
- B—Soleplate.
- C—Chocks.
- D—Holding Down Bolt.
- E—Nut welded to steel plate.

Diag. 11. Installation in a wooden vessel

CASINGS OR COMPARTMENTS

These can be constructed of $\frac{3}{8}$ " bonded marine plywood to BSS 1080 on substantial framing and have portable panels secured by cuphead screws for ease of servicing. The noise level can be effectively reduced by lining the box or compartment with resin impregnated glass fibre type 425 secured in position by 25 gauge perforated zinc plate having 51-3/32" dia. holes per square inch. Glass fibre can be obtained in varying thicknesses but for pleasure craft or vessels operating in confined waters a thickness of 2" is recommended.

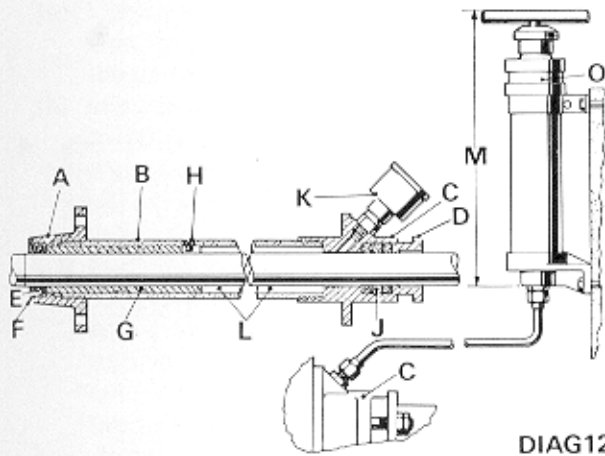
Where large openings in the casing cannot be avoided, the noise level can be further reduced by fitting plywood baffle plates faced with glass fibre and perforated zinc but it is essential that the area between the casing and the baffle is not below the specified requirement.

STERNGEAR (Diag. 12)

Packing glands should allow free rotation of the tailshaft. Stern tubes should be filled with grease before inserting shaft. Before launching, run engine to ensure that packing glands do not overheat. If necessary slacken back gland. Long lengths of unsupported shafting must be avoided by the use of plummer blocks.

IMPORTANT

The sterntube **MUST** be filled with a suitable grease, such as Vickers "NEOX DT" immediately after installation. To ensure complete filling of the tube it is imperative that a grease gun be used for the initial filling. For service, regular attention to the grease cup provided should be sufficient to make up any loss incurred.

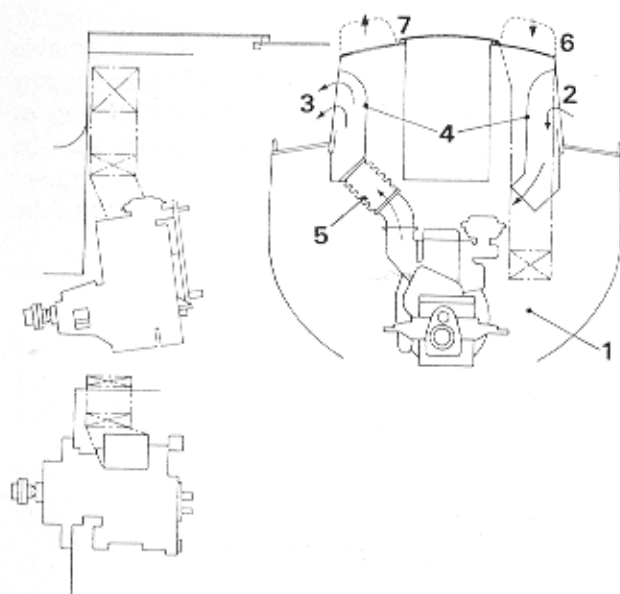


DIAG12

Fig. 12 Stern Gear

Tailshaft Size ENGINE	1 $\frac{1}{4}$ "—31.75 mm HR/W2MG	1 $\frac{1}{2}$ "—38.1 mm. HR/W2MGR HR/W3MG	1 $\frac{3}{8}$ "—44.45 mm. HR/W3MGR
Sterntube Grease capacity			
pints	0.49	0.96	0.34
litres	0.28	0.54	0.19

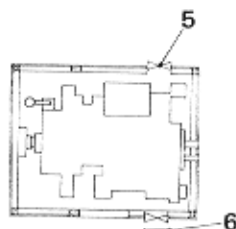
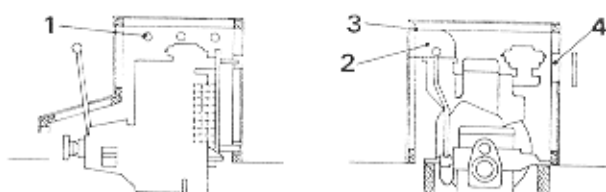
Information on ALIGNMENT, TEMPERATURES and AIR FLOW (through louvres or grilles), is the same as Industrial Engines—see pages 11 and 12.



Diag. 13. Installation below deck

Key to Diag. 13

- 1—Engine Room
- 2—Inlet
- 3—Outlet
- 4—Inlet and Outlet Trunks
- 5—Ducting of heavy canvas expanding from engine duct size to area of duct given in table
- 6—Cooling air
- 7—Air carrying radiated heat from engine room.



Diag. 14. Installation in open boat

Key to Diag. 14

- 1—1" dia. holes near top to expel radiated heat.
- 2—Hot air outlet duct.
- 3—Outlet duct to be a close fit but not secured to engine box.
- 4—Combustion Air Inlet.
- 5—Air inlet each side giving a total unobstructed area as shown in table.
- 6—To further reduce the noise, plywood baffles faced with fibre glass may be fitted in way of inlets, but inlet area between baffle and box must not be less than that specified.

Note—Engine Box may be constructed of $\frac{3}{4}$ " resin bonded marine plywood to BSS 1088 on substantial framing. To reduce the noise level, the inside of the box can be lined with resin impregnated fibre-glass of a minimum thickness of 1" (2" thick preferred).

COOLING AIR INLET AND OUTLET DUCTS

Engine Type	Hot Air Outlet Duct		Cooling Air Inlet Duct	
	sq.cm.	sq.ins.	sq.cm.	sq.ins.
HR/W2M	450	70	580	90
HR/W3M	645	100	970	150

The above are the minimum areas required for trunking up to 1.8 m. (6' 0") in length and free from any obstruction such as protective wooden slats or wire mesh. If either of these protective measures are used then the area of trunking must be increased to allow the free area to comply with the table above. Where the trunking is more than 1.8 m. (6' 0") long the above areas must be increased as follows:—

- 1.8 to 3.05 metres (6' to 10') multiply by 1.4
- 3.05 to 7.625 metres (10' to 25') multiply by 2.25
- 7.625 to 15.25 metres (25' to 50') multiply by 3.50

OPERATING INSTRUCTIONS**To Start the Engine — Hand Starting**

- (a) Check the fuel and lubricating oil levels.
- (b) If an oil bath air cleaner is fitted, fill the oil container with engine oil to the level marked on the air cleaner.
- (c) Ensure fuel and lubricating oil systems are primed.
- (d) If engine is fitted with fuel lift pump, prime fuel filter by using priming lever on the lift pump.
- (e) Move decompressor levers away from the flywheel.
- (f) In cold weather only lift overload stop to allow the pumps to deliver excess fuel.
- (g) Lightly oil the end of the crankshaft extension, or raised hand starting shaft, and fit the correct starting handle.
- (h) Important. Turn the engine slowly from 3 to 10 turns according to the temperature and period of standing unused in order to prime combustion chambers and the lubricating oil system.
- (j) Turn the handle smartly in the direction of rotation, move the decompression levers towards the flywheel and continue turning fast. Retain grip on starting handle until engine is firing and remove handle from shaft.

Note:—On engines fitted with speed control the control lever should be set to "Full" and when the engine starts, speed may be reduced as required.

ELECTRIC STARTING

Electric starting is available and can be operated by either direct or remote control; starting procedure and wiring diagrams of the electric starting systems are shown in Section 8.

TO STOP THE ENGINE

Move the control lever to the left (towards the flywheel) and hold in this position until the engine stops. On marine propulsion engines or engines fitted with remote stopping control, move control to STOP. **Do not use the decompressors for stopping.**

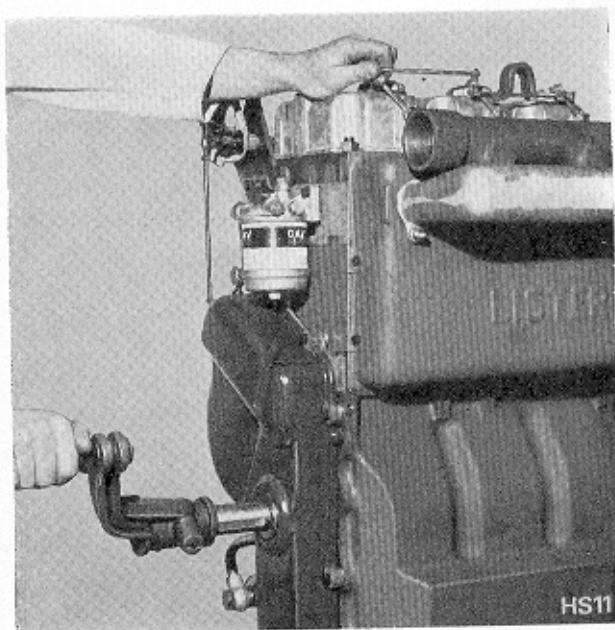
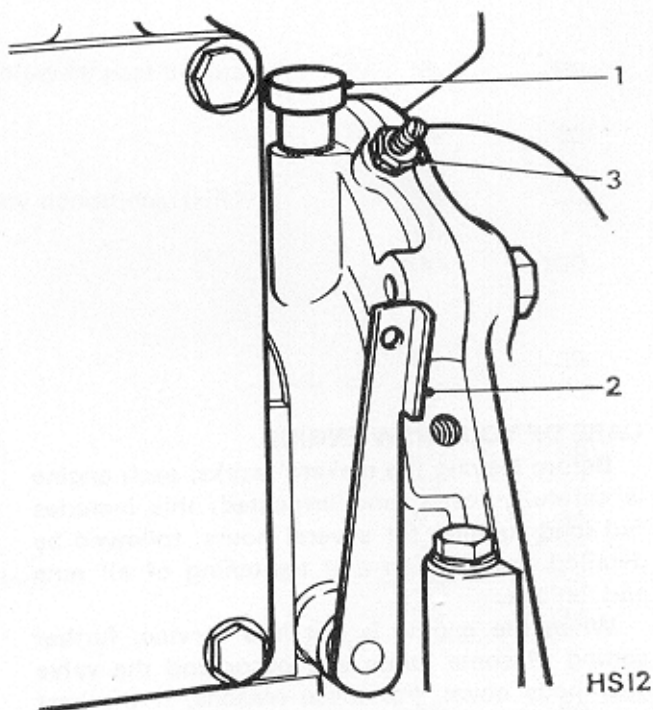


Fig. 1 Starting Engine



1. Overload Trip.
2. Control Lever.
3. Governor Adjusting Screw.

Fig. 2 Engine Controls

VARIABLE SPEED CONTROL

On all engines, in place of the standard fixed control as shown, a variable speed control can be fitted with a range of 650 rev/min. to maximum. A speed and stop control is a standard fitting on marine propulsion engines.

Details of these arrangements can be found in Section 5.

SPEED ADJUSTMENT

A small adjustment of speed may be made by loosening the lock nuts on the governor spring adjusting screw and turning the screw in to reduce speed and out to increase speed. Tighten locknuts.

Do not increase speed above 2½% without consulting R. A. Lister & Co. Ltd.

CARE OF YOUR NEW ENGINE

Before leaving the makers' works, each engine is carefully tested and inspected; this includes full load running for several hours, followed by detailed examination and tightening of all nuts and unions.

When the engine is put into service, further setting of some joints will occur and the valve gear beds down. For these reasons, if the best results are to be obtained from the engine, it is important that it should receive regular attention, particularly during the first 500 hours of its life. The same applies to an engine which has been completely overhauled.

INITIAL ATTENTION

To ensure that the top cups of the push rods are full of oil and that the valve springs are lubricated, pour ½ pint (0.3 litre) of lubricating oil per cylinder over the valve gear.

It is recommended that the following are attended to after the engine has run 25 hours and again after the engine has run 250 hours.

1. Adjust tappet clearances (see pages 44 or 65).
2. Check, and tighten, the nuts on the following joints: end cover, cylinder head covers, fuel pipes, fuel pump housing cover, lubricating and fuel oil pipe joints.

In addition to the above the following should also be carried out.

- a. Change the lubricating oil for the first time after 100 hours. Thereafter every 250 hours.
- b. Clean the engine and keep it clean.
- c. Observe the exhaust at the normal full load. The exhaust must be free from soot. A black exhaust means that the engine is overloaded or that the injection equipment is out of order. Do not allow the engine to run with a dirty exhaust without investigating the cause as this may result in an expensive breakdown.

ROUTINE MAINTENANCE

Following the initial attention, the normal routine maintenance must be carried out as laid down on next page.

LUBRICATING OIL

Always use oils of the correct viscosity and type Heavy Duty diesel engine detergent lubrication oil. (See "Lubrication" page 21.)

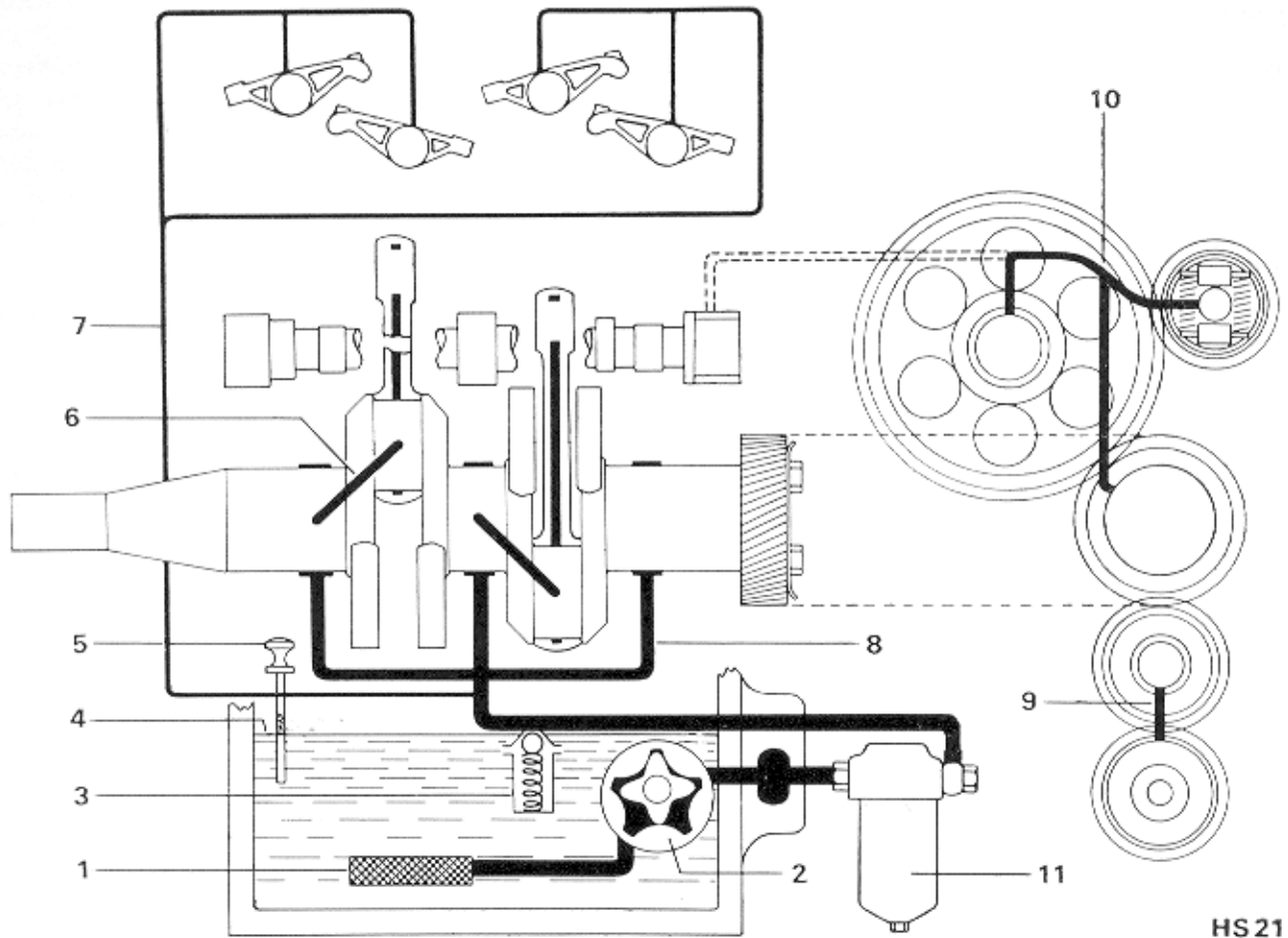
This will ensure easy starting, lowest fuel consumption, minimum wear and longest periods between overhauls.

ROUTINE MAINTENANCE

	Page No.	
	HR	HRW
Daily		
Check supply of fuel oil.	29	29
Check level and condition of lubricating oil (also in gearbox if fitted).	21	21
Clean air cleaner under very dusty conditions.	42	62
Drain moisture trap in exhaust pipe, if fitted.	6	6
Clean rotary cooling air fan screen, if fitted.	87	
Check the tightness of all fastenings and sealing of joints in the air cleaner system.	42	62
Every 100 Hours		
Clean air cleaner under moderately dusty conditions.	42	62
Check for fuel and lubricating oil leaks—tighten nuts and fittings as necessary.	—	—
Wipe engine and baseplate clean.	—	—
Clean cylinder and cylinder head finning under very dusty conditions (HR).	59	—
Check level of electrolyte in battery if electric starting is used.	110	110
Every 250 Hours		
Drain lubricating oil and refill with correct grade and type, renew lubricating filter element.	23	23
Clean the fuel injector nozzles if the exhaust is dirty.	35	35
Every 500 Hours		
Decarbonise if engine shows loss of compression, or blow-by past the piston. Do not disturb otherwise.	59	59
Adjust valve tappet clearances.	44	65
Wash engine down with paraffin or fuel oil.	—	—
Clean cylinder and cylinder head finning under dusty conditions (HR).	59	—
Clean fins on oil cooler—if fitted (HR).	95	
Change oil in Lister marine reduction gear.	100	100
Every 1500 Hours		
Decarbonise.	59	59
Clean inlet manifold and exhaust system.	43	63
Clean fins on cylinder head and cylinder (HR).	59	—
Examine fan blades and clean (HRW Radiator cooled).	—	68
Check free working of governor linkage.	37	37
Drain and clean fuel tank.	91	91
Renew fuel filter element.	30	30
Clean fuel injector nozzle and check the pressure settings.	35	35
Check fuel pump timing and balancing.	34	34
Every 6000 Hours		
Check big ends and main bearings.	56	56
Inspect camshaft bearings and tappets.	52	52
Renew valve springs.	47	72

A reasonable amount of time spent in checking over the details as described above is the user's best insurance against loss of valuable time and costly repairs.

Section Two LUBRICATING SYSTEM



HS21

- | | |
|--|-------------------------------|
| 1. Lubricating oil suction strainer. | 7. Oil pipe to valve rockers. |
| 2. Lubricating oil pump. | 8. Oil pipe to main bearings. |
| 3. Lubricating oil relief valve. | 9. Oil feed to idler gear. |
| 4. Oil level. | 10. Oil pipe to gear train. |
| 5. Dipstick. | 11. Lubricating oil filter. |
| 6. Oil passage to big end bearings and small ends. | |

Fig. 3 Lubricating Oil System

SPECIFICATION

1. The temperatures mentioned in the table are the ambient temperatures at the time when the engine is started. However if the running ambient temperatures are much higher than the starting temperatures, a compromise must be struck and a higher viscosity oil used, provided starting is satisfactory; multigrade oils overcome the problem provided they have a suitable specification. See Note 5.
2. HR and HRW diesel engines must be run on H.D. Diesel lubricating oils to specifications equal to or better than DEF2101D or BS1905 type B or MIL-L-46152 or AP1 CC. Straight mineral oils are not suitable, neither are oils of less detergency than specified.
3. MIL-L-2104B or MIL-L-2104C or AP1 CD oils are recommended for engines running at a high load factor, particularly in conjunction with high ambient temperatures. They must also be used if the sulphur content of the fuel exceeds 0.6%.
4. Series III oils must be used when oil changes are made at periods longer than 250 hours.
5. Multigrade oils must meet the specifications MIL-L-2104B or MIL-L-2104C. The oils must not be used in heavy duty applications.
6. The oil should be suitable for oil changes every 250 hours without undue oxidisation, with sump temperatures reaching 125°C in tropical climates under extremely severe applications, and 120°C under normal applications.

VISCOSITY

For starting temperatures:—

Below 5°C	SAE 10W
Between 5°C and 30°C	SAE 20/20W
Above 30°C	SAE 30

OPERATION (Fig. 3)

Oil is supplied under pressure from a rotary gear pump, to all crankshaft bearings, the camshaft locating bush, the gear train and the valve rocker gear.

The oil is drawn through a wire gauze strainer to the suction side of the pump. The pump delivers oil through a purolator filter to a gallery pipe and swivel union. A relief valve is fitted in the gallery pipe.

From the swivel union, oil is distributed to the main bearings and through internal drillings to the big and small end bearings. A connection from the centre of the swivel union supplies oil through a small bore pipe to the valve gear.

A separate oil pipe feeds oil through a locating plug to the gear end camshaft bush and to the gear train. A direct feed is supplied from the top of the oil pump to lubricate the idler gear.

The oil system is filled through the oil filler caps on the cylinder head covers or through the filler cap on the crankcase door, depending on installation. A drain plug is located on the fuel pump side of the engine; the dipstick is fitted either in the crankcase on the manifold side, or in the crankcase door. The working oil pressure in the system is 2.1/3.2 kgf.cm.² (30/45lbf.in²).

BEFORE STARTING OR AFTER OVERHAUL

Fill the engine crankcase through the oil fillers in the cylinder head covers—use all the oil fillers in the first instance—to the MAX mark on the dipstick. On engines with the oil filler on the crankcase door, the cylinder head covers should initially be removed and the valve gear well lubricated before starting.

STRAINER (Fig. 4)

Access to the oil strainer is gained by disconnecting the oil pipes to the filter at the crankcase and removing the crankcase door and filter complete.

The strainer is bolted to the crankcase dividing wall just clear of the sump floor with an outlet pipe pressed into the gear end of the crankcase directly below the oil pump. Every 1500 hours remove strainer, wash with clean fuel oil, thoroughly dry and replace.



Fig. 4 Oil Strainer

OIL PUMP (Fig. 5)

The rotary oil pump is fitted at the bottom of the crankcase at the gear end and is driven through an idler gear from the crankshaft pinion.

It is difficult to clearly specify the wear which can occur before a pump has to be replaced, because it depends on the lubricating oil system as a whole and the pump output margin in particular. In general if the lubricating oil has been kept clean and free from sand and other abrasives the oil pump should last at least 10,000 hours, and probably as long as the engine.

The oil pressures which can be obtained in the engine give a good guide as to the wear in the whole lubricating system which includes the pump and the pressure lubricated surfaces of the engine.

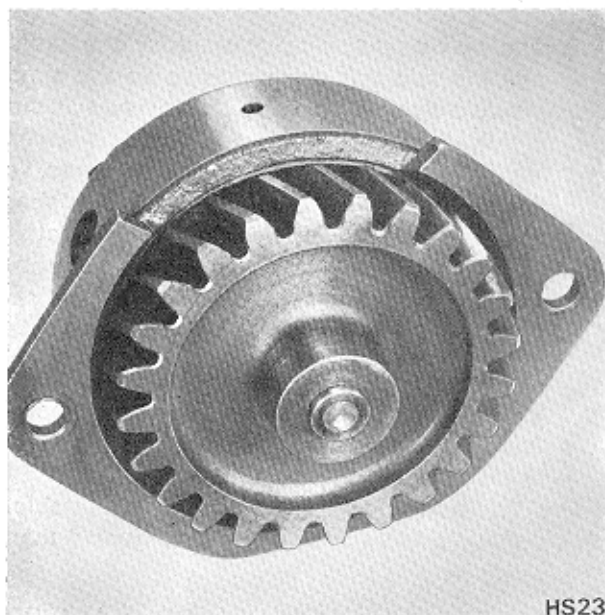


Fig. 5 Oil Pump

To Remove Pump

- (a) Drain lubricating oil.
- (b) Remove end cover.
- (c) Unscrew the two setscrews each side of the bottom gearwheel.
- (d) Lift out pump complete.

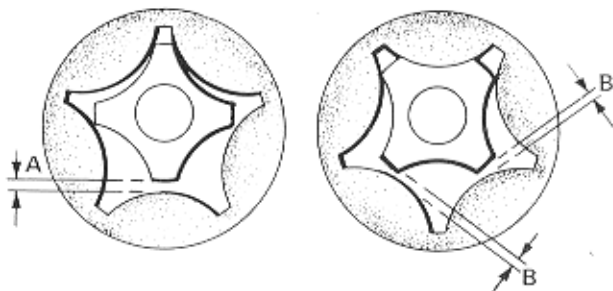


Fig. 6 Checking Pump Clearance

Servicing (Fig 6)

As a rough guide line the following amounts of wear should warrant the replacement of the pump:—

At point A:—	0.2 mm (0.08")
At point B:—	0.18 mm (0.007")
End clearance:—	0.15 mm (0.006")

Increase of end clearance is probably the best dimension on which to judge the wear of the pump as it has a marked effect on the pump output. Scored components are also a good reason for replacing the whole pump.

Should the spindle and impeller require renewal the eccentric ring must also be renewed.

Refitting Pump

Refitting is carried out in the reverse order to removal; ensure the cutaway section at the gear end of the pump is to the top.

When ordering and fitting a new pump, ensure that it is the correct rotation for the engine.

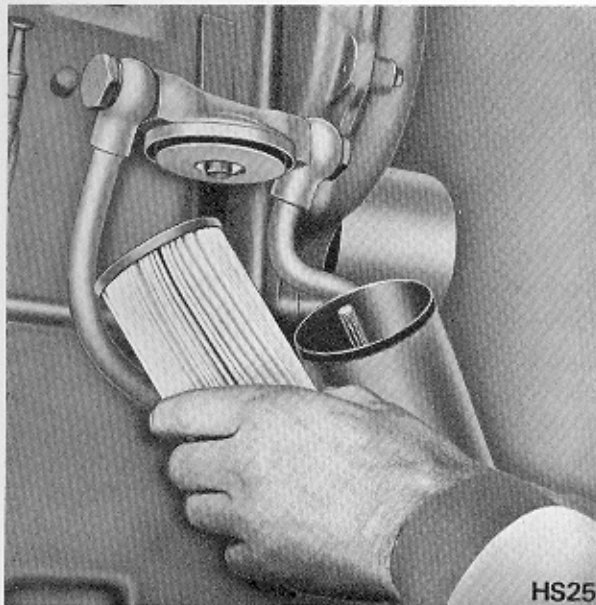


Fig. 7 Changing Oil Filter

LUBRICATING OIL FILTER

The filter assembly consists of a sump secured by a centre bolt to a filter head. The bolt screws into a centre tube which is locked in the filter head and retains an element guide. The sump beds on a seal carried in a groove formed in the filter head. The lower end of the centre bolt is fitted with a spring washer, gasket and a lower element guide retained by a circlip. The base of the sump has a reinforcing plate bored to accommodate a seal. A filter element is assembled in the sump between the upper and lower element guides.

The filter head is formed with inlet and outlet passages and bored to receive a relief valve which consists of a spring and ball valve retained in the bore by a threaded body.

Dismantling

Unscrew the centre bolt from the centre tube; withdraw the sump, extract the seal from the head and remove the filter element. Extract the circlip, slide the lower element guide, gasket, washer and spring off the centre bolt and withdraw the sump; remove the seal and reinforcing plate from the centre bolt.

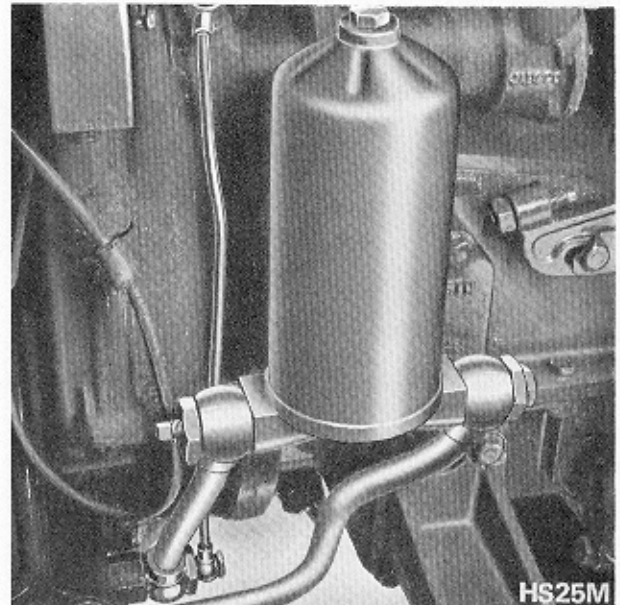


Fig. 8 Oil Filter—Marine Propulsion Engines

Changing the Filter Element (Fig. 7)

Note—The filter element should be changed every 250 hours.

- Clean the exterior of the filter assembly before removing the sump.
- Unscrew the centre bolt and withdraw the sump and filter element from the head, remove the element from the sump.
- Thoroughly clean the interior of the sump and ensure that the seal is in good condition and correctly assembled in its groove in the filter head.
- Place the new element in the sump so that it rests on the lower element guide and offer up the sump and element to the filter head ensuring that the former seats squarely on the seal. Screw the centre bolt into the centre tube firmly enough to ensure that there will be no oil leakage past the seals.

OIL SEALS (Fig. 9)

The crankcase is sealed at the flywheel end of the crankshaft by a screw type oil seal (A) and a felt ring (B). The screw seal must be concentric with the shaft, the maximum permissible variation of gap being 0.075 mm (0.003''). A ring type oil thrower (C) is fitted over the crankshaft and must be fitted before the main bearing housing. When an oil seal is refitted, the outside diameter of the seal should have a little Hylomar SQ32M applied. When fitting a new felt seal, coat the inside of the grooves with Wellseal before inserting the felt. Ensure the felt is not distorted during fitting and lightly oil before fitting assembly to the crankshaft.

The crankshaft extension is sealed in the gear case cover with a leather Gits seal. Great care must be taken not to scratch or otherwise damage this seal during assembly. A special service tool is available for fitting the end cover, see Section 7.

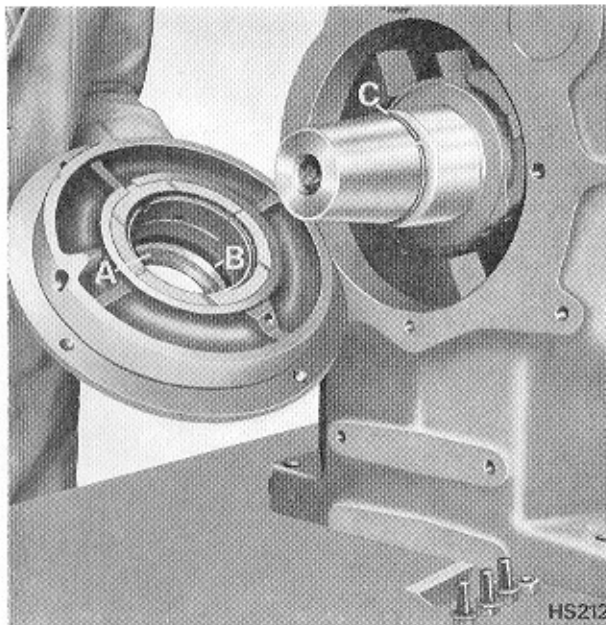


Fig. 9 Crankshaft Oil Seals

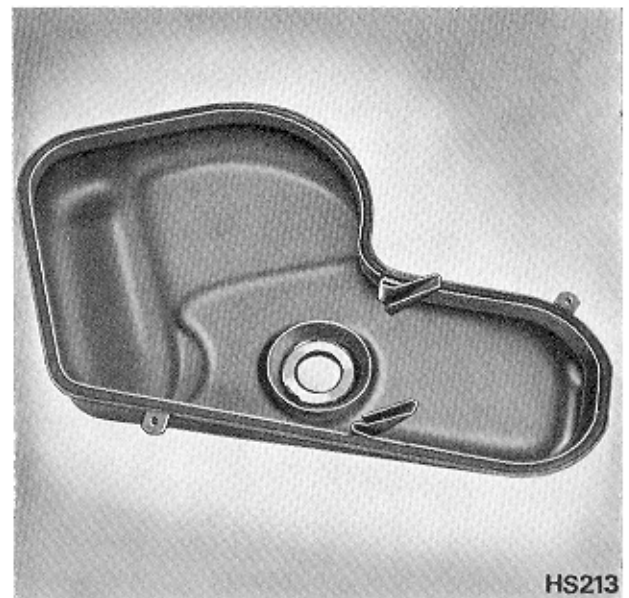


Fig. 10 Oil Seal and Oil Troughs in End Cover

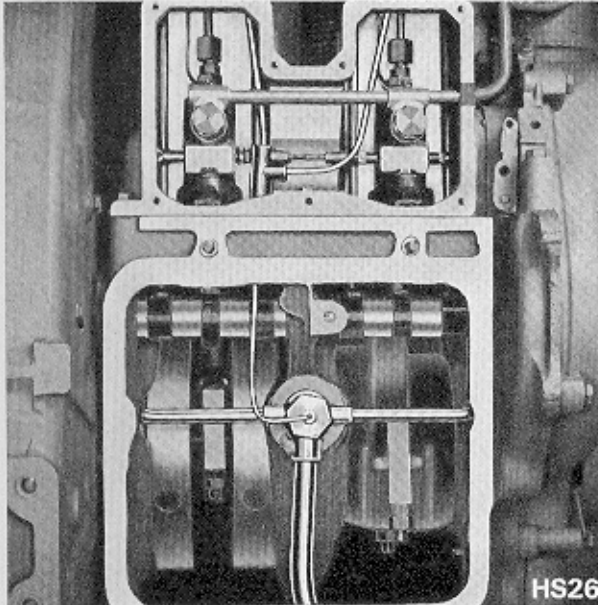


Fig. 11 Oil Pipes—2 Cyl. Engine

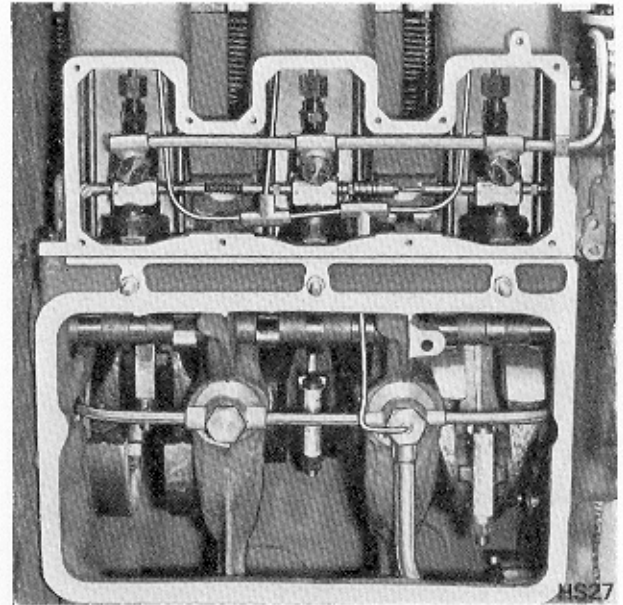


Fig. 12 Oil Pipes—3 Cyl. Engine

OIL PIPES

The variations in the oil system layout for two and three cylinder engines are shown in Figs. 11 and 12.

Two large bore pipes carry the oil from the oil pump to the top of the oil filter and from the filter back to the end of the crankcase. Each connection is made with an oil pipe plug and two washers.

The return connection, from the filter, is made to a pipe connector screwed into the end of the crankcase. Inside the crankcase, pipes then carry the oil via a relief valve to the main bearings—see Fig. 14.

A small bore pipe carries oil to the cylinder heads to lubricate the valve gear. When refitting the oil pipes to the rockers:—

- (i) Ensure that the feed pipe from the swivel union is pushed firmly home before tightening gland nut.
- (ii) When refitting the rubber tee pieces, ensure that the pipes are not pushed in beyond the internal counterbores. If they are pushed beyond the counterbores the oil feed can be blocked.
- (iii) To prevent the pipe chafing where it is routed through the top of the crankcase, ensure the polystyrene bush is in position.

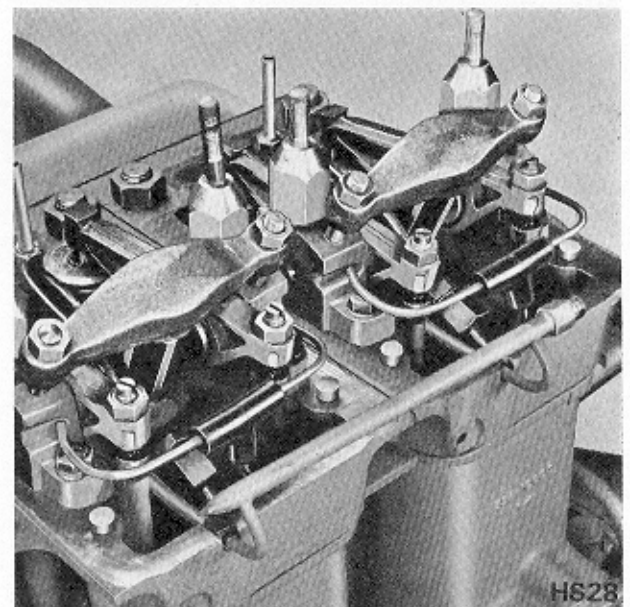


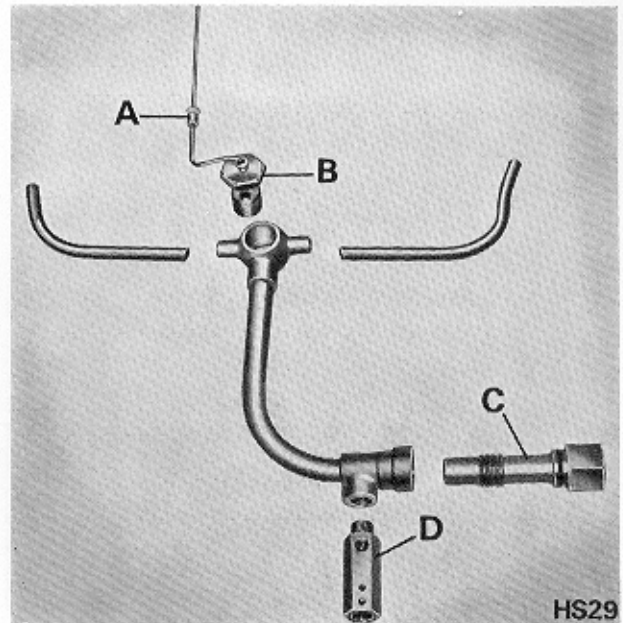
Fig. 13 Oil Pipes to Cylinder Head

To release main oil feed pipes (see Fig. 15):—

- (a) Remove rocker feed pipe from centre of swivel union.
- (b) Remove swivel union.
- (c) Remove pipe connector from crankcase.
- (d) Move pipe assembly towards gear end until pipe at flywheel end is released from the three way pipe connector.

When refitting these pipes, the kinked piece of pipe must be fitted at the gear end.

Above the gear train, see Fig. 16, a copper pipe is secured by a plug and tab washer into the top of the camshaft bush. The other ends of the pipe are located in the crankcase at the governor gear and crankshaft.



- A. Bush
- B. Swivel Union
- C. Pipe Connector
- D. Relief Valve

Fig. 14 Oil Pipes & Relief Valve (2 Cyl.)

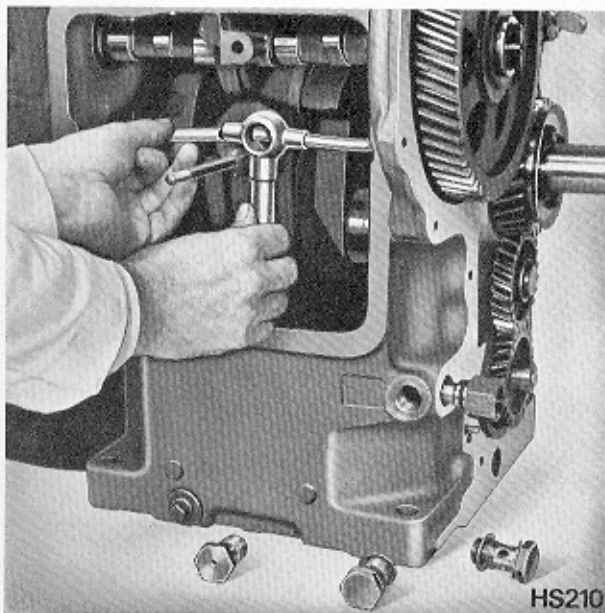


Fig. 15 Removing Oil Pipes

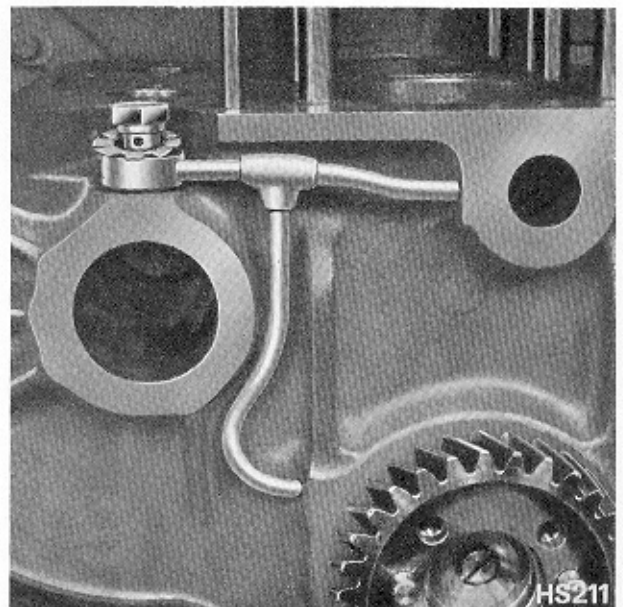


Fig. 16 Oil Pipe to Camshaft Bush & Governor



Fig. 17 Dipstick in Crankcase

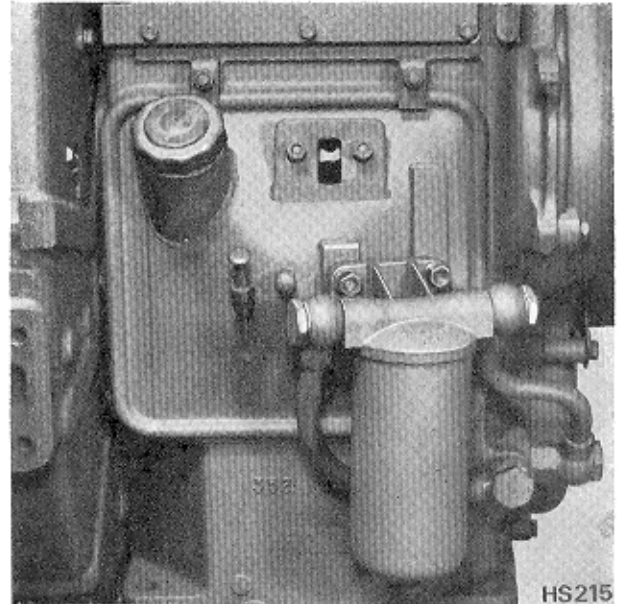
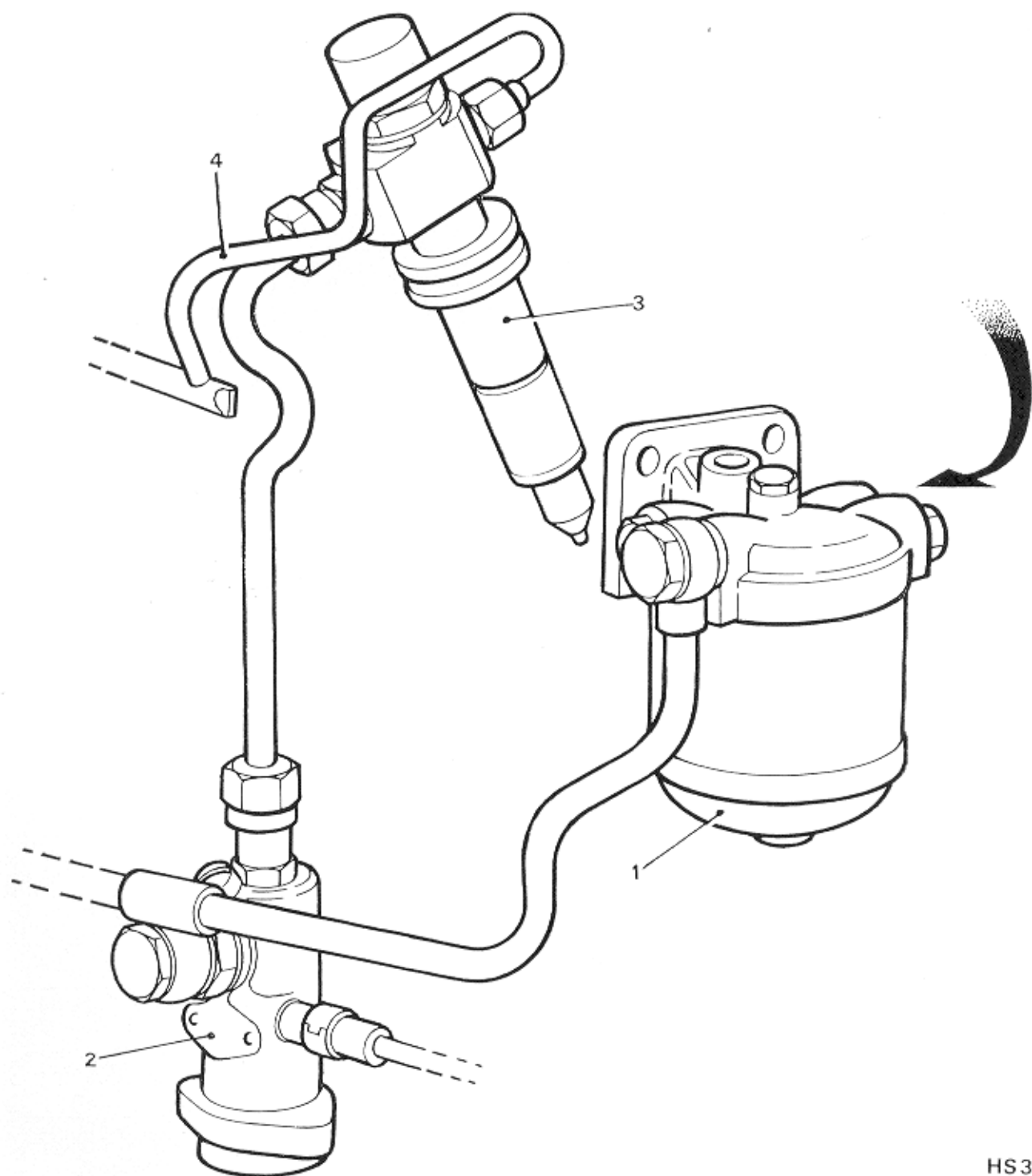


Fig. 18 Crankcase Door with Dipstick and Filler Cap

Engine	Dipstick Position	Dipstick Identification No.	Max. angle of inclination at which the engine may be run		Approx. oil capacity with engine level
			Flywheel Down	Flywheel Up	
HR/W 2	Crankcase	11	15°	15°	10.8 litres (19 pints)
HR/W 2	Crankcase Door	9	15°	15°	10.2 litres (18 pints)
HR/W 3	Crankcase	11	10°	13°	14.8 litres (26 pints)
HR/W 3	Crankcase Door	9	15°	15°	14.2 litres (25 pints)
HR/W 3	Crankcase	1	15°	5°	18.2 litres (30 pints)

Section Three FUEL SYSTEM



HS31

- 1. Filter
- 2. Pump

- 3. Injector
- 4. Leak-Off Pipe

Fig. 19 Fuel System

When refitting the fuel pipe from pump to injector the connection to the injector must be tightened before the connection to the fuel pump. This procedure will ensure that there is no leakage from these joints. It is most important that all fuel joints are tight and leakproof.

Always fill the fuel tank through a fine strainer, preferably at the end of a run. If any sediment is stirred up during the process this has time to settle before the engine is used again. If cans are used, avoid tipping out the last few drops.

Funnels are very difficult to keep clean in dusty conditions. Wash them before and after use and wrap them up when not required, or fill service tank direct from a small mouthed screw capped can such as a 2 gallon fuel can.

FUEL FILTER

The fuel filter is an essential part of a diesel engine and the engine must not be run without a filter element. The element should be renewed every 1500 hours, more frequently if for any reason the fuel is known to be dirty. The filter is located on a bracket at the gear end of the engine and is removed and serviced as follows:

Changing the Element (Fig. 21)

Isolate or drain fuel supply and remove securing screw from centre of filter cover. Clean inside of filter bowl and renew rubber sealing washers (2) and 'O' ring inside filter cover. Renew element and refit assembly. Ensure element fits squarely on to rubber sealing rings; tighten securing screw just sufficiently to prevent leaks.

Bleed system by connecting fuel supply and slackening vent screw on top of filter until all air is removed. If engine runs erratically, bleed fuel supply at fuel pumps.



Fig. 20 Fuel Pipe—Filter to Pumps (2 Cyl.)



Fig. 21 Changing Fuel Filter

PRIMING FUEL SYSTEM (Fig. 22)

Note: When carrying out this operation, care should be taken to prevent a large overflow of fuel into the crankcase. On completion, ensure all joints are serviceable or renewed and all bleed screws and connections are tightened firmly.

- (a) Fill fuel tank or connect fuel supply; remove fuel pump housing door.
- (b) Slacken bleed screw A on the top of the fuel filter body; tighten when an air free flow of fuel is obtained.
- (c) Slacken in turn, each bleed screw on the fuel pumps B starting from the pump nearest the filter. Tighten when all air has been displaced from the fuel at each pump.

Self Venting System

On starting for the first time, disconnect vent pipe at base of each pump to ensure an air free flow of fuel.

Fuel Lift Pump

When a fuel lift pump is fitted, on starting for the first time, loosen bleed screws on pumps and operate lever on lift pump until all air is displaced.

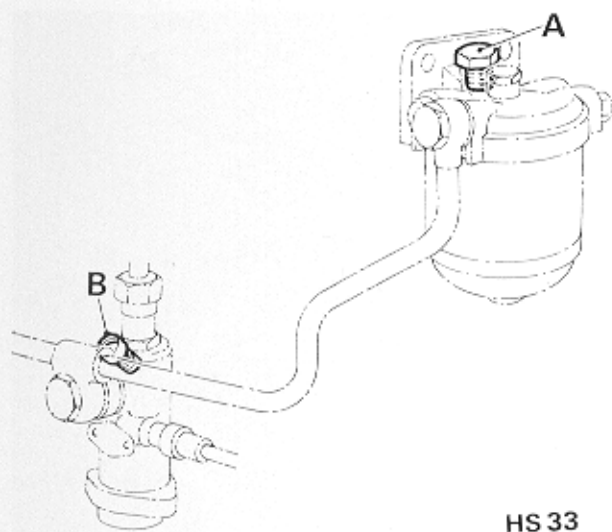


Fig. 22 Priming Fuel System

FUEL TANKS

A number of fuel tanks, both engine and wall mounted and tanks for marine applications are available for these engines. See Section Five for details.

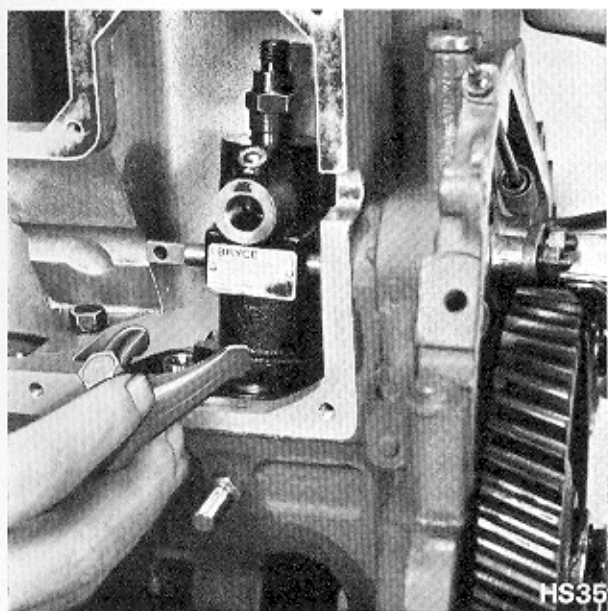


Fig. 23 Removing Fuel Pump

FUEL PUMPS

A separate Bryce Berger fuel pump is fitted for each cylinder. The pumps are located in a housing which is bolted to the top of the crankcase.

Removing Fuel Pump (Fig. 23)

- (a) Drain or isolate fuel supply.
- (b) Remove fuel pump housing door.
- (c) Disconnect fuel feed pipe at fuel pumps.
- (d) Disconnect fuel pipe to injectors.
- (e) Remove gear case end cover; this is to enable timing to be adjusted when refitting pumps.
- (f) Disconnect the linkage between pumps.
- (g) Remove fuel pump clamp setscrew and clamp. Lift out pump taking care to retain adjusting shims with their respective pump to avoid affecting the timing. (Spill timing must be checked when refitting pumps.)

Servicing

It is recommended that all servicing on the fuel pumps is carried out by accredited Service Depots. For operators wishing to carry out their own maintenance, see Bryce Berger Publication F158.

Refitting Fuel Pump

Refitting the fuel pump is carried out in the reverse order to removal. When tightening the fuel delivery connection, use two spanners to prevent the pump being twisted on its seat. The fuel injector pipe nuts should be torque loaded to 2.9 kgf.m. (21 lbf.ft.). Ensure the pump racks move freely otherwise erratic running or hunting will occur. Check fuel pump and governor setting and fuel pump timing; refit fuel pump housing door after coating jointing face with Hylomar SO32M and fitting a new joint. A special tapered sleeve should be used when refitting end cover to prevent damage to the oil seal. See Section 7, Service Tools. A new end cover joint should be used and Wellseal applied to the joint face and to the joint.

FUEL PUMP AND GOVERNOR SETTING

—(Fig. 25)

(a) SET ENGINE

Set the engine control to RUN position.

(b) CALIBRATE PUMPS

Adjust linkage so that all calibration marks A coincide with the sides of the pumps within 0.13 mm (0.005"). The fuel racks must move freely after this adjustment.

(c) ADJUST OVERLOAD STOP

Adjust overload stop B so that when it touches the overload trip C, the calibration marks are against the side of the fuel pumps as detailed in para. (b) above.

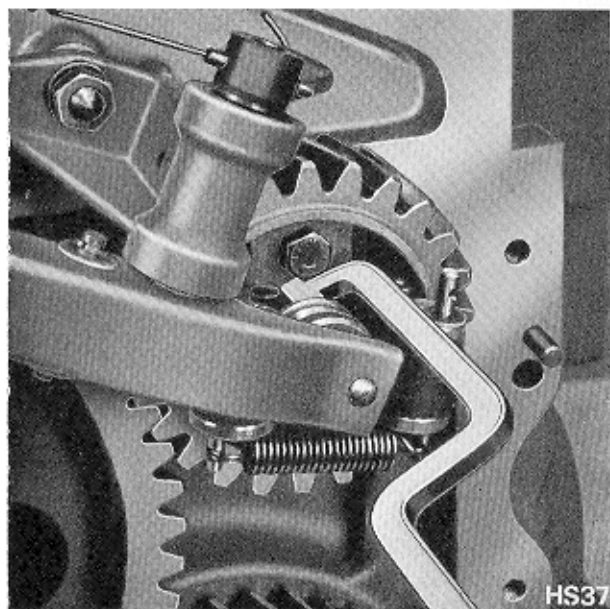
(d) SET GOVERNOR

Lift overload trip and wedge up whilst carrying out this operation. Adjust on link D—by removing split pin and turning link—so that when calibration marks A are against the side of the pumps, the distance between the governor weight carrier and the inside of the governor sleeve is 12.7 mm ($\frac{1}{2}$ "). Fit new split pin; allow overload trip to assume its normal position.

(e) SETTING ENGINE LOAD

Final setting for engine application is carried out by turning the overload stop B downwards or upwards. Settings are as follows:—

1200 to 1800 rev/min	4 flats down.
2000 rev/min	No further adjustment necessary.
2200 rev/min	3 flats up.
Rated Engines no overload (engines driving pumps or fans and all marine propulsion engines).	5 flats down.



*Fig. 24 Checking Governor Setting

*This illustration shows the clearance being checked on a constant speed engine with a locally made tool. One of the governor weight springs has been removed to improve accessibility.

Adjusting Idling Spring (Fig. 25 inset) Variable Speed Engines Only

The device consists of an idling spring H which is mounted over the shackle L of the fly-wheel end fuel pump and exerts a force on the fuel pump rack, by abutting against the pump body.

The fuel pump shackle L is fitted with a link stud K which has a long thread on which is screwed the idling spring adjusting sleeve I. This sleeve when rotated controls the spring force and is locked in position by the lock nut J.

To adjust the idling spring H the main speeder spring at the gear end of the engine is completely slackened and the adjusting sleeve I is rotated in the desired direction, until an idling of about one third of the rated engine speed is obtained, and then locked by the nut J. Care must

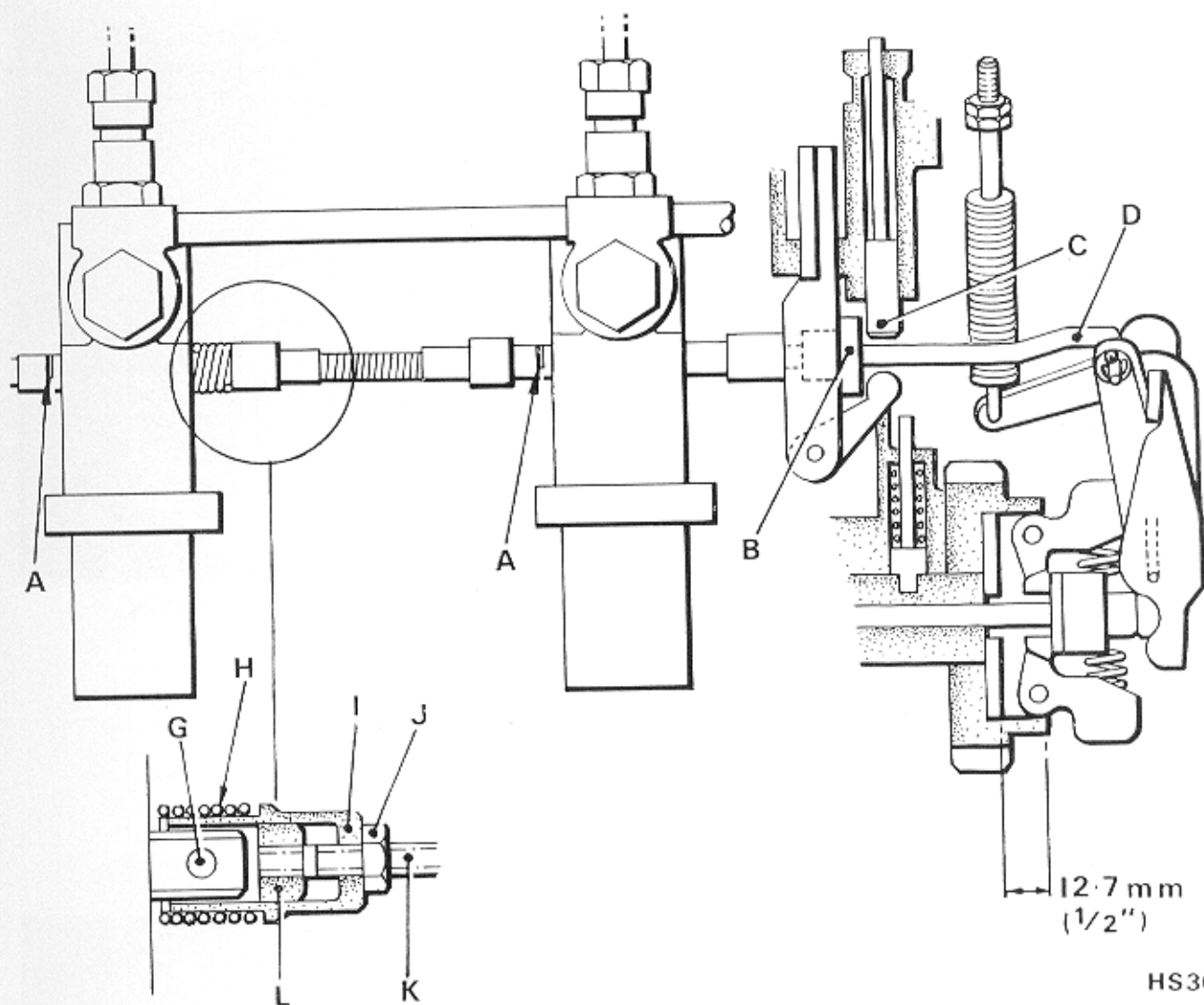


Fig. 25 Fuel Pump and Governor Setting

HS36

be taken that the shackle pin G is at least partially covered by the adjusting sleeve.

The speed control on the engine has an idling adjusting screw which should now be adjusted so that the main speeder spring just begins to

increase the engine speed; this will eliminate "hunting".

Information on Variable Speed Controls can be found in Section 5.

FUEL PUMP TIMING (Fig. 26)

A thoroughly cleaned container holding a supply of clean, fresh fuel oil should be available for washing dismantled parts. Components should be assembled wet although it is permissible to use non-fluffing paper during cleaning processes. Never use paraffin and never use woven cloths. The components of each individual pump should be kept together during dismantling.

- (a) Set the control lever to RUN.
- (b) Turn the flywheel to the firing position. Set the mark Z, which is on the rear face of the flywheel opposite the arrow on the fan shroud, HR engines (Fig. 27A), or opposite the pointer on HRW engines (Fig 27B), with both valves closed.
- (c) Remove the fuel pipe from the pump to the injector.
- (d) Remove the delivery valve holder A, delivery valve B and spring C. If fuel flows from the pump, turn the crankshaft in the direction of rotation until the flow ceases.
- (e) Replace the delivery valve holder without the valve and spring.

Note: A spill pipe, fitted to the top of the delivery valve holder will give a more accurate indication of fuel flow cut off.

- (f) Turn the crankshaft backwards until fuel commences to flow and turn in direction of rotation until flow ceases. Blow fuel from the top of the holder—or spill pipe to make sure flow has ceased. At this position the firing mark Z should be opposite the arrow—or pointer—or up to 4.76 mm (3/16 in.) before it in the direction of rotation. If it is not, the shims below the body must be adjusted.

Remove shims to advance

Add shims to retard

Shims 0.13 mm and 0.25 mm (0.005" and 0.010") thick fitted below the fuel pump body are used for this adjustment. A 0.13 mm (0.005") shim added under the pump will retard the timing approximately $1\frac{1}{2}^{\circ}$ (approximately 6.35 mm ($\frac{1}{4}^{\circ}$) on the rim of a 50.8 cm (20") diameter flywheel). When timing is correct, replace delivery valve and spring.

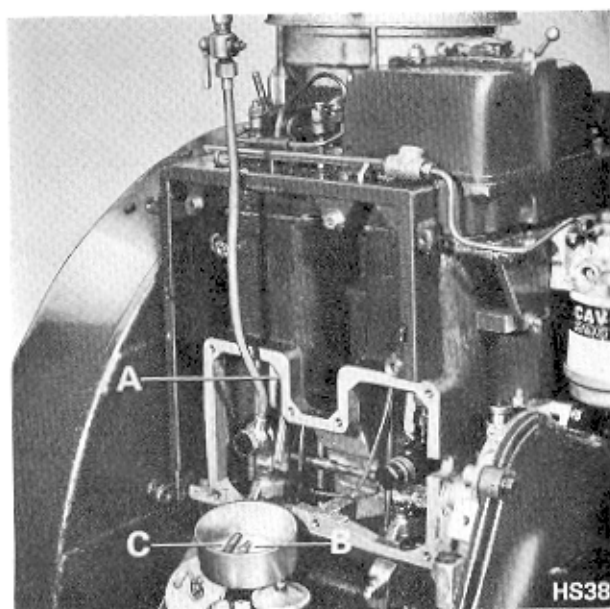


Fig. 26 Fuel Pump Timing

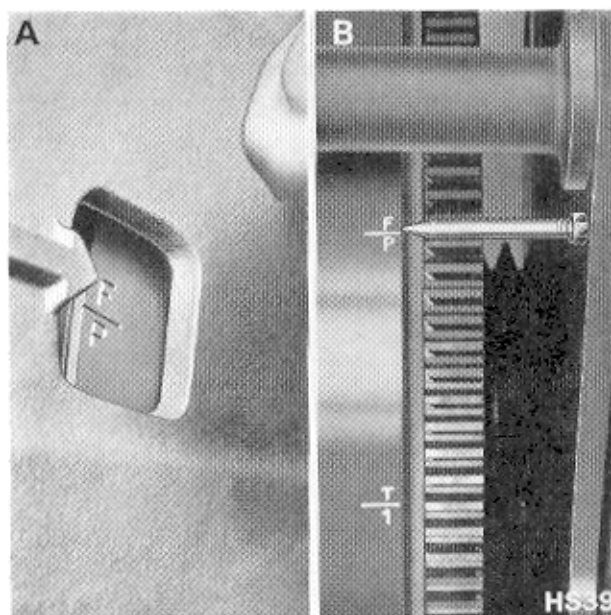


Fig. 27 Timing Marks

FUEL INJECTOR

The injection equipment, and the pipes and unions between the fuel filter and the fuel pump, and between the fuel pump and the injector must be absolutely clean; one particle of dirt can easily block one hole in the nozzle and produce a dirty exhaust. Every care is taken before the engine leaves the Works to ensure that this equipment is scrupulously clean, and after the engine is run in on test these injectors are checked and replaced if necessary, as sometimes particles of dirt get dislodged from the system when all the equipment is new. Therefore it is recommended that great care be taken not to introduce dirt into the system in any subsequent dismantling after the engine leaves the Works. This applies to the fuel pump, the fuel injector and all the pipes and unions between the fuel filter and the fuel pump and between the fuel pump and the injector.

SERVICING

Examine oil seal ring for damage or cuts, replace if necessary.

Ensure the seatings in the cylinder head (HR) are clean and smooth.

Fit new copper joint.

Check that the injector nozzle cap nut and outer cap are dead tight 9.0 kgf.m. (65 lbf.ft.).

A rubber plug in the nozzle cap nut gives access to the adjuster.

Refitting is carried out in the reverse order to removal. The clamp nuts must be tightened evenly to 2.07 kgf.m. (15 lbf.ft.) torque ensuring that the clamp is level and bears evenly on the injector. The pipe from the pump to the injector must not be tightened until the clamp is correctly secured.

REMOVING INJECTOR (Fig. 28)

Note. Fig. 28 shows the injector on an HRW engine.

- (a) Remove cylinder head cover.
- (b) Disconnect leak-off pipe to tank and fuel feed pipe from pump.
- (c) Remove injector clamp.
- (d) Remove injector complete with oil seal ring and injector joint.

The injector is set to 180 atmospheres; full instructions for testing injector can be found on next page.

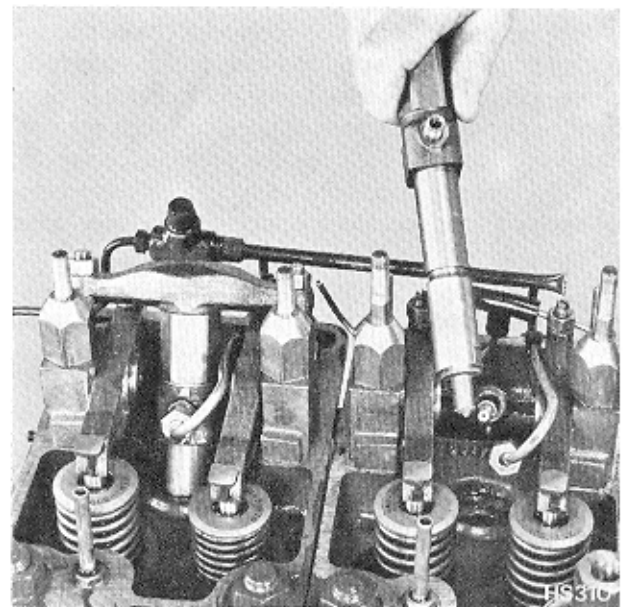


Fig. 28 Removing Injector

FUEL INJECTOR—TESTING INSTRUCTIONS

The injector nozzle has four spray holes each **0.27 mm. (0.010") diameter**. The setting pressure of the injector spring is **180 atmospheres**; this allows for settling to the normal pressure of 170 atmospheres.

To ascertain if the injector spray is in good condition, the injector is removed from the engine and reconnected to the fuel injection pump externally, so that the spray can be observed. This requires removing the injection pipe and using a spare one (the standard injection pipe must never be bent for this purpose otherwise it will be impossible to refit). The engine is turned at about 60 rev/min and after a few turns the nozzle will begin to function and the sprays can be observed. **Ensure sprays are directed away from the operator.** These should be in the form of a very fine mist, not streaky or dribbly.

All sprays should have the same appearance and the same length of penetration in the air. If one spray is shorter or weaker than the others this means that the corresponding hole is partially blocked and best results will not be obtained.

If one hole is totally blocked or the nozzle dribbles it must be replaced or sent to be cleaned and reclaimed by an accredited Service Depot.

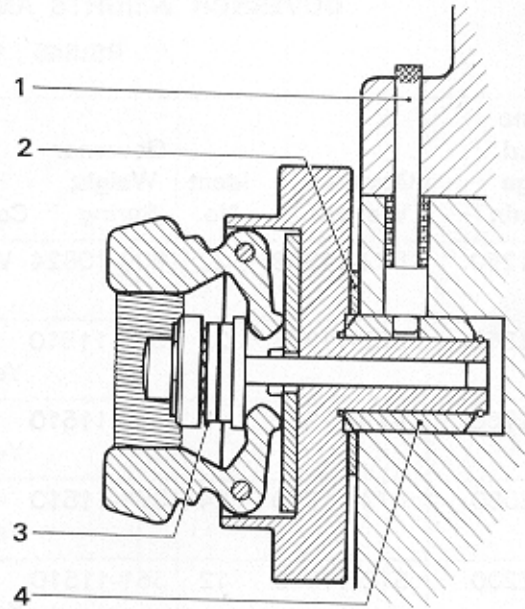
If the nozzle only is replaced, the injector spring pressure must be reset and this cannot be done without a special test rig consisting of a hand operated fuel pump and a pressure gauge. This rig is normally carried by Service Engineers but if it is not available it becomes necessary to replace the complete injector by a new or a serviced one which has a clean nozzle and has been properly set to the correct pressure; in this case the complete faulty injector should be sent to the Service Depot or returned to the Lister Works or Agents for reconditioning.

The back leakage measured with a hand pump and gauge must be such that the time for the setting pressure to drop from 150 to 100 atmospheres must be within **10 to 55 seconds**.

GOVERNOR

The engine governor assembly is located in the top of the gear case; access is gained by removing the end cover.

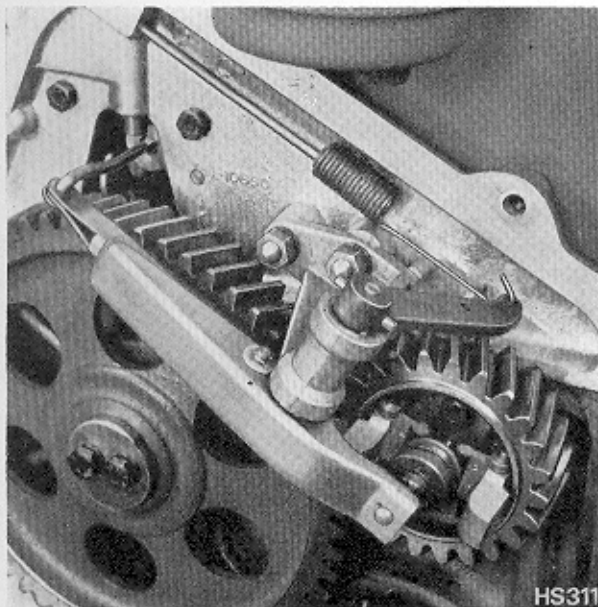
The governor lever operating the fuel pumps is carried on a bracket secured to the crankcase above the gear train. The right hand end of the lever makes contact with a thrust sleeve carried in the centre of a gearwheel. The thrust sleeve movement is controlled by two governor weights secured by pins to a carrier which is bolted in the recess of the gearwheel. A speeder spring, secured at one end to the lever and the other to the crankcase or speed control, controls the amount of movement for a given engine speed. The governor gear is driven directly from the camshaft gearwheel.



HS 312

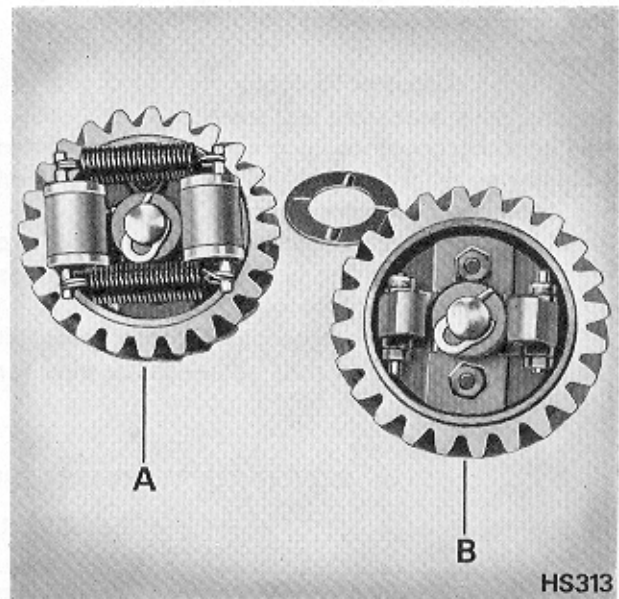
1. Spring Loaded Dowel
2. Thrust Washer
3. Thrust Race
4. Bearing

Fig. 30 Cutaway view of Governor



HS311

Fig. 29 Governor Gear



HS313

- A. Constant Speed
- B. Variable Speed

Fig. 31 Governor Pin, Weights and Thrust Bearing

GOVERNOR WEIGHTS AND SPRINGS—CONSTANT SPEED

BS:649 : 1958 Class A2

Engine Speed Range rev/min	Governor Weight	Ident No.	Governor Weight Spring Colour	Speeder Spring Colour	Position of Speeder Spring Hook on Lever	Speeder Spring Adjusting Screw
1000-1250	572-11393	22	203-10824 White	351-11011 Red	outer hole	382-00243
1260-1350	572-11393	22	351-11510 Yellow	351-11011 Red	outer hole	382-00243
1400-1700	572-11391	3	351-11510 Yellow	351-11011 Red	outer hole	382-00243
1750-2000	572-11680	24	351-11510 Yellow	351-11011 Red	outer hole	382-00243
2010-2200	572-11650	12	351-11510 Yellow	351-11011 Red	outer hole	382-00243

CHANGING GOVERNOR WEIGHTS AND SPEEDER SPRING

Note: See tables on this page for the weights and speeder springs required for various engine speeds. There are no governor weight springs on variable speed governors; all governor weights are supplied in pairs only.

To Change Governor Weights

- Remove gear case end cover.
- Remove governor lever and lift spring loaded dowel above bearing; lift off gearwheel complete with governor gear.
- Lift out thrust sleeve and remove the two setscrews securing governor carrier; remove carrier and weights.
- Remove governor weight fulcrum pins, fit new weights and refit pins—check pins for wear.

- Refit carrier complete with weights and secure with two setscrews.
- Refit gearwheel to engine ensuring locating dowel registers in the correct hole in the spindle bush.
- Ensure thrust sleeve is clean and serviceable and replace.
- Refit governor lever; check fuel pump and governor setting, see page 32.

Changing Speeder Spring

Remove end cover and disconnect spring from governor lever and crankcase. When refitting, ensure spring is securely hooked into the correct hole in governor lever; refit adjusting screw into crankcase and after final adjustment of speed, tighten locknut.

GOVERNOR WEIGHTS AND SPRINGS—VARIABLE SPEED

BS:649 : 1958 Class B

Engine Speed Range—rev/min	Governor Weight	Ident No.	Speeder Spring Colour	Idler Spring Colour
650—2000	572-11665	18	351-11013 Green	204-21491 Yellow
750—2200	572-11663	16	351-11013 Green	204-21491 Yellow

Section Four – Part One

HR ENGINES

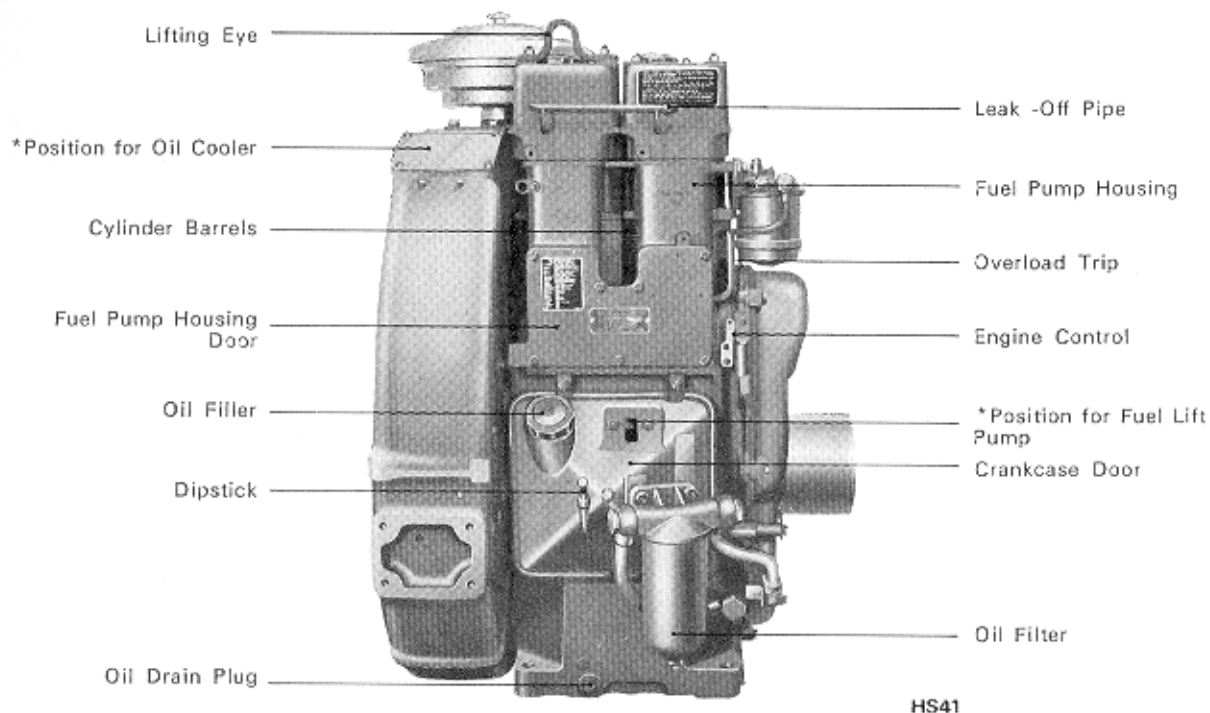


Fig. 32 Main Features—Fuel Pump Side

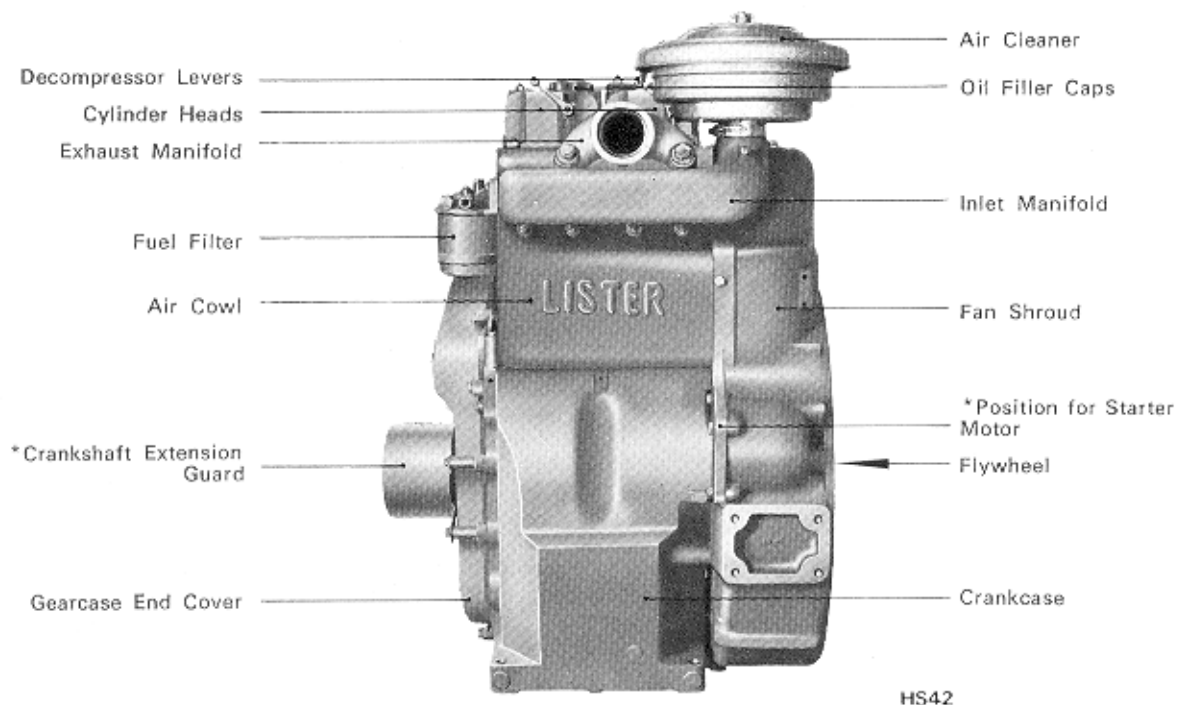


Fig. 33 Main Features—Manifold Side

* Information on accessories that may be fitted in these positions can be found in Sections Five and Eight.

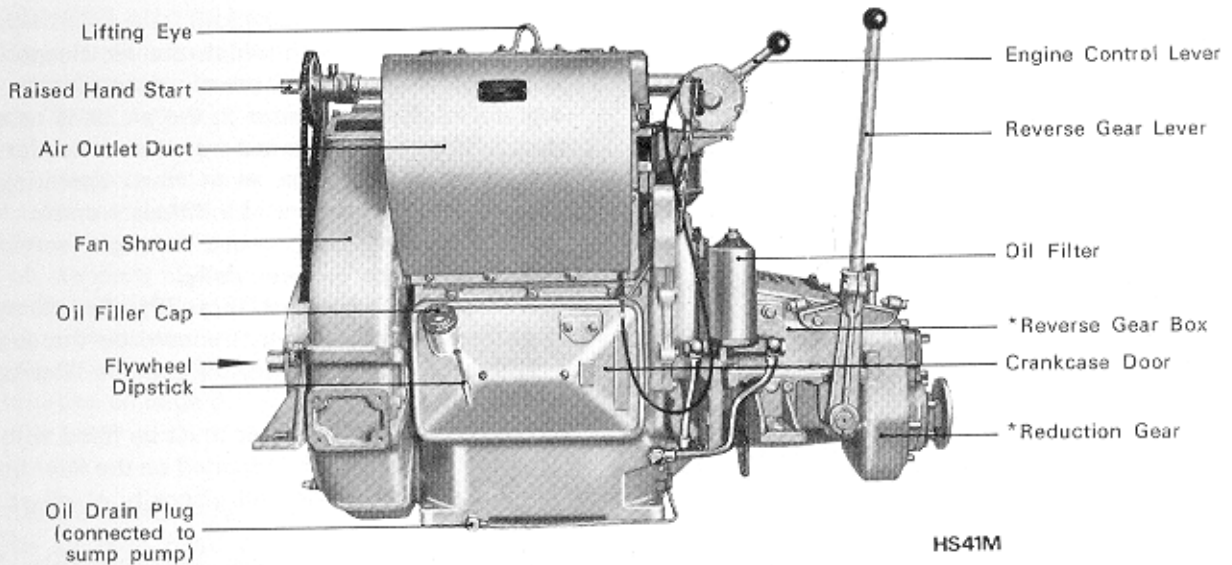


Fig. 34 Main Features—Fuel Pump Side—Marine Propulsion Engines

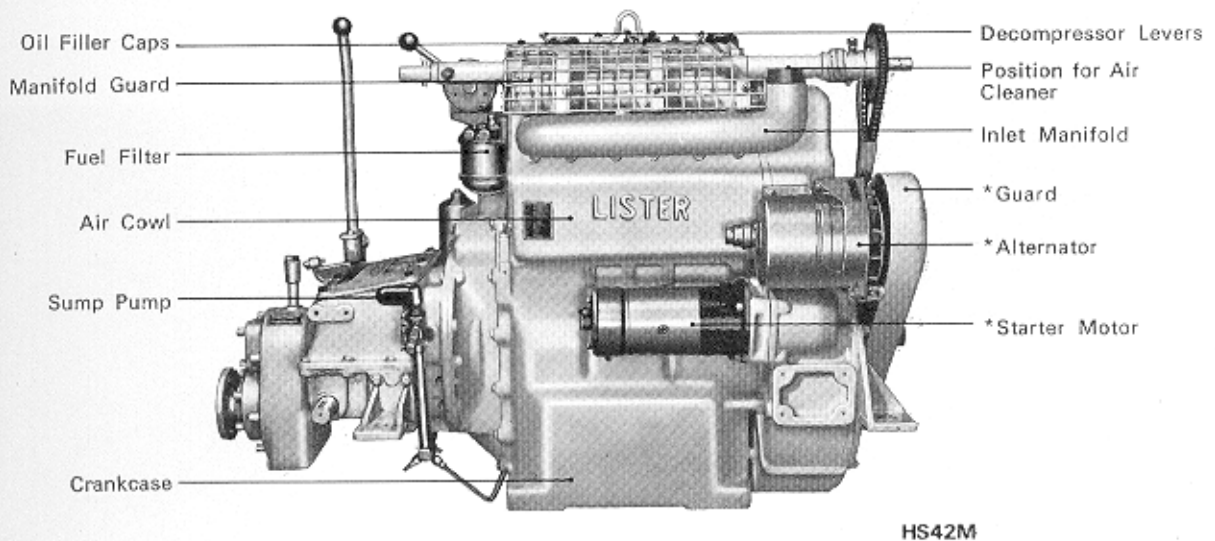


Fig. 35 Main Features—Manifold Side—Marine Propulsion Engines

* Information on accessories that may be fitted in these positions can be found in Sections Five and Eight.

INTRODUCTION

Every effort must be made to maintain the engine in a clean condition and oil leaks must be dealt with as soon as they occur. With a new or overhauled engine the joints settle during the first few hours running and their tightness must be subsequently checked. A table showing recommended jointing compounds and how to use them is given on page 57.

LUBRICATION ON ASSEMBLY

When assembling the engine, use a mixture of 2.5% colloidal molybdenum disulphide (Acheson's Hi Load additive or equivalent) and normal engine lubricating oil.

All bearing surfaces must be well lubricated including the valve stems and the cups of the push rods. New camshaft bushes should be immersed in clean engine lubricating oil for four hours before fitting.

AIR CLEANERS

The frequency with which the air cleaner requires servicing varies greatly according to the amount of foreign matter in the air. It is recommended that the element receives attention at least every 100 hours, even when operating in substantially dust-free conditions; under less favourable conditions more frequent servicing will be necessary — even daily.

With oil bath cleaners (Fig. 36) after dismantling the filter, the element should be thoroughly washed in paraffin or fuel oil and the filter bowl cleaned out.

On reassembly the filter must be filled with oil exactly up to the mark indicated on the filter bowl, using the same grade and viscosity of oil as for the engine.

Air cleaners with paper elements (Fig. 37) must have the elements replaced when there are indications of restriction, and the body of the air cleaner should be cleaned internally. When reassembling air cleaners, it must be ensured that all joints and connections on the cleaned air side are air tight so that no particles of dust can enter the engine (see also Section Five).

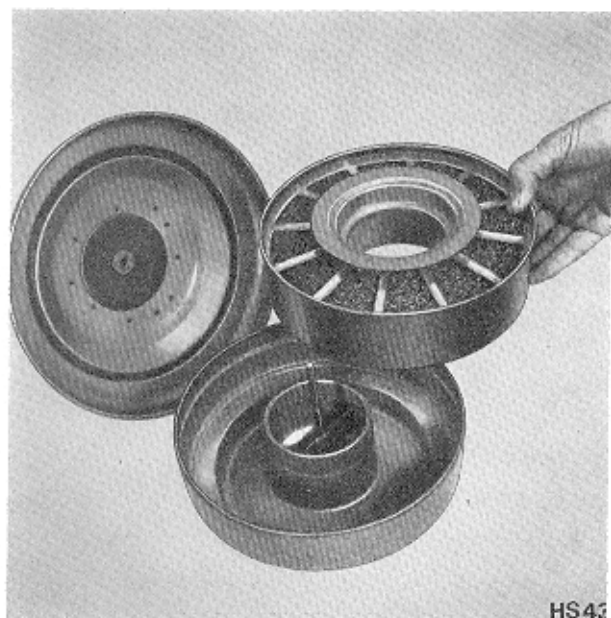


Fig. 36 Air Cleaner—Oil Bath



Fig. 37 Air Cleaner—Dry Type

MANIFOLDS AND SILENCER (Figs. 38 & 39)

The cast iron manifolds, with asbestos joints, are located on studs on the side of the cylinder heads. Brass nuts with spring washers retain the manifolds in position; the top row of studs have clamp washers fitted to hold both the exhaust and inlet manifolds. Marine propulsion engines have a wire guard fitted on the exhaust manifold.

The standard silencer is a "Pepper Pot" type, other fittings are available — see Section Five. If the exhaust system is modified in any way, consideration should be given to the installation information on page 6.

CYLINDER HEAD COVER (Fig. 40)

The cylinder head cover is an alloy casting and contains the decompressor lever and adjuster, an oil filler cap and on one cylinder, a lifting eye. The assembly is located on two studs and a joint seals the cover to the cylinder head; longer studs are used on the cylinder head holding the lifting eye. Joints are also fitted between the lifting eye and cover.

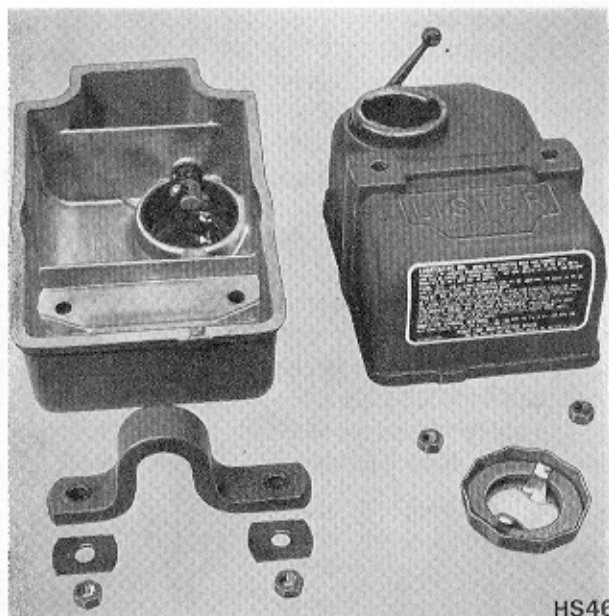


Fig. 40 Cylinder Head Covers

Breather

The crankcase breather, in the form of a pipe, is screwed into the top of the cylinder head and connects with the inlet port. The oil laden vapour is drawn into the inlet port and a partial vacuum maintained in the crankcase. This prevents the lubricating oil from working out through the joints and bearings.

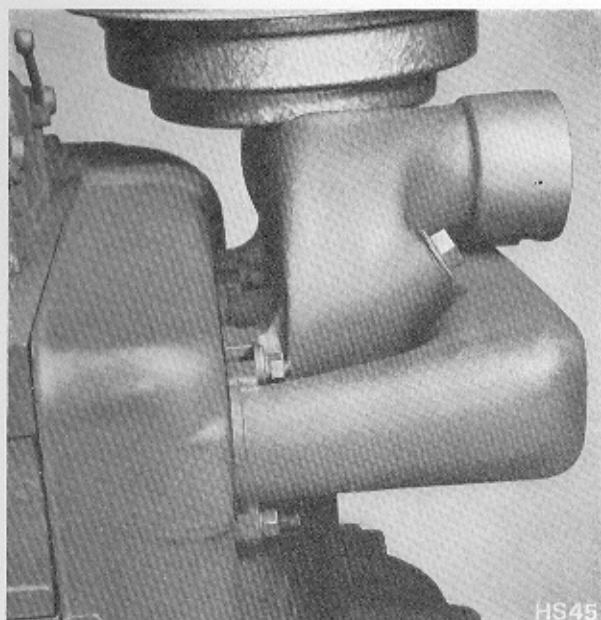


Fig. 38 Manifolds

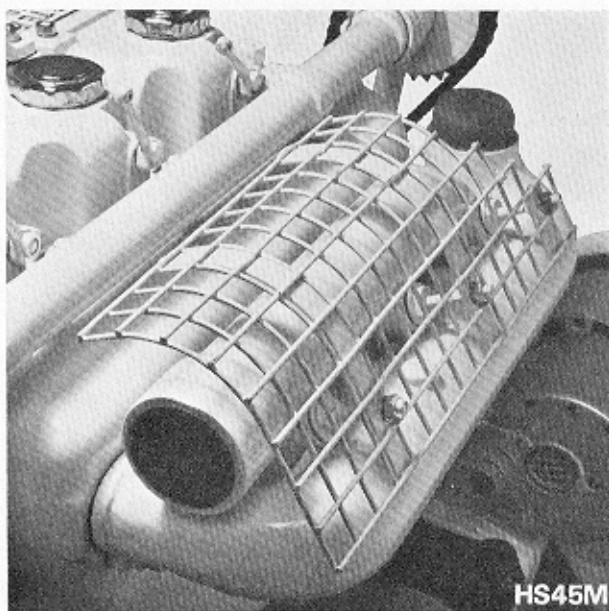


Fig. 39 Manifolds—Marine

Valve Clearance

It is important that the valve rocker clearances are maintained correctly, otherwise serious damage to the valve gear can result. With new engines or engines which have just been overhauled, the valve gear beds down rapidly during the first 500 hours running and for this reason it is essential that the valve to rocker clearance is checked at 25 hours, 250 hours and thereafter every 500 hours. It will be found that the clearance remains constant after 500 hours and if this is confirmed, the period before adjusting may be extended to 1500 hours.

The valve clearance for both inlet and exhaust, set with the engine cold is:—

- 0.05 mm (0.002") GO
0.10 mm (0.004") NOT GO

To Adjust (Fig. 41)

- Turn the piston to the T.D.C. position on the firing stroke (both valves closed).
- Slacken the locknut on the adjusting screw and turn the screw until the correct clearance has been obtained.
- Tighten the locknut whilst restraining the adjusting screw and re-check to ensure that clearance is correct.

Repeat the procedure for all valves.



Fig. 41 Adjusting Valve Clearance

Refitting Cylinder Head Cover

- Apply Hylomar SQ32M to cover jointing face and stick joint to it.
- Replace cover and fit lifting eye with joints (if applicable).
- Refit decompressor coupling rod(s) if removed.

Decompressor Adjustment (Fig. 42)

Access to the decompressor adjuster is through the oil filler cap in the cylinder head cover.

- Turn the piston to T.D.C. firing stroke (both valves closed).
- Move the decompressor lever towards the flywheel.
- Slacken the locknut and turn the decompressor screw down (clockwise) until the exhaust valve touches the piston.
- Turn the screw back half turn and tighten locknut.

Repeat the procedure for all cylinders.

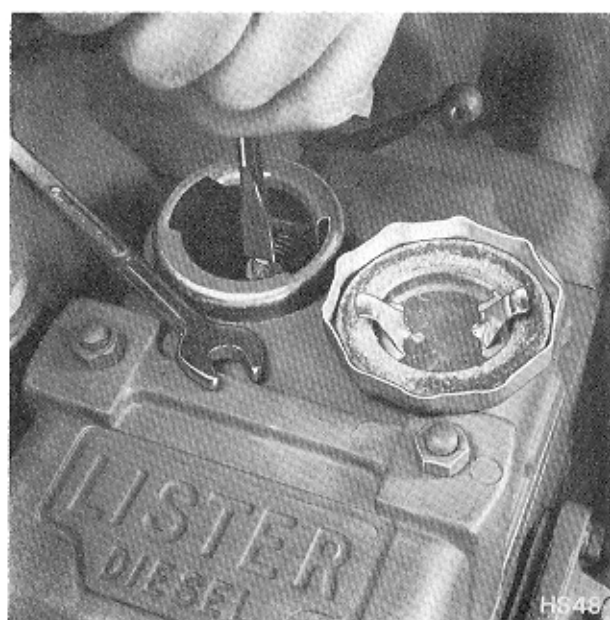
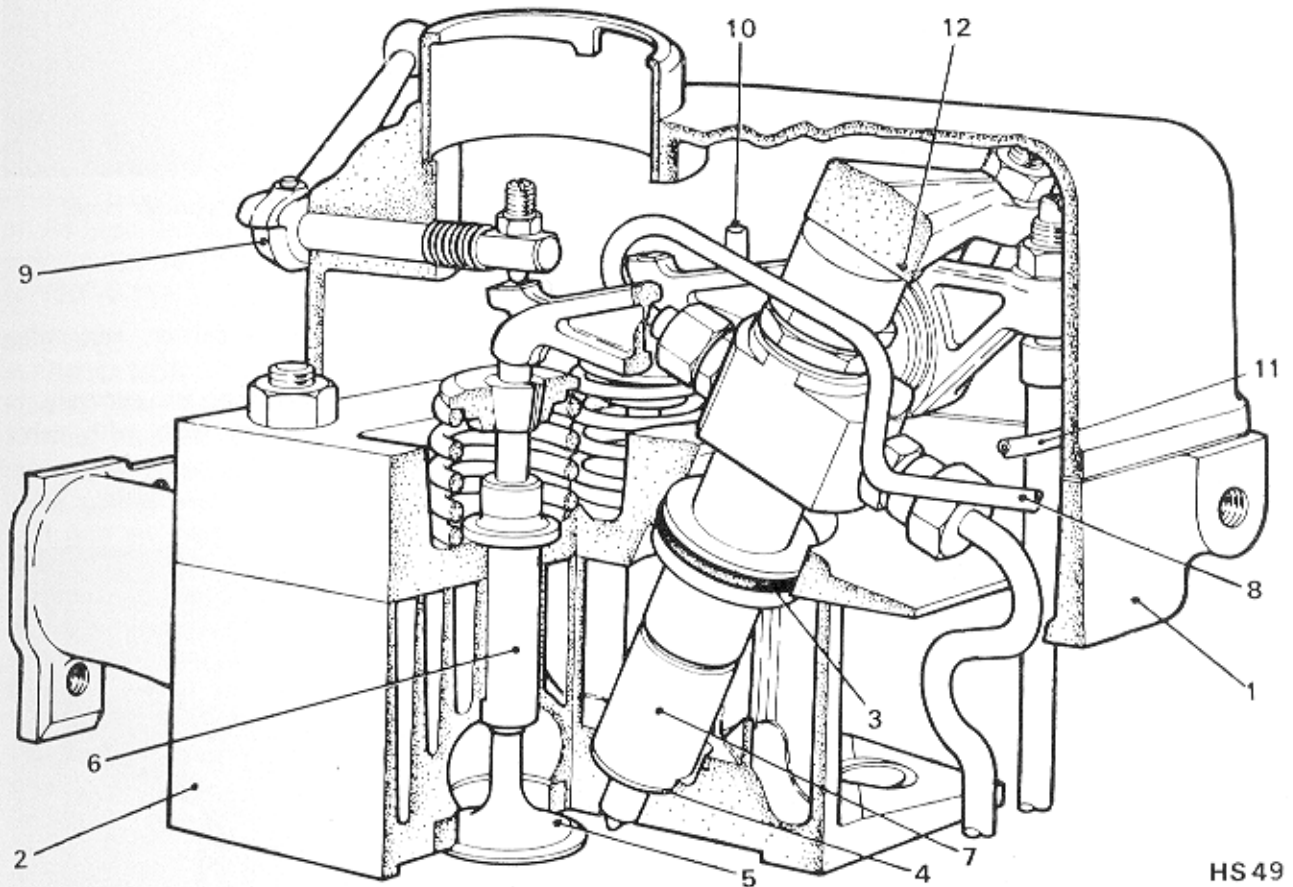


Fig. 42 Adjusting the Decompressors

CYLINDER HEAD (Fig. 43)

The cylinder head consists of two parts. The top half (top plate) is cast iron and contains the valve gear and breather tube. The lower half (cylinder head) is aluminium alloy in which are fitted the valve seat inserts. The valve guides which are a press fit, hold the two halves together.

Note: The two rubber blanking plugs fitted in the top face of each of the heads should not be removed.



- | | |
|---------------------------|---|
| 1. Top plate | 7. Fuel injector |
| 2. Cylinder head | 8. Fuel leak off pipe |
| 3. Injector oil seal ring | 9. Decompressor |
| 4. Injector joint | 10. Breather |
| 5. Exhaust valve | 11. Lubricating oil pipe to valve rockers |
| 6. Exhaust valve guide | 12. injector clamp. |

Fig. 43 Cylinder Head

Removing the Cylinder Heads (Fig. 44)

- (a) Remove cylinder head covers (and lifting eye where applicable); inlet and exhaust manifolds and gaskets.
- (b) Remove air cowling (two setscrews to air shield at gear end); disconnect strap between fan shroud and cylinder head at flywheel end.
- (c) When fitted, disconnect and remove air ducting and air outlet duct bracket on fuel pump housing door.
- (d) Remove fuel pump housing door.
- (e) Lift out lubricating oil pipes to rockers.
- (f) Disconnect and remove:—
 - (i) Fuel leak-off pipe.
 - (ii) Fuel pipe — pump to injector.
 - (iii) Fuel injector. (See Section 3)
- (g) Remove four holding down nuts and lift off head. Mark cylinder number for refitting and keep shims and gasket with head.
- (h) Lift out push rods.

To Remove Valves (Fig. 45)

- (a) Lay head upright on bench and place a circular block of wood about 114 mm (4½") in diameter under the heads of the valves.
- (b) Depress valve spring carrier.
- (c) Remove valve stem collets.

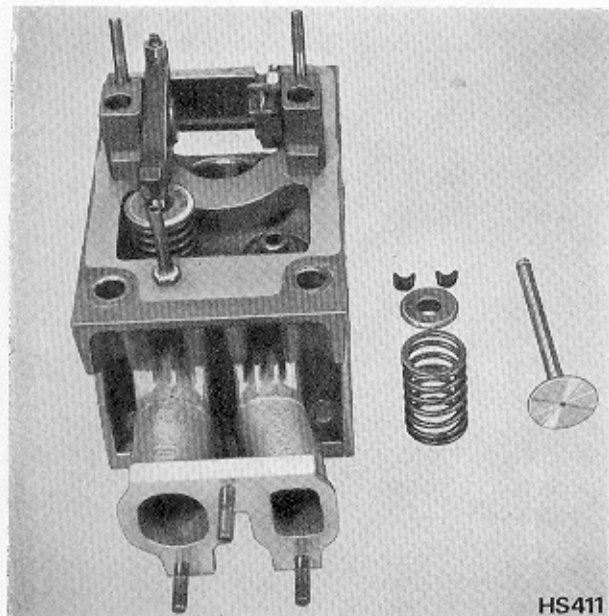


Fig. 45 Removing Valves

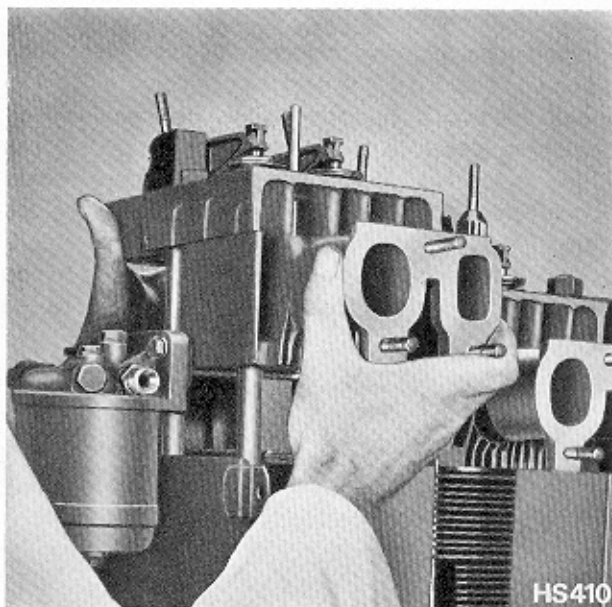


Fig. 44 Removing the Cylinder Head

- (d) Remove valve spring carrier, and valve spring(s).

When refitting, ensure collets are securely in position with top of collets flush with valve spring carrier.



Fig. 46 Valve Rocker Bracket

Rocker Lever Bush (Fig. 46)

If it is necessary to change rocker lever bush, remove setscrew and springwasher securing valve rocker bracket to head, lift off assembly. When removed, release circlip and slide off rocker lever. Use new joint when refitting assembly (Fig. 46). To prevent damage to the breather tube it is advisable to remove it when servicing the valve gear.

Valve Guides

The valve guides are a press fit and hold the two parts of the cylinder head together; the inlet guide is fitted with a rubber sealing ring and the guides are not interchangeable. (See Fig. 43, Item 6).

Valve Seats

The inlet valve is 1.01-1.27 mm (0.040"-0.050") and the exhaust valve is 0.89-1.14 mm (0.035"-0.045") below the combustion surface of the head. Width of valve seats: Inlet 2.78-3.2 mm (0.107"-0.127"); Exhaust 2.54-2.89 mm (0.100"-0.114").

Servicing

INFORMATION ON WEAR LIMITS CAN BE FOUND ON PAGE 116. TABLE OF CLEARANCES. Remove carbon from combustion area; thoroughly clean and inspect for cracks. Clean valve guides and check for wear; examine oil seal ring on inlet guide, replace if damaged or worn.

Check valve seats and inspect for nicks, cracks or pitting. Reface or change cylinder heads if not within limits. Check valve springs for free length. Examine rocker arms for cracks, damage and wear. Inspect push rods for bends and examine ball and cup ends for wear or cracks.

Valve springs must be replaced if they are rusty or pitted. They must be replaced after 6000 hours.

Good starting and satisfactory running depends to a great extent on the condition of the valve seatings, so the valves must be carefully ground and then tested, whenever they can be heard blowing on turning the engine slowly over compression.

Refitting the Cylinder Head

Examine the gasket, renew if necessary. Fit the necessary shims—see Checking Cylinder Head Clearance—nearest the head followed by

the gasket; these are retained in position with High Melting Point grease. (See page 58.)

The sequence for fitting the head is the reverse to removal. The cylinder head nuts and washers and top threads of the studs should have Well-seal applied.

The inlet and exhaust flanges of all cylinder heads must be lined up with a straight edge, or alternatively fit a manifold before finally tightening down head. Ensure holding down nuts are pulled down evenly and torque loaded to 11 kgf.m. (80 lbf.ft.). It is essential that these nuts be tightened before securing the injector. After fitting head reset valve clearance and check decompressor adjustment.

Checking Cylinder Head Clearance (Fig. 47)

Place two pieces of lead wire 1.5 mm (0.062") thick on the cylinder head, clear of valve recesses and the combustion chamber in the top of the piston; retain in position with grease. Space widely and as near as possible in line with the gudgeon pin. Tighten down the cylinder head to the correct torque loading (see previous paragraph) and turn the piston twice past T.D.C. Remove the cylinder head and measure the thickness of the lead. This should be between 1.07 and 1.14 mm (0.042" and 0.045"). This can be adjusted by shims 0.076 mm (0.003") thick placed between the cylinder head and the gasket.

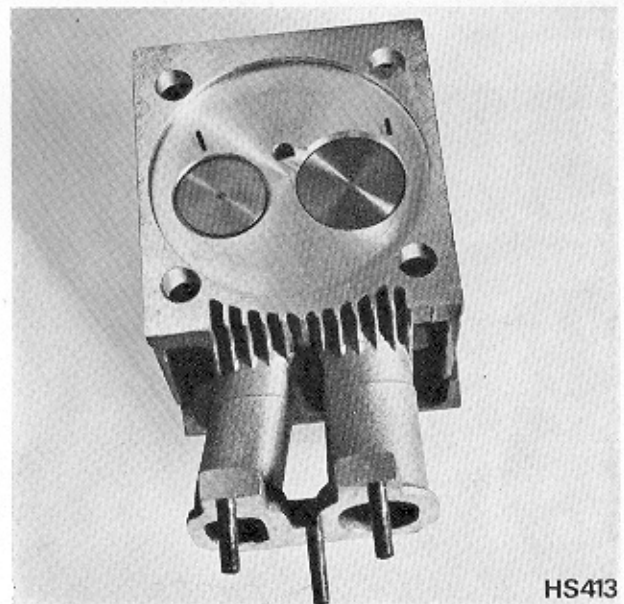


Fig. 47 Checking Cylinder Head Clearance

AIR SHIELDS (Fig. 48)

A side shield is fitted around the cylinder barrel at the gear end and flywheel end and a centre shield is fitted between each barrel. (One on an HR2, two on HR3 engines). It is essential that the air shields are fitted in the correct position.

The centre shield(s) and side shields at gear end can be easily lifted out once the cylinder heads are removed.

The side shield at the flywheel end has a sprung section abutting against the fan shroud and may therefore require some leverage to lift off.

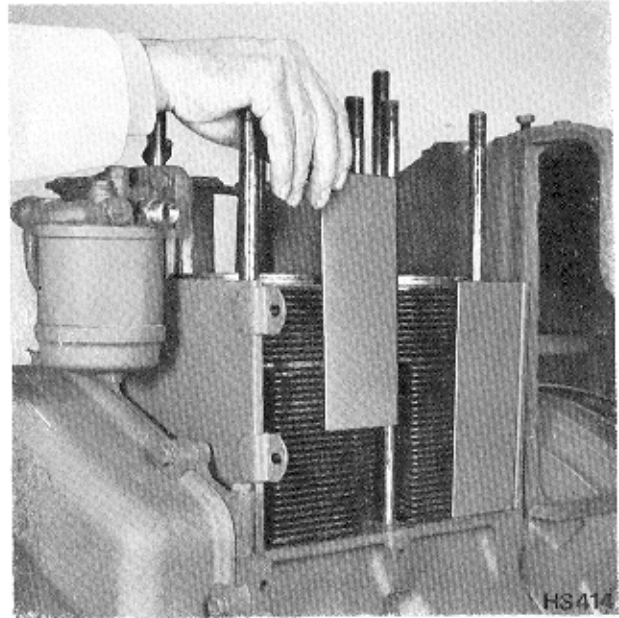


Fig. 48 Position of Air Shields

PISTON, PISTON RINGS AND CONNECTING ROD (Fig. 49)**Piston and Gudgeon Pin**

The piston is made of low expansion alloy with a machine recessed combustion chamber in the crown. The gudgeon pin is a clearance fit in the piston and is retained by two circlips. It runs in a copper faced steel backed bush in the small end of the connecting rod.

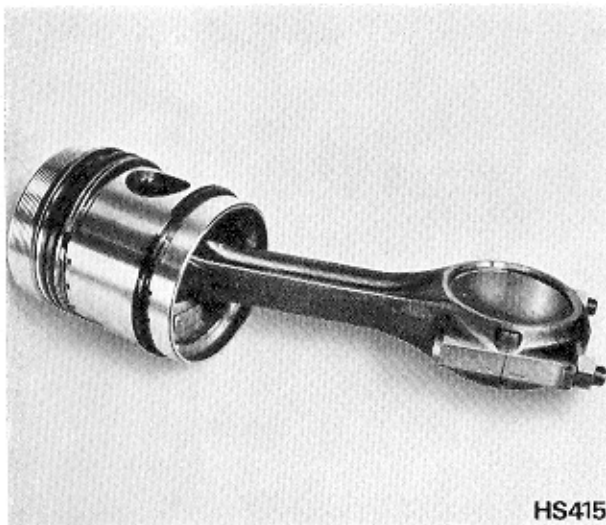


Fig. 49 Piston & Connecting Rod

Piston Rings

Five piston rings are fitted:—

Firing Ring

A barrel lapped chrome ring is situated at the top of the piston and is tapered on the sides to prevent sticking in the groove.

Compression Rings

Two compression rings are fitted. Each has a tapered face in contact with the barrel. One surface on each is marked TOP and the rings must be fitted the correct way up.

Scraper Rings

One conformable type—with spring expander—is fitted above and a slotted scraper ring fitted below the gudgeon pin.

Connecting Rod and Big End Bearing

The forged steel connecting rod is connected to the crankpin by a conventional big end bearing, the cap held in position by two bolts and nuts. The two halves of the big end bearings are steel backed copper lead. They are precision finished and should not be scraped or touched up in any way

To Remove Piston, Connecting Rod and Barrel

Note: Mark the cylinder number on each assembly removed.

No. 1 cylinder is the opposite end to the flywheel.

- (a) Drain sump.
- (b) Remove cylinder head. See page 46.
- (c) Remove side and centre shields noting positions for refitting.
- (d) Disconnect lubricating oil filter pipes at crankcase; remove crankcase door complete with filter.
Note: If a fuel lift pump is fitted, drain or shut off fuel supply, disconnect pipes and remove with crankcase door.
- (e) Remove connecting rod nuts and cap; fit thread protectors (Fig. 50).
- (f) Rotate piston to T.D.C.
- (g) Mark position of barrel for refitting and remove piston, connecting rod and barrel as a complete unit (Fig. 51).
- (h) Withdraw piston from barrel.
- (j) Gudgeon pin may be removed by releasing one spring clip and pushing out pin.
- (k) Using a standard ring expander, remove piston rings.

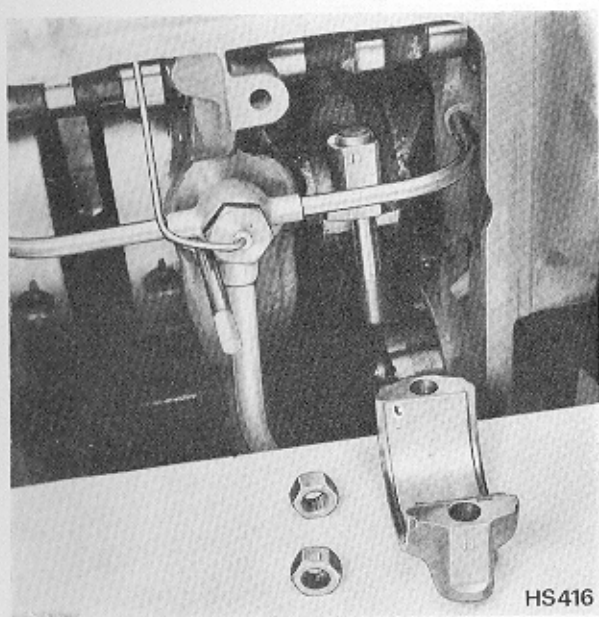


Fig. 50 Big End Bearing

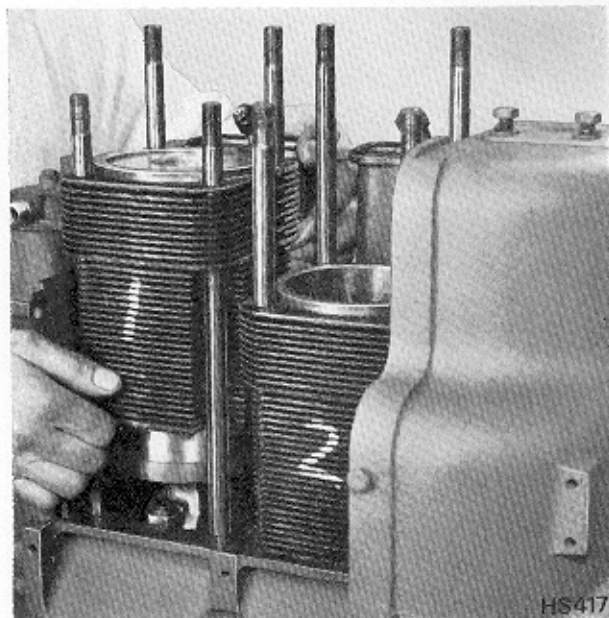


Fig. 51 Removing Cylinder Barrel

Servicing (see page 116 Table of Clearances)

Thoroughly clean the barrel and check for scoring and wear. Clean the piston, remove all carbon from both upper and underside of head, ring grooves and oil holes.

Check all piston rings in the cylinder barrel for correct gap clearance. Clean connecting rod and examine for bending and twisting—examine small end bush for wear.

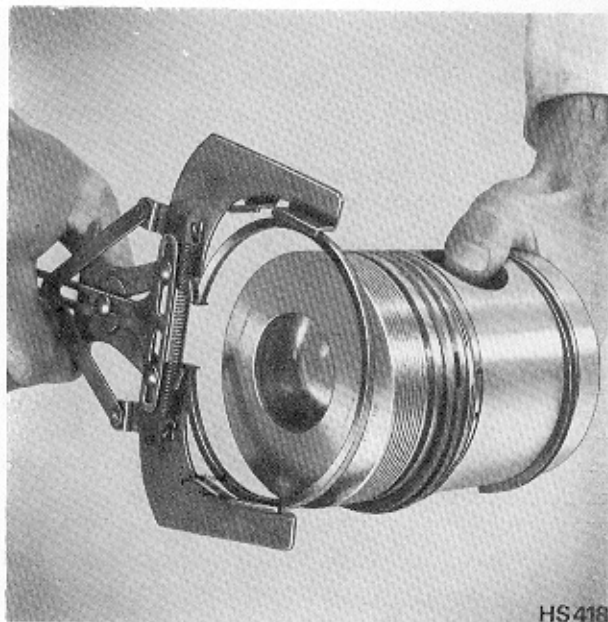
Check the connecting rod bearings and crankpin for signs of wear. If the big end has been dismantled because of metal failure, the oil passages in the crankshaft must also be examined for obstruction and fragments of metal.

Refitting Piston, Connecting Rod and Barrel

Note: the crown of the piston is marked CAM-SHAFT SIDE and the connecting rod and cap are marked on one side with "double" cylinder numbers i.e. 11, 22 or 33. When refitting the piston and barrel assembly, all these marks must face the camshaft side of the engine. A "V" notch is cut in the top fin of the cylinder barrel; this must be fitted nearest the flywheel end.

- (a) Fit piston to connecting rod and secure gudgeon pin circlips.

- (b) Fit piston rings as detailed on page 48 (Fig. 52).
- (c) Stagger piston ring gaps and fit piston into barrel.
- (d) Ensure bearing shells are correctly located in connecting rod and cap.
- (e) Fit joint to bottom of the cylinder using Hylomar SQ32M.
- (f) Position crankshaft with crankpin to T.D.C.
- (g) With the 'V' notch on the top fin of the cylinder barrel facing the flywheel end and the wording CAMSHAFT SIDE on the piston correctly positioned, lower the cylinder, piston and connecting rod assembly into position.
- (h) Push down on piston and turn crankshaft until access is gained to connecting rod bolts; fit cap with bearing shell and torque to 9.4 kgf.m. (68 lbf.ft.).
- (j) Coat groove in crankcase door with Bostik 772 and stick joint to it; refit crankcase door. Reconnect lubricating oil filter pipes.
- (k) Replace centre and side shields (Fig. 48). Refit cylinder head.
- (l) Fill sump with correct quantity and grade of oil.

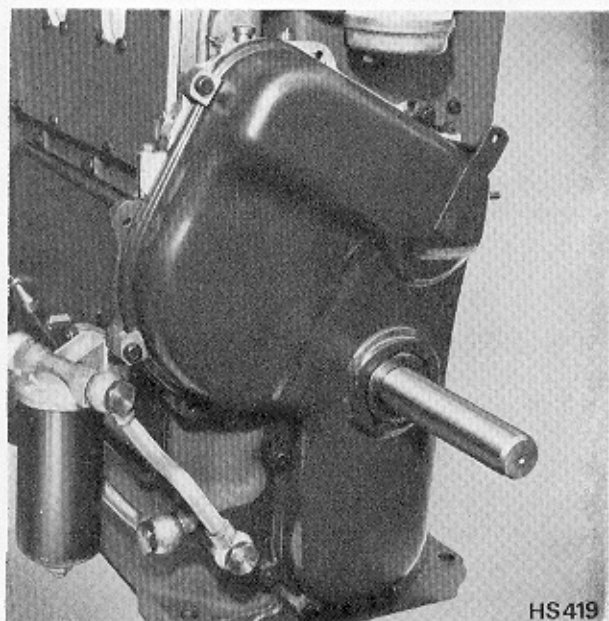


HS418

**Fig. 52 Fitting Piston Rings
GEARCASE END COVER**

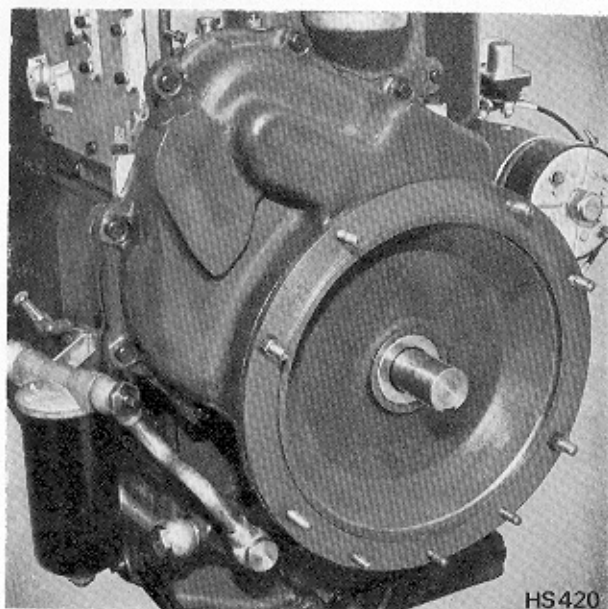
A number of end covers may be fitted to these engines depending on the engine application, two are illustrated on this page.

All end covers are located on two dowels and bolted either direct or with clamps to the end of the crankcase. An oil seal is fitted over the crankshaft extension and care must be taken when removing and fitting cover to avoid damaging this seal, see Section Two.



HS419

Fig. 53 End Cover—Sheet Metal



HS420

Fig. 54 End Cover—Cast Iron

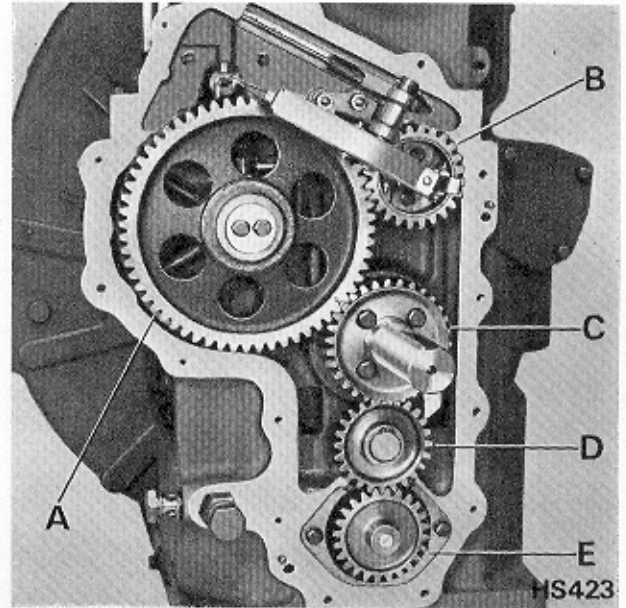
GEAR TRAIN (Fig. 55)

All the gears forming the gear train may be dismantled after removing the gear case cover, without the removal of additional parts of the engine. See that the keyway in the shaft extension is free from burr and turned to the bottom to prevent damage to the oil seal.

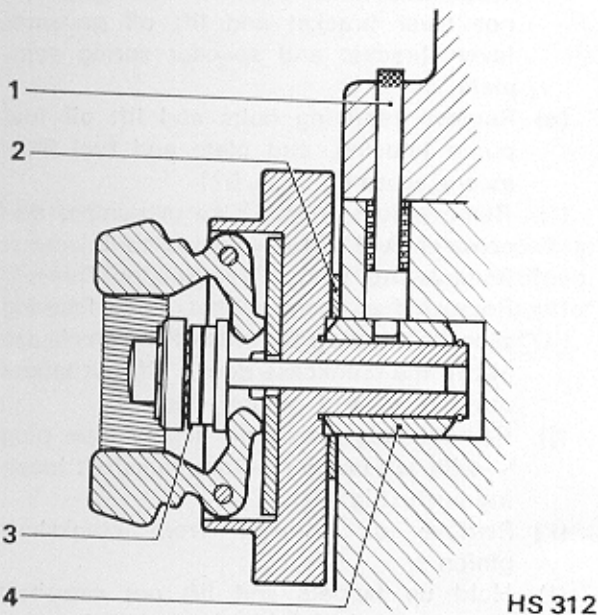
- (a) Drain lubricating oil sump.
- (b) Governor complete with gearwheel may be removed as described in next paragraph.
- (c) Camshaft gearwheel is secured by two setscrews and a key.
- (d) Crankshaft gearwheel pinion and oil thrower are secured by four setscrews and located by two dowels. These same setscrews and dowels secure the crankshaft extension for the starting handle.
- (e) Lubricating oil pump idler wheel is held on to the spindle by washer and spring clip. The spindle is a driving fit into the crankcase and must not be removed unless it requires replacement. A split pin is fitted inside the crankcase, as a safety precaution.

The crankcase is drilled to supply the spindle and idler wheel with lubricating oil direct from the lubricating oil pump.

- (f) The lubricating oil pump complete with driving gear is secured by two setscrews.



- A. Camshaft Gear
- B. Governor Gear
- C. Crankshaft Pinion
- D. Idler Gear
- E. Oil Pump

Fig. 55 Gear Train**Fig. 56 Governor**

1. Spring Loaded Dowel.
2. Thrust Washer.
3. Thrust Race.
4. Bearing.

GOVERNOR (Fig. 56)

The governor gearwheel complete with governor assembly can be withdrawn by removing the governor lever and then lifting the spring loaded dowel above the bearing. A copper thrust washer is located between the gearwheel and the crankcase. The governor weight carrier is secured by two setscrews in the recesses of the gearwheel. When refitting assembly, ensure that the larger—centre—hole of the three holes in the edge of the gearwheel bush is to the top. See Section Three for details and operation of governor.

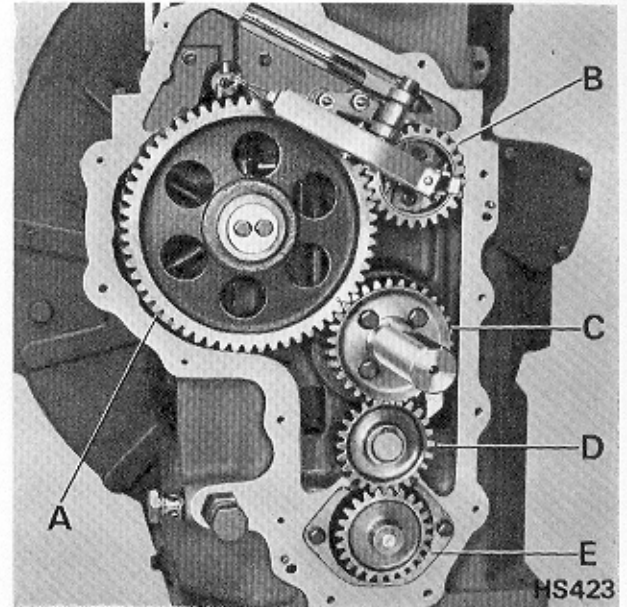
GEAR TRAIN (Fig. 55)

All the gears forming the gear train may be dismantled after removing the gear case cover, without the removal of additional parts of the engine. See that the keyway in the shaft extension is free from burr and turned to the bottom to prevent damage to the oil seal.

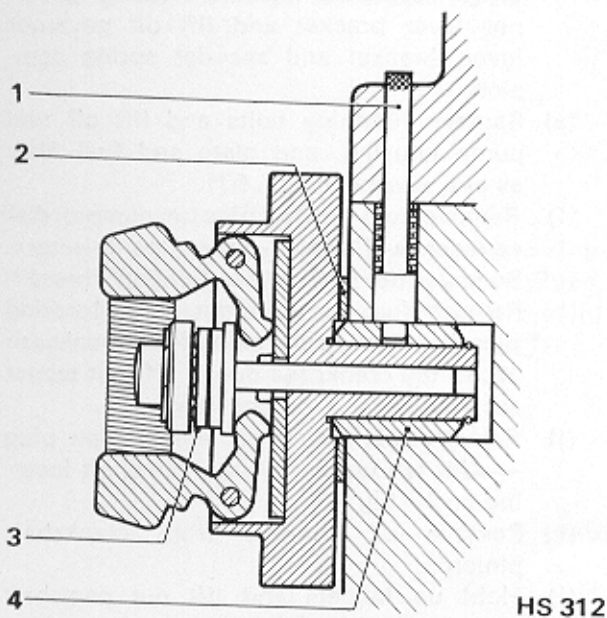
- (a) Drain lubricating oil sump.
- (b) Governor complete with gearwheel may be removed as described in next paragraph.
- (c) Camshaft gearwheel is secured by two setscrews and a key.
- (d) Crankshaft gearwheel pinion and oil thrower are secured by four setscrews and located by two dowels. These same setscrews and dowels secure the crankshaft extension for the starting handle.
- (e) Lubricating oil pump idler wheel is held on to the spindle by washer and spring clip. The spindle is a driving fit into the crankcase and must not be removed unless it requires replacement. A split pin is fitted inside the crankcase, as a safety precaution.

The crankcase is drilled to supply the spindle and idler wheel with lubricating oil direct from the lubricating oil pump.

- (f) The lubricating oil pump complete with driving gear is secured by two setscrews.



- A. Camshaft Gear
- B. Governor Gear
- C. Crankshaft Pinion
- D. Idler Gear
- E. Oil Pump

Fig. 55 Gear Train**Fig. 56 Governor**

1. Spring Loaded Dowel.
2. Thrust Washer.
3. Thrust Race.
4. Bearing.

GOVERNOR (Fig. 56)

The governor gearwheel complete with governor assembly can be withdrawn by removing the governor lever and then lifting the spring loaded dowel above the bearing. A copper thrust washer is located between the gearwheel and the crankcase. The governor weight carrier is secured by two setscrews in the recesses of the gearwheel. When refitting assembly, ensure that the larger—centre—hole of the three holes in the edge of the gearwheel bush is to the top. See Section Three for details and operation of governor.

CAMSHAFT

The steel camshaft is carried in porous bronze bushes located in the flywheel end and dividing walls of the crankcase. A cast iron bush carries the camshaft at the gear end and is secured by the lubricating oil supply plug.

Cams actuate the tappets for the valves and fuel pumps and when fitted, the fuel lift pump. A gearwheel is keyed on to the camshaft and secured by two setscrews. It operates directly from the crankshaft pinion. The governor is driven by the camshaft gearwheel.

A plug seals an oil hole in the gear end of the camshaft; a restrictor is fitted when a reduction gear, reduction gear and clutch or a marine reverse gear is used.

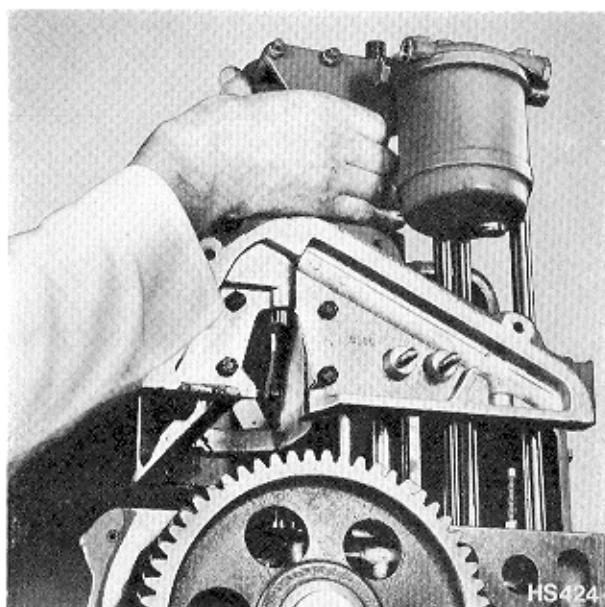


Fig. 57 Removing Fuel Pump Housing and End Plate

To Remove Camshaft

- (a) Remove cylinder heads (page 46 (HR)—page 72 (HRW)).
- (b) Remove fuel pump housing door, crankcase door and gearcase end cover.
- (c) Disconnect fuel connections at fuel filter.
- (d) Release speeder spring from outside of end plate; disconnect governor link; remove nuts and washers holding governor lever bracket and lift off governor lever, bracket and speeder spring complete.
- (e) Remove retaining bolts and lift off fuel pump housing, end plate and fuel filter as one assembly (Fig. 57).
- (f) Remove fuel supply pipe to pumps; disconnect fuel pipes—pumps to injectors.
- (g) Remove fuel pumps, see Section Three.
- (h) Remove fuel pump tappet guide locating pins (located on the side of the crankcase above the crankcase door). Lift out tappet assemblies and guides (Fig. 58).
- (j) Remove lubricating oil supply pipe plug—with tab washer—from camshaft locating bush (Fig. 59).
- (k) Remove oil thrower from crankshaft pinion.
- (l) Hold up tappets and lift out camshaft complete with gearwheel and locating bush. Remove tappets.

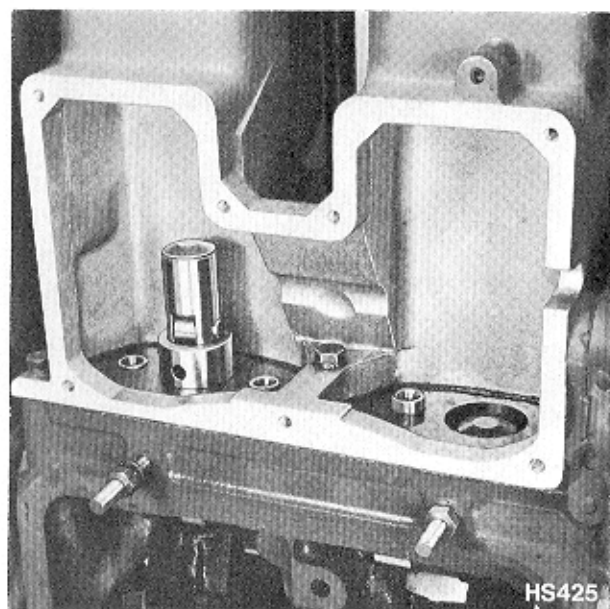


Fig. 58 Fuel Pump Tappet & Guide

Inspection (see page 116 Table of Clearances)
Examine camshaft bushes for scars or wear. Check the camshaft gearwheel, crankshaft pinion and governor gearwheel teeth for chipping or wear. Ensure cams are not chipped or damaged. Check the tappets for scars or damage to the contact face.

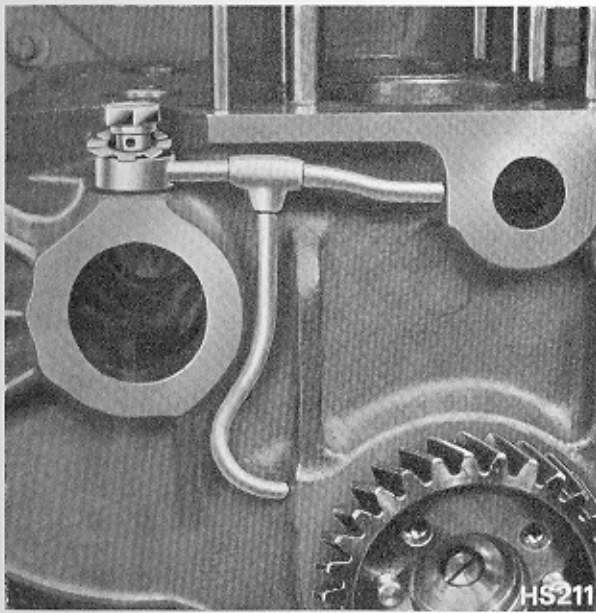


Fig. 59 Oil Pipe to Camshaft Bush

Changing Camshaft Bushes

New bronze bushes should be immersed in engine lubricating oil for four hours before fitting. They should be fitted with the thinnest part of the bearing wall towards the top (marked 'O').



Fig. 60 Camshaft Timing

Refitting Camshaft and Timing

Refitting the camshaft is carried out in the reverse order to removal. The cast iron bush at the gearwheel end should be fitted with the locating hole to the top. **When locating camshaft ensure 'O' mark on gearwheel coincides with 'O' on crankshaft pinion (Fig. 60).**

Apply Hylomar SQ32M to joint face on fuel pump housing, stick joint to it and coat joint. When fitting end cover, use a new joint with Wellseal; a tapered sleeve should be fitted to the end cover to prevent damage to the oil seal. See Section Seven.

Fuel pump timing should be checked in accordance with instructions on page 34.

FLYWHEEL AND FANSHROUD

The type and size of the flywheel and the type of fanshroud—either sheet metal or cast iron—is dependent on the engine build and application. Part numbers, with ordering instructions, for all flywheels and fanshrouds can be found in the HR Engine Parts List. Should it be necessary to change the application of the engine, R. A. Lister or their Distributors should be consulted.

Flywheel

The cast iron flywheel is mounted on a tapered shaft and secured with a 1" UNF setscrew and tabwasher.

Etched lines on the rear face of the flywheel give the T.D.C. positions for each cylinder i.e. T1, T2, T3; the firing points are marked FP. To find the firing point for No. 1 cylinder, turn the engine in direction of rotation until T1 is in line with the arrow with both valves closed. Turn engine slowly against direction of rotation until FP is in line. (Timing information can be found in Section Three).

To Remove Flywheel

- (a) Remove any accessories that may be fitted.
- (b) Slacken flywheel retaining screw not more than two turns.
- (c) Using service tool—see Section 7—withdraw flywheel.

Refitting is carried out in reverse order. The tapered shaft and the coned bore of the flywheel must be perfectly clean and should be smeared with clean lubricating oil before assembly. It will assist assembly if keyway is positioned to the bottom.

After fitting lockwasher, tighten flywheel retaining screw to a final torque of 55.2 kgf.m. (400 lbf.ft.) secure screw with lock washer.

Fan Shroud (Fig. 61)

The fan shrouds on HR engines are made of either cast iron or sheet metal. The shroud is secured by bolts to the end of the crankcase and a metal strap at the top of the shroud is secured to the adjacent cylinder head.

Provision is made for fitting an oil cooler—See Section Five, and an electric starter motor may be fitted to the rear face of the shroud. See Section Eight.

The shroud is removed by withdrawing flywheel, see previous paragraph, removing any accessories that may be fitted and removing all retaining bolts and washers.

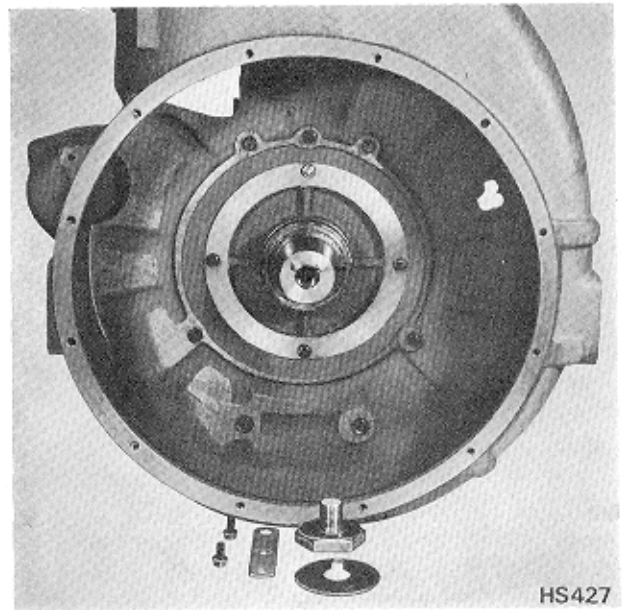


Fig. 61 Fan Shroud

CRANKSHAFT AND MAIN BEARINGS

The steel crankshaft is carried in two steel backed copper lead lined split bush main bearings which are located in the crankcase at the gear end and in a housing at the flywheel end. Centre bearings are housed in crankshaft dividing wall(s), one in the HR/W2 and two in the HR/W3 engine.

The centre main bearing(s) comprise copper lead lined steel backed shells contained in a housing, which is located in the crankcase by a plain hollow dowel tapped at one end.

End thrust is taken on steel backed copper based split thrust washers fitted inside the crankcase at the gear and flywheel ends. A pinion and oil thrower are bolted to the gear end of the crankshaft. Shims are fitted between the main bearing housing and the crankcase to provide crankshaft end float adjustment. An oil thrower ring (C) which fits over the crankshaft is held in position by the main bearing and a screw type oil seal (A) and a felt ring (B), seal the crankcase at the flywheel end.

A plug blanks off an oil hole at the gear end of the crankshaft; a restrictor is fitted when a reduction gear, clutch or marine reverse gear is used.

To Remove Crankshaft

- (a) Turn off fuel supply, drain lubricating oil sump.

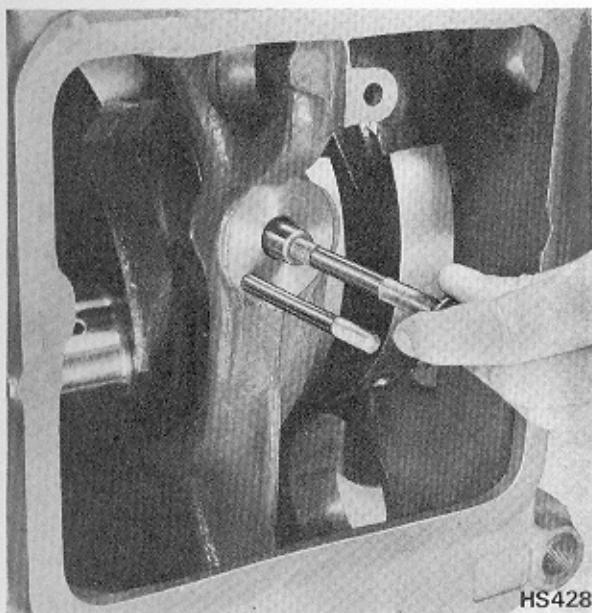


Fig. 63 Removing Bearing Locating Dowel

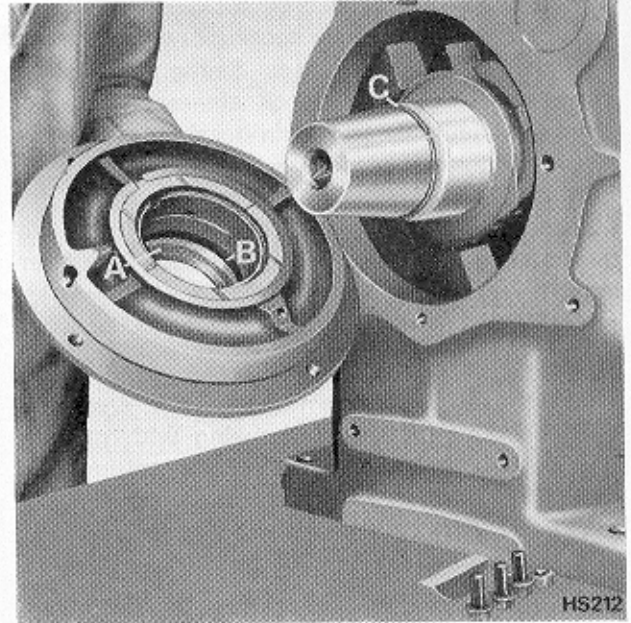


Fig. 62 Main Bearing Housing

- (b) Remove:—
Cylinder heads (page 46 HR — page 72 HRW).
Piston and barrels (page 49 HR — page 74 HRW).
End cover (page 50 HR — page 77 HRW).
Flywheel and fanshroud (page 54 HR — page 78 HRW).
- (c) Remove crankshaft pinion and oil thrower —located on two dowels and secured by four setscrews.
- (d) Remove lubricating oil pipes to centre and main bearings (See Section Two).
- (e) Remove main bearing housing taking care to retain any shims which may be fitted; remove split thrust washer; slide off thrower ring. (Fig. 62).
- (f) Insert a $\frac{3}{8}$ " UNF bolt into the end of the centre bearing(s) locating dowel and remove (Fig. 63).
- (g) Position crankshaft with balance weights on No. 1 cylinder (nearest gear end) to the bottom. This will help centralise crankshaft when removing. Lift out crankshaft.
- (h) Note the position of centre bearings for refitting. Unscrew and remove the two capscrews; separate the two halves of the bearing housing (dowelled).

SERVICING—SEE TABLE OF CLEARANCES

Inspect main bearings for scoring or wear, replace bearings if necessary (see Section Seven for special service tool), check clearance between crankshaft journals and main bearings and crankpins and connecting rod bearings.

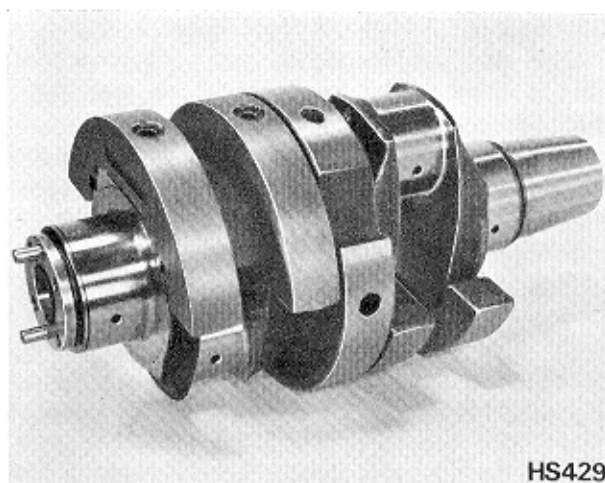
Examine crankshaft for scoring or wear. If a standard set of bearings will not fit with the required clearance, regrind and fit undersize bearings.

Replace split thrust washers if damaged or worn.

To Refit Crankshaft

- (a) If required, fit new bearings in crankcase and main bearing housing with grooved shell to the top and oil holes lined up. See Section Seven for special service tool.
- (b) Fit split thrust washer at gear end with tabbed piece to the top, copper face towards crankshaft. Grease may be used to retain thrust washer in position while offering up crankshaft.
- (c) Fit two halves of centre bearing on correct crankshaft journal. Note, when crankshaft is refitted, the locating dowel must line up with hole on fuel pump side of crankcase.
- (d) Insert crankshaft; locate centre bearing(s). Fit dowel(s) with the threaded portion to the outside.
- (e) Position oil thrower ring on crankshaft; fit split thrust washer onto main bearing housing.
- (f) Fit main bearing housing and shims after coating one side of each jointing face with Wellseal. Ensure housing is fitted with oil drain hole to the bottom.
- (g) Check crankshaft end float (Fig. 65).
 - (i) Set a dial test indicator so that the actuating plunger makes contact with the flywheel end face of the crankshaft.
 - (ii) Push crankshaft firmly towards gear end of engine and zero indicator.
 - (iii) Push crankshaft firmly towards the flywheel end of engine and note reading.

End float should be between 0.13-0.25 mm (0.005"-0.010"). This can be adjusted by 0.13 or 0.25 mm (0.005" 0.010") metal shims fitted between the main bearing housing and the crankcase.

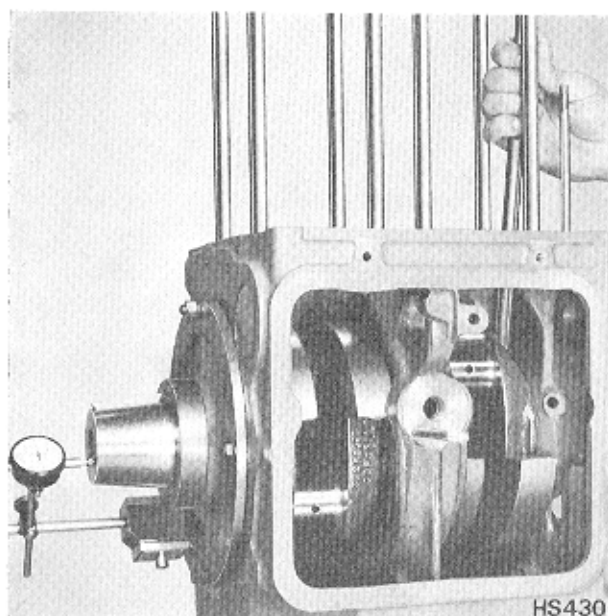


HS429

Fig. 64 Two Cylinder Crankshaft with Intermediate Bearing

See page 57 for type and use of jointing compound.

- (h) Fit crankshaft pinion and oil thrower.
- (j) Fit lubricating oil pipes and crankcase door.
- (k) Refit, flywheel, cylinder head etc. as previously described. Connect fuel supply and prime fuel system; fill engine sump with correct lubricating oil to full mark on dipstick.



HS430

Fig. 65 Checking Crankshaft End Float

JOINTING COMPOUNDS		
Joint Description	Jointing Compound to be used	Instruction for Applying Compound
Valve gear cover	Hylomar SQ32M	Coat valve gear cover jointing face and stick joint to it.
Fuel pump housing door	Hylomar SQ32M	Coat door jointing face and stick joint to it.
Crankcase end plate to fuel pump housing	Hylomar SQ32M	Coat end plate on jointing face, stick joint to it and coat joint.
Fuel pump housing to crankcase	Hylomar SQ32M	Coat housing on jointing face, stick joint to it and coat joint.
Fuel pump housing rubber joint ring	Bostik 772	Coat housing groove and stick joint to it.
Crankcase door	Bostik 772	Coat door groove and stick joint to it.
Pressed steel gearcase cover	Bostik 772	Coat cover groove and stick joint to it.
Cast gearcase cover	Wellseal	Coat gearcase on joint face, stick joint to it and coat joint.
Crankcase bearing housing shims	Wellseal	Coat all joint surfaces on one side, tighten bolts and re-tighten after about 10 minutes.
Bottom of cylinders	Hylomar SQ32M	Coat cylinder on jointing face, stick joint to it and coat joint.
Camshaft expansion plug in crankcase	Hylomar SQ32M	Apply a little compound to recess in crankcase before driving in plug.
Screw type seals	Hylomar SQ32M	Apply a little compound to outside diameter of seal.
Cylinder head holding down studs, upper threads and nuts	Wellseal	Coat the upper threads of the studs and the area of the rocker brackets and top plates in contact with the nuts.
Crankshaft felts	Wellseal	Coat inside of felt groove before inserting felt. Ensure that the felt is not distorted during fitting.
Valve guides	Wellseal	Coat outside diameters of the guides before fitting. Do not use grease or any other substance.
Breather tube to cylinder head	Hylomar SQ32M	Coat the outside of the cylinder head end of the tube before screwing it in the top plate. Do not block the bore of the tube.

JOINTING COMPOUNDS (continued)

Joint Description	Jointing Compound to be used	Instruction for Applying Compound
Water cooled cylinder holding down stud tubes	Hylomar SQ32M	Lightly smear the inside of the hole and the outside of the tube at the press fit end. Do not use any compound at the 'O' ring end—the ring may be kept in position with a little Shell Alvania 2 grease.
Cylinder shims and gasket—water cooled engines (HRW)	Wellseal	Lightly coat the recess on the head where the joints seat and the side of the counter bore. Place each shim in the recess and coat it in turn and finally place the thick gasket and coat it. The top of the cylinder is not coated. Use very little compound or grease.
Cylinder shims and gasket—air cooled engines (HR)	High Melting Point Grease	
Taper sump plug	Wellseal	Coat threads.

SPANNER TORQUES

Thread Size	Torque		Location
	kgf.m.	(lbf.ft.)	
$\frac{1}{4}$ " UNF	1.2	8.5	Injector clamp nuts. Valve rocker nuts.
$\frac{5}{16}$ " UNF	2.1	15	
$\frac{3}{8}$ " UNF	4.4	32	Dynamo shaft nuts. Connecting rod nuts.
$\frac{7}{16}$ " UNF	6.9	50	
$\frac{1}{2}$ " UNF	9.4	68	Cylinder head nuts—HR engines. Cylinder head nuts—HRW engines.
$\frac{9}{16}$ " UNF	11.0	80	
1" UNF	13.8	100	Flywheel setscrew. Fuel injector pipe nuts.
M12	55.2	400	
	2.9	21	Injector cap nuts Fuel pump delivery valve holder.
	9.0	65	
	5.5	40	

DECARBONISING

Decarbonising should be carried out after 1500 hours running or if the engine shows loss of compression or blow-by past the piston. To gain access, remove the cylinder barrel, piston and rings. See page 49 HR — page 74 HRW.

Thoroughly clean and examine for damage or wear:—

1. Piston.
2. Piston rings and grooves.
3. Combustion chamber in the top of the piston.
4. Valve ports, valves, and valve seats.
5. Exhaust manifold, piping and silencer.
6. Fins on cylinder, cylinder head and injector. (HR)
7. Check cylinder blocks and heads for sludge deposits (HRW).
8. Re grind valves.

Renew any defective parts as necessary, re-assemble as detailed on previous pages.

LAYING-UP PROCEDURE

The following routine should be carried out when it is known that the engine will not be required for some months:—

1. Replace fuel in tank with a small supply of calibration fluid or equivalent.
2. Drain lubricating oil from sump and refill with Shell Ensis 20 or equivalent.
3. Run the engine for a period to circulate the Ensis oil through the system and to ensure the calibration fluid is passed through the fuel pumps and injectors.
4. Stop the engine and drain off the Ensis lubricating oil from the sump, after which the crankshaft should NOT be turned until the engine is again required for service. The calibration fluid should be left in the fuel system.
5. Drain all water from the engine (HRW).
6. Seal all openings on the engine with tape.
7. Remove batteries, when applicable, and store fully charged with the terminals coated with Vaseline (petroleum jelly).
8. Grease all external bright parts and control linkages, etc.
9. Tie labels on the engine clearly stating what steps have been taken to inhibit the engine during storage, as above.

If the above is not carried out then the engine should be run about 15 minutes once a month —preferably on load.

CLEANING COOLING FINS (HR only)

The cylinder, cylinder head and injector cooling fins must be kept reasonably clean if the engine runs at high loads and speeds, otherwise seizure of various components can occur due to overheating.

Cleaning frequency depends on the nature and concentration of the substances contained in the cooling air. For example, fluff, hair, vegetable fibre, etc., have a greater clogging effect than dry dust.

The fins should always be cleaned when the engine is decarbonised but can also be cleaned by removing the manifold and air cowl and raking the dust off the fins with a hooked piece of wire.

Section Four – Part Two

HRW ENGINES

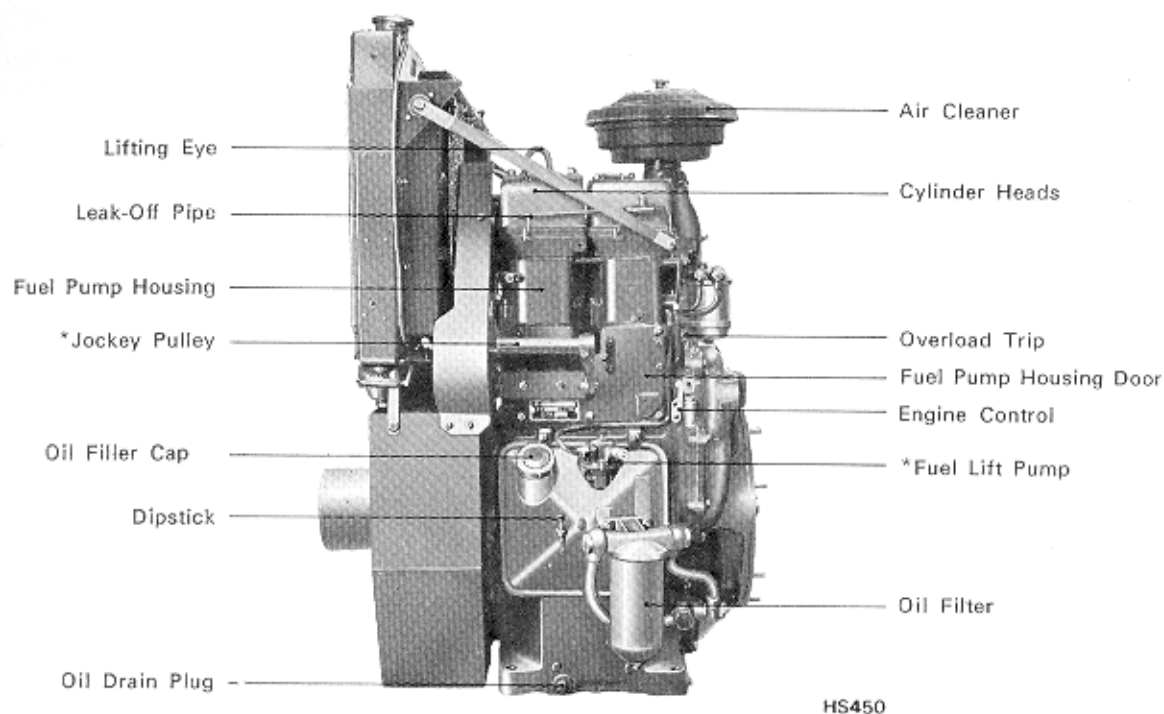


Fig. 66 Main Features—Fuel Pump Side—Radiator Cooled

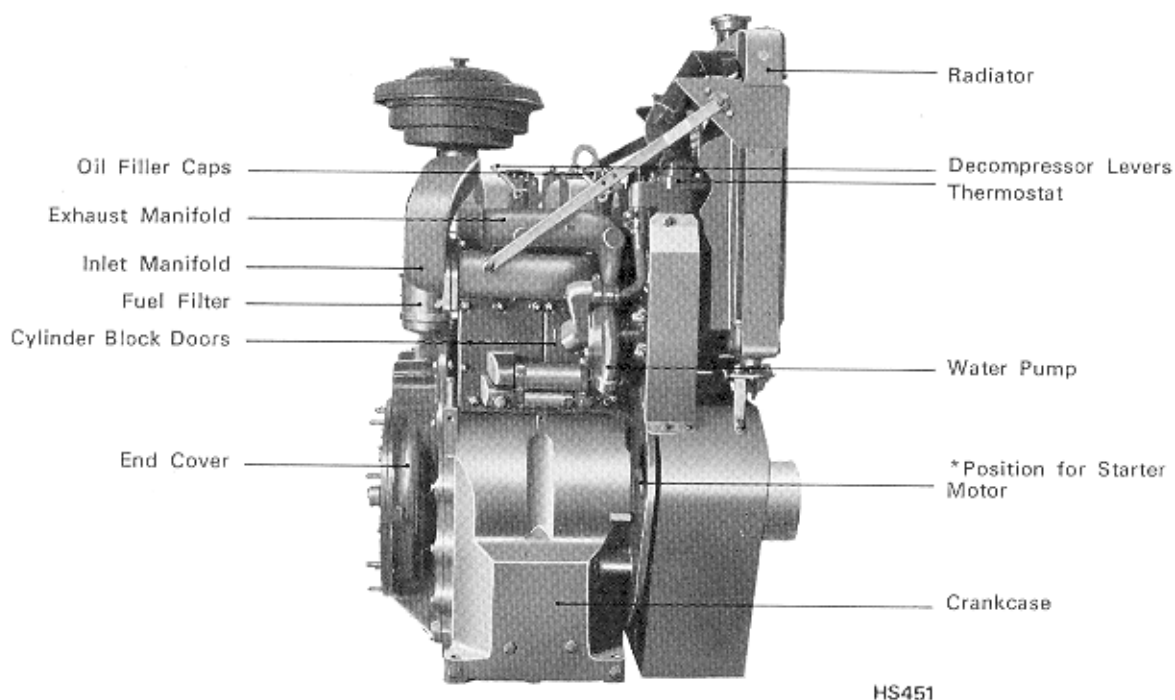


Fig. 67 Main Features—Manifold Side—Radiator Cooled.

* Information on accessories that may be fitted in these positions can be found in Sections Five and Eight.

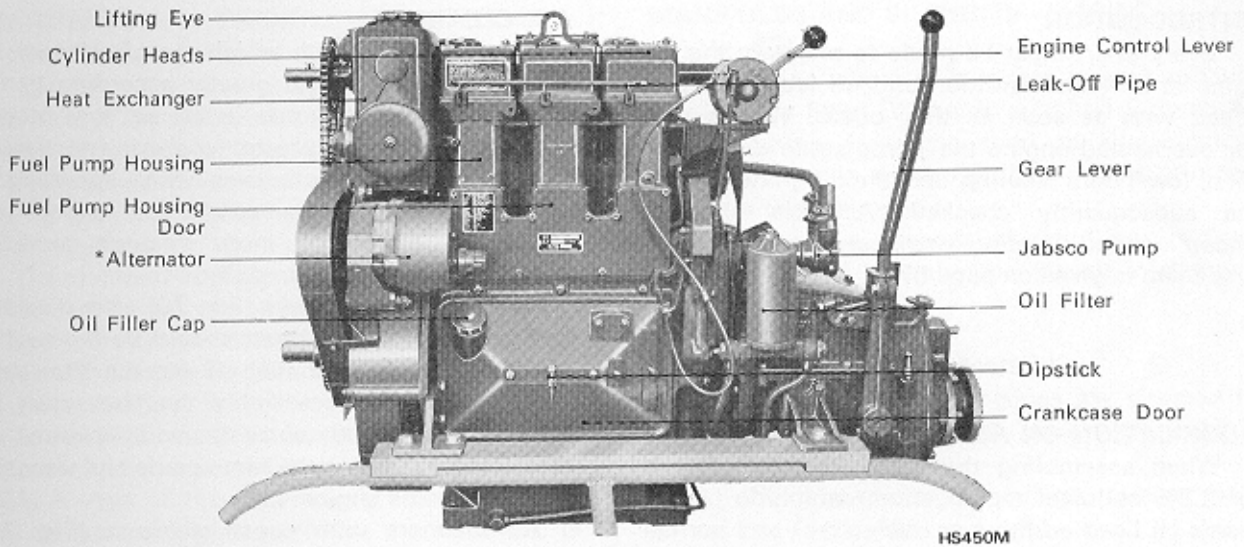


Fig. 68 Main Features—Fuel Pump Side—Marine Propulsion Engines

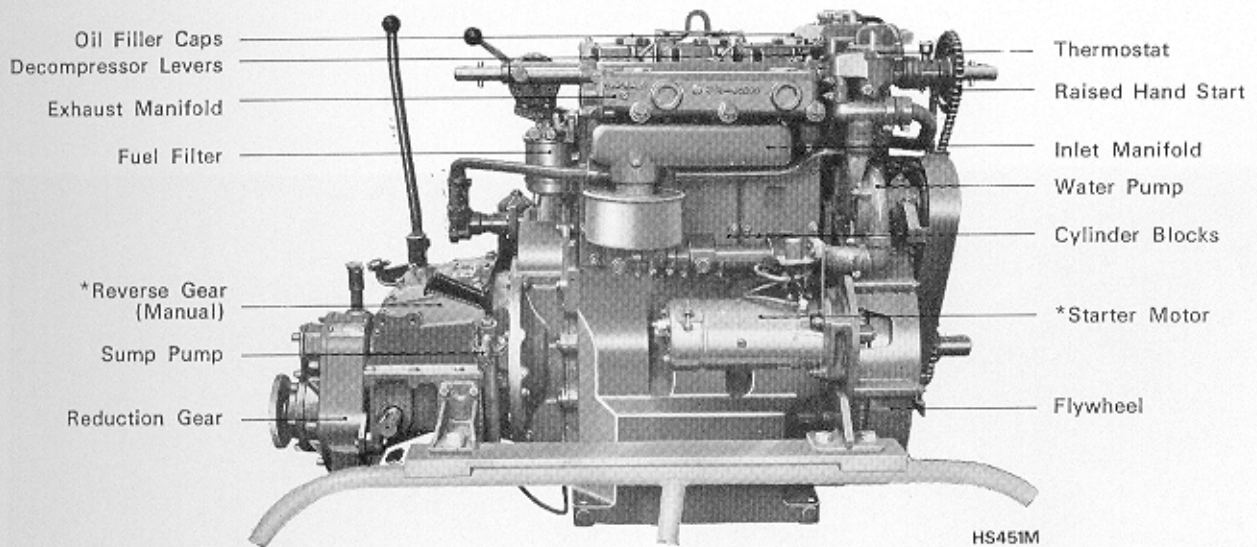


Fig. 69 Main Features—Manifold Side—Marine Propulsion Engines

* Alternative fittings and further information on these items can be found in Sections Five and Eight.

INTRODUCTION

Every effort must be made to maintain the engine in a clean condition and oil leaks must be dealt with as soon as they occur. With a new or overhauled engine the joints settle during the first few hours running and their tightness must be subsequently checked. A table showing recommended jointing compounds and how to use them is given on page 57.

LUBRICATION ON ASSEMBLY

When assembling the engine, use a mixture of 2.5% colloidal molybdenum disulphide (Acheson's Hi Load additive or equivalent) and normal engine lubricating oil.

All bearing surfaces must be well lubricated including the valve stems and the cups of the push rods.

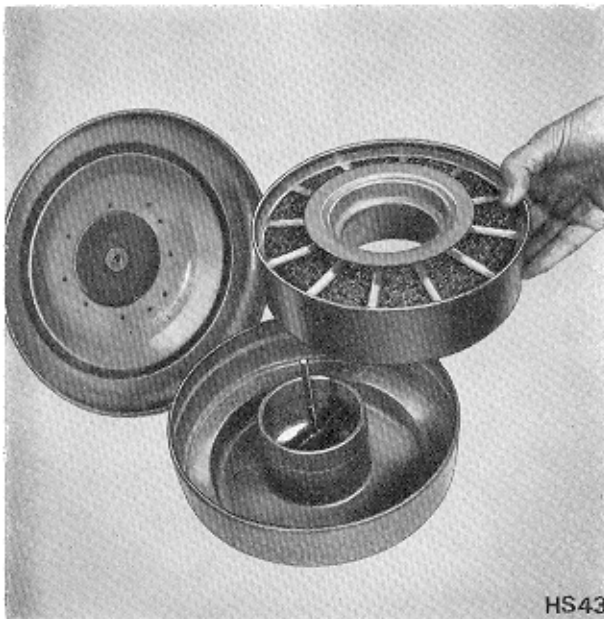
New camshaft bushes should be immersed in clean engine lubricating oil for four hours before fitting.

AIR CLEANERS

The frequency with which the air cleaner requires servicing varies greatly according to the amount of foreign matter in the air. It is recommended that the element receives attention at least every 100 hours, even when operating in substantially dust-free conditions; under less favourable conditions more frequent servicing will be necessary—even daily.

With oil bath cleaners (Fig. 70) after dismantling the filter, the element should be thoroughly washed in paraffin or fuel oil and the filter bowl cleaned out. On reassembly the filter must be filled with oil exactly up to the mark indicated on the filter bowl, using the same grade and viscosity of oil as for the engine.

Air cleaners with paper elements (Fig. 71) must have elements replaced when there are indications of restriction, and the body of the air cleaner should be cleaned internally. When reassembling air cleaners, it must be ensured that all joints and connections on the cleaned air side are air tight so that no particles of dust can enter the engine. (See also Section Five).



HS43

Fig. 70 Air Cleaner (Oil Bath)



HS44

Fig. 71 Air Cleaner (Dry Type)

MANIFOLDS AND SILENCER—INDUSTRIAL ENGINES (Fig. 72)

The cast iron manifolds, with asbestos joints are located on studs on the side of the cylinder heads. Brass nuts with spring washers retain the manifolds in position; the top row of studs have clamp washers fitted to hold both the exhaust and inlet manifolds.

The standard silencer is a "Pepper Pot" type, other fittings are available—see Section Five. If the exhaust system is modified in any way, consideration should be given to the Installation Information on page 6.

A complete manifold system fitted to a two cylinder radiator cooled engine is shown in Fig. 72A. A view of the water outlet manifold, after the exhaust and inlet manifolds are removed, is shown in Fig. 72B.

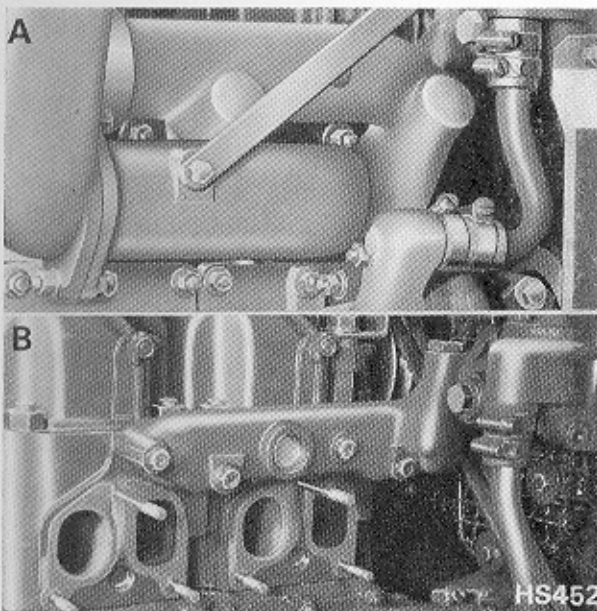


Fig. 72 Manifolds—Industrial Engines

MANIFOLDS AND SILENCER—MARINE (Fig. 73)

On marine engines, a water cooled exhaust manifold is fitted. Water is supplied through an external pipe from the feed to the cylinder blocks. From the manifold, the water is returned direct to the thermostat.

An air intake silencer of the "Pepper Pot" type is screwed directly into the air inlet manifold.

Removing Water Outlet Manifold

- (a) Drain water. (Drain plugs are situated in each block door below hoses— $\frac{1}{4}$ " B.S.P.).
 - (b) Disconnect hoses:—
 - (i) Thermostat to radiator, tank or heat exchanger.
 - (ii) Thermostat to water pump.
 - (c) Remove bolts securing manifold to each of the cylinder heads.
 - (d) Lift off manifold and thermostat complete.
- When refitting, use new joints with Hylomar SQ32M.

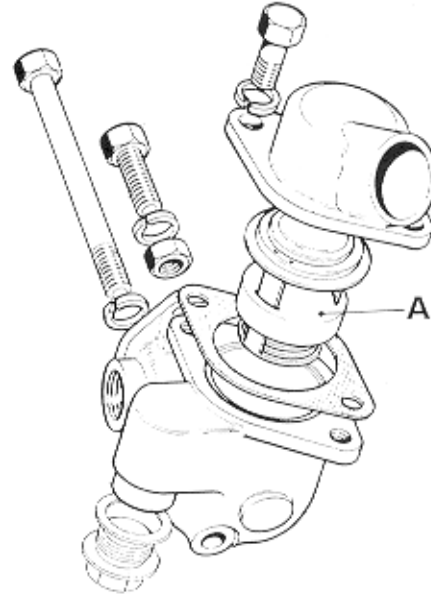


Fig. 73 Manifolds—Marine Engines

THERMOSTAT (Fig. 74)

To change thermostat unit:—

- (a) Drain water.
- (b) Remove hose from thermostat to radiator, tank or heat exchanger.
- (c) Remove two bolts and spring washers and lift off thermostat cover.
- (d) Fit new unit (A) and replace cover using a new joint and Hylomar SQ32M.
- (e) Reconnect hose to radiator, tank or heat exchanger and fill system; check for leaks.



HS469

Fig. 74 Thermostat

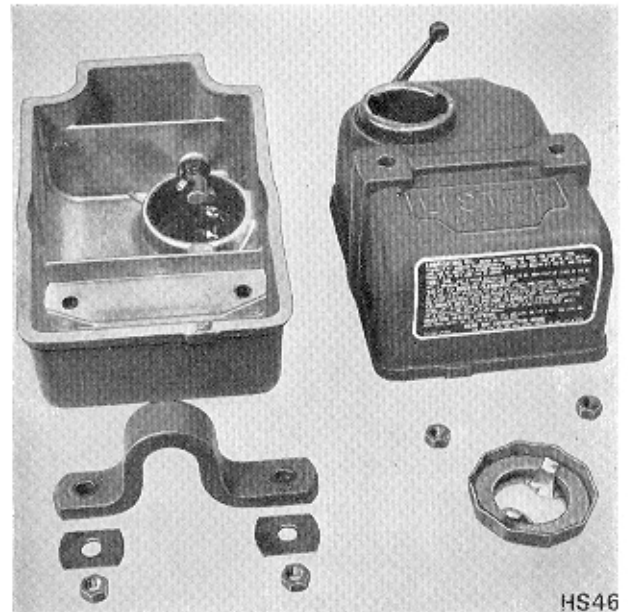
Breather

The crankcase breather, in the form of a pipe, is screwed into the top of the cylinder head and connects with the inlet port.

The oil laden vapour is drawn into the inlet port and a partial vacuum maintained in the crankcase. This prevents the lubricating oil from working out through the joints and bearings.

CYLINDER HEAD COVER (Fig. 75)

The cylinder head cover is an alloy casting and contains the decompressor lever and adjuster, an oil filler cap and on one cylinder, a lifting eye. The assembly is located on two studs and a joint seals the cover to the cylinder head; longer studs are used on the cylinder head holding the lifting eye. Joints are also fitted between the lifting eye and cover.



HS46

Fig. 75 Cylinder Head Covers

Valve Clearance

It is important that the valve to rocker clearances are maintained correctly, otherwise serious damage to the valve gear can result. With new engines or engines which have just been overhauled, the valve gear beds down rapidly during the first 500 hours running and for this reason it is essential that the valve to rocker clearance is checked at 25 hours, 250 hours and thereafter every 500 hours. It will be found that the clearance remains constant after 500 hours and if this is confirmed, the period before adjusting may be extended to 1500 hours.

The valve clearance for both inlet and exhaust set with the engine cold is:—

- 0.38 mm (0.015") GO
- 0.43 mm (0.017") NOT GO

To Adjust (Fig. 76)

- (a) Turn the piston to the T.D.C. position on the firing stroke (both valves closed).
- (b) Slacken the locknut on the adjusting screw and turn the screw until the correct clearance has been obtained.
- (c) Tighten the locknut whilst restraining the adjusting screw and re-check to ensure that clearance is correct.

Repeat the procedure for all valves.

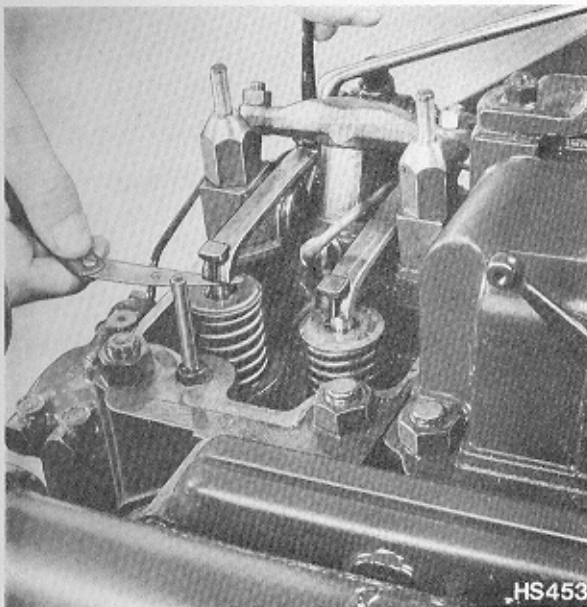


Fig. 76 Adjusting Valve Clearance

Refitting Cylinder Head Cover

- (a) Apply Hylomar SQ32M to cover jointing face and stick joint to it.
- (b) Replace cover and fit lifting eye with joints (if applicable).
- (c) Refit decompressor coupling rods if removed.

Decompressor Adjustment (Fig. 77)

Access to the decompressor adjuster is through the oil filler cap in the cylinder head cover.

- (a) Turn the piston to T.D.C. firing stroke (both valves closed).
- (b) Move the decompressor lever towards the flywheel.
- (c) Slacken the locknut and turn the decompressor screw down (clockwise) until the exhaust valve touches the piston.
- (d) Turn the screw back half turn and tighten the locknut.

Repeat the procedure for all cylinders.

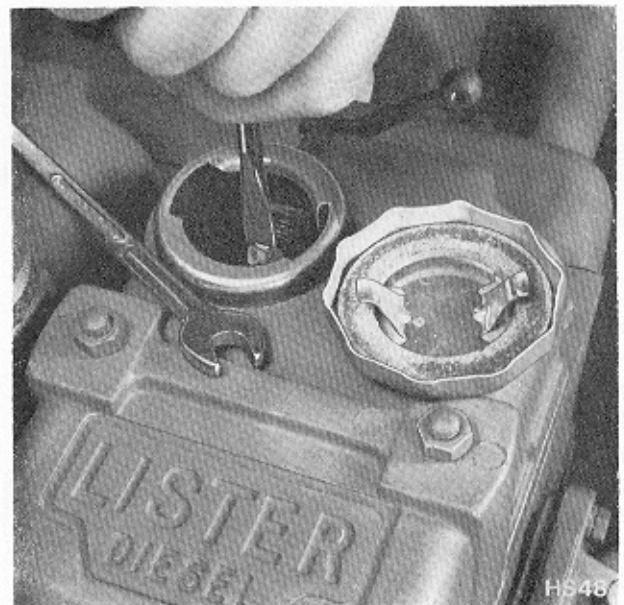


Fig. 77 Adjusting the Decompressor

BELTS (Fig. 78)

The water pump driving belts are of special materials and construction and no belts other than those supplied as genuine spares should be used for replacements. Belts are supplied in matched pairs. Belt tension initially must be such that when a weight of 1.8 kg. (4 lb.) is rested on top of the two belts half way between the dynamo and water pump, a deflection of 12.5 mm ($\frac{1}{2}$ ") is produced. It is particularly important that the belt tension be checked after overhaul (initially 25 hours) or after new belts have been fitted. Do not overtighten the belts or keep resetting the tension at short intervals.

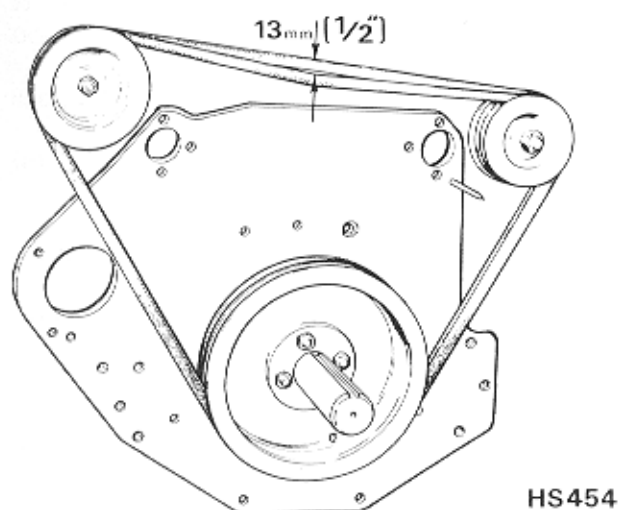


Fig. 78 Belt Tension

WATER PUMP (Fig. 79)

A fresh water circulating pump is fitted to the manifold side of the engine and is driven by twin belts from the crankshaft. Water is supplied from a radiator, tank or heat exchanger to the inlet of the pump and discharged through piping to the water jackets of the cylinder blocks. After circulating through the engine, the water is fed back—via a thermostat—to the top of the radiator or tank. A by-pass pipe from the thermostat feeds directly to the inlet of the pump.

Water Pump Removal—Radiator Cooled Engine (Fig. 80)

- (a) Drain water, slacken belts.
- (b) Release hoses:—
 - (i) Radiator to pump.
 - (ii) Thermostat to pump.
 - (iii) Pump to block.
- (c) Remove bolt securing retaining bracket at the base of the pump to the block door.
- (d) Remove the two bolts fitted through pump body adjacent to pulley.
- (e) Remove the two nuts holding pump bracket to block door.
- (f) Remove pump.

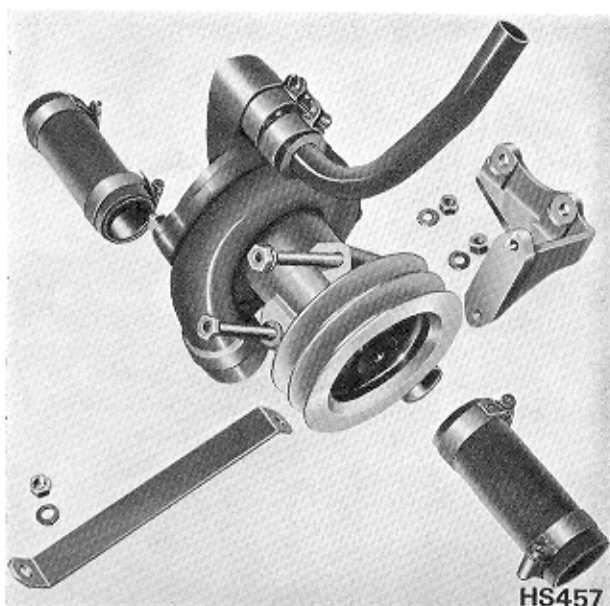


Fig. 79 Water Pump Fittings

Water Pump Removal—Tank Cooled Engine

- (a) Drain water, slacken belts.
- (b) Release hoses:—
 - (i) Tank to pump.
 - (ii) Thermostat to pump.
 - (iii) Pump to block
- (c) Remove bolt securing retaining bracket at the base of the pump in the block door.
- (d) Remove the two nuts holding pump bracket to block door.
- (e) Remove pump.

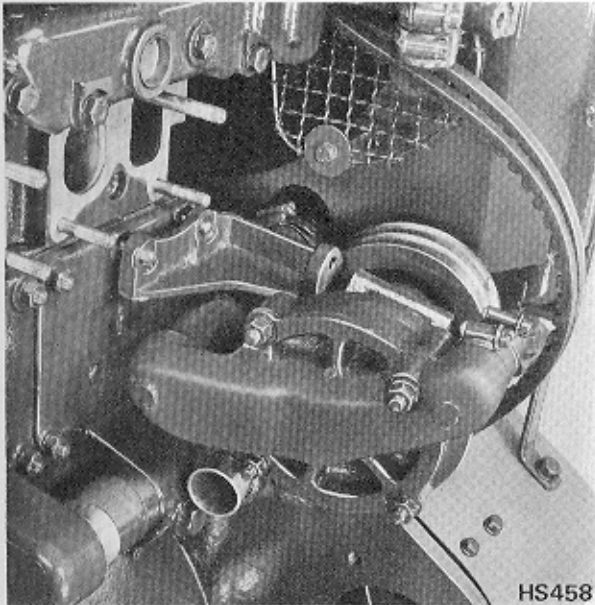


Fig. 80 Removing Pump (Radiator Engines)

Water Pump Removal—Marine Engines

- (a) Drain Water—slacken belts.
- (b) Release hoses:—
 - (i) Heat exchanger to thermostat.
 - (ii) Thermostat to pump.
 - (iii) Pump to block
- (c) Remove the two nuts and spring washers securing pump to mounting bracket; lift off pump.

Refitting Pumps

Refit in the reverse sequence to removal, ensure drain hole is to the bottom. Fill water system and check for leaks.

Key to Fig. 81

1. Impeller Shaft
2. Ball Bearing (small)
3. Impeller
4. Carbon Ring Driver
5. Carbon Ring
6. Bearing Spacer
7. Drain Hole in Pump Body
8. Ball Bearing (large)
9. Circlip
10. Clearance between impeller and cover 10.4 mm to 11.1 mm (0.410" to 0.438").

Changing Carbon Seal (Fig. 81)

NOTE: Failure of the carbon seal is indicated by leakage from the drain hole.

- (a) Remove belt pulley
- (b) Remove circlip (9)
- (c) Remove pump end cover
- (d) Using a brass drift tap the impeller shaft (1) out through the impeller and pump body.
- (e) Check ball bearing (2 and 8).
- (f) Fit shaft (1) and inner bearing (2) into pump body.
- (g) Replace bearing spacer (6).
- (h) Fit outer bearing (8) and circlip (9).
- (j) Fit pulley—end of shaft should be flush with face of pulley boss.
- (k) Lightly grease the seal seating, smear rubber ring with soft soap and fit seal assembly to shaft.
- (l) Place pump upright on bench, resting on the pulley, and fit the impeller (3). Care must be taken to ensure that the lugs on the carbon ring driver (4) enter the carbon ring (5) correctly.
- (m) Before fitting the cover check that the face of the impeller boss is between 10.4 and 11.1 mm (0.410" and 0.438") below the level of the body joint facing as shown at (10).
- (n) Fit new joint to cover and fit cover.

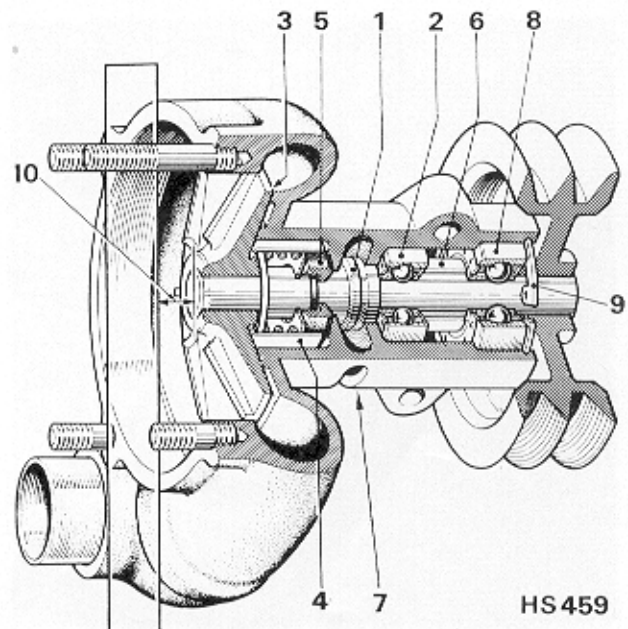


Fig. 81 Components of Water Pump

RADIATOR AND FAN**To Remove Radiator (Fig. 82)**

- (a) Drain water. Remove belt guard or that portion of the guard required to give access.
- (b) Disconnect hoses:—
 - (i) Top—thermostat to radiator.
 - (ii) Bottom—radiator to pump.
- (c) Disconnect support stays to manifold and cylinder head.
- (d) Remove the two $\frac{3}{8}$ " bolts which are fitted in the base of the radiator through the flexible mountings.
- (e) Turn fan so that one blade is vertical; lift radiator upwards to clear fan taking care that radiator and bottom hose do not foul the thermostat.

Flexible Mountings

Each mounting is secured by two bolts and should be changed as a complete unit.

Refitting the radiator is the reverse procedure to removal.

Fan and Pulley (Fig. 83)

The fan and pulley assembly is secured to the engine by a bracket bolted to the side of the cylinder block and a bolt secured to one of the cylinder head holding nuts.

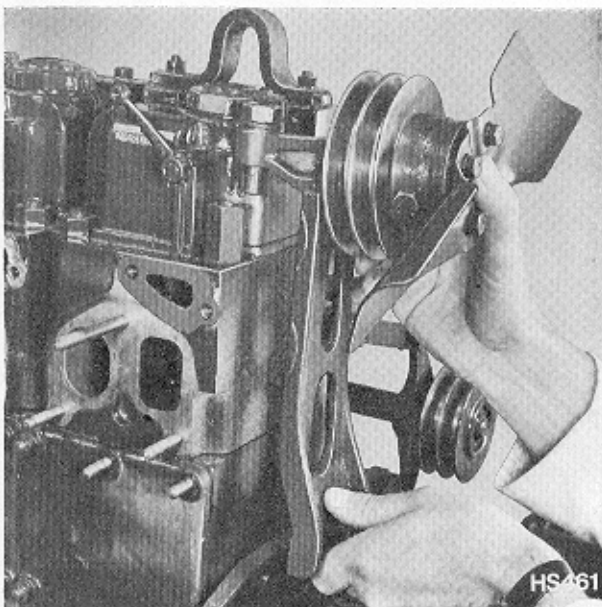


Fig. 83 Fan & Pulley

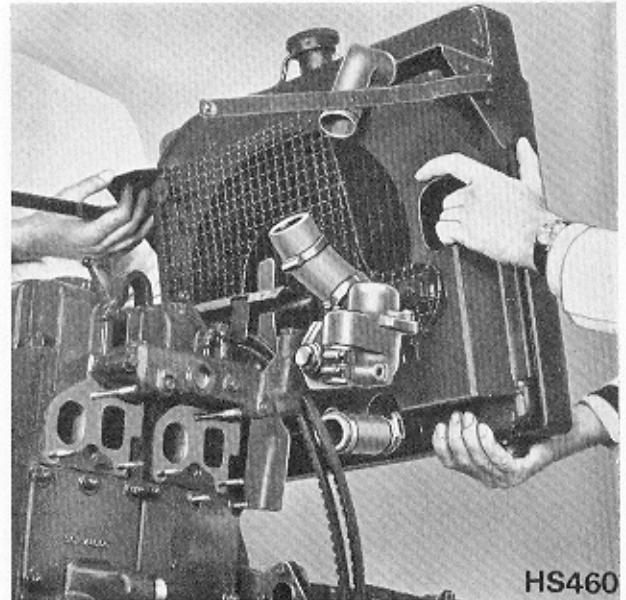


Fig. 82 Removing Radiator

TANK COOLED ENGINES (Fig. 84)

On a tank cooled engine the water supply pipe is fed through a guard which is bolted to the fly-wheel end of the engine.

The capacity of the water tank is dependent on engine application and the ambient temperature in the vicinity of the tank. Consult R. A. Lister for further information.

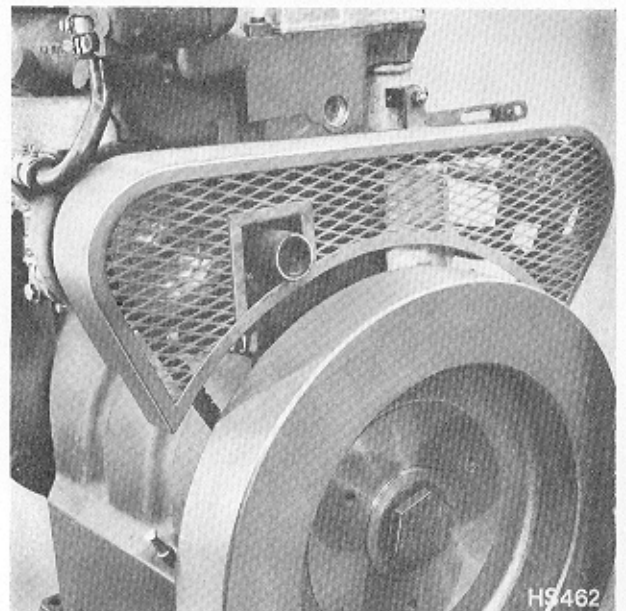


Fig. 84 Flywheel and Guard—Tank Cooled

HEAT EXCHANGER—MARINE ENGINES

(Fig. 85)

The combined heat exchanger and header tank is secured to a mounting bracket at the flywheel end (Fig. 86). Fresh water is passed from the bottom of the unit to the circulating water pump and returned from the engine via the thermostat to the top of the tank. A Jabsco raw water pump, fitted at the gear end of the engine, provides water for the cooling elements of the heat exchanger. A filler cap and relief valve are fitted in the top of the unit.

The system is pressurised to 6 lbf.in² (0.42 kgf.cm²) and care must be taken if the filler cap is removed when the engine is hot.

To Remove Heat Exchanger

- (a) Drain water.
- (b) Disconnect pipes:—
 - (i) Thermostat to heat exchanger.
 - (ii) Heat exchanger to pump.
 - (iii) Jabsco pump to heat exchanger.
 - (iv) Heat exchanger to raw water outlet.
- (c) Remove bolts securing base of heat exchanger to mounting plate; lift off unit.

Servicing

Servicing the unit should be in accordance with the manufacturers (Cov Rad) instructions. The periodicity for checking and cleaning the element will depend on the conditions and type of water under which unit is operated.

In use, water level should be checked daily.

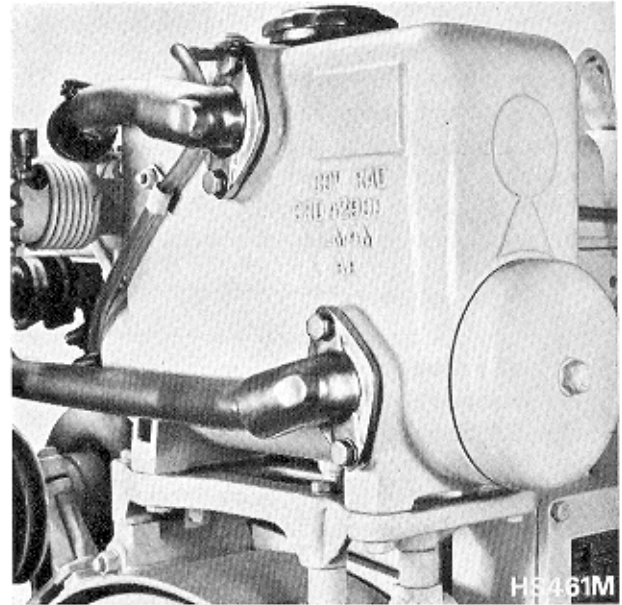


Fig. 85 Heat Exchanger

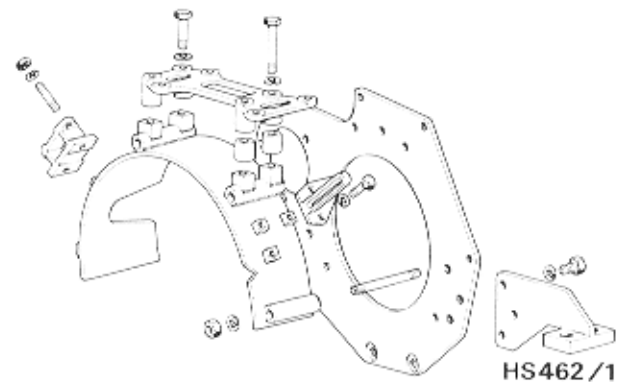


Fig. 86 Mounting for Heat Exchanger and Water Pump

JABSCO RAW WATER PUMP (Fig. 87)

The Jabsco pump is fitted on the gear end of the engine and is mounted on the end cover. The pump is driven through a gear train from the camshaft gearwheel and is lubricated by an external pipe from the inlet of the oil filter. It is removed by disconnecting the inlet and outlet pipes and removing the four setscrews at the flange.

Fitting a New Impeller

- (a) Remove the 6 end cover screws.
- (b) Pull impeller from pump body.
- (c) Moisten new impeller with water and fit on to shaft with a twisting motion.
- (d) Fit new gasket and refit end cover.

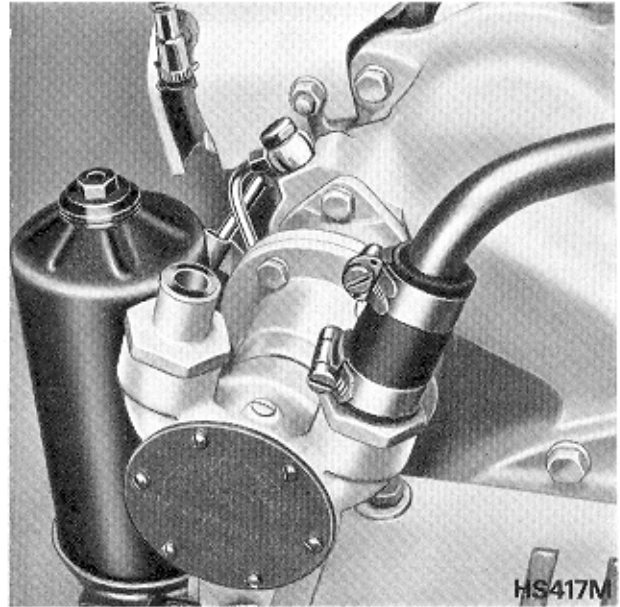
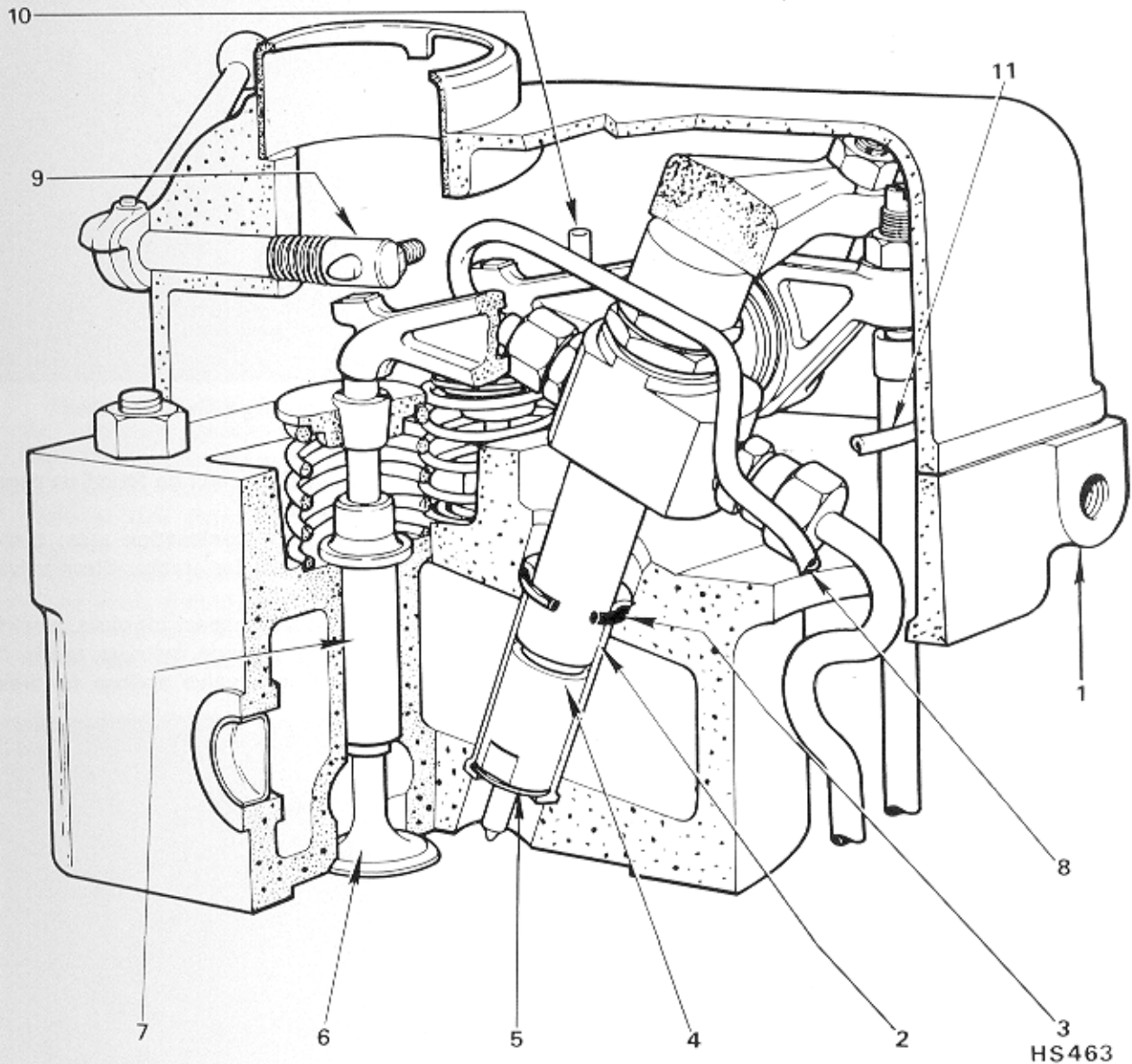


Fig. 87 Jabsco Pump

CYLINDER HEAD (Fig. 88)

The cast iron cylinder head is made in one piece and contains the valve gear, injector and breather tube. The valve guides are a press fit into the head and are not interchangeable.



- | | |
|-----------------------------|-------------------------------------|
| 1. Cylinder Head | 7. Exhaust Valve Guide |
| 2. Injector Sleeve | 8. Fuel Leak-off Pipe |
| 3. Injector Sleeve 'O' Ring | 9. Decompressor |
| 4. Fuel Injector | 10. Breather |
| 5. Injector Joint | 11. Lubricating Oil Pipe to Rockers |
| 6. Exhaust Valve | |

Fig. 88 Cylinder Head

Removing the Cylinder Heads (Fig. 89)

- (a) Drain water (Drain plug in each block door).
- (b) Remove cylinder head cover (and lifting eye where applicable); remove inlet and exhaust manifolds and gaskets.
- (c) Remove water outlet manifold and thermostat—see page 63.
- (d) If removing cylinder head at flywheel end on a radiator cooled engine. Slacken belt tensioner (jockey pulley, dynamo or alternator) and remove radiator and fan mounting bracket (see previous pages).
- (e) Remove fuel pump housing door.
- (f) Lift out lubricating oil pipes to rockers.
- (g) Disconnect and remove:—
 - (i) Fuel leak-off pipe
 - (ii) Fuel pipe—pump to injector
 - (iii) Fuel injector (see Section 3)
- (h) Remove four holding nuts and lift head. Mark cylinder gasket number for refitting and keep shims and gasket with head.
- (j) Lift out push rods.

To Remove Valves (Fig. 90)

- (a) Lay head upright on bench and place a circular block of wood about 114 mm ($4\frac{1}{2}$ "") in diameter under the heads of the valves.
- (b) Depress valve spring carrier.
- (c) Remove valve stem collets.
- (d) Remove valve spring carrier, and valve spring(s).

When refitting, ensure collets are securely in position with top of collets flush with valve spring carrier.

Rocker Lever Bush (Fig. 91)

If it is necessary to change rocker lever bush, remove setscrew and spring washer securing valve rocker bracket to head, lift off assembly. When removed, release circlip and slide off rocker lever. Use new joint when refitting assembly. To prevent damage to the breather tube it is advisable to remove it when servicing the valve gear.

Valve Seats

The inlet valve is 1.01—1.27 mm (0.040"—0.050") and the exhaust valve is 0.89—1.14 mm (0.035"—0.045") below the combustion surface of the head. Width of valve seats: Inlet 2.78—3.2 mm (0.107"—0.127"); Exhaust 2.54 mm—2.89 mm (0.100"—0.114").

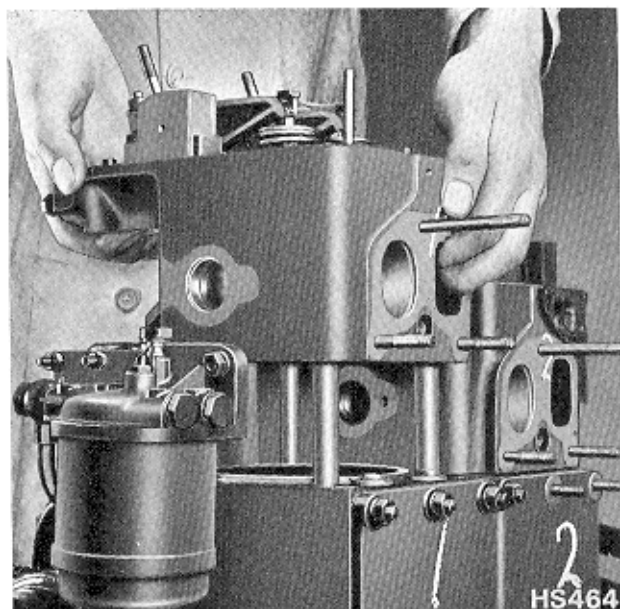


Fig. 89 Removing a Cylinder Head

Servicing—

Information on wear limits can be found on page 116 Table of Clearances

Remove carbon from combustion area; thoroughly clean and inspect for cracks. Clean valve guides and check for wear.

Check valve seats and inspect for nicks, cracks or pitting. Reface or change cylinder heads if not within limits. Check valve springs for free

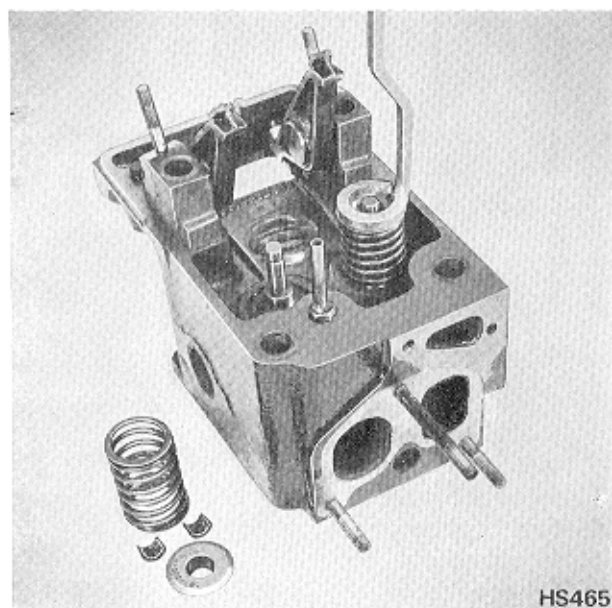


Fig. 90 Removing the Valves

length. Examine rocker arms for cracks, damage and wear. Inspect push rods for bends and examine ball and cup ends for wear or cracks.

Valve springs must be replaced if they are rusty or pitted. They must be replaced after 6000 hours.

Good starting and satisfactory running depends to a great extent on the condition of the valve seatings, so the valves must be carefully ground and then tested whenever they can be heard blowing on turning the engine slowly over compression.

Ensure a serviceable ferrule joint ring is located in each of the four holes to the water jacket in the cylinder block (Fig. 98A).

Refitting the Cylinder Head

Examine the gasket, renew if necessary. Fit the necessary shims—see Checking Cylinder head Clearance—nearest the head followed by the gasket; these are retained in position with Wellseal (see page 58). The sequence for fitting the head is the reverse to removal. The cylinder head nuts and washers and top threads of the studs should have Wellseal applied.

The inlet and exhaust flanges of all cylinder heads must be lined up with a straight edge, or

alternatively fit a manifold before finally tightening down head. Ensure holding down nuts are pulled down evenly and torque loaded to 13.9 kgf.m. (100 lbf.ft.). It is essential that these nuts be tightened before securing the injector. After fitting heads, reset valve clearances and check decompressor adjustment.

Checking Cylinder Head Clearance (Fig. 92)

Note: Fig. 92 shows an air cooled head but the method of checking applies to all engines.

Place two pieces of lead wire 1.5 mm (0.062") thick on the cylinder head, clear of valve recesses and the combustion chamber in the top of the piston; retain in position with grease. Space widely and as near as possible in line with the gudgeon pin. Tighten down the cylinder head to the correct torque loading (see previous paragraph) and turn the piston twice past T.D.C. Remove the cylinder head and measure the thickness of the lead. This should be between 1.27 and 1.34 mm (0.050" and 0.053"). This can be adjusted by shims 0.076 mm or 0.25 mm (0.003" or 0.010") thick placed between the cylinder head and the gasket. Note: When the shims required for establishing the cylinder head clearance exceed 0.25 mm (0.010"), rubber packing washers are fitted below each of the four ferrule joint rings at the top of the cylinder block. This is to maintain a uniform compression on the joint rings and thus prevent leaks.

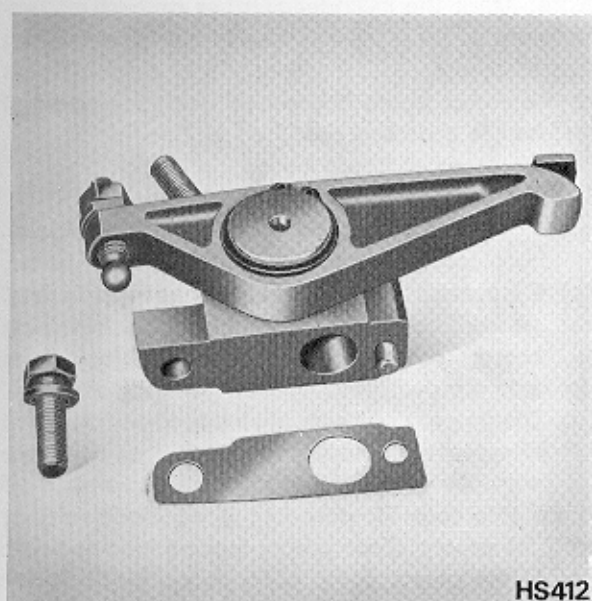


Fig. 91 Rocker Lever Bracket

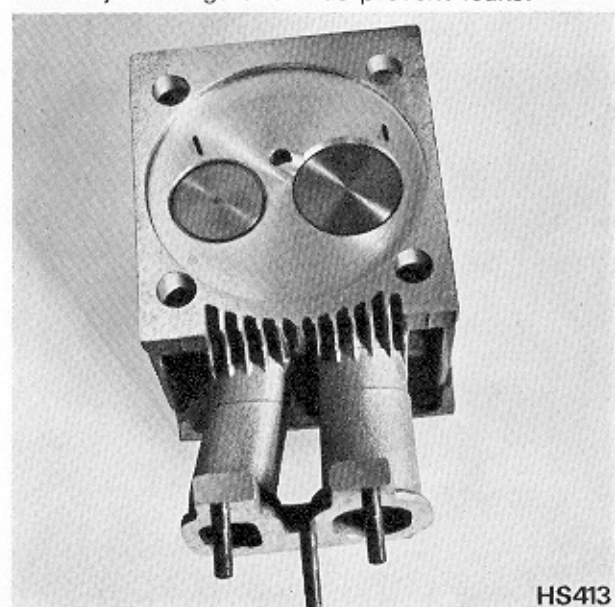


Fig. 92 Checking Cylinder Head Clearance

PISTON, PISTON RINGS AND CONNECTING ROD (Fig. 93)

Piston and Gudgeon Pin

The piston is made of low expansion alloy with a machine recessed combustion chamber in the crown. The gudgeon pin is a clearance fit in the piston and is retained by two circlips. It runs in a copper faced steel backed bush in the small end of the connecting rod.

Piston Rings

Five piston rings are fitted: —

Firing Ring

A barrel lapped chrome ring is situated at the top of the piston and is tapered on the sides to prevent sticking in the groove.

Compression Rings

Two compression rings are fitted. Each has a tapered face in contact with the barrel. One surface on each is marked TOP and the rings must be fitted the correct way up.

Scraper Rings

One conformable type—with spring expander—is fitted above and a slotted scraper ring fitted below the gudgeon pin.

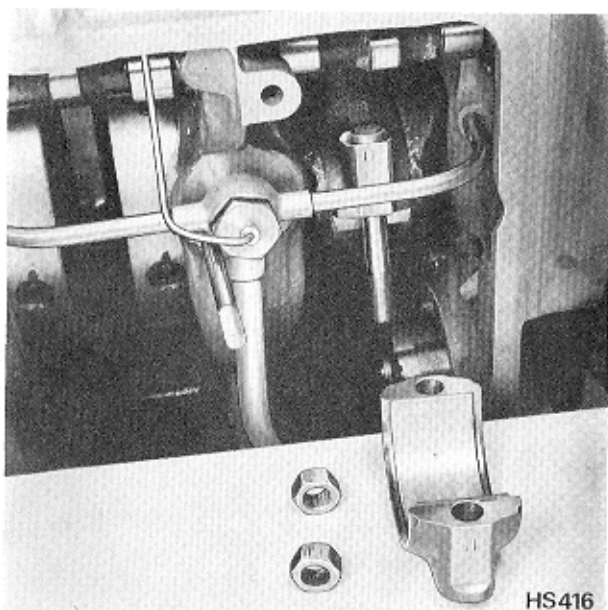


Fig. 94 Big End Bearing

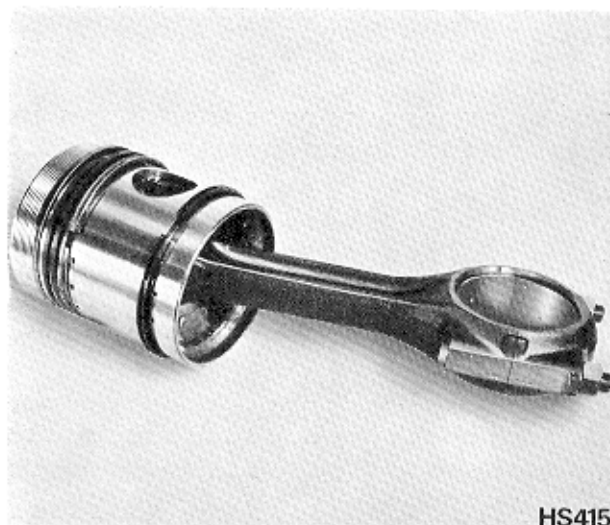


Fig. 93 Piston and Connecting Rod

Connecting Rod and Big End Bearing

The forged steel connecting rod is connected to the crankpin by a conventional big end bearing, the cap held in position by two bolts and nuts. The two halves of the big end bearing are steel backed copper lead. They are precision finished and should not be scraped or touched up in any way.

To Remove Piston, Connecting Rod and Barrel

Note: Mark the cylinder number on each assembly removed. No. 1 cylinder is the opposite end to the flywheel. The water block door adjacent to the water pump has a small recess and must be fitted in the same position.

- (a) Drain water, drain sump.
- (b) Remove:—cylinder heads (page 72), water pump (page 66) Not Marine. radiator and fan (page 68) Not Marine.
- (c) Disconnect water hoses between cylinders. (If difficulty is experienced in removing hoses, remove nuts securing block doors and remove doors and hoses complete).
- (d) Disconnect lubricating oil filter pipes at crankcase; remove crankcase door complete with filter.

Note: If a fuel lift pump is fitted, drain or shut off fuel supply, disconnect pipes and remove with crankcase door.

- (e) Remove connecting rod nuts and cap; fit thread protectors (Fig. 94).

- (f) Rotate piston to T.D.C.
- (g) Mark position of block for refitting and remove piston, connecting rod and block as a complete unit. (Fig. 95.)
- (h) Withdraw piston from block.
- (j) Gudgeon pin may be removed by releasing one spring clip and pushing out pin.
- (k) Using a standard ring expander, remove piston rings.

Cylinder Block Stud Sleeves (Fig. 96)

When removing the block, should the stud sleeves become attached to the studs and thus remain on the studs when the block is removed, the following procedure should be carried out.

- (a) Replace studs.
- (b) Examine block and sleeves and if in good condition carefully clean the bores in the block taking care not to increase the diameters.
- (c) Coat both ends of sleeves with Hylomar SQ32M.
- (d) Insert the ground outside diameter of the sleeve from the bottom of block and push up until it just enters the top bore.
- (e) From the top of the block, pull the sleeve into position until the top face is flush with the top face of the block.
- (f) Fit 'O' ring to each sleeve at the bottom of block (Fig 98B).
- (g) Pressure test water jacket to 1.4 kgf.cm² (20 lbf.in.²) if facilities available.

Servicing (see page 116 Table of Clearances)

Thoroughly clean the barrel and check for scoring and wear. Clean the piston, remove all carbon from both upper and underside of head, ring grooves and oil holes.

Check all piston rings in the cylinder barrel for correct gap clearance.

Clean connecting rod and examine for bending and twisting—examine small end bush for wear.

Check the connecting rod bearings and crank-pin for signs of wear.

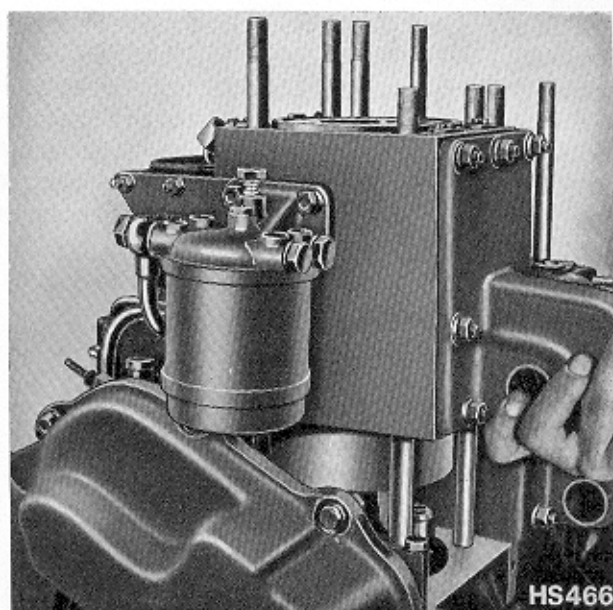


Fig. 95 Removing a Block

If the big end has been dismantled because of metal failure, the oil passages in the crankshaft must also be examined for obstruction and fragments of metal.

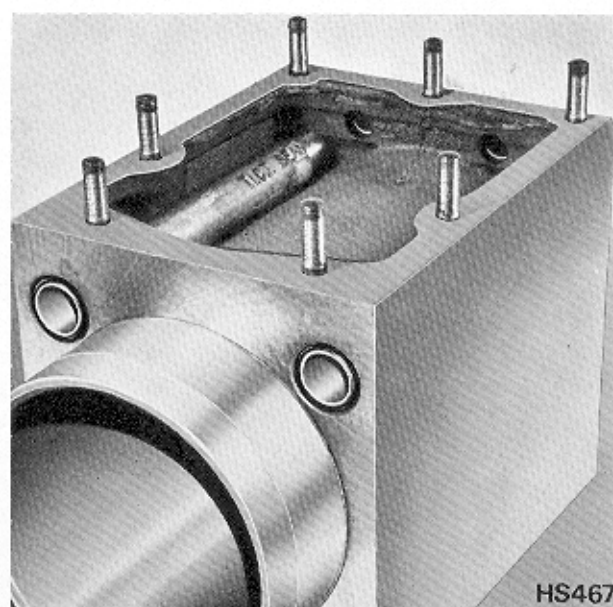
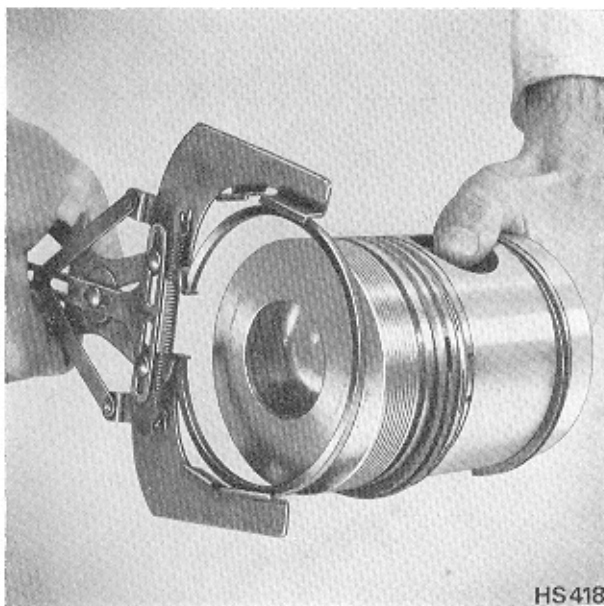


Fig. 96 Block Stud Sleeves

Refitting Piston, Connecting Rod and Cylinder Barrels

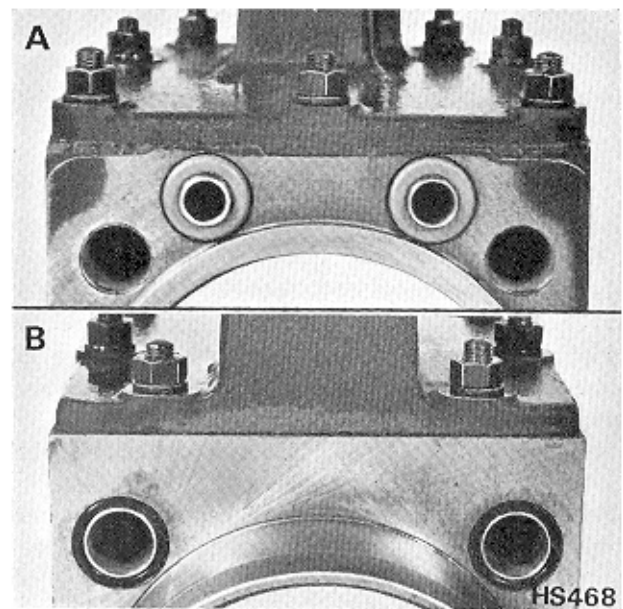
Note: The crown of the piston is marked CAM-SHAFT SIDE and the connecting rod and cap are marked on one side with "double" cylinder numbers, i.e. 11, 22 or 33. When refitting the piston and block assembly, all these marks must face the camshaft side of the engine.

- (a) Fit piston to connecting rod and secure gudgeon pin circlips.
- (b) Fit piston rings as detailed on page 74. (Fig. 97).
- (c) Stagger piston ring gaps and fit piston into block.
- (d) Ensure bearing shells are correctly located in connecting rod and cap.
- (e) Fit joint to bottom of cylinder using Hylomar SQ32M.
- (f) Ensure that a serviceable 'O' ring is fitted on each of the four sleeves at the base of the block (Fig. 98B). A ferrule joint should be located in each of the four holes to the water jacket in the top of the block (Fig. 98A).
- (g) Position crankshaft with crankpin at T.D.C.
- (h) With the wording 'CAMSHAFT SIDE' on the piston correctly positioned, lower the cylinder block, piston and connecting rod assembly into position.
- (j) Push down on piston and turn crankshaft until access is gained to connecting rod bolts; fit cap with bearing shell and torque to 9.4 kgf.m (68 lbf.ft.).
- (k) Coat groove in crankcase door with Bostik 772 and stick joint to it; refit crankcase door. Reconnect lubricating oil filter pipes.
- (l) If block doors removed, refit to correct cylinder blocks using Hylomar SQ32M; connect hoses between doors.
- (m) Refit:—radiator and fan.
water pump.
cylinder heads.
- (n) Fill sump with correct grade and quantity of lubricating oil, see Section Two. Fill water system and check for leaks.



HS418

Fig. 97 Fitting Piston Rings



HS468

Fig. 98 Top and Bottom of Block

GEARCASE END COVER

A number of end covers may be fitted to these engines depending on the engine application, two are illustrated on this page.

All end covers are located on two dowels and bolted either direct or with clamps to the end of the crankcase. An oil seal is fitted over the crankshaft extension and care must be taken when removing and fitting cover to avoid damaging this seal, see Section Two.

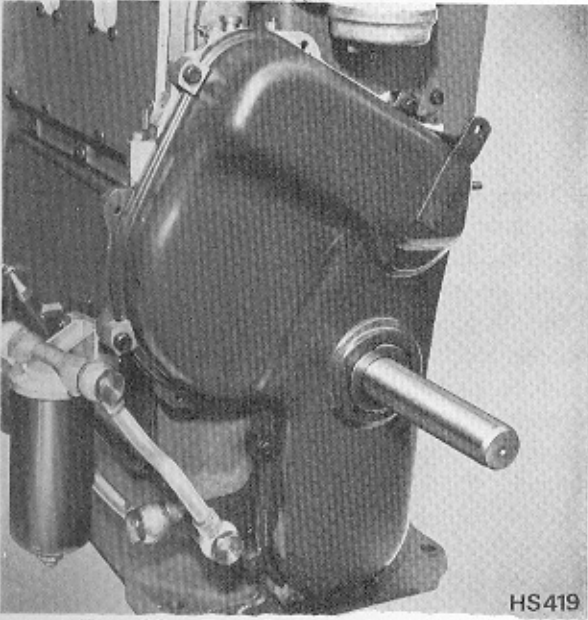


Fig. 99 End Cover—Sheet Metal

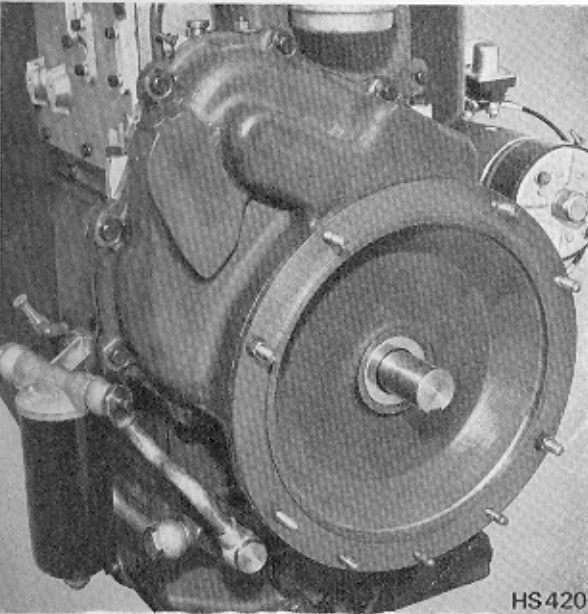


Fig. 100 End Cover—Cast Iron

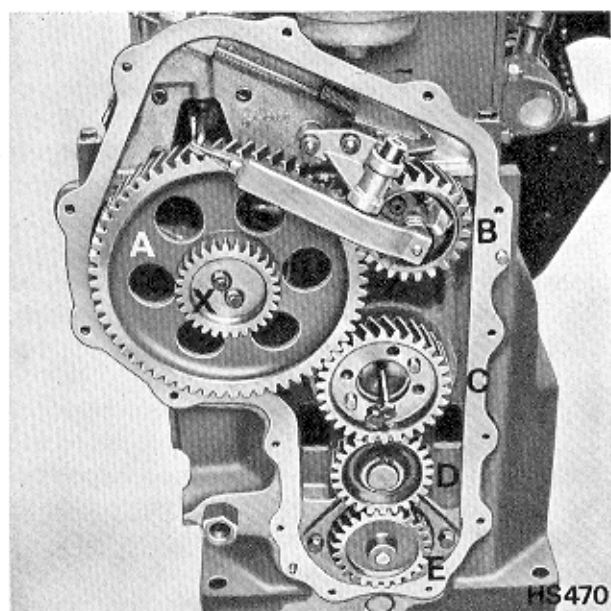
GEAR TRAIN (Fig. 101)

All the gears forming the gear train may be dismantled after removing the gear case cover, without the removal of additional parts of the engine. See that the keyway in the shaft extension is free from burr and turned to the bottom to prevent damage to the oil seal.

- (a) Drain lubricating oil sump.
- (b) Governor complete with gearwheel may be removed as described in next paragraph.
- (c) Camshaft gearwheel is secured by two setscrews and a key.
- (d) Crankshaft gearwheel pinion and oil thrower are secured by four setscrews and located by two dowels. These same setscrews and dowels secure the crankshaft extension for the starting handle.
- (e) Lubricating oil pump idler wheel is held on to the spindle by washer and spring clip. The spindle is a driving fit into the crankcase and must not be removed unless it requires replacement. A split pin is fitted inside the crankcase, as a safety precaution. The crankcase is drilled to supply the spindle and idler wheel with lubricating oil direct from the lubricating oil pump.
- (f) The lubricating oil pump complete with driving gear is secured by two setscrews.

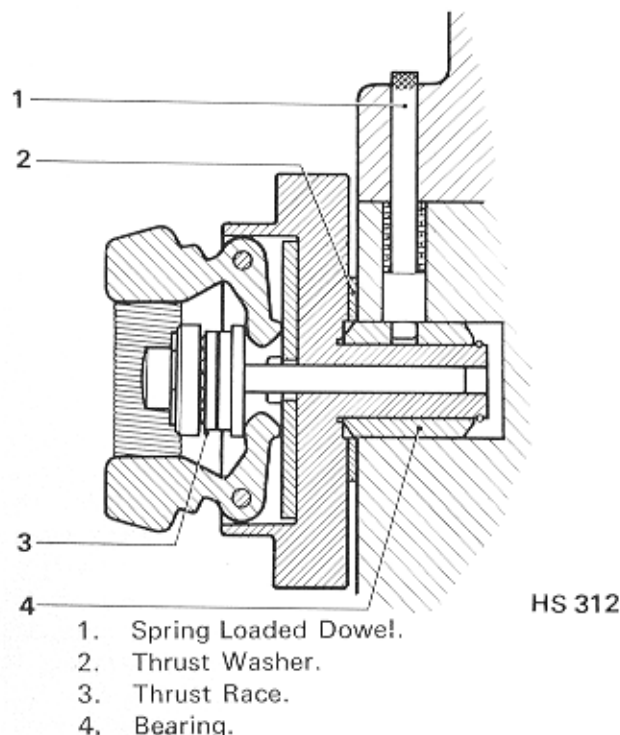
GOVERNOR (Fig. 102)

The governor gearwheel complete with governor assembly can be withdrawn by removing the governor lever and then lifting the spring loaded dowel above the bearing. A copper thrust washer is located between the gearwheel and the crankcase. The governor weight carrier is secured by two setscrews in the recesses of the gearwheel. When refitting assembly, ensure that the larger—centre—hole of the three holes in the edge of the gearwheel bush is to the top. See Section Three for details and operation of governor.



- A—Camshaft Gearwheel
 B—Governor Gear
 C—Crankshaft Pinion
 D—Idler Gear
 E—Oil Pump
 X—This gear drives an idler gear (or tachometer drive) which in turn drives the gear for the Jabsco pump.

Fig. 101 Gear Train



1. Spring Loaded Dowel.
 2. Thrust Washer.
 3. Thrust Race.
 4. Bearing.

Fig. 102 Governor

FLYWHEEL

The cast iron flywheel is mounted on a tapered shaft and secured with a 1" setscrew and tab-washer.

Etched lines on the rim of the flywheel give the T.D.C. position for each cylinder i.e. T1, T2 and T3; the firing points are marked FP.

To find the firing point for No. 1 cylinder, turn the engine in direction of rotation until T1 is in line with pointer with both valves closed. Turn the engine slowly against direction of rotation until FP is in line (Timing information can be found in Section Three).

To Remove Flywheel

Slacken flywheel retaining screw not more than two turns. Using service tool—see Section Seven—withdraw flywheel.

Refitting is carried out in reverse order. The tapered shaft and the coned bore of the flywheel must be perfectly clean and should be smeared with clean lubricating oil before assembly. It will assist assembly if keyway is positioned to the bottom.

After fitting lockwasher, tighten flywheel retaining screw to a final torque of 55.2 kgf.m. (400 lbf.ft); secure screw with lock washer.

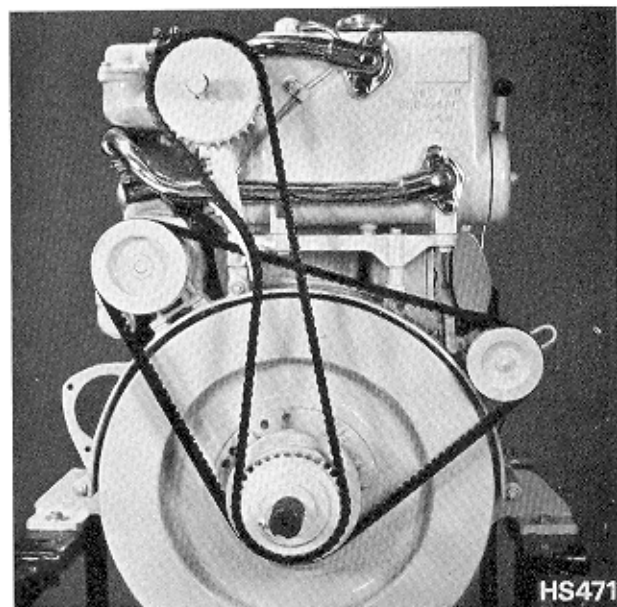


Fig. 103 Flywheel—HRWM Engine

Information on **CAMSHAFTS** and **CRANKSHAFTS** is the same as air cooled engines and can be found in Section 4 Part 1.

Information on **DECARBONISING, LAYING-UP PROCEDURE** and **SPANNER TORQUES** can be found at the end of Section 4, Part 1.

Section Five

ACCESSORIES

INTRODUCTION

This section contains fitting and servicing information on accessories which are available for HR and HRW engines. Some accessories listed are standard fittings on particular applications i.e. an air outlet duct is a standard fitting on a marine air cooled engine. Another factor affecting the use of accessories is compatibility, for example, coupled decompressors would normally be fitted when an engine mounted fuel tank is used. Further information on all the equipment listed in this section can be obtained from Lister Distributors. Part numbers with ordering instructions—are attainable from the appropriate Parts List (Book 1443PL or Book 1444PL) which is supplied with each engine.

AIR CLEANERS (see also page 42 or 62)

The correct fitting and maintenance of air cleaners cannot be over-emphasised. The air cleaner must be fitted to ensure no possibility of air entering the engine except through the cleaner. Loose or incorrect fittings will leave gaps through which dust will be drawn. Servicing periods will vary according to the conditions under which the engine is run, see Routine Maintenance.

Cyclopac Air Cleaner (Fig. 104)

The dust cap on the end of the cleaner should be emptied daily.

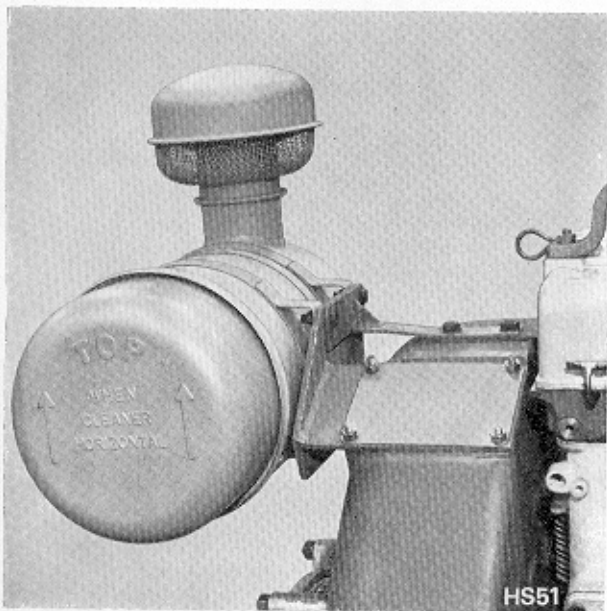


Fig. 104 Cyclopac Air Cleaner

To service cleaner, remove element and clean the outside with a soft brush or by tapping. If compressed air is available this can be used by blowing from the inside of the element only. Maximum pressure 100 lb. in². If air is blown on to the outside of the element it will force the dust through the element leaving holes and it will then be useless. These elements are renewable but if carefully maintained they can be re-used. To check if the element is still serviceable, clean and then insert an unshaded light inside the element in a darkened room. The light will show through any small holes which may be in the element and this will indicate that the element is no longer serviceable. A new element must then be used.

Clean the element container thoroughly, refit the element and ensure that all joints are in good condition and well made. Refit the complete unit to the engine and again ensure that all the fittings are tight and that there are no gaps through which unfiltered air can be drawn.

Air Cleaner With Mounted Tank (Fig. 105)

When an engine mounted tank is fitted to HRW engines, an oil bath air cleaner may be fitted below the manifolds—as illustrated. Servicing is the same as for a standard oil bath air cleaner—see page 62.



Fig. 105 Air Cleaner with Mounted Tank—HRW

FLYWHEEL SHAFT EXTENSIONS (Fig. 106)

Two diameters of shaft extensions may be fitted to the flywheel. A shaft carried in two pedestal bearings with a flexible half coupling may also be fitted at the flywheel end. See Installation Information on page 10.

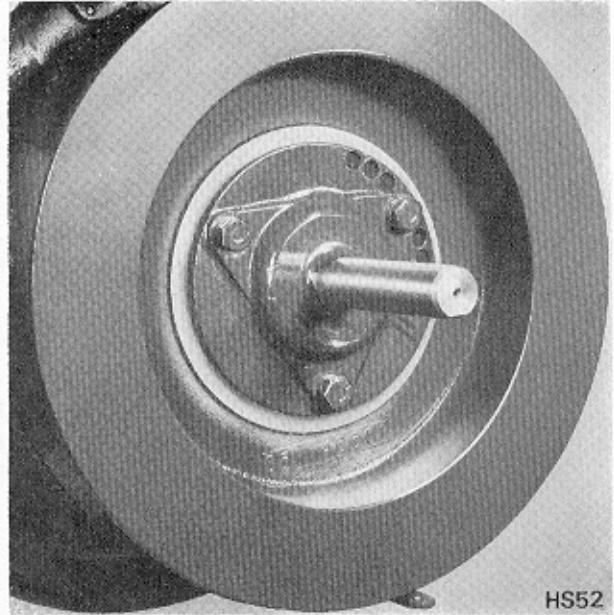


Fig. 106 Flywheel Shaft Extension

ADAPTORS—HR ONLY (Fig. 107)

The following flywheel housing adaptors may be fitted to air cooled engines:—

SAE 1, SAE 2, SAE 3, SAE 4, SAE 5.

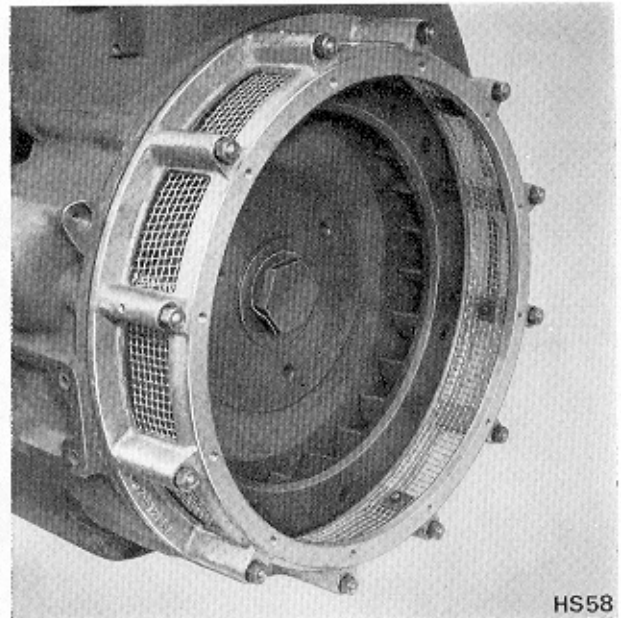


Fig. 107 S.A.E. Adaptor—No. 2

FLEXIBLE HALF COUPLING (Fig. 108)

Fitting Instructions

1. Fit equally spaced studs (A) with tab washers into flywheel; lock into position with tab washers.
2. Assemble three equally spaced bolts (B); each bolt through a spring disc washer, coupling disc spacer and half coupling; fit locknut.
3. Fit assembly over studs and secure with nuts (C) and dished washers.

Note: Spring disc washers should be fitted with concave side against coupling disc. Torque load all nuts to 3.9 kgf m (28 lbf.ft.)

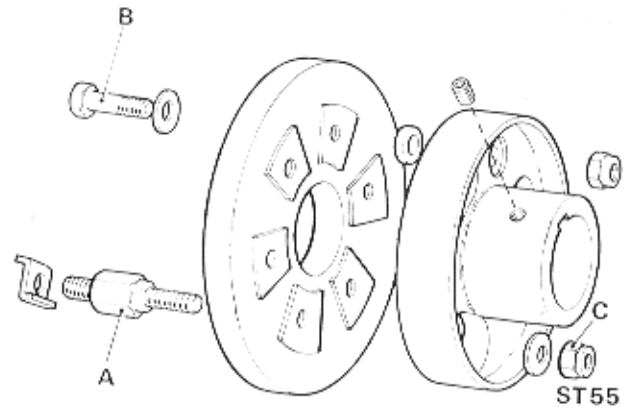


Fig. 108 Flexible Half Coupling

FLEXIBLE WHOLE COUPLING (Fig. 109)

Fitting Instructions

1. Assemble three equally spaced bolts (A); each bolt through a spring disc washer, coupling disc, spacer, and half coupling; fit locknut.
2. Assemble three equally spaced bolts (B) with spring disc washers and spacers to the

other half of coupling in the same manner. Note. All Spring disc washers should have concave face against coupling disc. All nuts should be torque loaded to 3.9 kgf m (28 lbf.ft.).

3. Fit assembly on to shaft using key and grub screw.

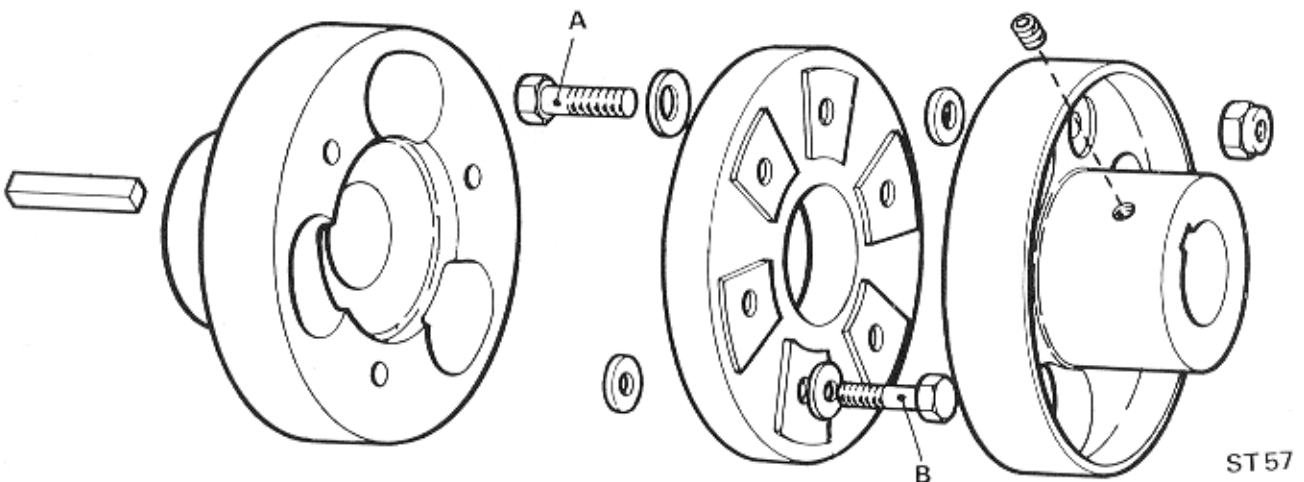


Fig. 109 Flexible Whole Coupling

LISTER CLUTCH

The Lister clutch is of the single plate type and can be fitted for direct drive or with a reduction gear. It is toggle operated and is therefore self-locking in either the engaged or disengaged position. Tension should be felt throughout the movement of the lever to engage the clutch and the lever should be released on completion of the movement.

The sleeve, yoke and toggle mechanism are lubricated from the main engine lubricating oil system, the oil being supplied through a restrictor plug which is fitted in the end of the crankshaft. No other lubrication is necessary.

Adjustment—see Fig. 110

The clutch plate is held between two pressure plates when fully engaged and it is essential that there should be no slip. If the full power is not being transmitted, the clutch should be adjusted as follows:—

- (a) Stop the engine.
- (b) Remove inspection cover on top of the clutch housing.
- (c) With the operating lever in the "neutral" position, revolve the clutch assembly until the adjusting peg A is conveniently accessible.

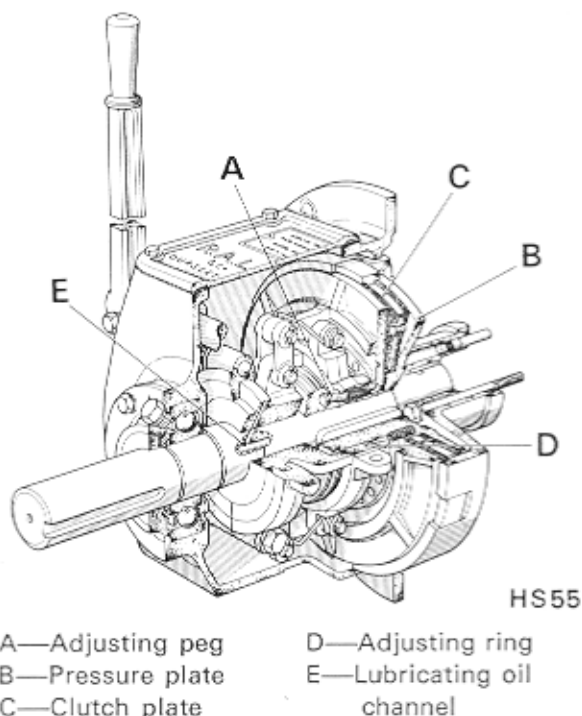


Fig. 110 Lister Clutch—cutaway

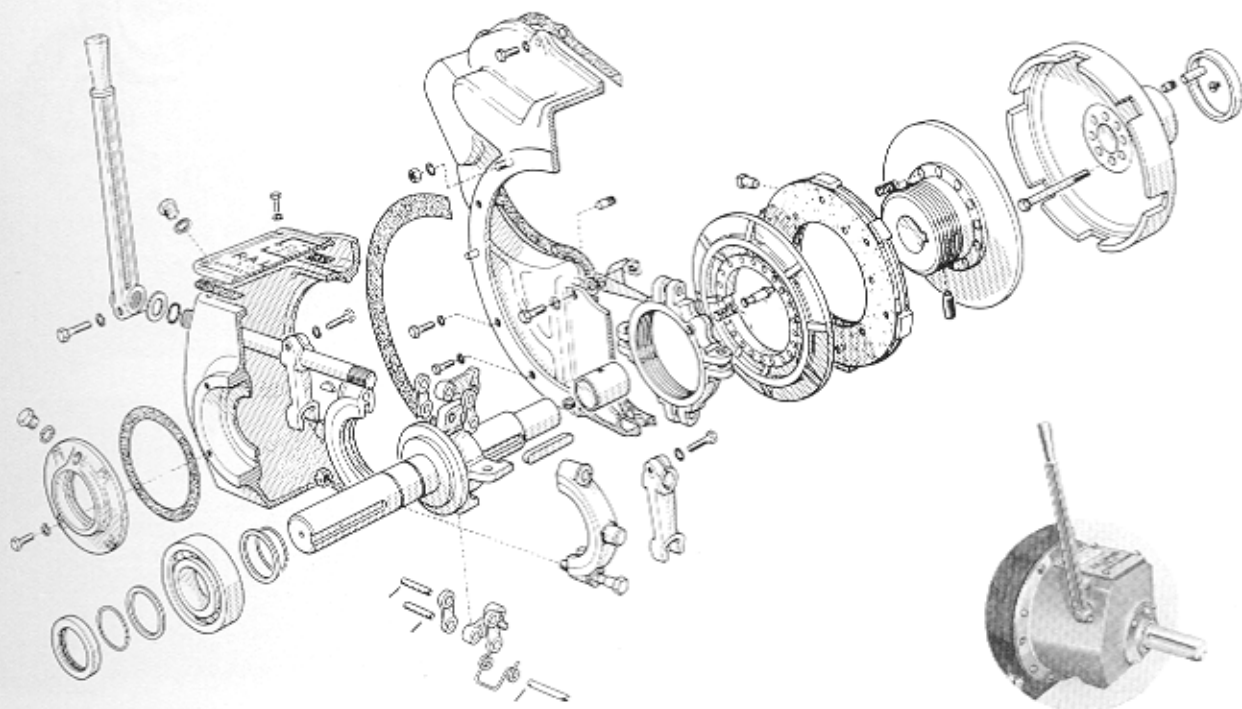


Fig. 111 Components of Lister Clutch

- (d) Pull out the adjusting peg by hand against its spring and revolve the screwed adjusting ring D in a clockwise direction (to increase the engagement pressure). Re-engage the peg in one of the holes provided.
- (e) Try the hand lever, which should offer a slight but positive resistance when being engaged.
- (f) Do not adjust more tightly than necessary to transmit the full power without slip.
- (g) Ensure that the clutch runs freely in the "neutral" position.

Note: It will generally be found that this movement is sufficient to take up any wear which may have occurred. If the drive is still unsatisfactory, it may be necessary to take the adjusting ring round to the next locking position.

Should any other make of clutch be fitted to the engine, then the clutch makers instructions on greasing and adjustment should be followed.

REDUCTION GEAR—INDUSTRIAL ENGINES (Fig. 112)

The drive for the 2:1 reduction gear is transmitted through an extension shaft fitted to a steel camshaft gearwheel. The blanking plug in the end of the camshaft is removed to provide an oil supply for an additional bearing which is fitted in the cast iron end cover. An oil seal and an oil thrower ring in the end cover prevent oil leaks around the shaft extension

Reduction Gear and Clutch

When a clutch is fitted with a reduction gear the drive is taken as described above, from the camshaft, and the clutch is mounted on the reduction gear end cover.

Adjustment is carried out in the same way as a direct drive clutch, see page 83.

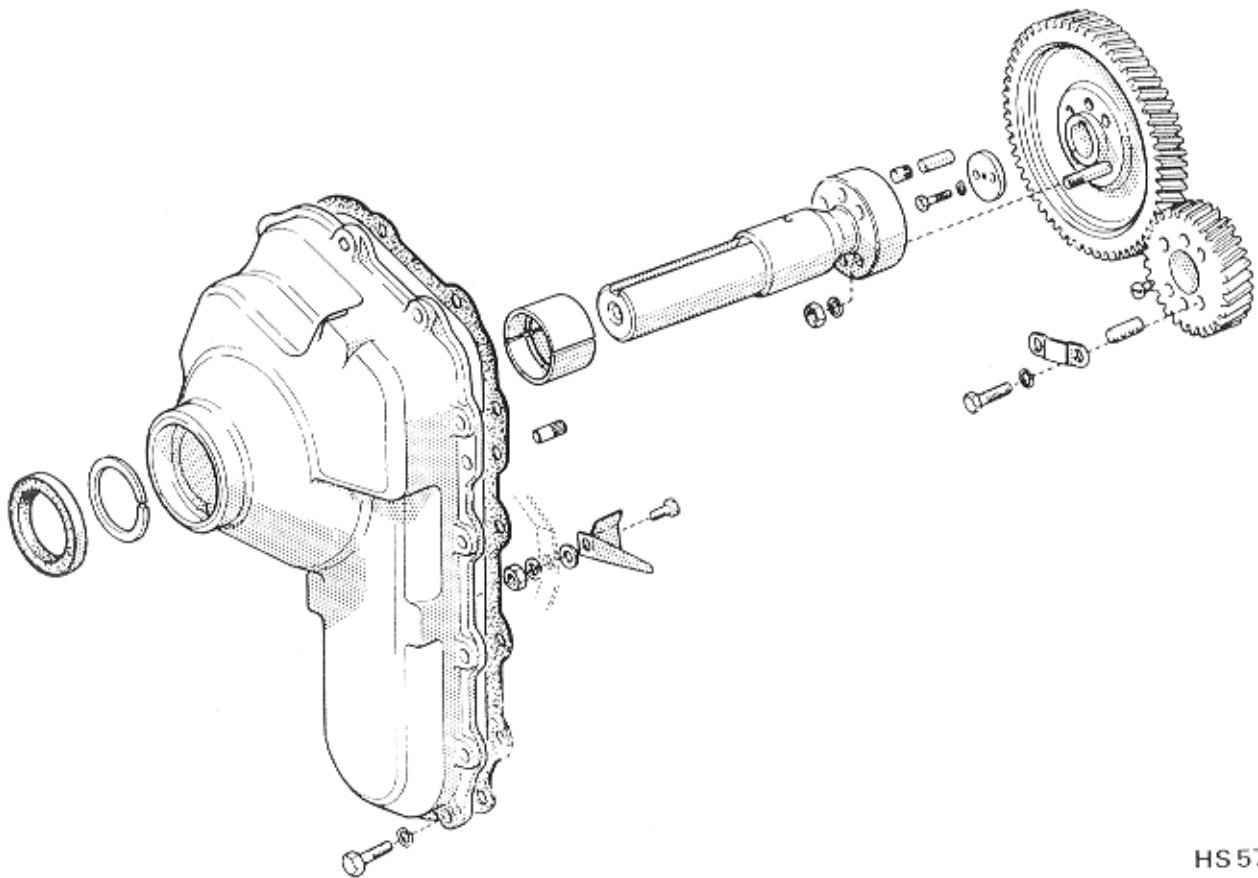


Fig. 112 Reduction Gear—Industrial Engines

HS57

AIR OUTLET DUCT (HR)

Two types of duct are available for air cooled engines; a vertical duct as illustrated (Fig. 113), and a horizontal type. An air outlet duct is a standard fitting on all HRM engines.

The duct is secured to the fuel pump housing door and on an adaptor plate at the gear end. When ducting or trunking is fitted to the air outlet duct, the Installation Information in Section 1 should be consulted.

Note.—When a horizontal type of duct is fitted, the dipstick and oil filler must not be in the crankcase door.

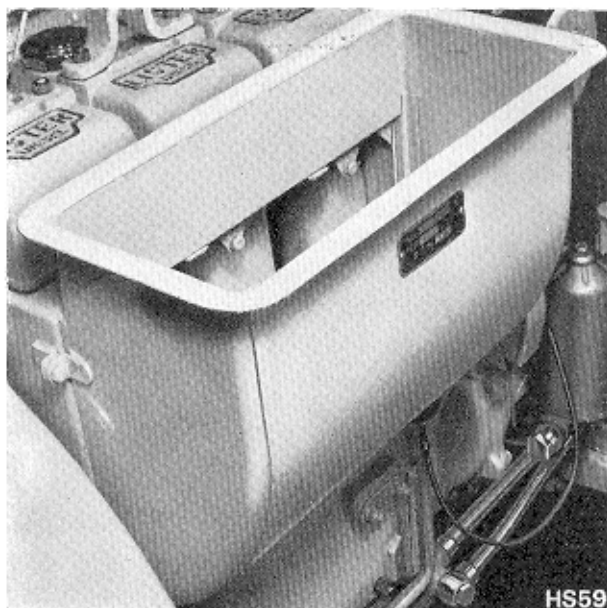


Fig. 113 Vertical Air Outlet Duct

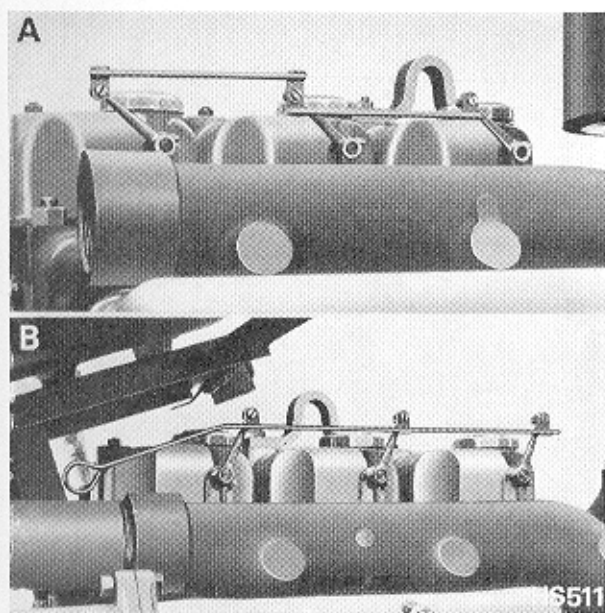


Fig. 114 Coupled Decompressors

COUPLED DECOMPRESSORS (Fig. 114)

Two types of coupled decompressors are available. Fig. 114, A shows a simple rod arrangement connecting the levers only. Fig. 114, B illustrates a longer coupling rod—as used with engine mounted fuel tanks—which has a ring fitted to enable the decompressors to be operated from the end of the engine.

When reconnecting coupling rods, coupling rod screws should not be secured dead tight. This is to allow free movement between pin centres when operating decompressors. Decompressor adjustment is detailed in Section Four.

Note: Coupled Decompressors are a standard fitting on all marine propulsion engines, and HR and HRW 3 cylinder engines.

HYDRAULIC PUMP MOUNTING (Fig. 115)

An hydraulic pump mounting arrangement is available for fitting on the gear end of the engine, the pump being driven from the crankshaft extension. Please note that R. A. Lister do not supply the pumps.

When fitting a new or serviced pump, a clearance of 0.793—3.175 mm (1/32"—1/8") must be maintained between the driving member and the coupling disc (item A, Fig. 115). This can

be obtained by shims fitted between the adaptor and the mounting plate (item B, Fig. 115). It is recommended that the hydraulic pump is serviced by the pump manufacturer or an accredited Service Depot.

HR engines can also be arranged with close coupled fan shroud and SAE1/5 adaptors at the flywheel end, to enable hydraulic pumps to be mounted at the flywheel end of the engine.

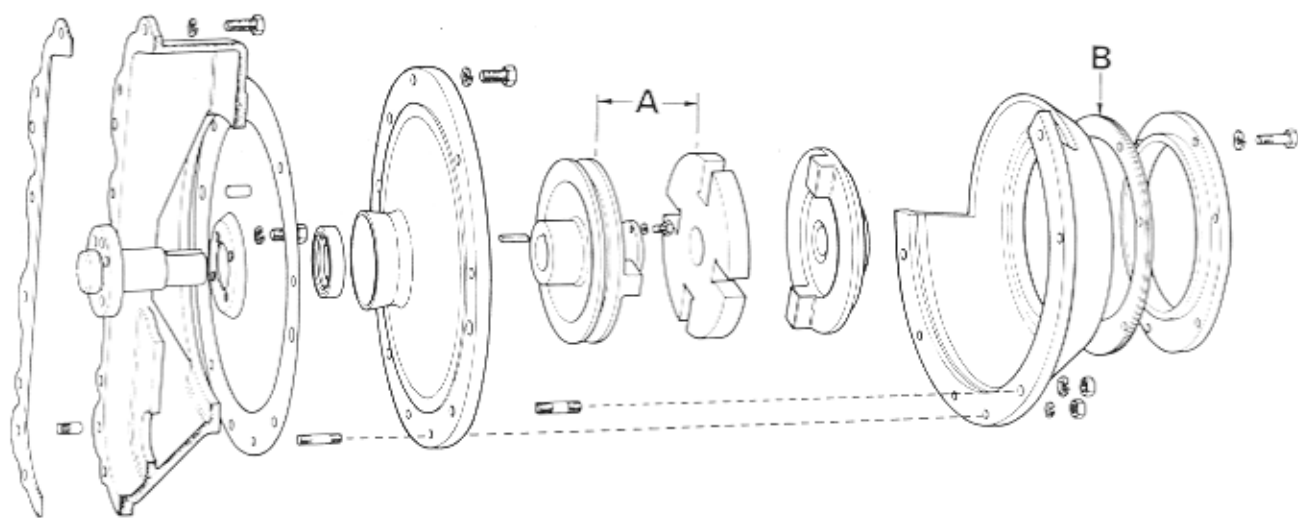


Fig. 115 Hydraulic Pump Mounting

HS512

GUARDS

A number of guards are available for these engines and their fitting and removal will depend on the installation and engine application.

Crankshaft Extension Guard (Fig. 116)

This is fitted over the crankshaft extension at the gear end and secured by three brackets to the end cover.

Radiator Cooled Engines (Fig. 117)

The guard arrangement on these engines will depend on the engine application and the operator's requirement. Fig. 117 shows two views of one such arrangement.

Belt Guard

An example of a belt guard on a tank cooled engine can be seen in Section 4, Part 2.

Fan Screen

This is a mesh screen bolted directly on to the flywheel to prevent hair, straw etc. from entering the cooling air intake. This guard requires a special flywheel.

Note.—This screen cannot be fitted on close coupled drives.

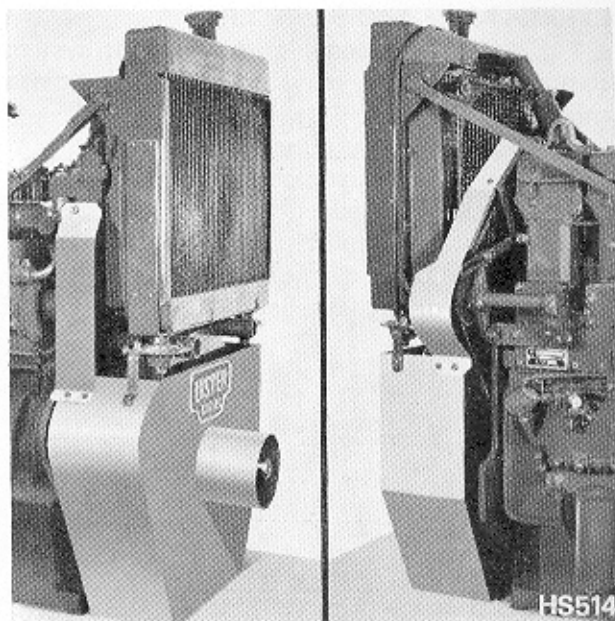


Fig. 117 Guard Arrangement on a Radiator Cooled Engine

Dynamo Guard (Fig. 118)

An example of a dynamo guard with a crankshaft extension guard is illustrated. This type of fitting will depend on the electric starting arrangement.

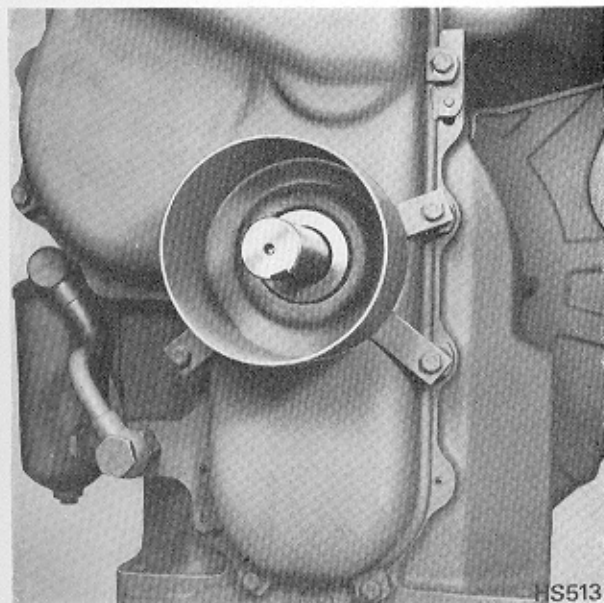


Fig. 116 Crankshaft Extension Guard

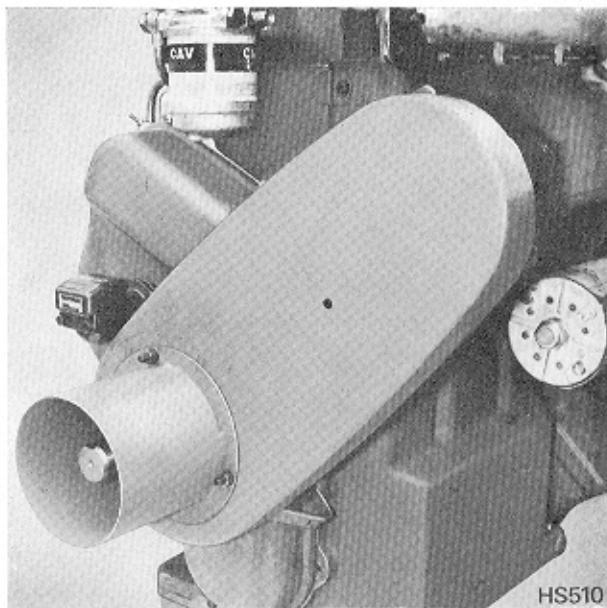


Fig. 118 Dynamo Guard with Crankshaft Extension Guard

DUPLEX FUEL FILTER (Fig. 128)

The filter body is divided into two separate compartments, each containing a wick filter element.

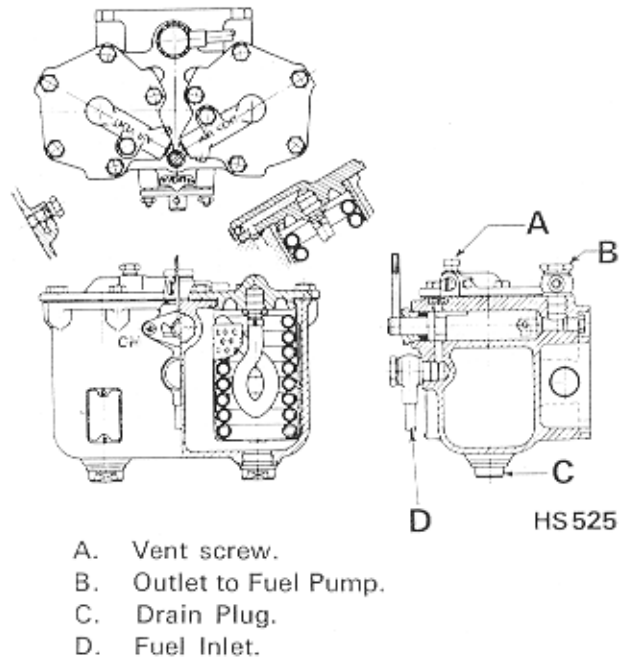
A change-over valve is provided between the compartments, so that either of the filters may be used while the other is being cleaned or replaced.

The wick has a screwed connection at one end, which is attached to the cover.

A jacket is provided on the back of the filter body so that hot water (or exhaust gases) may be used to warm the fuel oil under very cold climatic conditions.

Special vent screws are arranged in the covers so that all air may escape from the filter body and passages.

If both compartments of the filter have been properly vented, it is possible to change over from one filter to the other directly, while engine is running. Otherwise it will be necessary to move the change-over lever to the central position so that fuel may flow through both filters for venting purposes.



- A. Vent screw.
- B. Outlet to Fuel Pump.
- C. Drain Plug.
- D. Fuel Inlet.

Fig. 128 Duplex Fuel Filters

FUEL LIFT PUMP (Fig. 129)

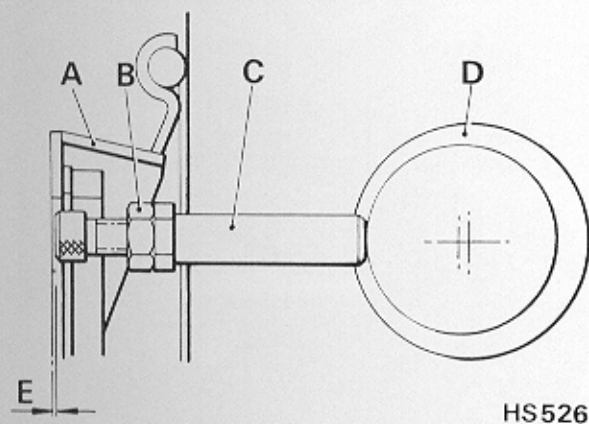
A fuel lift pump, when required, can be fitted to all engines on the crankcase door.* (See note below).

The pump is operated by a tappet from the camshaft. The inlet side of the pump is connected to the fuel supply and the outlet feeds fuel to the main engine fuel filter. All connections to the lift pump are made by solderless (nut and olive) fittings to suit $\frac{5}{16}$ " O.D. pipe.

*Note. A modified crankcase door must be fitted which has additional clamps securing the top of the door to the crankcase.



Fig. 129 Fuel Lift Pump



A—Crankcase door

B—Tappet locknut

C—Tappet

D—Camshaft

E—Measurement at this point should be 0.46-0.50 mm (0.018"-0.020")

Fig. 130 Adjusting Lift Pump

Resetting Fuel Pump Tappet

- (a) Remove fuel pipes at lift pump.
- (b) Remove fuel lift pump.
- (c) Clean up joint face on crankcase door.
- (d) Turn engine over with the tappet (C) in place and observe when the tappet reaches its maximum outward travel. At this point the tappet end should be 0.46-0.50 mm (0.018"-0.020") below the level of the face of the crankcase door. If adjustment is necessary pull out tappet and slacken locknut (B) and lengthen or shorten the tappet as required. When the clearance is correct retighten locknut.

TACHOMETER AND DRIVE (Fig. 131)

The tachometer is secured to the end cover and is operated from the end of the camshaft. It may be driven directly through an adaptor fitted to the end of the camshaft or from a gearwheel driven by a small gear fitted to the centre of the camshaft gearwheel. A drive from the tachometer is connected to a gauge, normally mounted on a panel at the gear end or fuel pump side of the engine.

Note: When refitting a gearcase end cover fitted with a tachometer driving gear, ensure drive gear is engaging before securing end cover.



Fig. 131 Tachometer Drive

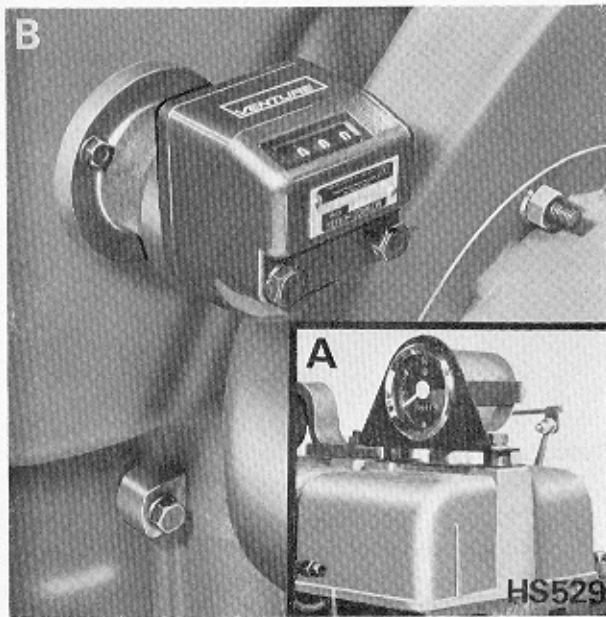


Fig. 132 Running Hour Recorders

RUNNING HOUR RECORDERS (Fig. 132)

Fig. 132A shows a vibration type running hour recorder which is bolted to one of the cylinder heads.

Fig. 132B illustrates a mechanical type recorder secured to the engine end cover through a mounting flange and operated from the camshaft. If it is necessary to change the component, remove the two screws securing the recorder to the flange. The end cover may be removed complete with the running hour recorder. Please note that this type of recorder cannot be used when a clutch and reduction gear is fitted.

JOCKEY PULLEY (Fig. 133)

A jockey pulley is fitted to maintain belt tension where an electric starting arrangement is not required. The illustration shows the pulley mounted on the fuel pump housing door on a tank cooled engine. Fan belt tension can be adjusted through an adjusting bracket connected to the top of the pulley. (See Section 4, Part 2).

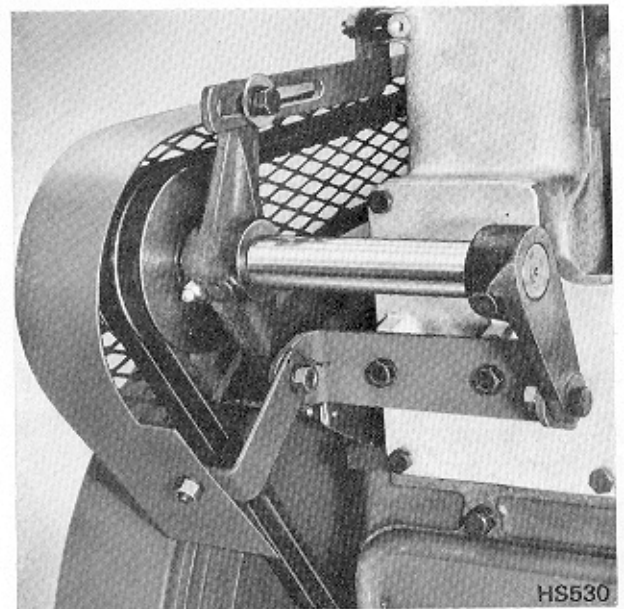


Fig. 133 Jockey Pulley

OIL COOLER—HR ENGINES (Fig. 134)

On air cooled engines, an oil cooler may be fitted in the fan shroud. Oil is supplied by an external pipe from the oil pump, to a finned oil cooler mounted in the top of the fan shroud (Fig. 134, inset). From the cooler, oil is returned through another external pipe to the lubricating oil filter and then to the engine. When the oil is cold, a by-pass valve allows oil to flow directly to the filter.

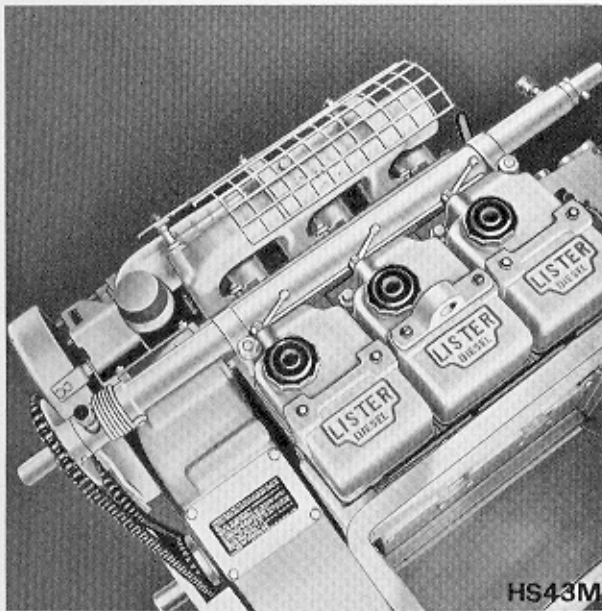


Fig. 135 Raised Hand Start

SUMP PUMP (Fig. 136)

The oil sump drain pump is secured to the gearbox on the manifold side of the engine with connections to the drain plugs on the engine sump and mechanical gearbox. The sump pump is not connected to an hydraulic gearbox—when fitted. A two way tap is fitted to enable either the engine or the gearbox to be drained independently.

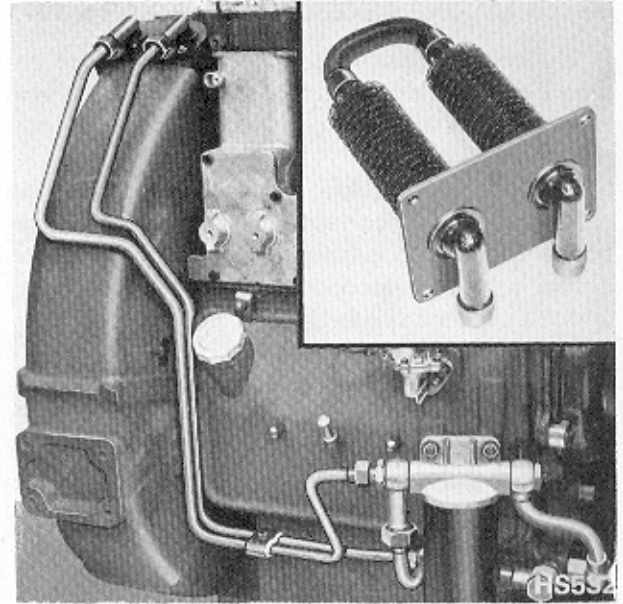


Fig. 134 Oil Cooler (HR)

RAISED HAND START (Fig. 135)

The raised hand start assembly is bolted to the top of the cylinder heads. A chain connects the chain wheel to the ratchet wheel on the crankshaft extension, one side of the chain being fitted with a chain tensioner.

Raised hand starting is a standard fitting on marine propulsion engines.

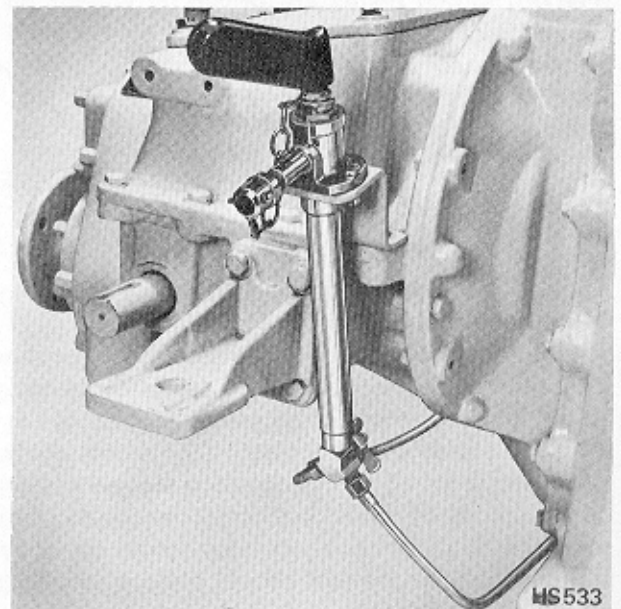


Fig. 136 Sump Pump

LISTER MARINE REVERSE GEAR 2G (Fig. 137)

The reverse gear is built integral with the engine incorporating a multi plate clutch for ahead drive and an epicyclic gear. Lubrication is from the engine system.

The clutch is of the metal to 'Ferodo' plate type and it is important that no "slip" should occur. Clutch slip causes excessive heat and the engine should be stopped at the first opportunity and the clutch adjusted at the first signs of overheating.

The thrust bearing is situated at the extreme after end of the reverse gearbox and is lubricated from the main oil circulating system. When a reduction gear is fitted, the thrust races are mounted in the reduction gearbox.

Operation—Ahead

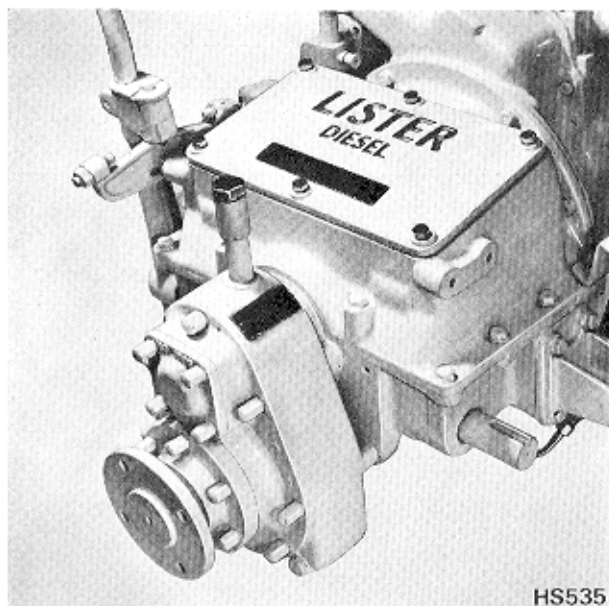
When the gear lever is engaged in the ahead position, the sliding sleeve moves along the clutch shaft forcing the toggle levers outwards and forwards until they lock slightly over centre.

Adjusting screws mounted in the toggle levers apply pressure upon the clutch gripping plate to lock the clutch plates together. The large (Ferodo) clutch plates are driven by splines on the inside of the clutch body. The drive from the Ferodo plates is transmitted by the gripping plate, small clutch plate and clutch spider key, to the output shaft.

Operation—Neutral

Drive from the engine is passed through the crankshaft spur gear to the two stepped pinions. These in turn drive the two spur pinions which drive the clutch shaft spur gear. The clutch shaft spur gear is keyed to the clutch shaft and to the clutch spider by individual keys. In the neutral selection the clutch shaft spur gear remains stationary whilst the two sets of pinions revolve.

The revolving pinions freely rotate the clutch body and large clutch plates.

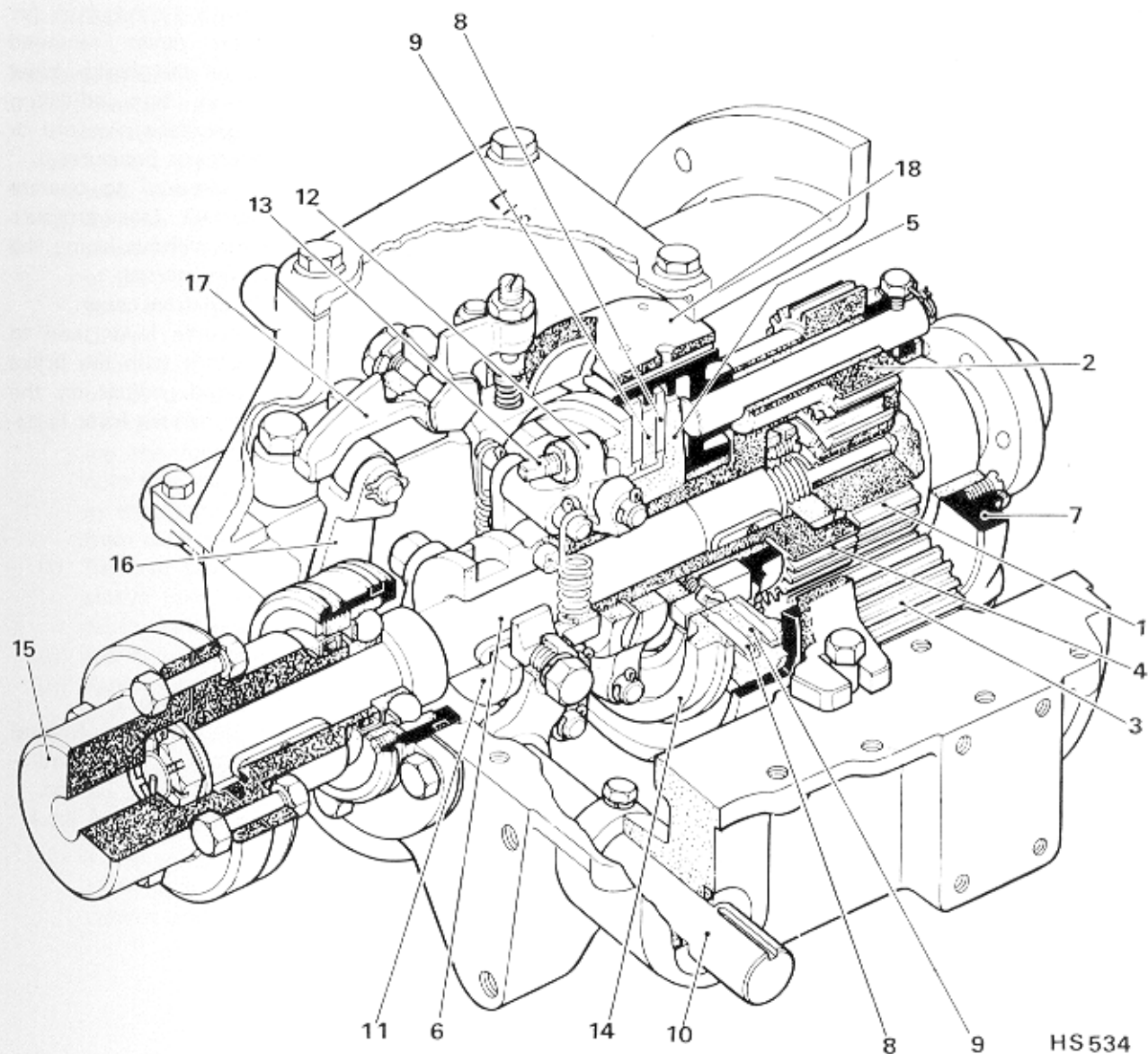


HS535

Fig. 137 Lister Marine Reverse Gear with Reduction Gear

Operation—Astern

When the control lever is moved aft, the brake band lever closes the brake band through the brake band lever roller. The brake band now holds the clutch body stationary. The drive from the engine passes through the stepped pinions and the spur pinions to drive the clutch shaft spur gear in the astern direction of rotation. There is no pressure applied to the clutch gripping plate and in consequence the small clutch plate and clutch rotate freely but transmit no drive.



HS 534

- | | |
|----------------------------|--|
| 1. Crankshaft spur gear. | 10. Fork lever cross shaft and roller lever cross shaft. |
| 2. Spur pinion (stepped). | 11. Sliding sleeve. |
| 3. Spur pinion. | 12. Toggle levers. |
| 4. Clutch shaft spur gear. | 13. Toggle lever adjusting screw. |
| 5. Clutch spider. | 14. Clutch gripping plate. |
| 6. Clutch shaft. | 15. Tail shaft half coupling. |
| 7. Clutch body. | 16. Brake band roller lever. |
| 8. Large clutch plates. | 17. Brake band lever. |
| 9. Small clutch plate. | 18. Brake band. |

Fig. 138. Components of 2G Reverse Gear

ADJUSTMENT**Ahead**

- (a) Place the reverse gear in neutral, remove the six set screws and lift off the inspection cover.
- (b) Rotate the sliding sleeve and as each toggle lever reaches the top, slacken the lock nut on the adjusting screw. Adjust toggle lever screws so that there is an equal clearance between the clutch gripping plate and the adjusting screw.
- (c) Adjust each toggle lever adjusting screw equally by fractions of a turn until the correct engaging pressure is obtained. An appreciable pressure will be required to move the reverse gear lever into the forward drive position.
N.B. Adjust screws clockwise to increase pressure, anti-clockwise to decrease pressure.
- (d) When adjustment is satisfactory tighten locknuts ensuring that the adjusting screws do not move.
- (e) Check that the sliding sleeve links are slightly over centre to ensure that the reverse gear lever does not tend to jump out of position.
- (f) With the forward gear fully engaged check that there is 0.25 mm to 0.38 mm (0.010" to 0.015") clearance between the toggle plate nut and the sliding sleeve. If this clearance is incorrect slacken locknut on the stop screw at the forward end of the reverse lever locating plate, turn the stop screw anti-clockwise to decrease or clockwise to increase clearance.
- (g) Retighten locknut when clearance is correct.
Note: It is important that "no drag" exists at the operating die due to the weight of the reverse gear lever, and a clearance of 0.002" is set during manufacture. This clearance between the sliding sleeve fork lever die and the inner face of the sliding sleeve should offer no problems during the life of the gearbox, but it is advisable to check a working clearance after assembly or adjustment operations.
- (h) Replace joint and inspection cover.

Astern

- (a) With the inspection cover removed slacken the locknut on the brake band lever adjusting screw, turn adjusting screw clockwise to increase pressure or anti-clockwise to decrease pressure.
- (b) When the pressure required to operate reverse lever is correct (see pressure chart) tighten locknut without losing the position of the adjusting screw.
- (c) Replace joint and inspection cover.
Note: Should the reverse lever tend to jump out of engagement with the brake band correctly adjusted, adjust on the rear stop screw of the reverse lever locating plate.

Operating pressures for 2G gearbox

	From Neutral to Astern	From Neutral to Ahead
2G with 655 mm Lever (25 $\frac{3}{4}$ ")	25 kgs. (55 lbs.)	20 kgs. (44 lbs.)

REMOVING REVERSE GEAR

The reverse gear case can be removed complete in one unit. To do this proceed as follows:—

- (a) Disconnect Propeller Shaft.
- (b) Disconnect sump pump pipes, and remove sump pump.
- (c) Disconnect oil filter pipes and remove filter.
- (d) Sling the gearbox.
- (e) Disconnect bearers.
- (f) Remove setscrews (ten) between reverse gear case and reverse gear adaptor.
- (g) Draw box back and lift out.

TO DISMANTLE REVERSE GEAR**Removal of Brake Band**

- (a) Remove inspection cover by removing the six set screws.
- (b) Loosen clamp bolt and remove reverse lever assembly.
- (c) Remove top half of gear case. Note: The setscrews holding top and bottom halves of the case are UNC, those holding gear-case to engine reverse gear adaptor are UNF.
- (d) Remove brake band lever bracket assembly by undoing the two securing nuts.
- (e) Remove fork lever cross shaft by removing the locating screw at either end—note that the cross shaft is manufactured in two parts and is therefore withdrawn from each end.
- (f) Remove brake band roller lever, sliding sleeve fork lever and die, and fork lever cross shaft collar from lower casing.
- (g) Remove reduction gear.
- (h) Remove brake band and brake band position screw.
- (i) Remove the reverse gear assembly from the lower casing being careful to retain the brake band position stud sleeve; note position of flange on sleeve.
- (k) If replacing brake band lining only proceed no further with the dismantling procedure and re-assemble in reverse order.

Removal of Ahead Clutch Plates

- (l) Remove toggle lever springs and dismantle toggle assembly.
- (m) Remove toggle levers.
- (n) Remove fulcrum pins through the machined recesses provided in gripping plate.
- (o) Loosen locking screw in the clutch shaft nut using special spanner; remove nut and knock out clutch shaft using a brass drift.
- (p) Bend the tag of the locking plate down and remove toggle lever plate nut, locking plate and toggle lever plate.
- (q) Remove clutch gripping plate, small clutch plate, Ferodo clutch plates and clutch spider being careful to retain the securing key.
- (r) Mark the gears to ensure correct re-assembly, then remove locking wire, shaft locating screws, pinion shafts, spur pinions and stepped pinions.
- (s) Remove the two locking screws and clutch body bush to enable the clutch shaft spur gear to be removed.
- (t) To remove ball bearing housing and register bracket the coupling and/or pinion retaining nut must be removed.
- (u) Assemble in reverse order. Note: It is recommended that all locking devices, gaskets, seals and joints are renewed on assembly.

Identification of all parts, part numbers and ordering instructions can be found in the relevant Parts List.

HRM Engines—Book 1444PL (HR)

HRWM Engines—Book 1444PL (HRW)

LISTER MARINE REDUCTION GEAR (Fig. 139)

It is important to see that the correct lubricating oil is used in the reduction gear box, i.e., S.A.E. 80 Oil when working in an air temperature below 5°C, and S.A.E. 90 above 5°C.

The level of oil in the casing should be examined daily at the same time as that in the lubricating oil tank, and the oil changed after every 500 hours running, the casing being thoroughly flushed out.

When the engine will not be required for some months and there is danger of frost the gearbox must be drained by removing the plugs.

On no account use grease as a lubricant in these boxes.



Fig. 139 Marine Reduction Gear

**BORG WARNER REVERSE GEAR (Fig. 140)
HYDRAULIC OPERATED**

Any servicing of this equipment should be in accordance with the instructions laid down by the manufacturers in the **Warner Gear Service Manual**—supplied with each engine fitted with this gearbox.

The gearbox is mounted on the gear end of the engine and is fitted as a direct drive or with a reduction gear. The lubricating oil is filled through a level plug on the fuel pump side.

On all units, an oil cooler is mounted above the gear box and is cooled by raw water supplied from the Jabsco pump.

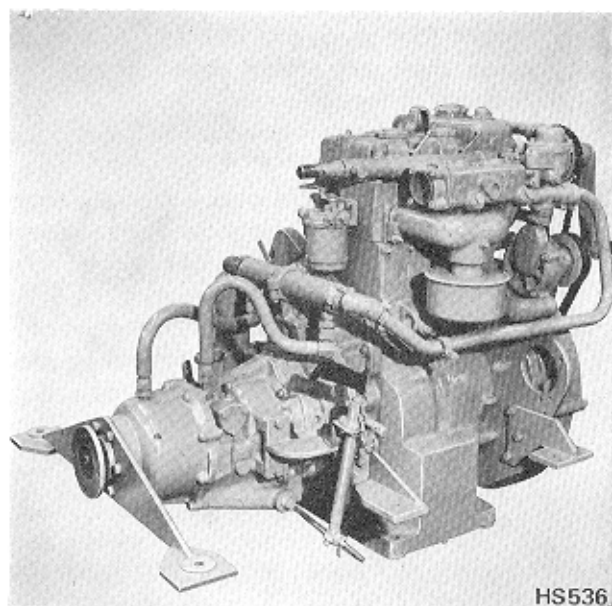


Fig. 140 Hydraulic Gearbox with Reduction Gear

MISCELLANEOUS ACCESSORIES—MARINE

For information on accessories not described in this section, e.g. Propellers, Bilge Pumps, etc., contact Lister Marine.

Notes on fitting and servicing sterngear can be found in the installation information on page 15.

Section Six

FAULT DIAGNOSIS

FAULT	PROBABLE CAUSE	RECTIFICATION	PAGE REFERENCE	
			HR	HRW
Difficult Starting	Overload trip not lifted.	Lift to give extra fuel for starting in cold weather.	17	17
	Unsuitable lubricating oil (too heavy).	Drain sump and refill with correct grade.	21	21
	Incorrect grade of fuel.	Drain system, refill with correct fuel and bleed.	30	30
	No fuel in tank.	Fill tank and bleed system.	30	30
	Choked fuel filter.	Clean and bleed system.	30	30
	Air lock in fuel system.	Bleed system.	30	30
	Injector nozzle valve stuck open.	Clean or replace nozzle or injector complete.	35	35
	Fuel pump delivery valve scored.	Replace valve and seat.	31	31
	Injector loose on seat.	Tighten evenly to 2.1 kgf.m. (15 lbf.ft.) torque	35	35
	Leaking valves.	Regrind.	47	72
	Sticking rings.	Decarbonise and check oil.	59	59
	Exhaust valve sticking.	Clean stem and guide.	46	72
		Check oil and lubrication of valve gear.	25	25
	Worn cylinder.	Renew.	49	74
Sticking fuel pump rack.	Inspect and rectify.	31	31	

FAULT	PROBABLE CAUSE	RECTIFICATION	PAGE REFERENCE	
			HR	HRW
Knocking.	Valve, probably exhaust, sticking in guide and touching piston. Slack bearing.	Clean stems and guides.	46	72
		Fit new shells if crankshaft is not worn.	49	74
	Worn gudgeon pin or small end bearing.	Renew.	49	74
		Check and adjust shims.	47	73
	Insufficient clearance between piston and cylinder head.	Check timing.	34	34
		Inspect and rectify.	54	78
	Injection too early. Flywheel coupling or pulley loose.	Renew thrust washers and re-shim as necessary.	56	56
		Decarbonise.	59	59
	Too much crankshaft end float.	Fit new pistons and cylinders.	49	74
Excessive carbon deposit on piston.				
Excessive Carbon Deposits	Choked air filter. Choked exhaust system.	Clean.	42	62
		Dismantle and clean.	43	63
	Unsuitable fuel oil.	Drain system, fill with correct fuel and bleed.	30	30
		Unsuitable lubricating oil.	Drain sump and refill with correct grade of oil.	21
	Continuous idling.	Increase engine load or stop engine.	—	—
	Defective injector spraying.	Check nozzle. Clean or replace.	35	35
	Late injection of fuel.	Check timing.	34	34

FAULT	PROBABLE CAUSE	RECTIFICATION	PAGE REFERENCE	
			HR	HRW
Smoky Exhaust (BLACK)	Overload.	Check setting of over-load stop.	17	17
	Choked air filter. inlet air temperature too high.	Clean. Reduce load or provide ducting to draw air from cooler source (outside engine room).	42 6/16	62 6/13
	Defective injector spraying.	Check nozzles. Clean or replace.	35	35
	Unsuitable fuel oil or water in fuel.	Drain system, fill with correct fuel and bleed.	30	30
Smoky Exhaust (BLUE)	Piston rings worn.	Renew.	49	74
	Cylinder bore worn.	Rebore and fit oversize rings.	49	74
Engine Stops	Lack of fuel.	Fill tank and bleed system.	30	30
	Air or water in fuel system.	Drain off water and bleed system.	30	30
	Choked fuel filter or blocked nozzle.	Inspect and rectify.	30	30
	Overload.	Allow engine to cool slowly. Turn by hand to ensure freedom of moving parts. Start, and check load.	17	17
	Overheating.	Ambient air temperature too high, probably caused by recirculation of hot air.	6/16	6/13
	Loss of compression.	Check valves, rings and cylinder wear.	49	74

FAULT	PROBABLE CAUSE	RECTIFICATION	PAGE REFERENCE	
			HR	HRW
Loss of Power	Loss of compression.	Check valves, rings and cylinder wear. Check cylinder head gasket. Adjust.	49	74
	Incorrect tappet clearance.		44	65
	Choked air filter.	Clean.	42	62
	Choked exhaust system.	Dismantle and clean.	43	63
	Fuel injector or pump out of order.	Inspect and renew defective components.	31	31
	Choked fuel filter.	Clean and vent fuel system.	30	30
Failure to obtain Normal Speed	Engine started on overload.	Modify load.	17	17
	Fuel system not properly primed.	Check and rectify.	30	30
	Insufficient fuel supply.	Check fuel pump/governor linkage for sticking and correct adjustment.	31	31
		Clean fuel filter.	30	30
	Injection retarded.	Check and rectify.	34	34
Low Oil Pressure	Low oil level.	Check on dipstick and rectify.	27	27
	Strainer choked.	Clean.	22	22
	Fractured pipe or leaking joint.	Inspect and rectify.	25	25
	Badly worn bearings.	Renew shells if crankshaft not worn.	49	74
	Relief valve not seating.	Inspect and clean.	26	26
	Oil pump worn or drive failed.	Inspect and rectify.	22	22
	Oil cooler choked.	Clean.	95	—

FAULT	PROBABLE CAUSE	RECTIFICATION	PAGE REFERENCE	
			HR	HRW
Overheating HR ENGINES	Cooling air being re-circulated. Fins of cylinder head or cylinder blocked with dirt. Cooling air inlet obstructed.	Deflect or duct outlet air away from inlet. Clean.	6/16	
		Check that inlet arrangement is in accordance with makers recommendations.	59	
	Cooling air outlet obstructed.	Check that outlet arrangement is in accordance with makers recommendations.	6/16	
		This practice is not approved. Independent cooling for driven unit must be provided.	6/16	
Engine cooling air used also to cool driven unit.			—	
Overheating HRW ENGINES	Thermostat faulty. Injection timing faulty. Overload.	Replace.		64
		Check and adjust.		34
		Reduce load — check setting of overload stop.		17
	Lubricating oil or water low.	Check level and replenish.		27
Water pump belt slipping.	Adjust.		66	
Blockage in water cooling system.	Check and renew all hoses and remove cylinder block inspection doors. Clean out water channels in block and cylinder head.		72	

Section Seven

SERVICE TOOLS

INTRODUCTION

Seven spanners are supplied with each engine. This section describes the special service tools that are available for particular servicing operations on HR and HRW engines.

Replacement spanners and the tools described in this section can be purchased from R. A. Lister or their Distributors. Part numbers for all the tools available for these engines can be found in the HR/HRW2 & 3 Engine Parts Lists, Book 1443PL or Book 1444PL.

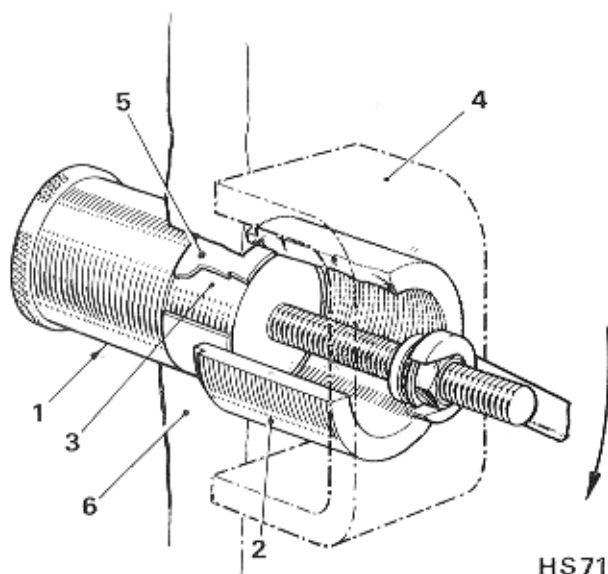


Fig. 141 Removing Main Bearing

1. Guide Block.
2. Sleeve.
3. Bearing Locating Ring.
(4 available for standard and undersize bearings).
4. Bridge Piece.
5. Main Bearing.
6. Crankcase.

Main Bearing Housing

The removal and fitting of bearing shells in the main bearing housing is carried out by the same method. The bearing housing should be held securely in a vice or refitted to the engine.

The oil seal assembly should first be pushed out from the centre of the housing; new oil seal refitting instructions can be found on page 24.

MAIN BEARING WITHDRAWAL AND ASSEMBLY TOOL

Removing Main Bearing (Fig. 141)

- (a) Fit guide block into main bearing from the outside of crankcase.
- (b) Fit sleeve with correct bearing locating ring inside crankcase and locate lug on sleeve into recess in crankcase.
- (c) Place the bridge piece over the threaded part of guide block and secure squarely against sleeve.
- (d) Tighten on nut until bearing is withdrawn.

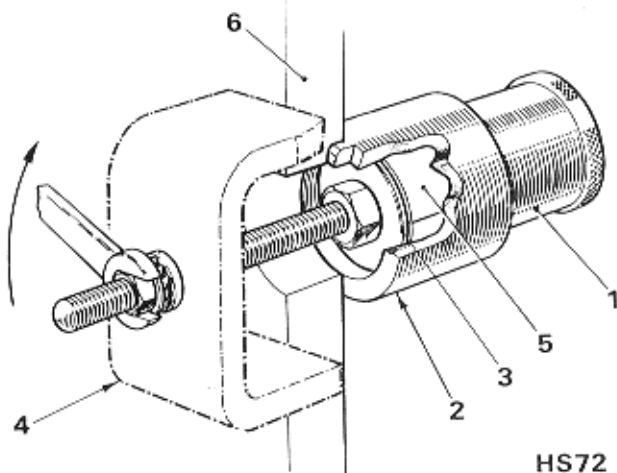


Fig. 142 Fitting Main Bearing

Fitting Main Bearing (Fig. 142)

- (a) Place the sleeve from the tool on a bench with the locating lug downwards.
- (b) Slide the two halves of the bearing into the sleeve ensuring that the locating tag on the bearing faces upwards in the guide groove.
- (c) Reverse the sleeve—so that its locating lug is upwards—and slide the sleeve, complete with bearing, over the guide block and bearing locating ring. Press down as firmly as possible.
- (d) Fit the complete tool from inside the crankcase and locate lug of sleeve into recess in crankcase.
- (e) Fit the bridge piece on to the screw projection outside crankcase. Tighten nut until bearing is pulled into position.

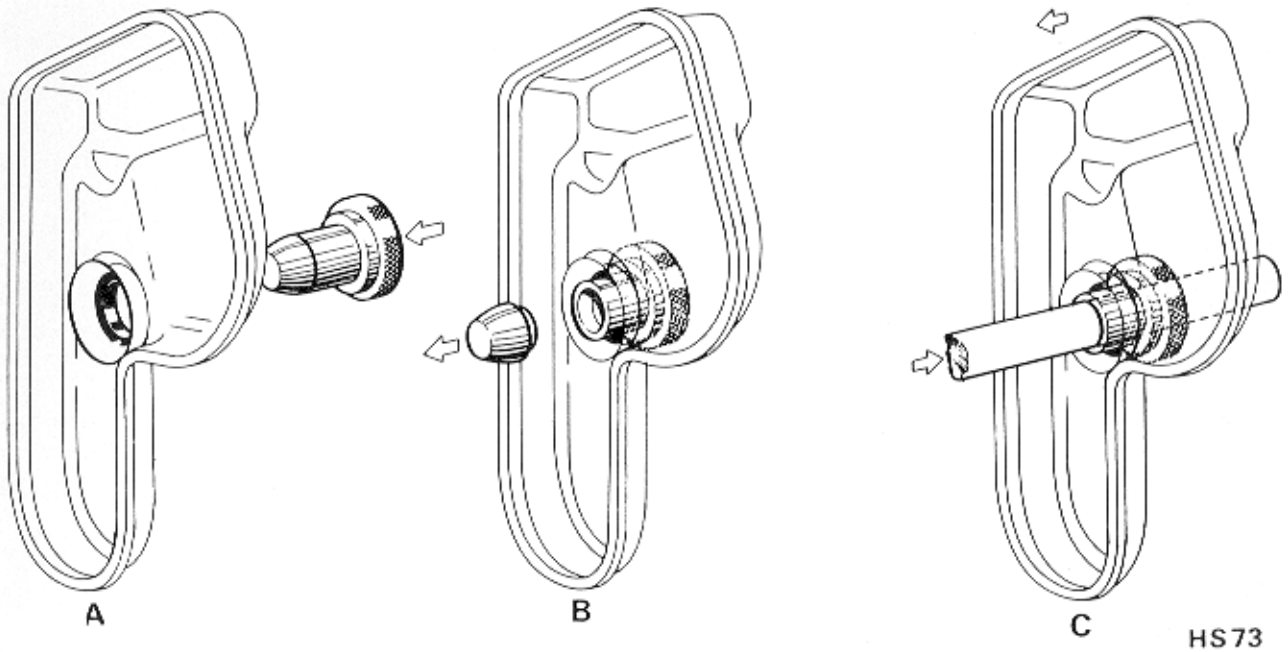


Fig. 143 Oil Seal Assembly Tool

END COVER OIL SEAL ASSEMBLY TOOL (Fig. 143)

When refitting the end cover to the engine, a special tool as illustrated should be used to prevent damage to the oil seal.

The tool is made in two parts, a sleeve and a plug.

- A. Fit the complete tool—sleeve and plug—through the oil seal from the outside of end cover.
- B. When it is firmly in position, remove plug.
- C. Fit end cover to engine allowing sleeve to slide over crankshaft. When end cover is in position, remove sleeve and retain with plug.

FLYWHEEL WITHDRAWAL TOOL (Fig. 144)

- (a) Slacken flywheel retaining screw two turns.
- (b) Bolt withdrawal tool to face of flywheel.
- (c) Tighten nuts equally until flywheel is loosened on tapered shaft.
- (d) Remove tool and support flywheel whilst removing retaining screw.

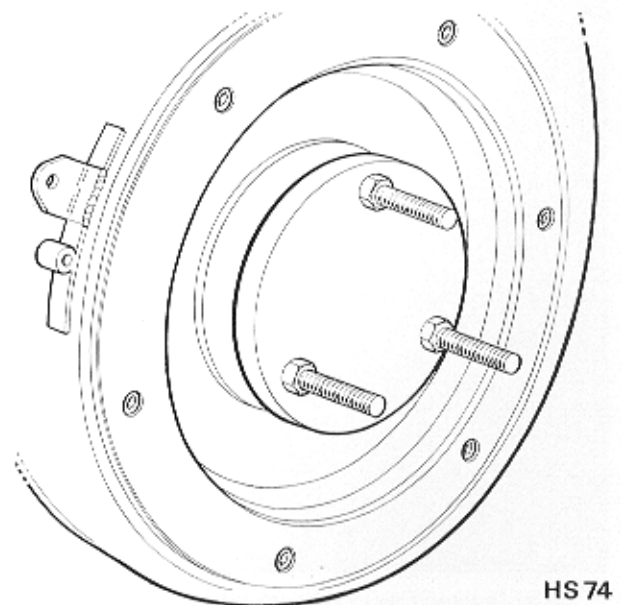


Fig. 144 Flywheel Withdrawal Tool

Section Eight

ELECTRICAL EQUIPMENT

INTRODUCTION

This section gives servicing information and wiring diagrams for electric starting systems that can be used on HR and HRW2 and 3 cylinder engines.

Parts for this equipment are listed in the engine parts lists. Book 1443PL or 1444PL. A glossary of books containing information on generating sets used with these engines is given at the end of the section.

Further information on electric starting can be obtained from R. A. Lister, Dursley; information on generating sets fitted by Lister from Lister Power Plant, Thrupp; or your nearest Lister Distributor.

STARTING PROCEDURE—ELECTRIC

- (a) Check the engine is free to turn without obstruction.
- (b) Ensure batteries are filled, charged and connected.
- (c) Ensure fuel and oil systems are filled and primed.
- (d) In cold conditions lift overload stop to allow the pumps to deliver excess fuel. On engines fitted with speed control, set lever to FAST. (When engine has started, return lever to the position for speed required).
- (e) Press starter button and release immediately the engine fires. Do not motor the engine continuously for more than 10 seconds.

To Stop Engine

Move engine control lever towards the fly-wheel and hold in this position until engine stops. If remote control is fitted, move lever to STOP position.

On marine propulsion engines move control lever to STOP.



Fig. 145 Gauge Panel with Ammeter and Starter Button

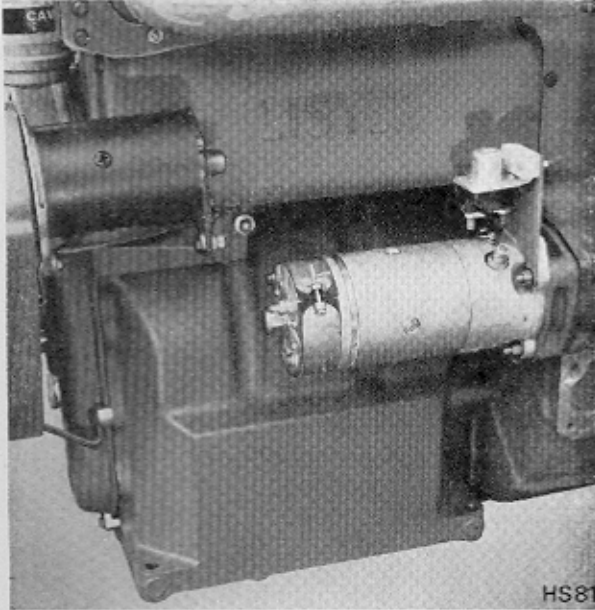


Fig. 146 Dynamo at Gear End

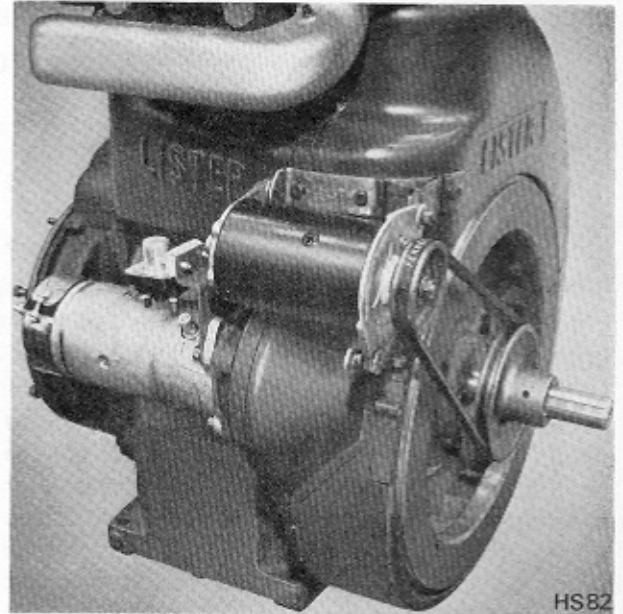


Fig. 147 Dynamo at Flywheel End

LOCATION OF COMPONENTS

Starter Motor

The starter motor is fitted on the manifold side of the engine and is secured to the rear of the fan shroud (HR), or to a plate attached to the end of the crankcase (HRW).

Dynamo or Alternator

The positioning of the dynamo, or alternator, is dependent on the application and installation of the engine. An adjusting link is always used to obtain the correct belt adjustment which should be set with sufficient tension only, to drive without slipping.

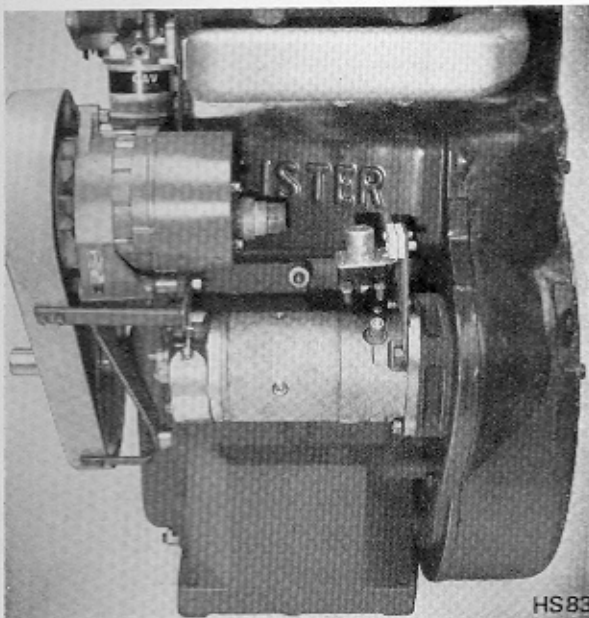


Fig. 148 Alternator at Gear End

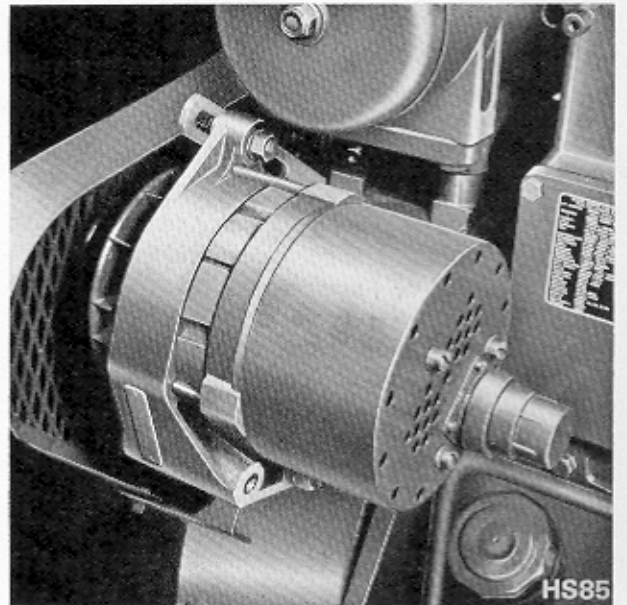


Fig. 149 Alternator on Fuel Pump side of Engine

INSTRUCTIONS FOR 'LUCAS' COMPENSATED VOLTAGE CONTROLLED DYNAMO

THE EQUIPMENT

The equipment consists of a specially designed dynamo and a separate regulator unit. The regulator unit also incorporates the automatic battery cut-out.

HOW IT WORKS—A COMPLETELY AUTOMATIC CONTROL

The regulator causes the dynamo to give an output which varies according to load on the battery and its state of charge. When the battery is discharged the dynamo gives high output, so that the battery receives a quick recharge which brings it back to its normal state in the minimum time. On the other hand, if the battery is fully charged, the dynamo is arranged to give only a trickle charge which is sufficient to keep it in good condition without any possibility of causing damage to the battery by overcharging.

MAINTENANCE IN SERVICE

The compensated voltage control equipment requires very little attention in service.

BATTERY

For details of how to prepare a battery with factory sealed charge for service see the instruction card supplied with the battery.

Care of the battery cannot be overstressed. Keep exterior clean and dry. Ensure filling plugs and connections are tight. Keep terminals and connections free from corrosion and coated with pure 'Vaseline' or Petroleum Jelly.

Regularly inspect level of acid in each cell and add distilled water (NOT ACID) so as to cover the plates by $\frac{1}{2}$ ". The specific gravity of the acid is the best indication of the state of charge or discharge in the cells.

DYNAMO

After every 2000 hours running, examine the brushgear and commutator to see that the brushes move freely and that the commutator is clean.

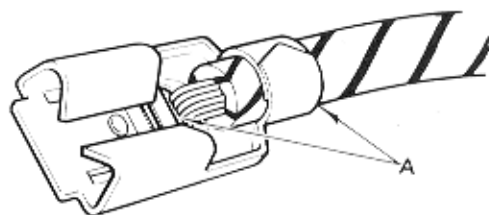
Occasionally inspect the dynamo driving belt taking up any undue slackness by turning the dynamo on its mounting. Do not over-tighten the belt which should have sufficient tension only to drive without slipping.

LUBRICATION

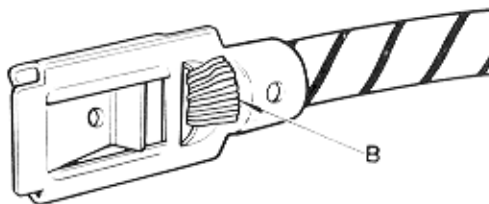
Every 400 hours inject a few drops of lubricating oil into the commutator end bearing of the charging dynamo. Use same lubricating oil SAE20 as engine and on no account over oil as this will lead to trouble with the brush gear.

REGULATOR UNITS

Cut-out and regulator units are accurately set during assembly and do not require any adjustment in service. The cover protecting these units is therefore sealed.



- A. Feed conductors through aperture and grip cable firmly in tags.



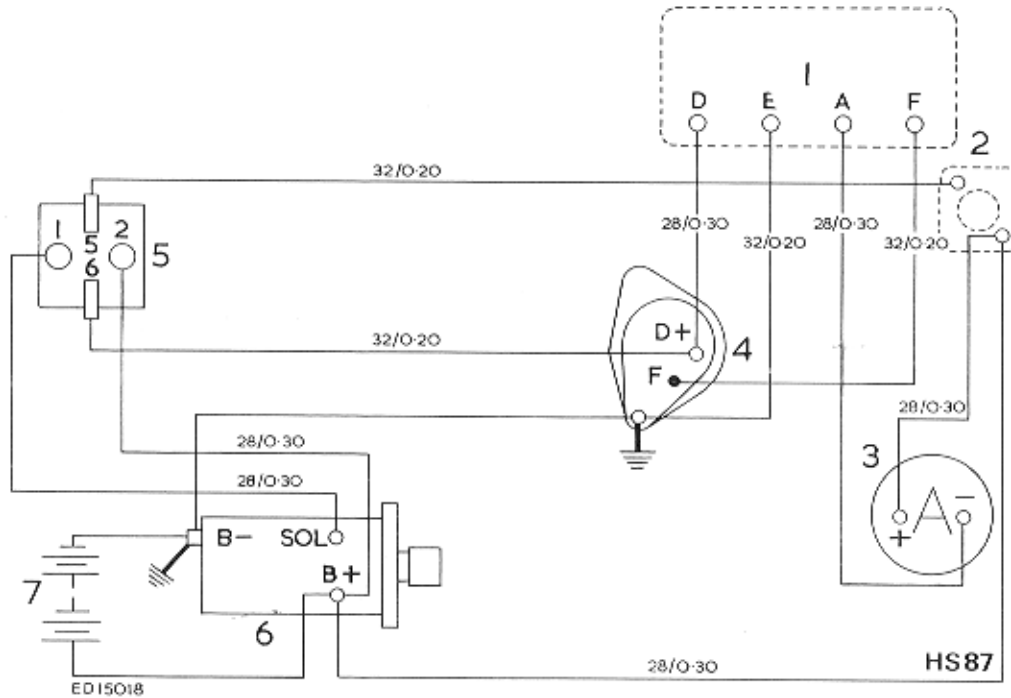
- B. Splay conductors back towards cable and solder securely. Do not allow solder to run through aperture.

Fig. 150 Instructions for Making Connections

FAULT DIAGNOSIS
VOLTAGE CONTROLLED DYNAMO EQUIPMENT

SYMPTOMS	PROBABLE FAULT	REMEDY
No dynamo output.	Dynamo not charging due to broken or loose connection in dynamo circuit, or control box not functioning correctly.	Examine charging and field circuit wiring. Tighten loose connection or replace broken cable. Particularly examine battery connections. If trouble persists, have equipment examined by a Lucas Service Depot, or Agent.
Battery in low state of charge. Shown by lack of power when starting and hydrometer reading below 1.200.	Dynamo giving low or intermittent output, due to:— (a) Loose or broken connection in dynamo circuit. (b) Dirty commutator or brushgear. (c) Worn brushes. (d) Slipping dynamo driving belt. (e) Control box not functioning.	Examine dynamo wiring. Tighten loose connections or replace broken cable. Particularly examine battery connections. Clean with petrol moistened cloth. Worn brushes must be replaced and properly bedded by a Lucas Service Depot or Agent. Adjust if necessary. Have equipment examined by Lucas Service Depot or Agent.
Battery overcharged, shown by frequent need for topping up.	Dynamo giving high output. Due to: Control box not functioning correctly.	Have equipment examined by Lucas Service Depot or Agent.

WIRING DIAGRAMS



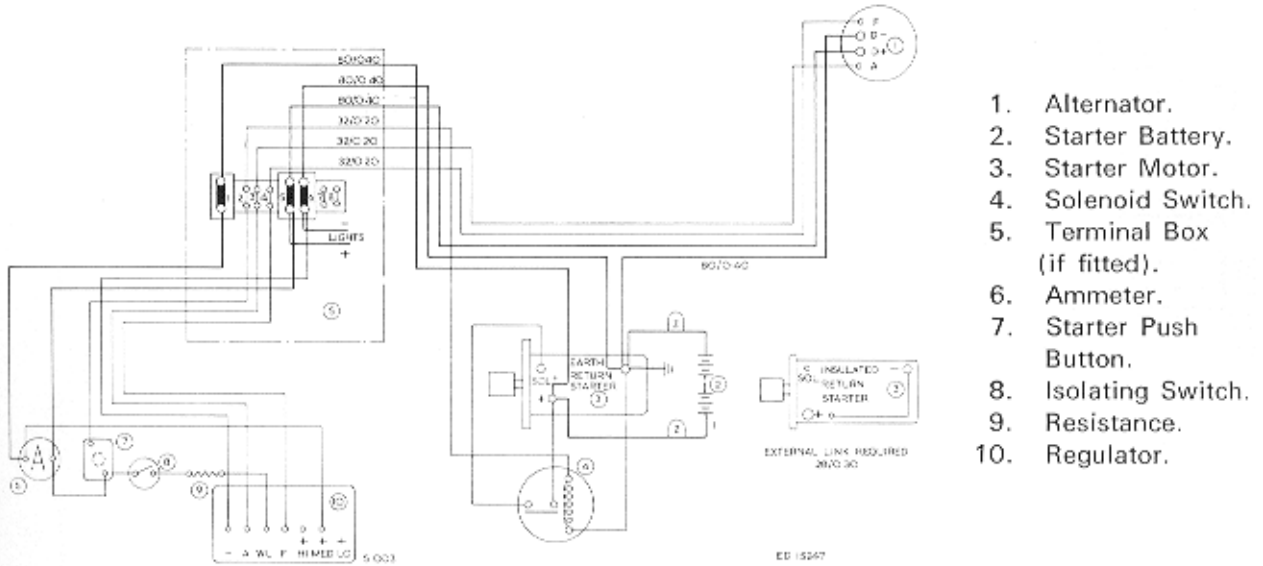
- | | |
|---------------------------|------------------|
| 1. Cut-out and Controller | 5. Solenoid |
| 2. Starter Push Button | 6. Starter Motor |
| 3. Ammeter | 7. Battery |
| 4. Dynamo | |

Fig. 151 Dynamo—Industrial. 12v (ED 15018)

ELECTRIC STARTING INCORPORATING LUCAS ALTERNATORS

The following points must be strictly observed when an alternator is fitted otherwise serious damage can be done.

- NEVER disconnect the battery whilst the alternator is running.
- NEVER disconnect a lead unless the alternator is stopped and all switches are in the 'OFF' position.
- ALWAYS ensure that leads are fitted to their correct terminals. A short circuit or reversal of polarity will ruin the diodes or transistors.
- NEVER connect a battery into the system without checking that voltage and polarity are correct.
- NEVER "flash" the connection to check the current flow.
- NEVER experiment with adjustments or repairs to the system.



1. Alternator.
2. Starter Battery.
3. Starter Motor.
4. Solenoid Switch.
5. Terminal Box (if fitted).
6. Ammeter.
7. Starter Push Button.
8. Isolating Switch.
9. Resistance.
10. Regulator.

Fig. 152—Alternator—Industrial or Marine Propulsion—non suppressed. 12/24v. (ED.15247)

1. Alternator.
2. Starter Battery.
3. Starter Motor.
4. Ammeter.
5. Starter Push Button.
6. Isolating Switch.
7. Resistance.
8. Screened Suppression Box.
9. Terminal Box (if fitted).
10. Solenoid Switch.
11. Warning Lamp.

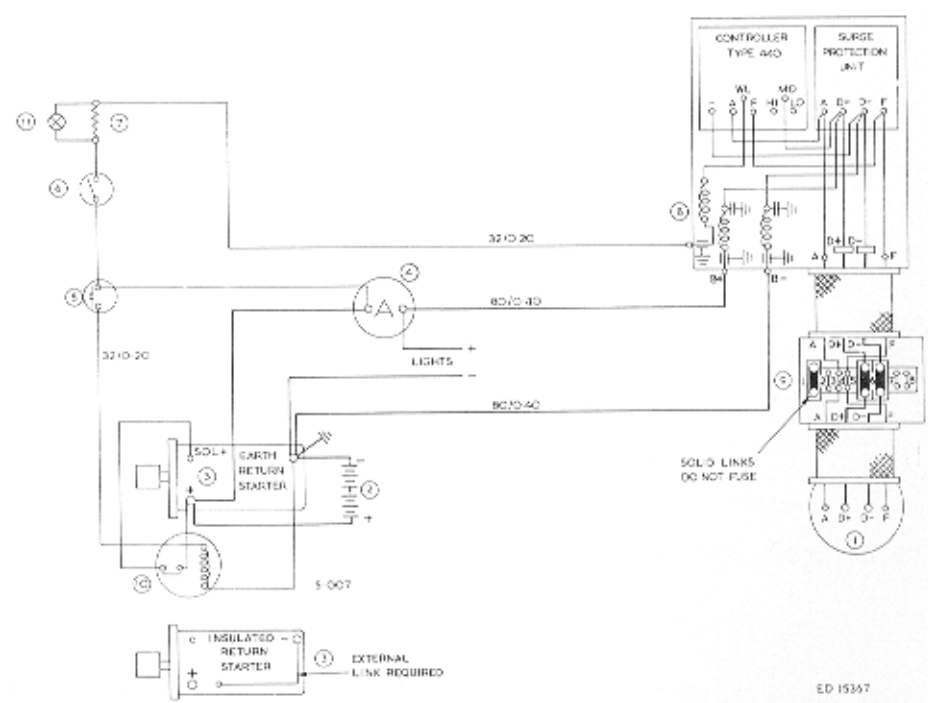
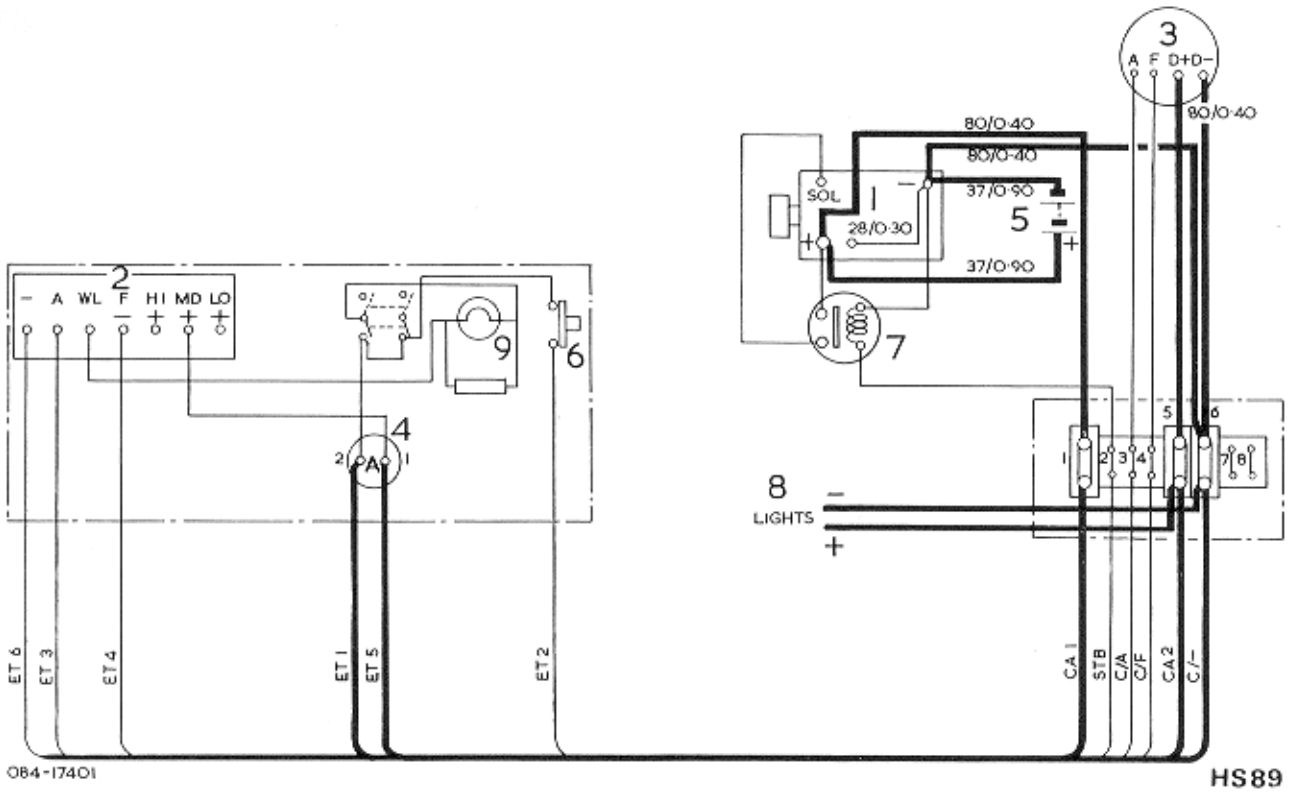
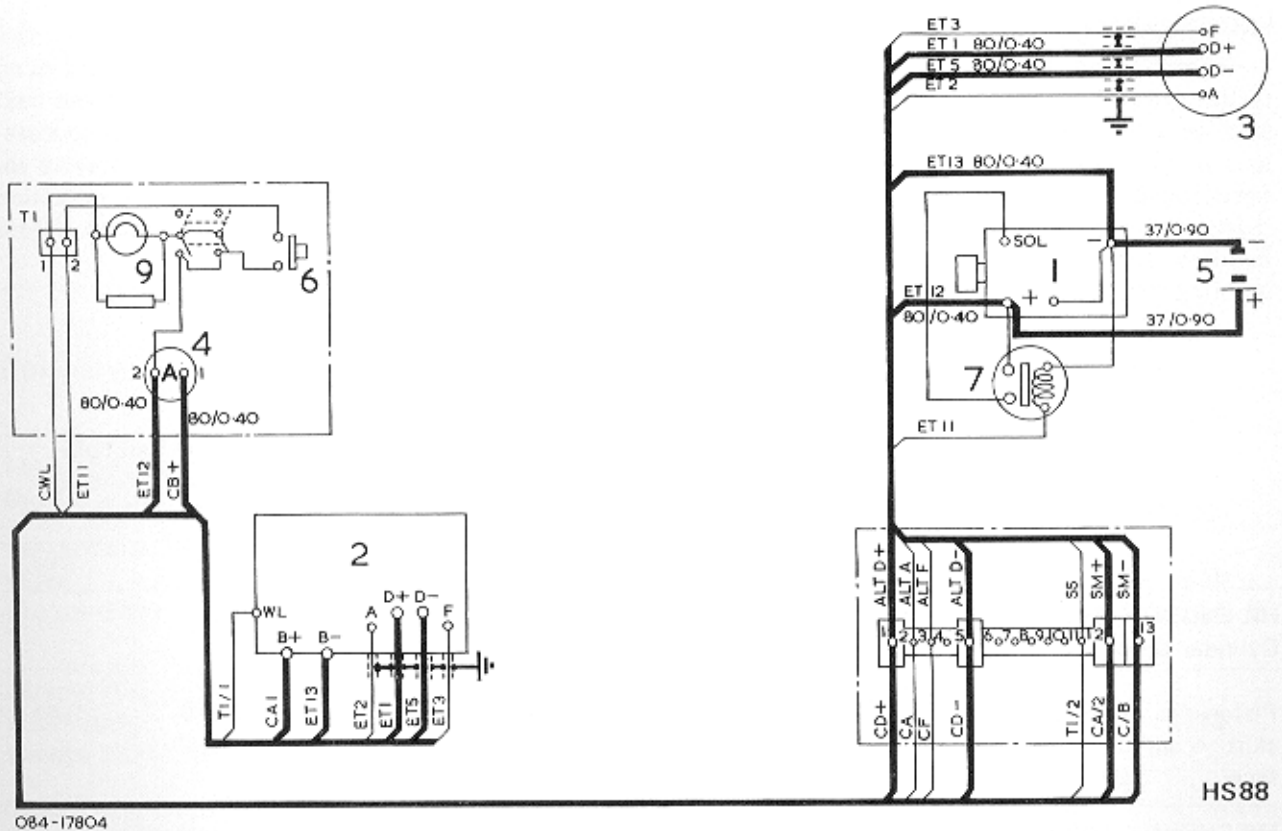


Fig. 153 Alternator—Marine Propulsion—suppressed. 12/24v. (ED.15367)



- | | |
|-------------------|------------------------|
| 1. Starter Motor | 6. Starter Push Button |
| 2. Regulator | 7. Solenoid |
| 3. AC5 Alternator | 8. Lighting Circuit |
| 4. Ammeter | 9. Warning Light |
| 5. Battery | |

Fig. 154 Alternator—Marine Auxiliary—non suppressed. 12/24v. (084-17401)



084-17804

HS88

- | | |
|-----------------------------|------------------------|
| 1. Starter Motor | 5. Battery |
| 2. Screened Suppression Box | 6. Starter Push Button |
| 3. AC5 Alternator | 7. Solenoid |
| 4. Ammeter | 9. Warning Light |

Fig. 155 Alternator—Marine Auxiliary—suppressed. 12/24v. (084-17804)

GENERATING SETS

General information and parts lists for generating sets which may be fitted to HR and HRW2 and 3 cylinder engines can be found in the following publications, available from R. A. Lister:—

- | | |
|---------------------|---|
| Book 930 | Electrical Accessories for Air Cooled Diesel Engines. |
| Book 1145 | Start-O-Matic Generating Sets—Air Cooled Engines. |
| Book 1750 | Automatic Stand By to Mains, Types HR and HRW Single Phase. |
| Book 1762 | Automatic Remote Controlled Diesel Engines and Generating Sets, HR and HRW. |
| Publication 15/3018 | RS Generators, 3-phase. |
| Publication 15/3019 | RS Generators, Single-phase. |
| Publication 15/3025 | SCA and SCT Generators. |

Table of Clearances and Dimensions of Wearing Parts

ENGINE WEAR

The following information is given as a guide to the extent by which components may reasonably be expected to wear, without appreciable loss of performance. To maintain the engine in good running order it is therefore recommended that when the "maximum advisable clearance" figure is reached, one or more components affecting the clearance be replaced.

The wear to be allowed in parts re-fitted to an engine depends on the life required to the next overhaul and the relative costs of labour to materials. If labour costs are high it may pay to replace parts before the maximum wear condition is reached, in order to avoid further work before the next scheduled overhaul.

COMPONENT	INITIAL DIMENSION		INITIAL CLEARANCE		MAXIMUM ADVISABLE CLEARANCE	
	in	mm	in	mm	in	mm
HR ENGINES ONLY						
Cylinder bore	4.254 4.253	108.05 108.03				
Piston dia. at bottom of skirt — across thrust face	4.2435 4.2425	170.78 107.76	0.0115 0.0095	0.29 0.24	0.016	0.41
HR ENGINES ONLY						
Fire ring gap	0.017 0.024	0.43 0.61	0.026 0.036	0.66 0.91	0.045	1.14
Compression ring gap	0.010 0.014	0.25 0.36	0.019 0.026	0.48 0.66	0.038	0.96
Top scraper ring gap	0.017 0.024	0.43 0.61	0.026 0.036	0.66 0.91	0.048	1.22
Bottom scraper ring gap	0.012 0.016	0.31 0.41	0.021 0.028	0.53 0.71	0.038	0.96
HRW ENGINES ONLY						
Cylinder bore	4.250 4.251	107.95 107.97				
Piston dia. at bottom of skirt — across thrust face	4.2435 4.2425	107.78 107.76	0.0065 0.0085	0.16 0.22	0.013	0.33
HRW ENGINES ONLY						
Fire ring gap	0.017 0.024	0.43 0.61	0.017 0.027	0.43 0.69	0.036	0.91
Compression ring gap	0.010 0.014	0.25 0.36	0.010 0.017	0.25 0.43	0.030	0.76
Top scraper ring gap	0.017 0.024	0.43 0.61	0.017 0.027	0.43 0.69	0.040	1.02
Bottom scraper ring gap	0.012 0.016	0.31 0.41	0.012 0.019	0.30 0.48	0.030	0.76

Note: Initial dimensions given for piston ring gaps assume the use of a gauge exactly equal to the nominal cylinder bore. The gaps given under "initial clearance" are those to be anticipated when checking rings in a new bore. For every 0.001" (0.02 mm.) by which the actual bore size exceeds the "as new" dimension, the ring gap will increase by approximately 0.003" (0.06 mm.).

COMPONENT	INITIAL DIMENSION		INITIAL CLEARANCE		MAXIMUM ADVISABLE CLEARANCE	
	in	mm	in	mm	in	mm
Fire ring width Groove width	SPECIAL GAUGE REQUIRED					
Compression ring width Groove width	0.125 0.124 0.130 0.129	3.17 3.15 3.30 3.28	0.004 0.006	0.10 0.15	0.008	0.20
Scraper ring width (both) Groove width (both)	0.1875 0.1865 0.1905 0.1895	4.76 4.74 4.84 4.81	0.002 0.004	0.05 0.10	0.006	0.15
Small End Bearing Dia. Gudgeon Pin Dia.	1.5642 1.5634 1.56255 1.56235	39.73 39.71 39.689 39.684	0.00085 0.00185	0.021 0.047	0.003	0.076
Big End Bore (In Rod) Bearing Shell Thickness Crankpin Dia.	2.916 2.9155 0.08225 0.0819 2.7492 2.7487	74.07 74.05 2.09 2.08 69.83 69.82	0.0035 0.0018	0.09 0.05	0.0055	0.14
Main Bearing Housing Bore Bearing Shell Thickness Crankshaft Journal Dia.	3.417 3.416 0.08225 0.0819 3.250 3.2495	86.79 86.77 2.09 2.08 82.55 82.54	0.0042 0.0015	0.11 0.04	0.006	0.15
Thrust Bearing Thickness	0.125 0.122	3.17 3.10	0.005 0.010	0.13 0.25	CRANKSHAFT END FLOAT 0.010 0.25 ADJUSTABLE	

CLEARANCES

COMPONENT	INITIAL DIMENSION		INITIAL CLEARANCE		MAXIMUM ADVISABLE CLEARANCE	
	in	mm	in	mm	in	mm
Camshaft Bush Bore (Gear End)	1.3762	34.95				
Camshaft Journal Dia.	1.3750	34.92	0.0037	0.09	0.005	0.13
	1.3730	34.87	0.002	0.05		
	1.3725	34.86				
Camshaft Journal Length (Gear End)	1.377	34.98				
Camshaft Bearing Length	1.375	34.92	0.010	0.25	0.015	0.38
	1.370	34.80	0.005	0.13	END FLOAT	
	1.367	34.72	END FLOAT			
Remaining Camshaft Bush Bores	1.7487*	44.42				
	FITTED					
	1.74825*	44.40	0.0032	0.08	0.005	0.13
Camshaft Journal Dia.	1.7460	44.35	0.00225	0.06		
	1.7455	44.34				
Valve Spring Free Length	2.328	59.13	—	—	3% SET	
	2.242	56.95	—	—		
Valve Guide Bore	0.3753	9.53				
Valve Stem Dia.	0.3745	9.51	0.0037	0.09	0.005	0.13
	0.3723	9.46	0.0022	0.05		
	0.3718	9.44				
Valve Rocker Bush Bore	1.0005	25.41				
Valve Rocker Shaft Dia.	1.0000	25.40	0.002	0.05	0.003	0.08
	0.9990	25.37	0.001	0.02		
	0.9985	25.36				
Backlash between Gears	—	—	0.009	0.23	0.012	0.30
	—	—	0.001	0.02		

*Note: A mandrel of 1.7487" dia. and the length of the crankcase must just pass through all camshaft bearings, but a mandrel of 1.74825" dia. must fall through freely when the crankcase is inclined at an angle of 45°.

Designed and Produced by the Technical Publications Department of R. A. Lister & Co. Ltd.

A HAWKER SIDDELEY COMPANY