BOOK 1420 PRICE 10/-

INSTRUCTION MANUAL

SW2M

PROPULSION & AUXILIARY

MARINE DIESEL ENGINES

LISTER BLACKSTONE
MIRRLEES MARINE
DURSLEY — GLOUCESTERSHIRE GL11 4HS — ENGLAND
Telegraphic and Cable Address: Power, Dursley.
Telephone: Dursley 2981 Telex: 43261
HAWKER SIDDELEY

You want the best out of this Engine, give this handbook to the man who has to look after it.

THE REGULAR USE OF A SPANNER ON LOOSE NUTS MAINTAINS A SOUND ENGINE

ENGINE	No.
GEAR BOX	No.
REDUCTION GEAR	No.
GENERATOR	No.
ALTERNATOR	No.
PUMP	No.
COMPRESSOR	No.

PLEASE NOTE THE ENGINE NUMBER AND ALWAYS QUOTE WHEN ORDERING SPARE PARTS

Correspondence and Spare Part Orders for Air Cooled Marine Diesel Engines should be addressed to:

LISTER BLACKSTONE MIRRLEES MARINE
DURSLEY,
GLOUCESTERSHIRE GL11 4HS

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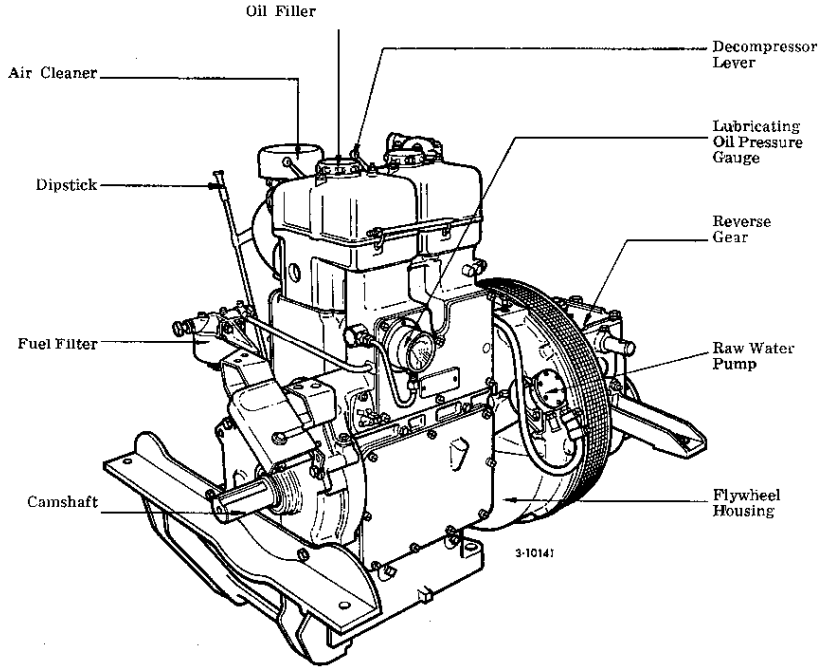


Fig. 1. SW2MGR—Port Side

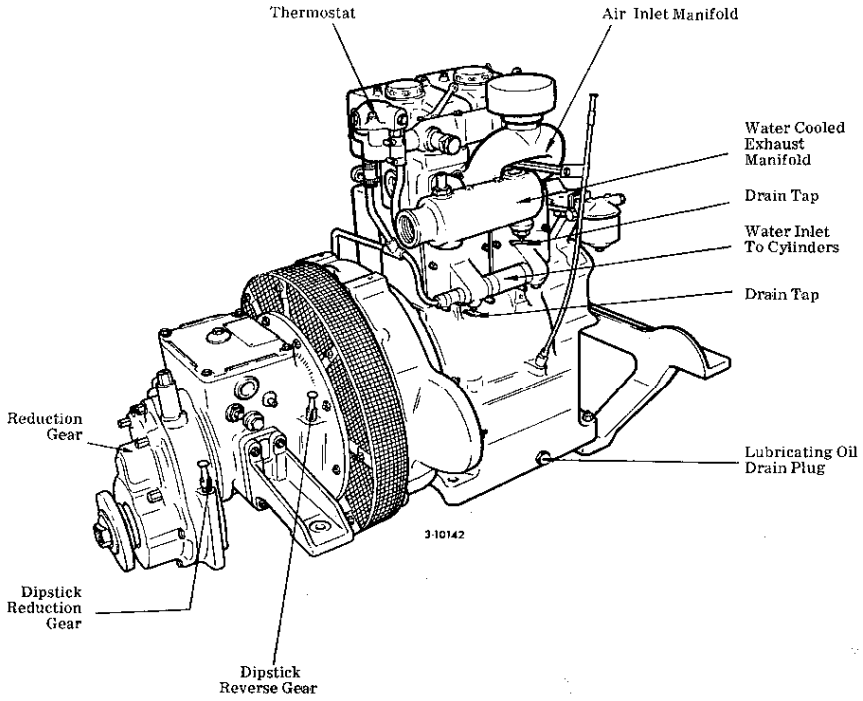


Fig. 2. SW2MGR—Starboard Side

TECHNICAL DATA

RATED BHP (BS 649:1958) continuous 2000 rpm	15
MAXIMUM GROSS BHP @ 2000 rpm	21
NUMBER OF CYLINDERS ...	2
B.M.E.P. (1800 rpm) lbs/sq.in. ...	90.5
kg/sq.cm. ...	6.3
BORE x STROKE ins.	$3\frac{1}{2}$ x $3\frac{1}{2}$
mm.	88.9 x 88.9
CYLINDER CAPACITY c.ins. ...	67.3
c.cm. ...	1103
FUEL CONSUMPTION at full load lbs/bhp/hr	0.44
gm/bhp/hr 2000 rpm subject to 5% BS tolerance	199
LUBRICATING OIL CONSUMPTION	Less than $\frac{3}{4}$% of full load fuel consumption
LUBRICATING OIL SUMP CAPACITY (engine level) Pt.	9.5
Litres	5.4
WEIGHT Approximate Nett. lbs.	630
with rev./red. gear kg.	283
STANDARD ROTATION IS ANTI-CLOCKWISE LOOKING AT FLYWHEEL END WITH DIRECT DRIVE CLOCKWISE WHEN REDUCTION GEAR IS FITTED No. 1 cylinder is at end opposite flywheel	

WHEN USING THIS INSTRUCTION MANUAL AND PARTS LIST PLEASE NOTE THE FOLLOWING:—

1. Instructions and statements contained in this book are given with our best intentions and are correct at the time of going to press. They are subject at any time to alteration.
2. The illustrations are subject to modification and must not be taken as representative of any individual specification.

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

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 page 23).
2. 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 lit.) of lubricating oil per cylinder over the valve gear.
3. 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. (See page 6).

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 page 17.

Lubricating Oil

Always use oils of the correct viscosity and type (Heavy Duty diesel engine detergent lubrication oil). (See "Lubrication" page 11).

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

Torque Spanner Settings

Note: Where torque spanners are available, the following tightening torques must be maintained:

Size	Torque lb.ft.	Torque kg.m.	Component
$\frac{1}{4}$" UNF	10	1.38	
$\frac{5}{16}$" UNF	15	2.07	Injector clamp nuts, big end nuts.
$\frac{3}{8}$" UNF	32	4.4	Balance weight setscrews.
$\frac{7}{16}$" UNF	50	6.9	Cylinder head nuts.
$\frac{1}{2}$" UNF	68	9.4	
$\frac{3}{4}$" UNF	200	27.6	Flywheel to crankshaft setscrew.
	65	9.0	Injector cap nut and locknut.

Note: The above torque settings must not be applied to unsupported components.

INSTALLATION

Before arranging an installation, it is imperative that careful consideration be given to the general layout of the machinery. The following details should be adhered to.

It must be appreciated that the smaller the rated power of the engine. the greater must be the care given to detail.

Cooling. The standard cooling system is of the raw water type. An impeller type pump is fitted and the cooling system is thermostatically controlled. When required a keel cooling system can be fitted in place of the standard system.

Ventilation. The efficient performance of any internal combustion engine depends on an adequate supply of cool fresh air. A rise of 10°F (5°C) in the air inlet temperature reduces the possible output of the engine by approximately 2%. It is therefore important that the engine room or case is well ventilated, admitting cool air below the engine and expelling hot air from above.

Exhaust. Pipes should slope gradually away from the engine down to outlet if this is taken to the ship's side or transom. Swan necks increase back pressure and make cleaning difficult. Wooden structure must be protected from exhaust heat by adequate clearance and lagging.

The standard arrangement allows for solid mounting but fittings can be supplied for flexibly mounting the engine.

Mounting and Alignment. Flexible couplings do not excuse bad alignment of engine to propeller shaft. A solid dummy bobbin should be used when aligning engine to shafting, and afterwards replaced by the flexible coupling. We will supply these solid bobbins on loan to the home market for a nominal charge. Misalignment stresses bearings and will lead to loss of engine power.

Sterngear. Packing glands should allow free rotation of the tailshaft. Stern tubes should be filled with grease before inserting shaft. Where a long length of propeller shafting is required it is essential to fit one or more plummer blocks of the self-aligning type in order to avoid whipping criticals of relatively small diameter shafts. Plummer blocks should be fitted when the unsupported shaft is about 36 times the shaft diameter.

Fuel. Clean fuel is essential for any diesel engine. Always fill tank through a clean tundish fitted with a fine gauze strainer.
Injectors should be examined and checked periodically. A faulty injector may considerably reduce engine output. The fuel tank must be checked or drained periodically to ensure that it does not contain water.

Propellers. Must be permitted to 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 half the diameter of the shaft.

Alignment

The engine may be lined up to the shaft temporarily while the boat is out of the water, but before launching the coupling bolts should be let go and the engine re-aligned when the vessel has taken up her normal shape in the water.

When lining up, steel chocks should be fitted in way of the holding down bolts, between the engine feet and the soleplate. Move the engine into position, with the chocks fitted, and draw the shaft half coupling up to the gearbox half coupling.

It is good practice to leave the engine uniformly high by 5-10 thousandths of an inch (0.127-0.254 mm.) as it will be pulled down about that much when the holding down bolts are pulled down hard, owing to the compression of the packing pieces and the bearers.

These sets can, on request, be supplied with flexible couplings, and flexible mountings. These, however, are not designed to take up bad alignment, and if the set is fitted in this way, great care must be taken to ensure that every component is accurately lined up to the next before running it initially.

Rotation

Standard rotation is **anti-clockwise** looking on the flywheel end of the engine.

Bearers

It is desirable that the engine bearers should extend a considerable length of the craft with a least a minimum length equal to twice the length of the engine. The bearers should be adequately braced athwartships by at least three deep floors adjacent to the engine.

Therefore it is imperative that all holding down bolts should be "fitted". In wooden vessels, long holding down bolts are required so that a larger bearing surface may be presented to resist the thrust of the propeller. These bolts should be fitted at their lower ends with steel plates, 2in. x 3in. (5 x 8cms.), to which their nuts have been welded, further to spread the load over the bearers.

In all vessels the engine and reverse gear should be seated on a steel strip, or soleplate.

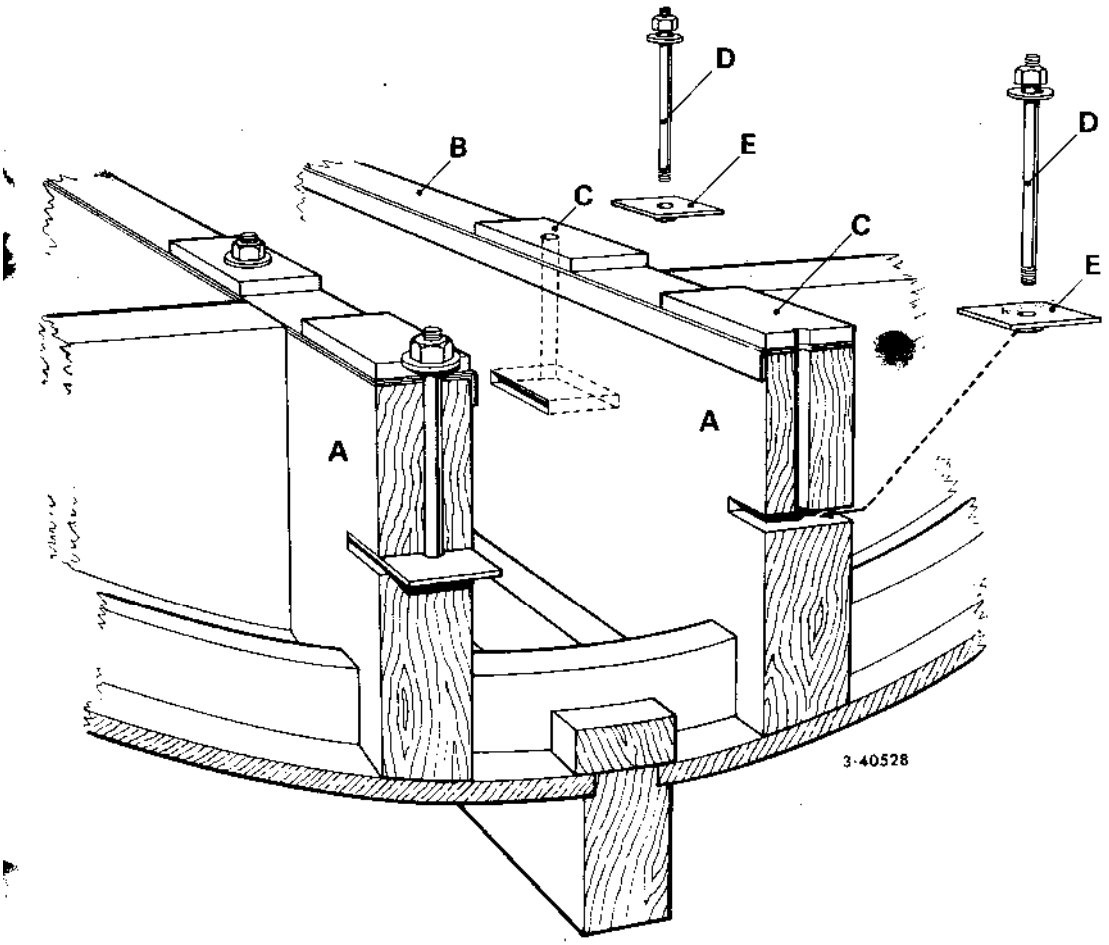
Rake

These engines should not be installed at a greater angle than 10° (standard).

The foregoing limits should be strictly observed during installation.

Fuel Tank — Auxiliary Engine

The bottom of the fuel tank should be not less than 30ins. (760mm.) and not more than 72 ins. (1875mm.) above the crankshaft when gravity feed to the filter is used.



A—Engine Bearers.

B—Soleplate.

C—Chocks.

D—Holding Down Bolt.

E—Nut welded to steel plate.

Fig. 3

INSTALLATION IN A WOODEN VESSEL

A—Packing Glands
B—Packing
C—Forward Bracket
D—After Bracket
E—After Bearing
F—Forward Bearing
G—Stern Tube
H—Tail Shaft
J —Greaser Union
K—Greaser Pipe
L—Greaser
M—Greaser Block
N—Gland Stud
O—Gland Nut

Grease Gun Height: Empty 12". Full 19½".
Grease Gun—¾ pt. cap.—optional.
(Part No. 501-723).

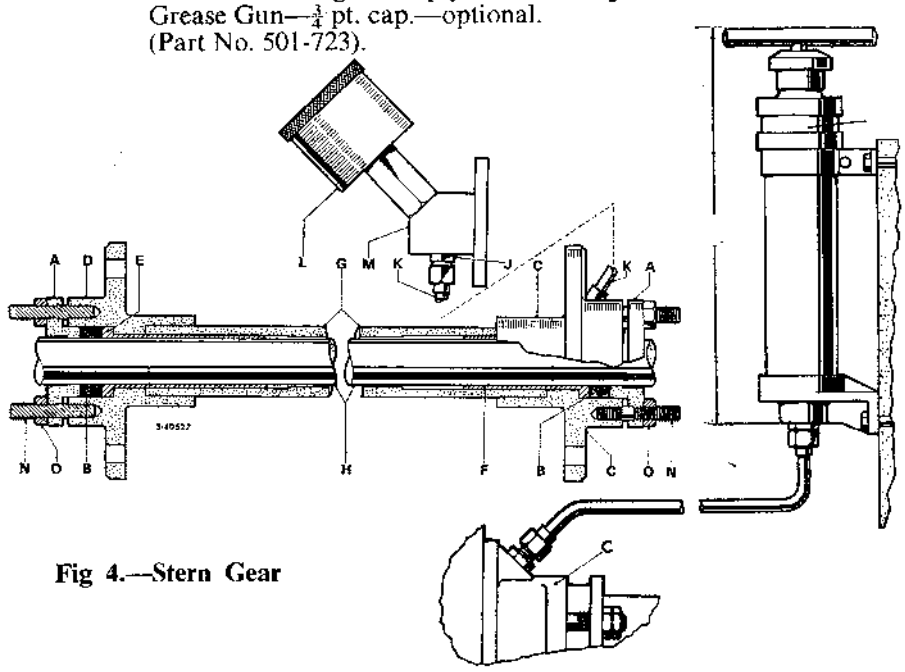


Fig 4.—Stern Gear

IMPORTANT—PROPULSION ENGINES

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 use regular attention to the grease cup provided should be sufficient to make up any loss incurred.

Tailshaft Size	1½—38 mm.
Engine	SW2MG/R3 SW3MG/R2
Grease Capacity approx. Pints Litres	 .49 .28

ENG — SHELL ROTELLA 20-20
G/BOX RED SAE 80 GEAR OIL
REDUCER YELLOW " " "

LUBRICATION

Specification SW

The engine must be run on good quality diesel engine heavy duty detergent lubricating oil.

The lubricating oils must meet specifications DEF2101C or BS1905 or MIL-L-2104A. Straight mineral oils are not suitable, neither are oils of less detergency than specified.

Supplement 1 or MIL-L-2104B 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 0.5%.

Series 3 oils must be used when oil changes are made at periods longer than 250 hours.

Multigrade oils—SAE 10W/30—must have a degree of detergency equivalent to MIL-L-2104B or Supplement 1, and must not be used in heavy duty applications.

Viscosity

Starting temperatures	Viscosity
Up to 32°F (0°C)	S.A.E. 10W
Between 32°F and 85°F (0°C and 30°C) ...	S.A.E. 20/20W
Above 85°F (30°C)	S.A.E. 30

Branded Oils

Your local Lister Distributor, or Agent, will be able to recommend the locally available brands of lubricating oil for your Lister engine; alternatively you may contact Listers direct at Dursley mentioning the Oil Company you prefer to deal with.

In cases where it is difficult to quickly ascertain which proprietary brands of lubricating oil meet the recommended specifications, it is permitted to temporarily employ the same lubricating oils which are used for the engines of diesel lorries and diesel tractors.

The use of good quality lubricants will give longer periods between overhauls and extend engine life.

Do not mix two different brands of oil. Thoroughly drain off the oil of one brand before changing to another. Lubricating oil additives are not considered necessary and some can harm the engine.

Lubricating Oil System

Oil is supplied under pressure from a plunger pump to all crankshaft bearings and to the valve rockers.

The oil is drawn through a wire gauze strainer and ball suction valve. The suction valve assembly is screwed into the base of the crankcase. The delivery valve is carried in the bottom of a hollow plunger, the oil passing into the hollow tappet and out into the delivery manifold. From the manifold the oil is distributed through a passage in the crankcase to the bearing in the crankcase, and by a pipe pressed into the bearing housing at the flywheel end and a single pipe which lubricates the valve rocker gear.

The relief valve is carried in the plug securing the oil pipes for the main bearings, and incorporates a reservoir which maintains oil pressure on the bearings during the suction stroke of the pump. The relief valve is set to open at 50 lbs./sq.in (3.5 kg/sq.cm.) and is not adjustable.

On engines fitted with a lubricating oil pressure gauge a recorded pressure of 15/20 lb./sq.in (1.05/1.4 kg/sq.cm.) is adequate.

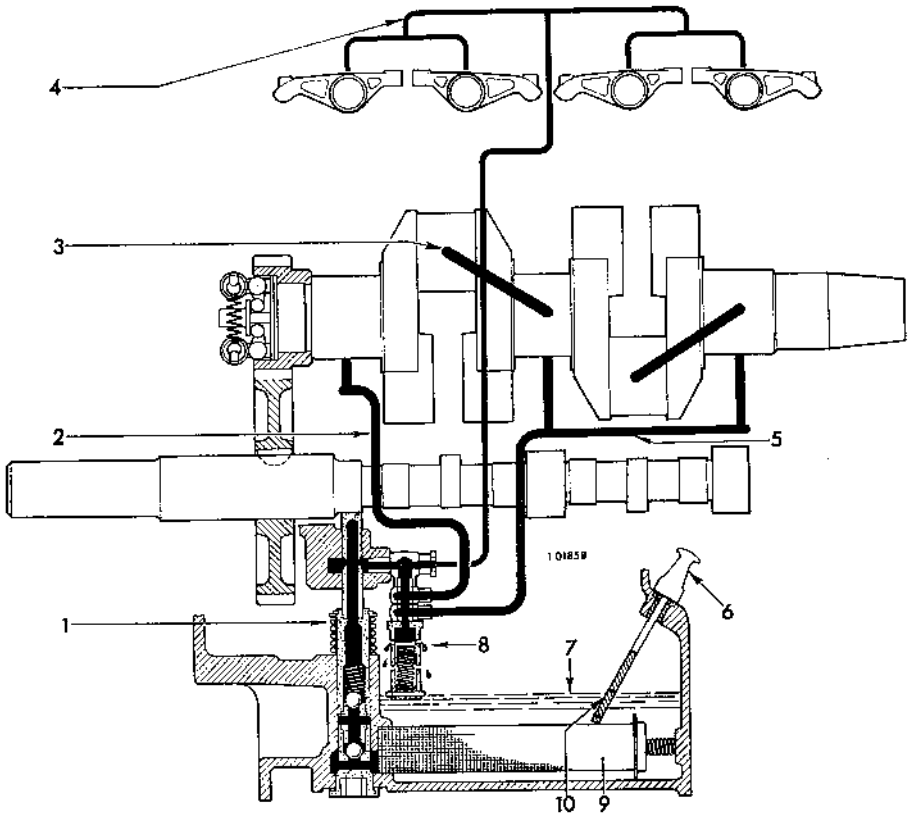
The crankcase may be drained through a drain plug on the starboard side of the engine. Alternatively a sump pump can be fitted.

Before Starting Initially or After Overhaul

Remove the caps on the cylinder head covers and pour ½ pint (0.28 litre) over the valve rockers in each cylinder.

Fill the engine crankcase through the oil filler to the mark "max." on the dipstick. Top up, if necessary, when the engine has been stopped after the initial run.

It is recommended that the fuel system be thoroughly flushed with fuel oil and the pump control rods checked for free movement.



1. Lubricating oil pump.
2. Oil passage to crankcase main bearing.
3. Oil passage to big end bearings.
4. Oil pipe to valve rockers.
5. Oil pipe to main bearings.
6. Lubricating oil dipstick .
7. Lubricating oil level.
8. Lubricating oil relief valve.
9. Lubricating oil strainer.
10. Dipstick—High and Low marks.

Fig. 5.—Schematic Diagram of Lubricating Oil System.

FUEL OIL

Fuel Oil System

The feed to the fuel injection pumps is either by gravity or by means of a mechanically operated fuel lift pump. A cartridge-type filter is always included in the system immediately before the fuel oil manifold.

Fuel is delivered under pressure from the fuel pumps to the injectors. Any drain from the injectors is returned to join with a bleed from the filter and pass back to the fuel tank.

Specification

SW2 engines must be used only with fuels which conform to the British Standard Specification 2869:1967, Class A1 or A2. They must be distillate, and not a residual oil or a blend thereof.

Specification Limits

	Class A1	Class A2
Viscosity, Kinematic at 37.8°C centistokes min. ...	1.6	1.6
centistokes max. ...	6.0	6.0
Cetane number, min.	50	45
Carbon residue, Conradson on 10% residue, % by weight, max.	0.2	0.2
Distillation, recovery at 357°C % by volume, min.	90	90
Flash point, closed, Pensky-Martens, min. ...	55°C	55°C
Water content, % by volume, max.	0.05	0.05
Sediment % by weight, max.	0.01	0.01
Ash % by weight, max.	0.01	0.01
Sulphur Content, % by weight, max.	0.5	1.0
Copper corrosion test, max.	1	1

The purchaser must satisfy himself that his whole equipment is capable of dealing with the oil at the lowest temperature to which it will be exposed.

In some cases summer grade oil is unsuitable for use in winter because it becomes cloudy and rapidly clogs the fuel filters on the engine.

In general the fuel must be free from foreign matter and water otherwise excessive wear may take place, particularly in the fuel injection system. Certain fuels are unsuitable owing to the excessive temperatures, pressures, deposits and corrosion resulting from their use.

The user is cautioned that although the engine may run satisfactorily for a short time on cheap fuel excessive wear and damage will ultimately be suffered by the engine and its life materially shortened. For these reasons we can accept no responsibility for such damage or wear caused by the use of unsuitable or dirty fuels.

Vapourising oils are NOT suitable as fuels for these diesel engines.

3. CLEAN FUEL OIL IS OF THE UTMOST IMPORTANCE IN ENSURING RELIABLE PERFORMANCE.

STARTING AND STOPPING

To Start Engine

(a) Check 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 the lubricating and fuel oil systems are primed. (See pages 12 and 29).

(d) If the engine is fitted with a fuel lift pump, prime the fuel filter by using the priming lever on the lift pump.

(e) Move the decompressor levers over toward the flywheel.

(f) Pull the control lever outwards and allow it to rotate anticlockwise so that it abuts against the top stop and is in a vertical position. See illustration below.

Note: On propulsion engines set the speed control lever at "Fast".

(g) Lightly oil the end of the camshaft extension or the raised hand starting shaft (if fitted) and fit the starting handle. It is recommended that these shafts are always used for starting the engine.

(h) **Important.** — Turn the engine slowly from 3 to 20 turns on the camshaft, according to the temperature and period of standing unused, in order to prime the combustion chambers and the lubricating oil system. system.

(j) Turn the handle smartly in a clockwise direction and whilst still turning, move the decompressor levers towards the fuel tank. Slip off the starting handle when the engine fires.

(k) As soon as the engine reaches normal speed, **turn the control lever clockwise to the horizontal position so that it abuts against the horizontal stop—THIS IS MOST IMPORTANT.**

or

(l) When speed control is fitted reduce speed to "Idling".

(m) Where an oil pressure gauge is fitted check that it shows 15-20 lb./sq. in. (1.05-1.4 kg./sq. cm.) at full speed.

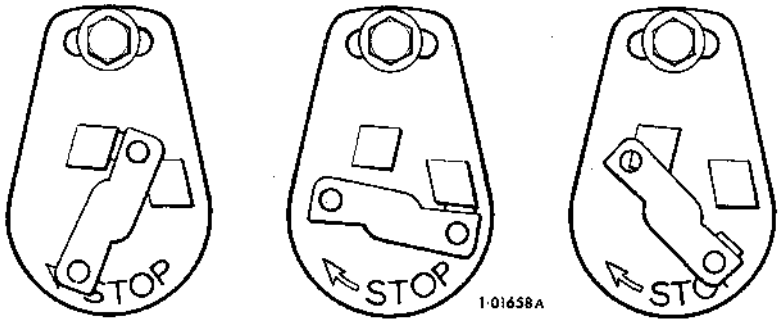


Fig. 6.—Engine Control—Auxiliary Engine

To Stop Engine (Auxiliary)

Turn the control lever clockwise and lock it under the spring on fuel pump housing door. When remote control is fitted, move lever to the "Stop" position.

To Stop Engine (Propulsion engine with combined speed and stop control)

Put speed control left into 'STOP' sector of control.

Remote Stopping Control

Remote control of the stopping lever is available if required, consisting of a hand lever and Bowden cable. The control can be mounted on a panel, together with variable speed lever, ammeter, electric starter push button and voltage control unit, should variable speed gear and/or electric starting be fitted. For cold starting the engine control (Fig. 6) must be set by hand to the start position.

Variable Speed Control

On all engines in place of the standard fixed speed control, a variable speed control can be fitted with a range of 700-2000 r.p.m. This arrangement is illustrated on pages 34 and 36.

Electric Starting

Electric starting is available and can be operated by either direct or remote control; diagrams of the electric circuit for both these methods of control are shown on pages 58 and 60.

Speed Adjustment

A slight adjustment of speed may be made by turning the screwed rod which projects through the gear case. Turn anti-clockwise to increase speed, clockwise to decrease. Secure the locknut.

Do not increase speed more than 2½% without consulting Lister Blackstone Mirrlees. Marine

ROUTINE MAINTENANCE

When the engine is in daily use:--

Daily:

Check supply of fuel oil.
Check the level and condition of lubricating oil (also in gearbox if fitted).
Drain the moisture trap in the exhaust pipe, if fitted.

Every 100 Hours:

Clean the air cleaner under moderately dusty conditions. Renew the element if necessary.
Check for oil and fuel leaks—tighten nuts and fittings if necessary.
Wipe the engine and baseplate clean.

Every 250 Hours:

Drain the lubricating oil and refill with the correct grade and type.
Renew the lubricating oil filter element (if fitted).
Clean the fuel injector nozzle if the exhaust is dirty.

Every 500 Hours:

Decarbonise if the engine shows loss of compression, or blow-by past the piston. Do not disturb otherwise.
Adjust valve clearances.
Wash the engine down with paraffin or fuel oil.
Remove cylinder block doors and check the blocks for scale formation.

Every 1500 Hours:

Decarbonise.
Clean the inlet manifold and exhaust system.
Check for free working of the governor linkage.
Drain and clean the fuel tank.
Renew the fuel filter element.
Clean the fuel injector nozzle and adjust the pressure settings.
Check the fuel pump timing and balancing.
Check the lubricating oil pump valve assemblies.

Every 5000 Hours:

Check the big ends and main bearings.

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

JOINTING COMPOUNDS

The following is a list of suitable jointing compounds and where they should be used.

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 and cast crankcase door	Hylomar SQ32M	Coat door jointing face and stick joint to it.
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.
Gear case cover	Wellseal	Coat gear case on joint face, stick joint to it and coat joint.
Crankshaft bearing housing shims	Wellseal	Coat all joint surfaces on one side —tighten bolts and re-tighten after about 10 mins.
Bottom of cylinders	Hylomar SQ32M	Coat cylinder on jointing face, stick joint to it and coat joint.
Camshaft cover in crankcase	Hylomar SQ32M	Apply a little compound to ring recess in cover.
Oil seals	Hylomar SQ32M	Apply a little compound to outside diameter of seal.
Oil pump suction plug	Hylomar SQ32M	Coat plug threads and both sides of joint.
Leak off connection at leak off manifold	Hylomar SQ32M	Coat threads lightly before screwing connection.
Cylinder head nuts and washers, and top thread of cylinder head studs	Wellseal	Dip nuts and washers, and coat stud threads and area of cylinder head or rocker bracket in contact with washers.

MAINTENANCE

Note: 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 subsequently be checked. This includes the following:

Gear train end cover joint.
Cylinder head cover joint.
Lubricating oil pipe joints.
Injector pipe nuts.
Fuel pump housing cover joints.

See Page 6 for torque settings.

For assembly use SAE10W heavy duty detergent lubricating oil with 5% concentrated colloidal graphite added. All bearing surfaces must be well lubricated including the cups of the push rods and the valve stems.

Oil Bath Air Cleaner

It is recommended that the element be cleaned at least every 1000 hours, even when operating in substantially dust-free conditions; under less favourable conditions more frequent cleaning will be necessary — even daily.

After dismantling the filter, the element should be thoroughly washed in paraffin or fuel oil and the filter bowl cleaned out. On re-assembly, the filter must be filled with oil up to the mark using the same grade of oil as for the engine.

Paper Type Air Cleaners

The element in this type of cleaner should not be cleaned but should be renewed.

Breather

A crankcase breather, in the form of a copper pipe, is screwed into the top of each cylinder head and connects with the inlet port. Vapour is drawn into the inlet manifold and a partial vacuum thus maintained in the crankcase which prevents oil leakage through joints and bearings.

Fuel Filter

The fuel filter is an essential part of a diesel engine. It must not be removed from the engine or used without a filter element.

Renew the filter element every 1,500 hours — more frequently if the fuel is known to be dirty for any reason. The element may be washed in clean paraffin or fuel oil, taking care not to allow dirt to reach the inside of the element or delivery pipes. Clean the inside of the filter bowl.

After carefully re-assembling the filter, the fuel should be turned on and all air vented from the system by slackening the two bleed screws "A" on top of the filter body, and the single bleed screw in the outlet banjo. After all air has been displaced, tighten the vent screws securely.

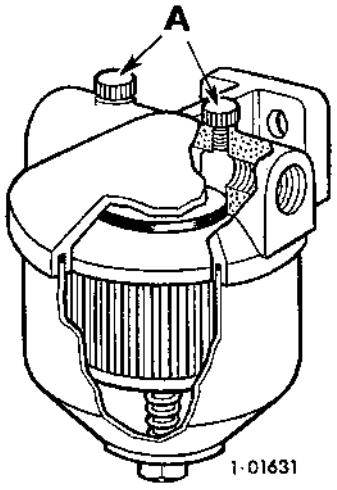


Fig. 7. Fuel Filter

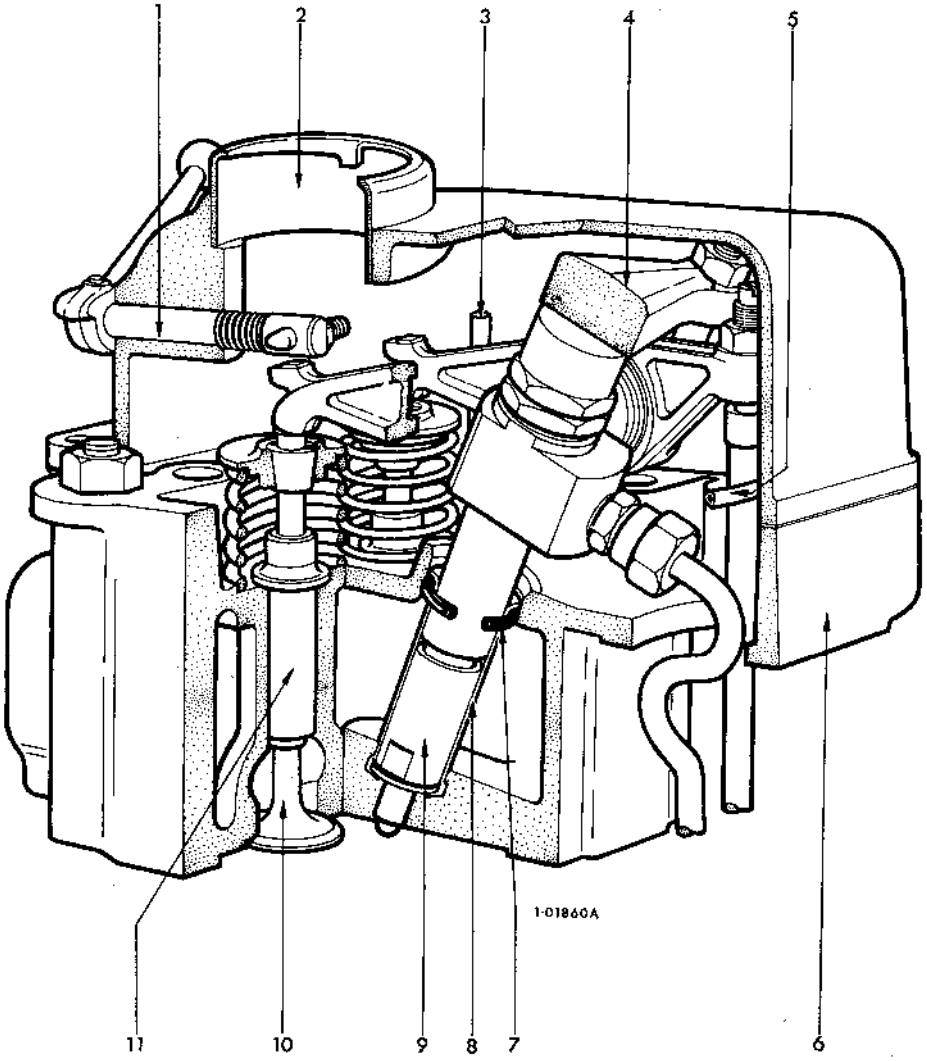


Fig. 8.—Cylinder Head

1. Decompressor Shaft.
2. Oil Filler.
3. Breather.
4. Injector Clamp.
5. Fuel Leak-off Pipe.
6. Cylinder Head.
7. Injector Sleeve Rubber Ring.
8. Injector Sleeve.
9. Injector.
10. Inlet Valve.
11. Inlet Valve Guide.

To Remove Cylinder Head

(a) Drain water from engine.

Remove:—

(b) Cylinder head cover.
(c) Fuel pump housing door.
(d) Lubricating oil pipe to valve rockers.
(e) Fuel leak-off pipe.
(f) Fuel pipe—fuel pump to injector.
(g) Fuel injector.
(h) Inlet and exhaust manifold.
(j) Water outlet manifold.
(k) Four holding down nuts and washers and lift off head.

Valve Guides

The valve guides are a press fit in the cylinder head and the inlet guide has a rubber ring seal fitted.

The exhaust valve guide is recessed at the lower end. Inlet and exhaust valve guides must therefore not be intermixed.

To Replace Cylinder Head

Examine cylinder head gasket—renew if damaged.

Replace cylinder head and pull down the four nuts evenly. Tighten to a torque of 50 lb. ft. (6.9 kg.m.).

It is essential that these nuts be tightened before securing the injector.

Note:—The inlet and exhaust flanges of all cylinder heads on multi-cylinder engines must be lined up with a straight edge, or alternatively fit a manifold, before finally tightening down to avoid distortion when fitting the manifolds.

To Check Cylinder Head Clearance

Place two pieces of lead wire 0.048″ x $\frac{1}{8}$″ on top of the piston clear of valve recesses and the combustion chamber in the top of the piston. Space widely apart and immediately over the gudgeon pin.

Tighten down the cylinder head and turn the piston past T.D.C.

Remove the cylinder head and measure the thickness of lead. This should be between 0.035″ (0.89 mm.) and 0.038″ (0.97 mm.), this may be adjusted by shims 0.003″ (0.075 mm.) thick, placed between the cylinder head and the gasket. Only one joint must be used between the crankcase and the cylinder barrel.

To Remove Piston

(a) Close sea cock.
(b) Open all drain cocks.
(c) Remove water outlet manifold—exhaust manifold—inlet manifold.
(d) Remove water inlet manifold.
(e) Remove cylinder head.

(f) Remove crankcase door.
(g) Disconnect connecting rod big end bearing.
(h) Lift off cylinder complete with piston and connecting rod.

Withdraw piston from cylinder.

To remove the gudgeon pin remove one spring circlip, and the gudgeon pin may then be pushed out.

Piston rings may be removed by inserting thin metal strips between the ring and the piston and easing off the ring, but it is recommended that a ring expanding tool, as made for car engines, be used when available.

To Replace Piston Rings

Clean piston ring grooves, oil holes and rings carefuly.

Roll each ring (except the top one which is taper sided) round its own groove.

When fitting new rings, measure the gap between the ends when the ring is inserted squarely in the bottom of the cylinder. The gap should be between 0.012″ and 0.016″ (0.305-0.406 mm.) for the top ring and between 0.008″ and 0.012″ (0.203-0.305 mm.) for the compression and scraper rings.

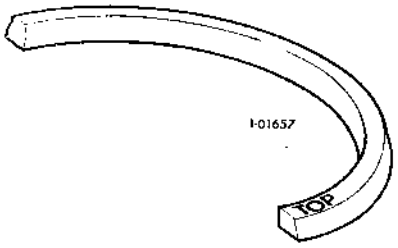


Fig. 9.—Piston Ring.

The top ring is taper sided and chromium plated.

The second and third rings have tapered faces against the cylinder. These should be fitted with the larger diameter of the taper at the bottom. New rings are marked "Top" on the top side.

To Replace Piston and Connecting Rod

Always check the clearance between the piston skirt and the cylinder which must not be less than 0.005″ (0.127 mm.) measured with a feeler pushed between the two.

Oil the piston and connecting rod and assemble into the cylinder block. Place one copper joint at the base of the cylinder block.

Turn the piston so that the wording 'CAMSHAFT SIDE' is towards the camshaft (fuel pump housing).

Turn the crankshaft to T.D.C., lower into position the cylinder complete, with piston and connecting rod, and when the connecting rod bolts have passed over the crankpin, turn the crank towards the door whilst the piston is being pressed down.

Assemble the big end bearing according to the identification marks and secure with the self locking nuts. Correct tightening torque is 15lb.ft. (2.07 kg.m.).

Connecting Rod Big End Bearing

Big end bearings are precision finished, and require no fitting; under no circumstances should they be scraped or touched up in any way.

If the big end has been dismantled because of failure of the metal, the oil passage in the crankshaft must also be examined for obstruction and fragments of metal. After cleaning out, it is advisable to crank the engine over by hand to see that oil reaches the bearing, and to flush out the oil passage.

Main Bearings—see also pages 54-55

Engines are built with steel backed, split bush main bearings with separate thrust washers. When re-assembling an engine, care must be taken that the thrust washers are correctly positioned. The centre main bearing housing is located in the crankcase by means of a plain hollow dowel tapped at one end. Care should be taken to ensure that this is fitted with the tapped end outwards to assist removal. If new bearings are fitted, ensure that the oil holes are in line with the holes in the bearing housing, and that the bearing is pressed in so that the inner edge is $\frac{1}{16}$" from the inner face of the bearing housing.

Valve Adjustment

Valve clearance must be set to 0.008" (0.20 mm.) GO, 0.010" (0.25 mm.) NOT GO on both inlet and exhaust valves. This can be done with the engine either hot or cold.

To adjust, remove the cylinder head cover and turn the piston to the T.D.C. position 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 the clearance is correct.

	SR	LR
Inlet Valve Opens	25° B.T.D.C.	10° B.T.D.C.
Closes	35° A.B.D.C.	30° A.B.D.C.
Exhaust Valve Opens	40° B.B.D.C.	30° B.B.D.C.
Closes	20° A.T.D.C.	10° A.T.D.C.

On SW engines inlet valve head is between 0.035-0.045" (0.89-1.19 mm.) below the face of the cylinder head. Corresponding figures for exhaust valves are 0.015-0.025" (0.38-0.64 mm.).

The width of valve seats must be 0.064"-0.083" (1.63-2.1 mm.). This width can be obtained by increasing the depth of the recess in the head using tool No. 317-86.

Decarbonising

Decarbonise after about 1500 hours.

(a) Remove cylinder heads.

(b) Remove pistons and rings.

All parts must be thoroughly cleaned and washed in paraffin.

Special care must be taken with regard to:—

(a) Recess in exhaust valve guides.
(b) Valve ports.
(c) Piston rings and grooves.
(d) Combustion chambers in top of the pistons.
(e) Remove doors on cylinder blocks and remove any sludge.
(f) The inside of the pistons.
(g) Regrind valve seats if not in perfect condition.
(h) Clean out exhaust piping and silencer.

To Adjust Decompressor

For engines provided with an oil filler hole in each cylinder head cover, access to the decompressors is through these holes.

Turn the piston to T.D.C. firing stroke.

Move the decompressor lever over toward the flywheel.

Slacken the locknut and turn the decompressor screw down until the exhaust valve touches the piston.

Turn the screw back $\frac{1}{2}$ turn and tighten the locknut.

When no filler is provided in the cylinder head cover the decompressor should be adjusted so that when the cover is tightened down in position, the adjusting screw just touches the valve rocker when operated. The adjusting screw should then be screwed down a further $\frac{3}{4}$ turn and locked in position.

Flywheel

The flywheel is mounted on a taper. A withdrawing tool is required to remove it. Do not slacken the nut more than two turns before loosening the flywheel on the taper. On reassembling tighten the retaining setscrew to a final torque of 200 lb.ft. (27.6 kg.m.).

To Remove Fuel Pump

(a) Drain fuel at fuel filter.
(b) Remove fuel pipe to injector.
(c) Disconnect fuel supply pipe.
(d) Release governor adjusting spring.
(e) Disconnect governor link.
(f) Remove fuel pump clamp setscrew and clamp. Lift out pump, taking care of adjusting shims below pump body.

When refitting the fuel pump, use two spanners to tighten the fuel delivery connection to prevent the pump being twisted on its seating. The pump racks **must** move freely, otherwise erratic running or hunting will occur.

Camshaft

The camshaft is carried in porous bronze bushes. One bush is pressed into the end cover and the remainder into the crankcase. See pages 56-57.

The camshaft is extended beyond the end cover and is the same diameter as the crankshaft extension providing a second position for power take off at half the engine speed.

The water pump drive gear together with a seal ring are fitted at the opposite end of the camshaft.

To Remove Camshaft

(a) Remove fuel pump housing door.
(b) Disconnect governor adjusting spring.
(c) Disconnect fuel pipes—filter to pumps and drain fuel.
(d) Remove fuel pumps and tappets.
(e) Remove set screws in gear end cover.
(f) Turn camshaft keyway to bottom.
(g) Remove crankcase door.
(h) Slacken the lubricating oil pump plug $\frac{1}{16}$", or remove, in order to compress lubricating oil pump return spring until pump tappet is below level of camshaft bearing.
(i) Remove gear end cover.
(j) Hold up tappets and slide out camshaft—collect tappets.

To Replace End Cover

(a) Clean joint faces, fit new joint with sealing compound both sides.
(b) Fit end cover **NOTE: Care must be taken not to damage oil seal.**
(c) Hook speeder spring on to governor link.
(d) Fit seven setscrews and copper washers in end cover.
(e) Fit swivel union screw and joints to connect fuel pipe to filter.
(f) Fill tank with fuel.
(g) Bleed fuel system at all points.
(h) Replace fuel pump housing door.
(j) Start engine.
(k) Adjust speeder spring screw to required speed and tighten lock-nut.

Governor

The engine governor is carried within the crankshaft pinion at the gearcase end of the engine.

The governor lever operating the fuel pumps is carried on a fulcrum bearing secured to the crankcase above the pinion. This bearing, fitted so that the centre line of the bearing is approximately $\frac{3}{4}$" from the facing on the crankcase, is adjusted in accordance with instructions given under "Setting Fuel Pump" (page 31), and secured with a lock nut.

The lever is curved to pass over the camshaft gearwheel and is joined to the fuel pumps by a link arm.

CARE MUST BE TAKEN AT ALL TIMES TO PREVENT ANY FOREIGN MATTER ENTERING THE CRANKCASE

To Time Camshaft

The camshaft is timed by matching the letters 'O' on the camshaft gear-wheel and the crankshaft pinion.

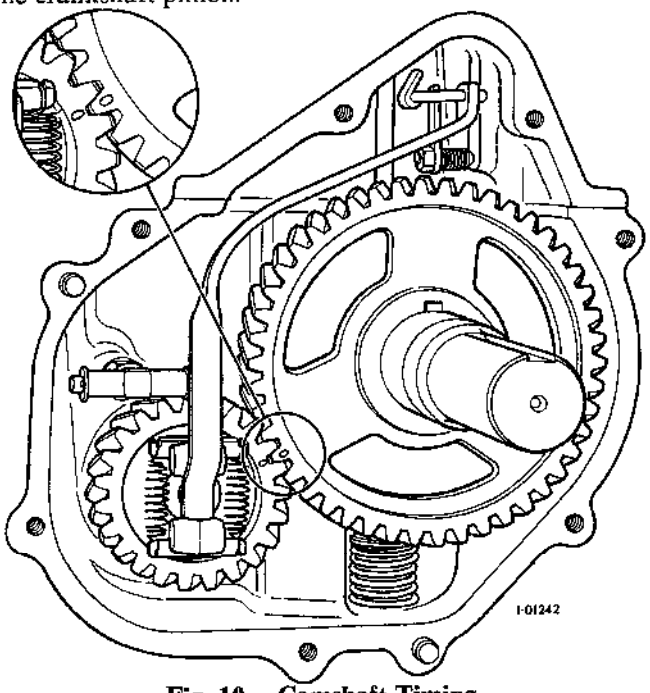


Fig. 10.—Camshaft Timing.

Lubricating Oil Pump

The plunger type pump is cam operated from the camshaft and the suction valve, being below the level of the oil, should require little attention.

At times of major overhaul, however, the pump should be dismantled for inspection.

Check that the plugs retaining the suction and delivery ball valves are solidly locked in position.

Under no circumstances dismantle these valve assemblies.

When re-assembling the pump ensure that the hollow end of the pump tappet is to the bottom.

To Remove Lubricating Oil Pump

(a) Compress pump return spring to relieve pressure on the circlip.
(b) Remove circlip.
(c) Release pump spring.

(d) Remove suction valve assembly from bottom of crankcase.

The pump plunger and tappet may now be pushed out.

Remove the spring and carrier ring from the crankcase.

The suction strainer is held in place by a spring end cap in front of the crankcase.

Main Bearing Housing

To remove:—

(a) Remove flywheel.

(b) Remove flywheel housing.

(c) Remove crankcase door.

(d) Remove oil pipe to main bearing in housing.

The housing may now be removed from the crankcase.

Before replacing, ensure that the main bearing bush is in its correct position — lubricating oil holes in line.

Crankshaft end play must be between 0.005″ and 0.009″ (0.12/0.21 mm.). This can be adjusted by **metal** shims of 0.005″/0.010″ (0.127/0.254 mm.) thickness between the housing and crankcase. No paper joints must be used. The metal shims must be jointed with clean jointing compound on both sides.

To Remove Crankshaft

(a) Remove pistons and connecting rods.

(b) Remove gear end cover.

(c) Remove governor and control rod.

(d) Remove crankshaft pinion (shrunk and keyed to crankshaft; to replace, heat in boiling water).

(e) Remove main bearing housing and centre bearing locating dowel (using a $\frac{1}{4}$″ UNF bolt screwed into end).

(f) Withdraw crankshaft through the housing bore.

Replace in the reverse order to removing.

Oil Seals

The crankcase is sealed at the crankshaft by screw type oil seals and felt rings, and the camshaft is sealed in the end cover with a Gits seal. Screw type seals must be concentric with the shaft, the maximum permissible variation of gap being 0.003″ (0.075 mm.).

There is a ring type oil thrower on the flywheel end of the crankshaft and care must be taken to guide this ring over the end of the crankshaft when fitting the main bearing housing.

Water Pump

To remove the impeller proceed as follows :—

(a) Drain all water.

(b) Remove pump end cover (six screws) and joint.

(c) Remove impeller—use thin nose pliers to pull out impeller.

To fit new impeller :—

(a) Fit impeller screw into the impeller.

(b) Apply a thin coating of soft grease to impeller bore.

(c) Start impeller into bore of pump using a rotary motion until the screw engages in the slot in the shaft.

(d) Fit new joint and refit end cover.

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 oil 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. Seal all openings on the engine with tape.
6. Remove batteries, when applicable, and store fully charged with the terminals coated with vaseline (petroleum jelly).
7. Grease all external bright parts and control linkage, etc.
8. 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.

FUEL EQUIPMENT

Engines of low horsepower can be overloaded without the user realising it, because even a fraction of a horse power is a big proportion of the total engine output. If a smoky exhaust is noticed in an engine the first thing to check is the setting of the overload stop.

Directions for adjusting the overload are given on page 31.

The injectors are most unlikely to be the cause of smoky exhaust on these engines and should only be disturbed after the overload stop has been properly set and the exhaust is still unsatisfactory. The injection timing of the engine may produce a smoky exhaust if more than $\frac{1}{4}$" (6 mm.) out on the flywheel.

IMPORTANT

When priming or checking the fuel pump timing, care must be taken to prevent the overflow of fuel passing into the crankcase.

Always fit a NEW joint when a joint has been broken.

Special care must be taken to see there is no leakage from the joints of the fuel pipe connection to the pumps.

When tightening or loosening the fuel pump delivery connection, use two spanners to prevent the pump from twisting on its seating and causing misalignment and possibly jamming of the fuel pump rack.

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.

To Prime Fuel System

(i) Fill fuel tank.

(ii) Vent fuel filter (see page 19).

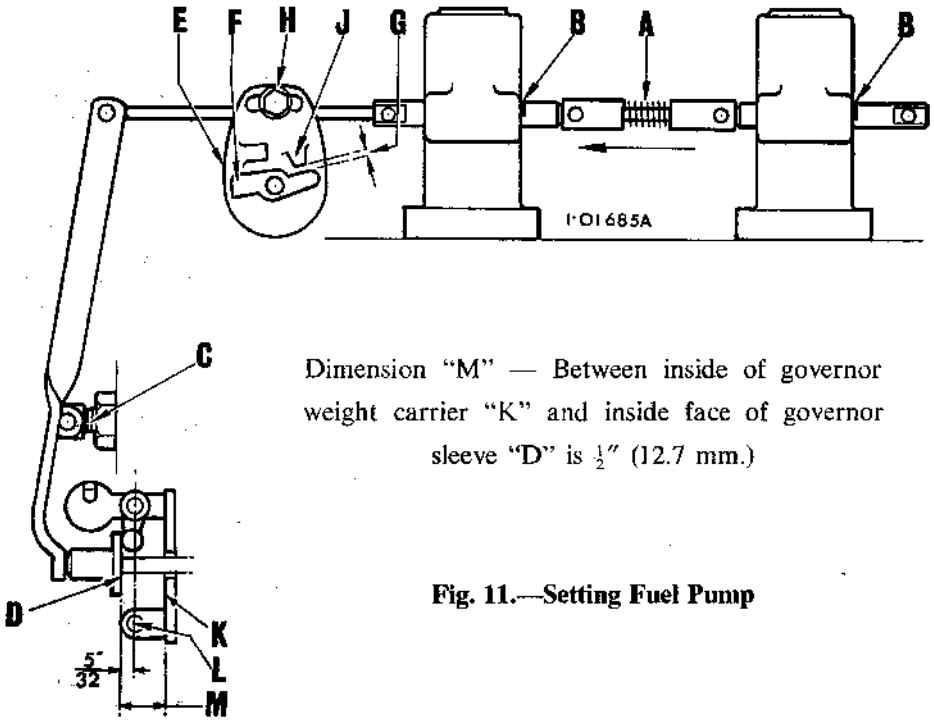
(iii) Vent fuel pipe at fuel pumps. Turn engine as for starting, i.e. 3 to 20 times, until the injectors can be heard to inject and then attempt to start the engine. If the engine fails to start, prime the injection pipes as follows:—

(a) Remove cylinder head covers.

(b) Undo injection pipe at injector two turns only.

(c) Set control to start position.

(d) Turn engine until fuel free from air flows from injector pipes. Retighten injector pipe nut and continue turning engine until injectors are heard to inject.



Dimension "M" — Between inside of governor weight carrier "K" and inside face of governor sleeve "D" is $\frac{1}{2}$" (12.7 mm.)

Fig. 11.—Setting Fuel Pump

KEY:

A—Fuel pump linkage.

B—Calibration mark.

C—Fulcrum.

D—Governor sleeve.

E—Control lever locating plate.

F—Control lever.

G—Control lever stop.

H—Locating plate setscrew.

K—Governor weight carrier.

L—Distance between inner face of governor sleeve and centre line of fulcrum—5/32" (3.97 mm.).

M—Dimension between outside face of governor weight carrier and inside face of governor sleeve—$\frac{1}{2}$" (12.7 mm.).

SETTING OF FUEL PUMPS and GOVERNOR WEIGHTS

1. Adjust linkage "A" so that all the calibration marks "B" accurately coincide with the sides of the fuel pumps within 0.005″ (0.127 mm.). The fuel pump racks must move freely after this adjustment.

2. Adjust fulcrum "C" so that when the calibration marks "B" are against the sides of the fuel pumps the distance "M" between the inside of the governor weight carrier "K" and the inside face of the governor sleeve "D" is $\frac{1}{2}$″ (12.7 mm.). This is the same for both constant speed and variable speed engines.

3. **For auxiliary engines** insert a shim 0.015/0.017″ (0.38/0.43 mm.) thick at "G" between the stop "J" and control lever "F". Rotate the locating plate "E" so that, with the shim in position, the calibration marks "B" are against the pump sides. The full width of each calibration mark must be visible. Lock locating plate "E" with screw "H" when this condition is attained. This setting corresponds to a movement of 0.046/0.052″ (1.17/1.32 mm.) of the pump rack in the direction of the arrow.

   Propulsion engines use a shim 0.010/0.012″ (0.254/0.30 mm.) at "G". This gives 0.031/0.037″ (0.79/0.94 mm.) on fuel pump rack.

	Thickness of Shim used at 'G'	**Movement of Rack given by Setting**
Auxiliary engines	0.015/0.017 in. 0.38/0.43 mm.	0.046/0.052 in. 1.17/1.32 mm.
Propulsion engines and engines driving centrifugal pumps	0.010/0.012 in. 0.254/0.30 mm.	0.031/0.037 in. 0.79/0.94 mm.

To Time Fuel Pump

(a) Set the control lever to the "start" position.
(b) Turn the flywheel to the firing position; this is when the mark is opposite the arrow at the back of the flywheel housing near the fuel pumps, and both valves are closed (see illustration).
(c) Disconnect the fuel injector pipe at the pump and injector.
(d) Remove the delivery valve holder, delivery valve and spring. If fuel flows from the pump, turn the crankshaft forward until flow ceases.
(e) Replace the delivery valve holder without the valve and spring and lightly tighten.
(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 to make sure flow has ceased. At this position the firing mark on the rim of the flywheel should be opposite the centre mark on the fan shroud. If it is not, the shims below the pump body must be adjusted.

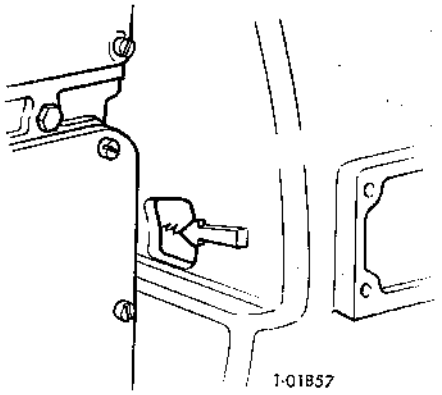


Fig. 12.—Fuel Pump Timing

Remove shims to advance.
Add shims to retard.

Shims 0.005″ and 0.010″ (0.127-0.254 mm.) thick to a total of approximately 0.035″ are normally inserted below the fuel pump.
One shim 0.005″ (0.127 mm.) thick is equivalent to a timing adjustment of 3/16″ (4.75 mm.) measured round the **rim** of a flywheel 14″ (35.6 cm.) diameter, or 13/64″ (5.16 cm.) for a flywheel 15″ (38 cm.) diameter.

Fuel Injector

The fuel injectors are in the cylinder heads and are fitted into copper sleeves around which the cooling water circulates.

Each injector is secured by a clamp which fits over two studs screwed into the valve rocker bracket. The clamp nuts must be tightened evenly to 15 ft. lb. (2.07 kg.m.) torque ensuring that the clamp is level and bears evenly on the injector. The steel fuel pipe from the pump to the injector **must not** be tightened until the clamp is correctly secured.

The injector nozzle has three spray holes each 0.0098″ diameter (0.25 mm.). The setting pressure of the injector spring is 200 atmospheres; this allows for settling to the normal pressure of 190 atmospheres.

The injection equipment, and 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 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 done 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.

Testing Fuel Injector

To check 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 directed **away** from the operator. This requires removing the injection pipe and using a spare one (the standard injection pipe must never be bent for this purpose as otherwise it will be impossible to refit it). The engine is turned at about 60 rpm (camshaft speed) and after a few turns the nozzle will begin to function and the sprays can be observed. These should be in the form of a very fine mist, not streaky or dribbly. All three sprays should have the same appearance and the same length of penetration in the air. If one spray is shorter or weaker than the other 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 one 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.

When fitting a new injector the following instructions must be observed:—

1. The injector nozzle cap nut and the injector spring lock nut and outer cap must be dead tight (65 lb.ft. (9.0 kg.m.) torque).
2. The lower end of the injector sleeve must be clean and the upper end should be checked to ensure it is water tight.
3. The injector clamp nuts must be tightened to 15 lb.ft. (2.07 kg.m.) torque.

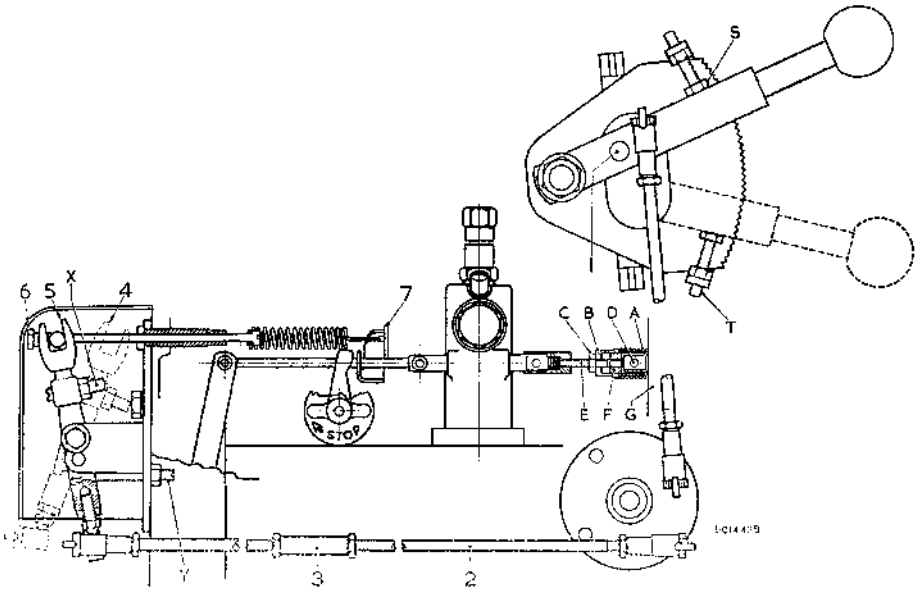


Fig. 13.—Arrangement of Rod Operated Variable Speed Control

1. Alternative position for connecting rod.
2. For flexibly mounted engines this connecting rod must lie in a plane close to the horizontal and must not be less than 10″ (254 mm.) long. Where it is necessary to carry the rod upwards fit universal rod coupling as above. Further rod couplings may be fitted as required.
3. Muff coupling for extending rods if required.
4. Idling position.
5. Full speed position.
6. Cover—not supplied with raised hand starting.
7. Fuel pump linkage.

Note:—The **upper holes** in the bracket and the lever are used.

Instructions for Adjusting Speed Control

The idling device consists of a spring "A" (Fig. 13) which is mounted over the left hand shackle "F" of the flywheel end fuel pump and exerts a force on the fuel pump rack, by abutting against the pump body.

The fuel pump shackle "F" is fitted with a long stud "E" which has a long thread on which is screwed the idling spring adjusting sleeve "B". This sleeve when rotated controls the spring force and is locked in position by the lock nut "C".

To adjust the idling spring "A" the main speeder spring at the gear end of the engine is completely slackened and the adjusting sleeve "B" is rotated in the desired direction, until a steady idling of about one third of the rated engine speed is obtained, and then locked by the nut "C".

The speed control on the engine has an idling adjusting screw "X" which should now be adjusted so that the main speeder spring just begins to increase the engine speed, and then screwed anti-clockwise one turn. The speeder spring must not exert any force when the engine is idling.

With control lever still held in "Slow" position adjust screw "T" until it just touches the operating lever and lock the nut.

Push the control lever in the direction of "Fast" and adjust screw "Y" until full revolutions are obtained on load and tighten the locknut.

N.B.—Ensure that the ratchet is engaged betwen two teeth in the "Fast" position, Adjust the length of the connecting rod or cable to suit.

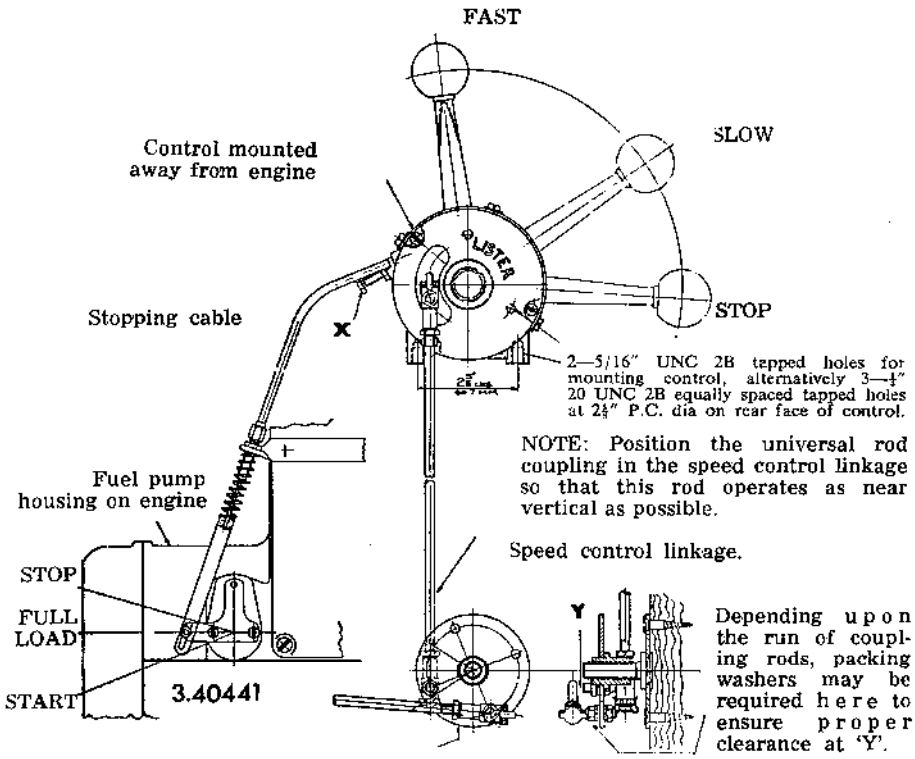


Fig. 14.—Arrangement of Single Lever Speed and Stop Control

ADJUSTMENT

Engine idling at 750 rpm: Adjust the connecting rod to the hand control so that the hand lever is in the bottom notch of the ratchet in the speed sector.

Engine at full speed 2000 rpm: With the hand lever held in the full speed position (on load), set adjustable stop X so that it just touches the hand lever. Tighten the lock nut.

Stopping control: Adjust cable so that the engine stops when the hand lever is at the limit of its travel in the stopping sector.

Speed Adjustment

A slight adjustment of speed may be made by turning the screwed rod which projects through the gear case. Turn anti-clockwise to increase speed, clockwise to decrease. Secure lock nut.

Do not increase speed more than 2½% without consulting Lister Blackstone Mirrlees Marine Ltd.

GOVERNOR WEIGHTS AND SPRINGS — CONSTANT SPEED

BS 649 : 1958 Class A

ENGINE Speed rev./min.	WEIGHTS 2 off		WEIGHT SPRING 2 off		Speeder Spring 1 off	
	Part No.	Ident. No.	Part No.	Colour	Part No.	Colour
1000	572-11380	2	201-10821	Green	201-10903	Yellow
1100-1300	572-11380	2	201-10821	Green	201-10900	Red
1400-1690	572-11380	2	201-10820	Red	201-10900	Red
1700-1800	572-11640	11	201-10820	Red	201-10900	Red
2000	572-11590	6	201-10820	Red	201-10900	Red

GOVERNOR WEIGHTS AND SPRINGS — VARIABLE SPEED

BS 649 : 1958 Class B

Engine Speed Rev./min.	Governor Weight		Speder Spring			Idling Spring	
	Part No.	Ident. No.	Part No.	Colour	No per Set	Part No.	No per Set
700-2000	572-11663	16	201-10900	Red	1	204-21491	1

INSTRUCTIONS FOR CHANGING SPEEDS OF SW2 MARINE AT CONSTANT SPEED

FIXED SPEED

Note: Before starting consult the table on page 37 to check which of the governor weight and springs are to be changed.

Remove the fuel pump housing door.
Unhook the speeder spring from the governor link.
Disconnect fuel piping and drain the fuel tank. (Engine mounted tank only).
Remove seven setscrews securing end cover.
Remove the end cover (complete with tank and filter when fuel tank is engine mounted).

To Change Governor Weight Springs Only

Unhook the governor weight springs.
Fit new springs (consult table).

To Change Speeder Spring

Remove the speed adjusting screw from the end cover.
Remove the existing spring and fit the new speeder spring.
Re-fit the adjusting screw into the end cover and tighten the lock-nut after final adjustment of speed.

To Change Governor Weight

Remove split pins and washers from the governor lever fulcrum pin, and from the outer end only of the link to the governor.
Remove the governor lever.

IMPORTANT NOTE: DO NOT ALTER THE GOVERNOR LEVER FULCRUM SETTING.

Remove the governor thrust sleeve.
Remove the two setscrews securing the governor weight carrier.
Remove the carrier and weights.
Remove the governor weight fulcrum pins, fit new governor weights and replace the pins.

NOTE: Governor weights must be fitted with steel boots. If necessary use boots from the weights being removed.

Replace the governor sleeve, ensuring that it is perfectly clean.
Refit the carrier complete with weights and pins and secure by means of the two setscrews.
Fit the correct governor weight spring (consult table).
Replace the governor lever and fit washers and split pins.

STARTING AND RUNNING FAULTS

Trouble	Probable Cause	Remedy
1. Engine does not turn easily when decompressed	(a) Lubricating oil too heavy.	Drain sump and change to correct grade—see page 11.
	(b) Incorrect decompressor clearance	Check and adjust—see page 24
	(c) Load too heavy for engine	A clutch should be fitted to disconnect the load
2. Engine will not start or runs erratically	(a) No fuel in tank	Fill tank and bleed the system—see page 19.
	(b) Air lock in system	Bleed system
	(c) Injector nozzle valve stuck open	Dismantle and free or fit reconditioned nozzle
	(d) Fuel pump delivery valve scored	Replace valve and seat (both must be replaced)
	(e) Faulty fuel pump	Replace with reconditioned pump
	(f) Exhaust system choked	Dismantle and clean
	(g) Incorrect cylinder head clearance	Check and adjust — see page 21.
	(h) Loss of compression	Check cylinder head gasket, valves and piston rings.
3. Knocking in engine	(a) Sticking exhaust valve	Remove cylinder head and clean valves.
	(b) Worn bearing	Renew bearing—crankshaft may also be worn
	(c) Injection too early	Check and adjust
	(d) Flywheel loose	Tighten setscrew- see page 24.
	(e) Excessive crankshaft end play	Adjust or replace shaft and bearings—see page 27
	(f) Excessive carbon on top of piston.	Decarbonize
4. Excessive carbon deposit	(a) Choked exhaust system	Dismantle and clean
	(b) Idling for long periods	Stop engine when not required
	(c) Unsuitable fuel oil	See page 14 for correct grade
	(d) Unsuitable lubricating oil	See page 11 for correct grade
	(e) Injector not spraying correctly	Check and clean nozzle
	(f) Injection timing late	Adjust timing—see page 32

Trouble	Probable Cause	Remedy
5. Smoky exhaust	(a) Overload—black smoke	Reduce load
	(b) Choked air intake	Remove and clean
	(c) Choked injector	Remove and clean or replace
	(d) Unsuitable fuel	Drain fuel tank and piping and refill with correct fuel —see page 14
	(e) Light load—faint blue smoke	Increase load
	(f) Excessive lubricating oil consumption — darker blue smoke— worn piston rings or cylinder or both	Renew piston rings and cylinder if necessary
6. Engine stops	(a) Lack of fuel or	Bleed system
	(b) Water or air in fuel system	Drain system, refill and bleed.
	(c) Overload	Reduce load
	(d) Overheating	See item 10
	(e) Loss of compression	Check cylinder head gasket, fuel injector joint, valves and piston rings.
	(f) Dirt in fuel system	Check injector and fuel filter and fuel tank. Clean/ replace as necessary
7. Loss of Power	(a) Loss of compression	See 6(e)
	(b) Incorrect tappet clearance	Adjust—see page 23
	(c) Choked exhaust pipe	Dismantle and clean
	(d) Fuel system out of order	Check as Section 2
8. Engine will not run up to speed	(a) Engine started on overload condition	Reduce load
	(b) Fuel system not properly primed	Bleed all air from system
	(c) Insufficient fuel	See 6(f) also check fuel tank
	(d) Injection retarded	Check and reset—see page 32
9. Loss of oil pressure	(a) Oil level too low in sump	Top up to mark on dipstick
	(b) Strainer choked	Remove and clean
	(c) Leaking joint	Renew

Trouble	Probable Cause	Remedy
	(d) Damaged bearing	See 3(b)
	(e) Relief valve stuck	
	(f) Oil pump plunger and/or valves worn	Replace—see page 26
10. Overheating	(a) Shortage of lubricating oil	Check on dipstick and top up
	(b) Sea cock closed	Allow engine to cool down before opening
	(c) Excessive sludge or scale in water spaces	Remove doors on cylinder blocks and clean out. Cylinder heads may also be affected
	(d) Pump impeller worn	Replace impeller

LISTER REVERSE GEAR

Manually Operated

General

The reverse gear is directly mounted on the engine fan shroud and also carries two brackets which support the after end of the engine. The gear box incorporates a cone type ahead clutch and an epicyclic reverse gear.

It is not necessary to fit a separate thrust block as the box is capable of absorbing the end thrust.

This box is robust and designed to give a long trouble free life. Abuse and/or the lack of maintenance will, however, affect this life, and the following points should be watched.

1. **Before changing gear, reduce engine speed.**
2. Move the gear lever firmly and steadily to change gear.
3. Never run with the reverse band slipping.
4. Check oil level in the reverse gear and also in the reduction gear (if fitted) every 24 running hours or weekly.

Operation — Neutral — See Fig. 15.

Drive from the engine is passed initially from the crankshaft spur gear (1) to the stepped pinions (2). These in turn drive the two spur pinions (3), thus driving the clutch shaft spur gear. The latter is situated forward of clutch and is integral with the clutch shaft. When in neutral this gear remains at rest and the two sets of pinions revolve round it, carrying with them the clutch body (4).

Operation—Ahead

When the gear lever is engaged in the ahead position, the cross shaft (5) is partially rotated allowing the forward facing roller (6) to move across the formed face of the ahead operating lever (7). This removes the restraining force on the clutch operating yoke (8) and under the influence of the clutch springs (9) the inner clutch (10) moves forward and engages with the clutch body (4). As the inner clutch cone (10) is splined to the clutch shaft, a direct through drive is obtained.

Operation—Astern

When the gear lever is put in the astern position the cross shaft (5) causes the aft facing roller (11) to move the astern clutch operating lever (12). This tightens the brake band (13) on to the clutch body (4) and the latter ceases to revolve. The drive then passes through the stepped pinions (2) and the spur pinions (3) thus rotating the clutch shaft spur gear and the clutch shaft in the astern direction.

Adjustment

Remove the gear box cover, and also the retaining screw at the port side end of the operating shaft (5). This will enable the shaft to be withdrawn sufficiently for the two rollers (6 and 11) to clear their respective levers (7 and 12).

Ahead Clutch

Adjust the forward facing roller (6) so that there is 1″ (25 mm.) of free movement at the knob end of the hand lever when it is fully in the ahead position and the roller (6) is engaged with the lever (7). This free movement is important an should not be allowed to become less than ½″ (12 mm.).

Reverse Band

Adjust the roller facing AFT so that the ASTERN drive can just be taken without the clutch slipping.

The roller facing aft (11) should be adjusted so that the full astern power can be taken without the clutch body slipping. It is very important, however, that the band is not overadjusted otherwise considerable damage may be caused. The force required to engage the hand lever at the knob should be about 30 lbs. (13 kgs.). When in the "off" position, the band rests on a lug in the bottom of the gear case, and it should be clear of the clutch body drum, although very light rubbing is permissible.

IMPORTANT.—DO NOT OVER ADJUST.

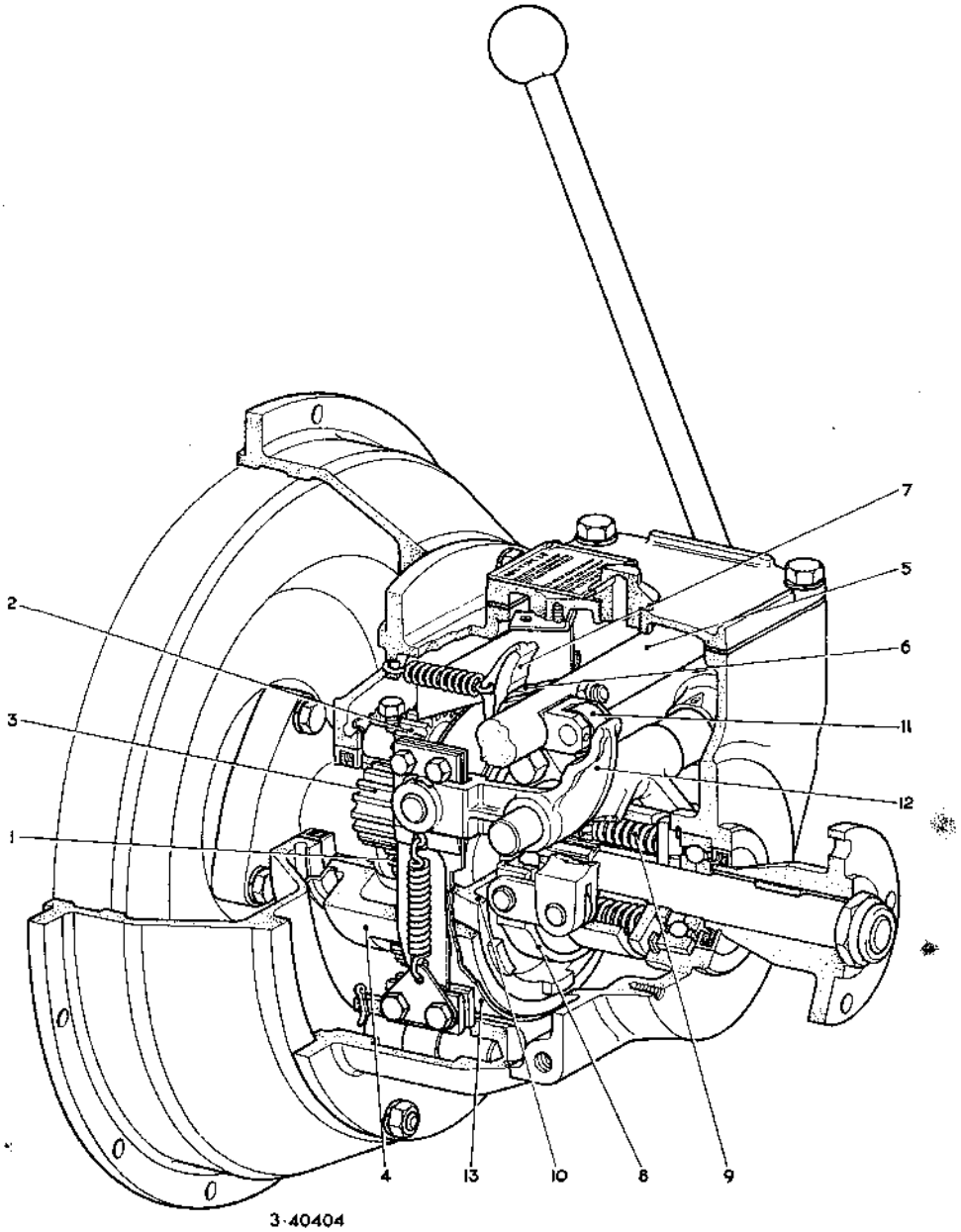


Fig. 15.—Lister Reverse Gear—Manually operated

TO DISMANTLE REVERSE GEAR

Refer to page 47—Fig. 17

Remove nuts (6) from reduction gear case (4) and withdraw reduction gear.

Refer to page 46—Fig. 16

Remove the following parts:—inspection cover (8) and joint (9), locating pin (92); draw operating shaft clear of operating levers (66 and 71); remove lock-nuts (98) and screw out roller adjusting screws (93) from shaft, now withdraw operating shaft (90) from reverse housing, remove retaining plug (87) and draw out fulcrum shaft (60), brake band anchor pin split pin (80), and anchor pin (79). On engines fitted with reduction gear see Fig. 17 and remove split pin (32) and nut (13), pinion (8), key (9), oil trap (7), and then supporting the gear gently drive reverse gear through bearing (5). For direct drive engines remove nut (55), half coupling (53), Fig 16, and remove gear as mentioned above. Having done this the bearing (5) can be removed, by removing circlip (6), gently tapping bearing from housing from reduction gear end (re-fit this bearing into housing first on re-assembly). Now with the reverse gear free from the housing remove thrust washes spacer (52), plate (51), spacer (50), springs (48), sleeve (49), circlip (47), ball race (46), yoke (45), cone (44), circlip (36), washer (35). To remove pinions withdraw screws (41), shaft (40), leaving gears (37 and 38) free to be removed from the housing. Withdraw bearing (34) and reverse gear shaft (33) can be withdrawn from gear housing.

TO REASSEMBLE

Assemble gear in reverse sequence to the above instructions to point where spacer (52) and ball race thrust washer is fitted to shaft. Slide brake band over gear housing making sure it is the right way round, then offer up gear assembly to ball race (5) in housing, and fit the other half of thrust washer, refit oil trap (7), key (9), pinion (8), ball race (11), nut (13). Lock reverse gear and tighten nut (13).

The distance between sleeve (49) and retaining plate (51) when nut (13) has been secured should be approximately 5/16″. This locates reduction pinion (8) in correct position to fit reduction gear.

Lubrication—Gear Box and Reduction Gear REDUCTION GEAR

Lubricating oil of the same grade as the ~~engine lubricating~~ oil should be used in the reverse gearbox.

Before initial starting, after installation or overhaul, fill with engine oil to the mark on the reverse gear dipstick. The reduction gearbox should be filled to maximum mark on dipstick with SAE80 oil (temperate climate) or SAE90 (tropical climate). Capacity of 2:1 and 3:1 boxes is 0.5 pts. (0.3 litres).

Efficient lubrication of the epicyclic gears is ensured, oil flung up by the clutch body being caught and deflected back into the gears by a plate mounted on the inspection cover.

The external ends of the reverse gear operating shaft must be oiled frequently to prevent rust formation which may stiffen the shaft. To lubricate the port side of the shaft. the locating screw should be removed and a few drops of oil poured down the hole.

Flexible Coupling

A flexible coupling capable of taking the full thrust of the propeller is supplied to accommodate the movements of resiliently mounted engines. Should any other type of flexible coupling be fitted it must be capable of transmitting this thrust.

If the stern tube inboard gland is more than 9″ from the flexible coupling, a bearing or plummer block must be fitted and positioned as near the coupling as practicable. If an intermediate shaft is installed, this bearing must be fitted close up to the coupling.

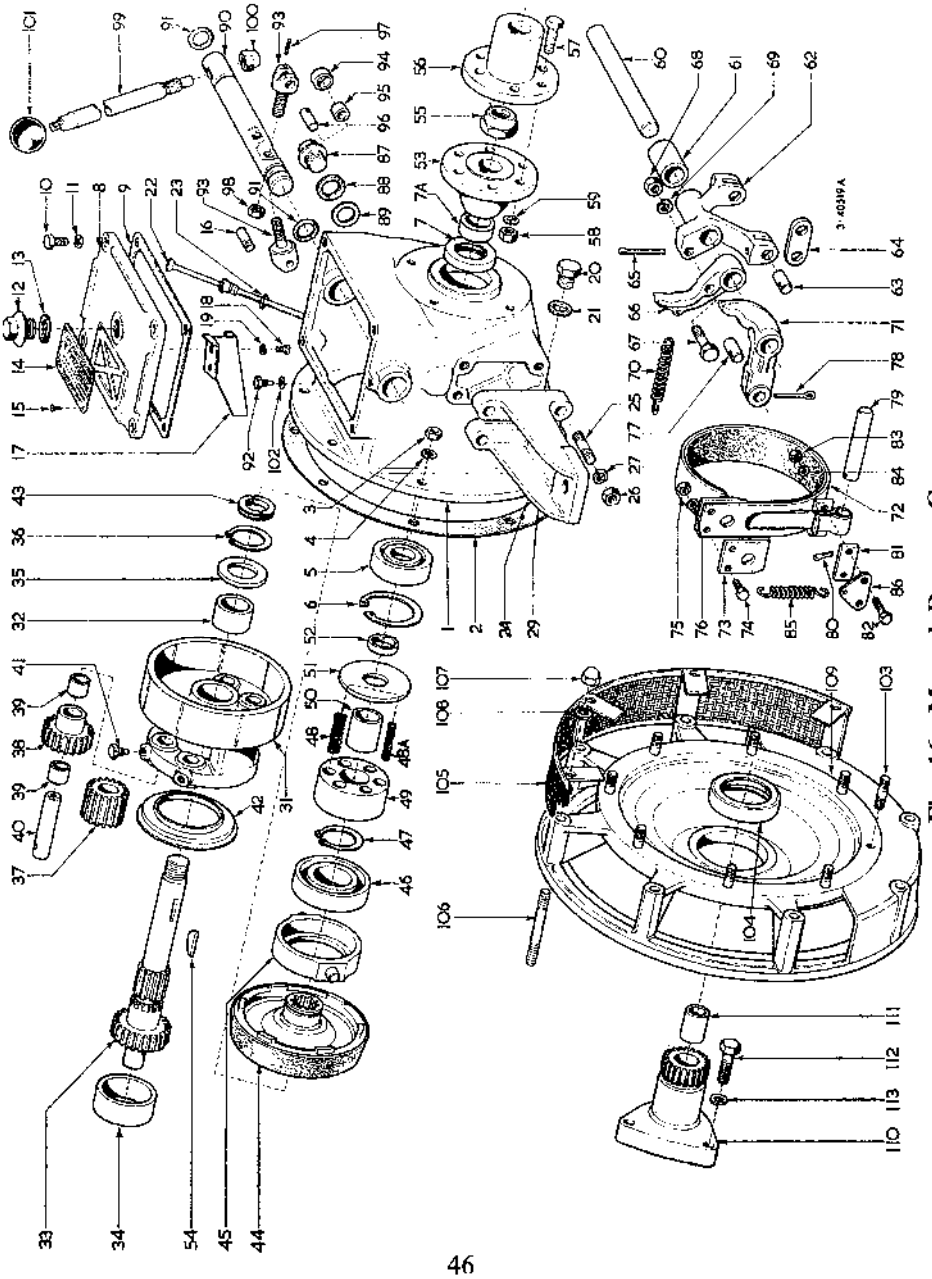


Fig. 16—Manual Reverse Gear

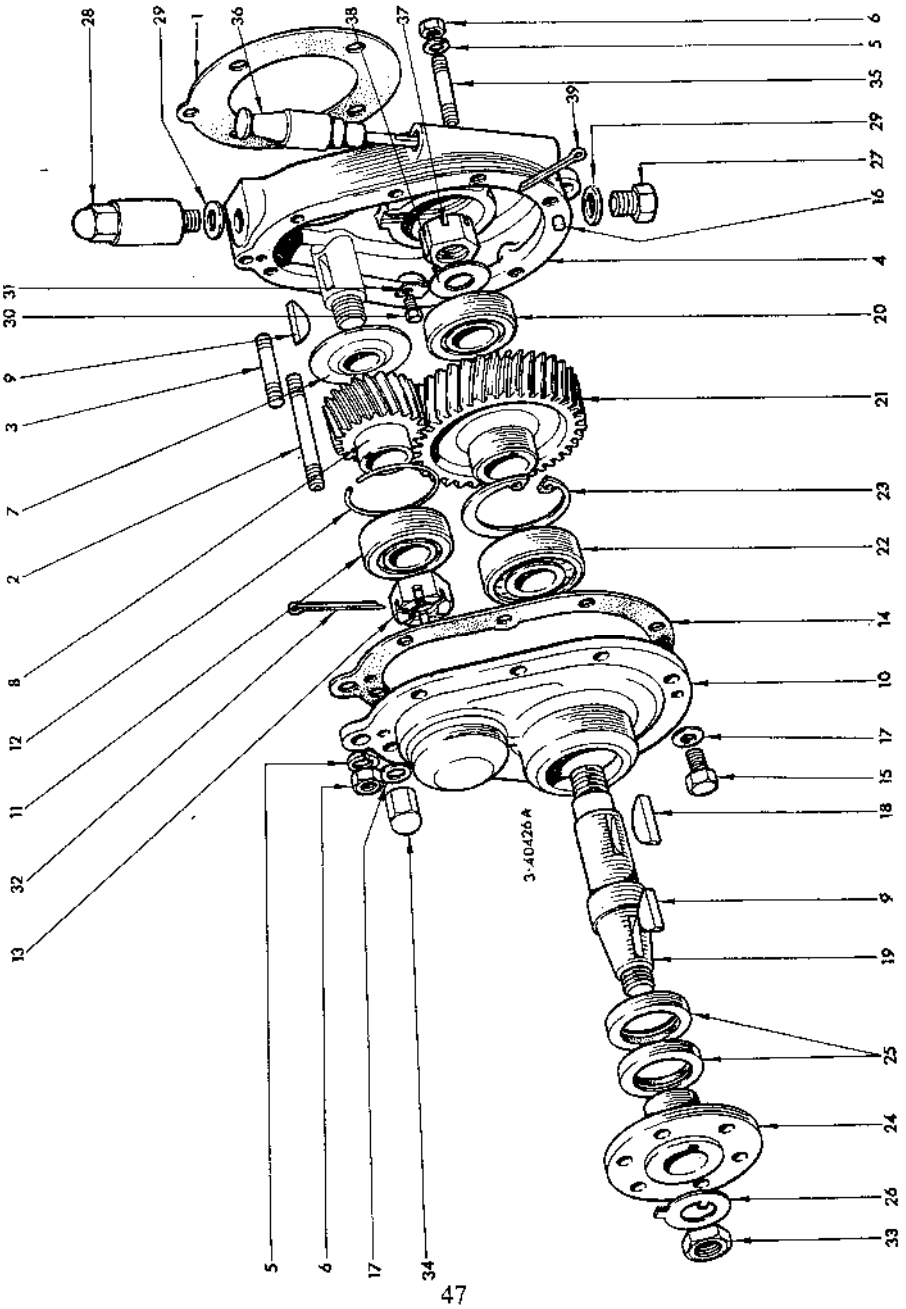


Fig. 17. Reduction Gear

LISTER LH1 HYDRAULIC REVERSING GEAR MAINTENANCE INSTRUCTIONS

Special Features: Hydraulic pressure is used only to obtain "neutral" and "astern" positions. There is no high oil pressure in the ahead position and therefore the power loss in this position is small. If the hydraulic system fails the clutch remains engaged in the ahead position. The propeller shaft remains engaged with the crankshaft until the engine is started when it disengages instantly if the control is in neutral. If it is decided to free the ahead clutch with the engine stopped, as for example, for lining up the engine coupling during installation, the screw "A" is removed, replaced by screw "B" and screwed carefully until the clutch just disengages and no more. The screws must be replaced before starting the engine.

Lubrication: Fill the reversing gear to the mark on the dipstick. Do not overfill. Capacity of reversing gear approximately 2 pts. (1.2 lts.). For engine room temperatures up to 30°C use SAE 80, above 30°C use SAE 90. Change the oil every 1000 hours and clean magnetic drain plug.

Adjustments (See Fig. 18): No regular adjustment of the gear box is required The following settings should be checked once a year or after about 25,000 engagements of the clutch.

Oil Pressure: Connect, with copper pipe having a bore of $\frac{1}{16}$" (1.5 mm.), a 400 psi (28 kg. per sq. cm.) pressure gauge to screw "A", Fig 18.

1. Place control lever in neutral and run engine at about 600/800 r.p.m. The oil pressure should be about 260-280 psi (18.3-19.7 kg per sq.cm.).
2. Remove plug "C", remove screw "D" which is under plug "C" and replace plug. Set control lever in astern position and run engine at about 600/800 r.p.m. (propeller will not turn). The oil pressure should be about 320-340 psi. (22.5-23.8 kg. per sq.cm.). Replace screw and plug in original positions after testing.

If pressure (2) is not correct, within 10 psi. (0.7 kg. per sq. cm), it must be adjusted by removing the relief valve adjusting plug "E" (which is under a seal behind the control lever "K") and inserting or removing shims "F" from under the spring "L". Before making any final adjustments ensure that the correct oil is used and that it is up to working temperature.

Ahead Adjustment: Remove the top cover and adjust screw "H" until the dimension "G" is $\frac{3}{32}$" (2.5 mm.) with the piston pushed right back.

Astern Adjustment: Remove the top cover and slacken nut "I" then holding this nut with a spanner, turn adjusting screw "J" anticlockwise until the brake band is felt to be tight on the drum, then slacken the screw (clockwise) 3 complete turns and lock the nut "T".

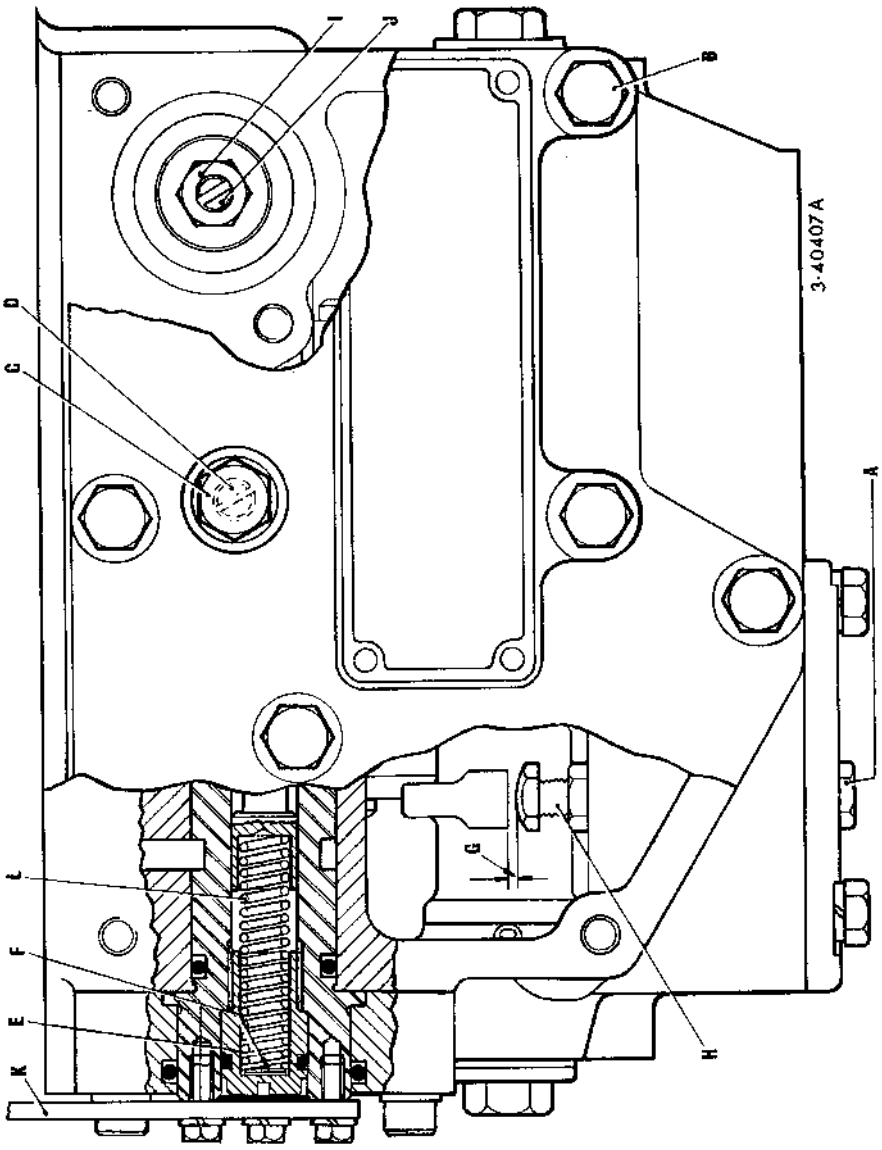


Fig. 18.—Lister Reverse Gear—Hydraulic operated, Control adjusting

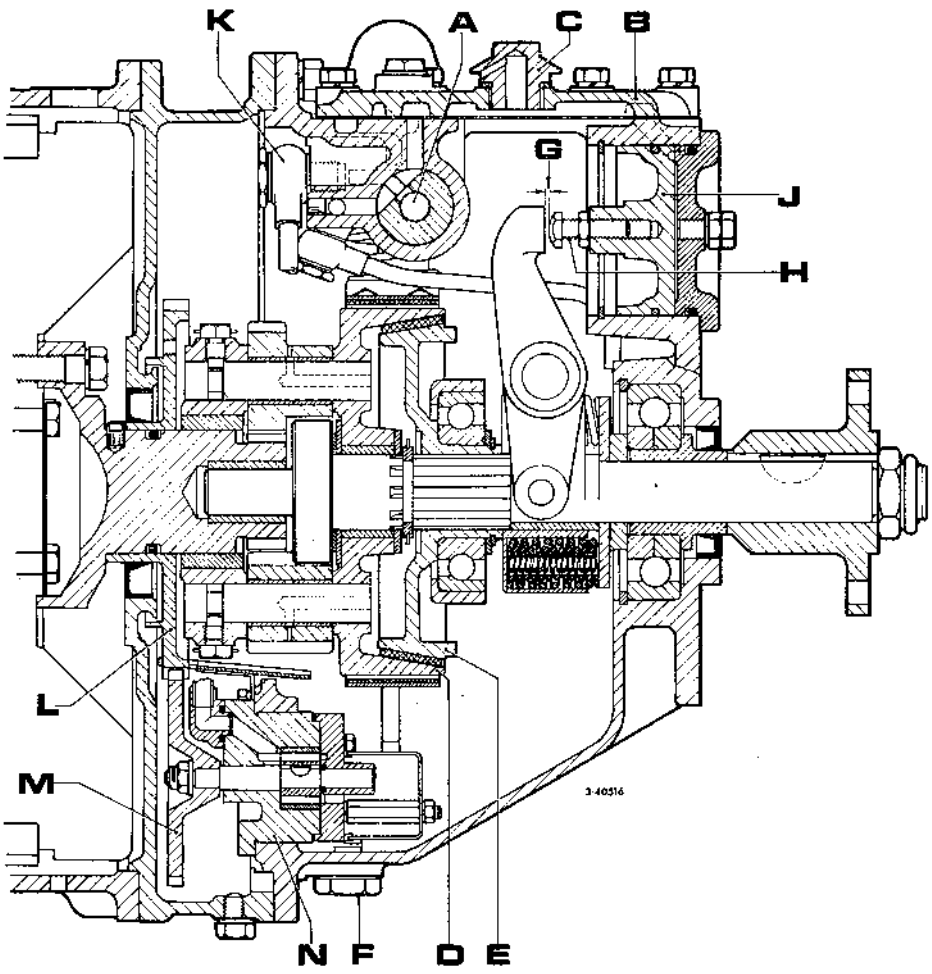


Fig. 19—LH1 Reverse Gear

A—Selector Valve.
B—Inspection Cover.
C—Oil Filler and Breather Plug.
D—Clutch Body.
E—Clutch Cone.
F—Magnetic Drain Plug.
G—Clearance of $\frac{3}{32}$" 2.38 mm.).
H—Adjusting Screw.
J —Astern Piston.
K—Oil Feed Pipe to Selector Valve.
L—Oil Pump Driving Wheel.
M—Oil Pump Driven Wheel.
N—Oil Pump.

LISTER DIRECT DRIVE CLUTCH

Direct Drive Clutch (Lister)

The clutch, fitted to either the crankshaft or camshaft, is of the multi plate type running in oil. 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 it should be released on completion of the movement.

The clutch housing is filled to the level of the side plug with light engine oil (SAE 10). The capacity is approximately $\frac{5}{8}$ imp. pint. An even lighter grade of oil may be used in cold weather to reduce oil drag of driven shaft.

Adjustment—see Fig. 20

The clutch plates are held between pressure plates when fully engaged. It is essential there should be no slip when fully engaged. If the full power is not being transmitted, the clutch should be adjusted as follows:

(1) Stop the engine.

(2) Remove the inspection cover on top of the clutch casing.

(3) With the lever in the "neutral" position, revolve the clutch until the adjusting plunger "C" is accessible.

(4) Pull plunger "C" out of engagement and rotate adjusting ring clockwise 1 to 3 holes, re-engage plunger "C", and then check "feel" of the clutch operating lever. Alter the adjustment until the full power is transmitted without slip.

(5) Do not adjust more tightly than is necessary to transmit the full power without slip.

(6) Ensure the clutch runs freely in the "neutral" position.

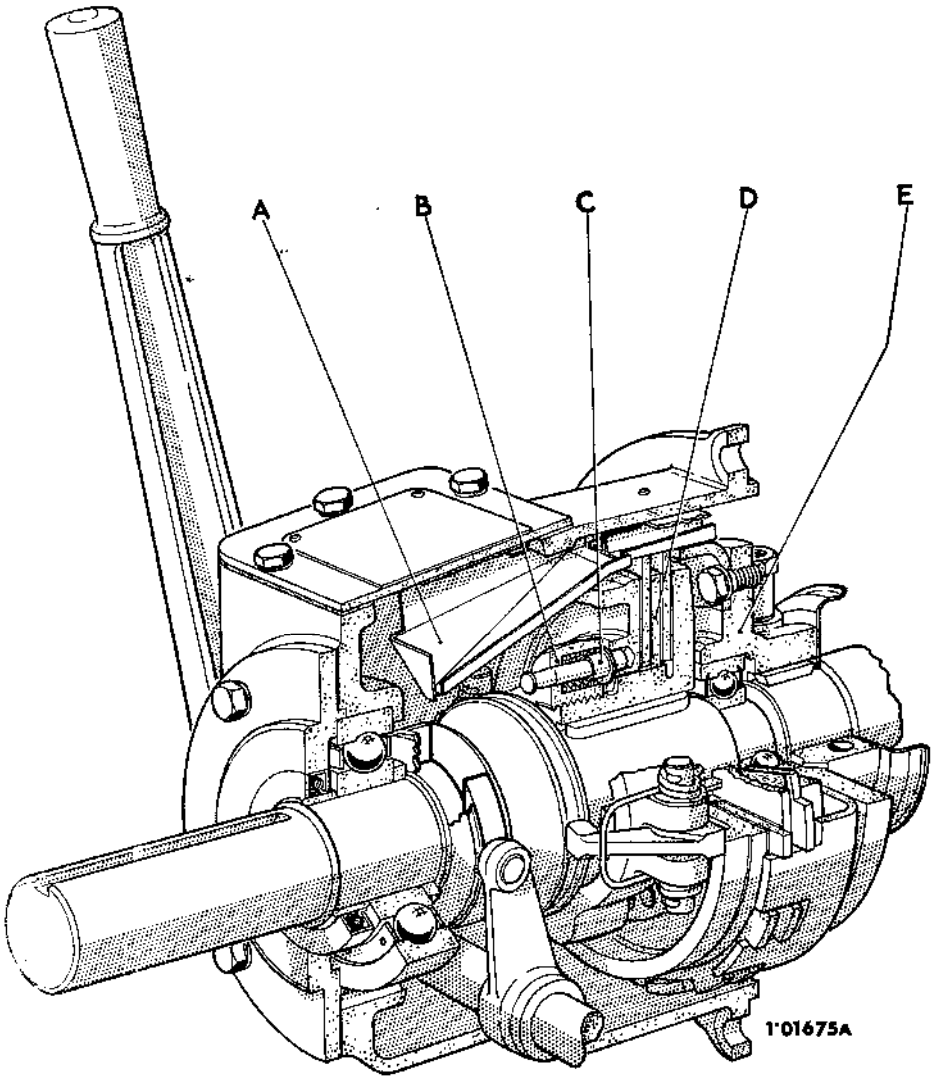


Fig. 20—Lister Clutch

A Lubricating oil return trough.
B Clutch adjusting ring.
C Clutch adjusting plunger.
D Clutch plates.
E Clutch driving member.

SPECIAL TOOLS

(supplied to special order only)

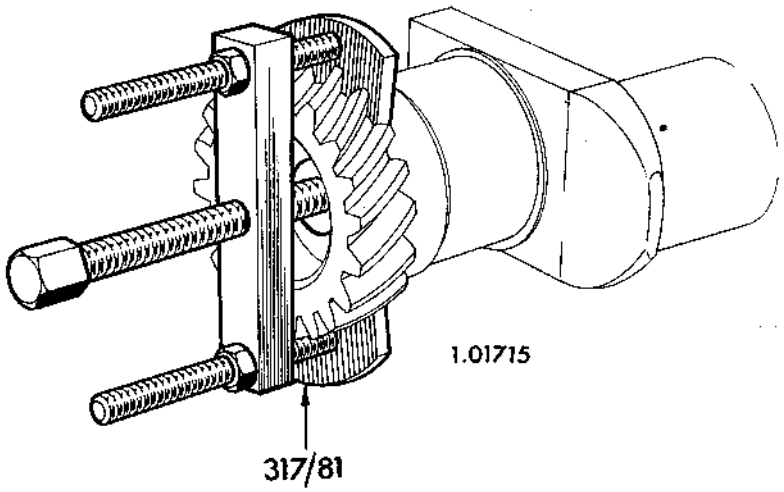


Fig. 21.—Pinion Withdrawal Tool

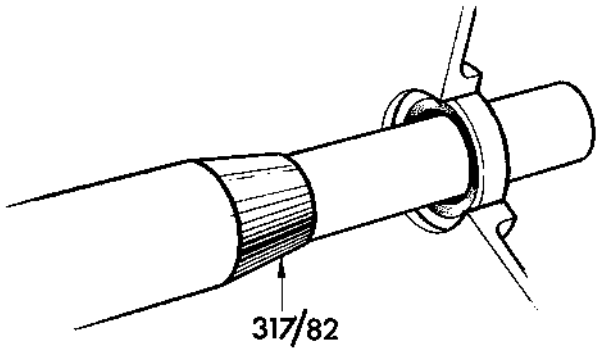


Fig. 22.—Tapered Sleeve.

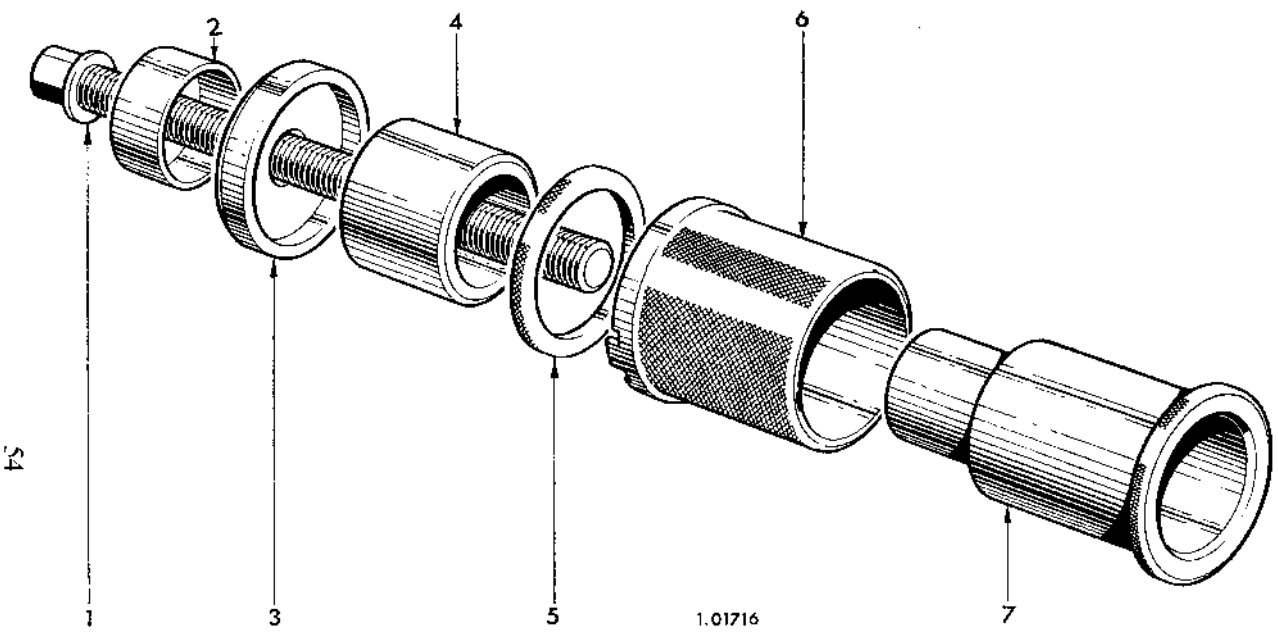


Fig. 23.—Main Bearing Tool Complete — Part No. 317-84

KEY

1. Drawbolt
2. Small Spacer
3. Large Spacer
4. Locating Ring
5. Spacer Ring
6. Sleeve
7. Plug

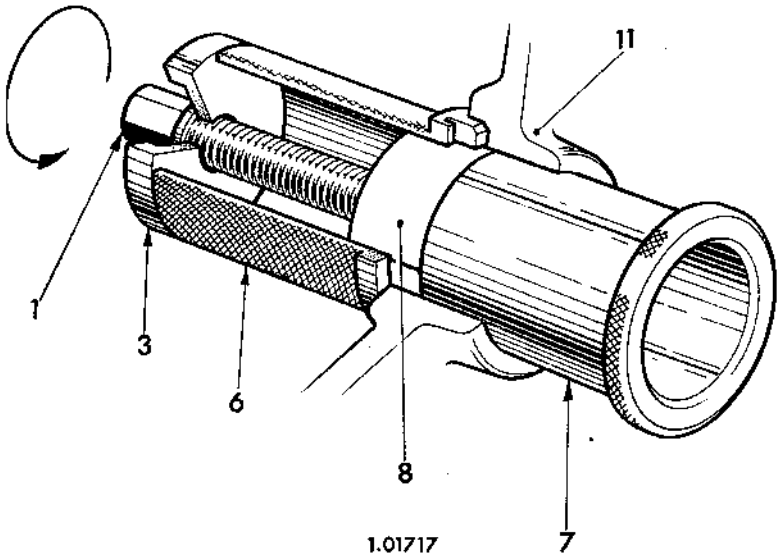


Fig. 24A—Main Bearing Bush Removal

To remove main bearing shells from the crankcase Figure 24A.

(1) Enter the plug (7) with bearing locating ring (4) into bearing (8).
(2) Fit sleeve (6) in position with lug in groove in crankcase (11).
(3) Fit large spacer (3) with its recessed face outwards, and the drawbolt (1).
(4) Tighten the drawbolt and continue tightening until the shells (8) have been drawn into the wide section of the sleeve (6).

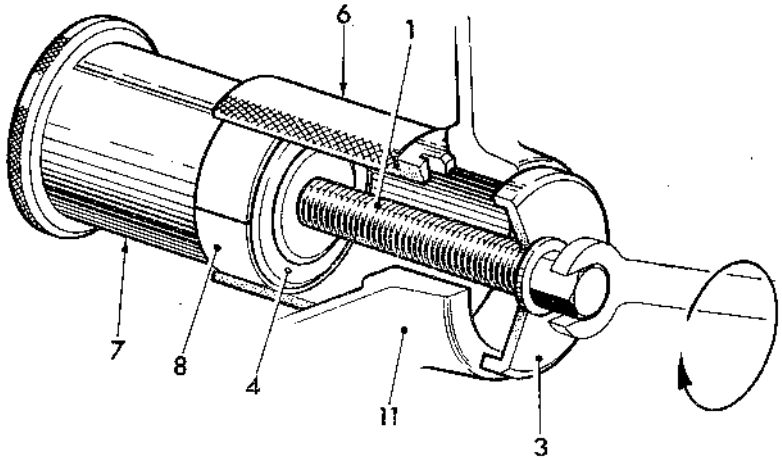


Fig. 24B—Main Bearing Bush Fitting

To fit main bearing shells to the crankcase Figure 24B.

(1) Remove sleeve (6) from the tool and turn the face with the locating lug downwards. Slide the two halves of the new bearing (8) into the top of the sleeve (6) with the locating tag of the bearing upwards.
(2) Reverse the sleeve (6) so that its locating lug is now upwards and slide it, complete with bearing (8), over the bearing locating ring (4) on the plug (7) and press down firmly by hand as far as possible ensuring that the widest diameter of the plug is actually entering the sleeve.
(3) Insert the tool with the bearing and sleeve into the crankcase (11), ensure that the lug on the sleeve (6) enters the groove in the crankcase.
(4) Fit the large spacer (3) and drawbolt (1), the plain face of spacer (3) should be outwards, draw up bolt and continue tightening until the plug meets the sleeve.

NOTE:—Main bearings in housings can be removed and fitted with this tool if the housing is carefully held in a vice.

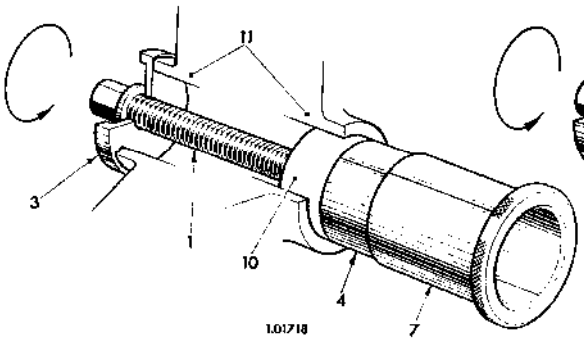


Fig. 25A—Camshaft Plain Bush Removal.

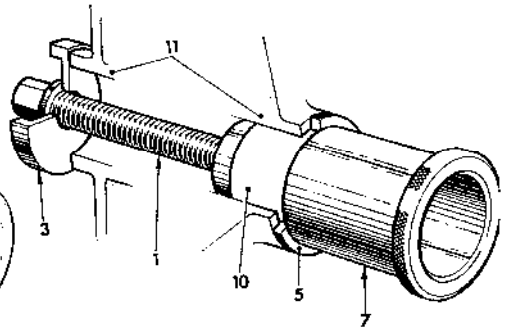


Fig. 25B—Camshaft Plain Bush-Fitting

Figure 25A—To remove camshaft bush (plain).

(1) Place plug (7) with sleeve (4) in position as sketch.
(2) Fit draw bolt (1) and spacer (3), with recessed face of spacer outwards, tighten draw bolt and continue tightening until bush (10) is withdrawn. Care must be taken to ensure that the plug (7) and sleeve (4) are accurately positioned and will not foul the crankcase when the draw bolt is tightened.

Figure 25B—To insert camshaft bush (plain).

(1) Place the spacer ring (5) on the plug (7).
(2) Place bush (10) on plug (7)—note the sleeve (4) is not required.
(3) Insert plug with bush in crankcase and fit large spacer (3) and drawbolt (1). Tighten drawbolt until bush is drawn into position.

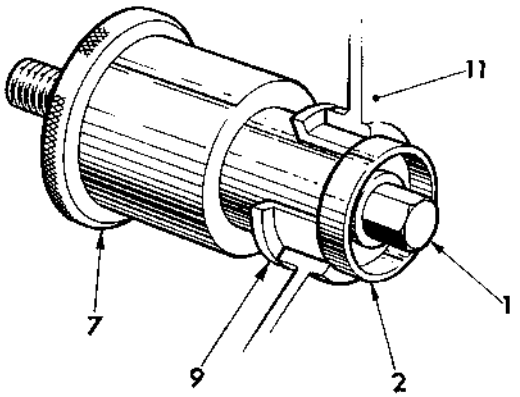


Fig. 26A—Camshaft Flanged Bush Removal

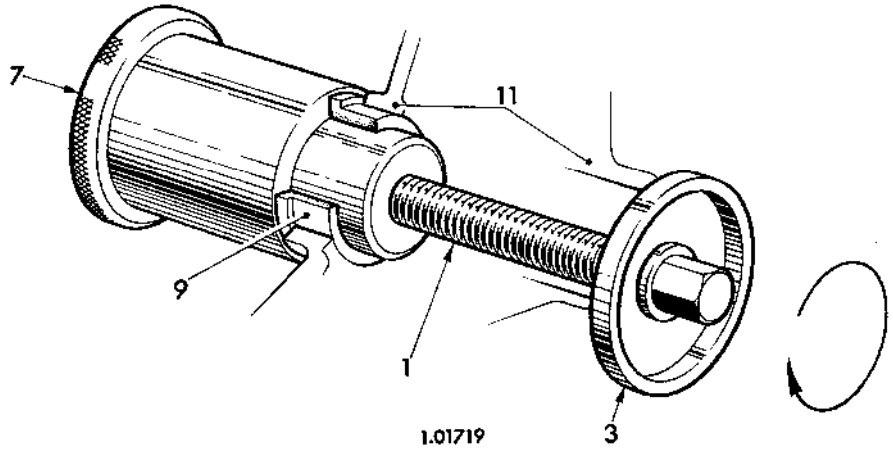


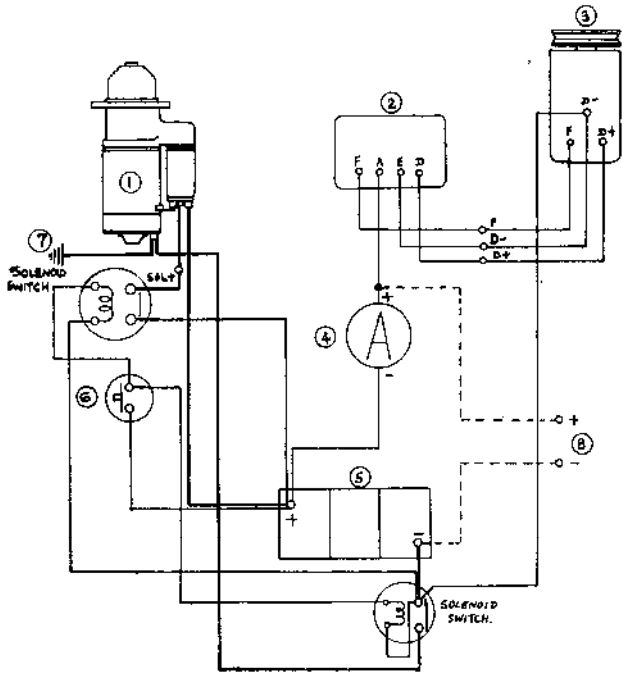
Fig. 26B—Camshaft Flanged Bush Fitting

Figure 26A—To remove camshaft bush (flanged).

(1) Insert plug (7) into bush (9).
(2) Fit small spacer (2), with recessed face outwards, fit drawbolt (1) and tap out bush using a drift on end of draw bolt.

Figure 26B—To fit camshaft bush (flanged).

(1) Place bush (9) on plug (7) as in sketch.
(2) Fit large spacer (3)—with recessed face outwards—and drawbolt (1).
(3) Tighten drawbolt and continue tightening until bush (9) is drawn into place.



1. Starter Motor.
2. Controller Unit.
3. Dynamo.
4. Ammeter.
5. Battery.
6. Starter Push Button.
7. Engine Earth.
8. Light—must not exceed 10 amps.

12v. Electric Starting Equipment Wiring Diagram ED.10916.

ELECTRIC STARTING INCORPORATING LUCAS AC5 ALTERNATOR

The following points must be strictly observed when an AC5 alternator is fitted otherwise serious damage can be done.

(a) NEVER disconnect the battery whilst the alternator is running.

(b) NEVER disconnect a lead unless the alternator is stopped and any/all switches are in the "OFF" position.

(c) ALWAYS ensure that leads are fitted to their correct terminals. A short circuit or reversal of polarity will ruin the diodes or transistors.

(d) NEVER connect a battery into the system without checking that voltage and polarity are correct.

(e) NEVER "flash" the connections to check current flow.

(f) NEVER experiment with adjustments or repairs to the system.

The foregoing must be strictly observed at all times.

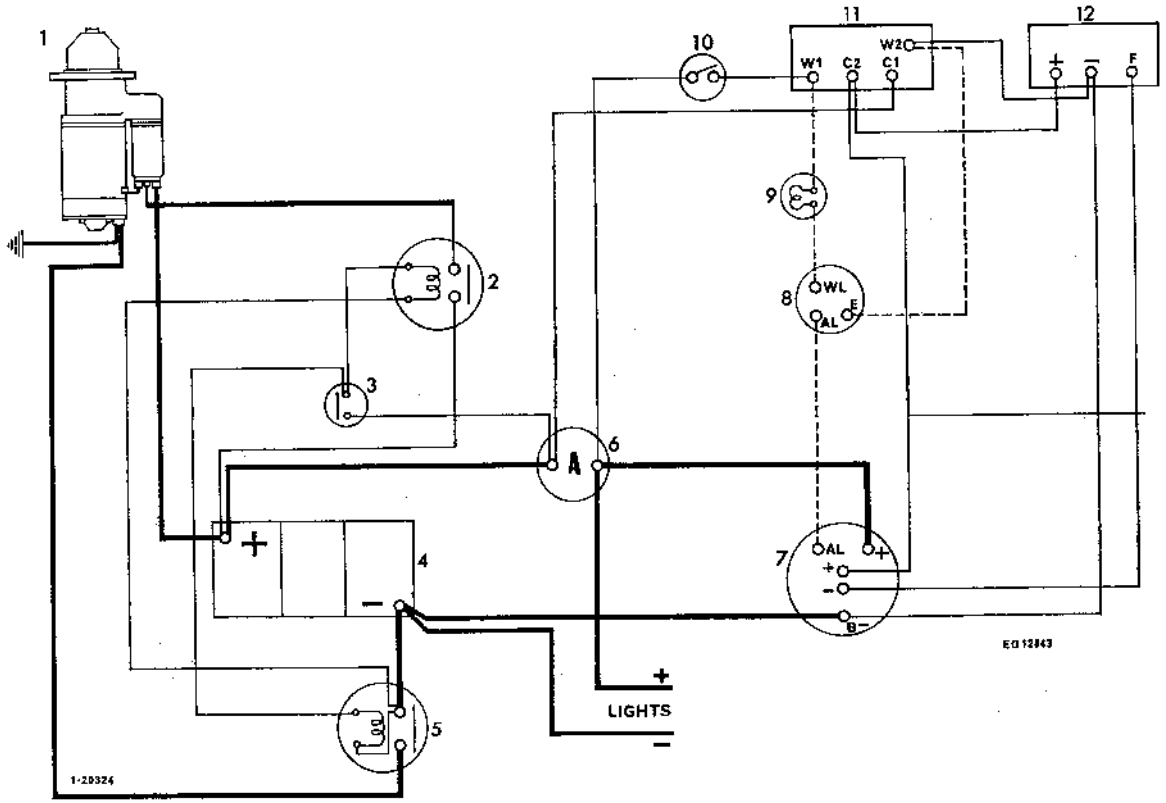
Maintenance

The maintenance as carried out by the operator should consist of the following only :—

(a) Keep the alternator clean. A cloth moistened with Kerosene or white spirit may be used.

(b) Ensure that the driving belt is in good condition and neither too tight nor too slack.

A fair check is when the belt, midway between the pulleys, can be turned 90° by hand.



12 Volt Electric Starting incorporating 11AC Alternator

1. Starter Motor.
2. Solenoid Switch.
3. Starter Push Button.
4. Battery.
5. Solenoid Switch.
6. Ammeter.
7. Alternator.
8. Warning Light Control.
9. Warning Light.
10. Isolator Switch.
11. Excitation Relay.
12. Alternator Control.

IMPORTANT

SPARE PARTS—DIRECTIONS FOR ORDERING

1. Always quote the **Engine No., Part No. and Description of Part** when ordering spare parts. The engine number will be found on the plate on the fuel pump housing door and stamped on the flywheel rim.

2. The engine components have been divided into convenient groups and illustrated. DO NOT quote illustration number when ordering.

3. Standard rotation is clockwise when looking on flywheel end.

4. Unified threads are used where applicable throughout the engine.

5. Undersize/Oversize parts, crankshaft, main bearings and connecting rod big end bearings may be obtained 0.010″, 0.020″ and 0.040″ undersize. Pistons and piston rings may be obtained 0.010″, 0.020″, and 0.040″ oversize.

INDEX

TO

LIST OF PARTS AND ACCESSORIES IN BOOK 1420 PL

Description

INDEX (Cont.)

Description

IMPORTANT

Unified threads conforming to International Standard are used where applicable.