BOOK 1029/470 PRICE 10/-

LISTER

INSTRUCTION MANUAL

&

PARTS LIST

AIR COOLED

DIESEL ENGINES

TYPES LRM & SRM
1 - 2 - 3 CYLINDERS

LISTER BLACKSTONE MIRRLEES MARINE

(Proprietors: R. A. LISTER & CO. LTD.)

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.

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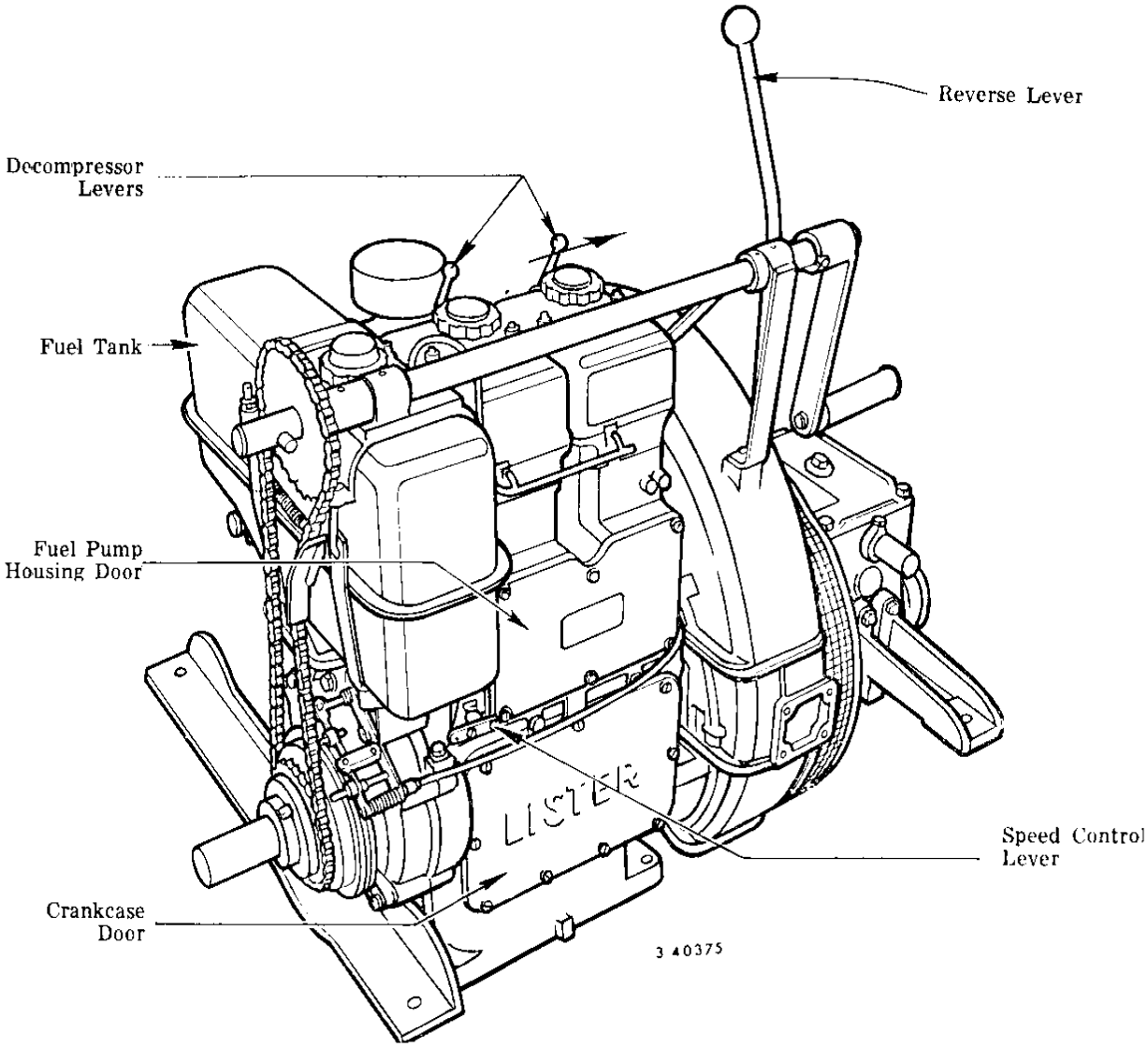


Fig. 1. Typical twin cylinder LR/SR propulsion engine

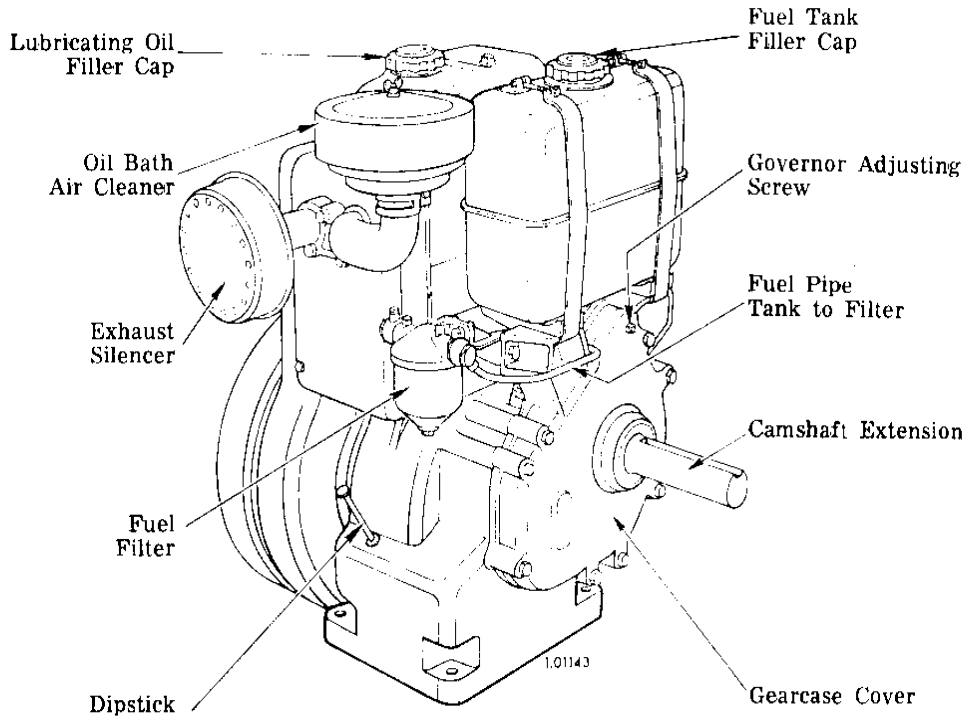


Fig. 2. Type SR1 Engine—Manifold Side

TECHNICAL DATA

	LR1	LR2	SR1	SR2	SR3
RATED BHP (BS 649:1958) continuous					
2000 rpm	4.5	9	6.5	13	19.5
1800 rpm	4	8	6	12	18
1500 rpm	3.3	6.6	5	10	15
1200 rpm	2.6	5.2	4	8	12
1000 rpm	2.1	4.2	3	6	9
750 rpm	1.5	3	—	—	—
MAXIMUM GROSS BHP	5.75	11.5	8.15	16.3	22.5
NUMBER OF CYLINDERS ...	1	2	1	2	3
B.M.E.P. (1800 rpm) lbs/sq.in. ...	—	—	78.4	78.4	78.4
kg/sq.cm. ...	—	—	5.5	5.5	5.5
(2000 rpm) lbs/sq.in. ...	72	72	—	—	—
kg/sq.cm. ...	5.06	5.06	—	—	—
BORE x STROKE ins.	3 x 3½	3 x 3½	3½ x 3½	3½ x 3½	3½ x 3½
mm.	76.2 x 88.9	76.2 x 88.9	88.9 x 88.9	88.9 x 88.9	88.9 x 88.9
CYLINDER CAPACITY c.ins. ...	24.7	49.5	33.7	67.3	101.0
c.cm. ...	405	811	552	1103	1655
FUEL CONSUMPTION at full load lbs/bhp/hr.					
subject to 5% 2000 rpm	0.49	0.49	0.45	0.45	0.44
BS tolerance 1800 rpm	0.49	0.49	0.44	0.44	0.43
1500 rpm	0.485	0.485	0.43	0.43	0.42
1200 rpm	0.5	0.5	0.435	0.435	0.425
1000 rpm	0.51	0.51	0.44	0.44	0.43
LUBRICATING OIL CONSUMPTION	Less than ¾% of full load fuel consumption				
†LUBRICATING OIL SUMP Pt.	3½	9½	3½	9½	13½
CAPACITY (engine level) Litres	2.0	5.4	2.0	5.4	7.7
EXHAUST CONNECTION BSP ins.	1	1¼	*1¼	1¼	1½
WEIGHT Approximate Nett. lbs.	222	405	250	415	475
kg.	101	184	114	189	216
STANDARD ROTATION IS CLOCKWISE LOOKING AT FLYWHEEL END On multi-cylinder engines No. 1 cylinder is at end opposite flywheel					

†When there is no lubricating oil filter used.

*With reducing socket.

Engine Rating

The engine is rated in accordance with BS649:1958, i.e. the engine will develop its rated HP continuously including 10% overload for a period not exceeding one hour in any period of twelve hours consecutive running.

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 settling 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 24).
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 of lubricating oil per cylinder over the valve gear.
3. *Check, and tighten, the nuts on the following joints : end cover, cylinder head cover(s), 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 page 19.

Lubricating Oil

Always use oils of the correct viscosity and type (Heavy Duty diesel engine detergent lubrication oil). (See " Lubrication " page 14).

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

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

Size	Torque		
	lb.ft.	kg.m	Component
¼" UNF	10	1.38	———
5/16" UNF	15	2.07	Injector clamp nuts, big end nuts.
⅜" UNF	32	4.4	Balance weight setscrews.
7/16" UNF	50	6.9	Cylinder head nuts.
½" UNF	68	9.4	
¾" 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 such as centre bolts in crankcase doors or, in the case of studs in aluminium parts, unless a thread insert is fitted which has a length of thread engagement of 1½ times the thread diameter.

INSTALLATION OF AIR COOLED MARINE ENGINES

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

Careful consideration should be given to the layout 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

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 nett 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.

Adaptors can be supplied at an extra charge to take circular flexible hoses for hot air discharge on LR1 and SR1 Engines.

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.

EXHAUST

Pipes should slope gradually away from the engine down to the outlet on ships side or transom and be kept as straight and short as possible, the minimum radius in any bend being not less than 5 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 should be fitted at the lowest point in the pipe.

Exhaust Pipe Diameter

	LR1/SR1	LR2/SR2	SR3
Up to 20ft.	1"	1¼"	1½"
Over 20ft.	1¼"	1½"	2"

CASINGS OR COMPARTMENTS

These can be constructed of ⅜" bonded marine plywood to BSS 1080 on substantial framing and having 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 57-$\frac{3}{32}$" 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 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.

With the LR/SR range of air cooled engine the fan and gearbox may be outside of the casing but from the point of view of noise and protection we strongly recommend that they are housed within the engine casing with the necessary openings for the air to the cooling fan.

PROPULSION ENGINE

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.

Since NO PROVISION is made in the engine design to take END THRUST, a thrust block must be provided for all propulsion installations other than those supplied with Lister type Reverse/Reduction Gears.

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.

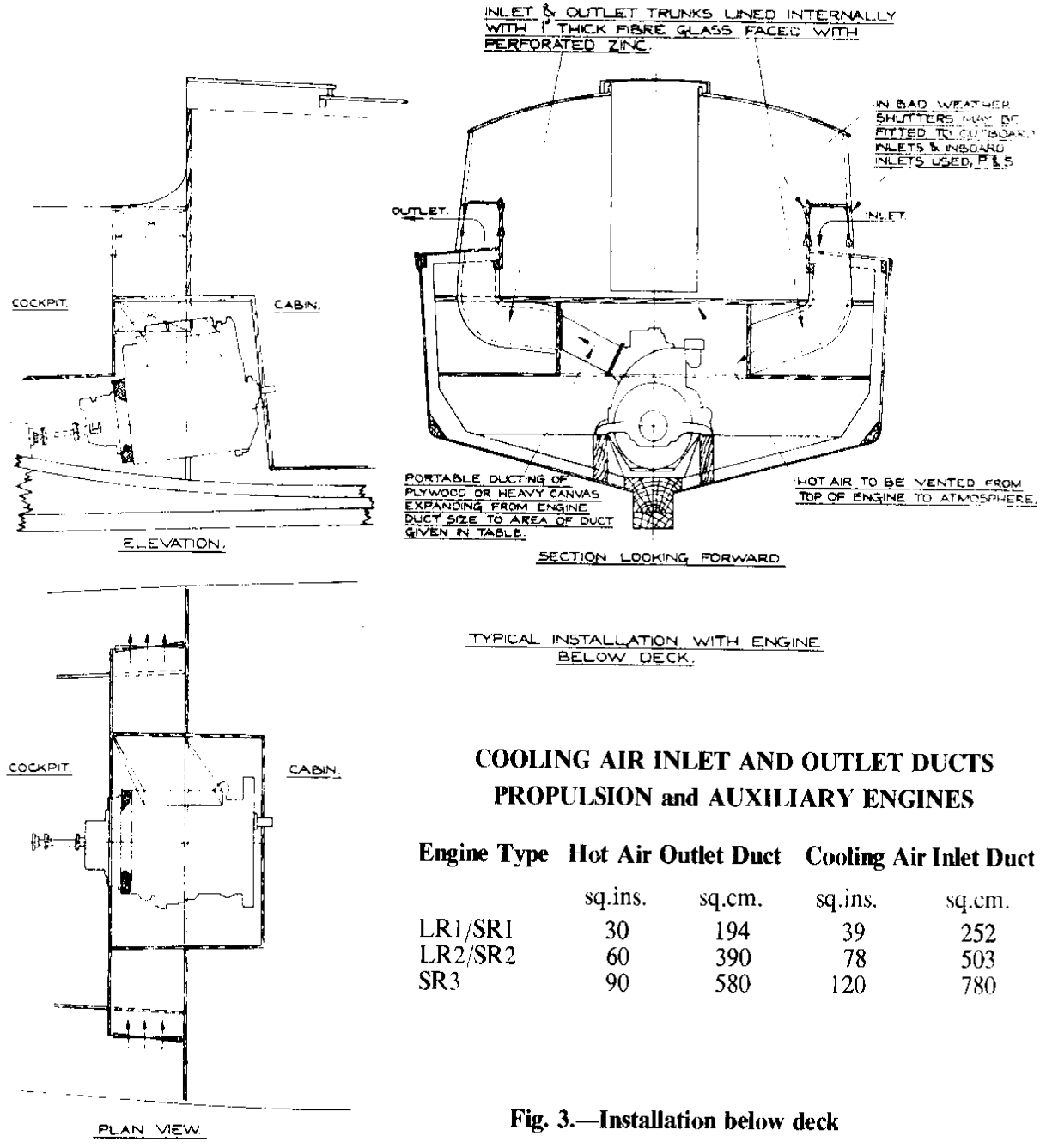
Propellers must run in adequate apertures and never behind heavy square ended body posts. These should be tapered off to an inclusive angle of about 40°. The distance between the outboard gland and the propeller boss should not be greater than the diameter of the shaft.

STERNGEAR

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.

FLEXIBLE MOUNTINGS

Allowance must be made for the engine to clear bearers by at least ½", and to clear any casing, including air ducts, or deflectors which might be fitted by 1" to allow for engine movement.



COOLING AIR INLET AND OUTLET DUCTS PROPULSION and AUXILIARY ENGINES

Engine Type	Hot Air Outlet Duct		Cooling Air Inlet Duct	
	sq.ins.	sq.cm.	sq.ins.	sq.cm.
LR1/SR1	30	194	39	252
LR2/SR2	60	390	78	503
SR3	90	580	120	780

Fig. 3.—Installation below deck

The above are the minimum areas required for trunking up to 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 6′ 0″ long the above areas must be increased as follows:

6′ to 10′ multiply by 1.4

10′ to 25′ multiply by 2.25

25′ to 50′ multiply by 3.50

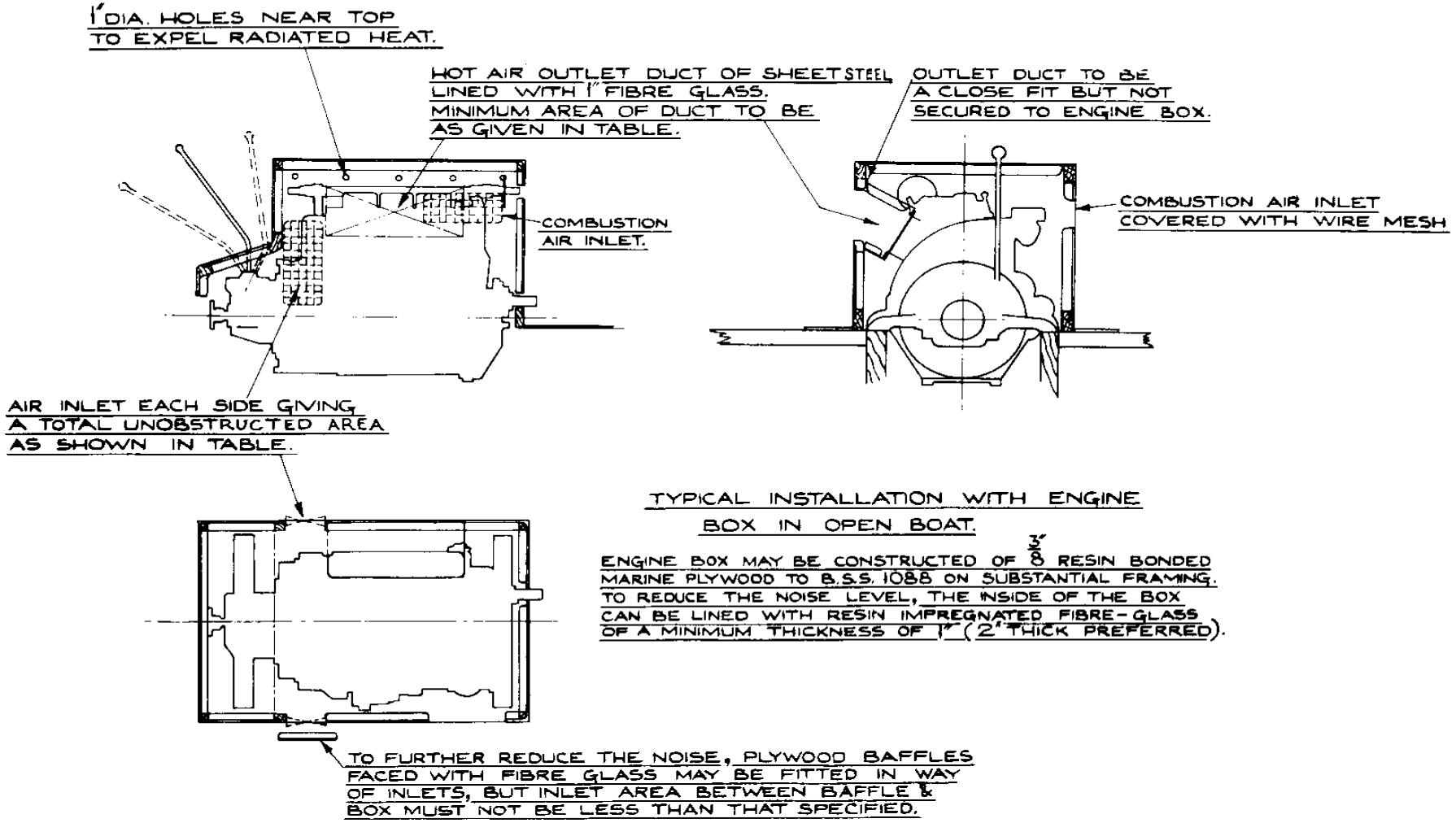
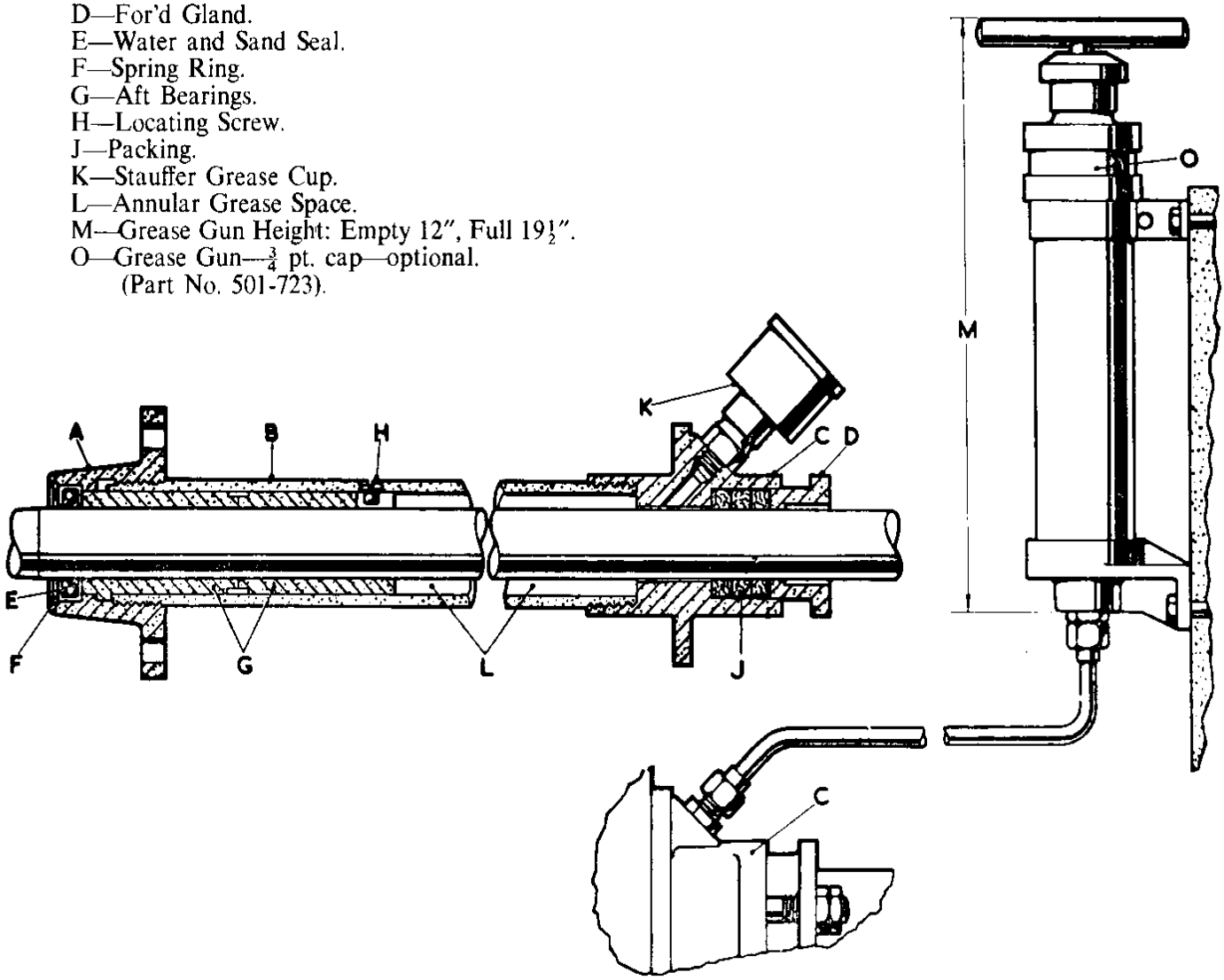


Fig. 4.—Installation in open boat.

Fig. 5.—Stern Gear

KEY

A—Tail Housing.
B—Stern Tube.
C—For'd Bracket.
D—For'd Gland.
E—Water and Sand Seal.
F—Spring Ring.
G—Aft Bearings.
H—Locating Screw.
J—Packing.
K—Stauffer Grease Cup.
L—Annular Grease Space.
M—Grease Gun Height: Empty 12", Full 19½".
O—Grease Gun—¾ pt. cap—optional.
(Part No. 501-723).



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	1"—25.4 mm.	1¼"—31.75 mm.	1½"—38 mm.	1¾"—44.25 mm.
Engine	SR1MG/R LR2MG SR2MG	LR2MGR2 SR1MGR3 SR2MGR2 SR3MG	SR2MG/R3 SR3MG/R2	SR3MG/R3
Grease Capacity approx. Pints	.6	.75	.49	.96
Litres	.34	.41	.28	.54

AMBIENT TEMPERATURES AND ENGINE DERATING FOR HIGH AMBIENT 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 engines 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 measured at the fan inlet. The highest 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 (as defined above) up to 29.4°C (85°F) without derating. Above this temperature, the rated brake horsepower must be reduced by 1% 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 Lister Blackstone Mirrlees Marine and their distributors must be consulted.

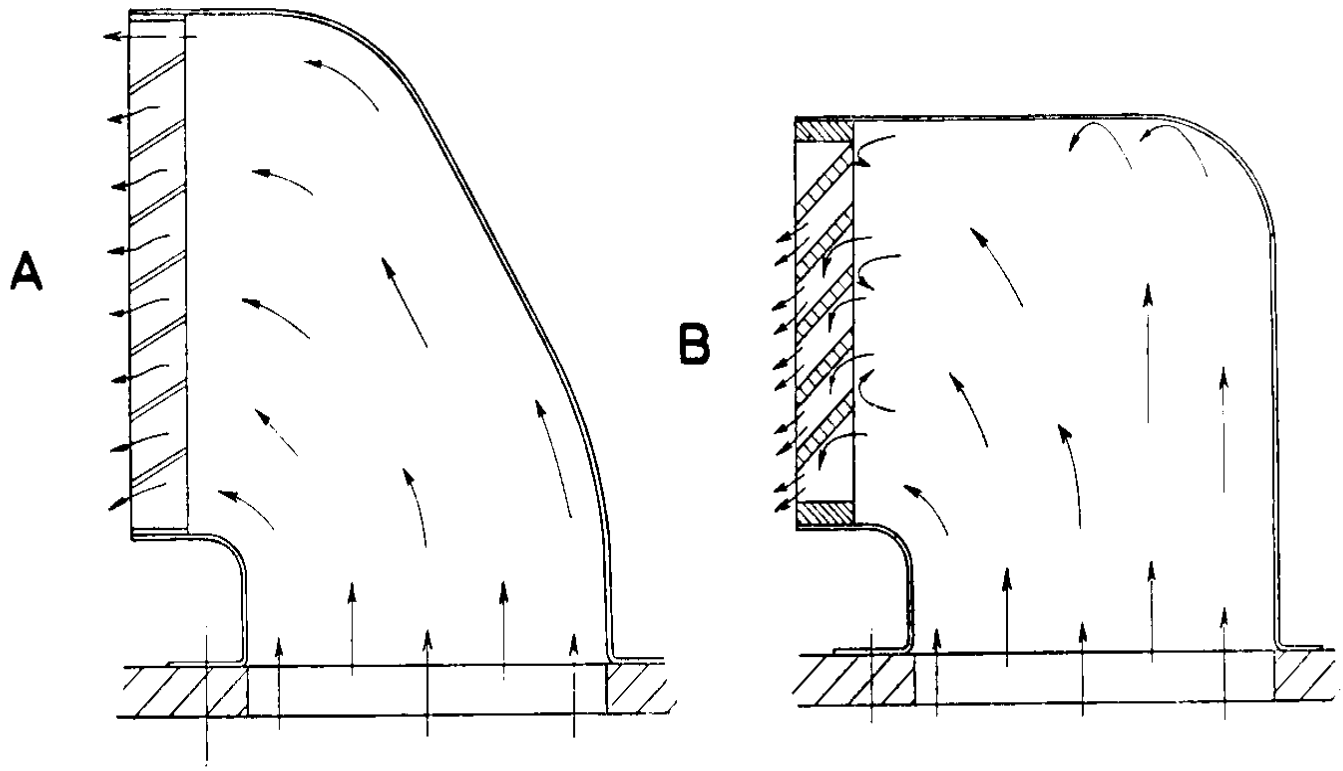


Fig. 7—Cowls

CORRECT—

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

WRONG—

B Louvres or grille obstructs air flow. Area through louvres is smaller than area of ducting.

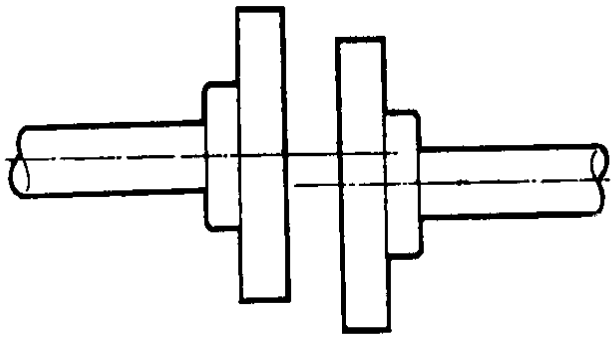
Grilles, wire mesh or louvres placed in the air stream are obstructions and allowance must be made for them. The free flow area of these must be calculated to ensure that it is at least 25% greater than that specified for the inlet and outlet passages.

Alignment — Fig. 8

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 minimised if proper attention is paid to the alignment problem.

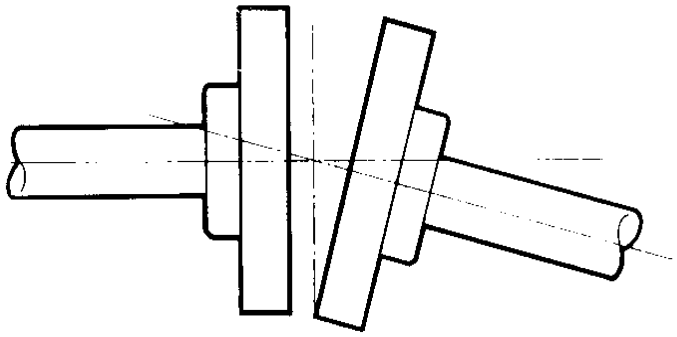
Two principal types of misalignment can occur—parallel misalignment and conical misalignment, or there can be a combination of these two.

(a) **Parallel Misalignment** — when the shaft of the driven unit is parallel to, but not in line with, the engine output shaft.



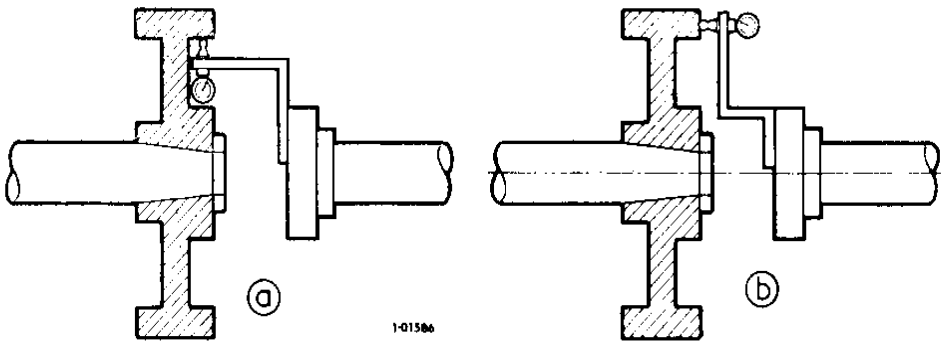
(i)

(b) **Conical Misalignment** — when the axes of the two shafts meet at the correct point, but the shafts are not parallel to each other.



(ii)

Each type of misalignment is checked individually by having a bracket or clock gauge rigidly bolted, where suitable, to the flange of the driven unit and rotating 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.



(iii)

Rotation

Standard rotation is clockwise looking on the gearcase end of the engine.

LUBRICATION

Specification

LR and SR engines must be run on Heavy Duty Diesel lubricating oils to specification — DEF2101C or BS1905 or MIL-L-2104A. Straight mineral oils are not suitable, neither are oils of less detergency than specified.

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

Series 3 oils must be used when oil changes are made at periods longer than 250 hours under the same conditions as shown for MIL-L-2104B above.

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

Viscosity	SR	LR
Below 32°F (0°C)	SAE 10W	SAE 10W
Between 32°F (0°C) and 85°F (30°C) ...	SAE 20/20W	SAE 10W
Above 85°F (30°C)	SAE 30	SAE 20/20W

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 to 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 lbs./sq.in. (1.4 kg./sq.cm.) is adequate.

The crankcase may be drained through a drain plug at the back of the engine, or alternatively a sump drain pump may be fitted.

Before Starting or After Overhaul

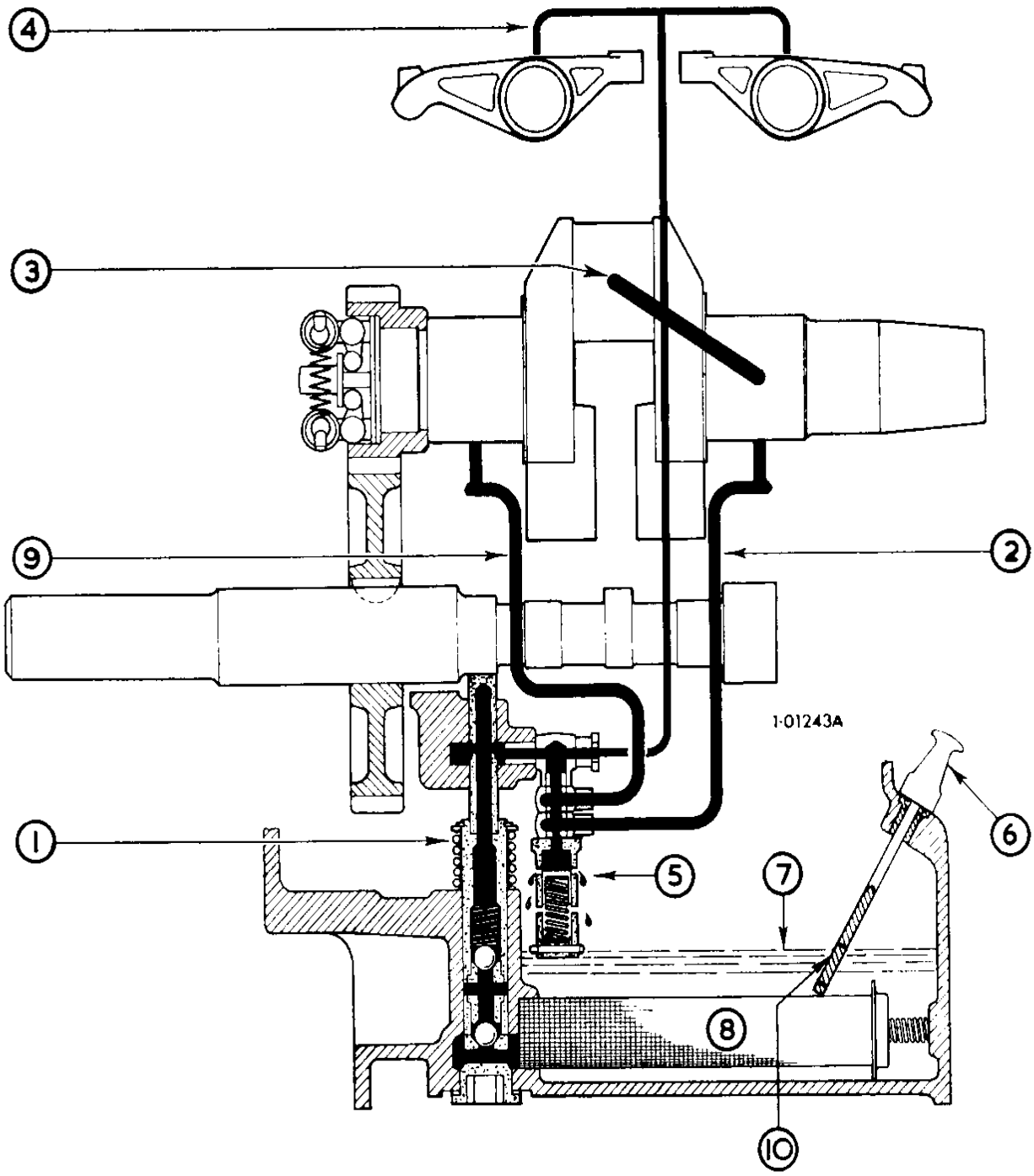
Fill the engine crankcase through the oil filler to the mark " max. " on the dipstick. Top up when the engine has been stopped after the initial run.

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

Lubricating Oil Sump Capacity

Engine	Dipstick Position	Dipstick Identification No.	Max. angle of inclination at which the engine may be run Flywheel Down	Flywheel Up	Approx. Oil capacity with engine level pints	litres
LR1-SR1	Crankcase	1	10°	10°	$3\frac{1}{2}$	2
	Crankcase Door	17	10°	10°	$3\frac{1}{2}$	2
LR2-SR2	Crankcase	16	15°	15°	$9\frac{1}{2}$	5.4
	Crankcase Door	19	15°	15°	*$9\frac{1}{2}$	5.4
	Crankcase Door	18	15°	13°	**$11\frac{5}{8}$	6.6
SR3	Crankcase	4	10°	10°	$13\frac{3}{8}$	7.6
	Crankcase Door	8	15°	15°	**12	6.8
	Crankcase Door	19	15°	10°	*16	7.7

*Door with lift pump, oil filter and filler.
**Door with dipstick only.



1. Lubricating oil pump.
2. Oil pipe to main bearings.
3. Oil passage to big end bearings.
4. Oil pipe to valve rockers.
5. Lubricating oil relief valve.
6. Lubricating oil dipstick.
7. Lubricating oil level.
8. Lubricating oil suction strainer.
9. Oil passage to crankcase main bearing.

Oil Level

Fig. 9.—Schematic diagram of Lubricating Oil System.

FUEL SUPPLY

It has not been found practicable to recommend any particular fuel for universal use, but the fuel must be a distillate, and not a residual oil or a blend thereof. It should have a Specification conforming to British Standard No. 2869:1957, Class A.

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 engine is capable of dealing with the fuel at the lowest temperature to which it may 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.

Vaporising oils are unsuitable as fuel for Lister diesel engines.

Fuel Tank

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 petrol can.

Leak-off from injectors must be led back to the fuel tank and NOT into the suction line.

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 14 and 30).

(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 lever(s) over towards 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 chamber(s) and the lubricating oil system.

(j) Turn the handle smartly in a clockwise direction and whilst still turning, move the decompressor lever(s) 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".

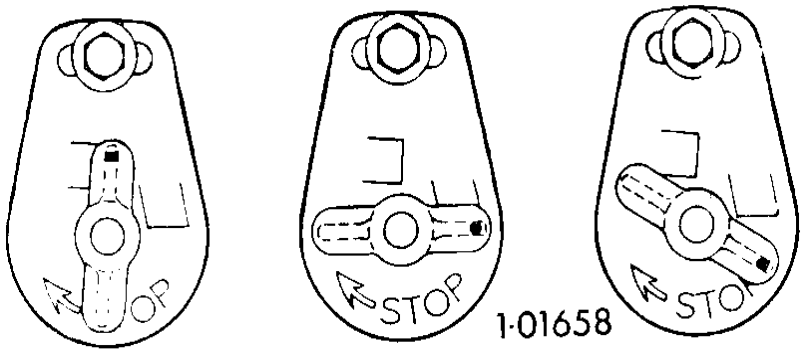


Fig. 10—Engine Control

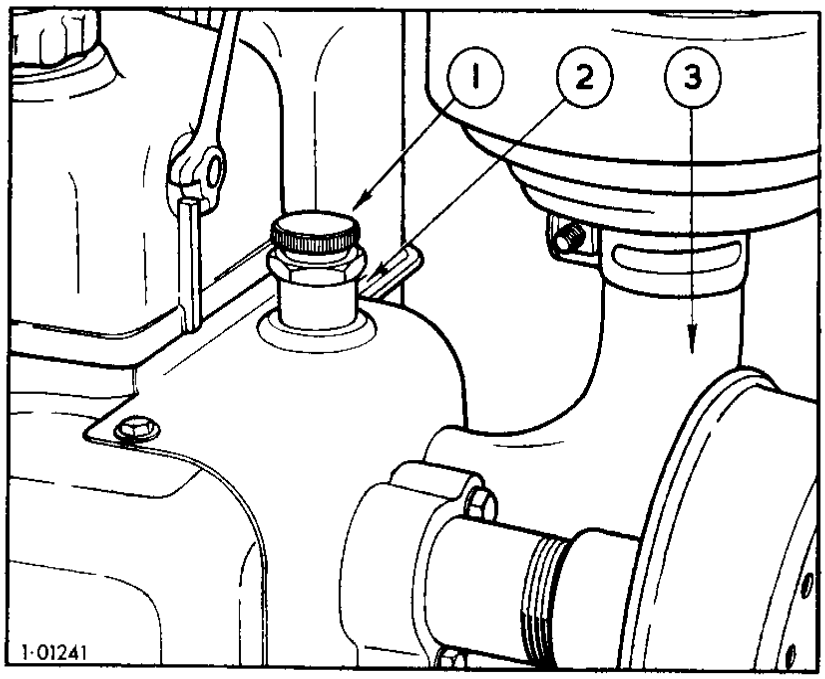
Starting Under Cold Conditions—Standard on LR engines; Optional on SR engines.

An oil cup, mounted on the inlet valve port, is provided to assist starting under frosty conditions and should be used as follows:—

For starting under normal frosty conditions the cup should be half filled with SAE10W lubricating oil, the plunger pressed to the bottom of its stroke and the engine turned at least 5 complete revolutions with the exhaust valve decompressed. The engine should then be started in the usual way.

For starting under extremely frosty conditions the cup should be completely filled with a mixture of 50% fuel oil and 50% SAE10W lubricating oil and the procedure then followed for normal frosty conditions.

The fuel and lubricating oil must be suitable for the temperature at which the engine has to be started — they must have a pour point lower than this temperature. For temperatures below 0°F it is permissible to dilute the SAE10W lubricating oil with up to 25% fuel oil, and to run and top up the sump with this mixture, or use SAE5W lubricating oil.



1.—Plunger.

2.—Oil Cup.

3.—Air Inlet.

Fig. 11.—Cold starting Oil Injector Device — standard on LR engines; optional on SR engines.

To Stop Engine

Turn the control lever clockwise and hold in this position until the engine stops. When remote control is fitted, move lever to the "Stop" position.

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. 10) 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 36 and 38.

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 page 54.

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).
Clean the air cleaner under very dusty conditions.
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.
Clean the cylinder, cylinder head and injector finning under very dusty conditions.

Every 250 Hours:

Drain the lubricating oil, renew filter element and refill with the correct grade and type.
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.
Clean the cylinder, cylinder head and injector finning under dusty conditions.

Every 1500 Hours:

Decarbonise.
Clean the inlet manifold and exhaust system.
Examine the fan blades and clean.
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.
Clean the cylinder, cylinder head and injector finning under normal conditions.
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. Flat joint	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 (Pressed steel)	Bostik 772	Coat door 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.
Fuel pump housing to crankcase. Rubber cord joint	Hylomar SQ32M	Coat groove in fuel pump housing and stick cord to it.
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.
Crankshaft felt rings	Wellseal	Coat inside of groove for felt before inserting felt. Ensure felt is not distorted during fitting.

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.

A table showing recommended jointing compounds and how to use them is given on page 20. 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.

Clean or 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 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.

1. Cylinder head—top plate.
2. Cylinder head.
3. Injector sleeve oil seal ring.
4. Washer for injector sleeve.
5. Inlet valve.
6. Inlet valve guide.
7. Valve guide oil seal ring.
8. Fuel leak-off pipe.
9. Breather.
10. Decompressor screw.

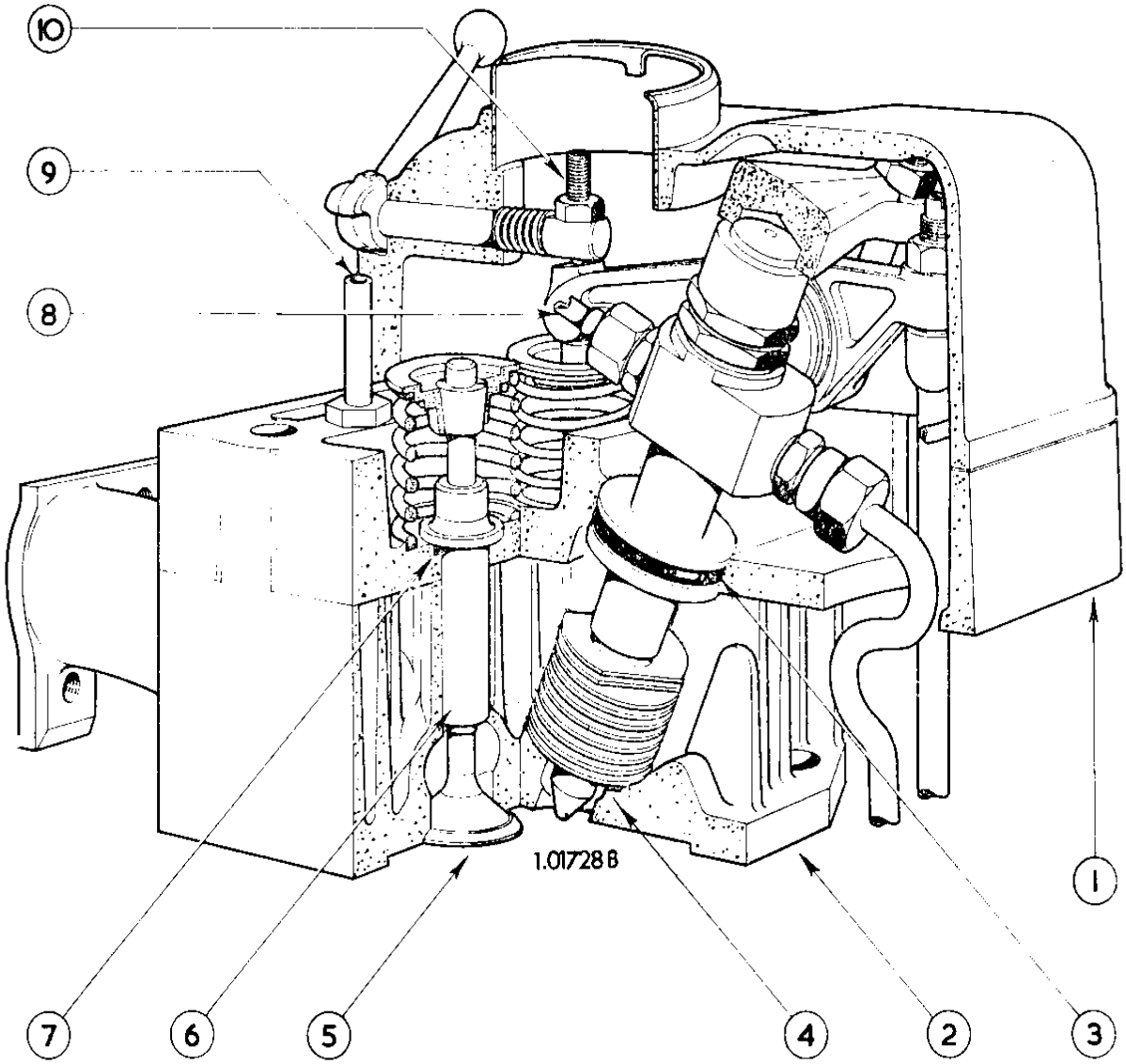


Fig. 12.—Cylinder Head—SR

To Remove Cylinder Head

Remove:—

(a) Cylinder head cover.
(b) Fuel pump housing door.
(c) Lubricating oil pipe to valve rockers.
(d) Fuel leak-off pipe.
(e) Fuel pipe—fuel pump to injector.
(f) Fuel injector.
(g) Inlet and exhaust manifold.
(h) Oil starting reservoir (if fitted).
(j) Air shroud at back of cylinder.
(k) Four holding down nuts and washers and lift off head.

Valve Guides

The cylinder head is in two parts (an upper and lower). The valve guides are a press fit in the lower half only and hold the two parts together. The inlet valve guide is jointed on a rubber ring under the collar at the top. The two parts should not be separated unless it is necessary to replace components.

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 $\frac{1}{8}$" (1.042 x 3.175 mm.) 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.) for SR engines and 0.025" (0.63 mm.) to 0.028" (0.71 mm.) for LR engines, 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) Remove cylinder head.

(b) Remove air guide plates at sides of cylinder.

(c) Remove crankcase door.

(d) Disconnect connecting rod big end bearing.

(e) Lift off cylinder complete with piston and connecting rod, after having marked the camshaft side of the barrel with chalk.

Withdraw piston from cylinder.

To remove the gudgeon pin, immerse the piston in hot water, 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 carefully.

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.

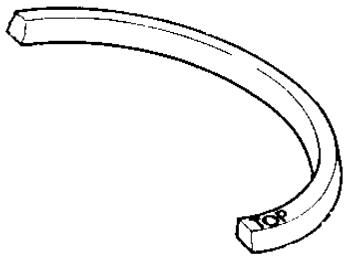


Fig. 13.—Piston Ring

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 cylinder block so that the flats on the fins are towards the flywheel and fuel tank ends respectively, and the side marked with chalk is towards the camshaft.

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 15 lb.ft. (2.07 kg.m.).

Connecting Rod Big End Bearings

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 50-51

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

LR—valve clearances are:— up to 1200 rpm — Inlet 0.002″ (0.05 mm.); Exhaust 0.006″ (0.15 mm.) COLD
over 1200 rpm — Inlet and Exhaust 0.002″ (0.05 mm.).

SR—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. The SR settings with aluminium push rods:— Inlet and exhaust 0.014″ (0.35 mm.) GO and 0.016″ (0.41 mm.) NOT GO, settings can be made with engine 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.

Inlet Valve	Opens	25°	B.T.D.C.	SR	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 LR engines both valve heads should be between 0.015″ to 0.020″ (0.38 — 0.50 mm.) below the surface of the cylinder head.

On SR engines inlet valve head is between 0.035″—0.045″ (0.89—1.14 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 on both LR and SR engines 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 head(s).
(b) Remove piston(s) 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 guide(s).
(b) Valve ports.
(c) Piston rings and grooves.
(d) Combustion chamber(s) in top of the piston(s).
(e) Fins must be cleaned on cylinder(s), cylinder head(s), and injector sleeve(s). **This is very important.**
(f) The inside of the piston(s).
(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.).

Cooling Air Fan

Engines with sheet metal fan shrouds: The fan shroud is secured by four setscrews which also retain the main bearing housing in position. To ensure correct crankshaft end float, metal shims are inserted between the main bearing housing and the crankcase. To ensure correct axial location of the cooling fan in the fan shroud, further shims may be inserted between the fan shroud and the main bearing housing so that there is between 0.040″ and 0.090″ (1.0—2.25 mm.) clearance between the side of the flywheel and the fan shroud.

All engines with cast fan shrouds: During initial assembly, the fan shroud is secured in position by means of the four centre setscrews, and the resultant gaps then gauged between the four bosses at the back of the fan shroud and the corresponding bosses on the end of the crankcase. The centre setscrews are then slackened, and long shims of corresponding gauged thickness are inserted transversely across the top bosses and across the bottom bosses. **Great care must be taken when stripping the engine down to note the position of all shims and to replace them as originally fitted.** This is particularly important when close coupled driven units are involved as incorrect shimming will cause distortion of the fan shroud and eccentric support of the driven unit in relation to the engine flywheel.

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 52-53.

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

To Remove Camshaft

(a) Remove fuel pump housing door.
(b) Disconnect governor adjusting spring.
(c) Disconnect fuel pipe(s)—filter to pump(s) and drain fuel.
(d) Remove fuel pump(s) and tappet(s).
(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 onto 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.

To Time Camshaft

The camshaft is timed by matching the letters 'O' on the camshaft gearwheel and the crankshaft pinion.

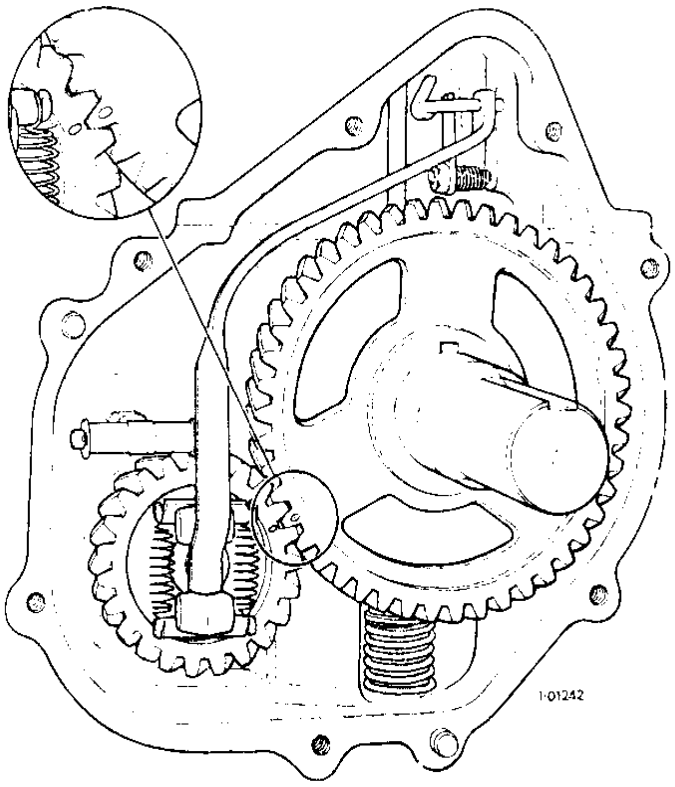


Fig. 14.—Camshaft Timing

Governor

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

The governor lever operating the fuel pump(s) 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 $\frac{3}{4}$" (19.05 mm.) from the facing on the crankcase, is adjusted in accordance with the instructions given under "Setting Fuel Pump" (pages 31-32), and secured with a lock nut.

The lever is curved to pass over the camshaft gearwheel and is joined to the fuel pump(s) by a link arm.

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

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 reassembling 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 air and exhaust manifold(s).
(c) Remove air shroud at back of cylinder(s).
(d) Remove fan impeller trunking.
(e) Remove crankcase door.
(f) Remove lubricating oil relief valve and 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" (0.127-0.229 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 piston(s) and connecting rod(s).
(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.

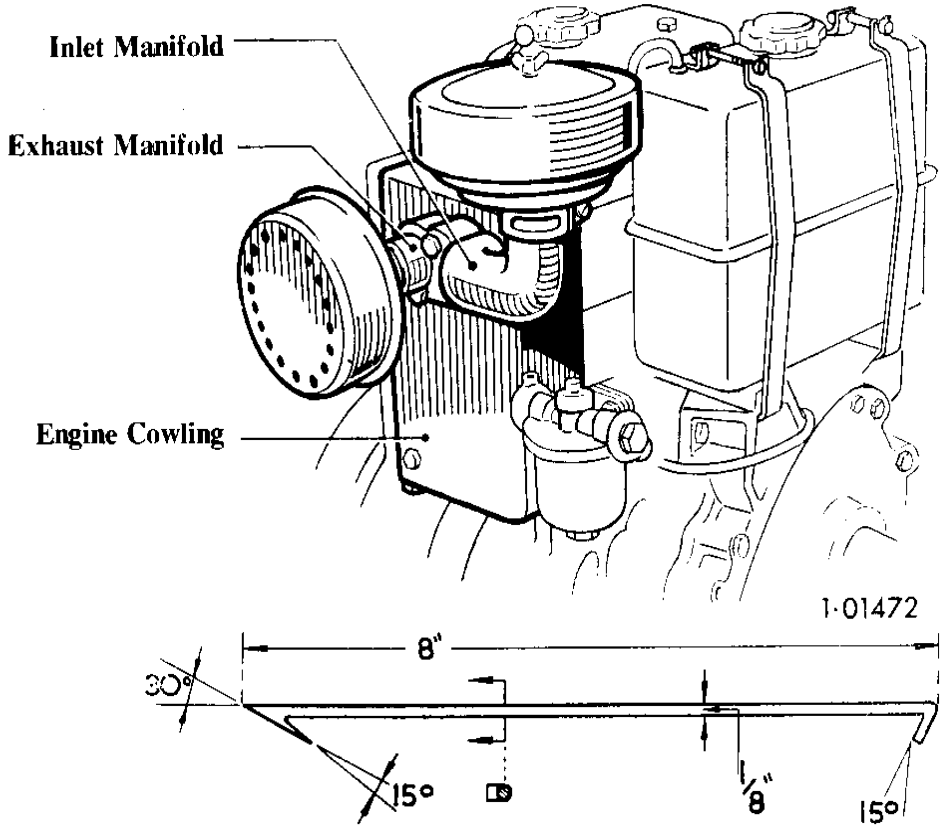
Cleaning of Cooling Fins

Under normal conditions the cylinder, cylinder head and injector cooling fins require cleaning at intervals of 1500 hours or even longer. **Regular cleaning is essential if overheating is to be avoided.**

In dusty conditions it is also particularly important to **eliminate oil leaks, so keeping the cooling fins dry and clean.**

The engine has ample cooling capacity and therefore cleaning is not so important if the average load is light, but if the load is heavy, serious overheating can occur and this will damage the engine although the piston may not seize. Damage due to overheating may show itself as fuel injection trouble, stuck exhaust valves, with corresponding valve gear troubles, poor starting and scuffed piston rings and pistons.

To clean the fins it is necessary to remove the cooling air cowling (item 36, plate 1), and in order to do this the inlet and exhaust manifolds must be taken down. In many cases the inlet and exhaust manifold joint becomes damaged during this operation and a new joint must be fitted. The cleaning is effected with a special hooked wire tool, Part No. 367-16170, the dimensional



Engine fin rake Cleaning Tool (367/16170)

Fig. 15.—Cleaning Cooling Fins

illustration of which is shown above. This tool is of special design to draw the deposits between the fins towards the operator and makes the cleaning operation speedy and effective.

To clean the injector fins it is necessary to withdraw the injector from the cylinder head.

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 30 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 Fusus oil 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.

The directions for how to adjust the overload are given on page 32.

The injectors are most unlikely to be the cause of smoky exhaust in LR or SR engines and should only be disturbed after the overload stop has been properly set and if 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.

Overheating of the engine and of the combustion air reduces the weight of air available for combustion, produces a darker exhaust as well as a loss of power and can cause serious damage, so this matter must receive immediate attention. Full information on cooling problems arising from the installation of air cooled engines is given on pages 6 to 12.

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 pump(s).

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.

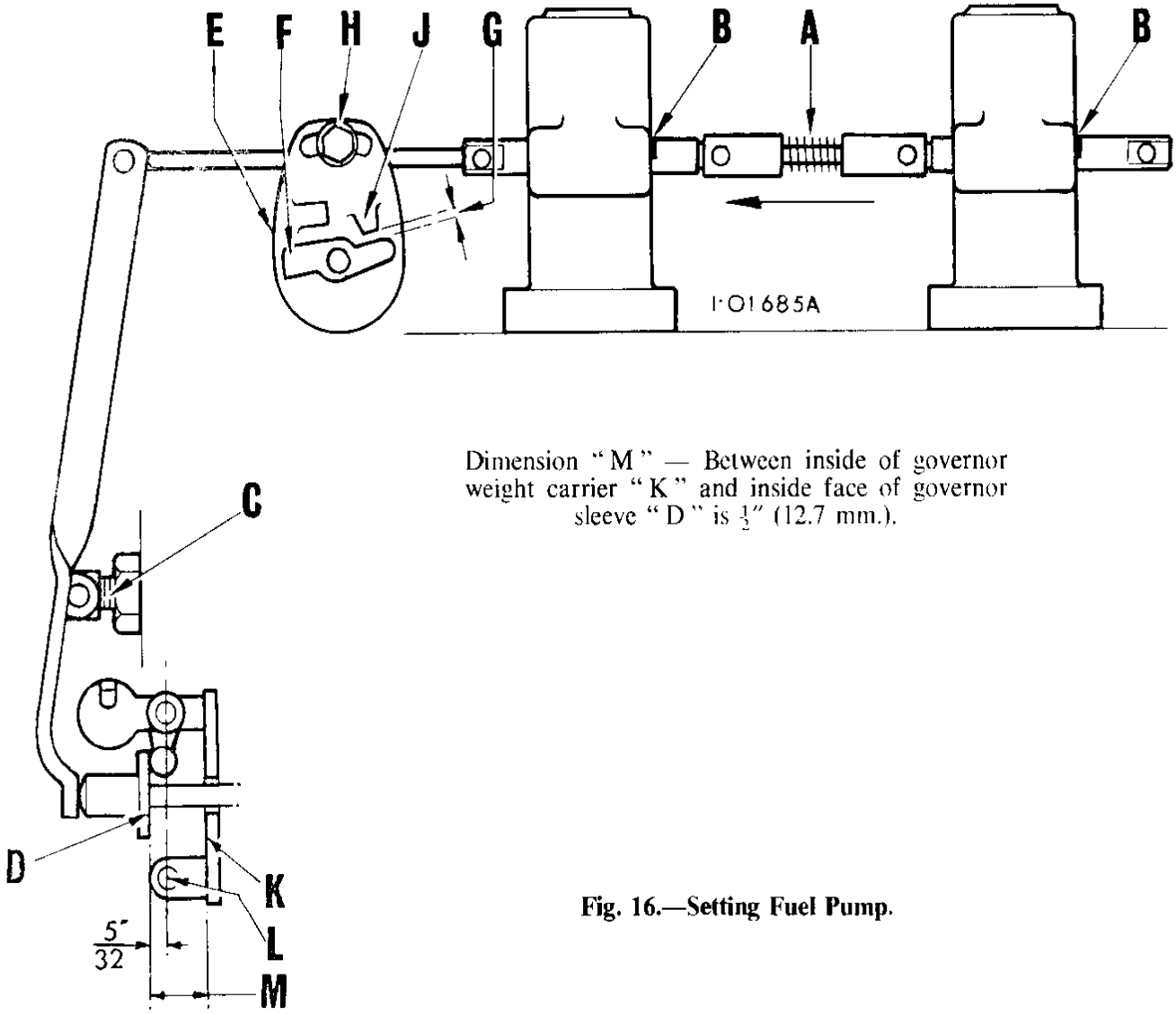
This procedure will ensure that there is no leakage from these joints.

To Prime Fuel System

(i) Fill fuel tank.
(ii) Vent fuel filter (see page 21).
(iii) Vent fuel pipe at fuel pump(s). Turn engine as for starting, i.e. 3 to 20 times, until the injector(s) 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 cover(s).
(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 pipe(s). Retighten injector pipe nut and continue turning engine until injector(s) are heard to inject.

When self-venting pumps are fitted it should not be necessary to carry out the above procedure except when putting the engine into commission.



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

Fig. 16.—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. On multi-cylinder engines, 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" $\frac{1}{2}$″ (12.7 mm.). This is the same for both constant speed and variable speed engines.

3. **For all auxiliary engines except LR1 at 750 rpm** 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.

   LR1 engines at 750 rpm—set "G" to 0.032/0.036″ (0.80/0.90 mm.) 0.102/0.114″ (2.59/2.9 mm.) movement on rack.

   LR and SR 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.

4. The lower settings are acceptable provided the engines carry the normal load but the higher ones must not be exceeded.

Engines Type and Speed	Thickness of Shim used at "G"	Movement of Rack corresponding to thickness of shim at "G"
LR1 @ 750 rpm auxiliary	0.032/0.036 in. 0.8/0.9 mm.	0.102/0.114 in. 2.59/2.9 mm.
LR1 @ 1000 rpm auxiliary	0.023/0.027 in. 0.58/0.68 mm.	0.074/0.086 in. 1.89/2.18 mm.
LR1-2 Auxiliary engines SR1-2-3 at all speeds	0.015/0.017 in. 0.38/0.43 mm.	0.046/0.052 in. 1.17/1.32 mm.
SR1-2-3 Propulsion LR2 Propulsion also when 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. On LR1 and SR1 engines, this is when the mark on the flywheel is opposite the top centre mark on the fan shroud and both valves are closed. On LR2, SR2 and SR3 engines the firing position is when the mark is opposite the arrow at the back of the fan shroud near the fuel pumps, and both valves are closed (see illustration). A table is given below showing the injection timing.

(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.

Remove shims to advance.
Add shims to retard.

Shims 0.005" and 0.010" thick to a total of approximately 0.035" are normally inserted below the fuel pump.
One shim 0.005" (0.125 mm.) thick is equivalent to a timing adjustment of $\frac{3}{16}$" (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.

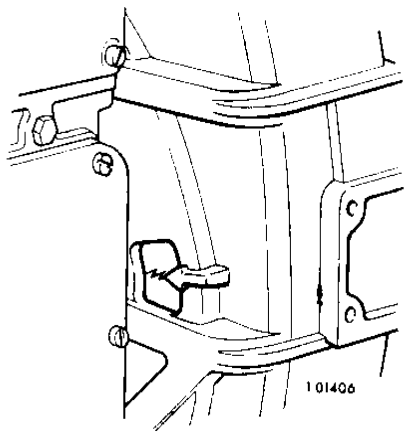


Fig. 17.—Fuel Pump Timing

FUEL INJECTION TIMING

Engine	B.T.D.C. Timing Degrees	Diameter of Flywheel	Distance Measured on Flywheel Rim
LR1 up to 1200 rpm ...	24	14" (35.6 cm.) 16" (40.6 cm.)	2.92" (7.4 cm.) 3.36" (8.5 cm.)
LR2 up to 1200 rpm ...	24	15" (38.1 cm.)	3.15" (8.0 cm.)
LR1 over 1200 rpm ...	28	14" (35.6 cm.) 16" (40.6 cm.)	3.42" (8.8 cm.) 3.91" (9.9 cm.)
LR2 over 1200 rpm ...	28	15" (38.1 cm.)	3.66" (9.4 cm.)
SR1	25	14" (35.6 cm.) 16" (40.6 cm.)	3.05" (7.7 cm.) 3.49" (8.8 cm.)
SR2 & SR3	25	15" (38.1 cm.)	3.27" (8.3 cm.)*

*On LR2—SR2 SR3 engines the mark is on the **side** of the flywheel; the above figures, which are measured on the flywheel **rim** or periphery are given for guidance only.

Note: On close coupled single cylinder engines there is a hole in the adaptor supplied by Lister Blackstone Mirrlees Marine at T.D.C.
Where adaptors other than above are fitted, they should also have a hole in this position in order to observe the flywheel timing mark.

FUEL INJECTOR TESTING INSTRUCTIONS

Fuel Injector—LR engines

LR engines are fitted with single hole, pintle type, injector nozzles, this being the most reliable type of nozzle known as it is almost impossible to block the hole completely.

The pintle nozzles used are of the delay type and this means that the profile of the pintle is such than on the first part of the needle lift, a relatively small proportion of finely atomised fuel is delivered, the bulk of the fuel going through after the needle has lifted a fixed amount. This feature gives good combustion and quiet operation.

It is strongly recommended that the nozzle should not be cleaned unless it is absolutely necessary. It is customary for a nozzle to run for 1,000 hours or more without cleaning, but under adverse conditions it should be inspected every 250 hours and the instructions given below must be followed.

Testing Fuel Injector

Owing to the above mentioned features it is not possible to test these nozzles for spray in the ordinary hand pump as in most cases good nozzles will appear defective. The correct way to check nozzles is as follows:—

(a) Check the "bursting" pressure with an ordinary hand test pump and if necessary set the injector to 160 atmospheres (165.4 kg/cm²). This setting is higher than the normal one of 155/140 atmospheres (160/145 kg/cm²) and is to allow for the inevitable fall in pressure during running of the engine.

(b) While the injector is still connected to the hand pump, check the tightness of the seating by drying the nozzle and applying a pressure of about 100 atmospheres (103.3 kg/cm²) when no leakage whatever should appear from the nozzle hole. At this stage the back leak past the lapped portion of the needle must be checked by bringing the pressure up to 160 atmospheres (165.4 kg/cm²) and noting the time the pressure takes to drop from 150 to 100 atmospheres (155 to 103.3 kg/cm²). This time should be between 10 and 55 seconds. When an injector is working in an engine the leak off should be between 1% and 5% of the engine fuel consumption per cylinder.

(c) Check the spray by connecting the injector externally to the engine fuel pump by means of a special pipe* (Part Number 317/92). The nozzle must point **away** from the operator as the spray can easily penetrate the skin. Set the overload stop to the running position (external lever horizontal), turn the engine from the camshaft at about 60 rpm camshaft speed and observe the spray in the usual way. A perfect spray is in the form of a fine mist and shows no signs of being "streaky" or "dribbling".

A nozzle must only be cleaned with the necessary special tools and by a qualified service engineer.

Note: *This can be made from a genuine spare pipe (correct length, bore and outside diameter) reversed and slightly set to allow the injector to be connected externally through the fuel pump housing door. After the pipe is bent, it **must** never be used for anything but test purposes, it is impossible to straighten it again to a sufficient degree of accuracy to give a satisfactory fit in the engine.

The section on fitting a new injector p.35 (SR engine) applies to LR engines also.

Fuel Injector—SR engines

The fuel injectors are fitted in the cylinder heads and have cooling fins on the nozzle cap nut—these must be kept clean.

The injectors are jointed on reinforced asbestos joint rings in the cylinder heads, and are fitted with rubber sealing rings on the upper part of the barrel.

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 lb.ft. (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. When tested on a hand pump the back leakage time should be 10 to 55 seconds for a drop from 150 to 100 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 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 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 reinforced asbestos joint between the cylinder head and the injector finned nut must be carefully placed in position ensuring that it is properly located in the recess and undamaged. Both the seatings in the cylinder head and the injector finned nut must be clean and smooth. Blowing at this joint causes over-heating of the injector and sticking of the nozzle valve.
3. The rubber joint on the upper part of the injector barrel is used to prevent lubricating oil escaping from the valve gear compartment into the air stream. The ring has to be examined for cuts or other damage and renewed if necessary.
4. If it is intended to remove the nozzle, or before reassembling into the engine if the nozzle is not being removed, the finned cap nut must be thoroughly cleaned and all dirt removed from the recess between the fins.
5. The injector clamp nuts must be tightened to 15 lb.ft. (2.07 kg.m.) torque.

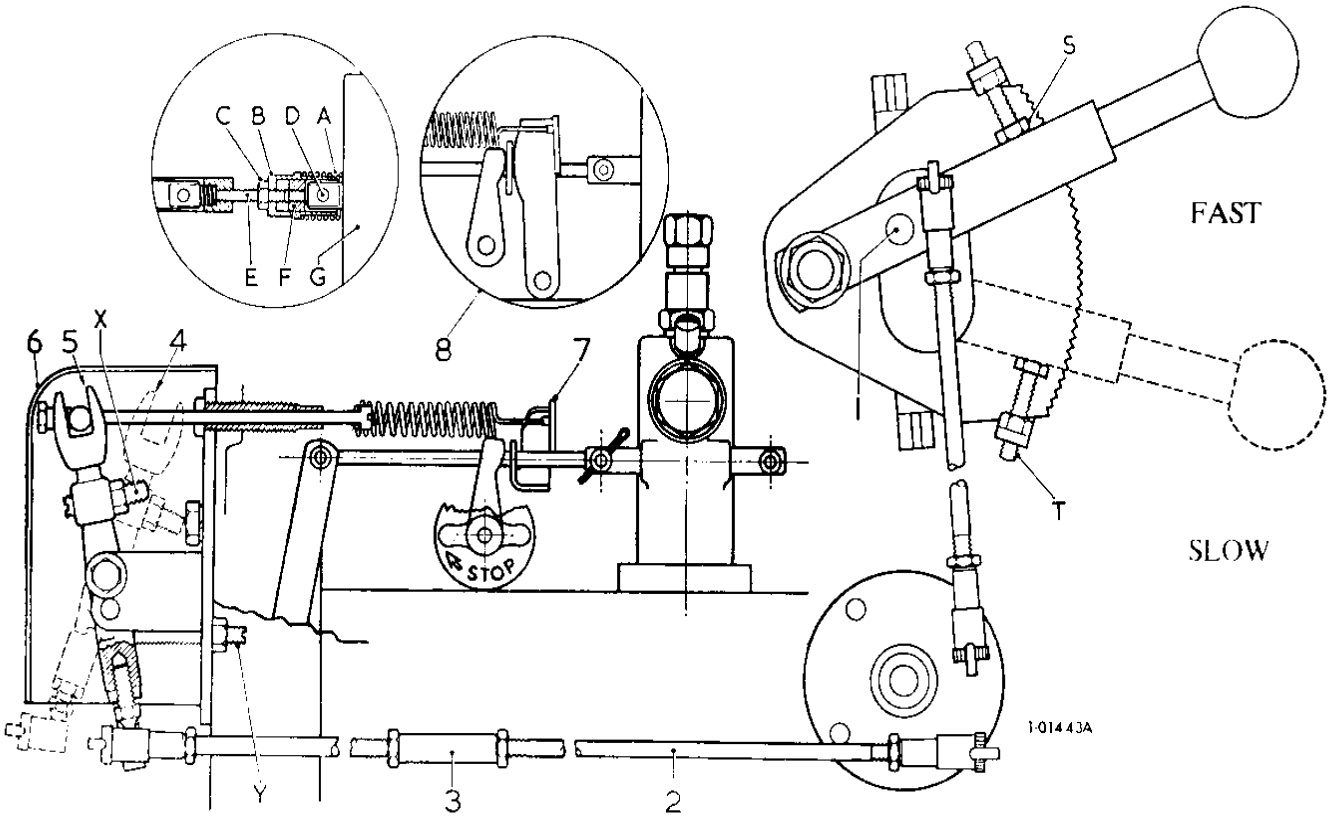


Fig. 18.—Arrangement of Rod Operated Variable Speed Control

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 for LR1—2 and SR1—2 engines.
8. Fuel pump linkage for SR3 engine.

Note: On LR1 & 2 and SR1 & 2 the **upper hole** in the bracket and the lever are used. On SR3 the **lower hole** in the bracket and lever are used.

Instructions for Adjusting Speed Control

LR1 & SR1 engines only. With the control lever in the "Slow" position -engine in neutral— adjust screw 'X' until the idling speed is 700 rpm and tighten nut.

LR2, SR2 & SR3 engines. The idling device consists of a spring "A" 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 link 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". Care must be taken, with earlier type engines, that the shackle pin "D" is at least partially covered by the adjusting sleeve "B" as otherwise the pin is not located sideways and will fall out.

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.

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

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

All engines. With control lever still held in "Fast" position adjust screw "S" until it just touches the operating lever and lock the nut.

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

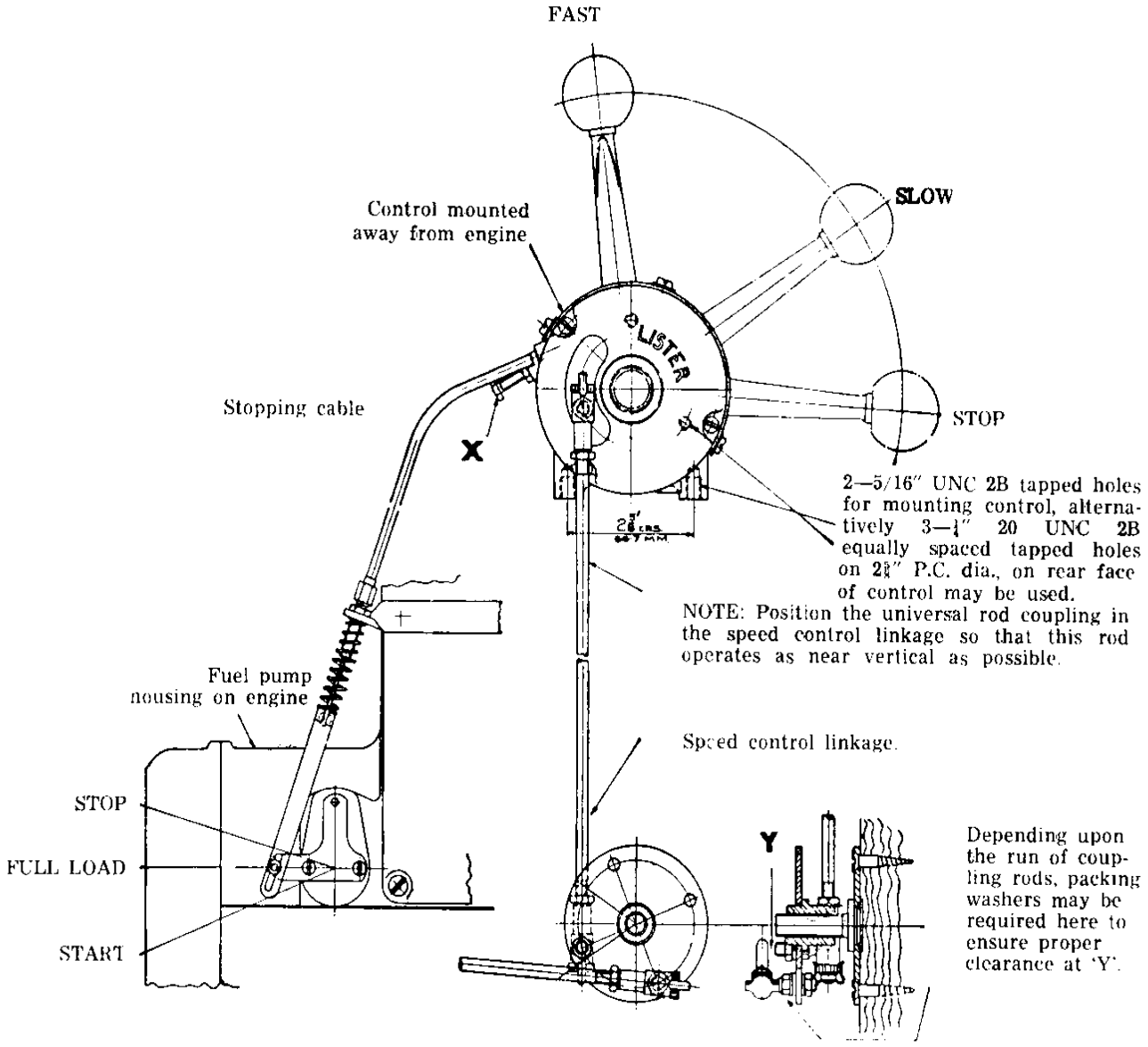


Fig. 19.—Arrangement of Single Lever Speed and Stop Control

ADJUSTMENT

Engine idling at 700 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.

GOVERNOR WEIGHTS & SPRINGS—CONSTANT SPEED

BS 649 : 1958 Class A

SINGLE & TWIN CYLINDER ENGINES

ENGINE Speed rpm	GOVERNOR WEIGHTS 2 off		WEIGHT SPRING 2 off		SPEEDER SPRING 1 off	
	Part No.	Ident. No.	Part No.	Colour	Part No.	Colour
750-850 LR	572-11380	2	201-10821	Green	201-10901	Blue
850-1000 LR	572-11380	2	201-10821	Green	201-10903	Yellow
1000 SR	572-11380	2	201-10821	Green	201-10903	Yellow
*1100-1300 LR & SR	572-11380	2	201-10821	Green	201-10900	Red
1400-1690 LR & SR	572-11380	2	201-10820	Red	201-10900	Red
1700-1800 LR & SR	572-11640	11	201-10820	Red	201-10900	Red
2000-2500 LR1 & 2/SR1 & 2	572-11590	6	201-10820	Red	201-10900	Red

THREE CYLINDER ENGINES—SR only

1000	354-28351		201-10820	Red	201-10903	Yellow
*1150-1300	572-11391	3	201-10820	Red	201-10903	Yellow
1500	572-11391	3	203-10824	White	203-10904	Black
1800	572-11380	2	203-10824	White	203-10904	Black
2000	572-11380	5	203-10824	White	203-10904	Black
2200-2500	572-11580	2	203-10824	White	203-10904	Black

*See page 24—Valve Clearances.

GOVERNOR WEIGHTS & SPRINGS—VARIABLE SPEED

BS 649 : 1958 Class B

Engine Type	Rev./min. Range	Governor Weights 2 off		Speeder Spring 1 off		Idling Spring 1 off
		Part No.	Ident. No.	Part No.	Colour	Part No.
LR1-SR1	700-2200	572-11663	16	201-10900	Red	——
	850-2500	572-11661	14	201-10900	Red	——
LR2-SR2	700-2200	572-11663	16	201-10900	Red	204-21491
	850-2500	572-11661	14	201-10900	Red	204-21491
SR3	700-2000	572-11665	18	201-10900	Red	204-21491
	850-2500	572-11665	18	201-10900	Red	204-21491

INSTRUCTIONS FOR CHANGING SPEEDS OF LR or SR ENGINES

FIXED SPEED

Note: Before starting consult the table on page 39 to check which of the governor weights 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.

Remove seven setscrews securing end cover.

Remove the end cover complete with tank and filter.

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: Brass 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

Essentials for Easy Starting

(a) Engine to turn easily when decompressed; if not it may be due to:—

unsuitable lubricating oil (too heavy).
incorrect decompressor clearance.
tight bearing.
load not disconnected from engine.

(b) Injector creak must be heard (or felt). If not, it may be due to:—

no fuel in tank.
air lock in system.
injector nozzle valve stuck open.
fuel pump delivery valve scored.

(c) Good compression, if not, it may be due to:—

worn cylinder.
piston rings carboned in grooves.
leaking inlet or exhaust valve.
injector loose on seat.

(d) Fuel pump rack(s) to be free.
(e) Control must be vertical to give extra fuel for starting.

Knocking, this may be caused by:—

(a) Valve, probably exhaust, sticking in guide and touching piston — clean stems and guides.
(b) Slack bearing - fit new bearing, if crankshaft is not worn.
(c) Insufficient clearance between the piston and cylinder head—check and adjust.
(d) Injection too early—check and adjust.
(e) Flywheel loose on shaft.
(f) Excessive crankshaft end play.
(g) Excessive carbon deposit on piston.

Carbon Deposit, excessive deposit may be due to:—

(a) Choked exhaust system — dismantle and clean.
(b) Long periods of idling.
(c) Unsuitable fuel oil.
(d) Unsuitable lubricating oil.
(e) Injector not spraying correctly — clean nozzle.
(f) Late injection of fuel — check timing.

Smoky Exhaust. — Black smoke due to incomplete combustion of fuel caused by:—

(a) overload, causing an excessive quantity of fuel to be injected.
(b) choked air intake.
(c) poor atomisation due to a choked injector nozzle.
(d) unsuitable fuel.

Note: Blue smoke, when faint, is generally the result of light load.
Heavy blue smoke is caused by lubricating oil passing the piston rings, due to either stuck piston rings or a worn cylinder.

Engine Stops.—This may be due to:—

(a) Lack of fuel—air or water in fuel system. Fuel system choked. (See page 30).
(b) Overload.
(c) Overheating, due to shortage of lubricating oil or recirculation of cooling air.
(d) Loss of compression.
(e) Dirt in injector or fuel system.

Loss of Power—This may be due to:—

(a) Loss of compression.
(b) Incorrect tappet clearance.
(c) Choked exhaust pipe.
(d) Fuel injector or fuel pump out of order. Air in the fuel system.
(e) Choked fuel filter.

Failure to obtain Normal Speed

(a) Engine started under overload.
(b) Fuel system not primed properly.
(c) Insufficient fuel.
(d) Injection retarded.

Loss of Oil Pressure

(a) Oil level below mark on dipstick.
(b) Strainer choked.
(c) Fractured pipe or leaking joint.
(d) Badly worn or run out bearing.
(e) Relief valve not seating due to dirt, or worn out.
(f) Oil pump plunger and valves, worn or dirty.

LISTER REVERSE GEAR

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 25 running hours or weekly.

Operation — Neutral — See Fig. 20

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 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 and should not be allowed to become less than $\frac{1}{2}$″ (12 mm.).

Reverse Band

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

IMPORTANT.— DO NOT OVER ADJUST.

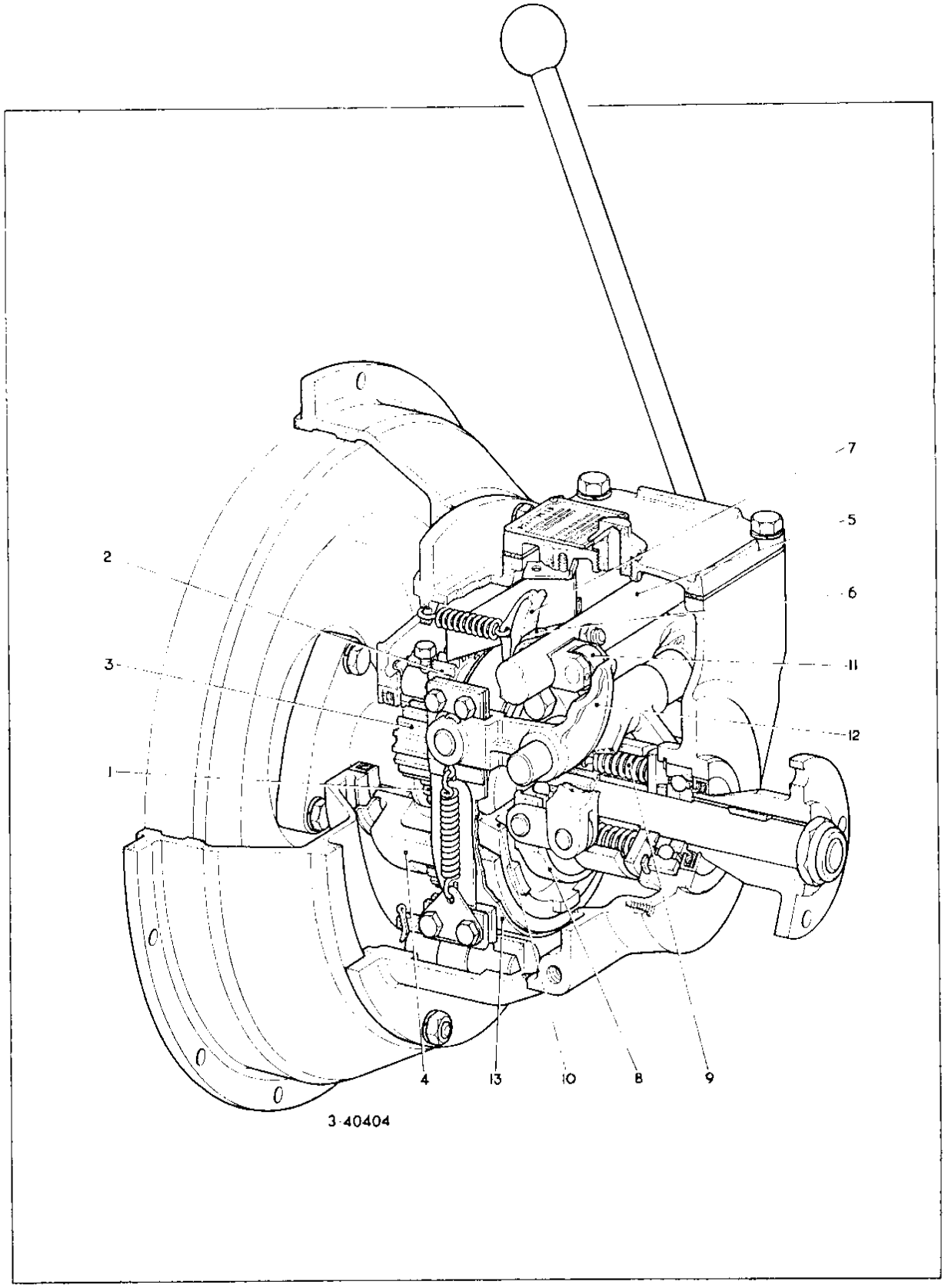


Fig. 20.—Lister Reverse Gear — Manually operated

Reverse Band (continued)

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.

TO DISMANTLE REVERSE GEAR

Refer to page 119—Plate 15

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

Refer to pages 105 and 119—Plates 11 and 15

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), remove nut (55), pinion (8), key (9), oil trap (7)—see page 111—then supporting the gear, gently drive reverse gear through bearing (5). 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 washer 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 $\frac{5}{16}$". This locates reduction pinion (8) in correct position to fit reduction gear.

Lubrication—Gear Box and Reduction Gear

Before initial starting, after installation or overhaul, fill the reverse gearbox to the full mark on the dipstick with SAE 80 oil for ambient temperatures up to 30°C and for temperatures above 30°C use SAE 90.

The reduction gearbox should be filled to maximum mark on dipstick with SAE 80 oil for ambient temperature below 0°C and SAE 90 above 0°C. Capacity of 2:1 and 3:1 box 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, particularly if the gearbox is little used, when rust formation 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 intermediary shaft is installed, this bearing must be used close up to the coupling.

LISTER LH150 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.). Oil of the following viscosities should be used: for ambient temperatures up to 30°C SAE 80; above 30°C SAE 90. Change the oil every 1000 hours and clean magnetic drain plug.

Adjustments (See Fig. 21): 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".

1. Place control lever in neutral and run engine at about 600/800 r.p.m. The oil pressure should be about 250 psi. (17.5 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 psi. (22.5 kg. per sq. cm.). Replace screw and plug in original position 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 "I".

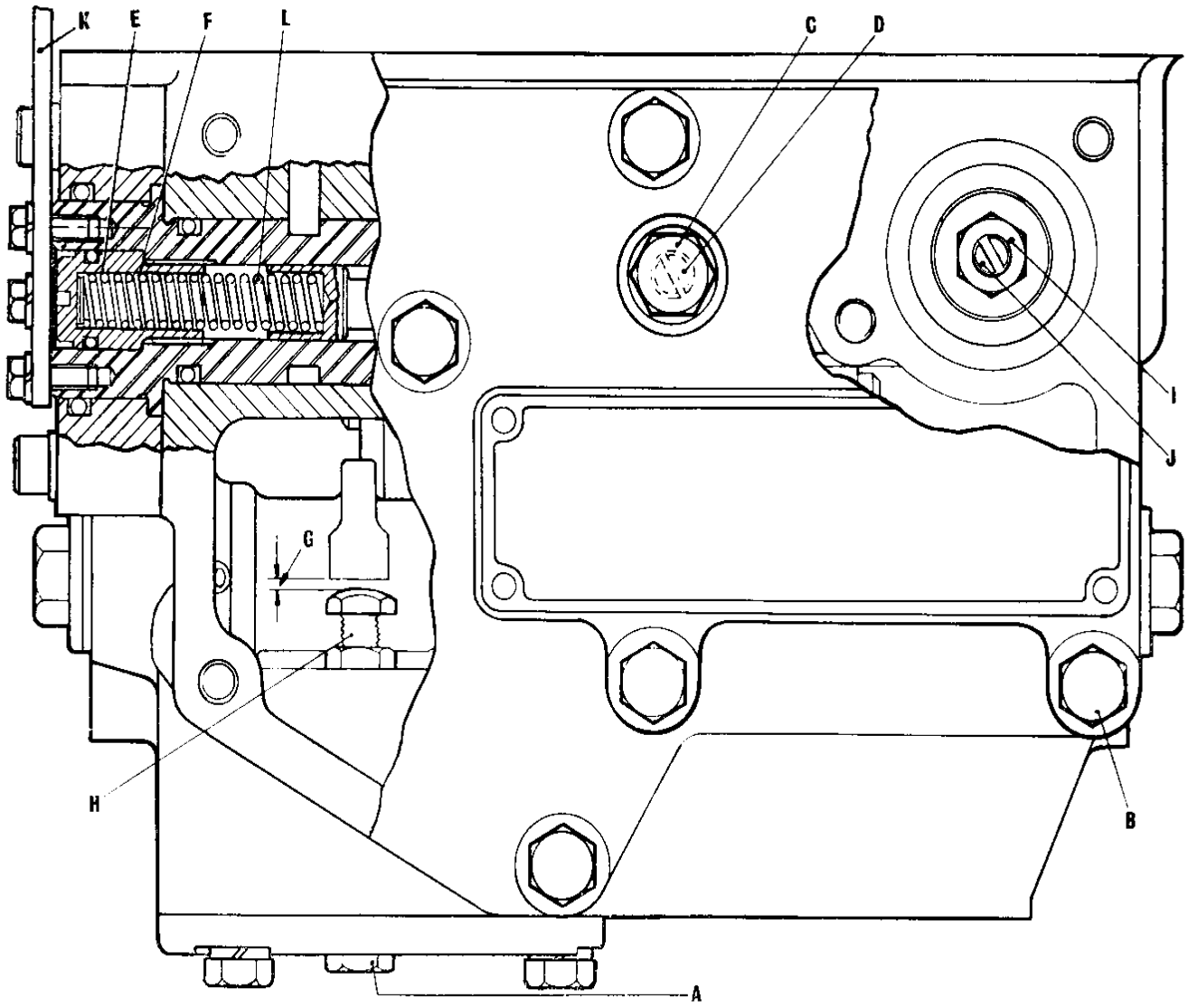


Fig. 21.—Lister Reverse Gear—LH150 Hydraulic operated, Control adjusting

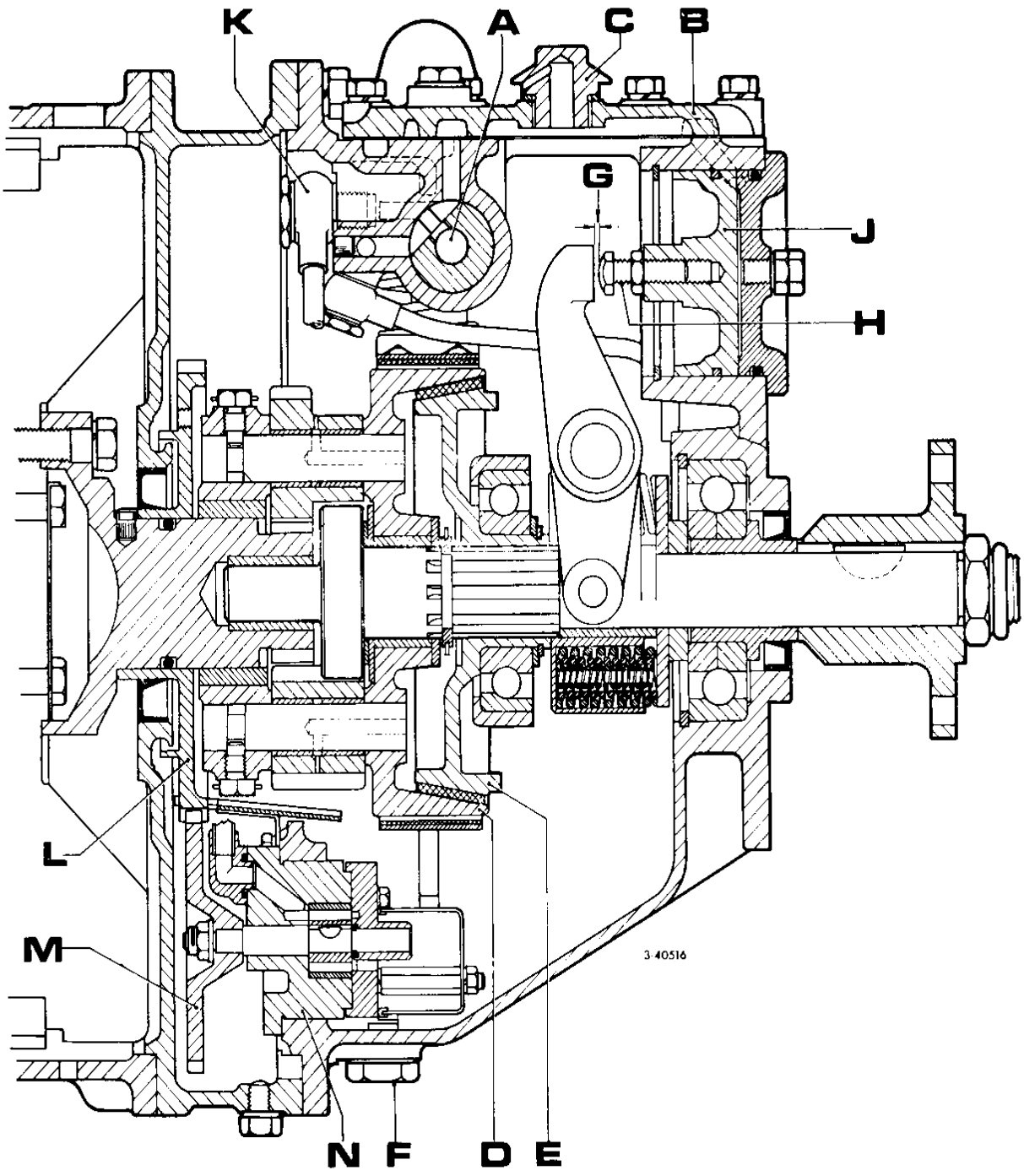


Fig. 22.—Section of LH150 Reverse Gear

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. 23.

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.

Adjustment of Rockford Clutch—Optional Fitting

The clutch plate is held between two 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 inspection cover on top of clutch casing.

(3) With the lever in the " neutral " position, revolve the clutch until the adjusting ring locking plate is accessible.

(4) Slacken the locking plate screw with a screw driver and when dis-engaged from the serrations turn the adjusting ring clockwise. Re-secure the locking plate.

(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.

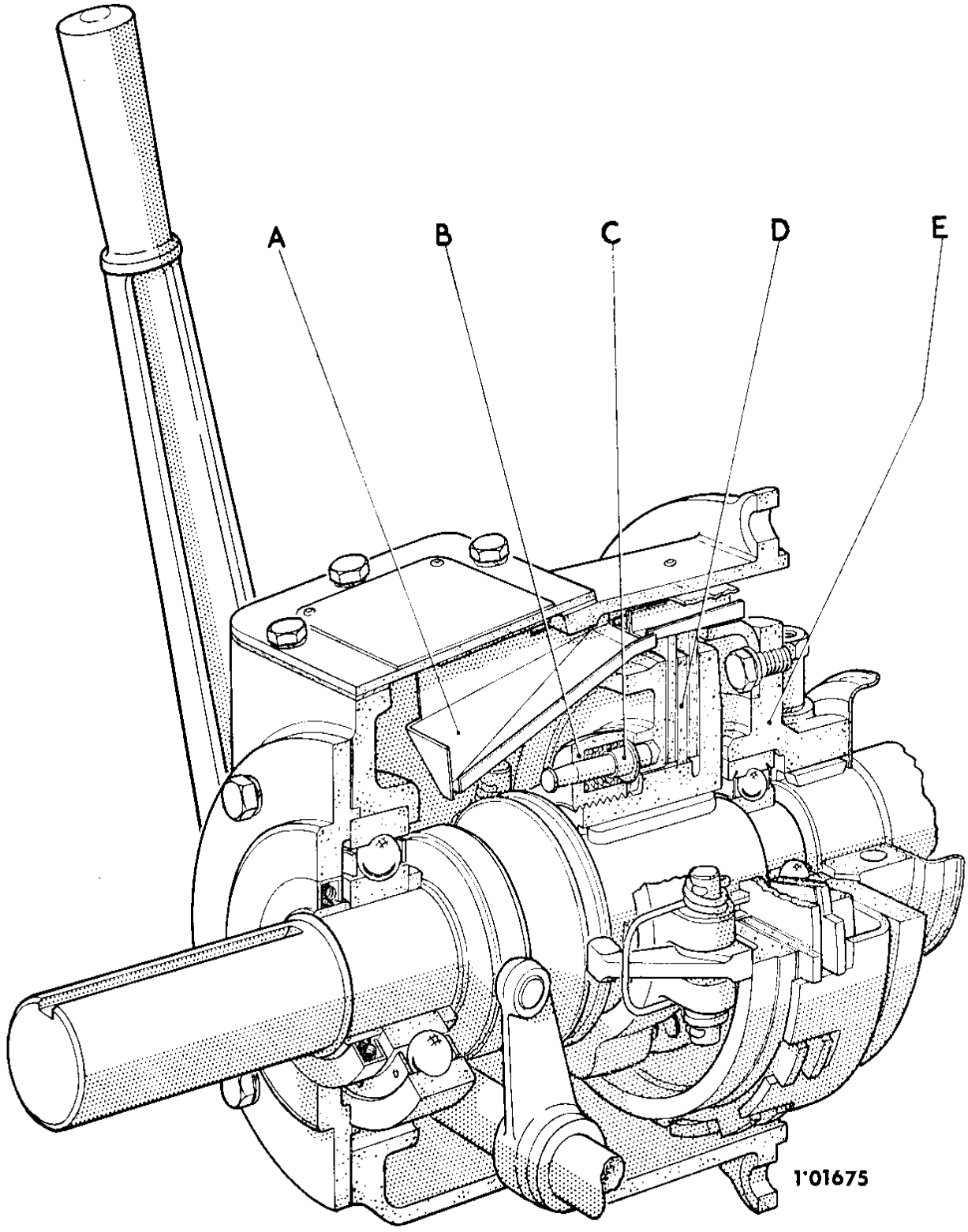


Fig. 23.—Lister Clutch

A Lubricating oil return trough.

B Clutch adjusting ring.

C Clutch adjusting plunger.

D Clutch plates.

E Clutch driving member.

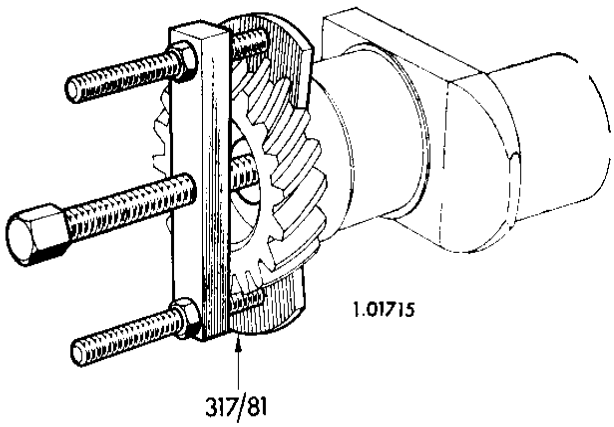


Fig. 24A—Pinion Withdrawal Tool.

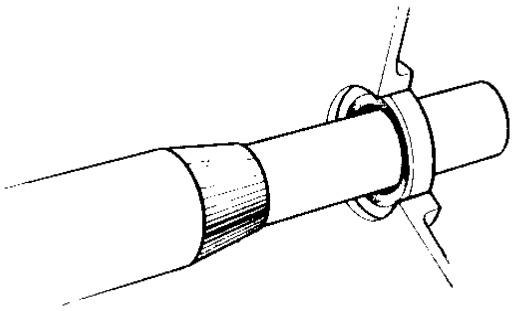


Fig. 24B—Tapered Sleeve.

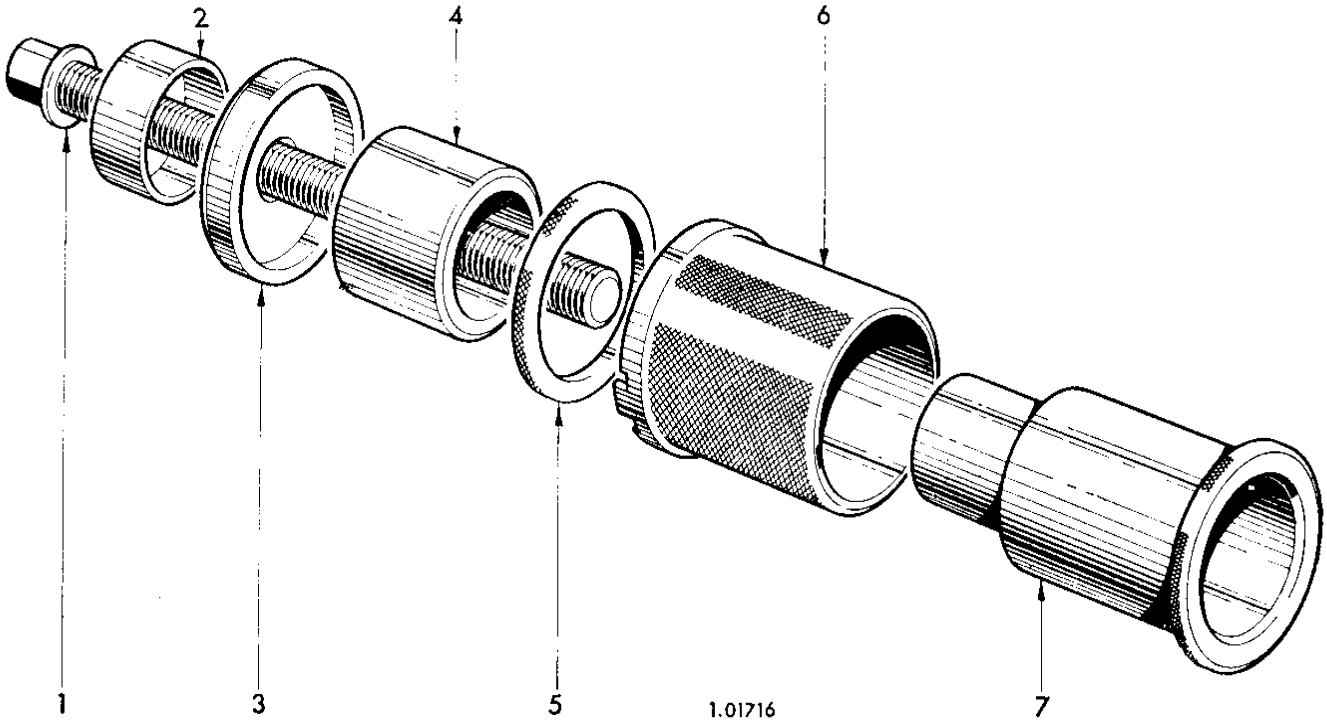


Fig. 24C—Main Bearing Tool Complete – Part No. 317-84

KEY

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

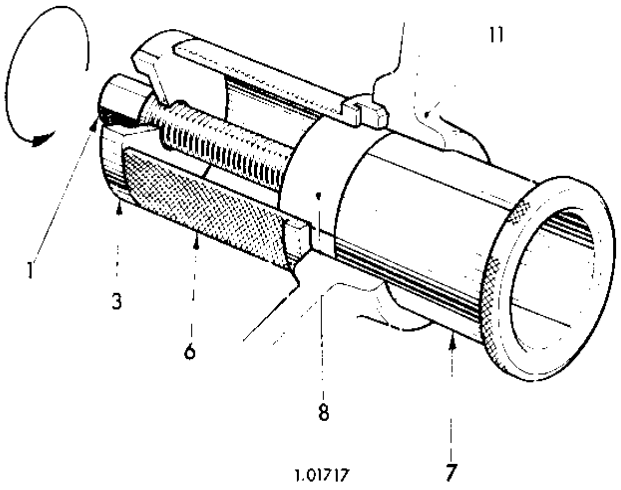


Fig. 25A—Main Bearing Bush Removal

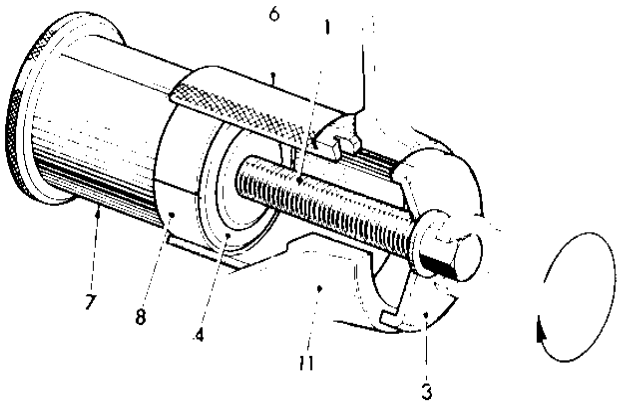


Fig. 25B—Main Bearing Bush Fitting

To remove main bearing shells from the crankcase Figure 25A.

(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).

To fit main bearing shells to the crankcase Figure 25B.

(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.

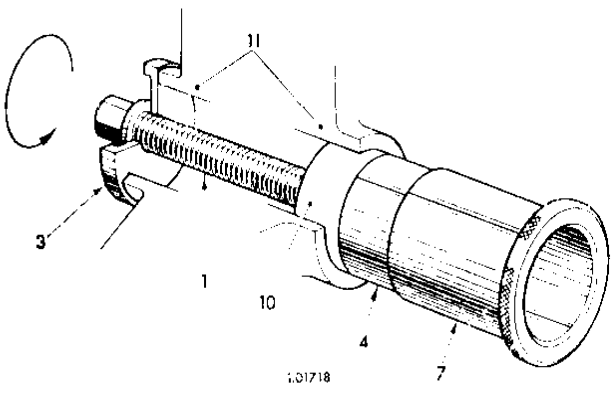


Fig. 26A—Camshaft Plain Bush Removal

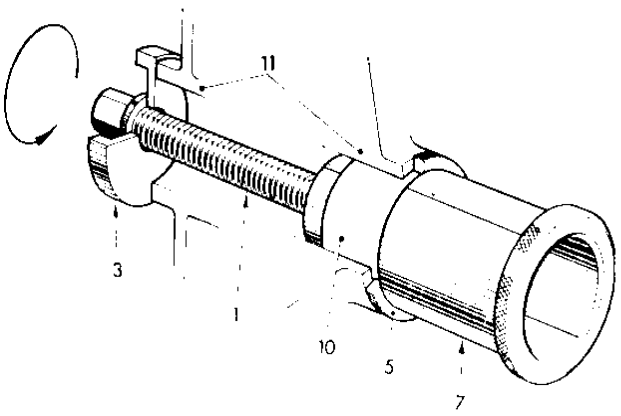


Fig. 26B—Camshaft Plain Bush Fitting

Figure 26A—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 26B- 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.

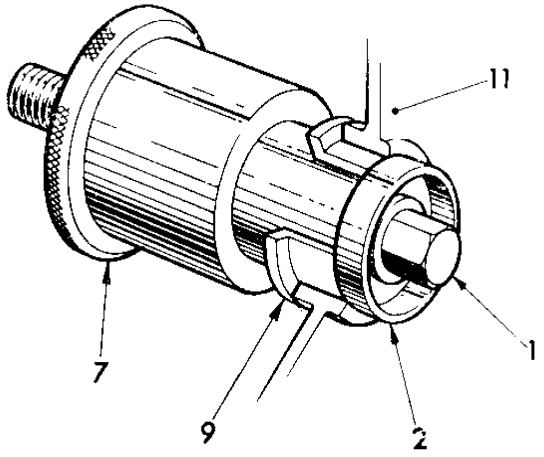


Fig. 27A—Camshaft Flanged Bush Removal

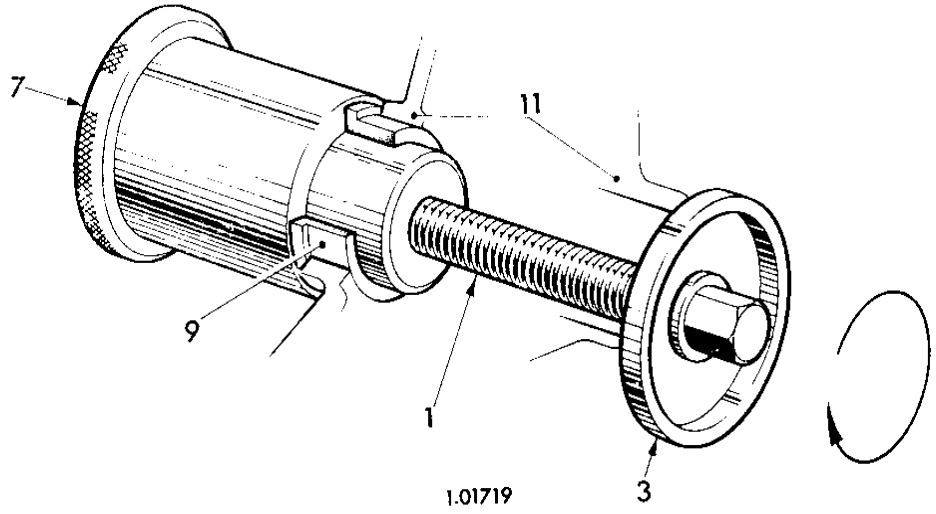


Fig. 27B—Camshaft Flanged Bush Fitting

Figture 27A—To remove camshaft bush (flanged).

(1) Insert plug (7) into bush (9).

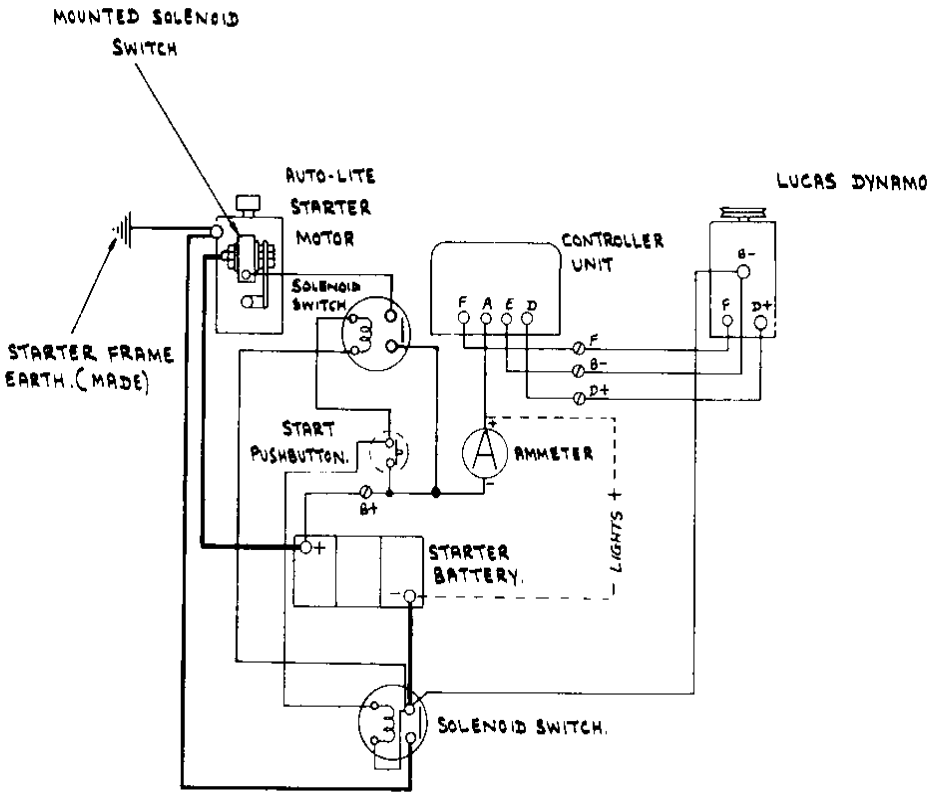
(2) Fit small spacer (2), with recessed face outwards, fit drawbolt (1) and tap out bush using a drift on end of draw bolt.

Figure 27B—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.



LR1 and SR1 12v Electric Starting Equipment — Wiring Diagram ED.10918

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

LR2—SR2 & SR3 12v. Electric Starting Equipment—Wiring Diagram ED.10916