Perkins

Diesel Engines Model Nos:

499
4107
4108

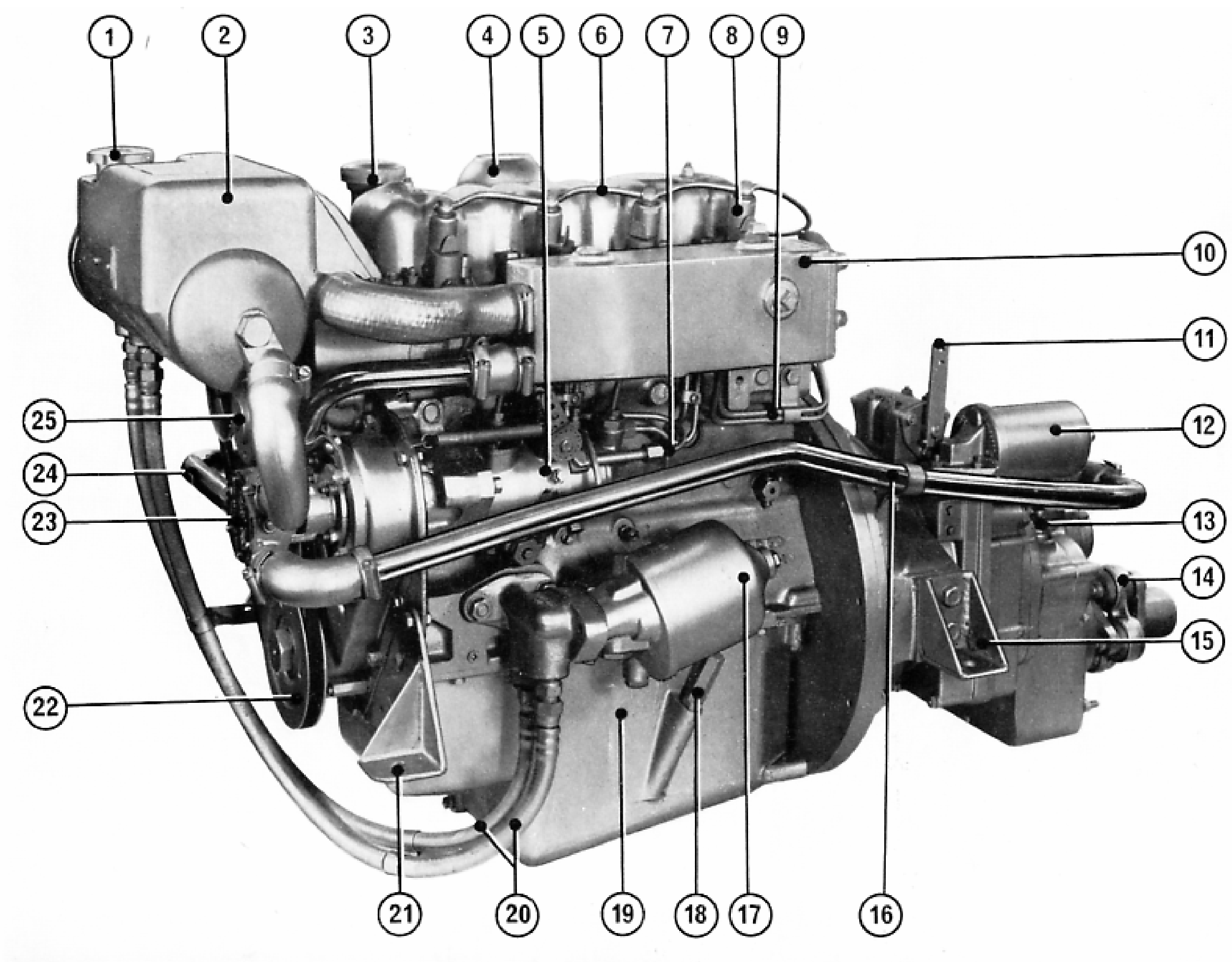
Documents reprinted 1972

Contents

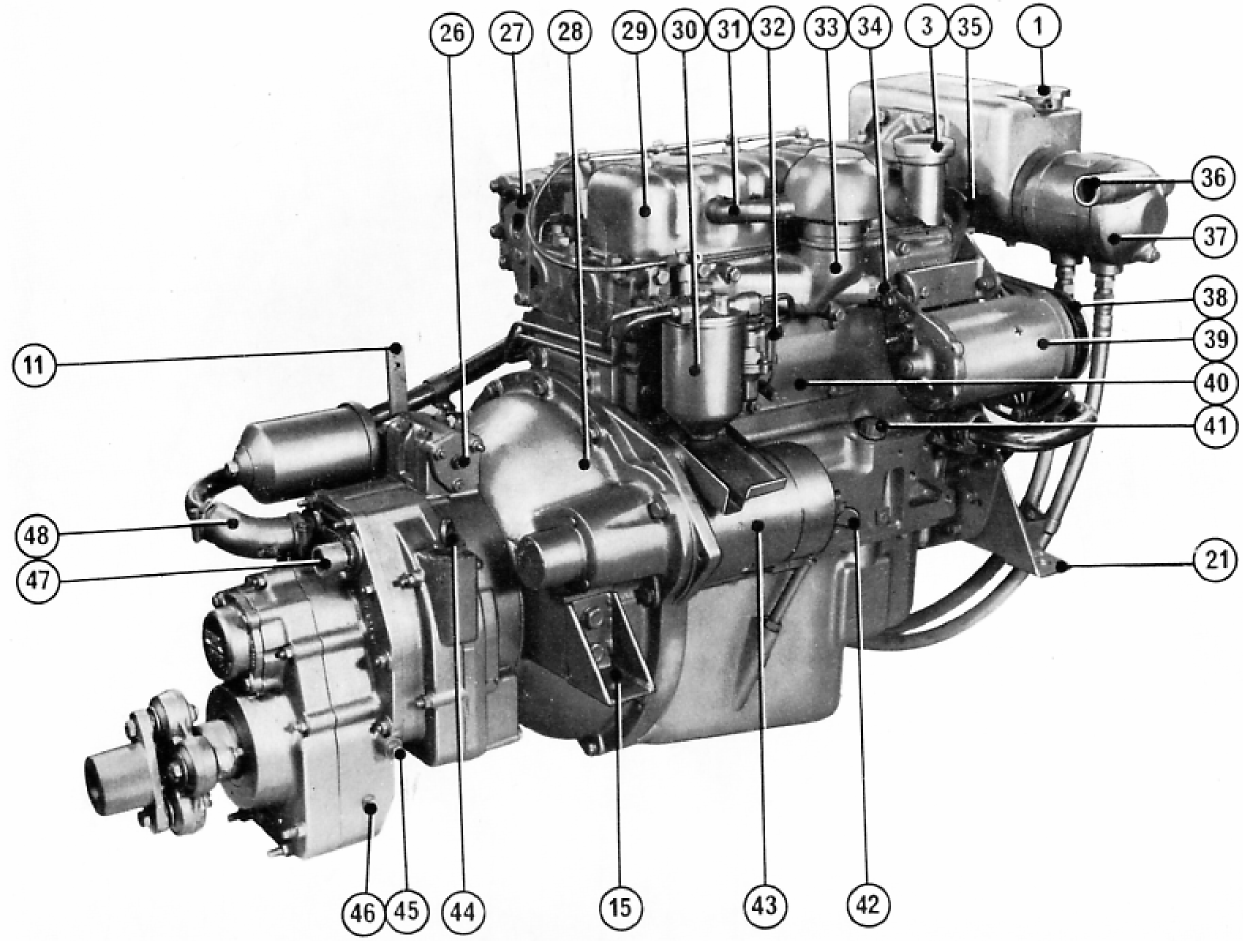
ENGINE PHOTOGRAPHS	Section
ENGINE DESCRIPTION	A
GENERAL INFORMATION	B
INSTALLATION DETAILS	C
STARTING THE ENGINE	D
FAULT DIAGNOSIS	E
PERIODICAL ATTENTIONS	F
CYLINDER HEAD MAINTENANCE	G
PISTONS AND CONNECTING RODS	H
CYLINDER BLOCK AND LINERS	J
CRANKSHAFT AND MAIN BEARINGS	K
TIMING CASE AND DRIVE	L
TIMING	M
LUBRICATING SYSTEM	N
COOLING SYSTEM	P
AIR FILTER AND FUEL SYSTEM	Q
FLYWHEEL AND FLYWHEEL HOUSING	R
ELECTRICAL SYSTEM	S
GLOSSARY OF TERMS	Appendix
APPROVED SERVICE TOOLS	„
APPROVED LUBRICATING OILS	„
INDEX	„
SERVICE FACILITIES	„

Index to Engine Photographs

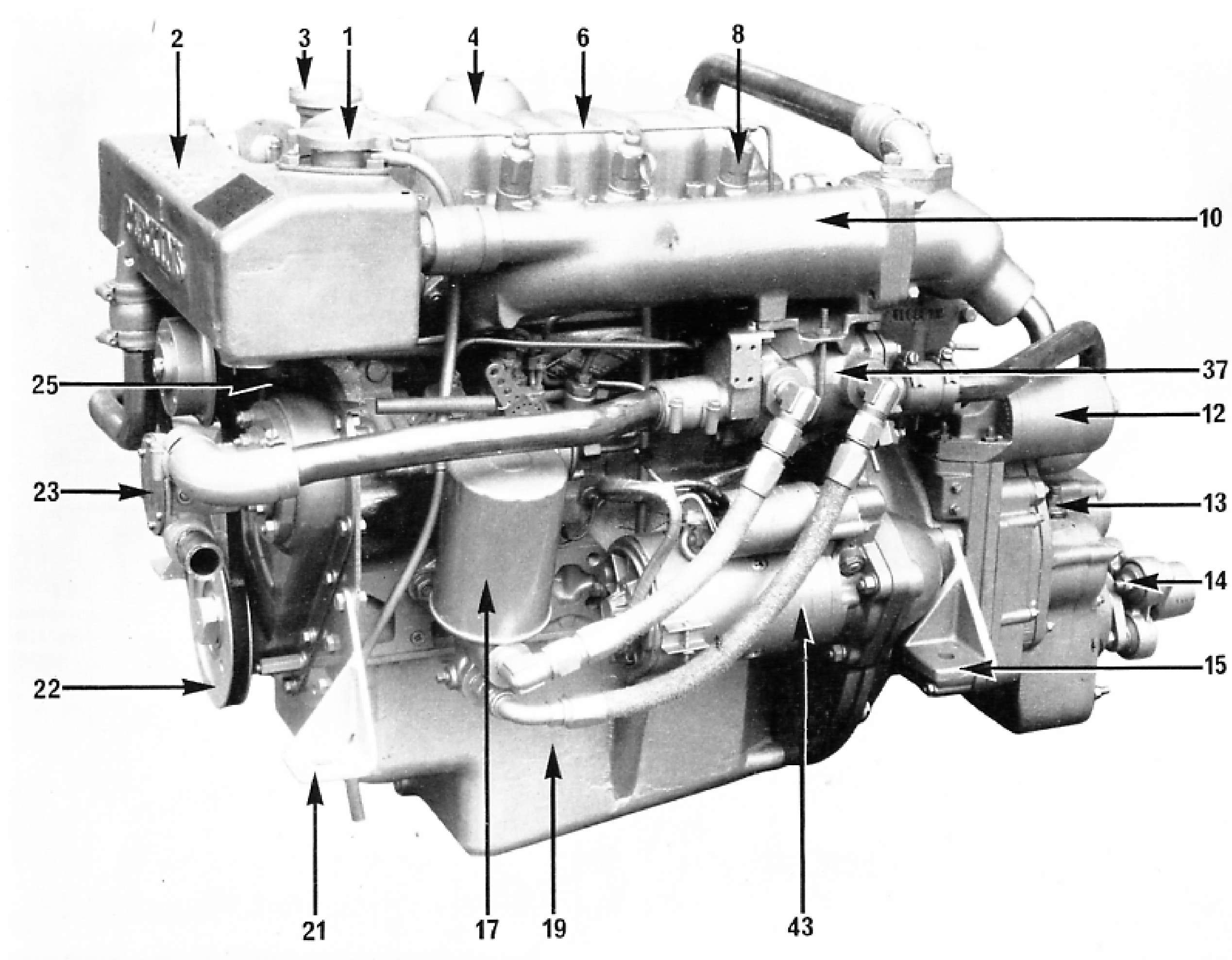
1. Fresh Water Filler Cap.
2. Header Tank.
3. Oil Filler.
4. Air Filter.
5. Fuel Injection Pump.
6. Atomiser Leak off Pipe.
7. Pressure pipes, Injection Pump to Atomisers.
8. Atomiser.
9. Fuel Pipes, Filter to Injection Pump.
10. Exhaust Manifold.
11. Ahead and Astern Engagement Lever.
12. Gearbox Oil Filter.
13. Reduction Gearbox Oil Filler.
14. Output Flange.
15. Rear Engine Support.
16. Water Pipe, Gearbox to Sea Water Pump.
17. Lubricating Oil Filter.
18. Connection for Oil Sump Pump.*
    *Where a "Z" Drive Transom unit is fitted, the sump drain pump is connected to the dipstick tube.
19. Sump.
20. Oil Cooler Pipes.
21. Front Engine Support.
22. Crankshaft Pulley.
23. Sea Water Pump.
24. Water Pipe Exhaust Manifold to Cylinder Block.
25. Fresh Water Pump.
26. Gearbox Pressure Gauge Connection.
27. Rear Lifting Eye.
28. Flywheel Housing.
29. Cylinder Head Cover.
30. Fuel Filter.
31. Breather Pipe.
32. Fuel Lift Pump.
33. Induction Manifold.
34. Cold Starting Aid.
35. Front Lifting Eye.
36. Sea Water Outlet Connection.
37. Engine Oil Cooler.
38. Dynamo Driving Belt.
39. Dynamo.
40. Tappet Inspection Cover.
41. Tachometer Drive.
42. Dipstick.
43. Starter Motor.
44. Gearbox Dipstick.
45. Gearbox Water Drain Plug.
46. Reduction Gearbox Oil Level Plug.
47. Gearbox Water Inlet Connection.
48. Gearbox Water Outlet Connection.
49. Heat Exchanger.
50. Alternator.
51. Sump Drain Pump.



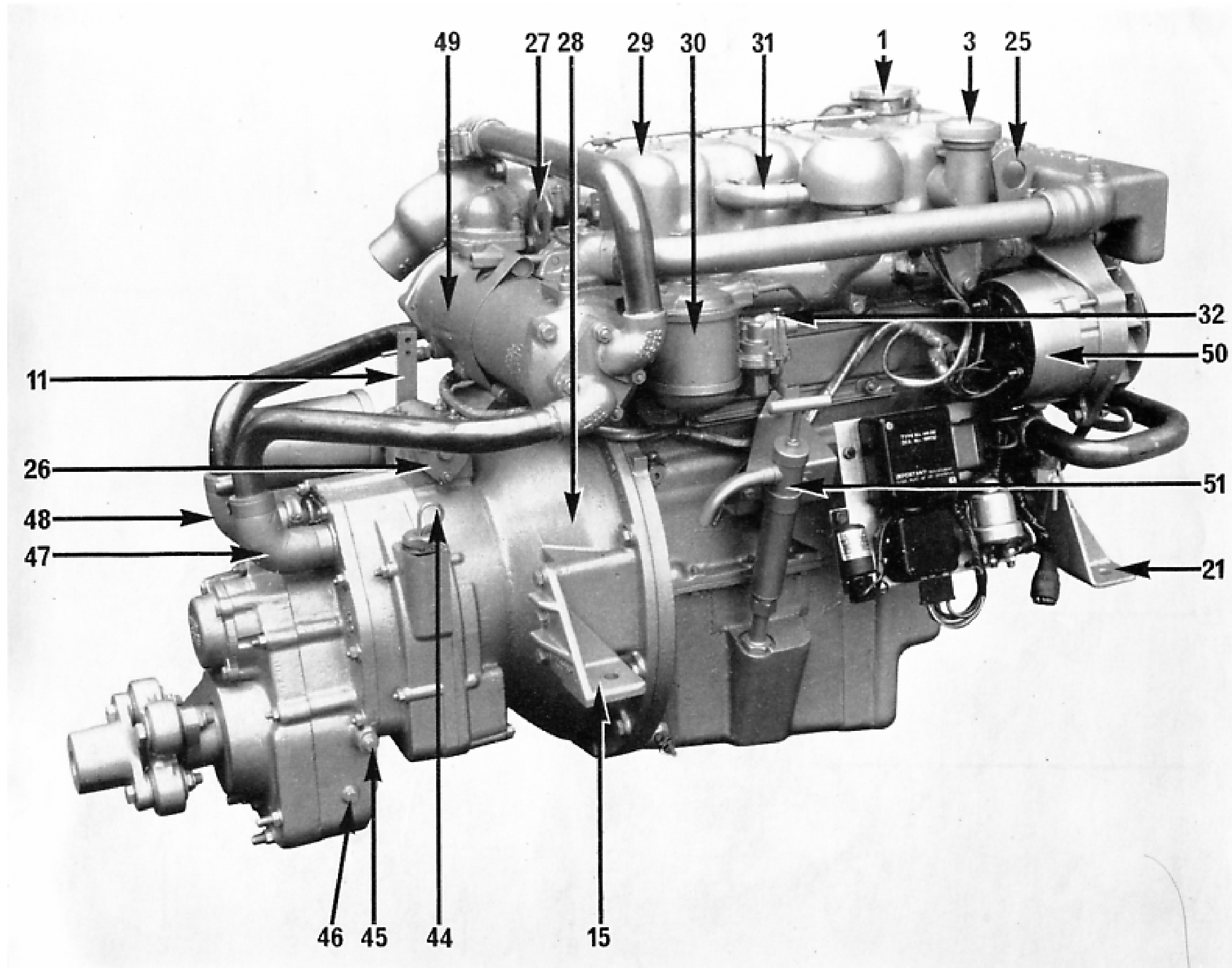
View of Fuel Pump side of Engine.



View of Camshaft side of Engine.



View of Fuel Pump Side of Low-Line Engine.



View of Camshaft Side of Low-Line Engine.

Connecting Rods

The connecting rods are in high tensile steel with an "H" Section Shank.

The big end facing is inclined at 45° to the axis of the rod, and is serrated for cap location, the cap being secured by two setscrews.

Pre-finished big-end bearings and lead bronze small end bushes are fitted.

Lubricating System

A rotary type oil pump, located in the sump, is driven by spiral gears from the camshaft.

An oil strainer, located in the sump, is provided at the pump suction inlet.

The oil is delivered through a full-flow filter on the left hand side of the engine to a main gallery drilled lengthwise through the crankcase. The lubricating oil filter is fitted horizontally, and incorporates a by-pass relief valve.

Drilled holes through the main bearing housings carry the oil from the main gallery to the main bearings, from whence it passes via drilled holes in the crankshaft to the big end bearings.

Drillings in the crankcase webs feed oil from the main bearings to the camshaft bearings. A supply of oil at reduced pressure is fed to the rocker levers from the centre camshaft bearing.

The cylinder bores, small end bush and gudgeon pins are lubricated by splash from the big end bearings.

An oil relief valve is provided in the lub. oil pump body, to control the maximum oil pressure.

The oil filler is mounted on the cylinder head cover.

The oil level dipstick is located on the right hand side of the engine, but provision is made for fitting on the left hand side of the engine if required.

A tapping is provided in the main oil gallery, whereby a pressure warning switch or a pressure gauge may be connected.

Lubricating Oil Sump

A cast aluminium lubricating oil sump is fitted with the drain plug at the front and if required a sump drain pump can be fitted.

Crankcase Ventilation

A closed type breather pipe is fitted from the rocker cover to the air intake and the air movement assists in drawing fumes from the crankcase.

Fuel Injection Equipment

A distributor type fuel pump is flange mounted on the left hand side of the cylinder block, and driven through a splined shaft.

An automatic device is incorporated in the fuel pump to advance or retard the point of fuel injection according to changes of engine speed, for variable speed engines.

The engine speed is controlled by a hydraulic type governor incorporated in the fuel pump, the speed control lever being located on the fuel pump together with an engine stop lever.

A fuel lift pump of the diaphragm type and equipped for hand priming is fitted on the tappet cover on the right hand side of the engine. The pump is operated by an eccentric from the camshaft, via a small push rod.

The atomisers are located on the left hand side of the cylinder head in an accessible position. They are retained in the head by flanges secured with nuts.

A fuel filter is mounted on the right hand side of the cylinder block. The filter is of the paper element type.

Induction Manifold

The induction manifold is made of die-cast aluminium, on the right hand side of the cylinder head, and an air filter is fitted on this manifold.

Exhaust Manifold

A water cooled exhaust manifold is fitted to the left hand side of the cylinder head. The water is not in direct contact with the exhaust gases but circulates in an outer jacket forming part of the engine cooling system.

Cooling System

Two methods of cooling are available according to customer's requirements.

1. Open Circuit Cooling

In this system sea or river water is drawn through a suitable sea cock by a rubber impeller type pump, circulated round the engine and discharged into the sea or river.

2. Closed Circuit Cooling

In this system fresh water is circulated round the engine by a centrifugal type water pump and this water is in turn cooled by either keel cooling pipes or a heat exchanger.

Electrical Equipment

Twelve volt electrical equipment is fitted to the engine.

The dynamo or alternator is mounted on the right hand side of the engine, and is belt driven from the front end of the crankshaft. Belt tension is adjusted by means of a slotted link.

The flange mounted starter motor is fitted on the right hand side of the engine.

Starting Aids

To aid starting under cold conditions, a "Thermostart" heater is fitted in the induction manifold.

Tachometer Drive

Provision is made, on the right hand side of the engine, for a drive at half engine speed to be taken from the oil pump spiral gear to a tachometer.

General Information

	4.108	4.107	4.99
Bore	3.125 in (79,37 mm)*	3.125 in (79,37 mm)*	3.0 in (76,20 mm)*
Stroke	3.5 in (88,90 mm)	3.5 in (88,90 mm)	3.5 in (88,90 mm)
No. of Cylinders ...	Four	Four	Four
Cubic Capacity ...	107.4 in^3 (1,76 litre)	107.4 in^3 (1,76 litre)	99 in^3 (1,62 litre)
Compression Ratio ...	22 : 1	22 : 1	20 : 1
Firing Order	1, 3, 4, 2.	1, 3, 4, 2.	1, 3, 4, 2.
Cycle	Four-Stroke	Four-Stroke	Four-Stroke
Combustion System ...	Indirect Injection	Indirect Injection	Indirect Injection

*Nominal—for actual bore size, see page J.3.

DETAILS OF RATINGS

	4.108	4.107	4.99
Maximum Intermittent Gross Rating (Special for high speed planing craft only)	49 shp at 4,000 rev/min	48 shp at 4,000 rev/min	43 shp at 4,000 rev/min
Maximum Intermittent Rating	46 shp at 3,600 rev/min	45 shp at 3,600 rev/min	40 shp at 3,600 rev/min
Maximum Continuous Rating	37 shp at 3,000 rev/min	36 shp at 3,000 rev/min	33 shp at 3,300 rev/min

Engines should not be operated at maximum intermittent speed for periods in excess of one hour after which, the engine speed should be reduced to the continuous rating speed for at least fifteen minutes before returning to maximum speed.

ENGINE WEIGHTS (Dry Approx.)

Direct cooled engine with mechanically operated direct drive gearbox	520 lb (236 kg)
Heat exchanger cooled engine with mechanically operated reduction gearbox	590 lb (268 kg)
Direct cooled engine with hydraulically operated direct drive gearbox	505 lb (229 kg)
Heat exchanger cooled with hydraulically operated reduction gearbox	570 lb (259 kg)

De-Rating for Altitude

This is not usually necessary for 4.99, 4.107 and 4.108 marine engines. A small loss of power will occur when temperature and humidity conditions are particularly adverse and allowance for this should be made when designing the propeller.

Where engines are called upon to operate in rarefied atmospheres occasioned by altitude, such engines should be de-rated.

The following table is given as a general guide, which may be applied on a percentage basis, where specific figures for a particular engine rating are not available.

Altitude	Maximum fuel delivery de-rating measured at 800 rev/min pump speed
0 — 2,000 feet (600 metre)	No change
2,000 — 4,000 feet (1,200 metre)	6%
4,000 — 6,000 feet (1,800 metre)	12%
6,000 — 8,000 feet (2,400 metre)	18%
8,000 — 10,000 feet (3,000 metre)	24%
10,000 — 12,000 feet (3,600 metre)	30%

Any necessary adjustments in this respect to the fuel pump should be carried out by the C.A.V. dealer for the territory concerned.

For any further information apply to Service Department, Perkins Engines Limited, Peterborough, or to those Overseas Companies listed on Page 2.

Recommended Torque Tensions

The following torque figures will apply with the components lightly oiled before assembly :—

	4.99 and 4.107	4.108
Cylinder Head Nuts	38— 42 lbf ft (5,25— 5,81 kgf m)	55— 60 lbf ft (7,6 — 8,3 kgf m)
*Connecting Rod Setscrews ...	38— 42 lbf ft (5,26— 5,81 kgf m)	38— 42 lbf ft (5,26— 5,81 kgf m)
Main Bearing Setscrews ...	79— 85 lbf ft (10,9 —11,75 kgf m)	79— 85 lbf ft (11,0 —11,5 kgf m)
Flywheel Setscrews	55— 60 lbf ft (7,6 — 8,3 kgf m)	55— 60 lbf ft (7,6 — 8,3 kgf m)
Idler Gear Hub Setscrews ...	33— 36 lbf ft (4,56— 4,98 kgf m)	33— 36 lbf ft (4,56— 4,98 kgf m)
Crankshaft Pulley Setscrew ...	140—150 lbf ft (19,35—20,74 kgf m)	140—150 lbf ft (19,5 —20,5 kgf m)
Atomiser Securing Nuts ...	10— 12 lbf ft (1,4 — 1,7 kgf m)	10— 12 lbf ft (1,4 — 1,7 kgf m)

*Where tabwashers are fitted, torque is 31-35 lbf ft (4.3-4.8 kgf m).

All threads used, except on proprietary equipment are Unified Series and American Pipe Series.
The crankshaft and pulley retaining setscrew are threaded 5/8 in U.N.F. (18 T.P.I.).

SERVICE WEAR LIMITS

The following "wear limits" indicate the condition when it is recommended that the respective items should be serviced or replaced.

Cylinder Head Bow	Longitudinal	0.006 in (0,15 mm)
	Transverse	0.003 in (0,08 mm) concave 0.005 in (0,13 mm) convex
Maximum Bore Wear (when new liners are necessary)	...	0.006 in (0,15 mm)
Crankshaft Main and Big End Journal	Wear	0.001 in (0,03 mm)
	Ovality	0.0005 in (0,01 mm)
Maximum Crankshaft End Float	... ...	0.020 in (0,51 mm)
Valve Stem to Guide Clearance	inlet	0.005 in (0,13 mm)
	exhaust	0.006 in (0,15 mm)
Valve Head Thickness at outer edge	... ...	0.025 in (0.64 mm)
Rocker Clearance on Shaft ...	... ...	0.005 in (0,13 mm)
Camshaft Journals—Ovality and Wear	... ...	0.002 in (0,05 mm)
Camshaft End Float	... ...	0.020 in (0,51 mm)
Idler Gear End Float	... ...	0.010 in (0,25 mm)

Installation Details (C)

The installation of a Perkins 4.99, 4.107 or 4.108 Marine Diesel presents no real problems, and by careful attention to detail, and the correct use of modern mountings and couplings and sound-proofing techniques it is possible to provide a really smooth and quiet installation that will compare very favourably with any petrol engine installation.

Installation Angle

The maximum angle at which the engine can be installed is 17° and is quoted on the engine installation drawing. It should be remembered that this angle increases when the boat is under way by an average of 3°.

Engines installed with vee-drives can usually be mounted with the crankshaft horizontal. Mounting the engines "down by the head" should be avoided as it can lead to air-locks in the water jackets at the rear end of the cylinder head which is not vented. Where this arrangement is unavoidable it may be necessary to arrange special vents at the end of the cylinder head.

The engine oil sumps are designed so that varying installation angles give approximately the same capacity of lubricating oil to the "full" and "danger" marks on the dipstick.

Drainage of the lubricating oil is effected by using a sump drain pump. Some engines with oil operated gearboxes also utilise the drain pump for the gearbox sump.

Auxiliary yacht installations may require the engine to be run while beating to windward. Under these conditions the boat may heel up to 30° without adverse effect on the lubrication system providing the boat is righted occasionally, in order to lubricate the valve assembly.

Engine Mounting

Generally speaking, in heavily timbered hulls, with long engine beds to distribute the load as in the cases of barges, workboats, etc., the engine may be solidly mounted on the bearers, but if these are timber, pressure plates in the form of rectangular steel pads should be fitted to the tops of the bearers under the engine feet, and the holding down bolts must be taken as far down through the bearers as possible to a morticed hole for the lower nut. A second pressure plate, must, of course, be inserted above this nut. Under no circumstances should coach screws be used to fasten down the engine as vibration and torque reaction causes these to loosen with consequent misalignment of the engine with the propeller shaft.

In some cases it may be desirable to reinforce the top of the engine bearers by bolting a length of steel plate or angle iron under the engine mounting brackets. The reinforcement should be carried along the bearers as far as possible and with the holding down bolts fitted as recommended, the plates may be additionally secured by coach screws.

When the hull is of very light construction and the primary use is for pleasure, flexible mountings are desirable. Perkins Engines Limited have carried out considerable experimental work on flexible mountings and couplings, and our recommendations should be followed in all cases where these items are fitted. Badly matched flexible mountings and couplings can give rise to more vibration than is experienced with solidly mounted engines.

The illustration figure C.1. shows the adjustable flexible mountings which are specified on all types of engines. This adjustment allows the coupling to be accurately aligned and also compensates for the small amount of settling which sometimes occurs after a period of service.

The inclusion of a flexible coupling or couplings in the tailshaft does not mean that liberties may be taken with the lining up of engine and tailshaft, and the same care must be used as when the engine is solidly mounted.

The types of flexible couplings and mountings recommended are capable of transmitting the considerable thrust exerted by the propeller on the tailshaft. The stern gear usually allows the shaft to move axially in the bearings when this thrust is acting in both directions according to the direction of rotation of the propeller. A special heavy duty race in the aft end of the reverse gearbox (or reduction gear when this is fitted) absorbs the propeller thrust. When an engine is being fitted to a boat which was previously powered by an engine

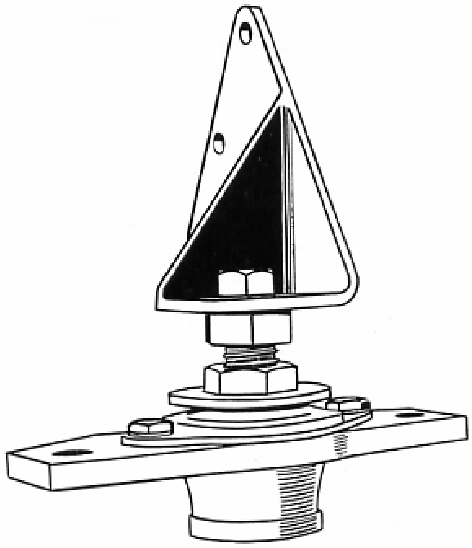


Fig. C.1.

having a gearbox which was unable to withstand the propeller thrust, it will be found that a thrust block is included at the inboard end of the stern-tube. If it is desired to retain the thrust block it will be necessary with Parsons type reverse gears to change the usual thrust bearing provided to a standard journal type.

Two arrangements of flexible mountings are available for 4.99, 4.107 and 4.108 engines.

The first is the conventional "four-point" arrangement utilising the adjustable mounts described previously.

The second arrangement is a "three-point" system with two vehicle type mountings fairly high up on the front of the engine and the third underneath the gearbox. This arrangement allows the engine to "swing" much more at lower speeds and is particularly suitable for very light craft as in the case of fast runabaout. This arrangement lends itself quite easily to installation on fore and aft bearings.

Final coupling up of sterngear to engine should never take place in wooden hulls until the vessel has been in the water for some days. As much as two or three weeks may be necessary for some hulls to take up their "wet" shape.

If there is more than say 6 ft (1,83 mm) of unsupported tailshaft of small diameter, it may be advisable to fit a self-aligning bearing as a support. If in doubt on this point it can be left until after the initial trials when it will soon be evident if whirling of the shaft is taking place.

Water Connections

Seacocks and strainers should be of the full flow type, and of a size at least equal to the inlet pipe of the seawater pump. The strainer should, where practicable, be of the type which may be withdrawn for cleaning whilst the vessel is under way. The water intake on the outside of the hull should not restrict the water flow. If an expanded metal or wire mesh type is used the effective area should be greater than the bore of the intake pipe.

The recommended sizes of water pipes to and from the engines are given on the engine installation drawings. The engine connections are intended to be coupled to copper pipes by lengths of reinforced rubber hose and secured by hose clips Solid connections should not be made as vibration can cause fracture. In cases where pipe lengths can be kept fairly short and out of harms way, sea water pipes can be of plastic.

Care should be taken not to use long lengths of soft rubber piping on the suction side of the water pump as, if the strainer should become partially blocked, the vacuum can cause the pipe to collapse with consequent loss of water delivery.

Where more than one engine is fitted it is important to have the water intake positions symmetrical about the keel, or if this is not possible, to ensure that the positions chosen give balanced intake flow conditions as unequal flows can cause variations in engine water temperatures.

Exhaust System

If a water injection silencing system is fitted—and this is almost always desirable where a quiet installation is required, it is better to fit a mixing chamber of a recommended type than to take the water discharge straight into the exhaust pipe. A properly designed mixing chamber will prevent any possibility of water finding its way back to the engine when the vessel rolls heavily with the engine stopped. (See fig. C.2). If, however, it is desired to fabricate the discharge fitting, the water entry should be at least 9 inches (228,6 mm) from the exhaust manifold flange. The exhaust pipe should run in a downward sweep from the manifold flange. See Fig. C.3.

Brass or copper is not acceptable for wet exhaust systems, as the combination of salt water and diesel exhaust gas will cause rapid deterioration. Iron fittings should be used, and with a mixing chamber fitted it is usually advisable to carry out the final run of pipe in rubber diesel exhaust hose.

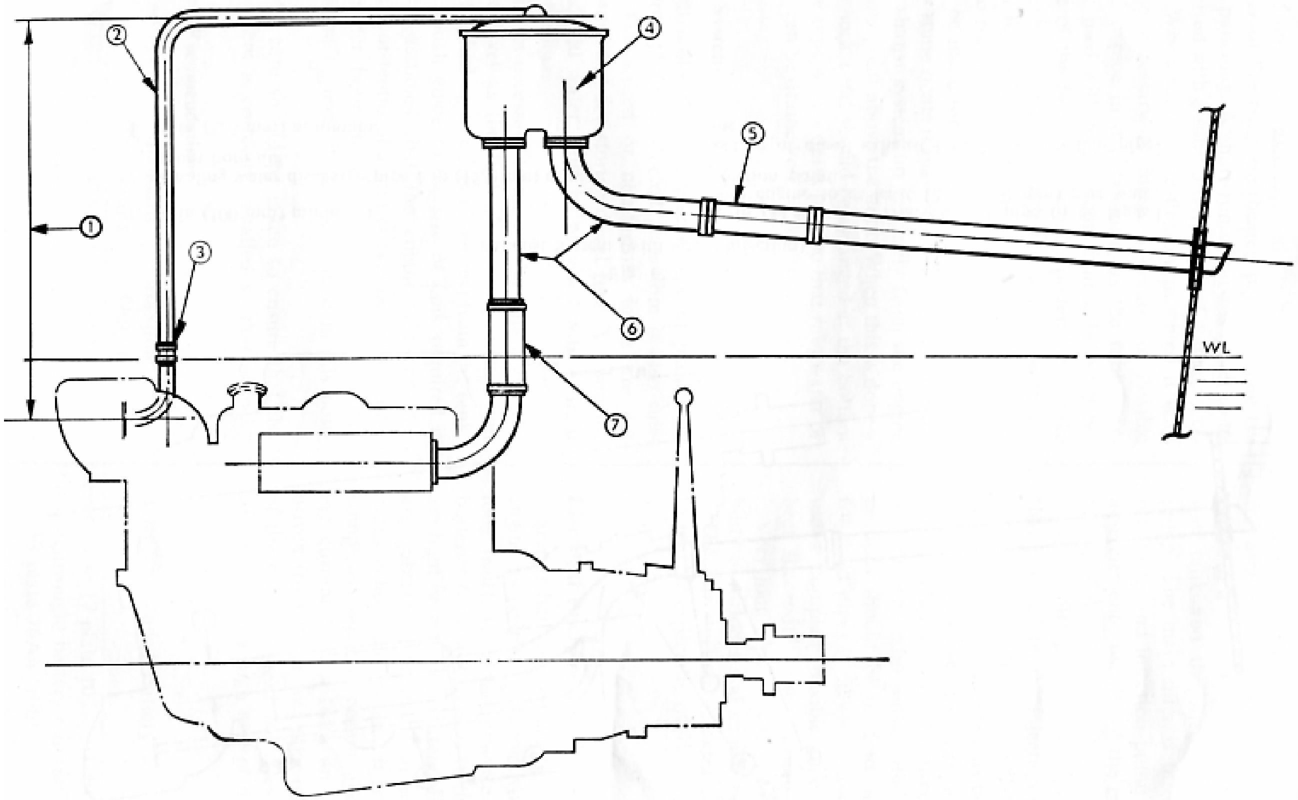


Fig. C.2.
Exhaust System with Water Injection Silencer.

1. 8 ft. (2438 mm) Maximum.
2. Cooling water discharge pipe $\frac{5}{8}$ in (15,9 mm) minimum bore diameter.
3. Pipe to be flexibly connected at, or near to engine.
4. Water injection silencer to be fitted well above water line.
5. Section of diesel exhaust hose to be fitted.
6. $1\frac{3}{4}$ in (44,4 mm) O/Dia. exhaust pipe portion from engine to silencer to be lagged.
7. Section of flexible exhaust pipe to be fitted if engine is flexibly mounted.

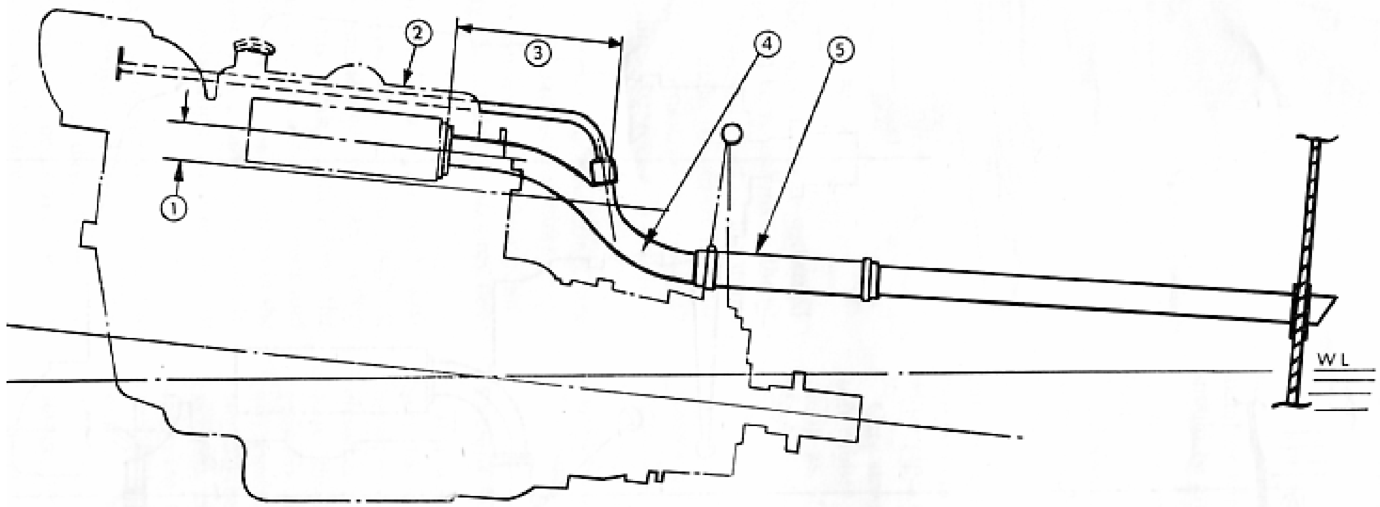


Fig. C.3.
Exhaust System (with water injection).

1. 4 in (100 mm) minimum
2. Cooling water discharge pipe $\frac{5}{8}$ in (15,9 mm) minimum bore dia.
3. 9 in (225 mm) minimum.
4. $1\frac{3}{4}$ in (44,4 mm) O/Dia. exhaust pipe to be lagged from engine to at least 12 in (300 mm) past water injection point.
5. Section of diesel exhaust hose to be fitted in pipeline.

With a dry exhaust system it is not wise to have long runs of pipe (which should again be iron for choice) through the after accommodation (1) because of the noise, which is much greater than that from a wet exhaust, and (2) because of the danger of fire from overheated pipes running behind panelling. A short run of pipe is much to be preferred with a substantial length of water jacketting. When engines are flexibly mounted it is of course necessary to insert a section of flexible metallic pipe in dry exhausts, as the rubber exhaust used with wet systems cannot be fitted because of the heat. It is usually preferable to take the exhaust pipes through the hull close to the water line. Where this is not possible and the pipe has to rise above exhaust manifold level, provision must be made for draining water from the pipe.

On some boats it may be convenient to take the dry exhaust system up vertically from the engine to some point above the deck. When this is done a swan neck bend should be arranged at the bottom of the pipe with a drain plug so that rain water or spray can be drained off.

Fuel System

Fuel tanks should preferably be of plain steel or terne plate; reinforced glass-fibre is also suitable. Galvanised or non-ferrous tanks are not recommended for storing diesel fuel. A sump for sludge and water must be provided with a drain tap or plug.

It is not necessary to mount the tank above the engine level as the fuel lift pump provided will raise the fuel up to 6 feet (2 metres) from the tank. As a rough guide to the size of tank required it can be assumed that the engine will consume about four-tenths of a pint of fuel per brake horse power per hour. If a tank is already installed above engine level it can be utilised in this position.

Great care should be taken to ensure that the fuel system is correctly installed so that airlocks are eliminated and precautions taken against dirt and water entering the fuel.

Two filters are provided with each engine. The first is a small glass bowl type which is either fitted to the engine fuel lift pump or supplied loose for attachment to or near the fuel tank. This serves as a water trap and is piped up between the fuel tank and the suction side of the fuel lift pump. The main filter is fitted between the fuel lift pump and injection pump and has a replaceable element—usually of the paper cartridge type. See fig. C.4.

As the lift pump has a capacity in excess of that required by the injection pump, the overflow is piped up to the tank and should be connected as near the top of the tank as possible.

Fuel pipes are provided with some types of engine. They are usually either $\frac{5}{16}$ in (7,94 mm) or $\frac{3}{8}$ in (9,53 mm) outside diameter. Flexible connections should be used to prevent fracture and for short pipes it may sometimes be convenient to use a complete flexible pipe. Nylon piping has been successfully used in many installations.

Very long pipe runs tend to increase the possibility of airlocks and should be avoided.

The introduction of extra filters can also lead to trouble especially overloading of the lift pump.

Electrical Equipment

Starter batteries should be sited as close to the engine as possible, to avoid voltage drop through long leads. It is bad practice to use the starter batteries for other services in the boat unless these are light or very intermittent. In cases where there are substantial loads from lights, refrigerators, radio, echo sounders, etc., it is essential to have a completely separate system, and to provide charging current to this from an auxiliary generator driven from the power take off shaft at the front of the engine. Starter batteries must be of a type which permits a high rate of discharge.

Battery Recomendations

Engine Type	Standard Generators	Maximum Output	Recommended Battery	Number of Units
4.99 4.107	Lucas C40A(12V)	11A	General Use 17 plate 102Ah (10h)	2
			When lightweight battery required	6V
			13 plate 76Ah (10h)	1
				12V
4.107 4.108	Lucas 11AC(12V)	43A	General Use 17 plate 102Ah (10h)	2
	Alternator		When lightweight battery required	6V
			13 plate 76Ah (10h)	1
				12V

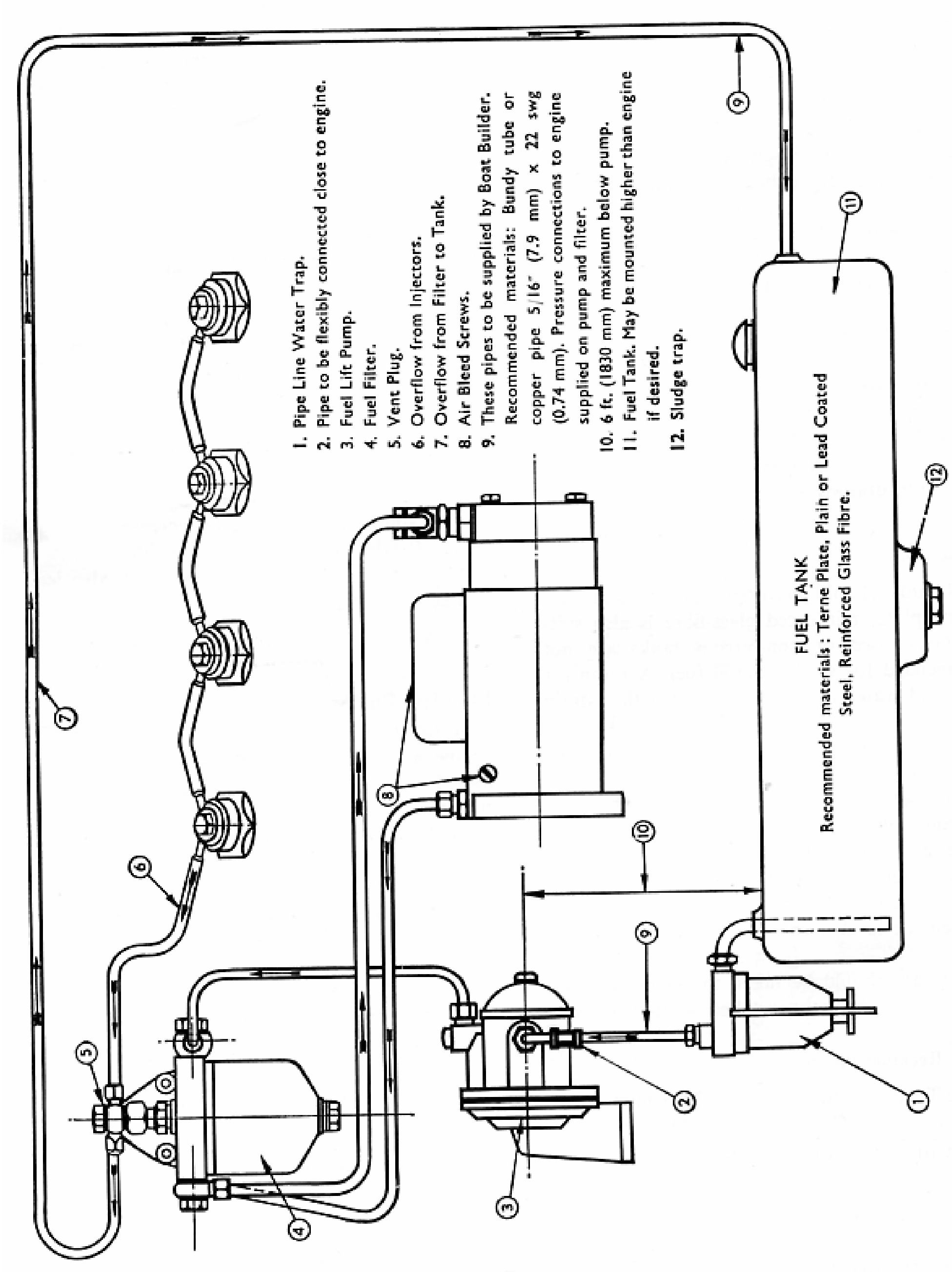


Fig. C.4. Fuel System.

On some engines it is possible to provide a special generator with a higher charging rate which will cope with some auxiliary requirements as well as battery charging. The recommended battery size should not be increased if the larger generator is fitted and the total current requirements should be kept within the lamp load specified. On multi-engined boats one set of batteries per engine is recommended. The use of too large a battery, can result in damage to the dynamo and alternator resulting from overheating during prolonged periods of charging at a high rate.

The standard dynamos and alternators supplied are not suppressed against radio interference. Engines can be supplied to special order with chokes and condensers fitted to the dynamo or alternator giving a degree of suppression. Further protection may be obtained by using screened leads and housing the regulator in a special enclosure. It is recommended that a specialist firm should be consulted in such cases.

Engines are wired up with an earth return system as standard. Typical wiring diagrams are shown in Figs. S.6 and S.7.

Starting Aid

Fuel oil from a separate reservoir is automatically metered by a valve in the "Thermostart" device which is screwed into the air intake. The fuel oil container is mounted alongside the engine, a head of 4 in (101 mm) being required to maintain sufficient flow (See fig. C5). With this system a special starting switch is provided so that on starting from cold the key can be held in the "Heat Only" position for several seconds before engaging "Heat and Starter." The switch is spring loaded returning to the disengaged position when pressure is released. For some types of engine required to operate under extreme conditions of temperature the "Start Pilot" ether starting device can be fitted.

Engine Controls

Engines having oil operated gearboxes may be equipped with a "single lever" throttle and gearbox control.

With the "single lever" throttle control, an over-riding arrangement is incorporated permitting the throttle to be opened in neutral to assist easy starting.

The system incorporates a self-contained control head which may be located on the engine or at the steering position, operating twin cables which are enclosed in flexible conduit and connected to the throttle and gearbox control levers.

For engines fitted with mechanical type gearboxes "single lever" controls are not suitable and separate controls for operation of throttle and gearchange lever must be provided. A force from 30 to 50 lbf (13,6—22,7 Kgf) is required at the end of the gear-change lever. If remote operating gear is to be fitted this must be extremely robust and it must be possible to select neutral accurately and "feel" the gear position.

Where separate manual controls are fitted for operation of throttle and gear change, it is important to note that it is necessary to reduce engine speed to idling before changing gear, otherwise damage to the gearbox may result.

Provision is made on all engines for a remotely operated stop control. This consists of a "push-pull" Bowden cable connected on the fuel injection pump which shuts off the fuel when it is desired to stop the engine.

Instrument Panels

These are usually optional items as some boatbuilders prefer to design their own panel to fit in with the space available or possibly to house other switches and equipment. With most engines there is a choice of cable and capillary lengths to suit varying distances from the engine to control position.

Standard Instruments include:

- Tachometer.
- Water temperature gauge.
- Oil pressure gauge.
- Ammeter.
- Heater and starter switch.
- Stop control.

Whether all or some of these items are supplied with the engine or not, the various pick-up points for these instruments are provided on all engines. The water thermometer is a direct mechanical type with the bulb screwed into the water outlet connection or front end of cylinder head.

Where the instrument panel is located at too great a distance from the engine to enable the ordinary mechanical water temperature gauge and tachometer to be used, electrical types are available. These have the advantage that they may be duplicated; for example a panel may be situated in the engine room and another in the wheelhouse.

On some engines the panel may be fitted to the engine and when this is so it is recommended that the wiring loom should be purchased with the engine.

No particular problems arise in assembling the remote panel. Coils should be arranged in the pressure gauge pipe and temperature gauge capillary to prevent vibration causing "work-hardening" and subsequent fracture of the thin copper tubes. The tachometer cable should be arranged with large bends to minimise friction and the total number of bends should be minimised.

Sound Proofing

Sound insulation is important, and it is well worth while giving the subject special attention when completing an installation. There are various proprietary makes of sound absorbent materials produced in panel form, or double panels may be made up and packed with loose sound absorbing materials such as granulated cork, fibre-glass matting, balsa wood, etc. When the soundproofing is carried out, make sure that the panels are easily detachable to allow access to the engine for maintenance and servicing, and remember that the engine uses a very large amount of air and due allowance must be made for an uninterrupted flow.

Air Cleaners

The standard dry type air cleaner is suitable for all applications except canal or river work where dust may be present. In this case an oil bath air cleaner must be supplied.

Bilge Pump

Provision is made at the forward end of the engine for driving a bilge pump which can be supplied with the engine when required. It is necessary to make a suitable mounting bracket which can usually be bolted to the engine beds. Slotted holes should be provided for adjustment of the driving belt. On flexibly mounted engines the bracket should be attached to the engine.

Reverse Gear

Two types of reverse gear are used and these are manually or hydraulically operated.

When oil operated reverse gears are used on auxiliary yacht or twin and multi-engined installations, care must be exercised when trailing the propeller with the engine or engines out of use.

On the Nicor TMP 12000 series gearbox, it is necessary to run the engine after trailing the propeller for 12 hours to lubricate the gearbox.

With the Borg Warner gearbox it is permissible to trail for 8 hours providing the following shaft speeds are not exceeded:—

Direct drive	1500 Rev/min
1.5	1000 ,, ,,
1.9	790 ,, ,,
2.1	715 ,, ,,
2.5	600 ,, ,,
2.9	520 ,, ,,

Proprietary propeller shaft brakes are now available to facilitate the above shaft speed range.

The Parsons type "DA" gearbox may be trailed for any length of time provided the gearbox oil is maintained to the top dipstick mark.

Vee-Drive

When this form of transmission is used it is advisable to use flexible couplings or universal joints between the engine end and the 'V' drive unit. The latter are essential when the engine output coupling is not on the same axis as the input coupling of the vee-drive. It should, however, be noted that the axis of the engine and vee-drive input shaft should be parallel.

As the vee-drive will usually have a thrust bearing designed to absorb the propeller thrust it is necessary for the bearing in the reverse gearbox to be a journal type which does not require thrust for centralisation. This only applies to Parsons gearboxes—all other types supplied have dual purpose bearings fitted.

The casing of the vee-drive will usually require a supply of cooling water from the engine. This is best taken from the engine water outlet before piping into the water injection silencer. Alternatively the vee-drive can be piped up on the suction side of the sea water pump.

Where keel cooling is employed and no sea water pump is used the vee-drive may be piped up on the return pipe from the keel pipes to the engine.

All engines may be fitted with some form of power take-off at the front end of the crankshaft. This usually takes the form of a 1.5 in (38,10 mm) or 2 in (50,80 mm) dia. steel shaft extending forward of the timing case to which the customer may attach his own pulleys or flexible coupling. When pulleys are used the overhang must be minimised and if in doubt on this point it should be referred to Perkins Engines Limited for approval. The use of flexible engine mountings makes the provision of a power take off drive more difficult—it being necessary to use a flexible

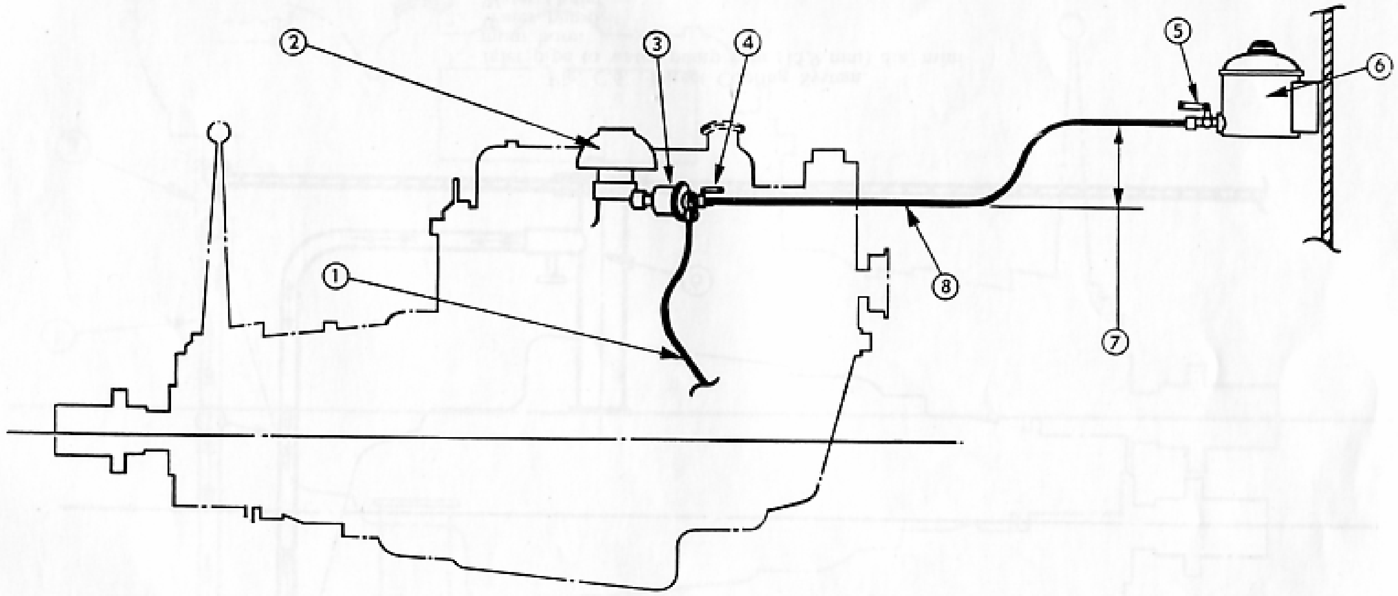


Fig. C.5.

Cold Starting Aid.

1. Cable to heater switch.
2. Air Intake.
3. Cold start aid.
4. and 5. These cocks may be left on as fuel is metered by valve.
6. Fuel container.
7. 12 in (300 mm) maximum — 4 in (100 mm) minimum.
8. 5 feet (1525 mm) long by 3/16 in (4,75 mm) o/d fuel pipe.

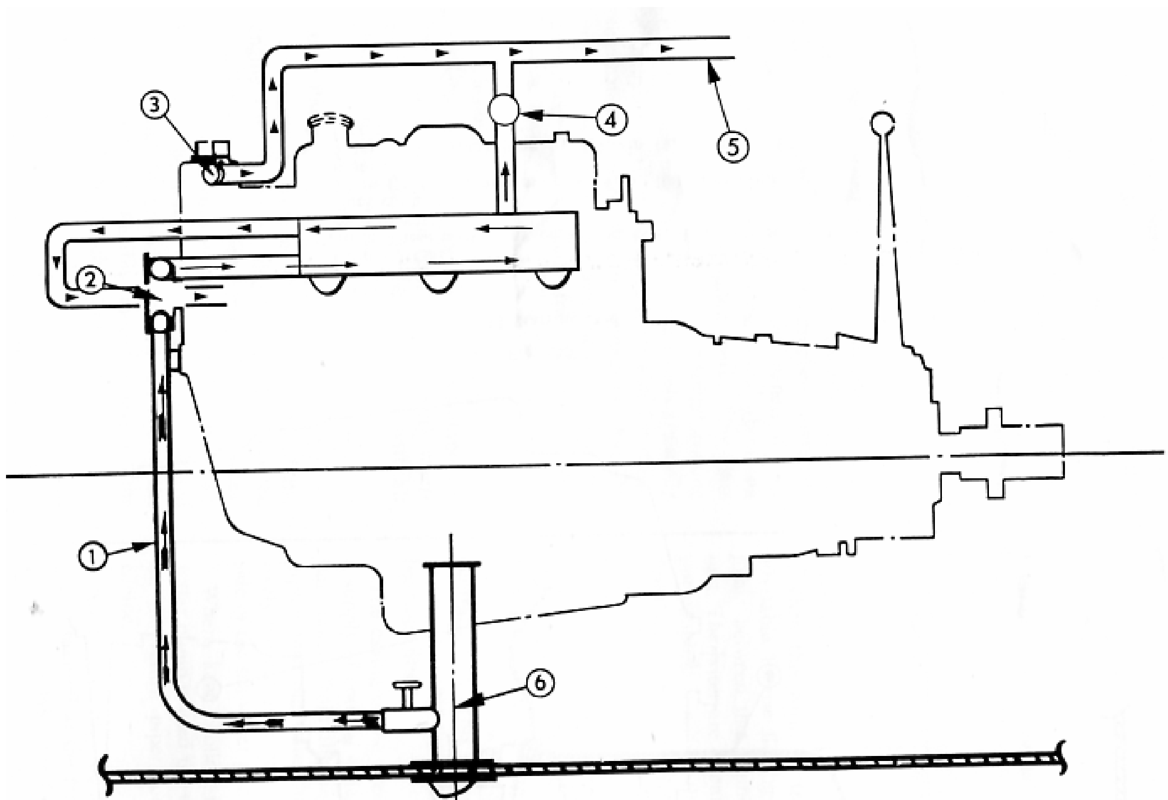


Fig. C.6. Direct Cooling System.

1. Inlet pipe to water pump $\frac{5}{8}$ in (15,9 mm) dia. minimum bore.
2. Water pump.
3. Water Outlet.
4. Pressure Relief Valve.
5. Water outlet pipe $\frac{5}{8}$in (15,9 mm) dia. minimum bore.
6. Seacock and strainer incorporating weed trap.

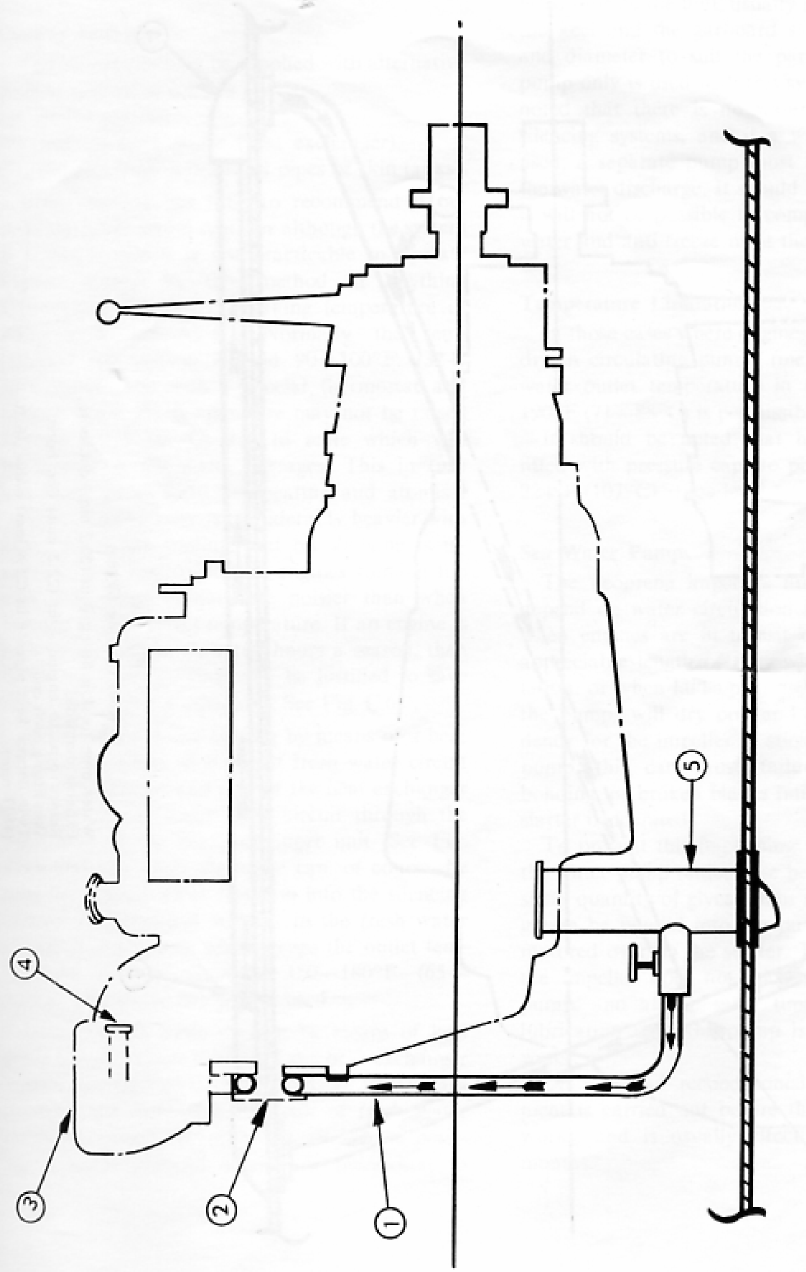


Fig. C.7. Indirect Cooling System.

1. Inlet pipe to water pump $\frac{5}{8}$ in (15,9 mm) dia. minimum bore. Inlet pipe to be flexibly connected at or near to engine.
2. Sea Water Pump.
3. Combined heat exchanger and oil cooler.
4. Sea water discharge from heat exchanger $\frac{5}{8}$ in (15,9 mm) dia. minimum bore.
5. Seacock and strainer incorporating weed trap.

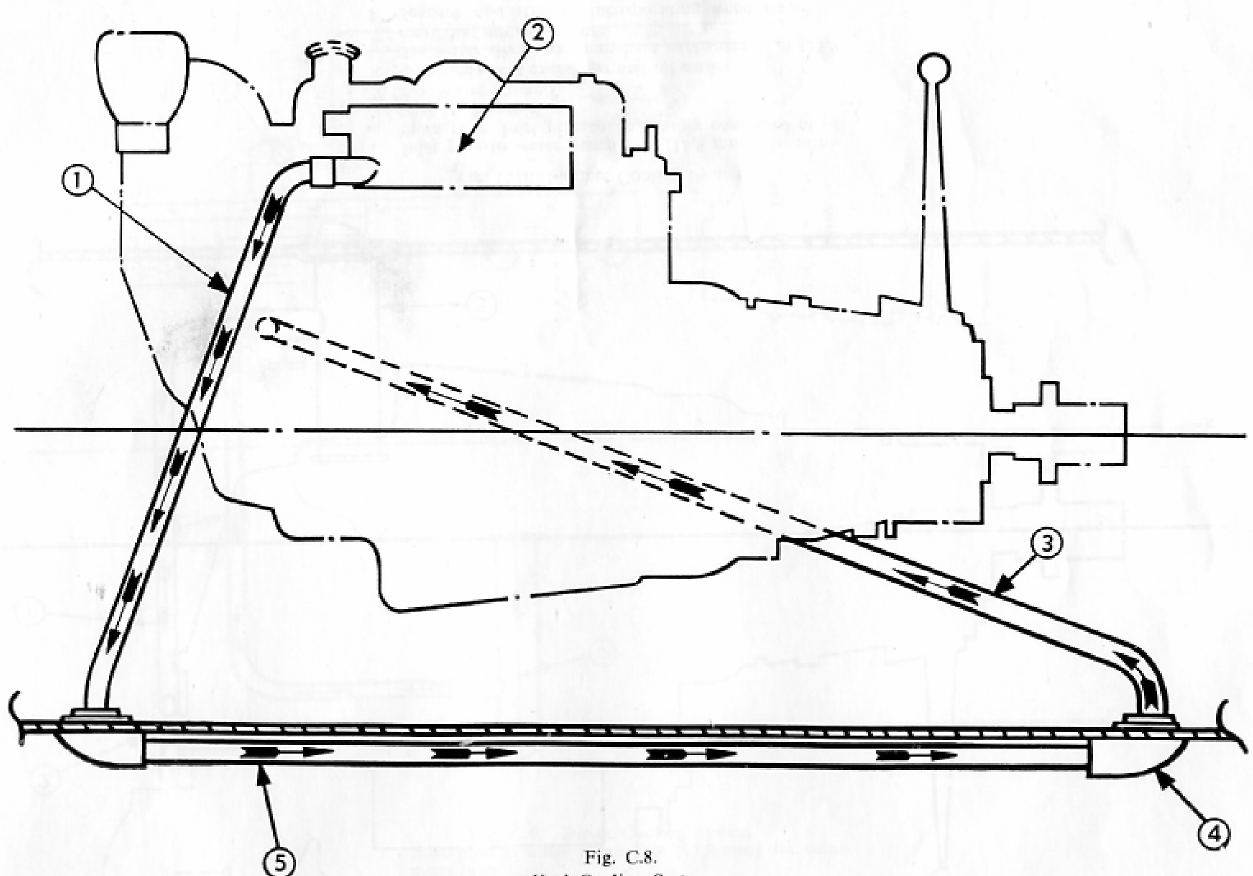


Fig. C.8.
Keel Cooling System.

1. Water pipe to skin fitting ⅞ in (22,2 mm) dia. bore.
2. Exhaust manifold.
3. Return pipe to engine ⅞ in (22,2 mm) dia. bore.
4. Skin fitting each end.
5. Twin copper keel pipes 1 in (25,4 mm) o/dia. 16 ft. (4877 mm).

coupling driving the winch, etc., in tandem with the engine.

Cooling Systems

Perkins engines may be supplied with alternative cooling systems as follows :—

(a) Direct seawater.

(b) Indirect fresh water (heat exchanger).

(c) Indirect fresh water (keel pipes or skin tanks).

Direct cooling has little to recommend it beyond the lower initial cost, for although the system is a simple one it is not practicable to operate engines cooled by this method at anything approaching the correct working temperature of 150—180°F (65—82°C). Normally the temperature will remain around 90—100°F. (32—38°C.) and even with a special thermostat and by-pass fitted, the temperature may not be raised beyond 120°F (49°C) due to scale which will be formed in the water passages. This in turn will bring about local overheating and atomiser troubles. Engine wear is considerably heavier with direct sea water cooling, and oil sludging is increased. It is noticeable that engines running too cold with direct cooling are noisier than when running at the correct temperature. If an engine is to be used for less than 100 hours a season, then direct sea water cooling may be justified to save initial cost, but not otherwise. See Fig. C.6.

Indirect fresh water cooling by means of a heat exchanger consists of a closed fresh water circuit around the engine, and part of the heat exchanger unit, and a salt water open circuit through the other part of the heat exchanger unit (See Fig. C.7). The salt water discharge can, of course, be used for normal water injection into the silencing system. A thermostat is fitted in the fresh water circuit of this system which keeps the outlet temperature at approximately 150—180°F (65—82°C). Two water pumps are used.

Indirect fresh water cooling by means of keel pipes is a simplified version of the heat exchanger system described above (See Fig. C.8). In this case we have the same closed circuit of fresh water round the engine, oil coolers, manifold, and possibly a water jacketed silencer, a thermostat to control the water temperature and a small header tank. The heat is extracted from the fresh water by extending the circuit to include a pipe or pipes fitted outside the hull, usually in the angle between the keel and the garboard strake, and of length and diameter to suit the particular engine. One pump only is used with this system, but it must be noted that there is no water discharge for wet silencing systems, and if a wet exhaust is to be used, a separate pump must be fitted to provide the water discharge. It should be remembered that it will not be possible to completely drain off the water and anti-freeze must therefore be used.

Temperature Limitations

In those cases where engines are fitted with belt-driven circulating pumps (metal impeller type) a water outlet temperature in the range of 160—190°F (71—88°C) is permissible.

It should be noted that heat exchangers are fitted with pressure caps to prevent boiling below 224°F (107°C) at sea level.

Sea Water Pumps

The neoprene impellers fitted in these pumps depend on water circulation for lubrication, and when engines are in transit or standing for any appreciable length of time whilst awaiting installation, or when laid up during the Winter season, the pumps will dry out, and there is then a tendency for the impeller to stick to the body of the pump, this can cause failure of the impeller bonding, or broken blades immediately the engine starter is operated.

To prevent this happening we recommend that the water pump outlet hose be disconnected and a small quantity of glycerine or melted Marfak 2HD grease be poured into the pump, the engine then motored over on the starter. This will ensure that the impeller does not stick to the body of the pump, and at the same time provide adequate lubrication until the pump is again primed with water.

On new and reconditioned engines this treatment is carried out before the engine leaves our works, and is usually effective for about three months.

Starting the Engine (D)

Preparation for Starting

Check the header tank water level, when fitted.

Check the engine sump oil level.

See that there is sufficient fuel oil in the tank.

Check that the starter battery is fully charged and that all electrical connections are properly made and all circuits are in order.

Check that sea cock is open, when fitted.

Lubricating Oil

During the normal winter period, a lubricating oil of S.A.E. 10W viscosity of high detergency conforming to MIL/L/2104B specification should be used. For approved oils, see appendix.

Priming the Fuel System

In the case of a new engine or an engine which has been standing idle for any length of time, it is important that the fuel system be "bled."

To bleed the system, proceed as described on page Q.6.

Starting the Engine

If the engine is warm and has only been stopped for a little while, place the throttle in the fully open position and engage the starter motor by turning the starter switch in a clockwise direction to the "HS" position (See Fig. D.1).

If the battery is well up, enough to turn the starter motor quickly, the engine should start.

Check following initial start, coolant water flow from discharge pipe and lubricating oil pressure.

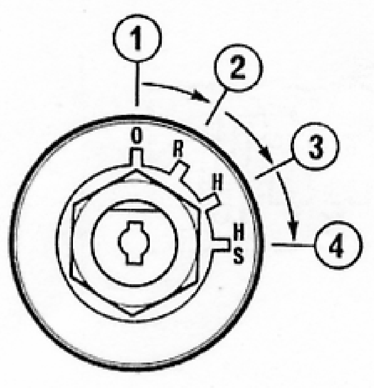


Fig. D.1.
Current Heat/Start Switch.
1. Off Position.
2. Run Position.
3. Heat Position.
4. Heat and Start Position.

Cold Starting Aids

Two different type starting aids have been fitted to the 4.99 Marine Engine, the Mk. I to earlier engines and the Mk. III to later engines. All 4.107 and 4.108 Marine Engines are fitted with the Mk. III type.

Description — Mk. I

Referring to Figs. D.2 and D.3 the unit consists of a core (3), a solenoid (6) a spring loaded plunger (4) fitted with a special rubber insert (5) which abuts on a valve seat (7). The coil carrier (8) bears two heater coils (9, 10) and a circular shield surrounding the coils has large perforations (11) on one side, small perforations (13) on the other and a small flange (12) running along its outer surface.

Gravity fed fuel oil fills the adaptor (1), filter (2) hollow plunger (4) and the groove in the surface of the plunger. When the switch on the application control panel is operated, the solenoid (6) and coils (9, 10) are energised. Magnetism induced in the plunger (4) and adaptor (1) by the solenoid draws the plunger and rubber insert off the valve seat (7). Fuel oil then flows at a controlled rate along and around the coil (9) which causes the liquid to be vapourised. Coil (10) reaches the ignition temperature of the fuel vapour.

As soon as the engine is turned over by means of the starter motor, fresh air drawn into the inlet manifold enters the circular shield through the small perforations (13) and mixes with the vapourised fuel within. The resultant mixture is ignited by the coil (10) and so heats the air to facilitate combustion by promoting easier ignition of the fuel injected into the engine cylinders.

The flange (12) running along the outer surface of the shield provides a sheltered zone around the outlet holes (11) and protects the flame from the incoming air stream.

Maintenance

Very little attention is required by the unit, but no reconditioning is possible. When in service the unit should be occasionally checked to ensure that it is firmly screwed and located in the manifold, with the arrow on the casing pointing in the direction of the airflow. It should also be ensured that the electrical lead wire is tightly fixed to the terminal, that the fuel banjo is tight and that there is no leakage.

To clean the unit, remove connections and withdraw from the inlet manifold. Wash components in cleaning fluid and brush off any carbon which may have accumulated on the circular sheath, ensuring that all holes are clear. While no mechanical attempt should be made to remove or clean the internal filter (2), compressed air may be used to remove any foreign matter which may have been extracted from the fuel oil.

Dry the dismantled components and before re-assembling, examine the plunger (4) and rubber insert (5). Should there be any apparent damage, particularly in the case of the rubber insert, the whole assembly must be rejected and replaced by a new unit.

Description — Mk. III

Referring to Fig. D.4, the cold start unit comprises a tubular valve body carried in a holder which screws into the inlet manifold and surround-

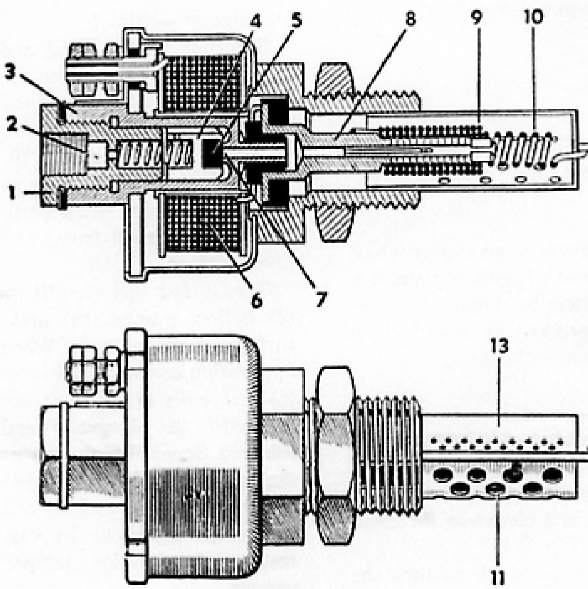


Fig. D.2 and D.3.
Mk. I Cold Starting Aid.

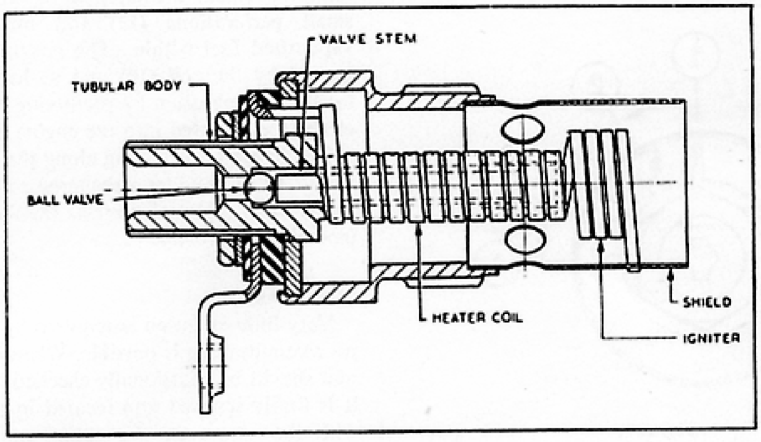


Fig. D.4.
Mk. III Cold Starting Aid.

ed by a heater coil, an extension of which forms an igniter coil. The valve body houses a needle, the stem of which holds a ball valve in position against its seating. The whole is surrounded by an open perforated seal. Fuel oil from the container enters through an adaptor.

When the unit is cold, the ball valve is held closed. On switching on the coil, the valve body is heated and expands, opening the ball valve and permitting the entry of the fuel oil. The fuel is vapourised by the heat of the valve body and when the engine is cranked and air drawn into the manifold, the air is ignited by the coil extension and continues to burn thus heating the inlet air.

When the coil is switched off, the flow of air in the manifold cools the valve body rapidly and the valve closes.

The cold start aid is a sealed unit and cannot be dismantled. If the unit ceases to function, it must be renewed.

Note:—

This cold starting aid has been superseded by a later unit which is identical in appearance and operation, but which gives a lower fuel rate. To identify the two units reference must be made to the proprietary reference, which in both cases is stamped on one of the hexagon flats, the earlier type being numbered 1854010 and the later type 1854050.

IMPORTANT

When fitting the later unit in place of the earlier type, where a ballast resistance is used in the starting aid lead, the lead must be removed and connected to the No. 4 terminal on the Heater/Starter switch.

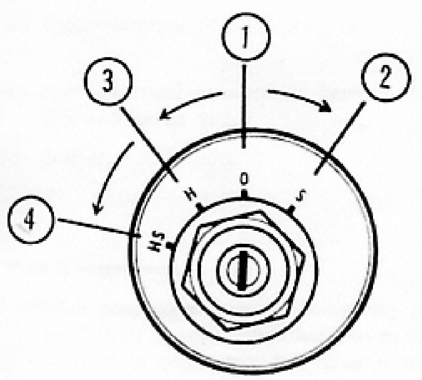


Fig. D.5.
Earlier Heat/Start Switch.
1. Off Position.
2. Start Position
3. Heat Position.
4. Heat and Start Position.

Using the Equipment

Turn on the fuel supply tap of the cold starting aid reservoir (where fitted).

Turn the starter switch to the "H" position and hold it there for fifteen to twenty seconds (see Fig. D.1).

With the accelerator in the fully open position, turn the starter switch to the "HS" position, thereby engaging the starter motor.

If the engine does not start within fifteen seconds, return the switch to the "H" position for ten seconds and then re-engage the starter motor by switching to the "HS" position.

As soon as the engine starts, the switch should be turned to the "R" position and the tap on the cold starting aid reservoir(where fitted), turned off.

Alternative Method

With some engines a different starter switch is provided and the cold start aid is operated by means of a separate push button switch.

The cold starting procedure is the same i.e. :—

Switch on by turning the starter switch in a clockwise direction to the first position.

Press the heater button for fifteen to twenty seconds and then, with the heater button still pressed, turn the starter switch in a further clockwise direction to engage the starter motor, as soon as the engine starts, release starter switch and heater button.

Earlier Heat Start Switch

The cold start switch fitted to earlier engines is shown in Fig. D.5.

With this switch, starting a warm engine is effected by turning the switch in a clockwise direction to the "S" position.

In cold weather, the switch should be turned to the "H" position for fifteen to twenty seconds and then to the "HS" position in order to engage the starter motor.

As soon as the engine starts, the switch should be returned to the "O" Position.

Where this type of switch is used, it was customary to have a separate switch for the electrical circuits and this should be turned on before starting the engine and turned off after stopping the engine.

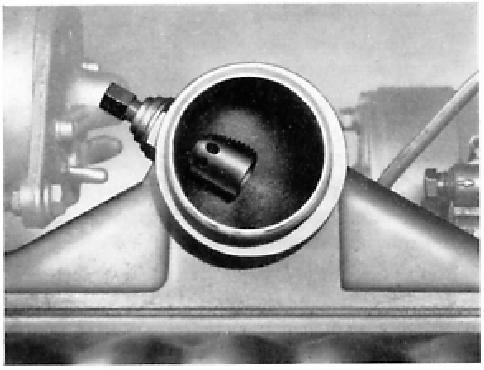


Fig. D.6.
Starting Aid Location.

Things to Note

Always be sure that the starter pinion and flywheel have stopped revolving before re-engaging the starter, otherwise the ring or pinion may be damaged.

Ensure that the electrical connection to the cold starting aid is correctly made.

Always ensure that the chamber feeding fuel to the cold starting aid is full and not leaking.

Extended use of the cold starting equipment above the time periods already stated should be avoided, otherwise the cold start aid in the induction manifold may be damaged.

In the event of difficult starting, check that fuel is reaching the cold starting aid in the induction manifold by unscrewing the inlet fuel union. If fuel is reaching it satisfactorily, then it may be that the cold starting aid itself is not working correctly. This can be checked by removing the air filter and watching the cold starting aid while the equipment is used. When the starting switch is turned to the heat position, the element should become red hot and on engagement of the starter motor, it should burst into flame.

4.99, 4.107 and 4.108 Marine engines are fitted with efficient cold starting equipment and no responsibility can be accepted for any damage arising from the use of unauthorised starting aids.

To ensure the future efficiency and life of the engine, careful treatment during the early life should be exercised. To obtain the best results of your new or replacement Marine engine, it should be operated within reasonable limits and not at maximum rev/min for the first 25 hours.

Stopping the Engine

A spring loaded stop control is located near the normal engine controls and functions by cutting off the fuel at the fuel injection pump.

To operate, pull the knob and hold in this position until the engine ceases to rotate. Ensure that the control returns to the "run" position, otherwise difficulty may be experienced in re-starting the engine.

Fault Diagnosis (E)

POSSIBLE CAUSE	REMEDY
ENGINE WILL NOT START	
1 (i) No Fuel at Atomisers :—	
(a) Stop control in "no fuel" position.	Turn control to "run" position.
(b) Insufficient fuel in tank, air has been drawn into the system.	Replenish fuel tank, then "bleed" system as detailed on Page Q.6.
(c) Fuel lift pump inoperative.	Remove lift pump and rectify or fit replacement pump.
(d) Fuel filters choked or fuel feed pipe blocked.	Check fuel feed to fuel pump and filters, rectify as necessary.
(e) Fuel pump not delivering fuel to the atomisers.	Remove pump for attention of specialised workshop or fit replacement.
(ii) Fuel at Atomisers :—	
(a) Atomisers require servicing.	Service or fit replacement set.
(b) Wrong type of Thermostart unit fitted.	Check that correct type is fitted.
(c) Thermostart unit inoperative.	Visually check unit as described on Page D.4, fit new unit if unserviceable.
(d) Valve and/or Pump timing incorrect.	Check and reset if necessary.
2 Cranking Speed Too Low :—	
(a) Battery not in well charged condition.	Fit fully charged replacement.
(b) Incorrect grade of lubricating oil.	Check oil viscosity against Approved Lists in Appendix for temperature range.
(c) Poor electrical connections between battery and starter motor.	Check and tighten or remake connections if necessary.
(d) Starter motor faulty.	Examine and rectify if necessary.
3. Poor Compression	
With poor compression starting may just be difficult in normal weather, but in cold weather the engine may just refuse to start altogether, dependent upon how much compression there is and the cranking speed. The causes are numerous, worn liners, piston rings, leaking valve, etc.	There is no quick remedy for this condition, generally speaking the engine will have been in service for some time. At least a top overhaul or probably a complete overhaul would be indicated to restore the lost compression which is so vital for the efficient running of a diesel engine.

ENGINE STARTS, RUNS FOR A FEW MOMENTS THEN STOPS :—

(a) Partially choked fuel feed pipe or filter.	Trace and rectify.
(b) Fuel lift pump not giving adequate delivery.	Check output of lift pump and rectify or replace as necessary.
(c) Fuel tank vent hole blocked.	Check and clear if necessary.
(d) Restriction in induction or exhaust systems.	Check and rectify if necessary.
(e) Air leaking into supply or return fuel pipes.	Check, trace and rectify.

ENGINE MISFIRING OR RUNNING ERRATICALLY :—

(a) Atomiser(s) require attention.	Isolate offender(s), remove and test. If faulty, service or fit replacement(s).
(b) Air in fuel system.	Check for air in fuel pump, if present prime the fuel system as described on Page Q.6.
(c) Water in fuel pump.	Thoroughly check fuel system for signs of water, remove if present, then prime with clean fuel.
(d) Valve and/or pump timing incorrect.	Check and reset if necessary.
(e) Valve clearances incorrect.	Check and reset if necessary.
(f) Fuel leaking from high pressure pipe	Observe with engine running and replace pipe if necessary.

ENGINE RUNS EVENLY BUT SUFFERS FROM LOSS OF POWER :—

(a) Atomisers require servicing.	Remove and service or fit a replacement set.
(b) Loss of compression.	Refer to previous remarks on Poor Compression.
(c) Pump not delivering sufficient quantity of fuel to meet engine requirements.	Observe throttle linkage for unrestricted travel, if satisfactory, pump should be checked for correct output in specialist workshop.
(d) Air cleaner causing restriction to the flow of air.	Check that the correct type is fitted and that it has been serviced in accordance with the instructions given on page Q.1.
(e) Fuel pump timing incorrect.	Check and reset if necessary.

ENGINE RUNS BUT WITH A SMOKING EXHAUST :—

(a) Incorrect air/fuel ratio.	Check for any restriction to the air flow. If satisfactory, have the fuel pump maximum fuel output checked.
(b) Cold starting aid (Thermostart) valve leaking.	Replace with a serviceable unit.
(c) Valve and/or fuel pump timing incorrect.	Check and reset if necessary.
(d) Atomiser(s) require servicing.	Remove and service or fit a replacement set.
(e) Excessive oil consumption.	Generally consistent with poor compression and long engine life, workshop examination required to give precise details.

ENGINE KNOCKING :—

(a) Faulty atomiser (nozzle needle sticking).	Fit replacement atomiser.
(b) Fuel pump timing too far advanced.	Check timing and reset if necessary.
(c) Piston striking a valve.	Check valve timing, piston topping and valve head depth relative to cylinder head face.
(d) Incorrect fuel.	Check that the tank has been filled with diesel fuel and not petrol by mistake.
(e) Worn or damaged bearings, etc.	Engine overhaul required.

ENGINE OVERHEATING :—

(a) Coolant level in closed (fresh water) circuit too low.	Replenish and check if leakage is taking place, if so, rectify at once.
(b) Heat exchanger or system partially blocked.	Check through the system, in particular the strainer and weed trap at the inlet side of the open circuit cooling system, also the heat exchanger tube stacks. Rectify as necessary.
(c) Blockage or restriction due to ice formation.	Locate trouble spot and take any action necessary to prevent re-occurrence.
(d) Dynamo and water pump driving belt slipping.	Check belt tension (See page P.6).
(e) Valve and/or fuel pump timing(s) incorrect.	Check and reset if necessary.
(f) Thermostat stuck in the closed position.	Check and replace with a new one if found unserviceable.
(g) Sea water pump not circulating sufficient coolant.	Check impeller blades for signs of damage. Check wear plate and end plate.

LOW OIL PRESSURE :—

(a) Oil level in sump too low.	Replenish to correct level.
(b) Incorrect grade or inferior oil being used.	Change to Approved Grade.
(c) Oil leaking externally from engine.	Rectify immediately.
(d) Pressure gauge or oil warning light switch inaccurate.	Check either against a master unit.
(e) Oil pump worn or pressure relief valve sticking open.	Remove and examine.
(f) Suction pipe to oil pump allowing air to be drawn in.	Rectify leak or renew pipe as necessary.
(g) Worn main or big end bearings.	Engine overhaul required.

HIGH OIL PRESSURE :—

(a) Incorrect grade of oil being used.	Change to Approved Grade.
(b) Pressure gauge inaccurate.	Check against a master unit.
(c) Pressure relief valve sticking closed.	Remove and examine.

EXCESSIVE CRANKCASE PRESSURE :—

(a) Partially choked breather pipe.	Check pipe for any obstruction.
(b) Worn or sticking piston rings.	Engine examination required.

Periodical Attentions (F)

KEEP ENGINE CLEAN

Daily

Check water in header tank (closed circuit cooling).

Check oil level in sump.

Check oil level in gearbox.

Check oil pressures (where gauges fitted).

Every 150 hours

Drain oil from sump and renew using an approved oil — see appendix.

Renew paper element in lubricating oil filter.

Clean air intake gauze.

Check belt tension.

Clean water trap.

Check engine for leakage of oil or water.

Lubricate dynamo rear bush (where fitted).

Every 400 hours

Drain and clean fuel tank.

Renew final fuel filter.

Check hoses and clips.

Every 2,400 hours

Arrange for examination and service of proprietary equipment, i.e. starter, dynamo etc.

Service atomisers.

Check and adjust tappets.

POST-DELIVERY CHECKOVER

After a customer has taken delivery of his engine, it is advisable, in his own interests, that a general checkover of the engine be carried out after the first 15-30 hours in service.

This checkover should comprise the following points :—

1. Drain lubricating oil sump and re-fill up to the full mark on the dipstick with clean new oil (Do not overfill).
2. Renew element in lubricating oil filter.
3. Check external nuts for tightness.
4. Check cylinder head nuts are to the correct torque and reset valve clearances (0.012 in (0,30 mm) cold).
5. Check for fuel and lubricating oil leaks, and rectify if necessary.
6. Check cooling system for leaks and inspect water level (closed circuit cooling).
7. Check generator belt for tension.
8. Carry out test to check general performance of engine.
9. Check engine mounting bolts for tightness.

Thereafter maintenance periods should be in accordance with those given on this page.

It is assumed that electrical equipment will have already been checked for such points as generator rate of charge, effectiveness of connections and circuits, etc.

PRESERVATION OF LAID-UP ENGINE

Where a craft which is powered by a Perkins engine is to be laid-up for several months it is advisable that some measure of protection be afforded the engine to ensure that it suffers no ill effect during the intervening period before operations are re-commenced.

It is recommended, that the following procedure be adopted and applied immediately the unit is withdrawn from service.

1. Clean all external parts of the engine.
2. Run engine until warm. Stop engine and drain lubricating oil sump.
3. Drain cooling system.
   To ensure complete draining of fresh water systems, remove filler cap from header tank then open cylinder block drain tap. Hose securing clips between cylinder block connection and copper pipe to header tank (keel cooled applications) or between cylinder block connection and copper pipe to exhaust manifold (heat exchanger applications) should be slackened and hose pulled away from connection to drain this area.
4. Renew paper element in full flow lubricating oil filter.
5. Clean out engine breathing pipe.
6. After renewing filter element, fill sump to correct level with clean, new lubricating oil or with a suitable preservative fluid.
7. Remove atomisers and spray into cylinder bores a $\frac{1}{3}$ pint (0,19 litres) of lubricating oil divided between the cylinders.
8. Turn engine slowly one revolution over compressions and replace atomisers using new washers.
9. Remove air filter and any intake pipe which may be fitted between the air filter and air intake. Seal air intake orifice with waterproofed adhesive tape.

10. Remove exhaust pipe and seal opening in manifold as in '9.'
11. Disconnect battery and before storing in a fully charged condition, treat the battery terminals to prevent corrosion.
12. When rubber impeller type water pump is fitted, remove water pump end plate and pack pump with MARFAK 2HD GREASE. Where this grease is not available glycerine may be used as an alternative.

The fuel system may be charged with a suitable preservative designed for the prevailing climatic conditions or alternatively, it may be left primed with normal fuel oil.

Where the latter course is taken, it should be noted that deterioration of the fuel oil may take place during the months the application is idle.

If this occurs, the fuel oil may become contaminated with a wax-like substance which will quickly clog the fuel filtering arrangement when the engine is returned to service.

Before re-commencing operations in respect of a unit primed with normal fuel oil which has lain idle for several months, it is recommended that the fuel tank be drained and the interior cleaned. The fuel oil drained off should be discarded.

Fuel oil contained in the remainder of the fuel system should also be dispelled and the paper element in the final fuel filter renewed. Prime the fuel system.

Preparations for starting the engine should be in accordance with instructions given on page D.1.

Note :—

Preservative used in the lubricating oil sump should be replaced by normal lubricant prior to re-starting the engine at the end of the storage period. Preservative utilised to charge the fuel system need not necessarily be drained off before returning the engine to service. The manufacturers of the fluid should be contacted, as to whether their product should be drained away prior to re-starting the engine.

PREPARING THE ENGINE FOR RETURN TO SERVICE

When the engine is to be returned to service, the following procedure must be observed :—

1. Clean external parts of the engine.
2. Bleed the fuel pump as described on Page Q.6.
3. Ensure that the cylinder block and heat exchanger drain taps are closed and fill the system with coolant as described on this page.
4. Rotate water pump by hand to ensure freedom of pump seals.
5. Lubricate rocker assembly with engine oil.
6. Remove adhesive tape from air intake orifice and ensure that the gauze is clean.
7. Remove adhesive tape from exhaust manifold orifice and refit exhaust pipe using new joints.
8. Connect batteries, fully charged, into circuit.

Keel Cooled and Heat Exchanger Cooled Engines

The following instructions are issued for the guidance of users of the above engines, and should be followed when putting the engine back into service following the winter lay-up period, or at any time the fresh water cooling system has to be refilled. The initial 'bleeding' of the cooling system will have been attended to when the engine is first installed by the boat builder but the air venting check is desirable following complete or partial draining for lay-up, top overhaul or other engine repairs.

Dealing first with keel cooled engines, under certain conditions of outboard pipe installation, an air lock can occur where the pipes bridge the keel at their ends farthest from the inlet and outlet connections. This air should be cleared and the pipes left completely full of water before the engine is started, and where possible treated as a separate entity, and the following procedure adopted:—

1. Disconnect the pipe hose (water outlet to keel pipe) at the lower stub at the forward end of the exhaust manifold and the pipe connection (water inlet to engine) below the generator on the right hand forward end of the cylinder block.
2. Fill pipe through the connection taken from the exhaust manifold by means of a funnel, filling until pipes are full to the cylinder block connection, and then making good this joint. When after further water has been added to fill the pipe to the manifold connection, this pipe can also be re-connected. In the event of a bridge connection between the keel pipes being inside the hull, and the connections being of the type that can be loosened, air can be cleared more easily by loosening an inboard connection on the pipe bridge, topping through the pipe as above and re-tightening the connection when free of air at this point.

To ensure that no air is trapped in the cylinder block or cylinder head on fresh water cooled engines, the following procedure should be adopted on heat exchanger cooled units and in addition to the above on keel cooled units.

1. Remove the square headed plugs in the top faces of the cylinder head and exhaust manifold marked 1, 2 and 3 in Fig. F.1 and add water steadily to the cooling system header tank.
2. Replace plug 1 at rear end of cylinder head when water appears at this point.
3. Start engine and run in neutral at about 700—800 rev/min.
4. Continue topping up header tank, replacing plug 2 at front end of cylinder head, and later plug 3 at front end of exhaust manifold as the water appears at these points in turn. Finally topping the header tank to a level approximately 1 in (25,4 mm) below the pressure cap sealing flange.
5. Re-check for the presence of air at plugs 2 and 3 by gently unscrewing after engine has been run at about half throttle for a period of a few minutes, or if a tendency to overheat is observed on the first run under normal load conditions.

FROST PRECAUTIONS

Precautions against damage by frost should be taken if the engine is to be left exposed to inclement weather either by adequately draining the water system or where this is not convenient an anti-freeze of reputable make and incorporating a suitable corrosion inhibitor may be used.

Should it be the policy to protect engines from frost damage by adding anti-freeze to the cooling system, it is advisable that the manufacturers of the relevant mixture be contacted to ascertain whether their products are suitable for use in Perkins engines and also to ensure that their products will have no harmful effect on the cooling system generally.

It is our experience that the best results are obtained from anti-freeze which conforms to British Standard 3151.

When draining the water circulating system, the tap on the cylinder block must be opened. This tap is on the fuel injection pump side of the cylinder block, near the flywheel housing.

Where a pressurised filler cap is fitted, this should be removed before draining the cooling system.

When the engine is drained, the fresh water pump is also drained but the rotation of the pump may be prevented by :—

(a) locking of the impeller by ice due to the pump hole being blocked by sediment.

(b) locking of the seal through the freezing of globules of moisture between the seal and the gland.

Operators are therefore advised to take these precautions when operating in temperatures below freezing point.

1. Before starting the engine, turn water pump by hand ; this will indicate if freezing has taken place. If freezing has taken place, this should free any ice formation.
2. If it is impossible to turn the pump by hand, the engine should be filled with warm water.
3. To avoid this trouble it is advisable when all water has been drained to run the engine for a few seconds at idling speed, thus dispersing any moisture remaining in the pump.

After an anti-freeze solution has been used, the cooling system should be thoroughly flushed in accordance with the manufacturers instructions before refilling with normal coolant.

If the foregoing action is taken, no harmful effects should be experienced but Perkins Engines Ltd. cannot be held responsible for any frost damage or corrosion which may be incurred.

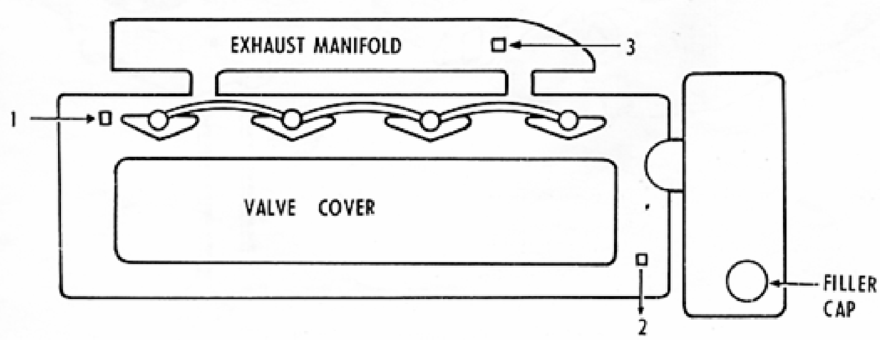


Fig. F.1.

Cylinder Head (G)

To Remove the Cylinder Head

1. Drain cooling system.
2. Disconnect battery terminals.
3. Detach exhaust pipe from exhaust manifold.
4. Uncouple water outlet connection on the front of the cylinder head.
5. Remove heat exchanger or header tank (where applicable) complete with pipes.
6. Remove air cleaner.
7. Disconnect fuel pipe and electrical connection to the starting aid.
8. Remove cylinder head cover.
9. Unscrew oil feed pipe to rocker shaft at cylinder head end (Fig. G.2).
10. Remove rocker shaft bracket nuts **evenly** and remove rocker shaft complete with oil feed pipe.
11. Remove push rods.
12. Remove atomiser leak-off pipe.
13. Remove low pressure fuel pipes between fuel filter and fuel pump, remove fuel filter after disconnecting feed pipe from lift pump.

Fig. G.2.
Oil Feed Pipe to Rocker Shaft.

14. Remove high pressure fuel pipes.
15. Remove atomisers.
16. Uncouple generator adjusting link.

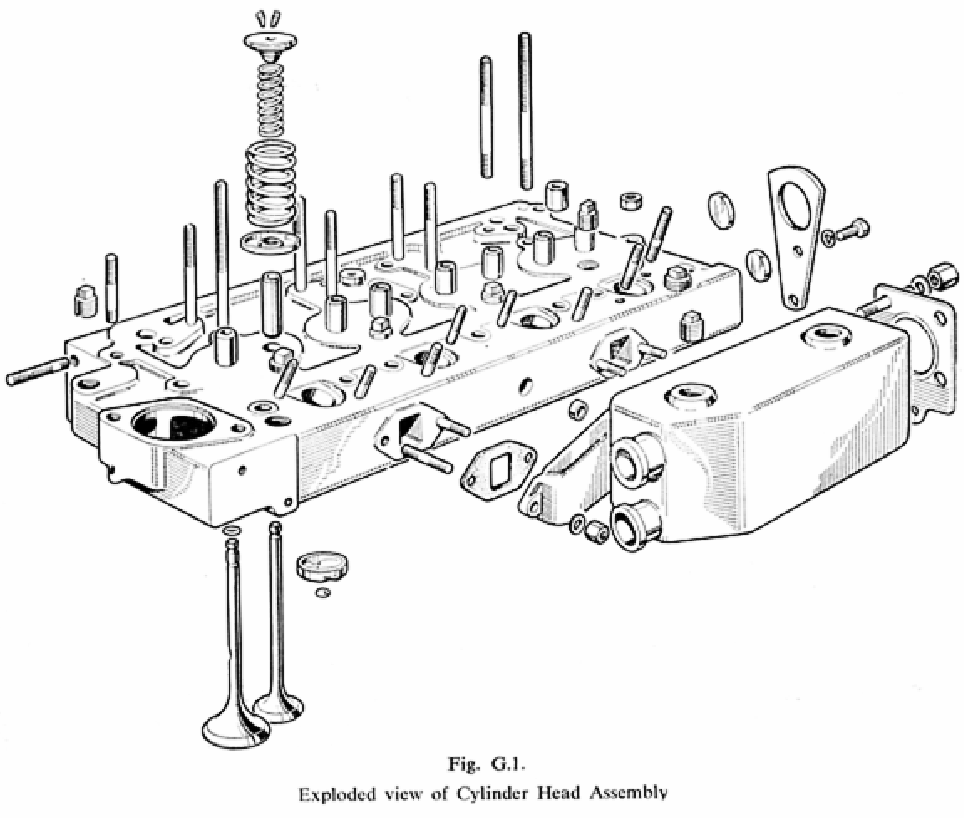


Fig. G.1.
Exploded view of Cylinder Head Assembly

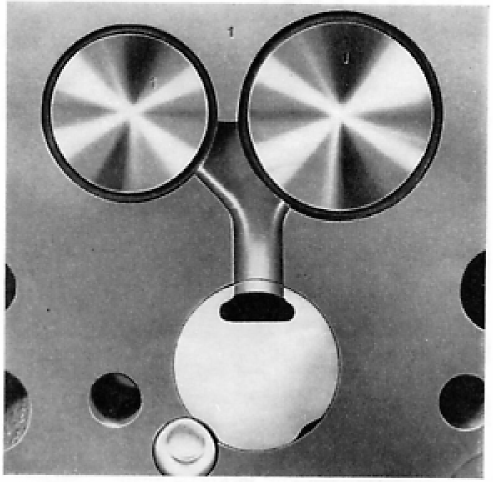


Fig. G.3.
Method of Valve and Valve Seat numbering.

17. Remove cylinder head securing nuts and lift off cylinder head complete with inlet and exhaust manifolds.

NOTE. On 4.99 and 4.107 engines to prevent liner movement, should the engine be turned with the cylinder head removed, it is suggested that the liners are held in position by suitable tubing placed over two of the cylinder head studs and locking with nuts and washers.

To Remove the Valves

All valves are numbered. The cylinder head is marked with corresponding numbers. (Fig. G.3).

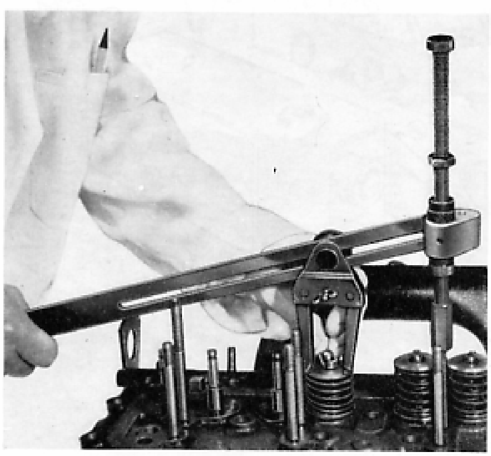


Fig. G.4.
Removing the Valve Retaining Collets.

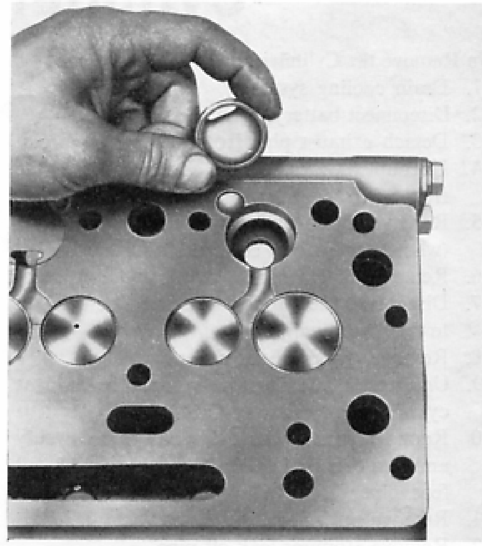


Fig. G.5. Combustion Chamber Insert.

1. Remove collets by compressing valve springs. (Fig. G.4).
2. Remove spring caps, springs, seals (where fitted) and spring seats. Remove valves.

COMBUSTION CHAMBER INSERTS

These can be gently tapped out of their locations by means of a short length of curved bar through the atomiser bore. When refitted they must be located by means of expansion washers in the recesses provided. (Figs. G.6 and G.7).

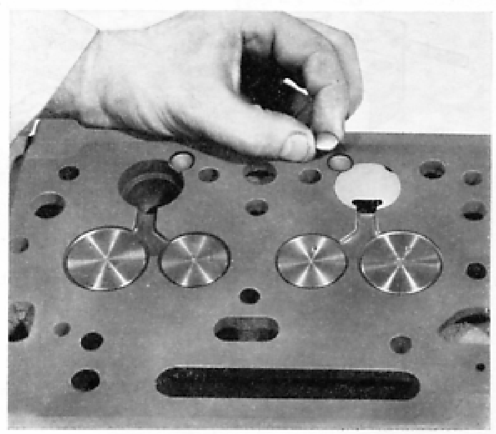


Fig. G.6.
Fitting the Combustion Insert Locating Washer.

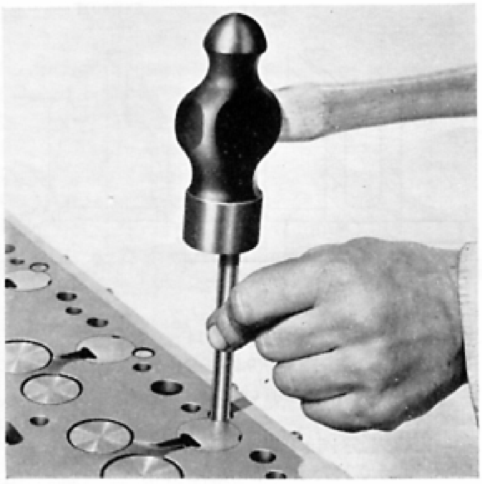


Fig. G.7.
Securing Combustion Chamber Insert.

Cleaning

Remove all traces of carbon from the cylinder head. If the water jacket within the cylinder head shows signs of excessive scale, then a proprietary brand of descaling solution may be used, if possible the cylinder head should be tested for water leakage after such treatment at the pressure given on Page G.9.

VALVE SPRINGS

It is advisable to fit new valve springs whenever the engine undergoes a major overhaul. Where a top overhaul only is being carried out the springs should be examined, paying particular attention to squareness of ends and pressures developed at specific lengths, the details of which can be found on Page G.10. Marine engine valve springs are zinc plated.

VALVE GUIDES

Worn guides should be removed either by means of a press and a suitable "dolly" or the valve guide removal tool shown in Fig. G.8.

Before fitting the new guides remove any burrs from the cylinder head parent bores, then smear the bores with clean oil and either press in the new guides or pull them in by means of the tool shown in Fig. G.9, until the guide protrusion above the head top face is that quoted on Page G.9.

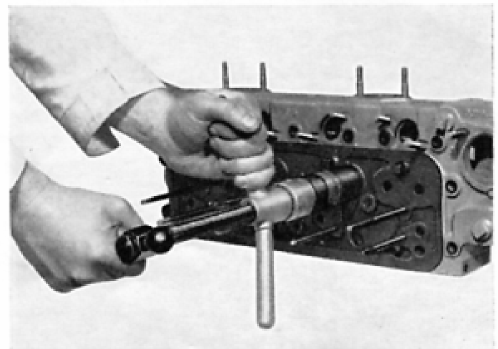


Fig. G.8. Removing a Valve Guide.

NOTE : Special care should be exercised during this operation as the guides, being made of cast iron, are therefore comparatively brittle.

VALVES AND SEATS

The valves should be checked in their respective guides for wear (ensure that the wear is on the valve stem and not in the guide bore).

The valve and valve seat faces should be reconditioned in the normal way using specialised equipment or with grinding compound, according to their condition. A valve seat cutting tool is shown in Fig. G.10. Valves should always be refitted to their original seats and any new valve fitted should be marked to identify its position. (See Fig. G.3).

Before refitting the valves it should be ascertained whether the valve head depth relative to the cylinder head face is within the limits given on Page G.9. This depth can be checked, as shown in Fig. G.11.

Where this depth exceeds the maximum limit and even the fitting of a new valve does not reduce this depth below the maximum limit, then the remedy is to fit a valve seat insert. See page G.4.

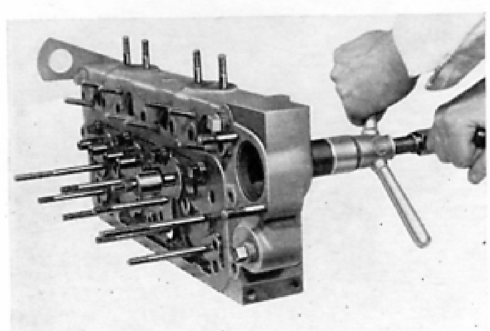


Fig. G.9. Fitting a Valve Guide.

Fig. G.10. Recutting a Valve Seat.

Hand Grinding

When grinding or lapping-in valves make certain that all signs of pitting are removed from the seats. Check valve head depths after lapping.

VALVE SEAT INSERTS

Valve seat inserts are not fitted to 4.99, 4.107 and 4.108 series production engines, but may be fitted in service.

When fitting inserts proceed as follows:—

1. Fit new valve guides as described on Page G.3.
2. Using the new valve guide bore as a pilot, machine the insert recess in the cylinder head face to the dimensions shown in Fig. G.12.

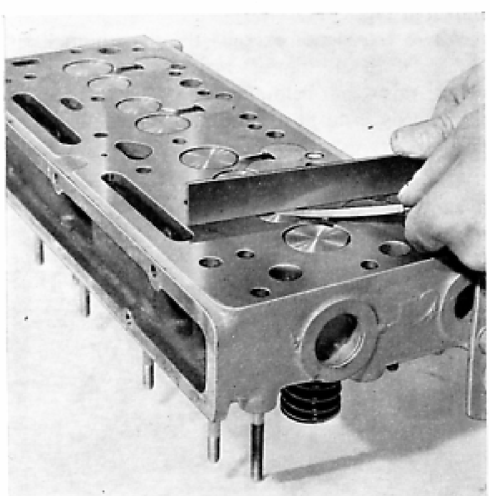


Fig. G.11. Checking the Valve Depth.

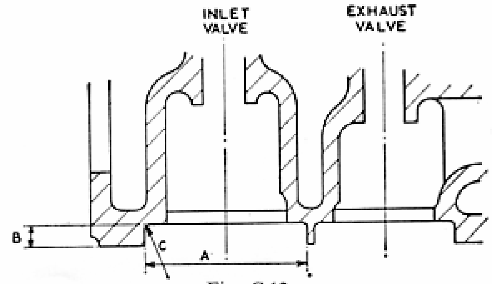


Fig. G.12.

Exhaust

A.—1.296/1.297 in (32,92/32,94 mm)
B.—0.3125/0.3175 in (7,94/8,06 mm)
C.—0.015 in (0,38 mm) chamfer at 45° (Max.)

Inlet

A.—1.530/1.531 in (38,86/38,89 mm)
B.—0.3125/0.3175 in (7,94/8,06 mm)
C.—0.015 in (0,38 mm) chamfer at 45° (Max.)

3. Clean the insert recess.
4. Using the valve guide bore as a pilot press the insert home with the inserting tool (Fig. G.13.

   NOTE: The insert must not be hammered in or any lubrication used.
5. Inspect to ensure that the insert has been pressed fully home.

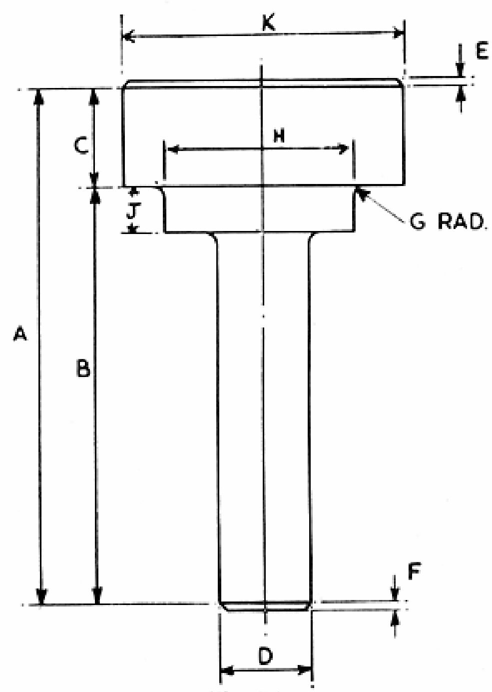


Fig. G.13.
Press Tool for Valve Seat Inserts.
Material EN32A Case Hardened and Ground.

Inlet Dimensions

A.—2.75 in (69,85 mm)
B.—2 in (50,8 mm)
C.—0.75 in (19,05 mm)
D.—0.309/0.310 in (7,85/7,87 mm)
E.—$\frac{1}{16}$ in (1,59 mm) at 45°.
F.—$\frac{1}{16}$ in (1,59 mm) at 45°
G.—1/32 in (0,79 mm) Radius
H.—1.238/1.239 in (31,45/31,47 mm)
J.—0.222/0.225 in (5,64/5,72 mm)
K.—1.523/1.533 in (38,68/38,94 mm)

Exhaust Dimensions

A.—2.75 in (69,85 mm)
B.—2 in (50,8 mm)
C.—0.75 in (19,05 mm)
D.—0.309/0.310 in (7,85/7,87 mm)
E.—$\frac{1}{16}$ in. (1,59 mm) at 45°
F.—$\frac{1}{16}$in (1,59 mm) at 45°
G.—1/32 in (0,79 mm) Radius
H.—1.018/1.019 in (25,86/25,88 mm)
J.—0.222/0.225 in (5,64/5,72 mm)
K.—1.287/1.297 in (32,69/32,94 mm)

6. Recut the valve seat at an included angle of 90° until the valve head depth reaches the minimum limit which is given on Page G.9. Lightly lap the valve to its new seat.

To Dismantle the Rocker Shaft Assembly

1. Remove retaining circlips from each end of shaft and withdraw rocker levers, springs and support brackets from rocker shaft.
2. Unscrew oil feed pipe from banjo and remove banjo. (When refitting this feed pipe it should be noted that the end of the pipe locates banjo position on the shaft).

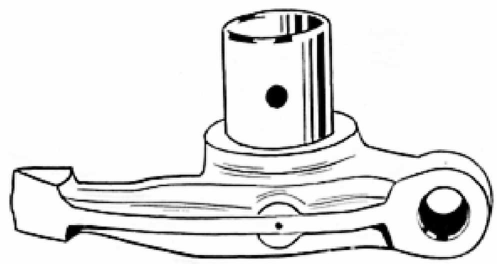


Fig. G.16.
Showing position in which rocker lever bush should be inserted.

Examine the rocker bushes and shaft for wear. The rocker levers should be an easy fit on the rocker shaft without excessive side play.

New rocker levers are supplied complete with bush fitted and reamed to size. If new rocker bushes are required they can be supplied separately.

NOTE: When fitting new bushes ensure that the oil feed holes are in alignment before pressing home, and when pressed fully home that the holes coincide. (Fig. G.16).

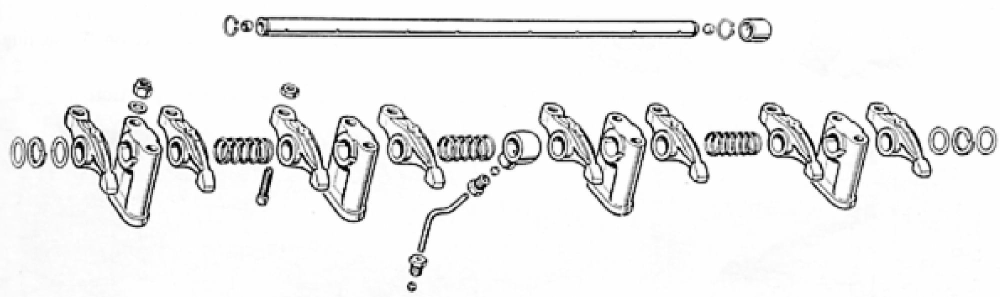


Fig. G.14. Exploded view of Rocker Shaft Assembly.

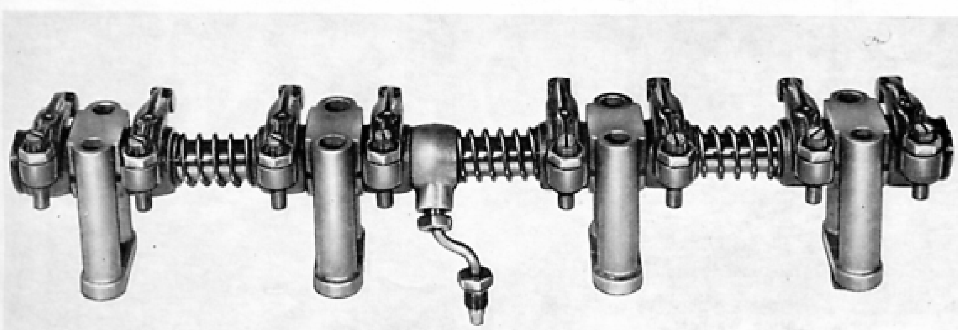


Fig. G.15. Rocker Shaft Assembly.

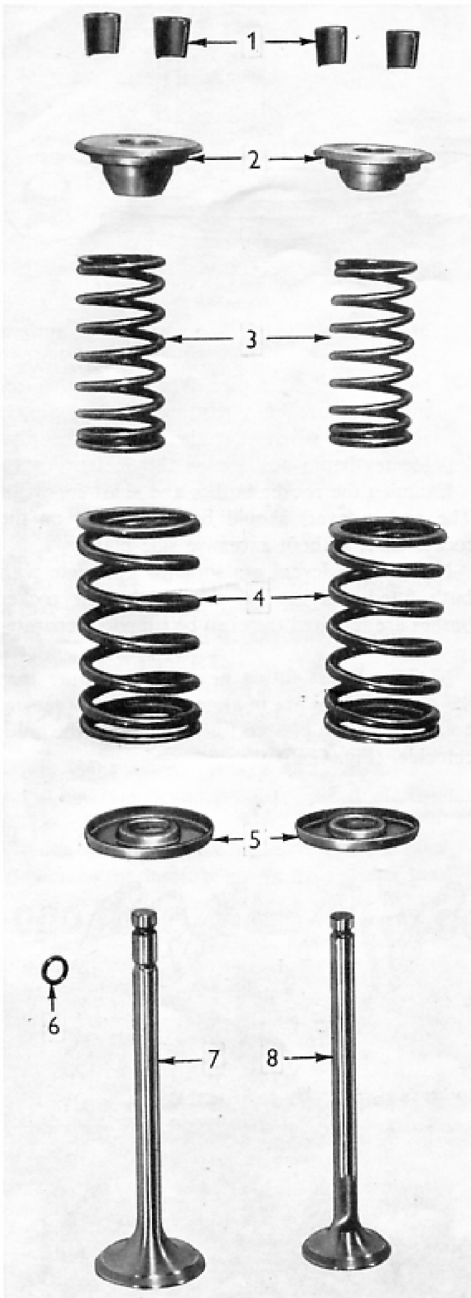


Fig. G.17.

Exploded view of an Inlet and Exhaust Valve Assembly.
1. Retaining Collets 3 Inner Valve Springs.
2. Spring Caps. 4. Outer Valve Springs.
5. Spring Seating Washers.
6. 'O' Sealing Ring (Inlet Valves only).
7. Inlet Valve. 8. Exhaust Valve

To Re-Assemble the Rocker Shaft Assembly

1. Refit oil feed banjo and locate with feed pipe.
2. Refit rocker levers, springs and support brackets in the opposite order to which they were removed. (Fig. G.14). Lightly oil the components during re-assembly and ensure that each rocker lever does not bind on the shaft.

PUSH RODS

Check the push rods for straightness, if any are bent then fit new replacements.

To Refit the Valves

1. Oil valve stems and insert each valve into its respective guide.
2. Locate the spring seat washers, valve springs and spring caps in position.
   NOTE: The valve springs should be fitted with damper coils towards the cylinder head top face. The longer spring caps fit on the inlet valve springs.
3. Compress the valve springs in turn and locate the retaining collets.
   NOTE: On the inlet valve stems are fitted rubber 'O' ring seals. They fit inside the valve spring cap bore and register with an annular groove on the valve stem. (Fig. G.17), therefore re-assembly of the inlet valve assemblies should be carried out as follows :—

1. Place spring seating washer in position.
2. Position valve springs correctly on the seating washer.
3. Place valve spring cap in position.

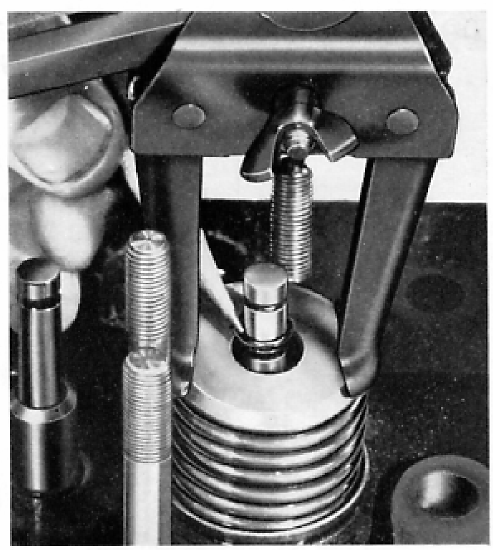


Fig. G.18. Locating a rubber 'O' Ring.

4. Compress valve spring until valve stem protrudes through cap sufficiently to allow the 'O' ring to be fitted.
5. Fit 'O' ring over valve stem and slide down until it locates in annular groove. (Fig. G.18).
6. Locate retaining collets.

CYLINDER HEAD GASKET

4.108 Engines

Always use a new cylinder head gasket. Ensure that only the correct type is used, it is made of a black composite material and is known as a Klinger type, it MUST be fitted DRY, on no account is it permissible to use any type of jointing compound.

Gaskets differ for direct cooled and indirect cooled engines.

It is very important that the gasket is placed correctly, otherwise the steel beading may be 'nipped' between the cylinder head face and the top of the liner.

4.99 and 4.107 Engines

These engines use a copper asbestos or a laminated steel gasket. The copper asbestos type should be fitted with a good quality jointing compound but the laminated steel type **must** be fitted **dry.**

To Refit the Cylinder Head

Check that the rocker assembly oil feed passage in the cylinder head is free from obstruction.

1. Place cylinder head gasket in position (the gasket is marked "TOP FRONT"). (Fig. G.19 shows a 4.108 engine gasket).
2. Lower cylinder head into position.
3. Lubricate cylinder head studs and nuts, then tighten nuts progressively in three stages in the sequence shown in Fig. G.20. to the torque given on page B.2. This final torque tightening stage should be repeated.
4. Fit push rods in their locations and fit rocker shaft assembly, noting that the oil feed to the rocket shaft is located correctly.
5. Locate oil feed pipe nut finger tight at this stage, then evenly tighten rocker shaft bracket securing nuts to a torque of 12—15 lbf ft (1,7—2 kgf m) now tighten the oil feed pipe nut. When correctly located the oil feed pipe will be as shown in Fig. G.2.
6. Adjust valve clearances (Page G.8) to 0.012 in (0,3 mm).
7. Replace generator adjusting link and tension belt (Page P.6).
8. Replace atomisers but do not tighten the securing nuts.
9. Replace leak off pipe assembly and four high pressure fuel pipes to atomisers. Tighten atomiser securing nuts.
10. Replace fuel oil filter and low pressure fuel pipes between filter and lift pump and filter and fuel pump.
11. Reconnect electrical and fuel supplies to starting aid.
12. Reconnect exhaust pipe to manifold.
13. Reconnect water outlet connection at the front of the cylinder head.
14. Fill the cooling system and check for water leaks.
15. Bleed air from fuel system as described on Page Q.6.
16. Reconnect battery.
17. After warming up, the engine should be shut

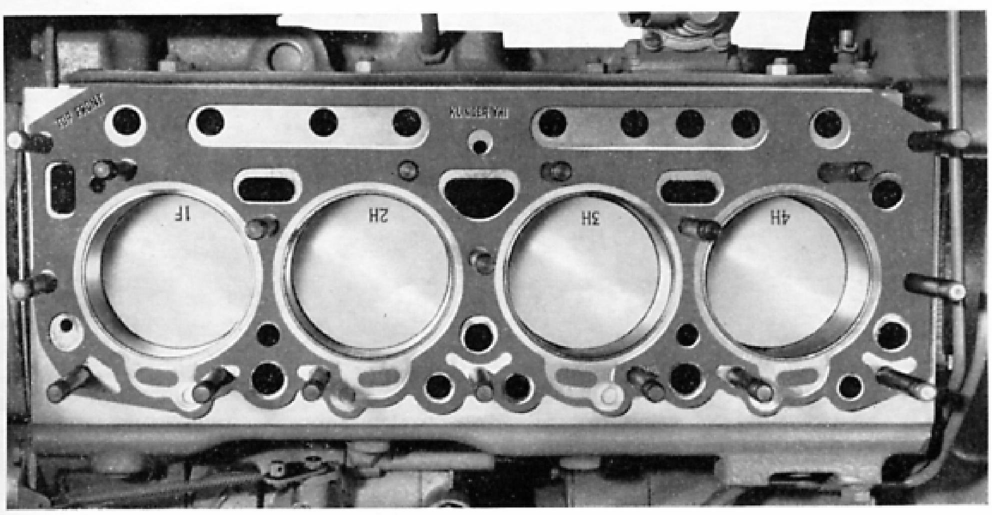


Fig. G.19.
Cylinder Head Gasket correctly positioned.

down and the cylinder head nuts again tightened to the correct torque in the sequence shown in Fig. G.20. (Refer to Note below).

18. Reset the valve clearances to 0.012 in (0,30 mm) cold (Fig G. 21). Fit the cylinder head cover.

NOTE for 4.108 Engines Only

It is essential that the cylinder head nuts are re-torqued to 60 lbf ft (8,3 kgf m) after the first 15-30 hours with the engine hot and in the sequence shown in Fig. G.20.

Adjusting Valve Clearances

Check valve clearances by placing the appropriate sized feeler gauge between valve stem and rocker lever tip, if any adjustment is necessary, slacken locknut and turn adjusting screw to increase or decrease the clearance as shown in Fig. G.21. When correct clearance is obtained, lock the adjusting screw and re-check the clearance, when satisfactory proceed to next valve in the adjusting sequence.

Valve Adjusting Sequence

Turn engine so that valves of No. 1 cylinder are in position of 'valve overlap', i.e. period between opening of the inlet valve and closing of exhaust valve. In this position adjust clearances of No. 4 cylinder; similarly with No. 3 cylinder valves in the 'valve overlap' position adjust valves of No. 2 cylinder, with No. 4 cylinder on 'valve overlap' adjust clearances of No. 1 cylinder and finally with No. 2 cylinder valves on 'valve overlap' adjust clearances of No. 3 cylinder.

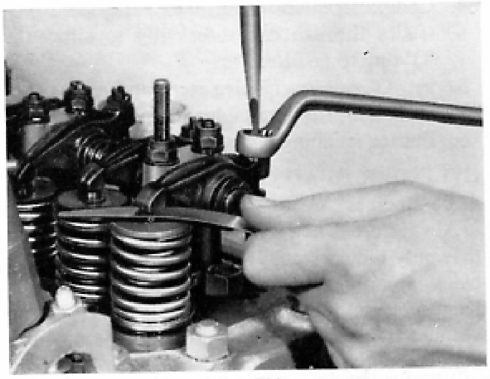


Fig. G21.
Adjusting Valve Tip Clearance.

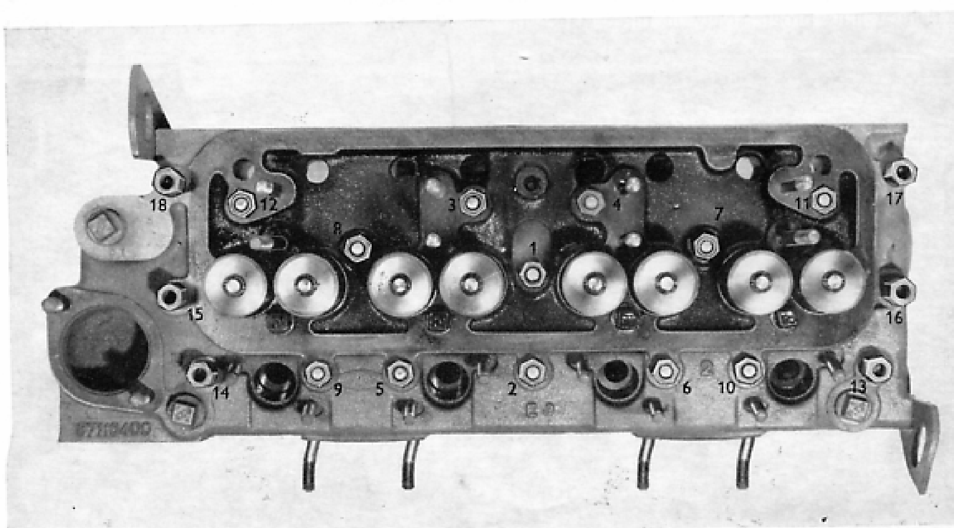


Fig. G.20.
Torque tightening sequence for Cylinder Head Nuts.

DATA AND DIMENSIONS FOR CYLINDER HEAD

Cylinder Head

Overall Length of Cylinder Head	20.000 in (508,000 mm)
Overall Depth of Cylinder Head	2.617/2.633 in (66,472/66,878 mm)
Skimming Allowance on Cylinder Head Face ...	NIL—On no account can the cylinder head face be skimmed.
Pressure for Water Leakage Test	20 lbf/in² (1,4 kgf/cm²)
Valve Seat Angle	45°
Bore in Cylinder Head for Guide	0.4995/0.5005 in (12,687/12,713 mm)
Bore in Cylinder Head for Combustion Chamber Inserts	1.250/1.252 in (31,750/31,801 mm)
Depth of Bore in Cylinder Head for Combustion Chamber Inserts	0.373/0.376 in (9,474/9,550 mm)

Combustion Chamber Inserts

Outside Dia. of Insert	1.248/1.249 in (31,699/31,724 mm)
Length of Insert	0.374/0.375 in (9,499/9,525 mm)
Height of Insert in relation to Cylinder Head Face	0.002 in (0,051 mm) Above or Below
Clearance Fit of Insert in Cylinder Head Bore ...	0.001/0.004 in (0,025/0,102 mm)
Method of Location in Cylinder Head	By Cylinder Block Face and Expansion Washer.

Valves Guides (Inlet)

Inside Dia.	0.3145/0.3155 in (7,988/8,014 mm)
Outside Dia.	0.50125/0.50175 in (12,744/12,757 mm)
Interference fit of Guide in Cylinder Head Bore	0.00075/0.00225 in (0,019/0,057 mm)
Overall length of Guide	2.130 in (54,102 mm)
Guide Protrusion Above Top Face of Cylinder Head	0.800/0.815 in (20,320/20,701 mm)

Valve Guides (Exhaust)

Inside Dia.	0.3145/0.3155 in (7,988/8,014 mm)
Outside Dia.	0.50125/0.50175 in (12,744/12,757 mm)
Interference fit of Guide in Cylinder Head Bore ...	0.00075/0.00225 in (0,019/0,057 mm)
Depth of Counterbore	0.380 in (0,650 mm)
Overall Length of Guide	2.440 in (61,98 mm)
Guide Protrusion above Top Face of Cylinder Head	0.800/0.815 in (20,320/20,701 mm)

Valves (Inlet)

Valve Stem Dia.	0.312/0.313 in (7,925/7,950 mm)
Clearance fit of Valve Stem in Guide	0.0015/0.0035 in (0,038/0,089 mm)
Valve Head Dia.	1.410/1.414 in (35,814/35,916 mm)
Valve Face Angle	45°
Valve Head Depth Below Cylinder Head Face ...	0.028 in (0,711 mm) Minimum 0.048 in (1,220 mm) Maximum
Overall Length of Valve	4.592/4.608 in (116,637/117,043 mm)
Sealing Arrangement	Rubber Oil Seal

CYLINDER HEAD—G.10

Valves (Exhaust)

Valve Stem Dia.	0.3115/0.3125 in (7,912/7,937 mm)
Clearance Fit of Valve Stem in Guide	0.002/0.004 in (0,051/0,102 mm)
Valve Head Dia.	1.191/1.195 in (30,251/30,353 mm)
Valve Face Angle	45°
Valve Head Depth Below Cylinder Head Face ...	0.021 in (0,53 mm) Minimum 0.048 in (1,220 mm) Maximum
Overall Length of Valve	4.600/4.616 in (116,840/117,246 mm)
Sealing Arrangement	No Seal fitted to Exhaust Valve

Outer Valve Springs

Fitted Length	1.780 in (45,212 mm)
Load at Fitted Length	56.0 lbf ± 2.8 lbf (25,4 kgf ± 1,27 kgf)
Fitted Position	Damper Coil to Cylinder Head

Inner Valve Springs Where fitted

Fitted Length	1.530 in (38,862 mm)
Load at Fitted Length	28.6 lbf ± 2 lbf (13,0 kgf ± 0,91 kgf)
Fitted Position	Damper Coil to Cylinder Head

Rocker Levers

Length between Centre Line of Adjusting Screw and Centre Line of Rocker Shaft	1.042/1.058 in (26,467/26,873 mm)
Length between Centre Line of Rocker Lever Pad and Centre Line of Rocker Shaft	1.567/1.583 in (39,802/40,208 mm)
Inside Dia. of Rocker Lever Bore	0.71825/0.71950 in (18,243/18,275 mm)
Outside Dia. of Rocker Lever Bush	0.7205/0.7215 in (18,301/18,326 mm)
Interference Fit of Bush in Rocker Lever ...	0.001/0.00325 in (0,025/0,082 mm)
Finished Inside Dia. of Rocker Lever Bush ...	0.6245/0.62575 in (15,862/15,894 mm)
Clearance of Rocker Lever Bush on Rocker Shaft...	0.00075/0.0035 in (0,019/0,089 mm)

Valve Clearances

Clearance between Valve Stem Tip and Rocker Lever	0.012 in (0,30 mm) Cold

Rocker Shaft

Overall Length of Shaft	14.5625 in (369,887 mm)
Outside Dia. of Shaft	0.62225/0.62375 in (15,805/15,843 mm)
Lubrication	Oil Feed from Cylinder Head through Central Passage to Individual Rocker Levers

Push Rods

Overall Length	8.527/8.560 in (216,58/217,42 mm)
Outside Dia.	0.250 in (6,350 mm)

Pistons and Connecting Rods (H)

To Remove Pistons and Connecting Rods

1. Remove cylinder head assembly (Refer to Page G.1) and oil sump. (Refer to Page N.1).
   NOTE: Any ridges or carbon deposits around the top of the cylinder bores should be removed with a suitable scraper before piston removal is attempted.
2. Rotate the crankshaft until one pair of big ends are at bottom centre, and remove their respective connecting rod cap securing bolts.
3. Remove the connecting rod caps and bearing shells. (Refer to Fig. H.1).
   NOTE: If the bearing shells are serviceable, they should be suitably marked to identify them to their original locations.
4. Push the pistons and connecting rods through the top of the block and remove as shown in Fig. H.2.
5. Rotate the crankshaft through 180° to bring the remaining pair of big ends to bottom centre and repeat removal operations.
   When piston removal has been carried out keep each piston and rod assembly separate, each to each as marked. Mark the pistons on the crown (before removing the gudgeon pin) to indicate the 'FRONT' in relation to the 'FRONT' marking cast on the connecting rods.

To Remove Pistons and Rings from the Connecting Rods

1. Remove piston rings from each piston, using a suitable piston ring tool. Fig. H.3.

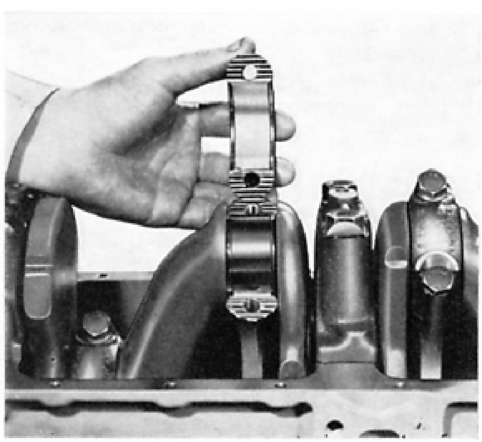


Fig. H.1.
Removing a Connecting Rod Bearing Cap.

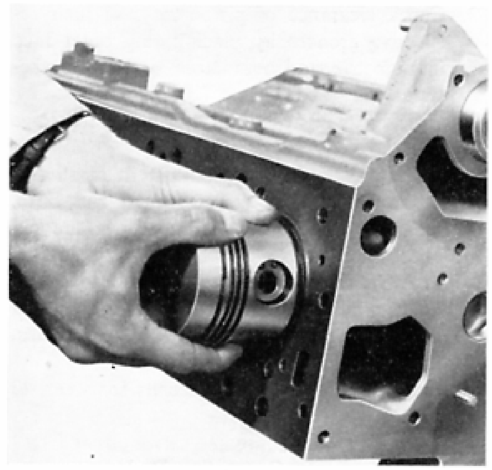


Fig. H.2.
Removing a Piston from the Cylinder Block.

NOTE: The laminated segments fitted in the fourth ring groove on 4.108 engines should be removed by hand.

4.108 Piston Only

There is a steel insert rolled into the top ring groove during piston manufacture, it should be regarded as an integral part of the piston and no attempt should be made to remove it from its location.

2. Remove gudgeon pin retaining circlip and push out gudgeon pin. Should difficulty be experienced in removing it, warm the piston in a suitable clean liquid to a temperature of 100—120°F. (40—50°C), this will then enable the pin to be pushed out quite easily.

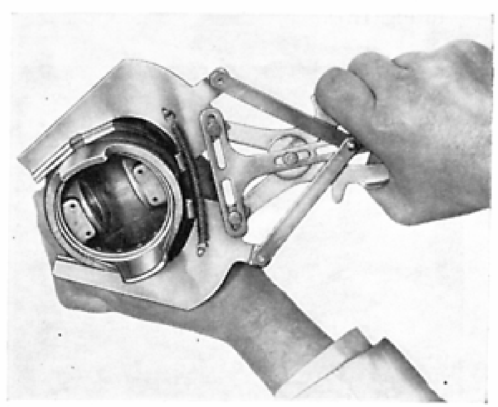


Fig. H.3.
Removing a Piston Ring.

Inspection

1. Examine pistons for scoring and any signs of groove damage.
2. Check clearance of piston rings in their respective grooves by placing ring outer face into groove and a suitable sized feeler between ring and groove face.
3. Check fitted gaps of piston rings. See Page H.6.
4. Check fit of the gudgeon pin in small end bush, if excessive, replace small end bush.
5. To renew small end bush, remove the old one by means of a suitable press and 'dolly'. Press in the new bush ensuring that the oil holes coincide when fitted. Ream out to suit gudgeon pin, then check rod for parallelism and twist. (Refer to Page H.8).
6. Examine big end bearing shells for wear, or pitting.

To Refit Pistons to Connecting Rods

If original pistons are to be refitted they must be re-assembled to their respective connecting rods. Refer to Figs. H.4 and H.5 for location of piston and rod numbering. Any new components fitted should be numbered similarly.

1. Place No. 1 piston onto its head, noting the position of the mark previously made to indicate the "FRONT."
2. Hold No. 1 connecting rod with the small end between the gudgeon pin bores so that the word "FRONT" cast on the rod is towards the same side.
3. Warm piston in a suitable clean liquid to a temperature of 100 — 120°F (40 — 50°C) which will enable the gudgeon pin to be easily pushed into the piston bore.
4. Fit the two retaining circlips ensuring that they locate correctly in their recesses. (Refer to Fig. H.7).

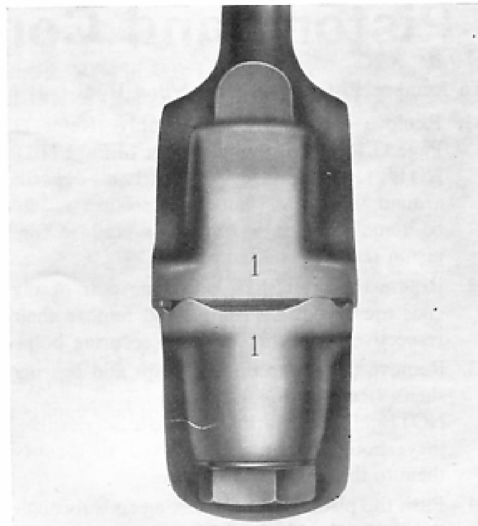


Fig. H.5.
Method of marking Connecting Rod and Cap.

NOTE: If the engine has been in service for some considerable time it is advisable to fit new circlips.

5. Repeat this procedure for the three remaining pistons and connecting rods.

Fitting the Piston Rings

The piston rings should be fitted to the piston in the following order.

1. Slotted oil control — below the gudgeon pin (fifth groove).
2. Laminated segment oil control — above the gudgeon pin (fourth groove). (4.108 engines). 4.99 and 4.107 engines have a slotted oil control ring in this groove.
3. Internally stepped compression (third groove).
4. Internally stepped compression (second groove).

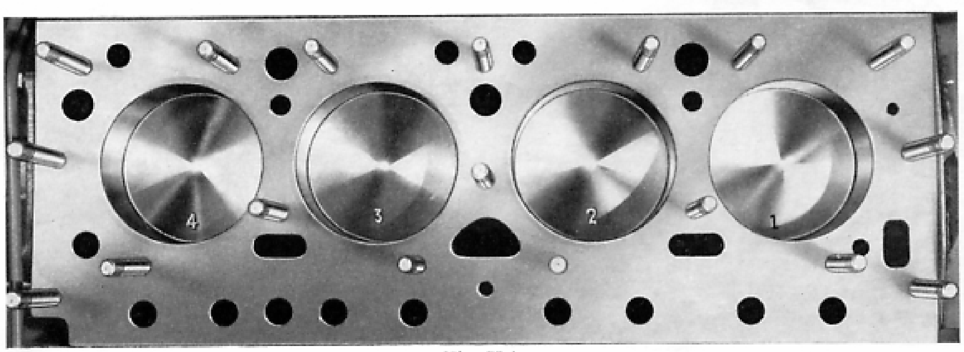


Fig. H.4.
Showing numbering of Pistons.

Inspection

1. Examine pistons for scoring and any signs of groove damage.
2. Check clearance of piston rings in their respective grooves by placing ring outer face into groove and a suitable sized feeler between ring and groove face.
3. Check fitted gaps of piston rings. See Page H.6.
4. Check fit of the gudgeon pin in small end bush, if excessive, replace small end bush.
5. To renew small end bush, remove the old one by means of a suitable press and 'dolly'. Press in the new bush ensuring that the oil holes coincide when fitted. Ream out to suit gudgeon pin, then check rod for parallelism and twist. (Refer to Page H.8).
6. Examine big end bearing shells for wear, or pitting.

To Refit Pistons to Connecting Rods

If original pistons are to be refitted they must be re-assembled to their respective connecting rods. Refer to Figs. H.4 and H.5 for location of piston and rod numbering. Any new components fitted should be numbered similarly.

1. Place No. 1 piston onto its head, noting the position of the mark previously made to indicate the "FRONT."
2. Hold No. 1 connecting rod with the small end between the gudgeon pin bores so that the word "FRONT" cast on the rod is towards the same side.
3. Warm piston in a suitable clean liquid to a temperature of 100 — 120°F (40 — 50°C) which will enable the gudgeon pin to be easily pushed into the piston bore.
4. Fit the two retaining circlips ensuring that they locate correctly in their recesses. (Refer to Fig. H.7).

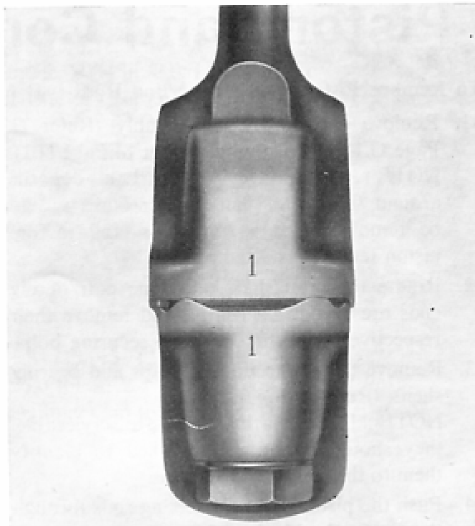


Fig. H.5.
Method of marking Connecting Rod and Cap.

NOTE : If the engine has been in service for some considerable time it is advisable to fit new circlips.

5. Repeat this procedure for the three remaining pistons and connecting rods.

Fitting the Piston Rings

The piston rings should be fitted to the piston in the following order.

1. Slotted oil control — below the gudgeon pin (fifth groove).
2. Laminated segment oil control — above the gudgeon pin (fourth groove). (4.108 engines). 4.99 and 4.107 engines have a slotted oil control ring in this groove.
3. Internally stepped compression (third groove).
4. Internally stepped compression (second groove).

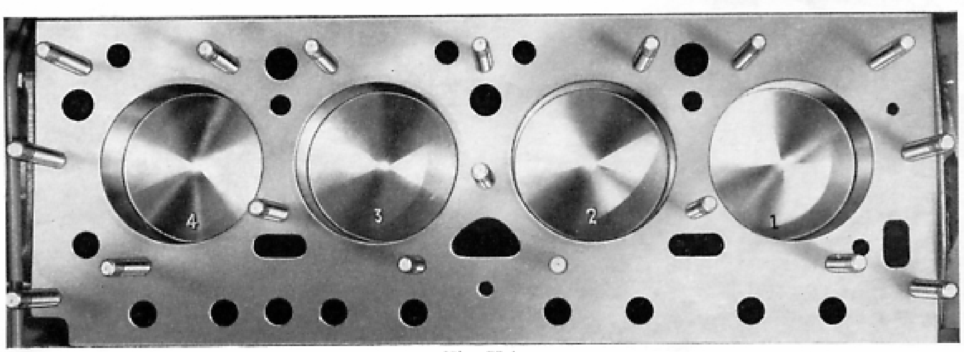


Fig. H.4.
Showing numbering of Pistons.

5. Plain parallel faced compression (top groove).
NOTE: All the rings quoted above except the laminated type may be fitted by means of an expanding tool of the type shown in Fig. H.3.

Internally stepped compression rings should be fitted with the step **uppermost.**

The top compression and slotted oil control rings may be fitted either way up.

After an appropriate period of service, when indications of piston ring and/or bore wear become apparent, a replacement ring pack has been made available for 4.107 and 4.99 Marine Service engines and includes a taper faced ring for the top groove. This ring is marked "T" or "TOP".

Earlier 4.99 Marine engines had a different ring layout to that already quoted. This consisted of a chrome plated compression ring in the top groove, two taper faced compression rings in the second and third grooves and two slotted scraper rings in the fourth and fifth grooves.

The procedure for fitting the laminated type is different, in as much as the ring comprises four separate segments, these may be fitted by hand in the following sequence with the piston crown uppermost.

Fig. H.7.
Fitting a Gudgeon Pin Retaining Circlip.

1. Fit the first segment to the piston so that when held horizontally between the thumb and fingers and radially compressed the ring ends point downwards (see Fig. H.6).
Place this ring on the bottom face of the fourth ring groove with the gap over the gudgeon pin bore.

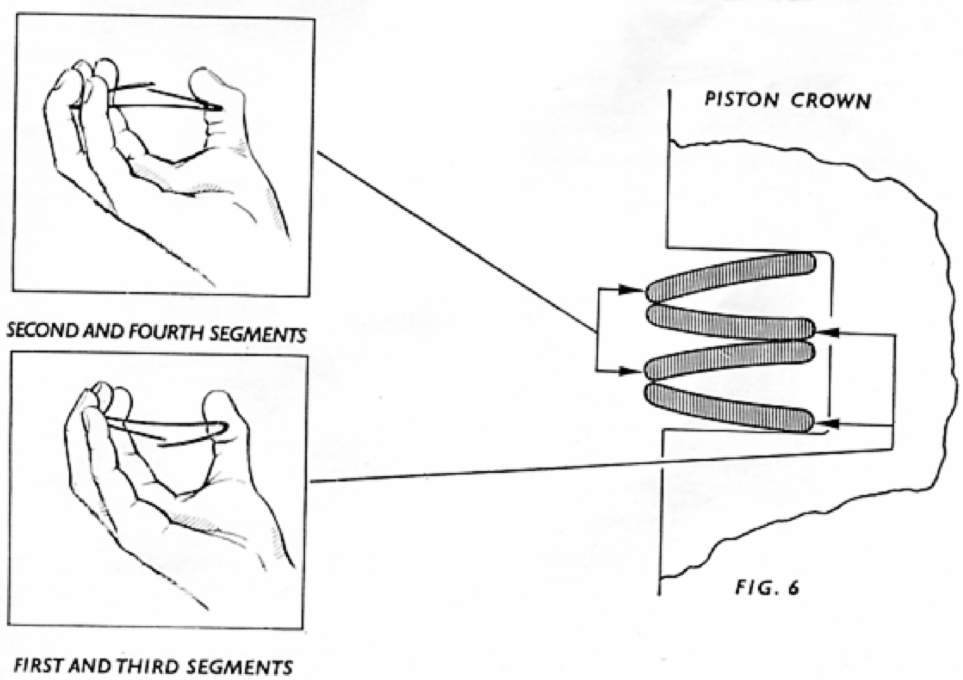


Fig. H.6.
Method of fitting Laminated Segment Piston Rings

2. Fit the second segment on top of the first, so that when compressed as described above the ends point upwards. Position the gap at 180° to that of the first segment.
3. Fit the third segment as in (1) above with the gap immediately above the gap of the first segment.
4. Fit the fourth segment as in (2) above with the gap immediately above the gap of the second segment. If all the segments have been fitted correctly then they will be positioned as shown above.

   The gaps of the remaining rings should be staggered alternately along the gudgeon pin axis.

   Lubricate the rings in their grooves and see that they can move freely in their locations, this does not apply to the laminated type in the fourth groove (4.108 engine), which if correctly fitted should **not** move freely due to the outward pressure of the top and bottom segments on the ring groove walls.

   When all the rings have been fitted, they should be as shown in Fig. H.8. (4.108 engine) or Fig. H.9 4.99 and 4.107 engines.

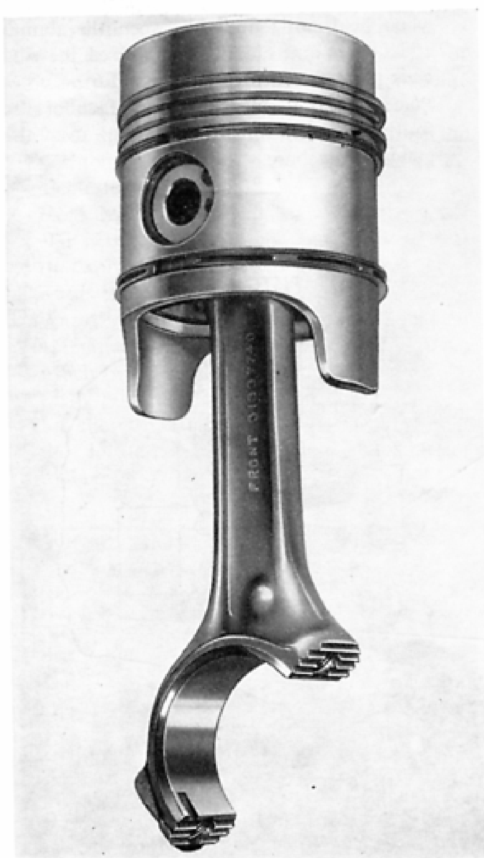


Fig. H.8.
Showing Piston Ring Layout.

To Fit Piston and Connecting Rod Assemblies

1. Turn engine until crankpins of numbers 1 and 4 cylinders are at bottom centre.
2. Using a suitable ring clamp of the type shown in Fig. H.10, compress rings of No. 1 piston and hold in this position.
3. With the word 'FRONT' on the connecting rod facing the front of the engine, insert rod into No. 1 cylinder bore.

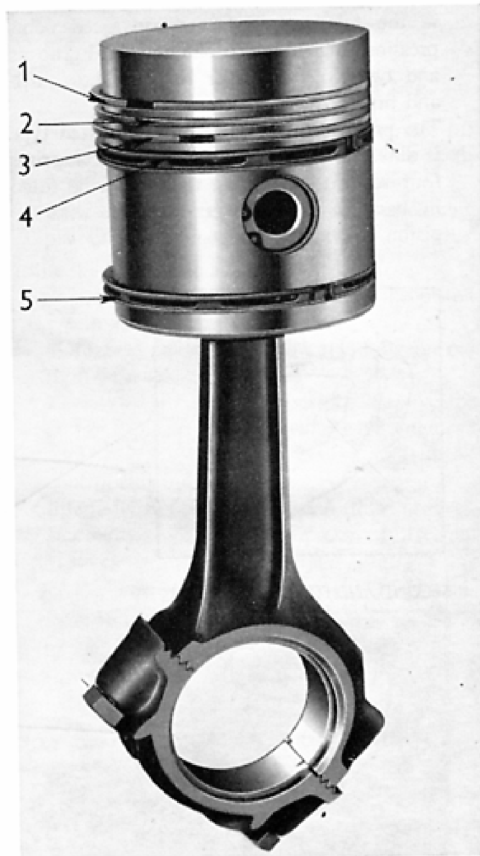


Fig. H.9. Piston and Connecting Rod Assembly.
1. Plain Parallel Faced Compression Ring.
2. Internally Stepped Compression Ring.
3. Internally Stepped Compression Ring.
4. Slotted Scraper Ring.
5. Slotted Scraper Ring.

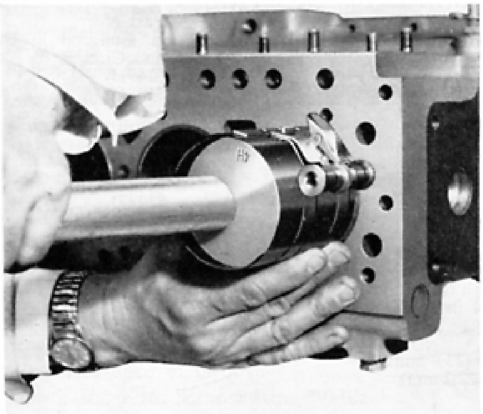


Fig. H.10.
Fitting the Piston into the Cylinder Block.

NOTE : The cylinders are numbered 1, 2, 3, 4 starting from the front (water pump) end of the engine. It is extremely important that these components (marked as shown in Figs. H.4. and H.5), are returned to their original locations.

4. The piston crown may be gently tapped with the shaft of a hammer as shown in Fig. H.10 until all the rings have entered the cylinder bore.
5. Draw rod towards crankpin, place top half bearing shell in position locating tag in machined slot, oil and draw rod onto crankpin.
6. Fit lower half bearing shell to connecting rod cap, locating tag in the machined slot, oil and fit cap to crankpin, ensuring that numbers on rod and cap coincide as shown in Fig. H.5.
7. Fit connecting rod securing bolts and tighten evenly to the torque quoted on Page B.2.
8. Repeat this procedure for No. 4 piston and connecting rod assembly.
9. Rotate crankshaft to bring numbers 2 and 3 crankpins to bottom centre.
10. Repeat procedures 2—7 to fit the two remaining assemblies. Refit sump and cylinder head.

Fitting New Pistons

With new pistons a machining allowance is provided on the crown of the piston to enable the necessary material to be removed so that when fitted the piston height above the cylinder block top face will be within the limits quoted on Page H.6.

Fig. H.11.
Method of checking Piston Height.

To determine the exact amount to be removed from the piston crown, the piston, connecting rod and bearing assembly will have to be fitted to its respective cylinder bore as previously described, and the piston height above the cylinder block top face measured with the particular piston at top centre. This can be measured by means of a piston height gauge of the type shown in Fig. H.11. Repeat for each new piston to be fitted and mark each piston with the number of the cylinder bore it will belong to, (not on the top as any marking here will be removed by the machining). When each piston has been skimmed it should be checked again when finally refitted. Once the piston height is correct, mark any such piston on the crown with the number of its respective bore. (Refer to Fig. H.4).

4.99 Pistons

In the case of 4.99 engines, pre-topped pistons are available in three grades (see separate table). For identification purposes, the grade letter is stamped on the piston crown.

It will of course be appreciated that grade F pistons are suitable for topping to give other grades where these are not to hand.

After fitting pre-topped pistons, the distance between the cylinder block face and piston crown should be checked to ensure that the limit is as already quoted (see Fig. H.11).

PRODUCTION PISTONS		EQUIVALENT SERVICE PISTONS		
Grade	Dimension from centre of gudgeon pin bore to Piston Crown	Grade	Dimensions from centre of gudgeon pin bore to Piston Crown	Part No. Piston Gudgeon Pin and Circlips
A to F	1.7986 to 1.7976 in (45,68 to 45,66 mm)	F	1.7955 in (45,61 mm) + 0.001 in (0,025 mm)	81491* 81485†
	1.7976 to 1.7966 in (45,66 to 45,63 mm)			
	1.7966 to 1.7956 in (45,63 to 45,61 mm)			
G to L	1.7956 to 1.7946 in (45,61 to 45,58 mm)	L	1.7925 in (45,53 mm) + 0.001 in (0,025 mm)	81493* 81487†
	1.7946 to 1.7936 in (45,58 to 45,56 mm)			
	1.7936 to 1.7926 in (45,56 to 45,53 mm)			
M to P	1.7926 to 1.7916 in (45,53 to 45,51 mm)	P	1.7905 in (45,48 mm) + 0.001 in (0,025 mm)	81495* 81489†
	1.7916 to 1.7906 in (45,51 to 45,48 mm)			

*Pistons having a gudgeon pin diameter of $\frac{15}{16}$ in (23,8 mm)
†Pistons having a gudgeon pin diameter of $\frac{7}{8}$ in (22,2 mm)

DATA AND DIMENSIONS FOR PISTONS AND CONNECTING RODS

Pistons 4.108

Type	Flat Topped
Overall Height (Skirt to Crown)	3.147/3.150 in (79,934/80,010 mm)
Centre Line of Gudgeon Pin to Piston Skirt ...	1.157 in (29,388 mm)
Piston Height in relation to Cylinder Block Top Face	0.002/0.006 in (0,051/0,152 mm) Above
Bore Dia. for Gudgeon Pin	1.06255/1.06275 in (26,989/26,994 mm)
Compression Ring Groove Width—Top	0.0805/0.0815 in (2,045/2,070 mm)
Compression Ring Groove Width—2nd	0.0645/0.0655 in (1,638/1,664 mm)
Compression Ring Groove Width—3rd	0.0645/0.0655 in (1,638/1,664 mm)
Oil Control Ring Groove Width—4th	0.126/0.127 in (3,200/3,225 mm)
Oil Control Ring Groove Width—5th	0.190/0.191 in (4,826/4,851 mm)

Pistons 4.107 and 4.99

Type	Flat Topped
Overall Height (Skirt to Crown)	3.146 in (79,91 mm)
Centre Line of Gudgeon Pin to Piston Skirt ...	1.344 in (34,14 mm)
Piston Height in relation to Cylinder Block Top Face	0.0085/0.012 in (0,22/0,30 mm) Above
Bore Dia. for Gudgeon Pin later 4.99 and all 4.107 engines.	0.93755/0.93775 in (23,81/23,82 mm)
Early 4.99 engines	0.87505/0.87525 in (22,22/22,23 mm)
Compression Ring Groove Width—Top	0.0801/0.0811 in (2,034/2,06 mm)
Compression Ring Grooves Width 2nd and 3rd ...	0.0645/0.0655 in (1,638/1,664 mm)
Oil Control Ring Grooves Width 4th and 5th ...	0.190/0.191 in (4,826/4,851 mm)

Piston Rings 4.108

Top—Compression	Parallel Faced
Second and Third Compression	Internally Stepped
Fourth—Oil Control	Laminated Segment
Fifth—Oil Control	Slotted Scraper
Top Compression Ring Width	0.0771/0.0781 in (1,958/1,984 mm)
Ring Clearance in Groove	0.0024/0.0044 in (0,061/0,112 mm)
Second and Third Compression Ring Width ...	0.0615/0.0625 in (1,562/1,587 mm)
Ring Clearance in Groove	0.002/0.004 in (0,051/0,102 mm)
Fifth Scraper Ring Width	0.1865/0.1875 in (4,737/4,762 mm)
Ring Clearance in Groove	0.0025/0.0045 in (0,063/0,114 mm)
Ring Gap—Top Compression	0.009/0.014 in (0,229/0,356 mm)

Ring Gap—Second and Third Compression	0.009/0.014 in (0,229/0,356 mm)
Ring Gap—Fifth Scraper	0.009/0.014 in (0,229/0,356 mm)

Piston Ring Gaps quoted are measured in a Ring Gauge of 3.125 in (79,38 mm) Bore. In practice for every 0.001 in (0,254 mm) difference in Cylinder Bore Diameter from Gauge size, 0.003 in (0,762 mm) should be allowed.

Piston Rings 4.107 and 4.99

Top Compression	Parallel Faced Chrome Plated
Second and Third Compression	Internally Stepped
Fourth and Fifth Oil Control	Slotted Scraper
Top Compression Ring Width	0.0771/0.0781 in (1,96/1,984 mm)
Ring Clearance in Groove	0.002/0.004 in (0,051/0,102 mm)
Second and Third Compression Ring Width	0.0615/0.0625 in (1,562/1,587 mm)
Ring Clearance in Groove	0.002/0.004 in (0,051/0,102 mm)
Fourth and Fifth Scraper Ring Width	0.1865/0.1875 in (4,737/4,762 mm)
Ring Clearance in Groove	0.0025/0.0045 in (0,064/0,114 mm)
Ring Gap—Compression Rings Chrome	0.012/0.017 in (0,30/0,43 mm)
Ring Gap—Oil Control Rings Cast Iron	0.009/0.014 in (0,229/0,356 mm)

Piston Ring Gaps quoted are measured in a Ring Gauge of 3.000 in (76,20 mm) Bore for 4.99 engines and 3.125 in (79,38 mm) Bore for 4.107 engines. In practice, for every 0.001 in (0,254 mm) difference in Cylinder Bore Diameter from Gauge size, 0.003 in (0,762 mm) should be allowed.

Connecting Rod 4.108

Type	'H' Section
Cap Location to Connecting Rod	Serrations, Offset 45° to the Horizontal
Big End Parent Bore Dia.	2.146/2.1465 in (54,508/54,521 mm)
Small End Parent Bore Dia.	1.21875/1.21975 in (30,956/30,981 mm)
Length from Centre Line of Big End to Centre Line of Small End	6.217/6.219 in (157,912/157,963 mm)
Big End Setscrew	0.375 in ($\frac{3}{8}$ in) U.N.F.
Connecting Rod End Float	0.0065/0.0105 in (0,165/0,267 mm)

Connecting Rod 4.107 and 4.99

Type	'H' Section
Cap Location to Connecting Rod	Serrations, Offset 45° to the horizontal
Big End Parent Bore Dia.	2.146/2.1465 in (54,508/54,521 mm)
Small End Parent Bore Dia. later 4.99 and all 4.107 engines	1.0625/1.0635 in (26,99/27,01 mm)
Early 4.99 engines	1.00/1.001 in (25,4/25,43 mm)
Length from Centre Line of Big End to Centre Line of Small End	6.405/6.407 in (162,69/162,74 mm)
Big End Setscrew	0.375 in ($\frac{3}{8}$ in) U.N.F.
Connecting Rod End Float later 4.99 and all 4.107 engines	0.0065/0.0105 in (0,16/0,27 mm)
Early 4.99 engines	0.0075/0.0105 in (0,19/0,27 mm)

Small End Bush 4.108

Type	Steel Backed, Lead Bronze Lined
Length of Small End Bush	0.935/0.955 in (23,749/24,257 mm)
Outside Dia. of Small End Bush	1.221/1.222 in (31,013/31,039 mm)
Inside Dia. before Reaming	1.0495/1.0545 in (26,657/26,784 mm)
Inside Dia. after Reaming	1.06315/1.0632 in (27,004/27,005 mm)
Clearance between Small End Bush and Gudgeon Pin	0.00045/0.0007 in (0,0114/0,0178 mm)

Small End Bush 4.107 and 4.99

Type	Steel Backed Lead Bronze Lined
Length of Small End Bush	0.865/0.885 in (22,00/22,48 mm)
Outside Dia. of Small End Bush	
Later 4.99 and all 4.107 engines	1.065/1.066 in (27,05/27,08 mm)
Early 4.99 engines	1.0025/1.0035 in (25,46/25,49 mm)
Inside Dia. after Reaming on later 4.99 and all	
4.107 engines	0.9382/0.93875 in (23,83/23,84 mm)
Early 4.99 engines	0.8757/0.87625 in (22,24/22,26 mm)
Clearance between Small End	
Bush and Gudgeon Pin	0.0005/0.00125 in (0,01/0,03 mm)

Note. Bushes to be reamed to suit respective Gudgeon Pins, and are provided with a reaming allowance.

Gudgeon Pin 4.108

Type	Fully Floating
Outside Dia. of Gudgeon Pin	1.0625/1.0627 in (26,987/26,993 mm)
Length of Gudgeon Pin	2.673/2.687 in (67,894/68,250 mm)
Fit in Piston Boss	Transition

Gudgeon Pin 4.107 and 4.99

Type	Fully Floating
Outside Dia. of Gudgeon Pin	0.9375/0.9377 in (23,812/23,817 mm)
Earlier Engines	0.875/0.8752 in (22,225/22,23 mm)
Fit in Piston Boss	Transition

Connecting Rod Bearings 4.108, 4.107, 4.99

Type	Pre-finished, Steel Backed, Aluminium Tin Lined
Shell Width	0.870/0.880 in (22,098/22,325 mm)
Outside Dia. of Con. Rod Bearing	2.1465 in (54,521 mm)
Inside Dia. of Con. Rod Bearing	2.0015/2.0025 in (50,838/50,863 mm)
Running Clearance	0.0015/0.003 in (0,038/0,076 mm)
Steel Thickness	0.060 in (1,524 mm) Max.
Aluminium Thickness	0.012/0.01225 in (0,305/0,311 mm)

Connecting Rod Alignment 4.108, 4.107, 4.99

Large and small end bores must be square and parallel with each other within the limits of ±0.010 in (0,25 mm) measured 5 in (127 mm) each side of the axis of the rod on test mandrel as shown in Fig. H.12. With the small end bush fitted, the limit of ±0.010 in (0,25 mm) is reduced to ± 0.0025 in (0,06 mm).

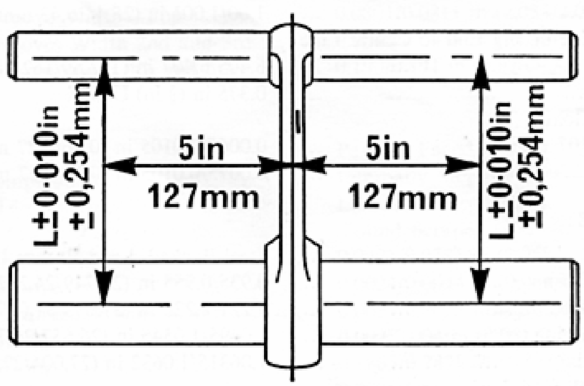


Fig. H.12.
Connecting Rod Alignment Test Mandrel.

Cylinder Block and Liners (J)

CYLINDER LINERS (4.108 ENGINES)

The cylinder liners are centrifugally cast alloy iron and an interference fit in the cylinder block parent bore.

Reboring of these liners is not possible and new liners should be fitted when a rebore would normally be considered necessary.

Dimensional checks of the cylinder bore are carried out by means of the gauge tool shown in Fig. J.1. When checking liners each one should be measured in three positions — top, centre and bottom ; the readings being taken parallel and at right angles to the centre line of the cylinder block giving six readings for each cylinder bore.

When checking the fitted internal bore of a new thinwall liner it is advisable to allow a period of time to elapse for the liner to settle.

To Renew Cylinder Liners

1. Remove all components from the cylinder block.
2. Using a shouldered metal disc slightly smaller on the outside diameter than the parent bore diameter, press the liners carefully out through the top of the cylinder block.
   NOTE : Support the block locally in the area of the top of the liner.
3. Lightly lubricate outside of liner with clean engine oil ready for fitting.

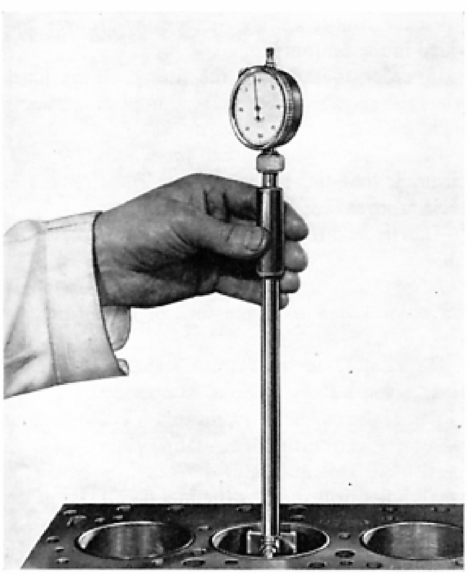


Fig. J.1. Dimensional check of Cylinder Bore.

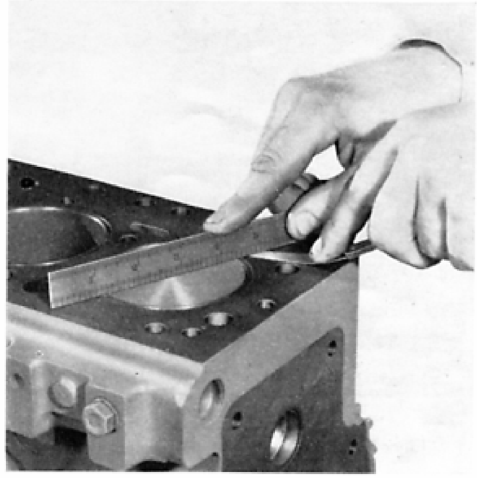


Fig. J.2. Method of checking Liner protrusion.

4. As the liner must protrude above the cylinder block top face and not be pressed fully home a solid stop washer should be available designed to give the correct liner protrusion.
   NOTE : The limits for liner protrusion are given on page J.3 and may be checked as shown in Fig. J.2.
5. Press liner into bore, releasing the load several times during the first inch to allow the liner to centralise itself until it reaches the solid stop washer.
6. Bore and finish hone the liners to the dimension quoted on Page J.3.
   NOTE : When boring equipment is mounted on the top face of the cylinder block, fit a parallel plate between the boring bar and cylinder block face. Such a plate should be thicker than 0.027 in (0,686 mm).
7. Re-assemble engine components to the cylinder block.

CYLINDER LINERS (4.99 and 4.107)

Cylinder liners fitted to 4.107 and 4.99 Marine engines are of the centrifugal cast iron wet type. They have flanges at the top and are sealed at the bottom by means of two rubber sealing rings which fit in machined recesses in the cylinder block.

Earlier 4.99 engines had only one sealing ring at the bottom of the liner.

4.99 and 4.107 cylinder liners have a pre-finished bore.

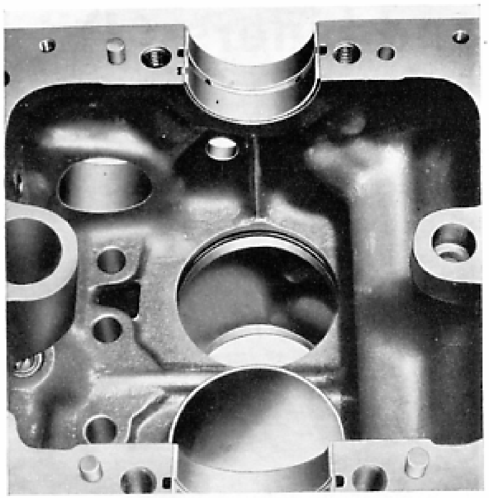


Fig. J.3.
Liner Sealing Ring Recess in Cylinder Block.

Under normal circumstances the liner would only need to be renewed during major overhaul, but should it be necessary to remove the liner for any other reason, this can be carried out without removal of the crankshaft.

If at any time the cylinder liners are removed and these same liners are to be refitted, then before they are removed from the cylinder block, ensure that they are suitably marked so that they may be refitted to their original parent bore and in the same position in that bore, that is, thrust side of the liner to the thrust side of the cylinder block.

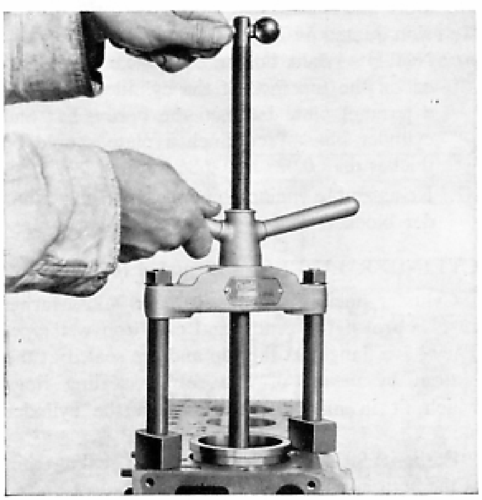


Fig. J.4. Removing Cylinder Liner.

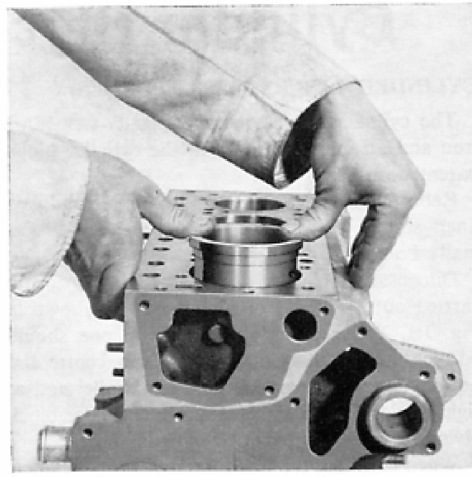


Fig. J.5. Fitting Cylinder Liner.

To Remove Liners.

Remove all components from cylinder block.

Remove liners using a suitable liner removing tool (See Fig. J.4).

Once the liner has cleared the rubber sealing ring in the cylinder block, the liner can be removed by hand.

To Fit New Liners

Over a period of service, corrosion may have taken place at the inner ends of the landings. This corrosion and any burrs which may be present should be removed with a scraper or emery cloth.

Fit the rubber sealing rings in the grooves provided in the bottom land.

In order to facilitate the fitting of the liners when the rings have been placed in position, smear them with soft soap or soapy water.

Place liner in position and press home by hand, ensuring that the rubber sealing rings remain in their grooves (See Fig. J.5).

The liners are a push fit and no force is required.

After fitting the liners, the cylinder block should be water tested to a pressure of 20 lbf/in^2 (1,4 Kgf/cm^2).

Reassemble engine as required and to instructions given for the various components.

Note : If the engine is overheated it could have an adverse affect on the liner sealing rings.

All 4.107(M) and later 4.99 engines have four small holes drilled along the fuel pump side of the cylinder block, each one breaking through into the area between the two sealing rings at the bottom of each cylinder liner. These holes permit any coolant which may have leaked past the upper sealing ring to escape thus relieving the bottom sealing ring of any pressure above it and preventing coolant from entering the engine sump.

In the case of a new engine, or where new cylinder liners and/or sealing rings have been fitted, it is possible that a slight leakage of coolant could occur from these holes. This should cease as the liners and sealing rings settle down after the initial period of running, but where difficulty is experienced, then the use of BARSEAL in the cooling system (in accordance with the manufacturers instructions) is approved for use in engines using closed circuit cooling systems.

DATA AND DIMENSIONS FOR CYLINDER BLOCK AND LINERS

Cylinder Block

Total Height of Cylinder Block between Top and Bottom Faces	4.108, 4.107, 4.99	9.936/9.939 in (252,374/252,451 mm)
Parent Bore Dia. for Cylinder Liner	4.108	3.249/3.250 in (82,525/82,550 mm)
Parent Bore Dia. for Cylinder Liner	4.107, 4.99	Wet Liners
Main Bearing Parent Bore	4.108, 4.107, 4.99	2.3950/2.3955 in (60,833/60,846 mm)
Camshaft Bore Dia. No. 1	4.108, 4.107, 4.99	1.794/1.7955 in (45,568/45,606 mm)
Camshaft Bore Dia. No. 2	4.108, 4.107, 4.99	1.784/1.787 in (45,314/45,390 mm)
Camshaft Bore Dia. No. 3	4.108, 4.107, 4.99	1.776/1.778 in (45,110/45,161 mm)
Tappet Bore Dia	4.108, 4.107, 4.99	0.562/0.56325 in (14,275/14,307 mm)
Fuel Pump Drive Hub Bearing Bore Dia.	4.108, 4.107, 4.99	1.8125/1.8141 in (46,037/46,078 mm)

Cylinder Liner 4.108 — **Cast Iron**

Type	Dry — Interference Fit
Interference Fit of Liners	0.003/0.005 in (0,076/0,127 mm)
Inside Dia. of Liner after Finish Boring and Honing	3.125/3.126 in (79,375/79,40 mm)
Height of Liner in relation to Cylinder Block Top Face	0.023/0.027 in (0,584/0,686 mm) above
Overall Length of Liner	6.495/6.505 in (164,973/165,227 mm)

Cylinder Liner 4.107 and 4.99 — **Cast Iron**

Type	Wet — Push Fit
Inside Dia. of Liner Pre-Finished 4.99	3.00/3.001 in (76,20/76,225 mm)
Inside Dia. of Liner Pre-Finished 4.107	3.125/3.126 in (79,374/79,4 mm)
Thickness of Top Flange 4.99	0.3125/0.3145 in (7,937/7,988 mm)
Depth of Recess in Block for Liner Flange 4.99 ...	0.3115/0.3135 in (7,912/7,963 mm)
Thickness of Top Flange 4.107	0.250/0.252 in (6,35/6,4 mm)
Depth of Recess in Block for Liner Flange 4.107	0.249/0.251 in (6,325/6,375 mm)
Height of Liner in relation to Cylinder Block Top Face 4.107 and 4.99 ...	0.003 in (0,076 mm) Above, 0.001 in (0,025 mm) Below
Liner Flange Outside Dia. 4.99	3.618/3.621 in (91,898/91,973 mm)
Cylinder Block Top Bore for Liner Flange 4.99 ...	3.625/3.627 in (92,075/91,125 mm)
Clearance Fit of Liner Flange to Block Bore 4.107 and 4.99	0.004/0.009 in (0,102/0,229 mm)

Tappets

Overall Length	2.250 in (57,150 mm)
Outside Dia. of Tappet Shank	0.560/0.561 in (14,224/14,249 mm)
Cylinder Block Tappet Bore Dia.	0.562/0.56325 in (14,275/14,307 mm)
Tappet Running Clearance in Cylinder Block Bore	0.001/0.00325 in (0,025/0,082 mm)
Outside Dia. of Tappet Foot	1.245/1.255 in (31,623/31,877 mm)

Crankshaft and Main Bearings (K)

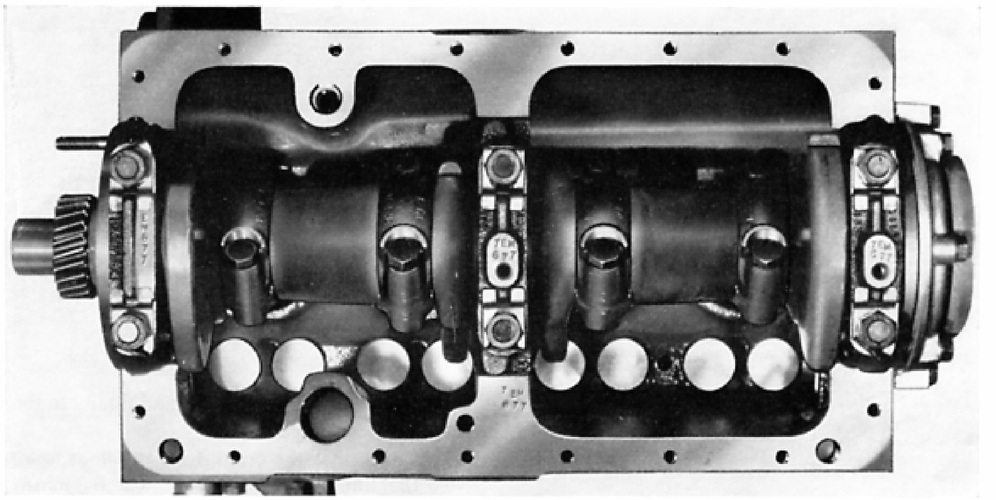


Fig. K.1.
View of Crankcase showing serial number locations on Cylinder Block and Main Bearing Caps.

Description

The crankshaft runs in three pre-finished replaceable thinwall, steel backed, aluminium tin lined bearings. Crankshaft end float is controlled by thrust washers located either side of the rear main bearing. 0.0075 in (0,19 mm) oversize thrust washers are available which if used on one side of the rear main bearing only will reduce crankshaft end float by 0.0075 in (0,19 mm) and by 0.015 in (0,38 mm) if used on both sides. The limits for the crankshaft end float are given on Page K.5.

The main bearing caps are numbered and are not interchangeable. The main bearing shells are located by tabs which locate in slots in the bearing housings.

NOTE: Before renewal of the main bearings is attempted make certain that the correct replacements are available, reference to the relevant parts list will ensure this, but for identification purposes the new bearings should have an annular groove machined in the inner (bearing) face along the centre line of the feed holes, when the bearings are correctly located these feed holes will correspond exactly with those machined in the cylinder block.

On later 4.107 engines the annular oil groove in the main bearing parent bore (cylinder block and bearing cap) has been deleted. Adequate lubrication is maintained by repositioning the oil feed holes radially in the shell bearings and continuing to machine the annular groove in the bearing on the centre line of these feed holes.

These later type shell bearings may be used on both early and later type engines, whereas the early type of shell bearing must NOT, on any account, be fitted to the later engines where the annular groove in the main bearing parent bore has been deleted.

To Renew Main Bearings and Thrust Washers

Removal of the main bearings and thrust washers can be carried out without removing the crankshaft as follows.

1. Remove sump and suction pipe assembly.
2. Slacken main bearing cap setscrews.
3. Remove one of the main bearing caps and remove bearing shell from cap.
4. Remove top half of bearing shell by pushing it, on the opposite side to the one having the locating tag, with a suitable strip of wood and rotating it on the crankshaft as shown in Fig. K.2.
5. Inspect bearing shells and if replacements are necessary continue by lightly lubricating and inserting the new top half bearing shell, plain end first, into the side having the tag location.
6. Rotate bearing shell on crankshaft until it locates correctly with the tag in the machined slot.
7. Locate lower half bearing shell in main bearing cap, lubricate and refit.

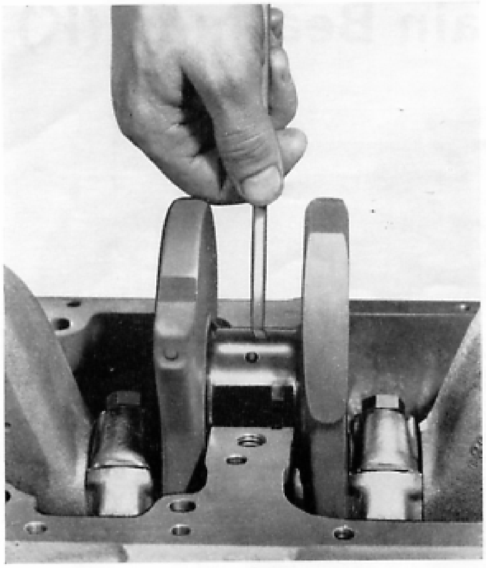


Fig. K.2.
Removing a Main Bearing Shell with the Crankshaft "in situ."

8. Tighten the two securing setscrews to positively locate the bearing shells then slacken a turn or two.
9. Repeat items 3—8 for the remaining two bearings.
   NOTE : To enable the **rear** main bearing cap to be removed, first remove the two oil seal housing setscrews as shown in Fig. K.3.
10. Finally tighten the main bearings to the torque given on Page B.2.

Renewal of thrust washers is carried out as follows :—

1. Remove the two setscrews securing the two rear main bearing oil seal half housings as shown in Fig. K.3.
2. Remove rear main bearing cap securing setscrews.
3. Remove rear main bearing cap and from it the two lower half thrust washers. (Refer Fig. K.4).
4. The single upper half thrust washer is removed by rotating it with a thin piece of wood until it can be lifted out of its recess.
   NOTE : The steel faces of the lower thrust washers should face inwards towards bearing cap (Refer Fig. K.5), the steel face of the upper thrust washer should also face inwards.
5. Locate upper thrust washer half as shown in Fig. K.6, place lower halves either side of rear main bearing cap as described and refit cap.

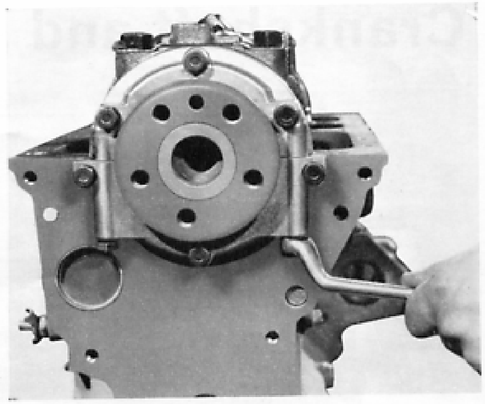


Fig. K.3.
Removing Oil Seal Housing Setscrews.

6. Tighten setscrews evenly and finally to torque given on Page B.2.
7. Check that the crankshaft end float is within the limits given on Page K.5 by means of feeler gauges as shown in Fig. K.7. If incorrect, oversize thrust washers are available to give an overall reduction of 0.015 in (0.38 mm). (Refer to Page K.1).
8. Refit the two setscrews securing rear main oil seal half housing.
   NOTE : If any leakage of oil is apparent from this seal then new seals should be fitted to the half housings as described under the heading "Crankshaft Rear End Oil Seal" or fit a new assembly.
9. Refit suction pipe assembly and sump.

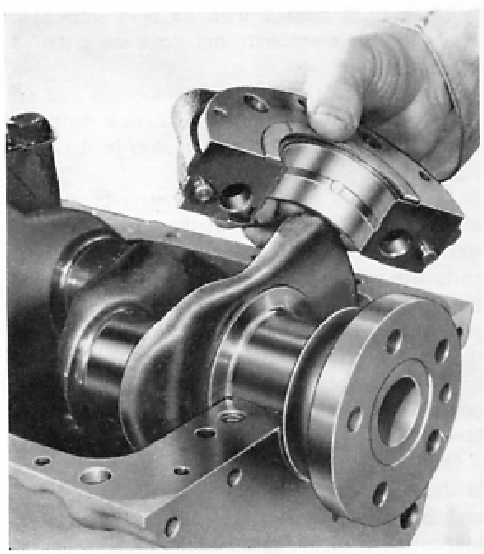


Fig. K.4.
Removing the rear Main Bearing Cap complete with Thrust Washers.

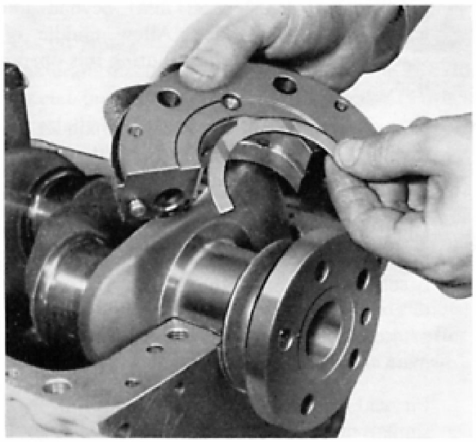


Fig. K.5.
Locating a lower Thrust Washer half in its recess.

To Remove the Crankshaft

To remove the crankshaft it will be necessary to remove the engine from the boat.

1. Remove gearbox, starter motor, flywheel and flywheel housing.
2. Remove crankshaft front pulley, timing case cover, timing gears and fuel pump drive hub. (Refer to Page L.1. for details of their removal).
3. Remove setscrews (also any studs) and remove timing case back plate.
4. Remove sump and lubricating oil pump complete with suction and delivery pipes. (Refer to Page N.1 for removal of these).
5. Remove connecting rod setscrews, caps and bearing shells. (Refer to Page H.1).

   NOTE : All bearing shells should be marked to indicate "top" or "bottom" and number of the rod assembly.

6. Unscrew main bearing cap setscrews.

   NOTE : The rear seal half housing securing setscrews will require removal to enable rear main bearing cap to be removed. (Refer to Fig. K.3).

7. Lift out crankshaft.
8. Remove top half main bearing shells.
9. Finally, remove the top half oil seal housing.

To Refit the Crankshaft

1. Ensure that crankshaft oilways are clear.
2. Place the three top bearing shells in position then oil.

   NOTE : Unless a new set of main bearings is being fitted, those removed must be returned to their original locations.

3. Place crankshaft in position.
4. Locate upper thrust washer in position as shown in Fig. K.6.
5. Fit the three lower bearing shells, oil and fit the three main bearing caps in their respective locations.

   NOTE : Ensure at this stage that the two lower thrust washer halves are positioned correctly either side of the rear main bearing cap when fitted.

6. Check main bearing setscrews prior to fitting for signs of stretch or thread damage. Re-

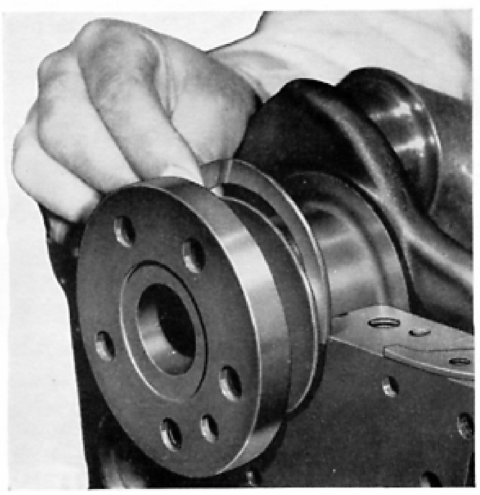


Fig. K.6.
Locating the upper Thrust Washer Half.

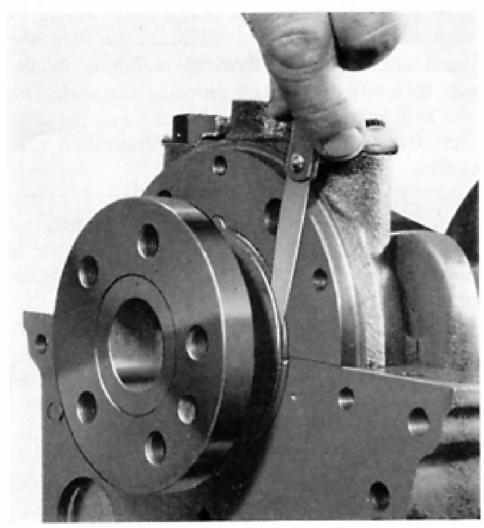


Fig. K.7.
Checking Crankshaft end float.

place where necessary.

NOTE : Steel shim washers fitted beneath the setscrew heads are fitted to maintain torque settings.

7. Fit setscrews using new shim washers and tighten to torque tension given on Page B.2.
8. Check that crankshaft can be rotated freely, and check crankshaft end float as shown in Fig. K.7. Should it be outside the limits quoted on Page K.5, then oversize thrust washers are available to give the necessary adjustment. (Refer to Page K.1).
9. Fit new sealing strips to rear main bearing oil seal housings and refit housings as described under the heading "Crankshaft Rear End Oil Seal" on this page.
10. Oil crankpins, locate connecting rod bearing shells, ensuring their correct relative positions, then fit connecting rod caps as described on Page H.5. The crankcase should now be as shown in Fig. K.1.
11. Refit lubricating oil pump. (Refer to Page N.3) and sump (Refer to Page N.1).
12. Refit timing case back plate, fuel pump drive hub, timing gears, timing cover and crankshaft front pulley. (Refer to later text commencing on Page L.1 for their reassembly).
13. Refit and correctly align the flywheel housing, (See Page R.1) flywheel, starter motor and gearbox.

CRANKSHAFT REAR END OIL SEAL

This sealing arrangement consists of two half housings bolted around the rear of the crankshaft. The bore of these housings is machined to accommodate a rubber cored asbestos strip which, in conjunction with a helix machined between the thrust collar and the flywheel mounting flange, acts to return surplus oil reaching the seal. The two half housings fit over this helix and the contact of the sealing strips with the crankshaft prevents leakage beyond this point.

NOTE : When traces of oil become apparent from behind the flywheel and a faulty rear oil seal is suspected, first ensure that the crankcase is breathing normally. Any build up in crankcase pressure could cause oil to be forced past the rear sealing arrangement. If crankcase pressure is normal and new seals require to be fitted the following procedure should be adopted with crankshaft in position.

1. Set up a half housing in the vice with the seal recess uppermost.
2. Settle approximately 1 in (25 mm) of the strip, at each end, into the ends of the groove ensuring that each end of the strip projects 0.010/0.020 in (0.25/0.50 mm) beyond the half housing joint face. Allow middle of seal to bulge out of groove during this operation.
3. With thumb or finger press remainder of strip into groove, working from the centre, then use any convenient round bar to further bed in the strip by rolling and pressing its inner diameter as shown in Fig. K.8. This procedure takes advantage of the friction between the strip and the groove at the ends to compact the rope, whilst ensuring that the projections of the end faces of the rope remain as set.
4. Fit sealing strip to other half housing in a similar manner.
5. Remove all traces of the old joint from cylinder block rear face and fit a new joint treated with a suitable jointing compound. Lightly coat the faces of the housing with a suitable jointing compound and spread a film of graphite grease over the exposed inside diameter surface of the strip.
6. Assemble half housings around crankshaft rear journal and fasten together by the two setscrews (See Fig. K.3).
7. Swivel the complete seal housing on the shaft to bed in the strips, and to establish that the assembly turns on the crankshaft. Bolt the seal housing in position on the block and the rear main bearing cap and tighten securing setscrews.

Fig. K.8.
Bedding in the rear Main Oil Seal.

Crankshaft and Main Bearings (K)

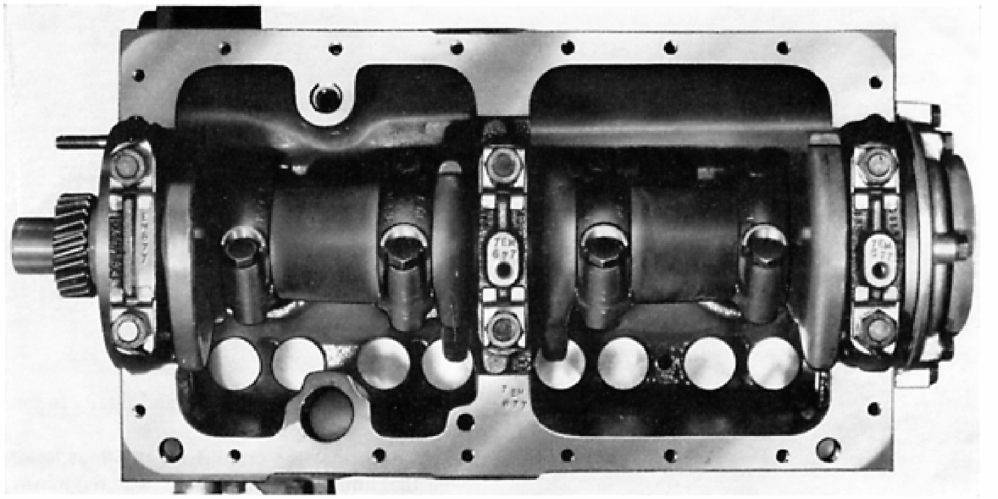


Fig. K.1.
View of Crankcase showing serial number locations on Cylinder Block and Main Bearing Caps.

Description

The crankshaft runs in three pre-finished replaceable thinwall, steel backed, aluminium tin lined bearings. Crankshaft end float is controlled by thrust washers located either side of the rear main bearing. 0.0075 in (0,19 mm) oversize thrust washers are available which if used on one side of the rear main bearing only will reduce crankshaft end float by 0.0075 in (0,19 mm) and by 0.015 in (0,38 mm) if used on both sides. The limits for the crankshaft end float are given on Page K.5.

The main bearing caps are numbered and are not interchangeable. The main bearing shells are located by tabs which locate in slots in the bearing housings.

NOTE: Before renewal of the main bearings is attempted make certain that the correct replacements are available, reference to the relevant parts list will ensure this, but for identification purposes the new bearings should have an annular groove machined in the inner (bearing) face along the centre line of the feed holes, when the bearings are correctly located these feed holes will correspond exactly with those machined in the cylinder block.

On later 4.107 engines the annular oil groove in the main bearing parent bore (cylinder block and bearing cap) has been deleted. Adequate lubrication is maintained by repositioning the oil feed holes radially in the shell bearings and continuing to machine the annular groove in the bearing on the centre line of these feed holes.

These later type shell bearings may be used on both early and later type engines, whereas the early type of shell bearing must NOT, on any account, be fitted to the later engines where the annular groove in the main bearing parent bore has been deleted.

To Renew Main Bearings and Thrust Washers

Removal of the main bearings and thrust washers can be carried out without removing the crankshaft as follows.

1. Remove sump and suction pipe assembly.
2. Slacken main bearing cap setscrews.
3. Remove one of the main bearing caps and remove bearing shell from cap.
4. Remove top half of bearing shell by pushing it, on the opposite side to the one having the locating tag, with a suitable strip of wood and rotating it on the crankshaft as shown in Fig. K.2.
5. Inspect bearing shells and if replacements are necessary continue by lightly lubricating and inserting the new top half bearing shell, plain end first, into the side having the tag location.
6. Rotate bearing shell on crankshaft until it locates correctly with the tag in the machined slot.
7. Locate lower half bearing shell in main bearing cap, lubricate and refit.

DATA AND DIMENSIONS FOR CRANKSHAFT AND MAIN BEARINGS

Special Note :

The crankshaft fitted to the 4.108 engine is hardened by the "Tufftride" process.
Special precautions are therefore necessary when regrinding. Only very light cuts should be taken, especially in the region of the fillet radii and adequate cooling should be ensured during grinding operations.

After regrinding the crankshaft it should be crack-detected and de-magnetised, then re-treated by the "Tufftride" process after which the crankshaft should again be crack-detected and de-magnetised. Where facilities are not available to re-harden the crankshaft by this process, a factory replacement crankshaft should be obtained.

Fillet radii and surface finish must be maintained during all crankshaft regrinding. Length of No. 3 main journal not to exceed 1.516 in (38,506 mm) after regrinding. Where necessary use oversize thrust washers to bring crankshaft end float within the correct limits.

Crankshaft

Overall Length	21.125 in (536,575 mm)
Main Journal Dia. Nos. 1 and 2...	2.248/2.2485 in (57,099/57,112 mm)
Main Journal Dia. No. 3	2.2475/2.248 in (57,086/57,099 mm)
Main Journal Length No. 1	1.40625 in (35,719 mm)
Main Journal Length No. 2	1.496/1.504 in (37,998/38,202 mm)
Main Journal Length No. 3	1.499/1.502 in (38,075/38,151 mm)
Main Journal Fillet Radii	0.125/0.141 in (3,175/3,581 mm)
Crankpin Dia.	1.9995/2.000 in (50,787/50,800 mm)
Crankpin Length	1.1875/1.1895 in (30,162/30,213 mm)
Crankpin Fillet Radii	0.15625/0.17187 in (5/32/11/64 in) (3,969/4,366 mm)
Surface Finish—All Journals	8 - 16 micro-in (0,2-0,4 micron)
Main Journal and Crankpin Regrind Undersizes ...	0.010, 0.020, 0.030 in (0,25, 0,51, 0,76 mm)
Oil Seal Helix Dia.	2.21075/2.21175 in (56,153/56,178 mm)
Oil Seal Helix Width	0.050/0.080 in (1,270/2,032 mm)
Oil Seal Helix Depth	0.004/0.008 in (0,102/0,203 mm)
Flange Dia.	3.9985/3.9995 in (101,562/101,587 mm)
Flange Width	0.500 in (12,700 mm)
Spigot Bearing Recess Depth	0.875 in (22,225 mm)
Spigot Bearing Recess Bore	1.250 in (31,750 mm)
Crankshaft End Float	0.002/0.015 in (0,0508/0,381 mm)

Main Bearings

Type	Pre-finished, Steel Backed, Aluminium Tin Lined
Shell Width	1.245/1.255 in (31,623/31,877 mm)
Outside Dia. of Main Bearing	2.3955 in (60,846 mm)
Inside Dia. of Main Bearing	2.2505/2.2515 in (57,163/57,188 mm)
Running Clearance — Nos. 1 and 2	0.002/0.0035 in (0,051/0,089 mm)
Running Clearance — No. 3	0.0025/0.004 in (0,063/0,102 mm)
Steel Thickness	0.060 in (1,524 mm) Max.
Aluminium Thickness	0.012/0.01225 in (0,305/0,311 mm)

Crankshaft Thrust Washers

Type	Steel Backed — Lead Bronze Faced
Position in Engine	Rear Main Bearing
Thrust Washer Thickness (STD)	0.089/0.091 in (2,261/2,311 mm)
Thrust Washer Thickness (O/S)	0.0965/0.1005 in (2,451/2,553 mm)
Thrust Washer Outside Dia.	3.245/3.255 in (82,423/82,677 mm)
Thrust Washer Inside Dia.	2.590/2.600 in (65,786/66,040 mm)

Cooling System (P)

Two methods of cooling are available for the 4.99, 4.107 and 4.108 Marine engine, these being open circuit and closed circuit cooling.

Open Circuit Cooling

With this system water from a source outside the boat is utilised, i.e. sea or river water. The coolant is fed by a rubber impeller type water pump into the exhaust manifold water jacket. The coolant then flows from the exhaust manifold into the front of the cylinder block where it circulates around the cylinder liners and the cylinder head water jacket by means of thermo syphon action. The coolant is finally discharged via a connection on the front of the cylinder head.

With earlier engines, the coolant was controlled by a hand operated valve on top of the water outlet connection, in order that the water temperature could be maintained at a maximum of 120°F (49°C). With sea water cooling, this temperature should not be exceeded otherwise salt deposits are liable to form in the water jackets of the cylinder block and head, thus causing a restriction.

With later engines, the coolant temperature is controlled by a thermostat and a pressure relief valve relieves the excess water pressure when the thermostat is closed.

Where conditions necessitate the use of an oil cooler, this is mounted on the front of the cylinder block and the coolant passes through the cooler before entering the block.

Closed Circuit Cooling

With this system a heat exchanger or keel pipes are utilised to cool the coolant after it has circulated round the water jackets.

When keel pipes are used the coolant is drawn from the pipes into the cylinder block on the right hand side, where it circulates round the cylinder liners and the cylinder head water jacket, movement being assisted by a centrifugal type water pump. The coolant is discharged from the front of the cylinder head into the header tank, which embodies a cooler for the lubricating oil. From the header tank the coolant flows to the exhaust manifold and finally returns to the keel pipes.

With standard engines employing a heat exchanger, a combined header tank and heat exchanger is mounted at the front of the cylinder head. Coolant is drawn from the heat exchanger into the exhaust manifold water jacket. The coolant then flows from the manifold to the right hand side of the cylinder block where it is circulated round the cylinder liners and cylinder head water jacket, being assisted by a centrifugal type water pump. The coolant is discharged from the front of the cylinder head into the heat exchanger, which in some cases also embodies an oil cooler. In the combined heat exchanger, the oil and water, in their respective compartments, are passed over a series of tubes running the length of the unit. Sea or river water is pumped, by a rubber impeller type pump, through these tubes and cools both the engine coolant and the lubricating oil.

With low-line engines incorporating heat exchanger cooling, the header tank is mounted at the front of the cylinder head and a separate heat exchanger at the rear of the cylinder head. On the open side of the system, water is delivered by the seawater pump through the engine oil cooler to the gearbox. From the gearbox, the water is delivered to the heat exchanger where it cools the fresh water coolant. The sea water then flows to the exhaust outlet and is discharged overboard. On the closed circuit side, fresh water flows from the heat exchanger to the header tank and then to the water cooled exhaust manifold and back to the heat exchanger. Coolant also flows from the header tank to the cylinder block. The block and cylinder head are cooled by thermosyphon action being assisted by the fresh water

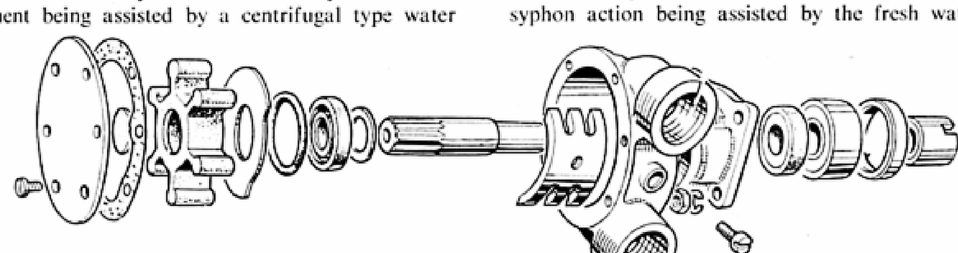


Fig. P.1.
Exploded view of Sea Water Pump.

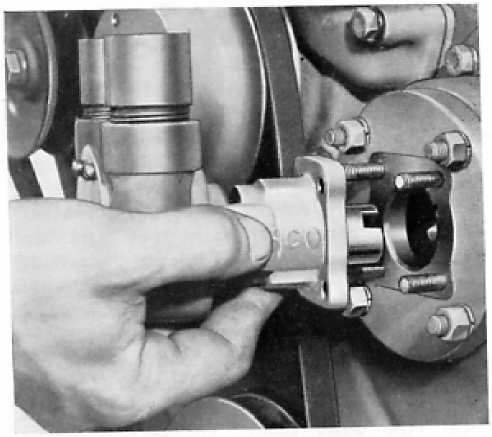


Fig. P.2. Removing Sea Water Pump.

pump mounted on the front of the cylinder block. The coolant is then discharged from the front of the cylinder head back to the header tank.

With a closed circuit cooling system, a thermostat is provided at the cylinder head outlet connection to ensure that the correct operating temperature is maintained. The coolant should never be allowed to boil. Where a pressurised filler cap is fitted, the coolant temperature at the outlet should be in the region of 190°F. (88°C). Otherwise the best temperature is 170°F. (77°C).

Sea Water Pump

The water pump, used for open circuit cooling, or in conjunction with a heat exchanger is mounted on the front of the timing gear cover and is driven at half engine speed from the fuel pump gear. The pump is self priming but it is advisable to prime it when first commencing service or after the engine has been laid up for any considerable period.

To Remove Pump

Uncouple inlet and outlet connections.

Unscrew the four nuts, thereby enabling the pump to be lifted away from the timing case (See Fig. P.2).

The pump may be replaced by reversing the above procedure.

Dismantling

To dismantle the pump, proceed as follows :—

Remove front end cover, impeller and wear plate.

A suitable press may be used to press out impeller shaft together with water pump bearing.

The cam in the impeller housing may then be detached by removing the single securing setscrew.

Remove rubber seal in impeller housing, 'O' ring and seal in bearing housing.

In the event of wear being present on the impeller wear plate or water pump end plate, both these may be reversed. In the case of the end plate, it may be necessary to remove the stamped instructions by means of emery paper. This will remove the arrows showing the rotation of the impeller, but this rotation can be ascertained by turning the engine and noting the rotation of the pump coupling.

To reassemble the water pump, the reverse order of the above procedure should be adopted, care being taken when replacing the rubber impeller that the blades all lay in the same direction relative to the rotation of the pump i.e. blades trailing.

When reassembling ensure that the rubber impeller is coated with MARFAK 2HD Grease or glycerine as an alternative.

When replacing cam fitted in impeller housing, be certain to coat the entire top surface, rear face and securing setscrew holes with a suitable jointing compound.

Note that the cam will go into place one way only.

IMPORTANT NOTE :

As the water pump contains a rubber impeller, on no account must it be run in a dry condition. If the engine is to be laid up for any period, the water pump should be packed with MARFAK 2HD grease or coated with glycerine.

Fresh Water Pump

The water pump for closed circuit cooling is mounted on the front of the cylinder block and is belt driven from the crankshaft.

An improved "ceramic counter-faced" insert

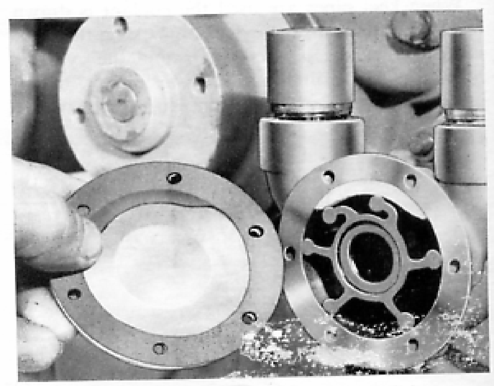


Fig. P.3. Removing Sea Water Pump End Plate.

Fig. P.4.
Removing the Water Pump Pulley.

ıas been incorporated into later water pumps.

The latest water pump, as an assembly, is inter-:hangeable with its predecessor. The body and all nternal parts except for the seal and insert re-nain unchanged.

The later seal and insert are interchangeable on :arlier water pumps and it is necessary to change he two together.

To Remove Water Pump

Slacken generator securing setscrews and re-nove driving belt.

Unscrew the four setscrews securing the water oump and backplate to cylinder block and re-nove.

To Dismantle Water Pump

1. Remove pulley securing circlip (4.108 engines).
2. Remove water pump pulley by means of a suitable puller, the holes in the pulley face may be utilised for this purpose. (See Fig. P.4).
3. Remove drive shaft locating clip (early engines) see Fig. P.5, and press shaft out of pump body from pulley end complete with water pump thrower, insert, seal and impeller.
4. Remove impeller from pump drive shaft by means of a suitable puller or press.
5. Remove bearing retaining circlip then using a suitable mandrel press the two shaft bearings complete with distance piece out through the front of the pump body.
6. Remove felt seal and retaining flanges.

Inspection

1. Examine pump body for cracks, corrosion or any other damage.
2. Examine shaft and bearing assembly for wear.
3. Examine the water thrower flange for damage.
4. Examine water pump seal and insert for excessive wear, scoring or cracks on sealing faces.
5. Remove rust and scale from impeller and examine for excessive corrosion or other damage.
6. Examine pump pulley for damage.

To Re-Assemble the Water Pump

(Refer to Fig. P.6).

1. Insert oil seal retainer (7) and oil seal (2) followed by oil seal retaining flange (6).
2. Fit the two bearings (3) and distance piece (5) onto shaft (4) and pack space between the two bearings approximately $\frac{3}{4}$ full of high melting point grease (Later engines only).
3. Press bearings and shaft assembly into pump body, impeller end first and locate with circlip (Later engines).
4. Press water thrower flange (8) into position on drive shaft.
5. Clean insert recess and drain hole in pump body with cleaning spirit or Locquic "Q".
6. Lightly coat inner diameter of insert recess and outside diameter of insert (11) with Loctite Retaining Compound.
7. After removing any traces of oil or grease from insert, press it fully home. Remove all

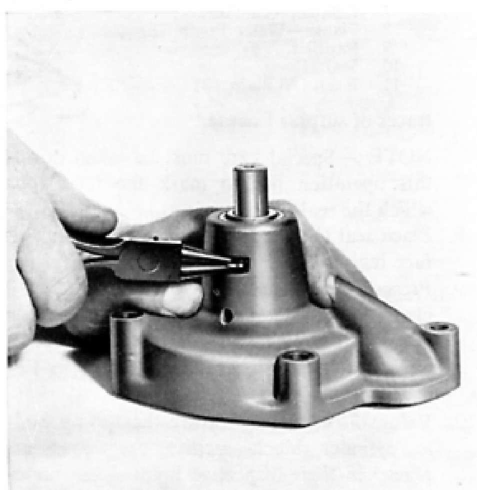


Fig. P.5. Removing Shaft Locating Circlip.

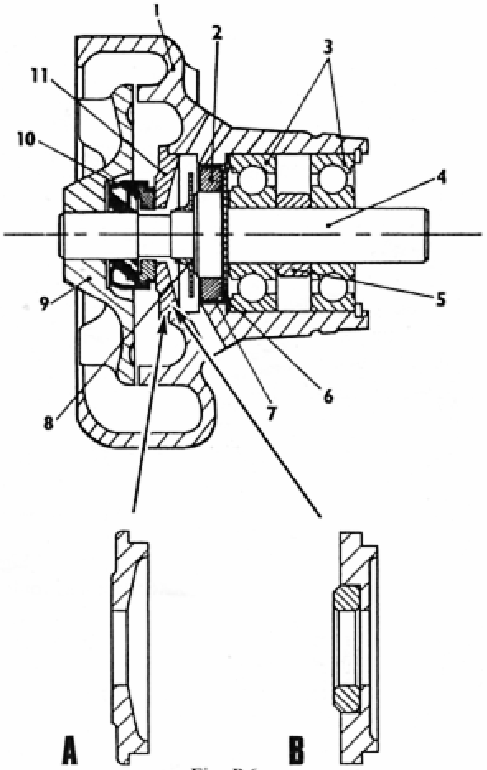


Fig. P.6.
Sectional View of Water Pump.

1. Pump Body.
2. Seal.
3. Shaft Bearings.
4. Pump Shaft.
5. Distance Piece.
6. Flange—Oil Seal Retaining.
7. Retainer—Oil Seal.
8. Flange—Water Pump Thrower.
9. Impeller.
10. Seal.
11. Insert (A) Plain. (B) Ceramic Faced.

traces of surplus Loctite.

NOTE :—Special care must be taken during this operation not to mark the face upon which the seal registers.

8. Place seal (10) on the drive shaft so that this face registers with insert face.
9. Press impeller onto shaft over this seal until clearance given on Page P.7 exists between back face of impeller and pump body. This clearance can be checked as shown in Fig. P.7.
10. Before fitting pulley ensure that pump body to cylinder block securing setscrews are placed in their respective holes. Press pulley fully onto shaft and fit the securing circlip (where fitted).

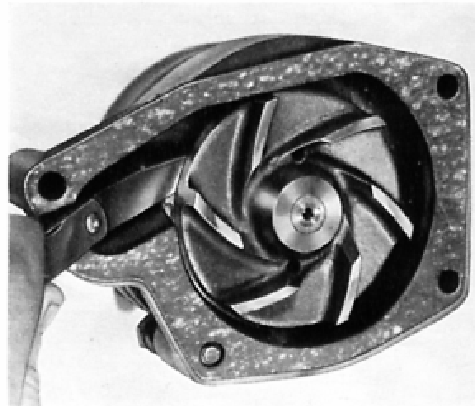


Fig. P.7.
Checking Impeller to Pump Body Clearance.

NOTE :—When pulley is originally pressed onto shaft during production a pressure of $2\frac{1}{2}$—3 ton/in^2 is required. Therefore it is recommended that if pulley interference on shaft is such that a substantially reduced pressure will press the pulley back onto shaft, then a replacement pulley and/or shaft should be fitted.

To Refit the Water Pump

Fit new back plate joint to cylinder block, followed by water pump back plate and then water pump joint, using jointing compound.

Fit water pump to cylinder block and secure with four setscrews.

Replace driving belt and tension as described on page P.6.

HEAT EXCHANGER AND OIL COOLER

General

The general purpose of the Heat Exchanger is to provide :—

(a) A reservoir of fresh water in the header tank to allow for expansion and contraction, evaporation, and unavoidable leakage.
(b) A method of cooling the fresh water by means of sea water. This is accomplished by passing the sea water through a series of small bore tubes and guiding the fresh water over the tubes with the aid of a number of circular shaped brass baffles.
(c) A method of cooling the engine lubricating oil by means of sea water. This is accomplished by passing the sea water through a series of small bore tubes and guiding the oil over the tubes with the aid of a number of circular brass baffles.

With standard engines, the unit therefore basically comprises :—

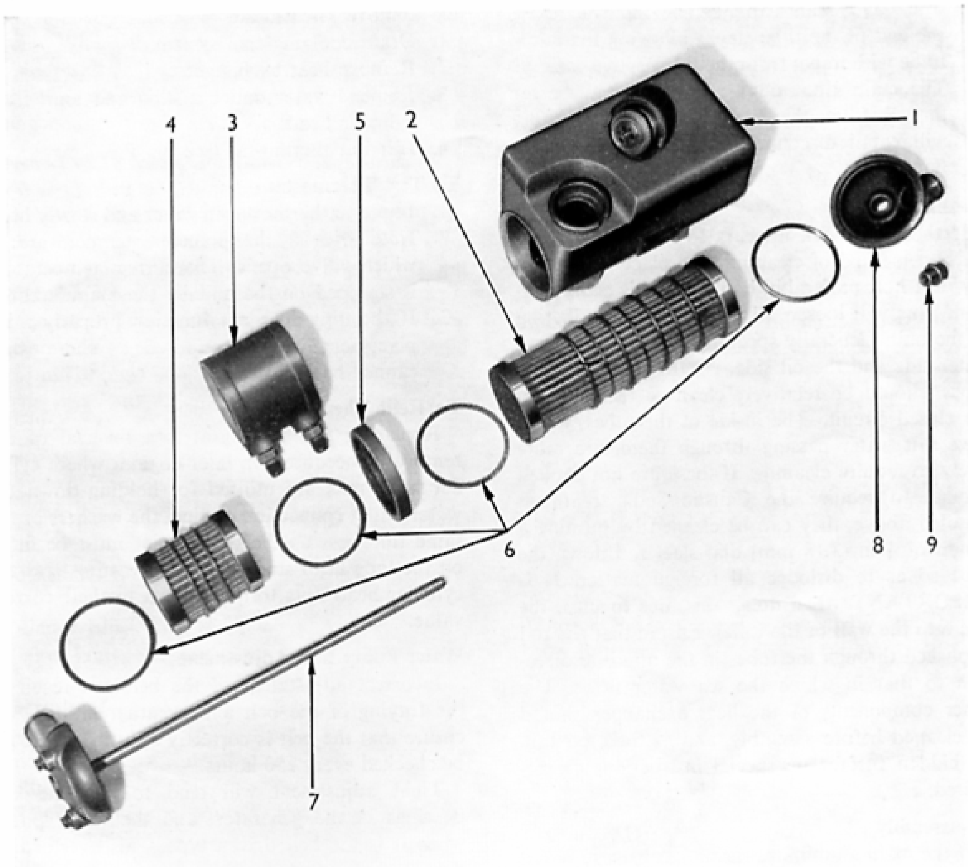


Fig. P.8.
Exploded view of Heat Exchanger.

1. Heat Exchanger Casing.
2. Tube Stack for Engine Coolant.
3. Oil Cooler Casing.
4. Tube Stack for Lubricating Oil.
5. Spacer.
6. "O" Rings.
7. Tie Rod.
8. End Cover.
9. Cap Nut.

(a) An aluminium casing providing the header tank and a machined bore into which the heat exchanger tube stack is located.
(b) A smaller aluminium cylinder into which the oil cooler tube stack is located.
(c) Two tube stacks each comprising a number of small bore tubes running between two tube plates.
(d) Two sea water end covers.
(e) A tie rod which passes between the end covers and secures the assembly together.

With low-line engines, both the engine oil cooler and heat exchanger are separate from the header tank, but the sevicing of these items is similar to that described.

Dismantling

1. Remove the two sea water pipes from their respective end covers.
2. Disconnect the two oil pipes.
3. Remove brass cap nut.
4. This end cover can now be removed.
5. The other end cover complete with tie rod can now be withdrawn. Care should be taken to support oil cooler and spacing ring after tie rod has been removed, as this will not be attached in any way to main casing.

LUBRICATING SYSTEM—N.6

Pump Clearances

Inner Rotor to Outer Rotor	0.0005/0.0025 in (0,013/0,063 mm)
Outer Rotor to Pump Body	0.011/0.013 in (0,28/0,33 mm)
Inner Rotor End Clearance	0.0015/0.003 in (0,038/0,076 mm)
Outer Rotor End Clearance	0.0005/0.0025 in (0,013/0,063 mm)
Inside Dia. of Bore for Pump Shaft	0.500/0.501 in (12,700/12,725 mm)
Outside Dia. of Pump Shaft	0.4983/0.4986 in (12,655/12,664 mm)
Running Clearance, Shaft in Bore	0.0014/0.0027 in (0,036/0,069 mm)

Lubricating Oil Pump Drive Gear

Number of Teeth	12
Inside Dia. of Gear Bore	0.4965/0.4970 in (12,611/12,624 mm)
Outside Dia. of Oil Pump Drive Shaft	0.4983/0.4986 in (12,655/12,664 mm)
Interference Fit of Gear on Shaft	0.0013/0.0021 in (0,033/0,053 mm)
Lubricating Oil Pump Drive Gear Backlash ...	0.0155/0.019 in (0,394/0,483 mm)

Relief Valve

Type	Spring Loaded Plunger
Pressure Setting	50/65 lbf/in² (3,5/4,6 kgf/cm²)
Length of Plunger	0.9375 in (23,813 mm)
Outside Dia. of Plunger	0.5585/0.5595 in (14,19/14,21 mm)
Inside Dia. of Valve Housing Bore	0.5605/0.5625 in (14,24/14,29 mm)
Clearance of Plunger in Bore	0.001/0.004 in (0,025/0,102 mm)
Outside Dia. of Spring	0.368/0.377 in (9,347/9,576 mm)
Spring—Free Length	1.5 in (38,10 mm)
Spring—Solid Length	0.754 in (19,15 mm)

Lubricating Oil Filter

Type	Full Flow
Element Type	Paper
By-Pass Valve Setting	Opens between 13-17 lbf/in² (0,91 - 1,2 kgf/cm²) pressure differential
Type of Valve	Spring Loaded Ball

Cooling System (P)

Two methods of cooling are available for the 4.99, 4.107 and 4.108 Marine engine, these being open circuit and closed circuit cooling.

Open Circuit Cooling

With this system water from a source outside the boat is utilised, i.e. sea or river water. The coolant is fed by a rubber impeller type water pump into the exhaust manifold water jacket. The coolant then flows from the exhaust manifold into the front of the cylinder block where it circulates around the cylinder liners and the cylinder head water jacket by means of thermo syphon action. The coolant is finally discharged via a connection on the front of the cylinder head.

With earlier engines, the coolant was controlled by a hand operated valve on top of the water outlet connection, in order that the water temperature could be maintained at a maximum of 120°F (49°C). With sea water cooling, this temperature should not be exceeded otherwise salt deposits are liable to form in the water jackets of the cylinder block and head, thus causing a restriction.

With later engines, the coolant temperature is controlled by a thermostat and a pressure relief valve relieves the excess water pressure when the thermostat is closed.

Where conditions necessitate the use of an oil cooler, this is mounted on the front of the cylinder block and the coolant passes through the cooler before entering the block.

Closed Circuit Cooling

With this system a heat exchanger or keel pipes are utilised to cool the coolant after it has circulated round the water jackets.

When keel pipes are used the coolant is drawn from the pipes into the cylinder block on the right hand side, where it circulates round the cylinder liners and the cylinder head water jacket, movement being assisted by a centrifugal type water pump. The coolant is discharged from the front of the cylinder head into the header tank, which embodies a cooler for the lubricating oil. From the header tank the coolant flows to the exhaust manifold and finally returns to the keel pipes.

With standard engines employing a heat exchanger, a combined header tank and heat exchanger is mounted at the front of the cylinder head. Coolant is drawn from the heat exchanger into the exhaust manifold water jacket. The coolant then flows from the manifold to the right hand side of the cylinder block where it is circulated round the cylinder liners and cylinder head water jacket, being assisted by a centrifugal type water pump. The coolant is discharged from the front of the cylinder head into the heat exchanger, which in some cases also embodies an oil cooler. In the combined heat exchanger, the oil and water, in their respective compartments, are passed over a series of tubes running the length of the unit. Sea or river water is pumped, by a rubber impeller type pump, through these tubes and cools both the engine coolant and the lubricating oil.

With low-line engines incorporating heat exchanger cooling, the header tank is mounted at the front of the cylinder head and a separate heat exchanger at the rear of the cylinder head. On the open side of the system, water is delivered by the seawater pump through the engine oil cooler to the gearbox. From the gearbox, the water is delivered to the heat exchanger where it cools the fresh water coolant. The sea water then flows to the exhaust outlet and is discharged overboard. On the closed circuit side, fresh water flows from the heat exchanger to the header tank and then to the water cooled exhaust manifold and back to the heat exchanger. Coolant also flows from the header tank to the cylinder block. The block and cylinder head are cooled by thermo-syphon action being assisted by the fresh water

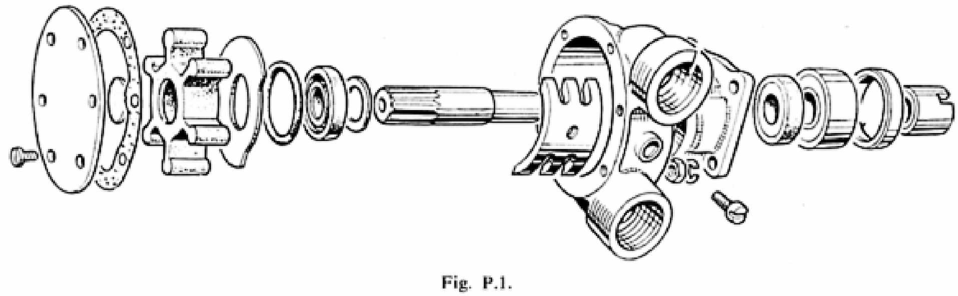


Fig. P.1.
Exploded view of Sea Water Pump.

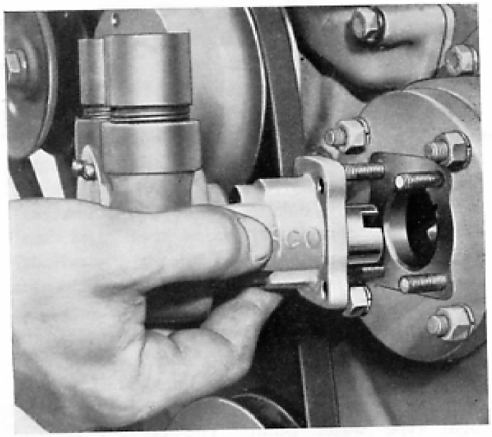


Fig. P.2. Removing Sea Water Pump.

pump mounted on the front of the cylinder block. The coolant is then discharged from the front of the cylinder head back to the header tank.

With a closed circuit cooling system, a thermostat is provided at the cylinder head outlet connection to ensure that the correct operating temperature is maintained. The coolant should never be allowed to boil. Where a pressurised filler cap is fitted, the coolant temperature at the outlet should be in the region of 190°F. (88°C). Otherwise the best temperature is 170°F. (77°C).

Sea Water Pump

The water pump, used for open circuit cooling, or in conjunction with a heat exchanger is mounted on the front of the timing gear cover and is driven at half engine speed from the fuel pump gear. The pump is self priming but it is advisable to prime it when first commencing service or after the engine has been laid up for any considerable period.

To Remove Pump

Uncouple inlet and outlet connections.

Unscrew the four nuts, thereby enabling the pump to be lifted away from the timing case (See Fig. P.2).

The pump may be replaced by reversing the above procedure.

Dismantling

To dismantle the pump, proceed as follows :—

Remove front end cover, impeller and wear plate.

A suitable press may be used to press out impeller shaft together with water pump bearing.

The cam in the impeller housing may then be detached by removing the single securing setscrew.

Remove rubber seal in impeller housing, 'O' ring and seal in bearing housing.

In the event of wear being present on the impeller wear plate or water pump end plate, both these may be reversed. In the case of the end plate, it may be necessary to remove the stamped instructions by means of emery paper. This will remove the arrows showing the rotation of the impeller, but this rotation can be ascertained by turning the engine and noting the rotation of the pump coupling.

To reassemble the water pump, the reverse order of the above procedure should be adopted, care being taken when replacing the rubber impeller that the blades all lay in the same direction relative to the rotation of the pump i.e. blades trailing.

When reassembling ensure that the rubber impeller is coated with MARFAK 2HD Grease or glycerine as an alternative.

When replacing cam fitted in impeller housing, be certain to coat the entire top surface, rear face and securing setscrew holes with a suitable jointing compound.

Note that the cam will go into place one way only.

IMPORTANT NOTE :

As the water pump contains a rubber impeller, on no account must it be run in a dry condition. If the engine is to be laid up for any period, the water pump should be packed with MARFAK 2HD grease or coated with glycerine.

Fresh Water Pump

The water pump for closed circuit cooling is mounted on the front of the cylinder block and is belt driven from the crankshaft.

An improved "ceramic counter-faced" insert

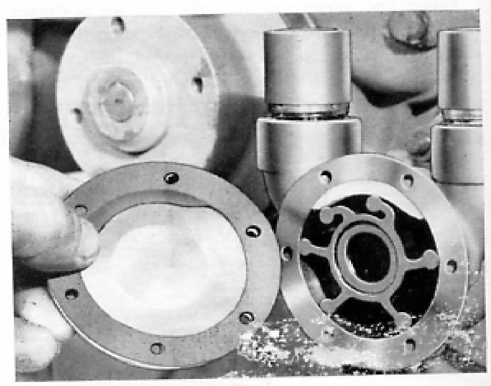


Fig. P.3. Removing Sea Water Pump End Plate.

Fig. P.4.
Removing the Water Pump Pulley.

ias been incorporated into later water pumps.

The latest water pump, as an assembly, is inter-hangeable with its predecessor. The body and all nternal parts except for the seal and insert re-nain unchanged.

The later seal and insert are interchangeable on arlier water pumps and it is necessary to change he two together.

o Remove Water Pump

Slacken generator securing setscrews and re-nove driving belt.

Unscrew the four setscrews securing the water ump and backplate to cylinder block and re-nove.

o Dismantle Water Pump

1. Remove pulley securing circlip (4.108 engines).
2. Remove water pump pulley by means of a suitable puller, the holes in the pulley face may be utilised for this purpose. (See Fig. P.4).
3. Remove drive shaft locating clip (early engines) see Fig. P.5, and press shaft out of pump body from pulley end complete with water pump thrower, insert, seal and impeller.
4. Remove impeller from pump drive shaft by means of a suitable puller or press.
5. Remove bearing retaining circlip then using a suitable mandrel press the two shaft bearings complete with distance piece out through the front of the pump body.
6. Remove felt seal and retaining flanges.

Inspection

1. Examine pump body for cracks, corrosion or any other damage.
2. Examine shaft and bearing assembly for wear.
3. Examine the water thrower flange for damage.
4. Examine water pump seal and insert for excessive wear, scoring or cracks on sealing faces.
5. Remove rust and scale from impeller and examine for excessive corrosion or other damage.
6. Examine pump pulley for damage.

To Re-Assemble the Water Pump

(Refer to Fig. P.6).

1. Insert oil seal retainer (7) and oil seal (2) followed by oil seal retaining flange (6).
2. Fit the two bearings (3) and distance piece (5) onto shaft (4) and pack space between the two bearings approximately ¾ full of high melting point grease (Later engines only).
3. Press bearings and shaft assembly into pump body, impeller end first and locate with circlip (Later engines).
4. Press water thrower flange (8) into position on drive shaft.
5. Clean insert recess and drain hole in pump body with cleaning spirit or Locquic "Q".
6. Lightly coat inner diameter of insert recess and outside diameter of insert (11) with Loctite Retaining Compound.
7. After removing any traces of oil or grease from insert, press it fully home. Remove all

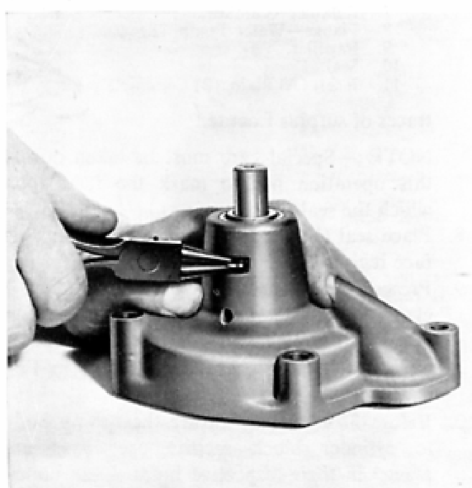


Fig. P.5. Removing Shaft Locating Circlip.

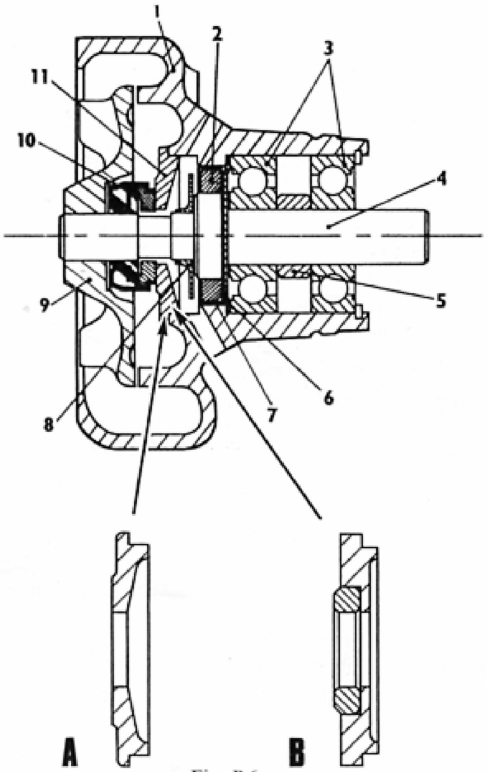


Fig. P.6.
Sectional View of Water Pump.

1. Pump Body.
2. Seal.
3. Shaft Bearings.
4. Pump Shaft.
5. Distance Piece.
6. Flange—Oil Seal Retaining.
7. Retainer—Oil Seal.
8. Flange—Water Pump Thrower.
9. Impeller.
10. Seal.
11. Insert (A) Plain. (B) Ceramic Faced.

traces of surplus Loctite.

NOTE :—Special care must be taken during this operation not to mark the face upon which the seal registers.

8. Place seal (10) on the drive shaft so that this face registers with insert face.
9. Press impeller onto shaft over this seal until clearance given on Page P.7 exists between back face of impeller and pump body. This clearance can be checked as shown in Fig. P.7.
10. Before fitting pulley ensure that pump body to cylinder block securing setscrews are placed in their respective holes. Press pulley fully onto shaft and fit the securing circlip (where fitted).

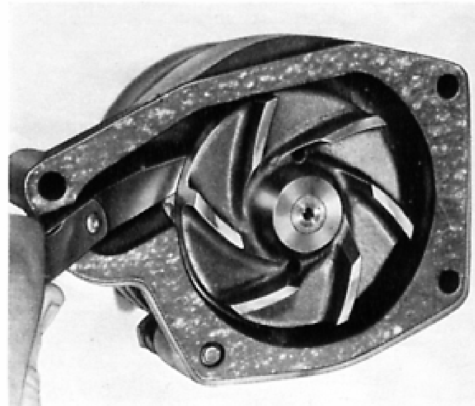


Fig. P.7.
Checking Impeller to Pump Body Clearance.

NOTE :—When pulley is originally pressed onto shaft during production a pressure of $2\frac{1}{2}$—3 ton/in^2 is required. Therefore it is recommended that if pulley interference on shaft is such that a substantially reduced pressure will press the pulley back onto shaft, then a replacement pulley and/or shaft should be fitted.

To Refit the Water Pump

Fit new back plate joint to cylinder block, followed by water pump back plate and then water pump joint, using jointing compound.

Fit water pump to cylinder block and secure with four setscrews.

Replace driving belt and tension as described on page P.6.

HEAT EXCHANGER AND OIL COOLER

General

The general purpose of the Heat Exchanger is to provide :—

(a) A reservoir of fresh water in the header tank to allow for expansion and contraction, evaporation, and unavoidable leakage.
(b) A method of cooling the fresh water by means of sea water. This is accomplished by passing the sea water through a series of small bore tubes and guiding the fresh water over the tubes with the aid of a number of circular shaped brass baffles.
(c) A method of cooling the engine lubricating oil by means of sea water. This is accomplished by passing the sea water through a series of small bore tubes and guiding the oil over the tubes with the aid of a number of circular brass baffles.

With standard engines, the unit therefore basically comprises :—

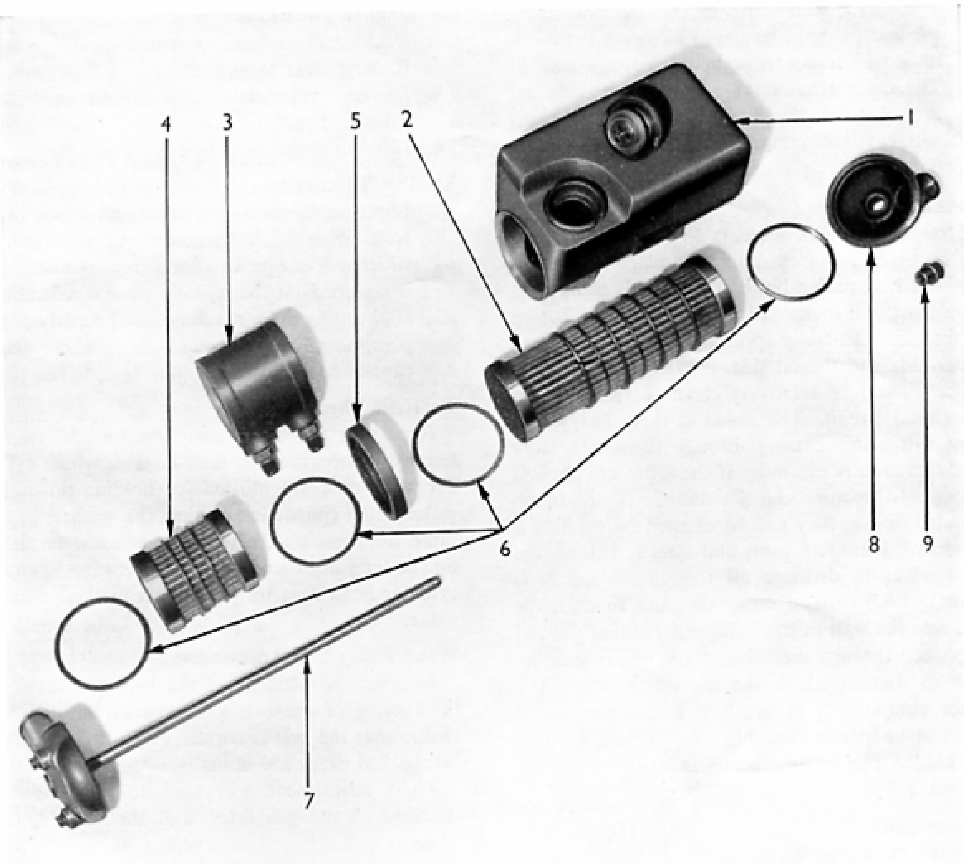


Fig. P.8.
Exploded view of Heat Exchanger.

1. Heat Exchanger Casing.
2. Tube Stack for Engine Coolant.
3. Oil Cooler Casing.
4. Tube Stack for Lubricating Oil.
5. Spacer.
6. "O" Rings.
7. Tie Rod.
8. End Cover.
9. Cap Nut.

(a) An aluminium casing providing the header tank and a machined bore into which the heat exchanger tube stack is located.

(b) A smaller aluminium cylinder into which the oil cooler tube stack is located.

(c) Two tube stacks each comprising a number of small bore tubes running between two tube plates.

(d) Two sea water end covers.

(e) A tie rod which passes between the end covers and secures the assembly together.

With low-line engines, both the engine oil cooler and heat exchanger are separate from the header tank, but the sevicing of these items is similar to that described.

Dismantling

1. Remove the two sea water pipes from their respective end covers.
2. Disconnect the two oil pipes.
3. Remove brass cap nut.
4. This end cover can now be removed.
5. The other end cover complete with tie rod can now be withdrawn. Care should be taken to support oil cooler and spacing ring after tie rod has been removed, as this will not be attached in any way to main casing.

Electrical System (S)

DYNAMO

1. General

The following information is concerned with the dynamo fitted to the 4.99, 4.107 and 4.108 marine engines, namely the Lucas C40-A model. Should information be required in connection with any other type of dynamo then the relevant manufacturer should be contacted.

Description

The C40A is a non-ventilated unit.

It is a shunt wound, two pole, two brush machine designed to work in conjunction with a compensated voltage control regulator unit. A ball bearing supports the armature at the driving end and a porous bronze bush at the rear supports the commutator end.

The output of the dynamo is controlled by the regulator unit and is dependent on the state of charge of the battery and the loading of the electrical equipment in use. When the battery is in a low state of charge, the dynamo gives a high output, whereas if the battery is fully charged, the dynamo gives only sufficient output to keep the battery in good condition without any possibility of overcharging. An increase in output is given to balance the current taken by lamps and other accessories when in use.

When fitting a new control box, it is important to use only an authorised replacement. An incorrect replacement can result in damage to the dynamo.

2. Routine Maintenance

(a) Lubrication

Every 150 running hours, inject a few drops of high quality S.A.E.30 engine oil into the hole marked "OIL" at the commutator end bearing housing (Refer to Fig. S.1).

(b) Inspection of Brushgear

Every 2,400 running hours, the dynamo should be removed from the engine and the brushgear inspected by a competent electrician.

(c) Belt Adjustment

Occasionally inspect dynamo driving belt, and if necessary, adjust to take up any slackness by turning the dynamo on its mounting. Care should be taken to avoid overtightening belt (see Page P.6).

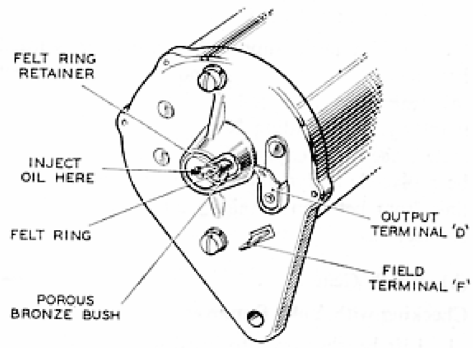


Fig. S.1.
Lubricator in Commutator End Bracket.

3. Performance Data

Cutting in and maximum output speeds quoted below are production test figures and refer to cold machines with brushes only partly bedded.

Model	C40A
Maximum output	11A
Maximum output speed	1650 rev/min
Cutting in speed	1050 rev/min
Rotation	Clockwise

4. Servicing

(a) Testing in Position

1. Inspect driving belt and adjust if necessary. (Refer to Page P.6).
2. Check connections on commutator end bracket. The larger connector carries the main dynamo output, the smaller connector the field current.
3. Switch off all lights and accessories, take off cables from terminals of dynamo and connect the two terminals with a short length of wire.
4. Start engine and set to run at normal idling speed.
5. Clip negative lead of a moving coil type voltmeter, (calibrated 0-20 volts) to one dynamo terminal and positive lead to a good earthing point on the yoke.
6. Gradually increase engine speed, when voltmeter reading should rise rapidly and without fluctuation. Do not allow volt meter reading to reach 20 volts, and do not race engine in an attempt to increase voltage. It is sufficient to run dynamo up to a speed of 1,000 rev/min (approx. 750 engine rev/min).

If voltage does not rise rapidly and without fluctuation, the unit must be dismantled for internal examination.

Excessive sparking at commutator in above test indicates a defective armature which should be replaced.

NOTE: If a radio suppression capacitor is fitted between output terminal and earth, disconnect this capacitor and re-test dynamo before dismantling. If a reading is now given on the voltmeter, then the capacitor is defective and must be replaced. If dynamo is in good order, remove link from between terminals and restore original connections.

(b) Brush Gear

Checking with Yoke Removed

1. Lift brushes up into brush boxes and secure them in that position by positioning brush springs at the sides of the brushes.
2. Fit commutator end bracket over commutator and release brushes.
3. Hold back each of the brush springs and move brush by pulling gently on its flexible connector. If the movement is sluggish, remove brush from its holder and ease the sides by lightly polishing on a smooth file. Always refit brushes in their original positions.

   If brushes are badly worn, new brushes must be fitted and bedded to the commutator. The minimum permissible length of brush is 9/32 in (7,14 mm) i.e. when the spring arm reaches the brush box.

   NOTE : Brushes of grade B carbon are specified for the model C40-A dynamo.

STARTER MOTORS

General

Two types of drive are available and both are covered in the following section. Should information be required in connection with any other type of starter motor then the relevant manufacturer should be contacted.

STARTER MOTOR—Run-off Helix Drive

1. Description—Model M45G Type RF 17

This electric starter motor is a four-pole four-brush machine having an extended shaft which carries the engagement gear, or starter drive as it is more generally known.

The starter motor is of a similar construction to the dynamo except that heavier copper wire is used in the construction of the armature and field coils. The field coils are series-parallel connected between the field terminal and the insulated pair of brushes.

The armature has 23 winding slots. The drive portion incorporates a special overload protective device known as the Run-off Helix.

2. Routine Maintenance

(a) The starter motor requires no routine maintenance beyond the occasional inspection of the electrical connection, which must be clean and tight, the brush gear, and the commutator.

(b) After the starter motor has been in service for some time, remove the starter motor from the engine and submit it to a thorough bench inspection.

MODEL C40-1 GENERATOR DISMANTLED

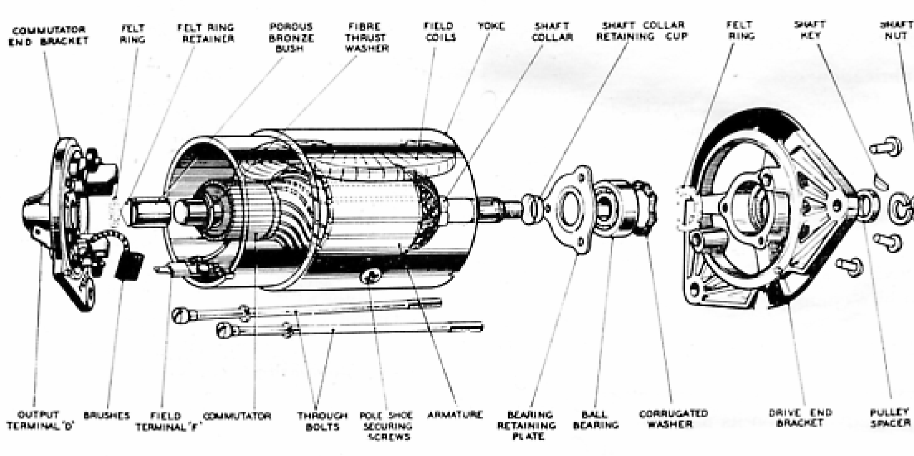


Fig. S.2.

If voltage does not rise rapidly and without fluctuation, the unit must be dismantled for internal examination.

Excessive sparking at commutator in above test indicates a defective armature which should be replaced.

NOTE: If a radio suppression capacitor is fitted between output terminal and earth, disconnect this capacitor and re-test dynamo before dismantling. If a reading is now given on the voltmeter, then the capacitor is defective and must be replaced. If dynamo is in good order, remove link from between terminals and restore original connections.

(b) Brush Gear

Checking with Yoke Removed

1. Lift brushes up into brush boxes and secure them in that position by positioning brush springs at the sides of the brushes.
2. Fit commutator end bracket over commutator and release brushes.
3. Hold back each of the brush springs and move brush by pulling gently on its flexible connector. If the movement is sluggish, remove brush from its holder and ease the sides by lightly polishing on a smooth file. Always refit brushes in their original positions.

   If brushes are badly worn, new brushes must be fitted and bedded to the commutator. The minimum permissible length of brush is 9/32 in (7,14 mm) i.e. when the spring arm reaches the brush box.

   NOTE : Brushes of grade B carbon are specified for the model C40-A dynamo.

STARTER MOTORS

General

Two types of drive are available and both are covered in the following section. Should information be required in connection with any other type of starter motor then the relevant manufacturer should be contacted.

STARTER MOTOR—Run-off Helix Drive

1. Description—Model M45G Type RF 17

This electric starter motor is a four-pole four-brush machine having an extended shaft which carries the engagement gear, or starter drive as it is more generally known.

The starter motor is of a similar construction to the dynamo except that heavier copper wire is used in the construction of the armature and field coils. The field coils are series-parallel connected between the field terminal and the insulated pair of brushes.

The armature has 23 winding slots. The drive portion incorporates a special overload protective device known as the Run-off Helix.

2. Routine Maintenance

(a) The starter motor requires no routine maintenance beyond the occasional inspection of the electrical connection, which must be clean and tight, the brush gear, and the commutator.

(b) After the starter motor has been in service for some time, remove the starter motor from the engine and submit it to a thorough bench inspection.

MODEL C40-1 GENERATOR DISMANTLED

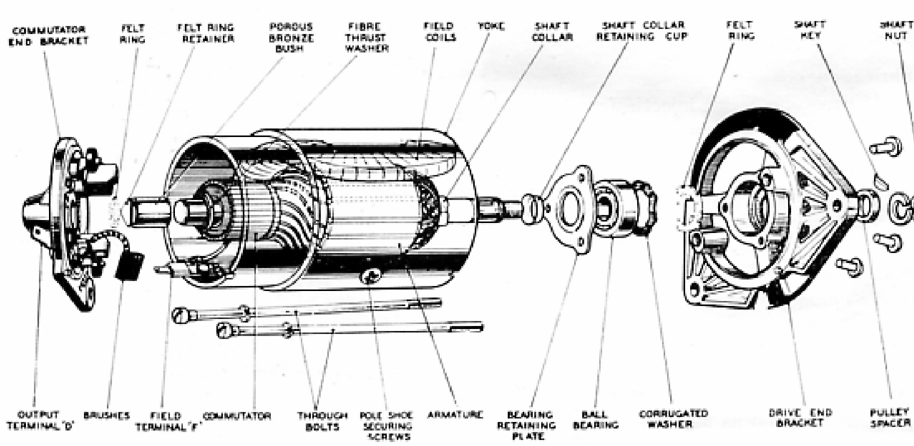


Fig. S.2.

1. Check that brushes move freely in their holders by holding back brush springs and pulling gently on the flexible connectors (Refer to Fig. S.4). If movement is sluggish, remove brush from its holder and clean its sides with a fluffless petrol moistened cloth. Replace brush in its original position. Brushes which are worn to less than 9/16 in (14 mm) long must be renewed.

   NOTE: This is the length when half the available wearing length has worn away. The time taken to reach this stage normally extends well beyond that to reach the point of major engine overhaul. After this time, the rate of wear accelerates due to reducing spring pressure.
2. The commutator must be clean and have a polished appearance. If necessary clean it by pressing a fine dry cloth against it whilst the armature is turned by hand. If the commutator is very dirty, moisten the cloth with petrol.
3. Keep all electrical connections clean and tight. Any which have become dirty should be cleaned and contacting surfaces lightly smeared with petroleum jelly.

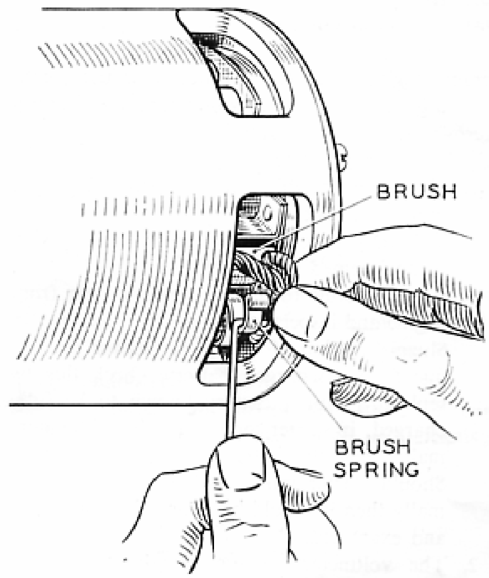


Fig. S.4.
Checking freedom of Brush Movement

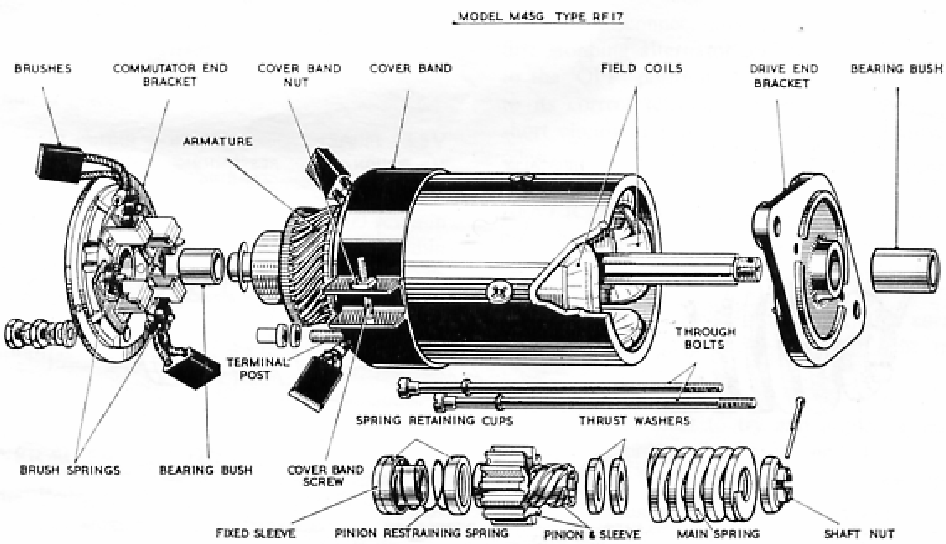


Fig. S.3.
Starter Motor Dismantled.

3. Servicing

(a) Testing in Position

If starter motor does not operate or fails to crank engine when starting button is used, connect a good quality 0—20 voltmeter across battery terminals, operate starter button and watch for the following symptoms:

1. Voltmeter reading falls appreciably but motor does not crank engine.
   This may be caused by starter drive pinion being jammed in mesh with engine flywheel. It is advisable to remove starter motor from engine and inspect starter drive.
   Sluggish action of the starter motor may be due to a discharged battery, check this by replacing with a battery known to be fully charged. If starter motor now functions normally then the battery must be examined. Should starter motor still not function normally then it should be removed from engine and examined.
2. The voltmeter reading remains unaffected and the motor does not crank the engine.
   Check first that the circuit up to the supply terminal on the starter motor is in order.
   If no voltage is indicated, check circuit from battery to motor via starter switch. Ensure that all connections are clean and tight. If switch is found to be faulty fit a serviceable replacement.
   A normal voltage supply reaching the starter motor terminal indicates that starter motor has an internal fault and must be removed for examination.
   If starter motor operates but does not crank engine, starter drive may require cleaning or may have developed some other fault. In either case starter motor requires removal from engine for a full examination.

'S' TYPE STARTER DRIVE ASSEMBLY

(a) OPERATION

This drive incorporates a protective feature known as the 'Run-off Helix.' The purpose of this feature is to prevent possible damage occurring to starter motor through excessive torque being applied while pinion is in engagement, as would arise for example in the event of an engine back-fire during starting.

Under normal conditions of engagement, axial movement of pinion is arrested when, in the one direction, the first cup washer has fully compressed the restraining spring and is abutted hard against the second cup washer and, in the opposite direction, the helically screwed sleeve is pressing the thrust washer hard against the main spring.

In the 'Run-off Helix' drive, the main spring is capable of greater compression than is the equivalent standard 'S' pattern drive spring. In addi-

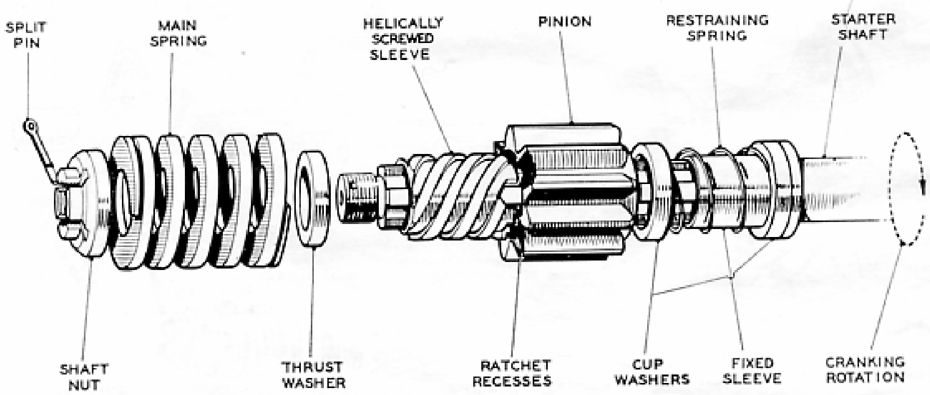


Fig. S.5.
'S' Type Starter Drive

tion, the trailing faces of the pinion and helically screwed sleeve are machined to form indented ratchet recesses.

In the event of a back-fire occuring during starting, the pinion (being able to rotate but incapable of further axial movement) forces the helically screwed sleeve along the straight-splines of the starter shaft. This further compresses the main spring and permits axial movement of the screwed sleeve to continue until it is clear of the interior of the pinion. At this stage, axial movement of the screwed sleeve ceases and the pinion, now jointly supported by the fixed sleeve and the recessed end of the screwed sleeve, is free to be rotated by the engine ring gear. In this way, excessive torque is harmlessly dissipated by the ratchetting action of the pinion and screwed sleeve against the reaction pressure of the main spring.

The operation of a 'Run-off Helix' drive can be checked by securing armature and drive assembly in a vice (using wooden vice-clamps) and applying a torque wrench to the pinion. The ratchet action must occur at a torque of not less than 36 lbf ft (5 kgf m).

(b) ROUTINE MAINTENANCE

If any difficulty is experienced with the starter motor not meshing correctly with the flywheel, it may be that the drive requires cleaning.

The pinion should move freely on the screwed sleeve ; if there is any dirt or other foreign matter on the sleeve it must be washed off with cleaning fluid.

Alternator

Alternator

The 11AC alternator has two parts, a stator and a rotor. When the rotor revolves inside the stator windings, alternating current (A.C.) is produced. This is unsuitable for charging the battery so a rectification unit comprising 6 diodes is used.

These are connected in such a manner that the alternator output is direct current (D.C.) when it is delivered to the battery.

Technical Data

Maximum output — cold	45A at 13.5V
Maximum output — hot	43A at 13.5V
Cutting in speed	1,000 rev/min
B.H.P. Absorbed	2.2 bhp at 3500 rev/min
Maximum speed	12500 rev/min
Rotation	Clockwise
Maximum Operating Temperature (Ambient)	93°C (199°F)
Ventilation	Force Cooled
Rectifier	Built-in silicon diodes

GENERAL PRECAUTIONS

The diodes in alternators function as one way valves and the transistors in the regulator operate as fast switches. Both are accurate and very sensitive. They do not wear and never need attention or adjustment but, because they are sensitive to voltage changes and high temperatures, the following precautions are vital to prevent their destruction :—

NEVER disconnect battery whilst alternator is running. This will cause a voltage surge in the system, damaging diodes and transistors.

NEVER disconnect any electrical lead without first stopping alternator and turning all switches to the 'OFF' position. ALWAYS identify a lead to its correct terminal before disconnection. A short circuit or reversed polarity will destroy diodes and transistors.

NEVER connect a battery into the system without checking for correct polarity and correct voltage.

NEVER 'Flash' connections to check for current flow. No matter how brief the 'flash', the transistors may be destroyed.

NEVER experiment to try and adjust or repair the system unless you have had training on alternators and you have the correct test equipment and technical data.

NEVER earth the field circuit.

NEVER run the alternator on an open circuit.

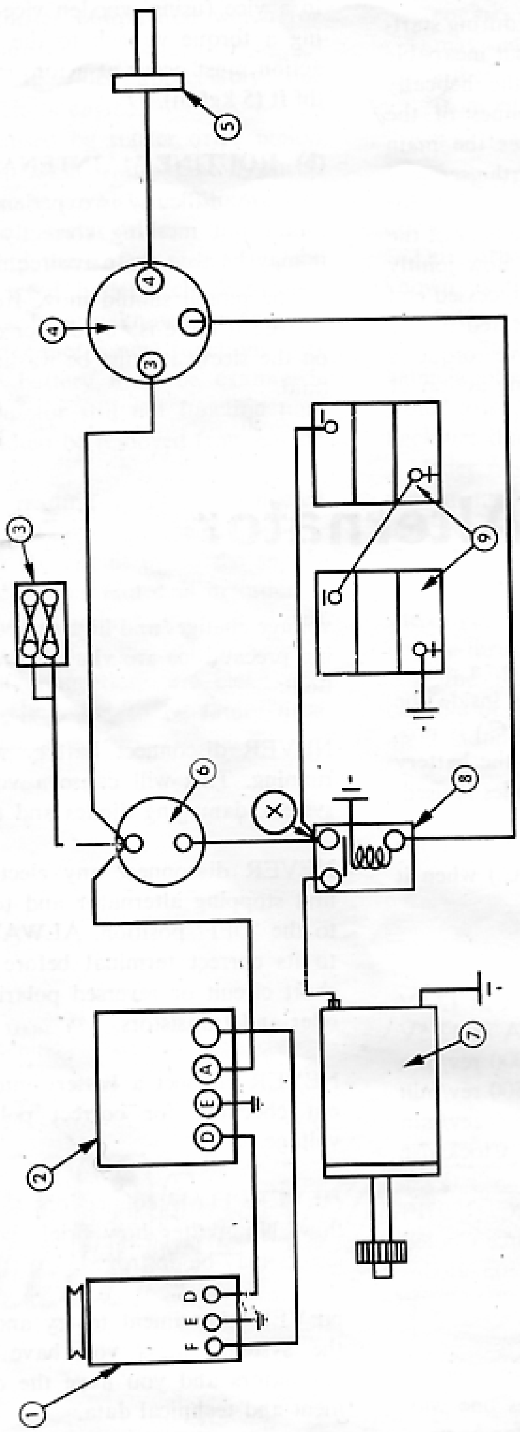


Fig. S.6. Typical Wiring Diagram.

1. Dynamo.
2. Control Box.
3. Fuse Box.
4. Heat/Start Switch.
5. Cold Start Aid.
6. Ammeter.
7. Starter Motor.
8. Solenoid.
9. 2 6V. Batteries wired in series

NEVER attempt to polarize an alternator.

When using a battery charger, disconnect battery cables.

NEVER apply a battery voltage direct to regulator or alternator field terminals as this will damage the transistors.

Disconnect alternator terminals before carrying out any electrical welding on the boat as the intense magnetic field created by the 'make' and 'break' of the arc may cause damage to the diodes.

Do not check for continuity of the alternator or regulator with an insulation tester, such as a 'Wee Megger' etc.

Ensure regulator is mounted in such a position that ambient temperature does not exceed 80°C (180°F).

Always disconnect battery before connecting test instruments (except voltmeter) or before replacing any unit or wiring.

GENERAL MAINTENANCE

Maintenance is limited to eliminating the build up of dirt and corrosion. To enhance cooling, keep alternator clean with a cloth moistened in kerosene. Ensure that ventilation slots or air spaces are clean and unobstructed.

Ensure that cooling air can pass freely over alternator housing. The drive belt on the alternator should be in good condition and at the correct tension (see page P.7). A slack belt will slip, wear and may not drive the alternator at the correct speed, if at all. Too tight a belt will create a severe side thrust on alternator bearings, considerably reducing their life.

Keep battery fully charged.

If alternator is producing no output or low output, system should be checked systematically.

TEST PROCEDURE

Instruments required

D.C. Voltmeter (0-20V)

D.C. Ammeter (5-0-60A)

Test 1 Drive Belt

Inspect driving belt for wear and tension.

Test 2 Checking the relay

A test ammeter is connected in the battery lead at the alternator. Link terminals 'C1' and 'C2' Run engine at approximately 1500 engine rev/min. If ammeter now indicates battery is being charged previous failure due to relay or its associated wiring connections etc. If the battery is **not** being charged, check alternator and control box.

Test 3 Checking the alternator and the control box (4TR)

Short out control box. Disconnect cables from control box 'F' and '—' terminals and join together.

Ammeter connected between alternator output terminal and battery lead.

Alternator run at charging speed (approxi-

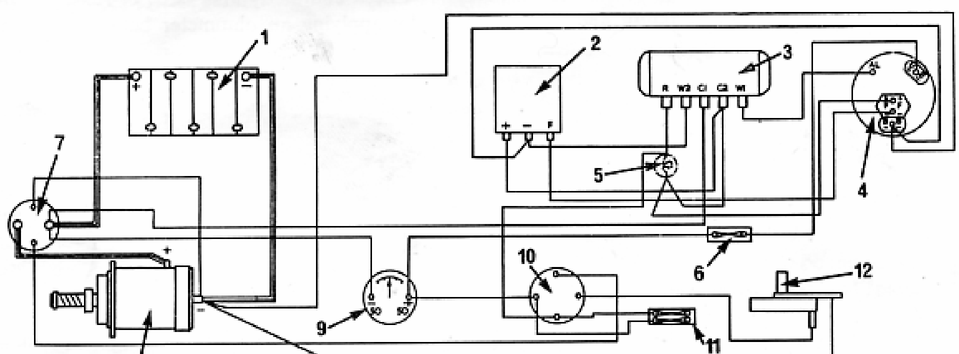


Fig. S.7. Typical Charging System.

1. 12V Battery.
2. 4TR Regulator.
3. 16RA Relay
4. 11AC Alternator.
5. Alternator Warning Light.
6. Fast Fuse.
7. Starter Solenoid.
8. M45G Starter Motor.
9. Ammeter.
10. Auxiliary Heat/Start Switch.
11. 4FJ Fuse.
12. Starting Aid.

mately 1500 rev/min.

Ammeter reading should be over 30A.

Note

1. Zero reading probably due to unsatisfactory rotor field circuit (Proceed to test 4).
2. Lower reading probably due to faulty alternator.
3. If correct ammeter readings now obtained (although alternator output previously considered low), indicates faulty control box or faulty earth connection of the control box.

Test 4 Checking rotor field circuit

Ammeter connected in rotor field circuit. Engine stationary. Ammeter should indicate a discharge of 3.0A. If these readings are obtained, it proves that rotor field circuit is satisfactory.

Test 5 Checking regulator setting (4TR)

The 4TR control board is checked on closed circuit when alternator is under load.

Voltmeter connected across battery terminals. Ammeter connected in main battery line. Start engine and run at charging speed (Approximately 1500 rev/min). Control box must be at operating temperature (if engine is cold run at charging speed for approximately 8 minutes.

Ensure that control box is regulating (Ammeter must indicate less than maximum output, and reading must not increase with speed).

Voltage regulator is then checked to ensure that it is within the limits 13.9—14.3V.

NOTE: If regulator setting is outside recommended limits control box is faulty and should be replaced.

Test 6 Checking alternator output

1. Ammeter still in main battery line.
2. Ensure battery is less than full charged (switch on electrical equipment whilst engine is stationary).
3. Electrical load kept on. Engine started and speed increased to 3000 rev/min.
4. Alternator output should be sufficient to 'balance' the electrical load, and ammeter should indicate a charge.

Test 7 Checking the 16RA relay

The relay cut-in voltage is 2.5 to 3.5V and the drop-off value is 0.5 to 2.0V (after saturation to 7.5V).

The above settings can be checked as follows:

1. Disconnect relay completely from normal external circuit.
2. Connect a variable d.c. voltage supply between terminals 'W1' and 'W2'.
3. Connect between the same terminals a good quality 0-10V d.c. voltmeter.
4. Connect a test lamp and battery circuit to terminals 'C1' and 'C2' so that closure of relay contacts will light the test bulb.
5. Increase variable voltage until at 2.5-3.5V relay contacts close (i.e. test bulb lights).
6. Raise voltage to 7.5 and then decrease its value until at between 0.5 and 2.0V contacts re-open and light is extinguished.
7. Check continuity and value of resistor supply by applying an ohmmeter between relay terminals 'R' and 'C2'.

Flywheel and Flywheel Housing (R)

Alignment of the Adaptor Plate, Flywheel Housing and Flywheel

It is most important that the adaptor plate, flywheel housing and flywheel be correctly aligned with the crankshaft. If the plate and housing have been removed as is necessary for a complete overhaul, the greatest care must be taken on replacement to ensure accuracy of alignment. The appropriate procedure is as follows :—

Secure adaptor plate to cylinder block with setscrews and spring washers.

Alignment of the Adaptor Plate Face

Secure base of a "clock" gauge to flange of crankshaft.

Set needle of gauge against vertical face of adaptor (See Fig. R.1).

Turn crankshaft and check that this face is perpendicular to crankshaft axis.

This facing should be within the following limits (total indicator reading) of being truly at right angles to crankshaft axis.

Adaptor Plate Diameter	Deviation
Up to $14\frac{1}{4}$ in (362 mm)	0.006 in (0,15 mm)
Over $14\frac{1}{4}$ in (362 mm) to $20\frac{1}{8}$ in (511 mm)	0.008 in (0,20 mm)
Over $20\frac{1}{8}$ in (511 mm) to $25\frac{1}{2}$ in (648 mm)	0.010 in (0,25 mm)
Over $25\frac{1}{2}$ in (648 mm) to 31 in (789 mm)	0.012 in (0,30 mm)

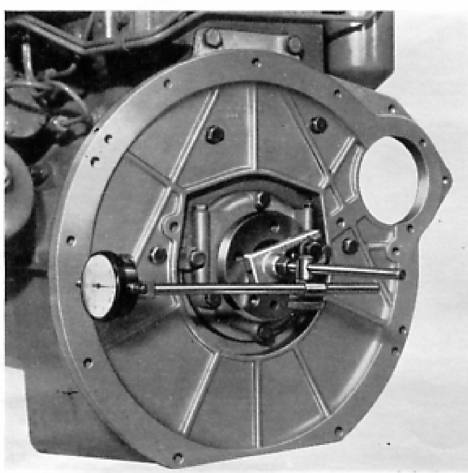


Fig. R.1.
Checking Alignment of Adaptor Plate.

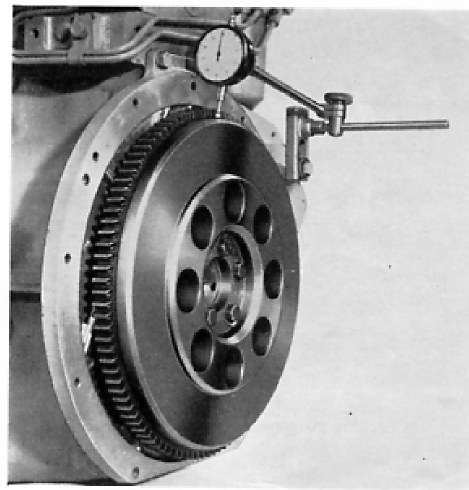


Fig. R.2.
Checking Alignment of Flywheel Periphery.

All adjustments to bring the adaptor plate within the limits must be on the adaptor plate and under NO CONDITIONS must the rear of the cylinder block be interfered with.

When the adaptor plate is properly aligned to the above limits, tighten the setscrews evenly.

Ream the dowel holes and fit the correct length and size of dowels.

Fitting Flywheel and Checking Alignment

Place flywheel on crankshaft flange and insert setscrews complete with tab washers into flywheel holes. Tighten evenly.

Secure base of "clock" gauge to adaptor plate. Set needle of gauge on periphery of flywheel (See Fig. R.2).

Turn crankshaft and check clock, flywheel should run truly within 0.012 in (0,30 mm) (total indicator reading).

With base of "clock" gauge still bolted to adaptor plate adjust clock so as to set needle against vertical machined face of flywheel. (See Fig. R.3).

Press crankshaft one way, to take up end float, and turn flywheel. The run-out on the flywheel face should be within 0.001 in (0,025 mm) per inch (25,4 mm) of flywheel radius from crankshaft axis to clock gauge plunger.

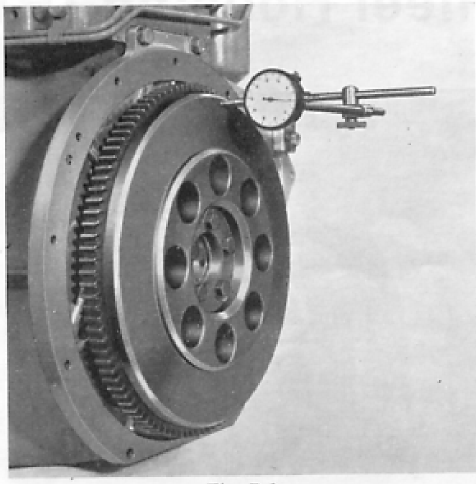


Fig. R.3.
Checking Alignment of Flywheel Face.

When flywheel is correctly aligned, lock securing setscrews by means of tab washers.

Finally grease spigot ball race if fitted.

Alignment of Flywheel Housing Bore

Secure housing to adaptor plate with setscrews and spring washers, but not overtight to allow for adjustment.

Attach clock gauge to flywheel centre and set needle of gauge to interior of bored hole in flywheel housing (See Fig. R.4).

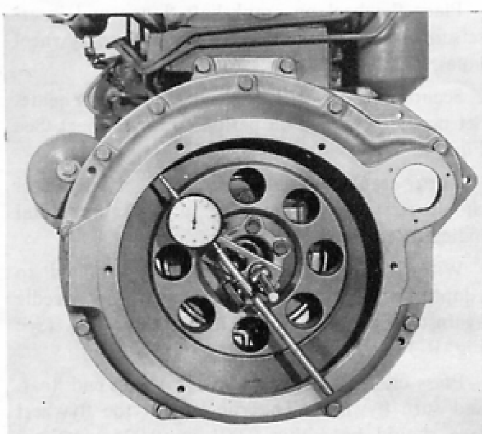


Fig. R.4.
Checking Alignment of Flywheel Housing Bore.

Turn crankshaft and check that this hole is truly central. The housing is adjusted until the bored hole is central.

The hole in the housing should be truly central with the crankshaft within the following limits (total indicator reading).

Flywheel Housing Diameter	Deviation
Up to $14\frac{1}{4}$ in (362 mm)	0.006 in (0,15 mm)
Over $14\frac{1}{4}$ in (362 mm) to $20\frac{1}{8}$ in (511 mm)	0.008 in (0,20 mm)
Over $20\frac{1}{8}$ in (511 mm) to $25\frac{1}{2}$ in (648 mm)	0.010 in (0,25 mm)
Over $25\frac{1}{2}$ in (648 mm) to 31 in (789 mm)	0.012 in (0,30 mm)

Alignment of the Flywheel Housing Face

With base of clock gauge still bolted to flywheel centre, adjust clock to set needle against vertical machined face of flywheel housing, and again turning crankshaft, check that this face is perpendicular to crankshaft axis (See Fig. R.5).

The limits for this facing are the same as those given for the adaptor plate facing. When the housing is properly aligned to the above limits, tighten the securing setscrews evenly.

Ream dowel holes and fit correct length and size dowels.

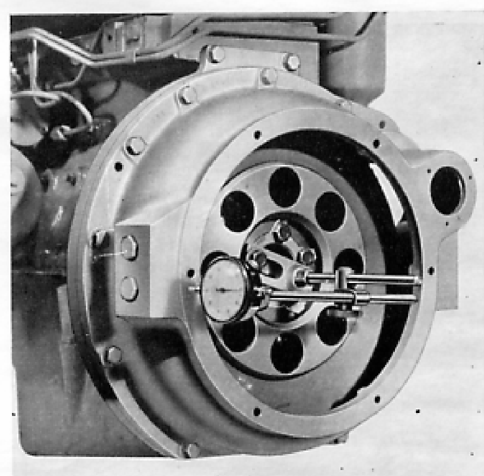


Fig. R.5.
Checking Alignment of Flywheel Housing Face.

Unified Threads and Engine No. Location

Unified Threads

All threads used on 4.99, 4.107 and 4.108 Marine engines, except on proprietary equipment are Unified Series and American Pipe Series.

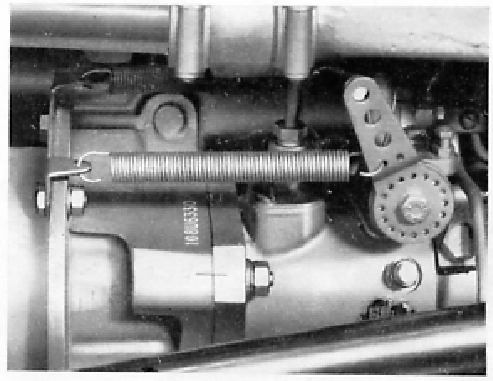
Engine Number

The engine number is stamped vertically on the right hand side of the cylinder block on the rear of the tappet inspection cover face or on later engines, on the top edge of the facing on the cylinder block to which the fuel injection pump is secured as shown in the three accompanying diagrams. The number should be quoted when requesting information or ordering Parts.

Engine types can be identified by the engine number. With current engines, an engine number commencing with the figures 99 denotes a 4.99 engine, a number commencing with the figures 107 is a 4.107 engine and commencing with the figures 108 is a 4.108 engine.

With earlier engines, the 4.99 engine number commenced with the figure 7 and 4.107 engines commenced with the figures 71.

Throughout this manual where it is considered necessary to use abbreviations, they are in accordance with those recommended by the British Standards Institute. A Glossary of terms for reference purposes is included at the back of this publication.



Engine Number Location on 4.108 Engines

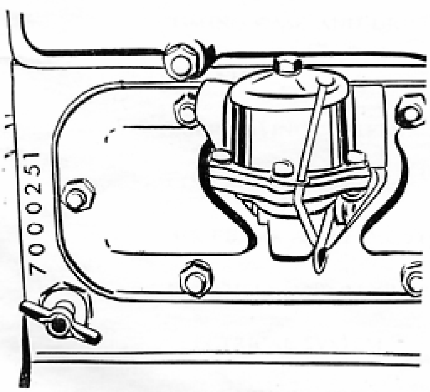


Diagram showing location of Engine No. on earlier 4.99 Engines.

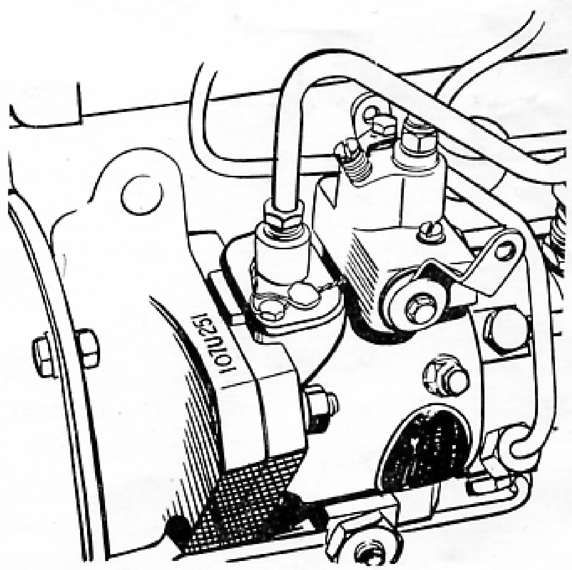


Diagram showing location of Engine No. on 4.107 and later 4.99 Engines.

APPROVED LUBRICATING OILS

Lubricating oils should meet the requirements of the U.S. Ordnance Specification MIL-L-2104B and below, we give a list of some of these oils. Any other oils which also conform to this specification, but are not listed here are, of course, also suitable.

The Lubricating oils for use in Perkins Diesel engines should have a **minimum** Viscosity Index of 80.

Company	Brand	S.A.E. Designation		
		0 °F(–18 °C) to 45 °F(7 °C)	45 °F(7 °C) to 80 °F(27 °C)	Over 80 °F (27 °C)
B. P. Ltd.	B.P. Vanellus	10W	20W/20	30
	B.P. Vanellus	10W/30	10W/30	10W/30
	B.P. Vanellus S3	10W	20W/20	30
Castrol Ltd.	Castrol/Deusol CRB	10W	20W/20	30
	Castrol/Deusol CRD	10W	20W/20	30
A. Duckham & Co. Ltd.	Fleetol 3	10W	20	30
Esso Petroleum Co. Ltd.	Essolube D.3HP	10W	20	30
Mobil Oil Co. Ltd.	Delvac 1200 Series	1210	1220	1230
	Delvac 1300 Series	1310	1320	1330
Shell	Shell Rotella T	10W	20W/20	30
	Shell Rimula CT	10W	20W/20	30

Abbreviations of Technical Terms Applicable to Service Literature

Where it is found necessary to use abbreviations in Service Literature the units and symbols adopted are those laid down in British Standards Publications 1991.

A glossary of such terms with their British Standard equivalent is given below for reference purposes.

GLOSSARY OF TERMS

TERM	BRITISH STANDARD	REMARKS
ampere	A	or ampere if confusion may arise
atmosphere	atm	
brake horse power	b h p	
British Thermal Unit	B t u	
centimetre	cm	
Cubic centimetre	cm^3	similarly for millimetre, etc.
cubic inch	in^3	similarly for foot, etc.
foot	ft	
foot pounds per minute (work)	ft lbf/min	
gallon	gal	
gallons per minute	gal/min	similarly for pint, litre, etc.
gramme	g	when referring to gramme mass.
gramme	gf	when referring to gramme force.
hour	h	
inch	in	or inch if confusion may arise.
kilogramme	kg	
kilogramme metre (torque)	kgf m	
kilogrammes per square centimetre	kgf/cm^2	similarly for gramme, etc.
kilometre	km	
litre	l	or litre if confusion may arise.
mile	mile	
millimetre	mm	
miles per gallon	mile/gal	similarly for pint, litre, etc.
miles per hour	mile/h	similarly for kilometre, etc.
minute	min	
ounce	oz	
pint	pt	
pound	lb	when referring to pound mass.
pound	lbf	when referring to pound force.
pounds feet (torque)	lbf ft	
pounds per square inch	lbf/in^2	similarly for ton, etc.
revolutions per minute	rev/min	
second (time)	s	
shaft horse power	s h p	
square centimetre	cm^2	similarly for millimetre, etc
square inch	in^2	similarly for foot, yard, etc.
ton	ton	
tonne (1000 kg)	t	
volt	V	
yard	yd	

APPROVED LUBRICATING OILS

Lubricating oils should meet the requirements of the U.S. Ordnance Specification MIL-L-2104B and below, we give a list of some of these oils. Any other oils which also conform to this specification, but are not listed here are, of course, also suitable.

The Lubricating oils for use in Perkins Diesel engines should have a **minimum** Viscosity Index of 80.

Company	Brand	S.A.E. Designation		
		0 °F(–18 °C) to 45 °F(7 °C)	45 °F(7 °C) to 80 °F(27 °C)	Over 80 °F (27 °C)
B. P. Ltd.	B.P. Vanellus	10W	20W/20	30
	B.P. Vanellus	10W/30	10W/30	10W/30
	B.P. Vanellus S3	10W	20W/20	30
Castrol Ltd.	Castrol/Deusol CRB	10W	20W/20	30
	Castrol/Deusol CRD	10W	20W/20	30
A. Duckham & Co. Ltd.	Fleetol 3	10W	20	30
Esso Petroleum Co. Ltd.	Essolube D.3HP	10W	20	30
Mobil Oil Co. Ltd.	Delvac 1200 Series	1210	1220	1230
	Delvac 1300 Series	1310	1320	1330
Shell	Shell Rotella T	10W	20W/20	30
	Shell Rimula CT	10W	20W/20	30

APPROVED SERVICE TOOLS

Available from V. L. Churchill & Co. Ltd., Daventry, Northamptonshire, England.

PD 1C Valve Guide Remover and Replacer

Engine Type: All.
With this tool, all valve guides can be removed and replaced provided puller bars are available.

PD 1C-1 Puller Bars

Engine Type: All
Two bars are supplied for use with PD 1C to suit $\frac{5}{16}$ in and $\frac{3}{8}$ in i/d valve guide bores.

PD 1C-2 Valve Guide Replacing Stop

Engine Type: 4.99 4.107 4.108.
When the valve guide is replaced using one of these stops, it will ensure that the guide protrudes the correct amount above the top face of the cylinder head.

PD 1C-4 Valve Guide Replacing Stop

Engine Type: P3 P3.144 3.152 4.192 4.203 P4 P6 6.288 6.305.
Remarks: See PD 1C-2.

PD 1C-5 Valve Guide Replacing Stop

Engine Type: V8.510.
Remarks: See PD 1C-2.

PD 1C-6 Valve Guide Replacing Stop

Engine Type: 6.354.
Remarks: See PD 1C-2.

PD 1C-7 Valve Guide Replacing Stop

Engine Type: 4.154.
Remarks: See PD 1C-2.

38 U3 Piston Assembly Ring

Engine Type: All.
This is an expandable piston assembly ring for Std. and oversize pistons.

PD 41B Piston Height and Valve Depth Gauge

Engine Type: All.
For checking piston heights and valve depths.

PD 155B Small Adjustable Puller

Engine Type: All.
Can be used with suitable adaptors to remove water pump pulley, oil pump drive gears and camshaft gear.

PD 155B-1 Small Adjustable Puller Adaptors

Engine Type: P3.144 3.152 4.192 4.203.
Removes water pump pulley only on 6.305 L4 4.270 4.99 4.107 4.108.
Removes water pump pulley and camshaft gear on 6.354 4.154 4.212 4.236 4.248.

PD 155B-2 Small Adjustable Puller Adaptors

Engine Type: P3 P4 P6.
To remove low position water pump pulley.

PD 155B-4 Small Adjustable Puller Adaptors

Engine Type: P3.144 3.152 4.192 4.203.
Removal of oil pump gear.

4RL Tension Wrench

Engine Type: All.
$\frac{3}{4}$ in square drive 150 - 400 lbf ft.

No. 13 Tension Wrench

Engine Type: All.
$\frac{1}{2}$ in square drive 50 - 170 lbf ft.

PD 150 Cylinder Liner Remover and Replacer

Engine Type: 6.354 4.212 4.236 4.248 3.152 D3.152 4.203 D4.203 6.305.

PD 150-1A Adaptors for PD 150

Engine Type: 3.152 D3.152 4.203 4.212 4.236 6.305 6.354.

PD 150-5 Adaptors for PD 150

Engine Type: 4.107 4.108

PD 150-6 Adaptors for PD 150

Engine Type: V8.510.
The replacer pad to be used with PD 150-8 when crankshaft is in position.

PD 150-7 Adaptors for PD 150

Engine Type 4.248 6.372

PD 150-8 Adaptors for PD 150

Engine Type: V8.510.
Used with PD 150-6 when crankshaft is in position.

PD 150-10 Adaptors for PD 150

Engine Type: 4.154.

316X Valve Seat Cutter Handle

Engine Type: All.
This tool is required for the operation of all cutters and pilots.

316-10 Valve Seat Cutter Pilot

Engine Type: P3 P3.144 3.152 4.99 4.107 4.108 4.154 4.192 4.203 P4 P6 6.288 6.305.
This pilot is suitable for all guides that have a nominal $\frac{5}{16}$ in i/d bore.

316-12 Valve Seat Cutter Pilot

Engine Type: L4 4.270 4.212 4.236 4.248 6.354 V8.510.
This pilot is suitable for all guides having a nominal $\frac{3}{8}$ in i/d bore.

316-125 Valve Seat Cutter Pilot

Engine Type: 4.212 4.236 4.248.
This pilot is for valve bores which have been reamed 0.015 in oversize.

316-130 Valve Seat Cutter Pilot

Engine Type: 4.212 4.236 4.248.
This pilot is for valve bores which have been reamed 0.030 in oversize.

PD 137 Valve Bore Reamer (0.015 in oversize)

Engine Type: 4.212 4.236 4.248.
This reamer is only suitable for guideless cylinder heads.

PD 138 Valve Bore Reamer (0.030 in oversize)

Engine Type: 4.212 4.236 4.248.
This reamer is only suitable for guideless cylinder heads.

PD 317-23 Valve Seat Cutter Exhaust

PD 317-26 Valve Seat Cutter Inlet

317-G22 Glaze Breaker Exhaust

317-G25 Glaze Breaker Inlet

Engine Type: P3 P3.144 3.152 4.192 4.203 P4 P6 6.288 6.305.
The above cutters have been designed to cut seats to the correct angle and at the same time reduce seat width. It is strongly recommended that the glaze breakers be used first as this will greatly reduce the chattering of the cutters.

PD 317-25A Valve Seat Cutter Exhaust

PD 317-29 Valve Seat Cutter Inlet

PD 317-G30 Glaze Breaker Exhaust and Inlet

Engine Type: L4 4.270.
Remarks: See PD 317-23.

PD 317-30 Valve Seat Cutter Inlet

Engine Type: 4.212 4.236 4.248 6.354 D4.203 D3.152 4.154 V8.510.
Remarks: See PD 317-23.

PD 317-30 Valve Seat Cutter Exhaust

Engine Type: D4.203 D3.152 V8.510.
Remarks: See PD 317-23.

PD 317-G30 Glaze Breaker Exhaust and Inlet

Engine Type: 6.354 4.212 4.236 4.248 D4.203 D3.152 4.154 V8.510.
Remarks: See PD 317-23

PD 317-18 Valve Seat Cutter Exhaust

PD 317-22 Valve Seat Cutter Inlet

PD 317-G19 Glaze Breaker Exhaust

PD 317-G22 Glaze Breaker Inlet

Engine Type: 4.99 4.107 4.108.
Remarks: See PD 317-23.

PD 317-22 Valve Seat Cutter Exhaust

Engine Type: 6.354 4.212 4.236 4.248.
Remarks: See PD 317-23.

PD 317-37M Valve Seat Cutter Exhaust

Engine Type: 4.154.
Remarks: See PD 317-23.

FC 9900 Atomiser Tester

Engine Type: All.
This is a portable tester fitted with a paper element filter.

7066 Circlip Pliers

Engine Type: All.
Two Types of points are available. $\frac{1}{2}$ in shaft size $\frac{1}{2}$ in — 1 in. "B" shaft size 1 in — 3 in.

335 Connecting Rod Alignment Jig

Engine Type: All.
Enables a quick check to be made on the alignment of connecting rods — various adaptors are required as follows:—

PD 336-6 Adaptor

Engine Type: 6.354 4.212 4.236 4.248.
This adaptor is fitted into the big end bore when checking alignment.

PD 336-7 Adaptor

Engine Type: V8.510.
Remarks: See PD 336-6.

6118B Valve Spring Compressor

Engine Type: All.
This valve spring compressor has been designed to remove valve springs without removing the cylinder head, providing the adaptors are available.

PD 6118-1 Valve Spring Compressor Adaptor

Engine Type: 4.99 4.107 4.108 4.154.
The adaptor is fitted to the rocker shaft securing studs.

PD 6118-3 Valve Spring Compressor Adaptor

Engine Type: P3.144 3.152 4.192 4.203 L4 4.270 V8.510.
Remarks: See PD 6118-1.

PD 6118-4 Valve Spring Compressor Adaptor

Engine Type: 6.354 4.212 4.236 4.248.
Remarks: See PD 6118-1.

PD 130A Fuel Pump Allen Screw Wrench

Engine Type: 4.192 4.203 4.99 4.107 4.108.
Used to remove the Allen screw securing the fuel injection pump.

PD 141 Timing Case Oil Seal Fitting Tool

Engine Type: V8.510.

6400A Crankshaft Fillet Radii Rolling Tool

Engine Type: P4 4.192 4.203 P6 6.288 6.305 4.270.
For cold rolling of fillet radii on certain crankshaft main journals.

6400A-1 Adaptor Set

For use with the above.

PD 140 Camshaft Bush/Thrust Collar Remover

PD 140-1 Adaptor for use with above
Engine Type : V8.510
Removes and replaces camshaft bush.

PD 140-2 Adaptor for use with PD 140

Engine Type : 6.354
Removes fuel pump drive thrust collar.

PD 143 Valve Seat Insert Rolling Tool

PD 143-1 Adaptor for use with above

Engine Type: V8.510.

INDEX

Abbreviations, Glossary of Technical — Appendix
Aid, Starting — Data — Q.8
Aid, Starting — Description — D.1
Aid, Starting — To Operate — D.3
Air Cleaner — Q.1
Alternator — General Maintenance — S.7
Alternator — General Precautions — S.5
Alternator — Technical Data — S.5
Alternator — Test Procedure — S.7
Alternator — Typical Charging System — S.7
Anti-freeze — F.3
Approved Lubricating Oils — Appendix
Approved Service Tools — Appendix
Atomisers — Data — Q.8
Atomisers — General — Q.5
Atomisers — Identification — Q.5
Atomisers — Testing on Engine — Q.5
Atomisers — Troubles — Q.5

Batteries — C.5
Backlash, Timing Gear — Data — L.7
Backlash, Timing Gear — Setting and Checking — L.1
Bearing, Connecting Rod — Data — H.8
Bearing, Connecting Rod — To Renew — H.1
Bearing, Crankshaft Main — Data — K.5
Bearing, Crankshaft Main — Description — A.1
Bearing, Crankshaft Main — To Renew — K.1
Belt, Generator Driving — To Remove and Refit — P.6
Block, Cylinder — Data — J.3
Block, Cylinder and Crankcase — Description — A.1
Bush, Connecting Rod Small End — Data — H.7
Bush, Connecting Rod Small End — To Renew — H.2

Camshaft — Data — L.6
Camshaft — Description — A.1
Camshaft — To Refit — L.5
Camshaft — To Remove — L.4
Capacity, Lubricating Oil — Data — N.5
Capacity, Water (Coolant) — Data — P.7
Case, Timing — To Refit Backplate — L.4
Case, Timing — To Remove Backplate — L.3
Case, Timing — To Remove and Refit Cover — L.1
Checkover, Post Delivery — F.1
Combustion System — Description — A.1
Controls, Engine and Gearbox — C.7
Cooler, Oil — Description — P.4
Cooler, Oil — Dismantling — P.5
Cooler, Oil — Re-assembling — P.6
Cooling System — Data — P.7
Cooling System — Description — A.2
Crankcase Pressure (Excessive) — Fault Diagnosis — E.4
Crankcase Ventilation — Description — A.2
Crankshaft — Data — K.5
Crankshaft — Description — A.1
Crankshaft — To Refit — K.3
Crankshaft — To Remove — K.3
Crankshaft and Main Bearings — Description — K.1

De-Rating for Altitude — B.1
Description, Engine — A.1
Dynamo, C40A — General — S.1
— Maintenance — S.1
— Performance Data — S.1
— Servicing — S.1

Electrical Equipment — Description — A.3
Engine, Failure to Start — Fault Diagnosis — E.1
Engine Number Location — 3
Engine Photographs — 9, 10, 11 and 12
Erratic Running — Fault Diagnosis — E.2
Engine, Runs only Momentarily — Fault Diagnosis — E.2
Exhaust, Smoky — E.3
Exhaust Systems — Description — C.2

Fault Diagnosis — E.1
Film Library — Appendix
Filter, Fuel Oil — Data — Q.9
Filter, Fuel Oil — To Renew Filter Element — Q.1
Filter, Lubricating Oil — To Remove Element — N.4
Filter, Lubricating Oil — To Remove Head Casting — N.4
Filter, Lubricating Oil — To Renew Filter Element — N.5
Flywheel and Flywheel Housing—
To Remove and Refit — R.1
Foreword — 7
Frost Precautions — F.3
Fuel Injection Equipment — Data — Q.8
Fuel Injection Equipment — Description — A.2
Fuel Oil Specification — Q.8

Gasket, Cylinder Head — G.7
Gear, Camshaft — Data — L.6
Gear, Camshaft — To Remove — L.2
Gear, Camshaft — To Refit — L.2
Gear, Crankshaft — Data — L.7
Gear, Fuel Pump — Data — L.7
Gear, Fuel Pump — To Remove and Refit — L.2
Gear, Idler and Hub — Data — L.7
Gear, Idler and Hub — To Remove and Refit — L.1
Gear, Lubricating Oil Pump Drive — Data — N.6
Gear, Lubricating Oil Pump Drive — To Remove — N.2
Gear, Lubricating Oil Pump Drive — To Refit — N.3
Gear, Reverse — C.8
Guide, Valve (Inlet and Exhaust) — Data — G.9
Guide, Valve (Inlet and Exhaust) —
To Remove and Refit — G.3

Hand Grinding (Lapping-in Valves) — G.4
Head, Cylinder — Data — G.9
Head, Cylinder — G.1
Head, Cylinder — To Refit — G.7
Head, Cylinder — To Remove — G.1
Head, Cylinder and Valves — Description — A.1
Heater (Starter) Switch — D.1
Hub, Fuel Pump Drive — To Remove and Refit — L.3

Index to Engine Photographs — 8
Information, General — B.1
Insert, Combustion Chamber — Data — G.9
Insert, Combustion Chamber —
To Remove and Refit — G.2
Insert, Valve Seat — G.4
Insert, Valve Seat — To Fit — G.4
Installation Angle — C.1
Instruments, Engine — C.7

Knocking, Engine — Fault Diagnosis — E.3

Laying-up, Engine Preservation — F.1
Levers, Rocker — Data — G.10
Liner, Cylinder — Data — J.3

Liner, Cylinder — Description	J.1
Liner, Cylinder — To Renew	J.1
Loss of Power — Fault Diagnosis	E.2
Lubrication, Engine —	
Description and Diagram	A.2 and N.1
Manifold, Exhaust — Description	A.2
Manifold, Induction — Description	A.2
Misfiring — Fault Diagnosis	E.2
Motor, Starter — M45G (Run-Off Helix Drive)	
Description	S.2
Maintenance	S.2
Servicing	S.4
Mounting, Engine	C.1
Oil Change Period — Periodical Attention	F.1
Oil, Fuel System Inhibiting	F.2
Oil Pressure, High — Fault Diagnosis	E.4
Oil Pressure, Low — Fault Diagnosis	E.4
Overheating, Engine — Fault Diagnosis	E.3
Overseas Companies and Manufacturing Licensees	2
Periodical Attentions	F.1
Perkins Drivers Club	Appendix
Pin, Gudgeon — Data	H.8
Pipes, Fuel — High Pressure	Q.5
Pistons and Gudgeon Pins — Description	A.1
Pistons — Data	H.6
Pistons — To Fit New Replacements	H.5
Pistons — To Remove from Connecting Rods	H.1
Pistons — To Refit to Connecting Rods	H.2
Pistons — To Remove from Cylinder Block	H.1
Pistons — To Refit to Cylinder Block	H.4
Plates, Camshaft Thrust — Data	L.6
Plate, Camshaft Thrust — To Remove	L.5
Plates, Camshaft Thrust — To Refit	L.5
Preparation, Engine for Return to Service	F.2
Pressure, Lubricating Oil — Data	N.5
Pressure, Lubricating Oil — General	N.4
Preservation of Laid-up Engine	F.1
Priming the Fuel System	Q.6
Priming the Fuel System after Fuel Filter Element Change	Q.8
Pump, Fresh Water	P.2
Pump, Fresh Water — Data	P.7
Pump, Fresh Water — To Dismantle	Q.8
Pump, Fresh Water — To Re-assemble	P.3
Pump, Fresh Water — To Refit	P.4
Pump, Fresh Water — To Remove	P.3
Pump, Fuel Injection	
Anti-stall Device	Q.4
Coding	Q.4
Data	Q.9
Description	Q.3
Idling Speed Adjustment	Q.4
Maximum Speed Setting	Q.3
To Refit (Fuel Pump)	Q.3
To Remove (Fuel Pump)	Q.3
Pump, Fuel Lift — Data	Q.9
Pump, Fuel Lift — To Dismantle	Q.2
Pump, Fuel Lift — To Re-assemble	Q.3
Pump, Fuel Lift — To Refit	Q.3
Pump, Fuel Lift — To Remove	Q.2
Pump, Fuel Lift — To Test in Position	Q.2
Pump, Lubricating Oil — Data	N.5
Pump, Lubricating Oil — Description	N.1

Pump, Lubricating Oil — To Dismantle	N.2
Pump, Lubricating Oil — To Re-assemble	N.3
Pump, Lubricating Oil — To Refit	N.3
Pump, Lubricating Oil — To Remove	N.1
Pump, Sea Water — Description	P.1
Pump, Sea Water Dismantling and Reassembly	P.2
Pump, Sea Water — Preservation	F.2
Pump, Sea Water — Removal and Fitting	P.2
Rating Details	B.1
Rings, Piston — Data	H.6
Rings, Piston — To Refit	H.2
Rings, Piston — To Remove	H.1
Rod, Connecting — Alignment	H.8
Rods, Connecting — Data	H.7
Rods, Connecting and Bearings — Description	A.2
Rods, Connecting — To Refit	H.4
Rods, Connecting — To Remove	H.1
Rods, Push	G.6
Running-in Procedure	D.4
Screw Threads	B.2
Seal, Crankshaft Front End Oil — To Renew	L.1
Seal, Crankshaft Rear End Oil — To Renew	K.4
Seal, Inlet Valve Stem	G.6
Service Facilities	Appendix
Service Instruction	Appendix
Shaft, Rocker — Data	G.10
Shaft, Rocker — To Dismantle	G.5
Shaft, Rocker — To Re-assemble	G.6
Shaft, Rocker — To Refit	G 7
Shaft, Rocker — To Remove	G.1
Springs, Valve	G.3
Springs, Valve — Data	G.10
Springs, Valve — To Refit	G.6
Springs, Valve — To Remove	G.2
Starting Procedure	D.1
Stopping the Engine	D.4
Strainer, Lub. Oil Pump	N.1
Sump, Lubricating Oil — Data	N.5
Sump, Lubricating Oil — Description	A.2
Sump, Lubricating Oil — To Remove and Refit	N.1
Switch,Starter	D.1
Tachometer, Drive	A.3
Tachometer, Drive Shaft	N.1
Tappets — Data	J.3
Tappets — To Refit	L.5
Tappets — To Remove	L.4
Thermostat — Data	P.7
Thermostat — To Remove	P.6
Timing Case and Drive	L.1
Timing Gear Arrangement — Description	A.1
Timing Gears — Data	L.6
Timing — General	M.1
Timing Marks	M.1
Timing Pin	M.2
Timing, Fuel Injection — To Reset and Check	M.2
Timing, Valve — To Check	M.2
Timing, Valve — To Reset	M.2
Timing, Fuel Injection Static Position	M.2
Torque, Recommended Tensions	B.2
Valve Clearances — Data	G.10

INDEX Continued

Valve Clearances —
Method of Adjustment and Adjusting Sequence G.8
Valves, Inlet and Exhaust — Data G.9
Valve Mechanism — Description A.1
Valves — To Refit G.6
Valves — To Remove G.2
Valves and Valve Seats G.3
Valve, Lub. Oil Filter By-pass — Data N.6
Valve, Lub. Oil Filter By-pass — Operation N.5
Valve, Oil Pressure Relief — Data N.6
Valve, Oil Pressure Relief —
To Remove and Dismantle N.3
Valve, Oil Pressure Relief —
To Re-assemble and Refit N.4

Washers, Crankshaft Thrust — Data K.5
Washers, Crankshaft Thrust — To Renew K.1
Weights, Engine — Data B.1