INSTRUCTIONS

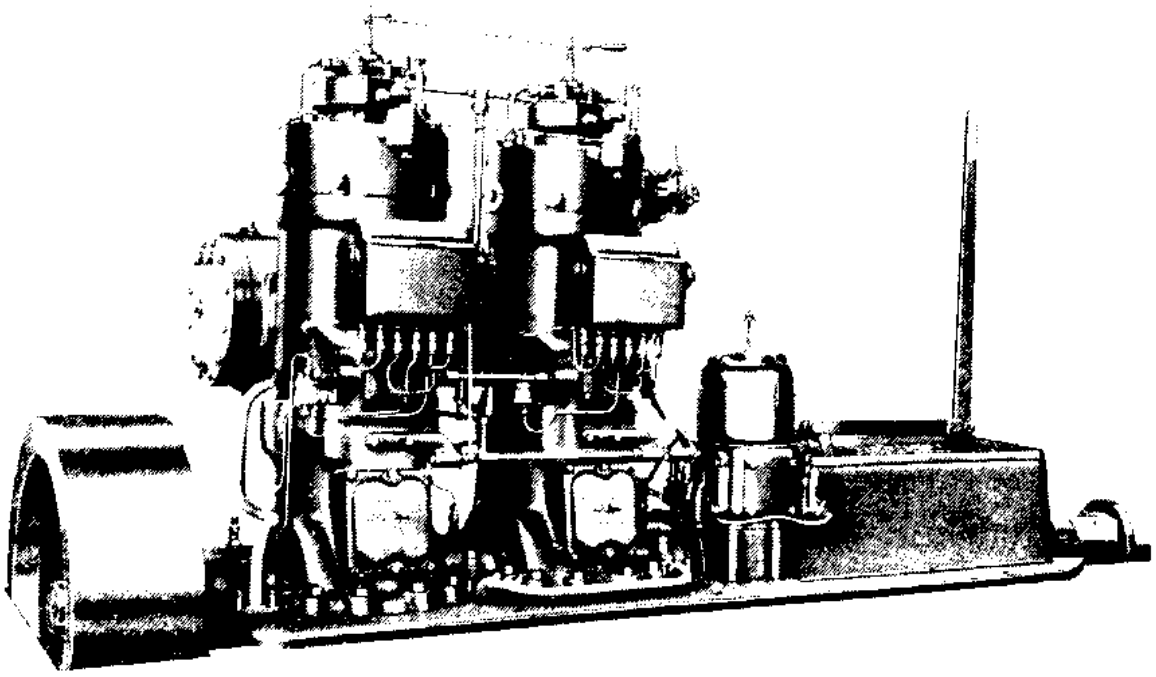
FOR THE CARE & RUNNING OF

T. J. MEADOWS

BOLINDER'S

MARINE OIL ENGINES

TYPE "B" AND "W"



AKTIEBOLAGET

BOLINDER-MUNKTELL

ESKILSTUNA SWEDEN

INDEX.

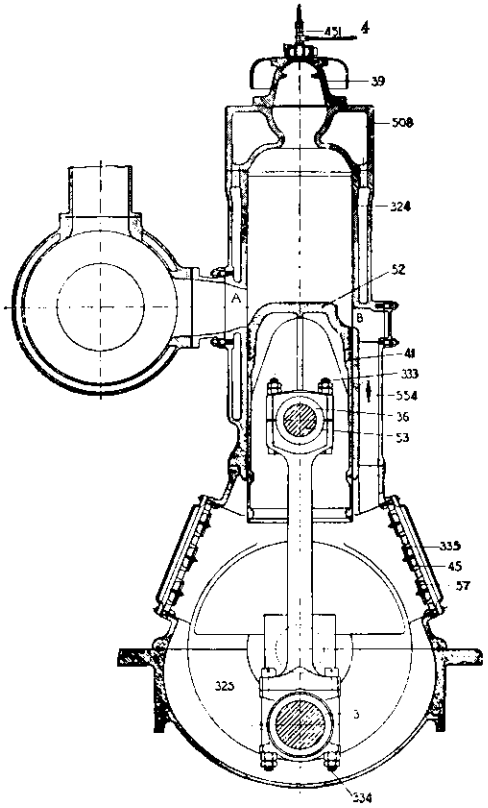


Fig. 1.

I. WORKING CYCLE OF THE ENGINE

The engine works on what is known as the 2 cycle principle, that is to say there is an impulse each revolution.

The working cycle is as follows: (see fig. 1).

When the piston (52) moves upwards from its lowest position in the cylinder, air is drawn into the crank housing (325) through the air valves (335). At the same time the air in the cylinder above the piston is compressed. When the piston on its upward movement arrives at a position about halfway between its highest and lowest positions, a quantity of fuel oil is injected by means of the fuel oil pump through the injection device (451) into the ignition chamber (39), the injection ceasing immediately before the piston has reached its highest position. On account of the high temperature

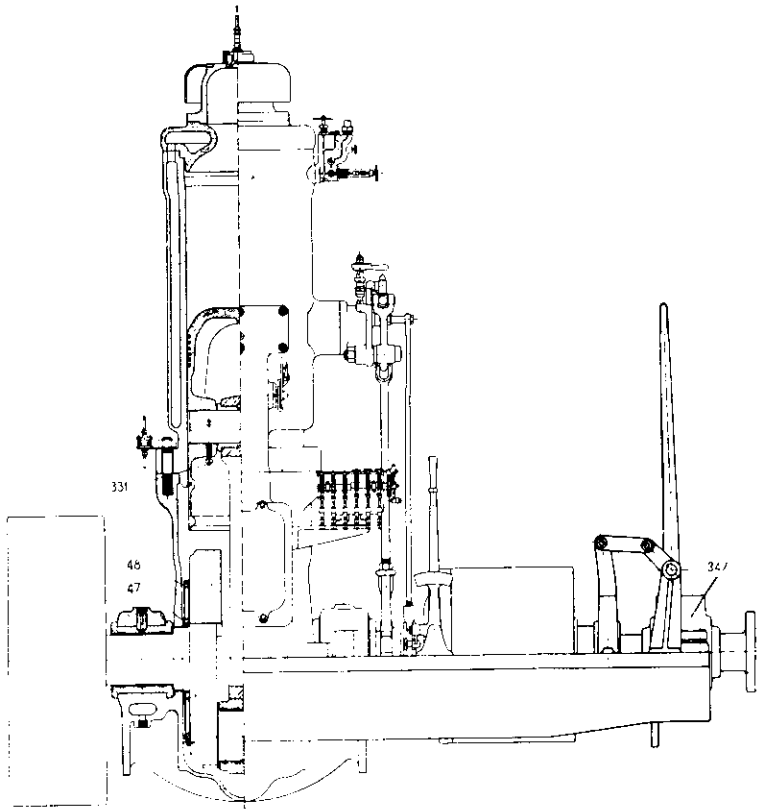


Fig. 2.

of the ignition chamber, the fuel oil injected is instantaneously gasified and together with the compressed air above the piston forms an explosive mixture, which explodes when the piston reaches its highest position and drives it downwards. During the downward stroke, the piston compresses the air in crank-housing. Just before the piston reaches its lowest position, it uncovers the exhaust port A and the exhaust gases flow out into the silencer. The piston immediately after uncovers the air port B and the compressed air in the crank-housing blows into the cylinder, driving out the remaining gases and filling the cylinder with fresh air to make up the next fuel charge.

From the silencer, the exhaust gases are carried through the exhaust piping to the atmosphere.

II. FUEL FOR OIL ENGINES

As is well known, there are a number of different fuel oils on the market possessing various characteristics. Most of these oils, however, can be used with more or less advantage in our engines.

The suitability of an oil is judged from the following characteristics:

Specific Gravity
Heat value
Flash point
Viscosity
Percent of Asphalt
» » Sulphur
» » Ash

The presence of water or other non-combustible matter.

The specific gravity, that is to say the weight of the oil as compared with the weight of an equal volume of water, should be between 0.85 and 0.90. The specific gravity in itself is of small importance, as the suitability of an oil for fuel is not dependent on its spec. gr. As ordinarily light oils are cleaner and easier gasified than heavy oils, this characteristic can serve as a guide, if other particulars regarding an oil are not to be had.

The heat value of an oil, or the quantity of heat per unit of weight which can be transferred into energy should preferably not be lower than 10.000 Calories per kilogram or 18.000 B. T. U. per lb.

The flash point, that is to say the temperature to which the oil must be heated in order that the gases given off by same are inflammable, must not be too low, as it would then be impossible to prevent preignition in the engine. It must not however be too high as in this case incomplete or late ignition will take place. The flash point should therefore lay between 60° and 150° C. (140° & 300° F.). Oils having a lower flash point are dangerously inflammable at orinary temperatures and should be avoided on this account also.

The viscosity of an oil expresses its »liquidity» as compared with water. As the temperature of an oil largely influences its viscosity, this latter is determined always at a temp. of 20° C. (70° F.) and its value should be as near as possible equal to unity, the same as for water. If the viscosity of an oil is very high, it

will be necessary to heat same, so as to allow it to flow easily through the piping and the pump valves. For oils having a specially high viscosity, this can be done by leading the circulating water coming from the silencer through a coil in the fuel oil tanks. A device for warming up fuel oil can also suitably be made by placing a small oil container in the aft cover of the silencer. This container should be partly inside and partly outside the silencer, so that it is possible to warm up same by a torch before starting the engine. As soon as the engine is running, the container will be kept warm by the exhaust gases. A number of oils partially solidify, that is to say become thick at a temperature corresponding to about freezing point, and the use of such oils should be avoided if possible, for engines working in cold climates, unless an effective heating device for the fuel oil can be arranged. A heavy, sluggish oil, if mixed with a lighter oil, can often be made sufficiently easy flowing.

Asphalt must not be present in greater quantities than 6 % and the less asphalt there is, the better, as the complete combustion of same is difficult and it is liable to cause deposits of carbon in the form of coke and soot in the cylinders.

Sulphur in the oil should not exceed 2 % as otherwise under combustion sulphuric acid can be formed in such quantities as to attack the iron of the cylinder and exhaust piping.

The percentage of ash should be the least possible. Preferably only a trace of ash should exist and never more than 0.1 %. Water should never be present in fuel oil but it is sometimes difficult to avoid, as, more especially with the heavier oils, it is difficult to separate water from the oil.

Sand, mud and other mechanical impurities must not be present. If it is necessary to use an impure oil, an effective filter should be used and the fuel oil tanks constructed so that impurities and water can sink to the bottom and be conveniently drawn off from there periodically. The fuel oil should always be passed through a strainer when filling the tanks.

When purchasing oil, it is as a rule impossible to obtain complete details of the above characteristics. Generally, the seller is only able to give the spec. gr. and possibly the heat value which as explained above cannot alone determine whether an oil is suitable. If therefore it is question of purchasing a

considerable quantity of an oil, it is wise to have same analysed first by a chemist or firm making a speciality of this kind of work.

Although the above figures give a valuable indication as to the quality and suitability of an oil, it is not possible to be absolutely certain of same until the oil has been actually tried in an engine, and for this reason we advise users of our engines, before making any considerably purchase of an oil, to send us a sufficient quantity to make a reliable test of same which we are always pleased to do. When one has found a suitable oil for the engine one should use this oil only and not, for the sake of a trifling reduction in price, try to use oils of inferior quality.

III. LUBRICATING OIL FOR THE ENGINE

In order to obtain satisfactory results, it is of utmost importance that the right sort of lubricating oil be used. An oil that can be used for all parts of the engine is naturally to be preferred, as in this case no mistake can be made by using the wrong oil for some particular part. Lubricating oil should only be purchased from well known firms.

IV. COMPONENT PARTS OF THE ENGINE, THEIR USE AND HOW THEY SHOULD BE TREATED

The Fuel Pump with »hit and miss» governor (engines type B, 124 A see fig. 3).

This is a plunger pump, the plunger being so carefully ground in that no packing box is necessary. If the plunger works stiffly or fastens in the housing, it must on no account be ground off to ease it. The cause will be found due to dirt or rust on the plunger, which must be carefully cleaned. Sticking of the plunger may also be due to the bolts of the pump housing being drawn up too hard or unevenly, whereby the casting can be distorted, spoiling the easy sliding fit of the plunger. This last mentioned condition is easily remedied by loosening up the bolts in question a trifle.

The fuel pump is provided with a suction valve marked S (9 A) and two discharge valves marked T (8). If impure fuel oil is used, impurities are at times deposited, especially on the suction valve seat. The valve should then be screwed loose and cleaned with parafin (kerosene).

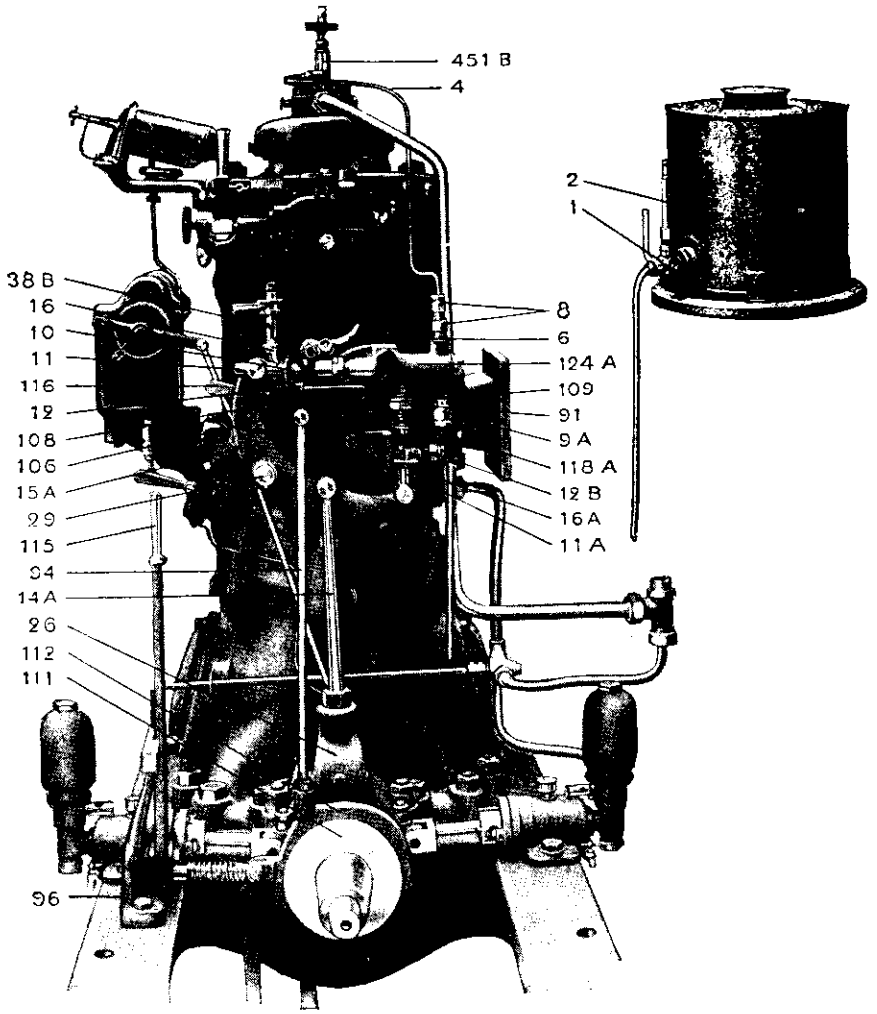


Fig. 3.

The pump is driven by the regulator weight (11), which through the rocker arm (15 A), eccentric rod (14 A) and eccentric strap (26) receives its movement from the eccentric. The ebonite washer (10) attached to the regulator weight (11) glides on the regulator plane (12) and is kept pressed against the latter by the regulator spring (16), the pressure of which is controlled by the speed regulator (38 B). The regulator plane (12) is provided with a cam surface, and when the ebonite washer (10) in its movement towards

the pump (124 A) meets this cam surface, the regulator weight (11) is thrown upwards. The amount of this upward movement is determined by the pressure of the regulator spring (16) so that if the pressure is slight the regulator weigh (11) is thrown so high that the edge of same misses the edge of the fuel pump plunger and consequently no injection of fuel is made, no explosion takes place and the engine slows down. The speed of the engine consequently can be regulated by increasing or diminishing the pressure of the spring by means of the speed regulator (38 B). The regulator spring should be adjusted so that a miss takes place at a speed somewhat higher than the normal when the speed regulator stands at full speed. The regulator plane should occasionally be lubricated by a few drops of oil.

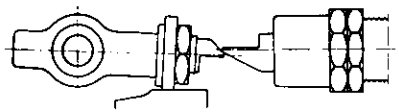


Fig. 3 A.

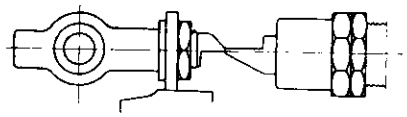


Fig. 3 B.

It is very important, that the ebonite washer (10) is not allowed to wear so that the edge of the regulator weight is working in too low a position as shown on fig. 3 A, which may cause breakage of the pump plunger.

The correct position of the edge is shown on fig. 3 B.

In order to diminish the stroke of the fuel pump when running on a light load or no load, there is an adjusting lever (No. 116 see fig. 3) which on engines fitted with reversible propeller blades, is fixed by an eccentric on the bolt (No. 29). The more this lever is moved downwards, the less will be the stroke of the fuel pump. If the lever is moved to its lowest position the fuel pumps will be thrown out of action and the engine will stop. When the engine is running under full load, the adjusting lever should stand in its upper position. When running without load an engine will best retain its heat if the above mentioned lever is adjusted so that the regulator weight makes a free stroke every 3rd or 4th revolution. When manœuvring, the adjusting lever should preferably stand in its top position, as otherwise it can easily happen that it is forgotten to move it into this position when he clutch is thrown in and which would result in the stopping of the engine. If with engines having

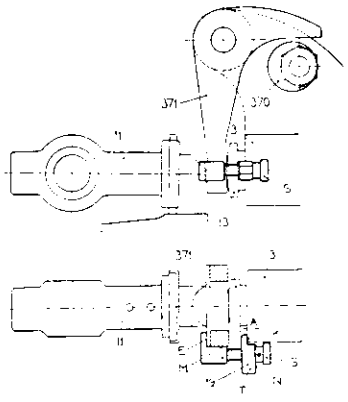


Fig. 4.

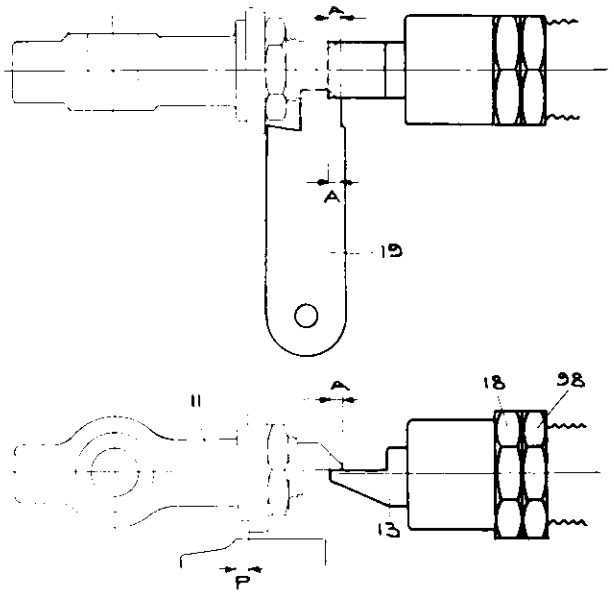


Fig. 5.

reversible propeller blades or reversing gear, the manœuvring levers are carried up to the deck, the lever which is connected with lever No. 116 should be placed so that it is not so accessible that it can in a moment of urgency be mistaken for the other hand lever and the engine caused thereby to stop under a manœuvre. Preferably it should not be carried up to the deck at all, as the speed of the motor should be regulated by the speed regulator (38 B).

The Fuel Pump Stroke.

Before the engine leaves our testing department the fuel pump is adjusted for the correct length of stroke. This length is noted on the trial certificate and stamped on the pump, and must under no circumstances be increased above the given figure. A gauge showing the correct length of stroke is also delivered with each engine.

From time to time the stroke should be checked as same for instance is apt to increase somewhat when main bearings become worn and the crank shaft consequently takes a slightly lower position. Such an increase should be remedied by decreasing the pumpstroke.

For 1-cylinder engines as well as for small 2-cylinder engines, in which the edge of the regulator weight works direct on the fuel

pump plunger, the pump stroke is checked in the following manner (see fig. 3).

The pump regulating lever (116 fig. 3) is placed at the top position on the segment and the engine turned over so that the regulator weight (11) comes to its extreme inner position. The striking end of the weight should then be lifted up and then rest on the flat end of the plunger (fig. 5). The gauge (19) is inserted with its one edge against the edge of the pump plunger (13). If the stroke is of correct length, i. e. equal to the dimension A on the gauge, the striking edge of the regulator weight should then be exactly in line with the other edge of the gauge. The adjustment is made by means of the nut 18, which then is locked fast by the lock nut 98. The distance P is different for different sizes of our engines and differs within the limit of $^1/_8$" to $^1/_4$".

All 4-cylinder and the larger 2-cylinder engines have an intermediate piece between the striking edge of the regulator weight and the pump plunger, for which reason the pump gauge is of a different pattern, and is handled in the following manner (fig. 4).

The pump regulating lever (116 fig. 3) is placed at the top position on the segment, and the engine turned over so that the regulator weight (11) holds the pump plunger (13) pressed to its extreme inner position. The gauge (19) is then placed as shown in fig. 4, care being taken to see that it is held quite level and in line with the edge (E) of the intermediate piece and the centre line of the pump plunger. It must also be kept pressed against the surface (M) and the edge (E). By means of the screw (S) the gauge is now adjusted so that it comes in contact also with the pump housing

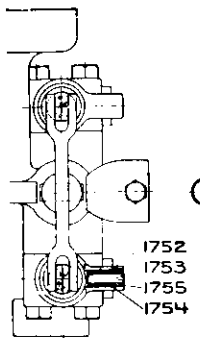


Fig. 6.

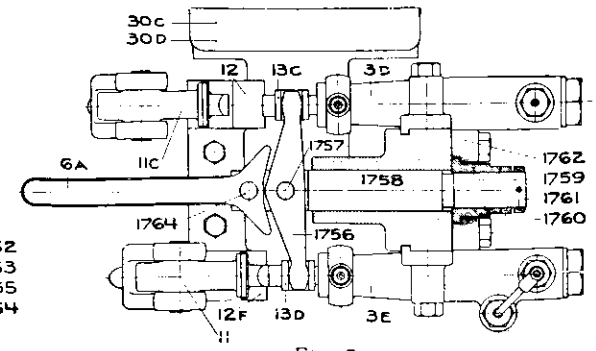


Fig. 7.

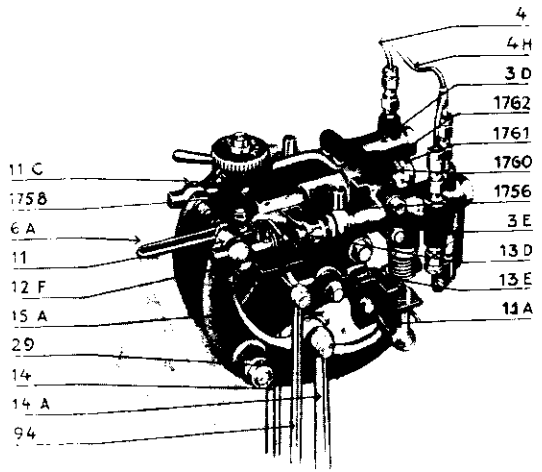


Fig. 8.

at the point (K). (The screw should remain now in the position it has.) The engine is turned over so that the regulator weight (11) does not touch the intermediate piece (371), and the part (T) is then turned over so that the edge (N) comes in contact with the pump housing. If the gauge is in contact with the edge (E) and the pump housing (K) at the same time, the pump stroke is equal to the dimension (A) on the gauge, which is the correct stroke.

The adjustment of the fuel pump stroke is made by means of the eccentric (370) wich is kept locked by a nut. The gauge is used as shown in fig. 4. For engines having a roller instead of the eccentric 370 (fig. 4) the pump stroke is decreased by placing a shim between the eccentric rod (14 A fig. 3) and the eccentric strap (26).

The pump hand lever (6) is used for injecting fuel oil when the engine is to be started (fig. 3 & 12).

The 2-cyl. engines up to and including 120 B. H. P. are from the year 1930 provided with co-ordinated fuel pump plungers.

The device is shown in the fig. 6, 7 & 8.

The outer ends of the fuel pump plungers are cross-slotted on the top and under side. A pump arm (1756) pivoted by the pin (1757) in the pump arm support (1758), works by means of its forked ends, in the above mentioned slots. The position of the pump arm support is adjustable in relation to the pump bracket (30 D), by means of the nut (1759).

The pump plungers are not in this case moved outwards by springs, the outward movement of each plunger being made by the corresponding inward movement of its companion pump through the pivoted arm (1756). Thus the one plunger, due to the action of the regulator weight, makes an in-stroke, the plunger of the other pump makes an out-stroke.

Fig. 7 shows the pump plunger (13 D) driving by the regulator weight (11) to its inner porition, and pump plunger (13 C) is at the same time by the pivoted arm (1756)driven to its outer position.

Supposing the regulator weight (11 C) now makes a »free stroke» (miss), and consequently does not drive in plunger (13 C) then both plungers will remain in their respective positions as shown, as plunger (13 D) is out of reach of the regulator weight (11), and no movement of either plunger will occur until the regulator weight (11 C) has driven in plunger (13 C), thereby carrying plunger (13 D) to its outer position again.

In other words a »free stroke» or miss for pump plunger (13 C) is followed always by a »free stroke» for pump plunger (13 D), and consequently both pump plungers make exactly the same number of strokes.

Not only is the number of strokes the same, but the length of the strokes is also the same so that both cylinders receive exactly the same amount of fuel.

The adjustment of the length of the fuel pump stroke is made by moving the pump arm support (1758) by the adjusting nut (1759). If the support (1758) is moved nearer the regulator weight the stroke of the pump will be increased.

The length of stroke of the plunger is controlled by means of a gauge in the usual way.

As both plungers make the same length of stroke it is only necessary to control the stroke of one of the pumps.

After the adjustment has been made the nut (1759) should be locked fast by the lock-nut (1760).

Pumping by hand is performed by the pump handle (6 A) which acts upon the pump arm (1756).

In order to ensure a steady movement of the pump arm (1756) and the pump plungers, each pump plunger is controlled by an equalising piston (1753) which by means of a spring (1754) is kept pressed against the pump plunger.

Reversing (see fig. 9.)

The reversal of the engine's direction of rotation is effected by means of a counter-impulse in the cylinder. The fuel charge for this counter-impulse is injected by the reversing pump (13 A), which is driven by the regulator weight (11 A). This regulator weight with its regulator plane (12 B) and regulator spring (16 A) is similar to the corresponding part of the main fuel pump device, but is attached to the opposite end of the rocker arm (15 A). From this follows that as the main fuel pump makes an injection when the piston approaches its highest position, the reversing pump makes an injection when the piston approaches its lowest position.

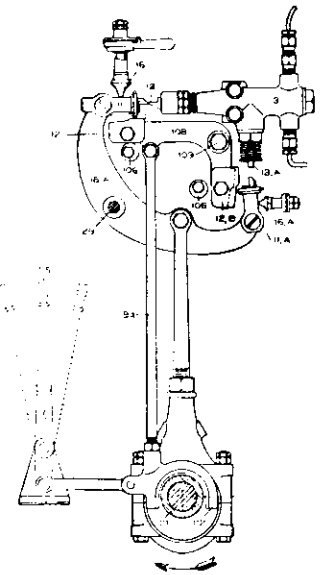


Fig. 9.

The regulator planes (12 & 12 B) are attached to the arm (108) working on the pin (109), the movement of this arm being controlled by the eccentrics (106). By means of the rod (94) the arm (108) is connected with the fork (112), which under ordinary running conditions hangs loose in the groove of the friction disc (111) keyed to the shaft. When it is desired to reverse from »ahead» to »astern», the reversing lever (115) is moved over astern. The fork (112) moves then in the opposite direction to that shown by the arrow in fig. 9. Due to the friction between the fork (112) and the friction disc (111) the first named is lifted upwards turning the arm (108) so that the regulator plane (12) is lifted and the regulator plane (12 B) of the reversing pump depressed. The regulator weight (11) of the main fuel pump is hereby lifted so high that its contact edge does not meet the corresponding edge of the intermediate piece (371) (on small engines the contact edge of the pump plunger). No injection of fuel oil consequently takes place and the engine slows down. On the other hand, the regulator weight of the reversing pump (11 A) comes into such a position that its contact edge hits the corresponding edge of the reversing pump's

intermediate piece (on small engines, the contact edge of reversing pump plunger). This however does not take place until the engine has slowed down to that speed at which the regulator weight ceases to make »miss strokes». The reversing pump (13 A) now makes an injection of fuel and as this occurs when the piston approaches its lowest position an impulse takes place before the piston has arrived at its highest position, which stops it and drives it down again. The direction of rotation of the engine is thus changed and runs «astern». The arm (108) with its regulator planes (12 & 12 b) now returns to its original position, that is to say the reversing pump (13 A) is thrown out of gear and main pump (13 fig. 9) comes into gear again running the engine astern.

Reversing from astern to ahead is accomplished in a similar manner, with the exception that the reversing lever (115) is moved over ahead. It is customary to slow down the engine before reversing, but if it is necessary the engine can be reversed at full speed, as the engine slows down automatically before reversing.

The propeller shaft must always be de-clutched before reversing, and if the clutch is not connected with the speed regulator, so that declutching at the same time slows down the engine, this latter must be done by hand, as otherwise the engine being without load will immediately race.

From what has been said above, it is clear that in order that reversing can take place, the regulator spring (16 A) of the reversing pump must be properly adjusted. If the pressure of the spring is too great the engine will not slow down sufficiently to allow the counter-impulse to stop the piston from reaching its highest position, and the speed of the engine will carry it over the centre, and it vill continue to run in the same direction.

If, on the other hand, the regulator spring does not exert sufficient pressure, the engine will slow down so much before the counterimpulse takes place, that this latter will not be sufficiently powerful. The piston thus is not driven back forcibly enough and the engine stops.

When the regulator spring (16 A) has been correctly adjusted, the locknut on same should be drawn tight so that there is no chance of it loosening up while the engine is running.

The regulator planes (12 & 12 B) and the arm (108) are adjusted at our Works, and should not be changed in any way.

Care should be taken to see that the ebonite washer (10) on the reversing pump's regulator weight is not allowed to become too worn, as then the regulator weight will fall so low that an injection of fuel will be made by the reversing pump each revolution, which may have serious consequences. When the reversing pump is not working, the contact edge of the regulator weight should clear the recess in ths intermediate piece (371 fig. 4) (on small engines, the pump plunger) by at least 1 mm. ($^4/_{100}$").

For direct reversible engines provided with coordinating fuel pump plungers and having a special pump for reversing, the governing is done by the forward regulator weight (11 C) only, the aft regulator weight (11) working on a plane surface (12 F fig. 7) without cam.

The reversing pump in this case has its own pumphousing with suction & discharge valves, connecting pipes with the air chamber and delivery pipe.

Fuel Pump With Centrifugal Governor (see fig. 10).

The centrifugal governor is used on engines type W30—W50 and is mounted on the bed plate and driven from the crankshaft by means of a worm gear. The fuel pumps A are fixed to the lower part of the governor housing and are operated by the arm B, which receives its motion from the pump curve C, mounted on the governor spindle.

The regulating of the fuel is done as follows: the governor weights F act on the spindle G, fixed to the spring K. At the lower end of this spindle the governor sleeve H is fixed by a bolt I which glides in the slot of the spindle. The sleeve H moves upwards and downwards together with the spindle G, and this movement of the tapered part of the sleeve on which the rollers are resting with their rounded edges L, increases or decreases the fuel pump strokes.

Further the speed of the engine can be increased by screwing the governor cap M upwards and decreased by screwing it downwards. If the cap is screwed downwards as far it will go the engine stops.

When dismounting the governor for cleaning etc. only the cap and the doors should be taken off. All the inner parts of the governor are then accessible.

The governor is lubricated by means of a drip cup on the cap and oil-holes. On engines with centrifugal governor the fuel pump stroke is fixed and must not be changed.

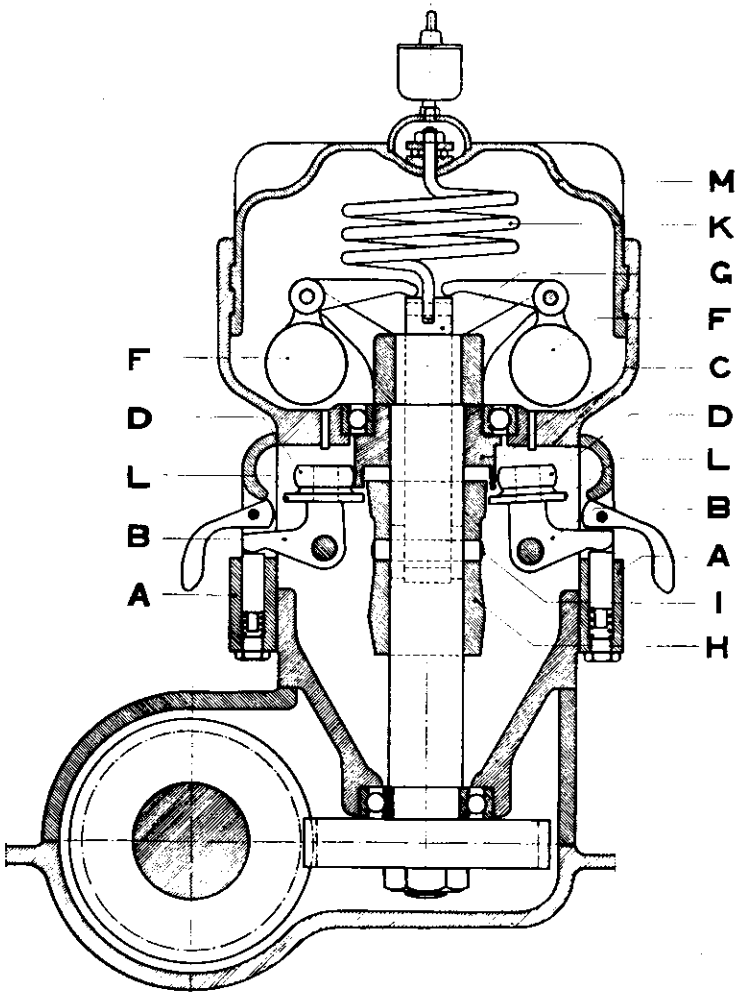


Fig. 10.

The Fuel Oil Suction Piping (see fig. 3).

The fuel pump's suction piping is fitted with an air chamber (118 A) which equalizes the flow of fuel oil, and a fuel cock (1) for shutting off the supply. The fuel cock is attached to a fitting located on the silencer cover (for the small engines, on the fuel tank or fuel filter). On the cock housing will be found a hand pump (2) for priming the fuel pump and fuel delivery piping. (See also page 38.)

The Fuel Injection Device (see figs 1, 2, 3 & 12).

From the fuel pump, the fuel oil is led through the fuel delivery piping (4) to the injection device (451) which is attached to the upper part of the ignition bulb. The injection device consists of an outer housing, an adjustable threaded spindle and a nozzle attached to the lower end of the housing. The spindle is regulated by means of a hand lever. On multicylinder engines the regulation of the spindles is accomplished through a link system. The injection device is attached to the ignition bulb by a flange and two bolts. When attaching the injection device care must be taken to see that the shoulder on the cooling house of the ignition bulb fits in the recess on the injection device.

When installing the regulating apparatus for the injection device spindles, the following points should be observed:

On older multicylinder engines from and including 135 B. H. P. upwards, the links connecting the spindles should be located on the front side of the fuel injection devices for starboard engines and on the rear side for port engines. For engines delivered from our Works after Jan. 1st 1923 these connecting links should be located on the front side for both port and starboard engines.

For multicylinder engines of 100 B. H. P. and lower, the connecting links should be located on the front side of the fuel injection devices for both starboard and port engines.

Before the links are screwed fast to the spindles, care should be taken to see that all of the latter are screwed down so that they bottom.

At the regulating handle, the engines type B 40, B 50 and B 60 have a plate showing the correct position of the handle for "Full load", "Manœuvring", "No load" and "Starting". When the spindles are screwed down as far as they will go, the handle should stand at "No load".

As soon as the load is thrown on, the spindles should be raised, which is done by moving the regulating handle towards the "Full load" position. The greater the load, the more the spindles should be raised. For half load or less, the handle should only be turned a small amount. The regulation of the spindles depends also upon the kind of fuel oil used. When engine is running the spindles should never be screwed up more than about a $^1/_4$ turn. Generally spaking the spindles can be screwed up fully when the engine is warm, otherwise they should be raised somewhat less.

In the event of it being necessary to change the nozzle of an injection device, the spindle should be raised one complete turn before the nozzle is screwed loose. The new nozzle must be screwed in well so that it makes a tight joint.

The spindles should be raised somewhat when the engine is stopped, in order to prevent them from fastening.

Before the heating lamps are lighted, the injection devices should be filled with fuel.

The Ignition Chamber (see fig. 1).

When the fuel oil enters the ignition chamber (39) it is gasified and combustion takes place due to the heat of the walls of the chamber brought about by each explosion. Before the engine can be started, the ignition chamber must be heated by the heating lamp; but as soon as the engine is running and carrying a load, the lamp can be extinguished. The heat of the ignition chamber is regulated by the spindle of the injection device, which by means of the regulating handle is raised if the ignition chamber becomes too hot and screwed down-wards if the ingition chamber becomes too cold. The ignition chamber must not become red hot neither must it become so cold that incomplete combustion takes place.

The upper part of the ignition chamber is fitted with a cooling house, which protects the injection device from over-heating.

Before the engine is started, the ignition chamber, as before mentioned must first be heated. For the care and operation of the heating lamps special instructions are furnished. For engines fitted with electric ignition for starting or quick starting lamp see special book of instructions for these apparatus.

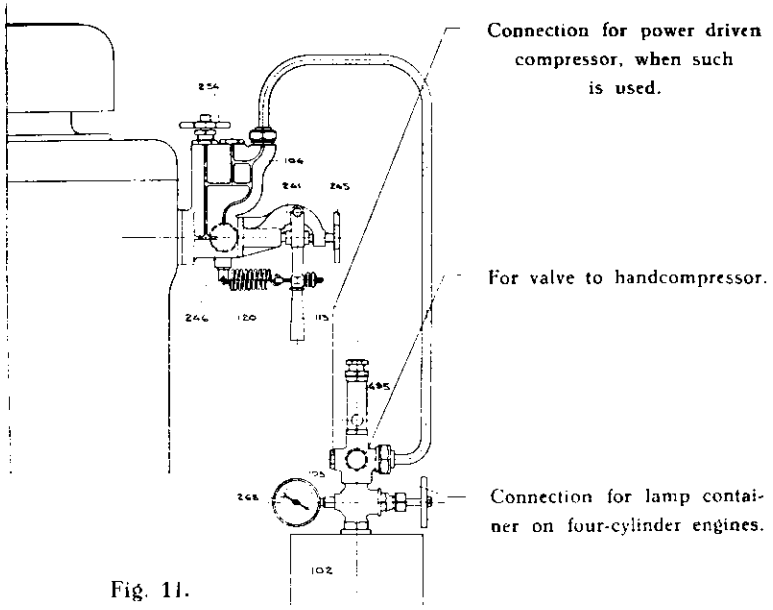


Fig. 11.

The Starting Device (see fig. 11).

All multicylinder engines and larger single cylinder engines are started by means of compressed air, or by the exhaust gases from the cylinder which are accumulated under pressure for this purpose, and admitted to the cylinder through the starting valve (104). The air or exhaust gas is stored up in the container or bottle (102) and if the exhaust gases are used this container should be recharged by means of the loading valve (254) but not before the ignition chamber becomes sufficiently hot. In order to start a newly installed engine, or if for any other reason the container is empty, it must be filled by means of a hand compressor or small power-driven compressor. If the installation includes a power-driven compressor, the container should be charged always from same and not by the loading valve. The discharge piping from the power-driven compressor should be fitted with a stop valve at the starting air container and this stop valve should always be kept closed except when the container is being charged. When this takes place however the valve must naturally be open.

The starting container (102) is fitted with a stop valve (103) for shutting off the piping from the container both to the engine

as well as the compressor. The stop valve (103) most only be kept open when the engine is to be started an the container charged.

The safety valve (495) on the container (102) should blow off when the gauge (268) shows a pressure of 12–15 atmospheres and care should be taken to see that the container is not charged beyond this pressure.

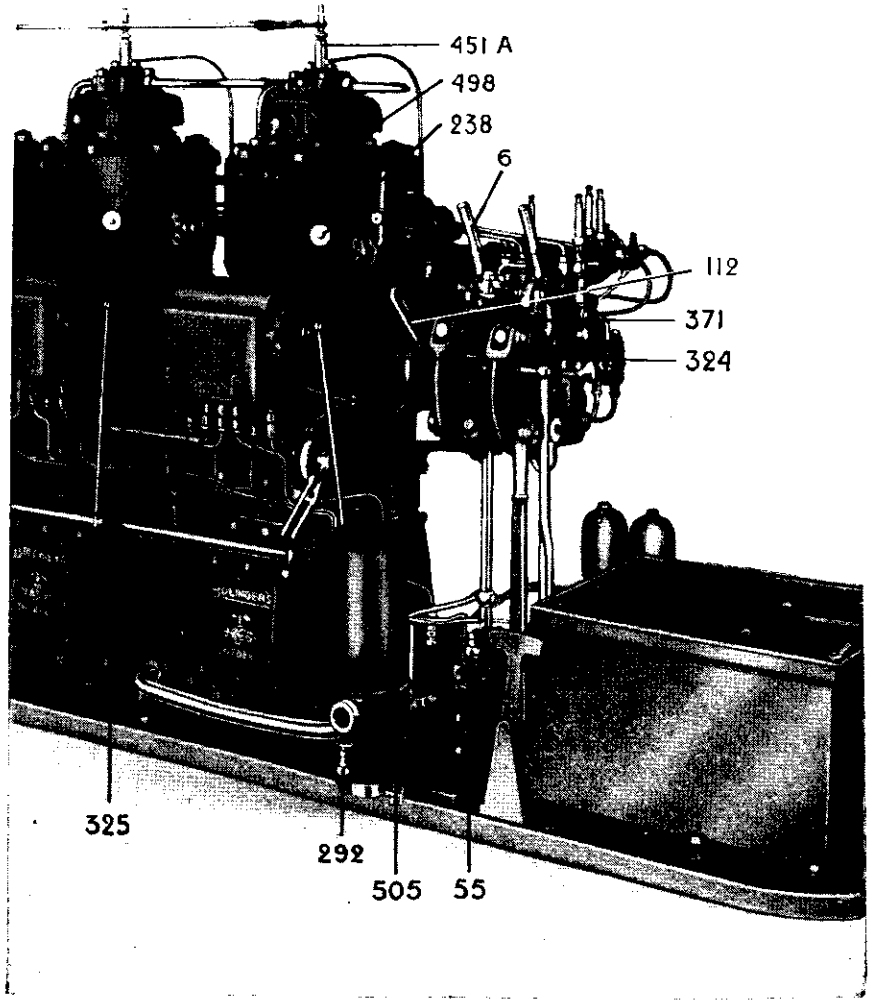


Fig. 12.

The starting valve (104) is opened by means of the hand lever (113) after the spindle (241) has been loosened up by turning the hand wheel (245) a few turns. The valve closes itself by the spring (120), the pressure of wich must always be sufficient to keep the valve from being opened by the pressure in the engine cylinder. The larger sized engines are fitted with a combined starting and loading valves.

On four-cylinder engines the starting air is admitted into two of the cylinders at the same time by means of the induction valves (498 see fig. 12). These valves must be closed immediately after the engine has been started.

Small engines are started by hand by means of a handle in the flywheel.

The Cylinder (see figs 1 and 12).

The cylinder (324) is water-cooled except at the lower end of same. On the rear side of the cylinder there is an opening for the exhaust gases leading to the silencer, and on the front side an entrence and a passage for the air compressed in the crank-housing (325). The amount of air admitted to the cylinder can be regulated by means of a damper (554) (this device does not exist with the smallest sizes of engines) in the air passage. When running normally under load, this damper should be wide open; but if the engine is run for a considerable time under no load, or if long periods of manœuvring are to take place, the damper should be closed, and it then only admits sufficient air for combustion. If too much air is admitted to the cylinder when running at no load, the ignition chamber will cool down so much that combustion will not take place. For the above reason, the damper must be wholly or partially closed if the ignition chamber, for any reason cools down, and the construction of the damper device is such that each cylinder can be regulated independently.

The Piston (see fig. 1).

The piston (52) is furnished with either four or five piston rings (41) in the upper part, and on the larger engines one ring at the lower end. The piston rings are held in correct position

by setscrews. The piston is lubricated from oil holes in the lower part of the cylinder which are connected by an oil channel in the cylinder walls.

The Gudgeon Pin (Wrist Pin) (see fig. 1).

The gudgeon pin (53) is fixed in the piston and held in position by two set screws (331) fitted with lockwashers and split pins. The gudgeon pin is ground exactly to its correct dimensions, and no adjustments or changes to these dimensions must be made.

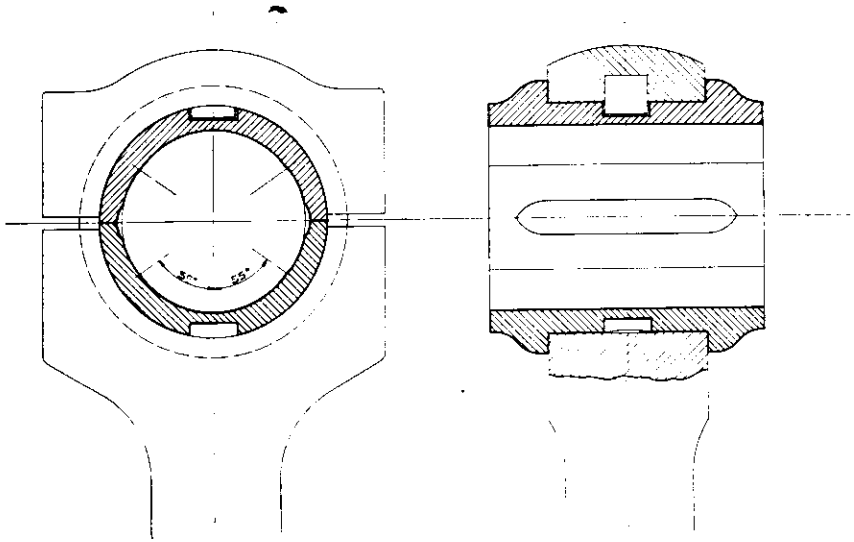


Fig. 13.

The Gudgeon Pin Bearing (see fig. 1 and 13).

The gudgeon pin bearing (36) is made in halves and (in the later constructed engines) so made that when the lower half is worn out, the upper half can be used in its place, the lower half being used for the top part of the bearing. On these engines the guide pin sits fast in the rod. If this is not the case, the bearing should be removed and a new bearing inserted. The top half, however, must not actually make contact with the pin. The lower half should be well scraped out on the sides so that the surface in contact with the pin does not exceed more than about 55° or less on either side of the vertical centre line, see fig. 13. If the lower half is not well scraped out in

the above manner sufficiently deep there will always be the risk of the bearing seizing the pin if it should run warm. At each end of the bearing, a distance of about 3/8" should be left to fit the pin, in order to prevent the lubricating oil from running out of the bearing. Marking colour should naturally be used to ascertain if the surface of the bearing makes a good fit with the pin and if this is not the case the bearing must be carefully scraped in to a running fit.

If a worm bearing has been filed down the bolts (333) of same will be naturally somewhat too long and the split pins will not come close against the nuts they are to hold. This space between the split pin and the nut must be filled up by a washer, as otherwise the nut may become loose and in time wear the split pin in two, after which there is nothing to prevent the nuts from loosening up altogether and leading to serious damage.

The gudgeon pin bearing is lubricated trough an oil hole in the cylinder wall, from where the oil is accumulated in a recess in the piston wall and led through an oil hole into the gudgeon pin which is drilled out on its centre line. From a hole in the pin, the oil runs out into the bearing.

In the latest design of motor types B 15 to B 50 the gudgeon pin bearing is a needle roller bearing consisting of two, three or four rows of needles separated by rings and locked in position by end washers or rings as shown on fig. 13 D and F.

These bearings need less oil than metal lined ones and the risk for overheating is entirely eliminated. Ordinary lubricating oil can be used.

Inserting of the needles.

After the distance ring A, fig. 13 A, has ben inserted in sleeve B, the fitting sleeve C is pushed in, the first row of needles D is placed on same and the second distance ring A_1 is put on as shown on the figure. The fitting sleeve C with needles and rings is then pushed in, the next row of needles D_1 is inserted, and the third distance ring A_2 is put on as shown on fig. 13 B.

The procedure is continued until all needles and rings are in position. Then the end washers F are placed as shown on

fig. 13 C. The most convenient way to insert the last row of needles is from the opposite end of the bearing.

On some types of engines the end washers F have been substituted with rings G as shown on fig. 13 D. These rings have exactly the same dimensiones as the rings A, A 1 and A 2.

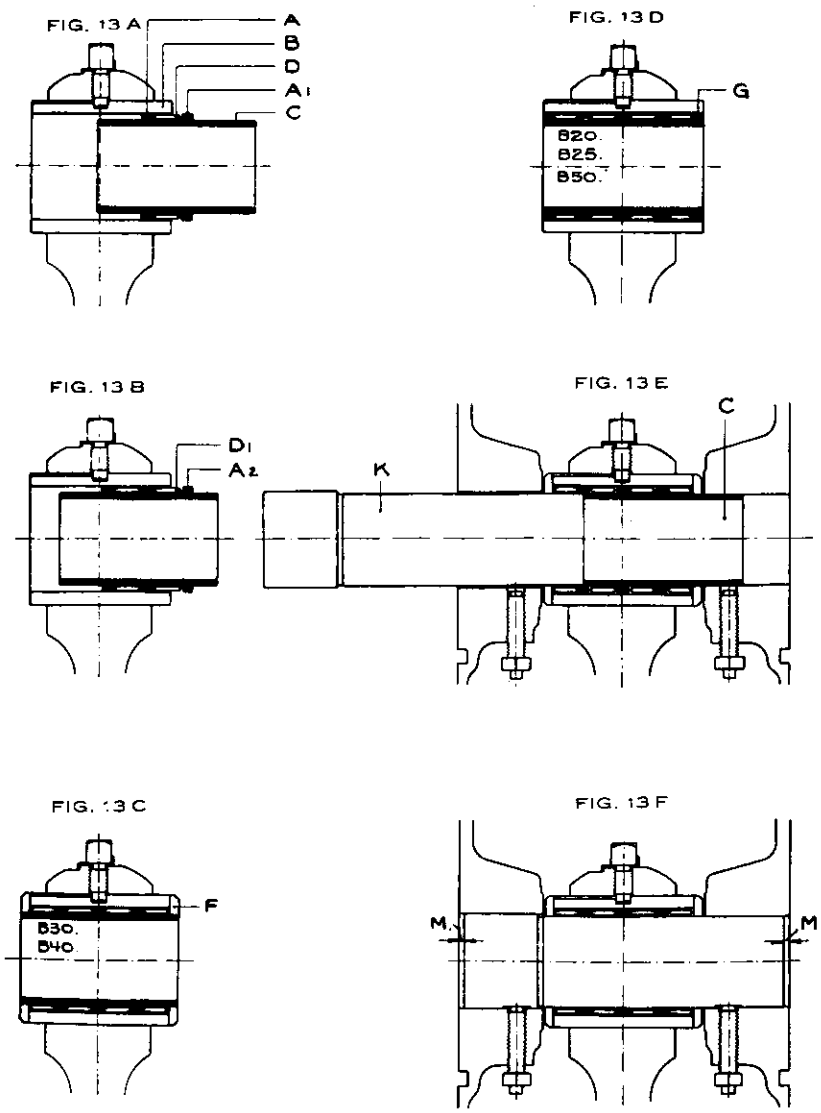


Fig. 13 A–F.

Inserting of bearing in piston.

When connecting rod with bearings has been put in place in piston. the gudgeon pin is pushed in replacing the fitting sleeve C as shown on fig. 13 E. It is important that the distances M between end of gudgeon pin and outside of piston are exactly the same. Fig. 13 F shows assembled gudgeon pin and bearing.

The bearing is removed from the piston in the opposite way. The gudgeon pin is pushed out by the fitting sleeve, which prevents the needles from falling out.

The Crank Pin Bearing (see fig. 1).

The crank pin bearing is lined with white metal. If the bearing has run hot and must be re-lined, only white metal recommended by us must be used. The white metal must not be overheated, otherwise it will be burnt. Generally, it is sufficient to heat it so, that when a piece of wood is dipped into same it becomes slightly carbonized (black) on the surface.

When fitting this bearing care should be taken to see that the upper half is scraped out as described for the lower half of the gudgeon pin bearing. The lover half of the crank pin bearing must not actually make contact with the pin, and if this should happen, then shims should be placed between the two halves of the bearing. These shims can be removed as the bearing wears. When filing down a worn bearing however the same care must be taken to see that any clearance between the split pins and the nuts of the bearing bolts (334) is filled up with washers, as described for the gudgeon pin bearing bolts. Care shold be taken to see also that the bearing has clearance longitudinally.

The crank pin bearing is lubricated from a centrifugal oil ring (48) from which the oil by centrifugal force is forced through a hole in the crank pin to the bearing. The ring is supplied with oil from a pipe attached to the wall of the crank housing.

If a crank pin bearing runs hot so that the white metal runs, care must be taken to see, before a new bearing is fitted, that the lubricating hole in the pin is not plugged up with old white metal. If this should be the case and these particles of white metal cannot be washed out with paraffin (Kerosene). the hole

must be cleared from the outside. The plug in the housing opposite the oil hole is removed and the plug in the oil ring taken out when the hole will be accessible from the outside. White metal which has fastened on the crank pin should be scraped away. If there are scores or marks on the pin, they should be evened out with a fine file, and the pin polished afterwards with emery cloth. When a crank pin bearing or gudgeon pin bearing is fitted, or new bearings installed, care must be taken to see that the bearings make contact with their respective pins throughout their entire length, so that no bending moment is possible.

When a bearing, either crankpin bearing or main bearing has been re-metalled, care must be taken to see that when boring same out, the centre of the bearing comes in exactly the same position as before.

The Crank-housing. Air valves and Packing rings
(see fig. 2).

As previously mentioned, the piston on its downward stroke compresses the air in the crank-housing (325). The air is drawn in during the upward stroke of the piston through the air valves (335) which consist of steel springs (45) their movement being limited by the stop (57). These valves are fitted into casings on either side of the crank-housing. In order to prevent the air from escaping around the shaft, packing rings (47) are fitted around same and make a tight joint with the shaft, either by careful fitting, or by leather packing inlaid in a grove in the ring. These rings which make a tight joint against the walls of the crank-housing, are on multi-cylinder and larger 1 cylinder engines held against the latter by spiral rings.

In the bottom of the crank-housing there is a drain cock for tapping out the waste oil. It is of the greatest importance that oil is not allowed to accumulate in the crank-housing, as if it is allowed to accumulate to the extent that the crank pin bearing dips into it, the oil will be splashed about and drawn up with the air into the cylinder, where it is liable to cause deposits of carbon. It is even possible for so much oil to be carried up with the air into the cylinder as to cause the engine

to race dangerously. The tapping off of waste oil should therefore be done every four hours, and care should be taken to see that the cock has not become clogged with dirt etc.

If the crank-housing, for any reason, must be removed, as for example if the crank shaft is to be lifted out, then the nozzle for the crankpin lubrication must first be screwed loose, as it will otherwise catch in the oil ring. Before the crank-housing is replaced again, the pipe through which oil is fed from the nozzle to the oil ring should be investigated to see that it is securely fastened, also that its lower end is in position inside the oil ring. When the crank-housing is in position again the oil pipe should be investigated to see that it has not been moved out of position or damaged, also that the nozzle leads into the centre of the bowl at the upper end of the pipe.

On the smaller single cylinder engines this pipe does not exist, and the oil drips from the nozzle direct into the oil ring.

The Main Bearings.

The main bearings are lined with white metal the same as the crankpin bearing. If it is necessary to re-metal a bearing, the same precautions must carefully be observed, as with the crank-pin bearing. The lower halves must be scraped clear at the sides, leaving a bearing surface of about 55° on either side of the vertical centre line. At each end of the bearings however about $^3/_8$" should be left to prevent the oil from running out. Between the upper half and the shaft there should be a clearance of about 0,1 mm. = approx. $^4/_{1000}$".

If a main bearing has been damaged and there is no time for lifting the shaft in order to fit a new bearing, the lower half can be turned up round the shaft, removed and the new bearings inserted in the same manner. It is difficult however to satisfactorily scrape in the new bearing in this way. The bearing cap must be scraped so much, that the fit is not tighter than in the other main bearings. Marking colour shall be placed on the shaft after the bearing has been placed in position and removed from the shaft before the bearing cap is taken up for scraping.

When the bearings have become so worn as to necessitate re-metalling, the shaft should be raised. When fitting new bearings any white metal which has possibly fastened to the shaft should

be carefully scraped away and the shaft re-polished. On the smallest singlecylinder engines the main bearings, however, consist of bushings, and have to be removed longitudinally on the shaft together with the side covers on the crank housings.

The medium size and largest engines are provided with drain pipes from the main bearings whereby the oil from these can be saved and used again after filtering. On the larger engines the underside of the main bearings are watercooled.

The Circulation Water Pump (see fig. 12).

The circulating water pump is located on the bedplate and is driven, on the larger engines, by a special eccentric (55). It is an ordinary plunger pump fitted with a large air chamber in order to insure an even flow of water. On the medium and largest size engines a safety valve (505) on the valve housing prevents the bursting of the engine's water jackets should the discharge from same for any reason become clogged up. The valve housing is fitted with a snifting valve (292) which admits air to the air chamber. The snifting valve should always be kept open a trifle when the engine is running, and should be opened wide if waterhammer should occur in the piping.

If the packing box of the pump should leak, the gland must at once be tightened. This must be done carefully, however, and only just sufficient to stop the leak. If in spite of this the pump continues to leak, the packing is probably worn out and new packing must be inserted; for this plaited cotton yarn dipped in melted tallow is used.

The circulating water is drawn from the sea-cock which is located on the round of the vessel at the bilge.

On engines of 135 B. H. P. and upwards, the sea-cock in the vessel is fitted with a strainer which can be removed and cleaned when same is necessary.

On the small engines, the sea-cock is only fitted with a strainer on the outside of the vessel.

The circulating water is drawn by the pump from the sea-cock and is pumped through the water jackets of the cylinders and cylinder covers from where it goes to the cooling houses of the injection devices on the top of the ignition bulbs and from there through the water jacket of the silencer and then overboard.

On multi-cylinder engines there is a circulating pump for each pair of cylinders. In the piping between the pump and the cylinder water jackets, there is a distributing cock for controlling the amount of water to each cylinder. Besides the above, all engines are fitted with a by-pass cock through which part of the water from the pump can be led direct to the water jacket of the silencer or returned to the valve housing when running on no load, whereby the cylinders, cylinder covers and ignition bulbs retain their heat better. This cock should only be kept open when running at no load and only in such cases where the ignition bulb will not retain sufficient heat. If possible it should always be kept closed and under any circumstances this must be the case when the engine is working under load, also when manœuvring. When closed the handle should stand vertically downwards (exept on type B 3 M 1). The bilge pump, which is located opposite the circulating pump, is driven by the same eccentric as this latter and is of the same construction.

The Friction Clutch.

When starting and manœuvring the engine the propeller shaft must be de-clutched. The design of the friction clutch varies however according to the size of the engine and a special description of this part accompanies each engine.

The Thrust Bearing (see fig. 2).

The thrust bearing (347) varies in construction according to the size of the engine. Some are of the ordinary collar type and some are of the ball-bearing type. With regard to the care of the thrust bearing there is little to say otherwise than that it should be kept well lubricated. Should the thrust bearing be damaged so that it is necessary to re-line same with white metal, this work as well as the fitting of the bearing to the thrust shaft should only be done by persons experienced in such work, as the greatest care is necessary.

If the thrust bearing is fitted with ball bearings care should be taken to see that the housing is always well supplied with oil. From time to time the bearing housing should be emptied of oil, cleaned out with paraffin (kerosene) and refilled with lubricating oil. Thrust bearings of the ordinary collar type are

lubricated by wick-oilers. When starting the engine attention should be given to see that the wicks are inserted, and when the engine is not running that they are lifted out. The wicks should be cleaned with paraffin (kerosene) from time to time.

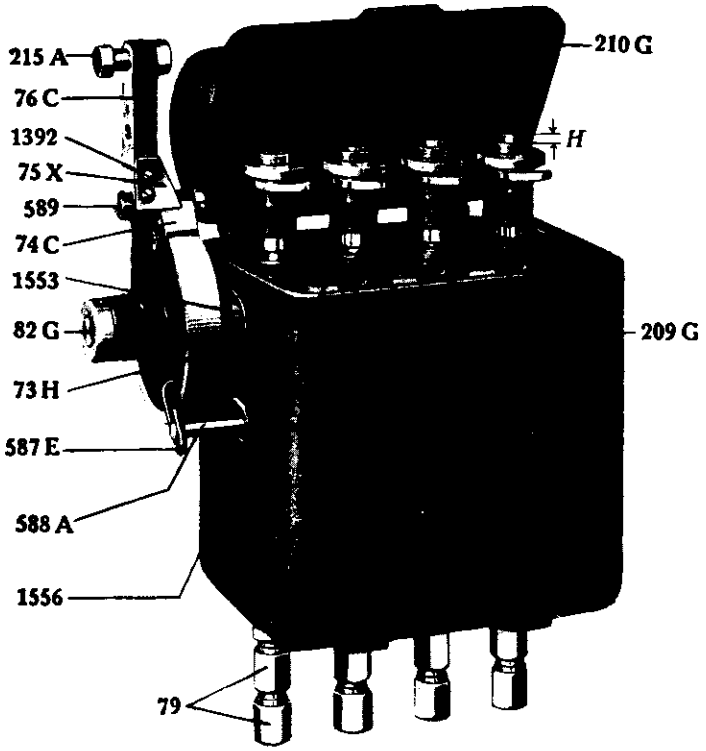


Fig. 14.

The Lubricating Device mod. 1927 and Lubrication of the engine (see fig. 14 and 15).

The cylinder, gudgeon pin bearing, crank pin bearing and main bearings (and on the large engines also the eccentric) are lubricated by the lubricating device, each part to be lubricated being served by a separate pump. The housing or container (209 G) of the lubricating device is divided up into compartments, one for each pump. The pumps work independently of each other but are driven by one common eccentric shaft (82 G) which in turn is driven by a ratchet wheel (73 H) and ratchet (74 C),

the arm of which (76 C) by means of a link is connected with the eccentric rod (14 A fig. 3) of the fuel pump.

When filling with lubricating oil, care should be taken to see that the oil does not come over the top edge of the strainer, as it thus running over the edge of the strainer may carry impurities.

There are no suction valves on the lubricating pumps. The oil is drawn through a hole in the pump housing, when the plunger is in upper position. When the plunger moves downwards it covers the hole and the oil is discharged through the discharge valves (79) under the pump housing. The amount of oil delivered each stroke depends therefore upon the distance which the plunger goes down past the inlet hole and the greatest amount of oil is delivered consequently when the plunger in its extreme upper position only just uncovers the hole. On the other hand, the least amount of oil is delivered when the plunger is so adjusted that in its lowest position it only just closes the inlet hole. The stroke of the pump is regulated by means of the adjusting socket.

The adjustment of the pump stroke is made by turning the adjusting socket 1559. The effective length of the pump stroke is always equal to the distance H between the top edge of the adjusting socket 1559 and the top edge of the spindle 1558. This distance can be varied between 1 and 6 mm.

When the engines are shipped from our Works, the lubricating pumps are adjusted to give a plentiful supply of oil. After the engine has been working for some time and the various parts have attained good working surfaces, the amount of lubricating oil delivered can be gradually diminished; care must be taken however so that no part of the engine runs hot. It is just as big a mistake to use too much lubricating oil as to use too little. In the cylinders, a too plentiful supply of oil causes deposits of soot and coke, this causes the piston rings to fasten in their grooves, the exhaust ports to become clogged up etc. Too little lubricating oil causes overheating, hot bearings etc. If a bearing has been repaired or a new bearing installed it should have an increased amount of oil until it has worn itself in.

If for any reason a more plentiful supply of oil for the moment is necessary to prevent a bearing from running hot, oil can be pumped by hand to the bearing in question.

Pumping by hand is performed by moving the yoke 1557 up and down, while the lock piece 1562 is kept pressed in. After pumping by hand, the yoke 1557 must be brought back into its normal position and locked, which is done in the following manner:

While the lock piece 1562 is kept pressed in, the yoke 1557 is raised as high as it will go. Then the lock piece is released and the yoke pushed slowly down until it is locked (by the lock piece). The pump should not be released until the is locked.

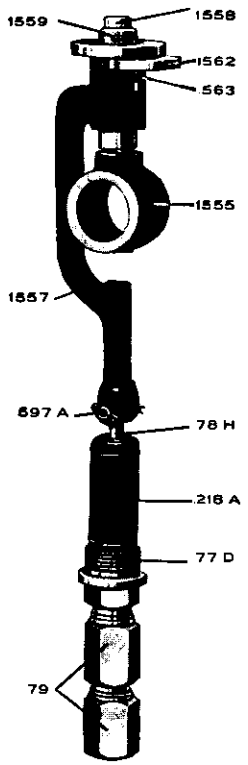


Fig. 15.

Extra oil to any part of the engine should only be given in this manner and not, as is sometimes done, by turning the ratchet wheel by hand, as in this case extra oil is pumped to other places in the engine, where it is not needed and where it can even do harm. In the lubricating piping system for the crank pin bearings, sightfeed glasses are fitted and similar devices are fitted on the main bearing oiling system. The water in these sight feed devices is carried away slowly with the oil and must from time to time be renewed.

If different kinds of oil are used in an engine, great care should be taken to see that the thick heavy oil intended for the gudgeon pin bearing does not come into the compartment intended for bearing oil. This is especially risky for the crank pin bearing, as the heavy oil easily clogs up the hole in the oil and the bearing runs hot.

The compartments of the oil container are fitted with a strainer and each pump is fitted with a strainer; in spite of this, however, dirt and impurities are carried along with the oil, so that the container as well as the strainers must be cleaned from time to time. The eccentrics on various sizes of engine are lubricated by oil cups, which are installed and cared for in the ordinary manner. The moving parts of the fuel oil pump mechanism are furnished with oil holes and should be oiled at least every second hour. Lubricating apparatus and oil cans should always be kept clean and any waste or spash oil wiped up.

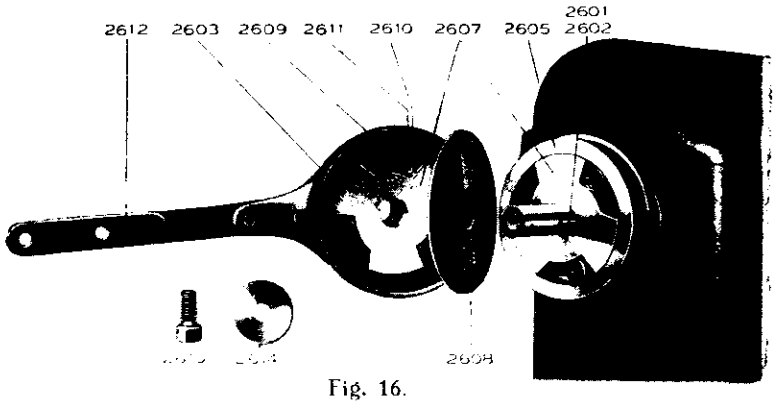


Fig. 16.

On our new lubricating devices the ratchet wheel is substituted with a friction roller stop, see fig. 16. The washer 2608 is located on the shaft between the two disks. The key 2601 is designed for driving to the right and 2602 for driving to the left. The driving housing 2603 and the stop housing 2605 should be filled with grease, and oil shall be used in the holes intended for lubrication.

V. OPERATION AND CARE OF THE ENGINE

In order to obtain good results with the engine, thoroughly experienced engineers or drivers should be put in charge of same. If desired, we shall be pleased at any time to recommend competent engineers and fitters for such positions.

The instruction book should be read through carefully and the instructions followed.

Cleanliness and order should always be observed. Spare parts and tools should be kept in the places reserved for them and used up spares should be replaced as soon as possible with new parts.

The lubrication and care of the engine should be attended to at stated periods, preferably given on a printed from clearly noticeable in the engine room, as otherwise some duty or another can easily be neglected.

The engine should only under extreme necessity be overloaded and then only for short periods.

Preparations for Starting.

Before the engine is started for the first time the following preparations must be made:

The air container or bottle (if the engine is provided with air starting device) must be charged by a hand pump or power-driven compressor to at least 8 athmospheres. It must not be charged from an oxygen gas bottle as an accident can easily result from this.

The fuel pipes and lubricating oil pipes are flooded through with paraffin (kerosene) in order to drive out any dirt in same and they are then screwed fast in their respective positions. The fuel piping is then filled with fuel oil by means of the hand pump (see fig. 3) on the fuel cock. This is done in the following manner. The fuel delivery pipe (4) is loosened at the valve so that one can see when the fuel pump (124 A) has been filled. The pet cock on the air chamber is opened. The handle of the fuel cock (1) is turned downwards and the plunger of the hand pump (2) drawn upwards, whereby fuel oil fills the hand pump. The handle of the fuel cock is then turned upwards putting the hand pump in connection with the fuel pipe, and the plunger is pressed down so that fuel oil is driven through the fuel pipe into the fuel pump (124 A). This manœuvre is repeated until the fuel pump is filled and the oil runs from the pet cock which is then closed. The oil then flows over the delivery valve after which 3 or 4 more strokes of the pump are given so that all air is driven out of the fuel piping and fuel pump. The fuel delivery pipe (4) is now screwed fast and is filled in the same manner until fuel spurts out of the injection device nozzle. The fuel cock handle is now turned straight out (horizontal) and by pumping a few strokes with the hand lever (6) it can be determined if the fuel pump works satisfactorily. This is shown to be the case if the fuel oil spurts powerfully from the nozzle of the injection device in the form of a mist when the spindle is in bottom. If this is not the case and the fuel is discharged feebly or unevenly, or if it continues to run after pumping has ceased this shows that there is air in the system. This can also be determined by holding a finger pressed over the hole in the nozzle while working the hand lever (6). If the latter has a certain amount of springiness or

give to it, it is a sign of air somewhere in the system, and this must be got rid of by continued pumping of the hand pump (2) as otherwise the engine will not work satisfactorily.

The injection device (451) should not be screwed fast in place before the engine is ready for starting; but when it is put in position care should be taken to see that the shoulder of the ignition chamber cooling house fits in the recess on the injection device, also that the nuts holding the latter are drawn up evenly.

The lubricating piping is filled by hand pumping. For this reason each lubricating pipe is loosened from the place it is to lubricate and when the pipe is filled so that the oil runs out it is replaced again in position. When all the pipes have been filled and screwed back in place the lubricating device is turned a few turns so that the places to be lubricated are filled with oil. By hand pumping each gudgeon pin bearing must be given 15 to 20 full strokes. When doing this the piston must be in its lowest position.

The stroke of the fuel pump is investigated, and if it does not agree with the pump gauge or the figure given on the trial certificate, it must be adjusted as described on pages 13 – 16.

The friction ring of the clutch is tightened so that the clutch will not slip.

All nuts and bolts should be examined to see that they are drawn tight. The engine is turned over a couple of turns to see that nothing has been forgotten in the engine which could damage same when it is started. Special care should be taken to control, that the regulator weight for the reversing pump (if used) does not touch the pump plunger (or intermediate piece) when the pump regulating lever (116) is in its lowest position.

The above, as previously mentioned, should be gone through when an engine is to be started for the first time after it has been installed, cleaned, repaired and if any new part has been inserted.

The following instructions are to be followed every time the engine is started:

The oil container of the heating lamp is filled with paraffin (Kerosene) and the lamp lighted. If electric ignition or quick

starting lamps for starting are fitted, see special instruction books on this subject.

The seacock for the circulating water is opened.

In the event of the circulating water piping being arranged so that it can be connected to an extra power-driven pump this latter may be started when the lamp (torch) is lighted so that circulating water flows through the engine while it is being warmed up. This prevents unequal heating or over-heating and should be done also immediately the engine is stopped.

If the engine is provided with air starting device.

The starting valve spindle is tried to see that it works easily.

The engine is turned over to starting position, that is to say with the crank pin for the cylinder to which the starting valve is attached, from 2—4 degrees passed the upper dead centre. When turning the engine over the regulating handle of the pump should stand in its lowest position so that no injection of fuel to the cylinder takes place.

The blow-off cocks of the cylinders (328 see fig. 12) are closed.

Ordinary heating lamps (torch) should not burn longer than about 5 minutes, for small engines less. The ignition chamber is then sufficiently hot and the engine ready to be started. If electric ignition or quick starting lamp is fitted see special instructions for these ignition devices.

Starting by compressed air (see fig. 11).

After the blow-off valve (246) on the starting device (104) has been closed, the stop valve (103) on the air container (bottle) (102) is opened and the hand wheel (245) is opened a few turns.

The induction valves (498) on the cylinders are opened. (These valves are only fitted to 4-cylinder engines. See fig. 12.) The pump regulating handle is moved to top position on the segment.

The speed regulating device is set to »slow», that is to say without pressure on the regulator spring. The regulating handle for the injection devices is set to »no load»-position, i. e. spindles screwed down.

The air damper is closed.

A forcible injection of fuel oil is made to the cylinders by the pump hand lever (on multicylinder engines the aft). Only

a single injection should be given as too much fuel can prevent a good start or cause an accident.

The hand lever of the starting valve (113) is opened quickly a moment whereby air flows into the cylinder and starts engine. The lever of the starting valve must not be held open too long, as the air then flows into the cylinder even after the piston has uncovered the exhaust port, and an amount of air will be lost unnecessarily in this way. If the valve is held open until the piston has even covered the exhaust port, back pressure will be caused, which will naturally stop the engine.

In the event of the engine immediately stopping after it has been started, this is generally due to the ignition chamber not being sufficiently hot. A fresh start should, in this case, not be made immediately as the ignition chamber would only be further chilled off. It must be heated a trifle longer and the pressure in the lamp container can be increased so that a more powerful flame is obtained. If the pressure in the air container has sunk below 6 atmos. due to the unsuccessful start made, it should be charged again before a new start is made. The engine must be turned over again to the starting position, and on this account the blow-off cock (238) must be opened first, care being taken when doing this as the gases blown from the cylinder are at a great heat. In other respects the procedure followed is as described above. Under no circumstances must the engine be turned over without the blow-off cock being open.

When the engine is running and has become well warmed up, the heating lamp should be put out as the engine will keep warm even when running at no load if the damper is then kept closed, and the handle of the injection spindle regulator set to »no load»-position (i. e. the spindle is screwed down).

The hand wheel (245) on the starting valve (104) is screwed down, the stop valve (103) is closed and the blow-off valve (246) opened.

The starting air container should be re-charged, as soon as the ignition chamber has become well warmed up but not before. This should be done in the following manner:

After the blow-off valve (246) has been closed, the stop valve (103) on the starting air container (102) is opened. The loading valve (254) on the cylinder is opened letting the exhaust gases

flow into the container. When the pressure in the container has risen to between 8 & 15 atm. the loading valve (254) should be closed after which the blow-off valve (246) is opened so that the remaining gas in the piping and the valve flow out.

Attention should be given to see that the safety valve on the air container lifts at 12—15 atm. pressure.

By opening the air valve on the cooling housings on the ignition bulbs, one at a time, it can be ascertained if the cooling water is circulating properly. If insufficient water is passing it can depend either upon the valves on the circulating pump being out of order, the strainer of the seacock being clogged up or that the by-pass cock is open to the silencer.

To clean the strainer of the seacock, shut off the cock after which the strainer can be removed and cleaned. If it is necessary to inspect the valves of the pump, the seacock must be closed and the air chamber of the pump removed after which the valves can be taken out and cleaned.

The propeller shaft can now be thrown in by the clutch and care should be taken to see when throwing the clutch in, that the connecting system (if fitted) between the clutch and the speed regulating device moves the latter automatically to increased speed as otherwise the engine may possibly stop (on small engines this adjustment of the speed regulator is done by hand). The pump regulating handle (116) should be in its highest position when the friction clutch is thrown in.

The regulating handle for the injection spindles is immediately set to »full load»-position, i. e. the spindles raised.

By opening the blow off cocks (238) on the cylinders one at a time it can be ascertained if good impulses are being obtained. If the combustion in any cylinder is bad or entirely absent the damper of same should be closed until the ignition chamber has become sufficiently heated. If this should not help, the corresponding heating lamp must be re-lighted.

When starting with compressed air the proceedings can be summarized as follows:

1. Give each gudgeon pin bearing 15 to 20 full strokes of lubricating oil by hand pumping, the piston being in its lowest position.

2. Light the heating lamp or turn on the electric current if electric ignition is fitted (see special instruction book).
3. Turn the engine over to the starting position (The blow-off cock on the cylinder open).
4. Shut the blow-off cock.
5. Open the induction valves (only fitted on 4-cylinder engines) also the stop valve on the starting air container.
6. Screw down the spindle for the injection device.
7. When the ignition chamber is suffiently hot make *one* single strong injection of fuel oil by the pump hand lever (on multicylinder engines the aft pump hand lever).
8. Open quickly, and for a moment only, the starting valve, thus starting the engine.
9. Shut the damper.
10. Put out the heating lamp or turn off the current if electric ignition is used (see special instruction book).

Small single cylinder engines which are not fitted with a starting device are started by turning the flywheel a halfturn backwards and forwards until an impulse is obtained. The ignition chamber must first however be heated, the fuel injection spindle screwed down and an injection of fuel made to the cylinder as previously described. The flywheel is fitted with a handle for the above purpose, which by means of a spring is held in the rim of the flywheel while the engine is running.

Where the engine is equipped with Quick starting lamps, these should *not* be in operation for more than $2^1/_2$ minutes from engine dead cold.

Manœuvring the Engine.

The speed of the engine is regulated by means of the speed regulator (38 B). When running slowly the air damper should be partly closed and the injection device spindles screwed down somewhat. When running very slowly or on no load (i. e. when the propeller is declutched) the air damper is entirely closed, the spindles of the injection devices are screwed down as far as they will go and the fuel pump stroke is diminished by means of the adjusting lever (No. 116). This lever is turned

down to a position allowing the governor weights to make a free stroke every 3rd or 4th revolution. If the engines is to run for a lengthy period with the propeller de-clutched and will not under these conditions retain its heat, the by-pass cock for the circulating water must be opened but should be closed again as soon as possible, as there is considerable risk of this being forgotten when the friction clutch is thrown in again, in which case the engine would very easily become overheated.

Reversing by direct reversible engines is accomplished as follows:

1. Throw the clutch out of gear.
2. Turn the spindle regulating handle to »no load»-position.
3. Throw the reversing lever over.
4. Return the reversing lever to its middle position.
5. Turn the spindle regulating handle to full load.
6. Throw the clutch into gear.

Reversing is sometimes made easier by raising the injection spindles a trifle.

Stopping the Engine.

When the engine is to be stopped, the pump regulating handle (116) is turned to its lowest position whereby, as presiously mentioned, no injection of fuel is made to the cylinders and the engine consequently stops.

As soon as the engine has stopped, the blow-off cock on the cylinder and the drain cock of the crank housing should be opened. The spindle of the injection devices should be raised a little. The fuel cock on the fuel tank closed. The seacock closed. All oil cups closed. If in a cold climate where frost is to be feared, the circulating water in the cylinder jackets and silencer should be drained off, as also the water in the circulating pump and piping and from the jackets of the main bearing if such jackets are fitted.

If, when running, packings or pipe connections start leaking, they should be drawn tight or re-packed. If the packing of the ignition chambers should not hold tight, this can be due to the expansion of the bolts by the heat and the trouble can be overcome the next time the engine is started by drawing tight the bolts, as they become warm.

Especially if the engine is new, the doors on the front side of the crank housing should be opened as soon as the engine has stopped and the gudgeon pin bearing and crankpin bearing felt to ascertain that they are not abnormally hot, i. e. so hot that the hand cannot be placed on same. If this should be the case, they should be removed and looked to. Generally these bearings, and especially the gudgeon pin bearing, are then scraped out insufficiently at the sides, which should be remedied; or they have been insufficiently lubricated.

The temperature of the main bearings both of the upper as well as the lower shells and the thrust bearing should be investigated by hand.

The ignition chamber and the top part of the piston are naturally hot when the engine stops. In order to prevent this heat from speading to the cylinder where it is liable to make the piston stick, it is advantageous to allow the circulating water to continue to run, should this be arranged for, until the above mentioned parts of the engine have cooled.

When the engine has stopped, the lubricating devices should be turned several turns by hand so that a plentiful supply of oil reaches each place to be lubricated.

Running Instructions.

When running the following should be observed:

See that the ignition chambers are at the right temperature, that is to say not hotter than what a dark brown colour indicates, and not so cold that poor combustion takes place (see page 22).

Drain the crank housing of waste oil every 4th hour or more often.

Fill up the lubricators and oil cups every second hour and at the same time lubricate all other parts requiring lubrication, including the stuffing box of the propeller shaft.

Make sure every half hour, that the lubricators are working properly and that the sight feeds show the oil being fed to the main and connecting rod bearings.

Every half hour, feel with the hand that the main bearings top and bottom, as also the thrust bearing, are not overheated. Feel the lower part of the cylinder and make sure

that it is not hot. This will show that the piston and gudgeon pin bearing are not hot. Should any bearing be hotter than the others, oil should be pumped to it by hand until it is cool. If in spite of extra oil the bearing remains hot, the engine shold be stopped and the trouble investigated.

Feel, every half hour, the water jackets of the cylinders, the cylinder heads and the cooling housings on the ignition chambers. If they are not as cool as they should be, the cooling water is not circulating as it should do. This must be investigated (see page 42).

Make sure every half hour that the cooling water around the injection device in the ignition chamber is circulating properly, so that the apparatus does not become too hot. If the water is not circulating, this goes to show that air or steam has accumulated in the coolinghousing on the ignition bulb and must be liberated by opening the air valve on this.

If in a multi-cylinder engine one cylinder becomes hotter than the other, this can depend upon the cylinder in question receiving less cooling water than the other. The handle of the distributing cock, which should normally stand vertically downwards, could then for the time being be moved towards the hotter cylinder, whereby this cylinder will receive more cooling water and the other cylinder less. As soon as both cylinders have the same temperature, the handle of the cock should be returned to its correct normal position pointing downwards.

Cleaning the Engine.

It is important that the engine from time to time is cleaned, especially when it is new, and the first cleaning should not be delayed later than after about one month's running. At the same time the bearings and other moving parts are examined and if necessary adjusted.

A thorough cleaning should take place one or twice a year, depending upon the kind of fuel and lubricating oil used and the care and attention given the engine.

Apart from the above, about every third or fourth mouth, and more frequently if an inferior fuel is used, the piston should be taken out and cleaned together with the cylinder, crank-housing and silencer. When drying the inside of cylinders,

crank-housings and lubricators, old pieces of cotton cloth should be used, never cotton waste, as the latter does not hold together and threads of same are liable to clog up oil holes piping, etc. When the piston is to be taken out, the ignition chamber and cylinder cover must first be removed. The soot deposited in the upper part of the cylinder is scraped away, the piston having first been covered so that nothing can fall between same and the cylinder walls. The doors of the crank-housing are removed and the crank pin bearing taken apart. The eye bolt for lifting the piston is screwed into same and the piston is screwed into same and the piston is carefully lifted out of the cylinder. When doing this care should be taken to see that the top half of the crankpin bearings remains on the crankpin, which is thereby safeguarded from scratches made by the bearing bolts. Attention must also be given so that the cylinder walls and piston are not scratched. The piston rings are removed and cleaned. When removing these rings the greatest care must be taken so that they are not broken or deformed. If they are stuck fast in their grooves they should be loosened up with paraffin (kerosene). The grooves for the rings are scraped clean. When the rings are put back in place again, each ring must be put in the same groove that it was taken from. If due to heat, hard patches appear on the piston, these should be ground down with a hone. These patches are recognized by their polished apperance and the harness can be tested with a file.

The exhaust passage in the cylinder is scraped clean. The crank housing and oil ring are washed out with paraffin (kerosene) and dried. The oil hole in the crankpin is flushed out with paraffin (kerosene) and cleaned as described on page 29.

The set screws holding the gudgeon pin are losened after the lockwasher has first been removed, and the gudgeon pin is knocked out from the end having the smallest diameter. When this is being done, the connecting rod should be secured so that it cannot fall against the piston and break it.

If the gudgeon pin bearing or crankpin bearing have worn so that their bearing surfaces are too large, they must be scraped out as described on pages 28 and 29. If the crankpin shows any scratches these should be smoothed off with fine emerycloth.

The ignition chamber and cylinder cover are scraped free from soot. The cleaning cover on the end of the silencer is removed and the silencer cleaned from soot.

When the engine is put together again care must be taken to see that the gudgeon pin is inserted with the bevelled surfaces for the set screws downwards. The piston is inserted with the side having a recess in same, towards the air passage. Before being put together, the gudgeon pin, crankpin, cylinder and piston should be well oiled. When the piston is let down in the cylinder the rings are pressed into the cylinder by the steel shims which are placed between the cylinder and the piston. Care must be taken to see that the ends of the rings fit around the guide pins in the piston.

The lock-washers and split pins for the set screws of the gudgeon pin must not be forgotten, nor must the split pins of the gudgeon pin and crankpin bearing bolts. If these bearings have been filed down at all, the instructions regarding the bolts as given on pages 28 and 29 must be followed.

When putting on the cylinder cover, the bolts should be drawn up evenly, each bolt being drawn up only a little at the time, otherwise strains will be developed in the casting tending to crack same.

Before bolting fast the fuel injection device, it should be taken apart and cleaned with paraffin (kerosene). The fuel oil filter should be cleaned.

At the half-yearly or yearly cleaning, besides the above mentioned parts, the fuel oil pumps, main bearings, lubricators, lubricating piping, the various water jackets, starting air container, circulating water pump, friction clutch, thrust bearing, fuel tanks, lubricating oil tanks and the strainer of the seacock should be cleaned and all parts of the engine inspected and if necessary adjusted and put right.

The fuel pumps are taken apart and cleaned together with the valves. The pins and bolts of the fuel pump device are examined and replaced if found necessary.

The top halves of the main bearings are removed and the lower halves taken out. When doing this, care must be given to see that the lower halves of the two adjacent bearings are not removed at the same time, as the shaft will then sink so

that it will be impossible to put the bearings in again. The lower halves of the bearings are forced up round the shaft by wooden blocks somewhat less in thickness than the bearing itself, these blocks being inserted successively as the lower half of the bearing is forced up. If the bearing surface has become too large, it must be scraped out as previously described. If any of the white metal has become loose, it must be scraped away, the shaft is polished and together with the bearing is washed with paraffin (kerosene). Before the bottom half of the bearing is re-installed, the place where it is to sit must be carefully cleaned. The shaft and bearings must be well oiled before being put together.

The lubricating devices are cleaned with paraffin (kerosene). The oil piping is taken apart and flushed out with paraffin. When putting same in place again they must be filled with oil as described on page 39.

The water jackets of the cylinder, cylinder cover, cooling housing on ignition chamber and silencer are cleaned out. Special care must be given to the cleaning of the cooling housing on ignition chamber and cylinder cover jacket.

The starting air container is cleaned internally with caustic soda as also the piping between same and the engine. Paraffin should not be used for this purpose as an explosion can take place if any remains in the container when same is taken into use again.

The circulating pump is taken apart. The valves are cleaned and re-ground on theier seats with grinding paste. New packing is put in if necessary. If pins and bushings are worn, new ones are fitted.

The friction clutch is taken apart and cleaned with paraffin (kerosene). The clutch must be lifted up together with the thrust bearing before it can be taken apart. To do this, it is loosened from the part attached to the shaft, the thrust bearing is loosened from the bedplate, the intermediate shaft is removed, the clutch is moved aft and at the same time is lifted carefully.

The thrust bearing is cleaned with paraffin (kerosène). If no loose play can be felt in same, it is not necessary to take it apart.

The fuel and lubricating oil tanks are emptied and cleaned with paraffin (kerosene). The fuel oil filter is cleaned.

If the seacock is fitted with strainer inside, this is taken up and cleaned.

If the vessel is to be laid up for the winter, or in any case, the engine not used for a long time, a thorough cleaning such as above described should be given and each part should be well covered with vaseline or thick oil. When laid up, it is advantageous to turn the engine over once or twice a month, attention being given to see that it is stopped in a different position each time. It may happen under unfavourable circumstances that during long interruptions of working, bearing pins and bearing bushings respectively bearing shells for crankshaft and piston are affected by rust. In fact, when the engine has been stopped the bearing surfaces gradually become dry and unprotected against rusting, which partly depends upon draining of the oil having become liquid through the warmth, and partly on evaporation of the oil on the warmest bearing surfaces. The risk of rust is greatest where the engine is exposed to moist air or other corrodent gases. In order to protect the bearings we therefore advise that during long intervals of standstill care be taken to see that the bearings and in particular the needle bearing are always well lubricated. After stopping the engine and preferably when it has coolened it is suitable to pump in an adequate quantity of lubricating oil into the bearings.

When lubricating the needle bearing, see that the working piston is at its lower centre as in this position the oil has a direct passage to the bearing.

The engine should also be turned over at least once a week. The circulating water piping is loosened and care must be taken to see that no water remains in same that can possibly freeze and crack the pipe. The engine should be covered to protect it from dust and dirt.

Before an engine which has been laid up, is started again, it must be cleaned of all vaseline (or oil) and well oiled again. Before starting, turn the engine over a few turns, see further page 39.

The engineer should naturally be present at the yearly official survey of the engine and personally convince himself that everything

is in good order. Should any part require repairing this should be done at once, independent of whether same is desired by the surveyor or not. If any main bearing has run hot during the year previous to the survey, so that the white metal has run, the shaft should be carefully looked to, as it is possible that cracks may have developed in same on account of the lack of support at the bearing in question, due to the white metal having run out.

VI. ENGINE TROUBLES

If the engine is attended to according to the instructions, no troubles need be anticipated. Should such, however, occur, they must be attended to immediately and the cause leading to same discovered, so that a continuation of the trouble can be obviated.

In order to quickly overcome a trouble with the engine, it is important that spare parts and tools are always ready to hand and in good condition.

When any part of an engine is exchanged for a new part, the new part should be carefully compared with the old part in order to see that they are exactly alike. As soon as a new part has been fitted, the engine should be turned over and the working of the new part examined so as to ascertain that it works exactly the same as the old part.

When taking down an engine or any part of same, attention should be given to see how the different parts are marked, as care in this will facilitate the re-erection of the engine and prevent mistakes. Especially in regard to bearings, attention should be given that bearings halves similarly marked should be placed with the sides so marked against one another.

In the following pages we point out the ordinary causes for engine troubles and advise how these troubles can be determined and obviated. Carelessness and want of attention are the causes of many troubles which we are unable here to touch on; but we must once more emphasize that good order and cleanliness prevent most (if not all) troubles in the running of an engine; and that however satisfactory it is to cure a fault, it is better to prevent same from occuring.

1. The engine cannot be turned over.

This is due to the piston being gummed fast in the cylinder, either on account of unsuitable or too much lubricating oil, or on account of incomplete combustion of the fuel due to the use of inferior fuel or too much of it. The piston can be loosened by pouring paraffin (kerosene) between same and the cylinder walls, which should afterwards be wiped dry as much as possible without, however, removing the piston. If there remains much paraffin (kerosene) in the cylinder this may cause the engine to race, when it is started up.

2. The engine cannot be started depends upon:

a. Lack of fuel due to:
Leakage of the fuel pump valves, probably the suction valves, either on account of wear or some impurity which has come between the valve and the seat.
The fuel tank being empty.
A vacuum in the fuel tank due to the absence of an air inlet.
The fuel cock being closed.
The fuel filter being clogged up and requiring cleaning.
The fuel suction piping leaking.

b. The ignition chamber not being hot enough. Sometimes, however, it can happen, that the engine fails to start due to the ignition chamber being too hot.
No fresh attemp to start up the engine should be made before the ignition chamber has been heated further, if not hot enough, as to do this would only chill it off still more. Above all, repeated injections of fuel to the cylinder must be avoided, as these not only chill the ignition chamber, but are liable to cause the engine to race dangerously when it does start.

c. The pressure in the air container not being sufficient.
If there is a leak in the container this should be found and remeided. The air container should be filled with the hand air pump if a power-driven compressor is not available. See page 22.

d. Water entering the cylinder due to the packing between the cylinder and the cylinder cover having given away.

This is shown by the water running down in the crank-housing and out through the drain of the latter.

3. The engine labours and stops of itself depends upon:

a. The engine overloaded which is shown by the ignition chambers being overheated. Very often an overload is due to some bearing running hot. The temperature of the main bearings is therefore examined by touch of hand. In order to examine the crankpin and gudgeon pin bearings, the engine must be stopped, the cover on the front side of the crank housing removed and the bearings felt with the hand. When a bearing has run hot, it should be taken apart, examined and if necessary a spare bearing should be put in instead. Sometime it is only necessary to scrape in the old bearing to good running fit again.

b. The supply of fuel oil stopping. See 2 a.

c. Unsuitable fuel being used whereby the piston gums itself fast. See I.

d. The fuel oil containing water.
Drops of water in the fuel can easily be discerned if a little is poured into the palm of one's hand. To eliminate this water the drain cock of the fuel tank is opened and kept open until all water has run out. The fuel oil piping is pumped through with fuel by the hand pump (see page 39) until no more water can be discovered. An examination should be made to find out if the presence of water is due to a leak in the tank, or whether it was present in the fuel oil when the tank was filled.

e. The presence of air in the fuel pump or fuel piping due to:
The air not being completely eliminated before the engine was started. See page 39.
The fuel being so low in the tank that air can enter the fuel pipe when the vessels rolls or pitches.
The suction piping being leaky.

f. The injection device being partly stopped up. This is possible if same has been overheated due to lack of cooling water. See page 46.

g. A piston has run hot. This, as a rule, makes itself known in time by a groaning noise in the cylinder and is due to:

Insufficient lubrication, or lubrication with unsuitable oil: The lubricating pumps for the cylinder should be examined.

A gudgeon pin bearing has run hot whereby the pin is elongated so that the walls of the piston are pressed outwards.

The circulating water has stopped or the by pass cock is open.

When a piston runs hot it fastens in the cylinder but loosens up generally when cold. It should be lifted out and any high spots which have possibly appeared on it due to the heat should be filed down and polished (see page 47).

4. Knocking in the cylinder is due to:

a. The ignition chamber being too hot whereby pre-ignitions take place. See that the spindle of the injection device is in its correct position (see page 22).
b. Too much fuel is being injected. Knocks or blows could also be due to the flywheel being loose on the shaft.

5. Over-heating of the Ignition Chamber is due to:

a. The injection device spindle not being correctly adjusted (see page 22).
b. Too much fuel being injected that is to say the stroke of the fuel pump is too great.
c. The exhaust pipe being of too small diameter or having too many or too sharp bends.
d. The exhaust piping partly stopped up by soot.
e. The exhaust ports in the cylinder being partly stopped up by soot or hard deposits. This should be removed. As soon as possible the engine should be cleaned as described on page 46.
f. The air damper being closed,
g. Trouble with the circulating water supply.

6. A cold Ignition Chamber due to:

a. No fuel being injected. See 2 a.
b. The fuel containing water. See 3 d.

c. The fuel containing air. See 3 e.
d. The fuel discharge pipe leaking, which shows up at each stroke of the fuel pump.
e. The fuel suction pipe leaking.
f. Deposits of soot or coke in the ignition chamber isolating same from the heat of combustion.
g. Water entering the cylinder. See 2 d.

Sometimes the ignition chamber can be kept hot if it is reheated with the lamp and the damper is closed, but if the engine stops an examination should be made to find out the cause of it stopping.

7. The engine runs unevenly due to:

a. The fuel being injected unevenly. See 3 d and 3 e.
b. Ignition bulb cooling off so that combustion in the cylinder belonging to same does not take place. See 6. This is determined by opening the cylinder blow-off cocks, one at a time.
c. The regulator spring having become loose or having lost its pressure, or the handle of the speed regulating device having turned so that miss-strokes take place.
d. The friction clutch slipping. This is shown by the outer drum becoming warm. The engine should be stopped at once and the clutch drawn up tight. See description of clutch.
e. The propeller being damaged, part of a blade or one entire blade being broken off.

8. Difficulty in reversing can depend upon:

a. Ignition chamber being too cold. See 6.
b. The regulator spring of the reversing pump being too tight or too loose. See page 19 and 20.
c. The fork for reversing (112) running too loose in the groove of the disc (111), so that there is not sufficient friction to lift same. This is due either to too much oil in the groove or that the steel wearing surfaces of the fork are worn out and need replacing.
d. Insufficient fuel is injected or that same contains water or air. See 2 a, 3 d and 3 f.
e. The injection device being overheated so that the fuel is vaporized in same.

9. A smoky exhaust is due to:

a. Overloading the engine. Black smoke.

In order to develop the extra power, more fuel is injected than the engine is intended to take. The combustion will then be incomplete as the amount of air in the cylinder is insufficient to burn more than a given quantity of fuel, corresponding to the amount used when developing the guaranteed power of the engine. A moderate overload can be allowed however for short periods.

b. Too liberal lubrication of the cylinder. Black smoke.

c. Ignition chambers being too cold. Light smoke. See 6.

d. Insufficient compression in the cylinders due to the piston rings having fastened in their grooves. Shown by the presence of smoke in the crank housing, which is blown out if one of the air valves is held open by a finger.

e. Waste oil not being drained from the crank-housing and being carried up with the air into the cylinder. See page 30.

A smoky exhaust should be avoided as it is a sign of incomplete combustion, which leads to the cylinder and piston being dirtied making repeated cleaning necessary.

10. The engine races.

In this case immediate action is necessary if the engine is to be saved from destruction and serious accidents avoided. The safest plan is to throw the friction clutch into gear and shut the air damper. The engine will then slow down or at least will not increase its speed. The engine can then be stopped in the usual way (see page 44) or by closing the fuel cock. For engines fitted with reversible propeller blades the blades should always be set for full speed ahead as far as this is possible, when the machine is started. If for any reason it is not possible to throw the clutch into gear, the fuel cock and the air damper should be closed. When the engine has stopped it should be examined to see if it has been damaged in any way, and also to find out the cause of the engine racing. This can be due to:

a. When starting, too much fuel has been pumped in (see page 41).

b. Crank-housing not being drained of waste oil (see page 30).

c. The regulator spring being too tight. See page 12.

d. The reversing pump pumping in fuel for some reason, generally due to the ebonite washer being worn too much or broken off. Or due to faulty adjustment some part of the regulator weight strikes the reversing pump making an injection in spite of the regulator making a miss-stroke.

e. The propeller coming out of the water in heavy weather. In this case the engine will only race if the regulator spring is .too tight. If it is adjusted properly the engine will make a miss-stroke at a speed slightly above the normal. See page 12.

11. Leaky Packing on the Injection Device occasions smoke in the engine room and should at once be attended to by putting in a new packing. No attempt should be made to make the joint tight by drawing up te flange bolts tighter as the flange can hereby be damaged. Before a new packing is inserted, the seat for same should be scraped clean both on the ignition chamber as well as on the injection device. The lower side of the packing should be given a coat of graphite (blacklead).

12. Overheating of the cylinder is due to insufficient or entire lack of cooling water caused by:

a. The seacock not having been opened.

b. The strainer of the seacock needing cleaning. See page 42.

c. Leaky circulating pump valves due to dirt having come between the valves and seatings or that they have become hung up, or are worn. Sometimes the pump can recover its suction if the air chamber is removed, the discharge valves lifted and the valve-housing filled with water, after which the discharge valves and air chamber are put back in place again. This should not be tried if the cylinder has already become dangerously hot, as in this case the engine should be stopped at once to avoid damage. If it is necessary to take out the valves to clean them or grind them in if they are worn, the seacock should always be closed before the air chamber is removed.

d. The distributing cock between cylinders (on a multi-cylinder engine) being so adjusted that one of the cylinders receives too little water.
e. The by-pass valve being open so that not all the cooling water passes through the cylinder jackets.
f. The suction piping of the circulating water being leaky.

13. The bearings or pistons running hot.

This is shown by the engine working heavily and slowing down. See 3 a and 3 g.

The heating is due to:

a. The lubricating device being empty.
b. The lubricating device needing cleaning.
c. The lubricating device having stopped for one reason or another.
d. Too small quantity of lubricating oil going to the engine.
e. Dirt or water in the bearings. If the packing of the cylinder cover leaks, it happens sometimes that the water running down the outside of the cylinder gets into the main bearings and washes away the oil. When the engine is not running rust forms on the shaft which causes the bearing to run hot.
f. An oil pipe being damaged so that it either leaks or has been crushed when oil will not pass through the pipe; or it can happen that a union on the piping is not drawn tight so that the oil leaks out.
g. An unsuitable lubricating oil being used. See page 9.

14. Thrust bearing running hot.

This is due too:

a. Lack of lubrication oil.
b. The bearing-housing requiring cleaning. See page 33.
c. Water in the bearing housing.
d. Unsuitable lubricating oil being used. See page 9.
e. The wicks (on engines fitted with wick oilers) not being in position or the wicks being dirty so that they will not draw up the oil. See page 33.

15. Air blows out of the crank-housing at the main bearings.

The result of this is that the lubricating oil is blown out of the bearings on account of the packing rings leking due to:

a. The rings not being properly adjusted to the crank-housing when the engine was erected.
b. The packings (if used) against the shaft being worn out or destroyed.

In both the above cases the engine must be dismantled and the crank-housing removed. Before lifting the crank-housing, the nozzle for the crankpin lubrication must be removed, as it will otherwise catch in the oil ring and damage same. Care should also be taken to see that the pipe carrying oil from the nozzle to the oil ring is not damaged, and before the crank-housing is put in position again make sure that this pipe is screwed fast in place and that its lower end lies in the oil ring. With the help of marking colour it is seen whether it is necessary to scrape in the packing rings, as these latter must make contact both in the upper as well as the lower part of the housing when the same is bolted in position. When the housing is in position an examination must be made to see that the above mentioned pipe has not been moved, and that the nozzle (230) leads into the middle of the bowl at the upper end of the pipe (see page 30).

c. The packing rings lying unevenly. This can, as a rule, be rectified without removing the crank housing by cautiously tapping them from the inside with the handle of a hammer or something similar.

16. Troubles with the friction clutch.

These can consist of:

a. The clutch slipping. This is shown by the outer drum becoming warm. The engine should be stopped at once and the clutch tightened up as described on the instruction sheet for the clutch. Under no circumstances must any substance be introduced into the clutch to prevent the slipping.
b. Knocking, especially at slow speed. The driving shoulder of the friction band or the groove for the shoulder being worn. The clutch should be taken apart and steel plates fitted to fill the groove in place of the worn shoulder. See also special description and instructions.

17. **Knocking and blows in the circulating water pump** are due to the want of air in the air chamber. The snifting valve (when fitted should be opened somewhat and closed when the noises cease. It should as a rule however stand a trifle open. A broken valve spring can sometimes cause knocking especially if the pump is located considerably under the level of the water. In order to fit a new spring, the engine must be stopped and the seacock closed.

18. **Air valves leaking.**

This is shown by the air blowing out through the air valve and is due to:

a. A broken valve. The engine should be stopped as soon as possible and a new valve inserted. Should it be impossible to stop the engine, the opening in the valve seat can temporarily be stopped up with a piece of board or other suitable material, as sufficient air will be drawn in through the other valves.
b. Rusty or dirty air valves.

VII. INSTALLATION OF THE ENGINE IN A VESSEL

Before the work of installing an engine can be commenced the engine bearers must be ready, the stern tube and the propeller shaft in place. The engine should therefore not be unpacked before the above mentioned work is done, but should be stored under roof and otherwise well protected from rain and damp.

Unpacking the engine.

The case must be opened with care, and crowbars or other tools not forced in farther than is absolutely necessary as otherwise some part of the engine can easily be damaged. The cases should be opened from the right side, that is to say commence with the top of the case, and remove each part of the engine with care.

When an engine is unpacked, the contents of each case should be compared with the packing list to make sure that every part has been taken from the case. As soon as the parts of an

engine have been unpacked, they should be cleaned, and if they are not to be used immediately, they should be stored in a location well protected from damp or damage, and the bright parts should be covered with oil or grease.

When lifting the heavier parts of the engine care should be given to see that the slings used do not crush or bend out of shape any of the more delicate parts. When crankshafts are lifted, especially those for 4-cyl. engines, the slings must be placed so that no bending strains are induced in the shaft. If the shaft is to be stored mounted on wooden chocks these must be placed with great care for the same reason.

The location of the engine.

The engine should be placed as low down in the vessel as possible. It is usual for the centre line to fall somewhat towards the stern, this fall however should not exceed 1 in 10. Preferably the centre line of the engine should be parallel with the water-line.

Engine bearers or seating.

The smooth running of the engine, its reliability and durability, are dependent in the most eminent degree upon the strength of the bearers and the care taken in connecting same to the hull of the vessel. This connection should be so complete that the bearers can be regarded as an integral part of the hull. In a new vessel therefore the engine bearers should be built in at the same time as the hull is built and in old vessels stiffeners, especially transversal, can be put in where necessary.

The bearers should be made as long as possible, especially for vessels lacking stiffness. The engine is often installed in the stern and it is then impossible to extend the bearers as far aft as is desirable. In such a case the bearers should be sturdily attached to a heavy floor at the aft ends or to a bulkhead. In twin screw vessels, with the engines placed in the stern, the outher bearers often run aft to nothing, and it is therefore necessary to attach them strongly to a floor or frame, as also to the inner bearers, in order to obtain sufficient strength. Forward, the bearers should be drawn to the engine room bulkhead.

Engine bearers in steel vessels.

For steel vessel, the engine bearers should preferably reach from bulkhead to bulkhead in the engine room. The bearers should be connected both to each other as well as to the hull and should extend down to the bottom of the vessel. All connections should be made by rivetting, not with screws or bolts.

Fig. 17 and 18 shows examples of a suitable construction of engine bearers in vessels of steel—Fig. 18 is recommended if the flywheel can not get sufficient space between the longitudinal plates A in fig. 17. Those constructions can also be used for vessels which were not originally built for engine power, the only difference being that the entire construction must be built on the existing floors and keelson. In order to obtain sufficient strength, especially if the bearer girders are very low, it is advantageous to connect same by a vertical plate to the hull between each floor.

The table on the next page gives the approximate dimensions for engine bearers of the above construction.

Between the bearers and the engine bedplate, space could be left for packing strips of wood according to the dimensions given in the tables, and the bearers made correspondingly lower. At each holding down bolt the packing strip is cut away to accommodate an iron washer.

Engine bearers in wooden vessels.

In wooden vessels the engine bearers must be made as long as possible. This is especially important in vessels lacking stiffness. Just as for steel vessels, the bearers must be well stayed transversely and strongly fastened to the hull. There should be a transverse stay at each frame. The bearer bolts should be through going and have large rounded heads on the outside of the planking. Fig. 18 shows the general construction of the engine bearers in wooden vessel and the table gives the approximate dimensions for same.

Engine bearers for twin screw vessels.

When installing two engines in a vessel the construction of the bearers both for steel as well for wooden vessels will be as previously described, but the two seatings must be inter-connected in the same manner as they are connected the hull of the vessel.

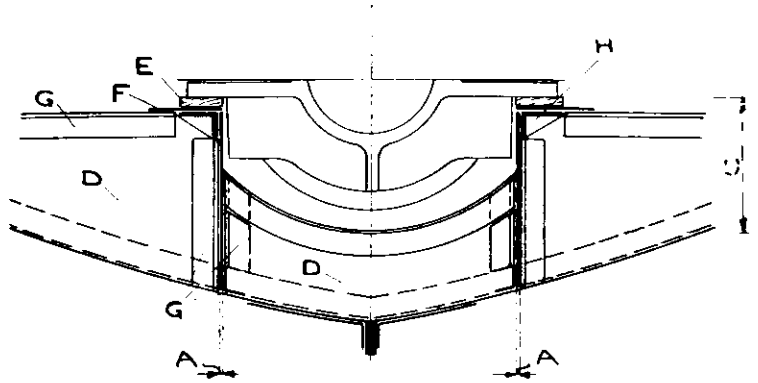


Fig. 17.

Engine bearers in steel vessels.

Type of Engine	No. of Cyl.	Dimensions in inches A	D	E	F	G	H
B 15	1	1/4	3/16	5/8 × 3 1/4	1/4 × 5 1/2	1 5/8 × 1 5/8 × 1/4	3 × 2 × 5/16
	2	1/4	3/16	5/8 × 3 1/4	1/4 × 5 1/2	1 5/8 × 1 5/8 × 1/4	3 × 2 × 5/16
	4	5/16	1/4	5/8 × 3 1/4	5/16 × 5 1/2	1 3/4 × 1 3/4 × 5/16	3 × 2 × 3/8
B 20	1	5/16	3/16	13/16 × 3 1/4	5/16 × 5 1/2	2 × 2 × 5/16	3 × 2 × 3/8
	2	5/16	3/16	13/16 × 3 1/4	5/16 × 5 1/2	2 × 2 × 1/4	3 × 2 × 3/8
	4	5/16	1/4	13/16 × 4 5/16	5/16 × 6 3/4	2 1/4 × 2 1/4 × 1/4	4 × 2 5/8 × 3/8
B 25	1	5/16	3/16	13/16 × 4 5/16	5/16 × 6 3/4	2 × 2 × 5/16	4 × 2 5/8 × 3/8
	2	5/16	3/16	13/16 × 4 5/16	5/16 × 6 3/4	2 × 2 × 5/16	4 × 2 5/8 × 3/8
	4	5/16	1/4	13/16 × 4 5/16	5/16 × 6 3/4	2 1/4 × 2 1/4 × 1/4	4 × 2 5/8 × 3/8
B 30	1	5/16	1/4	13/16 × 4 5/16	5/16 × 6 3/4	2 1/4 × 2 1/4 × 5/16	4 × 2 5/8 × 3/8
	2	5/16	1/4	13/16 × 4 5/16	5/16 × 6 3/4	2 1/4 × 2 1/4 × 5/16	4 × 2 5/8 × 3/8
	4	3/8	5/16	1 × 5 1/8	3/8 × 7 1/8	2 5/8 × 2 5/8 × 5/16	4 3/4 × 3 1/8 × 3/8
B 40	1	3/8	5/16	1 × 4 5/16	3/8 × 6 3/4	2 5/8 × 2 5/8 × 3/8	4 × 2 5/8 × 7/16
	2	3/8	5/16	1 × 5 1/8	3/8 × 7 1/8	2 5/8 × 2 5/8 × 3/8	4 3/4 × 3 1/8 × 3/8
	4	3/8	5/16	1 × 5 1/8	3/8 × 7 1/8	2 5/8 × 2 5/8 × 3/8	4 3/4 × 3 1/8 × 3/8
B 50	1	3/8	5/16	1 × 5 1/8	3/8 × 7 1/8	2 5/8 × 2 5/8 × 3/8	4 3/4 × 3 1/8 × 1/2
	2	3/8	5/16	1 × 5 1/8	3/8 × 7 1/8	2 5/8 × 2 5/8 × 3/8	4 3/4 × 3 1/8 × 1/2
	4	7/16	3/8	1 × 6 1/2	7/16 × 9 1/2	3 1/8 × 3 1/8 × 3/8	5 7/8 × 4 × 1/2
B 60	1						
	2						
	4	1/2	7/16	1 × 7 7/8	1/2 × 9 1/2	4 × 4 × 1/2	8 × 4 × 9/16

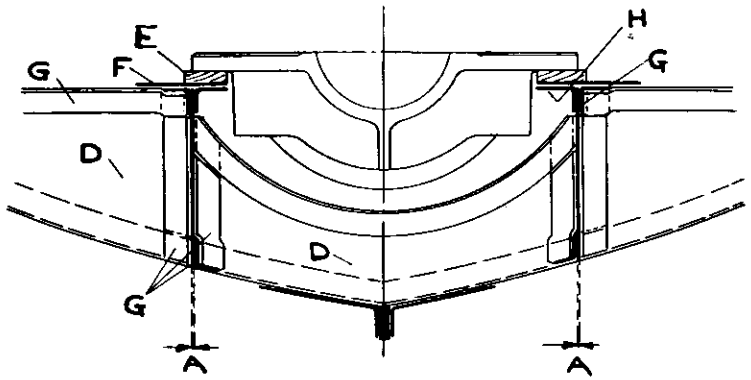


Fig. 18.

Engine bearers in steel vessels.

Type of Engine	No. of Cyl.	Dimensions in inches A	D	E	F	G	H
B 3	1	1/8	1/8	1/2 × 3	1/8 × 4 3/4	1 1/4 × 1 1/4 × 5/32	1 3/4 × 1 1/4 × 5/32
	2	1/8	1/8	1/2 × 3	1/8 × 4 3/4	1 1/4 × 1 1/4 × 5/32	1 3/4 × 1 1/4 × 5/32
B 5	1	5/32	1/8	1/2 × 3	5/32 × 4 3/4	1 5/8 × 1 5/8 × 5/32	2 3/8 × 1 5/8 × 3/16
	2	5/32	1/8	1/2 × 3	5/32 × 4 3/4	1 1/4 × 1 1/4 × 5/32	1 3/4 × 1 1/4 × 5/32
B 7	1	5/32	1/8	5/8 × 4	3/16 × 6 1/4	1 5/8 × 1 5/8 × 5/32	2 3/8 × 1 5/8 × 3/16
	2	5/32	1/8	5/8 × 4	3/16 × 6 1/4	1 5/8 × 1 5/8 × 5/32	2 3/8 × 1 5/8 × 3/16
B 9	1	3/16	5/32	5/8 × 4	3/16 × 6 1/4	1 5/8 × 1 5/8 × 3/16	2 3/8 × 1 5/8 × 3/16
	2	3/16	5/32	5/8 × 4	3/16 × 6 1/4	1 5/8 × 1 5/8 × 1/4	2 3/8 × 1 5/8 × 5/16
B 12	1	3/16	5/32	3/4 × 5	3/16 × 7 1/2	2 × 2 × 5/16	3 × 2 × 5/16
	2	3/16	5/32	5/8 × 4	3/16 × 6 1/4	1 5/8 × 1 5/8 × 1/4	2 3/8 × 1 5/8 × 5/16
B 15	1 2 4	1/4	3/16	3/4 × 5	1/4 × 8	2 × 2 × 5/16	3 × 2 × 5/16
B 20	1 2 4	5/16	3/16	3/4 × 5	5/16 × 8	2 × 2 × 5/16	3 × 2 × 5/8
B 25	1 2 4	5/16	3/16	3/4 × 5	5/16 × 9	2 × 2 × 5/16	4 × 2 5/8 × 3/8
B 30	1 2 4	5/16	1/4	3/4 × 5	5/16 × 9	2 1/4 × 2 1/4 × 5/16	4 × 2 5/8 × 3/8
B 40	1 2 4	3/8	5/16	1 × 5	3/8 × 9	2 1/4 × 2 1/4 × 5/16	4 × 2 5/8 × 3/8
B 50	1 2 4	3/8	5/16	1 × 5	3/8 × 10	2 5/8 × 2 5/8 × 3/8	6 × 4 × 1/2
B 60	4	1/2	3/8	1 × 5	1/2 × 12 3/4	4 × 4 × 1/2	8 × 4 × 9/16

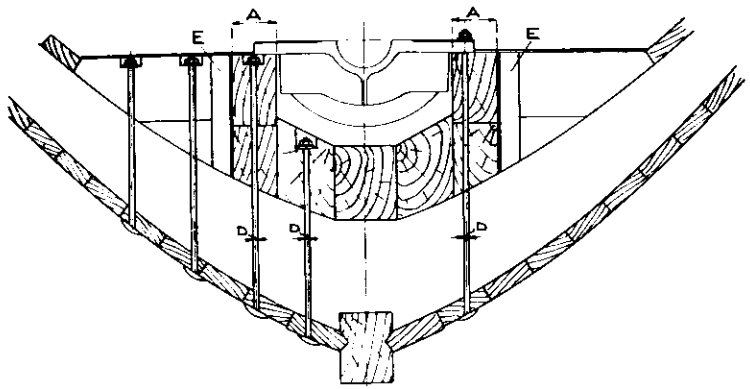


Fig. 19.

Engine bearers in wooden vessels.

Type of Engine	No. of Cyl.	Dimensions in inches A	D	E (angle iron)
B 15	1	5 7/8	3/4	1 5/8 × 1 5/8 × 1/4
	2	5 7/8	3/4	1 5/8 × 1 5/8 × 1/4
	4	5 7/8	3/4	1 3/4 × 1 3/4 × 5/16
B 20	1	5 7/8	1	2 × 2 × 5/16
	2	5 7/8	1	2 × 2 × 5/16
	4	5 7/8	1	2 1/4 × 2 1/4 × 1/4
B 25	1	7 7/8	1 1/8	2 × 2 × 5/16
	2	7 7/8	1 1/8	2 × 2 × 5/16
	4	9 3/4	1 1/8	2 1/4 × 2 1/4 × 1/4
B 30	1	7 7/8	1 1/4	2 1/4 × 2 1/4 × 3/8
	2	7 7/8	1 1/4	2 1/4 × 2 1/4 × 5/16
	4	7 7/8	1 1/4	2 5/8 × 2 5/8 × 5/16
B 40	1	7 7/8	1 3/8	2 5/8 × 2 5/8 × 3/8
	2	7 7/8	1 3/8	2 5/8 × 2 5/8 × 3/8
	4	7 7/8	1 3/8	2 5/8 × 2 5/8 × 3/8
B 50	1	9 3/4	1 3/8	2 5/8 × 2 5/8 × 3/8
	2	9 3/4	1 3/8	2 5/8 × 2 5/8 × 3/8
	4	9 3/4	1 1/2	3 1/8 × 3 1/8 × 3/8
B60	1			
	2			
	4	13 3/4	2	4 × 4 × 1/2

The propeller bracket.

For twin screw vessels, special attention should be given to the propeller brackets so that they are located exactly in line with the stern tubes. If these brackets are not strongly attached to the hull, vibration will result, which in a short time, will destroy the shafts.

The stern tube.

When fitting the stern tube, care should be taken to see that it makes a tight joint at the sternpost On steel vessels, red lead is used for packing the joint and in wooden vessels tow with red lead or tar.

The propeller and propeller shaft.

When the stern tube has been placed in position the propeller shaft is put in and the propeller fitted. This latter must fit the taper of the shaft and the key perfectly and is secured tight in position, the nut of the propeller being carefully locked fast. The stern tube packing box is packed with a grease packing and drawn up only fairly snug after which the stern tube is filled with lubricating grease with the help of the grease cup provided and should be kept well filled at all times. Very long stern tubes are more suitably lubricated with heavy oil.

The drip Tray.

Before the bedplate is put in position a tray of zinc, copper or galvanized sheet steel is placed underneath same to catch the drip oil from the main bearings and clutch. The tray should slope downwards aft and at the lowest point be furnished with a drain cock,

The drain cock for the crank-housing (and main bearings when fitted with drain cocks) must also be placed in position before the bedplate is laid down.

Lining up the bedplate.

If an intermediate shaft is used, this should be bolted to the propeller shaft, the bedplate placed in position and the crankshaft, clutch and thrust shaft laid in their bearings.

It is of utmost importance for the good running and reliability of the engine that the bedplate be lined up with all possible care. A fault in this respect will result in bending strains in the crank-shaft or thrust shaft which will lead to heating and possibly the breaking of the crank or propeller shaft. Even if it is

impossible to get the bedplate lined up correctly at the first attempt, it is of no use losing patience, and the work must not be considered accomplished before the bedplate is fast secured in place with the crank shaft laying evenly in all its bearings and its centre line coinciding with that of the propeller shaft.

If the thrust shaft and propeller shaft (or intermediate shaft) are flanged, blade feelers are used to find out whether the surfaces of the flanges are strictly parallel with one another. Care is taken too see also that the one flange does not overlap the other at any point. If the distance is considerable between the thrust shaft and the nearest shaft bearing for the propeller or intermediate shaft, these shafts will hang somewhat too low on account of the weight of the shafts. The end of the shaft should therefore be raised by about the same force corresponding with the weight of half the shaft between the bearing in question and the end of the thrust shaft. If the flanges do not come together exactly true, the bedplate must be lined up so as to accomplish this and bring the crankshaft and propeller shaft in correct alignment. Adjusting the bedplate in regard to height is done by means of the washers and packing strips under same, which are filed and planed off if the bedplate lies too high. These washers and strips must be fitted vere carefully. If the shaft ends are plain and intended for sleeve couplings, a steel straight edge and blade feelers are used to determine whether the shafts are in correct alignment. When the bedplate is in correct position, the bolts holding same should be drawn tight, taking care to draw each bolt only a little at the time, so that an even pressure is extended on the bedplate. When all the bolts have been drawn up tight, a further examination is made to see that the shafts are in correct alignment. Should it be found that this is not the case, the bolts must be loosened up and a further adjustment of the washers and packing strips made. The frection clutch must naturally be in gear when the bedplate is lined up so that the crank shaft and thrust shaft form one piece. In the event of the free end of the thrust shaft waving somewhat when, with the friction clutch thrown in the engine is turned over, care must be taken to see that the mean position of the centre line of the thrust shaft must coincide with the centre line of the propeller and intermediate shafts. Adjustment therefore should be made for each quarter of a revolution.

When the washers are filed off or planed, care should be taken to see that the packing strips are decreased correspondingly in thickness.

Index to illustrations fig. 20, 21 & 22.
(Pages 69—71).

No.	Name	No.	Name
1	Starting Air Container	30	Hold bilge pipe
2	Pipe to Starting Valve	31	Strainer for bilge pipe
3	Fuel Tanks	32	Bilge discharge from pump (standard)
4	Pipe between tanks		
5	Pipe to fuel filter	33	Oil Engine driving fire & bilge pump
6	Fuel filter		
7	Pipe to fuel cock holder	34	Suction pipe for ditto
8	Fuel cock holder	35	Seacock
9	Cock with hand pump	36	Circulating water suction pipe for pump unit
10	Fuel pipe for pump unit		
11	Bearing oil tank	37	Cock
12	Cylinder oil tank	38	Circulating water discharge from pump unit
13	Paraffin (kerosene) tank		
14	Methylated Spirit tank	39	Discharge pipe from fire and bilge pump
15	Filling pipe for tanks		
16	Deck connection to filling pipe	40	4-way cock
		41	Discharge pipe to fire hydrant
17	Air pipe for the tanks		
18	Drip tray under tanks	42	Bilge discharge
19	Oil can bracket	43	Pipe to circulating water system on main engine
20	Circulating water pump		
21	Circulating water suction pipe	44	Check valves
		45	Drain cocks
22	Seacock	46	Pipe to hand fire pump
23	Circulating water discharge	47	Pipe to hand bilge pump
24	Bilge pump (standard)	48	Exhaust pipe from main engine
25	Suction pipe for ditto		
26	Three-way cock	49	Ditto from pump unit
27	Mudbox for bilge piping	50	Beam for lifting tackle
28	Valve housing	51	Grease cup for sterntube
29	Engine room bilge pipe		

The above numbers are not to be used when ordering spare parts. See special catalogue with list of spare parts.

Fitting in the crankshaft.

When the bedplate has been finally drawn up tight in position, the main bearings are rubbed over with marking colour and after the shaft has been turned over a few times it lis lifted up to see whether it has a proper bearing in each bearing shell.

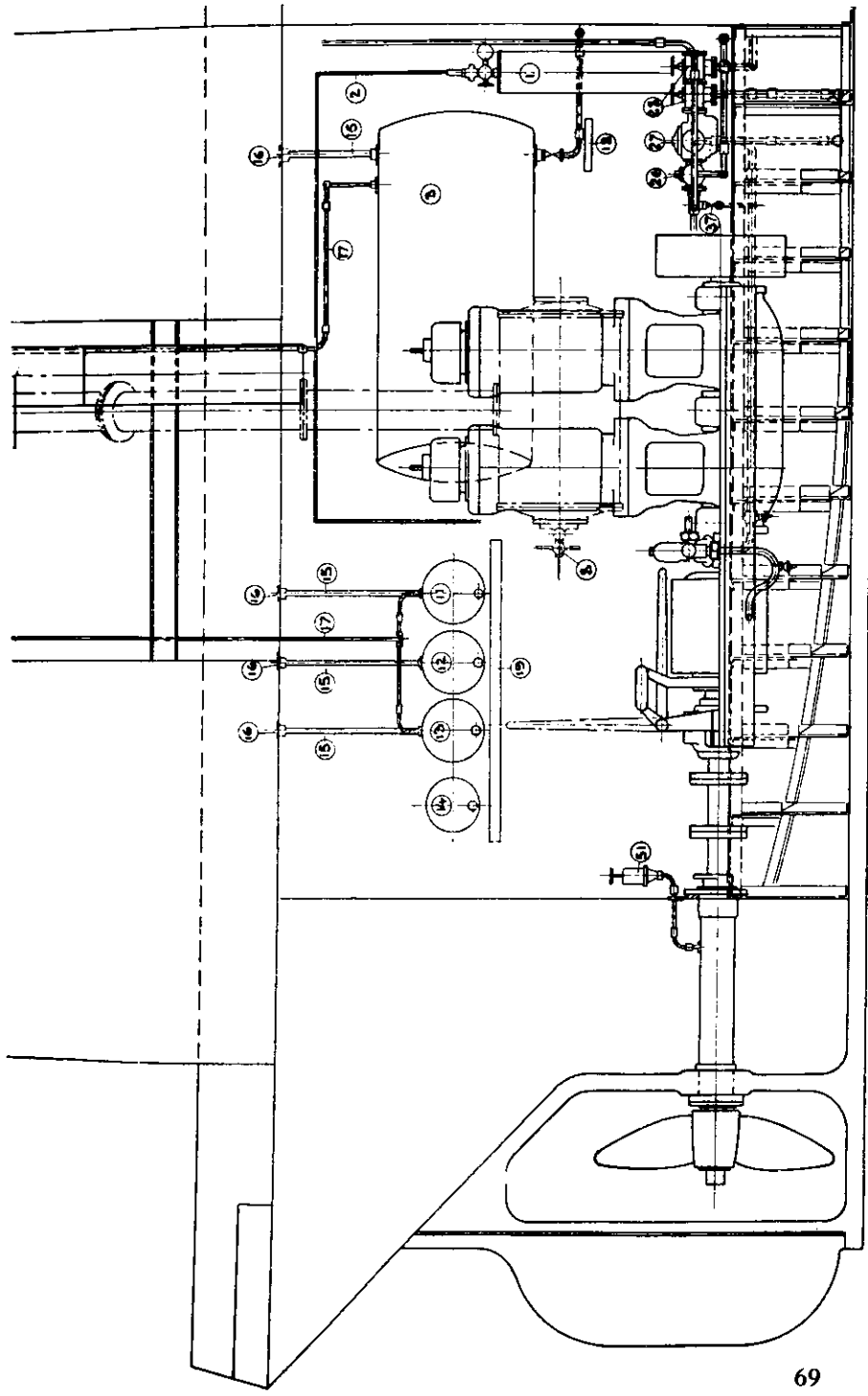


Fig. 20.
The above numbers are not to be used when ordering spare parts. — See special catalogues with list of spare parts.

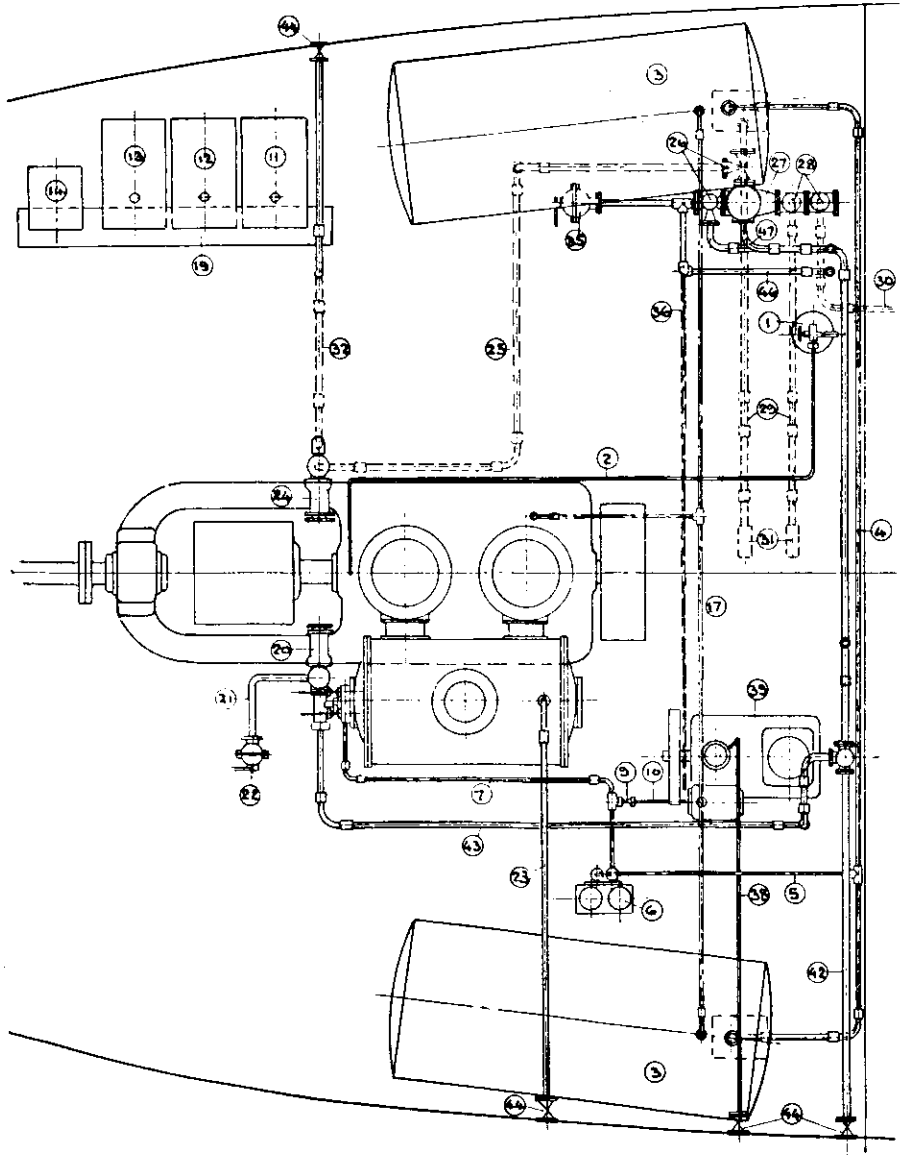


Fig. 21.

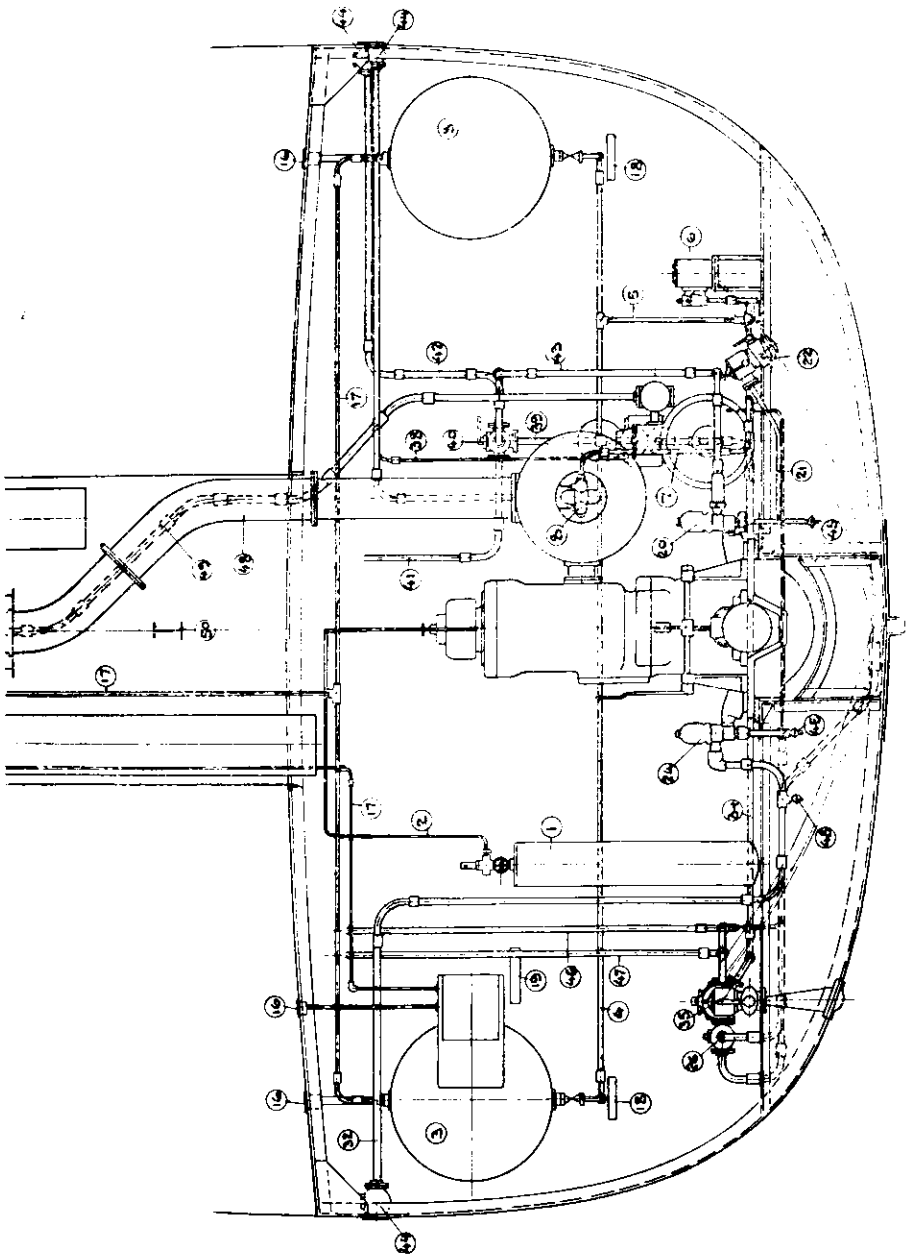


Fig. 22.

The above numbers are not to be used when ordering spare parts. — See special catalogue with list of spare parts.

If the shaft shows that it does not make contact in one of the bearings, this is due to the washers at that point being too thin so that the bedplate has been deflected when the bolts were drawn up tight. This trouble is remedied by inserting somewhat thicker washers. It can also happen that the washers on either side or on one side of a bearing are too thick whereby the bedplate is deflected upwards and the shaft lies heavier in this bearing than in the others. In this case the washers must be reduced in tickness. If after adjusting these washers the shaft still shows sign of lying somewhat too hard in any particular bearing, this latter can be scraped out a trifle. This work should be done very carefully however, as if too much is taken from the bearing in question it will be necessary to scrape all the other bearings also to the same hight. When this is done there is always a risk of bending moments in the thrust shaft and it becomes necessary to raise the bedplate. This must be looked to.

When the shafts has been finally adjusted to the bearings, a further examination must be made to see that the crankshaft and thrust shaft are in correct alignment with each other, and if everything is all right the shafts should be coupled together. If the shafts are provided with flanges, the bolt holes in same should be reamed out together, if this has not already been done, and turned bolts to exact size, used.

The above described lining up of the bedplate and shaft should be done when the vessel is afloat, as the hull always changes form when it is launched and if the above work has been done previously to the launching of the vessel, it will in most cases be necessary to go over the whole procedure again when the vessels is afloat.

Installation of the Engine.

When erecting the engine the precautions already referred to and instructions given concerning the different parts must be followed. Each part must be thoroughly clean and well oiled before being erected in position.

The Fuel Tanks.

The size of the fuel tanks depends naturally upon the size of the engine and the lenght of time the engine is required to run

on the capacity of the tanks. If there is sufficient space, the tanks are most suitable made cylindrical, but for vessels making long voyages and consequently in need of large tanks, they must be made to fit the form of the vessel and to be located where space can be found for them. A suitable positon is on either side of the engine room. They must be very well secured and well supported. In new steel vessels the tanks are generally built together with and at the same time as the hull. Fig. 22 shows a suitable location for the tanks as also for other details connected with the installation.

The tanks should be made of plate of ample thickness and must be carefully welded or rivetted and caulked. Internally they must be fitted with several wash plates. Test cocks must be fitted so that the approximate height of the oil in the tank can be ascertained. Each tank must be furnished with a stop cock on the fuel pipe line which should be located at least 4" above the bottom of the tank, in order to prevent the dirt etc. which settles at the bottom, being carried through the fuel pipe. If the cock is placed at the bottom of the tank, it should be fitted with a piece of pipe reaching up at least 4" above the bottom on the inside. A manhole for cleaning purposes should be furnished, also a plug in the bottom for draining off the tank. The tanks should be connected by piping and cocks one to the other, so that fuel can be taken from any of them, or the contents of one tank led to any of the others. Each tank should be provided with a ventilating pipe leading to the atmosphere, for example on deck. The tanks are filled from the deck. The pipe for filling the tanks should not be less than 2" internal diameter and should be fitted with a removable strainer. If the fuel tanks contain any water, this should be removed before the tanks are filled with fuel oil.

Daily Service Tank.

If the fuel tanks are not located at the same height as the fuel pumps on the engine, a daily service tank must be provided. This should have a capacity of from 6 to 8 hours running and must be located so that the bottom of same comes on the same level as the engine fuel pumps (in case of necessity, a trifle lower).

If this tank is placed in a higher position there is the risk of the fuel seeping through the fuel pump valves on account of the pressure. The high level of the oil should not lie higher than the oil pipe at the injection devices. The daily service tank must be provided with test cocks, ventilating pipe and drain cock at the bottom. The fuel cock should be located from 3" to 4" above the bottom of the tank.

This tank is filled by a pump which is preferably machine driven if there is electric current on board. A hand pump in reserve should however always be provided.

The Fuel Oil Filter.

A filter must be provided in the pipe line between the daily service tank and the engine. The upper part of the filter should be at a somewhat lower level than the bottom of the tank. Preferably a double filter should be fitted so that it can be cleaned when necessary, even while the engine is running.

The Fuel Pipe Line.

All fuel piping should be well protected and drawn at a slight incline upwards, so as to avoid air locks, which must not exist.

Preferably drawn copper piping is used, the joints being made with unions having cone seatings metal to metal. All brazing must be made with the hardest solder for bronze. If iron piping is used, care must be taken to see that all the joints are made absolutely tight. Only black iron pipe should be used, not galvanized.

The Lubricating Oil Tank.

The lubricating oil tank should have a capacity of about 5 % of that of the fuel tanks. It should be placed in an accessible position in the engine room and on larger vessels should be filled from the deck. When two different kinds of lubricating oil are used, each tank should be plainly marked giving the kind of oil it contains. A drip tray should be placed under the tanks.

Every tank in the engine room must be clearly marked stating what it contains, and be fitted with a sight glass or test cocks.

The Circulating Water and Bilge Piping.

The circulating water and bilge piping is preferably made of copper; but galvanized iron piping can be used. The dimensions of this piping is given on the installation drawings. The seacock should be placed on the round of the bilge. If it is placed right under the hull, mud and sand will be drawn up in shallow water and if it is placed too high up the side of the vessel, it will at times be uncovered when the vessel rolls. There must be no stop valve on the discharge piping, but only a check valve at the outlet. This outlet should be placed as high up the side of the vessel as possible.

The suction pipe of the bilge pump should go to the lowest point in the hull, and should be fitted with a strainer which must be accessible for cleaning. The bilge discharge should be arranged the same as that of the circulating water. Both circulating water and bilge piping must be arranged so that they can be completely drained when necessary to prevent damage by freezing.

The Exhaust Piping.

The exhaust piping should preferably be drawn straight up from the silencer free from any turns or bends. It should be made of steel or iron pipe and furnished with suitable means for hanging or supporting same, so that the weight is not borne by the silencer. If bends are necessary, they must be made long and easy as they will otherwise cause back pressure, diminishing the effect of the engine. If the exhaust exceeds 3 metres in lenght it should have a greater internal diameter than that given on the installation drawing. A long exhaust pipe must not be fastened at the upper end unless fitted with an expansion box or other device, to accommodate the expansion and contraction due to the changes in temperature.

The exhaust pipe is suitable led out into the funnel, which can be used as an auxiliary silencer, in which case the exhaust pipe should reach up in same about 1 metre (40 inches) over the level of the deck. The foot of the funnel should be furnished with a draincock for draining off the water.

If the exhaust pipe is carried right out abeam or astern the pipe should incline upwards towards the silencer so that sea water cannot enter the latter. The exhaust pipe should never be carried out under water.

Location of the Air Container.

The starting air container should be located in an accessible position so that it can be opened up for cleaning without the necessity of removing it. The piping in connection with same should be drawn copper piping and placed so as to be protected from damage. All joints should be made by unions with cone metal to metal joints. All brazing should be done with spelter (hard solder).

Surveyor's Regulations.

When putting in the piping, locating cocks and valves and doing the other work in connection with the installation of the engine, instructions should be requested from the representative of the associtation classifying the vessel (Lloyds, Bureau Veritas etc). or from the Govt. inspector if the vessel is not to be classified by one of these associations. If a drawing of the engine room has been made, a copy should be procured and carefully followed.

VIII. ARRANGEMENT OF THE ENGINE ROOM

The engine room should be made as spacious and light as possible. If electric light is installed on board, lamps should be arranged so that the engine is well lighted on all sides. Proper ventilation is of the greatest importance and if for any reason this cannot be obtained with ordinary ventilators, a fan should be installed, provided there is electric current on board. Attention should be given also so that the spaces under the engine flor plates are ventilated, as otherwise explosive gases can accumulate in these spaces.

Floor plates, ladders and platforms, if any, should be of iron and made so that one is not liable to slip on same. The floor plates should be made so that they can be raised. Ladders,

platforms and railings should be screwed fast in position not rivetted, so that they can be easily removed if it is necessary to dismantle the engine.

A beam with lifting tackle of sufficient strength to lift the crankshaft must be provided above the engine.

A rack for wrenches and spanners should be arranged in some accessible place in the engine room, and it is to advantage also to have a suitable storing place for the most used spares, such as springs, injection nozzles etc. The other spare parts carried should be kept in a dry store room under lock and key, each spare having its particular place in the store room. The spares should be well covered with oil or grease to protect them from rust.

The engine room should be provided with a bench and vice as also the most usual tools such as hammers, files, chisels, brazing and soldering tools, drilling and threading tools, etc. On larger vessels having electric current on board a small drilling machine and a lathe can be installed to advantage.

On wooden vessels the engine room must be plated with sheet iron as a safeguard against fire. One or more fire extinguishers should be ready to hand.

The walls, ceiling etc. should be painted a light colour.

The number of auxiliary machines necessary depends entirely upon the size of the vessel and the trade in which it is engaged. In any case, a hand compressor must be furnished for charging the starting air container, a hand pump for filling the daily service tank, and a bilge pump driven by the engine. Many vessels are fitted with a small stationary type oil engine driving an electric generator for the lighting. When this is the case, power is available for driving the above mentioned auxiliary machinery as also an extra bilge pump. An oil engine for the above purpose should however not be of larger capacity than what will give it a fair load, as if it runs for long periods underloated, it will not work satisfactorily. The electric unit should be located in the engine room, so that the engineer can give same careful attention, which is not likely to be the case if it is located in some passage-way or on deck. if a coal fired donkeyboiler is used, it must be located in a separate room from the engine room, having a separate way down from the deck.

The extra bilge pump, where such is furnished, should be so arranged that it can be connected to the circulating water piping in case anything should happen temporarily to the circulating pump. If the arrangement is made in this way, the extra pump can be used to circulate cooling water through the engine jackets while the engine is being warmed up and immediately after the engine is stopped, thus preventing any overheating. The connection with the seacock, however, must be made so that it is absolutely impossible under any circumstances for the seacock to be put in communication with the suction pipe to the bilge. If such a connection existed and by mistake was opened, the vessel would probably sink. An oil purifier for cleaning drain oil should be furnished, at least on vessels fitted with large engines. The oil thus purified should be stored in a separate tank, and only used for lubricating the main bearings etc. preferably with the addition of fresh oil.

When in any doubt regarding the installation, care or attention of the engine, consult us immediately. We are alwavs pleased to furnish any information tending to improve the installation of our engines. We have on hand a staff of efficient engineers and fitters and can furnish help of this kind at the current rate of charges at any time. It is, as a rule, more advantageous to a purchaser to pay for expert services when installing an engine, than to do without and run the risk of a faulty installation, incurring very much greater expenses in the long run.