# INSTRUCTIONS

**FOR**

## ERECTION AND RUNNING

**FOR THE**

# NEW CROSSLEY OIL ENGINE

**FOR REFINED, CRUDE, RESIDUAL OILS AND TAR**

O and OE 115

O and OE 117

O and OE 120

O and OE 122

O and OE 123

O and OE 126

O and OE 128

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CROSSLEY BROTHERS LTD.

ORENSHAW MANCHESTER

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# ERECTION

## Of Single and Double Cylinder

# NEW CROSSLEY OIL ENGINES.

(See Separate Foundation Plan for each different size of engine).

For ready reference, an arrangement of a foundation plan for a Single Cylinder Engine is shown on the opposite page, Fig. 2, and for a Double Cylinder Engine on page 7, **Fig. 3.** No dimensions are given.

**OWNER.**—Before the Owner or the "Engineer in Charge" accepts one of our engines, either from an agent or contractor, as being erected on site and ready for working, we strongly advise him to satisfy himself that the notes, given on the foundation and erection plan, as referred to in the extracts below, have been duly observed during the installation of the plant. When unpacking the engine from its packing case, great care must be taken to prevent damage to the engine or any of the parts which may be packed separately inside the case.

**CONCRETE FOUNDATION.**—This must be built on solid hard ground; if the ground is in any way of a yielding nature, the foundation must either be enlarged or a new site found. It is suggested that the concrete be made of three parts of hard broken brickbats or stone to one part of cement, with sufficient sharp sand to flux. The brickbats or stone should not be larger than will pass through one and a half inch mesh. The concrete foundation shown on this plan is based on our general experience, but the purchaser must be responsible for its proper adaption to his own circumstances. He must also satisfy himself that the materials for the foundation are of suitable quality. We recommend all trenches to be lined with a brick wall, and covered with removable Chequer plates. All trenches must be well drained. On size O. or OE. 120 and larger engines, a hole about nine inches square by three and a half deep, must be left in the concrete for an exhaust pipe guide socket, as shown on the foundation plan, to be secured in place with cement grouting when the exhaust pipe bend and socket have been placed in their positions. The holes for the foundation bolts (see foundation plan) must be filled in with cement after the engine and outer bearing are fixed in position and the foundation bolts have been adjusted to their correct heights. **The bolts must never be fixed in the concrete before the engine is on its foundation.)** The foundation bolts marked "0" are for the barring bracket, the bolts marked "P" for the belt-driven air compressor (if used). A hole, three inches square, to be left in concrete for each bolt marked "O" and "P". **IMPORTANT.**—The top of the concrete foundation to be left rough, and the engine to be lined up on iron packings. These should be about 3in. x 3in. x ½in. on sizes O & OE 115 to 117 engines, and about 5in. x 5in. x ¾in. on larger engines. A clay ridge should be made round the engine bed as shown, and cement grouting run in level with the oil groove from inside of the bed through holes provided for this purpose. By running the grouting in from the inside of the bed, it can be definitely seen whether the grouting has completely filled in the space all round the engine bed. The soleplate under the out-end bearing must be grouted up from the inside in a similar manner to the engine bed. Be sure to use good new cement for grouting.

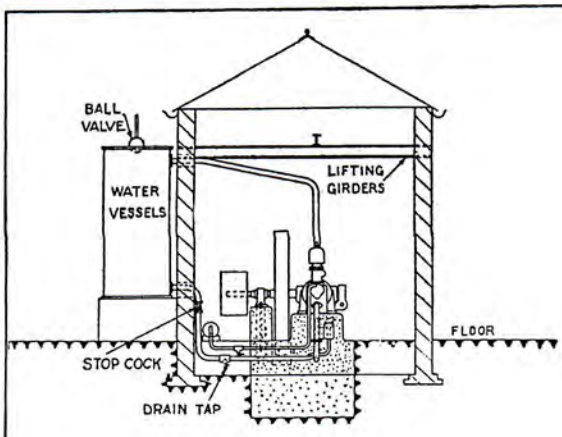
**EXHAUST PIPE, SILENCER AND BEND.**—This must be arranged as shown. It must never be turned into a drain or chimney. As water sometimes accumulates in the pipe, a small drain plug is provided at the bottom of the silencer for draining purposes. **NOTE.**—When the fuel oil contains **sulphur,** the condensation of water in the exhaust pipe will have the effect of corroding the exhaust pipe. The pipe should therefore in this case be kept as hot as possible and as short as possible, especially if the engine only works usually at reduced loads. **The exhaust pipe must not be made fast in any wall, but must be left free to expand.** To allow for the expansion of the hot pipes, the exhaust silencer must stand on iron rollers. These must be placed on a concrete or stone flag as shown on the foundation plan. The exhaust pipe and silencer must not be placed within twelve inches of timber as they become hot in working and might cause fire. On size O or OE 120 and larger engines the setscrews in the socket for the exhaust bend must be fitted so that they just touch the foot on the exhaust bend as shown in Figs. 2 & 3, but no pressure must be exerted on this bend. This is very important. This arrangement will allow the exhaust bend to expand vertically, but will prevent any strain being put on the breech end of the engine due to expansion of the horizontal pipes when the latter become hot in working.

**COMPRESSED AIR PIPES.**—Before erection all compressed air pipes must be well hammered while in a vertical position to loosen and clear out any rust or scale inside. After hammering the pipes should be painted inside to prevent the formation of further rust or scale, or pipes which are galvanised inside may be used.

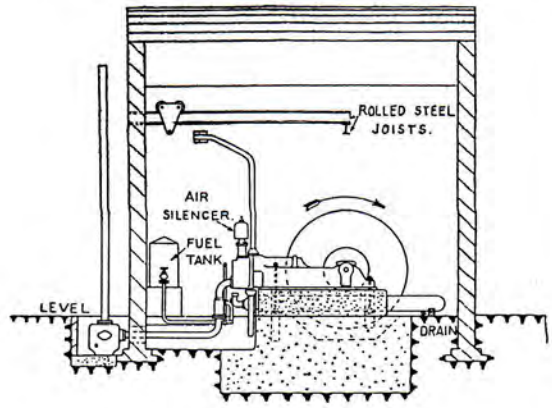
**COMPRESSED AIR RECEIVER.**—The stop valve is packed separately from the receiver. When securing the stop valve in place on the receiver all parts including the packing ring must be perfectly clean and free from dirt or grit. The nuts which secure the stop valve to the receiver on the O & OE 120 to 128 engines must be carefully screwed down to ensure equal pressure being taken by each stud. If when this is done the non-return valve L (Fig. 33) is not perfectly air tight the instructions given on page 48 must be carefully attended to.

**CIRCULATING WATER VESSELS AND PIPES.**—For engines to work in Great Britain the water vessels are sent out fitted with internal partitions. Water vessels for engines sent abroad are either sent out in (1) flat sections, or (2) nested together as stated below. When sent out in flat sections, the holes are punched and the internal partitions are bent to shape before being packed. Ample solder and rivets are supplied for joining together at destination. When sent out "nested" the internal partitions are bent to shape and sent loose (except on the inner vessel) with sufficient solder to joint them up after arrival at their destination. The arrangement of partitions in circular water vessels to aid in cooling, must be properly arranged as shown on the foundation plan. Water vessels must be supported under the whole of the bottom surface, otherwise the weight of water on the unsupported bottom plate will cause them to leak. In hot countries the amount of water used in the water vessels must be increased to suit the climate, an additional capacity of at least 50 per cent. is recommended. The above arrangement of tanks is usually adopted for all single cylinder engines except O and OE 128 and double cylinder engines O or OE 220 to 228 inclusive for which one large tank with pipes arranged as shown on the foundation plan is recommended. Circulating Water Pipes must be arranged so that the inlet for cold water is connected to the bottom of the water vessel, and the outlet for hot water connected to the top of another water vessel as shown on the foundation plan. The outlet

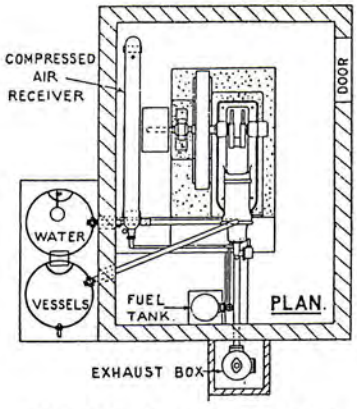
## Fig. 2.—ERECTION PLAN FOR SINGLE CYLINDER CROSSLEY OIL ENGINE.



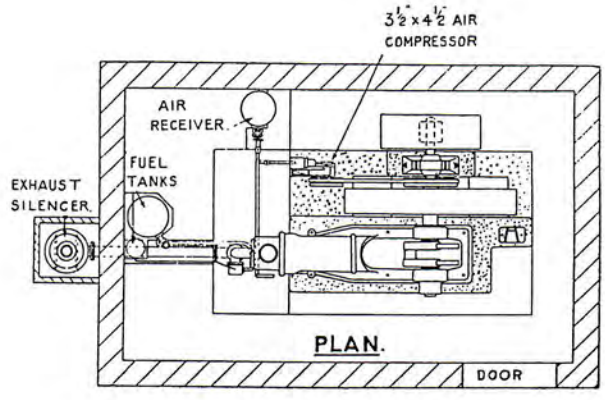

END ELEVATION.




SIDE ELEVATION




ILLUSTRATING ENGINES HAVING HORIZONTAL COMPRESSED AIR RECEIVER COMPRISING ENGINES SIZES 0 & OE 115 to 117.




ILLUSTRATING ENGINES HAVING BELT-DRIVEN AIR COMPRESSOR AND VERTICAL COMPRESSED AIR RECEIVER COMPRISING ENGINES SIZES 0 & OE 120 122 & 123.

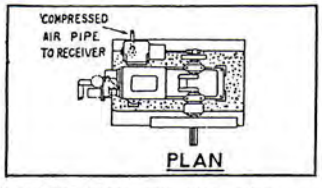



ILLUSTRATION SHOWING SIZE 1060 ENGINE HAVING COMBINED AIR COMPRESSOR AS USED WITH ENGINES SIZES 0 & OE 126 & 128.

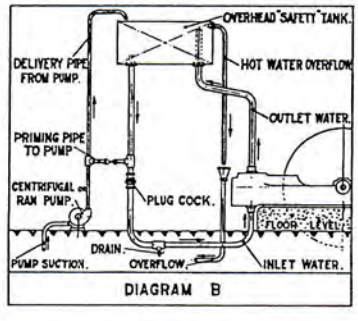
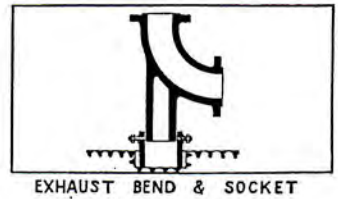



DIAGRAM B



EXHAUST BEND & SOCKET SIZES 0220 & UPWARDS.

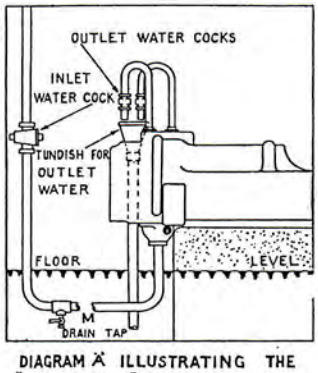



DIAGRAM A ILLUSTRATING THE "RUN-THROUGH" WATER COOLING SYSTEM FOR ALL SIZES, WHERE WATER SUPPLY IS CONSTANT.

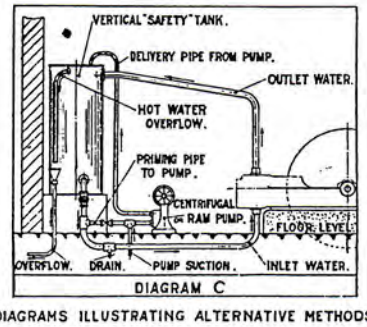



DIAGRAM C

DIAGRAMS ILLUSTRATING ALTERNATIVE METHODS OF APPLYING THE COMBINED "RUN-THROUGH" AND "THERMO-SYPHON" SYSTEM, WHERE THE WATER SUPPLY IS NOT CONSTANT

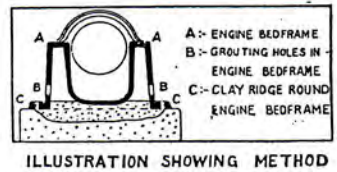



ILLUSTRATION SHOWING METHOD OF GROUTING UP ENGINE BED-FRAME FOR ALL SIZES.

**Note.**—Separate large scale erection plans are enclosed in each engine packing case, together with a copy of this book.

pipe from the top of the engine cylinder must slope upwards at every point, and sharp elbows must not be used on either the inlet or the outlet water pipes. A stop cock and drain tap are placed in the inlet water pipe. They are for use when the cylinder jacket requires draining, thus avoiding emptying the water vessels. A ball cock should be fitted to the cold water supply pipe for the water vessels where possible.

**"RUN THROUGH" WATER COOLING SYSTEM.**—Where a good supply of water is available, but where for some reason separate water circulating tanks cannot be used, the "run through" system of water cooling may be used in one of the following ways, each of which is illustrated in Figs. 2 and 3, on pages 5 and 7:—

1.—If an ample and continuously dependable supply of water *by gravity* is assured, such as from a reservoir, the circulating pipes may be arranged as shown in diagram A in Figs. 2 and 3, pages 5 and 7, the water running through the jackets to waste, a separate cock being fitted to the outlet pipe from both the cylinder jacket and the breech end.

2.—Where the supply of water is *not* so dependable, such as when it has to be pumped from a well or river up to the engine, the supply is liable to cease suddenly, say if air gets into the pump, or if the pump driving belt should break. If no foot valve were fitted to the pump, or if the foot valve stuck open or leaked, the water would run out of the engine jackets when the engine stopped ; then, when the engine was put to work again, there would be no water in the engine jackets for some time after starting, and the cylinder and breech end are then liable to become very seriously overheated before the pump becomes operative. When the water enters the jackets it will cool the overheated parts very suddenly and frequently result in one or more of them fracturing. *To avoid this danger* we strongly advise the use of a comparatively small overhead "safety tank" as shown on diagram B and C in Figs. 2 and 3, pages 5 and 7. The pump keeps this "safety tank" full of water instead of delivering the water direct to the engine. With this arrangement the circulating water pipes between the engine and the "safety tank" must be of the same large bore as used for the usual thermo-syphon system. Should the pump for any reason cease to deliver water to the tank, the water in the jackets and tank will continue to circulate and this will enable the engine to run with reasonable safety for a more or less short length of time, depending on the size of the "safety tank," during which time the water supply may be restarted or the attention of the engine attendant called to the mishap before any damage is done. The "safety tank" should be as large as possible. The overflow from the tank must be led into a tundish where it can always be under the observation of the attendant. The supply of water through the jackets may be adjusted by means of a cock in the inlet water pipe to the engine jackets. This cock should never be entirely shut when the engine is running. See further notes on water circulation under "Working," on pages 36 and 37, and under "Warnings," on pages 39 and 40.

NOTE.—We strongly recommend clients not to use either "hard" or muddy water with "run through" water circulation whether a "safety tank" is used or not. This is with the object of preventing the continuous deposit of scale or mud in the jackets.

**FUEL TANKS.**—When using crude or residual fuel oils, where space permits, it is advisable to provide fuel storage tanks of considerably increased capacity in addition to the fuel oil tanks supplied with the engine so that any water, sand or foreign matter contained therein may settle at the bottom of these tanks and not pass over to the fuel supply tank in the engine room. The supply pipes should not be taken from the bottom of the fuel tank. Any additional oil tanks of this nature must be provided with large cocks near the bottom to drain out any water and a door through which to clean out any mud or other sediment.

**LOOSE FLANGES.**—When required, these are sent with the engine, fuel tank, and exhaust box, and are screwed to suit wrought iron pipes up to and including three and a half in. bore with "British Standard" gas threads. Loose flanges above three and a half in. bore, are not included in the price of the engine, and are not supplied unless specially ordered.

**ERECTING TACKLE.**—The overhead carriage and eight inch by six inch rolled steel joists over centre lines of crankshaft, flywheel, etc., are not included with standard engine, but we can supply them (as an extra) if desired.

**CLEANING.**—After erecting, and grouting up the bedplate as described above, thoroughly clean it and all the parts packed separately before assembling them.

**PARTS INCLUDED AND SUPPLIED WITH STANDARD ENGINE.**—Unless ordered otherwise these are engine flywheel, pulley (with industrial single cylinder engines only), out-end bearing, exhaust silencer air silencer, and fuel tank, and, on sizes O and OE 120, and larger sizes, a barring bracket or gear.

**PARTS NOT INCLUDED WITH STANDARD ENGINE AND ONLY SUPPLIED WHEN SPECIALLY ORDERED.**—Pulley with single cyl. electric type engines and all double cylinder engines exhaust, water, starter, and oil pipes, water vessels, girders, ball cock, water supply pipes to vessels, handrails, floor plates, rollers under exhaust silencer, air compressor, air receiver, concrete foundation, the cutting and drilling of any floors walls, repainting or plastering, and any other builders' work in preparation or making good any structural alterations.

**PIPING.**—When quoting for a standard set of pipes and bolts, lengths equal to those shown on the foundation plan are included, and no extra price will be charged unless the lengths shewn are exceeded. The ball tap is not included

**DOUBLE CYLINDER OIL ENGINES.**—When erecting double cylinder engines it should be noted that the left hand engine is stamped "A" and the right hand cylinder "B" ; these letters may be found on the breech ends immediately above the engine number. The exact distance apart and alignment of the two bedplates must be determined by setting a pair of trammels to the length U on the crankshaft webs as shown on page 7. The distance apart of the encircled centre dots on the front of the bedframes V to V, and on the water outlet facings W to W must then correspond exactly with this length.

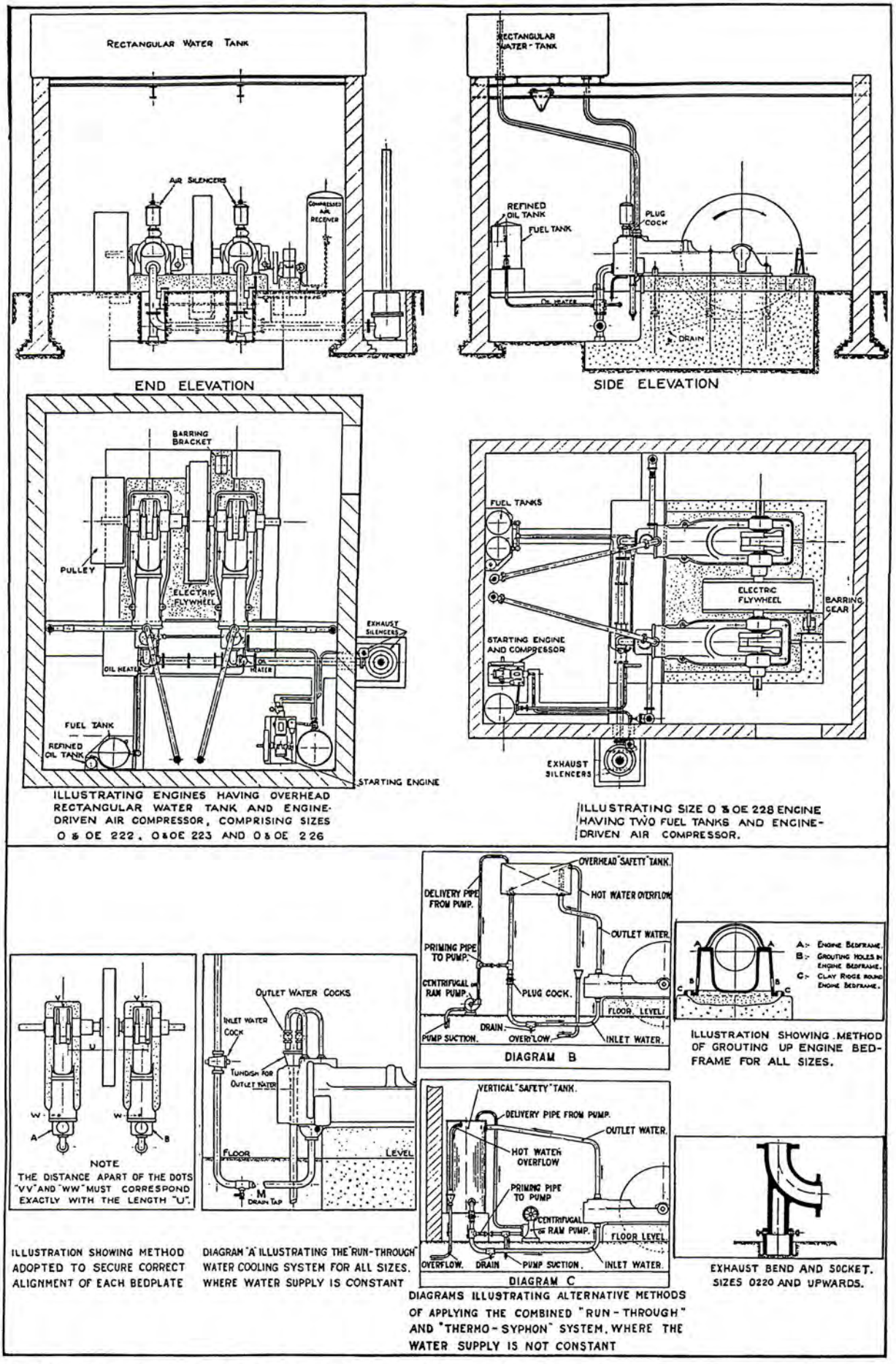
**BEARINGS.**—On both single and double cylinder engines it is most important to have the main and outend bearings perfectly in line. Heating of main bearings is frequently an indication of their being out of line, and the earliest opportunity must be taken of having them overhauled by a skilled man—see notes under "Maintenance," page 49.

**FLYWHEELS.**—For instructions for mounting or dismounting either solid or split flywheels, see page 53.

**SPARES AND ACCESSORIES.**—The Owner and the attendant should ascertain that the spares and accessories sent with the engine, as given on page 61 are complete and ready for use.

**LUBRICATION.**—Before attempting to start the engine for the first time make absolutely sure that all lubricators and oil wells are thoroughly cleaned out and in perfect working order. Also see that the pipes through which the oil is fed to the different parts, and particularly to the large end of the connecting rod, are thoroughly clean and thoroughly flushed out with oil so as to remove any dirt or other foreign matter which may have got in since the engine was tested and packed for delivery.

## FIG. 3.—ERECTION PLAN FOR DOUBLE CYLINDER CROSSLEY OIL ENGINE.




**Note.**—Separate large scale plans are enclosed in each engine packing case together with a copy of this book.

# GENERAL NOTES.

**Many thousands of our Engines are installed overseas at great distances from our works, both in the British Dominions and in Foreign Countries. As any requests for information by letter might cause delay we have purposely given these Working Instructions and List of Parts at much greater length than is usual. This has been done entirely in the interests of the owner and the attendant of the engine.**

**So far as we are aware every information is given in this book to enable the engine to be worked perfectly. The more important points are referred to in each of the separate sections into which the book is divided. Should any of our clients find it desirable for further points to be included, we shall be very pleased to do so the next time this book is reprinted if clients will kindly make suggestions.**

## IMPORTANT.

**SPECIAL NOTE to the Owner and also to the attendant of the engine :—**

*All machinery is valuable, and is therefore worthy of the best possible care and attention. This is especially the case in a works or factory where perhaps the whole output is dependent on the regular and efficient working of the engine.*

**Access to the engine-room should not be allowed to any persons not connected with it.**

**THE ATTENDANT** should take a pride in his work and **see that both the engine and the engine-room are kept perfectly clean and tidy :** the engine especially should be kept free from dust and grit. An engine which is kept clean is usually well cared for throughout, and is likely to give complete satisfaction. A dirty and neglected engine may be expected to give less satisfaction, to have a shorter life, and its wearing parts will invariably require to be renewed sooner than usual ; stoppages may also occur owing to hot bearings, or to the piston seizing in the liner, or to other troubles. If the engine is fixed in a position where a considerable quantity of dust is flying about, the engine-room should be made as dust-proof as possible. The attendant should make himself fully acquainted with, and understand the working of, every part of the engine, **and always make any adjustments as soon as they may seem to be necessary** All tools, accessories, spare parts, etc., should be kept in good order and stored in a proper place so as to be instantly available when required. It is only by taking an intelligent interest in this way, that an engine can be expected to be regular, quiet, and efficient in working.

**INSURANCE.**—It is essential to have periodical examinations of the principal parts made by a skilled engineer and in this connection we would call your attention to the advantages gained by insuring the engine against accident with one of the leading Engineering Insurance Companies, who provide periodical inspection services by skilled surveyors who have been specially trained for such work. Engine users are particularly advised to consult such Insurance Companies as to the suitability of the water in use for cooling the cylinder jackets. It is necessary to ascertain whether any, and if so, what kind of treatment of the water is advised to avoid scale deposits in the jackets, which might lead to fractures.

It is a good plan to keep a **Log Sheet** on the following lines, in the engine room. This will show if the Engineer's duties are being properly performed, and will also indicate to the Owner when those parts which require periodical examination were last inspected. An example of a Log Sheet is shown below. A further and more detailed list of points to be attended to is given on pages 50 and 51.

## ENGINE ROOM LOG SHEET.

SIZE OF ENGINE **OE 123.** ENGINE No. **80,850.**

| 1924 | Exhaust valve ground in. | Piston with-drawn for examination, and combus-tion chamber cleaned. | New piston rings fitted. | Large end connecting rod brass adjusted and crank pin examined. | Small end connecting rod brass adjusted and piston pin examined. | Main bearings adjusted and crank journal examined. | Water jacket and water pipes cleaned. | Sprayer and strainer cleaned. | Oil heater and strainer and all fuel pipes cleaned. | Fuel Oil pump cleaned and lift of valves examined. | Air receiver and piping drained. Air compressor cylinder and valves cleaned. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| JAN. | | 25th | 25th | 25th | 25th | | | 11th | | | 18th |
| FEB. | 12th | | | | | | 2nd | | 5th | | |
| MAR. | | | | | | 9th | | | | | 16th |
| APRIL | | | | 10th | | | | | | | |
| MAY | 29th | | | | | | | | 17th | | 15th |
| JUNE | | | | | | | | | | 14th | |

**NOTE.—The temperature of the engine-room should not be allowed to fall below 40° F. (4° C.) See note on "Frost."**

## CORRESPONDENCE.

**Note.**—In correspondence *always state the engine number* and *the engine size,* as given on engine name plate, and also the quality of fuel used.

EXAMPLE.—Engine No. 80,850. Siz OE 123. Persian Fuel Oil. Specific gravity .900.

**Note.**—When ordering spare parts state also the number required of each part and the correct name and stock number of each of the parts as given in the Spare Parts List on Pages 63 to 75.

EXAMPLE.—6, Piston Rings. Stock No. 941.

# PETROLEUM OILS. QUALITY TO USE. IMPORTANT.

(NOTE.—For "TAR OILS" see Page 56.)

## Fuel Oils suitable for these Engines are approximately as follows provided they comply with the "Buying Specification" given at the bottom of this Page.

| PETROLEUM OILS AND SHALE OILS. | Approximate Specific Gravity. | Beaume Degrees. |
|---|---|---|
| Refined Petroleum or Shale Oil, such as Kerosene, Paraffin Oil, or Distillate ..... | ·800 to ·830 | 45 to 39 |
| Gas Oil, Solar Oil, or Light Crude Oil ..... | ·830 to ·860 | 39 to 33 |
| Light Residual and Diesel Oils ..... | ·860 to ·900 | 33 to 25 |
| Medium Residual and Furnace Oils ..... | ·900 to ·920 | 25 to 22 |
| Heavy Residual and Furnace Oils (some are not suitable) ..... | ·920 to ·940 | 22 to 18 |

**SPECIFIC GRAVITY.**—Although the specific gravity is not a very reliable guide to the quality of an oil, all "petroleum" oils with a specific gravity above .900 should be tested for coke and asphaltum, which are undesirable contents.

**VISCOSITY.**—It is important that the oil should be of a sufficiently fluid nature to enable it to be atomised effectively. The viscosity must therefore not exceed 750 seconds at 100° F. (38° C.) in the Redwood Ordinary No. 1 Viscometer. As a general rule the viscosity of 500 seconds is a safer figure. Unless an oil is sufficiently fluid it will not run freely from the fuel tanks to the oil heater and oil pump. Consequently neither the pump nor the sprayer would operate efficiently and, should the pump suck in air, it would stop the engine at once.

**HARD ASPHALTUM.**—The amount of hard asphaltum in a residual oil (determined by the petroleum spirit method; precipitation process) must not exceed 4%, and 1% must not be exceeded if the engine is required to run for long periods, especially if the engine should usually work at or below one-third of its normal rated power.

**COLD TEST.**—To ensure the oil being sufficiently free from wax, which would prevent it flowing freely in the pipes, it must remain liquid at 32° F. (0° C.) for a period of one hour.

**ASH.**—This tends to accumulate in the engine cylinder and causes wear. Even a very slight ash content in an oil is a serious matter.

**WATER.**—The amount of water in the oil must not exceed 1%.

**Note on Petroleum Oils.**—In selecting an oil for use in an oil engine, it is not only its cost per gallon, or per ton, which should be considered. The chief point is the cost of running the engine. A low grade oil which may appear to be cheap, may in fact be very expensive, owing to high asphaltum, water, and sometimes sand contents, and to the more frequent cleaning and repairs, and the increase of lubricating oil necessary, all of which have to be paid for. Taking everything into consideration, we recommend the use (to the buying specification given below) of "petroleum fuel oils," having a specific gravity between .860 and .920 (33 to 22 Beaumé). Some of the heavier oils are suitable, but others are not, owing not only to high asphaltum and water contents, but because, in some cases, the proportion of these contents vary so much as to make the oil quite unreliable. See notes on using such oils in "Tar" Oil Engines on page 56.

**BUYING SPECIFICATION.**—When obtaining supplies of petroleum fuel oil we strongly recommend that they should **always** be bought to comply with the seven features of the following specification. If all oils bought come within this specification in all respects the user will save time, trouble and money :—

| PETROLEUM FUEL OIL—SPECIFICATION. | |
|---|---|
| 1. Product ..... | Petroleum or Paraffin Oil (no Tar Oil or other fuel to be added). |
| 2. Flash Point ..... | Not under 100° Fahr. Close Test (38° Cent.). |
| 3. Hard Asphaltum | Not over 4% (Not over 1% preferred). |
| 4. Cold Test ..... | Oil to remain liquid at 32° F. (0° C.). |
| 5. Water ..... | Not over 1% (Anything over 1% is due to carelessness on the part of the suppliers). |
| 6. Ash ..... | Not over 0·05% (one twentieth of one per cent.). |
| 7. Viscosity ..... | Not over 750 seconds (500 preferred) at 100° F. (38° C.) in the Redwood No. 1 Viscometer. |

NOTE.—Should a client desire to use a fuel oil which does not come within the limits of this specification we shall be pleased to advise as to its suitability, with possible modifications to the engine, if a sample pint (½ litre) is sent to us for examination. If a complete analysis of the oil is desired a small charge is made. For example crude cotton seed oil is an excellent oil. So also is Arachis (pea-nut) oil and other vegetable oils.

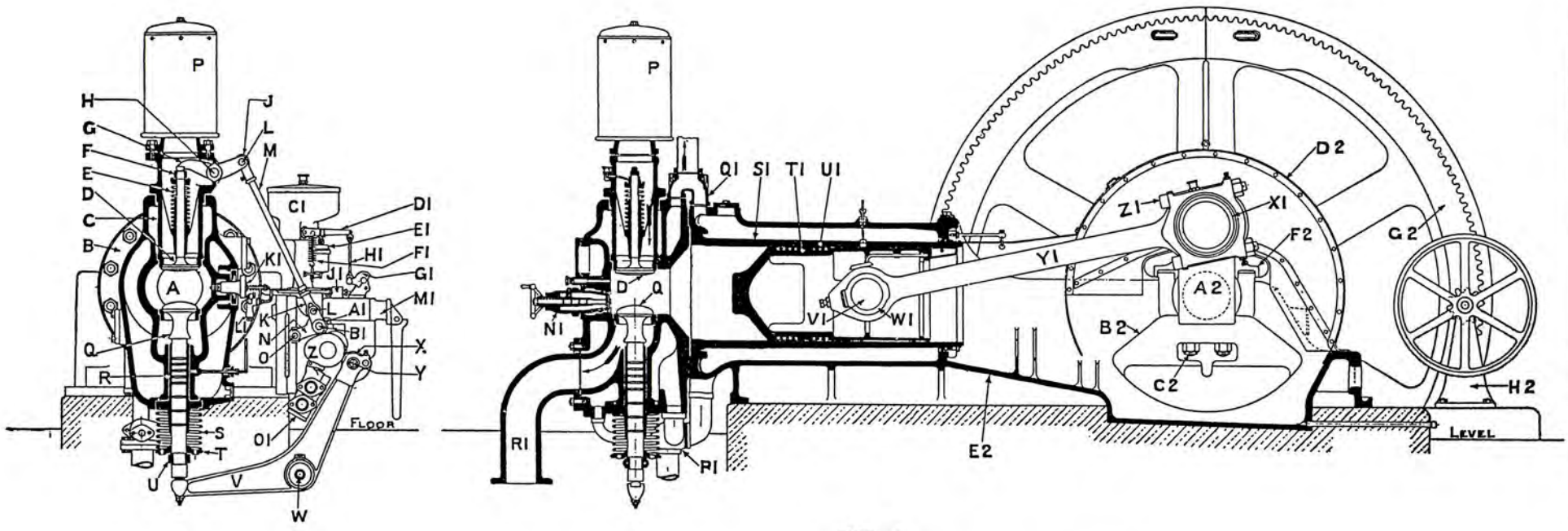



FIG. 4.

## SECTIONAL ARRANGEMENT OF ENGINE.

A—Combustion Chamber.
B—Breech End.
C—Admission Valve Block.
D—Admission Valve.
E— „ „ Spring.
F— „ „ Pusher Head.
G— „ „ Lever.
H— „ „ „ Fulcrum Pin.
J—Top Eye for Admission Valve Rod.
K—Bottom Eye for „ „ „
L—Pins for Admission Valve Rod.
M—Admission Valve Rod.
N—Rocking Lever.
O— „ „ Fulcrum Pin.
P—Air Silencer (Complete).
Q—Exhaust Valve.
R— „ „ Guide.
S— „ „ Spring.
T— „ „ „ Plate.
U— „ „ Clip.
V—Exhaust Valve Lever.
W— „ „ Lever Fulcrum Pin.
X— „ „ Roller.
Y— „ „ „ Pin.
Z—Combined Cam.
A1—Admission Valve Roller.
B1— „ „ „ Pin.
C1—Centrifugal Governor.
D1—Governor Lever.
E1—Governor Dashpot.
F1—Governor Speeder Spring.
G1—Quadrant.
H1—Quadrant Operating Rod.
J1—Control Valve.
K1—Fuel Oil Sprayer.
L1—Strainer on Sprayer.
M1—Fuel Pump.
N1—Starter Valve.
O1—Cam Controlled Compressed Air Starter Valve.
P1—Water Inlet Branch.
Q1— „ Outlet „
R1—Exhaust Bend.
S1—Cylinder Liner.
T1—Piston.
U1— „ Rings.
V1— „ Pin.
W1—Small End Bearings.
X1—Large „ „
Y1—Connecting Rod Body.
Z1— „ „ Bolts.
A2—Crankshaft.
B2—Balance Weights.
C2— „ „ Studs.
D2—Splasher Guard.
E2—Bedframe.
F2—Main Bearing Caps.
G2—Flywheel.
H2—Barring Gear.

# METHOD OF WORKING.

The engine works on the "Four Stroke" Cycle as follows :—(See diagram below).

**SUCTION STROKE.**—On the first forward or suction stroke of the engine piston, fresh air is drawn into the cylinder through the air admission valve.

**COMPRESSION STROKE.**—On the return stroke this air is compressed into the clearance space or combustion chamber at the back of the cylinder, and fuel oil is then injected in the form of fine spray, by a pump just before the end of the stroke.

**POWER STROKE.**—The mixture of fine spray and hot compressed air is then ignited, and the pressure resulting from the combustion drives the piston forward on the power stroke.

**EXHAUST STROKE.**—The exhaust valve having opened, the burnt charge is expelled by the return of the piston, when the valve again closes.

The above cycle of operations is repeated as long as the engine is at work.

**GOVERNING THE OIL SUPPLY.**—The governing of the supply of fuel to the engine, in proportion to the load, is effected by varying the time when this injection ceases. This is effected by opening a control valve in the delivery pipe so that more or less of the oil, according to the load on the engine, is delivered back to the suction side of the pump instead of being injected into the combustion chamber. A diagram of the complete fuel oil system is given in Fig. 61, inside back cover.

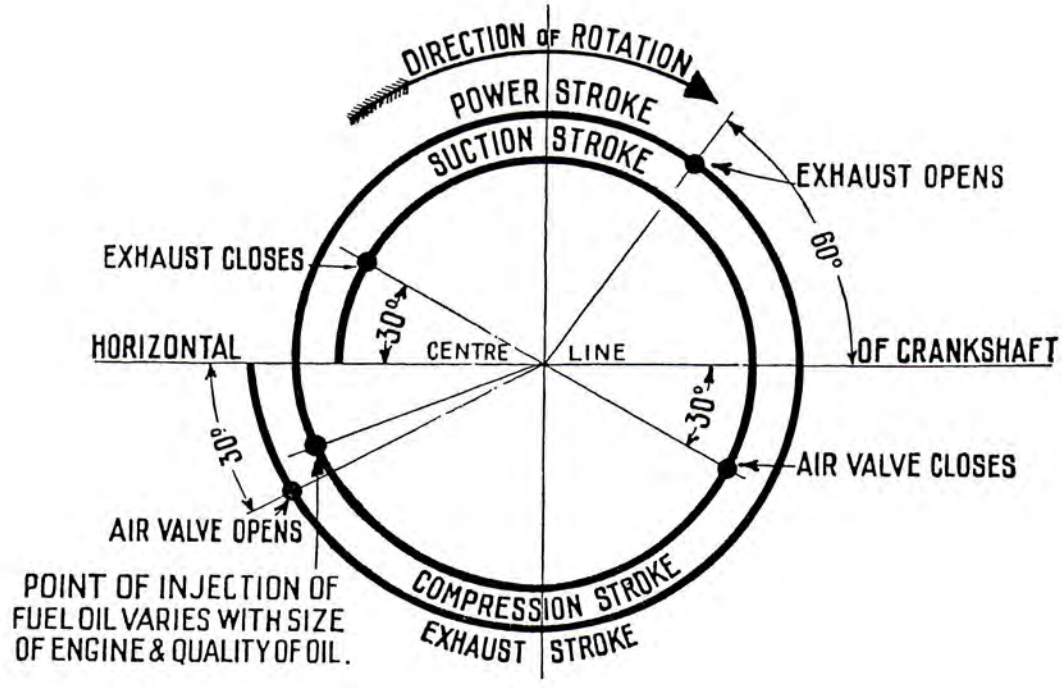



FIG. 5.

## VALVE SETTING DIAGRAM.

The above diagram shows graphically one complete "cycle," that is to say, two revolutions of the crankshaft. The angles given are approximately those which the crank occupies in relation to the horizontal centre line of the engine, when the valves are about to open or close. In the case of the oil pump, the point when the plunger is commencing the delivery stroke, varies according to the size of the engine and to the fuel used. The duration of oil injection varies according to the load on the engine.

## STARTING APPARATUS.

A compressed air starter is strongly recommended for all sizes of engines and is a necessity in most cases. These starters consist of a compressed air receiver fitted with stop valve, relief valve and pressure gauge, and connected by means of steel piping to the starter valve of the engine.

Three means of applying this system have been adopted :—

(1) On sizes O or OE 115 to 117, and 215 to 217, as illustrated in Fig. 6, the receiver is charged up with compressed air direct by the engine itself from the engine cylinder. The charging and starting valve on the engine wa formerly operated by hand, but this is now being arranged to be cam controlled as illustrated below.

(2) On sizes O or OE 120 to 123, as illustrated in Fig. 7, the receiver is charged with compressed air direct from a belt driven air compressor, driven either from the main engine or from a countershaft supplied by owners After the engine is started each day, the storage tank is charged up with air to the maximum pressure by mean of this air compressor.

(3) On sizes O & OE 126 & 128 and O or OE 220 to 228, as illustrated in Fig. 8, the working apparatus consists of an independent engine and compressor combined. The small engine can be arranged to work on town's gas paraffin or petrol, and can be run at any time independently of the main engine.

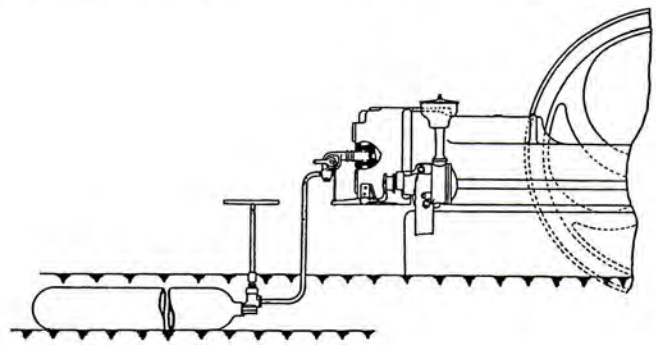


Fig. 6.

Starting apparatus for starting by either hand-operated valve or cam controlled valve, the receiver being re-charged from engine cylinder. Sizes O & OE 115 to 117, 215 to 217.

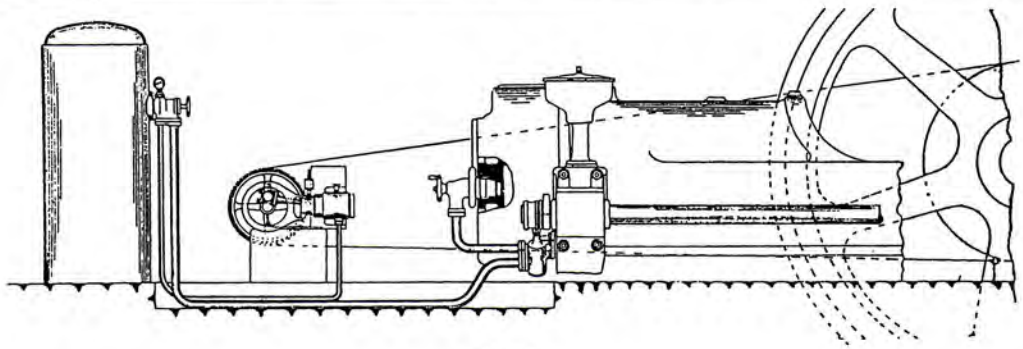


Fig. 7.

Starting apparatus of automatic type, receiver charged by belt driven air compressor. Sizes O & OE 120 to 123.

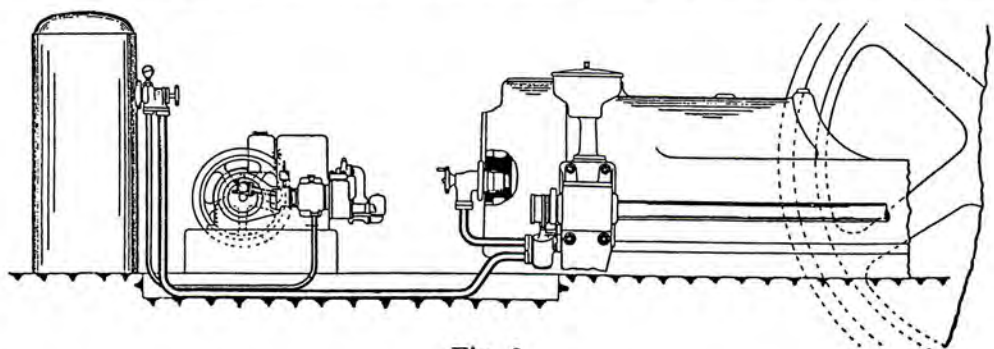


Fig. 8.

Starting apparatus of automatic type, receiver charged by independent combined engine and air compressor. Sizes O & OE 126 & 128 and O & OE 220 to 228.

# DESCRIPTION OF PARTS.

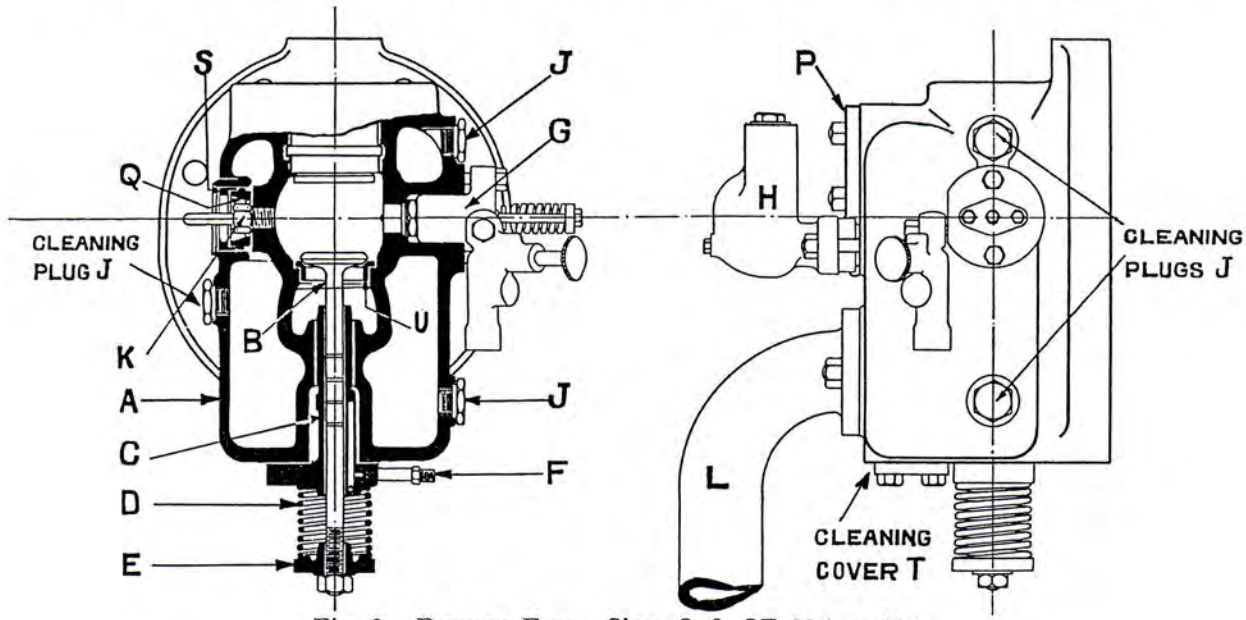



Fig. 9. BREECH END. Sizes O & OE 115 to 117.

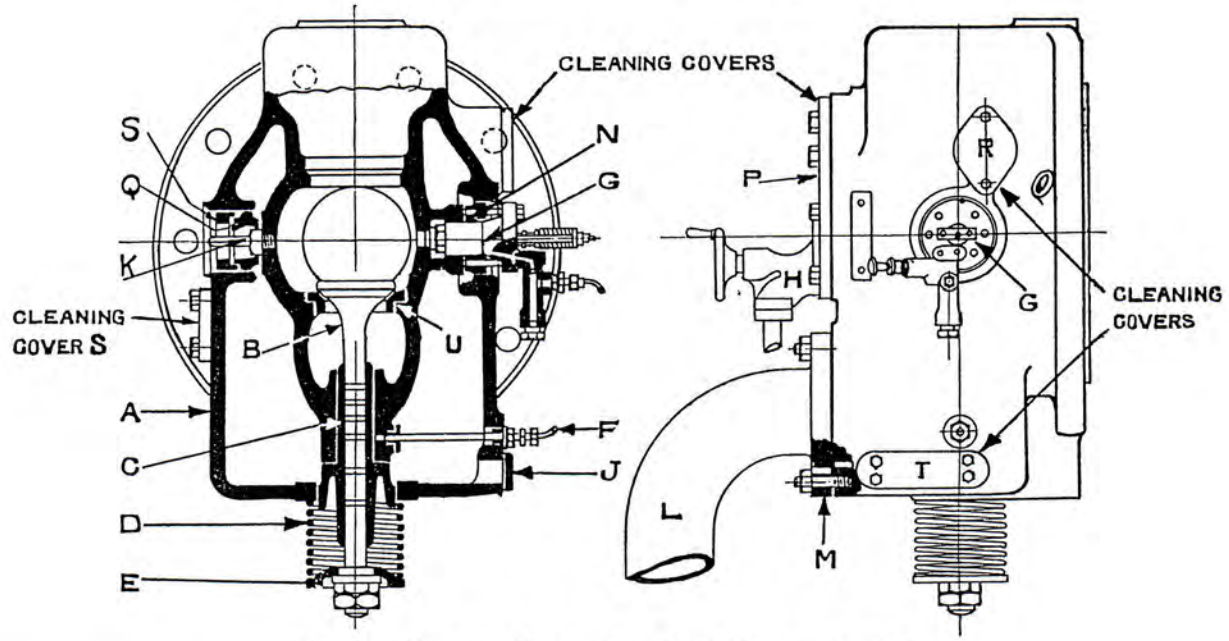



Fig. 10. BREECH END. Sizes O & OE 120 to 128.

A—Breech End.
B—Exhaust Valve.
C— „ „ Guide.
D— „ „ Spring.
E— „ „ „ Plate.
F— „ „ Oil Pipe.
G—Sprayer and Strainer.
H—Starter Valve.
J—Cleaning Covers and Plugs.
K—Ignition Tubes (Not used on O & OE 126 and 128).
L—Exhaust Bend.
M—Exhaust Bend Flange (Sizes O & OE 122 to 128).
N—Sprayer Expansion Joint Flange (Sizes O & OE 122 to 128).
P—Breech End Cover.
Q—Ignitor Expansion Joint Flange.
R—Cleaning Door at Side.
S—Gland for Expansion Joint Flange.
T—Cleaning Door at Bottom.
U—Exhaust Valve Seating.

**BREECH END AND COMBUSTION CHAMBER.**—The breech end casting, the inner portion of which forms the combustion chamber of the engine, is one of the most important parts of the engine. As shown in Figs. 9 and 10, the admission valve, exhaust valve, and starter valve are fitted in it. The whole efficiency of the engine depends largely on its cleanliness, both in the combustion chamber and the surrounding water jackets. Inspection covers or plugs are provided on both sides and at the back for the inspection and removal of any sediment from the water spaces. It is most important that this should be done at regular periods.—See notes on pages 39, 40 and 51. A compression plate is sometimes screwed inside the combustion chamber on the ignition tube side, of engines of the O & OE 115 to 123 types. This is for use with fuels having unusually high ignition temperatures.

**AIR SILENCER.**—The air silencer, which is mounted on the admission valve block, consists of a central perforated body surrounded by cocoa-nut matting and enclosed in a sheet iron cover.—See Fig. 50, on page 53.

## CRANKSHAFT, MAIN BEARINGS, AND FLYWHEELS.

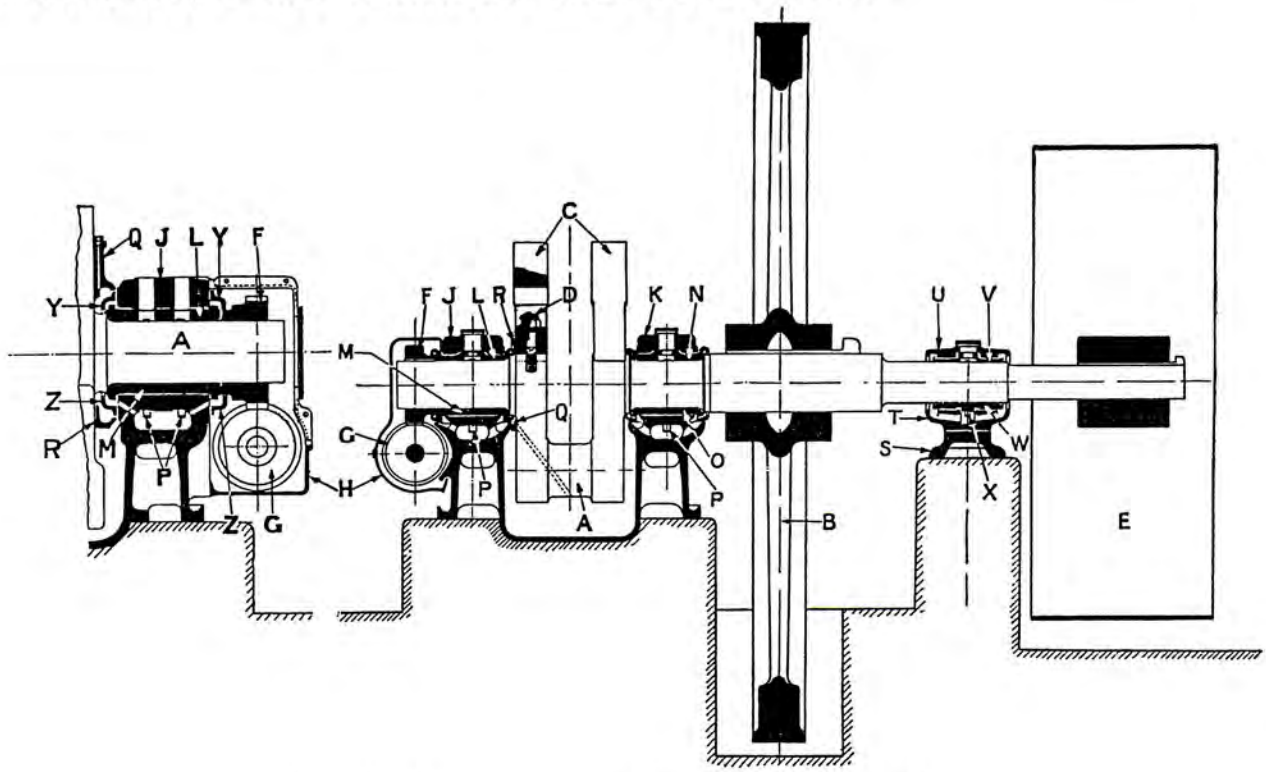



Fig. 11. CRANKSHAFT AND MAIN BEARINGS—ALL SIZES.

A—Crankshaft.
B—Flywheel.
C—Balance Weights.
D— „ „ Studs.
E—Pulley
F—Crank Worm Wheel.
G—Sideshaft Wheel.
H—Wheel Guard.
J—Main Bearing Cap Sideshaft Side.
K—Main Bearing Cap Flywheel Side.
L—Main Bearing Top half, SS. Side.
M— „ „ Bottom „ „
N— „ „ Top „ FW. Side.
O— „ „ Bottom „ „ „
P— „ „ Oiling Rings.
Q—Centrifugal Lubricator—Top Half.
R— „ „ —Bottom Half.
S—Outend Bearing Sole Plate.
T—Outend Bearing Pedestal.
U— „ „ Cap.
V— „ „ Top half.
W— „ „ Bottom.
X—Oiling Ring for Outend Bearing.
* Y—Top half Oil Catcher Ring.
* Z—Bottom half „ „

* Only supplied with sizes O 126 and O 128. See left-hand view above.

The above diagram illustrates the arrangement of the various parts and the lubrication of the principal bearings. It is most important that the alignment of these bearings is correctly made, when the engine is erected and maintained after the engine has been installed and run. See notes on 'Erection," page 6 and "Maintenance," pages 42 and 49.

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FLYWHEEL IN HALVES, FIG. 12.

A—Half Wheel.
B—Bolts and Nuts.
C—Dowels.
D—Cotters.
E—Split Pins

For size O & OE 128 and for all Double Cylinder Engines the flywheel is made in halves. These halves **A** are secured together by bolts and nuts **B** passing through the boss, and by dowels **C** and cotters **D** recessed in the rim. The split pins **E** must always be in place before attempting to start the engine.

See also "Erection" notes, page 6, and "Maintenance" notes, page 47 and "Dismantling" notes, page 53

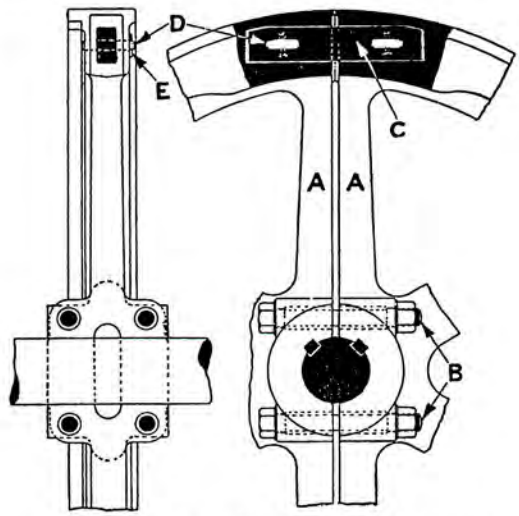



Fig. 12. FLYWHEEL IN HALVES.
Size O & OE 128 and all Double Cylinder Engines.

## PISTON.

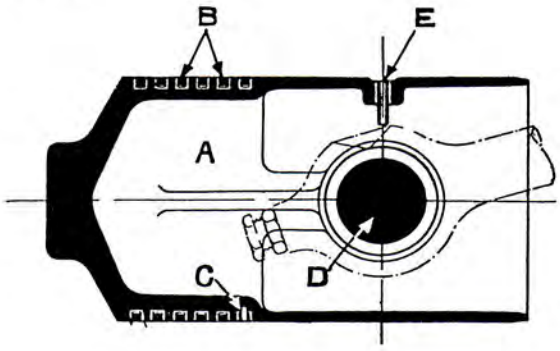



Fig. 13. PISTON. For Sizes O & OE 115 to 117.

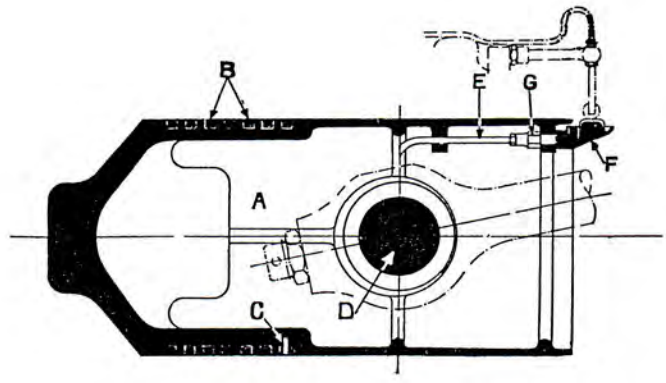



Fig. 14. PISTON. For Sizes O & OE 120 to 128.

Figs. 13 and 14 show the piston and the methods of lubricating the piston pin on different sizes of engines. See important notes *re* cleaning, etc., on pages 41, 51 and 52.

A—Piston Body.
B— „ Rings.
C— „ „ Stop Pegs.
D— „ Pin.
E—Oil Pipe to Piston Pin.
F—Oil Wiper Trough. Size O & OE 120 to 128.
G—Oil Pipe Connection. Size O & OE 120 to 128.

## CONNECTING ROD.

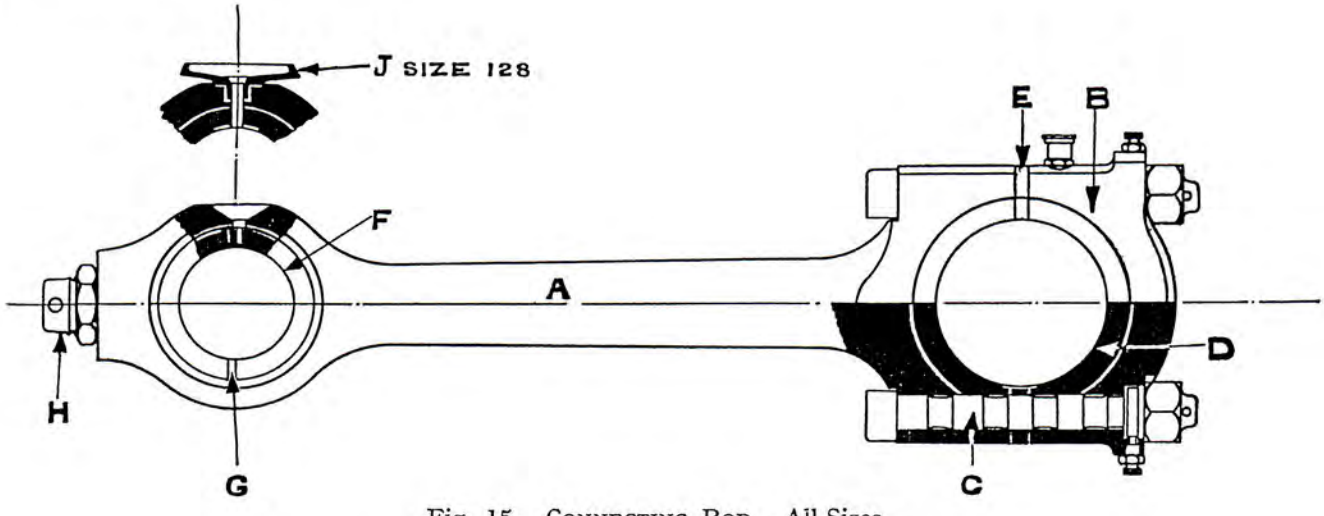



Fig. 15. CONNECTING ROD. All Sizes.

A—Connecting Rod Body.
B—Large End Cap.
C—Connecting Rod Bolts.
D—Large End Bearings.
E—Large End Liner.
F—Small End Bearings.
G—Small End Liner.
H—Small End Adjusting Screw.
J—Small End Oil Trough.

This is fitted with adjustable bearings which are set at our works to the correct running clearances. For their care and maintenance see other notes on pages 42 and 51.

**IMPORTANT.—Particular attention is called to the notes we give on page 42 respecting the examination and periodical replacement of the connecting rod bolts.**

## SIDESHAFTS AND CAMS.

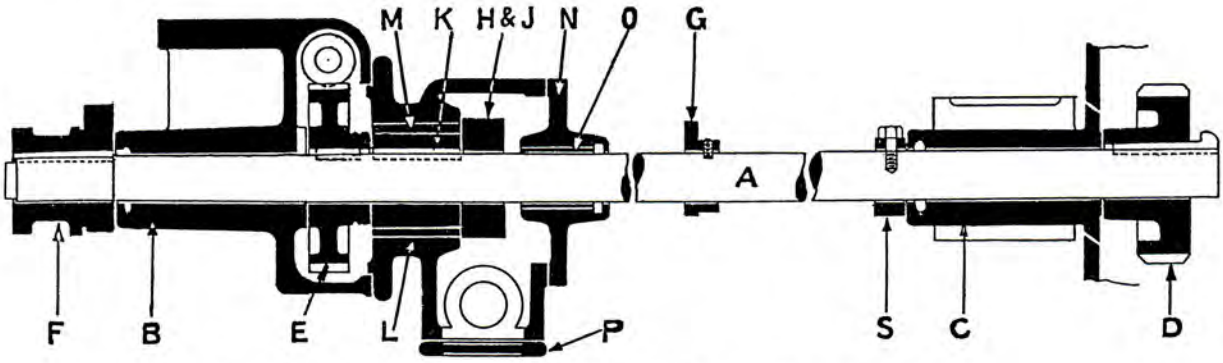



Fig. 16. SIDESHAFT AND CAMS. Sizes O or OE 115 to 126.

A—Sideshaft.
B—Sideshaft Bracket Cylinder End.
B1—Bush for ditto. ditto. (not shewn).
C—Sideshaft Bracket Crank End.
C1—Bush for ditto. ditto. (not shewn).
D—Sideshaft Wheel.
E—Governor Wheel.
F—Combined Cam.
G—Lubricating Cam.
H—Oil Pump Cam Disc.
J—Toe Piece (See detail on page 54).
K—Oil Pump Cam Boss.
L—Oil Pump Bracket.
M—Ditto ditto Bush.
N—Extra Bearing.
O—Extra Bearing Bush.
P—Oil Pump Guide Door.
R—Oiling Rings (on Sizes O & OE 126).
S—Collar for Sideshaft.

**NOTE.**—The extra bearing **N** and bush **O** are not necessary on Sizes O & OE 115 to 117, a plain cover without bearing taking their place.

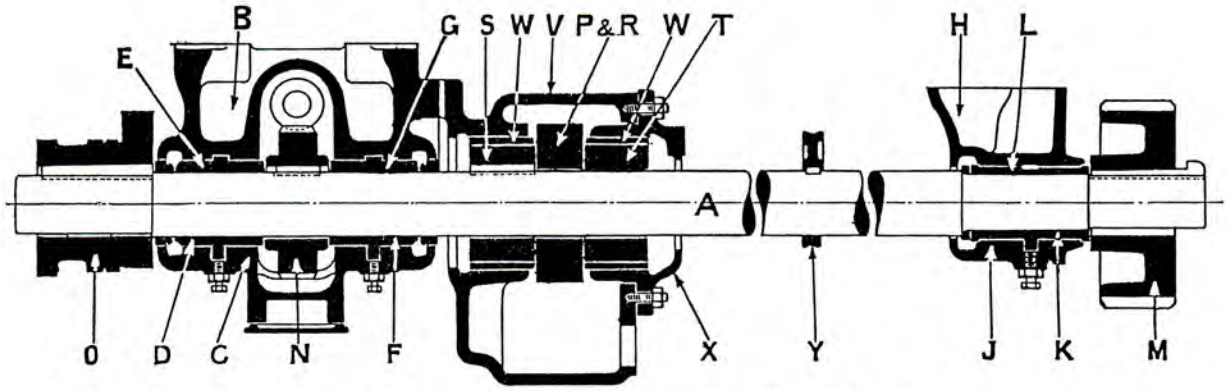
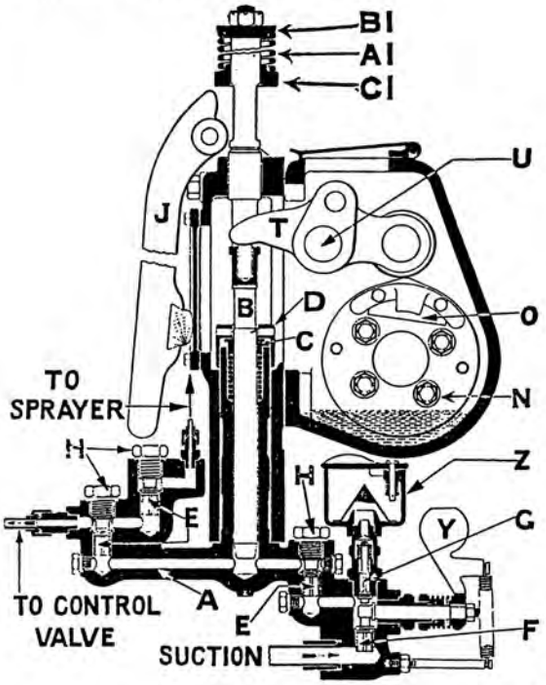



Fig. 17. SIDESHAFT AND CAMS. Size O & OE 128.

A—Sideshaft.
B—Sideshaft Bracket Cylinder End.
C—Cap for Bracket Cylinder End.
D—Left-hand Bearing with Pap.
E—Left-hand Bearing without Pap.
F—Right-hand Bearing with Pap.
G—Right-hand Bearing without Pap.
H—Sideshaft Bracket Crank End.
J—Cap for Bracket Crank End.
K—Bearing with Pap.
L—Bearing without Pap.
M—Sideshaft Wheel.
N—Governor Wheel.
O—Combined Cam.
P—Oil Pump Cam Disc.
R—Toe Piece for ditto. (See detail on page 54).
S—Oil Pump Cam Driving Boss.
T—Oil Pump Cam Bearing Boss.
V—Oil Pump Bracket.
W—Oil Pump Bracket Bushes.
X—Extra Bearing for Oil Pump.
Y—Lubricator Cam.

The cams and gear wheels for actuating the valve gears, fuel pump, lubricator and governor gear are mounted on sideshaft which is driven through spiral gearing from the crankshaft. It is supported at both ends by two rigid bearing both of which are attached to the side of the bedframe. Constant lubrication of these bearings was previously obtained on sizes O & OE 115, 117, 120, and 126, by means of oiling rings running in oil wells, and on sizes O & OE 122, 1 and 128, by the gear wheels acting as oiling rings, collecting the oil and distributing it over the bearings. The lat system has now been adopted on all sizes except O & OE 126 ; for Part Nos. and Engine Nos. where the alteration co menced see List of Parts on page 65.

## OIL PUMP.



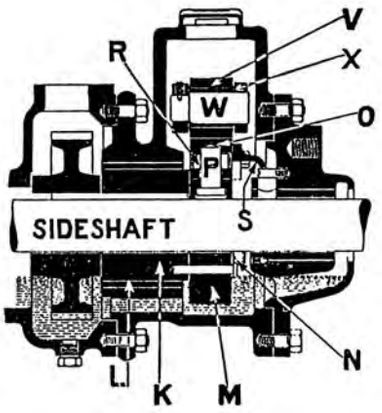




Fig. 18. Oil Pump. Sizes O & OE 115 to 126.

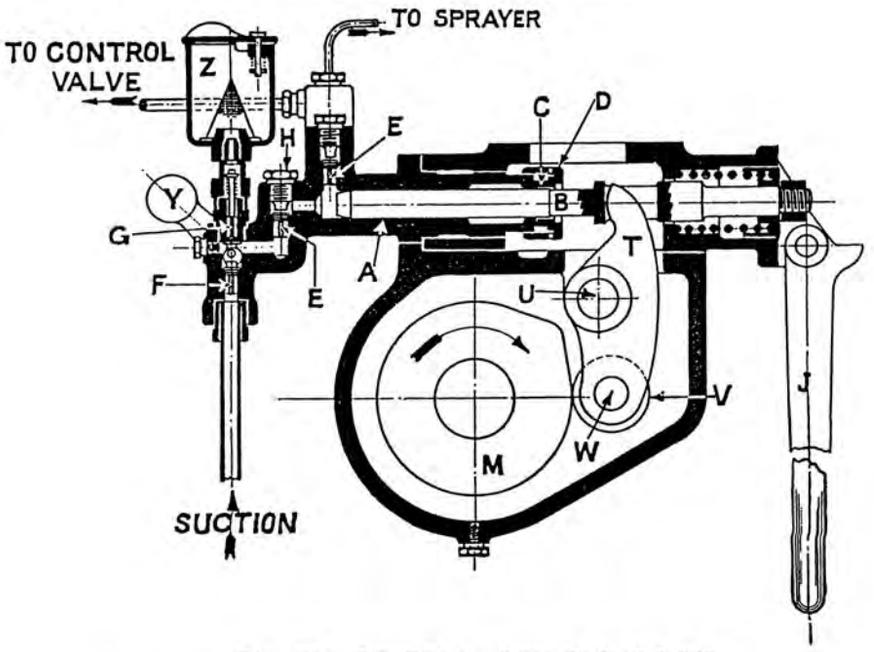



Fig. 19. Oil Pump. Sizes O & OE 128.

A—Oil pump body.
B—Pump plunger.
C—Pump gland.
D—Pump gland nut.
E—Suction and delivery valves.
F—Primary suction valve (for Crude Oil).
G—Primary suction valve (for Refined Oil).
H—Plugs over valves.
J—Priming handle.
K—Pump cam boss.
L—Cam bearing.
M—Cam disc.
N—Cam disc studs and nuts.
O—Cam toe piece.
P—Dowel for toe piece.
R—Cotter for toe piece.
S—Oil catcher and keep plate for R.
T—Oil pump lever.
U— „ „ „ fulcrum pin.
V— „ „ „ roller.
W— „ „ „ „ pin.
X— „ „ „ „ bush
Y—Change over valve handle.
Z—Paraffin Cup (see page 18).
A1—Spring for oil pump.
B1—Collar for spring,
C1—Bridge for spring.

**FUEL OIL PUMP AND CAM.**—The oil pump, as illustrated above, is operated by means of a lever **T,** which in turn is worked by the cam on the sideshaft. The pump cam consists of three principal parts, (1) a boss **K** which is keyed to the sideshaft ; (2) a disc **M** secured to the boss by studs and dowels ; and (3) a toe piece **O** of specially hard steel secured to the disc by the dowel **P** and cotter **R.** The periphery of the cam is submerged in an oil bath.

On later engines a relief valve is fitted in the oil pump body under the lower suction valve **F.** By unscrewing this it can be readily ascertained that the fuel oil is flowing freely from the heater to the pump.

The fuel oil is forced through the sprayer, Fig. 20, into the combustion chamber in the form of fine spray by the action of the oil pump. The oil pump is one of the most important parts of the engine, in fact, the successful working of the engine depends almost entirely upon the pump, the sprayer, and the control valve. See diagram of the complete fuel oil system shown on Fig. 61, inside back cover.

For sizes O & OE 115 to 126, Fig. 18, the pump plunger **B** is vertical. For sizes O & OE 128, Fig. 19, the plunger **B** is horizontal.

The paraffin cup **Z,** for refined oil, is fitted to all engines for starting purposes, *except in some of the larger engines, and in special cases such as when a very viscous fuel oil is used, when a separate refined oil tank is coupled up to the top of the oil heater by means of a pipe, thus enabling the engine to run longer on refined oil so as to thoroughly liquify the viscous oil in the oil heater* (See note on page 30 as to pouring a supply of refined oil into the tundish for a similar purpose). The hand-operated lever **Y** is used for changing over from one fuel to another while running. The end of the spindle between the heads of the valves **F** and **G** is eccentric, and presses either one or the other of these valves to their seat, according to which oil is required to be used.

When starting, the engine is usually cold and also runs slowly for the first few revolutions, and in consequence the oil is pumped slowly. On this account, refined oil is used as it will atomise more readily at slow speeds and when cold, than the thicker crude oils. The refined oil is drawn into the pump through the valve **G** and then delivered to the sprayer. After starting and as soon as the speed of the engine increases, the crude oil is admitted by pushing over the lever **Y** so as to close the valve **G** and allow the crude oil to enter through the valve **F.** See further notes under "starting."—Pages 30, 32. and 33. Care should be taken that the pump is kept in good condition.—See "Maintenance" notes, pages 43 and 51.

## OIL SPRAYER AND STRAINER.

A—Sprayer body.
B— „ nozzle.
C— „ „ cap.
D— „ valve.
E— „ gland ring.
F— „ „ nut.
G—Spring.
H— „ collar.
J— „ „
K— „ bar.
L— „ stop.
M— „ bar studs.
N—Relief valve.
O—Strainer body.
P— „ plug.
Q— „ end plug.
R—Wire gauze strainer.
S—Plug for inlet pipe.
T—Gland nut for relief valve.
U—Space showing lift of valve.
X—Distance pieces for spring bar studs (Length must not be altered).

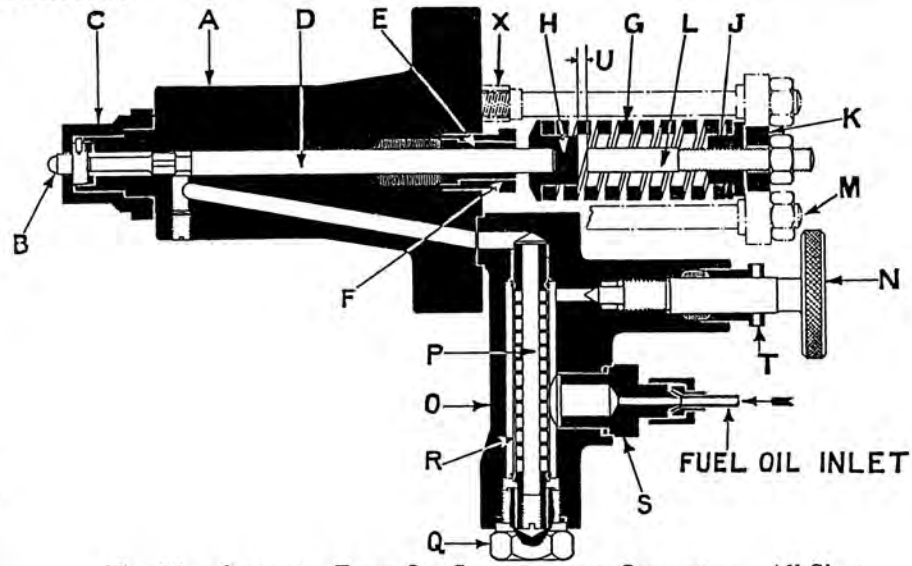



Fig. 20. ORIGINAL TYPE OIL SPRAYER AND STRAINER. All Sizes.

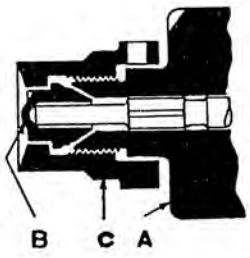



Fig. 20A. IMPROVED TYPE SPRAYER NOZZLE (See also Fig. 43A).

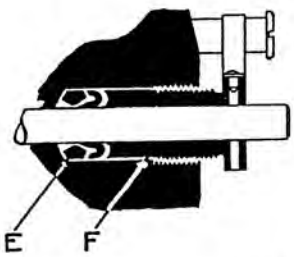



Fig. 20B. IMPROVED TYPE SPRAYER SPINDLE GLAND.

The oil from the fuel pump is delivered to the oil strainer shown above, and thence to the sprayer nozzle. The strainer body **O** is fitted with a relief valve **N** which, when opened, allows all the oil being delivered from the fuel pump to pass to the overflow tundish, Fig. 26, page 21, thus stopping the engine. The strainer plug **P** is enclosed by fine wire gauze **R** to remove any foreign matter, and through which all the oil from the fuel pump must pass before entering the sprayer block. The oil sprayer consists of a block **A** on the end of which a nozzle **B** is attached by means of the nozzle cap **C.** Formerly the joint between the nozzle and block was made with a copper washer, several spare washers being included in the spares outfit. In the latest sprayers, the joint between the nozzle and the sprayer body is made in the form of a coned seating, as shewn in Fig. 20A, the coned surfaces being ground together. A seating is formed in the nozzle for the valve **D.** The valve spindle passes through a packed gland, and its lift is limited by the stop **L.** In earlier engines a soft cord packing was used. In the latest engines, a special cup packing ring is used, as illustrated in Fig. 20B. See also notes on page 44. The valve is closed by the compression spring **G** and opened by the pressure of the oil from the fuel pump. As soon as the valve **D** is opened, oil in the form of a fine spray is injected into the combustion chamber until the control valve, Figs. 22 and 23 (see page 19) opens, when the spraying immediately ceases. **IMPORTANT.**—The oil sprayer is the most important part of the engine, and it is absolutely necessary that it is kept in first class order throughout.—See "Maintenance" notes on pages to 44 to 46.

**NOTE.**—A locking arrangement is provided in some cases to prevent the gland nut **F** slacking back and touching the spring collar **H,** which would prevent the sprayer valve **D** from closing and thus cause irregular working.

# GOVERNING AND FUEL CONTROL MECHANISM.

The governing of the engine is effected by means of a centrifugal governor, which varies the time of the opening of a control valve, connected to the fuel pump and the sprayer. A full explanation of this device whereby the quantity of fuel oil injected into the combustion chamber is brought under absolute control, thereby graduating the power of the impulse upon the piston to the speed and the load upon the engine, is given on pages 20 and 21.

**GOVERNOR.**—The action of the governor is as follows :—

When the speed of the engine increases, the centrifugal force causes the revolving weights **E** to move outwards, thus lifting the sleeve **K** and clip **M**, the motion of which is transmitted through the lever **L** to the gear operating the control valve, as already mentioned above.

**DASHPOT.**—As the governor is very sensitive, a dashpot **P** is provided to enable the movement of the governor levers to be damped. The spring **T**, on the top of the dashpot, is to prevent the engine pulling up in the event of a momentary overload, as referred to on page 35. When the dashpot and also the springs **H** on the governor weights are removed, the governor weights can be moved by hand.

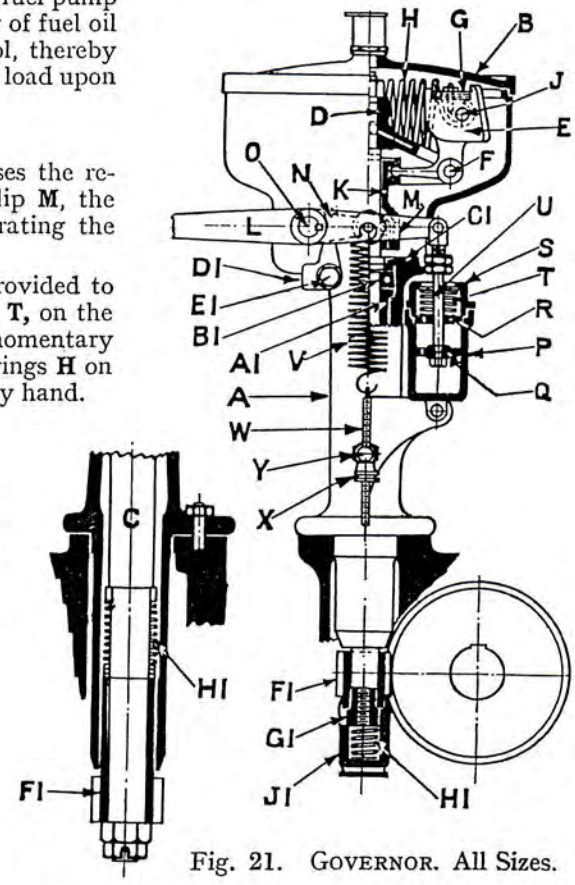
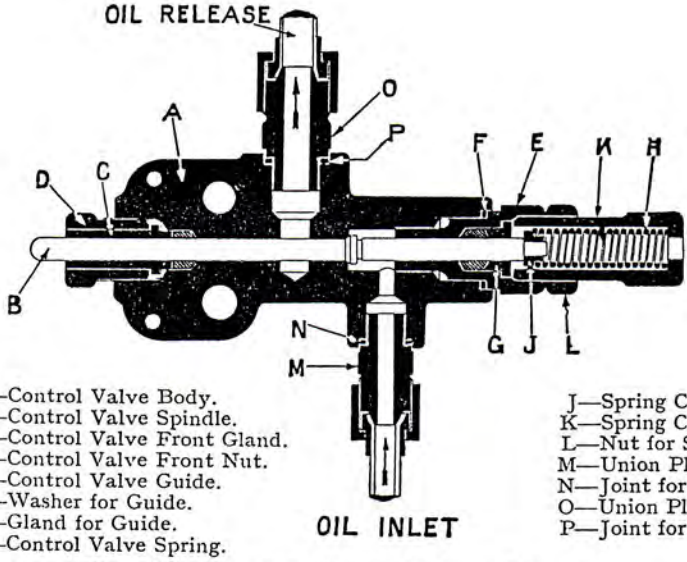


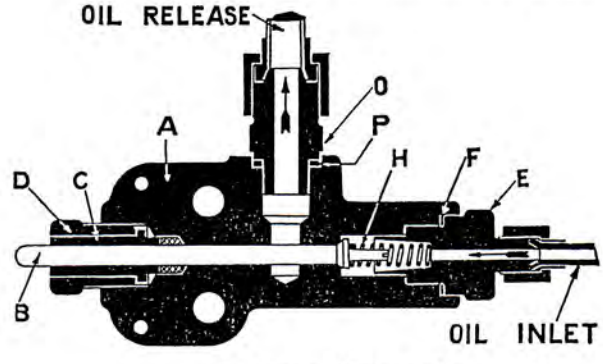

Fig. 21. GOVERNOR. All Sizes.

A—Governor Box.
B—Governor Box Cover.
C—Governor Spindle.
D—Governor Weight Carrier.
E—Governor Weight.
F—Governor Weight Fulcrum Pin.
G—Governor Weight Adjustment Washers.
H—Governor Springs.
J—Governor Springs Pins.
K—Governor Sleeve.
L—Governor Lever.
M—Governor Clip.
N—Governor Double Lever.
O—Governor Lever Fulcrum Pin.
P—Governor Dashpot.
Q—Governor Dashpot Piston.
R—Governor Dashpot Plate.
S—Governor Dashpot Cover.
T—Governor Dashpot Spring.
U—Governor Dashpot Rod.
V—Governor Speed Adjustment Spring
W—Governor Tension Rod.
X—Governor Speed Adjustment Nut.
Y—Governor Speed Adjustment Pillar.
A1—Governor Spindle Bush.
B1—Ball Thrust Washer.
C1—Oval Plate.
D1—Starting Prop.
E1—Pin for Starting Prop.
F1—Governor Pinion.
G1—Governor Pinion Locking Nut.
H1—Spring for Governor Drive.
J1—Spring Box for Governor Drive.




A—Control Valve Body.
B—Control Valve Spindle.
C—Control Valve Front Gland.
D—Control Valve Front Nut.
E—Control Valve Guide.
F—Washer for Guide.
G—Gland for Guide.
H—Control Valve Spring.
J—Spring Collar.
K—Spring Cap.
L—Nut for Spring Cap.
M—Union Plug for Inlet Pipe.
N—Joint for Plug.
O—Union Plug for Outlet Pipe.
P—Joint for Plug.

Fig. 22. CONTROL VALVE (Balanced Type).



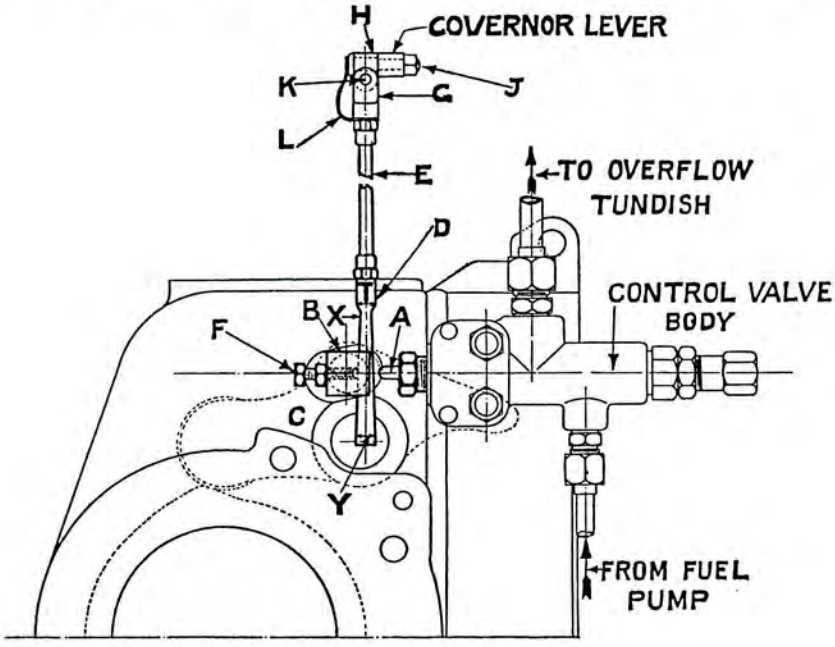

A—Control Valve Body.
B—Control Valve Spindle.
C—Control Valve Front Gland.
D—Control Valve Front Gland Nut.
E—Union Cap.
F—Washer for Union Cap.
H—Control Valve Spring.
O—Union Plug for Outlet Pipe.
P—Washer for same.

Fig. 23. CONTROL VALVE (Unbalanced Type).

**CONTROL VALVE.**—Two types of valve are used, one balanced as shown in Fig. 22, and one unbalanced as shown in Fig. 23. The latter type originally adopted on the smaller engines, is now used on all sizes. See page 69.

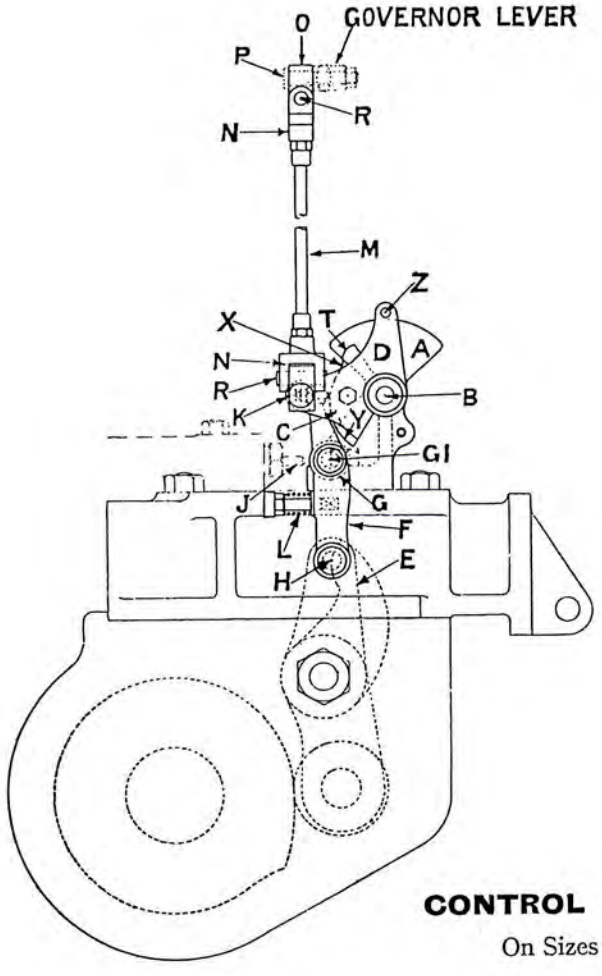
The function of this valve is to return a portion of oil back to the oil tank during every delivery stroke of the fuel pump plunger, the *quantity* of oil thus released, and the *time* at which the valve releases the oil, being determined by the operation of the governing mechanism. The control valve **B** is balanced, both ends of the spindle being provided with a stuffing box and soft packing. A strong compression spring **H** ensures the prompt closing of the valve. The crude oil is delivered under pressure from the fuel pump to the valve. A very slight opening of the valve places the inlet and outlet chambers of the valve body into communication. The pipe from the outlet chamber being free to the atmosphere, the pressure falls and injection through the sprayer ceases instantaneously. See diagram of complete fuel oil system, Fig. **61**. inside back cover.

## CONTROL VALVE OPERATING MECHANISM.




A—Control Valve Spindle.
B—Pecker Bolt.
C—Fuel Pump Lever.
D—Governor Wedge.
E—Hanging Rod.
F—Setscrew in Pecker Bolt.
G—Jaw in Universal Joint.
H—Eye for Universal Joint.
J—Fulcrum Pin for Universal Joint.
K—Pin for Universal Joint.
L—Spring for Governor Rod.
X—Thinnest part of Wedge (over load)
Y—Thickest part of Wedge (no load).

Fig. 24. Size O & OE 115 to 126.
For explanations of the positions T, X and Y see page 35.




A—Quadrant Bracket.
B—Fulcrum Pin.
C—Quadrant Plate.
D—Quadrant.
E—Operating Lever.
F—Floating Lever.
G—Floating Lever Roller.
G1—Floating Lever Pin.
H—Floating Lever Jaw.
J—Control Valve Spindle.
K—Pecker Bolt.
L—Spring.
M—Governor Hanging Rod.
N—Jaw for Universal Joint.
O—Eye for Universal Joint.
P—Fulcrum Pin for Universal Joint.
R—Pins for Universal Joints.

Fig. 25. Size O & OE 128.
For explanation of the positions T, X and Y see pages 21 and 35.

## CONTROL VALVE OPERATING MECHANISM.

On Sizes O & OE 115 to 126 the Control Valve spindle **A** is

actuated by the pecker bolt **B** fixed in an extension of the fuel pump lever **C,** as shewn in Fig. 24. The wedge **D,** attached to the governor lever by the governor hanging rod **E,** is interposed between the setscrew **F** in the pecker bolt **B** and the end of the valve spindle **A.** As the load and the speed of the engine varies the governor raises or lowers the governor wedge **D.** This results in the amount and the time of opening of the control valve **A** also being varied to suit the load.

In Sizes O & OE 128, the control valve itself is of the same construction, and works upon the same principle as the one previously described for smaller engines, but the method of controlling the time and amount of release differs somewhat in detail. In this case a quadrant **D,** Fig. 25, is used (instead of a wedge) and is connected to the governor hanging rod. The operating lever **E** is a continuation of the pump lever and operates the floating lever **F,** which in turn moves the control valve spindle **J** by means of the roller **G.** The necessary variation of lift and time of release is effected by varying the position of the quadrant **D** by means of the governor hanging rod. The radius of the face of the quadrant plate **C** is eccentric to the fulcrum, causing it to have a cam-like movement when rotated. The compression spring **L** holds the end of the setscrew **K** against the quadrant face, which thus forms the fulcrum for the lever **F.** The motion transmitted to this lever **F** by the pump lever does not vary, but any radial movement of the quadrant moves the end of the setscrew **K** horizontally, either nearer to or farther from the end of the control valve spindle, thus varying the amount of movement imparted to the roller **G** and to the control valve spindle **J.**

The maximum load position is when the position marked **X** on the quadrant is opposite the control valve, and the no load position is when the point **Y** is opposite the control valve. When working on the intermediate loads the governor moves the quadrant the necessary amount up or down, between these two positions.

## OIL HEATER AND STRAINER.

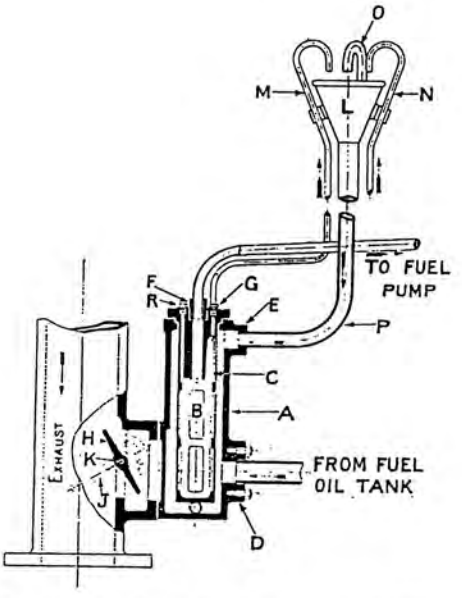



Fig. 26. OIL HEATER AND STRAINER.

When working with heavy, crude or residual oils, it is necessary, in order to obtain sufficiently fine atomisation of the fuel when issuing from the sprayer, to heat the oil before it reaches the oil pump. This heating reduces the viscosity, and makes it sufficiently thin or fluid to spray properly. An oil heater combined with strainer, is therefore fitted to all engines.

The illustration, Fig. 26, shows the heater body **A** attached to the exhaust pipe of the engine. A butterfly valve **H** is used to deflect some of the exhaust gases towards the heater to increase its temperature. The valve **H** is adjusted by an external handle **J.** On some of the larger engines the heater is modified to give a larger heating surface.

In some cases when only paraffin or gas-oil is to be used no oil heater is necessary and none is supplied.

In other cases when very viscous oil is to be used, an additional oil heater is fitted on the exhaust bend, through which the oil is passed after leaving the fuel pump, thus receiving additional heat before it enters the sprayer. (See position of this auxiliary heater indicated on the diagrammatic arrangement Fig. 61.)

A—Oil Heater body.
B—Strainer plug.
C—Gauze for strainer plug.
D—Flange for oil inlet pipe.
E— ,, ,, pipe from overflow tundish.
F—For outlet pipe to oil pump.
G— ,, air vent pipe.
H—Throttle valve in exhaust pipe.
J—Handle for exhaust throttle valve.
K—Spindle ,, ,, ,, ,,
L—Overflow tundish.
M—Air vent pipe.
N—Return pipe from sprayer.
O— ,, ,, ,, control valve.
P— ,, ,, ,, overflow tundish.
R—Plug for refined oil connection (when fitted).

**OIL STRAINER.**—A large oil strainer plug **B** is fitted in the oil heater. All the oil which passes to the oil pump must pass through the wire gauze **C** in the strainer, and so be thoroughly cleaned before passing to the sprayer. A plug **R** is provided which can be removed in order to fit the refined oil connections, on engines using very viscous oil. See also notes on page 18 under Fuel Oil Pump and Cam. Also see diagram of complete fuel oil system given in Fig. 61, inside back cover.

**OVERFLOW TUNDISH.**—An overflow tundish **L** is provided. This is connected to the oil heater by means of the pipe **P.** Three pipes are led to this tundish, namely :—an air vent pipe **M** which allows any air or water vapour to escape from the heater, a relief pipe **N** from the sprayer (oil only flowing from this pipe when the relief valve on the sprayer is opened), and the return pipe **O** from the control valve. Oil should always be issuing from this pipe when engine is working. All oil overflowing into the tundish returns to the heater.

## FUEL OIL TANK.

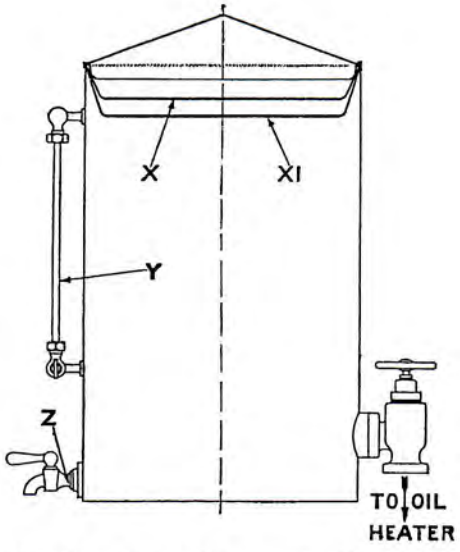



Fig. 27. FUEL OIL TANK. All Sizes.

A—Screw Down Valve Body.
B—Guide.
C—Cover.
D—Handle.
E—Valve Spindle.
F—Gland.
G—Gland Ring.
H—Joints for Cover & Guide.

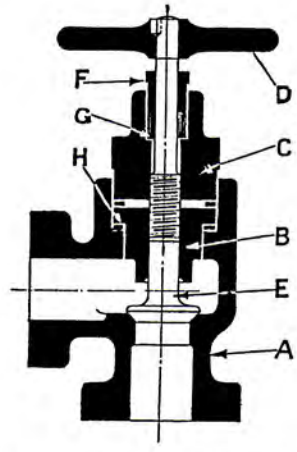



Fig. 28. SCREW DOWN VALVE. All Sizes.

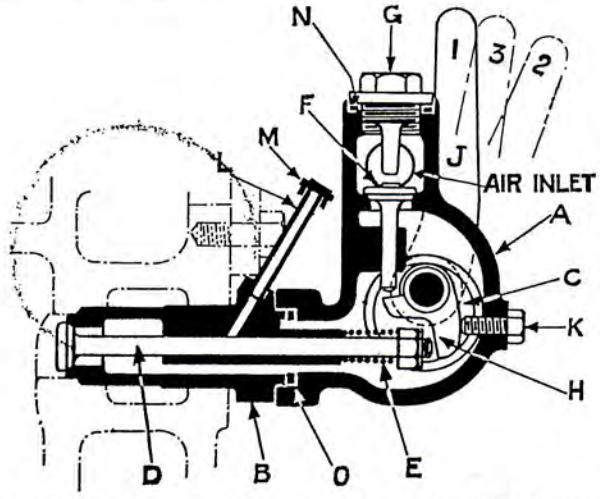
A large fuel oil tank is provided with strainers **X** and **XI,** to prevent any sediment in the oil getting through to the oil pump and oil sprayer. A gauge glass **Y** is fitted in the side of the oil tank to show the height of the oil. A drain tap **Z** is fitted at the bottom, through which any water which may tend to collect there may be drawn off *daily*. A screw down valve, Fig. 28, is fitted at the lower part of the oil tank, which communicates, by means of a pipe, with the oil heater. See further notes under "Maintenance," pages 47 and 51, and "Warnings," page 40.

In some cases, when only paraffin or gas oil is to be used, a different tank is supplied.

# STARTING APPARATUS.

The following parts are for use when starting by means of compressed air, as described on page 31.

## STARTER VALVE.




A—Starter Valve Casing.
B— ,, ,, Body.
C—Operating Lever Housing.
D—Starter Valve Spindle.
E— ,, ,, Spring.
F—Non-return Valve.
G— ,, ,, Cover.
H—Operating Lever.
J—Starter Handle.
K—Setscrew for Operating Lever.
L—Oil Tube.
M— ,, ,, Cap.
N—Copper Washer for Non-return Valve Cover.
O—Copper Washer for Starting Valve Body.

Fig. 29. HAND STARTER VALVE. Sizes O & OE 115 and 117. (*Now superseded by the cam controlled starter valve shewn in Fig.* 29A.)

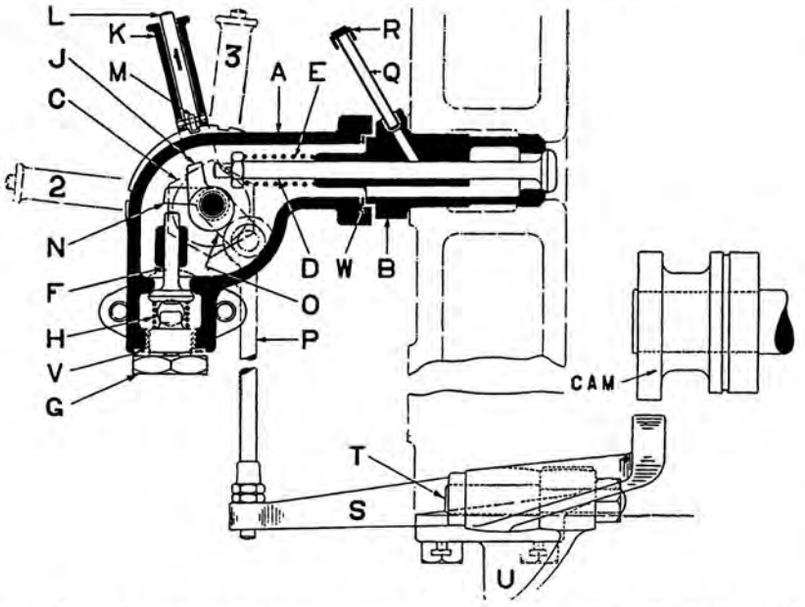
This valve is hand controlled by means of the hand lever **J.**

The compressed air from the receiver enters the casing above the valve as shown. The valve **F** must be lifted by the lever **H,** before the compressed air can pass through the starter valve **D** into the engine cylinder.

The handle **J** is shown in three positions :—

1—Running position when valves **D** and **F** are closed.
2—Starting ,, ,, ,, ,, ,, held open by the lever **H.**
3—Charging position when valve **D** is held open and valve **F** free to lift.

## STARTER VALVE—RE-CHARGING TYPE.




A—Starter Valve Casing.
B— ,, ,, Body.
C—Operating Lever Housing.
D—Starter Valve Spindle.
E— ,, ,, Spring.
F—Non-Return Valve.
G— ,, ,, ,, Cover.
H— ,, ,, ,, Spring.
J—Operating Lever (Starter Valve).
K—Starter Valve Handle.
I— ,, ,, Thumb-Piece.
M—Pawl for Handle.
N—Non-Return Valve Operating Lever.
O—Outside Operating Lever.
P—Starter Valve Push Rod.
Q—Lubricating Oil Tube.
R—Cap for Ditto.
S—Starter Valve Lever.
T—Fulcrum Pin for Ditto.
U—Starter Lever Bracket.
V—Copper Washer for Non-Return Valve Cover.
W—Copper Washer for Starter Valve Body.

Fig. 29A. CAM CONTROLLED STARTER VALVE. Sizes O & OE 115 to 217.

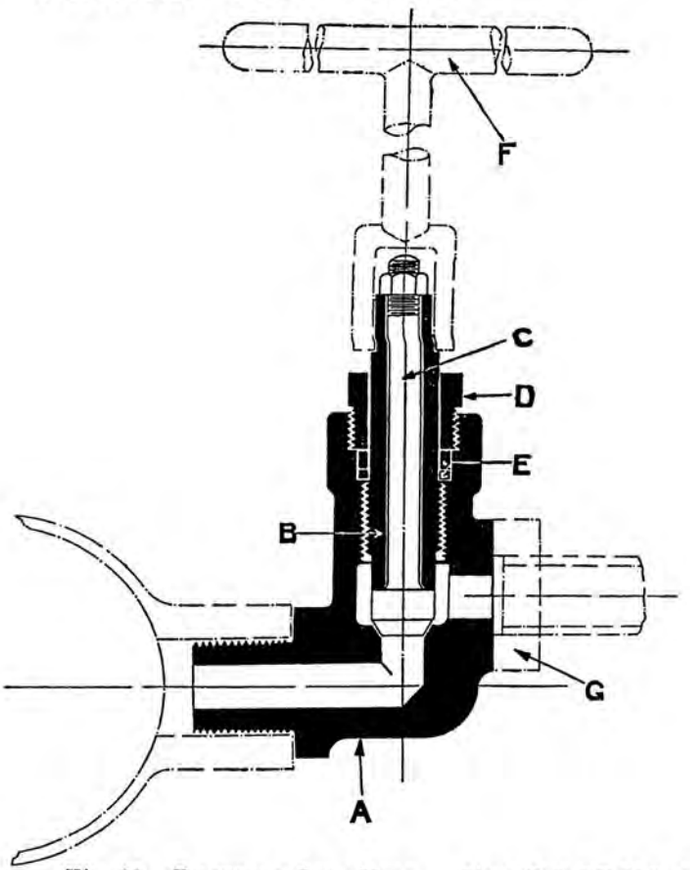
This valve is similar in many respects to the hand controlled starter valve illustrated in Fig. 29, except that it is operated by the admission valve cam on the camshaft.

The compressed air from the receiver enters the casing below the valve **F** which must be pressed open, from its seat by the action of the levers **S, O** and **N,** before the compressed air can pass through the starter valve **D** into the engine cylinder.

The handle **K** can be moved into three positions, viz. :—

1. Running position when valves **D** and **F** are closed.
2. Starting position when valve **F** can be opened by the cam operated levers.
3. Charging position when valve **D** is held open, and valve **F** is free to lift, to permit the compressed air in the cylinder to pass into the air receiver.

## RECEIVER STOP VALVE.




A—Stop valve Body.
B—Plug.
C—Spindle.
D—Gland Nut
E—Distance Piece.
F—Tee Handle.
G—Outlet Flange.

This valve is of the screw down type and is provided with a stuffing gland **D** and soft packing to prevent any leakage of air when open.

The valve **C** is opened and closed by the screwed valve plug **B,** the Tee handle **F** being used for the purpose.

Fig. 30. RECEIVER STOP VALVE. Sizes O & OE 115 to 117.

## CAM CONTROLLED STARTER VALVE.

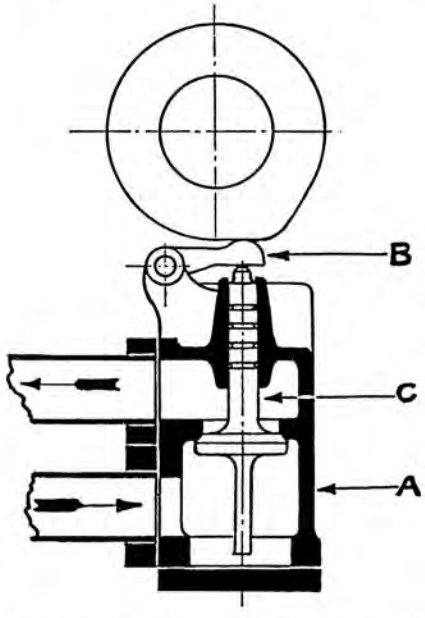



Fig. 31. CAM CONTROLLED STARTER VALVE.
Size O & OE 120 to 128.

A—Cam Controlled Starter Valve Body.
B—Lever.
C—Spindle.

This valve is secured to the sideshaft immediately under the cams. Its function is to control the admission of compressed air to the automatic starting valve at the back of the breech end. The cam on the sideshaft operates the lever **B** which in turn operates the valve **C.** When not in use the valve falls off its seat away from the cam. As soon as compressed air is turned on the air pushes the valve upwards to its seat until the cam comes round, pushes the valve off its seat and admits the compressed air to the engine cylinder.

## AUTOMATIC COMPRESSED AIR STARTER VALVE.

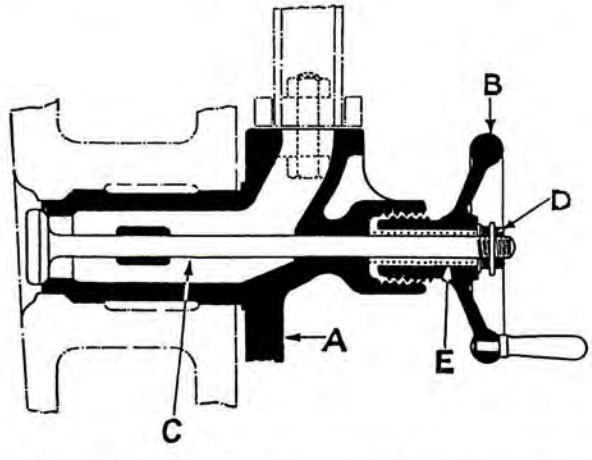



Fig. 32. AUTOMATIC COMPRESSED AIR STARTER VALVE.
Size O & OE 120 to 128.

A—Starter Valve Block.
B—Operating Handle.
C—Spindle.
D—Collar.
E—Spring.

The valve **C** is automatically opened by the incoming compressed air from the controller valve shown in Fig. 31. The compression spring **E** returns the valve to its seat on the supply of air being cut off. By turning the regulating wheel **B** in a clock-wise direction the valve is free to open to admit compressed air to the cylinder. When turned anti clock-wise it is screwed firmly on to its seat thus preventing any further compressed air entering.

## RECEIVER STOP VALVE.

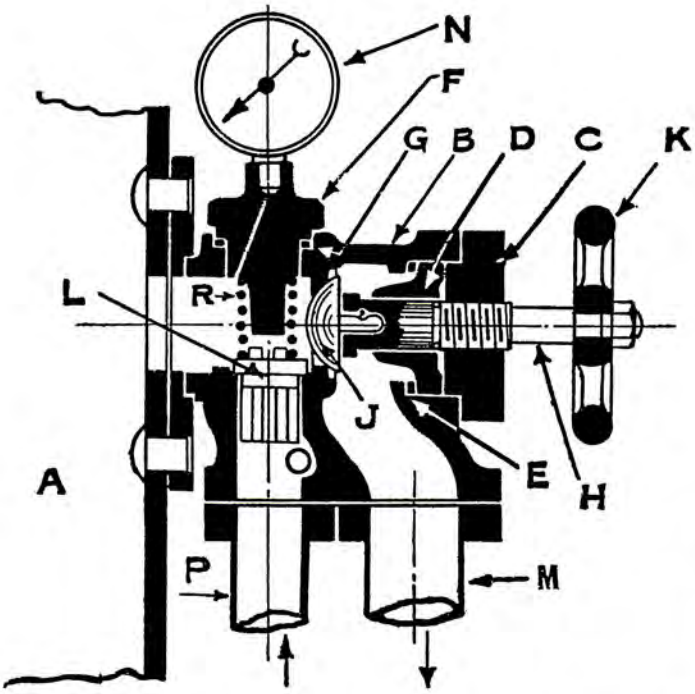



Fig. 33. RECEIVER STOP VALVE. Size O & OE 120 to 128.

A—Air Receiver.
B—Valve Body.
C—Valve Cover.
D—Valve Guide.
E—Joint for Guide.
F—Plug.
G—Joint for Plug.
H—Valve Spindle.
J—Valve Spindle Loose Head.
K—Hand Wheel.
L—Non-return Valve.
M—Pipe to Engine.
N—Pressure Gauge.
O—Relief Valve (not shown).
P—Pipe from Air Compressor.
R—Spring on Non-Return Valve L.

The pressure in the air receiver is retained by means of the stop valve shown in Fig. 33. A stop valve is also sometimes put on the pipe **P** in which case the safety valve is located between the stop valve and the compressor.

The stop valve **J** is closed while the receiver is being charged, by means of the handwheel **K.**

When the engine is ready for starting the stop valve is opened, the compressed air then passing through the pipe **M** to the controller valve on the engine.

## HEATING LAMP. For use, only when no compressed air is available.

A—Cover on Reservoir.
B—Cup for Petrol or light spirit.
C—Relief Valve.
D—Air Pump.
E—Burner Nipple.
F— ,, Cover.

This lamp used for heating the ignition tube in the side of the breech end previous to starting the engine, is of the well known pressure type. It need only be used when no compressed air is available.

The working principle of the lamp is as follows :—The kerosene or paraffin oil is forced through the previously heated burner tubes, becomes gasified during its circulation and issues through the small brass nipple **E,** after which it mixes with air, burning with a blue, atmospheric flame.

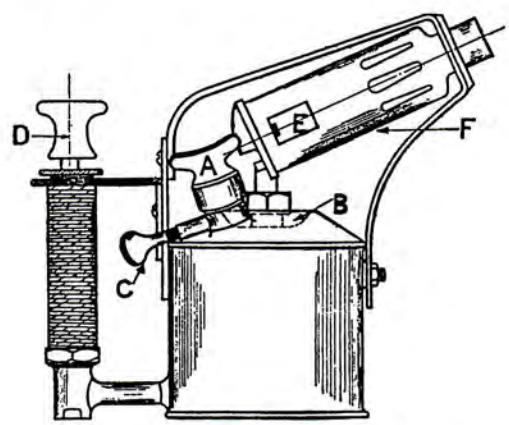



Fig. 34. HEATING LAMP.
Supplied with all sizes except O & OE 126 and 128.

## BARRING GEAR AND HAND TURNING GEAR.

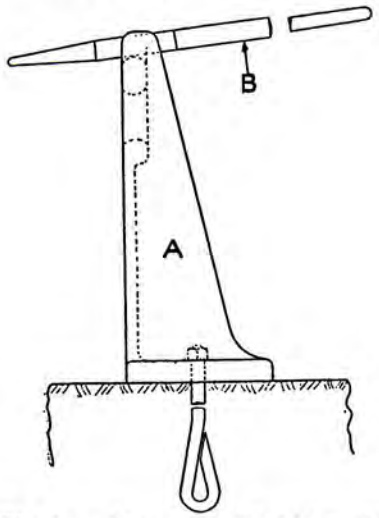



Fig. 35. Sizes O & OE 120 to 123.

For sizes O & OE 120 to 128, and also for double cylinder engines, means are provided for turning the flywheel round to any desired position such as when preparing to start the engine, re-setting the valve gear, etc.

A—Barring Gear Bracket.
B—Bar.

For sizes O & OE 120 to 123 a simple bracket **A** and tommy bar **B** is provided with the engines, Fig. 35.

A—Bracket.
B—Pinion.
C—Handwheel.
D—Shaft.
E—Safety Pawl.

For sizes O & OE 126 to 128 and O & OE 226, a hand turning gear, Fig. 36, is provided, having one pinion **B,** which can be placed in gear with teeth in the flywheel rim. See illustration, Fig. 4. A safety pawl **E** is fitted to ensure that when the pinion is disengaged it can be safely locked out of gear. **It is most important that this pawl is placed back in position before starting.** See further notes under "Warnings," on page 38.

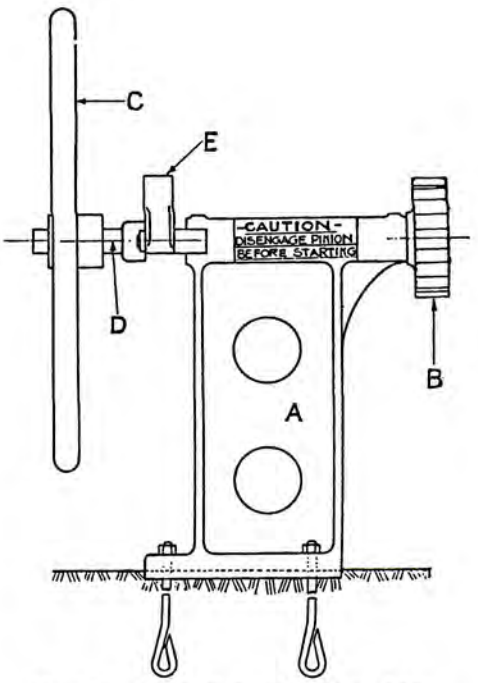



Fig. 36. Sizes O & OE 126 to 128.

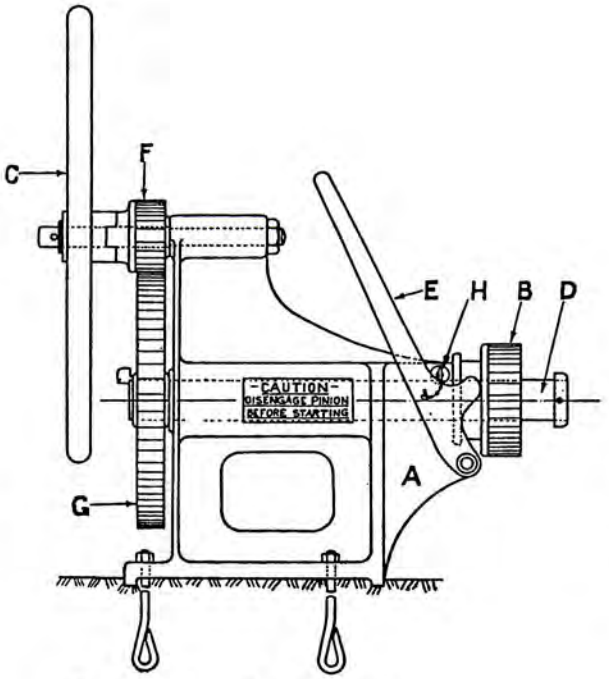



Fig. 37. Sizes O & OE 228.

A—Crab Frame.
B—Sliding Pinion.
C—Handwheel.
D—Shaft.
E—Hand Lever.
F—Pinion for Hand Wheel.
G—Gear Wheel.
H—Stop Pin for Hand Lever L.

For sizes O & OE 228 a similar gear is fitted but provided with reduction gearing **F** and **G,** Fig. 37. A hand lever **E** slides the pinion **B** in and out of gear. The safety stop pin **H** prevents the pinion re-engaging whilst the engine is running, **and it is most important that this stop is placed back in position before starting.** See further Notes under "Warnings," on page 38.

# LUBRICATION.

**All Engines** have forced lubrication to the cylinder and to the exhaust valve. On Sizes O & OE 123 to 128 forced lubrication is also provided for the piston pin and crank pin bearings. In all cases the forced feed lubricator is driven from the camshaft.

A full description and illustrations of the lubricators is given below, together with means provided for supplying the various parts of the engine with lubricating oil.

Particular attention must be paid to the instruction and hints given on pages 29, 34, 38, 39, 46 and 47.

## DOUBLE PLUNGER LUBRICATOR.

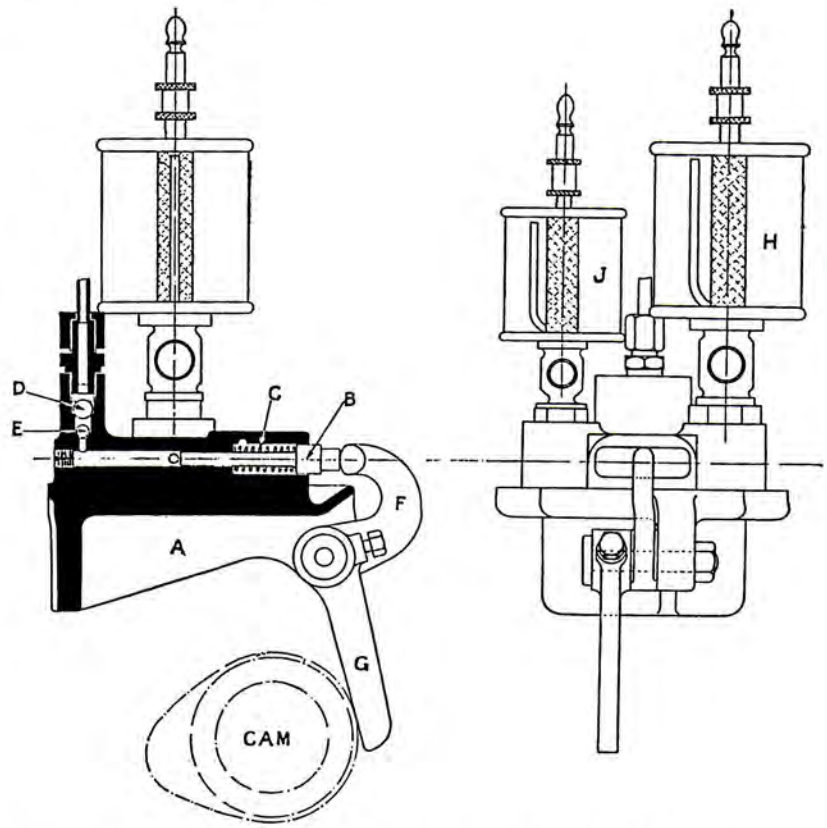


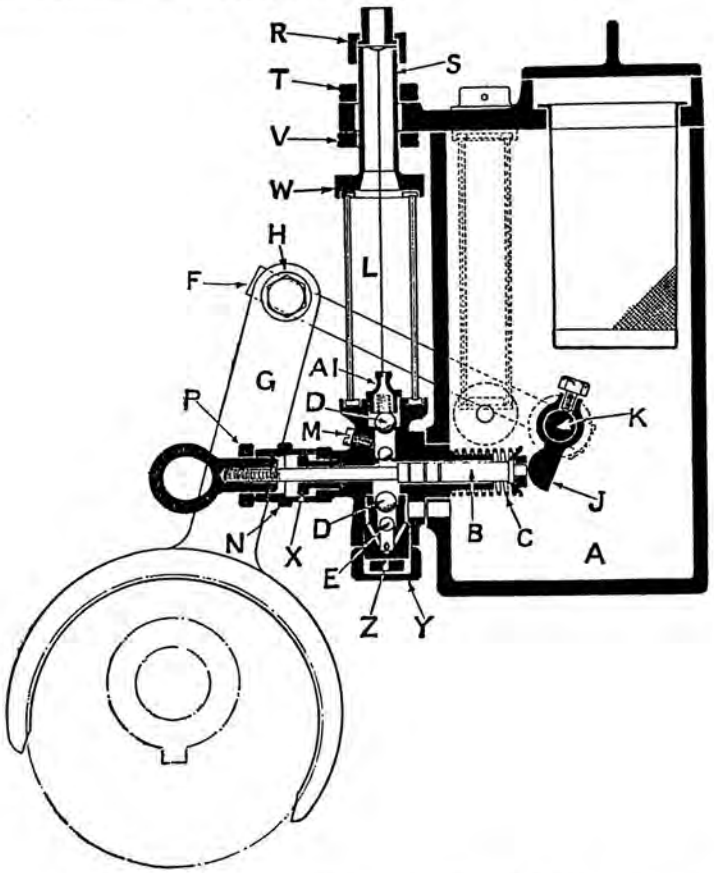

Fig. 38. DOUBLE PLUNGER LUBRICATOR. Sizes O & OE 115 to 122.

A—Lubricator Pump Body.
B—Plungers.
C—Plunger Spring.
D—Ball Valve (Upper).
E—Ball Valve (Lower).
F—Crank Lever.
G—Lever on Cam.
H—Large Sight Feed Lubricator.
J—Small ,, ,, ,,

This pump is very simple in construction. It supplies lubricating oil to the cylinder and exhaust valve. Ordinary care on the part of the attendant should suffice to keep it in good working order. The oil flows by gravity to the plunger barrel from the sight feed lubricators **H** and **J** on the top of the pump body **A** (the larger one being for the cylinder and the smaller one for the exhaust valve). For quality and quantity of oils to be used see page 34. The oil is forced through the delivery ball valves **D** and **E** by the displacement of the plunger **B** due to the movement of the crank lever **F** attached to the lever **G** operated by the cam. The compression spring **C** forces the plunger **B** outwards after each delivery stroke.

The adjustment of the feed is obtained by means of the milled units on the sight feed lubricators.

## CENTRAL MECHANICAL LUBRICATOR.




A—Container.
B—Plunger.
C—Plunger Spring.
D—Ball Valve, Large.
E—Ball Valve, Small.
F—Driving Rod.
G—Operating Rod.
H—Connecting Rod Pin.
J—Internal Tappet Lever.
K— „ „ „ Layshaft.
L—Sight Feed Glasses containing salt water.
M—Vent Screw.
N—Adjusting Sleeve.
P—Lock Nut for Adjusting Sleeve.
R—Union Nuts for Oil Pipes.
S—Shank Connections to Feed Glasses.
T—Lock Nut for Shank S.
V— „ „ „ S.
W—Joint Washers for Glasses.
X—Gland Ring for Plunger.
Y—Cap for Suction Valve Cage.
Z—Cage for Suction Valves.
A1—Delivery Nozzle.

Fig. 39. CENTRAL MECHANICAL LUBRICATOR.
Sizes O & OE 123 to 126 - 4 Feed. Size O & OE 128 - 5 Feed.

This lubricator supplies lubricating oils to the cylinder, exhaust valve, piston pin, and crank pin bearing.

A series of pumps, one for each feed, is attached to the oil container **A** which is divided into two reservoirs for two different qualities of oil.

Each pump plunger **B** is operated by a separate tappet lever **J** fixed to a layshaft **K** inside the container. This layshaft is actuated by the driving rod **F** and the operating rod **G** from the eccentric. The oil passes up through the sight feed glasses **L** in the form of drops. For method of filling these glasses with a saturated solution of salt, and for adjustment of feed, etc., see "Lubrication" on pages 29 and 34.

**CONNECTING ROD AND PISTON PIN BEARINGS.**—On sizes O & OE 115 to 122, adjustable sight feed lubricators are provided for the piston pin and the crank pin. On sizes O & OE 123 to 128 an adjustable supply of oil is pumped to these parts by means of the central lubricator.

The oil for the piston pin (except in sizes O & OE 115 to 117) runs down to a loose washer hanging in front of the cylinder—See Fig. 14, page 15. The bottom of the disc should be allowed to just *not* touch the projection in the centre of the oil boat on the front of the piston (the clearance recommended being .002 to .005 inches), each time the piston reaches the end of its outstroke. The drop of oil forming on the underside of the washer is thus continuously transferred to the oil boat in the piston, whence it passes down a tube in the piston, and drips into a recess on the top of the small end of the connecting rod, and thence down to the piston pin.

The oil to the crank pin is led to an oil ring on the crankshaft, see Fig. 11, from whence it flows by centrifugal force through an oil hole drilled through the crank web to the crank pin. Frequent attention should be given the lubrication of this important part of the engine, which must be well supplied with oil.

**CRANKSHAFT BEARINGS.**—These are lubricated by means of revolving rings, the lower parts of which dip into lubricating oil contained in oil wells. Brass sight gauges are provided to show the level of oil in the wells, which should be clearly visible at the top of the gauge when the engine is at rest.

**EXHAUST VALVE.**—The spindle of this valve is lubricated with paraffin from the smaller oil cup of the double plunger lubricator on sizes O & OE 115 to 122, and from the central lubricator with lubricating oil on the larger sizes.

**GOVERNOR, OIL PUMP CAM, GEAR WHEELS, VALVE GEAR, Etc.**—The governor gear-wheels, oil pump cam, and sideshaft gear wheels run in oil baths which must be well filled with oil. The governor is supplied with oil from a wick lubricator on the cover of the governor.—See Fig. 21.

# STARTING.

**PREPARING TO START.**—Before attempting to start the engine the following points must be attended to :—

**STARTING BY HAND.**—See page 31.

**COMPRESSED AIR RECEIVER, STOP VALVE AND PIPE.**—When first charging up the receiver raise the pressure in the receiver to about 10 lbs. Then disconnect the air pipe at the starter valve on the cylinder, open the stop valve wide and suddenly, and blow the air to waste. This will blow away any scale or dirt in the valves or pipe. On the O & OE 120 to 128 sizes the air pipe from the compressor to the receiver should be disconnected in the same way at the receiver and air blown through the pipe by working the compressor.

**STARTING WITH COMPRESSED AIR.**—See that the pressure gauge on the compressed air receiver registers a pressure of not less than 150 lbs. for engines having an ignition tube heated by the heating lamp, and not less than 200 lbs. for engines starting from the cold state.

For the first start after erection or in the event of the pressure being lower than given above, it will be necessary to prepare and start the belt driven air compressor or the combined small engine and air compressor, in accordance with the separate instructions supplied. When a belt-driven compressor is used and driven by the engine the first charging of the receiver must be done by working the compressor by hand. To do this the loose handle provided must be screwed into the hole provided in the rim of the driving pulley. The receiver should then be charged up to not less than 50 lbs. per sq. inch gauge pressure.

**HEATING LAMP.**—This is only used with engines not provided with compressed air starters or with engines which have to be started for the first time before the compressed air is available. Use nothing but ordinary paraffin or kerosene oil in the container. See Fig. 34.

**Filling:** Unscrew cover **A** and fill the reservoir not more than three-fourths full of the paraffin, then screw the cover on air-tight.

**Heating:** Fill cup **B** with methylated spirit (or a little petrol or paraffin soaked in cotton waste will do, except that it is not so clean). Then light the spirit and open valve **C.** Avoid draughts otherwise the burner will not become heated. The burner of the lamp should be re-heated, in the same manner, each time it is used.

**Lighting:** When the spirit is almost consumed, close the valve **C.** Give the pump **D** four to six vigorous strokes. The lamp should then begin to burn. Do not pump too soon. Pumping should not be started until the spirit is almost burnt out, otherwise the burner may not be hot enough to vaporise the oil, and liquid oil will issue giving a white flare. If the spirit should burn out before the burner is lit, apply a lighted taper to the burner. Matches and a taper should always be kept available.

**To increase the Flame:** After the spirit in the cup **B** is entirely burnt, the flame must be increased by pumping.

**To decrease the Flame:** Open valve **C** and allow some air to escape until flame is sufficiently lowered ; then close the valve again.

**To extinguish the Flame:** Open valve **C** and leave it open.

**To ensure perfect Burning:** Clean the nipple **E** with the cleaning needle before lighting, and also at any time if the flame does not increase after pumping or if the flame is streaky. Do not pump too soon when heating, because the burner, unless sufficiently heated, will flare up as described, causing smoke and smell. Should this happen, open the valve **C** at once.

The heating and lighting of the lamp should always be done according to the above instructions, otherwise the lamp will not work satisfactorily.

Before lighting the lamp be sure that it contains sufficient fuel, but *not more than three-quarters full.*

When properly lit and prepared for use, place the lamp upon the stand provided on the breech end with the burner directed so as to project a strong clear flame against the ignition tube in the side of the breech end until the tube appears cherry red in colour, which will indicate a sufficient temperature to ignite the charges.

**DOUBLE PLUNGER LUBRICATOR.**—Sizes O & OE 115 to 122, described on page 27. When the engine is packed for transit the pipes are in position. Uncouple these, therefore, at the cylinder and exhaust valve ends only. Fill the containers of each lubricator with oil (for quality see pages 34 and 39.) Lift the valve spindles of each lubricator in order to allow a little oil to pass into the barrels of the pump. Then work the pump lever by hand until oil fills the pipes and issues from the pipe ends. To do this the plungers must be in the "out" position. The coupling nut at each end of both pipes must then be connected up, making a thoroughly tight joint.

**CENTRAL MECHANICAL LUBRICATOR.**—Sizes O & OE 123 to 128, described on page 28. The glass tubes should be filled with a *saturated solution of salt*, that is to say, with water in which a quantity of salt has been well mixed and then allowed to settle for several hours, the water above the deposit being then carefully drawn off and poured into the glass tubes. It will be found that the oil drops will rise through this solution more quickly than through ordinary water, and the glass will remain cleaner inside. The salt also tends to prevent freezing of the water in cold climates. For quality of oil to use, see pages 34 and 39.

Fill each compartment of the container **A** with the proper quality of oil, loosen the coupling nuts on the far end of the delivery pipes, securing the nuts **R** at the pump end only. Open the air vent **M** a couple of turns, and work the pump by hand until the oil flows freely from the air vent, indicating that all air has been expelled from the pump. Then screw up the air vent tightly and continue pumping by hand till oil appears at each coupling, all of which can then be connected up, making thoroughly tight joints. The lubricator will then begin to feed oil as soon as the engine starts.

**Main Bearings, Sideshaft, Bracket Bearings, Piston Pin Lubricator** (On Sizes O & OE 120 to 122), **Oil Wells for Gear Wheels and Pump Cam, and all Oil Holes in the Valve and Fuel Pump Operating Mechanism.**

See that there is a sufficient quantity of lubricating oil of the right quality (see pages 34 and 39) in all the parts referred to above. The oiling rings should be examined to see they are free to revolve upon the shafts.

**COOLING WATER.**—See that the cock in the bottom (cold water) pipe from the tanks to the cylinder jackets is open. The water circulating through the jackets is regulated by this cock (See notes on "Working," page 36). The level of the water in the tanks must be *not less* than 2in. above the outlet of the hot water or return pipe from cylinder jacket to water tanks. See also that the ball cock connected to the cold water supply for maintaining the water in the tanks at this level is in good working order. See further notes under "Stopping," on page 37.

**FUEL OIL.**—Fill the fuel oil tank (see notes on pages 9 and 56 respecting the various qualities of fuel oils), being careful to pour all the oil through the strainers in the top of the tank. Open the cock on the pipe leading to the oil heater. If the engine is to run with a viscous residual oil, open the valve **H**, Fig. 26, to accelerate the heating of the oil heater. Viscous oils must be heated before they will pass through the filters in the fuel tank. A good plan to deal with very viscous oils which do not flow freely is to mix 10 to 25% of paraffin with the fuel.

**PARAFFIN STARTING CUP AND FUEL CHANGE-OVER GEAR.**—Fill the paraffin cup with paraffin, gas oil, or thin *fluid* crude oil. Place the handle in the starting position by pushing it *hard* over in the direction indicated by the "Refined" arrow on the ball end of this handle, see Figs. 18 and 19. This cup will contain sufficient paraffin to enable the engine to run for a minute or two before changing over to crude oil. Be sure to change over to the main supply well before cup is empty.

**PRIMING THE FUEL PUMP.**—Open the relief screw **N** on the sprayer, prime the pump by working it by hand, and then fill up the paraffin cup again. On later type engines a relief plug is fitted on the pump suction. Petrol spirit must *not* be used. For medium qualities of residual oil, such as oil of .92 specific gravity, pour a few pints of paraffin into the over-flow tundish, before priming the pump from the paraffin cup. This will tend to thin any cold, thick oil in the oil heater. For heavy residual oils, such as those of about .94 specific gravity, the same procedure as with the medium oils is adopted, but in addition to the paraffin cup, a special refined oil tank is required, the pipe from which must be coupled up to the union at the top of the heater so that refined oil (such as paraffin, gas oil, or even light, fluid, crude or residual oils which flow freely) can be used until the more viscous oil in the oil heater has become sufficiently hot and sufficiently *fluid* to be used. Care should be taken to see that the fuel pump is primed from the main supply pipe, otherwise, if this is not done, the pump may lose its suction when changing over from the paraffin cup to the main fuel supply.

**EXHAUST VALVE AND HALF COMPRESSION CAM.**—Open the exhaust valve by means of the hand lever, when provided, and put the exhaust roller under the half compression cam.

**SETTING POSITION OF CRANK.**—Set the crankshaft of the engine at an angle of about 10 degrees above the horizontal and on the Power stroke, that is, when all the valves are closed. *Then close the exhaust valve*, being particularly careful to let the exhaust valve return to its seat slowly. Careless handling may cause fracture of the valve spindle.

**BARRING GEAR.**—With engines provided with barring gear, *disengage* the pinion of the barring gear from the teeth in the flywheel rim.—See note on barring gear on pages 26 and 38.

**GOVERNOR LEVER STARTING POSITION.**—Raise the governor lever into its correct starting position by means of the starting prop D1 shown in Fig. 21.

The governor wedge, Fig. 24, sizes O & OE 115 to 126, will then be suspended between the end of the control valve spindle and the pecker bolt in such a position that most of the oil delivered by the fuel pump will pass through the sprayer, the remainder being released as the pecker bolt on the oil pump lever advances and opens the control valve, thus preventing the starting impulses being too great. Similarly for sizes O & OE 128 by raising the governor lever in a like manner the quadrant of the control valve operating mechanism, Fig. 25, is rotated so that the setscrew in the floating lever attached to the fuel pump lever will remain on the face of the quadrant plate in such a position that the horizontal movement of the roller is small enough to allow most of the oil to be delivered to the sprayer and the remainder to be released as the roller goes forward.

**BELT OR CLUTCH.**—When preparing an engine for starting the belt must *always* be on the loose pulley, or if a clutch is used, it must be put out of gear.

**CONNECTING ROD, LARGE END.**—Turn the flywheel round until the crank is at the lowest position where any oil in the centrifugal ring will at once run down to the crank pin. Immediately before starting, prime the large end bearing with oil by filling with oil the small oil cup provided for this purpose ; also flush the oil pipe from the lubricator to the centrifugal lubricator **Q**, Fig. 11, to ensure an ample supply of oil to the crank pin immediately the engine is started. It is also very important that there should be no dirt or grit in this centrifugal lubricator ring.

# STARTING. **Before starting the engine read through all notes on "Warnings" (page 38). Also study the diagram of the complete Fuel Oil System shown in Fig. 61, inside back cover.**

**O or OE 115 to 117, STARTING BY HAND, WITH LAMP AND WITHOUT COMPRESSED AIR.**—Two or three men are necessary, one to operate the fuel pump, etc., and the others to turn the flywheel as *quickly* as possible. As no separate air compressor is used with these sizes of engines, all engines must be started by hand when starting for the first time.

All the foregoing instructions given under "Preparing to Start," pages 29 and 30, must be carried out, and the attendant thoroughly satisfied that the engine is in perfect running order. Then close the relief screw **N** on the sprayer, and work the fuel pump by hand until the oil feels solid. Then with a very sharp movement inject one or two charges of oil into the combustion chamber. (Unless the pump is operated very quickly the oil will not spray properly).

Turn the flywheel "backwards" as far as it will go and then turn it "forward" for a few revolutions as *quickly* as possible. (When an exhaust lifting handle is provided the turning of the flywheel is facilitated by holding the handle up for a few revolutions. It must be closed again before injecting a charge of oil). As soon as the engine has increased a little in speed, inject a charge of oil sharply by means of the hand lever **just as the piston is about to commence a Power stroke (do not inject the charge before the beginning of the power stroke,** otherwise the engines will suddenly turn backwards when an ignition occurs). This may be continued until the engine gets well started. A large number of oil charges must not be pumped into the combustion chamber before starting. When a few ignitions have taken place and the speed of the engine begins to increase sufficiently, move the exhaust roller out of gear with the half compression cam, so that full compression may be obtained. The engine will then quickly pick up speed. The lamp may then be put out.

**CAUTION.**—**Never** turn the flywheel, when starting, by putting one's foot on the flywheel arms. This is *dangerous*, in case the engine might accidentally start back in the wrong direction.

**O or OE 115 to 117 STARTING WITH COMPRESSED AIR, with hand-operated starting valve, either with lamp, or from the cold state.**

If the compressed air in the receiver is less than 120 lbs. pressure, it may be advisable to heat the ignition tube as described, but if 150 to 250 lbs. pressure is available, no pre-heating should be necessary.

All the foregoing instructions given under "Preparing to Start," pages 29 and 30, must be carried out, and the attendant thoroughly satisfied that the engine is in perfect running order. Then close the relief screw **N** on the sprayer, and work the fuel pump by hand until the oil feels solid. Then with a very sharp movement inject one or two charges of oil into the combustion chamber (unless the pump is operated very quickly the oil will not spray properly).

Then open the relief screw **N** on the sprayer and open the stop valve on the receiver, allowing the compressed air to pass to the starting valve. Then pull the starter valve handle sharply forward into position No. 2, described on page 22, and the engine will at once start away. *Care must be taken to let the starter valve close as soon as the crank becomes* VERTICAL *on the outstroke, as shown in Fig. 4, otherwise, as the exhaust valve opens just afterwards, the pressure from the receiver would pass through into the exhaust pipe and be wasted. This is often forgotten by the operator, in which case much compressed air is lost. A few impulses given to the engine in this way on each power stroke will be sufficient to turn it a few times. After the engine has made, say* 10 *or* 12 *revolutions, close the compressed air starter valve.* Then close the relief screw **N** and *immediately* afterwards move the exhaust roller away from the half compression cam, so that full compression may be obtained. The engine will then commence to ignite its fuel charges and quickly increase in speed. Then close the stop valve on the receiver to prevent leakage of air. After two or three impulses with relief valve closed, open it slightly to reduce the strength of the impulse until speed is up to normal, when it must be closed again.

**RE-CHARGING COMPRESSED AIR RECEIVER O and OE 115 to 117.**—The compressed air receiver should be re-charged with air from the engine before any load is put on the engine, so that it will be already for starting again at any time. To re-charge the receiver proceed as follows :—

When the engine is running, unloaded, at full speed, open the stop valve, Fig. 30, on the receiver. Then open the relief valve **N**, Fig. 20, on the oil sprayer, thus releasing the oil supply to the cylinder. Immediately this is done, and not before, hold the starting handle **J** in the middle position 3 indicated by the dotted lines.—See illustration, Fig. 29, page 22. This will open the valve **D** but will leave the non-return valve **F** free to operate. The air, compressed by the engine piston, will then be forced through the non-return valve into the receiver. When this valve has been held open for a number of compression strokes and the engine speed has considerably decreased, first close the valve by releasing the handle **J**, put the governor tumbler under the governor lever, and then shut the relief screw so that oil may once more be sprayed into the combustion chamber. As soon as the engine has regained its normal speed, repeat the operations described above, thus alternately working the engine and charging the receiver, until about 200 to 250 lbs. pressure has been obtained. Then close the stop valve on the pressure receiver tightly.

**O & OE 115 & 117 STARTING WITH COMPRESSED AIR, with cam-controlled starting and charging valve, either with lamp or from cold state.**

If the compressed air in the receiver is less than 120 lbs. pressure, it may be advisable to heat the ignition tube, as described on page 29 in the Instruction Book, but if 150 to 250 lbs. is available, no pre-heating is necessary.

N.B.—Whilst the engine is being prepared for starting, as given under PREPARING TO START, on pages 29 and 30 in the Instruction Book, the handle **K** (see illustration 29A, page 23) must be in the notch marked WORK.

When the attendant is satisfied that all is in order, turn the engine into the correct starting position.

**STARTING.**—Close the relief valve **N** on the sprayer, and work the fuel pump by hand until the oil feels solid. Then with a very quick movement inject one or two charges into the combustion chamber.

Open the stop valve on the air receiver (see Fig. 30, page 23), allowing the compressed air to pass to the starting and charging valve.

Now place the handle **K** into the notch marked START (No. 2 in the illustration), and the engine will immediately start away.

After one or two impulses, reduce the strength of same by slightly opening the relief screw **N** until the speed is up to normal, when it must be closed again. (This prevents the heavy pressure, due to the impulse of the ignited charge, squeezing the oil film out of the bearings). As the speed increases move the exhaust roller away from the half compression cam, so that full compression can be obtained, and place the handle **K** back into the notch marked WORK. Close the stop valve on the air receiver tightly.

**RE-CHARGING COMPRESSED AIR RECEIVER.**—When running steadily at normal speed and before putting any load on the engine, the air receiver should be re-charged in the following manner :—

Open the stop valve on the air receiver.

Open wide the relief screw **N** on the strainer of the sprayer, thus preventing oil being sprayed into the cylinder.

Immediately this is done *and not before*, place the handle **K** into the notch marked CHARGE (No. 3 in the illustration).

In this position the starter valve **D** is held open and the valve **F** is free to lift, when the compressed air in the engine cylinder is forced through it into the air receiver.

When the engine speed has considerably decreased, first put the tumbler **D** (Fig. 21) under the governor lever, and then put the starting handle **K** back into the WORK notch.

Then close or nearly close the relief screw **N** so that the oil may again be sprayed into the combustion chamber.

The engine will then soon regain its normal speed, and these operations must be repeated, alternately working the engine and charging the air receiver until about 200 to 250 lbs. pressure has been obtained. Then close the receiver stop valve. Do not repeat these operations too quickly as these would tend to overheating of the charging and starting valve and its spring.

On double cylinder engines, use each cylinder alternatively, so as to prevent the charging valve overheating.

**MOST IMPORTANT.**—On no account must the starting and charging valve **D** be open whilst oil is being sprayed into the combustion chamber, **the relief valve N must therefore always be opened before the charging valve is opened and the charging valve must always be closed before the relief valve is closed again.**

**CAUTION.**—Charges of fuel oil must **not** be injected by means of the pump hand lever, when operating the handle of the starting and charging valve. After once priming the pump and pipes the handle should not be used. It must on no account be used once the engine has begun to ignite its charges regularly.

**OIL HEATER.**—The valve on the heater may be either partially or wholly closed, when the engine has been running for about 15 to 30 minutes, as found best by experience. If paraffin or gas oil is used for fuel continuously the valve on the heater should always remain closed.

**PARAFFIN CUP FOR STARTING OIL.**—The refined oil in the paraffin starting cup should be about an inch from the bottom, before the change over handle is pushed hard over, as far as it will go, in the direction indicated by the "crude oil" arrow. *Do not wait until the cup is empty*, otherwise air will be sucked into the pump and the engine will stop.

If, due to air lock, the crude oil does not begin to be delivered directly the change over handle is moved over, open the relief valve on the sprayer and work the pump quickly by hand until the crude oil appears at the overflow pipe. Then close the valve again and the engine should at once begin to ignite its crude oil charges.

When a separate refined oil tank is used the cock on the latter is to be opened when starting, and the cock on the crude oil tank closed. When the heater has become sufficiently hot the cock on the refined oil tank is to be closed, and the one on the crude oil tank opened.

## O & OE 120 to 123. STARTING WITH LAMP AND WITH COMPRESSED AIR.

## O & OE 120 to 128. STARTING FROM COLD WITH COMPRESSED AIR.

These sizes of oil engines are provided with cam controlled compressed air starting valves as described on page 24. The air receiver fitted with a stop valve, pressure gauge, etc., Fig. 33, is supplied when ordered. If the compressed air in the receiver is less than 120 lbs. pressure, it may be necessary to pre-heat the ignition tube as described in the section "Preparing to Start," but if 150 lbs. to 250 lbs. is available no pre-heating should be necessary.

All the foregoing instructions given under "Preparing to Start," pages 29 and 30, must be carried out, and the attendant thoroughly satisfied that the engine is in perfect running order. Then close the relief screw **N** on the sprayer, and work the fuel pump by hand until the oil feels solid. Then with a very sharp movement inject one or two charges of oil into the combustion chamber (unless the pump is operated very quickly the oil will not spray properly).

Then open first the relief valve **N** on the sprayer, and open the stop valve on the air receiver to allow the compressed air to pass through the cam controlled valve to the starting valve on the breech end. Put the latter valve in action by screwing the hand-wheel screw *clockwise* as far as possible into the valve block. This allows the valve to open and the engine will immediately start away. When two or three revolutions have taken place first close the relief valve **N** on the

sprayer, and immediately afterwards move the exhaust roller away from the half compression cam, so that full compression may be obtained. (**Ignition will not take place with the half compression cam in operation when starting from cold,** but it is necessary to use it for the first few revolutions to enable the engine to increase in speed sufficiently to turn against the full compression). When on full compression the engine will at once commence to ignite its fuel charges.

As soon as the speed of the engine increases screw down tightly the stop valve on the air receiver to prevent leakage, and then screw back the starting valve on the breech end. Then put out the heating lamp if this has been used.

**NOTE.**—If an engine of the O or OE 120 to 123 type should be required to be started without compressed air it may be done exactly as described for the O & OE 115 to 117 engines at the top of page 31.

**CAUTION.**—Charges of fuel oil must **not** be injected by means of the pump hand lever once the engine has begun to ignite its charges regularly.

**OIL HEATER.**—The valve on the heater may be either partially or wholly closed, when the engine has been running for about 15 to 30 minutes, as found best by experience. The important thing is that the oil must be maintained sufficiently thin and fluid to enable the oil to be finely atomised.

**PARAFFIN CUP FOR STARTING OIL.**—The refined oil in the paraffin starting cup should be about an inch from the bottom, before the change-over handle is pushed *hard* over, as far as it will go, in the direction indicated by the "crude oil" arrow. *Do not wait until the cup is empty*, otherwise air will be sucked into the pump and the engine will stop.

If, due to air lock, the crude oil does not begin to be delivered directly the change over handle is moved over, open the relief valve on the sprayer and work the pump quickly by hand until the crude oil appears at the overflow pipe. Then close the valve again and the engine should at once begin to ignite its crude oil charges.

When a separate refined oil tank is used the cock on the latter is to be opened when starting, and the cock on the crude oil tank closed. When the heater has become sufficiently hot the cock on the refined oil tank is to be closed, and the one on the crude oil tank opened.

**DOUBLE CYLINDER ENGINES.**—On Double Cylinder Engines do not close the relief valve on either cylinder until immediately before putting the half compression cam out of action. This will prevent any oil dribbling and carbonising on the sprayer owing to the very slow injection (see page 45).

**RE-CHARGING AIR RECEIVER.**—Re-charge the air receiver from the belt-driven compressor or engine-driven air compressor as quickly as possible, as it is *always* the best plan to have the receiver charged ready for re-starting again at any time.

## SUMMARY OF COMPRESSED AIR STARTING OPERATIONS.

1. Fill fuel tank.
2. Open fuel supply from tank to engine.
3. Prime fuel pump and pipes.
4. Fill paraffin cup, or tank.
5. Put governor wedge on starting prop.
6. Put exhaust roller under half compression cam.
7. Turn engine to starting position.
8. Put barring gear out of action.
9. Turn on cooling water supply.
10. Prime lubricating system, and oil parts as may be necessary.
11. Prime connecting rod large end bearing.
12. Open air receiver stop valve.
13. Open air starter valve on cylinder.
14. After 2 or 3 cycles close sprayer relief valve.
15. After one more cycle change over to full compression.
16. As soon as engine starts to ignite its charges close the starter valve (on O & OE 115 and 117 this must be done **before** closing the sprayer relief valve).
17. Close stop valve on air receiver.

# WORKING,

**INCLUDING**

# STOPPING.

After starting the engine, the load should not be put on until it has been ascertained :—

1.—That all working parts are properly lubricated.
2.—That the lubricators are all in working order.
3.—That the rings in the ring-oiled bearings of the crankshaft and sideshaft are rotating.
4.—That water is flowing properly through the jackets.

# LUBRICATION.

It is not possible to define any exact quantity of oil to use, as so much depends on the quality of fuel oil used, the average load at which the engine works, the temperature of the engine house, the amount of dust, the attention given to the engine, etc., but we give below a table showing the quality and approximately the amount to be used for the various parts when the engine is working under good average conditions. With a little experience the attendant will soon know how much to use. NOTE.—Unless the quality of lubricating oil used is supplied by, or approved by us we do not guarantee the working of the engine. *Do not be tempted to use "cheap" lubricating oil. This would only lead to trouble.* All lubricating oil should be passed through fine gauze strainers before being poured into the lubricators. This prevents any foreign matter getting into the lubricators and stopping the flow of oil which might lead to serious results. *See important notes on page* 39.

## QUALITY AND QUANTITY OF LUBRICATING OIL USED FOR VARIOUS PARTS OF THE ENGINE:—

| PART OF ENGINE. | QUALITY OF OIL TO USE. | APPROXIMATE QUANTITY IN DROPS PER MINUTE, PER SINGLE CYLINDER ENGINES. | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | SIZE 115 | SIZE 117 | SIZE 120 | SIZE 122 | SIZE 123 | SIZE 126 | SIZE 128 |
| **Cylinder and Piston** ... ... | Brand "O". | 14 | 15 | 16 | 18 | 8 | 9 | 10 |
| **Exhaust Valve** ... ... | Paraffin for O & OE 115 to 122 engines. Brand "O" for O & OE 123 to 128. | 1 | 1 | 1 | 2 | 1 | 1 | 2 |
| **Connecting Rod Large End Bearings** ... ... ... | Brand "H" oil. | 15 | 16 | 20 | 22 | 12 | 14 | Total 18 two feeds |
| **Connecting Rod Small End Bearings** ... ... | Brand "O" oil.* | — | — | — | — | *4 | *6 | *8 |
| | Brand "H" oil. | — | — | 5 | 6 | — | — | — |
| **Crankshaft Bearings and Sideshaft Bearings** ... ... | Brand "H" oil. | NOTE.—The drops for the O & OE 115 to 122 are much smaller in size than for the O & OE 123 to 128. This is owing to the different type of lubricator used. | | | | | | |
| **Miscellaneous Smaller Bearings, Governor & Governor Gear Wheels, Oil Pump, Cam, Etc.** ... ... ... | Brand "H" oil. | | | | | | | |
| **Gear Wheels at Crankshaft end of Sideshaft** ... ... | Brand "H" oil and Graphite. | | | | | | | |

*On later engines the lubricator is arranged so that "H" oil could be used instead of "O" oil.

## ADJUSTMENT OF LUBRICATORS.—

**Double Plunger Lubricator.** Sizes O & OE 115 to 122.

The quantity of oil delivered is regulated, as stated on page 27, by the milled nuts on the needle valve of the glass sight feed lubricators on the pump body. Each needle valve is held on its seat by a spring and can be raised by hand for flushing purposes without altering the normal adjustment. As the level in the glass falls, the tendency is for the oil to drip more and more slowly. The supply should therefore be adjusted to drip rather faster than necessary when the glass is full.

**Central Multiple Lubricator.** Sizes O & OE 123 to 128.

The stroke of each pump is adjustable and is regulated by altering the position of the milled adjusting sleeve **N** and locknut **P** on the plunger end. After determining the necessary position, this sleeve and nut must be locked one against the other. The finger ring on each plunger end allows a few extra strokes to be given by hand if required, without stopping the engine, or altering the normal rate of feed.

It is very important that the Sight Feed and Mechanical Lubricators are never allowed to become empty while the engine is working; neglect on the part of the attendant to maintain efficient lubrication may cause serious damage to the engine. Should the reservoirs be emptied, after refilling them with oil, the pump and delivery pipes must be primed in the manner described on pages 29 and 47.

**PISTON.—It is important that the correct amount of oil is used for the piston,** the whole surface of which must be lubricated. If an excessive amount of oil is used it will get on to the back of the piston or into the combustion chamber and then become burnt to a scale or crust. On the other hand, if too little oil is used, the piston will become dry and wear rapidly.

## GOVERNOR.

**DASHPOT.**—The dashpot must be kept quite full of a mixture of clean thin lubricating oil and paraffin, and it should be emptied and refilled every three months. Only mineral oil containing no fat should be used.

To fill the dashpot it is best to remove it from the engine. Unscrew the cover **S** and piston **Q** and partially fill the pot. Then replace the piston and press it down until it is submerged in the oil; this is necessary to prevent air being trapped beneath the piston. Then fill up to the top with oil and screw in the cover, when some of the oil will be screwed out, if the pot has been properly filled. As much oil as possible should be filled into the top of the cover to prevent air leaking in past the piston rod.

**SPEED REGULATION.**—By adjusting the tension of the spring **V** attached to the governor lever **L** the speed of the engine may be somewhat varied.

No slackness must be allowed in the governor pins or gear as this would lead to irregular running.

**FUEL OIL SYSTEM.**—The attendant should make himself thoroughly conversant with the complete fuel oil system. The diagram shown in Fig. 61, inside back cover, will be found very useful for this purpose.

**GOVERNOR WEDGE.**—To prevent the engine reversing its motion, in case a greater load is thrown on the engine than it can carry, causing it to slow down considerably, the supply of oil is arranged to be suddenly cut off. The adjusting nuts on the dashpot rod are set to begin to compress the dashpot spring, when the thinnest portion **X** of the governor wedge is in line with the control valve. The speed of the engine will then fall considerably before the oil supply ceases, the latter only taking place when the speed of the engine has become slow enough to allow the thicker part of the wedge **T** to fall in line with the valve, the whole of the oil then being returned through the control valve to the oil heater, thus acting as a safety device.

When the engine is running at reduced load, the governor wedge will rise until its thicker part **Y** rises level with the pecker bolt, the control valve will then be opened earlier, and nearly all the oil will pass back to the oil heater, only a sufficient amount being delivered through the sprayer to keep the engine working at its correct speed (See further notes under "Maintenance.").

**GOVERNOR QUADRANT.**—Sizes O & OE 128 only. When setting the gear the pecker screw only just clears the quadrant at the points **C** and **Y,** Fig. 25, when the roller is in contact with the end of the valve spindle and when the roller on the pump lever is quite clear of the pump cam toe-piece and is on the body of the disc of the pump cam.

The projecting portion of the quadrant at **T** acts as a safety device in case the engine should be suddenly overloaded and the speed fall considerably. This projection, owing to the fall of the governor hanging rod, would then be in line with the setscrew **K** and the maximum lift of the control valve would take place, and consequently no oil would be delivered to the sprayer.

A pointer **Z,** fitted in an arm of the quadrant, moves along the stationary segment **A.** It tends to indicate to the attendant the approximate load on the engine and shows at a glance, if the pointer takes up a new position when a regular load is on the engine, that something is out of order. A little experience will enable the attendant to gauge the position which the indicator should take up under normal working conditions, and when it varies with the usual load, to look round and see if all parts of the oil heater, pump, control valve, and sprayer are working properly, and if so, to see whether the piston or exhaust valve are short of lubricating oil, or whether any of the bearings are tending to run hot.

**OIL HEATER AND STRAINER.**—A temperature of 70 to 100 deg. Fahr. (20 to 38 deg. Cent.) is recommended for the lighter crude oils. For heavy viscous residual oils, the temperature should be raised to from 120 to 140 deg. Fahr. (50 to 60 deg. Cent.). These temperatures are approximate and may be observed by placing a thermometer in holes provided on oil pump body. Do not overheat thin oils. The best temperature for thin refined oils, such as Kerosene, is about 80 deg. Fahr. (27 deg. Cent.), for Gas or Solar Oil about 95 deg. Fahr. (35 deg. Cent.), and for light crude oils about 95 to 110 deg. Fahr. (35 to 43 deg. Cent.), according to the viscosity of the oil. A little experience will soon enable the attendant to judge the most suitable temperature to maintain. The essential thing is that oil will not atomise finely unless it is very thin and fluid. Some oils are quite fluid when cold, others require to be heated to 130 or 150 deg. Fahr. (55 to 65 deg. Cent.), before they are sufficiently fluid for fine atomisation. With very viscous oils we sometimes pass the sprayer pipe through the water in the breech end to raise the temperature of the oil between the pump and the sprayer to 130 to 150 deg. Fahr. (55 to 65 deg. Cent.), and in some cases we recommend the suction pipe, from the fuel tank to the oil heater, to be laid in the exhaust pipe trench. Should the oil over-heat when using thin non-viscous oils, even when the regulation valve **H** is closed, one or more thicknesses of asbestos sheet should be placed between the heater body and the exhaust pipe. An extra asbestos joint is sent loose with each engine. Viscous oils should be heated more than other oils, but not so much as to make them froth, or give off vapour. This would prevent the oil pump sucking the full charge of oil. **Important.**—The unused oil being visible when passing into the over-flow tundish, is valuable as an indication of the condition of the oil. If froth is seen issuing from the air vent pipe, it is usually a sign that the oil heater is too hot, and it should be cooled down by partly closing the heater check valve. Sometimes, however, frothing indicates that there is water in the oil, and the remedy is to drain off any water by opening the cock or plug at the lower part of the heater and also by opening the drain tap at the bottom of the fuel tank. The latter should be done periodically The oil strainer in the oil heater must also be cleaned periodically.

**OIL SPRAYER.**—**Important:** It is absolutely essential that the sprayer valve should seat itself **perfectly** on the sprayer nozzle. This can be tested when the engine is working by opening the relief valve **slightly** and noting the condition of the oil issuing from the relief pipe into the tundish. If the oil issues from the pipe in anything like a broken form (like foam) it is a sign that the air compressed in the engine cylinder is leaking out through the sprayer nozzle and past the sprayer valve seating, and that the latter is therefore out of order and requires attention. See notes on cleaning and assembling, pages 43 to 46.

**COOLING WATER.**—Never work the engine without water in the jacket of the cylinder. When water tanks are used they must be kept full by means of a ball cock (see erecting instructions). If the cylinder of the engine becomes much hotter than the water in the tanks, it is a sign that the circulation is obstructed, and it should be attended to **at once.** The temperature of the water should not be allowed to exceed 130 deg. Fahr. (55 deg. Cent.) on the sizes up to and including size O 123, and 110 deg. Fahr. (43 deg. Cent.) on sizes O 126 and O 128. With very viscous oils it is always best to keep up the circulating water temperature from 130 deg. to 160 deg. Fahr. (55 deg. to 72 deg. Cent.) especially when running at light loads when there is not much heat in the exhaust gas to liquify the fuel in the heater. Holes are provided in the outlet flanges on the top of the cylinder of engines for O & OE 120 and larger sizes, for the insertion of thermometers, so that the temperature of the outlet water can be ascertained at any time. This is much the best and safest method of cooling. There are two methods of circulating the cooling water, as follows :—

(1) **Tank Circulation.**—It is important to keep the water level in the tanks high enough to cover the return pipe from the engine cylinder by at least two inches, but not high enough to cover the pockets in the tanks. See therefore that the ball cock is operating correctly.

(2) **Run Through Circulation.**—When water is arranged to run through or to be pumped through the jackets to waste, it is best to have separate supplies to the cylinder jacket and to the breech end. The temperature of the jacket outlet water should not then be allowed to exceed that mentioned above. If the engine becomes over-heated at any time, it must not be cooled suddenly by passing a lot of cold water through it. The load on the engine must be reduced until the temperature is normal again. With run through circulation the water must enter at the bottom of the cylinder and separate outlets and regulating cocks arranged on both the top of the breech end and the top of the cylinder jacket.

It is also important with run through circulation that the engine should be allowed to run at no load for five or ten minutes before stopping, so as to cool down slowly. Or, as an alternative, the engine may be stopped immediately and the amount of run through water regulated by hand for five or ten minutes to prevent too rapid cooling. Any sudden cooling may result in fracture of the breech end. Also if the water is shut off suddenly when the engine is very hot, the heat stored in the metal may quickly raise the water to boiling point and over-strain the metal in this way also.

Beware of running water through the cylinder jacket without the use of a water vessel, when the water is "hard," as this tends to the new water *continually depositing its lime, salts, etc., in the jackets*, which makes the castings liable to over-heat and fracture. This is one reason why we prefer "tank" circulation. Run-through water should wherever possible be either natural soft water, or rain water, or water treated in some way so as to soften it.

Whether the water is run through or pumped through the jackets it is absolutely necessary for the jackets to remain full of water at all times except when it is purposely drained out through a drain cock. For example, when the water is pumped through the jackets, it is always possible for any non-return valve or foot valve to stick open or leak. This might enable all the water from the jackets to drain out, when the engine is stopped, without it being observed. This would be serious for two reasons :—(1) Parts of the engine would be very hot and might fracture, or (2) The engine might be started without water in the jackets until some parts were seriously over-heated, and a fracture would almost sure to be the result. This can be prevented by arranging the supply to be taken up from the pump or supply cock to say two feet above the top of the cylinder and for the water to then pass out into a tundish and down a separate pipe to the inlet passages to the cylinder and breech end. No water could then pass out of the jackets when the engine stops. A still better plan is for the pump to deliver its water into a "safety" tank 8 or 10 feet above the cylinder, the tank being arranged to act on the thermo-syphon principle and for the hot water rising into it from the engine to overflow down a pipe into a tundish and pass away. *See important note on page 6 and illustration in Figs. 2 and 3.*

**ADJUSTMENT OF THE TIMING OF THE FUEL PUMP CAM.**—(See also notes on Dismantling) page 54.

The disc of the cam which operates the fuel pump is provided with slotted holes for studs by means of which it can be secured in position against the cam boss which is firmly keyed on the sideshaft. The cam disc is therefore adjustable so that the timing of the oil injection can be adjusted when the engine is being tested at our works. When the correct position has been found, a steady pin is passed through the cam disc into the cam boss. Unless specially ordered otherwise, the pump cam is usually set for an average quality of fuel oil with a Specific Gravity of about .900. It is seldom necessary for any alteration to be made to the timing of the oil injection as settled during the engine's trials. If, when working with a heavy residual oil the exhaust gases issuing from the exhaust pipe are very dark it *may* be found advisable to very slightly advance the timing. This alteration must be done by a **thoroughly competent mechanic** and even then, only after the most careful attention has been given to :—

(1) The sufficient heating of the oil by adjusting the regulator valve of the oil heater.

(2) The efficient working of the fuel pump, control valve, and sprayer, and the general working condition of the engine.

In other words the advancing of the timing of the pump cam must be considered only as the last thing to do when it is desired to improve the working of the engine. Before making this alteration we recommend our clients to write for our advice, giving us **full particulars** of the oil, and stating why they suggest making any change.

Should any change be made the cam disc should be either (*a*) moved slightly clockwise, see Fig. 53, to make the injection later if an oil having a specific gravity of about .88 or under is to be used, or (*b*) move slightly anti-clockwise to make the injection earlier if an oil having a specific gravity of .92 or over is to be used.

If the injection is made later (by moving the cam clockwise) it should be done only when the ignition tends to be noisy. Care must be taken to distinguish between noise due to ignition and noise caused by any loose bearings, such as of the connecting rod, or of any backlash in the gear wheels.

When the injection is made earlier (by moving the cam anti-clockwise) it should be done only if the tendency is for the piston and for the exhaust gases to be black. Care must be taken to make sure that any black piston or black exhaust gas is not due to leakage of oil or the control valve, sprayer, fuel pump gland, or pipe joints, or to the oil not flowing freely to the fuel pump from the oil heater or oil tank, or to air or water being niched in with the fuel.

If, as a last resort, it should be desired to alter the setting of the pump cam it should be done in the manner described and illustrated in notes under "Dismantling," see Figs. 53 and 54, page 54.

## KNOCKING

A knock in an oil engine is generally the result of lost motion due to wear upon the moving parts or excessive running clearances having been given during repairs, and is especially pronounced when occurring in the reciprocating masses. It would take place if the large end or small end brasses were not kept in good condition.

A heavy thud may sometimes be heard immediately after injection has taken place, thus indicating too early ignition, the effect of which is a too sudden rise of pressure just before the end of the compression stroke. In this case it is necessary to retard the timing of the fuel pump cam, see notes above and "Dismantling" notes, page 54. Great care is exercised during the engine's trials, to obtain the most advantageous timing of this cam, and it is seldom necessary afterwards to make any alteration in this respect, provided a good quality of fuel oil is used.

Other causes of knock are as follows :—

1.—Backlash in the sideshaft wheel teeth. A setscrew is provided, fitted into the underneath side of the sideshaft bearing at the crank end. Its purpose is to raise the bearing and so set up the sideshaft wheel further in gear with the crank worm.

2.—Too much running clearance in (*a*) the large end connecting rod bearing, or (*b*) in the main bearing on the sideshaft side, or if the cap has not been properly tightened down, will permit the crankshaft to lift when the power impulse takes place.

3.—If the outer bearing is lower down than it should be there will be likewise a tendency for the shaft to lift on the sideshaft side.

4.—If the crank worm is not located close up against the crank bearing lateral movement of the shaft may ensue.

5.—Loosely fitting flywheel keys *must be tightened up immediately*. On no account must packings be inserted. New keys must be made if the existing ones cannot be made a good fit on their tops and sides. Serious accidents have occurred through slack keys setting up severe stresses which have resulted in the fracture of the boss of the flywheel.

6.—Badly fitting pistons or piston rings.

7.—Broken piston rings (remove at once and replace).

8.—Wear having taken place upon the internal surface of the cylinder liner and a ridge of metal formed. When new connecting rod bearings are fitted, if the correct distance between the centres of the piston pin and ring crank pin bearing is not maintained, the piston may travel further into the cylinder, and so cause the first ring to strike against this ridge. This obstruction should be filed away.

9.—Very severe stresses may also be set up in the connecting rod bolts, owing to excessive knock due to a worn crank pin bearing.—See "Maintenance" notes and "Warnings" for their renewal, pages 38 and 42.

10.—A knock may also be traced to too much clearance between the exhaust valve spindle and the tappet screw in the exhaust lever.

To locate where noise comes from, place the ear in succession close to the back of the cylinder, to the front of the piston, to the sprayer, to the fuel pump with its lid open, and to the sideshaft wheel guard with its lid open.

**BALL TAP.**—This is to keep the surface of water within 3in. (.076) of top of the vessels. If the engine is worked at full power all day, some cold water should be run in by holding the ball tap down and running out water through the overflow pipe.

**WITHDRAWAL OF THE WATER FROM THE CYLINDER JACKETS.**—In order to do this, the ball tap **N** must first be propped up, the stop cock on the inlet or bottom water pipe closed, and the drain tap opened (see Fig. 2). The water will then be drained from the outflow pipe and the cylinder jacket, without emptying water vessels. Care must be taken before restarting the engine to see that the stop cock is opened, the drain tap closed, and that the ball tap is released and works freely, so that the water in the vessel may be again above the top of the outflow circulating pipe. These points must be strictly adhered to, or great injury to the engine will result.

# STOPPING.

To stop the engine simply unscrew the relief valve **N** on the sprayer (see page 18). This returns all oil to the oil heater and prevents any being injected into the cylinder. In an emergency, such as if this pipe becomes choked, and should temporarily not have the desired effect, hold up the oil pump handle **F** to put the oil pump plunger out of action.

**IMPORTANT NOTES.**—If the engine should be working with *viscous residual oil*, or with *tar oil*, the fuel must be changed over to refined oil, for a few minutes, before stopping, so that the oil pump, pipes, sprayer, etc., may not remain with any residual oil or tar oil in them. This is important when using viscous oils to ensure that oil cannot solidify in the pump, which would become clogged and be difficult to clear, and that the pipes, pump and sprayer are primed with refined oil ready for the next start.

Further, when using crude, residual or tar oils, the general condition of the sprayer and particularly the spraying orifices of the nozzle, is greatly improved, if for a few minutes at starting and also at stopping the engine is run on paraffin.

This tends to prevent the growth of any carbon deposit on the nozzle, which is liable to appear if viscous crude oils are used when starting and stopping.

When the engine is stopping shut off all the glass lubricators and leave the engine with the air and exhaust valves closed, in a condition all ready for starting.

**COOLING WATER.**—When run through circulating water is used, the supply must not be turned off immediately the engine is stopped, regulate the quantity by hand and allow it to run for about 10 to 15 minutes before closing the cocks.

**FROST.**—If the engine is likely to be exposed to frost after stopping, drain the water from the cylinder jacket and bottom water pipe, as described above, leaving the cock open until starting next time ; an alternative is, to burn a lamp under the breech end, to prevent water freezing in the jacket. Neglect of such precuations may cause breakage.

**N.B.**—Starting is facilitated, especially in cold climates, if the water in the cylinder jackets is warm. This may usually be ensured by shutting off the circulating water a few minutes after the engine has stopped, **always remembering to turn the water on again at starting,** see notes on page 30. If this practice is adopted, however, the attendant must see that there is no danger from frost as described above. If in doubt, drain the water out of the cylinder jacket nightly, **but not until at least 15 minutes after the engine has been stopped.** See important notes under "Cooling Water," on page 36.

# WARNINGS.

## IMPORTANT.

**GUARANTEE.**—Our guarantee for this engine is contingent on the fuel and lubricating oil used being approved by us, and the engine worked according to the recommendations in our printed Instruction Book.

**FROST.**—If the engine is likely to be exposed to frost when not working, drain the water from the cylinder jacket and bottom water pipe by means of the tap **M** (see Figs. 2 and 3, pages 5 and 7) provided on the inlet pipe, leaving the tap open until starting next time, or use a lamp beneath the breech end, to prevent the water freezing in the jacket. Neglect of this precaution may cause breakage. If the water is drained out of the jacket be sure that the jacket is refilled before starting the engine again. If the water tank is frozen over, break the ice before starting. In frosty weather see that the water is circulating.

**DASHPOT ON GOVERNOR.**—In very cold weather the oil in the governor dashpot may become frozen. The dashpot should therefore be examined before starting the engine. Should the oil be frozen, and the dashpot piston unable to move, the engine may run away. Some kerosene mixed with the oil will prevent freezing; or glycerine may be used instead of oil.

**BARRING GEAR.**—It is most important that the barring gear should be disengaged before starting the engine, otherwise the barring gear will be damaged. A **stop** is provided for keeping the gear in the free position, see illustrations on page 26. **See that it is used.**

**AIR SILENCER.**—The matting in the air silencer should be examined periodically. If necessary it should be cleaned or renewed. If the atmosphere of the engine house is dusty, the cleaning is specially important. Do not add to the quantity of matting round the silencer casting.

**STARTING.**—When starting or when turning the engine it is dangerous to place the foot on the flywheel arms, because, if out of order, the engine might turn in the wrong direction at the first ignition.

The valves of the compressed air starter must be kept properly ground into their seatings. Neglect of this may cause a back fire and injury to the attendant.

Be sure to see that the circulating water is turned on before attempting to start.

**DISMANTLING.**—When taking out the piston or any of the valves, keep naked lights away. It is then impossible for any mixture which may be left in the cylinder to be accidentally ignited, especially if as a further precaution, the flywheel is turned round several times before the piston or valves are taken out, to clear away any gases.

**FAILURE OF GOVERNOR LEVER TO CONTROL THE ENGINE SPEED.**—If, for any reason, the governor lever does not rise when the engine attains full speed, the engine should be stopped at once by opening the relief valve **N** on the sprayer, and the cause investigated.

If at any time the opening of the relief valve does not slow down the engine, lift the pump handle and so put the oil pump out of action.

If from any cause a bad start has been made and a number of charges of oil have been pumped into the combustion chamber and not ignited, and the engine still increases in speed, although the relief valve is opened and the pump handle held up, the exhaust valve should at once be held open by the hand lever provided. The surplus oil will then be scavenged out, and on the exhaust valve being allowed to close again the engine should work correctly.

**CONNECTING ROD BOLTS.**—See important notes under "Maintenance," page 42, relating both to the bolts themselves and also to the necessity of keeping the large end bearings in proper condition and the bolts securely screwed up and locked. *Make sure also that any new bolts ordered as "Spares" or to replace old ones are ordered from us so that both the proper special material and its correct heat treatment may be guaranteed.*

**GEARING UP THE SIDESHAFT.**—Although a printed label is attached to the worm wheels directing mechanics in erecting the engine to gear up the wheels to the marks "00" on the teeth, we again call attention to this point as mistakes are often made in putting these wheels together. We also paint the tooth and corresponding space red, in order to further call attention to this important point.

Two keyways are cut in the sideshaft gearwheel. If considerable wear of the teeth takes place, the wheel may be keyed on in a position diametrically opposite to its original one. If the attendant should in due course effect this change the marks on the stamped painted teeth should be changed to suit. The valve settings should then be carefully checked over, as directed on page 41, to see that they agree with the diagram, Fig. 5, on page 11.

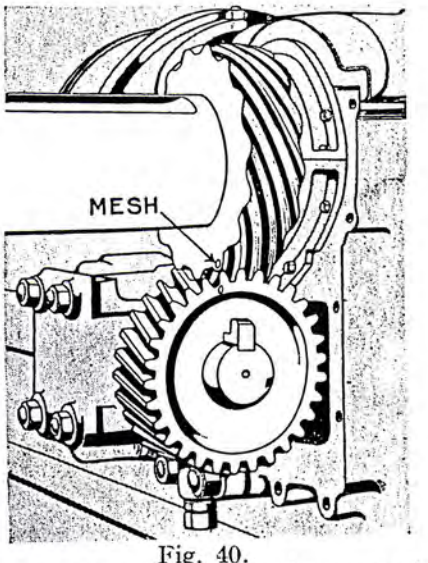


Fig. 40.

**LUBRICATION.**—**Important:** Pay particular attention to the lubrication of the large end of the connecting rod. This part requires as much oil as all the other parts of the engine together. It is also essential that the oil pipe from the lubricator and the centrifugal oiling ring, attached to the side of the crank, is maintained in an absolutely clean condition. It should be thoroughly cleaned out, including the hole through the crank, before the engine is started for the first time.

**SIGHT GLASSES ON CENTRAL LUBRICATOR.**—If in very cold weather there is a tendency for the water to freeze, salt water must be used, see page 29.

**LUBRICATING OIL FILTER.**—*Filter all lubricating oil before using.* We strongly recommend the use of an oil filter, by means of which all lubricating oil (except that coming away from the cylinder) may be filtered and cleaned after use, to be used again for the bearings and other purposes. We can supply a suitable filter if required. **Only new oil must be used for the cylinder and piston pin. The oil which drips from the mouth of the cylinder, into the bed can be drained from a pipe provided at the side of the bedframe on sizes 120 to 128 inclusive. This must not be used again, however, as its lubricating qualities have been impaired. It should be poured through the strainers into the fuel oil tank, as it is quite suitable for fuel oil.**

**QUALITY OF LUBRICATING OIL TO USE.**—This is a very important matter and must on no account be neglected. Many engines have been seriously injured by the use of totally unsuitable qualities of oil supplied to our customers, and in consequence we have been obliged to undertake the sale of suitable oil ourselves. We have made such arrangements with large oil manufacturers to produce two lubricating oils specially suitable for these oil engines as follows :—

**Cylinder Lubricating Oil, Brand "O."**—For use on sizes 115 to 228 inclusive. This has a high flash point and a suitable viscosity and boiling point and, in addition, has the least possible tendency to carbonise when heated. It should be borne in mind that the oil has to stand exposure to flame temperatures and high pressures about one hundred times a minute and no inferior oil, however good it may be for other purposes, can be used for the lubrication of the cylinders without leading to many troubles. **Bearing Lubricating Oil, Brand "H."**—This oil is specially prepared for use on bearings and has both a high flash point and a high viscosity suitable for the purpose. (*It is not suitable for the cylinders of sizes* O & OE 115 *to* 228 *inclusive.*) For use in tropical climates **Lubricating Oil, Brand "I H"** is specially recommended in place of the Brand "H" being of a very high viscosity. These oils can be obtained either from us or from any of our branch offices, or agents, in either five or ten gallon drums, or forty-gallon casks. For the convenience of overseas users we have now made arrangements for the delivery of any of these oils in 40 gallon wood or steel casks to most foreign ports. The prices are cut very low **and their use can be regarded as a first class insurance on the good working of the engine.** The Brand "O" oil must not be used in the air compressor, the Brand "H" only being suitable for this purpose.

**We cannot too earnestly recommend our friends to provide themselves with this oil for the lubrication of these engines. Nor can we take any responsibility if they do not do so.** *Do not be tempted to use "cheap" lubricating oils. It will only lead to trouble.*

**COOLING WATER AND TANKS.**—Never work the engine without water in the jacket of the cylinder. When water tanks are used they must be kept full by means of a ball cock (see instructions on page 6). If the cylinder of the engine becomes much hotter than the water in the tanks, it is a sign that the circulation is obstructed, and that it should be attended to at once. The temperature of the water should not be allowed to exceed 140 deg. Fahr. (60 deg. Cent.) on sizes O & OE 115 to 123, and 120 deg. Fahr. (50 deg. Cent.) on sizes O & OE 126 and 128, except in special cases such as when very viscous fuel oil is used (see page 36). Holes are provided in the outlet flanges on the top of the cylinder of the O & OE 120 to 128 engines for the insertion of thermometers, so that the temperature of the outlet water can be ascertained at any time. The water pipe from the top of the cylinder to the top of the water vessel must slope upwards and must have no bends where air can lodge.

Beware of using water from ponds and dirty rivers which hold much mud in suspension. When using such water the water spaces must be cleaned out very frequently. The dirtier the water the more frequent the cleaning.

**WATER JACKETS.**—In districts where the water is "hard" or contains much lime, chalk, mud or vegetable matter, it is necessary to examine the water jackets *periodically* (at first every month), and when found, to remove any scale or deposit. Inspection covers and plugs are provided for this purpose on the cylinder jacket, and on the back and both sides of the breech end, and also at the top and on the side of the bed, see Fig. 4, page 10, and Figs. 9 and 10, on page 13. When re-making the joints of the covers or flanges, first soak the asbestos in water. For joint between liner and breech end, smear the asbestos on both sides with boiled linseed oil.

**BREECH END.—Special care should be taken to remove any mud or scale from the spaces in the breech end which surround the admission and exhaust valve passages and ports.** A lighted taper can also be inserted through all the inspection holes to see the condition. These water spaces can be reached with rods from the back and from both sides of the breech end and the scale scraped away, see figs. 9 and 10.

**CYLINDER LINER.**—If scale is allowed to remain on the outside of the cylinder liner (S 1, in Fig. 4, page 10, the efficient cooling of the piston will be prevented and the lubricating oil film on the piston will be impaired. This results in the burning charge blowing past the piston rings, and the liner will wear out rapidly, and require to be renewed.

**REMOVAL OF SCALE.**—If the deposit in the breech end or on the liner is hard or difficult to scrape off, its removal may be facilitated by the use of suitable solvents, which render the deposit soft, and it can then be washed away with a hose pipe or softened sufficiently to be scraped off. Commercial hydrochloric acid (spirits of salts), is the most suitable solvent, and is used as follows :—After stopping the engine, drain all the water from the jackets, then fill up with diluted acid (about one part acid to three parts of water). Leave this in for a night or so. If the deposit is not then removed thoroughly, let out the acid and fill up again with fresh acid. If necessary a stronger solution may be used. By blowing in steam through the water inlet flange the temperature may be raised to 150 deg. Fahr., thus dissolving the deposit more rapidly. After letting out the acid, take care that the water jackets are well washed, as if the engine is not to be started at once, any acid remaining would rust the metal. In case the engine is worked at once, this washing is done automatically by the cooling water itself. In rare instances hydrochloric acid may prove unsatisfactory, in the event of which we shall be pleased to give advice as to the most suitable solvent to use, on receipt of a sample of the deposit. NOTE.—If the scale formed is excessive, it is advisable to use either a better source of water supply, or to soften the water artificially before use. If the scale is allowed to remain and increase it will lead to either the fracture or excessive wear of the insufficiently cooled parts.

NOTE.—In all cases after removing scale from either the breech end or the cylinder liner, it is important to see that no scale or deposit is left standing in the bottom water pipes and which would obstruct the free flow of water. These pipes should be removed and cleaned out before the engine is re-started.

It is important to keep the water level in the tanks high enough to cover the return pipe from the engine cylinder, by at least two inches, but not high enough to cover the pockets in the tanks.

If the circulating water is hard it is advisable to use large tanks in order to obviate the necessity of using make-up water. A ball tap should be fitted to maintain a constant level. The bottom of the tanks should not be lower than the centre line of the cylinder, and, if possible, a few feet higher. If the water is impure the tanks should be cleaned out occasionally.

**RUN THROUGH CIRCULATION.**—When water is arranged to run through the jackets to waste, it is best to have separate supplies to the cylinder jacket and to the breech end. The temperature of the jacket outlet water should not then be allowed to exceed that mentioned. If the engine becomes over-heated at any time, it must not be cooled suddenly by passing a lot of cold water through it. The load on the engine must be reduced until the temperature is normal again. With run through circulation the water must enter at the bottom of the cylinder and separate outlets and regulating cocks arranged on both the top of the breech end and the top of the jacket, see notes on previous page under "Water Jackets," respecting cleaning out deposit, etc. **Also see important notes on pages 6 and 36 and illustration on Figs. 2 and 3 with reference to the use of a "safety tank,"**

It is also important with run through circulation that the engine should be allowed to run at no load for five or ten minutes before stopping, so as to cool down slowly. Or, as an alternative, the engine may be stopped immediately and the amount of run through water regulated by hand for five or ten minutes to prevent too rapid cooling. Any sudden cooling may result in fracture of the breech end. On the other hand if the water is shut off suddenly when the engine is very hot, the heat stored in the metal may quickly raise the water to boiling point and over-strain the metal in this way also. The best safeguard is to adopt the "safety tank" arrangement.

Beware of running water through the cylinder jackets without the use of a water vessel, especially if the water is "hard," as this tends to the new water to be continually depositing its lime, etc. in the jackets. The safest water to use is rain water, as it is not hard. If rain water cannot be obtained the water should be treated in some way to soften it.

**OIL SPRAYER.**—Pay particular attention to the instructions given on pages 43 to 46, regarding this important part of the engine.

**CONTROL VALVE.**—This must be kept in first-class condition, and oil must not be allowed to leak past its seating.

**CHANGE OVER FUEL GEAR (when fitted).**—Be sure that the change over valve handle **Y**, shown in Fig. 18, is pushed hard over either one way or the other, otherwise air may be drawn into the oil pump when the paraffin cup **Z** is empty and so cause trouble. The best plan is to always leave a little oil in the paraffin cup. If it remains there no air can leak past it. If, on the contrary, the paraffin tends to be sucked in, it is a sign that either the handle is not pushed hard over, or that the valve is not seating properly. This should be attended to at once as air must not be allowed to leak past this valve into the pump. In no case must petrol spirit be used for starting.

**FUEL OIL PIPES.**—Before starting the engine for the first time thoroughly flush out all fuel oil pipes, especially the suction pipe to the pump, the delivery pipe to the control valve, and the delivery valve to the sprayer. Any core sand, pipe scale or pipe burrs, which may become loosened in these pipes can then be cleared away and cause no trouble.

**FUEL OIL.—IMPORTANT.**—Do not be put off with inferior qualities, see notes on pages 9 and 56. Be sure not to use oil with sand or earthy matter in it, as this will quickly spoil the control and sprayer valves and sprayer nozzle, and interfere with the regular working of the engine. It would also wear various parts of the engine such as the fuel pump. Sand and earthy matter is found in oils in the neighbourhood of oil fields and **must** be allowed to settle out **before** the oil is passed through the oil strainers on the fuel tanks.

**NOTE.**—To avoid trouble buy all **petroleum** fuel oil to the specification given on page 9, and **tar** oil to the specification given on page 56.

**COMPRESSED AIR RECEIVER, STOP VALVE AND PIPES.**—Keep all parts in good condition and drain water out occasionally by slacking back half a turn, the drain plug at the bottom of the receiver. If, at any time, the pressure falls in the receiver without apparent cause, make a thorough search at once for the point of leakage and, when found, take steps to rectify it immediately. See notes under "Maintenance," on page 47.

**ENGINE SPEED.**—The speed of any engine must never be increased above the rated speed at which the engine was sold. This is particularly to be noted in the case of electric lighting engines and still more particularly in the case of engines driving alternating current generators.

# MAINTENANCE
## INCLUDING
# ADJUSTMENTS, CLEANING AND REPAIRS.

**IMPORTANT.**—Valuable machinery is worth careful attention. A clean, well-cared for engine will always give better satisfaction than one which is kept in a dirty and neglected condition. The owner should therefore **insist** on the attendant keeping the engine in thorough working order, and on any adjustments or repairs being executed as soon as they are necessary; otherwise this instruction book is useless.

**PISTON.**—The piston should not be taken out unless cleaning is needed, say every six or eight weeks, or to replace a worn or broken piston ring. When it is taken out, scrape off any oil-crusts which may be found on the back of the piston. It is not necessary to remove any carbon deposit from the surface of the piston between the rings, as such deposit may have accommodated itself to any wear of either piston or liner, and have itself become part of the bearing surface. For a similar reason it is not always necessary to remove the piston rings when cleaning the piston. The rings must be quite free to move, but any carbon behind, or at the side of the rings, may remain there, providing it is not excessive. Any badly worn ring must be replaced by a new one. Only the big end of the connecting rod need be uncoupled to enable the piston to be drawn out, see Notes on Dismantling on pages 52 to 54. When replacing the piston, be careful that the steady pins in the grooves fit into the gaps of the rings, otherwise the rings may get broken when pushing the piston in. Thoroughly oil the whole of the surface of the piston. Never run the engine with a broken ring in the piston, as it would damage the liner. When wear of the piston rings occurs, replace the back ring only at first. Do not replace more than one worn ring at one time. When the piston is out the condition of the combustion chamber and cylinder may be inspected and the surfaces cleaned quickly at any time by removing the admission valve to let in light.

**COMBUSTION CHAMBER.**—This should be examined and, if necessary, cleaned every three months, but more often if viscous dirty oils are used. To clean out the combustion chamber, remove the admission valve block and the piston. Particular care should be taken to remove any carbon which may have become deposited around the hole through which the sprayer nozzle protrudes, and also from the slight working clearance space between back end of the cylinder liner and the back of the piston when the crank is on the inner dead centre. A pocket flash light is very useful.

**IGNITION TUBE.**—(Sizes O & OE 115 to O & OE 123). When the engine is started by means of a lamp it is sometimes found that the tube has become blocked up with carbon, thus making starting difficult. The tube must therefore be taken out occasionally and cleaned.

**ADMISSION AND EXHAUST VALVES.**—These should be examined monthly, and, if necessary, ground in on their seatings, see Notes on Dismantling on pages 52 to 54. Special care should be given to the grinding in of the exhaust valve. If the engine is worked when the valves are leaking, the heat and speed of gases escaping at the leak will very soon eat the metal away and thus necessitate new valves. **To "grind in" the valves**—This is done by oiling the face of the valve and sprinkling thereon some emery powder. (*Carborundum must not be used to "grind in" valves*). Then screw the grinding handle, provided, into the valve and secure it with the lock nut. Twist the valve on its seat, exerting a little pressure whilst doing so, lifting occasionally and turning it round to a different position on the seating. Withdraw the valve, clean it and the seating in the cylinder, thoroughly, and then replace it, and revolve it lightly on its seat a few times. Withdraw it once more, and see if both valve and seating have a bright, unbroken line all round; if not repeat the grinding operation until this is obtained. Most sizes have the exhaust valve made in cast iron, which is the best material for the purpose. This valve must be handled carefully when taken out to prevent breakage.

**EXHAUST PIPES AND EXHAUST SILENCER.**—If the engine has been run for long periods with the fuel injection timed too late, or with very viscous oil, or with the sprayer or control valve out of order, the exhaust pipes and silencer should be periodically examined, and if necessary cleared of any carbon deposits.

**RE-SETTING VALVE TIMINGS.**—If, owing to wear, it is necessary to reset the opening and closing of the valves, proceed as follows:—

Turn flywheel to the commencement of the **suction stroke,** that is, when the piston is as far in the cylinder as is possible, the crank and connecting rod being horizontal. Then turn the flywheel until crank is 30 deg. above the horizontal centre, as shown on diagram Fig. 5, page 11, when the exhaust roller should just be leaving the exhaust cam, and it is *just* possible to revolve the roller, while at the same time it is touching the cam. Then turn the flywheel further round until it is 30 degrees past the **outer** centre as shown on same diagram, when the air valve should just have closed, the roller just touching the cam as described above, but will revolve when the lever is pressed slightly against the valve spindle pusher head.

Continue turning the flywheel until the crank is from 22 degrees to 30 degrees *below* the horizontal **inner** centre, which is approximately when the fuel oil injection commences. (The exact point varies with different sizes of engines and also with different qualities of Fuel Oils).

Turn flywheel further round now on the **power stroke** until the crank web is 60 degrees before the **outer** horizontal centre as shown on the diagram, when the exhaust roller should just press against the commencement of the rise on the exhaust cam.

Rotate the flywheel round still further and when the crank reaches a position of 30 degrees under the **inner** centre on the **exhaust stroke,** the air valve should just commence to open, the roller touching the rise on the air admission cam as described above.

**BREECH END CYLINDER STUDS.**—The nuts of these studs, for attaching the breech end to the bedframe, must be tightly screwed up from time to time (especially when the engine is first started). On the O, or OE 122 and larger sizes, access to two of them is only possible when the admission valve block is removed. The special box spanner provided can then be passed through into the space over the combustion chamber and the nuts securely tightened.

**CRANKSHAFT BEARINGS.**—When adjusting the bearings, each half must be screwed up metal to metal, the requisite clearance being obtained by scraping the inside of the bearings just sufficiently to allow the engines to run without "knock" or heating up. On no account is the clearance to be obtained by adjusting the nuts. The filing and bedding down of bearing brasses should only be entrusted to a skilled mechanic.

**HOT BEARINGS.**—Should any bearings show signs of over-heating when touched by the hand whilst working, the most likely cause is that either the quantity of lubricating oil is deficient or that the quality of oil is unsuitable (see notes on Lubricating Oil on page 39). The oiling rings on the crankshaft and sideshaft should be examined to see that they are perfectly clean and rotating properly. If there is dirt or water in the oil wells or lubricators, or if the oil is of an inferior quality, there will in some cases be a tendency for a gummy substance to form and adhere to the oiling ring or to the inside of the supply pipe to the centrifugal lubricator for the crank pin, and so prevent an adequate quantity of oil being carried to and distributed over the bearings. Should the cause of any over-heating of bearings not be ascertained quickly, *the engine must be stopped immediately*, to avoid scoring of the bearings or perhaps even more serious damage resulting. Should any bearing, after having been over-heated, be found difficult to run cool again, it is recommended that it is lubricated with castor oil for some hours. Heating of main and out-end bearings is sometimes an indication of the bearings *being out of line*, possibly through incorrect alignment when erecting, or subsequent subsidence of the engine foundation. This must have immediate attention and be overhauled by a skilled erector. See "method of testing," page 49

**CONNECTING ROD BEARINGS.**—**Large End.**—Frequent attention should be given the lubrication of this important part of the engine, which must be well supplied with oil. The pipe which conveys the oil from the lubricator to the crank pin must not be allowed to touch the revolving parts. An oil cup is provided on the connecting rod end to prime the bearing with oil before starting. Any "knock" must be taken up as soon as it becomes apparent. No engine should be allowed to run with a perceptible knock in the connecting rod bearings, as a severe strain is put upon the bolts and may cause breakage. *This is a most important matter and must on no account be neglected.* The breaking of a connecting rod bolt when the engine is at work may lead to a very serious if not dangerous accident. It is very important to remember that when the clearance in the large end bearings is being reduced the requisite clearance must be left between the crank pin and the bearing, but **NO** clearance must be left between the two half bearings, and the nuts must be tightly screwed up, locked, and fixed by the locking screw. **On no account is the clearance to be obtained by adjusting the nuts of the connecting rod bolts.** A split pin is placed immediately behind the nut on the bolts. As the adjustment is taken up one or more thin washers must be placed between the face of the nuts and the split pin. **Small End.**—The bearing on the small end of the connecting rod must also be adjusted from time to time, and in exactly the same manner as described above. The clearance must be between the piston pin and the bearings, when the adjusting screw is screwed tightly up to the bearings and securely locked with the lock nut.

**CONNECTING ROD BOLTS.**—Some insurance companies advise their clients to replace the connecting rod bolts with new ones after 10,000 hours running, say every three or four years. This is to prevent any possibility of breakage, in case, at any time they may have been working in a loose condition, or with a piston that may have seized in the liner, due possibly to lack of lubricating oil, or excessively hot water in the jacket. **This renewal of bolts is a very wise precaution.** Furthermore the bolts may have become twisted or lengthened due to injudicious tightening up, when replacing after overhauling. The bolts must be tightened up equally. Accidents have been known to occur owing to one bolt being loosely adjusted, the other taking the greater part of the strain. Keep the bolts polished, a crack can then be seen at its early stage.

It is very necessary to examine the bolts carefully from time to time, as shewn in the engine room log sheet, see page 8, to see if any flaw can be detected. In recent engines we have marked each bolt with a line running along the whole length, as illustrated.

Place a straight-edge or steel rule along this line and examine very carefully to see that no twist has taken place. Another method which is more accurate, is to place the bolt in vee-blocks and try the line with a scribing block. In addition to this a small centre-punch mark has been made at "B." In the adjoining table we give the correct dimension from under the head of the bolt to "B." for each size of engine.

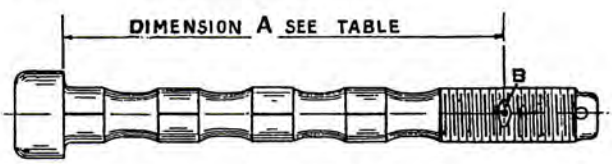



Fig. 41. CONNECTING ROD BOLT.

| SIZE ENGINE. | DIMENSION A. | | MAXIMUM EXTENSION. | | MAXIMUM TWIST. | |
|---|---|---|---|---|---|---|
| | Inches. | m/m | Inches. | m/m | Inches. | m/m |
| 115/116 | 7 | 178 | .014 | .355 | $\frac{1}{16}$ | 1.5 |
| 117/118 | $6\frac{1}{2}$ | 165 | .014 | .355 | $\frac{1}{16}$ | 1.5 |
| 120 | $7\frac{3}{4}$ | 197 | .015 | .380 | $\frac{1}{16}$ | 1.5 |
| 122 | 9 | 229 | .018 | .456 | $\frac{1}{16}$ | 1.5 |
| 123 | $10\frac{1}{4}$ | 260 | .020 | .507 | $\frac{1}{8}$ | 3.0 |
| 126 | $12\frac{1}{2}$ | 317 | .025 | .634 | $\frac{1}{8}$ | 3.0 |
| 128 | $13\frac{1}{2}$ | 343 | .027 | .685 | $\frac{1}{8}$ | 3.0 |

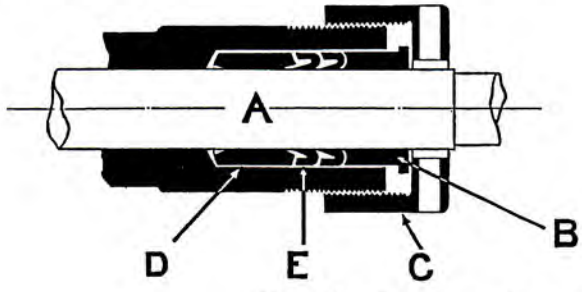
This must be measured carefully when the rod is dismantled for the first time, and upon each subsequent occasion the length must be checked to see that no undue elongation has taken place. We also give the maximum permissible twist and elongation for each size of bolt. *When either of these has been reached in either or both cases the bolts must be rejected and new ones fitted.*

**SPECIAL NOTE.**—Our connecting rod bolts *must not be annealed,* as they are made from a special steel and undergo a special form of heat treatment, known as "oil toughening," to ensure the best possible condition of the material in the way of the greatest strength combined with the greatest ductility. *Therefore when replacing the bolts with new ones be sure to order them from us so as to be absolutely sure of both the special material and the special heat treatment being properly carried out.* Should a piston at any time seize in the liner, great strain is thrown on the connecting rod bolts owing to the stored energy in the flywheel. Consequently the engine should never be run after such a seizure until new connecting rod bolts have been fitted, since the old bolts will be sure to have been over-strained, and therefore be dangerous to use.

**GOVERNOR WHEELS AND SIDESHAFT WHEELS.**—To reduce wear and ensure quiet running of these wheels we recommend that a mixture of oil and graphite is used in the oil bath in the proportion of about ten parts of oil to one of graphite.

**OIL PUMP.**—Particular attention must be paid to the packing of the stuffing box round the oil pump plunger. We now supply a special packing for this purpose (later engines are fitted with it when sent out from the works). We strongly recommend its use in all cases, and by using a gland ring and new type gland as illustrated below, existing oil pumps can be adapted to take the new packing.

After cleaning or when repacking is necessary, first place the metal gland ring in position and behind this two special cup packing rings. See that these are put in the right way up. Put in the gland and screw the gland nut down so as to press lightly on the rings to prevent them moving when the plunger is working.




A—Oil Pump Plunger.
B— ,, ,, Gland.
C— ,, ,, ,, nut.
D— ,, ,, ,, ring.
E—Cup Packing Ring.

Fig. 42. Oil Pump Gland Packing.

Wash the pump valves, plugs, and pump body in clean paraffin throughly before assembling. The pump valves seldom require grinding in, but when done *grind as little as possible.* When the seats are satisfactory examine the lift of each valve, this must be 1/32in. (about 0.8 m/m). The most important valve is the delivery valve nearest the sprayer. The satisfactory working of the engine depends to a large extent on this valve.

The lift of the valves can be corrected by adjusting the thickness of the copper washers under the plugs.

**Carborundum must not be used for grinding valves,** each valve must be returned to its own seat after examination, and not interchanged with another valve. Therefore **attend to one valve at a time,** and do not let the valves become mixed.

**OIL SPRAYER**—(See Figs. 43 and 43A below, and Fig. 20, 20A and 20B on page 18). After the engine has been tested at our works the sprayer (and also the oil pump and control valve) is thoroughly charged with lubricating oil. If, as may very occasionally be the case with engines shipped abroad, any parts such as the nozzle and spindle are rusted, they must be withdrawn from the body and cleaned in paraffin to remove all rust and dirt. On no account should emery powder or cloth, or carborundum be used. The valve must be rubbed on its seat with oil only. The lift of the sprayer spindle will usually be found not to exceed 1/32in. to 1/16in. (1 to 2 m/m); a gauge is provided to adjust this lift. See note 1 below. *In any case neither this lift nor the compression of the spring must be altered from the condition as received with the engine without good cause, because both are set when the engine is undergoing its test at our works.* If, after a long period of running, the lift of the sprayer spindle increases, it may be reset to the original lift, as described in Note 1 following. See letter U on illustration Fig. 20, on page 18.

A—Sprayer Nozzle.
B—Sprayer Body.
C—Sprayer Nozzle Peg.
D—Copper Washers.
E—Nozzle Cap.

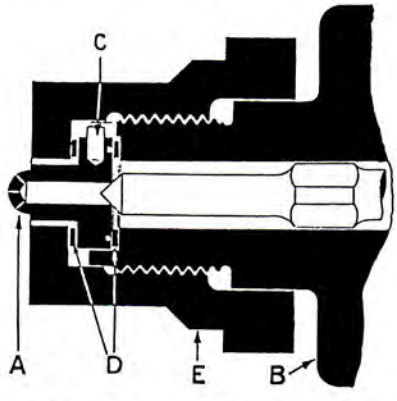



Fig. 43. Sprayer Nozzle and Cap. (Original Type).

A—Sprayer Nozzle.
B—Sprayer Body.
E—Sprayer Nozzle Cap.

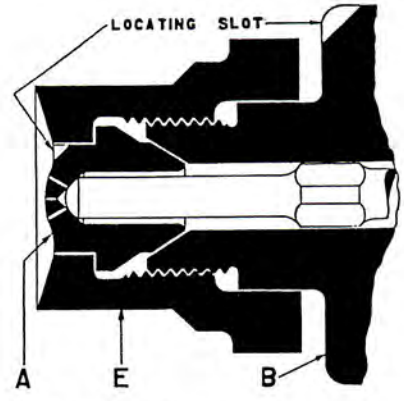



Fig. 43A. Sprayer Nozzle and Cap. (Improved Type).

For keeping the sprayer in good order the following notes must be carefully observed :—

(1) **Sprayer Gauges.**—To measure the lift of the spindle accurately, the crossbar should be put into position on the studs with the spring removed but the valve spindle in place. Take the little plate gauge C, Fig. 45, which will be found hanging by a chain to the sprayer and insert the end **C** between the end of the sprayer valve collar **H,** Fig. 20, and the end of the stud **L** in the crossbar. Then adjust and lock the stud **firmly** in the crossbar in such a position that the end **C** of the plate gauge, furthest from the chain, will just enter freely between them. It should be understood that this gauge is provided to record the previous conditions of the sprayer when the engine was tested. It is just possible that some slight modification to these gauge conditions may be advisable to suit local conditions, such as the quality of the fuel oil used, etc., but we do not usually recommend any change, and in any case any modifications should be very slight.

(2) Particular attention must be paid to the periodical cleaning of the sprayer and its oil strainer. Withdraw the plug **P** (see illustration on page 18) daily for three or four days when the engine is first put to work and wash off all dirt or fluff. After this period it should be cleaned out weekly or monthly as the attendant may find sufficient, bearing in mind that it is impossible for the engine to run well and economically if the engine is in a dirty condition. If, therefore, the fuel oil is unusually dirty or the strainers on the oil tank or in the oil heater are allowed to become broken and inefficient, the sprayer, and the strainer on the sprayer, may have to be cleaned more frequently.

(3) The packing of the sprayer gland must always receive careful attention. In the original type sprayers this was done with soft packing. An improved type of packing has, however, now been adopted, which consists of special cup packing rings, see Fig. 44. We strongly recommend this new type packing, and by using a gland ring and new type gland, as illustrated, existing sprayers can be converted to its use.

After cleaning, or when re-packing is necessary, having removed the spring bar and spring, first place the metal gland ring in position, and behind this one special cup packing ring in the direction shewn. **See that this is put in the right way up.** Screw in the gland nut so as to press lightly on the packing ring to prevent it moving when the sprayer valve works. When this has been properly done, put the spring and crossbar in position, and tighten up the nuts. There must **always be clearance between the gland nut and the spring washer,** otherwise the sprayer valve spindle will not be able to reach its seating and, in consequence, will not work satisfactorily. (In the more lately constructed engines a little locking device is added to prevent this sprayer gland nut slacking back). When the engine is working, **the sprayer valve should work very freely and very quickly, in fact so quickly that its motion can hardly be seen,** and the gland should be so adjusted that the fuel may leak past very slowly, say one or two drops per hour. This ensures efficient lubrication. If it does not work very quickly the gland nut should be unscrewed a little, say, a quarter of a turn. On the other hand it should be kept screwed up as much as possible, providing the valve works very quickly, otherwise there will be a tendency for too much oil to leak past the packing. **When the spring is removed it should be possible to move the spindle without difficulty when held between the thumb and forefinger.**

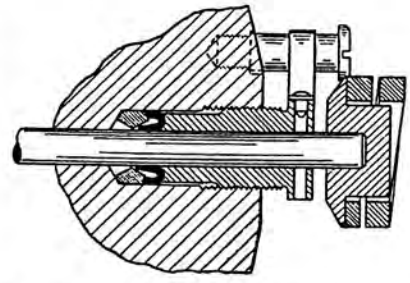
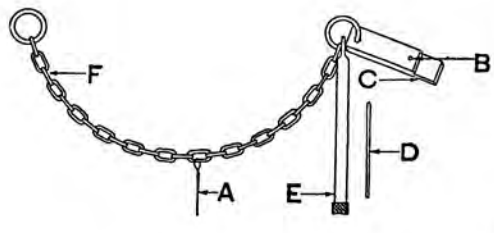


Fig. 44. SPRAYER GLAND PACKING.

(4) When cleaning the sprayer body and its nozzle and spindle (either in the first instance or after running), they should be carefully washed in paraffin, and the small holes in the end of the nozzle cleaned out carefully with a fine wire. Under no consideration must these holes be enlarged, as their size is of great importance. A hole is drilled in the plate gauge referred to in Note 1 above (see Fig. 45). In some cases two holes are drilled therein, to correspond to two sizes of holes drilled in the nozzle. In this case and unless a special separate instruction is issued to the contrary, the centre hole in the sprayer should be the same size as the smaller hole in the plate gauge, and the outer holes in the sprayer should be the same size as the larger hole. A small wire or wires **A** will be found attached to the chain **F,** carrying the plate gauge. This is a wire gauge and will be found to just pass into the hole or holes in the plate and the holes in the sprayer nozzle. If the holes in the sprayer nozzle are appreciably larger than the holes in the plate gauge (which can easily be ascertained by trying the wire gauge in both the plate and the nozzle) the nozzle should be changed for a new one. Small reamers for cleaning out the sprayer holes will be found in the little brass tube **E** attached to the chain. They must be used very carefully so as not to do more than clean any carbon out of the holes. **The holes must not be made larger than the holes in the plate gauge and for this reason the reamers must only be used with one's fingers and not with any form of holder.**




A—Wire gauge for spray holes.
B—Plate gauge with gauge hole of same size as spray holes.
C—End of plate gauge of same thickness as the lift of the sprayer valve (test only when engine is at rest).
D—Steel reamer.
E—Tube containing reamers.
F—Chain.

Fig. 45. SPRAYER GAUGES AND CHAIN.

(5) **Original Type Sprayer Nozzle.**—The sprayer nozzle **A,** Fig. 43, page 43, should not be removed from the sprayer body unless really necessary, and it is then **absolutely essential** that it should be replaced in the body again, when assembling, in exactly the same position as before its removal. The locating pin **C** in the side of the nozzle is inserted in the slot cut in the sprayer body to ensure the correct disposition of the small holes for forming the spray.

As it is **extremely important** that the accurate alignment of the sprayer spindle and the valve seating in the nozzle is preserved, **it is absolutely necessary** for the attendant to re-assemble the parts, after examination and cleaning, in the following stages (See Fig. 43) :—

(*a*) Place the two copper washers **D** on either side of the nozzle flange as shewn, and place the nozzle **A** in the recess at the end of the sprayer body, with its locating pin **C** in the slot.

(*b*) Screw the nozzle cap **E** on to the body, just far enough to keep the locating pin in the slot, but not far enough to tighten it down on the nozzle, which latter must be just free to move.

(*c*) Put the valve spindle, gland, spring bar, and spring in position. The load on the spring, due to the tightening up of the nuts on the studs will then locate the nozzle centrically on the spindle seating.

(*d*) Then further screw down the nozzle cap, to make the joint secure between the two faces and the copper washer—see notes below, under "Testing the Sprayer" and "Copper Washers."

**IMPROVED TYPE SPRAYER NOZZLE.**—Later engines are fitted with an improved type sprayer nozzle, see Fig. 43A. The joint between the nozzle and the body is a metal to metal one, in the form of a cone seating, the surfaces of which have been lightly ground together.

It is extremely important that the accurate alignment of the sprayer spindle, and the valve seating in the nozzle is preserved. The following instructions must be carefully observed :—

(*e*) Should a new nozzle be fitted at any time, it should only be lightly ground in on the coned seating with very fine emery knife powder (not carborundum), and then finished off with white or red lead powder and oil. When grinding in, do it by hand only and use no tools.

(*f*) Use only the special tool provided for screwing the nozzle cap into place. Do not use much force.

(*g*) When placing the nozzle in the body, see that the "locating slot" in same is in line with the slot in the sprayer body. Check this again when the nut has been tightened.

**IMPORTANT.**—The various parts of the sprayer **must** be always perfectly free from grit and dirt when being replaced. If the sprayer is not kept perfectly clean, imperfect spraying, bad combustion, and even burst fuel pipes will result. Furthermore, if the sprayer is out of order it may dribble and cause carbonisation and high fuel consumption, and the oil run down the wall of the combustion chamber and carbonise the exhaust valve seat.

**TESTING THE SPRAYER.**—After cleaning or re-assembling the sprayer, or if at any time the engine is lacking in power, or if the exhaust gas is dirty and the consumption of fuel high, remove the sprayer and test it as follows to see if the cause can be ascertained :—Secure the sprayer to the delivery pipe with the nozzle pointing into the open air away from the engine. Raise the governor lever on to the starting prop, as for starting, so that the control valve cuts out at each stroke of the oil pump handle, to prevent sprayer dribbling. Work the pump and see that there is no air in it or in the pipes. The joints of the suction pipe, strainer, cock and oil heater are very important and must not allow air to leak in. Any doubtful joint must be re-made. On later type engines a release screw is provided on the oil pump, which, when opened, shews that the fuel oil is passing freely through the pump. See notes on "Oil Tanks and Pipes," page 47. If testing with heavy, viscous oils, it will be necessary to somewhat heat the pump, pipes, sprayer and strainer to ensure satisfactory spraying. This is not necessary, however, with refined and less viscous oils. Work the pump by means of the handle with very sharp movements until it feels quite "solid." When there is no air in the pipes or sprayer, each charge of oil should be ejected in a fine spray which cuts off promptly, at the end of each stroke, when the control valve opens.

If there is any dribbling it is a sign that either the sprayer valve or the nozzle requires attention.

Examine the following parts and correct the defect as found necessary :—

**Original Type Nozzle.**

(*a*) See that the copper washer **D** between the nozzle and the sprayer body is sound, uniform in thickness, and annealed as described under "Copper Washers" page 46. If this does not make a perfect joint the fuel oil leaks past this joint and finds its way out between the nozzle **A** and the nozzle cap **E.**

(*b*) See that the sprayer valve is seating correctly in the sprayer nozzle, for, if not, the fuel oil will dribble through the spraying holes in the nozzle.

To remedy this remove the cap and the nozzle and examine the width of the valve seating on the nozzle. This should be 5/32in. diameter and should never exceed 3/16in. maximum, and if this size is not exceeded, and if the hole through the seating is $\frac{1}{8}$in. diameter, the nozzle may be considered as satisfactory, providing the seating all round is in good condition with no indentations in it caused by foreign matter in the oil. If, as a result of long working, the $\frac{1}{8}$in. hole in the nozzle seat has become somewhat hammered over by the sprayer valve spindle and become reduced in size, it must be carefully opened out to its correct size of $\frac{1}{8}$in. If the seating on the nozzle has increased in size until it is a full 3/16in. diameter it must be reduced again (until it nearly disappears) by rubbing the face of the nozzle evenly on a perfectly flat Carborundum stone, but the thickness of the flange on the nozzle must **never** be reduced to less than 5/32in. Then examine the seating on the end of the sprayer valve spindle, and if not in good order use a new one. The parts must then be re-assembled together **exactly** as described in paragraphs *a, b, c, d,* above, and the sprayer tested again to see if the dribbling has stopped.

**Improved Type Nozzle.**

(*c*) See that the coned seating of the nozzle **A** and the sprayer body **B** (Fig. 43A) has not been damaged when dismantling. If it has the fuel oil may leak past the joint and find its way out between the nozzle and the nozzle cap **D.** See notes above respecting renewal and grinding in the nozzle.

(*d*) It is **not** intended that the seating **C** shall be a seating over the whole of the cone, but only at the edge shown at **C,** and not wide enough to reach to the edge of the sprayholes. All the parts must be thoroughly cleaned out and freed from powder. Do not allow any powder to get up the sprayer spindle guide, therefore, never remove the spindle from the sprayer body when grinding-in, until the nozzle has first been removed and all the powder cleaned away. Carbon tends to fill up the space between the sprayer nozzle and the nozzle cap. When taking the nozzle out any such carbon must be scraped off the outside of the nozzle and from the inside of the cap before replacing either of them in position. Absolute cleanliness is necessary with all parts of the sprayer when putting them together.

(*e*) **Sprayer Valve Spindle Gland.**—The sprayer valve may not be working sufficiently freely in the gland. This should be examined for rust or corrosion. If in very bad condition renew both valve spindle and packing, see notes above.

NOTE.—Do not tighten the gland so as to cause the spindle to stick.

Of the items mentioned above, it should not be necessary to attend to those under *a* to *c* with a new engine which has only been running a short time, nor to *d* and *e* unless some foreign matter has got into the oil, or the spindle has been allowed to become rusty.

Make sure first, therefore, that the fault does not lie elsewhere.

When testing the sprayer, wipe the nozzle clean after each ejection, so as not to confuse any dribble caused by items *a, b,* or *c* with that from items *d* and *e.*

After re-making the sprayer nozzle joint any **slight dribble from the spray holes** will often be found to disappear after two or three days running owing to the sprayer valve spindle and the sprayer nozzle seat automatically making an oil tight-seating themselves.

**COPPER WASHERS.**—All joints, which have to withstand the oil pressure produced by the fuel pump, are made with **softened** copper washers. When any joint requires to be re-made the copper washer must either be a new soft one or, if the old washer is used, must first be re-softened. This may be done by heating the washer to a red heat in a gas jet or in a flame from a blow lamp and then immediately plunging into water. No old washer should be used if it has become very thin or distorted. **This is particularly important in the case of the washer D under the sprayer nozzle as shown in Fig. 43.**

**CONTROL VALVE.**—See Figs. 22 and 23, page 19. It is very necessary for this valve to work freely. It should also be quite clean, especially the valve seat, as if the valve does not return to its seat promptly, oil will leak past the seating instead of being delivered through the sprayer, and there will be a consequent loss of power.

It is a simple matter to test the control valve for leakage. Prop the governor lever up in such a position that the thinnest part of the wedge comes opposite the control valve spindle. Then close the relief valve on the sprayer and pump quickly by hand **without moving the pump far enough to open the control valve.** If any oil is seen to pass into the tundish, from the pipe leading from the control valve to the tundish, it is a sign that the control valve is leaking and must be attended to.

The glands **C** and **G** at each end of the valve must be neatly packed, with soft "Palmetto," packing and not adjusted too tightly. Place one of the separate packing coils in the stuffing box, wrapping it loosely round the spindle. Press each coil down into place, taking care that each coil is home before another is pressed hard behind it. Whilst doing this, work the valve spindle up and down and round and round, to see that it is quite free. If a leaky seating is suspected, the spindle may be slightly ground in. *As little grinding as possible* should be done.

**CONTROL VALVE OPERATING MECHANISM.**—If for any reason it has been necessary to use a new pecker bolt, or if the pecker bolt should become bent, it is most important that position of the set screw should be correctly fixed and pinned, when the roller on the oil pump lever is quite clear of the cam. The thicker portion **T** and **Y** of the governor wedge should be *only just able to pass freely* between the end of the set screw on the pecker bolt and the end of the control valve spindle. This means that the clearance is only $\frac{1}{100}$ of an inch.

The relative position of the governor weights and sleeve to the governor wedge, can be adjusted by means of the nuts on the governor hanging rod. The length of this rod, however, is correctly set at these works when the engine is put through its trials, and it should not be altered without good reason.

**DOUBLE PLUNGER LUBRICATOR.**—Fig. 38. To remove springs, or examine plunger barrels, withdraw the fulcrum pin of the cranked lever, when the plunger may be taken out. **Delivery Valves and Seats.**—These may be examined by first removing the sight feed lubricators and the union plugs of the delivery pipes, and then tilting the pump body until the ball valves roll out. **To Renew a Glass for the Sight Feed Lubricators** unscrew the milled cap at the top of the needle valve stem until the valve can be withdrawn. Then unscrew the milled and hexagon locknuts underneath this cap, together with the top brass cover of the glass, and the glass itself can be then lifted out.

Access to the small ball valve in the shank of the sight feed lubricator is obtained by removing the screwed plug in the bottom of the shank by means of a screw driver.

## CENTRAL MECHANICAL LUBRICATOR.

**Lubricators.—Use of Air-Vent on Multiple Lubricator (O and OE 123-128).** Should the lubricator be acciden allowed to empty, possibly admitting air to the pump, the air-vent **M** should be again used in the manner desc on page 29, see Fig. 39. **To clear or renew a Sight Feed Glass.**—Uncouple the union nut **R** and remove the guide **S**; slack off the milled nut **T** and run the milled nut **Y** down to its bottom position on the shank **W.** The shank then be lifted and the glass removed. **To Re-Fill a Sight Feed Glass** uncouple the union nut **R,** and remove the g wire **S**; see that the sight feed glass **L,** and the shank **W,** are thoroughly free from oil on the inside. Then fill it the saturated solution of salt to the top of **W,** and replace the guide wire **S.** NOTE.—*The salt keeps the glass and t clear and also prevents freezing when the lubricators are in an exposed position, or when the engine room temperature below freezing point.* **Plunger Packing Gland.**—A spanner is provided to tighten up the plunger packings. The plu **B** should be put on its extreme outward position and the parts **P** and **N** slacked back, to allow a spanner to be use the hexagon packing screw. The lubricators are sent out with this packing properly adjusted and this should require attention for a considerable time. Do not screw up too tightly. **Inspection of Suction Valves.**—Remove milled cap **Y** and unscrew the suction cage **Z** by means of the spanner. The suction valves are then accessible examination. Screw the cage **Z** up tightly after replacing. **Inspection of Delivery Valves.**—After removing the s feed glasses, as explained above, the nozzle **A** may be unscrewed to enable the delivery valves to be accessible. **In event of a lubricator not feeding** open the air-vent **M** and see that oil comes out when flushing by means of the fi ring. If the lubricator still does not feed, unscrew the suction cap **Y** and cage **Z,** clean the suction valves **D** and **E,** sc the cage **Y** home tightly, and the lubricator should then feed properly.

## OIL TANKS, PIPES, STRAINERS AND HEATER.

**IMPORTANT.**—All fuel joints must be very carefully made, as any air allowed to leak in, will result in irreg working of the pump and sprayer (see remarks under "Testing Sprayer," on page 45). The attendant must see t the wire gauze filters in both fuel tank and heater are securely fastened and are free from any holes or rents. Shc either become torn by accident it must be immediately replaced as it *is most important that every particle of fuel passes through all the strainers before reaching the sprayer.* Clean any sediment from the gauze very carefully each mo Drain the water out of the bottom of both the oil tank and oil heater daily or weekly as may be found advisable, means of the drain plugs or cocks provided for the purpose. Clean the oil heater out thoroughly every two or tl months. After longer periods, according to the kind of oil used, the number of hours worked, and other local conditi the tank, pipes and oil heater should be carefully dismantled, and thoroughly washed out with paraffin to remove slush, fluff, grit and water. The wire gauze in the strainers, if at all defective, *must* be replaced. Every possible me must be taken when re-assembling the parts to ensure perfect air-tight joints between the tank and the oil pump.

**FLYWHEEL KEYS.**—It is important that the flywheel keys be driven up tight and kept tight. A slack ke not attended to, will ultimately cause the breakage of either the flywheel or the crankshaft. Do not pack up a sl key with liners, as it is quite impossible to make a satisfactory job by so doing. A new key must be fitted, and fit most carefully.

**DUST AND DIRT.**—Protect both the engine and its air supply as far as possible from all dust and d which may cause rapid wear of both cylinder and bearings; also great care should be taken that the air supply is n drawn from a heated or impure source, which would reduce the power. The oil groove round the bed is provided catch any stray drops of oil and prevent them getting on to and thereby rotting the concrete foundation. This oil groc should be cleaned out each day.

**POLISHING.**—Do not use emery cloth. Some form of powder is better and gives a better finish.

## COMPRESSED AIR RECEIVERS, STOP VALVES, ETC.

All joints, valve seats, valves and pipes must be maintained in perfect order. Each receiver is tested unc hydraulic pressure to 450 lbs. per sq. in. After the stop valve and fittings are attached, each receiver is tested wi compressed air to 250 lbs. per sq. in. A loss of pressure of say 20 lbs. per square inch may be expected, owing to t cooling of the air. This is natural and cannot be avoided. If the pressure decreases to any material extent after so hours, the receiver, etc., should be carefully examined. When a leakage has been located, it should be immediate rectified. Only skilled mechanics should be entrusted with the work of remedying any leakage of air. Any leakage fro rivetted joints caused by mishandling in transit can only be remedied by caulking up the seams.

**LEAKAGE.**—A simple and effective method of detecting leakage is to pour a little thin lubricating oil over a suspected joints. If any joint is faulty air bubbles will be clearly visible rising through the oil.

**VALVE SEATINGS.**—All valve seatings must be kept carefully ground in. Coarse emery or carborundu must **not** be used. In all cases the grinding in must be finished off with fine rotten stone powder, or fine crocus powder so as to remove any scratches made by the fine emery powder and leave a perfectly smooth surface.

**COPPER WASHERS.**—When joints are made with solid copper washers all parts must be clean. Before any joint is made the copper washer must be annealed by heating it to red heat in a flame and immediately plunging i into water.

**INSIDE OF PIPES.**—Scale or dirt from inside of pipes are sometimes a source of trouble, as loose bits of sca or dirt may get between the valve seatings and damage them To prevent this the best plan is to thoroughly hamm the pipes before erection to dislodge any scale and to then paint them carefully **inside** to prevent rusting or further sca being formed.

**INSIDE OF RECEIVER.**—Scale or dirt from the inside of the receiver can also be a source of trouble and if such scale or dirt is found and cannot be traced to any other source, it may be advisable (if the trouble is persistent) for the pipes to be disconnected, a gallon of lead paint poured inside, and the receiver rolled slowly backwards and forwards two or three turns to ensure the whole shell being coated and the surplus paint then being drained out.

**The care of joints which can possibly cause loss of air pressure by leakage in the compressed air system.**

| Joint. | Remedy to Prevent Leakage on Sizes "115" and "117" Engines. |
|---|---|
| 1. Stop Valve to Receiver | Anneal the copper washer as described above and re-make the joint carefully. |
| 2. Stop Valve Spindle and its Seating. | Leakage may be detected when the receiver is charged and the stop valve closed by uncoupling the pipe and applying a light to the outlet passage. If leakage is found, grind the spindle in carefully after slacking back the nut on the end of the spindle and keeping the plug in place round the spindle to serve as a guide. |
| 3. Receiver Drain Plug. | Anneal the copper washers as described above and re-make the joint carefully. |
| 4. Gauge to Valve. | Anneal the copper washers and re-make joint carefully. |
| 5. Pipe Joints between Stop Valve and Engine. | These are only affected when the receiver is being charged. Test with lubricating oil as described above, and re-make any faulty joints with red or white lead paste. |

| Joint. | Remedy to Prevent Leakage on Sizes "120" to "128" Engines. |
|---|---|
| 6. Between Stop Valve Body and Receiver. | If copper washer used anneal it and re-make joint carefully. Screw all nuts up equally. This joint is now made with special flexible packing. |
| 7. Receiver Drain Plug. | Anneal the copper washers as described above and re-make joint carefully. |
| 8. Between Stop Valve and its seating. | If this leaks, air escapes past the spindle and is detected by pouring lubricating oil on the joints and on the spindle when the compressor has not been working, for say half an hour. If escape continues take valve out and carefully ease any bright places with fine emery cloth. |
| 9. Pressure Gauge and Plug. Also Plug and Stop Valve. | Anneal the copper washers and re-make joint carefully as described above. |
| 10. Relief Valve to Stop Valve. Also Valve seating. | Relief valve is only used when specially asked for. Anneal the copper washers and re-make joint carefully. If the **valve seating** leaks grind in carefully as described above. |
| 11. Between the automatic valve and its seating. | After coupling up stop valve to receiver, when engine is being erected, grind the automatic valve on its seat very lightly with fine rotten stone powder or fine crocus powder (not emery or carborundum). This ensures a perfect seating being made in case the stop valve should have been slightly distorted after detaching and re-bolting it to the receiver. Test this by dis-connecting the pipe to the compressor and holding a light in the passage under the valve. If flame is blown downwards there is leakage. In this case empty receiver on first opportunity and remove plug over valve. Grind in the valve whilst the stop valve body is coupled to the receiver and after the nuts used for this purpose have been finally tightened up. |
| 12. Pipe joints between Compressor, Stop Valve and Engine. | These are only affected when the receiver is being charged or engine is being started. Test with lubricating oil and re-make faulty joints with red or white lead paste. |
| 13. When opening the stop valve to start the engine unscrew the hand wheel as far as it will go. This brings the head of the valve up against the spindle guide and forms a seating. | |
| 14. Before starting for the first time, or when dirt is suspected in the piping, raise the pressure in the receiver to about 20 lbs. Then disconnect the air pipe at the starter valve on the cylinder. When this is done open the stop valve on the receiver to blow out any scale or dirt in the pipe which might otherwise cause trouble on the valve seats. The air pipe between the compressor and the receiver should also be disconnected at the receiver and air blown through this pipe by means of compressor. | |

**DRAINCOCKS.**—Drain cocks or plugs should be fitted at the lowest part of all pipes, including exhaust, water, and compressed air, and also at the bottom of the exhaust silencer and compressed air receiver.

Particular care must be taken to drain the compressed air receiver and exhaust silencer periodically.

**REPAIRS.**—When cleaning, the working parts should be carefully examined for any signs of wear or damage, and when considered necessary the parts should be replaced by new ones, or new parts ordered and kept in stock ready for use when further wear has taken place. This refers more particularly to such parts as the sprayer, oil pump, control valve, governor, connecting rod, large end bolts, etc. Generally speaking, more cleaning is necessary when working with viscous, crude, or residual oils and with tar oils, than when working with thin crude, semi-refined, or refined oils. The attendant must be guided by circumstances, after noting the suggestions in the foregoing chapters on "Working," "Maintenance," and particularly those on pages 38 to 40 on "Warnings."

**CRANKSHAFT BEARINGS—TESTING ALIGNMENT.**—On both single and double cylinder engines it is most important to maintain the main and out-end bearings perfectly in line. Heating of these bearings is frequently an indication that they are out of line, and should be attended to immediately. When checking the alignment, keep the bearing caps in position so as to obtain results under working conditions, and examine the crankshaft with an inside micrometer in the following manner :—

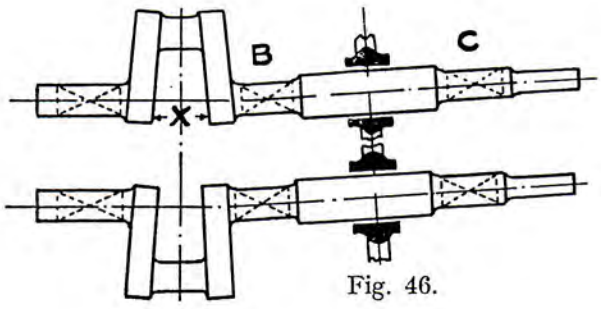


Fig. 46.

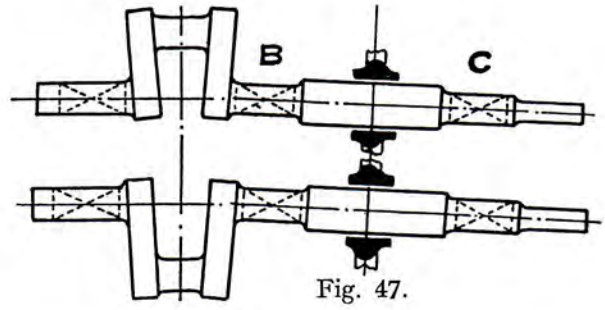


Fig. 47.

(1) Measure the distance between the crankshaft webs, first with the crank pin in its *top* position, and second with the crank pin in its *bottom* position, see Fig. 46. In order to place the micrometer in the same position at each operation, mark the place in the middle of the web and about ¼in. (7m/m) from the edge as at **X**, Fig. 46.

(2) Take careful note of the difference, if any, between the measurements taken in the two positions, and if the distance is greater when the crank pin is at the top, than when it is at the bottom as shewn in Fig. 46, either the middle bearing **B** is too low, or the out-end bearing **C** is too high.

(3) If however the distance between the webs is greater with the crank pin at the bottom, as shewn in Fig. 47, the out-end bearing **C** is too low.

The greatest permissible difference should not exceed three thousands of an inch on Sizes 115 or 215, to five thousandths of an inch on Sizes 128 and 228. N.B.—The difference between the two positions has been purposely exaggerated in the illustrations.

If the difference exceeds these limits, we strongly recommend our clients to have a skilled man to correct the alignment.

## SPARE PARTS.—IMPORTANT.

Do not run the risk of stopping the whole output of a factory for say a week, a day, or even an hour by keeping an insufficient supply of spare parts in stock—It would be a foolish policy. This is especially important in the case of engines at a distance from our works, and still more important in the case of engines shipped abroad (see page 62).

**ENGINE ROOM LOG SHEET.**—A suggested form of log sheet is given on page 8, but there are of course a number of other points, besides those mentioned there, to which regular attention must be given.

On page 50 we give in tabulated form, suggestions for dealing with any difficulties or troubles which may arise in the running or maintenance of the engine. On page 51 is an "Inspection Chart," which should be studied in conjunction with the log sheet. We cannot over emphasize the importance of regular and methodical attention to each part of the engine.

# TROUBLE CHART.

**Read this in conjunction with this Instruction Book.**

| TROUBLE | POSSIBLE CAUSE | REMEDY | See Pages |
|---|---|---|---|
| ENGINE WILL NOT START. | Fuel turned off or insufficient supply | Examine source of supply | 30, 47 |
| | Water in fuel system | Drain off and prime afresh | 6, 22, 47 |
| | Air-lock in fuel system | Open relief valve and pump by hand, also open plug on oil pump suction | 30 to 33, 36 |
| | Spray holes choked, or leakage | See instructions | 18, 43 to 45 |
| | Fuel oil too viscous | Prime with refined oil | 9, 18, 30 |
| | Insufficient starting oil in container | Supply deficiency | 18, 32, 33, 40 |
| | Insufficient pressure of compressed air for cold starting | Charge receiver | 29, 33, 47, 48 |
| | Ignition tube choked or not hot enough for lamp starting | Remove obstruction, or heat as required | 29, 31, 32, 41 |
| | Governor starting prop out of action | Put in position | 19, 30, 32 |
| ENGINE STOPS SOON AFTER STARTING. | Similar to the first six above | Corresponding to above | |
| | Compression pressure too low | Examine exhaust valve seat and spindle | 41 |
| ENGINE RACES. | Pecker clearance too great | Reduce amount. See instructions | 21, 35, 46 |
| | Dashpot piston stuck | Thin dashpot oil or use glycerine | 35, 38 |
| | Excess fuel in cylinder | Open relief valve, also exhaust valve | 38 |
| | Incorrect adjustment of speeder spring | Alter tension to reduce speed | 35, 40, 55 |
| ENGINE HUNTS. | Air-lock in fuel system | Dislodge air as above | 30 to 33, 36 |
| | Governor parts not free | Remove springs and locate cause | 19, 35, 38 |
| ENGINE WILL NOT CARRY LOAD. | Dirt in sprayer or leakage | See instructions | 18, 35, 43, 44, 45 |
| | Fuel oil too viscous | Prime with refined oil | 9, 18, 30, 37 |
| | Pecker clearance too little | Increase according to instructions | 35, 46 |
| | Sprayer spindle tight | Remove and clean | 44, 45 |
| | Half compression in gear | Release the half compression cam | 30, 31, 32 |
| | Control valve leaking | Grind-in lightly | 40, 46 |
| | Unsuitable fuel oil or wrong temp. | Change the fuel or regulate heat | 9, 40, 56, 57 |
| | Exhaust pipe or box choked | Clean parts affected | 41 |
| | Air silencer choked | Remove obstruction | 38 |
| | Insufficient lubrication | Examine lubricating system | 6, 27 to 30, 34, 38, 39 |
| | Dirt under fuel pump valves | Clean and grind-in if necessary | 43 |
| CARBONISATION OR BAD COMBUSTION. | Leaky sprayer or control valve | See instructions | 35, 40, 44 to 46 |
| | Unsuitable fuel oil or lubricating oil | Change the oil. See instructions | 9, 34, 39, 40 56, 57 |
| | Exhaust pipe choked or valve sticking | Dislodge any carbon and examine valve | 28, 41 |
| | Fuel heater or circulating water too cold | Regulate to give higher temperature | 21, 32, 33, 35, 60 |
| | Fuel heater too hot | Regulate heat supply | 21, 35 |
| | Loss of compression | Examine exhaust valve seat and spindle | 41 |
| | Injection of fuel oil too late | Alter timing in extreme circumstances only | 36, 54 |
| ENGINE KNOCKS. | Sprayer spring too tight | Reduce compression of spring | 44 |
| | Circulating water too hot or scale formation | Increase water supply or remove scale as necessary | 6, 30, 36, 39, 40 |
| | Carbon on piston or breech end | Clean according to instructions | 34, 41 |
| | Engine overloaded | Reduce the load | 35, 36 |
| | Unsuitable fuel oil | Change the fuel. See specification | 9 |
| | Loose flywheel key or connecting rod bearings | Refit or renew as necessary | 37, 42 |
| | Gear wheels not deep enough in gear | Adjust with screw | 37, 43 |
| | Injection of fuel oil too early | Alter timing in extreme circumstances only | 36, 54 |
| ENGINE STOPS SUDDENLY. | Failure of fuel supply | Replenish | 30 |
| | Piston or connecting rod bearings overheated | Attend to lubrication and water circulation | 28, 42 |
| | Fuel too hot | Regulate heat supply | 21, 35 |
| | Fuel heater empty due to clogged strainer | Clean strainer and prime afresh | 21, 35 |

# SUGGESTED PERIODIC INSPECTION CHART.

**Based on Engine working 50 hours per week.**

| PERIOD. | ITEM. | NATURE OF INSPECTION. | See Pages. |
|---|---|---|---|
| DAILY. | Engine house | Keep free from dirt, and have spare parts and tools handy | 8, 41, 62 |
| | Fuel oil | Maintain adequate supply | 9, 40, 56 |
| | Lubricating oil | Maintain adequate supply of brand recommended | 34, 39 |
| | Fuel oil system | Stop any leaks and drain off any water | 6, 17 to 22 |
| | Lubricating oil system | Examine oil levels and see that all feeds are acting | 6, 14, 15, 27 to 30, 34, 38, 47 |
| | Bearings | Be satisfied that all run cool | 6, 42 |
| | Water supply | To be clean and not hard, so as to avoid deposit | 6, 36, 40 |
| | Refined oil container | Refill after starting if using heavy oil | 18, 40 |
| | Piston | Examine for clean running | 15, 28, 34 |
| | Stopping | Leave engine in condition for starting | 33, 37 |
| | Minor points | Give prompt attention to any that arise | 8, 62 |
| WEEKLY. | Pecker clearance | Verify amount as per instructions | 35, 46 |
| | Clearance between cams and rollers | Verify amount as per instructions | 41 |
| | All fuel or lubricating oil strainers | Clean free from any obstruction | 18, 21, 22, 39 |
| | Fuel oil tank | Drain off any water if heavy oil is used | 22 |
| | Control valve | Be sure that no leakage is occurring | 19, 40, 46 |
| | Compressed air receiver | Drain off any water | 40, 48 |
| | Ignition tube | Clean out if heavy oil is used | 41 |
| MONTHLY. | Sprayer | Take out and operate spray. See that it does not dribble | 35, 44 to 46 |
| | Heater and strainer | Clean out if heavy oil is used | 21, 35 |
| | Admission, exhaust, starting and air receiver valves | Remove and clean. Keep seatings in good condition | 22 to 25, 41, 47, 53 |
| | Cylinder and breech-end jacket | Examine for deposit if water supply is hard | 13, 39, 40 |
| | Fuel oil and lubricating oils | Keep plenty of each in stock | 9, 34, 39, 40 |
| EACH THREE MONTHS. | Piston, cylinder and combustion chamber | Remove piston, decarbonise and clean, including under rings | 41, 52 |
| | Cylinder and breech-end jacket | Remove any deposit | 13, 39, 40 |
| | Exhaust pipe and box | Scrape out any carbon | 41 |
| | Fuel Pump Valves | Verify lift and keep seating in good condition | 43, 60 |
| | Governor dashpot | Replenish oil in dashpot | 35, 38 |
| | Air silencer matting | Free this from obstruction | 13, 38 |
| | Crankpit | Remove dirt and sediment | 39, 62 |
| HALF YEARLY. | Main bearings | Examine for wear | 42, 49 |
| | Connecting rod bearings and bolts | Examine bearings for wear and bolts for distortion | 42 |
| | All keys and fastenings | See if secure throughout | 37 |
| | Spare parts | Examine and see if sufficient | 61 to 76 |
| YEARLY. | All working parts | Examine carefully all working parts | 48, 49 |
| | | Replace any worn pins or bushes | 48 |
| | | Overhaul engine generally | 8, 39, 49 |
| ALL TIMES. | Spare parts and lubricating oils | Stock a good supply, especially if abroad, including spare sprayer | 61 to 76 |

# DISMANTLING.

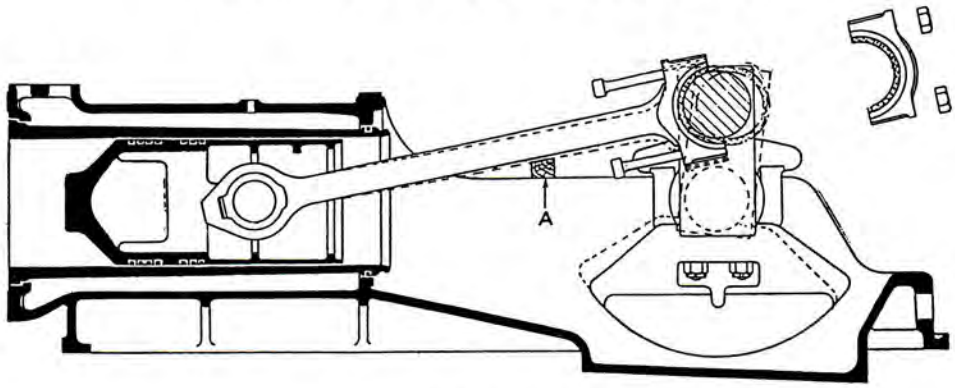



Fig. 48.

**TO WITHDRAW A PISTON** of the larger sizes of engines :—

(1) Place the crank in the vertical position with the balance weights underneath as shewn in Fig. 48.

(2) Place a piece of timber **A** across the top of the bedframe underneath the connecting rod in such a position that the balance weights will swing clear. This packing timber must be about 3/8in. to 1/2in. clear of the rod.

(3) Remove the connecting rod cap and front half of the bearing, and tap the bolts back clear of the rod, as shewn, to avoid injury of the crank pin by the bolts.

(4) Move the crank forward a little, and twist the back half bearing round the journal until it can be withdrawn.

(5) Move the crank further forwards until the large end is quite free and the rod rests on the piece of timber **A.**

(6) Bring the balance weights into their top position as shown in Fig. 45, and prop them up with pieces of wood **B** placed between them and the bottom of the bed.

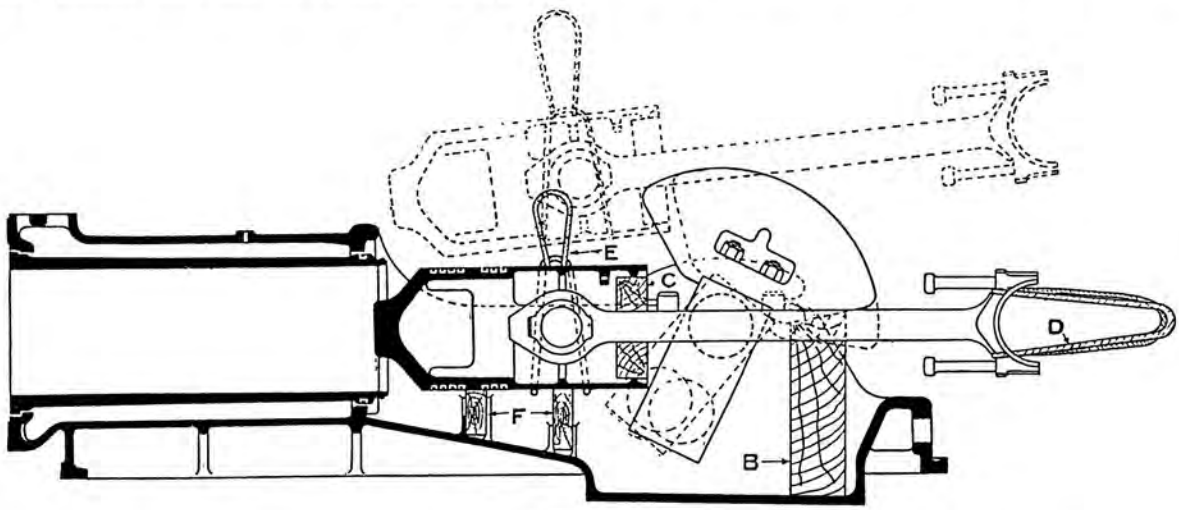



Fig. 49.

(7) Lower the rod end until it is in line with the centre line of the piston, and pack the rod in this position by placing pieces of wood **C** inside the piston at both top and bottom.

(8) Pass a rope sling **D** round the large end and bring the sling forward between the balance weights so that a lever may be inserted in the loop. Then pull the piston out of the liner until the first ring appears.

(9) Pass another sling **E** around the body of the piston and attach it to pulley blocks, fixed overhead, and arranged so that the pull will be slightly forward as well as slightly upwards.

(10) Pull the piston forwards until any further movement is prevented by the crank or weights.

(11) Remove the wood block **B** from the bedframe, turn the flywheel forwards slowly until the crank is in the dotted line position, as shewn in Fig. 49. Then hoist the piston upwards by means of the pulley blocks, into the upper position shown by dotted lines.

On sizes O & OE 126 and 128, ribs are provided on each side of the bed. The purpose of these is to receive pieces of timber **F** of a convenient depth so that when the piston is withdrawn from the liner it may rest upon them.

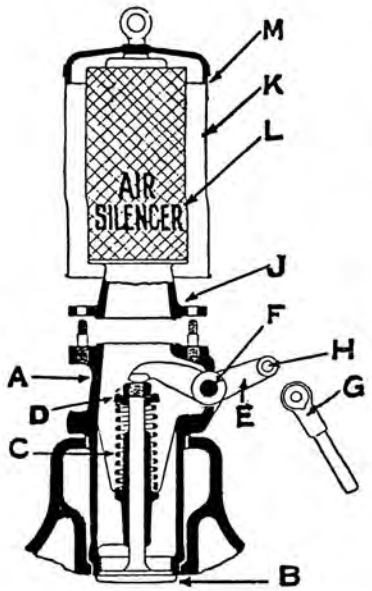


Fig. 50.

## TO REMOVE THE ADMISSION VALVE BODY, Fig. 50.

(1) Remove the complete air silencer from the admission valve body.

(2) Uncouple the valve rod **G** from the lever **E** by taking out the pin **H.**

(3) The admission valve and body can then be withdrawn.

## TO REMOVE THE EXHAUST VALVE, Fig. 51.

(4) Screw the studs **N** (supplied with the engine), into the holes provided in the underside of the breech end.

(5) Screw nuts on these studs until the pressure of the spring **O** is taken off the valve spindle **P.**

(6) Unscrew the nuts at **R** and draw the valve out upwards by means of the **T** ended grinding handle provided.

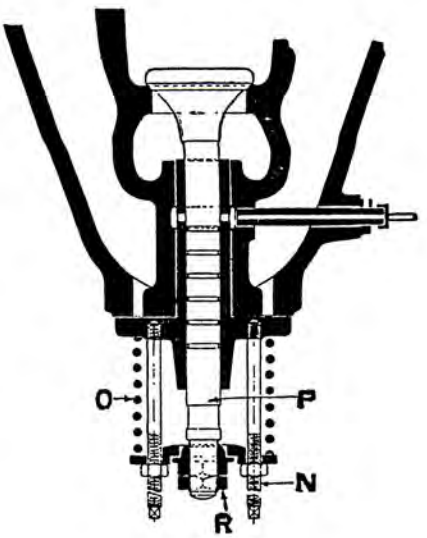


Fig. 51.

## TO REMOVE THE EXHAUST VALVE SPRING, Fig. 51 :—

(7) Remove the exhaust valve as described above (4, 5 and 6) and then remove the exhaust lever.

(8) Unscrew the nuts on the long studs **N** and remove the spring.

NOTE.—**When reassembling,** the plate which carries the exhaust valve spring must be screwed up until there is no tendency for the valve to lift when the engine is running at no load except when the lever and cam operate it.

## MOUNTING OR DISMOUNTING FLYWHEEL ON CRANKSHAFT, Fig. 52.

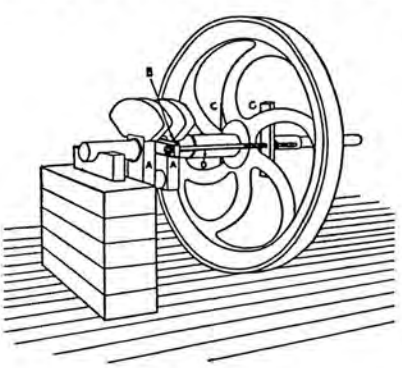


Fig. 52.

**SIZES O 115 to 126 and OE 115 to 122.**—On these sizes the flywheel rim and the boss are of the solid type. The bore of the boss is accurately machined to gauge to obtain a tight fit on the portion of the crankshaft on which the flywheel is mounted

Fig. 52 illustrates the best means of drawing the flywheel on to the crankshaft The flywheel is placed upright on the floor, or if preferred is suspended by a sling from an overhead crane, or pulley blocks. The crankshaft is then lifted into position and passed as far through the flywheel boss as is possible. The short end of the crankshaft is then placed on a packing case and vee block, as shown. Place a plate **B** between the crankshaft slabs pass long bolts **D** through holes in the plate and through the flywheel arms and put another plate **C** across the flywheel arms. Screw on the nuts and proceed to tighten up, putting an equal pressure on both bolts as far as possible, until the flywheel is in the correct position shown on the foundation plan. Then drive the flywheel keys in tightly.

To withdraw the flywheel proceed as described above except that after with drawing the flywheel keys, the bar **B** must be placed on the end of the crankshaft and the plates **C** on the opposite side of the flywheel arms, to that shown in the illustration.

**SIZES OE 123 and 126.**—On these sizes the flywheel boss is split. Before passing the crankshaft unto the flywheel it is necessary to unscrew the nuts on the flywheel boss bolts and then drive iron wedges between the halves of the flywheel boss. This permits the flywheel to be placed into the position on the crankshaft shown on the foundation plan, without difficulty.

**SIZES O and OE 215 to 228 and O and OE 128.**—These sizes are fitted with flywheels in halves, as shown in Fig. 12. Before assembling, the joints of the rims (which have been greased before being despatched) must be scrubbed clean with paraffin to ensure that the two halves of the wheel meet together metal to metal at the rim.

One half of the flywheel should then be lifted into the flywheel pit, being packed up to the correct height to suit the level of the crankshaft, which latter should then be lifted and carefully lowered into its bearings. The dowels should be placed in the holes in the lower half of the flywheel, particular care being taken to observe the number stamped on them, a corresponding number also being stamped on the large end of each cotter and against each cotter hole in the flywheel rim.

**IMPORTANT.—Cotters are always driven in from the side of the flywheel on which the number is stamped.**

The upper half of the flywheel should then be lifted carefully into position, and the cotters inserted, each being driven in a little at a time. Before finally tightening them, insert the key a few inches in the keyway and place the bolts in the flywheel boss and proceed to tighten up the nuts. When this is done, finish driving home the cotters and insert the split pin in each. Then drive home the flywheel key.

## FUEL OIL PUMP CAM.

To adjust the setting of the oil pump cam, for the purpose of altering the timing of the fuel injection, first withdraw the cover **N** or bearing **X,** shown in Fig. 16, 17, and 18, on pages 16 and 17. Then remove the split pins on the castle nuts **E** shown in Fig. 53, slack back the nuts and remove the steady pin **L.** The pump cam disc **A** can then be moved a little either backwards or forwards. The steady pin has been fitted after the best setting of the cam for the fuel injection has been found at our works when working with an average quality of fuel oil, and this setting should therefore not be altered without good reason. If the oil used is lighter than usual, such as Gas Oil or Paraffin, or if the ignition tends to be noisy, the pump cam may be adjusted by setting it a little later, that is to say, by moving it very slightly in a clockwise direction. If the oil used is heavier than usual and exceeds .91 specific gravity, and also tends to be viscous, or if the exhaust gas tends to be black, the pump cam may be adjusted by setting it a little earlier, that is to say, by moving it very slightly in a counter-clockwise direction (see arrows below the cam disc in Fig. 53).

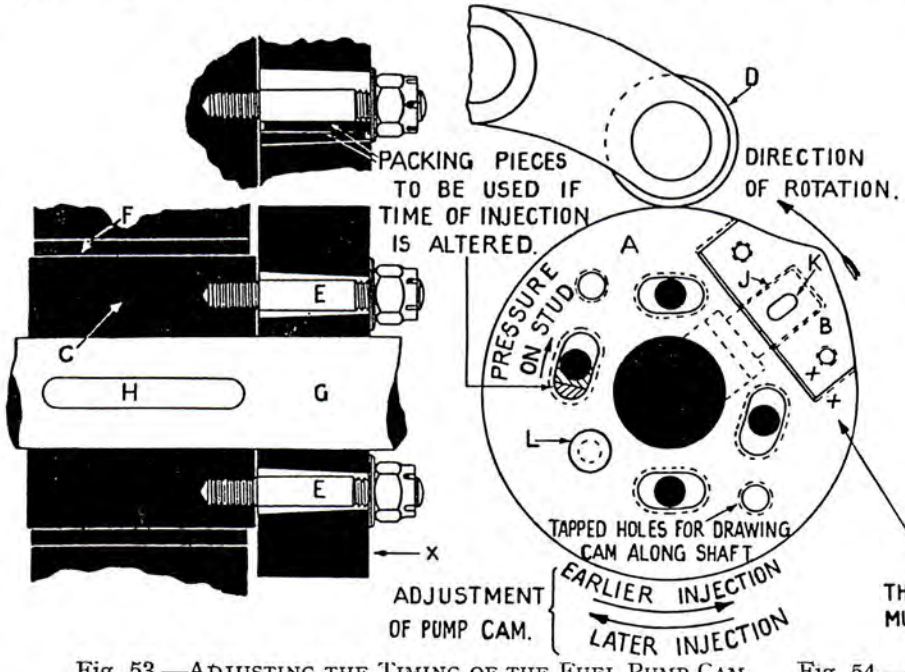



Fig. 53.—Adjusting the Timing of the Fuel Pump Cam.

A—Pump Cam Disc.
B—Pump Cam Toe Piece.
C—Pump Cam Boss.
D—Pump Cam Roller.
E—Pump Cam Studs and Nuts.
F—Bronze Bush.
G—Sideshaft.
H—Key.
J—Dowel Pin for Toe Piece.
K—Cottter for Dowel.
L—Steady Pin fitted after test by makers.

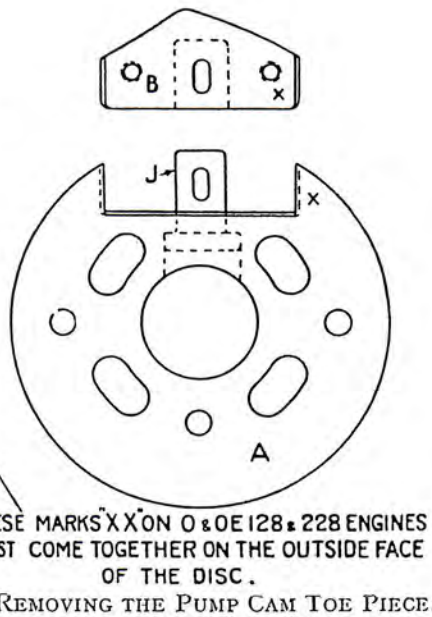



Fig. 54.—Removing the Pump Cam Toe Piece.

A—Pump Cam Disc.
B—Pump Cam Toe Piece.
J—Dowel for Toe Piece.

**A very small movement from the position fixed by the steady pin makes a considerable difference in the timing of the oil injection.**—It is necessary therefore, to be very careful in making changes, and the best method of procedure is as follows :—Replace the steady pin **L** in the position as found ; remove the nut from one of the driving studs **E** and measure very carefully the distance from the edge of the stud to the edge of the slot (Fig. 53). Then remove the steady pin **L** and adjust the cam disc for either earlier or later injection (see the two arrows). **Never move the cam disc at any one adjustment more than will alter the distance from the edge of the stud to the ends of the slot by more than 1/32in. (say 1 m/m)**, which is equivalent to changing the point of injection about two degrees on the path of the engine crank pin.

As it will be impossible after this alteration to re-insert the steady pin, a packing piece (or two packing pieces) should be inserted between one stud and the end of its slot as shown in the two views in Fig. 53. These should be carefully fitted so as to bed on the whole length of both the stud and the end of the slot as shown.

When this is done, screw up all the castle nuts **very securely,** and be sure to replace all the split pins.

This procedure should be carried out each time a change is made however slightly the change is. If the packing pieces are not inserted after an alteration, there is a possibility of the cam disc slipping, and the turning of the injection becoming perhaps much too late.

**TO DISMANTLE THE PUMP CAM** proceed in same way as described above for adjusting the setting. When the steady pin and the castle nuts are removed, the cam disc can be drawn along the shaft if set screws are screwed in the two tapped holes in the disc.

**TO DISMANTLE THE PUMP CAM TOE PIECE.**—Do not disturb the toe piece **B** (Fig. 54) if it can possibly be avoided. It has been very carefully fitted in its place, and the whole working of the engine depends on its accurate location. If it should be really necessary, **and not unless,** drive the cotter **K** out, in the direction from left to right when looking at Fig. 53. The toe piece can then be lifted by means of a very thin sharp wedge, see Fig. 54. **Do not disturb any shims or packing found below it** which must remain exactly as found.

Great care must be taken when assembling to see that the toe piece beds firmly on the disc, that the cotter is tight, and that when the nuts have been tightened up, the split pins are not omitted. Any packings found under the toe piece must on no account be disturbed, and it is extremely important that when replacing the toe piece the periphery of the cam disc exactly coincides with both ends of the toe piece. Should the toe piece be removed it is important that it is reinserted the correct way round. On engine O & OE 115 to 126 the toe piece should be in such a position that the holes for the oil catcher plate "**S**" in one side of the toe piece (see Fig. 18), are on the side nearest the crankshaft. On engine O & OE 128 the marks "**XX**" on the disc and toe piece respectively (see Figs. 53 & 54), must lie together and the face on which the mark "**X**" is stamped must be nearest the crankshaft.

# ADDITIONAL INSTRUCTIONS
# FOR STARTING AND WORKING
# DOUBLE CYLINDER OIL ENGINES.
## SIZES O & OE 215 to 228.

(When both cranks are in line on the same side of the crankshaft.)

This type of engine consists of two complete units. The flywheel is mounted on the crankshaft between the two bedframes. Each engine is despatched from our works with split flywheel packed in halves and the crankshaft removed from its bearing. When re-erecting the engine it will therefore be necessary in all cases **to replace the sideshaft wheels in gear with the crank worms, so that the timing of the cams and valve gears is precisely the same as fixed during the engines' test.** To ensure this, proceed as follows :—

(1) Put the sideshaft wheel of one cylinder into gear with the worm wheel on the crankshaft so that marks "00" stamped on the teeth of these wheels coincide.

(2) Turn the flywheel round through 360 degrees (exactly one complete revolution) and then see that marks "00" stamped on the crankshaft worm and the sideshaft wheel of the second cylinder coincide in the same way. An ignition will then take place at each revolution of the engine, first in one cylinder and then in the other.

**PREPARING TO START.**—Each unit must be prepared for starting in the manner already described on pages 29 and 30 for single cylinder engines.

**STARTING.**—When starting, the crank of the **right** hand engine must be set at an angle of ten degrees above the inner dead centre on the **power** stroke. In this position, the **left** hand crank will be ten degrees above the inner dead centre on the **suction** stroke.

Make sure that the fuel pumps and oil pipes are thoroughly primed by pumping a number of charges through the open relief valves *of each cylinder* into the tundish. Starter valves are usually fitted to both cylinders. Open the sprayer relief valve and starter valve on each cylinder. When all is ready open the stop valve on the air receiver. As soon as the engine has made one complete revolution shut off the air to the right hand cylinder, then at once close the sprayer relief valve and move the roller over on to full compression. Shut off the air to the left hand cylinder and close the relief valve, moving the exhaust roller over to full compression.

When regular ignitions are occurring close the stop valve on the receiver.

**STARTING WITH LAMP.**—If a heating lamp is used, the flame need only be applied to the ignition tube of the **left** hand engine.

**RE-CHARGING AIR RECEIVER, Sizes O & OE 215 to 217.**—Re-charge the compressed air receivers as described on page 32, but where a starting and charging valve is fitted on both cylinders, use each cylinder alternately so as to prevent the charging valves becoming overheated.

**SPEED AND LOAD.**—The governors of the two cylinders can be adjusted by means of the speeder springs, so as to divide the power equally between the two cylinders. This is ascertained by noting the position taken up by the governor wedge, which must be the same on both engines.

**FUEL CONSUMPTION.**—If a double cylinder engine is required to run for long periods, say weeks or months, at below half the total rated power, it is better to work with only one cylinder and, better still, if the piston, connecting rod and the admission and exhaust valve levers are removed. If this is done there should be a saving of about 10 per cent. of the fuel when running at half the total rated load, and 20 per cent. when running at quarter the total rated load.

**MAINTENANCE.—Re-setting the governors to synchronise.** If for any reason the governing gears have been dismantled, they must be re-assembled so that the following positions in the movement of the gear synchronise :—

**Sizes O and OE 220 to 226 :—**

(1) When the thinnest portion of the governor wedge, *i.e.*, point **X,** Fig. 24, is opposite the control valve, the nuts on the dashpot rod must be just about to compress the dashport spring.

(2) The governor hanging rods **E,** Fig. 24, must be of the exact length to bring this point **X** on the wedge opposite the control valve spindle when the governor weights are nearly at their innermost position. If correctly set, the parallel part **Y** at the bottom of the wedge will be opposite the control valve, when the weights are at their outermost position.

**Size O and OE 228 :—**

The quadrant **C,** Fig. 25, performs the same function as the governor wedge, and the point **X** on the quadrant plate must be opposite the control valve when the weights are in their innermost position (the maximum load position), and the point **Y** when the weights are at their outermost position (the no-load position). As in the case of the governor wedge, the correct positions of the quadrant are found by adjusting the nuts on the dashpot rod and also adjusting the length of the hanging rod.

# SPECIAL INSTRUCTIONS
## FOR WORKING
# TAR OIL ENGINES.

**TAR OILS. QUALITY TO USE.** Important—(Note : For "**Petroleum**" Oils, see page 9).

In selecting a **Tar Oil** for use in this engine, it is not only its cost per gallon, or per ton, which should be considered. The chief point is the total cost of running the engine. A low grade oil which may appear to be cheap, may in fact be very expensive, owing to high contents of tar, water, and other impurities, and to the more frequent cleaning and repairs, and the increase of lubricating oil necessary, all of which have to be paid for. Taking everything into consideration, our experience is that it is best, in all cases, to buy Tar Oils to definite specifications as given below.

The following are the names of some tar oils together with information as to where they can be obtained :—

| | |
|---|---|
| **Pit Coal "Tar" Oil (Creosote)** ... | This oil is obtainable from Gas Works and from Tar Distillers, and requires the use of the pilot ignition gear. |
| **Carburetted Water Gas "Tar" Creosote** ... ... ... ... | This oil is obtainable from some Gas Works and requires the use of the pilot ignition gear. |
| **Blast Furnace Creosote** ... ... | This oil is obtainable from Blast Furnaces, and requires the use of the pilot ignition gear. |
| **Lignite Tar Oil** (Distilled from "Lignite" or brown coal) ... | This oil is obtainable in India, Australia, New Zealand, Saxony and Spain. It does **not** require the use of the pilot ignition gear and can be used in the "petroleum" oil engine. |
| **Asphaltic and other Petroleum Oils** with high ignition temperature, high specific gravity and high viscosity (see next page) ... | Some residual oils of this class are obtainable in California, Mexico, and in South American and other countries, and are sometimes best used with the aid of the pilot ignition gear (see next page). |

## IMPORTANT.

**BUYING SPECIFICATIONS FOR "TAR" OIL.**—When obtaining supplies of "Tar" Oils, we strongly recommend that they should be bought to one of the following specifications, which the suppliers should guarantee. The oil which is more usually available is the "Pit Coal-Tar Oil." If all oils bought actually comply with these specifications the user will save time, trouble and money :—

| | Quality. | Pit Coal-Tar Oil (Creosote). | Carburetted Water Gas Tar Creosote. | Blast Furnace Creosote. | Lignite Tar Oil. |
|---|---|---|---|---|---|
| 1 | Specific Gravity at 60° Fahr. (15° Cent.) ... | 1.00 to 1.070 | .980 to 1.06 | .960 to 1.06 | Not over .920. |
| 2 | Flash Point ... ... | Not under 120° Fahr. close test (50° Cent.). | | | |
| 3 | Distillation Test (in a retort) ... ... ... | Not less than 60% to distil over to 572° Fahr. (300° Cent.). | | | |
| 4 | Mechanical Impurities insoluble in Benzene | Not over 0.5%. | | | |
| 5 | Ash ... ... ... | Not over 0.05% of hard ash, or 0.08% of soft ash. | | | |
| 6 | Coke Residue ... ... | Not over 3%. | | | |
| 7 | Fluidity ... ... | The whole of the oil must remain liquid when maintained at 60° Fahr. (15° Cent.) for one hour. | | | |
| 8 | Water ... ... ... | Not over 2%. | | | |

## METHOD OF OPERATION OF "TAR" OIL ENGINES.

The "Tar" Oil Engines work on the same principle and are similar in construction to the "Petroleum" Oil Engines already described, but are provided in addition with an ignition oil pump, Figs. 55 and 56, and ignition oil tank, Fig. 57 and 58. The sprayer, Figs. 59 and 60, is altered in detail to provide for the simultaneous use of two different types of oil, namely :—Refined "Petroleum" Oil as fuel for **ignition** purposes, and "Tar" Oil as fuel for **power** purposes.

## HIGH IGNITION TEMPERATURE OF "TAR" OIL.

The spontaneous ignition temperature of Tar Oils is much higher than that of Petroleum Oils and a small supply of petroleum oil is therefore arranged to enter the combustion chamber and become ignited in advance of the tar oil which then ignites readily.

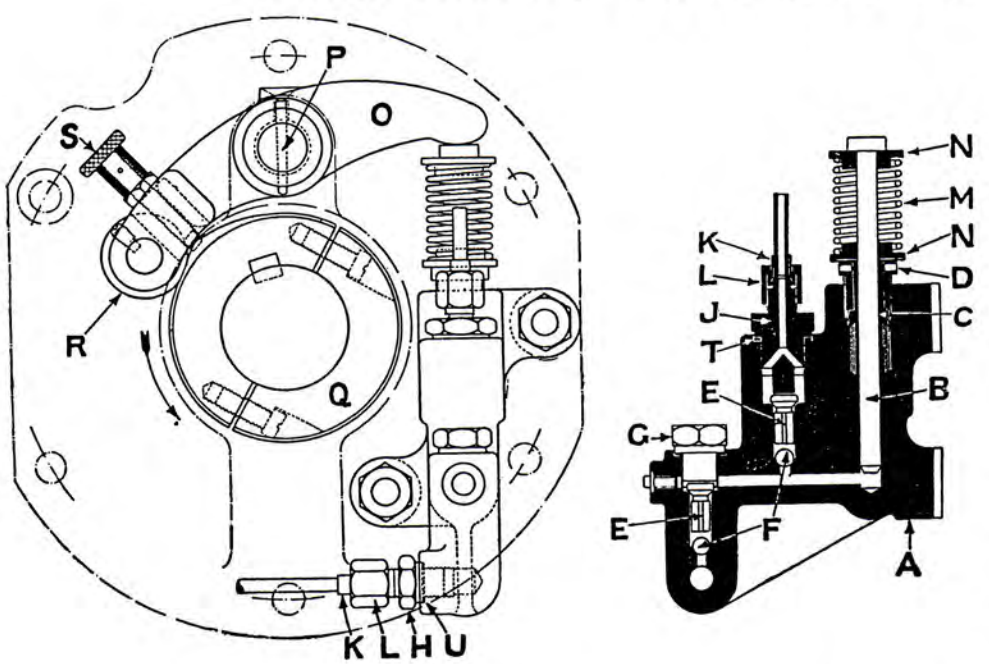
## HIGH VISCOSITY AND HIGH SPECIFIC GRAVITY OF SOME "PETROLEUM" OILS.

Some residual "petroleum" oils which do not come within the "petroleum" fuel oil specification given on page 9, have very high specific gravities and are extremely viscous, and some of them even when heated considerably do not atomise as well as other "petroleum" oils even when the latter are at a much lower temperature. Some of these "petroleum" oils have also a higher ignition temperature than usual. Owing to these characteristics we, in some cases recommend such oils to be considered as "Tar" oils and used in tar oil engines. These oils sometimes contain a high proportion of asphaltum in their composition which tends to inflame and burn much more slowly than the other constituents of the oil (see page 56).

## CONVERSION OF "PETROLEUM" OIL ENGINES TO "TAR" OIL ENGINES.

In view of the possibility of users of "petroleum" oil engines being sometimes unable to procure their usual supplies of "petroleum" oils, or in case they should desire to use some of the heavier or more viscous varieties of residual oils (some are not suitable) we construct all "petroleum" oil engines in such a manner that the "tar" oil parts can be supplied, at an extra charge, to users of these engines, who can quite easily convert the engines to "tar" oil engines by fitting the parts themselves to printed instructions which we supply with the parts.

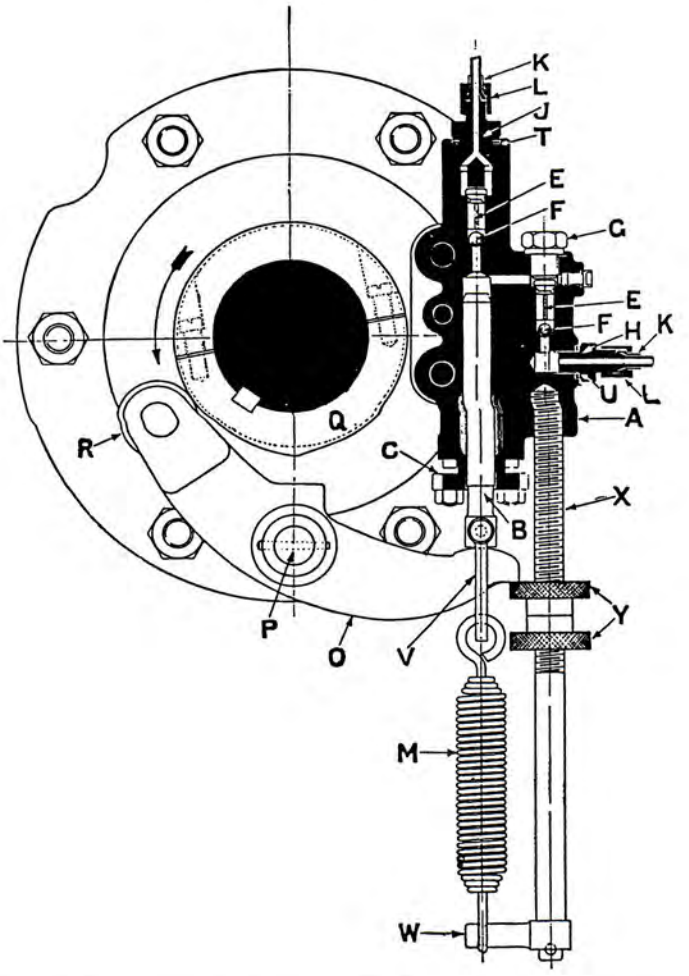
## DESCRIPTION OF PARTS (TAR OIL ENGINES).




A—Ignition Pump Body.
B— „ „ Plunger.
C— „ „ Gland Ring.
D— „ „ „ Nut.
E—Suction and Delivery Valves.
F— „ „ „ Ball Valves.
G—Plug for Suction Valve.
H—Male Plug for Suction Pipe.
J— „ „ „ Delivery „
K—Spigot for Suction & Delivery Pipes.
L—Union Nut „ „ „ „
M—Spring for Plunger.
N—Spring Collar.
O—Ignition Pump Lever.
F— „ „ „ Fulcrum Pin.
Q— „ „ Cam in Halves.
R— „ „ Roller.
S—Adjusting Screw.
T—Washer for Delivery Plug.
U— „ „ Suction „

Fig. 55. Size O & OE 115 to 126. **IGNITION OIL PUMP (used only for Tar Oil Engines).**

This oil pump, as will be seen from the illustration, is operated by a cam on the sideshaft. Its purpose is to cause a small pilot charge of petroleum oil to collect behind the sprayer seating, and enter the combustion chamber and become ignited in advance of the tar oil. When running at say the normal full load, the quantity of ignition oil required per charge in proportion to the tar oil is quite small, but the proportion increases automatically at reduced loads. The quantity may be adjusted by means of the milled screw **S** on the ignition pump lever, Fig. 55, or by the adjusting nuts **Y,** Fig. 56, for O & OE 128, but the amount should in no case be less than that for which this screw is set when the engine leaves our works. (This is unless the fuel used by the main pump is changed from tar oil to petroleum oil, in which case the ignition oil pump may be put out of action altogether).

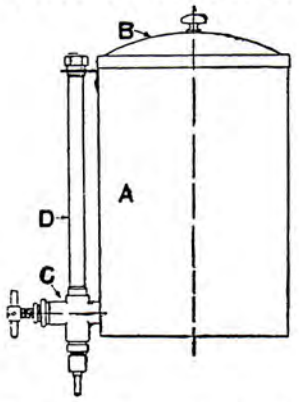



A—Ignition Pump Body.
B—Plunger.
C—Gland Ring.
E—Suction and Delivery Valves.
F— „ „ „ Ball Valves.
G—Plug for Suction Valve.
H—Male Plug for Suction Pipe.
J— „ „ Delivery Pipe.
K—Spigot for Suction and Delivery Pipes.
L—Union Nut „ „ „ „
M—Spring for Plunger.
O—Ignition Pump Lever.
P—Fulcrum Pin.
Q—Cam in Halves.
R—Roller.
T—Washer for Delivery Plug.
U— „ „ Suction „
V—Shackle for Spring.
W—Holder „ „
X—Rod „ „
Y—Adjusting Nut for Spring.

Fig. 56. IGNITION OIL PUMP for Sizes O & OE 128.

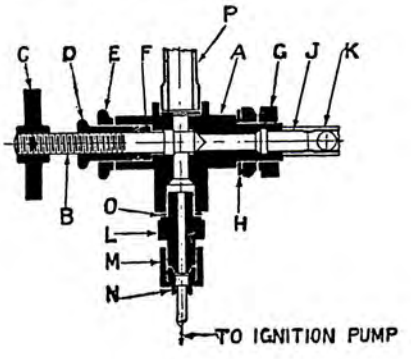
The Ignition Oil Pump for the O & OE 128 Engines is similar in principle to the one shown in Fig. 55, but differs slightly in the method used for adjusting the stroke of the plunger. A tension spring is used instead of a compression spring to actuate the plunger during the suction stroke of the pump.

## IGNITION OIL TANK WITH SCREW-DOWN COCK.




A—Ignition Oil Tank.
B—Cover.
C—Cock.
D—Oil Lever Gauge.

Fig. 57. IGNITION OIL TANK. All Sizes.




A—Cock Body.
B—Valve Spindle.
C— „ Handle.
D—Gland.
E— „ Lock Nut.
F— „ Ring.
G—Back Nut for Cock Body
H—Joint Ring.
J—Strainer Pipe.
K—Gauze.
L—Male Pug.
M—Female Nut.
N—Male Nut.
O—Washer for Plug.
P—Oil Level Gauge.

Fig. 58. IGNITION OIL COCK. All Sizes.

The Ignition Oil Tank, Fig. 53, is mounted on a bracket on the top of the engine cylinder and supplies refined oil to the ignition oil pump. It is provided with a screw-down oil cock (see Fig. 58 above), oil strainer, and oil level gauge **D.**

NOTE.—It is important that the fuel level in the gauge glass on this tank should be readily seen at all times. It is *dangerous* to work Tar Oil Engines without any ignition oil, as would happen, for instance, if this ignition oil tank became empty.

**TAR OIL SPRAYER.—**

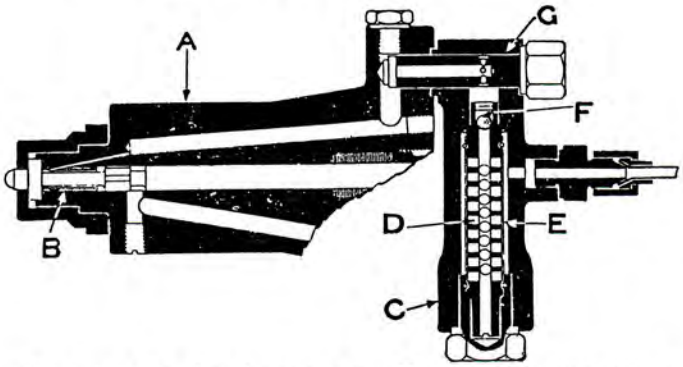



Fig. 59. TAR OIL SPRAYER FOR TAR OIL ENGINES ONLY.

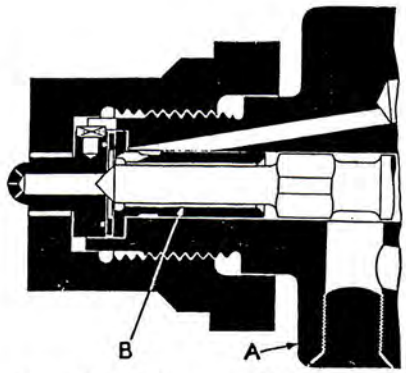



Fig. 60. ENLARGED VIEW OF TAR OIL NOZZLE AND TAR OIL SLEEVE.

A—Sprayer Body (in place of A in Fig. 20).
B—Tar Oil Sleeve for Sprayer Spindle.
C—Strainer Body for ignition oil.
D—Strainer Plug for ignition oil.
E—Wire Gauze for Strainer Plug.
F—Ball Valve.
G—Strainer Bolt.

The above parts are in addition to those given in Fig. 20, page 18.

The Tar Oil Sprayer, Fig. 59, differs from the crude oil sprayer, Fig. 20, by an additional inlet and an additional strainer **C** for the "ignition oil," and the insertion of a "tar oil sleeve" **B** immediately behind the sprayer nozzle. The ignition oil passes from the ignition oil strainer, through the main sprayer body, into the annular chamber in the tar oil sleeve immediately behind the sprayer valve seat.

The oil strainer is fitted with a non-return valve **F** at the upper end of the strainer plug.

The purpose of this valve is to prevent the return of the ignition oil, when the main fuel pump begins to operate. The clearance between the sprayer spindle and the tar oil sleeve is very small, consequently the ignition oil tends to push back the tar oil rather than mix with it, and as before explained the ignition oil passes through the sprayer valve into the combustion chamber and becomes ignited in advance of the tar oil, the latter then immediately igniting as it follows into the combustion chamber. The faces between the tar oil sleeve and sprayer body are ground together, and these should be protected as much as possible. The joint between the tar oil sleeve and the sprayer nozzle is made by menas of a copper washer, great care should be taken to see that this is not damaged. If it should be damaged in any way it must be removed at once, or the sleeve may be thrown out of alignment, and so cause either locking of the spindle or improper seating between the spindle and nozzle seat.

**IMPORTANT.**—For further instructions regarding the correct working of the sprayer, see "Maintenance" Pages 43 to 46.

## PREPARING TO START AND STARTING. (Tar Oil Engines).

**SPECIAL NOTE.**—These instructions are to be read in conjunction with the previous instructions for the "Petroleum" Oil Engines.

These engines start from cold with compressed air, but if desired the lamp may be used for the preliminary heating of the ignition tube on sizes O & OE 115 to 123. All the instructions and operations given for "Preparing to Start" and "Starting," pages 29 to 33, for petroleum oil engines, must be observed as they apply also to tar oil engines.

It is necessary to prime the ignition oil pump delivery pipe by working the ignition pump plunger by hand until the refined oil is seen to be flowing freely from the relief pipe into the overflow tundish.

To avoid air-locks when first starting or when the oil heater has been emptied and re-filled, it is advisable to prime the delivery pipes of both the main pump and the ignition oil pump in the following order :—

1.—Prime the suction and delivery pipes with tar oil from the oil heater by working the main pump by hand, with the relief valve open, until the tar oil is delivered into the tundish.

2.—Then move the change over gear handle so that the main pump will suck in refined oil, and work the main pump again until refined oil is delivered into the tundish.

3.—Then work the ignition oil pump by hand, until it also delivers refined oil to the tundish.

Having primed the suction pipes, pumps, delivery pipes and sprayer, as described above, the engine should be started just as in the case of the petroleum oil. Run for five minutes with paraffin. This results in the cylinder becoming slightly warm, and in some paraffin passing through the control valve into the oil heater and mixing there with the tar oil. The change over to tar oil is then more gradual, and is effected as described under "Starting," page 32, by means of the change over handle on the fuel pump.

## WORKING. (Tar Oil Engines).

**IGNITION OIL PUMP.**—The stroke of the ignition oil pump has been adjusted at our works when the engine is undergoing its trials and should not be decreased. Slightly more ignition oil may however be required with inferior grades of tar oils. In this case more ignition oil may be supplied by unscrewing the milled screw, or the adjusting nuts for size O & OE 128, so as to give a longer stroke of the ignition oil pump plunger. If the engine fails to ignite the charges of oil injected, or runs with a heavy thud, it is a sign that too little ignition oil is being supplied. This may occur if the valves in the ignition oil strainer or ignition oil pump are leaking. (See "Maintenance, Tar Oil Engines," below.)

**COOLING WATER.**—At whatever load the engine is running when working with tar oil the temperature of the jacket water should not be allowed to fall below 100 degrees to 120 degrees Fahr., see page 39. This has a marked effect in improving the fuel consumption. It also ensures satisfactory operation when running the engine at very light loads.

## LUBRICATION. (Tar Oil Engines).

**CYLINDER AND PISTON.**—When working on Tar Oil the piston should be well lubricated, more lubricating oil being required usually than with other fuel oils. This is particularly necessary when working at or near the maximum loads. The pistons must not be allowed to become dry and black for want of lubrication. A little experience will soon show the attendant how much to use.

**EXHAUST VALVES.**—Very little oil is required for this. Use paraffin in the exhaust valve lubricator for sizes O & OE 115 to 122.

## MAINTENANCE. (Tar Oil Engines).

**IGNITION PUMP AND IGNITION OIL STRAINER.**—See that the valves in the ignition oil pump and in the top of the ignition oil strainer are kept in working order and seat themselves properly.

The plunger of the ignition oil pump should be well packed with "Palmetto" packing in precisely the same way as described for the control valve spindle, page 46.

**SPRAYER.**—The copper washer making a joint on the faces of the tar oil sleeve and the sprayer nozzle must be preserved from the slightest damage. If it should be damaged in any way it must be removed at once, and a new one inserted of uniform thickness all round, or the sleeve may be thrown out of alignment and so cause either locking of the spindle or improper seating between the spindle and the nozzle seat. This washer as supplied by us is annealed. The faces between the tar oil sleeve and sprayer bodies are ground together and must be protected as much as possible. For the correct method of reassembling the sprayer nozzle, see Fig. 60.

## STOPPING. (Tar Oil Engines).

Work the engine with refined oil for a few minutes before stopping. This will tend to keep the sprayer clean and in good order. It also leaves the engine in condition ready to start again.

## WARNING. (Tar Oil Engines).

**IGNITION OIL TANK.**—The level of the oil as indicated by the gauge glass must be sufficiently high that the delivery of the ignition oil to the sprayer is always assured whilst the engine is working.

It is **dangerous** to work engines using "tar" oil without any "ignition" oil because the oil, instead of gradually burning as it is injected, may not ignite until most of it is injected when it may explode with considerable violence.