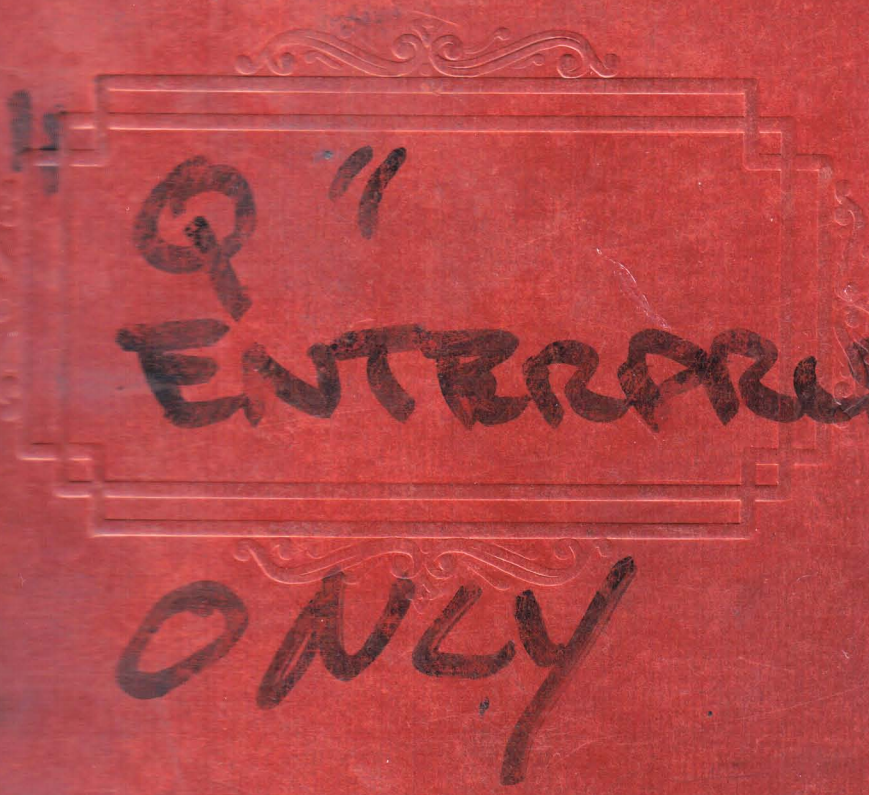

9"
ENTRANCE
ONLY

Serial # 4138

ENTERPRISE

DIESEL ENGINE

TYPE DMQ-38

ENGINE NUMBERS 42003-22

42213-27 : 43136-50

16" BORE 20" STROKE

1200 H.P. AT 275 R.P.M.

DISPLACEMENT 4021.2 CU. IN. PER CYL.

INJECTION SET 6 INCHES ON FLYWHEEL

BEFORE TOP DEAD CENTER

FIRING ORDER AHEAD 1-4-7-3-8-5-2-6

FIRING ORDER ASTERN 1-6-2-5-8-3-7-4

LUBE OIL CAPACITY 300 GAL. MIN. IN SYSTEM

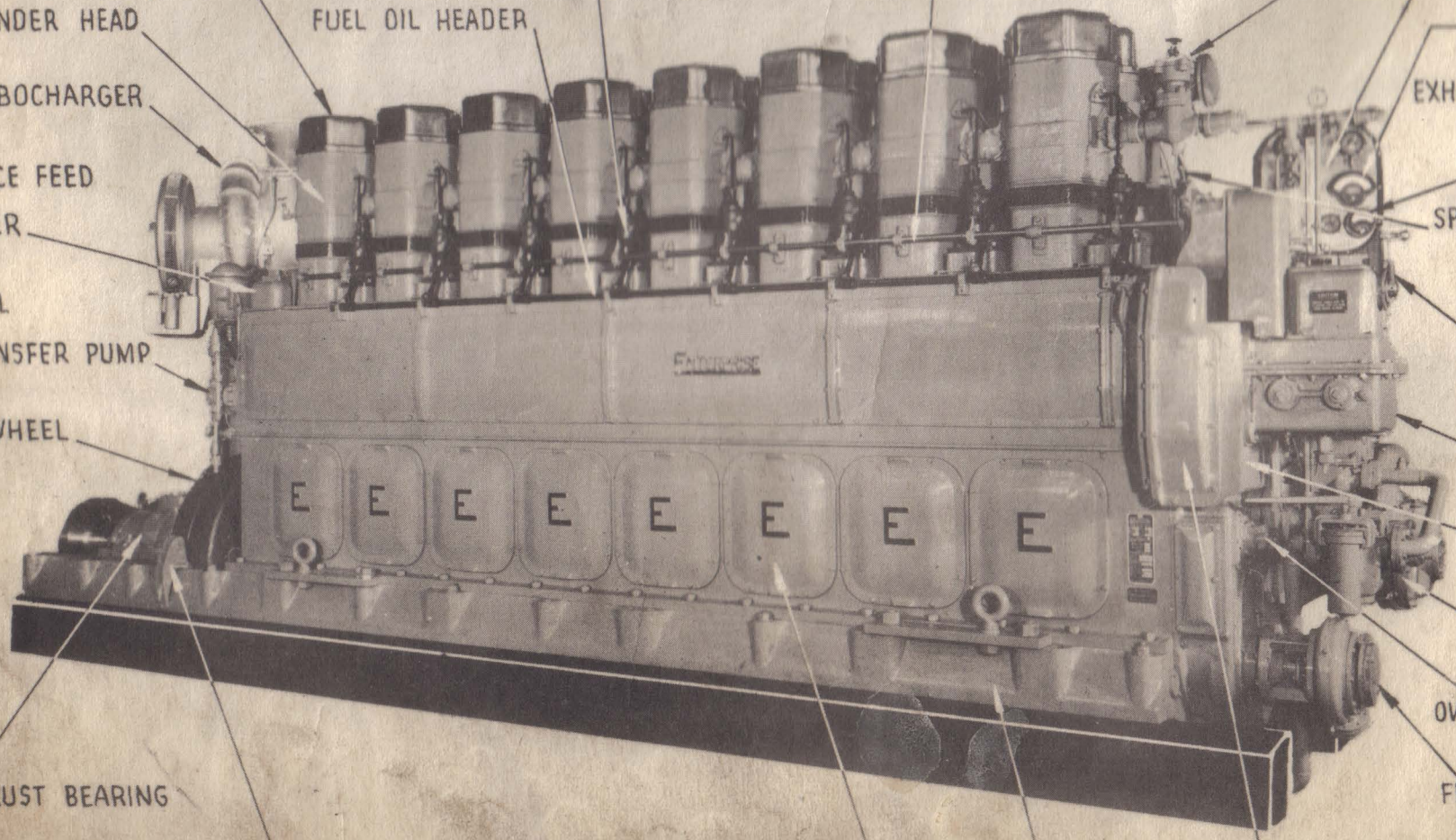
WHEN MAKING INQUIRIES FOR PARTS OR
SERVICE STATE ENGINE NUMBER & PART

ENTERPRISE ENGINE & FOUNDRY CO.

18th. & FLORIDA STREETS

SAN FRANCISCO, CALIFORNIA U.S.A.

D-1290



ENTERPRISE DMQ-38 DIESEL ENGINE - 1200 B.H.P.

D-1302

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PART I

INTRODUCTION

A. Introduction and Working Principles

The purpose of this booklet is to acquaint the owner and engineer with the operation of his engine. In order to obtain maximum efficiency and continuous trouble-free service, the contents of this booklet should be carefully studied and the instructions, particularly regarding inspection and maintenance, followed carefully.

Enterprise Diesel Engines have proven themselves, and are giving all over the World continuous trouble-free service, even under extremely severe working conditions. The design of the engines was selected after exhaustive research and many years of engine building experience, with the primary view in mind of obtaining maximum simplicity of operation and maintenance, and maximum dependability.

Every engine is carefully and thoroughly tested and inspected before leaving our plant, and only such adjustments should be made by the operator as are indicated in the succeeding pages. It is suggested that the operator establish a certain system of routine inspection suitable to his particular service condition. This will more than pay for itself in lowered maintenance cost and more satisfactory operation.

The matter of cleanliness can hardly be stressed enough. It indicates, in a large measure, the care the engine receives otherwise.

If there is any specific condition that troubles the operator, and for which there seems no explanation in this booklet, we suggest getting in touch with our Service Department, stating the condition in full.

Enterprise Diesel Engines operate on the four stroke cycle principle. They are of the full diesel, vertical, mechanical injection type. The fundamental principles of operation are as follows:

1. Intake Stroke:
   Air is drawn into the cylinder at atmospheric temperature and pressure.

2. Compression Stroke:
   The inlet valve closes when the piston is slightly past bottom dead center. During the upward stroke of the piston the air is compressed to approximately 400 lbs/sq.in. This raises the temperature sufficiently to ignite the fuel. Just before top dead center, the fuel is sprayed into the compressed air through a nozzle, which is designed for the proper distribution and atomization of the fuel.

3. Expansion Stroke:
   During this stroke work is done on the piston by the combustion of the fuel. The heated gasses expand during the downward stroke of the piston until, near bottom dead center, the exhaust valve opens.

4. Exhaust Stroke:
   The exhaust valve remains open during the next upward stroke of the piston, expelling the gasses, until the piston again reaches top dead center when the exhaust valve closes, the inlet valve opens and the cycle is repeated.

PART II

INSTALLATION

A. General

The installation of the engine will vary according to its use. In all cases the Enterprise Engine & Foundry's installation drawing should be followed closely. All service lines should be piped in accordance with piping diagrams supplied by Enterprise, except as modified by the Naval Architect; however such modifications are to be approved by Enterprise. Accurate alignment of the engine and its drive is of prime importance, and all precautions should be taken to obtain maximum accuracy.

B. Placing Of Engine On Its Foundations.

Installation dimensions of the engine unit are given on Enterprise certified installation plan. Care should be exercised in planning installation to allow adequate clearances for servicing.

When placing the engine on its foundations, make sure (1) That the crankshaft is exactly in line with the propeller shaft (2) That the engine is evenly supported over its entire length so that there is no distortion of the base.

After the engine has been bolted down, check crankshaft alignment as follows: Measure distance between inside faces of crank webs with crankshaft deflection gage, or, if not available, with inside micrometers. Check this distance at intervals of approximately 90 degrees. Readings should not differ by more than .003". If misalignment is indicated, determine the cause and correct. Distortion at the last two cranks only usually indicates crankshaft is out of line with the propeller shaft. See crankshaft alignment sheet among illustrations in this book.

C. Piping

Note: Recommended (minimum) pipe sizes for all service lines are given on a separate sheet further on in this book.

Piping must under no circumstances cause deflections in the mountings of rotating or reciprocating equipment. The weight of heavy auxiliaries - such as booster pumps, or silencers - should never be carried by engine piping. All pipes and fittings should be thoroughly cleaned before assembly, to eliminate the possibility of foreign particles damaging the engine or its auxiliaries.

RECOMMENDED PIPE SIZES
FOR Q'8 AND Q'6 ENGINES

Starting Air	2"
Exhaust	14"
Fuel Oil	3/4"
Lube Oil	2"
All Fresh Water	4"
All Sea Water	4"

D. Cooling Water Lines (Fresh Water Cooled)

Jacket Water Lines

The jacket water system must be individual for each engine. Jacket water must be clean and soft - i.e. free from scale forming ingredients. Hard water is almost certain to cause scale and must be treated prior to use in the engine.

The jacket water cooling system for these engines consists of the necessary pumps to circulate the water; the heat exchanger where the jacket water is cooled; the passages within the engine through which the water flows and where heat is absorbed from the engine; and the surge tank which maintains a constant head on the pump and also provides for expansion and bleeding of trapped air. The pump, engine, and heat exchanger are connected in a single series circuit and should be provided with a bypass around the cooler. The surge tank should be installed above the highest point on the engine and connected with 1/2" lines from the top of the exhaust manifold and from any other points that may be a source of trapping air. A continuous rise in these pipes must be provided to avoid air pockets.

These 1/2" lines are to have globe valves that are to be just "cracked" about 1/8 turn (1/4 turn maximum).

Proper valving or thermostatic control around the heat exchanger must be provided in order to allow regulation of fresh water temperatures.

A drain valve must be installed in the lowest point in the system. The system may be filled at the surge tank or in the line from the surge tank running to the pump suction.

Salt Water Lines

The salt water system provides a cooling medium for the various units which require cooling. The sea water is pumped from the sea through a lube oil cooler and heat exchanger and hence pumped overboard. Provision must be made by means of suitably-positioned valves, to maintain control over fresh water and lube oil temperatures. Such control can be obtained by by-passes in either the liquid-to-be-cooled lines or in the sea water lines.

In some applications, it may also be necessary to run sea water lines to the thrust bearing and lube oil coolers of accessory equipment.

The sea chest, from which water is drawn by the sea water pump, should be located as far below the water line as possible to prevent its uncovering when the vessel rolls; adequate strainers must also be provided in the sea suction to protect the pump from foreign matter and to minimize the possibility of clogging the coolers and lines.

Provision must also be made for cleaning of the sea chest and for draining the pump suction line.

If positive displacement pumps are used, a relief valve bypassing to the pump suction must be provided between the pump discharge and the first valve in the discharge line. This relief valve may be one nominal size smaller than the water lines.

E. Fuel Oil Lines

The fuel oil is drawn from the storage tank by the fuel oil transfer pump and pumped through a pressure accumulator tank and through the filtering system into one end of the fuel oil header. From the fuel oil header part of the fuel oil passes through branch lines into the fuel-injection pumps, individual for each cylinder, and injected into the engine cylinders. The balance of the fuel is bypassed through a relief valve from the other end of the header back to the suction side of the fuel transfer pump.

The accumulator tank serves to steady the flow into the fuel oil header and also acts as a vent to expel any air which may have gathered in the system.

The fuel oil filtering system must be highly efficient in removing even the most minute particles, in order to protect the precision made fuel injection pump and injection valve. This filtering unit must be kept in perfect working condition and should be of a duplex type, so that the filtering elements may be cleaned without stopping fuel flow into the engine.

A nozzle drain header to accumulate fuel oil bypassed from the fuel injection valves, and on some engines from leakage in the fuel injection pumps, is run the length of the engine and a line should be provided for gravity flow back to the bilge, waste tanks, or storage tanks.

A strainer ahead of the fuel oil transfer pump should be provided.

It is recommended that an auxiliary fuel transfer pump be provided for emergency operation.

F. Lubricating Oil Lines

The lubricating oil system is of the dry-sump type. Two pumps are required, one taking oil from the engine sump and pumping through a filtering unit into a service tank, and the other drawing from the service tank, pumping through a lube oil cooler, and discharging into the lube oil header running the length of the engine. By means of branches from this header and via proper grooves and drilled passages, the working parts of the engine are pressure lubricated. In some instances, lubricating oil is distributed to the pistons for their cooling, and also in some instances, a force-feed oiler, mounted on the engine, is used for lubrication of special working parts.

There are several precautions to be taken in installing lube oil servicing equipment:

Pumps must be positive-displacement and should be provided with adequate relief valves. Oil should be filtered when hot, that is, prior to cooling in the lube oil cooler. A strainer, cleanable without disassembling, should be provided where the lube oil enters the lube oil header. Provision must also be made for control of lube oil temperature by means of proper bypasses either in the lube oil or sea water system. Means should also be provided for completely bypassing the lube oil cooler in the event of a leak between the lubricating oil and water sections. This is normally accomplished by providing the engines with a four-way valve, which allows the oil to either pass completely through the cooler or to be completely bypassed. This valve is not a flow control valve. It must be either one way or the other.

It is also recommended that hand lubricating oil pump for priming the engine before starting, be provided.

G. Starting Air System

Air compressors are usually engine-driven and in many instances separate motor-driven air compressors are also supplied. The compressed air is stored in air tanks from which air is delivered through a control valve to the air starting valves in the cylinders on the engine.

Suitable drains should be provided near each compressor and at all points in the system where condensate might accumulate. Relief valves with provision for hand operation must be installed on all air tanks.

Where pressure-reducing valves are used, to reduce air pressure from air tank storage pressure to the 250 psi required for starting at the engine, valving to isolate and bypass the pressure-reducing valve should be provided, and a relief valve set at approximately 275 psi. This will allow starting should the reducing valve fail.

H. Intake System

The air intake manifold is cast integrally into the cylinder block, and branches are led into each cylinder head. The air enters through louvres in the manifold covers and passes through bronze wool cartridges which are fabricated as a component part of the covers. The bronze wool acts as both a filter and silencer for the intake air.

For supercharged engines, air intake covers have no louvred openings and air is piped from supercharger directly to intake manifold. Where exhaust-gas driven superchargers are used, the air is cleaned and the air flow is silenced in a special unit built into the supercharger. The air is discharged under pressure from the blower directly into the intake manifold.

Where other types of superchargers, either engine or motor-driven, are used, the air is cleaned and the flow is quieted prior to its entrance into the blower. Discharge from the blower is direct into the intake manifold.

Air filters must be kept clean and are a necessity in dusty atmospheres. Each engine should have an independent intake system.

J. Exhaust System

Each engine should be provided with an individual independent exhaust system.

For unsupercharged engines, the exhaust manifold is a unit mounted along the length of the engine and is built in several sections, with flanged connection provided either at each end, or centrally.

Exhaust-gas supercharged engines are provided with a multipipe manifold and discharge directly into the turbocharger mounted on the engine. The gas discharges from the turbocharger through the exhaust silencer and into the exhaust stack.

Engines supercharged by other means exhaust directly through the exhaust silencer into the exhaust stack.

In laying out exhaust piping, as few bends as possible should be used; where bends are necessary, they should be of long radius. If more than three bends are used, the entire pipe should be increased to the next nominal size. If more than six bends are necessary the pipe size should be increased two nominal sizes. The length of the exhaust piping is not critical although if too long a pipe is used, the pipe size should be increased to reduce the back pressure.

To allow for movement, heat expansion, and the isolation of vibration, a length of flexible metal tubing should be installed in the exhaust line as near the engine as possible.

The exhaust manifold on the engine is generally water-jacketed and the exhaust line should in almost all cases be fully lagged in order to minimize heat radiation into the engine room. The weight of the exhaust silencer and exhaust line must not be imposed on the engine, therefore separate support should be provided.

PART III

INSTRUCTIONS FOR STARTING

A. Before Starting for First Time

When an engine is just installed or has been out of service for a long time, or if extensive work has been done on the engine, the following points should be observed before any attempts are made to start:

Check all bolts and nuts to make sure they are tightened down thoroughly, particularly main bearing, connecting rod, cylinder head and foundation bolts.

Check crankshaft alignment as explained in Part II Installation.

Inspect all connections in lubricating and fuel oil, cooling water and starting air lines.

Bar engine over with relief cocks open, at least three complete turns, to make sure everything is clear.

Remove crankcase side covers and bar the engine over to allow easy access to lubricating oil suction inside the crankcase. Inspect lubricating oil suction in order to make sure it is not clogged and that no water or grit has accumulated in the crankcase.

Inspect also the lubricating oil service tank which should be at least 1/3 full when starting, with oil in the crankcase covering the suction inlet. If no oil is in the crankcase, the lubricating oil service tank should be at least 3/4 full. Open valves from the service tank and any other valves which are necessary to the flow of the lube oil through the system. If the lubricating and fuel oil filters have not been cleaned recently, clean as directed in the Maintenance Section.

All fuel systems should have a tank located above the engine or be supplied with an auxiliary fuel transfer pump to lift the fuel to the engine header.

The fuel system should be bled of air. To accomplish this proceed as follows: Open valve in fuel lines and vent plugs in filters and allow fuel to escape until all air has been expelled and solid oil is flowing.

Fuel injection pumps should then be bled of air in the following manner: Set speed control lever at full speed. Move operating control lever to the ahead or astern operating position. Open pump and nozzle bleeder screws and prime pumps by alternately opening and closing petcock on air balancing valve (also the overspeed shutoff valve) until solid oil is being bled from both pumps and nozzles then close all bleeder screws. If four pumps (six cylinder engine) or six pumps (8 cylinder engine) are primed, engine will start. After engine has started the rest of the pumps and nozzles can be bled of air by opening bleeder screws as indicated above.

B. Description of Controls

The engine is equipped with two control levers. One, the operating control lever, controls the starting, stopping, and reversing of the engine. The other lever is the speed control lever which controls the speed of the engine through the governor.

Starting the Engine

Set the speed control lever at about one third speed. The operating control lever is then moved away from the vertical or stop position to the ahead or astern position, whichever is desired at the moment. The lever must be moved to first notch encountered which causes the camshaft to be shifted to the proper position. Interlocks will prevent the lever from being moved to the second notch, which is the start position, until the camshaft has been shifted. When camshaft has shifted move lever to the second notch and engine will start. As soon as the engine fires release the lever and it will return to the normal running position.

Stopping and Reversing Engine

To stop engine move operating control lever to the vertical or stop position and the engine will stop regardless of speed control lever setting. It is recommended however, that the speed control lever be moved to the idling position when stopping or maneuvering.

When engine is running in the ahead position and it is desired to reverse the engine, move the operating control lever to the first notch on the astern side of the segment. The interlocks will again prevent starting of the engine until camshaft is shifted to the proper position. Do not force the control lever while interlocks are engaged.

When maneuvering, do not stop operating control lever between neutral and either ahead or astern running position, for to do so allows air to run through air motor and be lost.

Emergency Reversing

If the reversing air motor should fail and it becomes necessary to reverse the engine proceed as follows: make certain that operating lever is in vertical or stop position. Insert barring bar in capstan mounted underneath reversing mechanism housing and rotate capstan. Refer to indicator plate on top of reversing mechanism housing in order to determine which direction engine will rotate. Shift the camshaft until indicator shows it to be in its proper position and stops are felt within the housing. Then move the operating control lever to the start position in the direction which the engine is to operate. Release the lever when engine starts. It is of vital importance that the operating control lever be in neutral or stop position when the camshaft is shifted manually.

When pilot house control is used, provision must be made to provide bumper springs to bring operating control lever back to the running position, both ahead and astern.

C. Starting and Stopping

1. Air Pressure

Air pressure of not less than 200 lbs/sq.in. should be available although a warm engine may be started on 100 lbs/sq.in.

2. Operating Pressure Check

As soon as engine is running all the gages should be observed to check for proper operating pressure. Particularly note lube oil and circulating water. If conditions are not normal shut down and determine cause.

3. Warning!

Never use any other compressed gas but air for starting, and particularly do not use Oxygen under any circumstances as it will result in a violent explosion.

4. Emergency Stopping Procedure

If for any reason the engine cannot be shut off by the operating lever it may be stopped by opening the petcock on the balancing valve (same valve is used to prime pumps).

D. Running and Inspection

1. Pressures

While running under normal load, at rated speed, pressure gages should read as follows:

Lubricating Oil	25 to 28	lbs/sq.in.
Circulating Water	15 to 20	lbs/sq.in.
Fuel Oil	10 to 15	lbs/sq.in.
Starting Air	150 to 250	lbs/sq.in.
Sea Water	3 to 15	lbs/sq.in.

2. Temperatures

While running under normal load, at rated speed, temperature should read as follows:

Lubricating Oil From Engine	120° to 160° F.
Circulating Water From Engine	120° to 160° F.
Exhaust Temperatures	750° to 1000°F.

General Maintenance

All parts of the engine should be felt frequently, especially during the first few hundred hours of operation, to detect any excessive temperature on head and cylinder side covers. Undue high temperatures in any connecting rod or main bearing can usually be detected by the higher temperature of the respective side cover.

If the fuel injection pumps require adjustment in order to average the exhaust temperatures, (50° F. range), care should be taken to see that the difference between any two pumps is not in excess of 2 millimeters on the control rod. (See illustration "Fuel Pump"). If the difference in exhaust cannot be corrected without exceeding this maximum difference, it is an indication of wear or improper adjustment of pumps or nozzles, or obstruction in the holes of the injection nozzles. This condition may also be due to carbon deposits on the thermocouples or the use of a thermocouple with the wrong length of stem.

Hourly

A reading on all instruments should be taken and recorded in the engine room log. In addition, feel side covers and check level in lubricating oil day tank. Turn handles on all knife edge strainers once every four hours.

Daily (Every 24 Hours)

The drains in the fuel filter, lubricating oil filter and strainers should be opened at least once a day to drain out any water or sludge which may accumulate; also check fuel, lubricating oil, and water systems for air.

Weekly (Every 60 Hours)

Fill the line oiler to the reversing mechanism air motor with a light oil, approximately SAE 10.

Fill governor oil container with a light oil, SAE 30.

Oil starting and reverse control mechanism through holes provided in the housing. Also oil linkage pins and shaft bearings of the governor and fuel control. Remove and clean oil strainer screen in lube and fuel lines.

Monthly (Every 250 Hours)

Remove crankcase breather and wash in a mixture of kerosene and lubricating oil.

Inspect inside of crankcase sump for an excess of water. Drain oil from sump if any great quantity of water or sludge is present, and determine the cause.

Remove camshaft covers and inspect tappets and rollers. Tappet clearances in guides should be checked with feelers, when roller is on low part of cam. (Adhere closely to clearances as given in "Table of Clearances").

Tappets should be raised by means of a brass pry-bar, and rollers and needle bearings checked for freeness on pins and in slot.

The fuel and starting tappets should return readily by the force of the springs.

To adjust the clearance for proper air starting valve timing, it is essential that the valve is in the extreme upper position. (See illustration "Air Starting Valve".) To accomplish this most conveniently proceed as follows: Close the globe valve in the starting air pipe and open the bleeder valve on aft starting air connection on no. 6 cylinder. Open the main starting valve wide by means of the jack screw underneath. (See illustration "Main Starting Valve".) Then crack the globe valve just enough to maintain 25# - 35# pressure in the manifold. This pressure will hold the valves up but it is not enough to turn the engine over. Now by pushing down on the push rod end of the rocker arm until the tappet roller contacts the low part of the cam, the clearance can be measured between the rocker roller and the top of the air starting valve. The recommended amount of clearance is stamped on the engine nameplate.

CAUTION! Always before attempting to bar the engine over, be certain that the globe valve in the air starting line is closed, and manifold bled of all air.

Every Three Months (750 Hours)

Remove and inspect one or more connecting rod bearings.

Remove the thermocouples from the exhaust manifold, and check stems for an accumulation of carbon. Scrape if necessary.

Remove and check relief valve on cylinder head (use a hydrostatic tester if available) to make sure it will release at specified pressure of 900 lb./sq.in.

Every Six Months (1,500 Hours)

Remove one or more valves and check for pitting or wear, also inspect valve lifting mechanism.

Remove covers on timing gear case and inspect gears. Test backlash between all gears, also radial and thrust clearance of idler bushings. Remove shims if necessary behind idler thrust plates.

If backlash between any pair of gears exceeds value given in Table of Clearances by .006" or more, due to excessive wear of the teeth, replace the worn gear.

Inspect camshaft bearings by means of feelers. If wear is indicated above allowable clearances (see "Table of Clearances") replace with new shells.

Never attempt to scrape or rebabbitt worn shells as they are faced with a special thin bearing metal.

If supercharger is supplied with engine, thoroughly clean supercharger and inspect bearings.

Flush the cooling system thoroughly with an approved solvent opposite to direction of normal flow. Then thoroughly flush with fresh water for an additional two or three hours to remove all trace of solvent. This should be done at least once every 1500 hours and oftener if necessary.

Avoid the use of any corrosive substance such as muriatic acid in flushing cooling system.

Annually (Every 3000 Hours)

Overhaul and clean entire engine removing and thoroughly cleaning all parts and accessories, and inspecting for wear. Replace all broken and worn parts. Disassemble all relief valves and test for pressure. Repack all glands.

PART IV

MAINTENANCE, DESCRIPTION OF PARTS, METHODS OF ASSEMBLY AND DISASSEMBLY

A. Fuel Pumps and Nozzles

There is an individual injection pump and nozzle for each cylinder. Pumps are operated from the main camshaft and are all connected to a common supply header. Each pump discharges through a separate injection tube to its respective nozzle in the center of the cylinder head. A full description of pump and nozzle is given below.

Nozzles

If engine has been running unevenly and a fuel nozzle is suspected, remove this nozzle and replace it with a spare.

To Remove Nozzle:

Disconnect inlet and drain. Remove nozzle retainer. Nozzle assembly may then be pried out.

Before replacing nozzle, remove all carbon or other foreign substance from nozzle seat in head. See that gasket surface is clean and gasket clean and in good condition. Tighten hold down nuts evenly and just sufficiently to prevent blow-by.

The nozzle may be tested by connecting it to the high pressure fuel line from any pump. Engine should then be turned over slowly by air. Other cylinders can be prevented from firing by opening vent screws on nozzle, which allows fuel to be by-passed from other pumps.

Nozzle can also be tested by means of test pump. When pressure as shown on gauge of test pump reaches the proper value, valve in nozzle should snap open and a finely atomized fuel spray should emerge from each of the orifices in the

nozzle. These sprays should be symmetrical and of equal density. If test pump is operated slowly, valve in nozzle will open and close rapidly, the condition commonly known as chattering. An experienced operator can tell from the sound of this chattering whether the nozzle is in good condition.

Nozzle should be replaced and repaired if it shows excessive dribble or if fuel emerges in a solid stream. Dribble will cause excessive carbon formation, even though nozzle atomizes properly. A solid stream is caused by a sticky stem or by foreign particles within the passages or under the seat.

If nozzle valve opens at a pressure below or above 2200 - 2300 lbs, the spring tension should be adjusted.

For methods of adjustment, disassembly and cleaning of nozzles, see Section "Nozzles".

B-3 Pumps - See drawings "Fuel Pump" and "Timing of "Fuel Pump"

If one of the injection pumps does not function properly, first ascertain if fuel oil is flowing freely to pump. To do this, loosen vent screw (1) on front of pump just above supply connection. Fuel oil should flow freely without showing air bubbles. Allow fuel to flow until all air bubbles disappear. If flow is sluggish it is probably due to clogged filters. In this case clean filters.

Next open nozzle bleeder valve by turning handle on top of nozzle body in center of cylinder head two turns in a counter-clockwise direction. Then, with the control rods on the pumps set at approximately 20 mm., operate the pump a few times by means of priming shaft on pump base in order to bleed all air from injection tubing and passages in nozzle body; then close bleeder valve. If tappet is on cam lobe (as shown by mark "A" on slidable pump plunger being above line on inspection window - see Drawing "Timing of Fuel Pump"), bar engine over until tappet is clear of lobe. If Pump still does not function properly, remove and replace with spare pump.

Injection Pumps

Operation of Injection Pump

Fuel enters through inlet fittings 23 and 25 into the cavities surrounding the upper end of the barrel and, during the suction stroke of the plunger, is drawn into the cylinder through the inlet port. On the upstroke, the upper edge of the plunger closes the inlet port. Fuel is then delivered through delivery valve 2 to the spray nozzles. When the upper edge of the metering helix uncovers the by-pass port, the flow of fuel through the delivery valve is sharply terminated. During the remainder of the upstroke fuel is by-passed through a central hole in the plunger, through the metering helix and the by-pass port into the lower groove which surrounds the barrel. From here it may return to the inlet fitting.

It is seen from the above that the duration of injection and consequently the amount of fuel injected is determined by the angular position of plunger in the barrel. The quantity of fuel is regulated by rotating the plunger by means of the control sleeve 4 and the control rod 3. The plunger floats on a film of fuel during its entire stroke, and therefore requires only a very small amount of force for accurate and sensitive regulation. This condition is obtained by providing a small helical groove diametrically opposite the metering groove. These grooves distribute a fuel film evenly over the cylinder walls.

To Remove Pump

Take off short connection to fuel manifold. Remove lower end of injection tube. Draw out control rod pin; remove hold down nuts. Pump can now be lifted off pump base.

To Adjust Timing - See Illustrations "Timing on Fuel Pump"

Timing is controlled by position of tappet adjusting plug. Before replacing pump make preliminary adjustment by barring engine back one-half turn of the flywheel, or approximately 180 flywheel

degrees before firing top dead center. Tappet roller will then be clear of cam lobe. Top of adjusting plug should then be .197" below top surface of pump base. To change adjustment, loosen locknut on plug and screw plug up or down as required. One-half turn of plug changes position approximately .032". After this preliminary adjustment has been made, replace pump and tighten all hold down nuts. Bar over until top center mark on flywheel is as shown on title page. If timing is correct, mark "A" on slidable pump plunger will register with line on inspection window, as shown in Illustration "Timing on Fuel Pump".

Precautions to be Observed and Suggested Equipment for Repair of any Injection Unit.

Before disassembling any injection unit, cover bench with clean grease-proof paper. See that paper and all tools are perfectly clean. Place a pan, approximately 10" x 15" and about 2" deep about two-thirds filled with filtered kerosene in a convenient position. A pressed steel white enameled surgical pan is most convenient and is easy to keep clean. If parts are very dirty and a considerable number have to be washed, another pan arranged in the same way is advisable for final rinsing before re-assembly. A squirt can which allows a stream of kerosene to be directed under pressure through fine grooves and holes in various parts will also be found convenient. Hands should be kept clean, especially during re-assembly.

To Dismantle Pump - See Illustration "Fuel Pump"

Clamp pump in vise in inverted position. Press down plunger guide (5) and insert a 5/32" pin about 2" long in hole in flange spigot. Take out spring ring (6) by means of screw driver and pliers. Press plunger guide (5) down again and remove the temporary pin. All parts in lower portion of pump body (7) can then be removed in the following order: plunger guide (5), lower spring plate (8), plunger spring (9), pump plunger (10), regulating sleeve (4), spring ring (11), and upper spring plate (12).

Unscrew delivery nipple holder (13) and take out delivery valve (2) and delivery valve spring (14). Back off locking screw (15) about three turns. Carefully press out pump barrel (16) and delivery valve seat (17), including special gasket (18).

If plunger or pump barrel are found to be damaged, they should both be replaced. Never use a plunger from one barrel in another barrel, as the plunger and barrel are so accurately ground and lapped to fit that they cannot be interchanged. The same applies to the delivery valve and its seat.

Do not use grinding compound or extremely hard tools which may scratch closely fitted parts.

Before re-assembly, all parts should be washed in kerosene and oiled with a light lubricating oil.

To Re-assemble Pump

Install parts in reverse order from disassembly, proceeding as follows: Clamp pump body (7) in vise in upright position. Place pump barrel (16) in body in such a way that positioning groove on largest diameter lines up with locking screw (15). See that ground surfaces of joints are perfectly clean and free from scratches. Locking screw should fit into groove in pump barrel. Avoid binding and distortion of barrel. Test this by moving barrel up and down in body.

Next insert delivery valve seat (17), and special gasket (18). Be sure that lapped face of delivery valve seat makes a perfect joint with top face of barrel. Insert delivery valve (2) and spring (14). Screw delivery nipple holder (13) into body, tightening it sufficiently on gasket to prevent leaks.

Now invert pump body for installation of remaining parts. Position control rod (3) so that punch mark which is in center of rack in a space between the teeth is approximately in center of pump body.

Place regulating sleeve (4) in pump body so that punch marked tooth of sleeve meshes with punch marked space of control rod.

The following parts can now be re-assembled in the order given: upper spring plate (12), spring ring (11), plunger spring (9), pump plunger (10), and lower spring plate (8). When replacing pump plunger,

be sure to have mark on lug of plunger in line with marks on regulating sleeve and control rod. (See Illustration "Bottom View").

Insert plunger guide (5) on top of spring, press down, insert temporary pin in hole in flange spigot, press in spring ring (6) and remove temporary pin.

Re-assembly is now complete. For a check, work control rod back and forth. Test freeness of plunger by pushing plunger guide against spring a few times. This can be conveniently done by gripping a hammer handle in the vise and using end of handle as a tappet. Guide should return through force of spring and any sticking of plunger will be readily noticed.

INJECTION PUMP TROUBLES AND REMEDIES

No Delivery or Insufficient Delivery

Probable Cause	Suggested Remedy
1. Fuel tank empty or valve in line closed.	1. Refill tank with fuel. Check whether transfer pump delivers fuel to tank. Open all valves in line.
2. Fuel inlet pipe clogged or third stage filter element dirty.	2. Clear pipe. Clean filter element.
3. Air lock in pump.	3. Vent pump and nozzle.
4. Pump plunger remains suspended in barrel.	4. Thoroughly clean all parts, particularly plunger and barrel. If either are damaged, replace both with spares.
5. Plunger spring broken.	5. Replace with spare.
6. Delivery valve does not seat properly.	6. Clean delivery valve and seating. If either are damaged, replace both with spares.
7. Delivery valve spring broken.	7. Replace with spare.
8. Leakage back to suction chamber from surfaces between top of barrel and delivery valve seat.	8. Clean faces. Remove burrs and scratches from delivery valve seat and barrel.
9. Worn or defective plunger or barrel.	9. Replace with spare.

Control Rod Jammed or Binding

10. Dirt causes pump plunger to jam or control rod rack is coated with dirt.	10. Dismantle and clean.

INJECTION PUMP TROUBLES AND REMEDIES

(Continued)

Leakage of Fuel

	Probable Cause	Suggested Remedy
11.	Supply connection leaks.	11. Install new gasket or replace connection if damaged.
12.	Leakage past spring guide caused by worn plunger or improper seal of barrel in main body.	12. Replace defective parts with spares

Nozzle - See Illustration "Fuel Nozzle"

The nozzle consists of the nozzle proper, including the body (18), valve (19), nozzle holder (16), and the spray tip (17). Nozzle valve seals injection system from combustion chamber except during time that fuel pump has built up sufficient pressure to overcome spring pressure acting on valve. This pressure is set between 2200 - 2300 lbs/sq.in. and may be adjusted by pressure adjusting screw (11) and locknut (8) at the top of nozzle holder. When nozzle valve opens, fuel is injected into combustion chamber through orifices in spray tip in a finely atomized spray. Injection continues until pump plunger uncovers by-pass port, causing rapid drop of pressure. Nozzle valve then seats quickly to avoid dribble. A small amount of fuel leaks around nozzle valve, thereby lubricating valve stem. This fuel is drained through connection made to leak off nipple nut (6) at top of nozzle holder. The bleeder screw (7) also drains into this connection. Unscrewing bleeder screw allows ball valve to lift off its seat and fuel will by-pass, thus preventing injection.

An edge filter (2) is provided in fuel inlet stud (3). It consists of stainless steel and bronze discs of approximately .002" spacing. The purpose of this filter is to trap any particles which may be in the line past final fuel filter.

Before doing any work on nozzle see section "Precautions and Suggested Equipment for Repair of any Injection Unit".

To Adjust Nozzle Spring Pressure

Adjustment of spring pressure should only be attempted on test pump with gauge. While pumping fuel through nozzle in regular way, observe gauge and increase or decrease spring pressure to obtain opening pressure between 2200 - 2300 lbs/sq.in. To adjust spring pressure, remove protection cover (9). Loosen locknut (8) and adjust pressure adjusting screw (11) as required. Each quarter turn of adjusting screw changes opening pressure approximately 150 lbs/sq.in.

To Remove or Change Nozzle

Place nozzle holder body (15) in vise on flat portions provided for purpose with nozzle body (16) in upright position. Unscrew nozzle cap nut (16) holding nozzle body to holder body. Use close fitting wrench to prevent damage to nut. Wash nut (16), spray tip (17), nozzle valve body (18), and valve (19) in clean kerosene. Interior of nozzle body should be cleaned out with a small strip of wood soaked in kerosene. Rub valve with a clean, soft (but not fluffy) cloth soaked in kerosene. Do not use grinding compound or extremely hard tools which may scratch closely fitted parts. If the nozzle valve can be rotated freely in its body without friction or "rattle", then it fits correctly in the nozzle. If nozzle body or valve are found to be damaged, they should both be replaced. Never use a valve from one nozzle body in another body, as the valve and body are so accurately ground and lapped to fit that they are not interchangeable.

Re-assembling of Nozzle

Wash nozzle body, valve and spray tip in clean kerosene. Bring valve and body together and see that valve revolves easily. Before replacing nozzle body, valve, and spray tip in holder, be sure lapped sealing surface on nozzle, holder, and spray tip are perfectly clean and free from burrs and scratches. Care should be taken in screwing down nut to tighten just sufficiently for good seal without distorting any part by using excessive force.

To Overhaul and Clean Nozzle Holder

Place nozzle holder body (15) in vise on flat portions provided for purpose with nozzle protection cover (9) in upright position. Remove protection cover. Loosen lock nut (8), and unscrew adjacent screw (11). Draw out pressure adjusting spring (13), and spindle (12). Wash all parts in kerosene. Unscrew inlet stud (3). Press out edge filter (2) with 3/16" pin. Clean filter and inside of inlet stud with kerosene.

Re-Assembly of Nozzle Holder

When replacing filter, fit should be such that it is just possible to press filter into stud by hand with aid of 3/16" pin. If filter is too loose, replace with a new filter. Be sure seating faces of inlet stud and nozzle holder body are clean and that inlet stud gasket (1) is clean and in good condition. Tighten inlet stud sufficiently to prevent leaks without distorting any part by excessive force.

Replace spindle, spring, and spring cap nut. Adjust nozzle opening pressure according to instructions, page 4-A-9. Replace protection cover.

B. Fuel Transfer Pump

Fuel transfer pump is of the plunger type; it is directly connected to the camshaft by means of a coupling.

If difficulty should be encountered in maintaining the fuel pressure the trouble may be caused by dirt under the valve seats. To correct this remove the castings at both ends of the check valves and clean the valve seats. However, if the fuel filters are in working order the transfer pump should require no attention except an occasional inspection of the stuffing box for leaks. When repacking, use 3/16" square packing about 27" long of a type approved for oil pump plungers.

C. Lubricating System

General

The lubricating oil pump is of the duplex type, one the scavenge pump and the other the pressure pump. The scavenge pump transfers oil from the engine base through a filter to the service tank. The pressure pump takes oil from the service tank and forces it through a filter and oil cooler to the various points to be lubricated. A relief valve mounted on the pressure pump prevents oil pressure from exceeding 28 lbs/sq.in. by allowing excess oil to be by-passed back to the suction side of the pump. A four-way valve is placed in the line to and from the oil cooler. In case of any leaks between lubricating oil and water sections, turn four-way valve so oil flows from filter directly into lube oil header, and replace cooler element at earliest convenience. A leak between lubricating oil and cooling water sections may be detected by a depletion of lube oil in service tank, in excess of normal lube oil consumption.

Filters should be disassembled and cleaned at intervals of one to two months, depending upon the condition of the oil.

About once a month crankcase breathers should be removed and washed in a mixture of kerosene and lubricating oil. Inspect and clean inside of crankcase, especially lubricating oil suction screens and reservoir below. Remove oil from crankcase if any water or sludge is present.

Lubricating Oil Pump - See Illustration "Lubricating Oil Pump"

The duplex unit consists of two gear type pumps mounted in the same housing. This unit is driven by a gear meshing with the engine idler gear. The main impeller gears of both pumps are splined to the drive shaft which rotates within bronze bushings. The idler gears of the pumps are bronzed bushed and rotate on a stationary shaft.

If the main lubricating oil gauge shows that the oil pressure has dropped, first see that there is sufficient oil in the service tank and that the

filters are clean. Make sure that all pipe connections are tight, all lines are free. Check and see that the relief valve is seating properly.

After checking these points and the oil pressure is still low the pump should then be dismantled and the various clearance points should be checked. (See "Table of Clearances"). The proper side clearance is obtained by means of a .006" gasket on each side of the pump housing. If the inside face of the two covers on the pump have become worn; face them off on the lathe until all evidence of wear has disappeared. If the inner faces of the pump housing have become worn, face off outside faces of the housing until exactly flush with face of the gears. It may be necessary to replace gears and bushings. Gears are cut in pairs and should not be interchanged, however, any pair of gears may be used in either the pressure or scavenge pump.

Re-assembly

Place drive shaft in housing and assemble main gear and idler gear of rear pump. Replace inside cover and gasket of proper thickness to make end clearance .006" and bolt in place. Check clearance of shaft shoulders as follows: With drive gear held against thrust bushing, shaft shoulder facing the front pump should not protrude beyond the inner face of the front pump. Back out drive gear as far as it will go and determine clearance between this gear and the thrust bushing. This should be at least .010" to provide clearance for the shaft shoulder facing the rear pump. Replace main impeller gear and idler gear of front pump. Replace shims, thrust washer, lock washer and lock nut, installing sufficient shims to provide .004" to .007" end play in the drive shaft. Replace outside cover and gasket of proper thickness to make end clearance of gears equal to .006".

Relief Valve

The relief valve consists of a bronze plunger operating in a cast iron housing. When the line pressure equals the pressure at which the valve is set, the plunger moves off its seat allowing the excess oil to by-pass to the suction side of the pump. The spring is correctly set at the factory to maintain a pressure of 28 lbs/sq.in. when oil is hot. Under normal conditions, the adjustment should not be changed. If adjustment becomes necessary, proceed as follows: Remove cap, loosen adjusting screw lock nut and adjust as required.

D. Air Starting System - (See Illustration "Air Starting Valve")

The air starting system consists of a main valve, piston operated, a pilot valve, and the starting valve in each head. The mechanism is put into operation by moving the operating control into the start position, thus opening the pilot valve.

The function of the pilot valve is to bleed the air off of the upper side of the piston of the main valve. The resultant overbalance of pressure on the lower side of the piston opens the valve, and thereby charges the air manifold. The air starting valves in each head are so constructed that as soon as pressure builds up in the air manifold a piston is forced upward against the rocker arm, which in turn, through the push rod, forces the cam follower against the air starting cam. The pressure on this piston also overbalances the tendency of the air pressure to open the valve. The action of the cam, push rod, and rocker is to force this piston down against the air starting pressure, thus eliminating its closing effect on the valve and allowing the valve to open.

There is also an auxiliary piston in the starting valve which is connected directly to the valve stem. It is acted upon by air pressure and aids in opening the valve against cylinder pressure.

If it is desired to turn the engine over slowly by air without starting it, this can be done by cracking the main valve; by means of the jacking screw on the bottom of the valve body.

Be sure the jacking screw is fully released before attempting to start the engine.

Timing of Air Starting Valves

When adjusting the clearance for proper air starting valve timing, it is essential that the valve is in the extreme up position. To accomplish this most conveniently proceed as follows: Close the globe valve in the starting air line. Open the main valve wide by means of the jack-screw underneath. Then crack the globe valve just sufficient to maintain 25 - 35# pressure in the manifold. This pressure will hold the valves up but is not enough to turn the engine over. Now by pushing down on the push rod end of the rocker arm until the tappet roller contacts the cam, the clearance can be measured between the rocker roller and the top of the air valve. The recommended amount of clearance is stamped on the engine name plate.

It is very important, when checking clearance, to be certain that the air valve is in its normally closed position. If there is any doubt, bar the engine over until the inlet valve is open on the cylinder whose air valve is being adjusted.

CAUTION! Every time before attempting to bar the engine over, be certain that the globe valve in the starting air line is closed.

E. Reverse Mechanism

The air motor is geared to an eccentric shaft which, in turn, is strapped to the camshaft to shift it axially. The eccentric at each end of its travel reaches an adjustable bumper stop and remains at the stop due to tension in a spring holding it over center.

The position of the cams in respect to the tappet rollers in the operating position is obviously controlled by the adjustment of the bumpers. The importance of obtaining the proper operating position, therefore, cannot be over-emphasized and should be accomplished as follows:

Tighten the cork packing until considerable resistance is felt. Then operate the reverse eccentric manually and observe when the camshaft is in the extreme after position. By use of feelers, measure the distance between the after face of an inlet cam and the forward face of the adjacent bearing. Then operate the reversing eccentric in the same direction until the eccentric strap strikes the bumpers. The camshaft will be observed to have traveled a short distance forward. Again measure the clearance between the same inlet cam and bearing without maintaining a strain on the eccentric shaft. The clearance now should be .030 - .040 more than that previously measured. If the clearance is not as specified the bumpers should be screwed in or out with a spanner wrench provided for the purpose until this adjustment is correct.

This same procedure should be carried out with the camshaft in the forward position. In this case, the minimum clearance between the forward face of the fuel cam and the after face of the adjacent bearing should be ascertained, and on the final position against the bumper the clearance adjusted to obtain the same as in astern.

The forward bumper controls the clearance when the camshaft is forward and the after bumper controls the clearance when the camshaft is aft.

When the eccentric is on dead center in either direction there should be a minimum of .005" clearance between any one bearing face and the adjacent cam face.

Be sure to tighten the bumper locknuts firmly to prevent change in adjustment when tightening cork compressing screws.

Maintenance

Grease fittings have been provided on the housing to facilitate lubrication of the reversing mechanism. This should be done once a week.

The line oiler to the air motor should be filled with a light oil approximately SAE 10 once a week.

In both cases, if excessive maneuvering is being done, lubrication should be provided more often.

Starting and Reverse Control Maintenance

Starting and reverse control mechanism should be oiled once a week, through oil holes provided in housing. Should the reversing control mechanism be removed from the engine the following procedure must be strictly followed in the re-installation:

Remove one of the camshaft covers. By means of a wrench on the eccentric shaft extension below the reversing mechanism, set engine camshaft in "Neutral" position, which is exactly half way between the ahead and astern position.

Place operating lever in neutral position. See that indicator is also in neutral position. Set the control in place and bolt to engine.

To connect the air motor control linkage to the air motor, set the air motor handle in the center of its off position. Adjust yoke on link until clevis pin can be inserted. Make sure air motor lever is in its original position on shaft.

Starting and reversing mechanism should now be in time.

Before starting make sure all controls are free and all pins and cotter pins are in place.

F. Valves and Valve Mechanism - See Illustration "Valve Mechanism"

Description

Intake and exhaust valves are of alloy steel. Exhaust valve has a deflector on the stem just below the guide.

To Remove Valve, Intake and Exhaust

Remove cylinder head as explained in Section, "Cylinder Head". Take off rocker shaft stud nuts and remove rocker assembly and hydraulic lifters. Place valve spring tool (furnished with engine) over valve retainer. Clamp tool in place by tightening set screws against cylinder head. Screw down fork by means of handle until retainer is depressed far enough to allow valve keeper wedges to be removed. Valve is now free and can be drawn out. Remove springs and if necessary, replace valve guide.

To Remove and Install New Valve Spring (Without removing head)

Bar engine until piston in cylinder, on which valve spring is to be changed is at top dead center. Take off rocker shaft stud nuts and remove rocker assembly. Place valve spring tool (furnished with engine) over valve retainer. Clamp tool in place by tightening set screws against cylinder head. Screw down fork by means of handle until retainer is depressed far enough to allow valve keeper wedges to be removed. If retainer sticks to valve stem a slight tap with a hammer will release this and valve will drop down and come to rest on top of piston which must be at top dead center. Release valve spring tool and remove retainer and valve spring. Install new spring and set retainer on top of spring. Put valve spring tool in position and screw down on fork until valve keeper wedges can be inserted in retainer. Release valve spring tool, being sure keepers are correctly located in retainers. Replace rocker arm assembly. Under no circumstances bar engine while valve spring is being replaced.

Inspection

Upon inspecting the valves, particularly exhaust valves, the seat surface may have the appearance of pitting due to the fact that small carbon particles may be trapped on the seats and impress themselves upon the metal; this condition has no effect upon operation unless there is an indication of blow-by. In this case valves should be reseated.

Reseating Valves

Valve may be refaced on standard valve refacing machine or ordinary lathe. Seat should be exactly 45°. If done in lathe by means of cutting tool, be sure to use very fine feed and sharp tool for final cut. If grinding wheel is used, wheel should be dressed for exact trueness before final grinding cut is taken. Remove only sufficient material to eliminate pits and to make seat run exactly true with stem.

Reseating Heads

If guide is worn, a new guide should be installed before refacing. Reface head in drill press if available, otherwise use hand reamer. Use standard 45° reamer and face just sufficiently for trueness and removal of pits. Next, limit width of seat to 11/32" ± 1/64" by means of 75° reamer. After this operation, valve should be replaced in head and face of valve checked with seat by means of blueing.

If proper tools for making these corrections are not available, and it is absolutely necessary that repairs be made, valve may be ground by means of grinding compound in usual manner, however, this will not produce a satisfactory seat; therefore, if such repairs have to be made, heads and valves should be refaced as soon as possible in accordance with the above instructions.

Air Starting Valve - See Illustration "Air Starting Valve"

To aid in removing the valve, in case it is stuck in the head, jacking screw holes have been provided on each side of the valve cage. To dis-assemble the valve, first unscrew the upper cap. To do this it is necessary to lock the piston by placing a pin through one of the cored slots in the valve cage and into the cored hole in the bronze piston. Next, remove the lock-nut on top of the valve stem and all parts will then come out. When cleaning always check the drilled air passage in the bronze piston for any obstruction.

The piston rings in both the main and auxiliary pistons are the type that seal on one side only. Care should be taken upon re-assembly that these rings be inserted properly. The rings on the larger piston seal pressure applied on the bottom, whereas the smaller rings seal pressure applied on top as in a normal engine piston. It is essential that the cap be screwed down securely and locked by bending copper gasket over flats of the cap and bronze piston.

Valve Gear - See Illustration "Valve Mechanism"

General Description

Intake and exhaust valves are operated through rocker arms and push rods which are actuated by cams and tappets. Lower end of push rod rests in the tappet. Top of push rod contacts lifter body which actuates rocker arm through the hydraulic lifter.

Action of the hydraulic lifter: Oil under pressure from the lubricating system is led through a duct drilled in the rocker arm connecting the lubricating hole in the rocker shaft with the annular groove on the outer diameter of the lifter body. A hole connects this groove to the inside of the lifter body. With the cam roller on the base circle of the cam and the valve seated, a light spring lifts the hydraulic plunger, so that its upper end contacts the adjusting screw, thus eliminating backlash in the valve mechanism. As the plunger moves upward, increasing the volume of the pressure chamber, the check valve is moved off its seat and oil from the supply chamber fills the pressure chamber. As the cam lobe lifts the roller, the lifter body is forced upward, slightly decreasing the volume of the pressure chamber, thereby closing the check valve. Further rotation of the camshaft lifts the valve through the confined column of oil.

During the time the valve is off its seat, a predetermined slight leakage of oil occurs providing for added length in the valve mechanism due to temperature changes. When the roller leaves the receding flank of the cam and contacts the base circle, the oil which fills the pressure chamber is exactly the right amount to eliminate all backlash in the valve mechanism.

While the roller is on the base circle, the force tending to open the valve is that due to the spring, and the oil pressure. This is much less than the main valve springs which hold the valve closed. The pressure of the oil in the supply chamber is negligible under normal operation due to the small area of the plunger.

The self-adjustment of the hydraulic lifter is effective immediately upon starting as the supply chamber remains filled from previous operation of the engine.

The upper end of the push rod is lubricated by oil from the hydraulic lifter. Leakage from the lifter body and hydraulic unit escapes through holes above the lifter body lubricating the lower end of the push rod and cam roller. A trough along the outside of the rocker provides lubrication for valve stem and guide.

Maintenance

Under normal operation, the valve gear should require no attention. Since the hydraulic lifters compensate for small amounts of wear in the valve mechanism, it is not necessary to adjust the valves periodically.

If noise develops in the valve mechanism, it is usually due to one of the following causes:

1. Excessive oil pressure
2. Air or air bubbles (foaming oil) in the lifters
3. Insufficient oil supply
4. Improper setting of adjusting screw on top of rocker
5. Plunger or lifter body sticking
6. Ball check valve sticking
7. Worn plunger or cylinder
8. Ball check valve leaking
9. Lifter spring defective

If oil pressure on lifter unit is above 50 lbs/sq.in. cylinder of hydraulic unit may leave its seat in body and prevent plunger from acting, thus causing excessive valve clearance. This may be checked by holding hand on the adjusting screw with the engine running at about half speed. If this causes the roller to leave the top of the valve stem immediately, it is an indication that the lifter unit is not functioning properly. Do not do this for more than 8 or 10 strokes as this will cause roller to leave valve stem even if lifter is operating properly. Next, observe whether

oil flows from leakoff holes in rocker. If there is no oil at this point, ascertain cause immediately and correct. Next, inspect lubricating oil piping for air leaks, especially suction piping to pressure and scavenge pumps. Excessive air in the lubricating oil line will usually be indicated by a fluttering of the oil pressure gage or by a loss of oil pressure.

Next, adjust hydraulic unit as follows: While engine is running at approximately half speed screw down adjusting screw until valve begins to ride slightly open at all times. This may be observed by pressure on adjusting screw as well as roller being tight at all times. Then back off from this point 1 turn, which is equal to 1/16" oil column in lifter body.

If improper operation is still indicated, remove lifter unit as follows: Disconnect rocker shaft lubricating line; remove rocker shaft stud nuts; lift rocker shaft until lifter units will clear push rods; remove lifter units and take off rocker assembly; remove plunger from cylinder; wash thoroughly all parts of the lifter unit and bore of rocker with kerosene. Be sure hole in lifter body is clear. If plunger or cylinder is found to be worn, or if spring is broken or shows signs of set, renew plunger and cylinder. Never use a plunger from one cylinder in another cylinder as they are tested at factory for proper rate of leak-down. Do not use grinding compound or extremely hard tools which may scratch the surfaces of these accurately fitted parts. Make sure plunger is a free fit but not loose in cylinder. Check unit as follows: Wash thoroughly in kerosene and dry. Hold in vertical position, release spring from counter-bore in cylinder and pull plunger out as far as possible retaining alignment in cylinder. Press plunger down and release quickly. If plunger kicks back repeatedly, it indicates that considerable air is retained and unit is in good condition. Usually when plunger is depressed as quickly as possible with index finger, it should kick back almost half its length; if excessive leakage is indicated, it may be at check valve or at plunger. To ascertain where leakage occurs, repeat operation described above with check ball submerged in kerosene. A leaky check ball will be indicated by considerable bubbling.

Re-assembly

Wipe off plunger and inside of cylinder with a clean, soft, (not fluffy) cloth. Replace plunger in cylinder, making sure plunger spring snaps into bore of cylinder; this can be done readily by a slight twisting motion in the direction to wind up the coil of the spring. Assemble lifter in lifter body. Replace unit in rocker arm; see that lifter body is free in rocker arm bore. Replace rocker assembly and tighten stud nuts.

To adjust lifter unit after re-assembly with cylinder dry; back off adjusting screw about two turns. Bar over until piston is on firing dead center; cam roller is now on base circle of cam. Take up on adjusting screw until plunger rests against bottom of cylinder; at this time roller on rocker contacts top of vlave stem and valve end of rocker cannot be raised. Next, back off adjusting screw one complete turn. Valve mechanism is now in proper adjustment. After a lifter unit has been removed and replaced, the valve gear will clatter when the engine is started as some time is needed to expel the air from the lifter cylinder, however, if lifter unit is in good condition this noise should cease in about 5 to 15 minutes. If valve noise persists, check adjustment with the engine running at approximately half speed as explained on preceeding page.

After engine has been idle for a period of time, or after having been tested a long period of time elapses before installation, the zero lash units may stick. This will make them slow to seat when engine is first started causing noisy valve action. If this still persists after a short time proceed as follows: With engine running at about half speed back the adjustment off until the rocker has a slight clearance, then tighten adjustment nut slightly which should eliminate the noise. The same noisy action may appear at maximum speed, if so, it can be corrected by the procedure outlined above.

Tappets and Guides - See Illustration "Valve Mechanism"

Description

Roller pin is serrated on one end to keep it from turning. Lubrication for both tappet in guide and tappet roller is from the auxiliary force feed header. Individual lines connect to each tappet cluster. Ducts distribute oil inside cluster to tappets. Oil flows to the inside of the tappet to lubricate the push rod end.

The fuel tappet guides are individual for each cylinder and are integral with the fuel pump base. The fuel tappets are also lubricated from the auxiliary force feed header.

Maintenance

About once a month, camshaft covers should be removed and tappets and rollers inspected. Tappet clearances in guides should be checked with feelers. Tappets should be raised by pry bar and rollers checked for freeness on pins and in slot. The fuel tappet should return readily through force of fuel pump spring.

Recommended clearances are given in Table of Clearances and should be closely adhered to.

Assembly and Disassembly

The inlet, exhaust, and air tappets are included in one cluster which can be readily removed by disconnecting all oil lines and removing the nuts holding it to the crankcase. Before removing, place small pins in the holes provided in the exhaust and inlet guides to support the tappets as they are drawn away from the cams. Upon re-assembly, be certain that the dowels that mate with the slot in crankcase have not fallen out. If the dowels are to be replaced or returned to their reamed hole in the cluster, be certain the flats line up exactly and that they fit well into the slot in the crankcase before tightening the hold-down nuts.

To remove fuel pump tappet, first disconnect lines to fuel pump and remove it. Then disconnect lube oil lines and draw out tappet and guide. Again tappet may be supported by pin placed into hole provided in the guide.

G. Cylinder Head

To Remove Head

Drain water from engine. Loosen flanges which connect exhaust manifold and intake air elbow to head. Next remove rocker shaft assembly and hydraulic lifters. Disconnect fuel injection tube from pump. Disconnect nozzle drain fitting on outside of head. Remove nozzle as follows: Disconnect inlet and drain; remove nozzle retainer and pry out nozzle. Next unscrew all holding down nuts and head is ready to be lifted off. If head adheres to gasket, take strain on tackle and jar head with lead hammer.

Use new gaskets when re-assembling an engine. An old cylinder head gasket may appear to be in good condition, but after re-assembling the head and starting the engine the gasket may prove defective, necessitating the complete removal of the cylinder head and installing a new gasket.

With the head off, inside of combustion chamber and top of piston should be cleaned if excessive carbon is found. Piston should then be lowered to bottom dead center position and upper part of bore cleaned. Cylinder walls should be given a coating of clean lubricating oil before re-assembly.

Thoroughly clean off top of block and face of cylinder head to present a clean surface for the new head gasket.

When replacing head, screw hold down nuts hand tight. Next, insert capscrews holding exhaust manifold and air intake elbow to head and screw them hand tight. Then tighten hold down nuts with socket wrench furnished for the purpose. Tighten capscrews holding manifold and intake elbow.

H. Relief Valve

A relief valve is mounted on each cylinder head. An indicator cock connection is provided on relief valve body.

To release compression in cylinder, turn knurled handwheel on relief valve in clockwise direction until it lifts valve off its seat.

Relief valve is set at factory to release at 900 lbs/sq.in. pressure. If it should pop continually while engine is running, it is usually an indication that the maximum cylinder pressure is too high. This is caused by overloading of the engine or by too much fuel being injected into the cylinder.

If the operator has satisfied himself that the popping is not due to either of these causes, the relief valve should be removed and tested by hydro-static pressure. Valve should release when pressure reaches 900 lbs/sq.in. To increase release pressure, loosen locknut and screw down on adjusting nut. When making this adjustment care should be taken not to screw down on the adjusting nut until spring is compressed solid. If it is necessary to do this in order to prevent valve opening before pressure reaches 900 lbs/sq.in. it is an indication that the spring has become too weak and should be replaced.

I. Connecting Rod and Bearing - See Illustration "Cross Section"

Connecting rod is a solid steel forging bored out at top to receive connecting rod bushing. Rod is drilled through to allow oil under pressure from crankshaft to reach this bushing.

Connecting rod bearings are steel cast boxes separate from the connecting rods. They are provided with bronze shells lined with Bearing metal.

Compression shims between connecting rod and bearing allow adjustment of compression pressure if necessary. Normal clearance between top of piston and top of block with piston on top dead center should be .830 - .840. When actual clearance agrees with recommended value, compression pressure should be 370 lbs/sq.in. to 380 lbs/sq.in. at rated speed. If pressure is much below this value, compression is being lost, and gaskets, valves, rings, etc., should be checked.

About once every six months one connecting rod bearing should be removed and inspected.

To Remove a Connecting Rod Bearing

Raise piston to top dead center position and insert piston holding fixture in hole near bottom of cylinder liner in order to hold piston and connecting rod in top center position when bearing is removed. Remove nuts and connecting rod bolts. Bearing box is now free of rod. The removal of a small bolt on each side of bearing box will allow halves to separate, and bearing can be removed from journal.

When re-assembling, remove all burrs especially from around hole in cylinder liner and from the bottom of the piston skirt.

To Check Alignment of Connecting Rod and Bearing

With bearing assembled, loosen connecting rod nuts about three turns. Top connecting rod bolt on threaded end so it will drop down until bottom face of nut rests on top side of connecting rod foot. Bolts should now be free and have no binding action on bearing box. Bar engine over carefully to various

positions and check alignment between foot of rod and top of bearing box with feelers at forward and after faces of bearing box. If misalignment of more than .002" is found, check clearance of piston in liner and of piston pin in piston and bushing. Replace any worn parts. Recheck alignment and correct top surface of upper half of bearing to obtain correct alignment if necessary.

To Replace Bushing in Connecting Rod

A heavy press is necessary. If this is not available, bushing should be split by sawing with a hacksaw from the inside. This will relieve the pressure and bushing can then be readily driven out. To insert new bushing, remove all burrs and clean connecting rod thoroughly. Place entire connecting rod in a pan of oil heated to 350° - 450°F. Remove connecting rod and place on substantial support. Insert bushing with one of the oil holes in line with drilled hole in rod---drive in. This operation should be done quickly, as bushing will heat up and expand rapidly. Make sure bushing protrudes the same amount on both sides.

Tightening Connecting Rod and Main Bearing Nuts

When using a torque wrench to tighten connecting rod bolt nuts and main bearing stud nuts, the nuts should be set up to the following reading in foot pounds.

Con. Rod Nuts	500 ft. lbs.
Main Brg. Nuts	500 ft. lbs.
Cyl Heads Nuts	1200 lbs

J. Piston - See Illustration "Cross-Section"

Pistons are especially selected for heavy duty service. Rings used are plain compression rings, sealing rings and oil regulator and wiper rings.

Piston pin bearings are bronze alloy bushings pressed into the connecting rods. Four holes around the circumference provide full pressure lubrication from crankshaft oil ducts and hollow connecting rods.

Piston pins of carburized and hardened alloy steel are full floating, prevented from endwise movement by aluminum plugs in the pistons.

About once every six months to one year, one or more pistons should be removed and inspected.

To Remove Piston

Remove cylinder head as outlined in section "Cylinder Head". Then bar engine until piston is at top dead center. Disconnect connecting rod bearing as instructed in section "Connecting Rod and Bearing".

Install piston puller unit on top of piston, securing by capscrews in tapped holes in piston head. Be sure threads in tapped holes are clean so that capscrews may be inserted full length. Piston and connecting rod may now be lifted with chain tackle. Be careful to guide lower end of connecting rod through liner to prevent marring of liner bore.

To Remove Rings - (See Illustration "Piston Ring Arrangement")

Insert a screw driver in ring gap. Spread ring and insert four 1/32" x 1/2" steel strips about 8" long between ring and piston equally spaced around circumference. Slide ring off carefully. Rings above piston pin should be removed over top of piston. Remove lower oil ring over bottom. As each ring is removed, attach tag so that when re-assembling ring will be in same position in its proper groove.

Clean thoroughly all rings, grooves, and drain holes.

Check ring gap clearance as follows: Insert ring in liner and slide it down squarely, measuring gap at various levels in liner. Gap clearance should be determined at smallest diameter of bore traversed by ring. See Piston Illustration and Table of Clearances, for correct gap clearances.

If gap clearance exceeds by 1/16", or more, the recommended clearance given in the illustration and table, then the bore of the liner should be measured with inside micrometers. If bore at any point is worn more than .055" on the diameter, liner should be replaced. Liner wear is usually limited to last few inches of ring travel near the top, and if rings show excessive gap clearance near the bottom, it usually indicates ring wear. When replacing rings, fit gap clearance to amount given in illustration and table. Check gap clearance as outlined above.

If ring side clearance exceeds .008", or if groove is worn uneven or is tapered more than .003", remachine groove and use oversize rings, having proper clearances with new groove width.

To Remove Piston Pin

Withdraw each of the two aluminum plugs as follows: Place a washer 2" outside diameter, 9/16" inside diameter and 1" long over a 1/2" standard capscrew about 5" long. Insert capscrew in tapped hole in piston plug and withdraw plug using washer as a ram. The pin is a wringing fit in the piston and should push out easily with little force from either side.

Bushing end of connecting rod should be washed in kerosene and then blown out thoroughly with compressed air.

Correct clearances of piston pin in piston and bushing are given in Table of Clearances.

When installing new pin, scrape out all carbon and burrs from bore in piston. Make sure pin has proper clearance in both piston and bushing.

To Re-Assemble Piston in Liner

Assemble piston and rod, taking care to return them to their original relative positions. Aluminum plugs are marked and are not interchangeable. They should be from .003" to .008" below the diameter of the piston when checked with a long scale held against the surface of the piston skirt. Check with feelers, being certain to hold the scale parallel to the axis of the piston. Hang piston on chain tackle and install rings in proper positions. Cover cylinder walls with a coating of clean cylinder oil. Lower piston carefully into liner, using ring guide. With crankpin on top dead center and connecting rod bearing in place, let piston down slowly on bearing. Be sure proper number of shims are in place and that surfaces are clean. After assembly has been completed and before cylinder head has been replaced, measure distance from top of piston to top of cylinder block. (See Table of Clearances).

If any new wearing parts have been installed engine should be run for at least eight hours at about half speed and at a light load. During this time it should be stopped frequently to ascertain any undue heating of piston or pin.

K. Main Bearing

Main bearings are of the precision type. The cast steel caps are line bored with the engine base to insure accurate alignment. Upper and lower shells are identical; they are bronze back lined with bearing metal. No shims are used; accurate location of parts is accomplished by steel locking rings in cap, holding also upper shell to cap.

To Remove Main Bearing

Take off cap. Insert the tool provided into oil hole in crankshaft. Shell may now be rolled out by barring engine over carefully until shell is free. Remove one bearing at a time, inspect and clean it and replace before disturbing other bearings. Oil groove in shell is offset. When installing shells, make sure the grooves are staggered to prevent formation of a ridge in crankshaft journal by wear.

Alignment and Clearances

A careful check of alignment and clearances should be made about once every two months for the first six months and thereafter about once every six months.

Test Alignment As Follows:

Measure distance between inside faces of crank webs with crankshaft deflection gage, or if not available, with inside micrometers. Check this distance at intervals of approximately 90°. Readings should not differ by more than .003". Refer to form in back.

If misalignment is indicated, it may be due either to uneven wear in the bearing shells or to distortion of the engine bed.

If uneven wear is indicated, replace the shells which are worn. Do not scrape shells or base or attempt to rebabbitt shells. If engine bed distortion is indicated, check and correct.

L. Liner

Liners are of the water contact type. They are inserted in cylinder block and located at top and bottom surfaces. Material is a special alloy cast iron having a hardness of 200 to 240 Brinell. The cylinder head holds the liner firmly through the gasket; the latter also seals the combustion chamber and circulating water passages. Two rubber rings seal the liner at the bottom. To facilitate installation, these rings are placed in grooves machined in the block. There is a cored chamber between the two grooves; a drain hole at the bottom of this chamber on each cylinder, prevents water from reaching the crankcase and also gives indication of any leak.

To Remove Liner

Remove cylinder head and piston in accordance with instructions given in Sections "Cylinder Head" and "Piston". Withdraw liner by means of plates and puller bolt supplied for the purpose.

Before replacing liner, install new sealing rings. A coating of a good grade of grease for rubber lubrication should be placed on rings and on those portions of liner which fit into rings and into bore at top of cylinder block. It is essential that liners be replaced in their original cylinders and that each liner be re-assembled in its original position relative to the cylinder block.

M. Cams, Camshaft and Camshaft Bearing

Cams are nickel alloy steel carburized, hardened and ground. Each cam is securely fastened on the camshaft by key and two setscrews. Each setscrew is kept from turning by a plug formed by Cerro-Base. To melt out, heat with a small blow torch. Be careful not to heat cam to point where it discolors, as this will reduce hardness of surface. Cerro-Base should be used in re-assembly. If it is not available solder may be used.

Bearings should be checked by means of feelers about once every six months. If wear is indicated above allowable, replace shells. Do not attempt to scrape or rebabbitt.

Camshaft bearings are of the precision type. The cast steel caps are line bored with crankcase to insure accurate alignment. Upper and lower shells are not alike; so care must be taken upon re-assembly. The upper shell has a drilled oil hole. The shells are steel backed, lined with bearing metal. No shims are used; accurate location of parts is accomplished by steel locking rings in cap which also hold the upper shell to cap.

N. Timing Gears - See Illustration "Gear Set"

Timing gears have accurately cut helical teeth. Gear teeth are lubricated by streams of oil directed in such a manner that all gears will have an abundance of oil at all times. About once every six months covers on gear case should be removed and gears inspected and backlash tested between all gears. Test radial and thrust clearance of idler bushing. If backlash between any pair of gears exceeds value given in the Table of Clearances by .006" or more, adjust as described below provided the backlash is not caused by excessive wear of the teeth. In this case, replace the worn gear.

Accessories on the front of the engine are flange mounted. When installing these accessories proceed as follows: Position flange of housing or mounting bracket so that the gears have the correct backlash, and slightly tighten bolts. Check by turning accessory gear back and forth by hand. Bar engine to several positions and check backlash. Adjust if necessary then tighten flange securely and make final check for proper clearance.

To Remove Gear Case

Take off all accessories, disconnect all lines to gear case, remove pin in eccentric shifter strap, which allows reversing mechanism to be removed, and unbolt gear case from cylinder block and base.

To Remove Idler Gear

Take off idler thrust plate and shims. Gear may now be withdrawn. Install new bushings if radial clearance exceeds .010". When installing new bushings, remove all burrs from bore of gear. When re-assembling gear on idler stub shaft, adjust thrust clearance to .003" by use of proper number of shims.

If the idler only is to be removed, be certain to mark the mating teeth on crankshaft, idler and camshaft gear before disassembly. This will eliminate the necessity of going through the engine timing procedure as stated below when re-assembling.

To Replace Crankshaft Gear

The gear is a shrink fit on the crankshaft. To remove gear, split it by drilling a series of holes from top of keyway. Insert 3/4" studs about 24" long in tapped holes and withdraw gear. When installing a new gear, first fit a new key. Key should be a driving fit on the sides only in both crankshaft and gear; allow .005"-.010" clearance top or bottom. Remove all burrs from crankshaft.

Insert studs in tapped holes in gear. Place gear in a pan of oil heated to 350°- 450°F. Gear may now be placed in position on crankshaft.

To Replace Camshaft Gear Hub

Remove camshaft nut and washer. Insert 1/2" studs about 6" long in tapped holes in hub. For a puller, use a 3/4" x 1-1/4" bar about 10" long with two holes 9/16" in diameter and at 8-1/8" centers. When replacing hub a new key should be fitted. In assembling a new ring gear and hub, position so that four slotted holes in hub are centered over the respective drilled holes in ring gear. Clamp gear and hub, but do not drill and ream the remaining two holes in ring gear until after camshaft has been timed, as these are locating holes. Replace gear assembly on camshaft, install washer and nut.

To Time the Engine

Remove idler gear as instructed earlier. Bar engine until mark "1-6" or "1-8" on circumference of flywheel is exactly under the center of the flywheel pointer. Position camshaft so that gear keyway is exactly vertically upward. (See Illustration "Gear Set"). Replace idler gear. Loosen camshaft ring gear hub and adjust position of camshaft until top surfaces on intake and exhaust rollers on #6 or #8 cylinder are exactly on the same level, with the piston on top center, indicating that intake valve is about to open and exhaust valve is closed. (See Timing Diagram). The timing is now correct; ream locating holes in ring gear with reamer and insert fitted bolts.

Camshaft may be timed by means of No. 1 fuel injection pump if operator is certain that timing of this pump is correct. When using this method proceed as follows: Remove idler gear. Bar engine until mark "1-6" or "1-8" on circumference of flywheel is exactly under center of flywheel pointer. Position camshaft so that gear keyway is exactly vertically upward. Replace idler gear. Next bar engine until mark "1-6" or "1-8" on circumference of flywheel is* ahead of center of flywheel pointer. Adjust camshaft until mark on slidable pump plunger registers with line on inspection window. Clamp gear to hub. Bar engine a few degrees in direction of normal rotation and make sure fuel cam continues to raise pump plunger. When adjustment is satisfactory, ream locating holes in ring gear with a reamer and insert fitted bolts.

* See injection setting on title page.

To Time the Engine After Installing a New Ring Gear

Check setting of fuel tappets as follows: Remove fuel pumps from first and last cylinders. Bar engine over until one of the above fuel tappet rollers is on the base circle of the cam. Place a straight edge across the top of the fuel pump base and measure the exact distance to the top of the tappet. This distance should be .197" (3/16" - .010"). If the distance is less or greater adjust tappet until this figure is obtained. Now bar engine until the other tappet roller is on the base circle of its cam and carry out the same operation as on the preceeding tappet.

Remove the idler gear as instructed earlier. Now bar engine in ahead direction until mark "1-6" or "1-8" on flywheel is exactly under center of flywheel pointer.

Position camshaft to neutral position manually, by inserting barring bar in capstan mounted underneath reversing mechanism housing and then rotating capstan.

Set camshaft so that position of fuel cam for number one cylinder is in position to begin the raising of the fuel tappet, and position of fuel cam of last cylinder is in the position of completion of its action.

Replace the idler gear, and loosen the ring-gear bolts. The ring gear is held to the hub by four bolts which are in slotted holes, and two fitted bolts. With the four slotted bolts loosened, and the fitted bolts not yet in place, the hub can be moved a slight amount in either direction for final adjustment as follows:

Rotate camshaft in either direction by turning hub, until first and last tappet measure the same distance from top surface of fuel pump base to top of tappet. When this is accomplished, drill a ½" locating hole through ring gear and hub, and ream to size of fitted bolt. Insert and tighten fitted bolt, then repeat the drilling and reaming operation to install

the other fitted bolt. The engine is now correctly timed. All fuel injection pumps should now be re-timed as previously explained.

Camshaft may be timed by means of No. 1 fuel injection pump if operator is certain that timing of this pump is correct. When using this method proceed as follows: Remove idler gear. Bar engine until mark "1-6" or "1-8" on circumference of flywheel is exactly under center of flywheel pointer. Position camshaft so that gear keyway is exactly vertically upward. Replace idler gear. Next bar engine until mark "1-6" or "1-8" on circumference of flywheel is * ahead of center of flywheel pointer. Adjust camshaft until mark on slidable pump plunger registers with line on inspection window. Clamp gear to hub. Bar engine a few degrees in direction of normal rotation and make sure fuel cam continues to raise pump plunger. When adjustment is satisfactory, ream locating holes in ring gear to size of fitted bolt with a reamer and insert bolts.

* See injection setting on title page.

O. Overspeed Governor

The overspeed governor is engine-driven and acts upon the engine pneumatically. Its purpose is to provide protection over and above that offered by the normal governor to prevent the engine speed from exceeding its maximum allowable RPM.

When the engine speed exceeds tha maximum speed, as set on the governor, centrifugal force causes a set of weights to open a pilot valve which bleeds air from a balancing valve. This causes air pressure to be applied through a header running the length of the engine, to the fuel tappets, thereby lifting them. Lifting of the fuel tappets stops all fuel injection and halts the engine immediately.

When the engine slows, the pilot valve on the overspeed governor closes and the air pressure is removed from the fuel tappets, allowing normal operation to be resumed.

Diagram of the overspeed governor and balancing valve is shown at the rear of the book.

The setting of the bypass needle in the balancing valve is critical and its adjustment should not be disturbed.

For emergency stops, the cock on the balancing valve should be opened manually, causing air to be bled from the valve and causing the fuel tappets to be lifted, thereby stopping the engine.

P. Jacket Water Pump

The jacket water pump is a straight-vane centrifugal reversible type, mounted on the engine, and driven from the gear set at the front of the engine. The pump requires no attention under normal operation. Occasionally check packing for leaks. Do not tighten gland too tight, however, as the packing may score the shaft.

An illustration of the pump is given at the rear of the book.

Q. Sea Water Pump

The sea water pump is a positive-displacement gear type, mounted on the engine and driven from the gear set at the front of the engine. The pump itself is not reversible, since it pumps water in the opposite direction when its direction of rotation is changed. It is therefore used in conjunction with a water pump valve cage, which is a set of valves so arranged that the direction of water flow, so far as the external piping and engine is concerned, is the same no matter the rotation of the pump. Illustrations of [redacted] the valve cage [redacted] shown at the rear of the book.

R. Revolution Counter

Description: See Illustration

The revolution counter is mounted on engine gear case and driven from gear set through intermediate gears in counter housing. The revolutions of engine is recorded on the counter. The speed indication or tachometer generator is attached to connection flange on end of driveshaft. (See Chapter V "Tachometer") for description, maintenance, etc.

Maintenance:

Except for occasional check for wear on gears no maintenance is necessary.

Removal, Disassembly and Assembly:

To remove:

1. Remove tachometer.
2. Remove capscrews from housing and pull it off dowels.
3. Remove front connecting flange.
4. Remove gear on end of drive shaft and pull shaft out from front.
5. Remove revolution counter housing-nuts, and housing.

To disassemble revolution counter drive:

1. Remove front plate of counter.
2. Unbend lockwasher and remove ball bearing locknut.
3. Remove ball bearing retainer plate at bottom and pull out vertical shaft.
4. Clean all parts carefully in kerosene and dry before reassembling.

To assemble:

1. Reverse the disassembly procedure and use new gaskets if old gaskets are torn or damaged.

UG-8 Lever Type Governor Instructions

Refer to Drawing 030357D

Briefly, the operation of the governor is as follows:

The shaft 030193A which protrudes from the front panel carries a pinion which engages the rack cut on the speeder spring plug 030255A. Thus, by turning this shaft, the compression of the speeder spring 191465 can be varied. When the engine is running at a steady speed, the force exerted by the spring is just balanced by the centrifugal force of the flyballs 196038, and the lands on the pilot plunger 030084A just cover the ports in the pilot valve bushing 030088A. The gear cut on the bottom end of this bushing, together with the gear 204081A, form a pump which supplies oil under pressure to the pilot valve, to the top of the servomotor piston 030020A, and to the spring loaded accumulators. These consist of piston 030019A and spring 191323 working in bores in the controlet 030287A. The oil forces the piston up against the spring until a by-pass port cut into the bore is reached. Thus, the accumulators act as relief valves for the pump and as reservoirs for pressure oil, keeping the pressure at about 200 p.s.i.

When the load on the engine increases, it will slow down, thus reducing the speed of the governor flyballs and decreasing their centrifugal force. The spring will then force the pilot valve plunger downward through the speeder rod 030034A and the floating lever 030049A. This will admit oil under pressure to the bottom of the servomotor piston and cause it to move upward. This motion is transmitted through link 030168A and lever 030052A to the terminal shaft 030192A, and from here through suitable linkage to the engine fuel valves. When load is dropped from the

ADJUSTING THE COMPENSATION:

The compensation adjustments made at your factory may not be satisfactory when the engine is installed in the field. You should go through the procedure indicated here, even though the governor appears to work all right. The fact that a governor does not hunt does not necessarily mean that it is correctly adjusted.

(a) Loosen the nut holding the compensation adjusting pointer 030284A and set the pointer at its extreme downward position.

(b) Remove the compensating screw plug 138155A and open compensating screw 030009A two or three turns.

(c) Start the engine and let it hunt for thirty seconds or so.

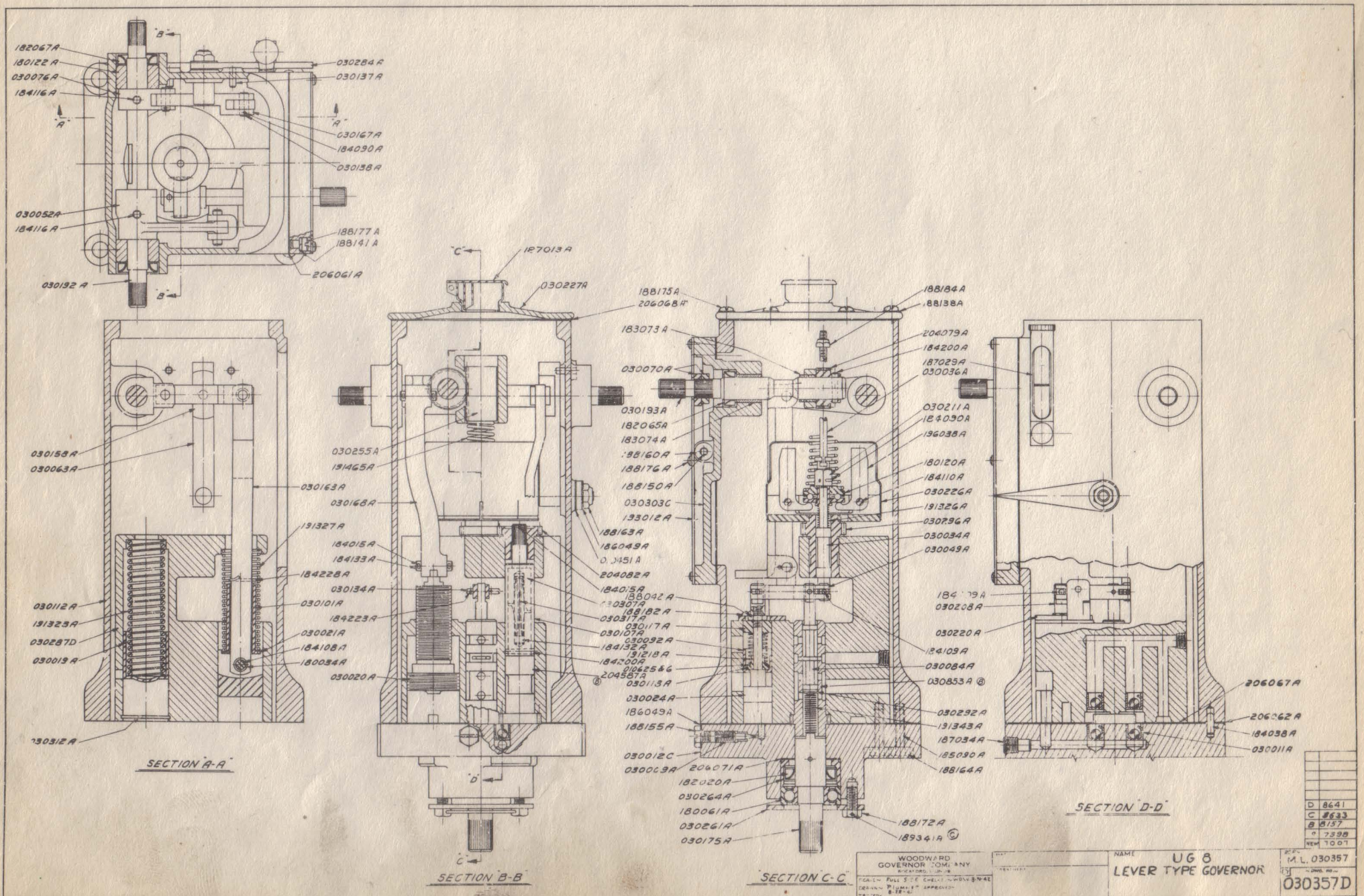
(d) Gradually close the needle valve until hunting stops, or until it is only about 1/8 turn open.

(e) If this does not stop the hunting, open the needle valve to about one turn and raise the compensation adjusting pointer about two graduations.

(f) Close the needle valve gradually again as under (d).

(g) Repeat until hunting stops.

(h) It is desirable to have as little compensation as possible. Closing the needle valve farther than necessary will make the governor slow to return to normal speed after a load change. Excessive dashpot plunger travel caused by adjustment of the compensation adjusting pointer too far toward maximum position will cause excessive speed change upon load change.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188177A
188141A
206061A
030192A
127013A
030227A
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188175A
183073A
030070A
030193A
182065A
183074A
188160A
188176A
188150A
030303C
193012A
188163A
186049A
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030117A
030107A
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188155A
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030287D
030019A
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SECTION A-A
SECTION B-B
SECTION C-C
SECTION D-D
WOODWARD GOVERNOR COMPANY
ROCKFORD, ILLINOIS
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DRAWN PLUMB 8-12-42 APPROVED
TRACED
NAME UG 8
LEVER TYPE GOVERNOR
REF. M.L. 030357
030357D
D 8641
C 8633
B 8157
A 7398
REV. 1007

PART V

TABLE OF CLEARANCES

Valves

Exhaust Valve Clearance in Guide - - - .0055" - .007"
Replace Guide if clearance exceeds .020"-.025"

Inlet Valve Clearance in Guide - - - - .0035" - .005"
Replace Guide if clearance exceeds .020"-.025"

Air Starting Valve Clearance in Cage - .015"

Main Piston in Cage - - - - - - - - - - .002" - .004"
Replace Piston if clearance exceeds .015"

Auxiliary Piston in Main Piston - - - .002" - .004"
Replace Worn Parts if clearance exceeds .015"

Rocker Arm

Radial Clearance on Shaft - - - - - - - .002" - .004"
Replace rocker arm bushings if clearance exceeds .010"

Roller on Pin - - - - - - - - - - - - - .0005" - .0025"
Replace pin and roller if clearance exceeds .010".

Tappets

Tappet in Guide - - - - - - - - - - - - - .005" - .007"
Replace with new Tappet Guide Liner if clearance exceeds .015" - .020"

Tappet Roller on Pin - - - - - - - - - - .0015" - .0030"
Replace pin and roller if clearance exceeds .012"

TABLE OF CLEARANCES
(Continued)

Connecting Rod Bearings

Clearance on Crankshaft - - - - - - - - .012" - .014"
Replace if Clearance exceeds .025"

Main Bearing

Clearance on Crankshaft - - - - - - - .010" - .012"
Replace if Clearance exceeds .025"

Piston

Piston in Liner (Skirt clearance) - - .014" - .016"
Replace liner if diameter of bore at any point exceeds 16.055".

Piston Pin

In Piston - - - - - - - - - - - - - Light Driving Fit @ 70°F.

Replace pin if clearance exceeds .002"

Piston Pin

In connecting Rod Bushing - - - .0065" - .0075"
Replace bushing if clearance exceeds .015"

Top of Piston to Top of Cylinder Block .830" - .840"
Adjust by means of compression shims between foot of connecting rod and bearing.

Piston Rings

Gap Clearance
Sealing Rings - - - - - - - - - - .040" - .055"
Top Compression Ring - - - - - - - .040" - .060"
Second and Third Compression Rings- - - - .025" - .040"
Oil Rings - - - - - - - - - - - - - .025" - .040"
Replace rings if wear exceeds .200"

Side Clearance in Groove
Top Two Rings - - - - - - - - - - .006" - .0085"
All Other Rings - - - - - - - - - .004" - .0065"
Replace ring if side clearance exceeds .014"

PART VI

ENGINE TROUBLES AND SUGGESTED REMEDIES

ENGINE FAILS TO TURN OVER WHEN OPERATING CONTROL IS MOVED INTO START POSITION

Probable Cause	Suggested Remedy
1. Air Starting Equipment out of order	
a. Insufficient air pressure.	a. Pump up pressure to 200 to 250 p.s.i.
b. Valves closed in air supply.	b. Open all valves.
c. Air valves improperly timed.	c. Adjust timing.
d. Air Starting valve stuck or leaking.	d. Release pressure in cylinder by means of the relief valve. Remove air valve and clean.
e. Air not being bled from top of Air Starting Valve.	e. Check pilot valve and line to pilot valve for obstruction.

ENGINE TURNS OVER ON AIR BUT WILL NOT START

1. No fuel is being delivered	
a. No fuel in tank or valve closed.	a. Refill tank and open all valves.
b. Fuel inlet pipe clogged or filter dirty.	b. Clean pipe and filter.
c. Air in fuel line.	c. Vent system of air.
d. Water in fuel.	d. Drain all water from fuel system and refill with clean oil.
e. Fuel control linkage sticking in "off" position.	e. Free linkage.

ENGINE TURNS OVER ON AIR BUT WILL NOT START (Cont'd.)

Probable Cause	Suggested Remedy
f. Injection pump timing improperly set.	f. Adjust timing.
2. Lack of compression	
a. Valves sticking	a. Free valves and deposit oil on stems.
b. Valves riding open.	b. Adjust hydraulic lifters.
c. Valves not seating properly.	c. Reseat valves.
d. Leaky head gaskets.	d. Replace gaskets.
e. Incorrect clearance between top of piston and top of cylinder block.	e. Adjust clearance by adding shims between connecting rod and bearing. Check clearance of connecting rod bearings and piston pin bushings.
f. Stuck piston rings.	f. Clean rings, ring grooves and oil drains.
g. Rings or cylinder liners worn,	g. Replace rings. Use oversize rings if necessary. If liners are scored or worn more than .040" replace liners.
h. Cracked piston.	h. Replace piston.

ENGINE STOPS OR SLOWS DOWN WHEN RUNNING

Probable Cause	Suggested Remedy
1. Fuel tank running dry.	1. Check whether transfer pump delivers fuel to tank. Check whether air release on tank is operating properly.
2. Water in fuel.	2. Drain all water from fuel system. Refill with clean oil.
3. Exhaust manifold becomes clogged.	3. Clear manifold and ascertain cause of excessive accumulation.
4. Piston seizing. Actual seizure accompanied by high-pitched squeaking noise.	4. Stop engine immediately at first sign of a tight piston. Check cooling and lubrication. Inspect piston and liner. Replace if necessary.

ENGINE FIRES IRREGULARLY

1. Lack of proper fuel delivery	
a. Fuel inlet pipe clogged or second stage filter element dirty.	a. Clear pipe. Clean filter.
b. Fuel tank running dry.	b. Check whether transfer pump delivers fuel to tank. Check whether air release on tank is operating properly.
c. Air in fuel line.	c. Vent filter, supply header, injection pumps and nozzles.
d. Water in fuel.	d. Drain all water from fuel system. Refill with clean oil.

ENGINE FIRES IRREGULARLY (Continued)

Probable Cause	Suggested Remedy
2. One or more cylinders misfires or fires irregularly	
a. Fuel nozzle bleeder valve open.	a. Close bleeder valve.
b. Fuel nozzle stuck, clogged, damaged or worn.	b. Replace with spare and check.
c. Leaky joints in injection tubing.	c. Clean joint faces and tighten joints.
d. Fuel pump control lever improperly set.	d. Adjust fuel pump control lever until pyrometer reading for this cylinder coincides within 20°F. to readings on other cylinders. If, when this condition is satisfied, control rod reading on pump differs by more than 2 mm. from that of other cylinders, check cause and correct.
e. Fuel pump timing improperly set.	e. Adjust timing.
f. Fuel pump dirty, damaged or worn.	f. Replace with spare and check.
3. Lack of compression in one or more cylinders.	3. See page 6-A-2.

SMOKY EXHAUST - BLACK SMOKE CAUSED BY EXCESSIVE FUEL

1. Intake louvres or elbows clogged.	1. Remove and clean.
2. Injection nozzle not closing tightly or not atomizing properly.	2. Replace with spare and check.

SMOKY EXHAUST - BLACK SMOKE CAUSED BY EXCESSIVE FUEL (Continued)

Probable Cause	Suggested Remedy
3. Fuel pump improperly timed.	3. Adjust timing.
4. Engine overloaded.	4. Check load. Reduce if necessary.
5. One or more injection pumps delivering too much fuel per stroke.	5. Adjust fuel pump control lever until pyrometer reading for this cylinder coincides within 20°F. to readings on other cylinders. If, when this condition is satisfied, control rod reading on pump differs by more than 2 mm. from that of other cylinders, check cause and correct.

SMOKY EXHAUST -BLUE SMOKE - LUBRICATING OIL IN EXHAUST

1. Piston rings stuck or drain holes clogged.	1. Clean rings, grooves and oil drains.
2. Rings or cylinder liners worn.	2. Replace rings. Use oversize rings if necessary. If liners are scored or worn more than .040" replace liners.

ENGINE KNOCKS

1. Fuel pump timing improperly set.	1. Adjust timing.
2. Nozzle sticking open.	2. Replace with spare and check.
3. Type of fuel not suitable.	3. Check fuel with specifications.
4. Piston too loose in liner.	4. To check: Cut out cylinder in question by opening bleeder valve. If knock disappears, check piston skirt clearance. Install new liner, or piston, if necessary.

ENGINE KNOCKS (Continued)

Probable Cause	Suggested Remedy
5. Loose piston pin or piston pin bushing worn or burned out.	5. To check: Place piston on bottom dead center. Check with pry bar on piston. Replace piston pin or piston pin bushing if necessary.
6. Connecting rod bearing burned out or badly worn.	6. Check clearance with pry bar. Replace shells if necessary.
7. Main bearings burned out or badly worn.	7. Remove cap and inspect. Replace shells if necessary.

INSUFFICIENT LUBRICATING OIL PRESSURE AS SHOWN ON MAIN LUBRICATING OIL GAUGE

1. Insufficient oil in service tank	
a. Lubricating oil suction connection from base covered with sludge.	a. Clean suction connection.
b. Piping connections loose.	b. Tighten connections.
c. Scavenging pump defective.	c. Check clearances.
2. Lubricating oil filter clogged.	2. Clean filter.
3. Clogging of oil line.	3. Clear line.
4. Relief valve sticking, not seating properly or improperly adjusted.	4. Free valve, reseat and adjust if necessary.

INSUFFICIENT LUBRICATING OIL PRESSURE AS SHOWN ON MAIN LUBRICATING OIL GAUGE - Continued -

Probable Cause	Suggested Remedy
5. Loose or worn bearings.	5. Adjust bearing clearances. Replace if necessary.
6. Pressure piping connections loose.	6. Tighten connections.
7. Pressure pump defective.	7. Check clearances.

EXCESSIVE LUBRICATING OIL PRESSURE AS SHOWN ON MAIN LUBRICATING OIL GAUGE

1. Relief valve stuck or adjustment incorrect.	1. Free valve and adjust if necessary.

INSUFFICIENT JACKET WATER PRESSURE AS SHOWN ON MAIN WATER PRESSURE GAUGE

1. Air in jacket water pump.	1. Open vents on pump or on top of suction. Inspect circulating water piping for air leaks.

JACKET WATER PRESSURE SUFFICIENT BUT TEMPERATURE EXCESSIVE

1. Insufficient water supply due to --	
a. Sea suction clogged or valves closed.	a. Clear suction and open valves.
b. Loose connections.	b. Tighten.
c. Air in water pump.	c. Open vents on pump or on top of suction.
d. Overboard discharge clogged.	d. Clear discharge.
e. Temperature control valve not properly set.	e. Reset to obtain correct temperature.

JACKET WATER PRESSURE SUFFICIENT BUT TEMPERATURE EXCESSIVE

Probable Cause	Suggested Remedy
2. Engine water passages clogged, or coated with scale.	2. Clean out engine with approved solvent.

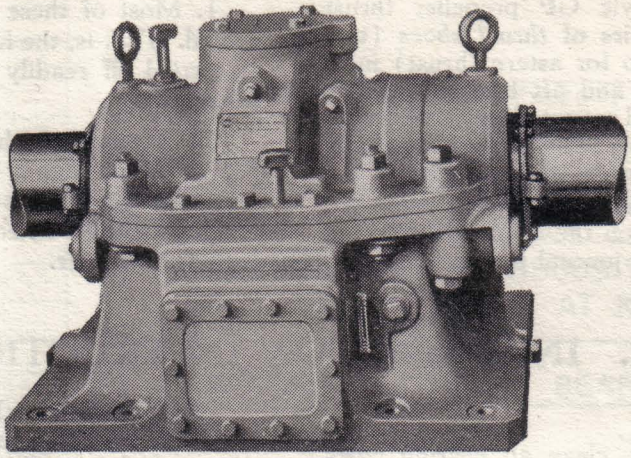
MISCELLANEOUS TROUBLES

1. Lubricating oil temperature too high due to oil cooler passages clogged or coated with scale.	1. Clean oil cooler.
2. Engine speed fluctuates or fuel control shaft changes position constantly due to --	
a. Governor linkage or fuel control shaft stuck.	a. Free governor linkage and fuel control shaft.
b. Fuel pump control rod stuck.	b. Replace pump with spare.
c. Governor linkage worn.	c. Replace worn parts.

MISCELLANEOUS TROUBLES - Continued.

Probable Cause	Suggested Remedy
3. Excessive smoke from crankcase breathers due to --	
a. Stuck piston rings.	a. Clean rings, ring grooves, and oil drains.
b. Rings or cylinder liners worn.	b. Replace rings. Use oversize rings if necessary. If liners are worn more than .040", replace liners.
c. Cracked piston,	c. Replace piston.

7755
8065



INSTRUCTIONS

for Installing and Operating

Style GF

(Horizontal Two-Shoe Adjustable Type)

KINGSBURY THRUST BEARINGS

STYLE GFS-21 THRUST BEARING
on propeller shaft
U.S. Army Tugs

Enterprise Engine & Foundry Co.
San Francisco, California
P.O. Nos. 5055, 2533, 621

KINGSBURY MACHINE WORKS, INC.

4316-28 Taekawanna Street **Frankford, Philadelphia, Pa.**

Cable Address "ALKING," Philadelphia

7-41-1M

PRINTED IN U. S. A.

KINGSBURY

I. GENERAL DESCRIPTION

DRAWING REFERENCES

(A) PRINCIPAL PARTS:

1. The standard Style GF propeller thrust bearing includes two pairs of *thrust shoes* (two shoes for ahead and two for astern thrust) individually adjustable fore and aft by *jack screws,* and a *journal bearing,* all mounted in one housing with suitable *end closures.* There is only one *thrust collar,* usually forged integral with the shaft.

2. Lubrication is automatic, being accomplished by an *oil scraper* riding on the collar, distributing oil to collar surfaces and journal bearing.

(B) COOLING:

1. Most of these Style GF bearings run air-cooled. That is, the heat resulting from oil friction is carried off readily by the surrounding air and foundation.

2. For large, high-speed bearings, water-cooling coils are usually provided in the housing oil reservoir. Sometimes oil is circulated through the bearing from an external oil supply system, which includes a cooler.

II. INSTALLATION INSTRUCTIONS

(A) CLEANING:

1. Before assembling, clean all bearing parts and the inside of the housing, also any oil piping. Remove anti-rust coatings with gasoline or kerosene. Use rags or cloth, as waste leaves lint, which clings to minute burrs and may cause trouble.

IMPORTANT. A poorly-cleaned bearing will score and wear out rapidly. A bearing surface is not clean till a white cloth wiped over it shows no soil.

(B) INSPECTION:

1. Inspect all bearing parts after cleaning, to make sure they are free from rust and bruises. Remove with a scraper any bruises on the babbitt faces. Remove slight bruises or rust on journal or collar surfaces with a fine oil stone. High spots due to heavier bruises may require filing or scraping; but always finish with an oil stone. Deep rust requires refinishing.

(C) LINING UP:

1. Close alignment of bearing and shaft is essential. This demands careful shimming or wedging, and strong, rigid foundations. The most accurate alignment will be disturbed if the foundation is so weak as to spring under load.

2. Either fitted bolts, or fitted blocks or wedges, should be used to secure the housing flange in position on the base. These should be arranged so that the collar will be about midway of its fore and aft clearance in the housing.

(D) ASSEMBLING DETAILS:

1. End play (or oil clearance) between ahead and astern shoes is strictly necessary. We recommend a total end play of .001" per inch of collar diameter. After the housing has been bolted down, and the endwise position of the thrust collar determined, run all the jack screws in until the shoes bear evenly on the collar. Do this with collar and shoes wiped dry. Lock the jack screws on the ahead (loaded) side. Then back the jack screws on the unloaded side by exactly equal amounts, using a "feeler" with thickness equal to end play, *back of the pivotal support* of each shoe on the unloaded side. Lock the jack screws and remove the "feelers." Now oil the collar.

2. Before placing the housing upper half, remove the top cover plate and the bronze oil scraper. Replace these after upper housing is bolted down.

3. For convenience, pour oil in before bolting down the top cover plate. Fill to "HIGH" mark on oil level gauge. Use only clean, high grade oil of the viscosity specified on the nameplate.

III. OPERATION

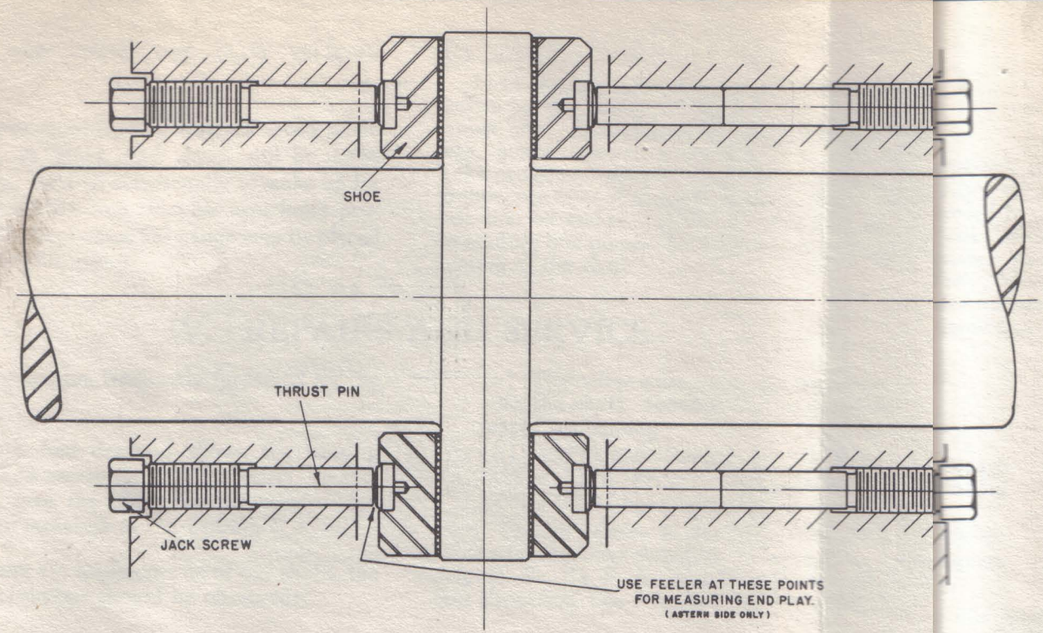
(A) GRADE OF OIL:

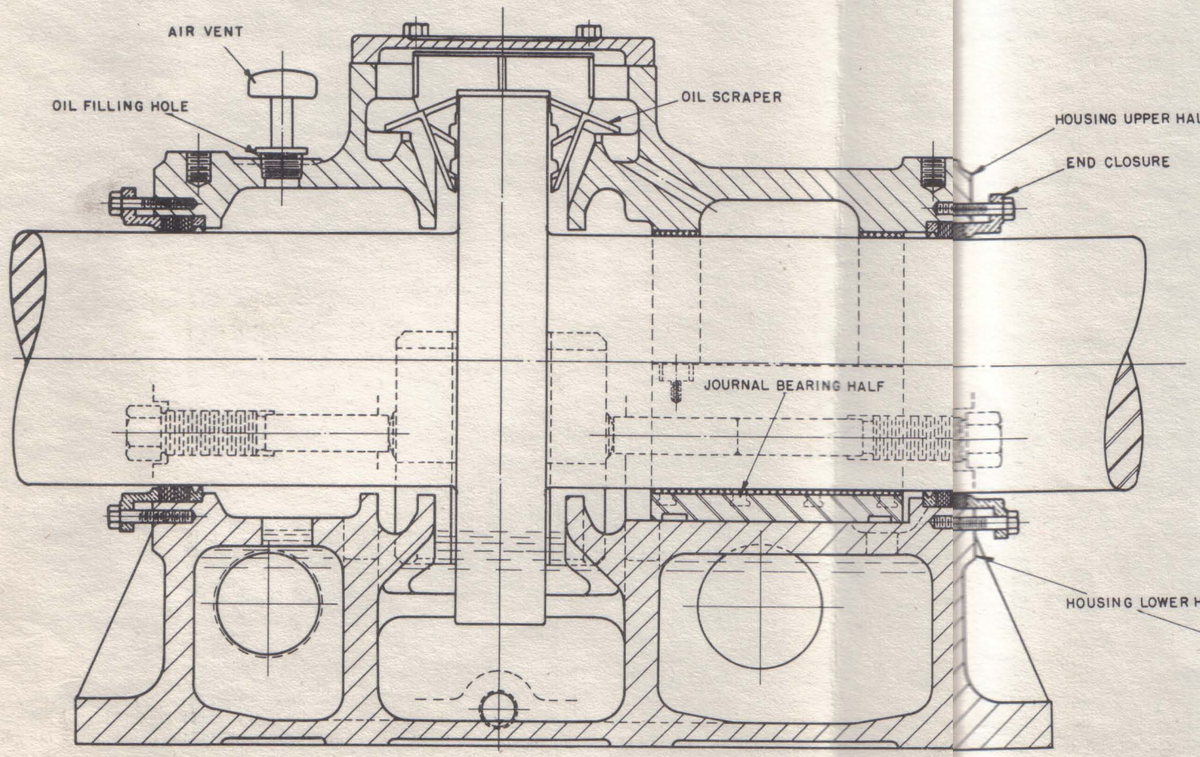
1. For average conditions with propeller thrust bearings, a heavy turbine or engine oil should be used. If the oil is too light, the lubricating film may be dangerously thin. If too heavy, the friction is needlessly high. Specific advice as to viscosity is marked on the nameplate.

2. The oil must be clean and free from grit and other injurious substances. Fine grit has a scouring action and may gradually wear down the bearing surfaces. Poor oil may cause corrosion.

(B) OIL LEVEL:

1. It is important to maintain the oil at the proper level. Plates are attached to both sides of



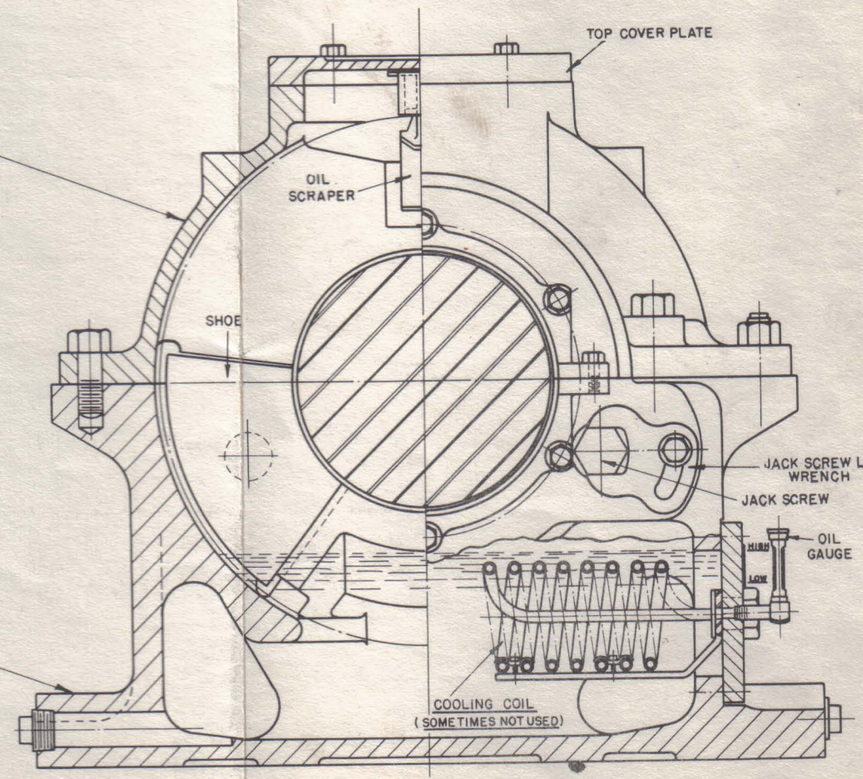


PARTS LIST	
1	HOUSING UPPER HALF
2	HOUSING LOWER HALF
3	TOP COVER PLATE
4	OIL SCRAPER
5	END CLOSURE
6	SHOE
7	THRUST PIN
8	JACK SCREW
9	JACK SCREW LOCK WRENCH
10	AIR VENT CAP
11	OIL GAUGE
12	COOLING COIL
13	JOURNAL BEARING HALF

SIZE	21"	RECOMMENDED END PLAY	.021"
R.P.M.	200 275	JOURNAL CLEARANCE	.012"
REF. No.	7755 8065	APPROXIMATE WATER FLOW	2-4 GPM

RECOMMENDED OIL VISCOSITY NOT LESS THAN 400 S.U.V AT 100° F.

STYLE "GFS"
KINGSBURY THRUST BEARING.



REF. DWG. 463000

KINGSBURY MACHINE WORKS, INC.
PHILADELPHIA, PA.
DR. W.H.P. DATE 12-28-42

NO. 263104

the housing, with "HIGH" and "LOW" oil levels noted.

2. Fill housing with oil to "HIGH" mark when not running. A slight draw down will be noted when running. Add oil occasionally to make up for leakage and evaporation. The air vent holes provided should be kept open. Oil gauge may be placed on either side of housing.

(C) OPERATION:

1. In normal operation, the only attention required by the bearing is as follows: Keep oil at proper level. In water-cooled and oil-cooled bearings, guard against interruptions of circulation. Take occasional samples of oil from housing base to show presence of water and sludge, if any. Make sure that oil added is clean. Do not take up hard on stuffing box glands, as it will cause unnecessary heating of the shaft.

IV. REPAIRS AND SERVICE

1. Spare shoes are frequently furnished for the loaded side.

2. The attached drawing shows the bearing construction and names the principal parts. In correspondence, give the order number stamped on the nameplate attached to the bearing.

3. If repairs are made outside of our shops, the following precautions should be observed:

(a) The collar must run perfectly square with the shaft. Remove tool or grinding marks by lapping.

(b) Use high-tin babbitt for the shoes. Scrape to a surface after machining. Round the radial edges slightly.

4. Prompt service is available from the home office of Kingsbury Machine Works, Inc., Philadelphia, Pa., U. S. A., and from branch offices in San Francisco, Los Angeles, and New Orleans.

INSTRUCTIONS FOR INSTALLATION OPERATION, AND MAINTENANCE OF THE ELLIOTT-BUCHI TURBOCHARGER UNIT

CONTENTS

ILLUSTRATIONS AND PARTS LIST

ELLIOTT COMPANY

DISTRICT OFFICES

Atlanta, Ga.	Haas-Howell Bldg.
Boston, Mass.	One Federal Street
Buffalo, N.Y.	Jackson Building
Chicago, Ill.	20 N. Wacker Drive
Cincinnati, Ohio	Union Central Bldg.
Cleveland, Ohio	Guardian Bldg.
Denver, Colo.	1925 Blake Street
Detroit, Mich.	Dime Bank Bldg.
Houston, Texas	M. & M. Bldg.
Kansas City, Mo.	Fairfax Bldg.
Los Angeles, Calif.	1732 E. Seventh St.
Minneapolis, Minn.	Baker Bldg.
New York, N.Y.	Transportation Bldg.
Philadelphia, Pa.	Morris Bldg.
Pittsburgh, Pa.	Frick Bldg.
San Francisco, Calif.	Rialto Bldg.
St. Louis, Mo.	1221 Locust St.
Seattle, Wash.	Northern Life Tower
Tulsa, Okla.	McBirney Bldg.
Washington, D.C.	Tower Bldg.
Wilkes-Barre, Pa.	Second National Bank Bldg.

ELLIOTT COMPANY

SALES HEADQUARTERS AND WORKS

JEANNETTE, PENNA.

SECTION I

GENERAL DATA

PURCHASER

Enterprise Engine & Foundry Company
San Francisco, California
Purchase Order No. 2532

INSTALLATION

Q.M.C. Tugs

DIESEL ENGINE

Manufacturer: Enterprise Engine & Foundry Company
San Francisco, California
Model: DMQ-38

Bore: 16 Inches, Stroke: 20 Inches

No. Cyl. 8

Manufacturer's Turbocharged Rating:

1200 b.h.p. at 275 r.p.m. continuously

ELLIOTT-BUCHI TURBOCHARGER

Record E-102699 S.O. 10542
Size BF44 Serial No. 564 to 577 Incl. And
611 to 616 Incl.

The following estimated performance data are based on continuous engine rating:

1. Inlet air temperature: 80° F.
2. Inlet air pressure: 14.61 lb. per sq. in. abs.
3. Inlet air volume: 3900 cu. ft. per min.
4. Blower discharge pressure, total: 4.35 lb. per sq. in. gage
5. Approximate blower speed: 8500 r.p.m.
6. Exhaust gas temperature at turbine inlet: 910° F.
7. Exhaust gas pressure before turbine: 4.1 lb. per sq. in. gage
8. Exhaust gas pressure after turbine: 4 inches of water maximum

Note: Actual performance may vary slightly from foregoing figures, as in some cases the air pressure drop through the Diesel engine may differ slightly from values anticipated when the turbocharger requirements of a particular engine are calculated.

Maximum conditions not to be exceeded in operation of turbocharger:

1. Blower speed: 12,500 r.p.m.

2. Exhaust gas temperature at turbine inlet: 1020°F. continuously; or 1100°F. for 15 minutes.

   Note: Exhaust gas temperature at turbine inlet will differ from exhaust gas temperatures at cylinder head elbow.

   Above temperature limitations are required by the turbocharger turbine material.

Turbocharger arrangement:

1. Number of exhaust leads from engine: 4

2. Shaft arrangement: horizontal

SECTION 2

GENERAL INFORMATION

The Elliott-Buchi Turbocharger is a self-contained unit, comprising a gas turbine and a centrifugal blower, mounted on a common shaft. The exhaust gas from the power cylinders of the Diesel Engine is led to the turbine section of the unit. The exhaust gas turbine utilizes a part of the energy in the exhaust gas which is otherwise wasted. This salvaged energy is used to drive the centrifugal blower, without demand on the power developed by the engine. The blower supplies all the air required by the engine power cylinders, at a low pressure, through the conventional air intake manifold.

The turbocharger unit is used in conjunction with the Buchi system of pressure scavenging and charging a four-cycle Diesel engine. In the Buchi system, the low pressure air delivered by the turbocharger accomplishes two ends; first, it scavenges the hot residual gases otherwise left in the engine cylinder at the end of the exhaust stroke, and replaces these hot gases with cooler, fresh air; second, it results in an air charge of higher density and pressure at the end of the suction stroke. The provision of a greater amount of fresh air permits the combustion of a greater quantity of fuel, and consequently, a higher output from a turbocharged engine than from an engine not so equipped.

The valve timing of an engine arranged for the Buchi system of pressure charging differs primarily from that of the same engine uncharged in that the exhaust valves of the pressure charged engine close later, and the inlet valves open earlier. This arrangement provides a greater period of valve overlap, during which both inlet and exhaust valves of a particular cylinder remain open. Scavenging is thereby effected when the piston is near top dead center. Timing of the valve opening and closing is so arranged, and the dimensions of the exhaust manifolding are so selected, that timed pressure fluctuations set up in the exhaust manifolding permit scavenging with the low pressure air delivered by the turbocharger blower.

Scavenging the combustion space with cool air effects a considerable degree of cooling of the cylinder head, cylinder walls, valves, and piston. For this reason, a greater amount of fuel can be burned, and greater power developed in an engine turbocharged with the Buchi system without harmful effects on these engine parts due to excessive heat.

No control over the turbocharger is necessary, as the correlated action of the turbine and blower is entirely automatic. The speed and output of the turbocharger vary automatically and promptly with variations in load or speed, or both, of the engine. No consideration need to be given to direction of rotation of the turbocharger when applied to a direct reversible marine engine. The turbocharger rotates in one direction only, regardless of the direction of rotation of the engine.

SECTION 3

DETAILS OF CONSTRUCTION

Construction of the Elliott-Buchi turbocharger is shown in the cross sectional view on the accompanying assembly drawing. Essentially, the turbocharger contains a rotor independent of the engine rotating elements, which carries a single stage impulse turbine driven by exhaust gases of the engine, and a directly coupled single stage centrifugal blower.

The engine exhaust gases are conducted to the cast steel turbine inlet (Piece #159-4) by several exhaust headers. The number and arrangement of these headers are dependent on the number of engine cylinders. The turbine nozzle ring (Piece #107-4) is attached to the turbine inlet casing. The nozzle ring is cast of a special heat resisting iron, in which are cast the alloy steel nozzle blades.

The turbine casing (Piece #1-4) is a special iron casting and is cored to provide cooling water passages. An oval flange is provided for the turbine exhaust gas connection. Pads are provided at three points for supporting bracket connections.

The turbine casing backplate (Piece #287) is a special iron casting and is also cored to provide cooling water passages. This casting forms the wall separating the blower casing (Piece #163-4) and turbine casing (Piece #1-4), and is split vertically to facilitate assembly when the rotor is in place. The backplate is attached on one side to the turbine casing, by a ring of studs, and is attached on the other side to the blower casing, by a ring of tap bolts.

The blower casing (Piece #163-4) is a heavily ribbed iron casting. Air enters the blower casing axially and is discharged radially from the impeller, through the diffuser ring, (Piece #103-4) into the volute, which has a tangential discharge. The diffuser ring is a disk casting with special vanes to control passage of air. The diffuser ring is held in place by compression between the blower casing and the turbine casing backplate.

The shaft (Piece #83-4) is counterbored at the inner end to center and receive a projection on the turbine disk. The shaft is driven by the turbine disk by two fitted dowels (Piece #82). The shaft is secured to the turbine disk by a socket head cap screw (Piece #35) which is retained by the locking tube (Piece #86). This tube provides an inward passage for the shaft cooling oil. A section of the shaft, adjacent to the turbine disk, overhangs the bearing support, and carries the blower impeller, (Piece #42-4). The shaft drives the impeller through four keys (Piece 212-4). The impeller is secured on the shaft by the impeller locknut (Piece #41-4) which is secured by a screwed dowel, (Piece #181-A).

The turbine disk assembly (Piece #30) comprises a slotted disk and inserted blades. The blades have a bulbous root and are pressed into the rotor disk and peened. The disk and the blades are constructed of a special heat resisting alloy steel.

The blower impeller (Piece #42-4) is of the single inlet, enclosed type. The impeller is a one piece casting of a special aluminum alloy, having a serrated steel insert cast in the bore. A steel bushing is pressed in the impeller bore on the one side of the serrated insert. The serrated insert and the bushing are bored for a close fit on the shaft, and are keywayed for the four driving keys. Steel labyrinth rings are retained in the backplate and blower casings, and seal the impeller discharge.

After finish machining, the impeller is balanced statically and dynamically. The balanced impeller is assembled with the turbine disk and shaft. This complete assembly is then balanced both statically and dynamically.

The bearing support (Piece #94) is carried in the blower casing and is supported and aligned by a press fit and an external flange. The bearing support fits closely in the blower casing, and is sealed on inner and outer fits by oil-proof synthetic rubber rings (Pieces #177 and 178). Inner and outer bearing shells (Pieces #180 and 179), are pressed in the bearing support, secured by locking screws(Pieces #99 and 100). The bronze oil baffle (Piece #174) is inserted in the inner end of the bearing support, is sealed by a synthetic rubber gasket, (Piece #173), and is secured by the oil baffle nut, (Piece #33).

The bearing support is drilled axially for lubricating oil. Supply connection is made at the bearing support flange face. Bearing sealing air is led from the blower casing volute through a throttling orifice, into one of the horizontal cored ribs. Air enters the bearing support through radial drilling aligning with the horizontal cored rib, and passes along axial drilling to the oil baffle. Bearing sealing air is introduced into the annular space in the oil baffle which lies around the shaft, inward from the oil slinger, to seal and scavenge oil in the bearing support.

The unbalanced part of the rotor end thrust is taken by the thrust collar (Piece #89) at the outer end of the shaft. The steel thrust collar has hardened thrust faces, is keyed to the shaft, and is secured by the special nut. The thrust bearing (Piece #34) is keyed in the bearing support and has a specially grooved surface to support high bearing loads. The end clearance or axial float of the rotor is determined by the amount of clearance of the thrust collar between the outer bearing shell flange and the thrust bearing.

The air intake silencer (Piece #120-4) is fabricated of sheet steel. The construction is indicated on the accompanying assembly drawing. The silencer mounts directly on the blower casing flange. The air passage walls are formed by the perforated steel plate, back of which is packed felt. Access to the oil pump and lubricating oil piping is possible through a removable cover on the silencer face.

Each turbocharger is equipped with a completely self-contained lubrication system. A diagram of this system and a general layout of the parts is shown on the accompanying assembly drawing. The oil tank (Piece #113-4) is fabricated of sheet steel and is supported by the silencer and by the blower casing drain fitting. A finned oil cooling tube (Piece #130-4) is immersed in the sump tank, is supported by an exterior flange at one end, and by a pin (Piece #119-B), at the inner end. The oil pump assembly (Piece #203) contains a reduction gear train having a ratio of 9.596 to 1, for the lubricating oil pump and tachometer drive, and is supported by the bearing support flange. The pump assembly is driven by the turbocharger shaft through an oil resistant rubber coupling (Piece #87) encircled by a retainer ring (Piece #211). Lubricating oil tubing is of steel. The ball type check valve (Piece #157), and the relief valve (Piece 141-4) are mounted in the oil piping. The lubricating oil filter (Piece #142) is of the replaceable yarn cartridge type.

SECTION 4

COOLING WATER

The requirement for clean, soft water for circulation in the water jacket of the turbocharger is just as important as in the engine proper. Condition of the cooling water should be such that there is no possibility of deposit of sludge or scale on the jacket surfaces, or of accumulation of free oxygen in the water.

The cooling water system performs three functions. One, it prevents excessive heat conduction from the turbine end of the unit to the blower end, two, it removes the heat from the oil that is generated in the bearings, and three, it prevents distortion of the mounting surfaces of the turbine casing.

Circulation of the water is divided into two parallel systems, which are to have common supply and discharge connections. One system consists of the oil cooler, a connecting pipe, and the backplate. The other system consists of the turbine casing by itself. Direction of flow through the first system is through the cooling tube, into the bottom of the turbine casing backplate out the top of the turbine casing backplate and into the discharge adapter on the turbine casing. Direction of flow through the turbine casing is in the bottom and out the top into the discharge adapter, where the flow of the two systems join.

Water circulation through the turbocharger should be provided and regulated at such a rate that the temperature rise of the cooling water does not exceed 25°F. at full engine load. This precaution will minimize the possibility of distortion of parts due to unequal temperatures. The discharge temperature should not exceed 180°F. for clean soft water, or lower temperatures may be required if dictated by characteristic of the water used.

Installation of piping should be made in accordance with Section 6 to assure proper water circulation and permit draining. In freezing weather, and when the unit is not operating the jackets and oil cooler should be completely drained to prevent damage.

Connections or plugs should be removed annually, the cooling water jacket spaces inspected for scale or sludge, and any accumulation removed, as discussed under Section 10, "Maintenance". If the cooling water used is not clean and soft, more frequent attention will be necessary.

Due to the amount of heat in internal parts and walls of the turbocharger it is recommended that the cooling water system be so designed that the turbocharger water jackets will be adequately vented, and that cooling water circulation through these jackets after shut-down of the unit will be provided by convection or by some separate pressure source, until the unit has cooled. Otherwise, heat remaining in the unit may be sufficient to boil the water in the turbocharger jackets, or in a small closed system.

Comments on cooling water piping installation are listed on Page VI-2.

SECTION 5

LUBRICATION SYSTEM

The oil flow diagram and general piping layout on the accompanying assembly drawing indicate the general details of the self-contained lubrication system. The lubricating oil pump is direct driven from the main rotor shaft, through a reduction gear train. Gears and bearings in the pump are oiled through drilled passages in the gears and in the pump shafts. The pump drive shaft is drilled for passage of cooling oil to the rotor locking tube.

The pump takes suction from the oil tank through a suction line check valve, and discharges through the oil filter into the bearing support, for lubricating the journal bearings and thrust bearing. Pressure of oil fed to the bearings is controlled by a relief valve in the pump discharge line, which by-passes excess oil back to the oil tank before passing through the filter.

Lubricating oil passages in the bearing support, and the cored drain space in the lower vertical blower casing rib, are shown in the accompanying illustration. Drilling in the bearing support header feeds the thrust bearing and the two journal bearings.

Cooling oil is conducted to the inner end of the shaft through the locking tube, and returns to the drain along the space between the locking tube and the shaft bore. Cooling oil leaves the shaft in the thrust bearing drain space, and drops into the drain rib. The thrust collar key controls the alignment of drain holes in the shaft and thrust collar.

Lubricating oil is returned from the oil baffle and from inner and outer bearing bushings through cored drain passages in the bearing support. The bearing sealing air is admitted into an annular space in the oil baffle, flows over the oil slinger, and aids in sealing and scavenging oil in the bearing support. Lubricating oil and cooling oil drains combine in the bearing support and are led into the cored drain rib. Sealing air is vented from the oil tank by risers. The drain pipe is flanged to attach to the blower casing flange, and conducts oil from the drain rib to the oil tank.

Lubricating oil pressure should be set by adjusting the pressure relief valve to a pressure of about 15 lb. per sq. in. at a turbocharger speed corresponding to full engine speed and load. This pressure will vary somewhat as the turbocharger speed varies.

Lubricating oil level should be checked with the bayonet type oil gage on the tank and the oil level properly maintained. If the oil level is maintained too high, excessive frothing and dissipation of lubricating oil will result.

Lubricating oil should be added to the tank through the filler opening. Only new, clean oil, free from acid, dirt, water, and foaming tendencies should be used in the turbocharger. The oil used should be of high quality and should be of medium weight, similar to an S.A.E. 30 grade, having a viscosity range of 185 to 255 S.S.U. at 130°F. The desired oil temperature in the tank is 100-125°F. and should not exceed 160°F.

It is not possible to stress too highly the need for assuring an uninterrupted supply of lubricating oil to the turbocharger bearings, and to use a high quality of oil, free from contamination. The high rotative speed of the unit, and the extreme heat to which it is subjected make such precautions essential to satisfactory operation.

SECTION 6

INSTALLATION

Initial Installation on Engine

The turbocharger is shipped completely assembled. Certain openings will be plugged to prevent introduction of foreign matter, and exposed surfaces will be protected against rust. Spare parts will be packed and shipped separately. It will not be necessary to disassemble the main unit before installation.

In order to lift the turbocharger, a hook should be passed through the eyebolt in the top of the blower casing. This will properly support and balance the unit. Under no condition should a rope or chain be used through the ribs in the blower casing air inlet, as damage to rotor might result.

Surfaces coated with a rust preventative compound should be cleaned with a solvent. Before mounting on the engine, gaskets of material suitable for high temperatures should be available for the flanges between the exhaust manifolds and the inlet casing. A gasket should be available for the blower casing discharge flange. Graphite and oil, or some suitable compound should be applied to bolt and nut threads subjected to the temperatures encountered in the exhaust lines.

It is essential that the turbocharger rotor turn freely. The rotor should be rotated in a counterclockwise direction by hand by reaching in the turbine casing discharge connection and an impression obtained concerning the ease of turning the rotor. After mounting the unit on its brackets, and also after coupling turbine inlet connection and air lines, a final check through the turbine casing discharge connection should be made to assure that the shaft is free.

It is important that the lower turbine casing flange and the bolting lugs on either side of the turbine casing be the points of support of the unit. Mounting brackets of suitable strength and rigidity are to be supplied by the engine builder. The piping to the inlet casing, the turbine casing or the blower casing, should not be depended upon for support of the turbocharger, nor can any appreciable weight of such piping be supported by the unit. The engine builder shall provide expansion pieces or joints, as required, in the exhaust gas or air lines, to and from the turbocharger, to prevent transmission of piping strains to the turbocharger.

The nameplate for the turbocharger, listing the numbers of patents applicable to the turbocharger, and also listing other pertinent data, is directly attached to the turbocharger. A separate nameplate is also supplied, listing the numbers of patents referring to application of the Buchi system of turbocharging to the Diesel engine. This must be attached to the engine in some readily visible location, preferably near the engine nameplate.

Service Installation

It is essential that expansion joints or flexible piping be installed

in the turbocharger exhaust piping to relieve the unit of piping strains. Such flexible provisions must be properly supported to prevent excessive weight being carried by the turbocharger casing.

Water inlet connections should be made at two places: one, the cooling tube companion flange, and two, the bottom of the turbine casing. The turbine casing inlet should be located preferably 180° from the water discharge adapter. Caution must be exercised that no throttling device such as a valve be installed between the two inlet water connections or in such a manner as to cause an unequal pressure at the two water inlets. The cooling system is designed to give the most efficient cooling when the water inlet pressures at the two water inlets are equal.

The water outlet connection should be made at the discharge adapter. A sight flow indicator should be installed in the outlet line to give positive indication of water flow through the unit. The water discharge line should be inclined upward to the main water discharge header or surge tank to vent the jackets, and to allow cooling by convection circulation after the unit is shut down, or if feasible, a separate pressure source should be provided for this purpose. If the turbocharger water discharge line cannot be carried upward to the main header or surge tank, a vent valve or tube should be provided in the high point of the water discharge piping to prevent vapor lock or siphoning.

In order to drain the interior of the turbine casing of any condensate, leakage, or water taken in through the exhaust lines, a nipple and valve should be fitted to the turbine casing drain tapped hole in the boss on the lower side of the turbine casing. This tapped hole is designated on the turbocharger outline drawing.

In order to avoid the danger of cracking the water jackets and developing leaks in the water passages during freezing weather, a nipple and valve should be fitted to the turbine casing water jacket drain tapped hole in the boss on the lower side of the turbine casing, and provisions should be made to drain the turbine casing backplate-oil cooler system. Drainage of the turbine casing backplate-oil cooler system can be accomplished by installing a tee and valve in the water inlet line adjacent to the companion flange or by grading this inlet line downward to some drainage point in the system.

SECTION 7

TYPE BF44 TURBOCHARGER

CLEARANCES

		Desired	Limit
1.	Rotor axial movement or end float, with surfaces oiled	.014-.018"	.025 max.
2.	Journal bearings		
	Shaft diameter	1.870-1.869"	
	Bushing I.D.	1.8740-1.8745"	
	Clearance on dia. dry	.004-.0055"	
3.	Labyrinth ring (Piece #176)		
	Clearance on diameter over impeller.	.038-.046"	
4.	Labyrinth ring (Piece #175)		
	Clearance on diameter over impeller.	.038-.046"	
5.	Clearance between end of turbine blade and nozzle ring with rotor shifted toward nozzle ring.	.054-.070"	
6.	Oil baffle bores		
	Threaded bore I.D.	2.509-2.511"	2.525 max.
	Smallest bore I.D.	2.196-2.198"	2.210 max.

NOTE: Worn parts should be replaced or adjustments made to assure that operating clearances will not exceed above values.

SECTION 8

STARTING INSTRUCTIONS

1. Cooling water connections as described in Section 6 "Installation", should be checked to assure proper cooling water circulation, and to see that the proper valves are open. The turbocharger water jacket must be filled with water before the engine is started. Water circulation should be started before operating the unit, if a separate source is available.

2. The lubricating oil sump tank should be filled to the middle of the gage range with lubricating oil having a viscosity of 185 to 255 S.S.U. at 130°F., or having an S.A.E. 30 designation. (See "Lubrication System" Section for detailed information).

3. The lubricating oil filter shell should be dropped and filled with lubricating oil.

4. The lubricating oil pump must be primed each time the lubricating oil lines have been broken, or when the unit has been standing for an appreciable time. Remove the upper half of the cover found on the front of the silencer for access to the 1/8" priming plug (Piece 158B) which will be found in the pump suction line connected to the left side of the pump. In priming, direct oil towards the pump, and also fill the line down to the check valve. The 1/8" plug must be replaced tightly, as a leak at this point may cause the pump to lose its prime.

5. Start the unit and operate idle or at low speeds and loads (turbocharger at 2,000 - 4,000 rpm). Check the oil pressure gage to see that the oil pressure develops properly.

6. If lubricating oil pressure does not develop in 20 seconds, shut the unit down and determine the cause of oil pressure failure.

7. Lubricating oil pressure is set at 15 lbs. per sq. in. at full load operating speed by relief valve adjustment during the factory test of each turbocharger. This pressure will decrease normally at reduced turbocharger speeds, and should be 5 to 7 lbs. per sq. in. at 2,000 to 4,000 rpm. Lubricating oil pressure is adjusted by removing the relief valve acorn nut, loosening the locknut, and running the slotted adjusting screw up to raise the pressure, or backing it down to lower the pressure.

8. Check the unit for rubs by using some such instrument as a screw driver placed on the unit with the ear against the outer end. If a rub develops shut down the unit and check for piping strains.

9. Check lubricating oil pressure and temperature, also cooling

water jacket pressures and temperatures shortly after unit has been started, to see that proper flow conditions are obtained.

10. The turbocharger is ready for continued operation if the above starting precautions have been observed.

11. Operating conditions must not exceed those specified on the turbocharger nameplate and in Section I of these instructions.

Excessive exhaust gas temperature before the turbine may be due to:

A. Engine conditions:

1. Stuck piston rings.
2. Spray nozzle difficulties.
3. Valve conditions.
4. Timing of valves or fuel injection.
5. Low compression pressure.
6. Air manifold leaks.
7. Exhaust manifold leaks.
8. Poor combustion.

B. Turbocharger conditions:

1. Low discharge pressure.
2. Clogged air intake.
3. Excessive back pressure on turbocharger exhaust.
4. Impeller and diffuser clogged with dirt.
5. High inlet air temperature.

Excessive turbocharger speed may be due to:

A. Engine conditions:

1. Smoky exhaust.
2. Incorrect valve timing.
3. Air passage restrictions.

B. Turbocharger conditions:

1. High discharge pressure due to restriction, in blower discharge piping.
2. Clogged air intake.
3. Impeller and diffuser clogged with dirt.

After turbocharger has been run 10 hours a rotor runout or stopping period of about one and one half minutes is to be expected when the unit and oil are warmed up, and when the turbocharger has been operating at one-fourth to one-third speed. This speed range will correspond to lightload conditions.

SECTION 9

SERVICE OPERATION

Engine log data taken hourly should be supplemented by sufficient information on the turbocharger to permit observation of performance of the unit, and particularly to detect any change in performance. If an hourly engine log is not kept, performance of the turbocharger should be observed at intervals of four hours of operation. Data recorded and conditions to be observed are as follows:

1. Oil Pressure - Lubricating oil pressure should be set at 15 lbs. per sq.in. at the turbocharger speed corresponding to full engine load. A marked increase in this pressure indicates faulty action of the pressure relief valve. A decrease in oil pressure indicates a need for changing the lubricating oil filter cartridge, stoppage in feed lines, or faulty action of the relief valve, although some variation in lubricating oil pressure with variation in speed is to be expected.

2. Oil Temperature - Temperature of lubricating oil supplied to the blower should not exceed 160°F., and lubricating oil at the drain should not exceed 180°F. Increase in lubricating oil temperature may be attributed to loss in pressure, stoppage of internal passages, or inadequate cooling water circulation.

3. Rotative Speed - The rotative speed of the turbocharger is sensitive to the exhaust gas temperature and condition. A high exhaust temperature and smoky exhaust will increase the turbocharger speed. Excessive accumulations of dust and dirt on the impeller and diffuser may cause an increase in rotative speed. A decrease in delivery pressure, such as caused by a leak in air intake manifold connections, will decrease the blower speed. The rotative speed of the turbocharger will be slightly affected by atmospherice conditions. For instance, r.p.m. of the unit will be increased over normal by a high inlet air temperature, or a low barometric pressure.

   The unit must not be operated above the maximum allowable r.p.m. indicated on the nameplate, and shown under Section 1 of this instruction book. If there is a tendency for the speed to exceed the specified limit, the engine load should be reduced or the engine should be shut down and the cause remedied.

4. Exhaust Gas Temperature - In addition to the engine exhaust elbow temperature recordings, the temperature of the exhaust gas in each of the cylinder exhaust manifolds, at a point just before the turbine inlet casing, should be logged. If this temperature exceeds the temperature specified as a maximum on the nameplate, the engine load should be reduced or the engine should be shut down and the cause remedied.

5. Water Temperatures - Water temperatures at the turbocharger supply and discharge connections should be recorded to keep a check on proper cooling of the turbocharger. If the water system design permits, cooling

water should be circulated through the turbocharger jackets for a short time after the unit has shut down, until the unit has cooled reasonably.

6. Vibration - Operation of the unit should be observed frequently, to detect any increase in vibration. If an appreciable increase in vibration should develop, the unit should be shut down, and the cause determined. Vibration might be caused by loosening of the thrust collar retaining nut, damage to the impeller, shaft, or turbine disk, or by loose bearings in the turbocharger or oil pump. Any specific deposit on the rotor might contribute to vibration.

In addition to the operating comments given in the preceding list, the following steps should be taken:

1. Lubrication - The lubricating oil tank and the screen at the suction line foot should be cleaned and flushed thoroughly after the first 200 operating hours, thereafter at intervals of 2000 operating hours. The lubricating oil should be renewed after each such cleaning of parts. The lubricating oil filter cartridge should be renewed, not cleaned, every 2000 operating hours or oftener if required to maintain proper lubricating oil pressure. The oil level should be checked frequently, and new oil added as required to bring the level in the oil tank up to the level range indicated on the bayonet gage in the oil tank. Lubricating oil consumption exceeding 1 quart per 24 operating hours should be investigated.

   Operation of the turbocharger lubrication system will otherwise be automatic, and no attention will be required unless changes in the feed pressure or operating temperatures indicate need for investigation.

2. Bearings - Inspection of the turbocharger journal and thrust bearings should be made after the unit has been in operation 100 hours, 1000 hours, and thereafter at intervals of 3000 hours. Disassembly and reassembly of the bearing support should be made as discussed in Section 10, Clearances should be checked against those listed in Section 7. Bearings should be replaced if surface condition shows severe pitting or scoring. Slight evidence of wiping of the thrust bearing is not objectionable provided that the clearances are within the limits specified in Section 7.

3. Impeller and Diffuser Cleaning - Accumulations of dirt and dust will be noticeable on the impeller and diffuser surfaces, even in apparently clean atmospheres. Such accumulations will particularly develop on the under side of the impeller vanes, and should not be allowed to reach 1/16" in depth. The required frequency of cleaning will depend on the operating atmosphere, and will vary, but cleaning after each 2000 operating hours, or less, will probably be required. The impeller and diffuser should be cleaned when the blower air discharge pressure drops off sufficiently to affect engine operation and increase the exhaust temperatures. For cleaning procedure see Section 10 on "Maintenance".

4. Complete Turbocharger Inspection - It is recommended that the turbocharger be completely inspected and cleaned at least once a year. Details of this procedure are discussed in Section 10 on "Maintenance".

5. Turbine Casing Drainage - When the engine and turbocharger are in continuous operation, there should be no collection of water in the turbine casing interior. However, water may accumulate in this space during shutdown, due to condensation, introduction of water through the exhaust lines, or leaky gaskets. Before starting up after any but a brief shutdown, the turbine casing drain shown on the attached outline drawing (not the water jacket drain), should be opened and any water collection drained. If lubricating oil collects in the turbine casing, check for oil leakage between the turbine disk and the shaft.

Should an accident or failure of some part of the turbocharger prevent or render inadvisable operation of the unit, the engine can still be operated until such time as repairs can be made to the turbocharger. Such a condition might occur if damage occurred to the impeller or turbine disk due to contact with some solid object, sudden increase in vibration, failure of bearings, or failure of lubricating oil supply.

If it is possible to do so, the turbocharger rotor should be removed, following the steps listed under "Maintenance", Section 10. The turbine casing backplate bore opening should be blocked with special tools consisting of plates, gasket, and through bolt, which are available. If there is not enough time available to permit removal of the rotor, the turbocharger rotor should be blocked to prevent further damage, using the special tools available to prevent rotation of the impeller. Load on the engine must be limited to prevent exhaust temperatures before the turbine from exceeding values noted in Section I and also stamped on the nameplate. If practicable, engine lubricating oil should be circulated through the turbocharger to cool internal parts. It will be necessary to continue circulation of cooling water through the backplate and turbine casing water jackets.

Operation of the engine with the turbocharger unit blocked should be kept at a minumum. If the unit has been operated under such emergency conditions, complete disassembly and inspection must be made as specified under Section 10, "Maintenance", before replacing it in operation.

SECTION 10

MAINTENANCE

Routine checks, inspections, and maintenance operations, as well as recommended frequency for such operations, are discussed under Section 9 on "Service Operation". For inspection of bearings, cleaning of impeller and diffuser, and complete inspection and cleaning of the unit, disassembly and reassembly methods should be followed as discussed in this section.

BEARING INSPECTION

Disassembly Procedure

1. Remove the lubricating oil tubing covers on the front of the silencer (Piece #120-4).

2. Draining the lubricating oil tank (Piece 113-4) is advisable to facilitate handling. Remove the lubricating oil pump suction and discharge flange cap screws (Piece #155). Break bearing oil line elbow (Piece #158-I) found at the right hand side of the silencer tube outer end. Remove oil drain flange cap screws (Piece #147) from blower casing. Disconnect the water line between the oil tank cooler flange and the backplate (Piece #299), also the oil cooler inlet connection. Remove all but the two top blower casing-silencer stud nuts (Piece #168).

3. Support the silencer and tank assembly and remove all blower casing-silencer stud nuts (Piece #168). The silencer and tank assembly weigh about 100 pounds, dry. Pull silencer and oil tank axially, preventing the weight of the silencer and tank from resting on the pump (Piece #203).

4. Turn bearing support special oil connection tubing fitting (Piece #133) to vertical position. Remove pump flange cap screws (Piece #97) and remove pump (Piece #203) axially by pulling out straight until the coupling is clear, then tilting pump upward to completely clear the special oil connection (Piece #134).

5. Remove the special nut (Piece #90) which has a right hand thread, and should be loosened by rapping the wrench with the rotor free. The rotor should not be jammed to facilitate loosening the special nut.

6. Remove thrust bearing (Piece #34), thrust collar (Piece #89), thrust collar key (Piece #95) and shaft locking tube (Piece #86), and washer (Piece #111).

7. Remove bearing support stud nuts (Piece #165) and back out bearing support by jack screws in the bearing support flange, pulling on both jack screws at once. Support the bearing support by hand when the first shoulder clears the blower casing, to prevent damage to the bearings. Entirely remove the bearing support from the blower casing, allowing the rotor to rest on the turbine casing backplate (Piece #287). Do not turn the rotor after the bearing support has been removed.

8. The assembly of the bearing support with bearing sleeves need not be disassembled for inspection of the bearing surfaces. Clearances should be checked against those listed in Section 7. Bearings should be replaced if surface conditions show severe pitting, scoring, or wear. Slight evidences of wiping of the thrust bearing (Piece #34) is not objectionable provided that the clearances are within specified limits as given in Section 7. The oil holes in the bearing support should be cleaned and blown out. A check should be made of the oil baffle (Piece #174) to make sure that it is not worn and that the oil baffle nut (Piece #33) is tight and center punched at the threads to lock it in place.

9. If required to remove either of the bearing shells, (Pieces #179 and #180) for replacement, first remove the two screw dowels with which each shell is secured. The outer bearing shell (Piece #179) may then be driven from its seat. To remove the inner bearing shell (Piece #180), also remove the oil baffle nut (Piece #33), pull the oil baffle (Piece #174) axially and press the bearing shell out.

Reassembly

Before reassembly, all parts should be thoroughly cleaned, flushed out, and all passages blown out with air. All parts should be inspected and replaced if damaged or worn. Bearing surfaces should be oiled before assembly. All gaskets encountered should be renewed.

1. In installing new bearing shells, several precautions must be observed. The side of the shell having the 45° chamfer should be first to enter the hole. The scribe line located on the side of the bearing shell must be lined up with the chisel mark which is found adjacent to the bearing shell seat in the bearing support. The oil hole in the bearing shell must line up with the oil hole in the bearing support. After pressing in the new shell, the alignment of the oil holes can be checked by passing a small piece of bent wire through the holes.

2. The two set screws used to secure each shell should then be replaced. In replacing the oil baffle (Piece #174) the locating pin in the bearing support must pass into the locating hole in the oil baffle. The oil-proof rubber gasket (Piece #173) installed and the oil baffle nut (Piece #33) tightened down and center-punched at the thread to lock it securely in place.

3. The bearing support oil-proof ring gasket (Pieces #177 and 178) should be renewed. Place the bearing shield, from the tools furnished with the turbocharger, on the shaft to protect the bearing shells during reassembly. Remove the thrust collar key (Piece #95) from the shaft or check the seating of this key to assure that it will not damage the bearing shells during assembly.

Oil the exterior of the bearing support (Piece #94) at the blower casing fits, and replace the bearing support in the blower casing, checking to see that the oil drain slot adjacent to the bearing support flange is down, and registers with the drain ribs in the blower casing. Handle the bearing support carefully to prevent damage to the oil baffle, bearing bushings, or impeller. To install the bearing support properly, remove two of the bear-

ing support blower casing studs and insert long studs to permit pulling the bearing support into place. Otherwise, cover a block of wood with a cloth to prevent scattering of splinters and dirt and carefully drive the bearing support in the blower casing until the bearing support can be pulled down to a seat by the flange studs.

When the bearing support is pulled up tight, rap the outer bearing shell face (Piece #179) to make sure it is firmly seated. Turn the rotor by hand to assure that it is free while the bearing support is being pulled or driven into place. When the bearing support is seated in the blower casing, the thrust bearing seating shoulder on the shaft should project beyond the outer bearing shell about 1/32" when the rotor is pulled outward as far as it will go. Remove the bearing shield from the shaft.

4. The thrust collar (Piece #89) and the thrust bearing (Piece #34) should be checked to see that these parts have not been subjected to excessive wear or scoring which would make replacement advisable. If a new thrust bearing is needed and is not available the edges of the radial slots in the thrust bearing should be well rounded to permit oil to flow on the thrust surfaces, and the thrust bearing can still be used by installing a thinner gasket between the pump and bearing support flange to give the proper rotor end clearance specified under Section 7.

5. The thrust collar key (Piece #95) must be installed to align the shaft oil drains and must seat properly when the thrust collar is slipped on the shaft. The thrust bearing (Piece #34) should not be a drive fit in the bearing support when cold, but should be fitted to obtain an easy hand push fit. The thrust bearing key must be installed to assure that the thrust bearing will not turn in the bearing support. Install the thrust collar and thrust bearing. Install the locking tube (Piece #86) and the copper locking washer (Piece #111), and the special nut (Piece #90). Tighten the special nut by rapping the wrench handle against the inertia of the rotor. Do not block the rotor to tighten the special nut. Install the special oil connection (Piece #134), assemble a new rubber oil pump coupling (Piece #87) and the retainer ring (Piece #211) on the pump shaft, aligning the driving lugs on the special nut with the oil pump coupling, and assemble the oil pump on the bearing support, using a gasket between the oil pump and bearing support flanges approximately .020" thick. Check the thrust by dial indicator and adjust the gasket thickness to obtain the desired clearances indicated in Section 7.

6. Before making up the oil connection to the bearing support, the oil passages and bearings should be thoroughly flooded with fresh, clean lubricating oil. Before reassembling, the lubricating oil piping should be thoroughly cleaned and flushed out. Flush and clean the lubricating oil tank. Renew the lubricating oil filter strainer element (Piece #143). Disassemble and check condition of the relief valve (Piece #141-4).

7. When the silencer, oil tank, and oil fittings have been reassembled, starting instructions given under Section 8 should be followed for the first start.

IMPELLER AND DIFFUSER CLEANING

AND COMPLETE TURBOCHARGER INSPECTION

Disassembly Procedure

1. Follow steps 1 to 8 inclusive as specified under "Bearing Inspection" in this section.

2. Pull the rotor outward as far as possible, to prevent damage. Support the blower casing (Piece 163-4) by the eyebolt (Piece 171A). Remove the backplate to turbine casing water discharge connection. Break the blower casing discharge flange joint.

3. Remove all but four stud nuts (Piece #12) attaching the backplate (Piece #287) to the turbine casing (Piece 1-4). Then loosen these four gradually while the backplate is moved clear of the turbine casing with the four backplate jackscrews, until the backplate is free.

4. Slide the backplate and blower casing out horizontally to prevent damage to the turbine. Set up the assembly on the floor, with the turbine disk side clear, and the blower casings blocked and lashed or clamped vertically.

5. Support the turbine casing backplate by eyebolts (supplied with tools), one in each half. Pull the rotor toward the backplate as far as possible. Remove the backplate - blower casing tapbolts (Piece #35) and swing the backplate and rotor free of the blower casing, taking care that the backplate does not drop and damage the impeller (Piece #42-4) when the registering fit slides clear.

6. Support the backplate vertically by attaching slings to each end of a bar or pipe, at least 2 feet long, which is passed through both backplate half eyebolts. Break the water tubing connections at the top and bottom of the backplate, and remove the four tap bolts coupling the backplate halves, supporting the rotor by hand so it will not drop when the backplate half tap bolts are removed.

7. Support the rotor by hand, and break the backplate joint by prying in the split notches at top and bottom. The two halves must be pulled apart straight and square to prevent damage to the labyrinth ring.

8. Remove the labyrinth ring from the backplate bore and lift the two backplate halves clear of the rotor. Take extreme care not to damage the turbine disk, shaft, or impeller.

9. Clean the impeller, diffuser (Piece #103-4) and shaft with a solvent such as Bendix cleaner (Used for cleaning automobile carburetors) to remove all deposits of dirt, carbon and oil. Do not scrape impeller or diffuser to remove dirt as this will remove the anadized protective coating. Remove the blower casing drain plug (Piece #183) to drain the solvent.

10. All parts should be thoroughly cleaned of dirt, grease, and gas-

ket compound before reassembly, particularly the rotor labyrinth ring. All parts must be handled carefully and must have all burrs removed from fit and contact surfaces. All gaskets should be renewed.

11. Complete cleaning and inspection of turbocharger parts is possible by removing the blower casing and backplate assembly, complete with the rotor as specified above: without breaking gas connections to the inlet casing or from the turbine casing.

Reassembly

1. The turbine disk (Piece #30) should be carefully examined to assure that it is in proper mechanical condition. The turbine disk and blade will have a slight surface coating, which can be removed with a cloth, for inspection of surfaces. The blades should be tight and undistorted and should not show wear between the blade and the lashing wire. If the turbine disk, turbine blades or shaft require disassembly and repair, the rotor must be returned to the factory for the necessary operations and rebalancing.

2. The impeller (Piece #42-4) should be checked to see that it is properly secured on the shaft and has not been subjected to damage. The assembly of the turbine disk and the shaft must not be disturbed by removal of the shaft-disk cap screw (Piece #35). These parts have been assembled and balanced at the factory and it will be necessary to rebalance the rotor if this assembly is taken down. Removal of the impeller from the shaft is not recommended unless essential.

3. The turbine casing and backplate water jackets should be cleaned of any deposit of scale and sludge, in the same manner used in cleaning the engine water jackets. If an acid is used to remove scale from the water jackets, these spaces should be thoroughly flushed out and the acid neutralized. All machine parts should be thoroughly cleaned. Particular care should be taken to clean the labyrinth ring seats in the backplate, diffuser ring, and blower casing.

4. Examine the nozzle ring (Piece 107-4) but do not remove unless absolutely necessary. The blades should be undistorted and the ring should seat on the inlet casing (Piece 159-4) at its outer radius. If it is necessary to replace the nozzle ring, drill out the copper locking dowels and remove the cap screws. When reassembling the cap screws, coat with "Lubriplate 130A" to prevent jamming from excessive heat.

5. Before reassembly, coat the backplate split surfaces very lightly with Permatex "Form-a-gasket No. 3" except near the labyrinth ring grooves. Support the two backplate halves spread apart, on a bar or pipe passed through the backplate eyebolts, and suspended at the ends by slings. Support the rotor by hand for reassembly. Check the seating of the rotor labyrinth ring (Piece #175) in each backplate half groove. Slide the backplate halves together on the labyrinth ring and rotor. Coat the backplate split capscrew threads with "Lubriplate 130A". Assemble the backplate halves, checking the split surfaces for alignment before tightly pulling the capscrews down on lockwashers. Connect the top and bottom water tube connections.

6. Coat the contacting blower casing and backplate faces lightly with Permatex "Form-a-gasket No. 3". Push the rotor toward the blower casing as far as possible before assembling. Assemble the backplate to the blower casing with socket head capscrews, guiding the impeller and shaft carefully to start the impeller in the blower casing labyrinth ring without jamming.

7. Apply Permatex "Form-a-gasket No. 3" to contacting surfaces of the backplate and turbine casing, and lay two 1/32" strands of asbestos cord in Permatex on the face of the turbine casing counterbore. Push the rotor toward the blower casing, support the blower casing and backplate assembly by the eyebolt, and attach the backplate to the turbine casing. Care must be exercised to prevent damage to the turbine disk during reassembly. When the backplate-turbine casing joint is made, connect the backplate water discharge connection, and make the blower casing discharge flange joint.

8. Check condition of bearings and need for replacement, also complete reassembly as specified under "Reassembly" for "Bearing Inspection" in the first part of this section.

General Maintenance Comments

If the machine is to be shut down for an extended period of time, the bearing support must be pulled and the shaft surfaces and all bearings thoroughly covered with vaseline for protection. All exposed surface should be slushed with rust preventive compound. Before placing the unit in operation again, it must be disassembled to permit thorough cleaning and removal of protective coating.

The turbocharger is designed and constructed to entirely eliminate hand fitting of moving parts. All repair parts should be entirely interchangeable without forcing or fitting. The original assembly of the turbocharger is tested by operation in the manufacturer's plant to assure that proper clearances have been obtained, and that parts are in proper working conditions. It is therefore, essential in assembly and repair of the turbocharger that parts be handled carefully and that these parts be kept entirely clean. These precautions are absolutely essential to assure proper operation of the unit.

The Service Department of the manufacturer is prepared to make shipment of replacement parts on reasonably short notice, although it is recommended that a reasonable amount of spare parts be maintained with the unit for emergencies. Identification of parts is made by the serial number of the specific unit and by the part or piece number shown on the accompanying assembly drawing.

Contained in this instruction book are views showing the construction of the turbocharger, giving the part numbers for the individual parts. In ordering repairs, the following information should be given:

(a) Name and address of purchasing agency.
(b) Make and serial number of Diesel engine.
(c) Serial number of turbocharger.
(d) Names or part numbers of parts wanted.
(e) Drawing number from which part numbers are taken.

SECTION 11

INSTRUCTIONS FOR THE OPERATION AND MAINTENANCE

of

JONES MOTROLA MECHANICAL TACHOMETER

General

The Jones Motrola tachometer is of the centrifugal mechanical type, and is driven from the turbocharger through a flexible shaft. The flexible shaft is driven by a take-off shaft on the outer end of the pump, through a reduction gear train having a ratio of 9.596 to 1. A right angle drive section at the top of the tachometer head provides a take-off shaft for checking speed with a hand tachometer or revolution counter and stop watch.

Mounting

The tachometer head is mounted on a panel which is carried on rubber mountings. The instrument panel should be installed so that it will be visible from the engine control stand.

Installation

The life of the tachometer depends on proper installation. In order to assure satisfactory operation the following precautions must be observed:-

1. When installed on the panel on the turbocharger silencer, the panel must float freely on the rubber mountings, and the mounting screws and rubber mountings must not strike the brackets or panel, within the normal motion allowed by the rubber mountings.

2. The cable must be installed with the easiest curve possible. Loosen the right angle drive section locknut. Tighten the locknut when the position is found which gives the easiest cable curves. Sharp bends near the ends of the cable must be avoided, as they cause binding and rapid wear of the cable. Binding of the cable is indicated by jumping of the pointer on the indicating head during operation.

3. To check the accuracy of the tachometer by the hand tachometer take-off shaft, use a hand counter and stop watch. If a hand tachometer is used, an error of plus or minus 2% may be introduced. Multiply the reading so obtained by 9.596 to get the correct turbocharger speed.

Maintenance

It is imperative that the following instructions and precautions be followed to insure satisfactory performance of this tachometer arrangement: -

Operation (Cont'd)

When the installation of the equipment has been completed in accordance with the foregoing instructions, check the installation and make sure that all parts rotate freely without binding.

The installation should then be operated to check performance of the Tachometer. If installation is properly made, the Tachometer Pointer should give a steady indication. If the Pointer has a tendency to jump, investigate immediately, checking particularly the installation of the Flexible Shaft to make sure that the foregoing instruction covering installation of the Flexible Shaft, and its brackets have been carefully observed. Violent fluctuations of the pointer may also be caused by binding or excessive friction in some part such as the Flexible Shaft or the Right Angle Sections.

Observe the operation of the installation generally. The tendency of any part to heat up indicates excessive friction and should be immediately investigated.

If for any reason either end of the Flexible Shaft is disconnected at any time, do NOT attempt to reconnect the Flexible Shaft while the driving member or engine tachometer outlet is rotating, as this places a severe strain on the tachometer mechanism and may cause serious damage. Therefore the driving member or the engine tachometer outlet should be stopped before the connection of the Flexible Shaft is made.

IMPORTANT

NOTE: The manufacturer's guarantee does NOT cover any tachometer on which the cover has been removed, or an attempt has been made to readjust or repair the instrument. If there is at any time a question concerning the operation of a Tachometer, the instrument should be returned to the factory intact for the required inspection and service.

SECTION 11

INSTRUCTIONS FOR INSTALLING AND SERVICING WESTON ALTERNATING CURRENT TACHOMETERS USING MAGNETO GENERATOR MODEL 752J7

Principle

The Model 545R and Model 752J7 Tachometer combination consists of a voltmeter type indicator (Model 545R) responding to the output voltage of an electrical generator (Model 752J7). The tachometer differs from the conventional d.c. type in that it uses an alternating current generator instead of a d.c. generator, operating a rectifier type alternating current indicating instrument. The generator consists of a permanent magnet rotor operating within a wound stator structure in which the output voltage is generated. This design is inherently simple and trouble-free and minimizes maintenance.

The tachometer generator is mounted on and driven from the lubricating oil pump. The lubricating oil pump reduction gear ratio of 9.596:1 is interposed between the turbocharger shaft and the generator shaft. However, the tachometer indicator is calibrated to read directly in r.p.m. of the turbocharger shaft.

Installation

Indicator: The tachometer indicator should be mounted on a panel free from excessive vibration. The metal indicator shield must not be removed from the indicator.

Generator: Remove the locking bolt assembly on the generator and screw the generator on the oil pump tachometer connection. Reassemble the locking bolt assembly from the side of the generator most convenient and tighten the locking nut about one turn beyond the point where the lockwasher closes. Safety wire the head of the locking nut through the holes provided.

Connections: Lead wires from the generator to the indicator should be #16 or 20 B. & S. gage. Lead wires should be soldered to the contacts (Piece #37G) shown on the accompanying plug connector sketch. A periodic check should be made to see that all connections are clean and tight. Extreme care must be exercised to prevent the wire from resting on some sharp corner or edge that would chafe off the insulation and cause a short circuit. The two pin AN plug connector is designed so that a conduit can be attached to its outer end thereby protecting the lead wires from possibility of wear. If a conduit is used it must be properly supported by brackets to prevent its weight from being carried by the plug connectors and also to ground the conduit against accumulation of static charges which may affect the readings. For conduit ordering information see accompanying plug connector drawing.

When assembling the two pin AN Plug Connector examine the accompanying plug connector drawing to determine the proper location of the various internal

parts. Special attention should be given to the proper placement of Piece #37F as this holds the two connection pins (Pieces #37G) in place in Piece 37B.

If the two pin AN plug connectors are missing, neither the indicator nor the magneto should be disassembled to make lead wire connections, as this will result in incorrect readings and damage to the instruments.

The manufacturer's guarantee is revoked if either instrument has been disassembled by the user.

Servicing

Indicator: The indicators require no servicing in the field other than an occasional check to see if the pointer rests on zero when the generator stands still or the connection is opened. The pointer may be reset to zero by means of the zero corrector on the front of the instrument.

Generator: The generators require very little attention once they are properly mounted and connected. The oil cups should be refilled after every 4,000 hours of service. If the generator operates at ordinary room temperatures use S.A.E. 30 high grade parafine base motor oil ("Uniflow" or equal). If operating temperature is below freezing use S.A.E. 10 oil of the same grade. Never use pressure in refilling the oil cups.

If it is desirable to check the operation of the tachometer with regard to proper speed indication, the magneto may be removed and a hand tachometer inserted into the take-off shaft in the pump. Multiply tachometer reading by 9.596 to obtain correct turbocharger r.p.m.

Do not attempt to reinstall the magneto while the turbocharger is in operation as damage to the magneto will result.

General

After several years of regular operation and whenever noticeable irregularities occur, it is advisable to return the generator and indicator to the Weston Electrical Instrument Corporation, 614 Frelinghuysen Avenue, Newark, New Jersey, for general overhauling and check.

SECTION 12

SPARE PARTS AND TOOLS LIST

Spare Parts	Part No.
Thrust Bearing	34
Oil Pump Coupling	87
Thrust Collar	89
Thrust Collar Key	95
Gasket - Oil Drain Flange	140
Relief Valve Spring	141C
Gasket - Oil Filter	142A
Oil Filter Core	143
Gasket - Oil Pump Suction & Discharge	154
Gasket - Oil Baffle	173
Labyrinth Ring - Inner	175
Labyrinth Ring - Outer	176
Gasket, Bearing Support - Inner	177
Gasket, Bearing Support - Outer	178
Bearing Shell - Outer	179
Bearing Shell - Inner	180
Oil Seal - Oil Pump	196
Oil Pump Assembly	203
Gasket - Turbine Casing water outlet	204
Gasket - Blower Casing Joint	206-4
Gasket - (Asbestos Cord) Backplate	289
Gasket - Oil Pump Flange	218
Tachometer Assembly Pts. 37, 217 and 247	249
1/4 Pt. can Permatex #3 Form-A-Gasket Cement	

Tools	
Allen Wrench - 1/2" Cap Screw	54
Allen Wrench - 5/16" Cap Screw	55
Allen Wrench - 1/4" Cap Screw	56
Allen Wrench - 1/4" Set Screw	57
Allen Wrench - 1/2" Set Screw	59
Bearing Shield	60
Rotor Blocking Rig Assembly	61
Impeller Puller - Assembly	62
Wrench - Oil Baffle Nut	63
Allen Wrench - 3/8" Cap Screw	64
Wrench - Oil Pump Pipe Connections	65
Impeller Nut Wrench	65C
Allen Wrench - 5/8" Cap Screw	65D
Allen Wrench #8 - 32 Set Screw	65E
Eyebolt, Backplate	282

NOTE: This list includes those spare parts and tools shipped with this installation.

SECTION 12

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Thrust Bearing	34
Oil Pump Coupling	87
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Gasket - Oil Filter	142A
Oil Filter Core	143
Gasket - Oil Pump Suction & Discharge	154
Gasket - Oil Baffle	173
Labyrinth Ring - Inner	175
Labyrinth Ring - Outer	176
Gasket, Bearing Support - Inner	177
Gasket, Bearing Support - Outer	178
Bearing Shell - Outer	179
Bearing Shell - Inner	180
Oil Seal - Oil Pump	196
Oil Pump Assembly	203
Gasket - Turbine Casing water outlet	204
Gasket - Blower Casing Joint	206-4
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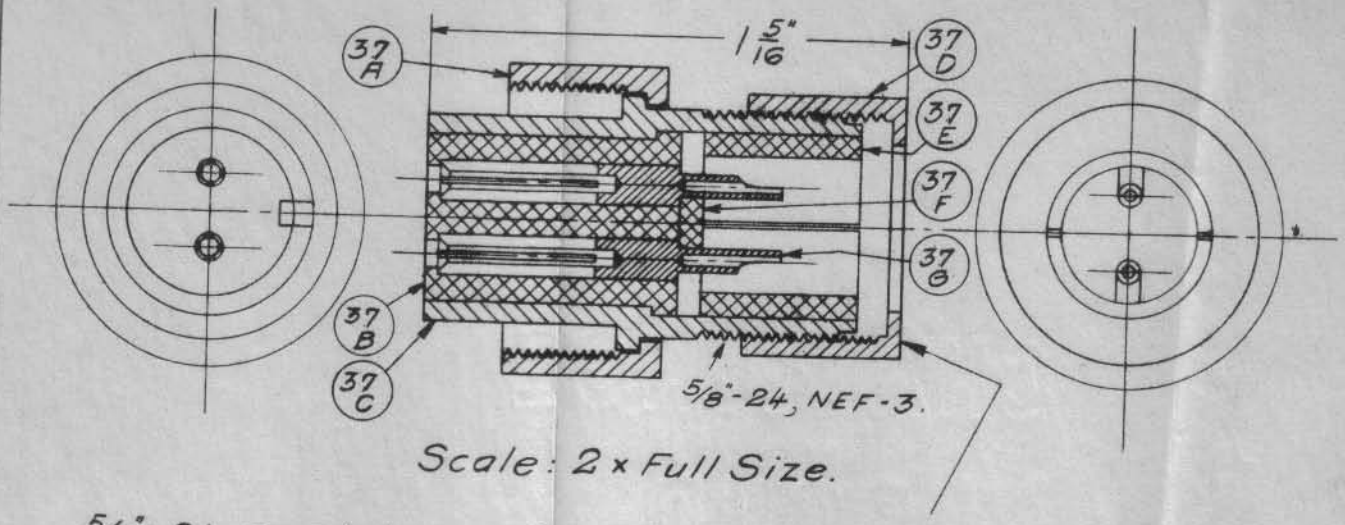
Allen Wrench - 1/4" Set Screw	57
Allen Wrench - 1/2" Set Screw	59
Bearing Shield	60
Rotor Blocking Rig Assembly	61
Impeller Puller - Assembly	62
Wrench - Oil Baffle Nut	63
Allen Wrench - 3/8" Cap Screw	64
Wrench - Oil Pump Pipe Connections	65
Impeller Nut Wrench	65C
Allen Wrench - 5/8" Cap Screw	65D
Allen Wrench #8 - 32 Set Screw	65E
Eyebolt, Backplate	282

NOTE: This list includes those spare parts and tools shipped with this installation.



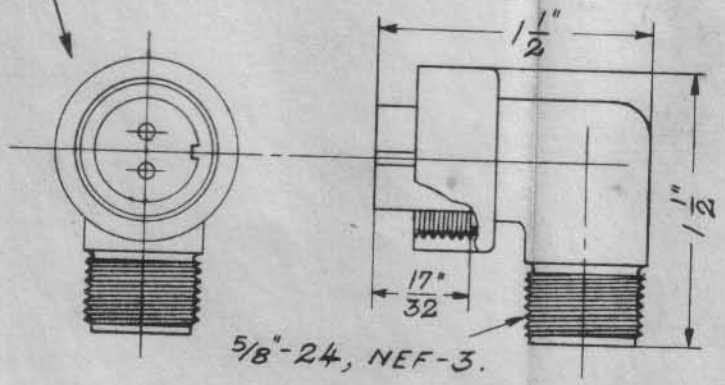
Scale: 2 x Full Size.

5/8"-24 Conduit Nut. Conduit For Wire Protection Can Be Coupled Here If So Desired. Conduit May Be Purchased From: Breeze Corporation Inc., Newark, New Jersey - Or From: Titeflex Metal Hose Co., Newark, New Jersey.

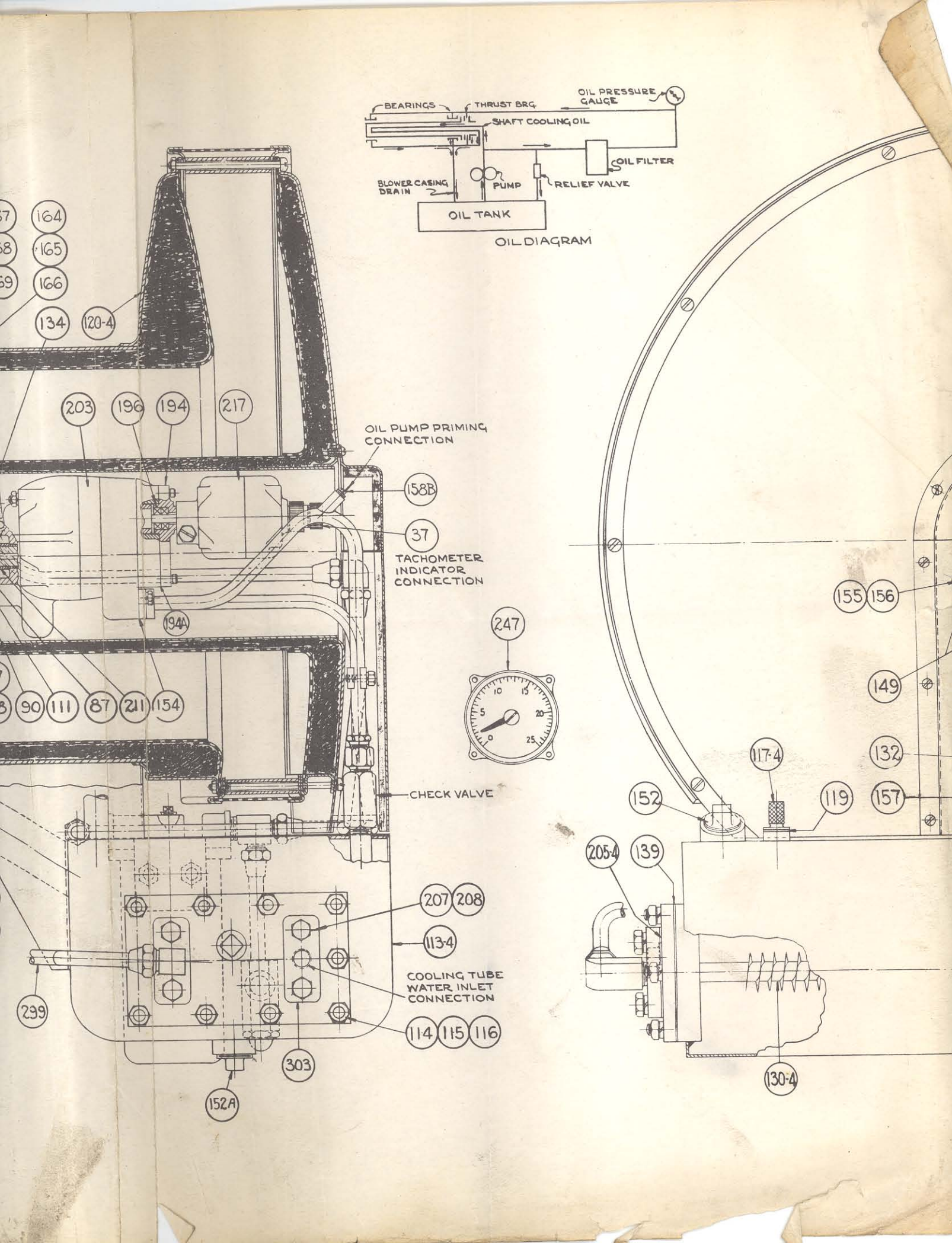
Breeze Ordering Information:
Part Number C-151-0250-____-2626, Coupling Nuts 5/8-24 Thread. (Fill In Space In Purchase Number With Length Of Conduit, Coded In Inches And Sixteenths Of An Inch.)
For Example - A 35 11/16" Length Would Be Ordered As Follows:
C-151-0250-3511-2626, Coupling Nuts 5/8"-24 Thread.

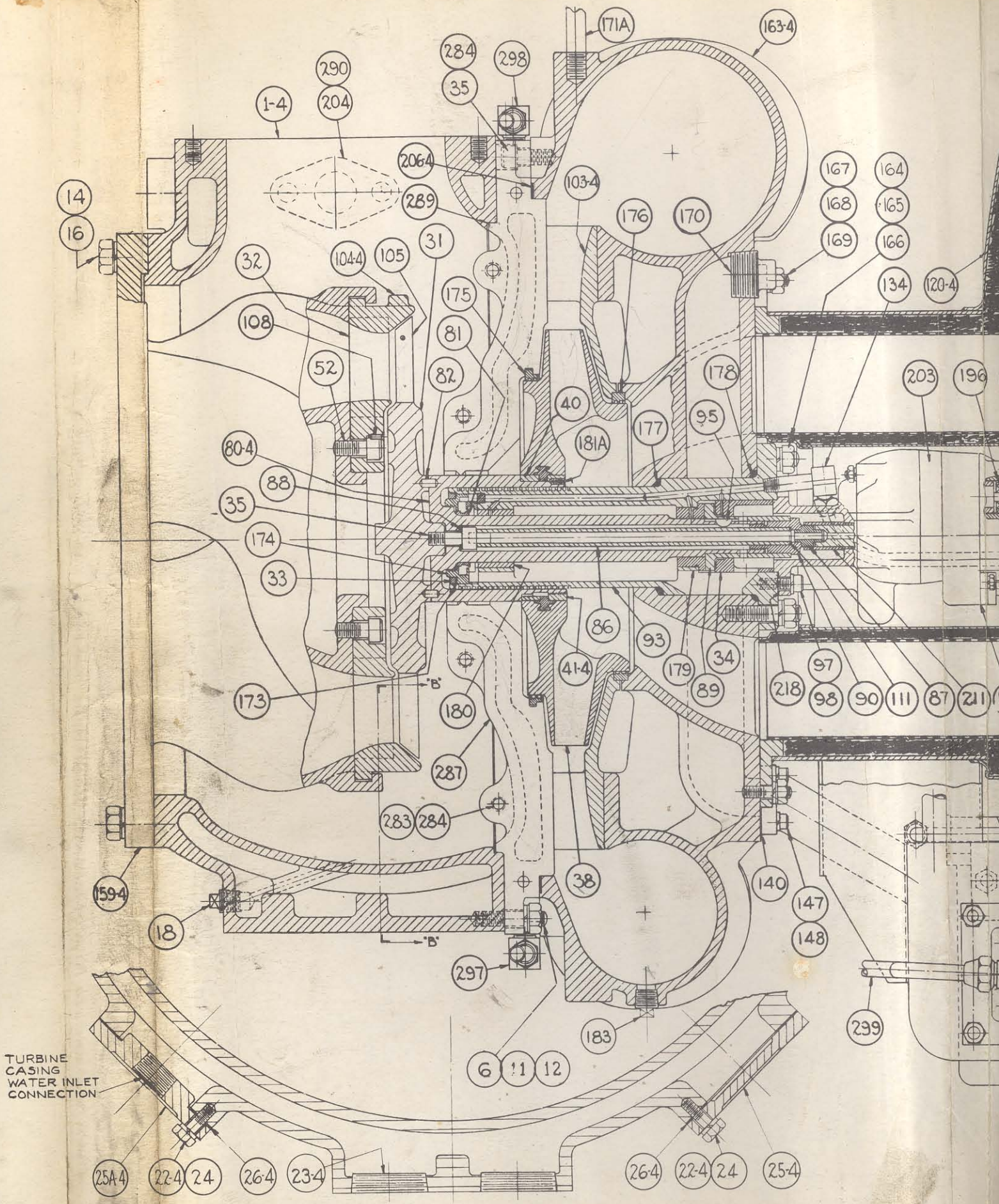
Titeflex Ordering Information:
#152-16 Conduit Fitted On Both Ends With Nut And Ferrule U1664-8A And U1664-8B, ____ Inches Long. (Fill In Space With Length Of Conduit.)
Use #16 Or #20 Single Strand Wire, Rubber Covered Or Some Such Insulation. Insulated Wire Must Not Be Over .120" Dia. Wire To Be Soldered To (Part #37G). Above 2 Pin AN Plug Connector, Army Navy Spec. 3106-12S-3S Furnished As Standard With Weston Electric Tachometer And Indicator.

This Plug Connector Is Available If Space Limitations Eliminate The Possibility Of Using The Straight Plug Connector Shown Above.



Tachometer & Indicator Plug Connector	
Elliott Company Jeannette, Pa.	
DR. Jensen	S-841368
Date. 11-20-42	


BEARINGS
THRUST BRG.
OIL PRESSURE GAUGE
SHAFT COOLING OIL
OIL FILTER
BLOWER CASING DRAIN
PUMP
RELIEF VALVE
OIL TANK
OIL DIAGRAM
164
165
166
134
120-4
203
196
194
217
OIL PUMP PRIMING CONNECTION
158B
37
TACHOMETER INDICATOR CONNECTION
194A
247
90
111
87
211
154
CHECK VALVE
207
208
113-4
COOLING TUBE WATER INLET CONNECTION
239
114
115
116
303
152A
155
156
149
132
117-4
152
119
157
205-4
139
130-4



PARTIAL SECTION "B-B"

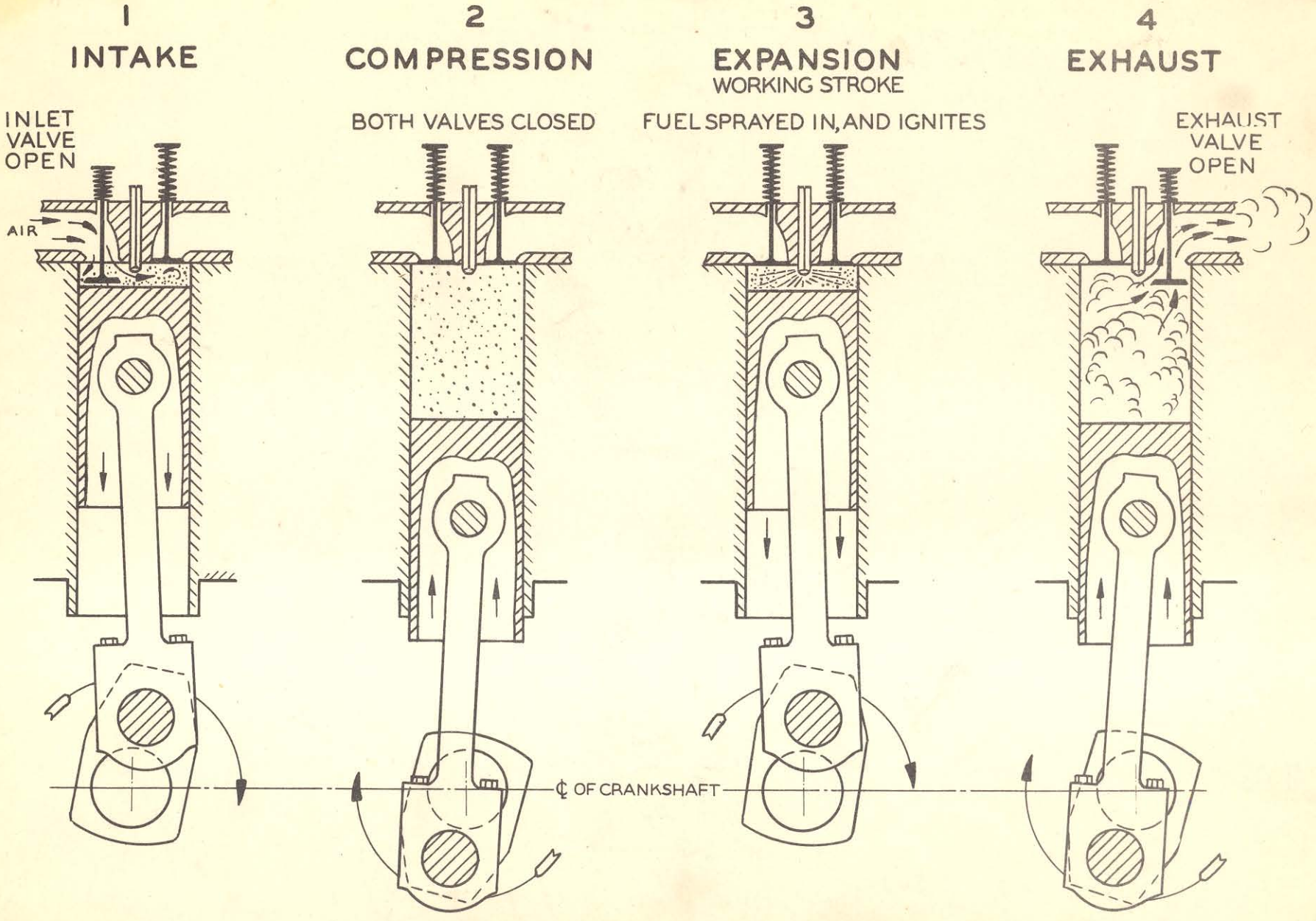


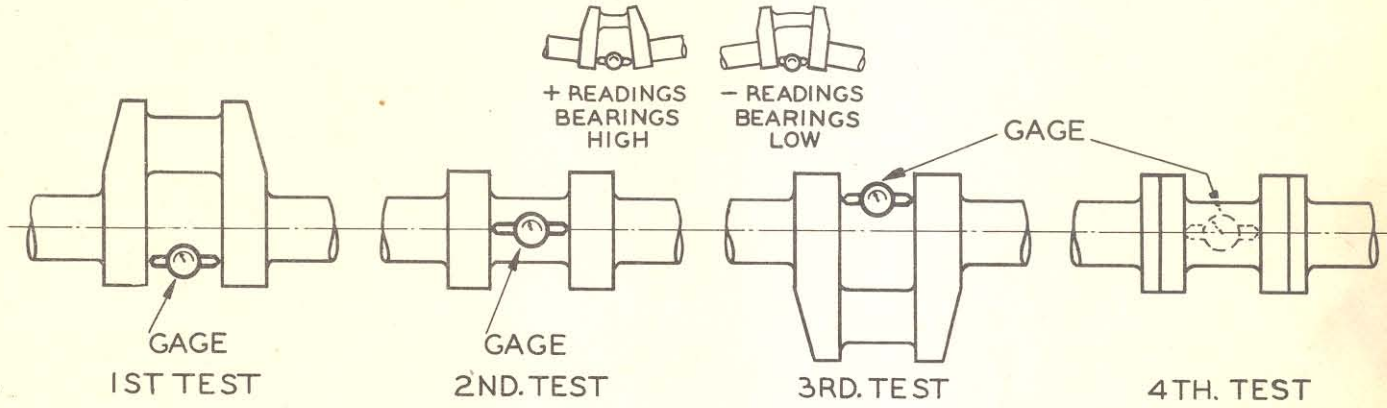
DIAGRAM OF WORKING PRINCIPLE

D-1061

CRANKSHAFT ALIGNMENT CHECK

READINGS TO BE TAKEN AFTER FINAL INSTALLATION, BEFORE FINAL TESTS

READINGS ARE IN THOUSANDTHS (.001 ETC.) WITH INDICATOR SET ZERO AT TOP DEAD CENTER OF PISTON. NOTE WHETHER + OR −



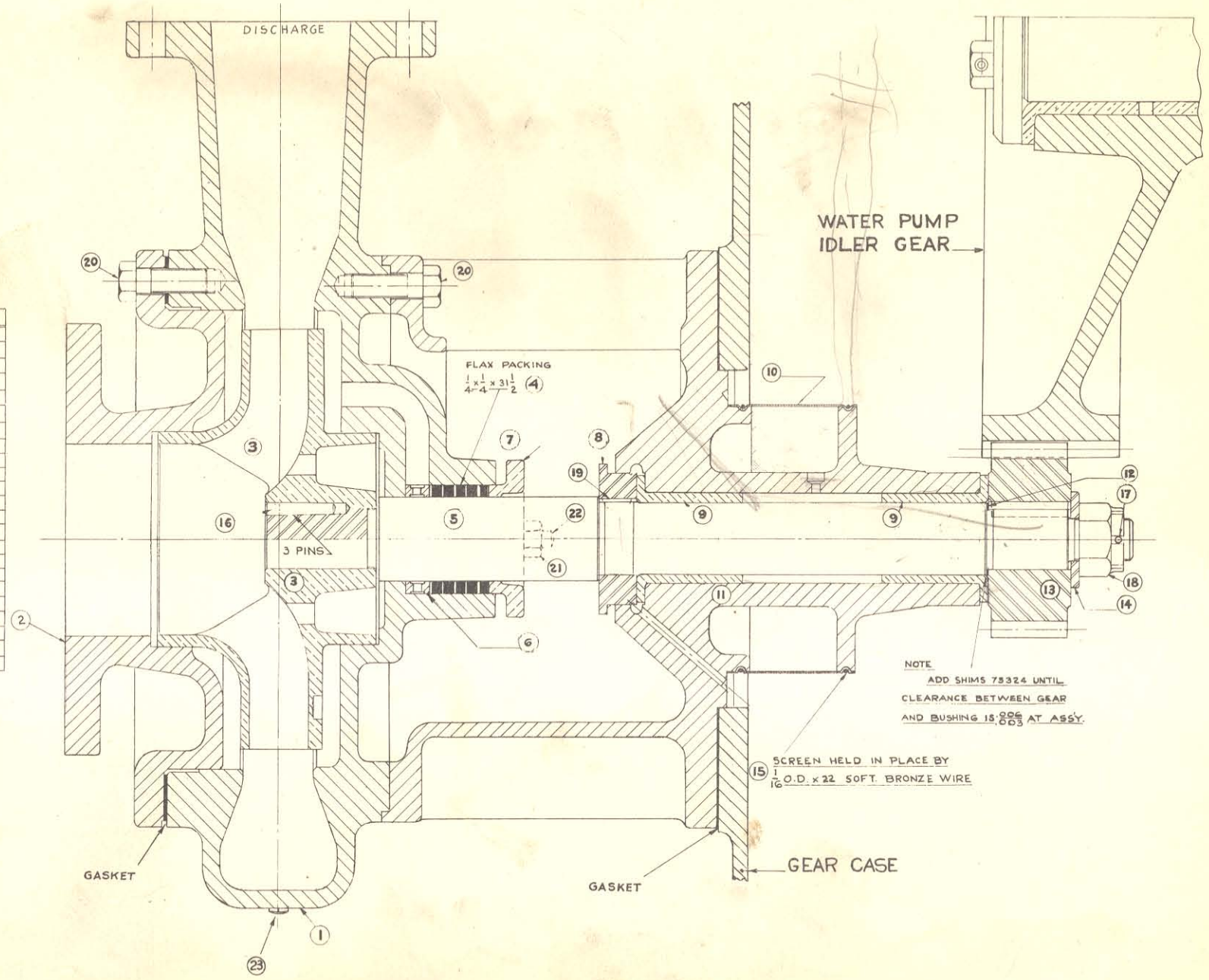
POSITION WHEN VIEWED FROM TIMING GEAR END

CYLINDER NO.

	1	2	3	4	5	6	7	8
TOP								
RIGHT								
BOTTOM								
LEFT								

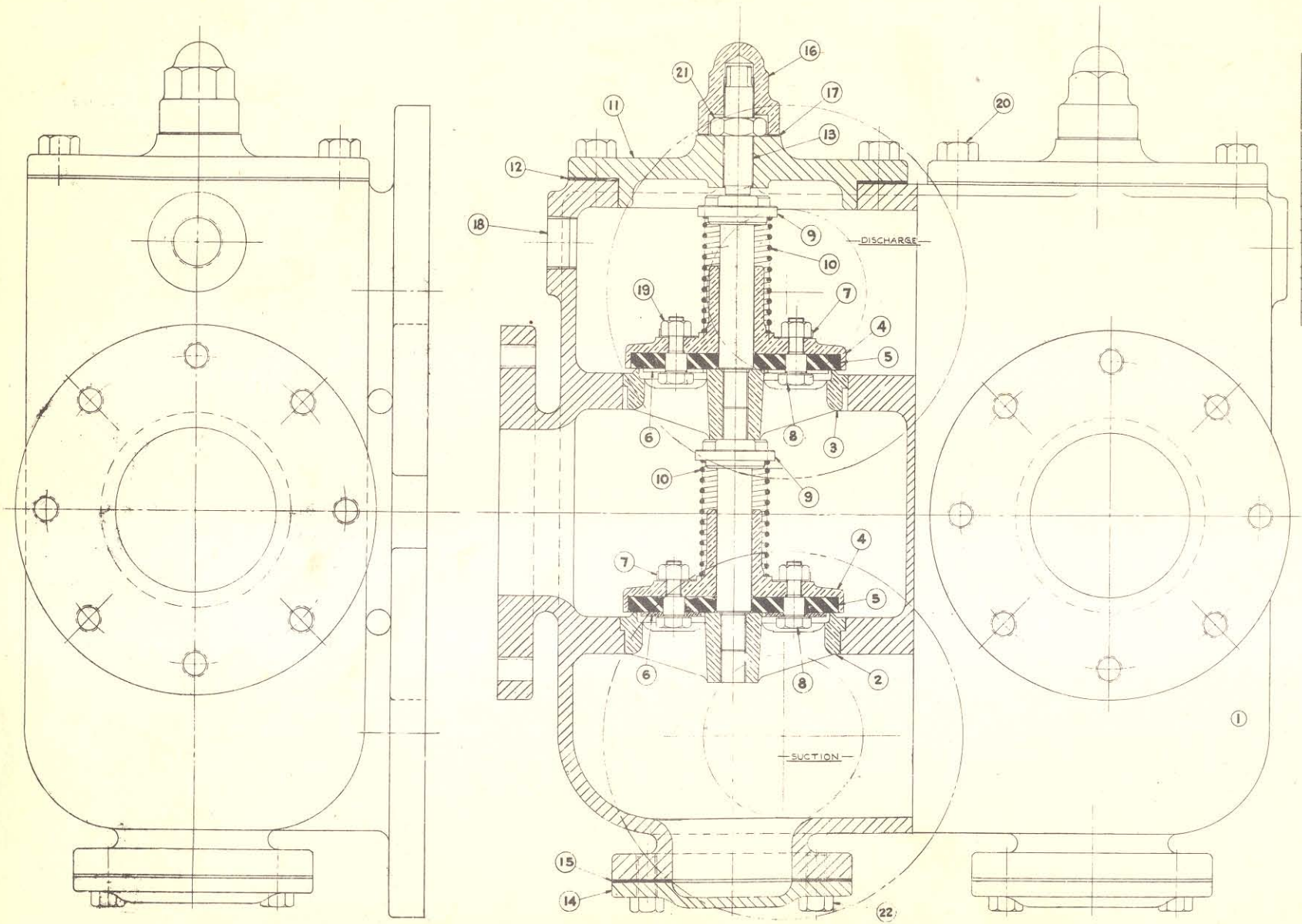
D-1063

ITEM	PART NAME
1	CASING
2	COVER
3	IMPELLER
4	PACKING
5	SHAFT
6	LANTERN RING
7	PACKING FLANGE
8	THRUST COLLAR
9	BUSHING
10	SCREEN
11	BRACKET
12	SHIM
13	GEAR
14	WASHER
15	WIRE
16	TAPER PIN
17	COTTER PIN
18	NUT, CASTLE
19	WOODRUFF KEY
20	CAPSCREW
21	NUT
22	STUD
23	PIPE PLUG



FRESH WATER PUMP

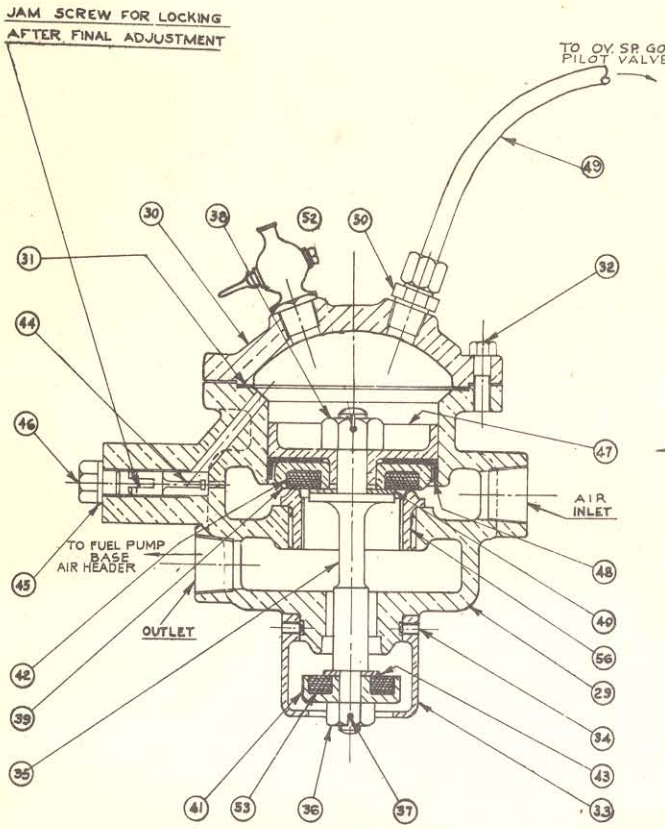
D-1023



	PART NAME
1	VALVE CAGE WATER PUMP
2	VALVE SEAT-SUCTION
3	VALVE SEAT-DISCHARGE
4	VALVE
5	VALVE DISC.
6	BACKING DISC.
7	LOCKING RING
8	BOLT-VALVE
9	SPRING RETAINER
10	SPRING
11	COVER-VALVE CAGE
12	GASKET-COVER
13	VALVE SCREW
14	BLIND FLANGE-VALVE GAGE
15	GASKET-FLANGE
16	CAP-VALVE SCREW
17	GASKET-CAP
18	PIPE PLUG-VALVE CAGE
19	NUT
20	CAPSCREW
21	JAM NUT
22	CAPSCREW

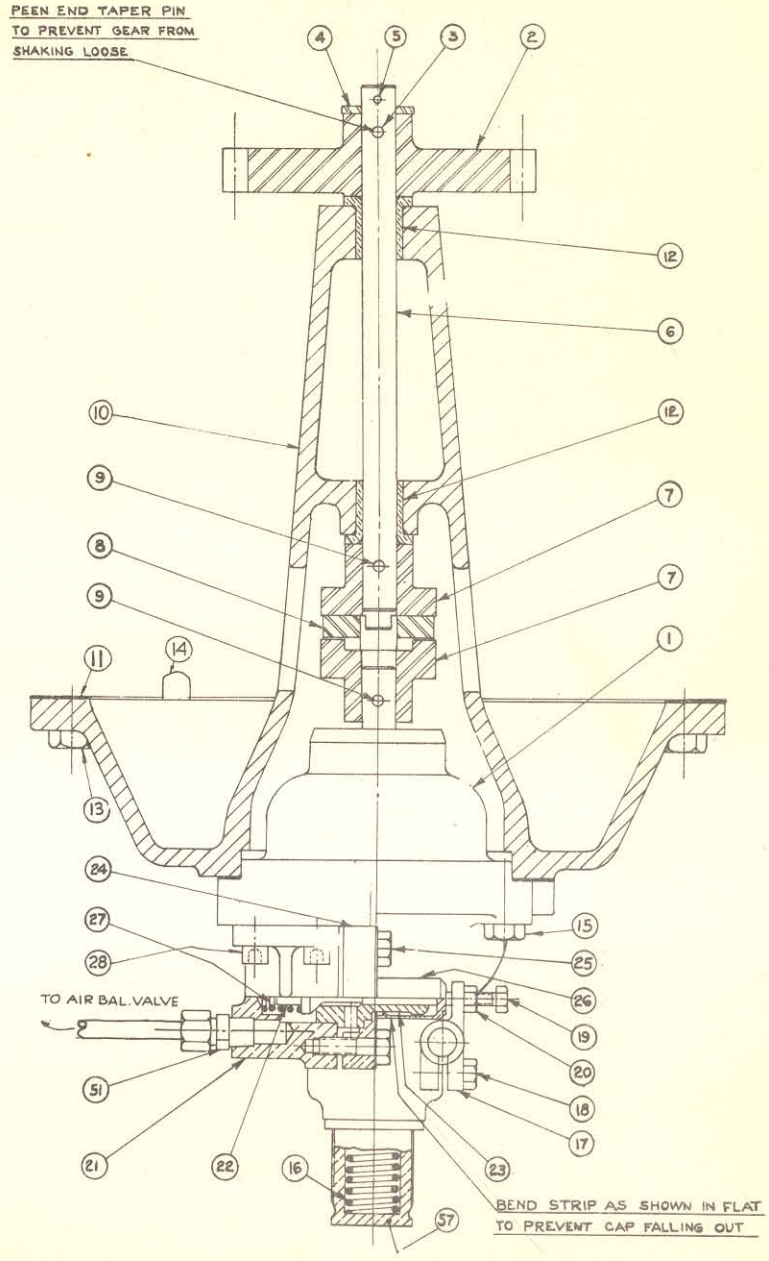
WATER PUMP VALVE CAGE

D-1026

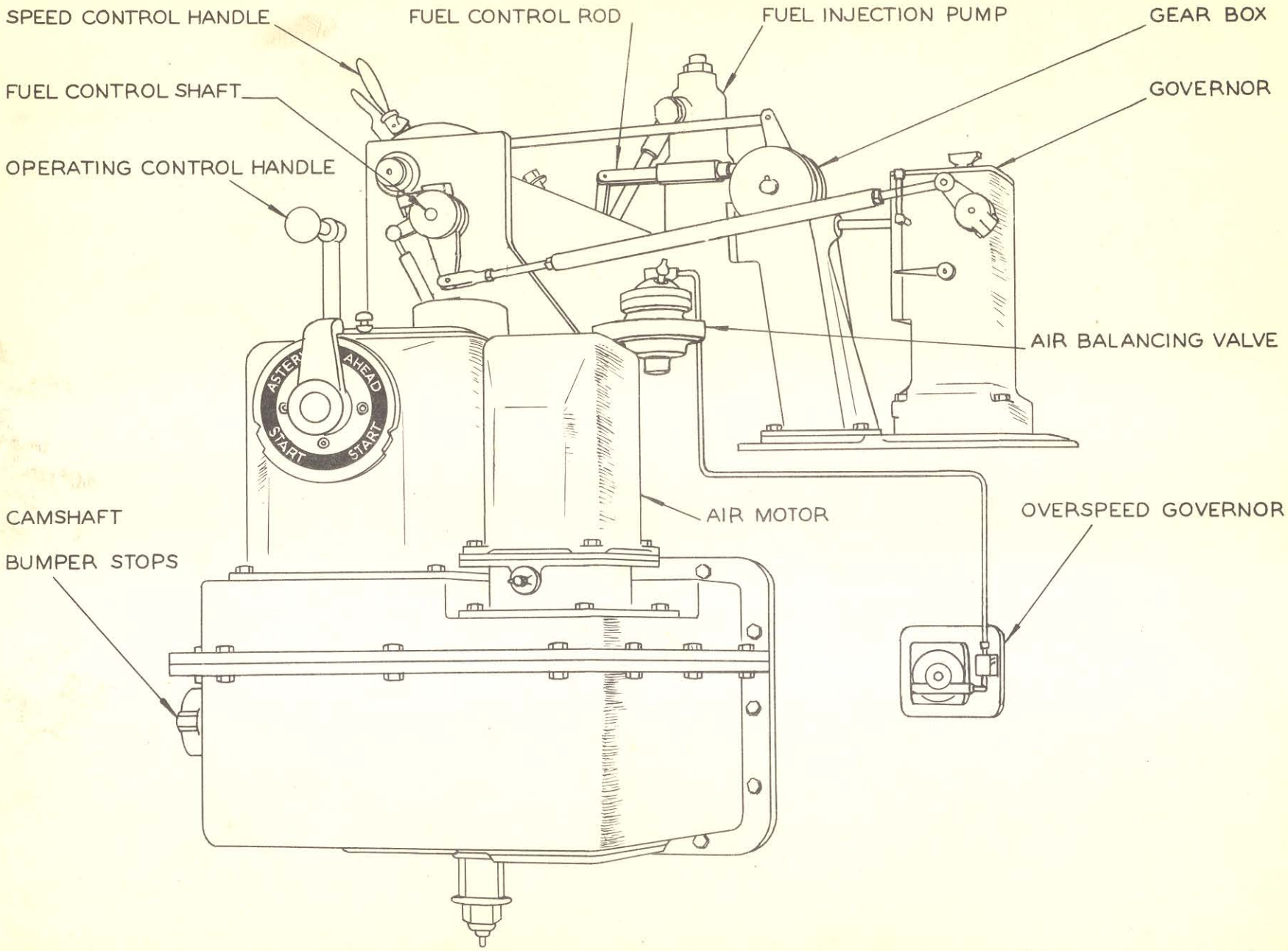


NOTE:
USE SLEEVE Nº 31984 FOR LAPPING
IN BY-PASS NEEDLE Nº 31987

ITEM	PART NAME
1	GOVERNOR, OVERSPEED
2	GEAR, GOV. OVERSPEED
3	PIN TAPER
4	WASHER
5	COTTER PIN
6	SHAFT
7	JAW, COUPLING
8	PLATE, COUPLING
9	PIN, TAPER
10	BRACKET, OVERSPEED GOV.
11	GASKET
12	BUSHING
13	CAPSCREW, BKT.-GEAR CASE
14	DOWEL, BKT.- GEAR CASE
15	CAPSCREW
16	SPRING, OVERSPEED GOV.
17	LEVER, OVERSPEED GOV.
18	CAPSCREW
19	CAPSCREW
20	NUT
21	BODY, PILOT VALVE
22	VALVE, PILOT
23	SEAT, PILOT VALVE
24	CLAMP, PILOT VALVE
25	CAPSCREW
26	CAP, PILOT VALVE
27	SPRING, PILOT VALVE
28	CAPSCREW, ALLEN
29	BODY, BALANCING VALVE
30	COVER, BALANCING VALVE
31	GASKET, COVER - BODY
32	CAPSCREW
33	GUARD, BALANCING VALVE
34	SETSCREW
35	SHAFT, BALANCING VALVE
36	NUT, SLOTTED
37	COTTER PIN
38	NUT, SLOTTED
39	RING, GASKET SUPPORT,- LGE.
40	WASHER, RETAINER (UPPER)
41	RING, GASKET SUPPORT, SMALL
42	GASKET, LARGE
43	WASHER, RETAINER (LOWER)
44	NEEDLE
45	GASKET, NEEDLE VALVE SEAL
46	CAPSCREW, NEEDLE VALVE SEAL
47	PISTON, AIR BALANCING VALVE
48	PACKING, PISTON BAL. VALVE
49	TUBING
50	CONNECTOR
51	CONNECTOR
52	COTTER PIN
53	GASKET, SMALL
56	VALVE SEAT

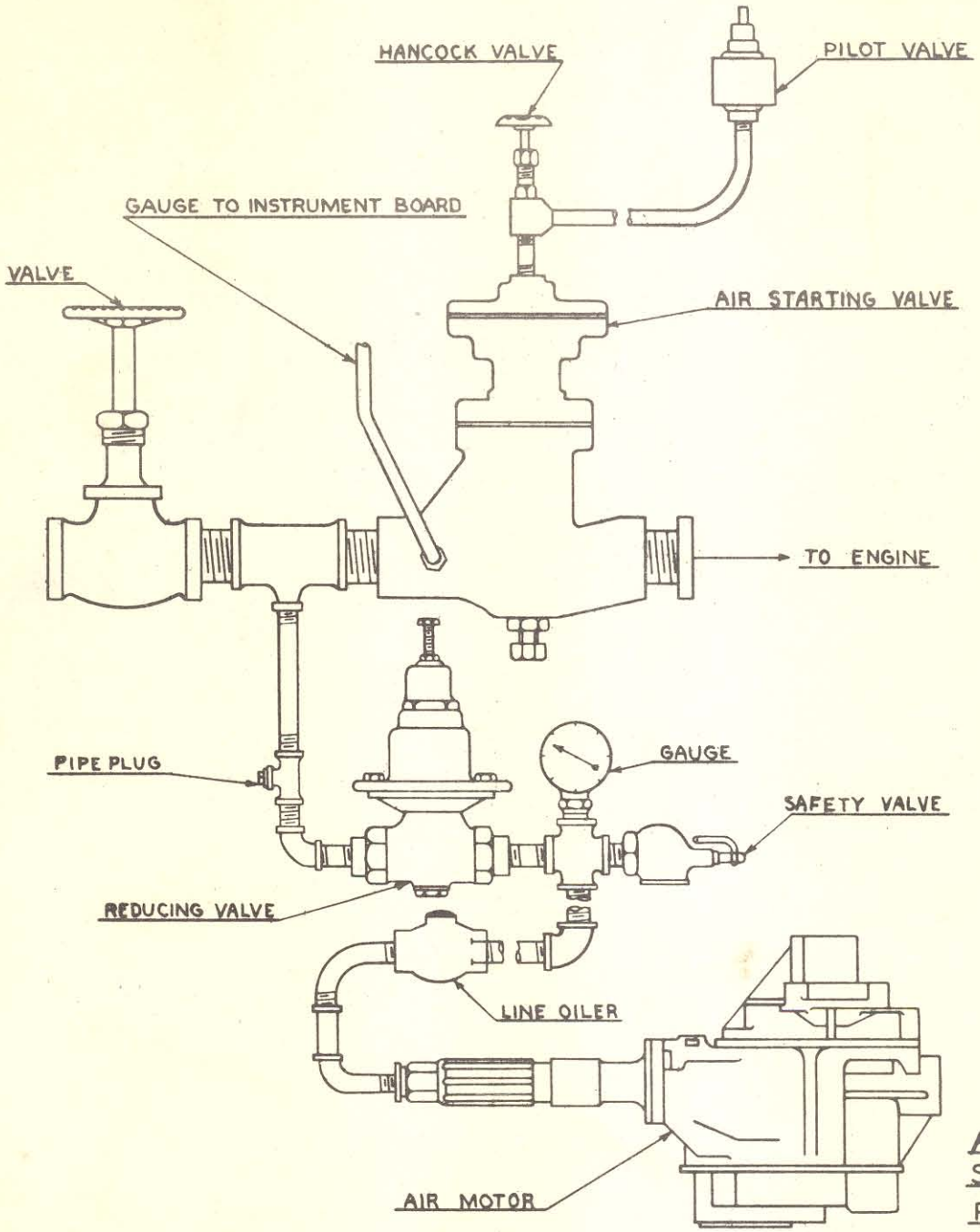


OVERSPEED GOVERNOR AND LINKAGE ASS'Y D-1036



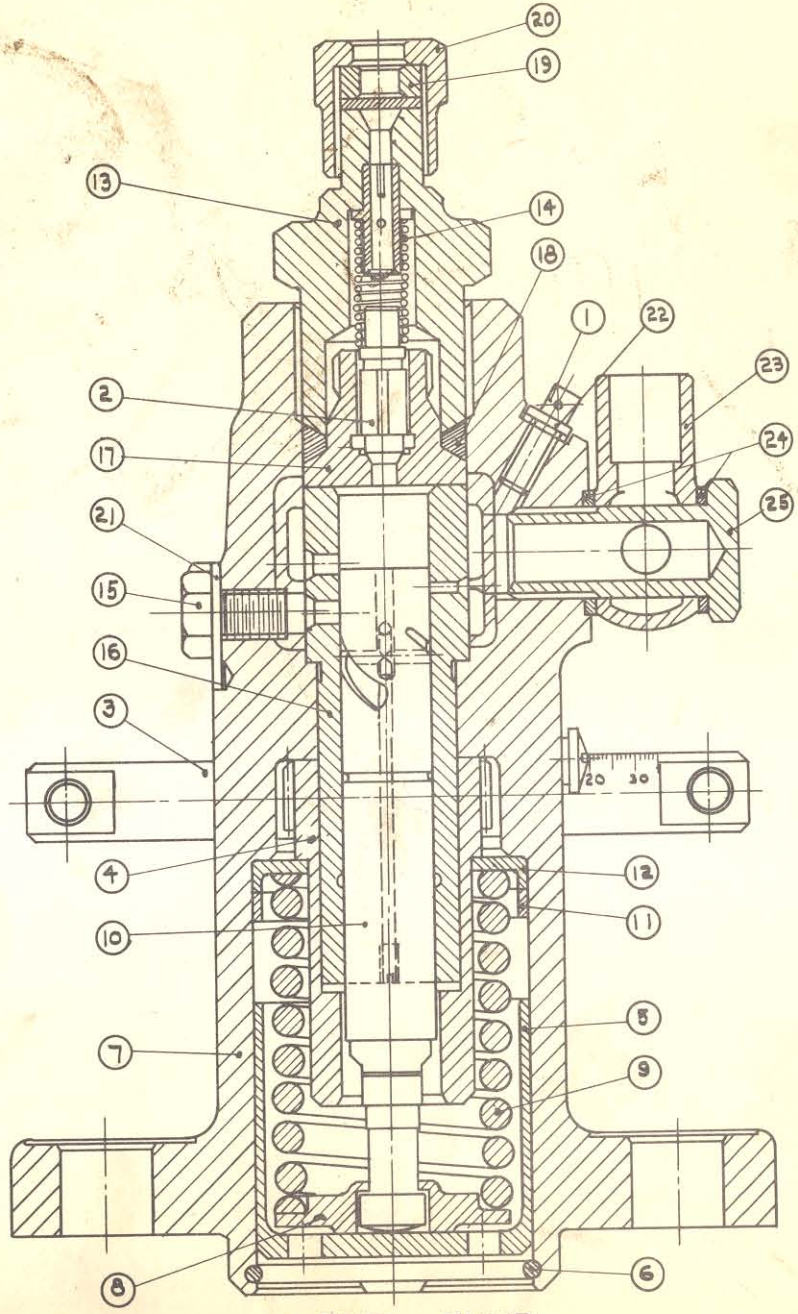
GOVERNOR AND FUEL CONTROL

D-1243

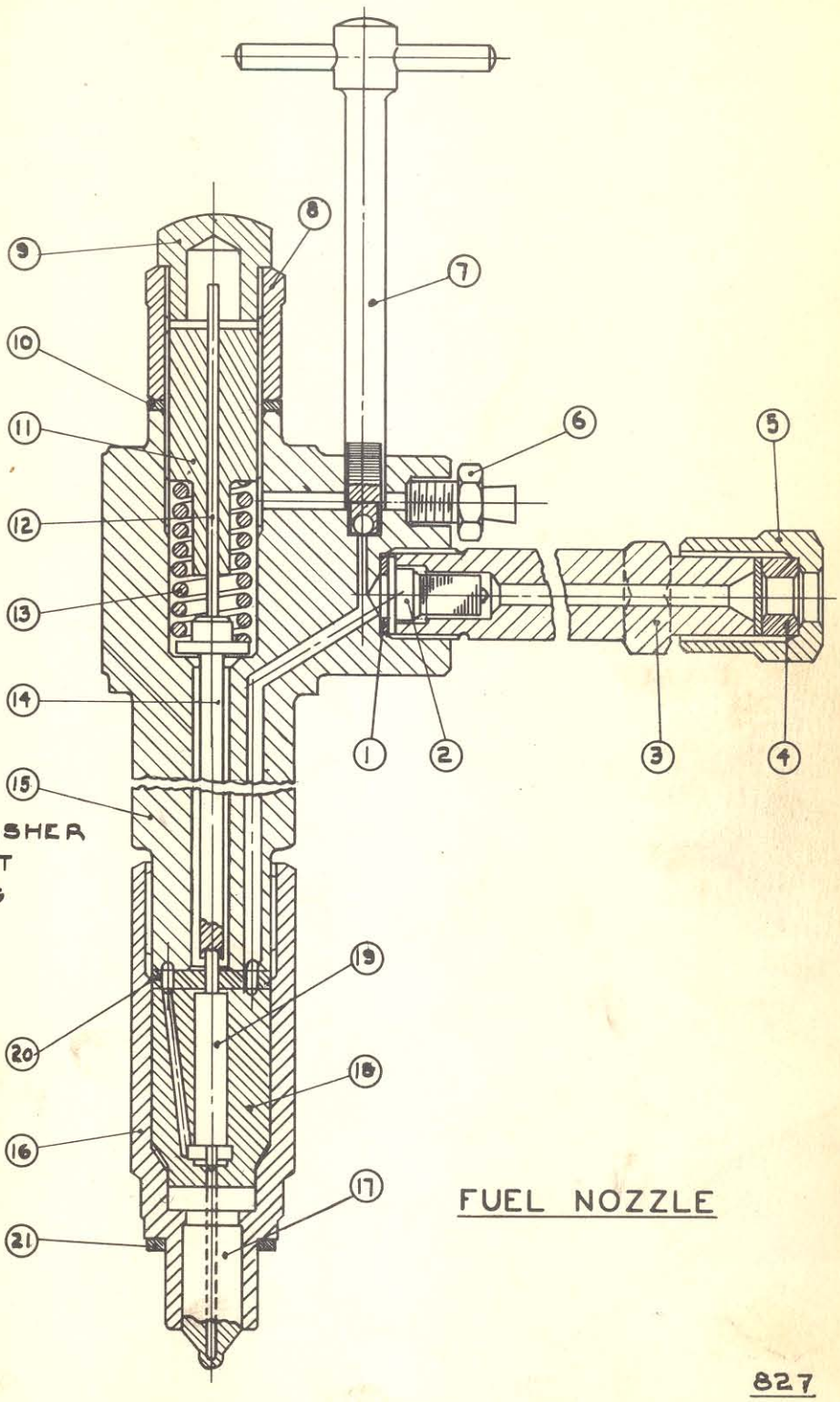


AIR SYSTEM
STARTING &
REVERSING
838-A

1. VENT SCREW
2. DELIVERY VALVE
3. CONTROL ROD
4. REGULATING SLEEVE
5. PLUNGER GUIDE
6. SPRING RING
7. PUMP BODY
8. LOWER SPRING PLATE
9. PLUNGER SPRING
10. PUMP PLUNGER
11. SPRING RING
12. UPPER SPRING PLATE
13. DELIVERY VALVE HOLDER
14. DELIVERY VALVE SPRING
15. BARREL SET SCREW
16. PUMP BARREL
17. DELIVERY VALVE SEAT
18. SPECIAL GASKET
19. WASHER, NIPPLE NUT
20. DELIVERY NIPPLE NUT
21. BARREL SET SCREW LOCKWASHER
22. VENT SCREW GASKET
23. FUEL INLET UNION
24. GASKET
25. RETAINING SCREW



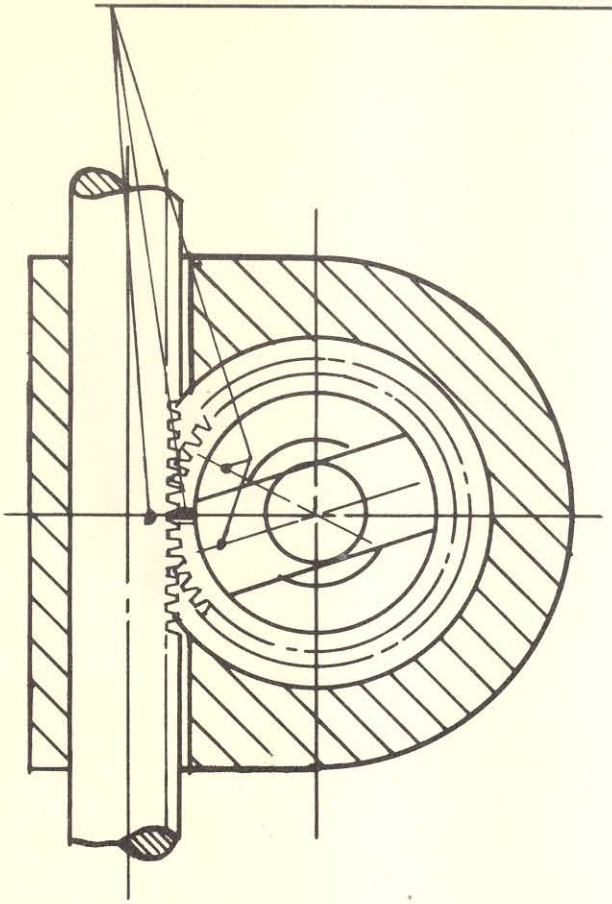
FUEL PUMP



1. COPPER GASKET
2. FILTER
3. INLET NIPPLE
4. HIGH PRESSURE LINE WASHER
5. HIGH PRESSURE LINE NUT
6. LEAKAGE RETURN FITTING
7. BLEEDER VALVE
8. LOCK NUT
9. CAP
10. COPPER GASKET
11. ADJUSTING SCREW
12. FEELER PIN
13. SPRING
14. PRESSURE PIN
15. HOLDER BODY
16. ASSEMBLY NUT
17. SPRAY TIP
18. NOZZLE VALVE BODY
19. NOZZLE VALVE
20. STOP PLATE
21. COPPER GASKET

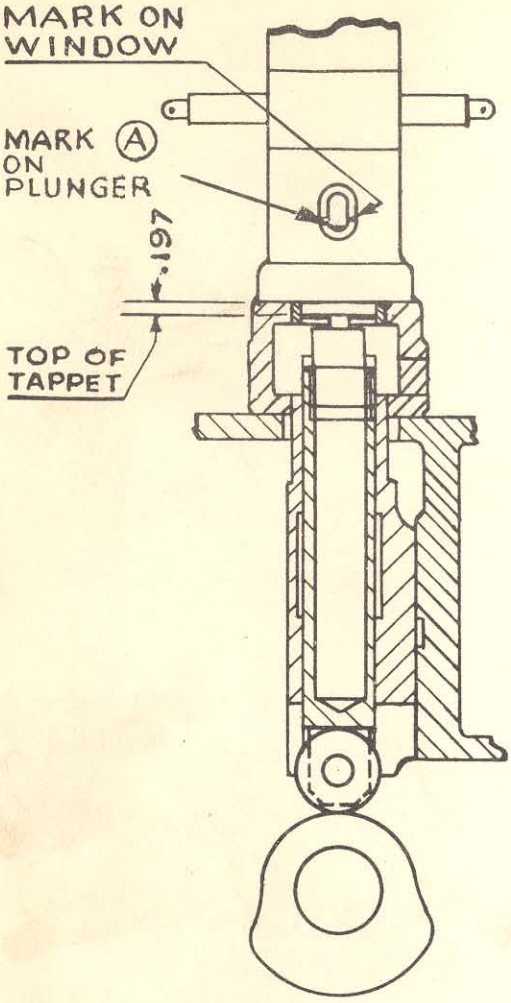
FUEL NOZZLE

ASSEMBLE PUMP ACCORDING TO THESE MARKS

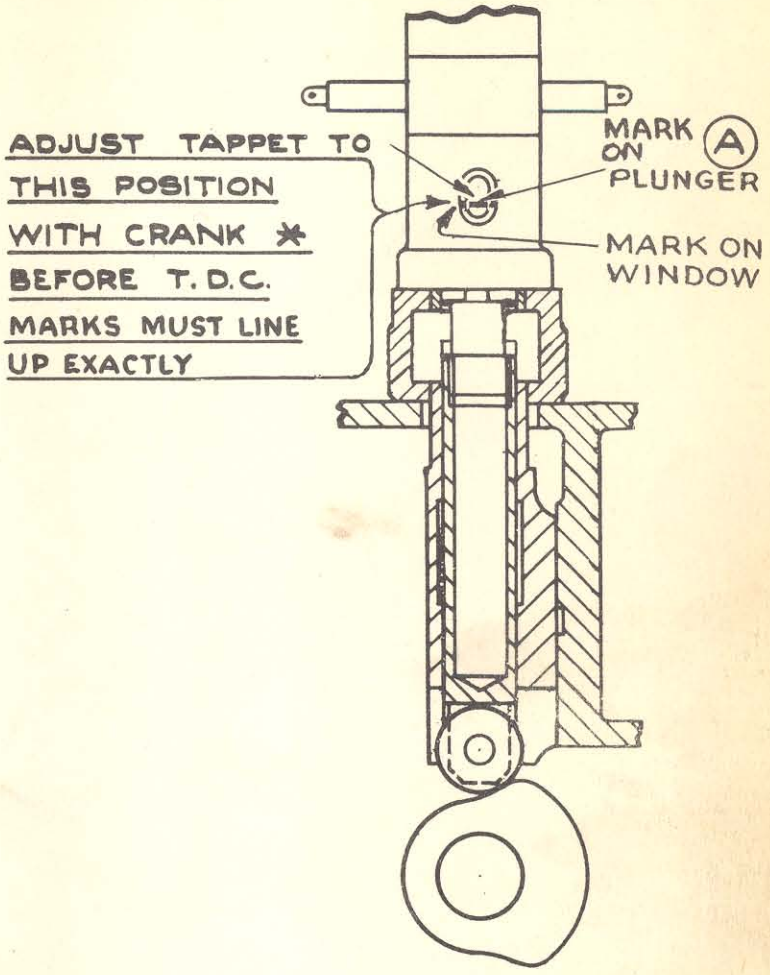


FUEL PUMP-BOTTOM VIEW SHOWING LOCATING MARKS 829

INITIAL ADJUSTMENT



FINAL ADJUSTMENT



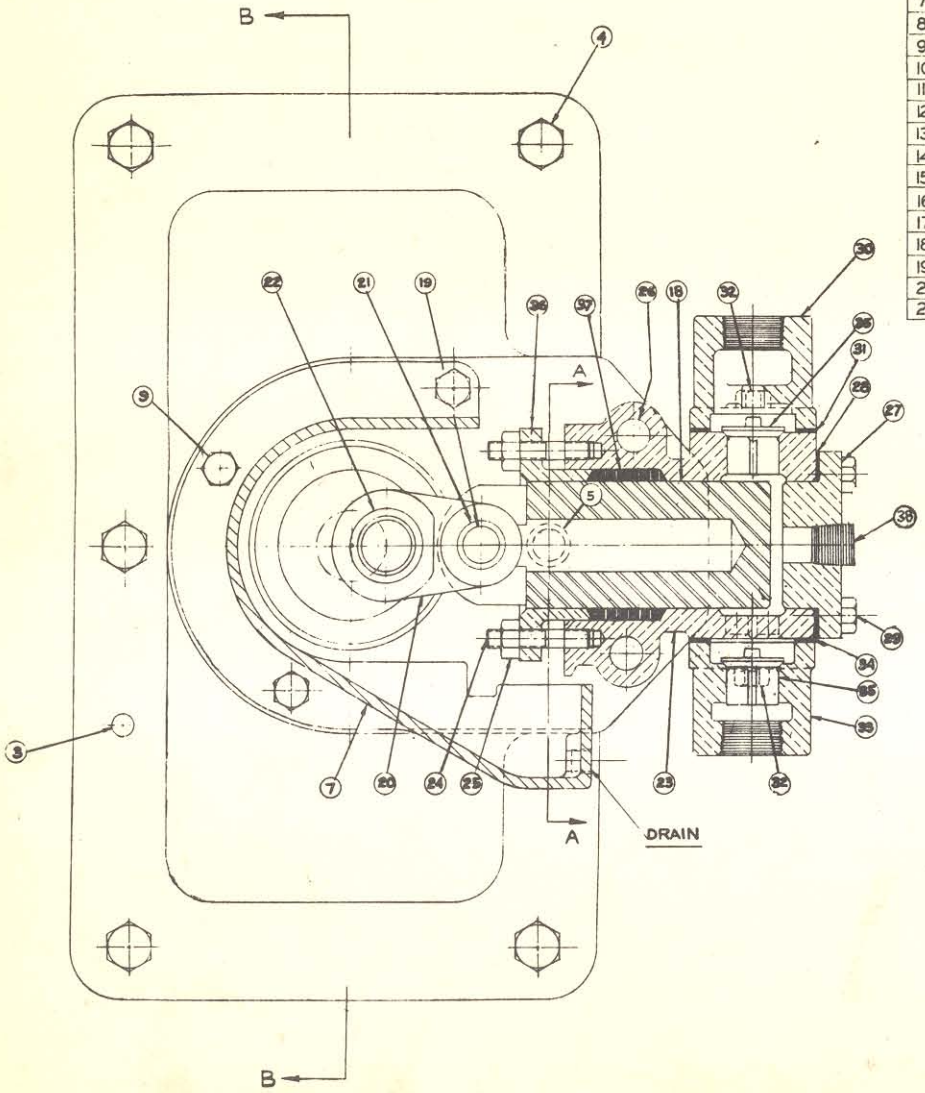
IF THE ADJUSTING MARK "A" ON THE SLIDING PLUNGER GUIDE DISAPPEARS AT THE UPPER EDGE OF THE INSPECTION WINDOW, MECHANICAL DAMAGE WILL OCCUR TO PLUNGER AND DELIVERY VALVE.

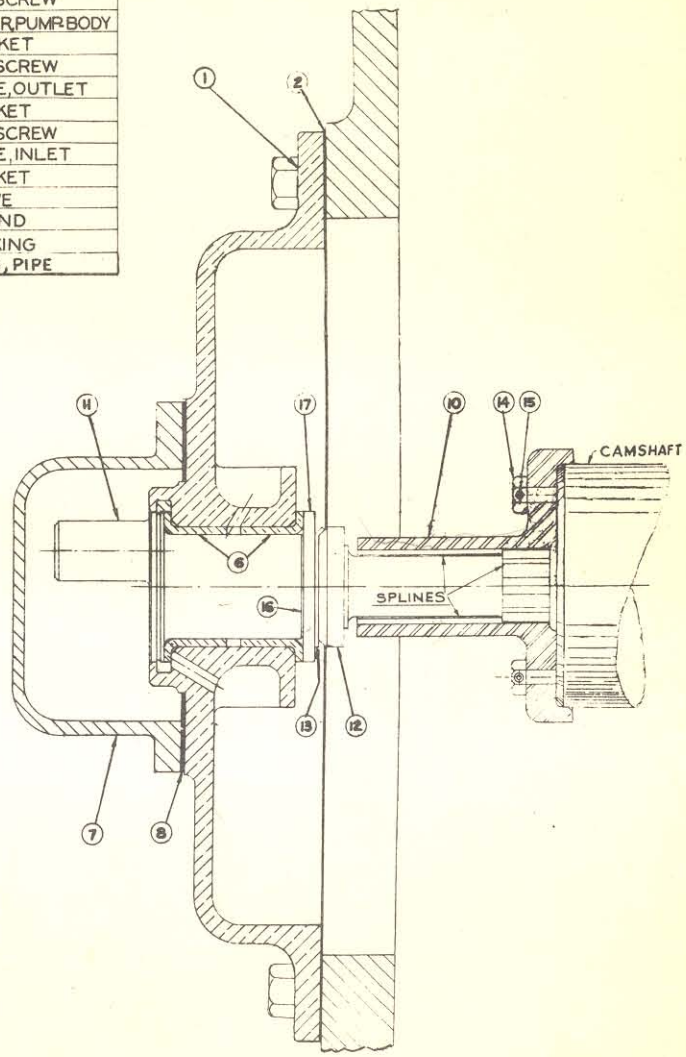
* SEE INJECTION SETTING ON TITLE PAGE

TIMING OF FUEL PUMP D-1112

ITEM	PART NAME
1	BRACKET
2	GASKET
3	DOWEL
4	CAPSCREW
5	CAPSCREW
6	BUSHING
7	COVER, TRANS. PUMP
8	GASKET
9	CAPSCREW
10	STUB SHAFT, SPLINED
11	ECCENTRIC
12	LOCKNUT
13	LOCKWASHER
14	CAPSCREW
15	WIRE
16	SHIM
17	THRUST RING
18	PLUNGER
19	PIN
20	CONN. ROD
21	BUSHING

ITEM	PART NAME
22	BUSHING
23	PUMP BODY
24	STUD
25	NUT
26	CAPSCREW
27	COVER, PUMP BODY
28	GASKET
29	CAPSCREW
30	CAGE, OUTLET
31	GASKET
32	CAPSCREW
33	CAGE, INLET
34	GASKET
35	VALVE
36	GLAND
37	PACKING
38	PLUG, PIPE



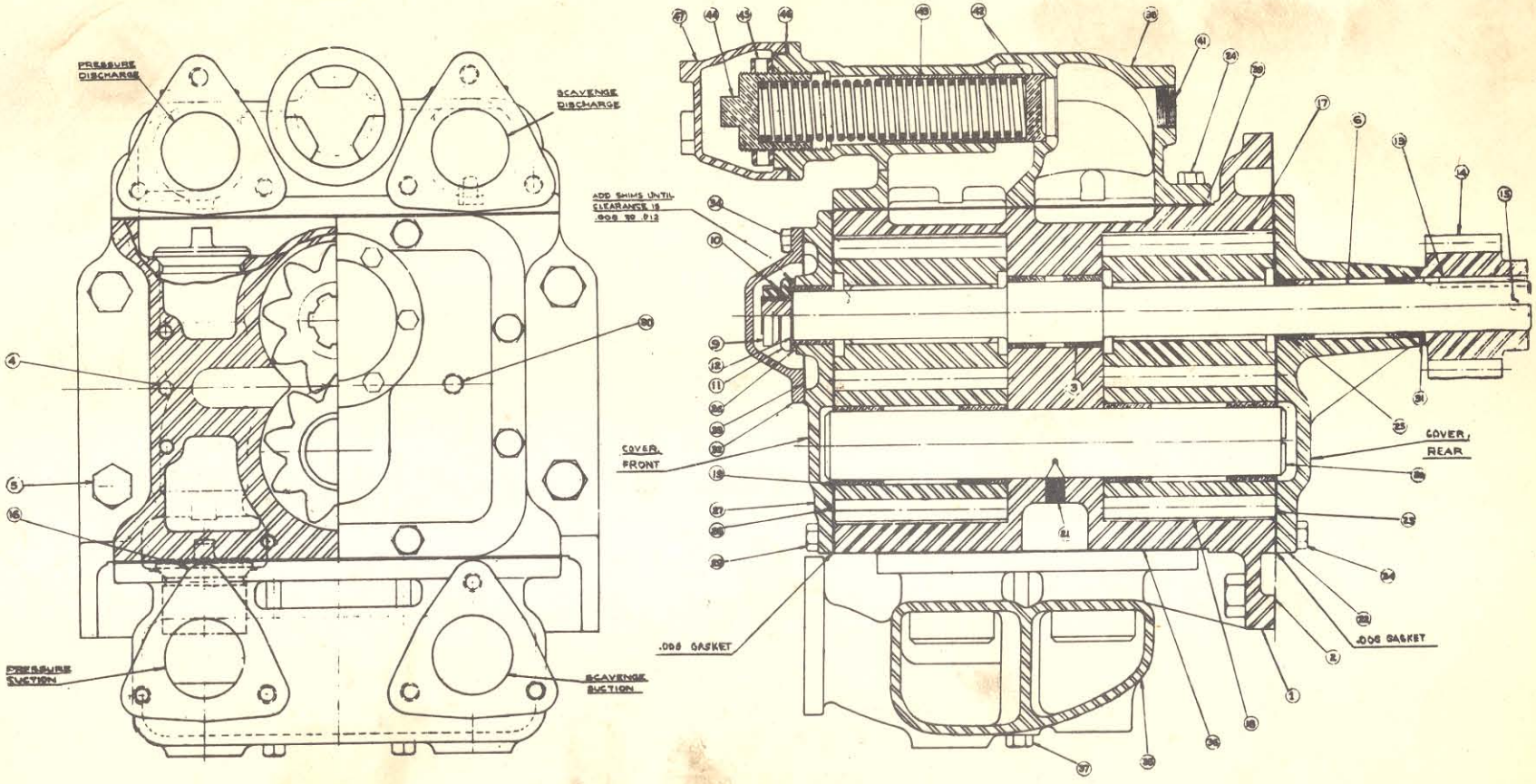


SECTION B-B

FUEL TRANSFER PUMP

D-1025

	PART NAME
1	HOUSING
2	GASKET, GEAR CASE
3	BUSHING
4	DOWEL
5	CAPSCREW
6	DRIVE SHAFT
7	COTTER PIN
8	WASHER
9	LOCK NUT
10	LOCK WASHER
11	THRUST WASHER
12	SHIM, THRUST WASHER
13	KEY STRAIGHT
14	DRIVE GEAR
15	TAPER PIN
16	VALVE, LUB. PUMP
17	MAIN GEAR
18	IDLER GEAR
19	BUSHING, IDLER GEAR
20	IDLER SHAFT
21	SETSCREW
22	INSIDE COVER
23	GASKET, HOUSING
24	CAPSCREW
25	BUSHING
26	THRUST BUSHING
27	FRONT COVER
28	GASKET, HOUSING
29	CAPSCREW
30	PIPE PLUG
31	THRUST BUSHING
32	CAP, FRONT COVER
33	GASKET, FRONT COVER
34	CAPSCREW
35	LOWER VALVE CAGE
36	GASKET, HOUSING
37	CAPSCREW
38	UPPER VALVE GAGE
39	GASKET, HOUSING
40	CAPSCREW
41	PIPE PLUG
42	PLUNGER
43	SPRING
44	ADJUSTING PLUG
45	LOCKING NUT
46	GASKET
47	CAP, RELIEF VALVE

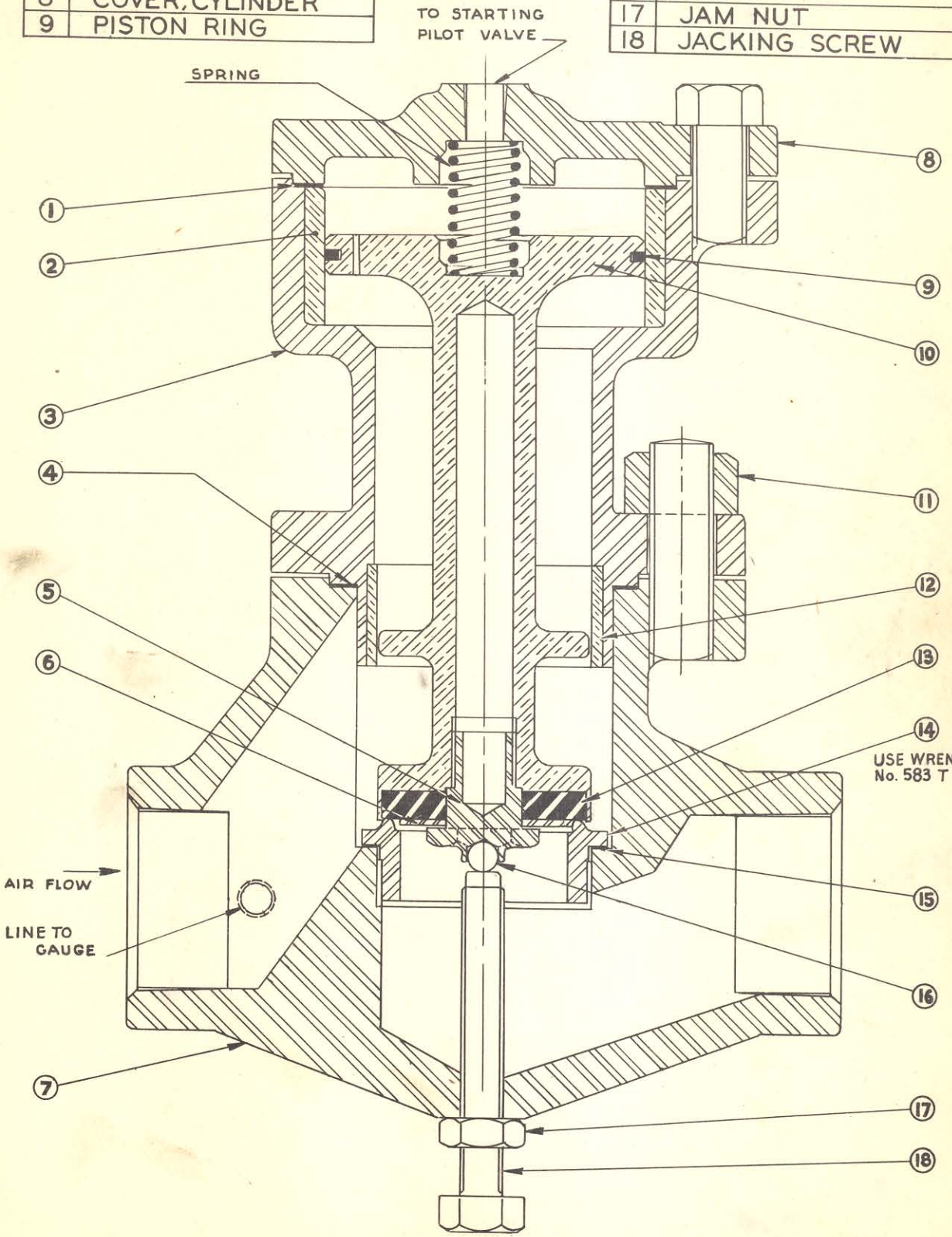


LUBRICATING OIL PUMP

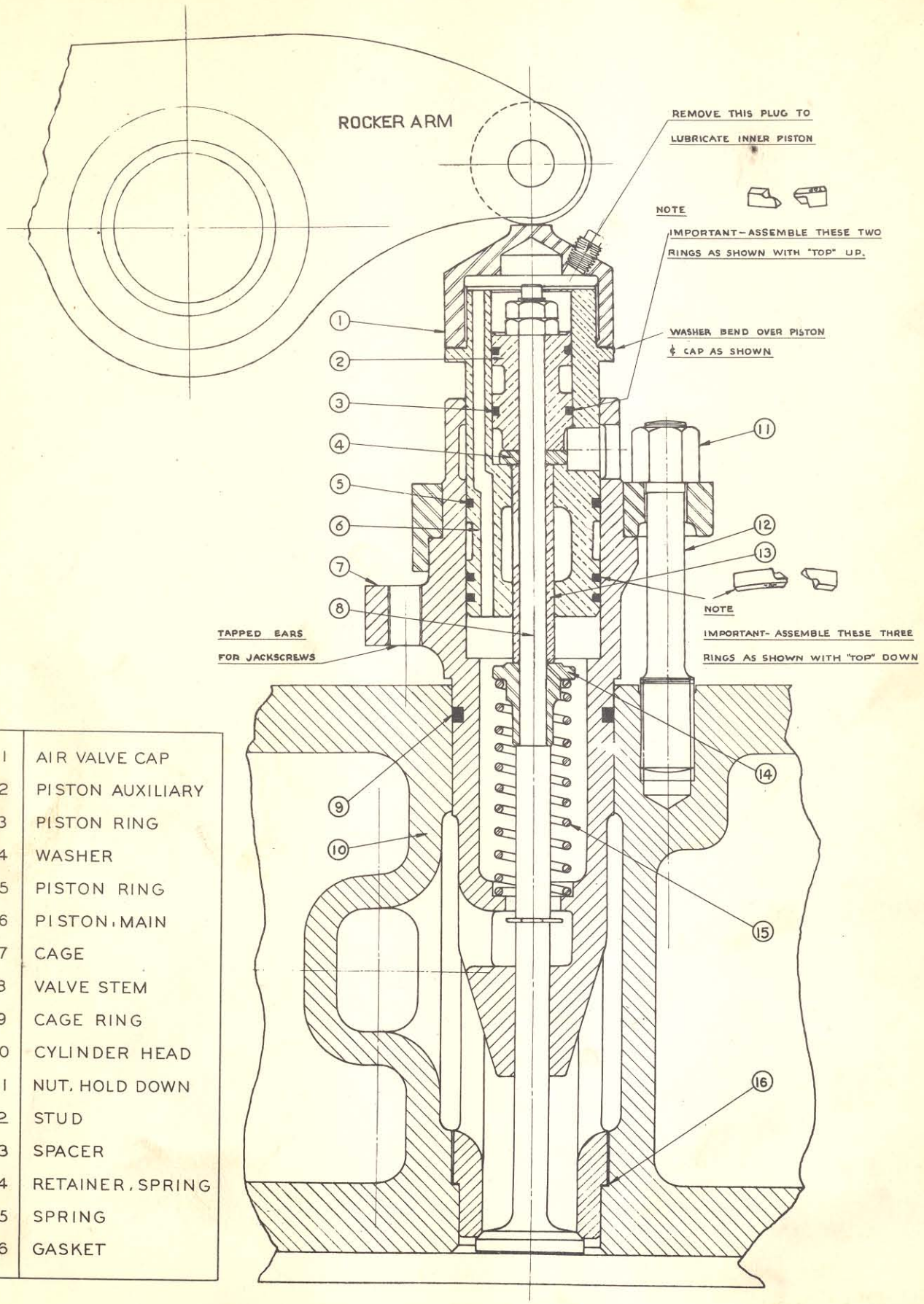
D-1021

1	GASKET, CYL. COVER
2	BUSHING
3	CYLINDER
4	GASKET, BODY CYL.
5	RETAINING SCREW
6	" " WASHER
7	VALVE BODY
8	COVER, CYLINDER
9	PISTON RING

10	PISTON
11	NUT
12	BUSHING
13	PISTON SEAT
14	VALVE SEAT
15	GASKET, VALVE SEAT
16	BALL
17	JAM NUT
18	JACKING SCREW



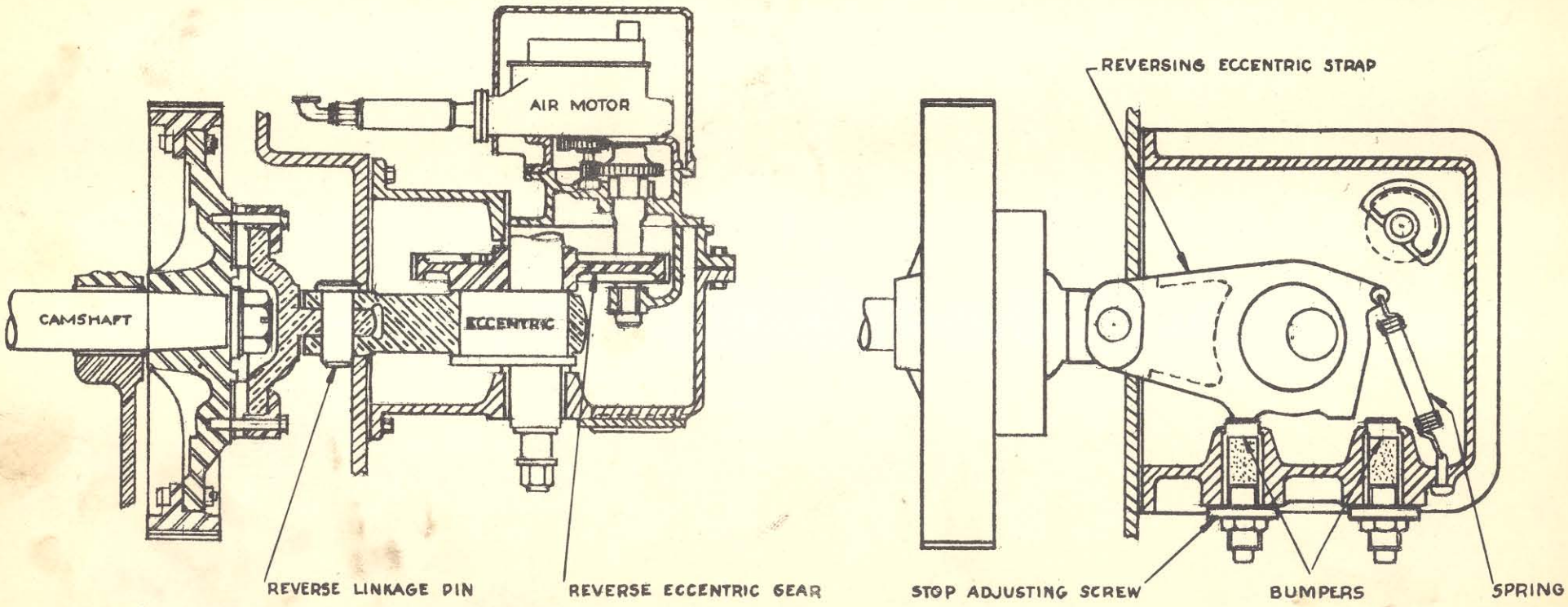
MAIN AIR STARTING VALVE D-1027



1	AIR VALVE CAP
2	PISTON AUXILIARY
3	PISTON RING
4	WASHER
5	PISTON RING
6	PISTON, MAIN
7	CAGE
8	VALVE STEM
9	CAGE RING
10	CYLINDER HEAD
11	NUT, HOLD DOWN
12	STUD
13	SPACER
14	RETAINER, SPRING
15	SPRING
16	GASKET

AIR STARTING VALVE

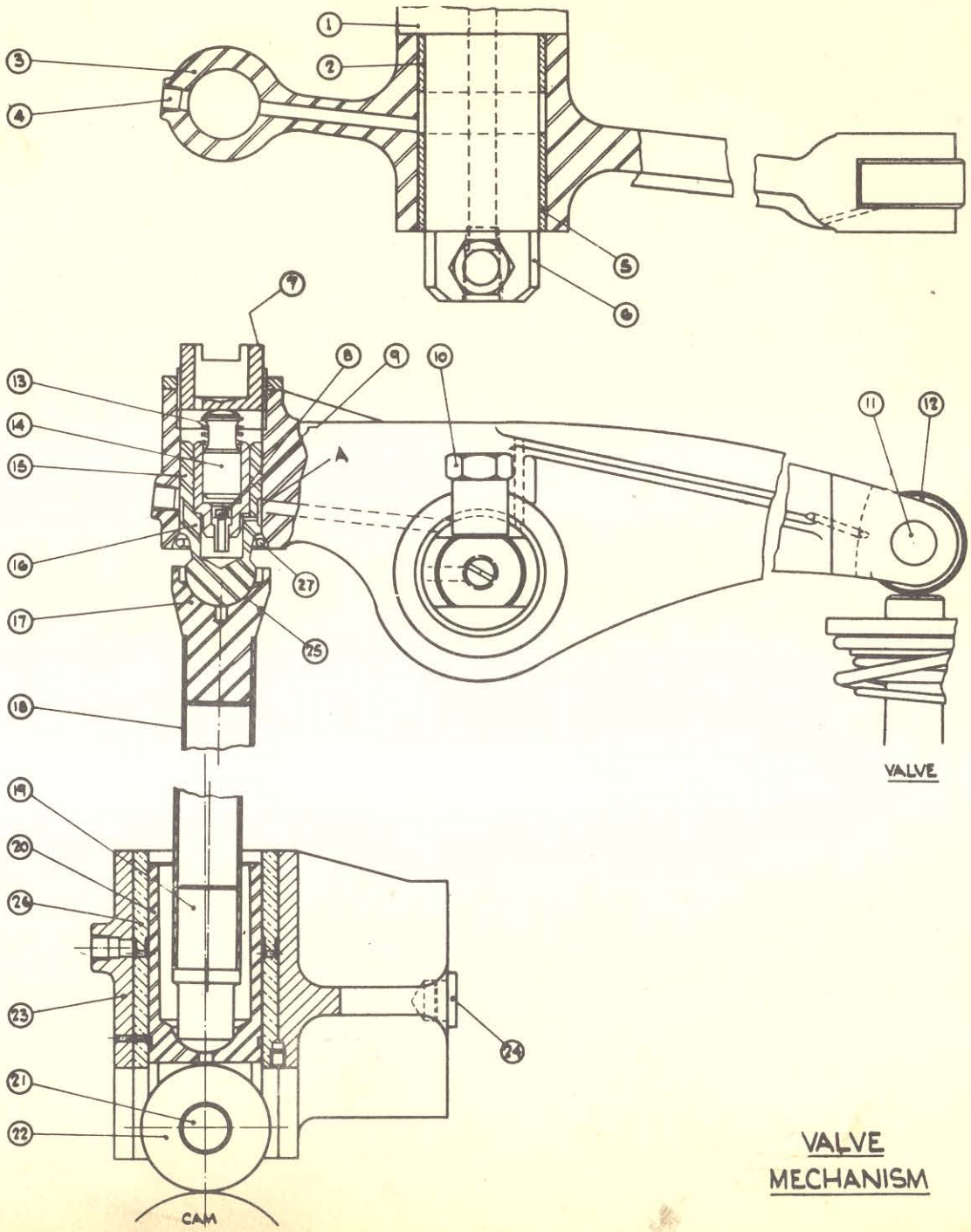
D-1020



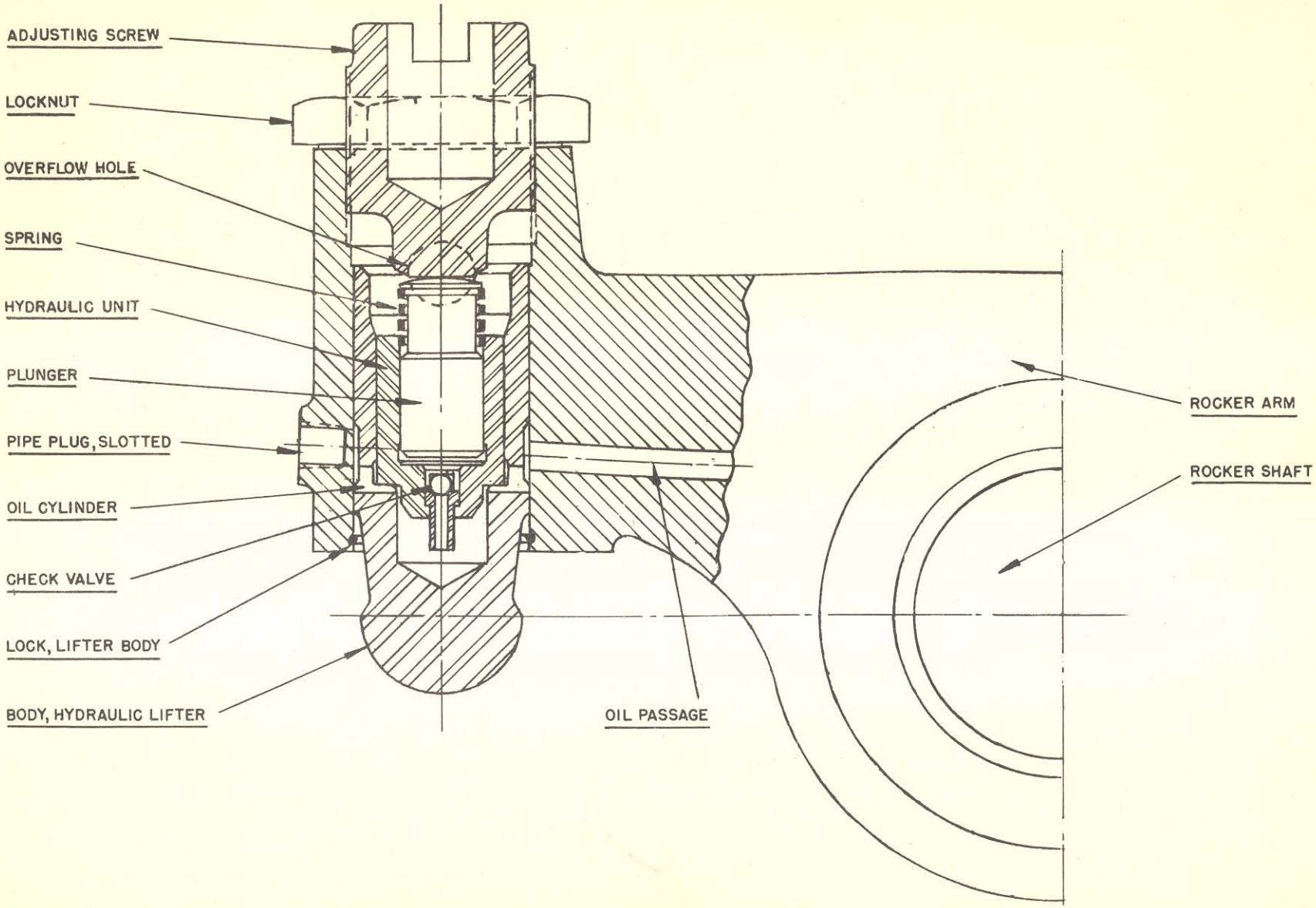
REVERSING MECHANISM

D-1030

1 AIR ROCKER
2 BUSHING
3 ROCKER
4 PIPE PLUG
5 BUSHING
6 ROCKER SHAFT
7 ADJUSTING SCREW
8 BALL RETAINER
9 CHECK VALVE
10 ROCKER SHAFT STUD NUT
11 ROLLER PIN
12 ROLLER
13 PLUNGER SPRING
14 HYDRAULIC PLUNGER
15 CYLINDER
16 LIFTER BODY
17 PUSH ROD END-UPPER
18 PUSH ROD
19 PUSH ROD END-LOWER
20 TAPPET
21 ROLLER PIN
22 ROLLER
23 TAPPET GUIDE
24 DOWEL
25 BALL SEAT
26 TAPPET GUIDE LINER
27 SNAP RING



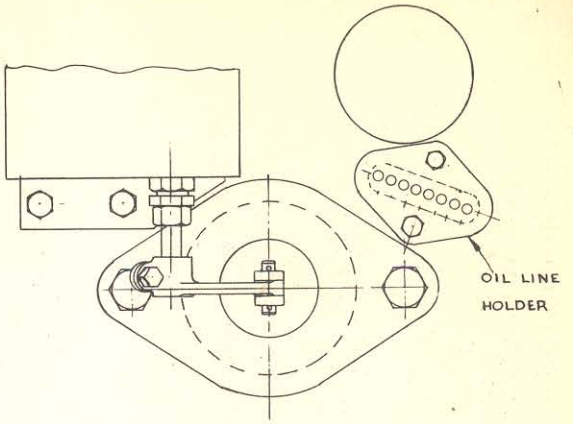
VALVE MECHANISM

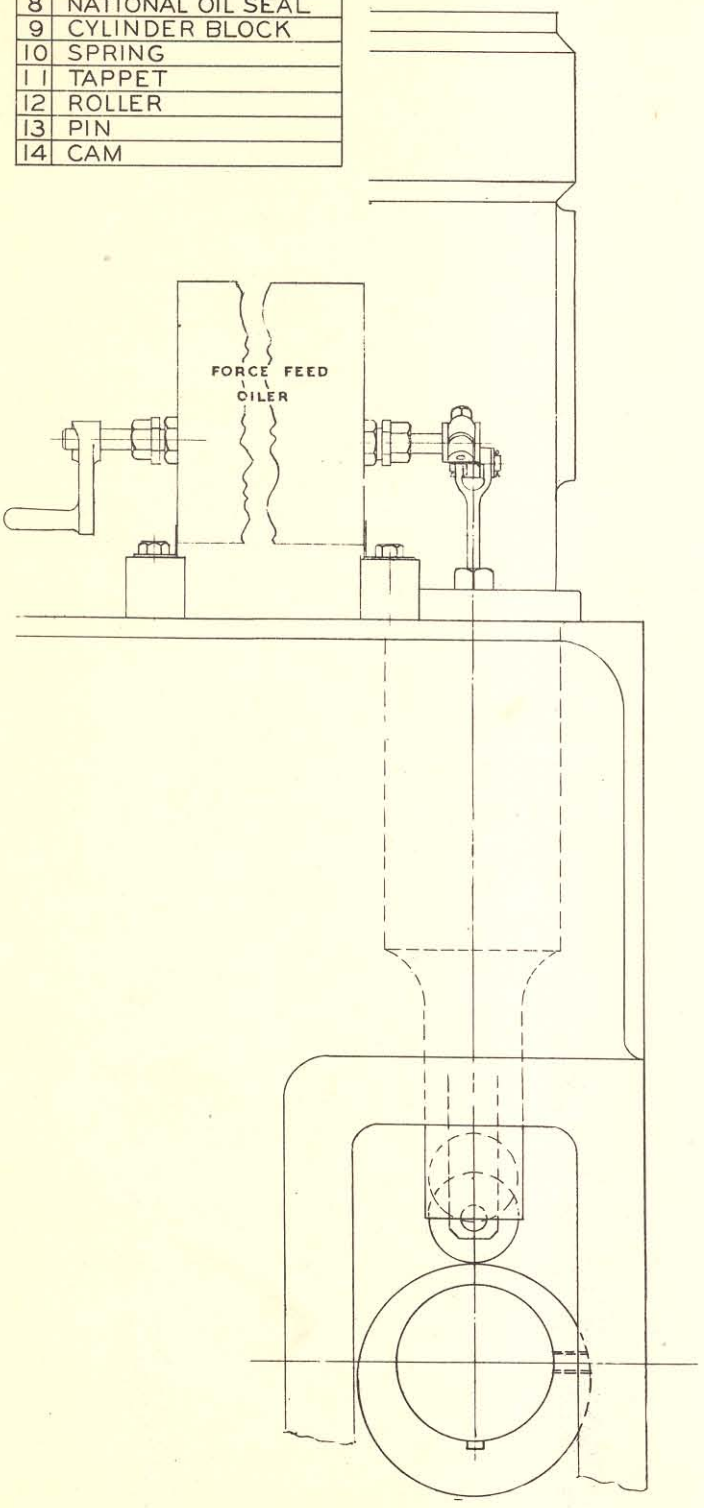


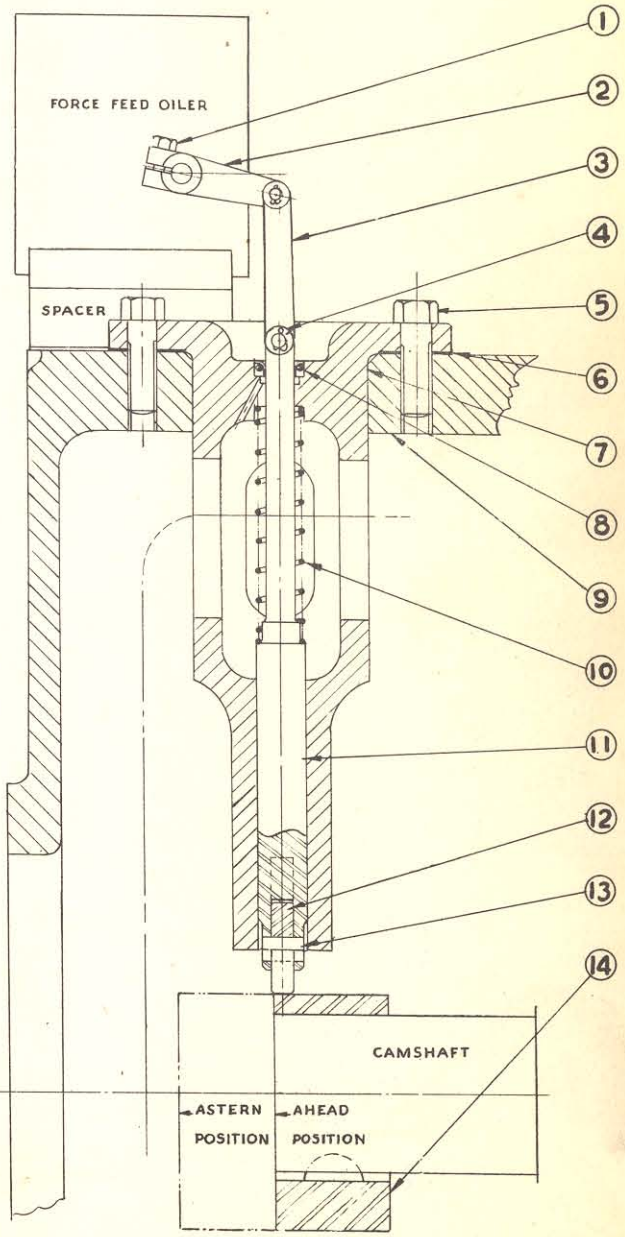
HYDRAULIC VALVE LIFTING MECHANISM

D-1403

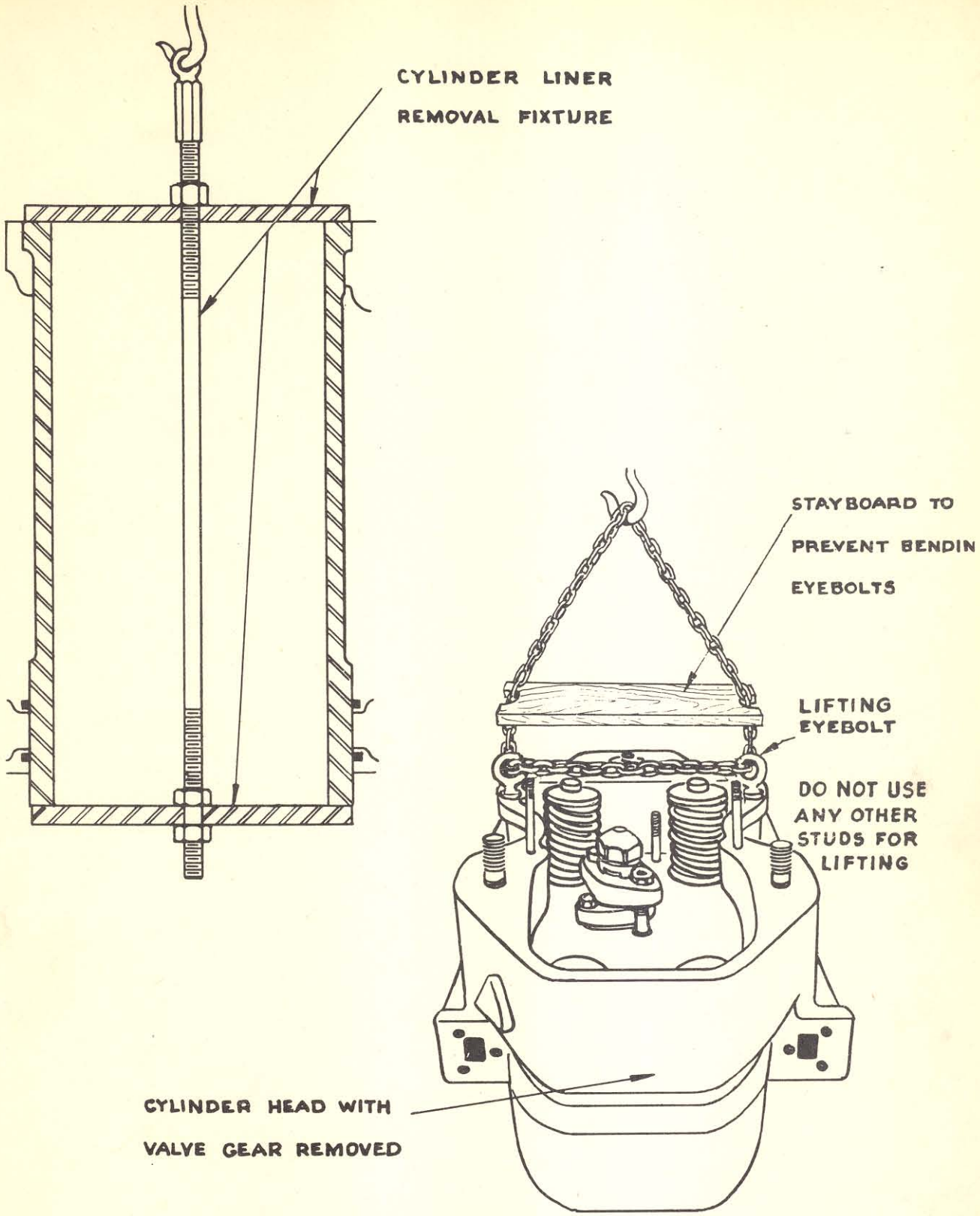
NO.	PART NAME
1	CAPSCREW
2	LEVER
3	LINK
4	PIN
5	CAPSCREW
6	GASKET
7	TAPPET GUIDE
8	NATIONAL OIL SEAL
9	CYLINDER BLOCK
10	SPRING
11	TAPPET
12	ROLLER
13	PIN
14	CAM





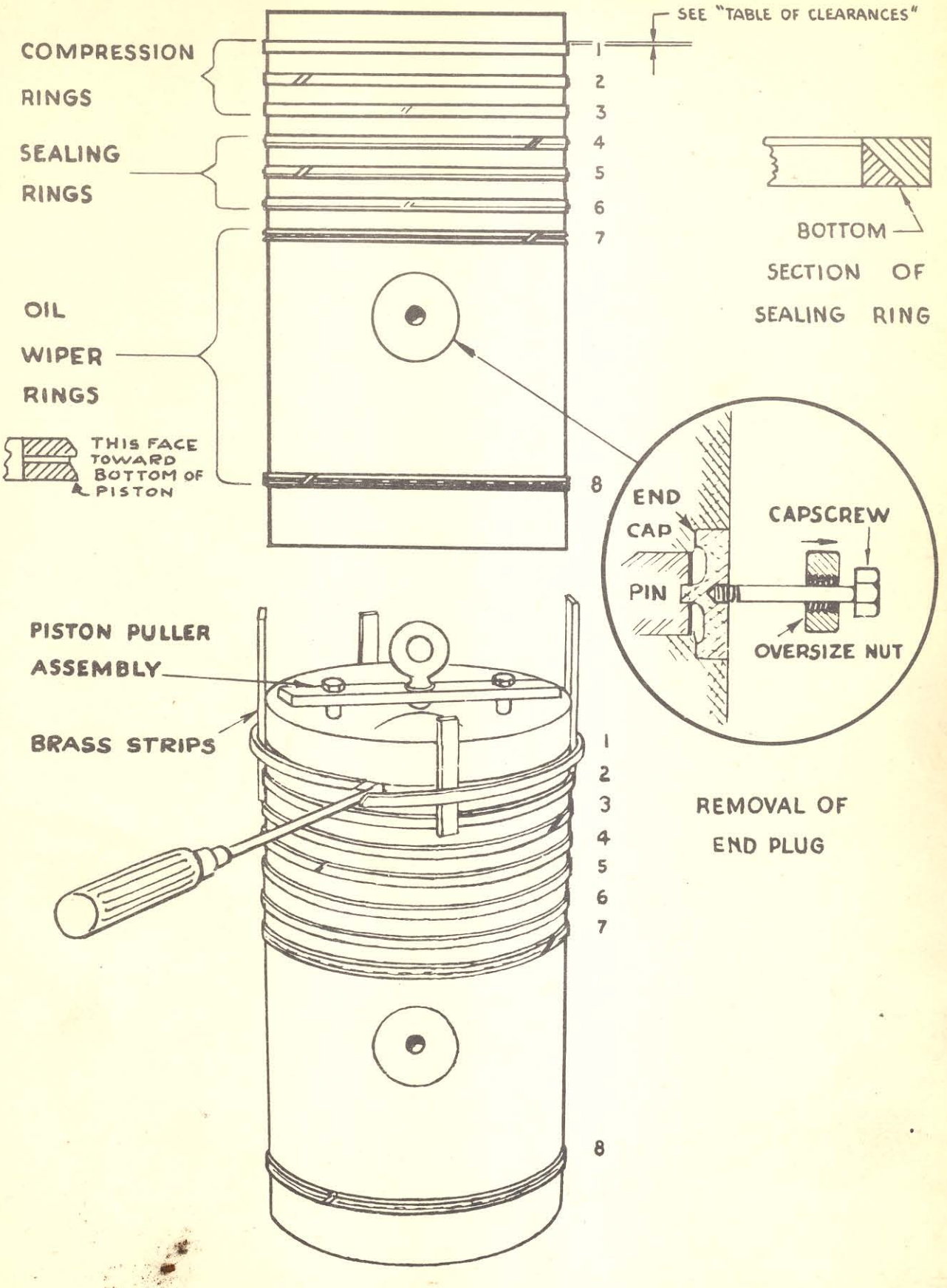


FORCE FEED OILER DRIVE D-1046



REMOVAL OF CYLINDER LINER
AND METHOD OF LIFTING HEAD

D 1019



REMOVAL OF PISTON RINGS

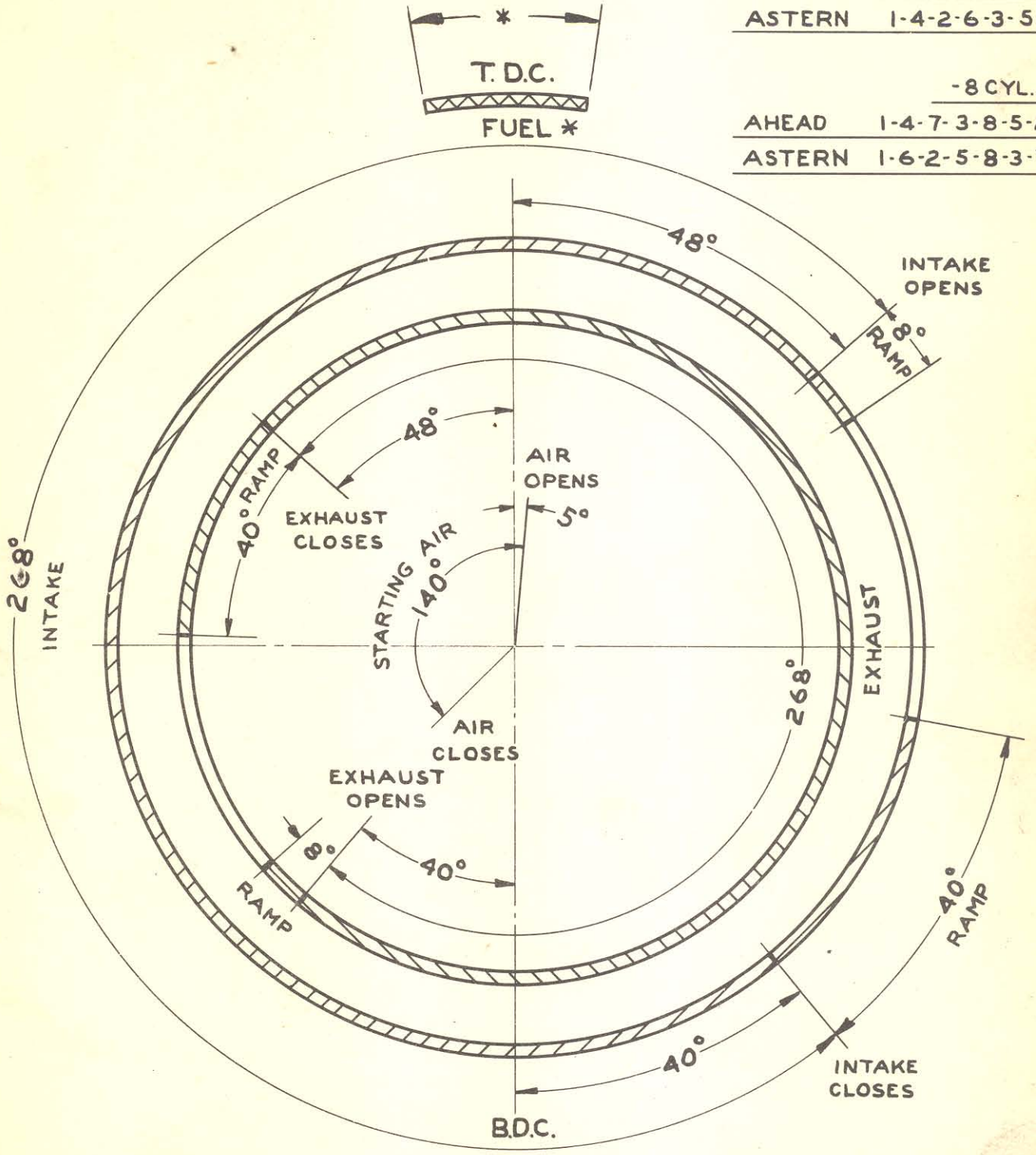
D-1288

ON 48" DIA. FLYWHEEL, 1° = .4189" & 1" = 2.387°

VALVE CLEARANCES	
INTAKE =	0
EXHAUST =	0
AIR STARTING =	.033"

FIRING ORDER - 6 CYL.	
AHEAD	1-5-3-6-2-4
ASTERN	1-4-2-6-3-5

	- 8 CYL.
AHEAD	1-4-7-3-8-5-2-6
ASTERN	1-6-2-5-8-3-7-4



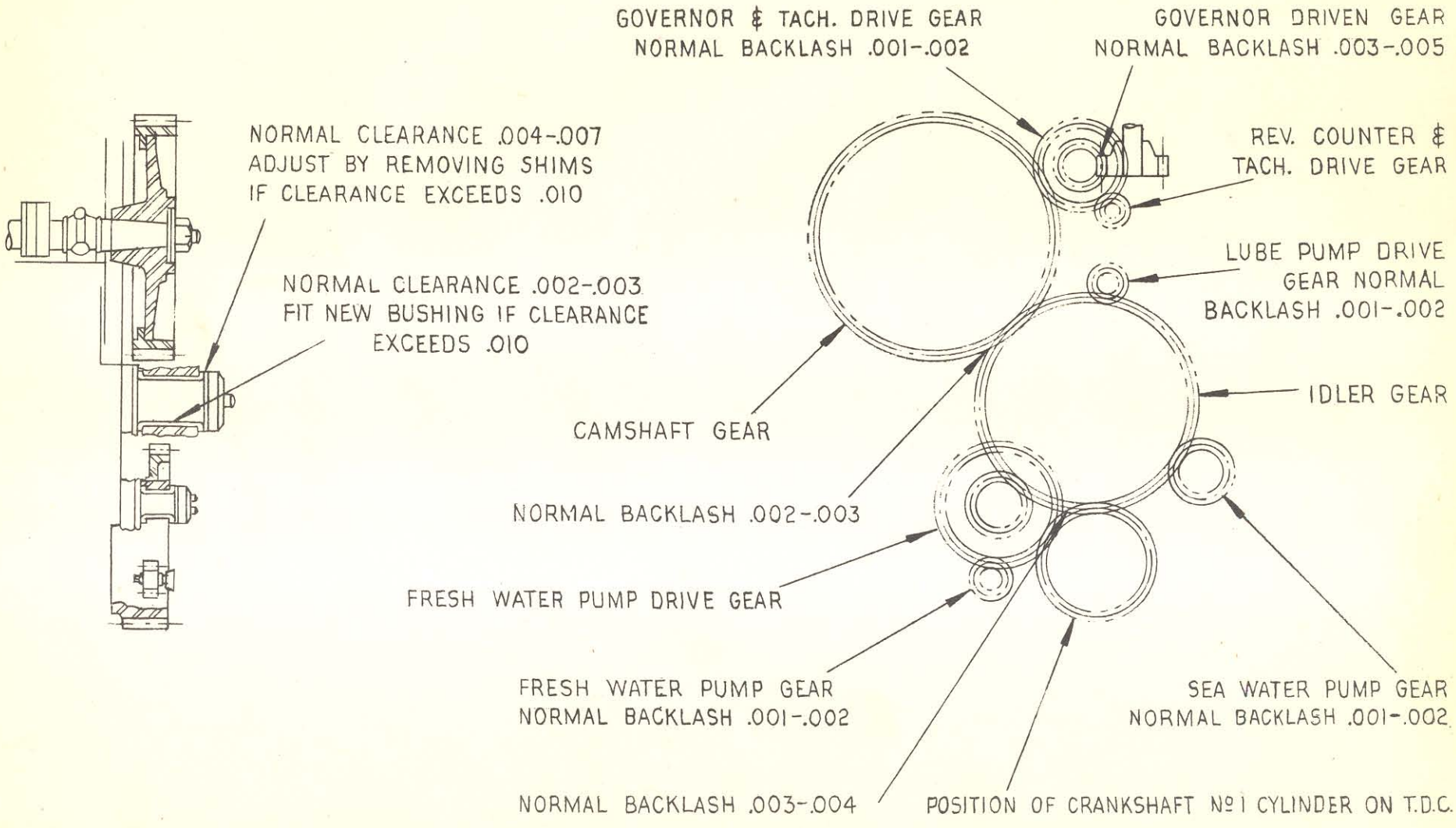
TIMING DIAGRAM

SUPERCHARGED 'Q'

* SEE TITLE PAGE

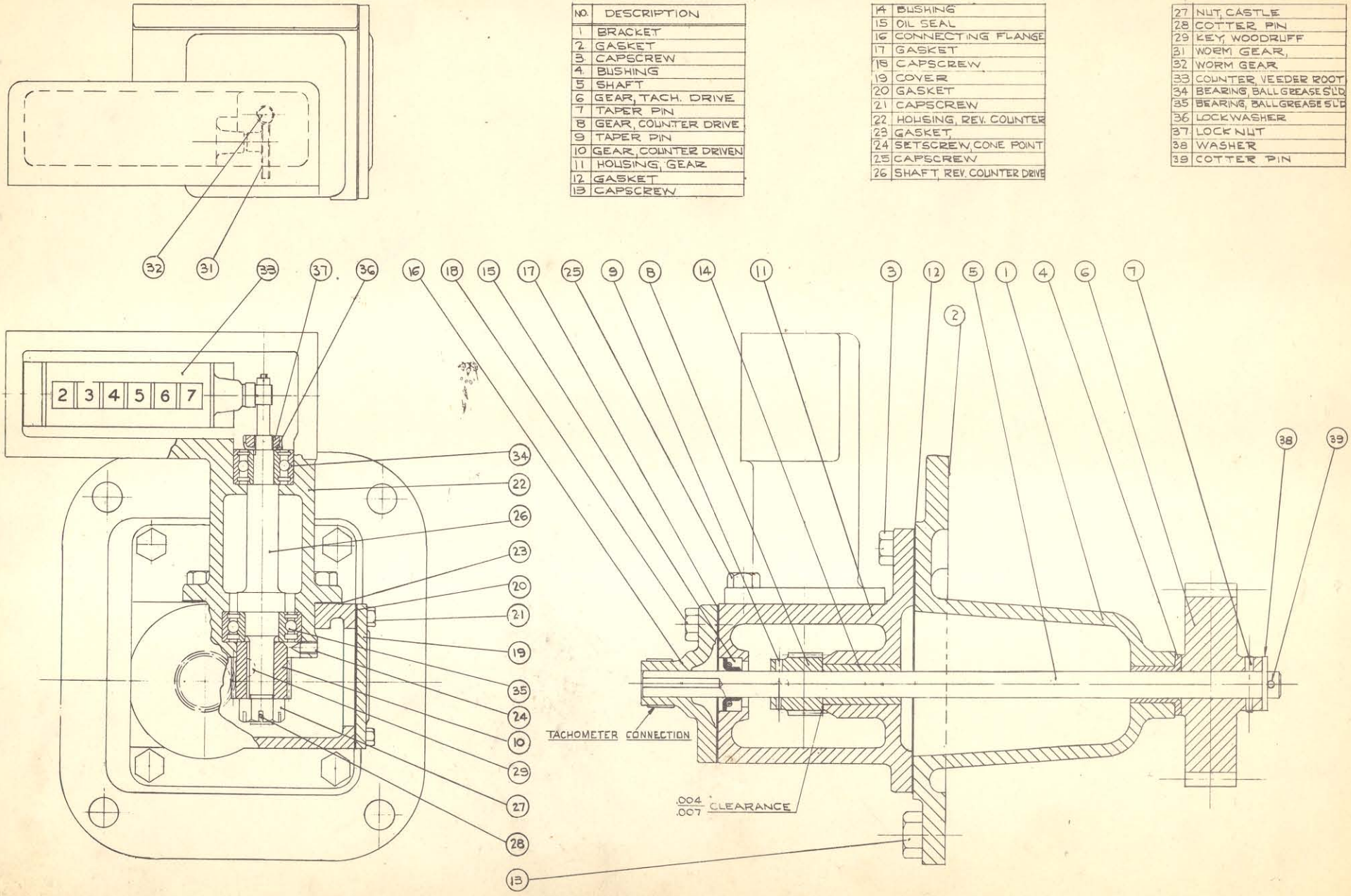
ENTERPRISE
ENGINE COMPANY
SAN FRANCISCO

D-1015



G E A R S E T

D-1248



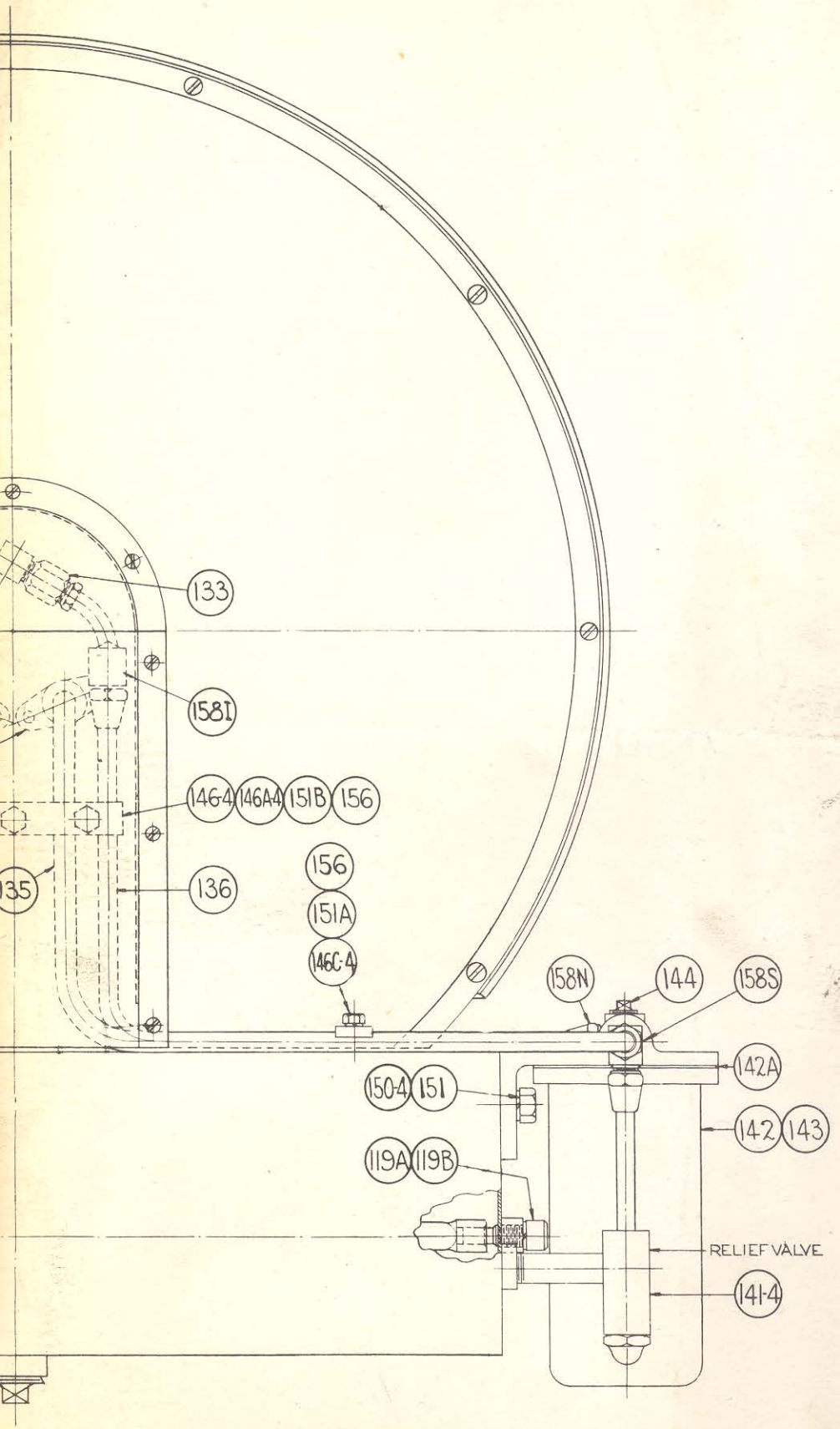
NO.	DESCRIPTION
1	BRACKET
2	GASKET
3	CAPSCREW
4	BUSHING
5	SHAFT
6	GEAR, TACH. DRIVE
7	TAPER PIN
8	GEAR, COUNTER DRIVE
9	TAPER PIN
10	GEAR, COUNTER DRIVEN
11	HOUSING, GEAR
12	GASKET
13	CAPSCREW

14	BUSHING
15	OIL SEAL
16	CONNECTING FLANGE
17	GASKET
18	CAPSCREW
19	COVER
20	GASKET
21	CAPSCREW
22	HOUSING, REV. COUNTER
23	GASKET
24	SETSCREW, CONE POINT
25	CAPSCREW
26	SHAFT, REV. COUNTER DRIVE

27	NUT, CASTLE
28	COTTER PIN
29	KEY, WOODRUFF
31	WORM GEAR,
32	WORM GEAR
33	COUNTER, FEEDER ROOT
34	BEARING, BALL GREASE S'LD
35	BEARING, BALL GREASE S'LD
36	LOCKWASHER
37	LOCK NUT
38	WASHER
39	COTTER PIN

REVOLUTION COUNTER AND TACHOMETER DRIVE

D-1086



PARTS LIST

1-4	- Turbine Casing	146A
6	- Lockwasher, Backplate to Turbine Casing	146C
11	- Stud, Backplate to Turbine Casing	1
12	- Stud Nut, Backplate to Turbine Casing	1
14A	- Tap Bolt, Inlet Casing to Turbine Casing	1
16	- Lockwasher	150
17	- Pipe Plug	1
18	- Pipe Plug	15
19A	- Stud, Turbine Casing Water Discharge	15
22-4	- Hex. Hd. Mach. Bolt, Cover	1
23-4	- Pipe Plug	15
24	- Lockwasher	1
25-4	- Cover Plate	1
25A-4	- Water Inlet Cover	1
26-4	- Gasket	1
27-4	- Turbine Casing Assembly - Parts #1-4;6;11;12; 14A;16;17;18;19A;22-4;23-4;24;25-4;25A-4;26-4	15 15
30	- Disk Assembly	15
31	- Disk	15
32	- Nozzle Blade	15
33	- Oil Baffle Nut	15
34	- Thrust Bearing	159
35	- Allen Socket Head Cap Screw	1
37	- 2-Pin A-N Plug Connector	163
38	- Impeller	1
39	- Impeller Insert	1
40	- Impeller Bushing	1
41-4	- Impeller Nut	1
42-4	- Assembly of Parts 38;39;40;41-4	1
52	- Socket Head Cap Screw	1
54	- Allen Wrench for 1/2" Cap Screw (Long Arm)	1
55	- Allen Wrench for 5/16" Cap Screw	17
56	- Allen Wrench for 1/4" Cap Screw	172
57	- Allen Wrench for 1/4" Set Screw	
59	- Allen Wrench for 1/2" Set Screw	1
60	- Bearing Shield	1
61	- Rotor Blocking Rig Assembly	1
62	- Impeller Puller Assembly	1
63	- Wrench, For Oil Baffle Nut	1
64	- Allen Wrench for 3/8" Cap Screw	1
65	- Wrench, Fol Oil Pump Pipe Connection	1
65C	- Impeller Nut Wrench Assembly	1
65D	- Allen Wrench, For 5/8" Cap Screw	18
65E	- Allen Wrench, For #8-32 Set Screw	182
80-4	- Shaft	
81	- Slinger	1
82	- Dowel	1
83-4	- Shaft Assembly - Parts #80-4;81;82	18
86	- Locking Tube Assembly	1
87	- Oil Pump Coupling	19
88	- Washer, Disk - Shaft Cap Screw	1
89	- Thrust Collar	2
90	- Special Nut	2
91	- Pin, Bearing Support to Oil Baffle	205
92	- Plug	206
93	- Bearing Support	2
94	- Brg.Support Assem. Parts #91;92;93;99;100; 179;180	2
95	- #1 Woodruff Key	20
96	- Key, Thrust Bearing	2
97	- Allen Cap Screw, Oil Pump to Brg. Support	212
98	- Lockwasher	2
99	- Allen Set Screw, Brg. Support	2
100	- Allen Set Screw, Brg. Support	2
101	- Jackscrew, Brg. Support	2
103-4	- Diffuser Ring	2
104-4	- Nozzle Ring	2
105	- Bucket	2
107-4	- Nozzle Ring Assembly - Pts. 32;104-4	2
108	- Locking Pin	2
109	- Lashing Wire	2
111	- Locking Washer	2
113-4	- Oil Tank Assembly	2
114	- Stud, Oil Tank to Oil Cooling Flange	2
115	- Stud Nut, Oil Tank to Oil Cooling Flange	2
116	- Lockwasher, Oil Tank to Oil Cooling Flange	
117-4	- Oil Gauge Assembly	2
118A	- Hex.Hd.Mach.Bolt, Oil Tank to Silencer	2
119	- Washer, Oil Gauge	28
119A	- Washer	2
119B	- Special Cap Bolt, Oil Tank	29
120-4	- Silencer Assembly	2
130-4	- Cooling Tube Assembly	2
132	- Tube Connector, Oil Piping	2
133	- Tube Connector, Oil Piping	2
134	- Special Connector, Oil Piping	2
135	- Tubing, Oil Piping	2
136	- Tubing, Oil Piping	2
139	- Gasket, Cooling Tube to Oil Tank	
140	- Gasket, Blower Casing Oil Drain	2
141-4	- Relief Valve Assembly	
142	- Oil Filter	2
142A	- Oil Filter Gasket	
143	- Oil Filter Straining Element	2
144	- Pipe Plug, Oil Filter	
146-4	- Clamp	

WHEN ORDERING ABOVE PARTS THE TURBOCHARGER

TURBOCHARGER SECT
ELLIOTT COMPANY

W-80

PARTS LIST

- Turbine Casing
- Lockwasher, Backplate to Turbine Casing
- Stud, Backplate to Turbine Casing
- Stud Nut, Backplate to Turbine Casing
- Tap Bolt, Inlet Casing to Turbine Casing
- Lockwasher
- Pipe Plug
- Pipe Plug
- Stud, Turbine Casing Water Discharge
- Hex. Hd. Mach. Bolt, Cover
- Pipe Plug
- Lockwasher
- Cover Plate
- Water Inlet Cover
- Gasket
- Turbine Casing Assembly - Parts #1-4;6;11;12; 14A;16;17;18;19A;22-4;23-4;24;25-4;25A-4;26-4
- Disk Assembly
- Disk
- Nozzle Blade
- Oil Baffle Nut
- Thrust Bearing
- Allen Socket Head Cap Screw
- 2-Pin A-N Plug Connector
- Impeller
- Impeller Insert
- Impeller Bushing
- Impeller Nut
- Assembly of Parts 38;39;40;41-4
- Socket Head Cap Screw
- Allen Wrench for 1/2" Cap Screw (Long Arm)
- Allen Wrench for 5/16" Cap Screw
- Allen Wrench for 1/4" Cap Screw
- Allen Wrench for 1/4" Set Screw
- Allen Wrench for 1/2" Set Screw
- Bearing Shield
- Rotor Blocking Rig Assembly
- Impeller Puller Assembly
- Wrench, For Oil Baffle Nut
- Allen Wrench for 3/8" Cap Screw
- Wrench, Fol Oil Pump Pipe Connection
- Impeller Nut Wrench Assembly
- Allen Wrench, For 5/8" Cap Screw
- Allen Wrench, For #8-32 Set Screw
- Shaft
- Slinger
- Dowel
- Shaft Assembly - Parts #80-4;81;82
- Locking Tube Assembly
- Oil Pump Coupling
- Washer, Disk - Shaft Cap Screw
- Thrust Collar
- Special Nut
- Pin, Bearing Support to Oil Baffle
- Plug
- Bearing Support
- Brg.Support Assem. Parts #91;92;93;99;100; 179;180
- #1 Woodruff Key
- Key, Thrust Bearing
- Allen Cap Screw, Oil Pump to Brg. Support
- Lockwasher
- Allen Set Screw, Brg. Support
- Allen Set Screw, Brg. Support
- Jackscrew, Brg. Support
- Diffuser Ring
- Nozzle Ring
- Bucket
- Nozzle Ring Assembly - Pts. 32;104-4
- Locking Pin
- Lashing Wire
- Locking Washer
- Oil Tank Assembly
- Stud, Oil Tank to Oil Cooling Flange
- Stud Nut, Oil Tank to Oil Cooling Flange
- Lockwasher, Oil Tank to Oil Cooling Flange
- Oil Gauge Assembly
- Hex.Hd.Mach.Bolt, Oil Tank to Silencer
- Washer, Oil Gauge
- Washer
- Special Cap Bolt, Oil Tank
- Silencer Assembly
- Cooling Tube Assembly
- Tube Connector, Oil Piping
- Tube Connector, Oil Piping
- Special Connector, Oil Piping
- Tubing, Oil Piping
- Tubing, Oil Piping
- Gasket, Cooling Tube to Oil Tank
- Gasket, Blower Casing Oil Drain
- Relief Valve Assembly
- Oil Filter
- Oil Filter Gasket
- Oil Filter Straining Element
- Pipe Plug, Oil Filter
- Clamp

146A-4 - Clamp
146C-4 - Clamp
147 - Socket Head Cap Screw, Oil Drain
148 - Lockwasher
149 - Flange, Oil Pump Suction & Discharge
150-4 - Hex.Hd.Mach.Bolt, Oil Filter to Oil Tank
151 - Lockwasher, Oil Filter to Oil Tank
151A - Hex.Hd.Mach.Bolt, Oil Piping Clamp
151B - Hex.Hd.Mach.Bolt, Oil Piping Clamp
152 - Pipe Plug, Oil Tank Filler
152A - Pipe Plug, Oil Tank Drain
I54 - Gasket, Oil Pump Suction & Discharge
155 - Mach.Bolt, Oil Pump Suction & Discharge
156 - Lockwasher, Oil Pump Suction & Discharge
157 - Check Valve Assembly
158B - Pipe Plug, Oil Pump Priming Conn.
158D - Caution Plate, On Oil Tank
158E - Drive Screws, For Caution Plate
158I - 90° Tube Elbow, Oil Piping
158N - 90° Elbow, Special,Oil Piping
158S - Run Tee, Male, Oil Piping
159-4 - Inlet Casing
160 - Jack Screw, Inlet Casing
163-4 - Blower Casing
164 - Stud, Blower Casing - Brg. Support
165 - Stud Nut, Blower Casing - Brg. Support
166 - Lockwasher, Blower Casing - Brg. Support
167 - Stud Blower Casing - Silencer
168 - Stud Nut, Blower Casing - Silencer
169 - Lockwasher, Blower Casing - Silencer
170 - Pipe Plug, Blower Casing
171A - Eyebolt, Blower Casing
172-4 - Blower Casing Assembly - Parts 163-4; 164;165;166;167;168;169;170;171A;183;184
173 - Gasket, Oil Baffle
174 - Oil Baffle
175 - Labyrinth Ring, Inner
176 - Labyrinth Ring, Outer
177 - Gasket, Brg. Support - Inner
178 - Gasket, Brg. Support - Outer
179 - Outer Bearing Shell
180 - Inner Bearing Shell
181A - Allen Set Screw, Impeller Nut
182-4 - Rotor Assembly - Parts #30;35;41-4;42-4; 83-4;86;88;89;90;95;111;175;181A;212-4
183 - Pipe Plug, Blower Casing Drain
184 - Orifice Plug, Blower Casing
184A - Socket Head Cap Screw
194 - Tachometer Adapter, Oil Pump
194A - Gasket, Tachometer Adapter
196 - Oil Seal, Oil Pump
203 - Oil Pump Assembly, Includes Pt. #194
204 - Gasket, Turbine Casing Water Discharge
205-4 - Gasket, Cooling Tube Water Outlet
206-4 - Gasket, Blower Casing - Backplate
207 - Mach.Bolt, Cooling Tube Water Outlet Flange
208 - Lockwasher, Cooling Tube Water Outlet Flange
209A - Instruction Plate, On Silencer
211 - Retainer Ring
212-4 - Key
213 - Name Plate
214 - Name Plate
215 - Name Plate Drive Screws
217 - Tachometer Magneto
218 - Gasket, Oil Pump Flange
247 - Tachometer Indicator
280 - Backplate, Right Half
281 - Backplate, Left Half
282 - Eyebolt, Backplate
283 - Allen Socket Hd. Cap Screw, Backplate
284 - Lockwasher For Pts. #35 & 283
285 - Pipe Plug, Backplate - 1" Solid Type
286 - Pipe Plug, Backplate - 3/4" Solid Type
287 - Backplate Assembly - Parts #280;281;283; 284;285;286;289A
288 - Sq. Hd. Jack Screw
289 - Gasket (Asbestos Cord), Turb.Casing-Backplate
289A - Dowel
290 - Adapter Flange, Turb.Casing Cooling Water
290A - Adapter Flange, Turb.Casing Cooling Water
291 - Orifice Plate, Adapter Flange
292 - Tubing, Cooling Water Piping
293 - 90° Elbow, Cooling Water Piping
294 - Tee, Cooling Water Piping
295 - Tee, Cooling Water Piping
296 - 90° Elbow, Cooling Water Piping
297 - Assembly Cooling Water Piping Pt. #293; 292; & Tube Nut from 294
298 - Assembly Cooling Water Piping Pt. #290; 292;294; & 293
298A - Assembly Cooling Water Piping Pt. #290A; 292;293;294
299A - Assembly Cooling Water Piping Pt. #293; 292; & 294 Less One Tube Nut
303 - Flange - Cooling Tube Water Outlet - Inlet
305 - Companion Flange

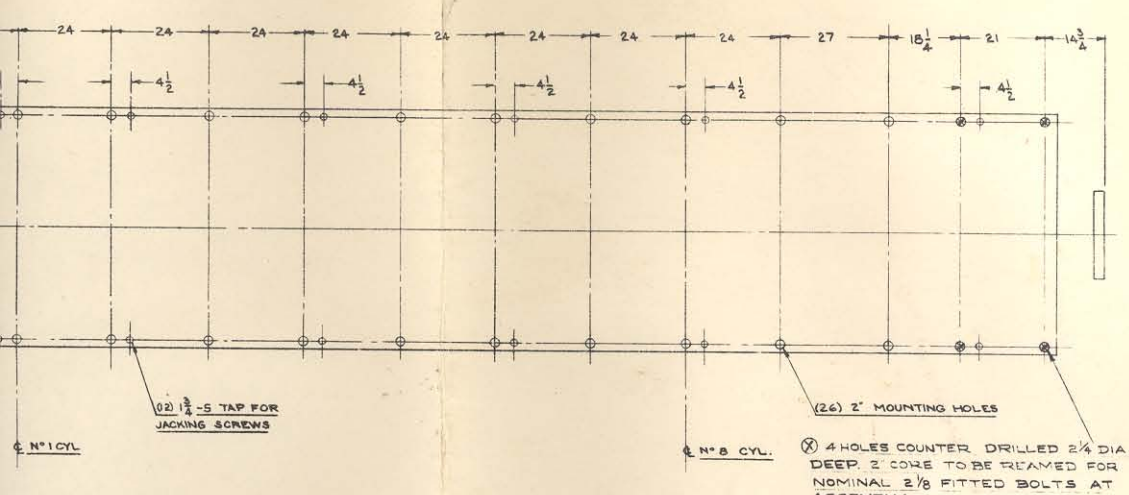
WHEN ORDERING ABOVE PARTS THE TURBOCHARGER SERIAL NUMBER MUST BE FURNISHED.

TURBOCHARGER SECTIONAL ASSEMBLY
ELLIOTT COMPANY- JEANNETTE, PA.

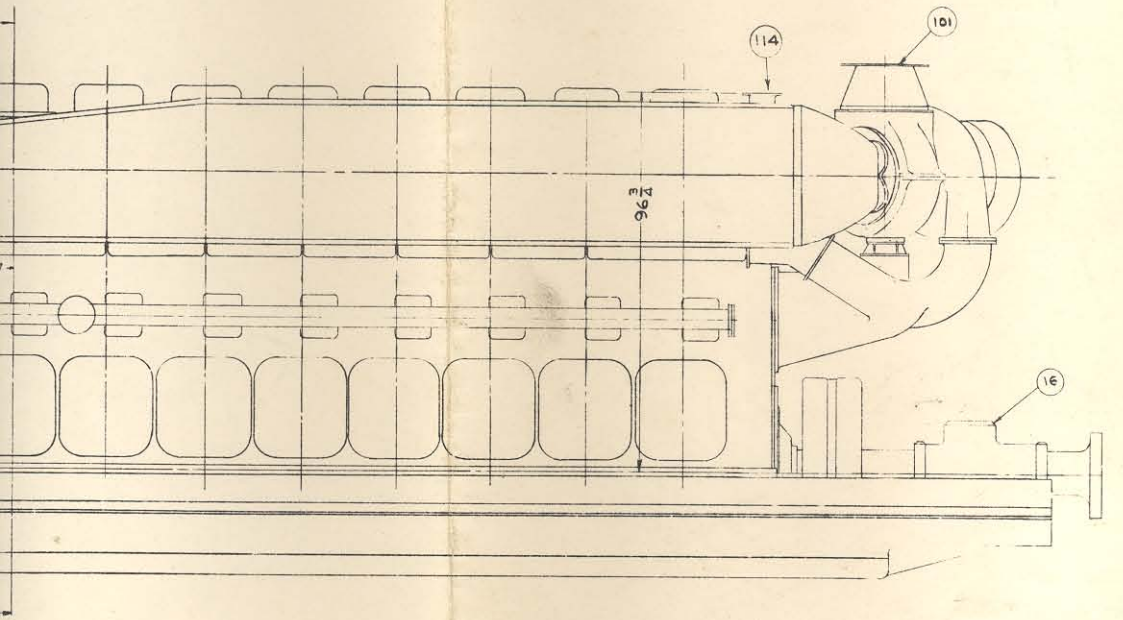
W-800295

118	DISCHARGE-L.O. PR. PUMP	2" PIPE TAP
119	INLET-L.O. PR. TO HEADER	2" 125 # AMER. STD. FLANGE

PIPE CONNECTIONS		
101	EXHAUST OUTLET	14"-125 LB. AMER STD FLANGE
102	SEA WATER SUCTION	4"-125 LB. AMER. STD. FLANGE
103	SEA WATER DISCH	4"-125 LB. AMER STD. FLANGE
104	FRESH WATER SUCTION	4"-125 LB. AMER STD. FLANGE
105	FRESH WATER PUMP DISCH	4"-125 LB. AMER STD. FLANGE
[illegible]	[illegible]	4"-125 LB. AMER STD. FLANGE
107	LUB. OIL INLET FROM HDR.	2" PIPE TAP
108	DISCH. L.O. SCAVENGE PUMP	2" PIPE TAP
109	FUEL OIL PUMP [illegible]	3/4 PIPE TAP
110	ACC. TANK [illegible]	3/4 PIPE TAP
111	[illegible] AIR TO ENGINE	2"-600 LB FLANGE
112	FUEL INLET TO HEADER	1/2 PIPE TAP
113	[illegible] WATER DISCH FROM [illegible]	4"-125# AMER. STD. FLANGE
[illegible]	[illegible] EXHAUST INSULATOR	5"-125# AMER STD FLANGE
115	THERMOSTAT ALARM	3/4 PIPE TAP
116	PRESS.-STAT ALARM	1/8 PIPE TAP
117	CONNECTOR, LUBE OIL, AUX	2"-125 LB AMER. STD. FLANGE



1	SEA WATER PUMP - VIKING POSITIVE DISP.
2	FRESH WATER PUMP. CENTRIFUGAL
3	LUB. OIL PUMP
4	FUEL OIL TRANSFER PUMP
5	FUEL OIL ACCUMULATOR TANK
6	
7	
8	FUEL INJ. PUMP BENDIX FDR 24
9	FLYWHEEL BARRING DEVICE
10	MANZEL OILER 25W 16 FEED
11	CONTROL HANDLE, REVERSE
12	CONTROL HANDLE, SPEED
13	GOVERNOR WOODWARD UG 8-DS -198
14	REVOLUTION COUNTER
15	OVERSPEED GOV.
16	THRUST BRG. KINGSBURY 21 GFS 10¼ SHAFT
17	INSTRUMENT BOARD
18	JACKET WATER VENT

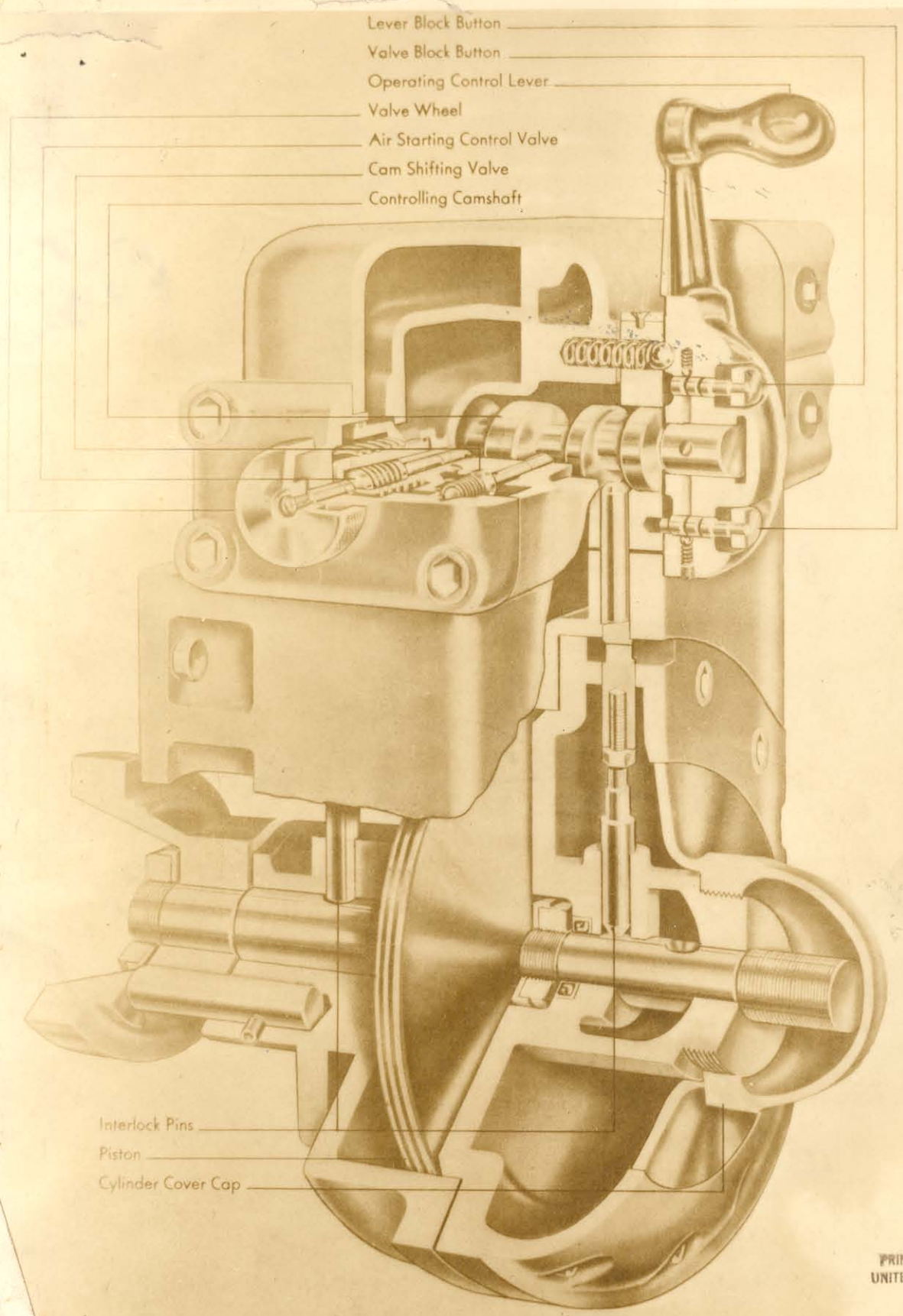


ENGINE DATA	
MODEL - ENTERPRISE MARINE DIRECT PROPULSION	
HEAVY DUTY FULL DIESEL DMQ 8	
BORE - 16"	STROKE - 20" N° CYL. - 8
BHP - 1200	R.P.M. - 275
CYCLE - 4	INJECTION - SOLID
BMEP 110 LB PER SQ IN.	
WEIGHT OF UNIT (APPROX) 102,000 LBS.	

FOR PIPING DIAGRAMS SEE DWG. 92004

USE CERTIFIED PRINT FOR INSTALLATION

ITEM	PART NAME	QTY.	MATERIAL
ENTERPRISE ENGINE & FOUNDRY CO. SAN FRANCISCO, CALIFORNIA			
DWG. NAME	INSTALLATION - G.A. SUPERCHARGED	42003-2	
DRAWN 1-31-42 A.F.		91927	
CHECKED		PART & DRG. NO.	
APPROVED			



with
Letter
29 July 1949
Capt Stephens

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UNITED STATES

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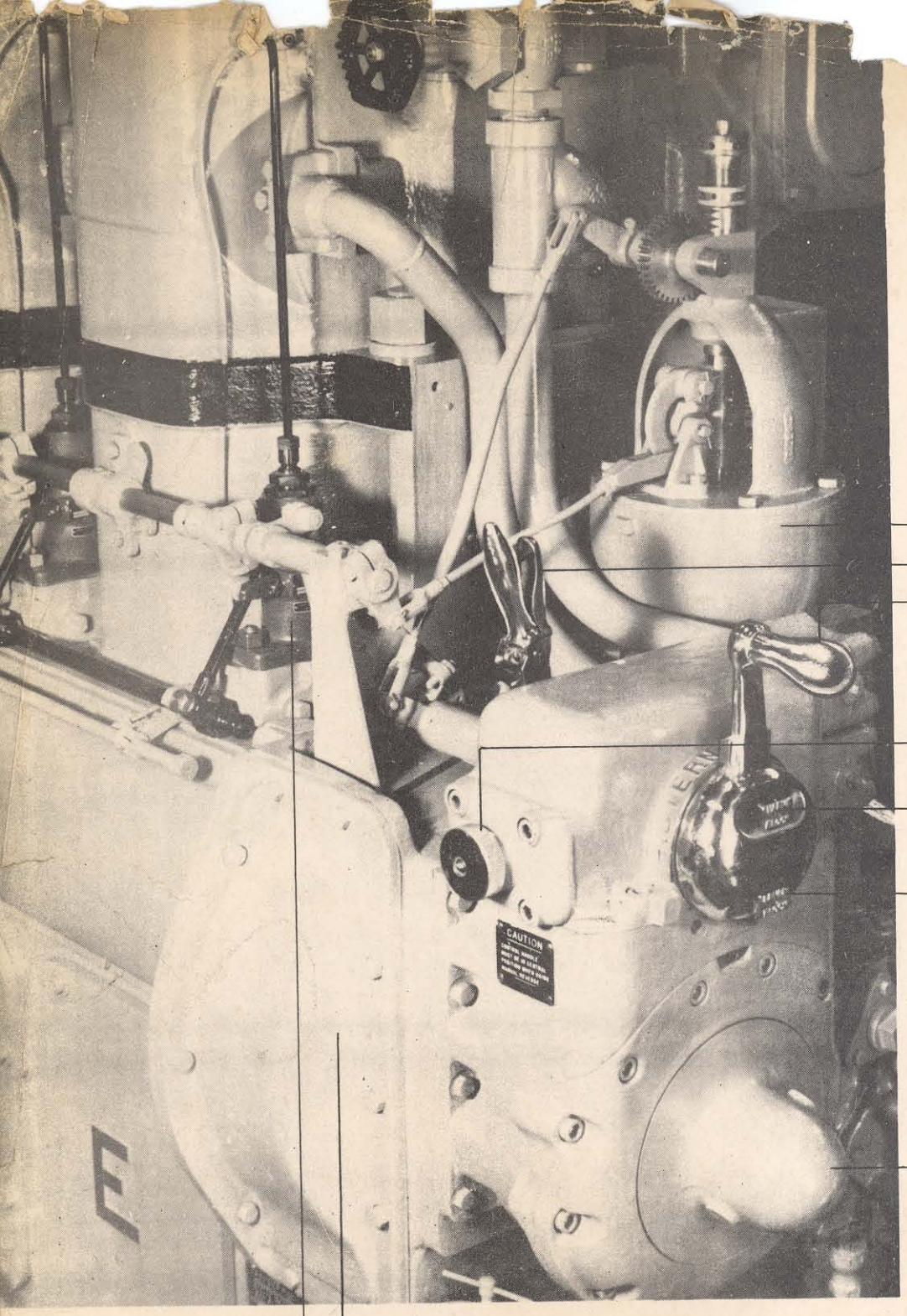
D-1995



Reversing Mechanism
Fuel Injection Pump
Cylinder Cover Cap
Lever Block Button
Valve Block Button
Wheel for Manual Operation of Air Starting Control Valve
Operating Control Lever
Speed Control Handle
Governor

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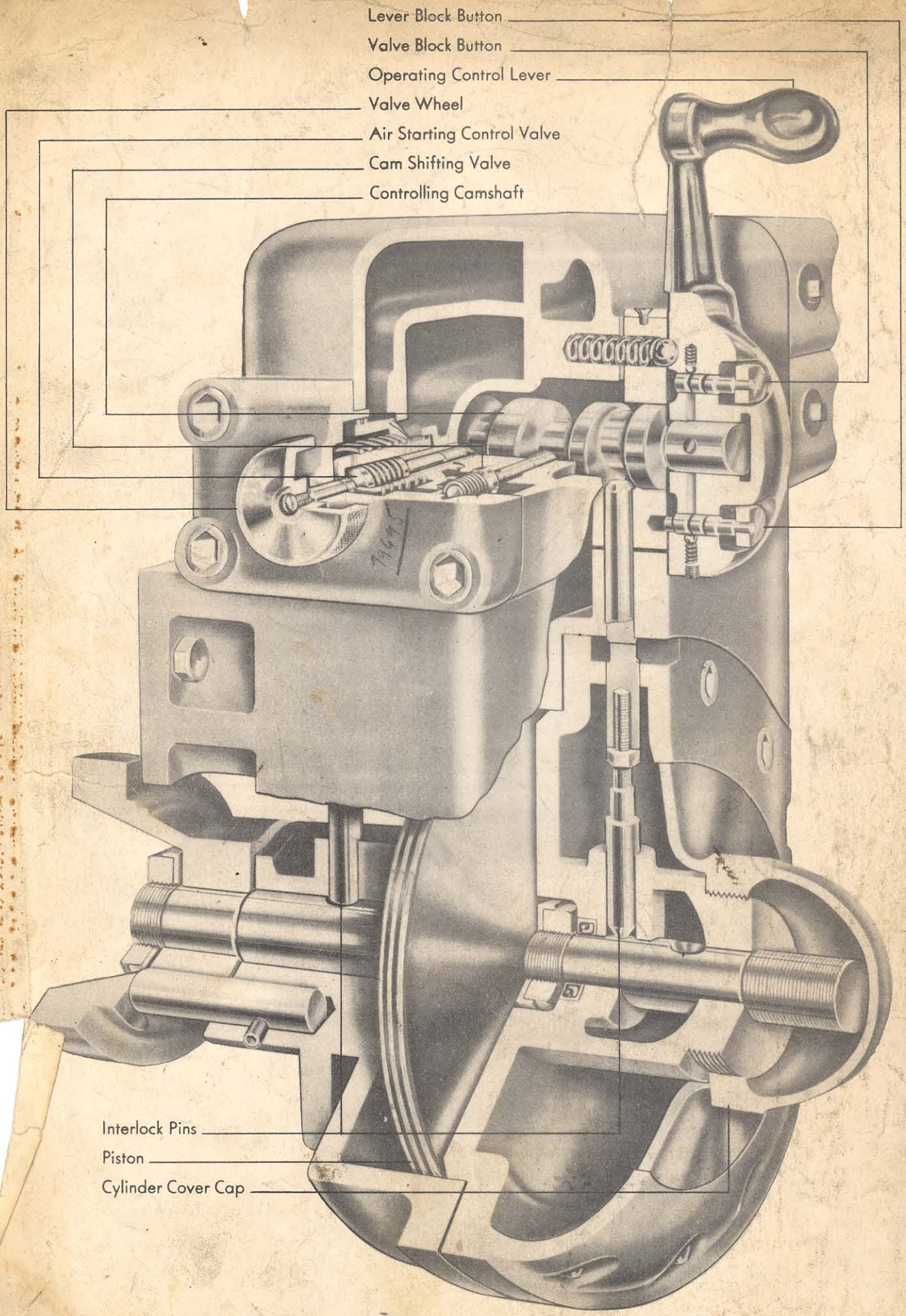
OPERATING CONTROLS



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