Peter Foss

ENTERPRISE ENGINES

Diesel • Dual Fuel • Tri Fuel • Spark Ignited

GENERAL METALS CORPORATION, ENTERPRISE DIVISION

18TH AND FLORIDA STS., SAN FRANCISCO 10, CALIF.

INSTRUCTION MANUAL

MODEL DMG-36

ENGINE SERIAL NO. 56051

"FOSS LAUNCH AND TUG"

ENTERPRISE

ENGINE & MACHINERY CO.

A SUBSIDIARY OF GENERAL METALS CORPORATION
18TH & FLORIDA STREETS
SAN FRANCISCO 10, CALIFORNIA

DIESEL ENGINE

MODEL DMG-36 ENGINE NUMBER 56051

BORE 12" STROKE 15"

H.P. AT 400 R.P.M.

TOTAL DISPLACEMENT 10,179 CUBIC INCHES

FUEL INJECTION TIMING 17° BEFORE TOP CENTER

SET 4-7/8" BEFORE TOP CENTER ON
33 IN. DIAMETER FLYWHEEL

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

FUEL INJECTION PUMP RACK 27.5 MM

MAXIMUM EXHAUST TEMPERATURE 900° F.

VALVE CLEARANCE WITH COLD ENGINE:
INTAKE .020 EXHAUST .025

WHEN MAKING INQUIRIES FOR PARTS
OR SERVICE, STATE ENGINE NUMBER.

D-2572
Rev. 2, 5/18/54

PRINTED IN U.S.A.

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* Provided this equipment is required, and is being furnished by "Enterprise", for this installation.

LIST OF ILLUSTRATIONS

*Provided this equipment is required, and is being furnished by "Enterprise," for this installation.

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PART I

INTRODUCTION

A. Introduction and Working Principles

The purpose of this manual 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.

Enterprise engines have proven themselves by giving continuous trouble-free service all over the world, even under severe working conditions. Many years of development and engine building experience have gone into the present engine design. Simplicity of operation and maintenance and maximum dependability were goals constantly kept in mind.

Every engine is carefully inspected and thoroughly tested before leaving our plant, therefore, only such adjustments as are indicated in the succeeding pages should be made by the operator. It is suggested that the operator establish a system of routine inspection suitable to his particular service condition. Keeping adequate records of inspections and the replacement of worn parts will be a valuable aid in a program of preventive maintenance which will pay for itself in lowered maintenance cost and more satisfactory operation.

The importance of cleanliness cannot be overstressed, as it indicates in a large measure, the care the engine receives in other ways.

If the performance of an engine is unsatisfactory or should trouble occur which is not adequately treated in this manual, contact our Service Department. A complete description of the difficulty must be given so that its cause may be determined and proper steps suggested to correct the condition.

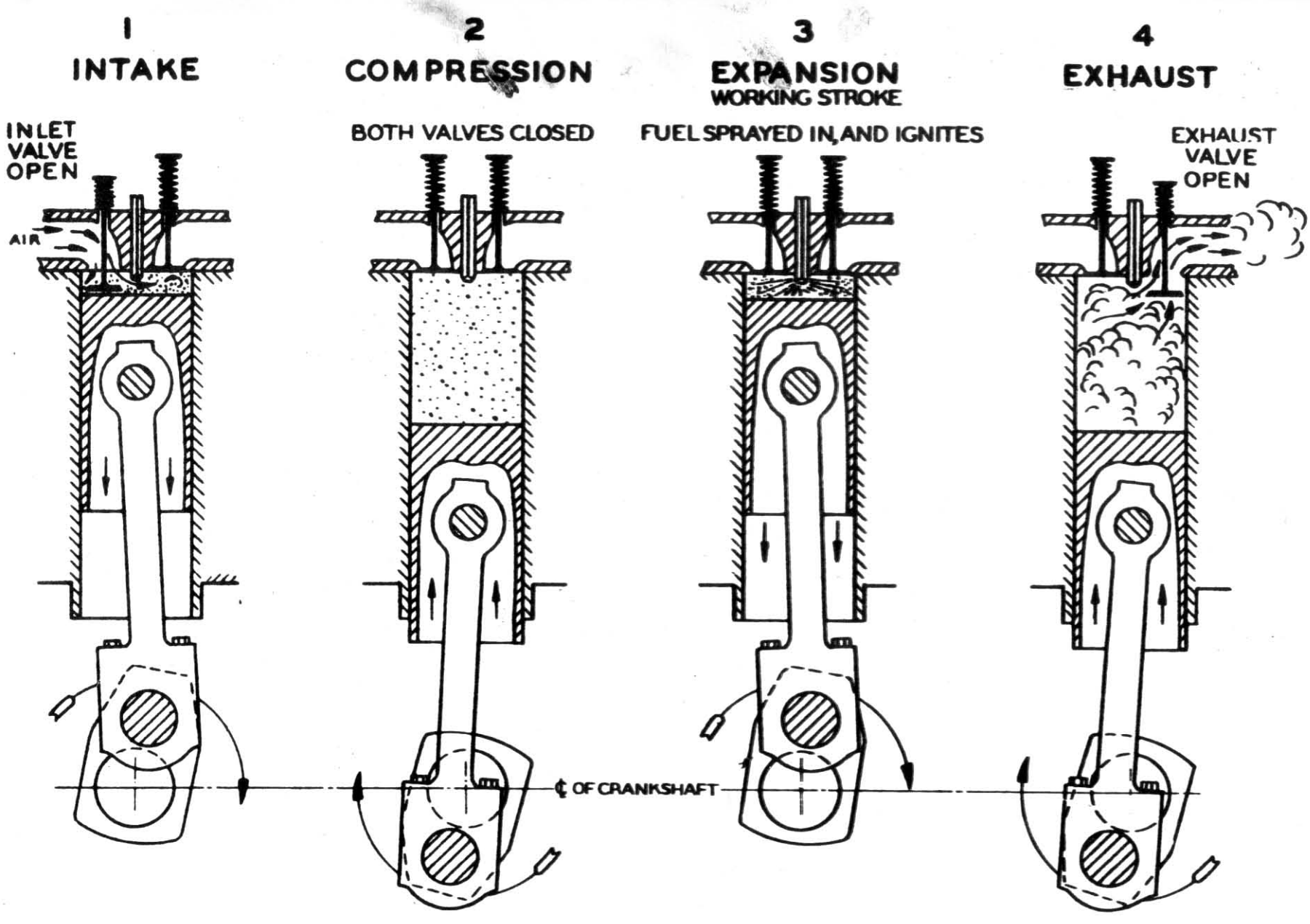

DIAGRAM OF WORKING PRINCIPLE

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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 gases 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 gases, until the piston again reaches top dead center when the exhaust valve closes, the inlet valve opens and the cycle is repeated.

PART II

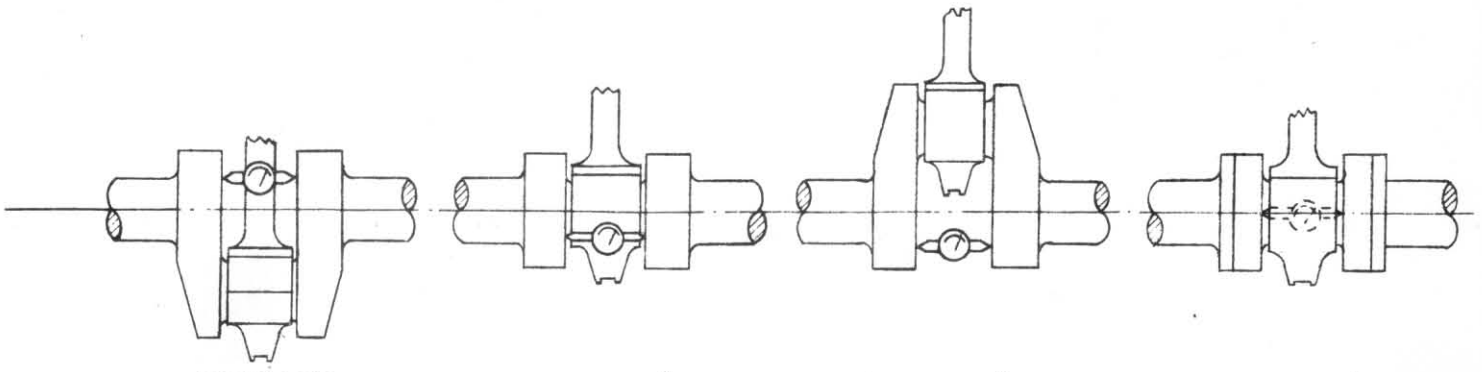
INSTALLATION

A. General

The installation of the engine will vary according to its use. In all cases, Enterprise Engine & Machinery Company'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.

CRANKSHAFT ALIGNMENT RECORD

USE THIS TABLE TO RECORD CRANKSHAFT DEFLECTION INFORMATION.
READINGS MUST BE TAKEN BEFORE INITIAL FIELD TESTING AND SHOULD BE TAKEN AFTER MAJOR OVERHAULS.
READINGS ARE IN THOUSANDTHS (.001) WITH INDICATOR SET ZERO AT POSITION ONE. RECORD PLUS (+) OR MINUS (-) OF OTHER POSITIONS.
READINGS SHOULD NOT DIFFER BY MORE THAN .003".



POSITION #1 BOTTOM DEAD CENTER

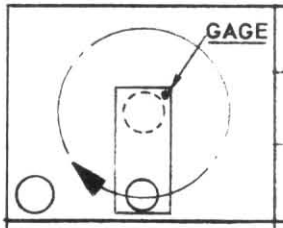
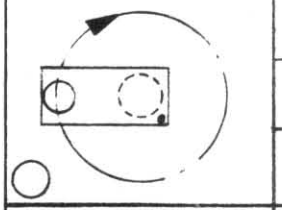
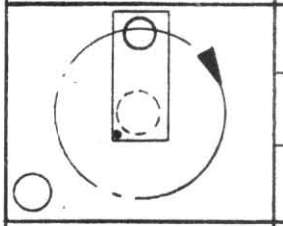
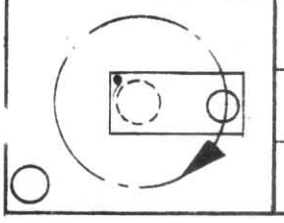
POSITION #2 ROD AWAY FROM YOU

POSITION #3 TOP DEAD CENTER

POSITION #4 ROD TOWARD YOU, GAGE OTHER SIDE

ROTATE GAGE TOWARD YOU AND ROD AWAY FROM YOU THIS WILL PREVENT KNOCKING OUT THE GAGE.

CYLINDER NUMBER STARTING AT GEAR CASE END

POSITION	1	2	3	4	5	6	7	8	DATE
 GAGE									
									
									
									

NOTE: DISTORTION IN LAST TWO CRANKS ONLY USUALLY INDICATES CRANKSHAFT IS OUT OF LINE WITH CONNECTING SHAFT.

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 lined up properly with its connecting shafting. (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 its connecting shafting. See crankshaft alignment sheet among illustrations in this book.

C. Piping

Note: Recommended (minimum) pipe sizes for all service lines are given on the separate piping diagrams furnished to the customer.

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.

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 by-pass 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.

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E. Fuel Oil Lines

The fuel oil is drawn from the storage tank through a strainer and into the fuel transfer pump. From this pump the fuel oil is forced on through an absorbent type duplex filter, and then through the fuel oil header, past a relief valve, and back to the day tank. From the fuel oil header the fuel oil is forced through branch lines into the fuel injection pumps, individual for each cylinder, and finally injected into the engine cylinders.

The relief valve at the end of the header, downstream of the last injection pump, serves to maintain constant pressure on the fuel header and the injection pumps; oil passing this relief valve is piped to the day tank. There is also a relief valve on the transfer pump set at a higher pressure than the valve on the header; this relief valve dumps oil into the section of the transfer pump in case of a plugged return line.

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

A nozzle drain header to accumulate fuel oil by-passed from the fuel injection valves 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.

The fuel oil filtering system must necessarily be highly efficient in order to perform the function of removing even the most minute particles of foreign matter from the fuel lines. It must be clearly understood that the fuel injection pump and injection nozzle are precision made and are fitted to extremely close clearances; this is why a very minute quantity of a foreign material can cause the engine to fail to function properly.

The filtering unit is of the duplex type so that one element may be cleaned while the engine is running on a supply of oil which is flowing through the remaining element. This unit must be kept in perfect working condition at all times.

F. Lubricating Oil Lines

The lubricating oil system is of the drysump 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 through a strainer 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. On turbocharged and other high output engines, lubricating oil is distributed to the pistons for their cooling. On "Q" engines a force-feed oiler is used to lubricate the pistons.

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.

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

LUBRICATING OIL RECOMMENDATIONS FOR DIESEL, GAS AND DUAL FUEL ENGINES

Where powerhouse or engine room temperature is 32°F. or below, use SAE 20 oil. Where temperature is above 32°F., use SAE 30.

In locations where temperatures frequently exceed 100°F., it may be desirable to use SAE 40 oil.

Heavy duty or additive type oils are recommended for all engines.

Where it becomes necessary to use fuel which has a high sulphur content or other undesirable property, the factory should be contacted in regard to lube oil recommendations. New extra heavy duty oils are available to minimize the extra wear and deposits which result from the use of low grade fuel.

The following may serve as a guide to the commonly specified properties of the lube oil:

GENERAL LUBRICATING OIL SPECIFICATIONS

	Maximum	Minimum
SAE Grade	40	20
Viscosity, SSU @ 100°F.	1100	340
Viscosity, SSU @ 210°F.	80	50
Viscosity Index	-	40
Gravity, °API @ 60°F.	30	20
Neutralization Number (Bearing material in lube)	0.50	-
Intrinsic Corrosion, Oil @ 300°F.	Non-corrosive	
Carbon Residue, %	0.90	-
Flash Point, °F. (P-M closed cup)	-	350
Pour Point	10°F. below coldest oil temperature	

Enterprise Engine & Machinery Company does not recommend lubricants by brand names. The final measure of quality of an oil is its performance in service; and the responsibility for a lubricant's quality and performance in service must remain with the oil company making the lubricant.

LUBRICATION OF ENGINE AUXILIARIES

1.	Turbocharger	See Manufacturer's Bulletin
2.	Cylinder Lubricator	Same oil as specified for engine
3.	Air Compressor	See Manufacturer's Bulletin
4.	Governor	Same oil as specified for engine
5.	Thrust Bearing	Same oil as specified for engine
6.	Governor Linkage	Same oil as specified for engine
7.	Fuel Control Shaft and Linkage	Same oil as specified for engine
8.	Starting and Reverse Controls	Same oil as specified for engine
9.	Clutch (Sailing or Winch Drive)	Cup Grease
10.	Compressor Shaft Sheave (where clutch is used)	Cup grease

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 by-pass 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.

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H. Intake System

The air intake manifold is cast as an integral part of the cylinder block. Cast elbows connect it with the air passage in each cylinder head.

Non-supercharged engines have filter panels in the air manifold covers.

Turbocharged engines have a silencer or combination filter and silencer mounted on the air intake of the turbocharger and air manifold covers are solid.

The air filters should be washed with cleaning solvent or fuel oil occasionally and then have lube oil poured over the screen to wet it.

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

INSTRUCTION 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 3/4 full before starting. Open valves from the service tank and any other valves which are necessary to the flow of the lube oil through the system. Keep the lubricating and fuel oil filters clean at all times.

Set all injection pumps at full fuel. The operating control interlock keeps the injection pumps in the stop, or no fuel position when the engine is shut down. Move the control to the ahead or astern operating position. When this is reached, the interlock will have cleared and the tension of the governor spring will open the fuel pumps to the full fuel position.

Open the nozzle bleeder valve slightly and prime the pumps by means of the priming shaft on the pump base until a definite resistance is felt, indicating that all the air has been expelled. Do not use too long a wrench nor too great a force on the priming shaft. If, upon attempting to prime a pump, no resistance at all is felt, it is an indication that the fuel tappet is on the peak of the fuel cam. First, prime those pumps that are not in this position, and then bar the engine over until the tappets are contacting a low point on the cam, thus making it possible to prime the remaining pumps. This condition can readily be seen by observing the timing mark in the window in the fuel pump body.

Inspect adjustment of hydraulic valve lifters as explained in Section "Valve Gear", and clearance of starting air valve as indicated on Engine Instruction Plate. Be sure air valve cap is in upper position when checking clearance. (See Section "Timing of Air Starting Valve")

Lubricate fuel pump control and governor linkage making sure all pins and cotter pins are in place.

Open all valves in the water suction and discharge lines and make sure there are no obstructions in the lines.

B. Description of Controls

A single lever for speed control and reversing the engine is located at the front of the engine on the camshaft side. When the lever is vertical, the engine is stopped.

Starting and Stopping the Engine

To start the engine in "ahead" rotation, the lever should be pushed away from the operator as far as the interlock will permit. After the engine starts, speed can be increased by pushing the lever farther or decreased by pulling the lever back toward the vertical "stop" position.

To start the engine in "astern" rotation, the lever should be pulled toward the operator as far as the interlock will permit. After the engine starts, its speed can be increased by pulling the lever farther or decreased by pushing the lever back toward the "stop" position.

The engine is stopped by merely returning the control lever to the vertical "stop" position.

Emergency Reversal

In an emergency, the control lever may be moved from the "run" position to the opposite air start position as fast as the interlock will permit.

This is definitely not recommended for normal practice as it imposes high stresses on all parts of the engine.

Manual Reversing

An auxiliary feature is provided for manually shifting the camshaft to the position for desired engine rotation. A flanged hex nut and a left hand threaded locking ring are supplied for this operation. Remove the reverse mechanism cylinder cover cap. (CAUTION: Cap has left hand threads.) Screw on flanged hex nut until it stops against cylinder cover. Screw on locking ring (left hand threads) until it stops against cylinder cover. The camshaft may then be shifted by using a large wrench on the hex nut. The nut must be rotated as far as possible in the opposite direction to desired engine rotation. CAUTION: CONTROL HANDLE must be in STOP position when using manual reverse.

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 gauges 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 pushing a fuel pump lever toward the engine. This will rotate the fuel control shaft in the direction to shut off the delivery from all pumps. Hold the lever until the engine stops.

D. OPERATING PRESSURES AND TEMPERATURES - TURBOCHARGED

1. Pressures

While running at normal speed, the operating pressures should be as follows:

Lubricating Oil	45 to 55 Lbs/Sq.In.
Jacket Water	3 to 15 Lbs/Sq.In.
Fuel Oil	10 to 15 Lbs/Sq.In.
Gas	10 to 20 In. of Hg.(5 to 10 PSI)
Starting Air	150 to 250 PSI

2. Temperatures

While running under normal load, the operating temperatures should be as follows:

Lubricating Oil into Engine	155° F.
Jacket Water into Engine	155° F.
Exhaust Temperature	See Title Page

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 of 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)

If governor is not pressure lubricated, then fill governor oil container with a light oil, SAE 30.

Oil linkage pins and shaft bearings of the governor and fuel control. Remove and clean oil strainer screen in lube and fuel lines.

On reversible engines, oil starting and reverse control mechanism through holes provided in the housing.

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 of pins and in slot.

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

To check the air starting valve clearance it is essential that the valve cap be moved into the extreme upper position. (See illustration "Air Starting Valve".) This operation should be done by hand although a pry bar may be used if necessary. 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 cap. 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 by opening bleeder valve on starting air connection on last cylinder.

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 1000 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 oppposite 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.

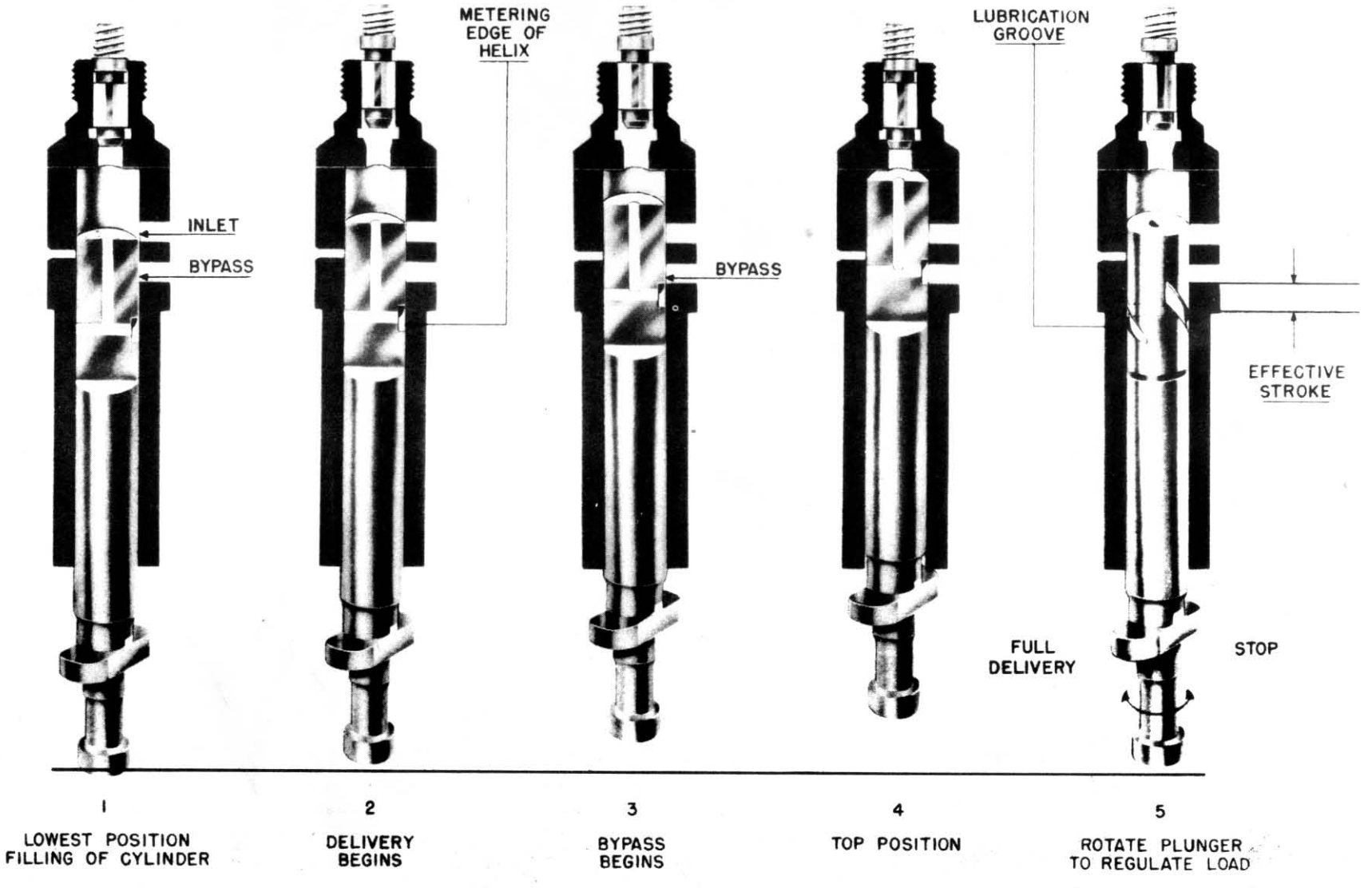
E. To Operate from the Pilot House

Operation of the engine from the pilot house is the same as from the engine room described on page 3-B-1. After any repair or extended shutdown, a start should be made from the engine room to check the engine before operating from the pilot house.

At each operating station, there is a synchronizing knob. If the position of the control lever at any station does not correspond to the position of the control lever on the engine, a convenient way to correct the condition is as follows: (1) Stop the engine, (2) Loosen the synchronizing knob about 1/2 turn, (3) Move the control lever to the "Stop" position, (4) Tighten the synchronizing knob. If stopping the engine is undesirable, the synchronizing knob can be loosened, the lever moved to what is judged to be the correct position and the knob again tightened.

If the control system becomes damaged, the engine can be controlled at the engine station by loosening the synchronizing knob on the engine 1/2 turn.

It will be noted that pressure gages in the pilot house read less than gages in the engine room due to the difference in static head or height. This difference must be taken into consideration when establishing normal pilot pressure readings.



OPERATION OF FUEL INJECTION PUMP

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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.

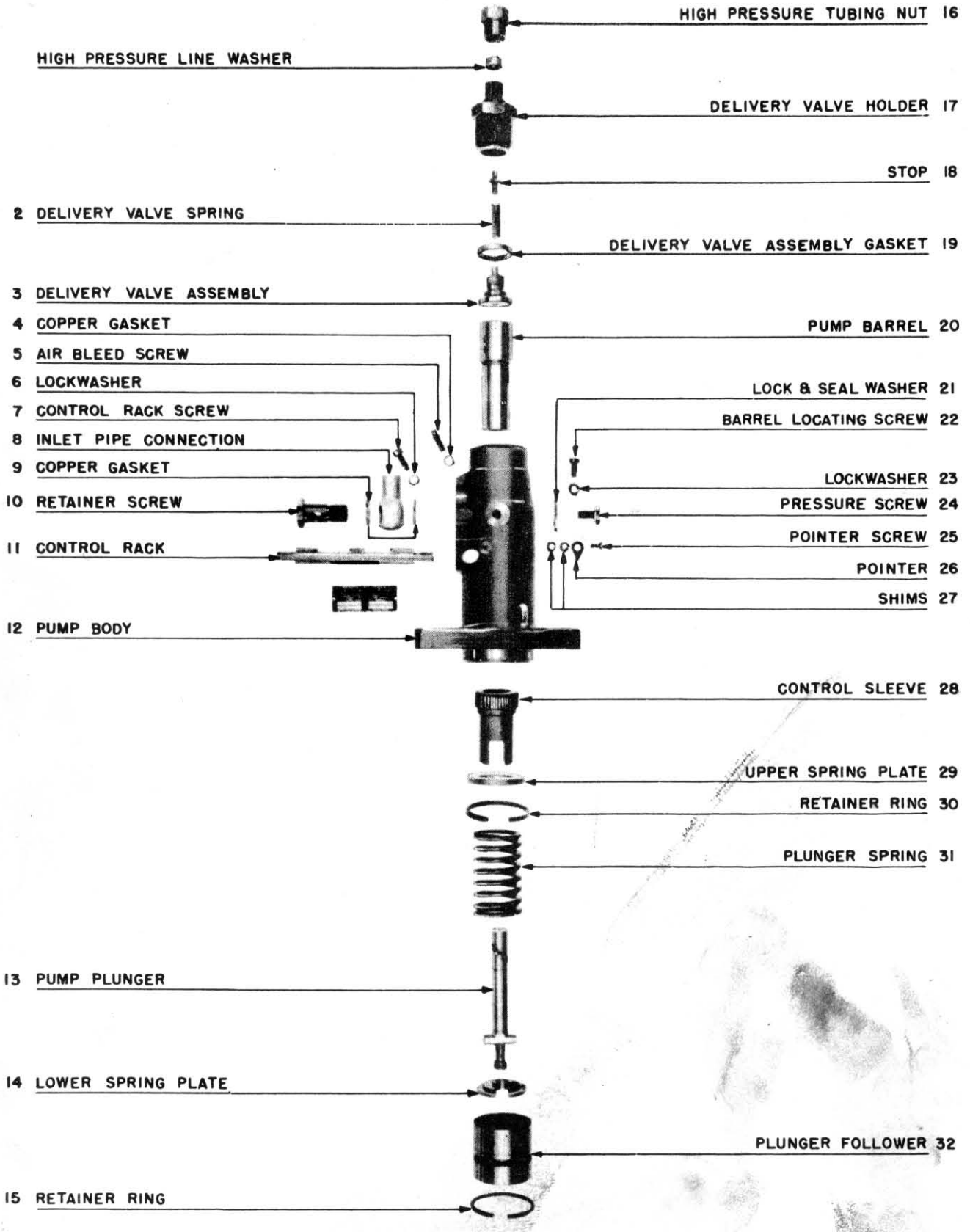
To Remove Nozzle:

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



FUEL INJECTION PUMP

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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 the following settings, the spring tension should be adjusted.

2200 to 2300 lb/sq.in.
(Non-Supercharged "X" and "G" Engines)

2500 to 2600 lb/sq.in.
(Supercharged "X" and "G" Engines)

3000 to 3100 lb/sq.in.
(All "Q" Engines)

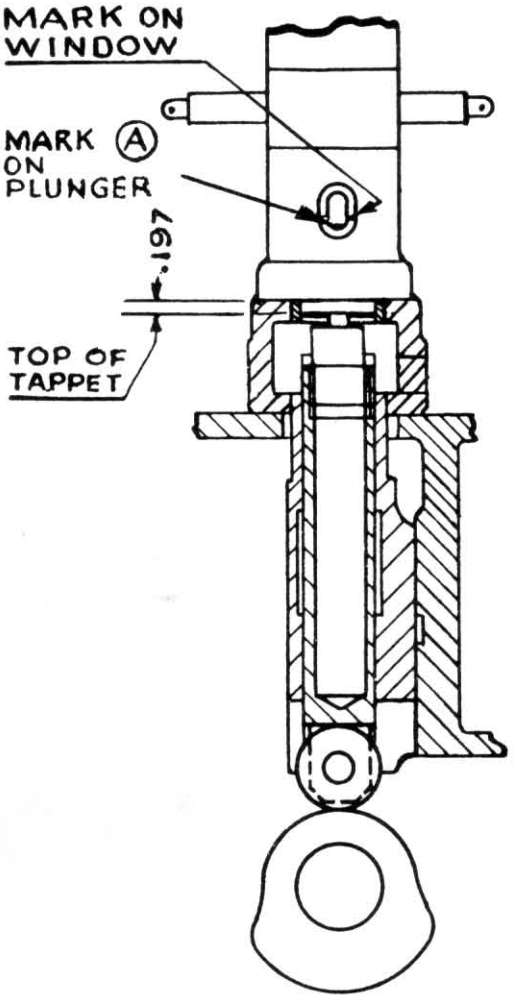
For method of adjustment, disassembly and cleaning of nozzles - see section "Nozzles".

Pumps - see drawings "Fuel Pump" and "Timing of Fuel Pump".

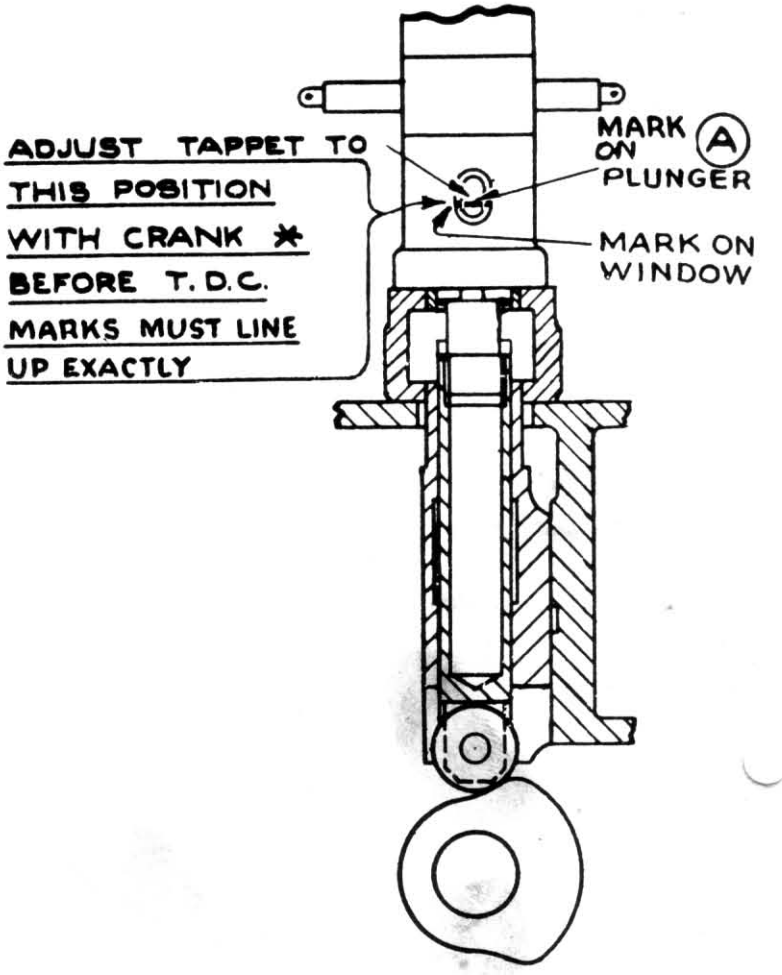
If one of the injection pumps does not function properly, first ascertain if fuel oil is flowing freely to pump. To do this, loosen air bleed (5) on front of pump just above supply connection. Fuel oil should flow freely without showing air bubbles. Allow fuel to flow until all air bubbles disappear. 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 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.

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

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Injection Pumps

Operation of Injection Pump

Fuel enters through inlet fittings 8 and 10 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 3 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 28 and the control rod 11. 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.

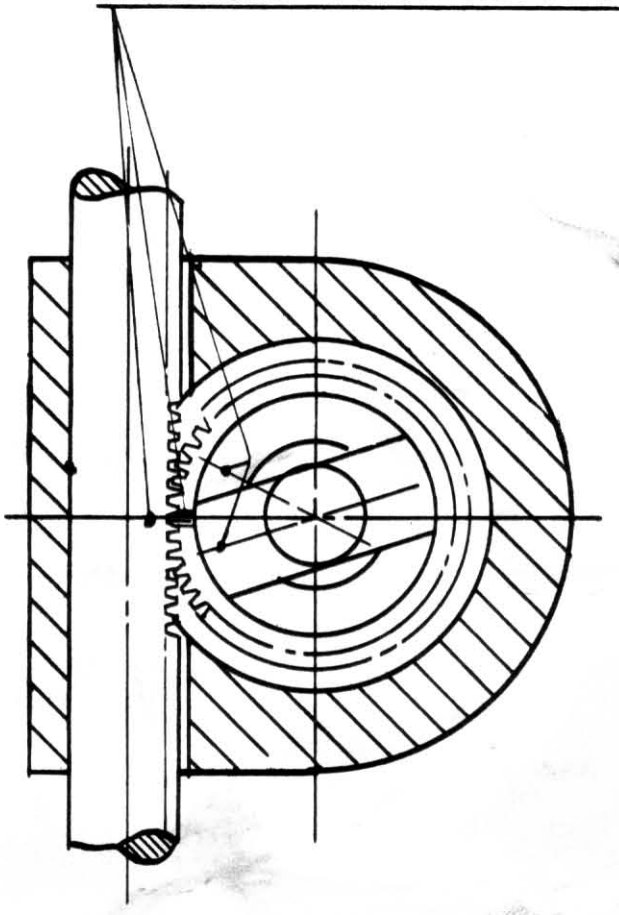
To Remove Pump

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

ASSEMBLE PUMP ACCORDING TO THESE MARKS



FUEL PUMP-BOTTOM VIEW SHOWING LOCATING MARKS 829

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degrees before firing top dead center. Tappet roller will then be clear of cam lobe. The distance from the top of adjusting plug to the top surface of pump base should be first set to a preliminary figure of approximately .197". To change adjustment, loosen lock-nut 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 on slidable pump plunger will register with line on inspection window, as shown in Illustration "Timing of 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 follower (32) and insert a 5/32" pin about 2" long in hole in flange spigot. Take out spring retainer ring (15) by means of screw driver and pliers. Press plunger follower (32) down again and remove the temporary pin. All parts in lower portion of pump body (12) can then be removed in the following order : plunger follower (32), lower spring plate (14), plunger spring (31), pump plunger (13), control sleeve (28), spring retainer ring (30), and upper spring plate (29).

Unscrew delivery valve holder (17) and take out delivery valve (inside (3)) and delivery valve spring (2). Back off pressure screw (15) about three turns. Carefully press out pump barrel (20) and delivery valve seat (3), including special gasket (19).

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 (12) in vise in upright position. Place pump barrel (20) in body in such a way that positioning groove on largest diameter lines up with pressure screw (24). 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 (3), and special gasket (19). Be sure that lapped face of delivery valve seat makes a perfect joint with top face of barrel. Insert delivery valve (inside (3)) and spring (2). Screw delivery valve holder (17) into body, tightening it sufficiently on gasket to prevent leaks.

Now invert pump body for installation of remaining parts. Position control rack (11) so that punch mark which is in center of rack in a space between the teeth is approximately in center of pump body.

Place control sleeve (28) 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 (29), spring retainer ring (30), plunger spring (31), pump plunger (13), and lower spring plate (14). When replacing 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 follower (32) on top of spring, press down, insert temporary pin in hole in flange spigot, press in spring retainer ring (15) 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.	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.	Clear pipe. Clean filter element.
3.	Air lock in pump.	Vent pump and nozzle.
4.	Pump plunger remains suspended in barrel.	Thoroughly clean all parts, particularly plunger and barrel. If either are damaged, replace both with spares.
5.	Plunger spring broken.	Replace with spare.
6.	Delivery valve does not seat properly.	Clean delivery valve and seating. If either are damaged, replace both with spares.
7.	Delivery valve spring broken.	Replace with spare.
8.	Leakage back to suction chamber from surfaces between top of barrel and delivery valve seat.	Clean faces. Remove burrs and scratches from delivery valve seat and barrel.
9.	Worn or defective plunger or barrel.	Replace with spare.

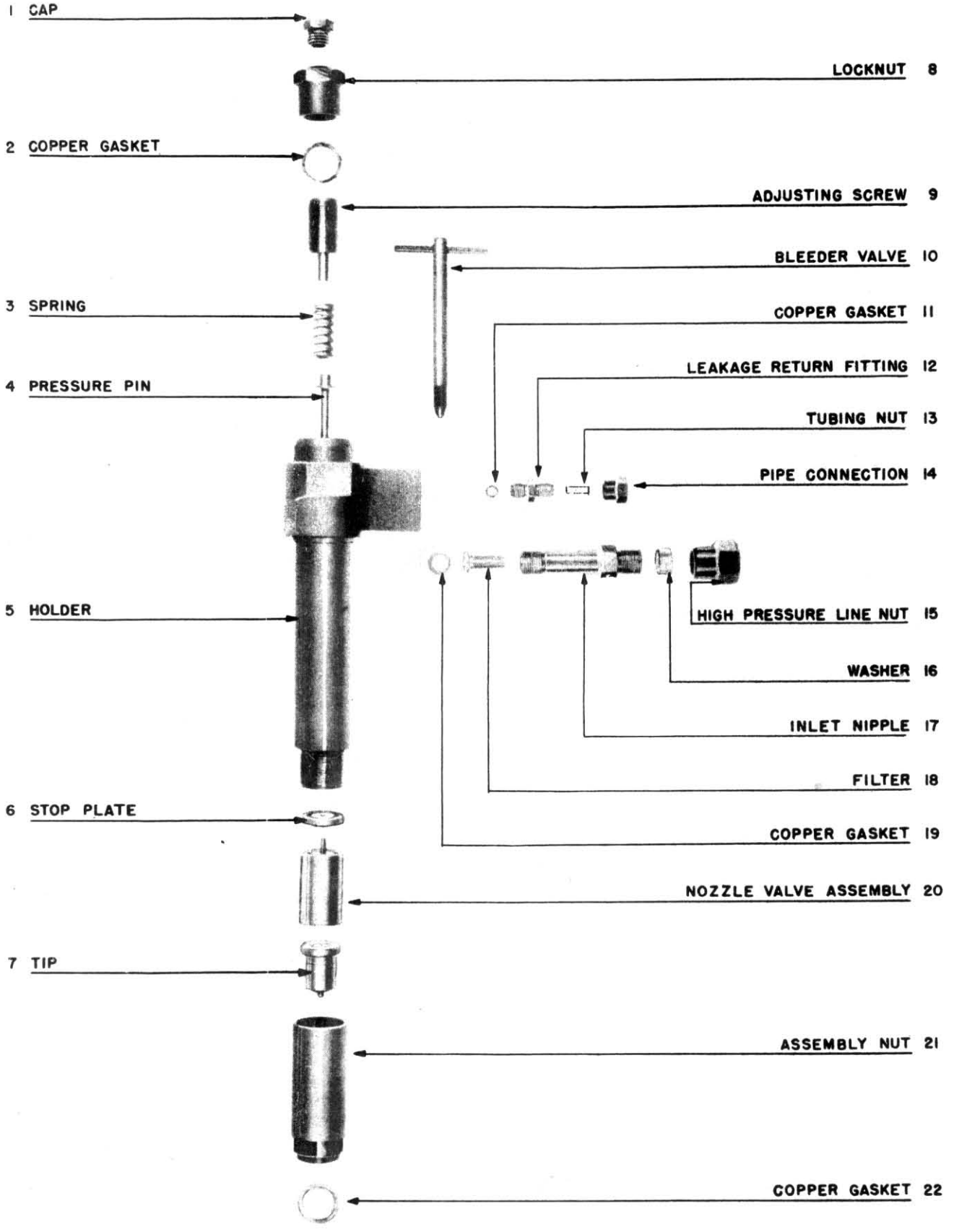
Control Rod Jammed or Binding

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



FUEL NOZZLE

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Nozzle - See Illustration "Fuel Nozzle"

The nozzle consists of the nozzle proper, including the holder (5), valve (20), assembly nut (21), and the spray tip (7). 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 as follows and may be adjusted by pressure adjusting screw (9) and locknut (8) at the top of nozzle holder.

2200 to 2300 lbs/sq.in.
(Non-Supercharged "X" and "G" Engines)

2500 lbs/sq.in. (Supercharged "X" and "G" Engines)

3000 lbs/sq.in. (All "Q" Engines)

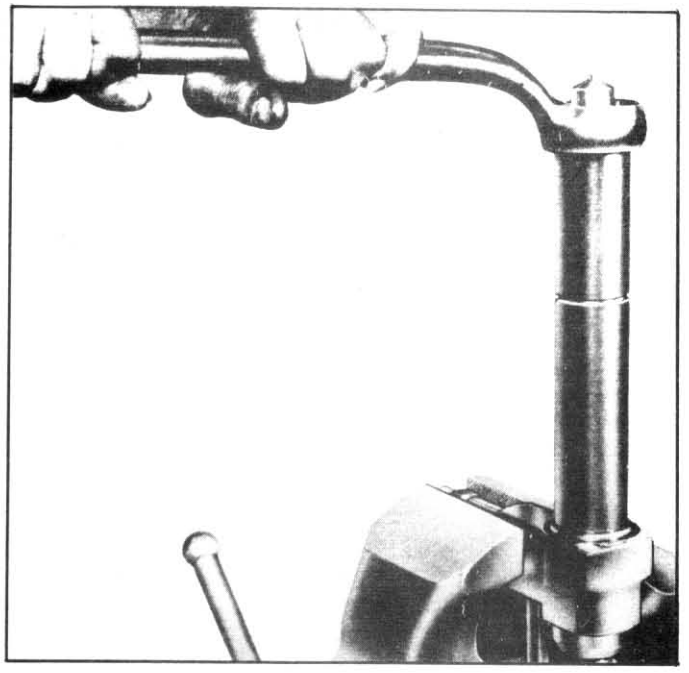
When nozzle valve opens, fuel is injected into combustion chamber through orifices in spray tip in a finely atomized spray. Injection continues until pump plunger uncovers by-pass port, causing rapid drop of pressure. Nozzle valve then seats quickly to avoid dribble. A small amount of fuel leaks around nozzle valve, thereby lubricating valve stem. This fuel is drained through leakage return fitting (12) at top of nozzle holder. The bleeder valve screw (10) 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 (18) is provided in fuel inlet (17). 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.

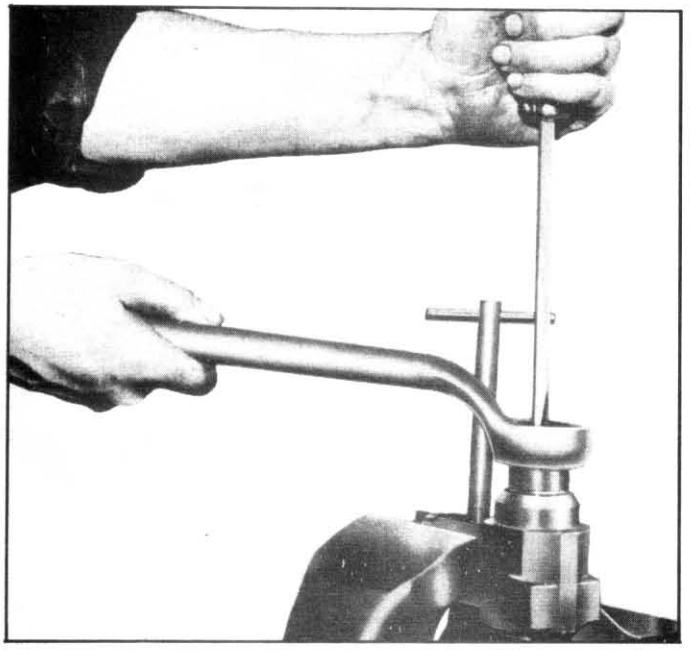
Before doing any work on nozzle see section - "Precautions and Suggested Equipment for Repair of any Injection Unit."

To Adjust Nozzle Spring Pressure

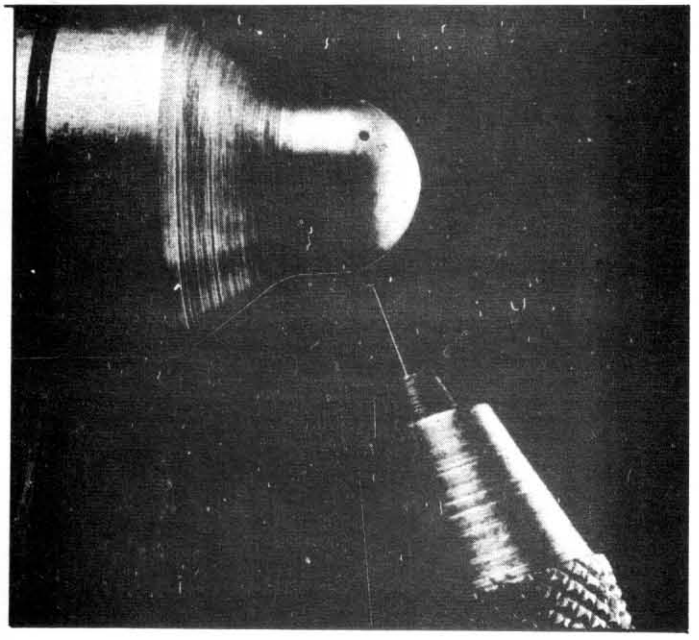
Adjustment of spring pressure should only be attempted on test pump with gauge. While pumping fuel through nozzle in regular way, observe gauge and increase or decrease spring pressure to obtain opening pressure as indicated above. To adjust spring pressure, remove cap (1); loosen locknut (8) and adjust pressure adjusting screw (9) as required. Each quarter turn of adjusting screw changes opening pressure approximately 150 lbs/sq.in.



To disassemble fuel nozzle, place nozzle holder in vise as shown. Observe parts as presented in "exploded" illustration of nozzle. Remove the assembly capnut, spray tip, valve body and stop plate. Then remove nozzle holder from vise.



Invert nozzle holder and replace in vise. Remove the locknut, adjusting screw, spring and pressure pin. In this position it is convenient to remove the bleeder valve and fitting, and the fuel inlet fittings. Reassemble nozzle in the same order it was taken apart.



The holes in the fuel nozzle spray tip may become clogged and interfere with engine operation. The holes may be cleaned by the method illustrated.

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To Remove or Change Nozzle

Place nozzle holder body in vise on flat portions provided for purpose with nozzle body on top. Unscrew nozzle cap nut. Use close fitting wrench to prevent damage to nut. Wash nut (21), spray tip (7), assembly nut (21) and nozzle valve assembly (20) 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 (5) in vise on flat portions provided for purpose with cap (1) in upright position. Remove cap. Loosen lock nut (8), and unscrew adjusting screw (9). Draw out pressure adjusting spring (3). Wash all parts in kerosene. Unscrew inlet nipple (17). Press out edge filter (18) 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 inlet nipple by hand with aid of 3/16" pin. If filter is too loose, replace with a new filter. Be sure seating faces of inlet nipple and nozzle holder body are clean and that inlet nipple is in good condition. Tighten inlet nipple sufficiently to prevent leaks without distorting any part by excessive force. Replace parts and adjust nozzle opening pressure according to instructions page 4-A-9. Replace protection cover.

INJECTION NOZZLE TROUBLES AND REMEDIES

Nozzle Valve Sticking

Probable Cause	Suggested Remedy
1. Dirt in nozzle	1. Remove and clean nozzle.
2. Poor lubricating qualities in fuel oil. (Fuel oil above 32° Baume gravity usually has poor lubricating quality)	2. Change to fuel of proper specifications.
3. Nozzle body and valve corroded or eroded due to acid, water or dirt in fuel oil.	3. Replace nozzle body and valve with spares. Check fuel and filters.

Leakage of Fuel Around Nozzle Holder or Excessive Leak-off Through Nozzle Drain.

4. Joint between nozzle holder and nozzle not tight.	4. Clean faces. Remove burrs and scratches from nozzle body and holder.
5. Nozzle valve worn and loose in nozzle body.	5. Replace nozzle body and valve with spares. Check fuel and filters.
6. Nozzle valve stuck in closed position or nozzle orifices clogged.	6. Remove and clean nozzle.

B. Fuel Transfer Pump

The fuel transfer pump is of the reversible gear type. This pump is mounted on the aft end of the engine and is driven from the engine camshaft.

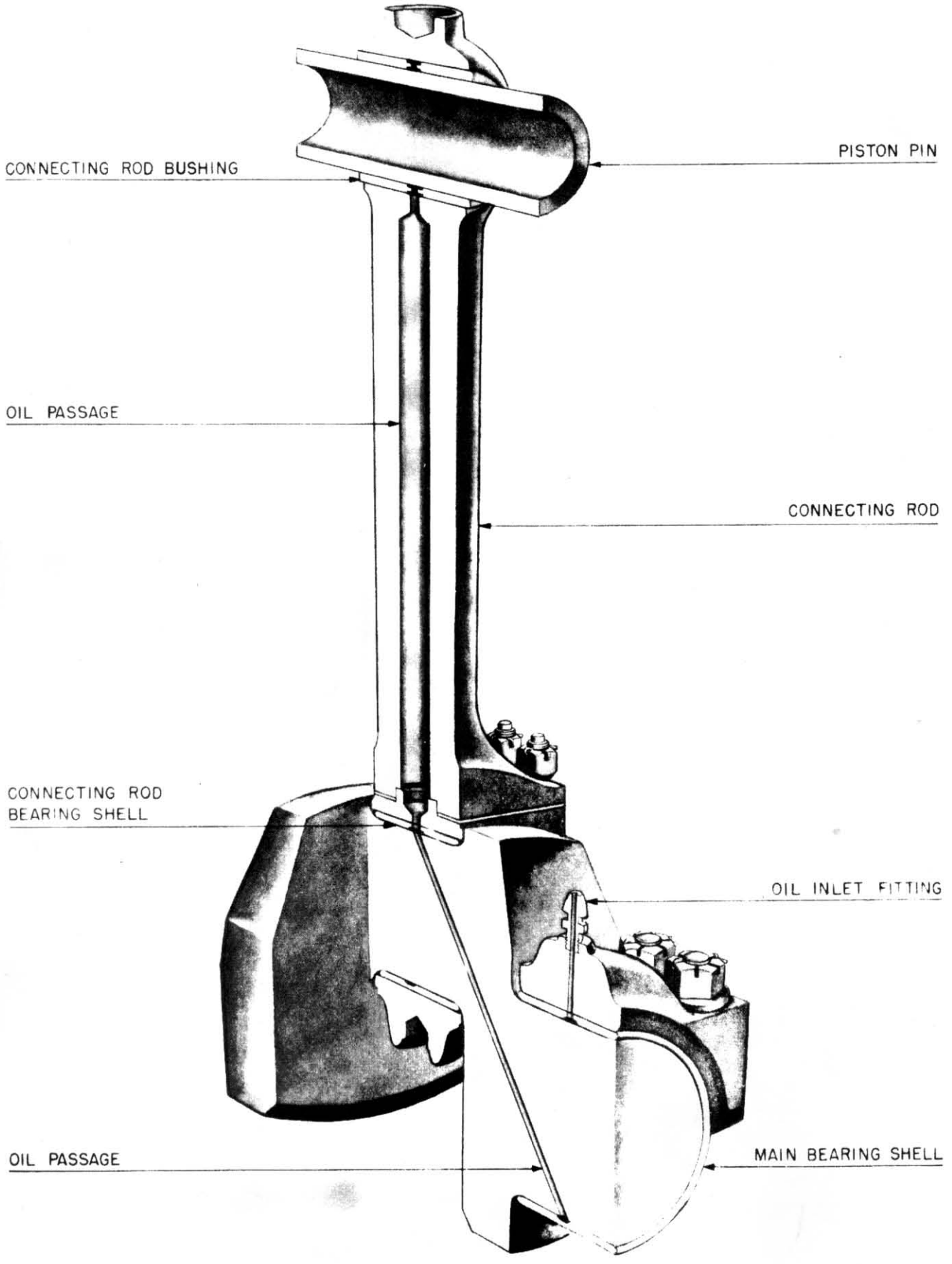
If difficulty should be encountered in maintaining the fuel pressure, the trouble may be caused by the dirt under the valve seats. To correct this, remove the castings at both ends of the check valves and clean the valve seats. If the fuel filters are kept clean, however, the pump should require no attention other than an occasional inspection of the packing gland for leaks. When repacking, use 1/8" round packing about 14" long of a type suitable for use with light fuel oil.

No lubrication service is required for this pump.

Relief Valve

A relief valve is bolted to the top of the pump to serve as a safety valve. The pressure regulating valve is at the end of the fuel header.

The pump is made reversible by the use of poppet valves. As long as the fuel is clean no difficulty should be experienced with either the safety valve or valves for reversing.



OIL FLOW IN CONNECTING ROD AND BEARING

D-1877

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C. Lubricating System

General

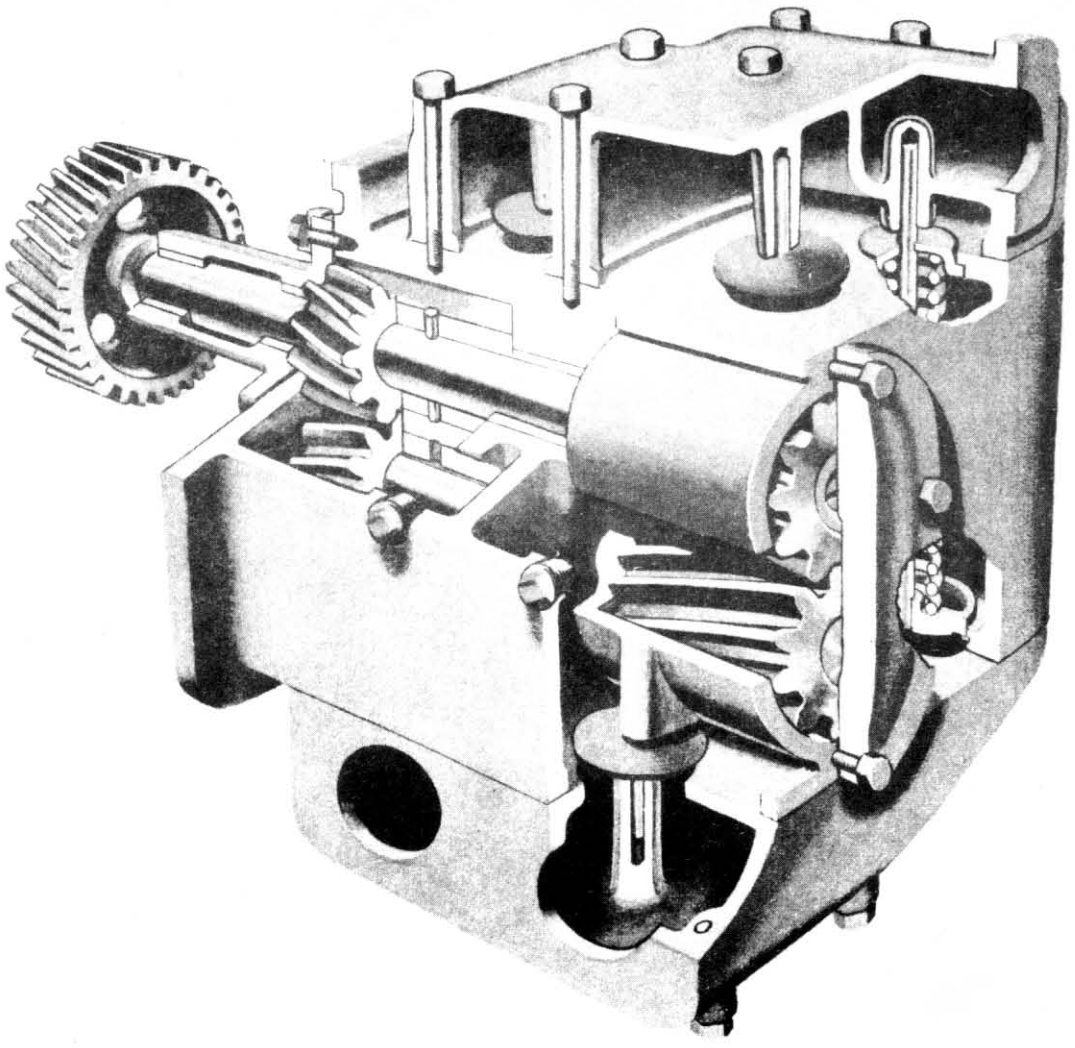
The lubricating oil pump is of the duplex type, one the scavenge pump and the other the pressure pump. The scavenge pump transfers oil from the engine base through a filter to the service tank. The pressure pump takes the oil from the service tank and forces it through an oil cooler and through a strainer to the various points to be lubricated. A control valve built in the pressure pump holds oil pressure at the allowable lbs/sq.in. by permitting excess oil to be by-passed back to the suction side of the pump. A relief valve built in the scavenge pump will by-pass oil if an external line valve is accidentally closed, thereby preventing damage to pump.

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 lubricating oil pump assembly consists of two gear type pumps mounted in the same housing. This unit is gear driven. The main impeller gear of the pressure pump is keyed to the drive shaft while the main impeller gear of the scavenge pump is taper pinned to the common drive shaft. The drive shaft rotates within bronze bushings which have been pressed into the duplex pump housing. The idler gears of both pumps rotate on a stationary shaft.



LUBRICATING OIL PUMP

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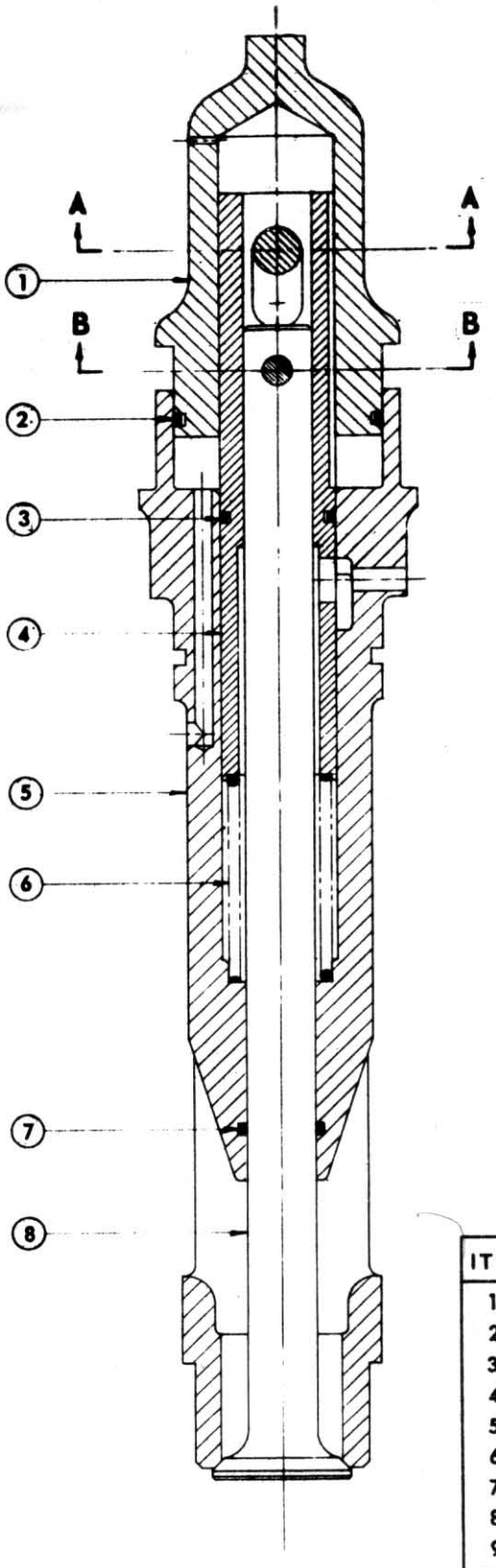
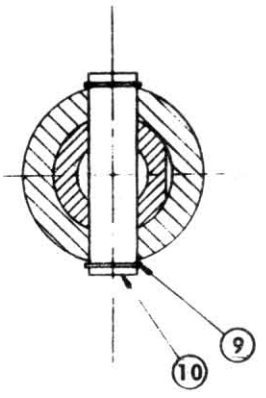
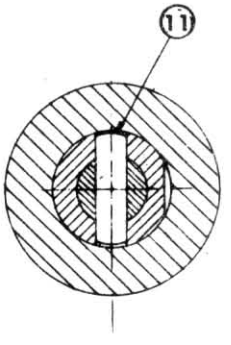




SECTION A-A



SECTION B-B

ITEM	PART NAME	QTY.
1	CAP, AIR START VALVE	1
2	RING, COMPRESSION	1
3	RING, COMPRESSION	1
4	PISTON, AIR START VALVE	1
5	CAGE, AIR START VALVE	1
6	SPRING, AIR START VALVE	1
7	"O" RING	1
8	VALVE, AIR INLET	1
9	RING, RETAINING	2
10	PIN, CAP	1
11	PIN, AIR START VALVE	1

AIR START VALVE ASSEMBLY
(PART OF CYLINDER HEAD GROUP)

D. Air Starting System

The air starting system consists of a control valve and the starting valve in each head. 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.

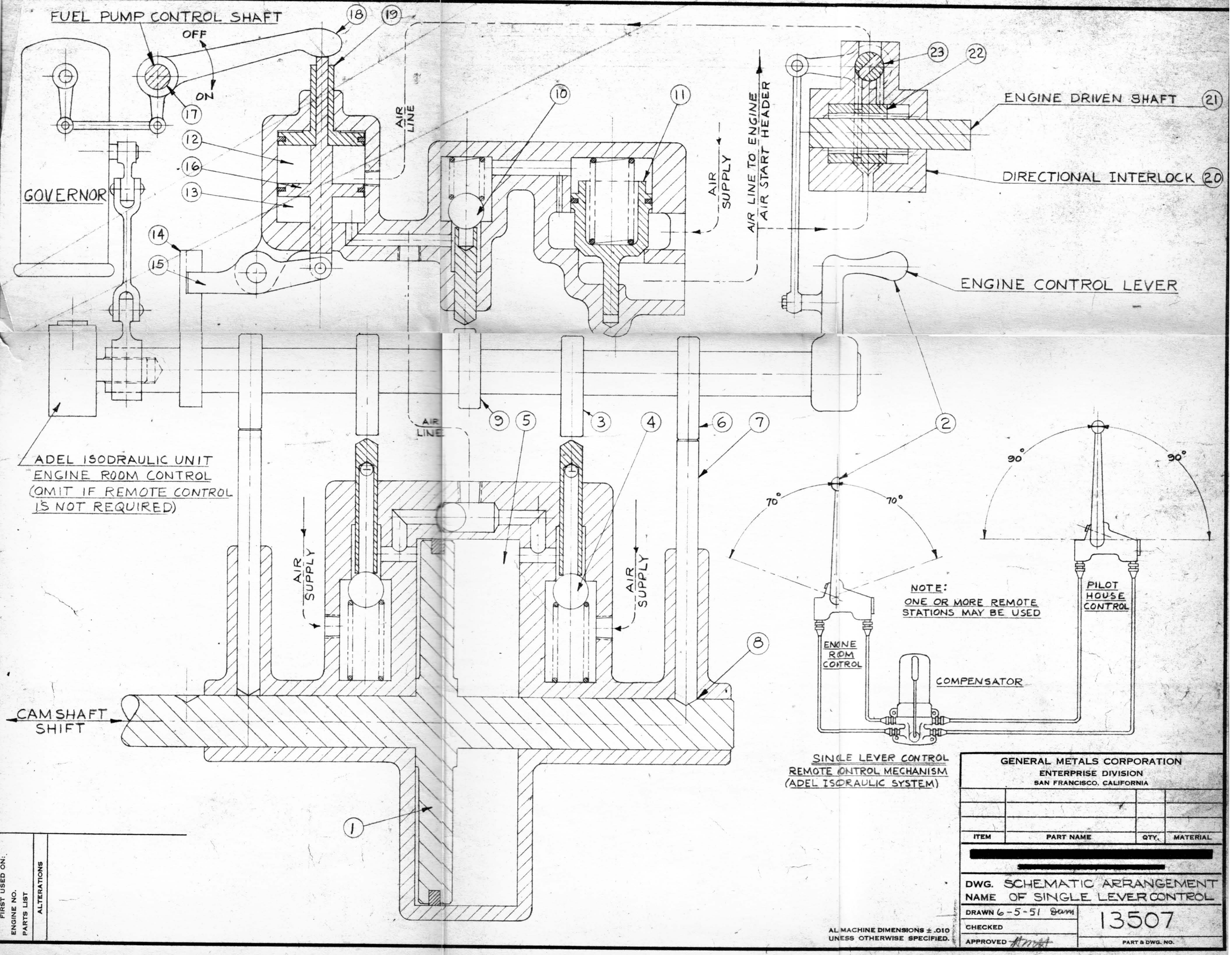
If it is desired to turn the engine over slowly by air without starting it, the manual air starting control wheel may be turned slightly thus allowing air to bleed into the starting air manifold.

Timing of Air Starting Valves

When adjusting the clearance for proper air starting valve timing, it is essential that the valve be in the extreme up position. To accomplish this proceed as follows: Be certain first, that the operating control lever is in the stop or vertical position, then for safety push in both the operating control lever block and the air starting control valve block. These are both located on the base of the operating control lever. Open the valve in the line leading from the air supply and then turn the manual control wheel of the air starting control valve in a counterclockwise direction just enough to maintain 25 to 35 pounds pressure. 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! Before attempting to bar the engine over, be certain that the globe valve in the starting air line is closed.



FIRST USED ON:
ENGINE NO.
PARTS LIST
ALTERATIONS

ITEM	PART NAME	QTY.	MATERIAL

GENERAL METALS CORPORATION
ENTERPRISE DIVISION
SAN FRANCISCO, CALIFORNIA

DWG. NAME: SCHEMATIC ARRANGEMENT OF SINGLE LEVER CONTROL

DRAWN 6-5-51 Dam
CHECKED
APPROVED

13507
PART & DWG. NO.

ALL MACHINE DIMENSIONS ± .010
UNESS OTHERWISE SPECIFIED.

E. Reverse Mechanism

The engine is reversed by moving the camshaft fore and aft, which brings alternate sets of cams into operation, so designed to cause opposite rotation of the engine.

The power for shifting the camshaft fore and aft is supplied by an air-operated, double-acting piston (1). The control lever (2) is directly connected to control the governor speed, the speed being increased by moving the lever away from the "STOP" position in the desired direction of rotation. The control lever shaft is coupled to an Adel hydraulic unit so that one or more remote control stations using a similar unit may be provided. The levers at different stations all move together. If a remote station is not desired, the Adel unit is omitted.

Description of Operation (See Drawing #13507)

The following is an explanation of the sequence of events occurring when the control lever is moved in either direction from the vertical "STOP" position.

Cam (3) opens valve (4) which admits air to camshaft shifting cylinder (5). At this point, cam (6) strikes against pin (7) which prevents further motion of operating lever (2). Piston (1) shifts engine camshaft to position for correct engine rotation, pin (7) drops into lock hole (8) as shown. This dropping of pin (7) allows cam (6) to ride over top of pin (7). This locks camshaft in place and allows continued movement of lever (2). Cam (9) now opens valve (10) which vents, unbalances and, therefore, opens main air start valve (11). This admits starting air to the engine and also air to chamber (12) of fuel shut off cylinder. At this point, further motion of lever (2) is restricted by cam (14) striking interlock lever (15). The starting air pressure to chamber (12) of fuel shut off cylinder forces piston (16) to the bottom which allows fuel shaft (17) to rotate to the starting position with lever (18) resting on sleeve of piston (19). Downward motion of piston (16) also releases cam (14) so control lever (2) may then be moved at will to full fuel position. However, piston (19) restricts fuel control shaft lever (18) to the starting position until the engine starts. The air start header pressure then begins to drop. This allows piston (19) to slowly retract, allowing full fuel to gradually come on. This prevents "Jack Rabbit" starting.

In returning lever (2) from idling to stop position, cam (3) opens valve (4) which admits air to cylinder (5) and also to fuel shut off cylinder (13). This raises piston (16) to shut off fuel control shaft (17). Also, air is admitted to underside of valve (10). The control lever is blocked in this position by cam (14) and lever (15) until these events do take place and the fuel control shaft (17) is shut off. Further motion of control lever (2) opens valve (10) but since pressure is also on the underside of the valve, it does not vent, unbalance and open the air start valve (11). Therefore, the air start valve does not open when bringing the control lever (2) to the stop position.

The same sequence of operation applies to either ahead or astern directions. While in the "STOP" position cam (14) and lever (15) keep fuel control shaft (17) locked in the shut off position.

In various marine applications it is not convenient to let the engine stop before reversing the controls. In certain applications, particularly with twin engines, one engine may keep on rotating until the controls are reversed. Therefore, a variable time interval exists during which the starting air should remain on and the fuel should remain off, terminating at the instant the engine changes direction of rotation.

A directional interlock (20) performs this timing. An acme threaded shaft (21) is engine driven to shift threaded rotor (22) from one position to another depending on engine rotation. A rotary valve (23) is directly connected to the main control lever (2). When the engine rotation corresponds to the control lever position, the air circuit through the interlock is completed. Air pressure from the starting air header is then admitted to the "fuel shut off cylinder" to turn the fuel on and the starting air off.

Adjustment and Maintenance

The cam shift valves are located in the housing on which is mounted the knurled main air start valve wheel. These ball valves may be inspected and reseated, if necessary, by removing brass caps on the side facing the operator.

If it is necessary to replace the shift ball valves or pins, the outer ends which contact the balls must be finished off accurately to provide .060/.050" clearance in the "STOP" position.

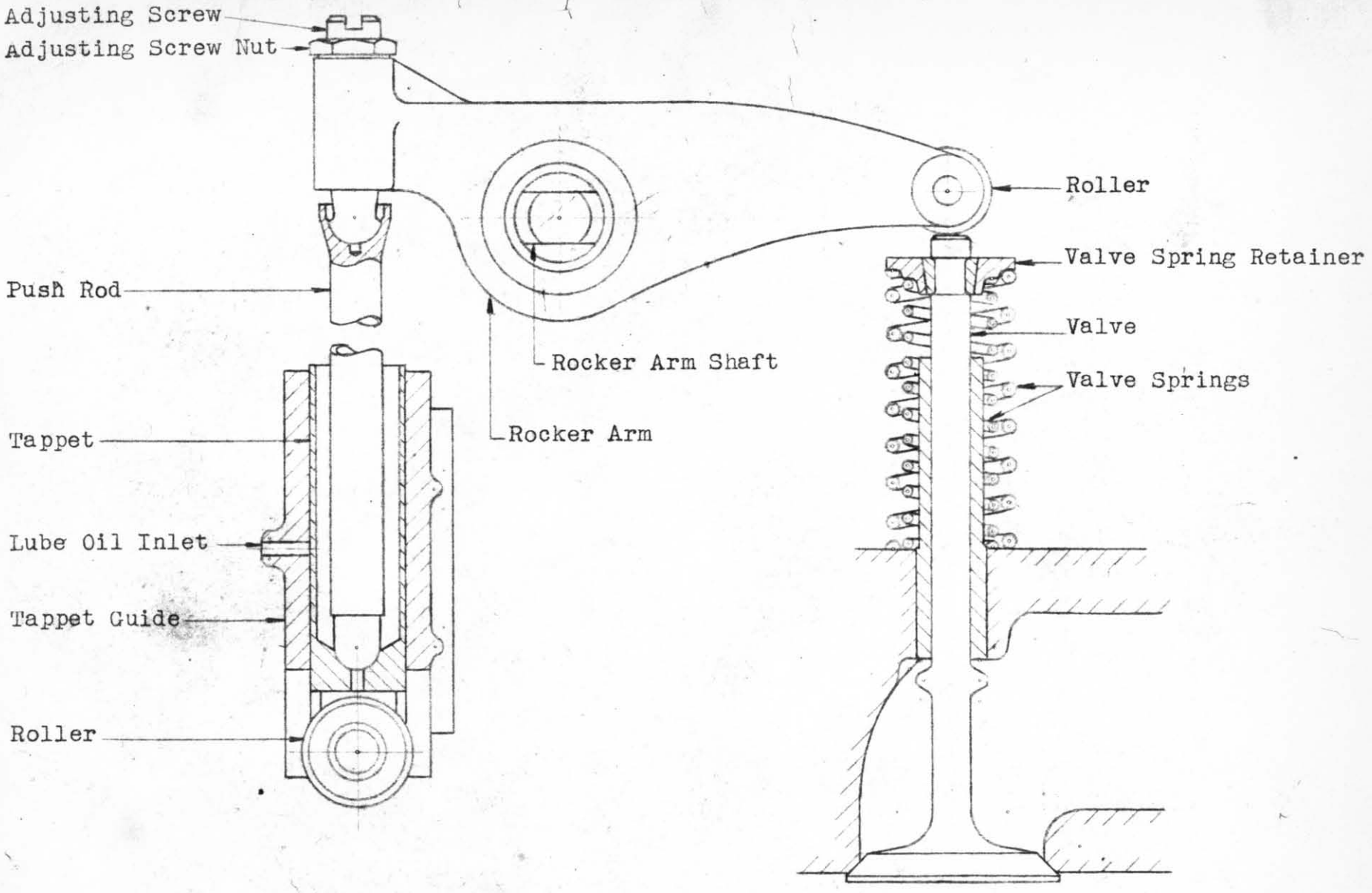
If it is necessary to replace the main air start pilot valve, the upper end which contacts the ball seat must be finished off accurately to provide .067/.057" clearance in the "STOP" position.

The two interlock pins are adjustable for length by means of screw threads and are accessible by removing the camshaft gear cover and the reverse mechanism cover cap. Cams on the operating control shaft wedge these cone-pointed pins into conical openings in the double-acting piston shaft. This locks the camshaft in its operation position. These pins are adjusted individually and should be a snug wedge fit with less than .005" clearance in their downward positions. The downward position may be observed by operating the control lever with the covers removed.

The five 1/4" oil holes are located on the upper deck of the control housing. These should be oiled daily.

Two petcocks are located at the bottom of the reverse mechanism, one on each side of the double-acting piston. These are provided to drain any water which may be admitted with the compressed air. Service conditions will indicate how often these should be opened.

A shoulder for service alignment check has been provided on the thrust plate. There is a nominal 1/8" gap between this shoulder and the rotating thrust ring which is attached to the cam gear hub. A minimum clearance of 1/32" at any point on the circumference is allowable. Shims are proved to adjust the .006" to .008" specified clearance between the thrust plate faces.



VALVE LIFTING MECHANISM

D-2382

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. P lace valve spring tool (furnished with engine) over valve retainer. Clamp tool in place. 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 and clamp tool in place. 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 by means of 75° reamer. Width to be 11/32 ± 1/64 for "G" and "X" engines and 19/32 ± 1/64 for "Q" engines. 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 D-2737, "Air Start Valve Assembly"

Jacking screw holes are provided on either side of valve cage to aid in valve removal.

To disassemble valve, remove one retaining ring (9) and drive pin (10) clear of piston (4). Lift off cap (1). When removing compression ring (2) on cap, be careful not to deform the ring. Also, note carefully which face of ring is up, and in reassembly, place the proper side up. Having removed cap, drive air start valve pin (11) through valve (8). Remove piston (4), ring (3) and spring (6). Valve (8) may require a light tap to remove. Care must be exercised in removing "O" ring (7).

In operation, the simplicity of the air starting valve design affords long life to its parts. The sealing "O" ring and spring should be carefully inspected if there is any reason to suspect faulty valve operation.

In reassembling the valve, make certain that the compression rings are assembled with the proper face up. Be certain all drilled passages in cage and cap are clear.

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 reassembly, 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.

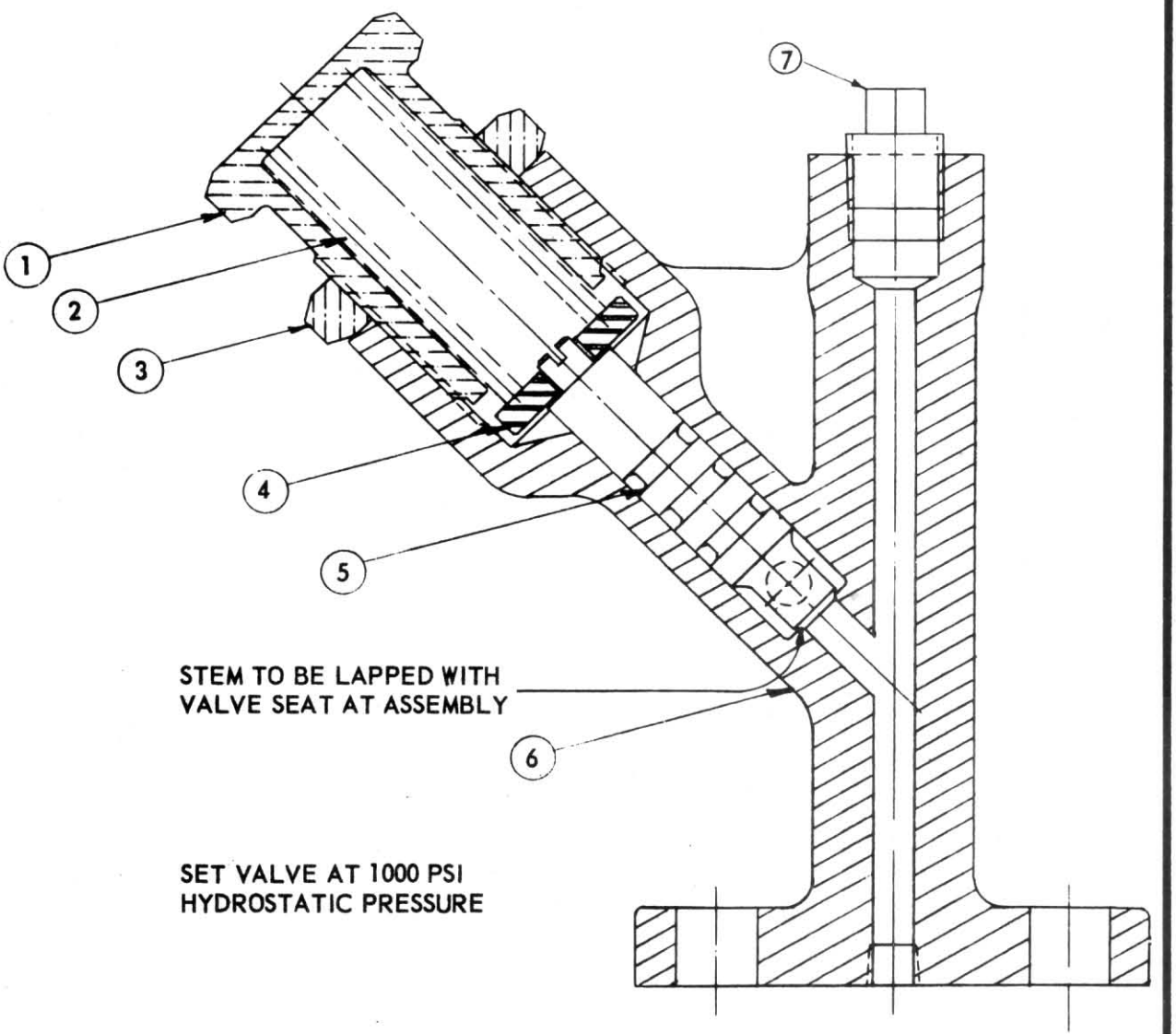
Use new gaskets when reassembling an engine. An old cylinder head gasket may appear to be in good condition, but after reassembling the head and starting the engine the gasket may prove defective, necessitating the complete removal of the cylinder head and installing a new gasket.

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 reassembly.

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.

ITEM	DESCRIPTION	QTY.
1	ADJUSTING SCREW	1
2	SPRING	1
3	NUT	1
4	WASHER	1
5	STEM	1
6	VALVE BODY	1
7	PIPE PLUG 1/2''	1



RELIEF VALVE ASSEMBLY
PART OF CYLINDER HEAD
GROUP

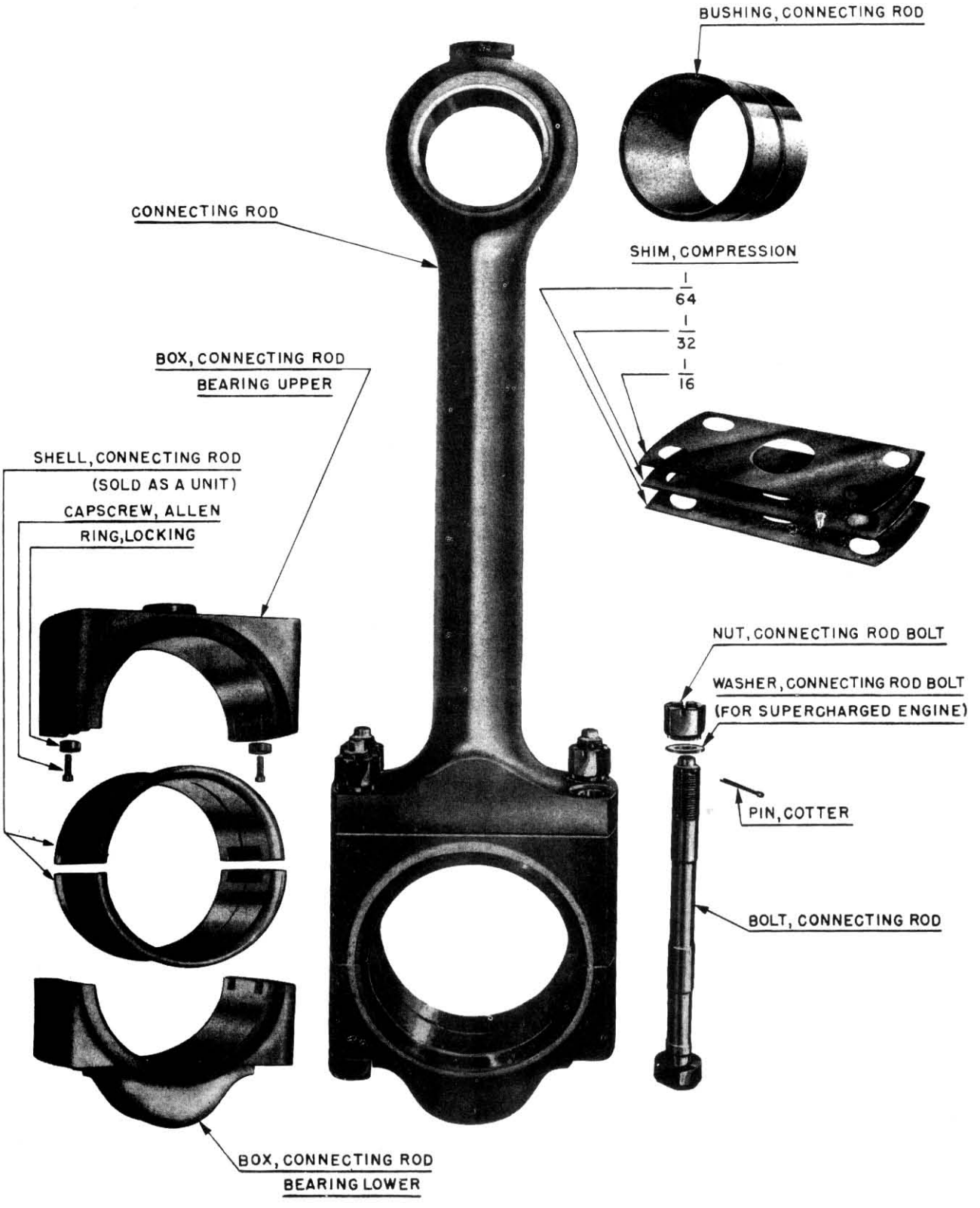
D-2869

H. Relief Valve

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

Relief valve is set at factory to release at 1000 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 may be caused by too much fuel being injected into the cylinder or insufficient tension on the spring.

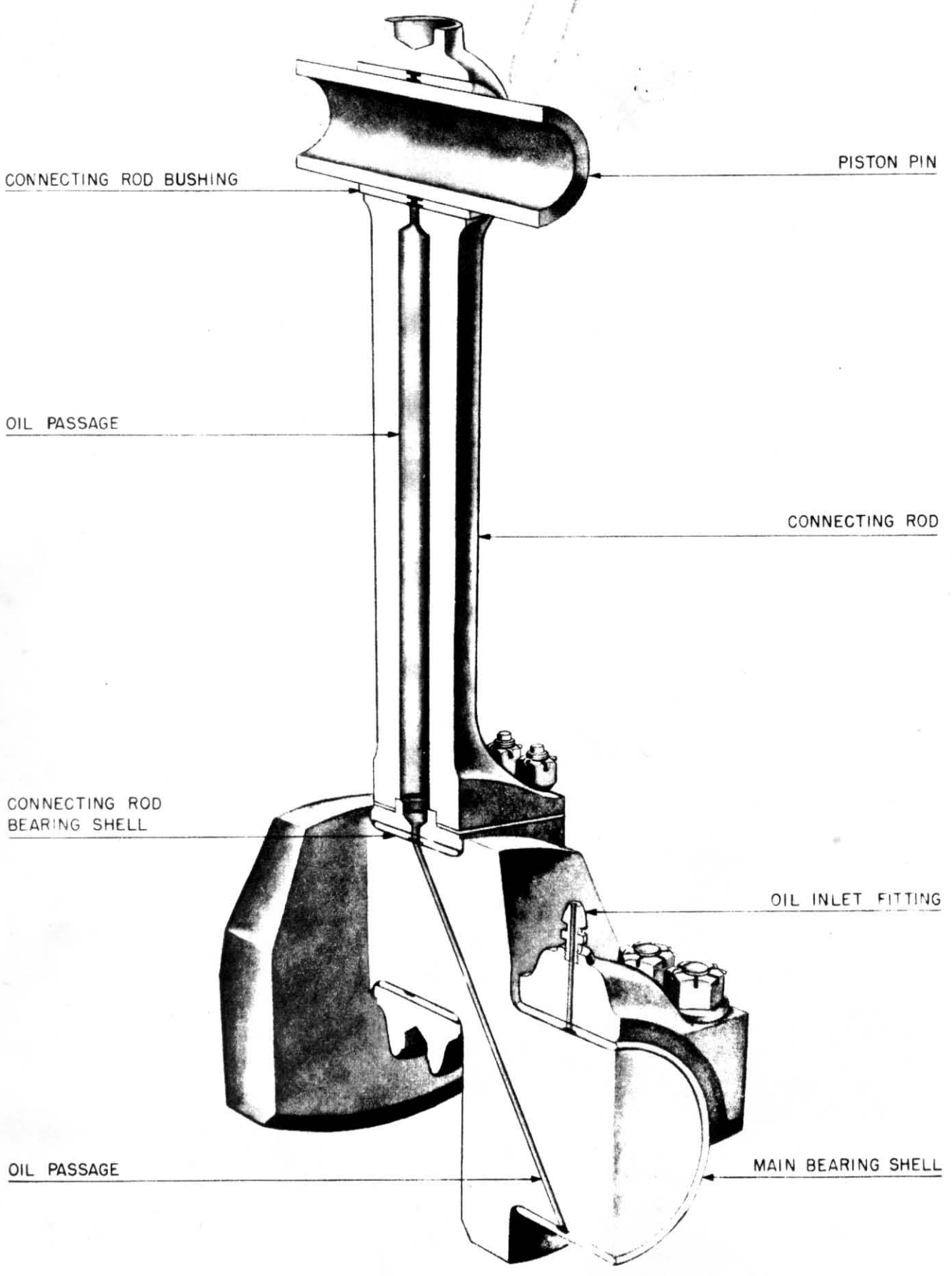
If the relief valve pops too frequently, it should be removed and tested by hydrostatic pressure. Valve should release when pressure reaches 1000 Lbs/Sq.In. To increase release pressure, loosen locknut and screw down on adjusting nut. When making this asjustment care should be taken not to screw down 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 1000 Lbs/Sq.In. it is an indication that the spring has become too weak and should be replaced.



CONNECTING ROD & BEARING
8" PINS

EE&F CO.
PL-4

Printed in United States



OIL FLOW IN CONNECTING ROD AND BEARING

D-1877

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1. Connecting Rod and Bearing

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

Connecting rod bearings are cast steel boxes and bronze shells lined with Bearing metal. The connecting rods are separate. Every six months remove and inspect one connecting rod bearing.

Compression shims between connecting rod and bearing allow adjustment of compression pressure if necessary. If piston top extends beyond face of cylinder block when piston is on top dead center, the dimension given in the following table is measured from face of block to top of piston. When piston does not come out of the liner then dimension given is from top edge of liner to piston top. These distances vary slightly from engine to engine and are given herewith only as a general or approximate dimension.

COMPRESSION DISTANCE

Engine Model	Non-Supercharged Engine	Supercharged Engine
X	1-3/8" Above Block	
G	15/16 Above Block	13/16 Above Block
Q	1-13/16 Below Liner	1-5/16 Below Liner

Each engine should be adjusted, by adding or taking out compression shims until cold compression pressure is in the range of 380 to 420 lbs/sq.in. for non-supercharged engines, and 360 to 400 lbs/sq. in. for supercharged engines. The pressure should be as low as possible and still readily start the engine under actual operating conditions.

If pressures are much below the values given, compression is being lost and gaskets, valves, rings, etc. should be checked.

After a general overhaul, compression pressures should be taken of each cylinder by indicator as follows:

Start the engine in the normal manner, and then open the bleeder screw on each fuel injection nozzle. The engine should be allowed to idle on the balance of the fuel oil with no load applied. Before attaching the indicator to each relief valve, it is recommended that the operator blow-off the relief valve in order to remove any carbon, etc. which may be obstructing the valve. The compression pressures of the various cylinders of an engine should be within twenty pounds of each other for smooth running and evenness of exhaust temperatures and fuel millimeter readings.

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 so as to hold piston and connecting rod in top center position when bearing is removed. Remove connecting rod nuts and bolts to free bearing box.

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

CAUTION: With a piston held at the top of the cylinder with the holding fixture, the crankshaft must not be rotated without removing the nuts holding the rocker shaft. This is to prevent the valves from striking the piston and bending the pushrods or causing more serious damage.

To Check Alignment of Connecting Rod and Bearing

With bearing assembled, loosen connecting rod nuts about three turns. Tap connecting rod bolt on threaded end so it will drop down until bottom face of nuts 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.

TORQUE WRENCH READINGS

A. When torque wrench is used to tighten nuts the minimum readings in foot-pounds should be as listed:

	M	G	Q&R	RV
1. Nut, con rod bolt	275	450	550	650
2. Nut, main bearing cap	275	450	850	3000
3. Nut, cylinder head studs	250	1000	2000	2000
4. Nut, camshaft bearing cap stud	---	75	120	120
5. Ring, con rod retainer	---	---	---	3000
6. Nut, base-crankcase thrubolt	---	---	---	5000

B. These minimum readings are based on using the lubricant specified when tightening nuts and do not apply when threads are dry or "Super Lubricated".

C. Procedure for tightening nuts on studs or bolts.

1. Lubricate nuts with a mixture of 50% lubricating oil and 50% graphite and tighten hand tight.

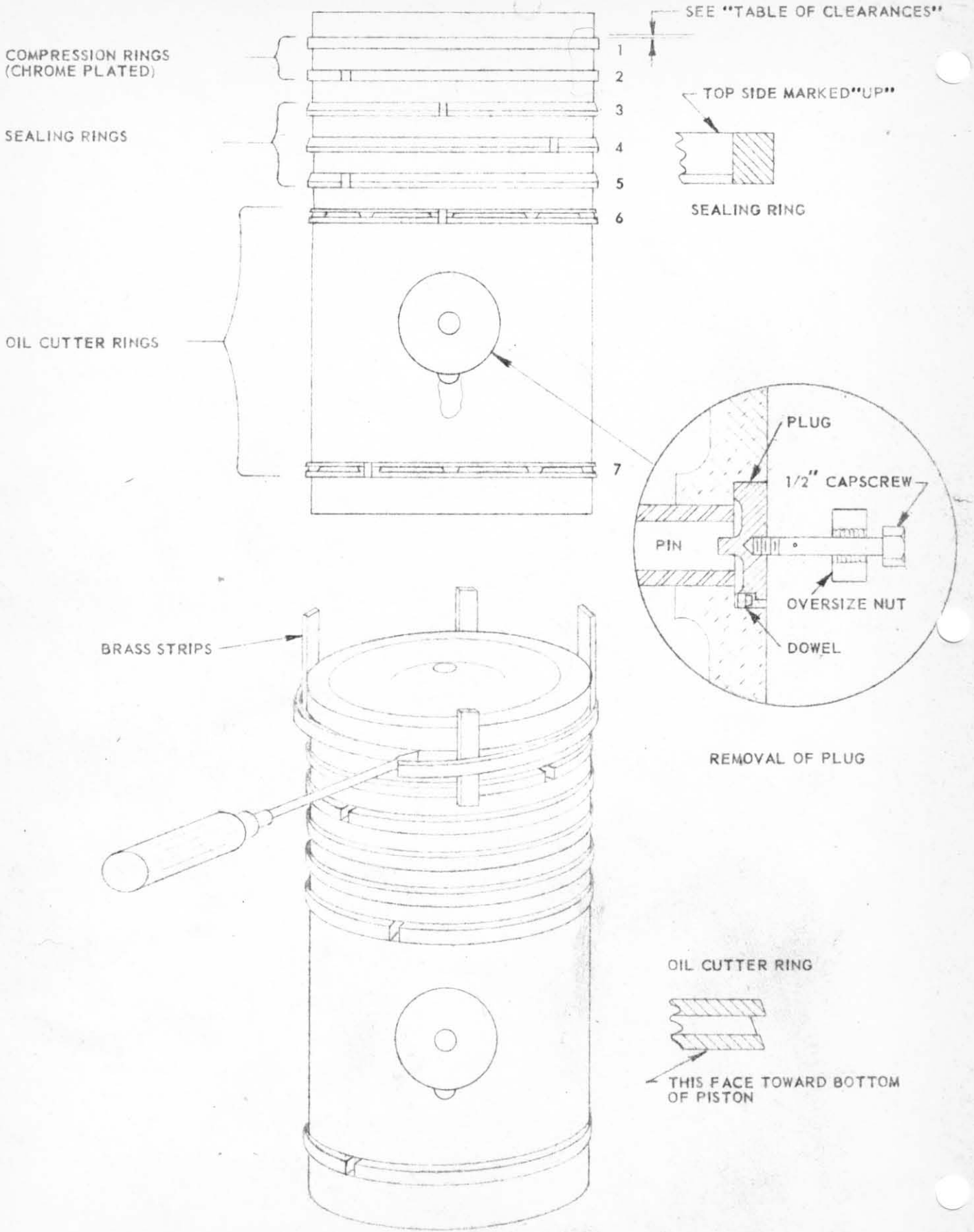
2. Tighten up all nuts by snugging the first nut and moving to the one furthest removed and continuing until all nuts are snug.

3. Apply a small torque to each of the nuts in the same order as above.

4. Finally tighten all nuts applying perscribed torque to the nuts in the order previously described.

5. When nuts are retightened at a later date the nuts must be removed and the threads relubricated in order to get accurate torque values.

   a. Dry thread torque readings can be as much as 50% in error.



REMOVAL OF PISTON RINGS

D-2849

J. Piston

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 the piston puller unit or the eye bolts in tapped holes in piston head. Be sure that threads in tapped holes are clean so that capscrews may be inserted full length. The eye bolts should be inserted at least 5/8". Piston and connecting rod may now be lifted with chain tackle. Make sure the holes in connecting rod foot are clear of the connecting rod bolts; otherwise there is danger of straining the piston with the tackle if the edges of the holes should catch in the bolt threads. Be careful to guide lower end of connecting rod through liner to prevent marring of liner bore.

To Remove Rings - See Illustration "Piston Ring")

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 .040" 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 .014" 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.

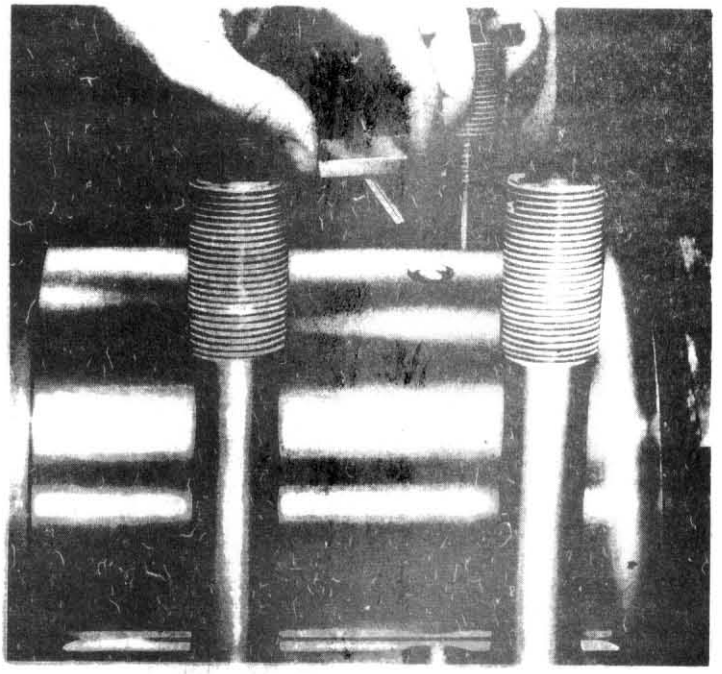
Correct clearances of piston pin in piston and bushing are given in Tables of Clearances.

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.

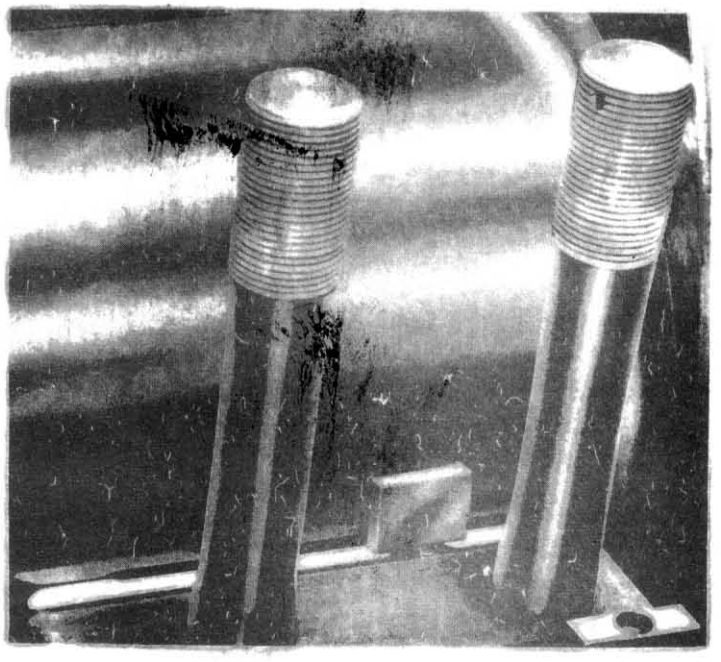
To Reassemble Piston in Liner

Assemble piston and rod, taking care to return them to their original relative positions. Aluminum plugs are marked and 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 carfully 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).

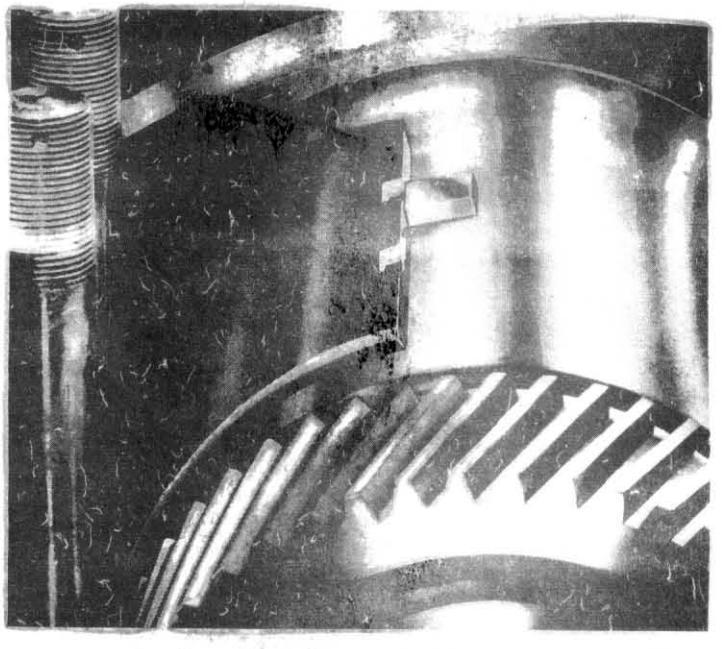
If any new wearing parts have been installed, engine should be run for at least eight (8) hours at about half speed and at a light load. During this time, it should be stopped frequently to ascertain any undue heating of piston or pin.



Special tool is provided with engine to allow easy removal of lower main bearing shell. Insert this tool into lubricating oil hole in crankshaft as illustrated.



Bar the engine over slowly until the bearing removal tool contacts the leading edge of bearing shell. Continue then to bar engine over slowly until bearing shell is free. Lift out both bearing tool and shell.



To install shell, first pour clean lubricating oil on both crankshaft journal and lower shell. Place shell on top of journal, being certain that it is so placed that when upper shell is installed the oil grooves will be staggered. Slide the shell around journal and then bar engine over very slowly until lubricating oil hole is exposed. Place bearing tool in this hole and continue to bar engine over very carefullly so as not to force shell. When shell is in place, remove bearing tool.

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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.

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 gauge, 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 glycerine or glycerine and soap stone for rubber lubrication should be placed on rings. It is essential that liners be replaced in their original cylinders and that each liner be reassembled 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"

Description
Accurately cut helical timing gears, lubricated by streams of oil, are enclosed in the gear case.

About once every six months, gear case covers should be removed and gears inspected and backlash tested between all gears. (If backlash exceeds value given on Gear Set illustration by .006" or more, adjust as described below.)

Test radial and thrust clearance of idler bushing.

To Remove Gear Case and Accessories
Take off all accessories, disconnect all lines to gear case. As will be noted, all front end accessories are flange mounted. When installing these parts, position flange of housing so that the mating gears have the correct backlash and slightly tighten bolts.

Check backlash and freedom of all parts by turning accessory gear back and forth by hand.

Bar engine to several positions and check backlash.

Adjust as necessary by shifting accessory and then tighten flange securely.

Make final check for proper clearance in several gear positions.

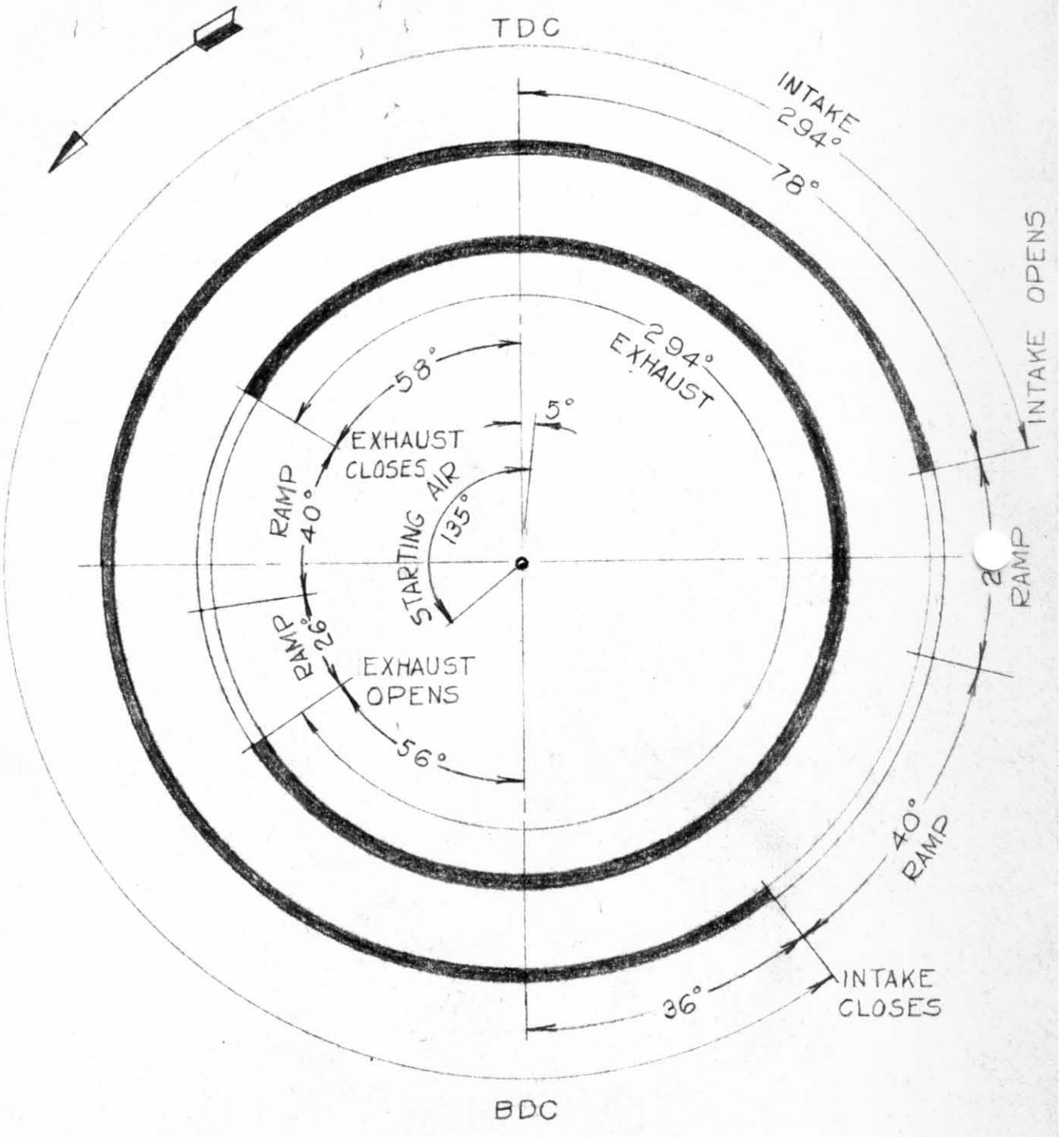
To Remove Idler Gear
With gear case removed, take off idler thrust plate and shims, and withdraw gear. When removing idler gear only, mark mating teeth on crankshaft, idler and camshaft gears before disassembly, so as to eliminate retiming engine when idler gear is reinstalled.

New bushings should be installed in idler gear when radial clearance exceeds .010". When pressing in new bushings, remove all burrs from gear bore. Thrust clearance of gear must be adjusted to .004"-.007" when reinstalling on stub shaft.

To Remove and Replace Camshaft Gear Hub
Remove camshaft nut, washer and cotter. Insert 1/2" studs, about 6" long, in tapped holes in hub. Use a 3/4" x 1-1/4" bar, about 10" long, with two 9/16" holes at 8-1/8" centers as a puller. When replacing with a new hub, fit a new key.

In assembly of new gear and hub, position the four slotted holes in hub over the four drilled holes in the gear. Clamp gear and hub. Install assembly on camshaft and replace washer, nut and cotter. After timing the engine, as explained on next page, drill and ream the two remaining holes in ring gear.

TIMING DIAGRAM
"G" ENGINE
DIESEL – SUPERCHARGED



FOR FUEL INJECTION SETTING
SEE TITLE PAGE

TO TIME ENGINE
See Illustration "Timing Diagram"

Two methods may be followed to time engine.

A. To time by tappet roller position.
   1. With idler gear removed, bar engine until the flywheel marking "1-6" (for 6 cylinder engine), or "1-8" (for 8 cylinder engine), is exactly centered under the flywheel pointer.

   2. Rotate camshaft until gear of #1 cam keyway is exactly straight up.

   3. Remove camshaft inspection cover closest to flywheel so that the tappet rollers for the cylinder closest to the wheel are available for measurement.

   4. Install idler gear on stub shaft.

   5. Loosen camshaft ring gear bolts and adjust camshaft position until the top surfaces on the intake and exhaust rollers on the last cylinder are exactly on the same level (this indicates that intake valve is about to open and exhaust valve is closed).

   6. Tighten cam gear bolts, ream locating holes and insert fitted bolts.

B. To time by fuel pump opening.
   1. Remove first and last fuel injection pumps.

   2. Bar engine over until #1 fuel tappet roller is on the base (lowest portion) circle of the cam.

   3. Measure distance from top surface of the fuel pump base (the assembly upon which the fuel injection pump mounts) to the top of the adjusting plug inside. This distance should be approximately .197". To adjust, one half turn of the plug equals about .032".

   4. Replace #1 pump.

   5. Bar engine over until "FUEL" mark on flywheel for cylinder "1-6" or "1-8" is under pointer. See Instruction Manual title sheet for number of degrees. The pump plunger mark will register with line on inspection window of pump.

   6. Repeat Steps 2 through 5 with the other pump.

   7. Remove idler gear.

   8. Set flywheel mark "1-6" or "1-8" under pointer.

   9. Set camshaft so that #1 fuel tappet roller is just beginning to climb ramp and so that the last fuel tappet roller is just leaving the ramp.

TO TIME ENGINE - continued

10. Replace idler gear.

11. Lossen cam gear bolts - removing the two fitted bolts entirely.

12. Rotate camshaft slightly by turning hub until the first and last tappets measure exactly the same distance from top of fuel pump mounting base to top of adjusting plug.

13. Finally, clamp gear and hub and insert fitted bolts.

Engine is now timed.

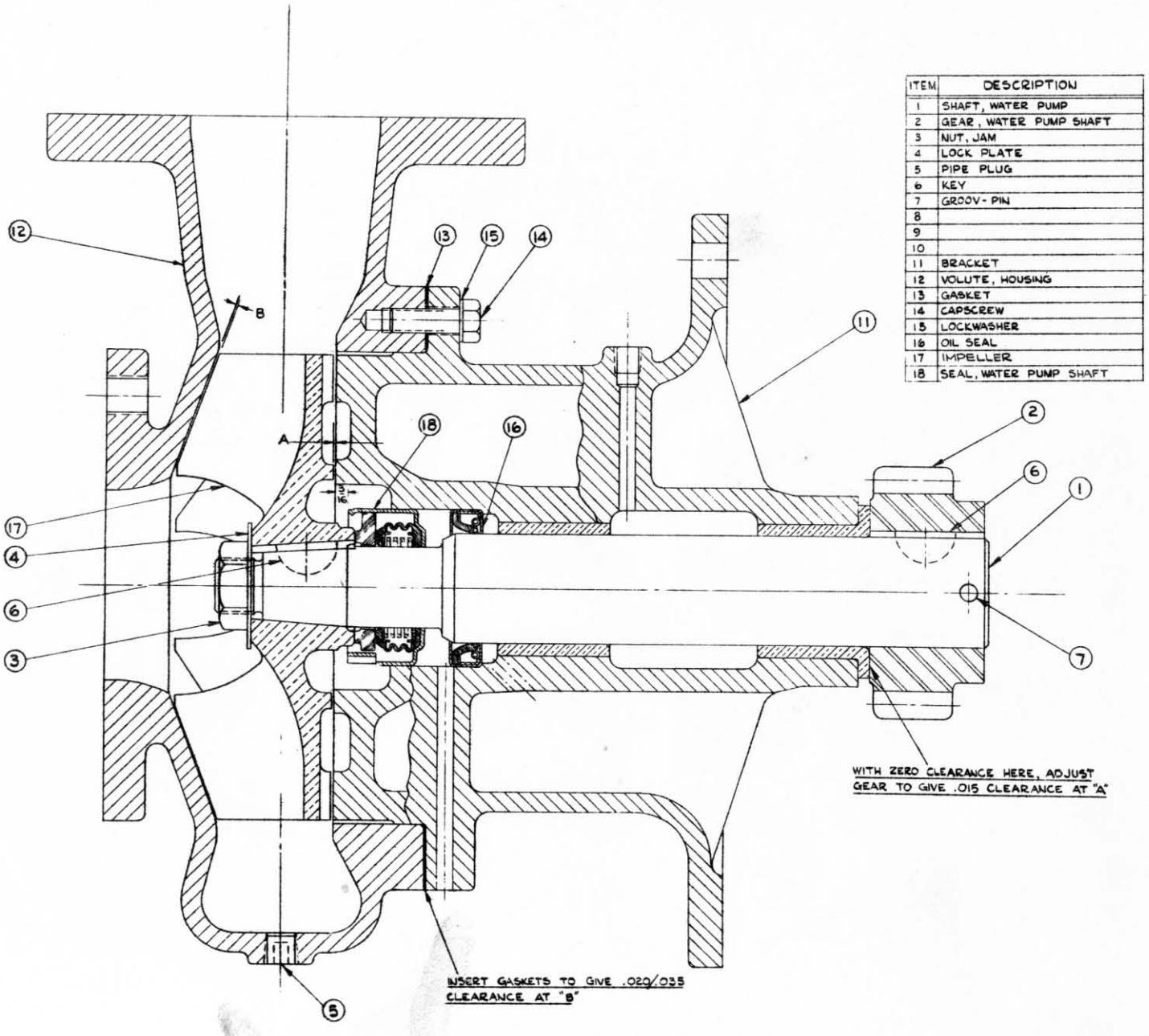
It is advisable to time all fuel pumps before continued engine operation.

To Remove and Replace Crankshaft Gear

To remove the gear, which is a shrink fit on the shaft, split it by drilling a series of holes from top of keyway. Insert 3/4" studs about 24" long in tapped holes in gear and draw it off shaft.

To install a new gear, first fit a new key, which should be a driving fit on sides only on both shaft and gear. Allow .005"-.010" clearance top or bottom. Remove all burrs from crankshaft.

Insert studs in tapped holes in gear and place gear in a pan of oil heated to 350°-450°F. (176°-232°C.). Let gear expand with heat. After brief immersion in the heated oil, rapidly place gear on crankshaft.



ITEM	DESCRIPTION
1	SHAFT, WATER PUMP
2	GEAR, WATER PUMP SHAFT
3	NUT, JAM
4	LOCK PLATE
5	PIPE PLUG
6	KEY
7	GROOV-PIN
8	
9	
10	
11	BRACKET
12	VOLUTE, HOUSING
13	GASKET
14	CAPSCREW
15	LOCKWASHER
16	OIL SEAL
17	IMPELLER
18	SEAL, WATER PUMP SHAFT

CENTRIFUGAL WATER PUMP

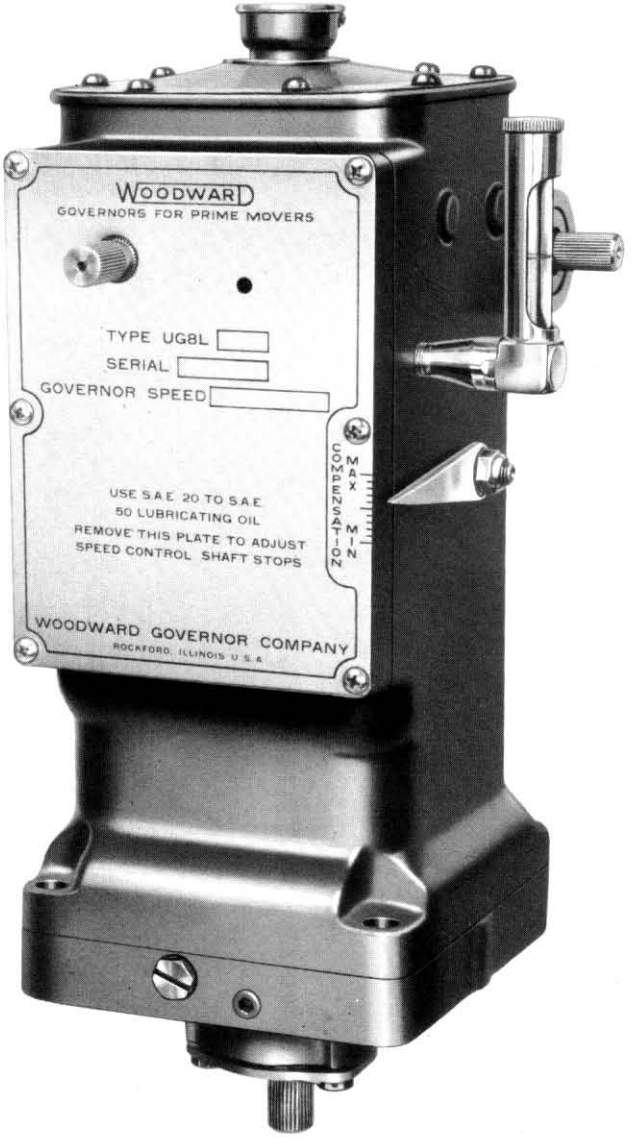
D 2513

WOODWARD®

UG8 GOVERNOR

LEVER CONTROL

BULLETIN 03005A



This bulletin covers the basic type UG8 governor as used on variable speed applications. The dial type governor with speed droop is covered by another bulletin.

WOODWARD GOVERNOR COMPANY

ROCKFORD, ILLINOIS

UG8 GOVERNOR

LEVER CONTROL

PART ONE

GENERAL INFORMATION — INSTALLATION — ADJUSTMENT — OPERATION

GENERAL: The UG8 lever type governor is of the hydraulic type and is isochronous (will maintain same engine speed regardless of engine load). The stalling work capacity of the governor is usually eight foot pounds. Occasionally engine design requirements necessitate reducing the capacity to four foot pounds.

It is desirable that the engine be equipped with an overspeed trip device to prevent runaway in the event of any failure which may render the governor inoperative.

INSTALLATION: When the governor is installed on the engine, particular care should be exercised to see that it is mounted squarely and that the drive connection to the engine is aligned properly. A gasket should be placed between the base of the governor and the mounting pad on the engine. If the governor is equipped with a serrated drive shaft, it should slip into the internal serrations of the drive freely enough to drop into place of its own weight. CAUTION: Do not drop or rest the governor on its drive shaft.

If a keyed type governor drive shaft is used, the gear placed on this shaft should be checked to insure that it is meshing properly. There should be neither excessive backlash nor binding. Irregularies caused by uneven gear teeth, shaft runout, etc., will be picked up by the governor, transmitted to the fuel control system, and will result in erratic governing.

The linkage from the governor terminal shaft to the fuel control system should be free from lost motion or excessive friction. It is often desirable to install a light spring acting to decrease fuel for the purpose of taking up lost motion due to wear. AVOID EXCEEDING THE WORKING CAPACITY of the governor by using too strong a spring.

OIL SPECIFICATIONS: Use SAE 20 or SAE 30 oil for ordinary temperature conditions. If governor operating conditions are extremely hot, use SAE 40 or SAE 50; if extremely cold, use SAE 10.

The oil must not contain additives which are used to free up rings, remove carbon, etc., unless a non-foaming additive is also present. The oil should not foam or sludge excessively when agitated, or form gummy deposits when heated.

DIRTY OIL CAUSES MOST GOVERNOR TROUBLES. Use clean, new oil or filtered oil. All containers must be clean and should be rinsed with light grade fuel oil before using.

Keep governor oil at correct level in oil gauge.

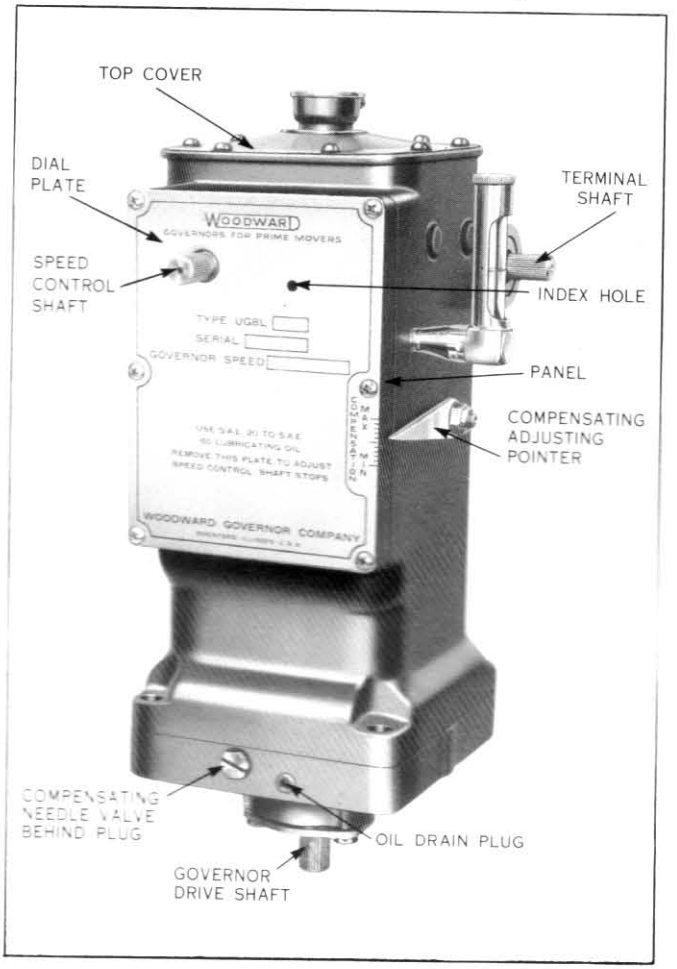
STARTING ENGINE: When starting the engine, set throttle to idle speed position.

COMPENSATING ADJUSTMENTS: Although the governor may appear to be operating satisfactorily because the engine runs at constant speed (without load) the governor still may not be adjusted correctly. High overspeeds and underspeeds after load changes and slow return to normal speed are results of incorrect compensation adjustments.

Make the following adjustments to be certain that the governor will give optimum control.

After the temperature of the engine and the oil in the governor have reached their normal operating values, the compensation should be adjusted without load on the engine as follows:

(1) Loosen the nut holding the compensating adjusting pointer and set the pointer at its extreme downward position. See Cut No. 1. Be sure to tighten the nut after the pointer has been re-set to a new position.



Cut No. 1

(2) Remove the plug covering the compensating needle valve, open compensating needle valve two or three turns with a screwdriver, and allow the engine to hunt or surge for about one half minute to bleed trapped air from governor oil passages.

(3) Gradually close needle valve until hunting just stops. Check the amount of needle valve opening by closing the valve completely, noting the amount of a full turn required to close. Open the valve to the previously determined opening at which hunting stopped. Test action by manually disturbing engine speed. If the needle valve is less than ½ turn open and more than ⅛ turn open, the adjustment is satisfactory and (4), (5), (6), and (7) instructions should be ignored.

(4) If hunting did not stop with the needle valve at least ⅛ turn open, raise the compensating pointer two divisions of the scale and continue with the following instructions.

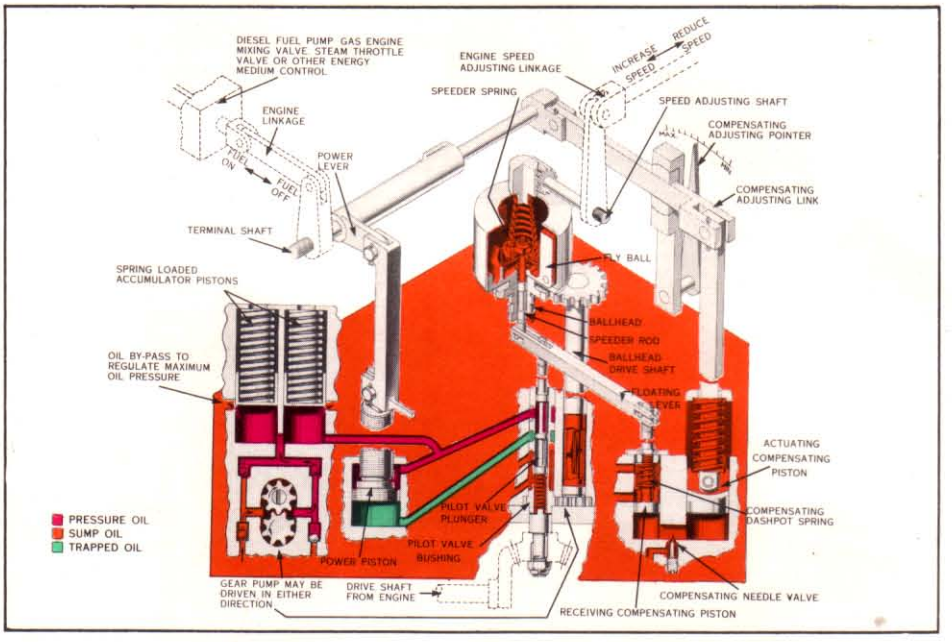
(5) Open needle valve approximately one turn to allow engine to hunt.

(6) Proceed with instruction (3).

(7) If necessary repeat (4), (5), and (3) until adjustment is satisfactory. Desirable needle valve opening is from ⅛ to ¼ turn open.

Note — It is desirable to have as little compensation as possible. Closing the needle valve farther than necessary will make the engine slow to return to normal speed after a load change. Excessive dashpot plunger travel caused by adjustment of the compensating adjusting pointer too far toward maximum position will cause excessive speed change upon load change.

(8) Replace plug over the needle valve.



Cut No. 2

SCHEMATIC DIAGRAM: The schematic diagram shows a UG8 lever control governor without auxiliary equipment. A differential type of servomotor is used in this governor. There is always full accumulator oil pressure on the top area of the power piston (regardless of pilot valve position) which will turn the terminal shaft in the direction to shut off fuel if there is no pressure (or low enough pressure) on the bottom area of the piston. The pilot valve will supply this same oil pressure to the bottom area of the power piston if the valve is moved down. Due to the difference of areas on the top and bottom of the piston a greater force on the bottom will then overcome the force on the top side and will move the piston turning the terminal shaft in the direction to increase fuel.

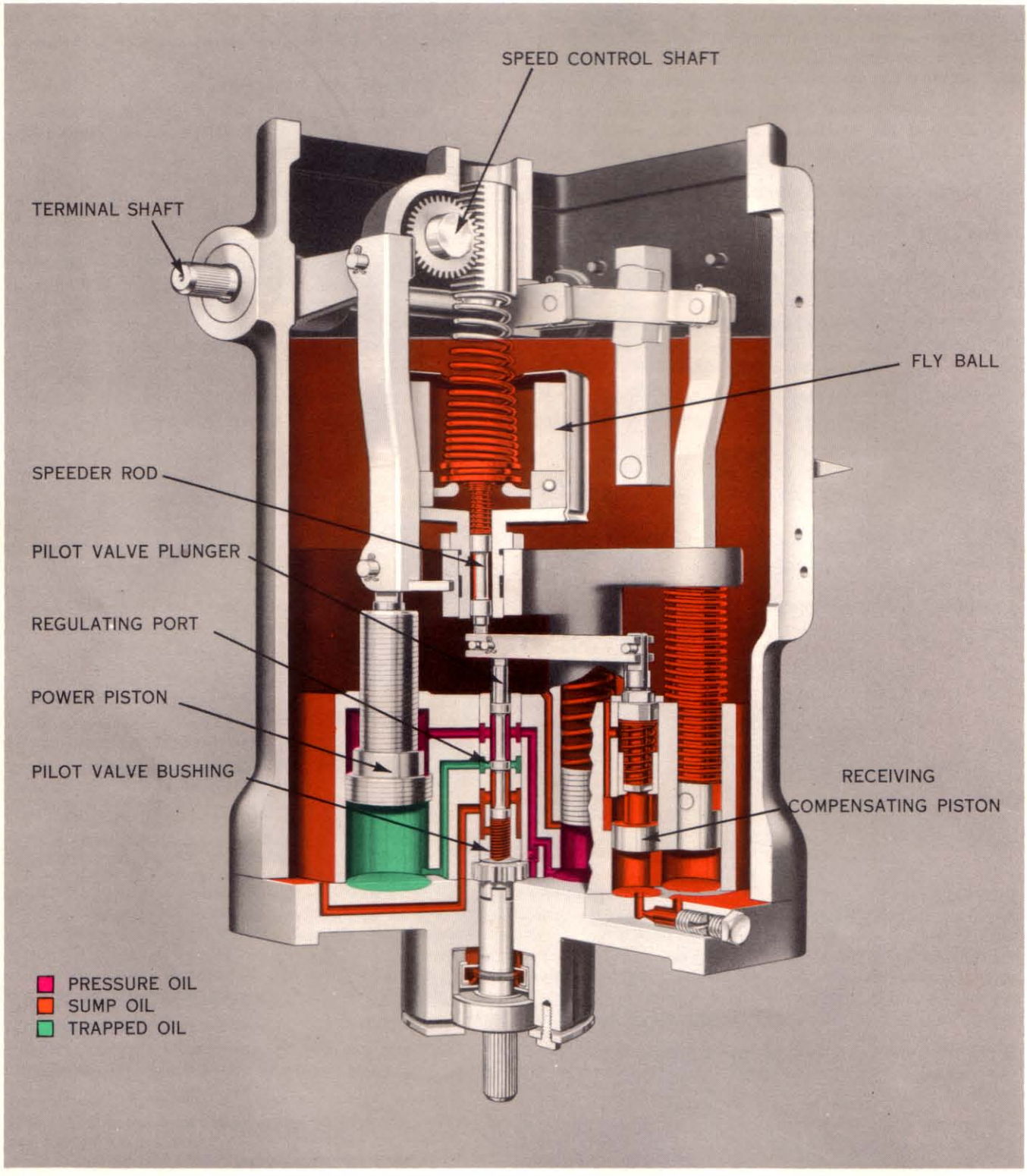
If the pilot valve is moved up the area under the piston is opened to sump, reducing the force exerted on the bottom of the piston. The force exerted by the oil pressure on the top will then be greater and will move the piston, turning the terminal shaft in the direction to decrease fuel.

The spring under the pilot valve supports the weight of the pilot valve, floating lever, etc., and has no effect in the operation of the governor.

The spring above the compensating actuating piston acts to eliminate lost motion in the compensating linkage and has no effect in the normal operation of the governor.

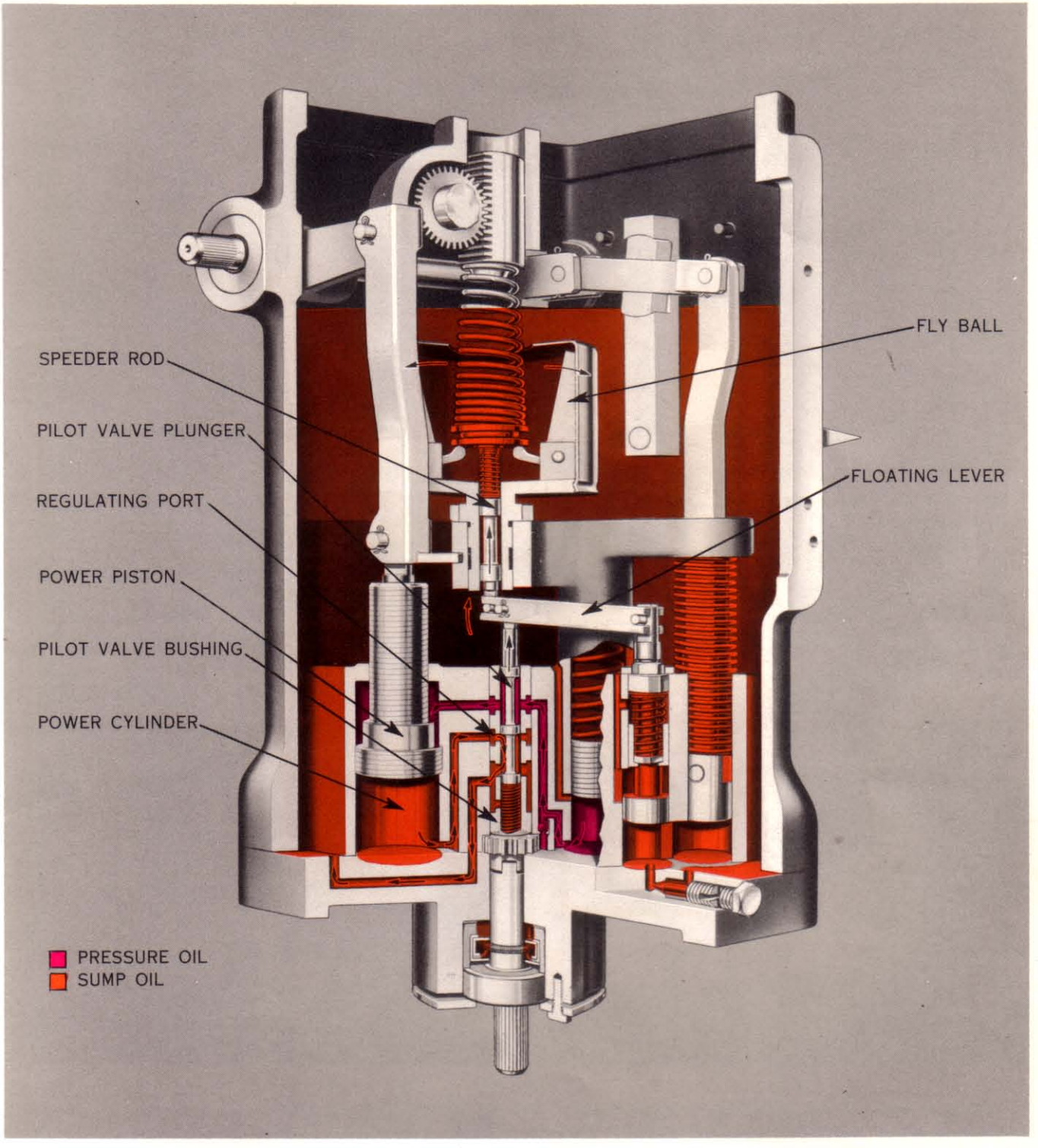
DESCRIPTION OF OPERATION: The photographs showing operation of the governor, Cut No. 3 to Cut No. 10, inclusive, have been simplified by removing the top cover and panel.

This description is based upon speed changes resulting from load changes. However, the same sequence of governor movements would occur if the governor speed setting were changed by repositioning the speed control linkage. Movements of the operating parts of the governor are actually proportional to the amount of speed change, but have been greatly exaggerated in the photographs to make them more visible.



Cut No. 3

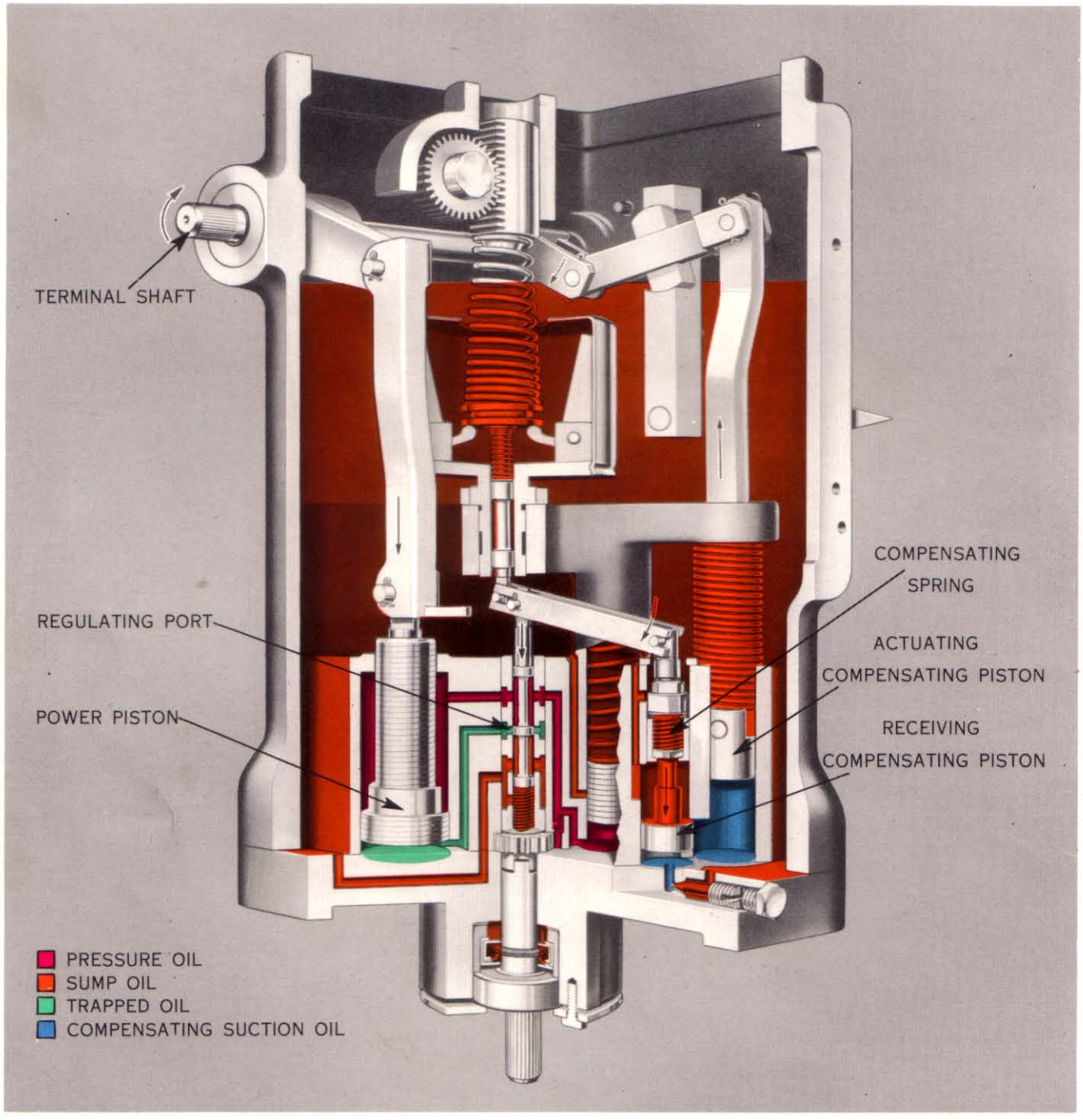
1. Engine is running at normal speed under steady load.
2. FLYBALLS, SPEEDER ROD, PILOT VALVE PLUNGER, and RECEIVING COMPENSATING PISTON are in normal positions; REGULATING PORT in PILOT VALVE BUSHING is covered by land on PILOT VALVE PLUNGER.
3. POWER PISTON and TERMINAL SHAFT are stationary.



Cut No. 4

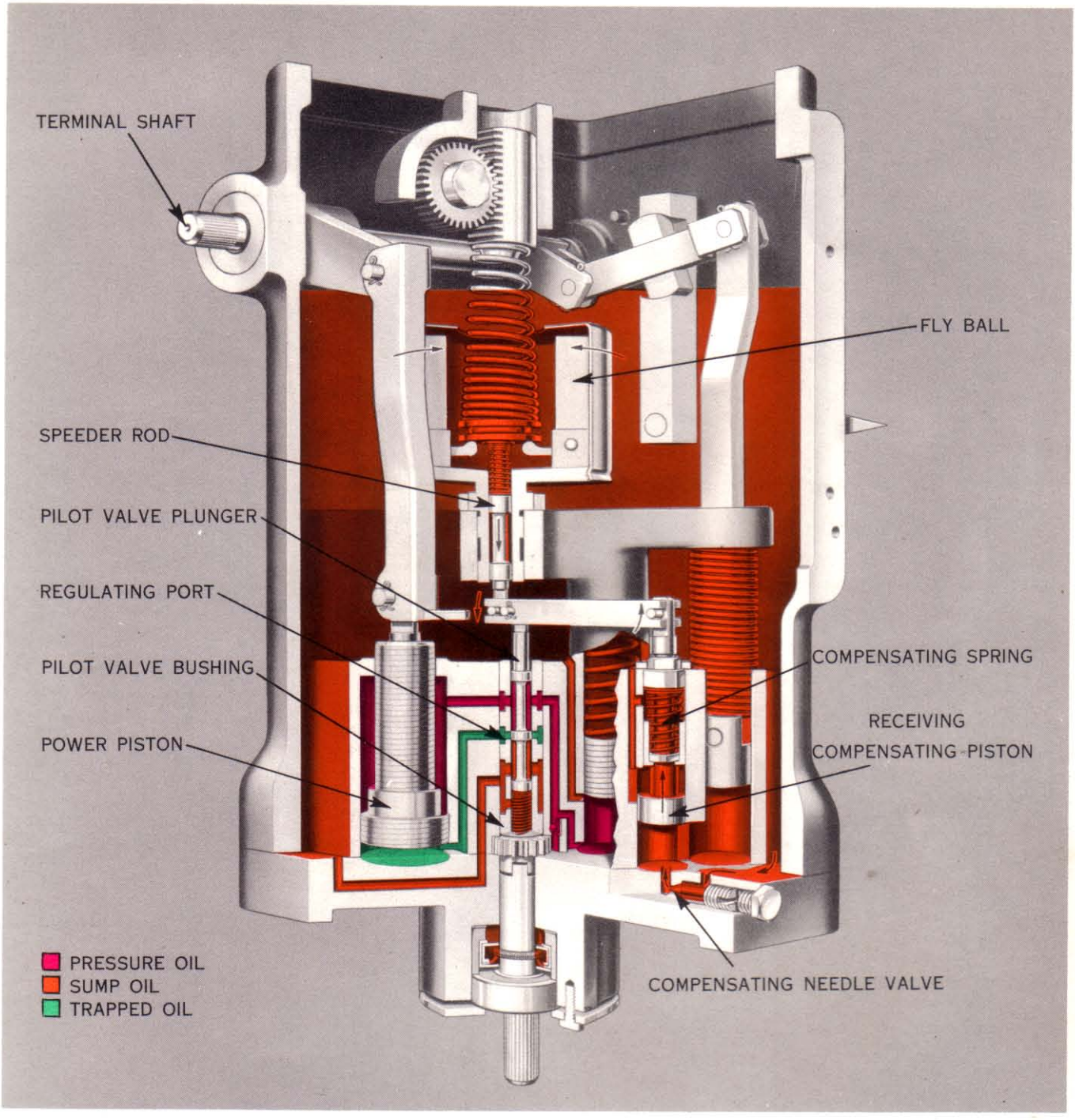
LOAD REDUCTION:

1. Load is decreased and speed increases.
2. As speed increases, FLYBALLS move out raising SPEEDER ROD and inner end of FLOATING LEVER, thus raising PILOT VALVE PLUNGER and uncovering REGULATING PORT in PILOT VALVE BUSHING.
3. Uncovering of REGULATING PORT opens bottom of POWER CYLINDER to sump and will allow oil pressure in top of POWER CYLINDER to move POWER PISTON down.



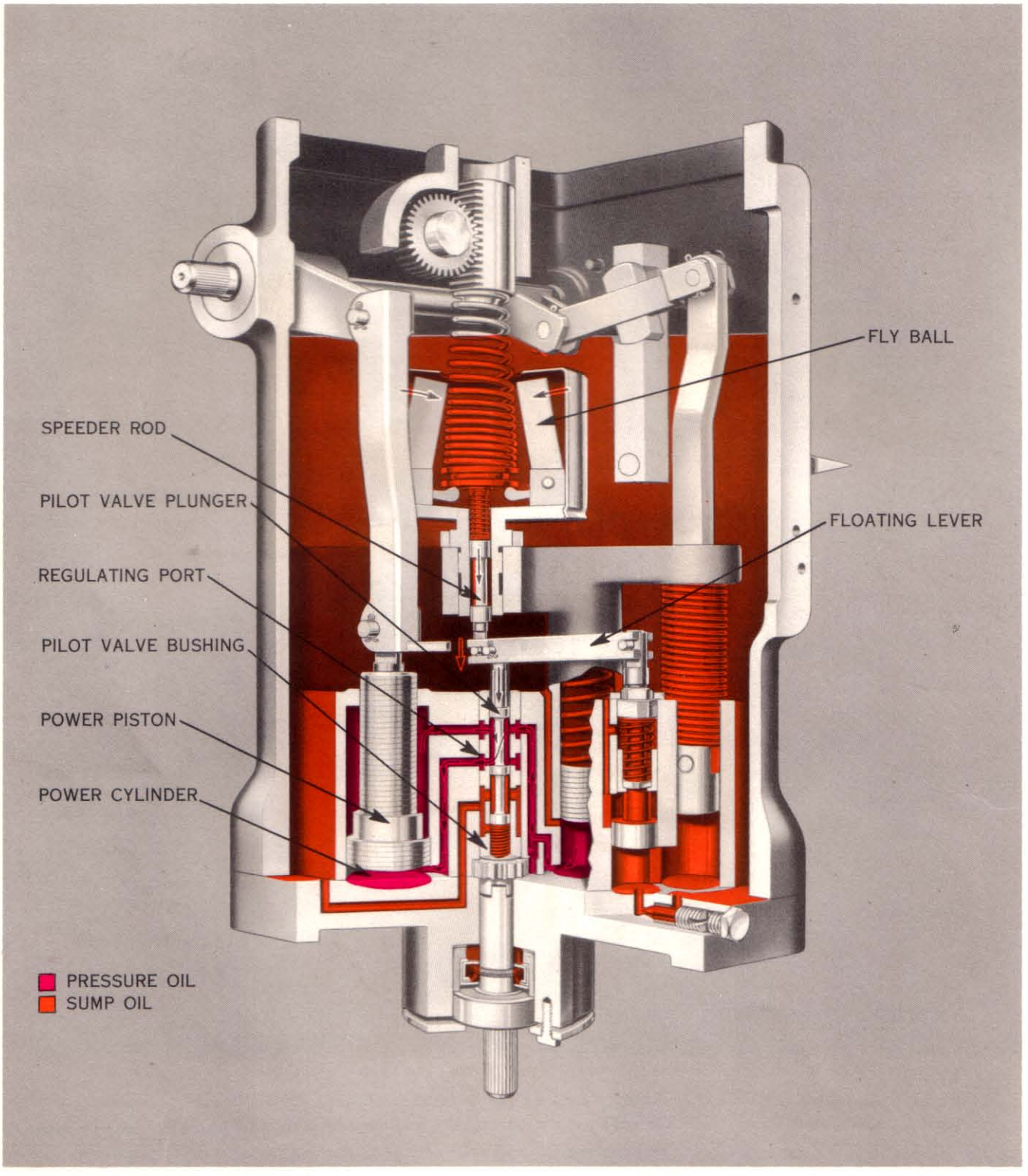
Cut No. 5

1. Oil pressure moves POWER PISTON down rotating TERMINAL SHAFT in the direction to decrease fuel.
2. As POWER PISTON moves down, ACTUATING COMPENSATING PISTON moves up and draws RECEIVING COMPENSATING PISTON down compressing COMPENSATING SPRING and lowering outer end of FLOATING LEVER and PILOT VALVE PLUNGER.
3. Movement of POWER PISTON, ACTUATING COMPENSATING PISTON, RECEIVING COMPENSATING PISTON and PILOT VALVE PLUNGER continues until REGULATING PORT in BUSHING is covered by land on PLUNGER.
4. As soon as REGULATING PORT is covered, POWER PISTON and TERMINAL SHAFT are stopped at a position corresponding to decreased fuel needed to run engine at normal speed under decreased load.



Cut No. 6

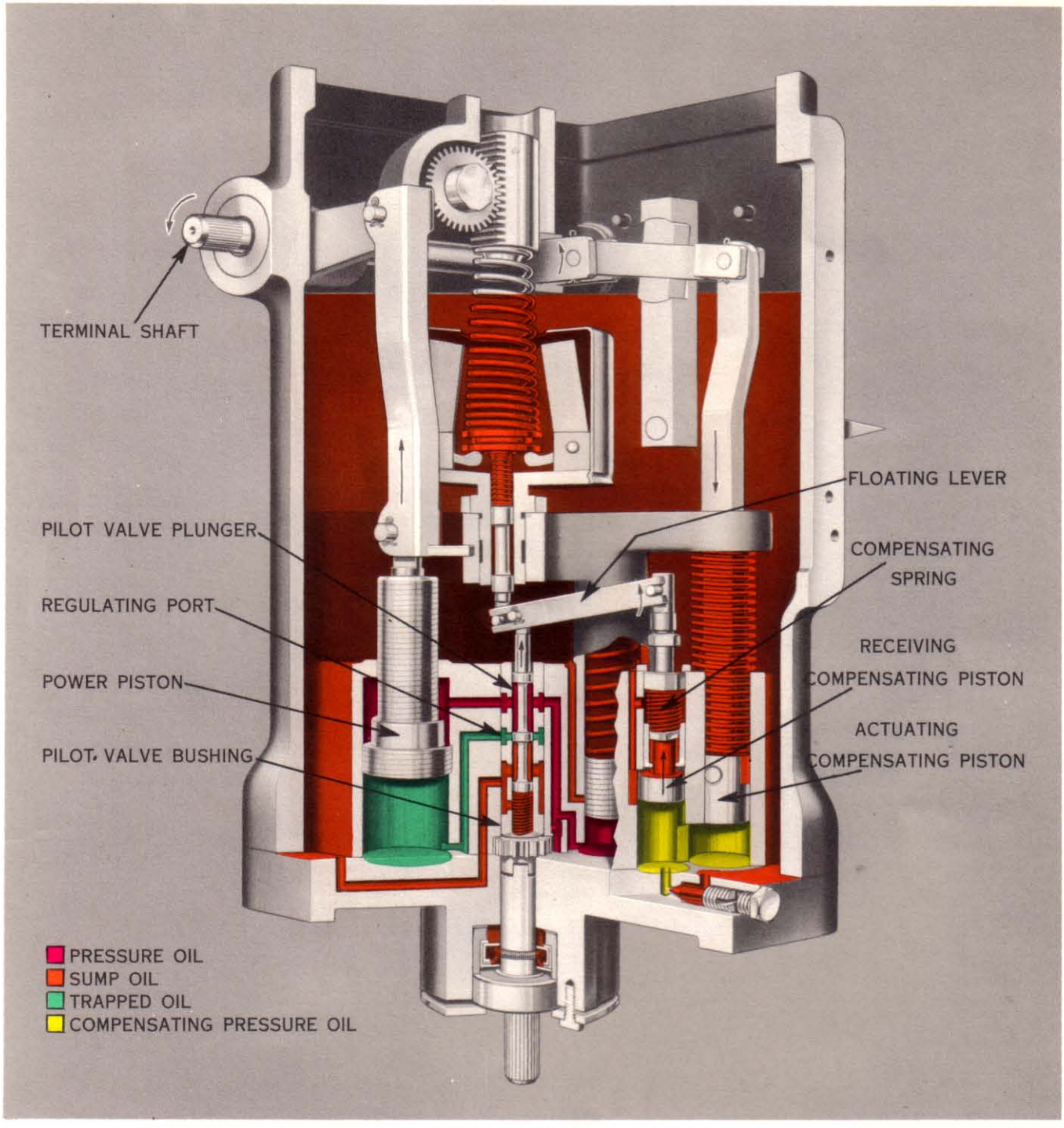
1. As speed decreases to normal, FLYBALLS return to normal position lowering SPEEDER ROD to normal position.
2. RECEIVING COMPENSATING PISTON is returned to normal position by COMPENSATING SPRING at the same rate as SPEEDER ROD thus keeping REGULATING PORT in PILOT VALVE BUSHING covered by land on PILOT VALVE PLUNGER; flow of oil through COMPENSATING NEEDLE VALVE determines rate at which RECEIVING COMPENSATING PISTON is returned to normal.
3. At completion of cycle, FLYBALLS, SPEEDER ROD, PILOT VALVE PLUNGER, and RECEIVING COMPENSATING PISTON are in normal positions; POWER PISTON and TERMINAL SHAFT are stationary at a position corresponding to decreased fuel necessary to run engine at normal speed under decreased load.



Cut No. 7

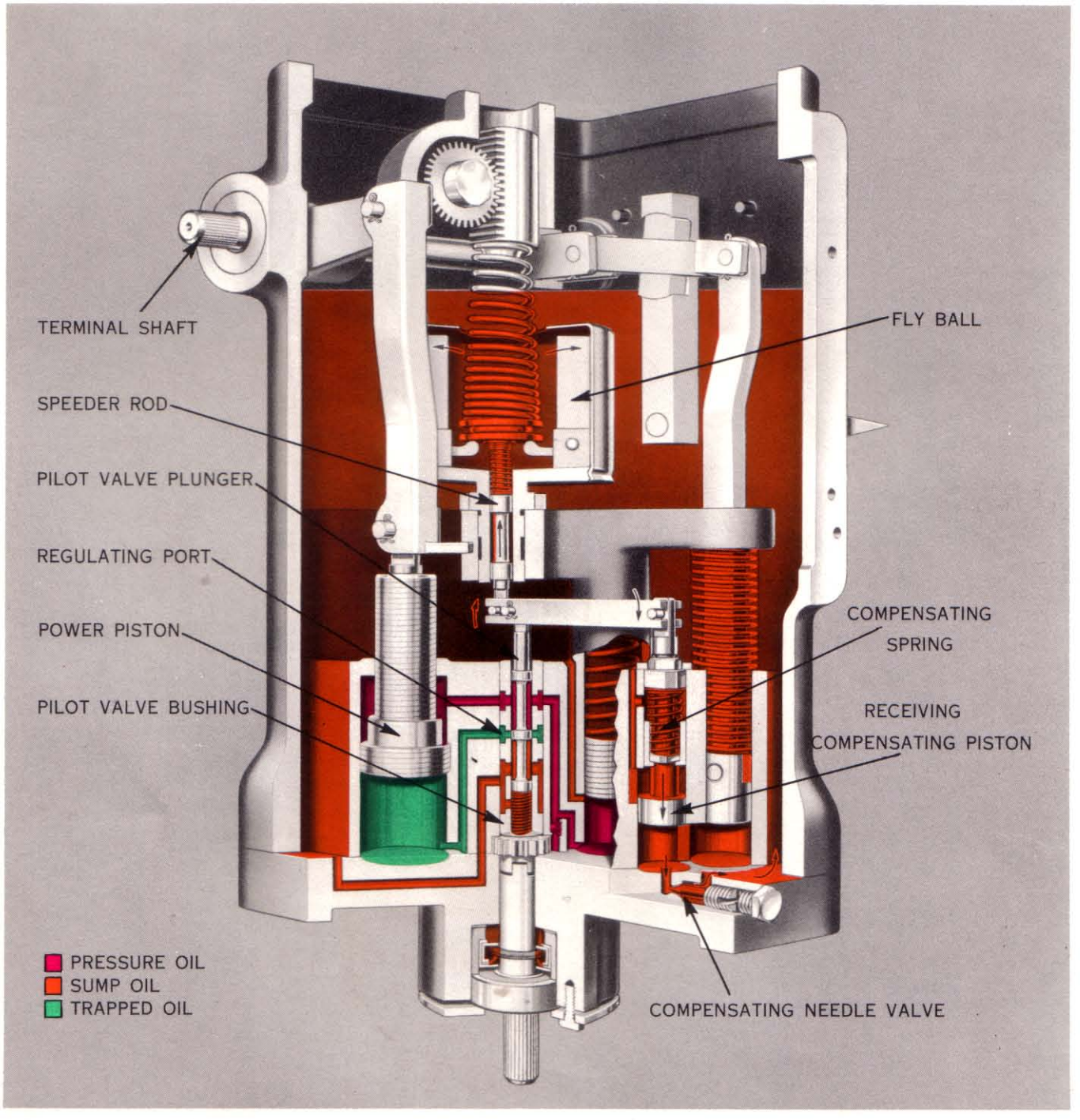
LOAD INCREASE:

1. Load is increased and speed decreases.
2. As speed decreases, FLYBALLS move in lowering SPEEDER ROD and inner end of FLOATING LEVER, thus lowering PILOT VALVE PLUNGER and uncovering regulating port of PILOT VALVE BUSHING.
3. Uncovering of REGULATING PORT admits pressure oil to bottom of POWER CYLINDER; since bottom area of POWER PISTON is greater than top area, oil pressure will move PISTON up.



Cut No. 8

1. Oil pressure moves POWER PISTON up and rotates TERMINAL SHAFT in direction to increase fuel.
2. As POWER PISTON moves up, ACTUATING COMPENSATING PISTON moves down and forces RECEIVING COMPENSATING PISTON up compressing COMPENSATING SPRING and raising outer end of FLOATING LEVER and PILOT VALVE PLUNGER.
3. Movement of POWER PISTON, ACTUATING COMPENSATING PISTON, RECEIVING COMPENSATING PISTON, and PILOT VALVE PLUNGER continues until REGULATING PORT in PILOT VALVE BUSHING is covered by land on PLUNGER.
4. As soon as REGULATING PORT is covered, POWER PISTON and TERMINAL SHAFT are stopped at a position corresponding to increased fuel needed to run engine at normal speed under increased load.

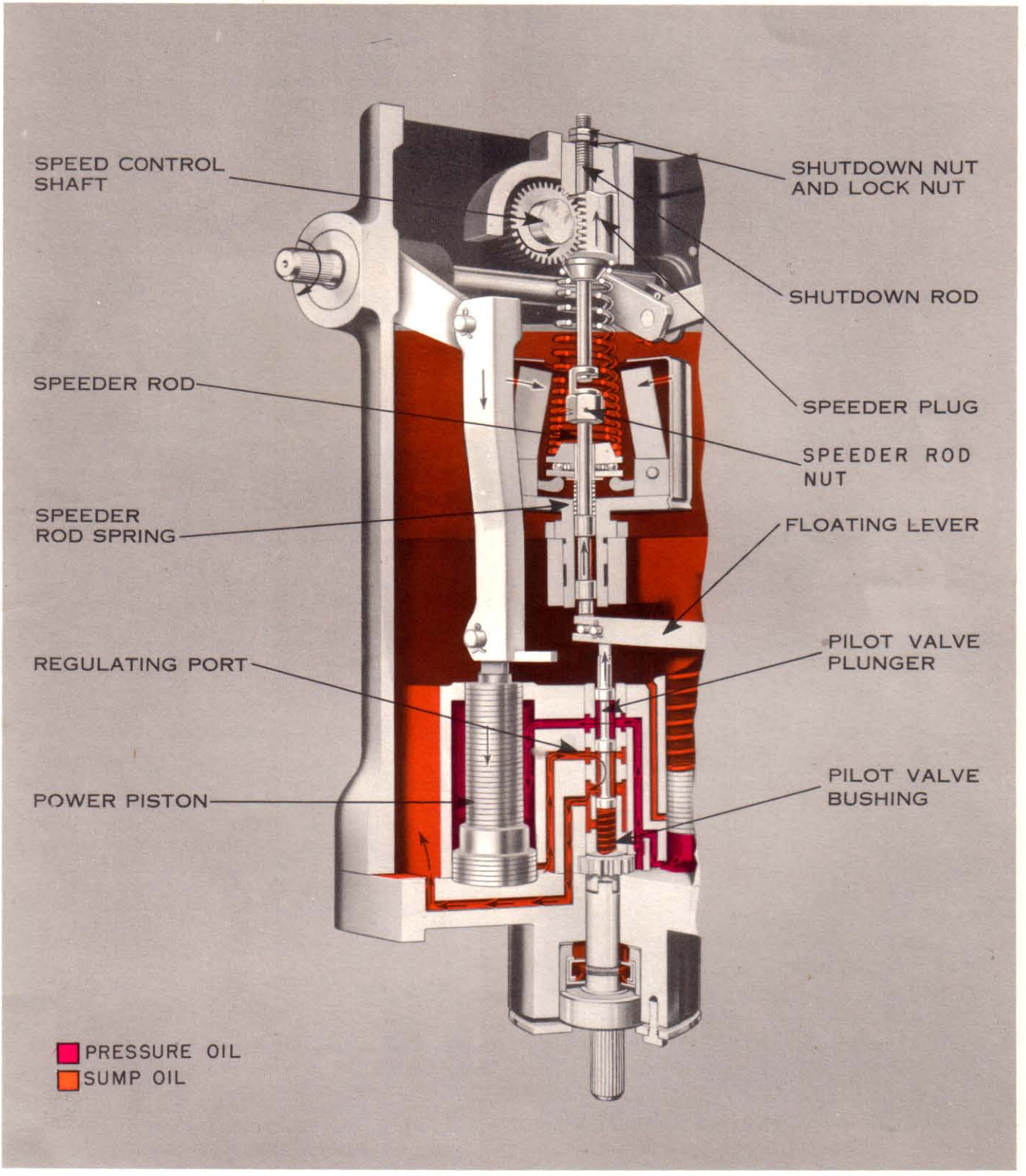


Cut No. 9

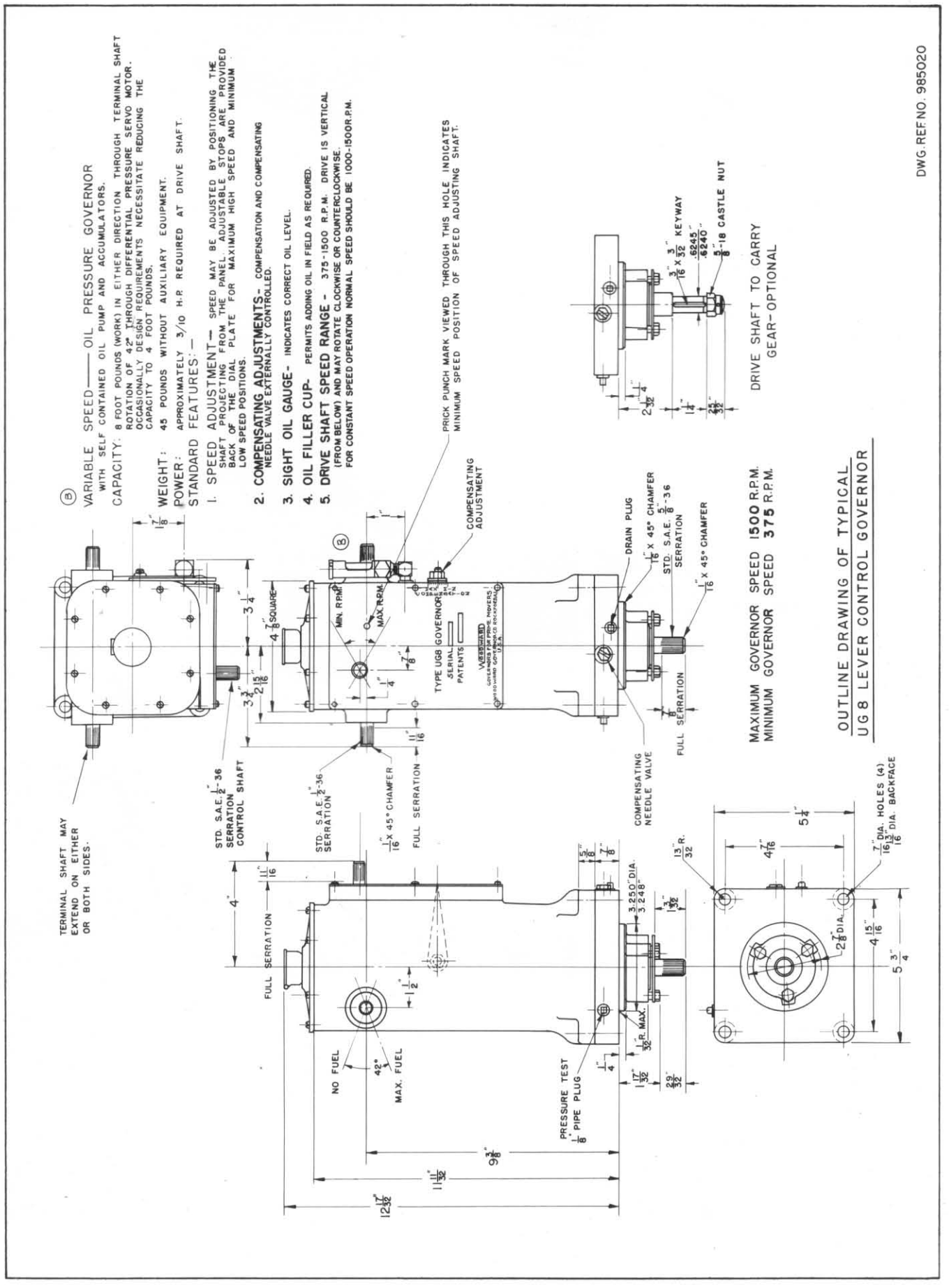
1. As speed increases to normal, FLYBALLS return to normal position raising SPEEDER ROD to normal position.
2. RECEIVING COMPENSATING PISTON is returned to normal position by COMPENSATING SPRING at the same rate as SPEEDER ROD thus keeping REGULATING PORT in PILOT VALVE BUSHING covered by land on PILOT VALVE PLUNGER; flow of oil through COMPENSATING NEEDLE VALVE determines rate at which RECEIVING COMPENSATING PISTON is returned to normal
3. At completion of cycle, FLYBALLS, SPEEDER ROD, PILOT VALVE PLUNGER, and RECEIVING COMPENSATING PISTON are in normal positions; POWER PISTON and TERMINAL SHAFT are stationary at a position corresponding to increased fuel necessary to run engine at normal speed under increased load.

UG8 LEVER TYPE GOVERNOR WITH SHUT DOWN ROD: If it is desired that the engine be shut down from the throttle position, the governor may be equipped with a shut down rod operating as follows: (See Cut No. 10)

When the throttle is moved toward the shut down position, the speeder plug rises contacting the nut on the shut down rod. Further movement lifts the shut down rod, lifting speeder rod and inner end of floating lever, thus raising pilot valve plunger and uncovering the regulating port in the pilot valve bushing. This permits oil under the power piston to flow to sump. Oil pressure in top of power cylinder forces power piston down to zero fuel position. If linkage to engine is properly adjusted, the engine will shut down.



Cut No. 10


(B)
VARIABLE SPEED—OIL PRESSURE GOVERNOR
WITH SELF CONTAINED OIL PUMP AND ACCUMULATORS.
CAPACITY: 8 FOOT POUNDS (WORK) IN EITHER DIRECTION THROUGH TERMINAL SHAFT ROTATION OF 42° THROUGH DIFFERENTIAL PRESSURE SERVO MOTOR. OCCASIONALLY DESIGN REQUIREMENTS NEGESSITATE REDUCING THE CAPACITY TO 4 FOOT POUNDS.
WEIGHT: 45 POUNDS WITHOUT AUXILIARY EQUIPMENT.
POWER: APPROXIMATELY 3/10 H.P. REQUIRED AT DRIVE SHAFT.
STANDARD FEATURES:—
1. SPEED ADJUSTMENT— SPEED MAY BE ADJUSTED BY POSITIONING THE SHAFT PROJECTING FROM THE PANEL. ADJUSTABLE STOPS ARE PROVIDED BACK OF THE DIAL PLATE FOR MAXIMUM HIGH SPEED AND MINIMUM LOW SPEED POSITIONS.
2. COMPENSATING ADJUSTMENTS- COMPENSATION AND COMPENSATING NEEDLE VALVE EXTERNALLY CONTROLLED.
3. SIGHT OIL GAUGE- INDICATES CORRECT OIL LEVEL.
4. OIL FILLER CUP- PERMITS ADDING OIL IN FIELD AS REQUIRED.
5. DRIVE SHAFT SPEED RANGE - 375-1500 R.P.M. DRIVE IS VERTICAL (FROM BELOW) AND MAY ROTATE CLOCKWISE OR COUNTERCLOCKWISE. FOR CONSTANT SPEED OPERATION NORMAL SPEED SHOULD BE 1000-1500 R.P.M.
PRICK PUNCH MARK VIEWED THROUGH THIS HOLE INDICATES MINIMUM SPEED POSITION OF SPEED ADJUSTING SHAFT.
COMPENSATING ADJUSTMENT
DRAIN PLUG
STD. S.A.E. 5/8"-36 SERRATION
1/16" X 45° CHAMFER
FULL SERRATION
COMPENSATING NEEDLE VALVE
TERMINAL SHAFT MAY EXTEND ON EITHER OR BOTH SIDES.
STD. S.A.E. 1/2"-36 SERRATION CONTROL SHAFT
STD. S.A.E. 1/2"-36 SERRATION
1/16" X 45° CHAMFER
FULL SERRATION
TYPE UG8 GOVERNOR
SERIAL
PATENTS
VERIFIED
MIN. R.P.M.
MAX. R.P.M.
NO FUEL
42°
MAX. FUEL
PRESSURE TEST 1/8" PIPE PLUG
3.250" DIA.
3.248"
1" R. MAX.
13/32" R.
7" DIA. HOLES (4) 13/16" DIA. BACKFACE
2 7/8" DIA.
MAXIMUM GOVERNOR SPEED 1500 R.P.M.
MINIMUM GOVERNOR SPEED 375 R.P.M.
DRIVE SHAFT TO CARRY GEAR-OPTIONAL
3/16" X 3/32" KEYWAY
.6245"
.6240"
5/8"-18 CASTLE NUT
OUTLINE DRAWING OF TYPICAL
UG8 LEVER CONTROL GOVERNOR
DWG. REF. NO. 985020

Cut No. 11

UG8 GOVERNOR

LEVER CONTROL

PART TWO

MAINTENANCE—INTERNAL ADJUSTMENT

INFORMATION AND PARTS REPLACEMENT: When requesting information concerning governor operation and maintenance or ordering replacements parts, it is very essential that the following information accompany the request:

1. Governor serial number (shown on governor name-plate).
2. Bulletin number. This is Bulletin No. 03005.
3. Part number, name of part, or description of part. See Pages 22, 23 and 24.

OIL CHANGES: See Oil Specifications in Part One. The governor oil should be clean and free of foreign particles. Under favorable conditions, the oil may be used for approximately six months without changing. If the governor does not operate properly, dirty oil may be the cause of the trouble.

To change the oil, take off the top cover, remove the governor from the engine, drain by turning upside down, and flush thoroughly with clean light grade fuel oil to remove any foreign matter. No parts of the governor will come out unless intentionally disassembled. Drain thoroughly and refill with clean governor oil. Follow the above procedure whenever the governor is removed from the engine for any reason.

If it is not possible to shut down long enough to remove the governor from the engine, drain the oil from the governor, fill with clean light grade fuel oil, run for approximately thirty seconds with the needle valve open, drain, and refill with clean governor oil. For the location of drain plug, see Cut No. 1.

If the governor is stored, it should be filled with oil.

WORK REQUIREMENTS: It is suggested that the best mechanic available (preferably one experienced with small parts assembly) be permanently assigned to all governor repair work. Cleanliness of tools and work space is essential. A work bench, vise, arbor press, speed lathe, air line, and containers for cleaning solvents should be provided if possible. The usual small hand tools are required, and a few special Woodward governor tools are desirable if subassemblies are to be disassembled. See Woodward Service Bulletin No. 03502.

GENERAL INSTRUCTION: The governor consists of seven main subassemblies; A, top cover; B, panel; C, case; D, ballhead; E, controlet; F, base; and G, drive shaft. If the governor is to be completely disassembled it should be taken apart in order: A, B, C, D, E, F, and G. If only a part of the governor is to be repaired or adjusted, refer to the particular instruction for that work only, and considerable time and work may be eliminated. *No force is required to separate or reassemble the governor into its subassemblies.* Connecting pins are slip fit and should not be marred with plier jaws.

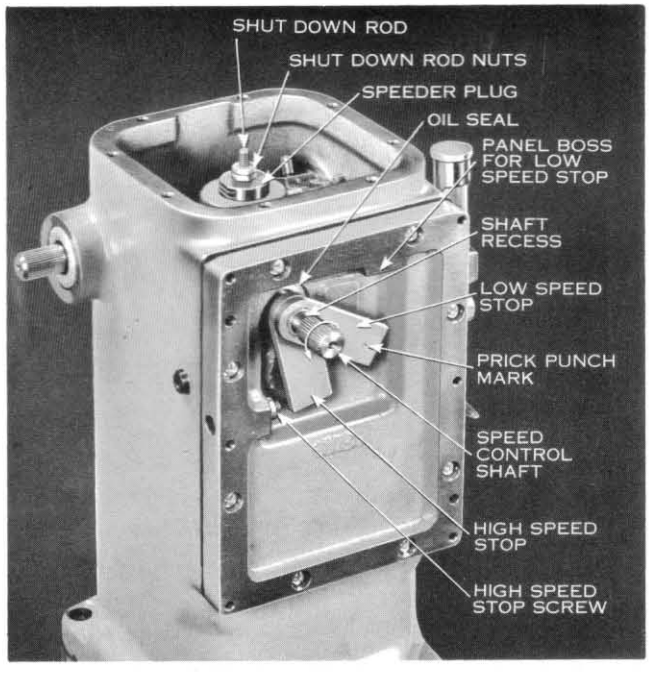
DISASSEMBLIES INTO MAIN SUBASSEMBLIES:

A. Top Cover (See Cut No. 1)

1. Remove eight cover screws and washers, and lift off.

B. Panel (See Cut No. 1 and Cut No. 12.)

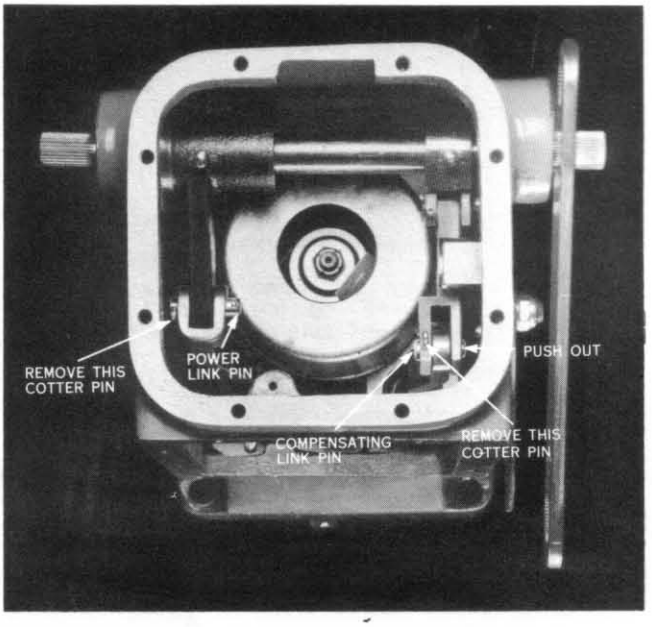
1. Drain governor oil by inverting governor; flush with fuel oil and drain again.
2. Remove nuts on shut down rod (if used).
3. Remove screws and take off dial plate.
4. Slip speed limit stop levers off speed control shaft.
5. Rotate speed control shaft in direction shown to remove speeder plug. If governor has a shut down rod, remove it by sliding rod out of slot in speeder rod nut. See Cut No. 10.
6. Remove 8 panel screws and washers.
7. Tap panel with plastic hammer or wood block to break panel gasket loose from case.
8. Remove panel and speeder spring.



Cut No. 12

C. Case (See Cut No. 13.)

1. Remove cotter and pull out power link pin.
2. Remove cotter and push out compensating link pin with bent wire or hook scriber.
3. Invert governor on bench (no parts will fall out). Remove the outside nuts (4) from studs holding the case to the base.
4. Hold case and base together and set governor upright. Lift case off base. It may be necessary to tap case lightly to break gasket joint loose and free case from dowel pins in base.



Cut No. 13

D. Ballhead.

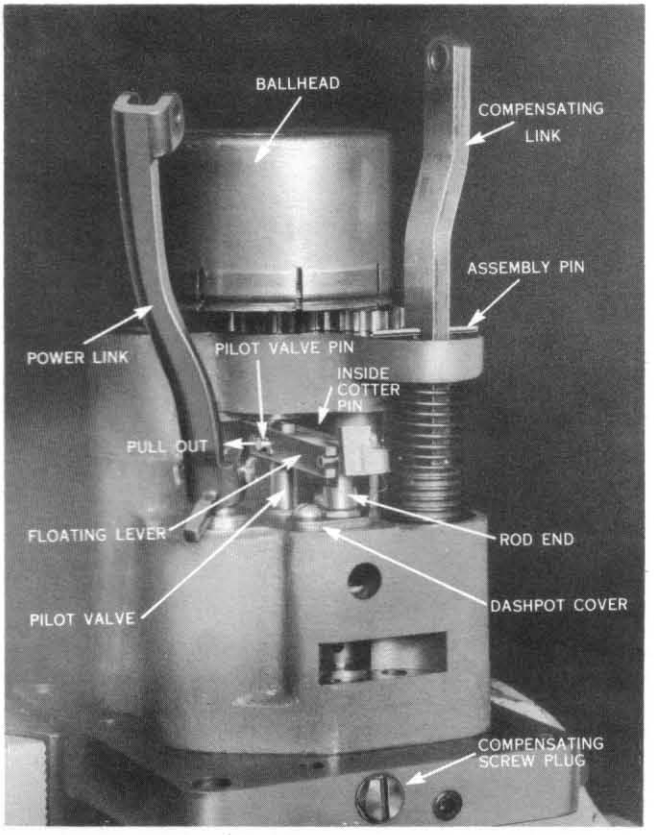
1. Remove inside cotter and pull out pilot valve pin. (Cut No. 14.)
2. Lift up inner end of floating lever, push down on rod end with screw driver, slip lever backwards releasing lever from rod end pin. (Cut No. 15.) Remove lever.
3. Lift out ballhead assembly.

E. Controlet

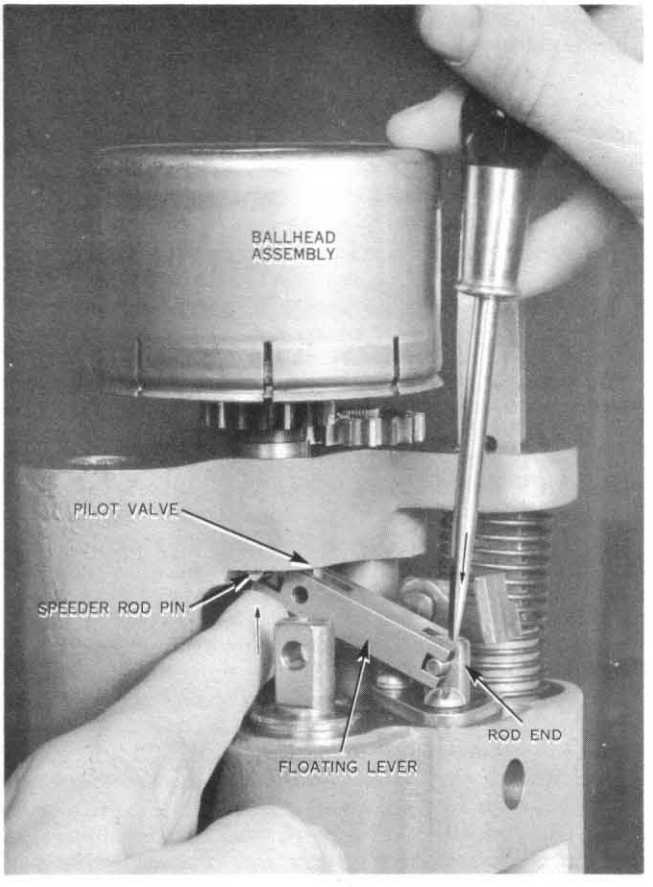
1. Pull up compensating link. Insert assembly pin or rod through hole. (Cut No. 14.)
2. Invert assembly and remove five nuts. If clamped in vise, do not use unnecessary force, and clamp at sides as shown in (Cut No. 16.)
3. Tap base lightly with plastic hammer and lift off carefully.
4. Let controlet remain in this position unless it is to be adjusted or repaired.

F. Base. (Cut No. 17.)

1. Clamp base inverted in vise, cut lock wire and remove three screws and retainer plate.
2. Pull out drive shaft assembly, oil seal retainer, and remove seal gasket in bearing bore.



Cut No. 14



Cut No. 15

3. If ground surface of base is not perfectly flat, has deep scratches, or is grooved from the pump gears, it must be resurfaced. Drive out dowel pins and surface grind not more than .010" or, if not possible to surface grind, lap smooth on a flat plate.

G. Drive Shaft

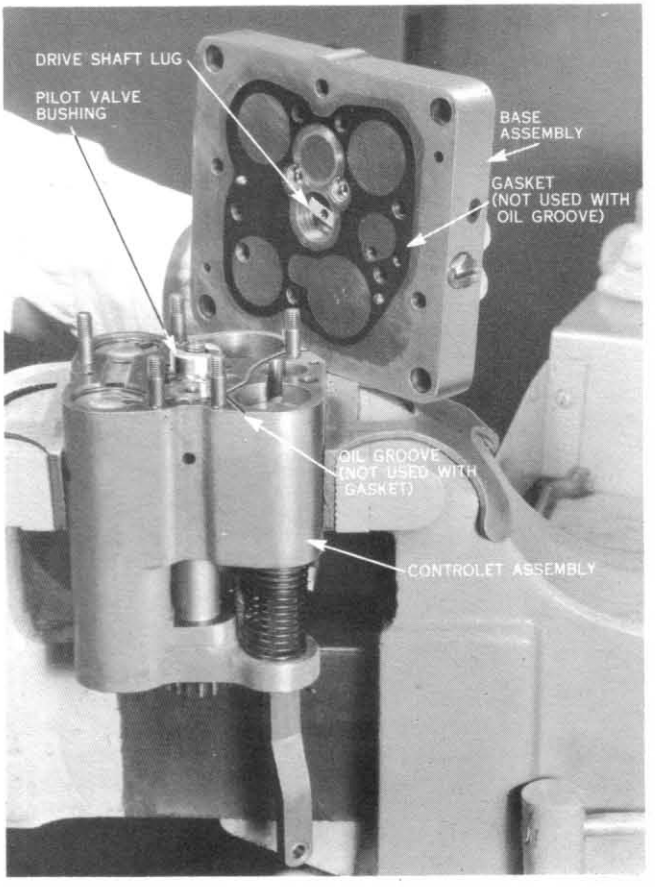
1. Pull off oil seal retainer if on shaft.
2. Remove snap ring. (See Cut No. 18.)
3. Press drive shaft out of bearing.

MAXIMUM OR MINIMUM SPEED LIMIT ADJUSTMENT: These adjustments must be made on a governor test stand or on the engine while running.

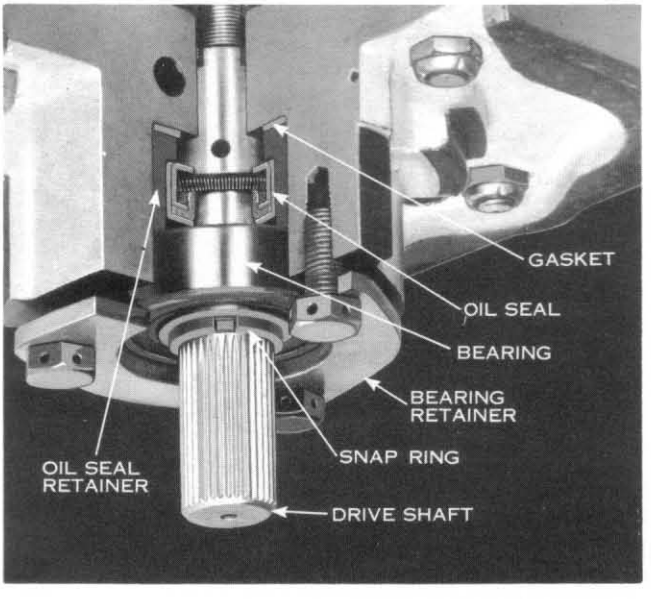
1. Remove lever on speed control shaft, remove dial plate and replace lever. Pull stop levers out into recess on speed control shaft. See Cut No. 12.
2. Start engine, set throttle to high speed position and adjust throttle-to-governor linkage to bring engine to desired high speed.
3. Slip high speed stop lever (the inner lever) back onto serrated portion of shaft. Stop lever should contact stop screw. Adjust screw if necessary.
4. Set throttle to low speed.
5. Slip low speed stop lever (the outer lever) back onto serrated portion of shaft. Stop lever should contact boss at top of panel. If desired adjustment cannot be obtained by the 10° steps provided by the serrations, the lever may be filed to provide an intermediate setting.
6. Mark position of lever on speed control shaft before removing to replace dial plate.

NOTE: 1. If the governor has a shut down rod, the low speed stop lever should be set so that the prick punch mark on the lever will appear opposite the index hole in the dial plate. See Cut No. 1. Stop lever should *not* contact boss on panel in order to allow the overtravel required for shut down.

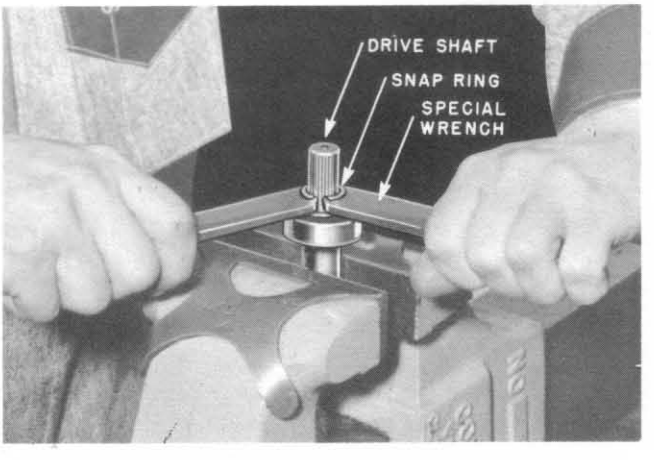
2. Rotate speed control shaft 10° below minimum speed position. This will be equivalent to 19/64" movement of the end of the stop lever.
3. Screw nut down on shut down rod until it contacts speeder plug and engine starts to shut down. Secure lock nut if used.



Cut No. 16



Cut No. 17



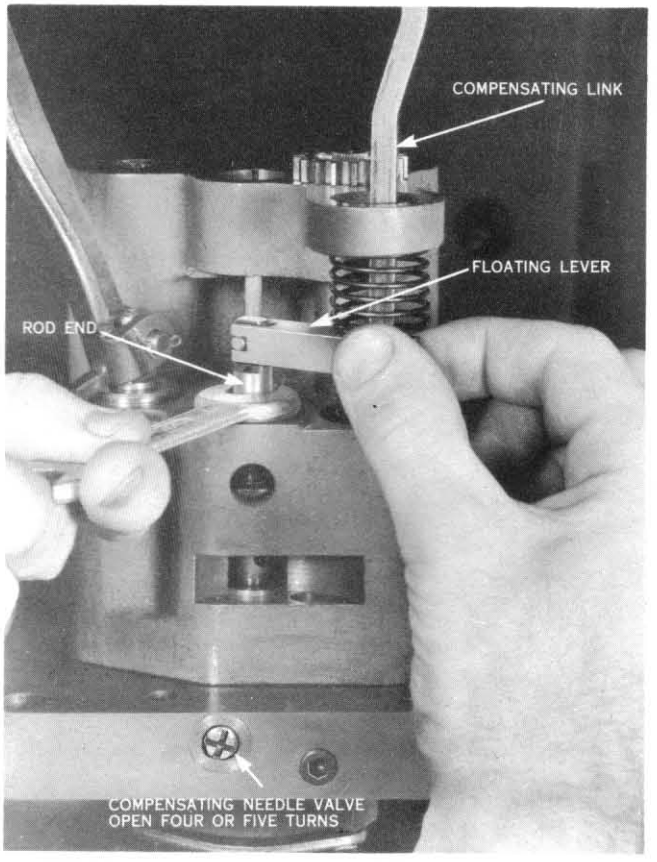
Cut No. 18

COMPENSATING SPRING ADJUSTMENT:

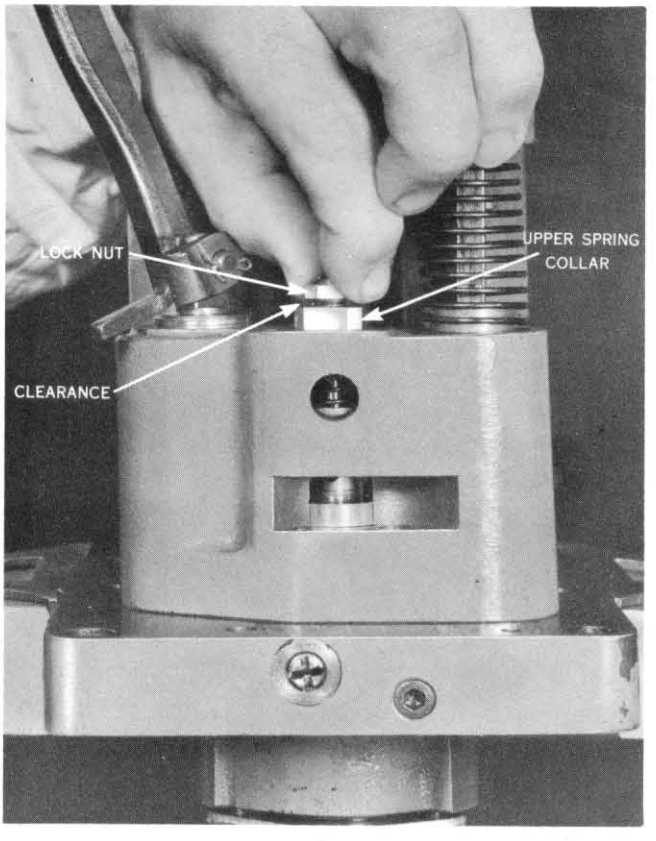
1. Make disassemblies A, B, C and D.
2. Remove compensating screw plug and open compensating needle valve four or five full turns. (Cut No. 1.)
3. Submerge assembly into solvent. Move compensating link up and down several times to flush out oil. Blow out controlet and base assemblies with air hose.
4. Remove dashpot cover. (See Cut No. 14.)
5. Unlock rod end and lock nut. Use floating lever for wrench on rod end. (Cut No. 19.) Remove rod end. Unscrew lock nut to make clearance between nut and spring collar when nut is lifted. (Cut No. 20.) Replace rod end.
6. Measure precompression (Cut No. 21). With the weight of the compensating receiving plunger supported by the upper spring collar, the top surface of the collar should be from .000 to .005 above the machined face of the controlet. A special Woodward gaging tool is available for checking this "Precompression" dimension. Shims are used between the spring and the upper spring collar to make corrections in this dimension, if necessary. Do not change the amount of precompression unless instructions given in Compensation Adjustments, Installation, and Oil Specifications, Part One, and Oil Changes, Part Two, have been followed and operation is still not satisfactory. After once being set for the particular engine and load characteristics, the setting should not be changed. Operating troubles are usually caused by some other factor.
7. Tighten nut on plunger stem until upper spring collar becomes exactly flush with machined surface. Sight over top as shown in Cut No. 22 while making this adjustment.
8. Replace rod end and lock to nut using floating lever as a rod end wrench. Do not disturb flush adjustment.
9. Replace dashpot cover.
10. Test for lost motion by very delicately moving the rod end up and down with the finger tips (Cut No. 23.) No end play or lost motion allowed. (*Use no force.* The compensating spring will be compressed and the test will be worthless.)
11. If lost motion is felt, it indicates the upper spring collar is not flush with the machined surface as shown in Cut No. 22.

PILOT VALVE ADJUSTMENT:

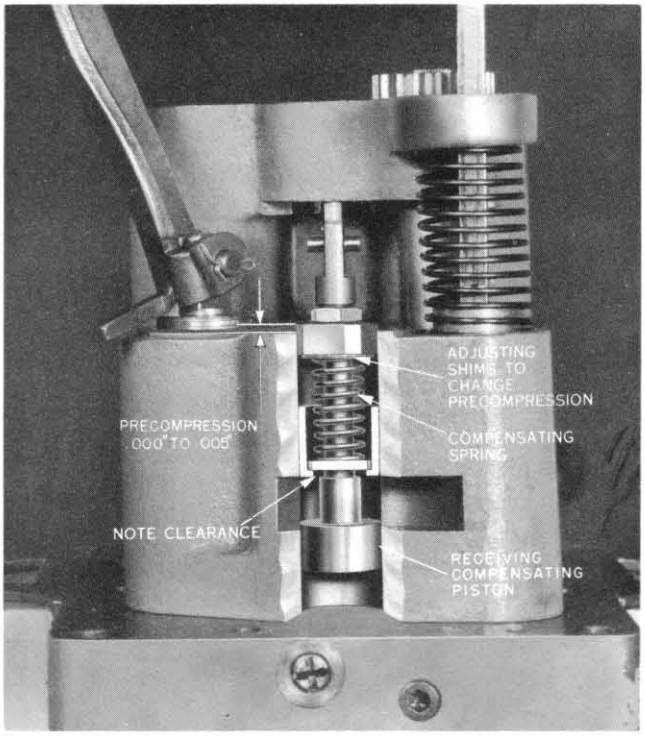
1. Make disassemblies A, B, and C.
2. Remove pipe plug in passage to control port, (Cut No. 24.) Use flashlight to inspect port opening.



Cut No. 19

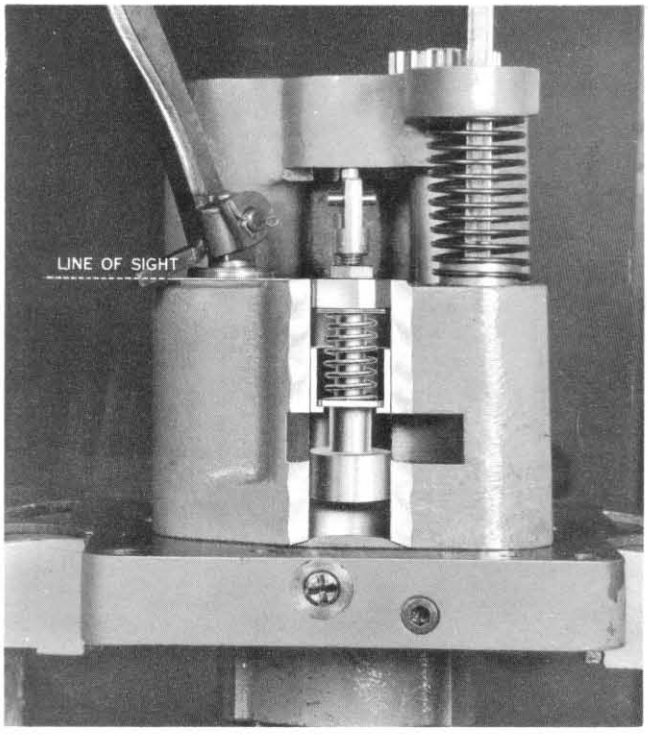


Cut No. 20

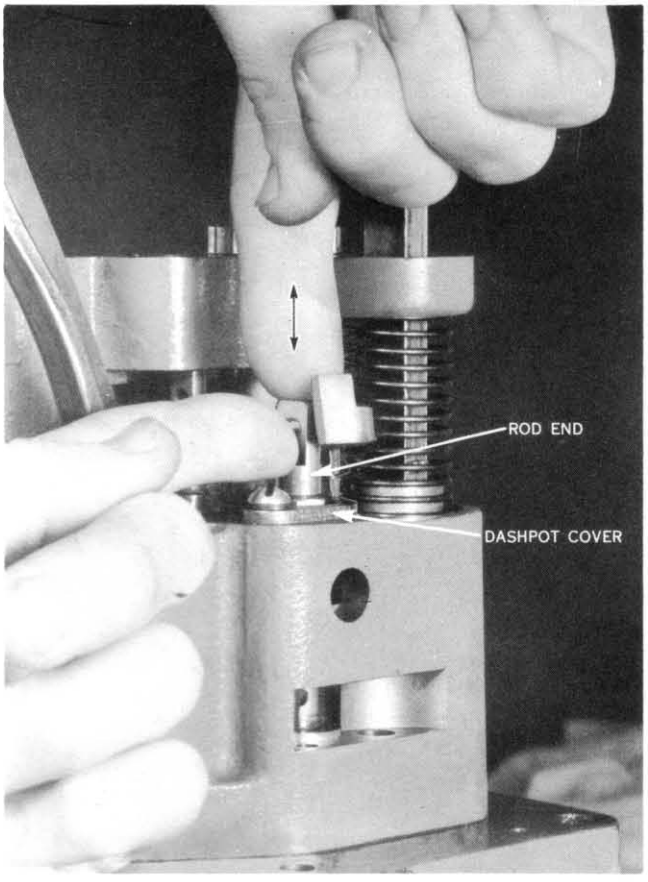


Cut No. 21

3. Push down on speeder rod, (Cut No. 25). This will move flyballs to inner position. Note amount of port opening.
4. Continue holding speeder rod down and move flyballs to outer position raising the pilot valve land, (Cut No. 26). Note amount of port opening.
5. The amount of opening for inner and outer positions of the flyballs should be exactly the same and should be correct to within .005".

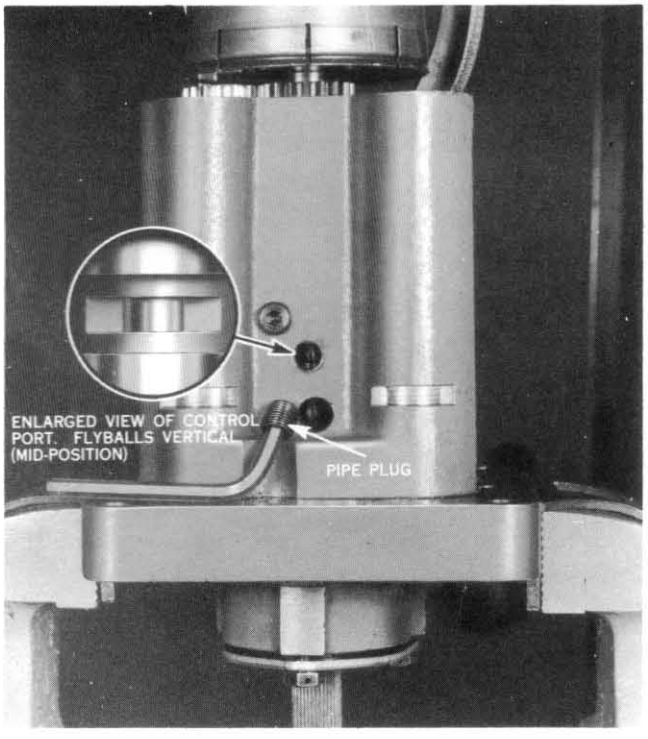


Cut No. 22

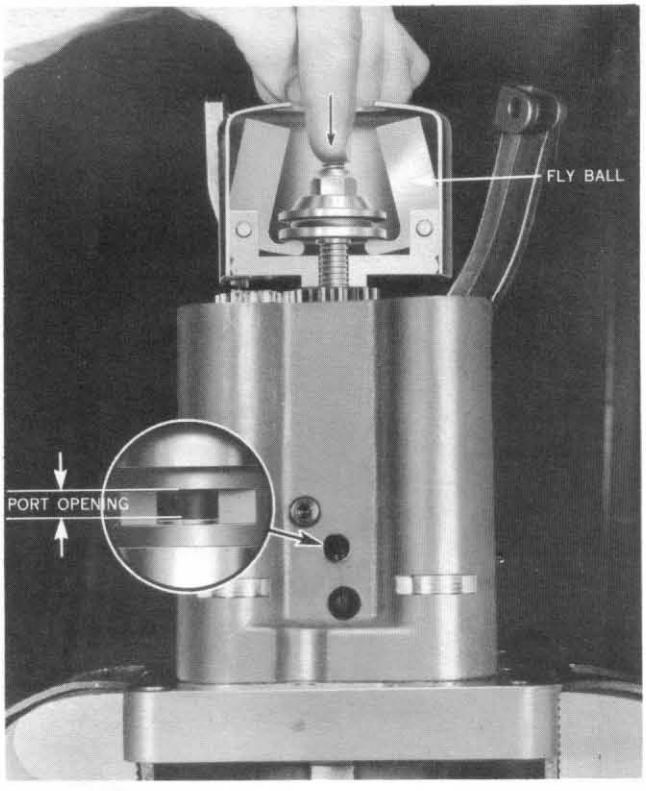


Cut No. 23

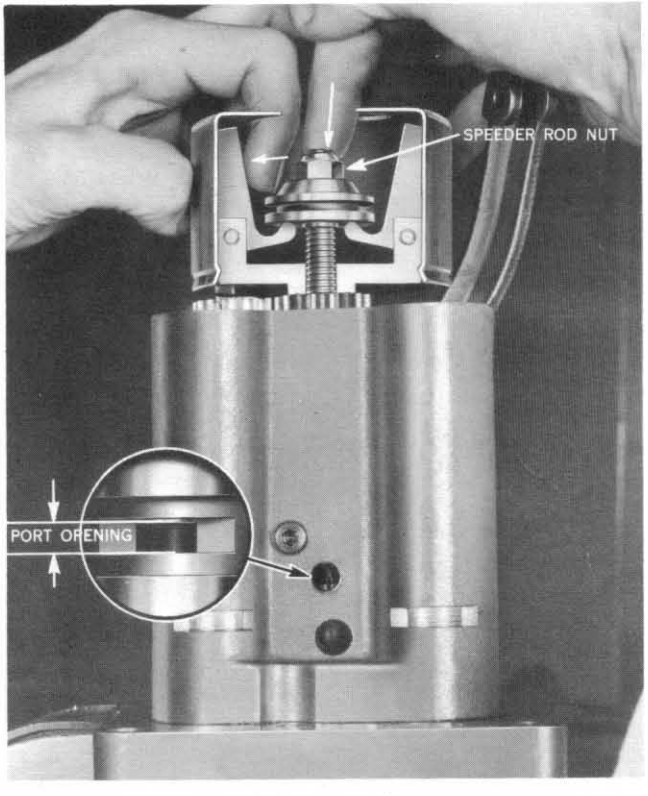
6. If the pilot valve land needs to be raised, turn speeder rod nut clockwise and vice versa. Recheck adjustment.
7. *Replace pipe plug.*



Cut No. 24



Cut No. 25



Cut No. 26

GENERAL REPAIR INSTRUCTIONS: Refer to paragraphs on Work Requirements and General Instruction, Page 13.

Most of the repair work consists of cleaning and polishing the governor parts. All pistons, plungers, valves, and rods should move freely without binding or catching. The receiving compensating piston and its spring collars frequently give trouble from this cause. Use three cornered scraper to break milled slot and bored hole edges. Do not lap in parts if possible to free up by other means.

Be extremely careful when polishing the pilot valve plunger land; *broken corners on the land will ruin this part.* Leave corners sharp.

DIAL PANEL LEAKAGE: If oil is visible at the dial panel, remove the dial plate and tighten the panel screws. If this does not eliminate the leak, inspect the oil seal. (See Cut No. 12.) The panel oil seal seldom leaks; do not replace unless necessary.

If necessary to replace the oil seal, remove panel (disassemblies A and B), drive out taper pin in gear, and pull shaft. Oil seal may now be removed and replaced. In assembly, use care in inserting shaft to prevent damage to lip of oil seal.

DRIVE SHAFT OIL SEAL AND DRIVE SHAFT BEARING: If necessary to add a small quantity of oil to the governor oftener than once a week, and there is no external indication of a leak, the drive shaft oil seal has been worn or damaged, allowing oil to leak from the governor into the engine housing.

1. Make disassembly A-1. Drain oil out of governor, flush and invert.
2. Make disassembly F and G-1. (Cut No. 17.)
3. Replace oil seal with lip towards chamfered end of oil seal retainer.
4. Inspect drive bearing for wear and freeness of rotation and the shaft for wear from oil seal. Polish or replace if necessary. Remove snap ring if used. (See Cut No. 18.) Press bearing off shaft and replace if worn or rough turning.
5. Replace bearing and snap ring if used. Insert oil seal and retainer on shaft, using special care not to damage leather lip of oil seal.

ASSEMBLY INSTRUCTION: A few precautions must be taken when reassembling the governor.

I. *Do not drop or rest governor on its drive shaft.*

II. Assembly of Drive Shaft Assembly to Base Assembly.

1. Be certain that the vellumoid gasket is in place in the bearing bore between the shoulder and the oil seal retainer. Use new gasket if it appears to be reduced in thickness (Cut No. 17).
2. Do not press the drive shaft assembly into the bore of the base with an arbor press.
3. Avoid tightening the retainer plate screws too much; it is not necessary, and may bend the plate. There should be 1/8" space between the plate and the boss.

III. Assembly of Controlet Assembly and Base Assembly.

1. Check all pistons and plungers for free movement in bores. Do not lap in if it is possible to free up by removing burrs.

2. Do not shellac the gasket between the base and controlet. If the old gasket is damaged or less than .0025″ thick, replace it with a new one. (See Cut No. 16.) Inspect controlet surface for scratches, nicks, dirt particles, etc. Coat controlet surface with oil, place gasket on controlet (if used), space it evenly around bores for pump gears, place 1/4″ or 3/8″ dia. ball on gasket at dowel pin holes and *tap* out for dowel pins.

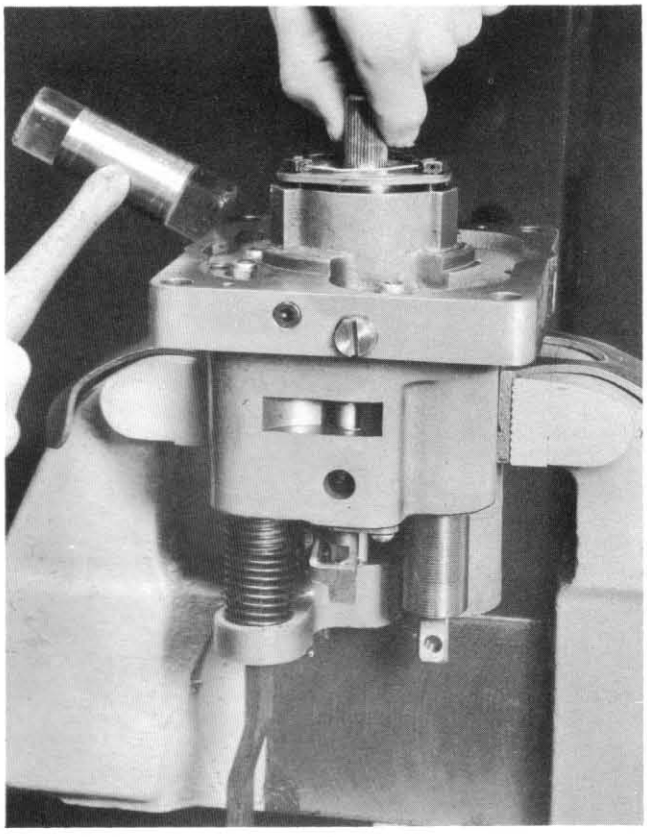
   NOTE: A gasket is *not* used if controlet has an oil groove. (See Cut No. 16.)

3. The pilot valve bushing, pilot valve plunger, pilot valve spring, and spring tip must be in place before setting on the base.

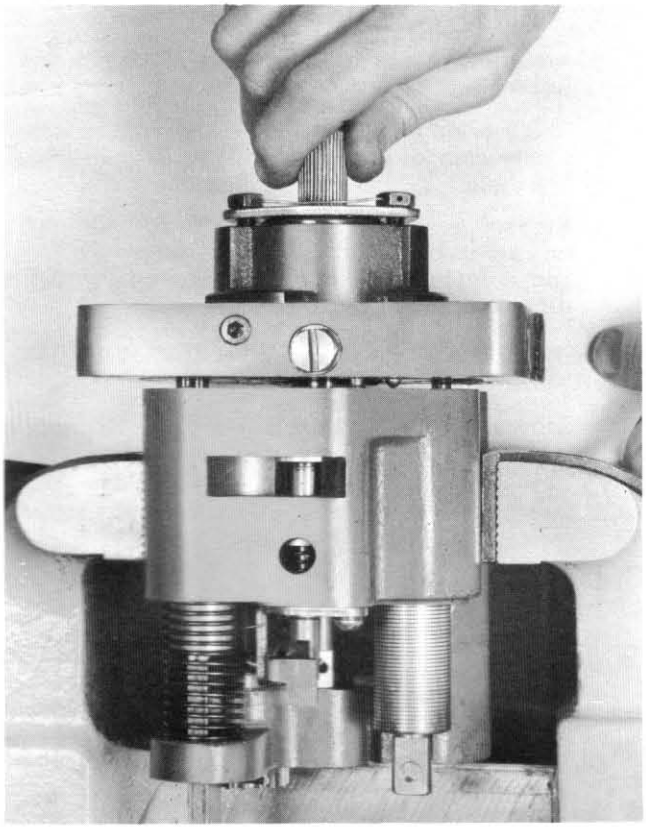
4. Clamp controlet lightly in vise (inverted), place base assembly, (Cut No. 16), and turn drive shaft to cause lug on shaft to drop into slot in pilot valve bushing. (Cut No. 27.)

5. Place and tighten nuts. Use cylinder head method for drawing down. Do not exert too much force; the threads may strip.

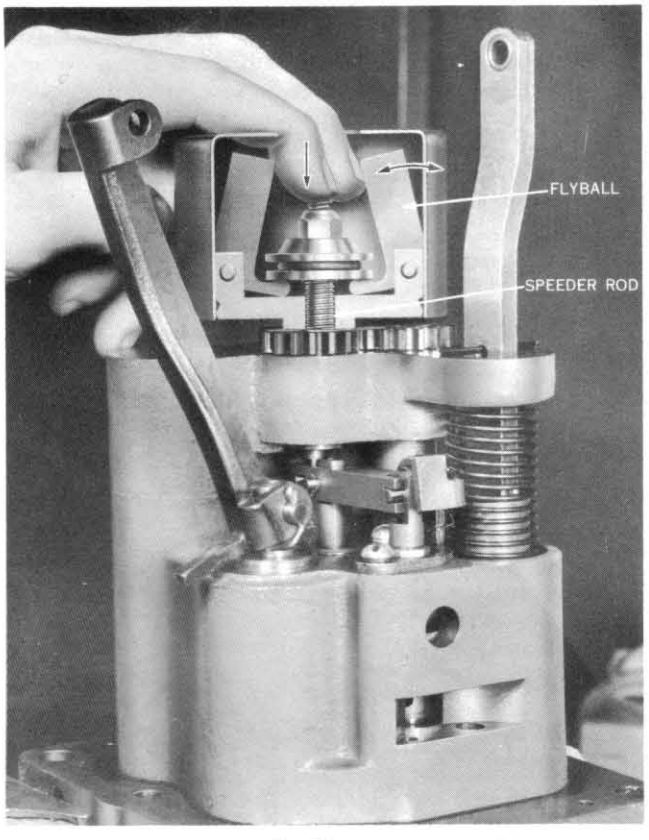
6. Turn drive shaft. If not free, it must be aligned by loosening nuts and striking at corners of base with plastic or light babbit hammer until shaft turns free, (Cut No. 28). If this does not free up the shaft, remove base and turn drive shaft lug 180°. (See Cut No. 16.)



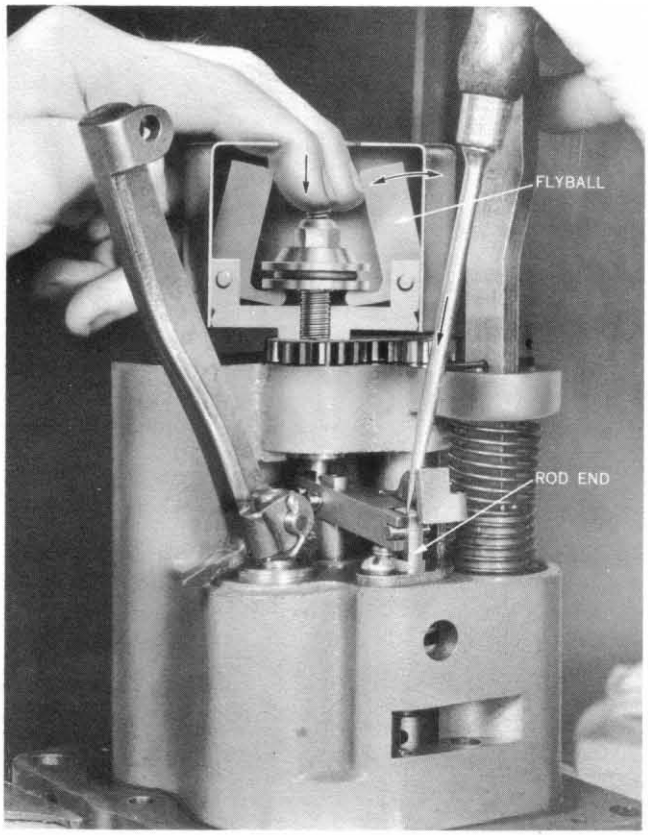
Cut No. 28



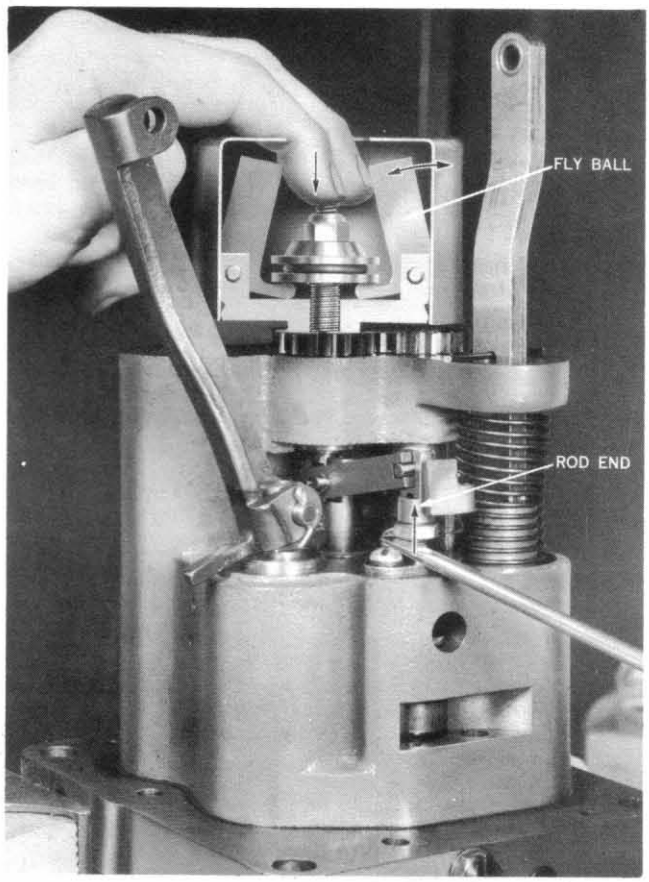
Cut No. 27



Cut No. 29



Cut No. 30



Cut No. 31

IV. Assembly of Ballhead and Controlet.

1. Place ballhead assembly in controlet. Slide floating lever on speeder rod pin, press down on rod end, and slip lever on rod end pin, straddling pilot valve. (Cut No. 15.) Insert pilot valve pin, (Cut No. 14.) If it will not enter easily, turn pilot valve plunger 180° and try again. Do not cotter yet.
2. Test for free action of floating lever.
   a. Push down lightly on speeder rod.
   b. Move one flyball through full travel several times. (Cut No. 29.)
   c. Press down 1/4" approximately on rod end, and move flyball through full travel. (Cut No. 30.)
   d. Lift rod end 1/4" approximately and move flyball through full travel. (Cut No. 31.)
3. If floating lever is not perfectly free under any of the conditions under 2, it will be necessary to try various arrangements of positions of the speeder rod, pilot valve plunger, rod end, and floating lever.
   a. Invert floating lever and test.
   b. If unsatisfactory, turn pilot valve plunger 180°, and test.
   c. If still unsatisfactory, try turning rod end or speeder rod 180°, or invert floating lever again.
   d. Continue with combinations of positions of the parts until free action is obtained.
4. Insert cotter pin through pilot valve pin and secure.
5. Check pilot valve adjustment and remove temporary dashpot assembly pin if in large dashpot link hole.
6. Replace governor case (tighten the four nuts on case-to-base studs), connect the power link and compensating link by inserting the link pins and cotter pins.

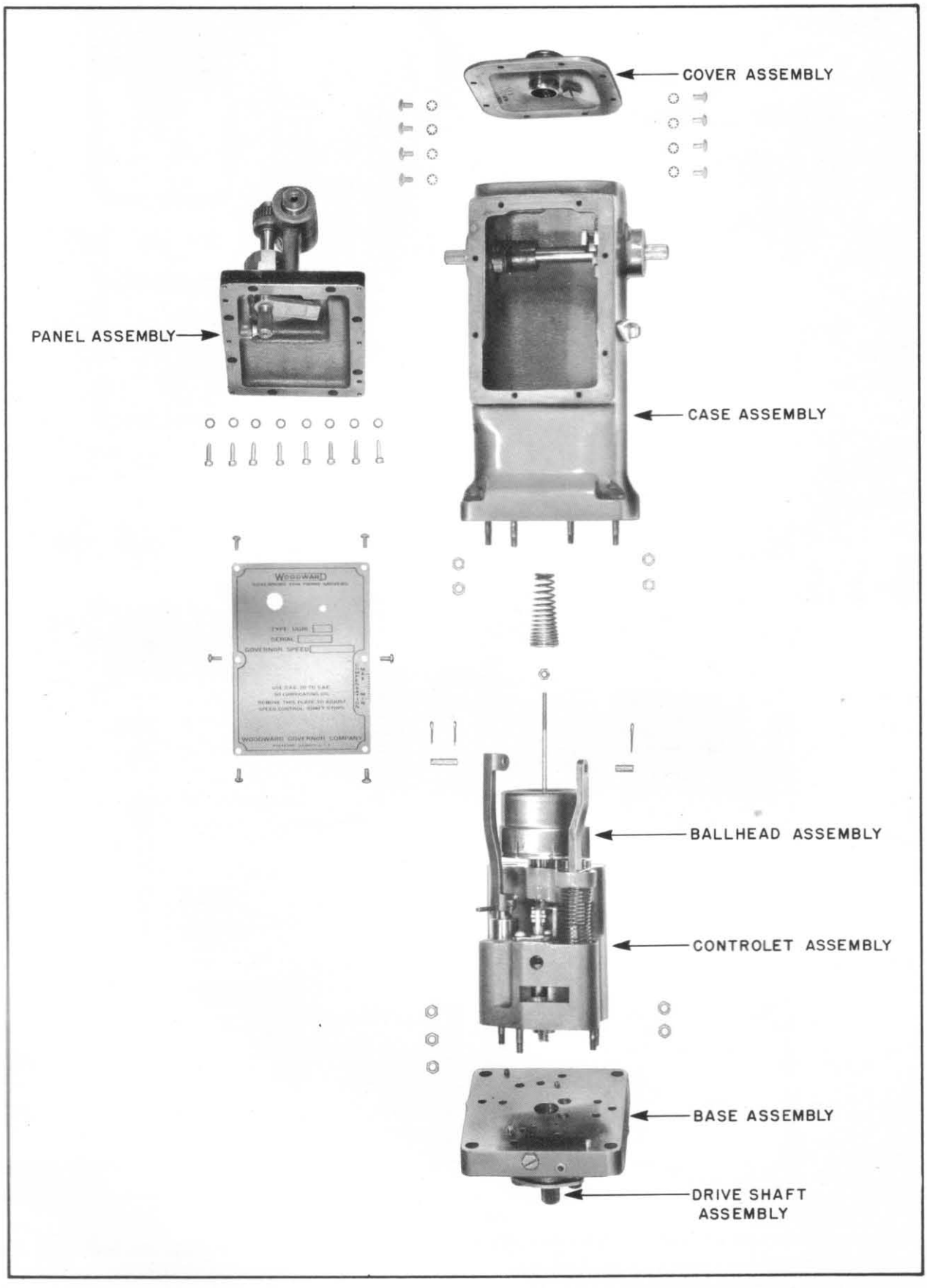
V. ASSEMBLY OF PANEL ASSEMBLY TO GOVERNOR.

1. Reinstall speeder spring.
2. Inspect gasket and replace if damaged.
3. Insert panel taking care to insert top of speeder spring into speeder plug hole.
4. Secure panel with lock washers and screws.
5. If governor has a shut down rod, replace rod and nut.
6. Insert speeder plug.

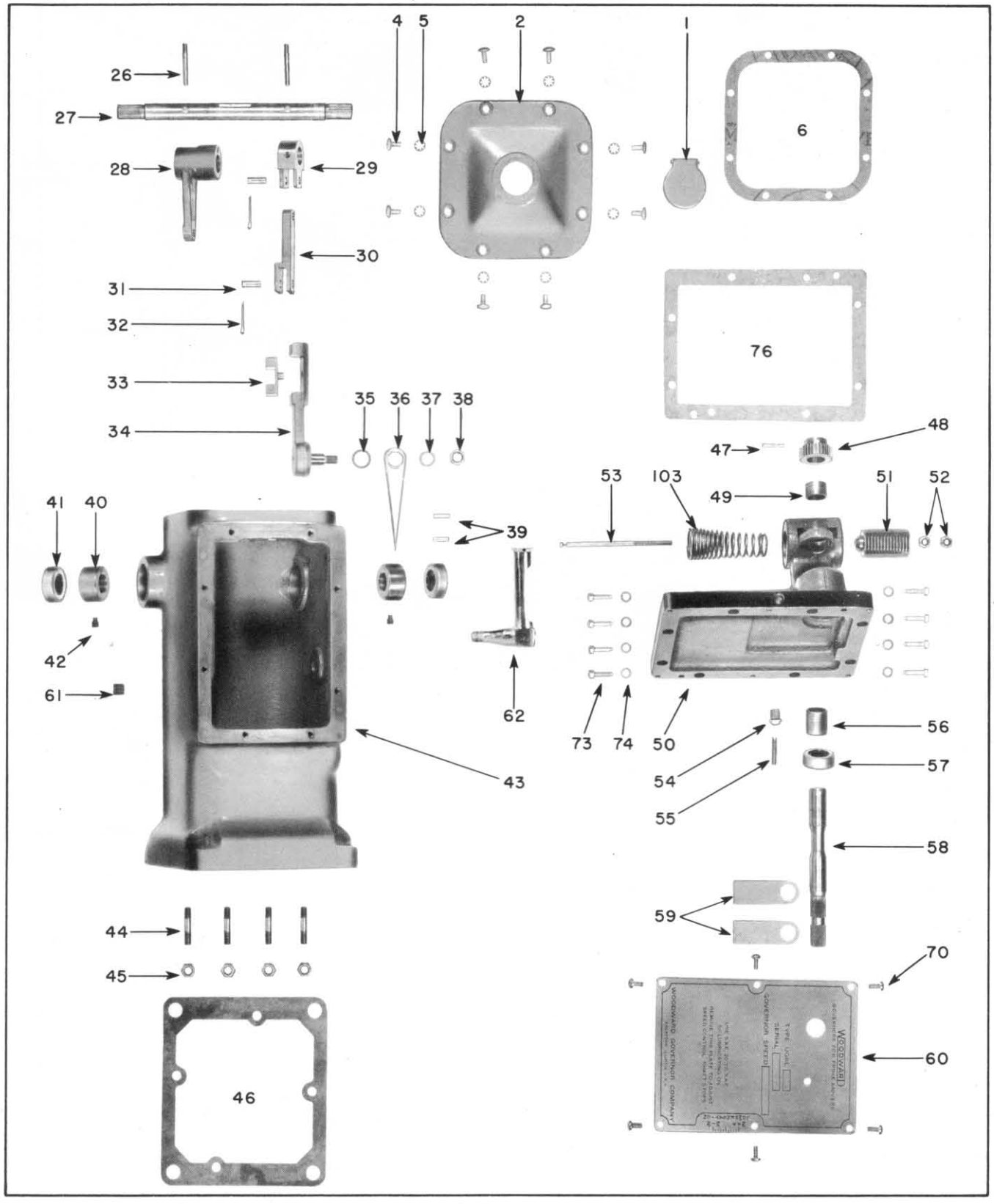
NOTE: To reset speed limit stops and shut down nut see instructions Page 15.

VI. Dial Plate and Cover.

Replace governor dial plate and cover, and tighten all screws.

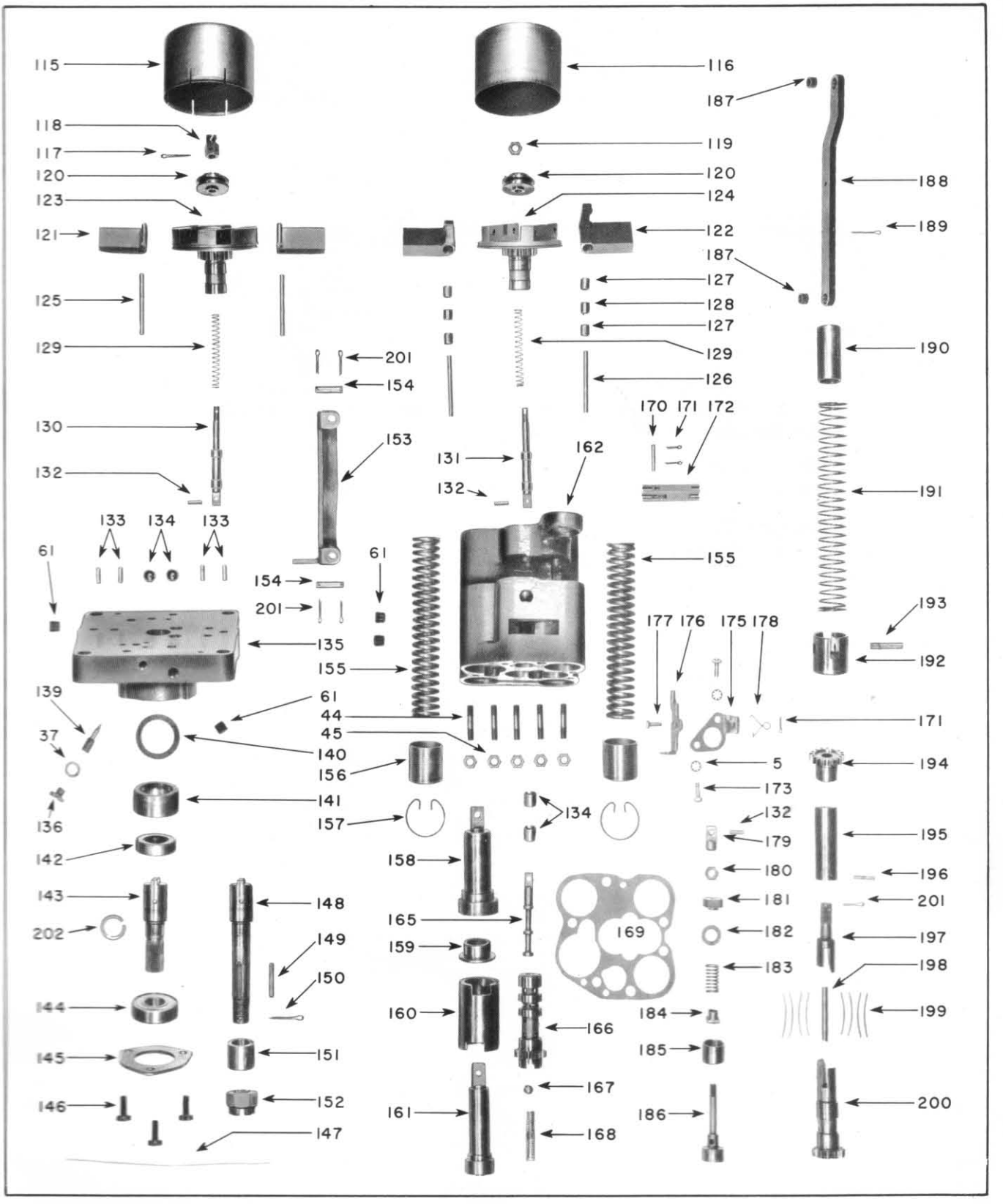

COVER ASSEMBLY
PANEL ASSEMBLY
CASE ASSEMBLY
BALLHEAD ASSEMBLY
CONTROLET ASSEMBLY
BASE ASSEMBLY
DRIVE SHAFT ASSEMBLY

Cut No. 32



Cut No. 33

Number of Part	Name of Part	No. Req'd.
1	Oil Filler Cup	1
2	Cover	1
4	10-32 x 3/8" Phillips Hd. Screw	8
5	#10 Shakeproof Lockwasher	10
6	Case — Cover Gasket	1
26	Taper Pin	2
27	Terminal Shaft	1
28	Power Lever	1

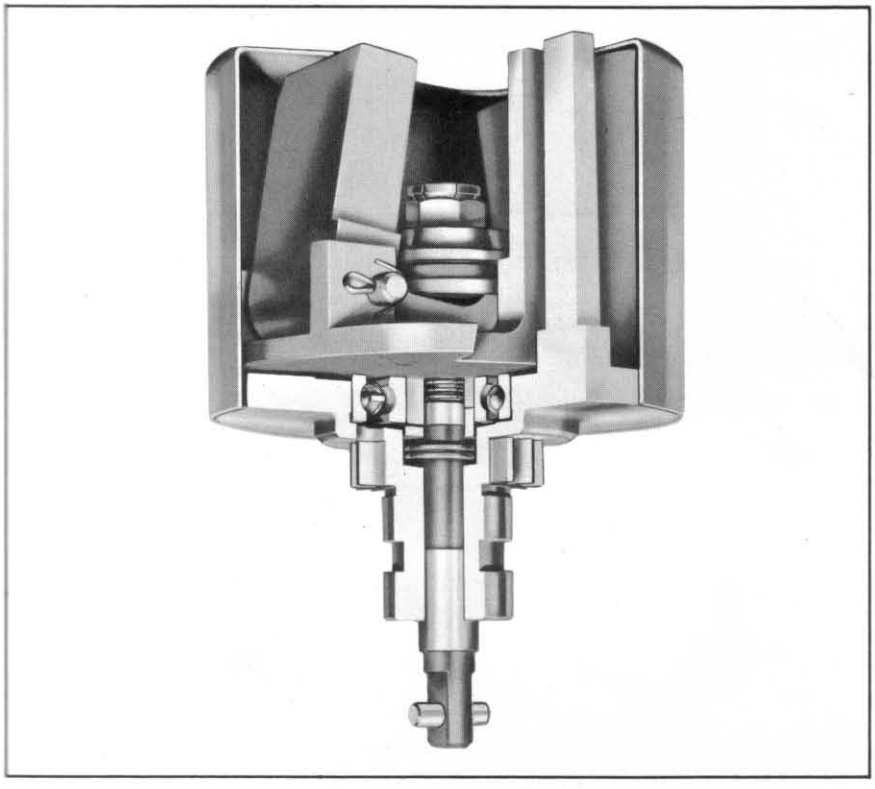


Cut No. 34

29	Compensating Lever.....	1	33	Compensating Adjusting Fulcrum..	1
30	Compensating Adjusting Link.....	1	34	Compensating Adjusting Lever....	1
31	Compensating Lever Pin.....	2	35	5/8″ x 7/16″ x 1/32″ Seal Washer.	1
32	1/16″ x 7/8″ Cotter Pin.....	2	36	Compensating Adjusting Pointer..	1

37	17/32" x 21/64" x 1/32" Copper Washer	2
38	5/16"-24 Elastic Lock Nut	1
39	Compensating Adjusting Lever Stop Pin	2
40	Terminal Shaft Bushing	2
41	Terminal Shaft Oil Seal	2
42	1/4"-28 x 5/16" Set Screw	2
43	Case	1
44	Stud	9
45	1/4"-28 Elastic Lock Nut	9
46	Column — Base Gasket	1
47	2/0 x 1" Taper Pin	1
48	Gear	1
49	Oil Bronze Bushing	1
50	Panel	1
51	Speeder Plug	1
52	Shutdown Rod Nut	2
53	Shutdown Rod	1
54	Special Elastic Lock Nut	1
55	10-32" x 7/8" Adjusting Screw	1
56	Oil Bronze Bushing	1
57	Oil Seal	1
58	Speed Control Shaft	1
59	Stop Lever	2
60	Dial Plate	1
61	1/8" Socket Hd. Pipe Plug	7
62	Oil Level Sight Gauge	1
70	8-32 x 3/8" Phillips Binding Head Screws	6
73	10-32 x 5/8" Phillips Fil. Hd. Screw	8
74	#10 Split Spring Lock Washer	8
76	Panel Gasket	1
103	Speeder Spring	1
115	Ballhead Cover—Old Style	1
116	Ballhead Cover—New Style	1
117	1/16" x 3/4" Cotter Pin	1
118	Speeder Rod Nut	1
119	1/4"-28 Elastic Lock Nut	1
120	Thrust Bearing	1
121	Ball Arm—Old Style	2
122	Ball Arm—New Style	2
123	Ballhead & Gear Assembly—Old Style	1
124	Ballhead & Gear Assembly—New Style	1
125	Ball Arm Pin—Old Style	2
126	Ball Arm Pin—New Style	2
127	Needle Bearing—New Style	4
128	Bearing Spacer—New Style	2
129	Speeder Rod Spring	1
130	Speeder Rod—Old Style	1
131	Speeder Rod—Old or New Style	1
132	Speeder Rod and Rod End Pin	2
133	Dowel Pin	4
134	Check Valve Assembly	4
135	Base	1
136	Compensating Valve Plug	1
139	Compensating Needle	1
140	Oil Seal Retainer Gasket	1
141	Oil Seal Retainer	1
142	Oil Seal	1
143	Serrated Drive Shaft	1
144	Double Shield Bearing	1
145	Bearing Retainer	1
146	1/4"-28 x 5/8" Hex. Screw—Head Drilled #50 for Wire	3
147	.035" Brass Lockwire	1
148	Keyed Drive Shaft	1
149	Drive Key	1
150	1/8" x 1-1/2" Cotter	1
151	Drive Shaft Gear Spacer	1
152	5/8"-18 Castle Nut	1
153	Power Piston Link	1
154	Power Link Pin	2
155	Accumulator Spring	2
156	Accumulator Piston	2
157	Accumulator Snap Ring	2
158	Power Piston—1-3/8" Dia	1
159	Reducer Bushing for 1" Power Piston	1
160	Reducer Bushing for 1" Power Piston	1
161	Power Piston 1" Dia	1
162	Controlet	1
165	Pilot Valve Plunger	1
166	Pilot Valve Bushing	1
167	Pilot Valve Spring Tip	1
168	Pilot Valve Spring	1
169	Controlet Gasket (Not used if controlet has oil groove. (See Cut No. 16)	1
170	Pilot Valve Pin	1
171	1/32" x 3/8" Cotter Pin	3
172	Pilot Valve Floating Lever	1
173	10-32 x 1/2" Rd. Hd. Machine Screw	2
175	Dashpot Cover	1
176	Load Limit Shutdown Lever (Dial Gov. only)	1
177	Load Limit Lever Pin (Dial Gov. only)	1
178	Load Limit Lever Spring (Dial Gov. only)	1
179	Compensating Receiving Piston Rod End	1
180	Compensating Receiving Piston Lock Nut	1
181	Upper Spring Collar	1
182	Compensating Spring Shim	As Rqd
183	Compensating Spring	1
184	Lower Spring Collar	1
185	Dashpot Bushing	1
186	Compensating Receiving Piston	1
187	Oil Bronze Bushing	2
188	Compensating Actuating Piston Link	1
189	3/32" x 7/8" Cotter Pin	1
190	Compensating Actuating Piston Spring Sleeve	1
191	Compensating Actuating Piston Spring	1
192	Compensating Actuating Piston	1
193	Compensating Actuating Piston Link Pin	1
194	Ballhead Drive Gear	1
195	Retaining Sleeve	1
196	2/0 Taper Pin	1
197	Ballhead Gear Driver	1
198	Spacer Pin	1
199	Spring Drive Lamination	As Rqd
200	Pump Driven Gear	1
201	1/16" x 1/2" Cotter Pin	5
202	Snap Ring	1

SPRING DRIVEN OIL DAMPED BALLHEAD



Sectional View of a UG8 Spring Driven Oil Damped Ballhead Assembly

An oil damped, spring driven ballhead is used in place of the standard solid ballhead on engine installations where the engine drive to the governor is rough.

A rough engine drive to the governor can usually be attributed to insufficient clearance, excessive backlash or run-out in intermediate gearing, chain whip, fuel pump, or camshaft impulses. Such a drive brings undesirable torsional vibrations to the governor drive shaft, which in turn transmits false speed signals to the governor ballhead. This condition will be visible at the governor terminal shaft in the form of a jiggle. This jiggle may not affect the operation of the engine or governor but can cause excessive wearing of injectors, linkage and governor, and in extreme cases can cause actual destruction of the governor.

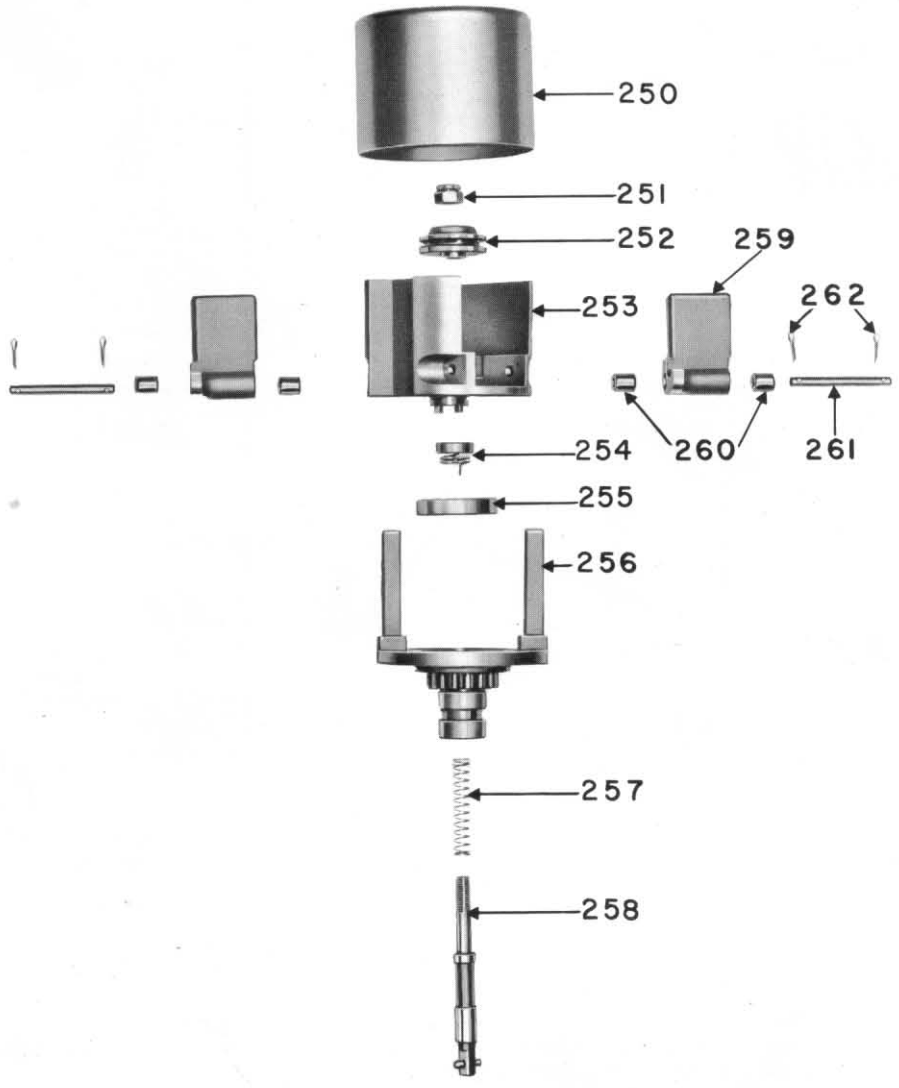
This ballhead provides a filter for these torsional vibrations, minimizing, or eliminating in many cases, the visual evidence of the drive irregularities. In some installations, although the terminal shaft and fuel linkage may be steadied by the use of this ballhead, excessive governor and engine drive wear may result from the torsional vibrations.

On governors built since July 1948, the spring driven ballhead is interchangeable with the standard solid ballhead and may be used to replace it. To install the spring driven ballhead in the field on a lever type governor it is necessary to install the spring driven ballhead and a new style speeder spring No. 103 and pilot valve bushing No. 166 as shown. This operation can be accomplished in the field by first disassembling the governor following instructions given on pages 13 and 14 and then reassembling as instructed on page 20.

On governors built before July 1948, replacement of the standard ballhead with the spring driven ballhead requires several machining changes in the main governor parts. This work must be done in our factory service department.

INFORMATION AND PARTS REPLACEMENT: When requesting information concerning governor operation, or ordering replacement parts, it is very essential that the following information accompany the request.

1. Governor serial number (shown on nameplate)
2. Bulletin number (This is bulletin 03005A)
3. Part number or name of part (Listed below)



Part No.	Name of Part	No. Req'd
250	Ballhead Cover	1
251	Adjusting Nut	1
252	Thrust Bearing	1
253	Spring Driven Ballhead	1
254	Torsion Spring	1
255	Ball Bearing	1
256	Sub Ballhead and Gear	1
257	Speeder Rod Spring	1
258	Speeder Rod	1
259	Ballarm	2
260	Ballarm Needle Bearing	4
261	Ballarm Pin	2
262	Cotter Pin	4

P. Water Pump

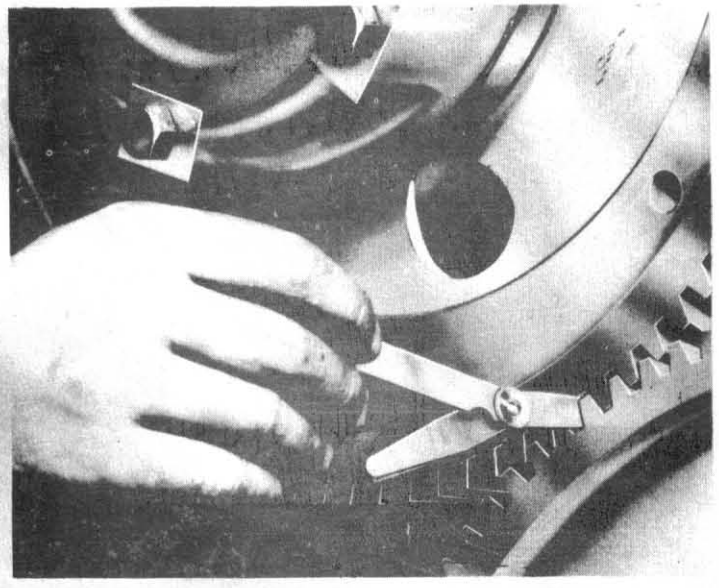
The fresh water pump and the sea water pump are both of the centrifugal reversible type, mounted on the front end of the engine and driven from the gear train.

The pump shaft rotates within bronze bushings pressed into the pump bracket. The bearings are lubricated by the engine oil system under pressure. An oil seal is located ahead of the inboard bearing to prevent the oil from entering the water chamber of the pump. A drain hole between the oil seal and the inboard bearing allows oil to drain into the gearcase and back to the sump.

To prevent water leakage, the pumps are equipped with face type seal which consists of a carbon ring and a synthetic rubber bellows enclosing a low rate compression spring, all encased in a metal cartridge. The water seal is located at the back face of the pump impeller with the carbon ring bearing against a smooth face on the impeller hub. The seal assembly is pressed into the pump bracket and does not rotate. The spring holds the carbon ring in contact with the rotating face of the pump impeller. This contact, maintained by the spring, provides the seal between stationary and rotating parts. Sufficient water creeps between the sealing surfaces to lubricate them and materials of the surfaces are selected to give the seal long life.

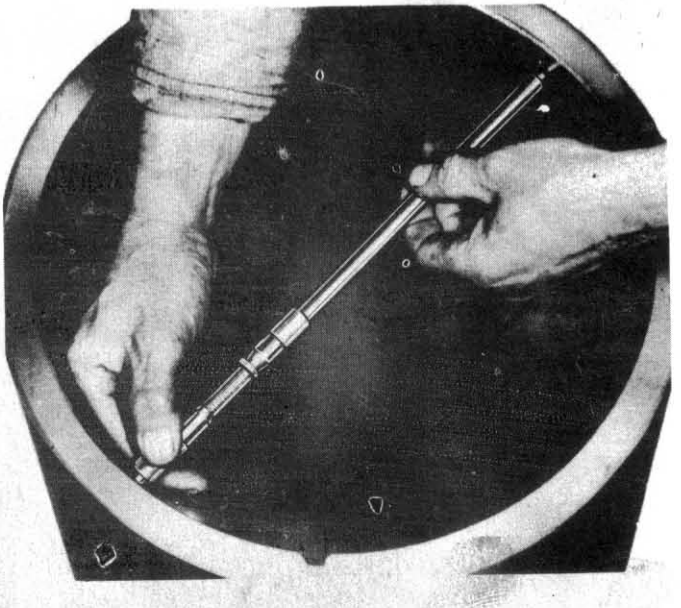
A drain hole between the oil seal and water seal allows any leakage from either one to drain outside the engine so no contamination of either water or lube oil can take place.

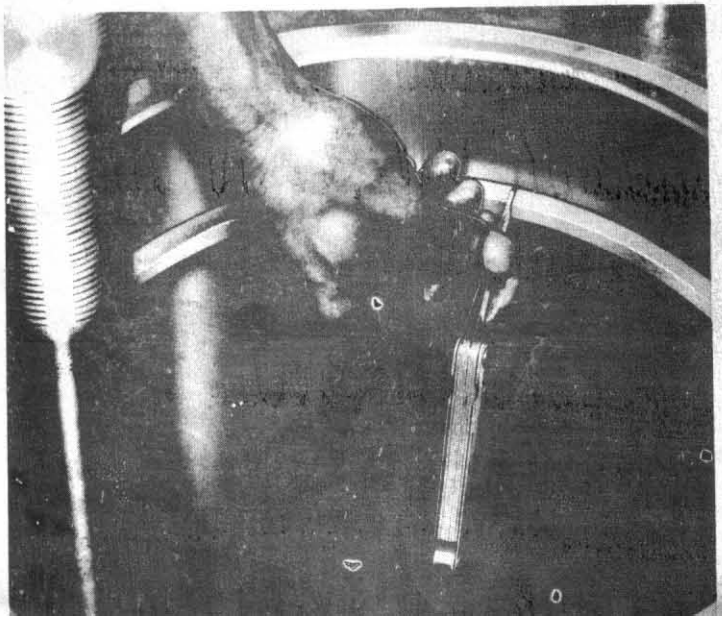
Using a feeler gauge to measure the clearance between the piston pin and bushing—the table of clearances will give the proper figure.



The backlash measurement of the timing gears is taken with a feeler gauge. If the clearance between the teeth exceeds the maximum clearance listed in the table of clearances, replace the gears concerned.

Liner bore measurement is taken with an inside micrometer. This will enable you to determine the amount of wear in the liner. Look on table of clearances for proper allowance of wear in liner.





Using a feeler gauge to determine the clearance between the two ends of the piston ring, when placed in the cylinder liner. The proper gap clearance is given in the table of clearances. Be certain that ring can be freely pushed around in the piston groove. Use a fine mill file to polish any rough spots.

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PART V

TABLE OF CLEARANCES

MODEL G ENGINE

Engine Part	New Clearance Minimum	New Clearance Maximum	REPLACE when worn clearance exceeds Minimum	REPLACE when worn clearance exceeds Maximum
Valve in guides				
Inlet	.0035	.005	.020	.025
Exhaust	.0055	.007	.020	.025
Air Valve Piston	.0055	.0075		
Rocker				
Bushing on shaft	.002	.0035	.010	
Roller on pin	.001	.0025	.010	
Tappet				
In guide	.001	.003	.015	
Roller on pin	.0015	.0030	.005	
Bearings				
Main on crankshaft	.008	.011	When wall thickness at bottom of lower shell is less than .3665.	
Con rod on crankshaft	.007	.0095	When wall thickness at top of upper shell is less than .3060.	
Camshaft	.002	.004	When wall thickness at bottom of lower shell is less than .1950.	
Pistons				
Pin - In piston	Light driving fit at 70°F.		.002	
In bushing	.0055 - .0065		.015	
Piston in liner (Skirt clearance)				
Cast iron - top	.014 - .016			
- bottom	.010 - .012			
Aluminum - top	.040 - .044			
bottom	.024 - .028			
Liner			When bore at any point exceeds 12.040".	

Top of piston above cylinder block (approximate)	
Non-supercharged engine	13/16"
Supercharged engine	3/4"
Spark ignited gas engine	1/4"

Part V, Table of Clearances - continued

Engine Part	New Clearance Minimum	New Clearance Maximum	REPLACE when worn clearance exceeds Minimum	REPLACE when worn clearance exceeds Maximum
Piston Rings				
Gap clearance				
Two top compression	.055	.080	When wear exeeds	
Lower compression	.040	.070	.200.	
Oil rings	.020	.045		
Side clearance in grooves				
Two top rings	.011	.015	When side clearance	
Other compression rings	.0075	.0115	exceeds .020.	
Oil rings	.0025	.0040		
Lube Oil Pump				
End clearance gears	.004	.007		
Diametral clearance of gears in housing - backlash in gears	.004	.007		
Backlash in gears	.004	.006		
End clearance of drive shaft	.004	.007		
Bushing - diametral	.0025	.005		.010

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 PSI.
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 (Continued)

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 times.	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 ans 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.

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

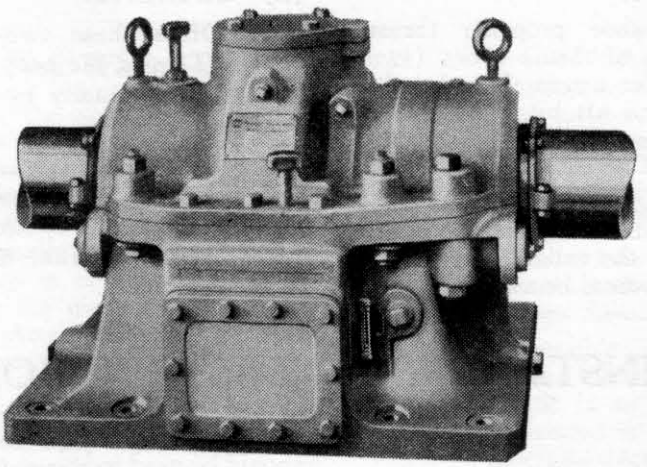
1. Insufficient water supply due to:	
a) Sea suction clogged or valves closed.	a) Clear suction and open valves.
b) Loose connections.	b) Tighten.
c) Air in water pump.	c) Open vents on pump or on top of suction.
d) Overboard discharge clogged.	d) Clear discharge.
e) Temperature control valve not properly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



INSTRUCTIONS

for Installing and Operating

Horizontal Two-Shoe Adjustable

KINGSBURY THRUST BEARINGS

Styles GH, GF and GK

Folder 350-A

KINGSBURY MACHINE WORKS, INC.

4316-28 Tackawanna Street Frankford, Philadelphia 24, Pa.

Cable Address "ALKING," Philadelphia

12-48-1M

PRINTED IN U. S. A.

KINGSBURY

I. GENERAL DESCRIPTION

DRAWING REFERENCES

(A) PRINCIPAL PARTS:

1. The standard two-shoe 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. Often these two-shoe bearings run air-cooled. That is, the heat resulting from oil friction is carried off readily by the surrounding air and foundation.

2. For higher running speeds, 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 with kerosene, also any oil piping. Blow them clean with air, if possible. Remove anti-rust coatings with kerosene. Use rags or cloth, as waste leaves lint, which clings to minute burrs and might 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. Take light fractional turns on alternate screws till the oil films stop yielding. 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 re-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

CHECKING END PLAY

OF TWO-SHOE THRUST BEARINGS

I. Checking End Play While Running

When it is feasible, the simplest method of checking end play is to use a suitable measuring instrument on any accessible part of the line shaft that is rigidly coupled to the thrust bearing, while running the engine or turbine slowly ahead and astern. This would normally be done at the end of a run when the ship is maneuvering to approach her pier, before the machinery and shaft are cold. The speeds should be slow, to avoid adding deflections of bearing parts and housing to the actual end play, but they should be sufficient to overcome the rake of the shaft and insure that the full end play is actually taken up.

The method of applying this procedure will depend somewhat on the type of bearing, as follows:

Micrometer at Forward End of Shaft

(a) When the drive, by steam or Diesel engine, is through reduction gearing, the end cover of the bearing sometimes has a central hole, through which a micrometer measuring device can be applied to detect the axial position of the end of the shaft. Using that device, a measurement is taken under forward thrust, and another under astern thrust. The difference between the two readings is the end play.

(b) Possibly the 2-shoe thrust bearing at the forward end of an electric motor direct drive may have a drilled end cover plate like that just described. If so, the same procedure can be used.

Indicator Aft on Shaft

(c) If the forward end of the shaft is not accessible, end play must be measured elsewhere. A dial indicator may be mounted on a rigid support close to some convenient coupling flange. Sometimes the shaft has a shoulder turned on it for the express purpose of applying a dial indicator. If the shaft has a flexible coupling, the measurement must be taken between the thrust bearing and the flexible coupling—not beyond.

If Starting from Cold . . .

(d) If it is not feasible to check end play while the machinery is still warm, it may be possible to start the engine from cold and run it slowly ahead and astern with just sufficient power to take up the end play. This requires more care, since it involves limbering the cold oil in the shaft bearings in order to avoid false readings. The measurements should be taken by the appropriate means above described.

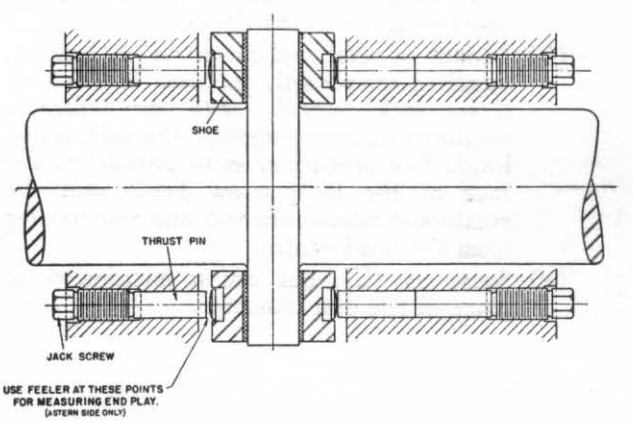
II. Jacking On Shaft Flange

If it is not feasible to measure end play while running, the next choice is to jack the shaft fore and aft at some suitably-located flange.

(a) If possible, jack while the shaft is still warm. Mount the indicator as in paragraph Ia or Ic. Be sure that the shaft movement is free (i.e. oil not cold) and *carefully avoid over-jacking,* which would add deflections to the actual end play.

(b) If the jacking must be done cold, begin by rocking the shaft by means of the turning gear to relieve the static friction. After rocking the shaft, apply the jack. If possible, mount the jack so that it can follow the rocking motions right and left. Jack forward till marked resistance to rocking shows that the oil films between collar and shoes are squeezed out. Note the indicator reading; then jack the shaft aft, rocking it as before, and take the new reading. Repeat to make sure of readings.

III. Measuring Inside Two-Shoe Bearing



If end play of a 2-shoe bearing is to be measured inside the bearing (instead of by a dial indicator on the fore-and-aft shaft movement) the correct method is to use a feeler between the thrust pin and the rounded pivot ("shoe support") set into the back of each shoe. This should be done on the astern side only, with the housing

cover lifted and the collar blocked or jacked against the forward shoes. Ordinarily this is the only check necessary. However, the following precautions should be noted.

With any 2-shoe bearing solidly coupled to a steam or Diesel engine shaft, it is essential that the thrust collar be so positioned fore and aft that the engine crankshaft is correctly located in reference to the main and crankpin bearing ends. Further, the thrust housing should be located to afford roughly equal clearances fore and aft for thrust collar adjustment. In subsequent re-checking and re-setting of end play, these points should be borne in mind.

In large 2-shoe bearings there is a certain amount of brinelling between the shoe supports and the thrust pins, mainly on the ahead side. In time this may make it necessary to readjust the ahead jack screws. Hence the safest procedure is to start by checking the crank clearances. If those clearances are not correct, the shaft must be jacked endwise till they are. (The thrust jack screws may be used for this purpose, with the opposite jack screws backed off.) At that point the shaft should be blocked and all the jack screws run in till the shoes bear solidly and equally on the thrust collar. As the shoes make contact, take small fractional turns on the jack screws till the oil films between shoes and collar stop yielding. Then back the astern screws to give the required end play.

If the *astern* shoes and thrust pins have been affected by brinelling, the use of feelers becomes uncertain. The astern jack screws may then be backed accurately by any of the following methods:

(a) Note the pitch of the jack screw threads, and use a protractor on the jack screw head to get the required number of degrees of turn for the desired end play.

(b) Mount a dial indicator on a bracket, attached temporarily in place of the jack screw lock wrench, with the indicator mushroom bearing against the jack screw head. The bracket must be parallel to the face of the jack screw head, and the mushroom square thereto and not too far from the head centre.

(c) Same as (b), but use a micrometer in place of the dial indicator.

The foregoing refers to the usual *outside* jack screws. If the bearing has inside jack screws the procedure is as follows:

(d) Mark the exact position of the turning wrench when the jack screw has been tightened. (A bar may be clamped in a raised position across the housing, and the wrench position marked on the bar.) Block the shaft, and back the screw sufficiently to free the shoe: lift the shoe out. Return the wrench to the marked position, and use a micrometer between the jack screw and thrust collar to back the jack screw for the desired end play. Repeat for the other shoe. Wipe the shoes with clean rags before replacing them. Or—

(e) Note the pitch of the jack screw threads, and use a protractor on the jack screw head to get the required number of degrees of turn for the desired end play.

IV. General Notes

Never try to measure the end play with feelers between collar and shoes. In a 2-shoe bearing the tilt of the shoes would make accurate measuring impossible.

A log of end play measurements should be kept and referred to after each checking. When new, there may be slight settling of the thrust pins and jack screws; but any noticeable later increase in the end play indicates that the thrust shoe surfaces should be examined, and repairs made if necessary.

In any jacking operations, make sure that the weight and rake of the shaft do not affect the measurements.

V. Some "Don'ts"

Don't jack the shaft without first slightly rocking it to restore the oil film.

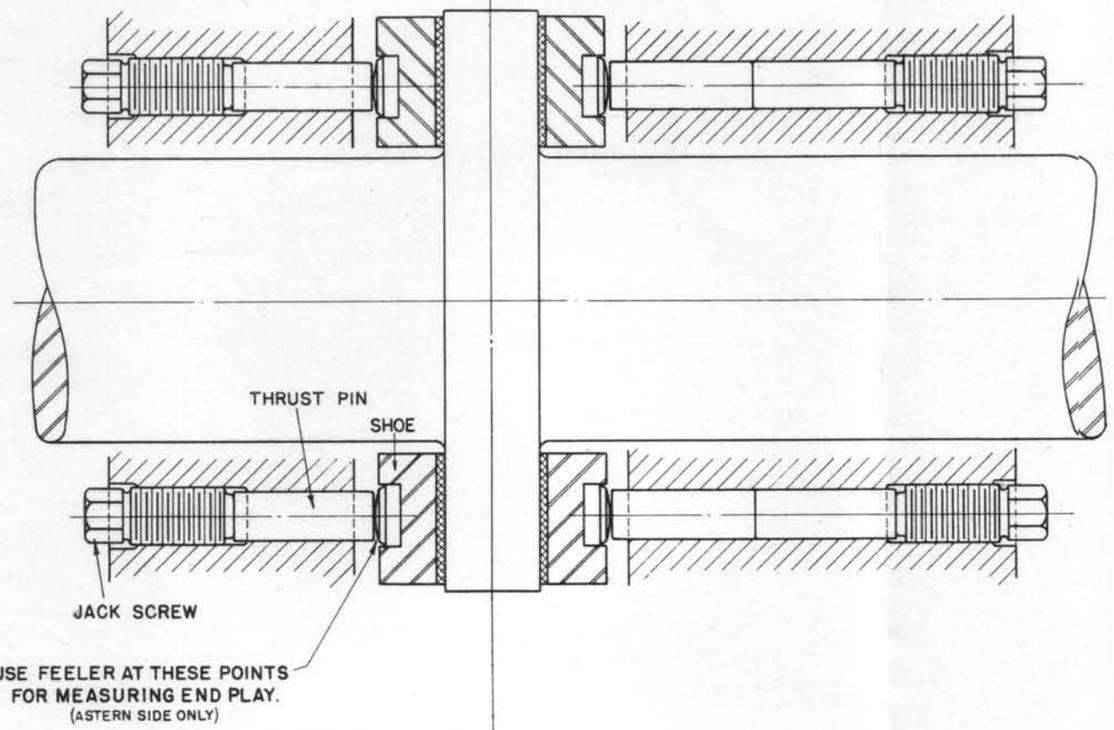
Don't try to measure end-play with feelers between collar and shoes.

Don't start checking without being familiar with the preferred and alternative procedures for your particular bearing and operating conditions.

KINGSBURY MACHINE WORKS, INC.

4316-28 Tackawanna Street Frankford, Philadelphia 24, Pa.

NOTE:- BEARING IS FREQUENTLY FURNISHED WITH A COOLING COIL WHEN COIL IS USED SEE DATA FOR WATER FLOW.

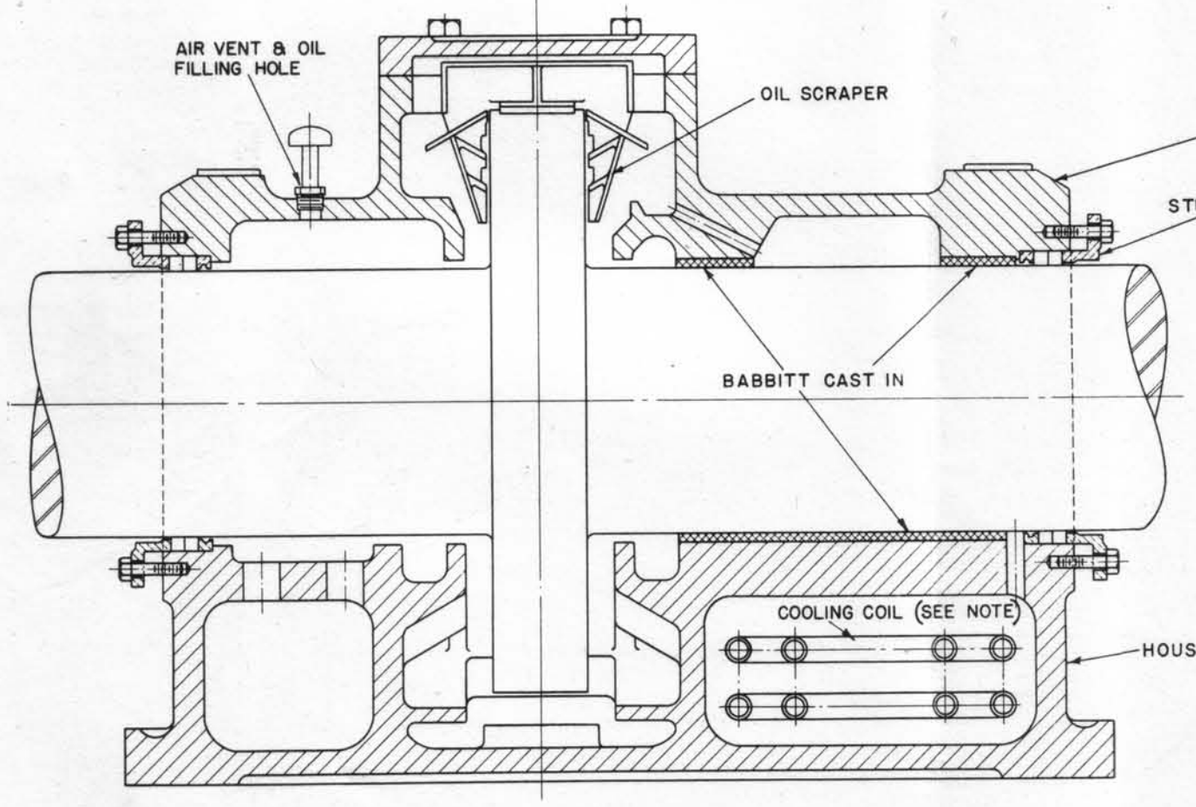


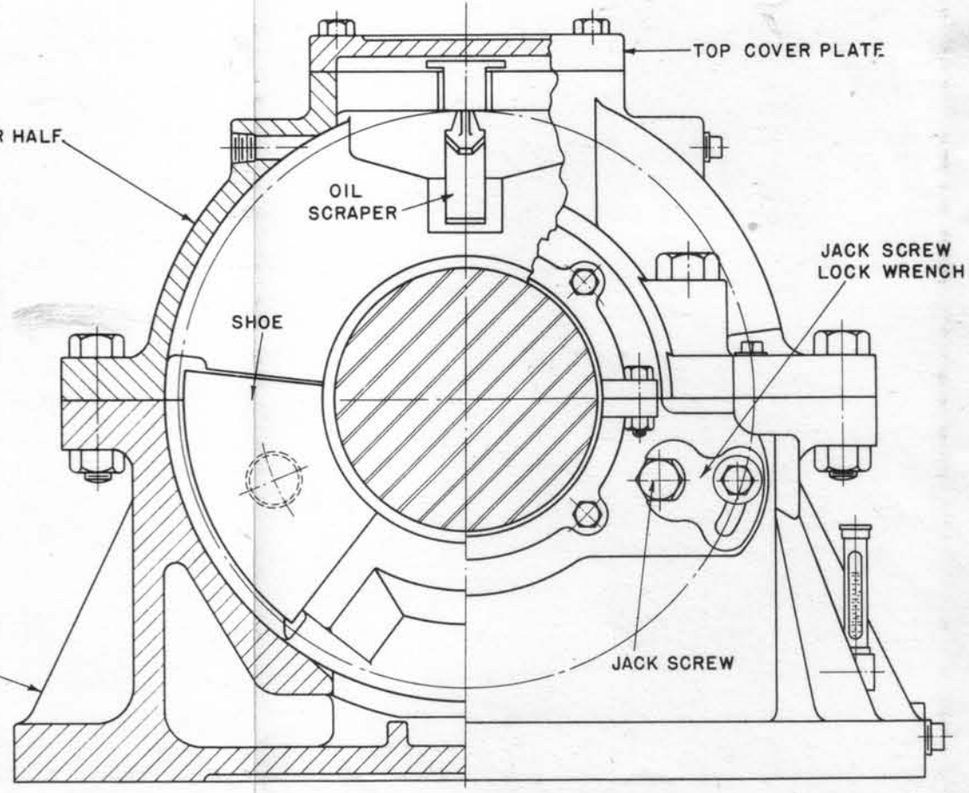
PRINCIPAL PARTS		
ITEM	REQ. FOR ONE BRG.	NAME
1	1	HOUSING UPPER HALF
2	1	HOUSING LOWER HALF
4	4	SHOE
5	6	THRUST PIN
6	4	JACK SCREW
7	4	LOCK WRENCH
8	2	STUFFING BOX ASSEMBLY
9	1	OIL SCRAPER
10	1	AIR VENT
11	1	TOP COVER PLATE
12	2	SIDE COVER PLATE
13	1	OIL GAUGE
14	1	COOLING COIL

SIZE		RECOMMENDED END PLAY	
R.P.M.		JOURNAL CLEARANCE	
REF. No.		APPROXIMATE WATER FLOW	

RECOMMENDED OIL VISCOSITY NOT LESS THAN SUV AT 100° F.

STYLE "GH" STANDARD
KINGSBURY THRUST BEARING





DRAWING REF. No. No. 262465

proper level. A plate attached near the oil gauge shows "HIGH" and "LOW" oil levels.

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.

(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. If adjustable stuffing boxes are used, do not take up hard on the glands, as that would cause unnecessary heating of the shaft.

2. With air or water cooling, an oil bath temperature up to 150° F. is not excessive, when using oil of 400 SUV at 100° F. or heavier. Erosion of water cooling coils can be minimized by avoiding a needlessly strong flow.

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, or indicated as "Ref. No." in the instruction drawing.

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 (or nearest substitute) 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 24, Pa., U. S. A.


KINGSBURY

PART VII

B. Safety Alarm System

The engine is equipped with a safety alarm system that warns the operator of a low lubricating oil pressure condition or an over-heated cooling water condition. A howler, for giving audible warning, is operated by contactors placed in the oil and water lines. The contactors are set to actuate the howler when engine oil pressure drops low enough to become dangerous (approximately 15 PSI), or when water temperature rises to the point where the engine is insufficiently cooled (approximately 180°F.). A throttle switch is provided in series with the oil pressure contactor to cut out the howler when the engine is shut down.

Wiring diagram of the system is furnished with the installation plans of the engine.

~~Supercharged engines are equipped with additional contactors to assure that the supercharger lube oil pressure and water temperature are being maintained within safe limits.~~

MAINTENANCE INSTRUCTIONS

Air-Maze Type "E" Intake Air Filter-Silencer

Servicing

1. Remove the air filter panels

2. Clean the filter panels thoroughly by boiling in a solution of hot water and Oakite or any commercial grease solvent. Flush out the dirt with pressure water stream and allow to dry.

3. Immerse the clean, dry filter panels in engine lubricating oil. Drain off excess oil completely and replace panels on filter silencer unit.

PART VIII

ENGINE DRIVEN AUXILIARIES

A. Air Compressor (See Illustration "Compressor Drive")

Description

The two stage air compressor, mounted on a bracket located over thrust bearing, is "V" belt driven from the flywheel. The drive is so designed, as to permit replacement of the "V" belts without disturbing flywheel or shafting. The compressor is equipped with an automatic unloader pilot.

If a water cooled compressor is used a sea water line must be run to the compressor and a separate over board discharge provided.

Maintenance

Occasionally check "V" belts for proper tension. Slippage will rapidly ruin the belt. Do not use any belt dressing. Adjustment is made by loosening idler pulleys and then moving pulleys until belts have proper tension.

Lubricate idler pulley bearings with a good grade of grease.

Lubrication is the only attention that the compressor will normally require. The oil level in the crankcase must be maintained between high and low marks on bayonet gauge. Use the same lubricating oil as used in the main engine. Watch condition of lubricating oil and when same becomes dirty or worn out, clean crankcase and refill with new oil. The time for this varies with operating conditions.

The valves are the vital part of the compressor and are not to be tampered with except that a two months inspection for an excessive accumulation of

WOODWARD®

UG8 GOVERNOR

DIAL CONTROL

BULLETIN 03004

This bulletin covers the basic type UG8 governor as used on A.C. and D.C. generating sets, pumping engines, and most single engine installations. These bulletins may also be helpful in working with type UG8 governor: 01011 Glossary of Governor Terms, 01012 Elementary Principles of Diesel Engine Governing, 01502 Plant Operating Problems, 03501 Type UG8 Governor Service Bulletin, 03005 Lever Control UG8 Governor.

WOODWARD GOVERNOR COMPANY

ROCKFORD, ILLINOIS

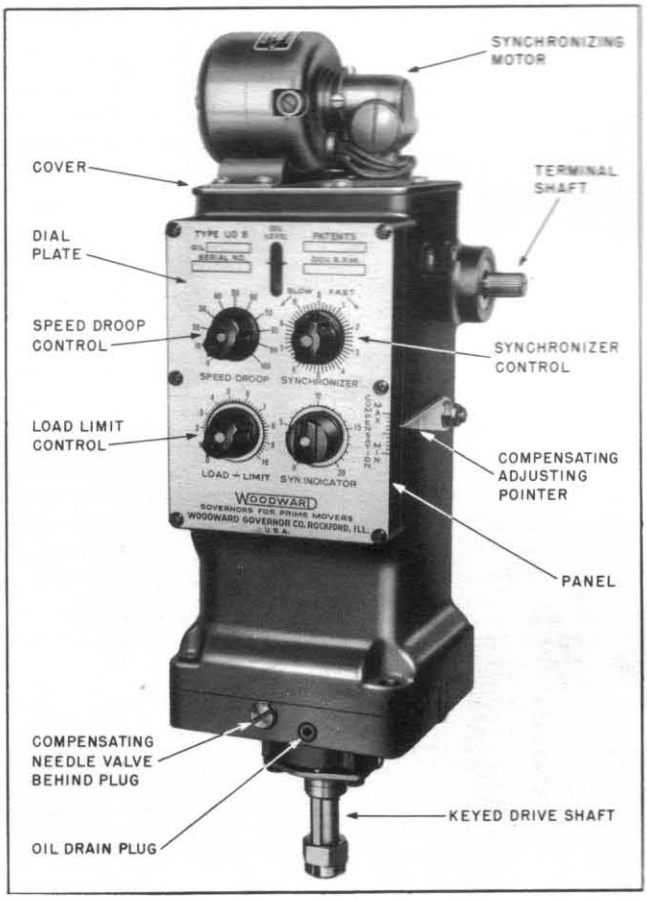
DECEMBER, 1954

UG8 GOVERNOR

DIAL CONTROL

PART ONE

GENERAL INFORMATION — INSTALLATION — ADJUSTMENT — OPERATION



Cut No. 1

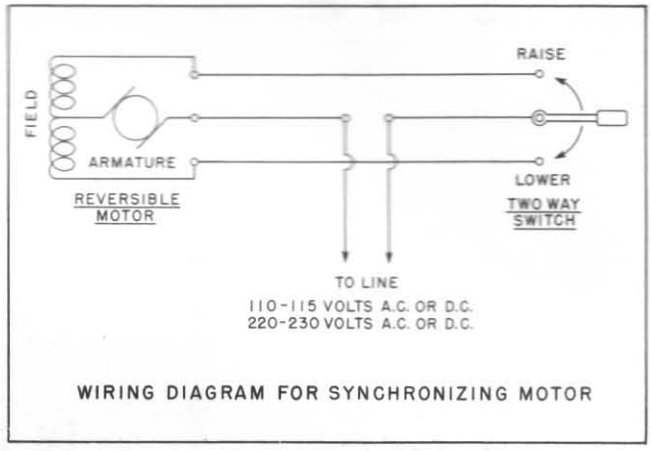
GENERAL: The UG8 dial type governor is of the hydraulic type and is normally isochronous (will maintain same engine speed regardless of engine load). Speed adjustment (synchronizer), speed droop and load limit controls are standard features. The stalling work capacity of the governor is usually eight foot pounds. Occasionally design requirements necessitate reducing the capacity to four foot pounds.

The governor with serrated drive shaft is shown on the front cover. Cut No. 1 shows the governor with synchronizing motor and keyed drive shaft.

THE SYNCHRONIZER, or speed adjusting control, is used to change the engine speed when running alone or to change the engine load when the engine has been paralleled with other units. The synchronizer indicator located directly below the synchronizer merely indicates the number of revolutions of the synchronizer knob.

THE SYNCHRONIZING MOTOR: A synchronizing motor may be mounted on a special cover for the UG8 governor to provide remote speed control. Its use enables the switchboard operator to match the frequency of an engine driven alternator with that of other units, or a system, before synchronizing and to change load distribution after synchronizing.

The motor used is of the split field, series wound, reversible type. It can be used on either direct current or alternating current at its specified voltage. It should be wired as shown in Cut No. 2.



Cut No. 2

A slip coupling is provided between the motor shaft and the synchronizer adjusting gear to allow the engine operator to adjust speed by turning the synchronizer control knob on the governor. This coupling is of the friction type. For adjustment of the friction coupling see Part 2.

THE SPEED DROOP control can be set to automatically divide and balance load between engines driving the same shaft, or paralleled in an electrical system.

Droop is incorporated in the governor through a linkage which varies the compression of the speeder (speed adjusting) spring as the terminal shaft rotates. Increased fuel reduces spring compression, reduces the governor speed setting accordingly, and the unit will gradually reduce its speed as load is applied. This relationship between load and speed acts as a resistance to load changes when the unit is interconnected with other units either mechanically or electrically.

As droop is reduced toward zero the unit becomes able to change load without changing speed. As a general rule, units running alone should be set on zero droop, interconnected units should be run at the lowest droop setting that will give satisfactory load division.

A. C. generating units tied in with other units should have droop set sufficiently high (30 to 50 on the dial) to prevent interchange of load between units. If one unit in the plant, or system, has enough capacity, its governor may be set on zero droop and it will regulate the frequency of the entire system. *This unit will*

take all the load changes within the limits of its capacity and will control frequency *if its capacity is not exceeded.*

The system frequency is adjusted by operating the synchronizer of the governor having zero droop. The distribution of load between units is accomplished by operating the synchronizers of the governors having speed droop.

For more detailed instructions on speed droop settings, see bulletin on Plant Operating Problems.

THE LOAD LIMIT control hydraulically limits the load that can be put on the engine by restricting the angular terminal shaft rotation of the governor, and consequently, the quantity of fuel supplied to the engine. The control may also be used for shutting down the engine by turning it to zero. CAUTION: Do not manually force engine linkage to increase fuel without first turning load limit knob to 10.

INSTALLATION: When the governor is installed on the engine, particular care should be exercised to see that it is mounted squarely and that the drive connection to the engine is aligned properly. A gasket should be placed between the base of the governor and the mounting pad on the engine. If the governor is equipped with a serrated drive shaft, it should slip into the internal serrations of the drive freely enough to drop into place of its own weight. CAUTION: Do not drop or rest the governor on its drive shaft.

If a keyed type governor drive shaft is used, the gear placed on this shaft should be checked to insure that it is meshing properly. There should be neither excessive backlash nor binding. Irregularies caused by uneven gear teeth, shaft runout, etc. will be picked up by the governor, transmitted to the fuel control system, and will result in erratic governing.

Since the load limit device operates hydraulically rather than mechanically the load indicating pointer position cannot be changed by turning the load limit control unless the governor is running (or has oil pressure in its accumulators). When installing governor the terminal shaft must be rotated by a lever in order to obtain no fuel (zero load) position.

CAUTION: Do not manually force engine linkage to increase fuel without first turning load limit knob to 10.

The linkage from the governor terminal shaft to the fuel control system should be free from lost motion or excessive friction. It is often desirable to install a light spring acting to decrease fuel for the purpose of taking up lost motion due to wear. *Avoid exceeding the working capacity* of the governor by using too strong a spring.

OIL SPECIFICATIONS: Use SAE 20 or SAE 30 oil for ordinary temperature conditions. If governor operating conditions are extremely hot, use SAE 40 or SAE 50; if extremely cold, use SAE 10.

The oil must not contain additives which are used to free up rings, remove carbon, etc., unless a non-foaming additive is also present. The oil should not foam or sludge excessively when agitated, or form gummy deposits when heated.

DIRTY OIL CAUSES MOST GOVERNOR TROUBLES. Use clean, new oil or filtered oil. All containers must be clean and should be rinsed with light grade fuel oil before using.

Keep governor oil at correct level in oil gauge.

STARTING ENGINE: When starting the engine, set the load limit (fuel limit) at 5 on the dial. This prevents the engine from getting excessive fuel and accelerating too rapidly. After the engine has warmed up, turn the load limit to 10. By means of the synchronizer adjust engine to its normal speed. Experience will determine if it is necessary to further limit the fuel on future starts.

COMPENSATING ADJUSTMENTS: Although the governor may appear to be operating satisfactorily because the engine runs at constant speed (without load) the governor still may not be adjusted correctly. High overspeeds and underspeeds after load changes and slow return to normal speed are results of incorrect compensation adjustments.

Make the following adjustments to be certain that the governor will give optimum control.

After the temperature of the engine and the oil in the governor have reached their normal operating values, the compensation should be adjusted without load on the engine as follows:

(1) Loosen the nut holding the compensation adjusting pointer and set the pointer at its extreme downward position. See Cut No. 1.

(2) Remove the plug, open compensating needle valve two or three turns with a screwdriver, and allow the engine to hunt or surge for about one half minute to bleed trapped air from governor oil passages.

(3) Gradually close needle valve until hunting just stops. Do not go beyond this position. Check the amount of needle valve opening by closing the valve completely, noting the amount of a full turn required to close. Open the valve to the previously determined opening at which hunting stopped. Test action by manually disturbing engine speed. If the needle valve is now less than ½ turn open and more than ⅛ turn open, the adjustment is satisfactory and (4), (5), (6), and (7) instructions should be ignored.

(4) If hunting did not stop with the needle valve at least ⅛ turn open, raise the compensation pointer two divisions of the scale and continue with the following instructions.

(5) Open needle valve approximately one turn to allow engine to hunt.

(6) Proceed with instruction (3).

(7) If necessary repeat (4), (5), and (3) until adjustment is satisfactory. Desirable needle valve opening is from ⅛ to ¼ turn open.

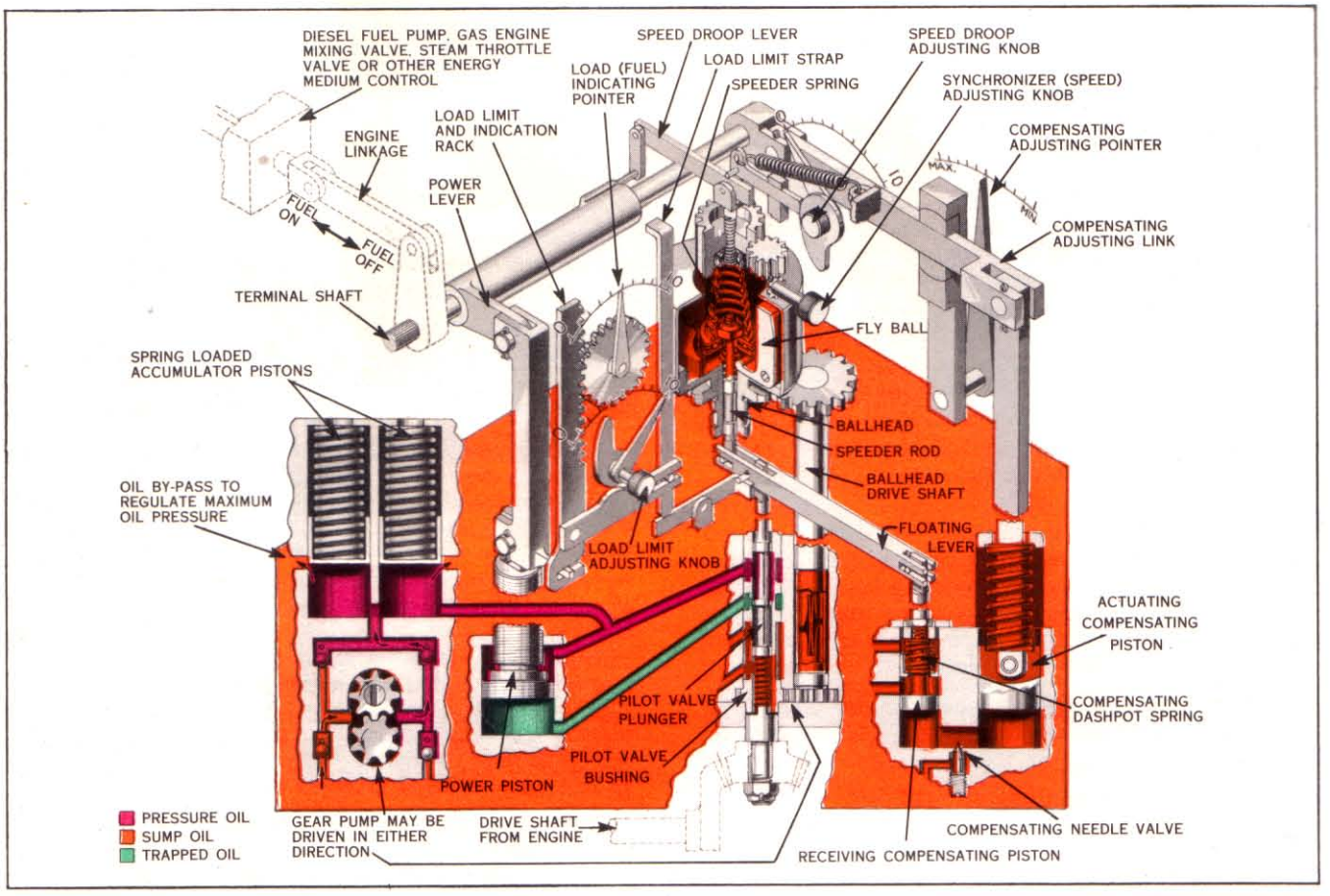
(8) It is desirable to have as little compensation as possible. Closing the needle valve farther than necessary will make the governor slow to return to normal speed after a load change. Excessive dashpot plunger travel caused by adjustment of the compensation adjusting pointer too far toward maximum position will cause excessive speed change upon load change.

SCHEMATIC DIAGRAM: The schematic diagram shows a UG8 dial control governor without auxiliary equipment. A differential type of servomotor is used in this governor. There is always full accumulator oil pressure on the top area of the power piston (regardless of pilot valve position) which will turn the terminal shaft in the direction to shut off fuel if there is no pressure (or low enough pressure) on the bottom area of the piston. The pilot valve will supply this same oil pressure to the bottom area of the power piston if the valve is moved down. Due to the difference of areas on the top and bottom of the piston a greater force on the bottom will then overcome the force on the top side and will move the piston turning the terminal shaft in the direction to increase fuel.

If the pilot valve is moved up the area under the piston is opened to sump, reducing the force exerted on the bottom of the piston. The force exerted by the oil pressure on the top will then be greater and will move the piston, turning the terminal shaft in the direction to decrease fuel.

The spring under the pilot valve supports the weight of the pilot valve, floating lever, etc., and has no effect in the operation of the governor.

The spring above the compensating actuating piston acts to eliminate lost motion in the compensating linkage and has no effect in the normal operation of the governor.

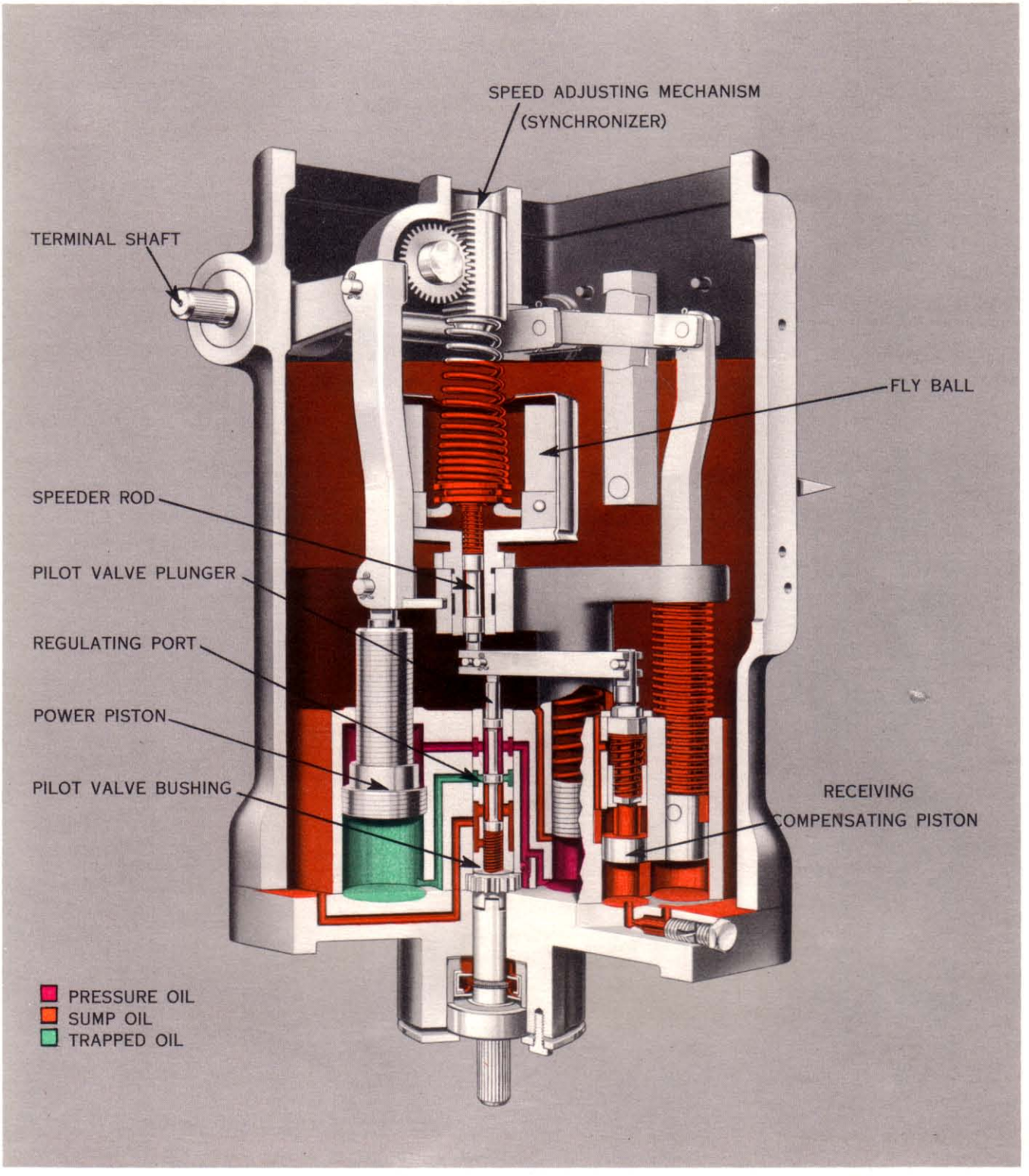


Cut No. 3

DESCRIPTION OF OPERATION: The photographs showing operation of the governor, Cuts No. 4 to Cut No.10 inclusive, have been simplified by removing the top cover, panel, load limit mechanism, and load indicating mechanism. In addition, the synchronizer or speed adjusting mechanism has been simplified.

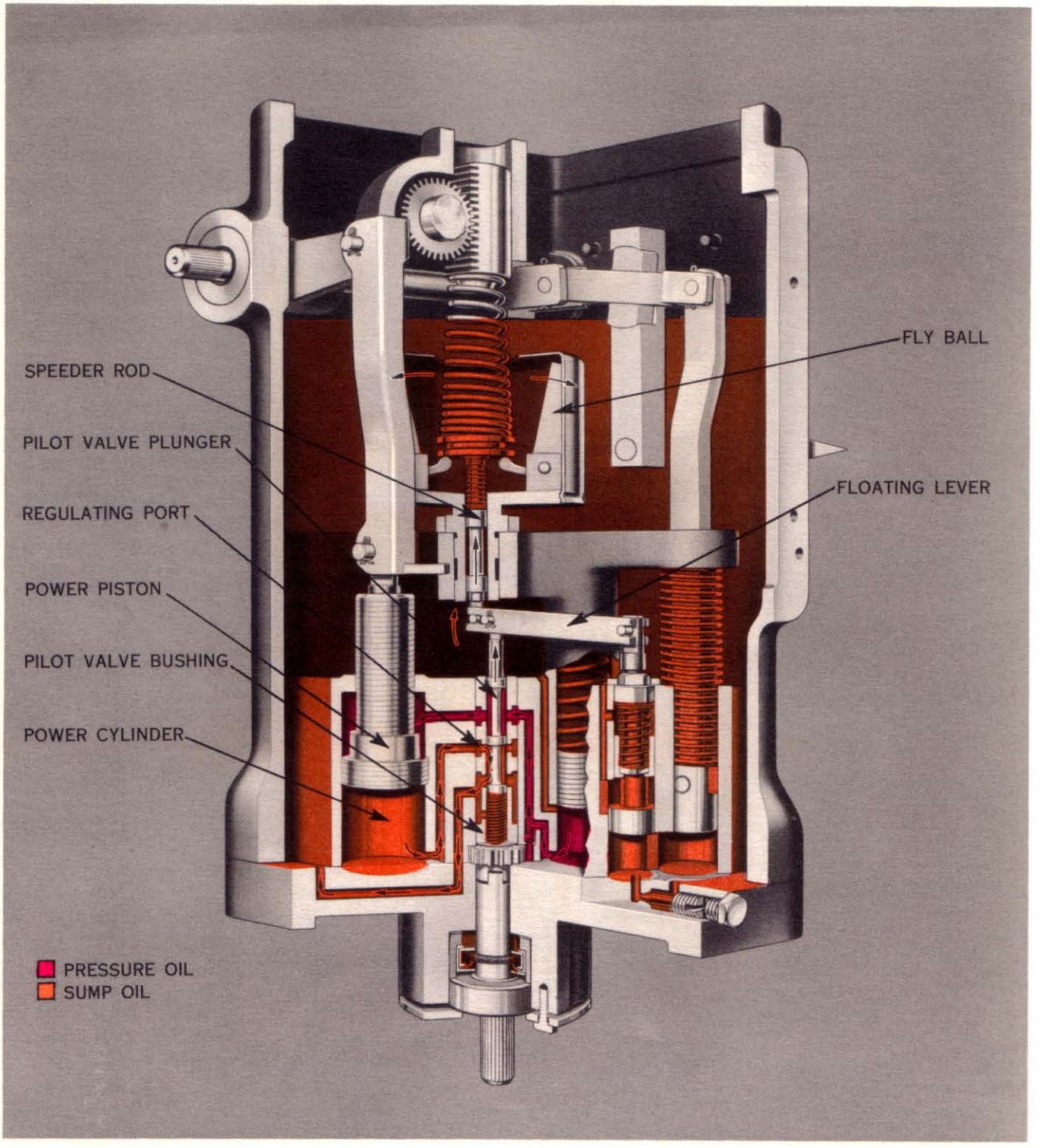
Speed changes as a result of load changes have been considered, but the same sequence of governor movements would occur if a difference between actual governor speed and governor speed setting is produced by turning the synchronizer adjusting knob (Speed Adjustment).

Movements of the operating parts of the governor are actually proportional to the amount of speed change, but have been greatly exaggerated in the photographs to make them more visible.



Cut No. 4

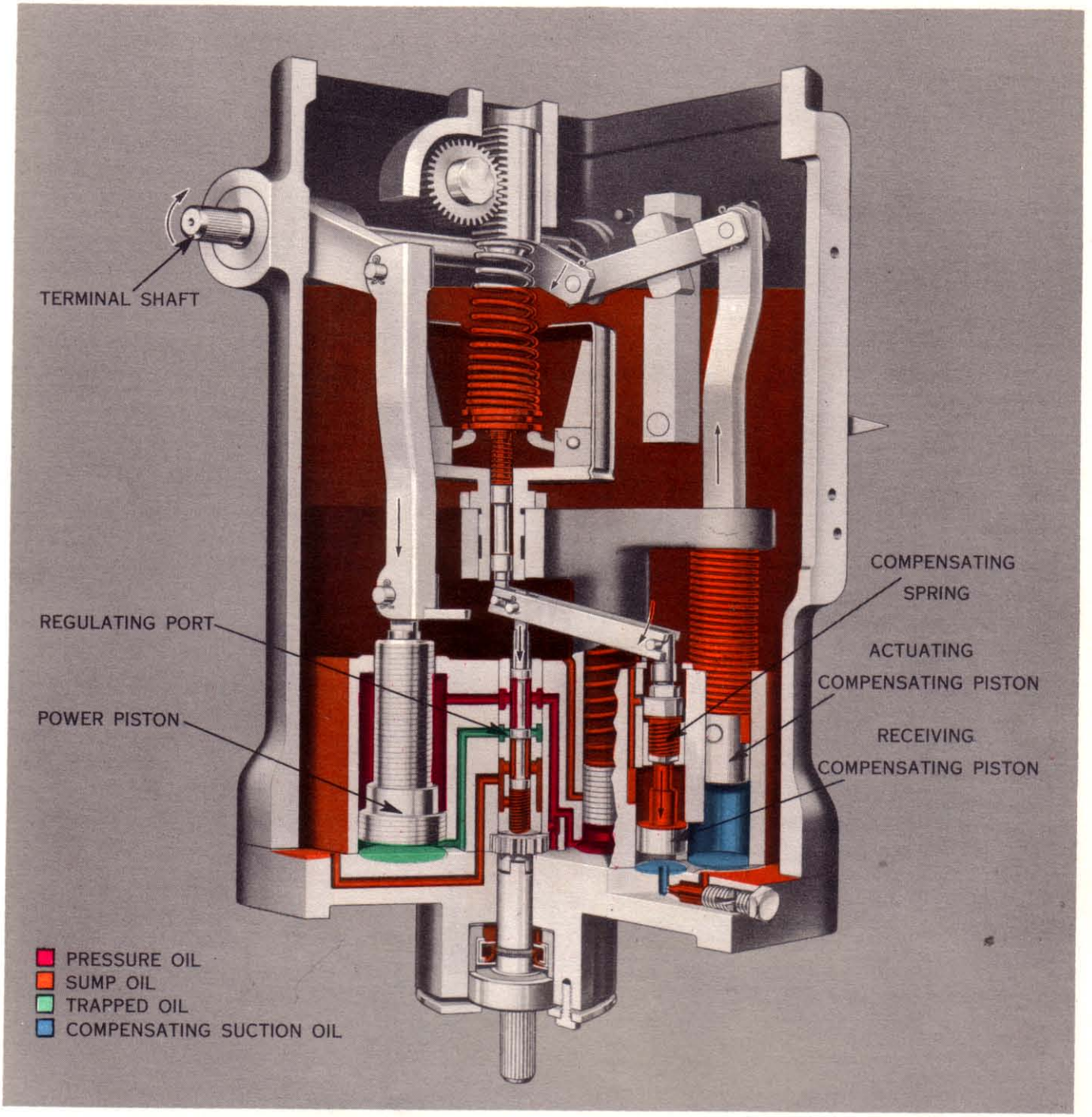
1. Engine is running at normal speed under steady load.
2. FLYBALLS, SPEEDER ROD, PILOT VALVE PLUNGER, and RECEIVING COMPENSATING PISTON are in normal positions; REGULATING PORT in PILOT VALVE BUSHING is covered by land on PILOT VALVE PLUNGER.
3. POWER PISTON and TERMINAL SHAFT are stationary.



Cut No. 5

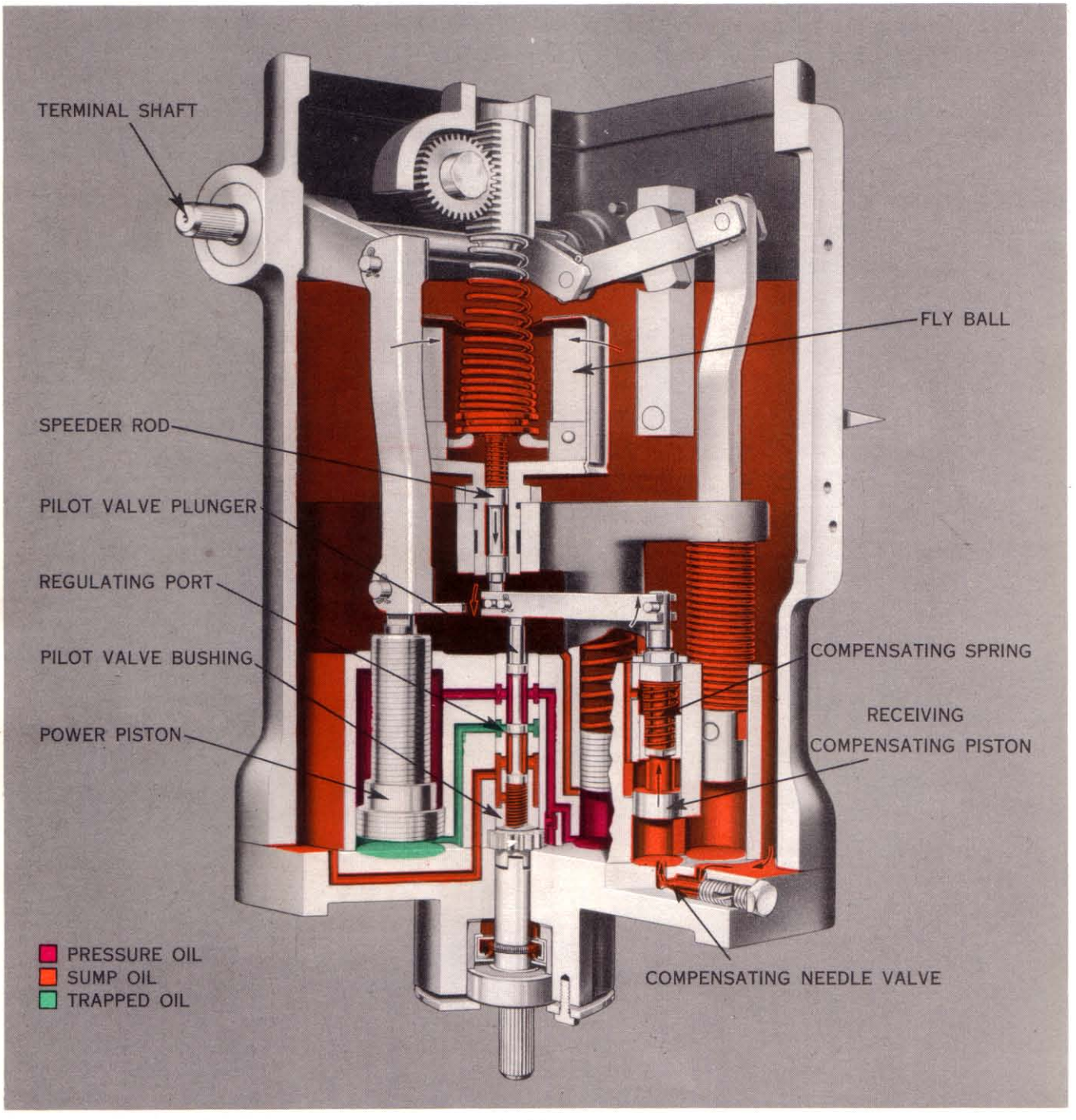
LOAD REDUCTION:

1. Load is decreased and speed increases.
2. As speed increases, FLYBALLS move out raising SPEEDER ROD and inner end of FLOATING LEVER, thus raising PILOT VALVE PLUNGER and uncovering REGULATING PORT in PILOT VALVE BUSHING.
3. Uncovering of REGULATING PORT opens bottom of POWER CYLINDER to sump and will allow oil pressure in top of POWER CYLINDER to move POWER PISTON down.



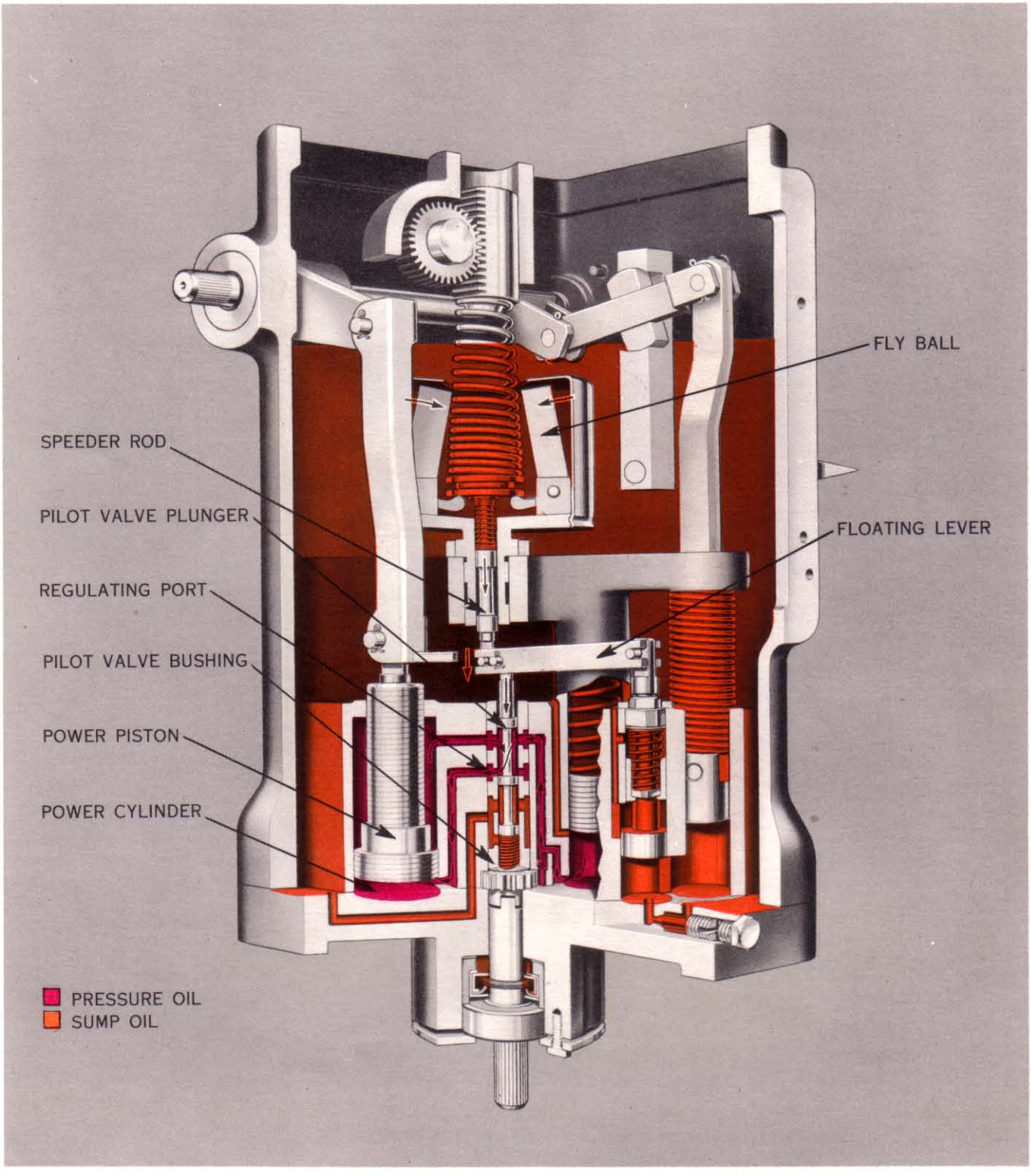
Cut No. 6

1. Oil pressure moves POWER PISTON down rotating TERMINAL SHAFT in the direction to decrease fuel.
2. As POWER PISTON moves down, ACTUATING COMPENSATING PISTON moves up and draws RECEIVING COMPENSATING PISTON down compressing COMPENSATING SPRING and lowering outer end of FLOATING LEVER and PILOT VALVE PLUNGER.
3. Movement of POWER PISTON, ACTUATING COMPENSATING PISTON, RECEIVING COMPENSATING PISTON and PILOT VALVE PLUNGER continues until REGULATING PORT in BUSHING is covered by land on PLUNGER.
4. As soon as REGULATING PORT is covered, POWER PISTON and TERMINAL SHAFT are stopped at a position corresponding to decreased fuel needed to run engine at normal speed under decreased load.



Cut No. 7

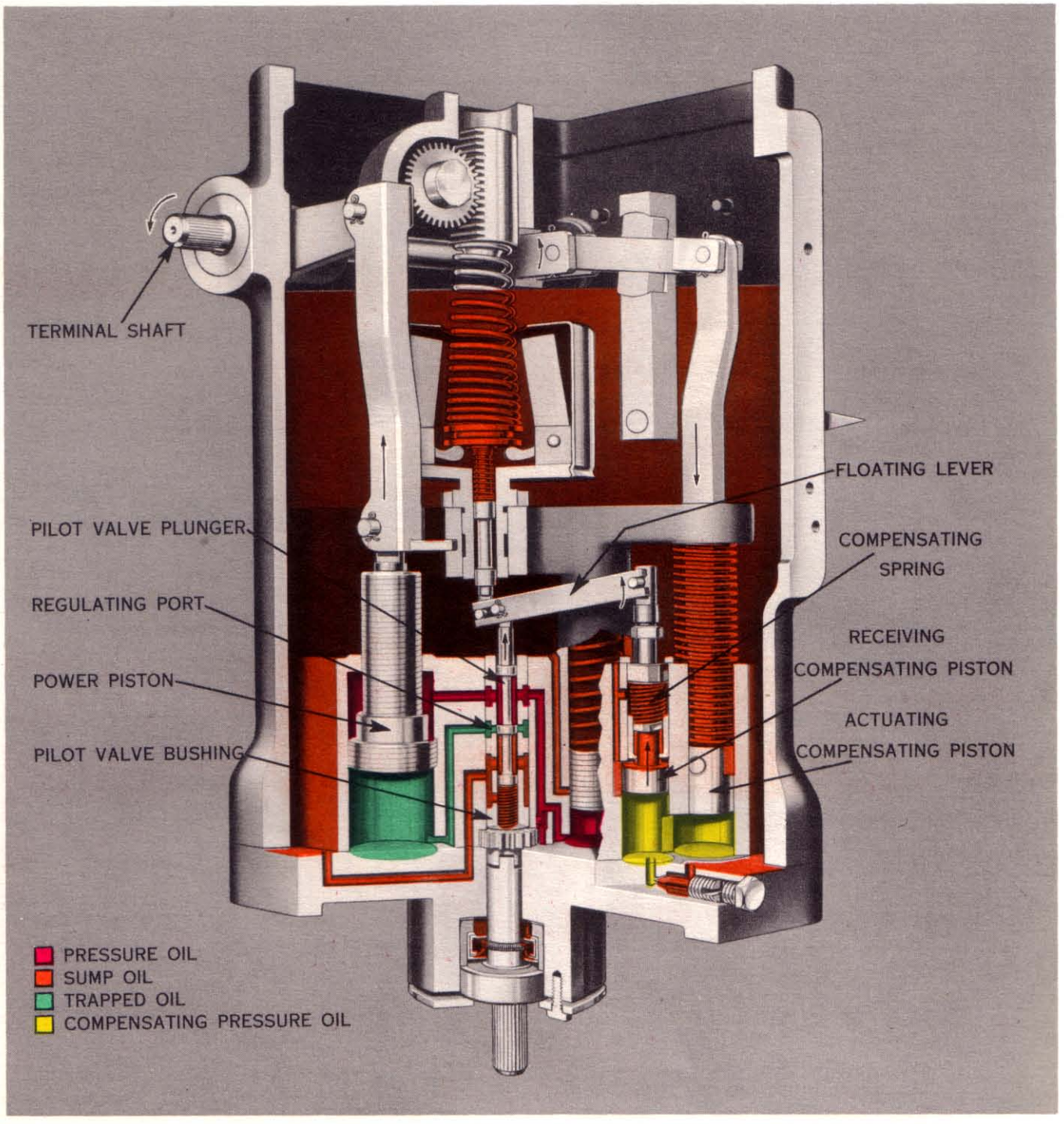
1. As speed decreases to normal, FLYBALLS return to normal position lowering SPEEDER ROD to normal position.
2. RECEIVING COMPENSATING PISTON is returned to normal position by COMPENSATING SPRING at the same rate as SPEEDER ROD thus keeping REGULATING PORT in PILOT VALVE BUSHING covered by land on PILOT VALVE PLUNGER; flow of oil through COMPENSATING NEEDLE VALVE determines rate at which RECEIVING COMPENSATING PISTON is returned to normal.
3. At completion of cycle, FLYBALLS, SPEEDER ROD, PILOT VALVE PLUNGER, and RECEIVING COMPENSATING PISTON are in normal positions; POWER PISTON and TERMINAL SHAFT are stationary at a position corresponding to decreased fuel necessary to run engine at normal speed under decreased load.



Cut No. 8

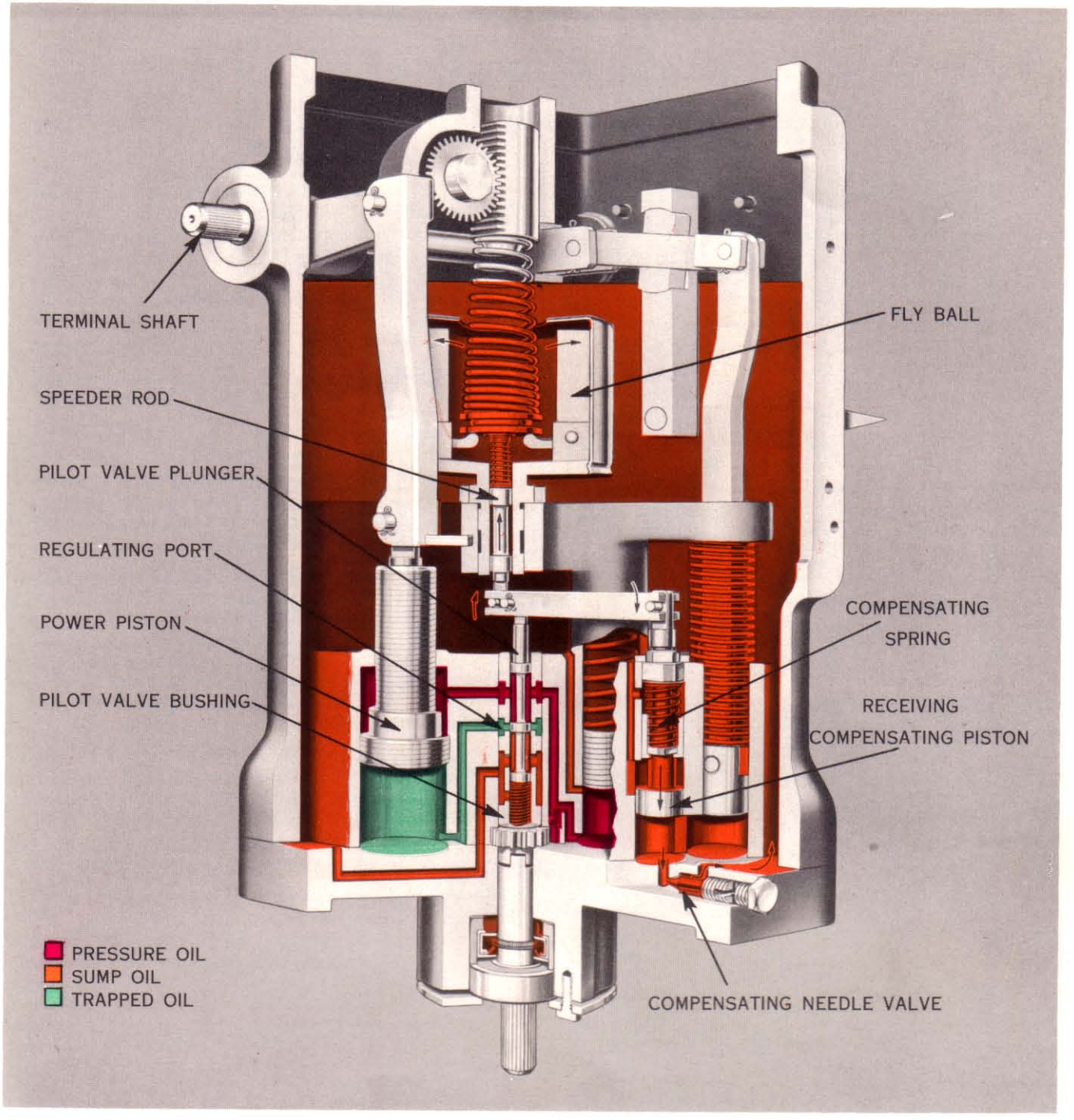
LOAD INCREASE:

1. Load is increased and speed decreases.
2. As speed decreases, FLYBALLS move in lowering SPEEDER ROD and inner end of FLOATING LEVER, thus lowering PILOT VALVE PLUNGER and uncovering regulating port of PILOT VALVE BUSHING.
3. Uncovering of REGULATING PORT admits pressure oil to bottom of POWER CYLINDER; since bottom area of POWER PISTON is greater than top area, oil pressure will move PISTON up.



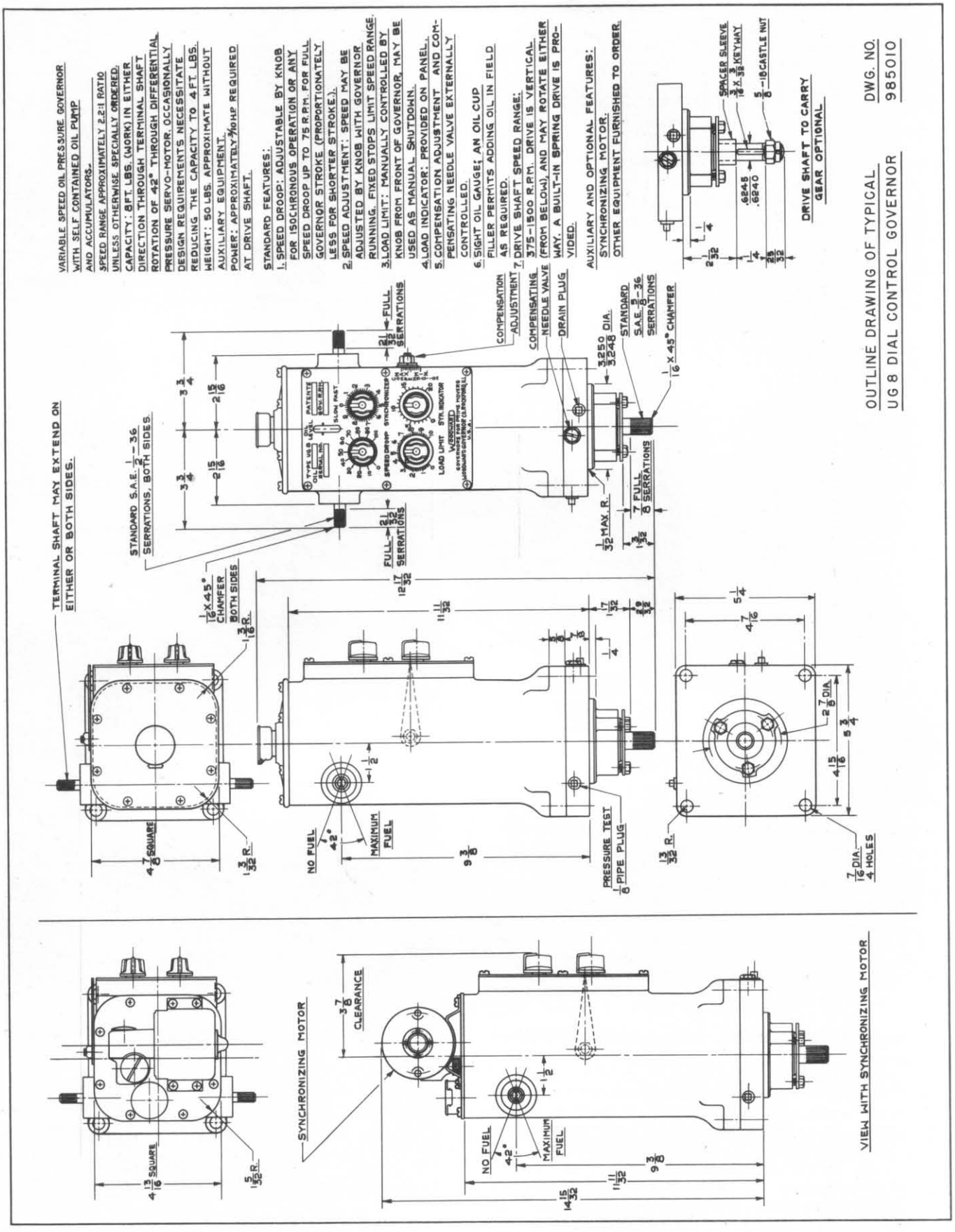
Cut No. 9

1. Oil pressure moves POWER PISTON up and rotates TERMINAL SHAFT in direction to increase fuel.
2. As POWER PISTON moves up, ACTUATING COMPENSATING PISTON moves down and forces RECEIVING COMPENSATING PISTON up compressing COMPENSATING SPRING and raising outer end of FLOATING LEVER and PILOT VALVE PLUNGER.
3. Movement of POWER PISTON, ACTUATING COMPENSATING PISTON, RECEIVING COMPENSATING PISTON, and PILOT VALVE PLUNGER continues until REGULATING PORT in PILOT VALVE BUSHING is covered by land on PLUNGER.
4. As soon as REGULATING PORT is covered, POWER PISTON and TERMINAL SHAFT are stopped at a position corresponding to increased fuel needed to run engine at normal speed under increased load.



Cut No. 10

1. As speed increases to normal, FLYBALLS return to normal position raising SPEEDER ROD to normal position.
2. RECEIVING COMPENSATING PISTON is returned to normal position by COMPENSATING SPRING at the same rate as SPEEDER ROD thus keeping REGULATING PORT in PILOT VALVE BUSHING covered by land on PILOT VALVE PLUNGER; flow of oil through COMPENSATING NEEDLE VALVE determines rate at which RECEIVING COMPENSATING PISTON is returned to normal
3. At completion of cycle, FLYBALLS, SPEEDER ROD, PILOT VALVE PLUNGER, and RECEIVING COMPENSATING PISTON are in normal positions; POWER PISTON and TERMINAL SHAFT are stationary at a position corresponding to increased fuel necessary to run engine at normal speed under increased load.


VARIABLE SPEED OIL PRESSURE GOVERNOR
WITH SELF CONTAINED OIL PUMP
AND ACCUMULATORS.
SPEED RANGE APPROXIMATELY 2.2:1 RATIO
UNLESS OTHERWISE SPECIALLY ORDERED.
CAPACITY: 8 FT. LBS. (WORK) IN EITHER
DIRECTION THROUGH TERMINAL SHAFT
ROTATION OF 42° THROUGH DIFFERENTIAL
PRESSURE SERVO-MOTOR. OCCASIONALLY
DESIGN REQUIREMENTS NECESSITATE
REDUCING THE CAPACITY TO 4 FT. LBS.
WEIGHT: 50 LBS. APPROXIMATE WITHOUT
AUXILIARY EQUIPMENT.
POWER: APPROXIMATELY 3/10 HP REQUIRED
AT DRIVE SHAFT.
STANDARD FEATURES:
1. SPEED DROOP: ADJUSTABLE BY KNOB FOR 150 CHRONOUS OPERATION OR ANY SPEED DROOP UP TO 75 R.P.M. FOR FULL GOVERNOR STROKE (PROPORTIONATELY LESS FOR SHORTER STROKE.).
2. SPEED ADJUSTMENT: SPEED MAY BE ADJUSTED BY KNOB WITH GOVERNOR RUNNING. FIXED STOPS LIMIT SPEED RANGE.
3. LOAD LIMIT: MANUALLY CONTROLLED BY KNOB FROM FRONT OF GOVERNOR, MAY BE USED AS MANUAL SHUTDOWN.
4. LOAD INDICATOR: PROVIDED ON PANEL.
5. COMPENSATION ADJUSTMENT AND COMPENSATING NEEDLE VALVE EXTERNALLY CONTROLLED.
6. SIGHT OIL GAUGE; AN OIL CUP FILLER PERMITS ADDING OIL IN FIELD AS REQUIRED.
7. DRIVE SHAFT SPEED RANGE: 375–1500 R.P.M. DRIVE IS VERTICAL (FROM BELOW), AND MAY ROTATE EITHER WAY. A BUILT-IN SPRING DRIVE IS PROVIDED.
AUXILIARY AND OPTIONAL FEATURES:
SYNCHRONIZING MOTOR.
OTHER EQUIPMENT FURNISHED TO ORDER.
OUTLINE DRAWING OF TYPICAL
UG 8 DIAL CONTROL GOVERNOR
DWG. NO. 985010
TERMINAL SHAFT MAY EXTEND ON EITHER OR BOTH SIDES.
STANDARD S.A.E. 1/2 – 36 SERRATIONS, BOTH SIDES.
1/16 X 45° CHAMFER BOTH SIDES
3/16 R.
4 7/8 SQUARE
1 3/32 R.
FULL 21/32 SERRATIONS
COMPENSATION ADJUSTMENT
COMPENSATING NEEDLE VALVE
DRAIN PLUG
3250/3248 DIA.
STANDARD S.A.E. 5/8 – 36 SERRATIONS
1/16 X 45° CHAMFER
1/32 MAX. R.
7/8 FULL SERRATIONS
1 3/32
12 17/32
11 11/32
1/32
29/32
1 1/4
9 3/8
NO FUEL
42°
MAXIMUM FUEL
1 1/2
PRESSURE TEST 1/8 PIPE PLUG
5 1/4
4 7/16
2 7/8 DIA.
5 3/4
4 15/16
13/32 R.
7/16 DIA. 4 HOLES
DRIVE SHAFT TO CARRY GEAR OPTIONAL
SPACER SLEEVE
3/16 X 3/32 KEYWAY
5/8 – 18 CASTLE NUT
.6245
.6240
2 1/32
1/4
25/32
4 13/16 SQUARE
5/32 R.
SYNCHRONIZING MOTOR
3 7/8 CLEARANCE
14 15/32
VIEW WITH SYNCHRONIZING MOTOR

Cut No. 11

UG8 GOVERNOR

PART TWO

MAINTENANCE—INTERNAL ADJUSTMENT

INFORMATION AND PARTS REPLACEMENT: When requesting information concerning governor operation and maintenance or ordering replacements parts, it is very essential that the following information accompany the request:

1. Governor serial number (shown on governor name-plate).
2. Bulletin number.
3. Part number, name of part, or description of part. See pages 24, 25, and 27.

OIL CHANGES: See Oil Specifications in Part One. The governor oil should be clean and free of foreign particles. Under favorable conditions, the oil may be used for approximately six months without changing. If the governor does not operate properly, dirty oil may be the cause of the trouble.

To change the oil, take off the top cover, remove the governor from the engine, drain by turning upside down, and flush thoroughly with clean light grade fuel oil to remove any foreign matter. The friction cover may fall out, if loose, but no other parts of the governor will come out unless intentionally disassembled. Drain thoroughly and refill with clean governor oil. Follow the above procedure whenever the governor is removed from the engine.

If it is not possible to shut down long enough to remove the governor from the engine, drain the oil from the governor, fill with clean light grade fuel oil, run for approximately thirty seconds with the Needle Valve open, drain, and refill with clean governor oil.

If the Governor is stored, it should be filled with oil.

WORK REQUIREMENTS: It is suggested that the best mechanic available (preferably one experienced with small parts assembly) be permanently assigned to all governor repair work. Cleanliness of tools and work space is essential. A work bench, vise, arbor press, speed lathe, air line, and containers for cleaning solvents should be provided if possible. The usual small hand tools are required, and a few special Woodward governor tools are desirable if subassemblies are to be disassembled.

GENERAL INSTRUCTION: The governor consists of seven main subassemblies; A, top cover; B, panel; C, case; D, ballhead; E, controlet; F, base; and G, drive shaft. If the governor is to be completely disassembled it should be taken apart in order: A, B, C, D, E, F, and G. If only a part of the governor is to be repaired or adjusted, refer to the particular instruction for that work only, and considerable time and work may be eliminated. *No force is required to separate or reassemble the governor into its subassemblies.* Connecting pins are slip fit and should not be marred with plier jams.

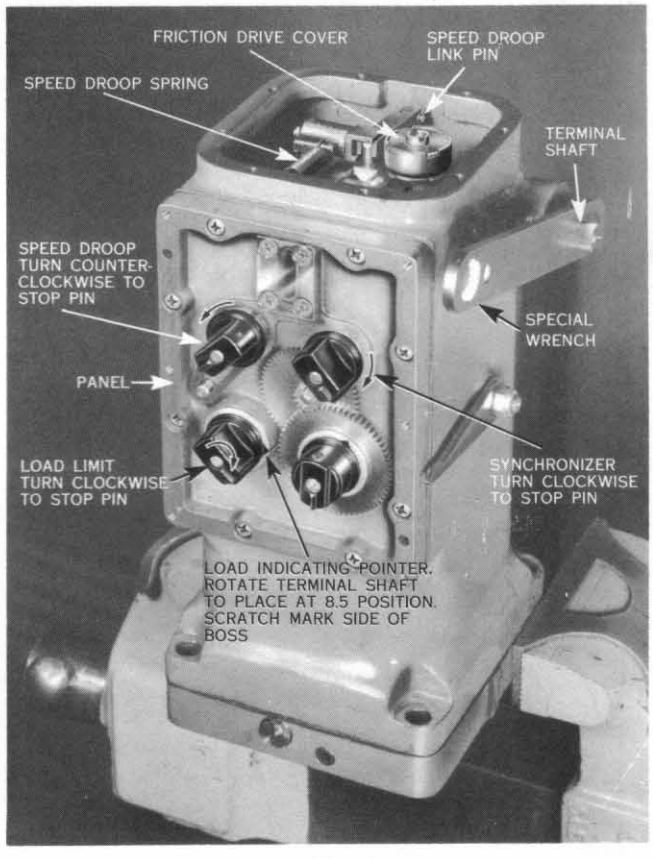
DISASSEMBLY OF MAIN SUBASSEMBLIES:

A. Top Cover (See Cut No. 1.)

1. Remove cover screws and washers, and lift off.

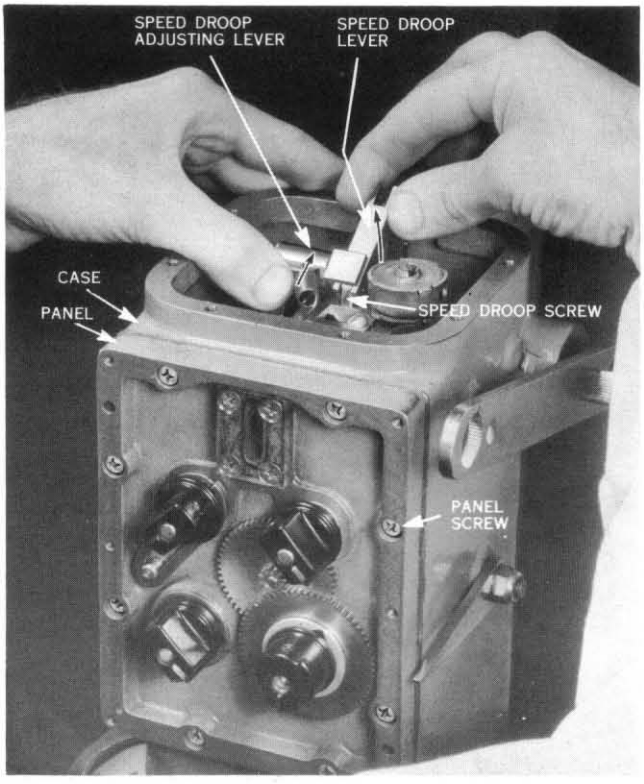
B. Panel (See Cut No. 1. and Cut No. 12.)

1. Drain governor oil by inverting governor; flush with fuel oil and drain again.
2. Turn speed droop knob to zero.
3. Turn synchronizer knob clockwise until it stops. (High Speed Position).
4. Set load limit knob at 10.
5. Rotate terminal shaft with special wrench or linkage lever to set load indicator pointer to 8.5 approximately. When rotating terminal shaft lever downward, push down on load limit strap to release trapped oil. See Cut No. 14 for location of strap.
6. Remove screws and take dial plate off.
7. Scratch mark position of load indicator pointer disk on side of panel boss. This is the 8.5 position. (See Cut No. 12.)



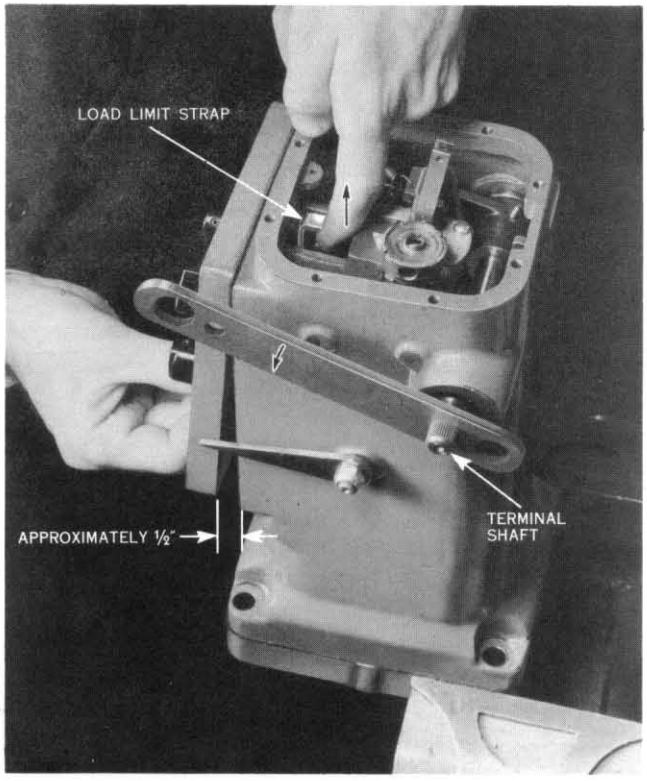
Cut No. 12

8. Unhook speed droop spring, either end.
9. Remove speed droop link pin.
10. Push speed droop adjusting lever back slightly and lift up speed droop lever releasing speeder spring tension. (Cut No. 13.) Do not turn speed droop lever and screw now or later in the work; it will change the maximum or minimum speed adjustment limit of the governor.
11. Remove eight panel screws and washers.
12. Tap panel with plastic hammer or wood block to break loose from case, if necessary.



Cut No. 13

13. Lift load Limit Strap and pull out bottom of panel approximately ½". Rotate terminal shaft as shown by arrow to get power lever down out of way. (Cut No. 14.)
14. Hold up speed droop lever and push bottom of panel in, and top of panel out. (Cut No. 15.)
15. Insert medium size screw driver in upper coils of speeder spring, press down on spring, and turn top of spring into space. Remove spring.
16. Lift up load limit strap again and remove panel turning sideways if necessary to clear other parts

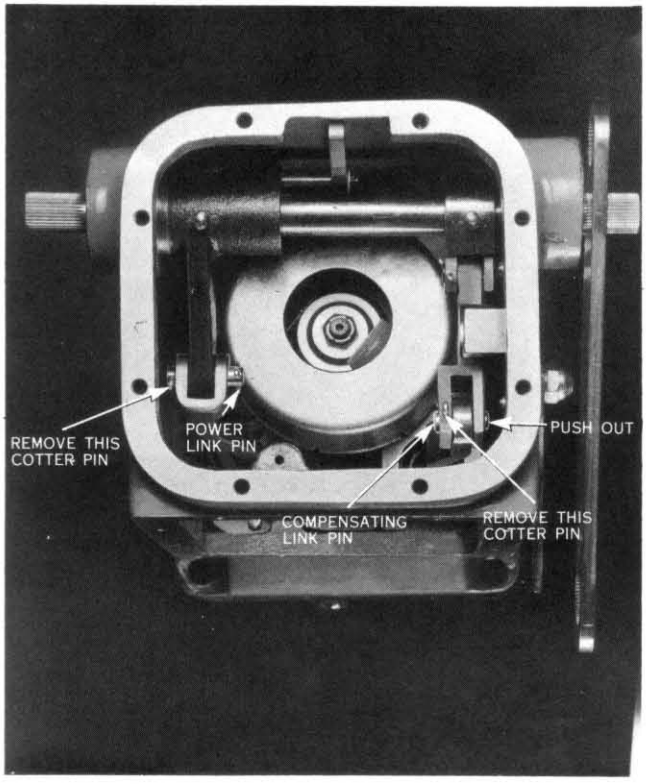


Cut No. 14

Cut No. 15

C. Case

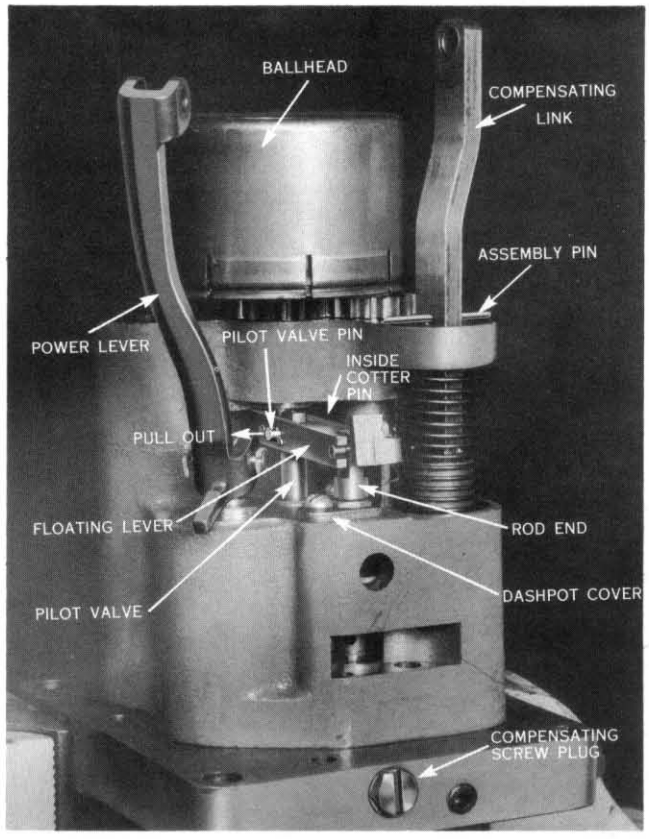
1. Remove cotter and pull out power link pin (Cut No. 16.)
2. Remove cotter and push out compensating link pin with bent wire or hook scriber.
3. Invert governor on bench (no parts will fall out). Remove the four outside nuts.
4. Hold case and base together and set governor upright. Lift case off base. It may be necessary to tap case lightly to break gasket joint loose.



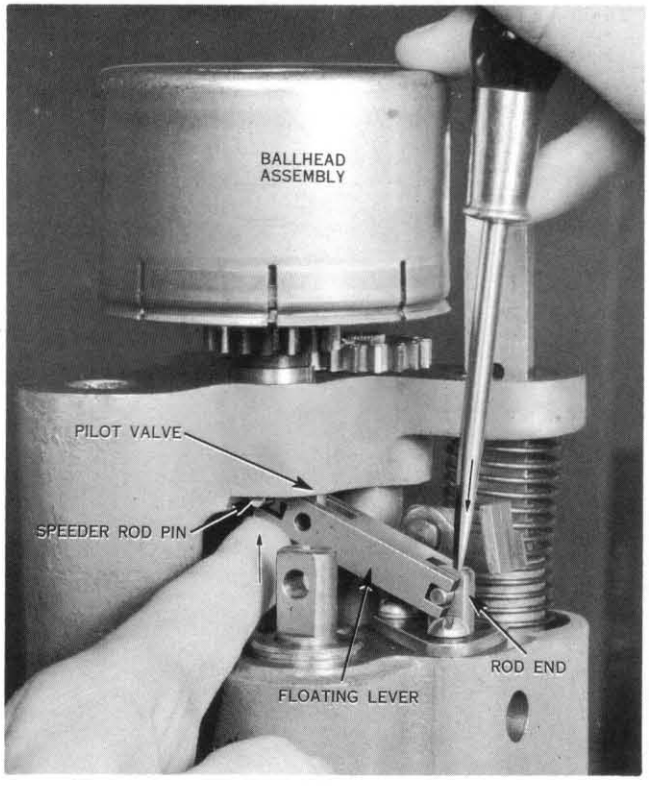
Cut No. 16

D. Ballhead.

1. **Remove inside cotter and pull out pilot valve pin.** (Cut No. 17.)
2. Lift up inner end of floating lever, push down on rod end with screw driver, slip lever backwards releasing lever from rod end pin. (Cut No. 18.) Remove lever.
3. Lift out ballhead assembly.



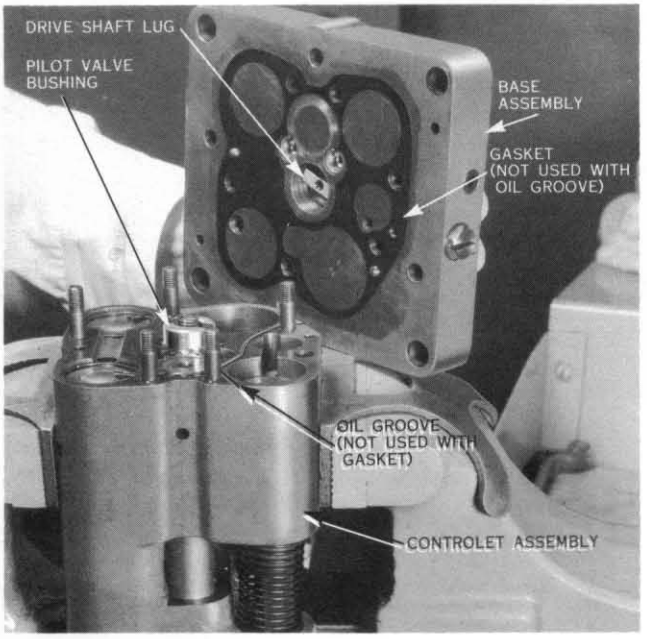
Cut No. 17



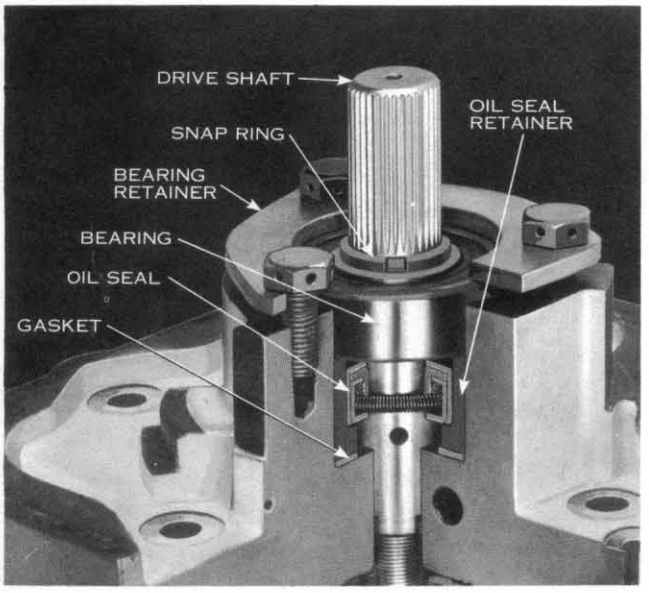
Cut No. 18

E. Controlet

1. Pull up compensating link. Insert assembly pin or rod through hole. (Cut No. 17.)
2. Invert assembly and remove five nuts. If clamped in vise, do not use unnecessary force, and clamp at sides as shown in Cut No. 19.
3. Tap base lightly with plastic hammer and lift off carefully.
4. Let controlet remain in this position unless it is to be adjusted or repaired.



Cut No. 19



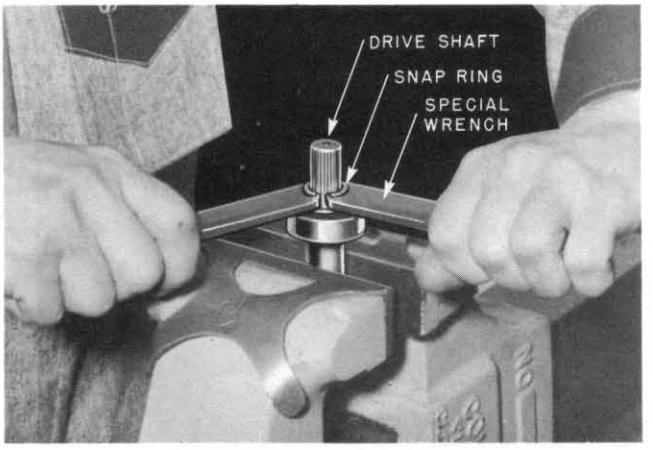
Cut No. 20

F. Base

1. Clamp base inverted in vise, cut lock wire and remove three screws and retainer plate. (Cut No. 20.)
2. Pull out drive shaft assembly, oil seal retainer, and remove seal gasket in bearing bore.
3. If ground surface of base is not perfectly flat, has deep scratches, or is grooved from the pump gears, it must be resurfaced. Drive out dowel pins and surface grind not more than .010″ or, if not possible to surface grind, lap smooth on a flat plate.

G. Drive Shaft

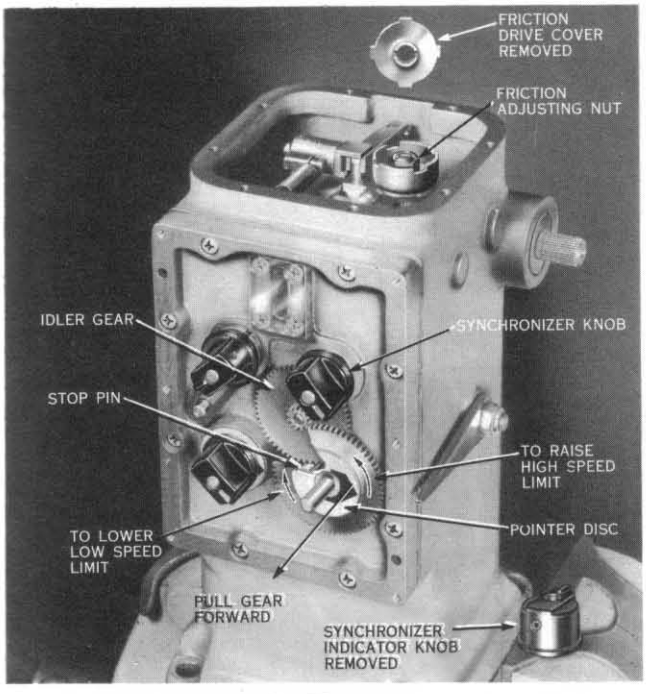
1. Pull off oil seal retainer if on shaft.
2. Remove snap ring if used. See Cut No. 21.
3. Press drive shaft out of bearing.



Cut No. 21

MAXIMUM OR MINIMUM SPEED LIMIT ADJUSTMENT:

1. This adjustment may be made with the engine running. Remove dial plate, (Cut No. 1.) Turn synchronizer to run engine at high maximum or low minimum speed desired.
2. Remove synchronizer indicator knob. The knob may be taper pinned to the shaft in addition to having a set screw. (See Cut No. 22.)
3. Pull gear out of mesh; turn clockwise until gear pin contacts idler gear for setting high speed stop. Turn counter-clockwise until gear pin contacts idler gear for setting low speed stop.
4. Pointer disc may be carefully pried off and reset if necessary. Insert screw-driver inside governor to back up shaft when reinstalling.



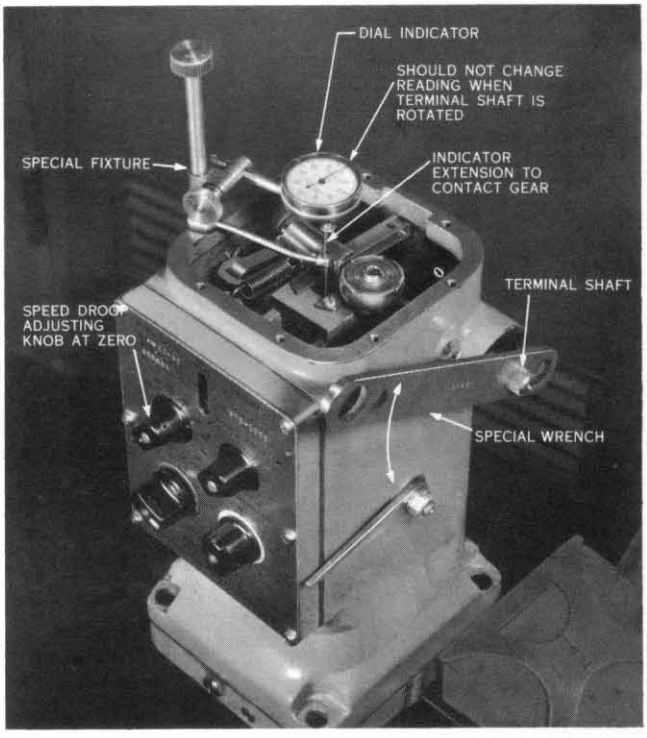
Cut No. 22

SYNCHRONIZING MOTOR: If governor fails to respond to the control switch on switchboard, it may be due to any of the following causes:

1. Low voltage.
2. Short in wiring.
3. Friction drive not properly adjusted. See adjustment procedure below.
4. Motor shaft drive pin slipping out of slot in friction drive cover. Invert cover over a bushing, place a 3/8" steel ball over center hole and strike sharply with hammer to increase crown of cover.
5. Dial plate binding dials or discs. See section V-17, page 23.
6. Motor shaft not linking up with friction drive cover. Loosen motor mounting screws and reposition motor.

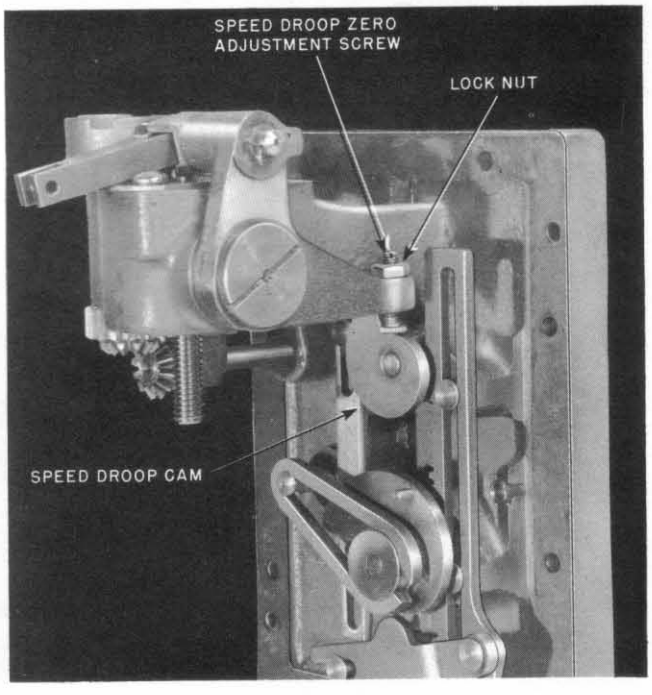
ADJUSTMENT OF FRICTION COUPLING: This coupling must be tight enough to avoid a speed adjustment change due to vibration, and also tight enough to enable the synchronizing motor, if used, to turn the speed adjusting gear. Do not tighten so that the speed cannot be adjusted manually by turning the synchronizer knob. The friction of the coupling may be increased by removing the cover from the governor, prying the drive cover out of the coupling and turning the nut on the shaft clockwise while holding the speed adjusting knob. If the special nut turns too freely, replace it with a new one. (See Cut No. 22.)

ZERO SPEED DROOP ADJUSTMENT: Full 42° rotation of the governor terminal shaft should cause no vertical movement of the speed adjusting gear (that is, no change of governor speed setting) if the speed droop adjusting knob is set on zero. Since perfect adjustment is impractical .002" movement of the gear is allowable.



Cut No. 23

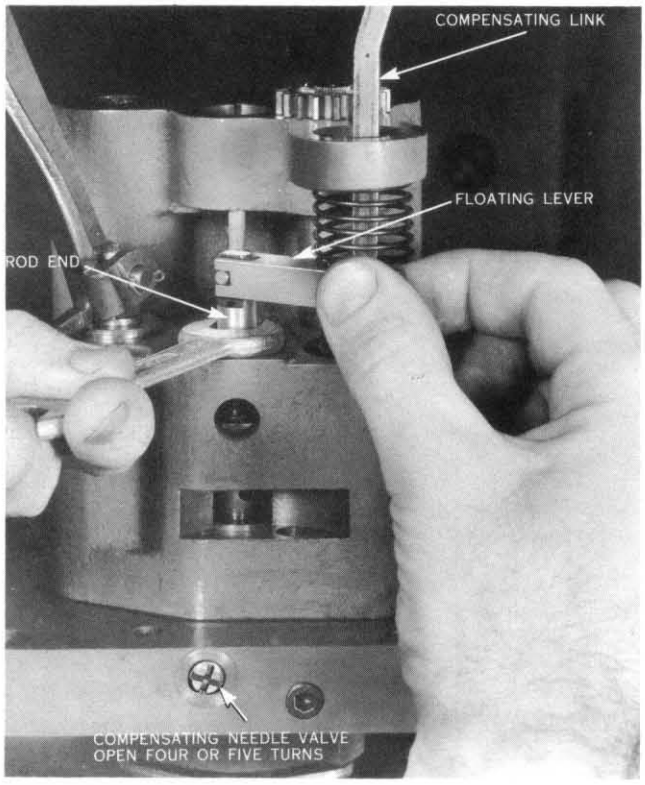
A dial indicator with a special fixture and rod as shown in Cut No. 23 is used in the factory to measure the speed adjusting gear movement. Turn speed droop zero adjustment screw counter-clockwise to reduce movement of gear. (See Cut No. 24.)



Cut No. 24

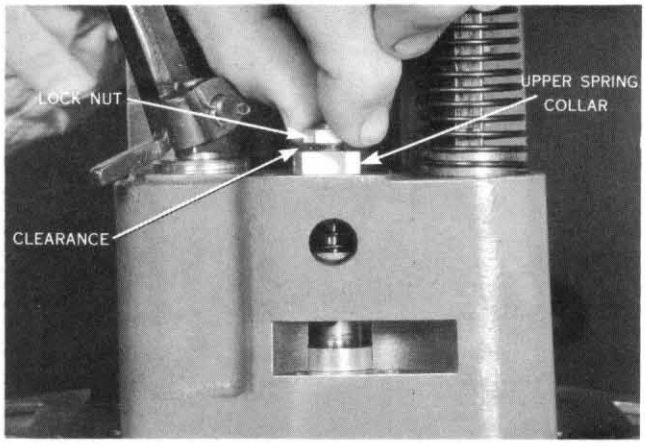
COMPENSATING SPRING ADJUSTMENT:

1. Make disassemblies A, B, C and D. Page 13, 14, and 15.
2. Remove compensating needle valve plug and open compensating needle valve four or five full turns. (Cut No. 25.)

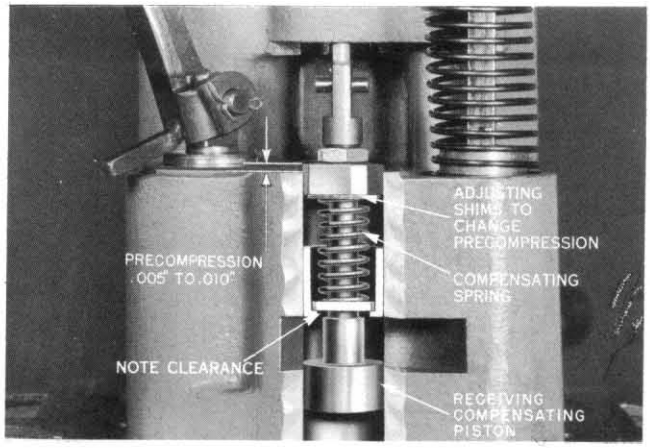


Cut No. 25

3. Plunge assembly into solvent. Move compensating link up and down several times to flush out oil. Blow out controlet and base assemblies with air hose.
4. Remove dashpot cover. (See Cut No. 17.)
5. Unlock rod end and lock nut. Use floating lever for wrench on rod end. (Cut No. 25.) Remove rod end. Unscrew lock nut to make clearance between nut and spring collar when nut is lifted. (Cut No. 26.) Replace rod end.

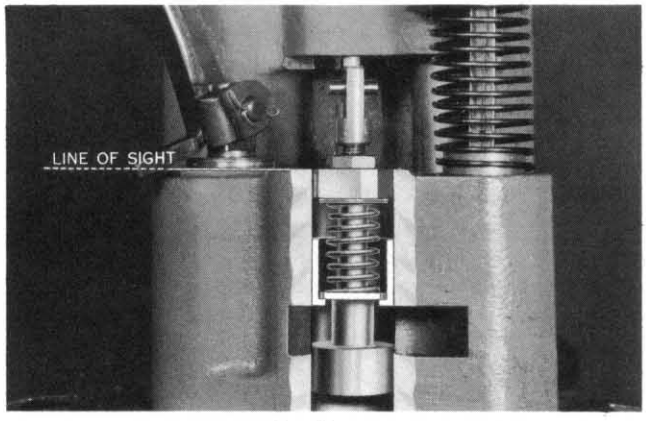


Cut No. 26



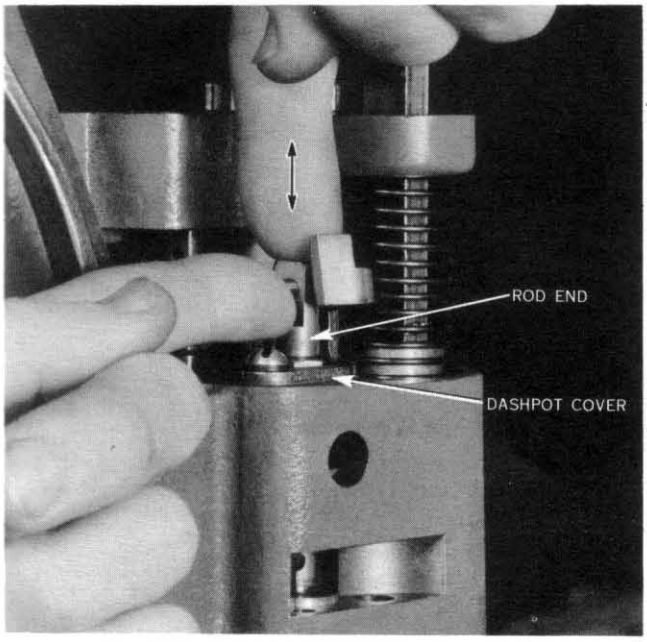
Cut No. 27

6. Measure precompression (Cut No. 27.) With the weight of the compensating receiving piston supported by the upper spring collar, the top surface of the collar should be from .005" to .010" above the machined face of the controlet. A special Woodward gaging tool is available for checking this "Precompression" dimension. Shims are used between the spring and the upper spring collar to make corrections in this dimension, if necessary. Do not change the amount of precompression unless instructions given in Compensation Adjustments, Installation, and Oil Specifications, Part One, and Oil Changes, Part Two, have been followed and operation is still not satisfactory. After once being set for the particular engine and load characteristics, the setting should not be changed. Operating troubles are usually caused by some other factor.



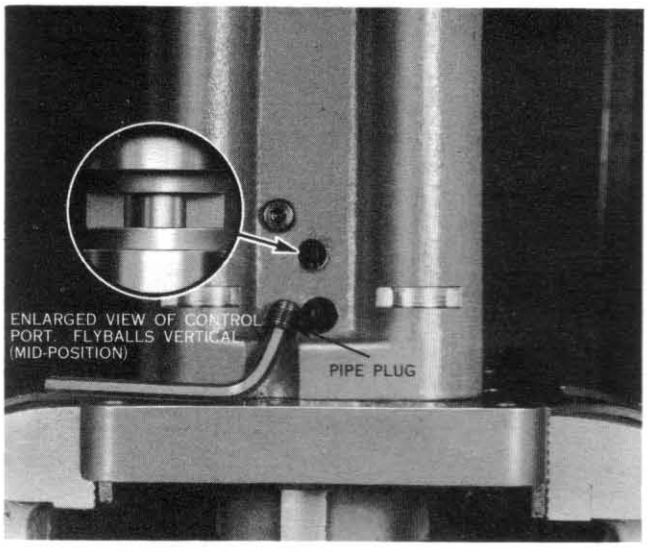
Cut No. 28

7. Tighten nut on piston stem until upper spring collar becomes exactly flush with machined surface. Sight over top as shown in Cut No. 28 while making this adjustment.
8. Replace rod end and lock to nut using floating lever as a rod end wrench. Do not disturb flush adjustment.
9. Replace dashpot cover.



Cut No. 29

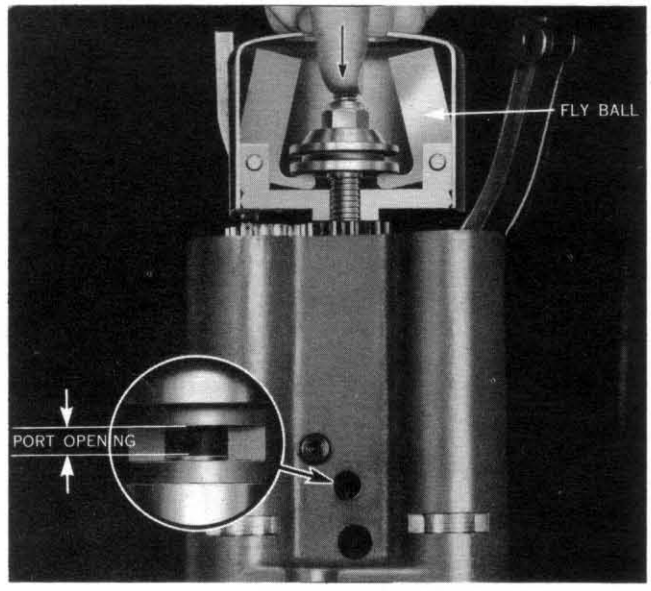
10. Test for lost motion by very delicately moving the rod end up and down with the finger tips (Cut No. 29.) No end play or lost motion allowed. *(Use no force.* The compensating spring will be compressed and the test will be worthless.)
11. If lost motion is felt, it indicates the upper spring collar is not flush with the machined surface as shown in Cut No. 28.



Cut No. 30

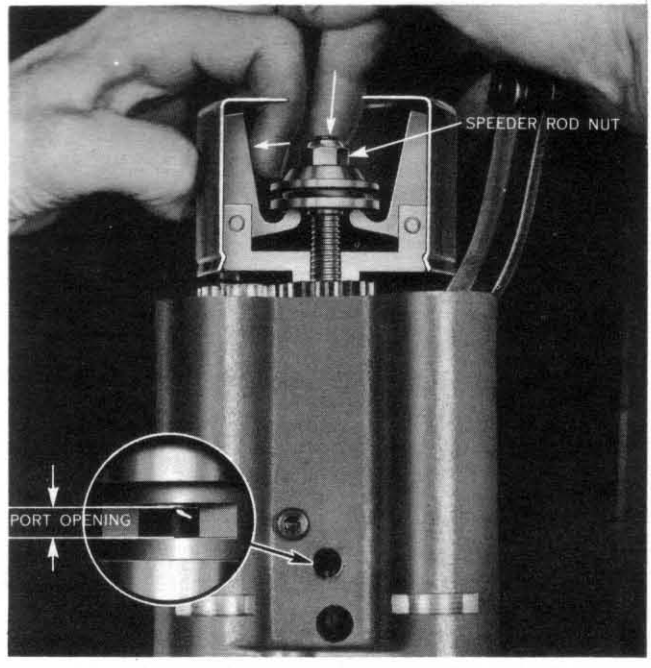
PILOT VALVE ADJUSTMENT:

1. Make disassemblies A, B, and C.
2. Remove pipe plug in passage to control port, (Cut No. 30.) Use flashlight to inspect port opening.
3. Push down on speeder rod, (Cut No. 31.) This will move flyballs to inner position. Note amount of port opening.



Cut No. 31

4. Continue pushing down on speeder rod and move flyballs to outer position raising the pilot valve land, (Cut No. 32.) Note amount of port opening.
5. The amount of opening for inner and outer positions of the flyballs should be the same and should be correct to within .005″.
6. If the pilot valve land needs to be raised, turn speeder rod nut clockwise and vice versa. Recheck adjustment.
7. Replace pipe plug.



Cut No. 32

GENERAL REPAIR INSTRUCTIONS: Refer to paragraphs on work requirements and general instruction, Page 12.

Most of the repair work consists of cleaning and polishing of the governor parts. All pistons, plungers, valves, and rods should move freely without bind or catching. The small dashpot piston and its spring collars frequently give trouble from this cause. Use three cornered scraper to break milled slot and bored hole edges. Do not lap in parts if possible to free up by other means.

Be extremely careful when polishing the pilot valve plunger land; broken corners on the land will ruin this part. Leave corners sharp.

DIAL PANEL LEAKAGE: If oil is visible at the dial panel, remove the dial plate and tighten the panel screws. If this does not eliminate the leak, inspect the load limit oil seal (See Instructions and Cut No. 33) and the oil gauge. The panel oil seals seldom leak, do not replace them unless necessary.

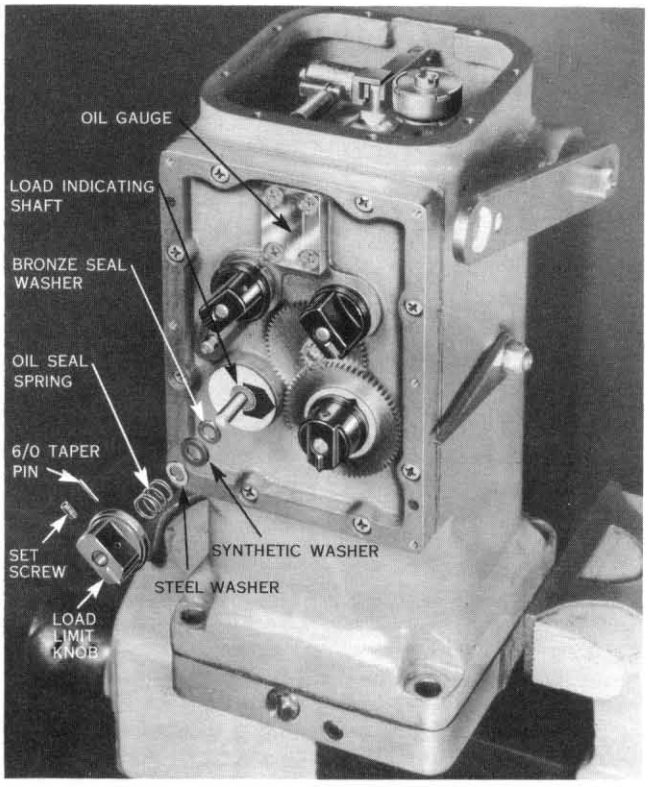
OIL SEALS: If necessary to add a small quantity of oil to the governor oftener than once a week, all of the oil seals should be inspected for leakage. If there is no external indication of a leak, the drive shaft oil seal has been worn or damaged, allowing oil to leak from the governor into the engine housing. See instructions below.

DRIVE SHAFT OIL SEAL AND DRIVE SHAFT BEARING:

1. Make disassembly A-1. Drain oil out of governor, flush and invert.
2. Make disassembly F-1 and 2 and G-1. (Cut No. 20.)
3. Replace oil seal with lip towards chamfered end of oil seal retainer.
4. Inspect drive bearing for wear and freeness of rotation and the shaft for wear from oil seal. Polish or replace if necessary. Remove snap ring if used. Press bearing off shaft and replace if worn or rough turning.
5. Replace bearing and snap ring if used. Insert oil seal and retainer on shaft, using special care not to damage leather lip of oil seal.

LOAD LIMIT OIL SEAL: This seal is of the refrigerator type and depends on perfect contact between lapped surfaces, in addition to the synthetic rubber ring seal on the shaft. (Cut No. 33.)

1. Loosen set screw and drive out the 6/0 taper pin.
2. Remove knob and spring.
3. Inspect surfaces of bronze washer and end of load indicating shaft. Lap together, if necessary.
4. Inspect synthetic rubber seal washer for snug fit on shaft. Replace if necessary.
5. If reason for leakage is not obvious, stretch load limit seal spring to increase sealing pressures.
6. Reassemble. CAUTION: Be sure taper pin holes are not 180° off when driving taper pin.



Cut No. 33

ASSEMBLY INSTRUCTION: A few precautions must be taken when reassembling the governor.

I. Do not drop or rest governor on its drive shaft.

II. Assembly of Drive Shaft Assembly to Base Assembly.

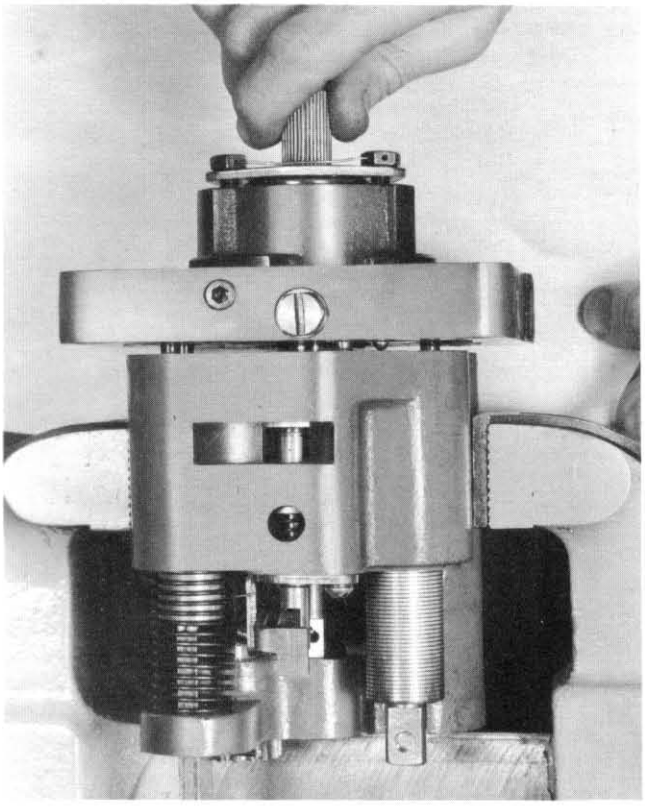
1. Be certain that the vellumoid gasket is in place in the bearing bore between the shoulder and the oil seal retainer. Use new gasket if it appears to be reduced in thickness (Cut No. 20.)
2. Do not press the drive shaft assembly into the bore of the base with an arbor press.
3. Avoid tightening the retainer plate screws too much; it is not necessary, and may bend the plate. There should be ⅛″ space between the plate and the boss.

III. Assembly of Controlet Assembly and Base Assembly.

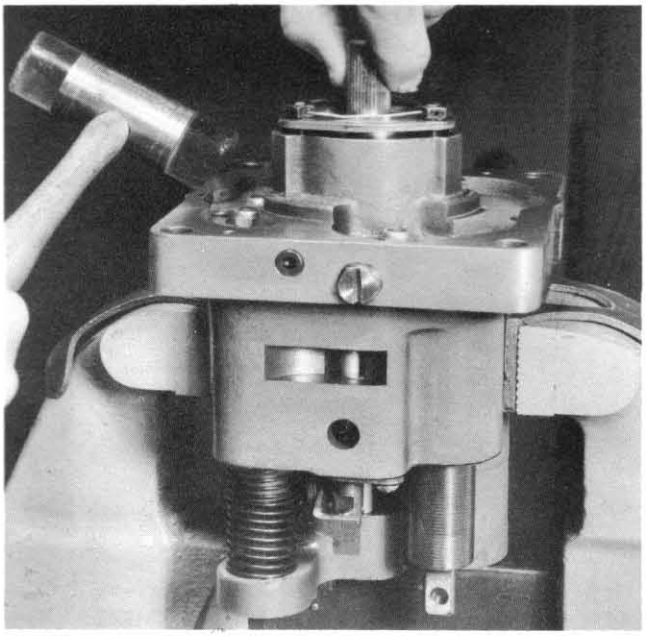
1. Check all pistons and plungers for free movement in bores. Do not lap in if it is possible to free up by removing burrs.
2. Do not shellac the gasket between the base and controlet. If the old gasket is damaged or less then .0025″ thick, replace it with a new one. (See Cut No. 19.) Inspect controlet surface for scratches, nicks, dirt particles, etc. Coat controlet surface with oil, place gasket on controlet (if used), space it evenly around bores for pump gears, place 3/16″ or ¼″ dia. ball on gasket at pin holes and tap the ball to cut out for dowel pins.

NOTE: A gasket is *not* used if controlet has an oil groove. (See Cut No. 19.)

3. The pilot valve bushing, pilot valve, pilot valve spring, and spring tip must be in place before setting on the base.



Cut No. 34

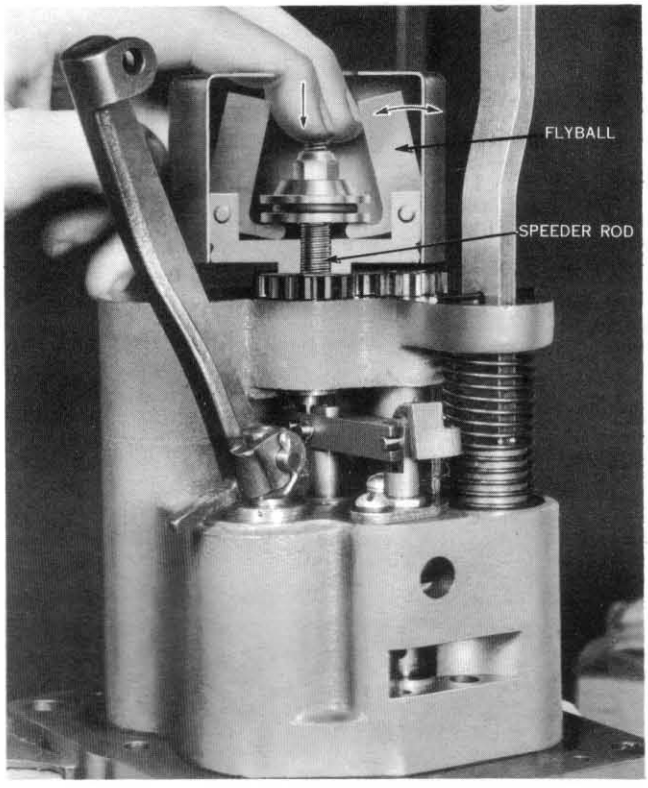


Cut No. 35

4. Clamp controlet lightly in vise (inverted), place base assembly, (Cut No. 19), and turn drive shaft to cause lug on shaft to drop into slot in pilot valve bushing, (Cut No. 34.)
5. Place and tighten nuts. Use cylinder head method for drawing down. Do not exert too much force; the threads may strip.
6. Turn drive shaft. If not free, it must be aligned by loosening nuts and striking at corners of base with plastic or light babbit hammer until shaft turns free, (Cut No. 35.)

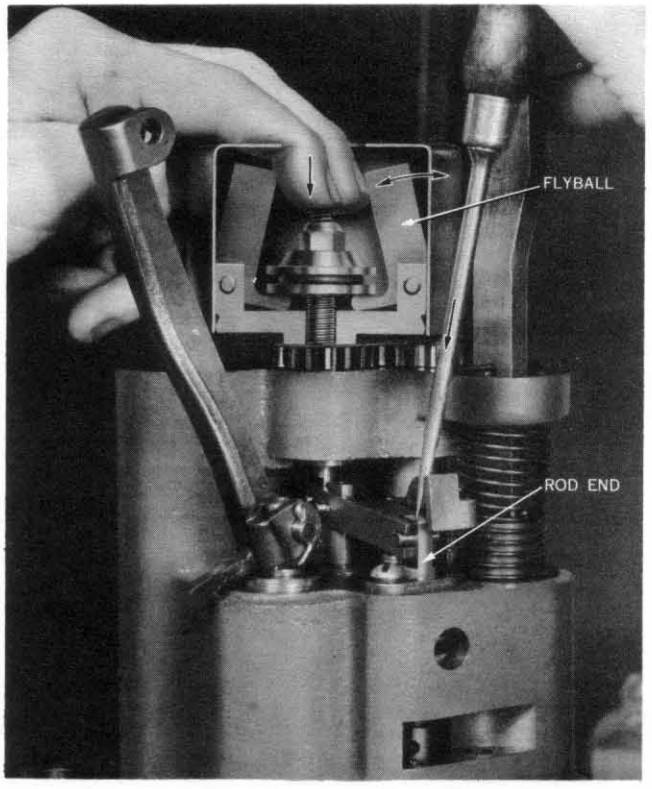
IV. Assembly of Ballhead and Controlet.

1. Place ballhead assembly in controlet. Slide floating lever on speeder rod pin, press down on rod end, and slip lever on rod end pin, straddling pilot valve. (Cut No. 18.) Insert pilot valve pin, (Cut No. 17.) If it will not enter easily, turn pilot valve 180° and try again. Do not cotter yet.



Cut No. 36

2. Test for free action of floating lever.
   a. Push down lightly on speeder rod.
   b. Move one flyball through full travel several times. (Cut No. 36.)



Cut No. 37

c. Press down ¼" approximately on rod end, and move flyballs through full travel. (Cut No. 37.)

d. Lift rod end ¼" approximately and move flyball through full travel. (Cut No. 38.)

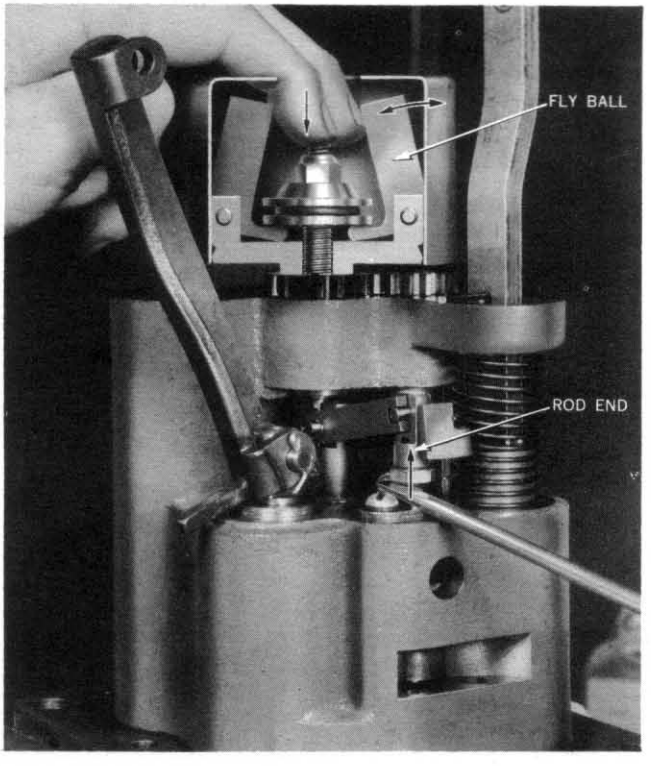
3. If floating lever is not perfectly free under any of the conditions under 2, it will be necessary to try various arrangements of positions of the speeder rod pilot valve, rod end, and floating lever.

   a. Invert floating lever and test.
   b. If unsatisfactory, turn pilot valve 180°, and test.
   c. If still unsatisfactory, try turning rod end or speeder rod 180°, or invert floating lever again.
   d. Continue with combinations of positions of the parts until free action is obtained.

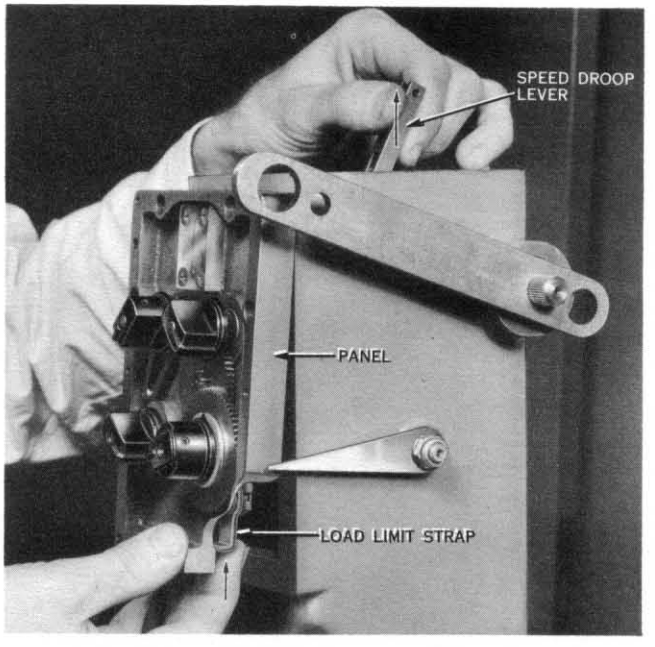
4. Insert cotter pin through pilot valve pin and secure.
5. Check pilot valve adjustment and remove temporary dashpot assembly pin if in large dashpot link hole.

V. Assembly of Panel Assembly to Governor.

1. Reinstall speeder spring.
2. Check to see that load indicator pointer is on 8.5 mark of panel boss, (Cut No. 12.) This may have been accidentally changed at some time during the assembly work.
3. Use special wrench or linkage lever to rotate terminal shaft and power lever prong down. Turn drive shaft to remesh ball head gears if necessary.

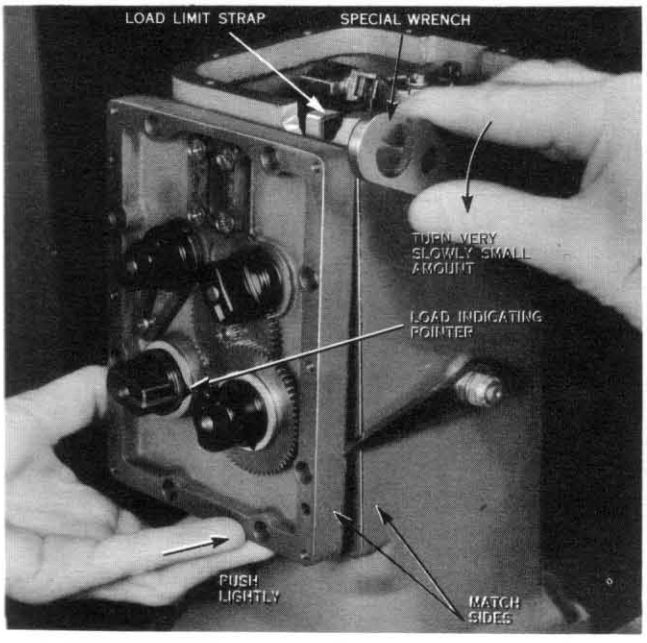


Cut No. 38



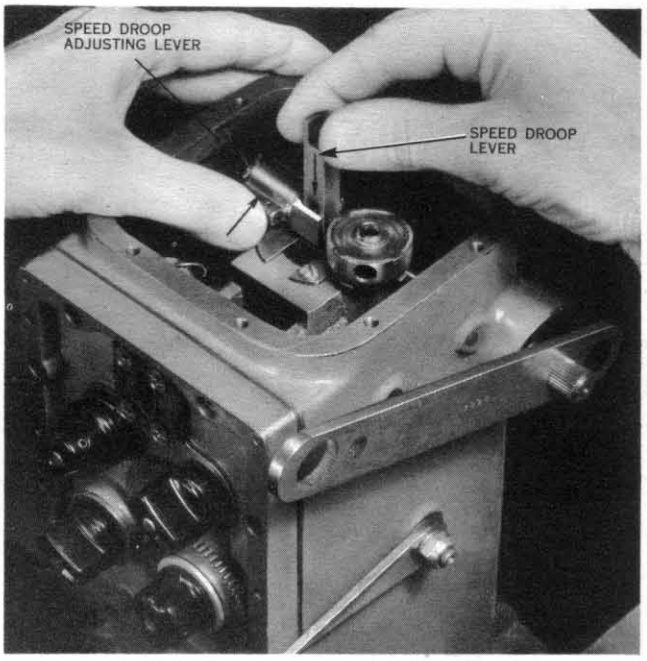
Cut No. 39

4. Insert panel. Push up on bottom of load limit strap to get bottom of panel in, (Cut No. 39.)
5. Insert speeder spring into place while lifting up speed droop lever, (Cut No. 15.)
6. Rest bottom of strap on panel opening shelf. Keep bottom of panel out ½″ and top in against pad.
7. Rotate terminal shaft to raise power link prong to highest position.
8. Match panel outline to outline of pad on sides only.
9. Push panel on gently and rotate special wrench down *very slowly* a small amount until power link prong goes into slot of rack and panel contacts pad surface, (Cut No. 40.) Secure with two panel screws.



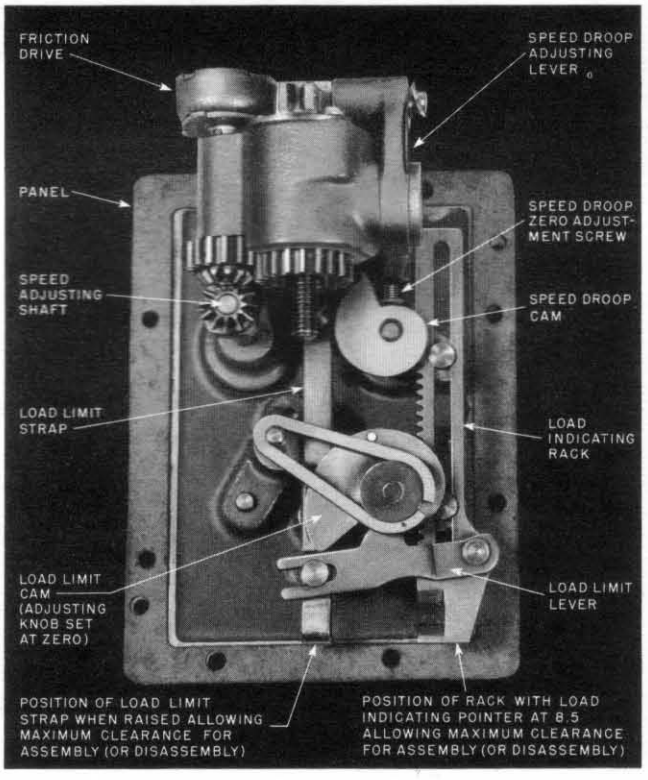
Cut No. 40

10. Rotate terminal shaft once or twice with special wrench. If an oil film remains in controlet, it will be necessary to release pressure in power cylinder when rotating terminal shaft lever downward by pushing down on load limit strap. The load indicating pointer must travel from 0 to 10. If it does not travel both ways, remove panel and try again, starting with 2. If the panel cannot easily be removed, push down on the rack with a screw driver or pull up with a hook until load indicator is at 8.5 position. (See Cut No. 42 and Cut No. 12.)
11. Press down on top of load limit strap. Spring load should be felt, but the strap should move down 3/16″. If not, remove panel and try again starting with 2.
12. Secure panel with lock washers and screws.
13. Push down with speed droop lever as shown in Cut No. 41.
14. Push speed droop adjusting lever back and turn speed droop lever down.

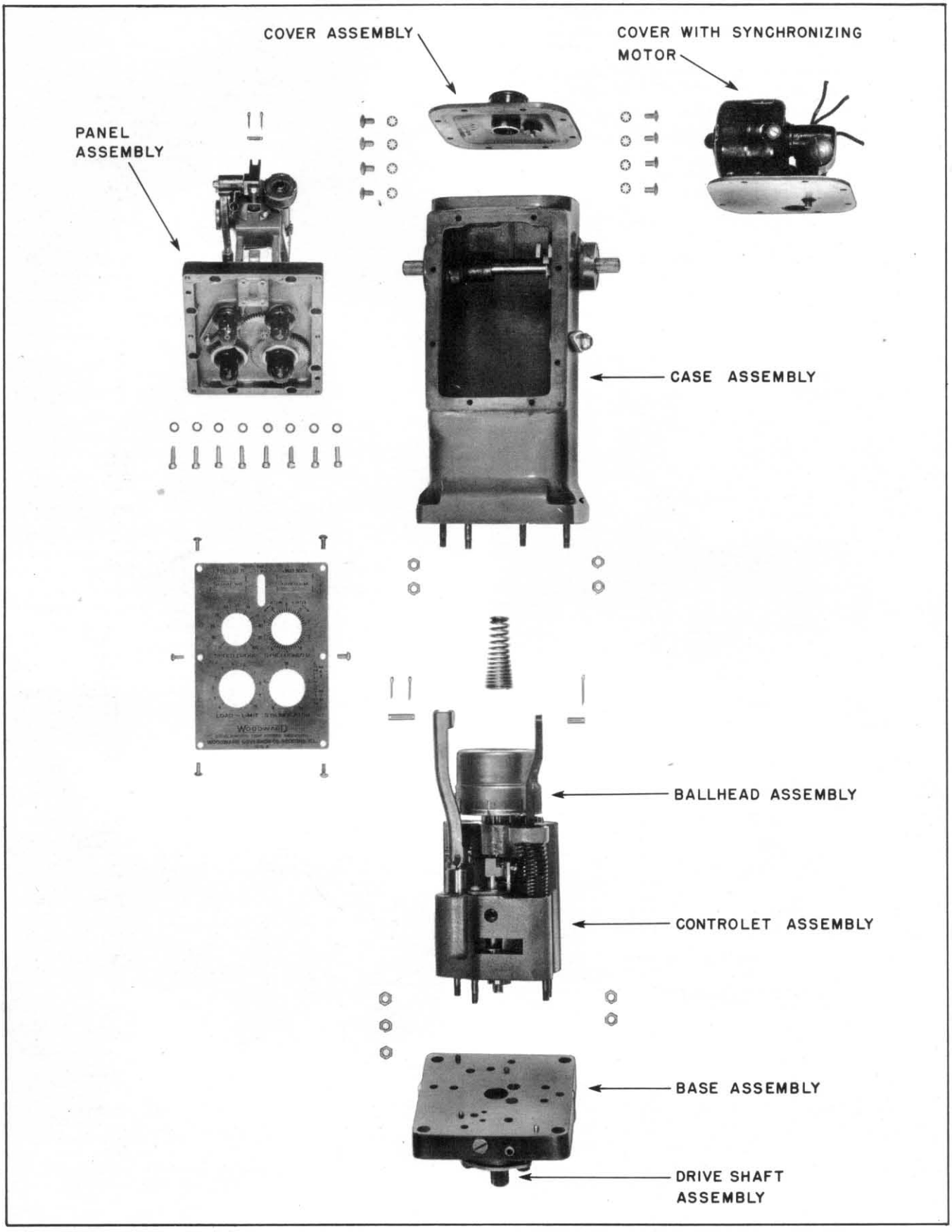


Cut No. 41

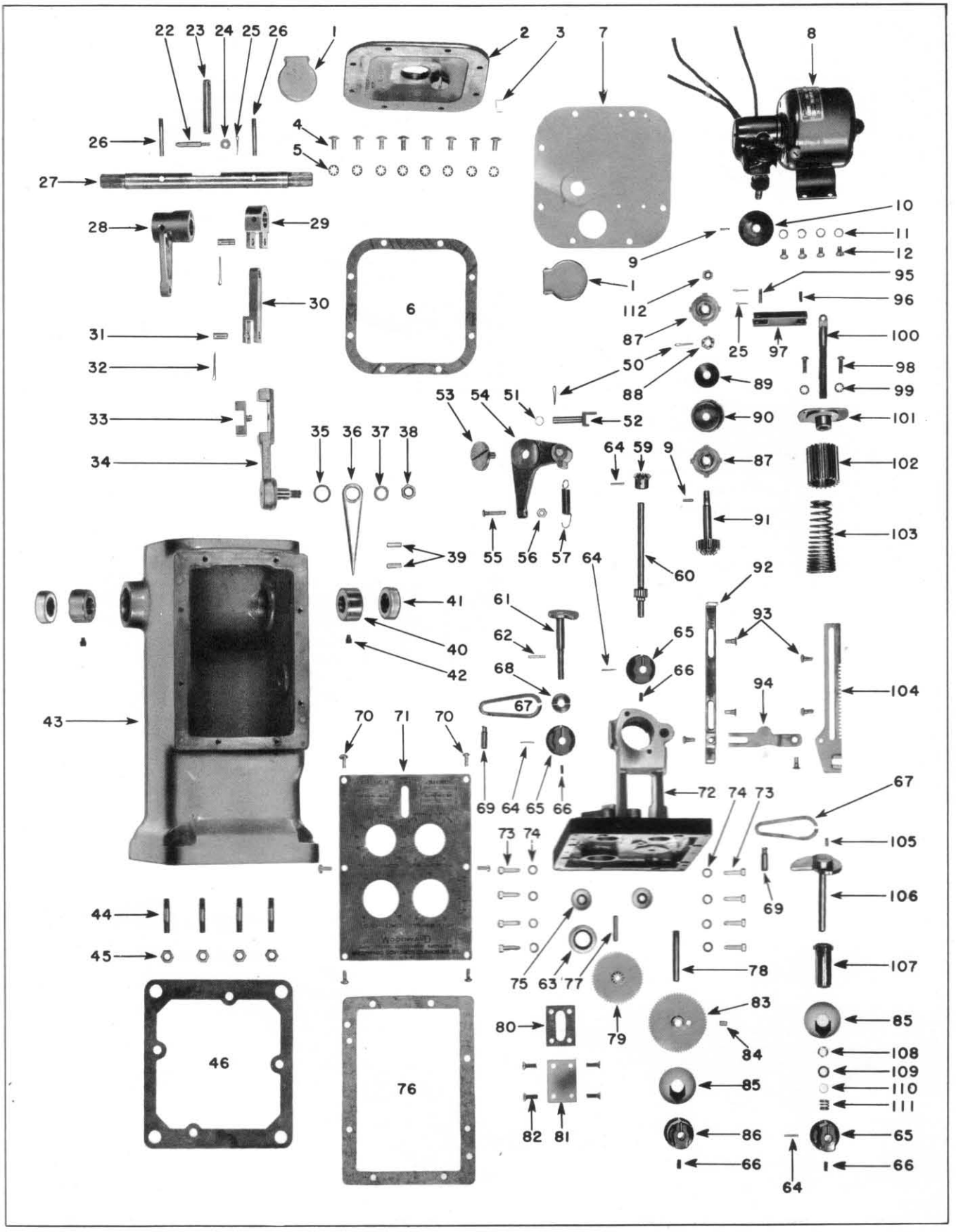
15. Install speed droop link pin, (Cut No. 12.)
16. Install speed droop spring, (Cut No. 12.)
17. Install dial plate. Turn knobs and rotate terminal shaft to be sure dial plate does not bind. If binding occurs, loosen dial plate screws and center dial plate or ream out holes with three corner scrapers.



Cut No. 42


COVER ASSEMBLY
COVER WITH SYNCHRONIZING MOTOR
PANEL ASSEMBLY
CASE ASSEMBLY
BALLHEAD ASSEMBLY
CONTROLET ASSEMBLY
BASE ASSEMBLY
DRIVE SHAFT ASSEMBLY

Cut No. 43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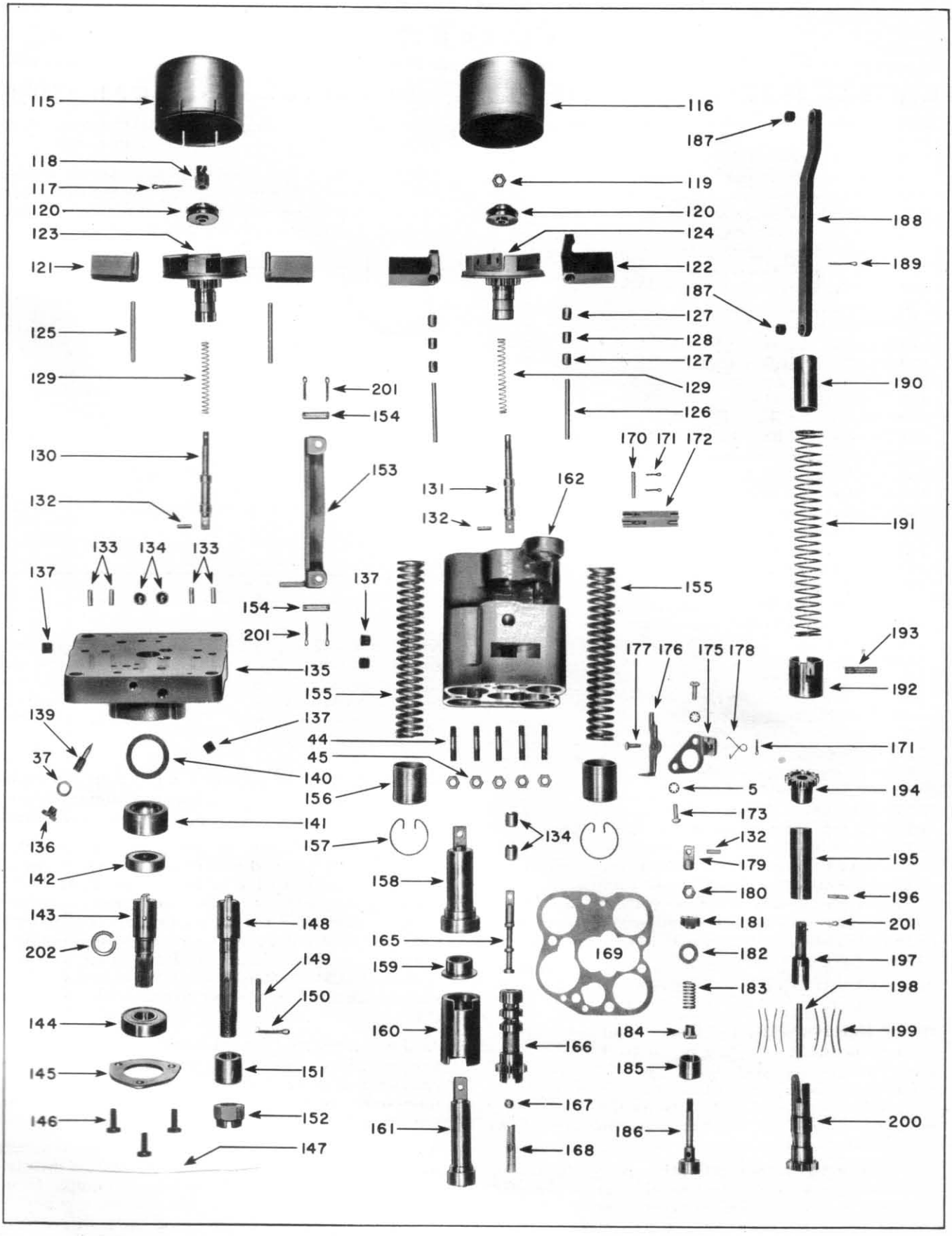
Cut No. 44

Number of Part	Name of Part	No. Req'd.
1	Oil Filler Cup	1
2	Cover	1
3	Key	1
4	10-32 x 3/8" Phillips Head Screws	8
5	No. 10 Shakeproof Lockwashers	8
6	Case—Cover Gasket	1
7	Motor Plate	1
8	Synchronizing Motor	1
9	3/32" x 3/8" Pin	2
10	Motor Seal Spring	1
11	3/8" x 13/64" x 1/16" Washer	4
12	8-32 x 1/4" Rd. Hd. Mach. Screw	4
22	Power Lever Pin	1
23	Speed Droop Link	1
24	9/64" x 3/8" x 1/32" Washer	1
25	1/32" x 3/8" Cotter Pin	3
26	Taper Pin	2
27	Terminal Shaft	1
28	Power Lever	1
29	Compensating Lever	1
30	Compensating Adjusting Link	1
31	Compensating Lever Pin	2
32	1/16" x 7/8" Cotter Pin	2
33	Compensating Adjusting Fulcrum	1
34	Compensating Adjusting Lever	1
35	5/8" x 7/16" x 1/32" Seal Washer	1
36	Compensating Adjusting Pointer	1
37	17/32" x 31/64" x 1/32" Copper Washer	1
38	5/16"-24 Elastic Lock Nut	1
39	Compensating Adjusting Lever Stop Pin	2
40	Terminal Shaft Bushing	2
41	Terminal Shaft Oil Seal	2
42	1/4"-28 x 5/16" Set Screw	2
43	Case	1
44	Stud	9
45	1/4"-28 Elastic Lock Nut	9
46	Case—Base Gasket	1
50	1/16" x 1/2" Cotter Pin	2
51	1/4" I.D. x 11/32" O.D. x 1/32" Washer	1
52	Speed Droop Fulcrum	1
53	Speed Droop Lever Screw	1
54	Speed Droop Adjusting Lever	1
55	Speed Droop Adjusting Screw	1
56	No. 8-32 Machine Screw Nut	1
57	Speed Droop Lever Spring	1
59	Synchronizer Adjusting Gear (Horiz.)	1
60	Synchronizer Shaft Assembly	1
61	Speed Droop Cam	1
62	Speed Droop Shaft Pin	1
63	Oil Seal (Load Limit)	1
64	No. 6/0 Taper Pin—3/4"	4
65	Adjusting Knob	3
66	Hex Socket Hd. Set Screw	4
67	Speed Droop Friction Spring (2 used on governor)	2
68	Speed Droop Friction Collar	1
69	Friction Spring Pin	2
70	No. 8-32 x 3/8" Phillips Binding Head Screw	6
71	Dial Plate	1
72	Panel	1
73	No. 10-32 x 5/8" Phillips Fil. Hd. Screw	8
74	No. 10 Split Spring Lockwasher	8
75	Oil Seal (Syn. Shaft)	2
76	Panel Gasket	1
77	Idler Shaft	1
78	Synchronizer Indicator Shaft	1
79	1st. Reduction Gear	1
80	Oil Level Gauge Glass Gasket	1
81	Oil Level Gauge Glass	1
82	No. 8-32 x 1/2" Long Phillips Flat Hd. Mach. Screw	4
83	Synchronizer Indicating Gear	1
84	Stop Pin	1
85	Synchronizer Indicator Pointer	2
86	Dummy Knob	1
87	Synchronizer Friction Drive Cover	2
88	1/4"-28 Castle Nut—Old Style	1
89	Synchronizer Friction Drive Spring	1
90	Synchronizer Friction Drive Case	1
91	Synchronizer Adjusting Gear	1
92	Load Limit Strap	1
93	Rack Pin	6
94	Load Limit Lever	1
95	Speed Droop Link Pin	1
96	Speeder Screw Pin	1
97	Speed Droop Lever	1
98	No. 8-32 x 3/8" Long Phillips Head Screw	2
99	No. 8 Shakeproof Washer	2
100	Speeder Screw	1
101	Speeder Screw Guide	1
102	Speeder Plug & Gear Assembly	1
103	Speeder Spring	1
104	Load Limit Rack	1
105	Stop Pin	1
106	Load Limit Cam Assembly	1
107	Load Indicator Gear	1
108	Bronze Washer	1
109	Neoprene Washer 3/8" x 1/4" x 1/16"	1
110	Steel Washer 11/32" x 1/4" x 1/32"	1
111	Oil Seal Spring	1
112	1/4-28 Elastic Nut	1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Cut No. 45

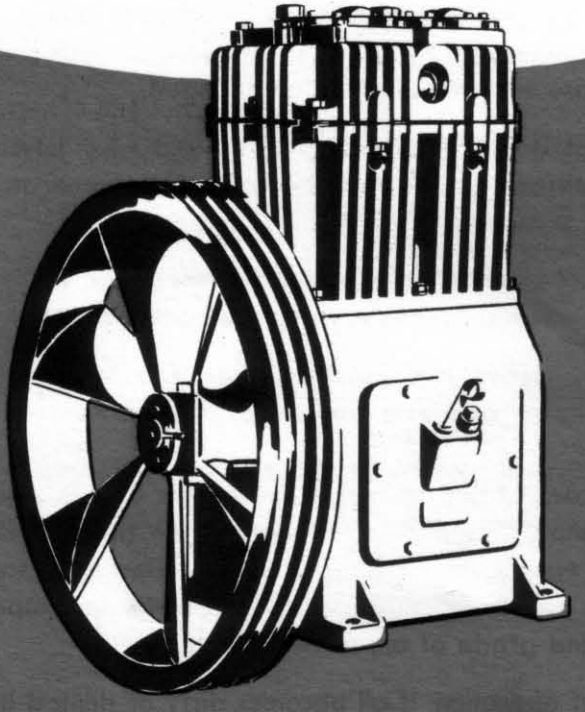
Number of Part	Name of Part	No. Req'd.
115	Ballhead Cover—Old Style	1
116	Ballhead Cover—New Style	1
117	1/16" x 3/4" Cotter Pin	1
118	Speeder Rod Nut	1
119	1/4"-28 Elastic Lock Nut	1
120	Thrust Bearing	1
121	Ball Arm—Old Style	2
122	Ball Arm—New Style	2
123	Ballhead & Gear Assembly—Old Style	1
124	Ballhead & Gear Assembly—New Style	1
125	Ball Arm Pin—Old Style	2
126	Ball Arm Pin—New Style	2
127	Needle Bearing—New Style	4
128	Bearing Spacer—New Style	2
129	Speeder Rod Spring	1
130	Speeder Rod—Old Style	1
131	Speeder Rod—Old or New Style	1
132	Speeder Rod and Rod End Pin	2
133	Dowel Pin	4
134	Check Valve Assembly	4
135	Base	1
136	Compensating Valve Plug	1
137	1/8" Socket Hd. Pipe Plug	4
139	Compensating Needle	1
140	Oil Seal Retainer Gasket	1
141	Oil Seal Retainer	1
142	Oil Seal	1
143	Serrated Drive Shaft	1
144	Double Shield Bearing	1
145	Bearing Retainer	1
146	1/4"-28 x 5/8" Hex. Screw—Head Drilled #50 for Wire	3
147	.035" Brass Lockwire	1
148	Keyed Drive Shaft	1
149	Drive Key	1
150	1/8" x 1-1/2" Cotter	1
151	Drive Shaft Gear Spacer	1
152	5/8"-18 Castle Nut	1
153	Power Piston Link	1
154	Power Link Pin	2
155	Accumulator Spring	2
156	Accumulator Piston	2
157	Accumulator Snap Ring	2
158	Power Piston—1-3/8" Dia.	1
159	Reducer Bushing for 1" Power Piston	1
160	Reducer Bushing for 1" Power Piston	1
161	Power Piston 1" Dia.	1

Number of Part	Name of Part	No. Req'd.
162	Controlet	1
165	Pilot Valve Plunger	1
166	Pilot Valve Bushing	1
167	Pilot Valve Spring Tip	1
168	Pilot Valve Spring	1
169	Controlet Gasket (Not used if controlet has oil groove. (See Cut No. 16)	1
170	Pilot Valve Pin	1
171	1/32" x 3/8" Cotter Pin	3
172	Pilot Valve Floating Lever	1
173	10-32 x 1/2" Rd. Hd. Machine Screw	2
175	Dashpot Cover	1
176	Load Limit Shutdown Lever (Dial Gov. only)	1
177	Load Limit Lever Pin (Dial Gov. only)	1
178	Load Limit Lever Spring (Dial Gov. only)	1
179	Compensating Receiving Piston Rod End	1
180	Compensating Receiving Piston Lock Nut	1
181	Upper Spring Collar	1
182	Compensating Spring Shim	As Rqd
183	Compensating Spring	1
184	Lower Spring Collar	1
185	Dashpot Bushing	1
186	Compensating Receiving Piston	1
187	Oil Bronze Bushing	2
188	Compensating Actuating Piston Link	1
189	3/32" x 7/8" Cotter Pin	1
190	Compensating Actuating Piston Spring Sleeve	1
191	Compensating Actuating Piston Spring	1
192	Compensating Actuating Piston	1
193	Compensating Actuating Piston Link Pin	1
194	Ballhead Drive Gear	1
195	Retaining Sleeve	1
196	2/0 Taper Pin	1
197	Ballhead Gear Driver	1
198	Spacer Pin	1
199	Spring Drive Lamination	As Rqd
200	Pump Driven Gear	1
201	1/16" x 1/2" Cotter Pin	5
202	Snap Ring	1

INSTRUCTION MANUAL

for proper lubrication of

Quincy COMPRESSORS



FOR PROMPT, DEPENDABLE SERVICE CALL YOUR LOCAL QUINCY AUTHORIZED SERVICE DEPOT LISTED ON THE BACK COVER OF THIS INSTRUCTION MANUAL

Read Carefully and Keep for Future Reference

QUINCY Compressors are built with three types of lubricating systems, using the crankcase as a sump or container for the oil.

MODELS X-2 and X-8 are lubricated by oil splash dippers on the connecting rods.

MODELS A-4, 106, R-15, R-17, 212, 216, 230, 308, 310 and 325 are lubricated by oil splash dippers on the connecting rods which dip into oil carried in troughs. The oil is maintained at a constant level in the troughs by a central oil supply ring.

MODELS 244, WW-33, WW-44, WW-64, WW-80, 330, 340 and 390 are lubricated by a self-reversing gear pump, supplying oil under pressure to both crankpin and wrist pin bearings. Other points are lubricated by spray from crankpins. Oil pressure should be maintained between 7 pounds and 15 pounds.

Oil pump is of the gear type mounted on the end of the crankshaft. It is self-reversing and will operate in either direction of rotation without any mechanical adjustment. **If, when the new compressor is first started, no oil pressure shows on the oil gauge, it will be necessary to stop the compressor and prime the oil pump.** The oil pump is primed easily by removing either of the hexagon plugs that screw into the top of the oil pump casting (see blue tag on compressor). After removing one of these plugs a steel ball valve will be seen which will have to be raised off its seat with a small tool or wire. With this ball valve held off its seat, proceed to pour oil over the ball sufficiently to prime the pump. After this is done, replace the hexagon plug and start the compressor and pressure should show on the oil gauge. It will not be necessary to prime the pump again until perhaps at some time when all the oil in the crankcase is drained out to be changed.

When compressors are operated only for short periods and very intermittent service, the regular automotive oils are satisfactory, but when compressors are operated fairly constantly, such as industrial applications, a quality lubricating oil should be used.

We recommend the use of a turbine oil or a compressor oil where available. If not available use a quality or heavy duty automotive oil.

The larger sizes of compressors are seldom used for services other than industrial and automotive type oils are not recommended.

CAUTION Crankcase of this machine was drained before shipping. Before starting this compressor be sure and fill crankcase to full mark on bayonet oil gauge. Oil level must be maintained between two marks on gauge. NEVER allow it to fall below the lower mark. Type of oil depends on operating conditions and surrounding temperature at point of installation. For proper type and grade of oil, refer to table.

Change oil every 500 hours of operation. If oil becomes dirty or diluted before 500 hours, it should be changed. Crankcase should be thoroughly cleaned every time the oil is changed.

The following table lists the crankcase capacity, grade of oil to be used with different climatic conditions and the type of oils for different operating conditions:

Automotive oils are shown in blue in the table.

Quality lubricating oils are shown in red in the table.

Instructions for Installing and Operating Quincy Compressors

Tapered Roller TIMKEN BEARING EQUIPPED

CONSTANT LEVEL LUBRICATING SYSTEM

THERE IS NO OIL IN THIS COMPRESSOR. SEE PARAGRAPH D BEFORE STARTING THIS MACHINE

Compressors should be installed in locations free from excessive dust and affording ample light and room for inspection. They should be supported on substantial foundations, the size depending upon local conditions.

(A) **The Compressor Intake** should be installed at the source of cool, clean air. If it is impossible to have a source of clean air, it is advisable to equip the intake with an efficient air filter to minimize the wear of the cylinder and valves occasioned by foreign matter.

(B) **The Size of Intake** piping should be the full diameter of opening in the cylinder head and as short and free from bends as possible. The intake should be so arranged as to exclude any possibility of water getting therein.

(C) **The Discharge piping** between compressor and tank should be full diameter of discharge opening in the cylinder head and should be as free from bends as possible. The joints in the discharge piping should be made as tight as possible by applying white lead to the threads. Even small leaks are expensive.

(D) **Compressor Lubrication.** For information covering proper amount and type of oil, see Instruction Manual for Proper Lubrication for Quincy Compressors.

(E) **Fan Type Flywheel.** Compressor should be run in the direction of the arrow on the flywheel for proper cooling. Deep cooling fins are provided on the cylinders, and two-stage compressors are equipped with a heavily finned tube intercooler. All the cooling fins should have the benefit of the air blast from the fan blades. It is best not to install the compressor with the fan flywheel too close to a wall.

Check Valve. No check valve is used between compressor and tank on complete outfits that we build and none is required on compressors purchased separately from us provided the compressor is equipped with a QUINCY "lapped" discharge valve. This valve is tight and a check valve which is usually noisy is not required.

(F) **Motor.** The electrician should check the name plate on the motor to determine whether the motor is the correct type for the available electric current. Some motors are designed to operate on more than one voltage and are so stamped on the nameplate. If it is stamped 110 or 220 volt, we at all times recommend using 220 if it is at all available, as all household appliances use 110 volt current and this causes considerable voltage fluctuation. If 110 volt current is used, install compressor as close to meter as possible and run a separate line of heavy wire from meter direct to motor through motor control switches. The electrician should see that the motor and compressor run in the direction of the arrow on the fan flywheel. A fused cut out switch should be installed near motor to permit cutting off current when outfit is not in use.

A Safety Starting Switch is essential on all polyphase motors. This is in addition to the fuses and is necessary to protect the motor from damage caused by phase failure, overloads and low voltage conditions. We can furnish this switch if desired or it may be obtained from your electrical dealer.

Direct Current Motors should never be operated without suitable motor starting switches.

(G) **Motor Lubrication.** For information covering electric motor, see Instruction Tag attached to motor.

(H) **Valves.** Each cylinder has two valves, one intake and one discharge. Each valve assembly consists of the valve itself, the valve seat, the valve spring and valve bumper, or spring holder. The suction valve assembly is installed with the spring underneath the valve. The valves are opened by the air passing through them and closed by the springs.

(J) **Unloading.** When starting with pressure in the tank the load on the motor is reduced by unloading the compressor (not allowing it to pump). The unloaded period must be long enough to permit the motor to come up to full speed. Unloading is accomplished by holding the intake valve off its seat and if the compressor is a "two-stage" type the air in both cylinders and intercooler is released to atmosphere. There are three types of unloaders:

Centrifugal Unloader for Service Station or Garage Compressors or any to be automatically unloaded whenever stopped.

Hand Unloader for installations where the operator is to have the responsibility of unloading manually; (Knob or "T" handle must be screwed down).

Suction Unloader for compressors used for paint spraying, operating pneumatic tools, or any service where the compressor is to run continuously but is to run unloaded whenever the air supply is greater than the demand.

(K) **Control.** Automatic switch is used on all outfits where the motor is to be started and stopped automatically. It is connected directly to the air receiver and starts and stops the motor at the pressures stamped on the name plate. DO NOT CHANGE THIS SETTING UNLESS TO REDUCE PRESSURE.

(OVER)

(L) **Belts.** V belts require no dressing of any kind and should not be run under excessive tension. Motor and compressor pulleys should always be in perfect alignment. If belt should become excessively loose the slack should be taken up by sliding motor back a trifle. When belt tension is adjusted, be sure to realign pulleys.

(M) **Shut Off Valve.** Be sure to place a union between this valve and air line.

(N) **Safety Valve** is set at a pressure slightly higher than the automatic switch or suction unloader. Proper setting is made at the factory and it should not be changed.

ADJUSTMENTS AND SERVICING

Low Voltage. If motor does not come up to full speed the trouble is undoubtedly caused by insufficient voltage. This may be proven by removing the silencer or air filter and holding your hand over the air intake opening. The compressor is then unloaded and if the motor accelerates to full speed it indicates that due to low voltage the motor hasn't sufficient power. This condition must be corrected at once. Have your local power company MAKE A VOLT METER TEST AT MOTOR TERMINALS while compressor is pumping against maximum pressure. Power companies are required to furnish current of normal voltage and if necessary you should demand this.

(O) **Valves.** If compressor does not operate as efficiently as when installed, be sure that there are no leaks in fittings, pipe line, or hose and that compressor is operating at proper speed. If still inefficient, probably some foreign matter has lodged between the valve discs and seats, preventing valve discs from seating properly. Do not attempt to inspect valves without releasing all the air from the air receiver or storage tank. Each valve assembly is located in a separate pocket in cylinder head and is held in place by a threaded sleeve. The threaded sleeve extends through the top of the cylinder head and is covered by a plain cap or part of the unloader. The unloader part can be removed altogether in the same manner as the plain cap. With the threaded sleeve screwed out, the entire valve assembly can be lifted easily with a pair of pliers and dissassembled in a vise. Clean the entire assembly in gasoline and replace, making sure that each assembly is put back in the correct pocket and that the correct side is "up." The spring must be on the top side of the valve disc in the discharge assembly. Each spring should be examined carefully before the assembly is put back in the head to make sure that it has life enough to snap the valve disc back on its seat quickly. Gaskets must be assembled in their original positions. All parts subject to wear are renewable. Do not attempt to grind valves or seats.

(P) **Centrifugal Governor** is a spring loaded type. It can be entirely dismantled by removing the crankshaft, taking out the pins that the weights swing on, pushing in on the pin in the center of the crankshaft and at the same time removing the flat bar. Complete governor and shaft assembly can be removed as a whole unit by pulling out as far as possible and then raising outer end of shaft.

(Q) **Three-Way Valve** consists of two valves proper that have special composition seats. When the compressor is stopped, the inner composition valve must be tight and the outer composition valve must be open (off its seat). When the compressor is running, the outer valve must be tight to shut off the air from the tank and the inner valve must be open to permit the air in the diaphragm arrangement to escape. (It leaks out into compressor crankcase.) To permit the outer valve to be tight, the tip on the opposite end of the three-way valve must not touch the governor plunger in the end of the crankshaft when the compressor is running. Shims are used between the three-way valve and the end casting on the crankcase to locate the three-way valve in the proper relation to the governor plunger.

(R) **Diaphragm Arrangement** on cylinder head is used with both centrifugal and suction type unloaders. The diaphragm plunger is pushed down to hold the compressor intake valve disc off its seat whenever air pressure is admitted to diaphragm.

On two stage compressors the plunger has a two-fold purpose. It not only holds the high pressure intake valve off its seat, but also releases the pressure in the intercooler and low pressure cylinder. When compressor is started the upper end of the plunger is seated by spring pressure to prevent further escape of air from the intercooler and the opposite end is moved away from valve disc to permit compressor to pump.

(S) **Connecting Rods** have extra large, well lubricated bearings, and are assembled with .0015 to .002 clearance, so that there is always a cushion of oil between bearing and shaft. No shims are used. Piston pin end has a hard rolled bronze bushing.

(T) **Timken Roller Main Bearings** should require no attention for a very long period of time. If any looseness should develop, this may be taken care of by removing one or more of the thin brass shims located under the adjustment plate on the pulley end of the compressor. After removing one shim, replace the adjustment plate and draw up on its screws tightly and then try turning the compressor over by hand to make sure the bearings are not too tight. If the compressor does not turn as easily as it did before the shim was removed, the adjustment will have been unnecessary and the shim will have to be replaced.

(U) **Breather Opening** is on the pulley side of the compressor. The leather flapper should have at least $\frac{1}{32}$" movement on free end.

(V) **Serial Number.** Do not fail to give this when necessary to write to the factory or when ordering repairs. The serial number is stamped on a raised pad on the crankcase. Do not fail to give this number whether you are writing about the compressor itself or the motor or some other part of installation.

QUINCY COMPRESSOR CO.

QUINCY, ILLINOIS, U. S. A.

X13 Rev. 20M—3-55

MODEL	CRANK-CASE CAPAC-ITY	INTERMITTENT DUTY				CONSTANT DUTY OR INDUSTRIAL USE			
		TEMPERATURE AT POINT OF INSTALLATION				TEMPERATURE AT POINT OF INSTALLATION			
		Below 0° F.	0° F. to 32° F.	32° to 80° F.	Above 80° F.	Below 0° F.	0° F. to 32° F.	32° to 80° F.	Above 80° F.
X2, DX2, FX2, HX2, FE2	¼ PT.	S.A.E. 5W	S.A.E. 10W	S.A.E. 20	S.A.E. 30	S.A.E. 5W	S.A.E. 10W	S.A.E. 20	S.A.E. 30
X8, DX8, FX8, VX8, HX8, TX8	¾ PT.	"	"	"	"	"	"	"	"
A4, DA4, FA4, VA4, HA4, TA4	1 QT.	"	"	"	"	"	"	"	"
106, D106, F106, H106	1 QT.	"	"	"	"	"	"	"	"
108, D108, F108, V108, H108, T108	1 QT.	"	"	"	"	"	"	"	"
R15, FR15, S15	1 QT.	"	"	"	"	"	"	"	"
R17, FR17, S17	1 QT.	"	"	"	"	"	"	"	"
212, D212, F212, H212	2¾ PT.	"	"	"	"	A	B	C	D
216, 216HS, D216, F216, H216, T216	2¾ PT.	"	"	"	"	"	"	"	"
*308, D308, D308S, F308, H308	2¾ PT.	"	"	"	"	"	"	"	"
*310, D310, D310S, F310, H310, V310, FQ310, V312, F312	2¾ PT.	"	"	"	"	"	"	"	"
*325, D325, D325S, F325, H325, V325	6 PT.	"	"	"	"	"	"	"	"
*330, D330, D330S, F330, H330	9 PT.	"	"	"	"	"	"	"	"
*340, D340, D340S, F340, H340, F345	9 PT.	"	"	"	"	"	"	"	"
230, D230, F230, H230, T230	6 PT.	A	B	C	D	"	"	"	"
244, D244, H244, F244, F246, T244	9 PT.	"	"	"	"	"	"	"	"
*390, D390, D390S, DF390, F390, H390	9 QT.	"	"	"	"	"	"	"	"
†308, D308, D308S	2¾ PT.	"	"	"	"				
†310, D310, D310S	2¾ PT.	"	"	"	"				
†325, D325, D325S	6 PT.	"	"	"	"				
†330, D330, D330S	9 PT.	"	"	"	"				
†340, D340, D340S	9 PT.	"	"	"	"				
WW33, WWD33, WWC33	9 PT.	"	"	"	"				
WW44, WWD44, WWC44	9 PT.	"	"	"	"	"	"	"	"
WW64, WWD64, WWC64	9 QT.	"	"	"	"	"	"	"	"
WW80, WWD80, WWC80	9 QT.	"	"	"	"	"	"	"	"

AUTOMOTIVE OIL

QUALITY LUBRICATING OIL

QUALITY LUBRICATING OIL

A turbine oil or a compressor oil having viscosities equivalent to indicated automotive grades should be used where available. If not available, use quality or heavy duty automotive oils of viscosities shown.

Grade	Viscosities
A	Equal to SAE 10W
B	Equal to SAE 20
C	Equal to SAE 30
D	Equal to SAE 40

*FOR PRESSURES NOT TO EXCEED 250 LBS. P.S.I.
†FOR PRESSURES EXCEEDING 250 LBS. P.S.I. AND INTERMITTENT DUTY ONLY.

Nationwide Authorized Service Depots' prompt service, factory parts keep your compressors on the job!

AUTHORIZED SERVICE is available to Quincy Compressor users so that when a compressor has failed for any cause whatsoever, compressed air supply can be restored with a minimum of delay and expense. Having the compressor in running condition is as important as having power to run it.

IDENTIFICATION OF SERVICE DEPOTS—Authorized Quincy Compressor Service Depots display the **Service** sign. Look for it when you need help with air compressor problems.

QUALITY SERVICE—All Authorized Quincy Compressor Service Depots are well established and selected because they are experienced in the air compressor field. Authorized Quincy Compressor Service Depot locations are listed below.

ADEQUATE STOCKS OF PARTS—Every Authorized Quincy Service Depot maintains an adequate stock of genuine parts for the wide range of sizes and types of compressor manufactured by QUINCY.

Quincy Sales Offices

Quincy Compressor
West Coast Distr.
1185 Mission Street
San Francisco 3, Calif.

C. L. LeVeck
1505 S. Fort Harrison Ave.
Clearwater, Florida

D. C. Lambert
1353 W. Washington Blvd.
Chicago 7, Ill.

Floyd Lepper
1353 W. Washington Blvd.
Chicago 7, Illinois

Phil S. Crutcher, Jr.
106 N. 4th Street
Louisville 2, Ky.

R. Carr
18051 James Couzens Highway
Detroit 35, Michigan

Calvin Keys
5823 Natural Bridge Blvd.
St. Louis 20, Mo.

A. E. Vincent
3917 Thaxton Ave., S.E.
Albuquerque, New Mex.

D. H. Francis
Room 504, 30 Church Street
New York 7, N. Y.

R. G. Morey
403 McClatchy Bldg.
69th & Market
Upper Darby, Pa.

Harold Stone
2310 Costa Mesa
Dallas 28, Texas

Loren Gillhouse
8207 Fremont Ave., S.
Minneapolis 20, Minn.

There's a Quincy Compressor Service Depot Near You

ALABAMA

Birmingham (3)
Equipment Service Co., Inc.
617 N. 9th St.

ARKANSAS

Fort Smith
Southern Air Compressor Co.
104 N. 5th St.

Little Rock
Nichols Equipment Co.
1401 E. 9th St.

CALIFORNIA

Los Angeles (21)
Essick Manufacturing Co.
1950 Santa Fe Avenue

Los Angeles (13)
Sharpe Manufacturing Co.
1224 Wall St.

Oakland (1)
Air Compressor Co.
500 29th Avenue

Sacramento
Franklin Machinery Co.
1715 19th St.

San Diego
Crofton Company
"G" Street Pier

San Francisco (3)
Quincy Compressor, West Coast Distr.
1185 Mission St.

COLORADO

Denver
Agnew Compressor Co.
70 Kalamath Street

Denver (4)
Gunderson-Taylor Machinery Co.
1237 Shoshone St.

FLORIDA

Jacksonville (7)
M. D. Moody & Sons, Inc.
4652 Phillips Highway

Miami (30)
Llewellyn Machinery Corp.
1030 North Miami Avenue

Tampa (1)
Weeks Equipment Co.
201 Morgan St.

GEORGIA

Atlanta (3)
Chandler Machinery Co.
120 Houston St., N.E.

Atlanta
Stovall & Co.
948 Bankhead Ave., N.W.

ILLINOIS

Centralia
Holtkamp Electric Service Co.
203 N. Poplar St.
(Compressor and vacuum pump parts)

Chicago (7)
Cochrane Compressor Service & Supply Co.
1353 W. Washington Blvd.

Moline
Fawks Color Co.
2309 Fifth Ave.

Peoria (2)
Peoria Auto Parts Co.
817-831 So. Adams Street

Rockford
Joseph Behr & Sons, Inc.
1100 Seminary St.

INDIANA

Evansville (9)
Mautoux Auto & Machine Co.
517 Locust St.

Indianapolis (7)
Brehob Electric Equipment, Inc.
824 So. West St.

Muncie
Kimm Paint Co., 2425 N. Broadway
(Branch in Fort Wayne, 2430 Broadway)

South Bend (24)
Coffield Supply Co., Inc.
1626 S. Main Street

IOWA

Algona
Thompson Distributing Co.
1009 N. Main

Davenport
Gierke-Robinson Co.
210-212 E. River St.

Des Moines (9)
Automotive Service Co.
1303-1305 Walnut St.

Dubuque
Dubuque Auto Supply Co.
900-916 Central Ave.

Sioux City (10)
Smith Electric & Industrial Suppliers
413-17 Jones St.

KANSAS

Wichita (4)
Zeller Co.
1738 N. Mosley St.

KENTUCKY

Louisville (4)
K & I Auto Parts, Inc.
508 Baxter Ave.

LOUISIANA

New Orleans (10)
Wm. F. Surgi Equipment Corp.
1149 Tchaupitoulas St.

MARYLAND

Baltimore (1)
Stuart M. Christhilf & Co., Inc.
134-136 W. Mt. Royal Ave.

Baltimore (18)
C. S. Bowen Co.
2103 Greenmount Ave.

MASSACHUSETTS

Boston (10)
Gustavo Preston Co.
113 Broad St.

MICHIGAN

Battle Creek
Air Engineering Co.
250 Grenville St.

Bay City
Aleco Equipment Co.
1206 Columbus Ave.

Detroit (8)
Amco Corp.
5733 Grand River Ave.

Detroit (5)
DeLuxe Air Compressor Service Co.
11802 E. McNichols Road

MICHIGAN (Contd.)

Detroit (8)
Irwin & Briggs, Inc.
1830 Marquette at 12th

Detroit (2)
Nelson Equipment & Service Co.
322 E. Milwaukee Ave.

Flint (4)
Kennedy Motor Parts
1208 N. Saginaw St.
(Branch—Flint Piston Service)
704 N. Saginaw St.

Grand Rapids (3)
Gillhespy Sales & Service
532 Grandville Ave., S.W.

Kalamazoo
John E. Kandler Co.
618 E. Michigan Ave.

Lansing (15)
Painters Supplies, Inc.
325 River St.

Scotts, Kalamazoo County,
White Sales Corporation

Wayne
Air Compressor Service
37655 Ford Road, near Newburg

MINNESOTA

Minneapolis (3)
Service Parts Co.
1601 Hennepin Ave.

MISSOURI

Kansas City (8)
R. L. Faubion Co.
2525 Southwest Blvd.

St. Louis (20)
St. Louis Compressor Service Co.
5823 Natural Bridge Blvd.

Springfield (3)
Springfield Equipment Co.
1215 W. Walnut

NEBRASKA

Grand Island
Kelly Supply Co.
1004 W. Oklahoma Ave.

Omaha (2)
Fuchs Machinery & Supply Co.
2401 N. 11th St.

NEW YORK

Buffalo (4)
Torsell Service
560 Jefferson Ave.

Endicott
Newing Equipment Corp.
203-211 Main St.

Liverpool
The W. G. Giersberg Co.
241 Russell Ave.

New York City (19)
Argo Compressor Service Corp.
401-403 W. 52nd St.

New York City (13)
Electric Motors Corp.
168 Centre St.

Rensselaer
Van's Equipment Sales, Inc.
P. O. Box 231

NORTH CAROLINA

Charlotte (1)
Southern Pump & Tank Co., Inc.
1730 N. Tryon St.
(Branch at Raleigh)

OHIO

Cincinnati (13)
Highway Equipment Rental Co.
Langdon Farm and Wiehe Road

Cleveland (14)
B & M Air Compressor & Motor Repair, Inc.
1375 E. 33rd St.

Columbus (8)
Lorenz Equipment Co.
547 W. Rich St.

Columbus (8)
Tuller Corp.
947 W. Goodale Blvd.

Springfield (35)
Johnston Auto Supply Co.
431-433 West Main St.

Toledo (2)
Toledo Buckeye Auto Parts
445 Tenth St. at Jackson

Youngstown (2)
Reynolds & Bookout Parts Co.
317 Wick Ave.

OKLAHOMA

Oklahoma City
Lee Connel Eqpt. & Supply Co.
923-925 West Main

Tulsa (4)
Kelleher Equipment Co.
1717 E. First St.
P. O. Box 3185

OREGON

Portland (9)
Equipment Service
1014 N. W. Hoyt St.

Portland (2)
Rogers Machinery Co., Inc.
5035 S.E. 17th Ave. at McLoughlin Blvd.

PENNSYLVANIA

Allentown
H. N. Crowder, Jr. Co.
444 Union St.

Hanover
C. H. Reed
129 Broadway

Philadelphia
Ace Electric Co.
129-131 N. 3rd St.

Philadelphia (39)
Hoves Spray Equipment Co.
243-47 N. 63rd St.

Pittsburgh (22)
Tranter Mfg. Co.
105 Fort Pitt Blvd.

SOUTH CAROLINA

Columbia
Jenkins Automotive Parts Service Inc.
1517-19 Sumter St.

Sumter
B. L. Montague Co., Inc.
East Liberty St.
(Branch in Myers, S. C.)
(Authorized Parts Stock in Sumter, S. C.)

TENNESSEE

Memphis (2)
Southern Co., Inc.
Georgia & Hernando Sts.

Nashville (4)
Peterson Machinery Co.
309 Seventh Ave. South

TEXAS

Abilene
Tesco
834 Walnut St.

Dallas (10)
Finishers Supply Co.
3209 Oakland Ave.

Fort Worth (7)
Southwest Equipment & Service Co.
2750 Tillar St.

Houston (3)
Bowman Equipment Co.
2102 Leeland Avenue

Houston (6)
Egner Bros.
3010 Smith Street

Houston (1)
Houston Engine & Pump Co.
1939 Cullen Blvd.

Odessa
Engine Service & Supply
1902 N. Grant

VIRGINIA

Newport News
Jones & Frank Oil Equipment Corp.
P. O. Box 389
810 39th Street

Norfolk (10)
General Automotive Supply Co., Inc.
1916 Granby St.

Richmond (21)
W. B. Goode Co.
2915 W. Leigh St.

WASHINGTON

Seattle (4)
Northwest Industrial Equipment Co.
2926 Sixth Ave. South

WEST VIRGINIA

Charleston (21)
Wm. S. Bolden Co., Inc.
706 Morris St.

WISCONSIN

Milwaukee (9)
Prime-Best, Inc.
3820 West Villard Ave.

CANADA

Toronto 4, Ontario
Compressed Air Equipment Ltd.
328 Dupont St.

Vancouver, B. C.
Pumps & Power, Ltd.
40 E. Cordova St.

Winnipeg, Manitoba
City Machinery Co., Ltd.

St. John's, Newfoundland
Basil Fearn, Ltd.
P.O. Box 2163
Becks Cove

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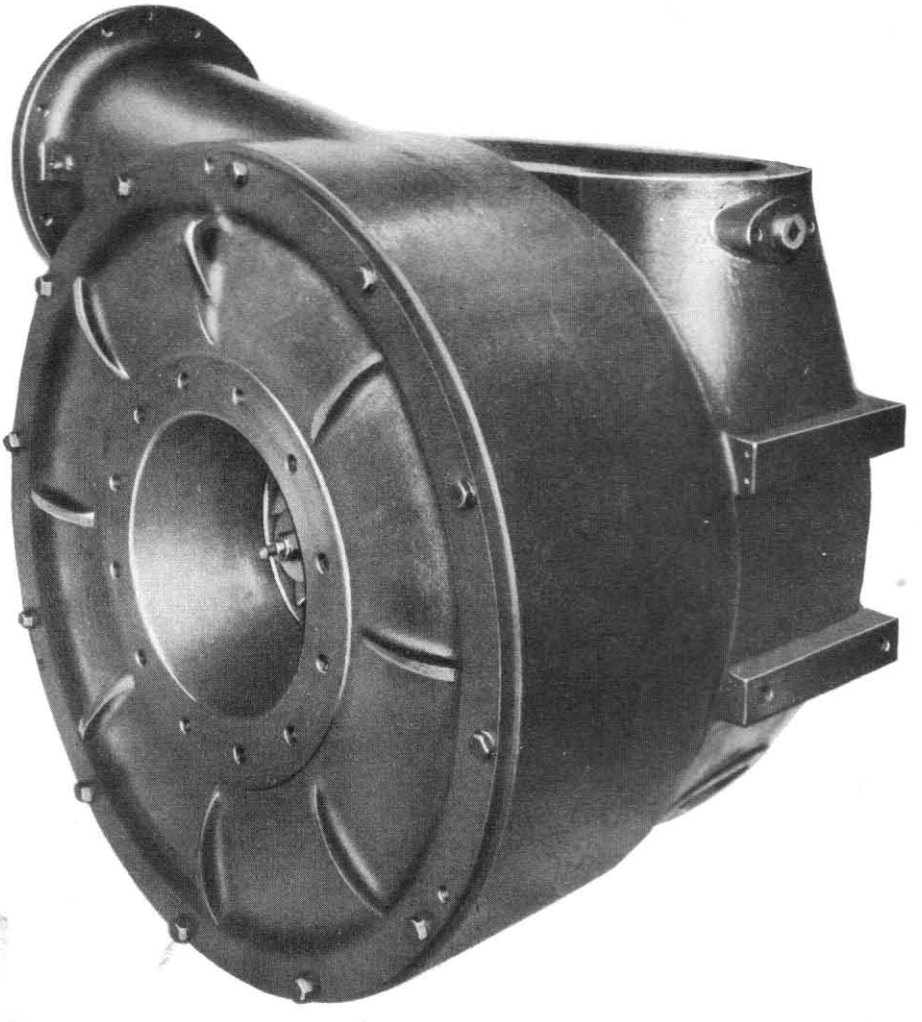
Form X17

10M-4-55

INSTRUCTIONS

For Installation, Operation and Maintenance of

ELLIOTT TYPE "L" LOW-PRESSURE TURBOCHARGERS



INSTRUCTION BOOK
TC-20-B

CONTENTS

LIST OF FIGURES

SECTION 1
GENERAL INFORMATION

The Elliott turbocharger is a self-contained unit, composed of a gas turbine and a centrifugal blower, mounted on a common shaft with the necessary surrounding casings (Fig. 8). The exhaust gas from the power cylinders of the Diesel engine is conveyed through multiple manifolds to the turbine, which utilizes some of the energy in the exhaust gas, otherwise wasted. This energy is used to drive the blower, which furnishes all the air required by the engine, at a pressure above atmospheric, through a conventional air intake manifold.

The turbocharger unit is used in conjunction with the Buchi system of pressure charging and scavenging a four-stroke cycle Diesel engine. In this system the compressed air delivered by the turbocharger accomplishes two ends: first, it scavenges the hot residual gases otherwise left in the cylinder at the end of the exhaust stroke, and replaces these with cooler fresh air; second, it fills the cylinder with an air charge of higher density at the end of the suction stroke. The provision of a greater amount of fresh air permits the combustion of a correspondingly greater amount of fuel and consequently a higher output from a turbocharged engine than from one 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 normally aspirated in that the exhaust valves of the pressure-charged engine close later, and the inlet valves open earlier. Thus, the valve overlap, or period when both valves are open simultaneously, is considerably greater, permitting effective scavenging of the cylinders. Timing of the valves and dimensions of the exhaust manifold are determined so that timed pressure fluctuations are propagated in the exhaust manifold. Both valves are open when the fluctuating pressure in the exhaust manifold is at a minimum, thus permitting scavenging with lower blower pressure than would otherwise be possible.

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 by 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 practically instantaneously with variations in load, speed, or both, of the engine. No consideration need be given to direction of rotation of the turbocharger when applied to a direct reversing engine. The turbocharger rotates in one direction only, regardless of the direction of rotation of the engine.

SECTION 2
DETAILS OF CONSTRUCTION

(Numbers in parentheses refer to part numbers on the cross-sectional assembly and outline, Figs: 7, 8, 9 and 10 respectively, and Parts List, page 13)

Essentially, the Elliott turbocharger consists of a single-stage turbine wheel and a single-stage centrifugal blower impeller mounted on a common shaft, with the necessary surrounding casings. The turbocharger rotor is entirely independent of the rotating parts of the engine (Fig. 1).

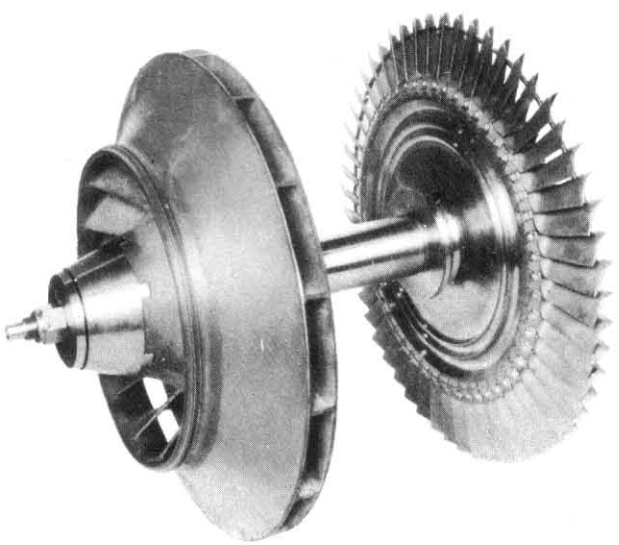


Fig. 1—Rotor Assembly

The engine exhaust gases are conducted to the cast inlet casing (50) by several exhaust manifolds. The number and arrangement of the manifolds is dependent on the number of engine cylinders. The turbine nozzle ring (59), is centered on and attached to the turbine inlet casing by bolts (62) wired together (63).

The nozzle ring comprises a special heat resisting Ni-Resist casting with stainless steel guide vanes cast into place. The outer ring is split into several segments to give greater freedom of radial expansion of the blades. A bayonet lock clamps the nozzle segments against the inlet casing, thus preventing thermal distortion but permitting full freedom for radial expansions. The nozzle ring directs the exhaust gases to the turbine blades (76) at the proper angle.

The turbine casing (1) is a Meehanite casting, cored to provide cooling water passages. A flat oval flange is provided for exhaust connection. Pads are supplied at three points for supporting bracket connections.

The intermediate casing (9) is of the same material as the turbine casing, and forms the division between

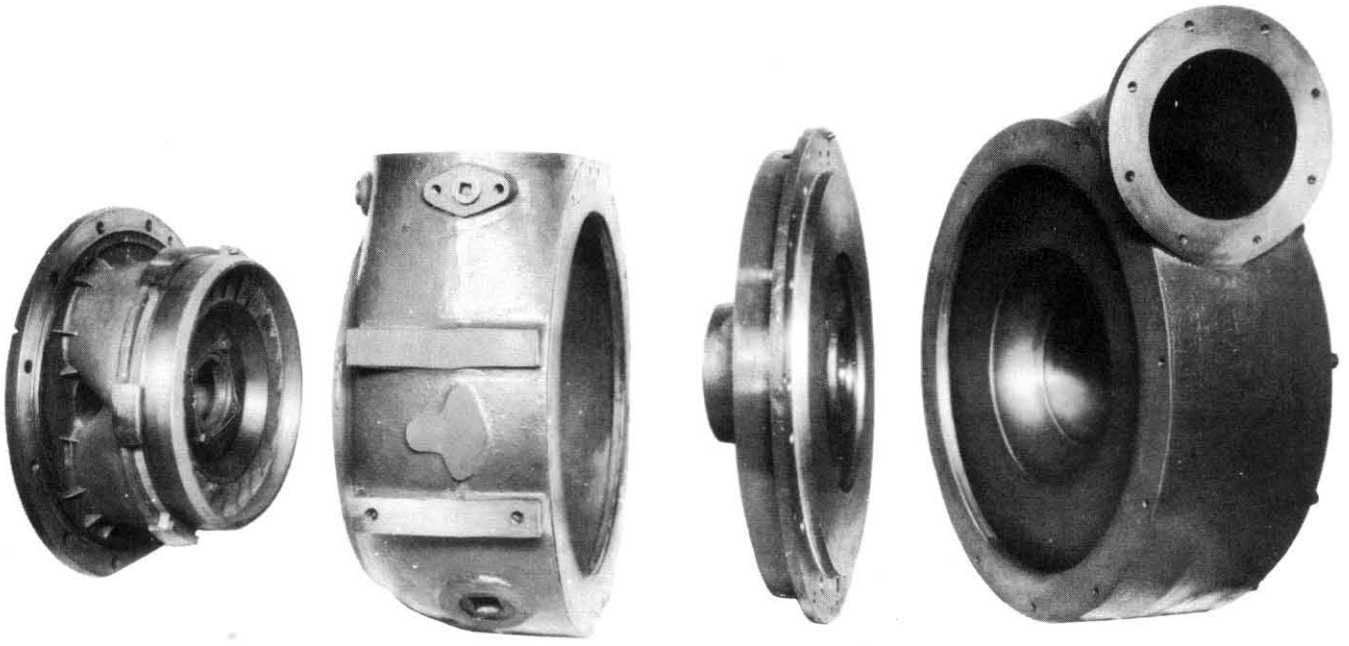


Fig. 2—Left to right: Inlet Casing Assembly, Turbine Casing, Intermediate Casing, Blower Casing Assembly.

the turbine casing and the blower casing. It is also cored for cooling water. The intermediate casing is attached to the turbine casing by cap screws (11), and to the blower casing by cap screws (28) for the L-20 and studs (27) for the L-10, L-40 and L-60.

The blower housing assembly comprises two Meehanite castings, a blower casing (26) and ribbed blower inlet (37). These are bolted together with bolts (38). Air enters the blower inlet axially and is discharged radially from the blower impeller (80) through the diffuser passage into the blower casing collector and it is discharged tangentially. For some applications a vaned diffuser is used. The vaned diffuser (44) is a precision aluminum casting which is attached to the blower inlet by flat head machine screws (45) peened for locking, and is clamped between the blower inlet and intermediate casing.

The rotor assembly is made up the following components: turbine disk (75), turbine blades (76), shaft (78), thrust collar (82), impeller (80), nose piece (85), stud (79), elastic stop nut (86), spline washer (88) and spline washer key (84). A counterbore is provided in the shaft to receive the projection on the turbine wheel. There is a slight press fit at this point to assure concentricity. Positive torque transmission to the shaft is assured by the axial dowel pins (77). The impeller fits snugly against the thrust collar (82) and is driven by the spline washer (88), which is keyed to the shaft. The entire assembly is held together by the stud and elastic stop nut combination.

The turbine disk and blades (75 and 76 respectively) are made of an austenitic stainless steel, having good physical properties at elevated temperatures. The blower impeller (80) is a precision aluminum casting.

Labyrinth rings machined on the impeller shroud serve to limit the leakage of high-pressure discharge air.

After machining, the impeller is separately balanced and overspeed spin tested, then assembled with the shaft and turbine disk and the complete rotor assembly (87) is dynamically balanced. The balance of the rotor is not disturbed by disassembly and reassembly.

The bearings (19 and 20) are of the sleeve type, steel backed and babbit lined, and are pressed into the line-bored holes of the intermediate casing. Rotation of the bearings in their housing is prevented by the pins (18). The turbine end bearing flange is provided with a grooved thrust face and carries the axial thrust load of the rotor. End play is limited by the clearance between the thrust collar (82) and the flange of the blower end bearing (20).

Oil leakage into the turbine casing and blower casing is prevented by the oil seals (16 and 21). A snap ring (17) retains the turbine end oil seal in place and the blower end oil seal is held by flat head machine screws (91) locked by peening.

Lubrication for the bearings is supplied through the steel tube and drilled passages in the intermediate casing, supply connection being made on top.

On the L10 and L20 impeller, discharge air is used to cool the turbine disk and pressurize both oil seals. This air passes from the space behind the impeller through a drilled hole in the intermediate casing (not shown), to the turbine disk. On the L-40 and L-60, air at impeller discharge pressure is used to pressurize the blower end oil seal (21). The turbine end oil seal (16) is pressurized by high pressure air from the blower casing (See Fig. 10).

SECTION 3
COOLING SYSTEM

The turbocharger cooling system must be supplied with clean, soft water, free from any substance which will cause sludge or scale on the interior surfaces.

Cooling water is circulated through the intermediate casing (9) and the turbine casing (1). The water inlet connection is at the bottom of the intermediate casing; the water discharge connection being at the top of the turbine casing on either side. The opening opposite the piped water discharge connection must be vented to prevent formation of steam pockets in the turbine casing. The water passage holes in the turbine and intermediate casings function as metering elements to proportion the flow correctly between the two circuits.

Water circulation through the turbocharger should be regulated at such a rate that the temperature rise does not exceed 30 F at full engine load. This will restrict thermal distortion to a reasonable amount. The discharge temperature should not exceed 190 F for clean soft water; lower temperature may be dictated by the characteristics of the water used.

The turbocharger cooling system should be adequately vented, and, if feasible, provision made to circulate the water for a few minutes after the engine has been shut down, since in many cases there is enough heat left in the casing walls to boil away the water remaining in the jackets.

Connections or plugs (2) Figs. 7 and 8, in the turbine casing, should be removed annually (or oftener if the character of the cooling water makes it necessary), the jacket and cooling water piping inspected for scale and sludge, and any accumulation removed. Intermediate casing cooling water piping should also be removed and the casing and piping treated similarly to the turbine casing.

SECTION 4
LUBRICATING SYSTEM

Lubricating oil for the turbocharger may be supplied either directly from the engine or by a separate, self-contained system with engine driven or separately driven oil pump. The separate oiling system is recommended. By this means, light clean oil will be used for lubrication which is advantageous for long trouble-free life of the high speed journals that operate with very small bearing clearances. In either case, adequate lube oil filtration and filter servicing is recommended. The dirt and sludge acquired by Diesel oils during operation make trouble-free service difficult if these deposits are not filtered out.

The lubricating oil piping should be designed to meet the following requirements:

1. There should be a minimum lapse of time between the start of rotation of the turbocharger and oil pressure indication on the pressure gage. This period should not exceed 12-15 seconds.
2. Desired oil pressure at the turbocharger is 30 to 40 psi gage.
3. The desired inlet oil temperature range is from 130 to 160 F and should not exceed 180 F. Inlet oil viscosity should be between 100 and 150 SSU and in no case should exceed 200. Oil heavier than SAE 40 is not recommended.
4. Sight flow indicator should be provided.

The turbocharger lubricating system is illustrated in the cutaway section, Fig. 3, and cross sectional assembly drawing, Fig. 9. Oil from the supply is piped to the tapped pipe at the top of the intermediate casing. The oil flows through the screwed-in stainless steel tube and then divides, approximately half of the flow going to each bearing. Discharge oil drains out of the drain hole near the bottom of the intermediate casing.

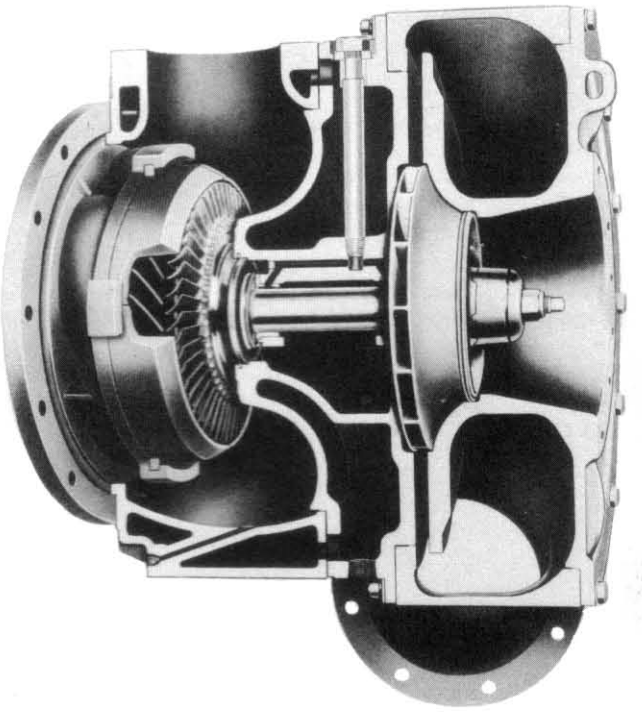


Fig. 3—Cutaway Section

Additional information on oil piping is given in Section 5.

SECTION 5
INSTALLATION

The turbocharger is shipped completely assembled, with openings plugged to prevent entrance of foreign matter and with exposed surfaces protected against rust. Spare parts and tools are shipped separately. No dismantling is necessary before installation.

Surfaces coated with rust preventive should be cleaned with a solvent. Three mounting pads on the turbine casing are provided for mounting the unit, with tapped holes for connecting to mounting brackets. Brackets for turbocharger support must be of suitable strength and rigidity to support the turbocharger as an integral part of the engine assembly. Piping must not be depended upon for turbocharger support.

Connections are to be made to the turbine inlet, turbine outlet, blower inlet (in case the air is taken from a remote point), blower discharge, cooling water system, lubricating oil system and casing drains. All connections must be made with flexible joints or other provisions made to prevent piping strains from being transmitted to the turbocharger, and to keep it from acting as a support for any piping. On the exhaust gas inlet and outlet connections, high-temperature gaskets should be used, and threads of studs and capscrews coated with a high-temperature thread compound to prevent galling when disassembling. On the blower connections, soft low-temperature gaskets are suitable.

The cooling water inlet connection is made at the bottom of the intermediate casing. The common cooling water outlet may be at either side of the turbine casing at the top, depending on the particular installation. The other side must be vented as noted in Section 3.

A sight-flow indicator should be installed in the water discharge line to give positive indication of flow through the unit. The discharge line should be inclined upward to the main water discharge header or surge tank, to vent the jackets and 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 discharge line or surge tank, a vent valve should be provided at the high point of the line to prevent vapor lock or siphoning.

A drain is provided for the turbine casing interior through a pipe tapped hole in the mounting pad (3) Fig. 7 and 8. The blower casing drain (32) is located at the bottom of the casing. Each of these connections should be fitted with a nipple and valve to permit drainage of any moisture that may collect during periods of shutdown. The turbine and intermediate casing water jackets may be drained by removing pipe plugs (5) or (97), Figs. 7 and 8, when unit is idle and exposed to freezing weather.

The lubricating oil connection is made in the tapped pipe provided at the top of intermediate casing. One-half inch O.D. tubing is recommended from header to turbocharger. A check valve should be installed in this line near the main engine oil header to prevent drainage when the unit is shut down. A full-flow filter should be installed to insure a flow of clean oil at all times. A pressure gage should be installed as close as possible to the turbocharger to eliminate any error in pressure reading due to pressure drop in the pipe or oil filter. A pressure regulating valve, of the type which remains open at low pressures and throttles the flow when the pressure exceeds that desired, must also be incorporated in the system. After the connections have all been made, the oil piping should be disconnected and thoroughly blown out or flushed out with clean oil to insure the removal of all chips and dirt.

The oil drain line must be of adequate size with a minimum number of bends. Horizontal runs are to be avoided. A 2-in. drop per foot and ¾-in. I.D. pipe is recommended for the L-10, 1-in. for the L-20 and 1¼-in. for the L-40 and L-60. This drain should be led directly to the crankcase or some well vented housing, and the end must not be submerged.

After all connections have been made, the rotor should be spun by hand to make sure it turns freely. If it does not, the reason must be ascertained and remedied before the engine is started.

The nameplate, listing the serial number of the unit and other pertinent data, is attached directly to the turbocharger near the blower discharge flange.

SECTION 6
CLEARANCES

(All dimensions are in inches)		*Model L-10*	*Model L-20*	*Model L-40 & L-60*
1. Rotor end play, with surface oiled		.006—.016	.006—.016	.006—.016
2. Journal Bearings—	Shaft diameter O.D.	1.2494—1.2500	1.6205—1.6210	1.8710—1.8715
	Bearing diameter I.D.	1.2525—1.2530	2.6240—1.6245	1.8740—1.8750
3. Labyrinth Rings—Clearance on diameter over impeller		.025—.035	.038—.0.48	.038—.048
4. Radial clearance between turbine blade O.D. and nozzle ring, cold		.010—.040	.020—.050	.040—.070
5. Oil Seal— Turbine End Style "A"	Seal I.D.	1.691—1.692	2.192—2.193	2.694—2.695
	Matching shaft diameter O.D.	1.686—1.687	2.186—2.187	2.686—2.687
	Clearance on diameter	.004—.006	.005—.007	.007—.009
6. Oil Seal— Turbine End Style "B"	Seal I.D.			3.287—3.288
	Matching shaft diameter O.D.			3.279—3.280
	Clearance on diameter			.007—.009
7. Oil Seal— Blower End	Seal I.D.	1.691—1.692	2.192—2.193	2.694—2.695
	Matching shaft diameter O.D.	1.686—1.687	2.186—2.187	2.686—2.687
	Clearance on diameter	.004—.006	.005—.007	.007—.009

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

WHEN ORDERING THESE PARTS, THE TURBOCHARGER MODEL AND SERIAL NUMBERS MUST BE FURNISHED

SECTION 7
STARTING INSTRUCTIONS

1. Check cooling water connections and make sure the proper valves are open. Fill the cooling water space before operating the unit. If a separate source of supply is available, start water circulation before starting the engine.

2. Pump oil into the turbocharger oil feed line, remove the oil drain line and check for oil flow from the bearings to make sure that the line between the check valve and the turbocharger is filled with oil and that the bearings are oiled for the initial start.

If there is not a continuous flow of clean oil from the drain line during the circulation period, the engine should not be started until the cause has been determined and corrected and drain line replaced.

3. Start the oil pump and operate the engine at idling or light load conditions. If lubricating oil pressure of at least 10 psi gage does not show on the gage in from 12 to 15 seconds, shut down and check for the cause. Recommended oil pressures are 30 to 40 psi gage over the operating range.

4. Operate the engine at a speed sufficient to develop normal lubricating oil pressure on the engine system. When oil pressure develops satisfactorily, set the turbocharger oil pressure at 35 psi gage.

5. The unit should be checked after the first half-hour of operation to make sure no oil leaks develop in the oiling system.

6. Check exhaust temperature before turbine at full load operation to make sure that maximum temperature is not exceeded. The turbocharger speed will adjust itself automatically to that required at the load and speed under which the engine is operating.

After the above steps have been taken, if no trouble develops, the turbocharger is ready for continuous operation.

After the turbocharger has been operating for a sufficient time to permit the unit and oil to warm up, the rotor should coast freely to a stop after the engine is shut off. If the rotor jerks to a sudden stop, the cause should be immediately determined and eliminated.

SECTION 8
SERVICE OPERATION

Performance of the turbocharger should be observed at intervals of about four hours. Data and conditions to be observed are as follows:

1. *Oil Pressure.*—Lubricating oil pressure should be kept at about 30 to 40 psi at the turbocharger speed corresponding to full engine load. The pressure relief valve and pressure gage should be observed each time the engine is started or shut down, to make sure they are operating. Particular attention should be paid to keeping the turbocharger oil clean by regular cleaning or renewing of the filter element.

2. *Oil Temperature.*—Temperature of lubricating oil supplied to the turbocharger should not exceed 180 F, and temperature at the drain should not exceed 215 F. Any sudden increase in lubricating oil temperature at the drain should be investigated, since it may be due to obstructions in the internal oil passages.

3. *Turbocharger Speed.*—Ordinarily, no attention need be paid to the speed of the turbocharger since this varies automatically with speed and load on the engine.

4. *Exhaust Gas Temperature.* — Temperature before the turbine must not exceed 1100 F for steady full-load operation, and 1200 F for a maximum of four 30-minute periods per 24 hours. The temperature before the turbine will be higher than that recorded at the exhaust elbows, and care should be exercised not to use the two temperatures interchangeably.

5. *Water Temperatures.* — Turbocharger cooling water temperatures should be checked occasionally to make sure that the temperature rise across the turbocharger does not exceed 30 F. A high rise across the machine indicates stoppage or plugging of the circulating passages.

6. *Vibration.*—Operation of the unit should be observed frequently to detect any noticeable vibration. If noticeable vibration develops, the unit should be shut down and the cause determined. Vibration might be caused by damage to the impeller, shaft, or turbine wheel or by worn or loose bearings in the turbocharger. Any uneven deposit of foreign material or dirt on the impeller will also be a contributing factor.

7. *Turbine Casing Drain.*—No water will collect in the interior of the casing during continuous operation. During an extended shutdown, however, water may collect in this space due to condensation, leaky gaskets, or other causes. After any but a brief shutdown, therefore, the casing interior (not the water jacket) should be drained before starting up again. If oil collects in this space, check for oil leakage between the shaft and oil seals.

EMERGENCY OPERATION

Should an accident or failure of some part of the turbocharger prevent or render inadvisable operation of the unit, the engine can be operated as a normally aspirated engine until repairs can be made to the turbocharger. If possible, the turbocharger rotor, blower casing and intermediate casing should be removed; the open end of the turbine casing can then be closed with a steel plate, and the engine operated unturbocharged.

If it is not feasible to remove any part of the turbocharger, the rotor should be prevented from turning by installing the rotor blocker (furnished with tools). See Fig. 11 for method of installing.

Under no circumstances must the preturbine temperature exceed the maximum temperature (1100 F) stamped on the turbocharger nameplate, and cooling water circulation through the turbine casing and intermediate casing must be continued.

If the engine has been operated under the above conditions, the turbocharger should be completely disassembled and inspected as described in Section 9, Inspection and Maintenance, before putting it back to normal operation.

SECTION 9
IMPELLER AND DIFFUSER CLEANING and COMPLETE TURBOCHARGER INSPECTION AND MAINTENANCE

Impeller and Diffuser Cleaning:

The impeller and diffuser should be cleaned every 4,000 hours or less, depending on service conditions, to maintain optimum turbocharger performance. Remove the blower inlet bolts (38), Fig. 9. Using these bolts as jacking screws, break the flange connection between the blower inlet and the blower casing. With the aid of the lifting lug and an overhead lift remove the blower inlet (37) (see Fig. 6). This part must be pulled out along the rotational axis to avoid damaging the impeller shroud labyrinth seal rings. The impeller, diffuser and blower casing may now be cleaned with bendix cleaner. Never use a caustic solution, wire brush, or scraper on these parts.

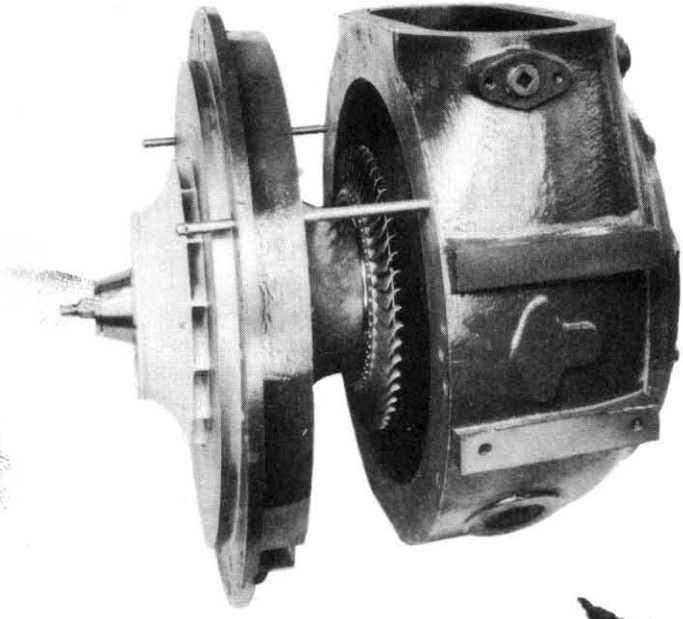


Fig. 4—Intermediate and Turbine Casing — Method of Assembly and Disassembly.

Complete Turbocharger Inspection:

The complete turbocharger should be cleaned and inspected every 8,000 hours. Procedure for dismantling, cleanout, inspection and reassembly of the unit is as follows:

Dismantling Procedure:

1. Remove all air inlet equipment (piping, silencer or air cleaner).
2. Remove the intermediate casing to blower casing cap screws (28) on the L-20 and nuts (29) on the L-10, L-40 and L-60. Using these cap screws or blower inlet bolts (38) as jacking screws in the threaded holes provided, break the joint. With the aid of the cast lug on the blower inlet and a sling, remove the blower casing assembly (See Fig. 5). This assembly must be pulled out along the rotational axis to avoid damaging the impeller shroud labyrinth seal rings.
3. Remove intermediate casing to turbine casing cap screws (11) install intermediate casing guide pins (103) and special jacking screws (102) (see Figs. 4 and 12) and break the joint. Remove special jacking screws.
4. Slide the intermediate casing and rotor assembly clear of the nozzle ring to avoid damaging the turbine blades (see Fig. 4).
5. The intermediate casing may now be supported with the eye bolt (15) for disassembly of the rotor.
6. It will not be necessary to "break" the joint between the turbine inlet casing (50) and turbine casing (1) or between the nozzle ring (59) and the turbine inlet casing, unless leakage is evident or if the nozzle ring is to be replaced. If the nozzle ring is to be replaced, remove locking wire (63) and bolts (62). Install nozzle ring wrench (111), (see Fig. 12) and rotate nozzle ring until bayonet lock is disengaged.

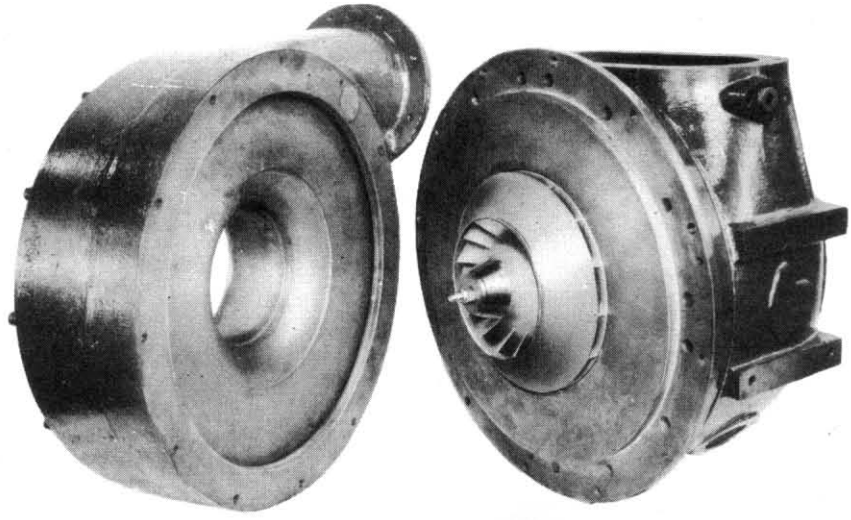


Fig. 5—Partially Dismantled View Showing Blower End Sub-Assembly with Vaneless Diffuser and Turbine and Intermediate Casing Assembled with Rotor.

turbine outlet, blower inlet (in case the air is taken from a remote point), blower discharge, cooling water system, lubricating oil system and casing drains. All connections must be made with flexible joints or other provisions made to prevent piping strains from being transmitted to the turbocharger, and to keep it from acting as a support for any piping. On the exhaust gas inlet and outlet connections, high-temperature gaskets should be used, and threads of studs and capscrews coated with a high-temperature thread compound to prevent galling when disassembling. On the blower connections, soft low-temperature gaskets are suitable.

The cooling water inlet connection is made at the bottom of the intermediate casing. The common cooling water outlet may be at either side of the turbine casing at the top, depending on the particular installation. The other side must be vented as noted in Section 3.

A sight-flow indicator should be installed in the water discharge line to give positive indication of flow through the unit. The discharge line should be inclined upward to the main water discharge header or surge tank, to vent the jackets and 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 discharge line or surge tank, a vent valve should

from header to turbocharger. A check valve shou
be installed in this line near the main engine c
header to prevent drainage when the unit is sh
down. A full-flow filter should be installed to insu
a flow of clean oil at all times. A pressure gag
should be installed as close as possible to the turb
charger to eliminate any error in pressure readin
due to pressure drop in the pipe or oil filter. A pre
sure regulating valve, of the type which remai
open at low pressures and throttles the flow when th
pressure exceeds that desired, must also be incorp
rated in the system. After the connections have
been made, the oil piping should be disconnecte
and thoroughly blown out or flushed out with clea
oil to insure the removal of all chips and dirt.

The oil drain line must be of adequate size with
minimum number of bends. Horizontal runs are to
avoided. A minimum of 2-in. drop per foot and ¾-in
I.D. pipe is recommended for the H15, H30 and H
and 1¼-in. for the H50 and H70. This drain shoul
be led directly to the crankcase or some well vente
housing, and the end must not be submerged.

After all connections have been made, the rot
should be spun by hand to make sure it turns freel
If it does not, the reason must be ascertained an
remedied before the engine is started.

The nameplate, listing the serial number of th
unit and other pertinent data, is attached directly
the turbocharger near the blower discharge flang

SECTION 6

CLEARANCES

(All dimensions are in inches)	*Model H15*	*Model H30 & H35*	*Model H50 & H7*
1. Rotor end play, with surface oiled	.006—.016	.006-.016	.006-.016
2. Journal Bearings— Shaft diameter, O.D.	1.2495—1.2500	1.6205—1.6210	1.8710—1.8715
2. Journal Bearings— Bearing diameter, I.D.	1.2525—1.2530	1.6240—1.6245	1.8745—1.8750
3. Radial clearance between turbine blade O.D. and nozzle ring, cold	.010—.040	.015—.045 (H30) .020—.050 (H35)	.030—.060 (H50) .040—.070 (H70)
4. Oil Seal— Seal I.D.	1.691—1.692	2.192—2.193	2.692—2.693
4. Oil Seal— Matching shaft diameter O.D.	1.686—1.687	2.186—2.187	2.686—2.687
4. Oil Seal— Clearance on diameter	.004— .006	.005— .007	.005— .007

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

WHEN ORDERING THESE PARTS, THE TURBOCHARGER MODEL AND SERIAL NUMBERS MUST BE FURNISHED

ng or light load conditions. If lubricating oil p
e of at least 10 psi gage does not show on
ge in from 12 to 15 seconds, shut down and ch
the cause. Recommended oil pressures are 3
psi gage over the operating range.

SERVI

erformance of the turbocharger should be
ved at intervals of about four hours. Data
ditions to be observed are as follows:

Oil Pressure.—Lubricating oil pressure sho
kept at about 30 to 40 psi at the turbocha
ed corresponding to full engine load. The press
ef valve and pressure gage should be obser
h time the engine is started or shut down, to m
e they are operating. Particular attention sho
paid to keeping the turbocharger oil clean by
cleaning or renewing of the filter element.

Oil Temperature.—Temperature of lubricat
supplied to the turbocharger should not exc
F, and temperature at the drain should not
d 215 F. Any sudden increase in lubricating
perature at the drain should be investigat
ce it may be due to obstructions in the internal
ssages.

Turbocharger Speed.—Ordinarily, no attent
d be paid to the speed of the turbocharger si
s varies automatically with speed and load on
gine.

Exhaust Gas Temperature. — Temperature
e the turbine must not exceed 1200 F for ste
l-load operation, and 1275 F for a maximum
r 30-minute periods per 24 hours. The temperat
ore the turbine will be higher than that recor
he exhaust elbows, and care should be exerci
to use the two temperatures interchangeably.

Water Temperatures. — Turbocharger cool
ter temperatures should be checked occasion
make sure that the temperature rise across
bocharger does not exceed 30 to 40 F. A high
oss the machine indicates stoppage or plugg
he circulating passages.

Vibration.—Operation of the unit should be
ved frequently to detect any noticeable vibrati
noticeable vibration develops, the unit should
ut down and the cause determined. Vibrat

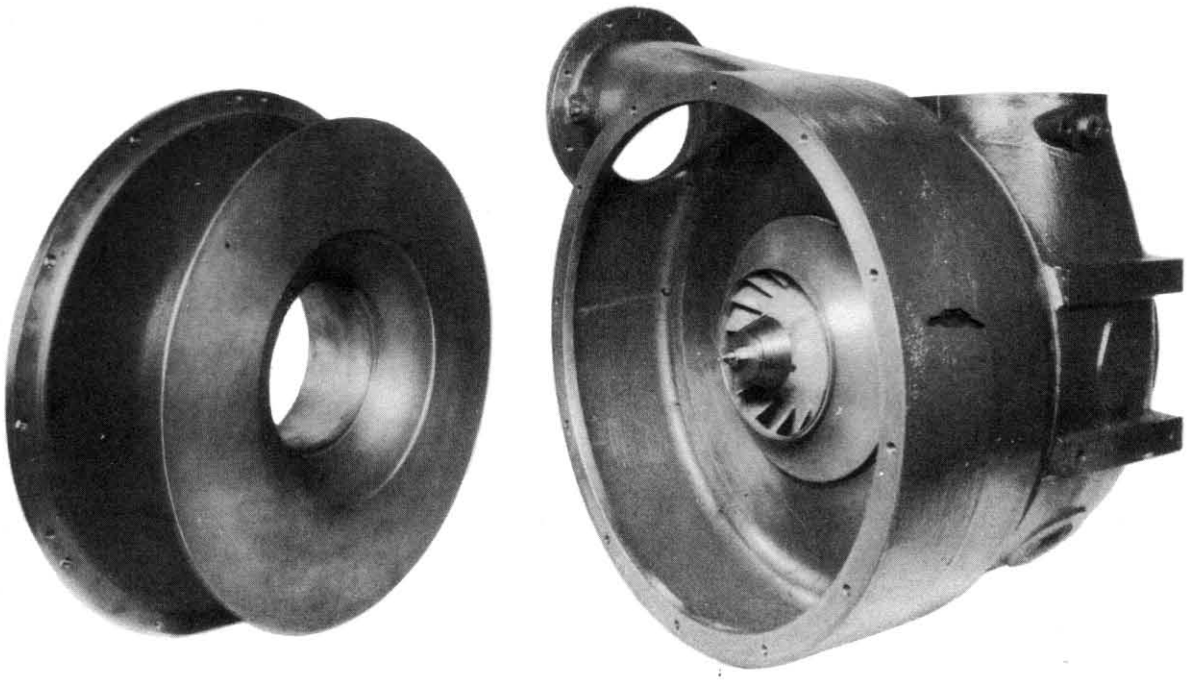


Fig. 6—Partially Dismantled View Showing Blower Inlet Removed for Cleaning.

Rotor Disassembly:

There are two types of rotor assemblies used in the L-40 and L-60 turbochargers. To determine the type in a particular unit consult the nameplate for a style A or B. (If the nameplate is unmarked, you have a style "A".) All L-10 and L-20 turbochargers have style "A" rotor assemblies.

Rotor Disassembly for Style "A":

1. Prevent rotor rotation by applying a wrench to the projected flats on the front of the stud (79), Fig. 9, and remove the elastic stop nut (86) and nosepiece (85). Support the turbine disk by hand and with a soft hammer tap the free end of the stud forcing the turbine disk from its mounting. Do not remove the stud from the turbine disk.
2. With the special pliers provided in the tool kit, remove the turbine end snap ring (17).
3. Remove the shaft and turbine end oil seal with the aid of the impeller remover (110) provided for this purpose (see Fig. 11). Support impeller by hand during this operation.

Rotor Disassembly for Style "B".

1. Prevent rotor rotation by applying a wrench to the projected flats on the front of the stud (79) Fig. 9, and remove the elastic top nut (86) and nosepiece (85).
2. Install impeller remover (113) on tight against end of shaft (See Fig. 11), then tap on head of remover to drive shaft out of the impeller. After impeller is free, remove tool and pull disk and shaft assembly from unit. Support impeller and disk by hand during this operation. Do not remove the shaft and stud from the turbine disk.
3. With the special pliers provided in the tool kit, remove the snap ring and pull-out the oil seal on the turbine end.

Cleaning:

The component parts of the unit are now ready for cleaning and inspection. The diffuser, nozzle ring, as well as mating surfaces should be cleaned with a good solvent or kerosene, and all deposits of grease, dirt, carbon and gasket compound removed. Turbine casing and intermediate casing water jackets should be cleaned of any deposit of scale or sludge in the same manner used in cleaning engine water jackets. If an acid is used to remove scale, the water jackets should be thoroughly flushed out and the acid neutralized. Oil and air passages in the intermediate casing should be blown out thoroughly.

The turbine disk and impeller should be cleaned in Bendix cleaner. Never use a caustic solution, wire brush or scraper on these parts. Extreme care should be exercised in handling the rotor parts. Slight damage to the disk or impeller may cause serious damage to the rotor, when reinstalled.

Inspection:

The bearings and the mating surfaces on the shaft are the only normal wearing parts of the machine. The bearings can be inspected both for size and surface finish without removal. Bearings should be replaced if worn beyond the limits set forth in Section 6, or if the surface shows pitting, corrosion or local wear. If the mating journal surfaces are scored, the finish should be improved by polishing with crocus cloth. Slight scoring of the thrust face is not objectionable if tolerances are within the limits as given in Section 6.

If bearings must be replaced, remove the screws (91) holding the oil seal, and pull out the bearings with the bearing puller. (See Fig. 11.) The blower end oil seal (21) and thrust collar (82) will come out with the blower end bearing (20). The turbine end bearing

(19) may be similarly removed. (See Fig. 11.) Precautions must be taken to prevent damage to bearing housing bore.

Normally, the oil seals are not subject to wear but the inside diameter should be checked to make sure that wear has not occurred. The oil seal clearances should be within the limits as given in Section 6.

The turbine disk should be inspected for mechanical condition, blade tightness, etc. The blower impeller should be checked for evidence of rubbing or mechanical wear and condition of the labyrinth seals.

The turbine nozzle ring should be examined for cracks and distortion or warping of blades. This part of the unit is always subject to cyclic elevated temperatures and should be checked carefully. Do not remove the nozzle ring from the inlet casing unless it is to be replaced.

Assembly Procedure:

Before assembly, all parts should be thoroughly cleaned and flushed and all passages blown out with air. Gasket (10) should be renewed.

Bearing Installation:

If bearings are to be replaced, several precautions must be observed. The bearing (19) having a grooved thrust flange must be put in on the turbine side. The drilled hole on the back of the bearing flange must line up with the locating pin in the intermediate casing before inserting the bearing. A bearing inserting tool is furnished and is to be used for pressing the bearings into the intermediate casing. (See Fig. 11 and 12.) It is extremely important that the bearings be installed in proper alignment. To check this, spread prussian blue lightly on the thrust face of the shaft and blue in the bearing thrust face to be sure of uniform contact over the bearing surface.

Rotor Assembly for Style "A":

1. Before replacing the shaft, place the shaft sleeve (see Fig. 12) on the impeller end of the shaft. The shaft and bearings are to be assembled clean and with a light film of oil. With the shaft sleeve in place, insert the shaft into the bearings taking care not to mar the bearing surfaces. Then remove the shaft sleeve.

2. Slide on thrust collar (82) Fig. 9. Insert oil seals coating surfaces with sealing compound as shown in Fig. 9. Install snap ring (17) with beveled side out. Install screws (91) locking securely by peening.

3. Coat the disk hub with anti-seizing compound (see Fig. 9.) Tap the turbine disk and stud assembly in place. The turbine disk will mount only one way, determined by the relative polar position of the pins (77) in the shaft and matching holes in the disk.

Rotor Assembly for Style "B"

1. Before replacing the disk and shaft assembly, insert the turbine end oil seal, coating the surfaces with sealing compound as shown in Fig. 9. Install snap ring (17) with beveled side out.

2. Place the shaft sleeve (See Fig. 12) on the impeller end of the shaft. The shaft and bearings are to be assembled clean and with a light film of oil. With the shaft sleeve in place, insert the disk and shaft assembly into the bearings, taking care not to mar the bearing surfaces. Then, remove the shaft sleeve.

3. Slide on thrust collar (82) Fig. 9. Insert blower end oil seal, coating the surfaces with sealing compound as shown in Fig. 9. Install screws (91), locking securely by peening.

For both Style "A" & "B" proceed as follows:

4. Assemble impeller (80) and spline washer (88). These parts must be assembled so that the punch marks line up to maintain rotor balance. Coat impeller and spline washer portions of shaft with anti-seizing compound (See Fig. 9).

Slip this assembly on the shaft. After the impeller has been pushed on by hand as far as possible, insert key (84), place nose-piece (85) in position and draw assembly tight with elastic stop nut (86). A torque of 35 foot-pounds should be used for the L-10, 50 foot-pounds on the L-20 and L-40 and 90 foot-pounds for the L-60. Hold centering stud with wrench on flats provided while tightening elastic stop nut. The rotor assembly should turn freely and the end play should be checked with a dial indicator. End play should be within the limits specified in Section 6. After checking the end play, the bearings should be oiled through the lube oil inlet at the top of the intermediate casing (9) Figs. 7 and 8. Turn the rotor by hand to be sure that the oil gets to all surfaces of the shaft and bearings.

Casing Assembly:

To assemble the casings and rotor assembly to the machine proper, the following steps should be taken:

1. If the nozzle ring has been removed from the inlet casing, upon assembly, coat the bolts with high temperature anti-galling compound to prevent galling of the threads due to heat. If the turbine inlet casing has been removed, the threads of the bolts used to secure the inlet casing to the turbine casing should be coated with an anti-galling compound (See Fig. 9.)

2. With the intermediate casing guide pins in place, install a new casing gasket (10). See Fig. 9 for cementing.

3. With the aid of eyebolt and overhead lift, slide the intermediate casing into place (See Fig. 4), being careful not to damage the turbine blades. Install cap screws (11) Fig. 7 and 8 and tighten evenly.

4. The intermediate casing and blower casing machined surfaces should be coated lightly with sealing compound (see Fig. 9)

5. Mount the blower casing assembly into place being careful not to damage the labyrinth rings on the shroud of the impeller. Install the blower casing cap screws and lockwashers (28 and 30) for L-20 or nuts and lockwashers (29 and 30) for the L-10, L-40 and L-60, and tighten evenly.

Check oil supply lines; they should be clean and fittings in good condition. If oil filter element is not in first class condition, it should be replaced.

With reasonable care and adherence to good shop practice, no trouble should be encountered in dismantling and assembling the turbocharger. Check air inlet equipment. It should be clean and tight to prevent entry of foreign particles.

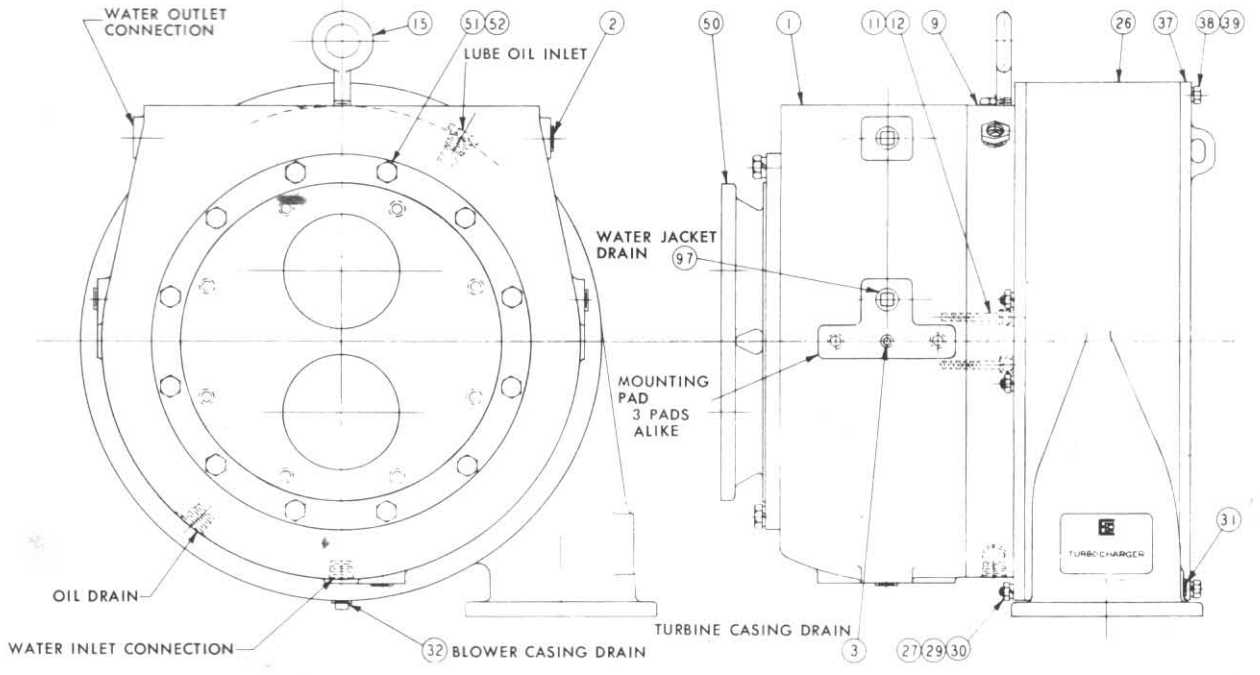


Fig. 7—Outline Drawing L-10 Turbocharger

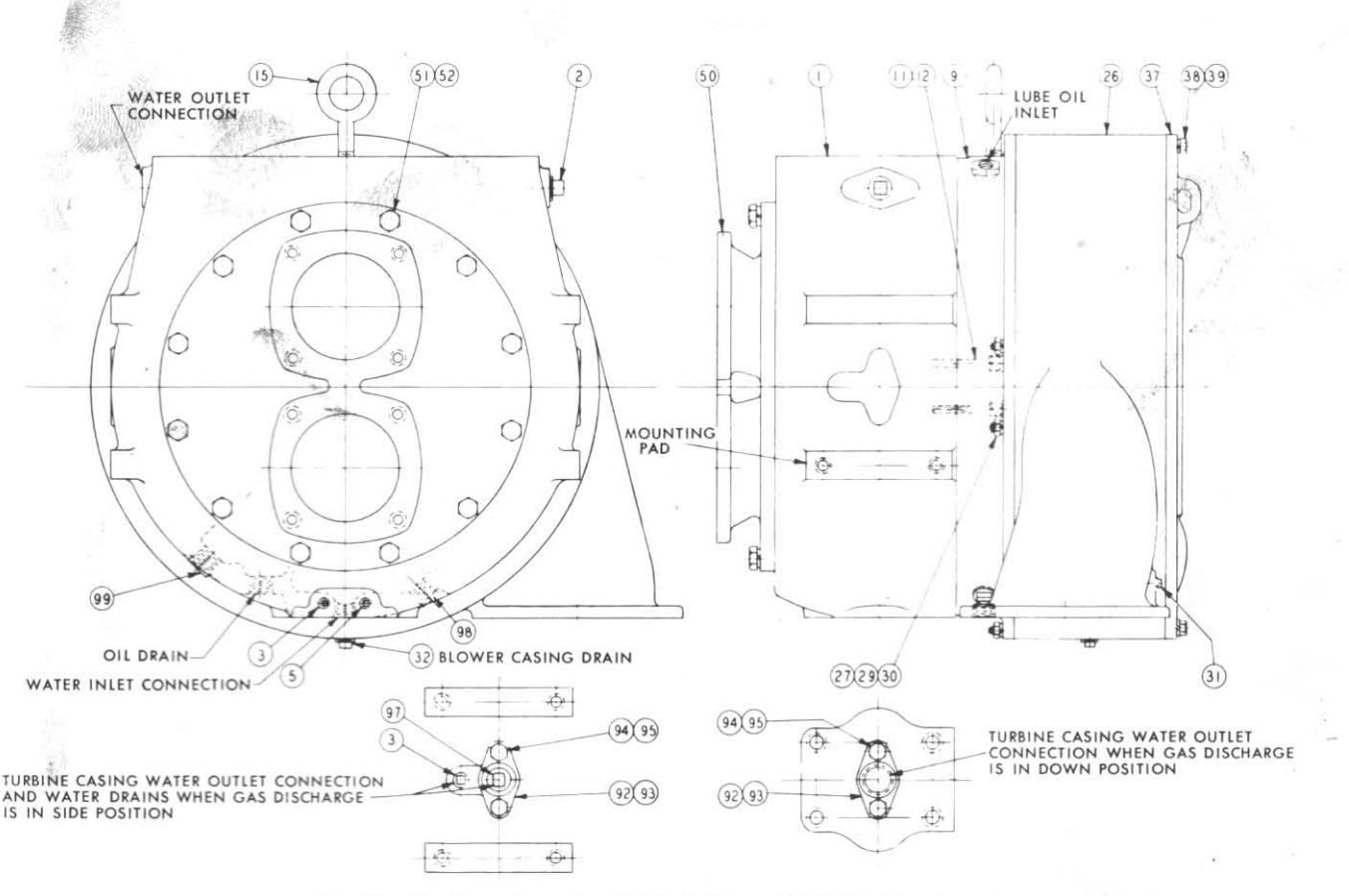


Fig. 8—Outline Drawing L-20, L-40 and L-60 Turbocharger

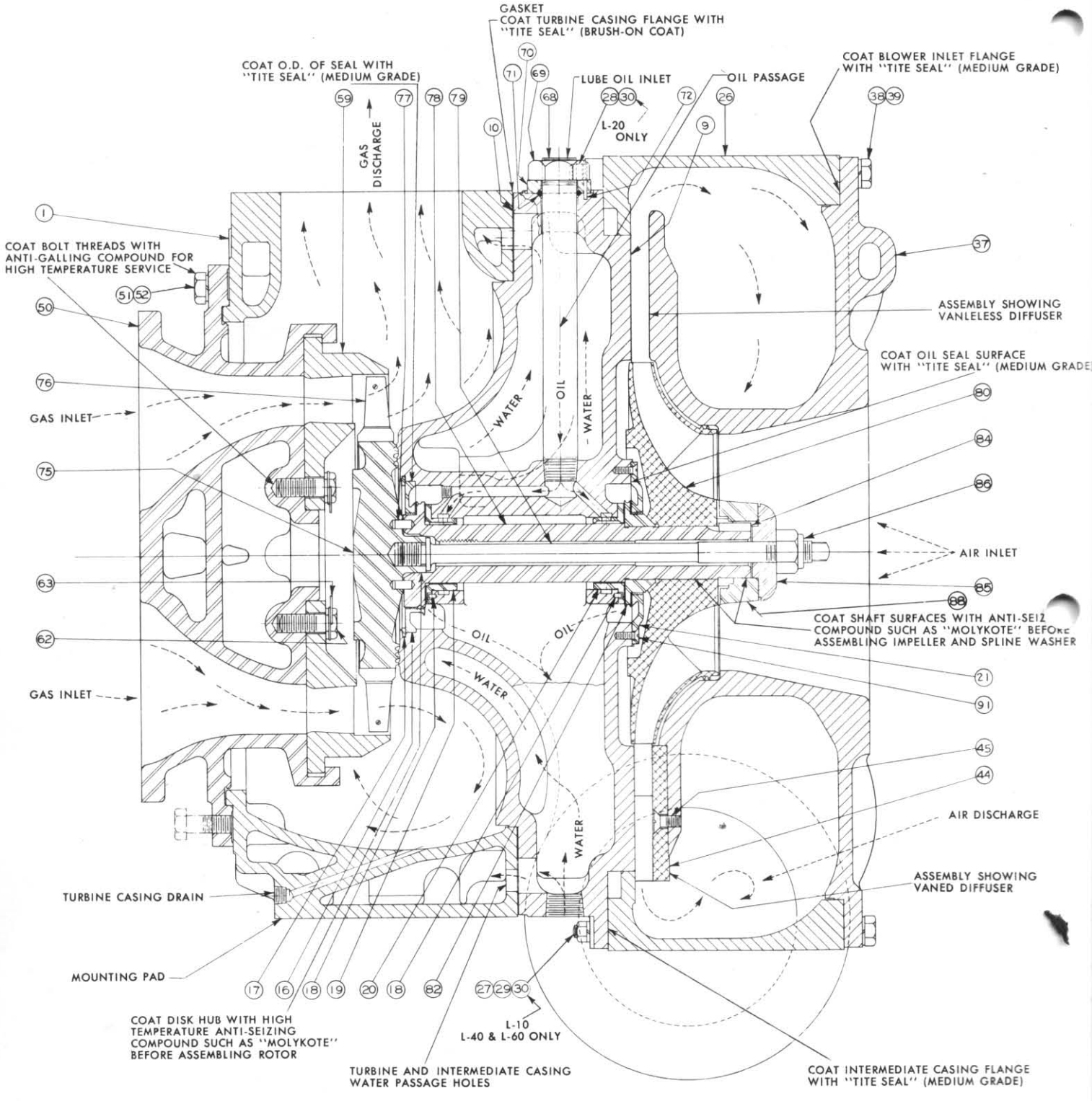


Fig. 9—Cross-sectional Assembly

Note: Turbine end oil seal detail for Style "A" rotor is shown *above* centerline; for Style "B" *below* centerline.

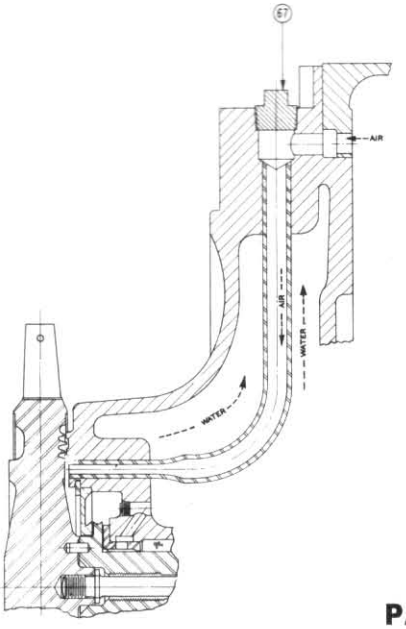


Fig. 10

Sealing Air Arrangement
Turbine End Oil Seal
(L-40 and L-60 only)

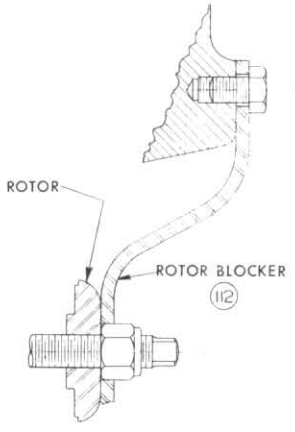
PART LIST

WHEN ORDERING THESE PARTS, THE TURBOCHARGER MODEL AND SERIAL NUMBERS MUST BE FURNISHED

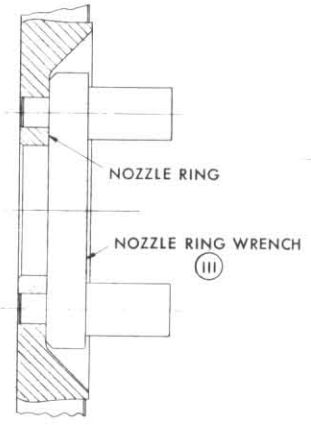
Number	Name of Part
1	Turbine Casing
2	Pipe Plug—Turbine Casing
3	Pipe Plug—Turbine Casing Drain
5	Pipe Plug—Water Jacket Drain
9	Intermediate Casing
10	Gasket—Intermediate Casing
11	Cap Screw—Intermediate Casing
12	Lockwasher—Intermediate Casing Cap Screw
15	Eye Bolt
16	Oil Seal—Turbine End
17	Snap Ring—Oil Seal
18	Pin-Bearing Locating
19	Bearing—Turbine End
20	Bearing—Blower End
21	Oil Seal—Blower End
26	Blower Casing
27	Stud—Blower Casing
28	Cap Screw—Blower Casing
29	Nut—Blower Casing
30	Lockwasher
31	Plug—Blower Casing
32	Plug—Blower Casing Drain
37	Blower Inlet
38	Bolt—Blower Inlet
39	Lockwasher
44	Diffuser Ring
45	Machine Screw—Diffuser Ring
50	Turbine Inlet Casing
51	Bolt—Turbine Inlet Casing
52	Lockwasher
59	Nozzle Ring
62	Bolt—Nozzle Ring
63	Locking Wire—Nozzle Ring Bolt
67	Plug
68	Oil Pipe
69	Nut—Oil Pipe
70	Washer—Oil Pipe
71	"O" Ring—Oil Pipe
72	Dowel Pin—Oil Pipe Nut
75	Disk
76	Turbine Blade
77	Dowel Pin—Shaft
78	Shaft
79	Stud
80	Impeller
82	Thrust Collar
84	Key—Spline Washer
85	Nose Piece—Impeller
86	Elastic Stop Nut
87	Rotor-Assembly
88	Spline Washer
91	Machine Screw—Oil Seal
92	Companion Flange
93	Gasket—Companion Flange
94	Bolt—Companion Flange
95	Lockwasher
96	Bushing—Oil Inlet (old style intermediate casing)
97	Pipe Plug—Water Jacket
98	Pipe Plug—Water Inlet (alternate)
99	Pipe Plug—Oil Drain (alternate)

These parts make up the rotor assembly, part 87. If any of these parts are to be replaced, the rotor must be returned to Elliott Co., Jeannette, Pa., for rebalancing.

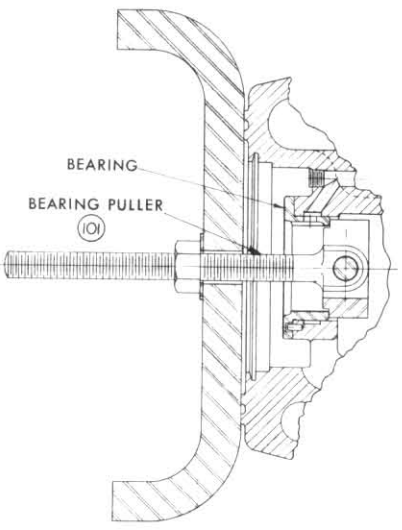
METHODS OF USING SPECIAL TOOLS



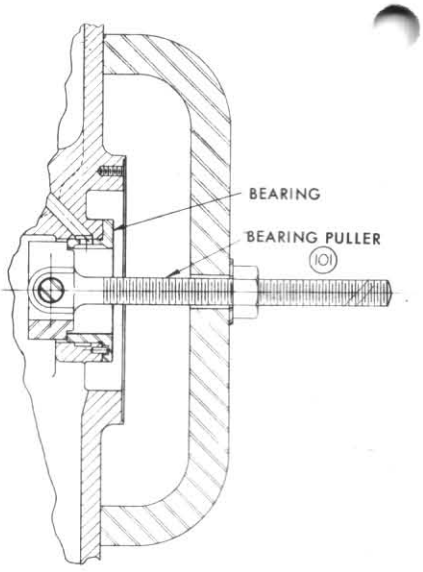
METHOD OF
BLOCKING ROTOR



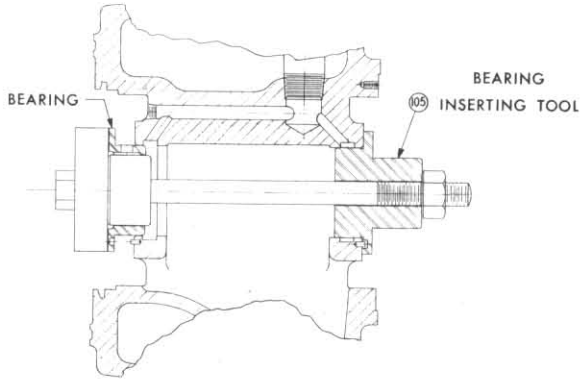
METHOD OF
REMOVING NOZZLE RING



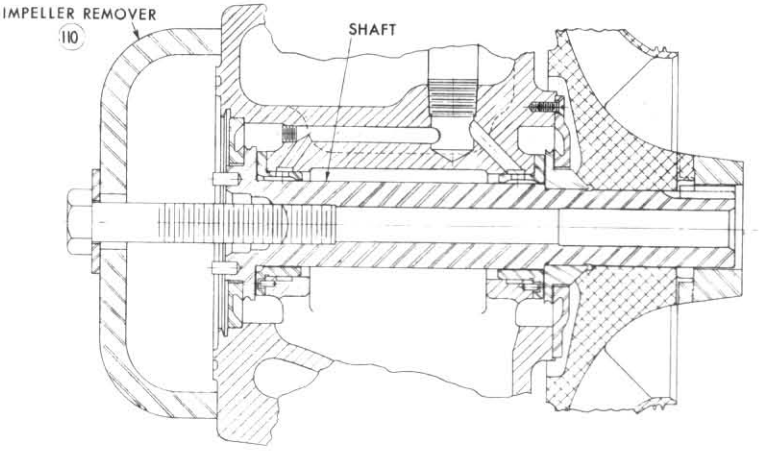
METHOD OF REMOVING BEARING
(TURBINE END)



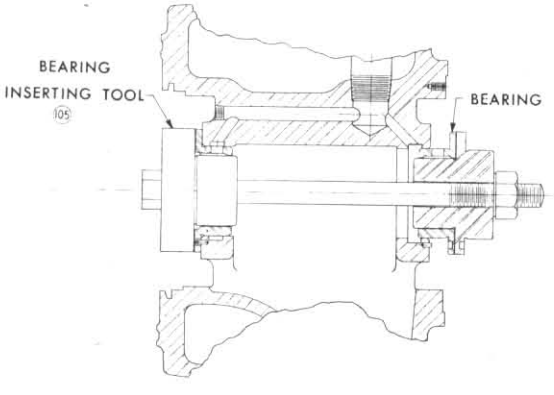
METHOD OF REMOVING BEARING
(BLOWER END)



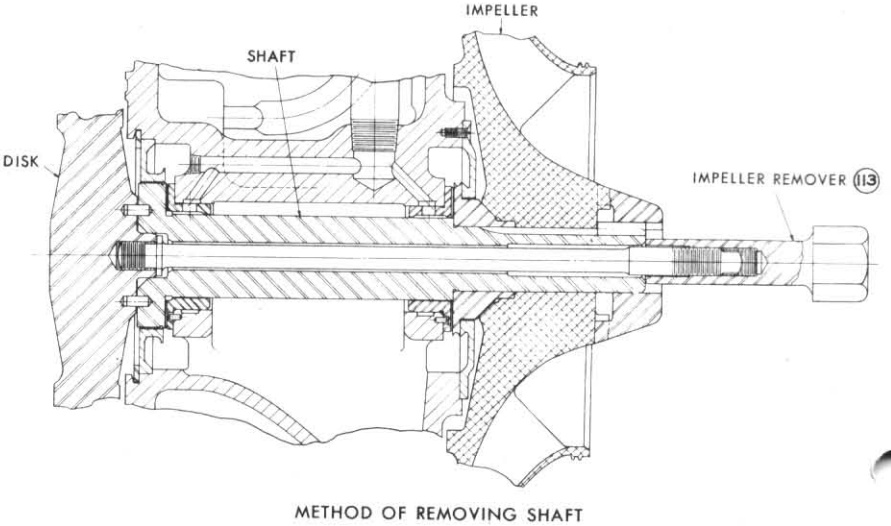
METHOD OF INSERTING BEARING
(TURBINE END)



METHOD OF REMOVING SHAFT
(FOR STYLE "A")



METHOD OF INSERTING BEARING
(BLOWER END)



METHOD OF REMOVING SHAFT
(FOR STYLE "B")

Fig. 11—Method of Using Special Tools

TOOL LIST

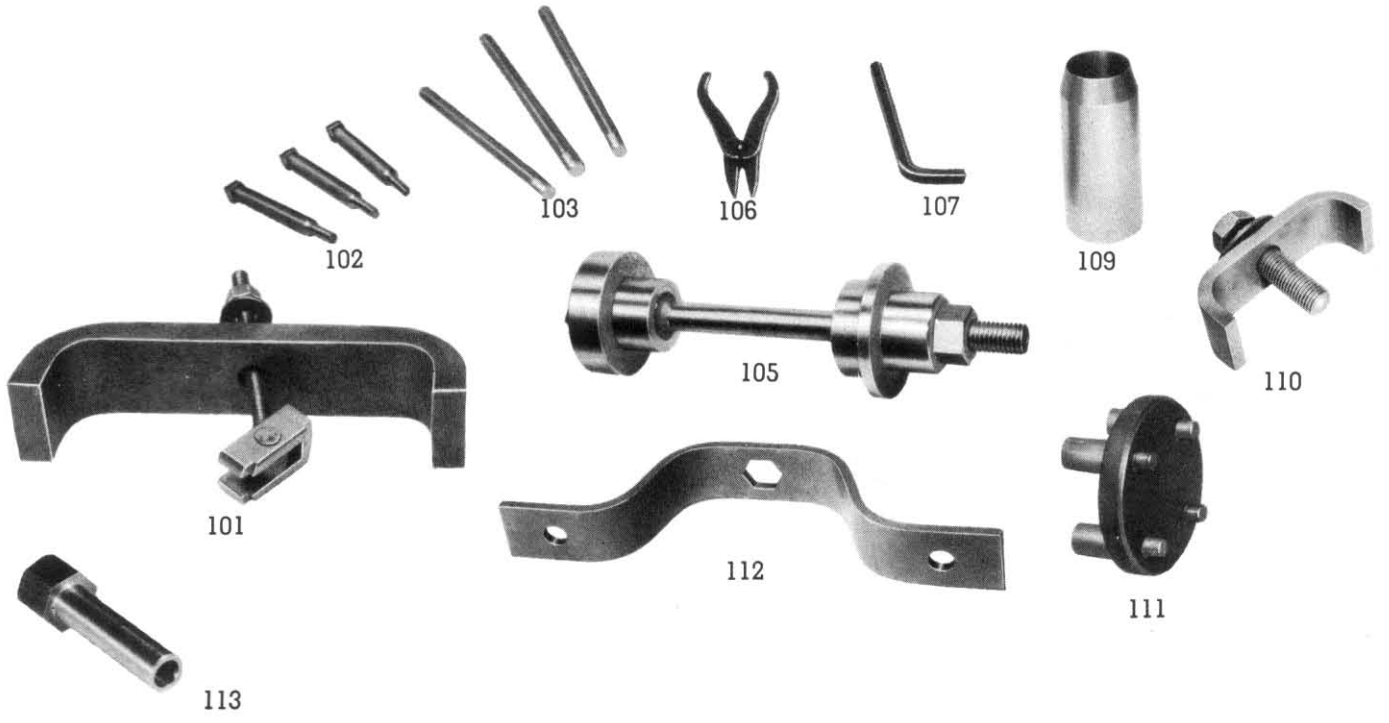


Fig. 12—Tools

Number	*Name of Part*
101	Bearing Puller Assembly
102	Jack Screws
103	Intermediate Casting Guide Pins
105	Bearing Inserting Tool
106	Snap Ring Pliers
107	Allen Wrench—3/8" (L-10, L-40 & L-60)
108	Allen Wrench—5/16" (L-20)
109	Shaft Sleeve
110	Impeller Remover (Style "A" Rotors)
111	Nozzle Ring Wrench
112	Rotor Blocker
113	Impeller Remover (Style "B" Rotors)

WHEN ORDERING THESE PARTS, THE TURBOCHARGER MODEL AND SERIAL NUMBERS MUST BE FURNISHED

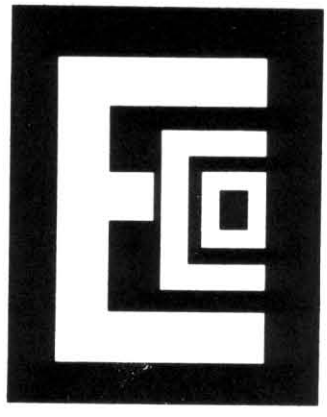
GENERAL MAINTENANCE COMMENTS

If the machine is to be shut down for an extended period of time, the turbocharger must be dismantled and the shaft surfaces and all bearings thoroughly covered with vaseline for protection. All exposed surfaces should be slushed with rust preventive compound. Before placing the unit in operation again, clean all parts thoroughly and remove the protective coating.

The turbocharger is designed and constructed to eliminate entirely hand fitting of moving parts. All repair parts should be entirely interchangeable without forcing or fitting. It is essential in assembly and repair of the turbocharger that parts be handled carefully and kept clean, since tolerances on some parts are such that nicks, burrs or dirt will interfere with proper operation of the machine.

It is recommended that a reasonable amount of spare parts be maintained with the unit for emergencies.

Experienced field service men are available when required.



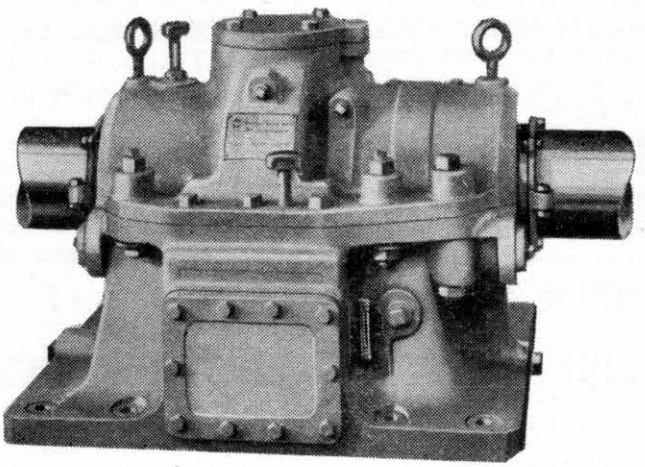
ELLIOTT COMPANY

Supercharger Department — Jeannette, Pa.

District Offices in Principal Cities

INSTRUCTION BOOK TC-20B 5-53

LITHO IN U.S.A.



INSTRUCTIONS

for Installing and Operating

Horizontal Two-Shoe Adjustable

KINGSBURY THRUST BEARINGS

Styles GH, GF and GK

Folder 350-A

GH. 15

KINGSBURY MACHINE WORKS, INC.

4316-28 Tackawanna Street Frankford, Philadelphia 24, Pa.

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KINGSBURY

I. GENERAL DESCRIPTION

DRAWING REFERENCES

(A) PRINCIPAL PARTS:

1. The standard two-shoe 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. Often these two-shoe bearings run air-cooled. That is, the heat resulting from oil friction is carried off readily by the surrounding air and foundation.

2. For higher running speeds, 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 with kerosene, also any oil piping. Blow them clean with air, if possible. Remove anti-rust coatings with kerosene. Use rags or cloth, as waste leaves lint, which clings to minute burrs and might 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. Take light fractional turns on alternate screws till the oil films stop yielding. 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 re-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. A plate attached near the oil gauge shows "HIGH" and "LOW" oil levels.

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.

(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. If adjustable stuffing boxes are used, do not take up hard on the glands, as that would cause unnecessary heating of the shaft.

2. With air or water cooling, an oil bath temperature up to 150° F. is not excessive, when using oil of 400 SUV at 100° F. or heavier. Erosion of water cooling coils can be minimized by avoiding a needlessly strong flow.

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, or indicated as "Ref. No." in the instruction drawing.

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 (or nearest substitute) 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 24, Pa., U. S. A.


KINGSBURY

CHECKING END PLAY

OF TWO-SHOE THRUST BEARINGS

I. Checking End Play While Running

When it is feasible, the simplest method of checking end play is to use a suitable measuring instrument on any accessible part of the line shaft that is rigidly coupled to the thrust bearing, while running the engine or turbine slowly ahead and astern. This would normally be done at the end of a run when the ship is maneuvering to approach her pier, before the machinery and shaft are cold. The speeds should be slow, to avoid adding deflections of bearing parts and housing to the actual end play, but they should be sufficient to overcome the rake of the shaft and insure that the full end play is actually taken up.

The method of applying this procedure will depend somewhat on the type of bearing, as follows:

Micrometer at Forward End of Shaft

(a) When the drive, by steam or Diesel engine, is through reduction gearing, the end cover of the bearing sometimes has a central hole, through which a micrometer measuring device can be applied to detect the axial position of the end of the shaft. Using that device, a measurement is taken under forward thrust, and another under astern thrust. The difference between the two readings is the end play.

(b) Possibly the 2-shoe thrust bearing at the forward end of an electric motor direct drive may have a drilled end cover plate like that just described. If so, the same procedure can be used.

Indicator Aft on Shaft

(c) If the forward end of the shaft is not accessible, end play must be measured elsewhere. A dial indicator may be mounted on a rigid support close to some convenient coupling flange. Sometimes the shaft has a shoulder turned on it for the express purpose of applying a dial indicator. If the shaft has a flexible coupling, the measurement must be taken between the thrust bearing and the flexible coupling—not beyond.

If Starting from Cold . . .

(d) If it is not feasible to check end play while the machinery is still warm, it may be possible to start the engine from cold and run it slowly ahead and astern with just sufficient power to take up the end play. This requires more care, since it involves limbering the cold oil in the shaft bearings in order to avoid false readings. The measurements should be taken by the appropriate means above described.

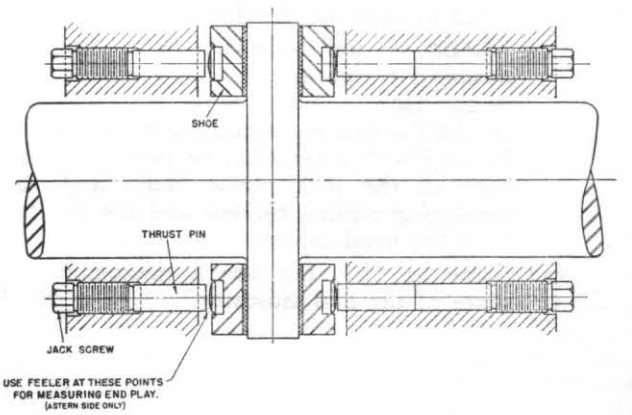
II. Jacking On Shaft Flange

If it is not feasible to measure end play while running, the next choice is to jack the shaft fore and aft at some suitably-located flange.

(a) If possible, jack while the shaft is still warm. Mount the indicator as in paragraph Ia or Ic. Be sure that the shaft movement is free (i.e. oil not cold) and *carefully avoid over-jacking,* which would add deflections to the actual end play.

(b) If the jacking must be done cold, begin by rocking the shaft by means of the turning gear to relieve the static friction. After rocking the shaft, apply the jack. If possible, mount the jack so that it can follow the rocking motions right and left. Jack forward till marked resistance to rocking shows that the oil films between collar and shoes are squeezed out. Note the indicator reading; then jack the shaft aft, rocking it as before, and take the new reading. Repeat to make sure of readings.

III. Measuring Inside Two-Shoe Bearing



If end play of a 2-shoe bearing is to be measured inside the bearing (instead of by a dial indicator on the fore-and-aft shaft movement) the correct method is to use a feeler between the thrust pin and the rounded pivot ("shoe support") set into the back of each shoe. This should be done on the astern side only, with the housing

cover lifted and the collar blocked or jacked against the forward shoes. Ordinarily this is the only check necessary. However, the following precautions should be noted.

With any 2-shoe bearing solidly coupled to a steam or Diesel engine shaft, it is essential that the thrust collar be so positioned fore and aft that the engine crankshaft is correctly located in reference to the main and crankpin bearing ends. Further, the thrust housing should be located to afford roughly equal clearances fore and aft for thrust collar adjustment. In subsequent re-checking and re-setting of end play, these points should be borne in mind.

In large 2-shoe bearings there is a certain amount of brinelling between the shoe supports and the thrust pins, mainly on the ahead side. In time this may make it necessary to readjust the ahead jack screws. Hence the safest procedure is to start by checking the crank clearances. If those clearances are not correct, the shaft must be jacked endwise till they are. (The thrust jack screws may be used for this purpose, with the opposite jack screws backed off.) At that point the shaft should be blocked and all the jack screws run in till the shoes bear solidly and equally on the thrust collar. As the shoes make contact, take small fractional turns on the jack screws till the oil films between shoes and collar stop yielding. Then back the astern screws to give the required end play.

If the *astern* shoes and thrust pins have been affected by brinelling, the use of feelers becomes uncertain. The astern jack screws may then be backed accurately by any of the following methods:

(a) Note the pitch of the jack screw threads, and use a protractor on the jack screw head to get the required number of degrees of turn for the desired end play.

(b) Mount a dial indicator on a bracket, attached temporarily in place of the jack screw lock wrench, with the indicator mushroom bearing against the jack screw head. The bracket must be parallel to the face of the jack screw head, and the mushroom square thereto and not too far from the head centre.

(c) Same as (b), but use a micrometer in place of the dial indicator.

The foregoing refers to the usual *outside* jack screws. If the bearing has inside jack screws the procedure is as follows:

(d) Mark the exact position of the turning wrench when the jack screw has been tightened. (A bar may be clamped in a raised position across the housing, and the wrench position marked on the bar.) Block the shaft, and back the screw sufficiently to free the shoe: lift the shoe out. Return the wrench to the marked position, and use a micrometer between the jack screw and thrust collar to back the jack screw for the desired end play. Repeat for the other shoe. Wipe the shoes with clean rags before replacing them. Or—

(e) Note the pitch of the jack screw threads, and use a protractor on the jack screw head to get the required number of degrees of turn for the desired end play.

IV. General Notes

Never try to measure the end play with feelers between collar and shoes. In a 2-shoe bearing the tilt of the shoes would make accurate measuring impossible.

A log of end play measurements should be kept and referred to after each checking. When new, there may be slight settling of the thrust pins and jack screws; but any noticeable later increase in the end play indicates that the thrust shoe surfaces should be examined, and repairs made if necessary.

In any jacking operations, make sure that the weight and rake of the shaft do not affect the measurements.

V. Some "Don'ts"

Don't jack the shaft without first slightly rocking it to restore the oil film.

Don't try to measure end-play with feelers between collar and shoes.

Don't start checking without being familiar with the preferred and alternative procedures for your particular bearing and operating conditions.

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