DFX DFX-F

OPERATION AND MAINTENANCE MANUAL

FOR

DFX - DFX-F SERIES

SIX CYLINDER

DIESEL ENGINES

HERCULES MOTORS CORPORATION
CANTON, OHIO, U. S. A.

August 1, 1952

DFX-F DFX

OPERATION AND MAINTENANCE MANUAL

FOR

DFX & DFX-F SERIES ENGINES

Serial Numbers ..... 365,001—380,000

MODEL	BORE	STROKE	NACC-H. P.	PISTON DISPL.
DFXB	5″	x 6″	60.0	707 Cu. In.
DFXC	5¼″	x 6″	66.2	779 Cu. In.
DFXD	5½″	x 6″	72.6	855 Cu. In.
DFXE	5⅝″	x 6″	75.9	893 Cu. In.
DFXH	5¾″	x 6″	79.4	935 Cu. In.
DFXHF	5¾″	x 6″	79.4	935 Cu. In.

HERCULES

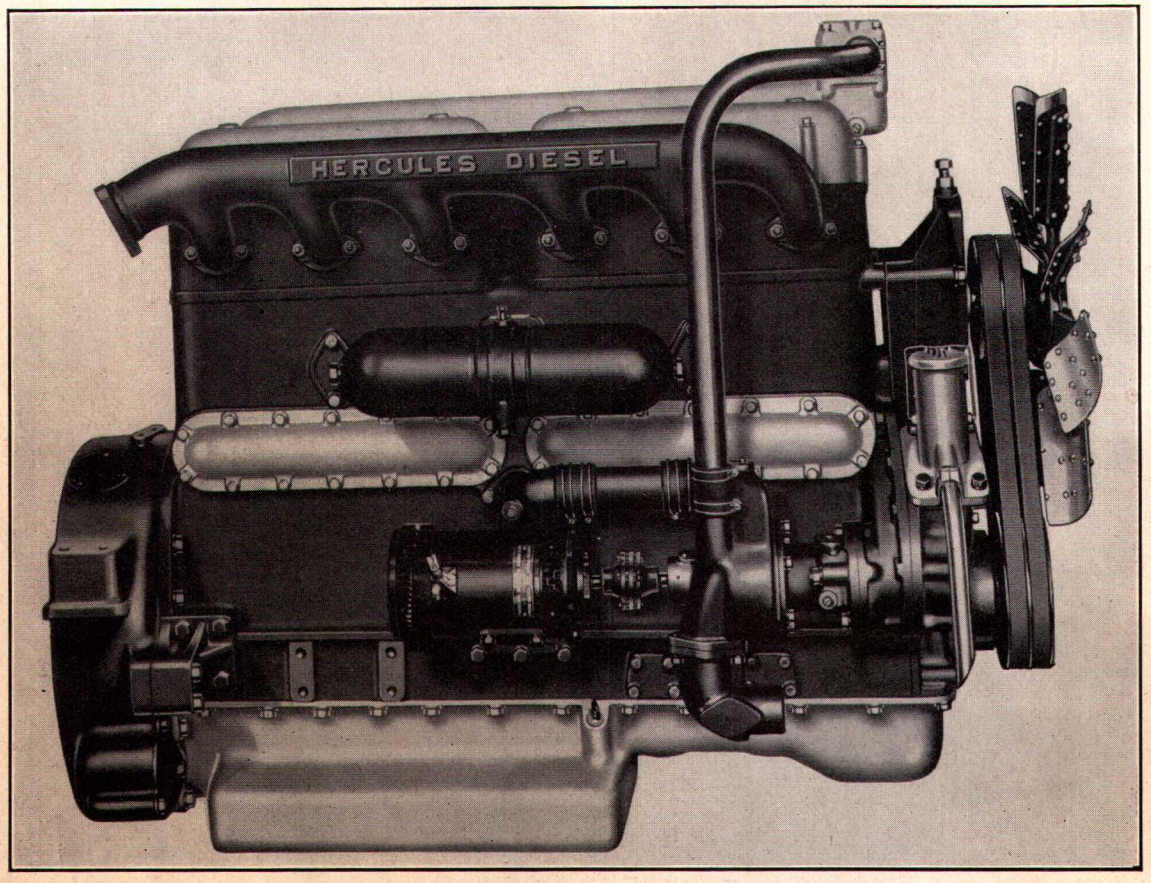
Compression Ignition Solid Injection Engine

(DIESEL TYPE)

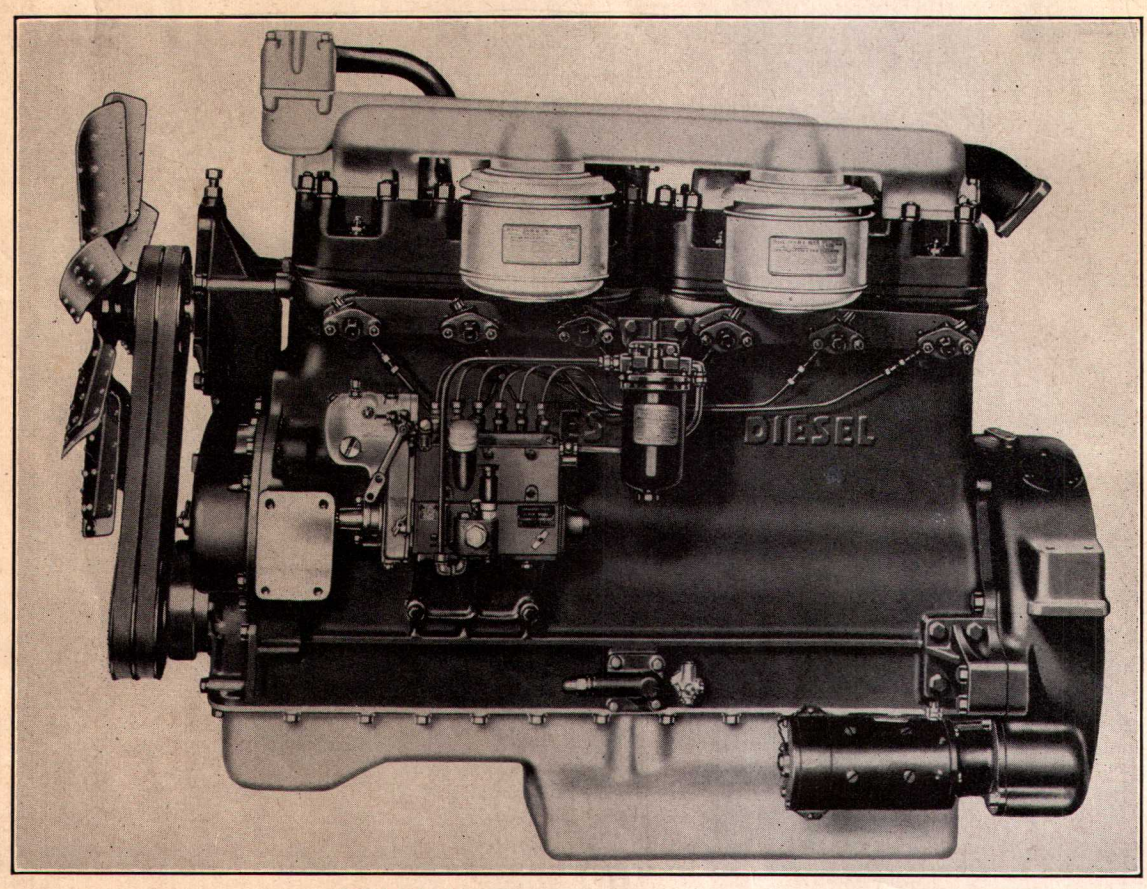
HERCULES MOTORS CORPORATION
(HERCANO)

Canton, Ohio U. S. A.

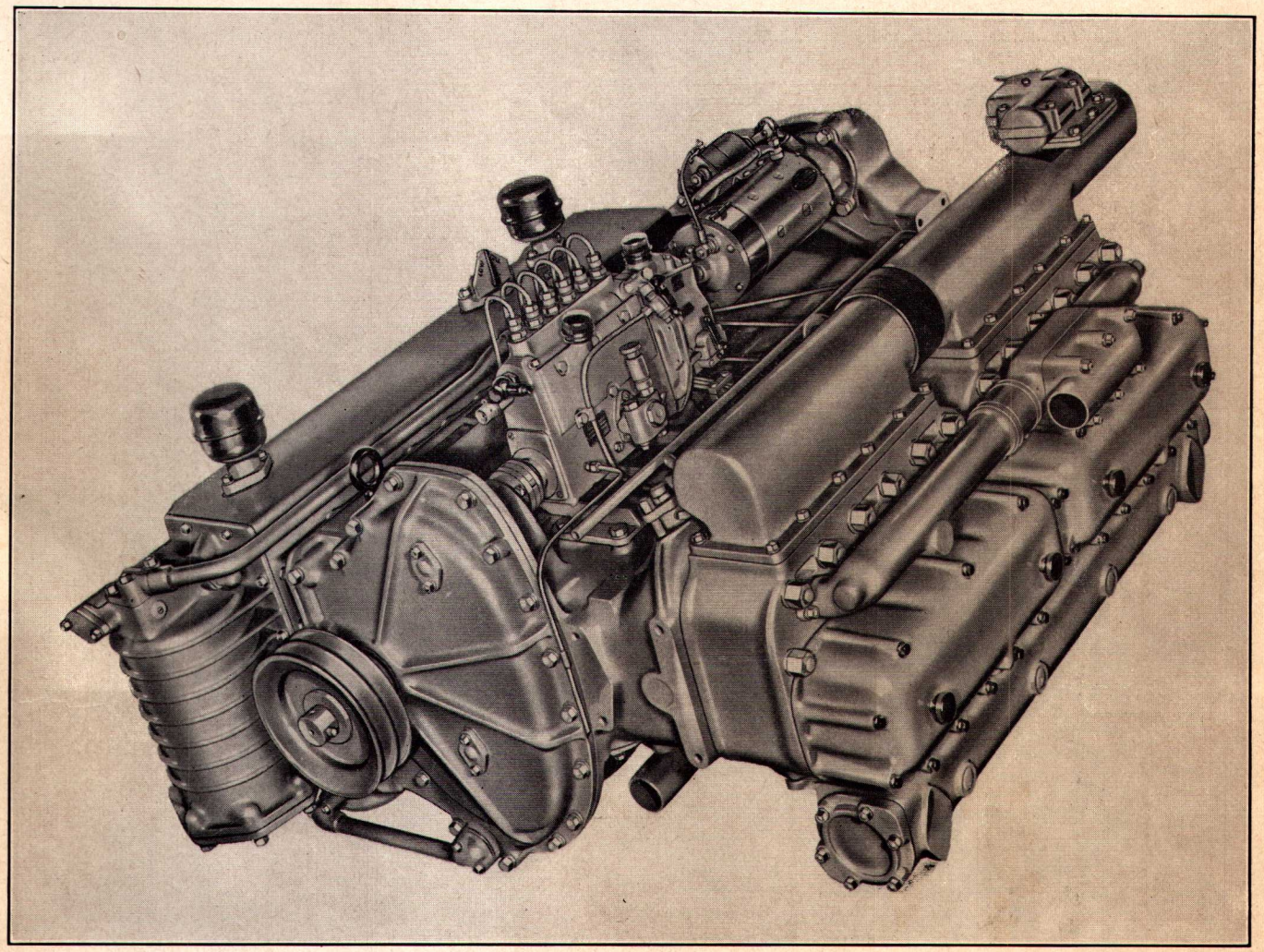
CABLE ADDRESS "HERCANO"



DFX Series Water Pump, Generator and Oil Filter Side



DFX Series Fuel Injection Pump Side



DFX-F Series Top Front of Engine

SPECIFICATIONS

	Model DFXB	Model DFXC	Model DFXD	Model DFXE	Model DFXH-DFXH-F
Bore and Stroke	5"x6"—127x152.4 M/M	5¼"x6"—133.3x152.4 M/M	5½"x6"—139.7x152.4 M/M	5⅝"x6"—142.9x152.4 M/M	5¾"x6"—146.1x152.4 M/M
No. of Cylinders	6	6	6	6	6
N. A. C. C. Horsepower	60	66.2	72.6	75.9	79.4
Piston Displacement	707 Cu. In. or 11.6 Litres	779 Cu. In. or 12.8 Litres	855 Cu. In. or 14 Litres	893 Cu. In. or 14.6 Litres	935 Cu. In. or 15.3 Litres

Rotation—Clockwise Standard, Looking at Cranking End. Anti-clockwise optional.

ALL MODELS

CYLINDERS

Cast ..... In Six
Sleeves ..... Removable, Dry Type

CRANKCASE

Material ..... Cast Iron
How Cast ..... Integral with Block

LUBRICATION

Forced Feed ..... To All Main Bearings, Connecting Rods, Rocker Arms, Etc.

CYLINDER HEAD AND VALVES

Detachable

Valve Arrangement ..... Valve-in-head
Exhaust Valve Diameter ..... 2¼"—57.15 MM
Intake Valve Diameter ..... 3"—76.2 MM

PISTON

Material ..... Aluminum

PISTON RINGS

	DFXB - DFXC - DFXD - DFXE	DFXH - DFXH-F
Number Above Pin	5	4
Number Below Pin	1	1
Ring Width		
Top	⅛"—3.17 MM	⅛" Keystone Type
2nd and 3rd	⅛"—3.17 MM	⅛"—3.17 MM
4th	⅛"—3.17 MM	¼"—6.35 MM
5th	¼"—6.35 MM	¼"—6.35 MM
6th	¼"—6.35 MM	

PISTON PIN

Diameter	2"	5.08 MM
Bearing Length	2"	5.08 MM
Bearing Location		In Rod
Number of Bearings		1

CRANKSHAFT

Number of Main Bearings		7
Bearing Diameter	4½"	114.2 M/M
Bearing Length—Front	2⅜"	60.3 M/M
Bearing Length—Center	3⅝"	92.1 M/M
Bearing Length—Rear	3"	76.2 M/M
Bearing Length—Intermediate	2"	50.8 M/M

CAMSHAFT

Drive		Helical Gear
No. of Bearings		8
Dia. of All Bearings	2⅜"	60.3 M/M
Length (Front 1)	2 $\frac{5}{32}$"	53.2 M/M
Length (Center 4)	2¾"	69.8 M/M
Length (Int. and Rear 2-3-5-6-7)	1⅜"	34.9 M/M

Location—Right Hand Side Looking at Flywheel

CONNECTING ROD

Material	Heat Treated Nickle Chrome Molybdenum Steel	
Connecting Rod Bearings, Diameter	3 $\frac{5}{16}$"	84.1 M/M
Connecting Rod Bearings, Length	2½"	63.5 M/M
Connecting Rod Length, c to c	12"	304.8 M/M

GENERAL DATA

Cooling ..... High Velocity Centrifugal Pump
Starting Motor Mounting ..... Flange
Method of Suspension ..... 3 Point
Flywheel ..... For Any Standard Clutch
Fuel Pump ..... Plunger Type
Fuel Nozzles ..... Pintle Type
Fuel Transfer Pump ..... Integral with Fuel Pump
Governor ..... Mechanical Type
Air Cleaner ..... Efficient Oil Bath Type

Provision For Air Compressor or Vacuum Pump.

NOTE: The Hercules Motors Corporation reserves the right to change design or specifications, without notice.

Introduction

THE Hercules compression ignition injection type engine is the result of years of development and field experience. Extensive tests have proved these different size engines adapted to all purposes for which such sizes and types are needed. The Hercules Motors Corporation was not satisfied to merely build an engine which would operate on the Diesel Cycle principle but this engine had to be of a type which would eliminate many of the objections to some of the existing compression ignition engines. These Hercules Diesel type engines have demonstrated their ability to operate smoothly and to be free from objectionable smoke while developing surprising power. It was essential that this type engine should demonstrate its fitness for a place in the Hercules line by giving the same satisfactory results which thousands of operators have obtained from several hundred thousand gasoline engines which have been manufactured by this company during the past thirty-seven years.

The Hercules Diesel Series has been designed to follow as closely as possible the characteristic features of the Hercules gasoline engines wherever the design has not required the introduction of entirely new features because of the compression ignition principle of operation. This made possible the use of the valuable experience obtained from field operation of several hundred thousand Hercules Engines and these features not only assure satisfactory performance but they also enable the average mechanic to make adjustments in exactly the same manner as he has been accustomed to make them on the Hercules gasoline engines.

An effort has been made to give sufficient information in this book to permit an experienced mechanic to make the various adjustments and replacements which may be needed.

To men trained in compression ignition type engine operation the Hercules Diesel series present no maintenance problems and the construction of the Hercules compression ignition engine is so similar to that of the more common gasoline engine that no good mechanic need hesitate to make all of the ordinary adjustments.

The mystery commonly surrounding the Diesel cycle engine will be eliminated by careful study of the various parts of this book which cover design, construction and maintenance, but we do not wish to encourage any inexperienced person attempting to make repairs or adjustments, for such action may result in very expensive repairs being necessary. **Do not attempt to start, operate or service a Hercules compression ignition engine without becoming familiar with the instructions given under these various sections.**

Compression ignition engines have generally been called Diesel engines in the past due to their operating on the Diesel cycle. For the sake of brevity the Hercules compression ignition engine will be referred to in this book as a Diesel engine by which name it is most commonly known.

HERCULES MOTORS CORPORATION.

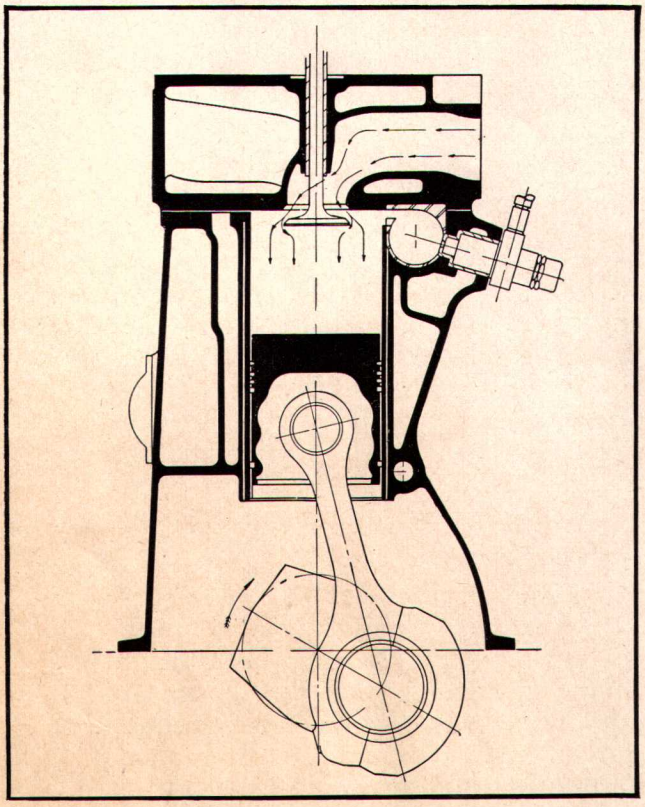


Illustration No. 1

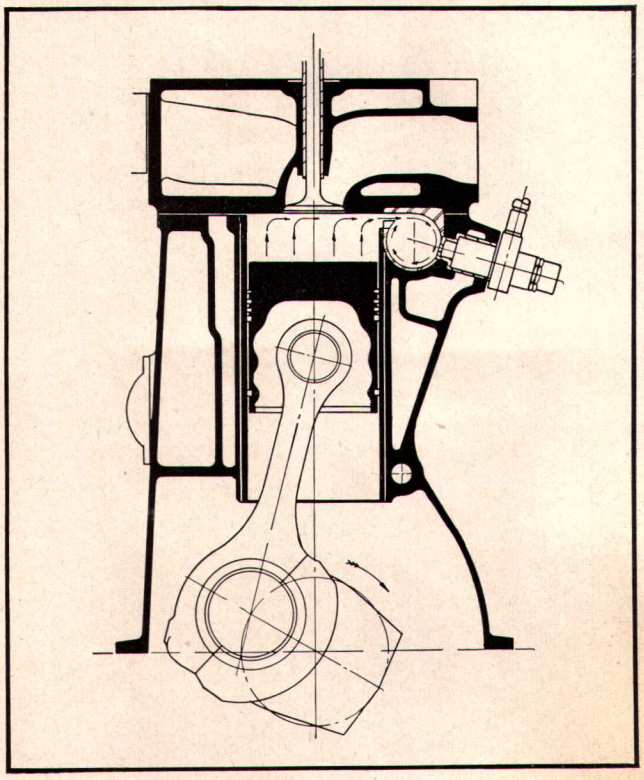


Illustration No. 2

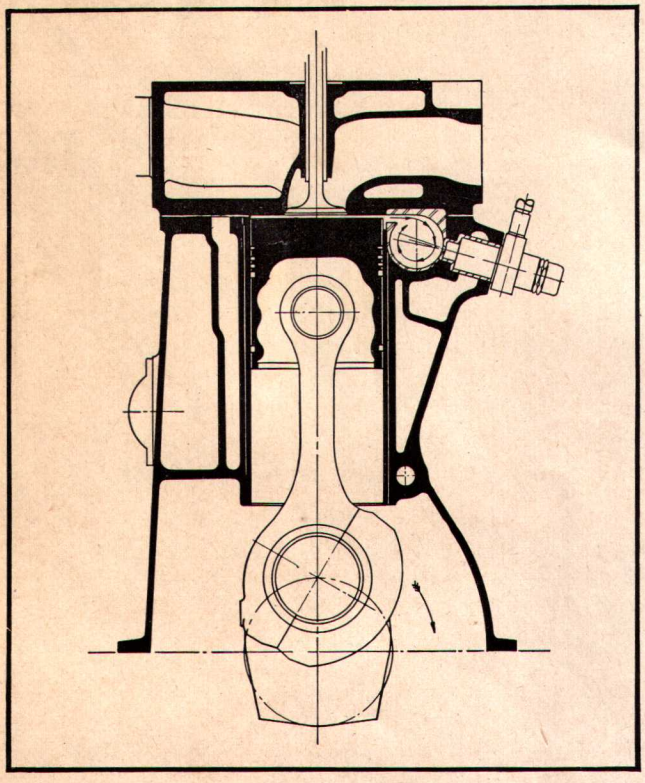


Illustration No. 3

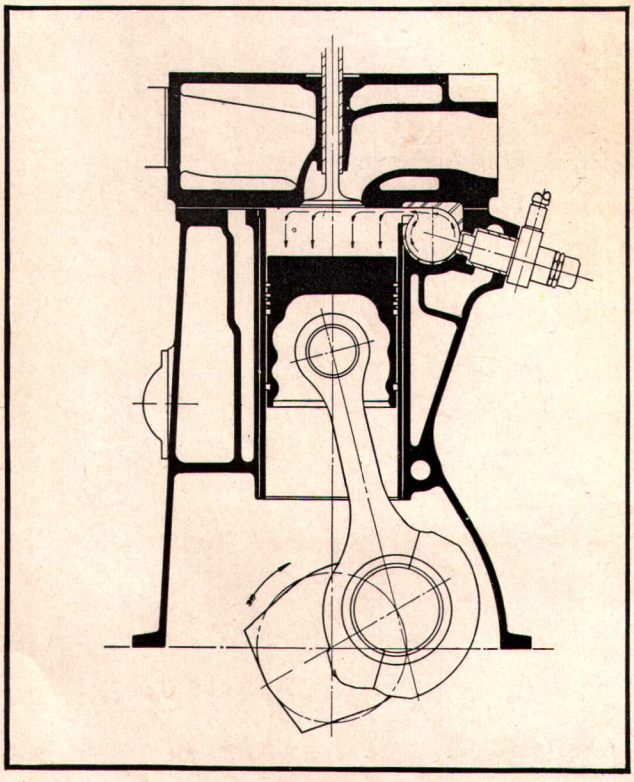


Illustration No. 4

PRINCIPLES OF THE DIESEL CYCLE

THE Diesel cycle principle is based on a law of nature that the more air is compressed the higher in temperature this air becomes. Dry air with an original temperature of 60° F. if compressed into one tenth of its original volume without heat loss through cylinder walls will reach a temperature of approximately 825° F.; if compressed into one fifteenth of its original volume it will be approximately 1050° F. and so on, the greater the compression the higher the temperature. The compression ignition engine makes use of this means to ignite the fuel instead of using an electric spark as in a conventional gasoline engine.

By using fuel injection pumps and nozzles fuel oil can be used instead of gasoline. The pumps raise the fuel to very high pressures and force it through a relatively small opening, or openings, in the nozzles which atomizes or breaks this fuel into very fine particles in the form of mist and sprays this mist into the hot compressed air where it ignites and burns. Any oil when subjected to a certain temperature will ignite and burn. Various Diesel fuel oils have different ignition temperatures but practically all are well below 1050° F.

In extremely cold weather it may be necessary to apply artificial heat to the intake manifold or heat the circulating water in the jackets or the lubricating oil in the base to accomplish quick starting. This is due to the heat generated in the air being compressed radiating rapidly into the cylinder wall. When the cylinder walls are very cold, such as in zero weather, they may absorb so much of this heat from the air that the air temperature may be below the ignition temperature of the fuel oil at the time the oil is injected.

The basic difference between the compression ignition engine and spark ignition is that in the Diesel engine the heat for firing the fuel is in the air in the cylinder previous to the introduction of fuel and in a gasoline engine the fuel is in the air of the cylinder previous to the introduction of heat—the spark—to fire the fuel. As fuel oil is heavier than gasoline and much harder to vaporize due to its natural formation it must be atomized by mechanical means. Basically both engines are otherwise similar.

There are both two and four stroke cycle gasoline and compression ignition engines. There are air injection and solid or mechanical injection compression ignition engines. As the Hercules Diesel engine is a four stroke cycle, solid or mechanical injection engine, this will be described in this book.

FUNCTION OF DIFFERENT STROKES:

The illustrations marked 1-2-3-4 and 5 show the various strokes of the Hercules Diesel type engine.

Intake Stroke—Illustration No. 1. Pure clean air is drawn through the air intake valve, which is opened by the rocker arm actuated by a cam through tappets and rods, into the cylinder as the piston travels downward.

Compression Stroke—Illustration No. 2. The intake valve has now closed and the exhaust valve remains closed so all of the air taken into the cylinder on the intake stroke is now being compressed between the cylinder head and piston. However on one side of the Hercules cylinder there is an opening to a spherical shaped combustion chamber. The air rushes into this opening and combustion chamber as shown by the arrows, and due to the shape of this chamber is set into a whirling motion. This compression of the air is heating it to temperatures higher than the ignition point of the fuel soon to be injected.

Fuel Injection—Illustration No. 3. This is not a stroke but is approximately the end of the compression stroke and the beginning of the expansion. The fuel begins to inject at approximately 18° before top center and continues for approximately 30° when the engine is carrying full load. This injection is controlled by the fuel pump timing, the nozzle pressure setting and the load on the engine operating the governor which in turn controls the length of time the pump will continue injection.

Turbulence at this point is a major reason for the Hercules compression ignition engine giving such phenomenal power with such exceedingly low fuel consumption and minimum smoke and noise.

Turbulence of air in the combustion chamber is of greatest importance just as the fuel is injected. This insures all of the fuel coming in contact with all of the air and this thoroughly mixing results in complete combustion or burning. Heretofore this has been a problem in all compression ignition injection engines, as no matter what design was used in shaping the heads or combustion chambers the air velocity would slow up and usually stop just when the fuel was being injected. This would cause high fuel consumption without maximum power accompanied by a smoky exhaust and noisy combustion.

The air velocity is dependent on the speed of the piston and the size of the opening through which this air must pass. The larger the opening the slower the velocity of air passing through it and the smaller the opening the greater the velocity for the same amount of air to pass through in the same length of time. An example similar to this is water passing through a garden hose and nozzle. If the nozzle is wide open and no obstructions the water passes through with only the velocity of its pressure. If the nozzle is nearly closed then the water comes out with much greater velocity even though there has been no increase of the pressure.

Hercules engineers solved this problem of turbulence by locating the combustion chamber opening on the side of the cylinder. As the piston travels upward from bottom center the air velocity is steadily raised due to the piston speed. The air passing into this chamber is set whirling in motion as explained under compression stroke. However, when this air velocity would tend to slow up due to reducing piston speed, the piston begins to cover the chamber opening so that the velocity is steadily increased until the piston is about 12° ahead of top center. By then the air revolves inside the combustion chamber from forty to fifty times the crankshaft speed. The injection of the finely atomized fuel mist into this rapidly moving air, insures a more complete mixing of air and fuel than can be obtained from any other known method. This results in more complete combustion therefore maximum power with minimum fuel consumption, smoke and noise. The uniform burning also results in smooth even power.

Injection starts while the air inside the combustion chamber rotates at top speed and continues for approximately 30° at full load.

Expansion or Power Stroke—Illustration No. 4. The rapid rise in temperature of the gases due to burning of the oil causes them to expand. As the only part movable in the cylinder is the piston these expanding gases push it downward and this downward force is transmitted to the crankshaft, through the piston pin, connecting rod, and connecting rod bearing, where this force is converted to rotary motion and useful work.

Exhaust Stroke—Illustration No. 5. The exhaust valve is now opened by its rocker arm which is actuated by its cam through tappets and push rods and the exhaust gases are expelled the same as in a gasoline engine.

The intake valve opens about the time the piston reaches top center and a similar cycle is begun.

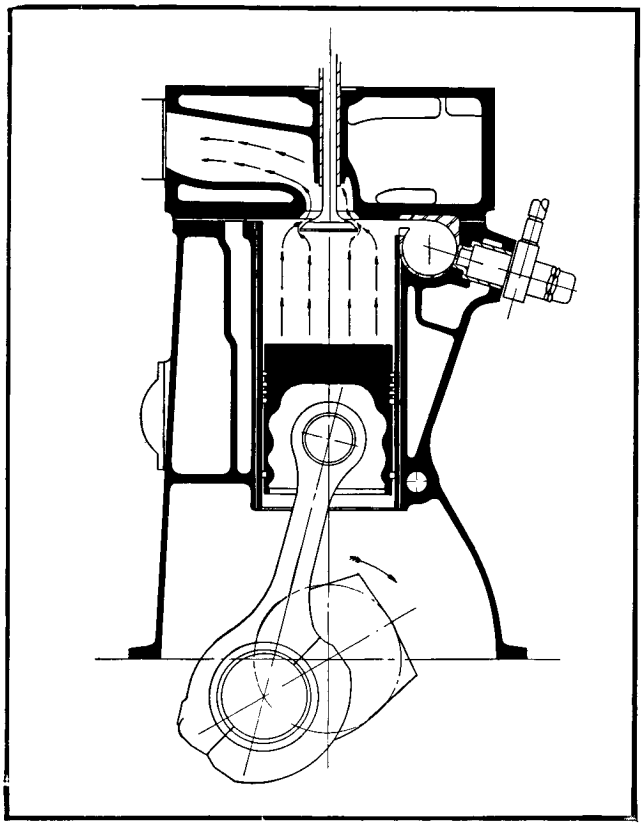


Illustration No. 5.

LUBRICATION is your biggest asset to offset your greatest liability . . . . Unnecessary Repairs

DFX SERIES

PRELUDE TO OPERATION

The "DFX" series of Hercules Diesel Engines consists of six models, the "DFXB," "DFXC," "DFXD," "DFXE" and "DFXH" differing primarily in bore diameter, and the "DFXH-F" which is a horizontal or "pancake" type engine, see Illustration No. 6.

Illustration No. 6 shows the front end and top of the "DFXH-F" horizontal type engine and also indicates the manner in which the fuel pump and starter are mounted.

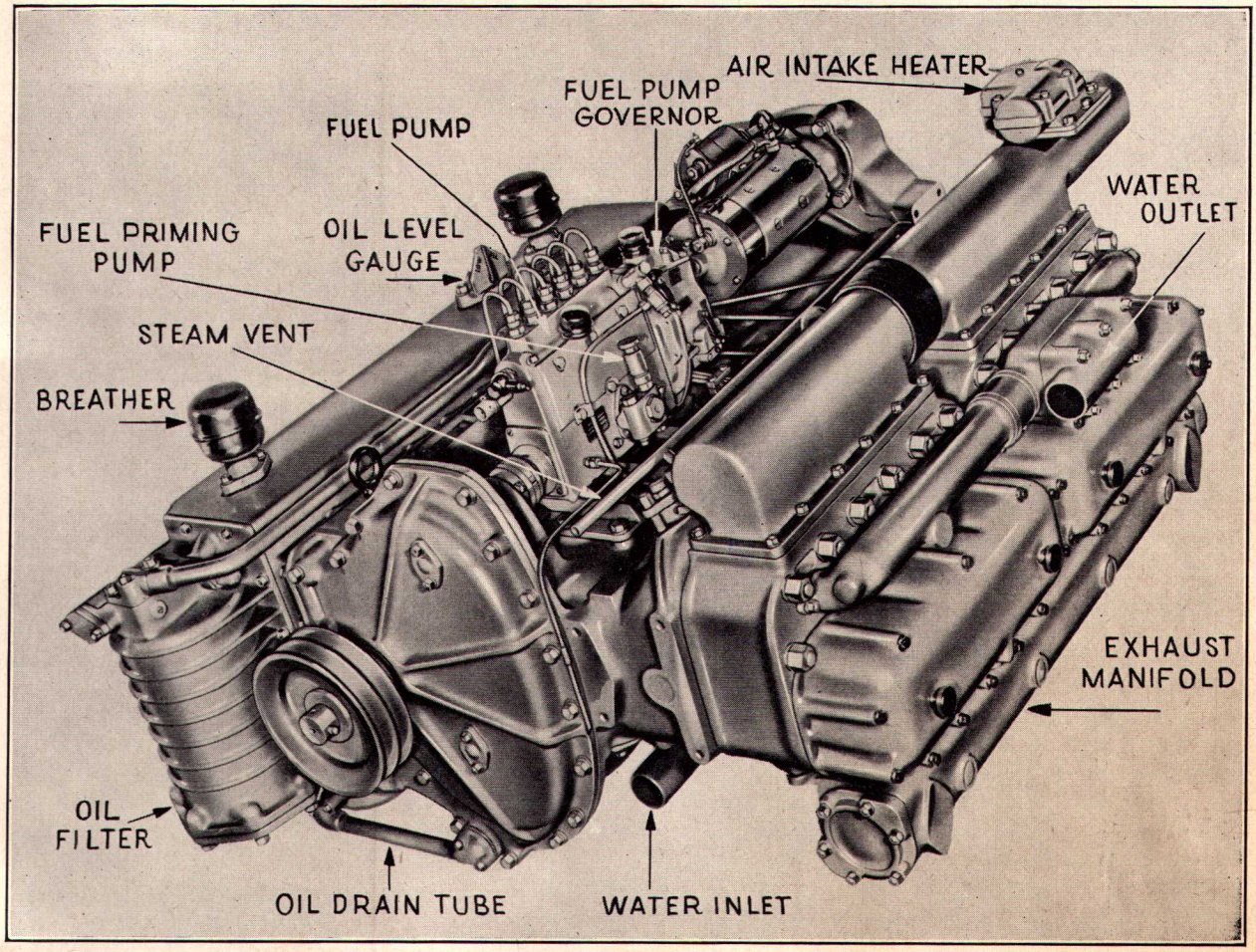


Illustration No. 6

The remarks hereafter will refer to the series in general unless a specific model is discussed.

All information relative to operation and maintenance is the result of many contacts with a variety of operations of Hercules Diesel Engines and suggestions contained in different sections of this book are based on actual experience.

The book has been compiled for your use in obtaining the maximum efficiency and trouble free operation which has been built into your diesel engine by Hercules craftsmanship.

Should you have a particular problem not covered in this book, we invite you to write the Service Department, Hercules Motors Corporation, Canton, Ohio, U. S. A., whose experienced personnel will be pleased to assist you.

If additional information relative to the various accessories is desired, a letter to the manufacturers of these will always get a prompt reply.

PRECAUTIONS—READ BEFORE STARTING ENGINE

The following precautions, if followed, will help eliminate operating difficulties and abnormal wear:

1. **FILTERS**—keep them clean—they are the guardians of your engine—dirty filters cause rapid wear and low engine power output. Read section starting on pages 92 and 93.
2. **Fuel Oil**—keep it clean—do not use dirty containers to handle it—insist on the fuel being clean and acid free when you get it. Procure it from reputable companies—See page 21 for specifications.
3. **Lubricating Oil**—keep it clean—drain crankcase often. Use best brands obtainable, regardless of cost, the best is none to good. Avoid oils having additives detrimental to alloy bearings. See section starting on page 18.

4. Do not allow **oil level** to fall much below the 4/4 mark on the bayonet gauge. As the lubricating oil is the medium for removing the friction heat in the bearings, the larger the volume, the more heat can be absorbed. Do not fill above 4/4 mark, Illustration No. 89.
5. **Do not run engine** at any time without lubricating oil or cooling solution (water or anti-freeze mixture).
6. Do not use oil, fuel oil or kerosene in the cooling solution or as a cooling medium as these will be detrimental to the synthetic rubber water pump seal.
7. **Never run engine** with water or anti-freeze solution **boiling.** This allows lubrication to break down and may seriously damage engine.
8. Do not put cold water in an **overheated engine.** It may crack cylinder head, block, etc. An overheated engine shows negligence in operation.
9. Do not allow **air cleaners** to become clogged or to operate without all connections being tight. Keep clean oil in them up to the proper level. These units protect your engine from undue wear only when they are given intelligent care.
10. Never allow your **batteries** to run low or dry of water. The plates will warp and ruin the battery.
11. **Do not attempt starting** engine until lubricating oil, water and fuel supply has been checked and the engine properly prepared for starting. See section starting on page 11.
12. **Do not run engine** at high speed without load, as this will cause undue wear and shorten the engine's life.
13. **Do not idle engine** for long periods as it is not only detrimental to the engine but also increases operating costs as you are using fuel without any benefit.
14. **Do not use engine as a brake** in intermediate or low gear in automotive service. The high engine speeds possible when using low or intermediate gear descending steep grade will turn the engine much faster than the speed for which it is designed and damage will result unless vehicle speed is held to that used in same gears on the level.
15. **Never allow engine to run without oil pressure** showing on the gauge or with viscosity so low the pointer is in the low register of the Visco Meter. Damage from lack of lubrication will result.
16. Do not operate **fuel injection pump** with one or more lines shut off or blocked. The high pressure may ruin the pump.
17. Do not attempt to make repairs, or adjustments to the fuel injection equipment unless you are familiar with it. It is far less expensive to take it to the nearest authorized service station.
18. **Correct fuel nozzle pressure** is essential to efficient operation. Have nozzles checked often. See page 36.
19. Do not allow fuel in tank to run low as it may allow fuel transfer pump line to uncover long enough to fill the lines with air and cause the engine to stop, resulting in lost time taken for repriming. See page 12 for more details.
20. Loss of power, erratic running and poor performance often results from **air in the fuel injection system.** Be sure there are no leaks in fuel lines and filters which will allow this condition to exist. Vent cocks on top of filters are for bleeding off any air which may accumulate from bubbles in the fuel and very minor leaks, therefore it is essential to bleed these often until the operator is sure air is not entering the fuel system. For more details see page 12.
21. Remember dirt, grit, water, lint or any foreign matter in both the fuel and lubricating oils is detrimental to the engine and it is your duty as an operator to see that it does not get into the engine.
22. Do not attempt to start engine in cold weather until you have read section covering **"Cold Weather Starting,"** page 13.
23. Some external heat will help starting in cold weather and saves the batteries.
24. Never run starting motor longer than 30 seconds at one time without a rest period of at least one minute before allowing it to run again. Failure to follow this procedure may result in a burnt out starting motor.
25. **Altitude** affects engine starting and operation.
26. Diesel engines will run in either direction, therefore, it is essential that the engine should never be stalled on a grade where the reverse action of the vehicle will cause the engine to start backwards. Same also applies to other applications where stalling may cause engine to start backwards. When this happens, which is seldom, open throttle wide open and stop engine with stop control before damage can occur.

    WARNING: DO NOT become excited and jerk on the stop control as it can be broken.
27. Do not attempt to start or operate this engine without first reading the instructions in this book carefully. As an operator you owe it to yourself.

INSPECTION OR ADJUSTMENTS

To Be Made Daily:

1. Go over the entire engine daily to make sure there are no loose bolts, nuts, screws, electrical connections, or parts, and also stop all fuel, lubricating oil and water leaks. There will probably be very little tightening needed but one loose part may cause serious damage.
2. Check lubricating oil level in engine, injection pump and governor, and keep filled to the full mark on gauges.
3. Remove pipe plug in bottom of both fuel and lubricating oil filters and drain all water and sediment which may have accumulated.
4. Air cleaners should be inspected and cleaned before starting the day's run. If oil bath type are used renew the oil, filling to the proper level. If the engine is working in extremely dusty atmosphere it may be necessary to clean these units more often than once a day.
5. See that there is a day's supply of clean fuel in the tanks before starting.
6. Electrical equipment requires very little attention but the batteries should be checked daily for water which should be kept at a proper level.
7. The water circulating system probably receives less attention and care than any part of the engine installation and yet it is one of the most important units. Water should be added daily to make up for that lost in evaporation and leaks. Also observe if scale or sediment is forming in the cooling system and if it is obtain water from a supply which will not cause these troubles. If the water pump is leaking badly, replace the seals with new ones.
8. If air temperature is freezing or liable to go down to freezing, check anti-freeze solution, making sure it will not freeze at temperatures well below those being experienced.

Inspection or Adjustments To Be Made After Each 100 Hours Operation:

1. Check fuel pump driving chain and tighten if necessary.
2. Inspect and adjust fan belts if loose.
3. Inspect radiator and clean if clogged or shows scale formation.
4. Drain the fuel supply tank and wash out thoroughly with clean fuel oil to remove all dirt and sediment. Remove air from fuel filters, by opening vent cocks.
5. Tighten cylinder head nuts and inspect valve clearance.
6. Examine timing marks on fuel injection pump coupling to see that the timing is correct and the coupling has not slipped or been tampered with.

Lubrication of Electrical Equipment at Each 500 Hours of Operation:

1. Lubricate generator. Three to four drops of the same grade and quality lubricating oil as is used in the engine crankcase is all that is necessary. Too much lubrication is as bad as too little, as too much will flood the generator with oil and get on the commutator and brushes, causing the brushes to stick in the holders.
2. Lubricate the starting motor, if equipped with oilers, with the same grade of oil as is used in lubricating the generator. These motors have absorbing bushings so fill cups with oil until the bearings are saturated. Motors not equipped with oilers have oilless bushings and need no lubrication except at time of overhaul.

STARTING AND OPERATING SUGGESTIONS

1. Procure a good brand of fuel oil coming up to the specifications of A. S. T. M. D-1 fuel oil as set forth on page 21.
2. Use only the best lubricating oil obtainable. See specifications on page 18.
3. An S.A.E. 30 oil is a good grade to start with, from this the proper grade can be determined by means of the Visco Meter. See page 20 for complete information relative to the function of the Visco Meter.
4. Fill cooling system with clean water (if in locality where water has a large percentage of dissolved minerals or is alkaline—use rain water). Allow sufficient time for water to seek lowest level, then complete filling.

5. If a 24 volt battery or two 12 volt batteries are not furnished with the unit, procure only those of a good brand and with the following capacity: 210 ampere hours (similar to Exide 6XCK25-3R, 12 volt 25 plate or Willard RHD-25-6, 12 volt 25 plate).
6. Be sure the batteries are hooked up properly before pressing the starter button.
7. Turn engine over three or four times by hand to be sure there is nothing sticking or water has not seeped into a cylinder, as the starting motor has sufficient power to bend or break certain parts should any thing be out of place.
8. Be sure all fuel line connections are tight and the fuel system properly primed, see below.
9. Always follow starting directions outlined below to eliminate difficulties.

STARTING THE ENGINE

Save Your Batteries. The two twenty-five plate 12 volt batteries commonly used will crank the engine against compression for about six periods of 30 seconds each with a recuperation or rest of one minute between each period of cranking. Hand cranking, or electric starter cranking with nozzle holders removed during tests for fuel oil delivery to nozzles will conserve the battery charge.

If the atmospheric air temperature is 50° F. or above the following instructions should enable anyone to readily start the engine. If air temperature is below 50° F. read cold weather starting instructions, page 13.

First Time Engine Started or starting engine after a long period of shut down.

1. Fill the fuel tank with suitable fuel oil. See fuel specifications, page 21.
2. Fill cooling system with clean pure water or if atmosphere is below freezing and engine is to stand or operate in these temperatures, use anti-freeze solution.
3. Fill crankcase with suitable lubricating oil to the 4/4 or full mark on the oil gauge rod. See lubricating oil specifications, page 18.
4. Leave nozzles out of engine while hand cranking to relieve compression.
5. Turn engine over by means of hand crank three or four times to start oil circulation and distribute the oil already on the surfaces. This hand cranking also prevents possibilities of damage due to water having accumulated in the cylinders. The clearance between the cylinder head and piston top is so little that a small amount of water in the cylinder would cause serious damage or wreckage if engine were rotated rapidly as with electric starter.

6. **Priming Fuel System—Air Lock Trouble**

Air or gas binding or lock in the fuel injection system is the most general cause of failure to start or hard starting if proper fuel is used. Air binding or lock is caused mainly from leaky fuel lines, check valves, or running out of fuel. Gas binding or lock is caused by heating of the fuel to a point higher than that at which the particular fuel used begins to throw off gaseous vapors. To eliminate either of these difficulties the following procedure should be followed:

Loosen the plug or cock at end of fuel manifold and by using the hand priming pump pull the fuel from the tank and force it through the filter located between the transfer pump and the injection pump. It is best to leave vent cock No. 1 in Illustration No. 109 open until all the air is out of the system up to this point, then close vent cock and pump fuel into the injection pump until a solid stream of oil comes through the opening created by loosening the plug or cock at end of fuel manifold. Then tighten the connection.

(a) Place governor control lever in wide open or full load position.

(b) Be sure stop control is not in shut off position.

(c) Install nozzle holders firmly in place, if these were removed for any reason.

(d) Loosen fuel line nut at the nozzle holder end.

(e) Remove side cover (inspection plate) of fuel pump.

(f) Work the fuel pump plunger up and down by means of a screwdriver until you hear the nozzle inject, at which time considerable pressure will be required to lift plunger, see Illustration No. 7. Continue the same operation with all lines being sure the stop control rod is not in "shut of" position.

(g) Replace side cover (inspection plate) on fuel pump. Any time this fuel pump inspection cover is removed for any purpose great care must be exercised to insure its proper replacement as well as to insure against any dirt getting into the fuel pump.

7. In addition to the procedure just described check the lubrication of fuel injection pump, generator, starter, governor, air compressor or vacuum pump (if used), fan, water pump, and any other accessories. Check air cleaners to make sure there are no obstructions., that they are properly installed, and are clean, and that they are properly filled with oil (if oil bath cleaners are used as recommended).
8. Check entire electrical system to be sure there are no obstructions and all component parts are properly connected together.
9. See that no loose bars, tools, parts, etc., are laying in or on any part of the engine as they could cause serious damage or wreckage of engine or bodily injury to anyone near.

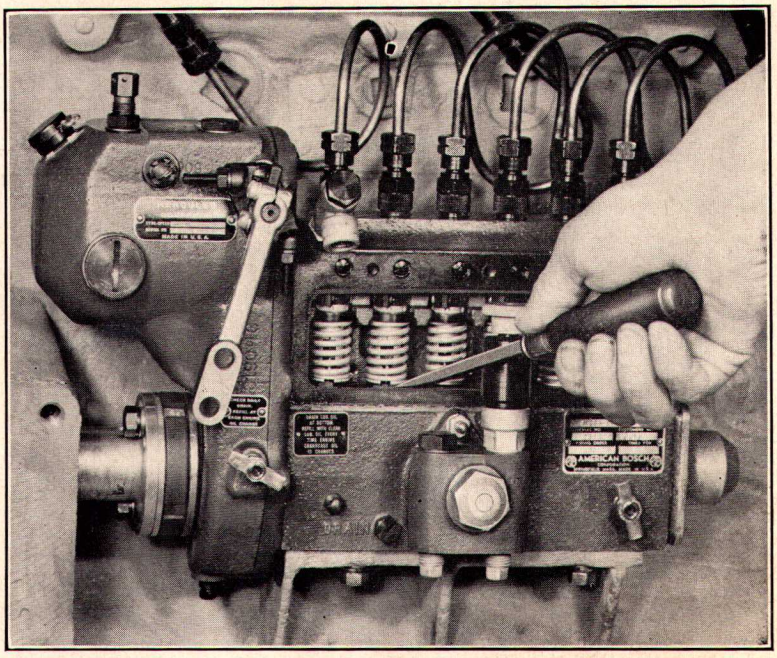


Illustration No. 7

10. Start engine by operating the starting button. If atmospheric temperature is 50° F. or above, and if all of the foregoing instructions have been properly followed and the proper grade and type of fuel oil has been used, the engine will start at once.
11. Allow engine to run for several minutes before load is applied to enable engine to properly warm up and insure proper lubrication. See page 16 for instructions when engine is started.

Usual Routine Way of Starting Engine. If the engine has been operating recently and nothing has been removed or repaired since it last operated, the following is all that is necessary to start:

1. Check fuel supply.
2. Check lubricating oil in engine base with gauge rod. Be sure oil is to 4/4 or full mark on rod. Recheck after engine has run 3 or 4 minutes.
3. Check cooling water or solution.
4. If atmospheric temperature is 50° F. or above nothing special need be done in preparation for starting. If below this temperature see "Cold Weather Starting.'
5. Inspect installation to see all is in good order and tight and no loose tools, bars, or parts lying on engine.
6. **Place governor control lever at half throttle or load position.**
7. **Be sure stop control is not in shut off position.**
8. Start engine by operating starter button.
9. Check engine as under "Operating Instructions After Starting," page 16.

COLD WEATHER STARTING

The increased temperature of the air due to compression is the only means of igniting the fuel sprayed into combustion chamber.

If the iron surrounding this chamber and cylinder is extremely cold and in addition the air entering the cylinder before compression is cold, the resultant temperature may not be sufficient to ignite the mist of fuel. The faster the starter turns the engine the less time is available for the heat of compression to be absorbed by the iron and water.

Two methods are available to increase this temperature.

1. Heat the water or cooling solution.
2. Heat the air before it reaches the cylinder.

One or both of the methods may be necessary, depending upon the temperatures of engine and air.

A heating device, Illustration No. 8, is available which makes starting easier in extremely cold weather or climate. This device can be installed by any competent mechanic or service station.

Starting Between 50° F. and 32° F. If engines are not equipped with an Air Intake Heater Assembly, much time can be saved and excessive drain on starting battery can be avoided by following these suggestions:

1. Crank engine over by hand several turns.
2. Remove large pipe plug in intake manifold, or remove air cleaning equipment if no pipe plug is available.
3. Before attempting to start, take an ordinary blow torch and direct the flame for a minute on the outside of each branch of the air intake manifold of cylinder heads.
4. **Place governor control lever at half throttle or load position.**
5. **Be sure stop control is not in shut off position.**
6. As the operator depresses the starter button hold the torch so the flame will be sucked into the air intake manifold through the opening exposed by removal of air cleaner or pipe plug in manifold. Do not hold torch so flame is directed into manifold as the flame may be extinguished just when it is most needed or all the oxygen may be burnt from air.
7. After engine has started replace pipe plug in manifold or replace the air cleaner, whichever was removed.

Starting Between 32° F. and 0° F. (If engines are not equipped with an Air Intake Heater Assembly) To obtain maximum cranking speed the oil must not be too heavy. When temperatures approach freezing many experienced operators drain all crankcase oil from engine at end of days run and heat it before returning it to crankcase when ready to start. This is a good practice for the hot oil insures more immediate circulation to the bearings and helps warm the engine. At freezing temperatures, the water or cooling system should be drained from engine and radiator and heated to near boiling point if water, and as hot as possible if some solution is used. (Beware of fire if alcohol solution is used.) When this is poured into engine the cold iron parts are heated and oil on cylinders thinned down. Most cooling systems hold from 10 to 24 gallons so an oil drum or wash tub can be satisfactorily used. This operation does not take nearly as long as changing batteries after they are run down and will greatly aid in starting.

Starting 0° F. and Below. If engines are not equipped with an Air Intake Heater Assembly, the heating of water, oil and air may be found desirable. Battery output is reduced at these low temperatures so every means should be used to conserve your battery.

Ether Starting Fluid. Use of ether or other starting fluids is dangerous. Keep away from flame. Use only with proper atomizing equipment and only when engine is being turned by starting motor, serious damage to pistons and rings may result if used improperly.

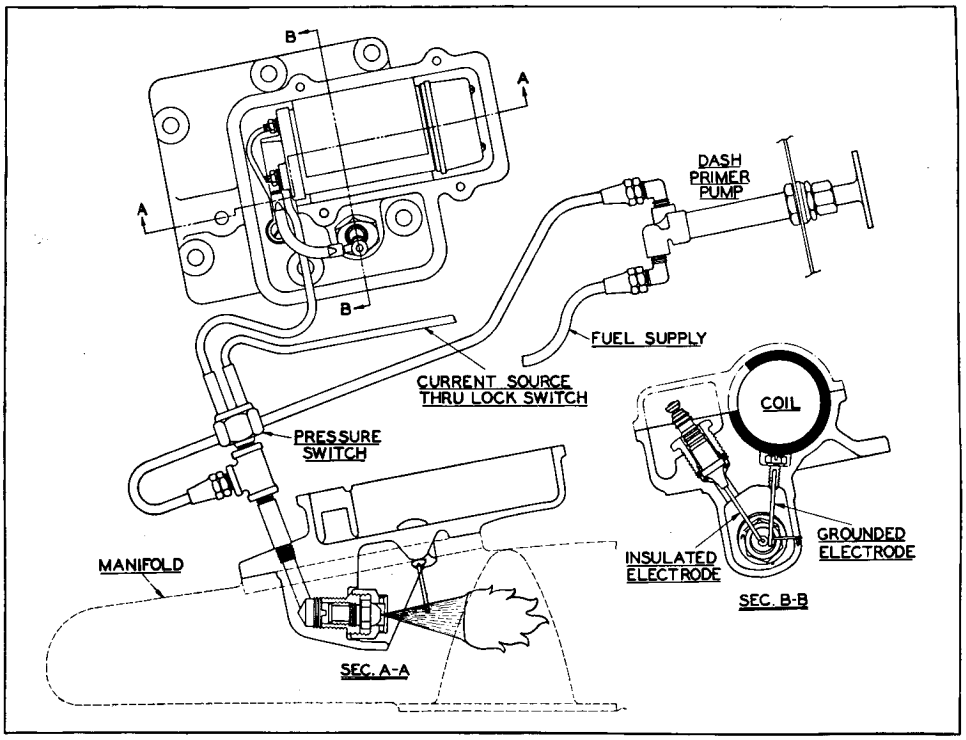


Illustration No. 8

Air Intake Heater. Some engines are equipped with a device built into the inlet manifold, called the "Air Intake Heater," Illustration No. 8. It consists of a small hand-operated pump located at the engine controls which pumps fuel oil through an oil burner nozzle, Illustration No. 9, using $\frac{3}{16}$ inch or smaller O. D. tubing. The nozzle is located inside the inlet manifold and directs the spray of fuel oil into the inlet manifold. The housing, Illustration No. 10, containing the nozzle also contains a spark plug with a very long electrode, and also a continuous vibrating spark coil suitable for 12 volt operation. A grounded electrode is adjusted with its end approximately $\frac{1}{8}$ inch from the spark plug's electrode, for a spark jump of about $\frac{1}{8}$ inch. This spark is in front of the fuel spray and ignites it as it emerges from the nozzle. The spark is continuous from the vibrating coil. A pressure switch, which should be mounted in a vertical position, is connected in the fuel line coming from the hand pump. When there is a spray of fuel coming from the nozzle, there is pressure on the switch which closes it and starts the spark to ignite the fuel spray.

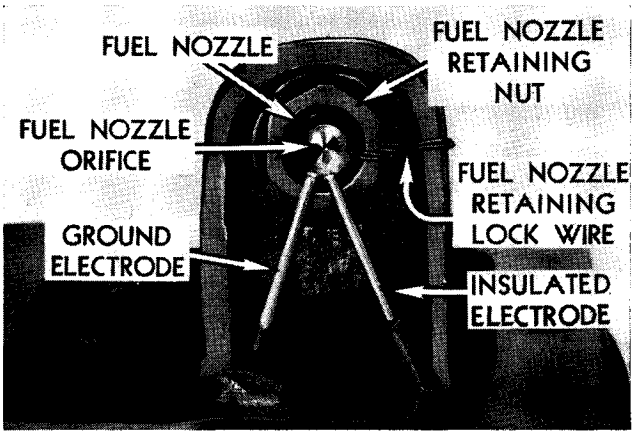


Illustration No. 9

CAUTION—It is possible to get an air bound condition in the fuel line between the hand priming pump on the dash and the heating unit mounted on the intake manifold. To prime, it is only necessary that the hand priming pump on the dash be rapidly operated until a definite resistance is felt. So long as the pump operates freely no fuel is being forced through the line but as soon as fuel starts to flow a definite resistance can be felt.

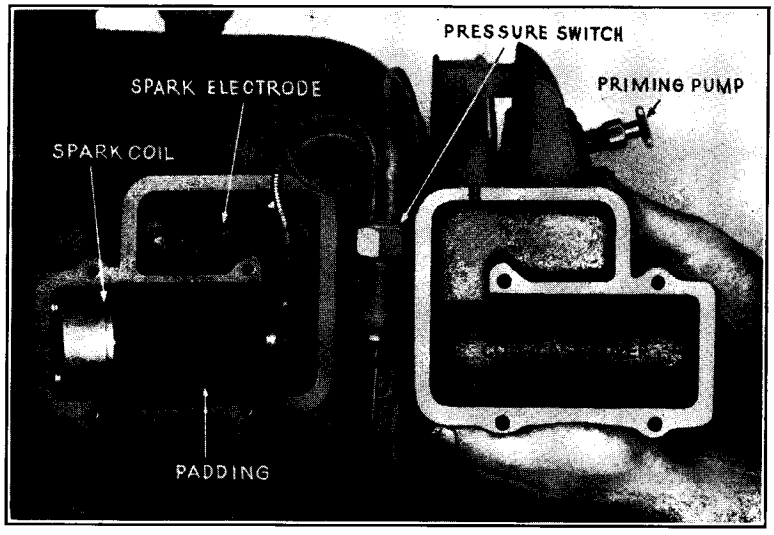


Illustration No. 10

The flame of the burning fuel is sucked into the engine as it is being cranked, and warms the air in the cylinders for cold starting. Of course, some of the "air" in the cylinders is only the burned gas from the flame because all the flame goes into the cylinders, and if the flame burns all the oxygen in the air going into the cylinders, there is none left to burn the fuel sprayed into the combustion chamber by the injection pump and the engine cannot start. Therefore, too much flame is just as bad as none at all for cold starting. It is necessary to give the engine some flame, but not too much, which is done by operating the hand pump until a definite resistance is felt, then operate the pump very slowly, just enough to maintain sufficient pressure in the system to keep the switch contacts closed and a small amount of atomized fuel entering the manifold. The operator should take enough time to learn the proper use of this unit. (It is possible to attain a condition similar to over-choking a carbureted engine.) Don't pump any more than absolutely necessary. When the firing of the cylinders slows down while pumping, stop pumping and if the engine slows down after pumping is stopped, give the pump another short stroke. Two or three strokes usually are sufficient to start engine in freezing weather. **Be sure engine is being cranked before operating the priming pump.**

To determine that the inlet air heater is working, remove the pipe fittings in the center of the inlet manifold. Give the priming pump one stroke while cranking the engine. Flame should come out of the open hole. DANGER—Keep away from this hole, a flame coming out may cause serious injuries. If the hand pump cannot be operated in the discharge direction, it is evidence the screen of the nozzle is plugged up. It may be removed for cleaning or replacing by taking the heater assembly off the engine. If the fuel spray is O. K., but will not ignite, check the pressure switch by removing the wires leading to it from the battery, and hold it against the other terminal while cranking the engine and operating the priming pump. If the fuel spray still does not ignite, remove the heater housing and clean the spark plug, readjust the spark gap, and observe the

spark. If there is none, check for a short in the wiring and listen for the buzzing of the vibrator in the end of the coil. The vibrator points may need cleaning or replacing.

In very humid climates the electrode may become grounded due to a collection of moisture resulting in a short across the gap. To remedy it is necessary to remove the electrodes and dry them. Loose oil line connections, or a lose packing gland at the dash can easily be corrected by tightening.

OPERATING INSTRUCTIONS AFTER STARTING

After the engine has started an inspection of the whole engine unit should be made to make sure all parts are functioning properly.

(1) Look at lubricating oil gauge. If no pressure shows after engine has run 10 or 20 seconds shut down the engine and ascertain what the trouble may be. With bearings in good condition and proper grade of oil, the pressure should be 40 to 50 pounds at full engine speed. If the oil is very cold or heavy this pressure may be much higher. As the oil heats up the pressure will reduce.

(2) Check water temperature. If water temperature is above 200° F. shut down engine and ascertain what the trouble may be. Never operate with the water boiling as this heat on the cylinder walls breaks down the oil film and also causes considerable water loss due to steaming.

(3) See that no loose tools or parts are lying on or near the unit as they might fall into a place where they would cause damage or personal injury.

(4) Observe engine operation for smoothness, quietness and exhaust condition. If the fuel is up to specifications and has the proper ignition and burning qualities, the engine may still run raggedly because a cylinder or two is firing irregularly due to being cold. As the engine begins to warm up however all cylinders should fire regularly. If they do not, the nut connecting the fuel line to the nozzle holder should be slightly loosened one cylinder at a time and fuel allowed to flow until all air has been expelled. When this nut is loosened, if the engine speed remains the same and the exhaust sounds the same, that cylinder is not firing or is firing irregularly. If after checking this trouble and allowing fuel to flow from the loosened nut a few times and cylinder still continues to fire irregularly or not at all, shut down the engine and trace out the trouble, some hints of which will be found in section starting on page 118.

(5) See that there is an adequate supply of fuel in the tank and that fuel is being deliverd to the fuel pump. The delivery can be checked by slightly loosening the nut connecting the supply pipe to the secondary fuel filter and if a good quantity of fuel appears it is an indication that the fuel injection pump is being supplied with sufficient fuel. If no fuel or very little appears, shut down the engine and check the supply tank again. If the fuel supply is adequate, check fuel lines from tank to transfer pump and transfer pump to filters for leaks from loose connections, broken nuts, and cracked or broken lines. Also check lines for obstructions inside or having been pinched closed or nearly so. If lines are found satisfactory, check transfer pump for broken springs, worn or broken valves or plungers or worn or stuck tappet rollers, followers or wrist pins.

(6) Observe Visco Meter for viscosity of lubricating oil. If needle on gauge is in the high section allow engine to run idle until the indicating needle shows the oil is of proper viscosity to insure safe engine operation. If indicating needle drops into the lowest section, stop engine and check trouble, starting with Visco Meter Instrument Screen, Illustration No. 11; clean if necessary. It may be necessary to change oil in engine sump, if the oil being used is not of proper grade or quantity or has not been changed recently. This Visco Meter is the indicator of the lubricating qualities of the oil lubricating the engine and should be observed often. This instrument should receive attention, as outlined on pages 20 and 21 frequently as it is the most used instrument on the engine. Go by what the needle indicates and give the gauge and instrument good care as it will repay you many times over.

(7) Check and see that there are no oil or water leaks.

(8) Observe fan and belt operation. Loose fan belts allow slippage which reduces the efficiency of the fan and wears belts out rapidly. Never allow fan to run without any lubricant but do not over-lubricate as it will throw off the excess on the surrounding parts. See page 91.

(9) See that the radiator, if one is used, is free of obstructions between fins or tubes as they will obstruct air flow and reduce the cooling efficiency of the radiator unit.

STOPPING THE ENGINE

1. Stopping is generally effected by pulling the stop control until engine stops.

2. If atmospheric temperature is below freezing and no anti-freeze solution is used, the complete water circulating system should be drained. This includes engine water jackets, water pump, radiator if used, and all water pipes.

3. If anti-freeze solution is used the solution should be checked with a hydrometer to make sure the solution will not freeze. It is best to have a solution that will not freeze at temperatures far below those then being experienced.

4. Do not fill batteries with water when shutting down as this makes them more liable to freezing. Fill batteries just before starting up for the day's run.

NOTE: If engine is kept in a warm storage or is located in a warmed building where freezing is not liable, 2, 3, and 4 can be disregarded.

STORING ENGINE FOR LONG PERIODS

If engine is to be idle for a month or more, special preparations should be made to properly prepare the engine so that rust will not form on the wearing surfaces or in the fuel system.

Preparing Fuel Injection Pumps and Nozzles. Just before the engine is shut down for the last time, heat approximately two quarts of lubricating oil of same quality as used in the crankcase to about 180° to 200° F. This is to reduce the viscosity—the thickness—of the oil so that it will flow through the fuel lines. Shut down the engine and disconnect the fuel line from the main tank to the transfer pump. Then place the hot lubricating oil in a container which can be located so the end of the fuel line which has been disconnected from the supply tank can be inserted in the container. Start engine and allow to run until practically all of the oil in the container has been taken into the engine, then shut down engine.

Another method to accomplish the same result is after the engine has been shut down to attach the two or three quart tank pouring about 2 quarts of this heated lubricating oil into it, disconnect the suction line from filter to the transfer pump either at the pump or at the tank so when the engine is started fuel from the main tank will not be pumped all over the surrounding equipment. Start engine and allow to run until most of the oil in the small tank has passed into the fuel pump. Then shut down engine.

After engine is shut down, tape a small piece of gasket material over the breather hole on the fuel injection pump cover or inspection plate. Fill the fuel pump and governor FULL of good quality acid and moisture free lubricating oil, through the fuel pump oil filler hole. Fill the pump until oil flows out of this filler hole and then replace cover. This procedure will fill the pump housing with oil, protecting the fuel pump camshaft, tappet assemblies, etc.

When engine is shut down after either method of filling the fuel system, remove all of the fuel or spray nozzle holders. Remove the fuel nozzle body from the holder and then remove the valve from the body. Put a coating of vaseline on the valve and return valve to body, then cover the outside of the body with vaseline. Reassemble body and holder.

Preparing Engine. Before reinstalling the nozzle holders take a pump type oil can with a long narrow spout with a tip that will fit into the $\frac{7}{32}$", or larger hole of the spray nozzle sleeve, and give it six or eight squirts per cylinder, then turn engine over slowly a few times to distribute the oil.

BEFORE STARTING remove spray nozzles and turn engine over with starting motor to blow excess oil out.

Drain the entire engine and water circulating system thoroughly.

Leave the lubricating oil in the engine base.

Disconnect the wires leading to the batteries and remove the batteries, storing them preferably at some place where they can be charged periodically, as batteries lose their charge rapidly if not in use.

Cover ends of air inlet and exhaust pipe so moisture cannot reach valve ports and cylinders; store the engine where it will not be exposed to the elements such as rain, snow, hail etc., and preferably where it can be kept warm and dry.

Every two weeks the engine should be cranked over by hand eight or ten revolutions to redistribute the oil film over the wearing surfaces. This will prevent rusting of the wearing surfaces inside of the engine.

As the fuel injection pump and nozzle assemblies are built to such close limits they require very close attention when storing the engine. American Bosch have a special oil to be put into these units when storing and a very good plan is to get in touch with the nearest American Bosch Diesel Service Station and obtain full information on how they store the fuel pumps and nozzles using this special oil.

If this is done it will not be necessary to fill transfer and injection pump, fuel lines and nozzles as just described under "Preparing Fuel Injection Pump and Nozzles." The engine proper however must be properly prepared and the rest of the procedure given should be followed.

Preparing Engine For Starting After Long Shutdown. If engine has been stored as outlined above it will be necessary to pursue the following procedure to prepare it for starting again:

1. Drain entire fuel system of lubricating or special oil. Open the drain on the bottom of the main fuel supply tank and allow all water and sediment in tank to drain, then reconnect the tube.
2. Check all fuel supply lines from main supply tank to filter to make sure connections are tight and lines are open with no obstruction or "pinched" places.
3. Remove nozzle holders and wipe vaseline from outside surface of each nozzle. Do not wipe the vaseline off the valve in the valve body. Prime pumps and lines as described on page 12.
4. When priming the fuel lines from pump to nozzles connect the nozzles to the fuel lines and test as described on pages 35 and 36 except instead of running the engine operate the pump plunger by hand.
5. If nozzles do not function properly clean as described on page 35.
6. Turn engine by hand three or four revolutions to spread the lubricating oil on the walls and bearings and start oil circulation.
7. Install fuel or spray nozzles and connect lines tightly.
8. Drain lubricating oil filtrator of all water and sediment.
9. Fill cooling system with clean water or anti-freeze solution.
10. Follow instructions as given for "Starting Engine First Time," described on page 12.
11. After engine is running follow instructions as given for "Operating Instructions After Starting," described on page 16.

LUBRICATING OIL AND VISCOMETER

Lubricating Oil. The Hercules Motors Corporation recommends that only the best quality oils manufactured by recognized concerns familiar with the lubrication requirements of Diesel engines be used. Uncompounded naphthenic oils or certain mixtures of naphtha and paraffin oils have in many instances given good service providing the film strength is equal to paraffin oils. Many refiners now advocate the use of compounded oils for high output Diesel engine lubrication. These various products which are secured by combining an additive with different base stocks are somewhat secret in their composition and, therefore, the refiners must be held responsible for proper recommendation as well as results obtained from their use. In general we suggest the use of compounded oils. The common gasoline engine oils are not generally suitable for use in Diesel engines. All corrosive types of lubricants must be avoided. Natural or added compounds of proved stability and merit are satisfactory but additives must not be destructive to alloy bearings or promote the formation of acid, alkaline and sludge.

If the sales divisions of these refiners cannot give you reliable first hand information about their compounded oils then present your problem to the technical divisions of these same refiners. The Hercules Motors Corporation cannot assume any responsibility for engine failures due to the use of incorrect lubricants in their Diesel engines.

Due to the differences in viscosity of different brands of oil at the same temperatures and the difference in crankcase temperatures in engines on different types of service it is difficult to give a definite S.A.E. number of oil to use in the engine crankcase. A Visco Meter instrument shown in Illustration No. 11 and 12 is frequently supplied to indicate the viscosity of the lubricating oil during the actual operation of the engine and this gauge should be used when possible in determining what grade of lubricating oil to use.

For most operations a pure, neutral, acid and moisture free, petroleum oil with no animal or vegetable matter of an S.A.E. 30 grade will be found satisfactory and should be obtained for trial. Do not obtain a large supply of any lubricating oil until a grade and brand suitable for the particular service the engine is to operate under has been proved. This may vary with the seasons of the year.

Try such an oil in the engine under normal working conditions. If the indicator hand on the Visco Meter gauge dial moves to the left into the "low" or "stop" section, any time after the engine crankcase oil is at maximum operating temperature, the oil is too light and a heavier grade should be tried. If the indicator hand does not get within 3 graduations on the dial. of the "low" or "stop" segment, the oil is too heavy and a lighter grade should be tried. Read the instructions for selecting oil by use of the Visco Meter carefully

In some very extreme cold operating conditions it may be necessary to use an ice machine oil to prevent oil from congealing while the engine is stopped for long periods, thus preventing valves from closing when trying to start and increasing the cranking friction so that the starting motor and battery do not have sufficient power to accomplish a start. Use a medium grade ice machine oil, after engine is restarted watch Visco Meter gauge. It is best practice, however, to warm the engine up before trying to start it by heating the oil or the cooling solution so that a standard lubricant can be used and eliminate the use of ice machine oil. **Do not put** kerosene in the lubricating oil to thin it out or prevent it from "freezing."

The length of time between draining and refilling with new oil is dependent upon the type of service and operation, and the grade and brand of oil used. Most operators find it wise to drain the oil every 50 or 60 hours of industrial operation and not over 1,000 miles of automotive operation (highway, hauling trucks and buses, not tractors or heavy duty slow trucks such as snow plows, etc., the latter the same as industrial operation). See page 98 for refilling instructions, also refer to "Oil Pan" page 102.

Some lubricating oils under certain operating conditions develop serious sludge and gumming problems. Avoid oils which are not free of gum or wax.

Avoid use of oils which have additives detrimental to alloy bearings.

Visco Meter. Some engines are equipped with a Visco Meter instrument that indicates the viscosity of the oil just before entering the main bearings. The instrument is located on a pad on the engine crankcase.

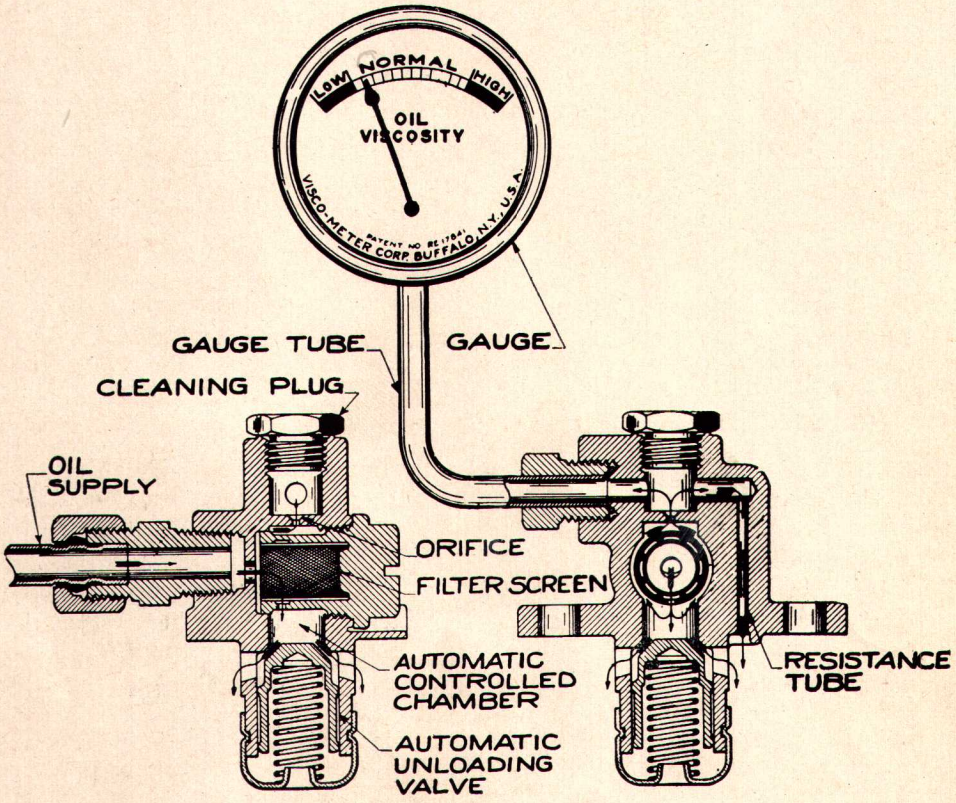


Illustration No. 11

Refer to Illustration No. 11 which is a schematic assembly of the instrument and gauge. Follow the arrows which show the direction of the oil flow.

Some of the lubricating oil is led from the main oil header in the engine through a short copper tube shown as "oil supply" to the instrument and enters the instrument through an orifice into a filter screen. It passes through the screen into an automatic controlled chamber which has an orifice on one side and a spring loaded check valve called an "automatic unloading valve" at the other. The oil may enter the instrument at any pressure but this check valve is permanently set at a pressure low enough so the oil in the chamber is under a constant even pressure regardless of engine pressure unless the engine pressure becomes less than the setting of the unloading spring. The excess oil flows past the check valve and spills back into the engine crankcase. The rest of the oil passes through the orifice on the other side of this

chamber into a passage which connects with the resistance tube. The other end of the resistance tube connects with the engine crankcase so some of the oil passes through this resistance tube and spills into the engine crankcase. This resistance tube is purposely restricted in size to restrict the flow of oil through it and thereby set up a pressure in the gauge tube line. Part of the oil therefore is under a pressure determined by the rate of flow of oil through the resistance tube and this is registered on the gauge dial by the indicator hand.

As thick oil will not flow as rapidly through the resistance tube as thin oil under the pressure, the indicator hand registers higher with the thick oil as the pressure in the gauge line is higher. The thinner the oil the less the pressure in the gauge line as there is less resistance to the flow through the resistance tube, and the lower the gauge reading.

Selecting Oil by Means of the Visco Meter. Pressure is no indication of the lubricating value of any lubricating oil. Pressure merely shows some kind of fluid is flowing through the system whether this fluid be water, fuel or anything else. Any fluid can be regulated in pressure so it will show exactly the right pressure on the pressure gauge and still not assure satisfactory lubrication. High pressure does not indicate better lubrication than the lowest pressure which still keeps an oil film on the metal surfaces as the object of the pressure is to keep the metal surfaces covered and any more will not assist in any way.

Pressure gauges do not therefore indicate whether the engine is being properly lubricated or not, they only show that the oil is flowing, and the lubricating qualities of the oil in the engine AT CRANKCASE TEMPERATURE must be assumed. Assuming the lubricating quality of an oil is not very safe practice because of the variations in oil and engine operations and demands.

Some oil when cold is extremely thick—high in viscosity—and the same oil when heated up is extremely thin—low in viscosity. When thick it flows very sluggishly through the system with high registered pressure but very poor lubrication and when heated to engine temperature is thin, will not keep the metal surfaces apart and the engine scores, seizes or abnormal wear takes place.

Another oil may be high in viscosity at low temperatures and just right at crankcase temperatures. This oil would cause hard starting when the engine was cold, due to the high viscosity at low temperature causing the oil to be sticky and thick which would put quite an additional load on the starting motor and battery.

Another oil may be satisfactory when cold but when at operating temperature would be too low in viscosity, causing troubles from lack of lubrication and high lubricating oil consumption.

One type of engine service will keep the engine crankcase temperature low while the same engine in another type of service may have a high crankcase temperature. The change in temperature during the seasons also affects the crankcase temperature to some extent.

From the foregoing it can be seen that it's practically impossible to specify an oil by physical characteristics for all types of service without giving a range the top of which would not be satisfactory with cool crankcase temperatures and the lowest of which would not be satisfactory for hot crankcase temperatures.

The Visco Meter instrument Illustration No. 12 as now supplied with some engines if attached to a Visco Meter gauge shown in Illustration No. 11 as recommended will allow the operator to select an oil which is particularly suited to his type of service and which will give the best lubrication with the least lubricating oil consumption.

To select the proper oil obtain an oil which comes within the lubricating oil physical specifications and try in the engine. Start the engine and observe the indicating hand on the Visco Meter gauge. A proper oil should first move the indicating hand to the right close to or into the "high" section on the dial when oil is cold. As the oil warms up the hand should move to the left gradually until it reaches a position approximately as shown in Illustration No. 11 which is almost to the "low" or "stop" line on the gauge when the oil is at normal crankcase temperature. The oil should stay at the viscosity represented by this location of the indicator hand as long as the engine is operating. If this hand drops from this location it indicates the viscosity has dropped—oil has thinned—to a point of danger and the engine should be stopped immediately and oil changed to another brand or heavier grade until a suitable oil is found. Be sure Visco Meter Instrument is clean.

If, after the engine is operating and the crankcase temperature has raised to maximum, the indicating hand does not drop into a position somewhere in the last three graduations above the "low" or "stop" line on the gauge the oil is too heavy and should be changed to another brand or lighter grade.

Do not select lubricating oil because it has certain S.A.E. number as certain brands of oil of S.A.E. 30 may not have the lubricating characteristics necessary for your type of service but another brand of S.A.E. 30 may, due to one being different at the top extreme limit and the other at the lowest extreme limit or at different points between these extremes. One brand of S.A.E. 20 may give the same satisfactory re-

sults as another brand of S.A.E. 40 may be necessary—Always select the grade of lubricating oil by its operation in the engine, in the type of service to be encountered, by the Visco Meter and not by physical characteristics or S.A.E. number. The indicator hand shows how thick or thin the oil is in the engine at all temperatures and the grade of lubricating oil should be selected by what this hand indicates.

The lubricating oil pressure may be anywhere between 10 pounds and 50 pounds when the engine is at normal operating temperature depending on the speed.When the engine idles at reduced speed and the crankcase is at normal operating temperature the pressure may reduce to 1 pound and still have safe lubrication. Due to the extremely low pressure at reduced idling speeds the Visco Meter indicator hand may drop into the "low" or "stop" section but this can be disregarded and safe lubrication assured if the indicating hand goes back to its normal position when the engine is back at full speed again.

Care of Visco Meter. The Visco Meter should receive proper care and attention.

The whole instrument should be cleaned periodically. The time depends upon the oil used as some oils gum or plug up passages more quickly than other oils. To clean, remove the instrument from the engine crankcase by removing the oil lead lines from the crankcase and to the gauge.

Remove the two cap screws which hold the instrument to the engine crankcase. Remove the plug No. 1 Illustration No.12 which holds the filter screen No.2 and remove screen and clean thoroughly in clean fuel oil, gasoline or kerosene. Also wash out plug. Remove "cleaning" plug over the chamber connecting with the resistance tube (See Illustration No.11). Wash and soak the whole body in clean fuel oil, gasoline or kerosene so all carbon, etc., becomes loosened. If compressed air is available blow out all chambers and the resistance tube, making sure all are perfectly clean, If compressed air is not available obtain a pipe cleaner or wood dowel which will go through the resistance tube easily. Work this up and down in the tube from the unloading valve end until the tube is clean. Then wash the whole body thoroughly again in clean fuel oil, gasoline or kerosene, paying particular attention to the resistance tube. Remove and wash both oil lines.Reassemble the parts and install instrument on engine and connect removed oil lines.

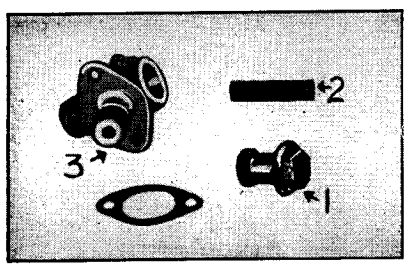


Illustration No. 12

The Filter Screen Should be Cleaned at Least Every Time the Crankcase Oil is Changed.

Never use anything except compressed air or PIPE CLEANER OR WOOD DOWEL to clean resistance tube as this is drilled to definite size and hard wire or drills are liable to ream or scratch this tube to a larger size and destroy the operation of the whole Visco Meter as the springs and gauge are calibrated for this original resistance tube.

Be sure gauge line connections are tight and line is not full of oil or gauge will not function properly as an air column is necessary for correct operation.

FUEL OIL SPECIFICATIONS

American Society for Testing Materials Specifications

Fuel Oil Specifications. To be chemically neutral distillate petroleum fuel oil of the following characteristics:

1.	Viscosity at 100° F.	Minimum	33 Sec.
	Saybolt Universal (Preferably 40 to 70)	Maximum	100 Sec.
2.	Sulphur (By Weight)	Maximum	1.5 %
3.	Conradson Carbon Residue (% by weight)	Maximum	.2 %
4.	Ash Content	Maximum	.02 %
5.	Moisture and Sediment (B. S. & W.) (% by volume)	Maximum	.05 %
6.	Flash (For insurance purposes only)	Maximum	150° F.

7. Pour Point at least 10° less than lowest temperature where engine operates.
8. Ignition and burning qualities to be equal to: A.S.T.M. Grade No. 1-D
   Cetane number, min. 45

The following paragraphs are not part of the A. S. T. M. Specifications, but are inserted here to allow interested parties to check the gum content of the fuel being used.

The "Gum content in the fuel oil is not to exceed 75 milligrams per 1000 cc's of fuel as determined by the "burn-out" test as follows:

Put 1000 cc's (approximately one quart) of the fuel in an enameled steel pan such as an ordinary wash basin. Set the pan at an angle of about three or four degrees. Ignite the fuel by the aid of three or four teaspoons of gasoline and allow to burn out com pletely. Keep the pan in a place free from draft.

At the completion of burning, the gum content is the tarry residue remaining in the bottom of the pan unburned. This amount should not exceed 75 milligrams as determined by brushing away all loose dry carbon soot, then dissolve the tarry gum residue with benzene and filter. Distill off the benzene and weigh the remaining residue.

If convenient methods of weighing this "gum" are not available, the maximum permissible quantity of "gum" without causing excessive ring sticking can be observed in the bottom of the pan as not exceeding an area of approximately 1" in diameter and 1/64" thick.

Fuel oil that has been "recracked" or "recycled" at the refineries is usually a hard oil to ignite. The ignitability of fuel oil cannot be determined by the usual characteristics of physical state oil of such as gravity, viscosity or color, all of which have no influence whatever on the ignitability of oil. Refineries and oil distributors agencies should assume the responsibility of supplying a good fuel oil of good ignition and burning qualities. They can determine the ignitability of their oil by methods recommended by A. S. T. M.

FUEL PIPING DIAGRAM

FUEL LINES OR PIPES. Fuel lines should be arranged as shown in Illustration No. 13. The suction line should never be less than 1/2" O.D. tubing with no restrictions or other fittings that are less than 3/8" I.D.

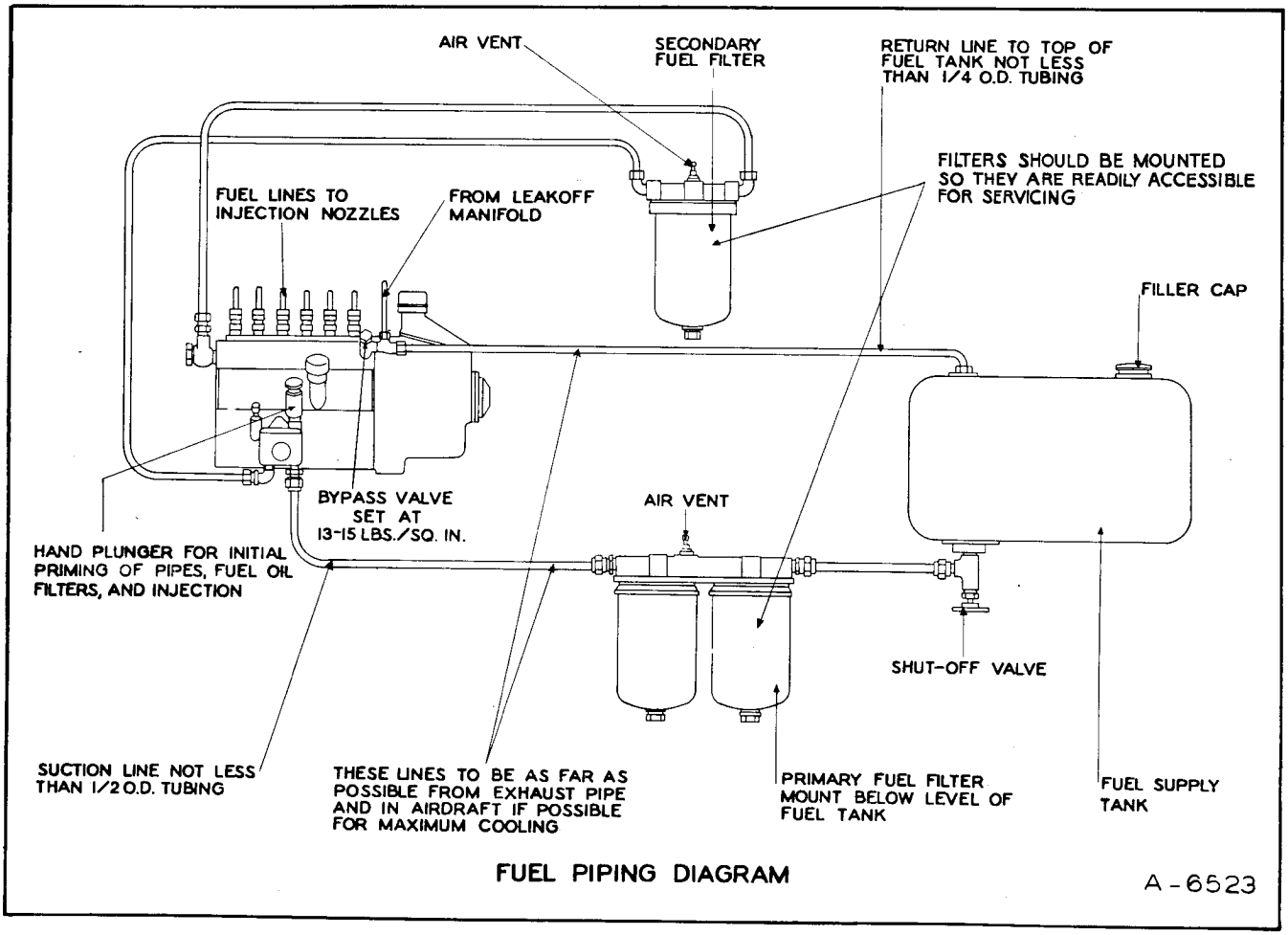


Illustration No. 13

FUEL INJECTION EQUIPMENT

For Governor Information See Pages 37, 49, 60, 63 and 69

DESCRIPTION:

The fuel injection equipment consists of an injection pump which is equipped with a fuel transfer or supply pump mounted on the side of the lower part of the injection pump case; a governor mounted on the end of the injection pump; a check valve to maintain a constant pressure in the fuel manifold; six fuel lines; six nozzles and a leak off manifold for six cylinder engine.

Illustration No.16 shows the American Bosch Injection Pump with Bosch GVA/PK type governor. Illustration No. 17 shows the American Bosch Injection Pump with Hercules Mechanical Industrial type governor. Illustration No. 18 shows the American Bosch Injection Pump equipped with a Pierce constant speed governor. Illustration No.19 shows the American Bosch Injection Pump equipped with a Pierce variable speed governor. Illustration No. 60 shows the Woodward Hydraulic Governor.

The Pierce governors are manufactured by the Pierce Governor Company, Anderson, Indiana.

The Woodward Governor is manufactured by the Woodward Governor Company, Rockford, Illinois.

Various parts of the fuel injection equipment with the care which each should receive will be taken up separately in the following paragraphs.

BOSCH FUEL INJECTION PUMP:

The fuel injection pump on the Diesel Engine can readily be compared to a magneto on a gasoline engine for the fuel injection pump must be properly timed with respect to camshaft and crankshaft so that the fuel injection period will correspond to the proper position at the time of maximum compression of the air in the cylinder, in exactly the same manner as a magneto must be properly timed with relation to the similar parts so that the spark will occur—due to the interrupter points breaking when the piston is at the top of the compression stroke. With the main shaft of the fuel pump—on which are suitable cams—properly timed it is then necessary to insure each of the six independent fuel pump plunger barrels being connected by means of the tubing with the proper cylinder which is under compression. This corresponds with the necessity of having the high tension wire from the magneto distributor connected with the proper spark plug so as to insure the spark produced being conducted to the cylinder under compression.

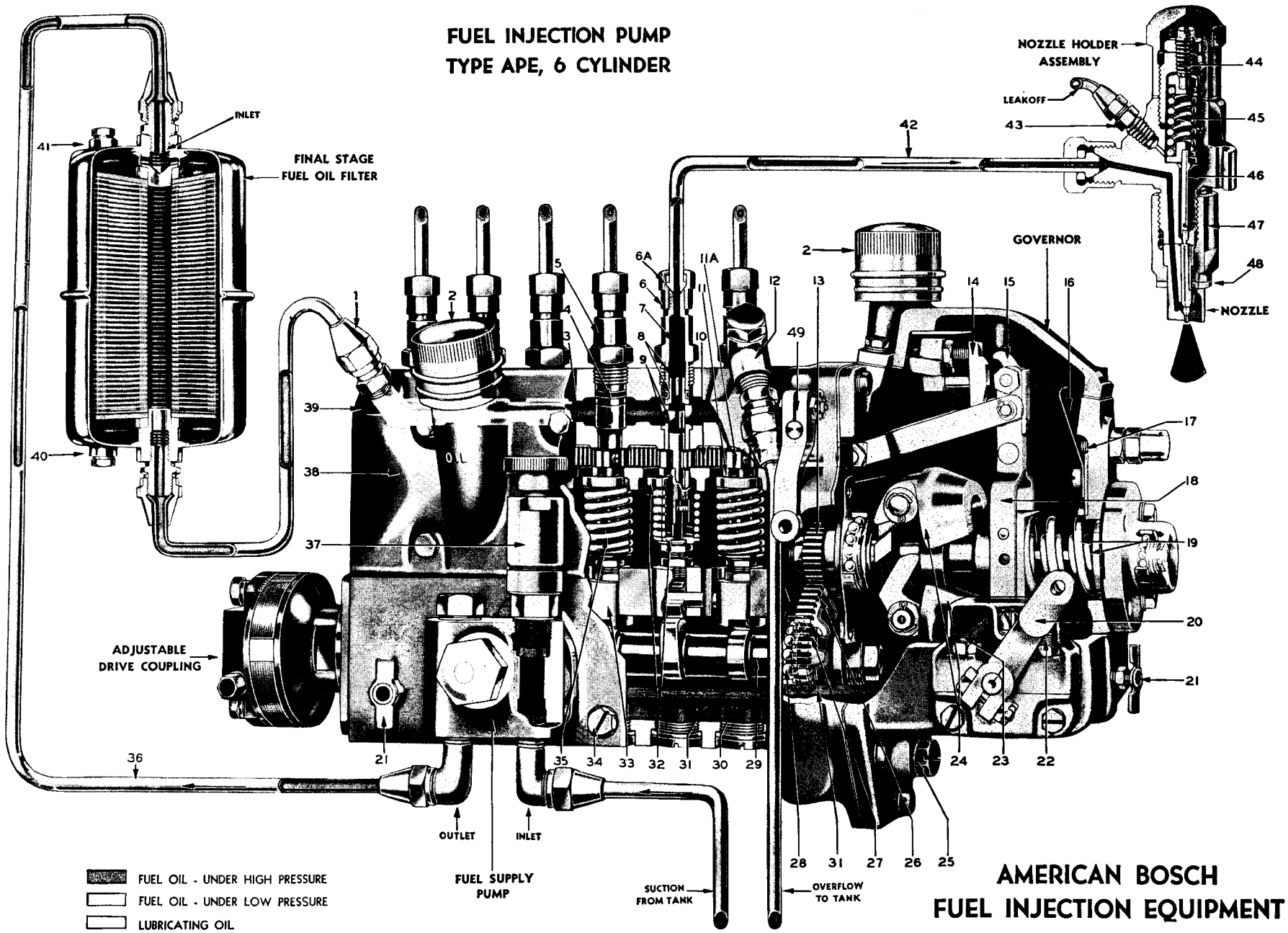
The cams on the camshaft of the fuel injection pump are arranged in the same firing order as the engine which is 1-5-3-6-2-4 so that beginning at the drive end of the pump the barrel should be connected with number 1 cylinder, number 2 barrel with number 2 cylinder, number 3 barrel with number 3 cylinder, number 4 barrel with number 4 cylinder, and number 5 barrel with number 5 cylinder, and number 6 barrel with number 6 cylinder in a six cylinder engine. (Counting or numbering the cylinders from the chain and gear train end of the engine.)

While the construction of the fuel injection pump requires such accurate workmanship and fits as to make impossible for any repairs to be made outside of authorized American Bosch Diesel Service Stations there is no mystery regarding the manner in which it operates and there is no particular complication regarding its construction, but in order to secure small plungers and barrels properly sealed to maintain a fuel line pressure of 3000 pounds per sq. in. during the injection period without the use of piston rings or packing glands these barrels and plungers have to be fitted with as much care as the jewel in a watch and any attempt to tear down or adjust one of these injection pumps will unquestionably result in the entire pump having to be rebuilt at great expense. It is therefore essential that no repairs be attempted by any one but an authorized American Bosch Diesel Service Station, unless fully conversant with Fuel Injection Pumps.

DESIGN AND OPERATION:

The general construction of the fuel pump can be readily understood by reference to section of the pump in Illustration No. 14 which shows the camshaft number 29 operating the different plungers by means of the cam rollers, and tappets number 33 also springs number 35 all of which construction is quite similar to the ordinary tappets and parts which are used to operate the valves of a conventional "L" head gasoline engine. The oil in the bottom of the case lubricates the cam and tappets. The fuel oil delivered by the supply pump shown in Illustration No. 14 is delivered into the upper portion of the injection pump assembly shown as number 3 in Illustration No. 14. When the plunger is at the bottom of its stroke fuel flows into the plunger barrel or cylinder through the holes or ports in the side of the barrel and on the return stroke as soon as the piston has passed the top edge of the holes in the barrel compression begins and any continued movement of the plunger naturally results in continued delivery of fuel. The starting point of the injection period however is determined by the spring in the nozzle holder and the timing of the injection pump. The amount of fuel oil delivered on each stroke of the plunger is determined by the position of the plunger or piston which part can be rotated inside of the barrel or cylinder. The manner in which this controls the amount of fuel oil injection is clearly shown in Illustration No. 15 together with the following description.

Illustration No. 14



CONTROL OF QUANTITY OF FUEL INJECTED—

Fuel Injection Pump Operation:

The fuel injection pump consists of six plungers or pistons fitted to and operating in six barrels or cylinders. The up and down pumping movement is actuated by springs, and by cams on the fuel pump camshaft, similar to an "L" head engine valves, and the length of the complete plunger stroke is constant. The plungers are rotated in their barrels by a control rod 10 Illustration No. 14. This rod has teeth along one side which mesh with toothed segments 11A Illustration No. 14 which are attached tightly to each pump plunger control sleeve. The rotation of the plungers may take place during any portion of their upward or downward stroke. The control rod is operated by the governor mechanism and its position depends upon the location of the outside control lever or the speed of the engine. The engine speed is determined by the load applied. When the governor moves the control rod to the right the plungers are rotated to the left.

The fuel supply pump keeps the fuel injection pump fuel reservoir completely filled with oil at all times. These pump plunger barrel ports "C" and "D," Illustration No. 15 are always submerged in this fuel oil—see Illustration No. 14, so that when the top edge of the pump plunger uncovers the top edge of the ports "C" and "D" and during the rest of its downward stroke and until the top edge of plunger closes the top edges of these ports on its upward stroke, fuel rushes in through these two ports filling the chamber above the plunger "B" Illustration No. 15 in the barrel "A" and as this chamber is connected by the vertical groove "E" with the recess in the plunger formed by the helical edge "F" and edge "G", fuel also flows down groove "E" filling this recess. This is the manner in which fuel is supplied to each fuel pump plunger. Figures number 1, 3, and 5 Illustration No. 15 show the plunger just as it has completed its downward stroke and is beginning its upward. In each case the fuel has and still is entering the chamber, groove, and recess in the manner just described.

FULL LOAD POSITION—FIGURE 1 AND 2—Illustration No. 15.

Figure 1 shows the location of the various grooves and edges in relation to the port openings, "C" and "D" when the pump plunger has been rotated to the extreme left giving the maximum effective pump plunger

NOMENCLATURE

(See Illustration No. 14)

1. Fuel Inlet Fitting
2. Breather and Oil Filler
3. Fuel Oil Sump
4. Delivery Valve Gasket
5. Delivery Valve Holder
6. Tubing Union Nut

6A. Tubing Union Washer

7. Delivery Valve Spring
8. Delivery Valve Assembly
9. Plunger and Barrel Assembly
10. Control Rack
11. Control Sleeve

11A. Control Sleeve Gear Segment

12. Overflow Valve Assembly
13. Governor Drive Gear
14. Governor Torque Plate
15. Governor Torque Control Cam
16. Governor Bumper Spring
17. Bumper Spring Adjustment Screw
18. Governor Fulcrum Lever Assembly
19. Governor Springs
20. Governor Operating Lever
21. Oil Level Fittings
22. Low Speed Adjustment Stop
23. High Speed Adjustment Stop
24. Governor Weight Assembly
25. Governor Oil Drain
26. Governor Drive Gear Assembly
27. Cam Shaft Oil Seal
28. Cam Shaft Ball Bearing
29. Cam Shaft
30. Cam Lobe Lubricating Pad
31. Lubricating Oil
32. Plunger Spring Seats
33. Plunger Tappet Assembly
34. Pump Lubricating Oil Drain
35. Plunger Spring
36. Fuel Supply Tubing
37. Hand Primer
38. Inspection Cover
39. Pump Housing
40. Filter Drain
41. Filter Bleeder
42. Fuel Injection Tubing
43. Leak-off Fitting
44. Opening Pressure Adjustment Screw
45. Nozzle Opening Pressure Spring
46. Nozzle Holder Push Rod
47. Nozzle Retaining Nut
48. Nozzle Holder Gasket
49. Shut-off Lever

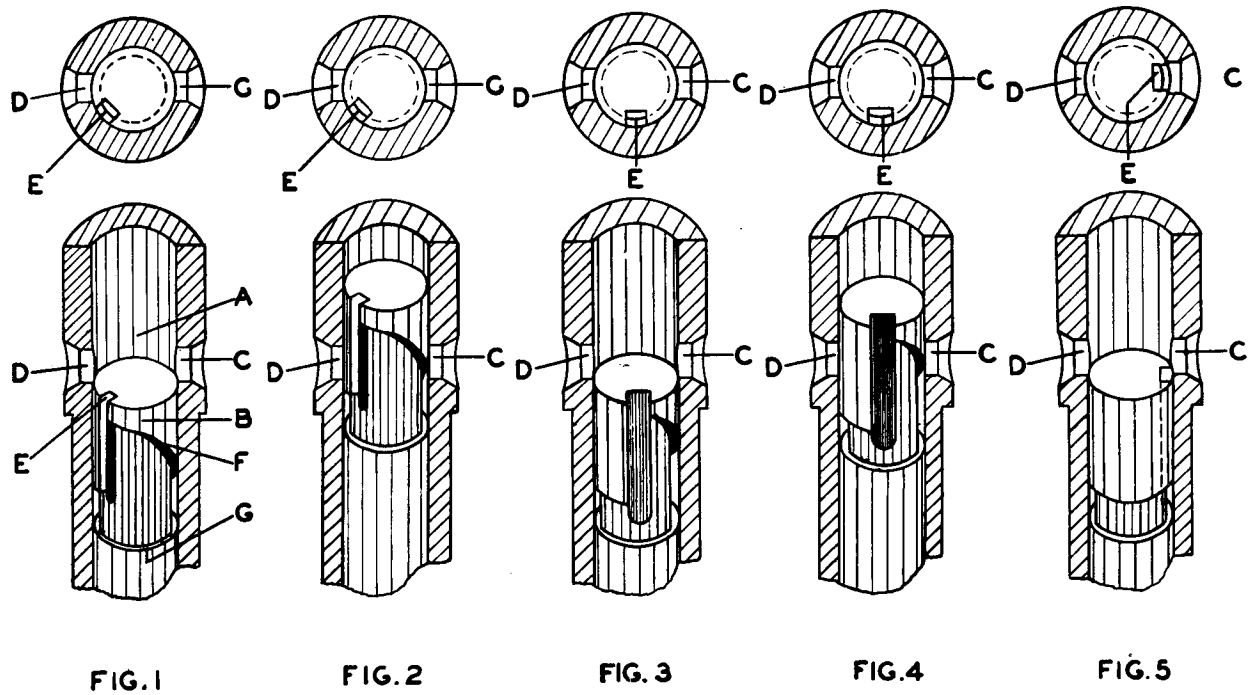


Illustration No. 15

stroke. This is the position of the plunger at the beginning of its upward stroke when starting the engine, or when and while maximum power is demanded. As the plunger travels upward the top edge of the plunger at one exact point just closes the two ports "C" and "D." At this exact point the fuel which has filled the chamber, formed above plunger "B" in barrel "A," and the groove "E" and the recess formed between helical edge "F" and edge "G" is trapped in this chamber, groove, and recess, and cannot escape as groove "E" and the edge "G" do not register with any port opening and helical edge "F" does not register with port opening "C." The only way fuel can escape is through these two port openings and therefore one of these edges or the top edge of the plunger must index with one or both of the port openings before the fuel can escape except by injection through the nozzle. From this exact point of port closing the result of the top edge of the plunger covering the top edge of the port openings, and until the helical edge "F" or vertical groove "E" uncovers port opening "C," or an intermediate position of this edge and groove from that shown in Figure number 2 to that shown in Figure number 5, the fuel in the fuel line to the nozzle, the chamber, the groove and the recess is being raised in pressure equally A spring set at a pre-determined pressure, holds the nozzle valve located in the nozzle holder assembly on its seat until the pressure in the recess, vertical groove and chamber in the pump, and in the fuel lines, equals this spring pressure, at which time the valve is lifted off its seat by this fuel pressure and fuel is sprayed into the combustion chamber and continues injection until either the helical edge "F" or vertical groove "E" uncovers port opening "C," which causes instantaneous release of pressure as described under Figure number 2 below.

FIGURE 2—Illustration No. 15.

Groove "E" has been in the same relative position with respect to port openings "C" and "D" as that shown in Figure number 1, by the control rod 10 Illustration No. 14.

The plunger has just completed its upward stroke and is at the exact point when helical edge "F" uncovers port opening "C" giving the maximum effective plunger stroke at which position it has delivered the maximum possible amount of fuel. This is the position of the plunger at the end of the injection stroke when the engine is being started or maximum power is demanded. At the instant helical groove "F" uncovers the bottom edge of port opening "C" the fuel in the chamber, groove and recess and is released through this port opening into the fuel reservoir and the pressure is thereby also instantly released. As the pressure is instantaneously released below this check valve the spring pressure applied on the nozzle valve in the nozzle holder assembly becomes intantaneously greater than the pressure in the fuel line and nozzle snaps back onto its seat which cuts off injection into the combustion chamber.

Just above the chamber in the pump plunger "B" Illustration No. 15 is located a check valve, called a "fuel pump delivery valve," see number 8, Illustration No. 14. As the fuel pressure is raised the valve is

lifted off its seat and allows the fuel to be forced into and through the fuel line to the nozzle. When this pressure in the pump, lines, and nozzle is equal to the pressure of the spring in the nozzle holder the nozzle valve is lifted off its seat and fuel is injected into the combustion chamber. When the fuel pressure is released by the helical edge "F" of the pump plunger, uncovering the port opening "C", the fuel in the fuel line closes this discharge valve in the fuel pump. In this way the fuel oil in the fuel line is trapped between the discharge valve in the pump and the nozzle valve in the nozzle holder assembly at a pressure just slightly less than the opening pressure of the nozzle valve. This eliminates the necessity of building up the pressure in the fuel lines for each plunger stroke.

PARTIAL LOAD POSITION—FIGURES 3 AND 4—Illustration No. 15.

Figure number 3 shows the pump plunger at the end of its downward stroke and beginnig its upward stroke. The operation of the plunger is the same as described under Figure number 1, the only difference being the location of the vertical groove "E" and helical edge "F" in relation to the port opening "C." The control rod has rotated the pump plunger into partial load position. Compare location of groove "E" with position shown in Figure number 1.

Figure number 4 shows the pump plunger at the end of its effective stroke when partial load is demanded of the engine. Helical edge "F" has uncovered the lower edge of port opening "C," releasing the fuel and pressure therefore injection has just stopped. It will be noticed that the top edge of the pump plunger is considerably below the top edge of the plunger shown in Figure number 2 but in each case injection has just stopped due to the helical edge uncovering the port opening. Fuel was therefore injected for longer period of time in figure number 2 than in figure number 4 so more fuel was injected during the longer effective stroke shown in figure number 2 than in the shorter effective stroke shown in figure number 4. The plunger however in both cases must make the same length of upward and downward stroke due to the cam action which operates it. In figure number 4 the rest of the upward stroke will not deliver any more fuel to the nozzle as there is no fuel under pressure left in the chamber, groove, and recess, as it has escaped through the port opening "C" into the fuel reservoir in the pump housing. The engine cannot carry as much load or if carrying the same load speed will be reduced with the shorter effective stroke shown in figure number 4 as compared with the longer effective stroke shown in figure number 2.

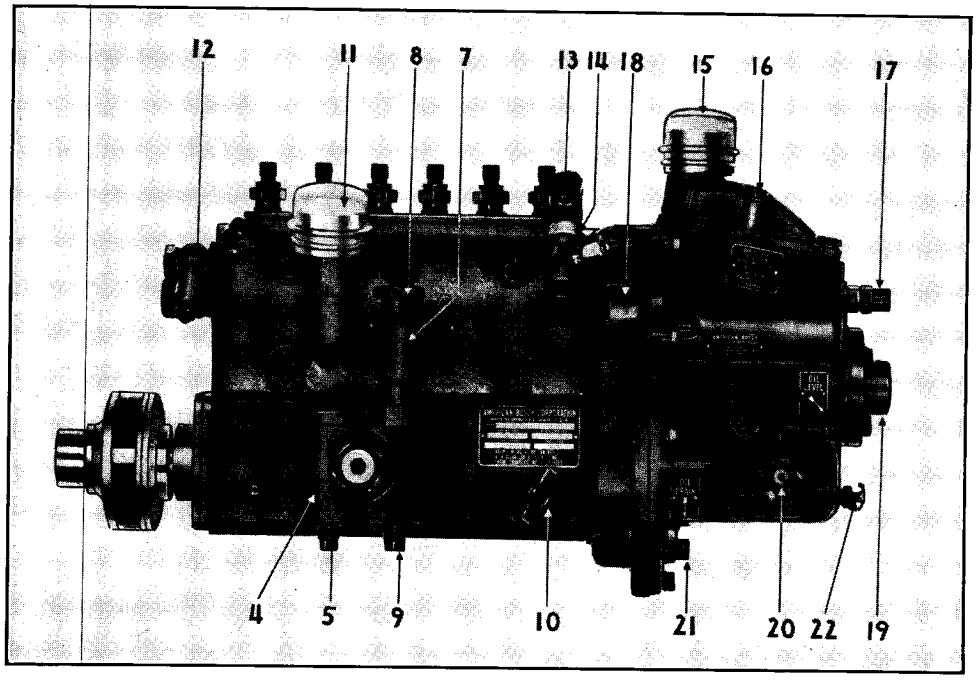


Illustration No. 16

STOP POSITION—

Figure number 5, Illustration No. 15, shows the pump plunger just beginning its upward stroke when it has been rotated manually to the extreme right to stop the engine. Notice in this case that vertical groove "E" is registered with port opening "C" and that as this slot is vertical it will register with port opening "C" during the whole stroke of the plunger. Fuel rushes in through both port openings, as long as the top edge of the plunger leaves them uncovered the same as in figure number 1 and number 3 filling the chamber, groove and recess. When the top edge of the plunger covers the top edge of the port the pressure is not raised however as in figures number 1 and 3 as the fuel is not trapped but can and does escape through vertical groove "E" back into the pump reservoir groove "E" is registered with port opening "C" during the complete plunger stroke. As no fuel is delivered to the nozzle the engine must stop.

These figures are to represent any one plunger and show the location of the various edges and grooves under different engine load conditions and are not shown as for engine cylinder numbers 1 - 2 - 3 - 4 - 5. All plungers in the pump are rotated to exactly the same position simultaneously by the fuel injection pump control rod so any one figure shown represents the location of all six plungers.

PLUNGER POSITION FOR FLOWING METHOD OF TIMING:

Read the description of the plunger operation shown in figures number 1 and 2, Illustration No. 15 carefully as when timing the fuel injection pump by the "flowing" method, the point at which the pump is timed is when the number 1 engine piston is correctly timed, see page 32, before top center the top edge of the number 1 cylinder pump plunger has exactly closed the two port openings "C" and "D" on its upward travel. This point must be exact or the pump at "A" timing will not be correct. That is why it is necessary that LESS than $\frac{1}{64}$" movement of the coupling hub shown in Illustration No. 23 is the difference between fuel flowing and not flowing as when fuel flows the top edge of the plunger is below the top edge of the port openings and fuel is flowing into the chamber above the plunger and when fuel stops flowing the top edge of the plunger has closed or passed the top edge of the port openings. The pump must be timed at the exact point of closing not just before or after to be timed correctly by the "flowing" method.

LUBRICATION:

Since lubrication of the various fuel injection parts is essential we will cover this phase first. When the fuel injection pump is first put into service, or after an over-hauling, and the lubricating oil has been drained it will be necessary to fill the pump base with the same oil as is used in the engine crankcase. It can be filled by removing breather cap, 11, Illustration No. 16 and should be filled to the oil level test petcock, 10, Illustration No. 16. It will be necessary to drain and refill this pump base. Every time engine oil is changed put a half of a pint of oil in pump, let excess drain out level cock.

An over-flow pipe is provided on some engines on the side of the pump. This is to over-flow any excess oil which might accumulate in the base due to slight leakage of fuel oil by the pump plungers. Normal leakage will not in any way affect the operation of the pump and is in fact the method of lubricating the pump plungers. As the pump plungers and barrels become worn the leakage will increase until the engine operation is affected when new barrels and plungers should be installed and this leakage will then be the same as with a new pump.

On engines not equipped with over-flow pipes the petcock on side of the pump should be opened daily and the excess oil allowed to drain until it stops. Then close the petcock firmly.

Lubrication of the American Bosch governor on the American Bosch pump is through the fuel injection pump on units which are interconnected and have a common sump. On other units it is necessary to put oil in governor through breather 15, Illustration No. 16.

For lubrication instructions for the Hercules Mechanical Industrial Governor, Illustration No. 17, and page 49.

The Pierce Governors, Illustration Nos. 18 and 19, are filled through oil filler 31 until oil drops from oil level test cock 36.

PROPER FUEL AND CLEANLINESS WITH CORRECT NOZZLE PRESSURE INSURE TROUBLE FREE OPERATION

GOVERNORS:

These are covered in another section of this book see pages 37, 49, 60, 63 and 69.

CHECK VALVE:

The check valve on the fuel outlet maintains a set pressure in the fuel manifold of the pump. These parts are shown as 13 in Illustrations No. 17 and No. 18. Should dirt or lint get between the valve and its seat, the valve ceases to function and the pressure on the manifold is reduced which may cause a slight drop in power. Remove and hold valve open while washing it out with fuel oil, kerosene or gasoline. Do not completely disassemble unless absolutely necessary. Also read section starting on page 92 regarding fuel filters.

The fuel return line to supply tank should be fastened by proper fittings to opening 14 Illustrations No. 17 and 18.

FUEL TRANSFER PUMP:

The Transfer Pump consists of both a mechanically operated piston type pump (driven by one of the lobes on the injection pump camshaft) and a separate hand operable plunger type priming pump (No. 7 and 8, Illustration No.18.) The hand priming pump is positive in operation regardless of the engine cycle or position of the injection pump camshaft. The mechanically operated transfer pump serves through a suitable arrangement of piston and valves, to draw fuel from the main supply tank, through suitable primary filters and deliver this fuel, through the final filter located between the transfer pump and the injection pump, to the injection pump.

Dirt sometimes gets imbedded in the transfer pump valves and reduces its efficiency if not actually causing the pump to cease working. Remove the valves and clean or replace from spares. The springs of these same valves sometimes break. Replace from spares when this trouble is found. Use only genuine parts in replacement as substitutes may cause considerable damage.

For complete priming details see page 12.

FUEL INJECTION PUMP:

The American Bosch fuel injection pump shown in Illustrations No. 16 and No. 17 has a camshaft, mounted on ball bearings in the ends of the case, whose cams operate the plungers inside their respective barrels through suitable tappets, rollers and springs. The helix on the plunger controls the amount of fuel delivered to the fuel nozzle. The relation of the helix to the port holes in the fuel manifold of the pump is controlled by a toothed segment on the plunger mechanism working in a toothed control rod which in turn is connected to the governor. The plunger compresses the fuel and forces it through the delivery valve, fuel pipes and through the spring loaded nozzle into the engine combustion chamber. Also refer to Illustration No. 14.

THE USE OF PROPER LUBRICATING OIL FREQUENTLY CHANGED WILL REDUCE REPAIRS TO THE FUEL PUMP AND GOVERNOR TO A MINIMUM. SHOULD REPAIRS BE NECESSARY EITHER PROCURE THE PROPER TOOLS OR RETURN PUMP AND GOVERNOR TO MANUFACTURER OR TAKE IT TO AN AUTHORIZED BOSCH SERVICE STATION.

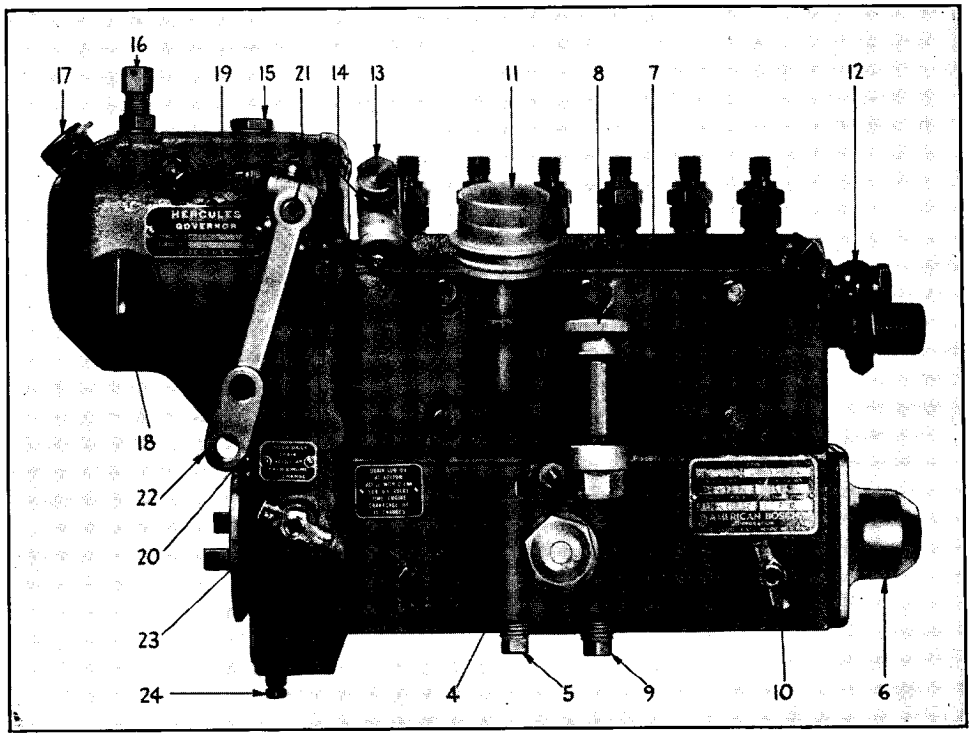


Illustration No. 17

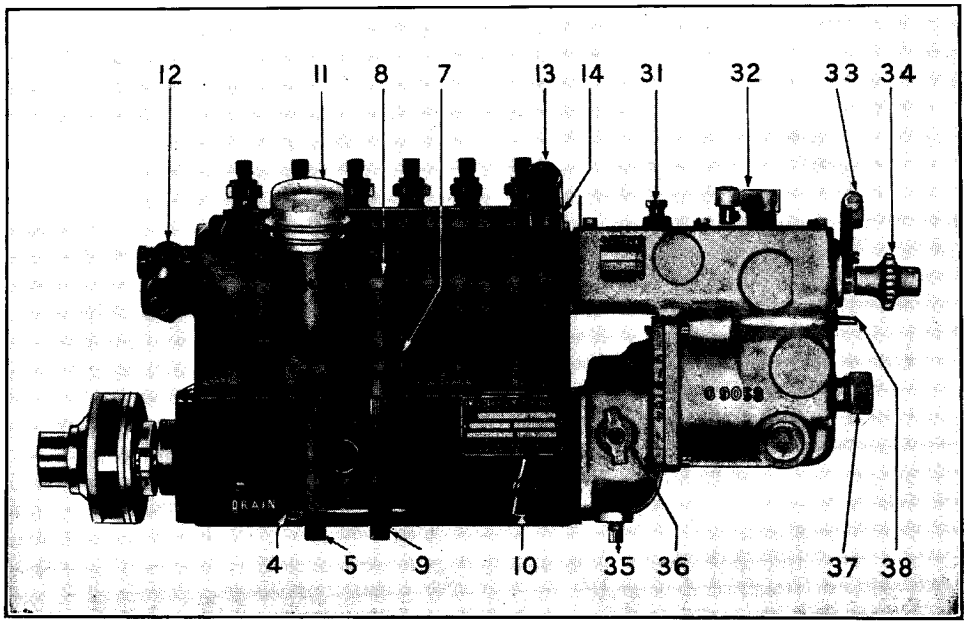


Illustration No. 18

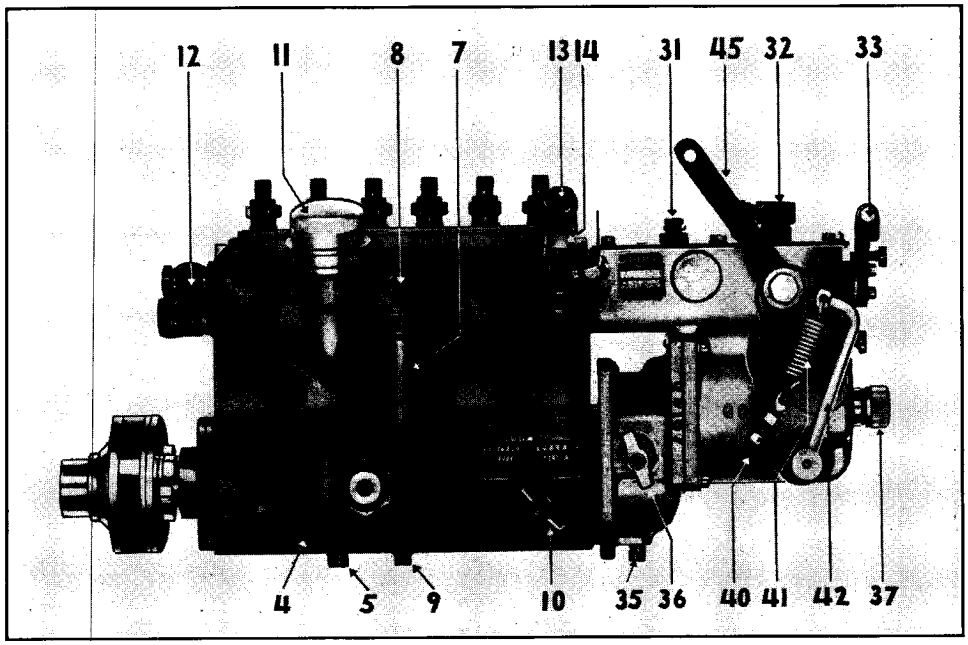


Illustration No. 19

IMPORTANCE OF CAREFUL PUMP ALIGNMENT

It is important that the American Bosch fuel injection pumps when mounted on Hercules engines be carefully aligned as any misalignment sets up severe stresses in the pump camshaft and engine drive shaft which is transmitted to supporting bearings. The flexible coupling through which the pump is driven is designed to protect both shafts and bearings from damage caused by slight misalignment but the coupling cannot compensate for gross errors in installation.

The pump housing is chamfered at its base and the governor which is attached to the pump is designed to provide installation clearance between the pump assembly and the engine crankcase. As might be expected, there is a slight difference from time to time in external casting dimensions of the pump, governor, and engine crankcase which have in some cases prevented correct pump alignment. It is therefore, very important that whenever a pump is installed on an engine the procedure outlined below should be carefully followed:

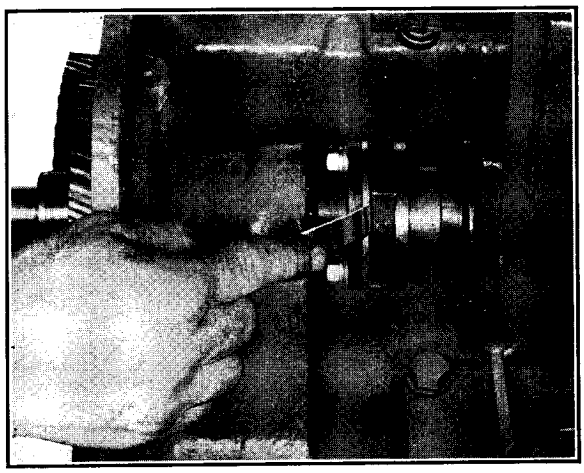


Illustration No. 20

1. Try slots of fibre intermediate disc on flanges of steel coupling. If there is any indication of wear on steel or fibre parts, the worn parts should be replaced. The fibre disc must fit smoothly on the steel flanges.

2. Place pump on supporting bracket and engage coupling. Insert securing screws in base of pump and tighten screws finger tight so that pump can be moved by gently tapping with a block of wood or the end of a hammer handle.

3. The pump camshaft and drive shaft must be parallel and in alignment. The coupling intermediate disc must float with a clearance of .020"-.040". The pump can be checked for alignment by matching the edges of the two coupling members. The pump can be checked for parallelism, by the use of a feeler gauge, Illustration No. 20, inserted in opposite sides of the drive coupling.

4. One of the most important steps in pump alignment is to provide ample end clearance for float of the intermediate disc. After tightening the pump holding screws, recheck this end clearance and be sure it is between .020" and .040". Without this clearance, the coupling is not free to compensate for minor misalignment or out-of-parallel condition.
5. Insert a sheet of paper or .005" feeler gauge back of the pump so that it passes between the engine crankcase and the pump and governor. If the paper or gauge will not slide freely between the two, then the pump and governor must be removed. Inspect the engine crankcase for possible high spots that would cause interference. The high spots should be ground off or removed with a file. It is likewise possible that high spots on the pump or governor may be interfering and they should be removed by grinding or filing.

Failures encountered due to disregard to the above instructions will lead to costly repairs.

FUEL PUMP TIMING

MODEL	DFXB	DFXC	DFXD	DFXE	DFXH	DFXHF	
AUTOMOTIVE	29°	29°	29°	27°	27°	27°	B.T.C.
INDUSTRIAL	28°	28°	29°	27°	27°	—	B.T.C.

Always Inspect and Adjust Timing Chain Before Timing Fuel Pump (Page 94)

TIMING FUEL INJECTION PUMP BY FLOWING METHOD, All flywheels have a line marked DC (Dead Center), Illustration No. 21, and from this line are graduations designating degrees of crankshaft travel. From DC these lines are marked 30° and 40° B.T.D.C. Also marked every two degrees from 20° to 40° B.T.D.C.

(1) SPOTTING FLYWHEEL:

(a) Rotate flywheel by means of hand crank until DC mark appears in timing hole in bellhousing, Illustration No. 21. Be sure No. 1 piston is just completing the compression stroke and beginning the expansion stroke which can be determined by observing that the No. 6 cylinder exhaust valve is nearly closed or remove No. 1 nozzle and "feel" the compression.

(b) Rotate the engine in direction of degree graduation marks which is counter-engine-wise several degrees past the correct degree mark, (see above chart). Then rotate the engine the opposite direction or engine-wise until the correct degree mark is in line with the mark in the center of the timing hole in the bellhousing. This will then have the crankshaft spotted at the correct degree mark before top center, at which point the fuel pump is set for port closing.

(2) Install pump assembly with number 1 plunger on upward stroke or with coupling flow marks lined up, tightening all attaching screws but leaving the rear half of coupling loose from front half so pump shaft can be rotated while the shaft remains stationary.

(3) Connect all fuel suction and discharge pipes from fuel tank to pump. Install all fuel lines except to No. 1 cylinder.

(4) With governor lever in wide open or full position prime pump as given on page 12 paragraph 6.

(5) Put governor lever in stop position and remove pump delivery valve holder from No. 1 pumping unit. Remove delivery valve and spring but not the seat, See Illustration No. 22. Replace delivery valve holder finger tight.

(6) Put governor lever in wide open or full load position. Fuel now should rush out of the delivery valve holder. Rotate pump shaft over the top and toward the engine by means of the rear half of coupling until fuel flow stops, Illustration No. 23. If fuel did not flow when governor stop lever was first opened, rotate shaft until it does, then back to where it is just off. Use hand priming pump to keep fuel pump manifold supplied with oil.

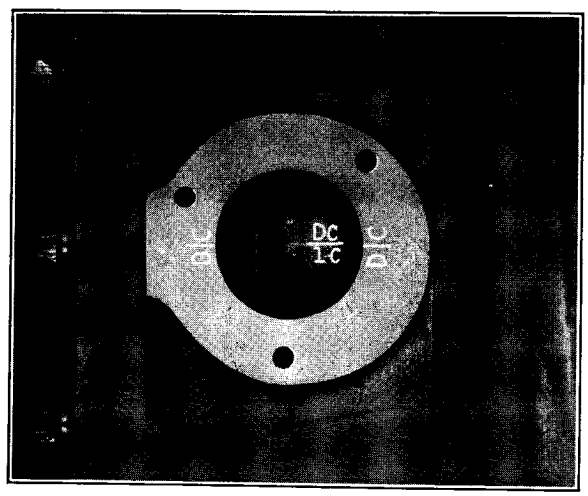


Illustration No. 21

(7) Very carefully rotate shaft until fuel just barely flows then back to point where flow is just barely shut off. Repeat this two or three times until a movement of less than $\frac{1}{64}$" on the circumference of the coupling is the difference between fuel flowing and not flowing, Illustration No. 23. This determines where the pump plunger just closes the fuel port and begins the period of building up pressure in the lines and nozzles so that injection can start and it is necessary this adjustment be extremely accurate.

(8) With capscrews provided connect the front and rear half of the coupling together. Be sure these screws are tight so no slippage can occur and yet do not strip the threads. It is not advisable to use a wrench over 6" long for tightening. Also observe if any slight movement which might occur while tightening the screws has started the fuel flowing again from the delivery valve holder. When these screws are tight no fuel should flow. The fuel pump is now timed to close the ports at the correct degree before top center.

Illustration No. 22

(9) Put governor lever in stop position again. Remove delivery valve holder and replace the delivery valve and spring. Install delivery valve holder, tightening firmly. Be careful not to get any dirt, water or any other foreign matter in or on any of these parts. Do not tighten so tight as to disort fuel pump case.

(10) Connect fuel line from pump to No. 1 cylinder. Prime fuel lines as explained on page 12, being sure the fuel pump, strainer and all lines are full of fuel with no air.

(11) Start engine. If engine runs ragged or one cylinder cuts out see page 120 for remedies. If after checking all points engine still runs ragged, stop and recheck timing.

(12) After engine is operating smoothly and has been properly warmed up, stop engine.

(13) With light chisel and hammer enlarge the single mark on the front hub and put a corresponding mark on the other hub so these two parts can be lined up together at any future time without the necessity of flowing the pump. See Illustration No. 23.

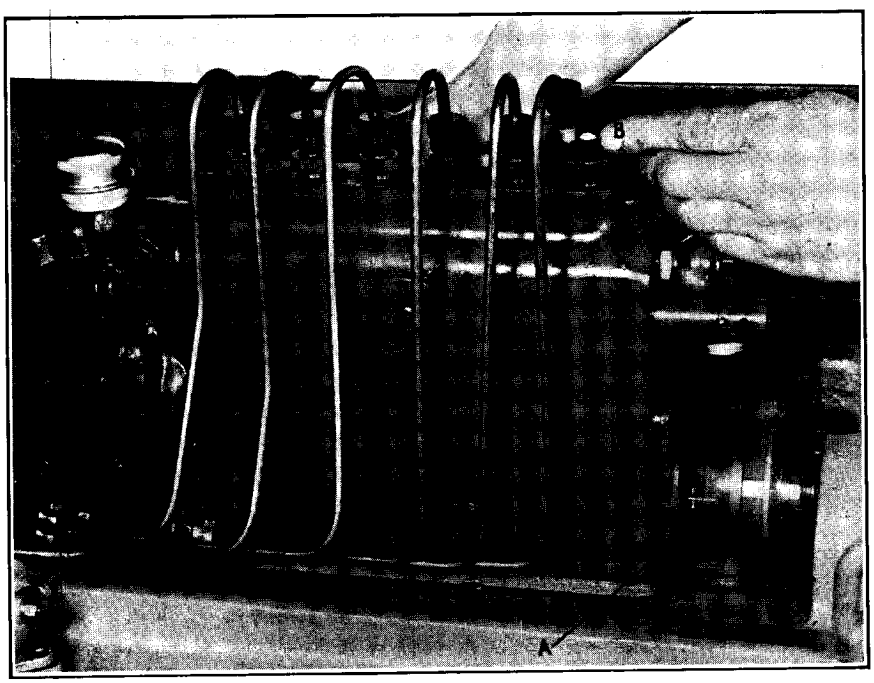


Illustration No. 23

FUEL PUMP TIMING WHEN COUPLINGS ARE MARKED. When engines are shipped from the factory the couplings are marked for fuel injection pump timing as shown in Illustration No. 23. Before removal of fuel pump assembly from the engine these markings should be carefully checked and if dim or obliterated should be re-marked so that re-assembly can be more easily, quickly, and surely made.

To re-assemble the pump assembly to the engine the following procedure should be followed:

1. Spot engine No. 1 piston at proper degree before top center. See page 32, paragraph (a) and (b) for procedure.
2. Install pump assembly on engine with marks coinciding as near as possible, tightening all attaching screws but leaving rear half of coupling loose from front half so pump can be rotated while the drive shaft remains stationary.
3. Rotate rear half of coupling until the heavy mark on it coincides with the heavy mark on the front half of coupling.
4. Install and tighten the attaching screws which lock the rear coupling hub. Make sure the marks are lined up perfectly and the screws are tight.
5. Install all fuel piping.
6. Prime fuel lines as described on page 12.
7. Start engine.

TIMING NEW FUEL INJECTION PUMP. If a new fuel injection pump is obtained from the Hercules Motors Corporation it will not be necessary to flow the pump as the dust shield and rear half coupling hub are marked at the point of port closing. See Illustration No. 23, To install a new pump assembly follow this procedure:

1. Spot engine No. 1 cylinder at proper degree before top center. See procedure, page 32, paragraph (a) and (b).
2. Install pump assembly, tightening all attaching screws but leaving the rear half of coupling loose from front half so pump shaft can be rotated while the drive shaft remains stationary.
3. Rotate rear half coupling until the mark on the rear hub coincides with the mark on the dust cover. See Illustration No. 23.
4. Bolt coupling halves tightly together.
5. Install all fuel lines.
6. Prime fuel lines as described on page 12.
7. Start engine and run until warmed up.
8. When engine operates properly shut down engine and with light chisel and hammer mark rear hub with line corresponding with heavy mark on front hub so these two parts can be lined up together at any future time by following procedure given above.

If engine does not function properly when started, shut down and check the marking of the rear hub and dust seal making sure these marks line up perfectly, also check spotting of flywheel so No. 1 piston is at correct degree before Top Dead Center when these marks line up. After this check if the engine still does not operate properly, flow the pump as given on pages 32 and 33.

FUEL NOZZLE AND HOLDER ASSEMBLY

COMPONENT PARTS:

The fuel nozzle and holder assembly is shown in Illustration No. 24 clamped in a vise preparatory to dis-assembling, while Illustration No. 25 shows the complete details of the nozzle and holder assembly, the component parts of which are as follows:

No. 4 Nozzle Body Retaining Nut
No. 6 Fuel Nozzle Body
No. 5 Fuel Nozzle Pintle
No. 3 Holder Assembly
No. 2 Holder Fuel Inlet Stud
No. 7 Fuel Inlet Stud Gasket
No. 1 Fuel Inlet Stud Edge Filter
No. 8 Fuel Leak Off Manifold Union

Parts No. 5 and No. 6 are not interchangeable with similar parts of other assemblies and should be used as pairs as originally furnished.

DO NOT MIX THESE PARTS—KEEP THEM IN SETS.

Illustration No. 26 shows sectional view of a typical nozzle and holder assembly.

CARE OF FUEL NOZZLES:

Cleaning spray nozzles is necessitated by:

1. Dirt or foreign matter in the fuel oil which is not removed by the fuel strainers, acid and gum in particular.
2. By overheated engine and spray nozzles causing the fuel oil in the nozzles to decompose or coke around the pintle stem of the valve, spray hole and face of the nozzle.
3. Acid in the fuel oil etching or corroding the nozzle valve and body. This type fuel should never be used under any circumstances. It will ruin the pumps and nozzles. Fuel oil which is contaminated with acid may be detected by dipping one end of blue litmus paper in the oil for a few seconds. If acid is present in the oil the litmus paper will turn pink.

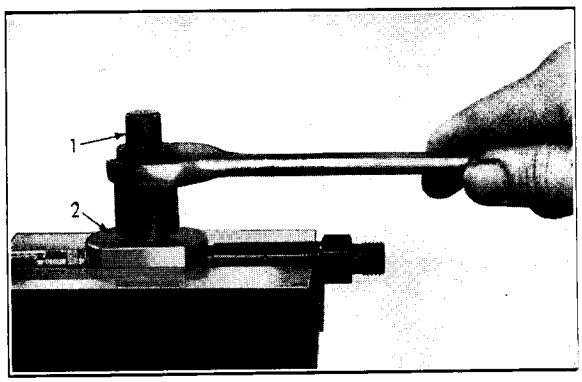


Illustration No. 24

When to clean spray nozzles:

1. When the engine exhaust has increased amount of black or dark smoke.
2. Loss of power accompanied with foul exhaust or increased leakage of fuel through the by-pass leak-off of spray nozzle.
3. When engine runs rough or "ragged."
4. Irregular fuel knocks.
5. Engine missing on one or more cylinders continuously.

Cleaning and Testing Spray Nozzles. The most important part of spray nozzle cleaning, testing and examination is CLEANLINESS. Spread some clean paper on the work-bench and have available a clean dish or open container of clean fuel oil or kerosene, approximately one pint is sufficient. Also have a supply of soft (not fluffy), dry, clean, wiping cloths, a clean squirt can of clean lubricating oil or a jar of vaseline available.

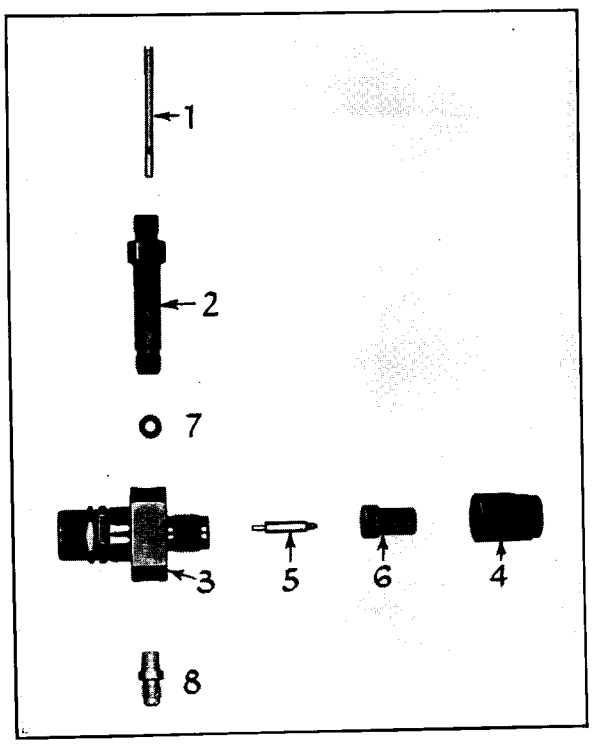


Illustration No. 25

Spray nozzles should be cleaned by first soaking them in kerosene or clean fuel oil to soften the dirt. The interior of the body can be cleaned with a small strip of wood dipped in the cleaning oil and the spray hole with a pointed piece of wood. The nozzle valve should be rubbed with a clean oil soaked soft rag (but not fluffy).

Hard or sharp tools, emery paper, crocus cloth, grinding powder or any abrasive of any kind should never be used.

Before assembling, wash and rinse all parts carefully and have them perfectly clean and smear with good clean lubricating oil or vaseline so that valve revolves freely. Tighten the nozzle retaining nut up hard.

The edge filter, No. 1, Illustration No. 25, inside of the fuel inlet tube, is cleaned by unscrewing the tube from the nozzle holder, No. 3, Illustration 25, and driving the strainer out with a punch, from the nozzle holder end. Rinse thoroughly with clean oil before reassembling.

If spray nozzle testing is necessary, this can be done on a hand operated testing unit, see Illustration No. 27, or it may be done by running the engine with the spray nozzle to be tested attached to the fuel delivery pipe, but not installed in the engine, and occasionally setting the throttle in full load position momentarily, while observing the spray and possible leakage.

The spray should be an 8° included angle and should be smooth and even, that is free from uneven branches or streams and the same thickness of oil spray all around the oil spray core as observed 2 to 5 inches from the nozzle. Uneveness or roughness of the stream indicates a dirty nozzle hole and pintle of valve which must be polished with a pointed stick and soft cloth.

If there should be an "after dribble" or "drool" of oil out of the nozzle after the spray is completed, it indicates that the nozzle hole and pintle are not clean and should be polished as above. Be sure both valve and barrel are perfectly clean, with no lint, dirt or foreign substance on surface of either when assembling.

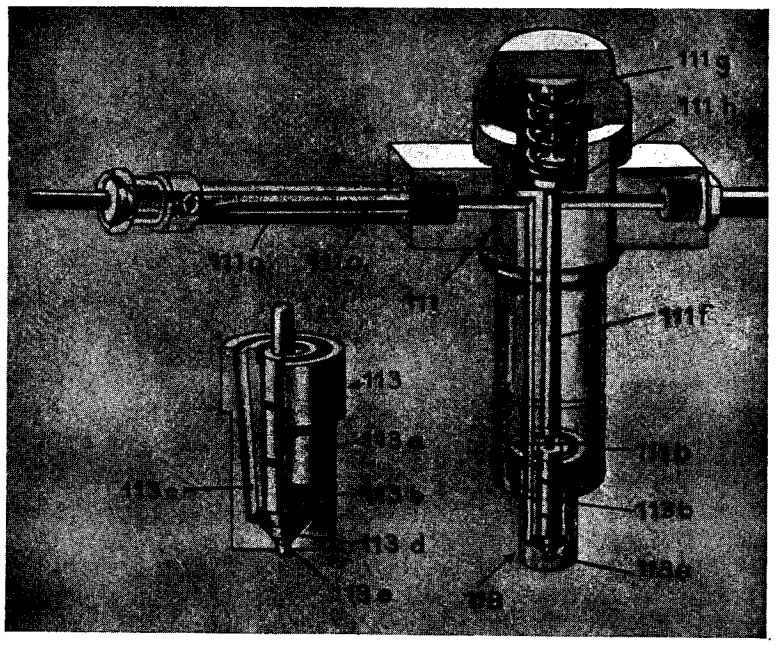


Illustration No. 26

FUEL NOZZLE PRESSURE

Fuel nozzles should be set for 2000 pounds per square inch pressure on a static fuel nozzle testing fixture, Illustration No. 27 (this fixture may be purchased from the Hercules Motors Corporation, Canton, Ohio, U.S.A.). However, no adjustment is required if this pressure has only dropped to 1950 pounds.

Adjustment is effected by removing the cap nut and turning screw clockwise to increase or anti-clock-wise to decrease the spring tension, thus raising or lowering the pressure.

New nozzle and holder assemblies are shipped from the factory set at 2050 pounds to compensate for the setting of the spring in the first few hours running.

Never attempt to adjust pressure without the proper testing fixture.

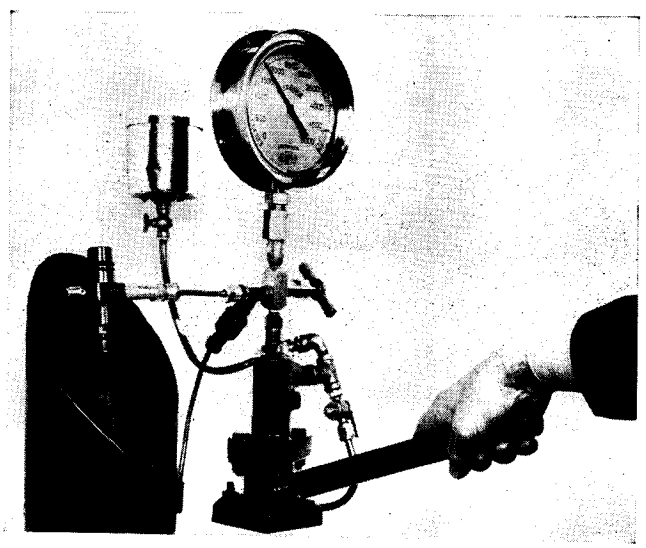


Illustration No. 27

GENERAL INFORMATION AND SERVICE INSTRUCTIONS FOR VARIABLE SPEED GOVERNOR (Bosch Type GVA PK)

WARNING: Before replacing the BK type governor with the PK type governor be sure to read "SPECIAL INSTRUCTIONS" on page 43.

PURPOSE

The prime purpose of these governors is to serve as a means for pre-setting and maintaining within close regulation any desired engine speed within the nominal idling and nominal maximum speed range, irrespective of engine load. In addition, this governor controls the engine idling speed to prevent stalling and the maximum speed to prevent racing. The GV type governor is used in Automotive, Industrial, and Marine applications.

DESCRIPTION

The governor is a fully enclosed unit, rigidly mounted to one end of the fuel injection pump (Illustra-

tion No. 14). A large gear is mounted on the end of the camshaft which extends into the governor housing and drives a smaller gear connected to the governor flyweight shaft. Through this combination of gears, the flyweight shaft is caused to travel at a higher speed than the injection pump camshaft. The centrifugal force exerted by the revolving weights cause a movement of the sleeve assembly (107), Illustration No. 29. This movement is opposed by the compression of the governor springs. The governor is internally connected to the injection pump control rod.

FUNCTION

All Illustration Numbers Refer to Illustrations No. 28 and No. 29.

The governor operating lever is connected to the throttle lever of the engine and is set to maintain a desired engine speed under a certain load. Whenever the load changes, it is the purpose of the governor to act upon the control rack of the injection pump in order to provide the proper fuel quantity to maintain the same speed under the new load conditions.

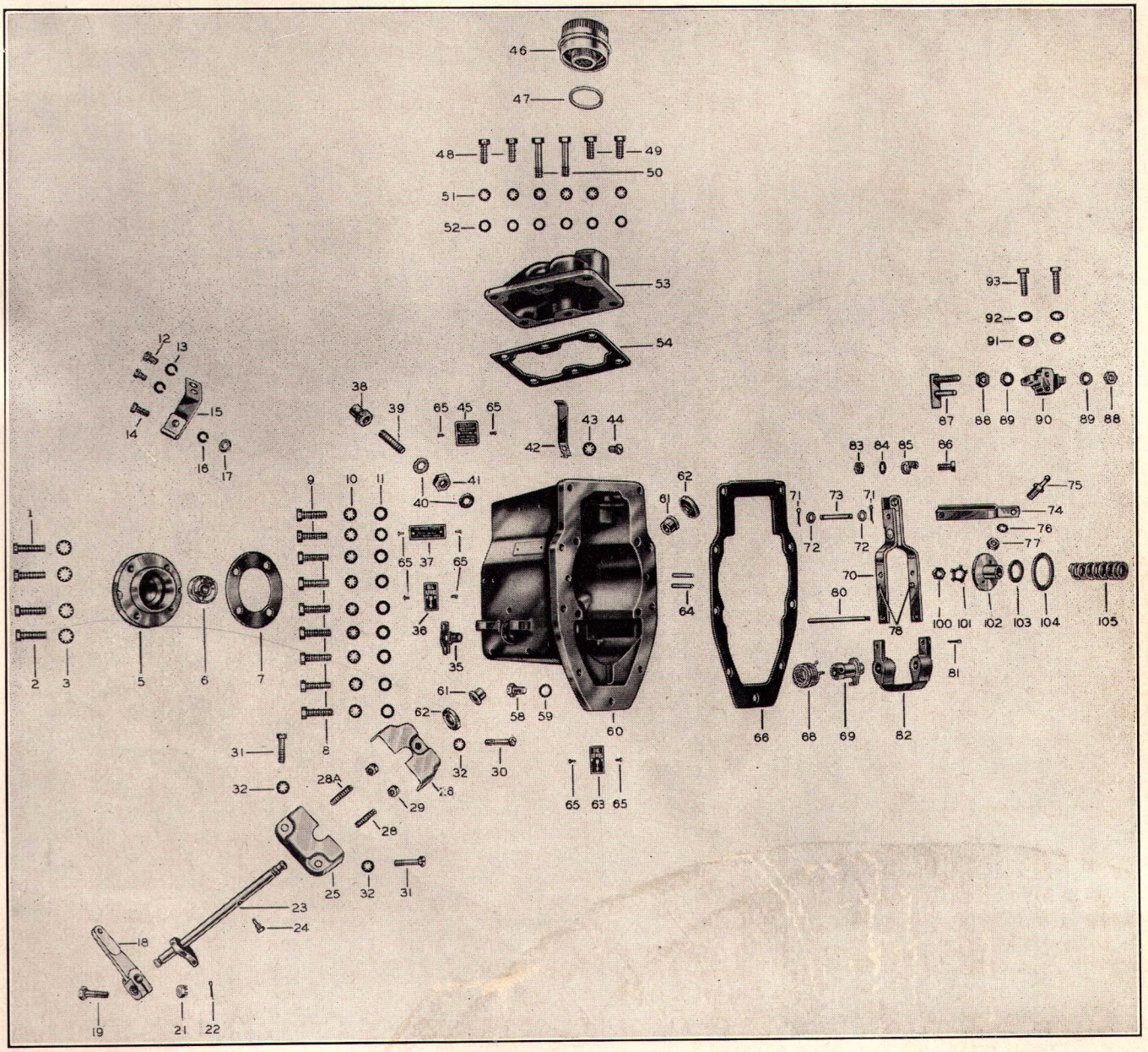


Illustration No. 28

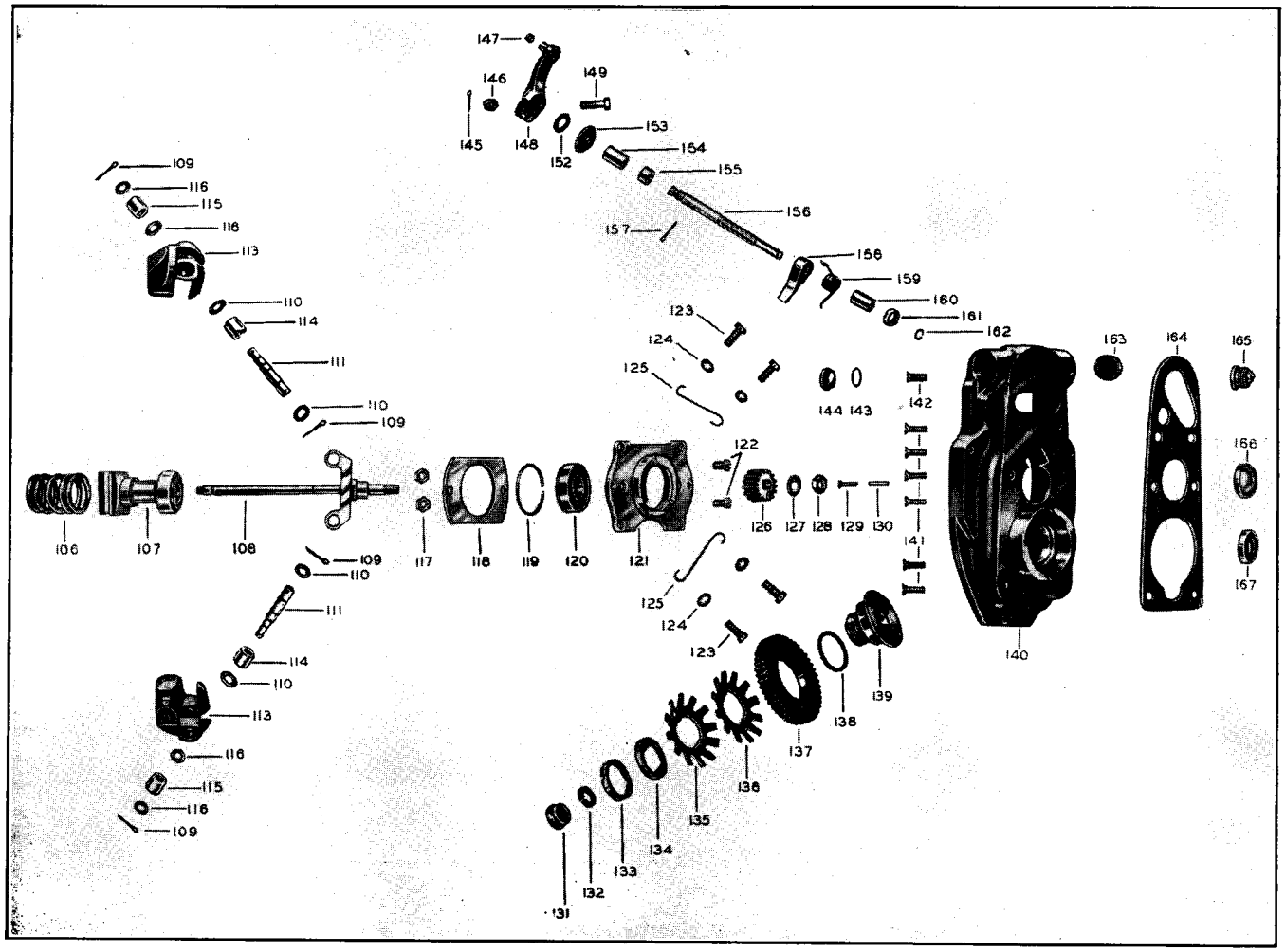


Illustration No. 29

In the event that the load on the engine is decreased, the engine naturally tends to accelerate providing the fuel injection pump is allowed to deliver the same amount of fuel. However, when the engine accelerates, the governor flyweights move in an outward direction, due to the increased centrifugal force. Since the flyweights are in constant contact with the sliding sleeve assembly (107) while the engine is in operation, this outward movement causes a longitudinal movement of the sliding sleeve away from the injection pump against the compression of the governor springs which oppose this movement. The movement continues until an equilibrium is established between the governor spring forces and the centrifugal force exerted by the governor flyweights. The fulcrum lever assembly (70) is connected to the sliding sleeve assembly by means of the pivot pins (78) and turns about the shaft (108). As the fulcrum lever assembly follows the movements of the sliding sleeve, it moves the injection pump control rack towards the stop position and less fuel is delivered by the pump and the engine returns to the pre-set speed.

In the event the load on the engine increases, the engine tends to slow down, thereby causing an inward movement of the flyweights. As the weights move inward, resulting in reduced force on the sliding sleeve, the compressed governor springs shift the sleeve towards the fuel pump until the spring forces and the centrifugal force exerted by the flyweights are balanced again. In this way, the fulcrum lever assembly, following the movement of the sliding sleeve moves the control rack of the fuel pump towards more fuel position and thereby returns the engine to the pre-set speed.

When the weights are fully extended the position is for no load and maximum speed. Full load is attained when the weights are fully collapsed.

With the operating lever of the governor in any one position, the governor maintains a certain engine speed, regardless of the changes in the load on the engine, as long as this speed is within the idling and maximum speed range.

In order to decrease or increase the engine speed, the engine operator shifts the throttle lever in the proper direction and thereby also the governor operating lever (18) to which it is connected. As the operating lever shaft(23) with the falcrum lever bracket (82) of the fulcrum yoke assembly is rotated, the fulcrum lever assembly turns about the pivot pins and moves the control rack of the injection pump. The quantity of fuel delivered is either decreased or increased, depending upon the direction in which the operating lever is moved. Irrespective of whether the engine speed was decreased or increased by resetting the operating lever, the flyweights will at once adjust themselves to the altered speed and will move the sliding sleeve (170) until a position is reached where the sleeve regains control over the movement of the fulcrum lever assembly, which it had lost momentarily when the fulcrum lever was actuated directly by the operating lever.

The fulcrum lever bracket (82) is not rigidly connected to the operating lever shaft but is linked through a double torsional spring (68) mounted on a separate hub (69) fastened to the operating lever shaft. The two open ends of the spring are so designed as to straddle the bar piece of the fulcrum lever bracket as well as the lip on the spring hub (69).

This Spring Construction Serves Three Purposes:

1. To avoid loading of the operating lever with the opposing centrifugal force of the flyweights, in the event the lever is shifted so that the fulcrum assembly and the control rack are pushed towards full load for accelerating the engine, as well as to avoid loading of the lever with the opposing governor spring forces in the event the lever is shifted so that the fulcrum assembly and the control rack are pushed towards stop for decelerating the engine. The spring winds up whenever the operating lever is shifted in either direction, without interfering with any opposing forces, and unwinds as the flyweights adjust themselves to the altered speed.

2. To prevent the governor operating lever from being forced into different positions by changes in the load on the engine causing a change in speed and resulting in an unbalance in the centrifugal force of the governor flyweights and the spring force the spring winds up and unwinds again only when the forces are balanced.

3. To absorb the inertia shocks created by the rotating masses of the governor upon sudden acceleration or deceleration of the engine. The spring absorbs these shocks by winding up and unwinding again as equilibrium is reestablished.

The adjustable bumper spring (42) provided in the governor end cover (60) prevents rapid oscillations of the control rack at high "no load" engine speeds. The spring contacts the fulcrum lever assembly at high "no load" speeds only and insures steady operation of the governor at these speeds. The spring does not contact the fulcrum lever assembly at low idle speeds. The bumper spring also assists in preventing stalling of the engine upon sudden deceleration of the engine from high to low idle speed, as it prevents the control rack of the injection pump from moving into the full stop position when this speed change occurs.

Two adjusting screws (28 and 28A) are provided on the governor, one to limit the movement of the operating lever in the direction of full load speed and the other to limit the stop position, or to serve as an idling adjustment on governors which are fitted with a separate stop lever (148). A rigidly-pinned stop plate is provided on the operating lever shaft.

The governor is also provided with an adjustable stop (87) against which a small cam (85) attached to fulcrum yoke assembly rides. The purpose of this arrangement is to definitely limit the fuel quantity which is delivered by the injection pump at any particular engine speed. As the control rack of the injection pump is attached to the governor fulcrum yoke assembly the maximum travel of the control rack towards full load is limited by the position of the cam (85) against the stop plate (87).

If the engine is overloaded, the speed decreases, the governor flyweights collapse and compel the sliding sleeve to move towards the injection pump, which in turn forces the control rack of the pump in the direction of more fuel. As more fuel is delivered by the pump, the engine will produce more power to take care of the overloaded condition. In some types of service, it is especially desirable to have high power output or "lugging power" at low engine speeds. The maximum engine torque is determined by the engine manufacturer. The governor is so designed that as the sleeve is caused to move in the direction of the injection pump, and the speed drops due to increase in the engine load, the fulcrum lever assembly turns about its pivot screws and allows a different portion of the nose of the cam to come in contact with the stop plate (87). In this way, the control rack of the injection pump is permitted to move somewhat beyond the normal full load fuel delivery position. The setting of cam (85) is done during engine tests. A friction clutch is built into the governor drive gear (131 to 139). The clutch is so designed that it causes the drive gear to slip on its hub (139), whenever changes occur in the speed of the injection pump camshaft. As the camshaft speed returns to normal, the drive gear again follows the speed of the hub.

SERVICE INSTRUCTIONS

Precaution

In the event it is necessary to dismantle the governor it is suggested that the complete fuel injection pump assembly be removed from the engine. The injection equipment can then be taken to a clean table or work bench.

When removing the units from the engine, the following precautions should be taken:

1. Before breaking any oil lines from the pump, thoroughly clean the equipment with fuel oil. When the lines are removed, the openings on the pump should be covered or plugged to prevent dirt from entering the system.
2. Remove inspection cover of injection pump. Slowly turn the engine over until it is noted that the plunger of the pumping element nearest the pump drive coupling is in its top position. If the engine is left in this position and the adjustment of the drive coupling is not touched, the pump can be reinstalled in this position on the engine without the necessity for retiming.
3. Disconnect the engine throttle linkage from the governor operating lever. Do not remove the governor operating lever from its shaft or alter its position.
4. Remove complete injection pump assembly (See Illustration No. 16).

DISASSEMBLY OF GOVERNOR (After Injection Pump Assembly is Removed from the Engine)

Refer to Illustration No. 28 and No. 29.

1. Open petcock (35) and drain all lubricating oil from governor unit. As there is an open connection between the injection pump camshaft compartment and the governor, the governor should be tilted downward in order that all oil may be drained.
2. Remove nine governor housing fastening screws (8 and 9) plain washer and lock washer (10 and 11).
3. Carefully withdraw governor end cover approximately one inch away from the housing and then slightly shift the governor assembly in a side ways movement toward the inspection cover side of the pump in order to disengage the control rack linkage pin from the extension arm of the fulcrum lever assembly. The governor end cover is then free.
4. Remove governor end cover gasket (66). If this gasket has not been damaged it may be used again when governor is reassembled.
5. Remove inspection cover (53) and gasket (54) by unscrewing six fastening screws (48 and 49), lock and plain washer (51 and 52).
6. The governor adjustable bumper spring assembly, as shown in Exploded View is comprised of bumper spring (42), adjusting screw (39), lock nut (41), dust cap (38) and gaskets (40). The bumper (42) is fastened to the governor housing by screw (44) with lockwasher (43). The bumper spring assembly has been set at the factory and the setting should not be changed. If, for some reason, the bumper spring assembly must be removed, the necessary meaasurements must be taken in order that the assembly can be reinstalled in governor in the same position. For resetting the bumper spring assembly, refer to item 8 under, "Adjusting the Governor on the Engine," Page 46.
7. The position of the governor operating lever is important. Some governors have a scratch line across the end of the lever shaft which registers with a mark on the operating lever. On those governors where there are no marks on the operating lever or shaft end, a scratch mark must be inscribed on the lever and shaft before disassembly, in order that these two parts can be clamped together in their proper relative positions when the governor is reassembled. The operating lever can be removed by loosening the operating lever clamp screw.
8. The setting of the stop plate (87) has been made at the factory and this adjustment should not be altered. The stop plate assembly should not be removed from the governor unless it is necessary in order to make replacement of parts. The upper front edge of the stop plate should line up with the locating lines which have been inscribed on the top machined surface of the governor end cover.

   If there are no markings on the governor end cover, a small line should be inscribed on both sides of the top machined surface of the cover directly in line with the upper front edge of the plate. These marks should be made for about ⅛" from each inner edge of the housing top and should not extend completely across this surface, in order to prevent the possibility of any oil leakage at this point.

9. The cam nose has likewise been adjusted by the factory, and its position should not be altered. It will be noted that there is a locating line inscribed across the cam nose and extending to the adjacent fulcrum yoke. If replacement of the cam nose or lever assembly is necessary its angle should be carefully noted in order that the reassembly may closely approximate the original setting.
10. Remove cover plates (25 and 26) by unscrewing three fastening screws (30 and 31).
11. Using a $\frac{3}{16}$" hex socket wrench (TSE 7918) remove set screw (24).
12. Slide out operating lever shaft (23).
13. Unscrew four fastening screws holding bearing bridge (121) to governor end cover and carefully pull out the internal operating parts of the governor as a unit.
14. Should it be necessary to remove end cap (5) with gasket (7) in order to replace the ball bearing in the cap, unscrew four fastening screws (1 and 2) and washer (3). The ball bearing can be removed by first removing nut (100) and washer (101).
15. The operating shaft and spring can be withdrawn.
16. To remove operating shaft bushing and oil seal a special tool (TSE 7936) is available. The pressing end of the tool is unscrewed from the shank and seated on the bushing inside the housing. The shank is run thru the opposite bushing and screwed into the end of the pressing tool and the bushing and oil seal is then pressed out.
17. The fulcrum lever (70) may be disengaged from sleeve (107) by raising the fulcrum lever up and tilting the assembly toward the weights. To remove fulcrum lever bracket (82) remove pin (81) use a brass drift to punch out bracket pin (80).

NOTE: Pin end of bracket pin and fulcrum lever bracket is a loose fit. The opposite end is a drive fit.

18. Remove pin (71) plain washer (72) and control rack link pin (73) to disengage control rack link (74). If necessary, control rack linkage stud (75) is disassembled by removing nut (77) and lock washer (76).
19. The stop cam has a scratch line inscribed, this line registers with a line on the fulcrum yoke proper. This setting should not be altered. If, for any reason, the cam must be removed or the setting disturbed, it is imperative that the inscribed line be in alignment after assembly.
20. Weight lubricating plungers (130) and spring (129) are removed from weight shaft (108) by turning plungers clockwise and using a slight pull. Remove nut (128) and lock washer (127) withdraw driven gear (126).
21. Remove nut (100) lock washer (101) from weight shaft (108). Withdraw spring seat (102) inner spring spacer (103) outer spring spacer (104) inner and outer springs (105 and 106) and sleeve (107).
22. Remove bearing bridge assembly (121) using suitable arbor press, place two bars underneath bearing bridge and as close to the weight shaft as possible, and press out. Care must be exercised not to damage end of shaft or crack bearing bridge during operation. Remove two bearing plate screws (122) and bearing plate nuts (117). Bearing plate (118) and ball bearing spring ring (119) can be removed. Use arbor press to remove ball bearing (120) from bearing bridge (121).
23. To disassemble weight assembly: Use Arbor Press: ½" pipe, 2½ inches long. Remove pins (109) and plain washer (110 and 116). Place required pipe under one side of weight and use suitable rod to press out weight pin (111).

CAUTION: Weight pin has one end of greater diameter than the other. Determine this point before pressing operation. Use special tool (TSE 7937) to press out weight bushings.

Reference should be made to Illustrations No. 28 and No. 29, which clearly indicates the position of the internal parts with respect to one another.

24. The drive gear and friction clutch assembly (131 to 139) can be removed from the injection pump camshaft extension by first removing hex nut (131) and lock washer (132). The camshaft is prevented from turning by holding coupling on the opposite end of the camshaft. Proceed with the disassembly by removing securing nut (133), using special wrench (TSE 7919). With the securing nut removed, the lock washer, spring discs, adjusting spacer or spacers and drive gear (Parts 134 to 138) may be removed.
25. Use special puller (TSE 7920) on thread of hub (139) to withdraw the hub from the camshaft taper.
26. It is not necessary to remove the governor housing (140) to repair the governor or injection pump,

even if it is necessary to remove the camshaft. The housing should remain tightened to the pump whenever possible. If, for some reason, it is necessary to remove the housing proceed as follows:

Remove stop shaft bore closing plug (163) from housing, by removing pin (157) and with a wooden or rubber mallet tap shaft (156) lightly until plug (163) may be removed. This will move the shaft sufficiently to permit spring ring (162) to be pried off. A pocket knife blade will readily do the job. Withdraw stop lever shaft (156).

When the lever shaft is withdrawn stop lever spring (159) inner stop lever (158) and spacer (155) are released from housing.

CAUTION: Stop lever shaft bushings have different inside diameters (154) has .377 inches I.D. and (160) has .331 inches I.D. Both bushings are finger press fit.

NOTE: The governor housing acts as an end plate for the camshaft of the pump. Therefore, it is necessary to install tappet holders (TSE 7692) under the tappet screws of the injection pump to insure that the internal parts and camshaft do not fall out of position when the camshaft is not held up by the bearing in the governor housing. See Illustration No. 30.

Remove six screws (141) and one screw (142) from governor housing. Withdraw governor housing (140) from injection pump.

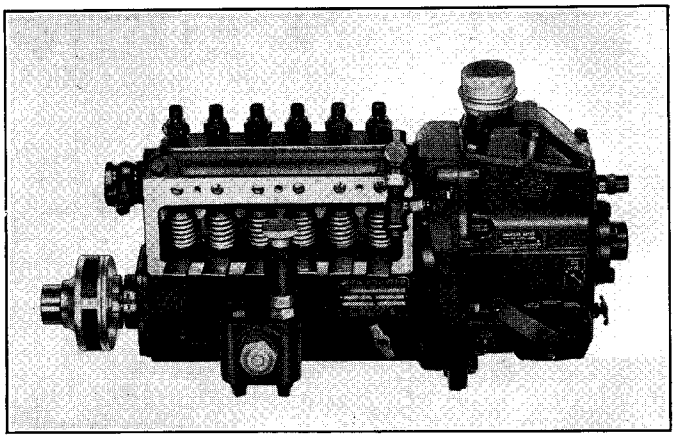


Illustration No. 30

EXAMINATION OF PARTS — WHEN TO REPLACE THEM

Refer to Illustrations No. 28 and No. 29

The individual parts should be carefully washed in a clean fuel oil or suitable solvent cleaner and dried off with compressed air.

Gaskets, Fastening Screws, Nuts and Washers: These parts to be replaced if at all damaged.

Drive Gear (126): Examine for wear or broken teeth and should be replaced if necessary.

Ball Bearings (6 and 120): Examine carefully for excessive wear, or roughness, replace if not in A-1 condition.

Governor Springs (105 and 106): Should be free from nicks, rust spots or signs of corrosion.

Sliding Sleeve Assembly (107): Inspect fulcrum lever pin grooves for wear. Check thrust washer face for excessive wear. Thrust washer must be free. Check bushing for wear, replace if necessary.

Flyweights and Shaft (108 to 113): Examine shaft for excessive wear. Flyweights should move freely on weight pins (111) needle bearings (115) and bushings (114) but they must not be too loose.

Fulcrum Yoke Assembly (68 to 86): Inspect control rack linkage stud (75) for wear. Replace if necessary. Examine cam stop for wear. As mentioned in section, "Disassembly of Governor", the cam should not be altered. Check to see that inscribed lines are in alignment and make sure that the unit is held firmly in place. Check control rack link (74) and control rack link pin (75) for excessive wear. Examine fulcrum lever pivot pins for round, there must not be any "flats". Check fulcrum lever bracket bushings (82) for wear. Replace parts when necessary.

Operating Lever Shaft Oil Seals and Bushings (62 and 61): Inspect these parts for wear or damage, replace if they are not in good condition.

Operating Lever and Shaft (23 and 18): Check at stop plate pin, it must be firmly in place. The stop plate must not be loose. Serrations on the operating lever and shaft should be in good condition. The hole in the operating lever shaft (for hub spring fastening screw) should not be excessively worn.

Stop Adjusting Screws and Nuts (28 and 29): If it has been necessary to remove these parts or replace them this fact should be noted so that they may be re-set in the proper positions, after the governor and injection pump is installed again on the engine.

Stop Plate Assembly (87 to 90): The stop plate (87) should be inspected for any wear which may have been caused by the cam (85). The threaded stud and the pivot pin must be firmly fastened to the stop plate. The adjusting nuts (88) must not be loose. If it appears that these nuts have worked loose, this fact must be noted as the position of the stop plate must then be carefully checked when the governor is reassembled. For details concerning the setting of the stop plate (87), see item 4 under, "Adjusting the Governor on the Engine".

Drive Gear and Clutch Assembly (131 to 139): The drive gear (137) should be examined for excessively worn or broken teeth. The surface on the face of the gear which contacts the clutch disc (136) should be smooth.

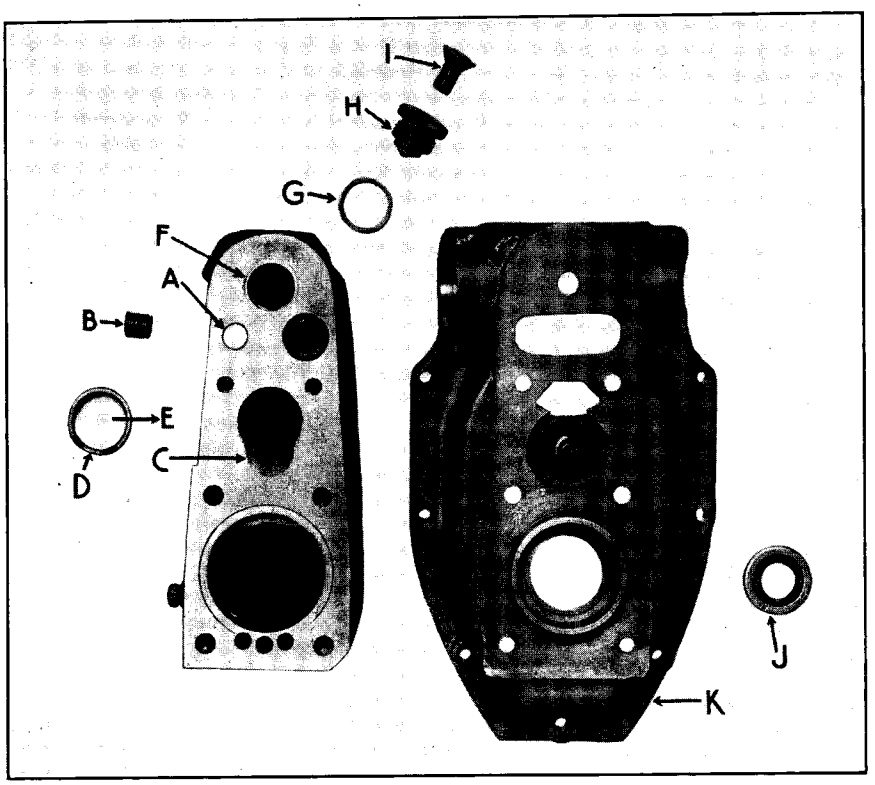


Illustration No. 31

placing a BK type governor with the later type PK governor. These changes are as follows:

1. With the fuel pump completely disassembled use a ⅛"-27 (Pipe Thread) tap to tap out hole A and install pipe plug B as shown at A. The pipe plug B should be turned in until it is flush, or filed off so that it is even, with the housing.
2. File housing as shown at C and cup plug E as shown at D. Then install cup plug in housing.
3. Counterbore hole F deep enough to allow adapter H and gasket G to be 1/64" below governor attaching surface when plug is tight.
4. Install oil seal J in housing K with lip of seal to fuel pump side.
5. It is necessary to remove stop control shaft to install screw I, see Illustration No. 32.

REASSEMBLY OF GOVERNOR

Refer to Illustrations No. 28 and No. 29.

CAUTION: Do not attempt to assemble Governor before reading the following instructions.

1. After parts have been cleaned, inspected and replaced when necessary in accordance with instructions outlined in preceding section, the governor can be reassembled.
2. Ordinarily, it will not be necessary to install the governor housing (140) as this part need not be removed to repair the governor or injection pump, even when it is necessary to remove the pump camshaft. However, if for some reason it has become necessary to install a new governor housing, proceed as follows: Press the outer race of the camshaft ball bearing into the housing. Press packing seal (167) into governor housing (140). The end of the injection pump and governor housing (140) must be absolutely

NOTE: Two clutch discs are used (135 and 136.) Disc without hole (136) is assembled next to drive gear (137). Disc (135) with hole, is on the outside. The hub (139) should be inserted into the drive gear (137) and the clearance between the two parts should not be excessive, to the extent that the gear could operate eccentrically. Lock washer (134) should be replaced if damaged or distorted.

Breather Cap: Inspect for damage, filter element to be cleaned and dried. Breather cap to be dipped in oil and excessive oil wiped off before installation.

SPECIAL INSTRUCTIONS

Refer to Illustrations No. 31 and No. 32.

It is necessary to make certain minor changes in the fuel pump housing as shown in Illustration No. 31, when re-

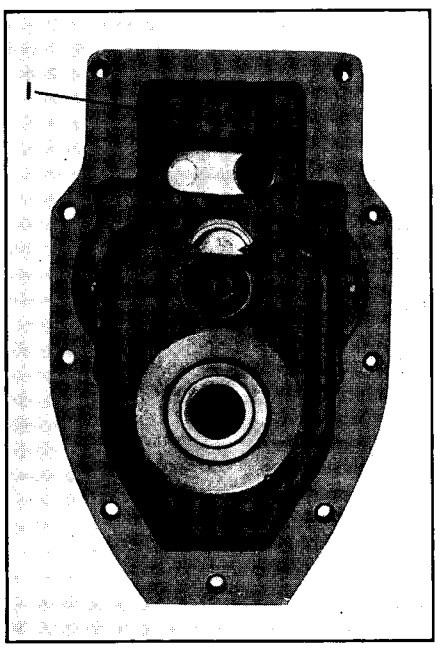


Illustration No. 32

clean. A thin film of sealing compound (TSE 76121) is to be applied on both sides of gasket (164). The governor housing (140) and gasket can be installed and secured by six fastening screws, (141) and one screw (142) at the upper end of the governor housing. After firmly tightening the screws they are to be secured with securing wire (125) in vertical pairs. The camshaft end play of the injection pump should then be carefully checked and should be within the limits of .004 inches and .008 inches, (.1 mm.-.2 mm). With the concave side facing the governor, press lubricating oil baffle (166) into governor housing until flush, opening must be at top.

Assemble Stop Lever Assembly as follows: Install bushing (154) in governor housing at operating lever side. Install bushing (160) in opposite side. Press in oil seal at operating lever side. Insert stop lever shaft part way and carefully install inner stop lever spring (159), inner stop lever (158) and spacer (155). Push the stop lever shaft in place. Press on countersunk washer (161), countersinking facing out, on end opposite operating lever (148). Install spring ring (162) and press on shaft bore closing plug (163). At operating lever end (148) install washer (152) and cotter pin (157). Assemble operating lever (148) to shaft (156) with clamping screw (149), nut (146), and cotter pin (145).

3. With the housing properly installed the drive gear and clutch assembly (131 to 139) should be mounted on the extending camshaft taper. No key is used, although a keyway is provided in the camshaft taper. The clearance between the drive gear hub and the drive gear should be re-checked after the hub has been securely tightened on the camshaft taper. With ample clean lubricating oil between the hub and the drive gear, the latter should rotate freely and easily without binding in any position. If necessary, the gear and its hub may be lapped slightly to provide a non-binding assembly. Reassemble the component parts of the clutch assembly in the relative positions.

   With securing nut (133) firmly tightened, the clutch tension should be carefully checked, as illustrated. The friction surface of the drive gear (137) and the spring disc (136) should be well lubricated with oil. The gear should rotate with a steady pull of 3 to 3.5 pounds. A one-foot lever, (TSE 7947) is used to measure this pull with spring scale (TSE 7927). See Illustration No. 33.

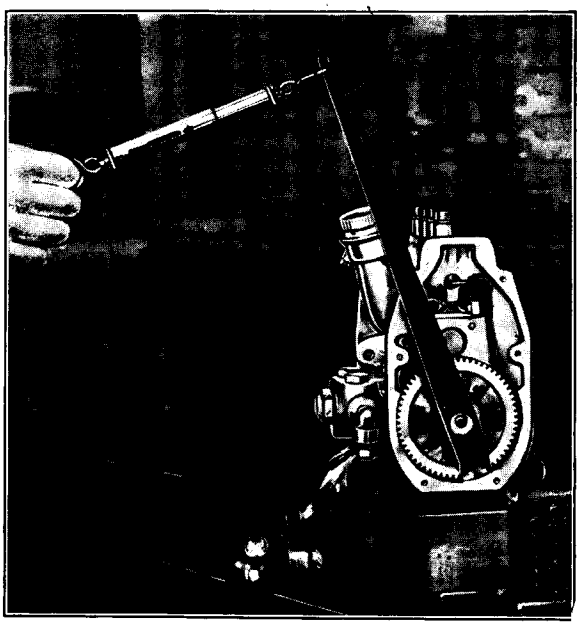


Illustration No. 33

   The drive gear should move through a complete revolution on its hub, with uniform resistance. The gears should not move freely in one spot and not in another, but should revolve without clutching with the pull of 3 to 3.5 pounds. If the tension is too great, install another spacer (138), or if the gears move too freely, remove spacers to give the proper slippage. Three spacer thicknesses are available (0.035 inches, 0.049 inches and 0.065 inches).

4. Weight assembly parts (108 to 116).

   Two types of weight assemblies must be considered. One type uses four weight bushings (114), the other type two weight bushings (114) and two needle bearings (115). When new bushings are installed, they must be reamed out. A special tool (TSE 7941) is used, consisting of step line reamer (TSE 7941-1) and guide bushing (TSE 7941-2).

   Assembly procedure in the case of two bushings (114) per weight (113) is as follows: Using tool (TSE 7935) carefully press in bushings (114). Clamp the weight in vise, with brass jaws or equivalent, in such a manner as to give easy access to the weight bushings. Insert the pilot of line step reamer into the bushing, and apply a little oil to cutting edges. Ream out the first bushing, continue reaming until the first step in the line reamer has reamed out the second bushing. As soon as the first step in the line reamer is through the second turn reamer in the same direction and carefully withdraw the reamer. Clean the unit thoroughly. Weight pin (111) is inserted at the same side as was the reamer. (Reason: One end of weight pin (111) has smaller O.D. than the other). Weight pin and bushings are checked for alignment and weight (113) must swing free but not loose.

   Position weight on spider of weight shaft (108), start weight pin into first bushing reamed.

CAUTION: Position weight pin so that lubricating holes are facing directly away from weight shaft.

Washers (110) are positioned at large diameter of weight pin and washers (116) at small diameter of weight pin (111). One washer (110) and one washer (116) are placed between spider and weight on both sides of the spider (108). Press weight pin (111) into place, assemble washer (110) small diameter end: Install cotter pin (109).

The second weight will be reamed out from the opposite side of the first. With regard to this difference the assembly is to be followed as given above.

Where the needle bearing (115) and bushing (114) are used, the method of assembly is as follows: Press bushing (114) into housing using special tool (TSE 7935). In the needle bearing side insert bushing (TSE 7941-2). Place weight in vise, using brass jaws or equivalent, in such a manner as to give easy access to the bushings. Insert pilot of reamer (TSE 7941) and ream out bushing (114) with the first and second steps of reamer. Continue to turn the reamer in the same direction and carefully withdraw the reamer. Clean the unit thoroughly. Press in needle bearing (115), using special tool, (TSE 7948) the tool is recessed to accommodate the needle bearing, also sets the correct position of the bearing when pressed into the weight. The second weight should have the needle bearing (115) installed on the opposite side of the first. The remaining assembly procedure is the same as for four bushing units.

NOTE: Stamped end of bearing must face out. Needles must be free after bearing has been pressed in.

5. Slide the sleeve assembly (107) over shaft (108) ball bearing end first.
6. Certain types of governors use only one spring, while others use two. Whenever inner spring spacers (103) are required, they should be installed at the spring seat end of the spring. Install the proper number of inner spring spacers (103) in accordance with the adjustments as given in the governor parts list for the type involved. Slide inner spring (105) over shaft (108). Slide outer spring (106) over inner spring (105) and seat the spring in the recess of the sleeve (107). Install the proper number of outer spring spacers (104) in accordance with the adjustments as given in the governor parts lists for the type involved. Whenever outer spring spacers (104) are required they should be installed at the spring seat (102) end of the outer spring.

NOTE: Ball bearing is installed correctly when convex side is facing spring seat. If the adjustments as given in the governor parts list call for an inner spring gap and outer spring setting, these spring adjustments with governor fully assembled will be found and covered under heading titled: "HOW TO CHANGE GOVERNOR SPRINGS WITHOUT DISMANTLING THE GOVERNOR".

7. After completing the proper spring adjustments, the securing nut (100) with lock washer (101) beneath should be tightened firmly. Bend the prongs of this lock washer.
8. In some governor types the ball bearing bridge assembly consists of ball bearing bridge (121) and ball bearing (120). Where this is the case the ball bearing is a press fit in bridge (121) and on the weight shaft (108). Where the bridge assembly consists of parts (117 to 122), the ball bearing is a finger press fit in bridge (121) a ball bearing securing spring ring (119) bearing plate (118) and bearing plate fastening screws (122) and nuts (117) complete the assembly. The ball bearing (120) is a press fit on weight shaft (108).
9. Install weight lubricating plunger and spring (129 and 130). Assemble driven gear (126), on shaft, lock washer (127) and firmly tighten in place by nut (128). Upset lock washer to sides of nut.
10. The forks of the fulcrum lever (70) have four holes in their side for the fulcrum pivot pins (79). The upper two holes are for governors requiring 10% regulation. The lower holes are used for 5% regulation, as determined by the governor parts list for type of governor involved. All Hercules engines use governors with 5% regulation. The fulcrum lever pivot pins (78) are a press fit from the inside of the fork. Assemble control rack linkage stud (75) with lock washer (76) and securing nut (77), tightened firmly. Assemble control rack link assembly (74), to fulcrum lever (70) using control rack link pin and secure on either side with washers (72) and cotter pins (71). The fulcrum lever bracket (82) is assembled to the fulcrum lever (70) with bracket pin (80) and secured with cotter pin (81).

NOTE: Both fulcrum lever bracket (82) and bracket pin (80) have holes drilled for cotter pin. These must be in alignment after assembly. Bracket pin (81) is tapered at end opposite cotter pin hole.

11. Assemble the operating lever spring (68) to the hub (69). The ends of the coil spring should straddle the spring plate which is an integral part of the hub. The spring may be drawn into position with a wire lock and should be so assembled that it will be under tension. The hub and spring (68 and 69) assembly should be installed so that the spring end straddle fulcrum lever bracket bar (82).

NOTE: Position of hub and spring assembly in fulcrum lever bracket is determined by which side governor operating lever (18) is located.

With control rack link (74) facing the weights assemble fulcrum lever assembly to weight shaft.

12. If necessary to install new control shaft bushings (61) press into housing using special tool, (TSE 7935) and ream out the bushings with line reamer (TSE 7940). New oil seals (62) which have been previously soaked in oil for twenty-four hours, should be pressed into position with tool (TSE 7938) after an application of oil resistant sealing compound (TSE 76121) has been applied on their outer circumferences. Install bumper spring (42) to governor end cover and secure firmly with lock washer (43) and screw (44).
13. The internal mechanism consisting of the shaft and fulcrum lever assembly should now be placed in the governor end cover (60). Locate the bearing bridge (121) on dowel pins (64) and secure firmly with lock washers (124) and fastening screws (123). After fastening screws (123) are firmly tightened, they are to be wired together vertically, one wire (125) on each side of the ball bearing bridge (121).

NOTE: Cut away in bearing bridge (121) must be face downward. IMPORTANT.

14. Slide the operating lever shaft (23) in place being careful not to injure the shaft seals (62) and align the hub and spring assembly on the shaft.
15. Securely fasten the hub (69) for spring (68) to the shaft (23) by means of set screw (24) which has a pilot stud fitting into a hole in the operating shaft. A $\frac{3}{16}$" socket wrench (TSE 7918) should be used to tighten screw.
16. If the control lever adjusting screws (28) have been moved, they should be reset to their original position.
17. Install the lower stop flange cover (25) fasten firmly with lock washers (32) and screws (31). Upper stop flange cover (26) is installed after the governor has been tested and all necessary adjustments made.
18. Assemble bumper spring assembly (Parts 38 to 44) to governor end cover (60) in relative position as shown in Illustration No. 28.
19. Make certain that the seating surfaces of the end cap (5) and governor end cover (60) are clean, apply a thin coat of sealing compound to end cap side of gasket (7), install end cap and gasket to governor end cover (60) fasten securely with lock washer (3) and screw (1) and (2).

NOTE: The upper screws are drilled.

20. Install governor end cover gasket (66) using sealing compound (TSE 76121).

NOTE: Before securing governor end cover to housing by means of fastening screws (8 and 9) make certain that the drive gear does not assume a position where there is a danger of the outer race of the gear rubbing on the bearing bridge (121). If the teeth of the gear rub it will be necessary to relocate the camshaft in the injection pump by shifting the bearing spacers.

Secure governor operating lever (18) by means of screws (19) and (21) and cotter pin (22). The lever should be installed in the same position as it was removed.

21. Inspection cover (53) and gasket (54) are secured in place with screws (48, 49 and 50), with plain washers (52) and lock washers (51).

NOTE: The two screws that are drilled are used at the bumper spring end (48).

Correct relative position is as shown in Illustration No. 28. A film of sealing compound is applied to the top cover side.

NOTE: All housing screws should be staked, except the four housing screws (141A).

ADJUSTING THE GOVERNOR ON THE ENGINE

1. Remove upper stop flange cover (25).
2. Withdraw bumper spring adjusting screw (39) as far as possible without allowing it to fall out.
3. Line up the scratch line on the cam (85) with the cross mark on the fulcrum lever (70).
4. Line up the upper front surface of the stop plate (87) with the scratch lines on the top machined surface of the governor end cover. Always line up the upper front edge of the stop plate with the marks on end cover, as the front surface of all governor types are not straight. A straight edge can be used for this purpose.

5. Add lubricating oil to the pump until oil flows from the overflow fitting. The pump camshaft and governor compartments are interconnected. Excessive oil is detrimental to the satisfactory operation of the governor and therefore, care should be taken not to add more oil than is necessary to reach the level of the overflow fitting.

6. The throttle linkage arrangement of the engine is so designed that with the engine hand throttle lever or foot accelerator in full load position, it will hold the control lever shaft stop plate (23) against the stop screw (28). In this manner, the control lever will be in full load position.

7. Warm up the engine thoroughly before attempting to make any governor adjustments. By referring to the governor type designation, the engine idling speed and the maximum full load speed may be obtained. EXAMPLE: GVA 225/600 PK 1. 225 indicates that the governor idle speed is 225 R.P.M., or in the case of a 4-cycle engine, 450 R.P.M. is the engine idle speed. 600 indicates a governed speed of 600 R.P.M., or in the case of a 4-cycle engine, 1200 R.P.M. maximum engine speed under full rated load. When the engine is under no load, the speed will increase above this governed figure to what is termed a high idle speed. The difference between the rated load speed and the high idle speed is commonly known as regulation and is usually expressed in percentage. If the engine is loaded above its rated load, then the speed will decrease below the rated speed given.

   With no load on the engine, move governor operating lever toward full load position until the stop plate on the lever shaft contacts the full load stop set screw (28). When the engine reaches its maximum speed, check by means of a tachometer whether this is the correct high idling speed. If the speed is too low, raise the stop set screw and if the speed is too high, lower the screw. After the correct high idling speed is obtained, secure the adjusting screw by means of the lock nut (29) and re-check the speed, making sure that stop plate on governor operating lever shaft is in contact with the set screw.

8. With the engine still operating at the high no-load speed, remove dust cap (38) from bumper spring assembly and turn in adjusting screw (39) until the spring (42) just touches the fulcrum lever assembly (70), without an appreciable increase in engine speed. If extension arm of the fulcrum lever assembly oscillates rapidly back and forth at high no-load speed, screw in the bumper spring slightly further until the governor mechanism is reasonably steady.

9. If the governor action appears rough and there is a rapid oscillation of the control sleeves of the fuel injection pump (this action can be noted if the inspection cover of the pump is removed), it is an indication that the tension of the disc in the governor drive gear assembly is too tight. A slow surge of the control sleeves of the injection pump is an indication that the spring is too loose. In either case, the tension should be re-checked and adjusted if necessary, in accordance with instructions in "Assembly of the Governor."

10. Those governors which are equipped with a separate shut-off arrangement at the top of the governor housing use the stop screw (28A) for an idling adjustment. Governors which are not provided with a separate shut-off arrangement use the stop screw (28A) as a positive stop. For the former type, follow instructions 10A below, and for the latter, follow instructions 10B below.

10A Move the control lever in the direction of less speed (toward the injection pump) until the engine reaches the correct idle speed. Hold the operating lever in this position and screw in idling set screw (28A) until its lower end touches the stop on the operating lever shaft. Lock the set screw in position. After locking the set screw, re-check the engine idling speed with a tachometer.

10B Slowly move the governor operating lever in the direction of stop (toward the injection pump) until it comes to a position at which the engine stops. Hold the operating lever in this position and screw in set screw (28A) until its lower end touches the stop on the operating lever shaft. Lock set screw in this position. The stop position of the operating lever brings the control rack of the injection pump into the zero fuel delivery position and not to the dead stop position of the control rack. After locking the stop screw, start the engine and re-check for a positive stop.

11. Sometimes, in order to get the proper maximum full load delivery setting the operating lever shaft spring is wound up too much and might permit the governor to let the engine reach excessive speeds. The remedy for this trouble is to install a sufficient number of shims behind the inner governor spring or correct the full load speed position of the operating lever by resetting the full load stop set screw somewhat.

12. The nominal idling and maximum speeds controlled by the governor cannot be varied to a great extent because they depend entirely upon the characteristics of the spring combination contained in the governor unit. In addition to the external adjusting screws (28 and 28A), slight adjustments are possible by removing or adding adjusting spacers between the inner spring and the sliding sleeve assembly.

HOW TO CHANGE GOVERNOR SPRINGS WITHOUT DISMANTLING THE GOVERNOR

Refer to Illustration No. 28 and No. 29.

If for any reason it becomes necessary to change the governor springs, either to replace the springs in the governor or to exchange them for springs providing a different speed governing characteristic, it is not necessary to dismantle the complete governor or remove the unit from engine—proceed as follows:

1. Remove the four end cap fastening screws (1 and 2) and lock washers (3).
2. Remove the spring retaining end cap (5) and its gasket (7).
3. The ½" hex nut (100) and lock washer (101) should next be removed. Weight shaft (108) is provided with a slot, a screw driver may be used to prevent the shaft assembly from turning when removing hex nut (100).
4. Slide the ball bearing (6) off the shaft. Remove spring seat (102). The springs (106 and 105) may now be removed, checked or replaced.

   If the springs have been replaced, the spring adjustments will have to be set in accordance with governor specifications for type governor involved. A spring gap gauge (TSE 7939) is used to set correct gap.
5. Procedure to use spring gap gauge (TSE 7939) is as follows: Replace springs (106 and 105) and spring seat (102). Two holes have been provided in the spring seat so that the gauge prongs can be inserted in order to touch the seating surface of the inner spring. This type gauge is graduated from 0 to 15 mm and a direct reading is obtained with the outer surface of the tool retaining cap.
6. Position the operating lever (18) so that the weights are totally collapsed.
7. Loosen the thumb screw in the measuring tool so as to allow the gap gauge to pass through the two holes in the retaining cap which have been provided for the gap gauge.
8. The measuring tool retaining cap should then be placed flush against the governor end cover, over the spring compartment. The retaining cap has been designed so that the distance of the spring seat extending beyond the spring compartment, caused by the pressure exerted by the outer spring, is equal to the same distance allowed by the spring retaining end cap gasket and the shoulder in the spring retaining end cap.

   Insert the prongs of the gap gauge into the spring seat (102) until they press against the inner spring (105), without compressing the spring.
9. Tighten the thumb screw sufficiently to lock the gap gauge, thereby, enabling an accurate reading to be taken. Add or remove spacers to obtain correct gap setting in accordance with governor parts list specifications for type of governor involved.
10. The new type spring gauge (TSE 7939) is not graduated. The holes in the spring seat (102) are not used when setting the inner or outer spring adjustments. It will be necessary to remove the outer spring (106) before adjusting the inner spring gap.
11. Method of using non-graduated type gauge. With the outer spring (106) removed, replace spring seat (102) or inner spring (105). Place gap gauge over spring compartment, unloosen, thumb screw and bottom gauge prongs on the spring seat (102). Tighten thumb screw, measure the distance prongs protrude in the gap gauge retaining cap. This measurement is the inner spring gap. Add or remove spacers to obtain correct gap setting in accordance with governor specifications for type of governor involved.
12. With inner spring gap correctly set replace outer spring (106). Outer spring may be a flush fit. The same gauge and method is used to determine this setting. Inner spring (105) need not be removed.
13. Assemble ball bearing (6) lock washer (101) and hex nut (100) to shaft. Replace gasket (7) and end plate (5) and fasten firmly with lock washers (3) and four screws (1 and 2).
14. After new springs have been installed, the governor should be readjusted and tested per instructions given under "Adjusting the Governor on the Engine".

MAINTENANCE

The governor dust covers and inspection covers should always be kept fastened in place to prevent dust from entering the unit. Some governor units and injection pumps are inter-connected, they have a common lubrication oil sump. To be sure that the moving parts of the governor are adequately lubricated at all times, the lubricating oil level in the injection pump should be checked every time the crankcase oil of the engine is changed. There are governor and injection pump assemblies where the units are not inter-connected, each unit has its own oil level and drain plugs. The oil level should be checked in the governor and injection pump separately every time the crankcase oil in the engine is changed. At such times, the oil should be completely drained from both units (by means of drain plugs located in the bottom of both the governor and injection pump), and refilled with clean engine oil, preferably S.A.E. No. 30, through the oil filler of the injection pump in the case of inter-connected units, or through the oil fillers of the governor and injection pump where they are not inter-connected.

GENERAL INFORMATION AND SERVICE INSTRUCTIONS FOR HERCULES MECHANICAL INDUSTRIAL GOVERNOR

See Illustration No. 34.

This governor is a self-contained unit designed for integral attachment to the fuel injection pump. All adjustments for proper control of engine speeds can be made externally.

Never use this governor for engine speeds greater than 1800 R.P.M. full load. (At this date, 1800 R.P.M. is the limit of this governor. However, in the future this governor may be revised to allow higher speeds.)

LUBRICATION:

Check daily the oil level. This level should be maintained so oil will run out test cock 23 in Illustration No. 17. Use same grade of oil as used in engine crankcase. Too much oil will cause governor to act sluggish. Therefore, keep at correct level. Check oil level only when engine is shut down.

CHECKING TROUBLE:

First check engine, injection pump and nozzles and if these are found in good order then proceed as follows with reference to governor troubles.

If engine runs away, this may be caused by one of the following:

1. Governor thrust sleeve, Illustration No. 46, out of adjustment. Stop engine, and adjust governor thrust sleeve as outlined under "Testing and Adjusting the Governor", Paragraph 3C, page 58. If this does not reduce speed, then trouble is elsewhere.
2. High speed control stop 20, Illustration No. 17, not properly adjusted. Loosen lock nut and turn in until engine speed is reduced to that required. (Less than 1800 R.P.M. engine speed.)
3. Thrust sleeve or flyweights in governor stuck or fingers worn. Replace with new parts or governor. (Instructions given later on removal of governor, etc.)

Should engine not idle smoothly, check following sources for trouble:

1. Idle spring out of adjustment. Loosen lock nut on adjustment screw 16, Illustration No. 17, and turn in or out until smooth idle is obtained.
2. Idle spring bent or caught in yoke. Remove spring and straighten.
3. The hand or foot control linkage worn or out of adjustment. Reset and take out slack in linkage.
4. Thrust sleeve in governor sticking, gears and weight fingers worn. Replace with new parts or complete governor.

PRECAUTIONS:

In the event it is necessary to dismantle the governor, it is suggested that the complete fuel injection pump assembly be removed from the engine. The injection equipment can then be taken to a clean table or work bench. When removing the unit from the engine, the following precautions should be taken:

1. Before removing any oil lines from the pump, thoroughly clean the equipment with fuel oil. When the lines are removed, the openings on the pump should be covered or plugged to prevent dirt from entering the system.
2. Remove inspection cover of injection pump. Slowly turn the engine over until it is noted that the plunger of the pumping element nearest the pump drive coupling is in its top position. If the engine is left in this position and the adjustment of the coupling is not touched, the pump can be reinstalled in this position on the engine without the necessity for retiming.
3. Disconnect the engine throttle linkage from the governor operating lever. Do not remove the governor operating lever from its shaft or alter its position.
4. Remove complete injection pump assembly.

SERVICE AND REPAIR

Removing governor from fuel pump:

1. Remove the coupling nut on the end of the camshaft, using a socket wrench and by holding the coupling from turning, as shown in Illustration 35. The coupling recess bore for the nut is threaded and a puller (13115-A) is used to pull the coupling, as shown in Illustration No. 35.
2. Remove the Woodruff key from the camshaft.
3. Remove all the screws that hold the governor to the governor plate.
4. Put the throttle lever in "full-power" position and pull the governor housing away from the plate. It is doweled to the plate and may require tapping to loosen from the dowels. Lift out as shown in Illustration No. 36.
5. When free from the dowels, lift the governor unit up carefully to release the governor yoke lever, shown by the pointer in Illustration No. 37, from the fuel control rod pin and rollers, as shown by

the other pointer in the same illustration. Use care not to lose the two small rollers, one on each end of the pin. The rollers are then removed.

6. Place tappet holders under the tappets as shown in Illustration No. 30.

7. The governor plate is then removed by removing the large slotted head screw in the upper part of the governor plate, and the four screws which are screwed into the injection pump housing, shown in Illustration No. 38. Remove the plate and oil resisting gasket around the control rod bushing, shown in Illustration No. 39.

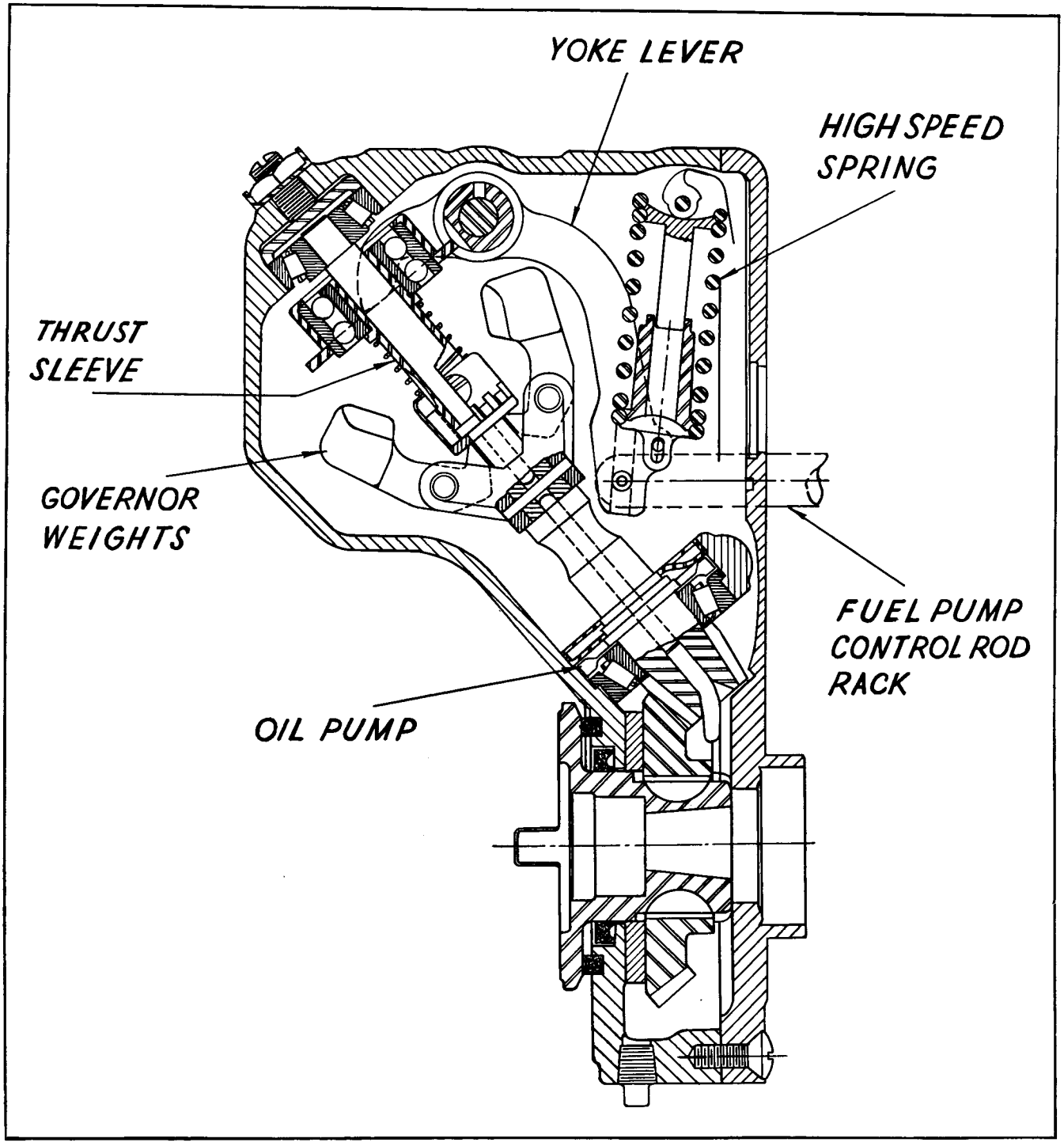


Illustration No. 34

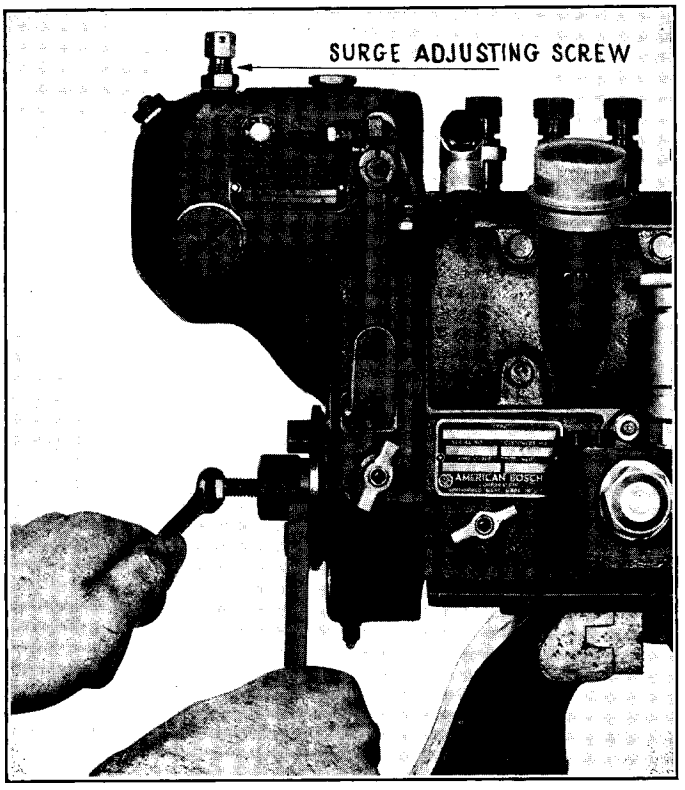


Illustration No. 35

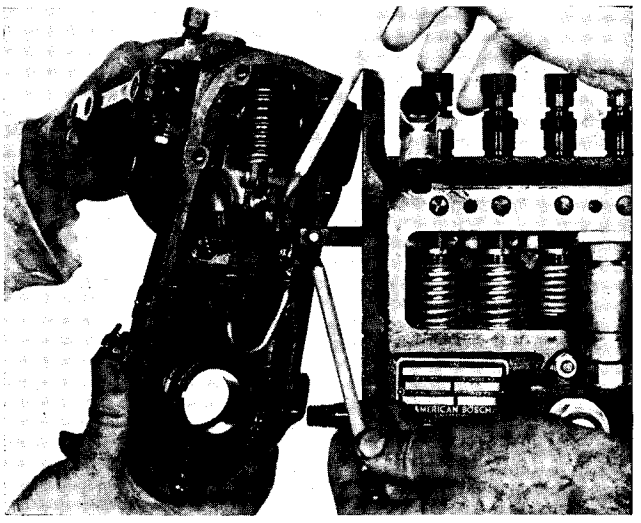


Illustration No. 37

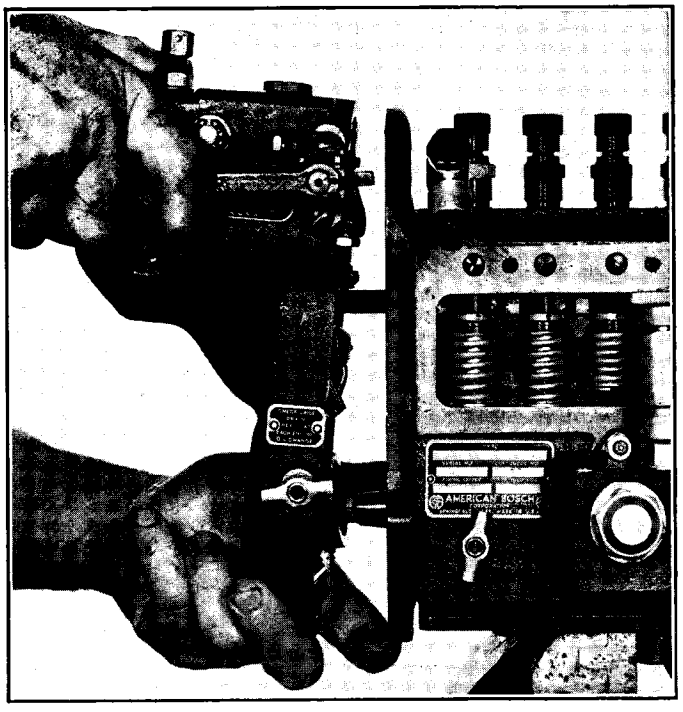


Illustration No. 36

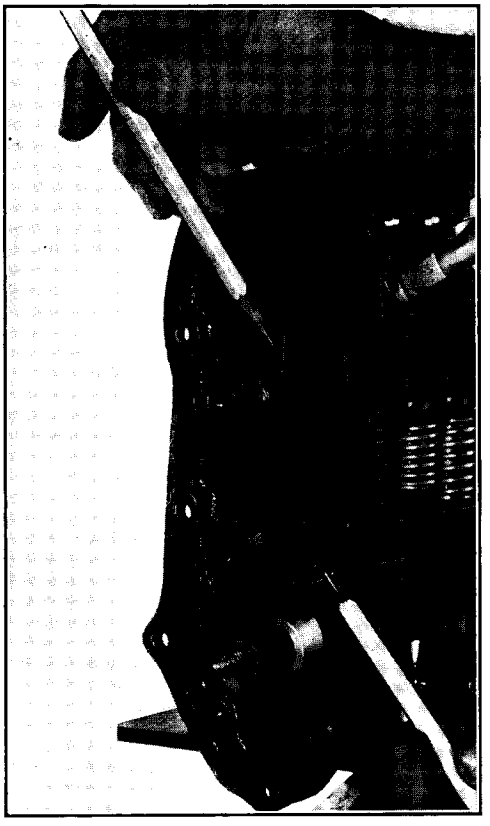


Illustration No. 38

Disassembling The Governor

1. The gear and gear washer are lifted out, as shown in Illustration No. 40.

2. After removing the governor from the pump, as described on page 49, remove the control lever and the control shaft bearings on both sides. These are held on with two screws each. See Illustration No. 41.

3. Remove the nut (some governors have screw instead of nut) holding the "high speed" spring to the yoke lever, as shown by the pointer in Illustration No. 41.

4. Hold the open end of the governor down as shown in Illustration No. 42, and with a pair of pliers, pull off the link eye. By holding the governor in this position, the spring lies in an advantageous position to facilitate removing the link eye. When replacing it, it is not necessary to hold the governor housing upside down as described herein to remove.

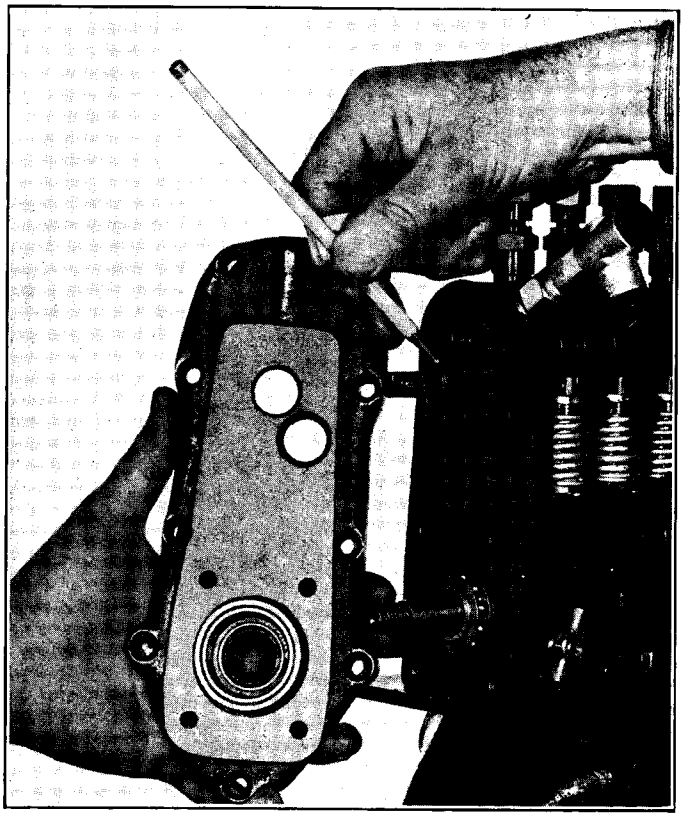


Illustration No. 39

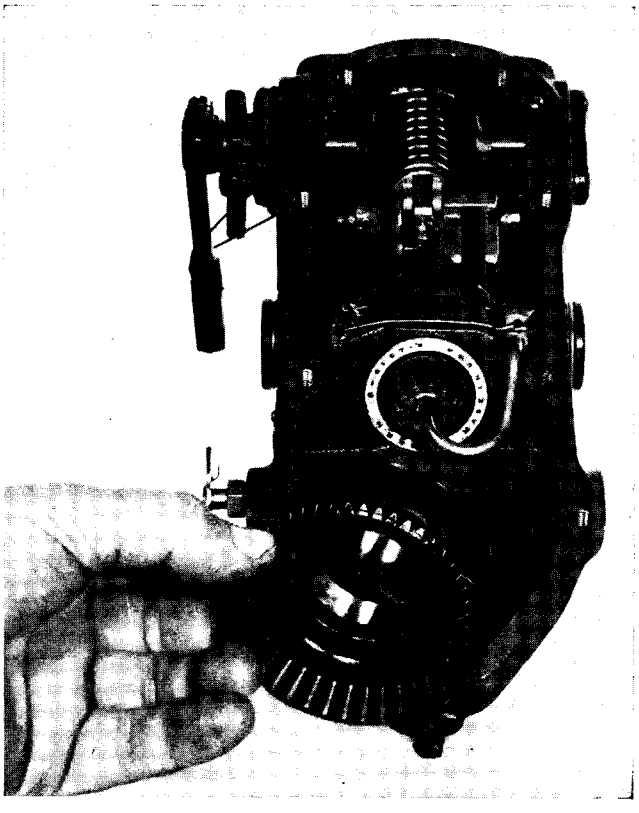


Illustration No. 40

5. The control shaft together with the high speed spring can then be removed from the housing—the short end first.

6. The pinion shaft bearing cap screws and cap are next removed and the pinion shaft lifted out, as shown in Illustration No. 43.

7. The yoke shaft is next removed and the yoke lifted out as shown in Illustration No. 44.

8. Use a puller (200016-A) as shown in Illustration 45 to remove the upper bearing on the shaft. The thrust sleeve assembly shown in Illustration 46 may then be pulled off the shaft.

9. The governor weight assembly is pressed off the shaft after pushing out the taper pin. The bearing and other parts are then removed. The pinion is cut integral with the shaft.

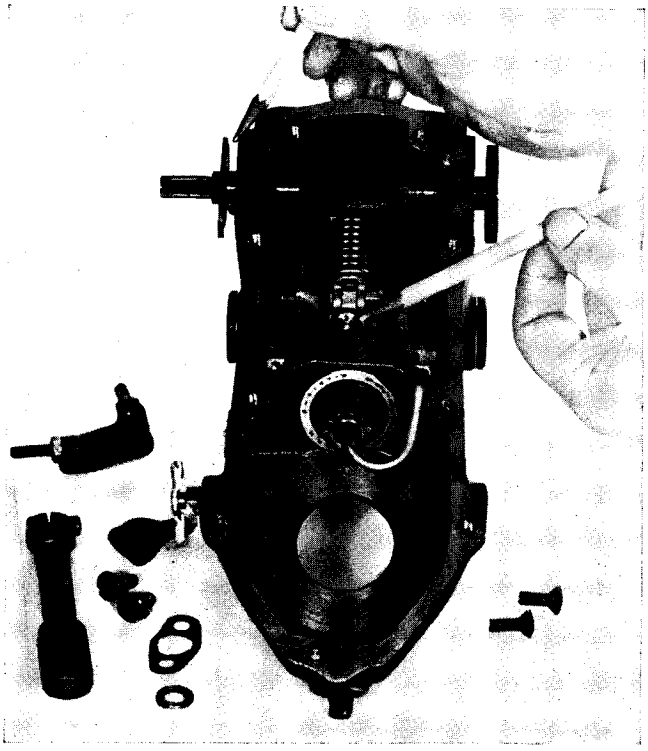


Illustration No. 41

Inspection Of Governor Parts

Before reassembling the governor, make a careful inspection of all parts and replace worn parts.

1. Oil seals part numbers BB and ZZ, Illustration No. 47 should be replaced at each overhaul or rebuilding period.

2. The thrust surfaces (X and W, Illustration No. 47) on the ends of the sliding sleeve should be given very careful inspection to determine that there are no rough spots or indentations made by the weight contact fingers of the flyball and yoke lever arm. If not perfectly smooth, replace the worn parts. The flyball weight contact fingers are made with a radius of 1/32".

3. Visual inspection of all other parts will reveal any damaged or worn parts which need replacing. See that bearings are in good condition.

4. The yoke lever, L, Illustration No. 47, is to be inspected for the following:

   a. Bearings must fit the yoke shaft without binding.

   b. Curved surfaces of fingers engaging the thrust sleeve must not be worn excessively.

   c. The control rod roller guide rivets must be tight.

   d. There must be adequate lateral play of yoke lever on the shaft and bearings to allow it to adjust itself to the position of the control rod and thrust surface, on which the fingers contact, without binding, as shown at X, Illustration No. 47.

   e. The two rollers on the control rod pin must not be tight nor have excessive freedom. See Illustration No. 37.

5. The thrust washer, shown in Illustration 46, of the thrust sleeve assembly engaging weights must be smooth and flat. The thrust sleeve bearing must rotate freely and be tight in the ring and on the sleeve.

6. The high speed spring is wound with initial tension. Replace if it is stretched so that the coils are not tightly together.

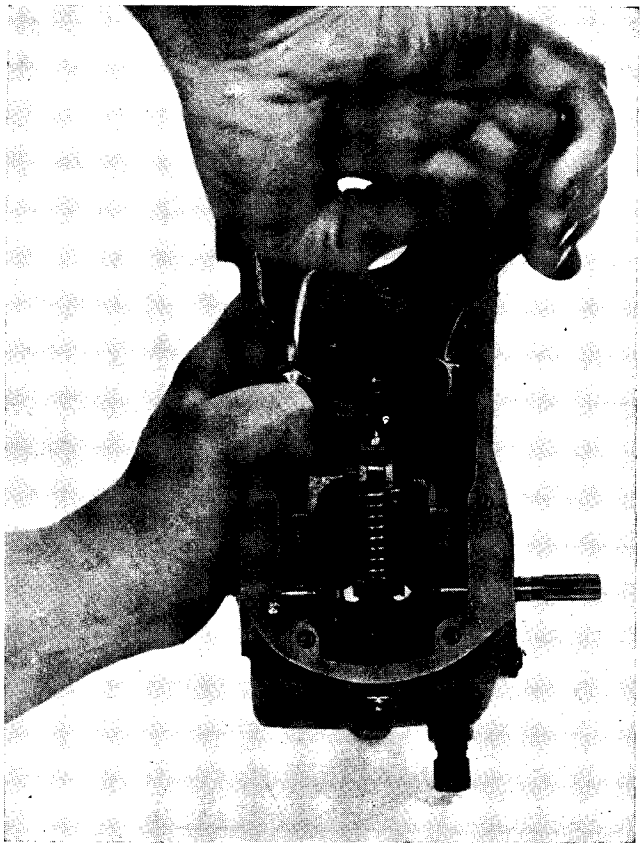


Illustration No. 42

7. Inspect the housing for stripped threads, cracks, or scars on the sealing surfaces.
8. Replace all gaskets after rebuilding or overhauling.

Assembling The Governor

Use the following procedure in assembling governor.

Be sure all parts are thoroughly cleaned and lubricated.

1. Install the governor plate on the fuel injection pump as shown in Illustration 38. Be sure the gasket between the pump and plate is in good condition, and put on the rubber ring over the control rod bushing, shown in Illustration No. 39. Start the slotted screw to hold the plate in alignment then set up the four screws. Prick punch the outer diameter of the screws to prevent unscrewing. Tighten the slotted screw.
2. If high speed spring assembly, shown in Illustration 48 must be renewed, unscrew the spring at the control rod end A sufficiently to remove pin B. To install the new spring assembly, connect the new spring assembly to the control shaft with the pin

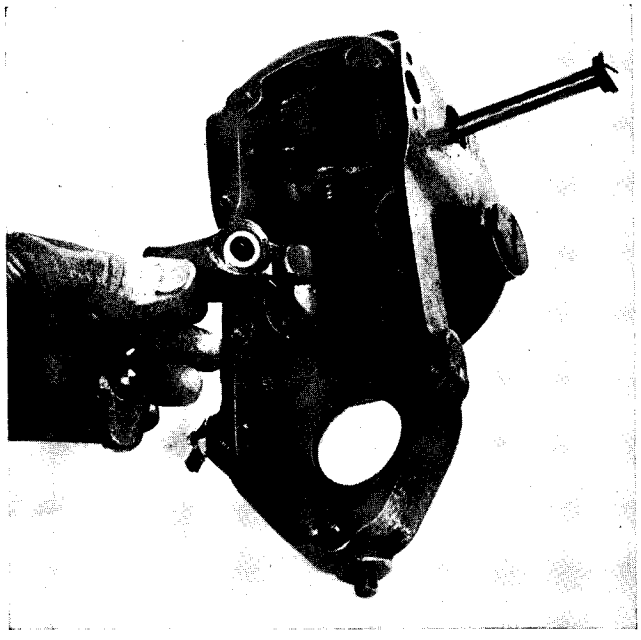


Illustration No. 44

6. Move the yoke lever axially on the shaft until the plunger of the fixture lines up with the slot in the yoke lever, shown in Illustration 50, and observe the space between the housing and the yoke lever bearing on the side opposite to the control rod side. Remove the yoke shaft and install shims to fill this space as shown in Illustration No. 51. Some trial and error is necessary to get the proper thickness of shims which should

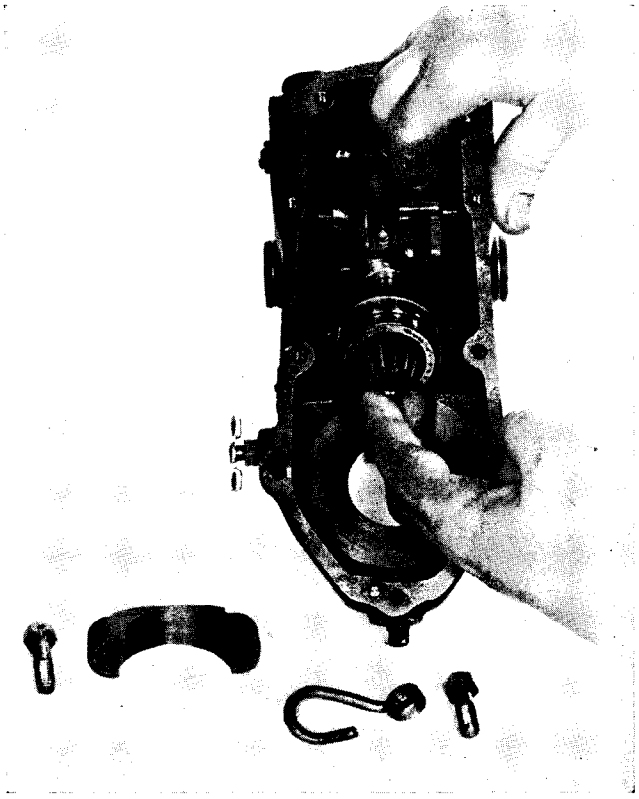


Illustration No. 43

and screw the spring on the link about ¼ turn so that the spring prevents the pin falling out. Do not disturb the spring on lower link D. Be careful not to scratch or gouge spring. The slot in the lower link must be parallel to the control shaft. Reassemble control shaft in housing. Install shaft bushings, Illustration No. 41.

3. Install the yoke lever, L, Illustration No. 47, in the governor housing, and insert the yoke shaft, as shown in Illustration No. 44.
4. Connect high speed spring assembly and link D, Illustration No. 48. to the stud or screw on yoke, Illustration No. 42.
5. Put the fixture, Part Number 13480-BS, shown as N, Illustration No. 47 on the governor housing with the dowels in the housing entering the holes in the posts of the fixture as shown in Illustration No. 49.

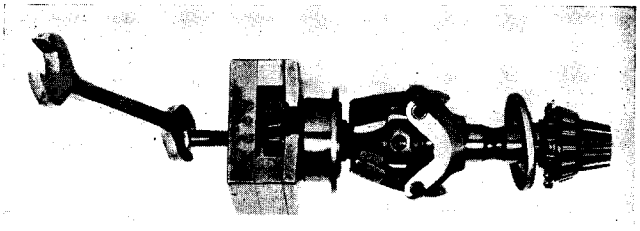


Illustration No. 45

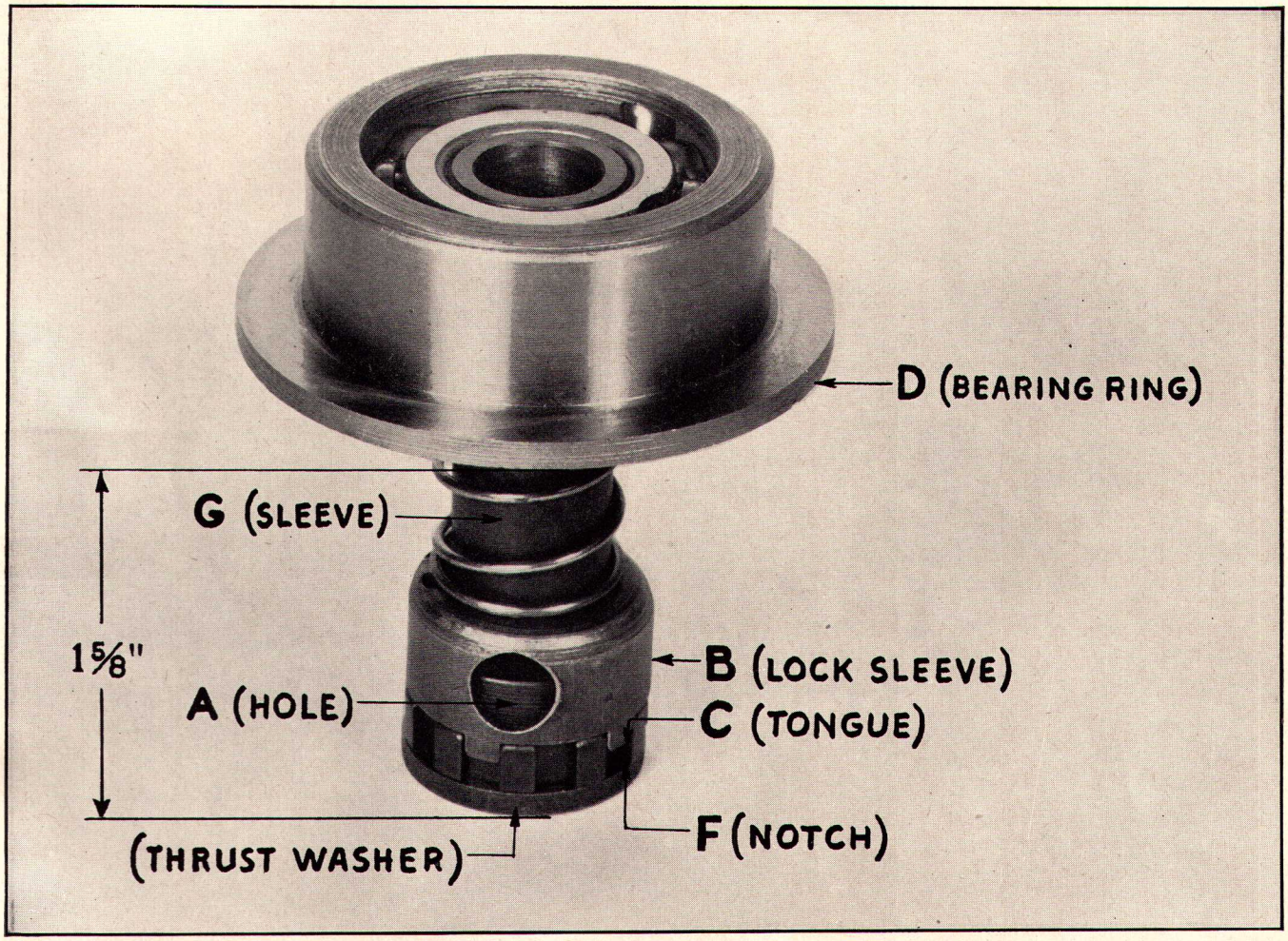


Illustration No. 46

be sufficiently accurate to permit the slot in the yoke lever to work freely over the flattened ends of the plunger. These shims prevent the yoke lever from sliding axially on the yoke shaft and causing binding of the fingers of the yoke on the thrust collar or in the slot connecting the other end of the yoke to the control rod. The fuel pump and governor are mounted on the engine at an angle from the vertical and due to this incline the yoke always lies against the shims.

7. Assemble the pinion shaft, bearing, oil pump, impeller, cup, shims, snap-ring fly-balls, thrust washer, thrust sleeve assembly and upper bearing in the order given. Illustration No. 45. Adjust the length of the thrust sleeve assembly to a length of 1⅝" between the lower face of the thrust sleeve, D. Illustration No. 46, and the lower thrust face of the thrust washer.

8. Insert the pinion shaft bearing adjusting cap, WW, in Illustration No. 47.

9. Insert the pinion shaft assembly as shown in Illustrations No. 43, and screw the bearing cap bolts up tight with the impeller pump and impeller cap in position as may be seen in the sectional Illustration No. 34. Adjust the thrust screw YY, Illustration No. 47 to give an end clearance of the pinion shaft of from .001" to .004". Then set up the locknut and bend over the locking tangs.

10. Insert the gear washer J, and the gear R, Illustration No. 47.

11. When parts are replaced that affect the backlash of the gears it is necessary to check the amount of backlash and adjust by using a thinner or thicker gear thrust washer J. These are obtainable in six different thicknesses. A change in washer thickness changes the backlash one-half the change in washer thickness.

12. To check the backlash of the gears, remove the oil seal BB and dust seal ZZ, Illustration No. 47, and insert the plug A through the gear, and insert the sleeve B in the gear and over the pilot on the plug A. This holds the gear in concentric position to check the backlash of the gears which should be .003" to .006". The gear and pinion shaft should turn freely. The ends of the teeth of the pinion gear should line up within .010".

13. Select the gear washer thickness which will give the proper backlash of .003" to .006".

14. Replace the hub oil seal BB, Illustration No. 47 (lip of seal BB must point toward governor gear); also replace the hub dust seal ZZ.

15. Replace the surge spring in the socket in the yoke and screw in the idle adjusting screw about half way.

16. Reassemble plate to pump and the governor to the plate per instructions on the previous pages.

    Note: If a new governor housing has been used without using a new governor plate, or vice versa, it is advisable to check the alignment of the two housings. This can be done by fastening the governor housing to the plate, inserting plug A, Illustration No. 47, as described previously and then inserting plug B in the bore of the governor plate and allowing the pilot on A to engage the bore B. Plug A must rotate freely. It may be necessary to relocate the dowels to eliminate binding.

17. Fill with clean oil to level of high level drain cock, 23, Illustration No. 17, page 30.

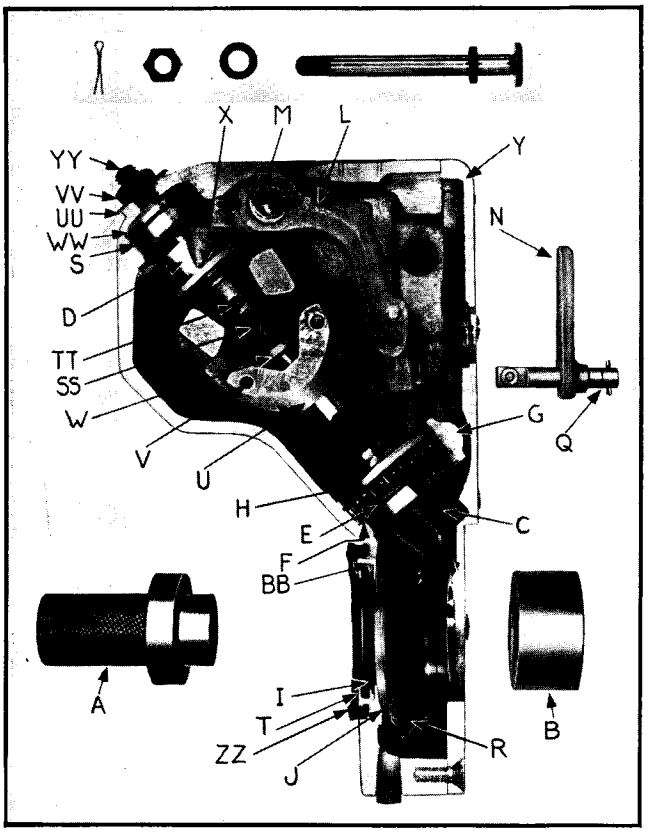


Illustration No. 47

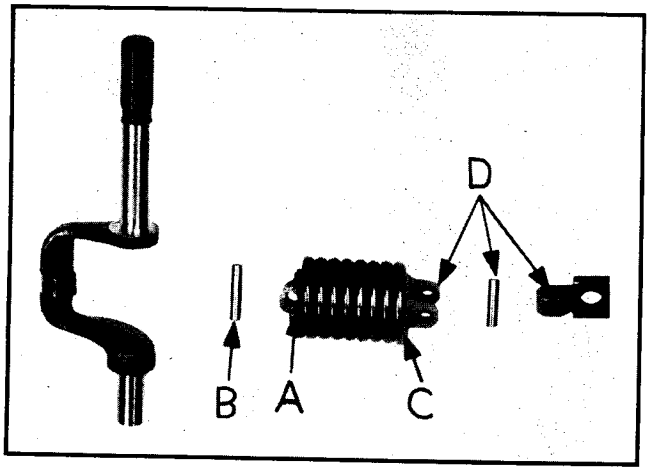


Illustration No. 48

Reassembling the Governor Assembly

The governor and injection pump housing are reassembled as outlined below.

1. All parts must be perfectly clean and in good condition.
2. Install a new oil-resisting ring, shown in Illustration No. 39, and secure the governor plate to the injection pump with the four screws, using the large slotted head screw screwed in only part way first to act as a guide. (See Illustration No. 38). Governor plates are doweled to the governor housing and should be used only with the housing they have been mated with.
3. Set the screws and slotted head screw up tight. Pein a small amount of the metal of the plate into the slots of the screws to prevent loosening.
4. Put the housing gasket in place. The machined surfaces of the housing should be given a very thin coat of gasket seal compound.

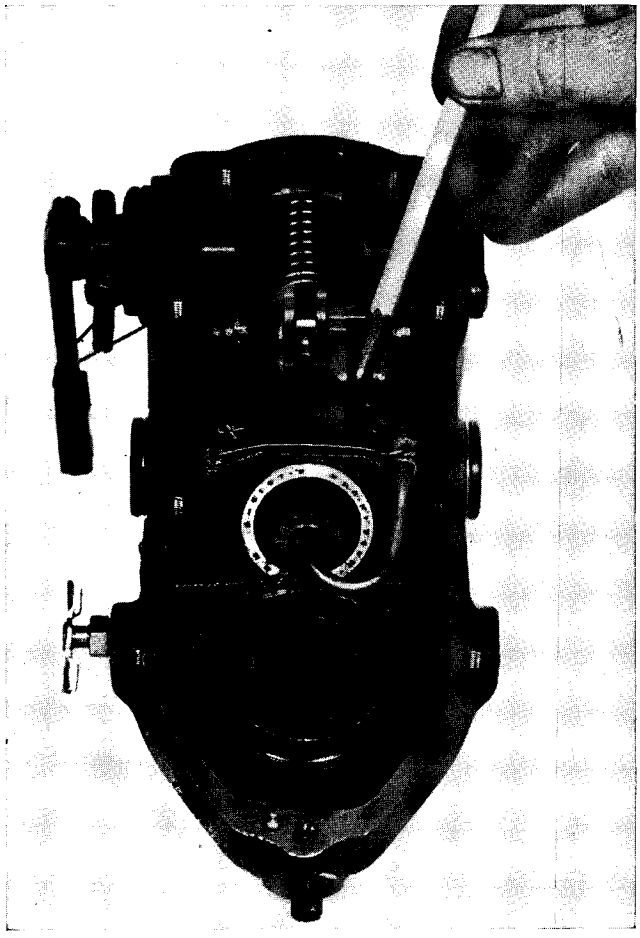


Illustration No. 50

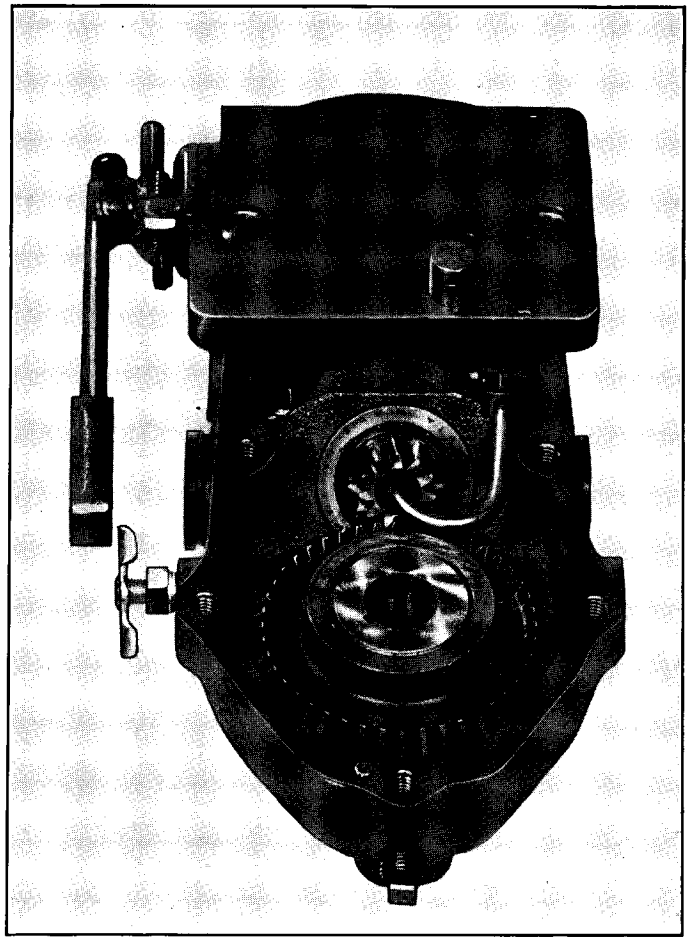


Illustration No. 49

5. Put the Woodruff key in the camshaft tapered end.
6. Put the two small rollers on the control rod pin, one on each end, shown in Illustration No. 37.
7. Put the throttle lever in full power position and lower the governor housing into position with the control rod pin rollers entering the slot of the governor yoke lever, as shown in Illustration No. 36. BE SURE THE ROLLERS DO NOT FALL OUT.
8. Line up dowel pins with holes and start the screws fastening the governor housing to the plate. Release the throttle from the full power position and tighten the screws solid.
9. Insert the Woodruff key in the coupling hub.
10. Insert the coupling hub and tighten up the nut on the end of the camshaft by holding the hub with a wrench as shown in Illustration No. 35.

Illustration No. 51

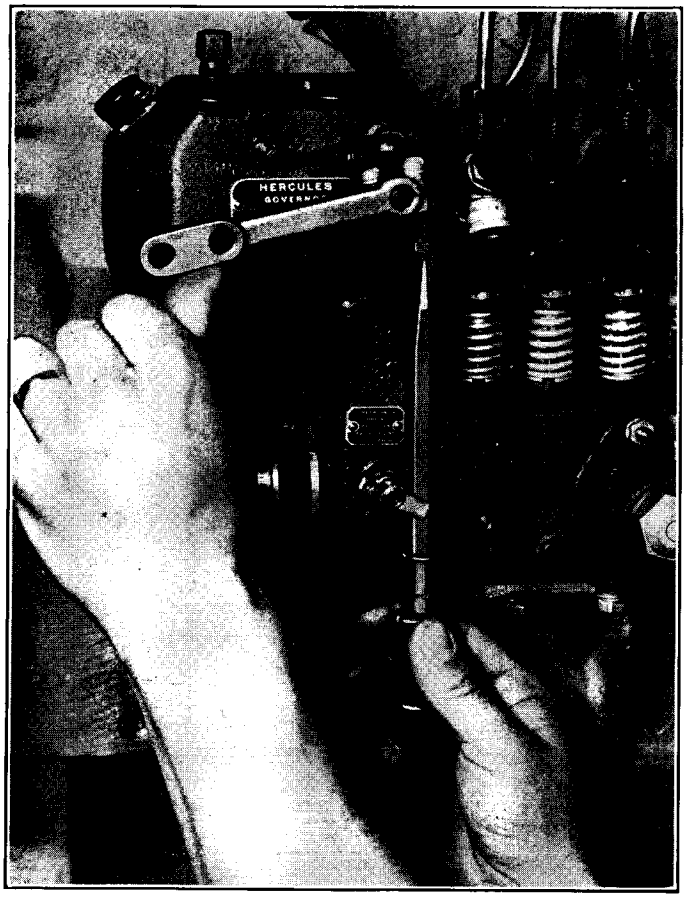


Illustration No. 52

Testing And Adjusting The Governor

1. Start engine and adjust the engine speed adjusting screw, Illustration No. 52 to hold the engine at a speed of about 40 to 50 r.p.m. above the speed required at full load. With engine running at this speed remove plug, 18, Illustration No. 17 and observe if any oil is being thrown off by the weights. Evidence of a small amount of oil indicates oil system is functioning properly.

   WARNING—NEVER INCREASE THE ENGINE R.P.M. ABOVE THAT SPECIFIED BY THE EQUIPMENT MANUFACTURER OR HERCULES MOTORS CORPORATION. TO DO SO MAY SERIOUSLY DAMAGE THE EQUIPMENT OR CAUSE PERSONAL INJURY.

2. If the gears are noisy (rattling sound), there is too much backlash and a thicker gear washer J, Illustration No. 47, should be used. If there is a "singing" or "humming" sound the backlash is inadequate and a thinner gear washer is required.

3. Warm the engine up by running at full speed until it is approximately normal operating temperature, which is with circulating water and oil temperature 150° or above. Adjust the governor as follows:

   a. Remove the surge spring screw 16, Illustration No. 17.

   b. With the engine fully loaded adjust the engine high speed adjusting screw, Illustration No. 52 to the speed specified by the equipment manufacturer. CAUTION: THIS SPEED MUST NOT EXCEED 1800 RPM.

c. Remove all the load from the engine and check the speed. It should be 35 to 50 r.p.m. above full load speed. If more than 50 r.p.m. above, stop the engine and remove the inspection hole plug, shown in Illustration No. 53. With the aid of two small screw drivers or pointed tools, such as an ice pick, turn the thrust sleeve, SS, shown in Illustration No. 47, in a convenient position to insert the point of one of the tools in the hole TT, of the locking sleeve SS, as shown in Illustration No. 47, and move it upward toward the bearing ring until the tongues of the locking sleeve are free of the slots of the adjusting nut, Illustration No. 54. Hold the locking sleeve in this position and with the other tool, ROTATE THE ADJUSTING NUT BACK OR UNSCREWING IT A FEW NOTCHES, TO LENGTHEN THE THRUST SLEEVE.

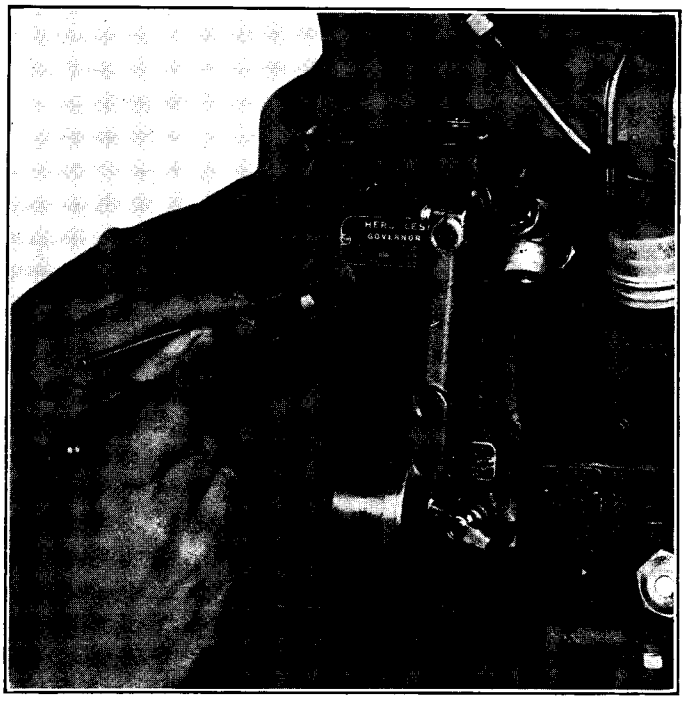


Illustration No. 53

d. If the load is removed as in paragraph (c) above and the speed is less than 35 r.p.m. plus the full load speed, or in other words less than 35 r.p.m. over-run, the thrust sleeve is too long and is to be shortened instead of lenghtened, as described in paragraph (c) above. Proceed in the same manner as in paragraph (c) by stopping the engine and remove the inspection hole plug, etc. However, ROTATE THE ADJUSTING NUT FORWARD OR SCREW IT UP a few notches as needed to obtain approximately 35 to 45 r.p.m. "OVERRUN".

e. Screw the surge spring in until the engine just starts to increase speed (with no load) and lock it in this position.

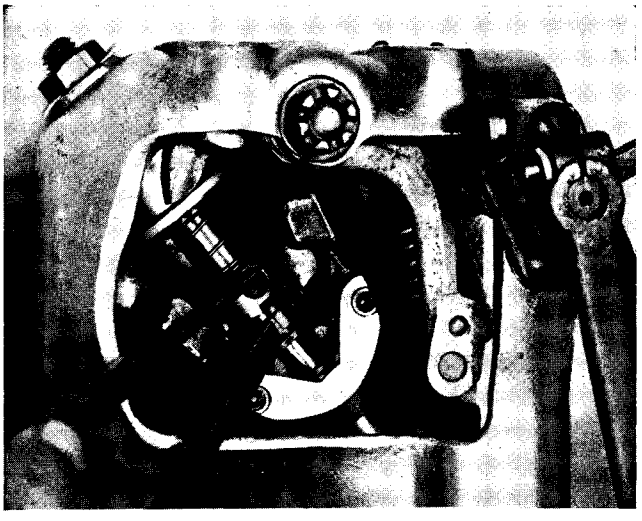


Illustration No. 54

PIERCE VARIABLE SPEED GOVERNOR

Illustration No. 19

The purpose of a governor as well as the functions have been discussed in previous chapters and therefore no further discussion of these subjects should be necessary.

Illustration No. 19 shows the Pierce variable speed governor with various items marked as follows, No. 31 is the oil filler, No. 36 is the oil level test cock, No. 35 oil drain plug, No. 32 stop control lever

to which the stop control wire is fastened, No. 33 stop control wire casing clamp, No. 37 tachometer drive, remove this cap to attach tachometer cable, No. 45 speed change lever to which the throttle control rod is fastened, No. 40 high speed adjusting screw, No. 41 governor control spring, and No. 42 is the operating lever.

SERVICE INSTRUCTIONS

Lubrication: Check Daily—Oil should drip from oil level cock 39, Illustration No. 55. It is necessary to drain oil by removing plug 1, Illustration No. 55 each time oil is changed in engine crankcase. Refill until oil drops from oil level cock 39, Illustration No. 55.

Precautions

If it should become necessary to disassemble the governor, the complete fuel pump and governor assembly should be removed from the engine and taken to a clean table or work bench. When removing the assembly from the engine, the following precautions should be taken:

1. Before loosening any oil lines, thoroughly clean the fuel injection equipment and fuel line connections. When the lines are removed, the openings should be covered to prevent any dirt from entering the fuel system.
2. Remove timing hole cover, see Illustration No. 21. Slowly turn the engine until the timing marks coincide. If the engine is left in this position and the adjustment of the fuel pump coupling is not touched, the pump can be reinstalled in this position without the necessity of retiming the fuel pump.
3. Disconnect the throttle linkage from the speed change lever, also the stop control wire.
4. Disconnect tachometer shaft, if one is used.
5. Remove complete pump and governor assembly from engine, see Illustration No. 19.

DISASSEMBLY OF GOVERNOR

1. Remove drain plug 1, Illustration No. 55 and drain lubricating oil from governor.
2. Remove governor cover plate screws 2, Illustration No. 55 and lift cover assembly 4, Illustration No. 55 from governor.
3. Remove snap ring 5 and clevis pin 6, Illustration No. 57.
4. Remove four screws 7, Illustration No. 55 and pull governor body away from pump. The pinion shaft and weight assembly 9, Illustration No. 56 will remain in the base.
5. Remove bearing retaining screw 10 and lockwasher 11, Illustration No. 56 and pull pinion shaft and bearing assembly from governor base 12, Illustration No. 56.
6. Remove base attaching screws (there are two inside the base as well as the two outside) and pull the base from

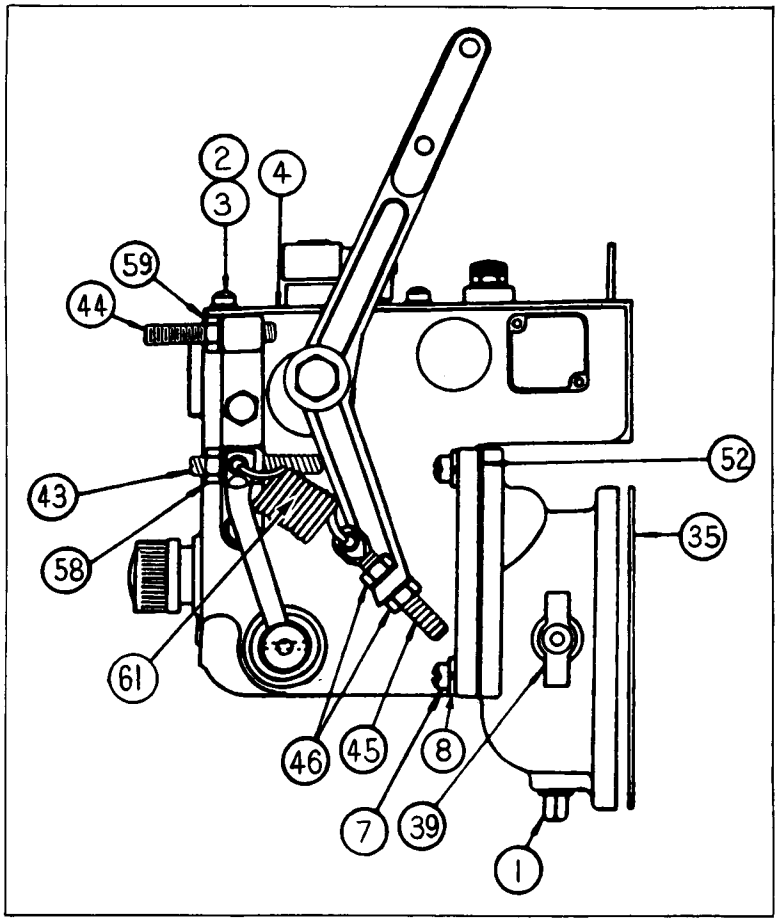


Illustration No. 55

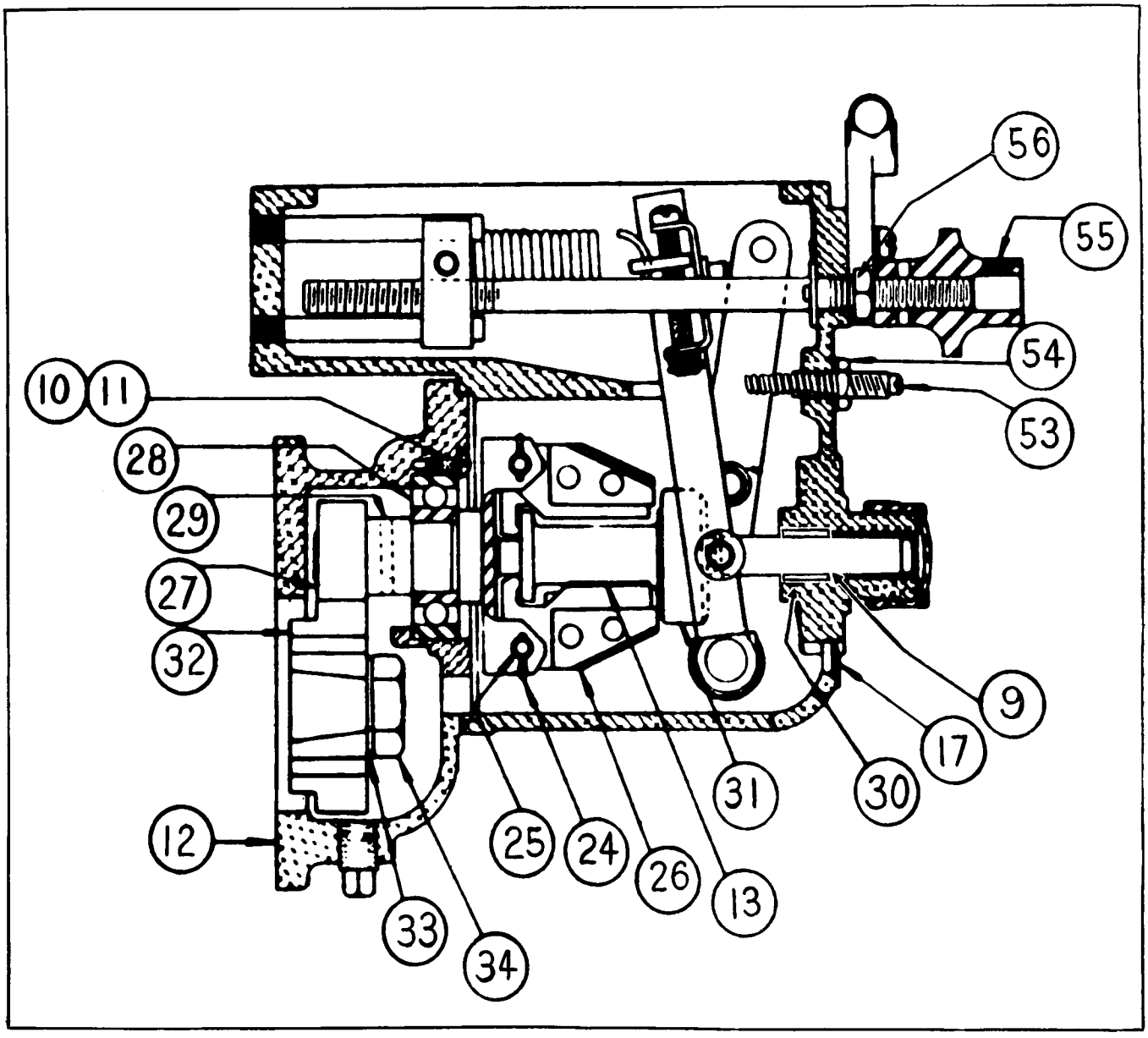


Illustration No. 56

the fuel pump. CAUTION: Be sure injection pump end plate remains in place unless tappet holders are inserted as shown in Illustration No. 30 or serious damage may happen to the fuel pump.

7. Remove snap ring from pinion shaft then pull thrust sleeve and bearing assembly 13, Illustration No. 56 from shaft.

8. If the governor yoke 14, yoke pins 15, or operating shaft 16, Illustration No. 59 are not worn or damaged it is not necessary to disassemble these parts. However, should disassembly be necessary, remove expansion plugs 17, Illustration No. 56 from the inside with a small punch. Then insert a small pin punch through these holes to remove the yoke pins 18, Illustration No. 59.

9. Remove cup plug 19 and snap ring 20, Illustration No. 58, then disconnect speed control spring 61, Illustration No. 55 and pull shaft and lever assembly 21, Illustration No. 58 from housing.

10. Remove bearings 22 and 23, Illustration No. 58.

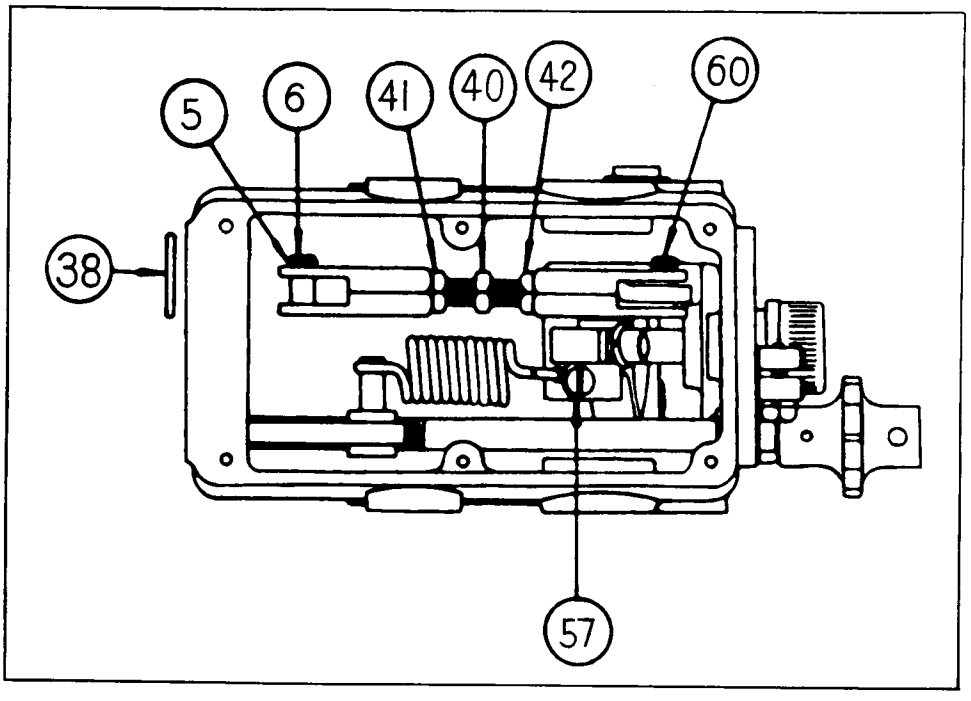


Illustration No. 57

11. Remove lock wires 24 and weight pins 25 and weights 26 from shaft 9, Illustration No. 56.
12. If gear or bearing, Illustration No. 56 are worn or damaged, remove gear pin 29 then pull gear 27 and bearing 28, Illustration No. 56, from shaft.
13. If bushing 30, Illustration No. 56 is worn a piece of $\frac{7}{16}$" diameter steel stock may be inserted in tachometer drive hole to press out this bushing.
14. It is not necessary to remove any other parts from the governor housing unless they are broken or damaged in which case they may be readily removed from the housing.

INSPECTION

1. Check pinion shaft for wear.
2. Check thrust sleeve 13, Illustration No. 56 for wear both inside and where weight noses contact end of sleeve, also check thrust bearing 31, Illustration No. 56 for wear.
3. Check pinion gear 27 and bearing 28, Illustration No. 56 for wear, also be sure pinion shaft thrust bearing retaining snap ring is tight in its groove.
4. Check weight pins for wear in both the spider and the weights, also check nose of weights 25, Illustration No. 56.
5. Check yoke shaft bearings 22 and 23, Illustration No. 58.
6. Replace all parts that are worn or damaged and use new gaskets and oil seals when reassembling the governor.

REASSEMBLY OF GOVERNOR

1. Place suitable support under weight spider, then press bearing 28 and gear 27, Illustration No. 56 on shaft. Install gear pin 29 and pein over ends.
2. Assemble weights 26 with weight pins 25 and lock wires 24, Illustration No. 56. Weights must move freely on pins and in weight spider without binding or tight spots.
3. Press bearings 31 onto thrust sleeve 13, Illustration No. 56 and install on shaft then lock in place with snap ring.

4. Insert woodruff key and install governor drive gear 32, Illustration No. 56. Use lockwasher 33 and nut 34, Illustration No. 56, to tighten and hold gear in place.
5. Place new gasket 35, Illustration No. 55 on fuel pump and install governor base on fuel pump using screws as removed.
6. Press new bushing 30, Illustration No. 56 into governor body and try shaft 9 in bushing. (Clearance should be .002" - .003".
7. Install pinion shaft 9 and weight assembly in governor base 12 and install bearing retaining screw 10 and lockwasher 11, Illustration No. 56.
8. Press bearings 22 and 23 into governor body, also install oil seal 37, Illustration No. 58.
9. Place yoke 14, Illustration No. 59 in position then insert shaft and lever assembly 21, Illustration No. 58 and install yoke pins 18 and snap ring 36, Illustration 59. Replace expansion plugs 17, Illustration No. 56.
10. Insert end cap 19, Illustration No. 58. Using a plastic sealing compound on end cap and expansion plugs to avoid oil leaks.
11. Place new gasket 52, Illustration No. 55 and rack seal ring 38, Illustration No. 57 in position then install body assembly on base with screws 7 and lockwashers 8, Illustration No. 55.
12. Insert rack clevis pin 6 and assemble lock ring 5, Illustration No. 57 on pin.
13. Open oil level cock 39, Illustration No. 55 and fill governor with oil to proper level.
14. Adjust governor, see Adjustment below.
15. Place new gasket on governor body then assemble cover assembly 4, Illustration No. 55 using screws 2 and lockwashers 3, Illustration No. 55.

ADJUSTMENT OF LINKAGE

1. Place throttle lever in wide open position.
2. Adjust turn buckle 40, Illustration No. 57 until rack is in full position, then lock with lock nuts 41 and 42, Illustration No. 57.

ADJUSTMENT FOR ENGINE SPEED

1. Start engine and warm up to operating temperature.
2. Set idling speed with adjusting screw 43, Illustration No. 55. Turn the screw in to increase speed and out to decrease the engine speed. Tighten lock nut 58.
3. Set high speed with adjusting screw 44, Illustration No. 55. Turn the screw out to increase the speed and in to decrease the speed. Tighten lock nut 59.
4. The governor spring 61, Illustration No. 55 controls the regulation of the governor. As the tension of this spring is increased the regulation or over run of engine speed between full load and no load is decreased which results in a very fast acting governor which in some cases has a tendency to surge. If the governor surges, the tension on this spring should be decreased. This will cause the governor to act slower which will reduce the surge.
5. Recheck both high and low engine speeds after adjusting the governor spring. Reset if necessary.

If any particular trouble is experienced please write to Service Department, Hercules Motors Corporation, Canton, Ohio. Give full information including engine serial number.

PIERCE CONSTANT SPEED GOVERNOR

Illustration No. 18

The Pierce Constant Speed Governor shown in Illustration No. 18 controls the engine speed only at the pre-set maximum speed. However, this speed may be changed, to some extent, by readjusting the governor. The maximum engine R.P.M. should never be increased before consulting the manufacturer of the equipment in which it is used. Serious damage may result.

Various items in Illustration No. 18 are marked as follows: No. 31 is the filler, No. 32 stop control lever to which the stop control wire is fastened, No. 33 stop control wire casing clamp, No. 34 maximum speed adjusting knob, No. 35 oil drain plug, No. 36 oil level test cock, No. 37 tachometer drive, remove this cap to attach tachometer cable and No. 38 which is the bumper screw. This screw is used to control surge.

SERVICE INSTRUCTIONS

Lubrication: See Page 60.

Precautions

If it should become necessary to disassemble the governor, the complete fuel pump and governor assembly should be removed from the engine and taken to a clean table or work bench. When removing the assembly from the engine, the following precautions should be taken:

1. Before loosening any oil lines, thoroughly clean the fuel injection equipment and fuel line connections. When the lines are removed, the openings should be covered to prevent any dirt from entering the fuel system.
2. Remove timing hole cover, see Illustration No. 21. Slowly turn the engine over until the timing marks coincide. If the engine is left in this position and the adjustment of the fuel pump coupling is not touched, the pump can be reinstalled in this position without the necessity of retiming the fuel pump.
3. Disconnect the throttle linkage from the speed change lever, also the stop control wire.
4. Disconnect tachometer shaft, if one is used.

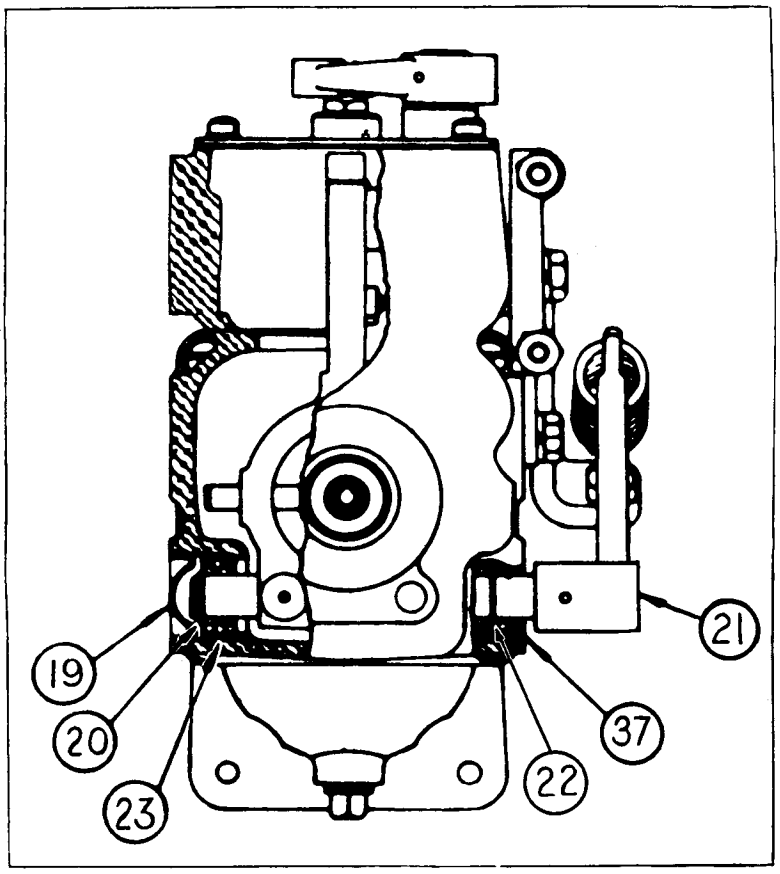


Illustration No. 58

5. Remove complete pump and governor assembly from engine, see Illustration No. 18.

DISASSEBLY OF GOVERNOR

1. Remove drain plug 1, Illustration No. 55 and drain lubricating oil from governor.
2. Remove governor cover plate screws 2, Illustration No. 55 and lift cover assembly 4, Illustration No. 55 from governor.
3. Remove snap ring 5 and clevis pin 6, Illustration No. 57.
4. Remove four screws 7, Illustration No. 55 and pull governor body away from pump. The pinion shaft and weight assembly 9, Illustration No. 56 will remain in the base.
5. Remove bearing retaining screw 10, and lockwasher 11, Illustration No. 56 and pull pinion shaft and bearing assembly from governor base 12, Illustration No. 56.
6. Remove base attaching screws (there are two inside the base as well as the two outside) and pull the base from the fuel pump. CAUTION: Be sure injection pump end plate remains in place unless tappet holders are inserted as shown in Illustration No. 30 or serious damage may happen to the fuel pump.
7. Remove snap ring from pinion shaft then pull thrust sleeve and bearing assembly 13, Illustration No. 56 from shaft.
8. Remove shoulder screw 47, Illustration No. 59 and lift out auxiliary lever 48.
9. If the governor yoke 14, yoke pins 15, or operating shaft 16, Illustration No. 59 are not worn or damaged it is not necessary to disassemble these parts. However, should disassembly be necessary, remove expansion plug 17, Illustration No. 56 from the inside with a small punch. Then insert a small pin punch through these holes to remove the yoke pins 18, Illustration No. 59.

10. Remove cup plug and snap ring 20, Illustration No. 58 then remove cup plug 50, Illustration No. 59 and pull shaft 51, Illustration No. 59 from housing.
11. Remove bearings 22 and 23, Illustration No. 58.
12. Remove lock wires 24 and weight pins 25 and weights 26 from shaft 9, Illustration No. 56.
13. If gear or bearing 28, Illustration No. 56 are worn or damaged, remove gear pin 29 then pull gear 27 and bearing 28, Illustration No. 56 from shaft.
14. If bushing 30, Illustration No. 56 is worn a piece of $\frac{7}{16}$" diameter steel stock may be inserted in tachometer drive hole to press out this bushing.
15. It is not necessary to remove any other parts from the governor housing unless they are broken or damaged in which case they may be readily removed from the housing for replacement.

INSPECTION

1. Check pinion shaft for wear.
2. Check thrust sleeve 13, Illustration No. 56 for wear both inside and where weight noses contact end of sleeve, also check thrust bearing 31, Illustration No. 56 for wear.
3. Check pinion gear 27 and bearing 28, Illustration No. 56, for wear. Also be sure pinion shaft thrust bearing retaining snap ring is tight in its groove.
4. Check weight pins 24 for wear in both the spider and the weights, also check nose of weights 26, Illustration No. 56.
5. Check yoke shaft bearings 22 and 23, Illustration No. 58.
6. Check auxiliary lever 48, Illustration No. 59, where it contacts the thrust pin 15, Illustration No. 59.
7. Replace all parts that are worn or damaged and use new gaskets and oil seals when reassembling the governor.

REASSEMBLY OF GOVERNOR

1. Place suitable support under weight spider, then press bearing 28 and gear 27, Illustration No. 56 on shaft. Install gear pin 29 and pein over ends.
2. Assemble weights 26 with weight pins 25 and lock wires 24, Illustration No. 56. Weights must move freely on pins and in weight spider without binding or tight spots.
3. Press bearing 31 onto thrust sleeve 13, Illustration No. 56 and install on shaft then lock in place with snap ring.
4. Insert woodruff key and install governor drive gear 32, Illustration No. 56. Use lockwasher 33 and nut 34, Illustration No. 56 to tighten and hold gear in place.
5. Place new gasket 35, Illustration No. 55 on fuel pump and install governor base on fuel pump using screws as removed.

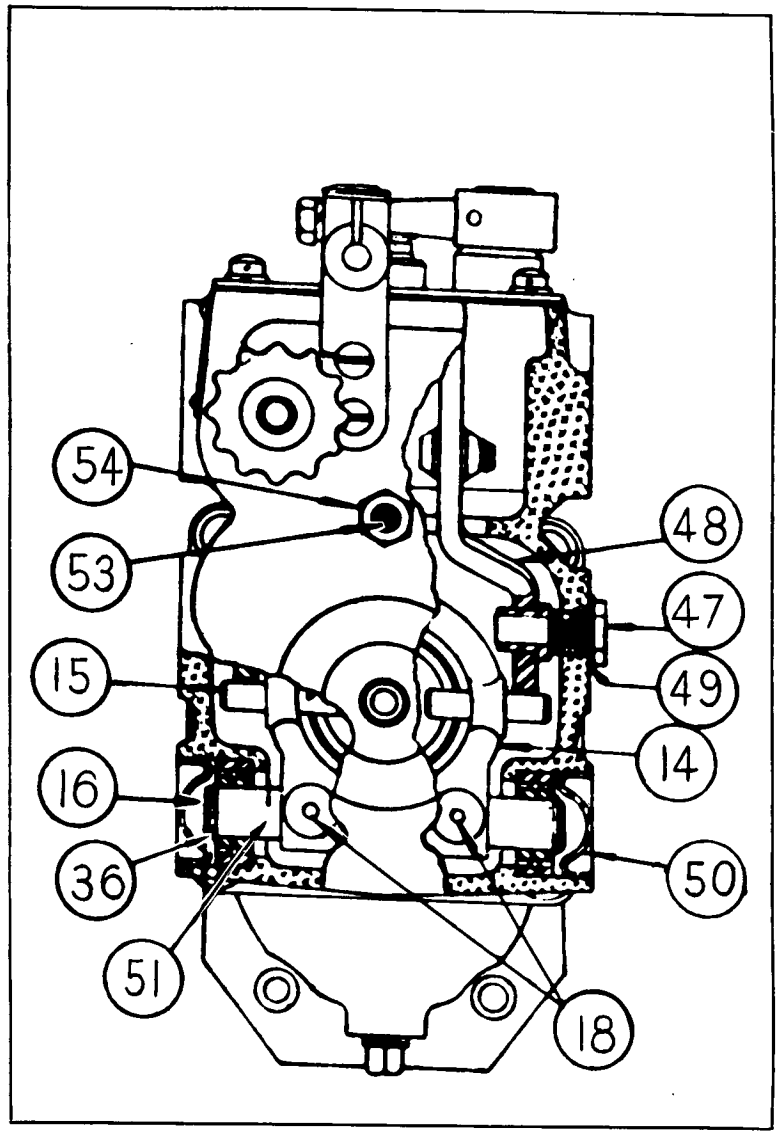
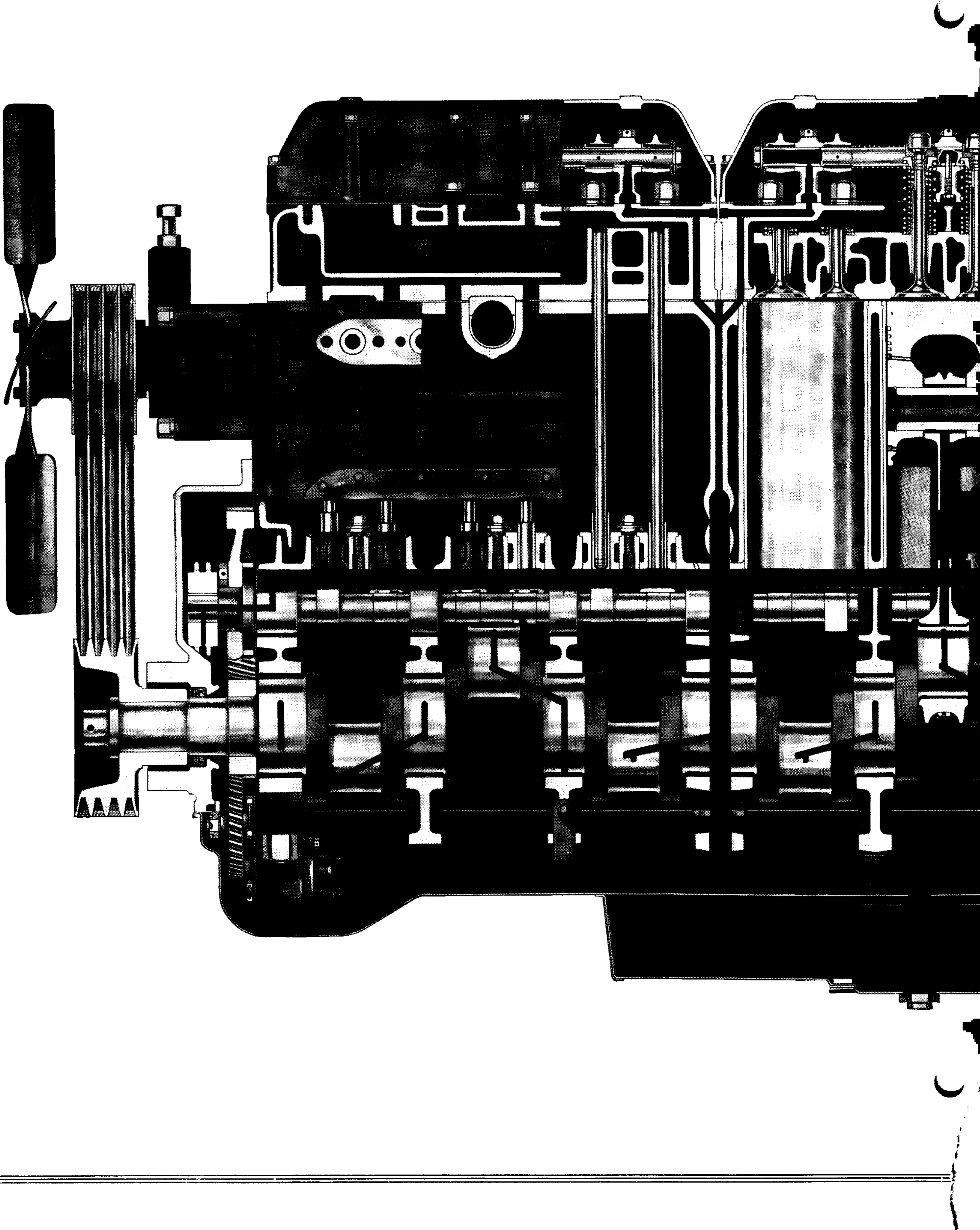
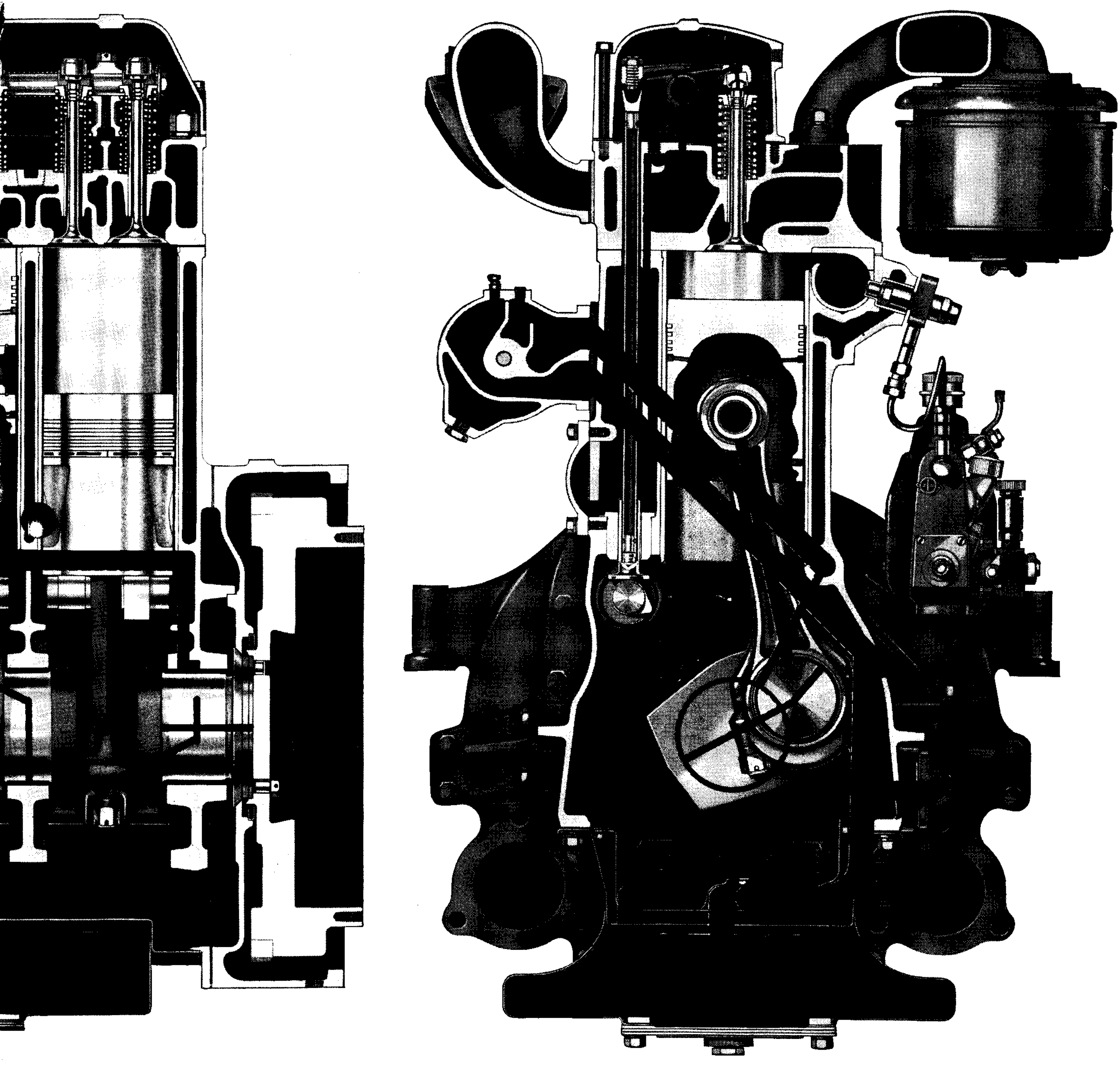


Illustration No. 59





6. Press new bushing 30, Illustration No. 56 into governor body and try shaft 9 in bushing. (Clearance should be .002"-.003").

7. Install pinion shaft 9 and weight assembly in governor base 12 and install bearing retaining screw 10 and lockwasher 11, Illustration No. 56.

8. Press bearings 22 and 23 into governor body, Illustration No. 58.

9. Place yoke 14, Illustration No. 59 in position then insert shaft 51, Illustration No. 59 and install yoke pins 18, Illustration No. 59 and snap ring 20, Illustration No. 58. Replace expansion plugs 17, Illustration No. 56.

10. Insert end caps 19 and 50, Illustration No. 58 and No. 59. Use a plastic sealing compound on end cap and expansion plugs to avoid oil leaks.

11. Place auxiliary lever 48, Illustration No. 59 in position and assemble shoulder screw 47 and lockwasher 49, Illustration No. 59.

12. Place new gasket 52, Illustration No. 55 and rack seal ring 38, Illustration No. 57 in position then install body assembly on base with screws 7 and lockwashers 8, Illustration No. 55.

13. Insert rack clevis pin 6 and assemble lock ring 5, Illustration No. 57 on pin.

14. Open oil level cock 39, Illustration No. 55 and fill governor with oil to proper level.

15. Adjust governor, see **Adjustment** below.

16. Place new gasket on governor body then assemble cover assembly 4, Illustration No. 55 using screws 2 and lockwashers 3, Illustration No. 55.

ADJUSTMENT OF LINKAGE

It is very important that the linkage turn buckle 40, Illustration No. 57 be correctly adjusted.

This adjustment is correctly set and sealed at the factory and no further adjustment should be attempted.

Should it be necessary to repair or replace the governor, be sure to accurately measure the length of the turn buckle between centers of the pin holes 6 and 60, Illustration No. 57.

ADJUSTMENT OF ENGINE SPEED

1. Back out bumper screw 53 until only three or four threads are engaged and lock with lock nut 54, Illustration No. 56.

2. Secure specified engine speed with adjusting screw knob 55. Turn knob clockwise to decrease governed speed, anti-clockwise to increase the speed. Lock with locknut 56, Illustration No. 56.

3. Regulation is controlled by adjusting screw 57, Illustration No. 57 clockwise rotation of this screw broadens regulation and tends to control surge. Anti-clockwise rotation of screw 57 makes the governor more sensitive to load changes.

4. Should governor surge when no load is applied to engine, turn screw 53, Illustration No. 56 in one half turn at a time until maximum control is obtained. Do not turn screw 53 in far enough to increase no load speed of engine. Tighten locknut 54 after adjustment is completed.

If any particular trouble is experienced please write to Service Department, Hercules Motors Corporation, Canton, Ohio. Give full information including engine serial number.

WOODWARD TYPE GOVERNOR

Illustration No. 60

PURPOSE

The prime purpose of this governor is to serve as a means for pre-setting and maintaining within very close regulation any desired engine speed within the nominal idling and nominal maximum speed range, irrespective of engine load. In addition, this governor controls the engine idling speed to prevent stalling and the maximum speed to prevent racing. This type governor is used in Automotive, Industrial, and Marine applications.

GENERAL INFORMATION

The SG lever control governor is of the hydraulic speed droop type. Speed adjustment and speed droop adjustment are standard features. Stalling work capacity is twelve inch pounds over the full thirty degrees terminal shaft rotation at one hundred pounds per square inch operating pressure.

Useful work capacity is six inch pounds at one hundred pounds per square inch pressure and twelve inch pounds at two hundred pounds per square inch pressure.

The governor uses engine oil as a control medium and does not have an independent oil sump.

Speed Adjustment: A control shaft is provided for adjusting speed. Suitable levers and linkage which may be adjusted for the desired running speed are used. If the engine is to be operated at one speed setting, screws may be used in the governor to lock the position of the shaft. These same screws may be used for limiting the speed range for variable speed service.

Speed Droop Adjustment: Speed droop adjustment is provided and can be adjusted inside the governor from one-half of one percent droop to approximately seven percent droop.

Installation: When the governor is installed on the engine particular care should be exercised to mount it square with the engine linkage, and in line with the engine drive. A gasket should be placed between the base of the governor and the engine mounting pad. Be certain the gasket does not block off the two holes alongside the centering pilot. The splined drive shaft must fit the engine drive with a free slip fit. No tightness is permissible, the governor must drop onto the engine pad of its own weight and no force should be used.

A ⅜" copper tubing oil line must be connected from the engine oil pressure supply pump to the relief valve sleeve. A minimum of five pounds per square inch oil pressure is required at the governor end of this line. Automotive type oil filters may be installed to eliminate possibility of dirty oil reaching the governor, but if used they must have capacity, when dirty, to supply one gallon per minute at 2400 R.P.M. governor speed or 1½ gallons per minute to close fuel must be provided on the engine linkage. This spring should be adjusted for twelve inch pounds work on a standard one hundred pounds per square inch governor.

The position of the governor relief valve assembly or oil supply connection depends on the direction of rotation of the governor drive shaft. The relief valve must be on the left side of the nameplate for clockwise rotation of the governor and on the right side for counterclockwise rotation.

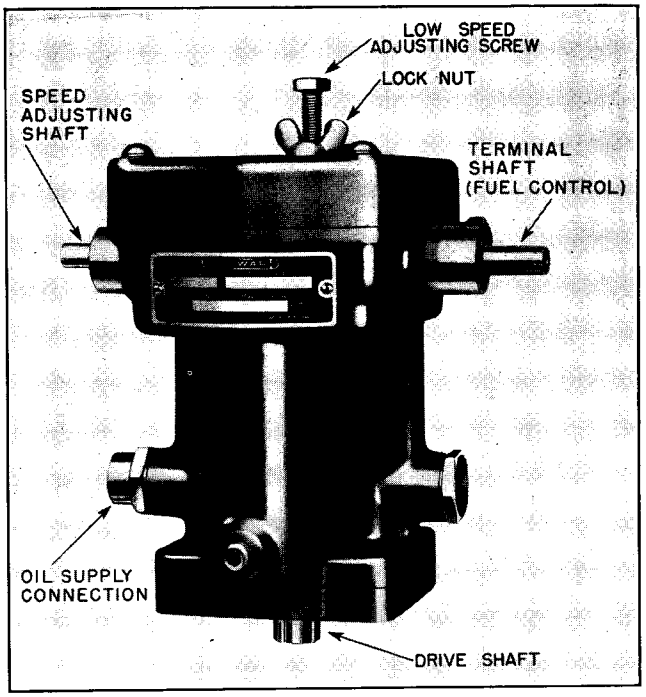


Illustration No. 60

Oil Specifications: Regular engine lubricating oil is supplied to the governor. Any dirt present in the engine oil will eventually be deposited in the governor unless filters are used. If filters are not used the engine oil should be changed oftener than required for purpose of engine maintenance.

Dirty Oil Causes Most Governor Troubles: Keep the oil supply to the governor clean to avoid unnecessary repair work.

Starting Engine for the First Time: Start the engine in normal manner. Position speed control shaft for desired running speed and allow the engine to warm up.

If the engine surges when warming up, remove the top cover while running and adjust droop bracket to maximum droop position. Illustration No. 61.

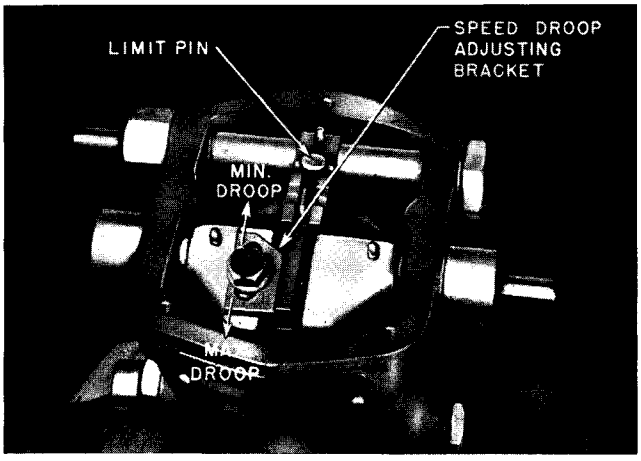


Illustration No. 61

Preliminary Speed Droop Adjustment: When the engine is warmed up reduce droop, Illustration No. 61, until as near minimum as possible consistent with maintaining steady speed. Manually move engine fuel linkage to cause temporary engine speed increase. If engine returns to original steady speed the adjustment is satisfactory for most single engine installations. If engine does not steady out increase droop slightly (approx. $\frac{1}{16}$" movement) and test again. Continue increase of droop until action is satisfactory.

PLANT OPERATING INSTRUCTIONS AND SPEED DROOP SETTINGS

Special control problems may require deviations from the following instructions, but in the majority of installations the speed droop settings suggested will be satisfactory.

One Engine Running Alone: Set speed droop as near minimum as possible as explained in starting engine for first time. Reduced droop will give least amount of droop in speed as load is picked up from no load to full load.

D. C. Generating Units Electrically Interconnected: Set speed droop as near minimum as possible as explained in preliminary speed droop adjustment. If load does not divide as desired (due to non-identical generator compounding in addition to the usual causes) increase droop on units taking too great a share of the load.

A. C. Generating Plants Operating Alone: These instructions do not apply if the plant is tied in with other plants.

This governor will not maintain system frequency automatically. It will be necessary to correct system frequency manually when using this governor if the system load is subject to changes.

An isochronous governor should be used on one of the units (with sufficient capacity) to regulate frequency by absorbing all load changes. The other units may then use SG speed droop governors if desired. Set the droop sufficiently high, (toward maximum) to secure satisfactory load division between units. If load does not divide properly, increase droop on the units taking too great a share of the load changes. Set the droop at maximum to prevent interchange of load between units.

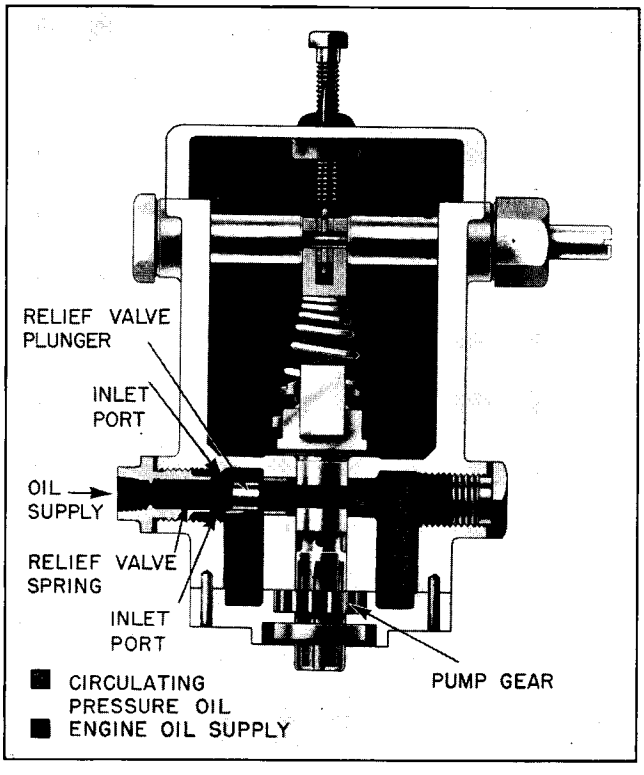


Illustration No. 62

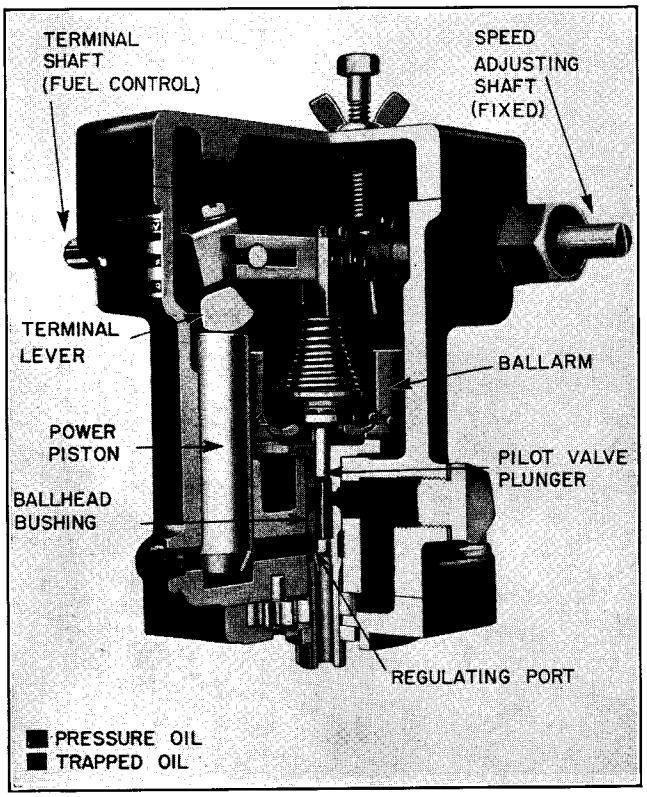


Illustration No. 63

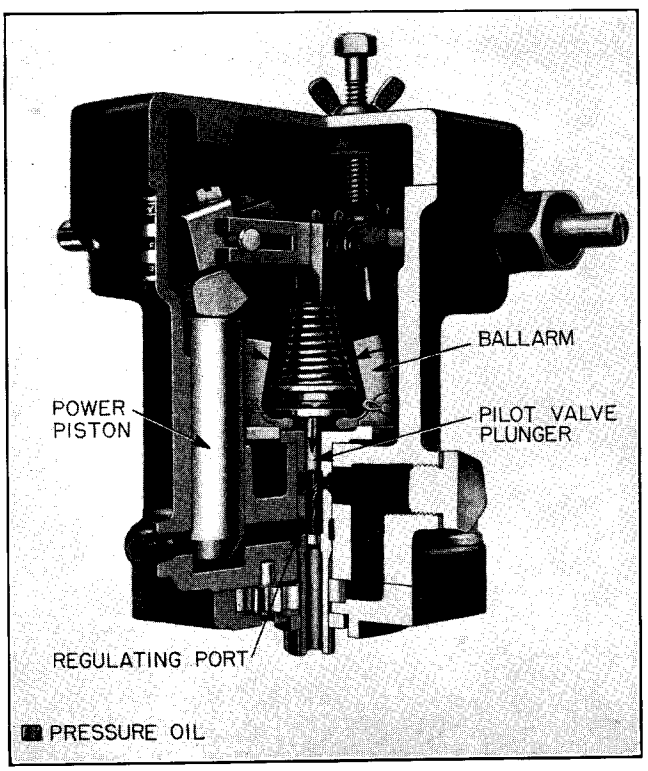


Illustration No. 64

The distribution of load between units when synchronized is accomplished by adjusting the speed of the SG governors or other governors with speed droop.

A. C. Generating Plants Tied In With Other Plants: This governor will not maintain the system frequency. An isochronous governor in the plant or in another plant on the system is necessary if system frequency is to be automatically maintained by means of governors.

Set speed droop at maximum to prevent interchange of load between units.

The distribution of load between units when synchronized is accomplished by adjusting the speed of the SG governors or other governors with speed droop.

DESCRIPTION OF OPERATION

As previously stated the governor uses engine oil as a control medium and does not have an independent sump. The engine oil enters the governor at the relief valve as shown in Illustration No. 62.

If the supply of oil is greater than required for governing purposes the governor pump will build up pressure causing the relief valve plunger to move to the left overcoming the spring. The governor pump will then recirculate the oil within the governor.

If oil is used for governing purposes the oil pressure will be reduced in the recirculating area. The spring will then move the relief valve plunger to the right blocking the recirculating passage to maintain operating pressure.

In Illustrations No. 62 to No. 67 engine speed changes as a result of load changes have been considered. The same sequence of governor movements occurs when a difference between actual governor speed and governor speed setting is produced by turning the speed adjusting shaft.

Pressure oil admitted under the power piston will cause it to move up to increase fuel supply to the engine. A spring provided in the engine linkage acts through the terminal lever to move the power piston down and decrease fuel to the engine.

Load Increase: Illustration No. 63.

1. Engine is running at desired speed without load.
2. Ballarms and pilot valve plunger are in normal positions. Regulating port in ballhead bushing is covered by land on plunger.
3. Power piston is stationary.

Load Increase: Illustration No. 64.

1. Engine load is increased and engine speed decreases.

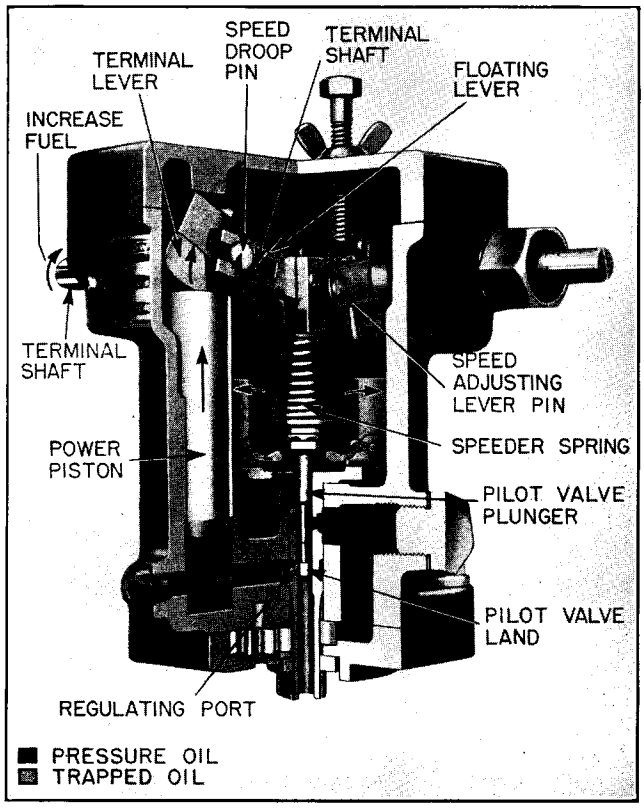


Illustration No. 65

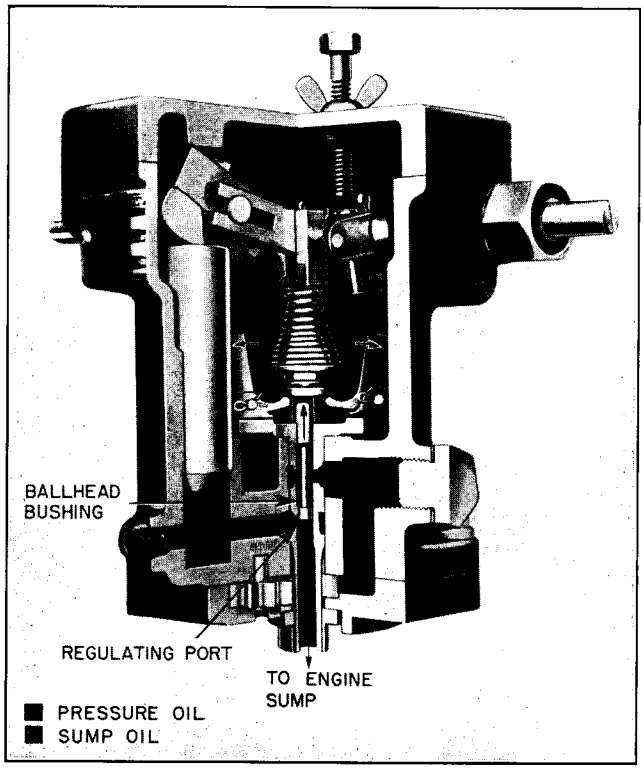


Illustration No. 66

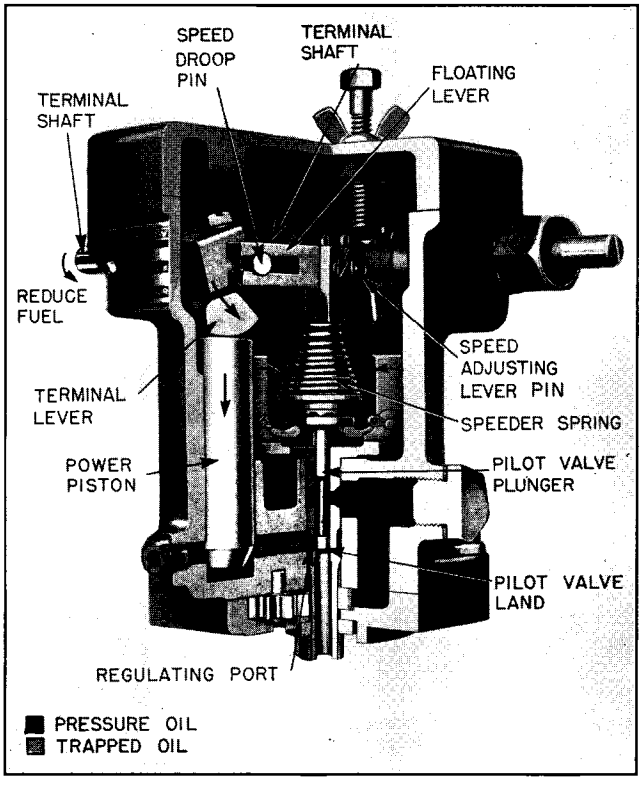


Illustration No. 67

2. As speed decreases, ballarms move in lowering pilot valve plunger and uncovering regulating port in ballhead bushing.
3. Uncovering of regulating port admits pressure oil to bottom of power piston.

Load Increase: Illustration No. 65.

1. Oil pressure moves power piston up in direction to increase fuel.
2. As power piston moves up the terminal lever rotates with the terminal shaft moving the speed droop pin up.
3. Movement of the speed droop pin rotates the floating lever up turning about the speed adjusting lever pin, reducing speeder spring force.
4. Reduction of the spring force allows the ballarms to return to normal vertical position raising pilot valve plunger and land, closing the regulating port.
5. Closing of the regulating port stops further movement of the power piston simultaneous with the return of the engine to the lower speed, which is determined by the new speeder spring force.

The return of the ballarms to vertical position does not indicate a return to the original speed

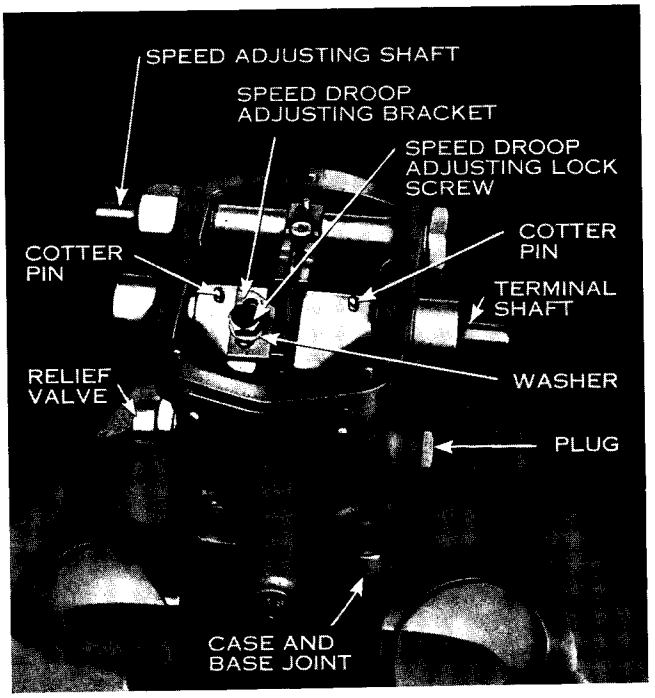


Illustration No. 68

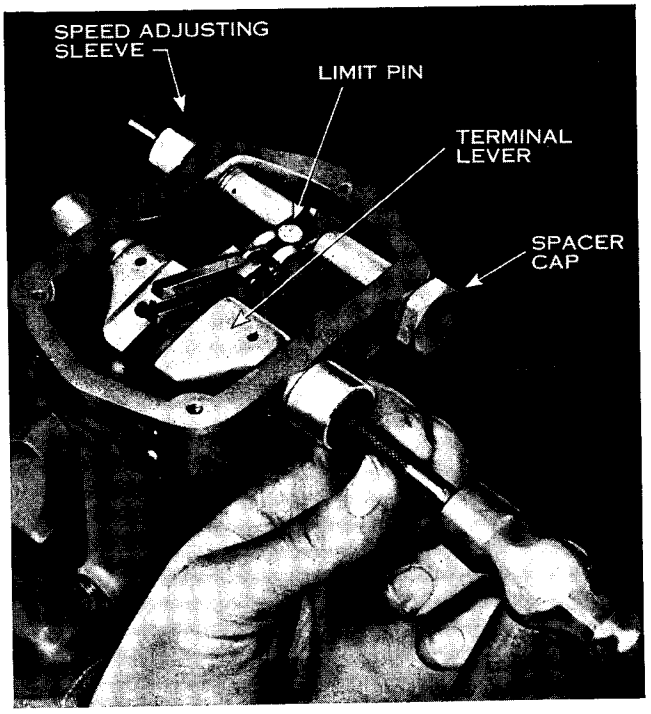


Illustration No. 69

because the centrifugal force required for balance is reduced due to the reduced spring force. Thus, load applied to the engine will cause the engine speed to be reduced slightly.

Load Decrease: Illustration No. 66.

1. Engine load is decreased and engine speed increases.
2. As speed increases, ballarms move out raising pilot valve plunger and uncovering regulating port in ball head bushing.
3. Uncovering of regulating port opens area under power piston to sump.

Load Decrease: Illustration No. 67.

1. Spring force in the engine linkage acts against the power piston moving it down to reduce fuel.
2. As power piston moves down the terminal lever rotates with the terminal shaft moving the speed pin down.
3. Movement of the speed droop pin rotates the floating lever down turning about the speed adjusting lever pin, increasing speeder spring force.
4. Increase of the spring force allows the ballarms to return to normal vertical position lowering the pilot wave plunger and land, closing the regulating port.
5. Closing of the regulating port stops further movement of the power piston simultaneous with the return of the engine to the higher speed, which is determined by the new speeder spring force.

   The return of the ballarms to the vertical position does not indicate a return to the original speed because the centrifugal force required for balance is increased due to the increased spring foce. Thus load dropped off an engine will cause the engine speed to be increased slightly.

MAINTENANCE—INTERNAL ADJUSTMENT

Information and Parts Replacement: When requesting information concerning governor operation and maintenance or ordering replacement parts, it is very essential that the following information accompany the requests:

1. Governor serial number (shown on governor name-plate).
2. Bulletin number.
3. Part number, name of part, or description of part.

Work Requirements: It is suggested that the best mechanic available (perferably 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, 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.

Disassembly of the Governor: If the governor is to be completely disassembled it should be taken apart in the order shown.

1. Clamp governor lightly in vise below case and base joint. Illustration No. 68.
2. Remove three screws and take off top cover.
3. Remove speed droop adjusting screw, washer, and bracket. Illustration No. 68.
4. Pry up two cotter pins with side cutters and remove.
5. Pull out terminal shaft.
6. Insert rod in opening and drive out opposite shaft. Illustration No. 69.
7. Remove terminal lever from governor.
8. Unscrew speed adjusting sleeve and spacer cap. Remove from governor.
9. Remove pilot valve, pilot valve bearing, and speed adjusting shaft assemblies from governor as shown in Illustration No. 70.
10. Disassemble speed adjusting shaft, lever, and floating lever by twisting off bent over end of "U" shaped lockwire. Use new lockwire or two cotter pins when reassembling.
11. Unscrew relief valve assembly and plug. Remove from case. Illustration No. 68.

Illustration No. 70

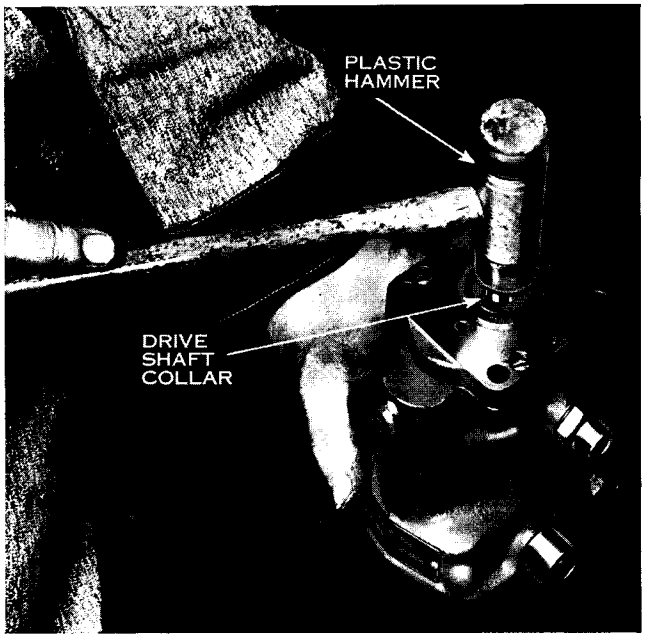


Illustration No. 71

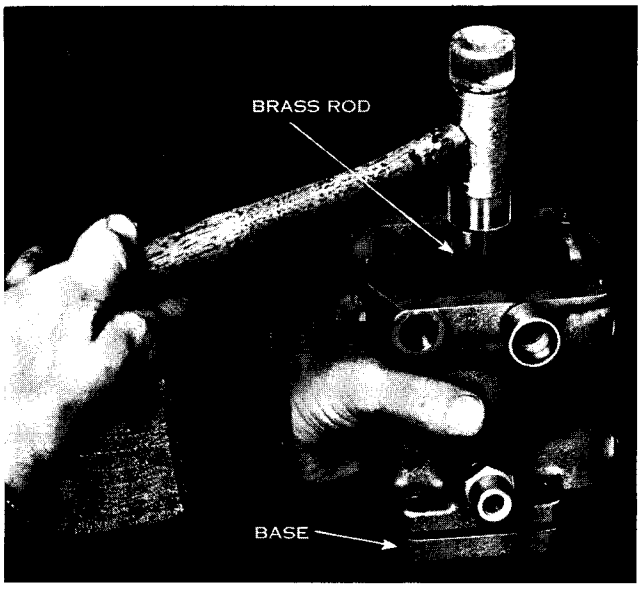


Illustration No. 72

12. Remove governor from vise, invert, catching power piston as it falls out.
13. Strike drive shaft with plastic hammer to remove drive shaft collar. Illustration No. 71. Remove drive shaft and ballhead from case.
14. Remove base if loose enough. If tight, place 9/16" diameter brass rod in case through center hole and drive apart as shown in Illustration No. 72 or, if desired, as shown in Illustration No. 73. Hold hand under base to case joint to catch pump gears. See Illustration No. 74 for arrangements of parts.

Disassembly of Case:

1. Clamp idler stud in split strap clamped in vise, as shown in Illustration No. 75. Twist and pull on case to remove idler stud.

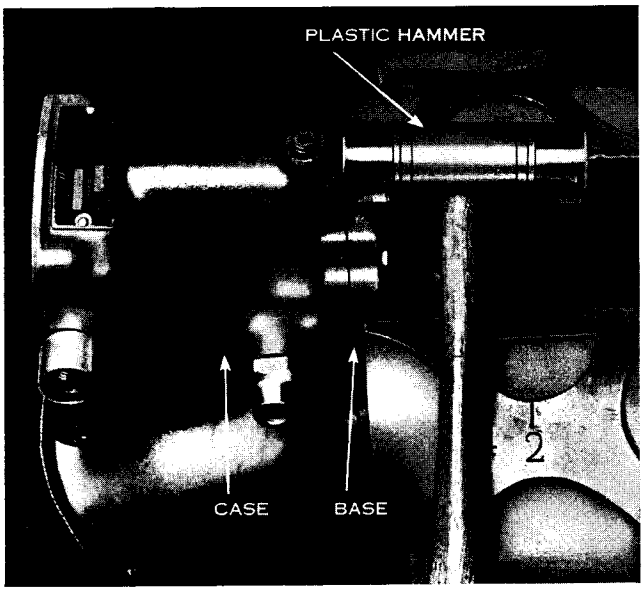


Illustration No. 73

2. The terminal sleeves are pressed into the case. Insert 5/16" threaded rod through one side, screw on a nut, and drive out sleeve. See Illustration No. 76.

Oilite Bearings in Terminal Sleeves. These bearings may be pressed out of the sleeves and replaced when worn. If replaced, they must be line sized (or line reamed with a 3/8" standard line reamer).

Disassembly of Spring Fork and Speeder Spring:

1. Remove pilot valve bearing.
2. Insert thin screwdriver between spring and spring fork. Clamp fork in vise and drive off spring, as shown in Illustration No. 77.

Disassembly of Relief Valve:

1. Insert long nose pliers in end depressing the plunger. Illustration No. 78.
2. At the same time grip pin and slide pin half way out.
3. Depress plunger and pull out pin with fingers.

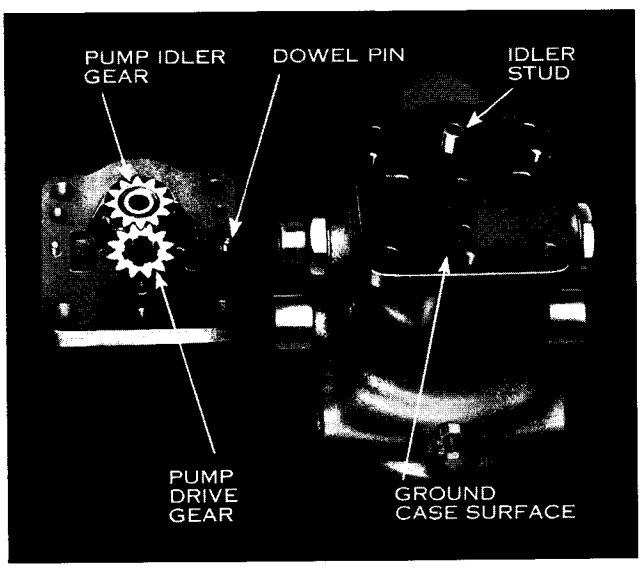


Illustration No. 74

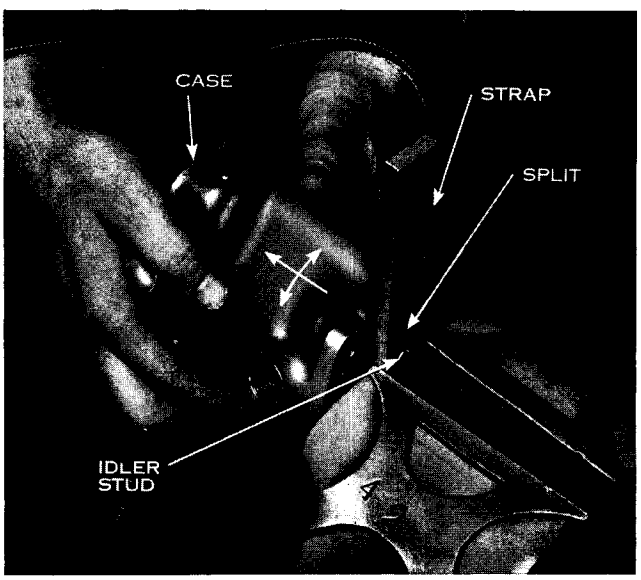


Illustration No. 75

GENERAL REPAIR INSTRUCTIONS

(Refer to **Work Requirements).** Most of the repair work consists of cleaning and polishing of parts. All pistons, plungers, valves and shafts should move freely without bind or catching. Do not lap in parts except as stated.

Use No. 320 to 500 fine grit emery cloth for polishing.

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

Case: If ground case surface is grooved or worn from rotation of the pump gears or scratched from mis-handling, Illustration No. 74, it may be surface ground, 1/32" stock may be removed, if necessary, to clean up. If surface grinder is not available, lap the surface smooth on a flat plate.

Base: If ground flat surface of base is warped, nicked, or deeply scratched, it may be lapped smooth on a fllat plate. *Do not remove more stock than necessary to clean up.* If depth of gear pockets is reduced the gears will bind and it will be necesary to lap the faces of the gears to free up.

Ballhead: If ballarm pins are cottered, remove cotters to disassemble. If ballarm pins are riveted, grind off one end to disassemble and use new pins to reassemble.

Limit Pin: This pin must be tight in speed adjusting lever. Stake tight, if loose.

Pump Gears: The pump gears should be tested for free rotation as shown in Illustration No. 79. If gears turn roughly, inspect for nicks or wear of the gear teeth and interference at internal corners of bores for gears.

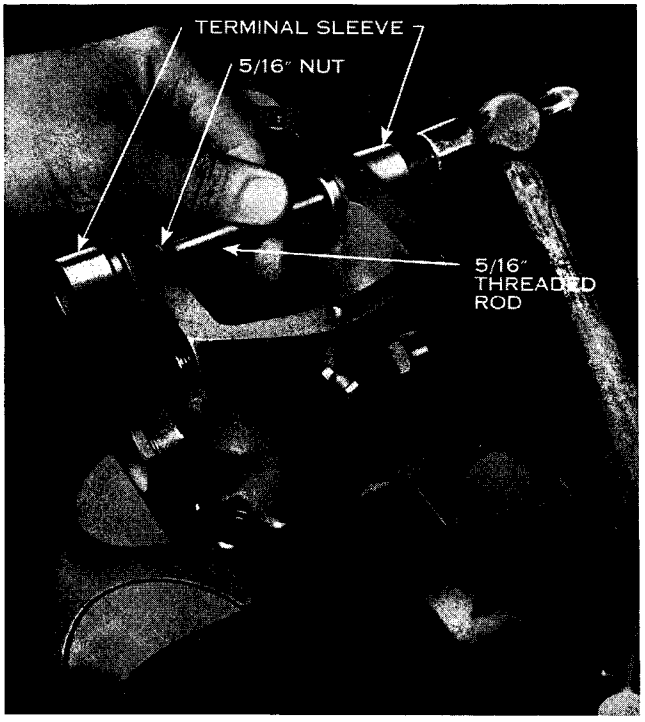


Illustration No. 76

Illustration No. 77

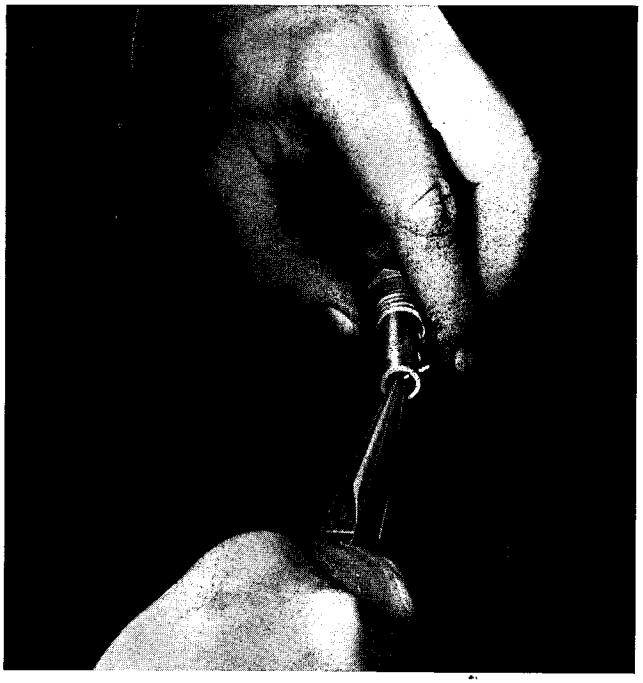


Illustration No. 78

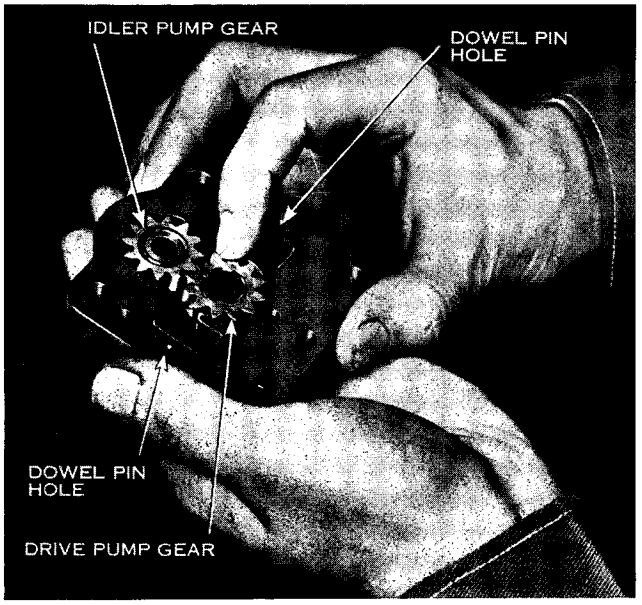


Illustration No. 79

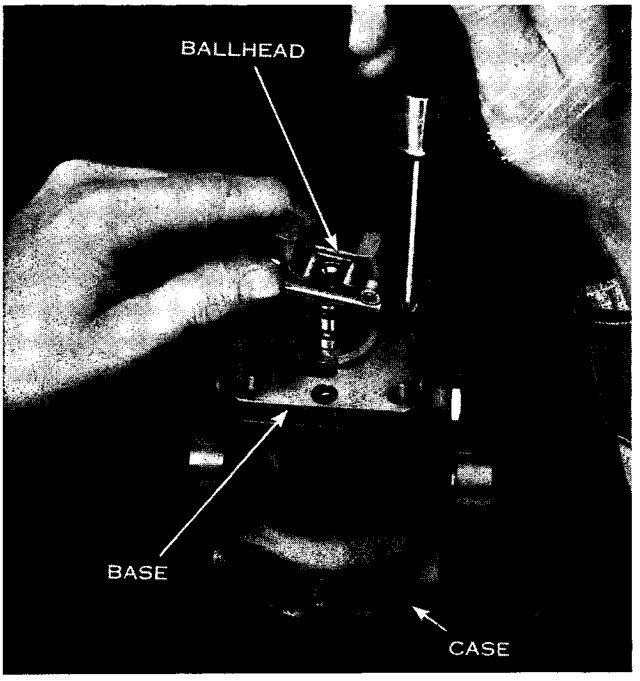


Illustration No. 80

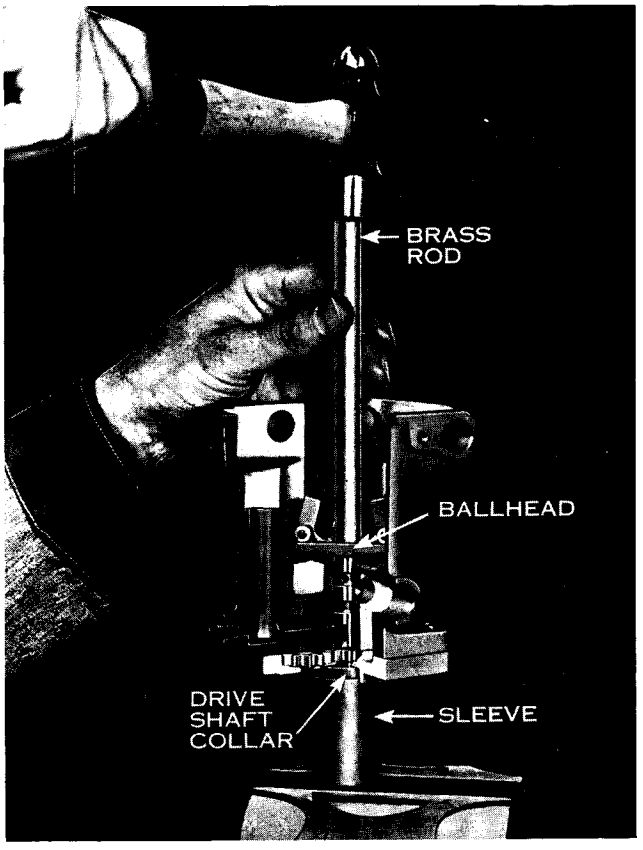


Illustration No. 81

ASSEMBLY INSTRUCTIONS:

Assembly of Base and Case:

1. Drive dowel pins out of base.
2. Place pump gears. Illustrations No. 74 and No. 79.
3. Coat surface of base with oil. Do not use shellac.
4. Place gasket (if used) on base spacing gasket evenly around edge of bores for gears. If the old gasket is damaged or compressed to less than .003" use a new .005" gasket. *Do not tap out a gasket* with a hammer, it will round the sharp edge at the bores for the pump gears resulting in excessive pump leakage.
5. Place case on base, invert and place ballhead through base and case, as shown in Illustration No. 80.
6. Insert three base screws and turn ballhead to obtain free rotation while tightening.
7. Insert dowel pins and set down below base surface approximately $\frac{1}{16}$". Use $\frac{3}{32}$" drift or rod.

8. Clamp a sleeve in vise, place ballhead in governor, place drive shaft collar on drive shaft, and drive collar onto drive shaft with 7/16" brass rod as shown in Illustration No. 81.
9. Tap end of drive shaft lightly with plastic hammer until ballhead and shaft turns freely with a minimum of end play. See Illustration No. 82.
10. Turn drive shaft with fingers. If it binds, loosen screws and free up by striking at corners of base, as shown in Illustration No. 83.

Assembly of Speeder Spring and Spring Fork: Press together in arbor press, as shown in Illustration No. 84.

Assembly of Pilot Valve Plunger, Speeder Spring and Spring Seat: Assemble parts in order shown in Illustration No. 86, and screw spring seat into spring.

Assembly of Terminal Sleeves and Case: If necessary to press terminal sleeves into case, insert support plate of exactly correct width between inside bosses of case. Press sleeves into case with arbor press.

Relief Valve: Put drop of oil into relief valve when reassembling.

Illustrations No. 85, No. 86 and No. 87 show the components of this governor.

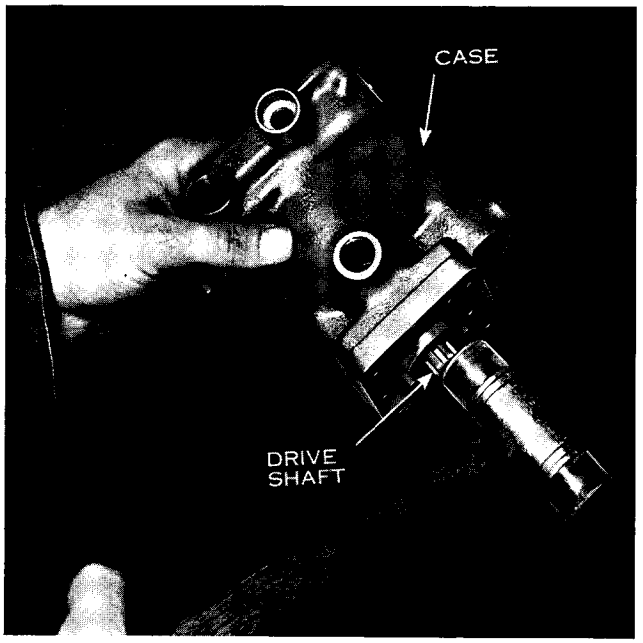


Illustration No. 82

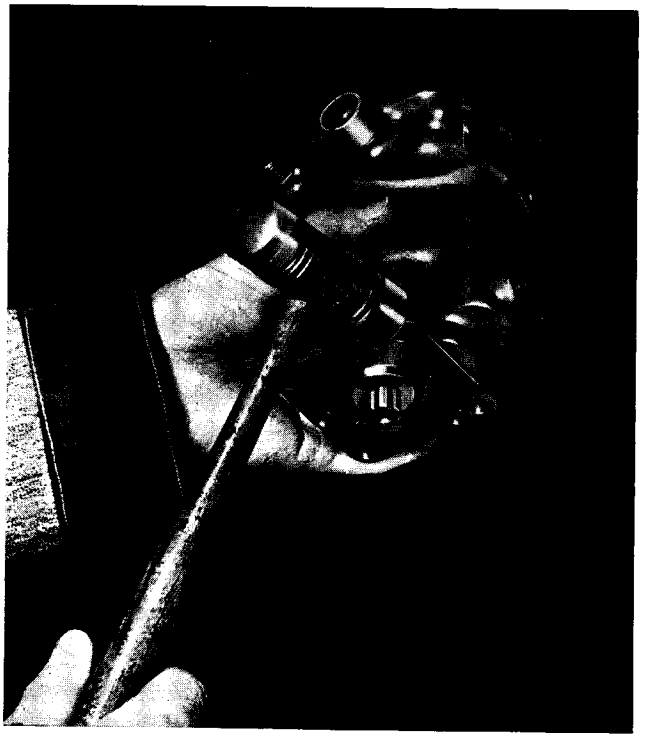


Illustration No. 83

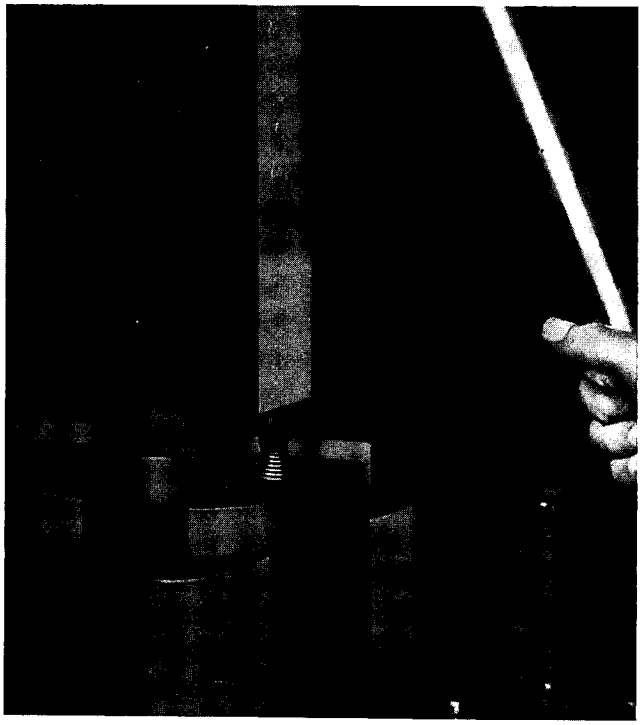


Illustration No. 84

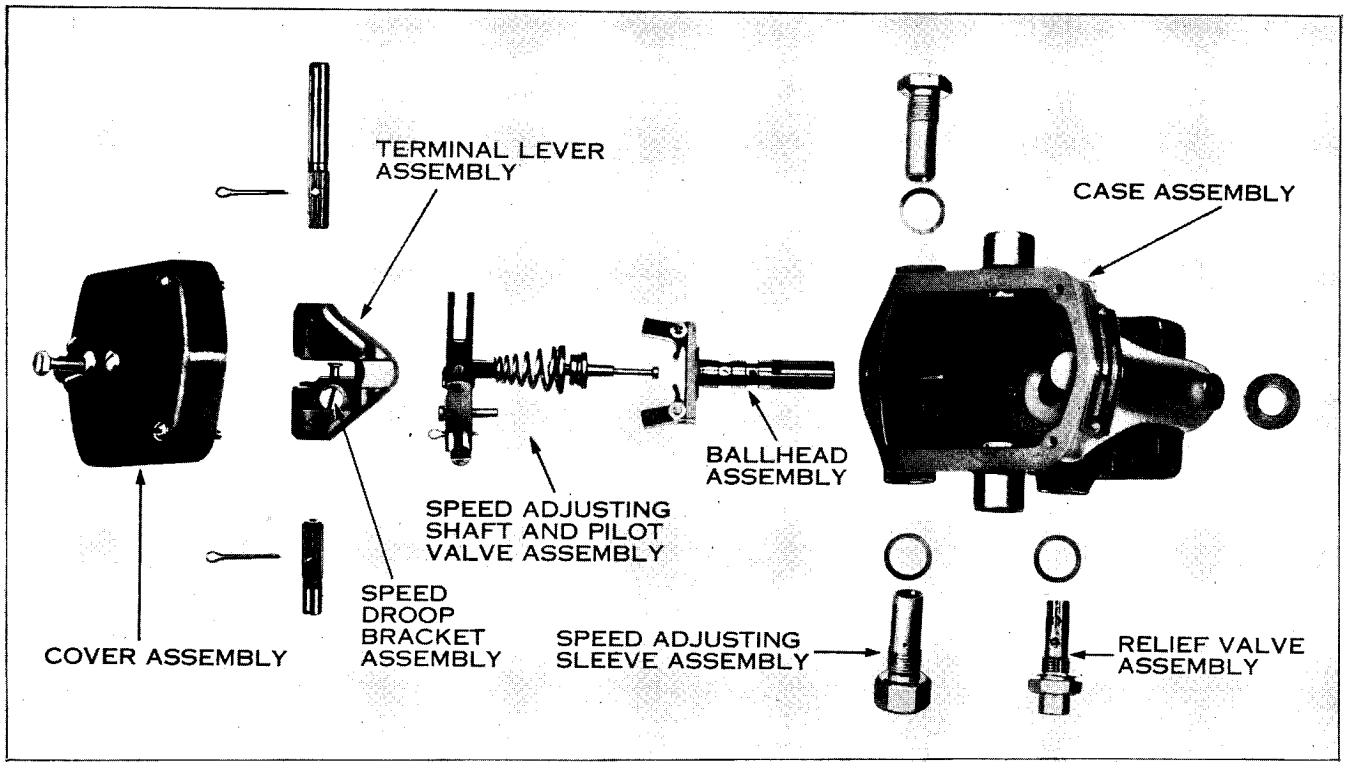


Illustration No. 85

THE USE OF PROPER LUBRICATING OIL FREQUENTLY CHANGED WILL REDUCE REPAIRS TO THIS GOVERNOR TO A MINIMUM. SHOULD REPAIRS BE NECESSARY EITHER PROCURE THE PROPER TOOLS OR RETURN GOVERNOR TO MANUFACTURER OR TAKE IT TO AN AUTHORIZED SERVICE STATION.

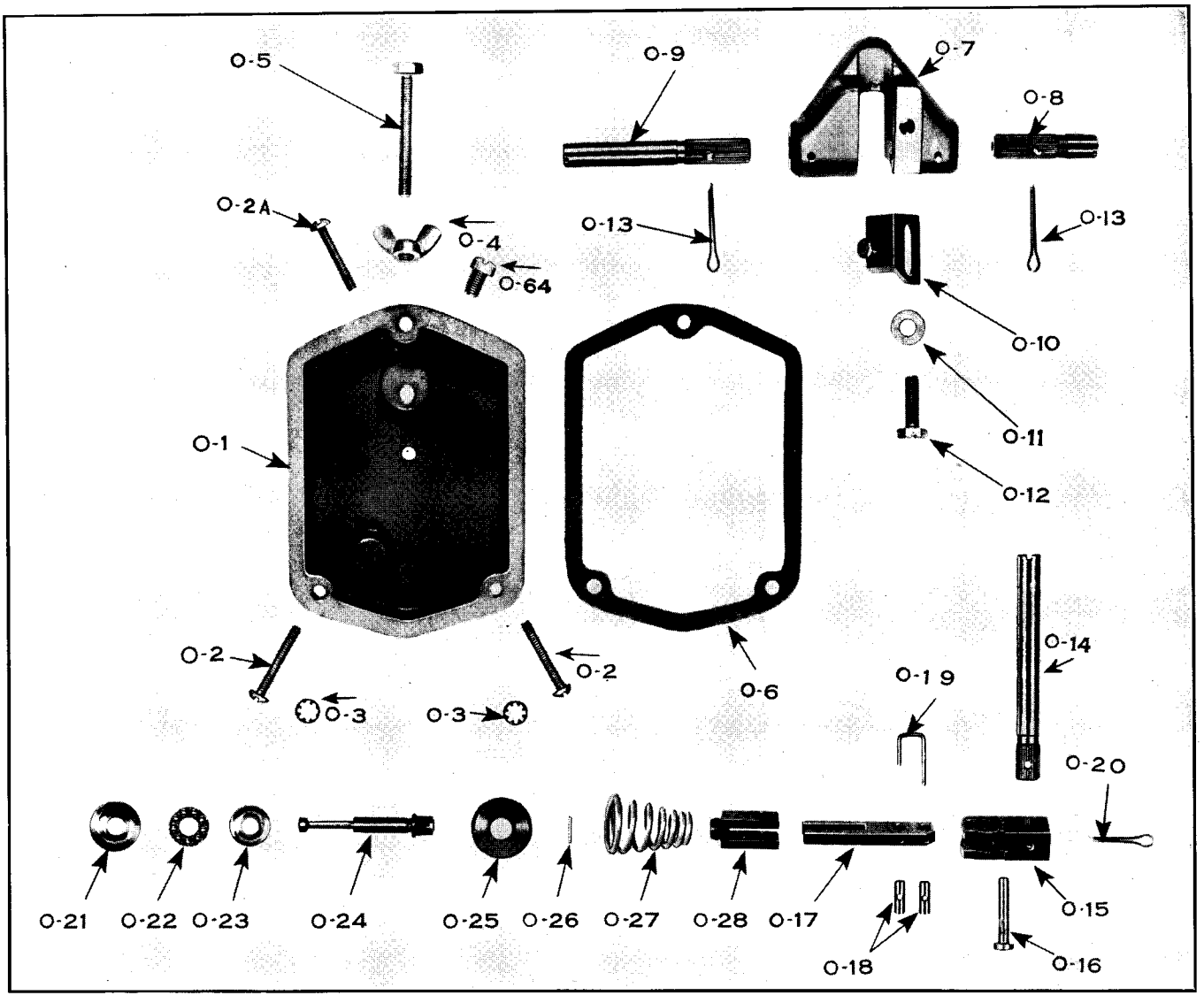


Illustration No. 86

Illustration Ref. No.	Name of Piece	No. Req'd
1	Cover	1
2	Cover Screw	3
3	No. 10 Shakeproof Washer	2
4	Wing Nut—Cadmium Plated	1
5	Screw (Low Adjustment)	1
6	Cover Gasket	1
7	Terminal Lever	1
8	Terminal Shaft (Short)	1
9	Terminal Shaft (Long)	1
10	Droop Adjusting Bracket Assembly	1
11	Speed Droop Washer	1
12	Speed Droop Adjusting Screw	1
13	3/32" Dia. Cotter Pin—1" long	2
14	Speed Adjusting Shaft	1
15	Speed Adjusting Lever	1
16	Speed Adjusting Lever Pin	1
17	Floating Lever	1
18	Spring Fork Pin	2
19	Lock Wire	1
20	3/32" Dia. Cotter Pin—5/8" long	1
21	Thrust Bearing Lower Race	1
22	Thrust Bearing Ball Cage	1
23	Thrust Bearing Upper Race	1
24	Pilot Valve Plunger	1
25	Spring Seat	1
26	Pin (Relief Valve and Spring Seat)	2
27	Speeder Spring	1
28	Spring Fork	1

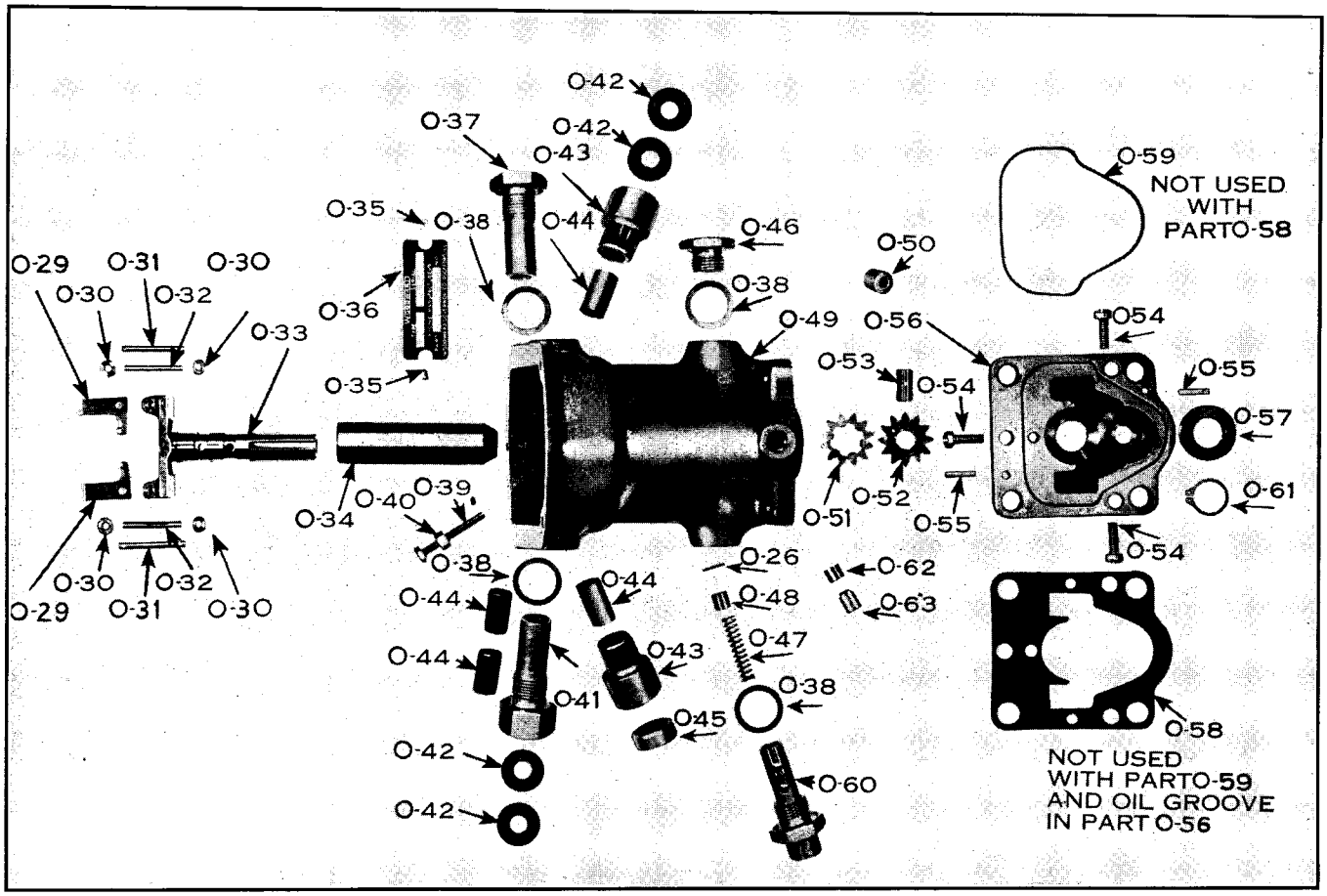


Illustration No. 87

Illustration Ref. No.	Name of Piece	No. Req'd
29	Ballarm	2
30	Ballarm Washer	4
31	Ballarm Pin— Cotter Pin Type (if used)	2
32	Ballarm Pin— Riveted Type (if used)	2
33	Ballhead and Pilot Valve Bushing	1
34	Power Piston	1
35	No. 2 Drive Screw	2
36	Nameplate	1
37	Spacer Cap	1
38	Copper Washer Gasket	4
39	Screw (High Limit Adjusting)	1
40	Speed Limit Nut	1
41	Speed Adjusting Sleeve	1
42	Synthetic Rubber Seal	4
43	Terminal Sleeve	2

Illustration Ref. No.	Name of Piece	No. Req'd
44	Oil Bronze Bushing	4
45	Welch Plug	1
46	Plug	1
47	Relief Valve Spring	1
48	Relief Valve Plunger	1
49	Governor Case	1
50	Pipe Plug	1
51	Pump Drive Gear	1
52	Pump Idler Gear	1
53	Idler Stud	1
54	Screw (Base)	3
55	Dowel Pin	2
56	Governor Base	1
57	Drive Shaft Collar	1
58	Base Gasket (If Used)	1
56	Base Seal Ring (If Used)	1
60	Relief Valve Sleeve	1

GENERAL DESCRIPTION AND MAINTENANCE

This section covers a brief description and function of the various parts of the engine along with instruction for repair, disassembly and reassembling of these component parts of the DFX and DFX-F series engines.

The various subjects are arranged alphabetically for convenience in locating.

This series of Hercules Diesel Engines is of the four stroke cycle type with a valve mechanism of the overhead type and with the cylinder block and crankcase cast integral. The crankshaft is supported in large main bearings with a diameter of 4½".

The general construction of the engine tends to produce a very rigid unit, since crankcase and cylinder block are in one piece; this results in maximum rigidity and minimum weight. In order to secure the high compression necessary for Diesel operation, the valves are located in the cylinder head.

The DFX series of Hercules Diesel engines consists of six models, the "DFXB", "DFXC", "DFXD", "DFXE" and "DFXH" differing primarily in bore diameter, and the "DFXH-F" which is a horizontal or "pancake" type engine, see Illustration No. 6.

The "DFXH-F" engines are built with the fuel pump mounted as shown in Illustration No. 6.

The remarks hereafter will refer to the series in general unless a specific model is discussed.

AIR CLEANER

There are many different types of air cleaners used, therefore, in a book of this size it is impossible to list or describe all of them. As the oil bath type is the one more commonly used and most efficient; it is the easiest to clean and service, the servicing of only this type is discussed.

These units should be cleaned at least once a day and if working in very dusty conditions they should be cleaned every six to eight hours.

Illustration No. 88

TO CLEAN:

1. Unscrew the winged nut or knurled knob on top of the filter, and lift the screen and cover from the filter.

2. Wash the screen in clean kerosene, fuel oil or gasoline. If compressed air is available, blow dry, blowing from inside to outside. If after first washing it still appears dirty, wash again and repeat until clean. Lay this unit after it is clean on a piece of clean paper.

3. Remove lower shell, empty the oil, and wash the shell as above. Some of these units have a baffle plate in the bottom; remove this before cleaning as most of the dirt will be found under this plate.

4. Replace lower shell and baffle, if used, and fill with clean lubricating oil (same grade as used in engine or S.A.E. 30) to bead, as indicated by arrow in Illustration No. 88.

5. Before installing the screen inspect gasket and if torn or broken, replace. Now dip the screen or unit in clean lubricating oil and install. This operation is essential since this unit if unoiled will absorb the oil from the lower unit thus reducing the amount of oil to a point which efficient air cleaning action is no longer available.

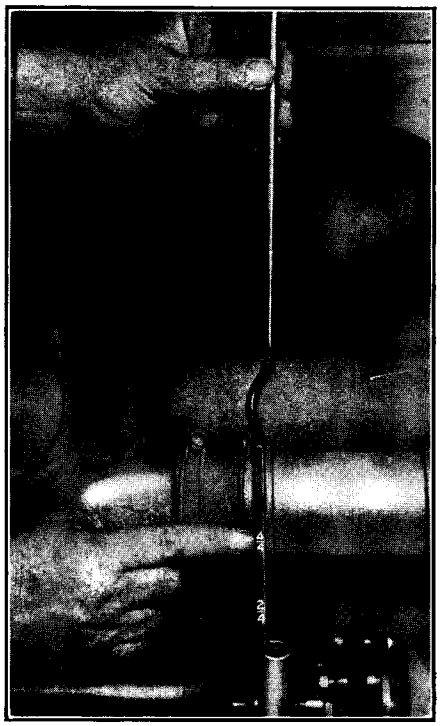


Illustration No. 89

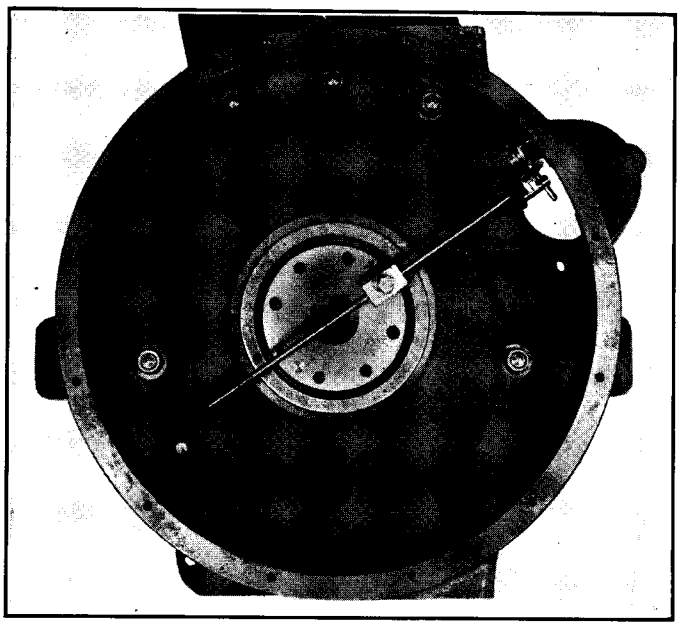


Illustration No. 90

BAYONET GAUGE

The bayonet gauge is used to determine the amount of oil in the oil pan and is readily accessible. See Illustration No. 89. The oil level in the oil pan should always be maintained at or near the 4-4 mark. Never allow level to go below 2-4 mark. Illustration No. 89.

BELLHOUSING OR FLYWHEEL HOUSING

The bellhousing is a casting which not only covers the rear end of the block and oil pan but also forms a housing for the flywheel and clutch. It also is the rear motor support and to it the transmission is fastened.

TO REMOVE BELLHOUSING

1. Drain crankcase oil.
2. Remove clutch.
3. Remove flywheel. See Page 96.
4. If engine is in unit, place suitable supports under the rear of oil pan to support engine. Block must be large enough so that oil pan is not damaged. Do not use jack unless large block is placed between jack screw and oil pan.
5. Remove rear motor support screws.
6. Remove bellhousing attaching screws.
7. Pull bellhousing away from engine. It may be necessary to tap housing with a soft hammer to loosen from saddle or gasket sticking to block.

TO INSTALL BELLHOUSING

1. Cement new gasket to bellhousing, allowing cement to dry sufficiently so gasket will not skid.
2. Assemble bellhousing to engine. Tighten the screws so that they are almost tight.
3. With dial indicator mounted as shown in Illustration No. 90, check concentricity of bellhousing bore with crankshaft. (This should be within .010"). The bellhousing may be shifted slightly on the screws if necessary. When bellhousing is properly centered, tighten attaching screws and install rear motor support screws. Recheck after tightening, as housing may have moved during this operation.

4. Set indicator as shown in Illustration No. 91 and check face of bellhousing. This should not exceed .006", out of square.
5. With the crankshaft pushed to the rear of the engine, check bellhousing to crankshaft champfer clearance. This should be from .014" to .020". Illustration No. 92.
6. Install new oil seal in bellhousing. Illustration No. 93.
7. Inspect flywheel oil seal surface for any possible nicks or rough places. A piece of Crocus cloth or very fine emery cloth may be used to polish this surface. Illustration No. 94.
8. Assemble flywheel to engine. (A thin coating of oil soap applied to the oil seal will be found beneficial during the run-in period).
9. Assemble clutch to flywheel.

BELLHOUSING OIL SEAL

Illustration No. 94 shows a section through the flywheel, flywheel housing, crankshaft and seal. This seal is of patented type using leather or synthetic rubber as the sealing material and supported in a steel housing. Proper sealing depends on the flywheel pilot surface being polished so as to not cause seal to wear rapidly. Be sure all "nicks" or rough spots are off this part. If necessary polish with "Crocus" cloth.

The clearance between the housing chamfer and the crankshaft flange should be maintained between .014" and .020" to eliminate possibility of rear end oil leaks.

BREATHER AND OIL FILLER

The breather is used to keep dust and dirt from entering the crankcase. It must be serviced regularly. It is very easy to service and should be cleaned at frequent intervals.

CAMSHAFT

The camshaft is supported in large diameter bearings in the crankcase; these bearings are removable and can be renewed. It is driven by means of a suitable gear which meshes with the crankshaft gear. The timing of these two gears requires no check of position of the valve. It is only necessary to line up the punch marks on the two gears, the cam gear being shown as B and the crank gear as A in Illustration No. 95. Also see A and B, Illustration No. 96. Illustration No. 99 shows the flywheel timing diagram.

The camshaft is seldom removed other than at a major overhaul with the motor out of the unit. Therefore, it becomes an easy task to remove the camshaft. With the cylinder head, oil pan and gear cover removed it is necessary to have the tappets in raised position, then pull the camshaft forward out of the engine. This is easily accomplished if the engine is set on bellhousing end or laid on cylinder head studs.

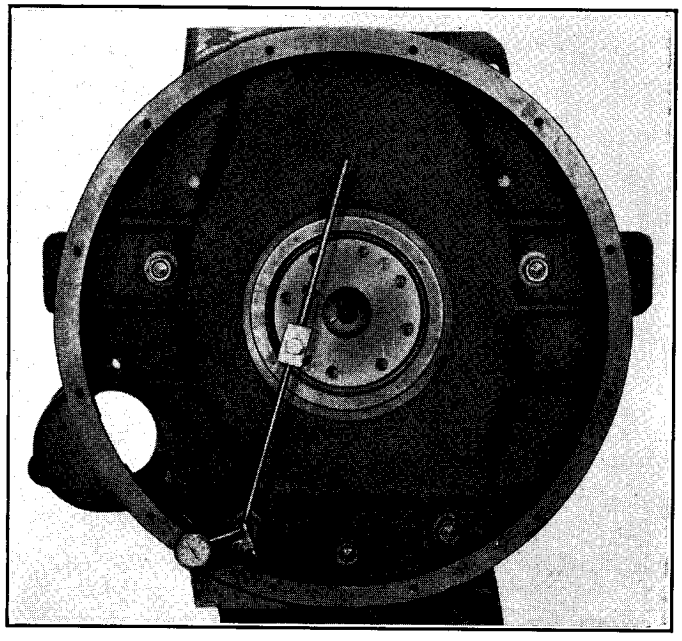


Illustration No. 91

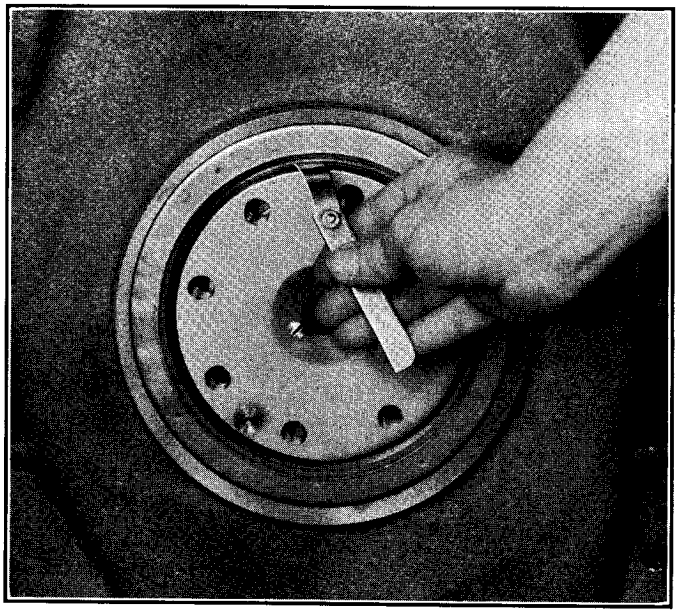


Illustration No. 92

The camshaft gear may be removed in the following manner if no puller is available.

Remove the lockwire from the three screws.

Turn the screws out until they bear on the sprocket. Then turn each screw alternately so that the sprocket is pushed from the camshaft. It will be necessary to use spacers between the screw heads and the sprocket to completely remove the sprocket.

The camshaft gear is then pulled forward from the camshaft.

If new camshaft bearings are needed, drive out old bearings with driver (13298-A). See Illustration No. 97. The same driver may be used to drive in the new bearings. See Illustration No. 98. These bearings are cut to allow for the press fit when the bearings are installed in the case. Therefore, no reaming should be necessary. However, the shaft should be checked in the bearings for proper clearance of .0015" to .0025".

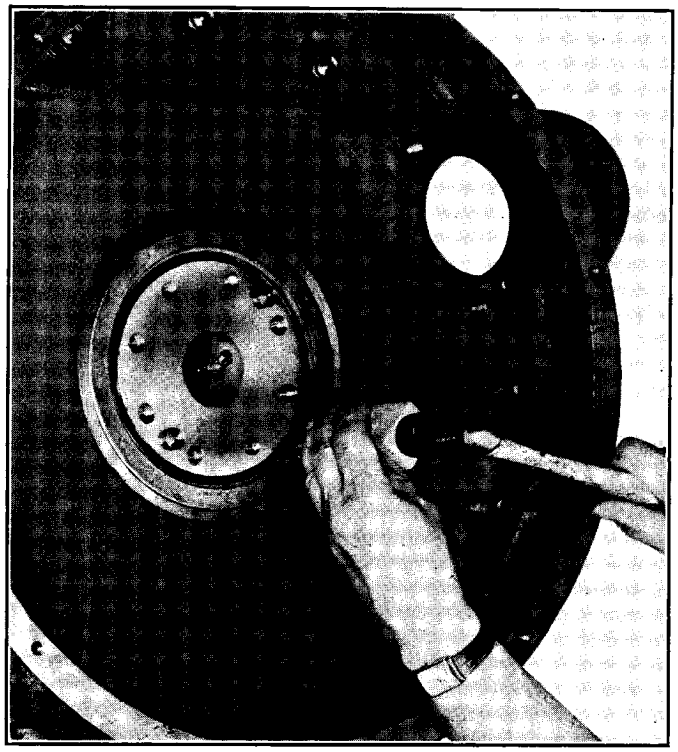


Illustration No. 93

CAMSHAFT DRIVE

The camshaft is driven by means of a suitable gear which meshes with the crankshaft gear. The timing of these two gears requires no check of position of the valves. It is simply necessary to line up the punch marks on the two gears, the cam gear being shown as B and the crank gear as A, Illustration No. 95, and No. 96, also see Fuel Pump Drive Chain, page 94 and Timing Gears, page 110.

CAMSHAFT AND FUEL PUMP DRIVE END PLAY ADJUSTMENT

The end movement of these shafts is adjusted by means of shims placed between the gear cover and the thrust plates on castings shown as 1 and 2 in Illustration No. 100. The removal of shims will permit the plates to be re-assembled so as to take up any end play. Care must be exercised to prevent taking out too many shims, as this would throw a heavy thrust load on various thrust bearings. Also see 5 and 6, Illustration No. 111.

One way of checking this condition is by putting a thin layer of Prussian Blue on the thrust surface, then bolt the plates into position, turn the engine over carefully one or two revolutions, remove the plate and observe the contact surface. If this shows a definite pressure the adjustment is too close, a clearance should be permitted for expansion of the various parts when they become hot. See clearance table on page 124.

CONNECTING ROD

The nominal diameter of the connecting rod journal is $3\frac{5}{16}$". The connecting rod bearings are of the precision shell type, and the bearing metal used is of various types of alloy metal. Shims are not used between the connecting rod and the cap. The shells are held in place and rotation is prevented by means of an ear on the shell at the split line. The connecting rod is drilled, permitting oil to pass from the big end bearing up to the piston pin. Illustration No. 101 shows the connecting rod and its various parts.

CAUTION: When removing piston and connecting rod from the cylinder bore the carbon which has collected at the top of the cylinder bore may make it necessary to use considerable force to push the piston out of the cylinder. Removal of the carbon around the top of the bore will make piston removal much easier. In order to prevent scratching the cylinder bore while forcing the piston and rod assembly out, it is advisable to either wrap the lower end of the connecting rod with a rag. Illustration No. 102, or place two

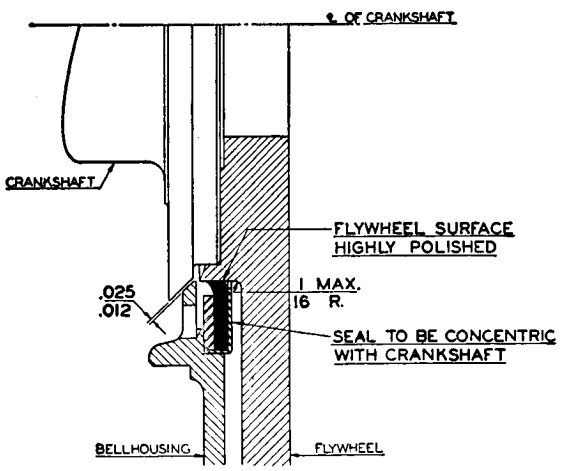


Illustration No. 94

strips of thin wood or cardboard between the rod and the cylinder wall. Then if the rod rocks it will not gouge or scratch the cylinder wall.
NOTE: As built at the factory the connecting rods and caps are marked on the camshaft side and to the front of the engine with the cylinder number in which they are used.

CONNECTING ROD BEARING ADJUSTMENT

Due to absence of shims adjustment of connecting rods is made by replacing of the bearing shells. A clearance of .0035" to .0045" is recommended between the connecting rod journal and the connecting rod shells. Should wear of journal cause this clearance to be more, then it is necessary to regrind the crankshaft and use undersize bearing shells.

WARNING: Do not file or grind caps as new bearings cannot be installed in a rod that has been filed or ground.

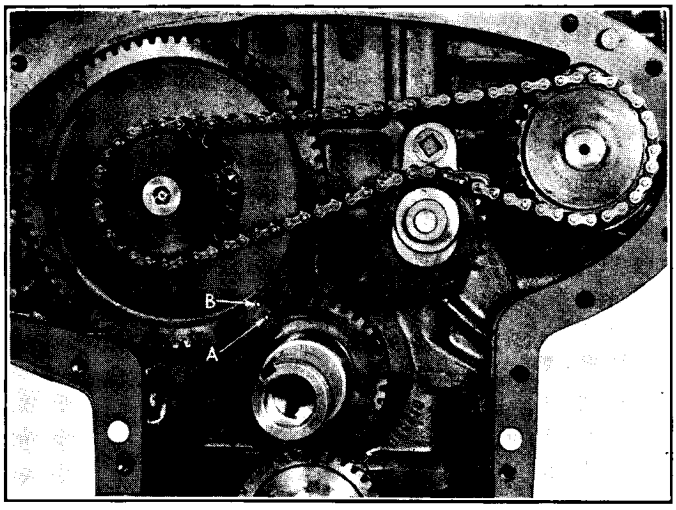


Illustration No. 95

TO REMOVE CONNECTING RODS

CAUTION: Connecting rods and caps are matched — keep these paired together as otherwise they cannot be reinstalled.

1. Remove oil pan.
2. Remove cylinder head.
3. It is not necessary to remove oil pump, However the oil lines should be removed.
4. Turn the crankshaft until the rod is in position for removal of cap, then remove cap and nuts.
5. With a soft hammer (such as plastic or fiber) tap the rod to loosen and remove cap.
6. With a suitable piece of wood, Illustration No. 102, push the piston and connecting rod out through the cylinder bore. Use care that the connecting rod does not scratch the cylinder wall. To insure against scratching, wrap lower part of rod with a wiping cloth.
7. Repeat the above operation for each connecting rod or a quicker method is to remove the two caps that are down at the same time.

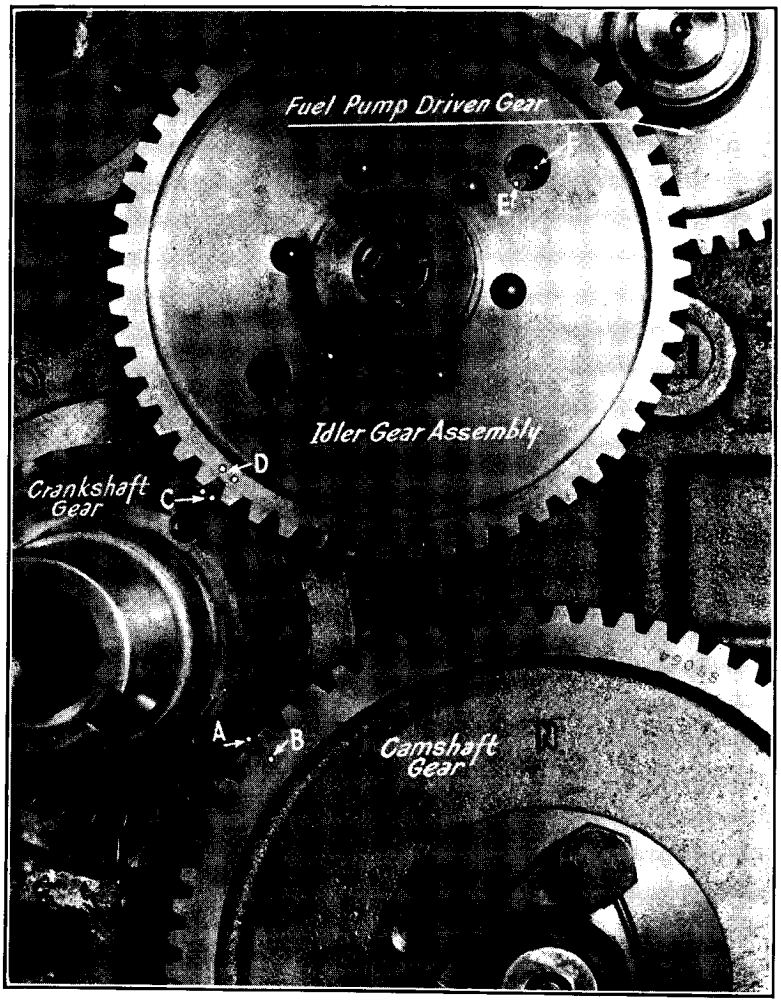


Illustration No. 96

TO REPLACE CONNECTING RODS AND PISTONS

1. Inspect the crankshaft for any rough or scored marks that might damage the new bearings. If any rough spots are found, use an oil stone, very fine emery cloth or crocus cloth to polish the shaft. Clean shaft thoroughly after polishing.

2. Select the proper piston and connecting rod assembly and turn the crankshaft so that it is in correct position.
3. With the piston rings compressed as shown in Illustration No. 103, use a hammer handle or block of wood to force the piston and rings into the cylinder bore. At the same time use care that the connecting rod is in line with the crankshaft journal.
4. With the piston entirely in cylinder bore, insert upper shell and pull connecting rod down to crankshaft.
5. Place a ¼"x½"x.004" piece of feeler stock in the cap. Place the lower shell in the cap and assemble the cap to the connecting rod. Tighten the cap nuts to proper tension and try the connecting rod for side movement. The connecting rod should move sideways with a firm pressure of the hands. After obtaining the proper movement of the rod in the above manner, remove the piece of feeler stock and reassemble the connecting rod cap. Tighten the nuts as before and and again try the side movement of the rod. It should move easily.
6. Assemble the cap to the connecting rod. Draw up the cap to proper tension. See chart on page 123. If no torque wrench is available this tension would require a tight pull on a 20" wrench. Illustration No. 104 shows use of torque tension wrench.
7. Repeat the above operations for all connecting rods.
8. Lock nuts as they were when removed.

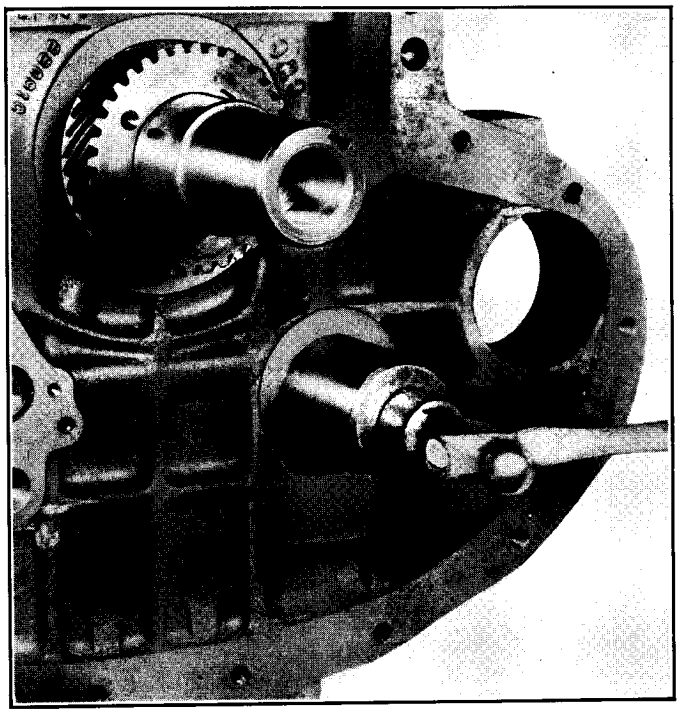


Illustration No. 97

CONNECTING ROD BEARING REPLACEMENT

If excessive clearance develops between shaft and bearing shells, new bearing shells should be installed. If the clearance is excessive with the new bearings, regrind the shaft and use undersize bearings.

The connecting rod bearing shells may be replaced as outlined below.

1. Remove oil pan.
2. Remove oil lines.
3. Locate crankshaft so connecting rod cap can be removed.
4. Remove cap nuts.
5. With a soft hammer, tap the cap lightly to loosen it and remove the cap.
6. Replace bearing shells as outlined under 4, 5, 6, 7 and 8 above.
7. Reassemble oil pan to engine.

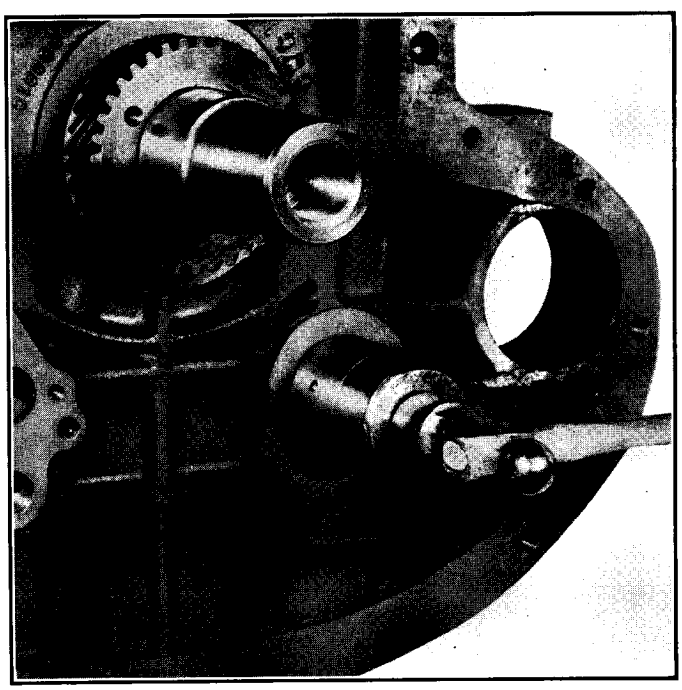


Illustration No. 98

COMBUSTION CHAMBER

The combustion chamber into which the air is compressed at the end of the compression stroke is located at one side of the cylinder bore, and is lined with two removable sections—one spherical shaped, No. 1, Illustration No. 105, which is located in the portion of the combustion chamber machined in the cylinder block while a cover section, No. 2, Illustration No. 105, extends up into a recess in the cylinder head.

When any of these parts are replaced, care must be used in replacing the cylinder head to make sure that the head does not rest on top of the combustion chamber liner, preventing the head being drawn down tight on the gasket. If this condition should be found to exist, file off a portion of the top of the upper liner Cover chambers with graphite grease when installing. The spherical section has a lip which is directly opposite the injection nozzle.

COOLING SYSTEM

Perhaps the best method for care of the cooling system is to clean and flush the system periodically, also use some good rust and corrosion preventive between cleaning periods. Almost all natural water contains some mineral salts which stimulate corrosion.

Exhaust gas leakage between cylinder head and gasket also results in corrosion since exhaust gases discharge into the water, combining to form a variety of acids such as carbonic, nitrous and sulphurous acids, all supporting electrolytic corrosion. It is therefore imporant that the cylinder head stud nuts be drawn down at regular and frequent intervals to prevent exhaust gases from leaking into the water jacket, by retightening the cylinder head stud nuts every 30 days or 2000 miles, as the case may be.

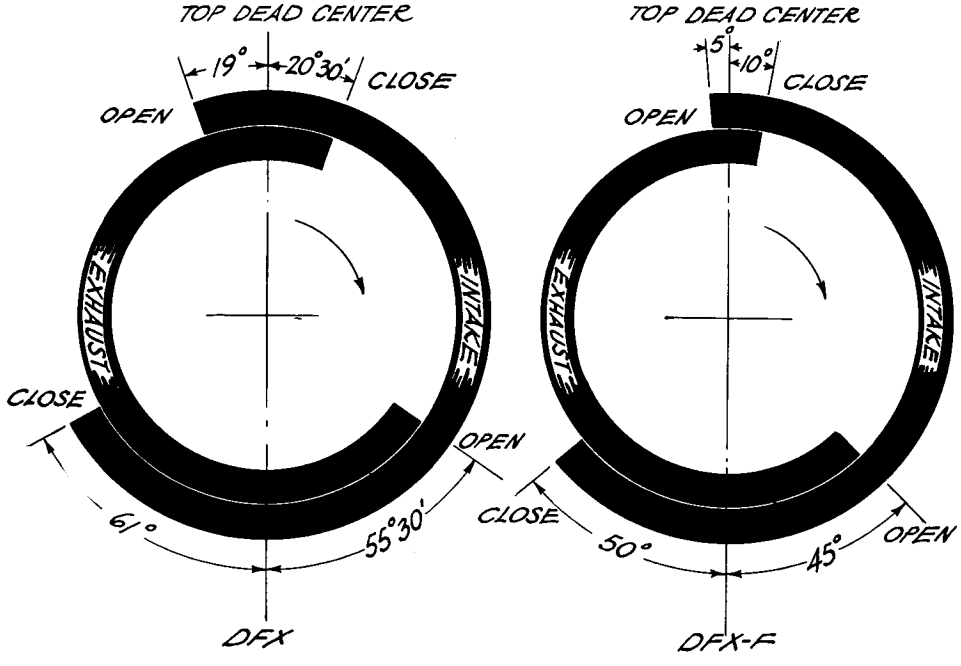


Illustration No. 99

Air leaks around the hose connections and through the water pump should be carefully guarded against, since oxygen is a major factor in promoting corrosion. Check the hose connections frequently for air leaks.

Use a good commercial neutralizer in the cooling system—one purchased from reputable companies, to obtain best results follow instructions of the manufacturer.

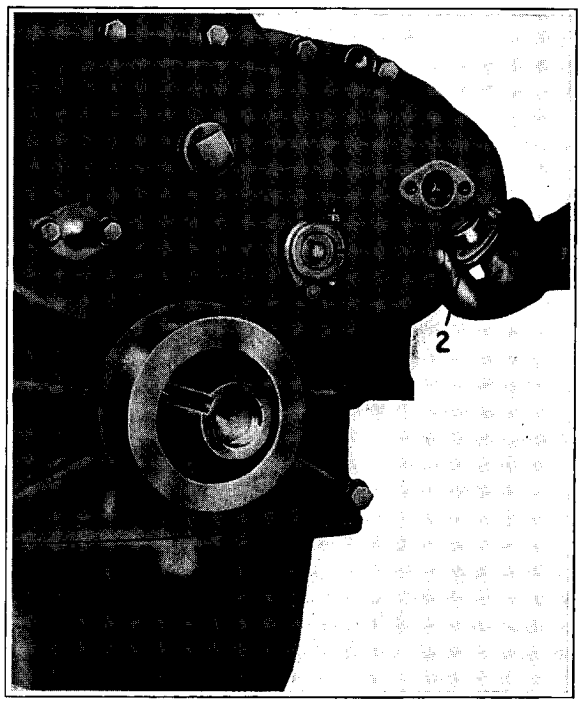


Illustration No. 100

CRANKCASE AND CYLINDER BLOCK

The combination of cylinder block and crankcase in one piece permits carrying the water jacket the full length of the cylinder bore. This results in uniform cooling of the piston and cylinder wall and has a very definite bearing upon maintenance of lower temperatures than is possible with any other type of construction. The most casual inspection of the cylinder block will disclose the rigid construction provided to support the main bearings and crankshaft, and this rigidity coupled with the extremely large diameter of the crankshaft results in a very smooth running engine, free from destructive vibration.

Illustration No. 105 gives the relation of various parts as shown from the top. No. 1 is the lower combustion chamber liner, No. 2 is the upper combustion chamber liner, No. 3 is the dowel which locks the liner in the block at provision No. 4 so that it cannot turn and block the opening. Illustration No. 104 shows view of crankcase from bottom.

CRANKSHAFT

The crankshaft is a machined forging having all bearing journals surface hardened by an electric induction process. The nominal diameter of the main bearing journals is 4½" while the nominal diameter of the connecting rod journals is $3\frac{5}{16}$". The shaft has drilled passages to carry oil under pressure to the connecting rod bearings. These passages should be cleaned with a wire brush. See Illustration No. 106 before shaft is installed in engine. (The crankshaft shown is not used in the DFX series engines).

While the diameters given above are only nominal, the following table gives actual sizes, both standard and undersize, to which the shaft may be reground.

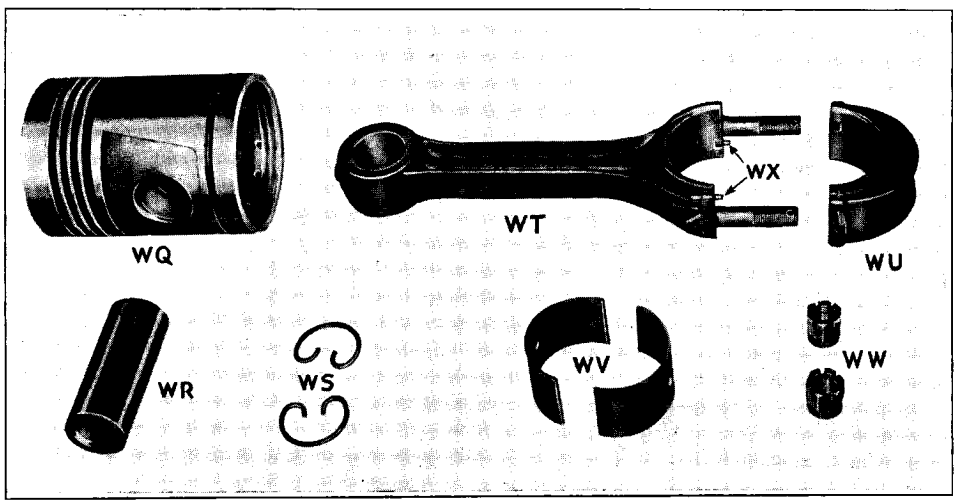


Illustration No. 101

Size	Main	Connecting Rod
Standard	4.500-4.499"	3.310-3.309"
.020" U. S.	4.480-4.479"	3.290-3.289"
.040" U. S.	4.460-4.459"	3.270-3.269"
.060" U. S.	4.440-4.439"	3.250-3.249"

To replace crankshaft main bearings, see Page 100. To replace crankshaft connecting rod bearing, see Page 87.

TO REMOVE CRANKSHAFT GEAR

If a suitable arbor press is not available the following method may be used. Due to the extremely tight fit of the crankshaft gear on the crankshaft, it is almost impossible to pull this gear with any of the commercial pullers. Since replacement of this gear would only be brought about by the gear being badly worn or damaged, it may be removed in the following manner. Using a ¼" diameter drill centered midway between the edge of the keyway and the base of the gear teeth drill through the gear parallel with the keyway, then spread the gear with a chisel and pull from shaft.

CAUTION: Be careful not to drill into the crankshaft.

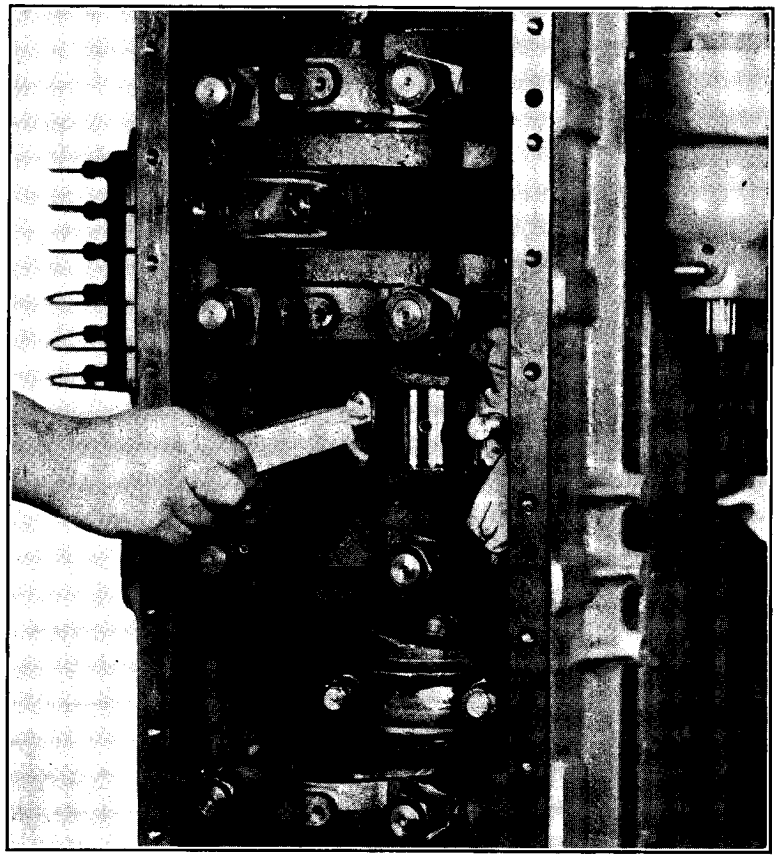


Illustration No. 102

TO INSTALL NEW CRANKSHAFT GEAR

1. Insert the Woodruff Key in the shaft.

2. Lay the gear on a sheet of asbestos or other fireproof material and heat the gear with a blow torch evenly on both sides until the gear turns a pale straw yellow. (If the gear is clean and untarnished, this color will indicate it is heated to approximately 450° F.).

3. Assemble the hot gear on the crankshaft and with suitable driver quickly force the gear into correct position. A piece of 3" diameter pipe may be used as a driver.

4. Allow the gear and shaft to cool.

CYLINDER HEADS

The cylinder heads are detachable. They are made of cast iron, cast three cylinders per head. Front and rear heads are interchangable. The valve seats and the valve guides are a part of these castings although the valve guide bushings are removable. The heads are held to the cylinder block by a number of strong studs, and in order to insure against leaks the heads must be carefully drawn down by means of the stud nuts which should be progressively tightened, working from the center of the head towards the ends and sides.

A torque wrench is recommended for this operation, see Page 123 for recommended tensions. If a tension type wrench is not available a wrench approximately 24" long should be used for this operation.

CYLINDER HEAD GASKET

The cylinder head gaskets are made of solid sheet copper which is carefully annealed in order to make the copper as soft as commercially practicable. When the gaskets are placed on the cylinder block, or the cylinder heads are installed on top of the gaskets great care must be exercised to prevent any dirt or foreign matter lodging between the gaskets and cylinder heads or cylinder block. If the gaskets becomes deeply scratched or marred a new gasket should be installed. Clean a used gasket thoroughly, removing all carbon and sealing compound before putting it on engine. When installing use a plastic sealing compound to insure a leakproof installation.

Illustration No. 103

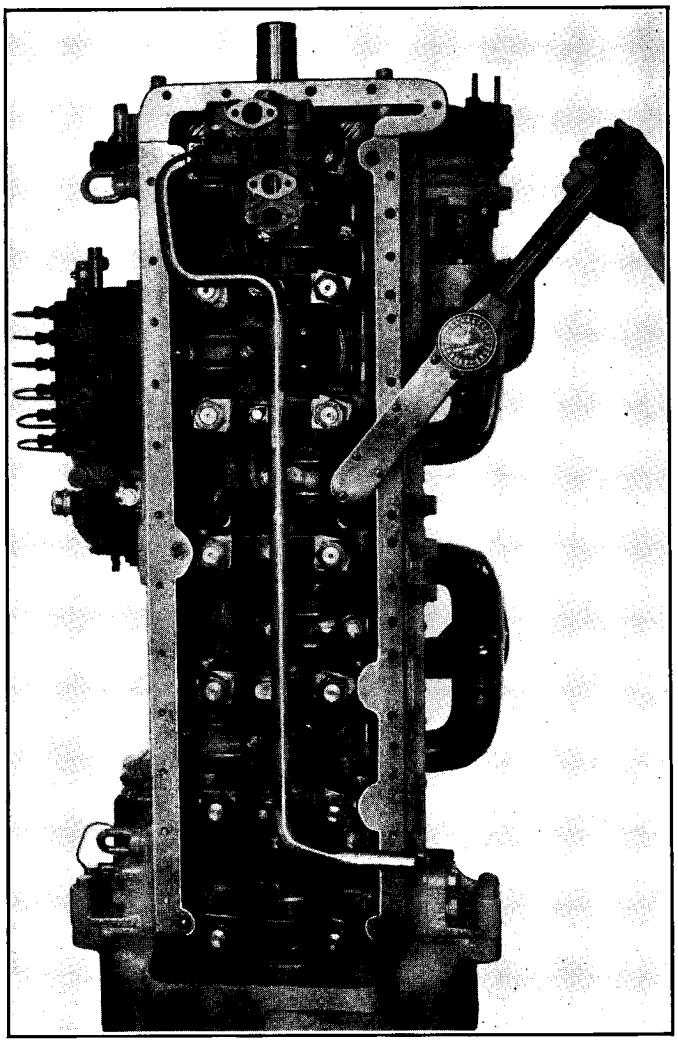


Illustration No. 104

CYLINDER SLEEVES OR LINERS

The cylinder sleeves or liners are of the dry replaceable type. These liners do not come in contact with the cooling solution and are installed with a tight press fit. Therefore, it is necessary to oil the sleeve or coat with white lead mixed with oil before attempting to install them.

INSTRUCTIONS FOR REMOVAL AND INSTALLATION

Two types of sleeve fixtures have been used, Illustration No. 107 shows one type, for latest type see Page 125 and Illustrations No. 164, 165 and 166.

Illustration No. 107 shows the position of the sleeve puller (designed and manufactured by the Hercules Motors Corporation) for removing and installing the dry type cylinder sleeves or liners, all necessary instructions are incorporated in this illustration.

Be sure to grease upper bearing through Zerk fitting before pulling out or pressing in each sleeve. Also oil sleeve before installing otherwise it may score the cylinder block sleeve bore or stick.

After sleeve is installed, hone or lap so as to obtain proper piston clearances as shown in Table of Clearances, page 124.

FAN ASSEMBLY (COOLING)

The cooling fan mounted on the front of the cylinder block is driven from a pulley mounted on the crankshaft by the use of "vee" belts. Various types of fans, drive pulleys, vacuum pumps, air compressors or generators may be driven from the fan belts. Therefore, it is not possible to list fan belt specifications.

The fan has a self contained lubrication system which should be checked frequently. See Illustration No. 108. The lubrication system may vary with different types of fans, but all types should receive systematic care.

FAN LUBRICATION

The fan is lubricated at assembly with a sodium soap grease, of the following specifications:

Soda Soap ----------11-12%
Oil ----------86-88%
Oil Viscosity @ 100°----------140-160
Trade Standard No. 1½---(Consistency)
Dropping ----------300°

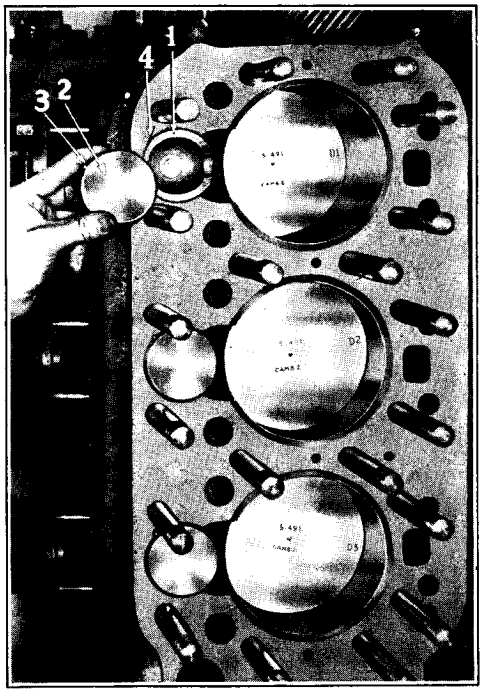


Illustration No. 105

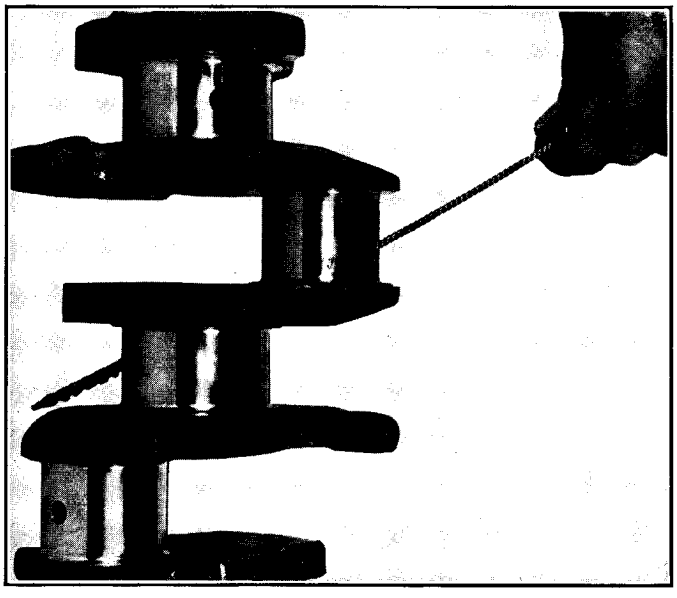


Illustration No. 106

similar to Standard Oil Company of Indiana, Oneida Grease, of high enough melting point so that the oil is fed to the bearings very sparingly. There is enough lubricant in the fan, when it leaves the factory, to last for 1,000 hours or 25,000 miles of operation. To add lubricant to the fan, remove the pipe plug in the fan hub, Illustration No. 108, add the lubrication and replace the plug.

CAUTION: If a grease fitting is installed in the fan hub when greasing the fan, be sure to remove the fitting and assemble pipe plug in the opening as centrifugal force may throw the grease out through the grease fitting or the weight of the grease fitting may so unbalance the fan that the shaft will break.

FILTERS

(AIR, FUEL OIL AND LUBRICATING OIL)

Since dirt is the greatest enemy of any internal combustion engine, it is necessary to take every precaution to exclude it from the engine. To help keep this dirt out of your Diesel engine the Hercules Motors Corporation has installed the type of filters which they have found by experience to best fulfill the various requirements of their engine. However, these filters cannot continue to keep the engine clean internally unless given intelligent care and serviced frequently. On each filter there appears an instruction plate which if followed will help in servicing these engines. (Certain special filter installations are not covered in this book).

FUEL OIL FILTERS

Because of the extremely accurate construction of the various parts of the fuel injection system and since repairs to these units are quite expensive, the Hercules Motors Corporation has worked out a filtering system which with intelligent care will reduce the wear on the accurately fitted parts of the injection system. This filtering system contains the following filters:

A dual, special metal unit, filter between the fuel tank and the fuel transfer pump. This unit is to remove the larger particles of dirt and water and some are equipped with a knife cleaner.

A metal and cloth combination final filter is installed between the fuel transfer pump and the fuel injection pump; this unit is shown in Illustration No. 109.

On some installations the final filter is of the sealed type instead of the metal and cloth combination. Units having this type of filter are generally equipped with a pressure gauge and the entire filter unit should be replaced with a new one (which should be carried in stock) when the pressure gauge hand remains in the red division of the gauge, which is usually less than five pounds. On units not equipped with a gauge, replace the filter when engine power falls off due to clogging of the filter and insufficient fuel reaching the fuel injection pump manifold.

In addition to these filters, each fuel nozzle has a stem filter shown as 1 in Illustration No. 25. The cleaning of this filter is covered under section about the care of nozzles, page 35.

TO CLEAN FUEL FILTERS

The dual filter some of which are equipped with a cleaning knife should have the turning handles on top turned once a day; this wipes off the largest pieces of dirt and drops of water which have been caught on the element. ONCE A WEEK the drain plug at the bottom of each case should be removed and this dirt and water allowed to flow out. After turning handle, check the packing nut around the stem, making sure it is tight. Filters not equipped with knife should be disassembled and cleaned weekly.

To reduce the amount of cleaning the filters should receive, insist on the fuel oil being clean and then handle it with clean containers. The filter unit should be removed every week or 100 hours operation and washed in clean gasoline, kerosene or fuel oil, since this unit is constructed with very fine spacing between the brass strips. Do not use a wire brush or hard instrument to scrape sludge but wash with a clean cloth or soft bristle brush. Frequency of cleaning is determined by the amount of dirt and gum or wax in the fuel oil.

The final filter shown in Illustrations No. 109 and No. 110, which is between the fuel transfer pump and the fuel injection pump contains a metal element surrounded by a fabric element which should be

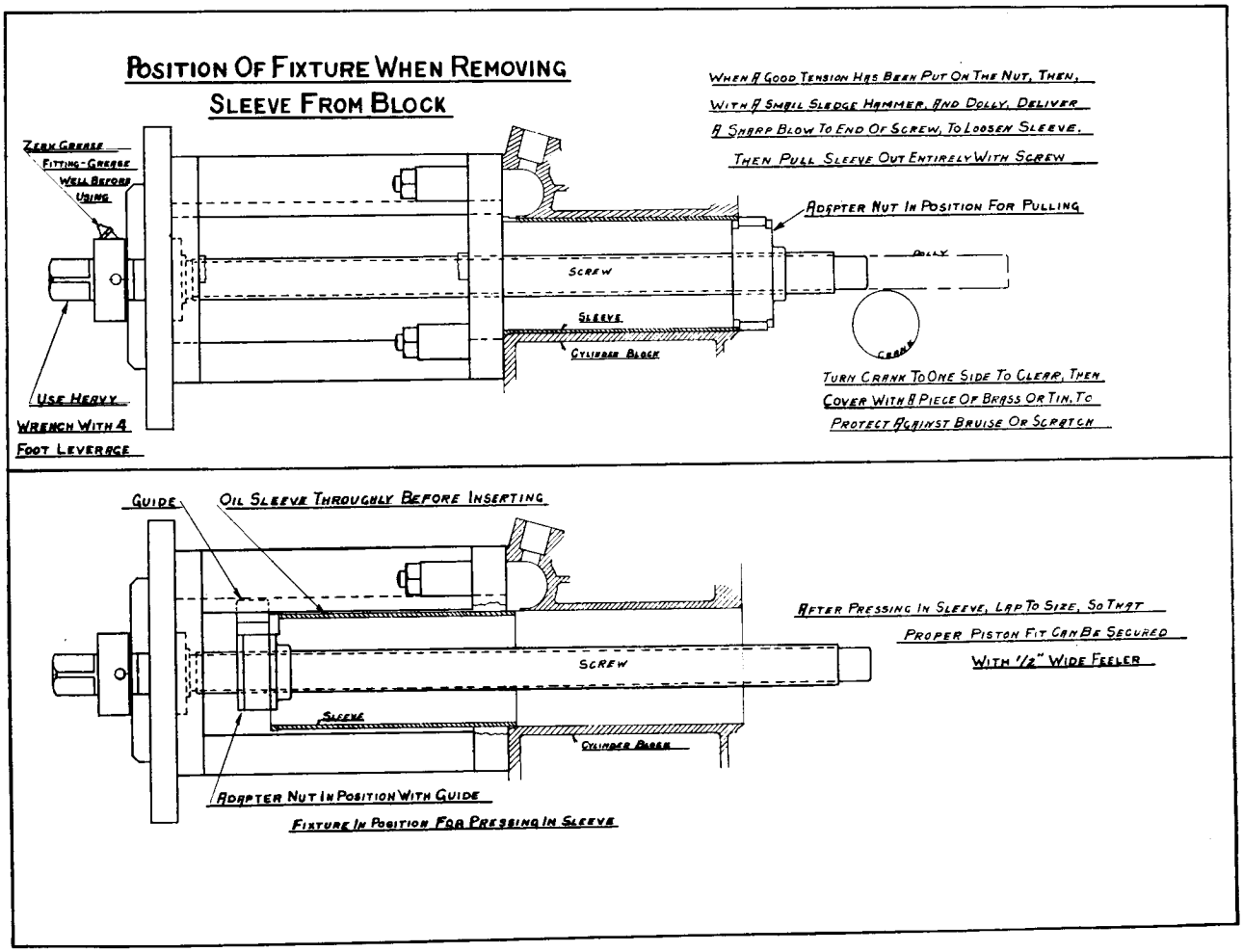


Illustration No. 107

cleaned once a week. To clean, remove case (3), cloth unit (2), also metal unit (4). This cloth unit (2), is equipped with a bayonet catch which is turned to right to release; the metal element (4) is screwed into the head casting. Wash metal unit with cloth in clean gasoline, kerosene or fuel oil. Do not use any hard or sharp tool to clean this unit as damage will result. The fabric element may be washed in the same cleaning fluid but care must be taken to see that all the gum and dirt is washed out of the fabric. Since certain fuels attack the fabric and cause it to deteriorate, it may be necessary to replace this unit with new one from the spares. After cleaning reassemble, reversing the procedure.

Alcohol is a good cleaning agent where gummy or wax forming fuels are encountered.

This filter will in all probability require more frequent cleaning than the dual filters due to the cloth element removing a large part of the gummy residue in the fuel oil.

Some specialized installations may have a different fuel filtering system but the above will also serve as a guide in maintaining a clean fuel system. Since dirty fuel filters affect the efficiency of the engine, it is necessary to keep them clean for low cost operation.

The vent cock, 1, Illustration No. 109, should be opened occasionally to release any air which may become trapped in the filter. See Page 12, Paragraph 6.

FUEL PUMP DRIVE

The fuel pump is driven by means of a chain and sprockets, one sprocket being attached to the camshaft and the other to the fuel pump drive shaft. The general construction is shown in Illustration No. 113. A sleeve is attached to the cylinder block and can be removed toward the front of the engine after the gear cover has been removed, and the chain has been taken off the sprocket. Suitable oil seals are provided at the rear of this shaft to prevent oil leakage.

FUEL PUMP DRIVE CHAIN ADJUSTMENT

The chain is adjusted by means of an idler sprocket mounted on an eccentric, which eccentric is supported by a stud 6, Illustration No. 113, this stud is fastened in the case by means of a flange and screws. The eccentric is controlled by a screw working in threads cut on the eccentric control split bushing which is keyed to the eccentric.

Perusal of Illustration No. 113 will show a projection 6 on the eccentric bushing which is longer and will come through the gear cover. Therefore, it is necessary whenever the gear cover is removed to be sure this extension is centered before tightening the attaching screws.

Illustration No. 111 shows the component parts of this adjustment. No. 1 is the threaded eccentric clamp bushing. No. 2 is the support for the adjusting screw which is shown as No. 3. No. 4 is the cork seal.

Illustration No. 112 shows the parts assembled on the engine and the method of adjustment is as follows:

1. Remove plug 1 which will allow you to feel chain movement. This should be approximately 3/8" up and down.
2. If movement is greater than 3/8" then remove cotter pin and loosen nut 3.
3. With a screw driver turn screw 4 clockwise, this causes eccentric threaded bushing 5 to turn clockwise thus tightening the chain.
4. Check tightness of chain at 2. This should be a movement of about 3/8".
5. Should the chain be too taut, turn screw driver anticlockwise until nut 3, Illustration No. 112 rests against support 2, Illustration No. 111 , then turn screw until chain is loose. Reverse action and again tighten as outlined above.

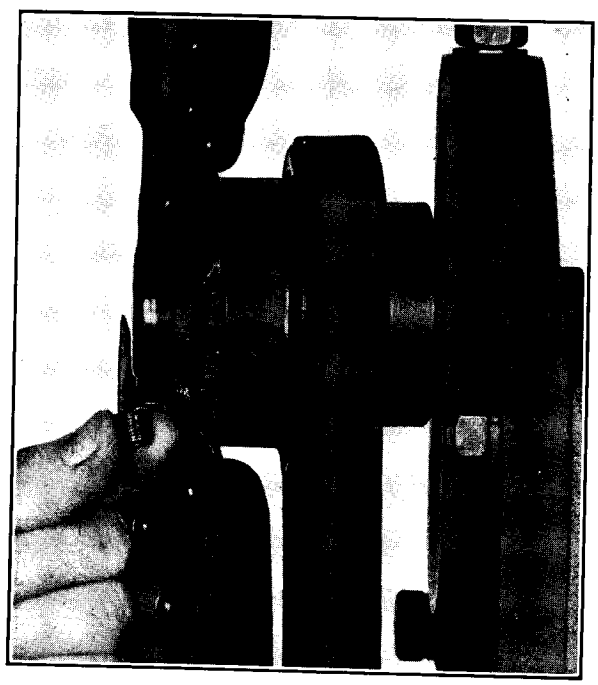


Illustration No. 108

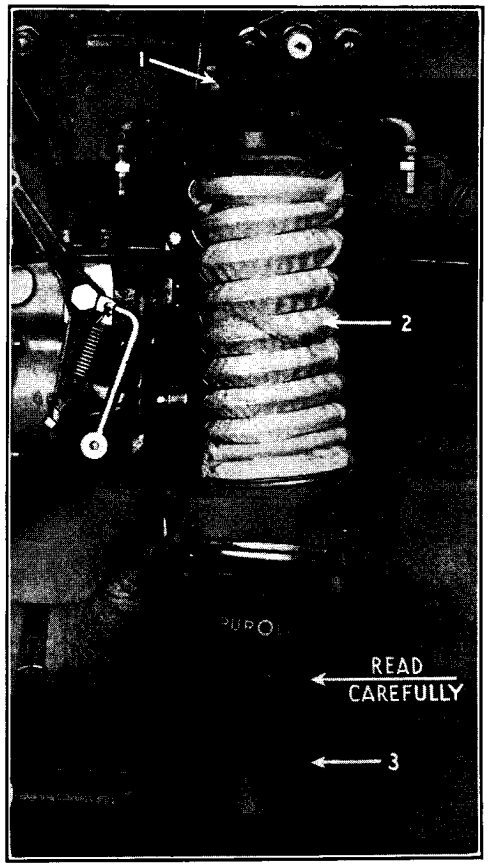


Illustration No. 109

6. Always turn screw clockwise before locking nut and putting in cotter pin as this insures all slack being removed which otherwise may cause the chain to be loose after engine is running.

It is never necessary to remove screw 6, Illustration No. 112, which holds adjustment support to gear cover except to replace seal 4, Illustration No. 111. By keeping these parts assembled to gear cover it facilitates reinstalling gear cover after it has been removed. Remember to always try working adjustment before finally tightening the gear cover attaching screws.

Should it be impossible to remove plug 1, Illustration No. 112, then check chain adjustment by rotating fuel pump drive coupling back and forth. This movement for backlash should be about $\frac{1}{64}$" on the O. D. of the coupling flange.

FUEL PUMP DRIVE CHAIN REMOVAL

The removal of the fuel pump chain is made by means of a small stamping which locks two of the chain rivets in place 7, Illustration No. 113. This stamping should be carefully spread so that it can be removed from the slots in the rivets; then the rivets can be pushed through the links of the chain, opening the chain and permitting its ready removal.

REPLACEMENT OF CHAIN: Illustration No. 113. When the chain is to be replaced turn the engine so that the pointer 3 on the hub of the sprocket attached to the camshaft is vertical with No. 1 cylinder on top center, and rotate the sprocket attached to the fuel pump drive shaft, also into a vertical position as shown in 4. The chain should then be placed on the sprocket so as to permit these arrows to remain in a vertical position.

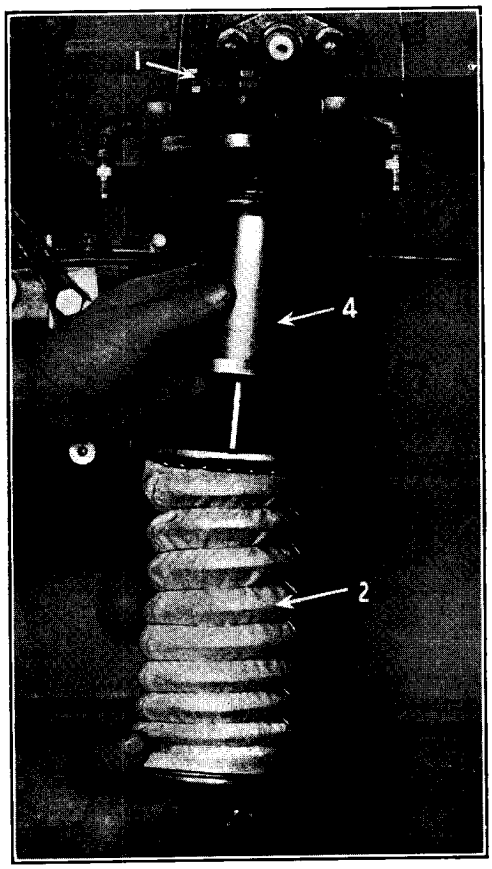


Illustration No. 110

FLYWHEEL

The various flywheels used on the DFX series engines are usually made of cast iron and may be machined to accommodate different types and sizes of clutches as well as generator and other types of couplings. The flywheel is fastened to the crankshaft with eight capscrews and two dowels. The timing mark which indicates that No. 1, or No. 6 pistons are on top center may be seen through a hole provided in the bellhousing. Illustration No. 21.

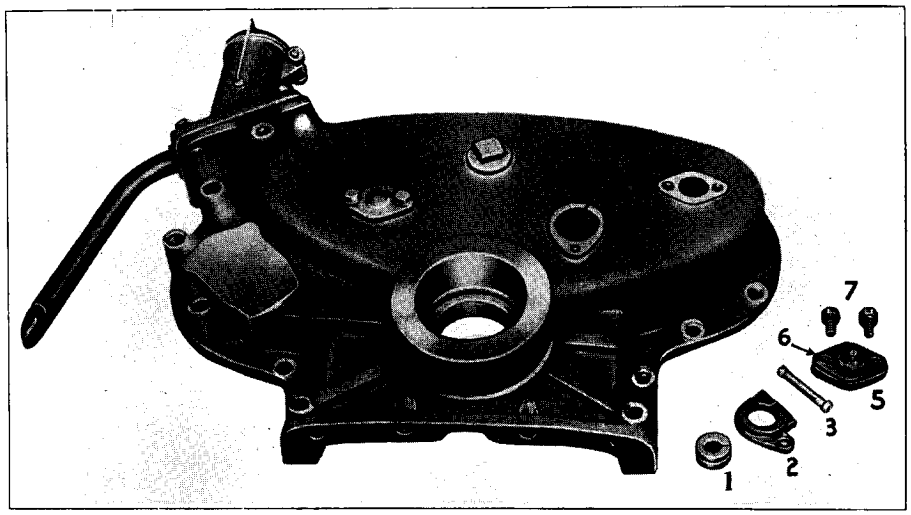


Illustration No. 111

NOTE: The location of the timing hole may vary with different installations.

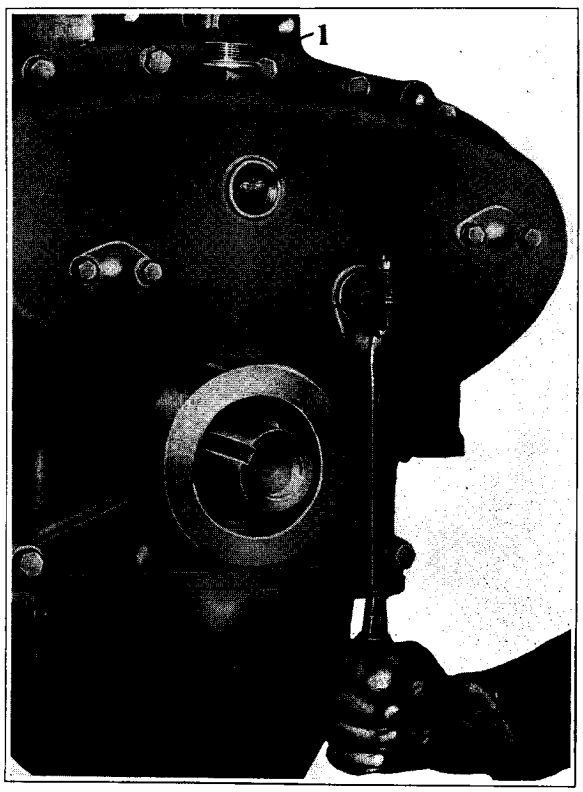


Illustration No. 112

TO REMOVE FLYWHEEL

1. Assuming that the clutch has been removed, remove lockwires and capscrews from the flywheel.
2. Remove starting motor.
3. Use two ½"-13 capscrews with approximately 2" of threads to pull the flywheel as shown in Illustration No. 114.
4. Inspect the flywheel and ring gear for damage
5. If necessary to remove damaged ring gear, note position of champfer on gear teeth, so new gear can be correctly installed.
6. The ring gear may be driven from the flywheel by use of a large drift and heavy hammer. When installing the new ring gear, it should be heated to, but not over 450°F. and then assembled to the flywheel. The ring gear must be assembled so that it is square and properly seated on the flywheel.

TO INSTALL THE FLYWHEEL

1. Assemble the new seal in bellhousing, See Page 84, Illustration No. 93.
2. Polish oil seal contact surface of flywheel. This surface must not be scratched, nicked or otherwise damaged.
3. One flywheel screw is out of position so that the flywheel can only be installed in one position. Therefore, it is necessary to properly locate the flywheel in relation to the crankshaft.
4. Install the flywheel on the crankshaft, (use care that the flywheel is properly located in relation to the crankshaft, and draw into place with the flywheel attaching screws. Do not draw any one screw down tight until all are progressively tightened.
5. Insert dowels and expansion plugs.
6. Attach indicator as shown in Illustration No. 116 to check concentricity of pilot bore. This should not exceed .005" total reading.
7. Place indicator in position shown in Illustration No. 115 to check face of flywheel. This should not exceed .005" total.
8. Install cotter pins.

GEAR COVER

The gear cover used on these engines may be made of either aluminum or cast iron and covers the gear train at the front of the engine.

The camshaft and idler shaft end thrust is controlled by suitable adjusting plates assembled in the gear cover. See Illustration No. 112.

TO REMOVE THE GEAR COVER

1. Assuming that the radiator has been removed, loosen fan adjusting screw and remove the fan belt.
2. Remove pin from fan drive pulley and with suitable puller remove the fan drive pulley.
3. Remove chain adjusting parts.
4. Remove gear cover attaching screws and pull gear cover forward away from the engine. If no gaskets or seals are available, use care when removing these parts.

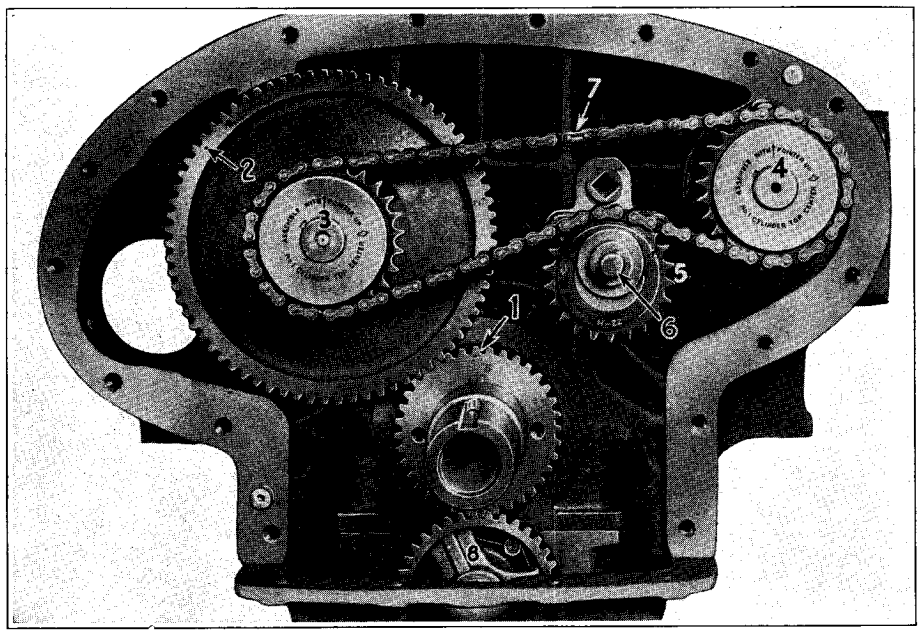


Illustration No. 113

TO ASSEMBLE GEAR COVER TO THE ENGINE

1. Assemble new oil seal in gear cover and cement new gasket to gear cover.
2. Remove thrust plates.
3. Assemble gear cover to engine with screws and washers as removed.
4. Adjust thrust plates, see page 85.
5. Insert Woodruff key in crankshaft and assemble fan drive pulley then lock pulley in place with pin and cotter pins as removed.
6. Install chain adjusting parts and adjust, see Page 94.
7. Install fan belt and adjust to proper tension. (The fan belt should have approximately ¾" deflection when grasped midway between pulleys).

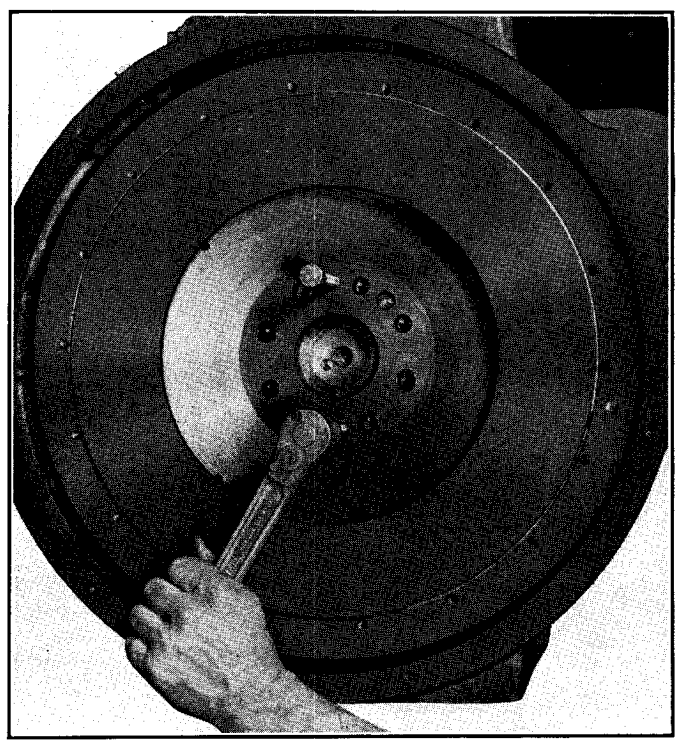


Illustration No. 114

GENERATOR

A periodic inspection should be made of the charging circuit. The intervals between these checks will vary depending upon the type of service. Dirt, dust and high speed operation are factors which contribute to increased wear of the bearing brushes, et cetera. Under normal conditions an inspection of the generator should be made every 100 hours.

1. **Wiring**—A visual inspection should be made of all wiring to insure that there are no broken wires and that all connections are clean and tight. Special attention should be paid to the ground connections at the battery and generator.

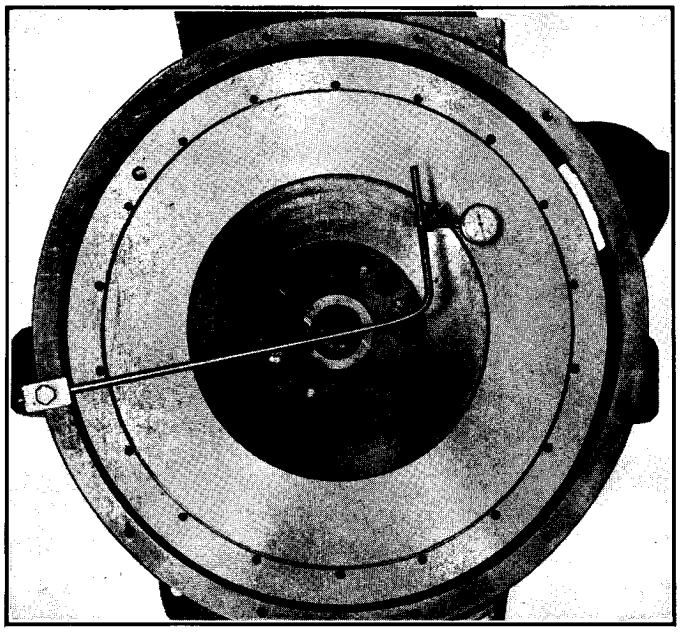


Illustration No. 115

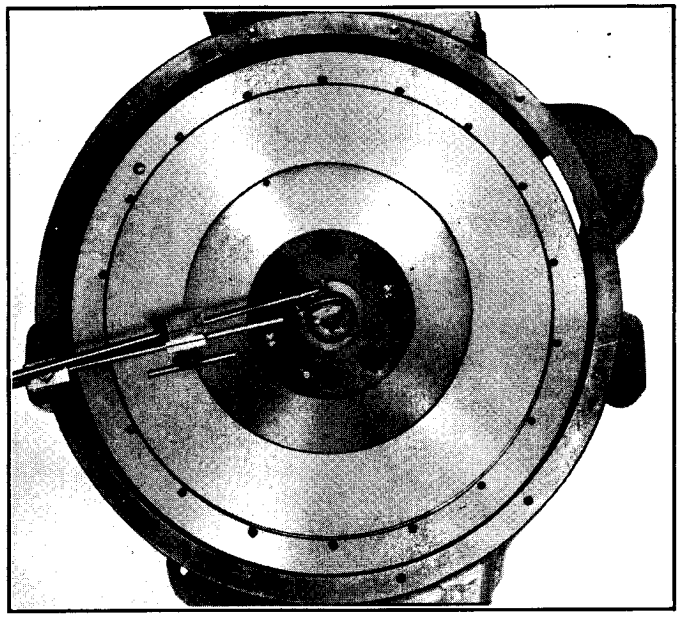


Illustration No. 116

2. **Commutator**—If the commutator is dirty or discolored it can be cleaned by holding a piece of 00 sandpaper against it while turning the armature slowly. Blow the sand out of the generator after cleaning the commutator. If the commutator is rough or worn the generator should be removed from the engine, the armature removed and the commutator turned down.
3. **Brushes**—The brushes should slide freely in their holders. If the brushes are oil soaked or if they are worn to less than one-half of their original length they should be replaced.
4. **Lubrication**—Add 3 to 5 drops of medium engine oil to the oilers in the end heads every 100 hours of operation.

If the generator does not function properly after the above checks, the generator and the regulator or circuit breaker should be taken to an authorized service station for inspection and repairs.

GENERATOR COUPLING

The generator when connected to the water pump shaft is driven through an "Oldham" type coupling. While this is a very simple type of coupling consisting of only three parts, a drive flange, a driven flange and an intermediate fibre disc, it is necessary to be sure there is at least .010" clearance between fibre disc and side of flange. See Illustration No. 117.

LUBRICATION

The lubricating system on this engine is the forced feed type to all main and connecting rod bearings by means of a gear type pressure pump. The oil pump is mounted on and doweled to the front main bearing cap and is held in place by the front main bearing studs and nuts. The pump picks up the oil from the oil pan sump through a suitable suction line and delivers it through another line to a drilled passage in the cylinder block. From there it flows through drilled passages to the by-pass type oil pressure regulator built into the oil filter base. From pressure regulator or oil filter the oil flows through various other drilled passages to the main bearings, idler shaft, water pump, front cam bearing and rocker arms. From the main bearings the oil is carried to the connecting rods through drilled holes in the crankshaft. The connecting rods are also drilled to permit oil to flow, under pressure, to the piston pins.

The balance of the cam bearings are lubricated by oil which drains from pockets cast into the cylinder block. The valve tappets and cylinders are lubricated by the mist of oil thrown off by the main and connecting rod bearings.

LUBRICATING INSTRUCTIONS

Oil Level—The level of the oil in the crankcase is determined by a bayonet or depth stick type of gauge. Wipe off gauge and reinsert to determine oil level accurately. The oil level should be maintained at or near the 4/4 mark on gauge. See Illustration No. 89.

The capacity of the standard type oil pan is 24 quarts U. S. measure. However, when refilling after draining, the best method to follow, since there are many special oil pans used, is the use of the bayonet gauge or dip stick. Fill crankcase to the 4/4 mark on this gauge, then run engine for about 4 or 5 minutes, stop, let set about ½ minute and measure oil level. If not up to 4/4 mark add enough oil to bring it to this level. If the oil had been measured, the next time the same amount may be used. Always recheck with bayonet gauge. With dry sump type, keep level in reservoir at proper height.

Oil Changing—Drain the crankcase and refill with fresh oil frequently. How often this should be done depends on the operating conditions and the kind of service to which the engine is applied. After changing the oil several times at 1000 mile or 30 hour intervals and by observing the condition of the old oil it can be determined whether the oil should be changed more frequently. Oil should be changed more frequently when an engine is new than after it is well run in. This is because initial wearing in of various parts will result in minute metal particles in the oil which frequent draining will help to remove. The oil should also be changed more frequently in cold weather or where the engine is frequently started when cold, as cold running will tend to dilute the oil with unburned fuel and water. Water vapor is a product of normal combustion and this vapor will condense to form drops of water when it comes in contact with cold surfaces. Traces of water in the crankcase will therefore result from cold running and frequent oil changing will help to remove this water.

When changing oil it is not advisable to flush out the crankcase with kerosene, as it is impossible to drain all the kerosene out of pockets without dropping the pan, as traces of kerosene will remain to dilute the fresh oil. Oil should be drained when the engine is hot as after a day's run, as the oil will then be agitated and will also run more freely and carry off more sediment.

Frequent and regular oil changing together with the use of good oil is low cost insurance against expensive repairs.

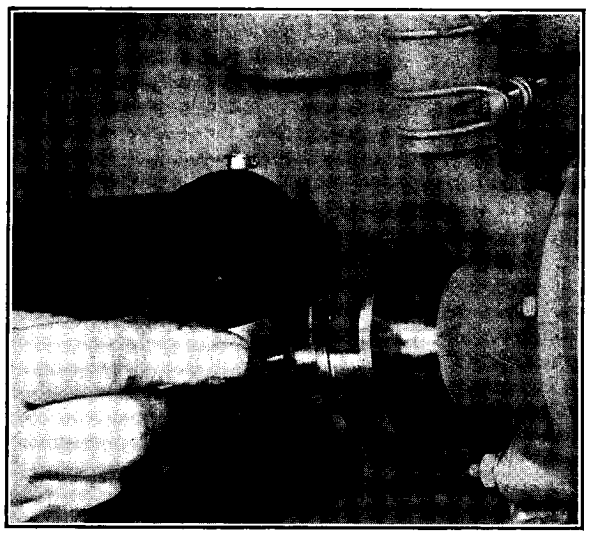


Illustration No. 117

Use Good Oil—The difference in cost between cheap oil and the best obtainable is money well invested as this cost will be multiplied many times when repairs are necessary due to using cheap oil. Some oils contain traces of sulphur which in itself is not harmful but when in the presence of certain products of combustion will combine to form acids which will attack the metal surfaces. It is difficult to judge the true quality of a lubricating oil except by use of elaborate equipment and prolonged tests. Therefore, the best practice is to buy oil of well known and established brand or from a company who have a reputation to maintain. The use of H. D. (Heavy Duty) oils is recommended.

Weight of Oil—In deciding what weight of oil to use it is well to obtain the recommendation of the oil company as to what weight to use for the working conditions under which the engine is operating. A suitable oil of one brand might be designated as an SAE 30 while a similar suitable oil of some other brand would have some other designation.

A lighter weight of oil should be used in a new engine during the breaking in period of 2,000 miles or fifty hours operation than can be used after the engine has been run for some time. For breaking in a new engine we suggest an SAE 20 oil for normal conditions and a lighter oil if could weather or cold climatic conditions prevail.

After the breaking in period and for normal conditions of climate and load we suggest an SAE 30 oil. For warm weather or climate conditions where the temperatures average above 75°F. an SAE 40 oil can be used. For cold weather or climate use an oil having a pour point at least 10° F. below the temperature to be encountered. For example, if a temperature of 0°F. is to be encountered the oil used should flow or pour at 10°F. below zero. Such an oil as 20W will be suitable for such conditions.

Quantity of Oil—When changing oil, approximately 15 to 30 quarts U. S. liquid measure are required (depending on type of oil pan used). The oil filter should be cleaned at the same time the oil is changed in the crankcase and about two quarts more than the above mentioned quantity will be required to refill the oiling system. In such cases the oil level should be rechecked after the engine has been run long enough to refill the filter. Always use bayonet gauge when replenishing the oil supply and fill to the 4/4 mark.

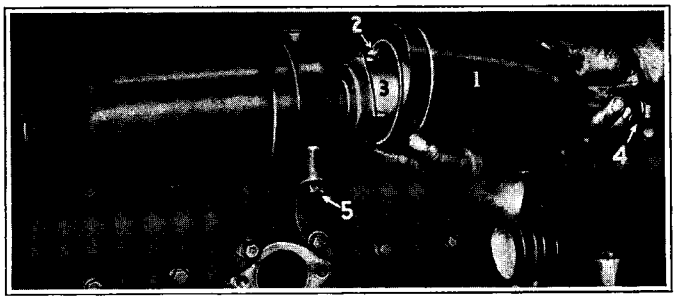


Illustration No. 118

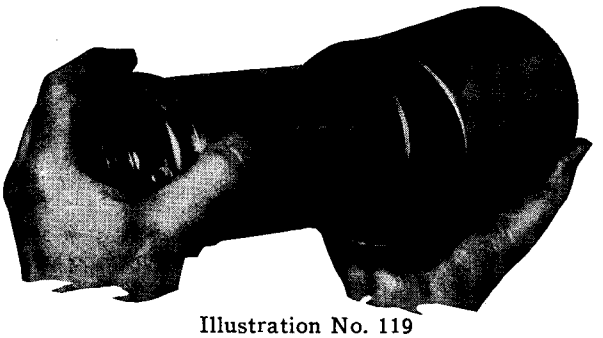


Illustration No. 119

After engine has been shut down for considerable time the oil level may be above 4/4 mark. Do not drain but start engine and run before checking.

Lubrication of Accessories—Accessories mounted on the engine usually carry their own lubricating instructions which should be followed. If not available write to accessory manufacturer.

Oil Pressure—Refer to 6, Illustration No. 137 and discussion of this subject under "Oil Pressure" starting on Page 106.

LUBRICATING OIL FILTER

The lubricating oil filter, for the DFX Vertical Engine, shown in Illustration No. 118 consists of two elements, No. 2 and No. 3 (also shown being pulled apart in Illustration No. 119,) enclosed in shell No. 1. These filtering or straining elements should be cleaned very frequently, an exact schedule can not be definitely established due to its being influenced by the kind of oil used and the particular duty demanded of the engine. We would suggest removing the shell and elements at least twice a week for cleaning and from the condition of the elements a schedule can be established to best meet any particular operating conditions.

To clean, remove shell, then elements, pull elements apart as shown in Illustration No. 119. Wash in clean gasoline, fuel oil or kerosene using a clean cloth or soft bristle brush. DO NOT USE WIRE OR HARD BRISTLE BRUSH OR SCRAPER as these harsh methods will ruin the elements. After unit is assembled to engine, start engine and check for oil leaks.

Frequently remove plug No. 5, Illustration No. 118, and allow the dirt, water and sludge which has accumulated to drain out of the filter.

The lubricating oil filter, for the DFX-F (Horizontal) engines, is mounted in a casting fastened to the front of the oil pan, Illustraion No. 6. This filter has closely woven cloth bags as a filtering medium. These bags are fastened to a central casting, which serves as inlet and distributor for the dirty oil.

To clean this filter it is necessary to remove cover plate as shown in Illustration No. 120. Then pull the filter element from the housing shown in Illustration No. 121.

After the element has been removed from the housing it should be unrolled and the bags removed from the center casting. See Illustration No. 122. The bags should be turned inside out and thoroughly washed in clean gasoline or kerosene.

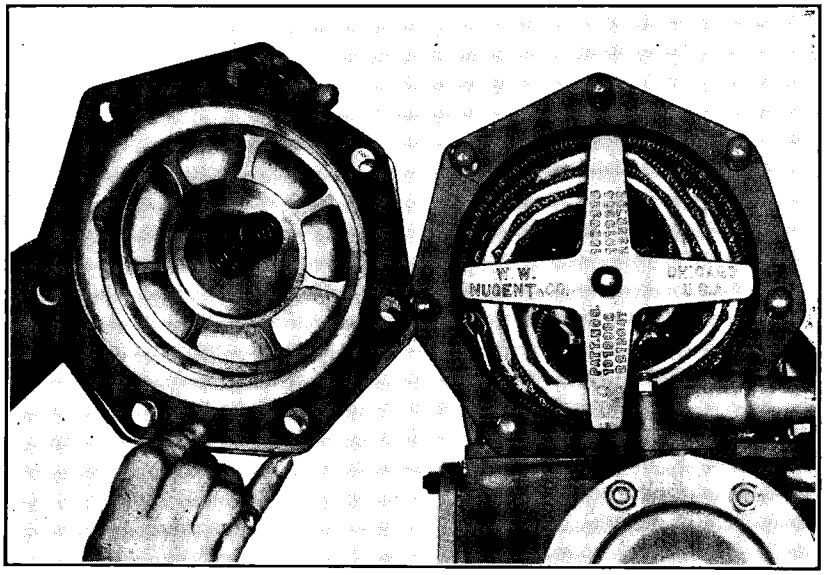


Illustration No. 120

MAIN BEARINGS

Main bearings are of the removable shell type. In this type there is a removable shell in both the crankcase and the bearing caps.

Replacement shells are not machined after installation in the case. Therefore, replacement of bearings becomes a very simple matter. See Illustration No. 123 which shows the the bottom view of the engine with the bearing caps in place.

The bearing shells are locked against rotation by means of a small ear or projection on each shell at the split line. Various types of alloy metals are used in the manufacture of these bearing shells. These alloy

metals are harder than tin base babbitt, and some additinal bearing clearance must be provided. It is therefore, recommended that .0050" to .0060" clearance be provided between the crankshaft and the main bearings. The main bearing caps are very rigid castings and are securely fastened to the crankcase by means of large diameter studs, two studs being used for each bearing. The main bearings are dowled in place so as to permit removal of caps and replacement without the bearings shifting on the case.

Tightening the main bearing cap nuts requires some care to prevent too much strain on the parts. Special wrenches are on the market which enables the mechanic to measure the force of his pull when tightening such parts. Illustration No. 124 shows a torque or tension wrench. The wrench tension values given on Page 123 show the correct amount of pull to use on various screws. No attempt should be made to refit these bearings by filing or grinding the caps as this will ruin the cap so new shells cannot be installed.

NOTE: As built at the factory the caps are marked on the camshaft side and to the front of the engine. No. 1 is the bearing nearest the timing gears.

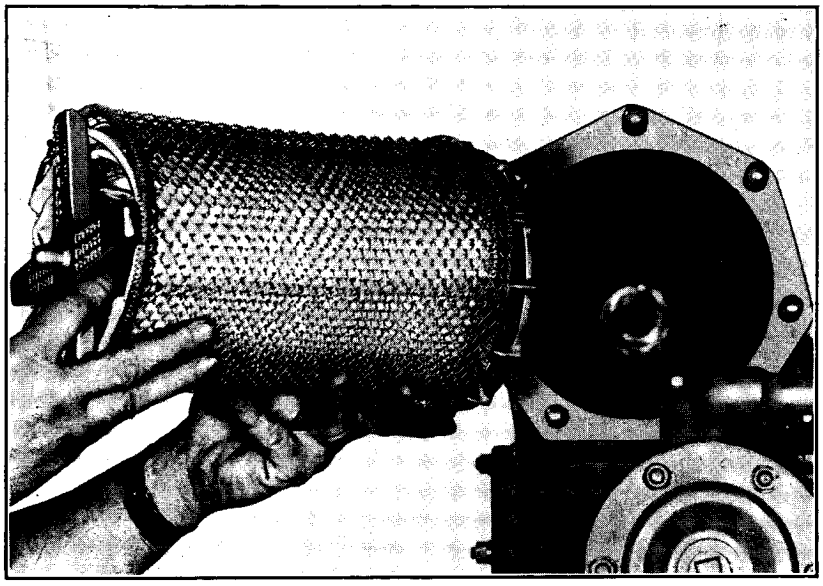


Illustration No. 121

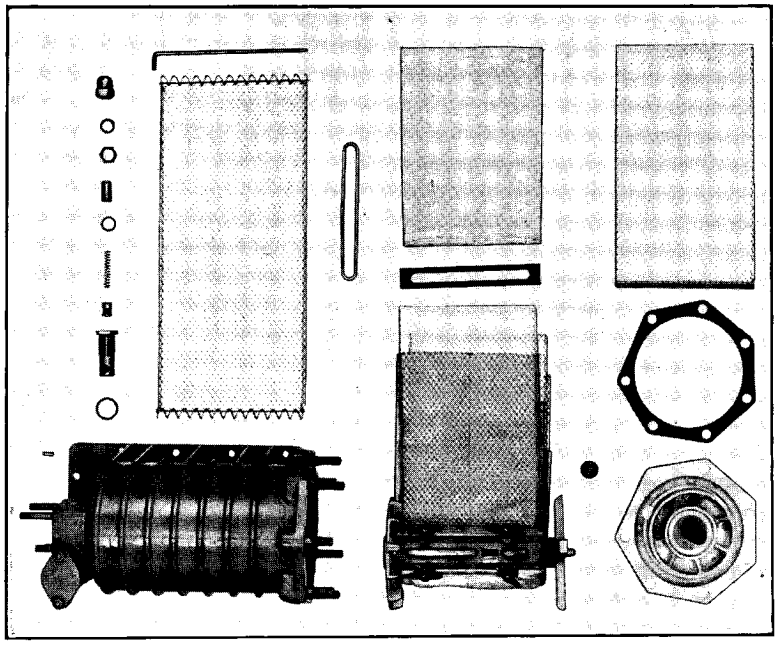


Illustration No. 122

MAIN BEARING ADJUSTMENTS

If excessive clearance develops between shaft and bearing shells, bearing fits are reconditioned by use of new shells. If clearance is excessive, regrind shaft and use undersize bearing shells. After readjustment of the bearings and their caps having all been tightened securely, it should be possible to turn the crankshaft in the bearings by taking hold of the cheeks of the shaft. Care must be exercised to prevent too tight a fit on any of these bearings. Refer to table of clearances Page 124.

Warning: Do not file or grind caps as new bearings cannot be installed in a cap that has been filed or ground.

REPLACEMENT OF MAIN BEARINGS

It is not necessary to remove the engine from the unit to replace the shell type main bearings. Unless of course, the crankshaft is damaged or worn to the extent that it must be replaced.

The following outline may be used as a guide when replacing the bearings when the engine has not been removed from the unit.

1. Disconnect battery cable at battery.
2. Disconnect starter cable and wiring then remove starter.
3. Drain crankcase oil.
4. Remove oil pan.
5. Remove oil pump or pumps and oil lines.
6. Loosen all main bearing cap screws.
7. Remove one bearing cap at a time and make bearing replacement. To remove the upper shell, a small pin may be inserted in the crankshaft oil hole and the shaft rotated so that the pin will push the bearing out. See Illustration No. 125. The new bearing may be inserted in the same manner. See Illustration No. 126 .

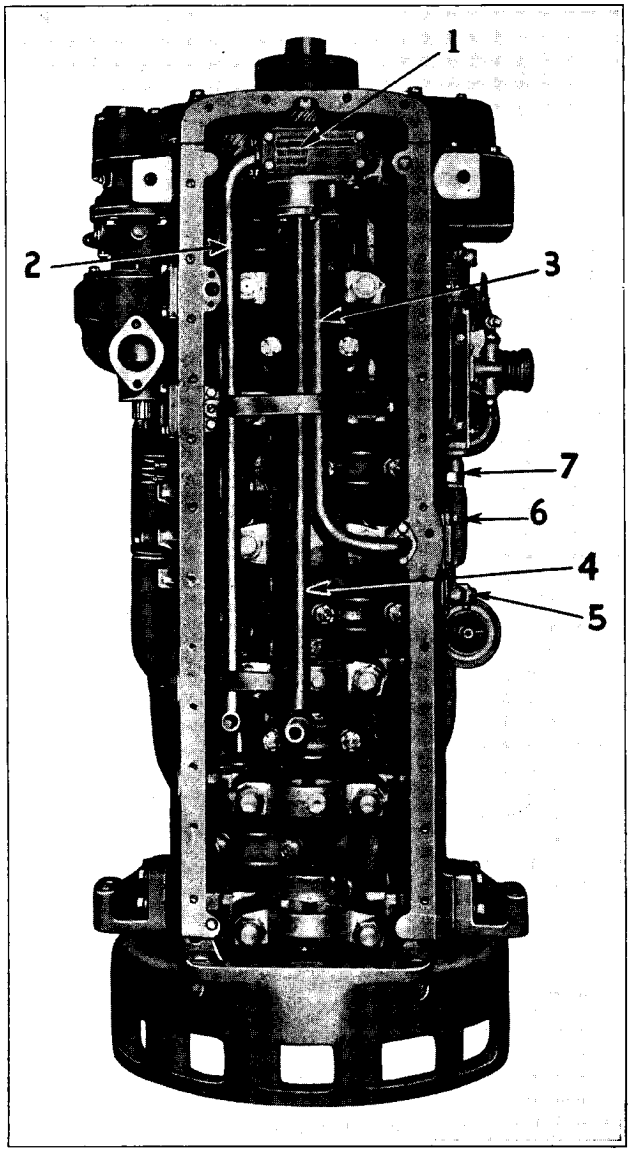


Illustration No. 123

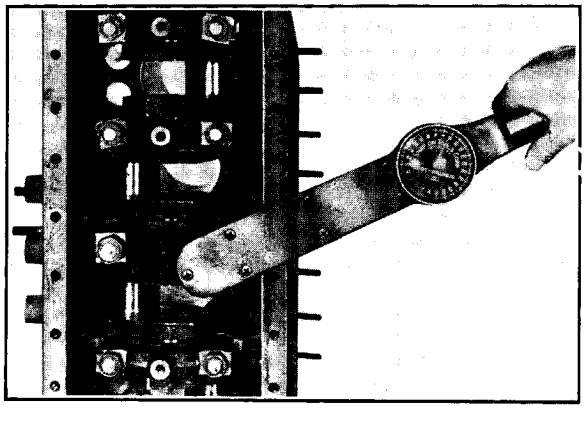


Illustration No. 124

CAUTION: Be sure to remove the pin before assembling the bearing cap.

8. Assemble bearing cap and lower shell and tighten nuts. See table on Page 123. If no torue wrench is available, use wrench with 24" handle.
9. After installing new thrust bearings on rear main bearing, check end thrust, Illustration No. 127 (see table Page 124). It is permissible to draw file the thrust bearings to obtain the proper clearance if necessary.
10. Thoroughly recheck inside of engine for loose screws, nuts, et cetera.
11. Install oil pan.
12. Install starter.
13. Connect starter cables.
14. Connect battery cable.
15. Fill crankcase to 4/4 mark on bayonet gauge, see Illustration No. 89, with proper grade of oil.
16. Start engine and immediately check oil pressure (some slight adjustment may be necessary). See Page 106. If sufficient, allow engine to run for a few minutes while checking for oil leaks, etc., then stop the engine and recheck the oil level. Add oil if necessary.

OIL COOLER

Some engines are equipped with an oil cooler which consists of a case, Illustration No. 128 that is fastened to the side of the crankcase. This case contains the cooling elements, Illustration No. 129, through which the lubricating oil flows. The coolant from the radiator flows through this case and over the elements before it enters the cylinder block.

The purpose of this oil cooler is, as the name implies, to cool the lubricating oil before it enters the main bearings, etc.

If for any reason, the coils are removed always use new gaskets and be sure all attaching nuts and screws are tight. Gasket cement may be used to insure a leakproof seal.

Oil in the cooling system indicates a leak in the cooler.

The thermostats shown at "A" Illustration No. 130 are used to prevent the lubricating oil from overcooling. When the oil is cold these thermostats contract, and open passages, which allow the oil to bypass the cooling elements. Then as the oil becomes hot, the thermostats expand and block the passages, which forces the oil to circulate through the cooler elements.

OIL PAN—DFX

The oil pan serves as a cover for the bottom of the crankcase and also as an oil reservoir. This part differs with various installations but should always have the same care. Keep all dirt out of it as it is the reservoir for the lubricating oil. It should be removed once every 2000 or 2500 hours (at least twice a year) and completely washed. While it is off the inside of the engine may be inspected and washed out.

Illustration No. 125

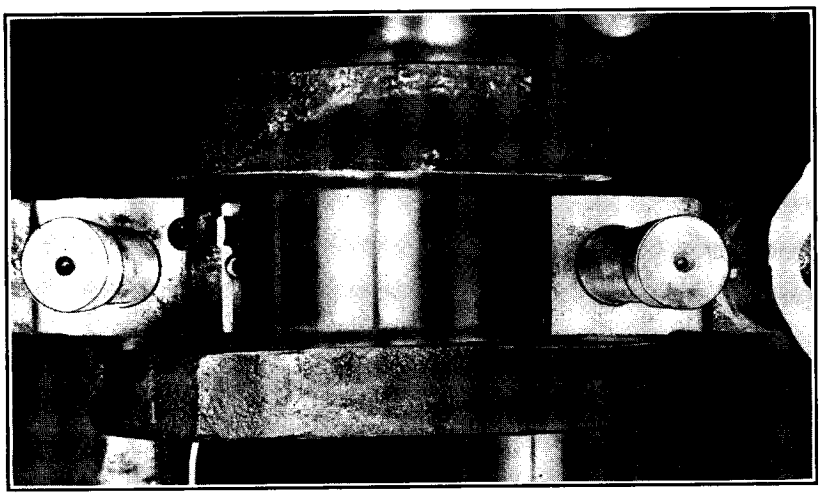


Illustration No. 126

This procedure may require from 3 to 5 hours but it is well worth the time spent and pays good dividends in helping secure trouble-free operation.

When reinstalling use new gaskets for a leak-proof job.

Suitable drain plugs are located in the bottom of the oil pan. See Illustration No. 131. Bayonet gauge is covered on Page 83.

See page 104 for DFX-F oil pan.

TO REMOVE OIL PAN

1. Drain crankcase oil.
2. Disconnect starter cable and remove starter. Tape any "hot" cable terminals.
3. Remove bayonet gauge assembly.
4. Remove oil pan strainer, Illustration No. 131.
5. Remove cap screws from oil pan and lift oil pan from engine.

TO INSTALL OIL PAN

1. Clean oil pan thoroughly, remove old gaskets. Install baffle plate and strainer.
2. Inspect inside of engine for loose nuts, screws, cotter pins and lock wires.
3. Cement new gasket in place and allow to set so gasket will not skid. If lower part of bellhousing gasket is damaged, cut at oil pan intersection at block and replace with similar part of new gasket.
4. Put oil pan in place and carefully start all screws. Be sure lockwashers are on screws.
5. Draw up all screws very lightly. Make sure pan is centered at crankshaft oil seal so as not to damage rubber ring.
6. Tighten progressively the five screws in the bellhousing and the three screws next to bellhousing (both sides) in crankcase, alternating between vertical and horizontal screws until tight. This is to pull the corner of the pan in against the corner formed by the bellhousing and cylinder block or crankcase.
7. Check alignment of oil pan at front and tighten four cap screws in gear cover.
8. Tighten all remaining screws.
9. Install oil pan strainer.
10. Reinstall starting motor and cables.
11. Reinstall bayonet gauge assembly.
12. Refill with oil to correct level.

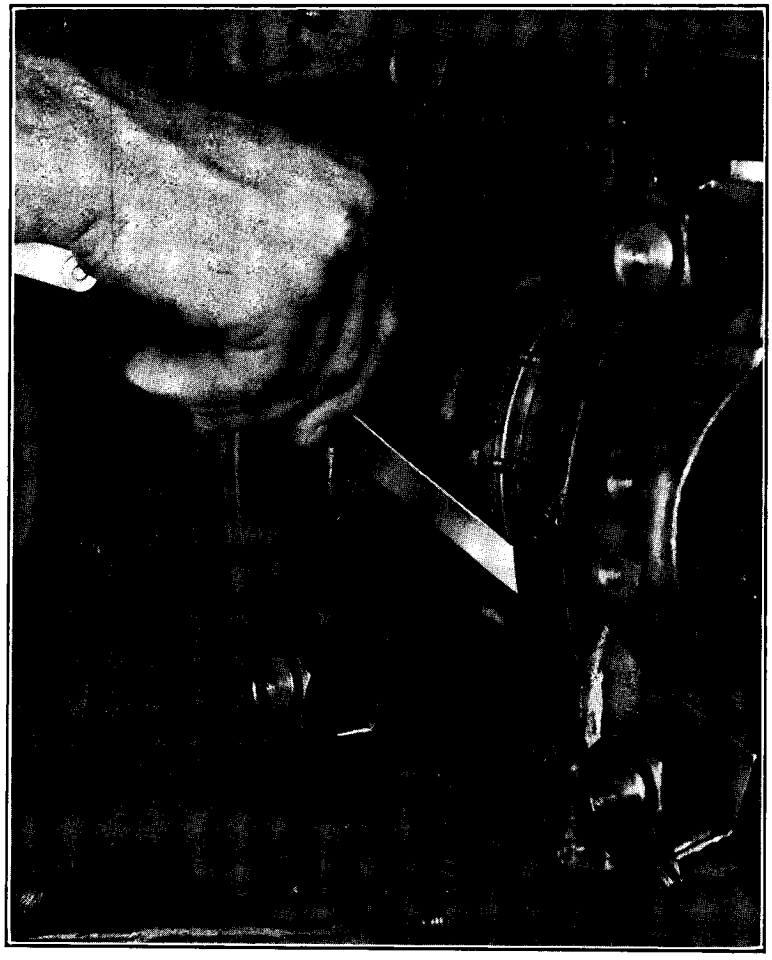


Illustration No. 127

OIL PAN AND OIL SYSTEM—DFX-F

The Oil Pan, Illustration No. 132, is designed with two compartments; one compartment, Illustration No. 133, is the sump containing the oil which supplies the oil pressure pump, the other compartment, Illustration No. 134 and No. 135, acts as a basin to catch the oil as it is thrown off by bearings and other parts of the engine. The oil is picked up by the scavenging pump as shown in Illustration No. 134 and discharged into the sump which supplies the oil pressure pump.

The oil is picked up by the pressure pump, through the pressure pump suction line, Illustration No. 135, and discharged through the pressure pump discharge line, Illustration No. 136, to the pressure regulator, Illustration No. 141 and No. 142, from the regulator the oil flows through the oil filter, main bearings, connecting rod bearings, etc. As the oil returns to the second compartment of the pan it is picked up through front and rear scavenging lines, Illustration No. 134, and No. 138, by the scavenging pump, and is discharged through the scavenging pump discharge line, Illustration No. 136, into the first sump to complete the cycle.

Before the oil pan can be removed it is necessary to disconnect the oil lines as shown in Illustration No. 135.

If the oil pan is removed, for any reason, always use new gaskets when reinstalling the oil pan.

OIL LINES

Oil lines are usually repaired by replacement, however, there are times when they can be resoldered or brazed. Each line is taken up separately as follows:

Oil Pump Suction Line—This line 4 Illustration No. 137 and No. 136 picks up the oil from the oil pan sump and carries it to the oil pump. Any leaks in this line will obstruct the suction action of the pressure pump and prevent sufficient oil reaching the bearings, etc. Each time the oil pan is removed inspect this line.

When removing the oil pan from the horizontal or "pancake" engines this line must be disconnected from the pump.

Oil Pump Discharge Line—This line 3 Illustration No. 137 and Illustration No. 136, carries the oil under pressure from the oil pump to the crankcase where it is carried through passages drilled in the crankcase to the oil pressure regulator and from there to the oil filter. From the oil filter the oil flows to the main bearings, connecting rods, etc.

This line should also be inspected each time the oil pan is removed.

Oil Pump Scavenging Line—These lines 2, Illustration No. 137 and Illustration No. 136, pick up the oil from the catch sumps and return it to the main oil sump so that it may be picked up by the suction line to repeat the cycle.

These lines should also be inspected each time the oil pan is removed.

A leak in either of these lines can usually be detected by the oil pressure gauge suddenly dropping off from normal pressure.

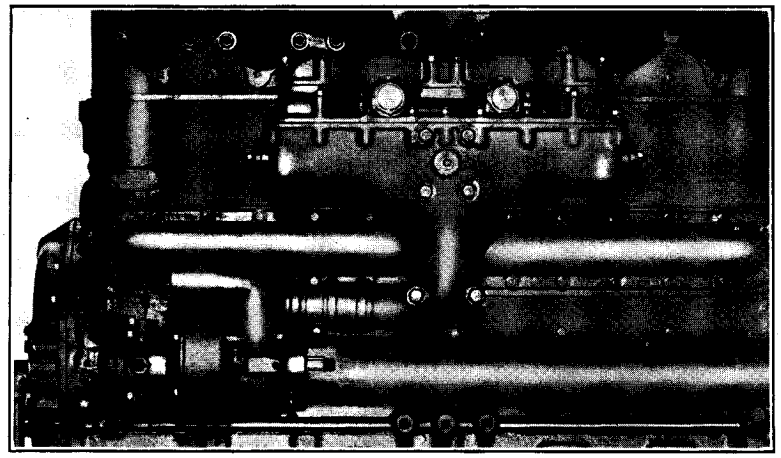


Illustration No. 128

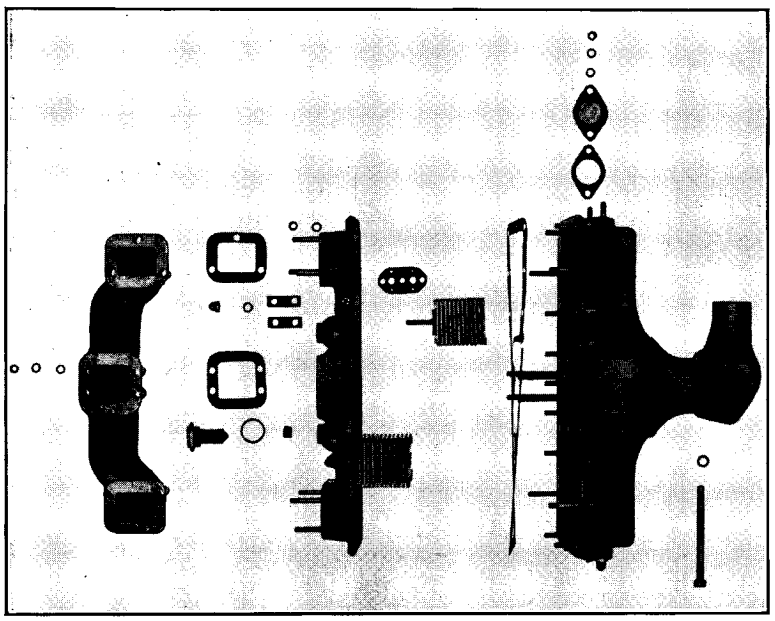


Illustration No. 129

OIL PUMP

The oil pump is a single unit, triple purpose pump, which is separate from, but mounted on and doweled to the front main bearing cap (See Illustration No. 136 and No. 137). The pump housing also provides an additional support for the front main bearing cap. Shims are used between the oil pump housing and the front main bearing cap to control the back lash between the crank gear and the oil pump drive gear, Illustration No. 139.

The oil pump is self-priming and as it operates in a bath of oil, seldom needs any repairs or other maintenance.

However, if it should become necessary to remove the pump, the following steps may be used as a guide.

REMOVING OIL PUMPS

After removal of the oil pan, see page 103 and the oil pump can be readily removed as follows:

1. Remove remaining oil lines.
2. Remove the main bearing stud nuts which hold the pump in place, (Illustration No. 139).
3. Lift the pump off as shown in Illustration No. 139 and be sure to save the shims, if any, between the oil pump and main bearing cap, which are used to obtain the proper back lash between the oil pump gear and the crankshaft gear.

   It may be necessary to use a plastic or other type of soft hammer to tap the oil pump to loosen it from the dowels.

DISASSEMBLY OF OIL PUMP

(Reference letters refer to Illustration No. 140).

1. Remove cotter pin I and hex nut H.
2. With suitable puller, pull drive gear D from shaft A. Remove Woodruff key F from shaft and, also, thrust washer E.
3. Remove cap screws Q and lift cover plate from pump body.
   It may be necessary to gently tap this cover with a soft hammer to loosen it from the dowels.
4. Remove cap screws from rear cover K and remove cover.
5. Remove shaft and gear assemblies L and C.
6. Place pump body B on suitable press and press shaft S out of gear.
   Care should be exercised when removing these gears that the Woodruff Keys do not damage the pump body while the shaft is being pressed out of the gear. After the pump has been completely disassembled, all parts should be thoroughly cleaned and examined for excessive wear.

REASSEMBLY OF PUMP

1. Assemble the gears and shaft S. (When assembling these gears, it is necessary that they be pressed on to the shaft, so that there is sufficient clearance for operation and still have no excessive end thrust).
2. Assemble gear and shaft L and install cover K.

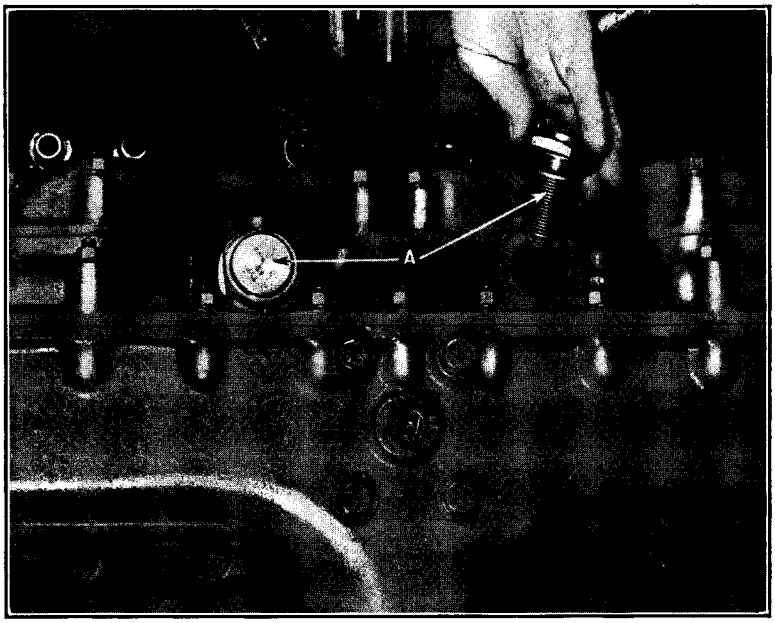


Illustration No. 130

3. Assemble shaft A and gear C in body B.
4. Install cover R, fasten in place with cap screws Q.

   After installing covers K and R, the pump shafts should be tried to be sure there is sufficient clearance, so that the pump gears do not bind.
5. Install thrust washer E, Woodruff Key F and with suitable support under opposite end of shaft, press drive gear D into place. Install washer G, nut H and cotter pin I.

   When reinstalling the pump on the engine, it should be noted that the pump is free and the gears rotate freely, also, that the drive gear has from .008" to .010" back lash after the pump has been installed on the engine. The back lash may be adjusted by adding or removing shims between the pump and main bearing cap as shown in Illustration No. 139.

OIL PRESSURE ADJUSTMENT

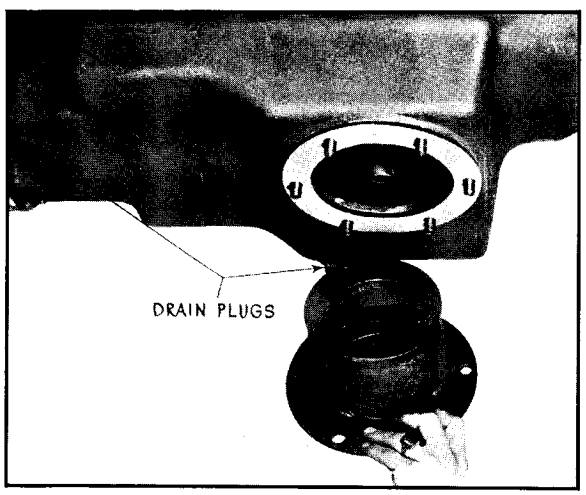


Illustration No. 131

The oil pressure is automatically controlled or regulated by a compression spring which controls a relief or bypass valve. This device is fastened to the side of the crankcase as shown by 6 in Illustration No. 137. The oil pressure should not be changed or judged to be too high or too low until it is known that the proper weight of oil is being used and that the engine is warmed up to normal operating temperature. As the bearings become worn more oil will escape around them into the crankcase and this will lower the pressure slightly. It is not advisable to try to correct this slight loss of pressure by an adjustment of the oil pressure regulator because the extra amount of oil being thrown off by the worn bearings is already over oiling the cylinder walls.

Although there are many special specifications as to oil pressure on these engines the most common setting is 50 pounds at 1600 R. P. M. with the oil hot (about 170° which at idling speeds results in a pressure between 5 and 15 pounds. At speeds higher than 1600 R. P. M. the pressure may be higher. When the oil is cold the pressure will be somewhat higher. The pressure may also vary with different brands and grades of oil. (On most engines the oil pressure is designated on the engine instruction plate). If it is necessary to change the oil pressure proceed as follows:

Remove acorn nut 7, Illustration No. 137 and No. 141, this uncovers a slotted screw, loosen locknut. Turn the slotted screw in to increase the pressure, turn out to decrease the pressure. If pressure does not increase or decrease as desired, remove the regulating screw, spring and piston, wash these parts in fuel oil or kerosene, reassemble and try again, if pressure shows no change, check oil pressure gauge, oil lines or bearings.

The DFX-F engines have the oil pressure regulator located on top of the oil filter as shown in Illustration No. 142.

OIL SEALS

The construction of this engine prevents oil leakage when gaskets are in proper condition and all bolts and screws are properly tightened. Whenever a shaft extends through the engine case and there is a possibility of oil leakage an oil seal is used which also acts as a dust seal preventing dust entering the engine.

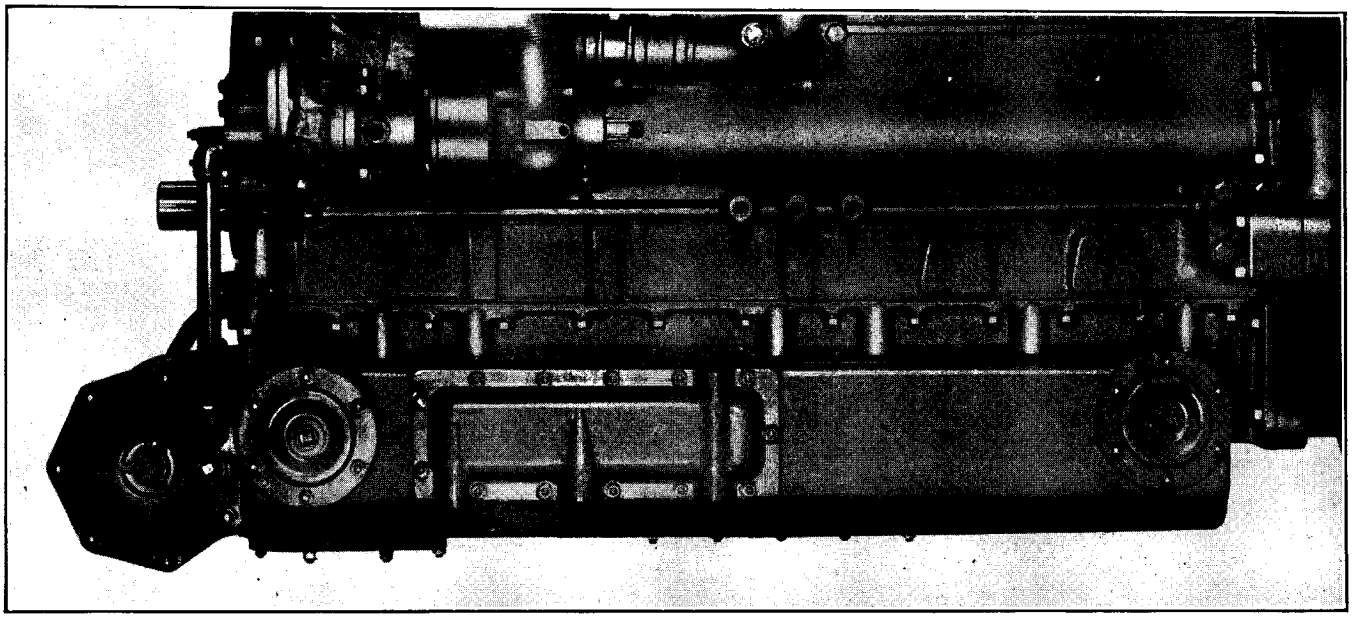


Illustration No. 132

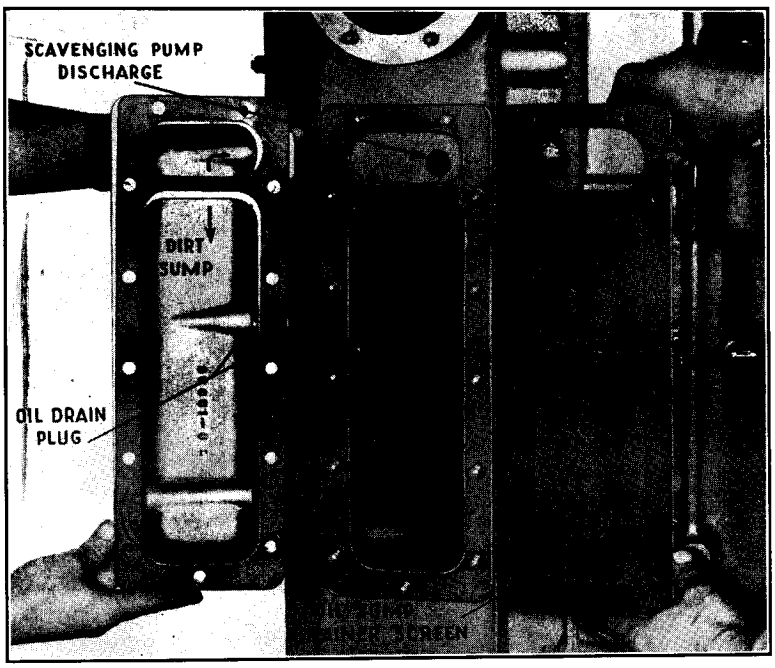


Illustration No. 133

A patented composition seal is used in the water pump and fuel pump drive shaft to seal against leakage at these points. The crankshaft is sealed at the front end by a patented steel encased leather or synthetic rubber type seal. It is necessary that the bore in the gear cover be concentric with the crankshaft, otherwise the seal will bear unevenly on the crankshaft and, besides wearing rapidly, will leak. The crankshaft must be free from nicks and other rough spots. To renew this seal, it is necessary to remove the gear cover to put new seal into place.

The bellhousing oil seal is also a patented type of oil seal and must be carefully installed. Be sure there are no nicks or rough spots on the flywheel pilot where the seal seats.

A thin coating of oil soap should be applied to the sealing surface as a lubricant during the run-in period.

When installing seals care must be exercised so that they are not mutilated.

Leakage is usually corrected by installing new seals.

PISTON

The piston is made of a very special aluminum alloy and is of the solid type, having no saw slot or split in the skirt. Six piston rings are used, the upper four rings being of the compression type, while the fifth ring from the top which is above the piston pin and likewise the ring located near the bottom of the skirt are of the oil regulating type. The top of the piston is made very thick in order to uniformly transfer the heat from the top of the piston to the various rings and into the skirt of the piston where it can be dissipated into the water jacket without any of the piston rings becoming extremely hot, which condition tends to rapidly destroy lubrication of such parts. The top ring is located well below the top of the piston to prevent its becoming too hot. This tends to eliminate the sticking of piston rings. Illustration No. 144.

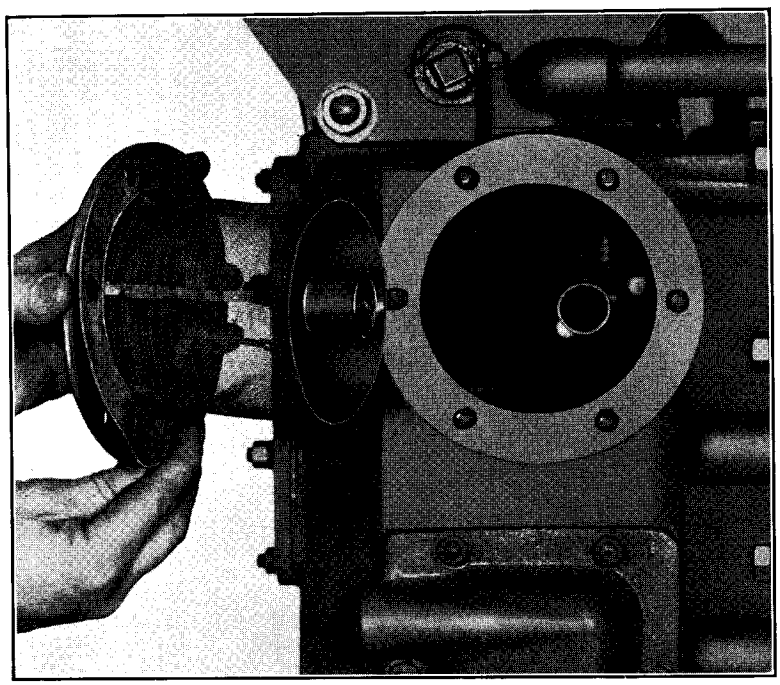


Illustration No. 134

When checking piston rings consideration must be given the fact that the rings are not as tight in the grooves when the piston is hot, and consequently rings which seem to be tight in the groove after engine has been in operation for a considerable period of time may in reality be loose enough to function properly when the engine is heated up. The appearance of the rings will usually show whether the ring has been functioning.

The pistons must be assembled with the rounded top edge, see Illustration No. 105, of the piston toward the combustion chamber.

PISTON CLEARANCES

The clearances as shown on page 124 are obtained by measuring the piston diameter of the skirt at the bottom of the piston with outside michrometers and measuring the cylinder bore diameter with inside michrometers. If feeler ribbons are used, two should be used; in other words, to obtain .009, one .004 and one .005 should be used together to obtain the .009, or if .015 is the clearance to be obtained, use one .007 and one .008 (Preferably 3 pieces .005" thick) to obtain the .015 rather than use the single feeler which would be too thick and not flexible enough to fit the contour of the cylinder bores. The ribbons used should be one-half inch wide and it should be possible to pull out the ribbons with four to six pound pull.

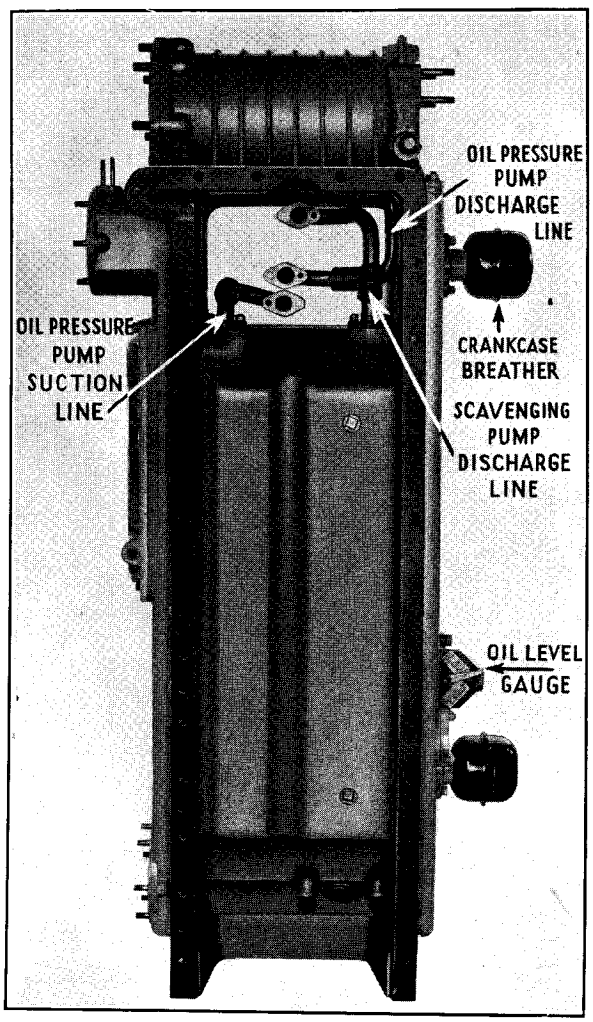


Illustration No. 135

PISTON PIN

The piston pin is of very large diameter, and is of the full floating type. This means that the pin can rotate in either the piston bosses or in the bushing at the top end of the conecting rod, but the fit in the piston is intended to be much tighter than the fit in the connecting rod; consequently the movement in the piston consists of a light creeping action, while the normal rotation of the pin occurs in the bushing in the rod. The piston pin is prevented from moving endwise and making contact with the cylinder wall by means of snap rings which lock in grooves machined in the bosses of the piston. The piston pin should have a clearance of .0005" to .0015" in the bushing in the top of the connecting rod.

PISTON RING GAP AND GROOVE CLEARANCE

The piston rings when fitted to the bore of the engine should have a gap clearance between .018" and .022". The top ring will have no land clearance as it is the Keystone type. The other rings should have from .0015" to .003" land clearance. See table of clearances, Page 124.

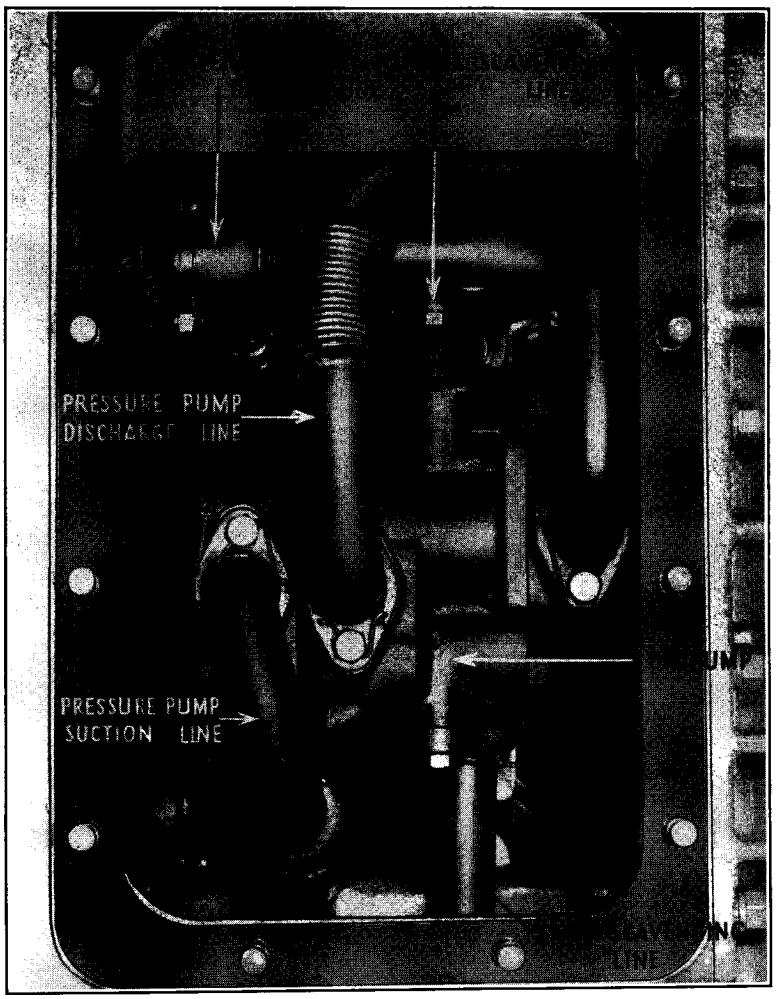


Illustration No. 136

handled carefully in order not to distort or break them.

PISTON RINGS

When installing new piston rings, each ring should be tried in the cylinder bore to see if it has the correct gap of .018" to .022". If necessary to increase the gap the ring should be held and filed as shown in Illustration No. 143. If the ring is held in a vise, the vise jaws must be covered with some soft metal. The ends of the rings are squeezed together and the file cuts on both sides. This will insure the ends being parallel. When inserting the ring in the cylinder bore to test the gap clearance, push the ring part way through the bore using the bottom of a piston to square the ring in the bore.

Each new ring should be tried for clearance in the piston groove by rolling the ring all the way around the groove as shown in Illustration No. 144. If the piston grooves have been carefully cleaned the rings will be found to fit correctly, but if they are tight they can be lapped slightly on a sheet of emery cloth (No. .000) laid on a flat surface. Use a light uniform pressure when lapping.

When assembling piston rings to the piston, if a ring spreader tool, Illustration No. 145, is not available the rings can be slipped over thin strips of metal. Whatever method is used the rings must be

STARTING MOTOR

The starting motor is designed to crank the engine when the switch closes the circuit between the storage battery and the motor. It consists of five main sub-assemblies, the frame and field, the armature, the commutator end head, the pinion housing and the Bendix Drive. The frame and field consists of the frame which supports the components of the starting motor, the pole pieces and the field coils. The coils supply the magnetic field which is needed to produce torque; the pole pieces and frame supply the path for the magnetic field. Illustration No. 146 is an assembly drawing of a starting motor.

The armature consists of a soft iron core, a commutator and the windings which are wound in slots in the core and are connected to the commutator. The commutator consists of a number of copper segments insulated from each other and from the armature shaft.

The commutator end head supports a bearing, brush holders and brushes. The pinion housing is a cast iron housing for the Bendix Drive and also provides the motor mounting lugs. The Bendix Drive is an Automatic clutch that engages the starting motor with the engine flywheel when the motor cranks the engine and disengages when the engine starts. It consists of a threaded sleeve fastened to the armature shaft thru a drive spring and a pinion mounted on the threads of the sleeve. When the starting circuit is closed the armature revolves, turning the sleeve within the pinion and forces the gear forward, meshing it with the flywheel gear. The sudden shock of meshing is absorbed by the spring. When the engine starts the pinion is driven faster than the sleeve and is forced back along the threads, automatically demeshing it from the flywheel.

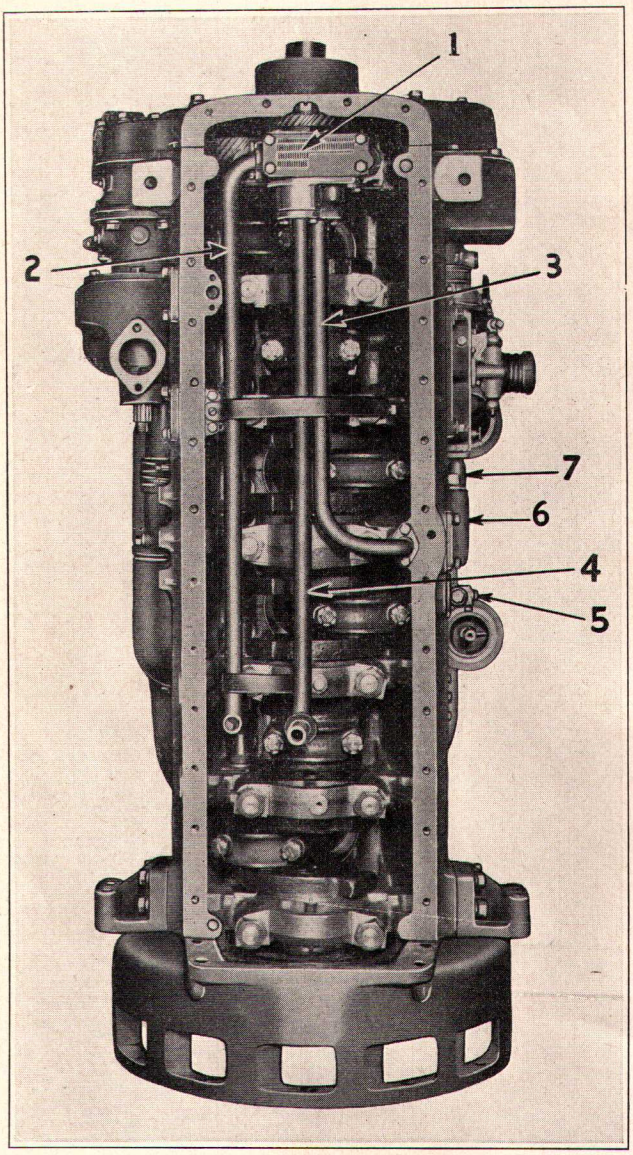


Illustration No. 137

LUBRICATION

Some starters are provided with an oil cup which should be filled with lubricating oil when unit is lubricated.

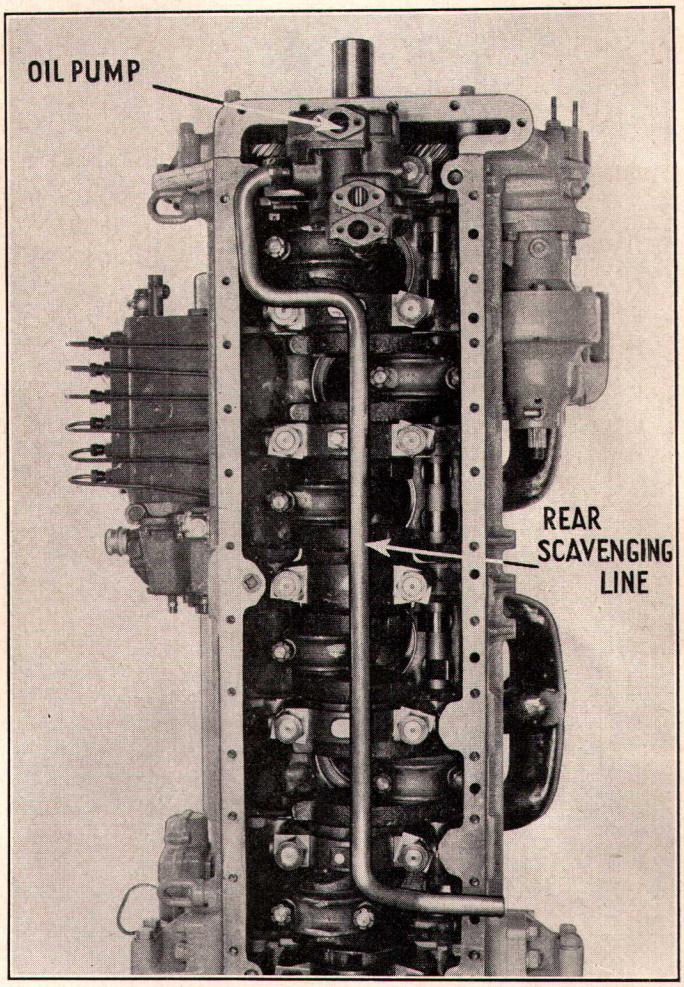


Illustration No. 138

Other starters have no provision for oiling and these are lubricated at time of overhaul.

After the starting motor has been in service for an extended period it should be removed, dismantled and cleaned. Clean the Bendix Drive thoroughly and lubricate sparingly with oil. Inspect the wiring for loose or corroded connections and for broken leads. Make sure the insulation on the wiring has not become frayed.

TIMING GEARS

The timing gears in the vertical engine consist of the crankshaft gear and camshaft gear which are timed with punch marks as shown in Illustration No. 95. In addition to these two gears, there are the oil pump drive gear and the water pump drive gear. As can be seen in Illustration No. 95, the fuel pump is chain-driven by sprockets and roller chain. The timing of these gears and sprockets have been discussed in earlier paragraphs of this book. See camshaft, page 85 and fuel pump drive, page 94.

The timing gears of the DFX-F are shown in Illustration No. 96 and are timed as shown in Illustration No. 147. Illustration No. 147 should be carefully studied before attempting disassembly or reassembly of the timing gears of this type engine. As you will note on this illustration, the timing marks as shown in Illustration No. 96 as C and D will only line up once in each six complete revolutions of the crankshaft.

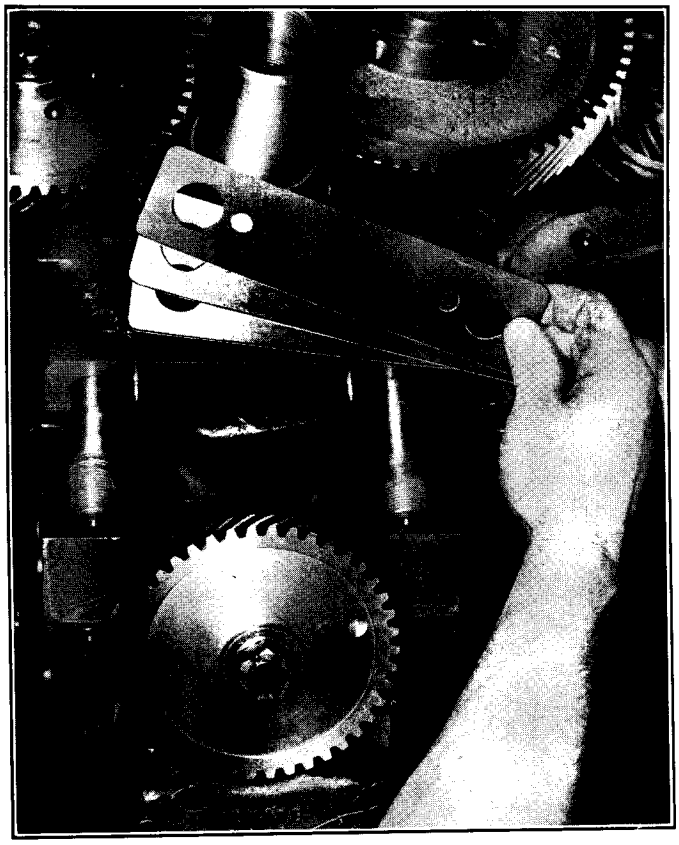


Illustration No. 139

The idler gear and fuel pump drive gear shown in Illustration No. 147 are fastened together and used as a single unit. This unit is supported on a stud or shaft which is fastened in place as shown in Illustration No. 148.

THERMOSTAT AND BYPASS

Some engines are equipped with one thermostat as shown in Illustration No. 149, while other engines are equipped with dual thermostats as shown in Illustration No. 150, either system is so designed that it will not allow water from the radiator to circulate through the engine until the water in the engine is at operating temperature but does bypass a certain amount of water from the cylinder block which is carried through the bypass tube to the inlet side of the water pump where it is again circulated through the engine. This is repeated until the water in the engine is heated to operating temperature, when the thermostat begins to open and permits the water from the engine to enter the radiator. This water is at the same time replaced in the engine by the water pump drawing from the bottom of the radiator. Thus the water temperature is constantly maintained in the proper heat range.

A defective thermostat of this type must be replaced as it cannot be repaired. The standard thermostat should start opening at 150° ± 2½° F. and be completely open at 175° in still water test.

The still water test is as follows: Place approximately 4" of water in a pan or pail. Insert a thermometer of this heat range in the in the water and set the thermostat in the water with the bellows submerged. Heat the water slowly and carefully observe when the thermostat valve starts to open and note the water temperature as indicated by the thermometer; continue to heat the water until the thermostat is fully open and again note the water temperature and then compare these temperatures with those given above.

Five degrees above or under those given are permissable.

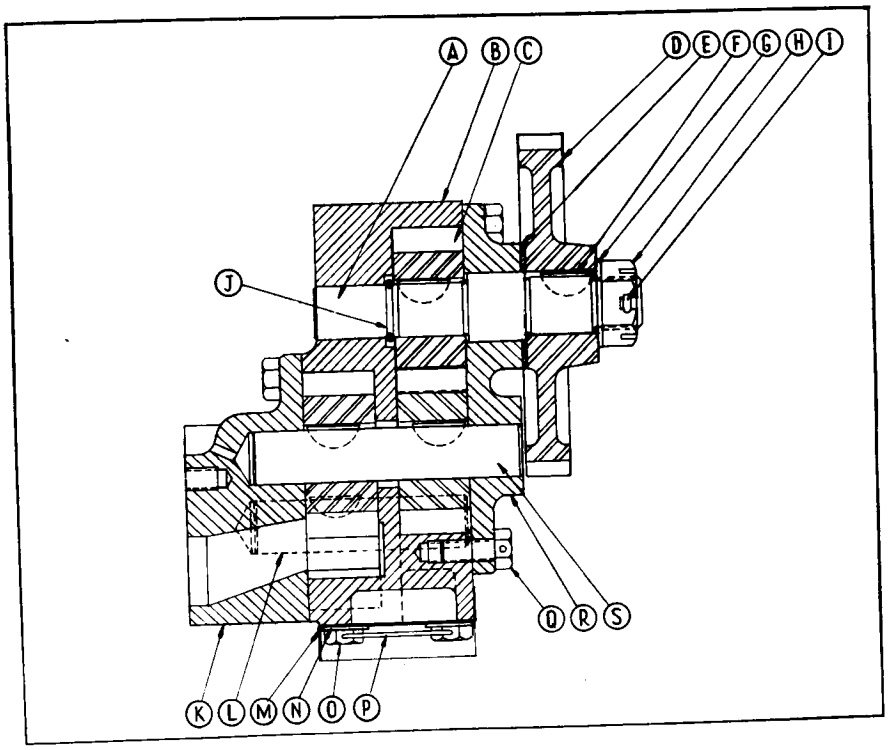


Illustration No. 140

VALVE MECHANISM

The valves being located in the cylinder head are operated by conventional type tappets with hollow push rods running from the tappets to the rocker arms. The rocker arms are lubricated by means of oil forced through the hollow shaft on which they rotate. Oil is forced out through small holes in the rocker arms

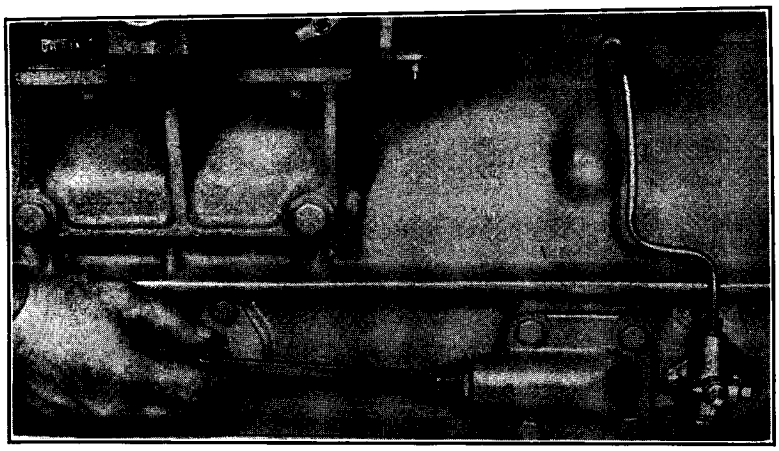


Illustration No. 141

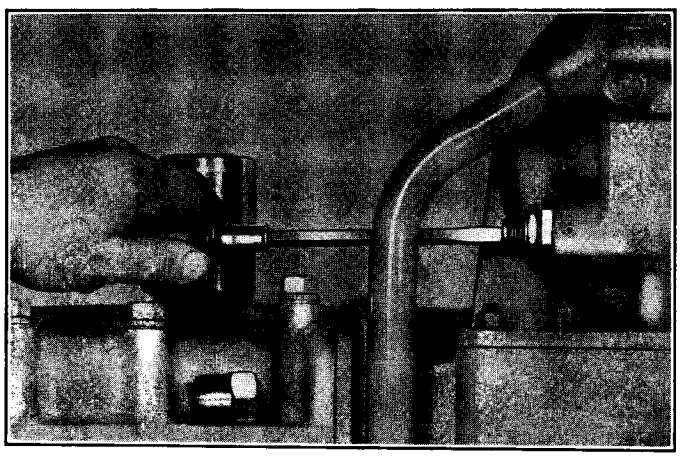


Illustration No. 142

over the valve stems and push rods. A clearance of .010" should be maintained between rocker arms and inlet valve stems. The clearance between valve stems and valve guides when new is approximately .0025" to .0035" for exhaust valves and intake valves. See clearances table, Page 124.

VALVE GRINDING

If proper fuel oil, lubricating oil, and air cleaners have been used, and cared for, and proper clearances have been maintained between valve stem and rocker arm, valve grinding will be necessary very infrequently. Their seating should be tested periodically by rocking the engine against compression. When the engine will not rock, compression is leaking through either the valves or cylinder head gaskt or past the rings. Check the leak by listening for a "hissing" sound, when the engine is cranked by hand, either at the cylinder head gasket or in the crankcase breather. If at cylinder head gasket, remove head and replace gasket. If in the breather, dismantle engine and install new parts for those found worn or scored. If no "hissing" is heard at either of these two places, remove head and valves, clean both thoroughly, removing all carbon and oil. Inspect valve seats and valves.

If deep pits are found, either replace valves with new or reface old, reface seats with a vibrating 45° angle grinder type reseating tool similar to that shown in Illustration No. 151. Because of the large diameter and surface of the valve seats it is very difficult to obtain a good reseating job with reamer type tool. Remove all shoulders and pits from the seat but do not grind any deeper than necessary. Then finish the new or refinished valve, to the reseated seat by hand in the usual manner making the same tests for seating.

If the valves and seats are not deeply pitted or shouldered, obtain a light spring with enough tension to just hold the valve off the seat. Lubricate the valve stem and apply a thin coating of good quality medium coarse grinding compound on the valve face. Insert the valve in the valve guide and rotate the valve, back and forth about a quarter of a turn a few times pressing firmly on the grinding tool. Release the pressure on the tool and the spring should lift the valve from its seat. Rotate the valve 15° or 20° and repeat the grinding process. It will probably be necessary to wipe off and inspect the valve and seat during this process to see what progress is being made or the compound may wear off the surfaces being ground. In either case re-apply another thin coating of compound until the test shows the surfaces are in contact. Then wipe off all heavy compound and apply a thin coating of "fine" compound and continue the grinding. When the surfaces are "finished" make ten or twelve pencil marks equally spaced across the face of the valve and lightly rotate the valve in the seat. If all the marks are wiped off the valve is properly seated. If any marks are left intact keep grinding until valve is properly seated.

Be sure to clean all grinding compound from valve seats and stems before reassembling.

When all valves are seated reassemble in head with springs and retainers. Turn head on exhaust opening side and pour gasoline in the intake openings. If any gasoline seeps out around valve remove that valve and regrind. Turn head over so the intake openings are down and repeat the test pouring the gasoline in the exhaust openings. If any exhaust valves leak regrind.

When valves are all properly seated and assembled install head on engine, install push rods and rocker arms and set valve stem to rocker arm clearances. See table Page 124.

Start engine and run until properly warmed up. Tighten heads down again with engine warm. Then recheck and adjust valve clearances with warm engine.

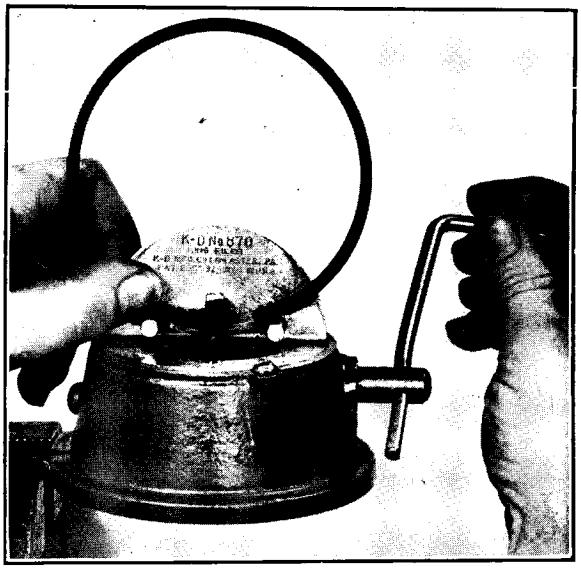


Illustration No. 143

VALVE TAPPET ASSEMBLY

Illustration No. 152 shows the arrangement of the valve tappets and guides in the side of the block. Each guide, 3, is pressed into the cylinder block casting. The tappets, 2, are hollow to receive the pushrods, 1.

Some engines had the tappet guides installed as shown in Illustration No. 153. The guides 3 in this type installation are held in place by the screw and washer 4. After removal of the screws, the guides may be readily removed.

WATER CIRCULATION AND WATER PUMP

Water is circulated by means of a centrifugal type pump as shown in Illustration No. 154. To remove this pump it is necessary to remove the generator, generator coupling, water inlet pipe, also disconnect the tachometer cable, if one is used. After the above parts are removed the attaching stud nuts may be removed and the pump pulled directly toward the rear of the engine as shown in Illustration No. 154. Illustration No. 155 shows a sectional view through the pump, also the relation of the component parts of the pump assembly.

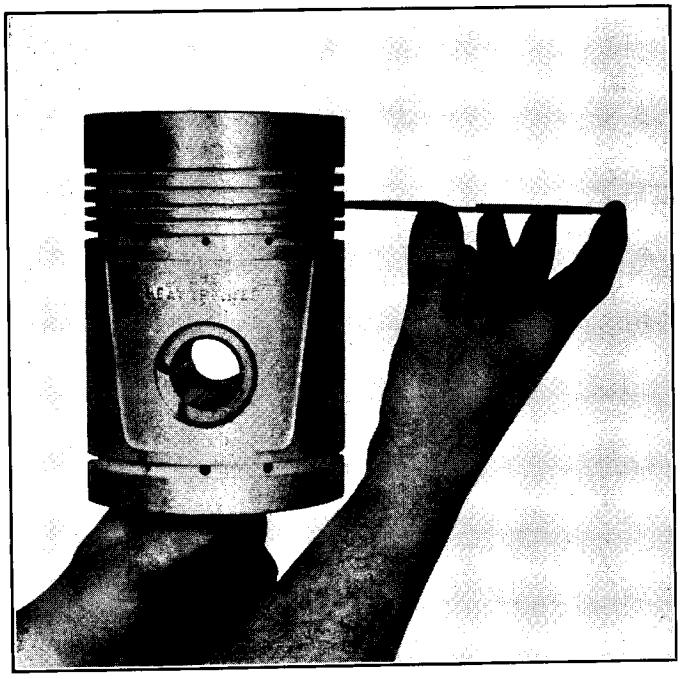


Illustration No. 144

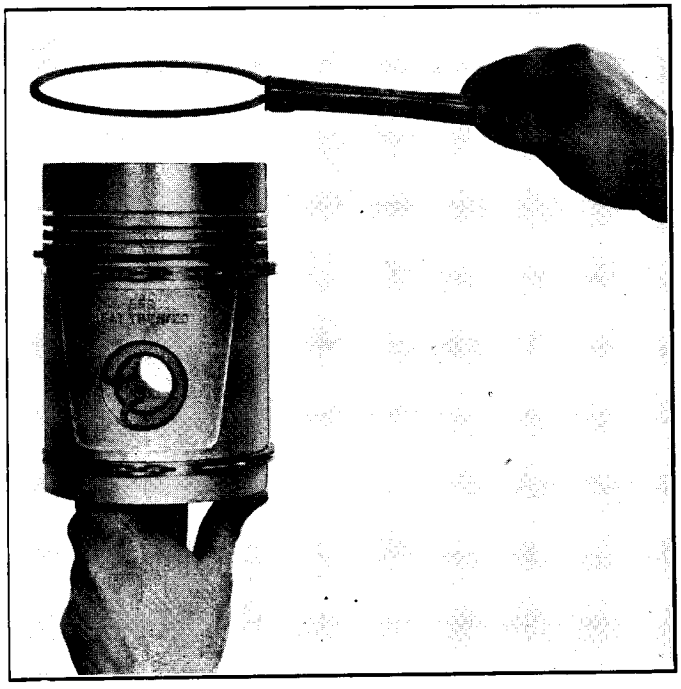


Illustration No. 145

The DFX vertical engine water pump will be discussed in this book. Since the water pump for the "flat" engine is very similar; the instructions will also serve as a guide for servicing that pump.

LUBRICATION: The oil plug, 2 Illustration No. 154 should be removed and filled with SAE No. 50 motor oil before start of each day of operation.

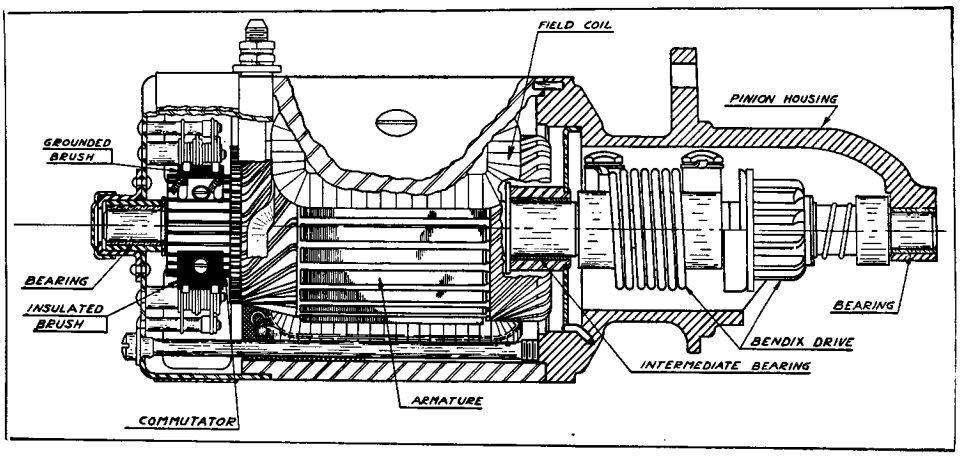


Illustration No. 146

DISASSEMBLY: (All letters refer to Illustration No. 155).

1. Remove lock ring (11) from housing.
2. Remove the six housing nuts (19) and lockwashers (20).
3. Pull housing (21) from shaft.
4. Press out the oil seal (29) and ball bearing (9) from housing.
5. Remove water pump seal snap wire (28) from exposed end of impeller (4). Remove seal parts (23 to 27).
6. Remove pin (22) from impeller.
7. Support bearing sleeve (2) on front mounting surface and press shaft out of impeller. Care must be taken not to crack bearing sleeve if impeller is very tight on shaft. Remove the second seal assembly from impeller.
8. Remove nut 15 and lockwasher 16. Then remove bearing 8, tachometer drive gear 6, oil slinger 13 and spacer 12.
9. Press oil seal (17) out of bearing sleeve (22).

SERVICE AND REASSEMBLY:

10. Inspect sealing surfaces on the housing (1) and bearing sleeve (2). If the sealing surfaces on these castings are rough and worn, they should be refaced in a lathe square with the axis of the shaft. A smooth flat surface is all that is required for satisfactory seal operation. If these seal faces are so badly worn that more than .030" has to be removed, new housing (1) and bearing sleeve (2) castings should be used.
11. Inspect ball bearing (7, 8, and 9) for wear. Replace worn parts.
12. Inspect impeller (4) for wear and erosion. Seal pockets should be in good condition so that seal assemblies will slide freely in the slots. Usually it is preferable to use new impeller and seal parts. The old impeller, however, can be used, after proper cleaning, by using new seal parts (23 to 27).
13. If a new shaft is to be used, press drive gear (5), tachometer gear (6) and oil slinger (13) on new shaft (3).
14. Press new oil seal (17) into bearing sleeve (2) making certain that sealing lip points toward drive gear end of shaft.

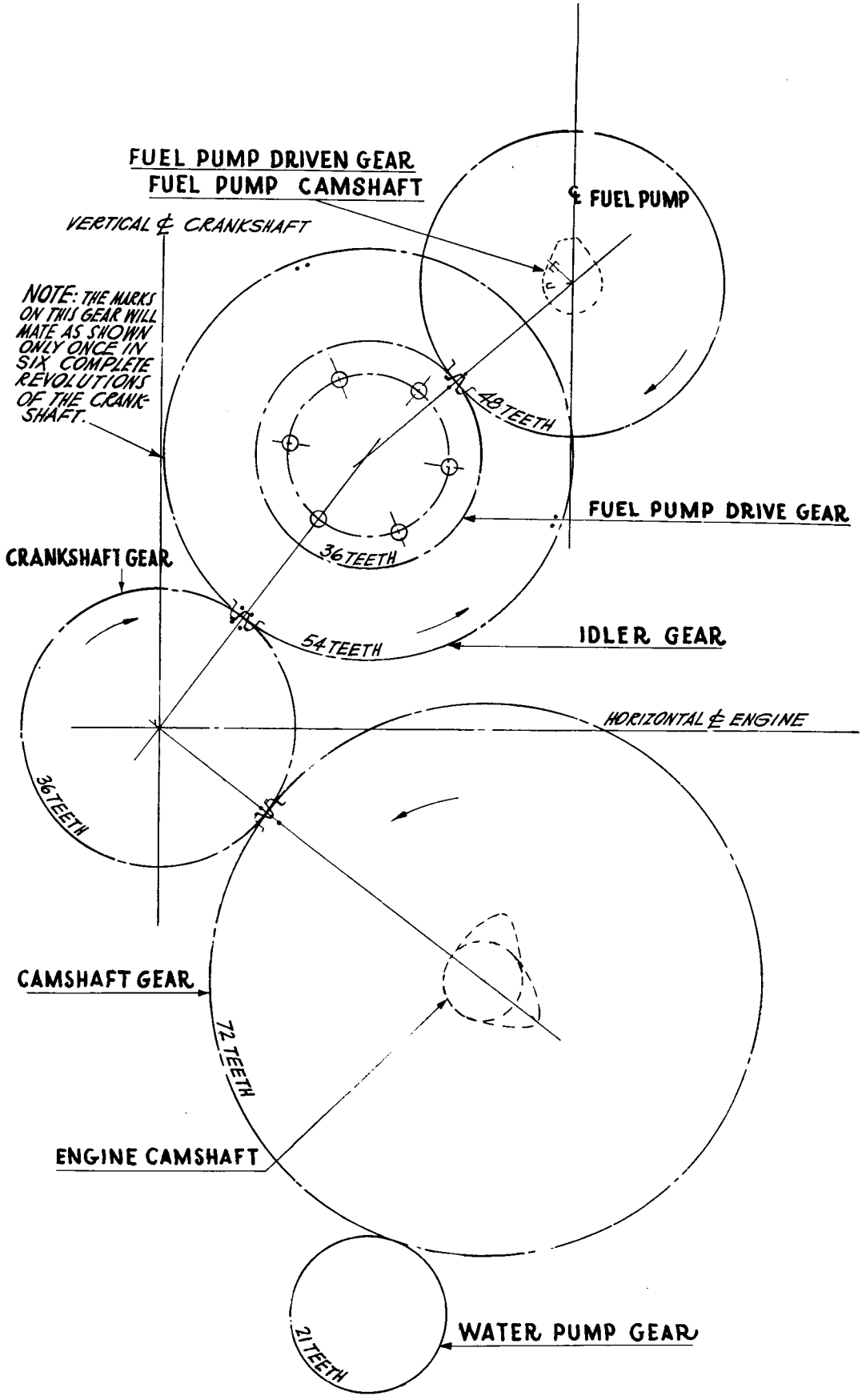


Illustration No. 147

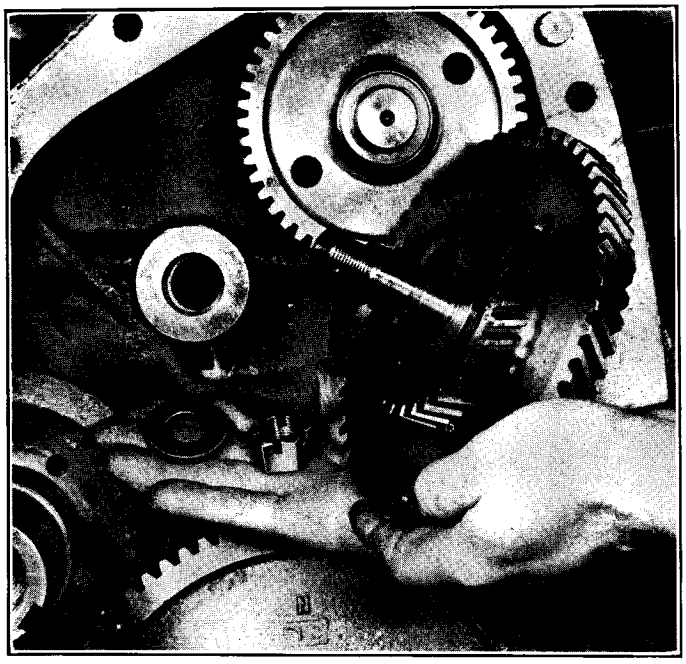


Illustration No. 148

15. Place bearing 7 on shaft, install spacer 12, oil slinger 13, tachometer drive 6 and bearing 8. Assemble lockwasher 16 and nut 15. Bend tongue of lockwasher 16 into slot in nut 15.

16. Insert shaft and bearing assembly into bearing sleeve (2) taking care not to damage oil seal (17).

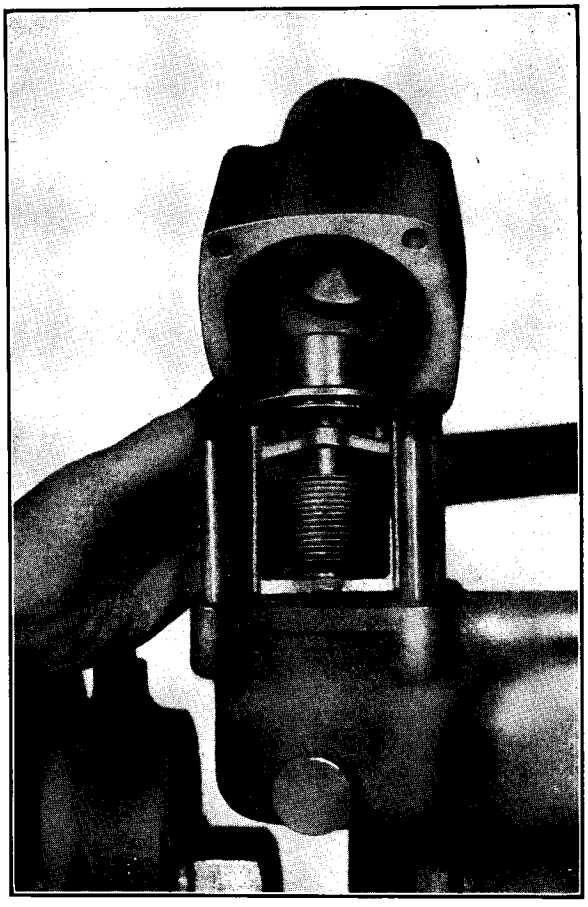


Illustration No. 149

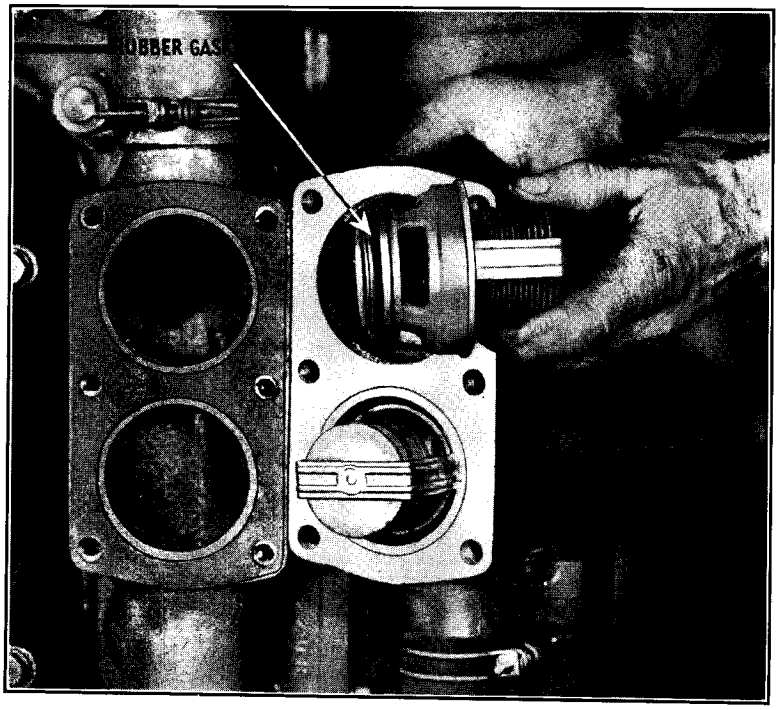


Illustration No. 150

17. Assemble seal parts (23 to 27) in the drive gear side of the impeller only. Insert snap wire (28) to lock seal parts in the impeller.

18. Press impeller on shaft. A dimension of 1" should be held between the impeller face and the mounting surface of bearing sleeve (2). See Illustration No. 156.

19. The impeller has a drive pin hole drilled in one side of the hub. Drill through this hole and through the shaft and opposite side of the impeller hub. Insert drive pin (22).

20. Install second seal (23 to 27) in impeller (4).

21. Press inner oil seal (29) into housing (1).

22. Assemble housing (1) over shaft and bolt to bearing sleeve (2).

23. Support shaft on drive gear end and press ball bearing (9) into housing.

24. Insert lock ring (11).

25. Turn shaft to see that it rotates freely.

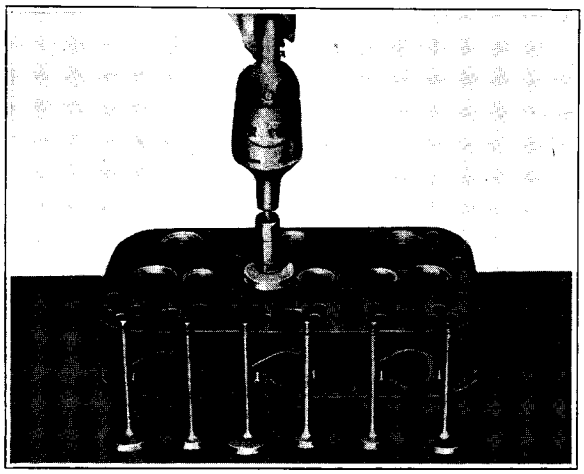


Illustration No. 151

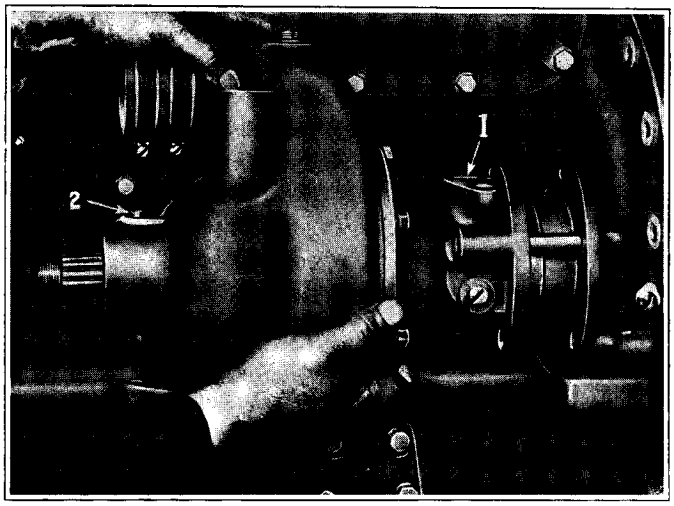


Illustration No. 154

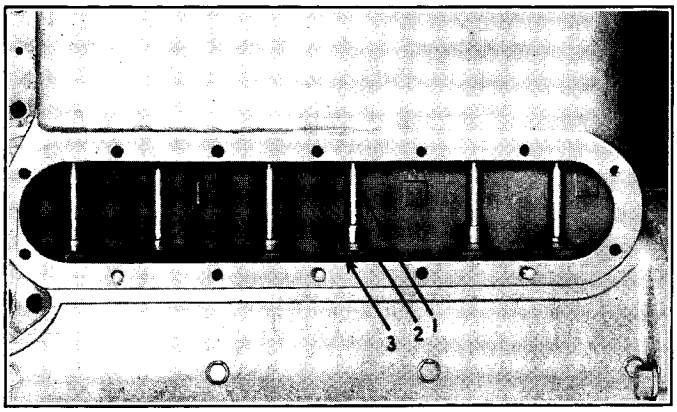


Illustration No. 152

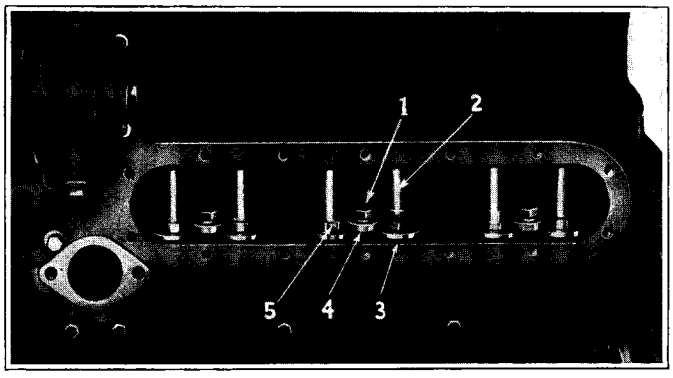


Illustration No. 153

CAUTION: When assembling coupling flanges, PUMP SHAFT MUST NOT be subjected to HAMMER BLOWS as it will result in SERIOUS DAMAGE to seals and bearings. Support pump assembly on front end of pump shaft and USE an ARBOR PRESS to press coupling onto shaft. Always use a puller to remove the coupling from the shaft. DO NOT hammer on the coupling.

WIRING DIAGRAMS

The wiring diagrams shown in Illustration No. 157, 158, 159, 160, 161, 162 and 163 are applicable to most installations. However, there are some special installations such as 32 volt systems where these diagrams cannot be used. If in doubt, write to the Service Department of Hercules Motors Corporation, Canton, Ohio giving full particulars, including engine serial number and model designations of starter, generator and voltage regulator.

On most heavy duty Diesel engines the cranking requirements are high and consequently a higher voltage starting motor is desirable so that adequate cranking performance will be obtained. To attain this high cranking voltage and still retain the lower voltage desirable for lighting and accessories, a series-parallel starting switch is required.

The series-parallel switch makes it possible to use two 12 volt batteries which are connected in parallel for normal operating conditions after the engine is started, but which are connected in series by means of the series-parallel switch to provide 24 volts rquired for the cranking motor when cranking the engine.

NOTE: Four 6 volt batteries may be used in place of the two 12 volt by connecting 2 of the 6 volt batteries in series to obtain 12 volts and then connecting these two sets of batteries to the series-parallel switch in the same manner as the 12 volt batteries.

Illustration No. 157 shows the wiring circuit with the mechanically operated series-parallel switch in charging position after the engine is started. NOTE: The ammeter shown connected to the series-parallel switch (if an ammeter of sufficient capacity for this connection is not available, an ammeter of lower

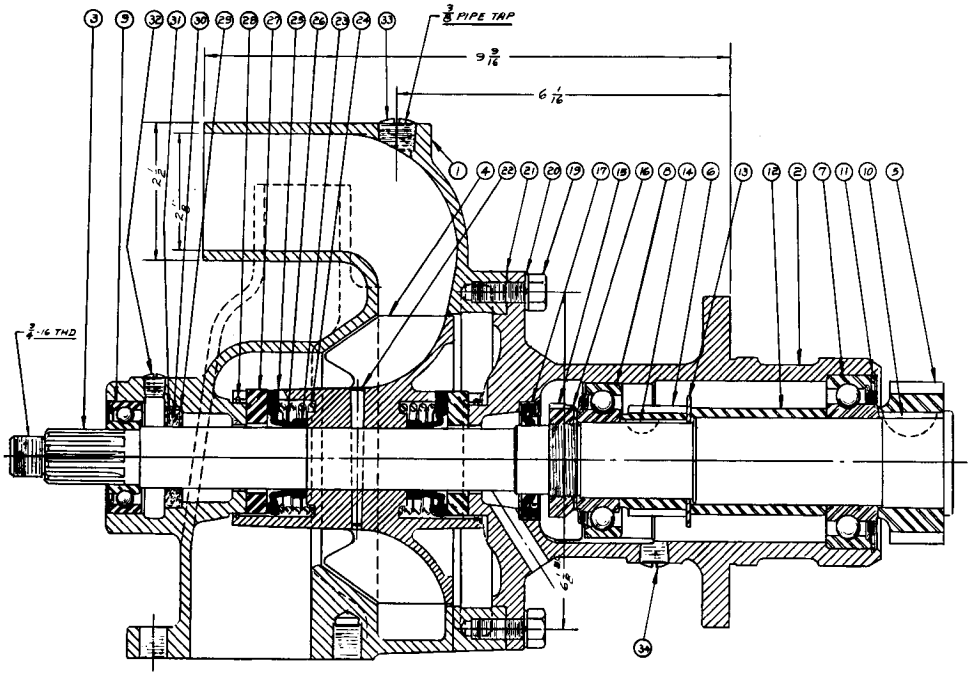


Illustration No. 155

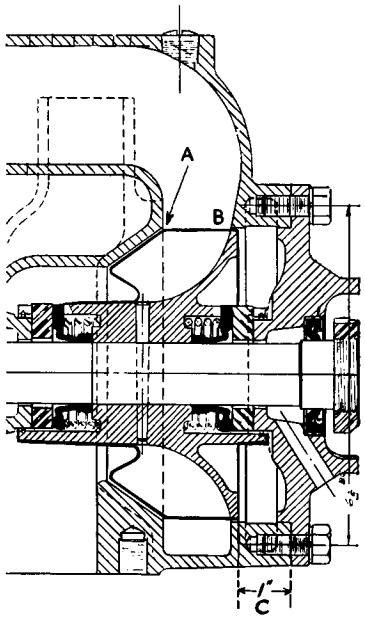


Illustration No. 156

rated capacity may be used if connected in the circuit between the switch terminal marked "B" and the starter terminal) is required to indicate that the battery marked "B" is being charged. The amount shown on this ammeter should be subtracted from that shown on the main ammeter to obtain the charging rate for the battery marked "A".

Since this a positive grounded system, the charging circuit can be traced through the wires shown in black.

Illustration No. 158 shows the wiring circuit with the series-parallel switch in starting position. The circuit shown in black indicates how the batteries are connected in series through the switch for cranking the engine.

Illustrations No. 159 and No. 160 show the same system except that an electrically operated solenoid type series-parallel switch is used instead of the manual type. This system requires the addition of a push button switch and suitable wiring, as shown, to operate the solenoid switch.

Illustration No. 161 shows the same system as shown in Illustration Nos. 157, 158, 159 and 160 except that the voltage regulator is completely insulated and consequently an additional wire is required to ground the regulator to the generator as shown.

Illustration No. 162 shows the straight 24 volt system with a solenoid type starting switch while Illustration No. 163 shows the same system with a manually operated starter switch.

"TROUBLE SHOOTING"

ENGINE WON'T START OR HARD STARTING

1. No fuel in tank—Fill Tank.
2. No fuel in pump—See Starting, 6 page 12.
3. Not properly prepared for starting at the atmospheric temperature being encountered—See Starting, pages 12, 13 and 14.
4. Weak batteries will not turn engine over rapidly enough—recharge batteries.
5. Fuel too heavy to flow through pipes properly—Lighter fuel. See Fuel Oil Specification, page 21.
6. Water in fuel—Drain fuel system and tanks. Change fuel supply.
7. Rings or cylinder walls worn badly—Replace with new.

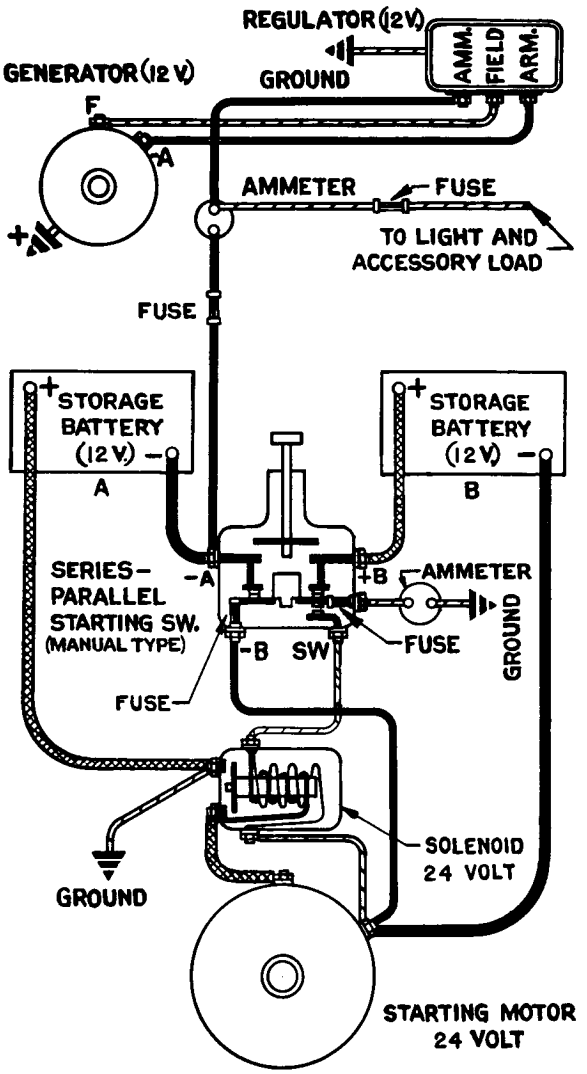


Illustration No. 157

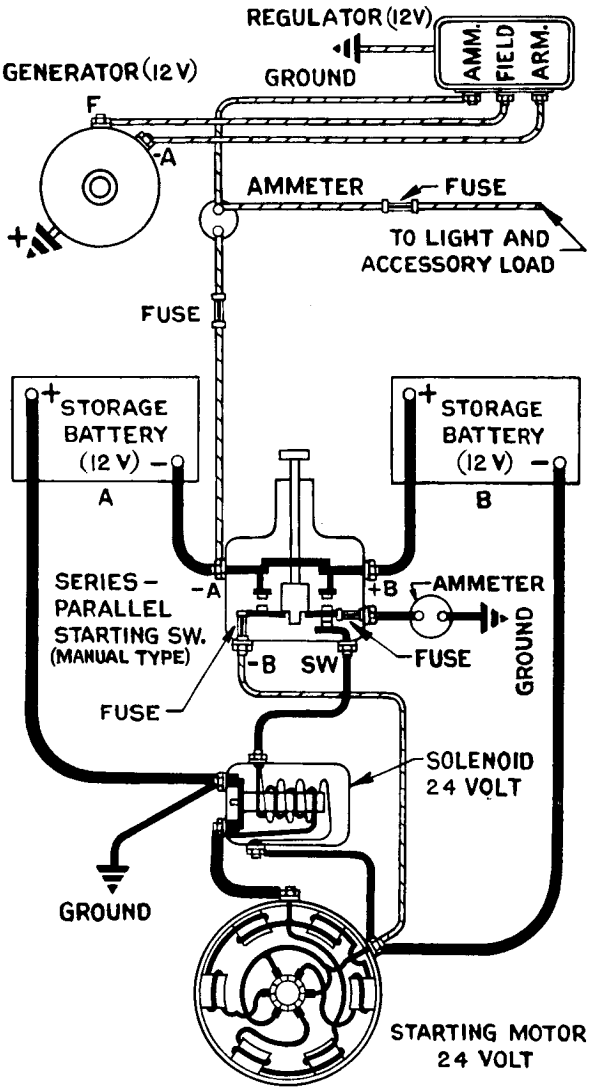


Illustration No. 158

8. Exhaust or intake valve pitted or worn—regrind valves.
9. Leaking head gasket—Replace gasket.
10. Air cleaner plugged, not allowing sufficient air to pass through—Clean air cleaner.
11. Governor stop lever stuck in shut-off or stop position.

ENGINE STOPS SUDDENLY

1. No fuel—Fill tank, prime and start as under Starting, pages 12, 13 and 14.
2. Fuel pumps or lines air or gas bound—See Starting, page 12.
3. Fuel filter plugged—Clean filter then prime lines.
4. Obstruction in or broken fuel line—Check, starting with fuel tank to strainer—replace.
5. Water in fuel—Drain entire system including tank and clean. Fill with clean fuel and then proceed as under Starting, pages 12, 13 and 14.
6. Transfer pump not functioning properly—Inspect valves, springs, gaskets, plunger, roller and guide.
7. Piston seizure due to lack of lubrication—Remove piston and replace with new if badly scored. Change lubricating oil after thoroughly cleaning oil pan, lines and filter.

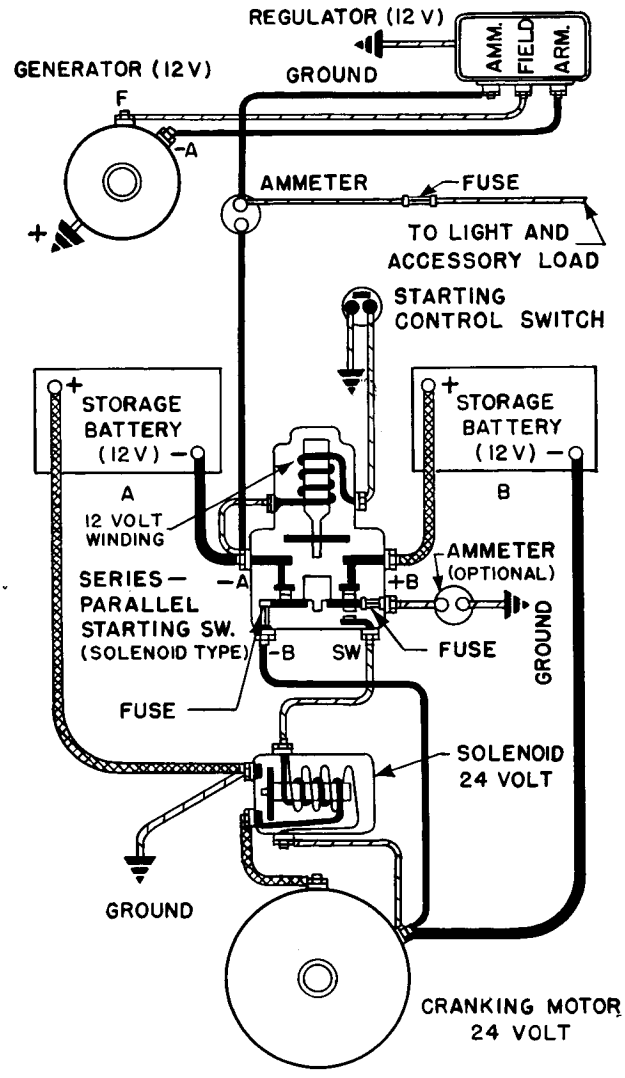


Illustration No. 159

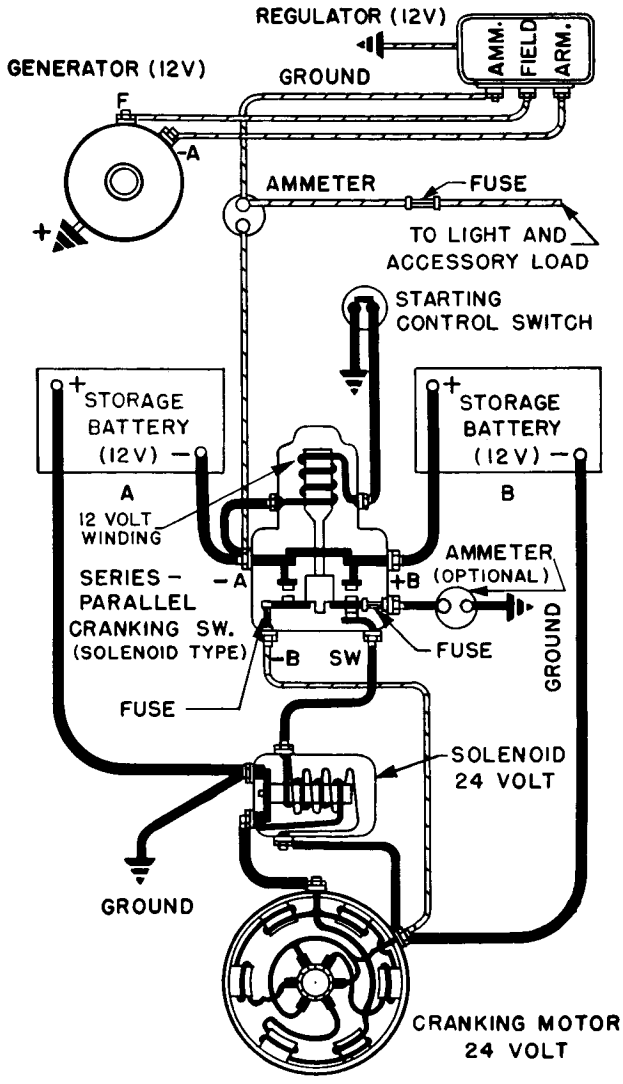


Illustration No. 160

8. Bearing seizure due to lack of lubrication—If not to badly wiped, scrape enough to clean up and re-install. If badly wiped, replace with new.

9. Fuel pump adjustable coupling slipped due to not being properly tightened—Retime pump. See section 4, starting on page 34.

ENGINE MISSING ERRATICALLY OR INTERMITTENTLY—On All Cylinders

1. Improper fuel, fuel with poor burning qualities—Drain system including tank and refill with suitable fuel.

2. Water in fuel—Drain fuel system including tank of all water and sediment. Refill with clean fuel.

3. Sticking nozzle valve stems or pump delivery valves or both—Remove stuck parts and clean. Caused usually from dirty fuel. Clean entire system after draining and fill with clean fuel.

4. Worn piston rings or cylinders or both—Replace with new.

5. Leaky intake or exhaust valves or both—Regrind valves.

6. Plugged air cleaner reducing air admitted into cylinders—Clean air cleaner.

ENGINE MISSING—On 1 or 2 Cylinders

To determine which cylinder or cylinders are missing, loosen the nuts connecting the fuel lines to the fuel nozzles one at a time. If the engine speed remains the same and exhaust sounds the same that is the

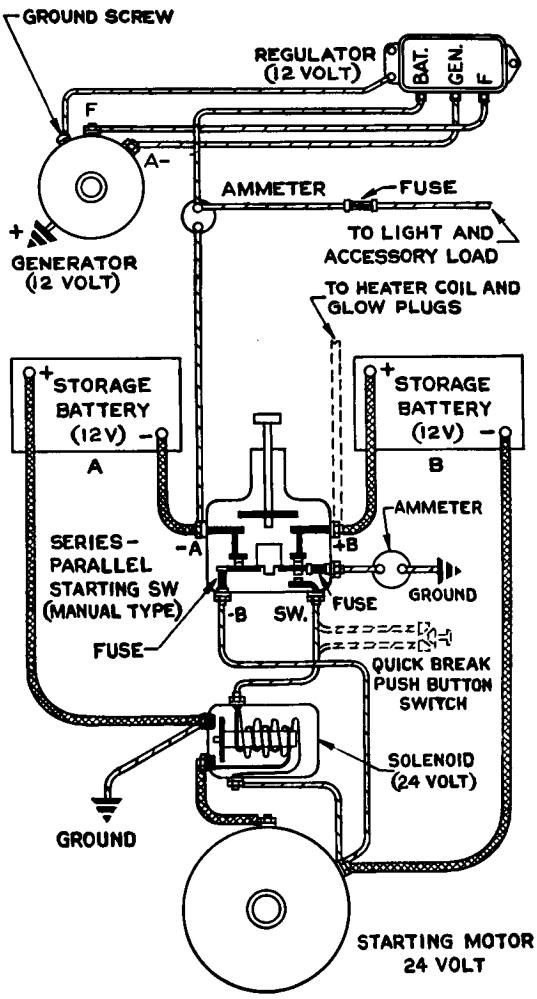


Illustration No. 161

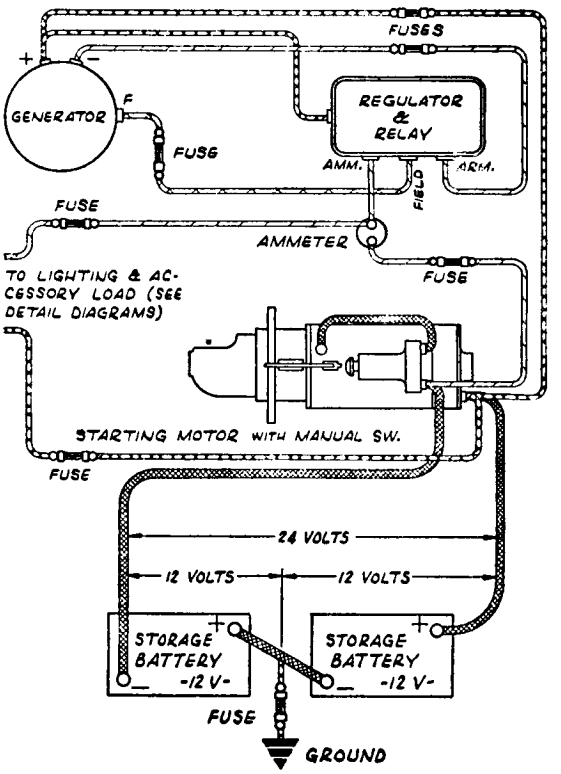


Illustration No. 162

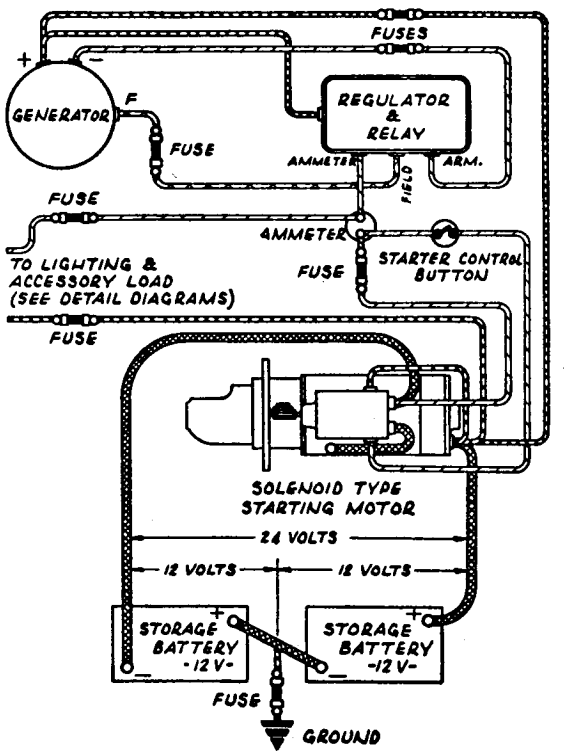


Illustration No. 163

cylinder missing. If the engine speed slows down and the exhaust loses its same rhythm then the cylinder is functioning.

1. Fuel valve stuck in body—Remove and clean.
2. Air or gas binding in fuel pump or lines—Usually when testing to see what cylinder is missing, this condition will be cleared up as opening the nut allows the air or gas to escape.
3. Exhaust or intaake valve stuck—Remove valve cover and check which one is stuck. Free with kerosene, gasoline or alcohol poured down stem. Alcohol is the quickest solvent. If still sticking, remove head and determine cause.
4. Leaky exhaust or intake valve—Regrind valve.
5. Exhaust or intake valve spring or spring retainer lock broken—Replace with new.
6. Improper exhaust or intake valve clearance between valve and rocker arm—Check clearance and reset to proper clearance.

7. Fuel pump delivery valve leaking or stuck—Remove and clean with soft cloth and clean fuel oil or Gasoline. If cleaning does not free the valve remove both valve and seat and install new. (These valves and seats must be used as an assembly as parts are not interchangeable one seat with another valve.)
8. Fuel pump delivery valve spring broken—Replace with new.
9. Piston rings or cylinder walls badly worn—Replace with new.

CAUSES AND REMEDIES

Smoke in Exhaust

The brown or black color in exhaust is pure carbon—one of the elements of the fuel, the other being hydrogen. When combined they form liquid oil or gas which may be perfectly transparent or clear in the case of oil and absolutely invisible in the form of gas. These minute particles of carbon are solid substances and black. Their presence in the exhaust gas makes it appear as dark or black smoke. The more carbon particles, the darker color the exhaust, ranging from a very light gray haze to brown and even black smoke. The cause is incomplete combustion. Since combustion is never perfectly complete, it is not presumed that exhaust gases will be absolutely invisible. Smoke from the exhaust, either brown or black, is not itself mechanically harmful to the engine but may indicate corrections that should be made particularly if an increase of smoke appears with no change in conditions such as load, speeds, temperatures, change of fuel oil, or engine taken to higher altitude.

Increase of Brown or Black Smoke in Exhaust Gas

Cause 1. Leaky cylinder head gasket.
Remedy Remove and clean or replace from spares.

Cause 2. Leaky valves.
Remedy Regrind.

Cause 3. Improper fuel oil.
Remedy Change fuel to brand with good ignition and burning qualities.

Cause 4. Dirty spray nozzles.
Remedy Clean or replace.

Cause 5. Fuel injection timing too early usually accompanied with "Fuel knocks" or "noisy engine."
Remedy Adjust timing of injection.

Cause 6. Fuel injection timing too late accompanied with loss of power but smooth and quiet running engine.
Remedy Adjust timing of injection.

Cause 7. Leaky piston rings.
Remedy Replace with new ones from spares.

Cause 8. Fuel delivery valve in fuel pump stuck.
Remedy Remove and clean with soft cloth. Do not use hard or sharp tools or abrasives. They will spoil these parts. If valve cannot be made to operate freely have replacement of new valve and seat assembly made at an American Bosch Service Station.

Cause 9. Fuel delivery valve spring in fuel pump broken.
Remedy Replace with new one from spares.

Cause 10. Fuel pump drive chain too loose.
Remedy Tighten and retime engine.

Knocking in Engine or "Fuel Knocks"

Fuel Knocks may come from one or more cylinders. If knocking is from one cylinder

Cause 1. Spray nozzle valve sticking from dirt or corrosion.
Remedy Clean valve with a cloth (not abrasives) and clean body with piece of wood. Turn valve stem in body until free, then smear with good clean engine lubricating oil or vaseline and replace.

Cause 2. Spray nozzle spring broken.
Remedy Replace complete holder from spares. Never attempt to change nozzle springs in field as they must be accurately calibrated with instruments, at the factory.

Cause 3. Fuel delivery valve in pump stuck open from dirt or corrosion.
Remedy Clean valve stem with cloth and valve seat with small piece of wood. Do not use abrasives or metallic tools, they will spoil these delicate parts.

If necessary, replace with new valve and seat at an American Bosch Deisel Service Station.

Cause 4. Broken delivery valve spring in fuel pump.
Remedy Replace from spares.

Cause 5. Inlet or exhaust valve not seating properly from sticking or in need of grinding.
Remedy Free valve with alcohol or other solvent, such as kerosene or clean fuel oil or gasoline. Grind valve is necessary.

Cause 6. Leaky cylinder head gasket.
Remedy Clean or replace from spares.

If "Fuel Knocking" is in more than one cylinder and erratic and intermittent:

Cause 1. Improper fuel. Has poor ignition qualities.
Remedy Add equal parts or more if needed of fuel oil with good ignition qualities or change fuel to a brand having good ignition and burning qualities. See specifications of fuel oil, Page 21.

Cause 2. Sticking nozzle valve. This comes from dirt in fuel oil or corrosion of these parts from acid in the fuel oil.
Remedy Dismantle and clean the parts and also fuel strainers. If parts are corroded, change fuel to an acid free brand and install new nozzle and pintle if necessary.

Cause 3. Water in fuel oil.
Remedy Drain fuel oil strainer sump and fuel tank of all water and sediment.

If "Fuel Knocking" is in all cylinders continuous and steady and is usually accompanied with dark smoky exhaust:

Cause 1. Improper fuel oil, has poor ignition qualities.
Remedy Change fuel to brand of suitable ignition qualities or add equal quantities or more if needed of fuel oil with good ignition qualities.

Knocking from Mechanical Causes may be from several sources some of which are:

Cause 1. Piston hitting inlet and exhaust valves from using improper gasket.
Remedy Use only those supplied by Hercules Motors Corporation.

Cause 2. Pistons hitting exhaust and inlet valves from bearings badly worn.
Remedy Replace with new bearing shells.

Cause 3. Valve tappet clearance too great.
Remedy Adjust clearances.

Cause 4. Badly worn bearings, either main or rod or both.
Remedy Adjust or replace with new bearing shells.

Cause 5. Badly worn piston pins or bushings, or both.
Remedy Replace with new.

Cause 6. Badly worn pistons or liners or both.
Remedy Replace with new.

Cause 7. Loose flywheel.
Remedy Tighten.

There are many other mechanical causes of knocks which must be found and remedied but it is impossible to list all of them in a book such as this. If impossible to determine what the trouble is after a thorough investigation it is best to have a factory trained expert investigate and remedy the trouble.

WRENCH TENSION

(For Tightening Nuts or Screws)

	Foot Pounds
Cylinder Head Stud Nut	350
Connecting Rod Screw	263
Main Bearing Stud Nut	260

All other screws, nuts, etc., are to be drawn up snug and tight but not to the point of stripping the threads.

CLEARANCES "DFX" SERIES

	Minimum		Maximum
BEARING CLEARANCES			
Camshaft Bearing Clearance	.003	to	.0035
Connecting Rod Bearing Clearance	.0035	to	.0045
Crankshaft Bearing Clearance	.005	to	.006
Fuel Pump Drive Shaft Bearing Clearance	.0025	to	.003
Idler Bearing Clearance	.001	to	.002
Oil Pump Shaft Bearing Clearance	.0015	to	.002
Rocker Arm Bushing Clearance	.001	to	.0015
Piston Pin Clearance In Rod Bushing	.0015	to	.002
END THRUST			
Camshaft Thrust (End)	.005	to	.008
Connecting Rod Side Clearance	.005	to	.012
Crankshaft Thrust Clearance	.004	to	.005
Fuel Pump Drive Shaft End Thrust	.005	to	.008
Oil Pump Shaft End Thrust	.002	to	.003
BACK LASH			
Crankshaft Gear Back Lash to Cam	.001	to	.002
Generator Back Lash	.003		
Oil Pump Gear Back Lash	.006	to	.010
Timing Chain—Measuring on O.D. of Coupling	1/64		
Water Pump Gear Back Lash	.002	to	.004
PISTON			
Piston Clearance DFXH-F Measured	.015	to	.016
Piston Clearance DFXH Measured	.014	to	.015
Piston Clearance DFXB Measured	.008	to	.0085
Piston Clearance DFXC, DFXD & DFXE Measured	.0085	to	.0095
Piston Clearance to Cylinder Head	.085	to	.125
Piston Pin Clearance in Piston (Push Fit)	.0000	to	.0005
Piston Ring Gap — Oil & Comp.	.018	to	.022
Piston Ring Land Clearance	.0015	to	.003
VALVES			
Valve Guide Clearance Around Stems — Exhaust and Intake	.0025	to	.003
Valve Head Below Cylinder Head — Intake	.030	to	.035
Valve Head Below Cylinder Head — Exhaust	.050	to	.055
Valve Seat Diameter Exhaust $1\frac{15}{16}$" Face of Seat $\frac{13}{64}$" Wide DFX			
Valve Seat Diameter Intake $2\frac{21}{32}$" Face of Seat $\frac{13}{64}$" Wide DFX			
Valve Seat Diameter Exhaust $2\frac{7}{32}$" Face of Seat $\frac{13}{64}$" Wide DFXH-F			
Valve Seat Diameter Intake $2\frac{29}{32}$" Face to Seat $\frac{13}{64}$" Wide DFXH-F			
Valve Tappet Clearance in Guide	.001	to	.0015
Rocker Arm Valve Stem Clearance — Exhaust Hot	.016		
Rocker Arm Valve Stem Clearance — Intake Hot	.010		

(All Above Clearances Given in Inches)

	Minimum		Maximum
MISCELLANEOUS			
Bellhousing Clearance on Chamfer	.012	to	.025
Cylinder Liner Above Block	.000	to	.001
Gear Cover Clearance Around Crankshaft	.006	to	.015

(All Above Clearances Given in Inches)

CYLINDER SLEEVE FIXTURE — Latest Type

Illustrations No. 164, 165 and 166 show a newly developed sleeve puller. This puller is lighter in weight and is equipped with a reversible ratchet type head.

Illustration No. 164 shows how the puller is to be set up to pull the sleeve.

Illustration No. 165 shows the pull nut in the pulling operation. The nut and screw are inserted from the top of the bore.

As can be noted from a perusal of Illustration No. 164, the top pull plate is amply supported by the angle part of the legs; however, as the sleeve is pulled up to these angles, it is necessary to release the pressure on the puller and turn the legs so the angles will clear the sleeve.

Illustration No. 166 shows the puller as set up to press the sleeve into the block.

The puller screw should be well lubricated before being used.

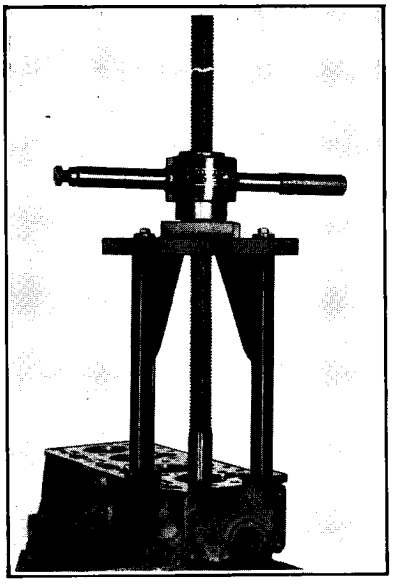


Illustration No. 164

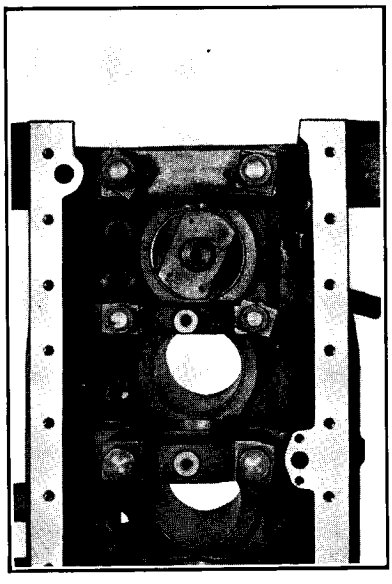


Illustration No. 165

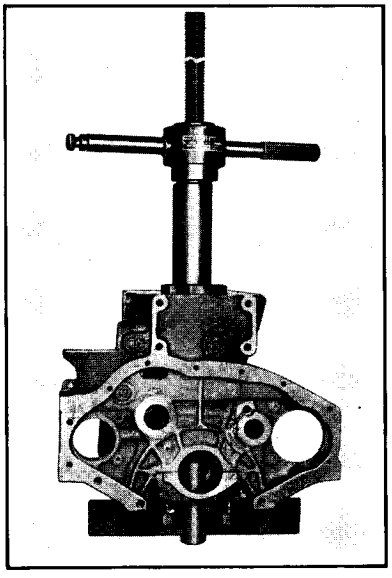


Illustration No. 166

ANY TYPE of oil filter must be given intelligent attention, and frequent cleaning if it is expected to remove dirt, etc. from the oil. Some filters must be inspected daily — study the service requirements of your particular type and save repair expense.

TOOLS

Part No.	Tool	Where Used
3108-A	7/16" Socket	Fuel Filter, Rocker Arms, Air Intake Heater
11462-A	1/2" Socket	Oil Pump and Oil Lines
3170-A	9/16" Socket	Tappet Covers, Rocker Arm Covers, Oil Pump
3171-A	5/8" Socket	Fuel Nozzles
3109-A	3/4" Socket	Gear Cover, Oil Pan, Fuel Pump Bracket, Manifold and Oil Filter
3172-A	7/8" Socket	Bellhousing
3173-A	15/16" Socket	
3113-A	1 1/16" Socket	Connecting Rod, Rocker Arm Retainer
3114-A	1 1/8" Socket	Cylinder Head
11258-A	1 1/2" Socket	Main Bearings
11464-A	Torque Wrench	Main Bearings, Cylinder Head and Connecting Rods
3100-A	Ratchet H.D.	With Above Sockets
3107-A	Ratchet Adapter	To adapt 1/2" Service Sockets To Heavy Duty Ratchet
11927-A	Flex Handle	With 1/2" Service Sockets
3168-A	Extension 1/2" x 6"	With 1/2" Service Sockets
3189-A	Ratchet 1/2" Service	With 1/2" Service Sockets
13587-A	Speeder Handle 1/2" Service	With 1/2" Service Sockets
13086-A	3/8" x 7/16" Box Wrench	Timing Chain Adjustment
13087-A	1/2" x 9/16" Box Wrench	General Purpose
12854-A	5/8" x 3/4" Box Wrench	Tappet Adjustment
3174-A	7/16" x 1/2" Open End Wrench	Leakoff Manifold, Oil Lines
13078-A	9/16" x 5/8" Open End Wrench	Fuel Pump Coupling, General Purpose
13099-A	3/4" x 7/8" Open End Wrench	Bellhousing, Oil Pan, Fuel Lines, Starter
3178-A	15/16" x 1" Open End Wrench	Timing Chain Inspection Plug, Oil Filter Drain
3179-A	1 1/16" x 1 1/8" Open End Wrench	Oil Filter Case, Oil Pressure Adjustment, Fuel Pump Drive
6334-A	1 1/2" x 1 5/8" Open End Wrench	Main Bearings
200108-A	9/16" x 9/16" Open End Wrench	Water Outlet Manifold
200083-A	3/4" x 3/4" Open End Wrench	Water Outlet Manifold
11924-A	Piston Ring Compressor	To Install Pistons
12799-A	Piston Ring Expander	To Install Piston Rings
13096-A	Valve Spring Compressor	Valve Springs
11925-A	Screw Driver 3/16" x 5" Blade	
13175-A	Screw Driver 1/4" x 6" Blade	
13095-A	Pliers 9" Heavy Duty	
11470-A	Adjustable Wrench 8"	

Part No.	Tool	Where Used
11919-A	Feeler Gauge Set 9"	
11920-A	Lady Foot Pry-Bar	
11921-A	Ball Pien Hammer 12 oz.	
6335-A	Tool Box	
13298-A	Camshaft Bearing Driver	
77900-DS	Nozzle Testing Kit	Illustration No. 167
77906-AS	Nozzle Cleaning Kit	Illustration No. 167
6278-A	Nozzle Sleeve Tool Kit	To Remove and Install Nozzle Sleeves
200602-BS	*Cylinder Sleeve Fixture DFXB	To Remove and Install Cylinder Sleeves
200612-BS	*Cylinder Sleeve Fixture DFXC	To Remove and Install Cylinder Sleeves
200613-BS	*Cylinder Sleeve Fixture DFXD	To Remove and Install Cylinder Sleeves
200614-BS	*Cylinder Sleeve Fixture DFXE	To Remove and Install Cylinder Sleeves
	* Any one of the above pullers may be converted for use on either of the other three models by purchasing an additional nut to fit model desired.	
200615-BS	Cylinder Sleeve Fixture DFXH-DFXHF Only	To Remove and Install Cylinder Sleeves
12792-CS	Cylinder Sleeve Hone	

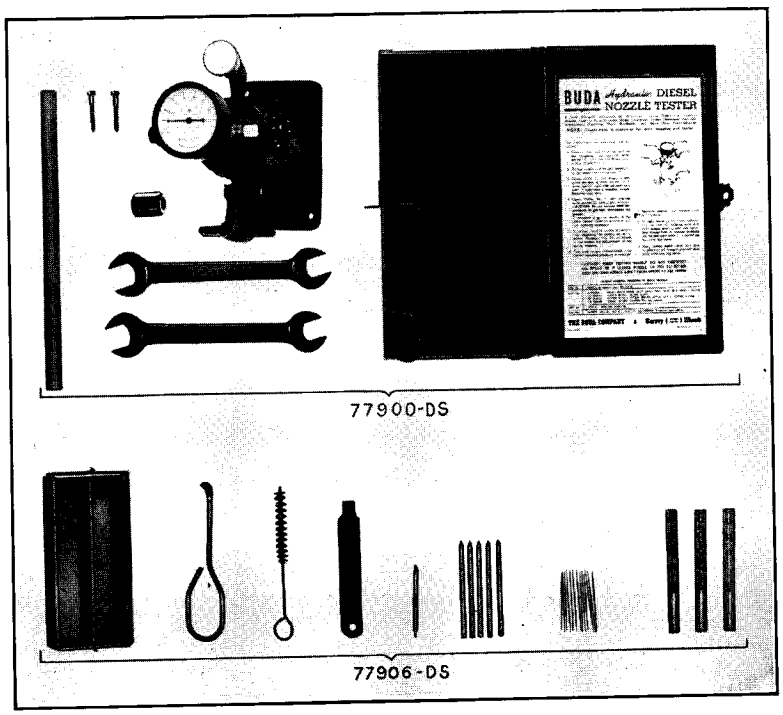


Illustration No. 167

GENERAL INDEX

GENERAL INDEX (Continued)

GROUP INDEX

HERCULES MOTORS CORPORATION

CANTON, OHIO

Hercules Motors Corporation is a Member of the Internal Combustion Engine Institute and is pleased to warrant all Hercules products sold by it in accordance with the following Basic Warranty adopted by the Institute May 8, 1947, which is subject to future amendment without notice. This warranty is in lieu of any warranty expressed or implied by law and supersedes any different warranty in customer's purchase orders.

BASIC WARRANTY

The Manufacturer warrants each new engine sold by the Manufacturer to be free from defects in material and workmanship for six (6) months from date of shipment, but not to exceed ninety (90) days of service, or such other period of time as may be agreed upon in respect to the application in which the engine is used. The obligation under this Warranty, statutory or otherwise, is limited to the replacement or repair at the Manufacturer's factory or at a point designated by the Manufacturer, of such part as shall appear to the Manufacturer, upon inspection at such point, to have been defective in material or workmanship.

This Warranty does not obligate the Manufacturer to bear the cost of labor or transportation charges in connection with the replacement or repair of defective parts, nor shall it apply to an engine upon which repairs or alterations have been made unless authorized by the Manufacturer.

The Manufacturer makes no Warranty in respect to trade accessories, such being subject to the Warranties of their respective Manufacturers.

The Manufacturer shall in no event be liable for consequential damages or contingent liabilities arising out of the failure of any engine or parts to operate properly.

No express, implied or statutory Warranty other than herein set forth is made or authorized by the Manufacturer.

New service parts are sold subject to the same warranty as new engines.