TM 55-1033

WAR DEPARTMENT TECHNICAL MANUAL

ENGINES, DIESEL, HERCULES MODELS DOOB, DOOC, AND DOOD

WAR DEPARTMENT • NOVEMBER 1944

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The Adjutant General

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For explanation of symbols, see FM 21—6.

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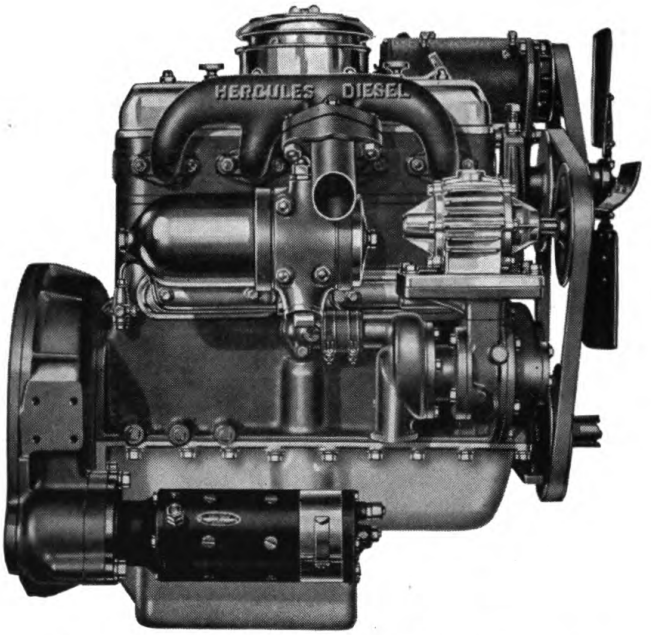
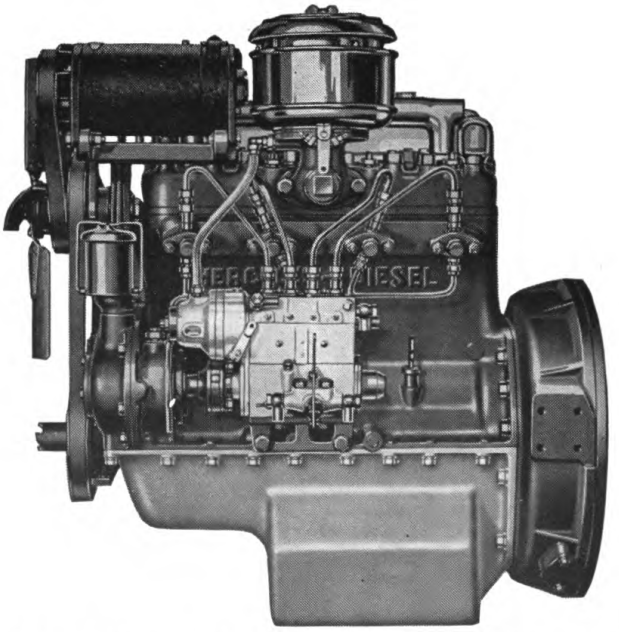


DOO Series Water Pump, Manifold and Starting Motor Side



DOO Series Fuel Injection Pump, Generator and Air Inlet Side

Introduction

THE Hercules compression ignition injection type engine is the result of years of development and field experience. Extensive tests have proven 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 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 to permit an experienced mechanic making the various adjustments and replacements which may be needed

To men trained in compression ignition type engine operation the Hercules Diesel series presents 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 covers 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

SPECIFICATIONS

Models DOOB - DOOC - DOOD Diesel Engines

	Model DOOB	Model DOOC	Model DOOD
Bore and Stroke	3¾"x4½"—95.2x114.3 mm	4"x4½"—101.6x114.3 mm	4¼"x4½"—107.95x114.3 mm
No. of Cylinders	4	4	4
N. A. C. C. Horsepower	22.5	25.6	28.9
Piston Displacement	198.8 cu. in. or 3.26 liters	226.2 cu. in. or 3.71 liters	255 cu. in. or 4.18 liters

Standard Rotation--Clockwise, looking at Cranking End.

MAIN BEARINGS

	All Models
No. of Bearings	5
Bearings, Diameter	3" — 76.2 mm
Bearings, Length (Front 1)	1 21/64" — 33.7 mm
Bearings, Length (Center 3)	2 1/32" — 51.6 mm
Bearings, Length (Rear 5)	2 1/16" — 52.4 mm
Bearings, Length (Int. 2-4)	1 11/32" — 34.1 mm

CAMSHAFT

Drive	Helical Gear
No. of Bearings	4
Diameter of all Bearings	2 1/16" — 52.4 mm
Length (Front 1)	1 1/8" — 28.6 mm
Length (2-3-4)	1 1/8" — 28.6 mm

Location, Right Hand Side Looking at Flywheel.

CONNECTING ROD

Material	Heat Treated Nickel Chrome Molybdenum Steel
Connecting Rod Bearing, Diam.	2½" — 63.5 mm
Connecting Rod Bearing, Length	1 25/32" — 45.2 mm
Connecting Rod Length, c to c	8" —203.2 mm

GENERAL DATA

Fuel Pump	Plunger Type
Fuel Nozzles	Pintle Type
Fuel Transfer Pump	Integral with Fuel Pump
Fuel Strainer	Efficient Type
Governor	Mechanical or Vacuum Type
Air Cleaner	Efficient Oil Bath Type
Compressor	Provision for 4 or 7¼ cu. ft. Air Compressor (or Vacuum Pump)
Exhaust Manifold Bore	2¼"—57 mm

On Right Hand Side, Looking at Flywheel.

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

"DOO" Series

Prelude to Operation

The "DOO" Series Hercules Diesel engine consists of three models, the DOOB, DOOC and DOOD differing primarily in bore diameter. The remarks hereafter will refer to the series in general except where a definite 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 page 42.
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 19 for specifications.
3. **Lubricating Oil**—keep it clean—drain crankcase often. Use best brands obtainable, regardless of cost, the best is none too good. Avoid oils having additives detrimental to alloy bearings. See section starting on page 15.
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.
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 7.
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 grades will turn the engine much faster than the speed for which it is designed and damage will result unless vehicle speed 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 them checked often. See page 29.
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 8 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 8.
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 9.
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. Please read carefully section on page 14 devoted to this subject.

26. Should an engine equipped with a vacuum governor ever stall and **start running backwards,** the pressure built up in the governor will not permit the stop lever to move far enough to shut down the engine if throttle is nearly closed. When this happens **open throttle** to full load position. This will permit the stop lever to be pulled back and stop the engine. (This very seldom happens.)
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.

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 19.
2. Use only the best lubricating oil obtainable. See specifications on page 15.
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 viscometer. See page 16 for complete information relative to the function of the viscometer.
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 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 cylinder, as the starting motor has sufficient power to bend or break certain parts should anything be out of place.
8. Be sure all fuel line connections are tight and the fuel system properly primed.
9. Always follow starting instructions outlined below to eliminate difficulties.

STARTING THE ENGINE

Save Your Batteries. The commonly used twenty-five plate 12 volt batteries 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 over the following instructions should enable anyone to readily start the engine. If air temperature is below 50° F. also read cold weather starting instructions pages 9 and 10.

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 19.
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 15.

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.

Priming Fuel System,—Air Lock Trouble

6. 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 proceed as follows:

Loosen the check valve fitting and by using the hand priming pump pull the fuel from the tank and force it through the small filter located between the transfer pump and the injection pump. It is best to leave vent cock No. 1 in Illustration No. 16 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 check valve fitting. Then tighten this connection. Be sure the engine is in a position other than on the compression and power stroke of number four cylinder as in this position the fuel pump cam is in such a position as to render the hand priming feature inoperative on some types of transfer pumps.

(a) Place governor stop 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) or plug of fuel pump.

(f) Work the fuel pump plunger up and down by means of a screwdriver until clear fuel with no air bubbles flows freely, then tighten nut, see Illustions No. 3 and No. 4. Continue the same operation with all four lines being sure the stop control rod is not in "shut off" position. Turn the engine by hand so the fuel pump cam of the plunger being operated is on the low side to obtain full benefit of the complete plunger stroke.

(g) Replace side cover (inspection plate) or plug 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 loose connections 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.

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 pages 10 and 11 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.
3. Check cooling water.
4. Check atmospheric air temperature if engine is cold. If 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 are laying on engine.
6. Start engine by operating starter button.
7. Check engine as under "Operating Instructions After Starting" pages 10 and 11.

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 temperatures of engine and air.

A starting device is available which makes starting easier in extremely cold weather or climate. This device can only be installed by an authorized fuel injection pump service station or by the Hercules Motors Corporation.

Starting Between 50° F. and 32° F. 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 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 head.
4. Put fuel control lever in wide open position.

5. Just as the operator closes the starter button direct the flame into the threaded hole in intake manifold from which the pipe plug was removed or into the air inlet exposed upon removal of air cleaner.

6. After engine has started replace pipe plug in manifold or replace the air cleaner, whichever was removed. **REPLACE PLUG QUICKLY AS THE VACUUM GOVERNOR IS INOPERATIVE WHEN PLUG IS OUT.** This does not apply to engines with the mechanical governor.

Starting Between 32° F. and 0° F. To obtain maximum cranking speed the oil must not be too heavy. Many experienced operators drain all crankcase oil from engine at end of day's run and heat it before returning it to crankcase when ready to start, when temperatures approach freezing. 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 solution 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 about 6 or 7 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.

Use nothing but pure mineral base oil. No compounds having animal or vegetable matter.

Starting 0° F. and Below. 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.

Glower Plug Equipment. When engines are equipped with glower plugs starting is effected as follows: Turn the special two stage starting switch to position marked (1) and hold in this position until the indicator glower plug in the dash becomes nearly white hot. Then move the lever to the point marked (2). This closes the switch from the battery to the starting motor through the solenoid switch and at the same time shunts out the indicator glower plug on the dash, but maintains the current flow through the six glower plugs in the engine. Do not hold switch in No. 2 position longer than one minute at a time.

OPERATING INSTRUCTIONS AFTER STARTING

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

(1) Look at lubricating oil pressure gauge. If no pressure shows after engine has run 10 or 12 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 30 to 45 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 circulation. If no water is flowing 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 laying 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 any 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 on pages 65 and 66.

(5) See that there is an adequate supply of fuel in the tank and that fuel is being delivered to the fuel pump. The delivery can be checked by slightly loosening the nut connecting the supply pipe to the fuel strainer 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 strainers 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 viscometer 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. Probably it will be necessary to change oil in engine sump. It may be that oil being used is not of proper grade or quality or quantity or has not been changed recently enough. This viscometer 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 18 and 19, frequently as it is the most useful 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) Clean lubricating oil filter often. This will insure maximum efficiency from this unit and does not require much time or energy to accomplish.

(9) Keep all fuel filters clean and give them regular attention. This will eliminate many costly fuel injection pump and nozzle troubles.

(10) 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.

(11) 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 affected by pulling the dash control out 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 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 the tank 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 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 oil gauge 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 nozzle 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. After the nozzle holders have been reinstalled in the engine, remove the glower plugs or the glower plug aperture plugs and retainers, (see next paragraph) fill the combustion chamber with an acid and moisture free lubricating oil, then turn engine over slowly with the turning crank to assure distribution of oil on the pistons and cylinder walls.

If the upper combustion chamber liner does not have a hole in it for the glow plug then proceed as follows: Before putting the nozzles and holders back in their place 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 sun, 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 with the engine. Bosch and Timken Service Stations 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 Bosch Diesel Service Station or Timken Factory Branch 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 the fuel 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 given in the previous chapter it will be necessary to follow 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 fuel 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 8.

4. When priming the fuel lines from pump to nozzles connect the nozzles to the fuel lines and test as described on pages 28 and 29 except instead of

running the engine operate the pump plunger by hand.

5. If nozzles do not function properly clean as described on page 28.
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 water cooling system with clean water.
10. Follow instructions as given for "Starting Engine First Time" described on page 7.
11. After engine is running follow instructions as given for "Operating Instructions After Engine is Started" described on pages 10 and 11.

ALTITUDE OPERATION

The starting and operation of Diesel engines encounters certain difficulties at higher altitudes. These difficulties are not commonly noticeable until 3000 feet is reached. Above this altitude it is necessary to make certain changes in the engine to facilitate starting, to increase power output and to eliminate incomplete combustion; these will be taken up separately in paragraphs to follow:

While the engine has lost only about ten percent at 3000 feet, at 6000 feet this loss is about 21%. From these figures one can readily see that no difficulty will be encountered in the first 3000 feet but that some provision should be made to help eliminate or overcome part of the power loss and hard starting. A small part of this loss may be recovered by the following methods.

Since the air is lighter, a longer period is required to effectively burn the fuel oil, the injection pump timing should be advanced about 1° per 1000 feet over the standard timing, unless the compression ratio is increased, in which case the timing can remain the same as originally set. This will help starting and combustion resulting in a little better power.

Due to the air at higher altitudes being lighter the cylinders do not fill as well as at sea level, therefore, the compression pressures are lower causing harder starting and poor combustion. This can be helped by changing the combustion chamber liners and cylinder head gasket thickness so as to get a higher compression of the lighter air entering the cylinders. When a thinner gasket is installed it is necessary to reseat the valves into the head as much as the reduction of gasket thickness.

It is also necessary to reduce the amount of fuel entering the cylinder as with the original setting and smaller amount of oxygen the combustion is incomplete and a smoky exhaust results.

It is sometimes desirable to follow the starting methods as outlined under "Cold Weather Starting" on page 9.

A starting device is available which makes starting easier in extremely cold weather or climate. This device can only be installed by an authorized fuel injection pump service station or by the Hercules Motors Corporation.

If operation requires the engine covering a route from sea level to high altitudes then an adjustable timing device may be installed on the injection pump which will allow the advancing and retarding of the timing as the operation requires.

For additional information on specific cases please write to Service Department, Hercules Motors Corporation, Canton, Ohio, U. S. A., giving as much data as available.

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 temperature in engines on different types of service it is difficult to give a definite SAE number of oil to use in the engine crankcase. A viscometer instrument shown in Illustrations No. 1 and 2 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 SAE 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 viscometer 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 viscometer 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 viscometer 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 depend-

ent 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 busses, not tractors or heavy duty slow trucks such as snow plows, etc., the latter the same as industrial operation). See page 62 for refilling instructions.

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.

Viscometer. Some engines are equipped with a viscometer 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 near the rear on the lubricating oil filtrator side of the engine.

Refer to Illustration No. 1 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 chamber 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 same 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 Viscometer. 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 a 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

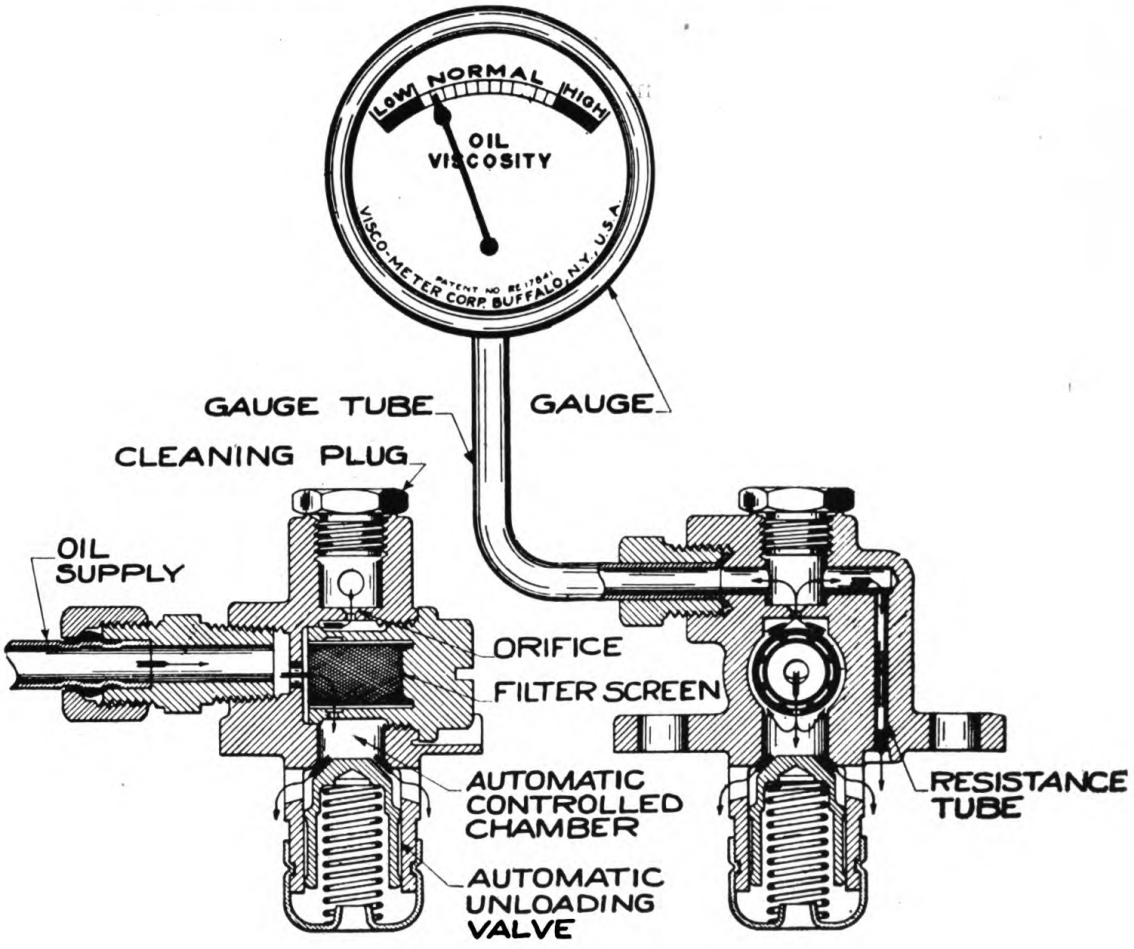


Illustration No. 1

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 is 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 viscometer instrument Illustration No. 2 as now supplied with some engines if attached to a viscometer gauge shown in Illustration No. 1 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 viscometer 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 number 1 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.

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. 20 may not have the lubricating characteristics necessary for your type of service but another brand of S. A. E. 20 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 results as another brand of S. A. E. 30 or with another brand, 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 viscometer and not by the price or 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 45 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 viscometer 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 Viscometer. The viscometer 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 capscrews which hold the instrument to the engine crankcase. Remove the plug No. 1, Illustartion No. 2, 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. 1.) 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.

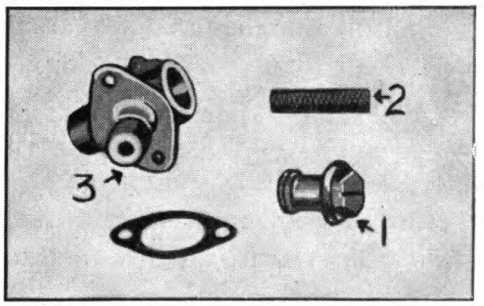


Illustration No. 2

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 a 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 viscometer as the springs and gauge are calibrated for this original resistance tube.

FUEL OIL SPECIFICATIONS

American Society for Testing Materials Specifications

Fuel Oil Specifications. To be a 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).....Minimum 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
9. 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 teaspoonfuls of gasoline and allow to burn out completely. 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.

NOTE: Recracked or recycled fuel oils are usually not satisfactory.

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 of oil such as gravity, viscosity or color, all of which have no influence whatever on the ignitability of oil. Refineries and oil distributing agencies should assume the responsibility of supplying a fuel oil of good ignition and burning qualities. They can determine the ignitability of their fuel oil by methods recommended by A. S. T. M.

Gravity is no measure of a satisfactory fuel oil and should not be used as a guide.

FUEL INJECTION EQUIPMENT

For Fuel Pump Timing Chart See Page 26

For Governor Information See Page 29 and Page 32

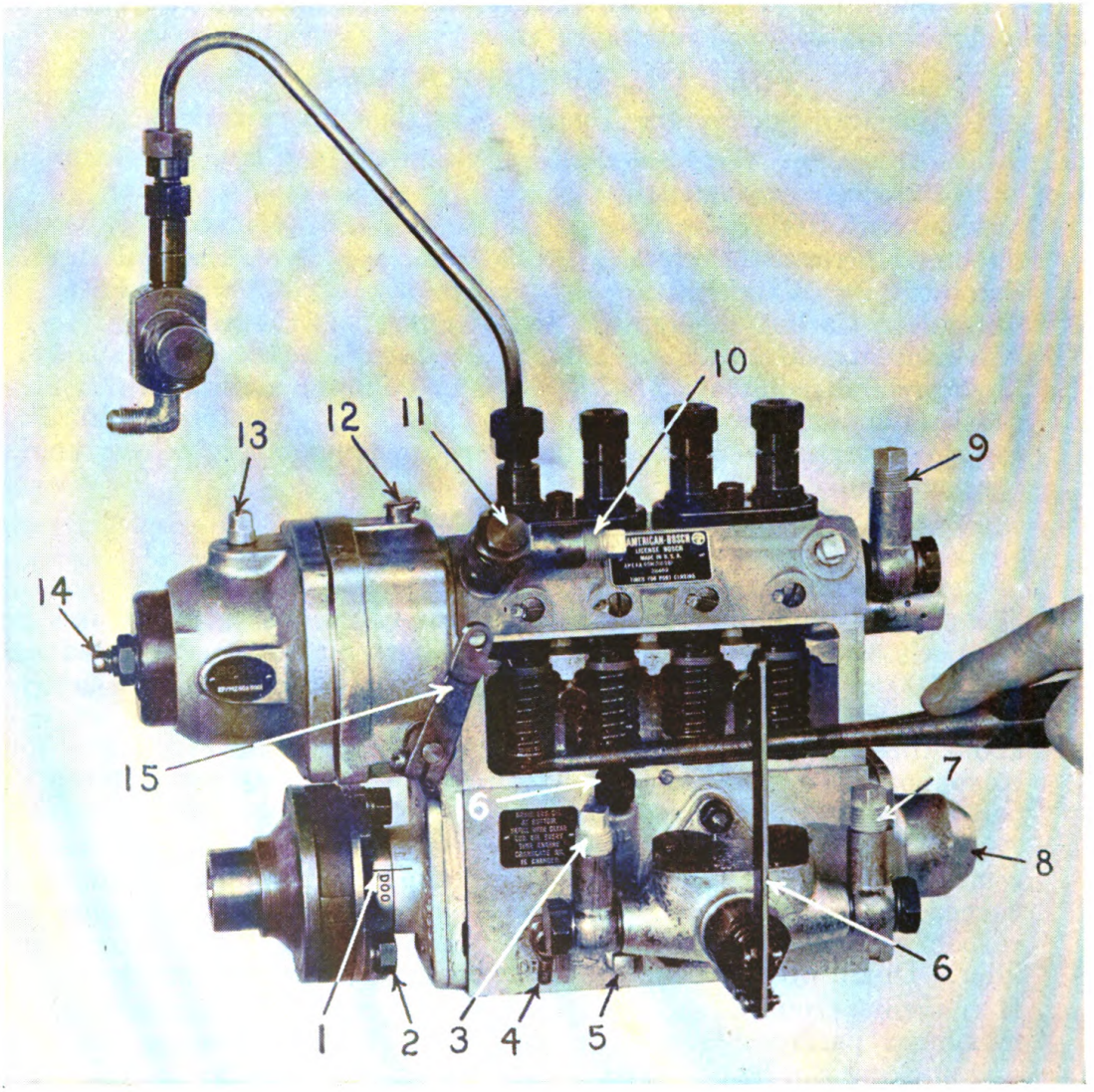


Illustration No. 3

DESCRIPTION. (Bosch and Timken)

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 (either vacuum or mechanical) is mounted on the coupling end of the injection pump; a check valve to maintain a constant pressure in the fuel manifold; four fuel lines; four nozzles and a leak off manifold.

Illustration No. 3 shows the Bosch Injection Pump with a Bosch vacuum governor. Illustration No. 4 shows the Timken Injection Pump equipped with a Timken vacuum governor. This type equipment is the preferable automotive installation. For industrial use the mechanical governor described in the section starting on page 32 is more preferable.

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

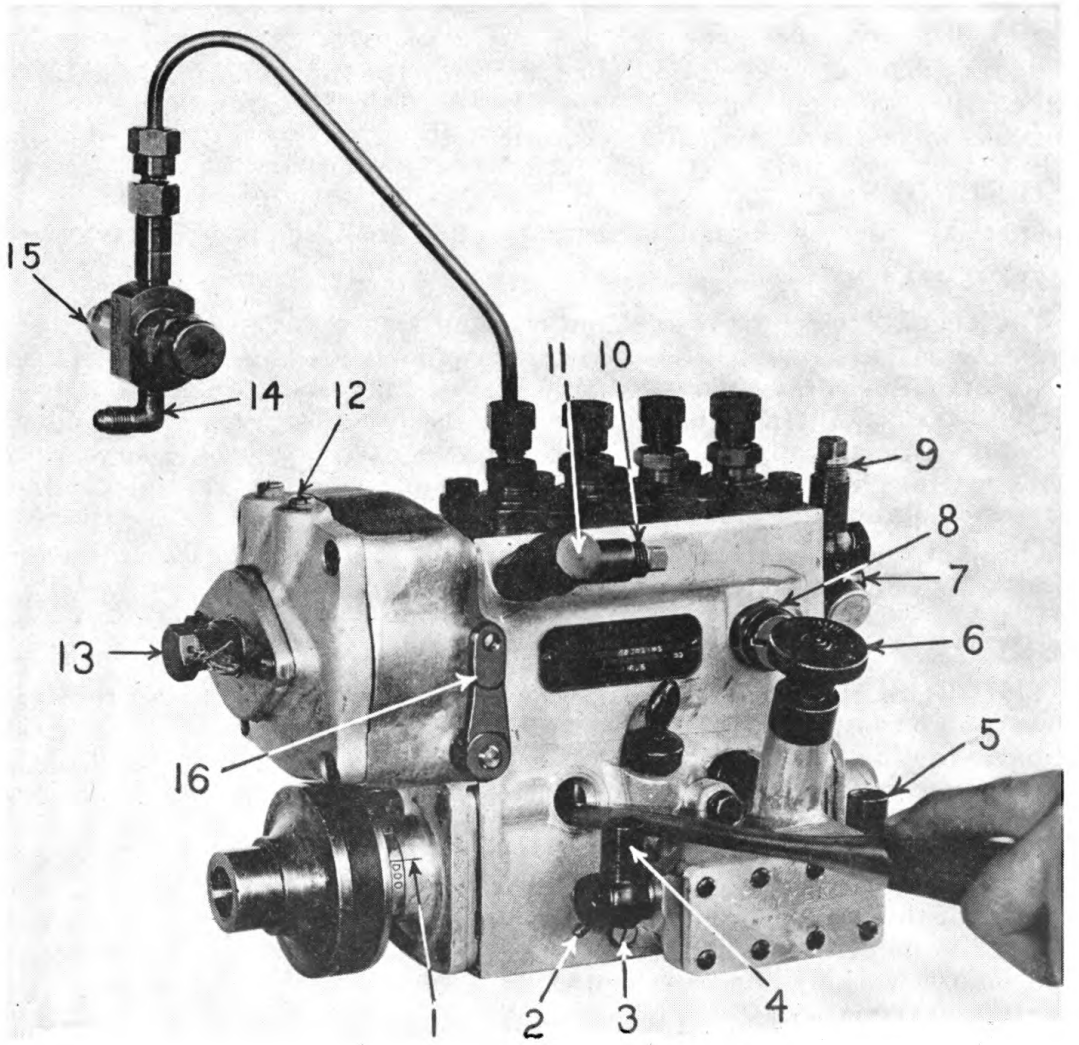


Illustration No. 4

LUBRICATION:

Since lubrication of the various fuel injection parts is essential we will cover this phase first. The pumps shown in Illustrations 3 and 4 are oiled by means of a pool of oil in base of the pump and the oil level should be maintained at all times either to the mark on the dip stick shown as 16 in Illustration No. 3 and the part in a similar position in Illustration No. 4 (not numbered) or by the oil level test cock shown as 4 in Illustration No. 3 and as 2 in Illustration No. 4. On these pumps new oil is added through the dip stick hole. This oil should be the same as is used in the lubrication of the engine. On some Bosch fuel pumps having a dust proofing feature, the oil level can only be ascertained by means of the test cock and filling with new oil can only be accomplished by removal of the breather on the side inspection plate.

Lubrication of the vacuum type governor on the Bosch pump is through oiler 12 in Illustration No. 3. Put in about one tablespoon of oil every 100 hours of operation. The vacuum type governor on the Timken pump does not require lubrication as does the Bosch, oil is detrimental to the diaphragm in this governor (Timken).

The mechanical governor is filled with oil (of the same grade as used in the engine) through the plug shown beside C in Illustration No. 9 until it runs out of test cock A in Illustration No. 9.

GOVERNORS:

These are covered in another section of this book, see page 29 and page 32.

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 11 in both Illustration No. 3 and Illustration No. 4. Should dirt or lint get between the valve and its seat, the valve ceases to function and the pressure in 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.

The fuel return line should be fastened by proper fittings to the opening created by removing plug 10 in Illustrations 3 and 4.

FUEL TRANSFER PUMP:

THE BOSCH FUEL TRANSFER PUMP is located on the side of the lower pump case, as shown in illustration No. 3, and is actuated by one of the cams on the fuel pump camshaft which moves the pump plunger and, through suitable valves and drilled passages, delivers the fuel to the final filter, located between the transfer pump and the injection pump. The Bosch priming handle (No. 6, Illustration No. 3) actuates the same plunger as the camshaft and, should the engine be in the position where number four cylinder is near the end of the compression stroke and the beginning of the power stroke this plunger is inoperative. Therefore, see that the engine is in some other position before working the Bosch priming handle.

THE TIMKEN FUEL 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. 6, Illustration No. 4.) The Timken 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 valve 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 8.

FUEL INJECTION PUMP (BOSCH)

The Bosch fuel injection pump shown in Illustration No. 3 has a camshaft, mounted on ball bearings in the ends of the case, whose cams operate the four 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.

FUEL INJECTION PUMP (TIMKEN)

The Timken Fuel Injection Pump is a constant velocity, cam operated, helical plunger and port controlled design. The camshaft is mounted on single row Timken tapered roller bearings. The amount of fuel delivered to the injection nozzle is regulated by a control rod, meshing with a metering pinion gear attached to the pump plunger mechanism, and connected to the governor. The Timken injection pump is equipped with renewable pumping units, comprising the plunger and barrel, tappet spring, spring plates, metering pinion gear and sleeve, delivery valve, delivery valve spring and holder. The renewable pumping unit is easily removed for replacement by removing the two clamping stud nuts while holding the governor stop control in full shut-off position, and pulling the unit out of the pump housing. Replace pumping units only with genuine Timken renewable pumping units of the same specification (number is stamped on unit flange) as those removed. No adjustments of any kind are necessary.

FUEL PUMP TIMING:

For Chart see Page 26

NOTE: Reference in the next three pages to degrees of advance timing is for the DOOC engines, 16° for DOOC with Timken pump and to run above 1500 R.P.M., therefore it is essential to refer to "Fuel Pump Timing Chart" on Page 26 for correct timing.

Timing Timken Fuel Injection Pump By Flowing Method. All flywheels have a line marked DC (Dead Center) and from this line are graduations designating degrees of crankshaft travel. From DC these lines are marked 5°-10° then every two degrees up to 30°. Numbered every ten degrees.

(1) SPOTTING FLYWHEEL:

(a) Rotate flywheel by means of hand crank until DC marks appears in timing hole in bellhousing. Be sure No. 1 piston is just completing the compression stroke and beginning the expansion which can be determined by observing that the No. 4 cylinder exhaust valve is nearly closed.

(b) Rotate engine in direction of degree graduation marks which is

counter engine-wise approximately 10° past the graduation marked 16° then turn engine clock-wise until graduation marked 16° is directly in line with the mark in the center of the timing hole in the bell-housing. This will then have the crankshaft spotted at 16° before top center at which point the fuel pump is set for port closing.

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

(4) With governor stop lever in wide open or full load position prime pump as given in page 8 paragraph 6.

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

(6) Put governor stop 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. 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.

(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 1/64" on the circumference of the coupling is the difference between fuel flowing and not flowing. 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 very 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 16° before top center.

(9) Put governor stop 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 distort fuel pump case.

(10) Connect fuel line to pump No. 1 cylinder. Prime fuel lines as explained on page 8 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 65 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 Illustrations 3 and 4, No. 1.

Timing Bosch Fuel Injection Pump By Flowing Method. Follow same instructions as above except see timing chart for proper timing advance.

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 Illustrations No. 3 and 4. 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 reassembly can be more easily, quickly, and surely made.

To reassemble 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 23, paragraph (a) and (b) for procedure.
2. Install pump assembly on engine—tightening all attaching screws but leaving rear half of coupling loose from front half so pump shaft 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 or bolts which connect the two coupling halves. Make sure the marks are lined up perfectly and the attaching screws or bolts are tight.
5. Install all fuel piping.
6. Prime fuel lines as described on page 8.
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 Illustrations No. 3 and 4. To install a new pump assembly follow this procedure:

1. Spot engine No. 1 cylinder at proper degree before top center. See procedure, page 23, 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 Illustrations No. 3 and 4.
4. Bolt coupling halves tightly together.
5. Install all fuel lines.
6. Prime fuel lines as described on page 8.
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 on pages 24 and 25.

If engine does not function properly when started, shut down and check the markings 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 16° before top when these marks line up. After this check if the engine still does not operate properly flow the pump as given on pages 23 and 24.

Fuel Injection Pump Timing Chart

Time engines as follows for port closing position as your requirements dictate.

BOSCH EQUIPMENT

(Regardless of the type of governor)

DOOB—Speeds below 1500 R.P.M.—22° B.T.C.*
DOOC—Speeds below 1500 R.P.M.—22° B.T.C.*
DOOB—Speeds above 1500 R.P.M.—25° B.T.C.*
DOOC—Speeds above 1500 R.P.M.—25° B.T.C.*
DOOD—Speeds below 1600 R.P.M.—24° B.T.C.*
DOOD—Speeds above 1600 R.P.M.—26° B.T.C.*

TIMKEN EQUIPMENT

(Regardless of the type of governor)

DOOB—Speeds below 1500 R.P.M.—14° B.T.C.*
DOOC—Speeds below 1500 R.P.M.—14° B.T.C.*
DOOB—Speeds above 1500 R.P.M.—16° B.T.C.*
DOOC—Speeds above 1500 R.P.M.—16° B.T.C.*
DOOD—Speeds below 1600 R.P.M.—15° B.T.C.*

*B.T.C.—Before Top Center.

FUEL NOZZLE AND HOLDER ASSEMBLY

The fuel nozzle and holder assembly is shown in Illustration No. 5 clamped in a vise preparatory to disassembling, while Illustration No. 6 shows the complete details of the nozzle and holder assembly, the component parts of which are as follows:

No. 1 Nozzle Body Retaining Nut
No. 2 Fuel Nozzle Body
No. 3 Fuel Nozzle Pintle
No. 4 Holder Assembly
No. 5 Holder Fuel Inlet Stud
No. 6 Fuel Inlet Stud Edge Filter

Parts No. 2 and 3 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.

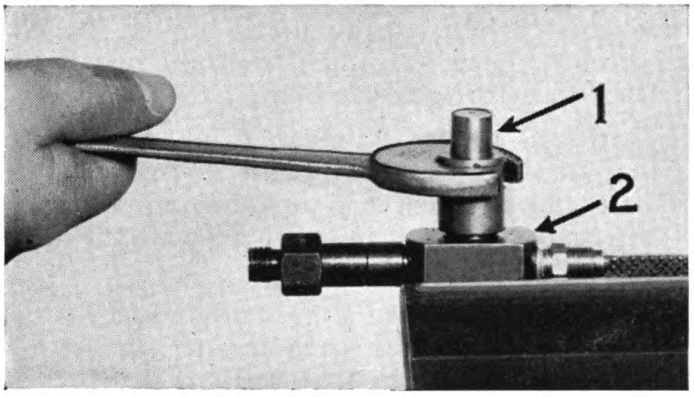


Illustration No. 5

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.

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 leakoff 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.

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. 6, Illustration No. 6 inside of the fuel inlet tube is cleaned by unscrewing the tube from the nozzle holder, No. 4 Illustration No. 6 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 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 cone 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 "drule" 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.

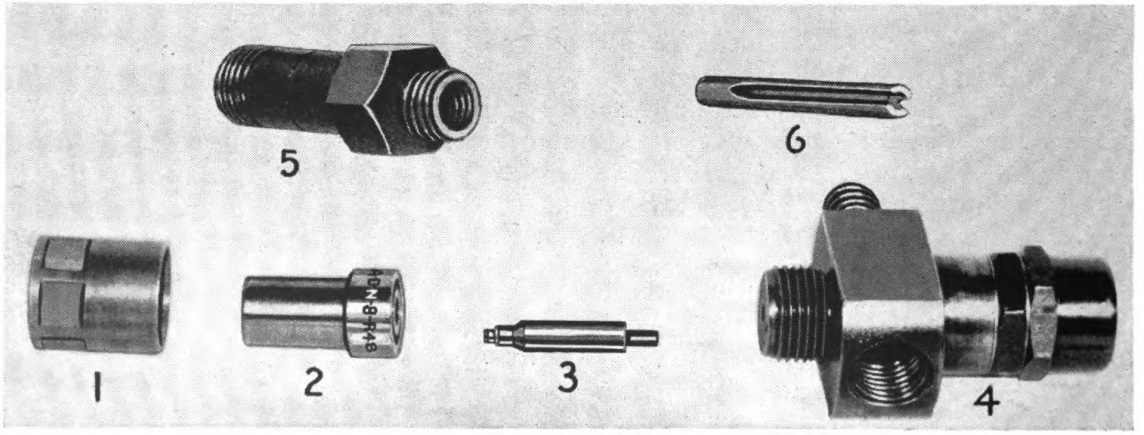


Illustration No. 6

FUEL NOZZLE PRESSURE

Fuel nozzles should be set for 1650 pounds per square inch pressure on a static fuel nozzle testing fixture (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 1600 pounds.

Adjustment is effected by removing the cap nut, loosening the lock nut and turning screw in the fuel nozzle holder, this screw increases or decreases the spring tension thus raising or lowering the pressure.

New nozzle and holder assemblies are shipped from the factory set at 1700 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.

GOVERNORS

FUEL PUMP GOVERNOR (Vacuum Type)

The vacuum type governor operates by the change in vacuum created when the throttle valve is open or closed. This valve is located in the air intake venturi housing shown in sectional view Illustration No. 8 as "L." Refer to Illustration at the bottom of page 2 which shows the venturi housing assembled to the air intake manifold of the engine. The governor is connected to the air intake venturi housing by a suitable flexible tube such as shown in the same illustration.

All Hercules Diesel engines have the governor properly set before the engine leaves the factory and need very little if any changing of this setting except in certain special instances.

Certain characteristics control the maximum speed of this type of governor, the size of the venturi in the venturi housing, the type of air cleaner being used, also any leaks in the vacuum lines or the governor will tend to increase the maximum speed.

If it should become necessary to reset this type of governor or to change the speed the suggestions and procedure outlined below should be followed.

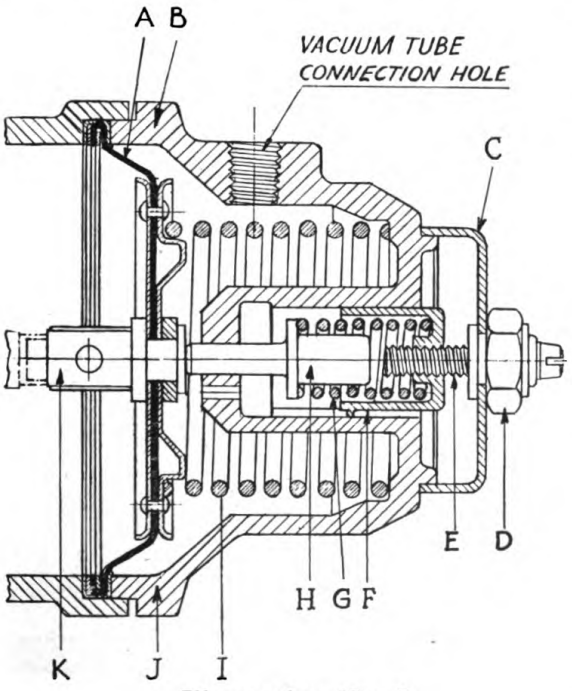


Illustration No. 7

Follow instructions for the particular make of governor with which the engine is equipped. Never attempt to adjust, set or change the governor with the engine cold or just warm. BE SURE WATER AND OIL ARE HOT. Be sure the air cleaner is in position and ready for operation.

Be sure all air is out of fuel lines and the injection system is operating perfectly. See that all linkages and connections hooked up to lever "U" Illustration No. 8, permit the butterfly valve to be opened until it is perpendicular or wide open.

The maximum speed for DOO series automotive engines is 2600 R.P.M. full load or approximately 2750 R.P.M. no load, while the maximum speed of industrial units should never exceed 1800 R.P.M full load or about 1900 R.P.M. no load.

Always use a tachometer or some instrument to count or indicate the R.P.M.; NEVER GUESS. Generally it is easier to set the governor for the no load speed as it is hard to maintain full load for any length of time. Always set maximum speed before idling speed.

FUEL PUMP GOVERNOR (Bosch Vacuum Type)

A sectional view of the Bosch vacuum type governor is shown in Illustration No. 7. This governor is shown attached to the fuel injection pump in Illustration No. 3. Refer to illustration at bottom of Page 2 which shows the venturi housing assembled to the air intake manifold of the engine. The governor is connected to the air intake venturi housing by a suitable flexible tube also shown in the same illustration.

ADJUSTMENT

Put the throttle in the full load position, check engine speed; if too high release tension on surge spring "G," Illustration No. 7, by bringing sleeve "F" toward housing "C." This is done by turning screw "E" in or in a clockwise direction after lock nut "D" is loosened. Be careful not to strip the threads out of the sleeve by turning screw after sleeve is back against the housing. Whenever it has been necessary to loosen lock nut "D" for any reason be sure it is tightened again before checking the engine speed as a slight air leak at this point will greatly affect the governor operation. If there has been too much tension on the surge spring this may reduce speed enough.

To reduce speed further it may be necessary to remove a few thin gaskets or shims "B," Illustration No. 8, in order to screw the tube connection "A" in farther.

Should the engine speed tend to be unsteady or surge when the desired speed is obtained then screw out or anti-clockwise on screw "E," Illustration No. 7; this increases the tension of the surge spring and compensates any surging action of diaphragm "A." Increase tension only enough to compensate surge without increasing overrun.

If the engine speed is too slow it is then necessary to add shims or gaskets at "B," Illustration No. 8, so as to move connection "A" out, decreasing the vacuum and increasing engine speed.

After governor is set as outlined above the idling speed should be all right; to check, close throttle until stop "J" touches screw "H." This should allow the engine to idle at about 450 R.P.M. Should this speed be faster, screw "H" should be backed out until a speed between 400 and 500 R.P.M. is reached. If speed is too low screw "H" should be moved in until desired speed is obtained. Should there be a surge at this speed, increase speed slightly and if this does not correct surge, then increase tension on spring "G," Illustration No. 7, enough to better idling yet not enough to interfere with maximum speed overrun.

FUEL PUMP GOVERNOR (Timken Vacuum Type)

A sectional view of the Timken vacuum type governor is shown in Illustration No. 7-A. This governor is shown attached to the Timken fuel injection pump in Illustration No. 4.

ADJUSTMENT

Put the throttle in the full load position, check engine speed; if too high relieve tension on the idle spring "G," Illustration No. 7-A, by loosening the idle adjusting screw lock nut "D" and turning the idle adjusting screw "E" counter clockwise, or outwardly. Whenever it is necessary to loosen the lock nut "D" for any reason be sure it is tightened again before checking the engine speed as a slight air leak at this point will greatly affect the governor operation. If there has been too much tension on the idle spring this may reduce speed enough.

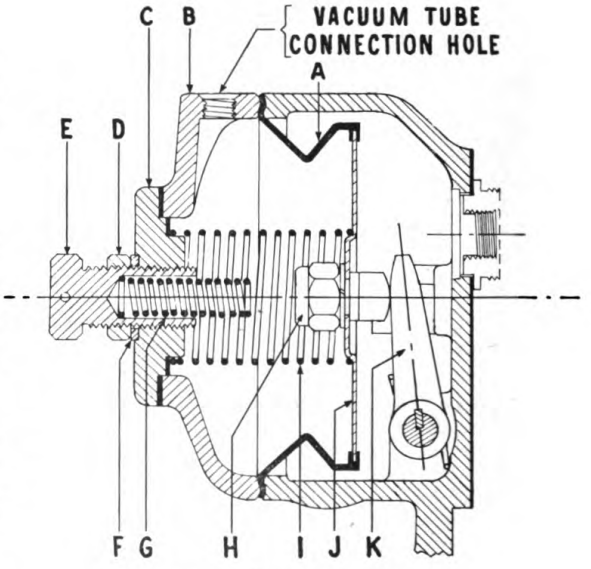


Illustration No. 7-A

To reduce speed further it may be necessary to remove a few thin gaskets or shims from "B," Illustration No. 8, in order to screw the tube connection "A" in farther.

Should the engine tend to surge or its speed be uneven when the desired speed is obtained then screw in the idle adjusting screw "E," Illustration No. 7-A, clockwise. This increases the tension on the idle spring "G" and tends to compensate any surging action

of the flexible diaphragm "A." Increase tension only enough to compensate without increasing the overrun.

If the engine speed is too slow it is then necessary to add shims or gaskets at "B," Illustration No. 8, so as to move connection "A" out, decreasing the vacuum and increasing engine speed.

After the Timken vacuum type governor is set as outlined above, the idling speed should also be set correctly and further adjustment will probably not be necessary. To check, close the throttle until butterfly valve stop "J," Illustration No. 8, touches screw "H." This should cause the engine to idle at approximately 450 R.P.M. Should the engine idle too fast, screw "H," Illustration No. 8, should be backed out until a speed of between 400 and 500 R.P.M. is obtained. If engine idles at too low a speed the adjustable idle screw "H" in the venturi assembly should be screwed inwardly until the desired speed is reached. Should the engine "roll" or surge at this speed, increase the idle speed slightly by means of screw "H," Illustration No. 8, on the venturi housing. If surge is not eliminated then screw the idle adjusting screw "E," Illustration No. 7-A, inwardly (clockwise) slightly, but only enough to increase the tension on the idle spring "G" sufficiently to give a smoother idle without increasing the maximum speed overrun.

FUEL PUMP GOVERNOR (Vacuum Type)

The following may prove helpful in locating certain troubles sometimes found in vacuum governors.

This type of governor may be adjusted for a variation of speed within certain limits, this being controlled by the size of the venturi and valve (K and L, Illustration No. 8). Should you require a greater increase or reduction in speed than obtainable in suggestions given above write the factory for additional information. Do not attempt to change speed by governor adjustment until you are sure you know what you are doing.

Should engine not start or starts and stops check stop lever (No. 15, Illustration No. 3; No. 16, Illustration No. 4) as it may be stuck in "off" position. Release and oil shaft, work until free then oil frequently to eliminate further sticking.

Should engine run away or top speed increases this may be caused by one of the following:

1. Vacuum line broken or connections loose (Replace line, tighten connections.)
2. Diaphragm punctured or has hole worn through it. (Replace with new diaphragm. Control speed with stop lever.)
3. Loose housing screws, nut on surge spring loose, cracked or broken housing. (Tighten screws, replace housing or gasket.)

When the engine does not idle smoothly this may be traced to one of the following:

1. Surge idle spring not properly adjusted. (Adjust as outlined on page 30 or 31 or follow instructions for particular make of governor being adjusted.)
2. Vacuum line may have leak, fittings may be loose. (Tighten fittings, replace line.)
3. Governor diaphragm twisted binding control rod. (As a last resort remove housing if twisted rotate until twist is eliminated replace housing, making sure screws are tight.)

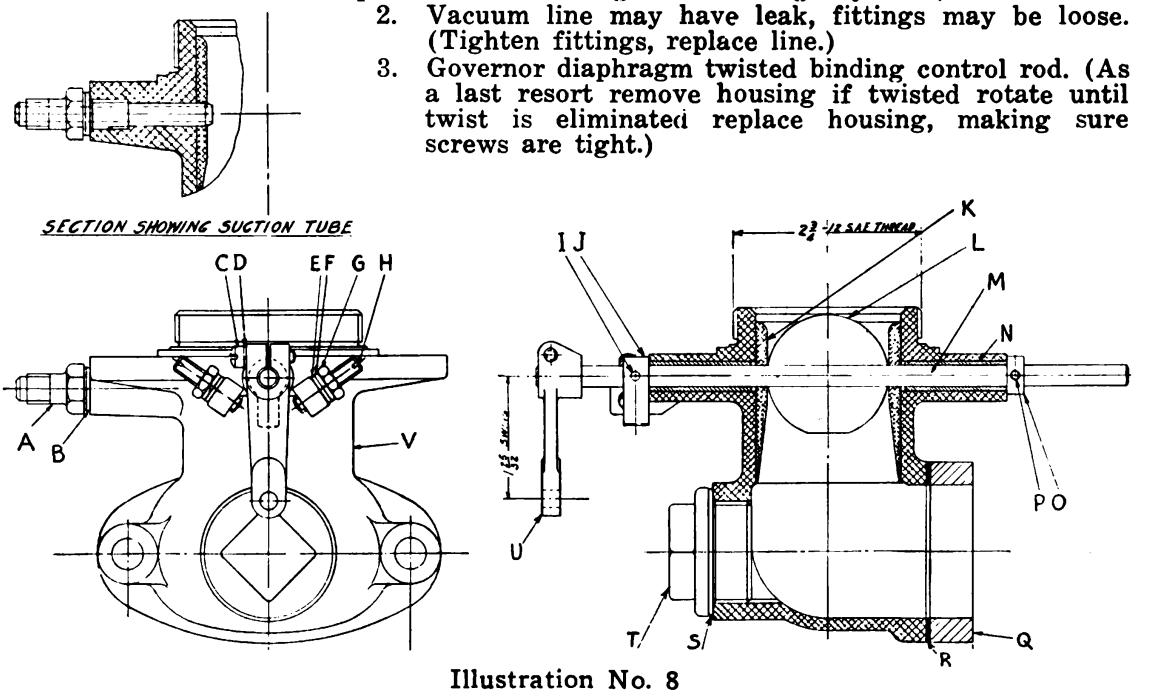


Illustration No. 8

4. Governor breather or breather hole plugged with dirt. (On Timken governor remove snap ring and filter located on underside of governor, wash filter in clean fuel oil and replace.) (On Bosch governor, without the dustproof feature, there is a small hole in the end plate of the fuel pump, this is the rear governor housing, open this by forcing a wire through it, this hole is "U" shaped going toward the rear of the engine, then up, and forward into the governor. On dustproofed pumps this breathing action is through the oil filler and breather cap on the fuel pump inspection plate, clean this cap often. On these dustproofed units the external air hole is plugged, do not remove this plug. Keep oil cup on Bosch governor clean.)

Should an engine equipped with a vacuum governor ever stall and start running backwards, the pressure built up in the governor will not permit the stop lever to move far enough to shut down the engine if throttle is nearly closed. When this happens open throttle to full load position. This will permit the stop lever to be pulled back and stop the engine. (This very seldom happens.)

TO SECURE BEST ADJUSTMENT

Be sure all air is out of injection system.
Be sure engine is hot.
Be sure there are not any leaks in vacuum system.
Be sure nut on surge or idling screw is always tight.
Be sure throttle butterfly valve is vertical when engine is under full load.
Be sure the air cleaner is in operating condition.
Never increase governor speed unless absolutely necessary as higher speeds decrease fuel economy.

HERCULES MECHANICAL INDUSTRIAL GOVERNOR

(In some illustrations the Governor is shown attached to Pumps not supplied on the DOO Series.) (Early type had slightly different construction but following instructions will generally apply.)

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, January 1, 1945, 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 shown in Illustration No. 11. 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.

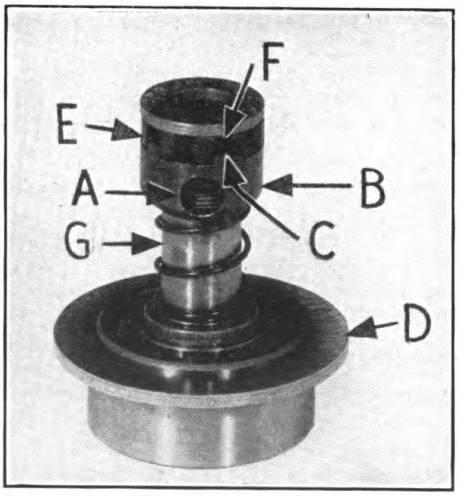


Illustration No. 9

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. 9, out of adjustment. Stop engine, remove plug M, Illustration No. 13, and adjust governor thrust sleeve as outlined under "How To Adjust Governor," paragraph 4. If this does not reduce speed, then trouble is elsewhere.

2. High speed control stop 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 G, Illustration No. 13, and turn in or out until smooth idle is obtained.

2. Governor thrust sleeve, Illustration No. 9, out of adjustment. Stop engine, re-

move plug M, Illustration No. 13, and adjust governor thrust sleeve as outlined under "How To Adjust Governor," paragraph 4. Then readjust idle spring adjustment for proper idle. After these changes have been made check top speed action as outlined above under 1.

3. Idle spring bent or caught in yoke. Remove spring and straighten.

4. The hand or foot control linkage worn or out of adjustment. Reset and take out slack in linkage.

5. Thrust sleeve in governor sticking, gears and weight fingers worn. Replace with new parts or complete governor.

Engine speed fluctuating or surging. Thrust sleeve out of adjustment. Readjust as outlined above.

A noisy governor denotes worn parts not correctly assembled. Replace with new unit.

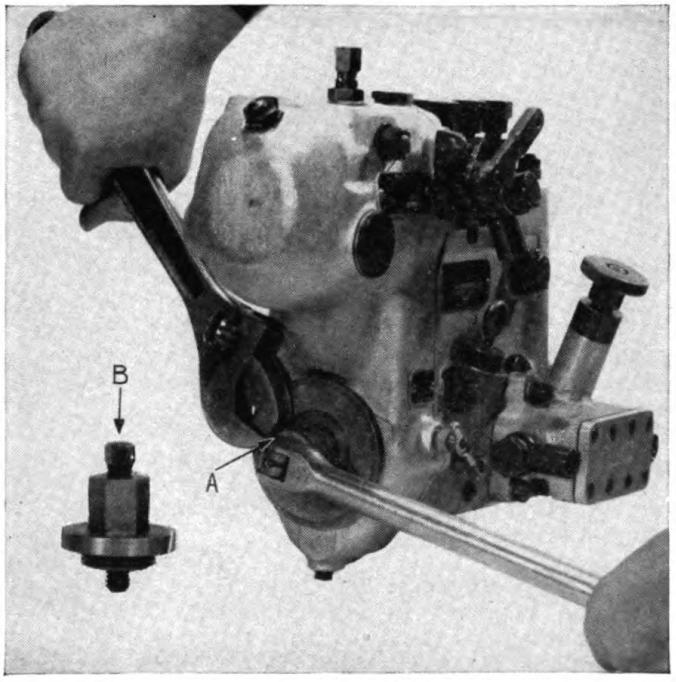


Illustration No. 10

INSTALLATION OF NEW GOVERNOR:

To accomplish this, follow carefully the following steps. Remember cleanliness is essential, therefore cover work bench with clean paper.

Removal of Injection Pump and Governor from Engine

1. Wash complete assembly thoroughly with fuel oil. Use brush and compressed air, if available. Before removing any fuel lines, be sure they and the fittings are clean.

2. Disconnect all high and low pressure fuel lines from injection and supply pump. Cover and plug openings. Remove control rod from governor lever.

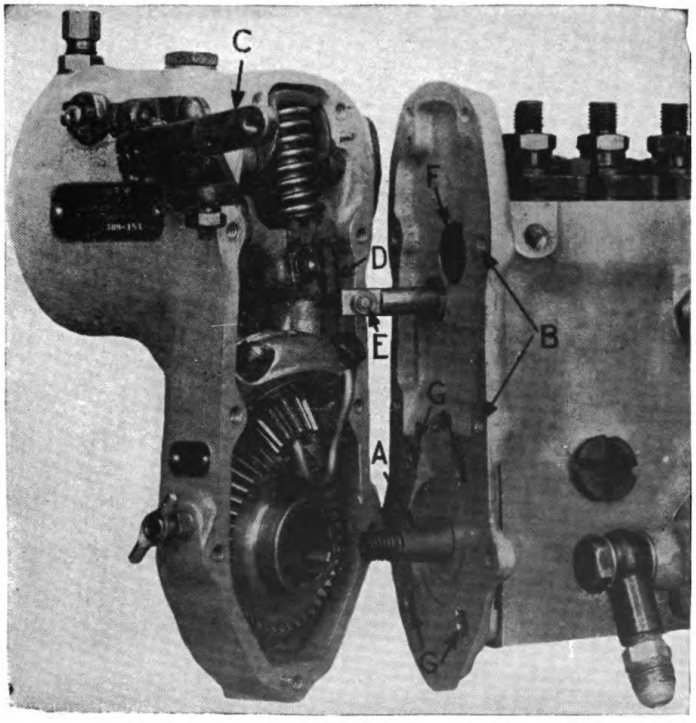


Illustration No. 11

3. Remove injection pump inspection cover. Crank over engine until the cam lobe for No. 1 unit is in a raised vertical position. (This can be seen through inspection hole.) Leave engine in this position until pump is again installed. If this cam lobe position is carefully noted it can be set in exactly the same position when pump is reinstalled and a tedious timing operation avoided. Do not loosen adjustable coupling clamp screws.

4. Loosen pump mounting bracket or pump hold down screws. (Hold down screws preferable if all of them can be reached without removing bracket.) Remove complete pump and governor assembly from engine. Wash thoroughly with clean fuel oil after removal.

To Remove Mechanical Governor

1. Remove governor drive flange by taking off the cam shaft nut A, Illustration No. 10, and, using a special gear puller B.
2. Remove Woodruff key from the cam shaft and lay in a clean place. A, Illustration No. 11.
3. Remove all the screws that hold the governor to the governor plate. B, Illustration No. 11.
4. Put the throttle lever in full open position. C, Illustration No. 11.
5. Grasp the governor firmly in one hand and pull it away from the injection pump as far as possible. The governor is dowelled to the plate and may be tapped loose, should it stick.
6. Then lift the governor unit slightly. This will release the governor yoke D, Illustration No. 11, from the control rod pin and rollers E. Be careful not to lose the two small rollers. Remove the rollers.
7. Remove large slotted-head screw in upper part of governor plate F, Illustration No. 11. Remove the four screws holding the governor plate to the pump housing end plate G. Remove the plate and oil-resisting gasket around the control rod bushing.

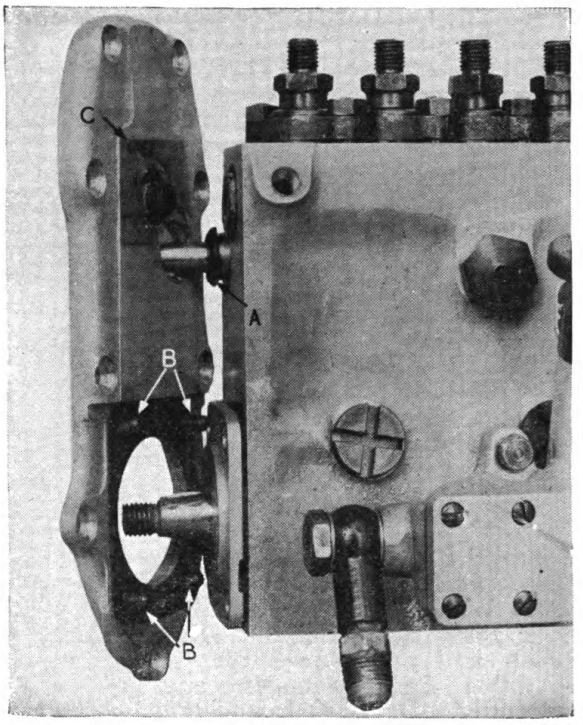


Illustration No. 12

To Install Mechanical Governor

1. For assembly to inspection pump, the plate must be removed from the new governor.
2. Put new oil-resisting ring on control rod bushing A, Illustration No. 12. Be sure control rod moves easily in and out of the pump. Fasten new governor plate to the injection pump, as it is dowelled to and must be used with the new governor. Start the four small screws into the cam shaft end plate B, Illustration No. 12. Insert large slotted head screw at top to locate plate. Tighten lower four screws first and with a thin feeler blade determine if the top portion of the governor plate is laying flat against the pump housing. If the plate is not against the governor, a shim should be inserted to insure flat sealing surface C, Illustration No. 12. Usually a .010″ shim is necessary. A flat sealing surface is necessary because otherwise, the plate may be warped or cracked. Replace the plate, tighten the four small screws, and repeat above until upper part of the governor plate is flat against the pump housing. Then tighten large slotted head screw. Pein small amount of housing material into slots of all five screws to prevent loosening. This paragraph for early type governor only.

2A. For late type governors install bearing outer race and seal. Put gasket in place using a sealing compound on both sides then carefully slide mounting plate over end of camshaft and in place. Install screws, pull up evenly. Check camshaft end play, if too much (more than .003″ to .005″) add shims in back of bearing on camshaft to reduce.

3. Pull the pump control rod out to full stop position and replace the two small rollers on control rod end E, Illustration No. 11.
4. Put the governor control lever in full open position C, Illustration No. 11. Be sure governor housing gasket is in place.
5. Hold governor unit in one hand and carefully lower it so that the governor yoke D, Illustration No. 11, engages the control rod rollers E. Be careful the two rollers do not drop out. Do not relift governor unit higher than necessary to start screws in the case.
6. Line up dowel pins with holes and start screws fastening governor to Plate B. Release control rod from full open position and tighten the screws holding the governor unit to the plate.
7. Be sure cam shaft key is in place. Engage the keys on the drive flange with the keyways of the drive gear, and at the same time be sure the keyway is lined up with the key in the cam shaft and push the coupling into the gear. Then put on the cam shaft nut and tighten. Turn pump and governor over several times to be sure there is no

bind. Pein small amount of housing material into slots of all housing screws to prevent their loosening.

8. Fill governor base to level as shown by test cock with good grade of light lubricating oil.

Replacing Injection Pump on Engine

If engine has crankshaft set as in paragraph 3 in "Removal of Pump," page 33, the pump can be installed as outlined below. If engine has been changed, see section on page 23 for complete timing instructions.

1. Rotate pump coupling until cam lobe, for pumping unit nearest to coupling, is in vertical position, as it was when pump and governor assembly was removed. (See paragraph 3 in "Removal of Pump," page 33.)
2. Mount injection pump assembly on engine. If pump cam shaft and engine crankshaft are in same position as when pump was removed the two halves of the coupling will line up and slip together easily. When pump mounting bracket has been left on pump no lining up will be necessary. If pump was removed from mounting bracket it must be lined up so coupling will run true and free before tightening down the bracket.
3. Attach all high and low pressure fuel lines to injection and supply pump. Be sure these lines and fittings are clean and that all joints are tight.
4. Attach equipment control rod to governor lever.
5. Open check valve connection in injection pump and pump priming pump until clear fuel flows from this fitting.
6. Start engine and let air clear out of high pressure lines. Check for air at filter bleeder cock and injection pump housing.

How To Adjust Governor

1. Start the engine and slowly warm up.
2. After the engine is warm, the no load high speed may be set by the control lever stop screw. This speed should not be over 1800 to 1900 R.P.M. Screwing the set screw to the right decreases the speed. Be sure to lock the set screw with the nut after the speed is set and sealed.
3. This governor may be idled at nearly any speed from 400 R.P.M. up. The equipment control rod stop should be adjusted to the proper position for the desired idle speed. Adjust the idle spring to obtain a smooth idle G, Illustration No. 13. To shut off the engine, pull the lever as far counter-clockwise as possible.
4. The governors are tested at the factory and should be set properly. If the overrun of the governor is not what is wanted, or if engine surges badly, it may be adjusted by the thrust sleeve, Illustration No. 9, as follows:

Remove the governor adjusting hole plug M, Illustration No. 13, rotate the governor thrust sleeve, Illustration No. 9, with a small screw driver until hole A can be seen through the governor adjusting hole. Insert the screw driver in the hole and move the locking sleeve B toward the bearing ring D until the tongues of the locking sleeve are free of the slots F of the adjusting nut E. Hold locking sleeve B in this position and with another small screw driver, rod or ice pick, rotate the adjusting nut E to the desired position. Then release the locking sleeve B, making sure the tongue C engages one of the notches in the adjusting nut F to lock adjustment. The adjusting nut D works on a right hand thread on the sleeve G and moving the notches of the adjusting nut clockwise past tongue C of the locking sleeve B shortens the sleeve, and counter clockwise lengthens the sleeve. Always note the original position of the sleeve and adjust two or three notches at a time until the best operation is obtained.

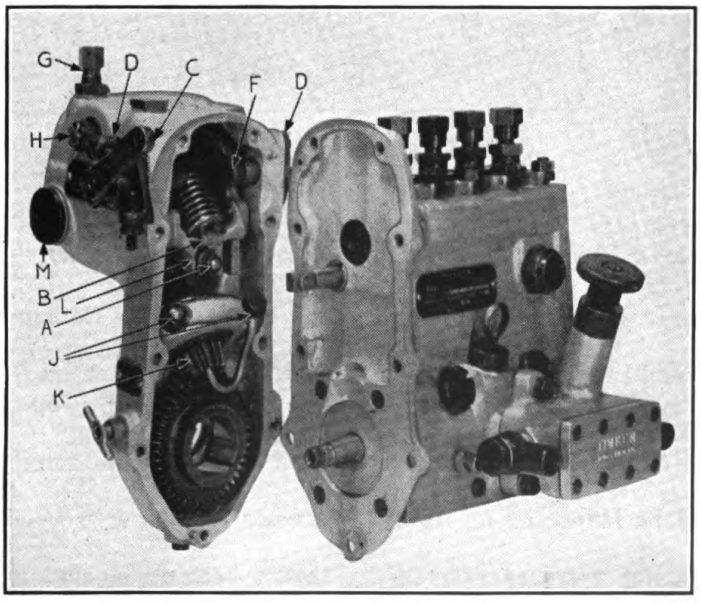


Illustration No. 13

INSTRUCTIONS FOR REPAIRING MECHANICAL GOVERNOR

To repair or replace worn or broken parts in the Hercules Mechanical Governor the following procedure will be helpful.

DISASSEMBLING THE GOVERNOR:

(All Illustration References are to Illustration No. 13 unless otherwise stated)

1. Remove injection pump and governor from engine and remove governor from pump as described on page 33.

2. Remove the idle spring and adjusting screw G.

3. Remove the high speed retaining nut and lockwasher A, then the spring link from the stud; remove pin B. Also remove pressed steel retainer for pin from the stud.

4. Loosen the clamp screws and remove the control shaft lever and shaft stop C. (Note lever positions as different installations have different levers as well as these levers being placed in different positions. It is necessary that the lever be replaced in the same position as when removed in order to hook up to equipment control correctly.) Remove shaft bushings D. To remove control shaft F, allow yoke L to move inward as far as possible, rotate control shaft until the part connected to spring is projecting at right angles to the face of the housing. Slide the control shaft sidewise in the housing until the short end clears the housing, then tilt the shaft and withdraw it.

5. Remove cotter, nut and washer from yoke shaft H and remove yoke from opposite side of housing.

6. Remove screw and oil tube, also nut from stud and remove pinion shaft bearing cap J. It may be necessary to tap cap lightly to loosen it. Pinion shaft K now may be lifted up and out of housing together with yoke. It may be necessary to pry the shaft slightly to release lower bearing cap. Be careful not to damage bearing mounting machined surfaces.

7. Remove gear and thrust washer R and J, Illustration No. 14.

8. The pinion shaft upper bearing cup and adjusting cap S and WW, Illustration No. 14, are a sliding fit and easily removed.

9. The hub oil seal T can be pried out with a screw driver if necessary to replace.

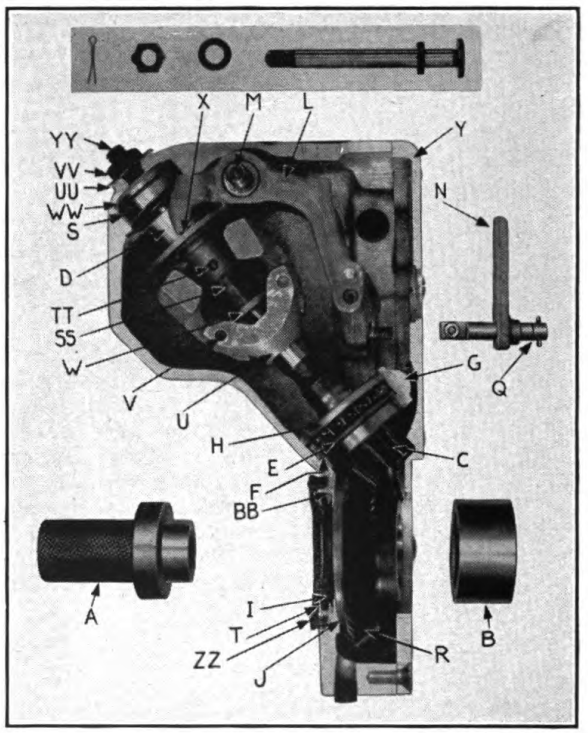


Illustration 14

INSPECTION OF PARTS:

(All Illustration References are to Illustration No. 14 unless otherwise stated)

Careful inspection will help in making correct and proper repairs.

1. The hub oil seal T must be in good condition and fit hub coupling. Replace this seal at every major overhaul.

2. Pinion shaft gear teeth C should not be broken, chipped or excessively worn.

3. Gear thrust washer J should be smooth and not scored. Should be of proper thickness for adjustment of back lash.

4. Pinion shaft bearings E and S should be in good condition and show no rough or rusted spots.

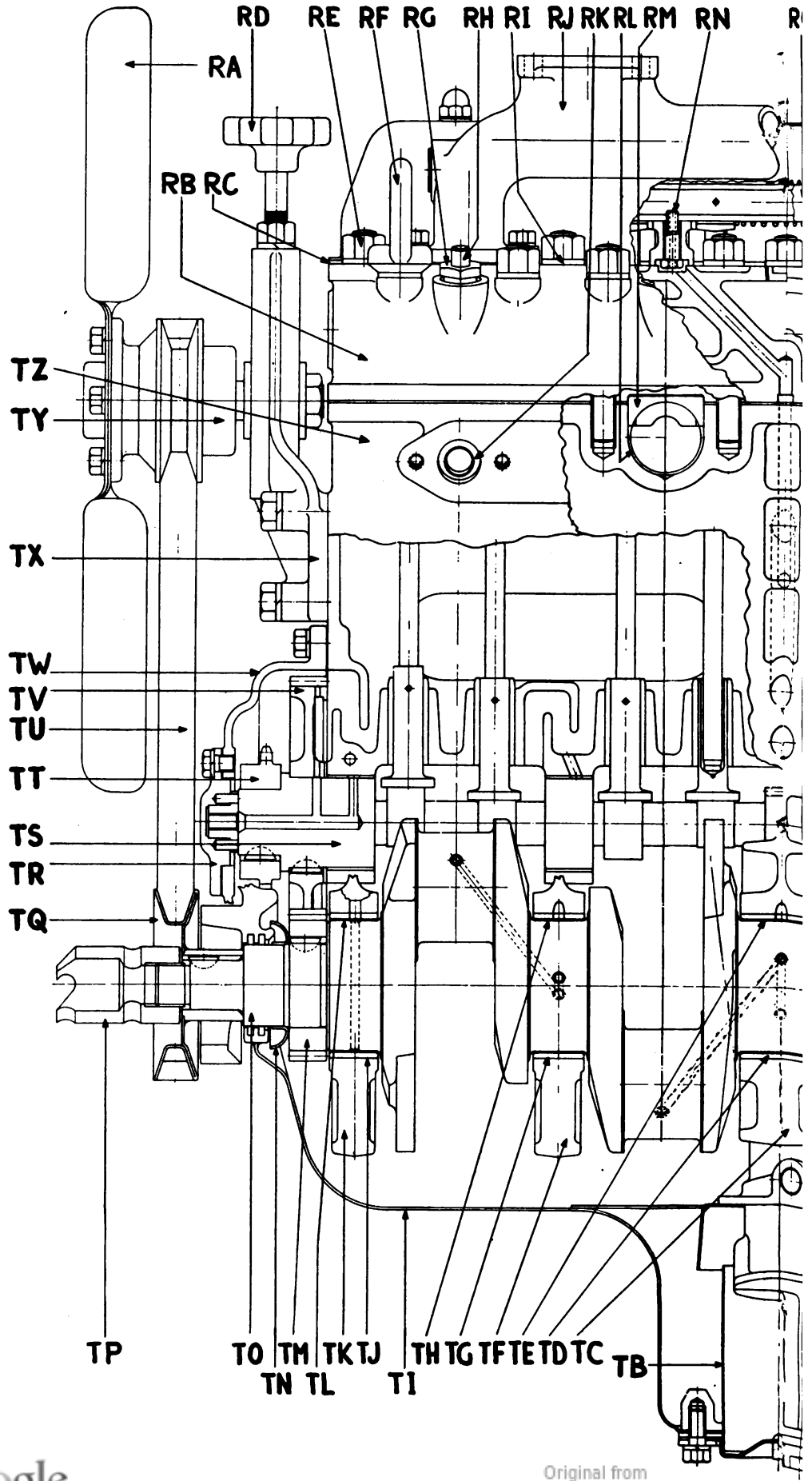
5. Pinion shaft assembly should be inspected as follows if gear was found in good condition under Item 2.

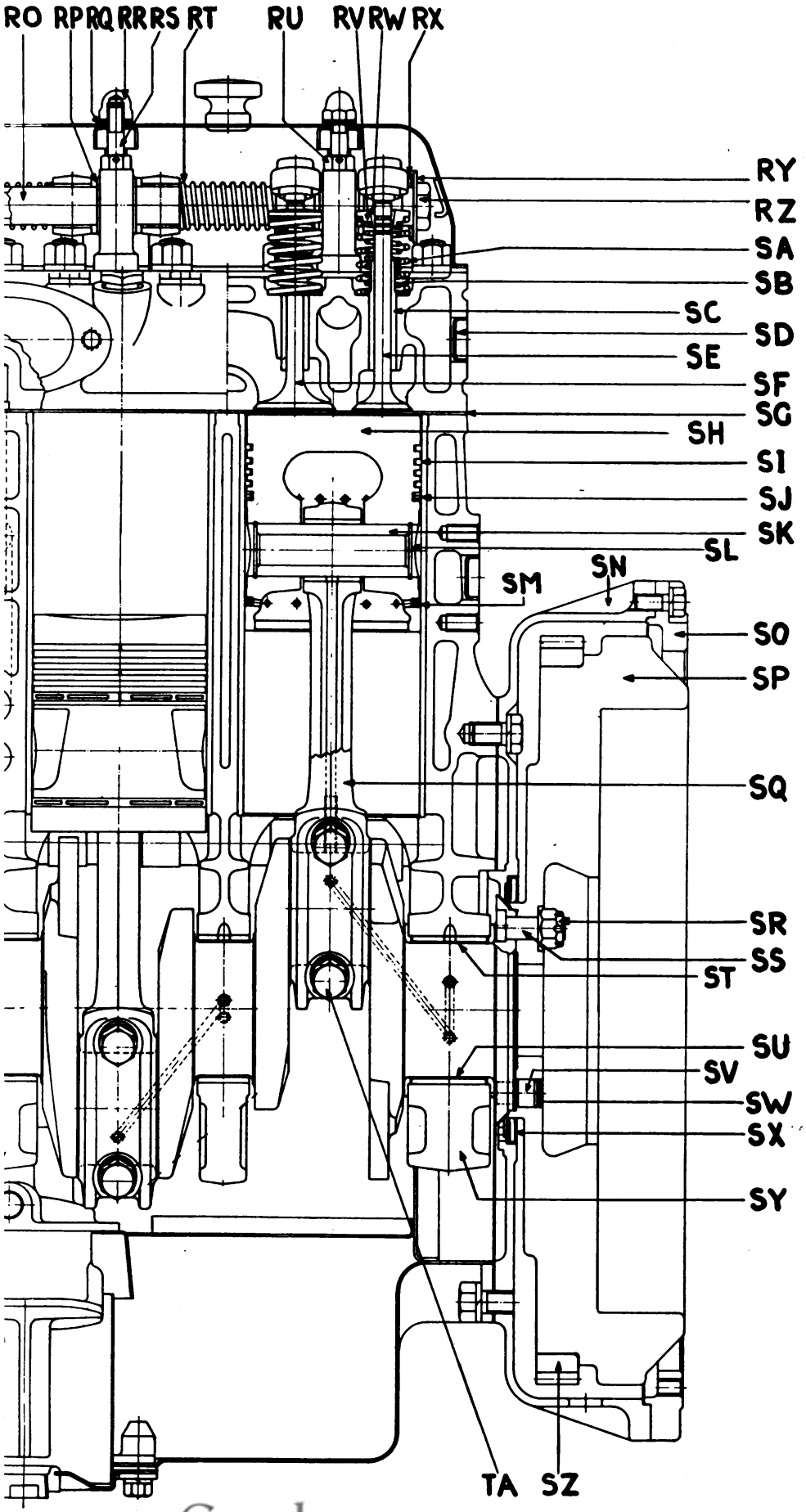
(a) Shaft must be straight and not worn excessively by thrust bearing sleeve.

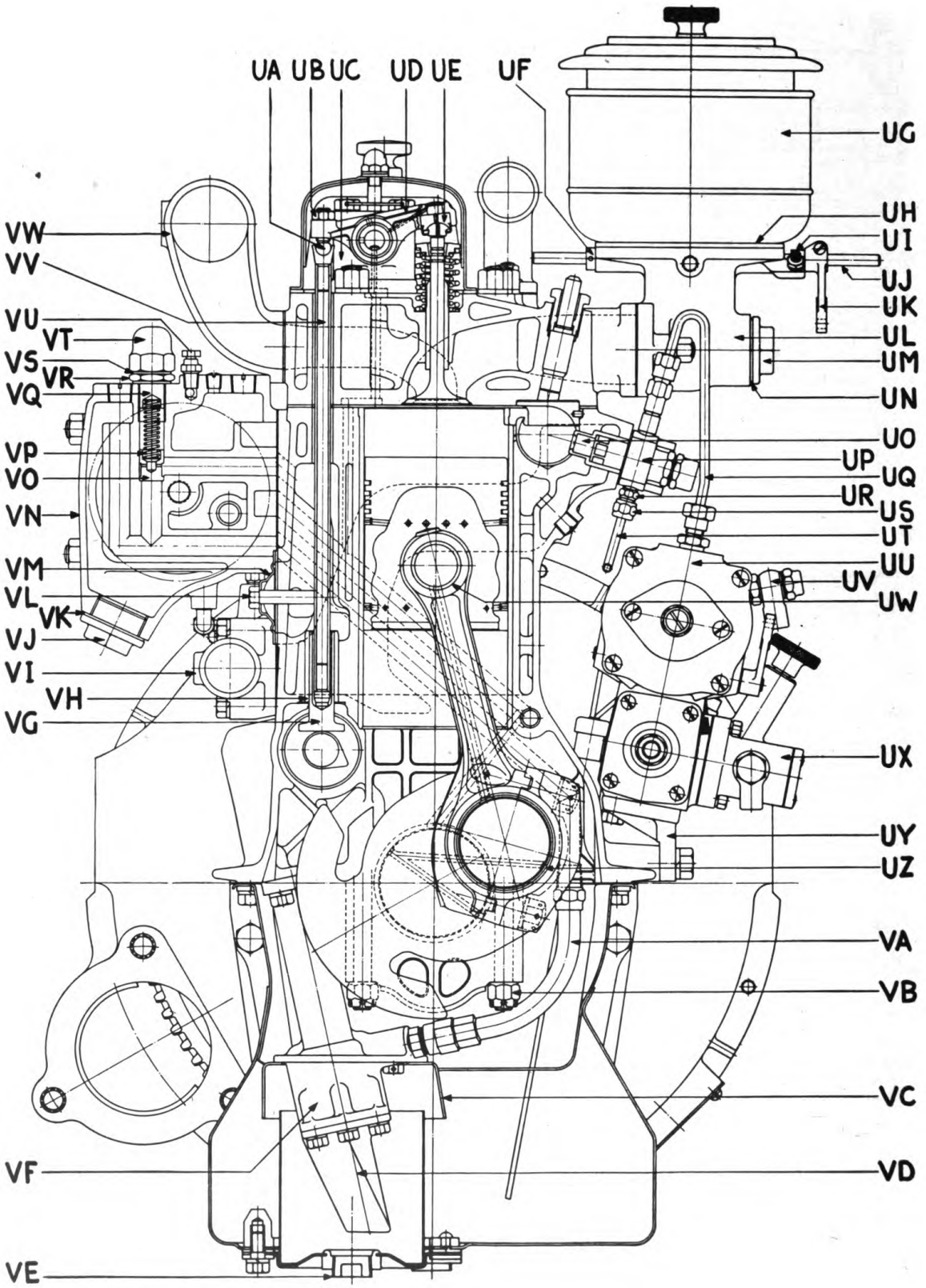
(b) Weight spider U must be tight on shaft.

NOMENCLATURE OF PARTS SHOWN IN SECTIONAL VIEWS

Reference Letter	Part Name
RA	Fan Blade
RB	Cylinder Head
RC	Cylinder Head Cover Gasket
RD	Fan Adjusting Screw
RE	Cylinder Head Nut
RF	Lifting Eye
RG	Glow Plug Hole Plug Retaining Nut
RH	Glow Plug Hole Plug
RI	Cylinder Head Nut Washer
RJ	Top Water Outlet Manifold
RK	Fuel Nozzle Sleeve
RL	Lower Combustion Chamber Liner
RM	Upper Combustion Chamber Liner
RN	Rocker Arm Shaft Locating Screw
RO	Rocker Arm Shaft
RP	Rocker Arm Spacer
RQ	Head Cover Nut Washer
RR	Head Cover Nut
RS	Head Cover Stud
RT	Rocker Arm Spacing Spring
RU	Rocker Arm Bracket Screw
RV	Valve Spring Seat
RW	Valve Spring Seat Lock
RX	Rocker Arm Shaft Conical Washer
RY	Rocker Arm Shaft End Washer
RZ	Rocker Arm Shaft End Screw
SA	Outer Valve Spring
SB	Inner Valve Spring
SC	Valve Guide
SD	Cup Plug
SE	Exhaust Valve
SF	Intake Valve
SG	Cylinder Head Gasket
SH	Piston
SI	Piston Compression Ring
SJ	Piston Oil Ring, Upper
SK	Piston Pin
SL	Piston Pin Lock Ring
SM	Piston Oil Ring, Bottom
SN	Flywheel Housing
SO	Flywheel Housing Adapter Ring
SP	Flywheel
SQ	Connecting Rod
SR	Flywheel Bolt Nut
SS	Flywheel Bolt
ST	Rear Upper Main Bearing Shell
SU	Rear Lower Main Bearing Shell
SV	Flywheel Dowel
SW	Flywheel Expansion Plug
SX	Flywheel Housing Oil Seal
SY	Rear Main Bearing Cap
SZ	Flywheel Ring Gear
TA	Connecting Rod Cap Screw
TB	Oil Pan Strainer Assembly
TC	Center Main Bearing Cap
TD	Center Lower Main Bearing Shell
TE	Center Upper Main Bearing Shell
TF	Intermediate Main Bearing Cap
TG	Intermediate Lower Main Bearing Shell
TH	Intermediate Upper Main Bearing Shell
TI	Oil Pan
TJ	Front Lower Main Bearing Shell
TK	Front Main Bearing Cap
TL	Front Upper Main Bearing Shell
TM	Crankshaft Gear
TN	Crankshaft Oil Thrower
TO	Crankshaft
TP	Crankshaft Turning Crank Jaw
TQ	Fan Driving Pulley
TR	Camshaft Thrust Plate
TS	Camshaft
TT	Camshaft Sprocket
TU	Fan Belt
TV	Camshaft Gear
TW	Gear Compartment Cover
TX	Fan Bracket
TY	Fan Hub Assembly
TZ	Cylinder Block
UA	Rocker Arm Adjusting Screw
UB	Rocker Arm Adjusting Screw Lock Nut
UC	Rocker Arm Bracket
UD	Rocker Arm
UE	Rocker Arm Cup Assembly
UF	Venturi Valve Shaft Collar
UG	Air Cleaner Assembly
UH	Air Cleaner Gasket
UI	Venturi Valve Stop Screw
UJ	Venturi Valve Shaft
UK	Venturi Valve Lever
UL	Venturi Housing
UM	Venturi Housing Plug
UN	Venturi Housing Plug Gasket
UO	Fuel Nozzle
UP	Fuel Nozzle and Holder Assembly
UQ	Fuel Injection Line
UR	Leak-off Manifold Union
US	Leak-off Manifold Nut
UT	Leak-off Manifold
UU	Fuel Pump Vacuum Governor
UV	Fuel Pump Check Valve
UW	Connecting Rod Upper End Bushing
UX	Fuel Pump Transfer Pump
UY	Fuel Pump Bracket
UZ	Connecting Rod Bearing Shell
VA	Oil Pump Discharge Flexible Tube
VB	Main Bearing Stud Nut
VC	Oil Pump Baffle Shell
VD	Oil Pump Cover and Intake
VE	Oil Pan Drain Plug
VF	Oil Pump Assembly
VG	Valve Tappet
VH	Valve Tappet Guide
VI	Water Inlet Pipe
VJ	Lubricating Oil Filter Drain Plug
VK	Lubricating Oil Filter Drain Plug Gasket
VL	Valve Tappet Chamber Cover Screw
VM	Valve Tappet Chamber Cover
VN	Lubricating Oil Filter
VO	Oil Pressure Regulating Piston
VP	Oil Pressure Regulating Spring
VQ	Oil Pressure Regulating Screw
VR	Oil Pressure Regulating Screw Lock Nut
VS	Oil Pressure Regulating Screw Gasket
VT	Oil Pressure Regulating Screw Cap Nut
VU	Lubricating Oil Filter Vent Cock
VV	Valve Push Rod
VW	Exhaust Manifold







(c) Weight pins V must be tight on spider.

(d) Weights must pivot freely but not be excessively loose on pins.

(e) Weight fingers must not be worn excessively, 1/32" radius on tip is normal.

(f) Oil passage through shaft must not be clogged. (Use air to check if open.)

6. Inspect yoke L for following:

(a) Bearings should fit yoke shaft M without binding.

(b) Curved surfaces X engaging thrust sleeve should not be excessively worn.

(c) Rack roller guide rivets must be tight.

(d) Sufficient lateral play of yoke to allow it to adjust itself to pump control rod and thrust bearing D without binding.

(e) Rack rollers should fit smoothly and be neither too tight nor too loose.

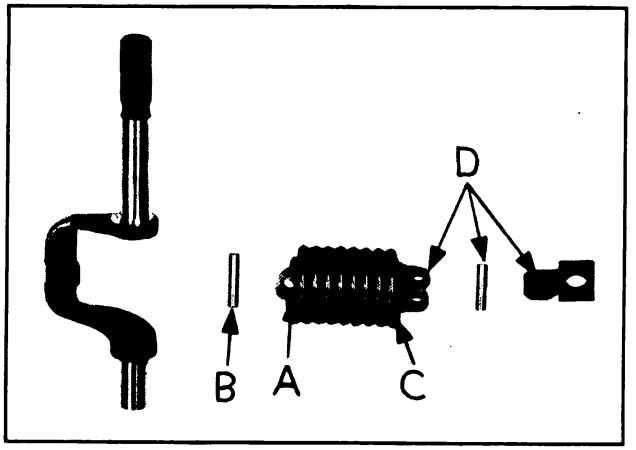


Illustration No. 15

7. The loose washer W of the thrust sleeve assembly engaging weights should be smooth and flat. The thrust sleeve bearing should rotate freely and should be tight in the ring and on the sleeve.

8. The idle spring should be of proper length and not bent.

9. Check high speed spring and control rod for following, Illustration No. 15:

(a) Shaft not sprung to cause binding.

(b) Springs should not be stretched, coils should be tight together.

(c) Spring pins should not be excessively worn.

10. Inspect housing for mechanical damages such as stripped threads, cracks or gouged sealing surfaces.

11. All seals and gaskets should be replaced.

ASSEMBLING GOVERNOR:

After parts have been inspected and all worn or defective ones renewed, the following procedure will help in assembling the governor.

1. Be sure all parts are thoroughly cleaned and lubricated.

2. If gear, gear washer, pinion shaft or housing have been renewed, it will be necessary to check the adjustment of the gears and the pinion shaft bearings. The proper adjustment of the gear teeth is .003" to .006" backlash. To check the backlash, insert plug A in oil retainer ring bore BB, Illustration No. 14, and assemble the gear and thrust washer in the housing and support on the small diameter of plug A. Place the pinion shaft assembly C in the housing and tighten the bearing cap. The thrust sleeve assembly D may be omitted for the present. The flange of the pinion shaft lower bearing cup D must be firmly and squarely seated on the housing F. The oil impeller cup H should be pushed up on the shaft and not clamped for this check. With the shaft now in place check the clearance between the gear teeth with a feeler gauge or piece of shim stock. The backlash is adjusted by selecting a gear washer J of suitable thickness. (These washers are obtainable in six different thicknesses.) For this purpose an increase in thickness of .002" decreases the backlash .001" and vice-versa. The ends of the teeth of the gear should line up with the ends of the teeth on the pinion within .010". The pinion shaft should have .001" to .004" end play obtained by adjusting screw YY at the upper pinion shaft bearings. Be careful with this adjustment.

3. When proper backlash adjustment has been obtained, the assembly can be completed. Remove the pinion shaft, replace the yoke L in the housing, place the thrust sleeve assembly on the pinion shaft and replace the pinion shaft in the housing. Be sure to include washer W next to the weight fingers. Insert yoke shaft M with the soft gasket in place in the recess in housing under both yoke shaft head and nut. Tighten yoke shaft nut against housing and secure with cotter pin. Do not tighten so tight as to deform housing and cause binding of other parts and maybe oil leakage. The pinion bearing cap G should be tightened with oil impeller cup in place and screw

and stud nuts secured with wire. The oil impeller cup must be aligned properly to avoid pinching and must not ride the impeller. Seat the impeller cup against shoulder in housing and cap.

Check pinion shaft bearing end play adjustment (.001" to .004") and tighten check nut VV. Recheck end play after tightening nut and if correct, bend one ear of washer UU down against housing and one ear up on side of nut to lock.

4. If high speed spring assembly, Illustration No. 15, 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 and screw the spring on to the link about ¼ turn so that the spring prevents the pin falling out. Do not disturb the spring on lower link C. Be careful not to scratch or gouge spring. The slot in the lower link must be at right angles to the control shaft. Reassemble control shaft in housing.

5. Connect high speed spring assembly and link D, Illustration No. 15, to stud on yoke L, Illustration No. 14.

6. Replace the hub oil seal T, Illustration No. 14 (Lip of seal I must point toward governor gear); also replace the hub dust seal ZZ.

7. Replace the idle spring in the socket in the yoke and screw in the idle adjusting screw about halfway.

8. Attach yoke travel fixture N, Illustration No. 14, to the flange of the governor with the pin or roller of the fixture inserted in the square hole in the rack roller guide of the yoke L. Insert sleeve adjusting wrench at M, Illustration No. 13, and adjust the length of thrust sleeve, Illustration No. 9, per instructions on page 35, until the line Q, Illustration No. 14, on the rod of the fixture N is flush with the face of the boss with the governor weights in wide open position.

9. Reassemble plate Y to pump and governor to plate per instructions on page 34.

10. Fill with clean oil to proper level, assemble pump assembly to engine, start engine and make adjustments as outlined on page 35. With engine running at idle speed of about 400 R.P.M. remove plug M, Illustration No. 13, 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.

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. 14, 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 in B. Plug B must rotate freely. It may be necessary to relocate the dowels to eliminate binding.

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 have installed the type of filters which they have found by experience to best fulfill the various requirements of their engines. 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. In the following paragraphs we take up each of these filters separately; air, fuel oil and lubricating oil.

AIR FILTERS OR CLEANERS

The oil bath type air cleaner and filter is one of the most efficient and yet the easiest to clean and service. These units should be cleaned at least once a day or if working in very dusty conditions should be cleaned every six or eight hours. To clean the type commonly supplied, remove the screen element and top shield by unscrewing the long screw with the knurled hand nut on top. Wash this unit 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. Next remove outside lower shell which holds the oil, clean old oil and dirt by washing with clean fuel oil, kerosene or gasoline. Some of the units have a baffle plate in the bottom, remove this before cleaning as most of the dirt will be found under this plate. Wipe dry with a clean cloth. Fill with clean lubricating oil up to oil level bead.

Before installing inspect gasket and if torn or broken, replace. Now dip the screen or top 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 where efficient air cleaning action is no longer available.

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 an elaborate 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. (Some automotive installations have a similar filter mounted in the bottom of the fuel tank.) This unit is to remove the larger particles of dirt and water and is 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. 16.

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.

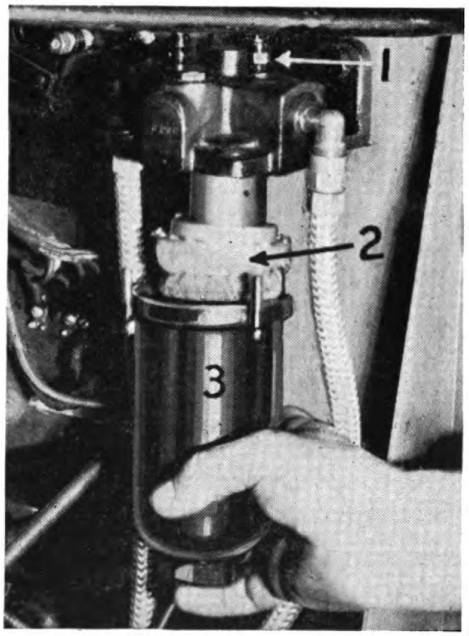


Illustration No. 16

In addition to these filters each fuel nozzle has a stem filter shown as 6 in Illustration No. 6. The cleaning of this filter is covered under section about the care of nozzles.

TO CLEAN FUEL FILTERS

The dual filter which is 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 can be removed and this dirt allowed to flow out. A similar type of filter is shown in Illustration No. 20 on page 46. In this illustration the handle referred to above is numbered 9, the drain plug is number 6. Vent cock No. 8 is for the purpose of bleeding air from these filters. After turning handle check the packing nut around the stem, making sure it is tight.

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 of 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 Illustration No. 16 which is between the fuel transfer pump and the fuel injection pump contains a metal element surrounded by a fabric element shown as No. 2 in this illustration. To clean remove case No. 3, cloth unit, also metal unit. The cloth unit is equipped with a bayonet catch which is turned to the right to release: the metal element 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 a new one from the spares. After cleaning reassemble, reversing 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.

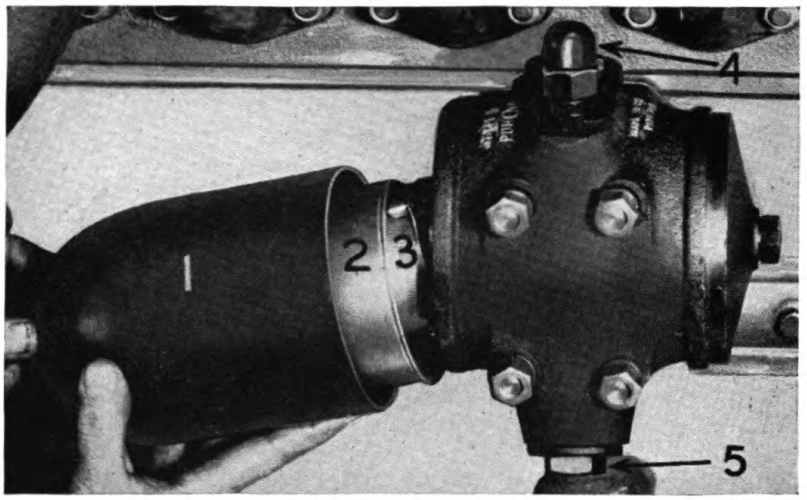


Illustration No. 17

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.

LUBRICATING OIL FILTER

The lubricating oil filter shown in Illustration No. 17 consists of two elements, No. 2 and No. 3 (also shown being pulled apart in Illustration No. 18), enclosed in shell No. 1. These filtering or straining elements should be cleaned very frequently, an exact schedule cannot 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. 18. 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.

Illustration No. 18

Frequently remove plug No. 5, Illustration No. 17, and allow the dirt, water and sludge which has accumulated to drain out of the filter.

Remember any type of filter (air, fuel oil or lubricating oil) must be given intelligent attention and frequent cleaning if it is expected to remove dirt, etc. Some filters must be inspected and cleaned daily. Study the service requirements of your particular operation and save repair expense.

POWER UNIT

This section is placed in this book to acquaint operators of the Hercules DOO Diesel Power Unit with the various instruments and the important points to maintain efficient operation. The three illustrations used in this section show the standard DOO Diesel Power Unit and with certain applications the position of parts shown may vary.

ILLUSTRATION NO. 19—INSTRUMENT PANEL

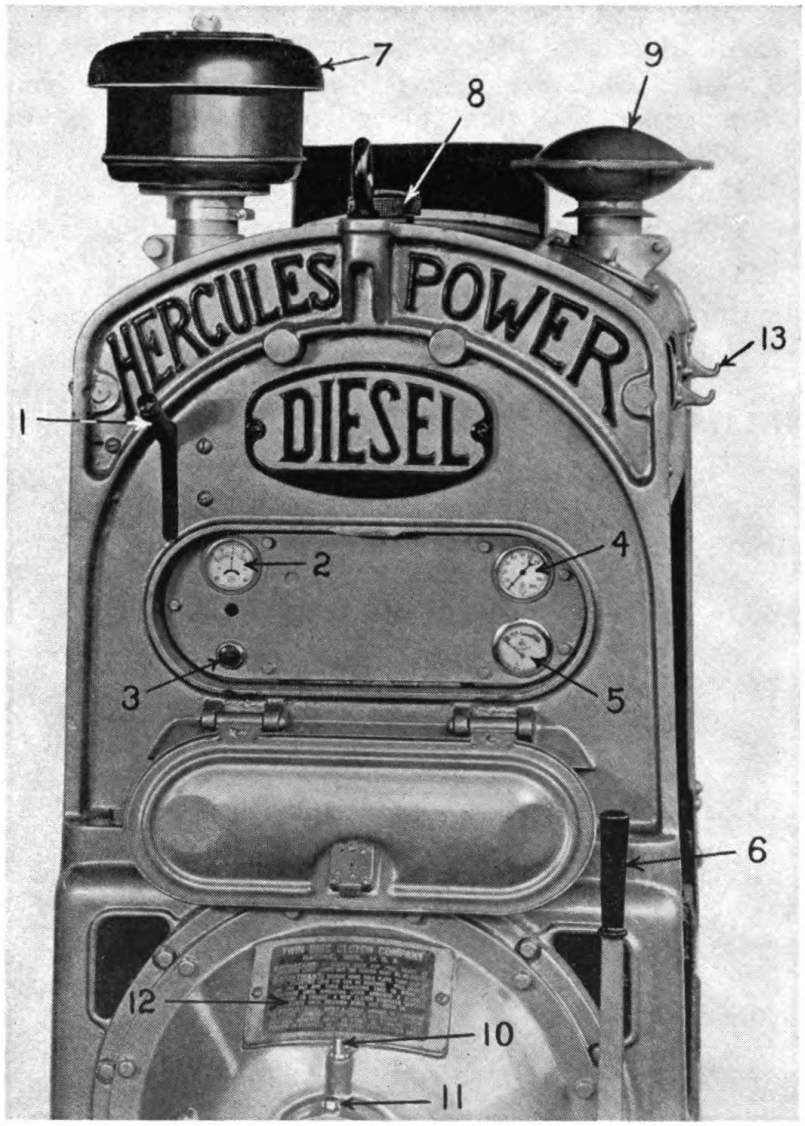


Illustration No. 19

1. Mechanical Governor Control Handle—Position shown is the full load position, to operate press button in end to release ratchet and push down to stop engine. This control allows the operator to set the governor for any desired speed from idle to full top speed.

2. Ammeter—This instrument shows the generator charging rate. If the batteries are not used quite frequently they may become overcharged; this condition is noted by the excess amount of water required to keep the correct water level in the battery, providing the battery is checked weekly. To relieve overcharging have generator adjusted to a lower charging rate. Should the unit require a greater electrical output than required for just starting the engine (such as lights) it may be necessary to increase the charging rate to keep the battery fully charged. Should help be required the manufacturers of the electrical equipment have a local representative near you who will be pleased to help you.

3. Starter Push Button Switch—This operates the magnetic switch shown as No. 14 in Illustration No. 21 which in turn controls the starting motor.
4. Oil Pressure Gauge—This registers the oil pressure and should be watched carefully as this gauge along with the viscometer gauge No. 5 give the true picture of your engine lubrication. The pressure at full speed should be around 30 pounds.
5. Viscometer Gauge—See pages 16, 17, 18 and 19 for a thorough discussion of the use of this instrument.
6. Clutch Control Lever—Disengage when starting engine.
7. Air Cleaner or Filter—See page 42 for details covering this unit.
8. Fuel Tank Filler Neck Cap—Clean away any accumulation of dirt before removing. See that only good clean fuel oil is put in tank. For specifications see page 19.
9. Muffler Assembly.
10. Lubrication Fitting for Clutch Bearing—See instruction plate No. 12.
11. Lock Screw for Clutch Adjustment.
12. Clutch Assembly Instruction Plate—Please read carefully.
13. Hood Latch Hooks.

ILLUSTRATION NO. 20—FUEL INJECTION PUMP SIDE

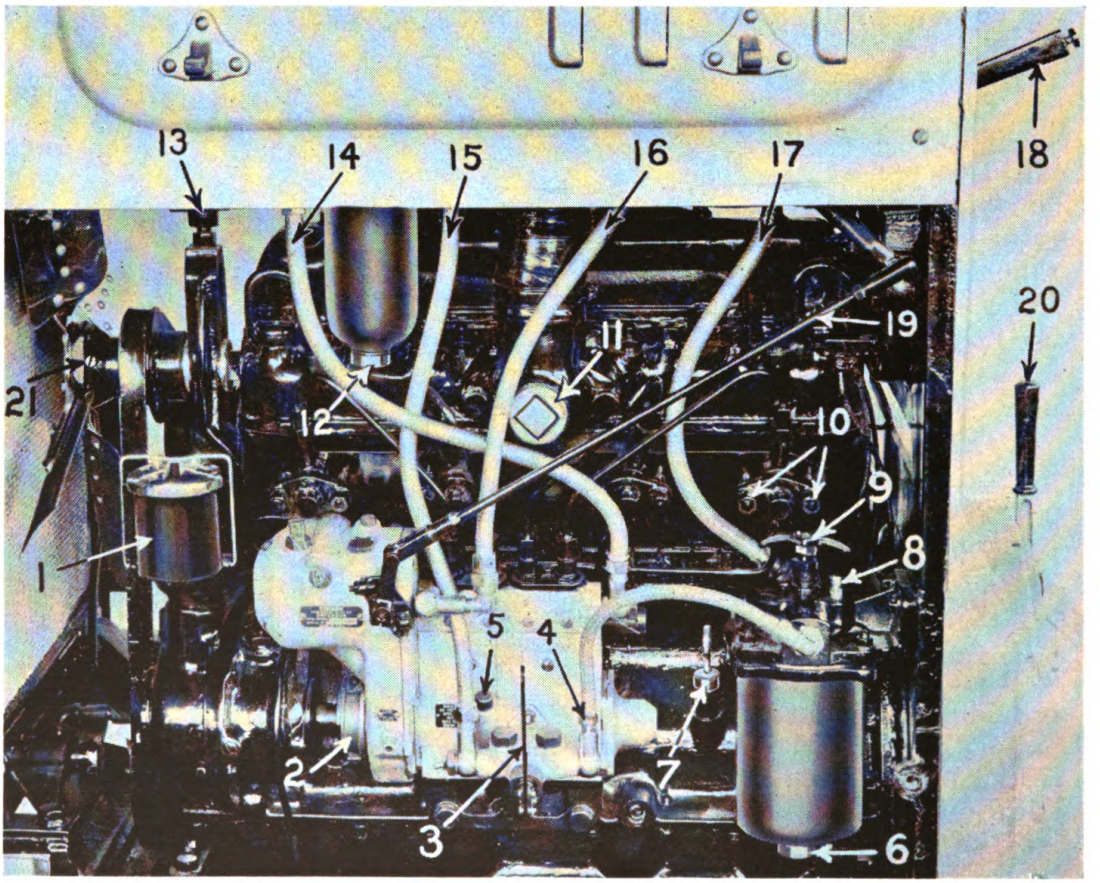


Illustration No. 20

1. Breather and Oil Filler Pipe— Be sure all dirt is removed from top before opening to fill with oil.
2. Fuel Pump Coupling—Keep screws tight to prevent slipping. Should slippage occur refer to section starting on page 23 which covers fuel pump timing and retime.
3. Fuel Transfer Pump Priming Lever—See "Fuel Injection Equipment" section.
4. Fuel Transfer Pump Inlet from Primary Fuel Filter.
5. Fuel Pump Oil Level Dip Stick—Shows lubricating oil level in pump. Check daily and keep level up to mark.
6. Primary Fuel Filter Drain Plug—Remove to drain dirt and sludge also any water which may have accumulated.
7. Bayonet Oil Dip Stick Gauge—This is marked 2/4 for half full and 4/4 for full. Maintain oil level near the 4/4 mark with a good brand of oil the grade of which has been ascertained by the viscometer as discussed on pages 16, 17 and 18.
8. Primary Fuel Filter Vent Valve—Open frequently to bleed off any accumulated air.
9. Primary Fuel Filter Ratchet Handle—These turn the elements so knife edge cleans or wipes the dirt from them, turn once a day. Keep packing nut tight so leakage of fuel does not occur around handle stem.
10. Fuel Injection Nozzle Clamp Nuts.
11. Air Inlet Pipe Opening Plug—When starting in cold weather the external application of heat in opening made by removal of this plug will help starting the engine.
12. Final Fuel Filter Drain Plug—Remove to drain any accumulated water.
13. Fan Belt Adjusting Screw—Tighten belts to point where belt will flex about one inch when pressed in between any two pulleys.
14. Fuel Line From Final Fuel Filter to Fuel Injection Pump.
15. Fuel Line From Fuel Transfer Pump to Final Fuel Filter.
16. Fuel Return Line From Fuel Injection Pump Check Valve to Fuel Tank.
17. Fuel Line From Fuel Tank to Primary Fuel Filter.
18. Governor Control Handle—Also see No. 1 Illustration No. 19.
19. Control Rod from Governor to Handle Linkage—Be sure all slack is out of these parts.
20. Clutch Control Handle.
21. Fan Hub Oil Plug—Remove at least once a week and fill with lubricating oil; more often is preferred.

ILLUSTRATION NO. 21—Water Pump Side

1. Clutch Control Handle.
2. Back of Viscometer Gauge—See No. 5 Illustration No. 19.
3. Viscometer Instrument—See Page 19 for care of this unit.
4. Oil Pressure Line from Filter to Gauge.
5. Oil Pressure Regulating Screw Cap Nut—See page 55 for pressure regulation.
6. Oil Pressure Gauge Line Connection in Top of Filter.

7. Water By-Pass Tube—Allows water to circulate while thermostat is closed.
8. Fan Belt Adjusting Screw—See No. 13, Illustration No. 20.
9. Air Cleaner or Filter.

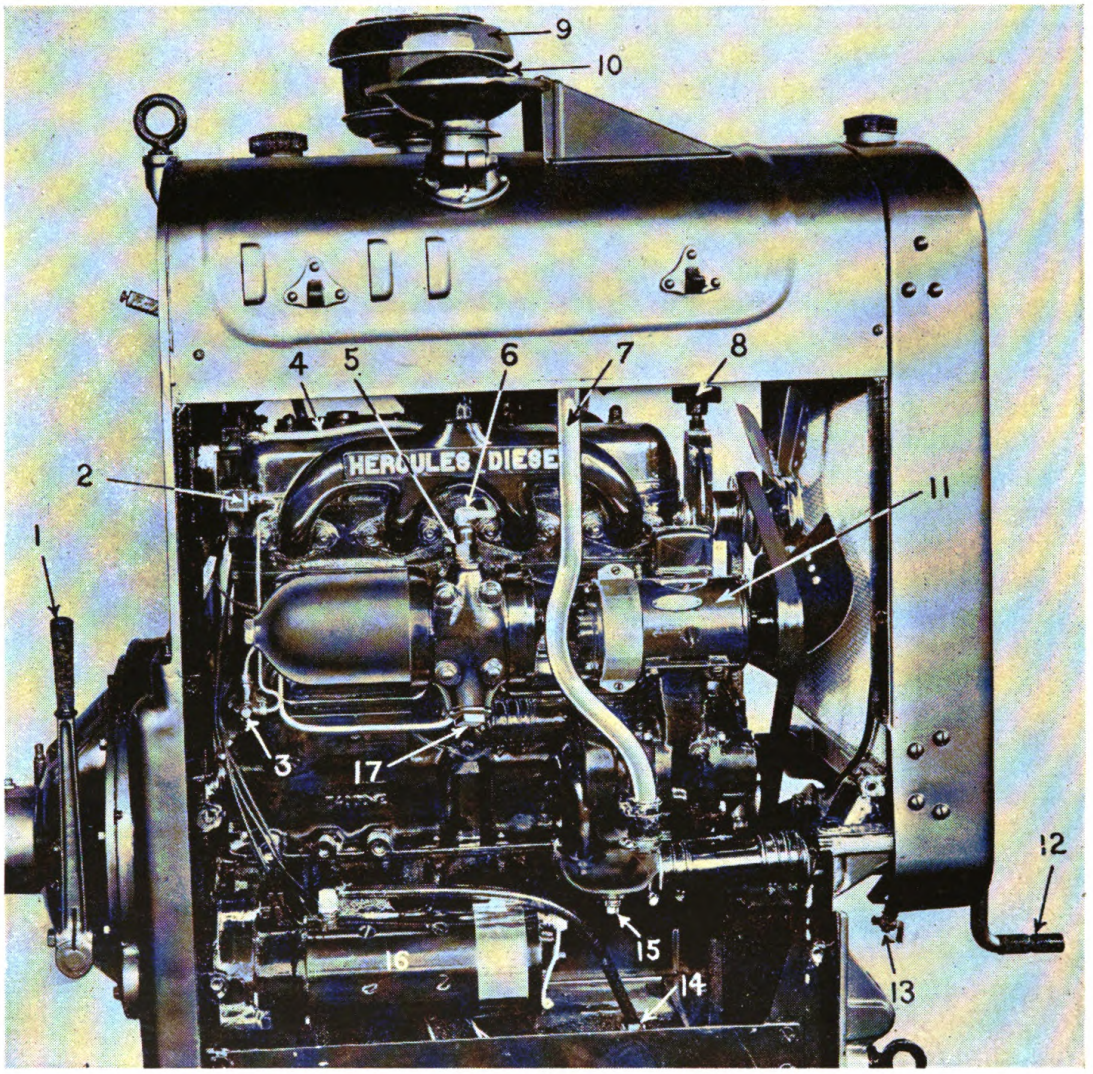


Illustration No. 21

10. Muffler Assembly.
11. Generator—Belt driven, third brush regulating type.
12. Turning Crank Handle.
13. Radiator Drain—Used in conjunction with drain on cylinder block and water pump pipe.
14. Magnetic Switch for Starter.
15. Water Drain Plug.
16. Starting Motor.
17. Lubricating Oil Filter Drain Plug—Remove and drain old oil and sludge when changing the oil in crankcase, about every 50 or 60 hours of operation. Clean filtering element at same time.

BATTERIES

The battery should have a capacity rating of 210 ampere hours and should be similar to Exide 6XCK25-3R, 12 volt 25 plate or Willard RHD-25-6, 12 volt 25 plate. These should be placed in a convenient location so that the water level can be checked at least once every week and if low should be brought up to proper level with clean distilled water.

RADIATOR

The following suggestions on the care of the power unit radiator may be of some help and if followed will eliminate replacement of expensive parts.

Keep radiator filled with clean water. Use soft or rain water if possible, "hard" or "alkali" waters form scale or corrode core and in localities where these are encountered it may be a sound investment to use distilled water. Another way to fight scale formation is the use of "boiler compounds" in the water.

Do not allow any foreign matter to flow into the radiator with the water such as leaves, twigs, bugs, soil, etc.

Flushing radiator and cooling system often will remove any sediment and will keep system clean, facilitating cooling of parts in contact with the water.

In freezing climate or weather care must be exercised to keep cooling solution of anti-freeze strong enough to not only cover the temperature being encountered but also any sudden change to lower temperatures.

GENERAL DESCRIPTION AND MAINTENANCE

The "DOO" series of Hercules Diesel engines is of the four stroke cycle type having four cylinders with a valve mechanism of the overhead type and with the cylinder block and crankcase cast integral. This series has three models of engines differing only in size of bore: the DOOB - 3¾"; the DOOC 4" and the DOOD - 4¼", the stroke being the same, 4½". The crankshaft is supported on 5 large main bearings with a diameter of 3".

The general construction of the engine tends to produce a very rigid unit, since crankcase and cylinder block is 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.

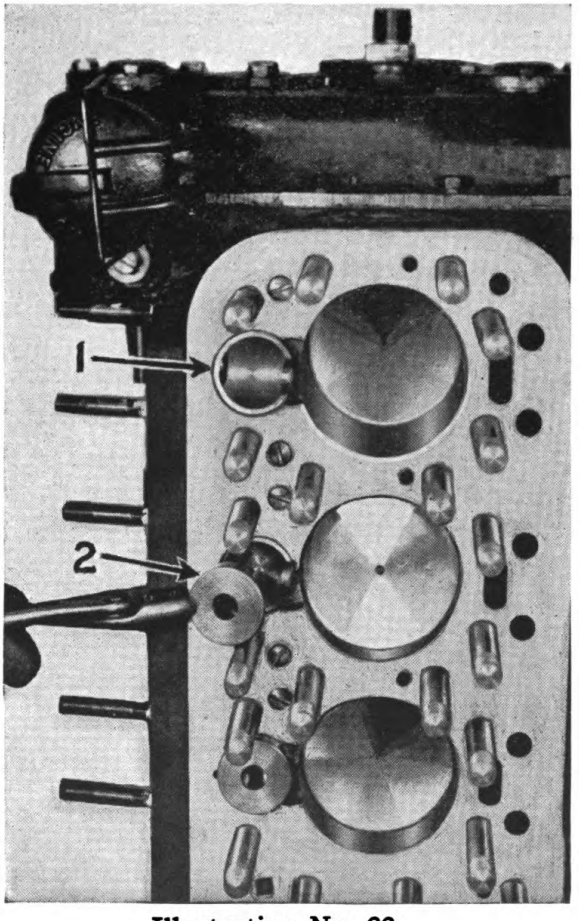


Illustration No. 22

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 oil temperatures than is possible with any other type of construction without the use of complicated oil coolers. 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, even at the higher speeds.

Illustration No. 22 although not of the DOO Series 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 with provisions for glow plug installation which is not commonly used. Illustration No. 23 shows the bottom view of the DOO series showing the main bearings, oil pump, etc.

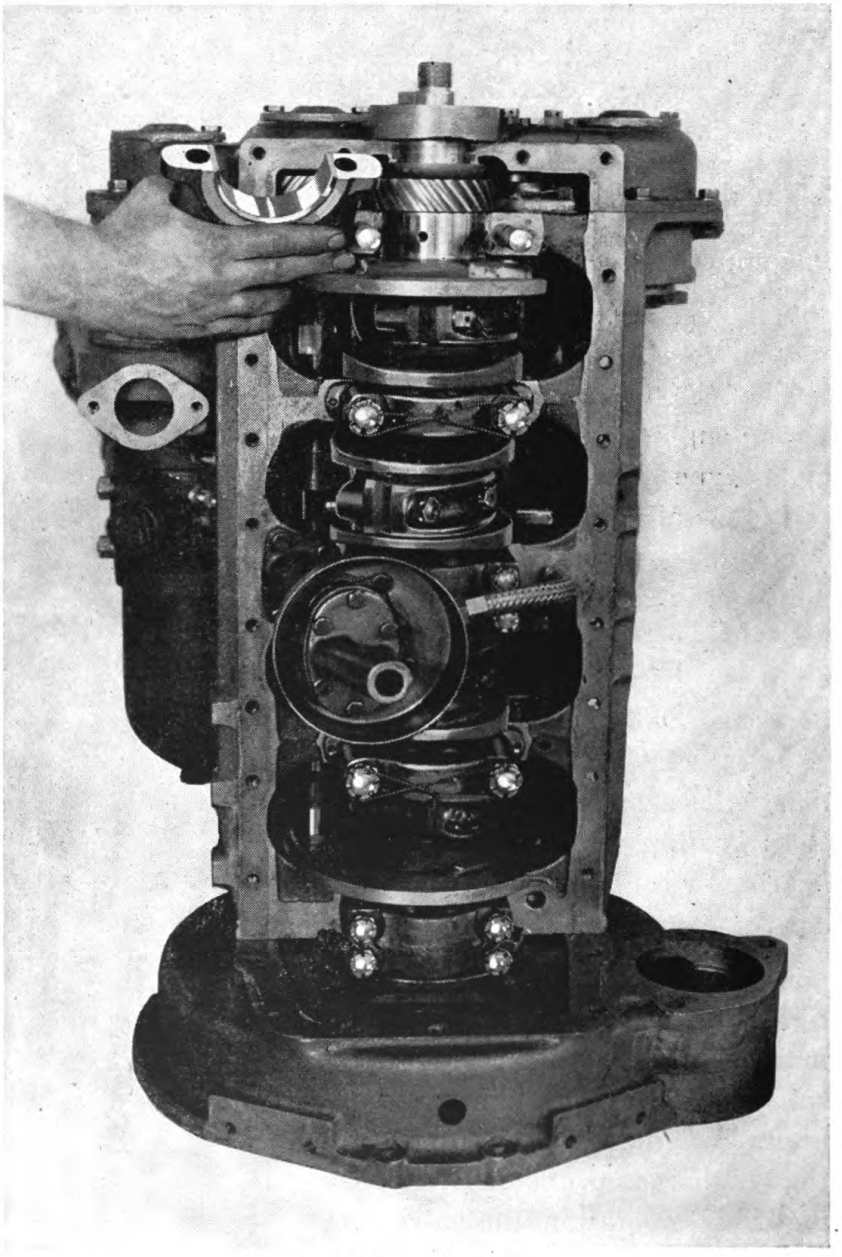


Illustration No. 23

Main Bearings:

Main bearings are of the removable shell type—in both the crankcase and the bearing caps. These shells are not machined after installation in the case. Therefore, replacement of bearings becomes a very simple matter. See illustration No. 23 which shows the front main bearing cap removed.

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 additional bearing clearance must be provided. It is, therefore, recommended that .003" to .004" clearance be provided between the crankshaft and the main bearings. The main bearing caps consist of a very rigid forging and are very securely fastened to the crankcase by means of large diameter studs, two studs being used on the front and intermediate bearings, and four studs are used on the center and rear bearings. The main bearings are doweled in place so as to permit removal of caps and replacement without shifting bearings on the case.

It is seldom necessary to use any shims between the caps and the case.

Main Bearing Adjustment

If excessive clearance develops between shaft and bearing shells and no shims are found in place between the caps and case 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 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 on page 70.

Connecting Rod. The nominal diameter of the connecting rod journal is 2½". In order to make use of this large diameter bearing and still permit assembling the connecting rod through the cylinder bore, it is necessary to split the connecting rod and cap on an angle. In order to prevent any shearing action on the connecting rod cap screws a very strong tongue and groove construction is used between the connecting rod and the cap which definitely locates the cap and relieves the cap screws of any shearing strain. 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 commonly 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. 24 shows the connecting rod and its various parts.

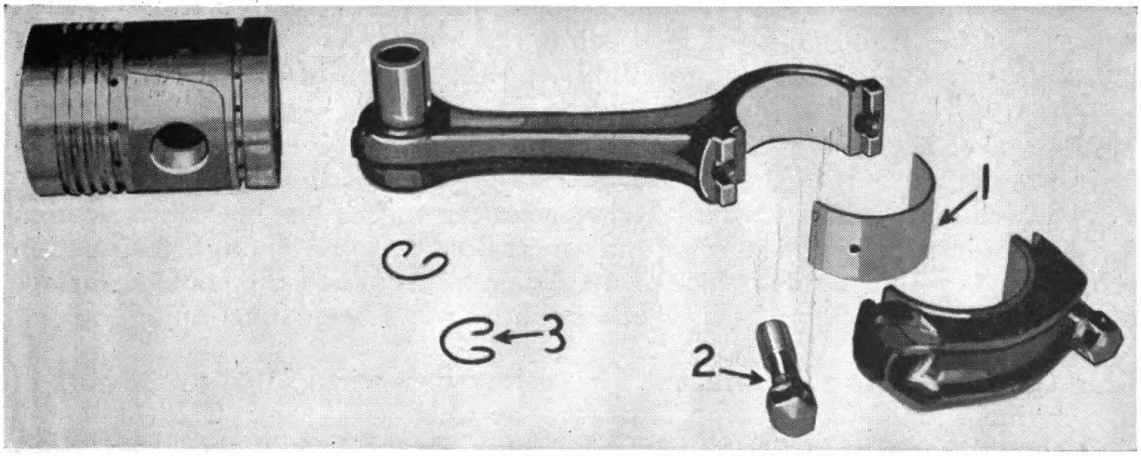


Illustration No. 24

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 the tongue 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 or place two strips of thin wood or cardboard between the rod and cylinder wall. Then if the rod rocks it will not gouge or scratch the cylinder wall.

Connecting Rod Bearing Adjustment. Due to absence of shims adjustment of connecting rods is made by replacement of the bearing shells. A clearance of .003 to .004" 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.

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 connecting 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 slight creeping action, while the normal rotation of the pin occurs in the bushing at 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 .001" to .0015" in the bushing in the top of the rod.

Piston. The piston is made of a very special aluminum alloy and is of the solid type, having no saw slots or split in the skirt. Six piston rings are used, the upper four rings being of the compression type, while the 5th 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. 24.

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 contact surface of the rings will usually show whether the ring has been functioning.

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 should have from .0035" to .004" land clearance while the other rings should have from .002" to .0025" land clearance.

Piston Clearances.	Min.	Max.
Piston Clearance in Cylinder bore—DOOB 3¾"	.0055	.006
Piston Clearance in Cylinder bore—DOOC 4"	.0055	.006
Piston Clearance in Cylinder bore—DOOD 4¼"	.006	.0065

The above clearances are obtained by measuring the piston diameter at the skirt or near the bottom of the piston with outside michrometers and measuring the cylinder bore diameter with inside michrometer. If feeler ribbon is used this should be a ribbon of .005" thickness for the DOOB and DOOC and .006" thickness for the DOOD. The ribbon used should be ½" wide and it should be possible to pull out the ribbon with but four to five pounds pull.

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, which is located in the portion of the combustion chamber machined in the cylinder block while a cover section 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. The hole in the center of the upper liner permits the glow plugs—when used—to extend into the upper part of the combustion chamber. The spherical section has a lip which is directly opposite the hole in the liner through which the injection nozzle is located. These various items are shown as No. 1 and No. 2 in Illustration No. 22.

Cylinder Head. The cylinder head for the four cylinders is made in one casting. The valve seats and the valve guides are a part of this casting, although the valve guide bushings are removable. The head is held to the cylinder block by a very large number of strong studs, and in order to insure against leaks the head must be carefully drawn down by means of the stud nuts which should be progressively tightened, working from the center of the head toward the ends and sides.

A wrench approximately 18" long should be used for this operation, preferably a tension type wrench. See page 71 for recommended tensions.

Cylinder Head Gasket. The cylinder head gasket is made of solid sheet copper which is carefully annealed in order to make the copper as soft as commercially practicable. When the gasket is placed on the cylinder, or the cylinder head is installed on top of the gasket great care must be exercised to prevent any dirt or foreign matter lodging between the gasket and the cylinder head or cylinder block. If the gasket 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

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 to the special ball cup over the valve stems. A clearance of .010" should be maintained between rocker arm and

exhaust valve stems and .010" between rocker arms and inlet valve stems. The clearance between valve stems and valve guides when new is approximately .0025" to .003". See clearance table, page 70.

Lubrication System. The engine is lubricated by means of a forced feed system which permits oil under pressure to be carried to the main bearings through channels drilled in the crankcase. The connecting rods are lubricated by means of holes drilled through the crankshaft which holes register with the oil groove in the upper shell of the main bearing. The piston pins are lubricated by means of a hole drilled in the connecting rod, and also by the oil scraped off the cylinder walls into the bosses of the piston.

The oil under pressure is also led to the rocker arms and valve compartment by means of suitably drilled passages in the cylinder block which register with one of the rocker arm shaft brackets, permitting oil to be carried to the hollow shaft on which the rocker arms rotate. The front cam bearing and the fuel pump drive shaft are also lubricated by the pressure system. The cylinders and pistons, valve tappets and balance of the cam bearings are lubricated by oil thrown off from the connecting rods and main bearings.

The gears in the front compartment as well as the timing chain are oiled by means of suitable holes drilled through the front camshaft bearing and shaft, the same construction is also built into the fuel pump drive assembly as well as the chain idler shaft. The drilled holes are also metered by the rotation of the shafts in order not to overload the front compartment with oil. These holes should be thoroughly cleaned every time the engine is overhauled. The use of good oil will eliminate any objectional sludge which will be the only cause for trouble.

Oil Pump. The oil pump is attached to the cylinder block and its gear is driven by a gear cut on the camshaft and located near the center of the

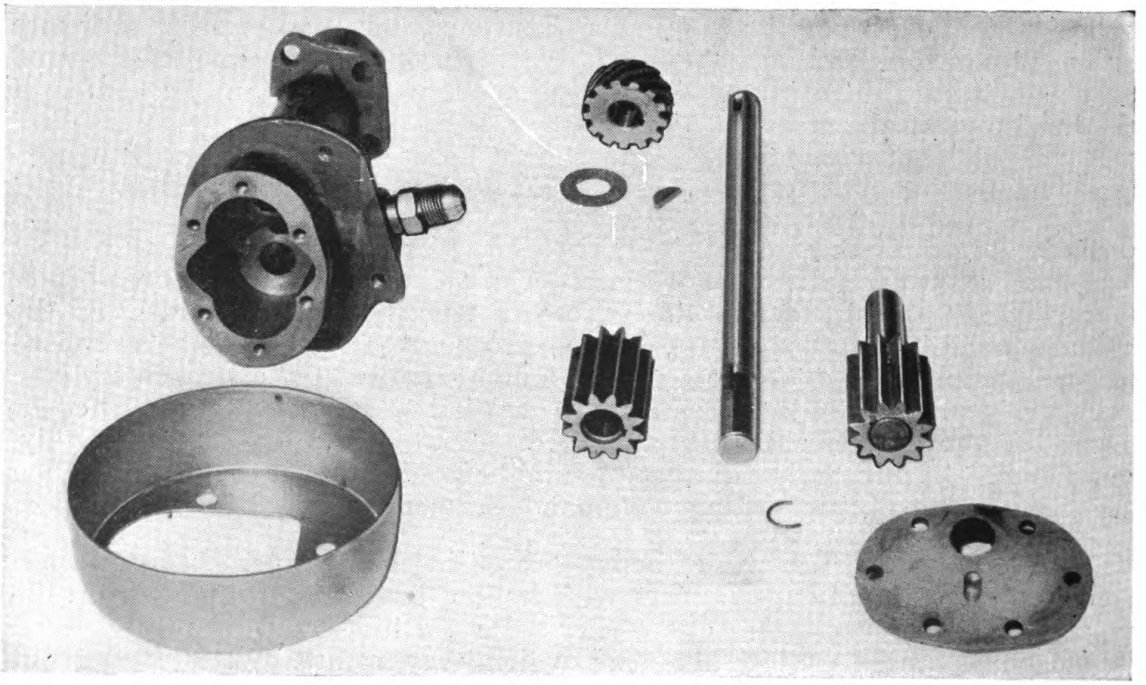


Illustration No. 25

camshaft. The lower end of the oil pump extends down into the oil pan and oil is drawn into the pump through a large screen which prevents coarse dirt being drawn into the lubricating pump. This strainer works in conjunction with the regular lubricating oil filter to remove foreign particles from the lubricating oil. The various parts of the oil pump are shown in Illustration No. 25.

Lubricating Oil Filter. The lubricating oil filter is shown in Illustration No. 17 and its care is covered on page 44. Refer to section on "Filters."

Oil Pressure Adjustment. Pressure adjustment is by means of a spring loaded plunger, the spring pressure is adjusted by means of the slotted screw uncovered when the acorn nut No. 4, Illustration No. 17, is removed, screwing in on the adjustment increases the pressure, out decreases the pressure. If pressure does not increase or change, remove regulating piston and wash the parts in fuel oil or kerosene, reassemble and try again; if pressure shows no change check oil pressure gauge, oil lines or bearings.

Water Circulation. Water is circulated by means of a centrifugal pump shown in Illustration No. 26, and the complete pump assembly is readily removed from the engine after taking out the attaching screws; the pump then being pulled directly toward the rear of the engine as shown in Illustration No. 26. The internal parts of the pump which is of the packless seal type are shown in Illustration No. 27.

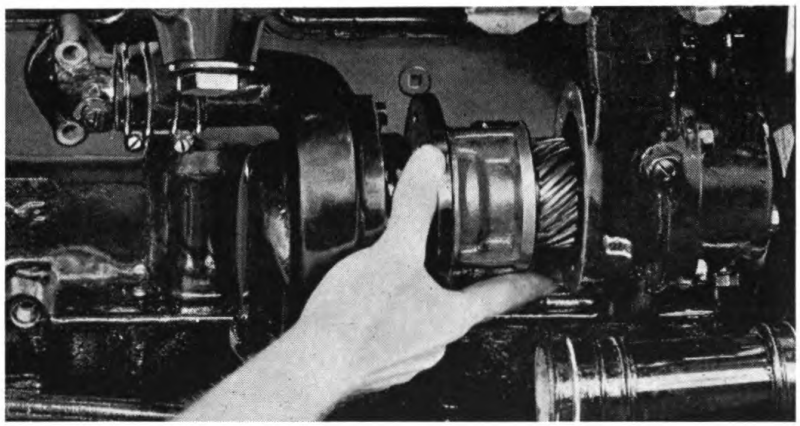


Illustration No. 26

There is a packless seal in the hub of the impeller. The seal has been removed and disassembled. Carbon Seal Washer "FS" is held against the face of the housing by means of spring "FO". Between the spring and the carbon washer are placed the special rubber seal "FQ" and the stampings "FP" and "FR". The stamping "FR" prevents the spring from cutting into the rubber and gives more equal pressure on all parts of the carbon washer. The small stamping "FP" surrounds the smaller diameter of the rubber seal and helps to compress this end of the seal, so that water will not leak out between the seal and the shaft. If water pump bushings are in good condition these seals should run indefinitely, but if the bearings become damaged the seals may begin to leak and replacement of seal parts will not definitely correct the condition until the bearings and possibly the shaft are replaced. The thrust surfaces against which the carbon washer bears must naturally be clean and smooth in order to prevent water leaking between these two surfaces. Snap Ring "FT" keeps the seal parts in their respective positions.

Water Pump Lubrication. The bushing in the pump at the timing gear end is lubricated by means of a suitable oil passage which communicates with

the gear compartment of the engine. External lubrication is not necessary and no provision is made for it.

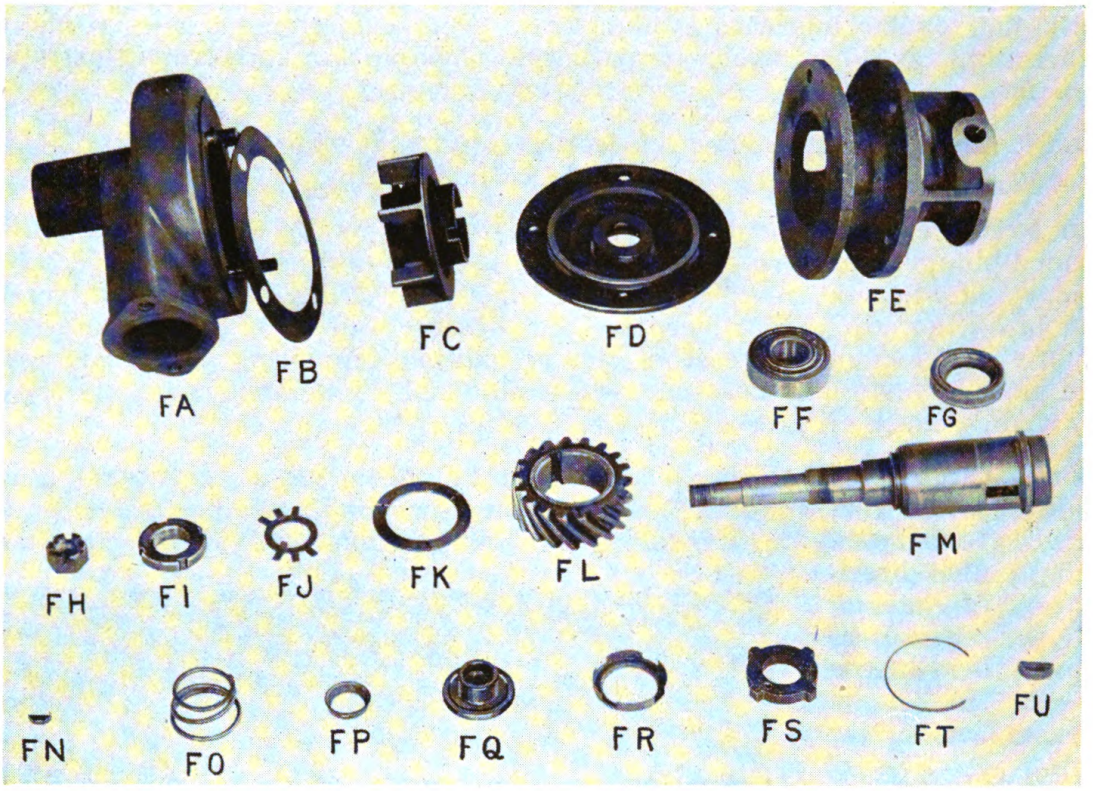


Illustration No. 27

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. 28. The fuel pump drive sleeve with shaft is shown in Illustration No. 29. This sleeve is attached to the cylinder block and can be removed toward the rear of the engine after the fuel pump 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

There are two different types of chain adjustments on the "DOO" engines, each will be discussed separately. The first type is shown in Illustrations No. 28, 30 and 31 and is an eccentric controlled by a plate having ten holes held to the gear cover by two screws, the gear cover has eight holes. A tongue and groove is used to couple the two major parts.

The second type shown in Illustrations No. 32, 33 and 34 has the eccentric controlled by a screw working in threads cut on the eccentric control split bushing which is keyed to the eccentric.

Fuel Pump Chain Adjustment—First Type. The chain is adjusted by means of an idler sprocket, which is mounted on an eccentric, which eccentric is supported by a stud No. 3, Illustration No. 28, which is fastened in the case by means of a flange and three capscrews. The eccentric is held in position

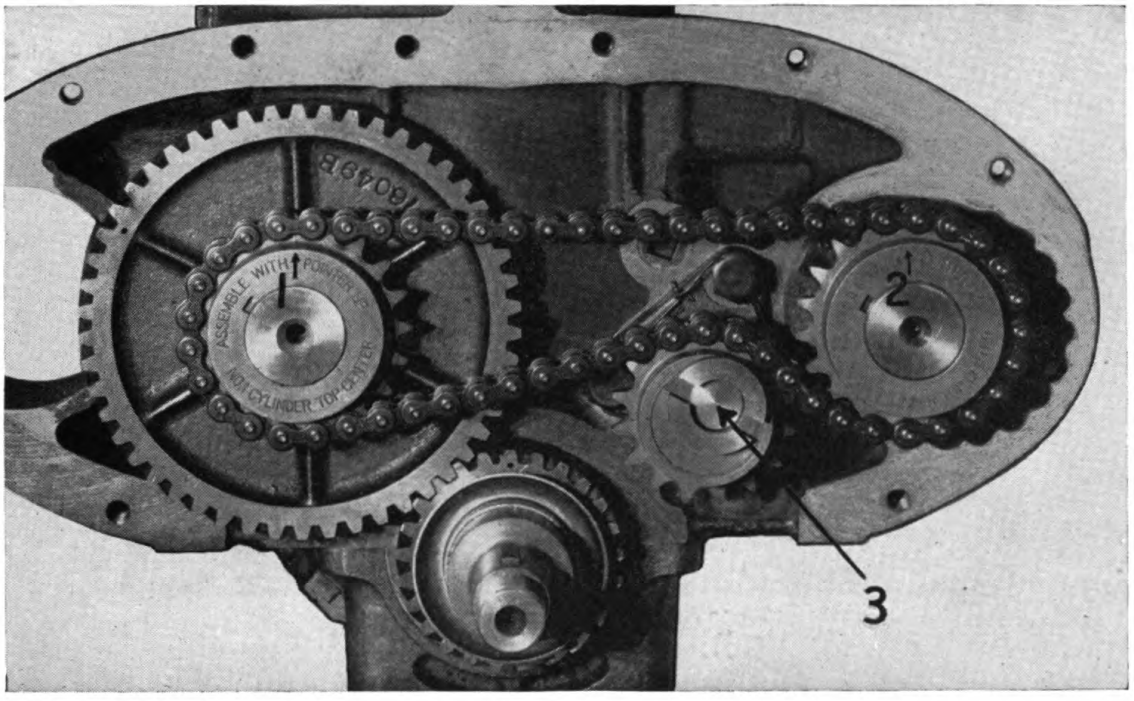


Illustration No. 28

by means of a plate bolted to the front of the gear cover, which plate is shown as No. 4 in Illustration No. 30. This plate engages with the slot in the eccentric, and the position of the eccentric can be changed by removing the screws holding plate No. 4 to the gear cover. Keep this plate pushed back toward the gear cover and rotate it in a clockwise direction until the chain is sufficiently tightened. This can be checked through the hole in the gear cover uncovered when Plug No. 8, Illustration No. 30, is removed. By feeling through this hole the chain can be felt, and the chain should be loose enough to permit it to move up and down approximately 3/8". Do not tighten the eccentric so tight that chain is perfectly taut. With chain properly adjusted move the washer between Plate No. 4 and the gear cover, so that screws can be inserted through the plate and the washer or gasket and tighten screws to cover. When the cast ear or projection No. 7 on plate No. 4 has been rotated so that it comes near to, or strikes pin No. 6 in the gear cover the adjustment of the eccentric has been all taken up, and any additional tightening will have to be

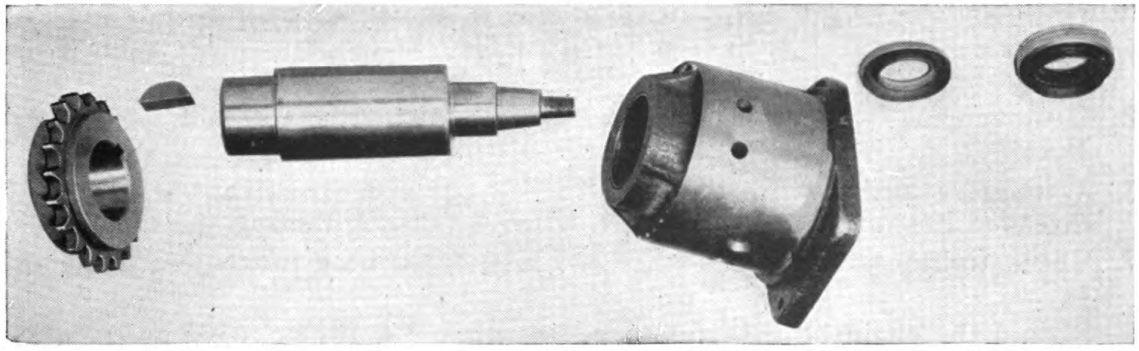


Illustration No. 29

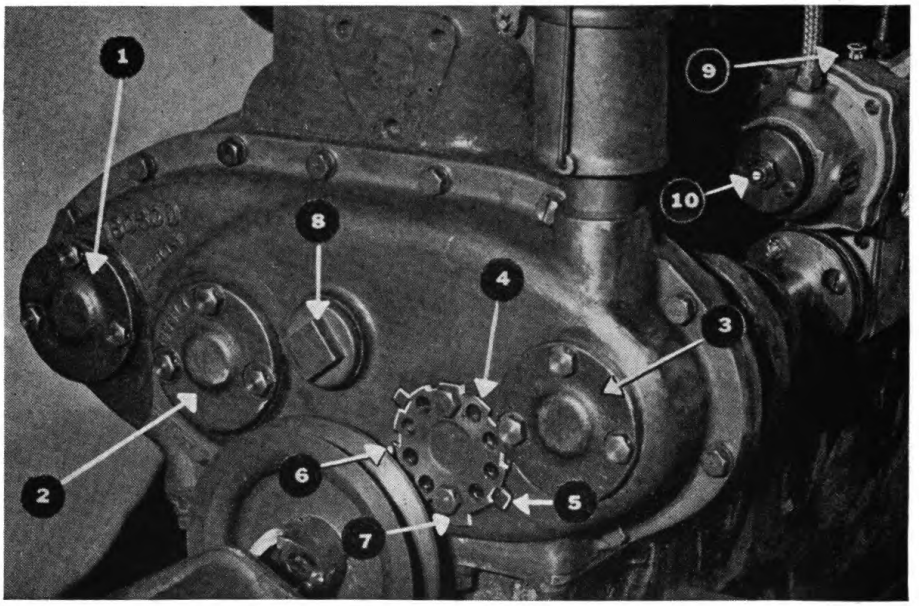


Illustration No. 30

made by means of installation of a new chain. If the adjustment plate has been removed for any reason be sure to reassemble with the projection toward the lower part of the engine. If it is impossible to remove plug No. 8 in order to get chain adjustment, the chain should be adjusted until the backlash of the fuel pump coupling flange is approximately 1/32" on the O. D. of the coupling flange.

Direction of arrow on gear cover shows rotation to tighten.

Fuel Pump Chain Adjustment — Second Type

This adjustment is supported on the crankcase in the same manner as the first type, however, perusal of Illustration No. 32 will show a projection 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 screws.

Illustration No. 33 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. 34 shows the parts assembled on the engine and the method of adjustment is as follows:

1. Remove Plug No. 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 No. 3.
3. With screwdriver turn screw No. 4 clockwise, this causes eccentric threaded bushing No. 5 to turn clockwise thus tightening the chain.
4. Check tightness of chain at No. 2. This should be a movement of about 3/8".
5. Should the chain be too taut turn screwdriver anti-clockwise until nut 3 rests against support (No. 2, Illustration 33) then turn driver until chain is loose. Reverse action and again tighten as outlined above.

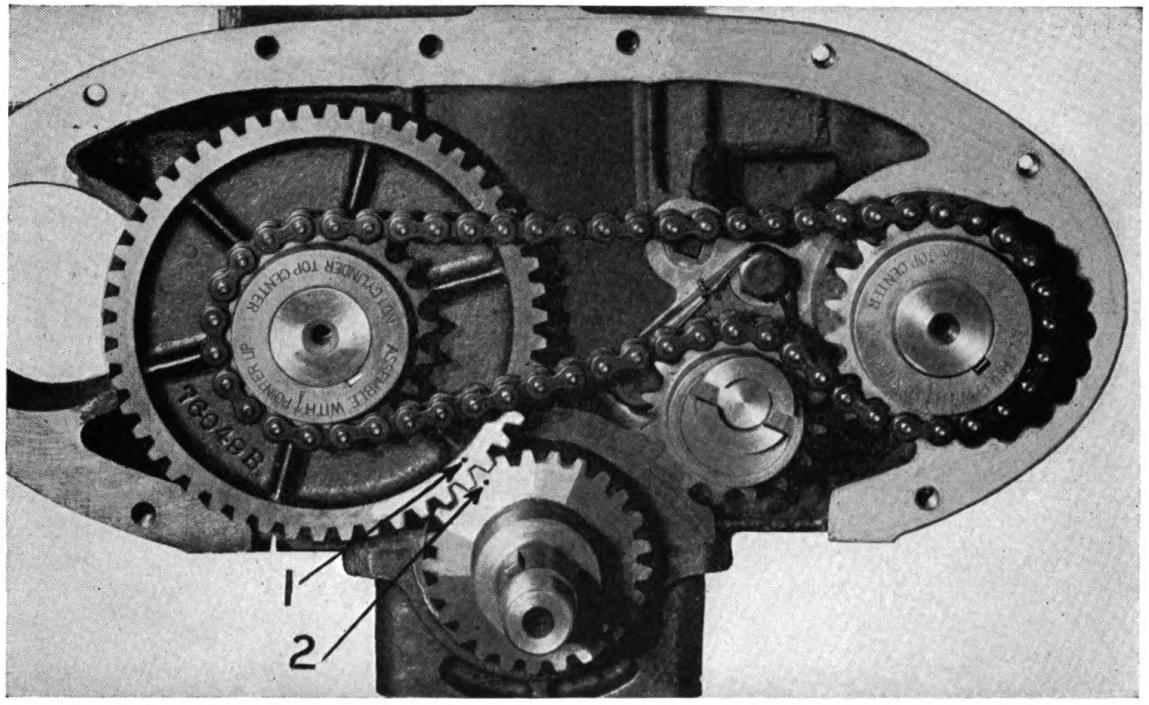


Illustration No. 31

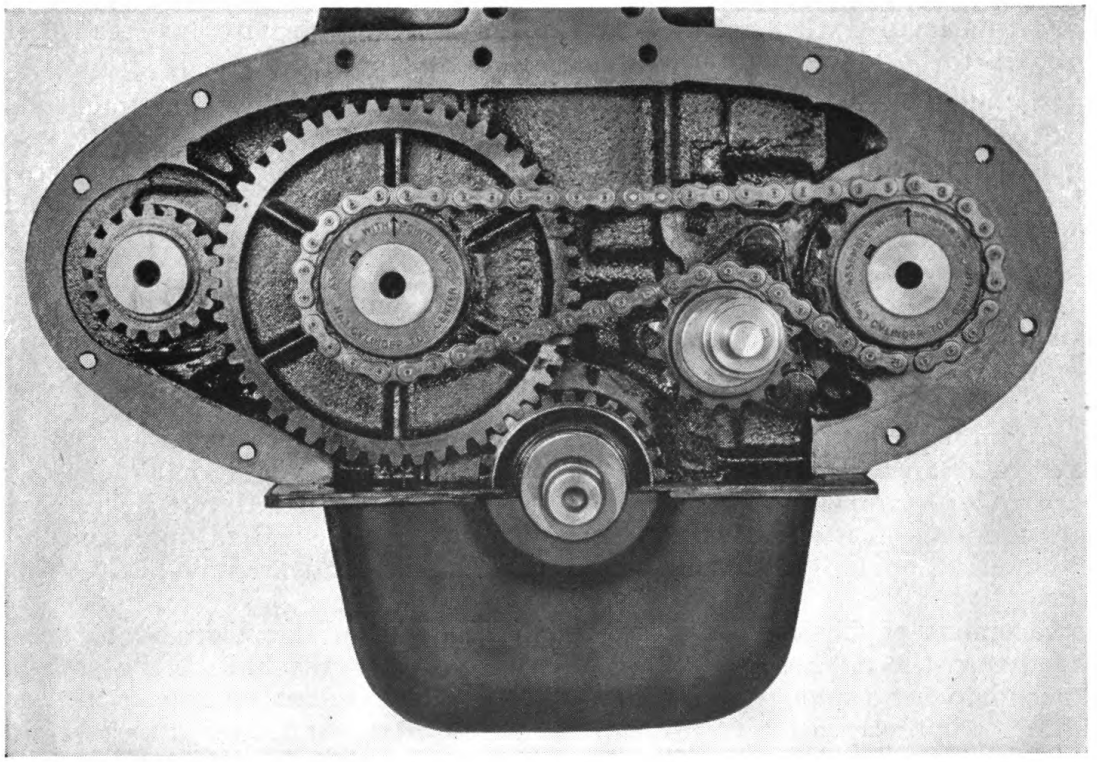


Illustration No. 32

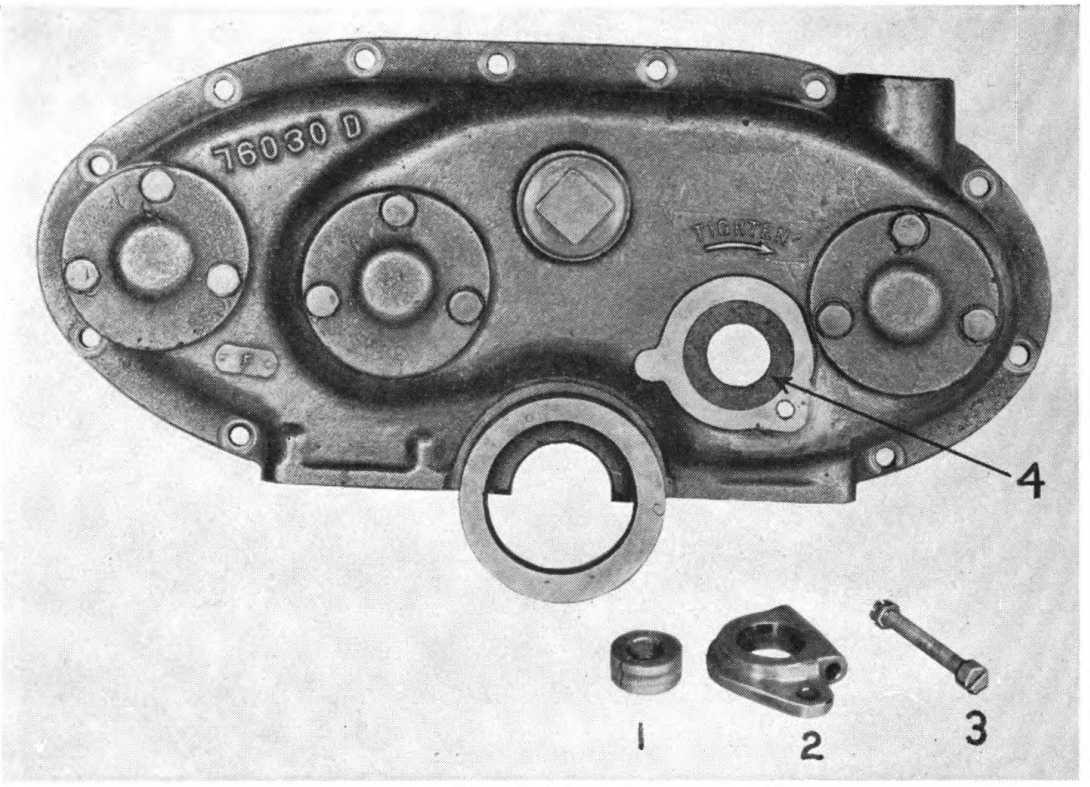


Illustration No. 33

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 No. 6 which holds adjustment support to gear cover except to replace seal No. 4, Illustration No. 33. By keeping these parts assembled to gear cover it facilitates re-installing gear cover after it has been removed. Remember to always try working the adjustment before finally tightening the gear cover attaching screws.

Should it be impossible to remove plug No. 1, Illustration No. 34, then check chain adjustment by rotating fuel pump drive coupling back and forth. This movement or backlash should be about 1/32" 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. 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. 28. When the chain is to be replaced turn the engine so that the pointer No. 1 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 No. 2. The chain should then be placed on the sprocket so as to permit these arrows to remain in a vertical position.

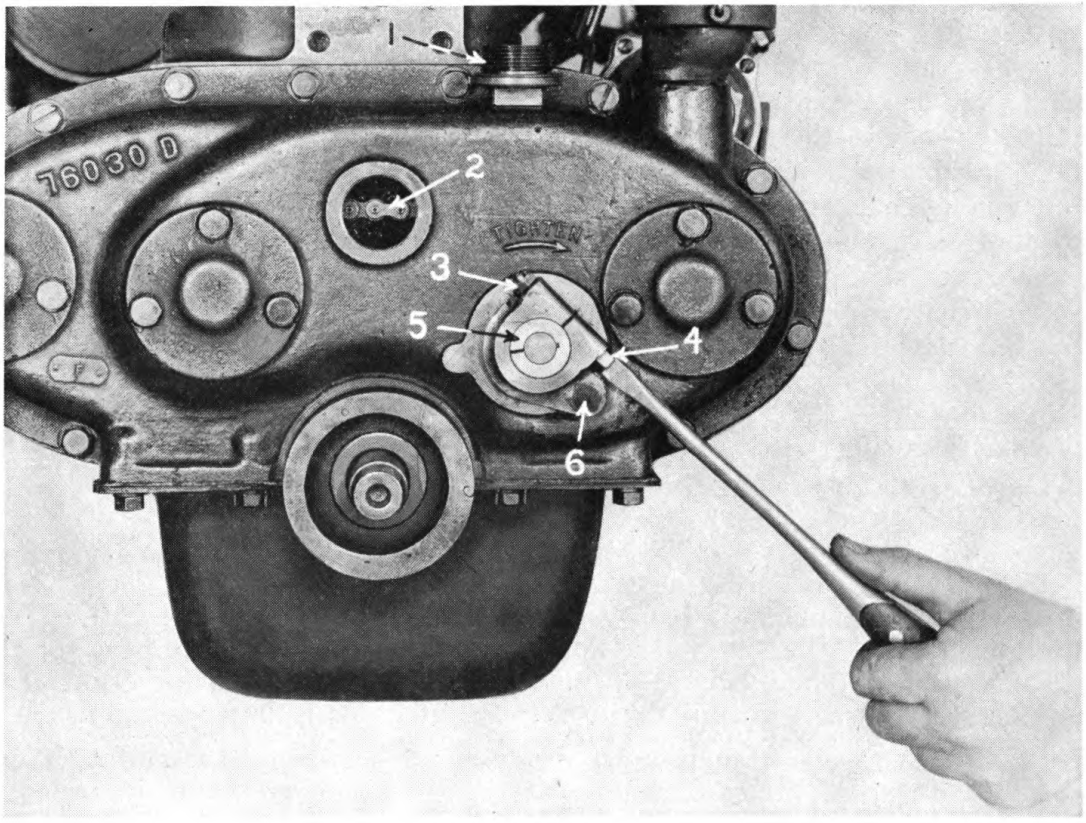


Illustration No. 34

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 as shown in Illustration No. 31, the cam gear being shown as No. 1 and the crank gear as No. 2.

Accessory Shaft Endplay Adjustment. The end movement of various accessory shafts are adjusted endwise by means of shims placed between the gear cover and the thrust plates on castings shown as No. 1, 2 and 3 in Illustration No. 30. The removal of shims will permit the plates to be re-assembled so as to take up any endplay. Care must be exercised to prevent taking out too many shims, as this would throw a heavy thrust load on various thrust bearings.

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, for .002″ to .004″ clearance should be permitted for expansion of the various parts when they become hot.

See clearance table on page 70 for recommendations.

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.

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 half rings of felt and cork, each one being used in the gear cover and oil pan. Leakage is always corrected by installing new seals.

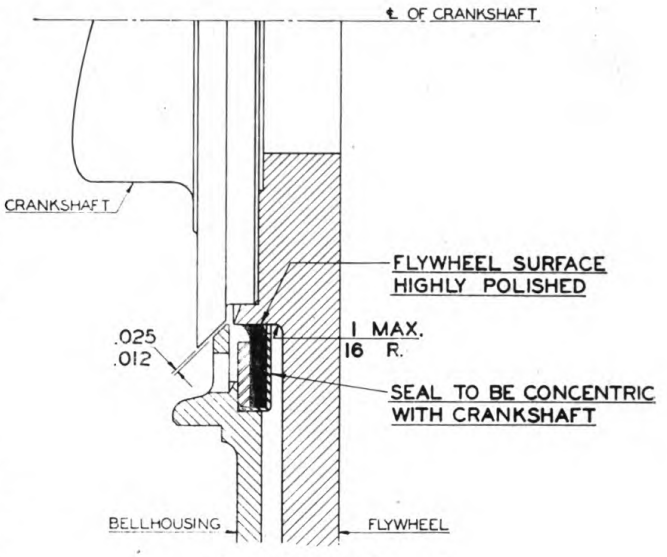


Illustration No. 35

Bellhousing or Flywheel Housing

This housing covers the flywheel and to it the clutch or transmission housing is fastened. In many cases it serves as the rear motor support. Its installation is not difficult but care must be exercised to keep the bore for the seal as well as the clutch housing pilot bore concentric with the crankshaft, therefore, to correctly install the use of an indicator is imperative.

It is also necessary to maintain a clearance of between .012" and .025" between the flywheel housing chamfer and the crankshaft bevel in order to allow the crankshaft flange to throw off a large quantity of the oil present at this point. A leak generally occurs when this clearance is incorrect.

Flywheel Housing Seal

Illustration No. 35 shows a section through the flywheel, flywheel housing, crankshaft and seal. This seal is of a 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.

Oil Pan or Crankcase Cover

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. 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 re-installing use new seals and gaskets for a leak-proof job. Be sure the crankshaft has equal clearance around it at the oil pan, otherwise the shaft will rub and cause a leak.

The capacity of the standard type oil pan is 10 quarts U. S. measure. However, when refilling after draining put in 12 quarts to replace the 2 quarts required to fill the filter. The best method to follow, since there are many special oil pans used, is the use of the bayonet gauge or dip stick. Fill crank case 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 has been measured, the next time the same amount may be used. Always recheck with bayonet gauge.

Gear Cover

The same instructions as given under the oil pan and its seals apply to this part.

Accessories

The manufacturers of these are always prepared to furnish additional information on their equipment to supplement the few remarks which we have been able to place in this book. Write to them direct or to the Hercules Motors Corporation and any available booklets on these parts will be sent you.

INSPECTION OR ADJUSTMENTS

To Be Made Daily:

1. Go over the entire engine daily to be 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 both engine and injection pump bases and keep filled to the full mark on the bayonet 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 get 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.

"TROUBLE SHOOTING"

ENGINE WON'T START OR HARD STARTING

(a) No fuel in tank—fill tank.

(b) No fuel in fuel pump—See starting, page 7.

(c) Not properly prepared for starting at the atmospheric temperature being encountered. See starting, pages 7, 8, 9 and 10.

(d) Weak batteries will not turn engine over rapidly enough—Recharge batteries.

(e) Fuel too heavy to flow through pipes properly—Lighter fuel. See Fuel Oil specifications, page 19.

(f) Water in fuel—Drain fuel system and tanks. Change fuel supply.

(g) Rings or cylinder walls worn badly. Replace with new.

(h) Exhaust or Intake valve seats pitted or worn—Regrind valves.

(i) Leaking head gasket—Replace gasket.

(j) Air cleaner plugged not allowing sufficient air to pass through—Clean Air Cleaner.

(k) 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 7, 8 and 9.
2. Fuel pumps or lines air or gas bound—
   See starting page 8.
3. Fuel Filter plugged—
   Clean filter then prime lines.
4. Obstruction in or broken fuel line—
   Check, starting with fuel tank to strainer.
5. Water in fuel—
   Drain entire system including tank and clean. Fill with clean fuel and then proceed as under starting pages 7, 8 and 9.
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.
8. Bearing seizure due to lack of lubrication—
   If not too badly wiped, scrape enough to clean up and reinstall. If badly wiped, replace with new.
9. Broken fuel pump driving chain—
   Replace with new chain and re-time engine. See "Timing Engine" page 23.
10. Fuel pump adjustable coupling slipped due to not being properly tightened. Retime pump—see pages 23, 24, 25, and 26.

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 cylinder missing. If the engine speed slows down and the exhaust looses 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 Intake Valve Stuck—
   Remove valve cover and check which one stuck. Free with kerosene, gasoline or alcohol poured down stem. Alcohol is the quickest solvent. If still sticks 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. Do not use abrasive or sharp tools on this part. 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 gases makes it appear as dark or black smoke. The more carbon particles, the darker color the exhaust ranging from a very light grey 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 Gases

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.
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 a Bosch Diesel Service Station or Timken Factory Branch.

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 Bosch Diesel Service Station or Timken Factory Branch.

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 oil such as kerosene or clean fuel oil or gasoline. Grind valve if 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.

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 cleanse the parts and also fuel strainers. If parts are corroded change fuel to an acid free brand and install nozzle and barrel 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 among 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.

SPRAY NOZZLE TROUBLES AND REMEDIES

TROUBLE	PROBABLE CAUSE	REMEDY
1. Fuel oil leaking around nozzle holder.	1-a Joint between nozzle and holder not tight.	1-a Remove nozzle from holder, clean the ends forming the joint with a cloth and replace. Tighten the nozzle cap nut up hard. Do not use abrasives, grinding compound or hard sharp tools of any kind or these polished surfaces.
	1-b Nozzle hole plugged up or dirty.	1-b Dismantle and clean nozzle.
2. Fuel oil leaking excessively through spray nozzle holder by-pass.	2-a Joint between nozzle and holder not tight.	2-a Dismantle and clean. Reassemble and tighten nozzle to holder firmly.
	2-b Nozzle plugged up or dirty.	2-b Dismantle and clean nozzle.
	2-c Nozzle valve stuck shut.	2-c Dismantle and clean.
	2-d Nozzle valve too loose in nozzle body.	2-d Replace with new nozzle and valve from spares. The body and valve of nozzles are made in pairs and are not interchangeable.
3. Nozzle valve sticking shut or open.	3-a Dirt in nozzle.	3-a Dismantle and clean.
	3-b Improper lubrication of nozzle valve stem.	3-b Smear with good engine lubricating oil or vaseline before assembling.
	3-c Insufficient lubricating qualities in fuel oil.	3-c Put one quart of lubricating oil in each 5 gallons of fuel oil. This lubricating oil may be of a cheap grade but must be absolutely clean and free from water, grit, dirt, or other foreign matter.
	3-d Nozzle body and valve corroded from water or acid in fuel oil.	3-d Replace both parts from spares.

Clearance "DOO" Series

Bearing Clearances	Minimum	Maximum
Camshaft Bearing Clearance	.0015	.0025
Connecting Rod Bearing Clearance	.003	.004
Crankshaft Main Bearing Clearance	.003	.004
Fuel Pump Drive Shaft	.0015	.0025
Oil Pump Shaft Bearing Clearance	.0015	.002
Rocker Arm Bushing Clearance	.001	.0015
Piston Pin Clearance in Rod Bushing	.001	.0015
Water Pump Drive Shaft Clearance	.0015	.0025
End Thrust		
Camshaft End Thrust	.005	.008
Connecting Rod Side Clearance	.007	.014
Crankshaft Thrust Clearance	.002	.004
Fuel Pump Drive Shaft End Thrust	.005	.008
Oil Pump Shaft End Thrust	.002	.004
Water Pump Shaft End Thrust	.005	.008
Back Lash		
Crankshaft Gear Back Lash to Camshaft Gear	.0005	.0015
Oil Pump Gear Back Lash	.006	.008
Timing Chain—3/8" total movement through inspection hole or 1/32" movement on O. D. of coupling.		
Water Pump Gear Back Lash to Camshaft Gear	.002	.004
Piston		
Piston Clearance in Cylinder Bore—DOOB	.0055	.006
Piston Clearance in Cylinder Bore—DOOC	.0055	.006
Piston Clearance in Cylinder Bore—DOOD	.006	.0065
Piston Clearance to Cylinder Head	.070	.095
Piston Pin Clearance in Piston—Push Fit with Piston Hot		
Piston Ring Gap	.018	.022
Piston Ring Land Clearance—Top Ring	.003	.0045
Piston Ring Land Clearance—All except Top Ring	.0015	.003
Valves		
Valve Guide Clearance Around Stems	.002	.003
Valve Head Below Cylinder Head	.005	.007
Valve Seat Diameter—Intake 1 61/64"		
Valve Seat Diameter—Exhaust 1 29/64"		
Valve Seat Angle 45°		
Valve Seat Face Width—Exhaust and Intake 5/32"		
Valve Tappet Clearance in Guide	.001	.0015
Valve Stem Clearance to Rocker—Exhaust (Hot)*	.010	.010
Valve Stem Clearance to Rocker—Intake (Hot)*	.010	.010
*Certain applications special settings.		
Miscellaneous		
Bellhousing Clearance on Chamfer	.012	.025
Gear Cover Clearance Around Crankshaft	.006	.015
Oil Pan Clearance Around Crankshaft	.006	.015
Valve Timing—Inlet Opens 12° before Top D. C.		
Valve Timing—Exhaust Closes 12° after Top D. C.		

(Above Tolerances Given in Inches)

WRENCH TENSION

(For Tightening Nuts)

	Foot Pounds	Inch Pounds
Cylinder Head Stud Nut	157½	1890
Connecting Rod Screw	140	1680
Main Bearing—Center & Rear	77	924
Main Bearing—Front & Intermediate	94½	1134

All other screws, nuts, etc., are to be drawn up snug and tight but not to the point of stripping the threads.

HERCULES MOTORS CORPORATION

Canton, Ohio

STANDARD WARRANTIES, FIELD SERVICE, RETURNS AND EXPENSES ISSUED BY THE INTERNAL COMBUSTION ENGINE INSTITUTE, OCTOBER 20, 1933

HERCULES MOTORS CORPORATION is a MEMBER of THE INTERNAL COMBUSTION ENGINE INSTITUTE and all engines, power units, parts and accessories are sold by us subject to the terms of the "STANDARD WARRANTIES, FIELD SERVICE, RETURNS AND EXPENSES" of said Institute adopted and issued October 20, 1933 and all amendments thereof which may be in effect from time to time hereafter. The following is a copy of the terms of the "Standard Warranties, Field Service, Returns and Expenses" issued October 20, 1933, but it is subject, however, to future amendment without notice. Notwithstanding any different terms or conditions which may be contained in any customer's purchase order received by us, we will be governed by and conform to the terms and provisions of the "Standard Warranties, Field Service, Returns and Expenses" of The Internal Combustion Engine Institute.

1. STANDARD SERVICE WARRANTIES

The term "member of this industry" as used herein means a member of the Internal Combustion Engine Institute.

The term "Buyer" as used herein means a customer of a member of this Institute.

a) The members of this industry shall guarantee their engines and parts thereof against defective material or workmanship as prescribed in paragraph 1-(b).

b)

Type of Application	Warranty Period
Bus and Truck Equipment	**Six** months from date of shipment but not to exceed ninety days or 15,000 miles of service.
Rail Cars and Locomotives	Six months from date of shipment but not to exceed ninety days or 15,000 miles of service.
Agricultural Equipment	Six months from date of shipment but not to exceed ninety days of service.
Industrial and Oil Field Equipment	Six months from date of shipment but not to exceed ninety days of service.
Marine Equipment	One year from date of shipment.
Fire Equipment	One year from date of shipment.

c) Parts returned to any member of this industry, transportation charges prepaid, which are found by the member to be defective in material or workmanship, shall at the member's option be repaired, replaced or credited. No claims will be allowed which, in the opinion of the member, result from engines or parts having been subjected to abuse or neglect or where failure has been caused by accident

W[illegible] ccessories furnished by each member shall be limited to the [illegible]ccessory manufacturer.

[illegible] void unless the Buyer or his agents provide proper care and [illegible]s and parts from date of shipment to date placed in service.

f) Each member reserves the right to improve his product through changes in design or materials without being obligated to incorporate such changes in engines of prior manufacture.

g) No responsibility for contingent liability through the failure of any engine or engine part will be assumed by a member of this industry.

2. FIELD SERVICE

a) The responsibility of maintaining or arranging for adequate and proper field service facilities shall be with the Buyer, and he shall not request the assistance of any member of this industry except in cases of a complex character

b) All requests for service in the field shall emanate from the Buyer of the engines. Requests received from a Buyer's dealer or the ultimate user shall, under normal conditions, be referred to the Buyer.

c) If a member renders field service at the request of the Buyer and the fault is found not to be with the engine, the Buyer shall pay the time and expense of the member's field representative

d) No member shall accept bills for service, labor or other expense that has not previously been approved and authorized.

e) Before consideration can be given to requests for adjustments covering field service and alleged defective material, the Buyer shall furnish the member with the following data:

Owner's name and address.

Engine model.

Serial number.

Information as to the nature of the trouble.

Date actually placed in service

Accumulated days or miles of service.

3. THE RETURN OF NEW MATERIAL

a) Any member of this industry may at his option accept the return of any part or parts provided such return has been authorized, and at prices agreed upon, transportation charges prepaid. Such authorized returns shall be subject to the member's inspection and to a handling charge to ten percent (10%) of the cost of the part or parts returned.

4. LABOR AND OTHER EXPENSES

a) No member of this industry shall assume any expense except direct labor in replacing parts or servicing engines within the warranty period, and in no case shall such expense be assumed unless authorized by the member.

The obligation hereinabove provided to repair, replace or credit at the option of Hercules Motors Corporation any engines, power units or parts that are found by it to be defective in material or workmanship is in lieu of any and all other warranties expressed or implied by law and all other obligations or liabilities on the part of Hercules Motors Corporation to the Buyer or to any other party.

HERCULES MOTORS CORPORATION
Canton, Ohio, U. S. A.

General Index

GENERAL INDEX (Continued)

GROUP INDEX