OPERATION AND MAINTENANCE MANUAL

FOR

JX SERIES ENGINES

SERIAL NUMBERS { 500001 - 600000
900001 - 1000000
1300001 - 2000000

FIVE GEAR MODELS

MODEL	BORE		STROKE	NACC-H.P.	PISTON DISPL.
JXA	3 3/8"	x	4 1/4"	27.33	228
JXF	3 13/32"	x	4 1/4"	27.84	232
JXLA2ER	3 7/16"	x	4 1/2"	28.36	250
JXG	3 1/2"	x	4 1/4"	29.4	245
JXB	3 5/8"	x	4 1/4"	31.54	263
JXC	3 3/4"	x	4 1/4"	33.75	282
JXLC	3 3/4"	x	4 1/2"	33.75	298
JXD	4"	x	4 1/4"	38.4	320
JXLD	4"	x	4 1/2"	38.4	339
JXLDER	4"	x	4 1/2"	38.4	339

THREE GEAR MODELS

JXE-3	3 1/2"	x	4 1/4"	29.4	245
JXC-3	3 3/4"	x	4 1/4"	33.75	282
JXD-3	4"	x	4 1/4"	38.4	320

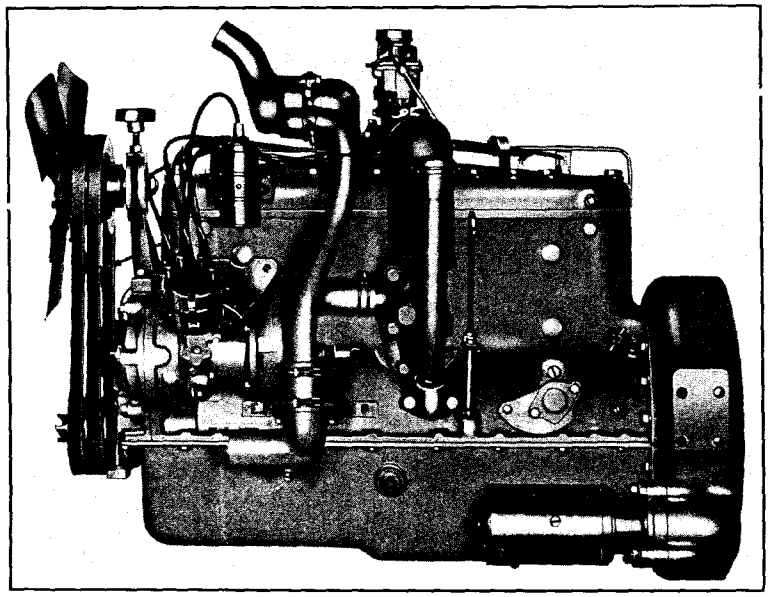
CB preceding model (CB-JXD) denotes counter-balanced crankshaft.

M or MM following model (JXDM or JXBMM) denotes Marine Engine.

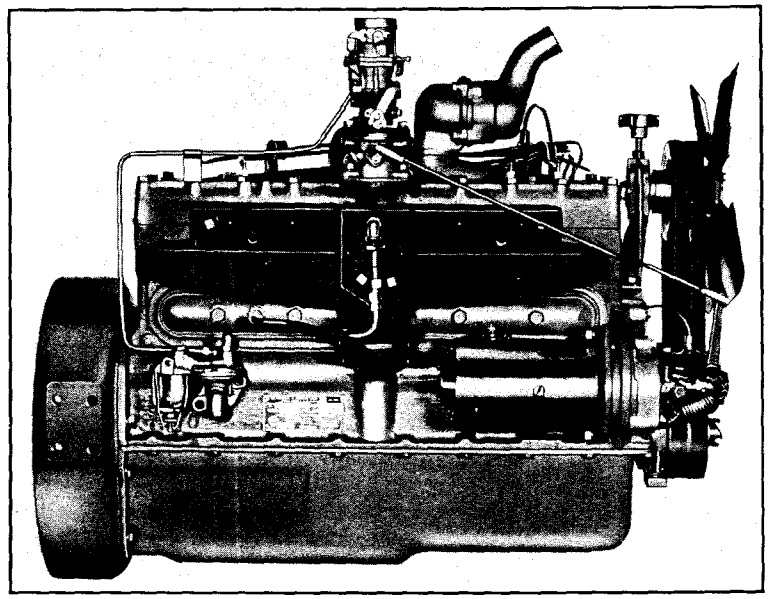
C following model (JXCC-JXDC-JXDCM) denotes counter-clockwise engine.

HERCULES MOTORS CORPORATION

CANTON, OHIO, U. S. A.



Oil Filter and Water Pump Side
(Left-Hand Side)



Camshaft, Manifold and Fuel Pump Side
(Right-Hand Side)

HERCULES MOTORS CORPORATION

CANTON, OHIO

Hercules Motors Corporation is a Member of the Internal Combustion Engine Institute and is pleased to warrant all Hercules products sold by it in accordance with the following Basic Warranty adopted by the Institute May 8, 1947, which is subject to future amendment without notice. This warranty is in lieu of any warranty expressed or implied by law and supersedes any different warranty in customer's purchase orders.

BASIC WARRANTY

The Manufacturer warrants each new engine sold by the Manufacturer to be free from defects in material and workmanship for six (6) months from date of shipment, but not to exceed ninety (90) days of service, or such other period of time as may be agreed upon in respect to the application in which the engine is used. The obligation under this Warranty, statutory or otherwise, is limited to the replacement or repair at the Manufacturer's factory or at a point designated by the Manufacturer, of such part as shall appear to the Manufacturer, upon inspection at such point, to have been defective in material or workmanship.

This Warranty does not obligate the Manufacturer to bear the cost of labor or transportation charges in connection with the replacement or repair of defective parts, nor shall it apply to an engine upon which repairs or alterations have been made unless authorized by the Manufacturer.

The Manufacturer makes no Warranty in respect to trade accessories, such being subject to the Warranties of their respective Manufacturers.

The Manufacturer shall in no event be liable for consequential damages or contingent liabilities arising out of the failure of any engine or parts to operate properly.

No express, implied or statutory Warranty other than herein set forth is made or authorized by the Manufacturer.

New service parts are sold subject to the same warranty as new engines.

Introduction

THE Hercules JX series engine is a six cylinder in line "L" head engine, four cycle, heavy duty, commercial type engine. The design is the result of years of development and field experience. Extensive tests have proven that these engines are adaptable to all purposes for which such sizes and types are required.

An effort has been made in this book to give sufficient information so that operators and maintenance crews can obtain the maximum efficiency and trouble-free operation which may be expected of this engine.

All locations given as right-hand (R.H.) or left-hand (L.H.) have reference to the observer's position when facing the flywheel or clutch. The right-hand side is the camshaft or manifold side, while the left-hand side is the water pump or accessory side. The front of the engine is the timing gear end. The flywheel and clutch end is the rear end of the engine. When the JX engine is used as a marine engine, the power take-off or reverse gear is usually attached to the timing gear or front end. Therefore, when reference is made to number one cylinder or front main bearing, it is always the one nearest the timing gears. Cylinders, connecting rods, et cetera, are numbered from the front or timing gear end of the engine. All dimensions are given in inches and fractions of inches, except as otherwise noted. All weights and measures are in United States avoirdupois or liquid measure standards.

The book is divided into the following sections, which appear in the order named—Specifications, Operation, Lubrication, Description and Maintenance, Trouble Shooting, Clearances and Tools.

Where necessary to refer to accessories which are not furnished by the Hercules Motors Corporation, information and comments given are general and may not apply to the specific accessory used.

As an operator, you owe it to yourself to read this book carefully.

SPECIFICATIONS

JX AND JXL SERIES ENGINE

GENERAL DATA

Bore and Stroke	See Page 1
No. of Cylinders	6
N. A. C. C. Rated Horsepower	See Page 1
Piston Displacement	See Page 1

Rotation—Clockwise Standard, Looking at Cranking End.
Firing Order—1 - 5 - 3 - 6 - 2 - 4.
Counter-Clockwise Rotation—Optional—Looking at Cranking End.
Firing Order—1 - 4 - 2 - 6 - 3 - 5.

MAIN BEARINGS (PRECISION TYPE)

No. of Bearings	7
Bearing Diameter	2½"
Bearing Length (Front 1)	1 5/16"
Bearing Length (Center 4)	2⅛"
Bearing Length (Rear 7)	2⅛"
Bearing Length (Int. 2-3-5-6)	1 5/16"

CAMSHAFT

Drive	Helical Gear
No. of Bearings	4
Diameter of All Bearings	2 1/16"
Length (Front and Rear)	1⅛"
Length (2-3)	13/16"

Location—Right-Hand Side Looking at Flywheel.

CONNECTING ROD

Material—Heat treated nickel chrome molybdenum steel.

Connecting Rod Bearing Diameter	2"
Connecting Rod Bearing Length	1½"
Connecting Rod Length, c to c	8"

MISCELLANEOUS

Cylinder and Crankcase	Cast Integral

Cylinder Head—"L" type, detachable.
Crankshaft—Surface hardened by electric induction process.
Piston—Aluminum alloy or cast iron.
Piston Pin—1" Dia. steel.

Specifications of other items will be found in **"Description and Maintenance."**

GENERAL DESCRIPTION AND FEATURES OF DESIGN

CYLINDER BLOCK AND CRANKCASE

The cylinder block and crankcase are cast in one piece, in order to permit more efficient cooling, by water jacketing the cylinders the full length of the bore. This construction also results in a very rigid unit, which provides a sturdy support for the crankshaft.

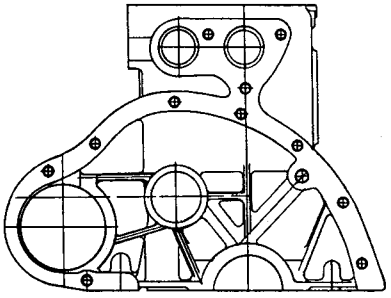


Fig. 1

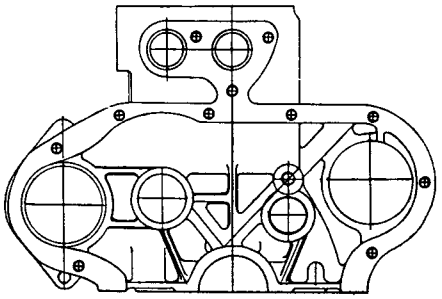


Fig. 2

Illustration No. 1

To help distinguish the "JX-3" cylinder block from the "JX-5" cylinder block, refer to Illustration No. 1. Fig. 1 shows the front of the "JX-3" block without the idler gear shaft provision while Fig. 2 shows the "JX-5" cylinder block and crankcase with provision for driving the water pump on the left-hand side of the engine, necessitating an idler gear to drive the water pump drive gear. Otherwise, the two "JX" cylinder blocks are similar.

MAIN BEARINGS

The use of seven main bearings permits a main bearing being placed on each side of each connecting rod bearing (see Illustration No. 2) and this construction helps to eliminate vibration at high speeds. The center and rear main bearing caps are each held in position by four alloy steel cap screws $\frac{7}{16}$" in diameter while the remaining ones are held by two alloy steel cap screws $\frac{1}{2}$" in diameter.

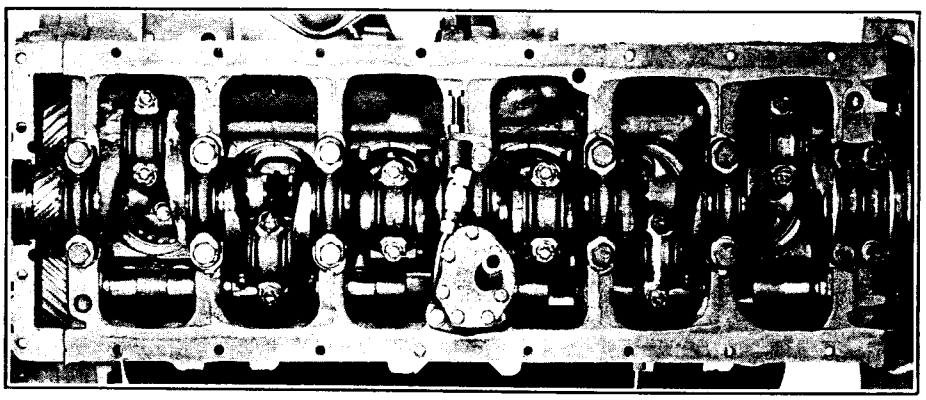


Illustration No. 2

Precision or insert type bearings are now used. In this construction there is a removable shell in each cap, as well as for the upper part, and the upper shell is interchangeable with the lower shell for each bearing. These shells are of the precision type and are completely finished before being put in place; no line reaming or scraping is required. This allows renewal of the bearings to be easily accomplished. The precision type shells each have a small ear or projection which fits into a recess. This allows the ear to rest against the adjoining case or cap to prevent the shell from rocking or rotating. These shells are approximately $\frac{1}{16}$" thick and are not interchangeable with the upper shells used with the babbitted type caps. The bearing metals commonly used in the precision shell type bearings are harder and have a higher melting point than ordinary babbitt metal; this requires the use of a hardened crankshaft.

CYLINDER HEAD

The cylinder head is of the removable type, having the major part of the combustion space over the valves, and is completely water jacketed. This construction permits easy removal of the cylinder head for cleaning carbon and grinding valves.

CONNECTING RODS AND PISTONS

Like the main bearings, the connecting rods have the precision or insert type of bearing construction. In this type, the cap and rod are split slightly below center so the split in the shells opposite the locking lugs does not match with the split in the forging. In some engines of this type, the adjusting shims are placed on one side only, no shims being used on the side having provision for locking the shells; other engines do not have shims on either side.

The piston pin, in some engines, is clamped in the top end of the rod. The piston pin lock screw is prevented from working loose in early engines by a lock wire and in later engines by a shakeproof lock washer. Some engines have full floating pins, which are held in the piston by snap rings which seat in grooves cut in the piston.

When cast iron pistons are used, they have bronze bushings for the piston pin. The aluminum pistons do not have bushings in the pin bosses, as the alloy metal of the piston forms a suitable bearing for the pin. Each piston has three compression and one oil control ring.

CAMSHAFT AND IDLER SHAFT

The camshaft is supported on four bearings in the crankcase. These bearings are of the removable, babbitt lined type. At the center of the shaft is located the spiral gear, which meshes with the gear attached to the oil pump shaft and drives the oil pump. There is a thrust washer placed between the cam gear and the crankcase. In the "JX-3" series there is no idler gear but in the "JX-5" the idler gear is supported by a shaft which is pressed into the gear. This shaft is supported by, and turns in, a babbitt lined bushing pressed into the crankcase. The idler gear is also supplied with a thrust washer between it and the case.

VALVES

The intake valve head is larger in diameter than the exhaust valve head in order to increase the efficiency and insure more power. Both intake and exhaust valves are forged from special alloy steel and the exhaust valves, in particular, are of high heat-resisting material. Valve tappets are of the mushroom type and each is provided with a suitable screw and lock nut to allow adjustment of the valve stem clearance. The valve guides, as well as the valve tappet guides, are removable bushings pressed into the cylinder block.

ACCESSORY DRIVE

On the "JX-5" engines, the accessory drive or water pump is located on the side opposite that on which the camshaft and valves are located and consists of a sleeve casting bolted to the front part of the crankcase. On the "JX-3", the water pump and distributor drive are on the camshaft side.

OILING SYSTEM

The oil pump is of the gear type and is fastened to the block so that the suction end is in the oil pan and needs no priming. The oil, under pressure, is delivered through suitable connections to a drilled passage in the crankcase. This drilled passage extends from the front to the rear of the engine on the side opposite the camshaft and is closed at either end by means of suitable threaded plugs. Radial holes are drilled from the crankshaft bearing to meet this horizontal oil passage and this permits oil to be delivered, under pressure, to the main bearings and through drilled holes in the crankshaft to the connecting rod bearings. The cylinder bores, tappets and valve stems are lubricated by means of the mist of oil thrown off around the connecting rod bearings.

In the "JX-5", the idler shaft and gear are oiled by pressure to the bearing bushing and through drilled holes in the shaft and gear. All of the camshaft bearings are supplied with oil by gravity feed from the oil collected in the pockets.

OPERATION

This section covers those items which are of particular interest to the operator and does not cover such work as might be required of a maintenance crew. This does not mean that an operator should not acquaint himself with the various subjects covered in other sections of this book.

PRECAUTIONS

READ BEFORE STARTING THE ENGINE

The precautions listed below, 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 output. See **"Oil Filter."**
2. **Fuel**—keep it clean—do not use a dirty container to handle it—insist on the fuel being clean and acid-free when you get it. Procure it from a reputable company.
3. **Lubricating Oil**—keep it clean—drain the crankcase often. Use the best brands obtainable, having specifications as set forth in **"Lubrication."**
4. Do not allow the **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 of oil, the more heat it can absorb and dissipate. Do not fill above the 4/4 or full mark.
5. **Do Not Run The Engine** at any time without lubricating oil and a 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 The Engine** with the water or anti-freeze solution **boiling.** This allows the lubrication to break down and may seriously damage the engine.
8. Do not put cold water in an **Overheated Engine.** It may crack the cylinder head, block, etc. An overheated engine shows negligence in operation.
9. Do not allow the **Air Cleaners** to become clogged or to operate without all the connections being tight. Keep them clean and properly serviced. 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 The Engine** until the lubricating oil, water and fuel supply have been checked and the engine properly prepared for starting. See **"Starting and Operating Suggestions."**
12. **Do Not Run The Engine** at high speed without load, as this will cause undue wear and shorten the engine's life.
13. **Do Not Idle The 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 The Engine As A Brake** in intermediate or low gear. 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 the vehicle speed is held to that used in the same gears on the level.
15. **Never Allow** the engine to **Run Without The Oil Pressure** showing on the gauge. Damage from lack of lubrication will result.
16. Do not allow the fuel in the tank to run low, as it may allow the line to the fuel pump to uncover long enough to fill the lines with air and cause the engine to stop, resulting in lost time taken for repriming.
17. Loss of power, erratic running and poor performance often result from **Air In The Fuel System or Vapor Lock.** Be sure there are no leaks in the fuel lines and filters which will allow this condition to exist.
18. Remember dirt, grit, water, lint or any foreign matter in the fuel and lubricating oil are detrimental to the **engine** and it is your duty, as an operator, to see that they do not get into the engine.

19. Do not attempt to start the engine in cold weather until you have read **"Cold Weather Starting."**
20. Some external heat will help starting in cold weather and saves the batteries.
21. Never run the 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.
22. 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.

STOPPING THE ENGINE

1. Stopping is generally effected by turning the ignition switch to "Off."
2. If the atmospheric temperature is below freezing and no anti-freeze solution is used, the complete water circulating system should be drained. This includes the engine water jackets, water pump, radiator and all water pipes.
3. If an 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 the batteries with water when shutting down, as this makes them more liable to freezing. Fill the batteries just before starting up for the day's run.

NOTE:—If the engine is kept in warm storage or is located in a warm building where freezing is not liable, No. 2, No. 3 and No. 4 can be disregarded.

STARTING AND OPERATING SUGGESTIONS

1. Use a good brand of fuel.
2. Use only the best lubricating oil obtainable. See **"Lubrication."**
3. An SAE 30 oil is a good grade to start with (unless extreme cold weather is prevalent); from this, the proper grade can be determined. See **"Lubrication"** for complete information relative to the grade to use for the climatic conditions encountered.
4. Fill the cooling system with clean water (if in a locality where the water has a large percentage of dissolved minerals or is alkaline—use rain water). Allow sufficient time for the water to seek the lowest level, then complete filling. Run the engine and recheck the level.
5. Be sure the batteries are hooked up properly before pressing the starter button.
6. If possible, turn the engine over three or four times by hand to be sure there is nothing sticking or water has not seeped into the cylinder, as the starting motor has sufficient power to bend or break certain parts should anything be out of place.
7. Be sure all fuel line connections are tight and the fuel system properly primed.
8. Always follow the starting instructions outlined below to eliminate difficulties.

STARTING THE ENGINE

First Time The Engine Started or starting the engine after a long period of shutdown.

1. Fill the fuel tank with suitable fuel.
2. Fill the cooling system with clean, pure water, or, if the atmosphere is below freezing and the engine is to stand or operate in these temperatures, use an anti-freeze solution.
3. Fill the crankcase with suitable lubricating oil to the 4/4 or full mark on the oil gauge rod. See lubricating oil specifications and Illustration No. 4.
4. If possible, turn the engine over by means of a 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.

5. In addition to the procedure just described, check the lubrication of the generator, starter, fan, water pump and any other accessories. Check the 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).
6. Check the entire electrical system to be sure there are no loose connections and all component parts are properly connected together.
7. See that no loose bars, tools, parts, etc., are lying in, or on, any part of the engine, as they could cause serious damage or wreckage of the engine or bodily injury to anyone near.
8. Turn the ignition switch to "On." Start the engine by operating the starting motor switch. If all of the foregoing instructions have been properly followed and the proper grade and type of fuel has been used, the engine will start at once.
9. Allow the engine to run for several minutes before the load is applied to enable the engine to properly warm up and insure proper lubrication. See **"Operating Instructions After Starting."**

Usual Routine Way of Starting the 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 the fuel supply.
2. Check the lubricating oil in the engine base with the gauge rod. Be sure the oil is to the 4/4 or full mark on the rod. See Illustration No. 4.
3. Check the cooling solution.
4. Inspect the installation to see that all is in good order and tight and no loose tools, bars or parts are lying on the engine.
5. Start the engine by operating the starter switch after turning the ignition "On."
6. Check the engine, as in **"Operating Instructions After Starting."**

OPERATING INSTRUCTIONS AFTER STARTING

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

1. Look at the lubricating oil gauge. If no pressure shows after the engine has run 10 or 12 seconds, shut down the engine and ascertain what the trouble may be. With the bearings in good condition and the proper grade of oil, the pressure should be 15 to 30 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 the water circulation. If no water is flowing, shut down the 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 evaporation.
3. See that no loose tools or parts are lying on, or near, the unit, as they might fall into a place where they would cause damage or personal injury.
4. Observe the engine operation for smoothness, quietness and exhaust condition. If the fuel is up to specifications and has the proper ignition 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, trace out the trouble, some hints of which will be found starting in **"Engine Trouble Shooting."**
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 carburetor; if a good quantity of fuel appears, it is an indication that the fuel 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 the fuel line from the tank to the pump for leaks from loose connections, broken nuts and cracked or broken lines. Also check the lines for obstructions inside or having been pinched closed or nearly so. If the lines are found satisfactory, check the pump for a broken diaphragm, springs and worn or broken valves.
6. Check and see that there are no oil or water leaks.
7. Clean the lubricating oil filter often. This will insure maximum efficiency from this unit and does not require much time or energy to accomplish.

8. Keep all the fuel filters clean and give them regular attention.
9. Observe the fan and belt operation. Loose fan belts allow slippage, which reduces the efficiency of the fan and wears the belts out rapidly. Never allow the fan to run without any lubricant but do not overlubricate, as it will throw off the excess on the surrounding parts.
10. See that the radiator, if one is used, is free of obstructions between fins or tubes, as they will obstruct the air flow and reduce the cooling efficiency of the radiator unit.

COLD WEATHER STARTING

At extremely low temperatures, difficulty may be encountered in starting the engine due to (a) battery charge or output being low due to temperatures or (b) gasoline with vapor pressure too low to readily vaporize.

At low temperatures where hard starting is encountered, the use of a priming system, consisting of one or more atomizing nozzles in the intake manifold connected to a priming pump conveniently located on the instrument panel, is recommended.

This permits the operator to force fuel into the intake manifold, which will be atomized by the nozzles. This atomized fuel will be carried into the cylinders, as the engine is cranked, where it will ignite much quicker than fuel which is drawn through the carburetor.

It is not possible to give definite instructions on how the priming system is to be operated, but the following may be used as a starting point until the operator gains experience and also becomes acquainted with the starting characteristics of his particular engine under known climatic conditions.

1.. Close the choke approximately two-thirds.
2. Pump the priming pump to inject two strokes and return the handle to the outer position.
3. Operate the starter.
4. If the engine falters, slowly push the primer in to inject more fuel. (It must be remembered that an engine may be very easily flooded when using the primer.)
5. Operate the choke to keep the engine running.
6. Be sure the primer is locked in the closed position after the engine is started.

In starting any engine, and particularly a cold engine, do not allow it to run up to governed speed or do not run the engine much over 800 or 1000 RPM until the oil has become warm enough to circulate and the water or cooling solution has become warm enough to take the chill off the cylinder block. This usually takes four or five minutes if the engine is equipped with a thermostat. A longer period is generally required for engines not so equipped; these engines should have the radiator covered for the first few minutes in order to allow the water or cooling solution to warm up. If the unit is not equipped with a thermo-gauge or thermometer, this can be then checked by placing the hand on the cylinder block or cylinder head and, as soon as the engine becomes warm enough, can be run up to maximum speed. This is probably the most important phase of the engine operation, as damage can result in the first few seconds of running if the engine is allowed to run maximum load and maximum speed before lubrication has been established and before the parts have started to warm up normally.

COLD WEATHER STARTING SUGGESTIONS

If ignition and carburetion are correct, starting in cold weather can be made less difficult by observing the following suggestions.

1. Late ignition timing causes hard starting. (Magneto impulse coupling should click or release on, or slightly after, top dead center.)
2. Never attempt to start with a wide-open throttle. Have the throttle open not more than one-fifth of the total opening.
3. Close the carburetor choke and turn the engine several times before the ignition switch is closed, if the engine is hand cranked.
4. Close the ignition switch and keep the choke closed nearly all the way, then crank the engine over in the same way as has been followed in warmer weather.
5. When the engine starts to fire, keep the choke partially closed until the engine warms up sufficiently to run normally.

6 Filling the cooling system with hot water will assist starting.

7. Thin oil, such as 10W or 20W, will make cranking easier.

8. Cheap gasoline makes cold weather starting very difficult.

9. Be sure the gasoline flows through the carburetor. Ice may have blocked the gasoline due to water in the gasoline.

10. If the engine has been standing idle for several days, remove the spark plugs and dry out; at the same time pour a tablespoon of oil in each spark plug hole.

ENGINE STORAGE

If the engines are to be stored or left idle for any length of time, certain preparations should be made for proper storage of the engine.

1. Engines which have been operating on leaded gasoline should be run on unleaded or standard white gasoline for at least 10 minutes in addition to the time required to run out the leaded gasoline in the lines and carburetor.

2. The crankcase should be filled to the 4/4 mark on the bayonet gauge with an oil similar to the following:

   Shell ENSIS 412, Specification 2-126, Grade 2
   Gulf No-Rust Engine Oil, Grade 2

   This oil should be placed in the engine crankcase at the beginning of the run outlined in paragraph 1.

   The above oils are graded the same as regular motor oil according to SAE weight. Therefore, the proper weight of oil for the climatic conditions should be chosen to facilitate starting.

   In cases where the engine is to stand idle for an extended period of time, approximately 1 quart of this oil should be poured into the carburetor air intake while the engine is operating at a fast idle (800 to 1000 RPM). Gradually increase the amount of oil through the carburetor until the motor stalls or stops. Shut off the ignition switch.

3. In damp or humid climates, seal off all openings with a moisture-proof tape (breather, air intake, et cetera).

The above methods have proven successful; however, Hercules Motors Corporation cannot assume responsibility for engine storage.

LUBRICATION

DESCRIPTION OF LUBRICATING SYSTEM

The lubricating system on this engine is the forced feed type to all main and connecting rod bearings by means of a gear type pressure pump. The oil pump is driven through a suitable gear arrangement at the center of the camshaft. The pump picks up the oil from the center sump of the oil pan and delivers it to a drilled passage in the block. From there, it flows through an oil manifold and through various leads to the main bearings. From the main bearings, the oil flows through suitable drilled holes in the crankshaft to the connecting rod bearings. The bypass type pressure regulator, consisting of a spring loaded piston, is incorporated in the oil pump body. The idler shaft and accessory shaft are pressure lubricated. The cam bearings, valve tappets, valve stems and cylinders are lubricated by the mist of oil thrown off by the main and connecting rod bearings.

LUBRICATION INSTRUCTIONS

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

Oil Changing. Drain the crankcase and refill with fresh oil frequently. How often this should be done depends on the operating conditions, the kind of service to which the engine is applied and whether or not the engine is equipped with a suitable oil filter. After changing the oil several times at 1500 mile or 75 to 100 hour intervals, and by observing the condition of the old oil, it can be determined whether the oil

should be changed more frequently or less frequently. Oil should be changed more frequently when an engine is new than after it is well run in. This is because initial wearing in of various parts will result in minute metal particles in the oil, which frequent draining will help to remove. The oil should also be changed more frequently in cold weather or where the engine is frequently started when cold, as choking and cold running will tend to dilute the oil with unburned fuel and water. Water vapor is a product of normal combustion and will condense to form drops of water when it comes in contact with cold surfaces. Traces of water in the crankcase will result from cold running and frequent oil changing will help to remove this water.

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

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

Use Good Oil. The difference in cost between cheap oil and the best obtainable is money well invested, as this cost will be multiplied many times when repairs are necessary due to using cheap oil.

The Hercules Motors Corporation recommends that only the best quality, heavy-duty, detergent type oils, manufactured by recognized concerns familiar with the lubrication requirements, be used.

A new system of lubricating oil designations has been devised by the American Petroleum Institute. This new system, known as the API system, uses code letters to designate the particular service for which an oil may be recommended.

This system, however, has nothing to do with the SAE grade number. The SAE grade numbers must still be used to indicate the relative viscosity or body of the lubricating oil. For gasoline engines an oil having an API service designation of MS is recommended. This oil is for start-stop operation and also for high temperature operation. Various refineries may mark their oil for a combination of services, which includes the MS service. This indicates that the oil is suitable for the recommended service.

If the sales divisions of these refiners cannot give you reliable firsthand 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 engines.

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

A lighter weight of oil should be used in a new engine during the breaking-in period of 2000 miles or fifty hours of operation than can be used after the engine has been run for some time. For breaking in a new engine, we suggest an SAE 20 oil for normal conditions and a lighter oil if cold weather or cold climate conditions prevail.

After the breaking-in period and for normal conditions of climate and load, we suggest an SAE 30 oil. For warm weather or climate conditions where the temperatures of the oil in the crankcase exceed 220° F., the use of an oil cooler is recommended. For cold weather or climate, use an oil having a pour point at least ten degrees F. below the temperature to be encountered. For example: if a temperature of zero degrees F. is to be encountered, the oil used should flow or pour at 10° F. below zero. Such an oil as SAE 20W will be suitable for such conditions.

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

ACCESSORIES

Accessories mounted on the engine should carry their own lubricating instructions, which should be followed.

OIL PRESSURE

Refer to Illustration No. 57, and **"Oil Pressure."**

DESCRIPTION AND MAINTENANCE

This section covers a brief description and function of the various parts of the engine along with complete instructions covering the repair, disassembly and reassembly of the various component parts of the JX series engines.

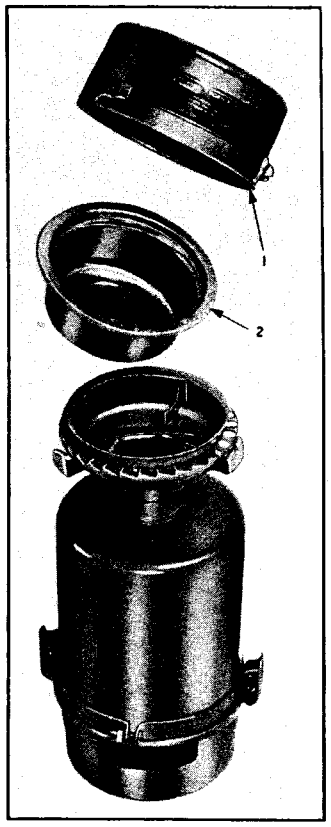


Figure 1

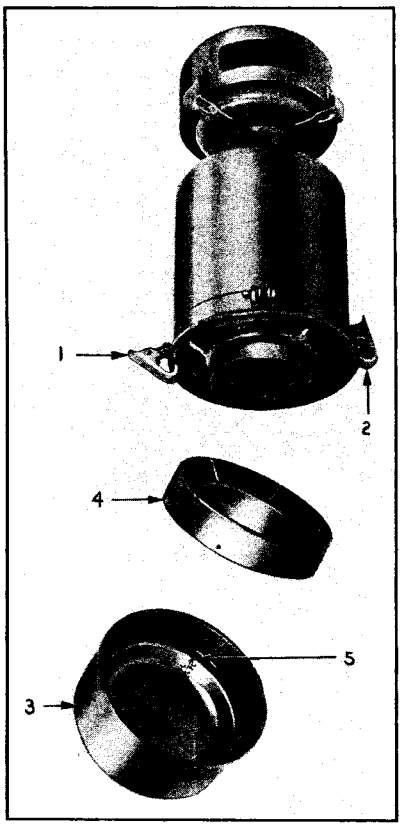


Figure 2

Illustration No. 3

This section has the various subjects arranged alphabetically for convenience in locating.

AIR CLEANER

Since dirt is the greatest enemy of any internal combustion engine, it is necessary to take every precaution to prevent it from entering the engine. Therefore, one of the most essential preventive measures is proper maintenance of the carburetor air intake air filter. These units should be cleaned at least once a day, or, if operating in very dusty conditions, they should be cleaned every six or eight hours. All connections between the air cleaner and the carburetor must be airtight. It is possible, under certain conditions, for enough abrasive laden air to be drawn into the engine through a loose connection to cause rapid wear of the pistons, piston rings and upper cylinder surfaces.

Various types of air cleaners are used. These include dry screen types and the various makes of oil bath air cleaners. However, for our purpose here, we are illustrating and giving maintenance instructions for the air cleaners as manufactured by the Vortox Corporation. These may also be equipped with a dry type pre-cleaner as shown in Fig. 1, Illustration No. 3. Items No. 1 and No. 2 are the pre-cleaner parts, which should be serviced frequently. Fig. 2, Illustration No. 3, shows the oil bath cleaner parts, with No. 3 being the cup and No. 4 the filter screen. No. 5 indicates the oil level in the oil cup.

The screen type air cleaner should be removed and washed in gasoline or kerosene, then dipped in clean lubricating oil and replaced on the engine.

Each 100 or 150 hours or until a satisfactory schedule can be worked out, depending on actual operating conditions, the complete air cleaner should be removed from the engine and thoroughly washed and cleaned. (This operation should not be necessary if the oil cup or screen has been cleaned daily.) A dirty, clogged air cleaner causes loss of power, excessive fuel consumption and dilution of the lubricating oil from the excess fuel.

The air cleaner element must be clean to allow free passage of air or the air cleaner will act as a choke, which would cause a rich carburetor mixture, excessive crankcase dilution and loss of power.

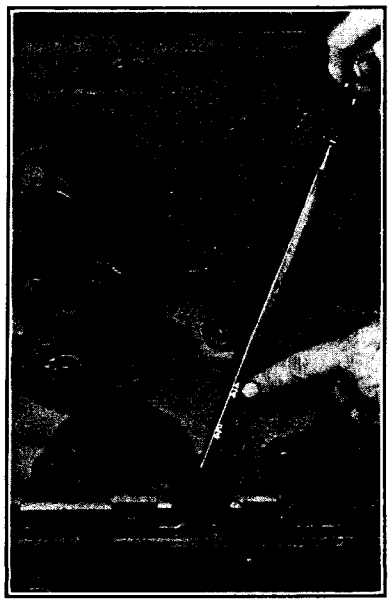


Illustration No. 4

SERVICE INSTRUCTIONS

1. Press down on the cover, No. 1, Fig. 1, Illustration No. 3, and rotate counterclockwise. This will allow removal of the cover, No. 1, and the dust collecting pan, No. 2, Fig. 1, Illustration No. 3. Empty the dust pan and reassemble, reversing the above procedure.

2. Release the two clips, No. 1 and No. 2, Fig. 2, Illustration No. 3, and remove the oil cup, No. 3. The filter, No. 4, Fig. 2, Illustration No. 3, can then be removed by pressing upward and turning to the left until

the locking tabs line up with the vertical slots; then pull downward. Wash the filter and oil cup in clean kerosene, fuel oil or gasoline and blow dry with compressed air. If compressed air is not available, wipe the oil cup dry and shake the cleaning fluid from the filter screen. Fill the oil cup with the same grade of oil as used in the engine crankcase to the point of the oil level arrow, No. 5, Fig. 2, Illustration No. 3. Reassemble by reversing the above procedure.

CAUTION: NEVER OPERATE WITHOUT OIL. Keep all the connections from the cleaner outlet to the engine inlet absolutely airtight. **THIS IS VERY IMPORTANT.**

BATTERY IGNITION DISTRIBUTOR DRIVE

(See "Water Pump")

BAYONET GAUGE

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

BELLHOUSING OR FLYWHEEL HOUSING

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

TO REMOVE THE BELLHOUSING

1. Drain the crankcase oil.
2. Remove the clutch.
3. Remove the flywheel. See Illustration No. 27.
4. If the engine is in the unit, place suitable supports under the rear of the oil pan to support the engine. The block must be large enough so that the oil pan is not damaged. Do not use a jack unless a large block is placed between the jack screw and the oil pan.
5. Remove the rear motor support screws.
6. Remove the bellhousing attaching screws.
7. Pull the bellhousing away from the engine. It may be necessary to tap the housing with a soft hammer to loosen from the saddle or a gasket sticking to the block.

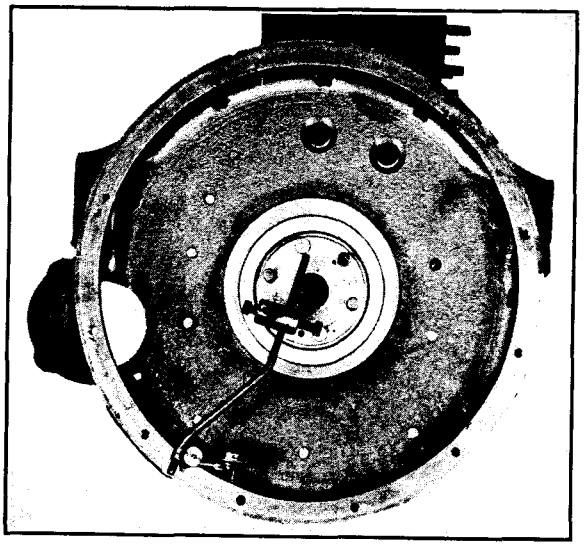


Illustration No. 5

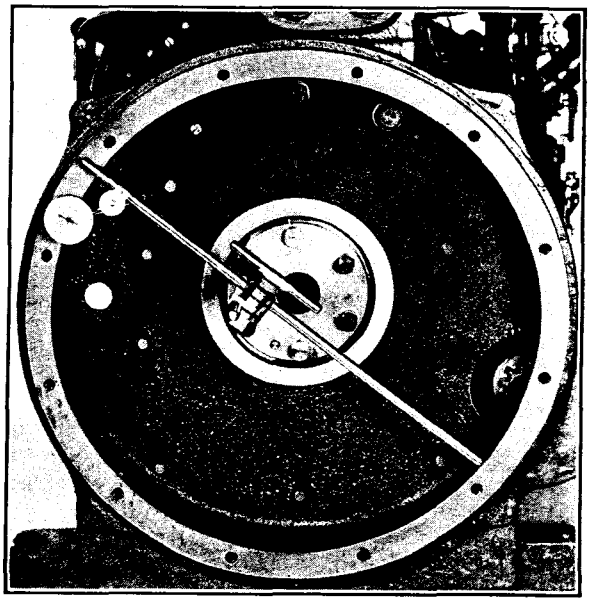


Illustration No. 6

TO INSTALL THE BELLHOUSING

1. Cement a new gasket to the bellhousing, allowing the cement to dry sufficiently so the gasket will not skid.
2. Assemble the bellhousing to the engine. Tighten the screws so that they are almost tight.
3. With the dial indicator mounted as shown in Illustration No. 5, check the concentricity of the bellhousing bore with the crankshaft. (This should be within .010".) The bellhousing may be shifted slightly on the screws, if necessary. When the bellhousing is properly centered, tighten the attaching screws and install the rear motor support screws. Recheck after tightening, as the housing may have moved during this operation.

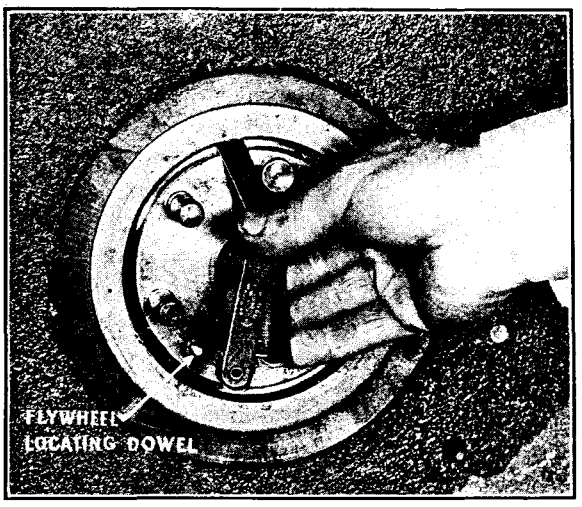


Illustration No. 7

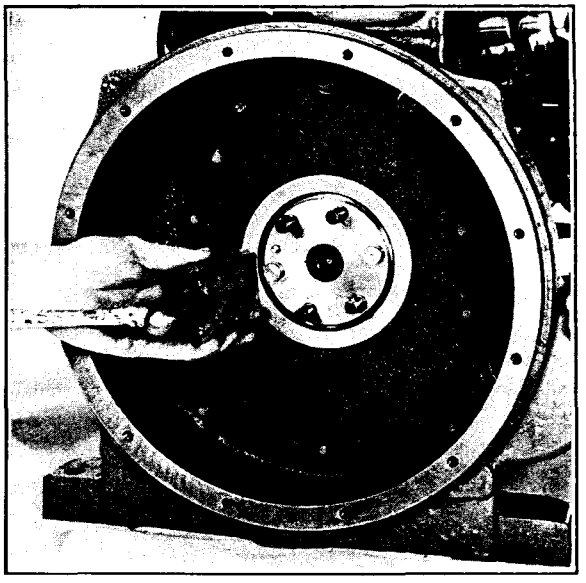


Illustration No. 8

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

BREATHER AND OIL FILLER

The breather allows air to enter the crankcase and lets accumulated gas escape. The type used keeps dust and dirt from entering the crankcase. It is very easy to service and should be cleaned daily.

TO CLEAN

1. Remove the accumulated dirt from the outside of the breather.
2. Remove the breather cap. See Illustration No. 10. Wash in clean kerosene and blow out with compressed air.
3. Dip in lubricating oil. If an oil bath type, fill to the level mark on the breather body.

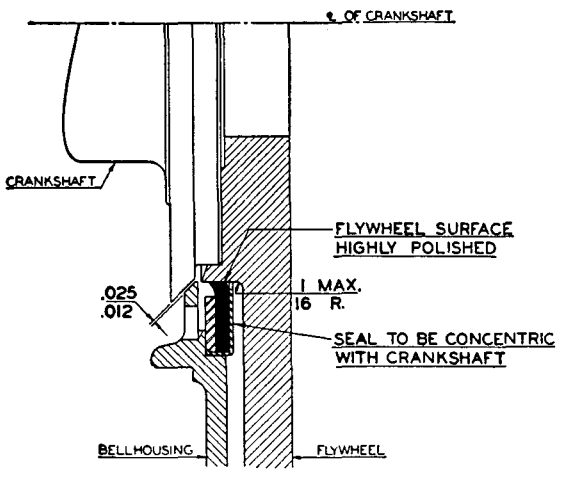


Illustration No. 9

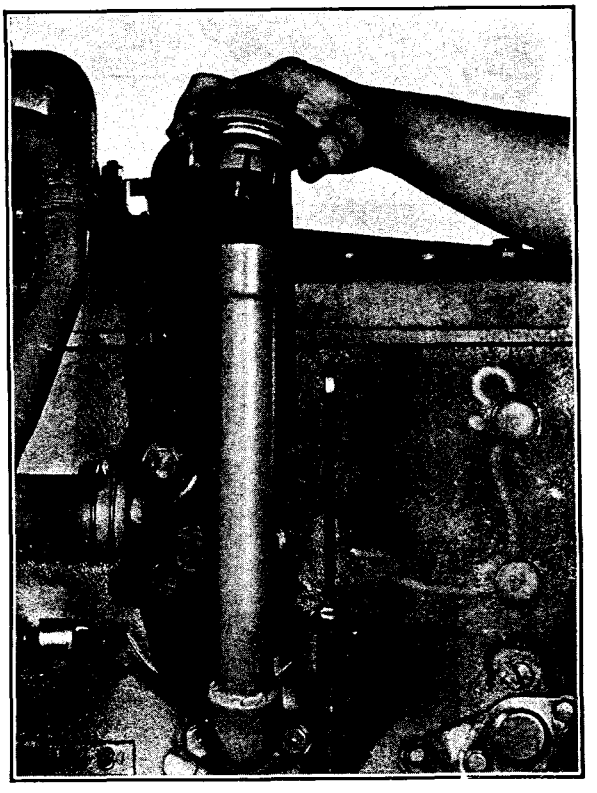


Illustration No. 10

CAMSHAFT

The camshaft is supported on four large diameter bearings in the crankcase; these bearings are removable and can be renewed. It is driven by means of a suitable gear which meshes with the crankshaft gear.

The timing of these two gears requires no check of position of the valve. It is only necessary to line up the punch marks on the two gears, the cam gear being shown as A and the crank gear as B in Illustration No. 11.

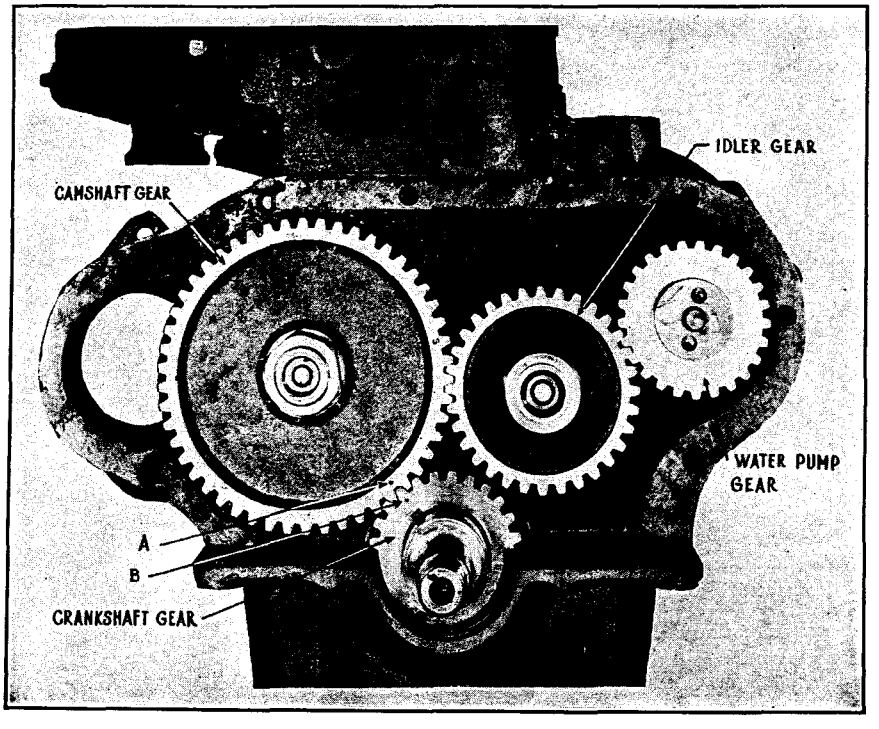


Illustration No. 11

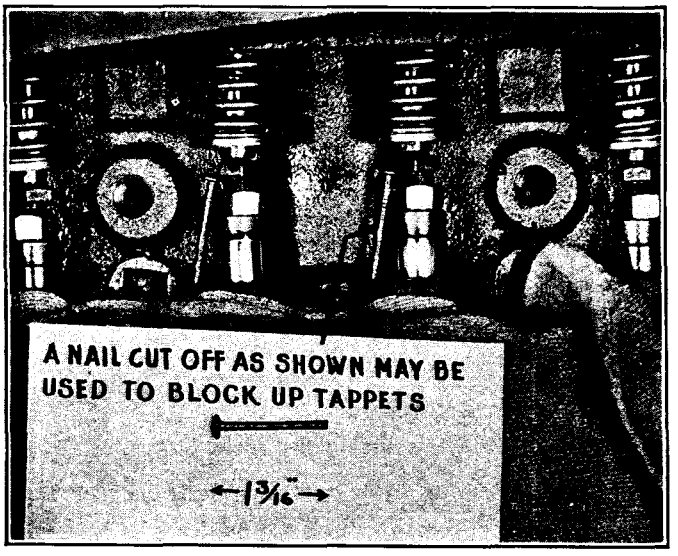


Illustration No. 12

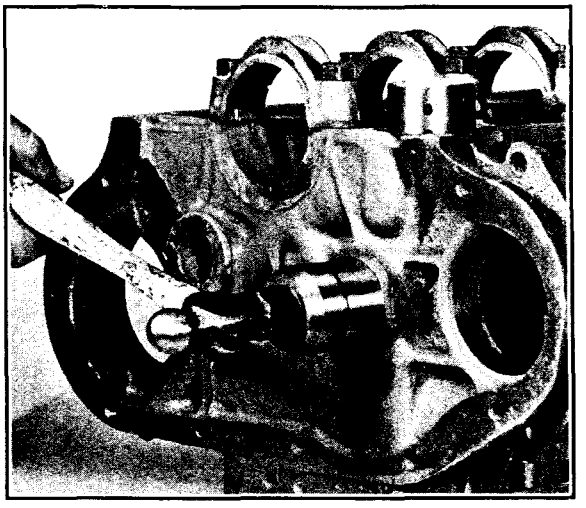


Illustration No. 13

TO REMOVE THE CAMSHAFT

1. Remove the oil pan. See "Oil Pan."
2. Remove the oil pump. See "Oil Pump."
3. Remove the gear cover. See "Gear Cover."
4. Remove the valve tappet covers and, with a valve spring compressor, lift the valves so that all the valve tappets may be blocked up, as shown in Illustration No. 12. A nail, cut off as shown in the illustration, may be used for this purpose. Lower the spring compressor carefully so the nail does not snap and pinch the fingers.
5. Pull the camshaft forward out of the engine. It may be necessary to turn the crankshaft slightly to permit the camshaft bearing journals to pass the crank throws.

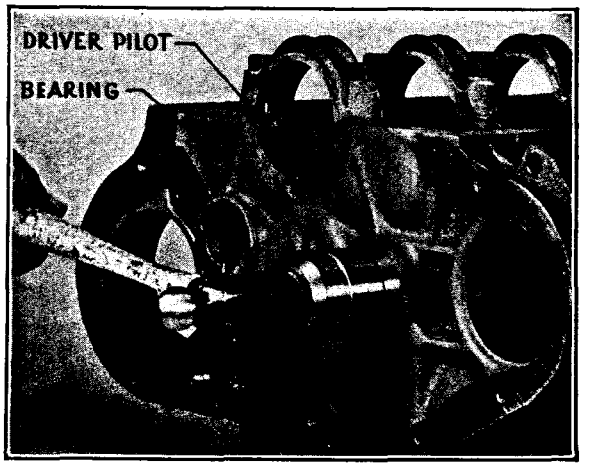


Illustration No. 14

6. Remove the nut; then place the shaft in an arbor press and, with suitable supports under the gear, press the shaft out of the gear.
7. Although it is seldom necessary to remove the thrust plunger from the camshaft, it may be removed in the following manner: With a torch, quickly heat the plunger to anneal it. Allow the plunger to cool, then drill through the plunger with a 5/16" diameter drill and tap the hole with a 3/8"-16 tap. Using a 3/8" cap screw of suitable length, the plunger may be pulled from the shaft.
8. If new camshaft bearings are needed, drive out the old bearings with a driver (13567-A). See Illustration No. 13. The same driver may be used to drive in the new bearings. See Illustration No. 14.

TO ASSEMBLE THE CAMSHAFT

1. Insert the Woodruff key in the shaft.
2. Place a small amount of grease or heavy oil on the thrust washer and place the thrust washer on the gear.
3. Press the gear on the camshaft. After the gear is pressed on the shaft, the thrust washer must turn freely on the gear shoulder.
4. Assemble and draw the nut up tight.
5. If the thrust plug has been removed, press in a new plug.

6. Drive the new bearings into place with a driver (13567-A). See Illustration No. 14. These bearings are cut to allow for the press fit when the bearings are pressed into the case; therefore, no reaming should be necessary. However, the shaft should be checked in the bearings for proper clearance of .0015" to .0025".
7. Use care when installing the camshaft that the cams do not damage the bearings, as this usually causes tight bearings.
8. Time the gears by lining up the punch marks, Illustration No. 11.

CARBURETOR

A carburetor is an accessory designed to mix gasoline and air in proper proportions and to furnish this proportionate mixture to the engine under varying operating conditions.

It is essential to clearly recognize that the function of the carburetor cannot extend beyond the proportionate mixing of fuel and air. This knowledge will avoid many false leads in diagnosing so-called "carburetor troubles". Bear in mind that the carburetor delivers the proper mixture into the manifold. The manifold carries this mixture to the cylinder. In the cylinder the mixture is compressed by the piston. While under compression, a spark from the spark plug ignites the fuel mixture. The explosion caused by igniting the fuel mixture causes the piston to travel downward in the cylinder, rotating the crankshaft, etc.

This seems to be carrying the subject a long way from the carburetor, but it is done only to point out that all of the other parts of the combustion system can affect the results obtained from the fuel and air mixture which was prepared by the carburetor.

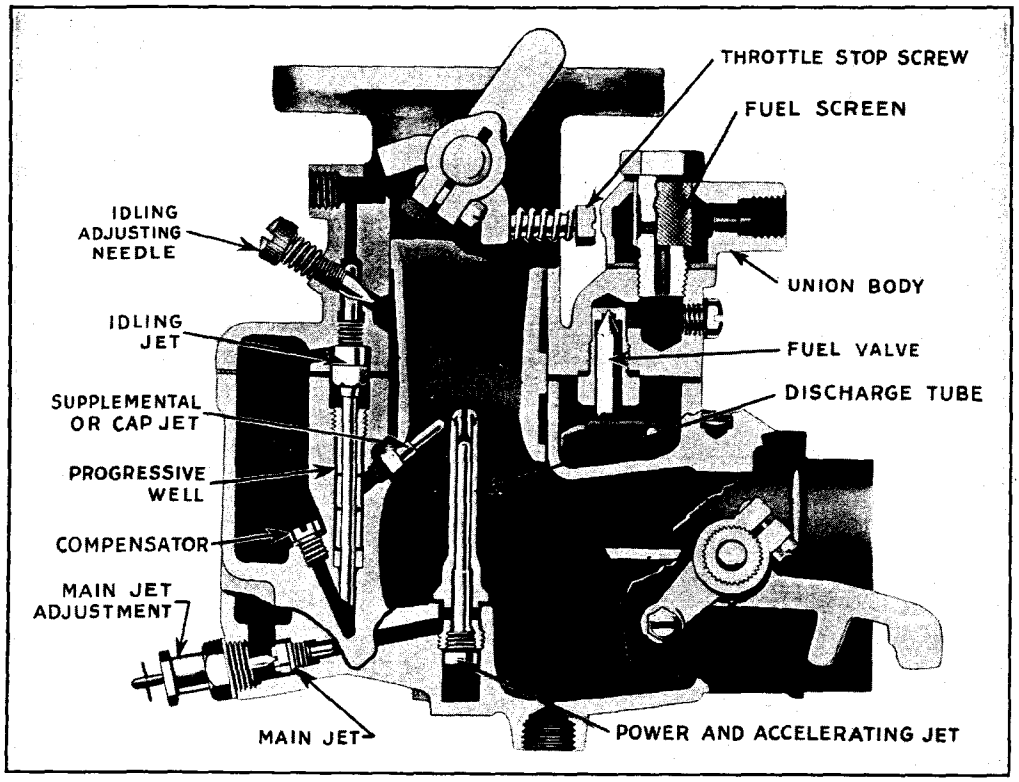


Illustration No. 15

OPERATION

The Zenith Compound Nozzle system, Illustration No. 15, of carburetion is used to illustrate this text. This consists of the Main Jet, directly connecting the fuel in the bowl with the air stream through the Discharge Tube, and the Compensating Jet, which flows into an open well connected with the air stream through the Supplemental Jet. The main jet flow varies with the suction and delivers an increasing amount of fuel as the suction increases. The open well kills suction on the compensating jet so it flows the same under all suctions. In combination, the rich and lean jets give an average mixture of the correct proportion.

Idling, acceleration and economizer action are provided by the idling and acceleration systems described in detail on the following pages.

NORMAL RUNNING: Refer to Illustration No. 15. On part throttle operation (between idling and full power) the fuel is measured by the main and compensating jets, the former being more effective at higher and the latter at lower speeds. The air is measured by the Venturi and the fuel is carried into the air stream slightly above the venturi throat from the main and compensating jets by the discharge tube and supplemental jets, respectively. These jets are of such size as to give a very lean and economical mixture.

IDLING: The idling system consists of an Idling Jet and tube to supply the fuel, an Idling Needle Valve to correct the idling mixture and a channel to carry the mixture into the carburetor barrel at the edge of the throttle. The desired idling speed is set by the stop screw on the throttle lever.

The idling system functions only while starting and idling. When the throttle is opened past the idling position, the fuel goes the other way through the discharge tube and supplemental jet and the idling system is automatically out of operation.

FULL POWER AND ACCELERATION: Full power, either for top speed or hard pulling, requires a richer mixture than part throttle operation. So does acceleration. See Illustration No. 16.

This additional richness of mixture is provided by means of the accelerating and economizer system feeding through the Power and Accelerating Jet, its fuel stream merging with that of the main jet at the top of the discharge tube.

Under part throttle, the suction (or vacuum) above the throttle is higher than when the throttle is open. This suction holds up the Economizer and Accelerating Piston Assembly. The Check Valve is open and the Economizer Valve is closed, thus shutting off fuel from the power and accelerating jet.

When the throttle is opened, the suction falls and so does the piston. The falling piston builds up a pressure below it, which forces the check valve to its seat, thus preventing the fuel from being forced back into the bowl. The piston falls on the economizer valve, pushing it open, and the fuel displaced by the piston is forced out through the power jet. This is the accelerating charge.

If the throttle is held open, the piston will remain at the bottom holding the economizer valve open. This allows the fuel to continue flowing through the power and accelerating jet. This jet has a measuring hole in its tip which measures only enough additional fuel to develop full power.

When the throttle is partly closed the suction increases above it, the piston is drawn up to the top, the economizer valve closes and only a very economical amount of fuel can be fed to the engine.

AIR CLEANER AND AIR FILTER RESTRICTION

Most air filters now used on gasoline engine carburetors accumulate the dirt they separate from the incoming air. As this dirt builds up, it has an action similar to closing the choke valve. Both cause a restriction and this increases the suction on the carburetor jets. Very little increase in suction is sufficient to create a mixture so rich that it will not only seriously impair engine operation but will also dilute the oil and cause as much wear as dirt.

CONNECTING ROD

The connecting rods have either one of two types of bearing construction. In the spun babbitted type, after the rod and cap are tinned, the bearing metal is spun in on a centrifugal machine and then machined to accurately fit the journals of the crankshaft. This type may be adjusted by removing or adding shims. The precision or insert type has the cap and rod split slightly below center so the split in the shells opposite the locking lugs does not match with the split in the forging. This type is also divided into two types, one having shims on one side only, no shims being used on the side having provision for locking the shells. The second type is machined without shims; therefore, when reconditioning of the bearings becomes necessary, it is accomplished by using new shells or inserts. Do not file or grind the cap, as new bearings cannot be installed in a rod that has been filed or ground.

NOTE: As built at the factory, the connecting rods and caps are marked on the camshaft side and to the front of the engine with the cylinder number in which they are used.

TO REMOVE THE CONNECTING RODS

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

1. Remove the oil pan. See **"Oil Pan."**
2. Remove the cylinder head. See **"Cylinder Head."**
3. It is not necessary to remove the oil pump. Its removal will facilitate working on the connecting rods.
4. Turn the crankshaft until the rod is in a convenient position for removal of the cap, then remove the cotter pins and cap nuts.

5. With a soft hammer (such as rawhide or fibre), tap the rod to loosen it; then remove the cap.
6. With a suitable piece of wood, Illustration No. 17, push the piston and connecting rod out through the cylinder bore. Use care that the connecting rod does not scratch the cylinder wall. To insure against scratching, wrap the lower part of the rod with a wiping cloth.
7. Repeat the above operations for each connecting rod or a quicker method is to remove the two rod caps that are down at the same time.

TO REPLACE THE CONNECTING RODS AND PISTONS

1. Inspect the crankshaft for any rough or scored marks that might damage the new bearings. If any rough spots are found, use an oil stone, very fine emery cloth or Crocus to polish the shaft. Clean the shaft thoroughly after polishing.
2. Select the proper piston and connecting rod assembly and turn the crankshaft so that it is in the correct position.

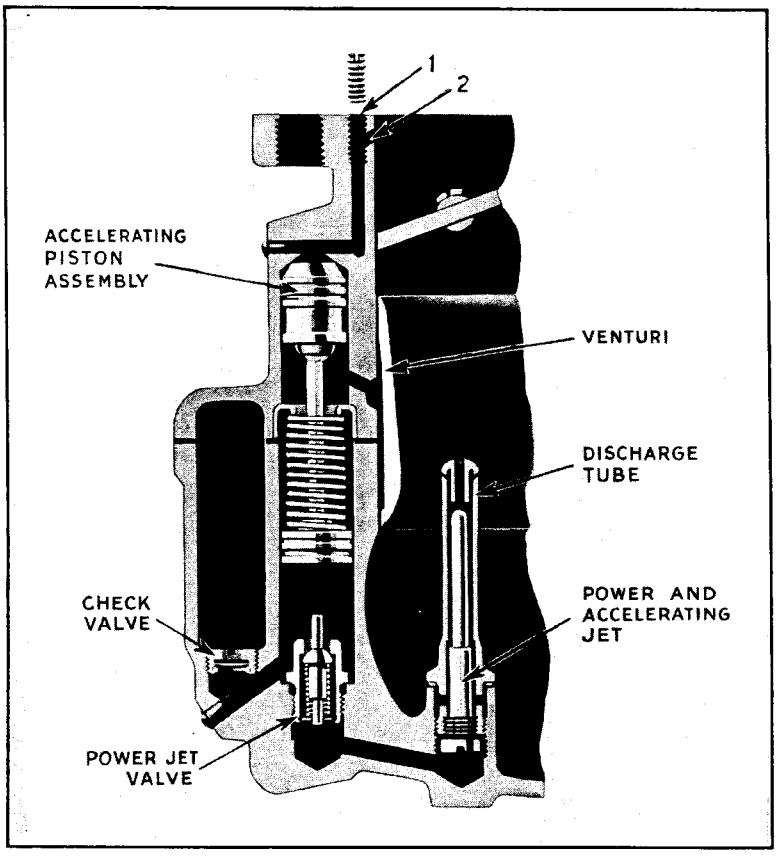


Illustration No. 16

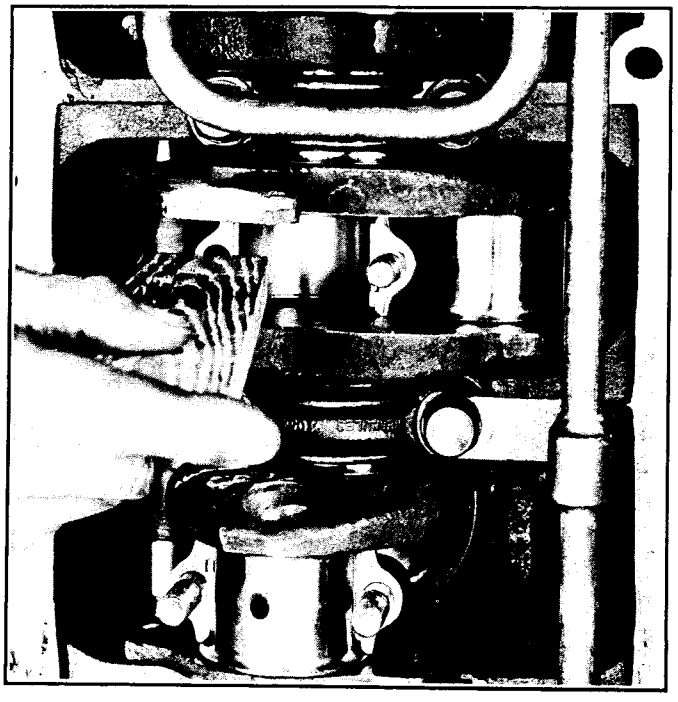


Illustration No. 17

3. With the piston rings compressed as shown in Illustration No. 18, use a hammer handle or block of wood to force the piston and rings into the cylinder bore. At the same time, use care that the connecting rod is in line with the crankshaft journal.
4. With the piston entirely in the cylinder bore, insert the upper shell and pull the connecting rod down to the crankshaft.
5. Place a ¼" x ½" x .0015 piece of feeler stock in the cap. Place the lower shell in the cap and assemble the cap to the connecting rod. Tighten the cap screws to the proper tension and try the connecting rod for side movement. The connecting rod should move sideways with a firm pressure of the hands. After obtaining the proper movement of the rod in the above manner, remove the piece of feeler stock and reassemble the connecting rod cap. Tighten the screws, as before, and again try the side movement of the rod. It should move easily.

6. Assemble the cap to the connecting rod. Draw up the cap to the proper tension. See **"Wrench Tension."** If no torque wrench is available, this tension would require a tight pull on a 10" wrench. Illustration No. 19 shows the use of a torque tension wrench.

7. Repeat the above operations for all connecting rods.

8. Install the cotter pins.

CONNECTING ROD BEARING REPLACEMENT

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

The connecting rods may be replaced as outlined below.

1. Remove the oil pan. See **"Oil Pan."**

2. Locate the crankshaft so the connecting rod cap can be removed.

3. Remove the cotter pins, nuts and cap screws.

4. With a soft hammer, tap the cap to loosen it; then remove the cap.

5. Replace the bearing shells as outlined above.

6. Reassemble the oil pan to the engine. See **"Oil Pan."**

Illustration No. 18

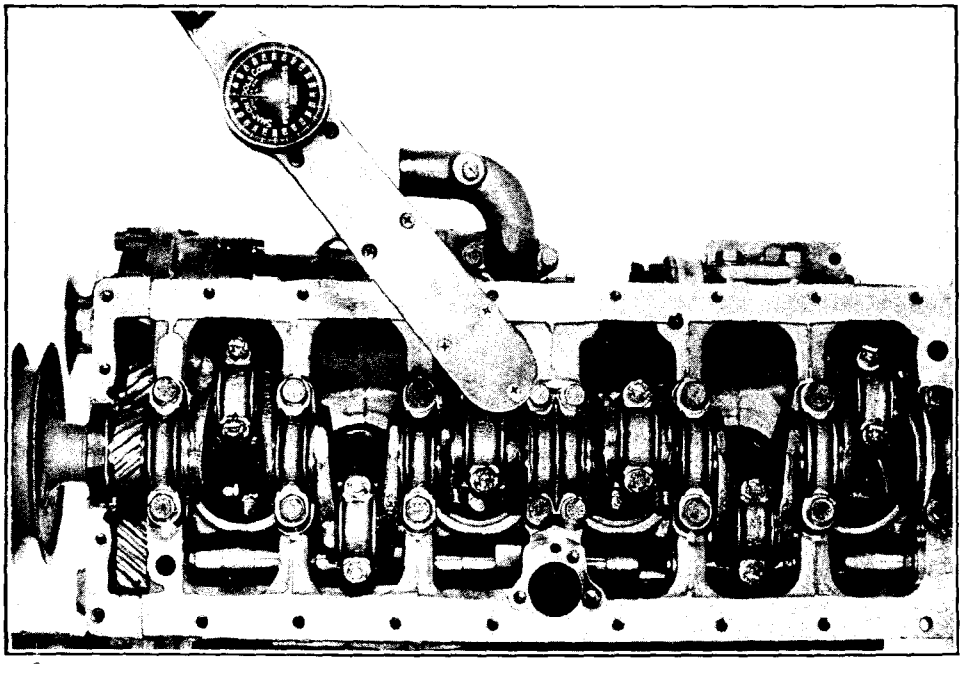


Illustration No. 19

COOLING SYSTEM

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

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

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

If the engine or unit is equipped with a pressure type sealed system, it is imperative that the correct type of radiator cap be used. This is determined by the type of system used.

There are two types of sealed cooling systems which are used extensively. One type has a safety relief valve arrangement built into the radiator filler cap, Illustration No. 20. The overflow pipe is also connected to the radiator filler neck above the lower seat of the pressure cap. In this manner, if excessive pressure develops in the cooling system, the lower part of the pressure cap will raise from its seat and allow the vapor to escape through the overflow pipe.

This type of cap should never be removed quickly. Always turn the cap off slowly until the pressure has escaped through the overflow pipe, then remove the cap.

The second type of pressure sealed cooling system has the pressure relief valve and overflow pipe built into the top tank as a separate unit (not connected to the filler neck).

However, if any type of sealed cooling system is used, the proper filler cap, good gaskets and a smooth gasket surface are essential if excessive loss of the coolant is to be prevented.

From the above, it can readily be understood why serious overheating of the engine results when the incorrect filler cap, bad gaskets or a rough surface are encountered.

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

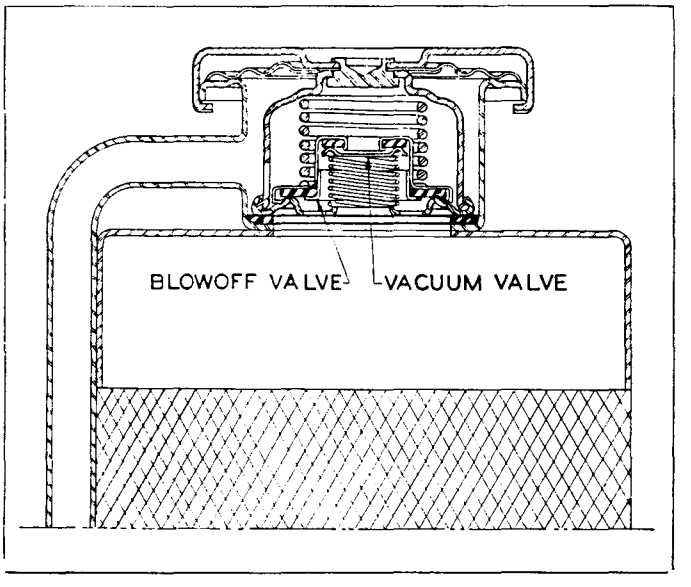


Illustration No. 20

GLANCE at the Instrument Panel gauges often. They tell how your engine is functioning.

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

UNNECESSARY REPAIRS . . . . . Use only the BEST OIL obtainable

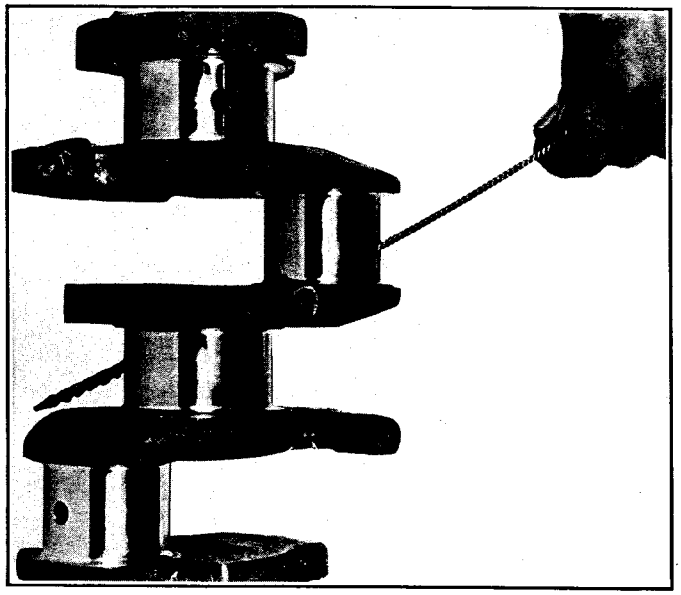


Illustration No. 21

CRANKSHAFT

The crankshaft is a machined forging, having all bearing journals surface-hardened. The nominal diameter of the main bearings is 2½" while the nominal diameter of the connecting rod journals is 2". The shaft has passages drilled to carry oil, under pressure, to the connecting rod bearings. These passages should be cleaned with a wire brush (see Illustration No. 21) before the shaft is installed in the engine.

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

Size	Main	Connecting Rod
Standard	2.498/2.497"	1.988/1.987"
.020" U. S.	2.478/2.477"	1.968/1.967"
.040" U. S.	2.458/2.457"	1.948/1.947"
.060" U. S.	2.438/2.437"	1.928/1.927"

WARNING! When regrinding a crankshaft, it is imperative that the original radius from the journal to the cheek be maintained. Crankshaft breakage may result from improper grinding of this fillet.

To replace the crankshaft main bearings, see **"Main Bearings."** To replace the crankshaft connecting rod bearings, see **"Connecting Rod."**

TO REMOVE THE CRANKSHAFT GEAR

If a suitable arbor press is not available, the following method may be used:

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

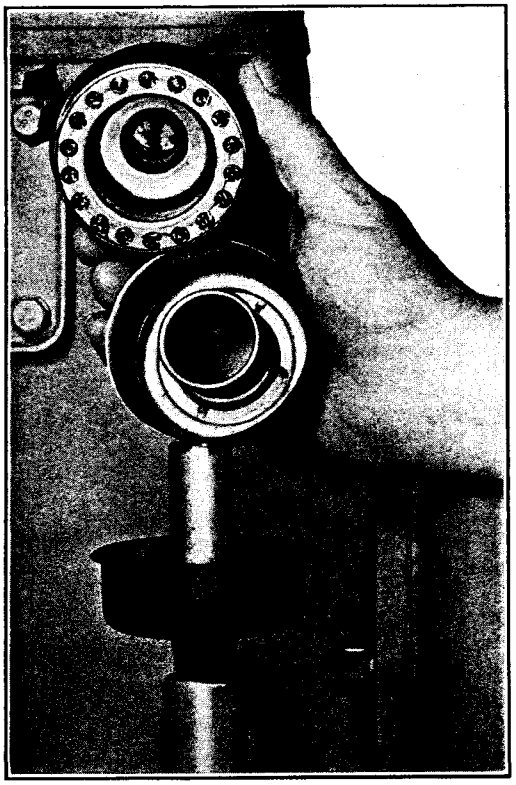


Illustration No. 22

TO INSTALL A NEW GEAR

1. Insert the Woodruff key in the shaft.
2. Lay the gear on a sheet of asbestos or other fireproof material and heat the gear, with a blowtorch, evenly on both sides until the gear turns a pale straw yellow. (If the gear is clean and untarnished, this color will indicate it is heated to approximately 450° F.)
3. Assemble the hot gear on the crankshaft and, with a suitable driver, quickly force the gear into the correct position. A piece of 2" diameter pipe may be used as a driver.
4. Allow the gear and shaft to cool.

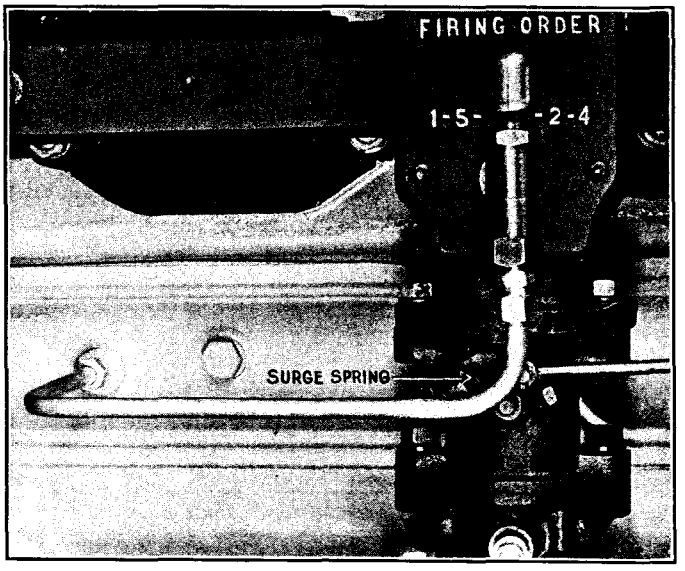


Illustration No. 23

CRANKCASE VENTILATION

Crankcase ventilation is to create a flow of clean air through the crankcase of the engine to help carry off the corrosive gases, which are the by-products of combustion and which leak by the pistons and valve stems.

This system consists of an oil bath type breather, Illustration No. 22, mounted on the left hand or water pump side of the engine, and a metering valve mounted in the intake manifold and connected through suitable tubes to the rear valve or tappet cover plate, Illustration No. 23. The metering valve consists of three major parts. See Illustration No. 24. The body is in two pieces, one which forms the connection into the intake manifold and the other which allows the attaching of the ventilation tubes from the crankcase. These two pieces form a body in which the weighted metering pin works. On some engines, one or two of these valves are mounted in the intake manifold; the function of these is to meter the amount of air which will flow through the crankcase while the engine is running at either full load or part load. In order that the carburetion is not upset at idling speeds, the increased vacuum offsets the gravity pull of the weighted metering pin, moving it to its uppermost position and thus cutting down the amount of air which it will bypass into the intake manifold.

Periodic cleaning of these parts will keep them functioning properly.

To clean the breather assembly, refer to **"Breather and Oil Filler."**

To clean the metering valve, remove the ventilation tubes, take the valve apart and wash it in gasoline or kerosene. Before assembling, put a small quantity of very light oil on the valve itself to prevent sticking until its own lubrication is established. See Illustration No. 24.

The ventilation tube and rear valve cover should also be cleaned at the same time, particularly if any noticeable amount of sludge accumulation is found.

CYLINDER AND CRANKCASE

The cylinders are cast integral with the crankcase and have the water jacket carried the full length of the cylinders and, also, around the intake and exhaust valve seats. 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 an oil cooler.

Material is cast iron with forged bearing caps fastened to the crankcase with ½" and 7/16" cap screws. The most casual inspection of the cylinder block will disclose the very rigid construction provided to support the crankshaft. This rigidity, coupled with the large diameter of the crankshaft, results in a very rugged and smooth running engine.

The cylinders may be rebored up to .060" oversize.

For reconditioning the valve seats and to replace the valve guides, refer to **"Valve Grinding."**

To replace the main bearings, see **"Main Bearings."**

Core openings are closed by expansion type brass or steel plugs. If any of these should leak, remove and replace with new plugs.

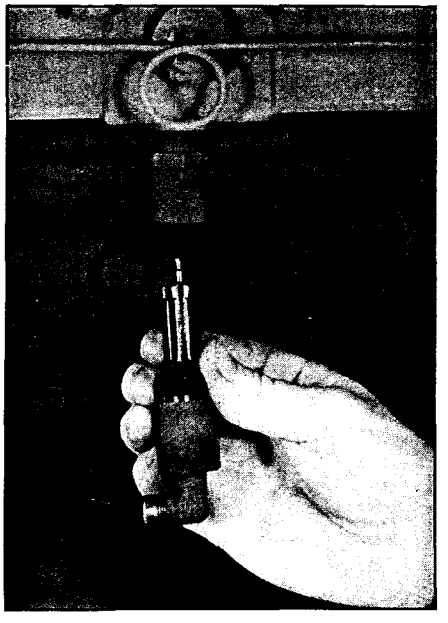


Illustration No. 24

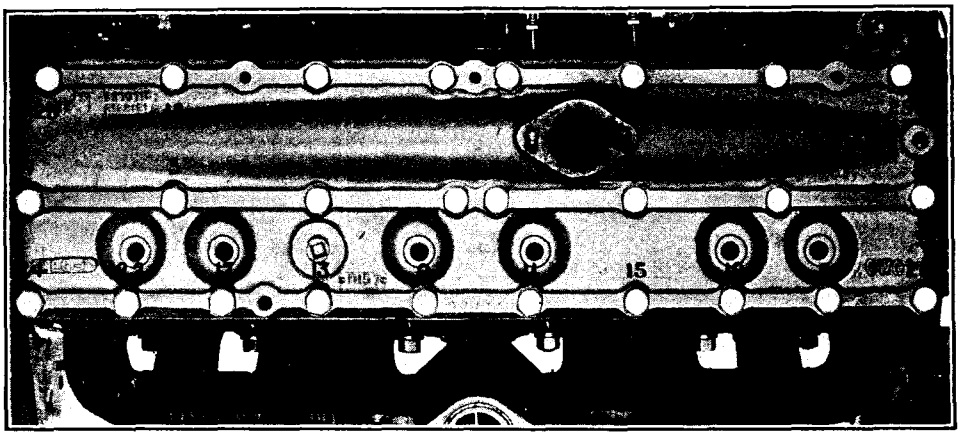


Illustration No. 25

CYLINDER HEAD

The cast iron cylinder head is the conventional "L" type and is detachable. The head is attached to the cylinder block with twenty-six ½" cap screws and a copper or steel asbestos gasket.

If cylinder head gasket failure is encountered, a thorough check should be made of contributing factors. Detonation, pre-ignition or spark knock (caused by ignition which is too far advanced) will cause a shock load in the combustion chamber which will damage cylinder head gaskets and, if allowed to continue, may destroy the pistons and piston rings. Fuel with an octane rating too low may also contribute to detonation and corrosion of the gasket to the point where it will start leaking.

TO REMOVE THE CYLINDER HEAD

1. Drain the cooling system.
2. Remove the water outlet pipe and hose.
3. Remove the cables and bracket assembly.
4. Remove the spark plugs.
5. Loosen and remove the cylinder head cap screws.
6. Lift off the cylinder head. Tap the head lightly with a soft hammer, if necessary, to loosen it. Do not pry on the contact surface.

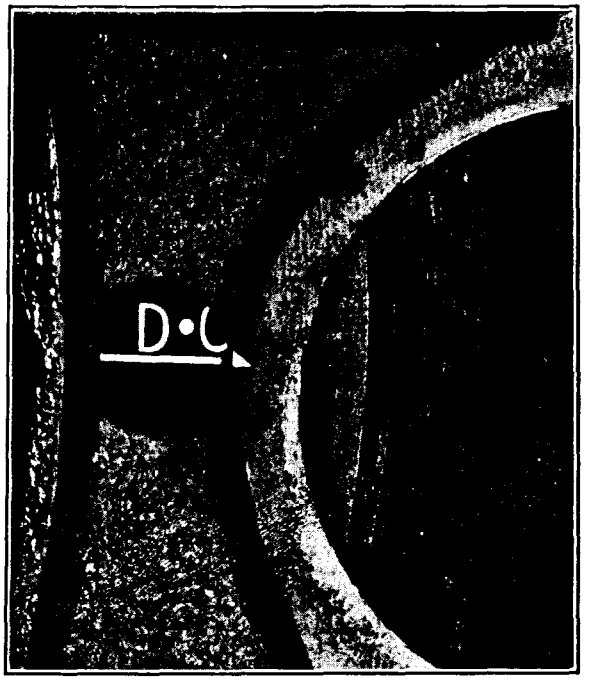


Illustration No. 26

TO REPLACE THE CYLINDER HEAD

1. Before reinstalling the cylinder head, clean out the carbon deposits by scraping or brushing.
2. Clean out the cap screw holes in the cylinder block; use a tap, if necessary.
3. Clean the cylinder block and cylinder head contact surfaces.
4. Clean the cylinder head gasket and place on the cylinder block. The gasket must be assembled with the bead (rolled edge around the combustion chambers) down. No shellac or gasket cement is necessary.
5. Assemble the cylinder head on the block.
6. Assemble the cable bracket, cables, etc., that are attached by the cylinder head cap screws.
7. Start the head cap screws and tighten evenly, starting at the center of the head and working progressively to the outer ends, following numerical sequence, Illustration No. 25, repeating until tight. See **"Wrench Tension."**
8. Install the spark plugs (be sure each has a clean gasket on it) and tighten in the head. Connect the cables to the correct spark plug.
9. Install the water outlet pipe and hose (use a new gasket and hose, if necessary).

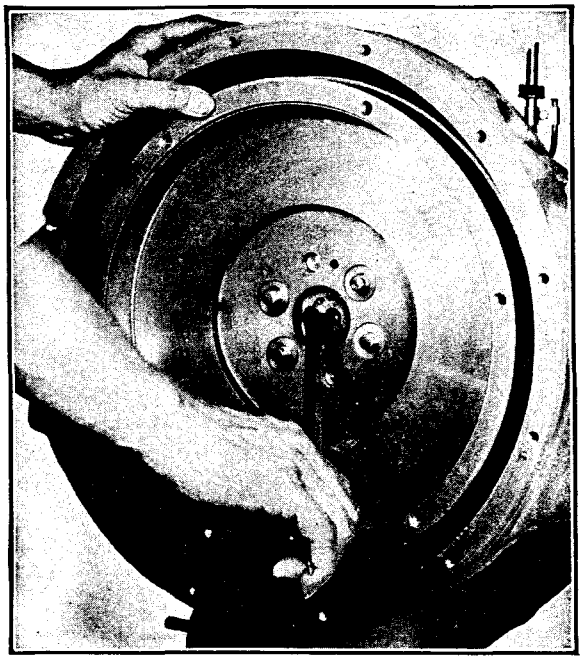


Illustration No. 27

FAN ASSEMBLY (COOLING)

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

The fan has a self-contained lubrication system which should be checked frequently. See Illustration No. 30. The lubrication system may vary with different types of fans, but all types should receive systematic care.

FAN LUBRICATION

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

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

similar to Standard Oil Company of Indiana, Oneida Grease, of a high enough melting point so that the oil is fed to the bearings very sparingly. There is enough lubricant in the fan, when it leaves the factory, to last for 1,000 hours or 25,000 miles of operation. To add lubricant to the fan, remove the pipe plug in the fan hub, Illustration No. 30, add the lubrication and replace the plug.

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

FLYWHEEL

The various flywheels used on the JX series engines are usually made of cast iron and may be machined to accommodate different types and sizes of clutches, as well as generators and other types of couplings. The flywheel is fastened to the crankshaft with four bolts and two dowels. There is also a smaller dowel used to locate the flywheel on the crankshaft for timing purposes, Illustration No. 7. The timing mark, which indicates that No. 1 and No. 6 pistons are on top center, may be seen through a drilled hole provided in the bellhousing, Illustration No. 26.

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

TO REMOVE THE FLYWHEEL

1. Assuming that the clutch has been removed, remove the cotter pins and nuts from the flywheel bolts.
2. Remove the starting motor.
3. Remove the flywheel, with the aid of a Lady-foot pry bar, as shown in Illustration No. 27.

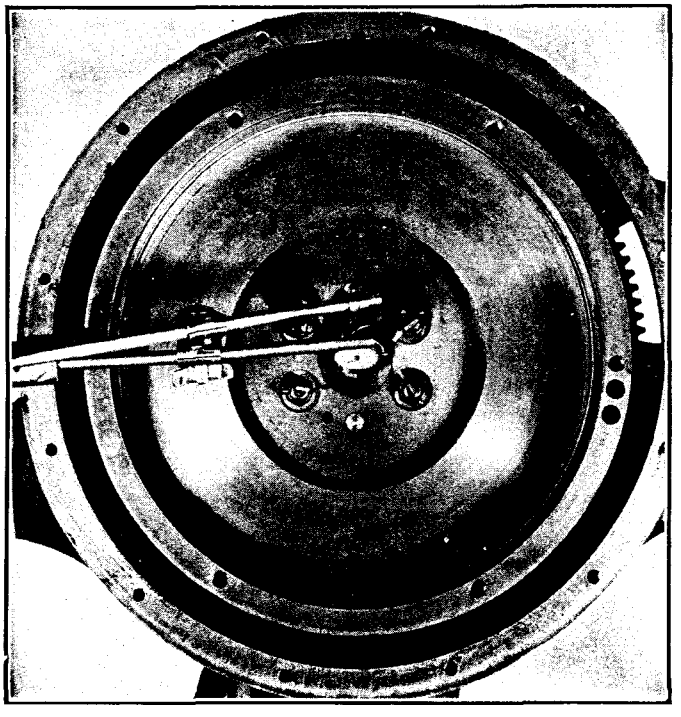


Illustration No. 28

4. Inspect the flywheel and ring gear for damage.
5. If necessary to remove the damaged ring gear, note the position of the chamfer on the gear teeth so the new gear can be correctly installed.
6. The ring gear may be driven from the flywheel by the use of a large drift and heavy hammer. When installing the new ring gear, the gear should be heated to, but not over, 450° F. and then assembled to the flywheel. The ring gear must be assembled so that it is square and properly seated on the flywheel.

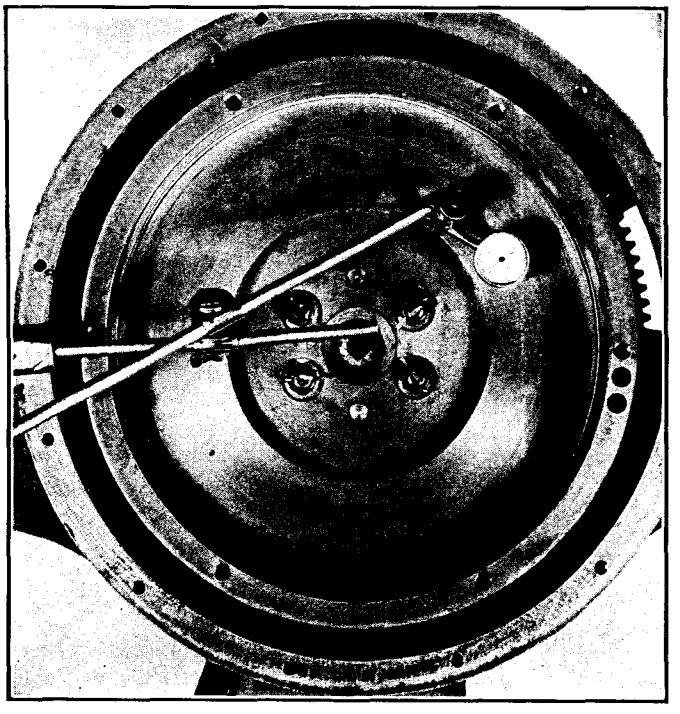


Illustration No. 29

TO INSTALL THE FLYWHEEL

1. Assemble the new seal in the bellhousing. See Illustration No. 8.
2. Polish the oil seal contact surface of the flywheel. This surface must not be scratched, nicked or otherwise damaged.
3. Turn the flywheel so the locating dowel hole is in line with the locating dowel in the crankshaft. See Illustration No. 7.
4. Coat the oil seal lightly with oil soap.
5. Install the flywheel on the crankshaft (use care that the flywheel timing or locating dowel is properly located in relation to the timing dowel hole in the flywheel) and draw into place with the flywheel attaching nuts. Do not draw any one nut down tight until all are progressively tightened.
6. Insert the dowels and expansion plugs.
7. Attach the indicator, as shown in Illustration No. 28, to check the concentricity of the pilot bore. This should not exceed .005" total reading.
8. Place the indicator in the position shown in Illustration No. 29 to check the face of the flywheel. This should not exceed .005" total reading.
9. Install the cotter pins.

FUEL PUMP

There are many different types of fuel pumps used on the JX series engines, but a careful study of the following instructions will be of assistance if repairs are necessary.

The fuel pump described is one of the diaphragm type, operated through suitable linkages by a rocker arm actuated from an eccentric on the camshaft and is mounted at the rear of the crankcase. Illustration No. 31 shows the sectional view of the pump with nomenclature of the various parts.

In the great majority of cases, trouble attributed to the fuel pump is generally caused by failure in some other part of the fuel system; therefore, be sure that the trouble is actually in the fuel pump before disassembling and repairing it. For instance, if the engine is not getting enough gasoline, check the level of the fuel in the fuel tank and check for broken, leaking or clogged fuel supply lines. Then, before removing the fuel pump from the engine, check for a leaking bowl gasket, loose diaphragm or top cover screws, or bad valves and springs. See Illustration No. 31.

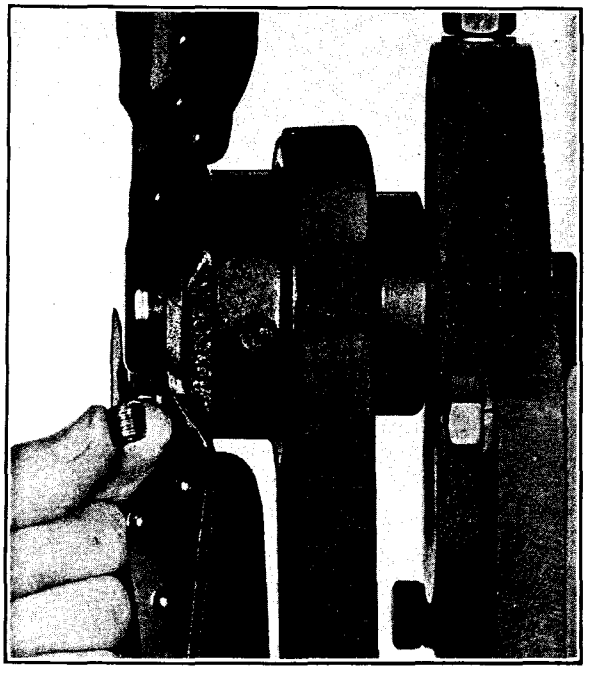


Illustration No. 30

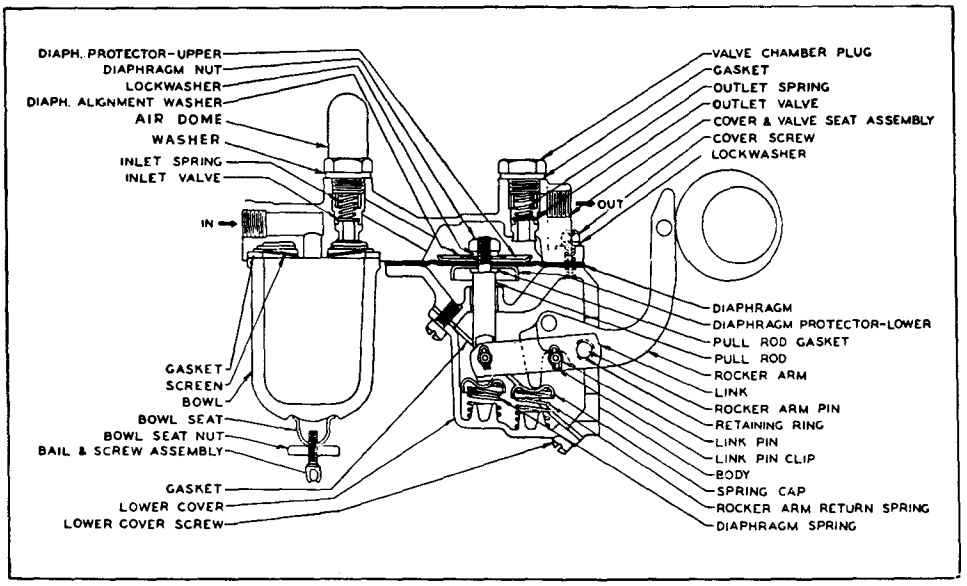


Illustration No. 31

If the engine is getting too much fuel, this is usually caused by a defective choke arrangement, punctured carburetor float, defective carburetor needle valve or improper carburetor adjustment; this is generally not caused by the fuel pump.

TO REMOVE THE FUEL PUMP

1. Disconnect the fuel line from the tank and the fuel line to the carburetor and move out of the way.
2. Remove the two attaching screws which hold the pump to the crankcase and remove the pump from the crankcase, remembering that the rocker arm will catch on the case unless it is carefully pulled out of the small opening.

NOTE: — If the fuel pump is forced away from the crankcase by the spring tension on the rocker arm, this will indicate that the high point of the eccentric is toward the pump; and, in order to facilitate installation of the pump, the engine should be cranked over one full turn to place this high spot away from the fuel pump, opposite to that shown in Illustration No. 31.

DISASSEMBLING AND INSPECTING

1. Loosen the thumb nut and remove the bowl.
2. Remove the bowl gasket and strainer.
3. Remove the check valves. These will be found under the hexagon nut and air dome. See Illustration No. 32.
4. Put a mark, with a chisel or file, on the top cover and body so the pump can be reassembled in the same position. See Illustration No. 38.
5. Remove the top cover screws. At this point, the top cover is completely disassembled.
6. Remove the diaphragm from the pull rod by taking off the nut and diaphragm protector.
7. Remove the three screws holding the bottom cover, being careful not to lose the springs and spring seats.
8. Remove the rocker pin. This will allow the pull rod, linkage and rocker arm to be removed.
9. Remove the link pin from the linkage to the pull rod.
10. Inspect all parts carefully, discarding those which must be replaced. Parts with holes worn out of round and worn pins should be replaced, as they cause lost motion in the actuating parts.

TO ASSEMBLE THE FUEL PUMP

A. To Assemble The Top Cover

1. Thoroughly rinse the fine mesh wire screen in gasoline or a good commercial solvent. Dry it, being careful not to bend the screen.
2. Turn the top cover upside down. Put the screen into the bowl recess.

Illustration No. 32

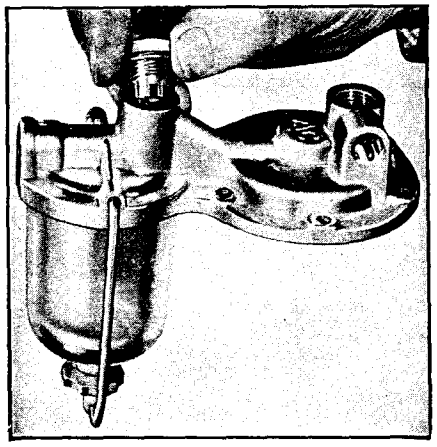


Illustration No. 33

Illustration No. 34

3. Place a new bowl gasket in position.
4. Thoroughly clean the bowl. Be sure that no lint is left in it. Then put the bowl in place over the gasket.
5. Swing the bail (wire loop) over the bowl. Tighten the bowl seat nut securely with your fingers. Be sure the bowl seat has not fallen off.
6. Turn the top cover right-side up. Put a drop of light oil, such as Finol (or equivalent), on a new inlet valve; then place the valve in the well or recess over the hexagon nut and air dome. See Illustration No. 32.
7. Place a new inlet valve coil spring on top of the inlet valve.

NOTE:—If the brass valve seats are worn or damaged, new ones can be installed. Special tools are required and can be secured from the manufacturer.

8. Replace the inlet valve chamber plug and gasket, starting it with your fingers to be sure the valve spring fits up into the pocket in the plug. See Illustration No. 33.
9. Put a drop of Finol (or equivalent) on a new valve and place the valve in the well or recess nearest the "outlet" opening.
10. Drop a new outlet valve coil spring down on top of the valve.
11. Replace the outlet valve chamber plug and gasket in the same way you replaced the other plug.

NOTE:—When an air dome is used, it is always placed over the outlet valve.

12. The top cover is now assembled.

B. To Assemble The Body

13. Assemble the two links with one link pin and clips.
14. Attach the two links to the pull rod with one link pin and clips. See Illustration No. 34.

WARNING!—Notice that one corner of each link is cut off. This indicates the corner which should be nearest the diaphragm when the links are attached to the pull rod. The pull rod slips between the links.

15. Install this assembly in the pump body, pushing the pull rod up through the hole provided for it.

NOTE:—Be sure that the two links will swing to one side toward the rocker arm pin hole. This is necessary so that the rocker arm pin will pass through the holes at the ends of the links.

16. Hold the pull rod in position and slip the rocker arm through the slot. Be sure that it slides in between the two links and that the projecting hook on it goes OVER the link pin.
17. Insert the rocker arm pin through the holes in the pump body (accessible from outside the pump body). See that the pin goes through one link, then the rocker arm, then another link.

18. Pein the edges of the pin hole over both ends of the pin with a pointed punch and hammer. If the rocker arm pin is the kind which uses rings to hold it, slip two spring rings into the grooves at each end of the pin. If the pin has a head on one end and a tapered, hollow end on the other, install a washer over the taper and spread the hollow part to retain in position.

19. Install the parts of the diaphragm assembly over the thread end of the pull rod in the following order: See Illustration No. 35.

Small pull rod gasket (use a new one).

Lower diaphragm protector.

Fabric diaphragm (use a new one and be sure that the "tab" is in a position which will not interfere with the bowl).

Diaphragm should be dipped in kerosene to soften. It also acts as a lubricant between the layers of the cloth in the diaphragm.

Upper diaphragm protector.

Diaphragm alignment washer (six-sided, very thin).

Lock washer.

Diaphragm nut.

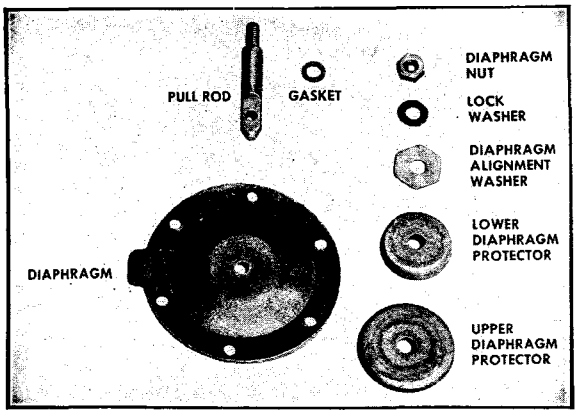


Illustration No. 35

20. Tighten the diaphragm nut with an open end wrench. Be sure that the holes in the diaphragm line up with the holes in the flange.

C. To Assemble The Lower Cover and Attach To The Body

21. Holding the lower cover in your hand, set the rocker arm spring and diaphragm spring in place over the two bosses (hollow cones) on the inside of the cover. See Illustration No. 36.

22. Put the two dished spring caps over the ends of the springs, rims down. See Illustration No. 36.

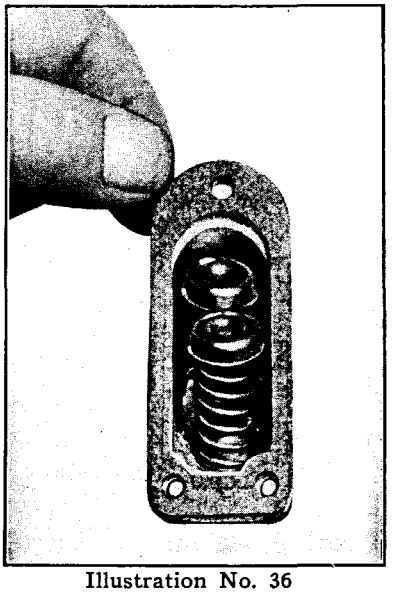


Illustration No. 36

23. Place the gasket on the cover flange. See Illustration No. 37.

24. Holding the pump body over this lower cover with your hand, bring them together. See Illustration No. 37.

NOTE:—Be sure that the cup of one cap fits around the end of the pull rod and the cup of the other fits around the end of the rocker arm.

25. Install the cover screws and lock washers in the holes provided and tighten securely.

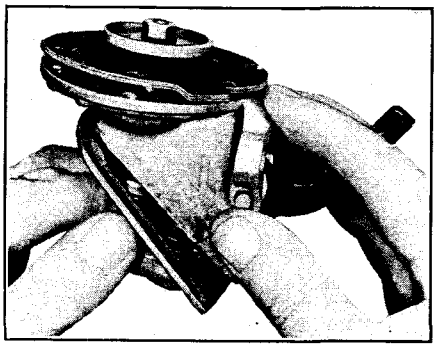


Illustration No. 37

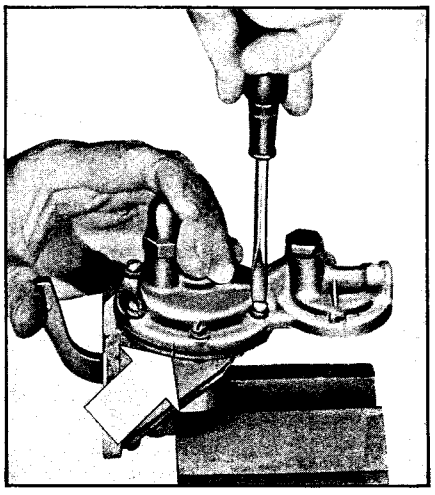


Illustration No. 38

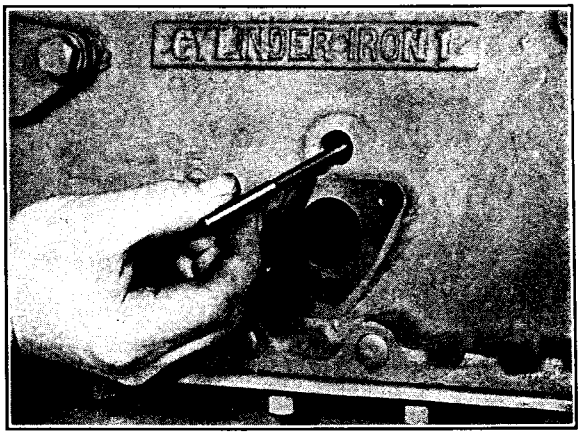


Illustration No. 39

D. To Attach The Top Cover To The Body

26. Put the body in a vise. Line up the scratch on the edge of the body with the scratch on the edge of the top cover. See Illustration No. 38.

27. Get the diaphragm level by moving the rocker arm. Hold it while you put in at least two opposite screws and washers finger-tight. Release the rocker arm and install the balance of the screws and lock washers. Be sure that they pass through the holes in the diaphragm easily without chewing the fabric. Tighten these screws only enough so that they just touch the lock washers. See Illustration No. 38.

28. Actuate the rocker arm several strokes, releasing with a snap.

29. Tighten the cover screws. Do this alternately—first, a screw on one side, then a screw on the opposite side. Tighten all screws securely. The most important single item in the repair of fuel pumps is the proper flexing of the diaphragm when the cover is assembled to the body.

TO TEST THE FUEL PUMP

Before installing the fuel pump, it is always desirable to test it. This can be accomplished as follows:

1. Hook the fuel supply line from the tank to the pump inlet connection.
2. Holding the pump in your hand, work the rocker arm, using long, even strokes. After quite a few strokes, the bowl will fill with fuel; and, after it is filled, a few more strokes will force it through the pump and out the outlet side.
3. With strokes approximately ¼" to ½" at the tip of the rocker arm, the pump should be able to deliver quite a bit of fuel. If it does not with these short strokes, this would indicate that the diaphragm was not correctly installed or that some of the valves were sticking.
4. Disassemble and recheck.

TO INSTALL THE FUEL PUMP

1. Place a new gasket on the fuel pump; and, if gasket cement is available, cement the gasket to the pump body and allow to dry.
2. Insert the rocker arm in the hole in the crankcase, being careful to keep the flange of the fuel pump in the correct position while the two cap screws are started (some installations use studs and nuts).
3. A slight pressure will be exerted by the rocker arm springs while the screws are being pulled tight. However, if this pressure is excessive, remove the pump, turn the engine over one turn and endeavor to install the pump as outlined above. This light pressure can be noted but it should not be so excessively strong as to tend to bend the rocker arm or prevent installation.

FUEL PUMP DRIVE PIN

Some engines have the fuel pump mounted on the water pump side of the engine and require a drive pin, Illustration No. 39, which extends across the cylinder block to the camshaft.

When installing a fuel pump on one of these engines, use care that the fuel pump rocker arm is correctly positioned on the pin, as breakage may result if the pump is drawn up tight while the tip of the rocker arm is under the drive pin rather than on the end of it.

GEAR COVER

The gear cover used on this engine is usually cast iron and covers the gear train at the front of the engine.

The governor and front support are mounted on the gear cover. The camshaft, idler shaft and water pump end thrust are controlled by suitable adjusting screws assembled in the gear cover.

TO REMOVE THE GEAR COVER

1. Assuming that the radiator has been removed, disconnect the governor to the carburetor control rod hooked to the governor lever, Illustration No. 40.
2. Remove the governor attaching screws and lift the governor away from the gear cover.
3. Remove the starting crank grab and fan drive pulley.
4. Remove the front motor support screws. If necessary to raise the front of the motor to release the front support, use a large block of wood under the oil pan so the jack will not damage it. The front support may be removed from the gear cover, if necessary.
5. Remove the gear cover attaching screws and pull the gear cover forward away from the engine. The crankshaft oil seal will pull off the shaft with the gear cover. If no gasket or seals are available, use care when removing these parts.

TO ASSEMBLE THE GEAR COVER

1. Wash and clean the gear cover and fasten a new gasket to the gear cover with gasket cement. Loosen the thrust screw lock nuts and back the screws out two or three turns.
2. Carefully install the oil seal on the crankshaft and slide the seal about one inch back on the shaft. If available, use a new seal and ring.

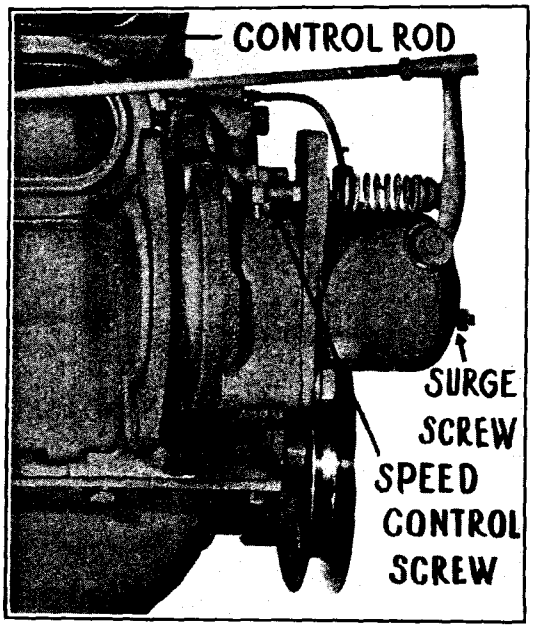


Illustration No. 40

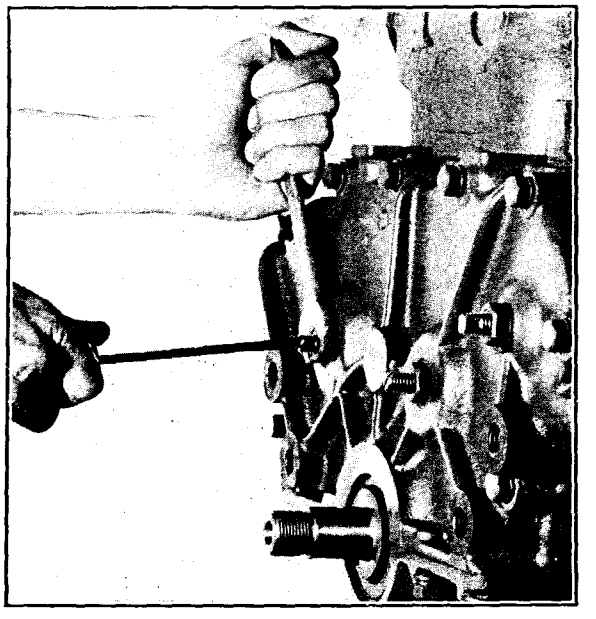


Illustration No 41

3. Assemble the gear cover on the seal. Use care that the seal properly seats in the groove provided for it in the gear cover.

4. In order to avoid any difficulty with the oil seal sleeve when pushing the gear cover back in place, loosen the oil pan and allow the front end of the oil pan to drop ⅛" to ¼". Then push the gear cover back into place. (To do this, relocate the jack supporting the engine.)

5. Check to see that the oil seal sleeve is properly located in the oil pan.

6. Start the gear cover attaching screws and, with some tension on the lock washers of the gear cover to the cylinder block screws, tighten the oil pan screws; also, the oil pan to gear cover screws. After these are tight, draw up the gear cover screws. Keep the seal concentric with the crankshaft.

7. Assemble the front motor support.

8. Assemble the fan drive pulley and starting crank grab.

9. Assemble the governor to the gear cover and fasten in place with the cap screws.

10. Connect the governor to the carburetor control rod.

11. Adjust the camshaft, idler shaft and water pump thrust screws. To adjust these screws, loosen the lock nut and turn the screw until it contacts the thrust plugs in their respective shafts; then, turn the screw out approximately ⅛th turn and tighten the lock nut. See Illustration No. 41.

GENERATOR

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

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

2. **Commutator**—If the commutator is dirty or discolored, it can be cleaned by holding a piece of 00 sandpaper against it while turning the armature slowly. Blow the sand out of the generator after cleaning the commutator. If the commutator is rough or worn, the generator should be removed from the engine, the armature removed and the commutator turned down.

3. **Brushes**—The brushes should slide freely in their holders. If the brushes are oil soaked or if they are worn to less than one-half of their original length, they should be replaced.

4. **Lubrication**—Add 3 to 5 drops of medium engine oil to the oilers in the end heads every 100 hours of operation.

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

GOVERNOR

Some engines are equipped with a governor for speed regulation, which is mounted on the gear cover and is driven by a gear meshing with the camshaft gear.

This governor operates on the principle of centrifugal weights or "flyballs". In operation, the force developed by the revolving weights is opposed or balanced by a spring called the operating spring. The spring is of the correct length and proper tension to control the engine speed at certain specified speeds with FULL LOAD.

CAUTION on maximum speed. The governor is set for the maximum engine speed at the factory and should require no further adjustment. However, if necessary, the governed speed may be changed, within certain limits, by turning the screw (Illustration No. 40) in to increase or out to decrease the speed. Do not set the governor for a higher speed than that spe ified for a particular application.

If the governor surges (sometimes called "hunting"), it may be necessary to make some slight adjustments. First, make sure that the spark plugs are clean and working properly and that the carburetor jets are clean; also, the carburetor throttle rod and all connections or joints on the governor rod work freely without binding and, at the same time, have no lost motion.

The length of the rod connecting the governor lever to the valve box lever is also important. The length of this rod should be such that with the engine at rest the valve box throttle should be wide open. The position of the surge spring, Illustration No. 40, should be such that it is compressed about 1/16" when the lever is pushed all the way to the closed position. However, it may be necessary, if the engine still surges, to loosen the lock nut and turn the surge screw out several turns. Then, slowly screw it back until the surging stops; tighten lock nut.

If necessary to inspect or repair the governor, it can readily be removed for this purpose. Disconnect the governor control rod and the lubricating oil line; then, remove the governor attaching screws and lift the governor away from the engine.

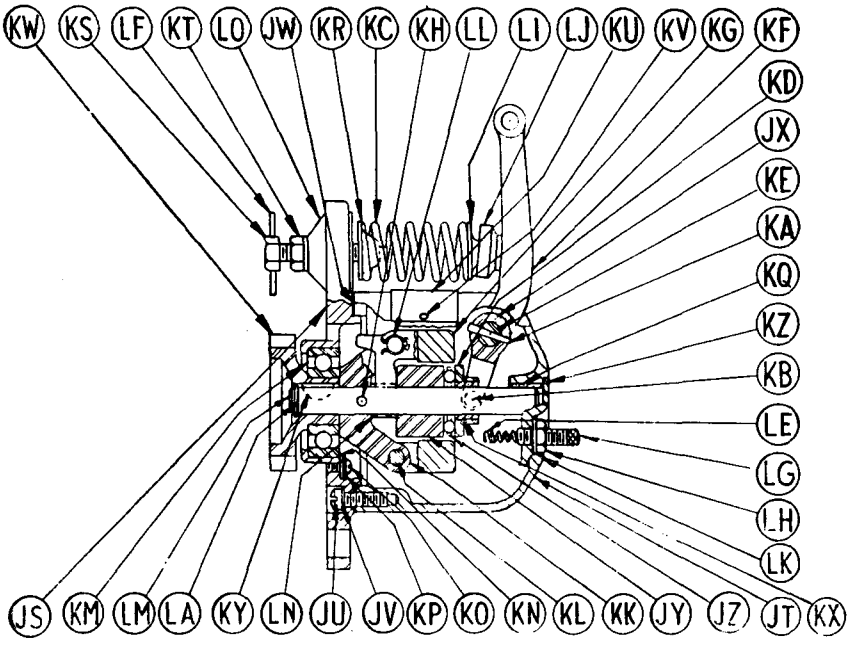


Illustration No. 42

TO DISASSEMBLE THE GOVERNOR

The following reference letters will be found in Illustration No. 42 (unless otherwise noted).

1. Loosen governor operating spring adjusting screw **(KS)** and remove spring **(KC)** and pilots **(KR** and **LI)**.
2. Remove screws **(JU)** and lock washers **(JV)**, then remove body assembly **(JT)** from base assembly **(JS)**.
3. Remove fork riser bearing **(JY)** from shaft **(LM)**.
4. Remove snap ring **(LA)** and pull gear **(KW)** from shaft **(LM)**, then remove Woodruff key **(KY)**.
5. Remove bearing retaining screws **(KO)**, lock washers **(KP)** and plain washers **(KN)**, then pull the shaft and the weights from the base.
6. Remove weight pin clips **(LL)**, weight pins **(KL)** and weights **(KG)**. (The weights are similar.)
7. Remove taper pin **(KH)** from weight carrier **(KK)**; then, with a suitable support under weight carrier **(KK)**, press shaft **(LM)** out of the weight carrier. (These parts should be serviced as an assembly; therefore, this paragraph may be disregarded.)
8. Press shaft **(LM)** out of bearing **(KM)**.
9. Remove the small expansion type plug from the body and, with a small pin punch inserted through this hole, remove fork pin **(KA)**.

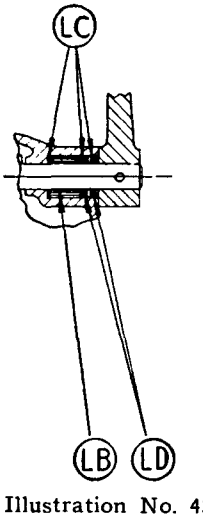


Illustration No. 43

10. Pull shaft **(KE)** and lever **(KF)** from the body as an assembly. (CAUTION: Be careful of the twelve roller bearings **(LB)**, Illustration No. 43, which may fall out when this shaft is removed.)
11. Remove packing retainer **(LC)**, packing **(LD)**, bearing retainer **(LC)**, roller bearings **(LB)**, inner bearing **(LB)** and inner bearing retainer **(LC)**, Illustration No. 43.

12. Remove bumper spring screw nut **(LH)**, screw **(LG)**, gasket **(LK)** and spring **(LE)**.
13. To remove bushing **(KQ)**, remove expansion plug **(KZ)** and press out the bushing.
14. Clean all parts; inspect for wear or damage.

TO REASSEMBLE THE GOVERNOR

1. Press bushing **(KQ)** into body **(KX)** and install expansion plug **(KZ)**.
2. Place bearing retainer **(LC)**, Illustration No. 43, in the control shaft hole and insert roller bearings **(LB)**, outer bearing retainer **(LC)**, packing **(LD)**, packing retainer **(LC)** in body **(JT)** and insert control shaft **(KE)**, Illustration No. 42, while holding the fork in position so that shaft **(KE)** may enter it. Be sure the fork bumper spring arm is on the correct side. (Light cup grease applied to the roller bearings will hold them in place until the control shaft is installed.)
3. Install fork taper pin **(KA)** and the small expansion plug.
4. Press shaft **(LM)** into bearing **(KM)**.
5. Press weight carrier **(KK)** on to shaft **(LM)** and insert taper pin **(KH)**.
6. Assemble weights **(KG)**, insert weight pins **(KK)** and lock with pin clips **(LL)**.
7. Assemble the shaft and weight assembly in base plate **(JS)** and install bearing retainer screws **(KO)**, lock washers **(KP)** and plain washers **(KN)**.
8. Insert Woodruff key **(KY)** and, with a suitable support under the shaft, press on gear **(KW)** and install snap ring **(LA)**.
9. Place fork riser bearing **(JY)** on shaft **(LM)** with the large end toward the weights.
10. Place new gasket **(JN)** on the base and assemble to the body with screws **(JY)** and lock washers **(JV)**.
11. Assemble operating spring pilot **(KR)** on adjusting screws **(KS)**.
12. Place pilot **(LI)** on spring **(KC)** and assemble the spring and pilot to the governor.

SAVE YOUR BATTERIES

Do not turn engine with starter unnecessarily.

IDLER GEAR

The idler gear is supported on a shaft which, in turn, is supported in a bushing pressed into the cylinder block. The shaft is pressure lubricated from passages drilled from the main oil passage. The shaft and gear are also drilled in such a manner that twice each revolution of the idler gear a spurt of oil is forced into a groove in the rear side of the idler gear. This oil is thrown by centrifugal force through small holes drilled from the groove to the outer circumference of the gear. By this method, the timing gears are assured ample lubrication. See Illustration No. 44.

TO REMOVE THE IDLER GEAR AND BUSHING

1. Remove the gear cover. See **"Gear Cover."**
2. Pull the idler gear and shaft forward out of the crankcase.
3. Press the shaft out of the gear.
4. The bushing may be removed by using a driver (13232-A), as shown in Illustration No. 45.

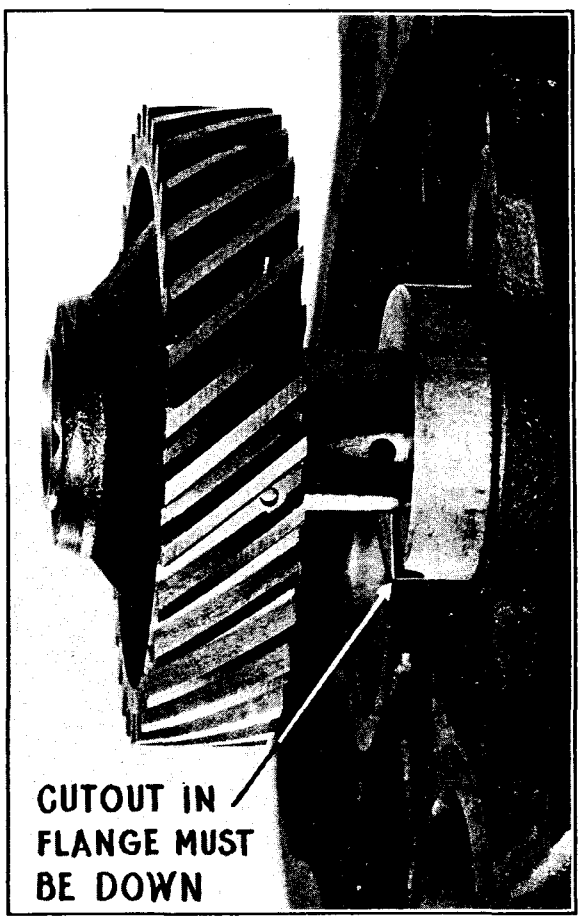


Illustration No. 44

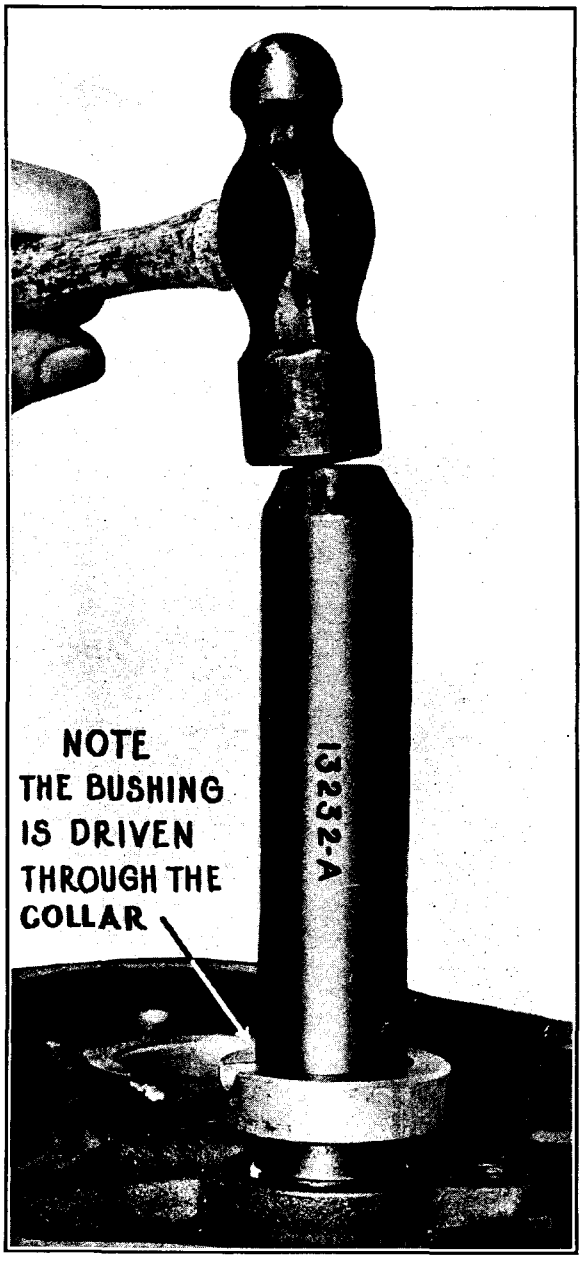


Illustration No. 45

TO INSTALL A NEW GEAR AND BUSHING

1. Install a new bushing. Note the position of the hole in the bushing. Use extreme care that the oil hole in the bushing is in line with the hole in the crankcase. (The same driver, 13232-A, is used to install the bushing. See Illustration No. 46.)
2. These bushings are usually reamed to size. However, try the shaft in the bushing; it should have .00075″ to .001″ clearance.
3. Insert the Woodruff key in the idler shaft and press the shaft into the gear.
4. Apply a small amount of grease to the thrust washer. This will tend to hold the thrust washer on to the gear hub while the gear is being installed in the engine.
5. Start the shaft in the bushing and line up the teeth so that they mesh with the cam and water pump; then, press the gear into place. If the camshaft or water pump gears have not been moved, it will not be necessary to retime the distributor. If the gears have been moved, see **"Ignition Timing"** below.
6. Reassemble the gear cover. See **"Gear Cover."**

IGNITION TIMING (Battery)

NOTE:—Since the ignition system is usually not furnished by the Hercules Motors Corporation, the following is inserted here for general information only. Instructions for ignition timing will differ slightly with different makes of electrical equipment, and the following is in the nature of general in-

structions suitable for any type of battery ignition. If the distributor has been removed or for any reason it becomes necessary to check or reset the ignition timing, proceed as follows:

There is a timing hole through the bellhousing for spotting the engine. See Illustration No. 26. When the dead center mark (DC 1 and 6) on the flywheel lines up with the mark across the center of the hole in the bellhousing, the pistons for No. 1 and No. 6 are on top dead center. The first step in setting or checking the ignition timing is to locate the (DC 1 and 6) mark and line it up with the mark on the bellhousing. To determine whether the engine is in firing position for No. 1 and No. 6, the engine can be cranked with the spark plugs removed to determine the compression stroke of one of these cylinders, or the valve tappet cover can be removed and the position of the valves noted. If both tappets for No. 1 cylinder are clear, indicating that the valves are closed, and the exhaust valve on No. 6 is not completely closed, this will indicate the firing position for No. 1 cylinder.

With the ignition points clean, making a square contact and set to the proper gap opening of .018" to .020", the points should be just beginning to open on dead center with retarded spark. The automatic advance or manual advance, or combination of the two, whichever is employed, will then advance the spark to the proper position when the engine is running.

There are several methods of checking accurately the exact point of contact opening. One method is by using a test light which, if connected in series with the primary circuit (when the ignition switch is on), will be lighted when the ignition contacts are closed and not lighted when the contacts are open. To change the ignition timing, loosen the clamp screw holding the spark control arm to the distributor and turn the distributor until the correct timing is obtained; then tighten the clamp screw. If the distributor is being retimed after having been removed, it is now necessary to see if the rotor lines up with the distributor cap segment connected to No. 1 cylinder and that the remaining ones are connected in the order 1-5-3-6-2-4, which is the firing order of the standard engine. For the counterclockwise engine, the firing order is 1-4-2-6-3-5.

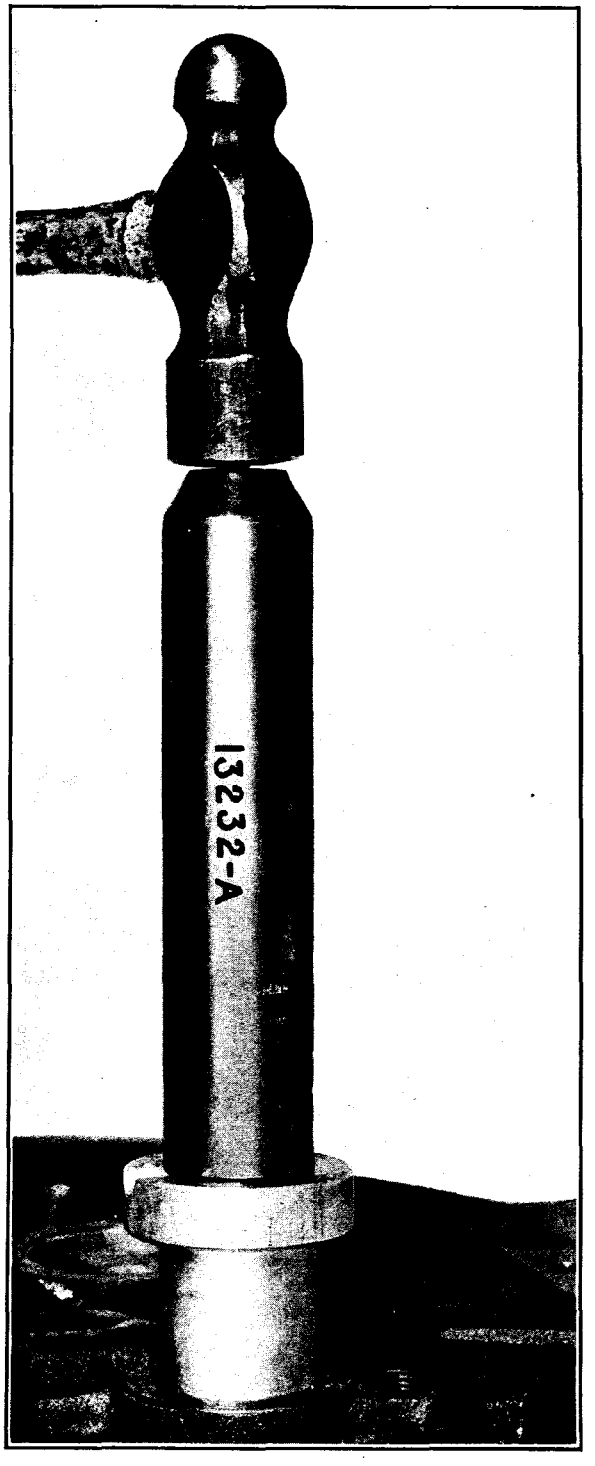


Illustration No. 46

MAGNETO IGNITION TIMING

The magneto, producing an ignition spark only at certain definite points in the rotation of the magnet rotor, must be connected and timed to the engine in such a manner that the spark is always available at the instant it is required in the cylinder.

If the magneto has been removed for any reason and it becomes necessary to check or reset the ignition timing, proceed as follows:

There is a timing hole through the bellhousing for spotting the engine. See Illustration No. 26. When the spark mark (do not confuse with the DC mark), which is before the top dead center mark on the flywheel, lines up with the mark across the center of the hole in the bellhousing, the cylinders are in firing position. The first step in setting or checking the ignition timing is to locate the spark mark and line it up with the mark on the bellhousing.

To determine whether the engine is in firing position for No. 1 or No. 6, the engine can be cranked with the spark plugs removed to determine the compression stroke of one of these cylinders, or the valve tappet cover can be removed and the position of the valves noted. If both tappets for No. 1 cylinder are clear, indicating that the valves are closed, and the exhaust valve on No. 6 is not completely closed, this will indicate the firing position for No. 1 cylinder. (No. 1 cylinder is the one nearest to the timing gears.)

a. Rotate the impulse coupling until the line on the distributor gear is visible in the observation window. This operation is best performed by turning the impulse coupling in the opposite direction of rotation to that in which it will be driven by the engine, thus eliminating the engagement of the impulse weights. (On some magnetos the timing marks are on the impulse coupling housing.)

b. Mesh the impulse coupling with the engine drive. Approximate timing is now obtained. Carefully align the magneto with the engine drive and securely fasten the unit in place.

c. Remove the distributor plate by loosening the four screws. This will expose the interrupter assembly.

d. To obtain the exact timing, the interrupter points must just begin to open. It may be necessary, in order to get that position, to loosen the adjustable drive member and turn the impulse coupling in a clockwise or anti-clockwise direction.

e. Reinstall the distributor plate and insert the cable between outlet No. 1 and cylinder No. 1, which is then timed to fire correctly.

Complete the installation by connecting the remaining cables of the magneto to the spark plugs in their proper firing order (marked on the engine manifold). The firing sequence on the distributor or high-tension end of the magneto follows the opposite direction of rotation from that indicated by the arrow on the magneto name plate and must be taken into consideration when the cables are connected to the spark plugs.

MAIN BEARINGS

The use of seven main bearings permits a main bearing to be placed on each side of each connecting rod bearing. See Illustration No. 2. This construction helps to decrease vibration at high speeds. The center and rear main bearing caps are held in position by four alloy steel cap screws 7/16" in diameter while the remaining ones are held by two alloy steel cap screws ½" in diameter. The bearing caps are supplied for either one of two types of bearings, depending on the requirements of the service to which the engine is applied.

In the poured babbitt type, the babbitt is poured directly to the caps after the caps have been properly tinned. In this type of bearing, the upper half of each bearing is a babbitt lined, bronze shell ⅛" thick.

The alternate type is known as the shell type. In this construction there is a removable shell in each cap, as well as for the upper part, and the upper shell is interchangeable with the lower shell for each bearing. The shell type is further divided into two types, one having shims for adjustment, the other having no shims, and reconditioning of this type bearing is accomplished only by replacing the shells. These precision type shells are completely finished before being put in place; no line reaming or scraping is required. This allows renewal of the bearings to be easily accomplished. The precision type shells each have a small ear or projection which fits into a recess, which allows the ear to rest against the adjoining case or cap to prevent the shell from rocking or rotating. These shells are approximately 1/16" thick and are not interchangeable with the upper shells used with the babbitted type caps. The bearing metals commonly used in the precision shell type bearings are harder and have a higher melting point than ordinary babbitt metal; this requires the use of a hardened crankshaft.

ADJUSTMENT AND FITTING OF BEARINGS — Except Shimless Type

The bearings in these engines are readily accessible after the oil pan and oil pump are removed. The bearings are adjusted for excessive clearance, due to normal wear, by removing the shims. The bearings should never be adjusted so tight that they bind or drag. A certain minimum clearance is required at all times to provide an adequate oil film between the shaft and the bearing and insure a free running engine. The bearings in these engines are of ample proportion and the full pressure lubrication system employed will give long lasting bearings, provided they are not adjusted too tight. The best method is to remove just

enough shims from each bearing, in turn, until the shaft can be turned only with considerable effort; then add the proper amount of shimming to each side of the bearing. See **"Clearance Table."** Shim thickness, corresponding to the clearance figure given in the table, should be added to each side of the bearing. While testing each bearing for tightness, by cranking, the spark plugs should be removed to relieve compression and the other bearings should be comparatively loose. After all the bearings are adjusted and all the caps tightened, it should be possible to turn the shaft readily with the crank. When using trial shimming to get the proper drag on the shaft and before adding the clearance shimming, the shims can be decreased .001" by removing a .003" shim and putting in a .002" shim on each side. To increase the shimming .001" at a time, remove a .002" shim and put in a .003" shim on each side.

Tightening of the main bearing cap screws requires some care to prevent too much strain on the parts. Special wrenches are on the market which enable the mechanic to measure the force of his pull when tightening such parts. The wrench tension values given in **"Wrench Tension"** show the correct amount of pull to use on various screws. No attempt should be made to refit these bearings by filing or grinding the caps, as this will ruin the cap so new shells cannot be installed.

REPLACEMENT OF THE MAIN BEARINGS

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

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

1. Disconnect the battery cable at the battery.
2. Disconnect the starter cable and wiring, then remove the starter.
3. Drain the crankcase oil.
4. Remove the oil pan.
5. Remove the oil pump.
6. Loosen all main bearing cap screws.

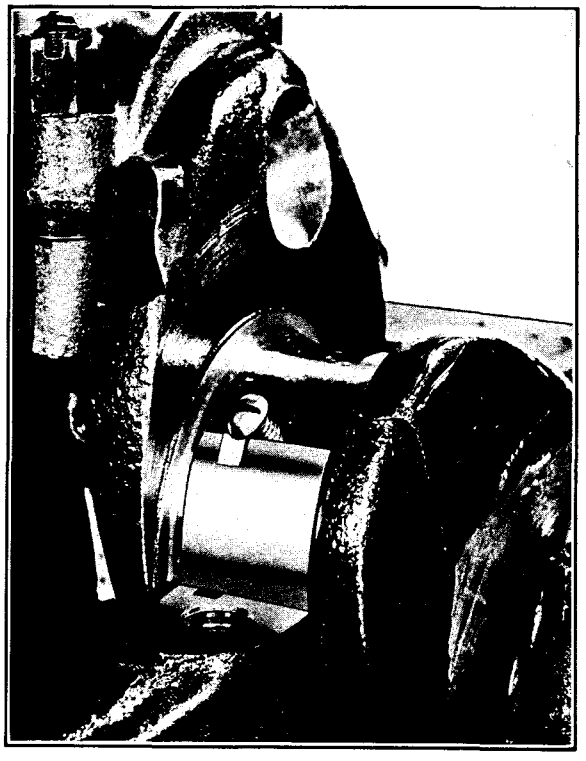


Illustration No. 47

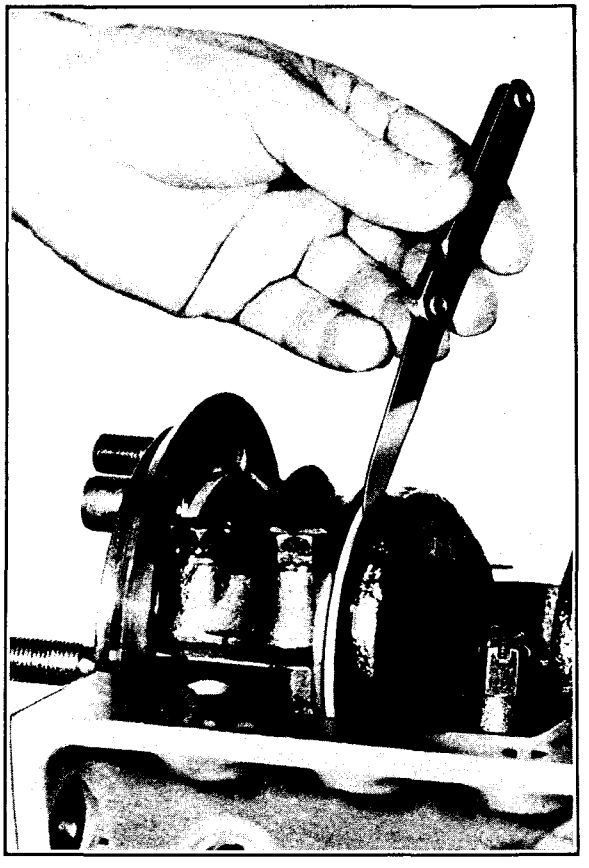


Illustration No. 48

7. Remove one bearing cap at a time and make the bearing replacement. To remove the upper shell, a small pin may be inserted in the crankshaft oil hole and the shaft rotated so that the pin will push the bearing out. The new bearing may be inserted in the same manner. See Illustration No. 47.

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

8. Assemble the bearing cap and lower shell and tighten the screws. See **"Wrench Tension."** If no torque wrench is available, use a wrench with a 12" handle.
9. After installing the new thrust bearings on the rear main bearing, check the end thrust, Illustration No. 48 (see **"Clearance Table"**). It is permissible to draw file the thrust bearings to obtain the proper clearance, if necessary.
10. Thoroughly recheck the inside of the engine for loose screws, nuts, et cetera.
11. Install the oil pan.
12. Install the starter.
13. Connect the starter cables.
14. Connect the battery cable.
15. Fill the crankcase to the 4/4 mark on the bayonet gauge (see Illustration No. 4) with the proper grade of oil.
16. Start the engine and immediately check the oil pressure (some slight adjustment may be necessary). See **"Oil Pressure Adjustment."** If sufficient, allow the engine to run for a few minutes while checking for oil leaks, etc.; then stop the engine and recheck the oil level. Add oil, if necessary.

MANIFOLD (Intake and Exhaust)

There are a great many different types of manifolds used on the JX and JXL series engines; therefore, it is not practical to discuss them at length in this book. Manifolds differ as to the size of the carburetor attaching flanges and the size of the intake galleries. Also, the intake manifold ports vary in size. Different exhaust outlets are used on different installations. Different manifolds are also manufactured for use with different types of fuel. From this list of differences, one can readily see the importance of replacing the manifold on the engine with the same type manifold unless the engine is to be applied to a different type of operation.

In installing manifolds, it is essential to use new gaskets and to be sure that the manifold intake and exhaust ports line up and are the same size as those in the cylinder block. When tightening the manifold stud nuts, a washer should be used under the nut and the manifold progressively tightened from the center to the end, repeating the operation at least three or four times to make sure that the manifold is tight.

In many instances, a companion flange and gasket are used for the installation of the exhaust pipe. Be sure these are drawn up tight and square with the manifold flange to avoid leaks.

TO REMOVE THE MANIFOLD

1. Disconnect the fuel lines.
2. Disconnect the carburetor controls. Carefully note how the controls are assembled so they can be replaced in the correct position.
3. Remove the air cleaner or air cleaner connections.
4. Remove the carburetor.
5. Disconnect the crankcase ventilating assembly, if used.
6. Disconnect the exhaust pipe from the manifold.
7. Remove the manifold attaching nuts and washers.

TO INSTALL THE MANIFOLD

1. Place the manifold gasket on the attaching studs and assemble the manifold to the engine.
2. With the nuts and washers as removed, tighten the manifold into place. Tighten all nuts lightly; then, starting from the center, work progressively toward the ends of the manifold, repeating until all nuts are tight.

3 Attach the exhaust pipe and tighten the screws.

4. If the crankcase ventilation valves were removed — reinstall.

5. Connect the crankcase ventilation tube assembly.

6. Install the carburetor.

7. Install the air cleaner or connect the air inlet tube.

8. Connect the carburetor controls. Make sure these controls are correctly assembled.

9. Connect the fuel lines.

OIL FILTER

When the engines are equipped with an oil filter or filtrator and cooler, this unit should be given regular and careful attention. The base of the filter should be drained at least every time the engine oil is changed. To drain the sludge from the filter, remove the large hex-headed plug and allow to drain for several minutes, or start the engine and allow to idle until about two quarts of the oil have run out. Then replace the plug and add sufficient oil to the crankcase so the oil level will be correct after the engine has run long enough to refill the filter. The filter can also be cleaned by removing the case and scraping the sludge from the outside of the element with a wooden paddle, or replace the element.

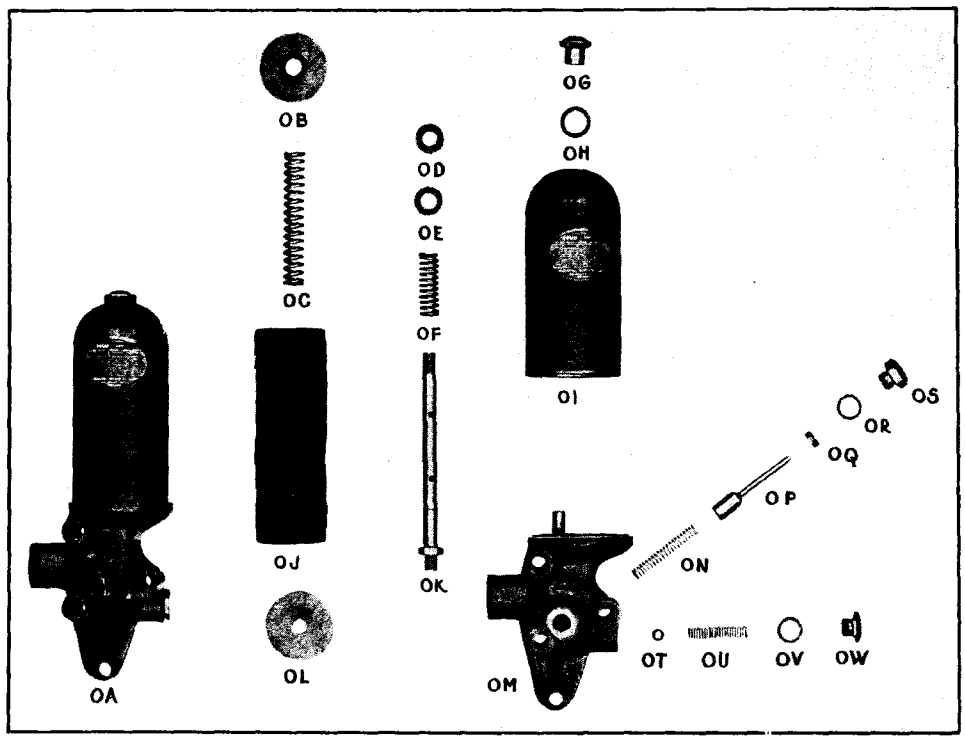


Illustration No. 49

TO REMOVE THE OIL FILTER

1. Drain the cooling system.
2. Loosen the hose connection to the water pump.
3. Remove the filter attaching screws from the base and lift off the filter.

TO DISASSEMBLE THE OIL FILTER (Illustration No. 49)

1. Remove the element cover.
2. Remove the element assembly.
3. Remove the relief check valve spring nut, spring and valve.
4. Wash and clean all parts.

TO REASSEMBLE THE OIL FILTER

1. Assemble the relief valve, valve spring and spring retaining plug in the filter base.
2. Replace the element assembly.
3. Place a new filter shell gasket in the groove in the base and assemble the shell.

TO INSTALL THE OIL FILTER

1. Place a small amount of cup grease on the filter attaching gasket and place the gasket on the filter dowel in the cylinder block. **Be sure the correct gasket is used.**
2. If the water pump hose is damaged, replace the hose.
3. Assemble the oil filter to the cylinder block with the screws, as removed.
4. Tighten the water pump hose clamps.
5. Fill the cooling system.
6. Start the engine and allow the oil filter to fill with oil, then stop the engine and refill the crankcase to the 4/4 mark with the proper grade of lubricating oil.

ANY TYPE of oil filter must be given intelligent attention and frequent cleaning if it is expected to remove dirt, etc., from the oil. Some filters must be inspected daily—study the service requirements of your particular type and save repair expense.

OIL LINES

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

SCAVENGING OIL LINES — (Illustration No. 50)

These lines pick up the oil at the ends of the oil pan and return it to the center sump. Any leaks in these lines will obstruct the suction action of the scavenging pump and prevent the oil being returned to the center sump. Each time the oil pan is removed inspect these lines and clean the screens. Repair or replace, if they leak.

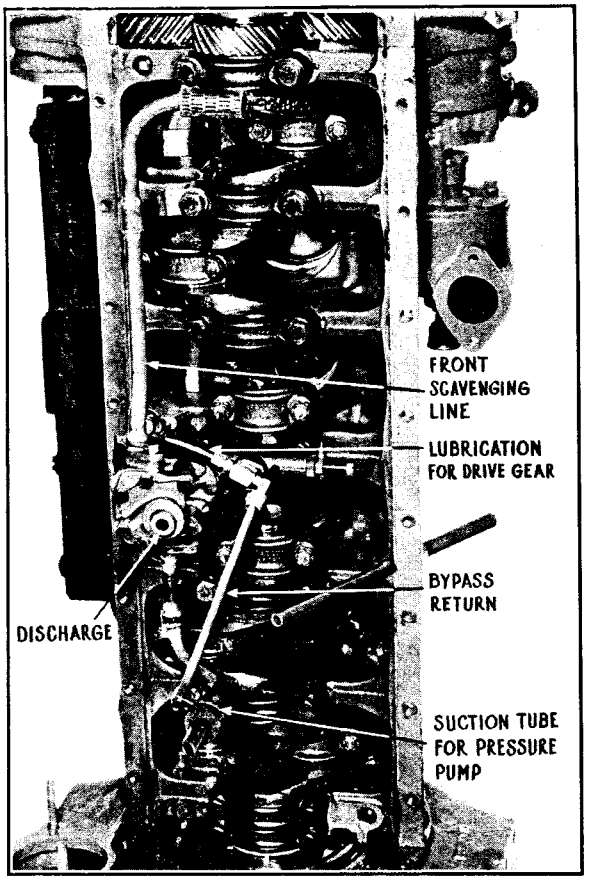


Illustration No. 50

GOVERNOR LUBRICATING OIL LINE

Since this is an external line, a leak will be observed by oil being blown over the engine. If broken, repair or replace. Clean each time the engine is overhauled or if the governor fails because of lack of lubrication. Be sure to clean before replacing, after repairing the governor.

OIL PAN

The oil pan serves as a cover for the bottom of the crankcase and also as an oil reservoir.

Suitable drain plugs are located in the bottom of the oil pan. See Illustrations No. 51 and No. 52.

TO REMOVE THE OIL PAN

1. Drain the crankcase oil.
2. Disconnect the starter cable and remove the starter. Tape any "hot" cable terminals.
3. Remove the oil strainer assembly, if one is used. See Illustration No. 52.
4. Remove the bayonet gauge assembly.
5. Remove the cap screws from the oil pan and lift the oil pan away from the engine.

Illustration No. 51

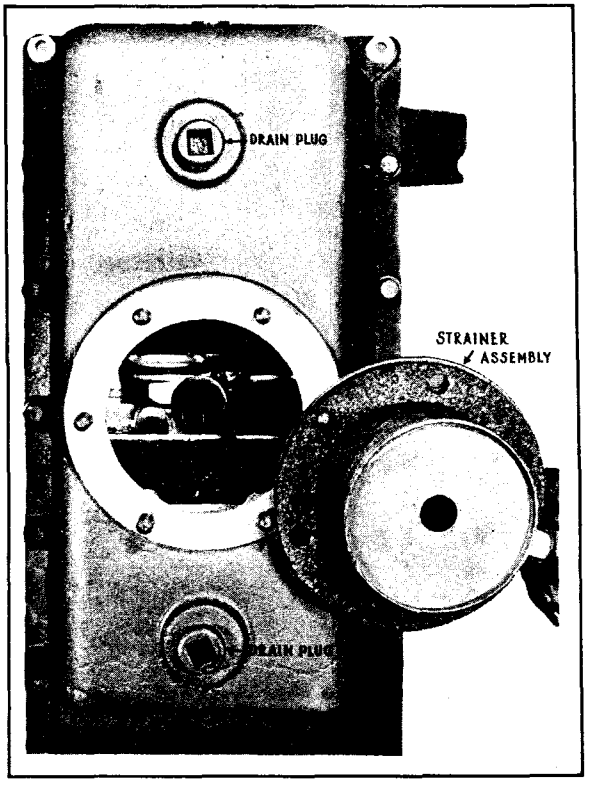


Illustration No. 52

TO INSTALL THE OIL PAN

1. Clean the oil pan thoroughly; remove the old gaskets. Install the baffle plate and strainer.
2. Inspect the inside of the engine for loose nuts, screws, cotter pins and lock wires. Tighten or replace.
3. Cement the new gaskets in place and allow the cement to set so the gaskets will not skid. If the lower part of the bellhousing gasket is damaged, cut at the oil pan intersection at the block and replace with a similar part of a new gasket.
4. Put the oil pan in place and carefully start all screws. Be sure the lock washers are on the screws.
5. Draw up all screws very lightly. Make sure the pan is centered at the crankshaft oil seal so as not to damage the rubber ring.
6. Tighten progressively the five screws in the bellhousing and the three screws next to the bellhousing (both sides) in the crankcase, alternating between the vertical and horizontal screws until tight. This is to pull the corner of the pan in against the corner formed by the bellhousing and cylinder block or crankcase.
7. Check alignment of the oil pan at the front seal and tighten the four cap screws at the front in the gear cover.
8. Tighten all remaining screws.
9. Wash the strainer assembly and install a new gasket on the engine with a strainer like that shown in Illustration No. 52.
10. Fasten the strainer in place.
11. Put in the drain plugs.
12. Reinstall the starter motor and cables.
13. Reinstall the bayonet gauge assembly.
14. Refill with oil to the correct level.

OIL PUMP

There are many different oil pumps used to suit various types of oil pans and types of operation. These include the basic or standard pump shown in Illustration No. 53 and the scavenging pump shown in Illustration No. 54, which has, in addition to the gear type pressure pump, a scavenging pump of the vane type mounted in place of the conventional cover. This pump is driven from the main pump shaft.

The purpose of the scavenging pump is to pick up oil from the front of the oil pan, Illustration No. 50, and return it to the sump where it is picked up by the pressure pump.

If the instructions for the disassembling and reassembling of the standard pump given in the following paragraphs are carefully followed, the mechanic should not find it difficult to make repairs on any of the oil pumps.

The oil pump is attached to the cylinder block and its gear is driven by a gear solid with the camshaft and located near the center of the 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. The oil pump extends into the oil; therefore, the pump needs no priming. After the oil pan is removed, the oil pump is readily removed for inspection or repairs. The various parts of the oil pump are shown in Illustrations No. 53 and No. 54.

TO REMOVE THE OIL PUMP
(See Illustration No. 55)

1. See the removal of the oil pan.
2. Remove the pump attaching screws.
3. Pull the oil pump out and away from the cylinder block. Use care that the pump does not fall out if the engine is in normal position.

   As the oil pump operates in a bath of oil, it seldom needs repair. However, if necessary to disassemble the pump, proceed as follows:

TO DISASSEMBLE THE OIL PUMP

The following reference letters will be found in Illustrations No. 53 and No. 54 (unless otherwise noted).

1. Remove pin (**WI**) from drive gear (**WA**), pull the gear from shaft (**WK**) and remove Woodruff key (**WB**).
2. Remove screws (**WE**) and pump cover (**WH**).
3. Remove idler gear (**WO**) and shaft (**WN**).

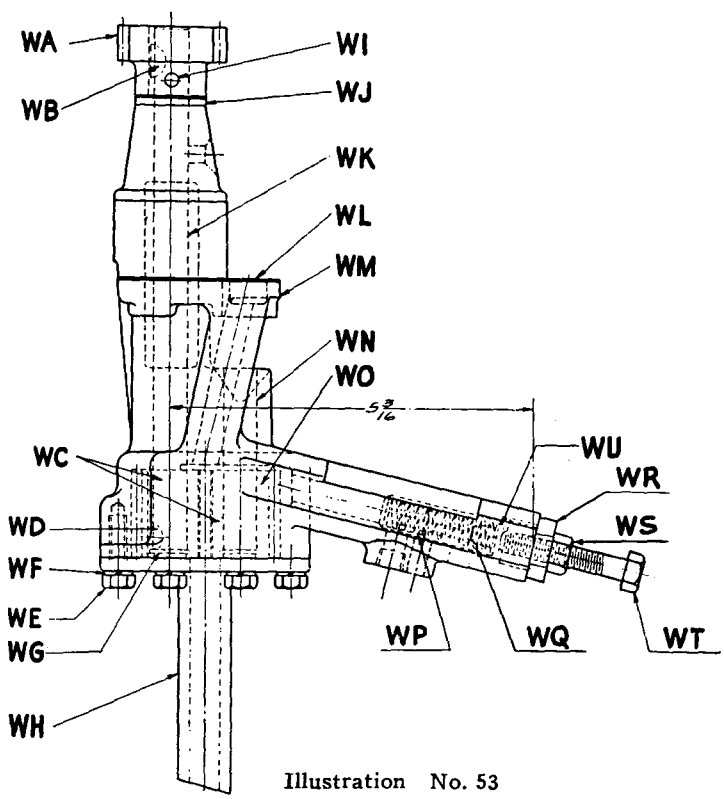


Illustration No. 53

4. Pull main shaft (**WK**) down through pump body (**WM**) to remove it.
5. Press idler gear shaft (**WN**) out of gear (**WO**).
6. Press main shaft (**WK**) through oil pump gear (**WC**) approximately 3/8" and remove snap ring (**WG**). Then press the shaft out of the gear.

TO REASSEMBLE THE OIL PUMP

(Certain operations may be disregarded if the pump is not completely disassembled.)

1. Insert Woodruff key (**WD**) in shaft (**WK**); press pump gear (**WC**) on shaft; install snap ring (**WG**). Then press the shaft back so that the snap ring seats in the gear.
2. Assemble shaft (**WK**) in body (**WM**), install thrust washer (**WJ**), insert Woodruff key (**WB**) and press on drive gear (**WA**). This shaft must have .0015" to .003" end thrust.

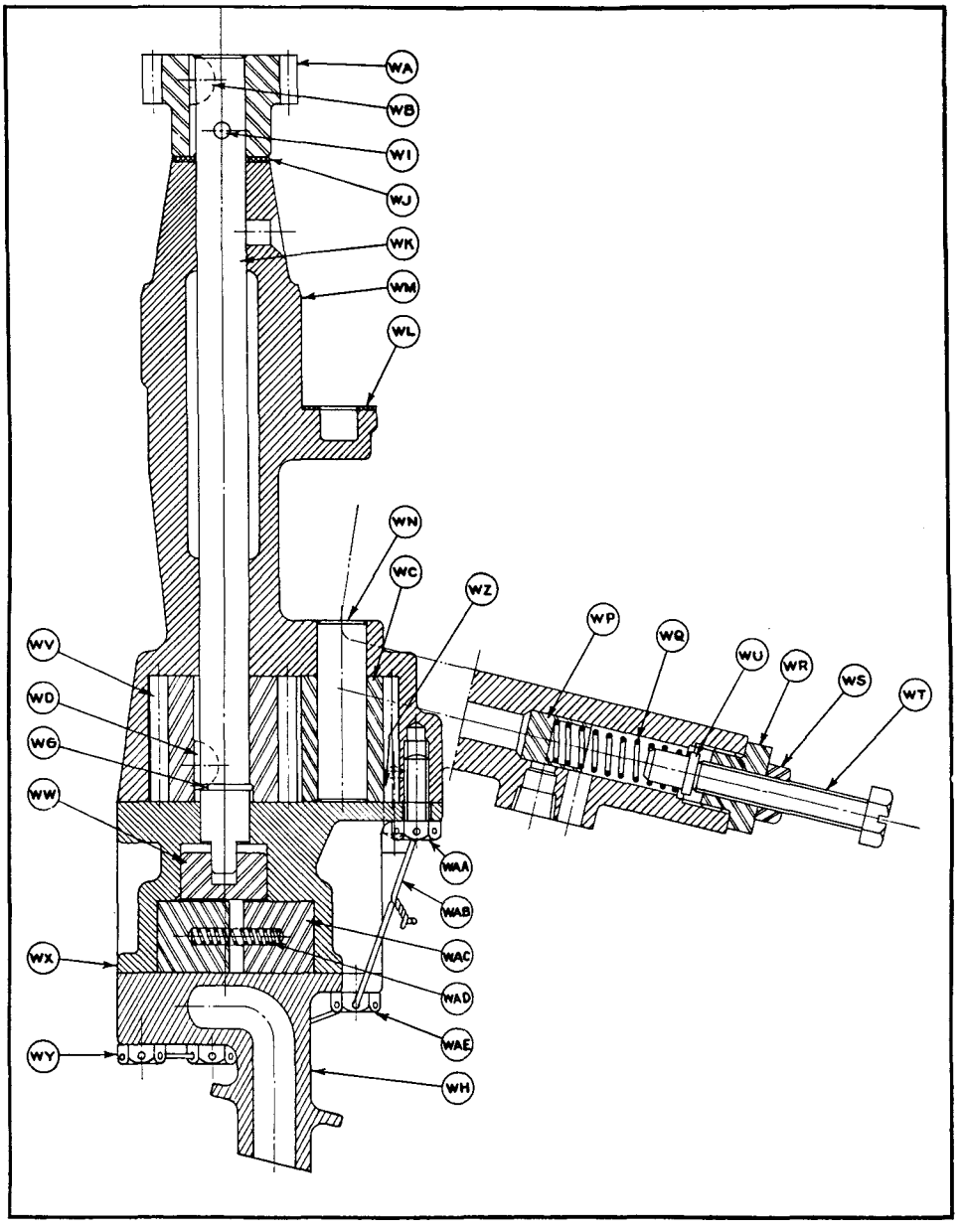


Illustration No. 54

3. Insert drive gear pin **(WI)** and pein over the ends of the pin. (If a new shaft is used, it must be drilled for the pin. Use the holes in the gear as a guide.)
4. Insert idler gear **(WO)** and shaft **(WN)**.
5. Rotate the shaft and check for tight places; the shaft should rotate freely. If the pump shaft does not rotate easily, disassemble and check for dirt or chips in the gear teeth or between the gear ends and body before proceeding.
6. Install the cover and tighten the screws; then check the same as in No. 5.

TO INSTALL THE OIL PUMP

1. Put the pump in place, using a new gasket. Fasten with the screws, as removed, securing them with the lock washers. See Illustration No. 56.
2. Place the steel washer and felt washer on the pump intake pipe, if used.
3. Install the oil pan. See **"Oil Pan."**

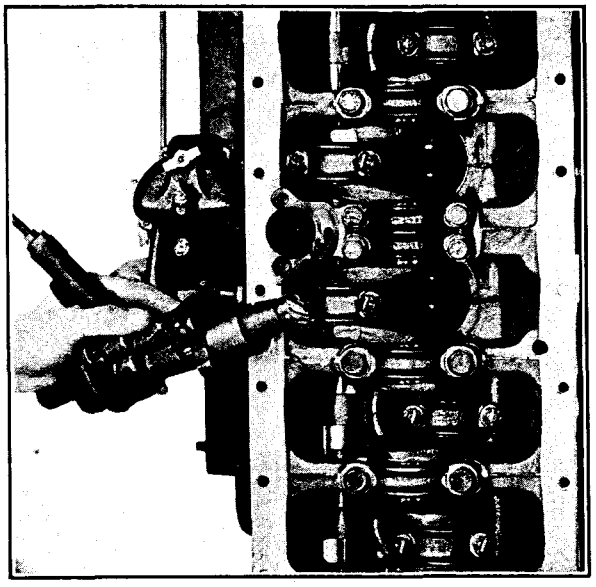


Illustration No. 55

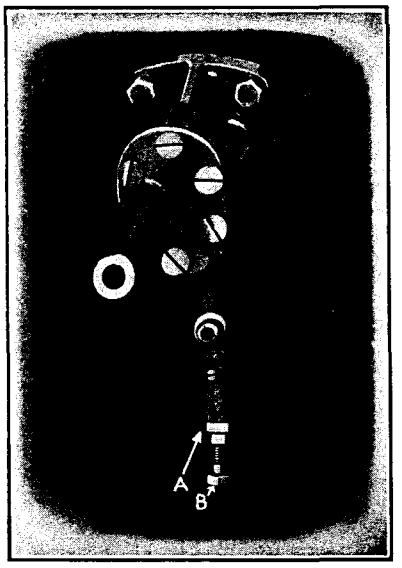


Illustration No. 56

OIL PRESSURE ADJUSTMENT

The oil pressure is automatically controlled or regulated by a compression spring, which controls a relief or bypass valve. This device is incorporated in the oil pump. The oil pressure should not be changed or judged to be too high or too low until it is known that the proper weight of oil is being used and the engine is warmed up to the normal operating temperature. As the bearings become worn, more oil will escape around them into the crankcase; this will lower the pressure slightly. It is not advisable to try to correct this slight loss of pressure by an adjustment of the oil pressure regulator because the extra amount of oil being thrown off by the worn bearings is already over-oiling the cylinder walls.

Although there are many special specifications as to the oil pressure on these engines, the most common setting is 26 pounds at 1600 R.P.M. with the oil hot (about 140° F.), which at idling speeds results in a pressure between 5 and 10 pounds. At speeds higher than 1600 R.P.M., the pressure will be higher. When the oil is cold, the pressure will be higher. The pressure may also vary with the different brands and grades of oil. (On some engines, the oil pressure is designated on the engine name plate.) If necessary to change the oil pressure, proceed as follows: Remove the pipe plug from the side of the oil pan on the left or side opposite the camshaft. By the use of special wrenches, the oil pressure can be adjusted through this opening (see Illustration No. 57). Using the special crowfoot wrench, loosen the lock nut (shown as A in Illustration No. 56) and, with the "T" handled socket or screwdriver, turn the screw (shown as B in Illustration No. 56) in for increased pressure and out for decreased pressure. After the adjustment is made, the lock nut must be tightened.

PISTON, PIN AND RINGS

FITTING PISTONS AND PINS

In fitting new or oversized pistons and rings to reground or honed cylinder bores, the clearances should be carefully controlled. See **"Clearance Table"** for various sizes and types of pistons. If a feeler ribbon is used, it should be the thickness shown in the minimum column, in each case, for all cast iron pistons. A slight drag should be felt when pushing the piston through the bore with the feeler ribbon. For aluminum pistons, a feeler of the thickness shown in the maximum clearance column should be used for each size. In other words, use a .003" feeler for cast iron pistons up to, and including, 3⅜" sizes and up to, and including, 3⅝" sizes in aluminum.

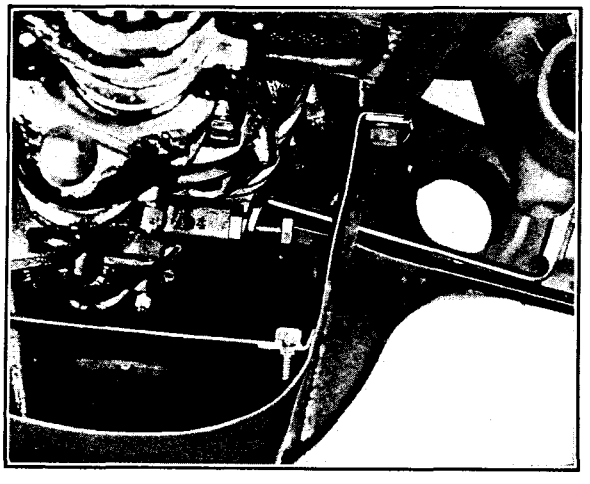


Illustration No. 57

The piston pins are clamped in the upper end of the rod but must be a proper fit in the piston. In the case of the cast iron pistons, which have bushings for the pin, the pins should be a light push fit. In the aluminum pistons, this must be a closer fit, and, at ordinary room temperatures, it will require a hard push with the palm of the hand to have the proper fit. To make it easier to assemble these parts, the aluminum pistons can be heated in boiling water for a few minutes. Some engines have full floating pins with a bushing in the rod. Fit pins in these engines in the same manner. Turn the notch in the pin in line with the clamp screw hole in the rod to prevent damage to the threads of the screw as it is screwed into place. Be sure the screw is up tight and locked in the same manner as when removed. To test the tightness of the piston pin (in aluminum pistons), hold the piston as in Illustration No. 58. The weight of the rod will not turn the pin in the piston while the cast iron piston should rock easily with this same test.

Aluminum pistons must be assembled with the split (or "T" slot) side on the left or side opposite the camshaft (in standard clockwise rotation engines). This is necessary due to the thrust side or camshaft side having more bearing area than the split side. The aluminum pistons are usually marked with the word "FRONT", indicating the side toward the front of the engine when properly assembled. In counterclockwise rotation engines (marine) using aluminum pistons, the split in the skirt will be on the camshaft side. Pistons for counterclockwise engines will have different part numbers but are the same as standard, except for the marking.

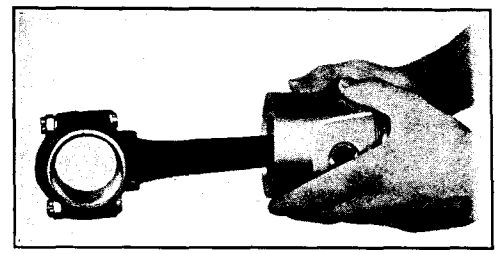


Illustration No. 58

PISTON RINGS

When installing new piston rings, each ring should be tried in the cylinder bore to see if it has the correct gap of .015" to .020". If necessary to increase the gap, the ring should be held and filed as shown in Illustration No. 59. If the ring is held in a vise, the vise jaws must be covered with some soft metal. The ends of the rings are squeezed together and the file cuts on both sides. This will insure the ends being parallel. When inserting the ring in the cylinder bore to test the gap clearance, push the ring part way through the bore, using the bottom of a piston to square the ring in the bore. Illustration No. 60.

Each new ring should be tried for clearance in the piston groove by rolling the ring all the way around the groove, as shown in Illustration No. 61. If the piston grooves have been carefully cleaned, the rings will be found to fit correctly; but, if they are tight, they can be lapped slightly on a sheet of emery cloth (No. 000) laid on a flat surface. Use a light uniform pressure when lapping.

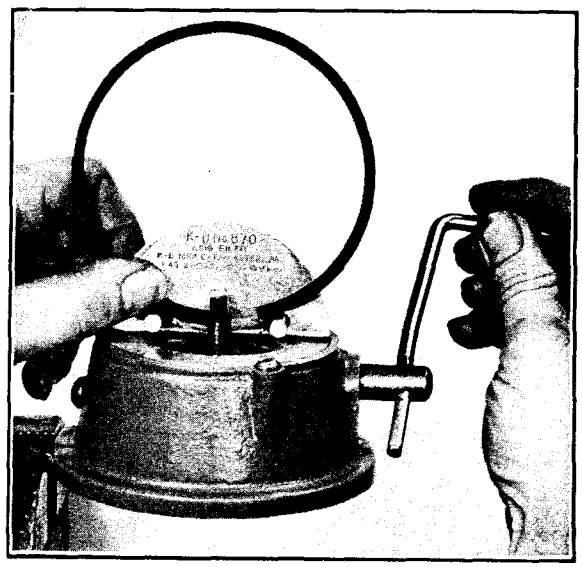


Illustration No. 59

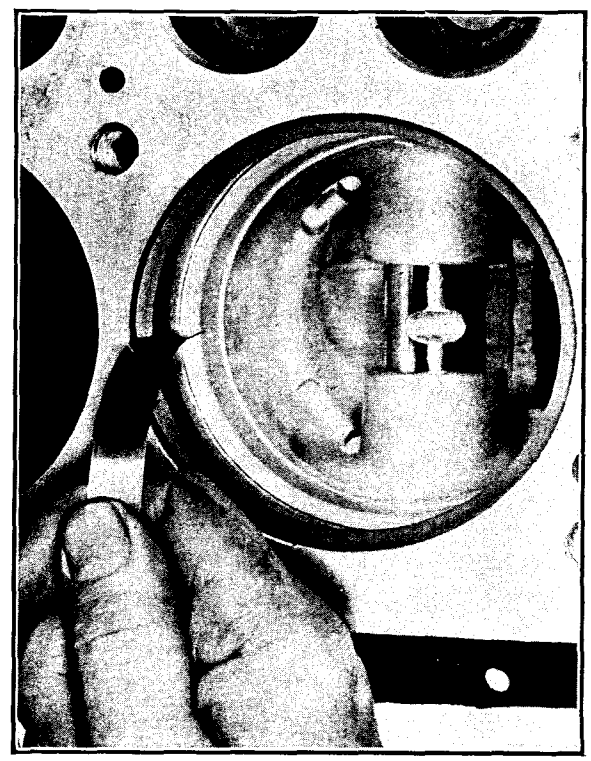


Illustration No 60

When assembling the piston rings to the piston, if a ring spreader tool, Illustration No. 62, is not available, the rings can be slipped over thin strips of metal. Whatever method is used, the rings must be handled carefully in order not to distort or break them.

TO ASSEMBLE THE PISTON TO THE CONNECTING ROD

To make it easier to assemble these parts, the aluminum piston may be heated in a pail of boiling water for a few minutes—this may be disregarded in warm climates.

1. Remove the pin from the piston.
2. Place the connecting rod in position in the piston with the clamp screw hole opposite the slotted side of the piston.
3. Insert the piston pin with the notch in line with the clamp screw hole. A spreader, as shown in Illustration No. 63, should be used to spread the rod so the pin may be readily inserted.
4. With the notch in the pin lined up with the clamp screw hole, remove the spreader and assemble the clamp screw and the lock washer.
5. Tighten the clamp screw with a firm pull on a 12" wrench.
6. Check the piston and connecting rod for alignment on a standard aligning tool or jig.

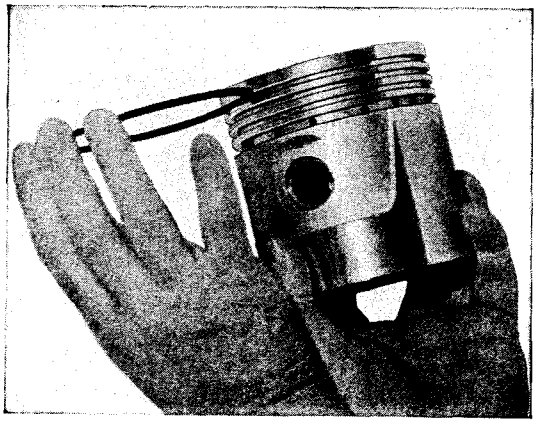


Illustration No. 61

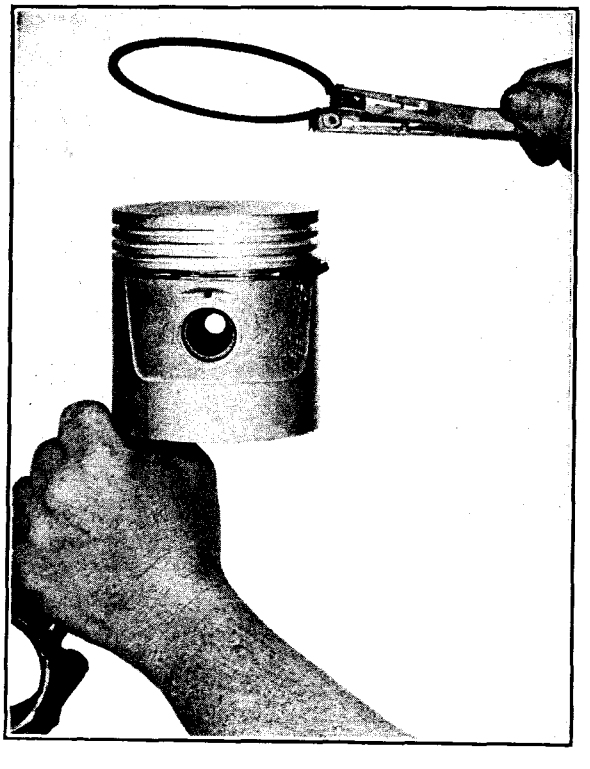


Illustration No. 62

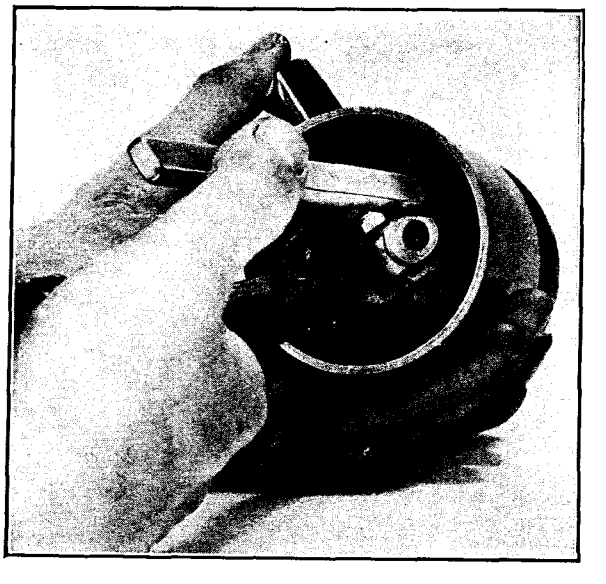


Illustration No. 63

SPARK PLUGS

Spark plug performance has a very important part in engine operation and economy. Therefore, it is important that the correct type of spark plug be selected for your particular engine operation.

Spark plugs are made in various types and each type has a definite purpose, which depends on the service required of the engine. For instance, one engine may be operated continually at, or near, full load and would require a colder type spark plug while another engine of the same type, which is operated at part load or with long periods of idling, would require a hot type spark plug. See Illustration No. 64.

Illustration No. 64 shows a comparison of spark plug types. The cold plug has a low insulator seat, which quickly carries away the heat from the insulator and keeps the spark plug insulator and points cooler. This results in longer plug life when the engine is in operation for long periods at full load.

The normal plug has a higher insulator seat, which allows the insulator to retain a normal amount of heat. This type of plug should be used when the engine is operated at intermediate and variable loads and speeds.

The hot plug has a very high insulator seat, which permits the core to retain the maximum amount of heat. This type of spark plug should be used when the engine is operated at part load with intermittent periods of idling.

Spark plug maintenance is very simple and easily accomplished and should not be neglected.

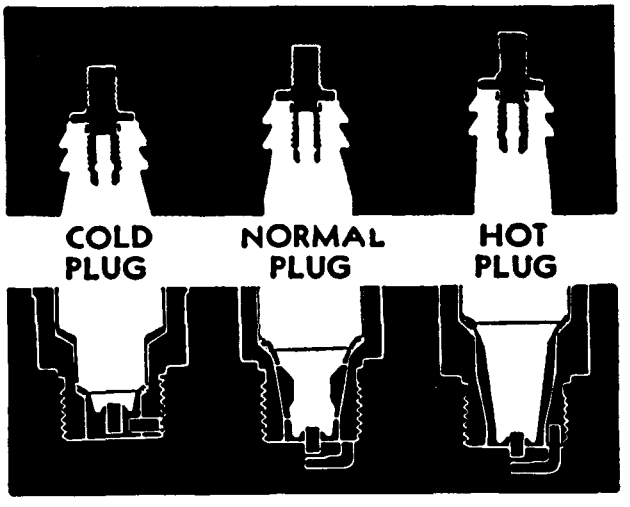


Illustration No. 64

After removal of the ignition wires, select the correct size socket and loosen each plug approximately two turns. Then, with compressed air or a brush, clean the dirt from around the spark plugs. This is important, as the dirt may fall into the cylinders and cause damage when the engine is started.

When the dirt has been removed from around the plugs, remove the plugs from the engine and carefully examine the condition of the points and insulator.

A careful study of the following illustrations and text will explain various spark plug conditions, as well as probable causes.

Illustration No. 65 shows the normal condition of a plug that has been carefully selected for a particular type of service. Notice the dry, light to dark brown, flaky deposits of combustion products which, when exhibited on each spark plug of a set, indicate a balanced ignition and combustion condition.

Illustration No. 66 shows a burned or overheated spark plug. These are usually identified by dry, shiny, glassy deposits on the insulator, or cracks in the insulator tip, which result from:

1. Too lean an air-fuel mixture.
2. Dirty, clogged radiator or cylinder block and head, or inefficient engine cooling.

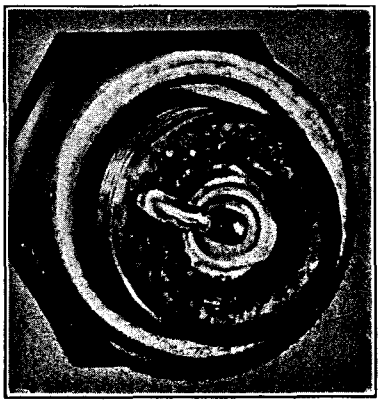


Illustration No. 65

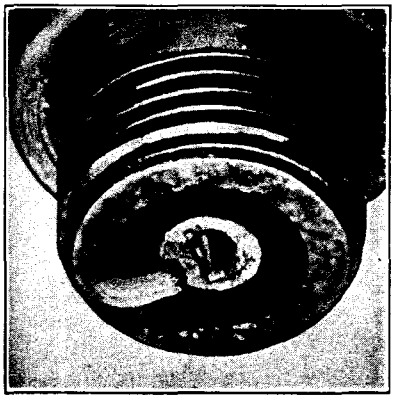


Illustration No. 66

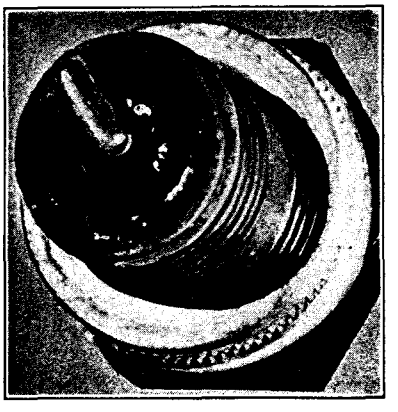


Illustration No. 67

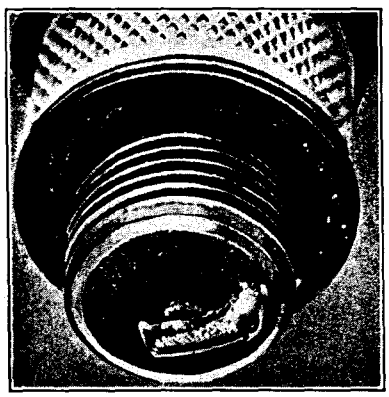


Illustration No. 68

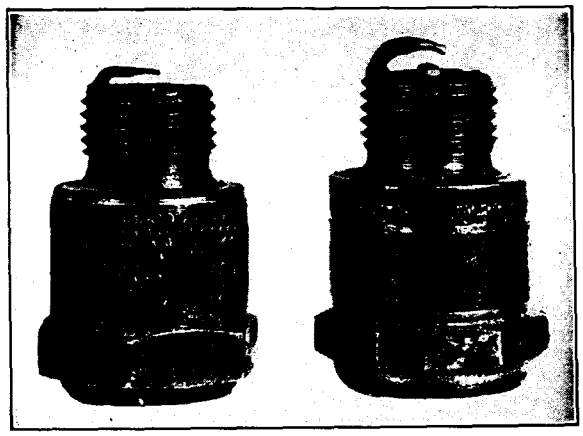


Illustration No. 69

3. Broken or slipping fan belt.
4. Too hot a spark plug for the service.
5. Improper installation of the spark plugs.
6. Compression leakage through the spark plug.

Illustration No. 67 shows a gas fouled spark plug. This condition is usually identified by a black, dry, fluffy deposit which results from:

1. Heat range of the spark plug too cold for the particular service.
2. Prolonged periods of engine idling.
3. Excessive use of the choke or improper adjustment of the automatic choke.
4. Too rich an air-fuel mixture.
5. Spark plug gaps set too close.

Illustration No. 68 shows an oil fouled plug. This condition is usually identified by the wet, black, shiny deposit. This may be caused by:

1. Heat range of the spark plug too cold for the particular type of service.
2. Distributor trouble or faulty ignition cables.
3. Weak coil or battery.
4. Spark plug gaps too close.
5. Worn piston rings or pistons.

Illustration No. 69 shows how the spark plug points wear or corrode with service. The amount of wear indicates the extent of service to which the plug has been subjected. When the plugs become worn to this extent, they should be discarded and replaced.

Before reinstalling the spark plugs, they should be cleaned and have the point gap adjusted. Always adjust the points by bending the ground electrode. Never attempt to bend the center electrode, as this may chip or crack the insulator and render the plug inoperative.

When installing the spark plugs, use a new gasket, if available.

The plug is properly tightened when the gasket is compressed to approximately one-half its original thickness when new. If a spark plug is tightened too tight, the body may become distorted and crack the insulator.

If the plug is too loose, it may allow exhaust gases to escape around the threads and, at the same time, the heat will not be carried away from the plug fast enough to prevent the plug from becoming damaged from excessive heat.

STARTING MOTOR

The starting motor is designed to crank the engine when the switch closes the circuit between the storage battery and the motor. It consists of five main sub-assemblies: the frame and field, the armature, the commutator end head, the pinion housing and the Bendix drive. The frame and field consist of the frame which supports the components of the starting motor, the pole pieces and the field coils. The coils supply the path for the magnetic field. Illustration No. 70 is an assembly drawing of the starting motor.

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

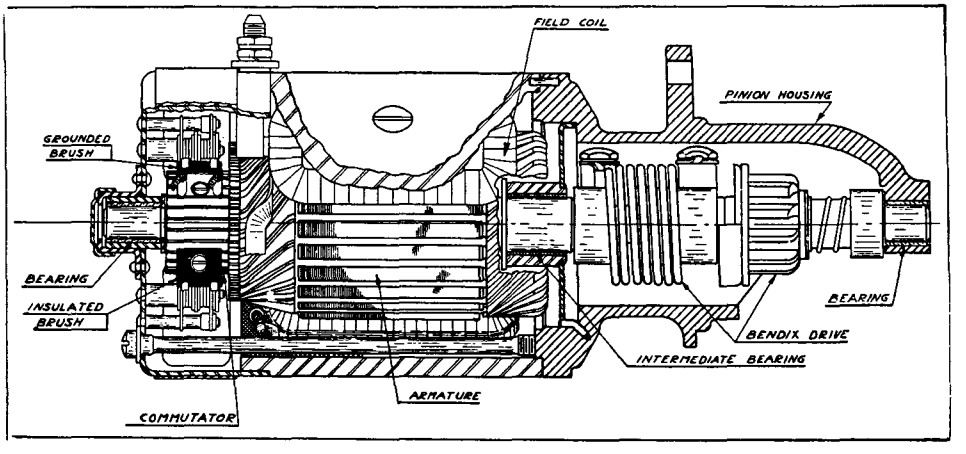


Illustration No. 70

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

LUBRICATION

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

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

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

MINOR ADJUSTMENTS

help to maintain the engine in good condition which alleviates major repairs and prolongs its usefulness.

THERMOSTAT AND BYPASS

Some engines are equipped with a thermostat, Illustration No. 71, so designed that it will not allow water from the radiator to circulate through the engine until the water in the engine is at operating temperature but does bypass a certain amount of water from the cylinder block, which is carried through the bypass tube to the inlet side of the water pump where it is again circulated through the engine. This is repeated until the water in the engine is heated to the operating temperature, when the thermostat begins to open and permit the water from the engine to enter the radiator. This water is, at the same time, replaced in the engine by the water pump drawing from the bottom of the radiator. Thus, the water temperature is constantly maintained in the proper heat range.

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

The still water test is as follows:

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

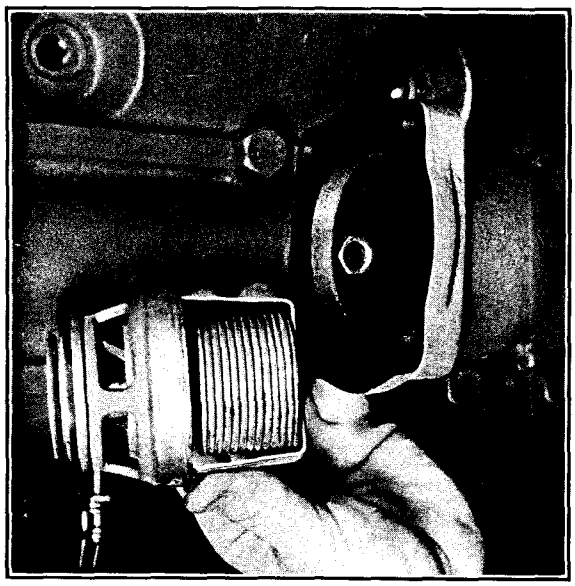


Illustration No. 71

Five degrees above or under those given are permissible.

VALVES

The intake and exhaust valves are made of special steel and operate in valve guides pressed into the cylinder block. They are held on their seats by strong steel springs, which are fastened to the valve stem by a suitable spring seat and valve lock arrangement. These valves are operated by the camshaft cams through mushroom type tappets. Replacement of the valves and valve guides will be found in **"Valve Grinding."** Replacement of the valve tappets is discussed in **"Valve Tappets."** Some engines are equipped with special rotor valves. See **"Valve—Rotator Type."**

VALVE GRINDING

In order to continue to get good performance from an engine, it may be necessary to grind or reseat the valves at varying intervals. The frequency for doing this depends on the care in the operation of the engine; but, if the instructions in this book are carefully followed, the necessity for doing this, as well as other service operations, will be reduced to a minimum.

The necessity of removing the cylinder head is sometimes due to excessive carbon, which makes its presence known by knocking. As this knocking is due to the carbon having partly filled up the combustion space and made the compression too high for the fuel being used, the knocking can be reduced by using a fuel of higher anti-knock qualities. Eventually, though, it will be necessary to remove the cylinder heads and clean out the carbon. It is a good policy to examine and reseat the valves while the head is removed.

At other times, the necessity for removing the cylinder head may be due to one or more leaking valves, which will cause an engine to misfire while pulling a load at low speeds and also may be detected by rocking the engine against compression on each cylinder, in turn, with the starting crank. When testing the compression in this manner, have the ignition off and the throttle wide open to allow a full charge of air to enter the cylinders.

Assuming that the carbon is to be cleaned out and the valves ground, we suggest several important steps in the general procedure.

1. Remove the cylinder head. See **"Cylinder Head."**
2. Remove the crankcase ventilation tubes, if used.
3. Remove the tappet covers.

4. With a conventional type valve spring lifter, compress the valve springs and remove the valve seat locks. Pack the holes in the lower part of the valve tappet chamber with rags to prevent the locks from falling into the oil pan. See Illustration No. 72.
5. Lift out the valves and place them in a cardboard or wood block, drilled and numbered so that the valves may be reinstalled in their respective places when grinding or reassembling. (Do not mark the valves with a file or punch.)
6. Clean all carbon from the cylinder head, piston heads, valve seats, valve guides and valves with suitable scraping or buffing tools.
7. Inspect the valve guides for excessive wear. If the valve guides are to be renewed, this should be done before any work is done on the valve seats. This will insure the seat being finished square with respect to the new guide. The exhaust valve guides will usually show the most wear. To allow space in the valve chamber for driving out the old guides, remove the valve springs and run the tappet adjusting screws all the way down and crank the engine so the tappet is on the low part of the cam. To drive out the guides, use a drift $\frac{5}{8}$" in diameter with a $\frac{3}{8}$" diameter pilot. Drive in the new guides to the same depth location as the old guides. After the new guides are driven in, they must be reamed to size on the inside diameter to correct any squeezing in or possible distortion due to being driven into place. This is important in order to get a proper fit and the proper clearance. See **"Clearance Table."**
8. Inspect the valve seats; and, if they are pitted or if new guides have been installed, the seats should be refinished. Valve seat tools with $\frac{3}{8}$" diameter pilots are required. The exhaust valve seats are finished on a 45° angle and should have an even width all the way around. The intake valve seats are usually finished on a 45° angle, although some engines have 30° seats.
9. Inspect the valves carefully; and, if the stems are badly worn or are not straight, the valves should be replaced by new ones. However, valves that are only slightly pitted can be used by refacing them on a valve face grinder. Valves must have an accurately finished face of the correct angle. See **"Clearance Table"** for the seat face width.

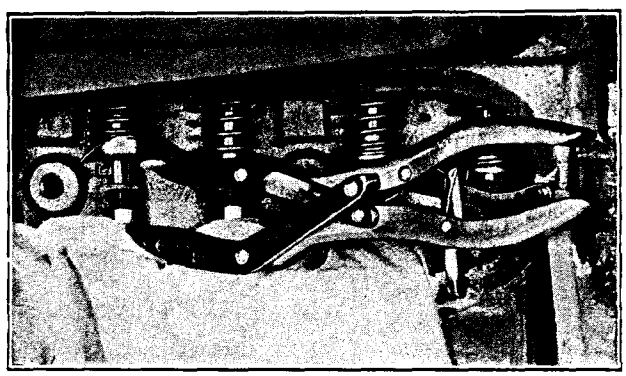


Illustration No. 72

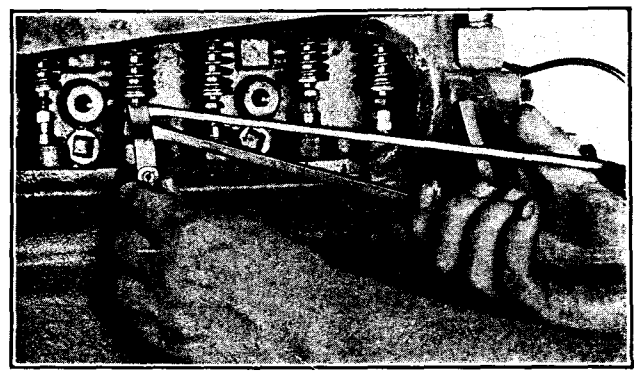


Illustration No. 73

10. Grind or lap each valve to its seat. Be sure the tappet is in such a position that it does not hold the valve off its seat. Use a light coil spring under each valve, as it is being lapped in, to raise the valve off its seat during the process. Use a medium grade compound and, using only a light pressure, rotate the valve only part of a turn with a screwdriver or other suitable tool before raising it off its seat and, rotating, while off, to a new position before again lightly bringing it against the seat for another part of a turn. Avoid continuous round and round motion that would cut grooves in the valve or seat. Repeat this process of lapping until a bright, silver-like band of uniform width is produced on the valve and seat. Clean off all traces of the compound and test each valve for a tight seat by making pencil marks across the face of the valve at short intervals; then, rotate the valve, with a firm pressure against its seat, for part of a turn and again lift out and observe if the pencil marks are all rubbed out on the contact surface. If not, regrind until this test shows a gas-tight mating of the valve and seat. It is imperative that the valves be assembled in the same seats to which they were ground.

TO REASSEMBLE THE VALVES

1. Clean all traces of the grinding compound off the valves, stems and guides and put a few drops of oil on the valve stems and insert the valves.
2. Pack the holes in the lower part of the valve tappet chamber with rags to prevent any locks from falling into the crankcase, Illustration No. 72.

3. Use a lifter, as in Item 4 in **"Valve Grinding,"** to compress the valve springs; insert the valve locks.
4. Remove the rags that were used for packing.
5. Adjust the tappets, as shown in Illustration No. 73, to the approximate setting. See **"Valve Tappets."**
6. Install the cylinder head and other parts. See **"Cylinder Head."**
7. Fill the cooling system with water or a cooling solution.
8. Start and warm the engine to the operating temperature.
9. With the engine idling slowly, adjust the tappets to the correct clearance.
10. Assemble the valve covers (use new gaskets) and crankcase ventilating tubes.

VALVE TAPPETS

The valve tappet assembly is the mushroom type and consists of three pieces: the valve tappet or push rod, the valve tappet screw and the valve tappet screw lock nut. When these three parts are assembled together they form the complete tappet, with the mushroom riding the cam on the camshaft and the head of the tappet screw in contact with the valve stem. These operate in cast iron bushings pressed into the cylinder block.

TO REPLACE THE VALVE TAPPETS

1. Remove the camshaft. See **"Camshaft."**
2. Remove the tappet from the cylinder block.
3. Check the tappet screws for wear and replace any which have started to cut or hammer out.
4. Check the tappet clearance in the cylinder block. This should be approximately .001". However, it will not be necessary to change the tappets unless this clearance is approximately .002" greater.
5. If necessary to replace the tappet, try a new tappet for clearance. If the clearance is still too great, it will be necessary to replace the tappet bushings.

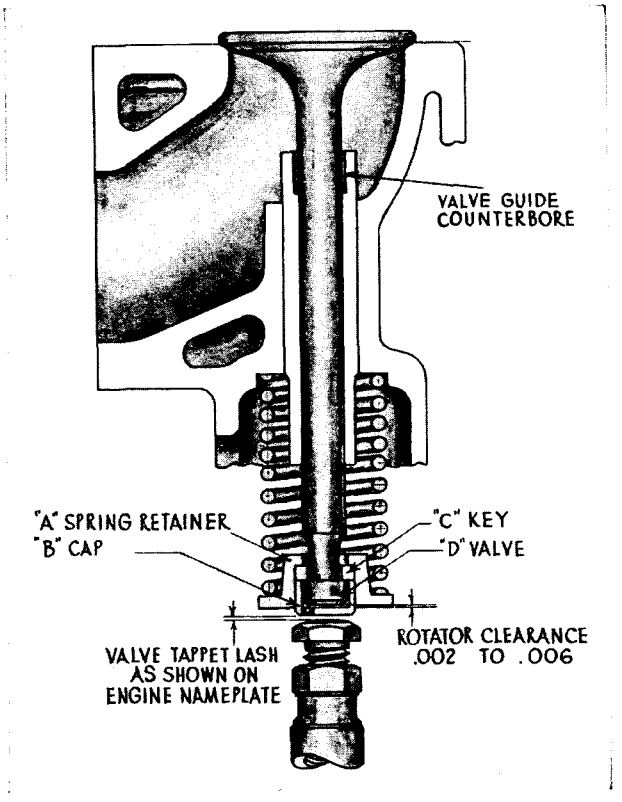


Illustration No. 74

TO REINSTALL THE TAPPETS

1. Assemble the tappet screws and nuts and insert the tappets in the cylinder block.
2. Reassemble the camshaft. See **"Camshaft."**
3. Adjust the tappets for each of the cylinders, setting them for at least .007" clearance on the intake and .010" clearance on the exhaust. After the engine has warmed up, and while running at idle speed, check and reset the tappet clearance, Illustration No. 73, to the clearance as shown on the serial number plate on the crankcase.
4. Replace the tappet covers.

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

VALVE — ROTATOR TYPE

GENERAL DESCRIPTION

Some engines are equipped with Eaton valve rotators, which consist of a special spring seat retainer "A," a cap "B," a pair of flat half-round keys "C" and a special valve stem shape "D." The normal tappet lash, as shown on the engine name plate, is maintained to accommodate valve expansion, Illustration No. 74.

At the beginning of the valve lift, the tappet first lifts cap "B" through the rotator clearance and lifts spring seat "A" through contact with keys "C," leaving the valve free to rotate.

During the lift cycle the valve motion is controlled but the valve is not located in any way which would prevent turning. The natural vibrations of the valve train, the flow of the gases around the valve head and the slight rotating motion imparted by the spring cause the valve to rotate slowly a small fraction of a revolution each lift cycle.

INSTALLATION AND SERVICE

The rotator parts, as furnished, are made to be interchangeable when new and unused. However, it is wise to check the rotator clearance after assembly to insure rotation. Be sure the valve and rotator parts are clean. Precaution should be taken against nicking the valve tip or rotator parts when assembling or handling, as this may cause a lack of clearance. BE SURE WHEN SERVICING TO KEEP THE ROTATOR PARTS WITH THEIR RESPECTIVE VALVE. THIS WILL SAVE UNNECESSARY WORK IN TRYING TO REFIT THE PARTS.

If no clearance exists after assembly, remove all parts and give clearance by removing stock from the tip of the valve. If the clearance is too great, remove enough stock from the top face or rim of the cap to reduce it to the proper limits. (To remove stock, either grind or lap on fine emery cloth or oil stone.) See Illustrations No. 75 and No. 76.

The rotator clearance, when the parts are assembled in the engine, should not exceed .006" or be less than .002". To check the clearance, turn the engine to raise the valve from the seat. The valve should turn freely and the clearance can be checked by an indicator reading on the valve head when the valve is moved vertically, Illustration No. 77.

ONCE THE PARTS HAVE BEEN FITTED THEY SHOULD BE KEPT TOGETHER AS SETS AND SHOULD NOT BE INTERCHANGED. After being in service, the faces of the keys may show signs of slight wear. This wear is not harmful, providing the rotator clearance is still within the recommended limits. Be sure, when reinstalling the keys, to get both parts of a set in position with the wear facing in the same direction in order not to cause cocking of the spring washer. As a final check, rotate the engine until each valve is lifted from the seat, in which position it should turn freely. If it does not turn freely, recheck rotator clearance.

When replacing the valves, check the valve guides. If they do not have counterbore, replace with new guides having counterbore.

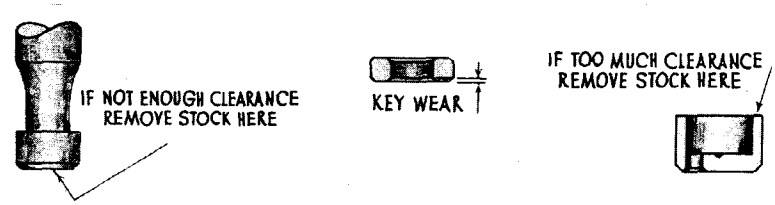


Illustration No. 75

Illustration No. 76

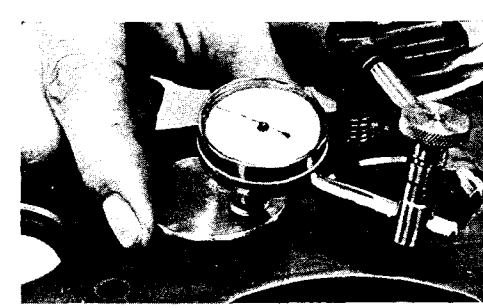


Illustration No. 77

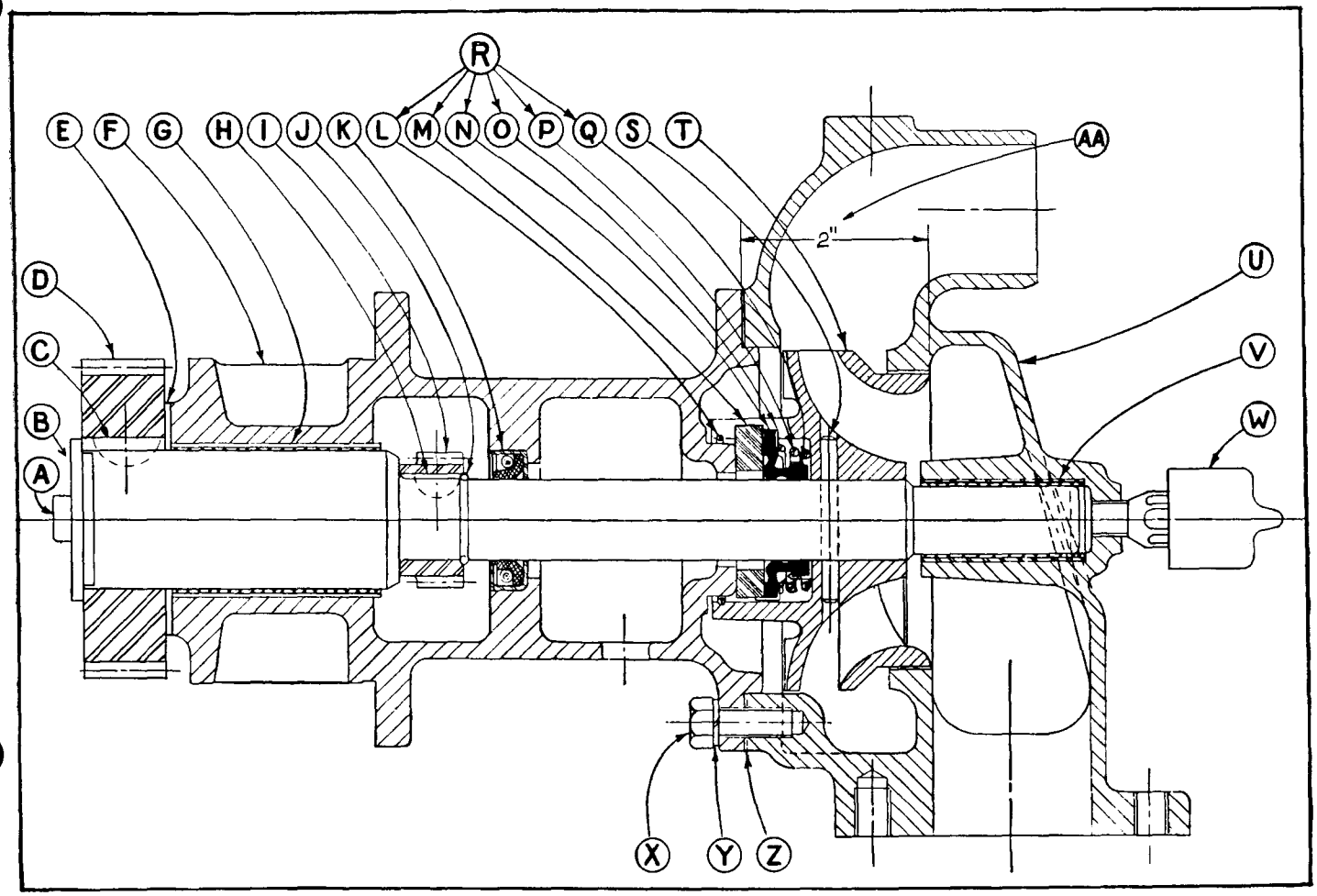


Illustration No. 78

WATER PUMP (Blind End Type)

Illustration No. 78 shows a longitudinal section through the water pump commonly used with distributor ignition. It is of the packless or auto seal type. This pump may be readily removed from the engine after the cooling system is drained. Remove the water discharge pipe and the water inlet pipe, disconnect the primary wire from the distributor and remove the distributor cap; then, remove the three cap screws holding the water pump to the cylinder block. The water pump can now be pulled back out of the cylinder block.

TO DISASSEMBLE WATER PUMP

The following reference letters will be found in Illustration No. 78 (unless otherwise noted).

1. Remove screws **(X)** and lock washers **(Y)**, then pull cover **(U)** away from cradle **(F)**.
2. Remove impeller pin **(S)**.
3. With a suitable support under the pump attaching flange, press shaft **(B)** out of impeller **(T)**. Be careful the shaft does not fall out of the pump cradle and damage the gear, etc.
4. Remove shaft **(B)** from cradle **(F)**.
5. If it is necessary to replace distributor gear **(I)**, it may be removed from the shaft with a drift punch after snap ring **(J)** is removed.
6. Press drive gear **(D)** from shaft and remove Woodruff key **(C)**.
7. Remove snap ring **(L)** from impeller **(T)** and remove seal parts **(R)**.

8. To remove the split type bushing **(V)** from cover **(U)**, drive a small chisel along one side of the split line. This will force one side, loosening the bushing, which will either drop out or can be pulled out with a pair of pliers.
9. To remove bushing **(G)**, a driver (13234-A) should be used. Drop the plate through the bushing and locate in the inner end of the bushing, then insert the driver shaft through the pump and press out the bushing.
10. Remove oil seal **(K)** from the cradle.

TO REASSEMBLE THE WATER PUMP (Illustration No. 78)

1. Press new bushing **(G)** into the cradle.
2. Install Woodruff key **(C)** and press shaft **(B)** into gear **(D)**, then press in thrust plug **(A)**.
3. Install Woodruff key **(H)**, press on distributor gear **(I)** and insert snap ring **(J)**.
4. Fit the shaft into the cradle bushing and check the clearance. This should be .0015"—.0025".
5. Install new oil seal **(K)** in the cradle. Be sure the lip of the seal is toward the front or the gear end of the cradle.
6. Place thrust washer **(E)** on the shaft and insert the shaft into the cradle sleeve. Be very careful that the oil seal is not damaged when assembling the shaft. A special tool (part No. 6372-A) is available from the Hercules Motors Corporation for installing the shaft.
7. Assemble new seal assembly **(R)** into the impeller, locking the assembly into place with snap ring **(L)**. Wipe the shaft lightly with tallow or other light grease and press the impeller into position on the shaft. If an old impeller and shaft are used, line up the holes in the impeller with the hole in the shaft and drive in new pin **(S)**. If a new shaft or new impeller is used, it will be necessary to position the impeller on the shaft, as shown at **(AA)**, and then drill a hole through the impeller or shaft, or both, for the impeller pin. Install the new pin and stake or pein both ends.
8. Press new bushing **(V)** into cover **(U)**.
9. Place new gasket **(Z)** on the cradle and install cover **(U)**, tightening into place with screws **(X)** and lock washers **(Y)**, as removed.

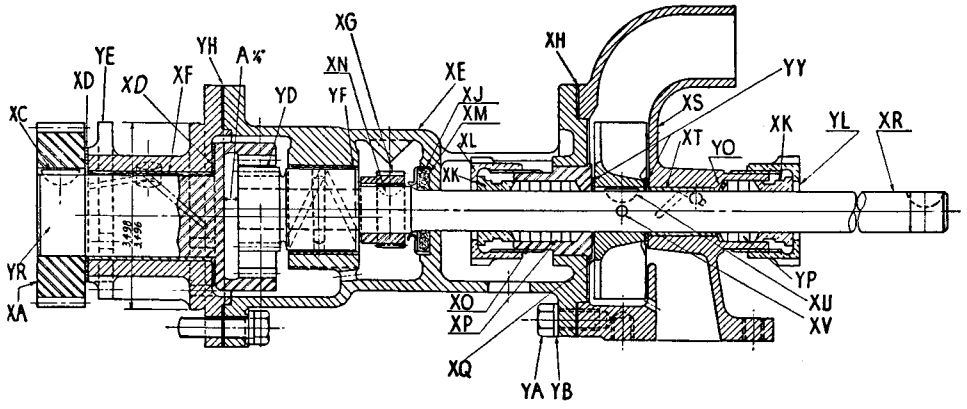


Illustration No. 79

WATER PUMP (Through Shaft Type)

The water pump shown in Illustration No. 79 is used with a magneto or distributor, or both. The water pump is of the centrifugal type and is composed of two sub-assemblies; one, the water pump drive, which is mounted in the cylinder block and is driven from the timing gears; two, the water pump proper, which is coupled to the drive with suitable internal gears. The two sub-assemblies are held together with the screws used to attach the complete assembly to the engine.

TO DISASSEMBLE THE WATER PUMP

The following reference letters will be found in Illustration No. 79 (unless otherwise noted).

1. Remove the water pump drive from the pump cradle. Remove the magneto drive coupling and the Woodruff key. Remove rear packing nut **(YL)**, gland **(XK)** and packing **(YP)**.

2. Remove four cap screws **(YA)** holding the body or impeller cover **(XS)** to cradle **(XE)** and remove the body and gasket from the cradle.

3. Remove impeller pin **(XV)** with a pin punch and pull impeller **(XQ)** from shaft **(XR)**. **CAUTION:** Do not press the shaft through the impeller, as key **(XU)** will damage the front packing gland or bushing **(YY)**. If no puller is available, the impeller may be removed in the following manner: Press the shaft through the impeller ⅛", then place a suitable spacer between the impeller and bushing. Press the shaft through the impeller until the key almost touches the bushing, then add more spacers. Repeat until the impeller is removed.

4. Remove impeller key **(XU)** and pull the shaft from the cradle.

5. Unless distributor gear **(XA)** is damaged or worn, it is not necessary to remove it. If damaged, drive the gear off with a drift punch and remove the key. NOTE: Further disassembly of this shaft is not practical, as the shaft is assembled before the final cutting of the gear teeth and grinding of the shaft.

6. Turn water pump drive key **(XC)** so that it is in line with the notch in the housing (see Illustration No. 80) and press shaft **(XR)** though the gear and thrust washer **(XD)** until key **(XC)** almost touches the bottom of the notch; then put spacers between the gear and the housing and continue to press the shaft out of the gear. Repeat, if necessary, so that the sleeve or housing bushing is not damaged. After the gear is removed, pull the key from the shaft and remove the shaft from the sleeve.

7. Press the bushing out of the sleeve.

8. To remove split type bushing **(XF)** in the body, drive a small chisel along one side of the split line. This will force one side in, loosening the bushing, which will either drop out or can be pulled out with a pair of pliers.

9. To remove rear cradle bushing **(XO)** or packing gland, screw packing nut **(XI)** on the bushing. Lay a flat piece of steel across this nut and drive or press the bushing out of the cradle.

10. Drive out cork oil seal **(XM)** and retainer **(XJ)** with a punch.

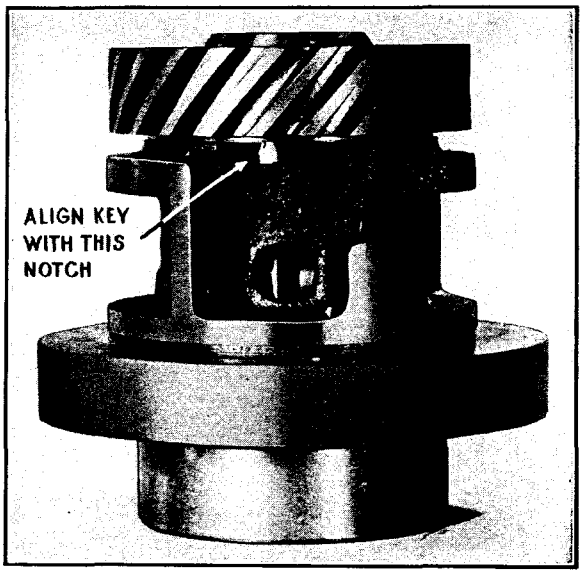


Illustration No. 80

TO REASSEMBLE THE WATER PUMP
(Illustration No. 79)

1. Press drive sleeve bushing **(XE)** in sleeve **(YE)**. Check drive shaft **(YR)** clearance in the bushing. The correct clearance is .0015"—.0025".

2. Put thrust washer **(XD)** on shaft **(YR)** and place the shaft in sleeve **(YE)**. Install second thrust washer **(XD)** and drive in gear key **(XC)**.

3. With a .003" feeler gauge on the thrust washer, press drive gear **(XA)** on the shaft. The gear should be pressed on until a light pull is necessary to remove the feeler. This should allow the drive shaft to have .003" end clearance in the sleeve.

4. Press bushing **(YF)** in cradle **(XE)** and bushing **(XT)** in body **(XS)**. Check the shaft clearance with a .0015" feeler gauge; if necessary, ream or burnish to size.

5. Install distributor drive gear key **(XN)** and press on gear **(XG)**.

6. If the packing gland or bushing **(XO)** has been removed from the cradle, cover the contact surfaces with white lead or a plastic type sealing compound and press into the cradle.

7. Remove any nicks on water pump shaft **(XR)**. Slide it through the front cradle, then through packing nut **(XI)**, packing gland **(XK)** and packing **(XP)**, before the shaft goes through rear cradle bushing **(XO)**.

8. Put thrust washer **(YY)** on the shaft and install impeller key **(XU)**.

9. Before pressing impeller **(XQ)** on shaft **(XR)**, position the shaft so that the front face of the gear is ¼" from the front flange of the cradle. Use a ¼" flat steel plate about 1½" square, placed on the end of the gear, so that the shaft will be correctly positioned when the assembly is placed on the bed of the press.

10. Press impeller (XQ) on the shaft, using a .003" feeler gauge between impeller **(XQ)** and thrust washer **(YY)**, to check the end thrust. Drill impeller **(XQ)** and shaft **(XR)** and drive in impeller pin **(XV)**; make sure it is tight. Put second thrust washer **(YY)** on the impeller and cement body gasket **(XH)** to the cradle.

11. Install water pump body **(XS)**; use screws **(YA)** and lock washers **(YB)**, tightening the screws progressively.

12. Install steel packing gland washer **(YO)**, packing **(YP)**, gland **(XK)** and nut **(YL)**.

13. Force packing **(YP)** into the cradle bushing and tighten the nut finger-tight.

14. Place a new gasket on the front of the drive assembly and assemble in the block; then place new gasket **(YH)** on the rear of the drive and assemble the pump to the drive, fastening with the screws and lock washers as removed.

15. Install the water inlet pipe and radiator hose; also, the water pump discharge pipe and hose.

16. Fill the cooling system with water or an anti-freeze solution.

17. Install the magneto. See **"Magneto Ignition Timing."**

18. Start the engine and tighten the water pump packing nuts sufficiently to stop water leaks. DO NOT tighten the packing nuts excessively.

SAVE YOUR BATTERIES

Do not turn engine with starter unnecessarily.

GLANCE at the Instrument Panel gauges often. They tell how your engine is functioning.

ENGINE TROUBLE SHOOTING

This section is devoted to giving the operator and maintenance crew some hints in tracing trouble, these suggestions being based on actual experience of servicing a great number of engines in various types of operation over a long period of time.

In order to locate trouble under different headings, refer to **"Index."**

A. ENGINE MISSES INTERMITTENTLY

Cause: Spark plugs dirty, cracked or shorted by moisture on the electrodes.
Correction: Clean, if dirty. Replace, if cracked. Dry, if wet or damp.

Cause: High tension wires broken or shorted.
Correction: Replace the wires.

Cause: High tension wires corroded in the distributor cap.
Correction: Clean the terminals.

Cause: Faulty distributor points, spark plug points, condenser or coil.
Correction: Clean and adjust or replace, if necessary, from spares.

Cause: Valve tappets adjusted too close.
Correction: Readjust the valve tappets to the correct clearance. See Illustration No. 73.

Cause: Badly worn valve guides.
Correction: Replace the valve guides.

Cause: Leaking head gasket.
Correction: Tighten the cylinder head nuts to the proper tension or replace the gasket, if necessary.

Cause: Warped or cracked cylinder head usually due to overheating or pouring cold water in an overheated engine.
Correction: Replace the cylinder head.

Cause: Cracked valve seat or water jacket, usually indicated by overheating and loss of cooling solution.
Correction: Replace the cylinder block.

Cause: Air leak in the intake manifold.
Correction: Replace the gaskets or manifold, if necessary.

B. LOSS OF POWER

Cause: Motor missing intermittently.
Correction: See part **A** above for the cause and correct.

Cause: Motor out of time.
Correction: Retime the ignition system. See **"Ignition Timing."**

Cause: Valves or valve seats worn and leaking.
Correction: Regrind the valves. See **"Valve Grinding."**

Cause: Piston rings broken, stuck in the grooves or worn.
Correction: Replace the rings and clean the ring grooves in the piston.

Cause: Tappets sticking or set too close.
Correction: Readjust the tappets, or if sticking, remove and clean.

Cause: Worn pistons, rings, et cetera.
Correction: Replace the worn parts or rebuild the engine.

Cause: Spark plugs leaking.
Correction: Tighten the spark plugs in the head.

Cause: Worn cylinders.
Correction: Rebore the cylinders and install new oversize pistons and rings.

Cause: Worn valve stems or guides.
Correction: Replace the valves or guides.

Cause: Valve springs weak or broken.
Correction: Replace the springs.

Cause: Valve timing incorrect.
Correction: Correct the timing. See **"Camshaft."**

Cause: Poor carburetor action.
Correction: Clean or repair the carburetor.

Cause: Water or sediment in the fuel tank or filter.
Correction: Clean the fuel system.

Cause: Air cleaner clogged.
Correction: Wash the element in a suitable cleaning solution such as gasoline, fuel oil, et cetera.

Cause: Exhaust pipes or muffler restricted.
Correction: Clean or replace the exhaust pipe, muffler or tail pipe.

C. ENGINE KNOCKING

Cause: Loose or worn main bearings.
Correction: Replace the main bearings.

Cause: Loose or worn connecting rod bearings.
Correction: Adjust or replace the bearings.

Cause: Loose piston pins.
Correction: Replace the pins with oversize pins or a piston and pin assembly.

Cause: Worn cylinder bores and pistons.
Correction: Rebore the cylinders and install new oversize pistons.

Cause: Tight piston pins.
Correction: Fit the pins to the proper clearance. See **"Clearance Table."**

Cause: Tight pistons.
Correction: Fit the pistons to the proper clearance. See **"Clearance Table."**

Cause: Overheated engine.
Correction: Allow the engine to cool, then determine the cause of overheating. See **"Cooling System."**

Cause: Lack of lubricating oil.
Correction: Fill the crankcase with the proper grade and quantity of oil. If the engine still knocks, check and replace the bearings.

Cause: Loose flywheel.
Correction: Tighten in place; if worn excessively by running loose, replace.

Cause: Excessive end play in the camshaft.
Correction: Adjust with the screw in the gear cover. See **"Gear Cover."**

Cause: Idler gear shaft has excessive end play.
Correction: Adjust with the screw in the gear cover. See **"Gear Cover."**

Cause: Bent connecting rod.
Correction: Check and straighten or replace, if necessary.

D. FUEL SYSTEM

1. **Excessive fuel consumption. This is usually accompanied by increased lubricating oil consumption due to dilution of the oil.**

Cause: Carburetor worn or not properly adjusted. Indicated by black smoke in the exhaust.
Correction: Check and repair the carburetor.

Cause: Fuel leaks.
Correction: Check the fuel tank, lines, connections, et cetera.

Cause: Sticking controls.
Correction: Oil the controls and eliminate the binding.

Cause: Excessive idling of the engine.
Correction: Shut off the engine when not in operation.

Cause: Excessive use of the choke.
Correction: Warm the engine to the operating temperature before applying the load, if possible; also, keep the choke mechanism properly adjusted.

Cause: Dirty air cleaner accompanied by lack of power.
Correction: Clean the air cleaner.

Cause: Engine overheating.
Correction: See Overheating under **"Cooling System,"** paragraph E-1.

Cause: Engine in poor condition and adjustment.
Correction: Overhaul the engine.

Cause: Poor or weak ignition, indicated by the engine misfiring and puffs of smoke from the exhaust.
Correction: See **"Ignition System,"** paragraph G-3.

Cause: Dirty and improperly adjusted spark plugs.
Correction: Clean and adjust.

Cause: Engine overcooling.
Correction: See **"Cooling System,"** paragraph E-2.

2. **Fuel pressure too low.**

Cause: Air leak in the system.
Correction: Tighten the connections and check the supply lines for leaks; replace, if necessary.

Cause: Fuel pump diaphragm out of order, also causing increased lubricating oil consumption due to oil dilution.
Correction: Replace the diaphragm. See **"Fuel Pump."**

Cause: Fuel pump rocker arm linkage worn.
Correction: Rebuild the fuel pump (see **"Fuel Pump"**) or replace from spares.

Cause: Fuel pump check valves and springs not functioning properly.
Correction: Clean or replace the valves and springs.

3. **Lack of fuel at the carburetor.**

Cause: Empty fuel tank.
Correction: Fill the tank with fuel.

Cause: Bent, kinked or broken fuel lines.
Correction: Straighten or replace the lines.

Cause: Dirty filtering screens.
Correction: Clean the filter screen. When replacing the element in the fuel filter, tightening the clamp nut finger-tight is sufficient.

Cause: Fuel leaks.
Correction: Check the tank, lines, connections, et cetera.

Cause: Broken fuel pump diaphragm.
Correction: Replace the diaphragm. See **"Fuel Pump."**

Cause: Sticking fuel valve in the carburetor.
Correction: Replace the fuel valve and seat.

Cause: Loose fuel pump cover plate screws.
Correction: Tighten the screws.

4. **Improper idling.**

Cause: Sticking control rods or linkage.
Correction: Oil the connections and eliminate the binding.

Cause: Idling screw not properly adjusted.
Correction: Adjust the screw for even idling.

Cause: Carburetor fuel and air mixture not properly adjusted.
Correction: Adjust the carburetor.

E. COOLING SYSTEM

1. **Overheating**

Cause: Lack of cooling solution, water, anti-freeze, et cetera.
Correction: Refill the system with the proper solution.

Cause: Fan belt not properly adjusted.
Correction: Adjust the fan belt for approximately 1" deflection.

Cause: Carburetor choke valve partly closed.
Correction: Adjust the choke valve or controls.

Cause: Thermostat sticking in the closed position.
Correction: Clean and test or replace.

Cause: Coating of calcium salts on the cylinders and the inside of the cooling system.
Correction Clean and flush the cooling system. The use of a good commercial type inhibitor may be recommended by the manufacturer of the radiator.

Cause: Dirt or insects in the radiator passages.
Correction: Clean or blow out with compressed air.

Cause: Hoses deteriorated. Cannot always be determined by the condition of the outside covering.
Correction: Replace the hose.

Cause: Inlet or outlet hoses collapsing.
Correction: Replace the hoses, using a hose with an inner support, if necessary.

Cause: Water pump not functioning.
Correction: Check and replace the drive shaft, impeller, supply lines, et cetera.

Cause: Exhaust pipes restricted, usually noted by a hissing sound in the exhaust.
Correction: Clean the pipes and remove the restriction.

2. **Overcooling**

Cause: Thermostat sticking open.
Correction: Clean and test or replace the thermostat.

Cause: Weather or climatic conditions too cold to allow the thermostat to hold temperature.
Correction: Cover the radiator sufficiently to bring the water temperature into the proper range or use winter front.

3. **Loss of cooling water**

Cause: Leaks in the radiator core.
Correction: Repair or replace.

Cause: Defective hose connections.
Correction: Tighten the clamps or replace the hose or clamps.

Cause: Radiator tubes clogged.
Correction: Clean or replace.

Cause: Water pump seals defective.
Correction: Replace the seals. See **"Water Pump."**

Cause: Loose freeze plugs (core plugs) in the cylinder block.
Correction: Tighten or replace the plugs.

Cause: Cracked cylinder head or block. Blown cylinder head gasket.
Correction: Replace.

F. CLUTCH ASSEMBLY

1. **Slipping**

Cause: Improper adjustment.
Correction: Adjust.

Cause: Weak pressure spring.
Correction: Replace the spring.

Cause: Sticking release sleeve.
Correction: Check the sleeve and pressure spring.

Cause: Worn facings on the driven disc assembly.
Correction: Replace the facings or the disc assembly.

Cause: Facings saturated with oil.
Correction: Clean the facings and correct the cause. Check the oil seal in the bellhousing, also, the pilot on the flywheel. Do not over-lubricate the clutch shafts, bearings, et cetera.

2. **Chattering**

Cause: Oil on the facings.
Correction: Clean or replace the facings.

Cause: Sticking release sleeve.
Correction: Check the pull back spring. If broken, replace.

3. **Rattling**

Cause: Loose release fork.
Correction: Tighten the fork.

Cause: Weak or broken pull back spring.
Correction: Replace the spring.

Cause: Improper pedal adjustment.
Correction: Adjust the pedal.

G. ELECTRICAL SYSTEM

1. **Starting motor**

(a) Slow cranking speed may be caused by:

Cause: Crankcase lubricating oil too heavy or cold.
Correction: Change to the correct grade of oil or heat the oil before attempting to start the engine. See **"Lubrication."**

Cause: Loose or dirty cable connections.
Correction: Clean and tighten.

Cause: Worn brushes.
Correction: Replace the brushes.

Cause: Dirty or worn armature.
Correction: Clean, repair or replace the armature.

Cause: Armature rubbing field coils.
Correction: Replace the starter shaft bushings.

Cause: Low battery voltage.
Correction: Check the generator and regulator, then recharge the battery.

(b) Starter failing to operate may be caused by:

Cause: Battery discharged.
Correction: Recharge the battery.

Cause: Burned circuit breaker.
Correction: Replace the circuit breaker.

Cause: Broken battery cables.
Correction: Replace the cables.

Cause: Poor connections.
Correction: Clean and tighten.

Cause: Burned commutator bars.
Correction: Recut the commutator.

Cause: Open or short circuits in the armature or fields.
Correction: Check and repair.

Cause: Defective starter switch (push button or solenoid).
Correction: Check and repair the contacts or replace the switch.

2. Generator

(a) Low or no output

Cause: Fully charged battery.
Correction: None. Check the output when the battery is slightly discharged.

Cause: Dry battery.
Correction: Refill the cells with distilled water.

Cause: Burned contacts on the regulator units.
Correction: Clean or replace the contacts.

Cause: Grounded armature wires or terminal posts.
Correction: Replace the wires and insulate the terminals.

Cause: Burned commutator bars.
Correction: Recut the commutator.

Cause: Worn or sticking brushes.
Correction: Clean or replace the brushes.

Cause: Open circuits in the field or armature.
Correction: Repair or replace the defective parts.

Cause: Brush springs weak or improperly adjusted.
Correction: Adjust or replace the springs.

Cause: Rough, dirty or greasy commutator bars.
Correction: Clean the commutator bars.

Cause: High mica on the commutator.
Correction: Undercut the mica.

Cause: Commutator out of round.
Correction: Recut the commutator.

(b) Noisy generator

Cause: Loose mountings.
Correction: Tighten the mounting bolts.

Cause: Worn or loose drive pulley.
Correction: Tighten or replace the pulley.

Cause: Worn bearings.
Correction: Replace the bearings.

(c) Excessive output

Cause: Generator field grounded.
Correction: Check the wires, et cetera, for external ground.

Cause: Regulator circuit breaker closed.
Correction: Adjust or repair the circuit breaker. Check the generator for damage.

Cause: Defective regulator.
Correction: Replace the regulator.

3. **Ignition system—distributor, coil and spark plugs.**

(a) Engine will not start

Cause: Breaker points not closing.
Correction: Check and adjust.

Cause: Breaker points defective.
Correction: Check and replace, if necessary.

Cause: Breaker arm grounded.
Correction: Replace the arm.

Cause: Defective cap or rotor.
Correction: Check and replace.

Cause: Defective coil.
Correction: Replace the coil.

Cause: Defective condenser.
Correction: Replace the condenser.

Cause: Loose terminals or grounded wires.
Correction: Check and tighten or replace.

(b) Engine misses at low speed

Cause: Breaker point gap too small.
Correction: Check and adjust the gap to the proper setting. See **"Ignition Timing."**

(c) Engine misses at high speed

Cause: Breaker arm spring tension too weak.
Correction: Replace the spring or the spring and arm.

Cause: Breaker point gap too large.
Correction: Adjust the gap.

(d) Engine pings excessively under load at high speed

Cause: Timing too far advanced or incorrectly set.
Correction: Check and properly adjust. See **"Ignition Timing."**

Cause: Inferior grade of fuel.
Correction: If it is impossible to obtain the proper grade of fuel, it may be necessary to retard the spark or distributor timing somewhat to overcome the pinging noise.

(e) Weak spark at plugs

Cause: Breaker contact points worn or defective.
Correction: Examine, repair or replace the points.

Cause: Condenser disconnected or defective.
Correction: Test the connection or replace the condenser.

Cause: Breaker cam worn.
Correction: Install a new cam and stop plate assembly.

(f) Engine lacks speed and overheats

Cause: Breaker cam retarded.
Correction: Readjust the distributor and advance arm.

(g) Timing incorrect or irregular

Cause: Breaker cam loose.
Correction: Examine the distributor governor weights, pivots, springs, shaft, et cetera. Replace, as necessary.

(h) Breaker points pitted or burnt

Cause: Grease or dirt on points.
Correction: Clean, repair or replace.

Cause: Defective condenser.
Correction: Replace the condenser.

(i) Engine misses at all speeds

Cause: Distributor points set too far apart.
Correction: Check and adjust.

Cause: Condenser defective or disconnected.
Correction: Check the connection; replace the condenser, if necessary.

Cause: Breaker point screw lock nut loose.
Correction: Adjust the points and tighten.

Cause: Breaker points burnt, oxidized or unevenly spaced.
Correction: Check, clean and adjust; replace, if necessary.

H. EXCESSIVE SMOKE FROM THE EXHAUST

Cause: Too much oil in the crankcase.
Correction: Fill only to the 4/4 mark on the bayonet gauge.

Cause: Carburetor float sticking or the fuel valve leaking.
Correction: Adjust or replace the fuel valve and seat. Examine the float for leaks.

Cause: Worn pistons, rings or cylinders.
Correction: Replace the worn parts or overhaul the engine.

I. EXCESSIVE OIL CONSUMPTION

Cause: Oil leaks at the gaskets, screws, oil seals, et cetera.
Correction: Tighten or replace the gaskets, et cetera.

Cause: Inferior grade of oil.
Correction: Use a good quality oil. See specifications.

Cause: Overheating.
Correction: See **"Cooling System,"** paragraph E-1.

Cause: Ring gaps too great or lined up.
Correction: Install new rings. If the ring gaps are lined up, the condition will correct itself.

Cause: Worn or broken rings.
Correction: Replace the rings.

Cause: Cylinder bores out of round or excessive taper.
Correction: Rebore the cylinders; install new pistons, rings, et cetera.

Cause: Main or connecting rod bearings loose.
Correction: Adjust or replace the bearings.

Cause: Oil ring slots clogged with carbon.
Correction: Clean the rings. Replace, if necessary.

Cause: Carburetor fuel mixture too rich.
Correction: Replace the worn jets and adjust.

Cause: Piston improperly fitted or installed.
Correction: Correct or replace the piston. See **"Piston, Pin and Rings."**

Cause: Piston rings improperly fitted in the piston grooves or the cylinder bores.
Correction: Fit the rings properly in the grooves and cylinders. See **"Piston, Pin and Rings."**

Cause: Air cleaner not clean, allowing dirt to enter the combustion chamber with resultant wear.
Correction: Keep the air cleaner clean.

J. BEARING FAILURES

Cause: Continuous overspeeding of the engine.
Correction: Continuous operation at maximum speed, or close to it, is to be avoided. Exercise caution when going downgrade. Do not allow the vehicular speed to exceed the same speed obtainable in the same gear on level terrain.

Cause: Lack of oil.
Correction: Keep the oil level at the 4/4 mark on the bayonet gauge.

Cause: Inferior grade of oil or oil of improper viscosity.
Correction: Use a good quality oil of the proper viscosity.

Cause: Low oil pressure.
Correction: Adjust the oil pressure. See **"Oil Pressure Adjustment."**

Cause: Bent connecting rod.
Correction: Replace the connecting rod.

Cause: Crankshaft rough or out of round.
Correction: Regrind or replace the shaft.

Cause: Restricted oil passages.
Correction: Clean the oil lines and passages.

Cause: Bearings loose or improperly fitted.
Correction: Adjust or replace the main or connecting rod bearings.

Cause: Dirt or other matter in the lubricating oil.
Correction: Use clean oil and service the breather air filter regularly. Replace the oil filter cartridges or the elements.

K. LOW OIL PRESSURE

Cause: Oil pump strainer screen in the oil pan clogged.
Correction: Clean the screen.

Cause: Oil too hot, resulting in low viscosity.
Correction: Correct the cause of the overheating.

Cause: Pressure regulator piston worn or clogged with carbon.
Correction: Clean and adjust properly.

Cause: Excessive main and connecting rod bearing clearance.
Correction: Adjust or replace the bearings.

Cause: Oil pressure gauge defective.
Correction: Replace the gauge.

Cause: Oil pressure gauge line bent or clogged.
Correction: Clean, straighten or replace the line.

L. RAPID CYLINDER OR PISTON WEAR

Cause: Breather and air cleaner not properly serviced, allowing dirt and abrasives to enter the combustion chambers.
Correction: Clean frequently and at regular intervals.

Cause: Inferior grade of lubricating oil.
Correction: Use a good quality oil. See specifications.

Cause: Lack of oil.
Correction: Keep the oil level at the 4/4 mark on the bayonet gauge.

Cause: Dirty oil.
Correction: Replace or change the oil and replace the oil filter elements.

Cause: Piston rings not properly fitted to the cylinders.
Correction: Replace the piston rings. See **"Piston, Pin and Rings."**

Cause: Carburetor fuel mixture too rich.
Correction: Replace the worn jets.

Cause: Cold operation of the engine.
Correction: Check the thermostat. Warm the engine before applying the load.

M. VALVES STICKING

Cause: Incorrect valve tappet clearance.
Correction: Adjust the clearance correctly. See **"Valve Tappets."**

Cause: Valve springs weak or broken.
Correction: Replace the springs.

Cause: Valve stems or guides scored, dirty or gummy.
Correction: Clean, polish or replace.

Cause: Incorrect clearance between the valve stem and the guide.
Correction: Fit the valve stems to the correct clearance in the guides.

N. BURNT VALVES OR VALVE SEATS

Cause: Valve tappet clearance adjusted too close.
Correction: Adjust the valves to the proper clearance.

Cause: Weak valve springs.
Correction: Replace the springs.

Cause: Excessive carbon.
Correction: Remove the carbon deposits.

Cause: Camshaft not timed correctly.
Correction: Retime the camshaft. See **"Camshaft."**

Cause: Lean fuel mixture.
Correction: Clean and adjust the carburetor.

Cause: Valve seats too narrow.
Correction: Cut the seats to the correct width.

Cause: Low grade fuel.
Correction: Use a good quality fuel.

Cause: Valve heads cut too thin when refacing.
Correction: Replace the valve.

O. SPARK KNOCK OR PING

Cause: Excessive accumulation of carbon in the combustion chamber.
Correction: Clean or remove the carbon deposits.

Cause: Hot spot in the combustion chamber due to a carbon deposit or a clogged water passage.
Correction: Remove the carbon and open the water passage.

Cause: Motor operating too hot.
Correction: See **"Cooling System,"** paragraph E-1.

Cause: Inferior type fuel.
Correction: Use a good quality fuel.

Cause: Ignition timing incorrect.
Correction: Correct or reset the timing.

Cause: Carburetion or fuel mixture incorrect.
Correction: Check the carburetor.

Cause: Spark plug gaps too wide.
Correction: Adjust the gaps correctly.

P. EXPLOSION IN THE MUFFLER

Cause: Ignition too late.
Correction: Correct the ignition timing.

Cause: Weak spark.
Correction: Check the condenser, distributor, coils, wires, et cetera.

Cause: Exhaust valves holding open.
Correction: Check the tappet clearance, springs, guides, et cetera.

Cause: Exhaust valves warped.
Correction: Reface or replace.

Q. EXPLOSION IN THE CARBURETOR OR AIR CLEANER

Cause: Fuel mixture too lean.
Correction: Clean the carburetor; check the fuel level in the bowl.

Cause: Intake valves holding open.
Correction: Check the tappet clearance, springs, guides, et cetera.

Cause: Intake manifold leaking.
Correction: Tighten the manifold nuts or replace the gaskets.

CLEARANCE TABLE

(All Dimensions in Inches)

	JX SERIES Min.	JX SERIES Max.	JXL SERIES Min.	JXL SERIES Max.
Valve seat diameter—exhaust	1 9/16		1 9/16	
Valve seat diameter—intake	1 11/16		1 23/32	
Face of the valve seat—exhaust	3/32	1/8	3/64	1/16
Face of the valve seat—intake	3/32	1/8	3/64	1/16
Valve stem clearance in the guide, Std.	.001	.0015	.001	.0015
Valve stem clearance in the guide, Marine and Fire Engine—exhaust	.0025	.003	.0025	.003
Valve stem clearance in the guide, Marine and Fire Engine—intake	.001	.0015	.001	.0015
Valve tappet clearance—See the instruction plate on the engine.				
Push rod or tappet clearance in the guide	.00075	.001	.00075	.001
Idler bearing (shaft) clearance	.00075	.001	.00075	.001
Camshaft bearing clearance	.0015	.0025	.0015	.0025
Accessory or water pump shaft clearance	.0015	.0025	.0015	.0025
Crankshaft main bearing clearance—				
babbitt in cap	.002	.003	.....	.....
babbitt lined shell	.001	.003	.....	.....
hi-lead bronze shell	.0035	.004	.0035	.004
Aircraft — F-77	.001	.0035	.001	.0035
Connecting rod bearing clearance—				
babbitt in rod	.001	.0015	.....	.....
babbitt lined shell	.001	.0025	.....	.....
hi-lead bronze shell	.0025	.003	.0025	.003
Aircraft — F-77	.001	.003	.001	.003
Crankshaft thrust clearance	.002	.004	.002	.004
Connecting rod side clearance	.005	.010	.005	.010
Bellhousing clearance on the chamfer	.012	.025	.012	.025
Accessory or water pump shaft end thrust	.002	.003	.002	.003
Accessory or water pump gear backlash to the idler gear	.002	.004	.002	.004
Camshaft gear backlash to the crankshaft	.000	.002	.002	.003
Idler gear backlash to the camshaft	.0005	.0015	.0005	.0015
Oil pump gear backlash to the camshaft	.008	.010	.008	.010
Piston ring gap	.015	.020	.015	.020
Piston ring land clearance	.00075	.0015	.00075	.0015
Piston pin clearance in the connecting rod	.....	.....	.0005	.0012
Piston pin clearance				
Cast Iron Piston	.00075	.001	.00075	.001
Aluminum Piston	Hand Push Fit		Hand Push Fit	

PISTON CLEARANCE (All Models)

Model	Cast Iron Piston		Aluminum Piston	
JXA	.003	.0035	.0025	.003
JXB	.0035	.004	.0025	.003
JXC	.0035	.004	.003	.0035
JXD			.004	.0045
JXF			.0025	.003
JXG			.0025	.003
JXC-3			.003	.0035
JXD-3			.004	.0045
JXE-3			.0025	.003
JXLD			.0045	.005

For Marine or Fire Engines add .001 to the Piston Clearance.

TORQUE WRENCH TENSION

	Foot Pounds
Cylinder Head Stud Nuts	65
Cylinder Head Screws—Manifold Side	75
Cylinder Head Screws—Center and Row Opposite the Manifold	85
Cylinder Head Screws—Marked "1041"	100
Connecting Rod Nuts	56
Main Bearings—Front and Intermediate	70
Main Bearings—Center and Rear	60
Camshaft Gear Nut	150

Clearance Table (ERDL Engines)

(All Dimensions in Inches)

	JXLA2ER		JXLDER	
	Min.	Max.	Min.	Max.
Valve Seat Diameter—Exhaust		1 15/32		1 15/32
Valve Seat Diameter—Intake		1 51/64		1 51/64
Face of the Valve Seat—Exhaust	7/64	1/8	7/64	1/8
Face of the Valve Seat—Intake	3/32	7/64	3/32	7/64
Valve Stem Clearance in the Guide	.002	.0025	.002	.0025
Valve Tappet Clearance—Intake (Hot)	.008		.008	
Exhaust (Hot)	.010		.010	
Push Rod or Tappet Clearance in the Guide	.00075	.001	.00075	.001
Idler Bearing (Shaft) Clearance	.00075	.001	.00075	.001
Camshaft Bearing Clearance	.0015	.0025	.0015	.0025
Accessory or Water Pump Shaft Clearance	.0015	.0025	.0015	.0025
Crankshaft Main Bearing Clearance—Babbitt lined shell	.001	.003	.001	.003
Connecting Rod Bearing Clearance—Babbitt lined shell	.001	.0025	.001	.0025
Crankshaft Thrust Clearance	.002	.004	.002	.004
Connecting Rod Side Clearance	.005	.010	.005	.010
Bellhousing Clearance on the Chamfer	.014	.020	.014	.020
Accessory or Water Pump Shaft End Thrust	.002	.003	.002	.003
Accessory or Water Pump Gear Backlash to the Idler Gear	.002	.004	.002	.004
Camshaft Gear Backlash to the Crankshaft	.000	.002	.000	.002
Idler Gear Backlash to the Camshaft	.0005	.0015	.0005	.0015
Oil Pump Gear Backlash to the Camshaft	.008	.010	.008	.010
Piston Ring Gap	.015	.020	.015	.020
Piston Ring Land Clearance	.00075	.0015	.00075	.0015
Piston Pin Clearance in the Connecting Rod	.0005	.0012	.0005	.0012
Piston Pin Clearance—Aluminum Piston	Hand Push Fit		Hand Push Fit	
PISTON CLEARANCE	.002	.0025	.0035	.004

TORQUE WRENCH TENSION

	Foot Pounds
Cylinder Head Screws—Manifold Side	80
Cylinder Head Screws—Center and Row Opposite Manifold	90
Connecting Rod Nuts	56
Main Bearings—Front and Intermediate	80
Main Bearings—Center and Rear	70
Camshaft Gear Nut	150

JX TOOLS

PART NO.	PART NAME	WHERE USED
3109-A	Socket—3/4"	Bellhousing, Valve Cover Front and Inter. Main Bearings Cylinder Head Water Pump Outlet or Oil Filter Flywheel, Fan Bracket
3171-A	Socket—5/8"	Connecting Rods Center and Rear Main Bearings
3170-A	Socket—9/16"	Oil Pan, Piston Pin Lock Gear Cover, Water Pump Oil Pump Distributor Bracket Water Inlet and Outlet Flanges Starter Attachments
11462-A	Socket—1/2"	Fuel Pump
2245-B	Square Speeder Handle—1/2"	To be used with the above sockets
3168-A	Socket Extension—6"	To be used with the above sockets
2252-A	Speed Wrench Universal	To be used with the above sockets
13078-A	Open End Wrench—9/16" x 5/8"	Water Pump, Oil Pan Water Inlet and Outlet Flanges Gear Cover, Oil Pump Manifolds (Intake and Exhaust) Carburetor, Fuel Lines
11916-A	Open End Tappet Wrench—1/2"	Tappets
3777-A	Open End Tappet Wrench—1/2"	Tappets
3256-A	Open End Wrench—1/2"	Water Pump, Fuel Pump Oil Pump
2268-A	Oil Adjusting Crowfoot Wrench	Oil Pump
3177-A	Open End Wrench—5/8" x 3/4"	Oil Pan, Bellhousing Valve Cover, Oil Pump
6359-A	Angle Wrench—5/8" x 5/8"	Manifolds
3189-A	Service Ratchet—1/2"	To be used with sockets
11927-A	Flex Handle	To be used with sockets
200082-A	Connecting Rod Spreader	To install piston pins
11924-A	Piston Ring Compressor	Used in installing pistons
13341-A	Valve Spring Lifter	Valve Springs
11913-A	Valve Guide Driver	To remove or install valve guides
13233-A	Push Rod Guide Driver	Removing and installing push rod guides
13232-A	Idler Bushing Driver	Removing and installing idler bearing
13567-A	Cam Bearing Driver	Removing and installing camshaft bearings
3296-A	Spanner Wrench	Water Pump Packing Nut
13964-A	Valve Guide Reamer	Valve Guides
13098-A	Piston Ring Expander	Removing and installing piston rings
11925-A	Screwdriver—5/16" x 5" blade	
13175-A	Screwdriver—1/4" x 6" blade	
13095-A	Pliers—9" Heavy Duty	
13278-A	Adjustable Wrench—8"	
11919-A	Feeler Gauge Set—9" blades	
11920-A	Lady--Foot Pry Bar	
11921-A	Ball Pien Hammer—12 oz.	
6335-A	Tool Box	
3444-A	Torque Wrench	

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